it is also being used in particle physics and astronomy. Geology and geophysics impose their own unique requirements on software frameworks which are not generally available in existing frameworks and so there is a need for research in this area. One of the special requirements is the way Lagrangian and Eulerian codes will need to be linked in time and space within a plate tectonics context. GeoFramework has grown beyond its initial goal of linking a limited number of exiting codes together. The following codes are now being reengineered within the context of Pyre: Tecton, 3-D FE Visco-elastic code for lithospheric relaxation; CitComS, a code for spherical mantle convection; SpecFEM3D, a SEM code for global and regional seismic waves; eqsim, a FE code for dynamic earthquake rupture; SNAC, a developing 3-D coded based on the FLAC method for visco-elastoplastic deformation; SNARK, a 3-D FE-PIC method for viscoplastic deformation; and gPLATES an open source paleogeographic/plate tectonics modeling package. We will demonstrate how codes can be linked with themselves, such as a regional and global model of mantle convection and a visco-elastoplastic representation of the crust within viscous mantle flow. Finally, we will describe how http://GeoFramework.org has become a distribution site for a suite of modeling software in geophysics.

URL: http://GeoFramework.org

NG31A MCC: Level 1 Wednesday 0830h

Nonlinear Processes in Geomorphologic Organization and Natural Hazards II Posters *(joint with B, H, OS, AE)*

Presiding: **E Foufoula,** St. Anthony Falls Laboratory, University of Minnesota**; I Rodriguez-Iturbe,** Princeton University**; S F Tebbens,** University of South Florida

NG31A-0596 0830h POSTER

Dissipation, Entropy and Geomorphological structures

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A wide variety of landforms can be viewed as dissipative structures. These persistent, organized structures (including river networks, sand dunes, sorted stone circles, etc.) exploit some driving energy source, whether potential energy in the case of hydrology, kinetic energy from wind, or heat flows into and out of the ground. It is instructive to compare the mechanical work required to construct these landforms with the energy available. A natural question is whether these structures seek some extremum, such as maximum dissipation or Maximum Entropy Production. Such principles appear to be supported by theoretical considerations, as well as the empirical observation of planetary climates. Dissipative properties of river networks have been extensively explored ; it has also been suggested that sand dunes may organize to maximize the sand transport normal to the dune crest, which is equivalent to maximizing frictional dissipation.

NG31A-0597 0830h POSTER

Channel Patterns as the Result of Self-Organization Within the Flow-Sediment-Vegetation System

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The familiar patterns of braided and meandering rivers can be thought of as the result of self-organization within a "three-phase" system comprising fluid, sediment, and vegetation. Interactions between these three components are also largely responsible for the organization of river systems into separate and distinguishable channels and floodplains. Key elements of the self organization include the space and time characteristics of seed dispersal and plant growth as well as the statistics of occupation, abandonment, and reworking of the bed by the flow. Seeds are transported and dispersed readily by wind and water and opportunistically colonize areas of the channel that are abandoned or exposed at low flows. Vegetation increases bank stability through root reinforcement of the sediment and increases the threshold shear stress needed for erosion. In addition, vegetation offers resistance to the flow by increasing the drag and reducing the velocity, thus decreasing the stream power available for erosion and transport. Vegetation that is not removed while young will become stronger and increasingly resistant to erosion and removal by the flow. Thus a key organizing parameter in the flow-sediment-vegetation system is the time scale for establishment of the vegetation relative to a characteristic channel or bed mobility time. Experiments at the St. Anthony Falls Laboratory demonstrate how repeated cycling of vegetation seeding and water discharge changes an unvegetated braided channel morphology: the flow is gradually corralled into a single sinuous channel that largely tracks the thread of maximum velocity in the original braided network. The experiments are carried out in a large unconsolidated sand bed flume in which alfalfa sprouts are used to simulate riparian vegetation and offer the only form of cohesion in the system. An initial braided pattern is allowed to evolve freely in conjunction with alternating high and low discharges and repeated seedings. As the vegetation density and age increase with time, smaller and weaker channels are choked off leaving a single relatively narrow channel with a sinuous thalweg. This channel develops its own internal bar forms with smaller length scales than the original braid bars.

