Dry and moist convective cells in the CBL over a Black Forest summit – synergy effect of combined in situ and remote sensing observations

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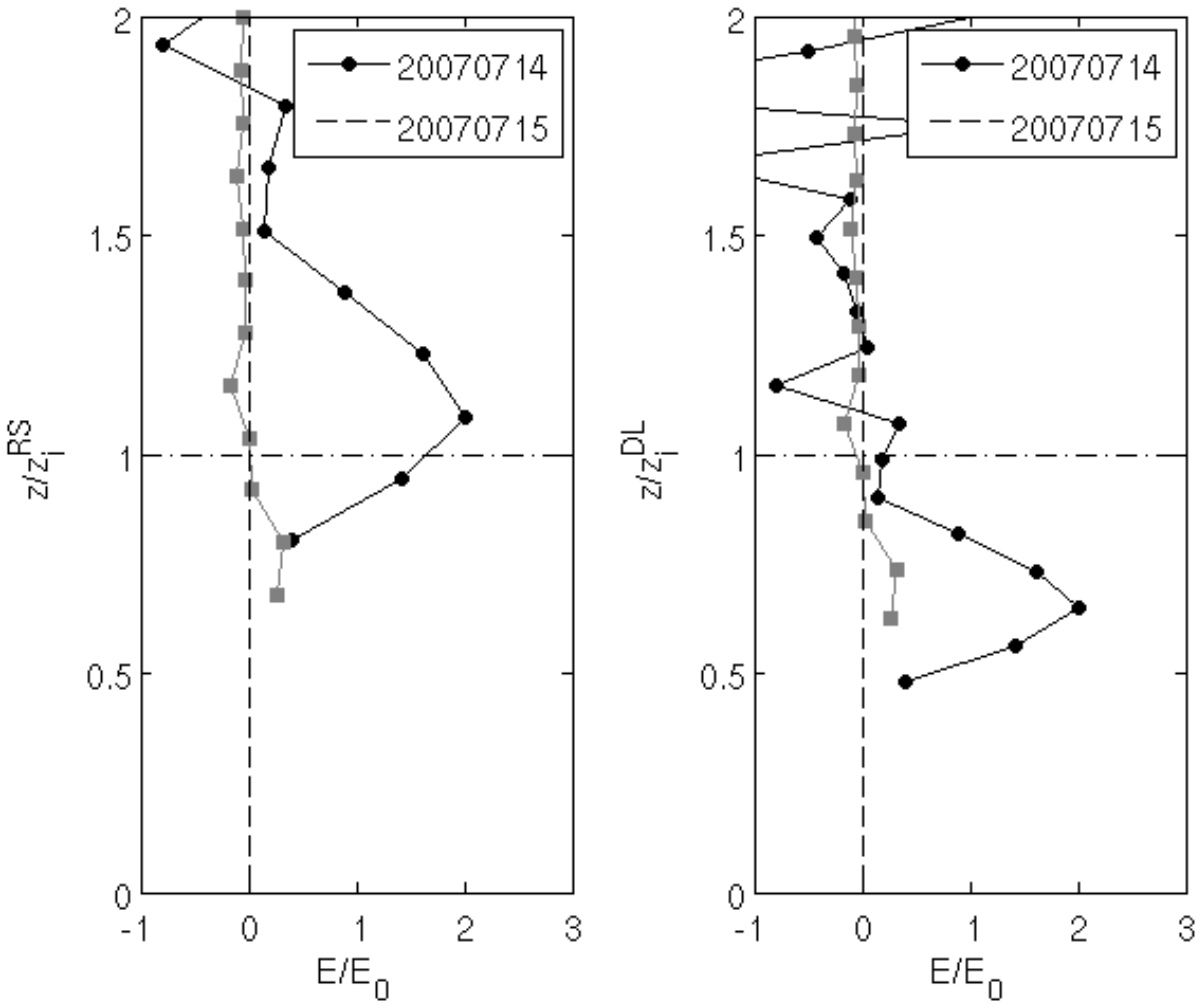
Available measurement at mountain top

- Surface energy balance station
  Resolution: 20 Hz, 30 min
- Doppler wind lidar (LIDAR)
  Resolution: 1 s, 96 m
- Differential absorption lidar (DIAL)
  Resolution: 10 s, 15 m
- Microwave radiometer (MWR)
  Resolution: 12 s, 50 m (near surface) to 200 m (at 2000 m agl)
- Cloud radar
  Resolution: 1 min, 30 m
- Radiosondes

