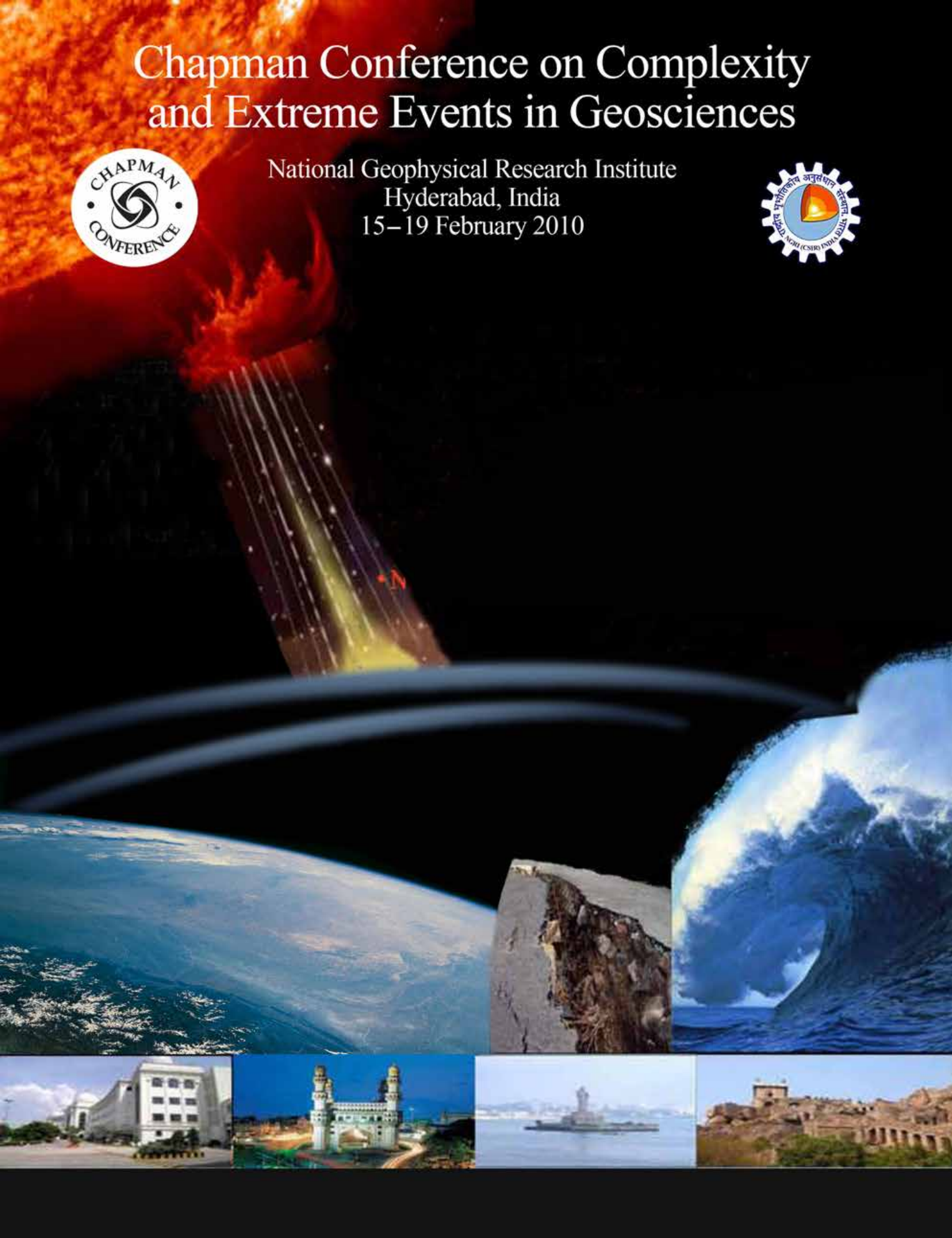
Chapman Conference on Complexity and Extreme Events in Geosciences

National Geophysical Research Institute
Hyderabad, India
15–19 February 2010



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The conference organizers wish to gratefully acknowledge the generous support of the following sponsors for their substantial support for this conference.

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Meeting At A Glance

Monday, 15 February

08:00 a.m. – 09:45 a.m.	Registration and Breakfast
10:00 a.m. – 11:00 a.m.	Inauguration
11:00 a.m. – 12:00 p.m.	High Tea
12:00 p.m. – 01:30 p.m.	Session 1
01:30 p.m. – 03:00 p.m.	Lunch
03:00 p.m. – 04:30 p.m.	Session 2
04:30 p.m. – 06:30 p.m.	Tea Break/Session 3 – Poster Session
06:30 p.m. – 10:00 p.m.	Cultural Program & Dinner National Geophysical Research Institute

Tuesday, 16 February

08:00 a.m. – 09:00 a.m.	Breakfast
09:00 a.m. – 11:00 a.m.	Session 4
11:00 a.m. – 11:30 a.m.	Tea Break
11:30 a.m. – 01:00 p.m.	Session 5
01:00 p.m. – 02:30 p.m.	Lunch
02:30 p.m. – 04:30 p.m.	Session 6
04:30 p.m. – 06:30 p.m.	Tea Break/Session 7 – Poster Session

Wednesday, 17 February

08:00 a.m. – 09:00 a.m.	Breakfast
09:00 a.m. – 11:00 a.m.	Session 8
11:00 a.m. – 11:30 a.m.	Tea Break
11:30 a.m. – 01:00 p.m.	Session 9
01:00 p.m.	Lunch and Excursion/Sight-seeing /Dinner at the Sailing Club

Thursday, 18 February

08:00 a.m. – 09:00 a.m.	Breakfast
09:00 a.m. – 11:00 a.m.	Session 10
11:00 a.m. – 11:30 a.m.	Tea Break
11:30 a.m. – 01:00 p.m.	Session 11
01:00 p.m. – 02:30 p.m.	Lunch
02:30 p.m. – 04:30 p.m.	Session 12
04:30 p.m. – 06:30 p.m.	Tea Break/Session 13 – Poster Session

Friday, 19 February

08:00 a.m. – 09:00 a.m.	Breakfast
09:00 a.m. – 11:00 a.m.	Session 14
11:00 a.m. – 11:30 a.m.	Tea Break
11:30 a.m. – 01:00 p.m.	Session 15
01:00 p.m. – 02:00 p.m.	Lunch
02:00 p.m. – 03:15 p.m.	Session 16
03:15 p.m. – 03:30 p. m.	Tea Break
03:30 p.m. – 05:00 p. m.	Session 17 - Panel Discussion and Closing

Chapman Conference on Complexity and Extreme Events in Geosciences

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MONDAY, 15 FEBRUARY **10:00 a.m. – 12:00 p.m.**	
08:00 a.m. – 09:45 am.	Registration and Breakfast
10:00 a.m. - 11:00 p.m.	Inauguration
11:00 a.m. - 12:00 p.m.	High Tea
MONDAY, 15 FEBRUARY **SESSION 1** **12:00 p.m. – 01:30 p.m. – KEYNOTE SPEAKERS**	
12:00 p. m. – 12:30 p. m. **D. N. Baker**	The Economic and Societal Impacts of Extreme Space Weather Events
12:30 p.m. – 01:00 p.m. **H. van Storch**	Marine Storms - Analysis, Statistics and Changes
01:00 p.m. - 01:30 p.m. **H. Gupta**	Complex Seismic Activity at Koyna
01:30 p.m. – 03:00 p.m. –LUNCH	

MONDAY, 15 FEBRUARY

SESSION 2
03:00 p.m. – 04:30 p.m.

Time	Abstract Title	Presenting Authors
03:00 p.m.	Quantitative Modeling of Extreme Seismic Events	**A.T. Ismail-Zadeh** *(Invited)*
03:30 p.m.	Seismicity in the Generalized Vicinity of Strong Earthquake as the Most Studied Example of Arising of Instability in Natural Systems	**M.V. Rodkin**
03:45 p.m.	Complex Tectonics and Recent Earthquakes in Northeast India: A Review	**J.R. Kayal**

04:00 p.m.	Complex Seismic Structures in the Andaman-Sumatra Subduction Zone: Fractal Dimension and B-Value Mapping	**S. Roy**
04:15 p.m.	Possibility of Slow Viscoelastic Process or Change in Rheology in Late and Long-distance Triggering of Shocks in Gujarat, Western India After the 2001 Mw 7.7 Bhuj Earthquake	**B.K. Rastogi**
TEA BREAK/SESSION – 3 **04:30 p.m. - 06:30 p.m.** *Posters will be posted from 10:00 a.m. in the hall*		
1	Examination of the Distribution of Maximum Earthquake Magnitudes by Combining the GEV and GPD Limit Distributions of Extreme Value Theory	**M.V. Rodkin**
2	Foreshock Clustering as Precursory Pattern for the Kachchh Earthquakes in Gujarat, India	**S.K. Aggarwal**
3	Fractal Analysis and B-value Estimation for Earthquakes from Northwest Himalayan Region	**A. Devi**
4	Simulation of Strong Motion Parameters Using Deterministic Modeling of Finite Source of Two Himalayan Earthquakes	**A. Joshi**
5	B-value and Fractal Dimension Imaging of the Epicentral Zone of the 2001 Bhuj Earthquake, Gujarat, India	**P. Mandal**
6	Spatial and Temporal Variations of B-value and Fractal Analysis of the Earthquake Distribution from the Andaman-Sumatra Subduction Zone of the Indian Ocean	**V.S. Rani**
7	Extreme Events Recovered in Subsurface Images Along the Tamil Nadu Coast	**R. Nair**
8	Doughnut Precursory Seismicity Patterns in the Indian Shield Earthquakes: An Observation	**B. Rao**
9	Statistical Study of Himalayan Seismicity	**K. Kanna Babu**
10	S-wave Spectral Modeling of 244 Aftershocks of the 2001 Mw7.7 Bhuj Mainshock	**S.K. Dutta**
11	Site-Dependent Attenuation Study for Peninsular Shield of India	**C. Singh**
12	Tectonic Implications and Seismicity Triggering During Mw 6.4 Baluchistan, Pakistan Earthquake Sequence of October 28-29, 2008	**R.B.S. Yadav**
13	Extreme Seismic Events and Gravity Anomalies in the Subduction Zones	**V.M. Tiwari**
14	Analysis of the Seismicity of the Andman Region	**A.R. Bansal**

15	Slip Predictable Behaviour for Seismicity of Garhwal Himalaya, India	**A. Chamoli**
16	Analysis of Earthquake Data of Himalayas - A New Approach	**V.V. Hara Gopal**
17	Identification of Seismicity Pattern for Some Destructive Earthquakes	**P.N.S. Roy**
18	Nonlinearity in Origin of Ridges in Indian Oceanic Lithosphere	**B. Ashalatha**
19	Seismotectonics in Northeast India: A Stress Analysis of Focal Mechanisms of Earthquakes and Its Kinematic Implications	**S. Baruah**
20	Attenuation Relation for Garhwal Himalaya Obtained Using Damped Least Square Method	**A. Kumar**
21	Seismogenesis of the Lower Crustal Intraplate Earthquakes Occurring in the Kachchh Seismic Zone, Gujarat, India	**P. Mandal**
22	Paleoseismological Study in the Nepal Himalaya – Present Status	**B.N. Upreti**
23	Earthquake Epicenters Linked to the Positions of the Sun, Moon and Planets: An Instance of Organized Behavior in Complex Systems	**S.K. Ghosh**
24	Fractal Clustering of Reservoir Induced Seismicity in the Koyna-Warna Reservoir Area	**S. Padhy**
25	B-value Mapping in Hindukush-Pamir Himalaya Region: Evidence of Phase Transformation of Material Within Subducting Slab	**R.B.S. Yadav**

06:30 p.m. – 10:00 p.m.

Cultural Program Followed by Hosted Dinner at NGRI

TUESDAY, 16 FEBRUARY

SESSION 4
09:00 a.m. – 11:00 a.m.

Time	Abstract Title	Presenting Aurthors
08:00 a.m.	Breakfast	
09:00 a.m.	The Complex Nonlinear Process of Equatorial Spread F: How Far Are We From Operational Predictability?	**R. Sridharan** *(*Invited)
09:30 a.m.	Electrostatic Solitary Waves in Non-Thermal Plasmas	**S.V. Singh**

09:45 a.m.	Severe and Long-Lasting Geomagnetic Storms, Their Solar Sources and Related Disturbances in Near-Earth Geospace	**B. Badruddin** **WITHDRAWAL**
10:00 a.m.	The Probability Distribution of Extreme Geomagnetic Events in the Auroral Zone	**R. Weigel** *(*Invited)
10:30 a.m.	Extreme Geomagnetic Storms and Low Latitude Geomagnetic and Ionospheric Response	**B. Veenadhari**
10:45 a.m.	Occurrence of Anomalous Geomagnetic Event During Recent Solar Cycle	**V.C. Dwivedi**
11:00 a.m.- 11:30 a.m. TEA BREAK		
TUESDAY, 16 FEBRUARY **SESSION 5** **11:30 a.m. – 01:00 p.m.**		
11:30 a.m.	Extreme Events in Space Weather: Characterizing the Inherent Statistical Properties	**T. Veeramani** *(*Invited)
12:00 p.m.	Index of Recurrence Asymmetry in Complex Systems: Application to Sunspots and Earth Surface Temperature Anomalies	**V.B. Kiselev** **WITHDRAWAL**
12:15 p.m.	A Study on Chaotic Behaviour of Equatorial/Low Latitude Ionosphere Over Indian Subcontinent, Using GPS-TEC Time Series	**K. Unnikrishnan**
12:30 p.m.	Stratospheric ozone Depletion and Its Management: Lessons from the Montreal Protocol for Combating Other Artificially Induced Perturbations	**R. Gopichandran**
12:45 p.m.	Characteristics of Auroral Electrojets During Intense Geomagnetic Activities	**A.K. Singh**
01:00 p.m. - 02:30 p.m. LUNCH		
TUESDAY, 16 FEBRUARY **SESSION 6** **02:30 p.m. – 04:30 p.m.**		
02:30 p.m.	The Challenge of Diagnosing a Nonlinear Geophysical Theory of Floods in River Networks and Potential Applications Under Climate Change	**V.K. Gupta** *(*Invited)
03:00 p.m.	Extreme Event for Earthquake Triggered Landslides	**J.R. Grasso**
03:15 p.m.	Seismicity Analysis and Simulation of a Possible Tsunamigenic Earthquake from the Andaman Region: Impact Along the East Coast of India	**V.P. Dimri**
03:30 p.m.	Multifractal Extreme Value Theory (MEV)	**D. Schertzer** (Invited)

04:00 p.m.	Fractal and Multifractal Characteristics of Time Series in Seismogenic Regions of 1897 Assam, 1905 Kangra and 1934 Bihar Great Earthquakes	**S.S. Teotia**
04:15 p.m.	Extreme Events – Methodologies for a Rational Approach to Deal with Extreme Natural Events Under Intrinsic Uncertainty	**F. Wenzel**
TEA BREAK / SESSION – 7 **04:30 p.m. – 06:30 p.m.** *Posters will be posted from 10:00 a.m. in the hall*		
1	Influence of Solar Wind Plasma and Interplanetary Magnetic Field on the Low-latitude Geomagnetic Variations During Descending Phase of Solar Cycle 23	**R. Rawat**
2	Understanding the Severe Magnetic Disturbances of October 2003 – Challenges for Modelling	**N. Nagarajan**
3	Nonlinear Solitary Electric Field Structures in the Earth's Magnetosphere	**R. V. Reddy**
4	Investigation of Intense Geomagnetic Storms and Associated Cosmic Ray Intensities: A Correlative Study	**S. C. Kaushik**
5	Space Applications in Disaster Assessment and Mitigation: Examples from Haryana State, India	**B. S. Chaudhary**
6	Using Forbush Decrease Events for the Prediction of Geomagnetic Storms	**M. Jain**
7	SKS/SKKS Splitting in the Kachchh rift Zone, Gujarat, India	**P. Mandal**
8	Modeling to Assess Tsunami Effects on the Indian Coasts From Earthquakes Along Makran and Andaman-Sumatra Subduction Zones	**A.P. Singh**
9	Inundation Modeling at Different Locations Along the West Coast of India Due to Tsunamigenic Earthquakes From the Makran Subduction Zone	**R. Krishna Kumar**
10	Investigations Into Cause of High Lightning Incidence and Accidents By It in a Region With Relatively Special Characteristics	**R. Vishnu**
11	Seismic Response in an Anisotropic Medium	**M. Majumder**
12	Inversion of 2-D Resistivity Data Using Rapid Optimization and Minimal Complexity Neural Network	**U. Singh**
13	Can We Resolve NMO and DMO-Nonlinear Problems in Exploration Seismic	**N.L. Mohan**
14	A Study on Non-Linear 3-D Wavelet for Scale Extraction	**D. Sujatha**
15	Estimation of Crustal Discontinuities From Reflected Seismic Waves Recorded at Shillong and Mikir Hills Plateau, North East India	**S. Baruah**

16	Discovery of Hydrocarbon in Cretaceous Deccan Basalt, India	**A.M. Dayal**
17	Artificial Neural Networks (ANN) Based Modeling for Landslides Susceptibility Zonation in Parts of Himalayas	**L. Nwankwo**
18	Radon Transform and Its Application In Seismic	**P.P. Mandal**
19	Multicomponent Seismic Applications in Coalbed Methane Development	**S. Gupta**
20	Gottwald-Melbourne Test for Chaos of Nonlinear Fluctuations in Complex Laboratory Plasmas	**A.N. Iyengar**
21	Characterization of Recharge Through Complex Vadose Zone of a Granitic Aquifer by Time-Lapse Electrical Resistivity Tomography	**T. Arora**
22	Study of Coseismic Ground Deformation Due to Recent Earthquakes & Crustal Deformation Measurements on Active Faults In and Around India Using SAR Interferometry	**S. P.Satyabala**

WEDNESDAY, 17 FEBRUARY

Session 8
09:00 a.m. – 11:00 a.m.

Time	Abstract Title	Presenting Authors
08:00 a.m.	Breakfast	
09:00 a.m.	A Peep into the Complexities and Dynamics of Large Himalayan Earthquakes to Assess Their Role in the Preparedness for Future Extreme Seismic Events	**B.R. Arora** (Invited)
09:30 a.m.	Continuous Time Random Maxima: Stochastic Models for Estimating Recurrence of Extreme Events in Time Series With Long Range Correlations	**R. Schumer**
09:45 a.m.	Estimation of the Ground Motion and Site Effects of Indo-Gangetic Plains	**D. Srinagesh**
10:00 a.m.	Entropy Production and Self-organised (sub) Criticality in Earthquake Dynamics	**I. Main** *(*Invited)
10:30 a.m.	Could the Magnitude of an Earthquake be Bounded From Above?	**V. Srivastava**
10:45 a.m.	Quality Assessment, Reserve Estimation & Economic Analysis of Roofing Slate in the West Central Lesser Himalaya-Nepal	**N.R. Neupane** **WITHDRAWAL**

11:00 a.m. - 11:30 a.m. **TEA BREAK**

WEDNESDAY, 17 FEBRUARY

Session 9
11:30 a.m. – 01:00 p.m.

11:30 a.m.	Long-term Memory in Climate Records: Clustering of Extreme Events and the Detection Problem	**S. Lennartz** *(*Invited)
12:00 p.m.	Extreme Events in Precipitation and River Flows: Effect of Linear and Nonlinear Correlations	**A. Bunde**
12:15 p.m.	Extreme Events, Return Intervals and Long Term Memory	**M. Santhanam** *(*Invited)
12:45 p.m.	Study on Hydro-chemical Change of Epikarst Spring Based on Extreme Weather in the Jinfo Mountain of Chongqing: A Case Study of Extreme Drought 2006, Chongqing	**L. Linli**
01:30 pm **Lunch and Excursion / Sight-seeing / Dinner at the Sailing Club**		
THURSDAY, 18 FEBRUARY **Session 10** **09:00 a.m. – 11:00 a.m.**		
Time	**Abstract Title**	**Presenting Authors**
08:00 a.m.	Breakfast	
09:00 a.m.	On the Statistics of Extremes in Space Weather Events – A Review of Statistical Methods Recently Applied on Solar Flare and Geomagnetic Storms Data	**J. Eichner** *(*Invited)
09:30 a.m.	Landslide Dam Outburst Flood in the Satluj Valley, Himachal Pradesh, India	**V. Gupta**
09:45 a.m.	Thermal Upwellings, Magmatic Extrusion and Intra-plate Rift Valley Earthquakes in India	**O.P. Pandey**
10:00 a.m.	Climate Catastrophe: Spectral Characteristics and Model Behavior of Abrupt Climate Changes Over Present to Millennial Time Scales	**R.K. Tiwari**
10:15 a.m.	Wavelet Analysis of Marine Oxygen Isotope ð18O Record	**M. Ravi Prakash**
10:30 a.m.	Archives of Extreme Events in Holocene in the Himalaya	**S.P. Sati**
10:45 a.m.	Surface and Deep Water Characteristics in the Northeast Indian Ocean During the Last 60,000 Years as Inferred From Carbon and Oxygen Isotopic Compositions of Foraminifera	**S.M. Ahmad**
11:00 a.m.	Rodinia Supercontinent, Snowball Earth and Extreme Global Paleoclimate Change: Evidences From the Lesser Himalaya and Marwar Supergroup, India	**V.C. Tewari**
11:00 a.m. – 11:30 a.m. TEA BREAK		
THURSDAY, 18 FEBRUARY **SESSION 11** **11:30 a.m. – 01:00 p.m.**		

11:30 a.m.	A Nonlinear Synthesis for Understanding Atmospheric Complexity: Space-Time Cascades	**S. Lovejoy** *(*Invited)
12:00 p.m.	Application of Doppler Wind Lidar Observations to Improve Scientific Understanding and Forecasting of Extreme Weather Events	**U. Singh**
12:15 p.m.	Assessing the Characteristics of Extreme Rainfall Through an Examination of Atmospheric Circulation States Using Self-Organizing Maps	**C.J. Lennard**
12:30 p.m.	Operation of Multi-objective Multi-reservoir System under Climate Change Complexities	**M. Zarghami** **WITHDRAWAL**
12:45 p.m.	Wintertime Climatic Analysis Over the Western Himalayas	**A.P. Dimri**
01:00 p.m. – 02:30 p.m. LUNCH		
THURSDAY, 18 FEBRUARY **Session 12** **02:30 p.m. – 04:30 p.m.**		
02:30 p.m.	Thermal State of the Indian Crust by Minimizing Rate of Entropy Production	**R.N. Singh (**Invited)
03:00 p.m.	Storm Coals: A Extreme Depositional Systems in South Brazil Deposits	**M.A.M. Medeiros**
03:15 p.m.	Recent Extreme Wet and Dry Spells Across India	**N. Singh**
03:30 p.m.	Influence of Debris Cover on the Melting Processes of Glacier - a Study on Chorabari Glacier, Garhwal Himalaya, India	**D.P. Dobhal**
03:45 p.m.	Spectral Characterization of Soil and Coal Contaminated Snow Reflectance Using Hyperspectral Analysis	**S.K. Singh**
04:00 p.m.	Impact of Glacial Lake Outbursts in the Buffer Zone of Nanda Devi Biosphere Reserve, Central Himalaya, Uttarakhand	**M.P.S. Bisht**
04:15 p.m.	The High Himalayan Orogeny Time: Upper – Early Oligocene?	**D. Gopala Rao**
TEA BREAK / SESSION – 13 **04:30 p.m. - 06:30 p.m.** *Posters will be posted from 10:00 a.m. in the hall*		
1	Declining Predictability of Indian Summer Monsoon Weather, in the Backdrop of Increasing Heavy Rainfall Events	**J.M. Neena**
2	High Intensity Rainfall Event on Subsurface Water Regime: A Case Study in Granite Watershed, Andhra Pradesh, India	**R. Rangarajan**
3	Analysis and Prediction of Rainfall Data: Fractal Approach	**R. Srivastava**

4	Scaling and Persistence in Ground Level Ozone Concentrations in Delhi	**A. Chelani**
5	Productivity Pattern in the Equatorial Indian Ocean During the Last 300,000 Years	**M.S. Krishna**
6	Extremely Long Duration Total Solar Eclipse on 22 July, 2009: Effect on D-region Ionosphere Dynamics as Studied from VLF Signals Observations	**R. Singh**
7	Consequences of the Fossil Fuel Extraction on the Climate Change of the Earth	**B. Kumar**
8	Some Characteristics of the K-T Boundary Mass Extinction Event	**P. Tripathi**
9	Complex Dynamics and Multi-scale Structure of Sediment Transport: Experimental Evidence and Theoretical Insights	**V. Ganti**
10	Geomorphic Evolution of Himalaya and its Foreland: The Last 60 ka Perspective	**P. Srivastava**
11	Active Deformation Within MBT-HFT Tectonic Wedge in Trans-Yamuna Dun of NW Sub-Himalaya: Implication on Seismic Slip Partitioning	**G.D. Singh**
12	A GIS Tool to Automatically Extract Area Altitude Distribution of Glaciers	**R. Kaur**
13	Seafloor Characterizations Using Multi-Beam Bathymetry and Backscatter Data: Appraisal of Numerical Techniques Employed	**B. Chakraborty**
14	Mantle Convection Stirring Efficiency With Both Basal and Internal Heating	**B. Deo**
15	Hydrological Complexity Model of Active Upper Crust Under Koyna (India) Region	**R.N. Singh**
16	Sustainable Management of Coral Island Aquifer Through Numerical Modeling	**P. Banerjee**
17	Deciphering Zeolitic Formations in Deccan Basalt – An Indirect Method of Finding Groundwater in Hard Rock Using Integrated Geophysical Approach	**D. Kumar**
18	Mantle Plumes, Their Depth of Origin Within the Mantle and Excess Temperatures	**S. Das Sharma**

FRIDAY, 19 FEBRUARY **Session 14** **09:00 a.m. – 11:00 a.m.**		
8:00 a.m.	Breakfast	
09:00 a.m.	Distributions of Extreme Bursts Above Thresholds in a Fractional Lévy Toy model of Natural Complexity	**N. Watkins** (Invited)
09:30 a.m.	Constraints on the Tectonic Setting of the Andaman Ophiolites, Bay of Bengal, India, From SHRIMP U–Pb Zircon Geochronology of Plagiogranite	**S.H. Jafri**
09:45 a.m.	Understanding the Complex Behavior of Crustal Heat Production	**N. Vedanti**
10:00 a.m.	Super Magnetic Storms: Hazard to Society	**G.S. Lakhina** (*Invited*)
10:30 a.m.	Nonlinear Development of Equatorial Ionospheric Plasma Bubbles: Evolution of intermediate scale structures	**A. Bhattacharya**
10:45 a.m.	Is There a Timescale Where the Clausius-Clapeyron Relation Describes Precipitation Rate Changes?	**J.O. Haerter**
11:00 a.m. – 11:30 a.m. TEA BREAK		
FRIDAY, 19 FEBRUARY **Session 15** **11:30 a.m. – 01:00 p.m.**		
11:30 a.m.	Landslide Studies and Mitigation –With a Focus on Varunavat Landslide in Uttarkashi, Uttarakhand Himalaya, India	**P.C. Nawani** (Invited)
12:00 p.m.	Analysis and Prediction of Extreme Day Mean Values of Total Ozone Amount Interannual Changes Over Europe in the Period From 1979 to 2006 Years	**M. Nikiforova**
12:15 p.m.	The Singularity Structure of Indian Monsoon Rain	**V. Venugopal**
12:30 p.m.	Modeling Flow Over An Aligned Flat Surface Using Blasius Equation	**B. Basu**
12:45 p.m.	Intercomparison of the Total Storage Deficit Index (TSDI) Over Two Prairie Catchments	**C.O. Agbona**
01:00 p.m. - 02:00 p.m. LUNCH		

Session 16 **02:00 p.m. – 03:15 p.m.**		
02:00 p.m.	Sesmological Constraints of Great Kangra Earthquake of 1905 and Associated Hazard in NW India	**H.N. Srivastava** (Invited)
02:30 p.m.	Crust-mantle Structure Below the Indo-Gangetic Plains	**R.K. Chadha**
02:45 p.m.	Earthquake Interevent Time Distributions Reflect The Proportion of Dependent and Independent Events Pairs And Are Therefore Not Universale	**M. Naylor**
03:00 p.m.	Interplanetary Transient Solar Wind Flows and Extremely Disturbed Geomagnetic Field Conditions	**S.C. Kaushik**
03:15 p.m. – 03:30 p.m. TEA BREAK		
Session 17 **Panel Discussion and Closing** **03:30 p.m. – 05:00 pm**		

Intercomparison of the Total Storage Deficit Index (TSDI) Over Two Prairie Catchments

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Retrieval of the terrestrial moisture storage dataset from the Gravity Recovery And Climate Experiment (GRACE) satellite remote sensing system is possible when the catchment of interest is of large spatial scale. These dataset are of paramount importance for the estimation of the total storage deficit index (TSDI), which enables the characterization of a particular drought event from the perspective of the terrestrial moisture storage over that catchment. Incidentally, the GRACE gravity signal over the 13000 km2 Upper Assiniboine River Basin on the drought-prone Canadian Prairie is so poor therefore making the computation of the total storage deficit index for this basin infeasible. Consequently, the estimation of the terrestrial moisture storage from other reliable sources becomes imperative in order to enable the computation of the TSDI over this basin.

This study explores the utilization of the Variable Infiltration Capacity (VIC) model, a physically based, spatially distributed hydrologic model to simulate the total moisture storage over the Upper Assiniboine River Basin which was then employed in the estimation of the TSDI over this basin for subsequent characterization of the recent Prairie-wide drought. Interestingly, the temporal patterns in the computed TSDI from the VIC model reveal a strong resemblance with the same drought characterization undertaken over the larger adjacent Saskatchewan River Basin, which was accomplished utilizing terrestrial moisture storage from the GRACE-based approach. Additionally, these independent techniques employed in the characterization of the last Prairie drought over the two adjacently situated basins resulted in similar drought severity classification from the standpoint of the total moisture storage deficits over these basins. This study has therefore shown that in the computation of the total storage deficit index over small-scale catchments during anomalous climatic conditions that propagates extreme dryness through the terrestrial hydrologic systems, simulations of the total water storage from a structurally sound model such as the VIC model could be resourceful for the computation of the monthly total storage deficit index if no constraint is placed on the availability of accurate meteorological forcing.

