NUVEM - New methods to Use gnss water Vapor Estimates for Meteorology of Portugal

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ABSTRACT

Nowadays, tropospheric products that contain information on atmospheric water vapor content above each receiving GNSS antenna is already obtained routinely from accurate geodetic data analysis. In this respect, the application of GNSS (Global Navigation Satellite System) observations for use in very short range weather forecasting (nowcasting) has improved considerably in the last few years due to:
a) Improved GNSS raw data timeliness (hourly uploads and/or real-time data streaming);
b) Improved coverage (the number of ground-based stations of the GNSS networks has increased enormously in the last 5 years); and
c) Increased temporal resolution of tropospheric estimates.
NUVEM (New methods to Use gnss water Vapor Estimates for Meteorology of Portugal) is a collaborative project funded by the Portuguese National Science Foundation (FCT) aiming to implement a multi-disciplinary approach in order to operationalize the inclusion of GNSS-PWV estimates for nowcasting in Portugal, namely for the preparation of warnings of severe weather. To achieve such goal, the NUVEM project is divided in two major components:
a) Development and implementation of methods to compute accurate estimates of PWV (Precipitable Water Vapor) in NRT (Near Real-Time) from GNSS derived ZTD (Zenith Path Delay);
b) Integration of such estimates in nowcasting procedures in use at IPMA (Portuguese Meteorological Service).
Methodologies will be optimized at SEGAL to passive and actively access to the data; the PWV estimations will be computed using PPP (Precise Point Positioning), which permits the estimation of each individual station separately; solutions will be validated using internal and external values; and computed solutions will be transferred timely to the IPMA Operational Center.
Validation of derived estimations using robust statistics is an important component of the project. The need for sending computed values as soon as possible to IPMA requires fast but reliable internal (e.g., noise estimation) and external (e.g., feedback from IPMA using other sensors like radiosondes) assessment of the quality of the PWV estimates.
At IPMA, the goal is to implement the operational use of GNSS-PWV to assist weather nowcasting in Portugal. This will be done with the assistance of the Meteo group of IDL. Maps of GNSS-PWV will be automatically created and compared with solutions provided by other operational systems in order to help IPMA to detect suspicious patterns at near real time. This will be the first step towards the assimilation of GNSS-PWV estimates at IPMA nowcasting models.
The collaboration with the UK Meteo Office where data assimilation are being implemented and are reaching an operational level is also an additional guarantee that this project will reach the proposed goals.
The NUVEM (EXPL/GEO-MET/0413/2013) project will also contribute to the active participation of Portugal at the COST Action ES1206 - Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate (GNSS4SWEC).
This work is also carried out in the framework of the Portuguese Project SMOG (PTDC/CTE-ATM/119922/2010).

PLANS & METHODS

Three tasks covers all activities planned in the framework of the NUVEM project in order to reach the ultimate goal of this project:
Task 1 – Optimization of the computation of hourly estimates of ZTD (and derived PWV) to be submitted to IPMA.
Task 2 – Support the weather nowcasting for Portugal using the ZTD/PWV estimates produced in Task 1.
Task 3 – Automatic operationalization of the entire process (from data collection to the use of the solutions by IPMA).

This poster focuses on the Task 1 activities.

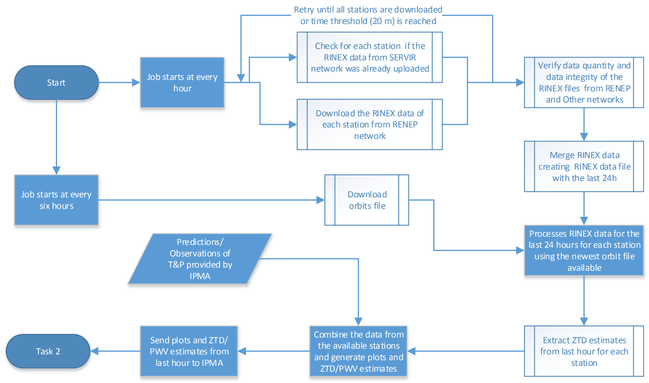

Figure 2 – Structure of Task 1: Hourly processing scheme at SEGAL to estimate ZTD/PWV in near-real time from RINEX observations using GIPSY-OASIS software package with the PPP (Precise Point Positioning) approach.
The RINEX data will be uploaded directly to SEGAL by the data providers (in case of the SERVIR network) or download as soon as available from the other networks.
In addition, the processing requires the regular download of the Ultra-Rapid Orbits provided by IGS [http://www.igs.org]. They are uploaded 4 times per day (03hUTC, 09hUTC, 15hUTC, 21hUTC) and they contain 48h worthwhile of orbits (24h estimated based on observations before the central time, which are 00hUTC, 06hUTC, 12hUTC, 18hUTC, respectively, and 24h of predicted orbits). Therefore, when processing the 24h windows, the part of the orbits that have been predicted varies between 3h and 8h, which covers always the last hour, which is the one that we are interested in.

