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Recent studies (Patil 2001) have shown that, when the Earth's surface is divided up into local regions of moderate size, vectors of the forecastuncertainties in such regions tend to lie in a subspace of much lower dimensionthan that of the full atmospheric state vector. We show how this finding can be exploited to formulate a potentially accurate and efficient data assimilation technique (Ott 2002). The basic idea is that, since the expected forecast errors lie in a locally low dimensional subspace, the analysis resulting from the data assimilation should also lie in this subspace. This implies that operations only on relatively low dimensional matrices are required. The data assimilation analysis is done locally in a manner allowing massively parallel computation to be exploited. The local analyses are then used to construct global states for advancement to the next forecast time. Numerical tests of successful implementations of the method on model systems show its potential advantages.

References:
D.J. Patil, et al. *Phys. Rev. Lett.* **86**, 5878 (2001).
E. Ott, et al., arXiv:physics/0203058.

URL: http://arxiv.org/pdf/physics/020305

NG71A-07 1020h INVITED

Nonlinearity, Uncertainty, Dynamics and Stochastics in the Geosciences

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It has been clear that it is indispensable to take nonlinearity into account, in order to better understand complex systems like the geosystem. There is a growing recognition of a role for the inclusion of stochastic terms in the modeling of complex and multi-scale phenomena in the geosciences.

During the last decade, significant progress has been made towards building a comprehensive theory of random dynamical systems, while the applications of these random dynamics ideas and techniques to other areas have not yet been fully explored. The core questions in the modeling, analysis, simulation and prediction of geophysical phenomena under uncertainty include: exploring appropriate ways to take stochastic effects into account; understanding the impact of randomness on the evolution of the geosystem; and designing efficient numerical algorithms to simulate nonlinear and random phenomena.

I will present recent work on nonlinear and stochastic dynamical systems methods, such as effective approximation, ergodicity principle, averaging principle, nonautonomous perturbations, and determining functionals, for geophysical fluid dynamics.

NG71A-08 1035h INVITED

Introduction to a Lagrangian-averaged Turbulence Closure Model

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This talk is not specifically about chaos or fractal structure, although it does refer to nonlinear dynamical systems that possess global attractors whose fractal, or Hausdorf, dimension is finite. Specifically, I shall speak about a new turbulence closure model that is based on Lagrangian averages (following the fluid parcels). I shall review how well this model describes the mean effects of fluctuations in turbulent flows by comparing its predictions with experimental data and numerical simulations. Mathematically, the turbulence model has a global attractor whose fractal, or Hausdorf, dimension has a finite upper bound, proportional to Reynolds to the 3/2 power. So the model is rigorously computable as a finite degree-of-freedom dynamical system. I shall also discuss how the model affects the Kolmogorov scaling laws for turbulence at small scales and large scales. Finally, I shall discuss the potential advantages of Lagrangian averaging for modeling GFD turbulence.

NG71A-09 1050h INVITED

On The Design of Ensemble Climate Experiments: A Simulation of climateprediction.net

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Obtaining meaningful long-term forecasts for nonlinear systems under transient forcing using imperfect models is nontrivial. We consider the issue of resource allocation in ensemble climate model experiments which aim to quantify the effects of uncertainty in initial condition, parameter values, parameterisations, model class and so on. A deployable approach to informed selection of the 'next' ensemble member is illustrated in a simple nonlinear system (see L.A. Smith, (2002) What Might We Learn from Climate Forecasts? *Proc. National Acad. Sci.* **4**, 99, 2487–2492). Interpretation of the results of such experiments, and their implementation within the climate*prediction*.net project are discussed.

URL: http://www.maths.ox.ac.uk/~lenny

NG71A-10 1105h

Multifractality and Universal Laws of the Extremes, beyond Frechet and Gumbel.

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The Gumbel law has been frequently considered as the universal law for the extremes, i.e. the probability distribution of the minimal value or maximal value observed on a given period. This consideration was based on a mathematical theorem that requires two hypotheses to be satisfied: (i) exponential fall-off of the probability distribution of the component of the series (ii) a short range correlation between these components. Unfortunately, both hypotheses are in general not satisfied by a (stochastic) multifractal field.

