Evolution in DA suites at MF: Arpège and Arome-France

C. Fischer, on behalf of many GMAP colleagues

cnrs
dépasser les frontières

METEO FRANCE
Toujours un temps d'avance

Context

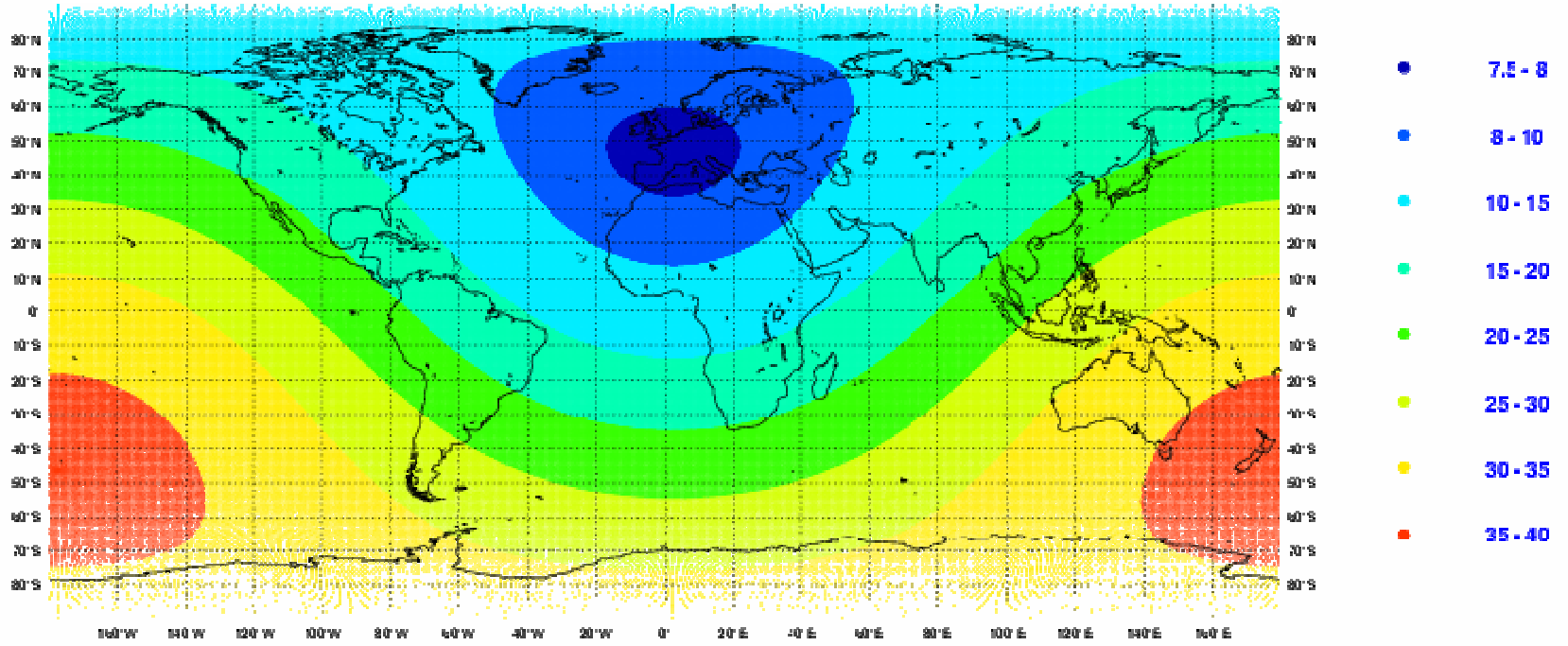
HPC resources: BULL Phase1 cluster x10 in CPU (since April 2014); next upgrade Phase 2 BULL (beginning of 2016)

Repartition of computing resources through MF's oper NWP applications: more CPU for km-scale NWP, in proportion w/r to global synoptic.

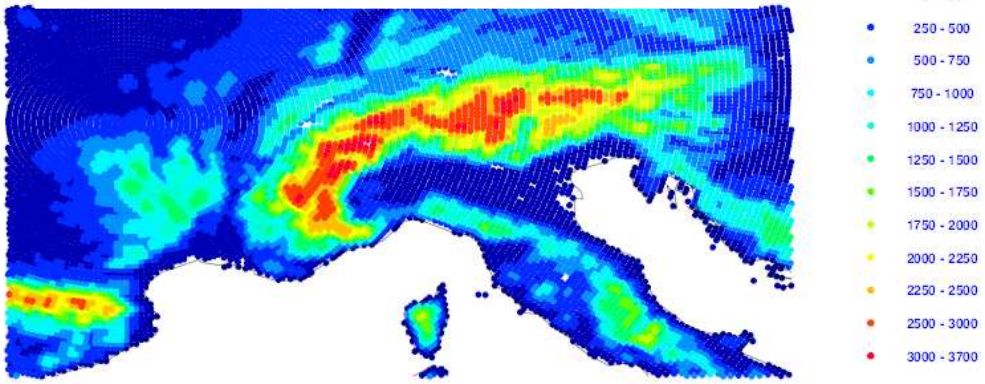
- Arome-France HR : cost x10 w/r to former NEC config
- Arpège HR : cost x5
- PEARP HR : cost x4
- New applications: Arome-PI (nowcasting), Arome-PE (km-scale EPS), Arome-OM (Overseas HR forecasts)

Increased horizontal resolution

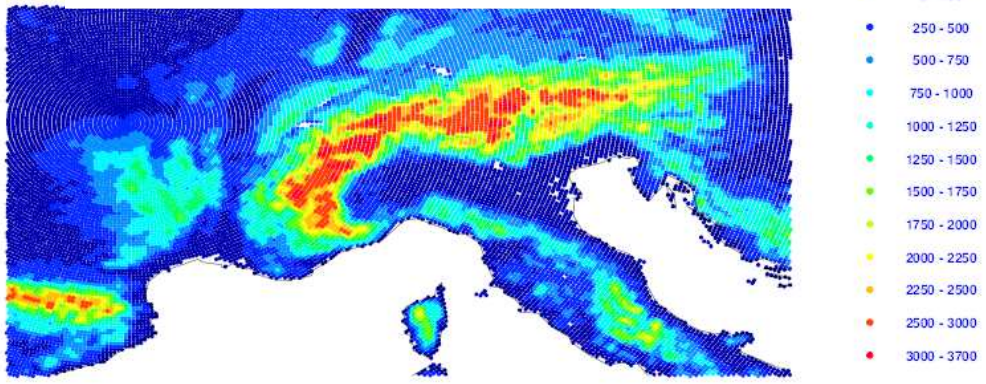
Tl1198c2.2 (~7.5km over France, ~36km at the antipodes)



T798c2.4 (oper)



T1198c2.2 (new)



Increased vertical resolution / 4D-Var settings

From 70 to 105 vertical levels:

- top level kept at 0.1hPa / lowest level at about 10m,
- quite homogeneous increase of resolution throughout the atmosphere
- identical to IFS up to 16km height
- $\Delta Z<140$m below 1.5km / $\Delta Z<320$m above 15km

	Std atm thickness (km)	Arp70	**Arp105**	IFS137
Surface boundary layer	0 - 0.15	3	**6**	6
Planetary boundary layer	0.15 - 1.5	11	**18**	18
Free troposphere	1.5 – 8.0	19	**26**	26
Tropopause	8.0 – 15.0	15	**24**	24
Stratosphere	15.0 – 50.0	19	**27**	51
Mesosphere	50.0 – 80.0+	3	**4**	12

