Data impact studies in the global NWP model at Meteo-France

Patrick Moll, Fatima Karbou, Claudia Faccani, Nathalie Saint-Ramond, Florence Rabier

Centre National de Recherches Météorologiques CNRS/GAME,
Météo-France, Toulouse, France

WMO Workshop on the
Impact of Various Observing Systems on Numerical Weather Prediction
Fifth Session

Sedona, Arizona (USA)
22 -25 May 2012

METEO FRANCE
Toujours un temps d'avance

Outline

- Observations in the Météo-France global model

- On the importance of land surface emissivity to assimilate low level humidity and temperature observations over land

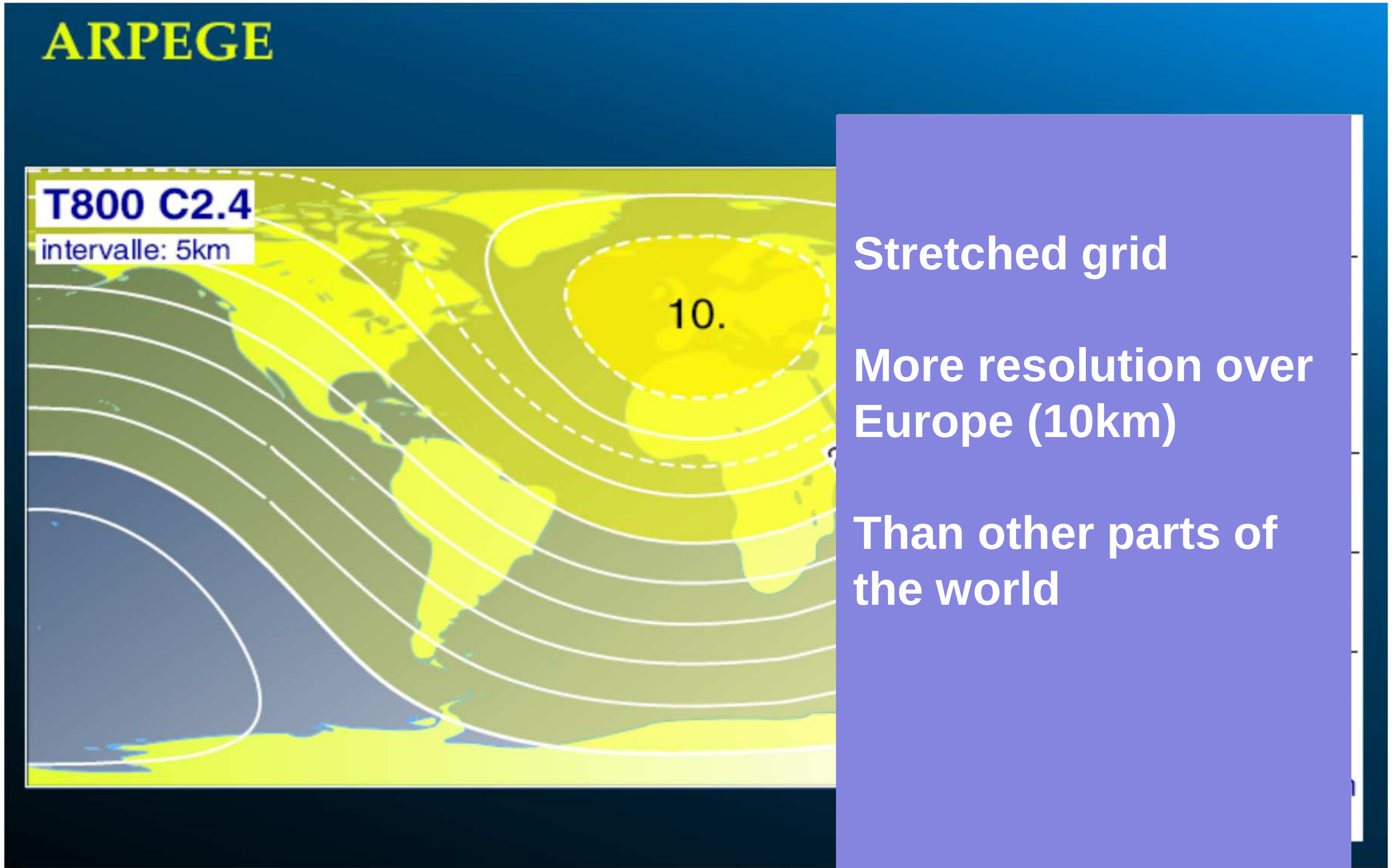
- Impact of the AMMA radiosonde data on the French global assimilation and forecast system

- A few words about ground-based GNSS data

Observations in the Météo-France global model

METEO FRANCE
Toujours un temps d'avance

ARPEGE 4DVar : T798 C2.4 L70

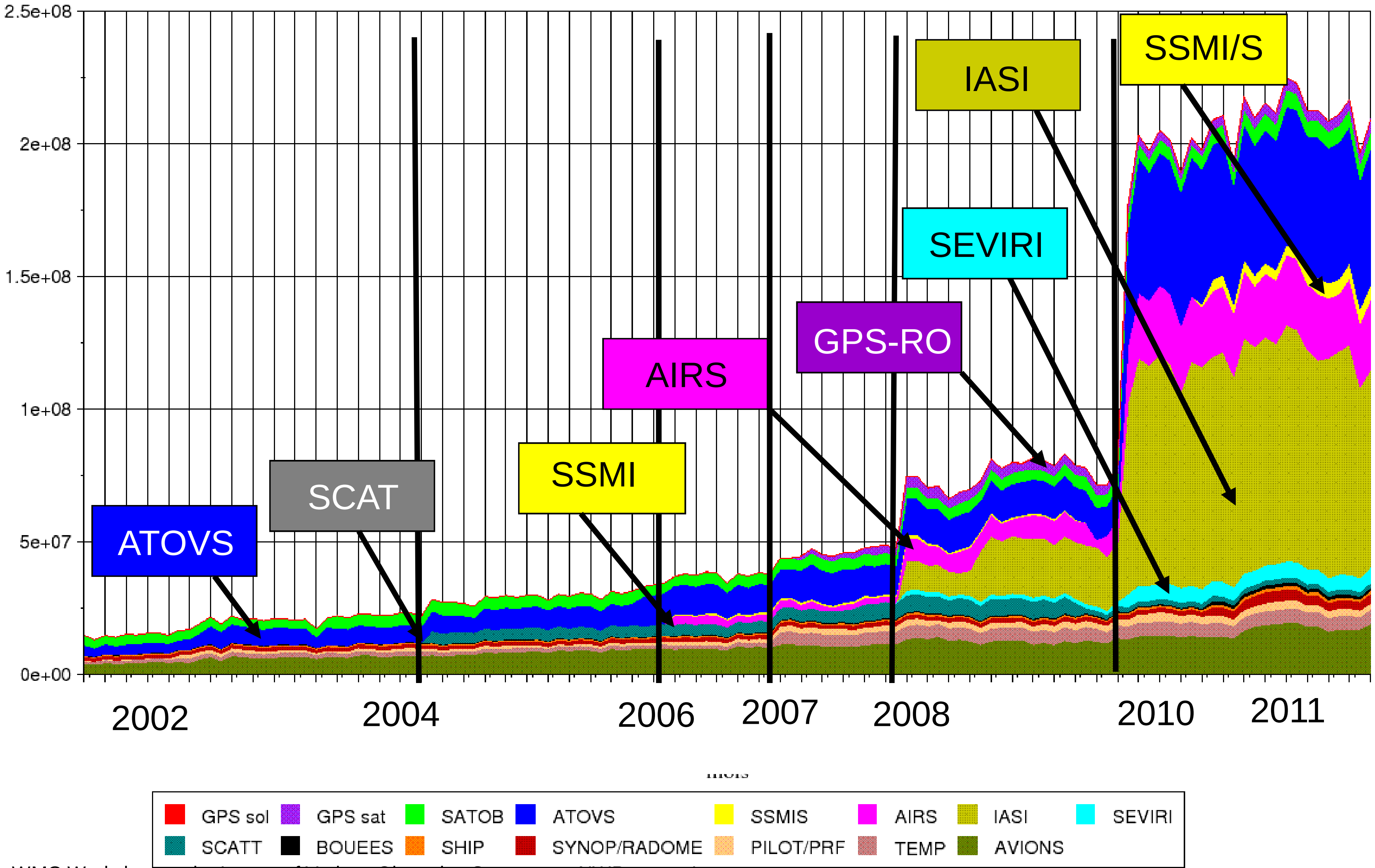


Stretched grid

More resolution over Europe (10km)

Than other parts of the world

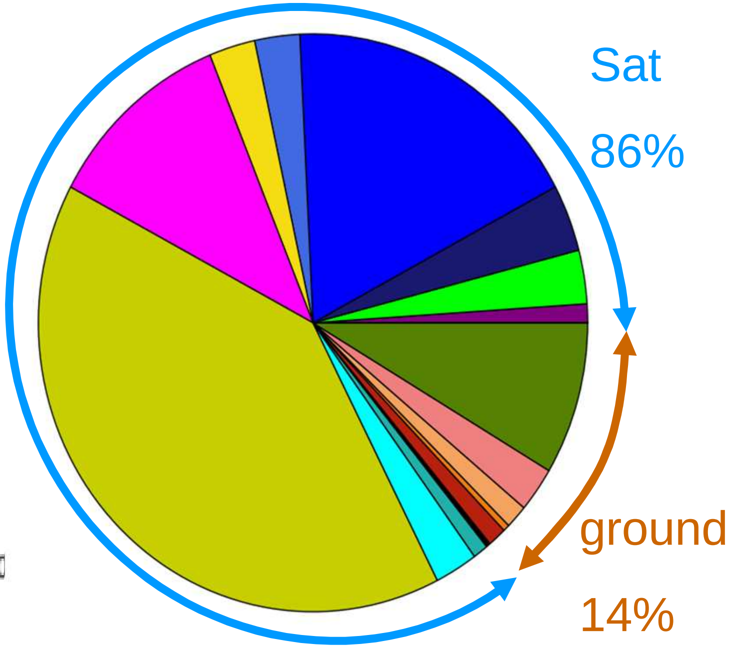
Monthly number of observations used in the global model



DFS in the global model ARPEGE

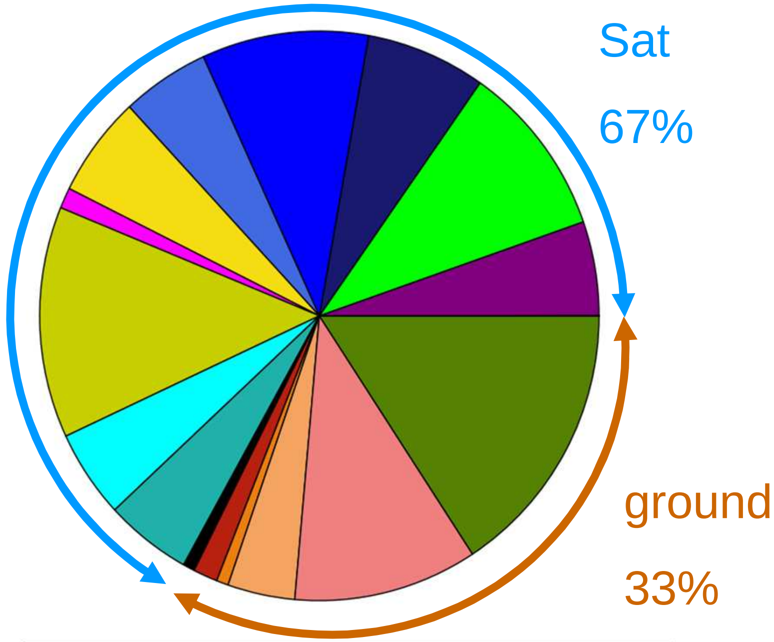
- GPS ground
- GPS sat
- SATOB
- ATOVS HIRS
- ATOVS AMSU-A
- ATOVS AMSU-B
- SSMIS
- AIRS
- IASI
- SEVIRI
- SCATT
- BUOY
- SYNOP/SYNOR/RADO
- SHIP
- PILOT/PRF
- TEMP
- AIRCRAFTS
- RADAR Vr
- RADAR Hur
- BOGUS

Observation number



GPS ground	0.01%	AIRS	11.09%	PILOT/PRF	1.32%
GPS sat	1.04%	IASI	40.26%	TEMP	2.51%
SATOB	3.00%	SEVIRI	2.53%	AIRCRAFTS	8.55%
ATOVS HIRS	3.75%	SCATT	0.89%	RADAR Vr	0.00%
ATOVS AMSU-A	17.97%	BUOY	0.25%	RADAR Hur	0.00%
ATOVS AMSU-B	2.65%	SYNOP/SYNOR/RADOME	1.10%	BOGUS	0.00%
SSMIS	2.71%	SHIP	0.38%		

DFS



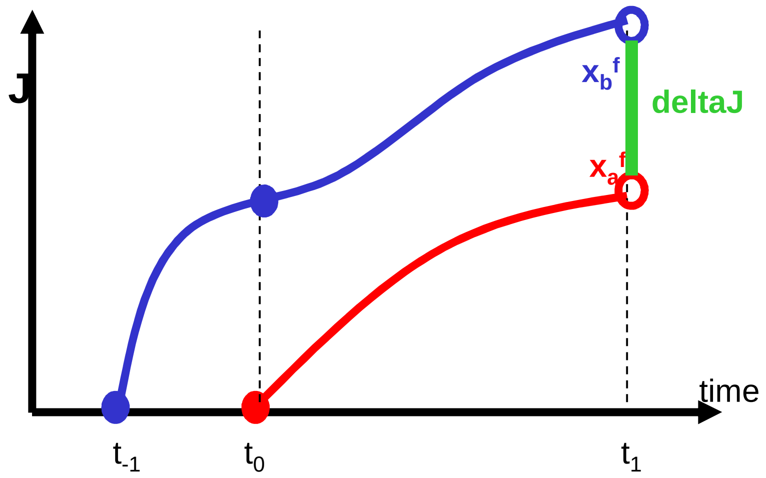
GPS ground	0.02%	AIRS	1.17%	PILOT/PRF	3.89%
GPS sat	5.34%	IASI	13.14%	TEMP	10.63%
SATOB	9.89%	SEVIRI	4.99%	AIRCRAFTS	15.77%
ATOVS HIRS	6.92%	SCATT	5.00%	RADAR Vr	0.00%
ATOVS AMSU-A	9.64%	BUOY	0.68%	RADAR Hur	0.00%
ATOVS AMSU-B	5.08%	SYNOP/SYNOR/RADOME	1.41%	BOGUS	0.00%
SSMIS	5.74%	SHIP	0.69%		

1 day: 3 nov. 2011

METEO FRANCE
Toujours un temps d'avance

How?