URL: http://www.geo.umn.edu/orgs/seds/

NG31A-0598 0830h POSTER

PHYSICAL INSIGHTS INTO THE SCALING OF AT-SITE HYDRAULIC GEOMETRY AND SCALING OF FLOOD PEAKS

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The dependencies between channel properties and river flows known for a long time as at-station hydraulic geometry (HG: power laws connecting discharge to stream geometry) have been recently shown to systematically vary with scale (contributing area), and a model based on the multiscaling framework has been proposed to statistically describe this scale-dependence (Dodov and Foufoula Georgiou, AGU Fall meeting 2002). In this paper, we attempt to provide a physical explanation for the scale-dependence of at-station HG. Namely, we postulate that it arises from the scale-dependence of river sinuosity and, thus, channel crosssectional asymmetry and we use observations and physical theories (channel stability analysis and linear theory of river meandering) to test this hypothesis. Also, physical insight to the multiscaling of flood peaks is offered. In particular, it is argued that the empirically observed break in variability of flood peaks with scale relates to the scale-dependent frequency of transition from below-bankfull to overbank flow, controlled by the systematic and interrelated variations of channel and flood plain geometries with contributing area.

NG31A-0599 0830h POSTER

Dynamic Bedrock Fluvial Channel Networks: Analytic Model and Field Evidence

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Fundamental processes in landscape evolution are the establishment and elaboration of stream channel networks. Network geometry, and in particular efficient concentration of discharge to incise channels, controls the first-order distribution of mountain range relief. This study explores the mechanisms that organize a pre-existing channel network into a series of regularly-spaced drainages that dissect a linear mountain range. The elevation of the channel network is approximated analytically using a stream power law. Channel elevations are minimized to produce an optimal channel network simulating competition between adjacent incising stream channels. Solving for the minimum range crest elevation predicts the position of the principle tributary junction point - where two tributaries join to form the main stream channel. For reasonable values of channel concavity of 0.4 to 0.7, the junction point resides at 3/4 to 5/6 the catchment length as defined by the distance from the outlet to the divide. Solving for the ridge line elevation between catchments predicts a catchment length / width ratio between 1.8 and 2.1, also consistent with published numerical models and studies of natural landscapes. Field investigations of the tectonically active Kyrgyz Range of the western Tien Shan reveal evidence for natural processes that optimize stream networks. Comparisons of youthful, intermediate, and mature catchments define a pattern of tributary junction points that migrate upstream to maximize concentration of discharge. Differential incision of adjacent tributary catchments leads to upstream drainage capture and formation of under-fit parallel paleo-valleys. The extent of evidence for dynamic bedrock fluvial channel networks in the Kyrgyz Range suggests that these networks undergo significant reorganization over several million years before reaching an optimal topology. Complete understanding of the time scale of drainage network evolution and response to changing tectonic boundary conditions will thus require calibration of processes that contribute to lateral bedrock channel migration and capture. Processes observed to be occurring in the Kyrgyz Range include differential channel incision rates, deep-seated landslides, and the effects of debris loading from tributaries

