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Detection of intermittent events in atmospheric time series

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The modeling approach in atmospheric sciences is based on the assumption that local fluxes of mass, momentum, heat, etc... can be described as linear functions of the local gradient of some intensive property (concentration, flow strain, temperature,...). This is essentially associated with Gaussian statistics and short range (exponential) correlations. However, the atmosphere is a complex dynamical system displaying a wide range of spatial and temporal scales. A global description of the atmospheric dynamics should include a great number of degrees of freedom, strongly interacting on several temporal and spatial scales, thus generating long range (power-law) correlations and non-Gaussian distribution of fluctuations (Lévy flights, Lévy walks, Continuous Time Random Walks) [1]. This is typically associated with anomalous diffusion and scaling, non-trivial memory features and correlation decays and, especially, with the emergence of flux-gradient relationships that are non-linear and/or non-local in time and/or space.

Actually, the local flux-gradient relationship is greatly preferred due to a more clear physical meaning, allowing to perform direct comparisons with experimental data, and, especially, to smaller computational costs in numerical models. In particular, the linearity of this relationship allows to define a transport coefficient (*e.g.*, turbulent diffusivity) and the modeling effort is usually focused on this coefficient. However, the validity of the local (and linear) flux-gradient model is strongly dependent on the range of spatial and temporal scales represented by the model and, consequently, by the sub-grid processes included in the flux-gradient relationship.

In this work, in order to check the validity of local and linear flux-gradient relationships, an approach based on the concept of *renewal critical events* [2] is introduced. In fact, in renewal theory [2], the dynamical origin of anomalous behaviour and non-local flux-gradient relation is associated with the occurrence of critical events in the atmospheric dynamics. The critical events are associated with transitions between meta-stable configurations. Consequently, this approach could give some effort in the study of Extreme Events in meteorology and climatology and in weather classification schemes. Then, the renewal approach could give some effort in the modelling of non-Gaussian closures for turbulent fluxes [3].

In the proposed approach the main features that need to be estimated are: (a) the distribution of life-times of a given atmospheric meta-stable structure (Waiting Times between two critical events); (b) the statistical distribution of fluctuations; (c) the presence of memory in the time series. These features are related to the evaluation of *memory content* and *scaling* from the time series. In order to analyze these features, in recent years some novel statistical techniques have been developed. In particular, the analysis of Diffusion Entropy [4] was shown to be a robust method for the determination of the dynamical scaling. This property is related to the power-law behaviour of the life-time statistics and to the memory properties of the time series. The analysis of Renewal Aging [5], based on renewal theory [2], allows to estimate the content of memory in a time series that is related to the amount of critical events in the time series itself.

After a brief review of the statistical techniques (Diffusion Entropy and Renewal Aging), an application to experimental atmospheric time series will be illustrated.

References

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