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

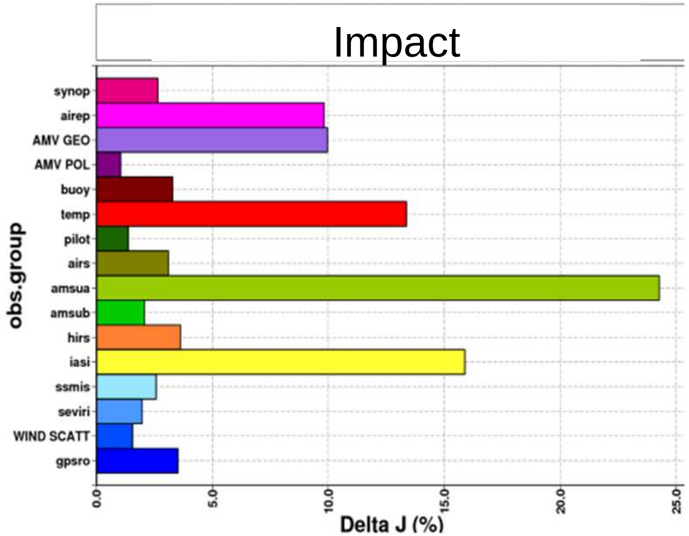


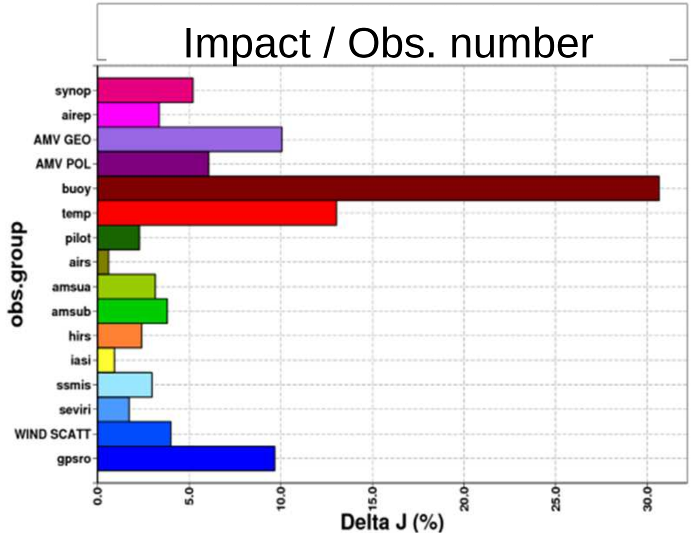
- Observation impact:

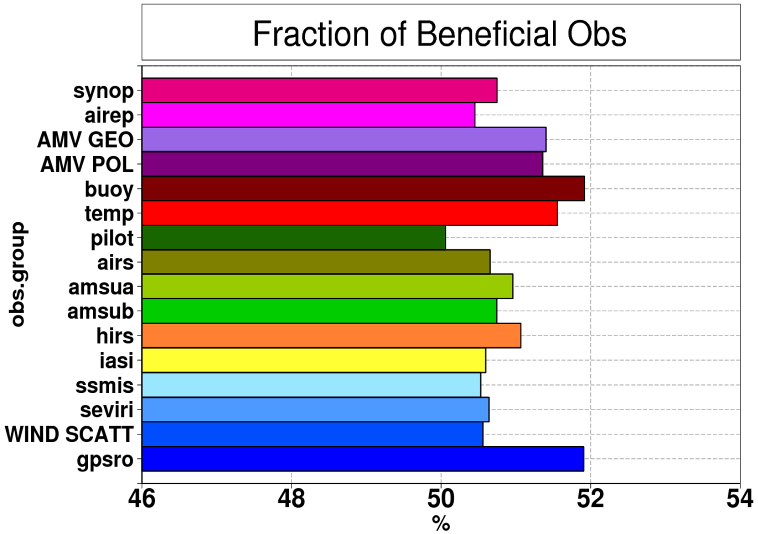
$$deltaJ = \frac{1}{2}(R^{-1}HA)\left(M_a^T \frac{\partial J^b}{\partial x_b^f} + M_b^T \frac{\partial J^a}{\partial x_a^f}\right)(y - Hx_b)$$

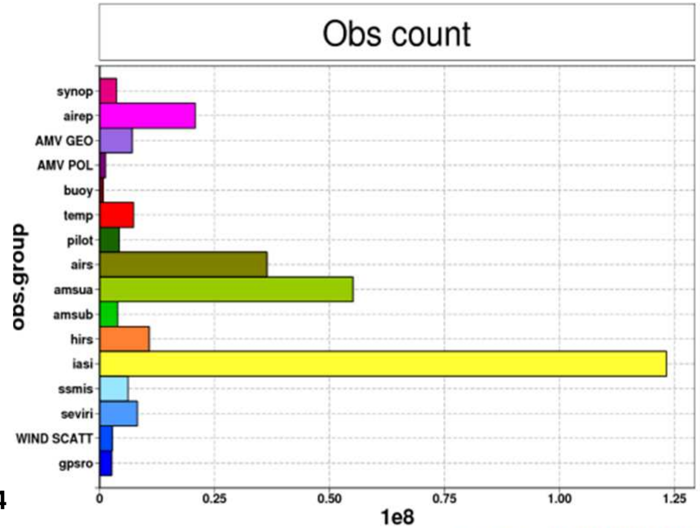
- second order approximation (Errico, 2007).
- With the help of Alexis Doerenbecher

Forecast impact experiment from Dec. 2010 to Jan. 2011









On the importance of land surface emissivity to assimilate low level humidity and temperature observations over land

METEO FRANCE
Toujours un temps d'avance

Dynamical land surface emissivity

Land surface emissivity :
« dynamical land emissivity parameterization » operational since July 2008 (Karbou et al. 2006)

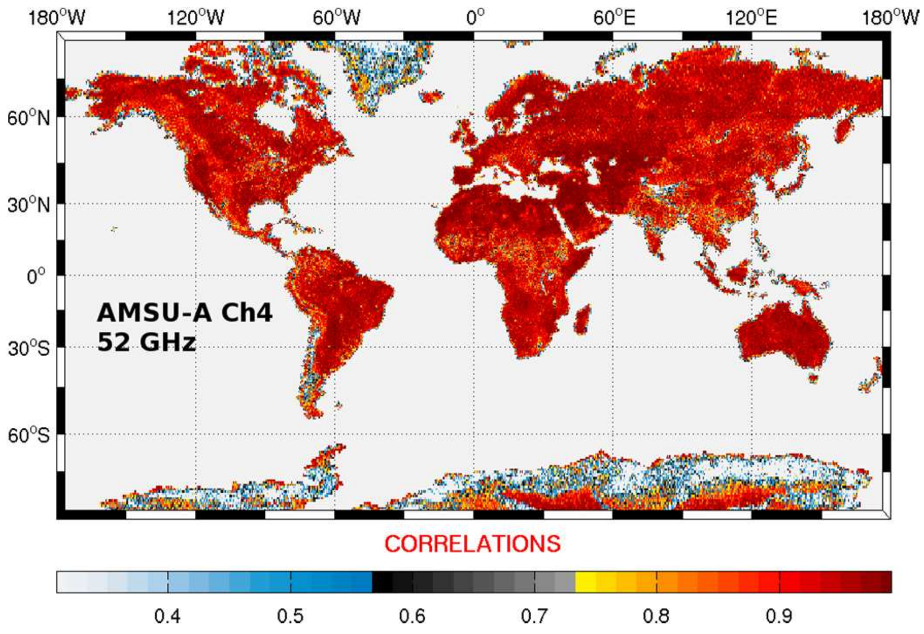
- Land emissivity is computed from selected surface channels (AMSU-A ch3 (50 GHz) and from AMSU-B ch1 (89 GHz))
- Emissivity is dynamically updated for each atmo. & surface situations
- Interfaced with RTTOV (Eyre 1991; Saunders et al. 1999; Matricardi et al. 2004)
- Large improvement of RTTOV performances (bias, std, correlations)

Dynamical land surface emissivity

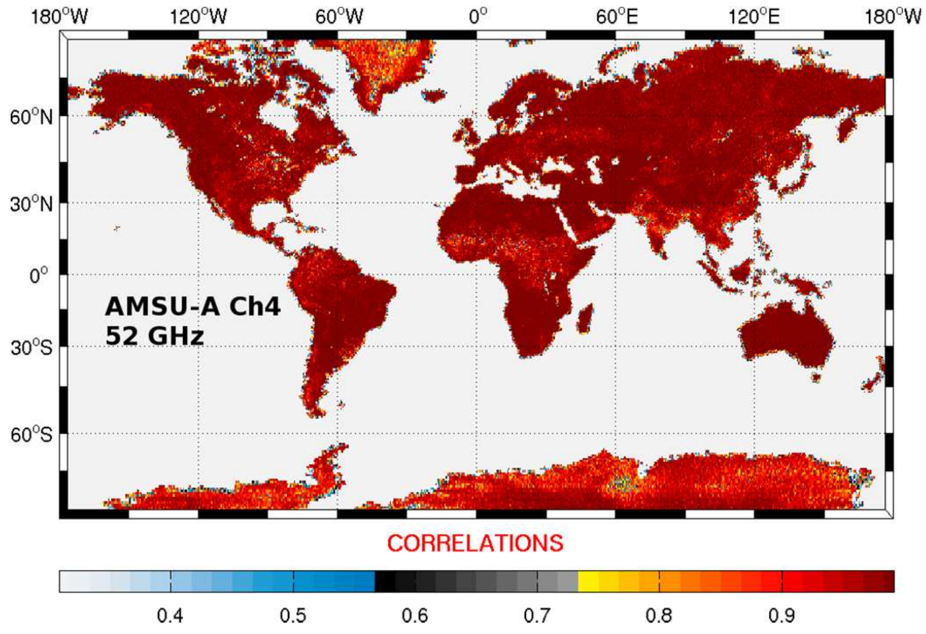
« dynamical land emissivity parameterization » operational since July 2008 (Karbou et al. 2006)

Correlations between Obs and RTTOV Sim., AMSU-A ch4, August 2006

CTL



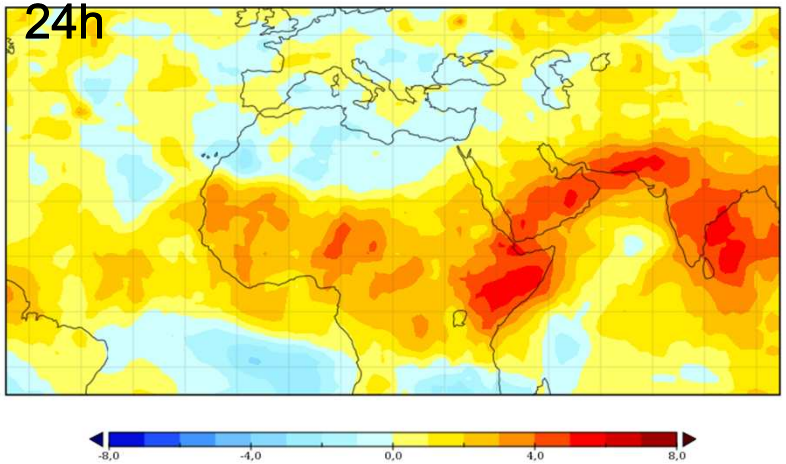
CTL + dynamical emis.