NG31A-0600 0830h POSTER

Patterns in tidal environments: salt-marsh channel networks and vegetation

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Salt marshes in tidal environments are characterised by complex patterns both in their geomorphic and ecological features. Such patterns arise through the elaboration of a network structure driven by the tidal forcing and through the interaction between hydrodynamical, geophysical and ecological components (e.g. microphytobenthos and vegetation). This contribution introduces observations of tidal environments from remote sensing and ancillary data collected in the field. In particular CASI, MIVIS and LiDar airborne data and IKONOS and Quick-Bird satellite data on the lagoon of Venice (Italy) have been acquired in the period 2001-2002Salt marshes in tidal environments are characterised by complex patterns both in their geomorphic and ecological features. Such patterns arise through the elaboration of a network structure driven by the tidal forcing and through the interaction between hydrodynamical, geophysical and ecological components (e.g. microphytobenthos and vegetation). This contribution introduces observations of tidal environments from remote sensing and ancillary data collected in the field. In particular CASI, MIVIS and LiDar airborne data and IKONOS and Quick-Bird satellite data on the lagoon of Venice (Italy) have been acquired in the period 2001-2002, within the European RTD project TIDE. The remotely sensed data have been radiometrically calibrated, atmospherically corrected and accurately georeferenced to allow the comparison with ground truth observations. Classification and unmixing techniques are then used to derive the spatial distribution of salt marsh vegetation species, which are also characterised through the use of vegetation indexes (e.g. NDVI), allowing an objective and quantitative analysis of vegetation patterns. The set of observations available are further used, together with mathematical models, to describe channel meandering characteristics and branching properties yielding an accurate and spatially distributed description of the tidal network. . The remotely sensed data have been radiometrically calibrated, atmospherically corrected and accurately georeferenced to allow the comparison with ground truth observations. Classification and unmixing techniques are then used to derive the spatial distribution of salt marsh vegetation species, which are also characterised through the use of vegetation indexes (e.g. NDVI), allowing an objective and quantitative analysis of vegetation patterns. The set of observations available are further used, together with mathematical models, to describe channel meandering characteristics and branching properties yielding an accurate and spatially distributed description of the tidal network.

NG31A-0601 0830h POSTER

Ground Penetrating Radar Technique to Locate Coal Mine Subsidence Features at Malakoff, Texas

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Coal mine subsidence features around Malakoff, Texas, are being studied with ground penetrating radar (using a pulseEKKO system from Sensors & Software Inc.). This work is being done in collaboration with the Railroad Commission of Texas (RRC). RRC has been carrying out reclamation of abandoned underground coal mines near this location since early 1990s. The history of the specific mining operations that took place in the 1920s and 1930s has been difficult to ascertain; therefore, the use of a geophysical techniques, like ground penetrating radar (GPR) to identify hidden voids and potential subsidence features, are vital to the reclamation process. The landscape at the field site in Malakoff is rolling with a moderate-relief, sandy mud substrate. Some of the mine workings have collapsed over time and, in some cases, have affected the surface structures by creating sinkholes. GPR data, employing 25 MHz and 100 MHz frequency, have been collected over a 3D grid pattern and azimuthal pattern in the vicinity of these sinkholes. The penetration depth of the radar signal was approximately 20 meters from the surface. GPR data represent the mine drifts/void spaces with hyperbolae that bound the top and bottom of the mine workings. Diffractions against possible boulders and variation in the stratigraphy are also seen. Post-processing of the acquired data, using software developed by Sensors & Software Inc., provided a 3D representation of the voids and subsidence features. The goal of this research was to identify the efficacy of GPR in locating the subsidence features. Azimuthal surveys provide information regarding the connectivity between existing sinkholes. RRC ground-truthed the data during its reclamation process (in turn, the acquired geophysical data were used to guide the reclamation). Mine drift openings observed during ground-truthing from some of the sinkholes matched the orientation of the void space observed in the GPR data lines. The GPR data is helpful in understanding the utility of 25 MHz and 100 MHz GPR in locating underground void spaces at varying depths. This study also denotes the importance of understanding the effect of varying physical properties of the stratigraphy, which could be misleading as radar signals representing a void space. GPR technique also enables in identifying the potential failure features and to quantify the safety hazard.

