VITAL II: A step towards closing the observational gap in the atmospheric boundary layer

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Spatially and temporally continuous observations of atmospheric boundary layer (ABL) dynamics and thermodynamics are key for a better understanding of land surface atmosphere coupling. State-of-the-art observational approaches are either limited by vertical resolution (satellites), spatial coverage (ground-based profilers) or spatial and temporal coverage (radiosondes). Thus, spatial-temporal ABL patterns will only be resolvable through sensor synergy. The VITAL II campaign (*Vertical Profiling of the Troposphere: Innovation, Optimization and Application*, Löhnert et al., 2025) aims at taking a first step in closing this observational gap. VITAL II is part of HErZ – the Hans Ertel Center for Weather Research, a cooperation on fundamental weather and climate research between the German Meteorological Service (DWD) and German universities.

VITAL II will take place from June 1 – August 31, 2026 in the Cologne Bay region between the west German cities of Cologne, Bonn and Aachen employing and installing seven profiling sites over a wide variety of land surface types. At the profiling sites, ground-based remote sensing systems such as water vapor lidar, Doppler lidar and microwave radiometers will be operated which yield high potential to reliably profile ABL temperature, humidity, winds and turbulence in a nearly continuous manner. Uncrewed aircraft systems (UAS) will additionally be operated at selected sites during an intensive observation period. A large number of radiosondes will complement the profiling observations.

During VITAL II, first data from the Meteosat Third Generation Sounder (MTG-S1) satellite instrument IRS (Infrared Sounder) will become available providing continuous 3D observations of temperature and humidity over large parts of Europe and Africa with a temporal resolution of ~30 min. However, IRS deficits will remain in observing the ABL, especially in cloudy conditions. VITAL II will leverage the use of these novel, hyperspectral IRS observations by combining them with the VITAL II surface-based in-situ and remote sensing observations. Novel machine learning algorithms which synthesize MTG-S1 data with surface-based observations will be applied to and assessed by the multitude of additional VITAL II profiling observations. The objective is to significantly enhance the observed information content in the ABL. The profiling observations will be used for data assimilation studies with the DWD numerical weather prediction model ICON and for evaluating and improving ICON land surface and ABL turbulence parameterization schemes.

Next to the extensive profiling, VITAL II will install a dense near-surface observation network on the meso-β-scale (20–200km = regional scale). Up to 50 surface stations of the updated autonomous cold pool logger (APOLLO 2.0) will be installed within Cologne Bay. This observational setup, together with the synergistic profiling approaches, will be used for enhancing the understanding of the evolution of the

stable and convective ABL over an urban – rural transition zone, as well as on convective cold pools. For the latter, the main focus is on merging dense spatial, near surface data with vertical temperature and humidity patterns.

This contribution will present in detail the VITAL II concept and ideally, first measurements and results of VITAL II highlighting the importance of sensor synergy for ABL coverage.

References

Löhnert, U., Ament, F., Platis, A., Sakradzija, M. et al. (2025). VITAL II Concept Paper: Vertical Profiling of the Troposphere: Innovation, Optimization and Application II. Zenodo. https://doi.org/10.5281/zenodo.17424652