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

closely to "truth", science should be regarded as the quest for compressibility. The goodness of a model can be judged by the degree to which it allows us to compress data describing the real world. The "logarithmic scoring rule" is a method for evaluating probabilistic predictions of reality that turns this philosophical position into a practical means of model evaluation. This scoring rule measures the information deficit or "ignorance" of someone in possession of the prediction.

A more applied viewpoint is that the goodness of a model is determined by its value to a user who must make decisions based upon its predictions. Any form of decision making under uncertainty can be reduced to a gambling scenario. Kelly showed that the value of a probabilistic prediction to a gambler pursuing the maximum return on their bets depends on their "ignorance", as determined from the logarithmic scoring rule, thus demonstrating a one-to-one correspondence between data compression and gambling returns.

Thus information theory provides a way to think about model evaluation, that is both philosophically satisfying and practically oriented.

P.C.W. Davies, in "Complexity, Entropy and the Physics of Information", Proceedings of the Santa Fe Institute, Addison-Wesley 1990

J. Kelly, Bell Sys. Tech. Journal, 35, 916-926, 1956.

NG72B-0929 1330h POSTER

Constructing and Evaluating Summary Data Sets for the Atmospheric Infrared Sounder

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This talk discusses a procedure for creating summary data sets from remote sensing data. Data are partitioned by space and time, and data within each subset are quantized using a modified data compression algorithm. We examine various quality measures for assessing how well the summary data represent the original data, and implications for science analysis. The methods are demonstrated using data from the Atmospheric Infrared Sounder (AIRS) on NASA's Aqua satellite.

NG72B-0930 1330h POSTER

Statistical analysis for U and V shaped valley profiles

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The cross valley profile of bedrock valleys that have been extensively glaciated are generally U-shaped; questions of interest include estimation of the actual shape from the data, ability to discriminate between shapes and comparison of these profiles across valleys. Data for such profiles are obtained from digital elevation maps (DEMs) via sampling transects across valleys. Current methodology as in Pattyn and Heule (1998) employs curve fitting without the use of any diagnostic measures. The shape of a profile can also be described by its derivatives. Functional data analysis techniques (Silverman and Ramsay, 1997) are used to estimate a function that is defined by the observations, and then to estimate its derivatives. The derivatives are used to describe the shape of the observed profile and then are compared to derivatives of the idealized U and V shapes. Other statistical improvements such as the use of model selection techniques in comparing nonlinear regression models are also discussed. These improvements also hold promise for describing other shapes in geomorphology such as river long profiles and upland erosion-surface remnants. Methods are illustrated with profiles from Himalayan valleys.

NG72B-0931 1330h POSTER

On the Convective Nature of Bar Instability

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Bar instability is recognized as the fundamental mechanism underlying the formation of large scale forms of rivers. We show that the nature of such instability is *convective* rather than *absolute*. Such result is obtained by revisiting the linear stability analysis of open channel uniform flow over a cohesionless channel of Colombini et al. (1987) and using Briggs (1964) criterion to distinguish between convectively and absolutely unstable temporally asymptotic response to an initial boundary-value perturbation of bed topography. Examining the branch-point singularities of the dispersion relation, which can be determined in closed form, we show that all the existing branch point singularities characterized by positive bar growth rate ω_i, involve spatial branches of the dispersion relation which, for large positive values of ω_i, lie in the same half λ-plane, λ denoting the complex bar wavenumber. Hence, the nature of instability is convective and keeps such for any value of the aspect ratio, the controlling parameter of the basic instability, as well as for any lateral mode investigated. The latter analytical findings are confirmed by numerical solutions of the fully non linear problem. In fact, starting from either a randomly distributed or a localized spatial perturbation of bed topography, groups of bars are found to grow and migrate downstream leaving the source area undisturbed.

Briggs, R.J. 1964. Electron-Stream Interaction With Plasmas. Cambridge, Mass: MIT Press.

Colombini, M., Seminara, G. & Tubino, M. 1987. Finite-amplitude alternate bars. *J. Fluid Mech.* **181**, 213-232.

