

Validation of the WRF model for PWV forecasting at the Roque de los Muchachos Observatory

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Abstract. The atmospheric Precipitable Water Vapour content (PWV) is crucial for astronomical observations in the infrared. In this work, we have validated the Weather Research and Forecasting (WRF) mesoscale numerical model as an operational tool for PWV at Roque de los Muchachos astronomical Observatory (ORM). We used radiosonde data obtained directly at the Observatory and at the sea level. An excellent agreement between PWV model forecasts and observations was found at both verification points with a correlation above 0.9.

1. Introduction

The atmospheric Precipitable Water Vapour content (PWV) is crucial for astronomical observations in the infrared [1]. We have validated the Weather Research and Forecasting (WRF) mesoscale Numerical Weather Prediction (NWP) model as an operational tool for PWV. The NWP models are increasingly being used as an additional and valuable tool for predicting weather variables affecting astronomical observations. The WRF model is a non-hydrostatic mesoscale meteorological model with hydrostatic option designed for both research and operational applications.

In the validation we used atmospheric radiosonde data. This allowed us to calibrate the model at the observatory and to validate it under different PWV values and atmospheric conditions. The forecasts will complement the PWV measured by a GPS monitoring system at the ORM¹. The forecast of the instantaneous PWV value and its temporal stability may also improve the scheduled operation time at ORM.

An extension of the present work including the effect of different model resolutions is being published [2].

2. Datasets: atmospheric radiosoundings

In the present study we used atmospheric radiosoundings (the accepted standard used in atmospheric research) for model validation on the basis of its accuracy. Balloons were launched

¹ <http://www.iac.es/site-testing/PWV ORM>



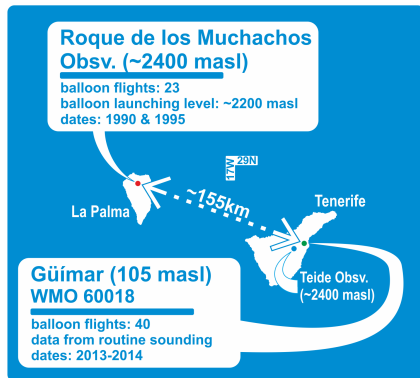


Figure 1. Location and characteristics of the two radiosoundings launching points (ORM and TFE), separated by ≈ 155 km.

Table 1. WRF model physics configuration and schemes selected for the physics modules.

LW Rad.	SW Rad.	Land Surface	Surface Layer	PBL	Cumulus	Microphysics
RRTM	Dudhia	Noah LSM	Monin-Obukhov	YSU	Kain-Fritsch	WSM6

at two separated locations (see figure 1), ORM at La Palma Island and Güímar WMO station 60018 at Tenerife Island (TFE, hereafter), close to the sea level.

A total of 23 balloons were launched directly from ORM during 3 intensive site testing assessments performed in April 1990, July 1990 and November 1995 [3], [4]. We have been used this unique dataset for the first time for Numerical Weather Prediction (NWP) model validation. As an additional verification point, we have used a sample of 40 operational soundings launched twice a day (00 and 12 UTC) near the sea level at TFE from May 2013 to April 2014 (1 year). These datasets allowed us to calibrate the model at the Observatory and to validate it under different atmosphere column heights and atmospheric conditions.

3. WRF model: configuration

We have configured the version 3.1. of WRF in a single model domain with a grid point separation of 54 km and dimensions 60×45 (thus covering a surface of 3240×2430 km). We have selected 32 vertical levels more concentrated near the ground in the case of ORM. The model physics configuration is shown in table 1. The ERA-Interim reanalysis produced by the European Centre for Medium Range Weather Forecasts (ECMWF) has been used to provide initial and boundary conditions (IBC) to WRF above ORM every 6 hours while the operational Global Forecasting Model (GFS) output has been used for IBC at TEN.

4. Results and discussion

An excellent agreement between PWV model forecasts and observations was found at both verification points (ORM and TFE) with correlations above 0.9 in both locations (figures 2 and 3). The WRF model performed quite well in different humidity conditions. The RMSE of the fit is ≈ 1 mm at ORM ($1 \text{ mm} < \text{PWV} < 13 \text{ mm}$) and ≈ 3 mm at TEN ($12 \text{ mm} < \text{PWV} < 40 \text{ mm}$).