NG31A-0602 0830h POSTER

Everglades Modeling

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The Florida Everglades is a vast, low-relief, nearly horizontal, densely vegetated subtropical wetland with slow-moving water and only trace inputs of sediment and nutrients. The natural system is a classic example of a self-organizing system, with feedbacks between hydrology, vegetation, and soil evolution, but not all controls on landscape patterns are well understood. Engineered features (roads, canals, levees, etc.) have since the 1920s greatly modified the hydrologic regime, resulting in significant loss of peat and degraded patterning. We are developing a nested flow and transport model to try to understand dominant processes in landscape formation. Flow is described in 2D, vertically integrated over the surficial aquifer and surface water (using vegetative-drag models rather than Manning's equation). Transport is described in 3D, with sediment and (in the future) nutrient transport considered. High correlation between vegetative resistance and microtopography allows a parsimonious large-scale [O(1 km)] flow model based on a truncated normal distribution for microtopography that is partitioned by vegetation class. A more complex landscape-unit model describes both flow and transport at the large scale, with the potential of considering landscape evolution. The landscape-unit model considers typical landscape units as additional embedded continua within a slough continuum. The large-scale models can be used on their own, and also to provide boundary conditions for fine-scale [O(10 m)] simulations considering individual landscape features and the local effect of engineered systems.

NG31A-0603 0830h POSTER

Petrology and Bulk Chemistry of Modern Bed Load Sediments From Rivers Draining the Eastern Tibetan Plateau

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We studied river bed load petrology and bulk sediment chemistry of the headwaters of the Changjiang, Huang He and Red rivers in China and Vietnam. These rivers drain the eastern and southeastern parts of the Tibetan Plateau which includes part of the Indian-Eurasian suture zone. The eastern Tibetan Plateau is dominated by marine sedimentary rocks with a few scattered intrusive igneous outcrops, while the suture zone is characterized by a mixture of high-grade metamorphic, ultramafic, granitic, volcanic arc and marine sedimentary rocks. The arithmetic average for Q_t: F_t: Rf_t along the suture zone varies from 56:2:42 along the Red River Fault (RRF) zone to 38:6:56 in the interior of the continent, while sands from rivers draining the plateau average 32:8:60. The sands analyzed in this study are relatively immature compared to most data available from most rivers in the tropics. The average Chemical Index of Alteration (CIA) for samples from the RRF suture zone (0.62) is similar to that of rivers draining other tropical regions like the Niger, Chao Phraya, Mekong, Ganges, Amazon and Brahmaputra. The CIA values from the RRF zone are also significantly different from the rest of the suture zone (0.36) and the plateau area (0.38). The difference can be attributed to the combined effect of relief and precipitation. The RRF lies in the Red River drainage and receives ∼1820 mm of precipitation annually, while the plateau area averages ∼620 mm annually. In the case of the Red River drainage, the relief combined with higher humidity can increase physical weathering and reduce the residence time of sediment in the river drainage, therefore, continuously replacing the sediment transported out of the drainage by freshly weathered immature materials. In the plateau area, lower precipitation and runoff may limit sediment transport and chemical weathering leading to sediment immaturity.

NG31A-0604 0830h POSTER

Anisotropic scaling of Hawaiian lava flow textures

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Highly variable processes spanning wide ranges of scale abound in volcanological, geophysical and environmental systems, consequences of the highly nonlinear dynamics. A particular and prominent aspect is the ubiquity of scaling properties, implying a scaling symmetry over a wide range of scales. Lava flow emplacement is an example of such natural scaling dynamic process. Textural morphology of lavas is an expression of the intense stress applied at the surface during an eruption over a large range of scales. While the existence of a scaling and multiscaling may reveal the continuity of a dynamic process over these scales it is also important to consider these properties in a more general context where the (scale by scale) differential anisotropy is taken into account. In such cases, generalized scale invariance (GSI) will provide new powerful insights for describing highly variable anisotropic phenomena. We will discuss this question through Hawaiian Pahoehoe and A'a textures. Anisotropy at one scale and differential anisotropy will be considered to quantitatively statistically distinguish between these two types of lava flows.