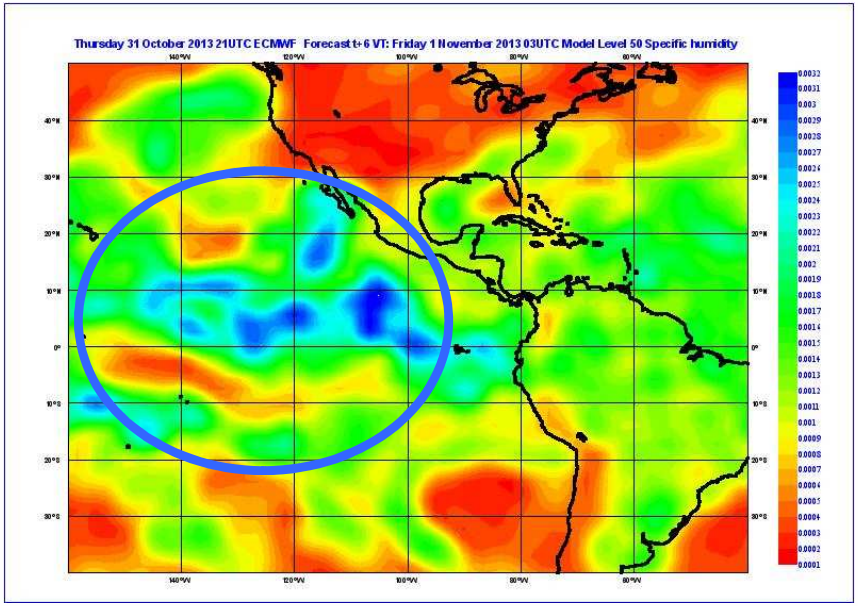
4D-VAR: two outer loops with increased resolution of the increments (new/old):

- T149c1L105 (~135km) with 40 iterations (T107c1L70 (~185km) with 25 it)
- T399c1L105 (~50km) with 40 iterations (T323c1L70 (~62km) with 30 it)

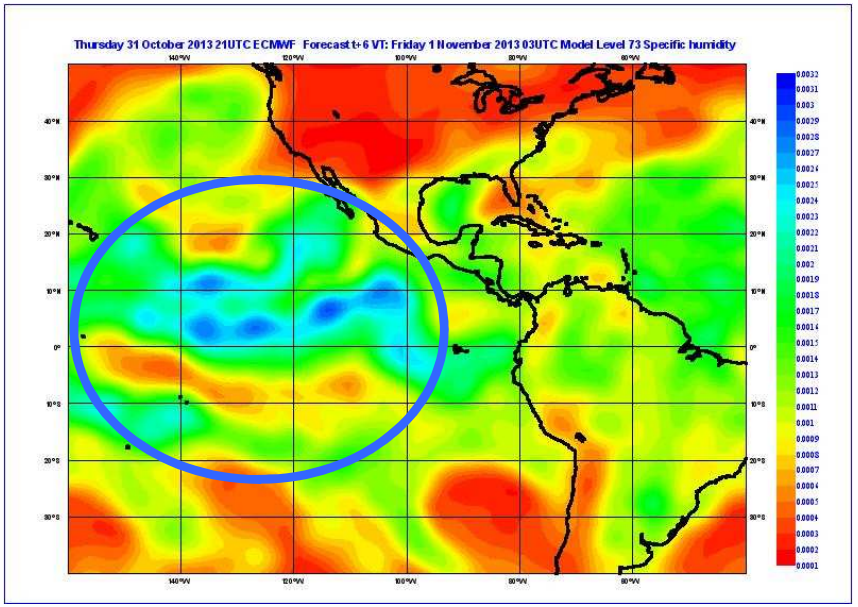
Ensemble assimilation (AEARP)

Move to 25 members (instead of 6)
Increased resolution T479 L105 (T399L70)
4D-Var with 1 minimisation T149L105 using 40 iterations (T107L70 with 25 it)
Covariances sampled over 1.5 days (instead of 4 days)

Var(q) at 700 hPa



6 members (oper)



25 members (new)

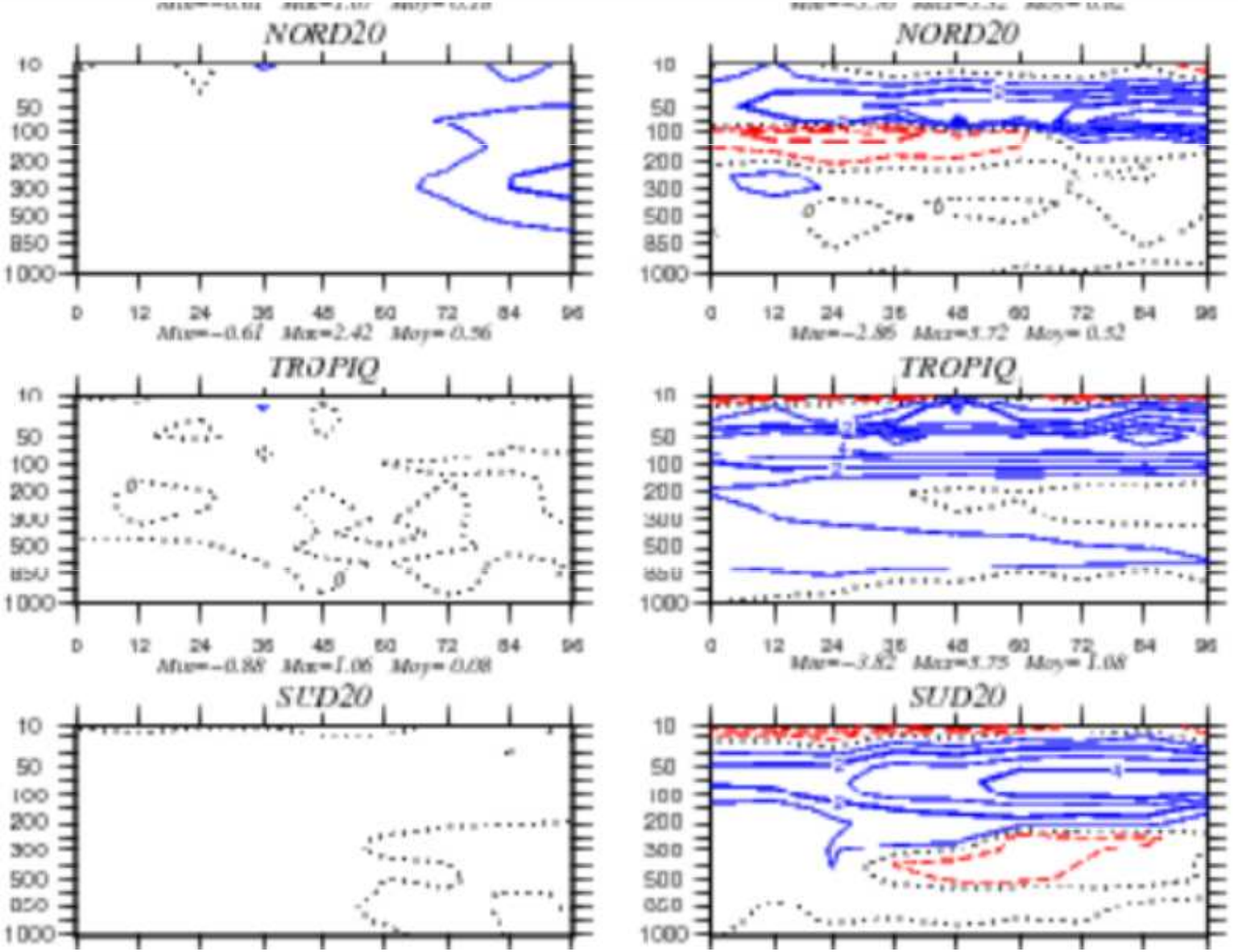
=> Better estimate of min/max values

(L. Berre, G. Desroziers)

Scores for new versus old configs AEARP/Arpège HR (all other input kept the same)

