Evaluation of the atmospheric water vapor in the regional climate model ALARO coupled to the land surface scheme SURFEX using GNSS observations

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Abstract

An assessment of the regional climate model ALARO has been performed using ground-based Global Navigation Satellite Systems (GNSS) observations. We evaluate the integrated water vapor (IWV) in ALARO at 20 GNSS sites that are integrated in the IGS repro1 database. The ALARO model runs at the Royal Meteorological Institute (RMI), and is coupled to the land surface scheme SURFEX. For this study, the climate was simulated in a long-term continuous mode, driven by boundary conditions from ERA-Interim. The analysis period covers 6 years from 1995 to 2000, with IWV values 2 times per day at 0UTC and 12UTC. The results show that the model simulates well the seasonal variation. The IWV is mostly overestimated by the model, which appears to be strongest in autumn, while the IWV is underestimated in July and August. The altitude of the GNSS station determines the mean IWV. Larger height differences between the model and the observations result in larger IWV differences. The spatial variability is high and we are not able yet to conclude what are the controlling factors for the differences. We suggest to apply a height correction and investigate a longer time series.

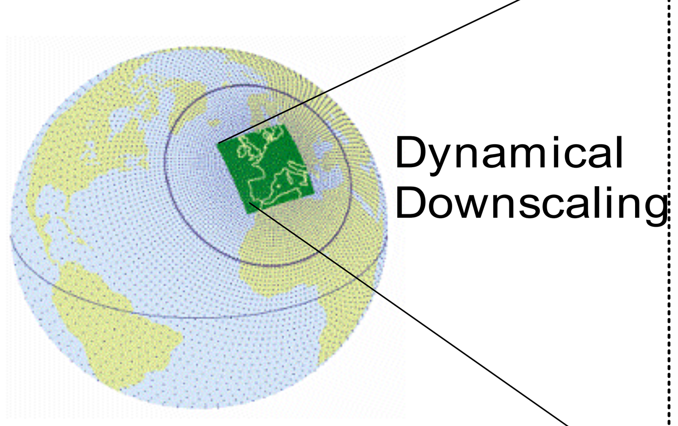
Research Question

How does the regional climate model ALARO perform for the IWV compared to the GNSS observations in terms of
[1] spatial variability?
[2] seasonal variability?
[3] altitudinal variability?

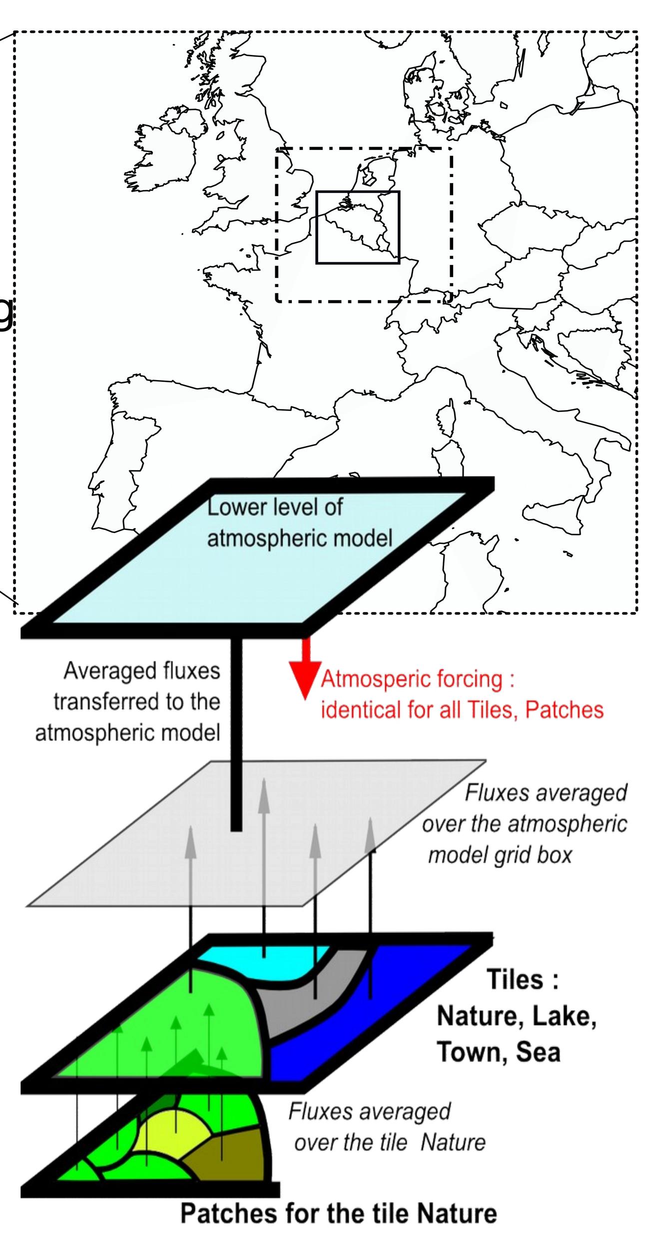
Experimental design

IWV MODEL

GLOBAL REANALYSIS ERA-INTERIM



LIMITED AREA MODEL (LAM) ALARO 20 KM



SURFEX

Calculation of the IWV

- surface pressure and specific humidity at each vertical pressure level (total of 46 levels)
- closest gridpoint to station in lat/lon, not in height