Foreshock Clustering as Precursory Pattern for the Kachchh Earthquakes Gujarat, India

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Aftershock activity to M5 level is continuing in the rupture zone of 2001 Mw 7.7 earthquake in Kachchh, western India. The activity has also expanded to nearby faults. The seismicity is being monitored by dense network of more than 20 broadband seismographs in about 60kmx60km area. As the earthquake locations are precise it has been possible to observe foreshocks clustering prior to eight mainshocks of Mw 3.8 to 4.7 during 2007 to 2009. Clustering of four to sixty-seven foreshocks in areas of 4 to 25km radius for duration of 7 to 25 days has been observed. One to six days quiescence is also observed for six cases. The foreshocks in general cluster from about 10 km depth to the focal depth of mainshocks of 21 to 30 km in seven cases. In one case of mainshock along Gedi fault (Mw 4.1 on 15 Apr 2008) the focal depth of the mainshock and foreshocks are 10-14 km. It has to be mentioned that similar clustering at other times was not followed by M~4 mainshocks. Nevertheless one M4.5 mainshock on September 5, 2009 was in-house predicted a day in advance from cluster model as there were 7 foreshocks of M3.0 to 3.7 and 60 foreshocks of M 0.5 to 2.9 in 20kmx50km area during 10-day period followed by a day's quiescence. This study

gives hope of prediction of earthquakes as is being done for Koyna, India and first time for Kachchh region in India.

Surface and Deep Water Characteristics in the Northeast Indian Ocean During the Last 60,000 Years as Inferred From Carbon and Oxygen Isotopic Compositions of Foraminifera

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Stable carbon and oxygen isotopes in planktonic and benthic foraminifera and grain size measurements are carried in a well dated sediment core (SK-157-14) from the Northeast Indian Ocean. The gravity core studied here was retrieved from a water-depth of 3306 m at lat. 5o11'N and long. 90o05'E. Chronology of the core was established using six AMS dates (for the younger section of core) and oxygen isotope stratigraphy (for older section). The average sampling resolution for planktonic isotopic data set is approximately 400 years. A comparison of the AMS derived ages from planktonic species of G. ruber and G. sacculifer with conventional radiocarbon ages from bulk carbonates show that the bulk carbonate ages are generally higher than the AMS ages. This suggests that the bulk carbonates at the studied location contain substantial quantity of old carbonate. The grain size measurements from the core samples suggest that the sediments are mainly composed of silt fraction.

Significant variations in del 18O of G. ruber between 2-60 ka are suggestive of large changes in the Indian monsoonal precipitation. A marked depletion in del 18O of near surface dwelling planktonic foraminifera (G. ruber) at 8-9 ka indicates strengthening of Indian monsoon. High-resolution measurements in planktonic foraminifera show a significant del 18O enrichment at 11.5-13 ka, corresponding to the 'Younger Dryas' cooling event.

The deep water characteristics in the northeast Indian Ocean were reconstructed using the carbon and oxygen isotopes of benthic foraminifera (mostly Cibicidoides wuellerstorfi). A comparison of the benthic del 18O and del 13C record from our core with that of a Pacific core (RC13-110) suggest a similar deep water evolution. The oxygen isotopes in benthic foraminifera indicate a glacial deep water cooling of about 2oC in the northeast Indian Ocean. A positive shift in del 13C during the early deglaciation is consistent with other records from this region. The observed fluctuations in del 13C during the deglaciation appears to have derived by the switch 'on' and 'off' of North Atlantic Deep Water (NADW)
fluxes in the deep northeast Indian Ocean.

Thermal State of the Indian Crust by Minimizing Rate of Entropy Production

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Many nonlinear systems evolve by minimizing their rates of entropy production. Thermal state of the Indian crust depends on a variety of processes which involve distribution of radiogenic heat sources, heat addition from the interior and removal from the surface, and nature of nonlinear and stochastic transport processes within the crust. These are highly variable processes and it is very difficult to quantify all of these based on inferences from geological, geochemical and geophysical data. Crustal domains with different thermal properties interact nonlinearly to establish an equilibrium thermal state. In such cases it might useful to invoke the rate of entropy production principle to constrain the thermal state. This principle has been used earlier for this purpose earlier by Singh and Negi (Geophy. Res. Lett., 1980), Bodri and Cermak (Tectonophysics, 1993), and Singh and Manglik (Sadhana, 2000). Recently extensive surface heat flow and heat generation data have been obtained for the

Indian region. In the present work, these data have been used to infer the thermal state of the Indian crust by minimizing the rate of entropy production. The effects of fluid transport and tectonic deformation have also been included in the analysis.

A Peep into the Complexities and Dynamics of Large Himalayan Earthquakes to Assess Their Role in the Preparedness for Future Extreme Seismic Events

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The occurrences of large and great earthquakes along the Himalayan arc are the extreme examples of the plate boundary ruptures marking penultimate state of strains accumulation due to continued collision of Indian-Eurasian Plates. On the other hand, space-time segmentation of earthquake activity along the entire length of the Himalayan arc signifies complexities of the tectonic setting and crustal structures controlling strain accumulation/release. Continuous enhancements in seismic monitoring network and improved location of earthquake parameters clearly bring out role of tectonic elements in defining the space-depth, diversity in source mechanism, concentration of earthquakes to narrow belt etc. Modeling of GPS measurements attribute this concentration of earthquakes to stress accumulation around the down-dip end of the locked portion of the Indian Plate. Geophysical deep imaging favors nucleation of strains in a ramp structure in the down going basement thrust as a possible mechanism responsible for concentration of earthquakes to a narrow belt. The electrical resistivity mapping, by virtue of its sensitivity to fluids, allow to explain the sharp cut-off depth and focusing of tectonic stresses on the brittle-ductile plane accounting for the alignment of hypocenters of large earthquakes on a single plane visualized as the top of the down-going Indian Plate. Integration of space-time distribution of seismicity with deep imaging allows to infer that sections of the Himalaya where the structure aligned with the geological fabric of the Himalaya are cut by local transverse structures define the asperity providing longitudinal segmentation of seismicity in the Himalayan arc. This understanding of tectonic seismic linkage permits to apply more modern tool of self organized criticality, statistical self-similarity and dynamical origin to understand and predict the event of extreme state of strain accumulation marking preparedness for ensuing great earthquake.

Characterization of Recharge Through Complex Vadose Zone of a Granitic Aquifer by Time-Lapse Electrical Resistivity Tomography

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The vadose zone is the main region controlling water movement from the land surface to the aquifer and has very complex structure. The use of non-invasive or minimally invasive geophysical methods especially electrical resistivity imaging is a cost-effective approach adapted for long-term monitoring of vadose zone. The main aim of this work is to know the fractures in vadose zone through which the recharge or preferred path recharge to the aquifer takes place and thus to relate moisture and electrical resistivity. Time Lapse Electrical Resistivity Tomography (TLERT) of subsurface processes is an emerging and promising area of hydrogeophysics. Experiment was carried out in the vadose zone of granitic terrene at National Geophysical Research Institute, Hyderabad along two profiles, 300 m apart to a depth of 18 m and 13 m each. Piezometric, rainfall and soil moisture changes were accounted to correlate with changes in recharge distribution. TLERT inversion profiles were matched with soil moisture, rainfall and piezometric data. These TLERT difference images showed that the conductivity distribution was consistent with recharge occurring along the minor fractures. We integrated TLERT images with other data sets like soil moisture, rainfall, water level. We analyzed the fractures in hard rock or

granites where recharge takes place from the secondary porosity to see the effect of recharge on resistivity variation and estimation of moisture content. We have measurement of soil moisture and resistivity from TLERT images and finally correlated them. We can map minor fractures through granite and the recharge is reflected in resistivity images in terms of decreasing resistivity with increase in recharge and vice-versa along the preferred pathways. A good correlation between the soil moisture and resistivity is established in the unsaturated zone of granitic aquifer. Since the vadose zone exhibit extremely high variability, both in space and time, the surface geophysical investigations such as TLERT has been simple and useful method to characterize the vadose zone, which would not have been possible with point measurements alone.

Nonlinearity in Origin of Ridges in Indian Oceanic Lithosphere

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Large scale oceanic bathymetry along with heat flow, gravity, geoidal and earthquake focii data have been explained using linear heat conduction model with local isostatic compensation. Local departures in gravity and bathymetry data have also been explained using linear approximation between topography and gravity. However there are still significant departures in both gravity and bathymetry data. These high frequency components may point to nonlinear processes which would have been operative during magmatic construction of oceanic lithosphere. It would thus be interesting to infer nonlinear characteristics of these anomalous data using fractal analysis. This has been done using iterated function methodology. Results show that a low order nonlinear dynamic system can explain the properties of the data. Further as evolution of surface topography of earth is modeled by nonlinear diffusion equations, applicability of such models in understanding various features of Indian ocean bathymetry will also be discussed.

Statistical Study of Himalayan Seismicity

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We analyzed a seismically active Himalayan region formed due to collision of Indian and Eurasian continental plates. The Himalayan region is divided into three parts: Western (29º-36ºN, 76º-80º E), Central (20º-32ºN, 80º-88ºE) and Eastern (20º-30ºN, 88º-96ºE) on the basis of seismicity. The NEIC catalogue is used from January 1973 to August 2009 with a magnitude completeness of 4.6, 4.6 and 4.3 for western, central and eastern Himalaya, respectively. The b-values are found to be 1.29, 1.17, 0.95 for western, central and eastern, respectively. The lower b – value in the eastern Himalaya indicates frequently occurrence of bigger earthquakes. The b - values varies with time and decrease of these values are observed corresponding to the earthquakes of M >=6.0. The depth distribution in the region indicates occurrence of shallower (<70 km) as well as deeper (>70 km) earthquakes in the eastern region, whereas western and central portion is dominated mainly by shallow earthquakes. Temporal clustering indicates non- Poisson fractal distribution of the earthquakes for all the three regions with a value of 0.08 (western), 0.06 (central), 0.06 (eastern). The lower values of fractal dimension in central and eastern Himalaya indicate isolating clustering in time. The temporal clustering in the eastern region is observed for shallow as well as deeper earthquakes. Four time windows in the eastern Himalaya have been modeled with Epidemic type aftershock sequence (ETAS) model, remaining western and central are not considered for ETAS model because of limited dataset. The productivity factor K values are found 1.42 (western), 0.28 (central), [0.11, 1.01] (eastern). The magnitude sensitivity parameter alpha values are 2.14 (west) 1.74 (central), [1.24, 1.95] (eastern), and the Omori-Utsu exponent p values are 0.83 (west), 0.81 (central), [0.36, 0.94]

(eastern). In general lower p values, b value and temporal clustering fractal dimension in Eastern Himalya indicate more heterogeneous and hazardous nature of the region as compared to the western and central part.

Severe and Long-Lasting Geomagnetic Storms, Their Solar Sources and Related Disturbances in Near-Earth Geospace

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Study and prediction of severe and long-lasting major storms is important, as the severity and duration play varying role in one space weather effect or the other. Study of such storms is also important so as to know about their different solar and interplanetary causes, and also to understand the physics of such events. We identify the solar sources and interplanetary structures causing both the severe (Dst < -250 nT) as well as the long-lasting (>10 days) major disturbances in geospace. We examine fluctuations in the interplanetary plasma and field parameters during the passage of such structures. During their passage through Earth, we study the charge particle dynamics by analyzing simultaneous perturbations in cosmic ray (CR) intensity measured by ground-based instruments. Disturbances originating at the Sun (CMEs/High-Speed Streams from Coronal Holes) and evolving in interplanetary space (Shocks/ICMEs/CIRs/Magnetic Clouds), and 'complex' structures formed due to merging of two or more of them, generally modulate both the geomagnetic activity as well as CR intensity, however, amplitudes of modulation ('geo-effectiveness' and 'CR-effectiveness') due to a particular structure is often quite different, both in magnitude and time profile. Simultaneous use and analysis of interplanetary plasma and field parameters (plasma velocity, density and pressure, interplanetary magnetic field, its variance and north-south component) during the passage of various distinct regions of interplanetary structures (Shocks/ICMEs/CIRs etc.) is utilized to provide insight not only about the relative 'geo-effectiveness' and 'CR-effectiveness' of various distinct structures, but also about the relative importance of interplanetary parameters and physical mechanism(s) playing important role in modulating geomagnetic activity and cosmic ray intensity. Such studies, during the passage of structures responsible for severe and long-lasting major storms, are useful in prediction of severe space weather conditions. Implications of our results for space weather prediction are also discussed.

The Economic and Societal Impacts of Extreme Space Weather Events

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Vulnerability of society to space weather effects is an issue of increasing concern. For example, electric power networks connecting widely separated geographic areas may incur damaging effects induced by geomagnetic storms. Also, the miniaturization of electronic components that are used in spacecraft systems makes them potentially more susceptible to damage by energetic particles produced during space weather disturbances. NASA has put into place a program to expand human activities with a future permanent settlement on the Moon and eventually a mission to Mars. However, despite all these potential space weather vulnerabilities, relatively few detailed studies of the socioeconomic impacts of severe space weather events have been carried out. A committee, operating under the auspices of the Space Studies Board (SSB) of the National Academy of Sciences, was charged in 2007 to convene a public workshop. This was to feature a discussion to assess current and future ability to manage the effects of space weather events and their societal and economic impacts. Although cost/benefit analyses of terrestrial weather observing systems and mitigation strategies have a long history, similar studies for space weather are lacking. Workshop sessions included an analysis of the effects of historical space weather events, and used the record solar storms of October – November 2003 to focus the presentations and provide data to project future vulnerabilities. The conclusion of the various assessments was that severe space weather events can cause tens of millions to many

billions of dollars of damage to space and ground-based assets. The most extreme events could cause months-long power outages and could cost >$1trillion. In this talk, I will discuss socioeconomic impacts of space weather and I will also discuss the immense potential benefits of improved space weather forecasts. Such forecasts take advantage of our increased understanding of the nonlinear dynamical evolution of the Earth's space environmental conditions, especially as seen during extreme space weather events.

Sustainable Management of Coral Island Aquifer Through Numerical Modeling

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Generally in small coral islands, groundwater is the only dependable source of fresh water supply. Androth is such an island of Lakshadweep archipelago, situated off the western coast of India. Coral sands, and coral shell limestone are the main water bearing formations. The topography of the island is undulating and the elevation above the mean sea level ranges from a few centimeters to about 6 m. Depending upon the topography, the depth to groundwater level below ground level varies from 0.5 to 4.0 m. Excessive pumping of the aquifer already caused erratic changes in its water quality and flow patterns due to sea water ingress in the aquifer. Therefore sustainable fresh groundwater development scheme is imperative. This in turn requires assessment of fresh groundwater potential on the island, aquifer behavior and response of groundwater regime to various stresses.

Among various approaches, a numerical model for variable density flow, SEAWAT is used to simulate the hydraulic head behavior and prognoses the current and future conditions of water level in the coral island aquifer under various pumping conditions. The results show that the hydraulic head is very sensitive to the pumping rates in island environment. The model was used to establish a sustainable pumping rate for a small coral islands aquifer system.

Analysis of the Seismicity of the Andman Region

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We analyzed the seismicity of Andman Island region (10 N -17.5 N, 91.5 E to 94.5 E) recently visited by the earthquake of 7.5M on 10 August, 2009 with an epicenter at (14.1 N, 92.91 E) on the border of Indian Burma plate an intra-plate earthquake with normal faulting. The region experienced 14 earthquakes of magnitude > 6.0 since January, 1973 in which 9 earthquakes occurred after the Sumatra mega earthquake 2004, M 9.3, which generated devastating Tsunami, a clear indication of the activation in the region. The magnitude completeness in the region decrease from 4.75 to 4.4 from 1985 until September 1, 2009 with a sudden decrease corresponding to the Sumatra earthquake. The b value in the region varies from 0.89 to 1.74 for a period from 1984 to September 1, 2009 with sharp decrease after the Sumatra earthquake. To study quantitatively the activation and quiescence in the region we applied epidemic type aftershock sequence (ETAS) model by dividing the dataset in two time intervals before and after the Sumatra earthquake. The background seismicity decreases from 0.02 to zero per day indicating the earthquakes are dominated by single sequence of aftershocks. The productivity factor is five times higher than before the Sumatra earthquake. The magnitude sensitivity parameter alpha increases from zero to 1.7 after the Sumatra earthquake, indicating larger aftershocks are proportionately easier to trigger, and the Omori-Utsu exponent p decreases from 1.71 to 1.05 indicating area is dominated by aftershocks of Sumatra. The trend of the seismicity indicates activation before the Sumatra earthquake and quiescence before the August 10, 2009 earthquake in the region as compared to the ETAS model.

Estimation of Crustal Discontinuities from Reflected Seismic Waves Recorded at Shillong and Mikir Hills Plateau, North East India

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In this study, an attempt is made for determining seismic velocity structure of the crust and upper mantle beneath the Shillong -Mikir Hills plateau in Northeast India region. The principle of the technique is to the relate travel time with the crustal thickness above the Conrad and Moho discontinuities. The digital waveforms of the seismic events make it possible precise detection of the seismic phases that are reflected at these discontinuities. The results show that the Conrad discontinuity is at 18±0.5-20±0.5 km beneath the Shillong -Mikir Hills plateau and the Moho discontinuity is at 30±1.15 km beneath the Shillong plateau and at 35±1.2 km beneath the Mikir Hills plateau.

Seismotectonics in Northeast India: A Stress Analysis of Focal Mechanisms of Earthquakes and Its Kinematic Implications

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Based on stress inversion of 285 double couple focal mechanisms of earthquakes, with 5 as average magnitude, we determine the regional seismotectonic stress in Northeast India. Although N-S compression prevails at the scale of the whole area, different seismotectonic regimes deserve separate consideration, as a function of geographic location and depth.

Consistent with India-Eurasia convergence, N-S compression dominates in the Eastern Himalayan region, where E-W extension also occurs as a result of permutation between principal stress axes. N-S compression also affects north-eastern regions of the Indian Plate including the Bengal basin, the Shillong-Mikir massif and the Upper Assam Valley. Despite the absence of significant motion related to present-day locking, the existence of widespread N-S compression in the Bengal Basin, far from the Himalayan front, is compatible with the already proposed convergence between the Shillong-Mikir-Assam Valley block and the Indian craton, including a probable component of eastward extrusion for this block accounted for by the additional occurrence of nearly W-E compression in this block.

More complicate are the stress patterns in the Indo-Burma Ranges, where a variety of stress regimes occur. N-S compression occurs in these areas, but mainly at depth where it affects the descending slab of the Indian lithosphere, as a result of increasing bending of the Burmese arc in its northernmost, NE-SW trending segment. Arc-perpendicular extension, with WNW-ESE trends in the northernmost arc segment and ENE-WSW trends in the main N-S arc segment, is also present in the upper lithosphere of the Indo-Burma ranges, in relation to the subduction beneath the Burmese arc. Major stress regimes in the Indo-Burma region are characterised by compression in the upper lithosphere that varies in trend from NE-SW in the inner and northern domains of the belt to E-W in the outer domains.

Considering the kinematic implications of the published geodetic information, we analyse the relationships between the present-day relative displacements of major blocks and the seismotectonic stress regimes that we have determined using focal mechanisms of earthquakes. This comparison reveals high levels of consistency between the clockwise change in the direction of compression in the Burmese arc region and the corresponding clockwise change in vectors of present-day relative displacement of north-western Sunda with respect to Burma (SSW-directed) and Burma with respect to India (SW-directed),

as a typical illustration of partitioning across a mountain belt at an oblique convergence boundary.

Modeling Flow Over An Aligned Flat Surface Using Blasius Equation

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The Blasius equation uses the similarity transformation technique to describe the properties of steady-state two dimensional boundary layer which forms over a semi-infinite plate held parallel to the unidirectional flow field. When the surface is aligned with the direction of the fluid, a modified Blasius equation is used. The equation is solved numerically using the Newton's iterative technique. However this method can be applied only when the system is consistent. If the system becomes chaotic in nature, then the method provides unreliable results as the dynamics at that situation is different than that of the regular system. As a chaotic system is highly sensitive to initial conditions, iterative techniques cannot be applied. Here the Blasius equation is solved numerically against different wedge angle values and the dynamics of the system is observed. Finally, the range at which the system becomes chaotic is established.

Mantle Convection Stirring Efficiency With Both Basal and Internal Heating

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Recent studies have tried to quantify convective stirring efficiency for either pure internal heating mode or with pure basal heating mode (Coltice, 2005) but the combination of both, which is more relevant to the earth and other planetary mantles have not been considered. We investigate the effect of mixed heating modes on mantle convective stirring efficiency. Using a 2-D finite difference code STREAMV (Samuel, 2009) to model mantle convective motions, we conducted a parameter study, in which we varied systematically the basal Rayleigh number (Ra=10^5–10^8) and the magnitude of the dimensionless internal heating H. We use the variance of the number of passive Lagrangian tracers to calculate the mixing time (Olson et al , 1984) for each combination (Ra,H), as a function of the wavelength of heterogeneity. As expected, mixing efficiency exhibits a power law dependence on the basal Rayleigh number, however the magnitude of internal heating H does not seem to make a significant difference in stirring efficiency compared to pure basal heating. We were also able to identify the boundary between the transition oscillatory regime between the steady and unsteady convections, although more simulationsneed to run to determine the exact dependence of this boundary on thecombination of Rayleigh number and Internal Heating modes.

Nonlinear Development of Equatorial Ionospheric Plasma Bubbles: Evolution of intermediate scale structures

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Plasma bubbles, a phenomenon observed in the nighttime equatorial ionosphere, are an important component of space weather. Irregularities of intermediate scale sizes (~ 100 m to few km) in the ionospheric plasma associated with equatorial plasma bubbles (EPBs) are capable of scattering incident radio waves of VHF and higher frequencies, and thus can cause degradation and even disruption in the operation of satellite-based communication and navigation systems such as the Global Positioning System (GPS). EPBs occur due to the growth of the Rayleigh-Taylor (R-T) instability on the bottom-side of the nighttime equatorial ionosphere, and their non-linear development depends on the ambient ionospheric conditions. Using a simplified model to describe an electromagnetic version of the R-T instability, a condition has been obtained for the non-linear evolution of the instability into an EPB with complex spatial structure capable of scattering GPS signals, instead of the instability developing into a regular pattern of the so-called bottom-side sinusoidal irregularities, characterized by

basically a single scale length, which have also been observed.

Impact of Glacial Lake Outbursts in the Buffer Zone of Nanda Devi Biosphere Reserve, Central Himalaya, Uttarakhand

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Glacial lake outburst floods (GLOF) have become major geomorphic events that bring about significant changes in the Himalayan watersheds. In Nepal Himalaya some progress has been made to understand the catastrophe caused by this event, however, in the Indian Himalaya that too particularly in the Central Himalaya of Uttarakhand, there is virtually no information exists. Present study is an attempt towards understanding the cause and consequences of GLOF in a 5860.69 km2 area of Nanda Devi Biosphere Reserve (NDBR) which seems to have experienced GLOF related calamities during the last few decades. However, authentic data base is still lacking. NDBR lies in the upper catchments of Alaknanda river in Higher Himalaya. The NDBR has about 138 glaciers that feed the Alaknanda, Dhauliganga Rishiganga, Pindar and Goriganga rivers.

Present study is an attempt towards scientifically documenting the distribution of lakes in the preiglacial areas of NDBR. Their presence itself suggests that ice volume of the valley glaciers in NDBR is decreasing in the recent times. Our preliminary data suggests that there are two types of lakes viz. (i) the meltwater stream dammed by terminal moraines and (ii) the lake formed due to the detached glacier ice. In the former case, we speculate that the lakes developed after the recession of the valley glacier following the Little Ice Age (LIA), whereas the later is attributed to the recent global warming related processes.

Considering that a sizeable population inhabits within 47 villages in the buffer zone it is important that these lakes should be monitored for changes in their geometry as also to asses the critical threshold required to break the blockades of moraines and ice walls. In this paper I will be presenting the nature and distribution of lakes in NDBR. Attempts will also be made to give a synoptic evolution of the lakes for last couple of years using satellite remote sensing technique supported by GIS environment.

Extreme Events in Precipitation and River Flows: Effect of Linear and Nonlinear Correlations

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It is well known that both precipitation and river flows show multifractal behavior, which may involve linear and nonlinear memory. While precipitation usually is characterized by the absence of linear long-term memory (Hurst exponent H=1/2), river flows usually show linear memory (H between 0.6 and 0.9). The question is, to which extend the nonlinear correlations in precipitation and river flows can be used to improve risk estimation of extreme floods or rainfalls? To answer this question, we concentrate on the return intervals between events above some threshold Q. We are interested in the probability K_Q(r) that return intervals of length above r occur. From K_Q(r) it is easy to determine the hazard function W_Q(t; Delta t), which describes the probability that in the next time window of size Delta t an extreme event above Q occurs, when the last event occurred t time steps ago. The time dependence of W_Q together with a decision algorithm can then be used for a prediction of extreme events. For uncorrelated data K_Q is an exponential and W_Q is approximately a constant. As a consequence, extreme events cannot be predicted. For linear correlated data K_Q can be described approximately by a stretched exponential with an effective exponent gamma, and W_Q decays as a power-law with exponent (gamma-1). For records with strong non-linear memory K_Q decays by a power-law, and W_Q(t) decays as 1/t. In both cases an improved risk estimation is possible. To check this possibility, we have determined K_Q for a large number of precipitation and river flow data. In both cases K_Q can be described by a stretched exponential, where the exponent decreases with increasing threshold Q. For rainfall data gamma is usually between 0.85 and 1. Accordingly K_Q deviates only weakly from an exponential, and the nonlinear memory has only a minor effect on hazard prediction. For river flows, on the other hand, gamma varies between 0.4 and 0.6, and the nonlinear memory contributes significantly to the hazard function.

The Singularity Structure of Indian Monosoon Rain

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50 years of gridded daily rainfall data (from numerous rain gauges, spread over the Indian land region) offer an important source of information for studying the structure of the rainfall process during the summer monsoon season and the evolution of its extremes at climatic scales. Evidence from the analysis of the behaviour of wet/dry spells as a function of temporal scale suggests that, similar to other parts of the world, we are dealing with a (probably nonlinear) multi-annual dynamic modulating the seasonal periodicity, which in turn is modulating a two-level scaling process. This latter scaling range comprises of a multifractal direct (large scale to small scale) cascade, originating at synoptic scales, and a sub-seasonal temporal scaling domain of less understood phenomenology. The parameters of the synoptic-scale cascade are important in the occurrence of the high-intensity extreme rainfall events; consequently the understanding of their evolution under the modulating larger-scale forcing is the key to estimating the climatic-scale variability of such extreme events.

The singularity spectrum of an almost-everywhere singular measure is a function that expresses the (fractal) dimension of the subset of points characterised by each Hölder exponent (points belonging to the measure's support), as a function of that Hölder exponent. This spectrum is, in turn, the Legendre transform of the scaling exponent function of the respective measure. Since rainfall depths generate a non-negative, countably-additive function on any compact space-time domain, the rainfall process generates a measure on its space-time support. Its scaling properties have been evidenced over a finite and significant range of scales. As a result, its singularity spectra and scaling exponents give a significant as well as a parsimonious description of the rainfall process in space and time.

The present work analyses the singularity spectra and scaling exponent functions of daily Indian monsoon rainfall over a period of 50 years. The two types of functions, theoretically connected by a Legendre transform, are used to reciprocally validate each other's estimates. The issue of climatic-scale variability of intensity-duration-frequency functions generated by the multifractal rainfall measures is presented in the light of the singularity spectra's evolution subject to the modulating larger-scale forcing.

Crust-mantle Structure Below the Indo-Gangetic Plains

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The Indo-Gangetic Plains is the largest and most dynamic foreland basin on the earth and is a consequence of lithospheric flexing in response to the continued north ward push of the Indian plate and loading of the Himalayan orogen. The sediment fill in the Ganga foreland basin is an asymmetrical sediment wedge with a few tens of meters thickness in the south and increases in thickness up to 5 km in the northern most part. The sediments of the Ganga plain foreland basin are deposited on a gently north sloping lithosphere comprising of metamorphosed Precambrian basement, Late Proterozoic sediments. A profile of 10 Broadband seismic stations was set up by NGRI to study crust-mantle structure across the Indo-Gangetic plains. The stratigraphy of the basin, revealed by the deep borehole located to the east of the profile, shows the recent alluvial sediments overlie the molassic Siwaliks group formation with a total thickness of 4.1 km Also, deep boreholes in and around Kanpur reveal the sediment thickness varies between 300-550 m while the basement is mostly comprised of granitic rocks

We used the receiver function analysis to constrain crust-mantle structure across the Indo-Gangetic plains. The preliminary analysis indicate the following: i) the thickness of the sediments across the profile varies between 600 meters to 3 km, ii) Moho depth varies from 36 km in the south of the profile to about 50 km in the north, iii) geometry of the depositional plane and the forebulge has been clearly brought out and iv) mantle transition zone below the Indo-Gangetic appears to be thickened.

Seafloor Characterizations using Multi-Beam Bathymetry and Backscatter Data: Appraisal of Numerical Techniques Employed

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Seafloor multi-beam bathymetric data analyses using numerous statistical techniques were long been carried out to understand the seafloor processes at large and small scales. Model technique such as Fourier is widely employed to estimate fractal dimension (D) parameter making use of power law. However, the superiority of semi-variogram technique for fractal dimension was predicted employing log-log plot of the semi-variance, which provides comparatively reliable D estimates. Moreover, modern multi-beam systems simultaneously acquire seafloor bathymetric data along with the backscatter. Classification and characterization of seafloor are also carried out using backscatter data. However, calibration and artifact removals are established technique for multi-beam backscatter data before being used for statistical operations. In this work we have estimated D values of the multi-beam bathymetric data utilizing semi-variance versus lag data of different study locations from slope part of the western continental margin of India. Again, D parameters were also estimated for same locations using semi-variogram of the backscatter data. Differences in estimated D values were observed for two types of datasets even for same locations. Present work critically assesses the related reasons, which may be related to the involvement of different signal / data processing techniques at data acquisitions stages.

Slip Predictable Behaviour for Seismicity of Garhwal Himalaya, India

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Garhwal Himalaya (India) has experienced three major earthquakes Kinnaur (1975, mb= 6.2), Uttarkashi (1991, mb= 6.5) and Chamoli (1999, mb= 6.4) from 1974 onwards. The energy released during this period shows the presence of seismic quiescence which reflects the accumulated energy. The cumulative energy curve is showing step type slip predictable model behaviour. The energy accumulated is equivalent to the major earthquake of mb > 6.4 in future.

Fractal analysis of seismicity of Garhwal Himalaya (India) is carried out. The earthquake events during the period are 153 for magnitude > 4.5 (Mc) and depth less than 80 km. The b-value estimated using maximum likelihood method is 1.18. The correlation dimension is estimated as 1.7. The fractal dimension of lineaments from satellite imagery is also estimated as 1.8 using the box counting method for the region. The fractal dimension of the earthquake events and lineaments are showing correlation. The temporal and spatial variation of the b-value and fractal dimension is also interpreted to characterize the earthquake distribution. Fractal dimension variation is from 1.0 to 1.9 and b-value variation is from 0.95 to 1.65 during the study period. The results are discussed in terms of seismotectonics of the study region.