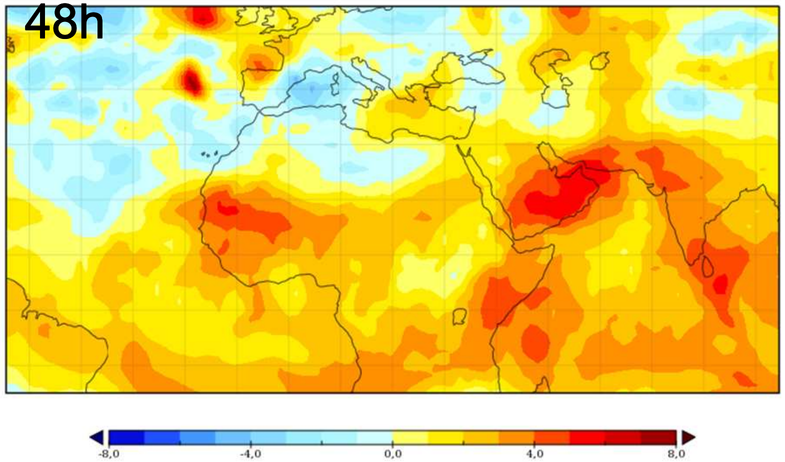
METEO FRANCE
Toujours un temps d'avance

Assimilation experiments
Forecast scores

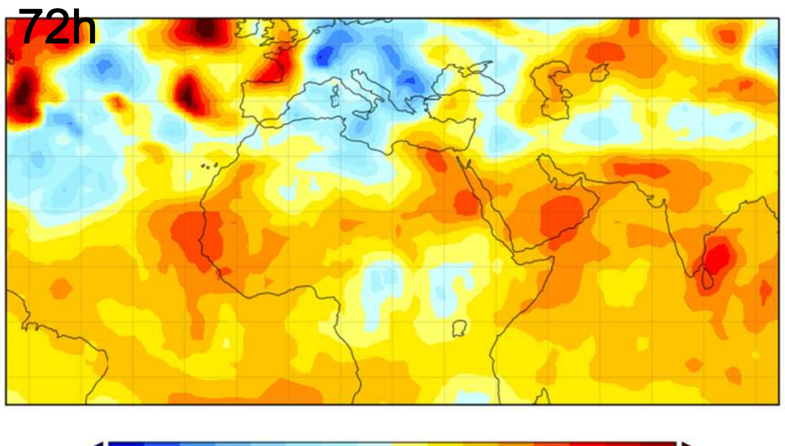
Differences of geopotential forecast errors with respect to ECMWF analyses (CTL-EXP), 200hPa, 1month



Smaller errors in EXP



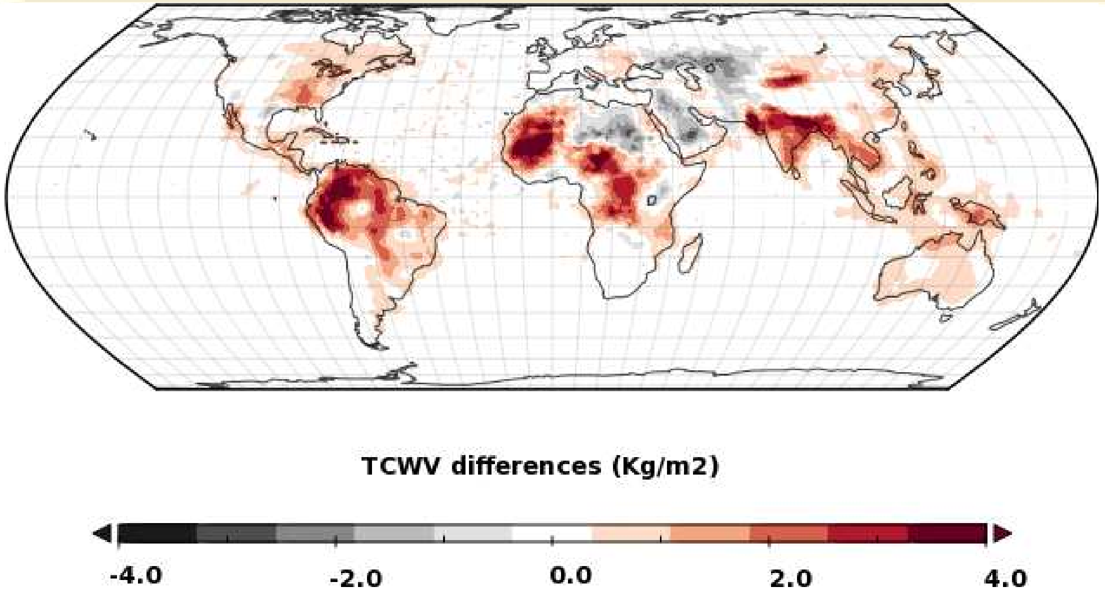
Smaller errors in EXP



METEO FRANCE
Toujours un temps d'avance

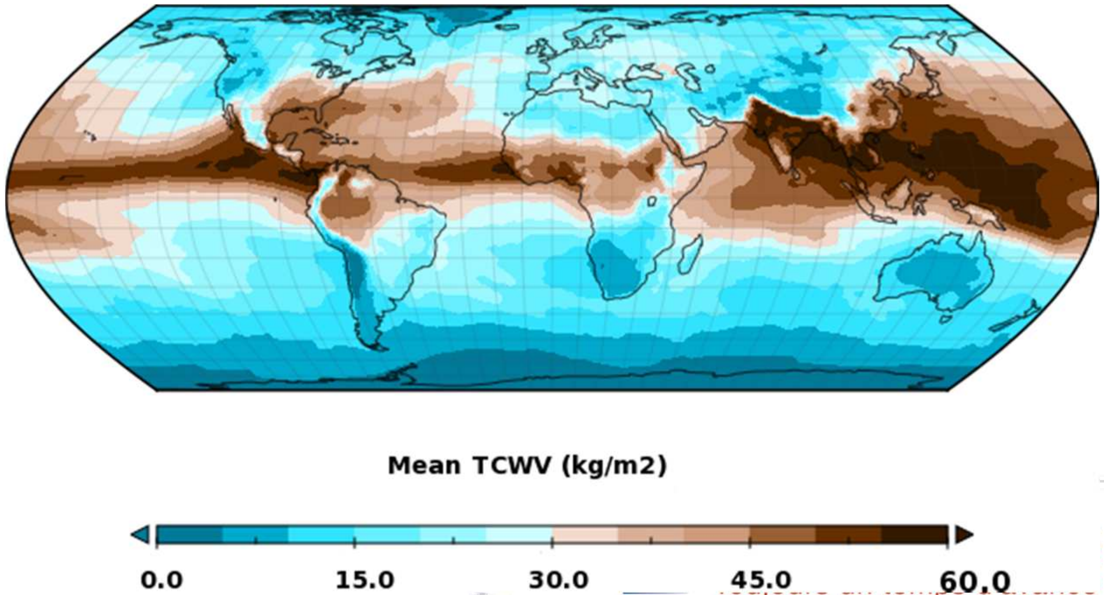
Assimilation experiments
Impact on humidity analysis

EXP-CTL

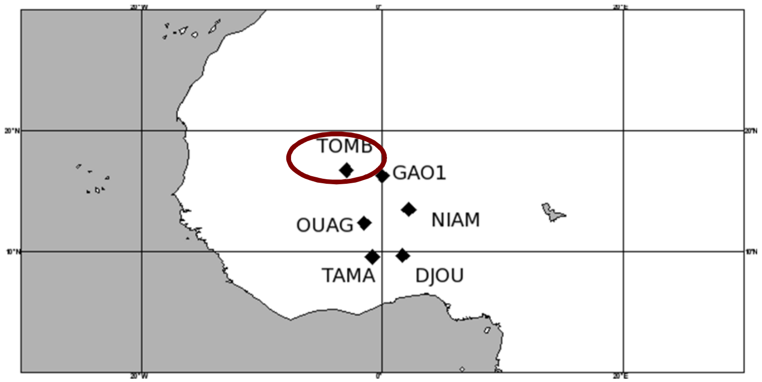


CTL

Mean analysis for Total Column Water Vapor (TCWV) for the CTL and Mean TCWV analysis difference for the experiment with respect to the control. Statistics have been derived using 45 days (from 01/08/2006 to 14/09/2006). Negative (positive) values indicate that the control assimilation is more moist (dry) than the experiment.

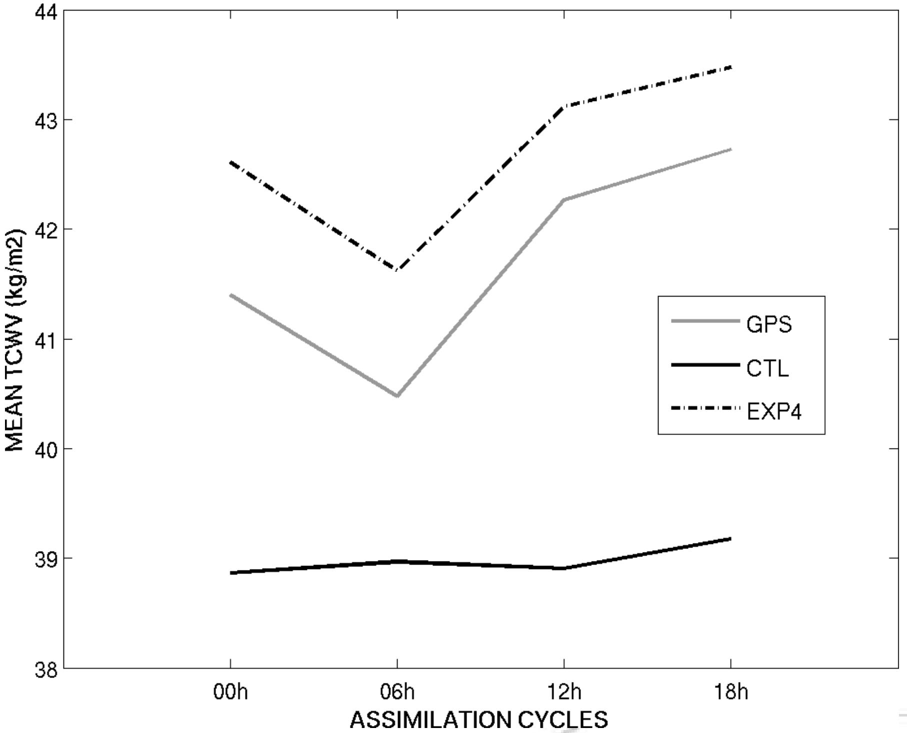


Assimilation experiments
Impact on humidity analysis



Mean estimates of Total Column Water Vapour (TCWV) obtained from measurements at TOMBOUCTOU gps station and Mean analysis near TOMBOUCTOU for TCWV for the CTL (black dashed curve) and for the EXP4 experiment (black solid curve) at 0h, 6h, 12h and 18h. at ecah cycle the TCWV mean values have been averaged over a 45 days period (from 01/08/2006 to 14/09/2006)

TCWV diurnal cycle at Timbuktu, 45 days



Conclusion

• A good representation of land surface emissivity motivated assimilation studies to assimilate low level humidity & temperature observations (usually blacklisted)

• The assimilation of these channels:

- Positive impact in scores % radiosondes : all domains
- Positive impact in scores % ECMWF analysis (500hPa, 200hPa): all domains
- Large impact on humidity analysis (& temp., wind) over the Tropics: low to mid-levels
- TCWV Change evaluated against independent GPS measurements
- Change in OLR and rain forecasts in better agreement with independent data

• Emissivity is one issue but surface temperature is as important as emissivity

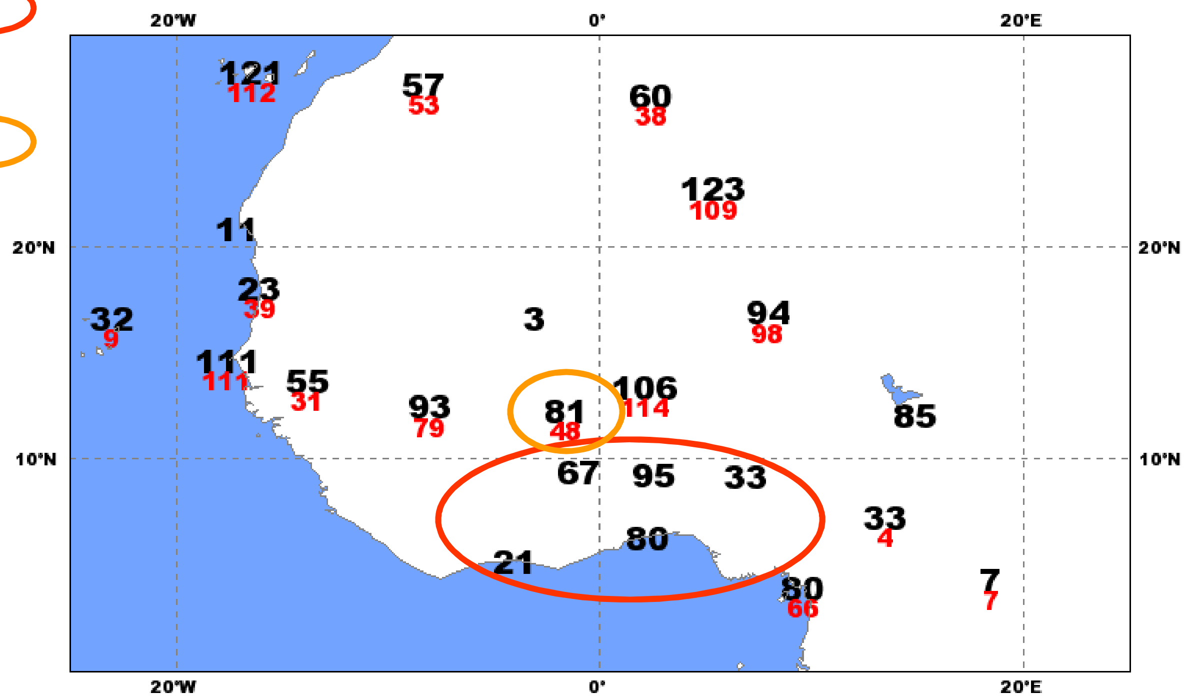
• More results in Karbou et al. 2010a-b (Weather and Forecasting)