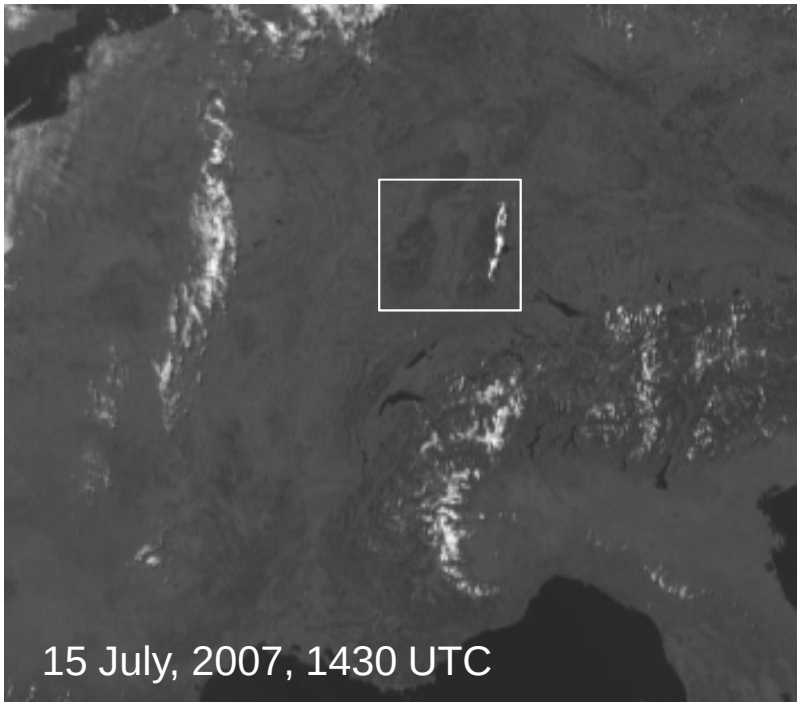
Supersite “Hornisgrinde”, 1200 m asl

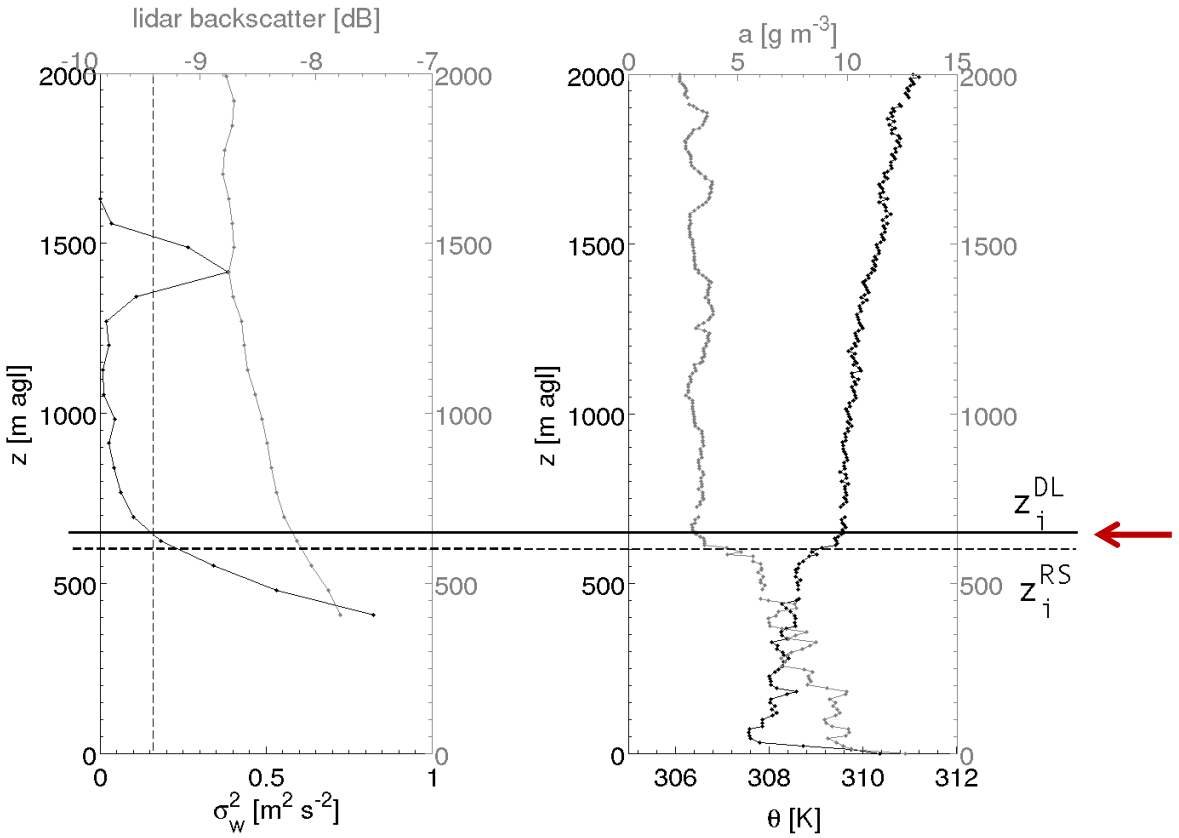
1. Calculation of the CBL top



Does it matter?

