Assessment of integrated water vapour inferred by GPS, miscellaneous measurements and atmospheric models

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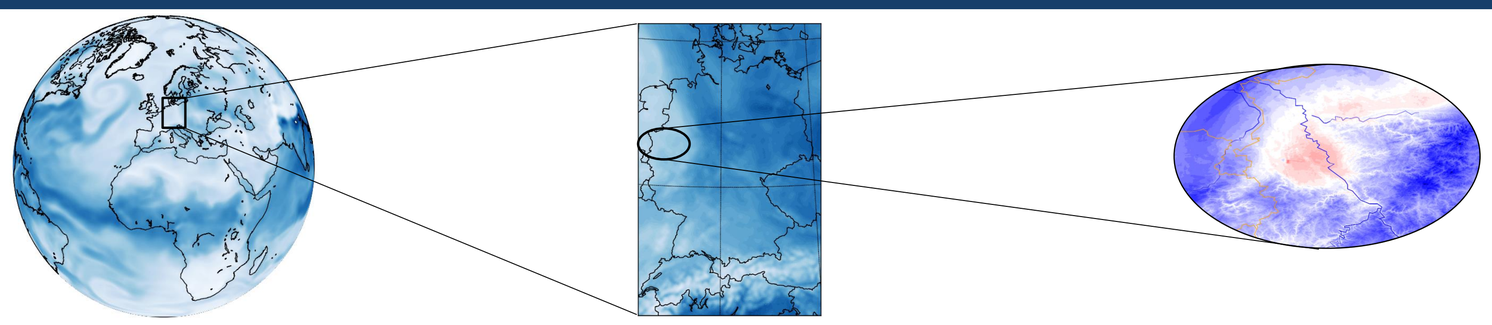
1. Motivation

Integrated water vapour (IWV) is highly variable in both space and time on different scales.

Question:

Which variability can be captured by models and (different) measurements?

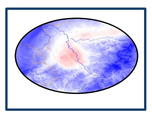


ERA-Interim
ca. 50 km horizontal resolution

COSMO-Reanlysis (see Poster 2-3 by Bollmeyer et al.)
6.2 km horizontal resolution

ICOsahedral Non-hydrostatic (ICON) model
156 m horizontal resolution

2. Which measurements can capture small scale variability of IWV?



High Definition Clouds and Precipitation for advancing Climate Prediction (HD(CP)²) Observational Prototype Experiment (HOPE)

- April and May 2013 in vicinity of the Juelich Observatory of Cloud Evolution (JOYCE), Germany
- Measurements with microwave radiometers (MWR) and GPS

Fig.1 : *Map of measurement area. GPS and MWR are located at JOYCE. ICON grid points and MWR2 are used in Fig. 5.*

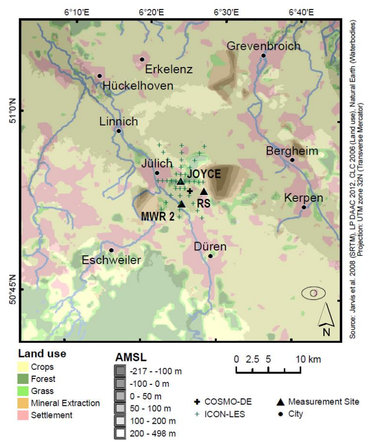


Fig. 2: *Autocorrelation of IWV during HOPE measured with MWR with 5 s resolution (solid black), with 15 min resolution (dotted black), GPS (solid blue), and simulated with COSMO-DE (green). The horizontal line represents e^{-1}.*

Data sets with resolution of 15 min show e-folding time of ca. 13 h. MWR measurements with 5 s resolution shows shorter e-folding time.