NG31A-0605 0830h POSTER

On the Universality of Power-Law Exponents for Snow Avalanches

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Snow avalanches are a significant natural hazard in the world's mountainous regions. In the United States, snow avalanches kill more people on an average annual basis than other earth movement hazards such as landslides or earthquakes. Understanding the relationship between avalanche frequency and magnitude can be helpful for avalanche planning and zoning, in addition to improving our understanding of these complex phenomena. Previous research demonstrates that frequency/magnitude relationships for snow avalanches can be described by power-laws, similar to other natural hazards like earthquakes, rockfalls and forest fires. In fact, in these early investigations some researchers have suggested that a universal power-law exponent might exist for snow avalanches. This poster utilizes an extensive snow avalanche dataset covering nearly 30 avalanche seasons at 29 different locations to examine the idea of the universality of power law exponents. The investigation covers a wide range of spatial and temporal scales. Spatial scales range from a single avalanche path to a network of observers measuring avalanches in mountain ranges throughout the western United States, while temporal scales investigated vary from a single snow avalanche season to over 30 seasons of data. For the single site and single path scale, this study uses data from Mammoth Mountain, California and Berthoud Pass, Colorado. Avalanche fracture depth is used to represent avalanche magnitude in this research. Our results demonstrate several points. First, snow avalanche frequency/magnitude relationships can be described with robust power-laws. This is especially evident when the data from all the sites for all the years is combined. Second, individual sites, with areas on the order of 10 square km, demonstrate unique power-laws with exponents ranging from less than 2 to around 5, suggesting that the universality perceived by others may due to chance and limited data. Third, the smaller spatial scale of individual slide paths within these larger areas also have their own power-laws, shedding light on the practical problem of why some avalanche paths tend to produce proportionally more large avalanches than other paths. Finally, for an individual area, power-laws exist for individual seasons and change from year-to-year. This latter result may be helpful for relating avalanche activity to climatological indices which might then prove useful for forecasting the nature of upcoming avalanche seasons.

NG31A-0606 0830h POSTER

Power Law Scaling and Recurrence Intervals of Tsunamis

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Many natural systems have cumulative frequency-size distributions that follow a power law. Using tsunami runup data archived by the U.S. National Geophysical Data Center, we study eight locations in Japan where the tsunami record spans at least one order of magnitude in runup height and the temporal record extends back several decades. A power law describes the cumulative frequency-size distribution of tsunami runup heights at these eight locations. The scaling relationship determined for each location may be used to predict the recurrence intervals of tsunami runup heights. In addition to the tsunami record used to determine the scaling relationship, at some of the examined locations the record extends back several centuries for large events with runup heights greater than five meters. We find that the recurrence intervals of these large events are consistent with the frequency predicted from the more recent record.

NG31A-0607 0830h POSTER

Nonlinear dynamics of alongshore shoreline position change: observations and modeling

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The horizontal, shore-perpendicular change in shoreline position along the Outer Banks of North Carolina is a self-affine signal. We measure shoreline change by determining the horizontal change in position of the 0.8m contour at 20m intervals along the coast. The profiles are obtained from two LIDAR surveys performed in September 1997 and September 1998 as part of a collaborative USGS, NOAA, NASA project. For six selected sections of coast, wavelet analysis of the shoreline change signal indicates that the signal is self-affine with a scaling exponent that varies from 1.2 to 2.1. This self-affine behavior indicates that the shoreline change signal is non-stationary with long-range persistence. The scaling exponent is found to vary depending on the orientation of the shoreline, suggesting that these changes are driven chiefly by subtle gradients on alongshore transport associated with subtle deviations from a smooth shoreline. Recent modeling work has shown that when waves approach shore from deep water at relative angles greater than approximately 45°, shoreline perturbations grow, causing alongshore-heterogeneous shoreline changes on any scale at which perturbations exist. Waves approaching from deep-water angles closer to shore-normal tend to smooth out the shoreline. The patterns of change over some extended time period will result at least partly from the interactions between the roughening and smoothing influences, which will depend on the regional wave climate, including the relative proportions of high and low wave-approach angles. The observed trend in scaling exponents found for the Outer Banks, with scaling exponent varying as a function of shoreline orientation, is predicted by the alongshore transport model.