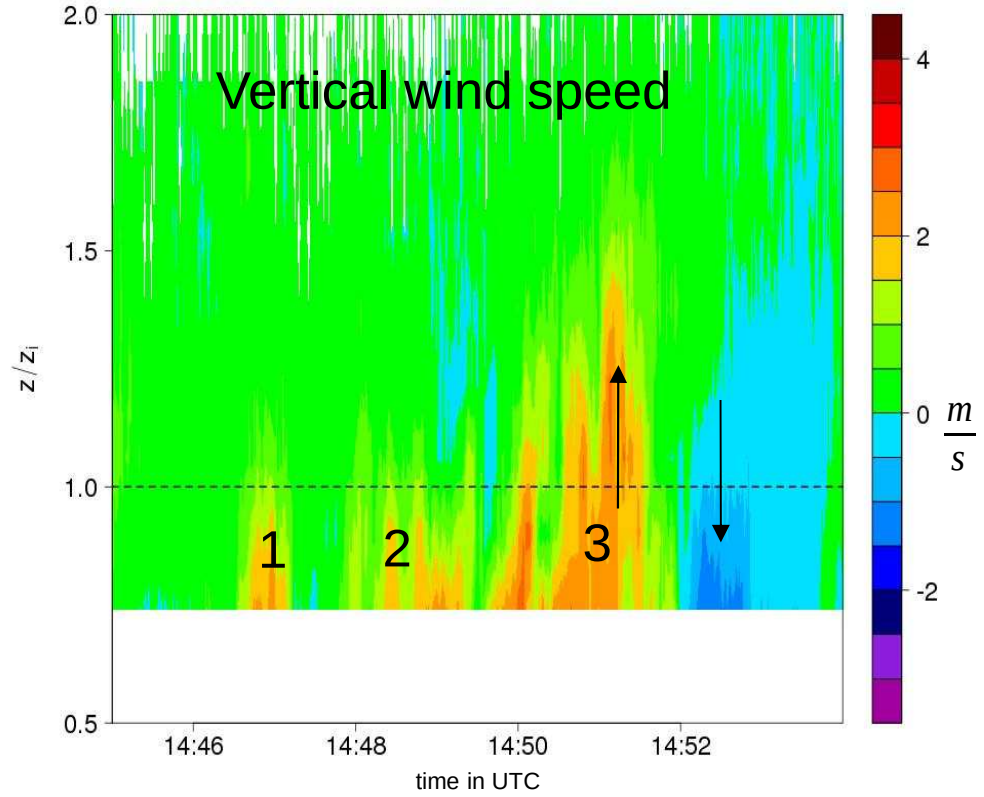
1. Dry convection

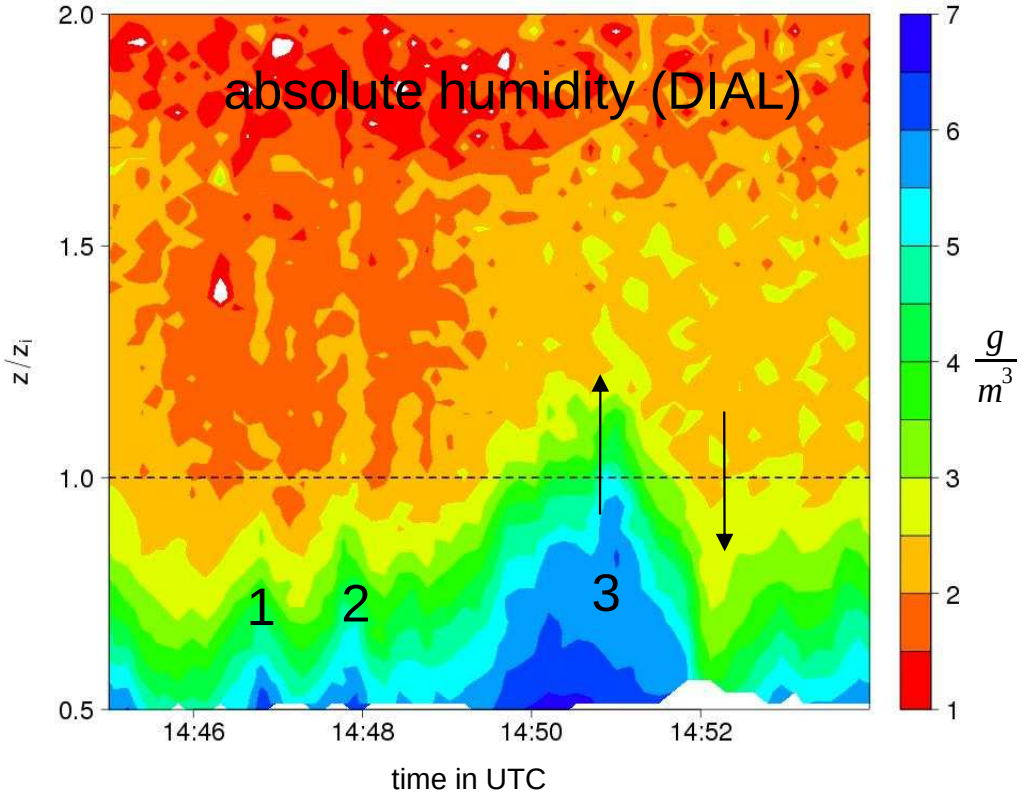




COPS area: nearly cloudless

Same CBL top

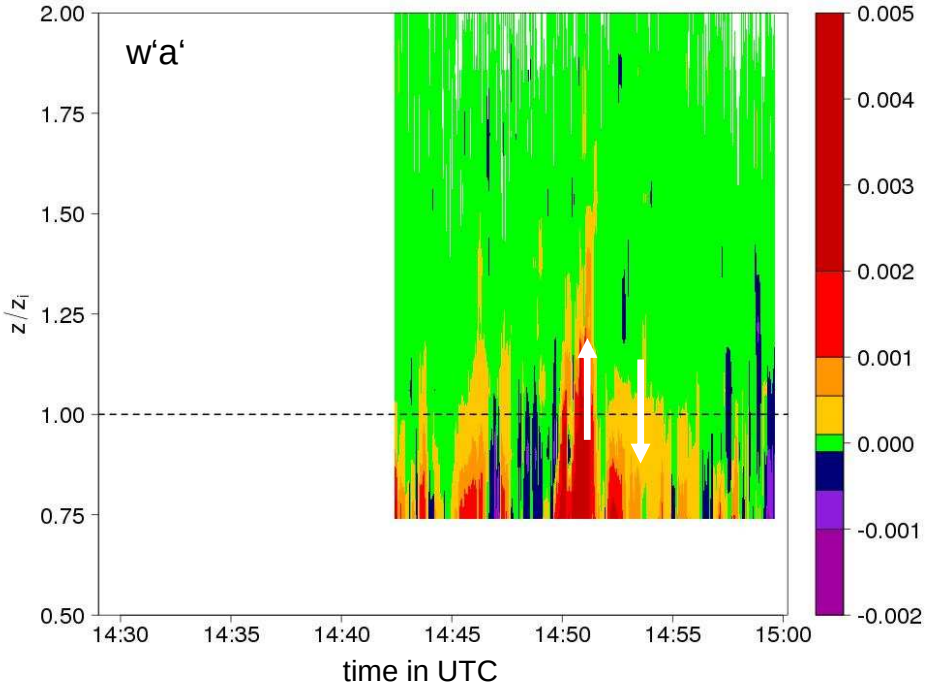


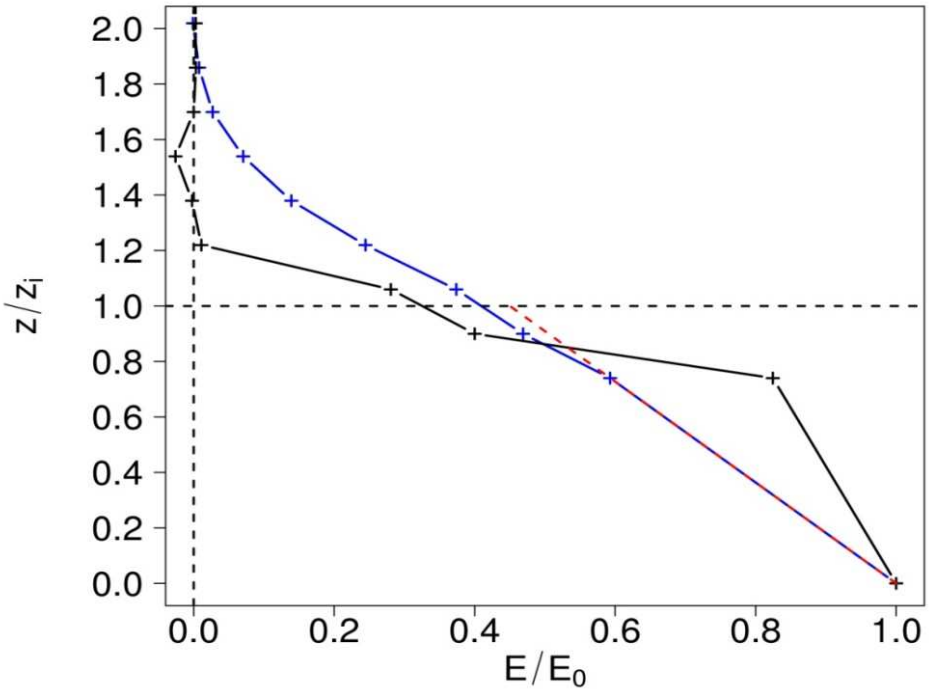


- *Most thermals are capped by the CBL inversion*
