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Validation of mixed layer heights and aerosol concentrations simulated with WRF/Chem

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Introduction

The height of the mixed layer is an important factor influencing the near surface pollutant concentrations. While of radiosonde data only supply mixing layer heights (MLH) at selected times ground based optical and acoustical sounding with Ceilometers and SODAR permit the continuous observation of the temporal evolution of the mixed layer height.

Ceilometer measurements from a long term campaign within the region of Augsburg (Southern Germany) were used for the validation of modeled boundary layer heights from WRF/Chem (Grell et al., 2005) simulations for July 2008 and January 2009. Additional air quality data from a monitoring station are also included for the model validation.

Ceilometers at the site in Augsburg. The right one is the instrument used for the continuous measurements

Model Simulations

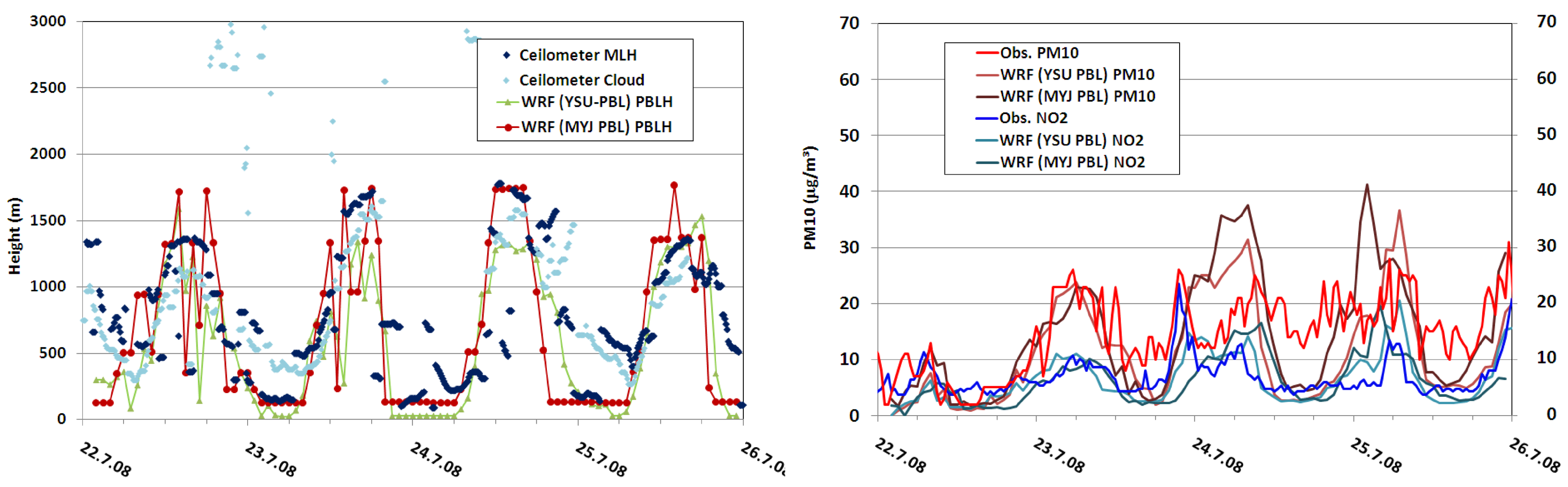
The simulations with WRF/Chem were carried out for three nested domains with horizontal resolutions of 36 km, 9 km, and 2.25 km. The model was set up with WSM 6-class microphysics, the NOAH land surface model, RADM2 gas phase chemistry and MADE/SORGAM aerosol module, and alternatively with the YSU and the Mellor-Yamada-Janijic (MYJ) boundary layer scheme.

