Characterization of turbulence and thermodynamic stability in the Atmospheric Boundary Layer for air quality and network applications

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Characterizing the structure and evolution of ABL

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- Local circulation and turbulence due to different sources determine the CBL height and the residual layer characteristics, which in turn are also determinant for air quality (Q. Li et al. 2021).
- A better knowledge of ABL processes is essential for improving the parametrization of these processes in numerical models (Löhnert et al. 2014).

JOYCE: Jülich Observatory for Cloud Evolution

- ACTRIS National Facility for Cloud Remote Sensing at JOYCE has been operating for more than 10 years

Strong stratification cases

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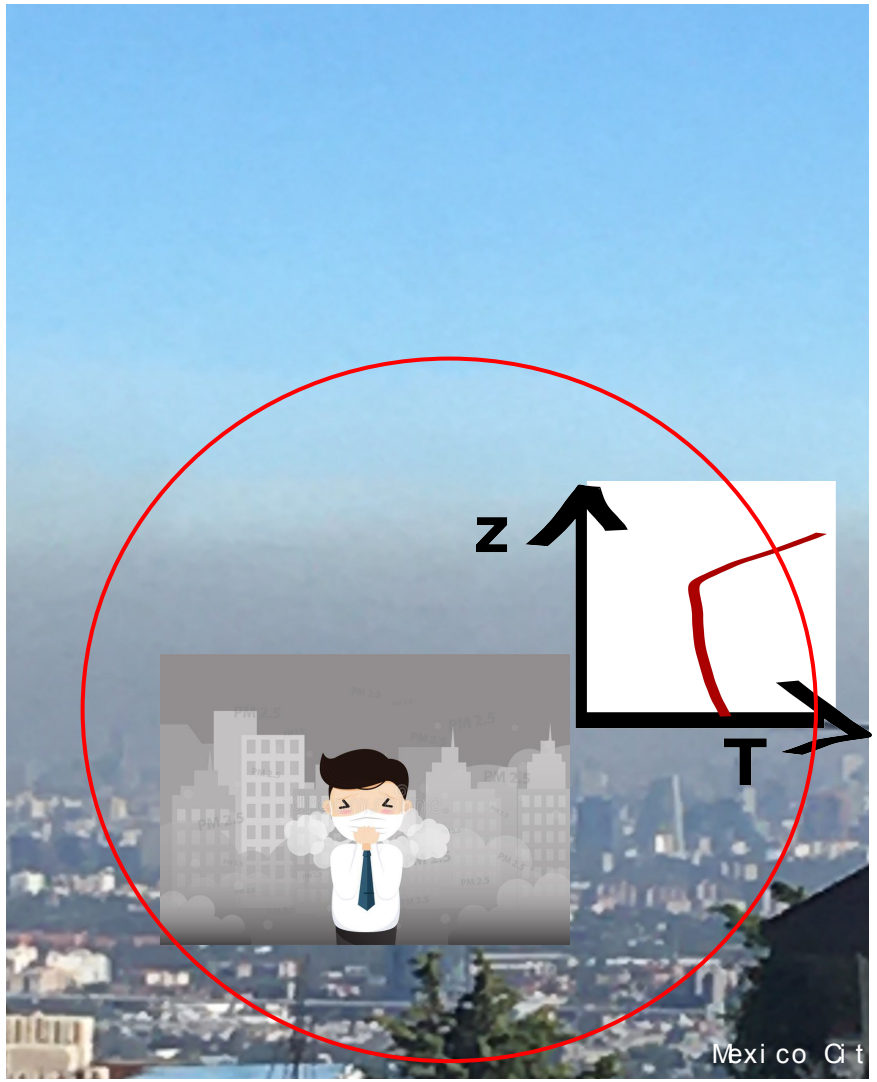
- While weak stratification in ABL is better described by similarity theory and numerical models, strong stratification is more difficult to resolve (Mahr et al. 2014).
- Air pollution episodes are known to be strongly related with persistent temperature inversions (Largeron et al. 2016, D. Zhao et al. 2019).



Synergistic approach: Turbulence and stability

Wind components and thermodynamic profiles with high temporal resolution available at JOYCE

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Doppler wind lidar

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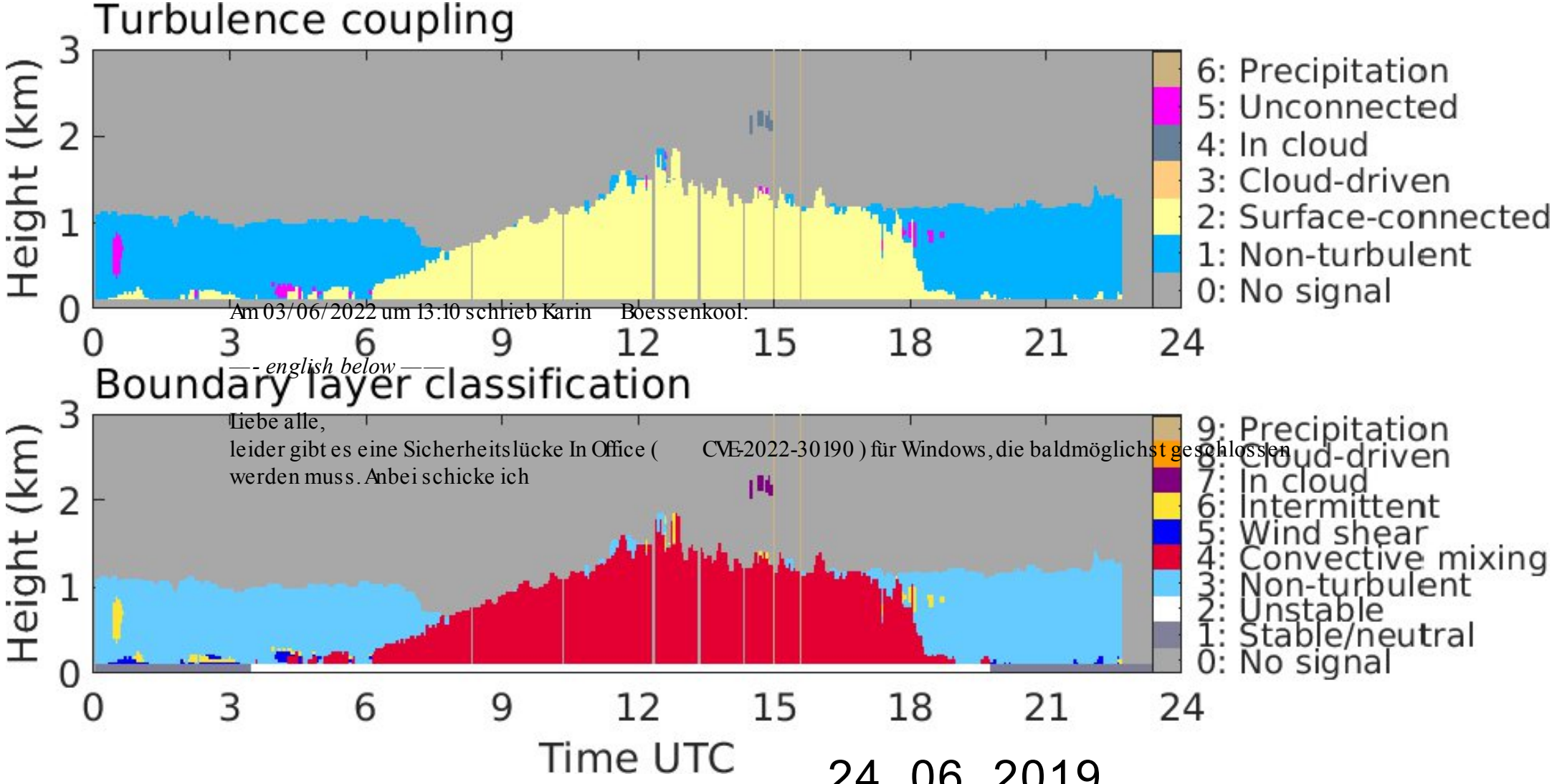
MWR

- Temperature profiles are used for boundary layer stability research (Saeed et al. 2016, D. Zhao et