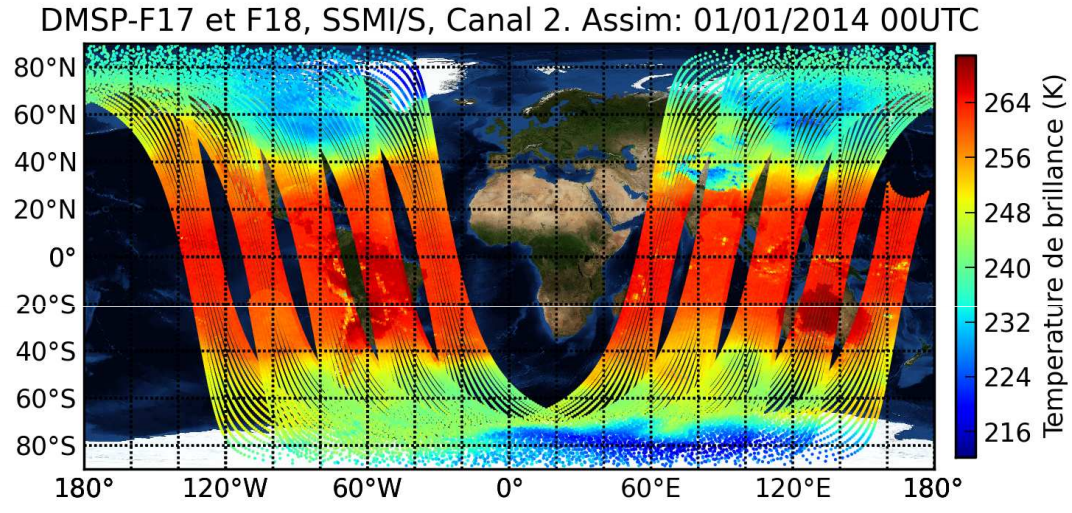
STDEV

BIAS

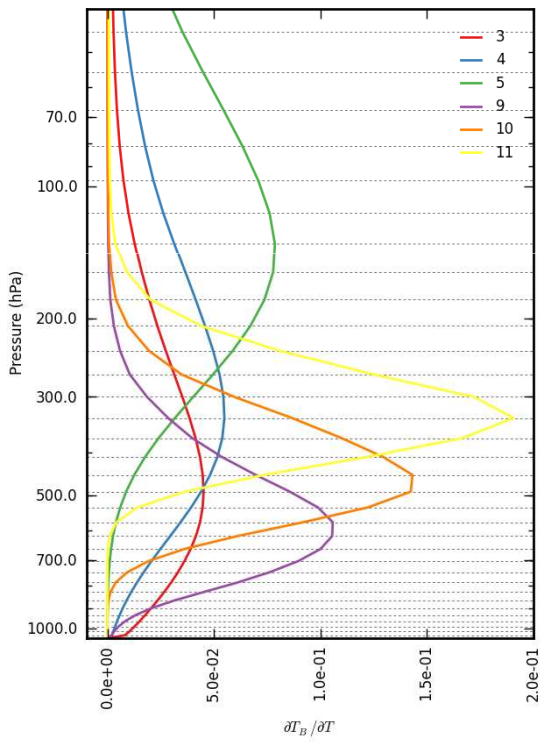


Geopotential
31/10 – 20/12
2013
w/r to RS

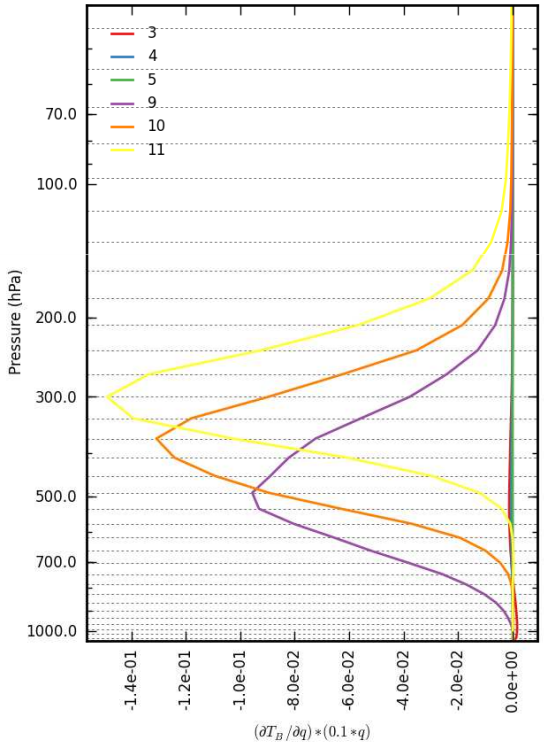
More SSMI/S assimilated (I)



Impact sur la température :



Impact sur l'humidité:



SSMI/S :
Onboard DMSP; polar heliosynchronous orbits => complementary to METOP

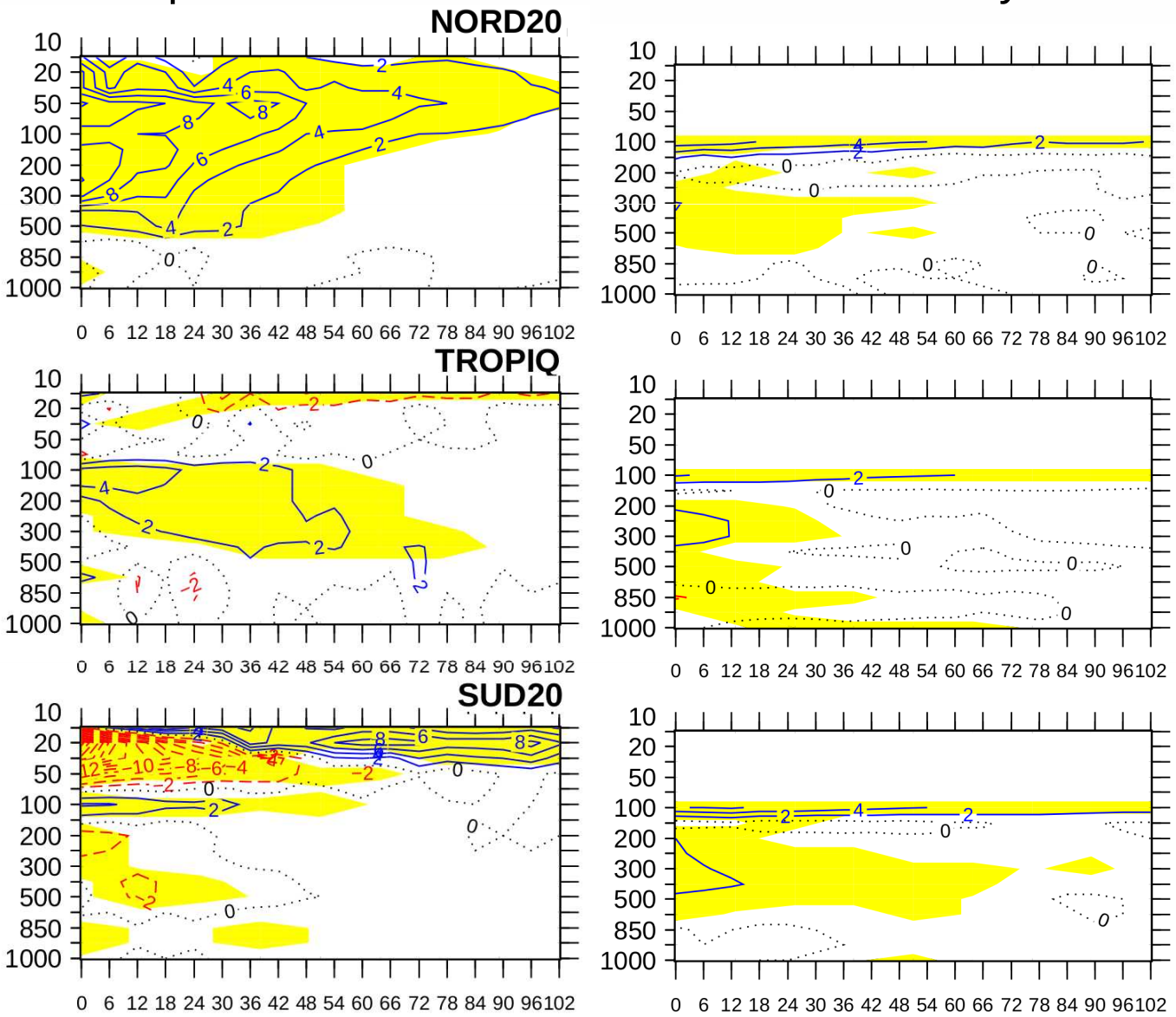
Utilisation :
Temperature and humidity sensitive channels are assimilated, only in clear-sky conditions

