

**2010 THE MEETING OF THE AMERICAS  
8–12 AUGUST, FOZ DO IGUAÇU, BRAZIL**



**ZENITHAL TROPOSPHERIC DELAY PREDICTIONS  
FOR SOUTH AMERICA USING DATA ASSIMILATION  
OF GNSS METEOROLOGICAL PRODUCTS**

**Speaker: Luiz Fernando Sapucci**

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## Talk Outline




- Definition of Zenithal Tropospheric Delay (ZTD);
- Predictions of the ZTD from Numeric Weather Prediction;
- Evolution of ZTD prediction over South America;
- ZTD prediction using data assimilation;
- Assimilation of GNSS meteorological products from:
  - based ground: IWV values
  - based spatial: atmospheric profiles;
- Final remarks.

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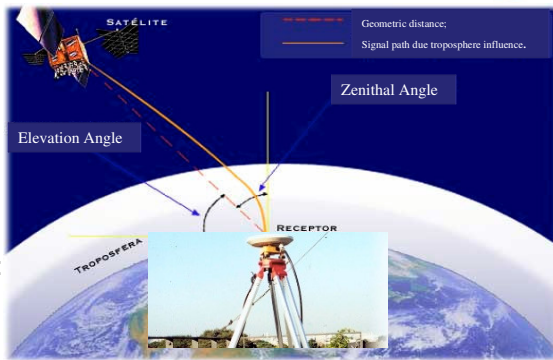
## Zenithal tropospheric Delay



The tropospheric Delay:

$$D_{TROP} = S - S_g = 10^{-6} \int N ds$$

Applying the mapping functions:



**Hydrostatic**

$$D_{z trop} = 10^{-6} \int_{h_0}^{\infty} (k_1 R_h \rho) dh$$


**component**

**Wet**


$$10^{-6} \int_{h_0}^{\infty} \left( k_2' \frac{e}{T} Z_w^{-1} + k_3 \frac{e}{T^2} Z_w^{-1} \right) dh$$

**component**

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## Some alternatives to minimize the ZTD influence in the GPS positioning in real time.

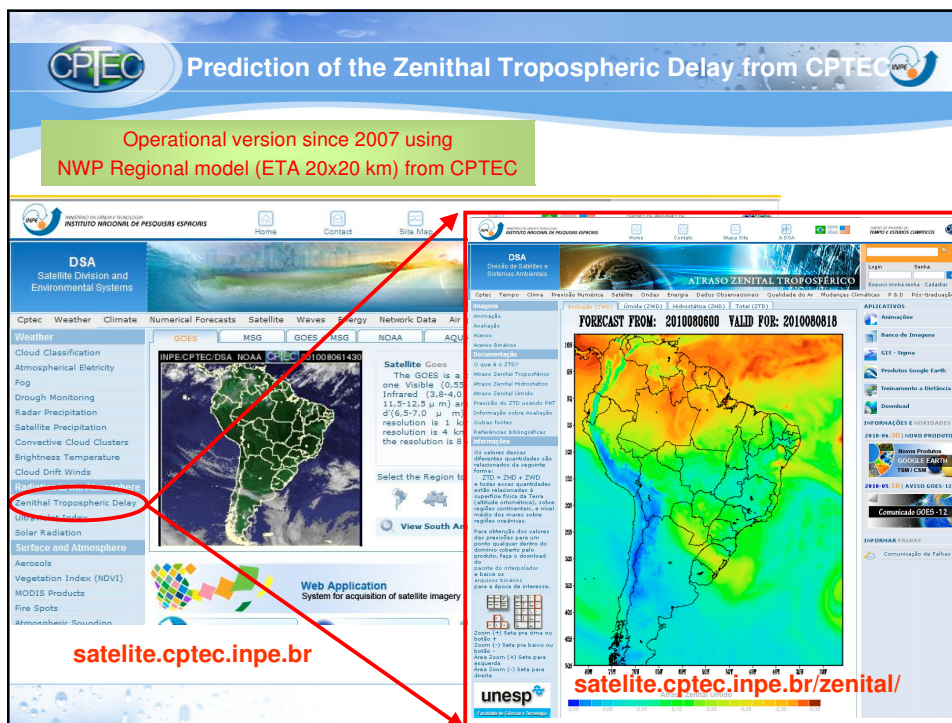
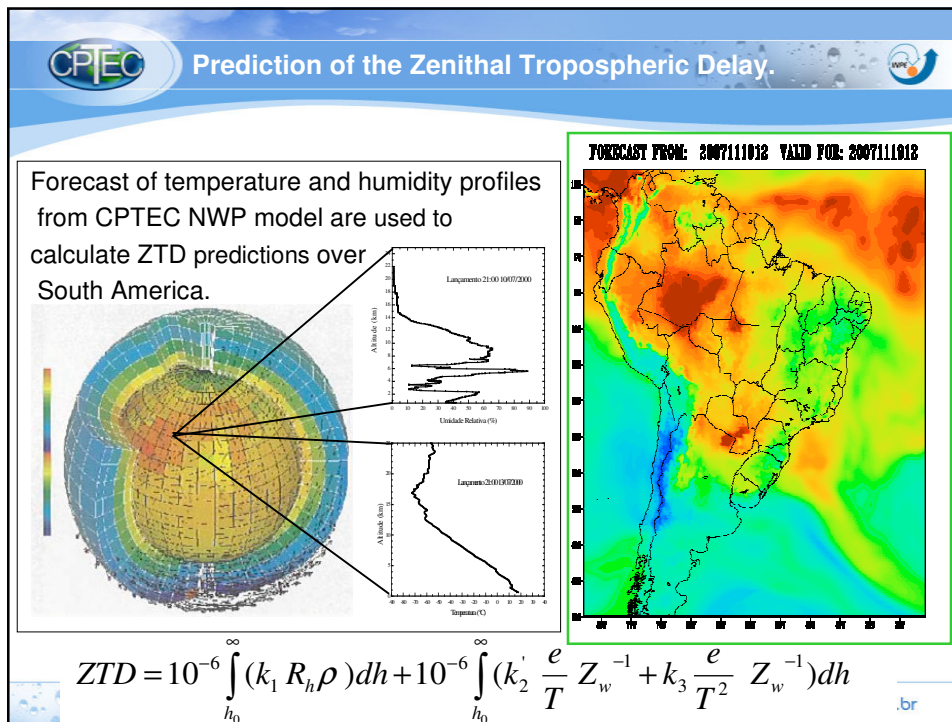