Space Applications in Disaster Assessment and Mitigation: Examples from Haryana State, India

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Disasters are becoming more and more frequently occurring events in India. Haryana is also suffering from a number of disasters such as Floods, desertification, soil erosion, land degradation etc. Earthquakes are also frequently occurring but of small magnitude so are not causing much concern and damage. Most of the damage in Haryana is due to floods. The present paper deals with the Remote Sensing applications in mapping

and management of floods which occurred in September 1995 in the state of Haryana. Haryana witnessed floods in the years 1978, 1988, 1993 and 1995. The floods of September 1995 were most severe as major portion of Haryana state was affected except few northern districts of Panchkula, Ambala and Yamuna Nagar. Satellite data from IRS, LANDSAT and SPOT were used for carrying out the study. Visual image interpretation was carried out for mapping flood affected areas. The flood affected areas were divided in to “standing water” and “receded water” categories. It was found that heavy downpour along with poor inland drainage, presence of localized depressions, breaching of canals and diminished carrying capacity of the water channels added to the woes. Back flush in the Drain No. 8 also caused flooding in the some areas of Gurgaon and Jhajjar districts. An attempt has also been made for preparing risk maps for various zones. The paper also suggests suitable recommendation measures for mitigating the ill effects of floods in the state.

Scaling and Persistence in Ground Level Ozone Concentrations in Delhi

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Air pollution is a nonlinear complex phenomenon depends strongly on the anthropogenic emissions from traffic, industries and household activities and meteorological, climatic and geographical conditions. Air pollution related to high concentration of ground level ozone is becoming a matter of concern due to its adverse effects on human health, vegetation and buildings. Due to participation in photochemical reactions, involving nitrogen oxides, hydro-carbons, solar radiation and weather conditions, ground level ozone concentration exhibits significant variability. The understanding of the variability in the ozone levels is useful as it provides detailed information about the long range temporal correlations, diurnal and seasonal fluctuations. This information can be utilized to initiate control measures by the regulatory authorities to reduce the concentrations of precursor pollutants. Photochemical modeling is the most efficient tool to understand the ozone characteristics over time and space however require huge amount of data on precursors and meteorology. Univariate time series analysis techniques provide an alternative way to study the periodicities, persistence and scaling properties in the concentrations. Due to nonlinearities involved as a result of various photochemical activities the techniques such as detrended fluctuation analysis, rescaled range analysis, correlation dimension are used extensively to study the scaling and persistence in the ozone concentrations. In this study scaling and persistence in the ozone concentrations observed in Delhi is analyzed using rescaled range analysis and correlation dimension. Different frequency resolutions varying from 1h, 4h and 8h to 24h are used to study the variations in the scaling and persistence property. The analysis is carried out separately for different seasons to account for the seasonal variability in the pollutant concentrations.

It is shown that the ozone pollution in Delhi follows persistence but up to very short time duration. As expected, a decrease in the variability is observed in the ozone levels with increase in the scales from 1h to 24h. The results indicated the temporal scale shifts are allowed from 1h to 4h and 8h resolution and vice versa. The ozone time series at low resolution (24h) however, should be dealt separately as the scale transformation is not uniform.

Discovery of Hydrocarbon in Cretaceous Deccan Basalt, India

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The Cretaceous Deccan basalt is one of the larger and better-preserved continental flood basalt (CFB) provinces of the world. The thickness of Deccan basalts is thin (100 m) towards northeastern part and gradually thicken towards the west coast, reaching a thickness of 1.5 km. Geophysical studies in the region suggest (Kaila, 1988) a hidden sedimentary basin of Mesozoic age, trending E-W near Tapti River, bounded by E-W faults, named the Tapti graben, with its thickness of 1.8 km decreasing to 400 meters near Surat and Akola. To search the presence of hydrocarbon in hidden Mesozoic sedimentary basin below the Deccan basalt geochemical study of soil samples was carried out for the light hydrocarbon (C1-C4).

The light gaseous hydrocarbons were extracted from soil by treating 1gm and 3gm of sieved sample with orthophosphoric acid in partial vacuum using a degasification apparatus for GC and GC-C-IRMS analysis, respectively. C1-C4 was measured using gas chromatograph. The accuracy of measurement of C1 – C4 components is < 1 ng/g. The calibration of GC was done by using external standards with known concentrations of methane, ethane, propane, i-butane and n-butane. Carbon isotopic composition of 13C1 (methane), 13C2 (ethane) and 13C3 (propane) was measured using GC-C-IRMS. The precision of the isotopic analysis for CH4 is 0.5 ‰ . The carbon isotope ratio in the sample was determined by comparing isotope ratios with that of standard, NIST RM 8560 (IAEA NGS2) using ISODAT software.

The adsorbed soil gas analysis for Deccan Syneclise indicates that the concentrations of methane, ethane propane and butanes are moderate to low Fig 2a, 2b, 2c). The cross-plots (Fig. 3) between C1-C2, C1-C3, C2-C3 and C1-C2+ show excellent correlation (r = >0.9) indicating that i) these hydrocarbons are genetically related; ii) are not effected by secondary alteration during their migration from subsurface to subsequent adsorption on to the surface soil and iii) might have been generated from a thermogenic source because of the presence of C2 & C3 components. The compositional signatures displayed by methane to ethane (C1/C2), methane to propane ratios (C1/C3), as defined by Pixler (1969) is shown in Fig. 4, it can be seen that majority of the samples fall in oil window and oil & gas window. The high concentrations of methane, ethane and propane are located in the northern part, southern part and some of samples scattered throughout the Deccan Syneclise.

Molecular ratios C1/(C2+C3) less than 50 are typical for thermogenic hydrocarbon gases with the 13C values between –30 ‰ to –60 ‰ w.r.t. PDB. The relationship between 13C1 and gas wetness C1/(C2+C3) indicates that majority of the samples fall within the thermogenic field (Fig. 5). The adsorbed soil gas data as well as 13C1 signatures suggest that the light gaseous hydrocarbons (C1-C3) are derived predominantly from thermogenic source.

The main objective of this work was to search the presence of hydrocarbon in the hidden basin of Mesozoic age below the Cretaceous Deccan basalt. The magnitudes and compositions of the near-surface soil gases were used to identify locations of anomalous seepage and in some cases to constrain the source or sources of the light hydrocarbons. The region in and around Upper Godavari lineament, Tapti graben and north of Tapti Graben indicate anomalous concentration of hydrocarbon gases.

Fractal Analysis and b Value Estimation for Earthquakes from Northwest Himalayan Region

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The NW Himalayan region (30°-36°N; 69°-80°E) has experienced some of the large earthquakes like the Hindukush earthquake in 1907 of magnitude 8.1, the Kangra earthquake in 1905 of magnitude 7.8 and the recent large Muzaffarabad earthquake 2005 of magnitude 7.6. Seismicity of the region is analyzed using b value and fractal dimension and is computed in space and time using moment magnitude ($M^3$3.9) covering a period from 1973-2009. The b-value, b with time and b with space is computed from the frequency-magnitude relation of earthquakes i.e.Gutenberg-Richter relationship. The b values range between 0.8 to 1.2 indicative that most of the seismicity is of thrust type. In most of the thrust zones the b-value is seen to be lower while strike slip & normal faulting regions are seen to have higher b-values. The fractal dimension have also been computed for this region and are approximately twice the b-value.

Wintertime Climatic Analysis Over the Western Himalayas

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The eastward moving synoptic weather systems, Western Disturbances (WDs), are the most dominant source of precipitation over the western Himalayas. Topographic variability and landuse heterogeneity influences these circulation features in the lower and upper troposphere. This interaction determines the accumulation of wintertime precipitation, in the form of snow, over the western Himalayas. Also, this winter precipitation is the main source for north Indian rivers. In the context of today's warming atmosphere, it is imperative to study the changes in the temperature and precipitation patterns over the western Himalayas to assess the impact of global warming on climatic conditions of the region. Therefore climatic indices are analyzed based on wintertime (DJF) data of 30 years (1975 – 2006) at number of observatories situated in the western Himalayas. Results indicate enhancement in the surface air temperature across the western Himalayas. Percent number of warm (cold) days has increased (decreased) during 1975 – 2006 over the western Himalayas. Further analysis of precipitation reveals variable trends but consistent five years cyclic variation in it.

Seismicity Analysis and Simulation of a Possible Tsunamigenic Earthquake from the Andaman Region: Impact Along the East Coast of India

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Andaman region had experienced a significant earthquake of magnitude Mw 8.1 in 1941 which triggered a tsunami that impacted the east coast of India and Sri Lanka. The Andaman Islands recently experienced an earthquake on August 10, 2009, which occurred in the boundary region of India plate and the Burmese plate, at the northern end of the rupture zone. This earthquake was not of thrust type and did not generate a tsunami. Seismicity analysis for the region has shown that some of the earthquakes in the region are thrust type and some of them are of strike slip mechanism. The b variation with time and fractal dimension values in the region is seen to be around 1.2 and 1.94. If the region was associated with lower b values then one could think of the earthquakes from the region having a thrust mechanism. But still if one did have a thrust type earthquake in the region it could be tsunamigenic in nature. Keeping in view the devastation of this event, a possible great tsunamigenic earthquake from this region has been simulated to quantify the impact of tsunami along the east coast of India. The tsunami arrival times and water levels at various gauge locations have been estimated. Tsunami from this region arrives at various locations at different times. Impact due to this possible scenario is not uniform at all places along the east coast of India as the run-up heights and inundation extents are governed by the morphological conditions of the coasts.

Influence of Debris Cover on the Melting Processes of Glacier - a Study on Chorabari Glacier, Garhwal Himalaya, India

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Melt rates and ground-line (terminus) retreat of glaciers are strongly influenced by the existing debris (supra-glacial moraine) on the glacier surface. The debris layer can enhance or reduce the ablation depending on the distribution and thickness of the layer. Himalayan glaciers have generally debris covered ablation area, especially glaciers in the Central and Eastern Himalaya. The Chorabari Glacier is the source of the Mandakini River (a tributary of Ganga River) and is located in the Garhwal region of central Himalaya. The glacier is 6.5 km long and has a surface area of 6.9 km2 out of the total catchment area of 15.8km2, and extends between altitudes 6600 and 3890 m. The accumulation area is comparatively small and is on steep slopes, whereas ablation area is relatively large, broad and covered by thick supra-glacial moraine (~ 67%). In the summer of 2004 a network of 20 stakes were drilled at different locations with varying

thickness on the ablation area. Parallel observations of meteorological parameters have been carried out from the AWS installed near the glacier snout (3810 m asl). Longitudinal surface profiles along the central line were drawn for the years 1962 and 2005 to calculate net surface lowering (elevation change) and terminus retreat was measured using stakes on a fixed date method during the study period. The results show that the melt rates varied from 1.5 to 5.5 cm/day with a mean of 3.5 cm/day, and show a strong influence from the thickness of supra glacial moraine. The maximum and minimum temperature recorded during the summer period was 120 C and 3.10 C respectively. Comparing longitudinal profiles, maximum surface lowering due to ablation was observed in the upper ablation area and less in lower areas. It is observed that the debris-covered surface has lower melting rates. The terminus retreat calculated was 49.3 m with an average rate of 9.3 m/yr during the period 2003-2008; whereas during the period between 1962 and 2003 the glacier retreated 262 m with an average rate of 6.3 m/yr. The study also reveals that the terminus retreat of debris covered glaciers is comparatively slower rate (9-12m/yr) than less debris covered (17-22m/yr). The enhanced retreat of terminus of glaciers may be attributed to the impact of ongoing global warming. Meteorological data collected during the period have shown that air temperature is a good melt indicator. Further, surface reflectance (snow/ice albedo) is influenced by the process of evaporation/condensation which happens on the glacier surface. Thus, surface morphology (debris, texture) needs further study in the Himalaya where majority of glaciers are debris covered.

S-wave Spectral Modeling of 244 Aftershocks of the 2001 Mw7.7 Bhuj Mainshock

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Spectra of the horizontal components of S-wave data from 244 aftershocks (Mw 2.4 – 4.2) of the 2001 Bhuj earthquake recorded (10th December 2008 – 31st March 2009) at 3-9 broadband stations in the Kachchh seismic zone (KSZ), Gujarat, India, were analyzed to estimate the source parameters. The hypocenters of the selected events are mainly confined to the E-W trending south-dipping north Wagad fault (NWF), which was the causative fault for the 2001 Bhuj mainshock. Fault plane solutions using first P-motion date from selected ten events suggest a dominant reverse motion along the south dipping NWF. The estimated seismic moment, source radius and stress drops are varying from 1011.3 to 1015.4 N-m, 130 to 249 meter and 0.02 to 92 MPa, respectively. The depth distribution of stress drop estimates suggests a concentration of large values (≥ 60 MPa) in the 10-30 km depth range with a maximum of 92 MPa at 25 km depth, which can be attributed to the presence of high velocity mafic to ultramafic lower crust below the region. The presence of aqueous fluids at hypocentral depths might also contribute to large stress drops associated with lower crustal earthquakes in the Kachchh seismic zone, Gujarat, India.

Occurrence of Anomalous Geomagnetic Event during Recent Solar Cycle

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In this study, we present the observations of solar and interplanetary sources of a very complex anomalous geomagnetic storm that is recorded during the start of the minimum phase of the solar cycle 23. It is the last major geomagnetic event occurred during the decline phase of solar cycle 23, this decline phase continued for few years up to 2009. During the observed event a very prominent and abrupt increase in He/proton density, and plasma dynamic pressure as well as depressed alpha/ proton ratio and low plasma beta, and more negative Bz is observed at the stream interface. Two days

before of the event coronal hole associated high speed stream and 1 day before a halo earth ward directed CME, with its linear speed 1774 km/s at 2:54:04 on 13/12/2006 is observed. This CME is ICME which pushed the forward shock as sheath region producing a ring current in equator of the earth's magnetic field.

For the reported study, the hourly values of interplanetary plasma and magnetic field parameters as well as geomagnetic disturbance index (Dst) and planetary index Ap have been used, for the period December 13-18, 2006. It is found that the major geomagnetic storm with a Dst~ -146 nT, which occurred on 15 December, 2006, had a more complex interplanetary structure with a X- class Solar flare and an ICME + Sheath. The geomagnetic event recorded by large Dst has a peculiar characteristic with complexity in nature, namely its association with CME and ICME, though it was expected to be associated with the CIR, because of its long recovery phase. These anomalous characteristics are discussed and will be highlighted in the detailed paper.

On the Statistics of Extremes in Space Weather Events – A Review on Statistical Methods Recently Applied on Solar Flare and Geomagnetic Storms Data

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We review recent publications on the statistics of extreme Space Weather events with a focus on the estimation of return period values of large impacts on Earth. Information on the largest historic space weather events, like the 1859 Super Storm or the 1989 Quebec event, reveal a significant tendency of clustering of strong storms. It is known that the statistics of Solar Flares shows strong similarities to aftershock statistics of earthquake data, explaining a natural tendency for clustering. However, in contrast to earthquakes, clustered Solar Storms reveal an increase in impact strengths for second and third events, which would recommend an alternative statistical approach for the estimation of return periods for very large events on the basis of short data sets.

Complex Dynamics and Multi-scale Structure of Sediment Transport: Experimental Evidence and Theoretical Insights

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Recently a large-scale flume experiment was conducted at the St. Anthony Falls Laboratory, University of Minnesota to examine the bed load transport fluctuations in a heterogeneous gravel bed under normal flow conditions. A rich multi-scale structure, which expresses itself as multi-fractality of the sediment transport series (dependence of sediment transport rates on sampling time), was documented. Further, linearity and dynamics similar to that of deterministic diffusion for bed elevations at low discharge conditions transiting to a pronounced nonlinearity and more complex dynamics for high discharge akin to that of a multiplicative cascading process was documented. Motivated by the observed non-Gaussian statistics and complex dynamics, we propose the application of an extension of the Brownian motion model, called the fractional Laplace motion model, for sediment transport which takes into account the heterogeneity in sediment transport driving mechanisms such as turbulent velocity fluctuations by randomizing the time over which the sediment particles are in motion. We show that our model reproduces the observed multi-scale statistical structure of sediment transport series and provides a way of inferring the micro-scale dynamics of sediment transport via the macro-scale statistics of sediment transport series. Finally, we explore our model implications in terms of predicting the documented non-linearity and complexity of the sediment transport series and its dependence on flow conditions.

Earthquake Epicenters Linked to the Positions of the Sun, Moon and Planets: An Instance of Organized Behavior in Complex Systems

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A connection between earthquakes and dynamics of the solar system has been suggested in the literature. We present evidence of lunar-solar and planetary influence on earthquakes by establishing a statistically significant link between the positions of the solar bodies such as the sun, moon together with the seven heavenly planets from Mercury to Neptune and the earthquake epicenters.

Our investigation originates from an ancient hypothesis whose enunciation would require the following fundamentals. While the ecliptic is the apparent path of the sun's annual journey on the celestial sphere, the longitude of an object on it is reckoned from the vernal equinox eastward up to 360 degrees. Earth's rotation causes, at a given place, progressively greater longitudes to rise in the eastern horizon, beginning from 0 to 360 degrees, in the span of a day. While the longitudes of the sun and moon coincide at the instant of a New Moon (NM), they differ by 180 degrees at the instant of a Full Moon (FM). A seismological fortnight (SF) has a precise definition and an approximate span of one-half synodic month; begins, on an average, one-eighth of a synodic month before a new moon (NM) or a full moon (FM), called the 'pivotal NM' (or pivotal FM); and ends three-eighth of a synodic month after it, while containing at least one earthquake of a specified magnitude threshold in its duration. (The definition of SF is justified eventually on statistical grounds).

The precondition of the hypothesis requires imagining four regions on the ecliptic that are more or less uniformly spaced i.e. they occur successively at an approximate interval of 90 degrees. Let all the solar bodies occupy some or all of these four regions at the instant of an NM or FM. Then the hypothesis forecasts earthquake(s) in the SF constructed about the NM (FM) at places where any of the four regions rises in the eastern horizon at the instant of the NM (FM).

To set the stage for testing the hypothesis we introduce the notion of Reduced Longitude (RL) where RL lies between 0 and 90 degrees and is obtained after expunging the maximum possible integer multiple of 90 degrees from the longitude of a celestial object. The RL of the rising point of the ecliptic in the eastern horizon at the instant of a pivotal NM (FM) at an epicenter is designated Reduced Ascendant (RA). In what follows RL's and RA's refer to observations at the instant of the NM (FM) pivotal to the SF.

In order to capture the approximate nature of the precondition we adopt the following strategy. When the RL values of the solar bodies are close the hypothetical RA would be determined by a mean of the RL's. If the RL values are dispersed, however, the number of means can be more than one, especially when the order of the RL's for the purpose of taking the mean is not unique. Initially, we restrict ourselves to the SF's possessing a single mean corresponding to the situations where the longitudes of the solar bodies approximately coincide or differ by 90, 180, or 270 degrees. The hypothesis predicts that an RA should have a statistically significant tendency to be near the mean. Indeed, this prediction is strongly fulfilled for the SF's characterized by a single mean and for earthquakes of magnitude 7.0 or above in the period 1900-2006. The hypothesis possesses remarkable internal consistency. If the mean (M) rule is indeed genuine then, occasionally, a pair of unconnected earthquakes in an SF should simultaneously display adherence to the rule and the overall number of such SF's should be statistically significant. This is eminently born out in practice.

If earthquakes, in general, abide by certain rules then, occasionally, the RA's corresponding to a pair of unconnected earthquakes in an SF would be close and the overall number of such SF's should be statistically significant. Indeed, the RA pairs for the pairs of shallow earthquakes of magnitude 7.0 or greater belonging to the common SF's during 1900-2006 show a statistically significant number of pairs of proximate values. This sets the stage for the search for other rules.

Just as mean is an attribute of the 9 RL's, inspection reveals another attribute designated Pseudomean (PM) which has a tendency to be close to an RA. Like mean it can assume single or multiple values. Initially, we focus on SF's characterized by a single PM corresponding to shallow earthquakes of magnitude 7.0 or greater for the period 1900-2006. Once again the RA's in this class show a statistically significant tendency to be near the PM. As in the case of the mean rule, an occasional pair of unconnected earthquakes in an SF display simultaneous adherence to the PM rule and the overall number of such instances is statistically significant. This provides a cross-corroboration of the PM rule.

For SF's characterized simultaneously by a single mean and a single PM the RA's also have significant affinity for four additional attributes. The first among this is called MPM which obeys a symmetry in that it is an average of the mean (M) and the PM. The remaining three attributes follow similar symmetry. The above six attributes are shown to be statistically significant also for smaller earthquakes, namely, the ones with magnitude 6.0 or above but below 7.0. In other words the study of large events predict the rules for the smaller ones.

The statistical confirmations for the efficacy of the rules obtain pervasively, through varied strategies and across diverse segments of data. Remarkably, the attributes embody symmetry, so much so that they could not have been deduced from the data without such considerations. Further, the operative framework exhibits a high degree of consilience, i.e. its various facets accord with and complement one another. Ultimately, the statistical confirmations, the symmetry features and the consilience together render the rules extraordinarily compelling.

It turns out that the hitherto unexplained proximate pairs of RA's belonging to common SF's follow straightforward extensions of the first three of the aforesaid six attributes in the context of multiple means and multiple PM's, thus supporting the theory that RA's, in general, are determined by astronomical attributes specific to an SF.

Chaotic nonlinear systems possess remarkable propensities to generate ordered spatial, temporal or spatiotemporal structures. Typically, such systems describe physical situations where there exists some connection with the outside environment in the form of a consistent small perturbation of the main system. As the outside influence is slowly altered a series of sudden changes occurs, during which the behavior of the local system changes in dramatic fashion. It is possible that due to the chaotic states prevailing in the seismically active regions, the minuscule gravitational forces of the solar bodies constructively organize triggering of earthquakes. The astronomical rules, in that case, would represent the spontaneously arising ordered structures common in such systems.

Stratospheric ozone Depletion and Its Management: Lessons from the Montreal Protocol for Combating Other Artificially Induced Perturbations

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One of the mainstays of successful preventive management of environmental perturbations is access to empirical evidences of causes and impacts of perturbations, that in turn drives appropriate regulation and market based interventions. This is best seen in the case of the implementation of the Montreal Protocol on substances that deplete the ozone layer.

• Detailed observations on the incidence of UV B through real time observations across latitudes in India, and related sunburn indices are complemented by well structured institutional mechanisms to ensure phase out of ozone depleting substances aligned with India's commitments to the Montreal Protocol.
• While these are positive attributes of the Protocol, technology leap-frogging has been another salient aspect.
• Ironically inspite of this leap-frogging the Protocol inadvertently ran into issues of having to develop an accelerated phase out plan targeting interim alternatives. It is also burdened with the task of tackling ozone depleting substances (ODS) in refrigeration & air-conditioning equipment that have reached their end-of-life stages. If concerted efforts are not taken expeditiously, the advantages derived by phasing out ODS are expected to be offset by the release of ODS from such equipment destined for scrapping.

The present effort is to
• Highlight some of the insights gained in the process of responding to these challenges and contextualize them with respect to growing uncertainties in the developing mitigation and adaptation strategies vis-a-vis climate change.
• Emphasize location-specific strategies to reduce vulnerabilities of ecosystems to perturbations that may impose themselves individually or synergistically.

Extreme Event for Earthquake Triggered Landslides:

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A large part of the fatalities induced by earthquakes are driven by the direct or indirect impacts of largest triggered landslides. We revisit various major sequences of earthquake triggered landslides to extract constrains and sensitivities on their space and size distribution as a function of the faulting style. Within the catalogue accuracies, the landslide distribution mimics the seismic aftershocks distribution in space. It suggests that the same rupture mechanics works for both instability types. Two different processes have been identified: a near field mechanism occurring at a distance of a few rupture fault lengths and a far field one occurring at a distance larger than ten fault lengths. We address the question of scales by (i) cross analysis of size and space distributions and (ii) deterministic analysis of the largest landslides setting. We review the possible candidates responsible for these scale-dependant behaviors, including dynamics of earthquake shaking through PGA and PGV as well as static brittle deformation induced by the earthquake slip.

Multicomponent Seismic Applications in Coalbed Methane Development

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Coalbed Methane (CBM) is an almost pure form of natural gas found in subsurface coals. Methane and coal are formed together during coalification, a process in which plant biomass is converted by biological and geological forces into coal. Methane is stored in coal seams and the surrounding strata and released during coal mining. In recent decades it has become an important source of energy in United States, Canada and other countries. On a global basis coalbed methane contribute more than 1TCF(trillion cubic feet) of gas per annum. So development of coalbed methane is a potentially important new energy source. Newly developed technologies demonstrates that seismic methods are an invaluable tool in CBM prospecting and development. Vertical seismic profiles obtained at Ardley coal zone strata near Red Deer, Alberta implies the effectiveness of multicomponent seismic applications In CBM development. Zero-offset surveys show that a broad-band mini-P vibratory source is ideal for imaging the coal zone. The extraction of Vp/Vs from P-wave and S-wave seismic data yields a high Vp/Vs value in the near surface (~5), decreasing to approx. 2.5 at 300m depth. Reflectivity values from walkway surveys conclude that converted-wave data better resolve the upper coal contact than compressional-wave data. Time-lapse seismic imaging, a numerical modeling will be able to monitor changes in the reservoir resulting from dewatering, allowing producers to optimize enhanced CBM production throughout reservoir life. Extreme situation for production of CBM can be easily solved through the application of Multicomponent survey. Thus this method has a great role in the development of CBM exploration.

Complex Seismic Activity at Koyna, India

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We examine the case of Reservoir Triggered Seismicity (RTS) at Koyna, India. Soon after the impoundment of the Koyna dam in 1961, triggered earthquakes started to occur. Globally the largest RTS event of M 6.3 occurred at Koyna on December 10,1967. Later, another reservoir, Warna, was impounded in the near vicinity of Koyna. Over the past 46 years, 20 earthquakes of M ≥ 5 and several thousand smaller events have occurred in the Koyna- Warna region.

Detailed investigations of this continued seismic activity in the Koyna- Warna region over the past 42 years has shown that:

1. Earthquakes occur in a small area of 20 X 30 sq. km, there are no other seismically active regions in the near vicinity.

2. Earthquakes have been occurring every year following an increase in the water level during the monsoon period.

3. A rate of loading of 12 m/week appears to be a necessary but not a sufficient condition for M ≥ 5 earthquakes to occur in the region.

4. Most M ≥ 4 earthquakes are preceded by well-defined foreshocks and are followed by aftershocks.

5. It is inferred that the region was stressed close to critical before the impoundment of the Koyna reservoir and capable of having an M 6.8 earthquake. However, loading of the reservoir and the corresponding changes in the pore pressure regime introduced heterogeneity in the media and thereby triggering earthquakes. So far the seismic energy released is about 3/4th of a M 6.8 earthquake. The remaining energy would be released in the next couple of decades or so. The occurrence of the future M ≥ 5 earthquakes would be governed by the Kaiser effect (water level in the reservoir exceeding the previous maxima), rate of loading and duration of retention of high water levels in the reservoir.

6. Some precursory changes in b- value, spatial/temporal fractal dimensions, stress drop and corner frequency have been noticed prior to moderate size Koyna earthquakes.

7. A quasi-dynamic nucleation process is observed 100s hours before M ~ 4 earthquakes.

8. A detailed study of the RTS sites globally revealed some of their common characteristics, which discriminate them from natural earthquake sequences also occurring in the same region.

Beginning from August 2005, with the support of the Department of science and Technology, Government of India, monitoring of earthquakes in real time started in Koyna (after the formation of the Ministry of Earth Sciences (MoES), this program was taken up by MoES). Through V-Sat connectivity seismic data from several stations were brought to NGRI in real time and analysis carried out. It was found that earthquakes of M ~ 4 are preceded by well-defined nucleation. If the nucleation could be identified in real time, it could lead to short-term earthquake forecast. This was indeed achieved. The following short-term forecast was made on May 16, 2006:

The Challenge of Diagnosing a Nonlinear Geophysical Theory of Floods in River Networks and Potential Applications Under Climate Change

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For decades, hydrologic studies have shown that quantiles of the annual peak streamflow distribution, e.g. the mean annual peak flow, the 100-year peak flow, have a power-law dependence on upstream basin area with an exponent that usually varies between 0.5 and 1.0. A new geophysical theory has been developing to understand the scaling in peak flows in terms of space-time rainfall, runoff generation processes and water transport dynamics in channel networks. The central hypothesis of the theory is that scaling in peak flows for RF-RO events arises from solutions of mass and momentum conservation equations in self-similar network topologies and geometries in the limit of large drainage areas. Scaling is an emergent property that is common to many nonlinear geophysical systems. The key idea of diagnostics that serves as the intellectual framework for future development of the theory will be illustrated through examples involving data analysis and theoretical calculations. Our ability to better understand how physical processes and conditions are connected to the spatial statistical variability of peak streamflows, can be used to predict peak flows across multiple spatial and temporal scales. Self-similar river networks serve as the heart of the theory and they change little over the time scales at which climate change is viewed. Therefore, applicability of the theory does not depend on assumptions regarding climatic stationarity or non-stationarity due to global warming that is currently being discussed.

Landslide Dam Outburst Flood in the Satluj Valley, Himachal Pradesh, India

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Landslides and related mass movement activities are common in the Himalayan terrain. Owing to the inherent geomorphic setting in the form of steep slopes and narrow valleys, these landslides often temporarily dam the major rivers or their tributaries, thus creating lakes. The landslide dams are formed in a wide range of geomorphic setting by variety of natural processes like excessive rainfall, snowmelt and earthquake. Most common type of these

dams is due to rock and debris avalanches, rock and soil slumps and debris flow. These landslide dammed lakes breach at a timescales varying from days to years after their formation depending upon the characteristics of the material involved and the quantum of water flowing through the channel. Often these lakes fail catastrophically causing landslide lake outburst flooding (LLOF) in the downstream regions.

The examples of the landslide dammed lakes and their subsequent breaching were documented in literature worldwide. From the northwestern Himalaya, these were reported on the Indus river (1841), Birehiganga river (1893; 1970), Dhauliganga river (1956), Rishiganga river (1967), Patalganga river (1970), Bhagirathi river (1978), Madhmaheshwar river (1998), Kali river (1998), Satluj river (1998; 2000) and Spiti river (2005). The present article discusses and analyzes the formation and breaching of historical and recent landslide dams in the Himalaya. The causes and consequences of the landslide dams created on Tibetan plateau in the Satuj river in 2000 and in the Paree-Chu Nala in 2005 the have been analyzed in great detail. The data indicate that the frequency of the creation of the dams in the Himalayan terrain has increased in the recent past possibly due to climate change in the form of increase in temperature in the Tibetan Plateau and the more area falling under the influence of rainfall.

The outcome of this study has two major implications. First with the repeated LLOF in the Satluj valley, the risk posed by the natural hazard must be evaluated. This is well exemplified by 2000 and 2005 LLOF in the area. With these case studies, further work aim to link landslide / flood activity to temperature and rainfall intensity duration trends so that stochastic relationship may be developed. Secondly, if a successful relationship between the temperature, melting of glaciers, landslide activities and the flash flood can be established for the Himalayan region, analysis of the palaeo-flood deposits may provide important new information on past variation in temperature / rainfall trends. Equally such relationship may predict changes in mass movement activities in the Himalayan region based on modeled regional impact of global climate change.