In order to clarify this issue, we investigated the multifractal and extreme behaviours of various series of 10 years of tipping bucket measurements, estimated time resolution of the order of 5 minutes (Meteo-France PRECIP data base,). We got universal exponent estimates in good agreement with those obtained in other studies. As expected in the framework of stochastic multifractals, we also found a power-law tail for the pdf, not an exponential one. If correlations between components will be only short range, then the corresponding universal law will be Frechet, rather than Gumbel.

We do find that Frechet law fits quite better the empirically observed extremes than Gumbel law. However, we empirically note a slight overestimation of the extreme events by the former. An equivalent of the Frechet's law for components with a scaling dependence is presumably needed to get a better fit

NG71A-11 1120h INVITED

From Boundary Layer Turbulence to Hydrologic Response: Recent Results on Scaling, Nonlinearity, and Predictability and Their Implications

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Deepening our understanding of the space-time variability of atmospheric/hydrologic processes and their interactions over a range of scales has important implications for improving model parameterizations and increasing the accuracy of predictive models. At the same time, the inherent nonlinear and chaotic character of some of these processes imposes limits on their predictability, and therefore provides upper bounds on the expected prediction accuracy from numerical models. This paper will address questions of scaling, nonlinearity and predictability in processes active at two major interfaces of the hydrologic system: the land-atmosphere interface, and the land-water interface. Specifically, recent findings and their practical implications will be presented on: (a) multiscale interactions in turbulent boundary layers and implications for boundary condition formulations; (b) predictability assessment of turbulent velocities in a boundary layer as a function of scale; and (c) nonlinear dynamics of basin hydrologic response as a function of spatio-temporally varying forcing and basin geomorphological organization.

NG71A-12 1135h INVITED

Scaling, a key issue of the Prediction in Ungaged Basins (PUB)

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PUB (Prediction in Ungaged Basins) is a scientific initiative launched by the IAHS to provide hydrological data in ungaged or information poor basins. PUB is a scientific endeavor to assemble, promote and capacity build the science and technology to predict and estimate the hydrological phenomena without depending on calibration data. The hydrological phenomena to be predicted and estimated include precipitation, land surface processes, stream flow, groundwater flow, snow and ice, sediments and water quality.

The collection of Hydrological data remains a fundamental task, but PUB requires new and significant advances in:

- Better understanding of currently the observed variability over a wide range and space scales of rainfall and runoff processes (within and between catchments), including extremes (at time scales ranging from diurnal to inter-annual and even inter-decadal, and space scales ranging between 0.1 to 15,000 sq. km.).
- Development and use of advanced mathematical techniques for the characterization of space-time variability at multiple scales: fractal structures and multifractal fields, nonlinear dynamics.
- Derivation and validation of new balance equations at various scales and in particular at the basin scale,
- Development of measurement techniques, as well as new data processing methodologies, especially for remote sensing, to measure and estimate over a wider range of scales quantities, which are fundamental to the development and validation of these new theories and the remote monitoring of state variables such as saturated areas and groundwater levels.
- Improve our understanding of the interactions between runoff processes, and the chemical and biological processes, at all time and space scales, which is crucial for water quality predictions (salinity, sediments, nutrients, heavy metals etc.) at the basin scale.
- Development and advancing of the emerging focus on holistic thinking, ecohydrology, Gaia theory etc. that will enable more parsimonious descriptions of climate-soil-vegetation-topography interactions.

As for an illustration, we will discuss some recent multifractal analysis of the rainfall-runoff process.

NG72A MCC: Hall C Sunday 1330h

Scaling and the Fluid Earth: Chaos and Multifractals in the Atmosphere, Oceans, Hydrology, and Climate II Posters *(joint with A, B, H, OS, SA, SH, SM, T, PP, MR)*

Presiding: **D Schertzer,** Laboratoire de Modelisation en Mecanique**; S Lovejoy,** McGill University

NG72A-0908 1330h INVITED POSTER

Rain is Earthquakes in the Sky

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N G

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We demonstrate how, from the point of view of energy flow through an open system, rain is analogous to many other relaxational processes in Nature such as earthquakes. By identifying rain events as the basic entities of the phenomenon, we show that the number density of rain events per year is inversely proportional to the released water column raised to the power 1.4. This is the rain-equivalent of the Gutenberg-Richter law for earthquakes. The waiting times between events is also characterised by a scaling region, where no typical time scale exists. This is the rain-equivalent of the Omori Law for earthquakes. All of our findings are consistent with the concept of self-organised criticality, which refers to the tendency of slowly driven non-equilibrium systems towards a state of scale free behaviour.

