Signature on GNSS ZTD and PWV Estimates of Relevant Storms Affecting Iberia in Recent Years

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ABSTRACT

PWV (Precipitable Water Vapour) estimates derived from GNSS (Global Navigation Satellite Systems) observations are nowadays used in many studies focused on atmospheric extreme events. The direct product that is obtained from the GNSS data is ZTD (Zenith Tropospheric Delays), which can be converted into the column of water vapour above the station knowing pressure and temperature. If a sufficient dense number of stations are available, the estimates obtained at discrete points can be interpolated in order to create 2D fields (PWV + time)

In this study, we present results obtained using PWV solutions from the available networks of GNSS stations in Portugal (~70) and Spain (~300). These networks are mainly managed by the National and Regional (Spain) Mapping Agencies providing data in near-real time, which are nowadays also being used for weather nowcasting operational applications.

We present here the signature on the GNSS derived ZTD and PWV Estimates for some extremes meteorological events that occurred in Portugal (and extended to Spain) recently: Xynthia (27-28 February 2010); and Lisbon Floods (22 September 2014). The available GNSS data have been processed using the GIPSY-OASIS software, which permits to compute a ZTD estimate for each station every 5 minutes.

This study has been conducted in the framework of the SMOG (PTDC/CTE-ATM/119922/2010) and NUVEM (EXPL/GEO-MET/0413/2013) projects, supported by the National Portuguese Science Foundation (FCT) and the GNSS4SWEC (ES1206) Cost Action funded by European Union.

