Laboratoire : Laboratoire d'Optique Atmosphérique

Directeur de Thèse : Hervé Herbin

Co-directeur de Thèse : Laurent C.-Labonnote

Thématique : Physique Atmosphérique

Adresse mail du directeur de thèse : herve.herbin@univ-lille.fr

Téléphone du directeur de thèse : 03 20 33 61 83

Improvement of CO2 products in scattering atmosphere and determination of particle's microphysical properties from the high spectral resolution measurements of the MicroCarb instrument.

Understanding the lower troposphere/limit layer on the one hand, and the tropopause region on the other, is a major challenge to better understand and simulate climate change. This is true for temperature, water vapor or greenhouse gases (GHG), including CO2, but also for clouds or aerosols whose radiative forcing remains one of the major unknowns of the current climate system.

Advances in the evolution of the state of the atmospheric column are based on the close coupling between modelling and observation. The restitution of the atmospheric parameters that make up the column, such as GHGs (CO2, CH4) using hyper-spectral measurements has been the subject of numerous studies, and has led to (1) a massive use of these measurements in order to "reset", through their assimilation, the forecasting models, or (2) a monitoring of the evolution of the atmospheric composition in order to alert politicians to possible climate change. However, the majority of this work only concerned pixels labelled "clear sky", which is easier to process, in order to obtain information on atmospheric parameters such as temperature profile or concentrations of certain gases. However, scattering particles (aerosols or clouds) contaminate a large majority of the measurements, which are then either rejected, because they are more difficult to process, or processed by ignoring the effect of the scattering layer on the restitutions. Simplified parameterizations of the effect of the scattering particles exist but give only partially satisfactory results.
The advantage of high spectral resolution measurements for the study of scattering layers lies in their high sensitivity to the presence of this layer when an appropriate absorbing band (or a set of bands) is used to avoid the signal coming from the surface. A number of restitution algorithms use not a single band, but a contrast between an absorbing and a non-absorbing band, in order to obtain information on the altitude of the scattering layer and its optical thickness. Moreover, if the spectral resolution is sufficient and the spectral range used has a set of different absorption lines (which is the case in the A band of oxygen for example), additional information on the thickness of the layer is possible. The use of spectral regions sensitive to microphysics such as 1.6 µm or around 2 µm also provides information on the nature, concentration or size distribution of cloud and aerosol particles.

The objective of this thesis will thus be to demonstrate the feasibility of using high spectral resolution measurements such as those of MicroCarb, and more particularly the pixels contaminated by fine ice clouds or aerosols, in order to find the microphysical and optical properties of the latter, as well as the vertical position and thickness of the layer. Initially, an information content study will be conducted in order to better determine the potential of this type of observation to retrieve the parameters of the diffusing layer. Then, an algorithm based on the optimal estimation method will be developed in order to test the restitution capacities of the properties of the scattering particles and the CO2 columns simultaneously. Finally, if the launch date of Microcarb allows it, this algorithm will be used for the processing of real measurements.