Geophysical Research Abstracts
Vol. 14, EGU2012-5772-1, 2012
EGU General Assembly 2012

Stochastic downscaling of numerically simulated spatial rain and cloud fields using a transient multifractal approach

M. Nogueira (1,2), A. P. Barros (2), and P. M. Miranda (1)

(1) IGIDL, University of Lisbon, Portugal (mdnogueira@fc.ul.pt), (2) Pratt School of Engineering, Duke University, Durham (NC), U.S.A

Atmospheric fields can be extremely variable over wide ranges of spatial scales, with a scale ratio of 10^9-10^{10} between largest (planetary) and smallest (viscous dissipation) scale. Furthermore atmospheric fields with strong variability over wide ranges in scale most likely should not be artificially split apart into large and small scales, as in reality there is no scale separation between resolved and unresolved motions. Usually the effects of the unresolved scales are modeled by a deterministic bulk formula representing an ensemble of incoherent subgrid processes on the resolved flow. This is a pragmatic approach to the problem and not the complete solution to it. These models are expected to underrepresent the small-scale spatial variability of both dynamical and scalar fields due to implicit and explicit numerical diffusion as well as physically based subgrid scale turbulent mixing, resulting in smoother and less intermittent fields as compared to observations. Thus, a fundamental change in the way we formulate our models is required.

Stochastic approaches equipped with a possible realization of subgrid processes and potentially coupled to the resolved scales over the range of significant scale interactions range provide one alternative to address the problem. Stochastic multifractal models based on the cascade phenomenology of the atmosphere and its governing equations in particular are the focus of this research. Previous results have shown that rain and cloud fields resulting from both idealized and realistic numerical simulations display multifractal behavior in the resolved scales. This result is observed even in the absence of scaling in the initial conditions or terrain forcing, suggesting that multiscaling is a general property of the nonlinear solutions of the Navier-Stokes equations governing atmospheric dynamics. Our results also show that the corresponding multiscaling parameters for rain and cloud fields exhibit complex nonlinear behavior depending on large scale parameters such as terrain forcing and mean atmospheric conditions at each location, particularly mean wind speed and moist stability. A particularly robust behavior found is the transition of the multiscaling parameters between stable and unstable cases, which has a clear physical correspondence to the transition from stratiform to organized (banded) convective regime. Thus multifractal diagnostics of moist processes are fundamentally transient and should provide a physically robust basis for the downscaling and sub-grid scale parameterizations of moist processes.

Here, we investigate the possibility of using a simplified computationally efficient multifractal downscaling methodology based on turbulent cascades to produce statistically consistent fields at scales higher than the ones resolved by the model. Specifically, we are interested in producing rainfall and cloud fields at spatial resolutions necessary for effective flash flood and earth flows forecasting. The results are examined by comparing downscaled field against observations, and tendency error budgets are used to diagnose the evolution of transient errors in the numerical model prediction which can be attributed to aliasing.