



Observational impact of ground-based water vapor profiling networks on convection-permitting numerical weather prediction – an ensemble sensitivity analysis case study

Nina Raabe¹, Maria Toporov¹, Philipp Griewank², Martin Weissmann², Takumi Matsunobu³, and Ulrich Löhnert¹

¹Institut für Geophysik und Meteorologie, Universität zu Köln, Cologne, Germany

²Institut für Meteorologie und Geophysik, Universität Wien, Vienna, Austria

³Meteorologisches Institut, Ludwig-Maximilians-Universität München, Munich, Germany

The demand for accurate weather forecasts is increasing because of, for example, high-impact events becoming more frequent and more extreme. However, convection-permitting numerical weather prediction systems still lack precise initial conditions due to observational gaps. In order to improve the predictions, filling those gaps is of great importance.

Ground-based water vapor profiling networks could contribute to that using broadband differential absorption light detection and ranging systems (DIALs). In this work, the impact of different hypothetical configurations of such networks on the convection-permitting Icosahedral Non-hydrostatic (ICON) D2 model operationally used by the German Weather Service is assessed. For that, an ensemble sensitivity analysis (ESA) is employed. Using an ensemble-based sensitivity, the ESA method quantifies the change of variance in a forecast metric ensemble due to the assimilation of additional data. Compared to other observational impact assessment (OIA) methods, it benefits from not requiring forecast validation, actual measurements, or additional model runs.

First results indicate that for the default network configuration and two summer afternoon cases, the additional observations decrease the spread of an ensemble of the model on average by 5.5 to 7 percent (%) depending on the specific water vapor forecast metric used. The forecast metrics respond as expected to changes in the network parameters, that is, the spread decreases further for smaller instrumental errors and larger vertical ranges of the DIALs. Assimilating point measurements leads to a 70% smaller spread reduction relative to the one obtained for water vapor profiles up to a height of 1200 meters.

On the one hand, the results of these case studies confirm the expected benefit of a DIAL network, while also indicating what to focus on for further improvements. On the other hand, they demonstrate the applicability of the flexible and computationally cheap ESA method to this kind of evaluation. With the results being comparable to those obtained by other OIA methods, an assessment of how realistic the ESA results here are could be conducted. That could help to judge whether the method could and should be applied in OIA more broadly.