Active Deformation Within MBT-HFT Tectonic Wedge in Trans-Yamuna Dun of NW Sub Himalaya: Implication on Seismic Slip Partitioning

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The exhumation of Sub Himalaya along the Himalayan Frontal Thrust (HFT) by recurrence earthquake led to the growth of Duns as piggyback longitudinal synclinal basin, which is bounded by Main Boundary Thrust (MBT) as roof thrust, in the north. The HFT is active since 0.5 Ma with the peak activity postdating-100 ka in the Garhwal, Sub-Himalaya (Thakur et al., 2007). A series of out-of-sequence structures within the MBT-HFT wedge partitions the intra-wedge deformation, in the Trans Yamuna Dun valley. These out-of-sequence thrust originating from basal décollement. Attitude of these out-of sequence structures increases towards MBT and in MBT vicinity they often become vertical with dominant strike-slip movement. The evidences of active deformation along these out-of-sequence thrust are observed in the form of structural and geomorphic expressions. These geomorphic landforms like piedmont fan and river terraces have yielded the ages ranging from 33.9 Ka to 4.9 Ka. The cross cutting relationship of out-of-sequence structure with these Quaternary landforms clearly suggest that the structures are active even during early Holocene.

The development of out-of-sequence thrust within MBT-HFT tectonic wedge is analyzed in light of critical wedge theory, which suggests that all orogenic wedges develop taper toward their undeformed foreland and move only after attaining a critical angle (Davis et. al., 1983). This critical taper is attained either in the form of (a) under-critical wedges that increase their topographical slope by internal thickening or (b) over-critical wedges that decrease their topographical slope by internal deformation.

In Trans Yamuna Dun Valley, the MBT-HFT wedge taper is < 15° and ~ 10 km bulk shortening on the basis of retrodeformable cross sections, which is comparable to the adjoining regions. These parameters along with the observed movement on these out-of-sequence thrust suggests a bulk shortening in the hanging wall by internal thickening leads to a condition analogous to the under-critical wedge. The long term strain obtained by retro-deformable cross-section (Power et al., 1998) or short term neotectonic / paleoseismic data (Wesnousky et al., 1999; Kumar et al., 2001) suggests a comparable shortening rate with ~600 to 1000 yrs repeat interval for great earthquake event. A bulk slip of the same is accommodated on these out-of sequence thrusts within MBT-HFT wedge in addition to the rupture along HFT during great earthquakes.

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Is There a Timescale Where the Clausius-Clapeyron Relation Describes Precipitation Rate Changes?

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Based on a total of 190 years of observational precipitation data at a temporal resolution of five minutes from six stations in Germany we obtain scaling relations of the probability distributions of precipitation intensity with temperature and timescale. By producing a cascade of averaging intervals, we obtain the behavior of precipitation intensity from the instantaneous to the daily resolution. The distribution of the shortest timescale displays a strict power-law tail with a remarkable coefficient. We explore whether this coefficient arises as a consequence of the self-regulating nature of the moisture-precipitation system. When temperatures are distinguished or when precipitation and dry periods are mixed at longer averaging intervals the distribution acquires a more elaborate scaling. The coefficient of increase with temperature is a continuously and strongly varying function of temperature and of percentile and does not show an abrupt increase as noted previously. Especially for extreme precipitation the increase with temperature is found to be large at the shortest timescales, whereas at longer timescales the situation is reversed. We caution that the Clausius-Clapeyron relation may not provide an accurate estimate of the temperature dependence of precipitation at any temporal resolution.

Quantitative Modeling of Extreme Seismic Events

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Extreme seismic events are manifestations of complex behavior of the lithosphere structured as a hierarchical system of blocks of different sizes. Driven by mantle convection these lithospheric blocks are involved into relative movement, resulting in stress localization and earthquakes. I present a quantitative approach to simulation of earthquakes in models of block-and-fault dynamics, which feature the occurrence of large seismic events, earthquake clustering and interaction. Several applications of this model to study earthquake sequences and extreme events in the models will be discussed: the regional models (the Tibetan

plateau and Himalayans, and the Sunda Arc region) and a global spherical model.

Gottwald-Melbourne Test for Chaos of Nonlinear Fluctuations in Complex Laboratory Plasmas

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Plasma is a highly complex system exhibiting a rich variety of nonlinear dynamics over a range of parameters. Glow discharge plasmas possess a unique characteristic of not only being complex but also have a negative resistance under some conditions. Hence depending on the conditions, it can exhibit either a transition from order to chaos or vice versa. Chaos in laboratory plasmas are explored by standard techniques of analysis like correlation dimension, and Largest Lyapunov exponent. As far as we are aware no work has been reported of correlating Largest Lyapunov exponent with Hurst exponent which is a standard diagnostics for long range correlations. In our work we have found that at the transistion from order to chaos, the Largest Lyapunov exponent exhibits a sharp jump by a factor of ten, while the Hurst exponent shows a drop from 1 to 0.72 which is a typical value of real world fractal signals(chaotic). In addition we have for the first time carried out a 0-1 test suggested by Gottwald and Melbourne[1] on laboratory plasma data and observe clear transition from order to chaos which will be reported in this paper.

Constraints on the Tectonic Setting of the Andaman Ophiolites, Bay of Bengal, India, From SHRIMP U–Pb Zircon Geochronology of Plagiogranite

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Andaman ophiolites are well exposed in Andaman group of islands, which is a part of Sunda-Burmese double chain arc system in the Bay of Bengal, India. Plagiogranites occurring on the eastern margin of the southern part of South Andaman island show the occurrence of interstitial vermicular and micrographic intergrowths of quartz and plagioclase. They are tonalites to trondhejemites in composition, and the Rb, Yb, Ta and Y abundances in these plagiogranites are characterisitic of volcanic-arc affinity.

U-Pb ion microprobe (SHRIMP) dating of zircons from plagiogranites of Andaman ophiolite, has yielded a weighted mean 206Pb/238U age at 93.6 + 1.3 Ma, interpreted as the age of its crystallization. The plagiogranite which is characterized by an island arc affinity is inferred to have intruded the gabbro unit of the Andaman ophiolites at 93.6 Ma in a subduction zone setting. The Andaman ophiolitic rocks which were formed before this intrusive event, (probably Early Cretaceous), are believed to have been obducted onto the leading the edge of the Eurasian continent during the Middle Cretaceous to Late Oligocene subduction event, prior to the currently active Late Miocene Andaman- Java subduction.

Using For bush Decrease Events for the Prediction of Geomagnetic Storms

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Forbush decrease (FD) is sudden decrease in the counting rates of neutron monitors, caused by fast Coronal Mass Ejections (CMEs) mostly associated with intense X-ray solar flares. The geomagnetic storm is known to occur simultaneously with large Forbush decrease events. Both phenomena have common origin – entry of the Earth into an interplanetary shock – therefore, study of FD can be used to anticipate an impending storm. The author has analyzed 61 FD events of magnitude >= 3.5% occurred during the 23rd solar cycle (1996-2008) which are registered by Moscow Neutron Monitor

Station. Temporal evolution of individual FD event is studied along with the variation in interplanetary magnetic field intensity, solar wind velocity and geomagnetic activity indices- Dst and Kp index. It is shown that besides the known enhanced disturbances in the magnetic field of the Earth, the FDs in majority of events are accompanied by abrupt increase in the solar wind velocity. Though the correlation coefficient between the magnitude of FD and Dst index is 0.3, but 91% of FD events (55 out of 61) are associated with geomagnetic storms. The onset time of FD is found to be few hours earlier than that of the storm; this fact can be used to forecast a geomagnetic storm. The present investigation also verifies the relation of occurrence of FD with fast CMEs and subsequent transients.

Storm Coals: A Extreme Depositional Systems in South Brazil Deposits

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The brazilian paleozoic coals have low quality due to the high content of ash and sulfur. The presence of coals layers with HCS structures has led to reinterpretation of the depositional history of the studied deposits. It was observed that the coal deposits of the Carboniferous Province of Santa Catarina corresponding to allochthonous sediments, redeposited along the prodelta facies. The coal analysis, in the state of Rio Grande do Sul (a near site), denoted that the coal have been reworked by storm waves, but were redeposited in shallow platform conditions. Associated with these deposits was found paraconglomerates with plant fragments, clasts of fine-grained and lytic sandstone, which extend for up to 5 km with widths not exceeding 200 meters. These paraconglomerate are interpreted as hyperpycnal flows associated with flood deposits. The deposition of these coals is associated with regressive pulses within transgressive post glacial event of Permian that filled the Paraná Basin.

Attenuation Relation for Garhwal Himalaya Obtained Using Damped Least Square Method

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Attenuation relations are most commonly used relations for predicting strong motion parameters. In the recent past the Garhwal Himalaya has been visited by two devastating earthquakes viz., the Uttarkashi earthquake of 20th October, 1991 and the Chamoli earthquake of 19th March, 1999. These earthquakes are among very few major Himalayan earthquakes recorded in the strong motion network. In this work strong motion data of these two earthquakes from 20 stations have been used to develop regression relation of peak ground acceleration. The selection of regression model is based on various statistical tests like mean, standard deviation, correlation coefficient and stand error of estimate. Coefficients of regression model are estimated using the method of damped least square inversion. Following regression relation has been obtained for this region:

PGA = 1.106e1.54M e.00323R (R+15)-1.51

Where PGA is peak ground acceleration in cm/sec2, M is the surface wave magnitude and R is the hypocentral distance in km. The resolution and correlation matrix of the coefficient suggest that the values of coefficients of regression relation obtained from present inversion gives minimum error and better resolution. In order to compare the efficacy of developed relation we have compared the root mean square error (rmse) in computing peak ground acceleration from present relation with that obtained from attenuation relations of applicability for worldwide and Himalayan earthquakes. It is seen among all studied relations minimum rmse error of value .64 is obtained from the developed relation which indicates its

applicability in estimating strong motion parameter of major earthquakes in this region. Statistical check of various properties also indicates suitability of this relation over existing relations for prediction of strong ground motion.

Simulation of Strong Motion Parameters Using Deterministic Modeling of Finite Source of Two Himalayan Earthquakes

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Peak ground acceleration during an earthquake plays an important role in deciding the engineering parameters of large structure. Scarcity of desired strong motion data poses hindrance in estimation of these important parameters at the site of construction. Recently it has been shown in different studies that semi empirical approach is among most successful methods in simulation of strong ground motion for Himalayan earthquakes (Joshi and Patel, 1997; Kumar et al. 1999; Joshi, 1997, 1998, 2004; Joshi et al. 1999, 2001). In this paper attenuation relation derived from strong motion data of the Uttarkashi and the Chamoli earthquake has been used in the semi empirical method initially develop by Midorikawa (1993) and latter modified by Joshi et al. (2001).

Strong ground motion for the Uttarkashi (Ms 7.0) and the Chamoli (Ms 6.6) earthquakes were simulated at those stations which has recorded these earthquakes using semi empirical approach. The parameters of rupture modeled for the Uttarkashi and the Chamoli earthquakes are same as those identified earlier by Joshi (2004). The division of rupture of target event into subevents is based on self similarity laws. In an attempt to check the dependency of attenuation relation on this semi empirical approach, strong ground motions were simulated by using the developed relation and the attenuation relation of Abrahamson and Litehiser (1989), respectively. The root mean square error in the peak ground acceleration computed using the developed attenuation relation and that given by Abrahamson and Litehiser (1989) in the semi empirical approach is obtained as .675 and .451 respectively. This shows that the attenuation relation given by Abrahamson and Litehiser (1989) can be preferred over the developed relation for simulation of the Uttarkashi and the Chamoli earthquake because of its wide range of applicability in terms of magnitude and distance parameter. Further the rmse obtained while directly using the attenuation relation of Abrahamson and Litehiser (1989) is .682 which indicate the advantage of semi empirical method over conventional attenuation relation in predicting strong motion parameter.

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A GIS Tool to Automatically Extract Area Altitude Distribution of Glaciers

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The snow in the Himalayan ranges plays a very significant role in the water resource management of various basins in northern states of India having rivers like Indus, Ganga and Brahmaputra. But this source of water from glaciers is not permanent as glacier dimensions are constantly changing with time. All over the world glaciers are retreating in response of climate change. These retreating glaciers have significant implications for the ongoing rise in global sea level, water resources and hydropower potential. In order to measure glacier retreat, it is urgently required to first accurately determine its area altitude distribution. Similarly, mass balance and area accumulation ratio (AAR) measurements are also dependent on area altitude distribution of the glacier. Traditional methods of determination of area altitude distribution are time consuming and expensive. Therefore, a tool is developed in Arc GIS environment for automatic extraction of area enclosed by glaciers in each elevation zone. In this paper this tool will be discussed which determines the area altitude distribution of glaciers automatically. The tool is tested for its performance in Baspa Basin having and it is found to be efficient in terms of time and accuracy. This tool will be useful in various snow field studies.

Interplanetary Transient Solar Wind Flows and Extremely Disturbed Geomagnetic Field Conditions

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In the present investigation we have analyzed the interplanetary transients associated with the extremely disturbed geomagnetic field variation. These interplanetary transients are large scale structures containing plasma and magnetic field expelled from the active regions of solar atmosphere. We have studied the Bi-directional Electron Heat Flux (BEHF) Events. These are the fast magnetized plasmoids moving away from the Sun in to interplanetary space. As they come to interplanetary medium the interplanetary magnetic field drape around them. This field line draping was thought as possible cause of the characteristic eastward deflection and giving rise to complex geomagnetic activities. In this paper a systematic study has been performed to analyze these BEHF events occurred during solar cycle 23, by dividing them in two categories 1. Associated with coronal holes (CH) and 2. Non - Associated with coronal holes. In this work we used hourly values of IMF data obtained from the NSSD Center. The analysis mainly based on looking into the effects of these transients on earth's magnetic field. The high-resolution data IMF BZ and solar wind data obtained from GOES satellite was available during the selected period. Dst and Ap are taken as indicator of geomagnetic activities. It is found that Dst index, solar wind velocity, proton temperature and the Bz component of magnetic field have higher values and increase just before the occurrence of these events. Larger and varying magnetic field mainly responsible for producing the short-term changes are observed during the BEHF events associated with coronal holes

Investigation of Intense Geomagnetic Storms and Associated Cosmic Ray Intensities: A Correlative Study

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In this study we discuss the behavior of cosmic rays during the phase of highly intense or ultra intense geomagnetic storms, as shocks driven by energetic coronal mass ejections (CME's) and other interplanetary (IP) transients are mainly responsible for initiating large and intense geomagnetic storms. Observational results indicate that galactic cosmic rays (CR) coming from deep surface interact with these abnormal solar and IP conditions and suffer modulation effects. In this paper a systematic study has been performed to analyze the CRI variation during super storms i.e. very intense geomagnetic storms with Dst index ≥ -300 nT. The neutron monitor data of three stations Oulu (Rc = 0.77 GV), Climax (Rc =

2.97 GV) and Huancayo (Rc = 13.01 GV) well distributed over different latitudes and hourly values of IMF parameters derived from satellite observations near Earth IP medium from OMNI Data base is used for the period spanning over solar cycles 20, 21, 22 and 23. It is found that AP and AE indices show rise before the forward turnings of IMF, while the Dst index shows a classic storm time decrease. The analysis indicates that the magnitude of all the responses depends on BZ component of IMF being well correlated with solar maximum and minimum periods. Transient decrease in CR I with slow recovery is observed during the storm phase duration.

Complex Tectonics and Recent Earthquakes in Northeast India: A Review

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The complex seismotectonics of northeast India region is reviewed in this paper. The different tectonic/seismic zones are examined using the teleseismic and the recent local microearthquake network data. The earthquakes in the northeast Himalayan collision zone are deeper (0-80 km) compared to that (0-20 km) in the western Himalayan seismic zone. The deeper earthquakes in the northeast Himalaya are mostly caused by transverse tectonics including the 1950 great earthquake (Ms 8.7) that occurred in the Assam syntaxis zone. The earthquakes in the Indo-Burma region on the other hand, are caused by the atypical continent-continent subduction; the shallower (< 90 km) events show normal and strike-slip faulting, and the deeper earthquakes, depth 90-180 km, are generated by thrust faulting within the dipping seismic zone. The Shillong plateau activity is explained by the plateau pop-up tectonics, and the intense activity along the Kopili fault by transverse tectonics that extend to the northeast Himalaya. The lower activity of the Bengal basin is attributed to thicker sediments and locking of the plate below the basin.

Further, seismic structures of the earthquake source zones are imaged using the large data set of the temporary and permanent microearthquake networks in the region. The earthquake source zones below the Shillong plateau is imaged as a high velocity structure at a depth 20-30 km in the lower crust. A high velocity structure is also imaged at a depth of 40 km at the end of the Kopili fault, below the Assam valley, which is inferred to be the source zone for intense activity along the ~300 km long Kopili fault, a transverse structure to the Himalayan trend. The Kopili fault is well reflected as a low velocity structure down to 30 km depth. The thick Bengal basin sediment is well imaged as a low velocity structure down to a depth of 20 km. The frequency-magnitude relation of the earthquakes, b-value, is mapped along with the fractal dimension mapping. The fractal dimension of the seismogenic faults/structures are imaged estimating correlation dimension of the relocated epicenters. These two maps clearly illustrate the circular pop-up seismic structure beneath the Shillong plateau and a long transverse structure beneath the Kopili fault as the most active source zones beneath these two areas.

Index of Recurrence Asymmetry in Complex Systems: Application to Sunspots and Earth Surface Temperature Anomalies

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It is possible to obtain data series of the same phase space variables from different, spatially separated parts of complex, spatial extensive systems (such as Sun, Earth atmosphere, human body, etc) as well as from whole system. Sunspot data are available for the full Sun, the northern hemisphere, and the southern hemisphere. Earth surface temperature anomalies data are available in similar way. Well known indexes of asymmetry (standard NA and modern LOS) are instantaneous indexes that don't contain any information about system dynamics and interaction between hemispheres and the whole system. We introduce a new index -- index of recurrence asymmetry, called RRNA, which not have these disadvantages. We describe graphs of this index constructed for the following data: sunspots, Earth surface temperature anomalies (ocean, land, ocean and land) and show zones of asymmetry.

Productivity Pattern in the Equatorial Indian Ocean During the Last 300,000 Years

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We reconstructed the variability in the surface ocean primary productivity in the equatorial Indian Ocean during the last 300, 000 years using multiple (paleo) productivity proxies, calcium carbonate, organic carbon, biogenic silica (opal) and barium in bulk sediments. The gravity sediment core of 5 m long was recovered from the equatorial Indian Ocean region at 3oN and 77oE at a water depth of 4050 meters. Oxygen and carbon isotopic composition was determined on surface dwelling planktonic foraminifer Globigerinoides sacculifer. Chronology of the sediment core was established by tuning oxygen isotopic composition (δ18O) of G. sacculifer with SPECMAP track and radiocarbon ages measured on coarse carbonate fraction (+25µm). Three characteristic carbonate minima occurred during 292-274 kyr, 200-190 kyr and 85-56 kyr periods. Peak carbonate concentration was recorded during 27-25 kyr period. Calculated calcium carbonate accumulation rates (AR) were ranged from 28.3 g cm-2 kyr-1 to 192.5 g cm-2 kyr-1 with minimum accumulation during glacial and maximum accumulation during interglacial periods. Organic carbon showed two characteristic maxima during 211-191 kyr and 25-24 kyr periods. Organic carbon accumulation rates were ranged from 0.37 g cm-2 kyr-1 and 4.31 g cm-2 kyr-1 with high accumulation rate during the same periods. Bulk sedimentary barium varied between 0.002% and 0.014% (wt %) with two characteristic minima during 208-191 kyr (avg: 0.004%) and 27-25 kyr (avg: 0.004%) periods. Maximum Ba concentrations were recorded at around 120 kyr and 284 kyr. Barium to aluminium ratio was also shown more or less similar pattern as bulk sedimentary barium. Our results have shown that there are no clear glacial-interglacial variations in surface water primary productivity during the last 300 kyrs. However, 100 kyr cyclicity was observed in calcium carbonate indicating preservation/dissolution cycles.

Consequences of the Fossil Fuel Extraction on the Climate Change of the Earth

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The understanding of the causes of climate change of the earth is a very complex process. It can not be explained on the basis of one or two factors because it is governed by the various processes going on for a long time in the solar system. We are creating more complexity in the climate change by ruthless exploitation of natural resources of the earth which is resulting in the climate change at a faster rate. The climate change such as global warming due to burning of fossil fuels, i.e. coal, minerals, gases etc. is very well reported in the literature, but very little work has been done on the contribution of the extraction of fossil fuel from the earth's crust, in changing various physical properties of the earth, affecting the climate of the earth.

The extraction of fossil is a very old practice but for last 6-7 decades, it has increased very rapid. The imbalance between extraction and generation of fossil fuel is increasing day by day, which is changing the climate, of the earth in a different way. The change in the mass of the earth due to the extraction of fossil fuel from the earth' crust, is changing the moment of inertia of the earth because the extraction is at the farthest distance from the axis of rotation. Thus a small change in the mass in the earth crust will affect the moment of inertia substantially. In order to conserve the angular moment (L = IW), the angular frequency of the earth on its own axis as well as around the sun, must change. On the other hand the extraction of fossil fuels may not be uniform throughout the earth, as the extraction in northern hemisphere is reported to be much higher than in southern hemisphere which may cause weight imbalance around the axis of rotation of the earth as well as around the sun. This may result in the change of the angle of tilt of the earth. This change in the tilt may be a very important factor, contributing in changing the climate at various places of the earth. Thus,

the extraction of fossil fuels may contribute to the change in various mechanical properties of the earth, making the process of climate change such as global warming more complex to understand.

We shall give an account of the change in the physical properties of the earth rotation such as moment inertia and angular velocity resulting from the extraction of fossil fuel and predict its impact on climate change of the earth.

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Deciphering Zeolitic Formations in Deccan Basalt – An Indirect Method of Finding Groundwater in Hard Rock Using Integrated Geophysical Approach

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Groundwater is the important natural resources of the earth that we use daily and is elixir for human life. The scenario both in present day and future is challenging in the area of water resource sector especially in hard rock eg. Deccan Traps. Geologically Deccan volcanism is associated with the separation of the Seychelles micro continent from India and this breakup itself is often ascribed to the reunion plume head impact. The trappean rocks are the result of fissure type volcanic eruptions which spread over the vast area in western, central and southern parts of India at the end of the Mesozoic era (about 70 million years before). In hard rock water is available mainly due to secondary porosity while in Deccan trap - another variety of hard rock, the presence of zeolites along with weathered/fractured basalt is the direct indication of availability of water. Zeolites are porous crystalline solids and they are associated with vesicular/weathered basalts. These zeolites are a group of silicates containing true water of crystallization; hence identification of the zeolite/zeolite cavities which are the contributing sources for groundwater in Deccan traps is a challenging task.

Keeping in view Integrated study using surface 1-D Vertical Electrical Sounding (VES), 2-D Electrical Resistivity Imaging (ERI), geological drilling & litholog preparation and lastly sub-surface resistivity logging using specially designed logging tool was carried out both for zeolites and groundwater in Pune, Nasik and Aurangabad regions of Western India. In total 39 2D resistivity survey completed and covered about 18 km profiles.

The present integrated geophysical and geological interpretation had revealed zeolite bearing zones both at shallow and deeper depths. The ERI results have clearly shown the signature of high resistivity anomaly indicating the cavity effect or could be the cavity created due to zeolite, which is our main interest here in addition to groundwater exploration. In some of the 2-D sections the specific range of resistivity between 40 – 50 Ohm-m and 90 – 105 Ohm-m had quite clearly indicated the zeolite bearing zone. At the same time the low resistivity zone/anomaly in few 2-D sections had also clearly indicated the potential water bearing zone(s). The layered structure of the basalt formation is seen in the 2-D resistivity sections with appreciable resistivity contrast. In addition, 1-D sounding results had delineated mostly the 4 layer case of the sub-surface. The % of RMS error for the 1-D sounding interpretation ranges from 2.79 to 5.86 which shows the interpreted model parameters (resistivity and thicknesses) of the resistivity curves represents very close to the sub-surface resistivity values for the different layers. The qualitative nature of the model VES curves indicated namely A, H and K type and its combination which shows variation in the geological set up of the basaltic rock. Based on the confirmed resistivity anomaly/results five borewells drilled up to a maximum depth of 91.5 m and successfully encounter the aquifer zone in association with zeolite. Latter resistivity logging was performed at six borewells right from the static water levels to the bottom depth to confirm our results. On combined interpretation the characteristics resistivity obtained for fresh basalt in association with zeolite have a resistivity ranges between 90-105 Ohm-m while the weathered zeolitic basaltic layer lies between 40-50 Ohm-m as compared to 500-600 Ohm-m which corresponds to fresh basalt without the presence of zeolite. It is very interesting to

note that the change in resistivity values in resistivity logs beautifully reflected conductive and resistive formations and the kinks observed in these logs very well shows even the minor variation in resistivity including the saturated part of the aquifer. Finally the resistivity logging aids in drawing the final conclusions and serves as a supplementary tool to understand better the geological set up of the Deccan basalt in the present study.

Keywords: 1-D sounding, 2-D Imaging, Resistivity Logging, Deccan Traps, Zeolites, Groundwater, Western India

Super Magnetic Storms: Hazard to Society

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Magnetic storms are the most important component of space weather effects on Earth. Super-intense magnetic storms (defined here as those with Dst < -500 nT, where Dst stands for the disturbance storm time index that measures the strength of the magnetic storm), although relatively rare, can be hazardous to technological systems in space as well on ground. Such storms can cause life-threatening power outages, satellite damage, communication failures and navigational problems. The data for such magnetic storms during the last 50 years is rather scarce. Research on historical geomagnetic storms can help to create a good data base for intense and super-intense magnetic storms. The super-intense storm of September 1-2, 1859 is analyzed in the light of new knowledge of interplanetary and solar causes of storms gained from the spaceage observations. We will discuss the results in the context of some recent intense storms, and also the occurrence probability of such super storms.

Assessing the Characteristics of Extreme Rainfall Through an Examination of Atmospheric Circulation States Using Self Organizing Maps

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Extreme rainfall events are associated with significant societal and infrastructural impacts including fatalities and the massive displacement of communities. The Intergovernmental Panel on Climate Change (IPCC) has reported an increase in the frequency and intensity of extreme rainfall and also state it is "very likely" that such events will become more frequent and intense as a result of greenhouse gas warming of the atmosphere (IPCC, 2007). Investigations into future changes in climate as a result of this warming are dependent on general circulation models (GCMs) that characteristically have coarse spatial resolutions. However, extreme rainfall is usually expressed at the regional scale and it is beyond the ability of GCMs to resolve this scale. Furthermore, regional climate models (RCMs), which dynamically downscale from the GCM resolution to a finer one, do not accurately capture the frequency and intensity of extreme rainfall events nor their temporal and spatial characteristics. In this context several questions emerge: regionally, have extreme rainfall events become more or less frequent, during which seasons and do we understand why? How do we assess extreme rainfall in the future given the effect global warming may have and the many uncertainties pertaining to potential changes in atmospheric dynamics and their influence on extreme rainfall. Are the changes in the characteristics of extreme rainfall a symptom of global warming or a consequence of the natural variability of climate on longer time scales?

In an attempt to answer these questions, the synoptic scale circulation (the primary driver of local weather) was related to extreme rainfall events using a type of artificial neural net. Self organizing maps were used to identify circulation states associated with exreme rainfall in South Africa through the non-linear projection of the probability density function of high-dimensional input data onto a two-dimensional array of nodes. This technique spans the full continuum of data space results in the categorization of daily synoptic atmospheric data into characteristic synoptic circulations. With this information it is possible to relate extreme precipitation events to a driving circulation mode and examine the events within this synoptic context. It is thus possible to not only document changes in the characteristics of extreme precipitation such as frequency and intensity but also investigate the dynamical drivers of the change. To this end, decadal, seasonal and monthly attributes of the synoptic states will be related to the extreme rainfall data obtained from station records and the attributes of these presented and discussed.

Long-term Memory in Climate Records: Clustering of Extreme Events and the Detection Problem

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In the first part of this presentation, we start with a review of our recent results on the statistics of return intervals between events above some threshold q (a) in long-term correlated (monofractal) records characterized by a Hurst exponent H>1/2 where the linear autocorrelation function decreases by a power law and (b) in multifractal data sets where the linear autocorrelation function vanishes and only nonlinear correlations are present. Both monofractal and multifractal data sets play an important role in geoscience, examples are temperature records, river flows, and precipitation. It is shown how the long-term memory affects the statistics of the return intervals and how it can be used for a superior risk estimation. In the second part, we focus on the detection problem in long-term correlated records, which is particular relevant in the context of global warming. In the detection problem, one is interested in the probability W(Delta) that an observed trend Delta occurs naturally, from which the anthropogenic part A_Q(Delta) of the temperature increase within a given confidence interval Q can be derived. It is shown that for confidence intervals with Q above 80%, analytical expressions for W(Delta) and A_Q(Delta) can be derived, which request as input solely the Hurst exponent, as well as the temperature increase Delta obtained from the linear regression line and the standard deviation sigma_t around it. We apply this methodology to a large number of global and local stations and discuss the results.

Study on Hydro-chemical Change of Epikarst Spring Based on Extreme Weather in the Jinfo Mountain of Chongqing: A Case Study of Extreme Drought 2006, Chongqing

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To understand Epikarstificaiton mechanism and the hydro-chemical change of karst water that responds for the extreme weather, a research was carried out at the Shuifang spring under extreme drought, 2006. A site`s automatic records (CTDP300) was fixed up which can inspect five indexes such as rainfall, pH, conductivity, water temperature and water level. According to the data from automatic records the study was showed that: (1) Karst dynamic process of Epikarst zone is highly sensitive to the environment. Hydro-chemical change and karst intensity of Epikarstic water were obviously controlled by soil CO2 and H2O. Under extreme drought weather of long time the soil CO2 mainly flowed from deeply soil to shallow soil and released into atmosphere in the end. It leaded that Pco2 of karst water depressed and its SIc and pH inclined. It indicated that flow direction of soil CO2 was different contrasted with normal weather for little rainfall even in summer. Its intensity of karst also depressed. (2) “Soil CO2 effect” occurred for rain did not happened under drought weather of long time through diurnal inspect. On the contrary soil CO2 was accelerated to release into atmosphere for higher hot rain water and did not enter into karst system. It leaded that Pco2 of karst water depressed and its SIc and pH inclined. (3)Temperature of Epikarst water depressed even in summer under drought weather of long time because of strong evaporation (4) Epikarst water is formed in the open system of the carbonate rock-water-CO2 interaction. So, in the study on Epikarst water chemistry, both the water-rock interaction and the variation of CO2 with space and time have to be taken into account. Only when the three-phase system (carbonate rock-CO2-water) is considered as a whole, the regularity of the spatial and temporal variations in karst hydrochemistry could be understood.

