Assimilation of GPS radio occultation observations at Météo-France

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GPS RO at Météo-France : operational assimilation

Assimilated in the global 4DVAR and European LAM 3DVAR, since September 2007

Bending angles (1D operator + TL/AD from GRAS-SAF)

GRACE-A data from GFZ via GTS
FORMOSAT-3/COSMIC1-6 data from UCAR via GTS

Rising and setting occultations

Up to 25 km altitude. Lower limit depending on latitude: from 1 km (pole) to 6 km (tropics)

Vertical thinning: 1 datum per model vertical layer (46 layers between 1 and 25 km)

Quality Control:

Apply BUFR quality flag to remove profiles:
- with confidence ≤ 99.9 %
- non nominal quality
  - excess phase processing non nominal
  - bending angle processing non nominal
  - background profile non nominal

Retain bending angle data only if
- $dN/dz < -0.001 km^{-1}$
- dN/dz at all levels above $> -50 km^{-1}$
- $|d^2N/dz^2|$ at all levels above $< 100 km^{-2}$
- occultation extends down to 10 km altitude or below

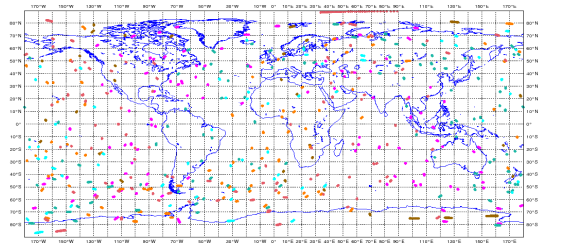

Fig. 1: METEO-FRANCE data coverage – GPS satellite 20100721 00H UTC
long cut-off. Total number of observations after screening: 17607
1088 GRACE A 3634 F3C-1 3033 F3C-2 0 F3C-3
4005 F3C-4 3741 F3C-5 2103 F3C-6 0 METOP A

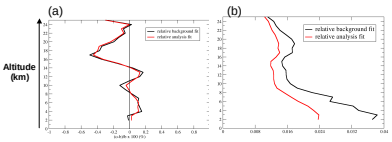

Fig. 2: 1 month experiment in April 2010. Relative background (black) and analysis (red) fit of GPSRO observations to the model:
(a) biais (b) rmse

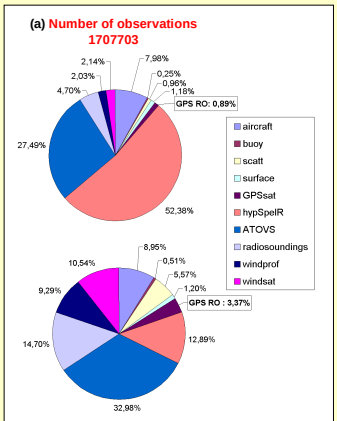

Fig. 3: (a) Number of observations assimilated in one analysis time in the global 4DVAR. (b) Degrees of Freedom for Signal (DFS) calculated in T107 truncation from ensemble assimilation system, on 15th of July 2010 at 00H. Courtesy of G. Desroziers.

Recent improvements : current experimental suite

Assimilation of METOP-GRAS

Down to 8 km (10 km in the tropics), up to 25 km altitude

Evaluation over a 27-day period during April 2010

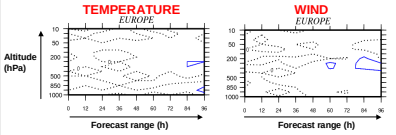

Fig. 3: Impact of GRAS assimilation wrt radiosoundings for temperature (left panels, 1 isoline every 0.05K) and wind (right panels, 1 isoline every 0.2 m/s) averaged over Europe.

RMSE(noGRAS wrt radio.) – RMSE(GRAS wrt radio.)
Blue = positive impact, red = negative impact

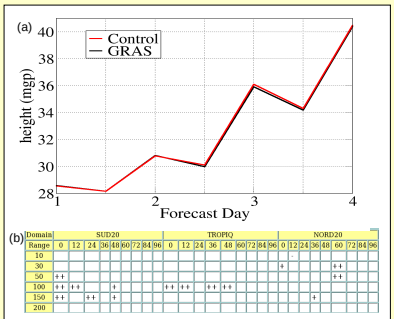

Fig. 4: Impact of GRAS assimilation wrt radiosoundings for geopotential height averaged over Northern hemisphere at 50 hPa level. (a) RMSE with (black) or without (red) GRAS (b): bootstrap significance test. Experiment with GRAS is better (worse) with + (-): 99% or ++ (- -): 99.9% confidence