NG72A-0909 1330h POSTER

Low-Dimensional Chaos in River Flow Dynamics: Remarks on the Performance of Local Approximation Prediction and Inverse Chaos Identification Approaches

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This study addresses the issue of whether or not river flow dynamics exhibit low-dimensional chaotic behavior, by investigating the ability of the inverse chaos identification approach (i.e. identification using prediction results) in river flow series. For this purpose, the study presents an extension of the application of a recently proposed optimal inverse approach, which was previously demonstrated on artificial chaotic series and also tested on real river flow series. The present extension comes in the form of its application also to stochastic series. For purposes of consistency with flow series and assumption involved in chaos studies, the stochastic series is obtained by adding artificial noise to noise-free chaotic series instead of a complete random generation. However, to facilitate the interpretations, different levels of stochasticity are considered, by adding 5, 20, and 50 per cent noise levels. The artificial chaotic series studied is the Mackey-Glass series, and the daily flow series observed in Tryggevaelde catchment in Denmark and in Altamaha River in USA represent the real flow series. The results from the inverse approach indicate that the characteristics (i.e. absence of optimum combination of parameters) of the two river flow series are somewhat similar to those of the high-level noisy series, implying that these flow series may be on the stochastic domain rather than the chaotic domain. However, the predictions for these series are near-accurate, which indicates the appropriateness of the nonlinear local approximation prediction approach. Further, a comparison of the correlation dimensions of these flow series with those of the artificial series studied indicates that the flow series are more similar to the low-noisy chaotic series than to the high-noisy series, suggesting the presence of chaos. In view of these mixed results, utmost caution must be exercised in interpreting whether or not river flow dynamics exhibit chaotic behavior, but the usefulness of the local approximation prediction approach, developed within the context of chaos theory, cannot be dismissed.

NG72A-0910 1330h POSTER

The Global Water Cycle: Is it a non-linear feedback system that helps to maintain homeostasis in the Earth's climate system?

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The Earth's climate record has been marked by periods of relatively stable climate interspersed with relatively abrupt changes. On some occasions these changes appear to have been associated with changes in the global water balance. Although the feedbacks in a dry atmosphere due to greenhouse gas increases would likely be trackable, the non-linearities in the Earth's moist atmosphere and land areas make it difficult to predict the changes that could take place in the global water cycle, and to assess how these changes would contribute to the stability or instability of the Earth's climate.

Understanding the potential contributions of the global water cycle to climate is very important because, without this understanding, it will be impossible to predict with accuracy the changes and impacts that will result from "greenhouse warming." This talk reviews the role of non-linearities in water cycle processes and explores the evidence for and value of addressing water cycle/ climate system linkages as a fundamental hypothesis in a national global water cycle program.

NG72A-0911 1330h POSTER

Global change and space-time multifractal behavior of river runoff

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To investigate the influence of climate on river runoff processes we use about three million river runoff measurements at very different locations all over the World. This database permits valuable space-time multifractal analyses and modeling of the runoff process. On seasonal time-scales, the influence of climatic changes becomes immediately visible by the change in the scaling behavior of such multifractal runoff. To illustrate how such runoff processes can by affected by climatic changes - both on much longer as well as on much shorter time-scales, we use two rather exotic data sets. The first is a series of 1515 annual values teperature proxies fron South American ice boreholes. The second is an extreme rain event from Grenoble (France) during the summer of 1992.

We demonstrate how our results allow a unification within the multifractal framework of both basin factors and climatic change which strongly modify precipitation input. It is a significant improvement with respect to current modeling and forecasting of river runoff phenomena.

