Ecole Doctorale - 104

Sciences de la Matière, du Rayonnement et de l'Environnement

EDSMRE

ESTABLISHMENT : University of Lille

Laboratory of affiliation : Laboratoire d'Optique Atmosphérique

Scientific field, Speciality: DS3 | Earth, fluid envelopes

Thesis director: Fabien WAQUET, Associate professor (fabien.waquet@univ-lille.fr)

Co-supervisor: Odran SOURDEVAL, Associate professor (odran.sourdeval@univ-lille.fr)

Affiliate programme: Labex CaPPA

Planned co-funding: Labex CaPPA (in progress), Doctorate School (in progress)

Advancing our understanding of aerosol-cloud interactions in aerosol-above-cloud conditions using satellite remote-sensing

Understanding aerosol-cloud interactions (ACI) remains a key longstanding challenge faced by the climate community. By serving as condensation nuclei for droplets, aerosols are closely linked to cloud formation and growth mechanisms; therefore, any change in aerosol amount and type can substantially impact cloud properties, lifetime and coverage. These combined effects constitute the largest uncertainties on current climate predictions.

Satellites, and in particular passive instruments, offer the global and long-term coverage needed for ACI studies but their operational products are often poorly adapted. One important issue lies in that such studies largely focus on scenes where aerosols and clouds coexist, whereas nearly all passive satellite retrievals assume single cloud or aerosol layers in the atmospheric column. This has two major consequences on ACI studies. First, strong biases are expected in retrievals of cloud properties, since the absorption and scattering effects from the aerosol layer will wrongly be attributed to the cloud. This makes cloud properties in polluted scenes largely unreliable for ACI studies, as such biases could wrongly be attributed to physical processes. A second issue arises from the lack of exact coincidence between cloud and aerosol properties, since both are typically not retrieved simultaneously by passive instruments in multi-layer scenes.

This PhD thesis aims to tackle both issues by proposing simultaneous and reliable retrievals of cloud and aerosol properties for emergent satellite remote sensing techniques. As a first step, a sensitivity study based on radiative transfer tools will be performed to better understand the response of cloud retrievals to different aerosol types and distributions. Then, a correction technique will be proposed for most commonly used cloud retrievals techniques, such as provided by bi-spectral approaches using a couple of absorbing and non-absorbing channels. Finally, a dedicated retrieval method of clouds and aerosol properties will be investigated and developed for emergent satellite instruments.

In its final steps, this thesis aims to use its newly developed dataset of cloud and aerosol properties, which are robust to aerosol-above-cloud conditions, to further understand aerosol-cloud interaction effects when both layers are in close proximity. Radiative fluxes as well as aerosol forcings will then be computed to quantify direct and indirect effects of aerosols transported above clouds on both the dynamics and the radiative balance of the atmosphere.

This thesis will develop a largely synergistic approach that will benefit from and take part in the current momentum at LOA for developing novel research and operational products for the upcoming MetOp-SG instruments, and in particular for the 3MI mission. The novel approaches will be tested on specific case studies and will benefit from additional constraints from in situ campaigns (AEROCLO-SA campaign) and/or regional modelling approaches for defining its sensitivity studies.

Expected date of recruitment : 01/10/2023

Contact (e-mail address) : odran.sourdeval@univ-lille.fr