In additional simulations we have also found that the WRF model is a very useful tool for reconstructing the history and evolution of the humidity field above the observatories as well as to assess the spatial structure of such field through 2D plots. The spatial structure allows to identify synoptic meteorological patterns in the PWV evolution. This circumstance may be used for an additional analysis based on the local expertise of the observer (figure 4).

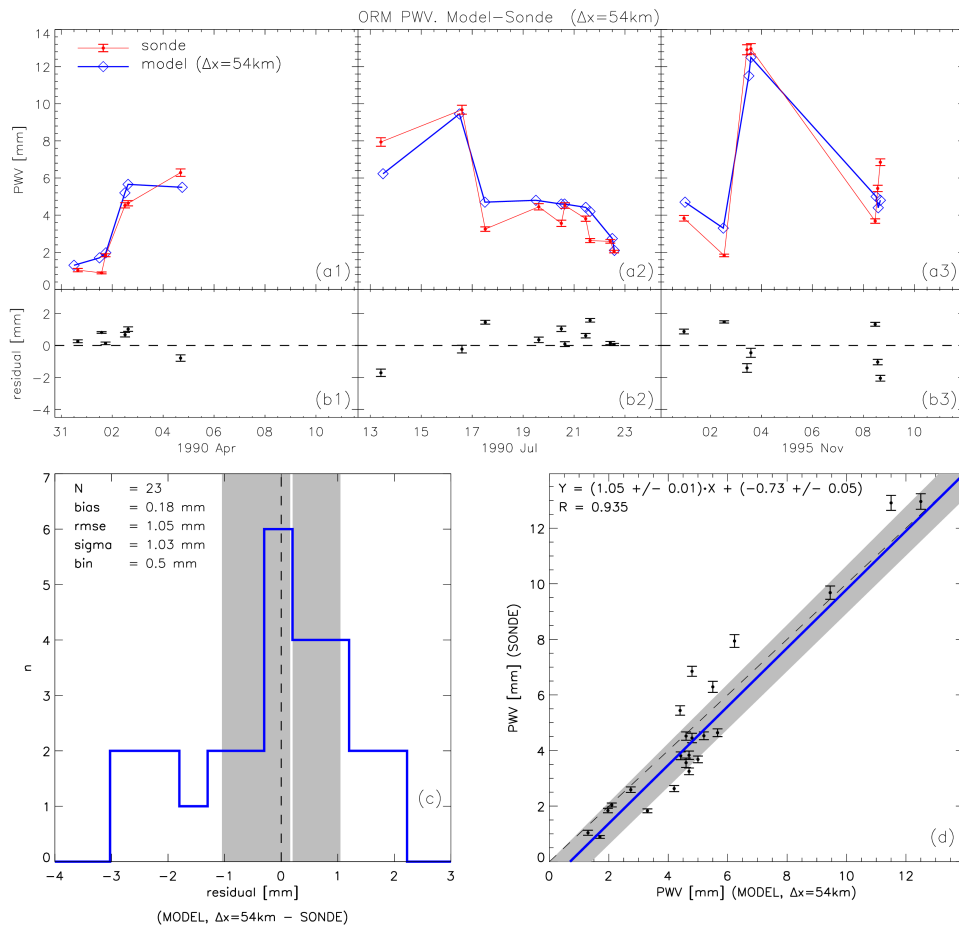


Figure 2. Time series of radiosonde measured (red) and forecasted (blue) PWV (a1 to a3), time series of residuals (b1 to b3), distribution of residuals (c) and regression analysis (d) at ORM. The indices 1, 2 and 3 refer to the 3 separated campaigns in April 1990, July 1990 and November 1995.