Key words: Epikarst spring, extreme drought, hydro-chemical change of karst water, Jinfo mountain

Background: Jinfo mountain is located at the south of Chongqing city, which is the north branch of Dalou mountain system., extending 28°50′-29°20′N and 107°32′-107°20′E(Fig 1). it is in the subtropical humid monsoon zone with annual mean temperature of 8.2 and precipation of 1,434.5 mm on the top of the mountain.

Fig1. Location of study area

Since karst is quite developed in this area, few surface water generated in the cathment except intermittent stream, which is at the flat bottom of the depression whith relatively thick soil distribution and lower permeability, eventurally into shuifang spring

Methods

Automatic monitoring of rainfall, water stage, water temperature, pH and specific conductivity

To measure detailed hydrochemical variations in epikarst aquifer, a Greenspan CTDP300 multi-channel datalogger was used in Shuifang spring, which includes the diffuse flow from karst fracture and/or conduit flow from karst conduits(the sensors being fixed tightly in a PVC tube with small holes on its wall, and then the PVC tube was located in flowing spring water about 10 cm below base flow`s surface). Rainfall, water stage, water temperature, pH and specific conductivity have been monitored every 15 min since June 2006. the logger was calibrated prior to deployment using pH(4,7 and 10) and conductivity(1412 us/cm) standards. Hand-held water quality (WTW multiline P3 pH/LF-SET) measurements were undertaken to check the reliability of data logger measurements at monthly interval, when retrieving data from data logger was conducted in each month. It is found that hand held meter and logger measurements are identical within 4% error.

Ananysis of concentrations of major ions in springs

In situtitrating was used to measure the HCO3- and Ca2+ of water with the Aqumerck Alkalinity test and Hardness test. The resolutions are 6 and 1 mg/l respectively. To understand the general chemistry of other major ions in the systems, water samples from the Shuifang spring was collected by filtering with 0.45um Minisart filter and analyzed in the lab. The analysis methods used were standard titration for bicarbonate, atomic absorpiton for K+ and Na+, titration with EDTA for Ca2+, Mg2+ and SO42-, and the Mohr titration for Cl-

Estimate CO2 partial pressure and calcite/dolomite saturation index from continuous records of temperature, pH and specific conductivity The CO2 partial pressure and calcite/dolomite saturation index of spring water are related to its calcium, magnesium and bicarbonate concentrations, pH and temperature as discribed in an earlier study. However, while the continous monitors directly measure pH and tempeature, continuous calcium, magnesium and bicarbonate concentrations have to estimated indirectly. the Shuifang spring composition is dominated by calcite/dolomite dissolution. So, calcium and magnesium are the major cations and bicarbonage is the major counter-balancing anion. Consequently, these ions dominate the electrical conductivity and their concentrations are directly poportional to the eletrical conductivity. As the electrical conductivity is directly measured continuously, this feature is used to estimate calcium, magnesium and bicarbonate concentrations from the continuous electrical conductivity data. For the purpose, the linkages between concentrations and electrical conductivity need to be established from the spot-sampled monthly data.

At the Shuifang spring experimental site, these concentrations are linearly related to specific conductivity by the relationships

$[Ca2+]=0.2032\times spc+2.4794 \quad r2=0.9954$
$[HCO3-]=0.0095\times spc+0.2029 \quad r2=0.982$

Fig 1. Linear relationships between electric conductivity vs. calcium and bicarbonate, respectivity for the Shuifang spring

Respectively, where Kcalcite and Kdolomite are the temperature-dependent equilibrium constant for calcite and dolomite respectively. If SI>0, water is supersaturated with respect to the mineral; if SI<0, water is aggressive to the mineral; and if SI=0, the equilibrium reaches.

Results

Hydrochemical varaition of Shuifang spring in long time scale

In abserved time the waterlevel of Shuifang spring sustainedly falled under longtime drought through the curve of rain contrasted with curve of spring waterlevel(Fig 2). It meaned the discharge of spring sustainedly dropped down. At the same time spring water temperature and CO2 partial pressure also began to drop down. But pH and Sic of spring water sustainedly increased. Maybe there are two factors which caused these variation. The first, because of sustained high air temperature soil humidity decreased and void volume of soil increased.

Soil CO2 more easily emissed into atmosphere than ordinary weather. Thus soil CO2 which entered into epikarst water is sustainedly reduced. It also leaded that CO2 partial pressure of spring water decreased and pH and Sic of spring water increased. The second the water temperature of spring sustainedly decreased because strong evaporation must absorb too much heat

Fig 2.Hydro-chemical variation curve of Shuifang spring in Jinfo mountain（2006/7/18-2006/9/7）

Diurnal hydrochemical varaition of Shuifang spring under summer drought

In abserved time it rained at 8:15. the amount of rain was 7.5 mm. The spring water temperature began to increase at 9:45. pH, Sic and specific conductivity of spring water also began to increase and the CO2 partial pressure began to decrease(Fig3). The added soil CO2 which rain soluted did not enter into the epikarst water system because rain temperature began to increase in summer drought. It leaded that pH, Sic and specific conductivity of spring water inclined and CO2 partial pressure of spring water decreased.

Fig 3.Hydro-chemical variation curve of Shuifang spring in Jinfo mountain（2006/8/10：00-24：00）

A Nonlinear Synthesis for Understanding Atmospheric Complexity: Space-Time Cascades

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In spite of the unprecedented quantity and quality of meteorological data and models, there is still no consensus about either the atmosphere's or the models' elementary statistical properties as functions of scale in either time or in space. We propose a new synthesis based on a) advances in the last 25 years in nonlinear dynamics, b) a critical reanalysis of empirical aircraft and vertical sonde data, c) the systematic scale by scale space-time exploitation of high resolution remotely sensed data d) the systematic reanalysis of the outputs of numerical models of the atmosphere including GFS, GEM models and the ERA40, and the NOAA 20th Century reanalyses) and e) a new turbulent model for the emergence of the climate from "weather" and climate variability.

We conclude that Richardson's old idea of scale by scale simplicity - today embodied in multiplicative cascades - can accurately explain the statistical properties of the atmosphere and its models over most of the meteorologically significant range of scales, and perhaps some of the climate range. The resulting space-time cascade model combines these nonlinear developments with modern statistical analyses, it is based on strongly anisotropic and intermittent generalizations of the classical turbulence laws of Kolmogorov, Corrsin, Obukhov, and Bolgiano.

Entropy Production and Self-organised (sub) Criticality in Earthquake Dynamics

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We derive an analytical expression for entropy production in earthquake populations based on Dewar's formulation, including flux (tectonic forcing) and source (earthquake population) terms, and apply it to the Olami-Feder-Christensen (OFC) numerical model for earthquake dynamics. Assuming the commonly-observed power-law rheology between driving stress and remote strain rate, we test the hypothesis that maximum entropy production (MEP) is a thermodynamic driver for self-organized 'criticality' (SOC) in the model. MEP occurs when the global elastic strain is near, but strictly sub-critical, with small relative fluctuations in macroscopic strain energy expressed by a low seismic efficiency, and broad-bandwidth power-law scaling of frequency and rupture area. These phenomena, all as observed in natural earthquake populations, are hallmarks of the broad conceptual definition of SOC, which to date has often in practice included self-organizing systems in a near but strictly sub-critical state. In contrast the precise critical point represents a state of minimum entropy production in the model. In the MEP state the strain field retains some memory of past events, expressed as coherent 'domains', implying a degree of predictability, albeit strongly limited in practice by the proximity to criticality and our inability to map the stress field at an equivalent resolution to the numerical model.

Seismic Response in an Anisotropic Medium

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Earth materials through which seismic waves propagate are rarely isotropic.Different causes of such anisotropic behaviour indicates anisotropy of rock is rule rather than exception. For study of anisotropic nature of wave propagation media which is used for AVO interpretation, an approximation of Zoeppritz equations has been used.

Variation of P to P reflection coefficients has been studied for VTI and HTI media and also AVO analysis for different model has been done.It has been found that for small angles of incidence (~ 10 to 15 degrees); the reflection coefficients do not differ significantly from that for the isotropic case. However the effect of anisotropy becomes fairly appreciable at large angles of incidence. The amplitudes of reflection coefficients for large angles are governed by the contrast in Thomsen parameters.

B-value and Fractal Dimension Imaging of the Epicentral Zone of the 2001 Bhuj Earthquake, Gujarat, India

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The devastating intraplate earthquake of Mw 7.7 of 26 January, 2001 took place along the south-dipping reverse fault in the lower crust (~23 km) of Kachchh, Gujarat, India, obliterating some 14,000 people. The aftershock activity has been continuing for almost last nine years since the occurrence of 2001 mainshock. We jointly analyzed 2159 aftershocks of Mw ≥3.0 (2001-2008) to study the distributions of b-value, earthquake density and fractal dimensions in space and depth. We found that our dataset strictly follows the Gutenberg-Richter law, thus, all events of Mw≥3.0 are listed in this dataset. Correlations of images show a south dipping zone of high b-value, fractal dimensions and earthquake density at 5 – 35 km depth below the aftershock zone coinciding well with the inferred causative fault zone of the 2001 Bhuj mainshock. We can infer that these high b value as well as formal fractal dimension anomalies are regions of increased heterogeneity, crack density, and/or high pore pressure caused by the presence aqueous fluids or volatile CO2. This interpretation is supported by all the available geophysical evidence, such as tomographic and geological studies. We also examine the dependence of the studied parameters with time.

Seismogenesis of the Lower Crustal Intraplate Earthquakes Occurring in the Kachchh Seismic Zone, Gujarat, India

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Large intraplate continental earthquakes like the 1811-12 New Madrid (Mw 8.0) and the 2001 Bhuj (Mw7.7) were highly destructive because they occurred in strong crust, but the mechanisms underlying their seismogenesis is not understood. Here we show, using local earthquake velocity tomography, and joint inversion of receiver functions and surface wave dispersion that the crust and uppermost mantle beneath the 2001 Bhuj earthquake region of western India is far more complex than hitherto known through previous studies. A new image of the crust and underlying mantle lithosphere first time delineates the presence of a 18-km thick high velocity (Vp: 7.15 - 8.11 km/s) differentiated crustal and mantle magmatic layer above a hot and thin lithosphere (only 70 km) in the epicentral region of 2001 Bhuj earthquake. This magmatic layer begins at the depth of 24 km and continues down to 42 km depth. Below this region, brittle-ductile transition reaches as deep as the Moho (~34 km) due to the possible presence of olivine rich mafic magma. Our study also demonstrates an updoming of Moho (~ 4-10 km) as well as asthenosphere (~ 6-12 km) below the Kachchh rift zone relative to surrounding areas. Restructuring of this warm and thin lithosphere may have been caused due to two-fold rifting and thermal plume interaction at around 184 and 65 Ma. It appears that such kind of crust-mantle structure control the seismogenesis of lower crustal earthquakes in the continental rift zones and thus has a relevance to the global intraplate earthquake activity.

SKS/SKKS Splitting in the Kachchh rift Zone, Gujarat, India

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410 measurements of SKS/SKKS phase splitting were obtained from twelve seismic stations in Kachchh, Gujarat. The estimated mean fast directions and splitting times range from 70.9o to 117.6o and 1.26 to 1.92, respectively. The mean fast polarization directions are 89.1 9.2o in the south of Kachchh rift, 88.8 8.5o in the western Kachchh mainland unit, 84.3 12.6o on the Wagad uplift, and 88.7 7.73o in the north of Kachchh rift. The simple mean for all the stations is (, t) = ((88.11 13.4)o, (1.59 0.20) s). The fast directions are mostly E-W in the Kachchh rift zone, which are parallel to the axis of rift. The main cause of this rift axis parallel anisotropy is attributed to the pre-existing lattice preferred orientations of olivine caused by asthenospheric flow and thin melts pockets in the partially molten asthenosphere directly beneath the Kachchh rift zone, which favors a transtensional deformation of the lithosphere during rifting episodes.

A Study on Non-Linear 3-D Wavelet for Scale Extraction

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The 3-D anti-symmetric band limited wavelet (ASW) f(x, y) is defined. The present work deals with the extraction of the scale parameters of 3-D anti symmetric band limited wavelet (ASW) using the 2-D Mellin transform (TMT), a scale invariant transformation in real and complex domains. Further the 2-D Fourier transform (FT) of the 3-D anti symmetric band limited wavelet (ASW) is derived. Also, the 2-D Mellin transform of the Fourier transform (M-F) of ASW is derived. In case of complex domains the amplitude and phase components play a key role for scale extraction. Algorithms for the estimation of the scale parameters of 3-D anti symmetric band limited wavelet (ASW) are developed, using the mathematical transformations. 3-D anti symmetric wavelet models are simulated for different range of scales and subjected to the scale extraction procedure and thus established the validity of algorithms. Further, numerical procedure are tested on seismological data sets for extraction of scale parameters and proved the robustness of algorithms. The nonlinear phenomena of waveforms like x-rays, satellite images, data compression, computer vision, 3-D animation, human finger prints etc are potential areas for extraction of scale parameters, using the algorithms developed in the present study.

Analysis of Earthquake Data of Himalyays - A New Approach

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The voluminous earth quake data sets, covering entire Northern part of India comprised of Himalayan Mountain belt is divided in to 3 parts i.e., North Western(NW), Central (C) and North Eastern(NE), and also the total data samples of entire Himalayan belt , constitute with Latitude, Longitude, Magnitude($M \geq 4$) and Focal depth(Lt, Ln, M, Fd) are considered for the present study. An attempt is made to analyze the relation between the 4 parameters Lt, Ln, M and Fd using the Cluster and Factor analyses. Cluster analysis sorts out different objects into homogeneous groups in a way the degree of association between two objects is maximal if they belong to the same group and minimal otherwise. In short, cluster analysis identifies structures in data without explaining why do they exist. Further, to substantiate this study the data sets are analyzed, using factor analysis technique which attempts to identify the underlying factors that explain pattern of correlations with a set of observed variables. Interestingly, it is determined that the total number of clusters is 20 in each zone (NW, C, and NE) and also for the entire area, respectively. It is observed that the distance from the centre point to each cluster (within a group of 20 clusters) varies for all the 3 zones and as well for the entire Himalayas for all the parameters Lt, Ln, M and Fd. From Factor analysis (for the 4 parameters) it is noticed that NE and NW follow the same pattern of Commonalities M,Ln,Fd and Lt in descending order, whereas the Central Himalayas and total Himalayas follow the

similar pattern of commonalities in Ln,Lt,Fd and M .It is evident that from Factor analysis the Longitude (Ln) is a Common factor, which is dominant, extracted from the data sets of Central and Total Himalayas though independently. However, the Magnitude parameter is the Common factor which is dominant, extracted from data sets of Western and North Eastern Himalayas though independently. The most significant inference that is drawn from this analysis is that it could be possible only when the stress is applied on opposite directions that is, North western and North Eastern Parts of Himalayan zones are compressing against each other as a result the distribution could take place along the Longitudinal direction. Further it also correlates with the crustal thicknesses in the Central portion of the Himalayas is more compared to the neighboring North Eastern and North Western blocks. It is like when the stress is applied on opposite directions of a clay ball that would not only make the clay ball elongate in perpendicular directions of forces but also the thickness would increase in the central portion.

Can We Resolve NMO and DMO-Nonlinear Problems in Exploration Seismic

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The most primary and unresolved problems in exploration seismics are normal move out (NMO) and dip move out (DMO) corrections. The reason is that the NMO and the DMO are nonlinear time functions t(x) and velocity estimation is based on trial and error approach. Since of NMO and DMO are essentially related to 'scaled time functions'. The NMO equation is transformed into the's' domain, using the scale invariant transformation, called Mellin transform. The transformed expression is recasted into logarithmic form, a simple linear equation which constitutes with velocity and depth. The mathematical algorithm is formulated for determination of the velocity and depth parameters. Further, the Mellin transform of the nonlinear time function of DMO is derived. Also, the derived transformed expression is reformulated into linear form and mathematical procedure is formulated for determination of parameters- velocity, depth and angle of inclination of dipping layer. The algorithms are tested on numerically simulated models. Also, validity of the algorithms is demonstrated on seismic data sets. The algorithms do not require assumptions for determination of parameters –velocity, depth and angle of inclination of dipping layers. The algorithms can also be used for fractal analysis, attribute analysis and for resolving the anisotropy. The algorithm can be adopted, using concepts of artificial intelligence and expert system, for automatic estimation of parameters.

Understanding the Severe Magnetic Disturbances of October 2003 – Challenges for Modelling

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The adverse effects of severe space weather on modern technology are well known and well documented, and risk-mitigation procedures and technologies have been developed. The physical processes underlying space weather are also generally well understood, although improvements in our ability to model the space environment and to forecast severe space weather events are needed.

The worldwide network of magnetic observatories, augmented by satellites, monitor magnetic variations in near-real time and provide forecasts of possible electromagnetic disturbances, that would affect critical communications and navigation. Models have been developed to predict the effects of magnetic storms, in the earth's near-space –ionosphere and atmosphere. Less well documented and understood, however, are the potential economic and societal impacts of the disruption of critical technological systems by severe space weather.

Recent magnetic storms in October and November 2003 come under this category of 'extreme disturbances'. Apart from provided insights into the triggering of unusual solar phenomena, the accumulated data from interplanetary measurements, and a host of observations from ground-based instruments, of these events, have been modelled to understand the effects on the earth and its magnetosphere. The large amounts of energy transferred into the Earth's near-space, have been the impetus for more effective means to protect satellites in space and decrease hazards of air travel

and navigation Explanations of related phenomena, of ionospheric and atmospheric disturbances, were sought using current models of magnetic disturbances. However, the failure of these 'mean-state' models have provided valuable pointers for a new approach to model these extreme events and some progress made in these efforts.

Extreme Events Recovered in Subsurface Images Along the Tamil Nadu Coast

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The 2004 Indian Ocean Tsunami event devastated a number of major coastal regions in South Asia, including the Tamil Nadu coast of India. In many areas on the east coast of India, distinct deposits of tsunami sands drape the landscape and overlie the muddy deposits of the coastal plain (Srinivasalu et al., 2007). The event highlighted the need for long-term research into extreme events, however to date little is known about the geological history of tsunamis to provide a meaningful assessment of their future impact on the coast (Rajendran et al., 2006; Monecke et al., 2008). Using erosional, as well as depositional features of the 2004 tsunami as proxy for past events, we present new subsurface evidence of past erosional events along the south-east coast of India (Figure 1). Earlier, limited luminescence dating efforts to date paleo-tsunamis (Huntley and Clague, 1996) provided stratigraphically reasonable ages in the range 260 ± 20 to 1,200 ± 95 BP for tsunami-sourced sediments in Washington state and British Columbia. However, truly 'zero age' tsunami samples have not been analyzed in detail and the recent tsunami event provided a unique opportunity to examine the extent of zeroing and hence the first possibility of establishing the 'zero error', if any, in the application of optically stimulated luminescence (OSL) for the dating of paleo-tsunami events. We use OSL dates on relict scarps within a prograded coastal sequence to reconstruct the chronology of earlier tsunamis on the Mahabalipuram coast, situated 55 km south of Chennai on the east coast of India. The coastline of Mahabalipuram comprises long open beaches with casuarinas' plantations. The shoreline is oriented N-S with a coastward relief. The beaches have wide-ranging subaerial and subaqueous sand volumes (Subrahmanyan and Selvan, 2001). The near-shore zone of Mahabalipuram has an irregular seabed with rocky outcrops of granitic boulders, occasional sand patches, and a moderate relief towards the east. OSL dates obtained from sediments immediately overlying heavy-mineral concentration (HMC) anomalies associated with relict erosional disconformities (buried scarps) suggest probable tsunami events -ca. ~1,000 and 3,700 years ago.

The identification of tsunami deposits is the first step in tracing past events, yet it is often difficult to distinguish tsunami deposits from those produced by other high-energy event, such as storms (i.e., tempestites). The evidence left by a tsunami in the coastal stratigraphy can assist in providing direct modern analogs for the identification and interpretation of paleo-tsunami in the geologic record (Srinivasulu et al., 2007). Ground-penetrating radar (GPR) imaging has proven to be a successful tool for identifying and mapping sand-rich costal sequences, by providing high-resolution images of the extent and geometry of various facies boundaries (Meyers et al., 1996; Buynevich et al., 2007). The diagnostic signatures of erosional events (e.g. HMCs and disconformities mapped in trenches) can be mapped with GPR and their chronology may be established by OSL dating of associated sediments.

Shore-normal geophysical records from Mahabalipuram Beach reveal a series of steep prominent reflections in the shallow subsurface (Figure 2) that can be used as diagnostic signatures of past erosional episodes. Each reflection coincides with a concentration of heavy minerals in sediment cores. HMCs typically contain 15-45% heavy minerals (the GPR response being primarily due to high magnetite content) compared to the background concentration of 5-10%. Although the storm origin cannot be ruled out, the extent and height above sea level, as well as geometry of the buried scarp is similar to that produced by the 2004 tsunami. The OSL dating of the two oldest sand layers from profiles P1 , approximately 40 m landward and P2 around 50 m landward from the beach (Figure 2) yield ages of 1,080 ± 60 (M4) and 3,710 ± 200 (M5) years ago (before 2009). M4 and M5 represent the major significant erosional events, if analyzed further for other samples as well; we can obtain the recurrence intervals of these major events with high

resolution. These findings are the first step toward establishing an integrated geophysical and OSL database of erosional events along the south-east coast of India.

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Acknowledgments

Funding from INCOIS, Ministry of Earth Science, India, is acknowledged.

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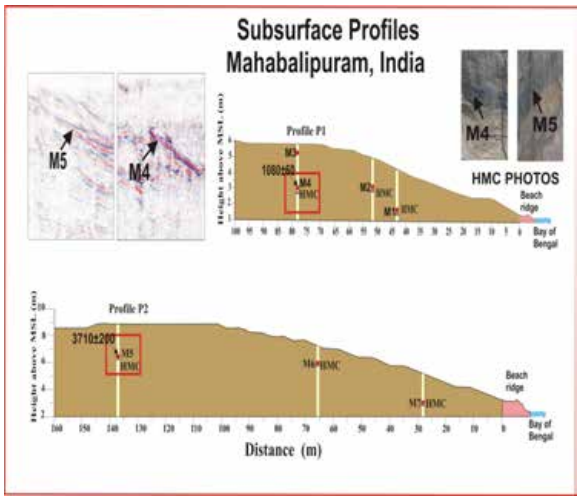
Figure Captions:

Figure 1. Location of the study area along the east coast of India (profile P1 and P2). Insets show the location of the study area, the area of origin of the 2004 Indian Ocean Tsunami (star) and the ground photographs of profiles P1 and P2.

Figure 2. Topographic profiles and subsurface data of shore-normal transects P1 and P2 (location shown in Figure 1). Also shown are heavy-mineral concentration (HMC; red boxes) and optical dates obtained on sands immediately overlying the HMCs (M4&M5). Segments of the Geophysical Survey Systems Inc. (GSSI) ground-penetrating radar profiles highlight prominent reflections in the upper part of the coastal plain sequence, which are interpreted as erosional disconformities. The OSL ages of samples associated with anomalies M4 and M5 are indicated in years before 2009. MSL- mean sea level.

Figure 1

Figure 2



Landslide Studies and Mitigation – With a Focus on Varunavat Landslide in Uttarkashi, Uttarakhand Himalaya, India

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Landslides, though occur as localized events, are the major natural hazards which affect at least 15% of land area in India, covering more than 0.49 M Km2. In the seismically sensitive and geodynamically active Himalayan region, landslides occur very frequently and affect the population severely. In Uttarakhand Himalaya, the landslides that had catastrophic effect include Varunavat Project Landslide (2003) in Uttarkashi, Malpa Landslide (1998) along Kailash Mansorover Yatra route, Kanaudiagud slide (1978) which blocked Bhagrathi river, Gohana Gad Landslides (1893) which blocked Birchiganga etc.

On 23rd September 2003, a huge and massive landslide was witnessed on Varunavat Parvat in Uttarkashi which disastrously affected the life and property of the population living at the toe of the hill. About 3000 people were affected and about 5000 lacs worth property was damaged. However, fore-warning, given about one month back, based on the geologists' observations helped the administration to evacuate the local population from high risk areas at the toe of the hill, thus preventing any loss of life. Considering the huge dimension of the slide and its critical location, most effective design solutions based on the detailed engineering geological investigations/assessment were adopted for a long term stabilization of the slopes. A scheme of post treatment monitoring using state-of-the-art techniques – microseismic/nanoseismic monitoring and slope stability radar has also been proposed.

Earthquake Interevent Time Distributions Reflect The Proportion of Dependent and Independent Events Pairs And Are Therefore Not Universal

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Seismic activity is routinely quantified using event rates or their inverse, interevent times, which are more stable to extreme events [1].

It is common practice to model regional earthquake interevent times using a gamma distribution [2]. However, the use of this gamma distribution is empirically based, not physical. Our recent work has shown that the gamma distribution is an approximation that drops out of a physically based model after the commonly applied filtering of the raw data [3]. We show that in general, interevent time distributions have a fundamentally bimodal shape caused by the mixing of two contributions: correlated aftershocks, which have short interevent times and produce a gamma distribution; and independent events, which tend to be separated by longer intervals and are described by a Poisson distribution. The power-law segment of the gamma distribution arises at the cross over between these distributions. This physically based model is transferable to other fields to explain the form of cascading interevent time series with varying proportions of independent and dependent daughter events. The role of correlations in a time series of interevent times also affects estimates of the mean interevent time [1]. When quantifying the uncertainty in the mean interevent time, we must take into account that interevent times are not independently drawn from this distribution; correlations exist between successive interevent times due to the aftershock activity. The error on the mean earthquake interevent time therefore does not exhibit simple Gaussian convergence with increasing sample size according to the central limit theorem.

We have found that when the independent or background rate of earthquakes is high, as is the case for earthquake catalogues spanning large regions, significant overlapping of separate aftershock sequences within the time series "masks" the effects of these aftershock sequences on the temporal statistics. The time series qualitatively appears more random; this is confirmed in the interevent time distribution, in the convergence of the mean interevent time, and in the poor performance of temporal ETAS parameter inversions on synthetic catalogues within this regime [4]. The aftershock-triggering characteristics within the data are thus hidden from observation in the time series by a high independent rate of events; spatial information about event occurrence is needed in this case to uncover the triggering structure in the data.

We show that earthquake interevent time data from the Kilauea volcano can be explained by this physical model and demonstrate that the form of the interevent time distributions separated in space reflect

the diversity of processes across the volcano [5].

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Declining Predictability of Indian Summer Monsoon Weather, in the Backdrop of Increasing Heavy Rainfall Events

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Weather in tropics, controlled by fast growing convective instabilities is, intrinsically less predictable than that in extra-tropics. Increased frequency and intensity of extreme rain events in the tropics in the backdrop of global warming has a potential for further decreasing the potential predictability of the tropical weather. Using nonlinear dynamical techniques involving estimation of Lyapunov spectrum of gridded daily rainfall data over India for 104 years (1901-2004), here we show that the deterministic predictability limit of monsoon weather over central India in the latest quarter of the period has indeed decreased significantly compared to that in the earlier three quarters. The increased moisture in the atmosphere as a result of increasing global temperature makes the tropical atmosphere increasingly more unstable, as evidenced by the increasing trend in the convective available potential energy. This provides the favorable environment for the high frequency events, whose increase in occurrence would lead to faster growth of errors in the synoptic scales, lowering the predictability of the monsoon weather. The decrease of initial error doubling time from approximately 3.0 days to 1.5 days is consistent with increased frequency of extreme events and increased potential instability of the atmosphere in the recent quarter.

Quality Assessment, Reserve Estimation & Economic Analysis of Roofing Slate in the West Central Lesser Himalaya-Nepal

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Quality Assessment, Reserve Estimation and Economic Analysis of Roofing Slate can be carried out at Tharpu of Tanahun District, which lies in the Nawakot complex of the Lesser Himalaya-Nepal. It represents a part of northern limb of the Mahabharat Synclonorium. Petrological study (Presser and Temperature of Metamorphism, and Thing Section) and Physio-chemical Test (Flexure Testing, Water absorption, Wethering Resistance, Abration Resistance, Sulphuric Acid Immersion Test, Wetting and Drying Test) have been done in the laboratory for quality assessment. Geological mapping and preparation of columnar sections have been done in the field for Reserve Calculation. The total reserve of an area is determined by dividing the tonnage with its tonnage factor. The volume is calculated by multiplying the total cross-section area by the perpendicular distance between each cross-section. Cost Benefit Analysis was applied for cost and benefit of slate mining to evaluate the viability of the slate business as well as environmental problem created due to the extraction of slate.

The major slate deposits of the study are belonging to the Benighat Slate and Nourpul Formation of the Lesser Himalaya. The

pressure and temperature of the metamorphism on the basis of b0-spacing and IC methods are 4.23 kbar and 380 C for Benighat Slate and 5.10 kbar and 375 C for Nourpul Formation roofing slate. Flexure strength of the slate along grain ranges from 26. 26 to 50.57 MPa with average 36.24 MPa and standard deviation (SD) of 9.28 MPa. While, the same property across grain ranges from 36.37 to 59.78 MPa with average value 43.1 MPa and SD of 9.59 MPa. Similalry, the elasticity of the tested sample of slate ranges from 1055.4 to 2974 MPa having mean value of 1774 MPa and SD of 740 MPa. Water absorption by weight is 0.789 to 1.473 having mean value 1.02 and SD 0.3. While, the weather resistance of the slate lies within 0.31 mm to 0.55 mm with average value of 0.41 mm and SD is 0.1. Abrasion by weight has a range from 14.3 to 20.4 with average value 16.22 and SD 2.73. The permeability, sulphuric acid immersion, and wetting and drying tests give excellent results to the slate.

It was observed that from the field study, there is fine-grained with a fairly perfect natural cleavage, readily splitable into thin and smooth sheets of slate at Seratar (3000 m northwest from Tharpu Bazaar) and Otandi (1000 m west from Tharpu Bazaar). Due to this thin splitting properties, most slate are used for roofing purposes. On the basis of physio-chemical testing and Petrological study, the slate of Nourpul Formation at Seratar and Benighat slate at Otandi are best for roofing as well as construction purpose even though inferior to the ASTM standard.

The total probable reserve of the slate calculated by the cross-sectional method is to be 52.9 million m3 at Otandi. Mining method appropriate for the slate deposit is open pit mining. As cost benefit analysis (B/C ratio = 1.23), the mining of slate is good profitable. For profitable business, the benefits and cost ratio should always be greater than one. However, the slurry of quarry materials is affecting downward forest, water bodies and agriculture land with environmental degradation.

Analysis and Prediction of Extreme day Mean Values of Total Ozone Amount Interannual Changes Over Europe in the Period From 1979 to 2006 yrs.

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Dynamics of total ozone amount (TOA) over different planet's regions is one of the most significant factors of biologically active UV radiation flux changes, which can affect on their ecosystems and on the formation of troposphere ozone in them. Hence now TOA monitoring over the entire planet's territory is being provided with the use of artificial Earth satellites and numerous ground based stations.

