effects of climate variability and terrain focused on the spatial patterns of the codimensions of rainfall time-series (convex time scaling exponents) for all raingauge locations and precipitable water fluxes on the NCEP re-analysis grid over two time-periods: 1950 to 1970 and 1971 to 1997. Overall, the analysis resulted in consistent estimates of multifractal parameters over both time and space. Over short durations (1 to 30 days), the spatial variability exhibited by the codimensions is consistent with synoptic weather patterns. Daily codimensions along the Atlantic and Gulf coasts decreased over time, which coincided with increased coastal precipitation maxima in the second period. Elsewhere, the changes were not statistically significant, although it should be noticed that differences between the two periods at any location are larger that the spatial differences associated with orographic precipitation enhancement. Over longer durations (1 to 12 months), spatial variations in rainfall accumulations suggest an intensification of orographic enhancement effects (> 500 m elevations). The scaling behavior of precipitable water fluxes was similar to that of the raingauge data in that the spatial patterns of the co-dimensions at short time-scales reflect the predominant synoptic scale weather patterns, while at seasonal to interannual timescales the variability is controlled by regional orography. Building upon this study, a framework for risk assessment of the severity extreme events for climate impacts' studies at regional and global scales is presented. Douglas, E. and Barros, A.P., 2003: Probable Maximum Precipitation Estimation Using Multifractals: Application in the Eastern United States. J. Hydrometeorology, Vol. 4, No. 6, 1012-1024.

NG21A-03 0900h INVITED

Atmospheric Turbulence Structure and Precipitation Occurrence in a Tropical Climate

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Our work presents a connection between the estimated structure of turbulence in the lower atmospheric boundary layer and the probability of occurrence of a convective storm at the location of estimation, in a tropical climate. The same-day predictive capability of turbulent structure is being evaluated, given that during the rainy season, tropical storms develop in a matter of less than an hour, so a forecast lead time of only a few hours can therefore be useful. The evaluation procedure has been run on data collected in 1999 during the TRMM-LBA project at a site in Rondonia, Brazil, and the results have been found to be very encouraging.

NG21A-04 0915h

Modeling Hydrothermal Mineralization: Fractal or Multifrcatal Models?

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Hydrothermal mineralization occurs when the natural geo-processes involve the interaction of ore material-carrying hydrothermal fluids with rocks in the earth's crust in a specific geological environment. Mineralization can cause element concentration enrichment or depletion in the country rocks. Local enrichment may form ore body that can be mined for profit at the current economic and technological conditions. To understand the spatial distribution of element concentration enrichment or depletion caused by mineralization in a mineral district is essential for mineral exploration and mineral prediction. Grade-tonnage model and mineral deposits size distribution model are common models used for characterizing mineral deposits. This paper proposes a non-linear mineralization model on the basis of a modified classical igneous differentiation mineralization model to describe the generation of multifractal distribution of element concentration in the country rocks as well as grade-tonnage fractal/multifractal distribution of ore deposits that have been often observed in hydrothermal mineralization. This work may also lead to a singularity model to explain the common properties of mineralization and mineralization-associated geochemical anomaly diversity and the generalized self-similarity of the anomalies. The model has been applied to a case study of mineral deposits prediction and mineral resource assessment in the Abitibi district, northern Ontario, Canada.

NG21A-05 0930h INVITED

Seveso 1986, Chernobyl 1976: a physicist' look at 2 ecological disasters

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Seveso suffered a chemical accident with a severe loss of supertoxic material (TCCD) released in the atmosphere; Chernobyl was a world known nuclear accident. The pollution induced by the two accident are analysed in term of fractal models. The first case involved a limited micro ecological system; the second one spread over a macro ecological system. The pollution is reproduced by means of simple Fractal Sum of Pulses models in the Seveso region; for the Chernobyl accident in northern Italy and in several european Countries. The 2 accidents are also analysed in terms of Universal Multifractals showing that thethe parameters α and C_1 are those describing respectively rainfall (Seveso) and cloud formation (Chernobyl).

NG21A-06 0945h INVITED

El Niño Model Identification: Deterministic or Stochastic?

