Impact study of Integrated Precipitable Water estimated from Indian GPS Measurements

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Outline:

- 1. Brief Description of GPS-IPW Data.
- 2. Experimental Setup.
- 3. Results and Discussion.
- 4. Conclusion.

GPS – IPW Data

- Integrated Precipitable Water (IPW) is the amount of atmospheric water vapour (in kilogram) overlying per unit area of the earth surface. Its unit is kg/m².
- The GPS (Global Positioning System) is a satellite based navigation system that consists of a network of 24 satellites placed into orbit in six orbital planes at an altitude of 20,200 km above the earth surface with an orbital period of 12 hrs.
- It transmits dual frequency L band radio signals (L1=1575 MHz; L2=1225 MHz).

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- These L band radio signals are delayed by lonosphere and Troposphere as they travel from GPS satellites to ground based receivers.
- ➤ The Ionosphere delay or error is removed by the linear combination of L1 and L2 frequencies.
- The Troposphere delay cannot be removed easily.
- In troposphere the GPS signals are delayed in part, by atmospheric water vapour referred to as <u>Zenith</u> <u>Wet Delay, (ZWD)</u>.

Contd.:

Some part of the signals are delayed by the Dry air, hydrometeors and other particulates. It is referred to as the *Zenith Hydrostatic Delay*, *ZHD*.

One of the advantage of the GPS receivers are that they work under all weather conditions.

Other advantages of GPS-sensed IPW include high sampling resolution (every few minutes or better), self-calibration, low cost, and large coverage.

Experimental Setup

- The analyses and forecasts are carried out at horizontal triangular truncation of wave number 254 with 64 levels in vertical.
- Global analyses are carried out four times (00z, 06z, 12z and 18z) a day and with all the observations that are received at NCMRWF in +/- 3 hours time window. Model forecasts are carried up to 120 hours.
- Gridpoint Statistical Interpolation (GSI) scheme for analysis is being used with the global spectral model T254L64.
- The methodology used by GSI is 3 Dimensional Variational Assimilation.

- GPS-IPW data of five Indian stations namely New Delhi, Kolkata, Guwahati, Mumbai and Chennai are assimilated and subsequent 120 hr forecasts are made through the NCMRWF's GFS for the entire month of June-2008.
- The analyses and forecasts are also repeated for the entire period without the IPW data.
- The set of data as shown in next slide and the model setup remains the same for both types of simulations. Henceforth, the simulations without IPW data will be termed as "CTRL" and those with IPW data will be termed as "IPW" / "EXP".

The operator used for IPW is

$$P_{w} = \frac{p_{s}}{g} \sum_{\sigma=1}^{64} q_{\sigma} \Delta \sigma$$

where, q_{σ} is the specific humidity at the vertical level σ . The surface pressure $p_s \& q_{\sigma}$ are obtained from the 6-hr forecast guess.

P_w is transformed model first guess.

Physical Parameterization Schemes in T254L64 GCM

Physics	Scheme				
Surface Fluxes	Monin-Obukhov similarity				
Turbulent Diffusion	Non-local Closure scheme (Hong and Pan (1996))				
SW Radiation	Based on Hou et al. 2002 –invoked hourly.				
LW Radiation	Rapid Radiative Transfer Model (RRTM) (Mlawer et al. 1997) – invoked 3 hourly				
Deep Convection	SAS convection (Pan and Wu (1994))				
Shallow Convection	Shallow convection Following Tiedtke (1983)				
Large Scale Condensation	Large Scale Precipitation based on Zhao and Carr (1997)				
Cloud Generation	Based on Xu and Randall (1996)				
Rainfall Evaporation	Kessler's scheme				
Land Surface Processes	NOAH LSM with 4 soil levels for temperature & moisture.				
	Soil soisture values are updated every model time step in response to forecasted land-surface				
	forcing (precipitation, surface solar radiation, and near-surface parameters: temperature,				
	humidity, and wind speed).				
Air-Sea Interaction	Roughness length determined from the surface wind stress (Charnock (1955))				
	Observed SST,				
	Thermal roughness over the ocean is based on a formulation derived from TOGA COARE				
	(Zeng et al., 1998).				
Gravity Wave Drag	Based on Alpert et al. (1988)				

