Understanding aerosol mixing as tracers of boundary layer convective development, *BL-TRACE*

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Introduction and motivation

The development of the boundary layer in convective conditions, or the depth of the layer in which surface emitted constituents are well mixed, must be well understood to relate fluxes and concentrations. Air pollution and greenhouse gas communities are interested in precisely tracing the mixing depth to improve predictions of atmospheric constituents such as fine-mode aerosols or CO2.
Several tracers and parameters can be used to define the mixing layer depth, such as the potential temperature, water vapor mixing ratio, wind variance, aerosol concentration or extinction coefficient. Retrieving the mixing depth then requires instruments that can provide vertical profiles of these parameters, preferably several times per day to cover mixing depth variations in the diurnal cycle. Well known candidates are aerosol backscatter profiles from lidars, wind velocity variance profiles from Doppler Lidar, potential temperature profiles from micro-wave radiometers (MWRs) and radiosondes, turbulence profiles from sodars.

Scientific objectives

Several authors have shown that there are discrepancies between mixing depth retrievals based on different tracers and methods. Seibert et al, 2000 have presented the state of the art at the time of COST Action 710. More than a decade later, we witness break through development of high resolution in time and space measuring techniques, and so the retrieval method became a subject of studies a source of uncertainties.
The aim of this project is to identify and describe physical reasons that can explain discrepancies or consistencies between retrievals based on aerosol profiles and those based on potential temperature profiles and wind velocity variance.

Reason for choosing station

The SIRTA site was chosen for the study because of its rich observation programme, modern equipment and high level quality-controlled, reprocessed and harmonized dataset containing more than 40 parameters (ground, surface, profiles), h*ttp://climserv.ipsl.polytechnique.fr/cfmip-obs.html*

Method and experimental set-up

The primary task of the visit was to analyze the mixing depth retrieval datasets that have been derived from Lidars (Pal et al., 2013), MWRs (Cimini et al. 2013), Doppler Lidars and sodars at the SIRTA observatory to investigate the differences in the diurnal cycle of mixing height observed using different tracers (profiles of aerosol, temperature, CT2, W). The secondary task was to analyze the radiosoundings data from Trappes station in order to recognize daytime, nighttime and transition periods characteristic profiles of all measured parameters. Third task was to analyze when the air masses at SIRTA and Trappes are with same characteristics and when the influence of the city of Paris causes differences and it is not recommended to use the radiosoundings as a reference.

Retrieval data are available and were provided by SIRTA during the visit. The main data analysis was conducted by Orlin Gueorguiev, a PhD student from NIMH, by focusing on case studies (both clear-sky and boundary layer cloud cases).

The visit included training for Orlin Gueorguiev in analysis of cloud and aerosol remote sensing data, while prof. Batchvarova gave a lecture for MSc and PhD students on her work on **Convective boundary-layer paramers over heterogeneous conditions: theory, measurements, applications.**

Preliminary results and conclusions

The study covered a period from April to September 2011 and measurements with Micro-Wave Radiometer (MWR) and aerosol lidar at SIRTA, as well as radiosoundings from Trappes (30 km away from SIRTA). To retrieve the mixed-layer height, the Parcel's method was applied to MWR data and both Parcel's and Richardson's methods were used for the radiosounding data. The STRAT+ estimated from lidar data were also used in the comparisons.

153 days were analysed and only one showed very good coherence between all the methods of calculation from all the measurement instruments – the 2nd September 2011 (245th Julian day). Four days were coherent partially – the 1st of May, 27th of June, 26th and 29th of September 2011 (Julian days 121, 178, 269 and 272 correspondingly) – Figure 1.

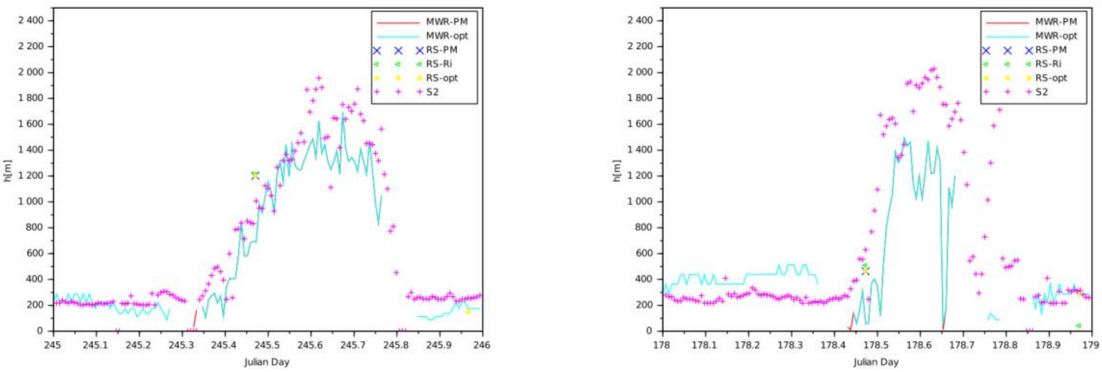

Figure 1. Examples of consistent estimates for the mixed-layer height

During most of the days in the study period, "a shift" between the results of MicroWave Radiometer and the Lidar (S2) was noticed during the convective conditions. It is either direct "shift" as on the 10th of August (222nd Julian day) or with some coherence in the beginning of development of the layer and "shift" after that, as on 1st of June (152nd Julian day).

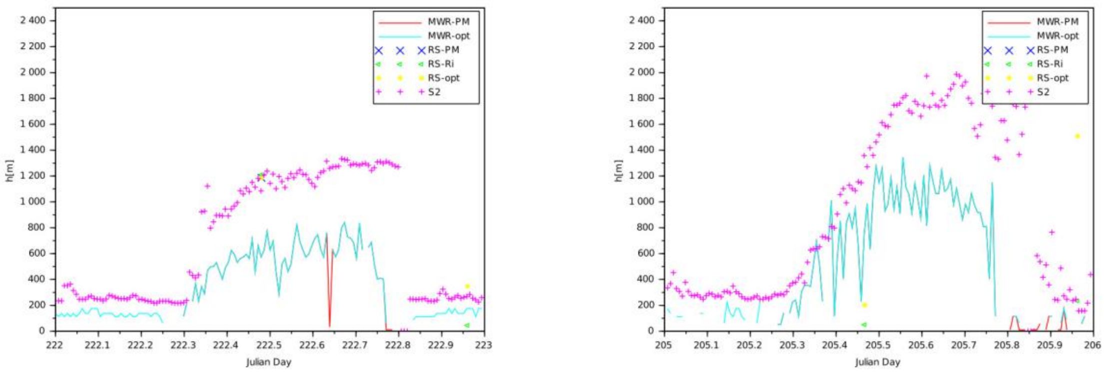

Figure 2. Examples of discrepancy of the estimates for the mixed-layer height

The study will continue to cover longer period and to test if the observed discrepancies are caused by differences in the methods, or by factors related to the physiscal conditions. The interaction between urban and rural air masses can form complex structure of the convective boundary layer.

Outcome and future studies

The collaboration with IPSL/SIRTA gives opportunities for common theoretical and empirical studies based on modern technology high resolution data on the profiles of meteorological parameters, clouds and aerosols within the boundary layer. continued collaboration with Dr. Sandip Pal (U. of Virginia) and Dr. Nico Cimini (CNR). The rich observation programme and quality control procedures applied at SIRTA constutute a valuable opportunity for the PhD student to work with state of the art observations despite the modest equipment and sparse vertical profiles measurements available at NIMH in Bulgaria.

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