→ Importance of small scale processes

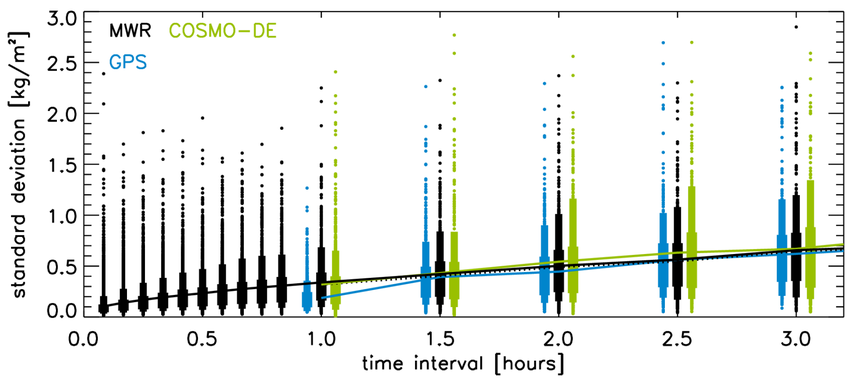


Fig.3 : *Lines: Mean standard deviation of IWV during HOPE computed for varying intervals. Displayed are: MWR with 15 min resolution (dotted black), MWR with 5 s resolution (solid black), GPS (blue), and COSMO-DE (green). For the 5 s MWR measurements, the GPS measurements, and the COSMO-DE simulation the vertical bars indicate the 10%, 25%, 75%, and 90%-percentiles of the standard deviation for varying intervals. The single dots indicate the outliers.*

- Standard deviations of 2 kg m^{-2} occur at time intervals less than 1 h
- MWR: Mean standard deviation of 15 min means are only slightly smaller than mean standard deviation of 5 s means

→ For time scales of a few hours a resolution of 15 min is sufficient for resolving mean IWV variability

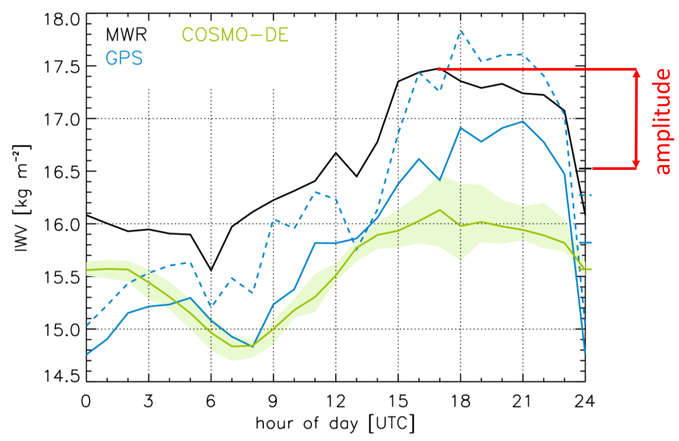


Fig. 4: *Mean diurnal cycle of IWV during HOPE measured with MWR with 15 min resolution (black), GPS (solid blue), GPS for coincident measurements with MWR (dashed blue), and simulated with COSMO-DE (green). The shaded green area represents the spread of differently aged forecasts of COSMO-DE. The ticks on the y-axis represent the respective two month mean.*

- Clear diurnal cycle over HOPE period with lowest values in the morning and maximum in afternoon/evening
- Amplitude range from 0.5 to 1 kg m^{-2} depending on the data set.