Increase of bending angle assimilation upper limit

From 25 km to 36 km

Evaluation over one-month period during June 2010

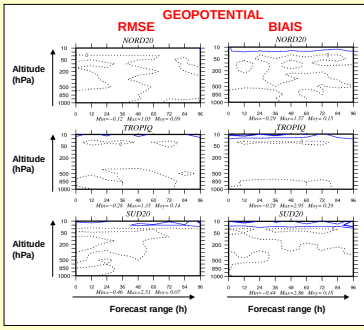

Fig. 5: Impact of increase of GPS RO assimilation upper limit from 25 to 36 km wrt radiosoundings for geopotential height (1 isoline every 1 m) averaged over Northern hemisphere (top panel) tropics (middle) and Southern hemisphere (bottom panel).
Left: RMSE (25 km wrt radiosoundings) – RMSE (36km wrt radiosoundings)
Right: BIAIS (25 km wrt radiosoundings) – BIAIS (36km wrt radiosoundings)
Blue = positive impact, red = negative impact

Overall impact of GPS radio occultation assimilation in global model ARPEGE

Evaluation over a 1-month period in June 2010.

Observations assimilated in the control experiment « noGPSRO »:
- Surface: pressure, 10m wind over sea only, 2m relative humidity over land (daytime only)
- Aircraft data: temperature and wind
- Sounding data: temperature, wind and humidity
- American and European wind profiler data
- GPS Land-based zenith total delays
- GPS radio occultations from FORMOSAT-3/COSMIC1-6, GRACE, METOP/GRAS up to 36 km.
- Geostationary satellite data: atmospheric motion wind vectors derived from the Meteosat, GOES and MTSAT satellites. Clear-Sky radiances from SEVIRI (Meteosat)
- Polar orbiting infrared data: cloud-free HIRS (NOAA satellite data), cloud-free IASI (METOP satellite), and cloud-free and cloud-affected AIRS (aqua satellite) radiometer channels.
- Polar-orbiting microwave data: AMSU (NOAA series and Aqua satellites) , MHS (MetOp satellite)
- Polar-orbiting scatterometer data: ambiguous sea-surface wind retrievals from the Quikscat satellite, Metop/ASCAT and ERS2/AMI

Observations assimilated in the impact experiment « withGPSRO »:
- Observations assimilated in the control experiment
- GPS radio occultations from FORMOSAT-3/COSMIC1-6, GRACE, METOP/GRAS up to 36 km.

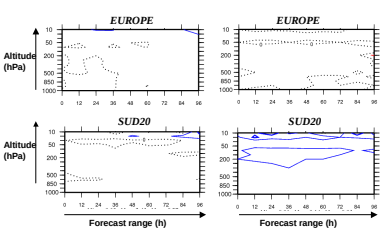

Fig. 6: Impact of GPSRO assimilation wrt radiosoundings for geopotential height (left panels, 1 isoline every 1 m) and temperature (right panels, 1 isoline very 0.05 K) averaged over Europe (top panels), and latitudes between 20S and 90S (bottom panels)

RMSE(noGPSRO wrt radio.) – RMSE(withGPSRO wrt radio.)
Blue = positive impact, red = negative impact

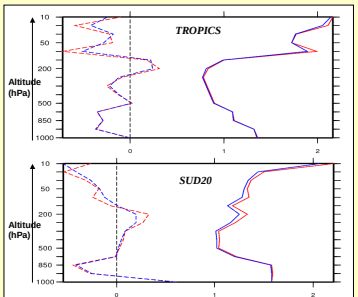

Fig. 7: Averaged profiles of biais and RMSE with respect to radiosoundings for temperature (K), at 24 h forecast range for latitudes between 20N and 20S (top panel) and latitudes between 20S and 90S (bottom panel). Reference in red, addition of GPS radio occultations in blue.

References

Poli, P., Moll, P., Puech, D., Rabier, F., Healy, S.B., 2009: Quality control, error analysis, and impact assessment of FORMOSAT-3/COSMIC in numerical weather prediction, Terrestrial Atmospheric and Oceanic Sciences, 20, 101-113, doi: 10.3319/TAO.2008.01.21.02(F3C)

Poli P., S.B. Healy, F. Rabier, and J. Pailleux: Preliminary Assessment of the Scalability of GPS Radio Occultations Impact in Numerical Weather Prediction. Geophysical Research Letters, 35. doi:10.1029/2008GL035873

METEO FRANCE
Toujours un temps d'avance