Convective and Orographically Induced Precipitation Study – COPS

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Diurnal cycle and microstructure of the CBL derived from Doppler lidar measurements over complex terrain

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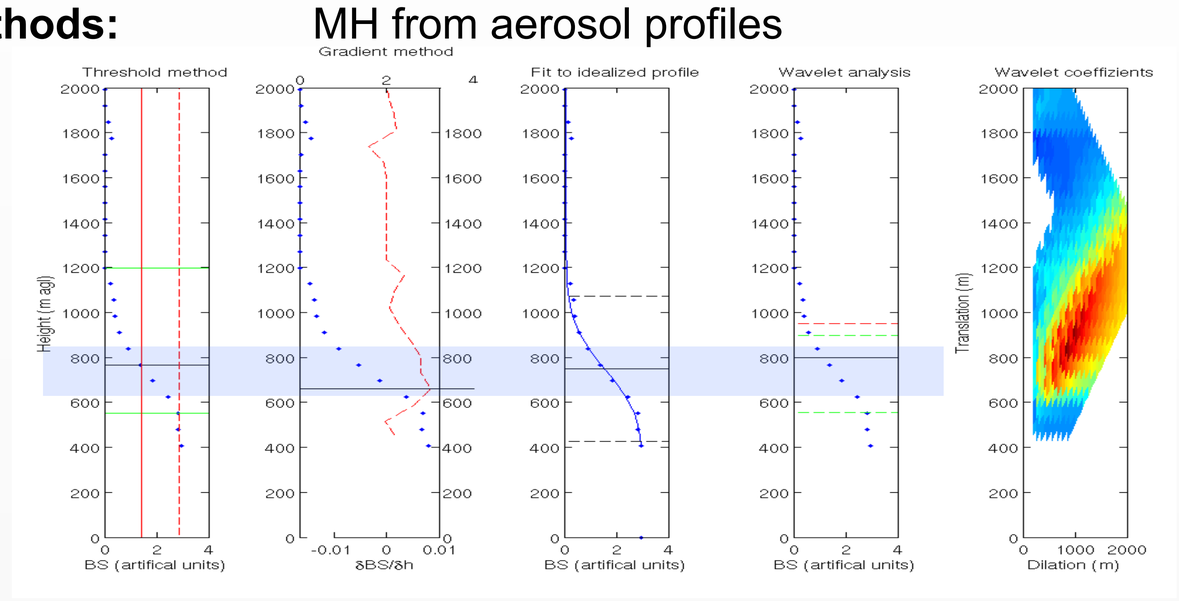
Problem: Mixing height (MH) is a fundamental parameter for specifying the convective planetary boundary layer (CBL). It undergoes diurnal changes due to various processes and feeds back on convective initiation, since CBL heating rate and MH are coupled via surface heat flux. MH determination from lidar measurements is based on the assumption, that the mixed layer shows a significant higher aerosol content than the free atmosphere. The detection of the aerosol backscatter gradient allows the determination of CBL height over flat terrain. **Is this approach suitable even over complex terrain?**

Methods:

MH from aerosol profiles



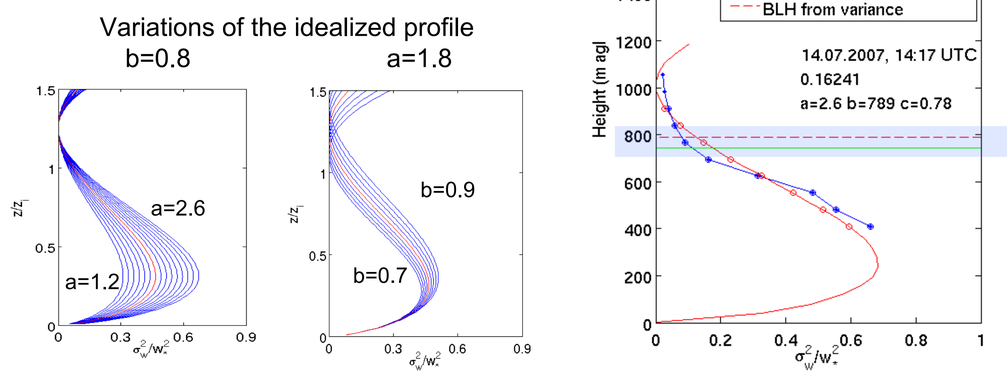
+ Four methods – evaluated against each other – provide a robust determination of the aerosol layer height
+ High temporal resolution (0.1 Hz)
+ Estimation of the entrainment zone possible (either from aerosol transition zone or from MH variation)
- No distinction between CBL and residual layers
- Difficulties if multiple layers, e.g. moist layers above the CBL exists