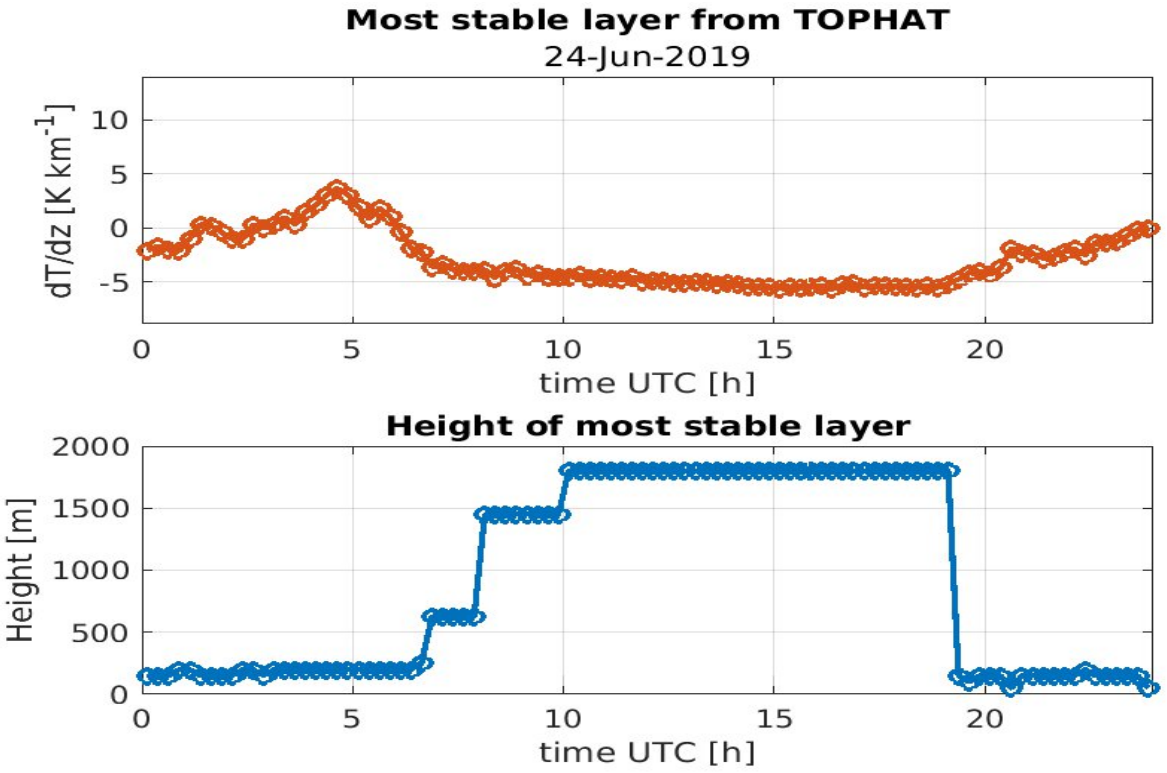
Doppler lidar ABL Classification



24. 06. 2019

(Manninen et al.

Thermal stability from MWR



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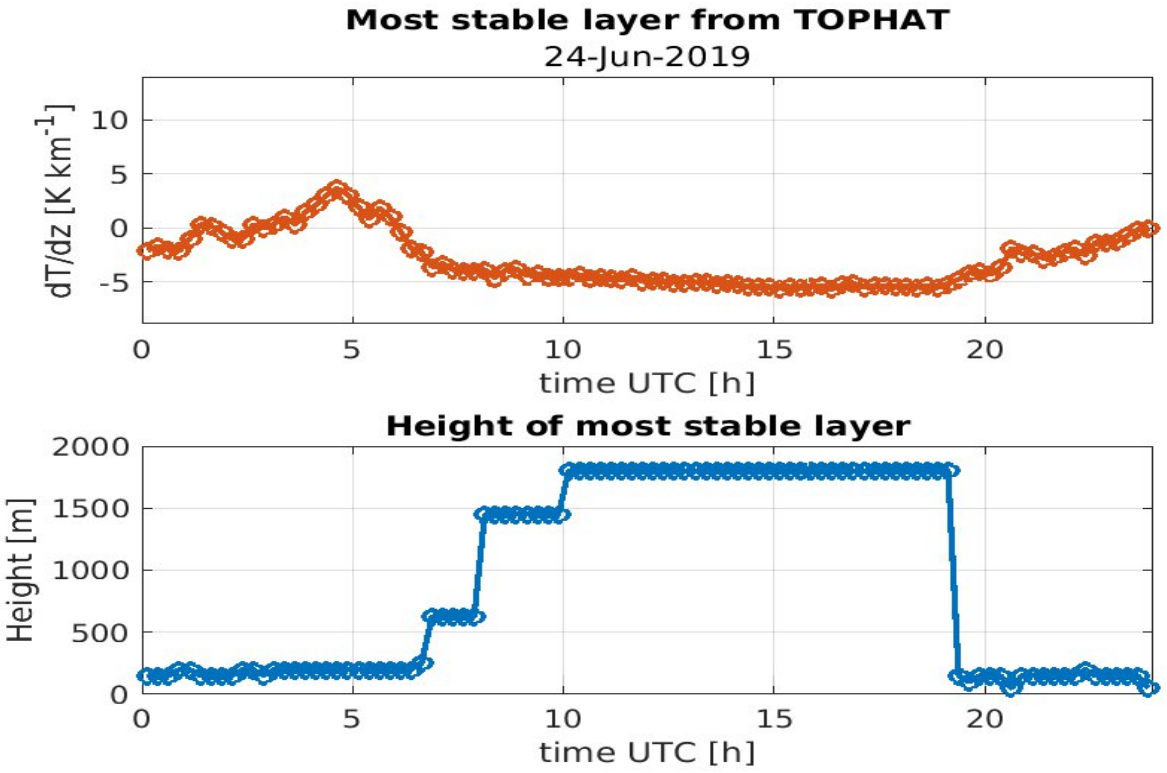
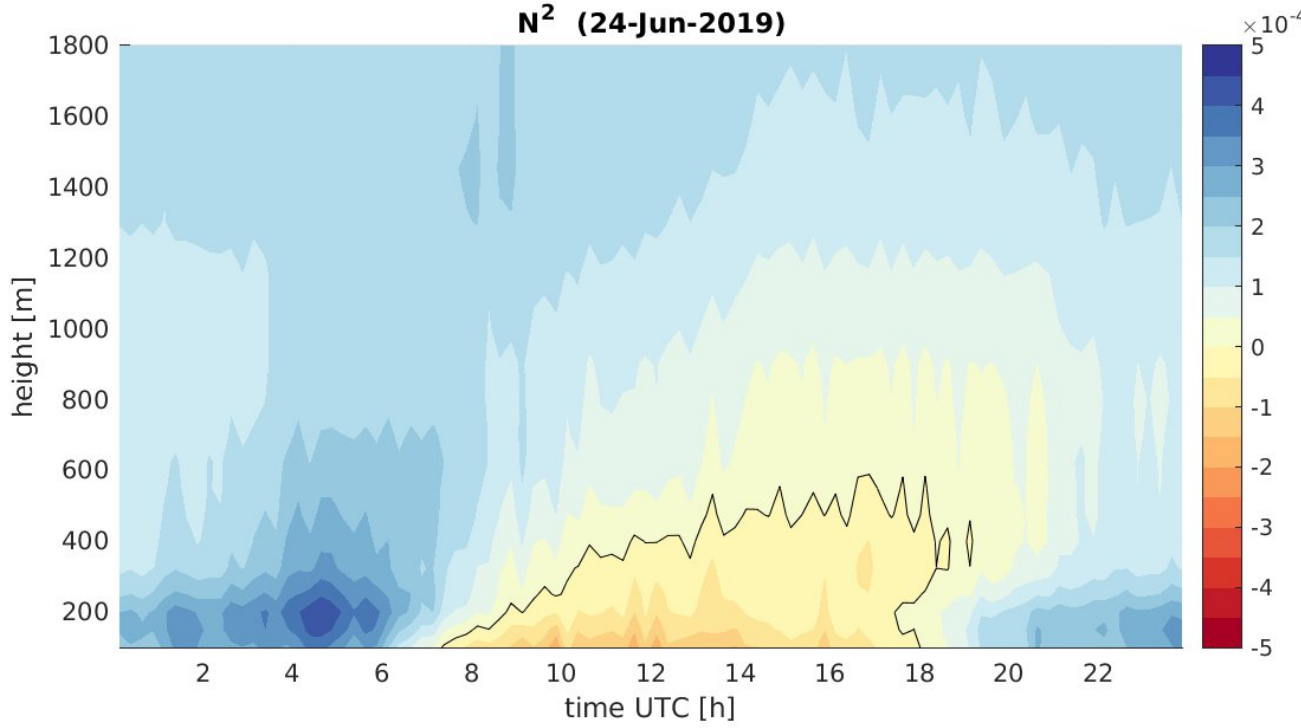
Thermal stability from MWR





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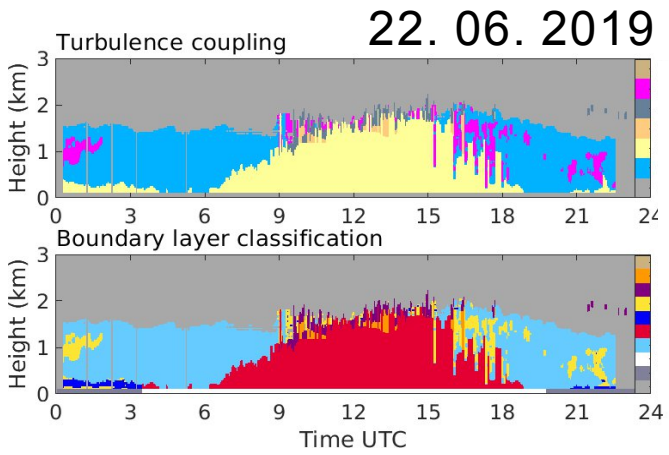
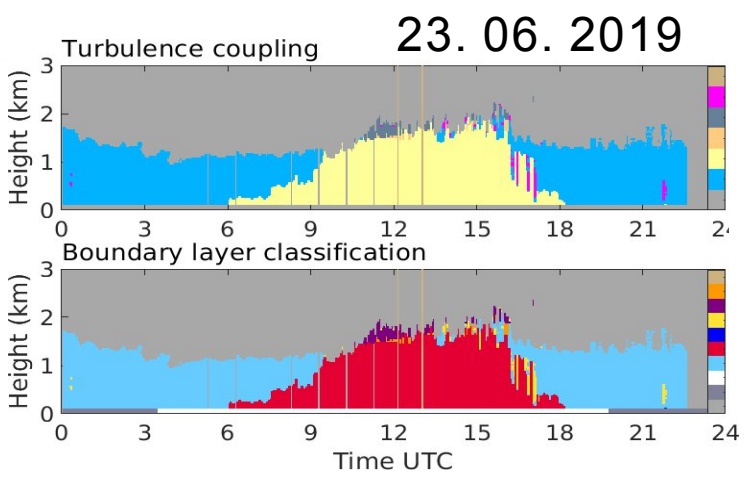
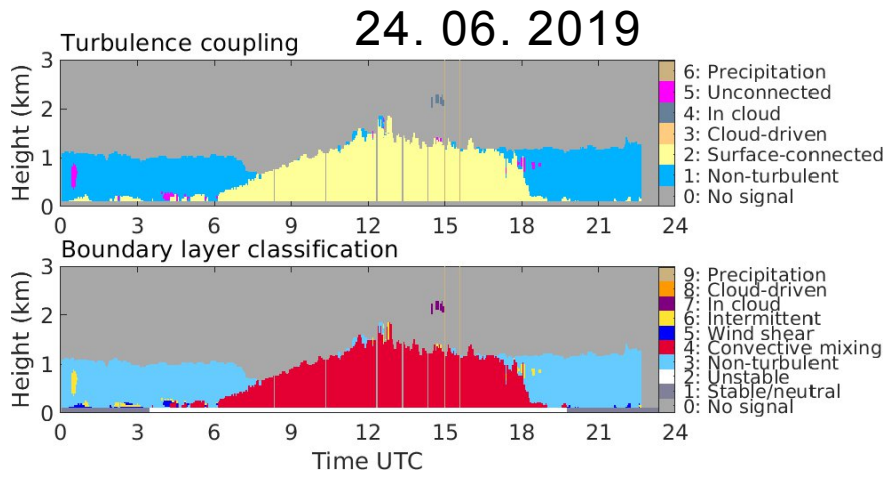
Summer 2019