NG72A-0912 1330h POSTER

Multifractal continuum in rain

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Stereophotographic data from 10m3 regions containing 5,000 15,000 rain drops (18 triplets from 5 storms) is used to measure the positions and volumes of the drops. By determining the drop statistics in spheres of increasing size, we conduct a basic continuum mechanics thought experiment. We show that presumably due to turbulence - there is no micro-macro scale separation, we find that the large scale continuum limit is multifractal, inhomogenous, nonclassical and discuss the implications for radar remote sensing, space-time rain measurements from rain gauge networks, and cloud physics.

NG72A-0913 1330h POSTER

Multiscale Interactions Between Surface Shear Stress and Velocity in Turbulent Boundary Layers

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Understanding the multiscale nonlinear interactions between surface shear stress and velocity is essential to improving boundary condition parameterizations used in numerical models of turbulent boundary layers. In this study, high-frequency measurements obtained in a wind tunnel are used to identify dominant scales of interaction between wind velocity and shear stress via wavelet cross-correlation analysis. Three ranges of scales of interaction are identified: (i) in the inertial sub-range, the correlation is negligible; (ii) in the energy production range, the correlation follows a log-law which is invariant with kz (z = distance to the surface; k = wavenumber); and (iii) for scales larger than the boundary-layer height, δ, the correlation reaches a plateau (a function of z/δ). Our results allow us to estimate the linear correlation between shear stress and wind velocity at multiple scales and assess the reliability of typical boundary condition formulations in numerical models (for instance, LES) that compute shear stress (or its fluctuations) as a linear function of wind velocity at the first vertical grid point.

NG72A-0914 1330h POSTER

Fractal aircraft trajectories and 23/9 dimensional atmospheric turbulence

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Analysis of the horizontal structure of the atmosphere using nearly 1000 satellite images of clouds has showed that from planetary scales down to at least 1 km, they are multiscaling with statistics very close to those predicted by cascade processes: there is no meso-scale gap between isotropic two dimensional and isotropic three dimensional turbulence. Lidar data of aerosols directly shows how this is possible: it shows that the scaling in the horizontal and vertical directions are quite different. In fact, the ratio of the multifractal exponents is close to those predicted by the unified scaling model of stratification (= (Kolmorogov 1/3 / Bogliano-Obhukhov 3/5) =5/9). Using data from trajectories of scientific aircraft flights in the stratosphere (roughly 2000km long) during a "Mach cruise" flight mode (in which an autopilot maintains a constant Mach number) we show that $<Dz2>^a$ Dx2Hz where z and x are the vertical and horizontal coordinates of the aircraft: the trajectory is fractal with Hz^a 0.545 close to the predicted 5/9=0.555... thus giving direct quantitative supporting this picture. In addition, we find that the temperature and velocity exponents are indeed in the correct ratio although not surprisingly, their values are nonclassical. If other aircraft trajectories are found to be fractal and this seems likely then these results have potentially far reaching consequences for the interpretation of aircraft data. This is because the statistics on fractal and standard (i.e. linear) sections are fundamentally different. This finding could thus explain a number of apparently contradictory claims about the nature and limits of scaling of the horizontal wind particularly in the meso-scale.

NG72A-0915 1330h POSTER

Stratified, causal, space-time multifractal modeling of anisotropic clouds, rain and pollution including radiative transfer

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Although to date over twenty geophysical fields have been shown to be multifractal over various space-time ranges, the corresponding models are still surprisingly underdeveloped. One reason for this stems from the

basic extreme nature of multifractals themselves and can be understood by considering conservative multifractals (i.e. resulting directly from a cascade process). The simulation of a continuous in scale (infinitely divisible) conservative multifractal, involves two basic steps: first one fractionally integrates a Levy noise; second, one exponentiates the result. Unless precautions are taken - the first step is very sensitive to the large wavenumber numerics whereas the second greatly amplifies those instabilities. These and other related technical problems are discussed. We show how stable simulations both causal and acausal in two and three dimensions, including scaling anisotropy - can be produced using appropriate filters. While the isotropic (self-similar) multifractals can be simply rendered stable, the anisotropic case is much more involved, although we present a simple fairly general solution. Simulations using 2**24 points require only a few hours on a personal computer. We demonstrate the simulations using both space-time models of clouds, pollution and rain as well as simulating radiative transfer through stratified multifractal clouds.

