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Multifractal downscaling: physical principles and application to GCM's

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A fundamental issue for GEWEX and related research is our capacity to downscale global and regional data and GCM outputs to much smaller space-time scales. We will first argue that some physical principles are indispensable to avoid the limitations of ad-hoc procedures, and in particular that the search for invariance properties across scales should guide the development of downscaling models. In this respect, we discuss the interest of cascade models that model a hierarchy over a wide range of space-time scale of the dynamical structures and processes that transport and distort fields such as the water content. These models yield extremely intermittent small scale fields. They are generically multifractal in the sense that regions of high activity (e.g. high transfer of water content to smaller scales) have much lower dimensions than those of low activity, i.e. an infinite hierarchy of dimensions characterizes the different levels of activity. As a case study, we downscale the montlhy DEMETER predictions (EU project "Development of a European Multimodel Ensemble system for seasonal to inTERannual prediction" based on 7 European GCM's) from their coarse resolution (e.g., 256 km x256 km x 1month) to finer hydrological model resolution (e.g., 1kmx1kmx1day). We first perform a time/scale and space-time multifractal analysis of the PRECIP database of Météo-France to evaluate the universal multifractal exponents, as well as the anisotropy/dynamical exponent of the generalised space-time scale. We show that these exponents are quite robust and enable us to perform space-time downscaling down to micro-scale of meso-scale data. We discuss the correspond-

ing analytical results, such as the Almost Surely Probable Maximal Precipitation, as well as the quality and various uses of numerical simulations. We greatly acknowledge the financial support from Electricité de France, as well as Météo-France for providing access to the PRECIP database.