ABL Classification DL





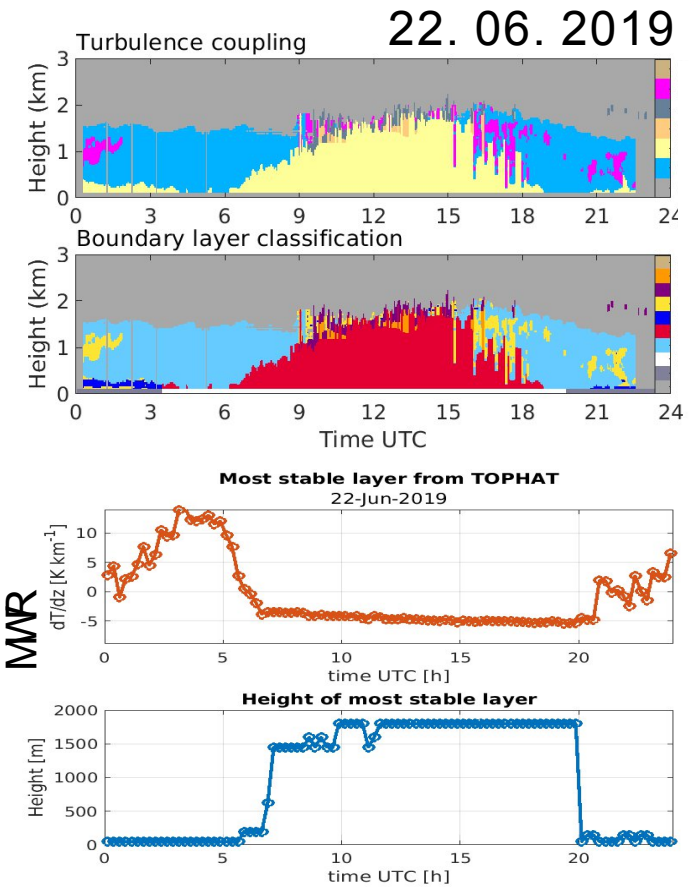


Summer 2019

ABL Classification DL

Most Stable Layer MWR

22. 06. 2019



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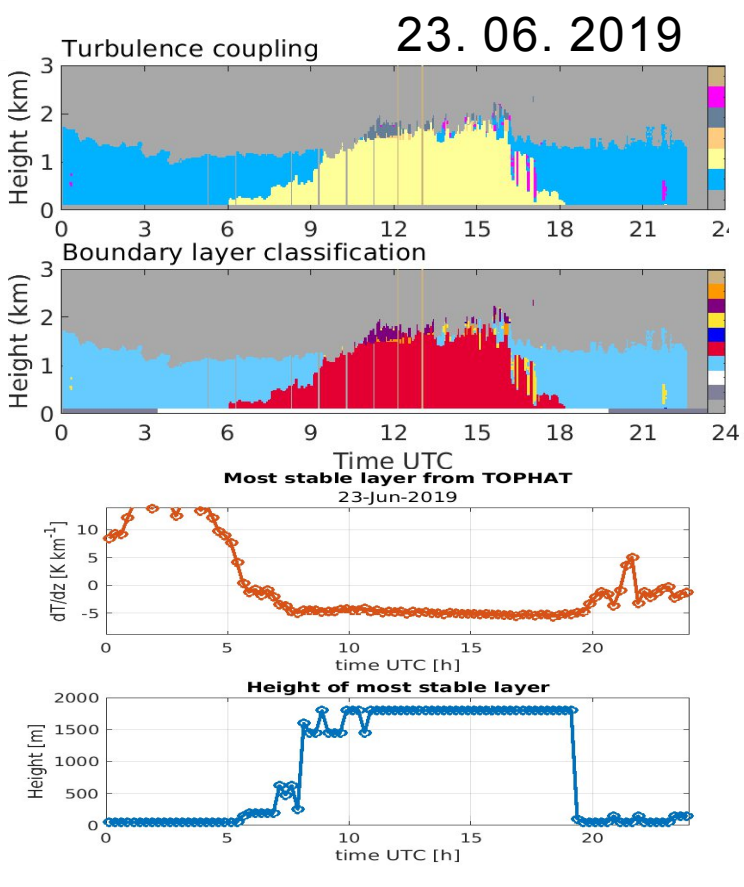

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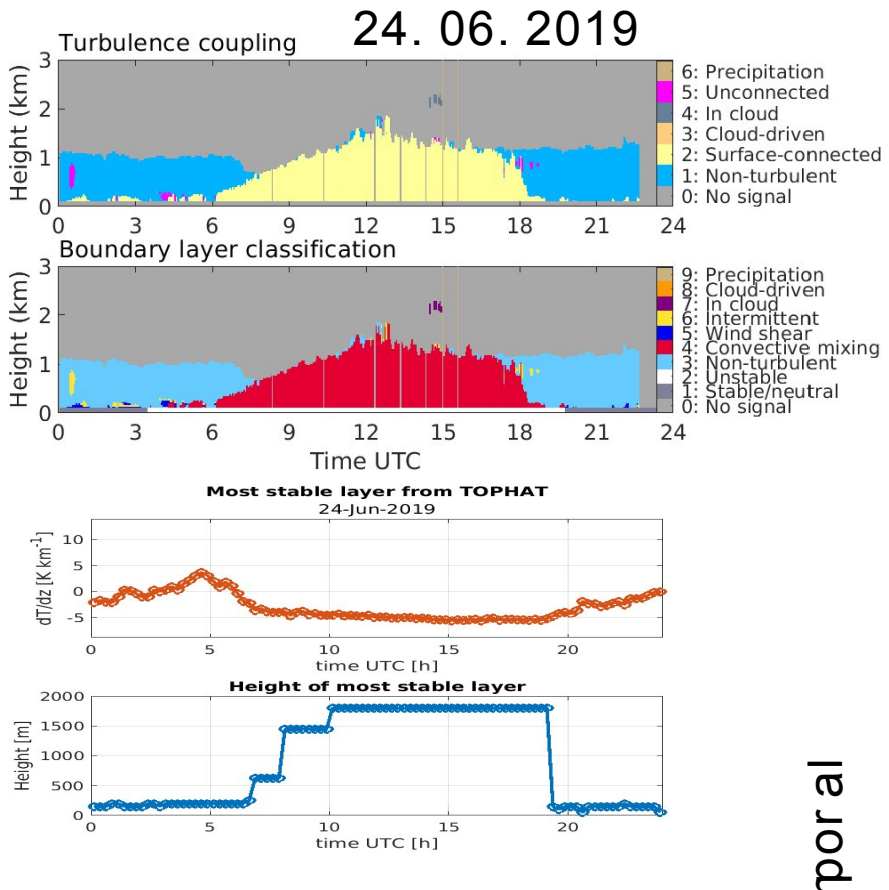

(15 min temporal resolution)

Summer 2019

ABL Classification DL

Most Stable Layer MRW

Brunt Väisälä frequency (N^2) MRW

(15 min temporal resolution)

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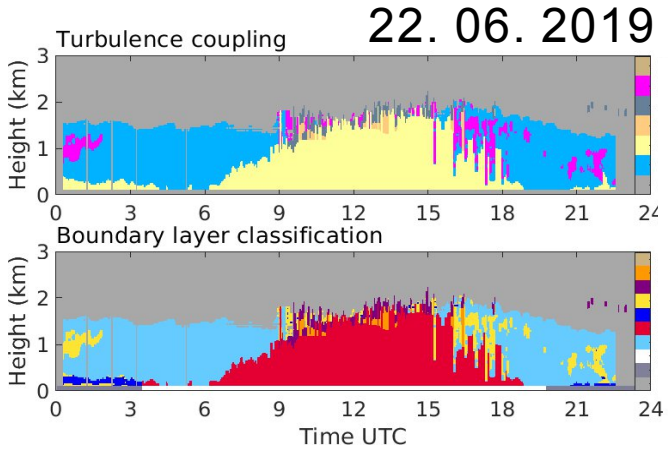