IWV GNSS

$$IWV = \Pi . ZWD = \Pi . (ZTD - ZHD)$$ (Vey et al. 2009)

$$\Pi = \frac{10^6}{\rho_w R_v \left(\frac{k_3}{T_m} + k'_2\right)}$$

$$ZHD = \left[0.0022768 \frac{m}{hPa}\right] \frac{P_{GPS}}{f(\lambda, H)}$$

Temperature and pressure from ERA-Interim

Results

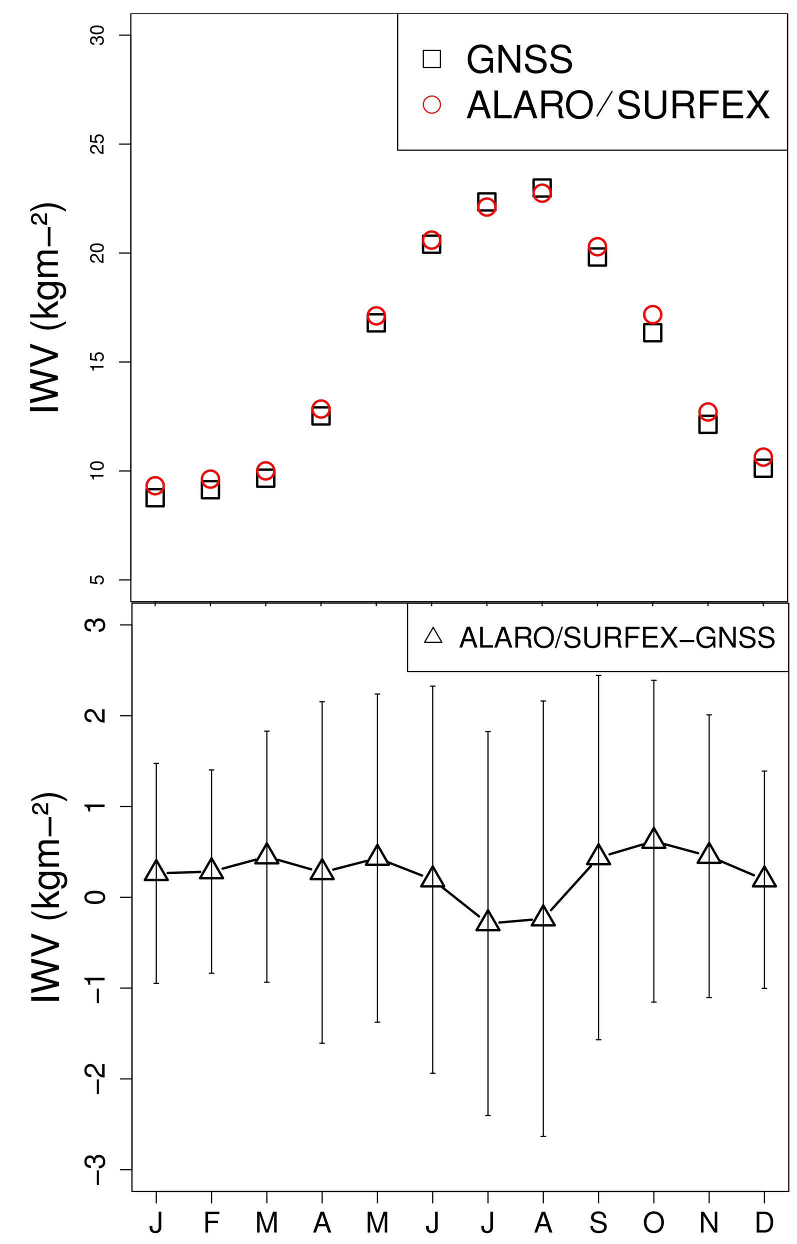


Figure 1. The time series of the monthly mean IWV of (a) the absolute values for GNSS observations and ALARO-SURFEX model, and (b) the difference and standard deviation between the model and observations, averaged over 6 years and all stations.

- Good performance of the model
- Underestimation of the summer IWV
- Standard deviations of IWV larger during summer

Table 1. Statistics from the comparison of ALARO and GNSS observations, averaged over 6 years.

	GPS IWV (kg/m²)	Mean difference (kg/m²)	Standard deviation (kg/m²)
All stations	15.09	0.26	1.72
Stations > 100m	14.67	0.48	2.34
Stations < 100m	15.39	0.11	1.05

- At higher altitudes, the mean IWV of the GNSS stations are higher.
- Stations with larger height differences between model and observations result in higher IWV differences.