Impact of the AMMA radiosonde data on the French global assimilation and forecast system

METEO FRANCE
Toujours un temps d'avance

AMMA radiosondes datasets

- New radiosonde station
- Increased time frequency
- AMMA database
  additional data (not in real-time) + high vertical resolution
- RH bias correction
  implemented at ECMWF
  (Agusti-Panareda et al, 2008)
- Impact studies
  - with various sets of data
  - with and without RH bias correction



Number of Radiosonde on the GTS in **2006** and **2005**

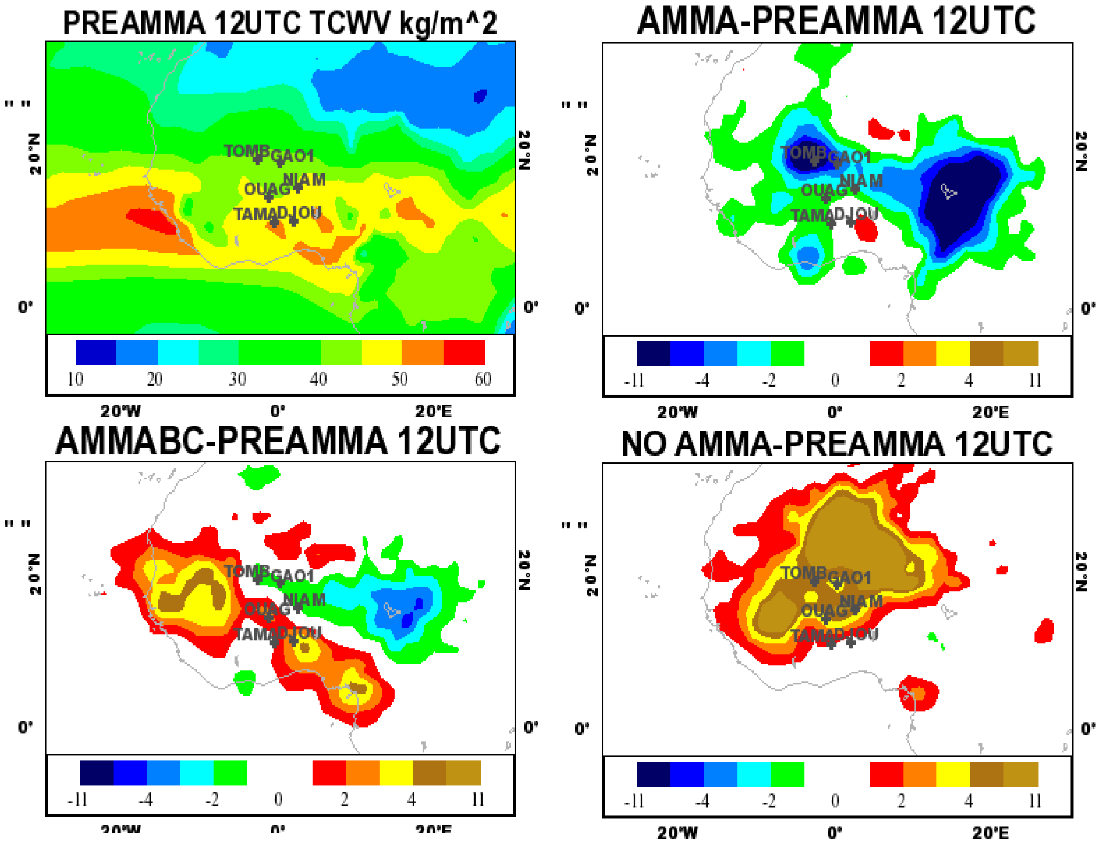
Period : 15 July - 15 September, 00 and 12 UTC

METEO FRANCE
Toujours un temps d'avance

AMMA experiments

Experiment	Description	RH Bias correction
CNTR	GTS data in 2006	No
AMMA	GTS data in 2006 + additional AMMA radiosondes	No
AMMABC	GTS data in 2006 + additional AMMA radiosondes	Yes
PRE AMMA	GTS data in 2005	No
NO AMMA	No AMMA radiosondes	No

Impact on the TCWV



45-day averaged **total column water vapour** at 12UTC for PREAMMA (top left), and the differences AMMA-PREAMMA (top right), AMMABC-PREAMMA (bottom left), and NO AMMA-PREAMMA (bottom right).
The averaging period is from August 1st to September 14th, 2006.
Locations of GPS measurements are indicated in the figure with the first letters of the names of the stations.

METEO FRANCE
Toujours un temps d'avance

Validation of the TCWV analysis against the GPS data of Tombouctou

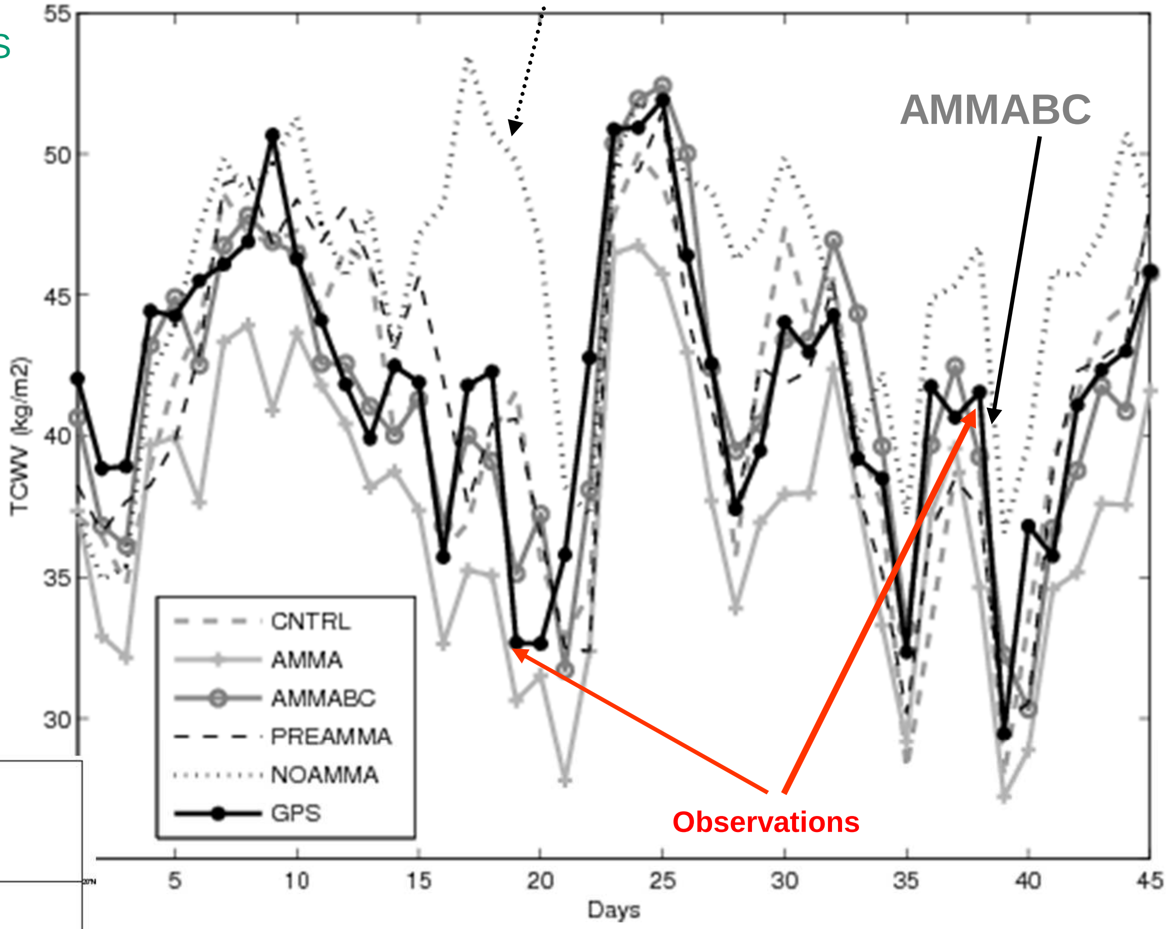
CNTR : available data in 2006 on the GTS

AMMA : available data in the AMMA database

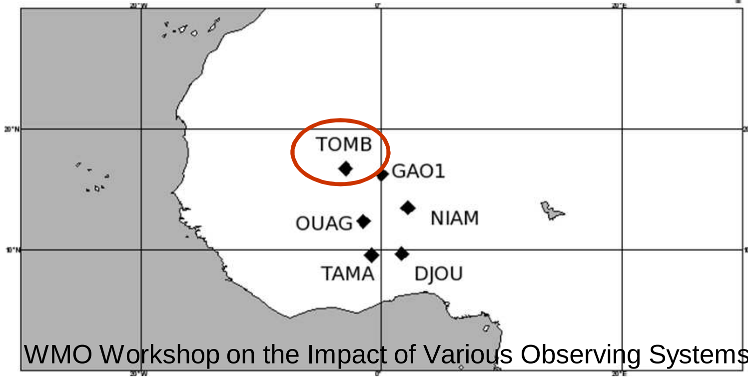
AMMABC : AMMA with the ECMWF humidity bias correction

PreAMMA : with the 2005 network

No AMMA : No radiosonde in the area



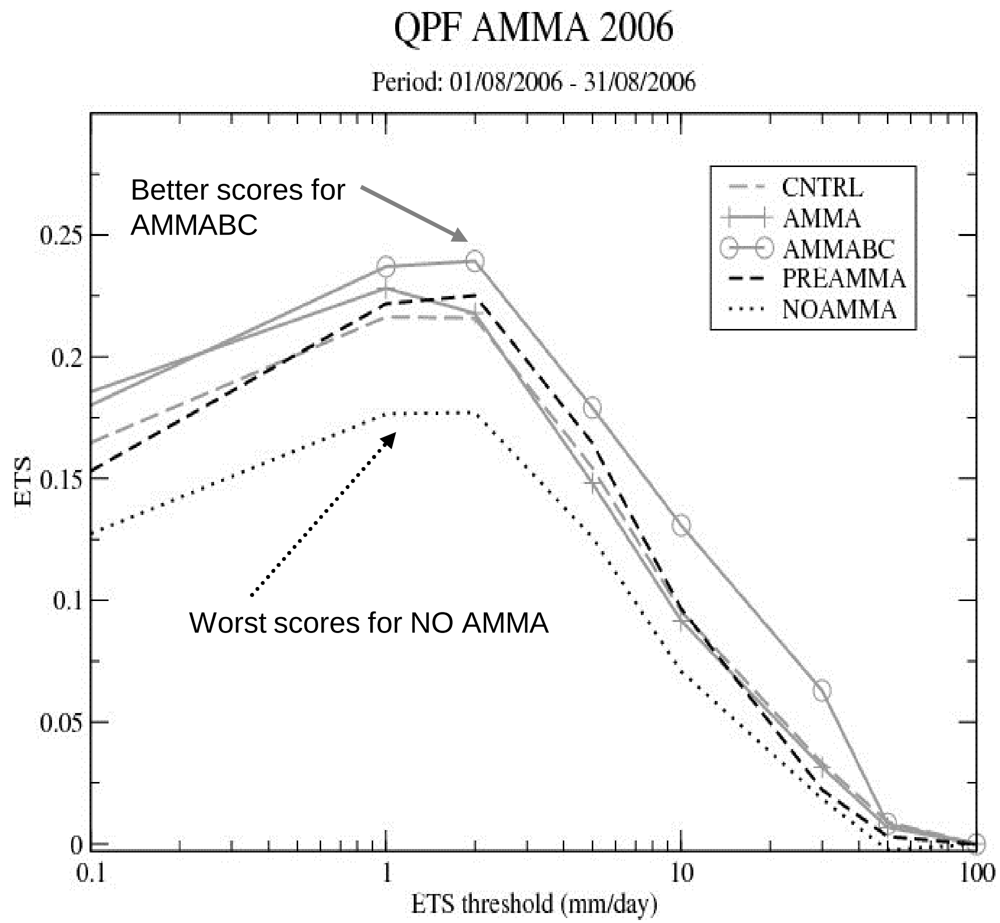
Validation of the TCWV : comparison with Tombouctou GPS data. Daily averages of analyses and GPS observations at Tombouctou from August 1st to September 14th, 2006.