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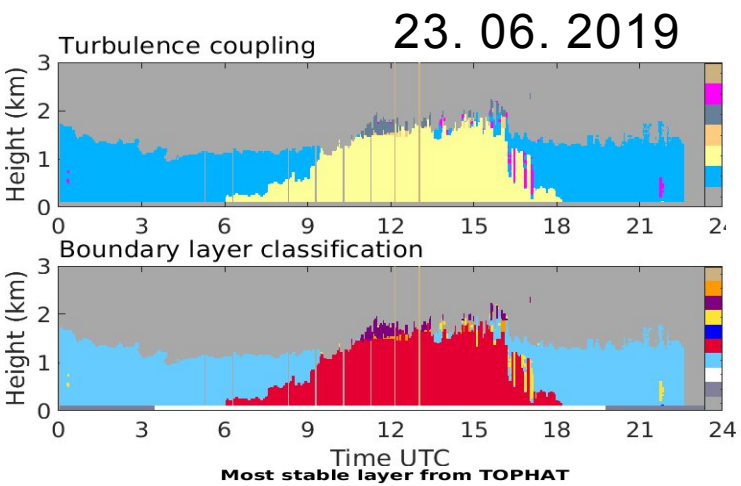

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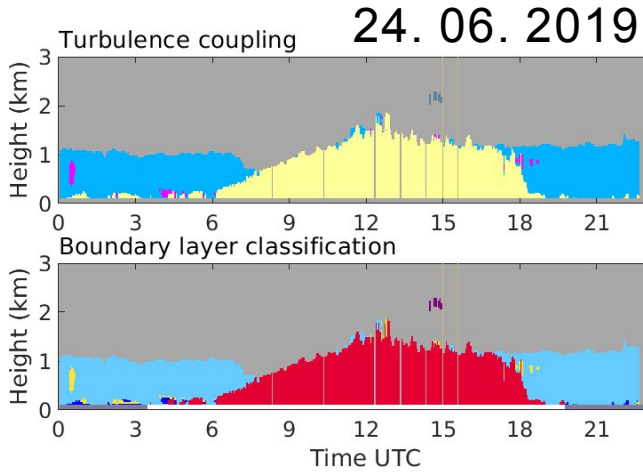
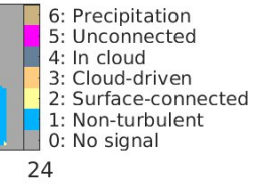
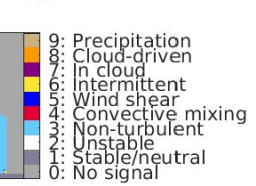
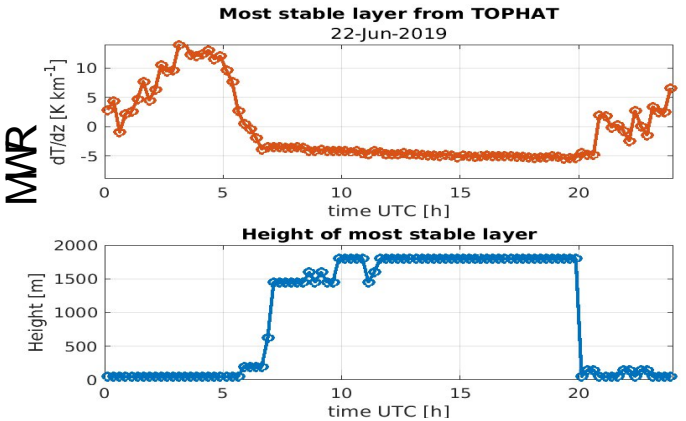
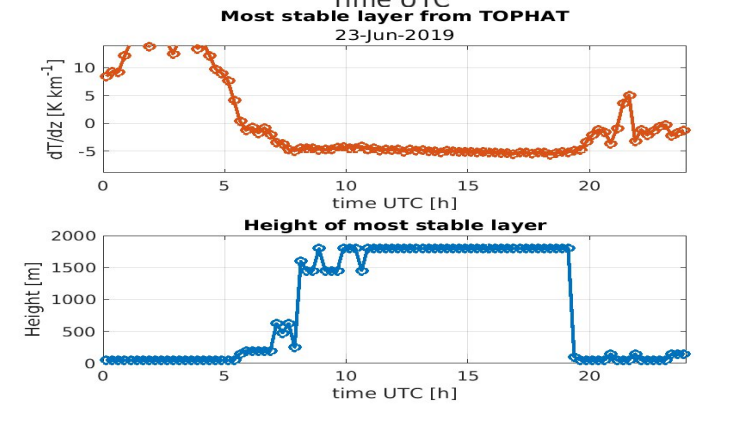
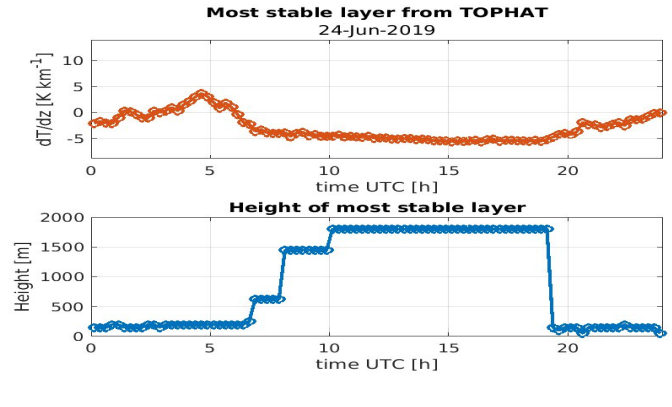