Near earth surface the most essential influence on the ecological conditions make extreme (maximum and minimum) day mean TOA values changes. It is deter-mined, that statistical features of these atmosphere characteristics' changes allow to look on their dynamics as unsteady and multifactor process. This decreases its simulation validity while using traditional methods and allows to infer the possibil-ity of using a method, which accounts the indicated features. The method men-tioned above showed its efficiency in the tasks of the monthly mean TOA values dynamics' simulation. Nevertheless, earlier, the possibility of using it for the ex-treme day mean TOA values changes' analysis and prediction have not been viewed. As the result, now the regularities of extreme TOA values interannual changes over different planet's regions are not clearly understood. Also the meth-ods of its prediction are not enough perfect. Thus, the development of the analysis and prediction method of mentioned processes is one of the topical problems of ecology and atmosphere physics.

Solving of this problem for the heavily populated areas is in the main interest. One of such areas is Europe. The purpose of this work is the analysis of regularities of extreme day mean TOA values spatial-temporal changes over Europe, which are seen in different months and also to study the possibility of its prediction using the method shown in .

With this aim in mind day mean TOA values time series over different Europe re-gions in the period from 1 January 1979 yr. to 31 December 2006 yr. have been analyzed. To retrieve such time series graphic data was used, which is presented on the internet site of World ozone and ultraviolet data centre (WOUDC – http://www.woudc.org). This graphic material was converted with the use of a pro-gram to the digital data, corresponding to different squares of studied territory in size 1x1 angular degrees.

Adequacy of the information attained with the method described above was estimated with the use of ground based measurements data from the stations Provance (France), Aroza (Switzerland), Hradek Kralove (Czech Republic), Belsk (Poland), Kairo (Egypt) and Oxford (United Lingdom).

For every year and every month maximum and minimum day mean TOA values within every square were defined.

A comparison of energy spectrums of extreme day mean TOA values time series different segments, that were attained with the method mentioned above, has showed that its dynamics can be described with the next mathematical model:
, (1) where – linear trend of a studied process;
– steady, Gauss noise of measurements, which has a zero mean value;
– correlative, unsteady part, which has a zero mean value.

For the model parameters identification a numerical procedure, which is based on the random choice method, was used. The spatial distributions over the Europe ter-ritory of linear trends slope ratios of extreme day mean TOA values and also simu-lation errors dispersion were studied. The spectral composition of characteristics dynamics mentioned above was analyzed. The possibilities of its prediction using the errors dispersion assessments, which were deduced with the regard to the stud-ied processes prehistory in the mentioned stations of the ground based observa-tions, were estimated. The developed method can be used for simulation and pre-diction of extreme day mean TOA values interannual changes over other planet's regions and also any other extreme parameters, which can be described by time se-ries with the similar statistical features as for the TOA values ones.

Artificial Neural Networks (ANN) Based Modeling for Landslides Susceptibility Zonation in Parts of Himalayas

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Landslides are major natural geological hazards and each year these are responsible for enormous loss of human lives and property in Himalayan region spreading over Pakistan, India, Nepal, and Bhutan. Recent studies have revealed that landslides occur due to complex interaction of several geoenvironmental parameters such as lithology, geological structures (faults, lineaments), geomorphology, slope gradient, slope aspect, soil texture, soil type, drainage, land use and anthropogenic factors. Attempts have been made to integrate such factors based on either statistical or heuristic approach and produce landslide hazard zonation maps showing relative susceptibility of a given area to landslide hazards. However, such methods have several limitations and therefore, an attempt is made to integrate layers by training the data set using artificial neural network (ANN) to arrive at more reliable results. The methodology was developed on a small area in Bhagirathi basin and is being tested with databases from two different areas. Causative parameters and landslide maps were derived from interpretation of satellite images, topographic maps, field survey and other maps. These parameters were taken into consideration while using the back-propagation of neural network method. The weights obtained from the trained network were consequently utilized for map integration and classification. The resulting landslide susceptibility zonation map delineates the area into five classes: Very High, High, Moderately High, Low and Very Low. These classes were validated by correlating the results with actual landslide occurrences. The early results are very encouraging and attempts are being made to further improve the training and classification results.

Fractal Clustering of Reservoir Induced Seismicity in the Koyna-Warna Reservoir Area

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The Koyna-Warna region has been prone to reservoir-triggered seismic activity, where 18 earthquakes of magnitude ≥ 5, and several hundred thousand smaller earthquakes have occurred over the past 40 years, is an ideal site for monitoring earthquake precursors. Here, we study the present day activity, from August 2005 to June 2009, characterized by

the cluster of events occurred around the Koyna-Warna seismic zone in terms of seismic b-value and the fractal dimension D of the earthquake epicenters both in space and time. We estimated the spatial fractal dimension over six blocks of dimension 0.1º×0.1º. The results imply that scale-invariant fractal clustering occurs in both space and time with temporal fractal dimension Dt (0 < Dt < 1) and spatial dimension Dr (1 < Dr < 2). The areas exhibiting low b and relatively high Dr are consistent with low magnitude, clustered earthquakes in space. Over the time period we discuss the correlation between b and D values statistically significant at 1σ level in terms of present day seismic activity, where the seismicity rate starts deviating from the mean rate of background seismicity (number of events/day). We discuss the changes in b and D values in relation to stress loading and unloading of the reservoir. Possible seismogenic interpretations of the results will be presented.

Thermal Upwellings, Magmatic Extrusion and Intra-plate Rift Valley Earthquakes in India

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Geodynamically, the Indian shield with dynamic past and active history of rifting, multiple plume interaction and continental breakup episodes differs considerably from other stable areas of the world. It is made up of several ancient cratonic blocks which are separated by prominent rift valleys and mega suture zones. Many of these rift valleys have been frequented by number of destructive earthquakes since historical times which caused heavy loss of human life and property. These include 1819 Kutch, 1927 Son Valley (Mw 6.4), 1938 Satpura (Mw 6.3), 1956 Anjar (Mw 6.0), 1967 Koyna (Mw 6.3), 1969 Bhardachalam (Mw 5.7), 1970 Broach (Mw 5.4), 1997 Jabalpur (Mw 5.8) and 2001 Bhuj (Mw 7.7) earthquake. In spite of several geoscientific investigations by various agencies, siemotectonics of these rifted regions are still being debated.

Our multiparametric study of such regions indicate massive restructuring of the crust and underlying subcrustal mantle lithosphere due to episodic thermal upwellings which resulted into (i) large scale removal of the granitic-gnessic crust from the surface due to sustained uplift and erosion, (ii) high input of heat flow from the mantle, sometimes exceeding 40 mW/m2, (iii) thin and warm lithosphere and (iv) thick high velocity and high density magmatic underplating across the crust mantle boundary. These characteristics have made the underlying crust below the rift zones extremely weak and vulnerable to multiple tectonic reactivations, thereby causing seismic instability.

Radon Transform and Its Application In Seismic

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Radon transform is able to transform two dimensional images with lines into a domain of possible line parameters, where each line in the image will give a peak positioned at the corresponding line parameters. This have lead to many line detection applications within image processing, computer vision, and seismic. The very strong property of the Radon transform is the ability to extract lines (curves in general) from very noise images.

In seismic it is used for signal enhancement and removal of multiples. Both the forward and inverse transform have contribution in seismic survey. In the conventional Radon transform, integration surfaces are hyperbolic rather than linear. This specific hyperbolic surface is equivalent to a parabola in terms of computational expense, but more accurately distinguishes multiples from primary reflections. Multiples can be suppressed by an inverse transform of the data, where the forward transform separates seismic arrivals by their differences in travel time move out. Parabolic Radon transform is one of the most effective methods to eliminate multiple. Based on the parabolic Radon transform, a new method is utilized for missing offset restoration, resampling and regularization of pre-stack individual common depth point (CDP) gathers. The method is also valid for resampling spatially aliased seismic data. An application of radon transform is discussed which shows how the multiples are attenuated and improve signal strength.

Analysis and Prediction of Rainfall Data: Fractal Approach

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We have analyzed rain fall behavior of India for all the seasons. The four seasons are considered as summer (March, April, and May), monsoon (June, July, August, September) and winter (November, December, January). Further, to study the rainfall time series data, we divided study areas into six regions like North East (NE), North West (NW), North Central (NC), West Peninsula (WP), and East Peninsula (EP) and Southern Peninsula (SP). Due to very little rain fall in NW, it often suffers from drought. On the contrary due to heavy rain fall in NE and EP, these regions experience flood. Thus, our main aim of the paper is to predict the possibilities of extreme drought and flood which will be very much useful information for agriculture. This prediction is also helpful to reduce hazard. Statistical analysis (power spectrum, variogram and Hurst coefficient) of Indian rainfall data depicts typical characteristic of power law behaviour. Our approach for possible prediction of rainfall in extreme conditions of NW and NE India uses combination of fractal and Autoregressive Moving Average (ARMA) methods. From fractal theory we estimate Hurst coefficient and scaling exponent from the available rainfall data which tells about the persistence of the time series. Further, using fractional differencing technique based on ARMA we simulate rainfall data in order to predict the flood or drought situations. We have used monthly averaged data for our analysis. Our technique clearly demarcates the possible flood/draught period in predicted sequence. However, a more high resolution data can provide better estimates.

Wavelet Analysis of Marine Oxygen Isotope δ18O Record

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There has been a growing recognition of the importance of global climatic changes to the future well being of humanity, in particular to the mechanism of climate. In the present study an attempt has been made to study the climatic dynamics through wavelet analysis of δ18O record from five deep-sea cores (V22-174, V28-238, V30-40, RC11-120, DSDP 502). From the Auto-Correlation and Wavelet Spectrum analysis of denoised signal, it is observed that the variations in δ18O record are strongly correlated over the past 780,000 years. The first zero crossing of autocorrelation, which corresponds to the Milankovitch precession period is between 23-24ka. A lower fractal dimension (1.51 ± 0.02) for short time scales ranging from ~3-20ka and significantly higher dimension (1.74 ± 0.05) for longer time scales between ~20-65ka, is obtained from spectrum analysis. On carrying out wavelet variance analysis, it is observed that the fractal dimensions are repeated for different scales around 1.29 and 1.79. The advantage of analyzing a signal with wavelets is its ability to study features of the signal locally with a detail match to their scale, i.e., broad features on a large scale and fine features on small scales. This property is especially useful for signals that are either non-stationary, or have short lived transient components, or have features at different scales, all these features are present in δ18O record, hence most suitable for its analysis.

Inundation Modeling at Different Locations Along the West Coast of India Due to Tsunamigenic Earthquakes From the Makran Subduction Zone

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The Makran subduction zone is seismically active and the notable earthquake from this region is the great earthquake of magnitude Mw 8.1 which occurred on 27th November 1945. This subduction zone is one of the world's largest forearc regions and the age of the deformation front is around 70-100 Ma. The region is divided into two segments by Sistan Suture Zone based on morpho-tectonic features, contrasting seismicity patterns and the varying rupture histories. The eastern segment is experiencing small to moderate sized thrust earthquakes and in past experienced a large thrust earthquake whilst the western segment has no established historical records of any large earthquake. One of the major differences between the two segments is the absence of coastal earthquakes in the Western Makran. This subduction zone which is 1000 km in length is a consequence of shallow subduction of northward moving Oman oceanic lithosphere beneath the Iranian micro plate and the active orogenesis has resulted in densely faulted coastal mountain ridges along the coastal region. The 1945 earthquake occurred in the eastern segment and was felt in several parts of Baluchistan, Pakistan and northern India and had generated a large destructive tsunami. The seismicity analysis for the region has been carried out using Fractal Dimension. The Fractal Dimension in this region is seen to vary from 1.8 to 2.4.

A possibly large tsunamigenic earthquake from the region is modeled to quantify the tsunami propagation, the arrival times and run ups at different locations along the west coast of India. The state of Gujarat being close to the Subduction zone has to be closely monitored and detailed inundation modeling has been carried for several coastal location like Dwarka, Porbandar, Somnath, Nagoa Beach, Gulf of Khambhat. The run up heights are seen to range from 3 to 4 m. Inundated distances have been obtained only at few locations. The varying nature of the width of the shelf in this region is responsible for the variation in the arrival times of the tsunami along the Gujarat coast. Also as the shelf is wide in this region the inundated distance is not very significant.

Hydrological Complexity Model of Active Upper Crust Under Koyna (India) Region

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Crust under Koyna region is exhibiting continuous seismicity since last four decades. This crustal section is highly fractured and is being fed by rivers and reservoirs and is also subjected to fluctuating plate boundary forces and significant gravity induced stresses due to crustal inhomogeneities. The ongoing seismicity thus requires understanding coupled hydrological and tectonic processes in the region. Water table fluctuations are one reflection the ongoing hydro-tectonics of the region. We have performed nonlinear dynamical analysis of these observations at several locations and show that these time series appear to be generated by a low dimensional attractor. Changes in the dimension of this attractor with time have also been investigated. Now there is good understanding of turbulence phenomena in fluids and solids and changes in the fractal dimensions are seen in the way the line, surfaces and volume elements of the turbulent media evolve. Implications of these results towards predictability of seismic phenomena in this region will be discussed.

High Intensity Rainfall Event on Subsurface Water Regime: A Case Study in Granite Watershed, Andhra Pradesh, India

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Soil moisture, the primary control on vegetation and eco systems; groundwater recharge, replenishing groundwater reserves and surface runoff feeding streams & rivers are potentially very sensitive to changes in climate in Semi Arid Tropical (SAT) regions. Local flooding is often triggered by short

duration high intensity rainfall events. This paper evaluates the impact of a one day high intensity and high quantum daily rainfall event on moisture flux transfer in the vadoze zone of a semi arid granite watershed and the resultant improvement of groundwater availability and its quality.

A high intensity and high quantum daily rainfall event was recorded during 2005 monsoon season in Wailapalle granite watershed (115 km2) in Nalgonda district of Andhra Pradesh, India. The watershed covered by red sandy loam to loamy sand soils experiences an average annual rainfall of 600 mm. On a single day in the month of October 25, 2005, the rainfall recorded at 7 rain gauge stations in the watershed area varied in range from 157 – 313 mm, with the mean value of 225 mm and the coefficient of variation of about 45 %. This average single day rainfall amount in the watershed constitutes about 40 % of average seasonal rainfall. The rainfall intensity recorded from the automatic rain gauge station in the watershed area is about 23 mm/hr with a rainfall period of more than six hours. The moisture flux transfer below the root zone evaluated through tritium tracer studies at different sites due to rainfall is in the range from 86 to 175 mm with the average value of 138 mm, which far exceeds the average total moisture flux transfer in this watershed during normal rainfall years. Repeated depth moisture measurements through neutron moisture probe also indicate increase in moisture flux and deeper migration of infiltrated moisture front in the vadoze zone. Groundwater level monitoring revealed significant water level rise in bore wells even over deep water table condition areas with the maximum water level change of about 16 mts.

The impact of these types of typical high intensity and high quantum rainfall events on changes in vadoze zone and groundwater conditions in the areas of dry semi arid tropical regions can be used as an indicator of impact assessment on climate change.

Doughnut Precursory Seismicity Patterns in the Indian Shield Earthquakes: An Observation

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During the past six to seven decades before the onset of the Cratonic Killari earthquake of 30 September 1993; deep crustal (geofractured rift zone) Jabalpur earthquake of 21 May 1997 and Continental rift margin Bhuj earthquake of 26 January 2001, the doughnut precursory seismicities have been observed. Recently, Desamangalam, Trishur-Palghat region, Kerala has also been exhibiting the precursory doughnut seismicity in the region, which may infer the impending moderate earthquake in future. The occurrences of micro to moderate earthquakes may be the signatures of reactivation of old faults. According to Mogi (1979), the doughnut precursory seismicity may be observed mostly in continental rifts and subduction zones.

The analyses of stress conditions visa-a-vis the Coloumb-Navier criterion of failure indicates the necessity of the reduction of normal stress. This reduction of normal stress due to pore–fluid pressures, differential erosion or a combination of both (and thereby the uplift of the crustal blocks in the area) could be the possible cause of the occurrences of the above earthquakes in the peninsular shield. The estimated pore-fluid pressures of about 67MPa at the depth of 6.5km, 880MPa at the focal depth of 35km and 559MPa at the depth of 23km for Killari, Jabalpur and Bhuj earthquakes respectively. The causative factors for the occurrences of these major earthquakes might be predominantly due to pore fluid pressures. Pore fluid pressure developed during the earthquake process, has been estimated by using Mohr's diagram. It is found to be very high in the above case studies, which might be generated by the dehydration of serpentinites in the lower crust and has diffused isotropically vertically upwards through the fault zones. Thus, the physical significance of the doughnut seismicity pattern can be identified with the presence of the strongest material that accommodates the high strain accumulation in the region.

The High Himalayan Orogeny Time: Upper – Early Oligocene?

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Collision between India and Eurasia during Eocene has resulted in closure of Tethys Sea, but time for high rises of Himalayas especially the Tibetan Plateau is being

speculated. Imprints of kinematics and geologic structure, seismic sequence stratigraphy of sediments of the western continental margin of India (WCMI), Bay of Bengal (BOB), Central Indian Ocean Basin(CIOB), Seafloor spreading in the Eastern Arabian Sea (EAS) and published results of the Tibetan Plateau have been reviewed to constrain on time of the Himalayan mountains/plateaus reaching high levels. The crustal deformation of the CIOB has been noted to occur prior to 15 Ma and intimately connected to the geodynamics of the high Himalayan mountain ranges, outward push (potential energy) of the mountains. The Tibetan plateau had reached present elevations, 1000 - 2500 m prior to 15 Ma and perhaps 25-30 Ma ago as suggested from Stable isotope Paleo-altimetry and fossil leaf assemblages studies of the plateau regions. Morphological similarities of flat surfaces of the plateaus of western Himalayas and the southwest Tibetan Plateau areas have been considered for their coeval origin. Second episode of seafloor spreading in the EAS began since 30 Ma (magnetic chron 20/21time) after pause for about 15 Ma. The plateau formation and

recurrence of spreading times mark close kinematics as plate end geodynamics, the obduction process and crust generation at the diverging plate boundary in the eastern Arabian Sea are in separable and closely linked as proposed in case of the CIOB. The mid-crustal fluid flows noted from resistivity and seismic reflection images beneath the plateau region shall evidence convection destabilizing it. Increased sedimentation (Progradation/ aggradation) during Oligocene/middle Miocene to Recent of the WCMI marks rapid denudation from high plateaus of the east. The Oligocene turnbidite sediment sequence of the northern Bay of Bengal and eastern Arabian Sea (~15 degrees north) and pre-rift sedimentary units, clastics and carbonates carpeting the Eastern Continental Margin of India basins by the same period mark massive fluid flow of sediments from the north resulting in turbidites sequences and Leeve- Channel complexes, cut and fill type and over bank build-up thick fan sedimentation. Therefore denudation and transport processes must be much earlier to the sediments deposition. Plus negligible subsidence during upper late Eocene and early Miocene i.e. 40 Ma to 22 Ma of Dahanu Depression of Bombay coast in the north and Vijayadurg Depression of Ratnagiri coast in the south of the WCMI is an event noting quiescence in tectonics followed by supply of sediments in large quantities from north /the high plateau areas into the seas resulting in the thick Neogene sediments sequences. The significant 0nshore/offshore geodynamics and imprints of geologic structure have lead to suggest the orogeny resulting in formation of the high plateaus of the Himalayas prior to late Oligocene. The timing had implications in considering onset of Indian/Asian monsoon pattern and offshore mass fluid flow of sediments.

Possibility of Slow Viscoelastic Process or Change in Rheology in Late and Long-distance Triggering of Shocks in Gujarat, Western India After the 2001 Mw 7.7 Bhuj Earthquake

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The Gujarat region in western India is seismically one of the most active intraplate regions. It was known to have low seismicity but high hazard region in view of the occurrence of several large earthquakes but fewer moderate or smaller shocks. The scenario is changed during the first decade of the 21st Century when 30 felt shocks (of M4 or so) occurred at 20 different locations. In contrast the twenty decades earlier to this decade experienced hardly one or two felt shocks with the exception of the decade of 1930's when 5 earthquakes of M4-5 were felt at Paliyad in Saurashtra. The Gujarat region has EW trending major faults of the failed Mesozoic rifts of Kachchh and Narmada which are getting reactivated by thrusting. There are some smaller transverse strike-slip faults. South of Kachchh, in the Deccan Volcanics of Saurshtra, the NW and NE trending smaller strike-slip faults are activated in the form of moderate earthquakes in response to the plate-tectonics stress.

Aftershocks in the 2001 Mw 7.7 rupture zone in Kachchh are continued at M5.7 level until 2006 and M≤5 level subsequently. For two years the activity concentrated along the 2001 rupture zone in 80kmx50km area. The epicentral area expanded to nearby areas along different faults in EW direction (more towards E). By 2004 and July 2006 the epicentral area expanded to 100kmx75km and 125kmx75km. By 2008 the area further expanded to 200kmx80km covering South Wagad and Banni faults. Additionally the epicentral area expanded by 60 km towards NE to Gedi fault and transverse fault across it by March 2006. The EW expansion was as predicted from Coulomb stress change due to

2001 earthquake but not in other directions. Moreover, the activity along the Allah Bund and Island Belt faults has also increased, making north Kachchh area of 250km x150km sparsely active by 2008 with mostly M<4 shocks.

The activity had also spread towards south to Saurashtra and mainland Gujarat: 120km by 2006, 200km by 2007 and 400km by 2008 along several faults. At three sites the activity is in the form of sequences along faults with largest shocks of M≤5 and several hundreds of M≥0.5 shocks recorded on local networks. At some sites the sequences had fewer shocks. Only one such sequence was reported earlier during 1986 in south Gujarat.

The shear deformation for adjustment process in Bhuj earthquake zone is now negligible as deduced from only 2-3 mm/yr movements of GPS stations. The viscoelastic process / rheology change appears to be the plausible mechanism for long distance and delayed triggering of earthquakes with diffusion rates of 5-50 km/yr.

Influence of Solar Wind Plasma and Interplanetary Magnetic Field on the Low-latitude Geomagnetic Variations During Descending Phase of Solar Cycle 23

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Occurrence characteristics of transient sporadic emissions from the Sun, like solar flares and coronal mass ejections vary during different phases of solar cycle. Solar cycle 23 witnessed numerous energetic solar eruptions in the descending phase (2002-2006) unlike the previous solar cycles. Many intense geomagnetic storm events were produced by these eruptions. Geomagnetic storms are large disturbances in the geomagnetic field caused when highly energetic charged particles emitted from the Sun penetrate into the Earth's magnetosphere and enhance existing current systems therein. Investigative analysis is carried out to ascertain the contribution of solar wind and interplanetary parameters like IMF By, Bz and dynamic pressure for development of intense main phase for the storms occurred during the descending phase of solar cycle 23. Geoeffectiveness of the rapidly changing interplanetary conditions on the geomagnetic field variations are examined using the digital magnetic data from the chain of low-latitude geomagnetic observatories in the Indian longitude sector along with the multisatellite observations of solar wind plasma and interplanetary parameters. Interplanetary drivers like interplanetary coronal mass ejections (ICMEs) comprising magnetic cloud structures responsible for producing significant southward Bz are also discussed.

Nonlinear Solitary Electric Field Structures in the Earth's Magnetosphere

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Electrostatic solitary waves exhibiting unipolar, bipolar and tripolar pulses in the electric field parallel to the ambient magnetic field have been observed throughout the Earth's magnetospheric regions such as plasma sheet boundary layer, auroral ionosphere and the bow shock. The most commonly observed solitary waves in the Earth's magnetosphere are electron solitary waves and ion solitary waves. The fluid theory of plasmas is being used by several authors to study the nonlinear evolution of electron and ion solitary waves in a multi-species space plasmas. The electron (ion) solitary waves are also interpreted as Bernstein-Greene-Kruskal (BGK) electron (ion) phase space holes by using kinetic theory of plasmas. The BGK nonlinear structures are formed through a process of coalescence of the vortices of the trapped particles in an electric potential well, which are described by solutions of nonlinear Vlasov-Poisson system of equations in a

collisionless plasma. Using one dimensional electrostatic particle simulation code in a multi-species plasma we study the nonlinear evolution of electric field structures in an auroral plasma consisting of cold, hot, and beam electrons and ions. We discuss the evolution of both solitary waves and envelop solitary waves and the results are compared with satellite observations.

Examination of the Distribution of Maximum Earthquake Magnitudes by Combining the GEV and GPD Limit Distributions of Extreme Value Theory

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A new method for the statistical estimation of the tail of the distribution of rare strong events is presented for the cases of earthquake sizes recorded in the Harvard catalog of seismic moments converted to Mw-magnitudes and a few regional catalogs. The method is based on the two main limit theorems of the theory of extreme values and on the derived duality between the Generalized Pareto Distribution (GPD) and Generalized Extreme Value distribution (GEV). We establish the direct relations between the parameters of these distributions, which permit to evaluate the distribution of the T-maxima of earthquake size in future time intervals of arbitrary duration T. We develop several procedures and check points to decrease the scatter of the estimates and to verify their consistency. The traditionally used maximum magnitude Mmax values are shown to be potentially non robust that can explain the known fact of repetition of underestimations in the Mmax value evaluation in seismic assessment. We test our procedure on the global Harvard catalog (1977-2006), the regional Fennoscandia catalog (1900-2005), and Japan catalog (1923-2007). The tail distribution behavior can be characterized besides the Mmax values by quantile Qq (T) at any desirable statistical level q and time interval T. The quantile Qq(T) provides a much more stable and robust characteristic of seismic risk than the traditionally used absolute maximum magnitude Mmax value; note that Mmax can be obtained as the limit of Qq(T) for large T values. Because of result of such comparison we recommend to use in seismic risk assessment Qq(T) values instead of potentially non robust Mmax values. The same statistical approach can be used in other cases of examination of risk resulting from the rare strong events.

Seismicity in the Generalized Vicinity of Strong Earthquake as the Most Studied Example of Arising of Instability in Natural Systems

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The earthquake origin is probably the most known example of origin of instability in natural systems. However, even in this carefully studied case there are a few notions on the typical features of the process of pre- and post- period of strong earthquake seismicity. Having this vagueness in mind the average evolution typical of the vicinity of strong earthquakes was examined. Earthquake catalogs were used to construct a generalized space–time vicinity of large earthquakes and to investigate the seismicity behavior in the generalized vicinity of strong earthquke. The character of the inverse cascade (increase in seismicity rate toward the moment of the main shock) and of the aftershocks, as well as the weak seismicity increase occurring in the larger vicinity of the main shock were examined. It was shown that the inverse and aftershock cascades are accompanied by several anomalies indicating the decrease in strength of the lithosphere in the space–time vicinity of strong earthquake; this effect consists in decrease of apparent stress values, an increase in relative contribution of lower frequency domain into the earthquake oscillations spectrum, and an increase of correlation (homogeneity) of strain state in the vicinity of strong events. The revealed features concern to a common development of instability irrespective of a particular mechanism of instability origin, and to a more specific features characterizing the physical mechanism of process of very seismic instability.

Complex Seismic Structures in the Andaman-Sumatra Subduction Zone: Fractal Dimension and b-Value Mapping

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The Anadaman-Sumatra subduction zone is seismically one of the most active and complex subduction zones that produced the December 26, 2004 mega thrust earthquake (Mw 9.3) and large number of aftershocks. About 8100 epicenters, including more than 3000 aftershocks (M>4.5) of the 2004 earthquake, recorded during the period 1918 - 2007, are relocated by the EHB method. We have analysed this large data set to map the fractal dimension and b-value characteristics of the seismogenic structures of this ~ 3000 km long mega thrust subduction zone in southeast Asia in the region between 15°S-15°N latitude and 90°E-125°E longitude.

Fractal dimension, more precisely the correlation dimension (D2) of the epicenters, and the b-value, the frequency-magnitude relation of the earthquakes, are estimated using the above large data set. The D2 is estimated by the correlation integral technique and the b-value by the maximum likelihood method. In order to spatially map the D2 and b-value, the study area is divided into 2°×2° grid with an overlapping of 1°. The grids are overlapped along the X direction, Y direction and both in X-Y direction. This exercise generated about 200 grids with at least 50 events in each grid. Center of each grid is taken as the plotting point for making contour maps.

The maps revealed the major complex geological structures of the region, like the Andaman-Sumatra trench, West Andaman fault (WAF), Sumatra fault, and the Andaman Sea Ridge (ASR), the back arc spreading zone with an quantitative estimates of D2 and b-value. A prominent NW-SE trending contours with fractal dimensions between 0.70 and 1.4 indicate that the epicenters mostly follow linear features, which are basically correlated with the major seismogenic structures of the region. The spatial variation of fractal dimension is prominent; the D2 <1.0 indicates more of a cluster zone of the epicenters, where as the structures with D2> 1.0 indicates that the seismogenic structure is more linear in nature. It may be noted that linear nature of the seismogenic structures increases from north to south, from the ASR to the Sumatra fault. The Andaman-Sumatra trench shows fractal dimension ~ 1.0 in some parts, but in major parts it shows greater fractal dimension ~ 1.80, which indicates a 2-dimensional nature of the trench. Similar observation is made at the ASR. A spatial variation of the b-value (0.8-1.8) is also observed; along the Andaman-Sumatra trench the b-value is higher (1.4-1.8). The b-value is much low along the WAF and Sumatra fault, whereas the D2 is higher along these structures; a negative correlation between the fractal dimension and b-value is thus observed in the subduction region.

Extreme Events, Return Intervals and Long Term Memory

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One of the important quantities of interest in the study of extreme events is the distribution of times between successive occurrences of the extreme events or the return intervals. This is useful for estimation of probabilities for the next occurrence of extreme event and also as an indirect method to characterise and infer the autocorrelation exponent of a process. For an uncorrelated or memory less process, the return interval distribution is known to be an exponential. Hence, in this case, the probability for return intervals being much longer than the average are very low. On the other hand, most of the natural processes as well as many of the socio-economic time series display long term memory. For example, it is known that the magnitude of earth quakes, temperature records, river flow records, precipitation etc. display long term memory. This implies that their autocorrelation function displays a slow algebraic decay. In such cases, what is the return interval distribution for extreme events? In this work, we obtain an approximate analytical expression for the return interval distribution of extreme events for long range correlated time series. It turns out that the distribution we obtain is a product of a power law and a stretched exponential and depends on (i) the autocorrelation exponent of the original time series and (ii) on the threshold used to define the extreme event. We obtain a good agreement with the simulation results as well as with the observed data. We also point out some of the limitations of our result.

Archives of Extreme Events in Holocene in the Himalaya

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The Himalaya is known as a multi hazard prone regions of the world. Most of its landscapes are either the result or largely influenced by either extreme climatic events or tectonic pulses or the combination of both. These events have been the destiny of this loftiest and youngest mountain system of the world throughout its geological past, though the size and extend may be varied at time to time. Efforts are being made the reconstruct the dimension and timing of these events.