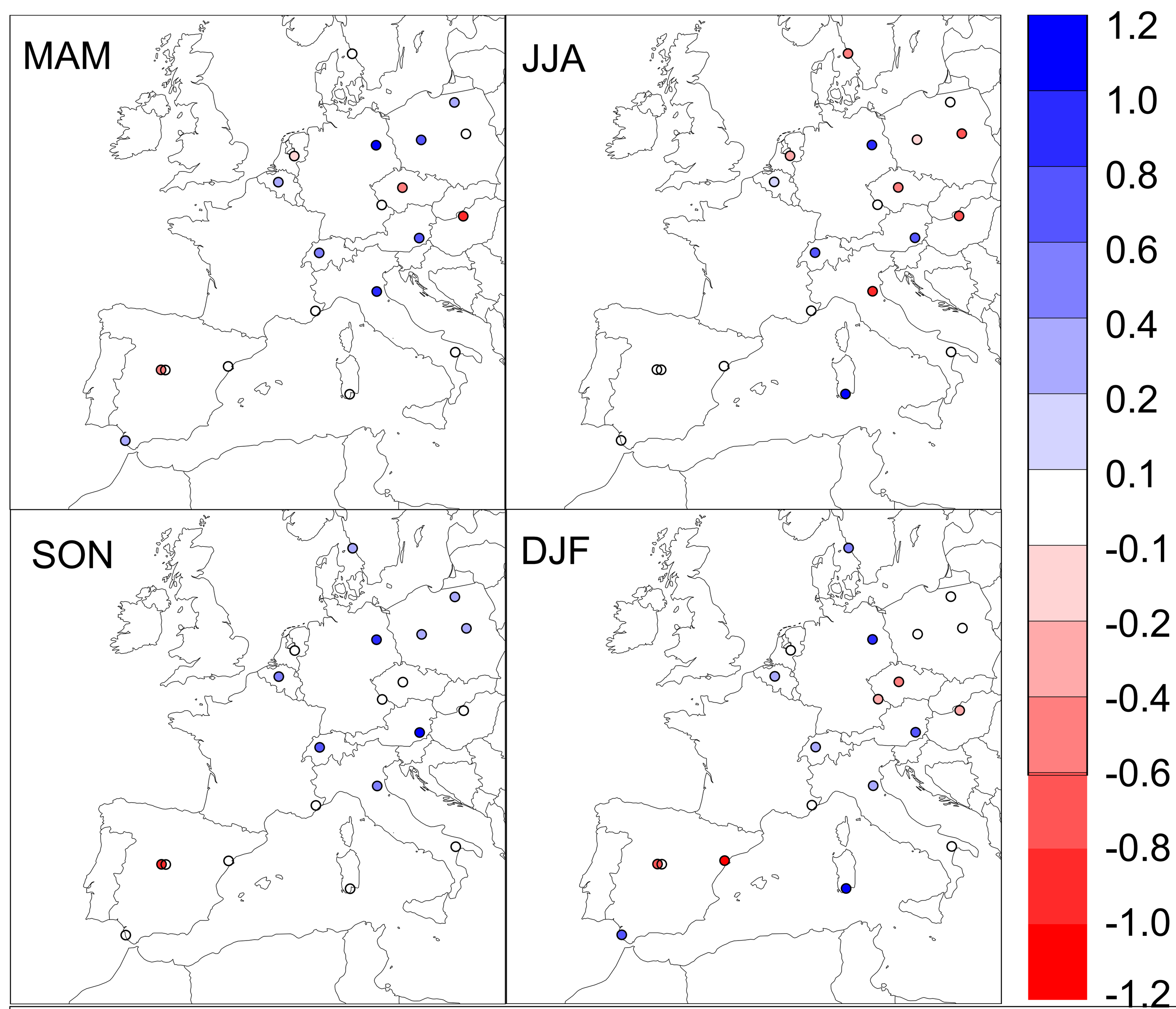


Figure 2. The spatial variation of the mean IWV difference (kg/m²) for ALARO/SURFEX - GNSS for each season, averaged over 6 years.

- Seasons MAM, JJA and DJF show mixed under -and overestimaten of IWV, while SON shows more persistent overestimation, except for MADR.
- Small to zero IWV differences for MATE, GRAS, VILL, KOSG, WTZR, LAMA.
- Strong underestimation of IWV for MADR.
- Opposite signs in different seasons for ONSA, MEDI, JOZE.

Discussion and future prospects

- Results for the seasonal variation are in agreement with Ning et al. (2013).
- The changing sign of the difference at MEDI station is in agreement with the change from dry bias in summer to wet bias in winter.
- Only 50% of the stations with height differences > 100m show IWV differences.

- In future, apply height correction.
- In future, use longer climate dataset, ALARO at 12.5 km (within CORDEX). This will provide a cover period of 15 years.
- Hourly conversion of ZTD to IWV from GNSS observations in order to present diurnal cycle.

References
Vey S., Dietrich R., Fritsche M., Rülke A., Steigenberger P. and Rothacher M. (2009), “On the homogeneity and interpretation of precipitable water time series derived from global GPS observations”, Journal of Geophysical Research: Atmospheres, 114 (D10)
Ning T., Elgered G., Willén U., Johansson J.M. (2013), "Evaluation of the atmospheric water vapor content in a regional climate model using ground-based GPS measurements", Journal of Geophysical Research, 118, 329-339

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