NG72B-0932 1330h POSTER

Evaluation Of Ensemble Forecasts By PECA

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A method called Perturbation vs. Error Correlation Analysis (PECA), which evaluates the ensemble perturbations instead of the forecasts themselves by measuring their ability to explain forecast error variance, is used to evaluate ensemble forecasts from NCEP and ECMWF. Ensemble perturbations from NCEP and ECMWF were found to perform similarly. The error variance explained by either ensemble increases with the number of members and the lead time. The dynamically conditioned NCEP and ECMWF perturbations outperform both randomly chosen perturbations and differences between lagged forecasts ("NMC" method). Thus ensemble forecasts potentially could be used to construct flow dependent short-range forecast error covariance matrices for use in data assimilation schemes.

NG72B-0933 1330h POSTER

Model Valid Prediction Period

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A new concept, valid prediction period (VPP), is presented here to evaluate model predictability. VPP is defined as the time period when the prediction error first exceeds a pre-determined criterion (i.e., the tolerance level). It depends not only on the instantaneous error growth, but also on the noise level, the initial error, and tolerance level. The model predictability skill is then represented by a single scalar, VPP. The longer the VPP, the higher the model predictability skill is. A theoretical framework on the base of the backward Fokker-Planck equation is developed to determine the probability density function (pdf) of VPP.

Verification of a Gulf of Mexico nowcast/forecast model is used as an example to demonstrate the usefulness of VPP. Power law scaling is found in the mean square error of displacement between drifting buoy and model trajectories (both at 50 m depth). The pdf of VPP is asymmetric with a long and broad tail on the higher value side, which suggests long-term predictability. The calculations demonstrate that the long-term (extreme long such as 50-60 day) predictability is not an outlier and shares the same statistical properties as the short-term predictions.

References

Chu P. C., L. M. Ivanov, and C.W. Fan, Backward Fokker-Plank equation for determining model predictability with unknown initial error distribution. J. Geophys. Res., in press, 2002.

Chu P.C., L.M.Ivanov, T.M. Margolina, and O.V.Melnichenko, 2002b: On probabilistic stability of an atmospheric model to various amplitude perturbations. J. Atmos. Sci., in press

Chu P.C., L.M. Ivanov, L. Kantha, O.V. Melnichenko and Y.A. Poberezhny, 2002c: The long-term correlations and power decay law in model prediction skill. Geophys. Res. Let., in press.

NG72B-0934 1330h POSTER

A new class of simple, coupled nonlinear models for the study of planetary climate.

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Models used in climatology have been developed on every level of complexity, ranging from 0-d/0th order models like that of Budyko (1969) and the Daisyworld model of Watson and Lovelock (1983) to full, 3-dimensional General Circulation Models such as the NCAR Community Climate model (CCM3). This rich modeling heirarchy provides a potential basis for understanding climate processes on all space and time scales, but is unfortuntately rarely fully utilized in favor of more exclusive use of complicated models. This situation is at least partially responsible for the discrepancies and difficulties found today in interpreting climate data, since such complex models are not only too expensive to run in ensembles but are also subject to large errors in finite timescales due to a high level of nonlinearity. Therefore they are not suitable for long-timescale integrations.

We demonstrate here how a simple 0-dimensional model developed to reconcile conceptual problems in a Daisyworld model can represent reasonably complex climatic processes in a fully coupled way. Examples of such processes include but are not limited to biota, oceans, dynamic cloud cover, circulations, ice caps, and surface runoff. With such a simple model it is possible to investigate the effects of various parameterizations much more easily, as well as to estimate error and to run ensembles.

NG72B-0935 1330h POSTER

Noise Intensity and Waiting Time Distributions at the Dansgaard-Oeschger Transitions as an Identification of Triggering Mechanism for Climate Shifts

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The transitions into and out of the interstadials are triggered by internal variability in the climate inducing shifts between two stable states of the Atlantic termohaline circulation. By studying the variability of the high resolution $\delta^{18}O$ record at the transition and the waiting time distribution it is possible to distinguish between climatic shifts governed by a stochastic resonance as proposed recently, or if the transitions are purely a result of a barrier penetration triggered by the internal climatic noise. The difference is seen by applying a fluctuation-dissipation theorem for the transition. The results indicate that the distinction between the two models can be made and the transitions should rather be described by the latter scenario.