- *Some strong thermals penetrate the capping inversion*
- *Moist air is transported into the free troposphere (≈ 1.2 z_i)*
- *Dry air is transported into the CBL (≈ 0.5 z_i)*

Latent heat flux profiles

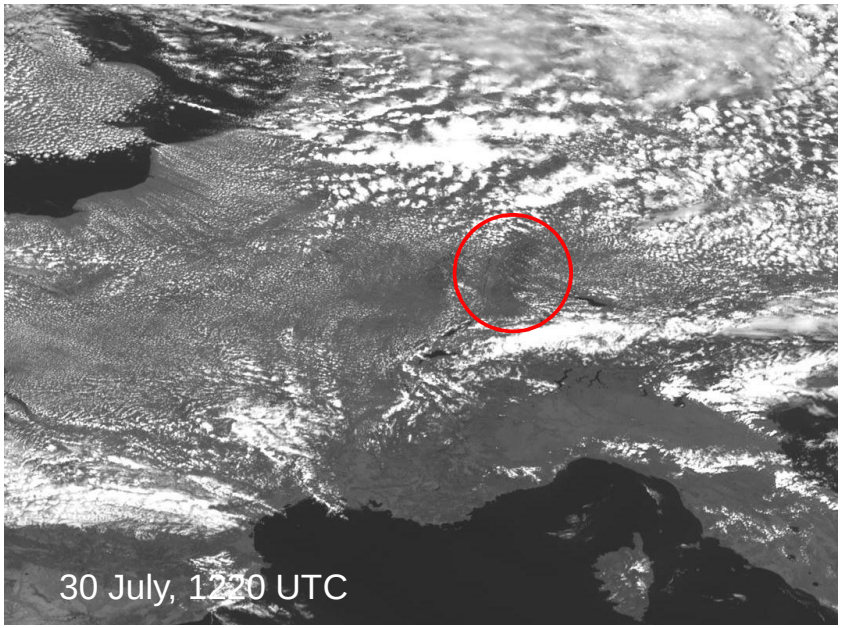