MH from turbulence profiles

$$\frac{\sigma_w^2}{w_*^2} = 1.8\left(\frac{z}{z_i}\right)^{\frac{2}{3}} \cdot \left(1 - 0.8\frac{z}{z_i}\right)^2$$

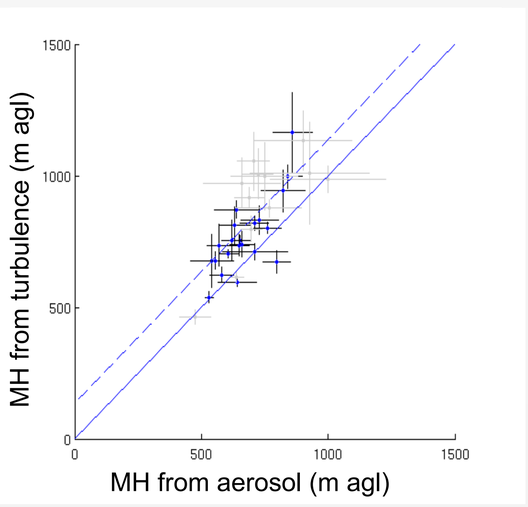
$$\sigma_{w_{fit}}^2(z,a,b,z_i) = \left(\frac{g * \overline{w'\theta'}_s}{\theta}\right)^{2/3} * a * z^{\frac{2}{3}} \cdot \left(1 - b\frac{z}{z_i}\right)^2$$

Variations of the idealized profile



+ Based on the root idea of a turbulent mixed layer
+ Distinction between turbulent CBL and residual layers possible
- Low temporal resolution (due to statistic certainty)
- Need of additional information about turbulent surface heat flux

Comparison of the methods and MH calculations from radiosonde data

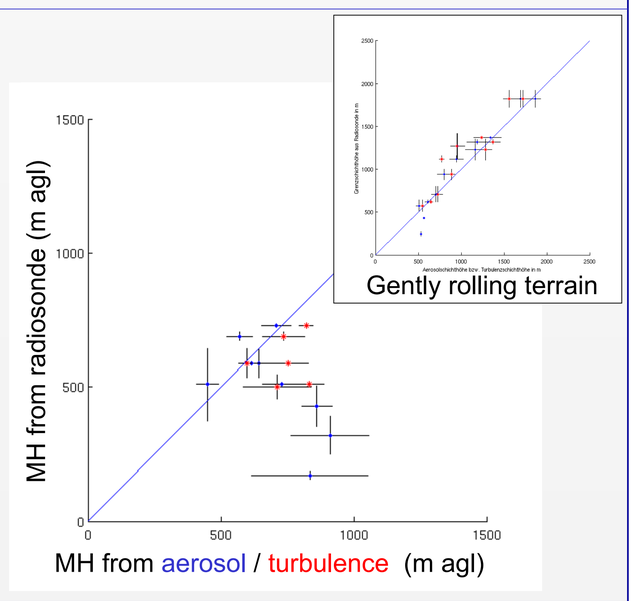


Analysis of four cloud free days over Hornisgrinde mountain (supersite H, 1170m asl) during COPS (14.07., 15.07., 01.08., 05.08. 2007) and three days with small cumulus clouds (30.07., 31.07., 04.08.2007); radiosondes only for three days available.

➢ MH from turbulence is on average 140 m higher than MH from aerosol over complex terrain (left), bias not found in analysis of data over gently rolling terrain (upper right).

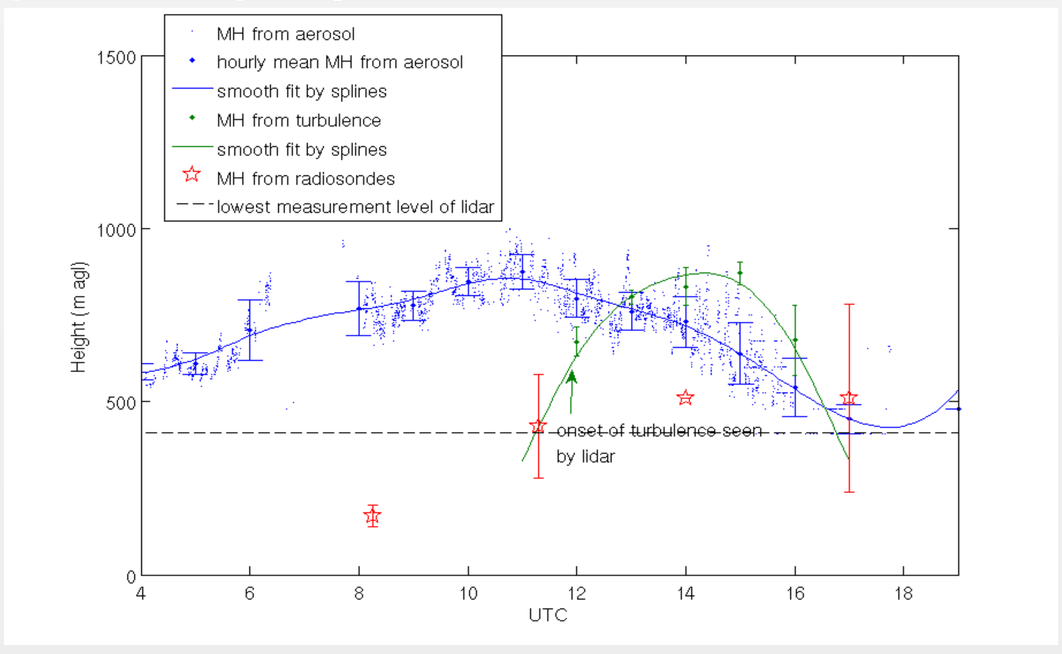
➢ MH from turbulence fits better to MH from radiosonde determined from potential temperature than MH from aerosol (right).