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There is an ongoing discussion about the dynamical properties of El Niño/Southern Oscillation (ENSO). According to one hypothesis ENSO can be fully described as a low dimensional chaotic process. A second hypothesis states that stochastic forcing has to be taken into account. Deciding for one hypotheses by fitting different model classes to observational data appears to be difficult: Conceptual models might all be rejected in statistical terms because of high discrepancies due to the too simple model structure. On the other hand too complex models lead to overfitting, inhibiting any significant selection due to the lack of data. We rather focus on another strategy for model identification by defining characteristics that have to be reproduced by a useful model. Recently the relation between amplitude and period of oscillations in conceptual ENSO models has been investigated. We suggest to choose this relation as a criterion for model identification. This way we present a detailed study for different ENSO models of intermediate complexity as well as for real data.

NG22A CC: 516 D Tuesday 1030h

Scaling and Fractals in the Earth, Atmosphere, and Hydrosphere: Resolution Dependence and Nonlinear Variability III

Presiding: **J Pomeroy,** University of Saskatchewan**; S Lovejoy,** McGill University

NG22A-01 1030h INVITED

Use of Radar Profilers as Tools for the Determination of Space-Time Variability of Precipitation

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For remote sensing of precipitation from radar and satellites to fulfill its ultimate potential it will be necessary to improve the precision of rain retrievals and to optimize the assimilation of the data into numerical models. It is well known from developments in data assimilation that for optimal performance models require information on the error covariance of the parameter being measured. In general, this means information is required on the measurement error of instruments as well as the representativeness of the measurements themselves. In the case of precipitation measurement it is necessary to develop more information on the variability of precipitation fields within precipitating cloud systems. This presentation considers approaches to the determination of space time variability of precipitating cloud systems using profilers and scanning radars.

NG22A-02 1045h INVITED

Multifractal prediction of hydrological extremes and the RIO research program

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One of the main research themes of the current RIO (Risque Inondation / Flood Risk) program of the Ministry of Environment in France is the prediction of extreme hydrological events and the development of new tools for their prediction, prevention and alert. Deterministic models based on various physical and/or statistical approaches are still not capable to capture the phenomena of extreme precipitation and floods. It is well known that one of the main difficulties for the description of hydro-meteorological extremes is the colossal variability of their intensities over a wide range of space-time scales. To contribute to the RIO program, our group uses the multifractal framework not only to explain the power-law fall-off of probability distributions for hydrological-meteorological extremes, but also to explore a link between the observed variability and the underlying physics. We analyze space-time distributions of precipitation and discharges over widely different hydrological regions. A multifractal data analysis performed in the space-time domain produces - amongst other results - a physically-based tool for the clear distinction and multifractal description of flash-floods. We illustrate these methods on two recent flooding events in France: the Abbeville phreatic floods in 2001 and the flash floods in Gard in 2002.

URL: http://www.multifractal.jussieu.fr

NG

NG22A-03 1100h

Are snowcovers monofractal or multifractal?

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Previous research has identified the spatial variability of snowcovers as being fractal at very small scales, transitioning to random variability at scales larger than a fractal cutoff. The fractal component of the variability has been identified as the primary cause of the observed fractal geometry of partially ablated snowcovers, and as the primary source of the frequency distribution of snow water equivalent (SWE) in the original snowcover. To date, the simple monofractal model has been sufficient to explain observed snowcover behaviors for individual landscape units. Given the widespread evidence of multifractality in geophysical data sets, it was hoped that its presence might be used to describe snowcovers at large scales. Accordingly, linear transects of snow depth were analyzed using the method of trace moments. In simple landscapes (no trends in data, a single landform and vegetation type), the fractal portion of the SWE variation appears to be monofractal. Transects across a large valley also show no signs of multifractality, although they do display evidence of deterministic variation at large scales. Some evidence of multifractality at small scales appears to exist for transects where the SWE increases or decreases monotonically or where a single large drift is present on otherwise open ground. It appears that the observed multifractality is due to combining data from distributions that would normally be considered as being separate. Because the maximum scale of multifractality is limited by the fractal cutoff, which is very small (typically less than 100m), snowcovers in complex landscapes can be represented as being composed of adjacent monofractal distributions of SWE.