NG72A-0916 1330h POSTER

Scale Similarity in Large Eddy Simulation for Large Scale Ocean

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We consider the problem predicting local averages of the velocity of a turbulent flow like large scale ocean. Averaging primitive equations leads to the problem of closure. In scale-similarity models, the mean effect of the unresolved scales are extrapolated from the resolved scales. Scale-Similarity models have typically been found to give very accurate models of the unresolved scales but have often been unstable in simulations. We consider a new scale similarity model that is (apparently) so simple that it has escaped serious investigation. This new model has an interesting, important and subttle kinetic energy balance that we present. Using this energy balance, we are able to prove that the model possesses almost all the mathematical properties desired in a LES model.

URL: http://www.maths.univ-rennes1.fr/~lewandow

NG72A-0917 1330h POSTER

Scaling in a simple, physical model of tropical oceanic convective rainfall.

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Hydrologists have for many years used stochastic models in an attempt to represent the scaling statistics observed in mesoscale convective rainfall. The need for such stochastic models has stemmed from a variety of hydrometeorological and hydroclimatological issues on river basins. However, these stochastic models are generally difficult to interpret in terms of the underlying physical processes associated with rainfall, which leaves modelers with a tool designed to represent distributions but not to predict them from physics.

We present here the results of a Fractional Wetted Area scaling analysis (Over and Gupta, 1994) performed on data from a simple, 2-dimensional space-time dynamical model. The model was developed directly from the physics of tropical oceanic atmospheric convection without the a priori specification of any statistical or stochastic assumptions. However, data from this model is found to exhibit statistical scaling which is similar to that found in an identical analysis performed on datasets from tropical oceanic rainfall.

NG72A-0918 1330h POSTER

Nonlinear Growth of Singular Vector Based Perturbations

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The nonlinearity of singular vector-based perturbation growth is examined within the context of a global atmospheric forecast model. The characteristics of these nonlinearities and their impact on the utility of SV-based diagnostics are assessed both qualitatively and quantitatively. Nonlinearities are quantified by examining the symmetry of evolving positive and negative twin perturbations. Perturbations initially scaled to be consistent with estimates of analysis uncertainty become significantly nonlinear by 12 hours. However, the relative magnitude of the nonlinearities is a strong function of scale and metric. Small scales become nonlinear very quickly while synoptic scales can remain significantly linear out to three day. Small shifts between positive and negative perturbations can result in significant nonlinearities even when the basic anomaly patterns are quite similar. Thus, singular vectors may be qualitatively useful even when nonlinearities are large.

Post-time pseudo-inverse experiments show that despite significant nonlinear perturbation growth, the nonlinear forecast corrections are similar to the expected linear corrections, even at 72 hours. When the nonlinear correction does differ significantly from the expected linear correction, the nonlinear correction is usually better, indicating that in some cases the pseudo-inverse correction effectively suppresses error growth outside the subspace defined by the leading (dry) singular vectors. Because a significant portion of the nonlinear growth occurs outside of the dry singular vector subspace, an a priori nonlinearity index based on the full perturbations is not a good predictor of when pseudo-inverse based corrections will be ineffective. However, one can construct a reasonable predictor of pseudo-inverse ineffectiveness by focusing on nonlinearities in the synoptic scales or in the singular vector subspace only.

NG72A-0919 1330h POSTER

Uncertainty in numerical prediction models: the lack of convergence of the Lorenz model

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Most computational models are non-linear and it is usually implicitly assumed that the solutions of the numerical algorithms in which they are based converge to the analytic solutions of the underlying differential equations, for small time-steps and grid-sizes. The Lorenz equations are used to show that for highly nonlinear systems there is no apparent convergence.