(L-F Meunier)

More SSMI/S assimilated (II)

Geopotential:

Relative humidity:



Impact :

Scores over 49 days

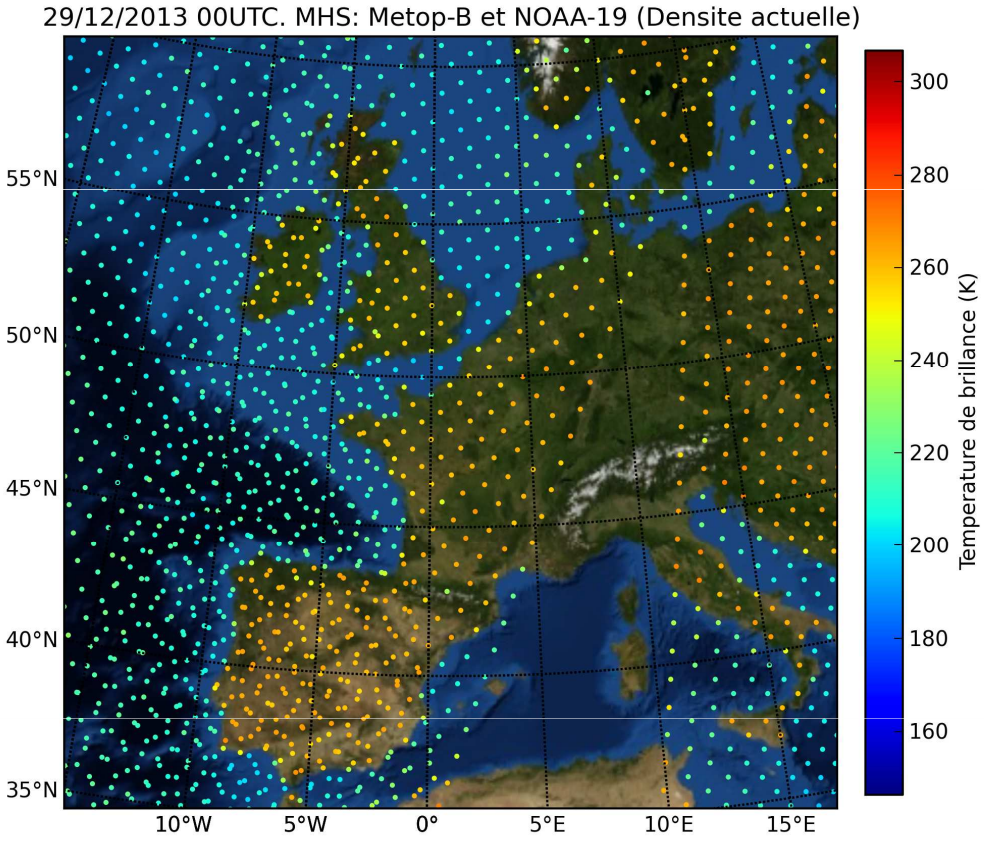
Positive for Φ and RH w/r to EC analysis

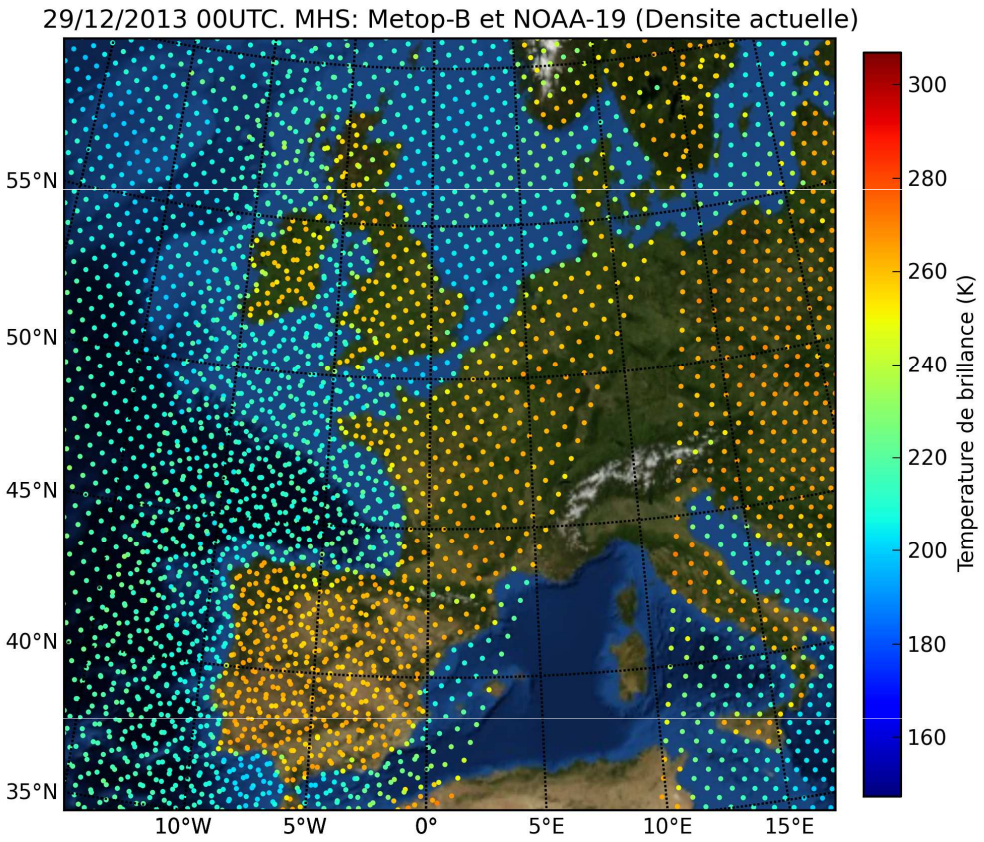
Overall neutral scores w/r to TEMP/RS

(L-F Meunier)

Density of satellite observations

Increased density at the start of screening:



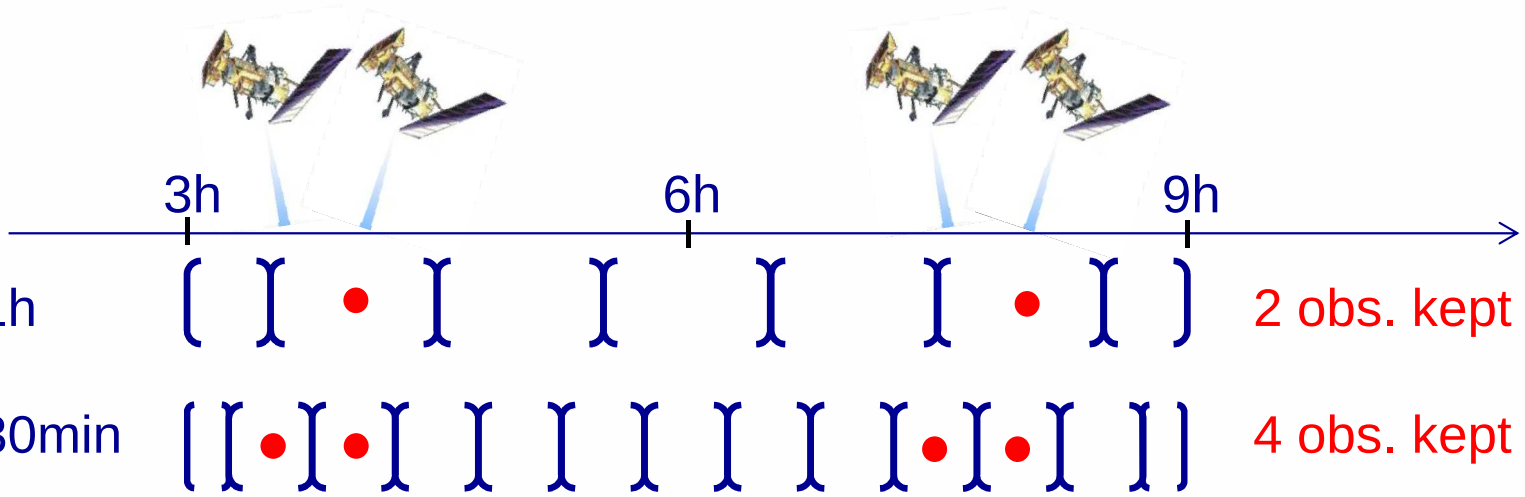


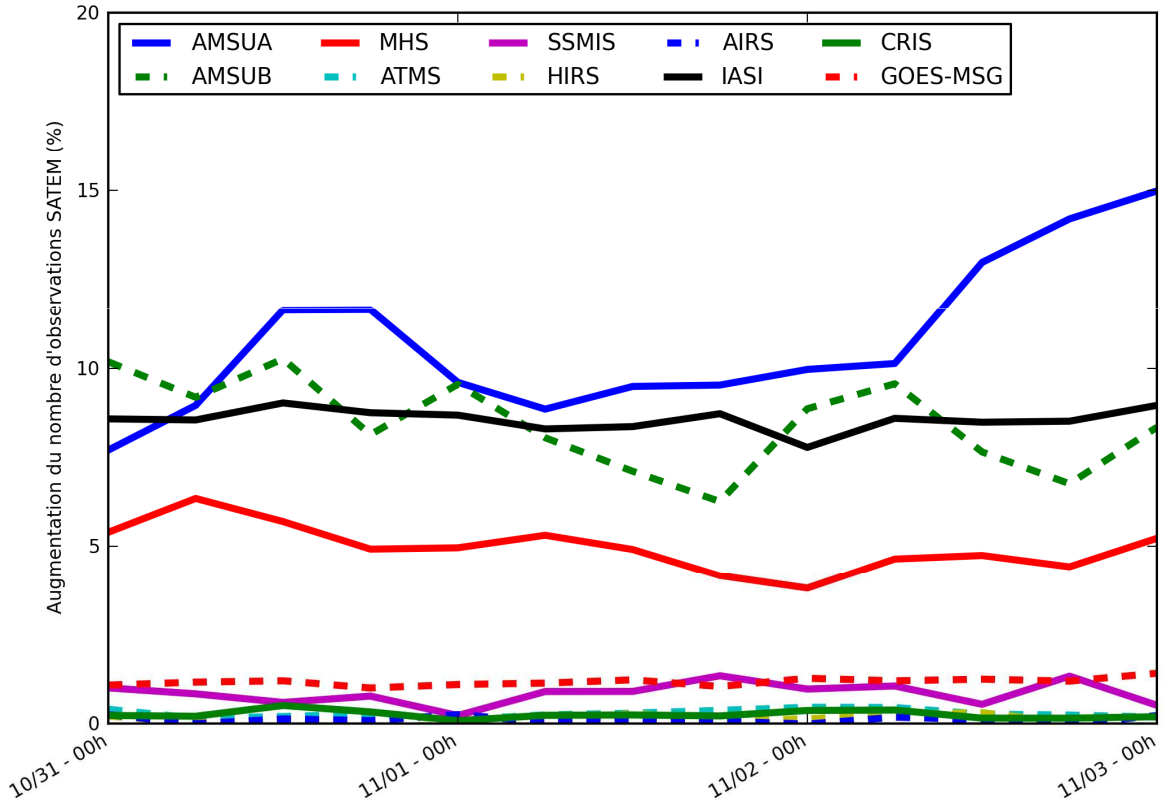
Impact :

- Doubled the number of pixels treated
- amount of assimilated radiances increased by about 10%
- scores positive especially over Southern Hemisphere

(L-F Meunier)

Move to 30’ time slots in 4D-Var





More obs kept in 4D-Var analysis:

- 80 % more GPS ZTD (GNSS)
- 8 % more IASI
- 10% more AMSU-A, AMSU-B …

(P. Chambon)

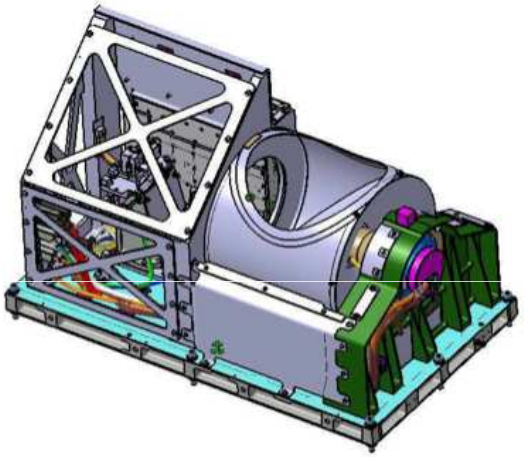
Megha-Tropiques/SAPHIR

Megha-Tropiques:

French-Indian satellite (ISRO & CNES)

Altitude: 875 km

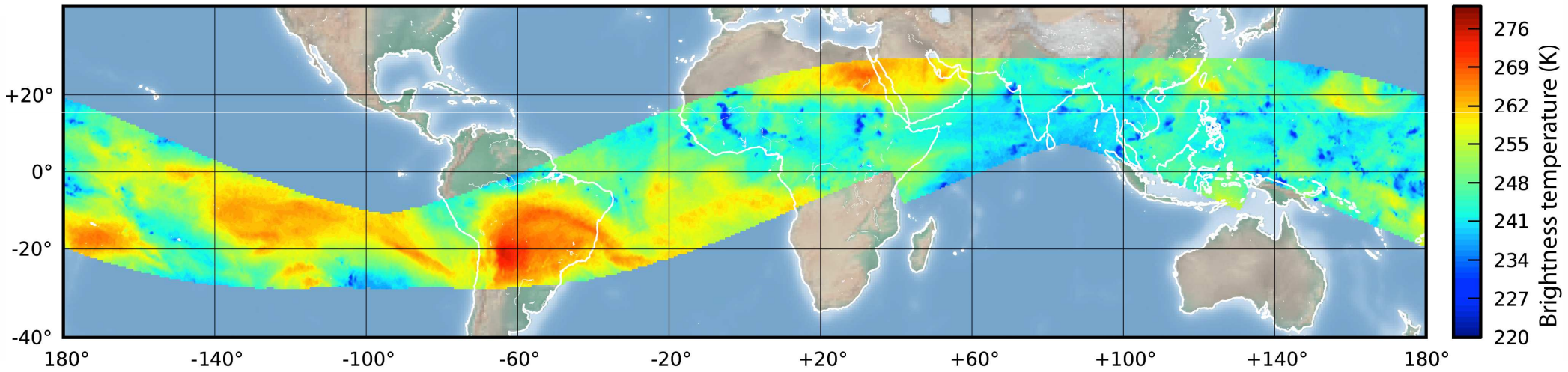
inclined orbit of about 20° leads to a rather high frequency of flights over the Tropical regions (3-5 scenes per day)



SAPHIR (Sondeur Atmosphérique du Profil d'Humidité Intertropicale par Radiométrie):