It is found that in most of the parts of the Himalaya, the traditional tools are not much effective to record the extreme events of past. Present paper is an attempt to describes some convincing tools to find the imprints of these events. The paper also deals that why these tools are effective in reconstructing the past extreme events.

Study of Coseismic Ground Deformation Due to Recent Earthquakes & Crustal Deformation Measurements on Active Faults In and Around India Using SAR Interferometry

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The technique of SAR Interferometry (InSAR) has been used to study recent earthquakes and active faults in and around the Indian tectonic plate. Our InSAR data for the 1999 Chamoli, 1993 Latur earthquakes are the only geodetic measurements for these earthquakes. InSAR studies of two active faults, viz the Chaman Fault and the Salt Ranges were taken up as both the regions exhibit very low levels of seismicity. InSAR study of the Chaman Fault, on the western margin of the Indian plate, revealed a slow earthquake. In the Salt Range region, InSAR study revealed seismic rupture of the décollement beneath the Kohat plateau. These results will be presented emphasizing their importance for Seismic Hazard studies in and around India.

Multifractal Extreme Value Theory (MEV)

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The classical Extreme Value theory is an extremely convenient mathematical framework that is widely used in all scientific domains, e.g. from theoretical physics to engineering applications. Indeed, the resulting and ubiquitous Generalized Extreme Value distribution (GEV) is often considered as the universal probability distribution of time-series extrema. However, it suffers from strong limitations: it cannot be extended to long range time-series or processes and becomes a bit weird for non uni-dimensional fields.

We first argue that the multifractal framework is rather generic to study the extremes of long range and /or higher dimensional fields and leads in a rather straightforward manner to an alternative extreme value theory. The already available applications to geophysical fields, in particular rainfall and river discharges, are amply discussed.

Continuous Time Random Maxima: Stochastic Models for Estimating Recurrence of Extreme Events in Time Series With Long Range Correlations

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Power-law interarrivals can be the source of long-range correlations found in Earth,

atmospheric, and geospace time series. Long term evolution of these time series have been modeled using continuous time random walks (CTRW) and fractional kinetic equations that govern CTRW scaling limits. However, these models can not quantify the recurrence of extreme events that result in high cost or physical risk to humans.
Continuous time random maxima (CTRM) are similar to CTRW but track event maxima instead of sums. Their solutions are probability densities governing the size of the largest event over time and can be used to calculate recurrence intervals. CTRM generalize classical extreme value models through accommodation of non-Poissonian interarrivals such as power-laws. Densities that are limiting solutions to CTRM with random power law waiting times can be obtained via subordination of classical EV densities (Gumbel, Frechet). CTRM can also be designed to predict recurrence of extremes when event magnitude is dependent on interarrival length.

Modeling to Assess Tsunami Effects on the Indian Coasts from Earthquakes Along Makran and Andaman-Sumatra Subduction Zones

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East coast of India is affected by tsunami generated along Andaman-Sumatra subduction zone and west coast from Makran subduction zone. Modeling of tsunami amplitude, travel time and run-up have been made for the Indian coasts from both the sources using Tunami N2. The bathymetry data is taken from ETOPO-2 and near shore data from C-MAP. For tsunami run-up the land topography data was collected using SRTM data.

Makran, Fault strike 270°: The fault parameters of the earthquakes for the generation of tsunami are: fault area (200km length and 100km width), angle of strike, dip and slip (270°, 15° and 90°), focal-depth (10 km), magnitude (8.0). From the source in central part of Makran the amplitude of tsunami near the source is 6m and Gujarat coast is 4.5m or less (Jakhau 4.5 m, Porbandar 4.0 m and Dwarka 3.0 m). In Gulf of Kutch tsunami reaches in 3 hr with 1m run up. The simulation of model results show that the tsunami wave propagated initially very fast in Arabian Sea and it slowed down when it reached shallow region of Gujarat coast. The tsunami waves reach the Indian coast in 2hr that is in good agreement with the 1945 tsunami travel times given by Pendse (1948). At Dwarka, positive tsunami waves arrive within approximately 2 hours and 10 minutes and to Mandvi after 3 hours 10 minutes. If the tsunami strikes during high tide, we should expect more serious hazards which impacts local coastal communities.

Makran, Fault strike 250° and other parameters as above: Directivity is found to be directed towards India. If the source is considered along the western part of Makran the travel time increases.

Andaman-Sumatra, 1300km fault divided into five segments: Each segment is assumed to have different fault parameters. The northern three segments are found to be contributing to the tsunami amplitude affecting east coast of India. The combined effect of all the segments is also estimated. This estimate gives 7-8 m run up at Nagapatanam (which matches well with the observation than 5 m estimated by other workers considering only one fault in their model.

Characteristics of Auroral Electrojets During Intense Geomagnetic Activities

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Variations in auroral electrojet indices, AU and AL during the intense geomagnetic storms, representing the maximum current density of the eastward and westward auroral electrojets, respectively, have been investigated in conjunction with interplanetary conditions. It is found that sometimes during the main phase of intense storms the AU index comes close to zero or even becomes negative in some cases. This gives an impression that the eastward

auroral electrojet disappears for sometime during intense storms and the whole auroral oval is dominated by westward electrojet only. Movement of eastward electrojet towards the equator could lead to such phenomena as auroral stations are under the sole influence of westward electrojet. Few intense cases have been looked into by examining magnetic data from chain of stations so that such movement could be tracked. The similarities and dissimilarities between normal and intense events, defined in terms of Dst index, have been brought out.

Site-Dependent Attenuation Study for Peninsular Shield of India

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The knowledge of regional values of attenuation factor Coda Qc and its spatial variation attracts considerable interest in relation to tectonics and seismicity, being an important subject in seismic risk analysis and engineering seismology. For the present study Qc estimates have been obtained by analyzing coda waves of ~ 400 local earthquakes in the Indian Peninsular shield to find whether the distinct geologic provinces of Indian shield region with differential heat variation show any disparate attenuation characteristics. The earthquakes have their epicentral distances within 250 km with 2.5_ M _ 4.0. The investigation sites include four from the Archaean Dharwar craton, one from the Proterozoic Cuddapah basin of southern India, one from Eastern Ghat, lower Gondwana belt, three from the southern part of the Cretaceous-Eocen Deeccan Volcanic Province (DVP) of central India and one site from recent Cenozoic era. Qc estimation is done at different central frequencies with variation of lapse time starting at double the travel time of the S-wave. The result indicates the level of crustal heterogeneities to varying degrees.

Recent Extreme Wet and Dry Spells Across India

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For the analysis of wet and dry spells the country has been divided into 19 subregions by considering spatial annual rainfall distribution, physiography, drainage and onset and withdrawal of the summer monsoon. Daily rainfall of 1˚ grid cells over the country for the period 1951-2007 is used in the study. The wet (dry) spell has been identified by applying an objective criterion 'a continuous period with daily rainfall equal to or greater than (less than) daily mean monsoon rainfall (DMMR) over the area of interest'. Variability of rainfall amount, rainfall intensity, duration and starting date of extreme wet (dry) spells in respect of (i.r.o.) of rainfall amount, rainfall intensity and duration is reported. In total, characteristics of 24 parameters of the extreme wet and dry spells have been studied.

EXTREME WET SPELL IN RESPECT OF RAINFALL AMOUNT - Duration of extreme WSs in this category is longer (22-30 days) over the south peninsula and West Coast and shorter (13-21 days) elsewhere; rainfall amount higher (590-1051mm) along the West Coast followed by 361-367mm over WCI, ECI and NEI and lower (154-338mm) elsewhere; and rainfall intensity greater (32-40mm/day) along the West Coast followed by 17-20mm/day over east/northeast India and weaker (11-16mm/day) elsewhere. In general, the duration of extreme WSs is 2.16 times longer than that of the actual WS (SDAI = 8.7 days), rainfall amount 2.34 times (SDAI = 173.2mm) and rainfall intensity 1.12 times (SDAI = 4mm/day). The spell occurs over parts of WC, northeast and

extreme north during the month of June, over most parts during July and over the southeastern peninsula, moving from North to South, during August, September and October. The SDAI is about 27.3 days which suggests that extreme WS can occur anywhere during the period of rainfall activities. The heaviest amongst subregional extremes occurred over the SCWC (SR3) which started on 24 June 1961, continued for 42 days and produced rainfall of 2080.2mm at the rate of 49.5mm/day. The year 1961 was the wettest recorded since 1813.

EXTREME WET SPELL IN RESPECT OF RAINFALL INTENSITY - Duration of such extreme WS is longer (15-23 days) over the south peninsula and West Coast and shorter (6-12 days) elsewhere; rainfall amount is higher (504-520mm) along the West Coast and 259-292mm over ESEP and WCI and lower (87-205mm) elsewhere; and rainfall intensity greater (35-43mm/day) over the West Coast followed by 20-25mm/day over east/northeast India and weaker (12-19mm/day) elsewhere. Broadly, duration of the extreme WS is 1.33 times (SDAI =8.5 days), rainfall amount 1.65 times (SDAI =185.6mm) and rainfall intensity 1.27 times (SDAI = 4.1mm/day) than that of the actual WS. Rainfall amount and rainfall intensity is higher over high (annual) rainfall areas and lower over low rainfall areas. Duration, however, shows a typical spatial pattern- it increases from north/northeast to south/southeast. The extreme WS can start around 10 July along WC, 30 July over the northwest, 10 August over the east/northeast and 30 September-15 October over the southeast peninsula. The SDAI is about 48.3 days which suggests occurrence of extreme WS anywhere between the first and last WSs, inclusive. The most intense extreme wet spell occurred over NWC (SR-8) starting on 20 June 2005 with rainfall amount of 1042.2 mm, rainfall intensity of 61.3mm/day and duration of 17 days.

EXTREME WET SPELL IN RESPECT OF DURATION - Duration is longer (23-31 days) along the West Coast and over the central peninsula and shorter (14-22 days) elsewhere; rainfall amount was higher (576-1046mm) along the West Coast followed by 341-366 mm over central and northeast India and lower 145-314mm elsewhere; and rainfall intensity 30-39mm/day over the West Coast and 9-19mm/day over other places. The average duration for the whole country is 2.23 times (SDAI =8.4 days), rainfall amount 2.28 times (SDAI =176.6mm) and rainfall intensity 1.04 times (SDAI =3.4mm/day) than that of the actual WS. The duration increases from northwest to extreme southeast peninsula, however, rainfall amount and rainfall intensity is higher over highlands and low over plains. It starts around 30 June along the West Coast and northeast, during July over areas north of 18˚N, mid-August over the central peninsula (SRs 6 and 7) and 10-25 September over the southeast peninsula. The SDAI is about 24.7 days suggesting occurrence of extreme WS anywhere during the period of seasonal rainfall activities. The longest wet spell on record occurred over SR2 starting on 28 June 2005 with duration of 91 days, rainfall amount of 1645.2 mm and rainfall intensity of 18.1mm/day. In general, the different extreme wet spells are lengthier (2.16 times), wetter (2.09 times) and more intense (1.14 times) than the actual.

EXTREME DRY SPELL IN RESPECT OF RAINFALL AMOUNT - Duration is 11-16 days over northern India and 4-7 days over all other subregions; rainfall amount 24-49mm over the West Coast, 1-7mm over the southern peninsula and 9-17mm elsewhere; and rainfall intensity near-zero (0.4-2mm/day) over hot, dry regions of the northwest and southern peninsula, 6-11mm/day along the West Coast and 3-4mm/day over other places. Broadly, the duration of extreme DSs is shorter (0.42 times) than the actual DS; the rainfall amount lower (0.34 times) and the rainfall intensity slight weaker (0.96 times). Such extreme DS occurs during July over western India (SRs 1, 3, 5, 8, 11 and 15) and northeastern parts, during August over central and eastern parts, and during 8-11 September over the southeastern peninsula (SRs 2 and 4). The most extreme DS of nil rainfall occurred over dry regions of ESEP during 24-25 December 1965, SCP on 13 September 1960 and NNWI on 31 July 1983.

EXTREME DRY SPELL IN RESPECT OF RAINFALL INTENSITY - Duration of extreme DSs is shortest (10 days) over CIGP (SR17) and it increases in all directions: 37 days over ENI, 26 days over NNWI, 23 days over SCWC and 13 days over ESEP; rainfall amount is 7mm over NNWI, 3-9mm over SCP and SEP, 72-154 mm along the West Coast and 18-51mm elsewhere; and rainfall intensity near-zero (< 2mm/day) over NNWI, SCP, CEC, CSEP and ESEP, 3-8mm/day along WC and 2-3mm/day elsewhere. For the country as a whole, the duration of extreme DS is 1.28 times than that of actual DS; rainfall amount 0.87 times and rainfall intensity 0.64 times. Such extreme DS occurs around 18 June over ENI (SR19), during July along the West Coast and SNWI

(SRs 1, 3, 5 and 11), CIGP (SR17) and NEI (SR18), during August over almost the entire area of central India and ESEP (SR2) and around 21 September over CSEP (SR4). The most extreme DS with the lowest rainfall intensity (0.0mm/day) occurred over ESEP during 24-25 December 1965 and over NNWI on 31 July 1983.

EXTREME DRY SPELL IN RESPECT OF DURATION - Duration is shortest (24 days) over CIGP and ECI and it increases to 32 days over NEI, 36 days over NNWI, 50 days over ENI and 58 days over ESEP; rainfall amount is lowest (13mm) over NNWI and it increases to 220mm along the West Coast, 89mm over NEC, 150mm over ENI and 78mm over ENI; and rainfall intensity near-zero (<2mm/day) over NNWI and the southeast peninsula, 5-9mm/day along the West Coast and 2-5mm/day elsewhere. Broadly, the duration of extreme DSs is 1.28 times the duration of an actual DS, rainfall amount 1.93 times and rainfall intensity 0.89 times. It occurs around 15 May over ESEP (SR2), during June over CSEP (SR4) and ENI (SR19) and during July-August over remaining areas. The most extreme dry spell occurred over NNWI (SR15) starting from 8 July 1980; duration was 168 days, rainfall amount 56.3 mm and rainfall intensity 0.3mm/day. In recent years/decades, persistent positive/negative tendencies spread over 11 or more subregions are seen in some of the parameters. Notable among them are a decreasing tendency in duration and an increasing tendency in rainfall intensity of actual and extreme WSs, and an increasing tendency in duration and a decreasing tendency in rainfall intensity of actual and extreme DSs. These changes in rainfall time distribution appear to be related to changes in frequency, duration and intensity of rain producing weather systems. Over the country, the number and duration of low pressure areas (LPA; central pressure difference of 2mb from surrounding and surface wind speed <17 knots) show an increasing trend since 1961 at the rate of 1.4/10-year and 8.1 days/10-year respectively, and the number and duration of depressions/storms (DDS; central pressure difference >2mb from surrounding and surface wind speed >17knots) shows a significant decreasing trend at the rate of 1.5/10-year and 6 days/10- year respectively. Further it appears there is some change in middle tropospheric (850-500 hPa) circulations (trough, convergence zone and cyclonic circulations) due to a warmer environment. In random occurrences, if surface and middle tropospheric circulations were coherent (both lower and upper troposphere warmer) shorter, intense WSs occurred otherwise (lower and/or upper troposphere cooler) longer, severe DSs occurred.

Extremely Long Duration Total Solar Eclipse on 22 July, 2009: Effect on D-region Ionosphere Dynamics as Studied from VLF Signals Observations

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An extremely long total eclipse of the Sun, greatest during the century happened to be observed on 22 July, 2009 from the narrow corridor on the Earths eastern hemisphere. The Moons umbral shadow began on western coast of India then moved through middle India, Nepal, Bhutan, China and after crossing mainland ended in Pacific Ocean. Solar eclipses are the rare events to observe and understand its effect on Earths geo-sphere for scientific community. As obvious, blocking of solar radiation during eclipse decrease the level of ionization and thus affects dynamical processes in different layers of the ionosphere. But it is the D-region of the ionosphere which experiences drastic changes during eclipse. It is affected most because the principle sources of its ionization, the Lyman alpha line of solar spectrum (121.5 nm), EUV radiation (80-111.8 nm) and X-ray (0.2-0.8 nm) are blocked for the duration of eclipse. Naturally occurring ELF/VLF broadband (03-30 kHz) and man-made VLF transmitter signals provides one of the best tool for continuous monitoring of D-region ionosphere. VLF waves travel long distances in Earth-ionosphere waveguide due to multiple reflections without any appreciable attenuation. A special campaign for the observation of VLF signals was carried out at

the three locations of Allahabad, Varanasi and Nainital in India. Two sites are located in the totality path and one out of the totality, suitable to study the D-region dynamics in and out of the totality region. Apart from broadband signals, amplitude and phase of the fixed frequency VLF transmitter signals were monitored. The signals monitored were JJI at 22.2 kHz, transmitting from Japan and NWC at 19.8 kHz from Australia. The path of JJI signals to sites in India is parallel to the movement of totality, whereas the NWC signal path is intersecting the totality path. The observation of JJI signal at Bushan, South Korea is also used in present study. The data analysis has revealed significant increase/decrease in amplitude and phase of the signal, signifying major change in the behavior of the D-region ionosphere. Lower boundary of the ionosphere, the D-region is pushed up by ~6-8 km during different phases of eclipse and decrease in electron density is also observed. Detailed results will be discussed during the conference.

Electrostatic Solitary Waves in Non-Thermal Plasmas

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Interaction of solar wind with the Earth's magnetic field leads to the formation of the magnetosphere which has several boundary layers like magnetopause, plasmas sheet boundary layer and auroral zone etc. These boundary layers play important role in the distribution of energy extracted from solar wind to various regions of the magnetosphere. The free energy available in the boundary layers in the form of gradients and currents can drive several plasma waves at different scale lengths. Thus, the boundary layer offers an opportunity to study the physics of the variable scale plasma processes. Broadband plasma waves, having wide range of frequencies from lower hybrid to electron plasma frequency and above, have been observed by many satellites on the auroral and cusp field lines. The amplitude of the electric field of these waves can be from a few tens to hundreds of mV/m. Higher electric amplitude suggests importance ofnonlinear phenomena in Earth's magnetosphere. Electrostatic solitary waves (ESWs) have been observed by many satellites in various regions of the Earth's magnetosphere. These ESWs are found to be having bothpositive as well as negative potentials. Eare studied in a four-component unmagnetized plasma consisting of by using the Sagdeev pseudo-potential method. The amplitude, velocity and width associated with the electron-acoustic solitary waves are numerically obtained. ResultsEarth's magnetosphere.

Application of Doppler Wind Lidar Observations to Improve Scientific Understanding and Forecasting of Extreme Weather Events

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For nearly 30 years, the atmospheric research community has been aware that pulsed laser-based Doppler wind lidars (DWL) promised new insights to the evolution of severe weather such as tropical cyclones, tornadic storms and mesoscale convective complexes. Although there have been a few airborne pulsed DWL field campaigns in this period, advances in the lidar technology and investment in its utility for atmospheric studies is now accelerating, being targeted at not only basic research but also operational meteorology and a future space-based mission. Recent (2008) experiments in the western Pacific involved two airborne pulsed DWL systems in a focused investigation of typhoon genesis and intensification. Results from that effort are now going into the design of an ambitious program of hurricane research using airborne lidars on such platforms as NOAA's P3, NASA's DC8 and Global Hawk and the Navy's P3 and Twin Otter. If all goes as planned, within the next 5 years there will be more than 1000 flight hours of pulsed DWL equipped aircraft collecting data that has the potential to transform the way in which we monitor and predict the lifecycles of severe storms.

NASA Langley Research Center has a long history of developing 2-micron laser transmitter for wind sensing. With support from NASA Laser Risk Reduction Program (LRRP) and Instrument Incubator Program (IIP), NASA Langley Research Center has developed a state-of-the-art compact lidar transceiver for a pulsed coherent Doppler lidar system for wind measurement.

Recently, LaRC 2-micron coherent Doppler wind lidar system was selected to contribute to the NASA Science Mission Directorate (SMD) Earth Science Division (ESD) hurricane field experiment in 2010 titled Genesis and Rapid Intensification Processes (GRIP). The Doppler lidar system will measure vertical profiles of horizontal vector winds from the DC-8 aircraft using an existing 2-micron, pulsed, coherent detection, Doppler wind lidar system that is ready for DC-8 integration. The measurements will typically extend from the DC-8 to the earth's surface. They will be highly accurate in both wind magnitude and direction. Displays of the data will be provided in real time on the DC-8. The pulsed Doppler wind lidar is much more powerful than past Doppler lidars. The operating range, accuracy, range resolution, and time resolution will be unprecedented. We expect the data to play a key role, combined with the other sensors, in improving understanding and predictive algorithms for hurricane strength and track.

Inversion of 2-D Resistivity Data Using Rapid Optimization and Minimal Complexity Neural Network

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The steepest descent method of optimization algorithm, backpropagation (BP) is well known for poor performance and unfortunately a proof of global convergence for an algorithm does not ensure that it is an efficient method. The inappropriateness of BP for Artificial Neural Network (ANN) training is the subject of considerable research activity. Well-established optimization methods, as well as novel algorithms, frequently used Radial basis and Levenberg–Marquardt (LMA) algorithms appear in the neural network literature. Our own work has addressed the suitability of fast inversion technique LMA of the interpretation of data resistivity surveys, simulated annealing algorithms for computational neural network training. Improvements in the computational ANN modeling process are described with the goals of enhancing the optimization process and reducing ANN model complexity. Improvements to the optimization process not only speed computation also can enhance the quality of the result. Complex ANN model require more intensive optimization procedures and are considerably more difficult to interpret. The efficiency of trained LMA and Radial basis (RB) network by results is applied and tested on synthetic 2-d resistivity data and finally applied to actual field vertical electrical resistivity sounding (VES) data collected from the Puga Valley, Jammu and Kashmir, India. This ANN reconstruction resistivity results are compared with the result of conventional inversion approach, which are in good agreement. The depths and resistivity structures obtained by the ANN methods correlate extremely well with the known drilling results and geologic boundaries.

Identification of Seismicity Pattern for Some Destructive Earthquakes

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Earthquake occurrence pattern studies are carried out globally in order to make proper hazard estimate in a region spatially as well as temporarily. Scores of studies has contributed substantially but not robustly for the hazard estimate of a region. Here an attempt has been made to understand the spatio-temporal scaling of intermediate earthquakes prior to some of the strong earthquakes. The August 17, 1999 Izmit earthquake of 7.8Ms, November 3, 2002, Dennali earthquake of 8.5Ms, December 26, 2004 Great Sumatra of 9Mw, October 8, 2005 Muzafarabad Earthquake and May 12, 2008 Sichuan Earthquake of 7.9Mb are some of the destructive earthquake studied with the help of spatial correlation fractal dimension (Dc) variation with time for the intermediate earthquake distribution. The scaling of intermediate earthquakes prior to the strong earthquakes shows that they are highly clustered which is indicated by low Dc. Identification of low Dc value for the clustering of intermediate earthquake from well constrained catalogue may be used as an indicator of strong earthquake of a seismically active region. Hazard map developed with this spatio-temporal pattern input for the active seismicity region will be more appealing for the purpose of disaster mitigation and management.

The Complex Nonlinear Process of Equatorial Spread F: How Far Are We From Operational Predictability?

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The post sunset phenomenon of Equatorial spread F is one of the most complex equatorial ionospheric processes that had been posing a challenge through its various manifestations. Though the gross features are fairly well understood this being an outcome of mutually interacting neutral atmospheric and ionospheric processes, its day to day variability had been a real challenge. Some of the recent results from systematic investigations have revealed that, one could circumvent the problem and even be able to make reasonable prediction of the phenomenon well ahead of its actual occurrence. The role of the background ionospheric and thermospheric conditions and also the possible role of initial perturbations, the intensity and the duration of the phenomenon all being crucial for operational forecast would be highlighted with an aim to show how far we are from real operational forecasting.

Estimation of the Ground Motion and Site Effects of Indo-Gangetic Plains

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We have operated 10 broad band seismological stations in the Indo Gangetic plains and the Bundelkhand craton with the objective to quantify the ground motion due to earthquake sources are mainly from Himalaya. The site effect has been estimated by analyzing earthquakes which have been located near Khursali, Pithoragarh and Delhi of which the first two are from the Himalayan collision front. The magnitudes of all these earthquakes are around 4.7. The acceleration spectra for Khursali and Pithoragarh have been estimated at various locations in the Indo Gangetic plains vis a vis stations located in Bundelkhand craton and Uttaranchal Himalaya. The response spectra estimates clearly show the stations on the soft sediments have been modified and amplified in correspondence to the stations located on the hard rock. Using Random vibration theory we simulated the ground motion for an earthquake of 7.5 magnitude at Pitoragarh and found that the Peak ground acceleration in the soft sediments is three times larger in comparison to the stations located on hard rock.

Seismological Constraints for Great Kangra Earthquake of 1905 and Associated Hazard in NW India

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The great Kangra earthquake of 1905, occurred when seismological instrumentation with low gain optical recording seismograph were very sparsely located. However, attempts are made in recent time not only to refine the epicentral data but even to postulate new earthquake (Hough et al 2005) to explain secondary meizoseismal area near Dehradun. Careful re-examination of their analysis has brought out that the postulated earthquake near Dehradun was misleading interpretation. The seismological data given by them fits better with the large aftershock of great Kangra earthquake which occurred within a few minutes The meizoseismal area near Dehradun was a indeed a site response effect similar to that of Bihar Nepal, 1934, Bhuj 2001, Mexico (1985) and other earthquakes as was inferred earlier by most of the scientists. It has also been highlighted that for earthquake hazard assessment, the role of secondary meizoseismal areas should not be ignored. Also, the places which were already affected by earthquakes of magnitude ≥ 8, should be prioritized from earthquake hazard and disaster management point of view.

Geomorphic Evolution of Himalaya and Its Foreland: The Last 60 ka Perspective

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The past glacial events are the driving forces behind the geomorphic evolution of the Earth. North Indian Subcontinent is being drained by several major rivers that originate from glaciated zones of Himalaya. A study in Spiti, Ganga and Brahmaputra river systems indicate that although the glaciation was the major source of sediment generation but it the shorter phase of climatic transition (e.g. 18-11 ka) from drier to wetter that was responsible for huge sediment supply and floodplain aggradations in the Himalayan foreland and Delta. Separate studies from the deltaic zones suggest 4-9 times increased sedimentation rates during the climatic transitions. Spiti River in the arider Himalaya experienced increased landslide activity and related river damming. Humid Ganga river valley, both in its mountainous and foreland segments, experienced extensive wide aggradation. The chronology of the sediments in Himalayan river valleys indicates two pulses of sedimentation being surged into the valley as a result of deglaciation of and. The two-phased deglaciation from ~63-18 ka (MIS-3 and MIS-2), supplied pulses of higher sediment loads and massive valley aggradation in NW Himalayan. The ~40 luminescence ages represent aggradation in the Ganga valley was centered ~40-25 ka and 18-11 ka. The Spiti River showed deviation conforming to present day rainfall conditions. The wetter conditions (~11-6 ka) of the early Holocene led to increased stream power and river incision. Although, the catchment in the Ganga plain responded asynchronously with their Himalayan counterparts and incised after 7 ka. Similar results are obtained from Nepal, Sikkim and NE Himalaya. The study indicates that evolution of landscape takes place in pulses where the climatic events like glaciation and deglaciation play important role.

Could the Magnitude of an Earthquake be Bounded From Above?

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It is suggested that the formation of microfractures in the course of theprogressive damage of the earth system that leads to a critical failure and eventually results into an earthquake could follow a fractal pattern. This is combined with ideas from 'self-organized-criticality' to study if there is a maximum scale, or upper fractal limit, at which the rupture reaches the size of the entire system and thus imposes a limit, or a cut-off, on the maximum magnitude of which an earthquake can occur.

Mantle Plumes, Their Depth of Origin Within the Mantle and Excess Temperatures

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Mantle plumes are classified as one of the extreme candidates that can leave large-scale imprints on the global biogeosphere. Some of the contentious issues that need detailed examination and understanding are detectibility, strength and depth of origin etc. of the mantle plumes. Innovative techniques are already on way to address these issues (Montelli et al., 2004, Science, v. 303, p. 338; Putirka, 2008, Geology v. 36, p. 283). In this study we develop an alternative approach and attempt to resolve these issues of importance through integration of our geophysical results with isotope geochemical data, mineral-melt equilibria results and those from mineral physics. Using P-to-S converted seismic waves from the 410-km and 660-km depth discontinuities, we investigate disposition of these boundaries beneath 12 prominent oceanic hotspot regions distributed on the globe. The thickness of the mantle transition zone (MTZ), measured from P660s-P410s differential times (tMTZ), is determined. Our analyses reveal that the MTZ thickness beneath hotspots studied by us varies between 210 km and 250 km. The MTZ thickness follows a power law relation with the strength of the plume, measured as their

buoyancy flux, B. The shrinkage of the MTZ beneath hotspots yields the following order: Hawaii > Kerguelen > Pitcairn > Galapagos > Samoa > Iceland > Canary. Hoggar, St. Helena, Easter and Afar are characterized by marginally low MTZ thickness compared to the global average of ~ 250 km, possibly because of a lower heat budget associated with these hotspots or because of their relatively small size or both. It is also possible that the observed MTZ response for these four hotspots relates to the waning stage of hotspot activity, well past their energetic phase. Two plume-ridge interaction affected hotspots such as Afar and Azores yield near-normal MTZ thickness of ~250 km.

Excursions induced to the MTZ thickness are used to estimate the excess temperatures beneath each hotspot location using the concept of effective seismological Clapeyron slope [Bina & Helffrich, 1994, JGR v.99, p.15, 853]. The insight obtained from our results concerning the depth character of the studied plumes, their excess temperatures and the relationship they exhibit with the available U-series disequilibria measured in hotspot lavas (Bourdon et al., 2006, Nature, v. 444, p. 713) are discussed. Finally, hotspots are indeed geophysically detectable and associated with an excess temperature of 200-300 degrees. Many Pacific Ocean hotspots seem to have their origin in the transition zone or deeper.

Spectral Characterization of Soil and Coal Contamination on Snow Reflectance Using Hyperspectral Analysis

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Snow is highly reflecting object found naturally on the Earth and its albedo is highly influenced by the amount and type of contamination. In present study, two major types of contaminants (soil and coal) have been used to understand the effects on snow reflectance in Himalayan region. These contaminants were used in two categories quantitatively - addition in large quantity and addition in small quantity. Snow reflectance data were collected between 350-2500 nm spectral ranges and binned at 10 nm interval by averaging. The experiment was designed to gather the field information in controlled conditions and radiometric observations were collected. First derivative, band absorption depth, asymmetry, correlation coefficient and percentage change in reflectance in optical region were selected to identify and discriminate the type of contamination. The band absorption depth has shown initially increasing pattern for small amount of concentration but for large amount of concentration, a decrease in band depth could observed at 1025nm. The absorption peak was left asymmetric in nature and not significant difference was found for the width of absorption feature at 1025 nm. The percentage change in reflectance was quite high for small amount of coal contamination rather than soil contamination, however, a shift of peak was observed in soil contaminated snow which was not present in coal contamination. The albedo significantly drops due to coal contamination rather than soil contamination. This will provide an important input to understand the effect of contamination on snow and glacier studies due to changed atmospheric conditions.