NG72A-0920 1330h POSTER

Using Independent Component Analysis for Non-Linear Decorrelation of SST Modes

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Independent Component Analysis (ICA) is a novel and powerful technique that can be used to analyze the temporal and spatial variability of geophysical variables. ICA is a general extension to Principal Component Analysis (PCA), and is capable of decomposing mixtures of independent, non-Gaussian signals by performing non-linear decorrelation. While many linear techniques (including PCA) rely on the variance/covariance information contained in a dataset, ICA uses higher order statistical moments to uniquely identify source signals of linear mixtures by exploiting properties of non-linear transformations of the data. In contrast to linear techniques such as PCA, ICA is able to extract non-linear and non-Gaussian signals from multivariate geophysical data.

SST is a key component of the climate system because it serves as a strong, large-scale boundary condition to the atmosphere. In this paper, ICA is applied to northern hemispheric sea surface temperature (SST) anomalies for 1948-2000 to estimate independent modes of variability. Results show that ICA is capable of separating the two leading modes of Pacific SST variability: the Pacific Decadal Oscillation (PDO) and the El Niño Southern Oscillation (ENSO). In this context, one of the outstanding questions concerning the PDO is its relation to variability in the tropical and subtropical Pacific. The results suggest that a large fraction of SST variability in the north Pacific evolves independently from the SST anomalies in the equatorial regions. Furthermore, results from the ICA suggest that the canonical ENSO mode of variability may in fact comprise three separate and independent modes superimposed upon one another. Specifically, one mode appears to capture the base-state evolution of the equatorial anomalies independent of teleconnection features outside the tropical region, while the two other modes capture basin-scale variations related to the onset of intensified El Niño and La Niña events over the past two decades. By isolating these independent modes of variability, it may be possible to better analyze and diagnose the dynamics and boundary condition forcing associated with SST anomalies.

NG72A-0921 1330h POSTER

The climate, high dimensional chaos and strongly non-gaussian perturbations.

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Chaos revolution has been a popular theme. Indeed, low dimensional deterministic chaos had been very helpful in order to better understand the limitations of classical methods in analyzing and modeling complex systems in Geophysics. This was achieved with the help of apparently simple caricatures of complex systems) leading nevertheless to nontrivial behaviors.

Unfortunately, this success has lead to an awkward tendency to reduce complex systems -including climate systems- to their low dimensional caricatures. This tendency was reinforced by the apparent success of the rather straightforward correlation dimension algorithm in giving low dimensional estimates. We will briefly discuss the shortcomings of these estimates, in particular for (stochastic) multiplicative cascade processes.

At the theoretical level, ergodic theory of chaos is the key to understand high dimensional chaotic systems. The determination of their invariant measures (i.e. stationarity states) is of prime importance. Unfortunately, many are physically irrelevant so that classically to select the "physical invariant measure", following Kolmolgorov, one perturbs the system with the help of a gaussian white noise and considers the limit measure obtained for a vanishing intensity. However atmospheric noises are colored and strongly non-gaussian, which brings the relevance of this approach into question.

In order to illustrate this problem, we discuss the almost academic example of the physical invariant measure of particles submitted to noisy forcing and their corresponding (fractional) Fokker-Planck equation.

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NG72A-0922 1330h POSTER

Self-Organised Criticality at the Onset of Aeolian Sediment Transport.

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Despite decades of rigorous investigation, reliable prediction of aeolian sediment transport rates remains impossible. Transport rate formulae are based on the governing principle of steady state equilibrium such that wind velocity produces a linear response in sediment flux. Field experiments, however, demonstrate a highly non-linear response and considerable deviation exists between observed and predicted transport rates. The limited predictive ability of the transport rate equations is largely attributed to crude measurement techniques that characterise wind velocity and sediment flux as time averaged values on the order of minutes, effectively concealing a time scale on the order of seconds in which the equilibrium condition is established. All attempts to resolve a characteristic time scale persistently reveal complexity. From the study of multi-component systems, it is now becoming apparent that such non-linearity is a pervasive attribute of system dynamics.

Wind tunnel experiments were conducted to examine the nature of steady state sand transport under uniform forcing. Images of grains traversing an illuminated plane in the tunnel were acquired by video camera at a rate of 10 frames per second. A suite of image analysis techniques were then applied to quantify the volume of sand recorded in sequences of thousands of images and a transport time series generated. Wind velocity measurements were also acquired simultaneously with transport measurements.

