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InSAR water vapor data may have a major impact in the skill of weather forecasts

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Images produced by the interferometry technique from C-Band Synthetic Aperture Radar (SAR) Sentinel 1 images, with a 20 m pixel, offer the highest available spatial resolution for the distribution of precipitable water vapor (PWV). Such images are currently available up to twice every 6 days, when combining Sentinel 1A and B in both the ascending and descending passages, in locations over land. The potential impact of those data in weather forecasting is here assessed, through the assimilation of the PWV product into the WRF atmospheric model by the 3DVAR technique, which computes an optimal distribution of 3D water vapor, and of corresponding perturbed fields of the other model prognostic variables (temperature and wind), compatible with the 2D PWV field.

A first case study (Mateus et al 2018) considers a high-impact flash flood event that occurred in Adra, southern Spain, in 5-6 September 2015. The event consisted of two storms, each lasting less than 1 hour, and each taking place less than 6 hours after one passage of Sentinel 1A. None of these storms was predicted by the different forecast systems (global or national), neither by WRF at 3km resolution when forced by the global systems (by NCEP and ECMWF). However, the assimilation of InSAR PWV by WRF 3DVAR led to excellent results, in what concerns the timing and intensity of precipitation in both events, closely matching local and regional observations (available from meteorological radar and the udometer network). An analysis of the different simulated fields indicates that the PWV data corrected significant underestimation of low-level water vapor near Adra, but also led to an increase in low level temperature, both contributing to an increase in Convective Available Potential Energy to levels conducive to deep convection, and also to small changes in the low level wind that favoured its triggering.

A more extensive assessment of the proposed methodology studies the full set of available images in a sector of the eastern USA, near the Appalachian mountains. The region is very well monitored in terms of geodesy (through a freely available GNSS network) and of precipitation (through freely available 4km gridded radar data). The methodology followed the technique described above, with 45 available interferograms, only for the ascending images about every 12 days. Results (Miranda et al 2019, submitted) indicate a significant positive impact of InSAR data, with no cases of reduced skill, and most cases with an increase in the forecast skill for a period comparable with the transit time of the air mass over the InSAR footprint. Remarkably, the set of results also indicate an improvement in the mean distribution of precipitation, suggesting that InSAR data could help constrain the climate of meteorological models.

Mateus P, Miranda PMA, Nico G, Catalão J, Pinto P, Tomé R (2018) Assimilating InSAR maps of water vapor to improve heavy rainfall forecasts... Journal Geophysical Research: Atmospheres, 123, 3341-3355. doi:10.1002/2017JD027472
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