NG31A-0608 0830h POSTER

Signatures of Self-Organized Criticality as System Forcing Changes

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Because of the broad claims of applicability made for self-organized criticality (SOC), it is important to define measurable characteristics which can validate or invalidate a statement that a system or model is SOC. We examine two such measures, spectral and R/S analysis, on a SOC sandpile model with varying driving rate and very long time records and find that: 1) the length of the data record can be crucial in distinguishing SOC from random dynamics, 2) R/S analysis gives a more consistent indication of the dynamics (whether correlated or not) in a SOC system than does the power spectrum, 3) a 1/f region in the SOC power spectrum does not arise from just a random superposition of events (pulses) from a power law distribution and 4) the 1/f spectrum can be substantially altered by keeping the same events and simply changing the spacing between them. The first result implies that SOC should not necessarily be discounted as a model for a geophysical process whose data do not match SOC signatures, since many such processes have long time scales that preclude the collection of relevantly long time series. The second result is an argument for including R/S analysis in one's standard toolbox when characterizing the dynamics of any physical system. The final two results imply a test to see if a process with a 1/f signal is possibly due to SOC.

NG32A MCC: 3001-3003 Wednesday 1340h

Critical Point Theory and Space-Time Pattern Formation in Precursory Seismicity I *(joint with S, T)*

Presiding: **K Tiampo,** University of Western Ontario**; M Anghel,** Computer and Computational Sciences Division**; C G Sammis,** University of Southern California

NG32A-01 1340h INVITED

Long-Term Prediction of Large Earthquakes: When Does Quasi-Periodic Behavior Occur?

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I argue that the prediction of large earthquakes for time scales of a few decades is possible for a number of fault segments along transform and subduction plate boundaries. A key parameter in ascertaining if forecasting is feasible is the size of the coefficient of variation, CV, the standard deviation of inter-event times of large earthquakes that rupture all or most of a given fault segment divided by T, the average repeat time. I address only large events, ones that rupture all or most of the downdip width of the seismogenic zone where velocity-weakening behavior occurs. Historic and paleoseismic data indicate that the segment that ruptured in the great 1946 Nankaido, Japan, earthquake broke 9 times in the previous 1060 years yielding T=118 years and CV=0.16. The adjacent zone that broke in 1944 exhibits similar behavior as does the Copper River delta, the site of 8 paleoseismic events dated by Plafker and Rubin (1994) above the rupture zone of the 1964 Alaska earthquake. Lindh (preceding abstract) finds that many fault segments in California have similar small values of CV. Paleoseismic data for inter-event times at Pallet Creek and Wrightwood, however, indicate a large CV. Those sites at situated along the San Andreas fault near the end of the 1857 rupture zone where slip was much smaller than in the Carrizo plain, rupture in large events to the northwest and southeast overlap and deformation is multibranched as plate motion is transferred in part to the San Jacinto fault. Plate boundary slip is confined to narrow zones along the 1944 and 1946 segments of the Nankai trough but is more diffuse in the Tokai-Suruga Bay region where the Izu Peninsula is colliding with the rest of Honshu and repeat times appear to be longer (and CV perhaps is larger). Dates of uplifted terraces likely give repeat times of inter-plate thrust events that are too long and large estimates of CV since imbricate faults within the upper plate that generate terraces do not rupture in every great earthquake. The 2002 Working Group on large earthquakes in the San Francisco Bay region followed Ellsworth et al. (1999) in adopting much larger values of CV for several critical fault segments and underestimating their likelihood of rupture in the next 30 years. The Working Group also gives considerable weight to a Poisson model, which is in conflict with both renewal processes involving slow stress accumulation and with values of CV near 0.2. The failure of the Parkfield prediction has greatly influenced views in the U.S. about long-term forecasts. The model of the repeated breaking of a single asperity is incorrect since past Parkfield shocks of about magnitude 6 likely did not rupture the same part of the San Andreas fault.