In contradiction to the steady state hypothesis, sand transport events obeyed a clear power-law scaling (number size) over about 2.5 orders of magnitude, consistent with the dynamics of self-organised critical systems and suggesting that the dynamics of aeolian sediment transport are similar to those of avalanches observed in a sand pile. Such systems are inherently unpredictable - a fact which may contribute to our understanding of the intractability of the aeolian transport problem.

NG72A-0923 1330h POSTER

Exploring the Castaing Distribution Function to Study Intermittence in the Solar Wind at L1 in June 2000

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We considered 31,561 consecutive 64-second values of radial solar wind speed reported by the SWEPAM instrument (D. McComas, Los Alamos, Principal Investigator) on the ACE spacecraft at L1 upstream of the earth's bow shock beginning day 157 of the year 2000. Running values, moments and probability density functions (pdfs) were calculated for the speed differences over a range of lags from 64 seconds to several days. Running values show local intermittency in their amplitudes, and correlate with local solar wind speed. Moments of order greater than 6 are dominated by the largest values, which increase slowly with lag in the inertial range causing the exponent of the structure function at large q to be a straight line. The pdfs are compared to "Castaing distributions" which are superpositions of Gaussians whose standard deviations are lognormally distributed. Although the Castaing distribution does not and in principle cannot precisely fit actual pdfs of velocity increments in the solar wind, it looks good and provides a basis for a handy two-parameter description of the pdfs. The run of those two parameters with scale provides a further handy description of the intermittency in the cascade that is independent of any particular model of the cascade. Proving the disability of the Castaing distribution, the third moment of the longitudinal velocity increments does exist and it scales consistent with Kolmorogov's 4/5 law that is a requirement for all theories of the inertial cascade.

NG72A-0924 1330h POSTER

Wavelet-based Analysis of Scaling Phenomena in the F-Region Electron Concentration

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The present work provides a contribution to the study of scaling phenomena observed in the F region ionosphere. By concatenating the five days together one can see scaling phenomena that may be of interest. The analysed data are quantities describing properties of the ionosphere; time variations of the critical frequencies (i.e. maximum of electron concentration at the electron density profile of the ionosphere) of the F region and corresponding height of this maximum and time variations of electron density at fixed heights below the F-layer region. This data are obtained by vertical incidence ionospheric sounding method. Ionospheric sounding is one of the most important ground based measurements that is running at many places of the world for several tens of years and gives information about electron density profile at height level from 100 km up to height of maximum of electron density profile. Scaling phenomena are studied in the wavelet framework. One-dimensional Time Series are represented through their discrete wavelet coefficients. Then, Partition Functions are computed, consisting of sum along time of q-th powers of the absolute values of wavelets coefficients as a function of scale. When the partition functions present power law behaviour with respect to scales, the analysed data are said to posses scaling properties. From the range of scales were power laws exist and the dependence on q of the measured exponents, the nature of the scaling can be determined. From the wavelet-based analysis of the fluctuations of the maximum height of the F-layer and in those of the maximum concentration, we can show the existence of interesting scaling phenomena in an intra-day range of scales (from 20 to 600 minutes (10 hours)). The dependence on the order q of the exponents measured on the partition functions indicate intricate scaling properties in data. Therefore, to describe them, models with simple scaling properties such as self-similarity are to replaced by others with more complex scaling, such as multifractal or infinitely divisible process.

NG72A-0925 1330h POSTER

Finite Size Scaling in the Solar Wind Magnetic Field Energy Density as Seen by WIND

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The geomagnetic field fluctuations of the fluid Earth are driven in part by energy supplied by the turbulent solar wind. Statistical properties of the interplanetary magnetic field fluctuations can provide an important insight into the solar wind turbulent cascade. Recently, analysis of the Probability Density Functions (PDF) of the velocity and magnetic field fluctuations has shown that these exhibit non-Gaussian properties on small time scales while large scale features appear to be uncorrelated. Here we apply the finite size scaling technique to explore the scaling of the magnetic field energy density fluctuations as seen by WIND. We find a single scaling sufficient to collapse the curves over the entire investigated range. The rescaled PDF follow a non Gaussian distribution with asymptotic behavior well described by the Gamma distribution arising from a finite range Levy walk. Such mono scaling suggests that a Fokker-Planck approach can be applied to study the PDF dynamics. These results strongly suggest the existence of a common, nonlinear process on time scales up to 26 hours.

