



Ecole Doctorale - 104

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

ESTABLISHMENT : Université de Lille

Laboratory(ies) of affiliation : Laboratoire d'Optique Atmosphérique

Scientific field, Speciality: DS3 | Earth, fluid envelopes

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AEROSOL AND CLOUD INTERACTIONS : SYNERGY OF IN-SITU AND REMOTE SENSING MEASUREMENTS

The interaction between atmospheric aerosols and clouds (Aerosol–Cloud Interactions, ACI) is one of the main sources of uncertainty in estimating anthropogenic radiative forcing and climate projections. Ground-based measurements provide an accurate characterization of the physical, chemical, and optical properties of aerosols in the atmospheric boundary layer, but remain spatially limited. Conversely, satellite observations provide extensive coverage, but present uncertainties related to methods of reconstructing the microphysical properties of clouds. The central scientific challenge is therefore to develop a robust methodology that combines these two observational approaches in order to better constrain ACI sensitivities and reduce the associated uncertainties.

A methodology has been developed at LOA (Crumeyrolle et al., submitted) to co-locate in situ aerosol measurements and satellite reconstructions of cloud properties. Recent results have made it possible to sort the data significantly by limiting the study to a fairly small number of data points (4% of the initial database). The relative variations in cloud droplet concentration and/or effective radius relative to the relative variations in the aerosol scattering coefficient have been estimated: $ACI_n \approx 0.33 \pm 0.35$ ($LWP < 100$) and 0.17 ± 0.33 ($LWP > 100$), and $ACI_{re} \approx 0.08 \pm 0.10$ ($LWP < 100$) and 0.05 ± 0.10 ($LWP > 100$). These values are consistent with previous studies on continental stratus clouds.

The objectives of this thesis are to (i) test the methodology at other instrumented sites in order to propose a generalizable methodology for better overall constraint of ICAs, (ii) quantify the sensitivities of cloud microphysical properties (droplet concentration, effective radius) to variations in the concentrations and chemical composition of cloud condensation nuclei (iii) evaluate the dependence of aerosol-cloud interactions on the liquid water content of clouds. The analysis will focus on low-level stratiform clouds formed under stable atmospheric conditions, distinguishing between different classes of liquid water content (LWC). ICA sensitivities will be estimated via logarithmic relationships between cloud properties and CCN concentration proxies (aerosol light scattering).

This thesis will contribute to:

- Reducing uncertainties about the intensity of aerosol-cloud interactions in continental regimes.
- Proposing a transferable methodological framework for observational constraints on ACIs.



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- Improving the representation of indirect aerosol effects in climate models.

Profil: Candidate with a master in Physics or Atmospheric Sciences

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