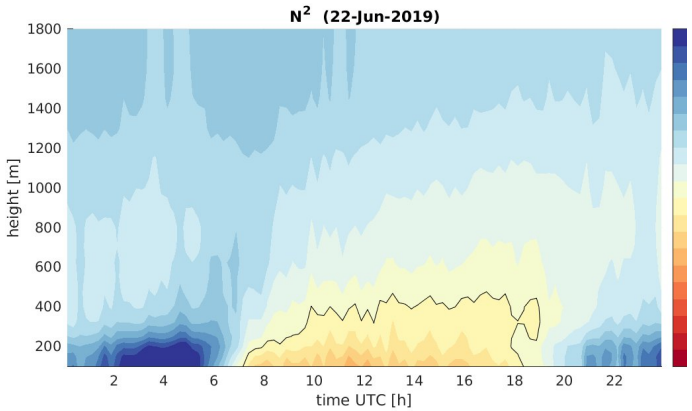


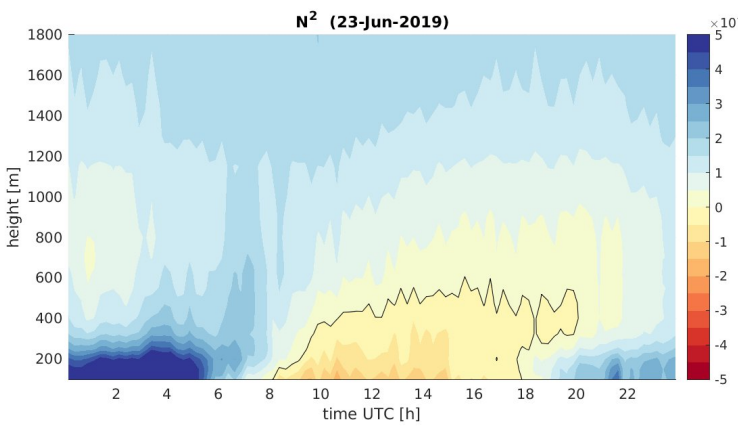


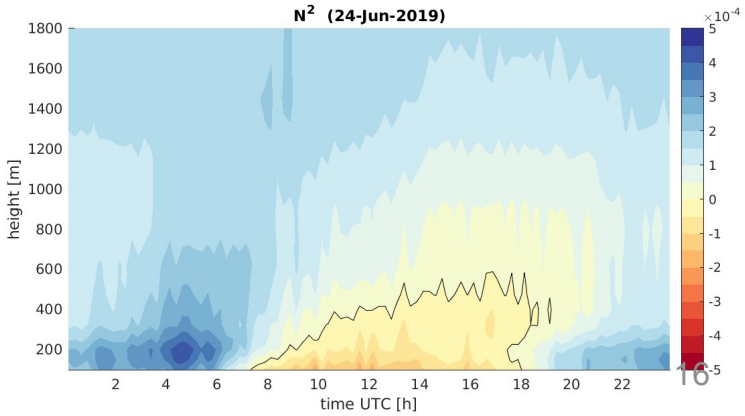






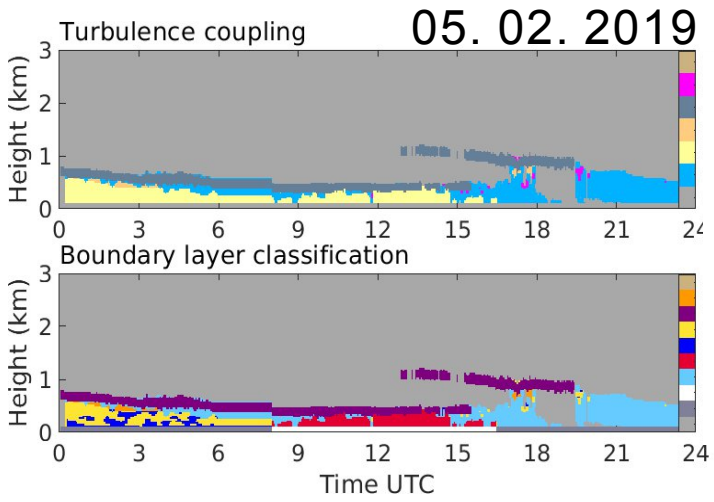


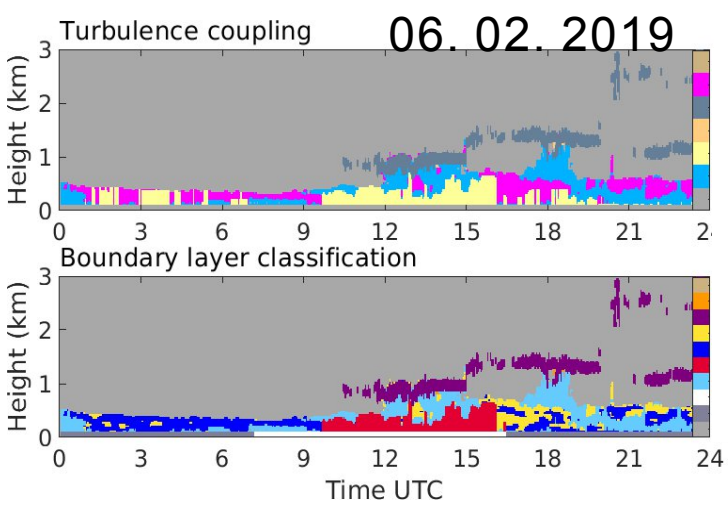


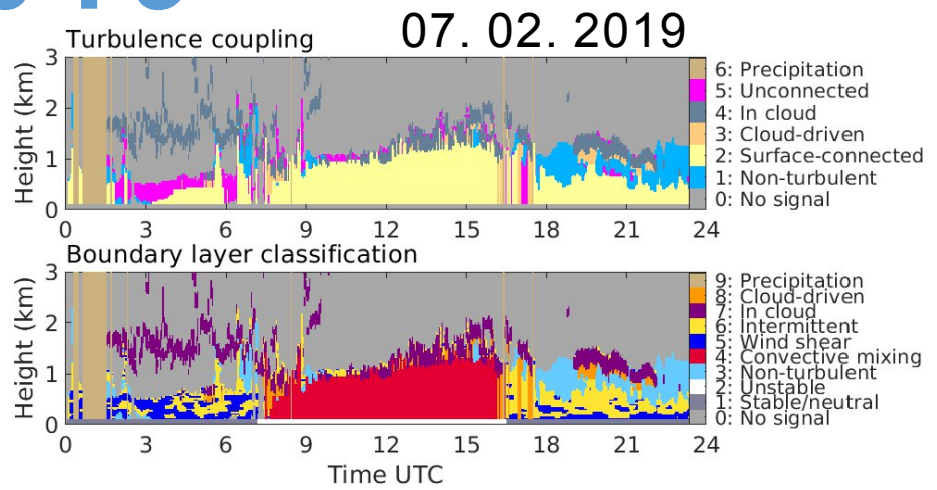


Winter 2019

ABL Classification DL



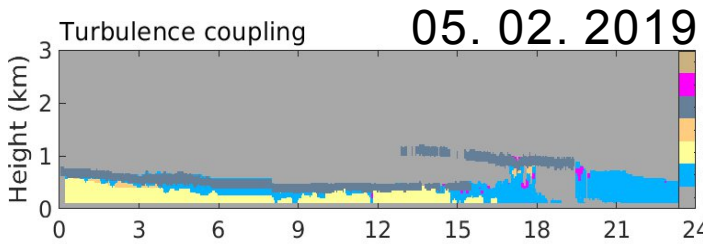


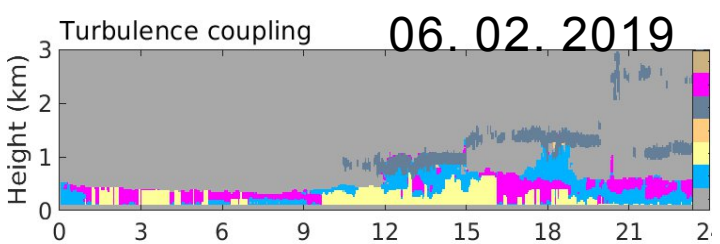


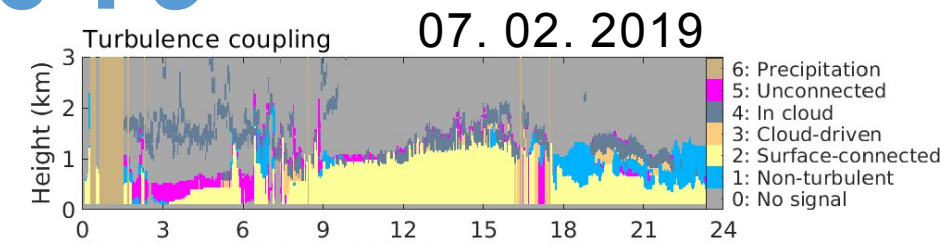
Winter 2019

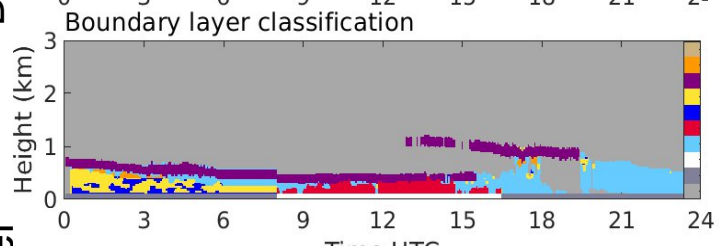
ABL Classification DL

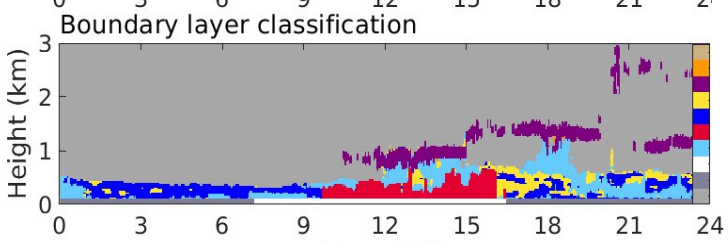
Most Stable Layer

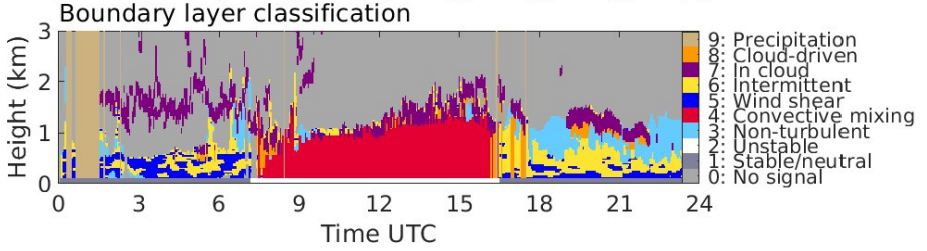


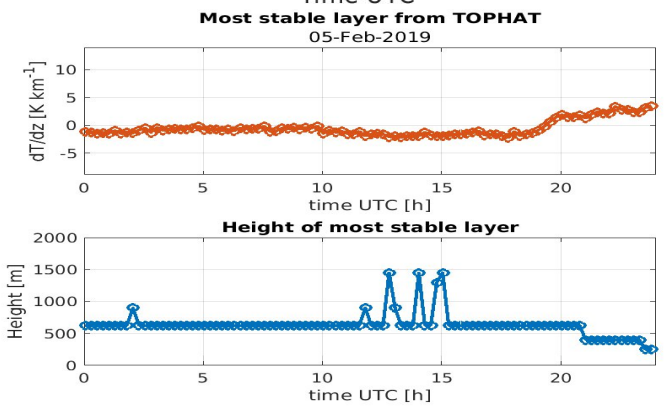


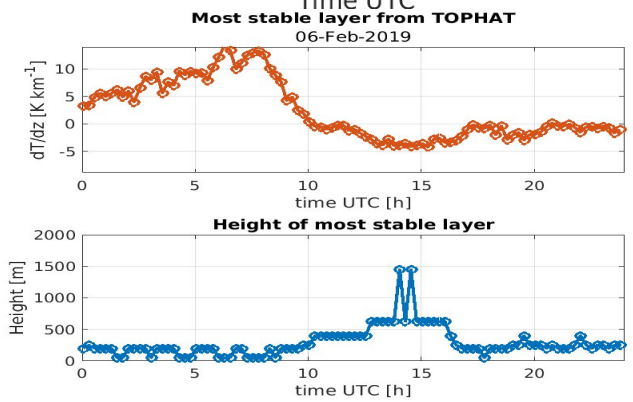


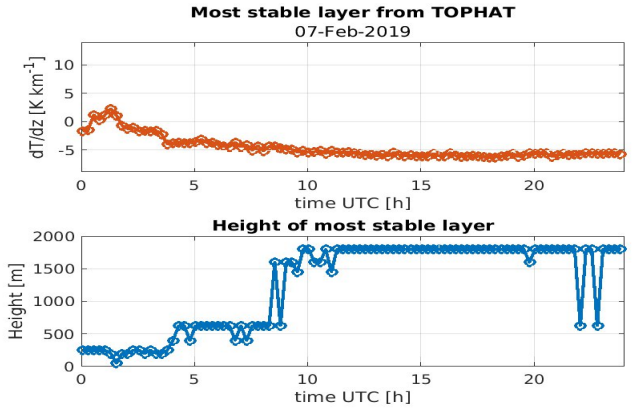












(15 min temporal resolution)

Winter 2019

ABL Classification DL

Most Stable Layer MRW

Brunt Väisälä frequency (N^2)

