MASTER THESIS PROPOSAL

Title: Multifractal analysis of surface temperature of a vegetated canopy

Supervisors:

- Alain Arneodo, CNRS Research Director emeritus, Laboratoire Ondes et Matière d'Aquitaine (LOMA), Turbulence and Instability team (T-IN)
- Sylvain Dupont, INRA Research Director, UMR Interactions Sol-Plante-Atmosphère (ISPA), Environmental Mechanics team

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Summary:

Dynamic systems in nature are often characterized by a complex spatial-temporal structure with strong irregularities involving a large range of spatial scales. Instantaneous fluctuations of vegetation surface temperature are one of these complex systems exhibiting a strong spatial-temporal variability related in particular to the atmospheric turbulence. This variability is in particular constraining for interpreting high-resolution infrared (IRT) remote sensing measurements, as planned in the future space missions HyspIRI (NASA, USA) or THIRSTY (CNES, NASA, ISRO). This variability has to be quantified in order to assess in which extent IRT measurements at the proposed spatial resolution (60-80 m) will be representative of average surface temperatures.

Turbulence at vegetation canopy top is highly intermittent due to the occasional penetration of strong wind gusts within the canopy (Dupont et Patton, 2012). This turbulence depends on the thermal stability of the atmosphere. In unstable condition (daytime under sunny day), the turbulence is mostly buoyantly-driven and characterized by strong convective structures scaling with the atmospheric boundary layer, while in neutral condition (beginning of the day), the turbulence is mostly shear-driven with elongated structures in the wind direction, scaling with the canopy height. The wind velocity components, and thus the surface temperature, do not respond to Gaussian distributions. Therefore, one cannot only look at second order moments to characterize the statistical behavior of surface temperature fluctuations; one need also to look at higher moments to better characterize the largest fluctuations. Compared to standard statistical methods limited to the second order moments (energy spectrum, variogram), the multifractal analysis is more adapted to the non-Gaussian character of the turbulence at the canopy top.

We propose to address the complexity of the vegetation surface temperature fluctuations through a multifractal analysis in order to

identify the existence of a scaling law. We expect to observe a scaling law for scales ranging from the main turbulent structures within the surface atmospheric layer (~100 m) to vegetation canopy scale (~ m). The existence of such scaling law would allow us to quantify statistically the intra-pixel fluctuations of IRT images. The multifractal analysis will be performed from the wavelet transform modulus maxima (WTMM, Arneodo et al. 1995). The student will rely on high-frequency measurements of wind velocity, air temperature, and surface temperature of a Maritime pine forest. The scaling laws obtained for each meteorological variables would be intercompared, following the thermal stability of the atmosphere.

The originality of this master thesis relies on its multidisciplinarity between multifractal analysis, turbulence, and atmospheric physics. For this, the student will be followed by Sylvain Dupont (INRA Research Director**), specialized in micrometeorology, and Alain Arneodo (**CNRS Research Director emeritus**), specialized in multifractal analysis.**

This master thesis could lead to a PhD.

Expected profile

- **Master or engineer in applied mathematics, physics, fluid mechanics, complex signal processing**
- **Good experience in programming under Matlab**
- **Rigorous, autonomous, creative and motivated by working in a research environment**

Working conditions

The master student will be located in both ISPA and LOMA labs. Both labs offer an excellent scientific environment, members of the Labex COTE and Idex of Bordeaux University. ISPA is located at INRA campus, within a few minutes from downtown Bordeaux, and LOMA is located within the campus of the University of Bordeaux.

The traineeship grant will be 554 € per month.

How to apply?

Any student interested in this project is required to send his/her CV and his/her Master 1 scores to sylvain.dupont@inra.fr and alain.arneodo@u-bordeaux.fr.

References:

Arneodo A., Argoul F., Bacry E., Elezgaray J., Muzy J.-F. (1995). Ondelettes, multifractales et turbulence : de l'ADN aux croissances cristallines, Diderot Editeur, Arts et Sciences, Paris.

Dupont S., Patton E.G. (2012). Momentum and scalar transport within a vegetation canopy following atmospheric stability and seasonal changes: The CHATS experiment. Atmospheric Chemistry and Physics, 12, 5913-5935.