Ceilometer measurements

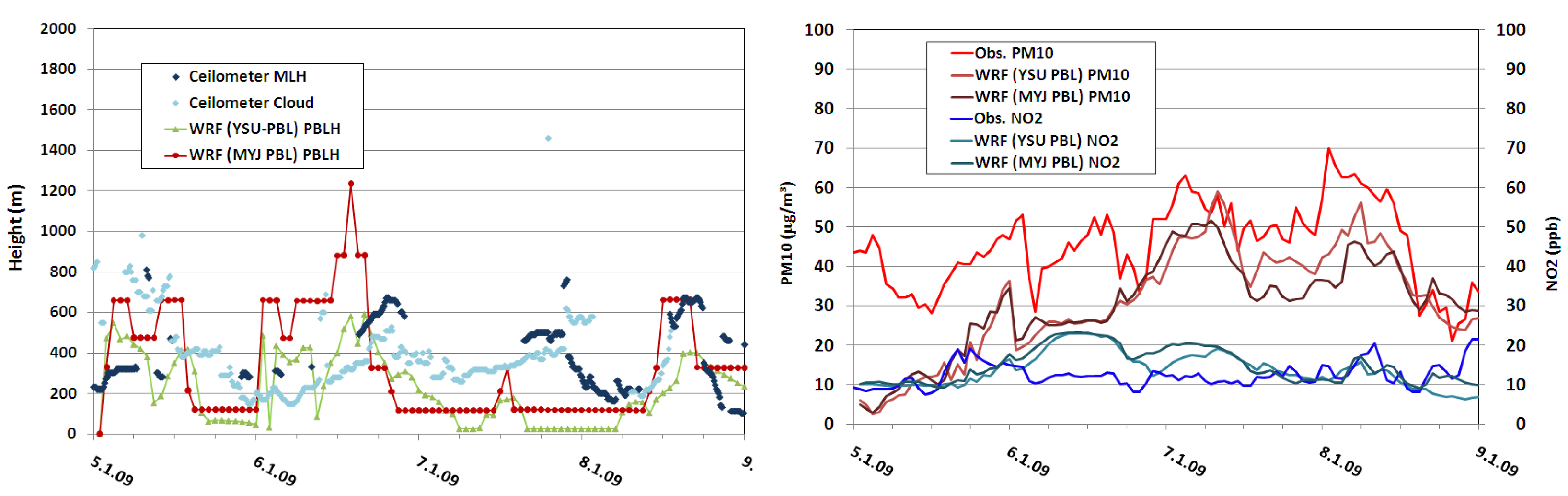
The mixing layer height was determined with a Vaisala CL31 ceilometer.The heights of the near surface aerosol layers and the MLH are analyzed from optical vertical backscatter profiles. The performance of the ceilometers is sufficient to detect convective layer depths exceeding 2000 m and nocturnal stable layers down to 50 m.

Results

Summer situation



Winter situation



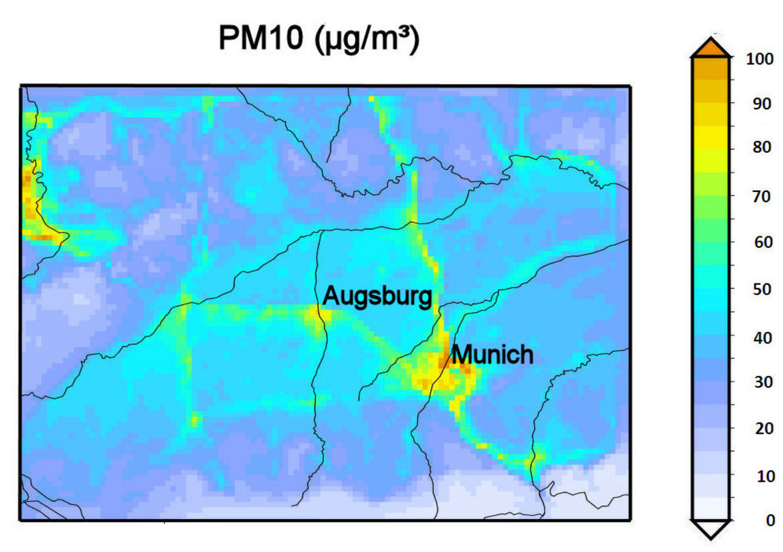
For summertime conditions reasonable to good agreement is found between the observed mixing layer height (MLH) and modeled boundary layer heights. However, it must be considered that the boundary layer height from the model simulations depends on the way how it is diagnosed from the simulated temperature and wind profiles and is not a prognostic variable itself. During night time the oscillations between higher and lower values of the MLH are generally not reproduced by the model, which is also reflected by the simulated course of the pollutant concentrations.

Fog and shallow high fog situations, which occur frequently in the region of Augsburg during wintertime are generally more difficult to reproduce by model simulations than clear sky conditions or frontal passages. In the current example the ceilometer measurements indicated shallow cloud layers and during the first three days. For clear conditions or days with dissolving cloud layers, a comparison between the observed and simulated development of the mixed layer height is possible.

The simulations based on MYJ boundary layer scheme generally resulted in a higher boundary layer. The shape of the temporal course during daytime is better represented for the YSU boundary layer scheme.

Summary

Mixed layer heights from long term ceilometers measurements near Augsburg were compared against model simulations with WRF/Chem for a summer and a winter situation. Generally, better agreement between observations and simulated mixed layer heights and near surface pollutant concentrations was found in summer situation than in winter. In particular, the occurrence of fog and high fog situations and shallow cloud layers and their representation in model simulations remains a crucial point for air quality simulations during winter time. It determines critically whether a realistic course of the MLH and resulting simulated pollutant concentrations can be reproduced by WRF/Chem.



Simulated PM10 on Jan 7 2009, 7h

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