Wind, air temperature and CO_2 profiles of a tall spruce forest during WALDATEM-2003 summer experiment

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High resolution vertical profiles (20 Hz to 10 min means) of wind speed, air temperature and CO_2-concentration were continuously obtained within and above a 19 m tall spruce forest during the summer field campaign WALDATEM-2003 (WAveLet Detection and Atmospheric Turbulence Exchange Measurements) at the Waldstein research site located in the north-eastern mountain range of Bavaria, Germany. This summer field campaign was carried out during May, June and July in the framework of the Bayreuth Institute for Terrestrial Ecosystem Research (BITÖK) program and aims on the intensive investigation of energy and matter fluxes within and above a spruce forest.

The wind profile was obtained by six sonic and seven cup anemometers at different heights, the temperature and the CO_2-concentration was measured at six and eight different heights respectively, covering all parts of the canopy and the atmospheric layer above.

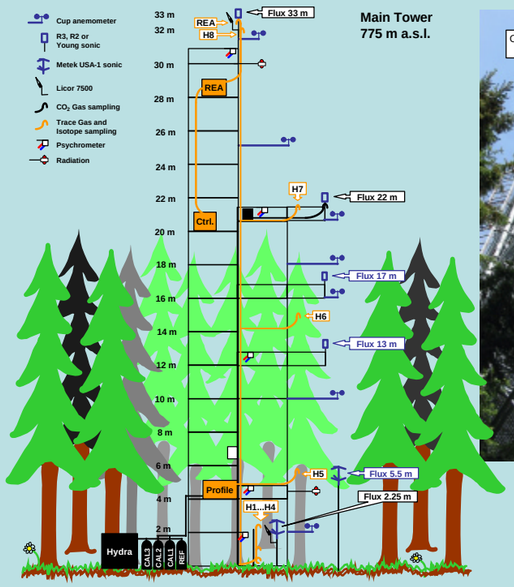
“Akima” interpolation method was applied for the vertical interpolation of the two dimensional profiles and a simple smoothing algorithm for the time scale.

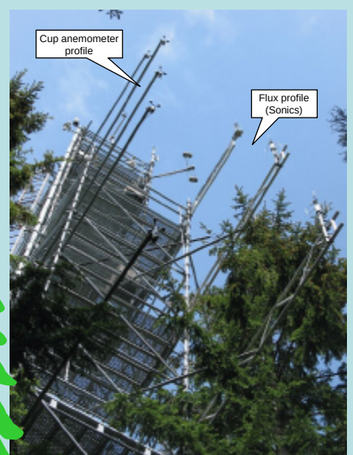
This contribution shows typical and exceptional situations and effects like coupled or decoupled conditions between the sub-canopy layer and free atmosphere, the influence of thunderstorms or cold drainage flows along the smooth slope during night conditions.

Experiment Design

Vertical profiles of wind, air temperature and CO_2-concentration. Main tower (32 m tall). Different measurement heights (depths):

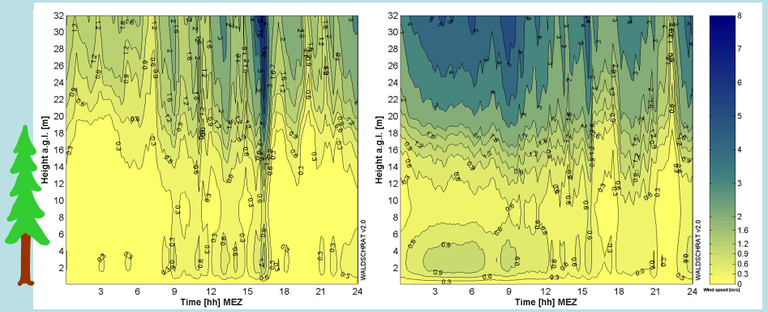
- high frequent measurements (20 Hz): six sonics, four CO_2/H_2O-analysators (fluxes)
- averaged measurements (10 min): seven cup anemometers, six air temperature probes, four soil temperature probes and eight CO_2-sampling inlets.



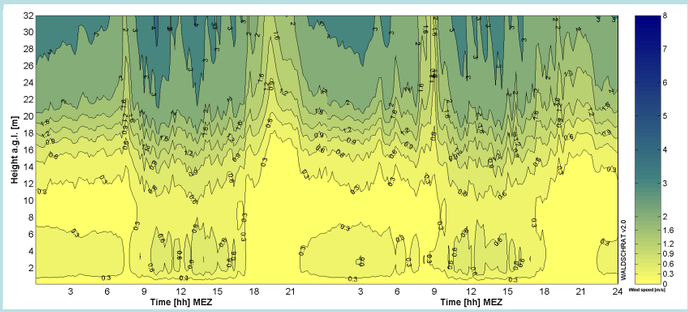


Schemata and photograph of the Main Tower at Waldstein location. The 32 m tall tower is used as a platform for micrometeorological measurements

Examples of 2D interpolated **wind profiles** based on 10 min means of horizontal wind speed (cup anemometers) measured at seven different heights in and above the spruce forest at Waldstein location.