NG72B-0936 1330h POSTER

A simple analytic benchmark for mantle flow: testing a 3-D spherical stokes solver at one per mil numerical accuracy

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Global mantle convection models have made great progress over the past years owing in large part to numerical advances in 3-D spherical stokes solvers involving (1) the implementation of highly efficient iterative methods based on local basis functions such as finite element or finite volume techniques, (2) scalable parallel algorithms using active message-passing such as MPI, as well as (3) rapid increases in computational resources using, for example, cost-effective dedicated clusters of PCs. The development has already resulted in substantial overall convergence of different modeling techniques employed in mantle convection studies. However, despite this convergence numerous numerical

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validation strategies exist in benchmarking the techniques, although a 3-D spherical so-called European benchmark was suggested by Uli Christensen more than a decade ago. Here we present a simple analytic benchmark for Stokes flow that can be implemented straightforwardly across different numerical solution strategies in order to verify pressure and velocity solutions. Solving the forward problem $A * u = f$ (where A is the Laplacian) analytically for a given velocity field u that is divergence free, we compute a right-hand side f. Subsequently we use our numerical code for the inverse problem $u = A^{-1} * f$ to retrieve u from f. Our numerical modeling code is a modified version of the mantle dynamics code TERRA introduced by Baumgardner 1985, with pressure and velocity defined on a staggered mesh, where an Uzawa algorithm is applied to take the pressure solution step. We observe a divergence reduction from an initial first-guess velocity field by more than six orders of magnitude, confirming the incompressibility constraint is enforced to high numerical accuracy. We also verify 2nd order accuracy for the velocity field with velocity and pressure solutions in agreement of better than one per mil in our high resolution cases. These benchmark results indicate high numerical accuracy for the momentum solution of the TERRA mantle dynamics code.

NG72B-0937 1330h POSTER

Testing A New Model for Quantifying Anisotropic Scale Invariance and Unmixing Geophysical and Geochemical Patterns

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A new power-law model has been proposed to represent the relationship between area of the set consisting of wave numbers with spectral energy density above S (A(>S)) on the 2-D frequency plane and S. Comparing the new model with the commonly used spectral energy density and wave number model, the new model can be used to quantify the anisotropic scaling property whereas the latter may wash out the anisotropy of the field. The power-law relation is exact if the field concerned possessing isotropic scale invariance or generalized scaling invariance involves only rotational and ratio-scale changing transforms. The relation, however, approximates to power-law type for a field with linear generalized scale invariance. The equation is valid for dealing with common exploration geophysical and geochemical fields encountered in mineral exploration and environmental assessment. The S-A filtering technique developed on the basis of the new power-law relation can decompose a mixing field into components on the basis of distinct scaling properties in the frequency domain. It is demonstrated that the method has potential to become a general technique for image processing and pattern recognition. This paper will introduce the principal of the model and several case studies will be used to demonstrate the validation of the model and the application of the S-A method in separation of geophysical and geochemical anomalies from background values in assist in mineral exploration. The testing datasets include Landsat TM images from the Mitchell-Sulphurests Mineral district, northwestern BC; Airborne radiometric data and airborne Magnetic data from Abitibi Greenstone Belt; and Trace element concentration images interpolated from point lake sediment samples from the Nova Scotia, Canada. It has been demonstrated that the model generally holds true for all the testing datasets. More interestedly, the separated anomalous and background components by means of the S-A method on the basis of distinct scaling properties of have shown clear spatial patterns related to mineralization and background geological processes, respectively. The S-A can be suggested as an effective method for separation of anomalies from background for mineral exploration.

URL: http://www.gisworld.org/geodas

NG72B-0938 1330h POSTER

Modeling and Synchronizing Chaotic Systems From Geomagnetic Time Sequences at Etna Volcano

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Natural geomagnetic variations are due to secondary fields induced in the Earth by ionospheric and magnetospheric current systems. These variations point out a strongly dissipative and nonlinear system, which is a necessary condition for the existence of chaotic dynamics. The magnetospheric data analysis revealed an organized evolution, which is a manifestation of low-dimensional magnetospheric dynamics. Moreover, it appears that a relatively small number of magnetospheric state variables dominate the evolution. The entities of these variables are not known at present, and very little of the dynamic system that governs their evolution is understood. The magnetospheric system could be considered as an input-output system perturbed externally by a deterministic solar wind signal. External disturbances of the magnetosphere by the solar wind system make the system non-autonomous.