NG22A-04 1115h INVITED

Scale-Dependent Hydraulic Conductivity in Anisotropic Media: A Dimensional Effect

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As in the case of dispersion in flow through porous media, it is often assumed that the hydraulic conductivity, K, naturally increases with scale of an experiment. The effective value of K has, in general, no relationship with a geometric mean value of K; only the remarkable coincidence that the two-dimensional percolation threshold is 50% could support such a generalization. But since percolation thresholds in 3D are typically much less than 50%, it is possible to find infinite interconnected paths of high conductivity, which only sample the fastest 5-10% of the medium, depending on the system. In small realizations, it is possible to find interconnected paths, which are even more highly conductive, leading to positive corrections on K, which, however, diminish asymptotically with approach to infinite size. Because the effective K can thus be much larger than the geometric mean value of K, introducing additional heterogeneity with increasing scale can easily lead to suites of measured K values with means that increase dramatically with scale. Interpretation of this as a “scale effect” reveals inaccurate theory. More importantly, however, real increases in K with scale can be predicted for anisotropic media, or for strongly non-equidimensional volumes. However, the cause of such increases, as predicted in percolation theory, is traced to a cross-over in the dimensionality of conduction; from 1D at small scales, to 3D at large scales. Results from percolation theory compare favorably with experimental results from Wisconsin carbonate aquifers. Thus it is suggested that apparent increases in K as a function only of scale result also from inability to isolate the scale variable.

NG22A-05 1130h

Nonlinearity of Climate Change in the Past 420,000 Years

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Evidence of past climate variations are stored in polar ice caps and indicate glacial-interglacial cycles of ∼100kyr. Using advanced scaling techniques we study the long-range correlation properties of temperature proxy records of four ice cores from Antarctica and Greenland. These series are long-range correlated in the time scales of 1-100kyr. We show that these time series are nonlinear for time scales of 1-100kyr as expressed by temporal long-range correlations of magnitudes of temperature increments. Our results suggest that temperature increments appear in clusters of big and small increments—a big (positive or negative) climate change is most likely followed by a big (positive or negative) climate change and a small climate change is most likely followed by a small climate change. We then suggest two nonlinear stochastic models for glacial-interglacial dynamics that exhibit similar nonlinear properties as in the data. We conjecture that interaction between fast random fluctuations (representing atmospheric variability) and slowly varying fluctuations (representing oceanic variability) may underlie the observed nonlinearity of time series for glacial-interglacial oscillations.

NG22A-06 1145h

Numerical Tests of Asymptotic Single Scattering Statistics in Universal Multifractal Clouds

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In previous contributions we have presented asymptotic forms for single scattering statistics in thick universal multifractal clouds with parameters $1 < \alpha < 2$ and $H = 0$. An essential feature was that short- and long-photon paths exhibit qualitatively different scaling behaviors. In the near regime the direct transmission is approximately exponential with a renormalized extinction coefficient $\kappa_{eff} < \kappa$, where the transmission behaves as if all scattering were from the most probable singularity in the cloud density field. In the far regime, the transmission falls off much more slowly (on account of "Levy holes"). A study of the moments of the photon pathlengths also supports this idea. The negative moments obey a scaling law algebraic in κ, while the positive moments follow logarithmic scaling according to $(\log \kappa)^{-\alpha}$. We present now the results of numerical simulations (Monte Carlo and discrete angle radiative transfer equations) that address the degree to which the above are relevant to light scattering in real clouds. Three issues are addressed. First, the asymptotic formulas rely on the underlying assumption that the actual multifractal water density field over all but the largest length scales may be replaced by the bare field developed to the same scale. A second issue is that real cloud density fields are not conserved but have $H \approx 1/3$. Finally, we have argued that if density correlations are ignored the multiple scattering should be well-described by an even softer effective extinction coefficient $\kappa_{eff} \approx (\log \kappa)^{\alpha/2}$. We examine the validity of this conjecture and the degree to which correlations require modification.