Observation type	Variables		
Radiosonde	$U, V T, q, P_s$		
Pibal winds	U, V		
Wind profilers	U, V		
Surface land observations	P_{s}		
Surface ship and buoy observations	U, V, T, q, P _s		
Conventional Aircraft observations (AIREP)	U, V , T		
AMDAR Aircraft observations	U, V, T		
ACARS Aircraft observations	U, V, T		
GMS/MTSAT AMV (BUFR)	U, V, T		
INSAT AMV (SATOB)	U, V, T		
METEOSAT AMV (BUFR)	U, V, T		
GOES (BUFR)	U, V, T		
SSM/I	Surface wind speed		
Scatterometer (QSCAT)	10 m U, V		
AMSU-A radiance	Brightness Temperature		
AMSU-B radiance	Brightness Temperature		
HIRS radiance	Brightness Temperature		
SBUV ozone	Total Ozone		

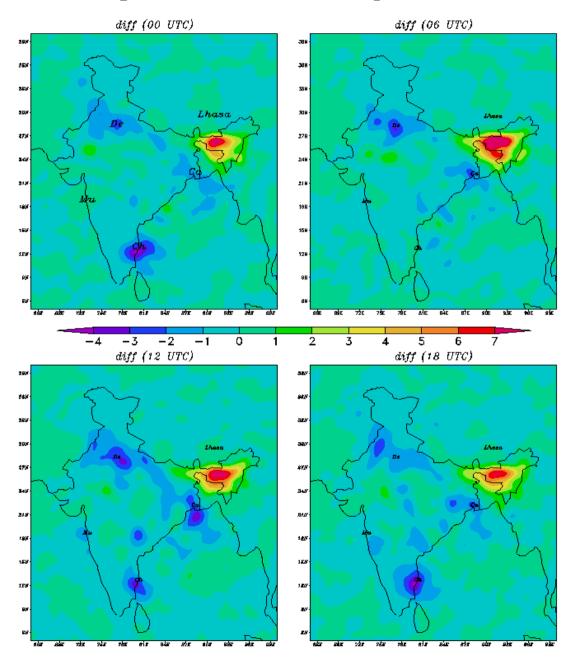
Standard Deviation of IPW Measurements for June 2008.

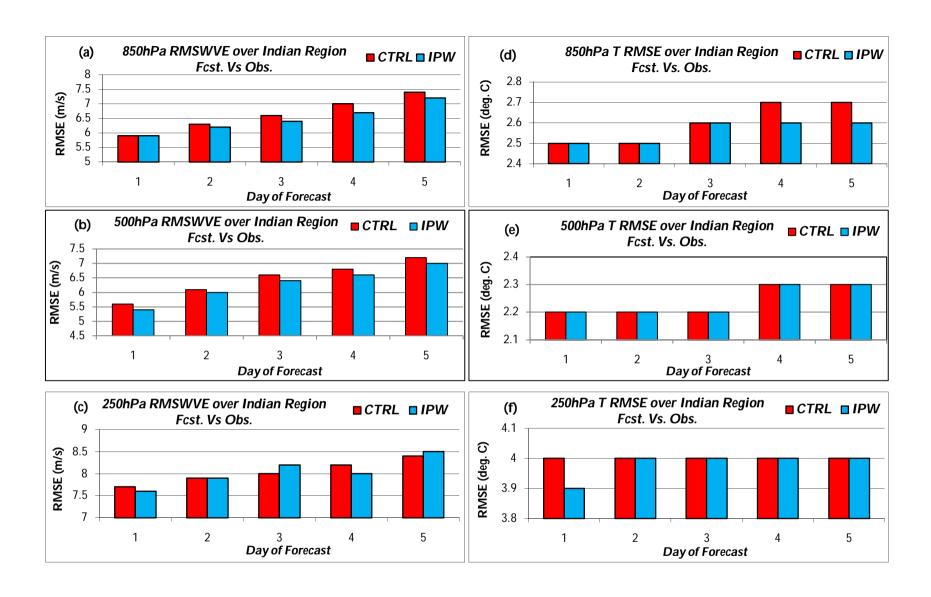
	00Z		12Z	
	RSRW	GPS	RSRW	GPS
Guwahati	14.202	4.889	12.978	4.328
Kolkata	7.94	5.334	6.306	5.775
New Delhi	12.069	8.379	11.323	8.041
Mumbai	14.013	9.351		
Chennai	7.017	3.306	8.85	5.181