METHODOLOGIES

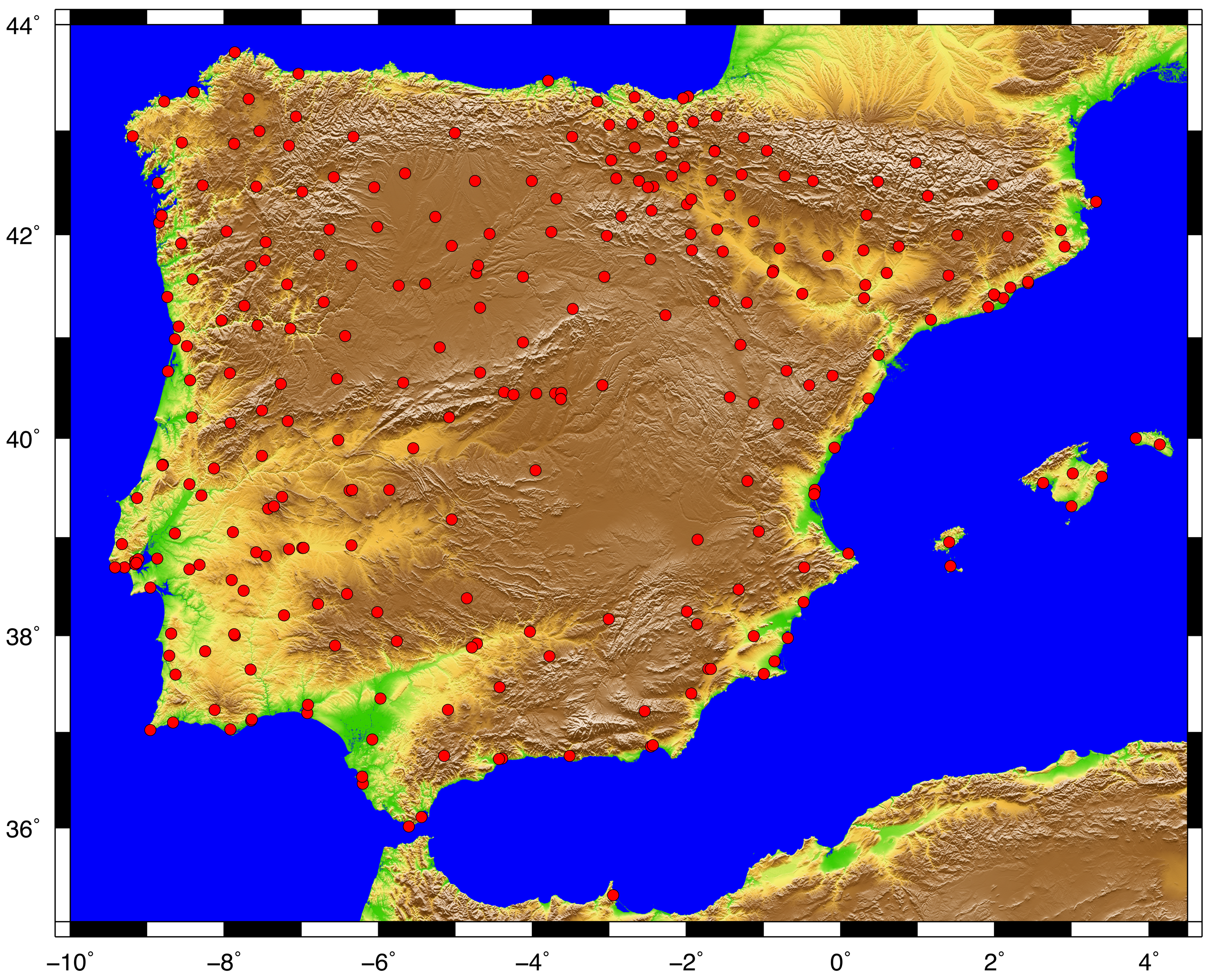


Figure 1 – SEGAL is processing all public GNSS stations available in Iberia in the framework of several projects dedicated to sense geophysical signals. Many different entities contribute with the data from their networks for this effort:

Portugal:

RENEP [http://www.dgterritorio.pt/cartografia_e_geodesia/geodesia/redes_geodesicas/renep/],
SERVIR [http://www.igeoe.pt/servir/servir.asp];

Spain:

IGN [http://www.fomento.es],
Galicia [http://www.cartogalicia.com/],
Castilla and Leon [http://gnss.itacyl.es],
Extremadura [http://194.224.247.162:8080/WebExtremadura/],
Andalucia [http://www.juntadeandalucia.es/obraspublicasytransportes/redandaluzadeposicionamiento/rap/],
Pais Vasco [http://www.gps2.euskadi.net/],
Asturias [http://rgapa.cartografia.asturias.es/],
Navarra [http://www.navarra.es/appsext/rgan/default.aspx],
Valencia [http://icverva.icv.gva.es:8080/],
La Rioja [http://www.iderioja.larioja.org/index.php?id=20&lang=es],
Catalunya [http://catnet-ip.icc.cat/],
Illes Balears [http://xarxagnss.caib.es],
Aragón [http://gnss.aragon.es/],
Cantabria [http://gnss.cantabria.es].

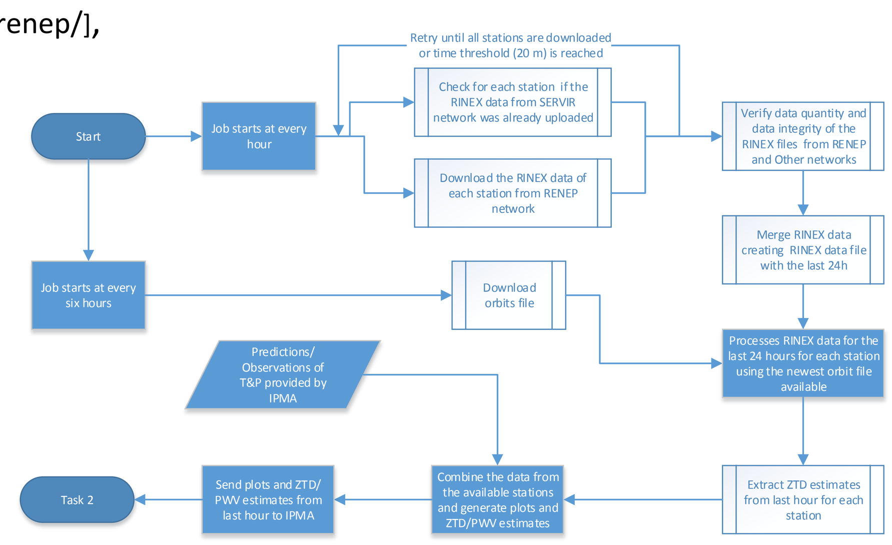


Figure 2 – In recent years, SEGAL has dedicated particular efforts to develop the operational processing of GNSS data to estimate ZTD (and PWV) in NRT (Near Real Time). This Figure depicts the current methodology implemented to deliver PWV estimates at IPMA where they are analized for nowcasting.