Fractal and Multifractal Characteristics of Time Series in Seismogenic Regions of 1897 Assam, 1905 Kangra and 1934 Bihar Great Earthquakes

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Recent advances in seismology and rock physics are very useful in understanding the available empirical laws in seismology. Such laws are interpreted from a fractal perspective, and earthquakes are viewed as a self organized critical phenomenon (SOC). Earthquakes occur as an energy dissipation process in earth's crust to which tectonic energy provides continuous input. As the crust gets self-organized into critical state, the temporal and spatial fractal structure emerges naturally.Power laws relations known in seismology may be considered as the expression of critical state of the earth's crust. SOC model for earthquakes are able to

explain the Gutenberg-Richter in size, the Omri's law of aftershocks in time, the hypocentral distribution in space. Most fractal systems in nature are hetrogeneous. For such fractals, a unique fractal dimension is insufficient to characterize them and same differs depending upon the method used to estimate it. Fractals and multifractal characteristics are studied using seismicity data from USGS catalogue in various seismogenic regions i.e.1897 Assam, 1905 Kangra and 1934 Bihar great earthquakes in Himalaya.

The correspondence between fractal dimension and other seismotectonic parameters are also studied in the region for understanding the implications in seismic hazard and risk mitigation.

Rodinia Supercontinent, Snowball Earth and Extreme Global Paleoclimate Change: Evidences From the Lesser Himalaya and Marwar Supergroup , India

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The Rodinia Supercontinent existed during Meso- Neoproterozoic and its breakup and reassembly as Gondwana Supercontinent is now well established in the Proterozoic earth history.The Rodinia breakup resulted in the rifting around 650 Ma and rift basins and passive margins were formed. Neoproterozoic glacial events recorded globally , now better known as snowball earth have strong evidences from the Lesser Himalayan glacial diamictite deposits known as Blaini Diamictites with pink cap carbonates in the north India and Pokharan Boulder beds in the Marwar Supergroup, western Rajasthan.The global distribution of Neoproterozoic diamictites and cap carbonate occurrences in the low paleolatitudes inferred from paleomagnetic data and carbon isotopic excursions have been discussed in the present paper. The reconstruction of Rodinia Supercontinent and the paleoposition of India (Lesser Himalaya , southern China and Marwar basins) strongly suggest that they were very closely situated and shared the identical paleolatitude and paleoclimate. Post Rodinia breakup on earth possibly witnessed the most extreme climatic fluctuations between 750- 600 Ma.Paleoglacieres might have reached the equator around 635 Ma covering the whole earth. Carbon isotopic evidences from Australia, China, India, Oman, northern polar Europe, Canada, North America, Africa and South America suggest there are Sturtian, Marinoan and Gaskiers glacial events. General paleomagnetic reconstructions are available on breakup of Rodinia, Neoproterozoic rifting , glaciation and emergence of multicellular Ediacaran biota in the Indian Lesser Himalaya.. However , detailed rock magnetic and paleomagnetic data is still to be generated to reconstruct APW path of Indian subcontinent

Climate Catastrophe: Spectral Characteristics and Model Behavior of Abrupt Climate Changes Over Present to Millennial Time Scales

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Complex climate variability indicate role of land-ocean-atmosphere-cryosphere-biosphere coupling and possible linkages with various types of external forcing such as changes in CO2 and solar variability. These various non-linearly interacting components have different response time and spatial variations and hence produce beat frequencies, resonances and modulations cycles in the climate system. Internal rearrangements of the system dynamics make it further quite difficult to determine true equilibrium in abrupt dynamical system. Present modeling studies have often represented such complex and transient spacio-temporal structure simply as uniform which appears to have contributed to reduced model sensitivity to threshold crossing compared to the real response.

Steady state climate variability in a certain time window, however, could be characterized by significant oscillations. Modern spectral analyses of proxies of climate variability indicate some evidence of quasi-periodicities in well recognized astronomical frequency bands ranging from some couple of years to thousand of years. We analyzed here some recently published climate proxies' records using multiple methods of spectral analyses. The analyzed data include: sea surface temperature off central Japan since the last glacial minima, Indian Rainfall (IRF) time series covering the time span of 1826-1994 and the coral growth rate time series for a relatively short period from the Arabian Sea, NINO3 temperature

records to investigate the signature of ENSO response of the Indian monsoon and temperature variability record decoded from tree-rings of western Himalayas.Multi-taper spectral analysis of IRF time series resolves (reveal coherent cyclic modes of varying order.) statistically significant variability (i) at multi-decadal (66-70 year's) scales related to the well-known global temperature variability of internal atmospheric-ocean origin, (ii) relatively weak signals at 13 and 22 years (solar cycles) and (iii) the 2.5 to 7.5 year cycles associated with the ENSO frequency band. Spectra of the coral growth rate record also reveal statistically significant periodicities within 1.8-4.2 ENSO frequency band, and at 12.8 years. Wavelet spectra reveal non-stationary "localized modes" of ENSO evolution corresponding to 2-7 years and higher order terms. Although matching periodicities are present in these records, cross-spectral analysis of IRF and NINO3 temperature records exhibits significant "coherency" at periods 5.4 years and 2.7 years suggesting the significant role of ENSO dynamics in organizing the subtle Indian monsoon at these frequencies.
Bimodal and hysterisis pattern observed in abrupt climate change records (e.g. in Greenland ice core and several other records) appears quite interesting, which possibly indicate "critical state" of climate variability. This observed "catastrophic jump" and delayed asymmetric patterns could be explained more precisely by using the concept of "catastrophe theory". Model response suggests that such extreme events could be induced at the time of "criticality" in the system dynamics even in the presence of slow external forcing (solar / CO2 variability) which could be further amplified by stochastic forcing.

Extreme Seismic Events and Gravity Anomalies in the Subduction Zones

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Extreme Seismic Events (ESE), i.e. mega-thrust earthquakes in the Sumatra-Andaman subduction zone are located in the relatively low gravity anomalies over forearc. The differences in the nature of gravity anomalies are originated from variations in the geometry of subduction zone, evolved over geological time period. Complex geometry and thermal property in the Sumatra-Andaman subduction zone appear to govern width of Seismogenic coupling zone and thus the lateral variation in the seismozonic behavior (Gravemeyer and Tiwari, EPSL, 2006). We further investigate the nature and sources of gravity anomalies and their association with ESE, through analyses of gravity data over Aleutian, Kamchatka and other subduction zones. Gravity anomalies, corrected for bathymetry, sediment and crustal thicknesses show a remarkable visual correlation with location of ESE. The sources of the gravity anomalies are debatable however; causal link of subduction process to gravity anomalies might suggest that gravity anomalies may be useful indicators for the long term seismic behavior in the subduction zones.

Some Characteristics of the K-T Boundary Mass Extinction Event

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Our earth is known to be an extremely dynamic system associated with complex evolutionary processes. It underwent several cycles of evolution and extinction during the course of its geologic history. In the last 250 ma, there have been about eight major mass extinction events. K-T boundary event was one of them which eliminated simultaneously a wide spectrum of animal and plant groups from the land as well as oceans, viz., dinosaurs, reptiles, invertebrate groups of planktic and benthic foraminifera, calcareous nannoplanktan and molluscs etc. In the present study, we have studied the nature of marine and non-marine extinction across the K-T boundaries which indicates that the extinction pattern have differed for different groups of animals and plants. For example, dinosaurs disappeared entirely at the end of Mesozoic era but much smaller mammals suffered only moderate losses. In the sea, ammonoids and large marine reptiles (plesiosaurs and mosasaurs) died and other groups also declined sharply. Many species of the inoceramid bivalves and ammonoids declined in diversity over most of maastrichtian age and disappeared before its end. A periodicity of 33 3 Ma has been reported in mass extinction episodes.

K-T boundary mass extinction was apparently caused by an asteroidal impact induced massive volcanism on the western margin and adjacent offshore. It was also the time when this region was uplifting due to massive melt generation underneath. These phenomena led to shallowing of the sea, alteration of seawater chemistry and ultimately biological catastrophe.

A Study on Chaotic Behaviour of Equatorial/low Latitude Ionosphere Over Indian Subcontinent, Using GPS-TEC Time Series

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The deterministic chaotic behaviour of ionosphere, over Indian subcontinent falling under equatorial/low latitude region, -0.3–22.19oN (Geomagnetic), was studied using GPS-TEC time series. The values of Lyapunov exponent are low at Thiruvananthapuram, and Agatti (-0.30 and 2.38oN, Geomagnetic, respectively), and thereafter increase through Bangalore, and Hydrabad (4.14, and 8.54oN Geomagnetic, respectively), and attain maximum at Mumbai (10.09oN Geomagnetic), which is ananomaly crest station. Correlation dimension and entropy computed for TEC time series show no appreciable latitudinal variabilites. The values of non linear prediction error exhibit a trough, around the latitude sector, 2.38-19.84oN (Geomagnetic). The observed latitudinal variabilities of chaotic behaviour of TEC over Indian sub-continent could be due to the influence of features like, equatorial electrojet, equatorial noon time bite-out, the equatorial ionization anomaly, and day-to-day variability of electron density.

Paleoseismological Study in the Nepal Himalaya – Present Status

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Based on the study of the aerial photographs and field observations, the present authors have mapped a large number of active faults in the Nepal Himalaya, and the detailed active fault maps of the entire country are in the process of publication. The active faults belong to the Main Frontal Thrust, Main Boundary Thrust, Main Central Thrust and Lesser Himalayan Active Fault systems. Himalaya represents seismically one of the most active regions on our planet. Historic records are far and few except the great earthquakes of the last two centuries. Active fault trenching began only very recently in the Himalaya, and a few successful trenching in Nepal and India have produced important results which with further works will help to build up database for the earthquake hazard assessment in this region.

The first successful trenching on an active fault that was carried out in the Himalaya in eastern Nepal on the Main Frontal Thrust, produced a result indicating the most recent surface rupture around 1200 AD with a displacement of at least 4 m (Nakata et al, 1998, Upreti et al., 2000). This observation clearly precludes the rupture to belong to the 1934 earthquake. Similar trenchings in east-central and western Nepal also demonstrate that no surface ruptures associates with the known great earthquakes of the last two centuries (1897, 1905, 1934 and 1950) seem to be present. Instead, in all these studies carried out so far in Nepal along the Himalayan Frontal Thrust (HFT), two large earthquakes with surface displacement reaching as much as ~20 m have been recognized (Lave et al., 2005, Yule, et al, 2006). They date approximately 1100 (east-central and eastern Nepal), post ~1450 AD (western Nepal, probably belonging to the known 1505 historic earthquake). These two earthquakes with such large displacements may have produced magaearthquakes exceeding magnitudes Mw 8.6, much larger than the 1934 or 1833 earthquakes of Nepal. Thus, the central Himalayan seismic gap of 1505 and the eastern Nepal seismic gap of ~1100 are now potentially dangerous and the seismic gaps are now sufficiently matured to trigger renewed rupture producing large earthquakes. This puts Nepal on a global map of very high earthquake risk zone. However, to strengthen the database for a better understanding of the seismic history and to evaluate seismic hazard in the region, a large-scale trenching activity

combined with shallow seismic survey is needed along the Himalayan front.

Key words: Active fault; Paleoseismology; Himalaya; Trenching; Earthquakes.

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Spatial and Temporal Variations of B-value and Fractal Analysis of the Earthquake Distribution from the Andaman-Sumatra Subduction Zone of the Indian Ocean

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Spatial and temporal distribution of b-value and fractal dimension which help in deciding which region is highly stressed up and which is not, have been carried out for earthquakes from the Andaman-Sumatra subduction zone. Using these values the stress levels before and after the mainshock have been deciphered. We have observed a decrease in b-value with time before the mainshock signifying that the region having enough stresses and is ready to rupture. Similarly an increase in b-value after the mainshock signifies that the region had released the accumulated stresses and has ruptured. This trend has been observed in all the blocks where we had the 26th December 2004, Sumatra earthquake of Magnitude Mw 9.3, 2005 Nias event of magnitude Mw 8.6 and the 12th September 2007 Bengkulu earthquake of magnitude Mw 8.4. Comparing the spatial and temporal variations of ‘5’ blocks it is clear that some regions are still having stresses and could be regions for significant earthquakes.

Understanding the Complex Behavior of Crustal Heat Production

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The distribution of crustal heat production, which is the most important component of all estimates of continental thermal structure, still remains a theoretical assumption. In general the heat production values must decrease with depth but the form of decrease of heat production in crust is not known in detail. The commonly used heat production models are ‘block model’, in which heat production is constant from the surface to a given depth and the ‘exponential model’, in which heat production diminishes as an exponential function of depth. The exponential model is more widely used but the sources of errors in this model are heterogeneity of rock and long wavelength changes due to changes in lithology and tectonic elements. Therefore, to derive an exponential distribution for the model of entire crust seems to be risky. Thus, to

understand the behaviour of distribution of heat production in the upper crust, heat production data of two boreholes, German Continental Deep Drilling Project(KTB) and Soultz, Germany, was analyzed. The power spectrum of both the data sets exhibit power law behaviour. Also, the covariance of heat production data of both the boreholes decreases with lag, which also indicates power law behaviour. Further, the variogram analysis of heat production data indicates the presence of nonstaionarity in the data. The semivariogram of both the data sets didn't obtain any 'sill'. This implies that the variogram is unbounded and the data is nonstationary, which needs further analysis. Moreover, the variogram can also be used as a lithology indicator. Major peaks/ trends in the semivariogram correspond to the change in major lithologies of the boreholes. In case of KTB, the variogram exhibits three trends corresponding to changes from granites to amphibolite-metagabbro and then Franconian lineament and granite. However, in case of Soultz borehole, the variogram didn't exhibit many trends because there in no major lithology change in the borehole.

Extreme Geomagnetic Storms and Low Latitude Geomagnetic and Ionospheric Response

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The manifestation and development of magnetic storm is closely related to the interaction of solar wind and magnetosphere following the reconnection processes of interplanetary magnetic field with the earth's magnetic field boundary. Perturbations associated with the changes in the earth's magnetosphere are known to have immense contribution to the structure and dynamics of the ionosphere. During extreme solar events such as big flares or/and energetic coronal mass ejections (CMEs) high energy particles are accelerated by the shocks formed in front of fast interplanetary coronal mass ejections (ICMEs). The ICMEs (and their sheaths) also give rise to large geomagnetic storms which have significant effects on the Earth's environment and human life. The present solar cycle witnessed many solar flares and CMEs which gave rise to intense geomagnetic storms due to highly active solar environment. Solar region 486 produced one of the largest solar flares of this solar cycle, an X17/4B proton flare peaking and had intense radio bursts. A very fast earth ward directed full halo CME was observed. This powerful CME produced an intense magnetic storm on 29 October. In continuation to this effect, another major storm impact was seen on 31 October, caused by a strong solar flare with magnitude X10/2b. Subsequently other CME was observed and strong southward component of interplanetary magnetic field resulted in severe magnetic storm occurred on 20th November. Varied development pattern during the storm main phase for the events which occurred during 2001 and 2003 are considered for the present study using the ground geomagnetic data with one minute resolution from low and equatorial latitudes and also multi satellite data of solar wind and interplanetary parameters. The equatorial low latitude ionospheric signatures as inferred from F region plasma parameters in Indian region will be investigated in response to intense magnetic storms and associated perturbed electric fields. This study delineates the magnetosphere-Ionosphere interaction processes evolved during the intense magnetic storms.

Extreme Events in Space Weather: Characterizing the Inherent Statistical Properties

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Space weather is driven by the solar wind and many extreme geomagnetic events such as geospace storms and substorms are potential natural hazards. The statistical studies of these vents are complicated because of the turbulent nature of their driver, the solar wind. The archived data of geospace storms and substorms for very long periods are available and are analysed using many techniques of complex science. A database of substorms consisting of more than 5 million events have been compiled for this study of the inherent statistical characteristics of extreme events in geospace. The auto-correlation and mutual-information functions are used to obtain the scaling exponents and they show the presence of long-term correlations and clustering. The scaling is represented by two exponents, the break arising due mainly to the turbulent nature of the solar wind driving the events. The auto-correlation functions show stronger long-term correlation than the

mutual information functions, which represent correlations of all orders. The return intervals for varying thresholds show long-range correlations with decreasing strength for higher thresholds, similar to the case of multifractal systems. The techniques of detrended fluctuation analysis are used to study of the long-range correlations and clustering among the geospace events.

High Frequency of Landslides in Aizawl, Mizoram, India A Case Study

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Geological investigations are being carried out in the area around Aizawl (Latitude 23° 43' N- 23° 73'N and longitudes 92° 43' E-92° 71' E), the capital of State of Mizoram, India. The aim of the present work is an attempt to assess the status of slope sustainability and instability in the very region.

Mizoram, being one of the most landslide prone zones of India, has always suffered extensive damage to life and property. To evaluate the causes of these landslides, a case study of Aizawl Township is presented herewith.

The landslides in this region are mostly controlled by the natural elements such as Climate (very heavy rainfall), physiography, topography and geology .The human activities are adding further to the problem.
The township is situated on the acute N-S trending hills. These hills are a part of Mizoram-Naga Hills. Geologically, Mizoram is a part of Tripura - Mizoram mio-geosyncline which constitute a part of the Assam - Arakan geosynclinals basin. The Mizoram Hills (Lushai Hills) have been considered to be forming an integral part of the mobile belt (Indo-Mynmar Arc). Owing to these facts, the whole region is placed in **Zone-V,** of the Landslide Hazard Zonation Map of India.
The regional geology predominantly consists of sandstone and shale of Bhuban Formation of Surma Group (Late Oligocene-Early Miocene). Most of the shales are highly weathered and friable. The massive sandstone beds are extensively jointed and fractured, rendering a blocky nature to these rocks. Moreover these rocks are highly prone to weathering and erosion.

The slope map of India reveals the fact that nearly 70% of the area of Mizoram has very steep slope (more than 600mts/kilometers)and the rest comes under steep slopes (300-600 meters/kilometer).The average slope in the Bhuban rocks in the Aizawl Township is 45^{o} and at most places nearly 60^{o}. Moreover, heavy rainfall (+ 200 cm) and cloudbursts lead to the weakening of slope material at the shale –sandstone contacts, causes excessive load on the slope material. As a result, the larger rock masses slide down to create greater havocs like substantial mud flows and landslides
All these aggravating factors combined, put the Aizawl region in Very High Frequency Region of active landslides, with a Landslide Susceptibility Index > 40.

The contribution of human activities such as “aggressive cutting of forests, burning forests (Jhoom system), extensive undermining, uncontrolled urbanization, improper sanitation and drainage etc, also aggravates the problem.

In order to reduce the frequency of landslide in the region, preventive measures must be taken on priority basis to provide stability and strength to the slope material. Some important control measures are: construction of retaining walls, concrete foundation and plantation along the slopes.

Last, but not the least, a rational approach towards the sustainable urban growth with due geological consideration in building construction, would certainly impart reduction in the frequent landslides in the region.

Investigations Into Cause of High Lightning Incidence and Accidents by it in a Region With Relatively Special Characteristics

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Investigations into cause of relatively high lightning incidence and accidents by it in

Kerala, a state in India reveals relatively special characteristics. The bounding of the state on the west by the Western Ghats and by the sea on the east results in the state having a relatively high incidence of lightning. Investigations with weather stations and a lightning detector show evidence indicating the existence of weather conditions conducive for formation of convective thunderstorms on the mountain slope. Spatial distribution data of lightning also shows the influence of the mountain range in forming convective thunderstorms. The lightning accident scenario in the state is also different. The high vegetation density of the state makes the conventional lightning rod almost ineffective in according external protection to dwellings. This is because lightning discharge gets attached to trees near the buildings. The discharge involves objects and personnel in dwellings as far as 100 m from the tree through ground conduction. The role of differing ground resistivity in ground conduction accidents and role of metal objects in the vicinity of lightning in getting involved is also discussed.

Marine Storms - Analysis, Statistics and Changes

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Storms represent the major geo-risk in marine and coastal environments – almost everywhere. They may cause significant damage both by their own wind-force but also indirectly through storm surges and ocean waves. Thus, knowledge about the statistics of marine storms and their current and possible future changes are of utmost interest not only for coastal and marine stakeholders but also for the public at large.

We consider three types of marine storms, tropical storms, extra-tropical baroclinic storms and polar lows. Because of changing observational capabilities, the observational record of the frequency of intensity of such storms is methodologically difficult; sometimes, conclusions about changing storminess are based on inhomogeneous data, due to changing local conditions, observation practices and instrumentation.

Homogenous statistics of storminess for sufficiently long times can be derived by combining two sources of knowledge, namely the “reconstruction” with regional climate models for the last six decades (during which global re-analyses are available), and the assemblage of long series of suitable proxy data. The availability of suitable regional climate models allows also the construction of consistent scenarios of possible future storm statistics.

Results for extra-tropical storms in Europe are given in some detail; first results for tropical storms in East Asia and North Atlantic polar lows are given as well.

Distributions of Extreme Bursts Above Thresholds in a Fractional Lévy Toy model of Natural Complexity.

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In 2 far-sighted contributions in the 1960s Mandelbrot showed the ubiquity of both non-Gaussian fluctuations and long-ranged temporal memory (the “Noah” and “Joseph” effects, respectively) in the natural and man-made worlds. Much subsequent work in complexity science has contributed to the physical underpinning of these effects, particularly in cases where complex interactions in a system cause a driven or random perturbation to be nonlinearly amplified in amplitude and/or spread out over a wide range of frequencies. In addition the modelling of catastrophes has begun to incorporate the insights which these approaches have offered into the likelihood of extreme and long-lived fluctuations.

In my talk I will briefly survey the research in Natural Complexity which the British Antarctic Survey mounted since 2005, in which the application of the above ideas in the earth system has been a key focus and motivation [e.g. Watkins & Freeman, Science, 2008; Edwards et al, Nature, 2007]. I will then discuss in detail a standard toy model (linear fractional stable motion) which combines the Noah and Joseph effects in a controllable way, contrasting it with the widely used continuous time random walk. I will describe how it is being used to explore the interplay of the above two effects in the distribution of bursts above thresholds [Watkins et al, PRE, 2009]; and will conclude by exploring more recent work on multifractal models [Watkins et al, PRL comment, 2009].

The Probability Distribution of Extreme Geomagnetic Events in the Auroral Zone

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Earth's magnetosphere is strongly controlled by the solar wind. The statistics of solar wind fluctuations tend to dominate the signal of magnetospheric response measurements. We have computed the probability distribution function that describes extreme changes (greater than 4σ) in the ground magnetic field at an auroral zone magnetometer station and found that the functional form, a power law, is nearly independent of the state of the solar wind and other variables such as day-of-year and local time. The primary difference in the tails of the probability distribution function during weak and strong solar wind forcing is the standard deviation. Based on this result, we conclude that differences in solar-generated conductivity, seasonal effects, strength of solar wind forcing and variability, and position of the magnetometer ground station in local time do not change the structure of the extreme-value dynamics but rather serve to amplify the intrinsic variability.

Extreme Events – Methodologies for a Rational Approach to Deal with Extreme Natural Events Under Intrinsic Uncertainty

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In general, the definition of an extreme event is context dependent. Here we refer to low probability high impact events with return periods that are outside the 'window' where standard regulatory measures apply (residual risks), and with significant societal impact (lives, property, social structures, environment, economy) that disrupt functions in a large area and cause large losses as compared to the Gross National Product (GNP) of a country. The risks (i.e. potentials for future losses) associated with these events are not only high but also very difficult to quantify, as they are characterized by high levels of uncertainty. Uncertainties may relate to frequency, time of occurrence, strength and impact of extreme events but also to the coping capacities of society in response to them. The characterization, quantification, reduction in the extent possible of the uncertainties is an inherent topic of extreme event research. However, they will not disappear, so a rational approach to extreme events must include more than reducing uncertainties. It requires us to assess and rate the irreducible uncertainties, to evaluate options for mitigation under large uncertainties, and their communication to societal sectors. Thus the primary objective of a recent research programme established in Germany is to develop methodologies that aim at a rational approach to extreme events associated with high levels of uncertainty. Addressing this objective requires (a) novel methodologies in natural and social sciences to quantify and to reduce uncertainties in data, models, and predictions; (b) the consideration of several types of disasters as the comparison of impacts is a constituent part of a rational approach; (c) interaction with social sciences for rationalizing uncertainties in the context of societal values, in communication with societal sectors with the aim of creating rational mitigation strategies.

b-value Mapping in Hindukush-Pamir Himalaya Region: Evidence of Phase Transformation of Material within Subducting Slab

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The Hindukush- Pamir Himalaya region is one of the most active orogenic regions of the world, which is located at the western syntaxis of the Himalaya created by the collision of the Indian and Eurasian plates. This region is one of the most complex and peculiar tectonic regions in the world, which has experienced several large to great earthquakes in the past. The Himalayan part of Alpide belt and its neighboring region, which include India, Pakistan, Afghanistan, Hindukush, Pamirs, Mangolia and Tien-Shan bounded by 25^0-40^0N and 65^0-85^0E, have

been considered as the study region for b-value mapping. For this purpose a homogeneous and complete seismicity database has been prepared for the period 1853 to Oct. 10, 2005 with the help of all existing earthquake catalogues and lists pertaining to the region. The prepared seismicity database is homogenized for surface wave magnitude (Ms) with the help of various empirical relationships developed among different magnitude scales (Ms, m_b and Mw). The cut-off magnitude (threshold magnitude or magnitude of completeness, Mc) for this seismicity database is estimated as Ms 4.0. However, the spatial distribution of Mc shows its variation from 4.0 to 4.8 in the whole region. The completeness periods for different magnitude ranges are also estimated and it is observed that earthquakes falling in the magnitude range of 4.0 - 4.4, 4.5 - 4.9, 5.0 - 5.4, 5.5 - 5.9, 6.0 - 6.4 and ≥ 6.5 are complete since 1965, 1960, 1955, 1920, 1915 and 1882, respectively.

The frequency-magnitude distribution in the study region has been analyzed in the terms of the distribution of *a* and *b* parameters of G-R relationship (*Log N = a – b M*). In order to map *a* and *b*-values for the study region, the most complete seismicity database for Ms ≥ 4.0 during the period 1963 to Oct. 10, 2005 has been used. The *a* and b-value has been estimated with the help of maximum likelihood method using spaced grids of 0.5^0 X 0.5^0 with 50 to 200 nearest earthquakes and considering spatial variation of Mc. The spatial variation of '*a*' value ranges from a low of 5.20 to as high as 8.51 and *b*-value ranges from a low of 0.7 to as high as 1.5. The high *a* (>7.50) and b (>1.2) values are observed in the Kashmir-Dharamsala region of Himalayan Frontal Arc, where a catastrophic earthquake has occurred on April 4, 1905 of magnitude Ms 8.6. Another high *a* and *b* values region are observed in the east and west of Pamir Himalaya. Medium *a* (6.5 – 7.5) and *b* (1.0 – 1.2) values are observed throughout the Afghanistan region, northern Pakistan region to the southwest of Hindukush, Kirthar ranges, Quetta, Kunlun and western part of Tibet region. Low *a* (< 6.5) and *b* (< 1.0) values are observed at the Caucasus, Hindukush, a large area in southeast of the Hindukush, Middle Himalayan Frontal arc with Nepal region, Sulaiman Mountain ranges and NW of it. Low *b*- value regions infer as the growing stress regime unleashing larger magnitude earthquakes while high b value indicates increased crustal heterogeneity and low stress buildup with continued stress release through numerous smaller magnitude earthquakes.

The Hindukush-Pamir region of intermediate depth seismicity shows a random distribution of low to high *b*-value showing the heterogeneous crustal structure beneath it. The *b* value varies as a function of depth in subduction zones which may indicates a phase transformation of material in subducting slab. A low *b* value is observed at the depth of 70 to 150 km and below 180 km showing the high stress regime within the subducting slab. A reasonable high *b*-value (> 1.0) is observed throughout the crust of the Indian and Eurasian plates up to depth of 70 km in which shallow depth seismicity is concentrated. A high *b* value (> 1.2) is observed at the collision zone of the Indian and Eurasian plates of about 150 km wide area up to depth of 100 km. The high *b*-value is also observed within the subducting slab of Indian plate within a depth of 150 km. This high *b*-value zone may be characterized by the region of phase transformation of material with low effective stress due to high pore pressure which results from the dehydration of the subducting slab.

Tectonic Implications and Seismicity Triggering During Mw 6.4 Baluchistan, Pakistan Earthquake Sequence of October 28-29, 2008

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A damaging and widely felt earthquake (Mw 6.4) hit the rural, mountainous region of southwestern Pakistan on October 28, 2008 at 23:09 UTC. The main shock was followed by another earthquake of similar magnitude (Mw 6.4) on the next day. The spatial distribution of aftershocks revealed a NW-SE striking rupture in accordance with the centroid moment tensor focal mechanism solution implying right-lateral strike slip motion. The occurrence of these earthquakes

suggests that strike-slip faults are present beneath the fold-and-thrust belt of Sulaiman-Kirthar ranges and they accommodate some of the relative motion of the Indian and Eurasian plates.

To assess the properties of this sequence, the statistical parameters like aftershocks temporal decay (p-value), b-value of G-R relationship and spatial fractal dimension (D-value) have been examined. The b-value equals to 1.04±0.42 suggest the tectonic origin of the sequence and crustal heterogeneity within crust. The low p-value equals to 0.89±0.07 implies slow decay of aftershocks activity which evidences low surface heat flow. A value of spatial fractal dimension equal to 2.08±0.02 indicates random spatial distribution and source is a two-dimensional plane that is being filled-up by fractures.

The static coseismic Coulomb stress changes due to the foreshock (Mw 5.3) were found to increase stress by more than 0.004 bars at the hypocenter of the main shock, thus promoting the failure. This indicates that the foreshock triggered the main shock. The coseismic Coulomb stress changes due to main shock suggest that most of the aftershocks were triggered by the main shock as most of the aftershocks lie in the region of positive coulomb stress, SE to the main shock rupture.

Operation of Multi-objective Multi-reservoir System Under Climate Change Complexities

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Optimal operation of multiple-reservoir systems is one of the important tasks in the field of complex and non-linear water resources management. In addition, more than a single objective must be considered in the planning of these systems, which adds the complexity of the model. The mathematical model of a multi-reservoirs system in Sefidrud watershed (Northern Iran) is formulated and the uncertain system parameters are assumed to be stochastic. In this study, the expected benefit-cost, recreational uses and also controlling the extreme events (flood) are the objectives of the study. The study finds appropriate releases from various reservoirs in the system in order to satisfy the multiple conflicting objectives. The main source of the uncertainty is due to the stochastic inflows, which are affected by the climate change. The stochastic simulation on the results will give robust and reliable outcomes in the uncertain conditions.

Key words: Complex Systems, Multi objective reservoir systems, Climate change.