Geophysical Research Abstracts
Vol. 17, EGU2015-15351-1, 2015
EGU General Assembly 2015

Lewis Fry Richardson Medal Lecture: Motionless travel across scales: Gulliver's scale free geophysics and the Pandora's multifractal box.

Daniel Schertzer
U. Paris-Est, Ecole des Ponts ParisTech, LEESU, France

The EGU's 2015 theme "a voyage through scales" is a recognition of the wild variability of geophysical fields over wide ranges of scales. However, we cannot forget Samuel Becket's criticism of all voyages: "We don't travel for the fun of it, as far as I know; we're foolish, but not that foolish." Such travels would be in fact hardly manageable: atmospheric dynamics are already beyond the yotta scale (10^{24})!

Fortunately, Pandora's box has been opened enough to take us on a motionless travel across scales *à la Gulliver*. Scale symmetry is becoming generalized to the point that geophysical systems can be perceived as fixed points of (generalized) space-time contractions/dilations, depending on the side of the Wonderland mushrooms bitten by Alice. The now dated scale dependent observables are going to be replaced by scale independent singularities yielding scale free (nonlinear) geophysics.

The (not yet solved) millennium problem of hydrodynamic turbulence is surprisingly a pedagogical example to illustrate what is at stake and motivated a series of paradigm shifts. Indeed, this problem can be stripped down to a network of triadic interactions. This graphically highlights how field components "talk" to each other, i.e. how an infinitely small perturbation propagates through this network. This points out the dead ends of previous approaches (e.g. quasi-normal assumptions) and provide a first tier of concepts such as: multifractal cascades, singularities, universality, phase transitions and predictability limits.

These concepts already provide a wealth of non trivial results, particularly the emergent "dressed" properties generated by the whole set of interactions with respect to the "bare" properties resulting from a scale truncation. Their extremes can be qualitatively different, having respectively "heavy" and "thin" tailed probability distributions. Moreover, the ubiquitous anisotropy of geophysical fields and patterns required another paradigm shift: a generalized notion of scale had to supersede the Euclidean metrics, which had surprisingly remained a building block of the 'Fractal Geometry of Nature'. Geophysics also required vector or manifold valued cascades, which can be obtained by exploring the Lie algebra of their symmetry generators. Sounds cumbersome? This task turns out to be both stimulating and visually appealing! This approach can be illustrated with the help of the mysterious wobble of Hyperion and gyroscopes, which in a given way puts a damper on the long lasting Lilliputian disagreement between the Big Enders and the Little Enders on determinism and stochastics. These generalizations open ways to understand and simulate (not without aesthetic pleasure!) geophysical turbulence, precipitation, clouds, climate, hazards, resilience and other Wonderland phenomena.