CASE STUDY – XYNTHIA STORM (27-28 FEB 2015)

Figure 3 - Xynthia was a storm that developed and evolved over the North Atlantic in late February 2010. It passes over the North of Iberia and reached France in the early hours of the February 28th. It caused around 60 casualties and more of 1 billion of Euros in damages.

in http://www.eumetrain.org/data/2/227/print.htm

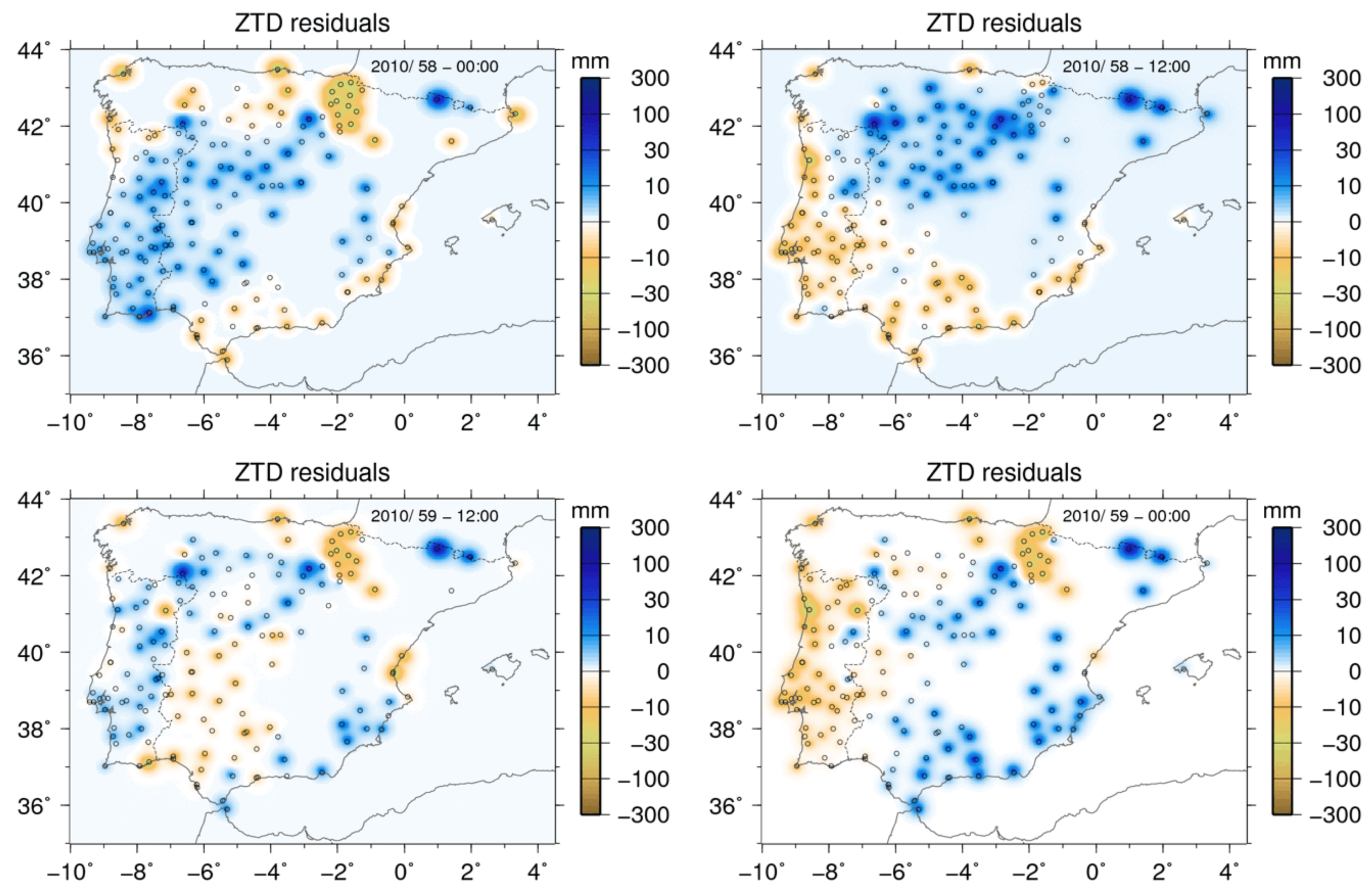


Figure 4 – Four snapshots of the variability of the ZTD during the passage of the Xynthia storm. The residuals were computed using the following formula:

ZTDr = ZTDe – 2459.0 + 0.346 * h, where:

ZTDr is the residual (mm),
ZTDe is the estimated ZTD (mm)
h is the height of the station (m).