DIAL/wind lidar (+), MWR/wind lidar (+) 1400–1530 UTC

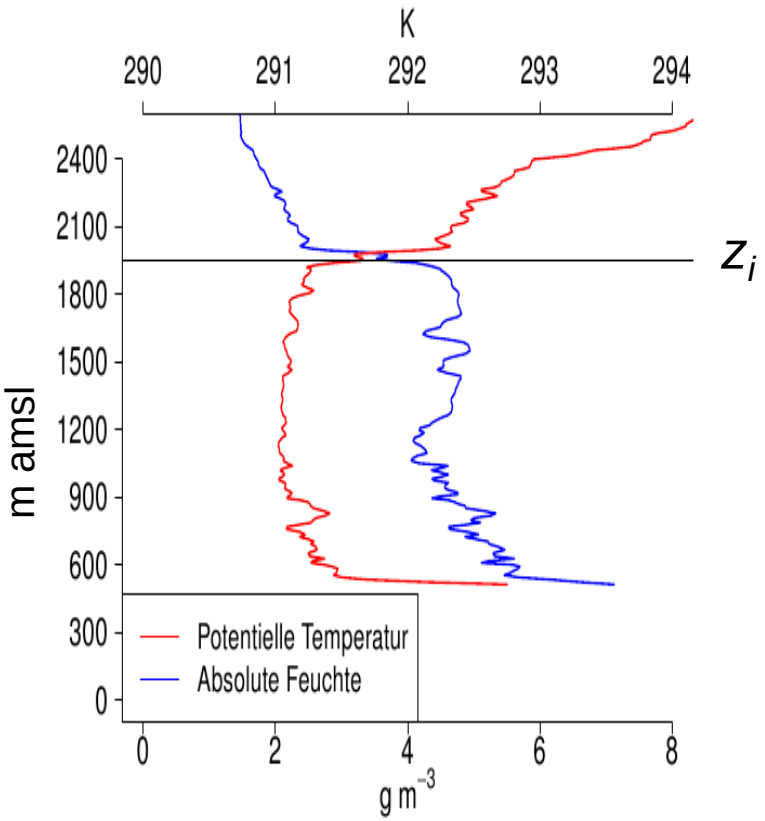




- moist up- and dry downdrafts result in positive latent flux
- positive latent heat flux near top of CBL (E > 0.5 E_o)
- Entrainment zone up to 1.2 z_i