➢ during 8 and 20 UTC, on clear air days over complex terrain, 48% of the determined MH from aerosol are not linked to turbulence in the layer (no MH from turbulence determination possible); over gently rolling terrain only 26% are unlinked.



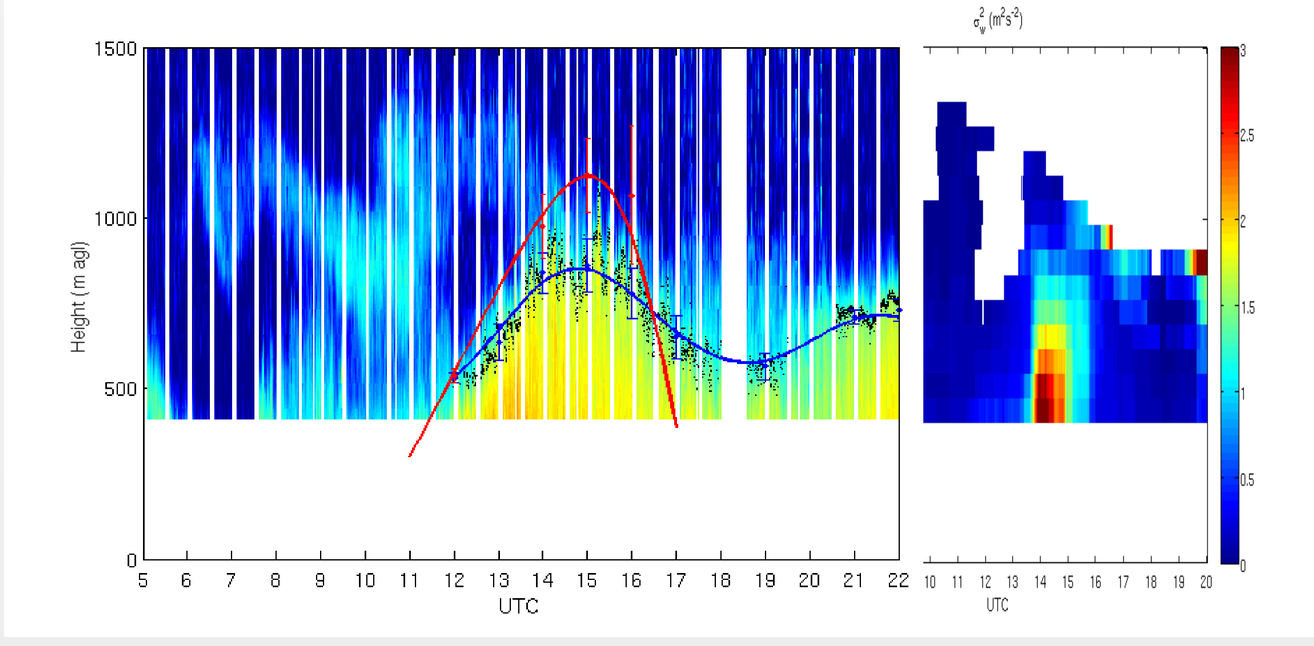
Diurnal MH development of 2 selected COPS cases

„Morning problem“ – high aerosol levels from the previous day / night, Example 14.07.2007, IOP 8a



„Evening problem“ – transition of CBL to residual layer

Example 05.08.2007, no IOP



Conclusion: Both methods for MH determination, the one from aerosol profile and the other using the turbulence information, have their individual advantages and drawbacks. For the detection of the diurnal cycle of CBL height a combination of the two approaches is a favorable solution.

The MH from turbulence profile may act as a control parameter, if the detected high resolution MH from aerosol can be linked to turbulence activities and therefore represent the CBL height. Using only the information from the aerosol profile can lead to incorrect MH, especially in complex terrain.