Very bad performance of NOAMMA

Best performance for AMMABC

Impact in the forecast

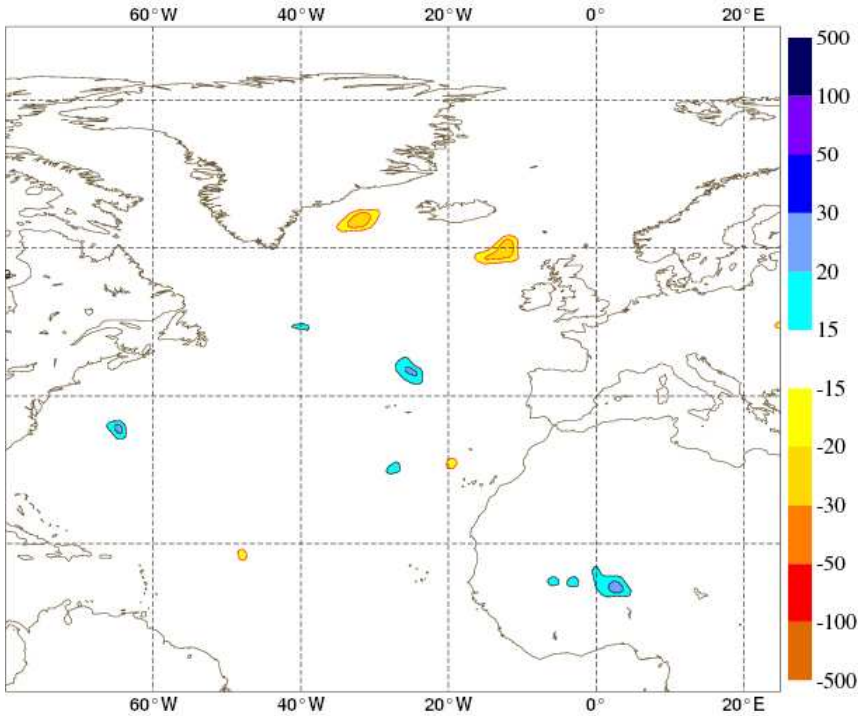


Impact on the quantitative precipitation forecast : Equitable Threat Score (ETS), averaged over August 2006 for various assimilation experiments. The verification is provided by the NOAA CPC FEWS-NET based on satellite and rain gauge data.

METEO FRANCE
Toujours un temps d'avance

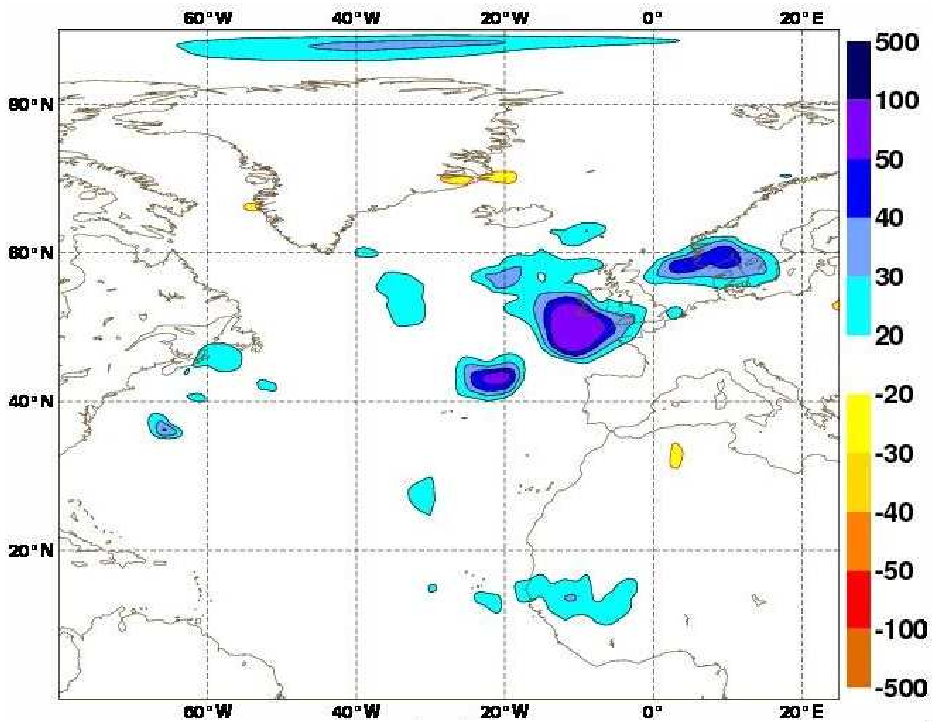
Impact of the AMMA radiosondes on the global forecast

Differences in RMS errors between the AMMABC and PREAMMA forecasts.
The errors are computed with respect to the ECMWF analysis, for the geopotential at 500 hPa at the 24h, 48h and 72h range, over the period 1 August - 14 September 2006.

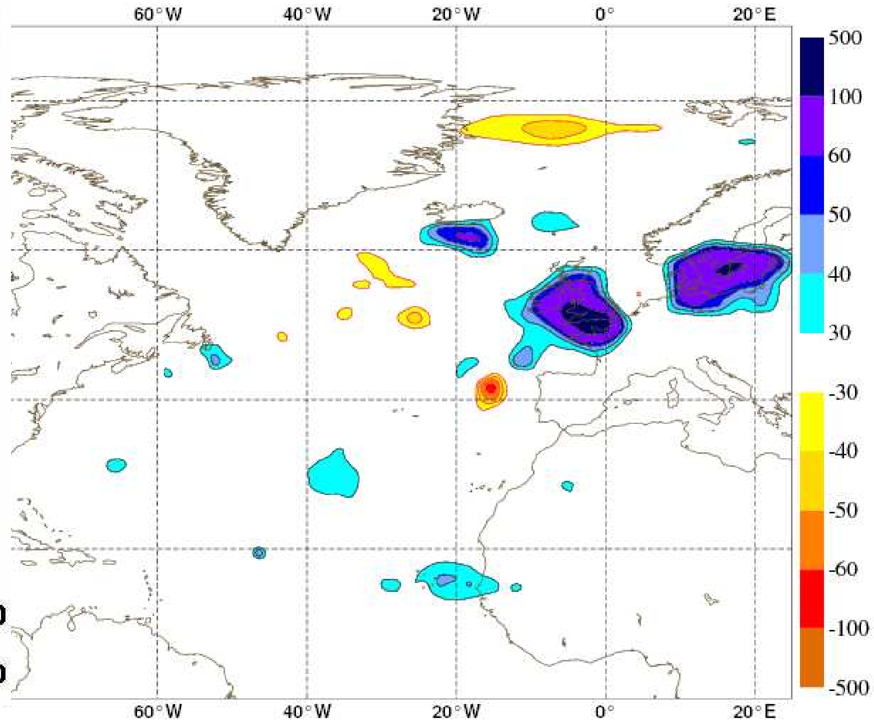


Impact of the AMMA radiosondes on the global forecast

48 hours



72 hours



METEO FRANCE
Toujours un temps d'avance

Conclusion

• The radiosonde relative humidity bias correction in the AMMA region is very beneficial.

• Significant impact of the additional AMMA radiosondes on the humidity analysis, on the wind field and on the precipitation over Africa.

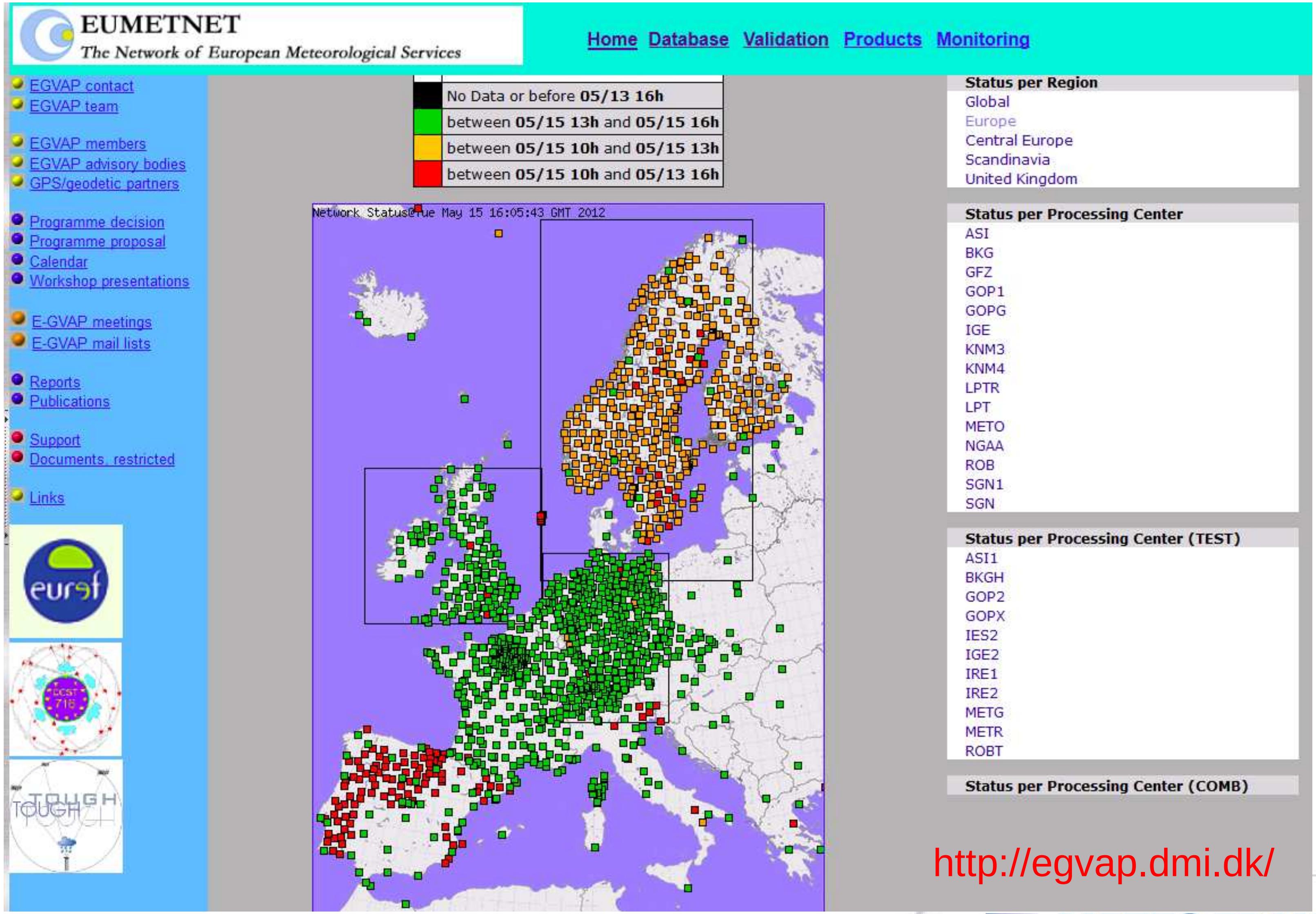
• Downstream positive impact of the AMMA radiosondes over Europe.