2. What happens in a cloud-topped CBL?

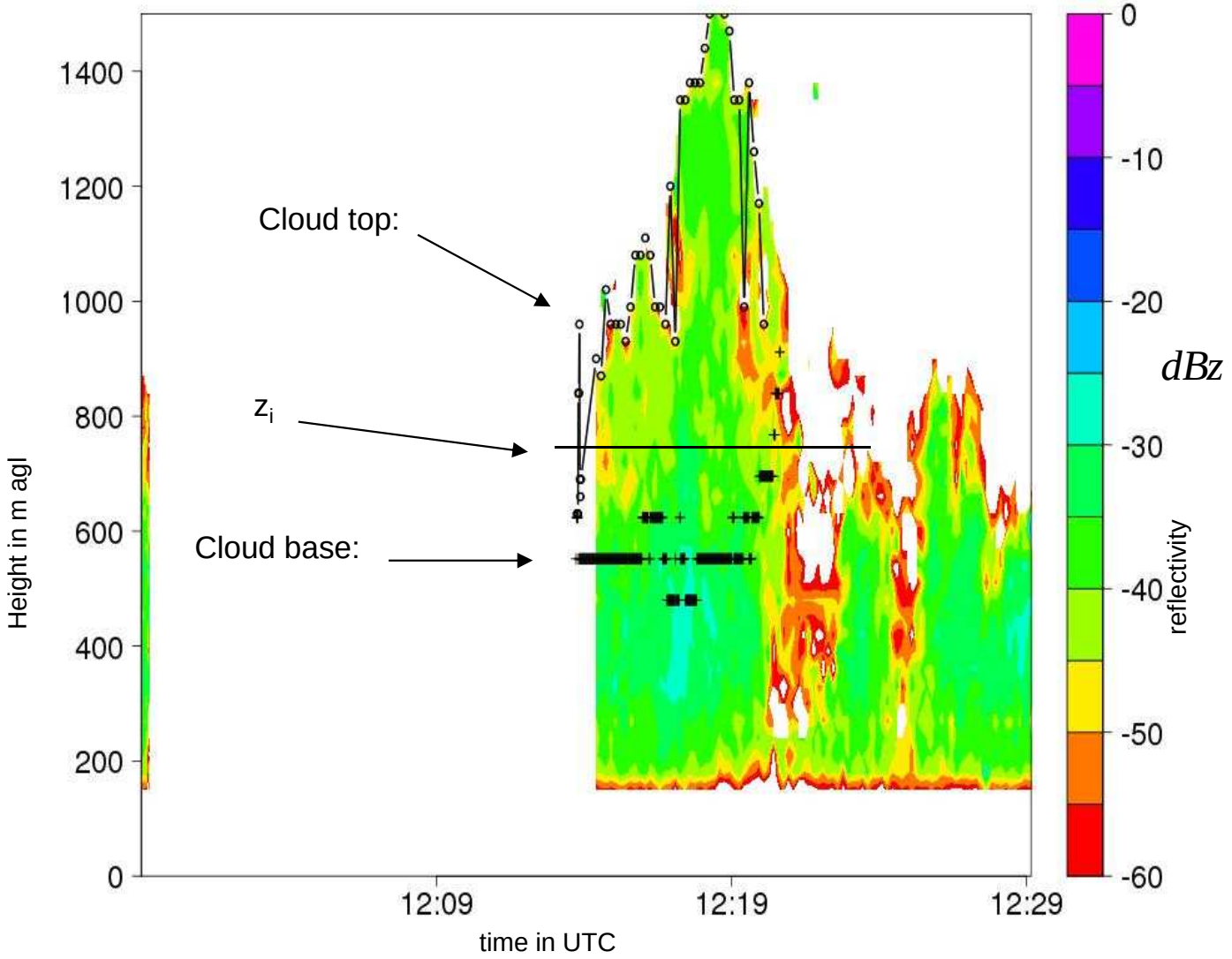




COPS area: cumulus clouds

CBL top, z_i: 1950 m amsl (800 m asl)