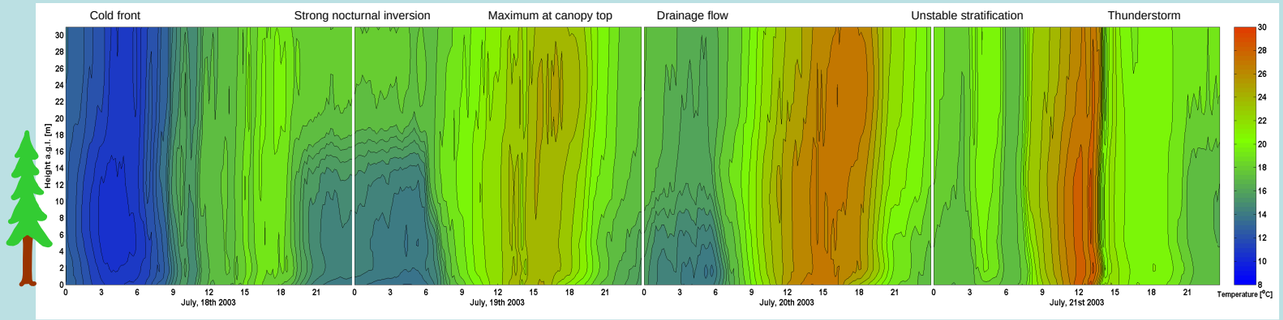


2D wind profiles (Akima interpolation method): **Left plot**: Warm summer day, 05. June 2003, calm conditions during nighttime and a passage of a heavy thunder storm between 15 und 17 CET. **Right plot**: Hot summer day, 27. July 2003, well pronounced nocturnal secondary wind speed maxima between 2 m and 6 m a. g. l. (subcanopy space).



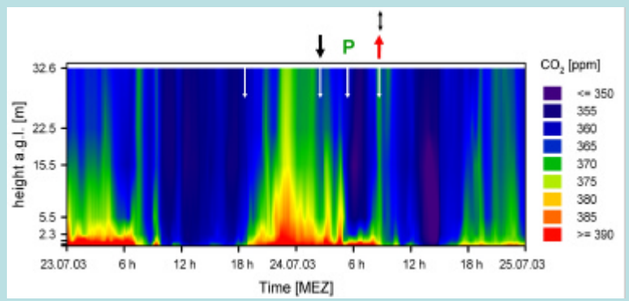
2D wind profiles (Akima interpolation method): Warm summer days, 02. and 03. June 2003: typical decay of dynamically generated turbulence during calm conditions starting at 18 CET. Development of a wind speed maximum in the 2nd half of the night. Breakdown of dynamically generated turbulence during transition from nocturnal to diurnal conditions at approx. 8 CET.

Examples of 2D interpolated **air temperature profiles** based on 10 min means of psychrometer measurements at six different heights (Waldstein location and same interpolation methods as above).



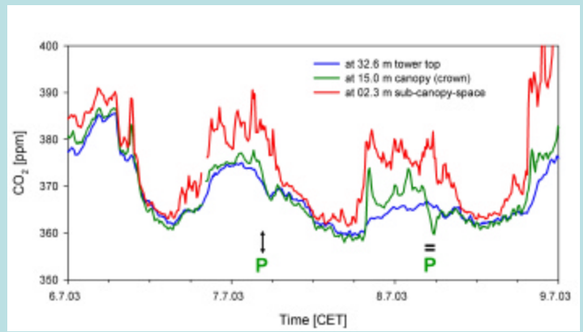
The plot starts at July 18th 2003 and ends at July 21st 2003. It demonstrates a typical summer situation. After a fast passage of a low pressure disturbance prevailing for only one day at July 17th during a hot weather period, air temperatures slowly raise up again. In the following night an exceptionally strong inversion (4 K) appears in the canopy between 12 m and 19 m. The following day (July 19th) exhibits the temperature maximum at canopy top located at 19 m. During the second half of the next night, a drainage flow occurs between 2 m and 6 m. July 20th is a cloudless day showing a nearly symmetric diurnal temperature pattern. The night to July 20th is exceptionally warm with an unstable stratification around 5 CET. The 21st shows a typical summer situation: a heavy thunderstorm at 14 CET concludes the diurnal warming during this hot day.

Examples of 2D interpolated **carbon dioxide profiles** based on 8 min means of simultaneously gas sampling at eight different heights (Waldstein location).



= decoupled situation
↕ coupled situation
P start of photosynthesis
↓ nocturnal insertion of fresh air
↑ storage depletion

2D carbon dioxide profiles. This example shows a typical situation in a forest canopy in mid summer (days July 23th and 24th 2003). When turbulent mixing decreases during evening at July 23th, we observe a build up of CO_2 due to soil respiration. At 2:30 CET fresh air from above the canopy is mixed into the forest. The start of photosynthesis (July 24th, 5 CET) leads to a steep decrease of CO_2-concentration in the canopy, while close to the ground concentrations still remain high. Only at 8:30 CET the subcanopy space is fully coupled to the air above. This leads to a exceptional sudden depletion of the near ground CO_2-pool.



Carbon dioxide concentrations at different heights a.g.l. after a short cold and rainy period. The CO_2-concentration during start of photosynthesis at July 7th around 5 CET indicates a good coupling of atmosphere and canopy (well mixed, s. green and blue lines). Next morning at same time the conditions has changed and the canopy is now decoupled from the atmosphere above. This leads to a steep decrease in CO_2-concentration in the sub-canopy space at 15 m (s. green line).