URL: http://xxx.lanl.gov/abs/astro-ph/0204287

NG72A-0926 1330h POSTER

The Application of Computational Mechanics to the Analysis of Geomagnetic data

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We discuss how the ideal formalism of Computational Mechanics can be adapted to apply to a non-infinite series of corrupted and correlated data, that is typical of most observed natural time series. Specifically, a simple filter that removes the corruption that creates rare unphysical causal states is demonstrated, and the new concept of effective soficity is introduced. We believe that Computational Mechanics cannot be applied to a noisy and finite data series without invoking an argument based upon effective soficity. A related distinction between noise and randomness is also defined: Noise can only be eliminated by increasing the length of the time series, whereas the resolution of random structure only requires the finite memory of the analysis to be increased. The benefits of these new concepts are demonstrated on simulated times series by (a) the effective elimination of white noise corruption from a periodic signal using the expletive filter and (b) the appearance of an effectively sofic region in the statistical complexity of a biased Poisson switch time series that is insensitive to changes in the wordlength (memory) used in the analysis.

The new algorithm is then applied to analysis of a real geomagnetic time series measured at Halley, Antarctica. Two principal components in the structure are detected that are interpreted as the diurnal variation due to the rotation of the earth-based station under an electrical current pattern that is fixed with respect to the sun-earth axis and the random occurrence of a signature likely to be that of the magnetic substorm. In conclusion, a hypothesis is advanced about model construction in general.

URL: http://xxx.lanl.gov/abs/cond-mat/0110228

NG72B MCC: Hall C Sunday 1330h

Model Testing and Validation in the Geosciences Posters *(joint with OS, P, S, T)*

Presiding: **A Braverman,** Jet Propulsion Laboratory**; K F Tiampo,** University of Colorado**; D Nychka,** National Center for Atmospheric Research

NG72B-0927 1330h POSTER

Toward a Multi-scale, Multi-moment Physics-based Validation Protocol in Computational Simulation

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Predictive capability is the Holy Grail of contemporary computational physics. The quantitative comparison between experiments and simulations, i.e., *meaningful* code validation, remains its Achilles' heel. Although major advances in experimental and computational capabilities have brought simulation science to the threshold of an elevated standard for code validation, this threshold cannot be crossed without an array of tools for quantitatively comparing experimental data with computational results. A recently begun activity, "Physics-Based Analysis of Dynamic Experimentation and Simulation," underway at Los Alamos National Laboratory with academic collaboration, directly addresses this problem. This talk outlines the path of inquiry for this effort, which has as its goal the development and implementation of an arsenal of new physics-based statistical analysis methods adapted specifically to code validation.

We discuss the ideals behind this approach, namely, methodologies that strike a workable balance between appropriate simplicity (to enable practicable extraction of information from measured data) and adequate complexity (to ensure that the extracted information is indeed meaningful). Our fundamental premise is to treat model and instrument outputs on an equal footing, adding as needed a stage of geophysical parameter retrieval or of (forward) detector signal estimation. To qualify as "physics-based," we require at present analysis methods where: (1) no observable scale is ignored or given special favor; (2) no statistical moment or histogram feature is given preference; and (3) special attention is given to extreme events. Furthermore, we favor parametric statistical representations that capture the essential nonlinear processes, e.g., instabilities or cascades. These criteria, all firmly grounded in contemporary nonlinear science, will guide us in designing new validation metrics, i.e., innovative ways of quantitatively comparing data and simulations.

We illustrate our strategy with a preliminary investigation on shock-induced fluid mixing using fractals, wavelets, and structure function analysis. This example exhibits some of the above characteristics and has already provided useful guidance in computational algorithm development. We further speculate on specific regimes and phenomena to which our evolving analysis techniques may apply.

NG72B-0928 1330h POSTER

INFORMATION AS A MEASURE OF MODEL SKILL

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Physicist Paul Davies has suggested that rather than the quest for laws that approximate ever more