• More results of this AMMA RS impact study in the paper **Faccani et al (2009**), in Weather and Forecasting, AMMA special issue. Bias correction is described in the paper Agusti-Panareda et al., QJRMS (2009)

A few words about ground-based GNSS data

METEO FRANCE
Toujours un temps d'avance

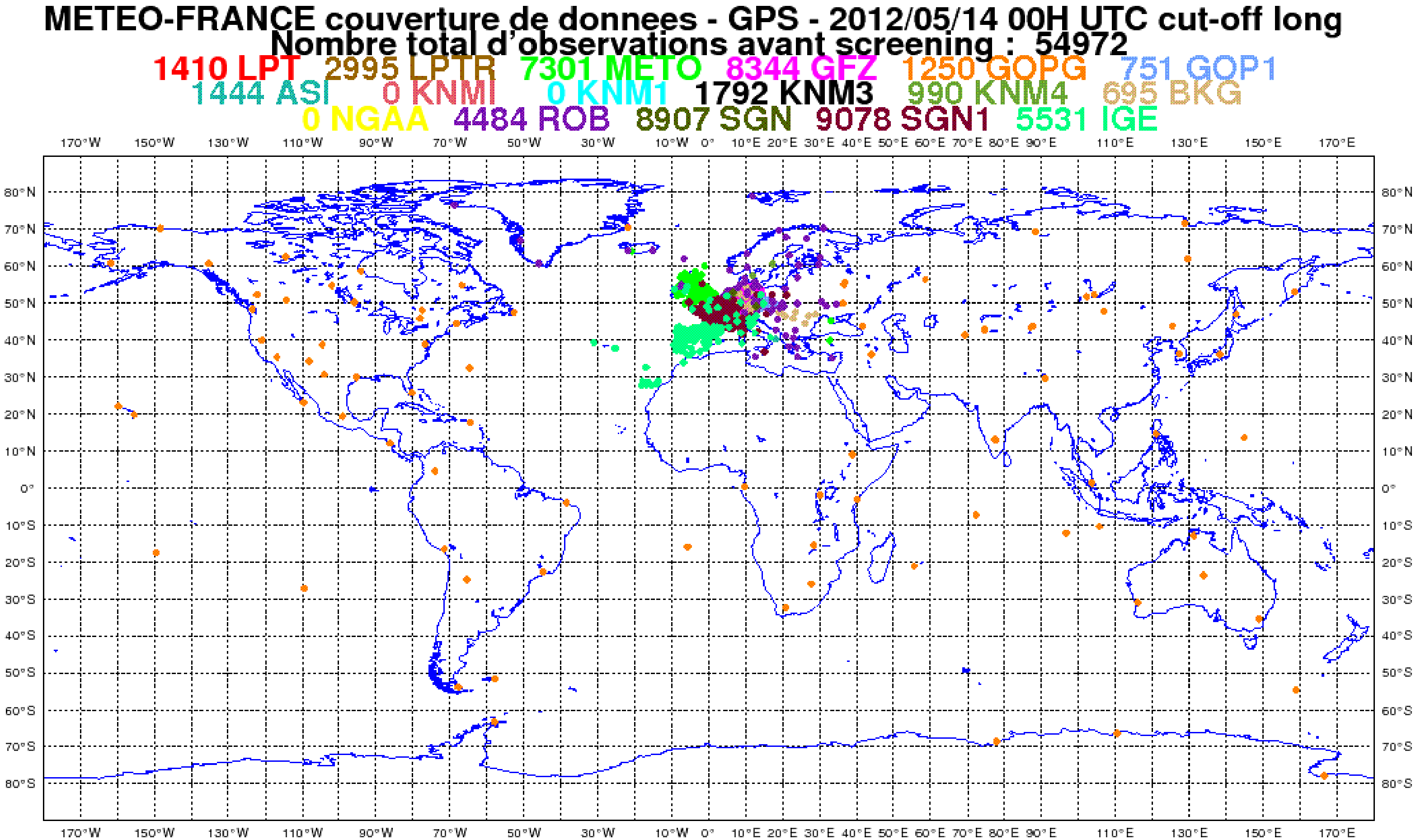
GNSS data (EGVAP)



http://egvap.dmi.dk/

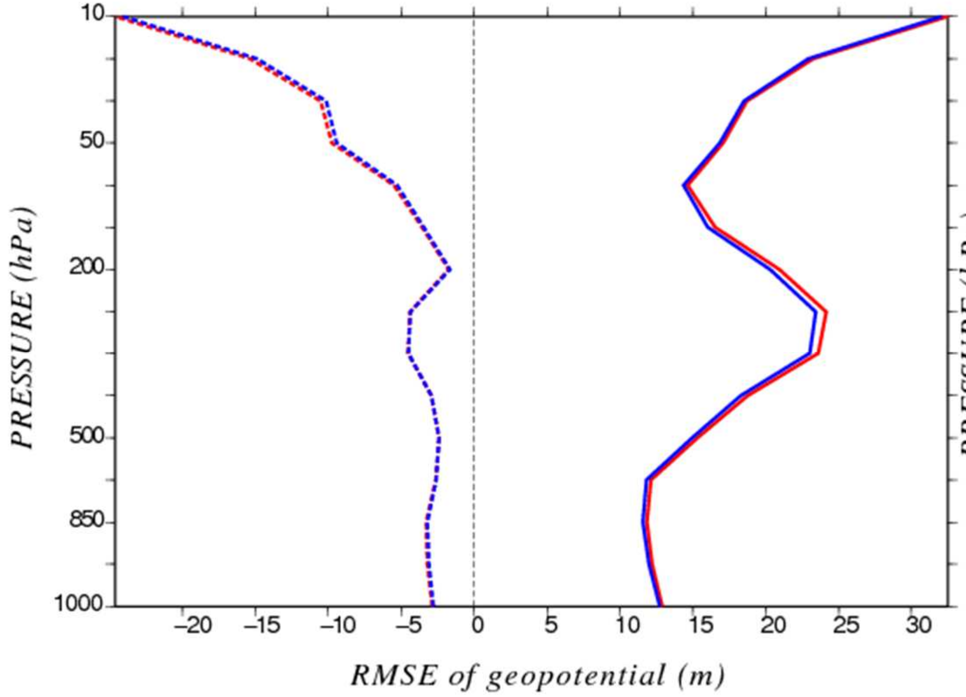
METEO FRANCE
Toujours un temps d'avance

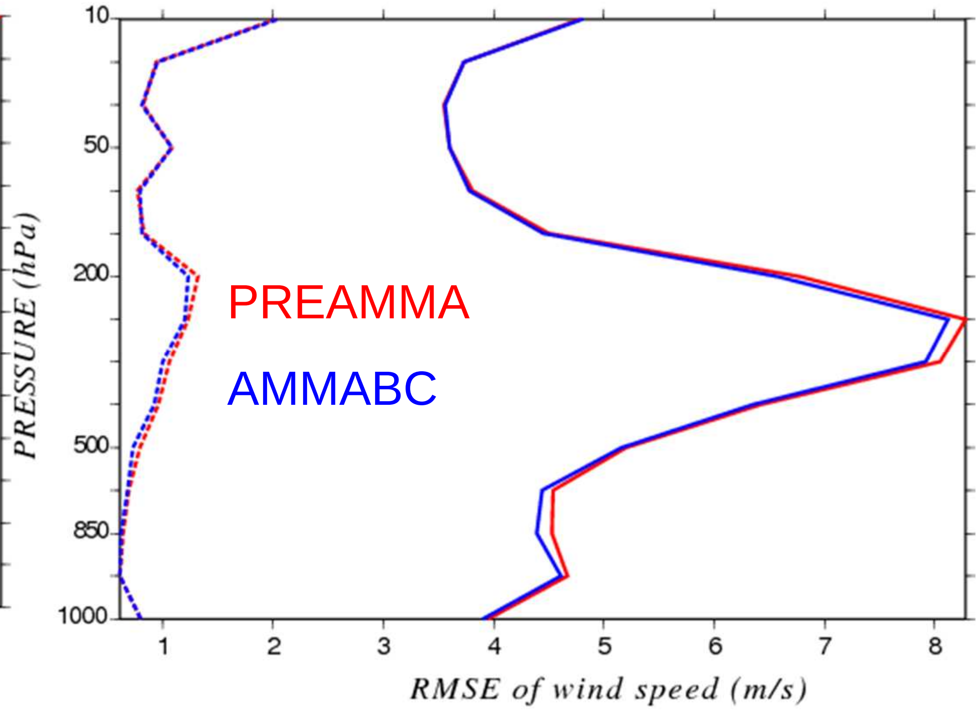
GNSS data available for the ARPEGE global model



