Nonlinear Geophysics

NG11A MC: 131 Monday 1045h

Scaling Geophysics: Where We've Been, Where We're Going I *(joint with A, G, H, OS, S, SA, T, V)*

Presiding: **D Schertzer,** Universite P. et M. Curie**; R Lawford,** NOAA

NG11A-01 1050h INVITED

Dynamic renormalization of multifractal fields

Roberto Benzi
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We discuss in this talk how the statistical properties of time-dependent multifractal fields.

We show that the constrains imposed by the equations of motions (if any) induce a dynamic renormalization of the scaling exponents in a non-trival way.

We present some results based on random multiplicative model. Finally, we discuss the relevance of our findings for time-space rainfall analysis.

NG11A-02 1105h INVITED

Multifractality of Geophysical Flows: from Scaling Exponents to Description of Real Flows

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Multifractal scaling of turbulence was considered one of the central and mysterious features of turbulence. Now, after more thanforty years of research, the origin and the magnitudes of the exponents can be obtained directly from the Navier-Stokes equations.

How important is this knowledge for accurate description of the real-life flows? Recent studies indicated that a general turbulent flow develops the large-scale structures (condensates) , which reflects non-universal (i.r. divergent) properties of the flow. This symmetry breaking leads to the superposition of the ordered (condensate) and disordered (universal, multifractal) phases. The large-scale component, which is largely responsible for the heat and mass transfer, must be accurately predicted if we want to achieve quantitative predictions.

In an interesting example of the Kolmogorov inverse cascade, where the multifractality is absent, the condensates are manifested as jets, strong vorteces or combination of both. The possibility of an effective equation of motion,predicting the large-scale features will be discussed and demonstrated.

NG11A-03 1120h INVITED

Dynamical Origin of the Anoamalous Transport of Passive Particles

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Anomalous transport of passive particles is considered from the dynamical point of view. We are able to formulate general principles how the phase space topology can influence the appearance of sticky trajectories and, as a result, superdiffusional or Levy-type processes.

A general approach to particle chaotic dynamics is based on the space-time fractional description known as fractional kinetics. The kinetic equation is defined by at least two critical exponents that characterize fractional properties of space and time behavior of trajectories. Using microscopic evaluations of the sticky domains properties and the renormalization group approach, we have calculated the critical exponents from the first principles.

The theory shows how one can consider different complicated systems and how to control them. The illustrations are proposed for passive particles dynamics in the system of point vortices.

NG11A-04 1135h INVITED

Modeling Multiscale Phenomena in Nonlinear Systems: Applications of Scale-invariance in LES of Turbulent Flows

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Several applications of scaling and scale-invariance in numerical predictions of turbulent flows (large-eddy simulations - LES) will be reviewed. In one example, we show how the empirical observations of self-affinity of turbulent fields can be exploited to formulate a fractal closure for the subgrid-scale stresses (Scotti & Meneveau, Physica D 1999). Initial applications, so far restricted to isotropic turbulence, have highlighted important issues related to dynamical phase information that needs to be included alongside fractal descriptions. In a different approach, scale-invariance is also used in the so-called dynamic Smagorinsky model for LES. We review our experiences in applying this model to LES of neutrally buoyant atmospheric boundary layers and show that it can be generalized to allow for scale dependent behavior in the vicinity to the ground (Porte-Agel, Meneveau & Parlange, J. Fluid Mech. 2000). Some future directions for research will be highlighted.

NG11A-05 1150h INVITED

Horizontal Scaling in the Up and Down Branches of the Brewer-Dobson Circulation

Adrian F. Tuck (1-303-497-5485; tuck@al.noaa.gov); Susan J. Hovde[1] (1-303-497-5217; hovde@al.noaa.gov); David W. Fahey[1] (1-303-497-5277); Ru-Shan Gao[1] (1-303-497-5431; gao@al.noaa.gov); Kenneth K. Kelly[1] (1-303-497-3355); Erik C. Richard[1] (1-303-497-3536); Thomas L. Thompson[1] (1-303-497-3410)

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We examine ER-2 data from the airborne polar ozone missions of 1987 (AAOE), 1989 (AASE), 1997 (POLARIS) and 2000 (SOLVE), using the Lovejoy and Schertzer 3-exponent approach, with the Levy Index (alpha), persistence (H1) and intermittency (C1) to characterize the scaling for atmospheric fluid motion and chemistry in the downward branch of the Brewer-Dobson circulation at high latitudes. It is demonstrated that neither 2D horizontal or 3D isotropic theories of atmospheric turbulence are consistent with the observations. Scaling results are used to obtain rates of adiabatic mixing and diabatic descent for the inner vortex region. The scaling of ozone is shown to be a balance between intermittency induced by PSC processing and persistence induced by solar radiative driving of the photochemistry. The same scaling techniques are applied to WB57F and a few ER-2 flights in the potential temperature range 350 to 415 K near the tropopause at tropical and subtropical latitudes, to examine scaling behavior in the upward branch of the Brewer-Dobson circulation. Inferences are made about the nature of the transport processes in the region. Looking to the future, we consider the improvements necessary in instrumental and platform performance needed to establish, observationally, physical and chemical causality in the reacting, turbulent atmosphere.

NG11A-06 1205h INVITED

Fractal Scaling Applied to Time Series of Ground-based Measurements of the Atmosphere

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The Atmospheric Radiation Measurement (ARM) Program has been collecting ground-based measurements of the atmosphere for several years. These time series are amenable to analysis by fractal techniques. We have analyzed time series from microwave radiometers and cloud radars. The results show promise in terms of identifying aspects of instrument performance and time series behavior. However, the question of whether these analyses bring new insights into the physical processes of the atmosphere remains to be answered. In this presentation, we examine this dilemma.

NG12A MC: 308 Monday 1330h

Scaling Geophysics: Where We've Been, Where We're Going II *(joint with A, G, H, OS, S, SA, T, V)*

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NG12A-01 1330h INVITED

MULTISCALE ANALYSIS OF FLOODS ON SELF-SIMILAR RIVER NETWORKS

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River flows shape landforms and create channel networks, and the space-time dynamics of river flows depends on the geometry and hydraulic-geometry of networks. This reciprocal coupling between channel networks and river flows is depicted in empirical power-law relationships that have been observed within the last fifty years. However, only in the last decade, systematic attempts have been made to begin to understand these empirical power laws on the basis of mathematical ideas of scale invariance and scale dependence (Gupta and Waymire, 1998). I will illustrate some elements of a new physical-statistical hydrologic theory in interpreting recent empirical multiscale spatial observations involving floods or peak flows. These developments also point to the urgent need for carrying out new field experiments and data collection programs to test specific hypotheses. A long-term goal is to develop site specific mathematical models for making predictions from basins that have inadequate stream flow data in space and time. Referred to as, poorly gauged and ungauged, most basins worldwide fall into this category.

NG12A-02 1345h INVITED

Ensemble of Premonitory Seismicity Patterns

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Uniform scaling and renormalization of premonitory seismicity patterns is demonstrated in the models and data analysis. Patterns reflect four paradigms in earthquake prediction: (i) existence of several types of premonitory transformation of seismicity; (ii) long-range interactions; (iii) similarity; and (iv) dual origin of PSPs (partly universal and partly Earth-specific).

NG12A-03 1400h INVITED

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Recent statistical studies indicate that the magnitude-frequency relation for earthquake mainshocks is not scale independent. A number of geophysical observations indicate consistency of the statistics with a fracture model for larger earthquakes that