M2 SOAC: Fiche de stage de recherche en laboratoire

Laboratoire : CNRM

Titre du stage : Estimating the 3D structure of boundary-layer clouds from point measurements of solar irrradiance.

Nom et statut du (des) responsable (s) de stage :

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Sujet du stage :

In cloudy conditions, timeseries of surface solar irradiance bear the complex signature of clouds, from their microphysical properties to their spatial organisation (Gristey et al., 2020). While numerous cloud microphysical retrieval methods have been developed based on such observations and assuming plane parallel clouds, the capability of these observations to elucidate the 3D structure of clouds has been much less investigated. The spatial organisation of clouds is an active research topic (Brient et al., 2019), and is often studied through Large Eddy Simulations (LES). As they fully resolve cloud processes, LES tend to be considered as a realistic representation of clouds fields, providing 3D fields for several physical variables for which there is no observational alternative. Considering these simulated clouds as realistic remains questionable, though, in particular because LES of identical situations performed with distinct models often differ to some extent, in particular when it comes to cloud characteristics. This points to the need to evaluate LES themselves. For the case of clouds, suites of instruments have been used to estimate cloud fraction, bottom height or total amount of condensed water, but few studies have looked at the consistency of the spatial structure of simulated cloud fields with observations. Yet this would be a stringent test for the quality of the simulations. This work will explore how solar irradiance measurements performed with standard pyranometers could be used to 1) infer cloud 3D structure, and 2) validate simulated cloud fields in a comprehensive manner.

The objective of this internship is twofold. First, it will look at the radiative signature of cloud fields with the intent to retrieve cloud macrophysical properties from solar irradiance measurements. To this end, solar irradiance will be simulated by applying a Monte Carlo ray tracing tool (Villefranque et al., 2019) on high temporal resolution outputs of various LES performed with the Meso-NH model (Lac et al., 2018). The simulated irradiance will be analyzed with respect to cloud properties extracted for the same LES. In a second step, the simulated irradiance will be compared to actual measurements using standard statistical tools (probability distribution of irradiance, typical time scales of the timeseries). Based on these statistical indicators a metric will be derived that comprehensively evaluates the quality of the simulated cloud field in terms of resulting irradiance. This methodology will be applied on various sites, amongst the Météopole instrumented site, Carpentras, SIRTA, the ARM site of the South Great Plains, and possibly using data from the HOPE campaign in Germany. This work will provide an efficient way to evaluate simulated cloud fields, but will also assess the errors in terms of energy budget due to a generally poor representation of cloud geometrical and physical properties in LES.

References :

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Gristey, J. J., Feingold, G., Glenn, I. B., Schmidt, K. S., & Chen, H. (2020). Surface Solar Irradiance in Continental Shallow Cumulus Fields: Observations and Large-Eddy Simulation. *Journal of the Atmospheric Sciences*, *77*(3), 1065-1080.

Lac, C., Chaboureau, P., Masson, V., Pinty, P., Tulet, P., Escobar, J., ... & Aumond, P. (2018). Overview of the Meso-NH model version 5.4 and its applications. *Geoscientific Model Development*, *11*, 1929-1969.

Villefranque, N., Fournier, R., Couvreux, F., Blanco, S., Cornet, C., Eymet, V., ... & Tregan, J. M. (2019). A Path-Tracing Monte Carlo Library for 3-D Radiative Transfer in Highly Resolved Cloudy Atmospheres. *Journal of Advances in Modeling Earth Systems*, *11*(8), 2449-2473.