Acknowledgments

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References

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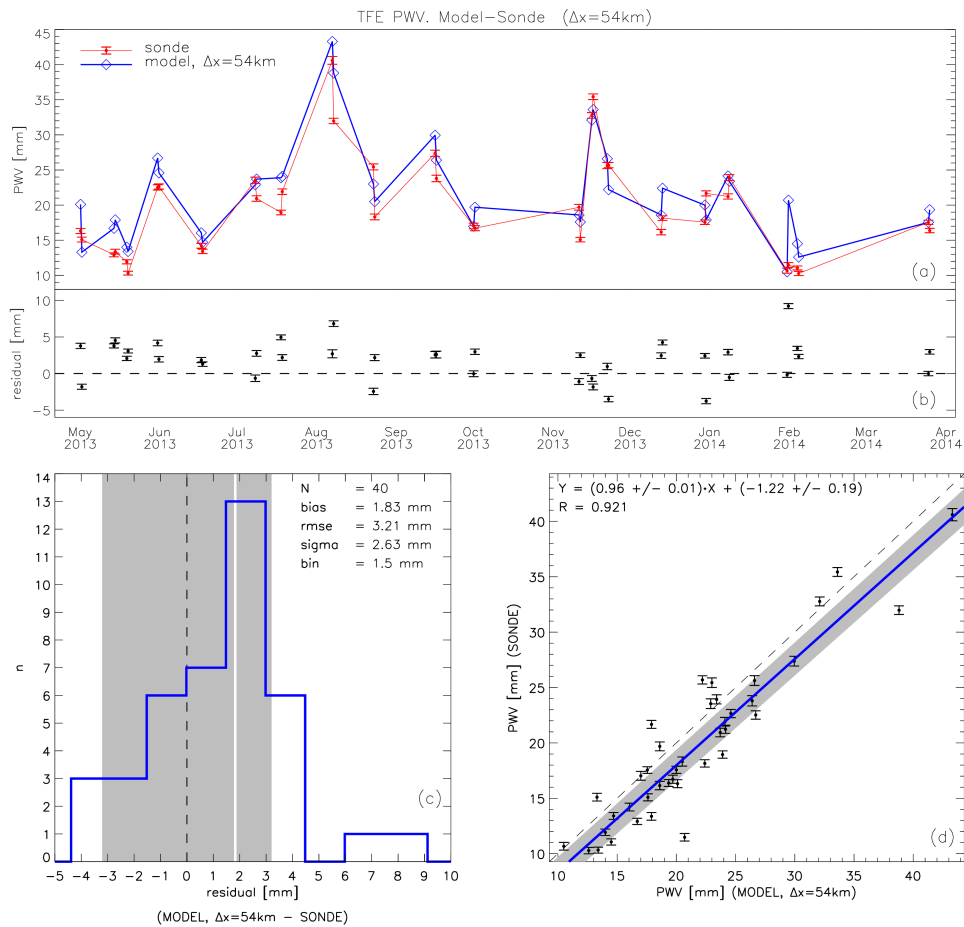


Figure 3. Time series of radiosonde measured (red) and forecasted (blue) PWV (a), time series of residuals (b), distribution of residuals (c) and regression analysis (d) at TFE. Radiosoundings are launched twice a day at 00 and 12 UTC as part of the WMO Global observing network.

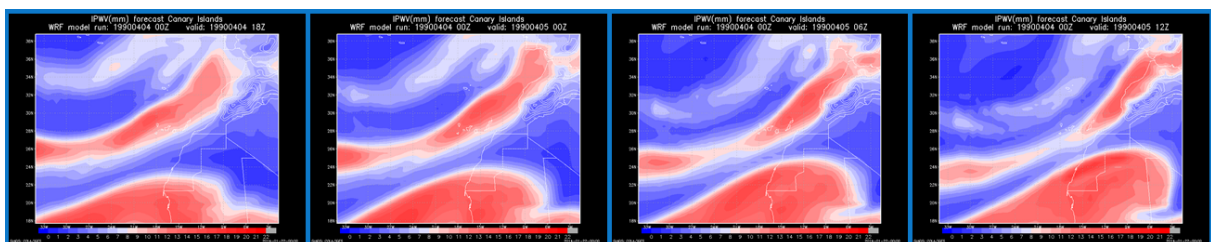


Figure 4. Passage of a moist air mass over the observatories (PWV integrated above 787 hPa) in the Canary Islands on the night of April 5, 1990, reproduced by the WRF model.