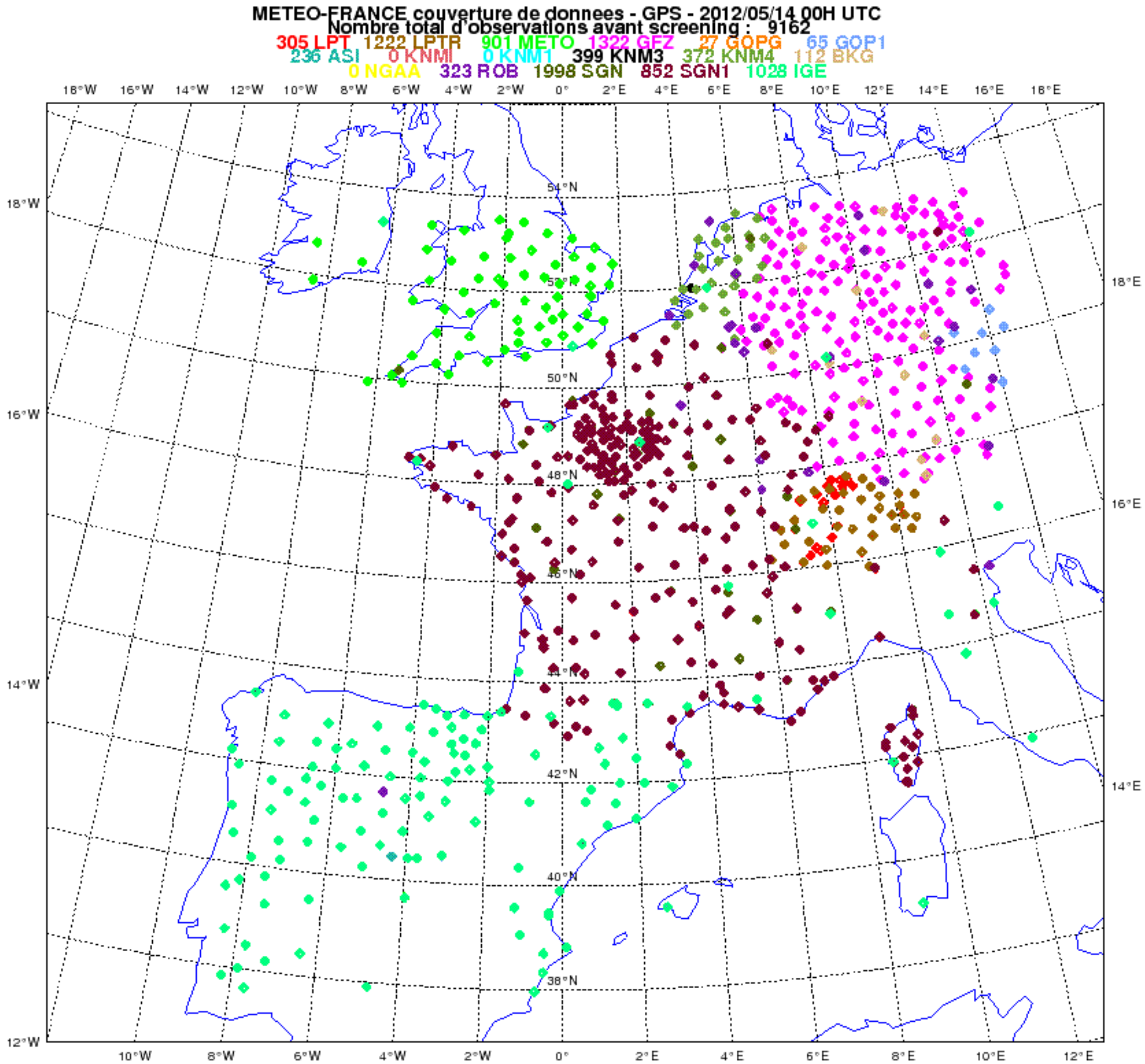
METEO FRANCE
Toujours un temps d'avance

Impact of the AMMA RS on the global forecast



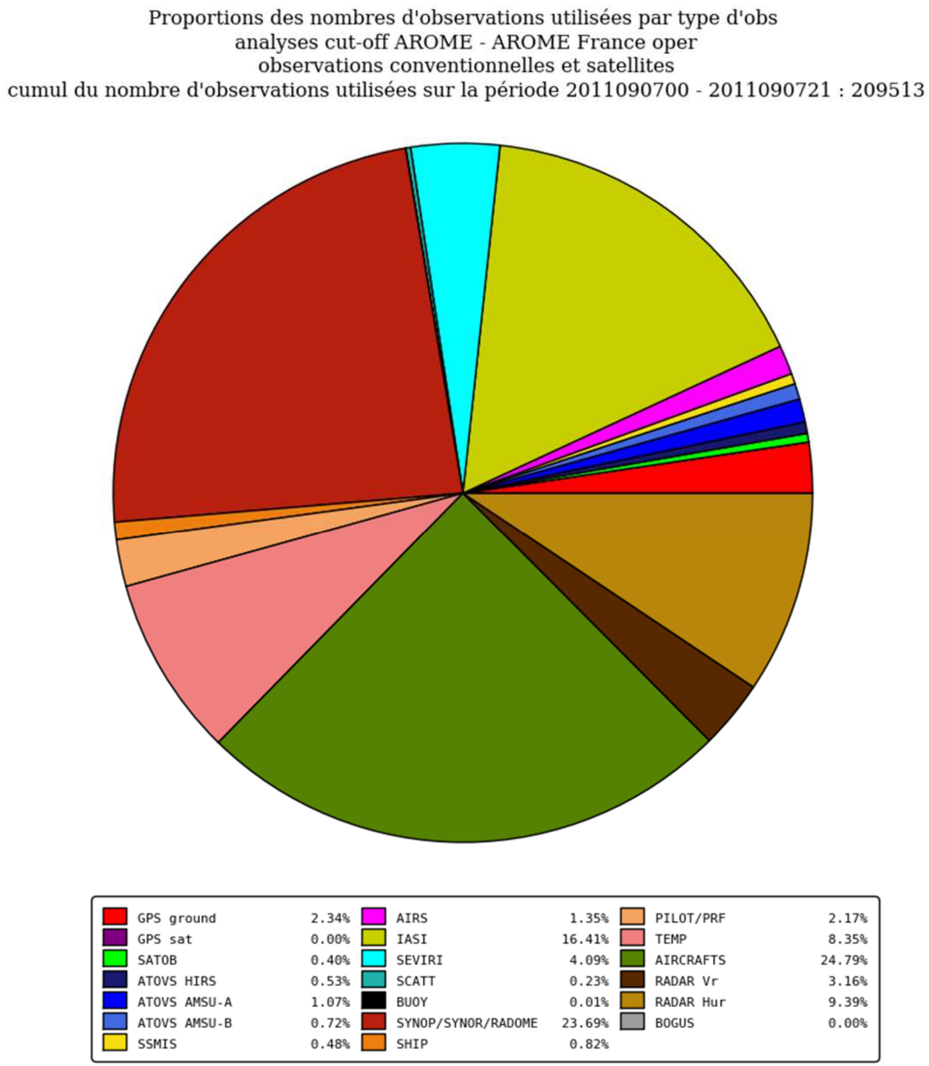


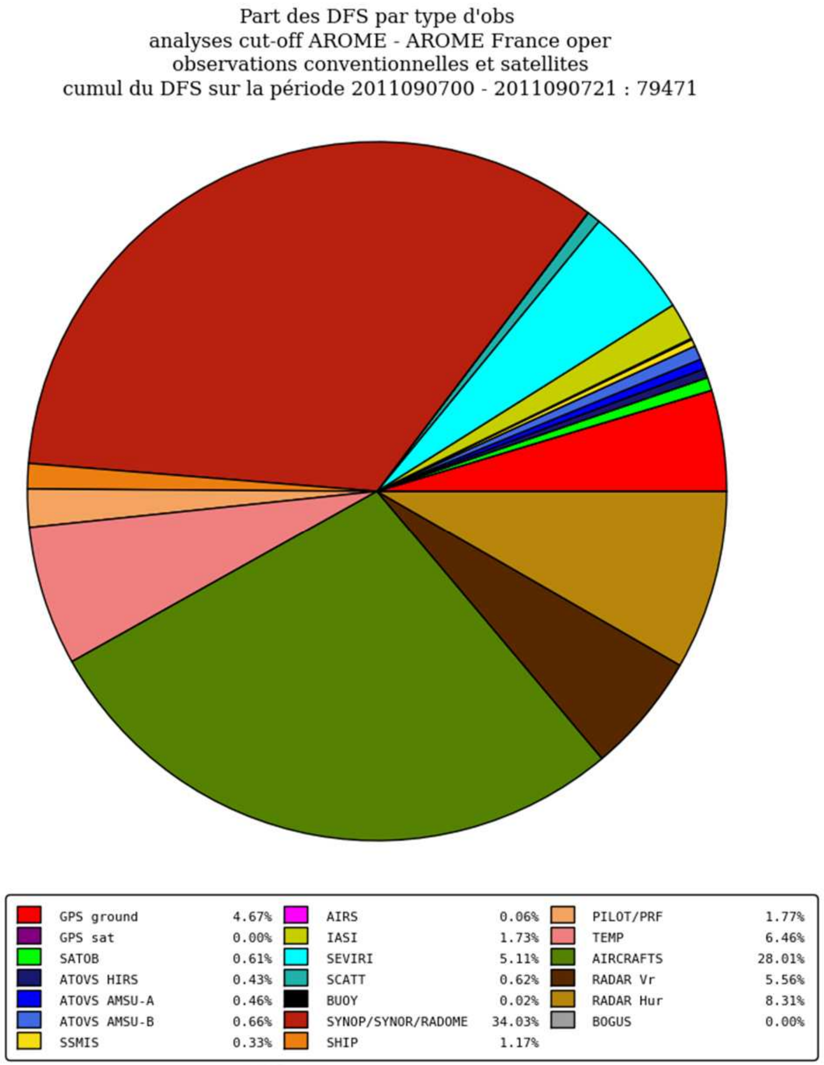
GNSS data available for the AROME mesoscale model



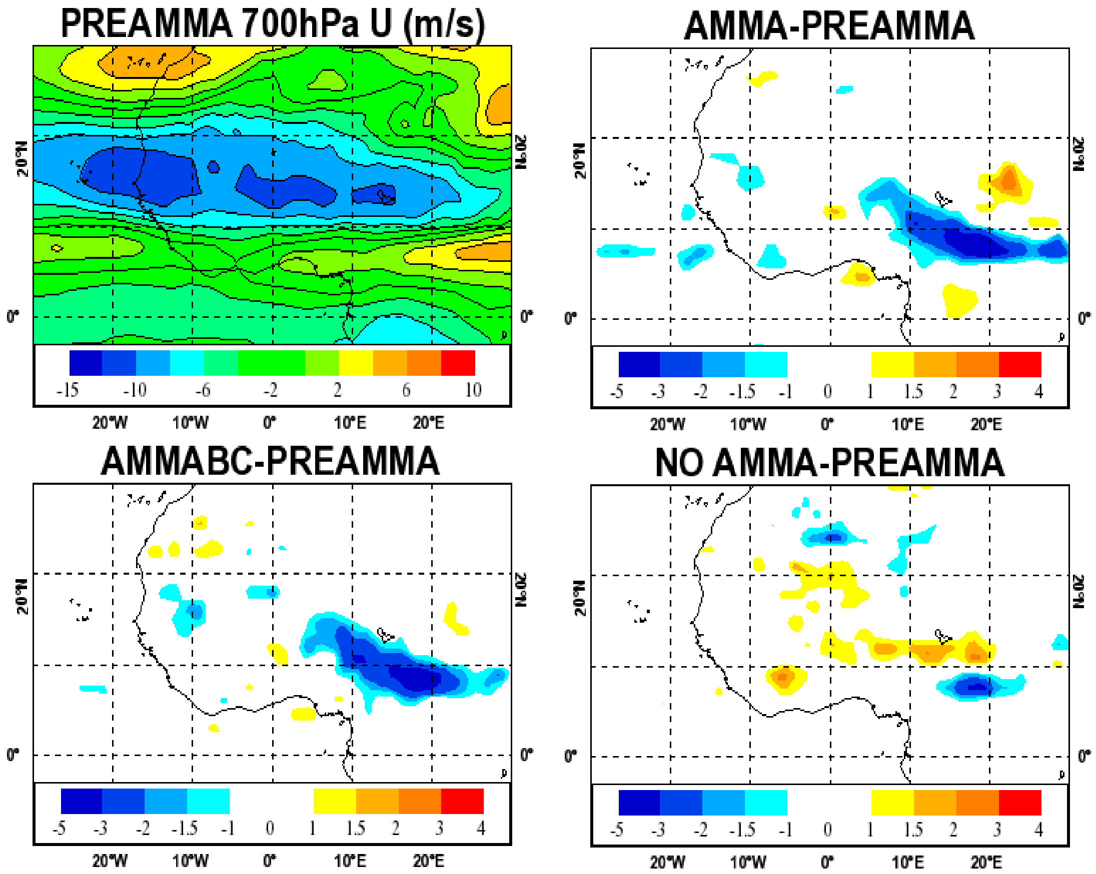
METEO FRANCE
Toujours un temps d'avance

DFS in AROME mesoscale model





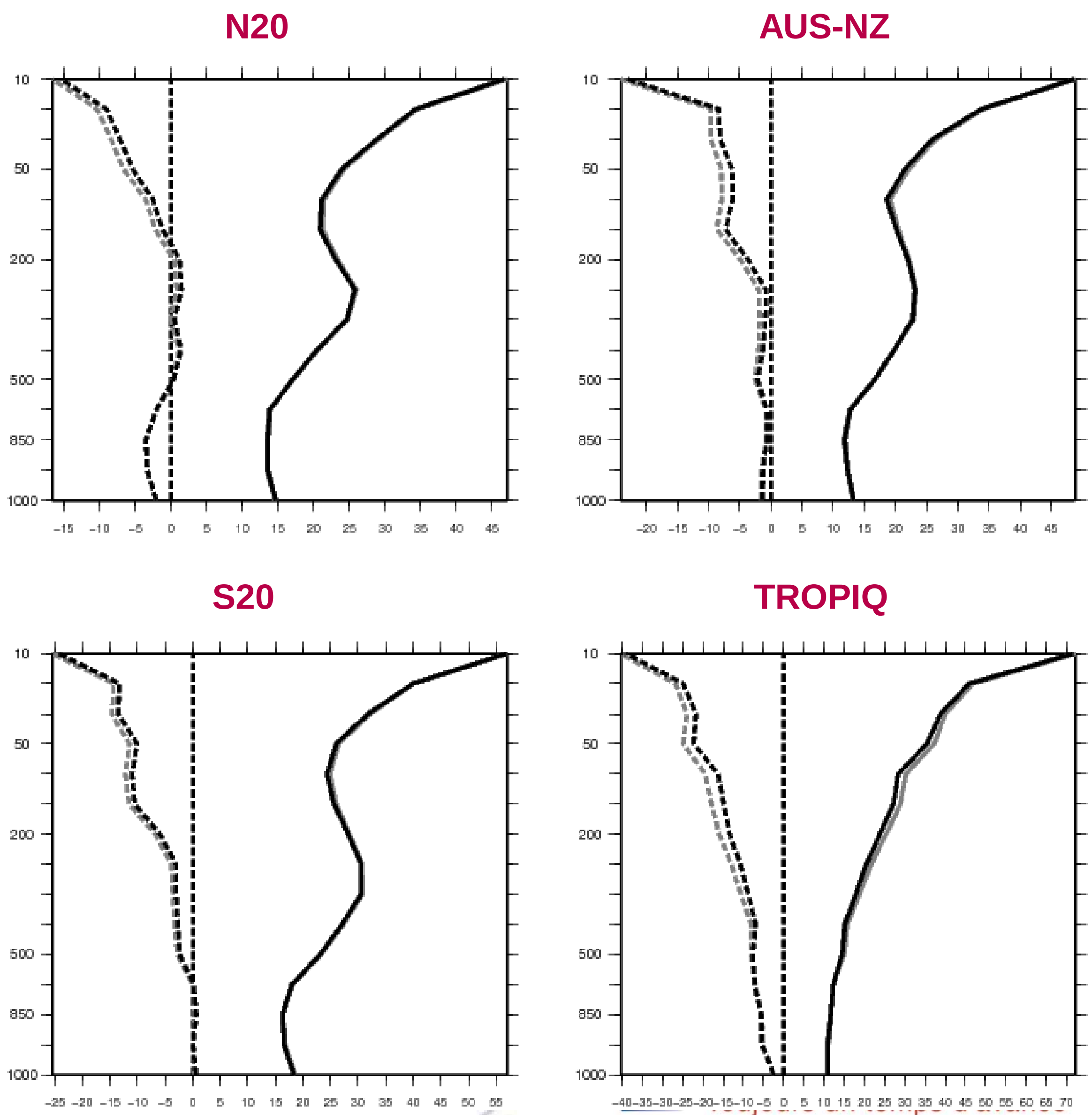
Impact on the wind



700hPa **zonal wind** (m/s) averaged over the period 1 August - 14 September, at 12UTC for PREAMMA (top left), and the differences AMMA-PREAMMA (top right), AMMABC-PREAMMA (bottom left), and NO AMMA-PREAMMA (bottom right).