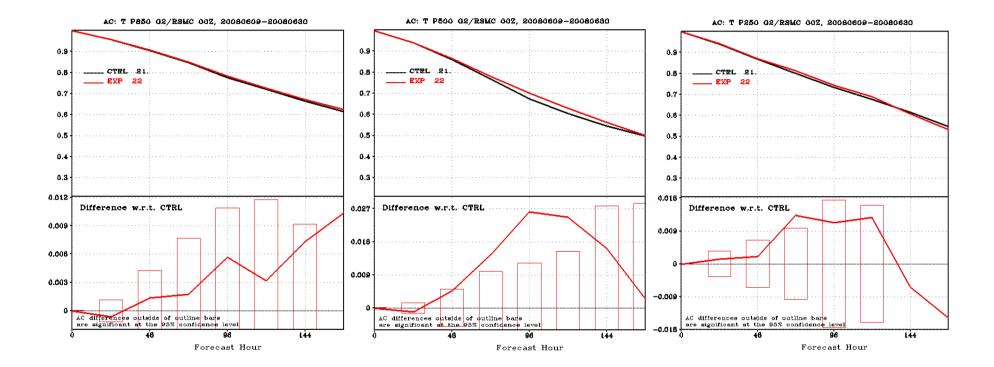
Results & Conclusion

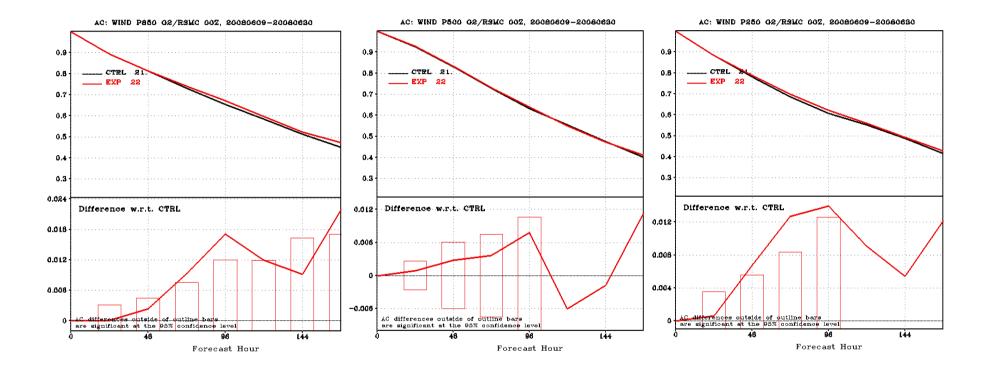
Atmospheric Column Precipitable Water (kg/m2) Atmospheric Column Precipitable Water (kg/m2) 00UTC of 20080602 00UTC of 20080615 Analysis - First Guess Analysis - First Guess 36N 33N 30N 27N 24N 21 N 21N 15N 15N-12N 80E Atmospheric Column Precipitable Water (kg/m2) Atmospheric Column Precipitable Water (kg/m2) 00UTC of 20080628 00UTC of 20080630 Analysis - First Guess Analysis - First Guess 36N -36N -33N -33N -30N -24N -24N -21N-21 N 18N -18N -15N 80E 85E -4 -3 -2 -1 0 1 2 3 4 5 6 7

