Assimilation of GPS radio-occultation observations at METEO-FRANCE

Nathalie Saint-Ramond

Alexis Doerenbecher, Florence Rabier

CNRM-GAME, Météo-France and CNRS



ROWG Workshop 28 March 2012, Estes Park, Colorado, USA.





- GPS RO operational assimilation
- Recent addition of Terrasar-X and C/NOFS
- Reduction of observation error
- Forecast sensitivity to GPS RO observations : adjoint based estimate
- Summary and Outlook



# GPS RO operational assimilation

Assimilated in the global 4DVAR and LAM 3DVAR since september 2007

- Bending angles
- Rising and setting occultations Up to 36 km
- Accounting for tangent point drift
- Horizontal / Vertical thinning
  1 datum per model vertical layer
- Screening



### **GPS RO operational assimilation**



- GRACE-A
- FORMOSAT-3COSMIC 1-6





### **GPS RO operational assimilation**



1 day: 3 nov. 2011



### **GPSRO:** recent added satellites

SAC-C

#### Observations caracteristics COSMIC-6



#### Score on forecast skill:

Verification for 24h forecast wrt ECMWF analysis





EXP (CTL + Terrasar-X)



### **GPSRO** recent added satellites

#### Conclusion:

- Small but significant impact on forecasts
- Terrasar-X and C/NOFS bring up to 20% more observations
- In operational model since september 2011





# **GPSRO:** reduction of observation error

#### Context:

- Can we better use observations ? AMSU-A, GPSRO, radiosondes...
- Test for GPS RO:



Observation error is a fraction of observed value of bending angle Physical lower limit :  $3\mu$ rad (not shown here) Evaluation over one month and a half in august-september 2011



### **GPSRO:** reduction of observation error

#### Results :



Reduction for RMS of (O - B) / B

screening test based on observation errors ( $\sigma_o$  value) :

$$(obs - guess)^2 < \alpha(\sigma_0^2 + \sigma_b^2)$$



### GPS RO: reduction of observation error

#### Scores on forecast skill:

Verification for 96h forecast wrt ECMWF analysis





## GPS RO: reduction of observation error

#### Conclusion:

- Small but significant impact
- Modification could be modified to depend on latitude...
- Reduction of errors were tested for others observations : AMSU-A, radiosoundings
- In our experimental suite Should become operational this year



### Why?



Such a large number of observations need to be monitored to indicate their influence on analysis and forecasts skills



#### How?

- Implemented in IFS (ECMWF) by C. Cardinali and M. Fisher.
- J: 3D integrated dry total energy of the difference between the 24h forecast and a reference state
- Observation impact:



$$deltaJ = \frac{1}{2} (R^{-1}HA) \left( M_a^T \frac{\partial J^b}{\partial x_b^f} + M_b^T \frac{\partial J^a}{\partial x_a^f} \right) (y - Hx_b)$$

- second order approximation (Errico, 2007).
- With the help of Alexis Doerenbecher



#### Forecast impact experiment from Dec. 2010 to Jan. 2011



#### **GPSRO** results





#### **GPSRO** results

- bad impact in the tropics ?
- due to J calculation ?
- due to the model ?

2°x2° grid

- due to the weather regime ?

CE

ours un temps d'avance





- GPS RO operationally assimilated since 2007
  1D + AD/TL from GRAS-SAF
- Recent addition of Terrasar-X and C/NOFS have brought a small impact but increase the number of GPS RO data assimilated.
   GPS RO data are assimilated without bias correction and are an anchor point for radiances bias correction
- Reduction of GPS RO observation error will now be tested in conjonction with other observations: AMSU-A, radiosounding
- Forecast sensitivity to GPS RO observations:
  Impacts at high altitude in tropics area need more investigation



### Thank you

00