NG23A CC: 220 C-E Tuesday 1330h

Scaling and Fractals in the Earth, Atmosphere, and Hydrosphere: Resolution Dependence and Nonlinear Variability IV Posters

Presiding: **S Ratti,** Instituto di Physica Nucleare**; F Agterberg,** Canadian Geological Commission

NG23A-01 1330h POSTER

Fractal Aircraft Trajectories, Scaling Stratification, Nonclassical Turbulent Exponents

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The dimension (D) of aircraft trajectories is fundamental in interpretating airborne data. To estimate D, we studied data from 18 trajectories of stratospheric aircraft flights 1600km long taken during a "Mach cruise" (near constant Mach number) autopilot flight mode. Mach cruise implies correlated temperature and wind fluctuations so that $\Delta Z \approx \Delta x^{H_z}$ where Z is the (fluctuating) vertical and x the horizontal coordinate of the aircraft. Over the range ≈ 3 to 300km, we found $H_z \approx 0.58 \pm 0.02$ close to the theoretical 5/9=0.56 and implying $D = 1 + H_z = 14/9$ i.e. the trajectories are fractal. For distances < 3 km aircraft inertia smooths the trajectories, for distances > 300 km, D=1 again because of a rise of 1m/km due to fuel consumption. In the fractal regime, the horizontal velocity and temperature exponents are close to the nonclassical fractal value $H_K = 1/2$ (rather than the Kolmogorov value $H_K = 1/3$). Taking into account (multifractal) intermittency corrections, this implies the corresponding spectral slopes =1.9. We also discuss ESS and cross-ESS estimates of multfractal exponents. We show that there exists a critical average trajectory slope $s = \Delta x/l_s)^{H_z - 1}$; when the aircraft exceeds this, the velocity, temperature fluctuations are dominated by the vertical rather than horizontal statistics; ls is the scale where average horizontal and vertical temperature and velocity fluctuations are equal, we find it to be ≈ 4 cm (although it fluctuates depending on energy and buoyancy force variance fluxes). At this scale, even even small deviations from perfectly flat horizontal trajectories (of the order of 1m/km) will lead to Bolgiano-Obhukov ($H_{BO} = 3/5$) rather than H_F = or H_K. We show that this can explain recently published data from MOZAIC; we also review over a dozen other aircraft and radiosonde experiments showing that they are all compatible with the 23/9 dimensional unified scaling model. Finally we compare this with some direct estimates of H_z from passive scalar surrogates (lidar backscatter of pollution) with shows $H_z = 0.56 \pm 0.02$.

NG23A-02 1330h POSTER

Monte-Carlo and Sparse Matrix Radiative Transfer Calculations on Multifractal Clouds: Flux Tubes and Singularities

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A current challenge of climate modeling is that general circulation model results are extremely sensitive to parameterizations of the poorly understood cloud/radiation interactions. In order to work out some fundamental problems occurring in radiative transfer in the atmosphere, one first needs a physically based model of cloud liquid water density which is able to yield realistic radiance multifractal variability over ranges spanning thousands of kilometers down to less than a meter. Indeed, analysis of nearly 1000 satellite and in situ cloud radiances has shown (in both infrared and visible wavelengths) that the radiances fields are highly multifractal on such huge ranges of scales. After discussing some technical points needed to obtain accurate liquid water density multifractal statistics, we then use both Monte-Carlo techniques as well as new (highly accurate, rapid) sparse matrix methods to simulate the radiative transfer in the cloud and relate scale by scale the resulting radiation fields and the scattering statistics to those of the cloud. Theoretically based on closure techniques, we have predicted that in multifractal clouds, the popular ‘independent pixel approximation’ (IPA) should work except when applied to radiation flux tubes; and the latter are expected to be fractals. We directly test this hypothesis on the simulations.

NG23A-03 1330h POSTER

Scaling Anisotropy in Cloud Satellite Images at Mid-Latitudes: Directional Structure Function Measurements and Exponents Determination

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Motivation We investigate scaling anisotropy in cloud images. Even if these images look pretty much