Variability of the mixed layer height derived by ceilometer measurements in the Bavarian pre-Alps

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Abstract

Aim: Detection of small scale spatial and seasonal differences of the mixed layer height (MH) at three sites in complex terrain in Bavarian pre-Alps.

Method: Ceilometer data + minimum gradient method

Results: Decrease of MH from July to October, MH significantly higher with surrounding mountains, wind from direction with mountains elevates the MH, no influence of mesoscale circulations detected

1. Motivation

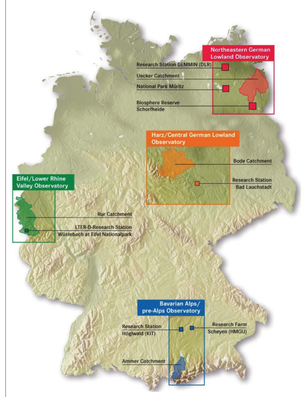
The mixed layer height (MH)

- i.a. defined by strong mixing of air and dispersion of ground sourced aerosols
- is an important parameter in air pollution studies and for modelling atmospheric turbulences
- undergoes diurnal and seasonal variations
- behaves complexly in complex terrain

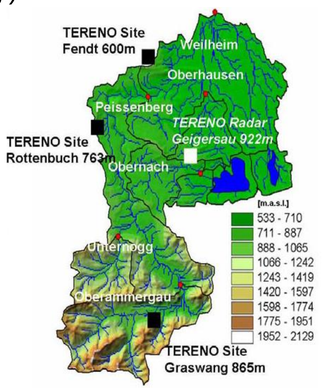
Little is known about the variation of the MH over short distances. Here we compare the MHs at three sites in complex terrain in the Bavarian pre-Alpine region from July to October 2012.

2. Study sites

- 3 sites within the Ammer catchment, 30 km north-south distance (Terrestrial Environmental Observatories network (**TERENO**)
  - ➢**Fendt**: plateau (130 m agl) to the west
  - ➢**Rottenbuch**: surrounded by gentle hills
  - ➢**Graswang**: surrounded by mountains (1000 m above ground level (agl)



TERENO network



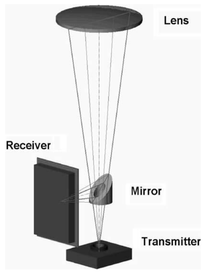
Study sites, distance Fendt-Graswang ~30 km

3. Methods

- Ceilometer (type CL51, Vaisala), single-lens type
- Eddy-covariance systems

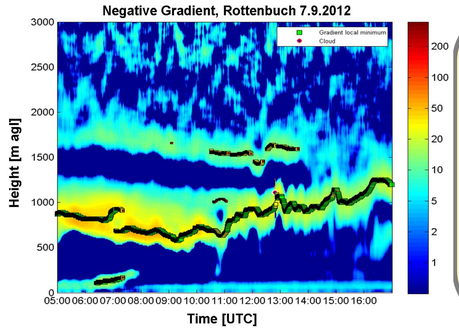
Ceilometer

- Mini-LiDARs that emit light beams
- Use the elastic scattering of light at particles and molecules
- Backscattered signal received in the ceilometer
- Single-lens type: capable of detecting layers < 200 m agl



Schematic of a single-lens ceilometer

- Backscatter signal recorded every 15 s
- Data processed in Vaisala software 'BL_Matlab'
- Layer detection via the **minimum gradient method**
- Detection of up to 3 layers possible
- Output: data averaged in intervals of 10 minutes



Examplary gradient in Rottenbuch. MH: persisting line

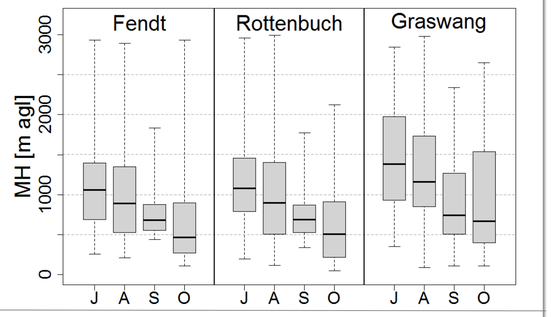
Minimum gradient method

Decrease of aerosol concentration above MH → Detection of the steepest gradients from high to low back-scatter signal (see figure on the left)

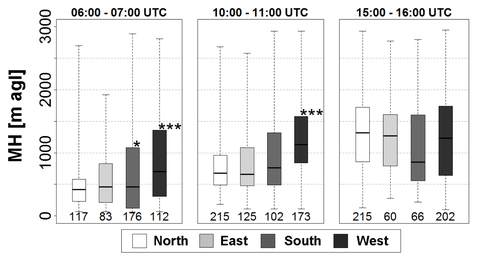
4. Results and Discussion

4.1 Influence of topography and season

- ➢Surrounding mountains in Graswang have an elevating effect on the MH
- ➢No differences between Fendt and Rottenbuch
- ➢MH decreases from summer to autumn



4.2 Influence of wind direction in Fendt

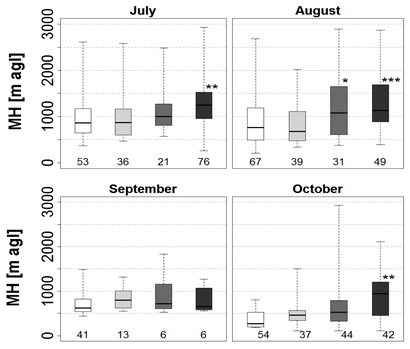


Numbers below the boxes show the data included

a) Time period

Morning/noon: significantly elevated MHs during west wind situations

- ➢Effect of the plateau west of the study site



Numbers below the boxes show the data included

b) Months (noon time)

- Elevating effect of the plateau in July, August, October
- Not enough data in September
- No effect of south or north wind
- ➢No effect of mesoscale circulations like Alpine Pumping visible in the data

5. References

Zacharias et al. (2011): A network of Terrestrial Environmental Observatories in Germany, Vadose Zone J 10:955-973.

Münkel et al. (2007): Retrieval of mixing height and dust concentration with lidar ceilometer. Boundary-Layer Meteorol 124:117-128.