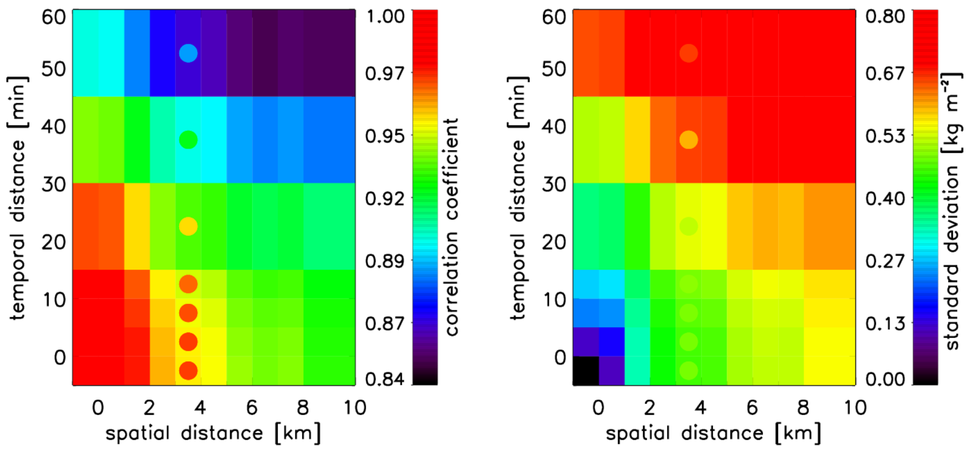
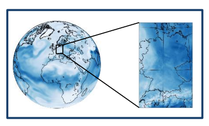


Fig. 5: *Correlation coefficients (left) and standard deviations (right) of IWV from ICON grid points (simulation for 5 May 2013) as a function of temporal and spatial distance. The circles represent the correlation coefficients and standard deviations from two MWRs positioned 3.3 km apart*

- **ICON** shows that correlation (standard deviation) decreases (increases) distinctly with temporal and spatial mismatch
- **2 MWRs** 3.3 km apart from each other confirm ICON results

Only MWR can capture full temporal variability of IWV. GPS measurements are well suitable for larger scales (15 min). On larger scales GPS networks exists

3. Larger scales



Within the Hans Ertel Centre for Weather Research a regional reanalysis with the COSMO model for the European CORDEX EUR-11 domain is produced.

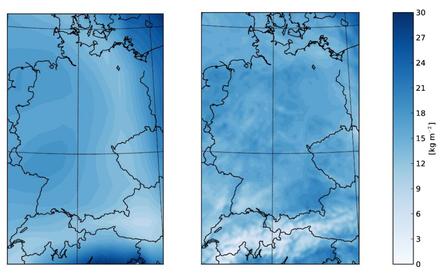


Fig. 6: *IWV of ERA-Interim (left) and COSMO-REA (right) for 1/7/2011 12 UTC*

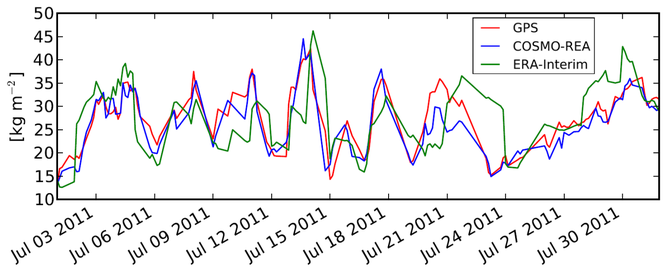


Fig. 7: *IWV time series of GPS (red), COSMO-REA (blue), and ERA-Interim (green) for July 2011 in Dresden*

Compared to ERA-Interim spatial and temporal variability of IWV can be captured on smaller scales by COSMO-REA.

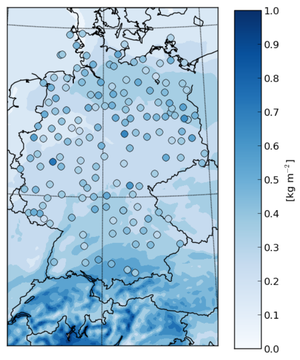


Fig. 7: *Mean amplitude of diurnal cycle of IWV of COSMO-REA and GPS stations for the years 2007-2012*

Differences between measurements and COSMO-REA will be investigated in respect of seasons, weather situations, and time of minimum and maximum.

Reference:

Steinke, S. et al. "Assessment of Small-Scale Integrated Water Vapour Variability During HOPE", Atmos. Chem. Phys., in review.