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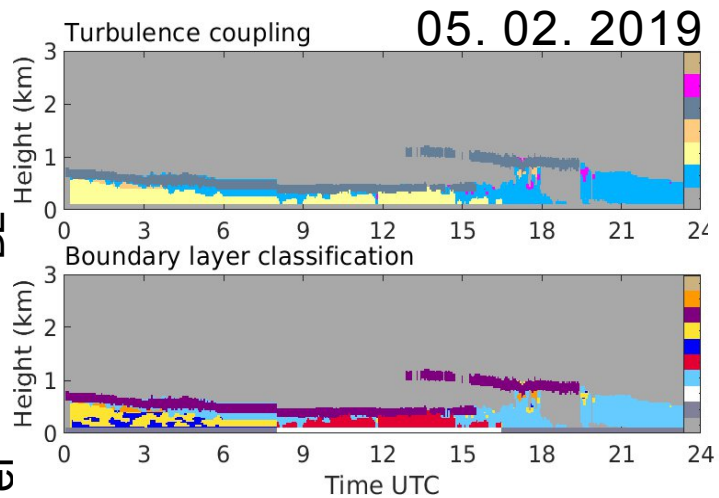
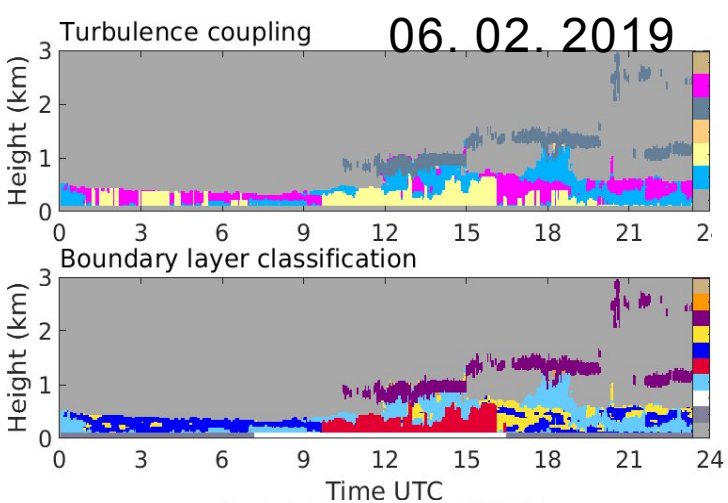
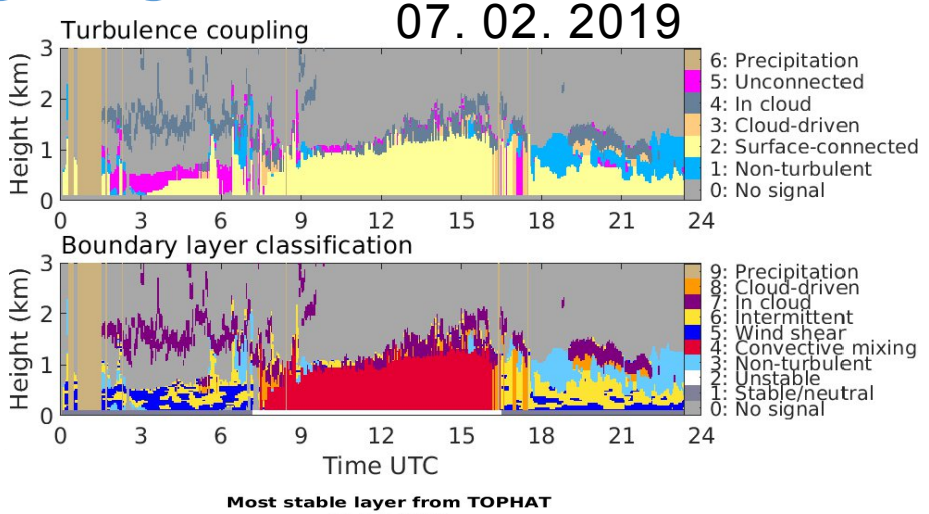
05. 02. 2019