Modeling of the Zenithal Tropospheric Delay:

- Empirical Models : Saastamoinem, Hopfield and other;
- Double differences in short bases applications;
- Combined solution using empirical model and resultant residues estimated in the processing of GPS data;
- Applying correction obtained using reference station (examples: DGPS, WADGPS);

- Prediction of the Zenithal tropospheric Delay from Numerical Weather Prediction.

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## Evolution of the ZTD predictions over South America



- The next version of ZTD predictions will take into consideration:
  - CPTEC's Data assimilation results;
    - Sophisticated assimilation system based in Kalman Filter;
  - Additional data source:
    - GNSS meteorological products;
    - New generation of satellites sensor;
  - Model with high spatial resolution (5 km);

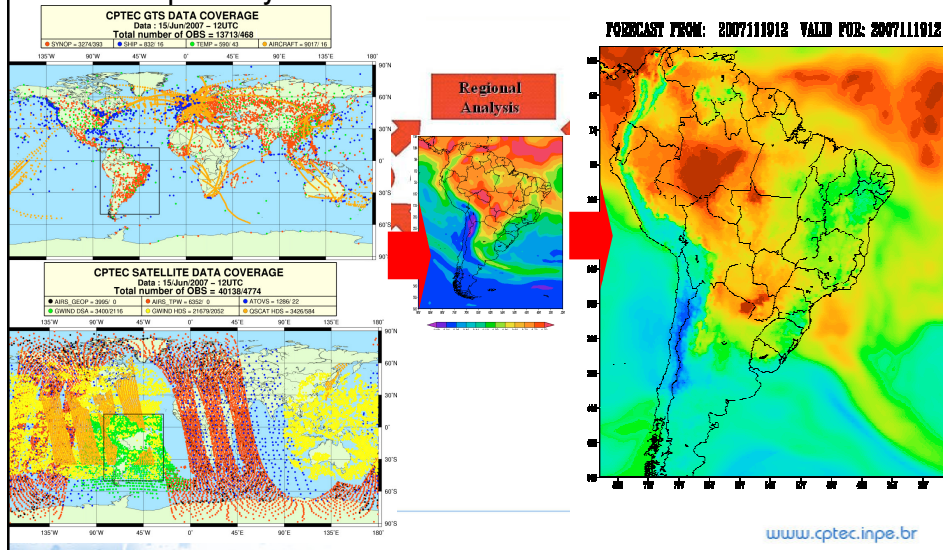
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## Data assimilation

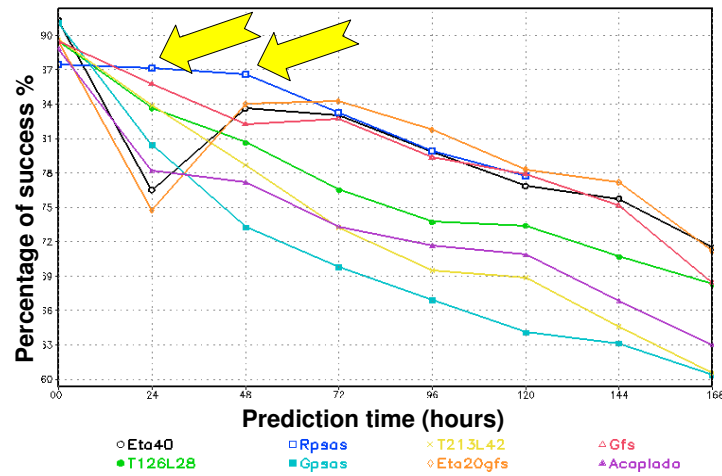


- Complete cycle of data assimilation:

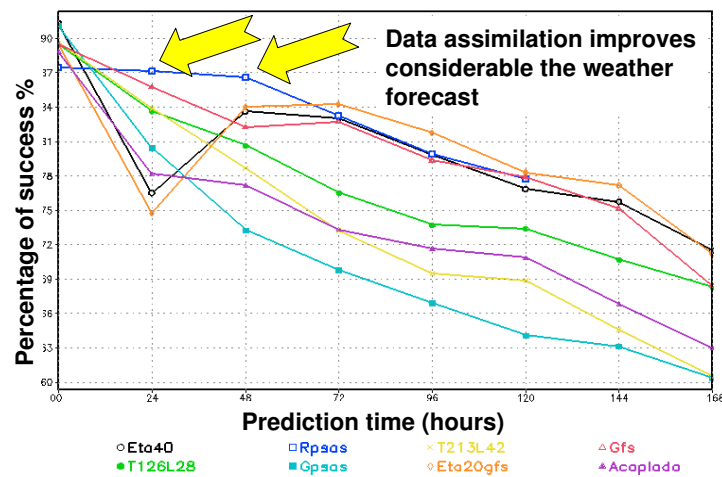


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## Prediction x Observation



## Prediction x Observation





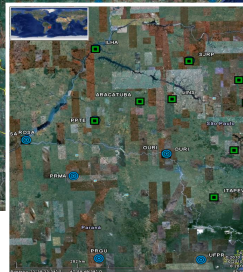
- Acquisition of the super-computer CRAY;
  - 30000 processor;
  - 2° faster super computer applied in NWP;
- Significant increase of the number of researcher in the Group for Data Assimilation Developments;
- Operationalization of a new data assimilation system\* in collaboration of University of Maryland (USA);

\*Local Ensemble Transform Kalman Filter

- GNSS based ground: strong densification in the Brazilian territory in progress:



Integrated Water vapor (I WV) with good quality and



**SIPEG project  
85 new stations**

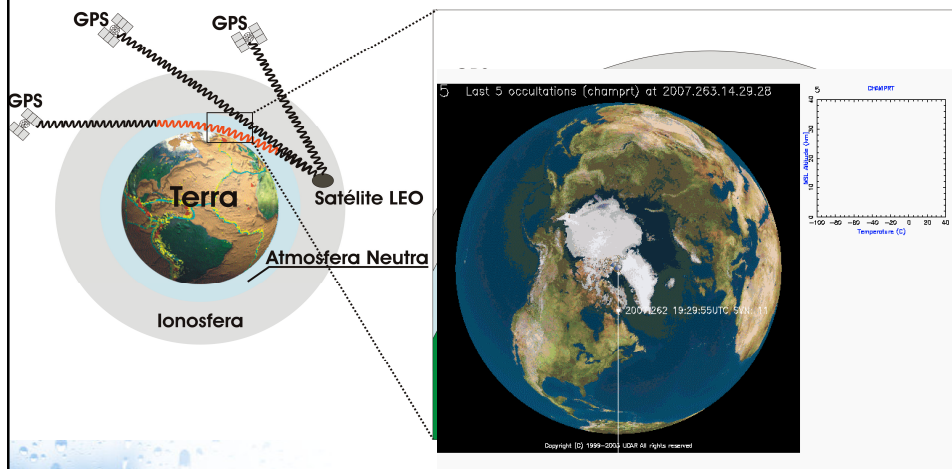


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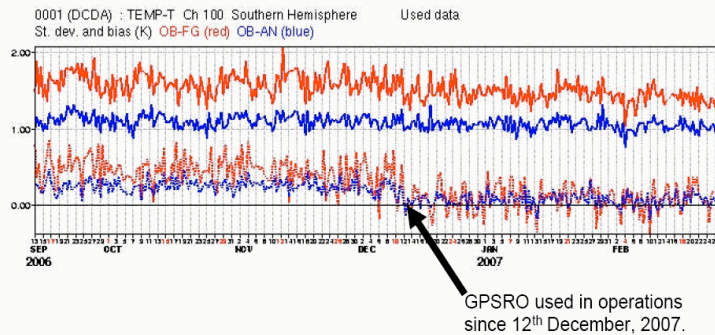


- GNSS radio occultation data: temperature and humidity profiles.



### Impact on ECMWF operational analyses

- We would expect improvements in the stratospheric temperatures. The fit to radiosonde temperatures is improved (eg, 100 hPa, SH).





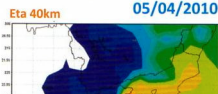


## Final Remarks

### Future new version of ZTD predictions

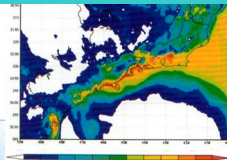


- ZTD will be produced at higher spatial resolution: 5km



Assimilation of GNSS meteorological products in the data assimilation system.

The future integration of all these developments will contribute to CPTEC/INPE's ability to generate the best ZTD prediction over South America.



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Thanks for your attention.

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