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Observation of a phase transition in the multifractal spectra of turbulent temperature fluctuations at a forest canopy top

Sylvain Dupont (1), Evgeniya Gerasimova-Chechkina (2), Mark Irvine (1), and Alain Arneodo (3)

(1) ISPA, INRA, Bordeaux Sciences Agro, F-33140 Villenave d'Ornon, France, (2) Laboratory of Physical Foundation of Strength, Institute of Continuous Media Mechanics UB RAS, Perm, Russia, (3) Laboratoire Ondes et Matiere d'Aquitaine, CNRS UMR5798, Université de Bordeaux, 33405 Talence, France

Understanding turbulence at the top of vegetation canopy is crucial for better quantifying momentum, heat and mass exchanges between canopy and the above atmosphere. Here we use the wavelet transform modulus maxima (WTMM) method to perform a multifractal analysis of air temperature time-series collected at a pine forest canopy top for different atmospheric stability regimes. We show that the multifractal spectra exhibit a phase transition as the signature of the presence of strong singularities corresponding to sharp temperature drops (resp. jumps) bordering the so-called ramp (resp. inverted ramp) -cliff patterns commonly observed in unstable (resp. stable) atmospheric conditions and previously suspected to contaminating and possibly enhancing the internal intermittency of (scalar) temperature fluctuations. Under unstable (resp. stable) atmospheric conditions, these 'cliff' singularities are indeed found to be hierarchically distributed on a 'Cantor-like' set and surrounded by singularities of weaker strength typical of intermittent temperature fluctuations observed in homogeneous and isotropic turbulence. Under near-neutral conditions, no such a phase transition is observed in the temperature multifractal spectra which is a strong indication that the statistical contribution of the 'cliffs' is not important enough to account for the stronger intermittency of temperature fluctuations when compared to corresponding longitudinal velocity fluctuations.