6 channels around the band of absorption of H2O at about 183.3 GHz

10 km resolution at nadir

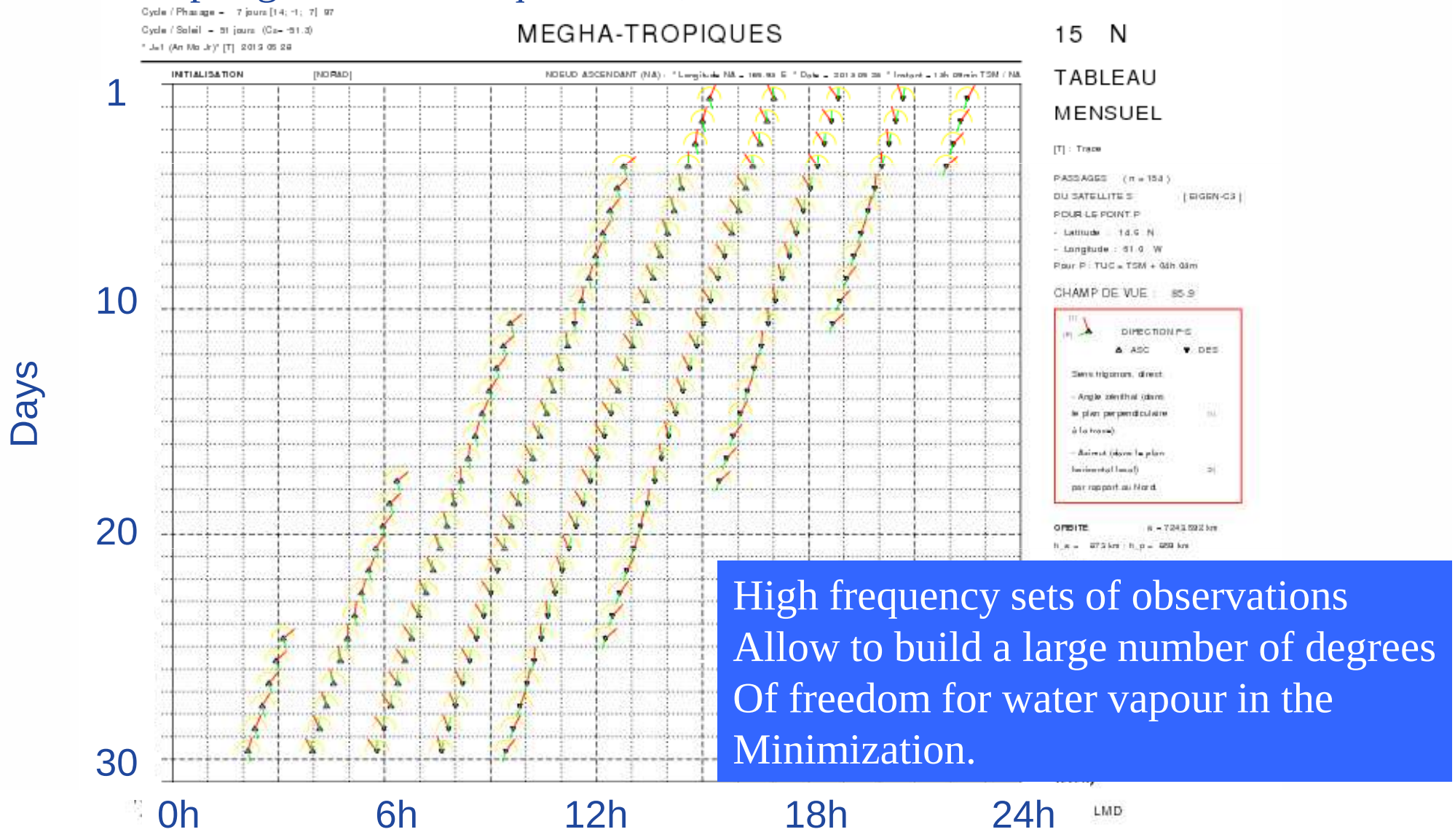


(Example of 6h coverage for 02/07/2012 00 UTC network; channel at 183.1 +/-1.1 GHz)

(P. Chambon)

The non-heliosynchronous orbit allows a high frequency sampling in the Tropical regions:

SAPHIR sampling over Martinique Island, for June 2013



High frequency sets of observations
Allow to build a large number of degrees
Of freedom for water vapour in the
Minimization.

(Source IXION
M. Capderou)

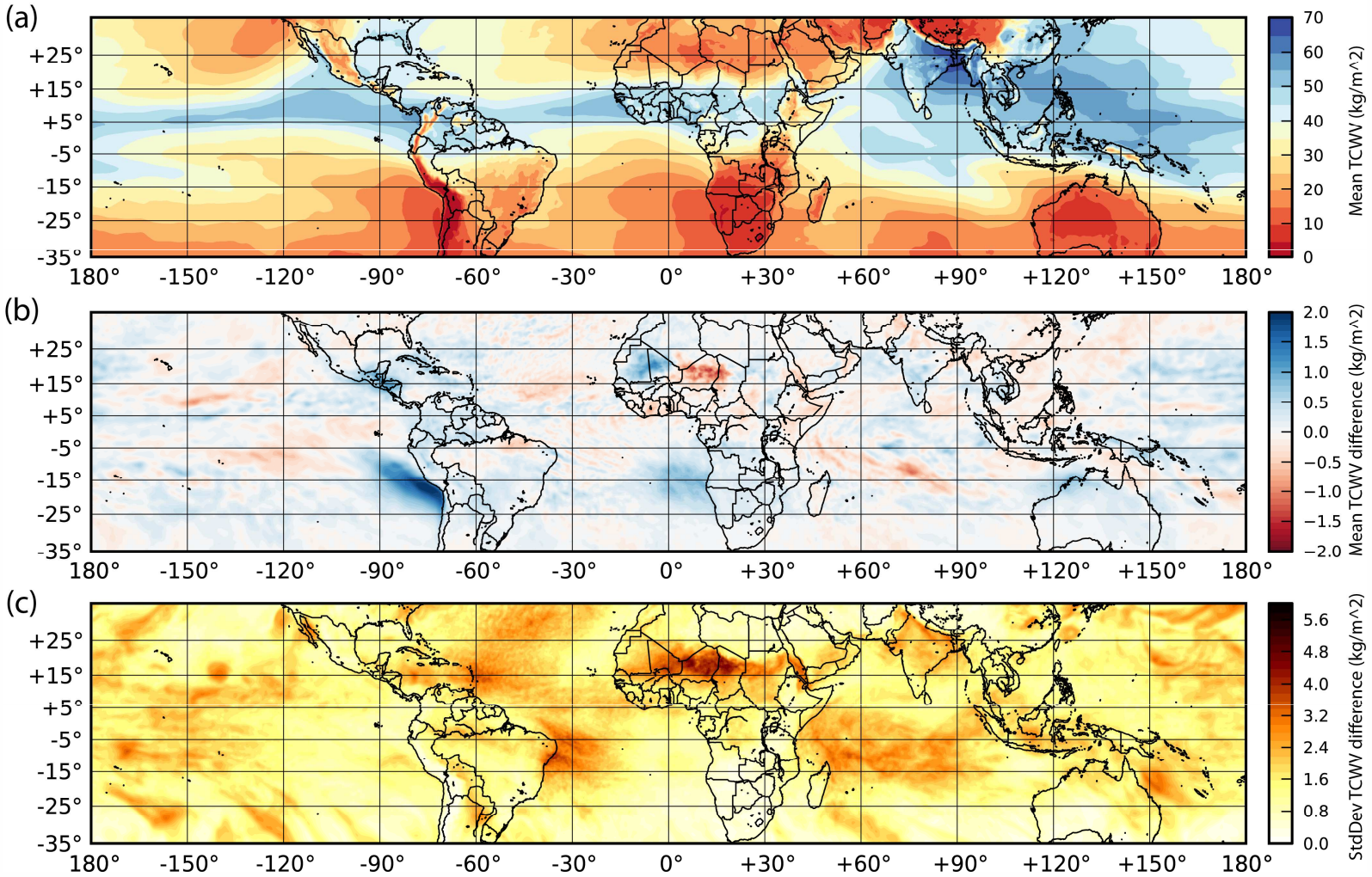
(P. Chambon)

Impact on Arpège analyses and forecasts

TCWV (averaged)

Impact of SAPHIR On TCWV

Impact of SAPHIR On the variance of TCWV



- Drastic increase of microwave observations for humidity (x3.8 with 2012 constellation, x2 to x3 with 2014 constellation)
- Positive impact on humidity up to 12h lead time between 400 and 150 hPa (≈10% reduction of RMS) and up to 72h at 700hPa (≈1% to 3% reduction of RMS)

(P. Chambon)

