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Assimilation of Sentinel-1 estimates of Precipitable Water Vapor (PWV) into a Numerical Weather Model for a more accurate forecast of extreme weather events

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In the last two decades, SAR interferometry has been used to obtain maps of Precipitable Water Vapor (PWV).This maps are characterized by their high spatial resolution when compared to the currently available PWV measurements (e.g. GNSS, radiometers or radiosondes). Several previous works have shown that assimilating PWV values, mainly derived from GNSS observations, into Numerical Weather Models (NWMs) can significantly improve rainfall predictions.It is noteworthy that the PWV-derived from GNSS observations have a high temporal resolution but a low spatialone. In addition, there are many regions without any GNSS stations, where temporal and spatial distribution of PWV areonly available through satellite measurements.

The first attempt to assimilate InSAR-derived maps of PWV (InSAR-PWV) into a NWM was made by Pichelli et al. [1].They used InSAR-PWV maps obtained from ENVISAT-ASAR images and the mesoscale weather prediction model MM5 over the city of Rome, Italy. The statistical indices show that the InSAR-PWVdata assimilation improves the forecast of weak to moderateprecipitation (< 15 mm/3-h). The second and last attempt, was performed by Mateus et al. [2]. They used the same satellite mission and the Weather Research and Forecast (WRF) model over the city of Lisbon, Portugal, during a light rain event not forecast by the model.Results showed that after data assimilation, there is a bias correction of the PWV field and an improvement in the forecast of the weakto moderate rainfall up to 9 h after the assimilation time.

We used, for the first time, the Weather Research and Forecast Data Assimilation (WRFDA) model, at micro-scale resolutions (3 km), over the Iberian Peninsula (focusing on the southern region of Spain) and during a convective cell associated with a local heavy rainfall event, to study the impact of assimilation PWV maps obtained from SAR interferometric phase calculated using images acquired by the Sentinel-1 satellite. It's worth noting that, in this case, the model without assimilation PWV maps fails to reproduce the amount and the region of heavy rainfall. The assimilation of InSAR-PWV maps with high spatial variability by the WRF model, promoted alterations in the buoyancy force over the study area and consequently increased the atmospheric instability, were new convection cells were generated over the correct area. We assessed the results using in-situ meteorological data and with a meteorological radar. With the Sentinel-1 A/B C-band sensors its possible generate maps of PWV over large areas with a length of hundreds of kilometers and a width of about 250 km (country-spanning areas), a spatial resolution of 5×20 m and an absolute revisiting time of 6 days or fewer when combined with other sensors, opening new perspectives to the application of SAR meteorology concept. The availability of interferometric PWV maps on a routine basis can help to capture the high variability of the water vapor distribution at micro-scales. In this study, we show that the knowledge of the PWV with high spatial resolution can change the system thermodynamics to improve the NWP accuracy.

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