

INTERNSHIP OFFER

Impact of rain gauge biases on multiscale rainfall analysis

Host Laboratory	CEREA — Centre d'Enseignement et de Recherche en Environnement Atmosphérique (https://www.cerea-lab.fr/)
Location	ENPC 6 et 8 avenue Blaise-Pascal - Cité Descartes - Champs-sur-Marne - 77455 Marne-la-Vallée cedex 2
Duration	5 to 6 months
Preferred period	Ideally 03/2027
Level / Educational background	M2 (MSc) or Engineering School
Supervisor(s)	Auguste Gires (auguste.gires@enpc.fr) In collaboration with Arianna Cauteruccio (arianna.cauteruccio@edu.unige.it) from Univ. of Genova (Italy)
Application deadline	01/12/2026

Scientific context

Rainfall and wind are geophysical fields that exhibit an extreme variability across a wide range of spatial and temporal scales, from a few seconds to a few years in time and a few meters to planetary scale in space. This variability makes rainfall complex to measure, analyse and model. Quantifying rainfall variability across scales, which gives access to the corresponding extremes, is much needed for numerous practical challenges such as design of rainfall management infrastructures, or real time storm water management. Universal Multifractals are a good candidate to cope with these features. It is a physically based framework that relies on the underlying concept that rainfall is generated through a multiplicative cascade process, inherited from the governing Navier-Stokes equations. See Schertzer and Lovejoy (1987) for early developments and Seppe et al. (2025) for a recent application to comparison of rainfall measurement devices.

The most commonly used rainfall measurement device is tipping bucket rain gauge. It is affected by several known biases. This first one is discretization, i.e. that it does not measure rainfall continuously but only the cumulative depth with steps of 0.1 or 0.2 mm. It also suffers some instrumental and wind induced biases. Rainfall intensity measurements from tipping bucket rain gauges are subject to a systematic underestimation due to the amount of water that is not measured by either of the two compartments of the bucket during the tilting movement (see e.g., Cauteruccio et al., 2021a). This bias can be quantified using a dynamic calibration procedure as described in the European Standard EN 17277:2019 (see CEN, 2019), and the associated calibration curve can be used to adjust the raw data. Wind is the main environmental factor that causes bias in precipitation measurements. The aerodynamic behaviour of the gauge geometry, when impacted by wind, deflects the trajectories of hydrometeors away from the collector (see Cauteruccio et al., 2021b). This results in a significant reduction in collection performance. When contemporary wind speed and rainfall intensity measurements are available, numerically derived collection efficiency curves (see e.g., Cauteruccio and Lanza, 2020) can be used to adjust raw data.

Objectives

The aim of the project is to quantify the impact of those biases on the outcome of multifractal analysis of rain gauge data.

Tasks

In order to achieve this, the student will first use disdrometer data (Gires et al. 2018, 2022) collected during various measurement campaigns over about 10 years. Such device provides continuous data at drop scale, which enables to mimic discrete rain gauge data, and then compare outcome of UM analysis on raw disdrometer data and corresponding “virtual” rain gauge. In a second step, the student will use a thirty-year rainfall time series from the DICCA rain gauge station (Genoa, Italy), available at one-minute resolution as both a raw dataset and after the application of a dynamic calibration curve. For the most recent years, co-located wind measurements are also available and the correction for the wind-induced bias has been applied. He / she will perform UM analysis on raw series, and the corresponding series corrected for instrumental and / or wind induced biases. Impact on quantification of extremes will then be assessed.

Wanted background

- Currently in M2 (or MSc) or last year of engineering school in environmental science or physics
- Some basic knowledge in Python

References

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- Cauteruccio, A., Brambilla, E., Stagnaro, M., Lanza, L.G. and D. Rocchi (2021b). Experimental evidence of the wind-induced bias of precipitation gauges using Particle Image Velocimetry and particle tracking in the wind tunnel. J. of Hydrol., 600, 126690. <https://doi.org/10.1016/j.jhydrol.2021.126690>
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- Gires, A., Tchiguirinskaia, I., and Schertzer, D.: Two months of disdrometer data in the Paris area, Earth Syst. Sci. Data, 10, 941–950, <https://doi.org/10.5194/essd-10-941-2018>, 2018.
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- Schertzer, D. and Lovejoy, S.: Physical modeling and analysis of rain and clouds by anisotropic scaling multiplicative processes, J. Geophys. Res.-Atmos., 92, 9693–9714, <https://doi.org/10.1029/JD092iD08p09693>, 1987.
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