Temperature and humidity profile retrievals from synergistic satellite (MTG-IRS) and ground-based (Microwave Radiometer, SYNOP) observations

Spatially and temporally resolved temperature and humidity fields within the planetary boundary layer (PBL) are key variables for short-term forecasting with convection-resolving numerical weather prediction (NWP) models. Despite their importance, current observing systems still lack sufficient vertical, horizontal, and temporal resolution to adequately constrain these variables.

The recently launched hyperspectral Infrared Sounder (IRS) aboard the Meteosat Third Generation (MTG) geostationary platform will provide an unprecedented temporally and spatially resolved view on the atmosphere. However, even hyperspectral infrared measurements still leave gaps in the observation of the PBL structure, mainly due to the limited vertical resolution of the satellite and the strong influences from surface properties and clouds. Consequently, retrieval uncertainties increase within the lowest kilometers of the atmosphere.

In order to fill the existing observational gap, ground-based remote sensing systems capable of continuous temperature and humidity profiling have been developed. In particular, passive microwave radiometers (MWRs) provide reliable all-weather observations of temperature and humidity profiles and are increasingly suitable for network operation. On the European level, first instrument networks are in the process of being established, e.g. within the European Research Infrastructure Consortium ACTRIS and within EUMETNET E-PROFILE.

This study, conducted within the DWD-funded Hans-Ertel Centre for Weather Research (HErZ), investigates the extent to which the synergistic use of ground-based MWR observations and standard 2-m temperature and humidity measurements (SYNOP) can improve hyperspectral IRS-based profiling.

We develop retrievals of temperature and humidity profiles based on reanalysis as the truth, applying a Neural Network (NN) approach to optimally blend IRS radiances with surface-based MWR observations and standard 2m meteorology. Satellite observations are simulated with RTTOV model while ground-based MWR observations are generated using a line-by-line radiative transfer model. In the first attempt, the retrievals are developed for the Jülich Observatory for Cloud Evolution (JOYCE).

We present first results of the study including simulated observation datasets, neural network architecture and performance of the MWR-only, IRS-only and synergistic MWR+IRS and SYNOP+IRS retrievals applied to simulated observations. If real IRS observations become available in summer 2026, preliminary applications to real measurements collected during the VITAL II measurement campaign (DOI 10.5281/zenodo.17424651) will also be presented.