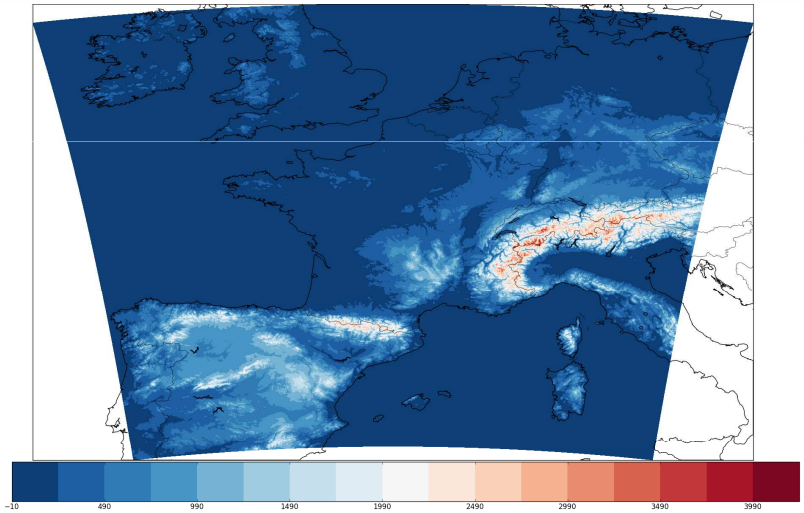
HR E-suites at MF: status overview for Arpège and Arome

- **Arpège and Arome**: E-suite started in R&D environment in June 2014 (V1), with an upgrade completed in mid-September (V2)
- E-suite in MF's Operations: Sept 2014 – March 2015 (target switch to oper)
- **Aladin models at MF** (Overseas): will inherit changes in observations, but resolution kept constant (8km, L70) in assimilation
- **Arome-France**: will inherit changes in observations ++
  - 1.3km L90 (higher resolutions); model top decreased from 1.0hPa to 10hPa
  - 1h cycle with IAU update of HH+1h 3D-Var increment into HH initial time forecast
  - Observations: (in addition to changes as in Arpège 4D-Var)
    - SEVIRI channel 8 assimilated
    - New VarBC predictors defined (to take into account the lower model top)
    - Increased number of vertical levels in RTTOV (to avoid gaps in vertical gradient)

New horizontal grid: AROME-France 1.3km

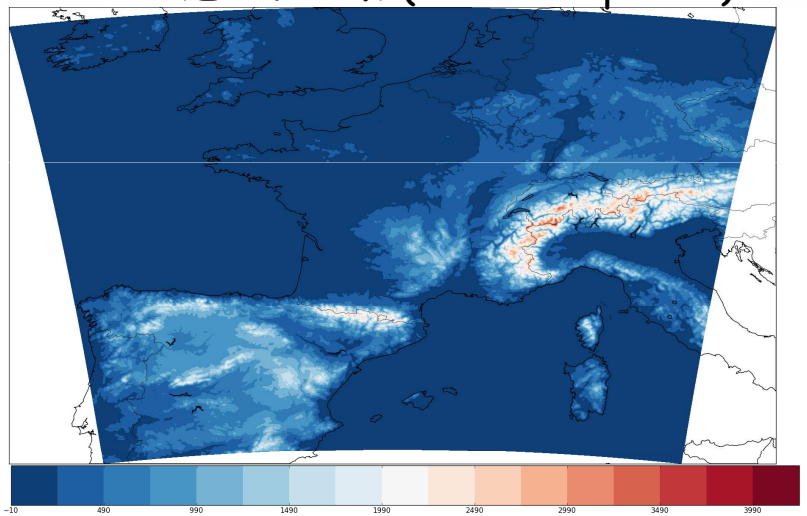
- Enlarged model domain to the North

AROME 1.3km orography (1440x1536 points):



From GMTED2010 250m

AROME 2.5km (750x720 points)

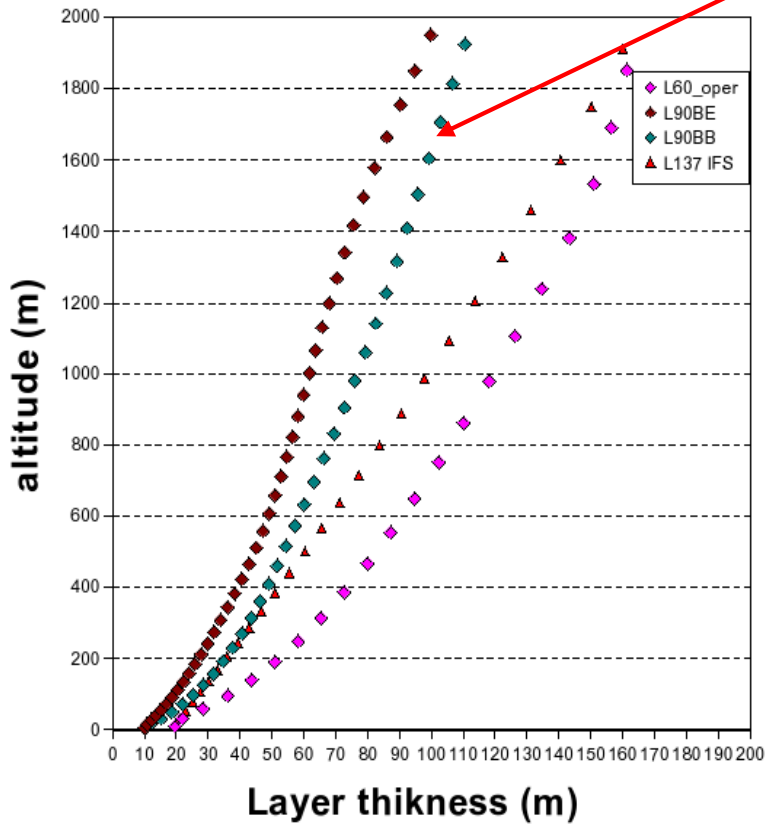


From GTOPO30 1 km

Max slope	38°	23°
Mt Blanc (4807m)	4272 m	3870 m
Aneto (3404m)	3008 m	2812 m
ABS(model height minus SYNOP+RADOME)	20.6 m	58 m

Vertical grid of AROME-France 1.3km

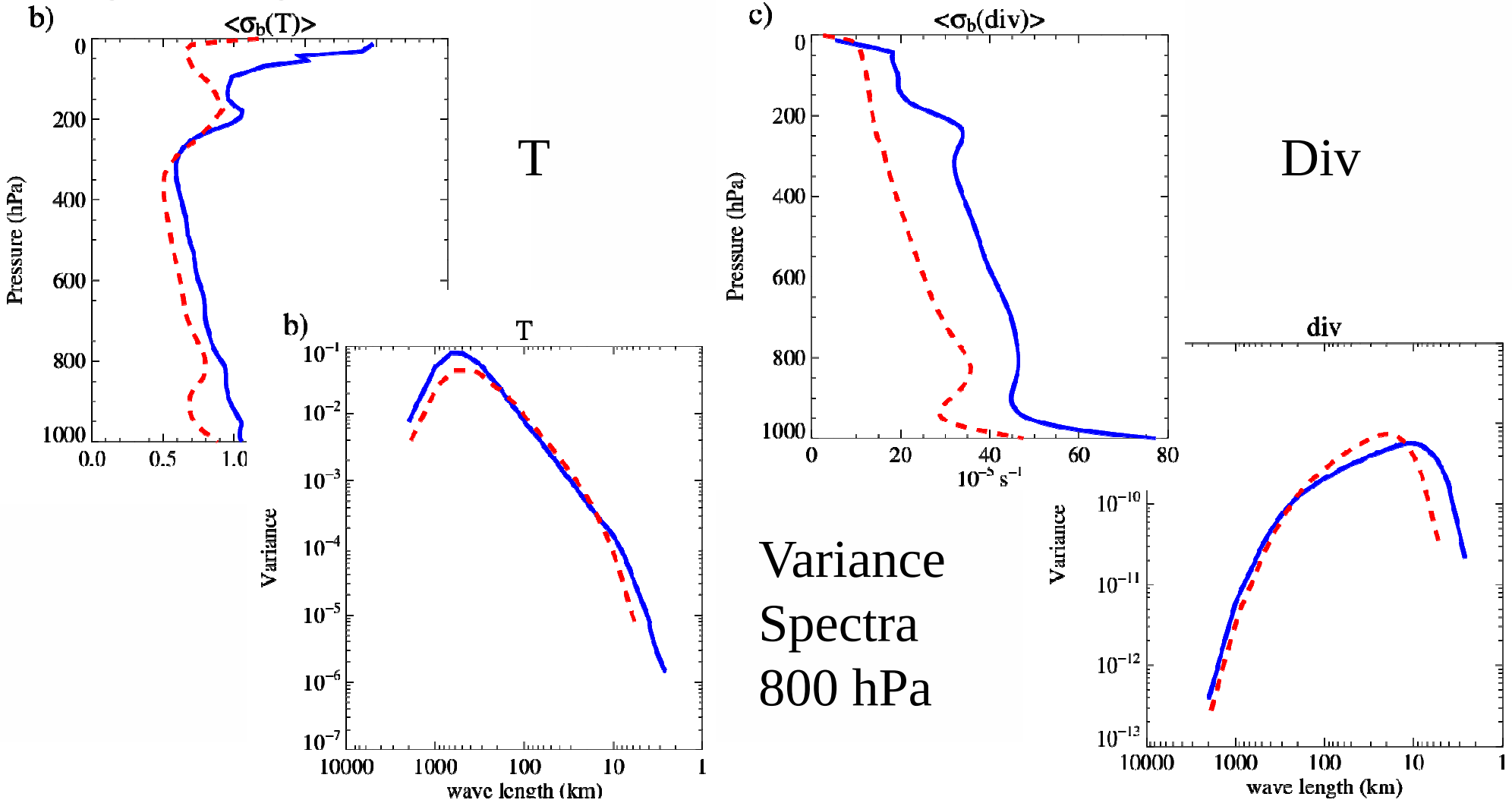
	AROME 1,3km	AROME 2,5km
Nb vertical levels	90	60
Top model level	10 hPa	1 hPa
Lowest model level	5m	10m
Nb levels < 2000m	33	21



