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Assimilation of GPS-ZTD in meteorological models by 3D-Var

Alessandra Mascitelli (1,2), Stefano Federico (1), Elenio Avolio (3), Claudio Transerici (1), Mattia Crespi (2), and Stefano Dietrich (1)

(1) National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Via del Fosso del Cavaliere 100, 00133 Rome, (2) Sapienza University of Rome, Faculty of Civil and Industrial Engineering, Department of Civil, Constructional and Environmental Engineering (DICEA), Geodesy and Geomatics Division, Via Eudossiana 18, 00184 Rome, (3) National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), zona industriale comparto 15, 88046 Lamezia Terme (CZ).

The purpose of the data assimilation is to optimally use all the available information, to determine as accurately as possible the state of the atmosphere.
We show the assimilation of the GPS-ZTD (Global Positioning System - Zenith Total Delay) by a 3D-Var data assimilation system that can be used in cycling mode with the Regional Atmospheric Modeling System (RAMS). The water vapour mixing ratio and temperature given by the background are modified according to the assimilation of the GPS-ZTD to improve the representation of the humidity and temperature fields and decrease the model spin-up time.
To verify the impact of the GPS-ZTD data assimilation on the representation of the humidity field, two numerical experiments are performed: the first refers to the HyMeX-SOP1 period (6 September 2012 - 5 November 2012) over Italy, and the second, focused on the local scale, is performed over the Lazio region, in Central Italy, and refers to summer 2017.
For both experiments, the background error matrix is computed by the NMC method and is invariant for the whole period. The observation error is the RMSE of the GPS data and varies form few millimetres to centimetres.
For the first experiment, GPS-ZTD values are downloaded from the HyMeX database and analyses are produced every six-hours. The spatial grid for the analysis has 4 km horizontal resolution.
To verify the improvement of the representation of the atmospheric humidity given by the analysis, the integrated water vapour column (IWV) is compared with the ECMWF analysis of the same quantity. Results show the improvement of the IWV analysis compared to the background and the RMSE decrease for all GPS-receivers, with a reduction of the error of about 30%. The absolute value of the bias is also reduced.
To evaluate the impact of the GPS-ZTD data assimilation at the local scale, a numerical experiment is performed using a network of 26 dual frequency GPS receivers distributed over the Lazio Region, in Central Italy, from 27 July to 30 September.
The ZTD values were obtained by processing the data coming from the Italpos, Netgeo and Rete Lazio databases. Processing was carried out in PPP (Precise Point Positioning) using RTKLIB (http://www.rtklib.com/). Also for this experiment the analysis is performed over a 4 km horizontal resolution grid and the background is given by the RAMS model.
The whole dataset is divided in two parts: a set of receivers is used for the data assimilation, while the remaining stations are used for verification.
Results show a substantial decrease of the RMSE of the GPS-ZTD and IWV for the stations used for verification and the bias decreases, showing the potential of the assimilation of the GPS-ZTD.
The results of this study are promising and will be further developed to evaluate the impact of GPS-ZTD data assimilation on the forecast of the atmospheric water vapour as well as on the rainfall prediction.