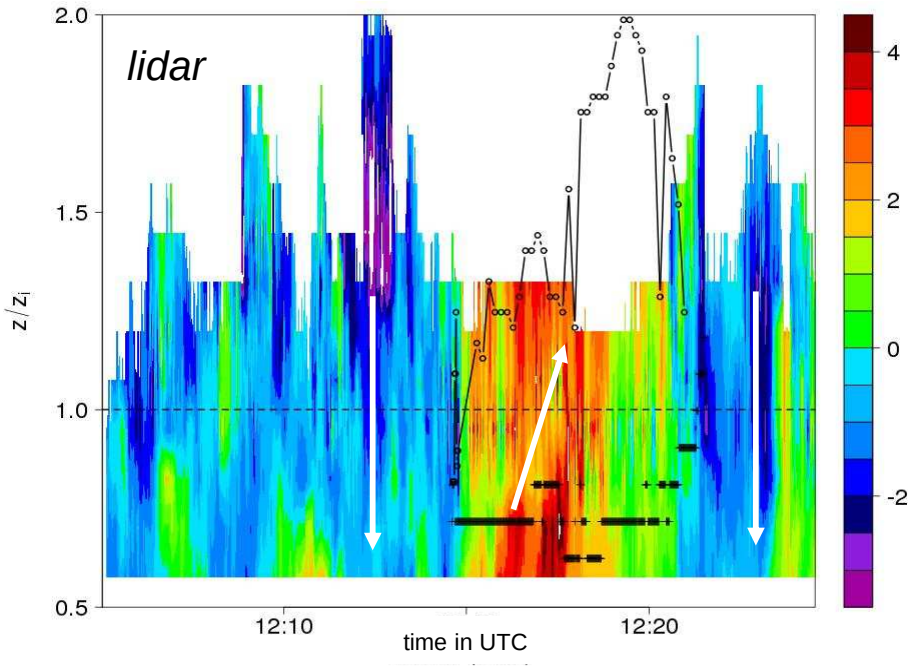
A convective cloud passed Hornisgrinde

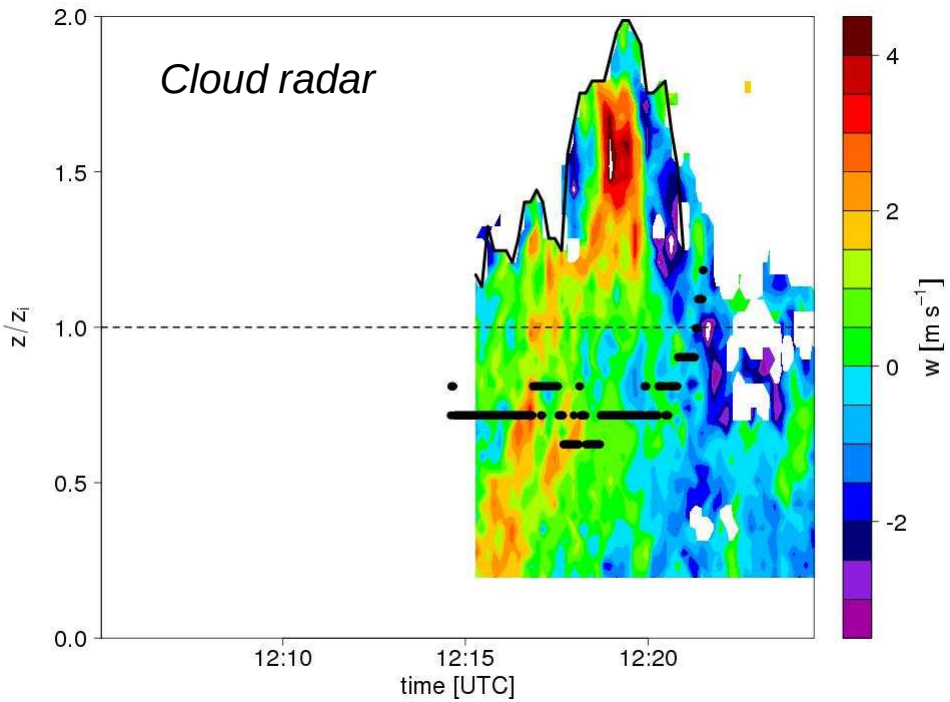


cloud radar reflectivity → cloud top

Wind lidar backscatter → cloud base

Vertical wind speed



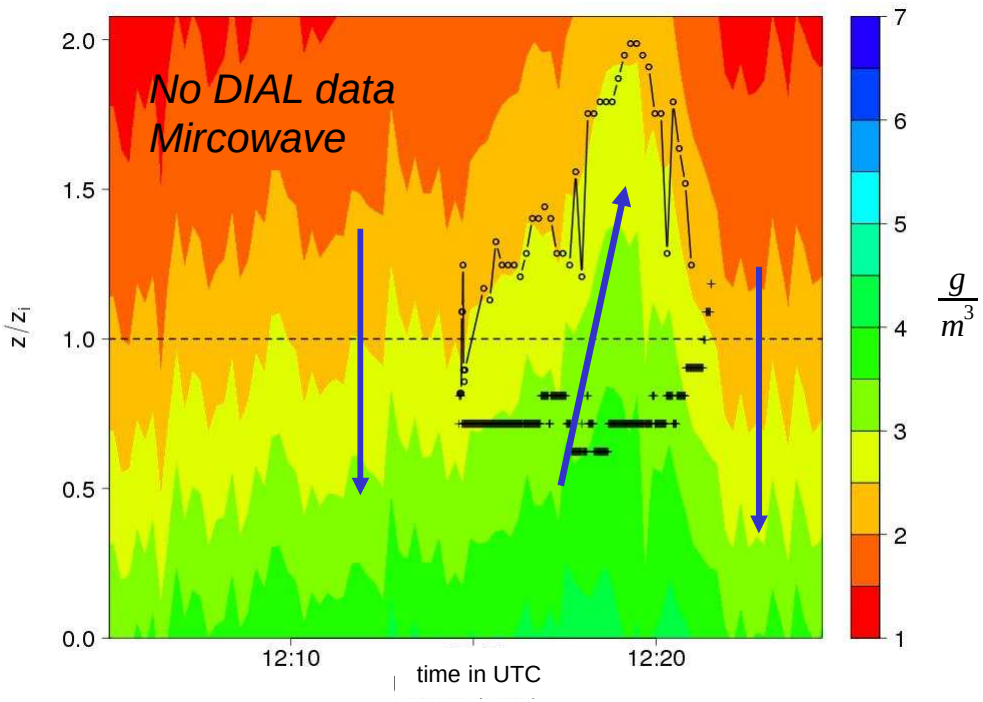


Cloud characteristics

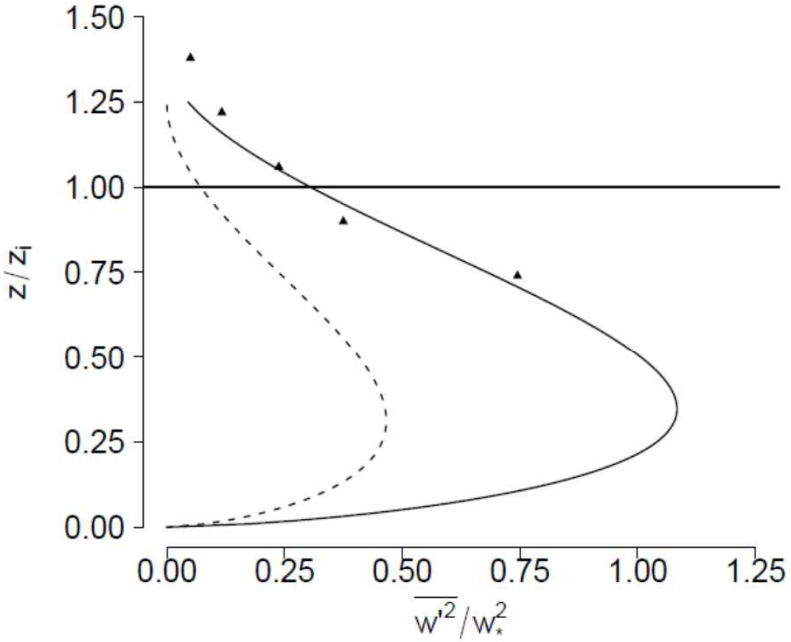
- cloud reached from 0.7 z_i to about 2 z_i
- Strong updrafts (no data in the cloud top)
- Strong downdrafts in the surrounding
- Updrafts extend to the cloud top
- moist air up to 2 z_i ; dry air down to 0.5 z_i

- ***Synergy!***

Humidity



What are the differences between turbulence in cloud-free and cloud-topped CBLs?



(a) 15.07. 14:30 - 15:00 UTC

- σ_w^2 *in dry CBL becomes is low at CBL top*
- σ_w^2 *in cloud-topped CBL does not diminish at CBL top*

Summary and conclusions

- Redundant measurements are neccessary to investigate dry and moist convective cells (limitations of remote sensing systems)
- Estimation of CBL top over mountains sometimes difficult
  →independent measurements helpful
- CBL clouds penetrate deeper into the free troposphere than dry thermals → σ_w^2 high at CBL top
- Latent heat flux is high at CBL top - similar to flat terrain