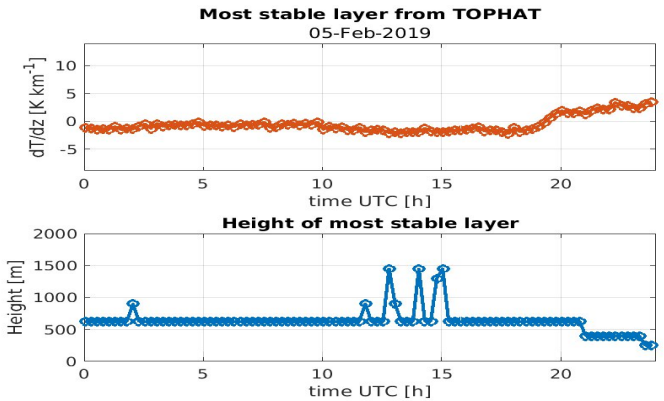
06. 02. 2019

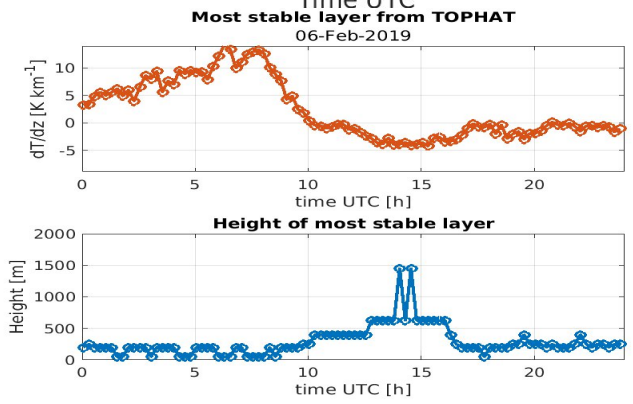
07. 02. 2019

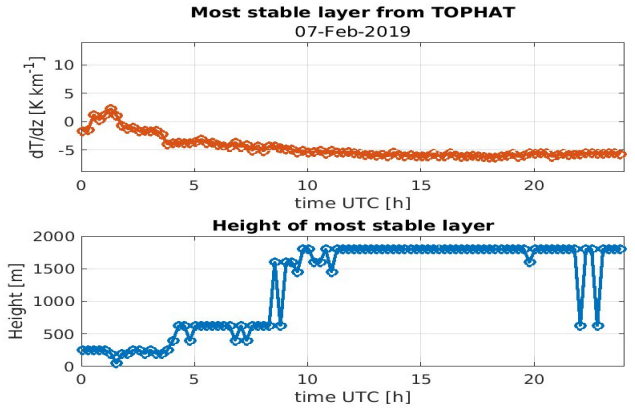


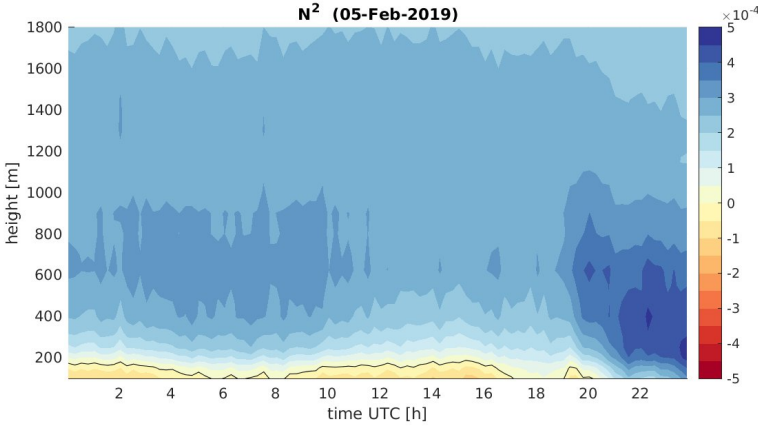


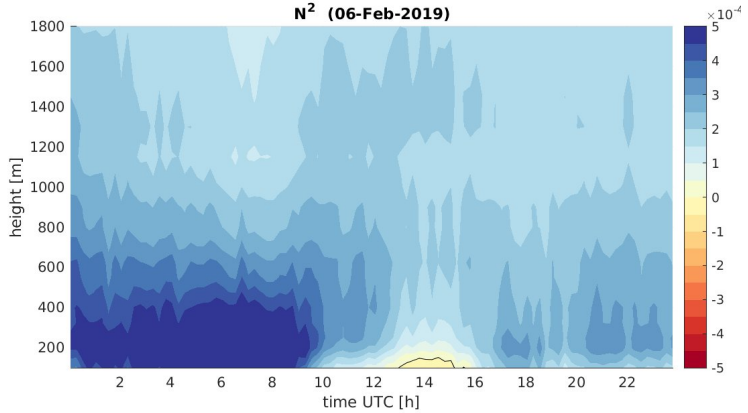


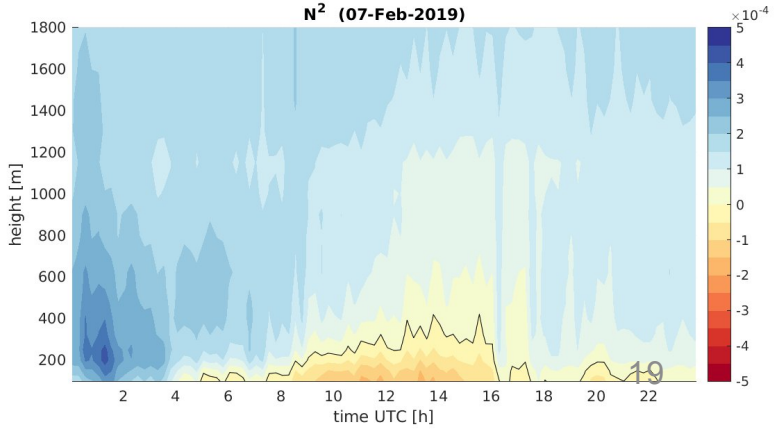






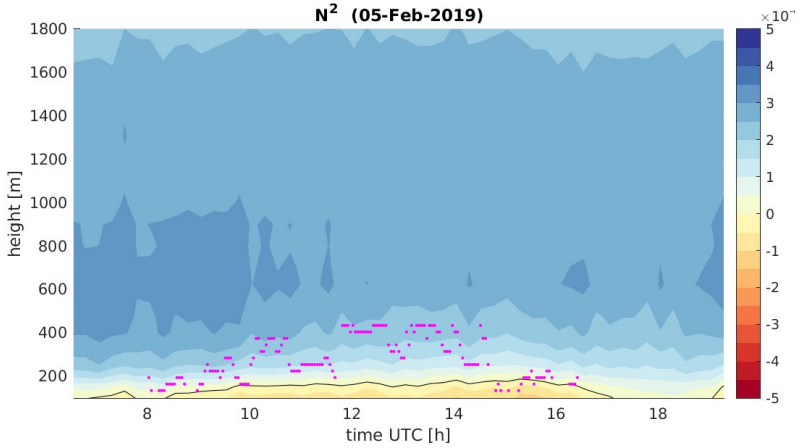


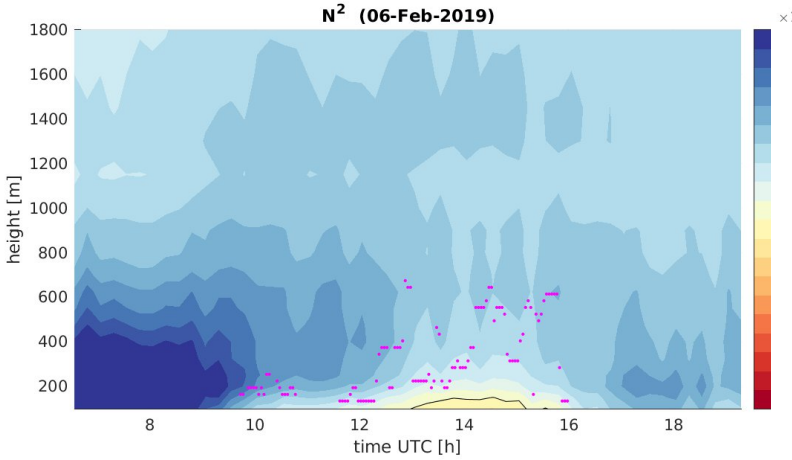


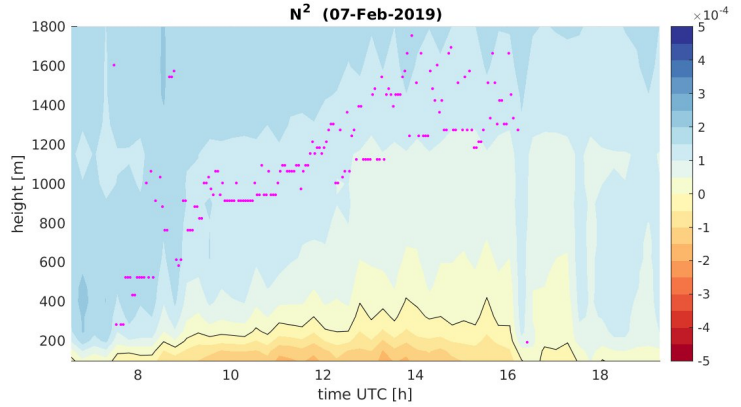


Comparing convective layer height and N^2

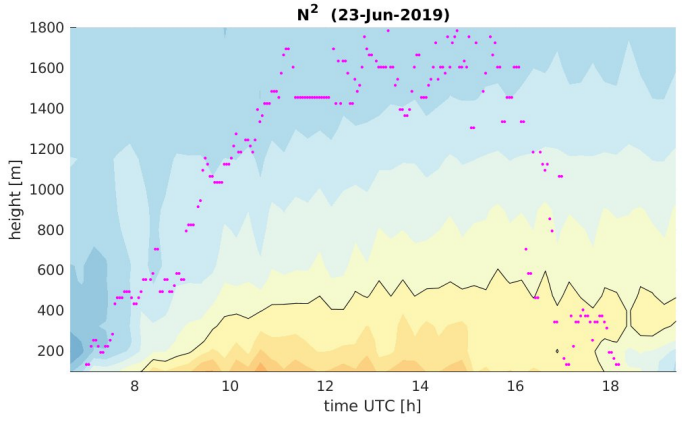
Winter 2019

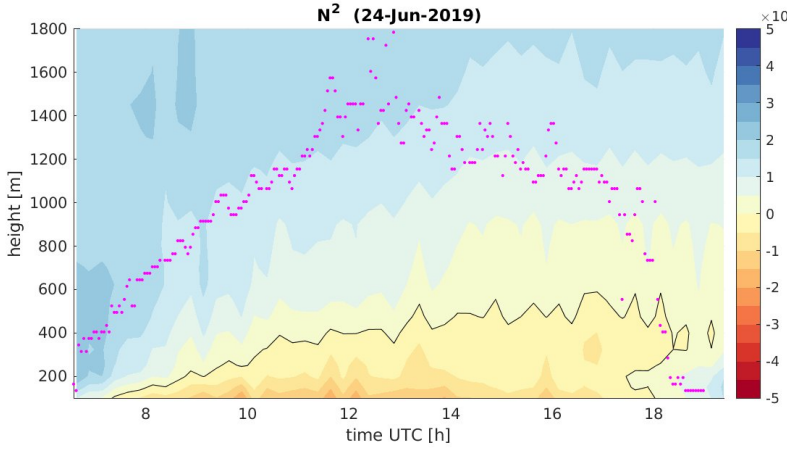


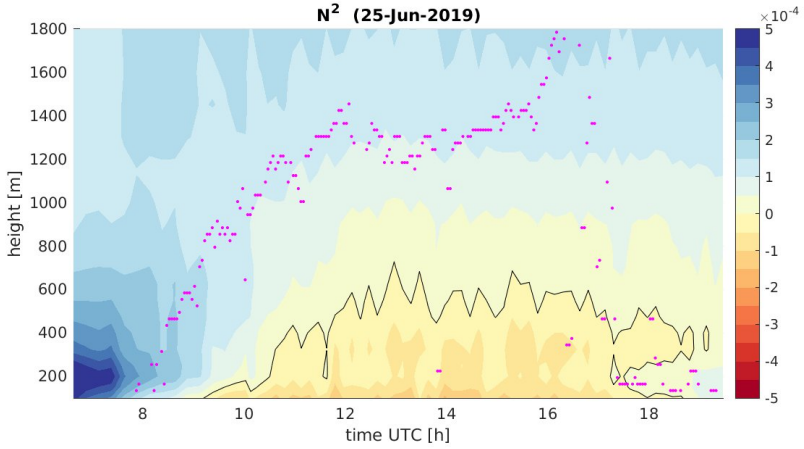




Summer 2019

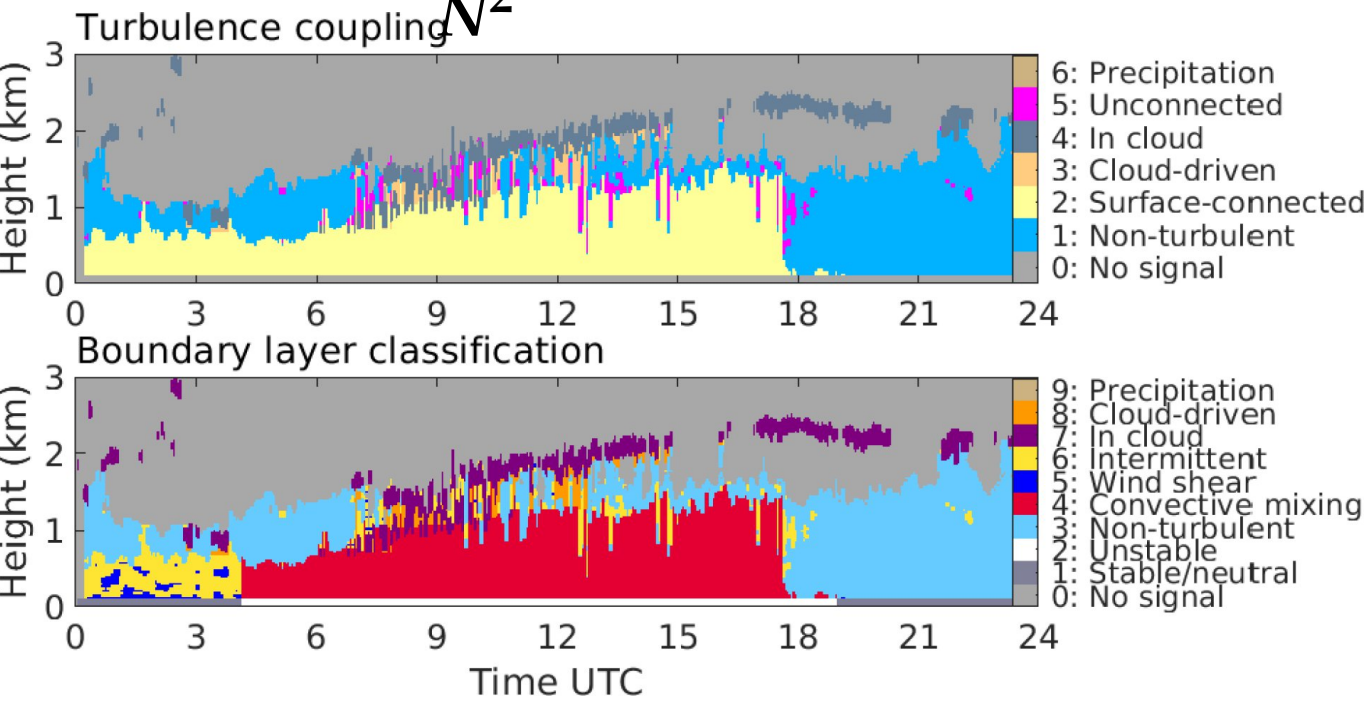




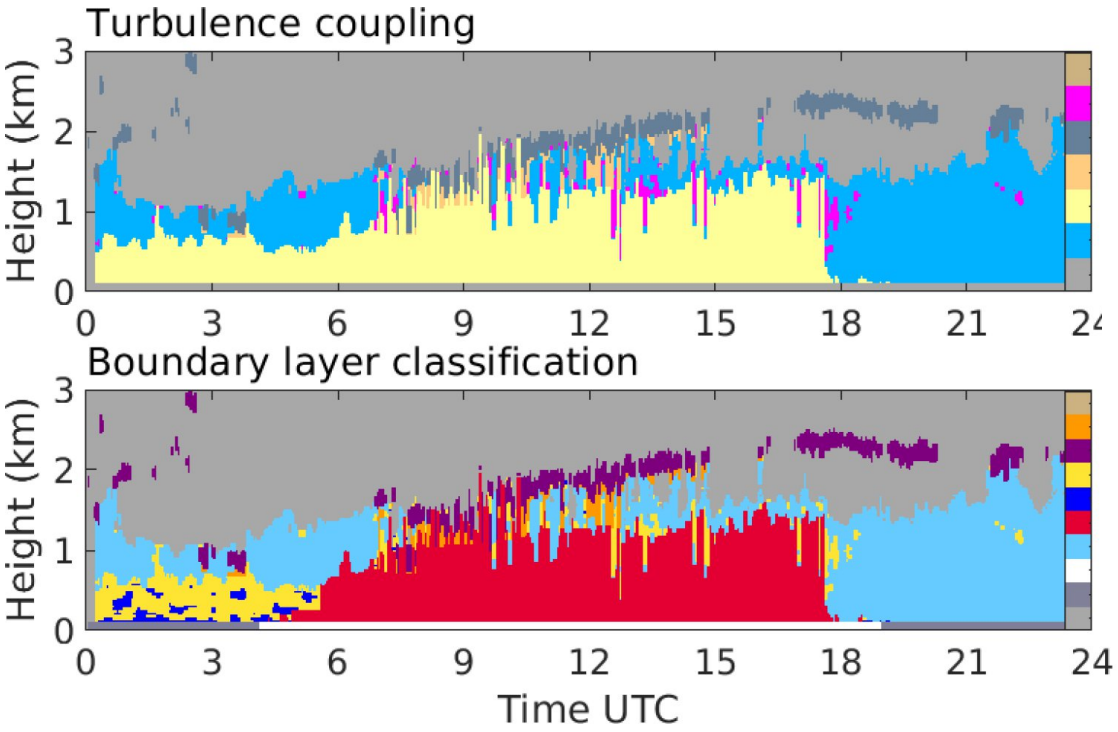


N^2 tested for ABL classification (T. Marke)

without N^2



with N^2