NG32A-02 1355h INVITED

Hazard Forecasting by MRI: A Prediction Algorithm of the First Kind

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Seismic gaps do not tell us when and where the next earthquake is due. We present new results on limited earthquake hazard prediction at plate boundaries. Our algorithm quantifies earthquake hazard in seismic gaps. The prediction window found for M7 is on the order of 50 km by 20 years (Lomnitz, 1996a). The earth is unstable with respect to small perturbations of the initial conditions. A prediction of the first kind is an estimate of the time evolution of a complex system with fixed boundary conditions in response to changes in the initial state, for example, weather prediction (Edward Lorenz, 1975; Hasselmann, 2002). We use the catalog of large world earthquakes as a proxy for the initial conditions. The MRI algorithm simulates the response of the system to updating the catalog. After a local stress transient dP the entropy decays as (grad dP)2 due to transient flows directed toward the epicenter. Healing is the thermodynamic process which resets the state of stress. It proceeds as a power law from the rupture boundary inwards, as in a wound. The half-life of a rupture is defined as the healing time which shrinks the size of a scar by half. Healed segments of plate boundary can rupture again. From observations in Chile, Mexico and Japan we find that the half-life of a seismic rupture is about 20 years, in agreement with seismic gap observations. The moment ratio MR is defined as the contrast between the cumulative regional moment release and the local moment deficiency at time t along the plate boundary. The procedure is called MRI. The findings: (1) MRI works; (2) major earthquakes match prominent peaks in the MRI graph; (3) important events (Central Chile 1985; Mexico 1985; Kobe 1995) match MRI peaks which began to emerge 10 to 20 years before the earthquake; (4) The emergence of peaks in MRI depends on earlier ruptures that occurred, not adjacent to but at 10 to 20 fault lengths from the epicentral region, in agreement with triggering effects. The hazard enhancement in space is shaped like a Mexican hat function. The central part is the aftershock region, separated by a ring of quiescence from an outer region of increased rupture probability(Lomnitz, 1996b). In conclusion, we may speak of seismic weather prediction using MRI. Hasselmann, K. (2002). Is climate predictable? In The Science of Disasters, A. Bunde, J. Kropp and H.J. Schellnhuber, eds. (Springer, Berlin, 140-169). Lomnitz, C. (1996a). Predicting earthquakes with the MRI algorithm, Seismol. Res. Letters, 67, 40-46. Lomnitz, C. (1996b). Search of a worldwide catalog for earthquakes triggered at intermediate distances, Bull. Seismol. Soc. Am., 86, 293-298. Lorenz, E. (1975). Climate predictability: The physical basis of climate and climate modeling. World Meteorol. Org., Geneva, Report 16, 132.

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Characterization of space-time correlations in aftershock and seismicity patterns

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Correlations in space and time play a fundamental role in earthquake processes. The direct manifestation of the effects of correlations is the occurrence of aftershocks due to the stress transfer in the vicinity of the main shock. Less obvious and more debatable changes in correlations might occur in the background seismicity before large earthquakes. Using statistical physics it is possible to introduce a measure of spatial correlations through the correlation length. This quantity characterizes how local fluctuations in space can influence the occurrence of earthquakes over distances comparable with the value of the correlation length in a seismogenic region. Partial information of correlations is also present in the well-known Gutenberg-Richter frequency-magnitude statistics which is reflected in the change of the shape of the distribution during different time periods. Time correlations are well documented for aftershock sequences and described by the modified Omori's law. This law specifies a temporal decay of aftershocks and has power-law scaling. The physical basis of these laws will be discussed in the context of correlations. In addition we have obtained scaling laws for the spatial clustering of aftershocks using pair and density correlation functions and a radius of gyration. We have also obtained the variations in time of the correlation function and correlation length associated with the spatial and temporal processes in seismogenic regions. Applications of the correlation analysis to background seismicity will also be discussed.

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Spinodal Critical Points, Scaling and Predictibility

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The critical point hypothesis, that there exists a critical point in earthquake fault systems, is attractive in that it provides a physical basis for the observed scaling laws seen in the data. However, the existence of a critical point is not enough to explain other observed properties of fault systems such as the earthquake cycle, including the possible existence of runup to failure. In addition, the critical point itself provides no physical basis for prediction or forcasting. Over