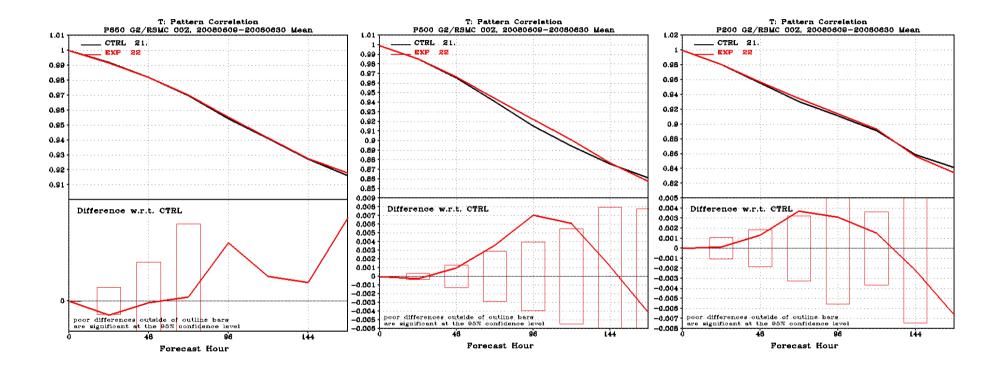
Difference (EXP. - CTRL.)
Atmospheric Column Precipitable Water