The height correction was applied to remove the systematic effect of the topography on the ZTD values. The value was obtained a linear regression between station height and mean ZTD.

Since most of the GNSS stations do not have co-located meteo sensors, we have used ECMWF (16Km resolution) to obtain PWV from the estimated ZTD.

The movies showing the complete passage of the Xynthia storm as sensed by the ZTD and PWV estimated at SEGAL can be downloaded at:
http://segal.ubi.pt/nuvem/movie/animatedZTD.gif and http://segal.ubi.pt/nuvem/movie/animatedPWV.gif

CASE STUDY – LISBON FLOODS (22 SEP 2014)

Figure 5 – In September 22nd, 2014, Lisbon suffered sudden and localized heavy rain fall (13h-15h UTC). Most of the downtown suffered with this extreme event, which caused substancial damages and it was not captured by the nowcasting models in use.

These results intends to demonstrate the benefits of the use of GNSS derived estimates to both meteorological studies and nowcasting. We compare the current existing predictions (using ECMWF) with the estimates done by GNSS using several of the stations around Lisbon.

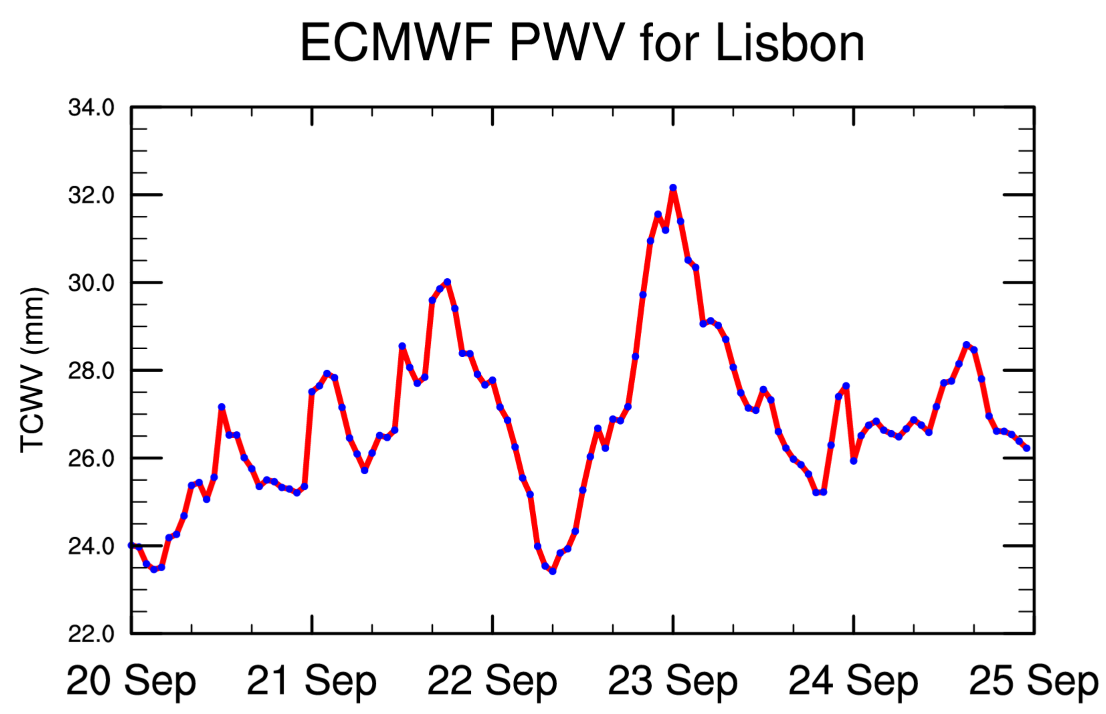


Figure 6 – PWV values derived from the ECMWF model for the Lisbon area enclosing the period of interest, which are currently at use at IPMA for nowcasting.

Although it is evident the increment of PWV during the hours of the event, the resolution (16x16 Km) and the delay on the update of the predictions (up to 12 hours) create large uncertainties on the ECMWF predictions.