In this work, data collected from the magnetic monitoring network of Etna volcano are analyzed in a very short sampling interval. We firstly apply a nonlinear time series analysis to examine the behaviour of geomagnetic signal to obtain useful information about the internal deterministic component of a magnetospheric time series. These results reveal the low-dimensional character of the dynamics and give us information about relevant properties of a suitable model for the description of geomagnetic dynamic behaviour. Using a nonlinear forecasting approach, the limited predictive ability has been tested, revealing a strong sensibility to initial conditions, which is a necessary condition for a time series to be chaotic. The dependence of initial conditions represents a difficulty when an analogue model describing the geomagnetic variations should be derived. To overcome this problem, we propose a innovative method for chaotic dynamic system identification using a procedure based on a master-slave synchronization approach. Once a possible internal dynamic of the system has been estimated, a fundamental point is to understand what the major external factors of influence are. In such a way, we make an estimate of a possible external deterministic forces of the system. Certainly, the strong coupling between solar wind parameters, magnetosphere and ionosphere constitute the most significant state variables, which determine the dynamic behaviour.

NG11A MCC: 121 Monday 0830h

Recent Advances in Nonlinear Geophysics I: Model Testing and Validation *(joint with OS, P, S, T)*

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

NG11A-01 0830h

Does Geophysics Need "A new kind of Science"?

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Stephen Wolfram's book "A New Kind of Science" has received a great deal of attention in the last six months, both positive and negative. The theme of the book is that "cellular automata", which arise from spatial and temporal coarse-graining of equations of motion, provide the foundations for a new nonlinear science of "complexity". The old science is the science of partial differential equations. Some of the major contributions of this old science have been in geophysics, i.e. gravity, magnetics, seismic waves, heat flow. The basis of the new science is the use of massive computing and numerical simulations. The new science is motivated by the observations that many physical systems display a vast multiplicity of space and time scales, and have hidden dynamics that in many cases are impossible to directly observe. An example would be molecular dynamics. Statistical physics derives continuum equations from the discrete interactions between atoms and molecules, in the modern world the continuum equations are then discretized using finite differences, finite elements, etc. in order to obtain numerical solutions. Examples of widely used cellular automata models include diffusion limited aggregation and site percolation. Also the class of models that are said to exhibit self-organized criticality, the sand-pile model, the slider-block model, the forest-fire model. Applications of these models include drainage networks, seismicity, distributions of minerals,and the evolution of landforms and coastlines. Simple cellular automata models generate deterministic chaos, i.e. the logistic map.

NG11A-02 0845h INVITED

Assessing uncertainty in mesoscale numerical weather prediction models

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Current methods of meteorological forecasting are largely deterministic and produce predictions with unknown levels of uncertainty. Specifically, forecast errors and uncertainties arise from an incomplete knowledge of initial conditions and from shortcomings in model physics. We report on the early stages of a project aimed at developing calibrated probabilistic forecasts based on operational ensembles of mesoscale numerical weather predictions. Our approach builds on the general ideas of Bayesian model averaging, conditionally heteroscedastic regression, and simulation-enhanced ensembles. Joint work with Fadoua Balabdoui, Yulia Gel and Anton Westveld.

NG11A-03 0900h INVITED

Discriminating Cloud Over ice Using MISR Data

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The uncertainties in the radiative feedback to climate by clouds pose the most formidable obstacle to climate prediction by General Circulation Models (GCMs). Particularly, in polar regions where the ice and snow cover the ground, the net radiative impact of clouds is uncertain (Charlock and Ramanathan 1985; Li and Leighton 1991). One of the reasons for this uncertainty is that scene identification and cloud detection remain difficult over snow- and ice-covered surface.

MISR (Multi-angle Imaging SpectroRadiometer) is a sensor in EOS, and contains nine cameras looking at the earth from different angles simultaneously. Its multi-angle information allows a relatively new approach for discriminating cloud from snow/ice. In this talk, we propose a novel method to discriminate cloud over ice based on MISR observations. Demonstrations and validations of the proposed method will also be given based on MISR data from the polar regions.

NG11A-04 0915h

The Risk of Spurious Model Validation, An Illustration with Cloud Remote Sensing Data

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Dynamical models with many degrees of freedom (i.e., spatial grid-points) that claim to be realistic should reproduce the structure and evolution of the geophysical fields they represent over a large range of spatial- and temporal scales, not just large domain averages and their slow tends in time. Atmospheric-, oceanic- and coupled general circulation models (GCMs) as well as meso-scale and micro-scale models