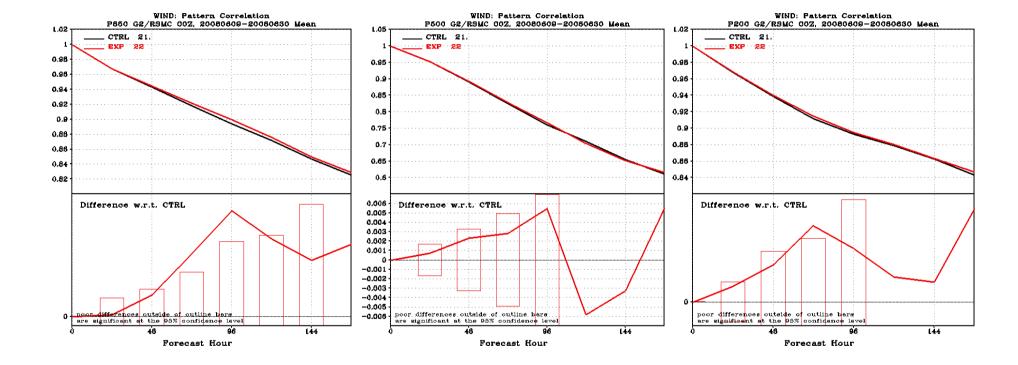


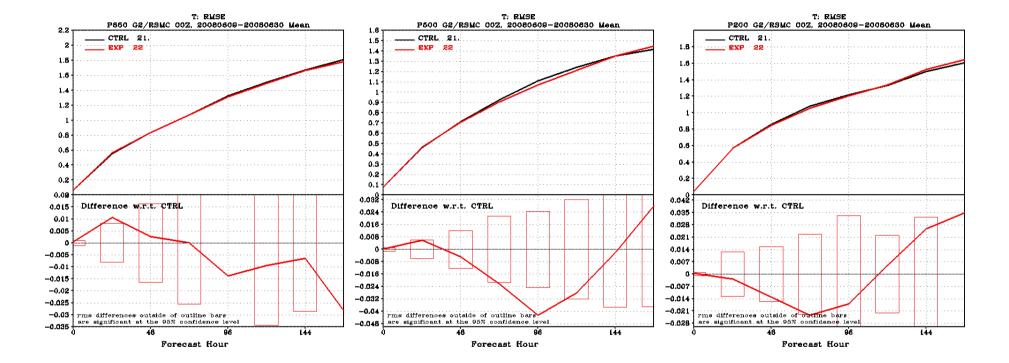


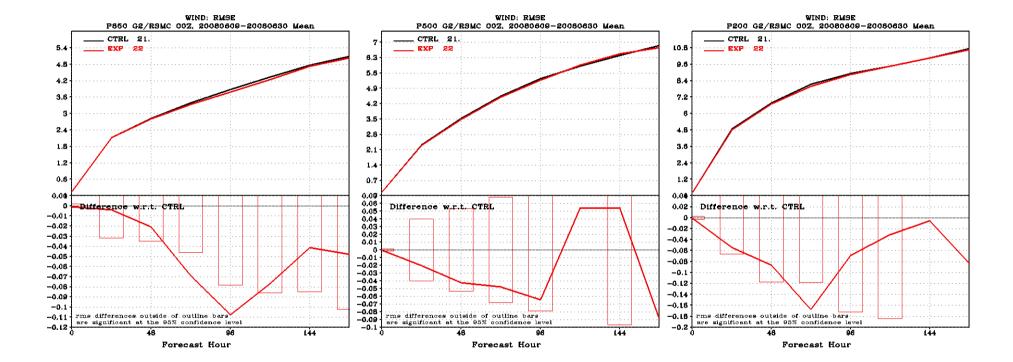




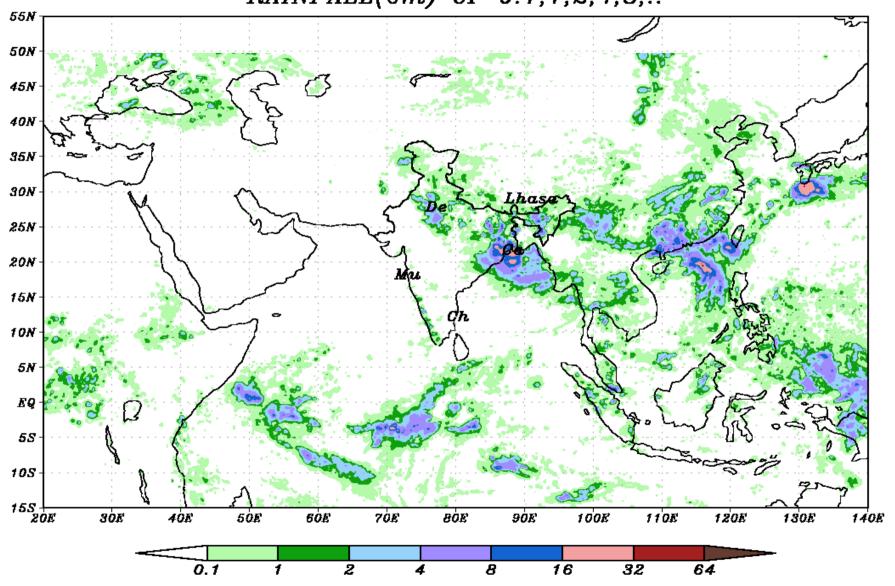


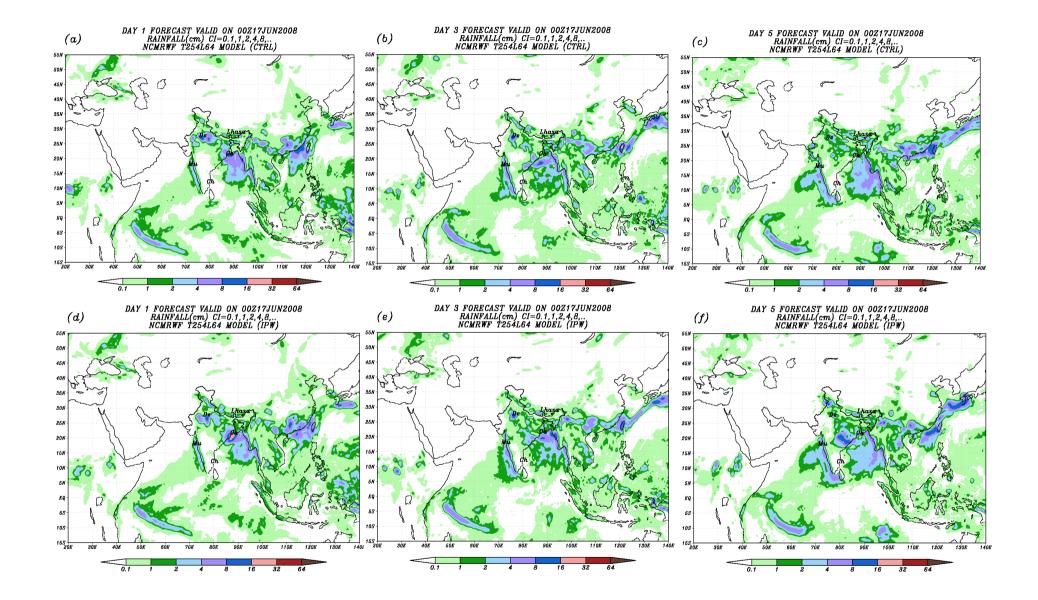






TRMM 3B42V6 Daily Rainfall VALID ON 00Z17JUN2008 RAINFALL(cm) CI=0.1,1,2,4,8,...

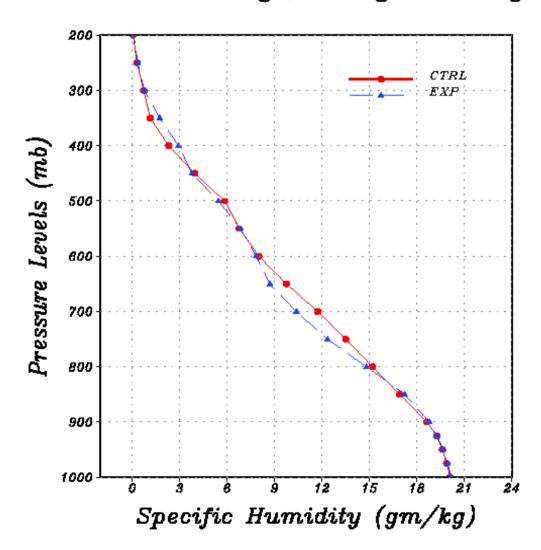




Analysis Valid on 00Z17JUN2008

Vertical profile of Specific Humidity (gm/kg)

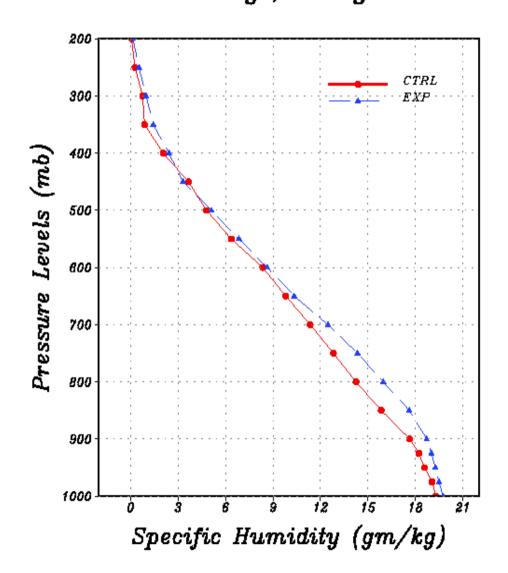
Lat.=23deg., Long.=90deg.



Analysis Valid on 00Z17JUN2008

Vertical profile of Specific Humidity (gm/kg)

Lat.=23.243deg., Long.=87.857deg.



Conclusion

 It should be noted that the amount of data assimilated is less compared to the vastness of the domain.

- The difference in the results is solely due to the IPW data and is encouraging.
- By increasing the number of GPS-IPW stations over the Indian region and assimilation of the data recorded keeps the scope of further and better improvement in the forecasts over the said region.

Thank You