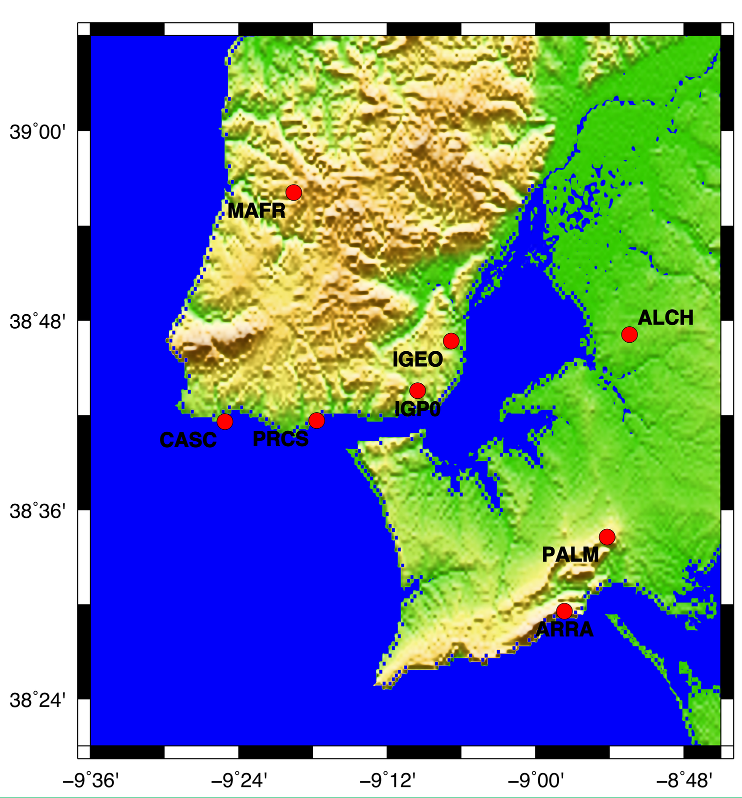
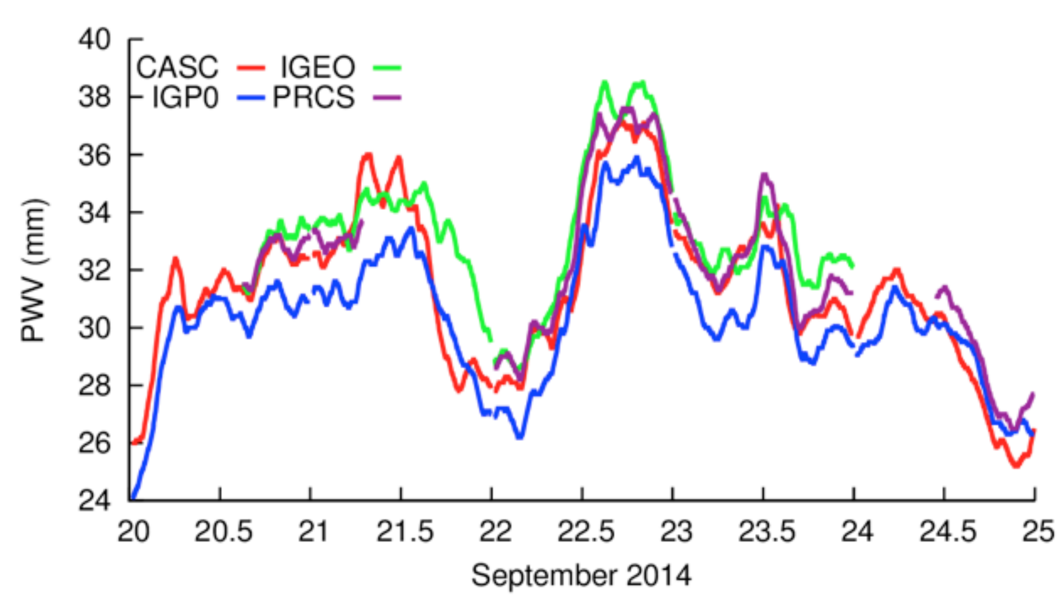


Figure 7 (left) – Distribution of available GNSS stations (SERVIR and RENEP networks) in Lisbon area (downtown located between IGEO and IGP0 stations).

Figure 8 (right) – Estimates of PWV derived from GNSS observations for the stations in Lisbon area for the period of the event.

The correlation between the GNSS estimates and the ECMWF predictions is excellent.

The bias between the meteorological model and the GNSS derived values needs to be further investigated. Using a long data-span (> 5 years) of existing data, we can also include the radio-sondes estimates to have an independent validation of results.



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