07. 05. 2015

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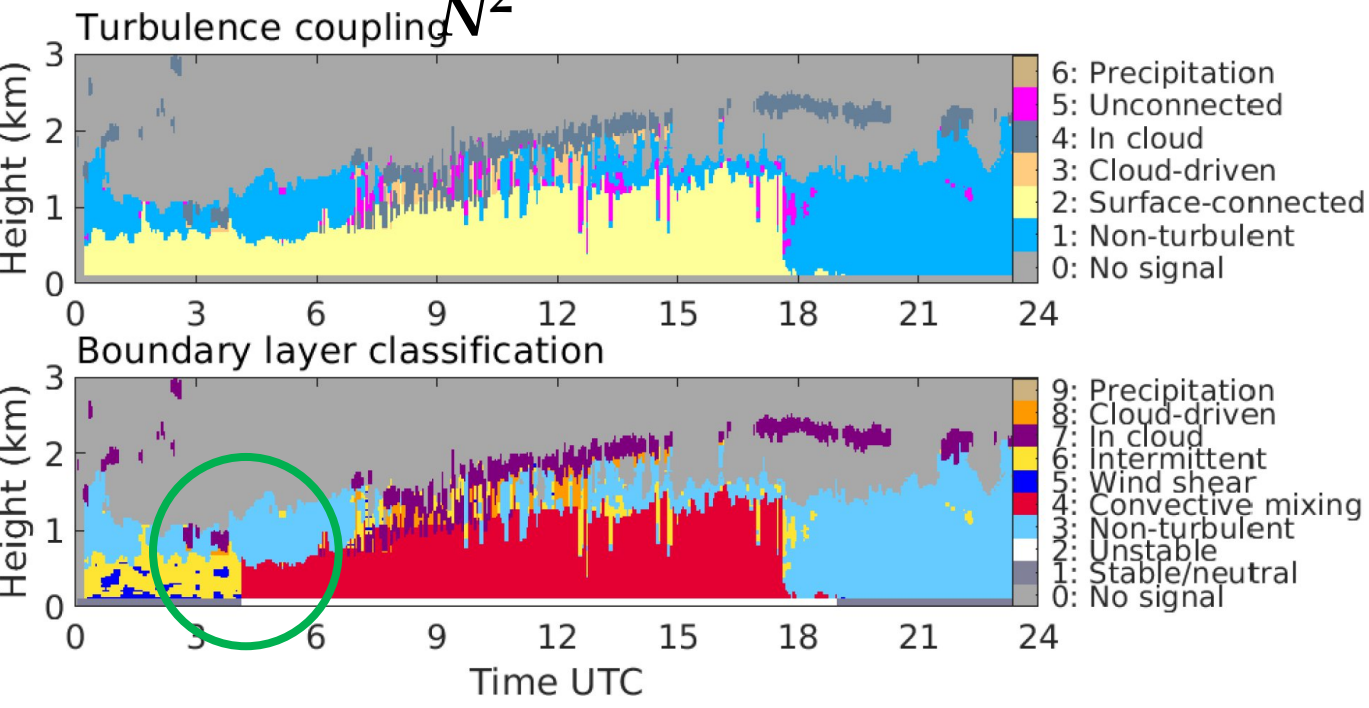

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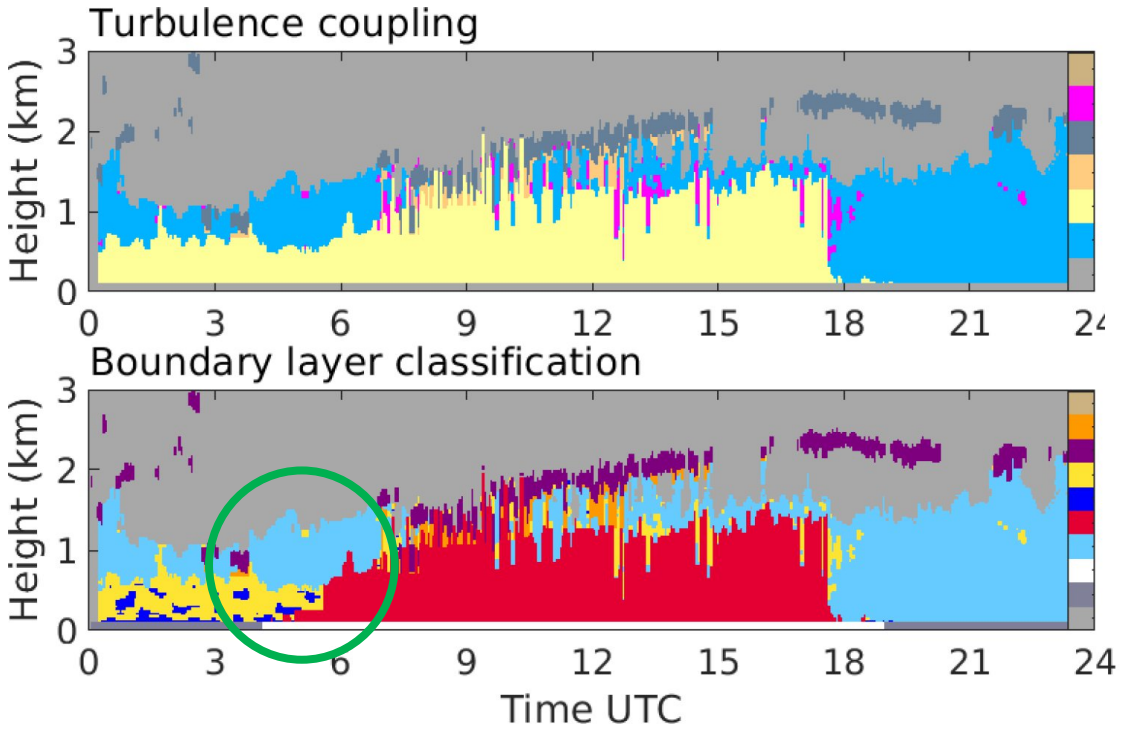

07. 05. 2015

Preliminary Conclusions

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- The implementation of N^2 in the ABL classification, allows to **identify more accurately the sources of turbulence**.
- **The present turbulence and stability characterization can be combined with in situ observations of aerosols in the frame of ACTRIS.**
- **Future:** estimation of Richardson number and thermodynamic indices will help us to better characterize the ABL stability and identify sources of turbulence.
- **Future:** investigation of sensible and latent heat fluxes