For the meteorology inputs (T&P), since most of the GNSS stations do not have co-located meteo sensors, two model outputs are going to be used, as each one has its own advantages. The ECMWF (16Km resolution) forecasts will be downloaded as soon as they become available, around 6/18 UTC. The other model that will be used is AROME (2.5Km resolution), which is a non-hydrostatic convective scale model. AROME is run with the initial conditions of ARPEGE/ALADIN and is available twice a day, at around 7:30/19:30UTC.

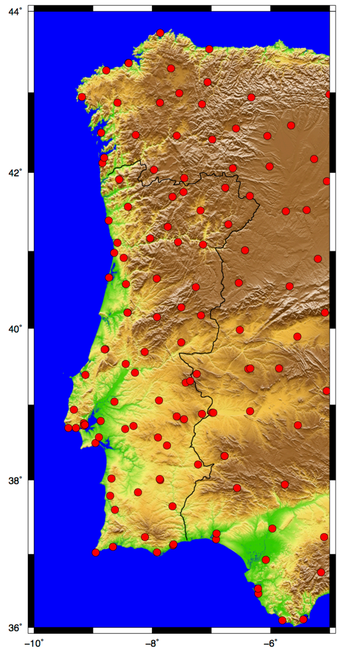

Figure 1 – In the framework of Task 1, the objective of NUVEM project is to adapt and develop the current processing already performed at SEGAL in order that ZTD (and PWV) estimates will be computed in NRT (Near Real Time), i.e., few minutes after each hour for all available stations in

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

and neighboring networks in 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/].

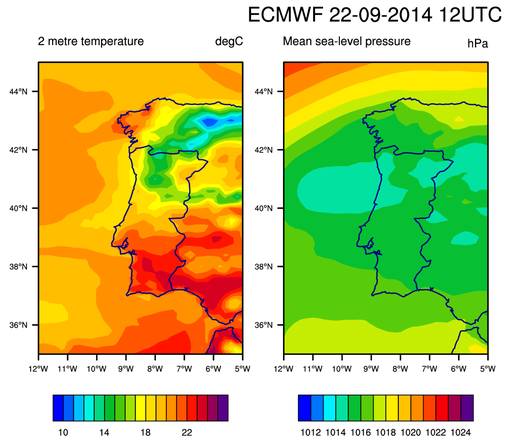

Figure 3 – Example of the Temperature & Pressure predicted by the ECMWF model for 22-09-2014 (see case study).

CASE STUDY – LISBON FLOODS (22 SEP 2014)

Figure 4 – 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 well captured by the nowcasting models in use.

Figure 5 – 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 derived predictions.

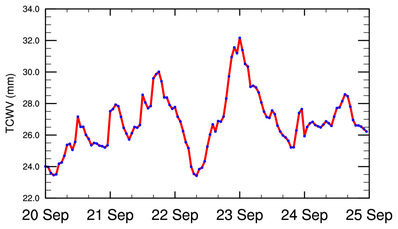

Figure 6 – Distribution of available GNSS stations (SERVIR and RENEP networks) in Lisbon area (downtown located between IGEO and IGP0 stations).

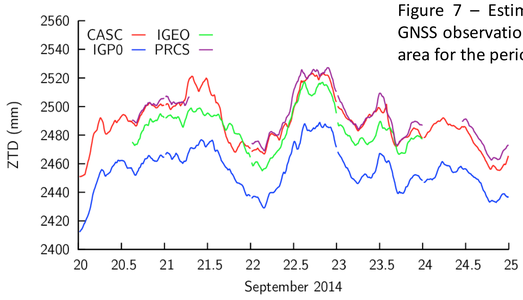

Figure 7 – Estimates of ZTD derived from GNSS observations for the stations in Lisbon area for the period of the event.

Although ZTD and PWV are different quantities, they are highly correlated. This is evident when the estimates in Figure 5 and Figure 7 are compared. The large and fast increment in ZTD during the morning of 22-09-2014 is clearly observed in the ZTD estimates obtained from the GNSS observations. The goal is that these estimates will improve the present solutions shown by Figure 5.

The results presented here for this event intends to demonstrate the future benefits of the NUVEM project by stressing out the advantages that the GNSS derived estimates can bring to the nowcasting being produced and used at IPMA. We compare the current existing predictions with the potential estimations to be implemented in the framework of the NUVEM project.

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