Assimilation experiments
Forecast scores

Scores geopotential height / Radiosondes, 48h

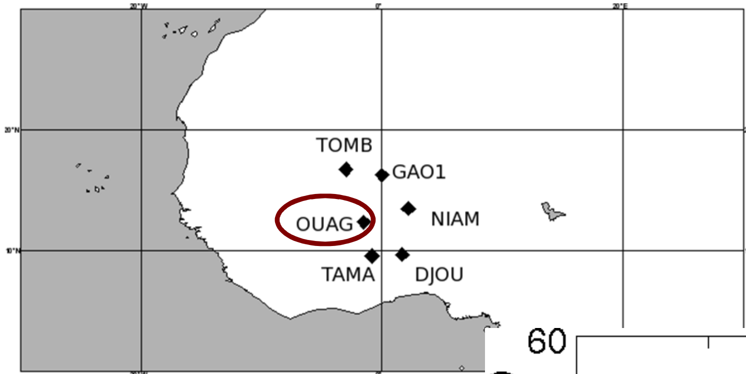


CTL --- BIAS
__ RMSE

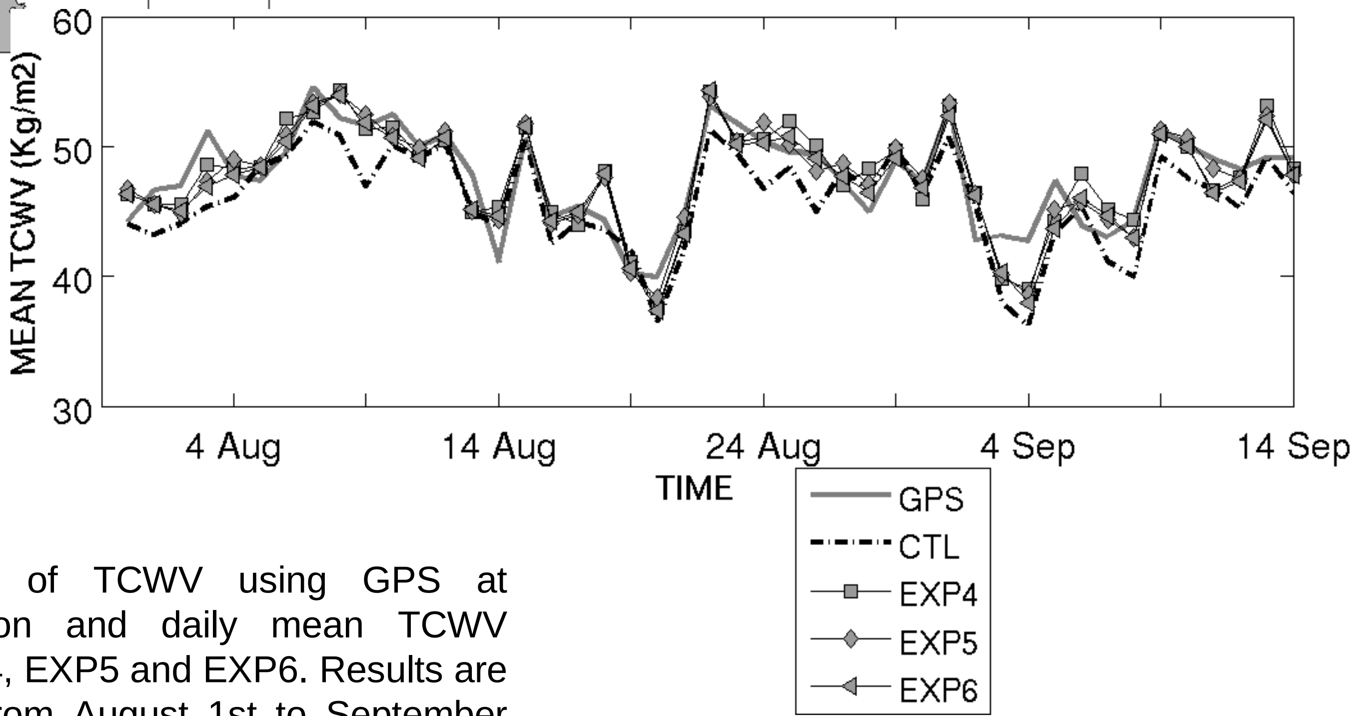
EXP --- BIAS
__RMSE

Root Mean Square Error (RMSE) (solid lines) and mean bias (dashed lines) for geopotential differences between 48h forecast of CTL (in grey) and EXP6 (in black), the radiosonde being the target observations. Results are given for the Northern Hemisphere, Australia/New Zealand, the Soutern Hemisphere and for the Tropics

Assimilation experiments
Impact on humidity analysis



TCWV Daily time series at OUAG



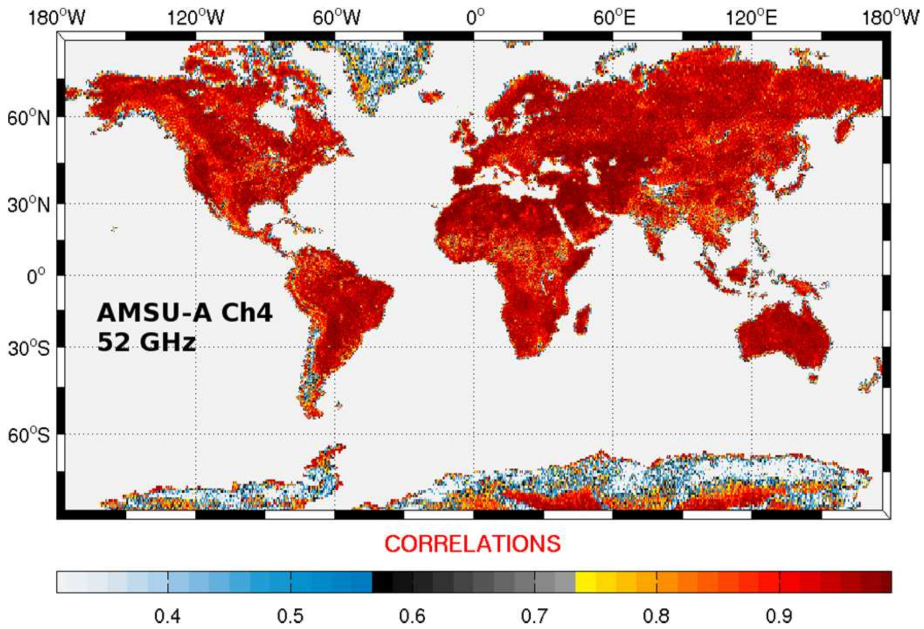
Daily mean estimates of TCWV using GPS at OUAGADOUGOU station and daily mean TCWV analysis from CTL, EXP4, EXP5 and EXP6. Results are for a 45 days period (from August 1st to September 14th, including all synoptic times)

Dynamical land surface emissivity

« dynamical land emissivity parameterization » operational since July 2008 (Karbou et al. 2006)

Correlations between Obs and RTTOV Sim., AMSU-A ch4, August 2006

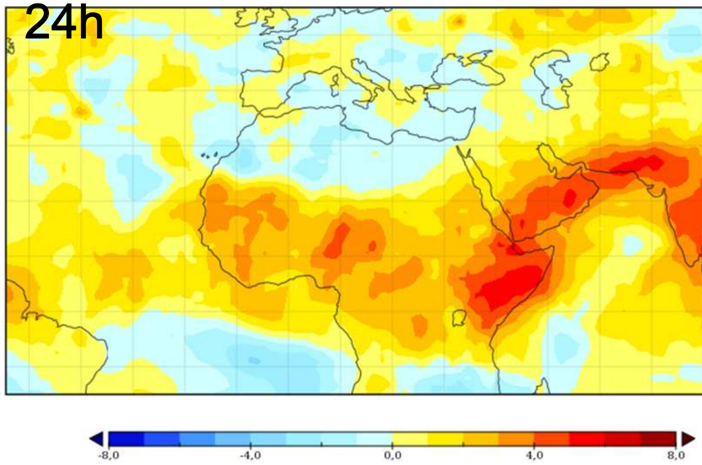
CTL



METEO FRANCE
Toujours un temps d'avance

Assimilation experiments
Forecast scores

Differences of geopotential forecast errors with respect to ECMWF analyses (CTL-EXP), 200hPa, 1month

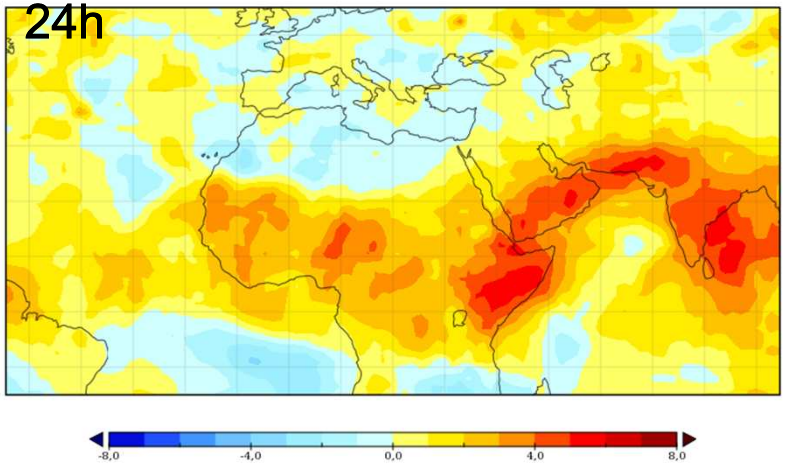


Smaller errors in EXP

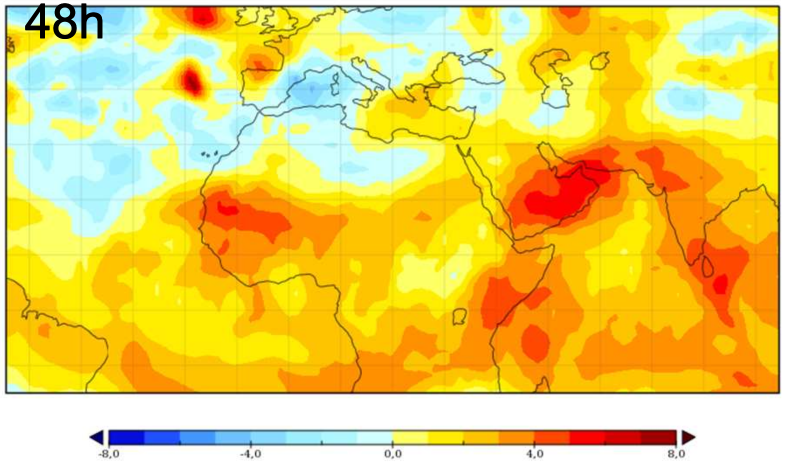
Differences in RMS error between CTL and EXP4 forecasts (CTL-EXP4) at 24h, 48h and 72h range. Errors are computed for August for geopotential height at 200hPa with respect to ECMWF analyses.

Assimilation experiments
Forecast scores

Differences of geopotential forecast errors with respect to ECMWF analyses (CTL-EXP), 200hPa, 1month



Smaller errors in EXP

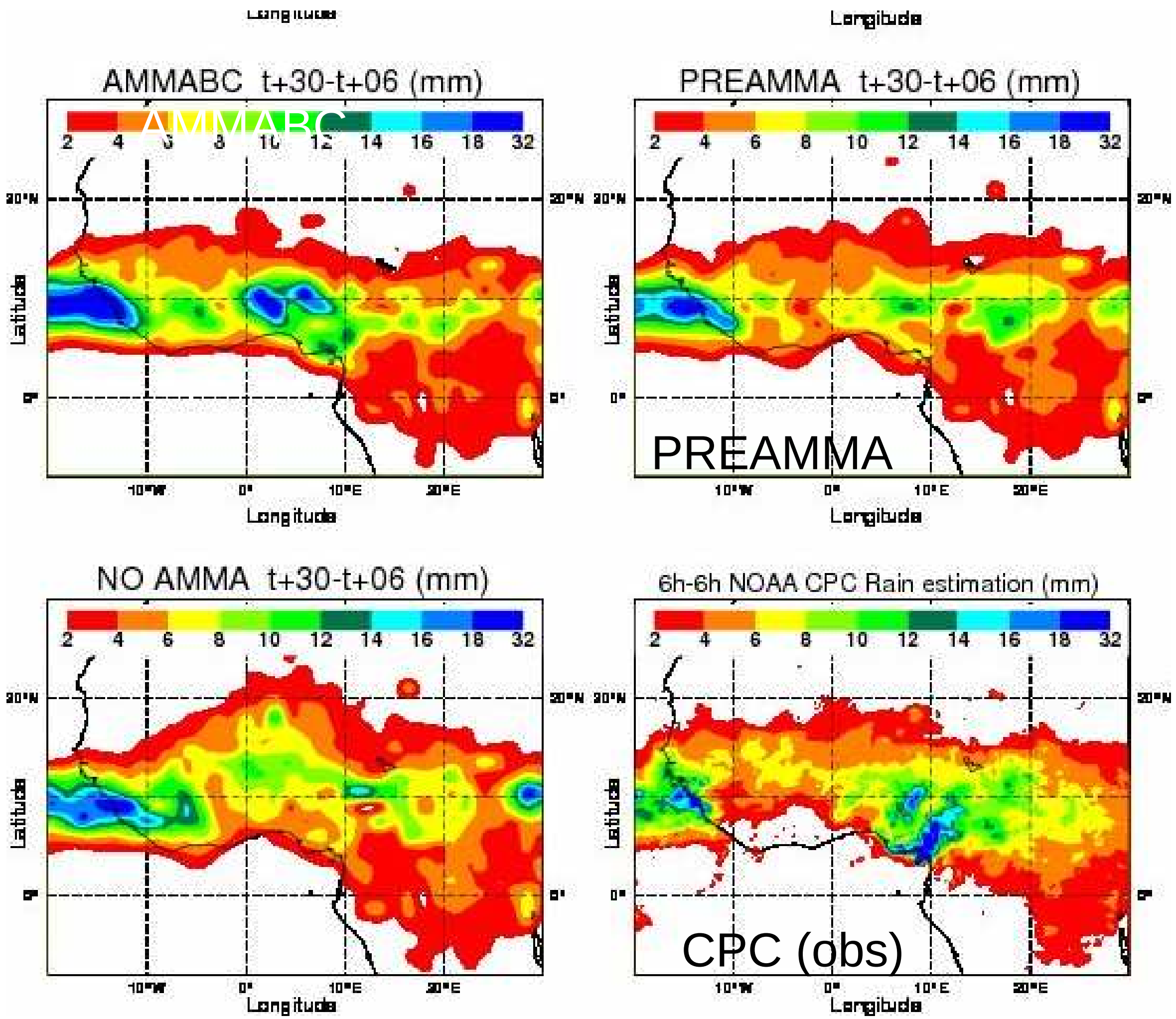


Smaller errors in EXP

METEO FRANCE
Toujours un temps d'avance

Impact on the monthly rainfalls over Africa
August 2006

24h cumulated rainfalls from 6h to 30h range



Bad quality of NO AMMA

Best performance for AMMA BC

Same kind of results
at ECMWF

Better monthly rainfalls
with bias correction

METEO FRANCE
Toujours un temps d'avance