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THE INCLUSION OF HUMIDITY ESTIMATES FROM BRAZILIAN GROUND-BASED GNSS NETWORK INTO THE CPTEC/INPE GLOBAL DATA ASSIMILATION SYSTEM

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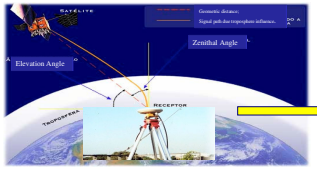
Although the zenithal tropospheric delay generated in the radio-frequency signal in the ground-based Global Navigation Satellite System (GNSS) receivers should be minimized for geodesic applications, it can be estimated with relative precision and converted to Integrated Water Vapor (IWV) values (Section 1). In recent years the density of the Brazilian Network for Continuous GNSS Monitoring (RBMC) has increased significantly, doubling the number of ground-based GNSS receivers during the last two years (Section 2). One of the main goals of these research projects is the continuous monitoring of the IWV to improve numerical weather prediction over the Brazilian territory. The main objective of this work is to investigate the contribution of humidity values from GNSS receivers to the improvement of the quality of the analyses and forecasts in numerical models. In order to assess the impact of these datasets on the performance of CPTEC/INPE's assimilation system, experiments with and without the inclusion of humidity values from GNSS receivers have been conducted (Section 3). Other studies in the Group on Data Assimilation Development (GDAD) at CPTEC/INPE are in progress, including the inclusion of radiooccultation GNSS profiles and the operational implementation of a Local Ensemble Transform Kalman Filter methodology in collaboration with the University of Maryland, College Park, USA. (Section 4).

Section 1: Humidity estimates from Ground-based GNSS Network



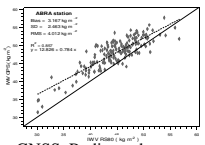
The data collected by GPS receiver are processed and Zenithal Tropospheric Delay values are estimated.

Zenithal Hydrostatic Delay is obtained from pressure values taking into consideration the hydrostatic equilibrium.

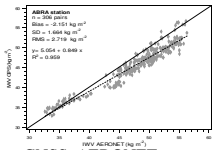
$$D_{TROP} = D_{ZH} + D_{ZW}$$

$$IWV = \frac{D_{ZW}\, 10^6}{R_w \left[k_2' + \frac{k_3}{Tm} \right]}$$

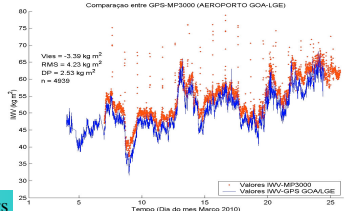
Modelling from relationship between temperature profiles and values measure in the surface (Ts and Ps).



GNSSxRadiosondes



GNSSxAERONET



GNSSxRadiometer MP3000 (preliminary results)

These values have shown good quality and their association with GNSS receivers network can mitigate the deficiency for upper tropospheric humidity measurements.

Section 2: Current densification of the RBMC and other GNSS network in Brazil.

RBMC (IBGE): currently 67 stations.

GNSS-SP project (Fapesp): 11 new stations underway.

SIGEO project (Petrobras/INPE) 85 new stations being implemented.

With continued research supported by Brazilian agencies, the number of receivers available over Brazilian territory should double over the next 2 years, reaching a total of 163 stations.

Problem: unsuitable pressure measures in some RBMC station

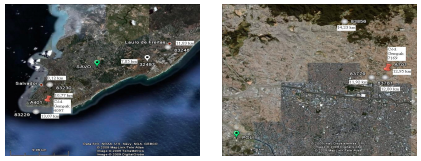
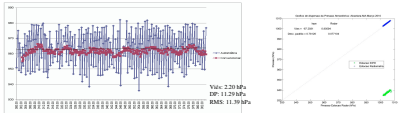


Illustration of the large distances between meteorological and GNSS stations in SALV (left) and SAOP (right)



Comparison between two pressure sensor: high dispersion in PPTE station (left) and elevated bias in SALU one (right).

Propagation study of covariance of the pressure measurements in the IWV-GNSS values

Propagation of the pressure error in the IWV values (kg m⁻²)			
Station/Lat	Uncertainty of the pressure measurement (hPa) 0.3	1	2
BELE/1°	0.0648	0.0008	0.1309
BRAZ/15°	0.0017	0.0021	0.3468
SAOP/23°	0.3385	0.4145	0.6838
SMAR/29°	0.0043	0.0053	0.8721

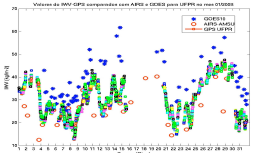
Additional studies are being carried out to determine the best temporal and spatial interpolation for the meteorological values.

Section 3: First experiments of GNSS data assimilation in progress at CPTEC

Localization of the stations processed in near real time by LGE/UNESP laboratory.

Schematic for the current CPTEC's data assimilation system (PSAS). It has been used in the first experiments of IWV-GNSS data assimilation.

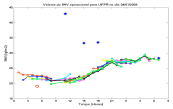
The IWV values from some selected GNSS receivers are being used as supplemental source of humidity information in the pre-operational tests and some comparison with other sources are also being conducted.



Comparison IWV-GNSS with satellite sensor in Curitiba station.

Statistic values obtained in the comparison IWV-GNSS with satellite sensor.

Comparison between IWV-GNSS and values from satellites.							
Sensor	Statistic	Station UFPR	PPTE	RJCG	CUIB	CEFE	SMAR
GOES10	n.	56	57	45	50	56	66
	Bias	9.30	13.19	6.82	15.24	3.79	-0.69
	DP	8.27	8.35	11.13	10.17	12.00	7.04
	RMS	11.19	15.57	12.95	18.26	12.48	7.02
AIRS-AMSU	n.	19	18	14	13	8	14
	Bias	-8.39	-2.45	-1.81	9.55	-3.48	-10.19
	DP	9.27	16.51	18.67	14.08	16.76	10.25
	RMS	12.32	16.23	18.09	16.56	16.05	14.19

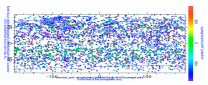


IWV values in Curitiba station from LGE/UNESP using split-window of 8 hs.

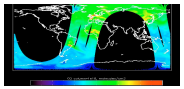
Section 4: Further steps in the IWV-GNSS data assimilation at CPTEC

Local Ensemble Transform Kalman Filter

The LETKF produces an analysis in terms of weights of the ensemble forecast members at the analysis time tn, giving the trajectory that best fits all the observations.



Radio occultation profiles from COSMIC constellation and others LEO satellites.



Radiance observations from IASI sensor and others ones.

Other additional sources of data and the new assimilation system. Additional studies will be necessary for the future integration of all these developments, which will contribute to CPTEC/INPE's ability to generate improved forecasts over South America

Acknowledgements:

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