From L60 to L90, a rather smooth and regular increase of resolution was chosen

AROME-France 1.3km L90 : B matrix (P. Brousseau)

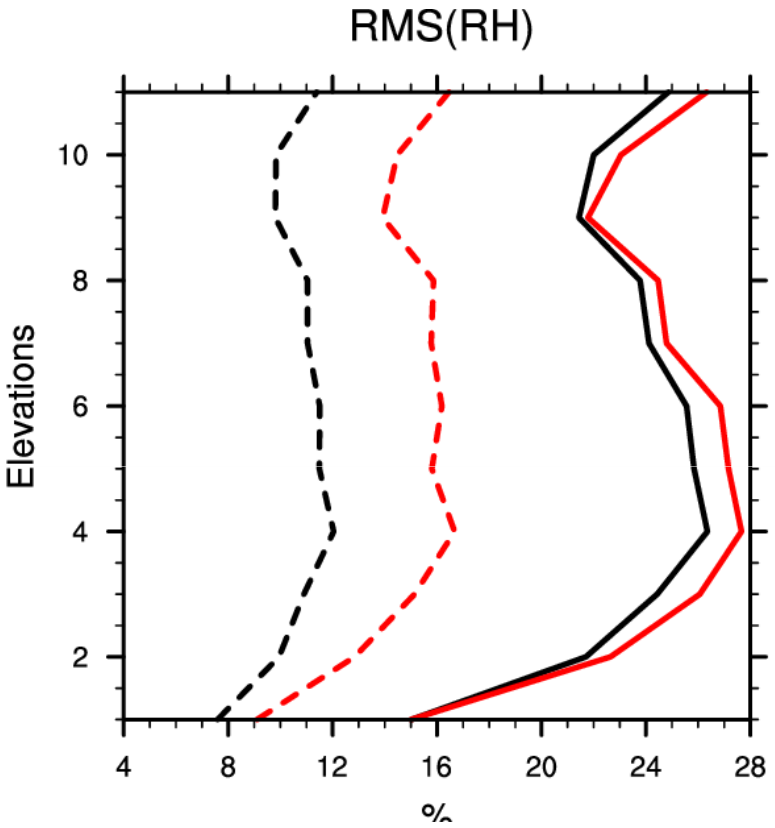
- **Estimated using an ensemble data assimilation over two 2-weeks (winter and summer)**
- **Sigma-b higher, mainly for vor and div and for small horizontal scales**



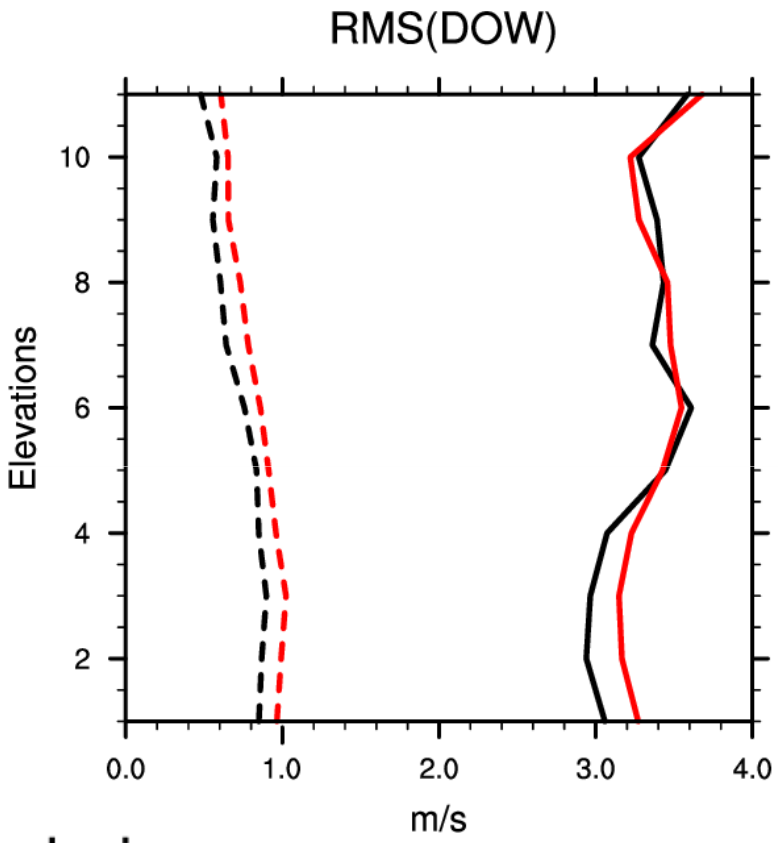
AROME-France 1.3km L90 : assimilation experiment (P. Brousseau)

- New channel selection and VARBC predictors (due to change of model top)
- New gpssol whitelist
- Rms of obs-guess and obs-analysis for radar observations over a 2-week convective period

Relative humidity from reflectivity



Doppler winds



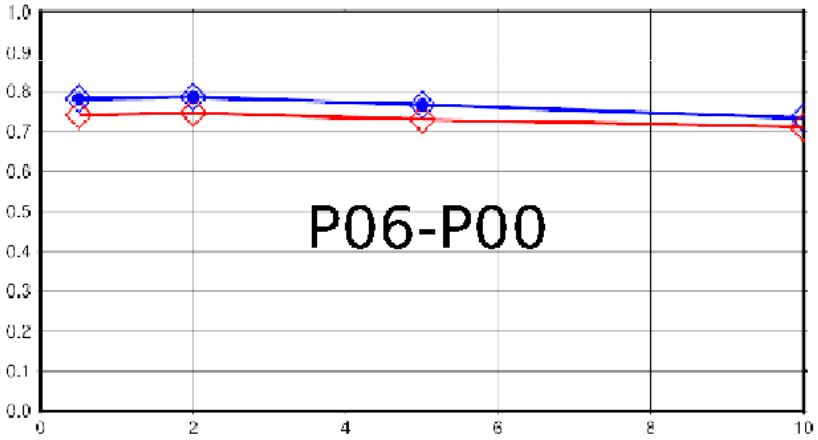
Red: 2.5km, black:1.3km

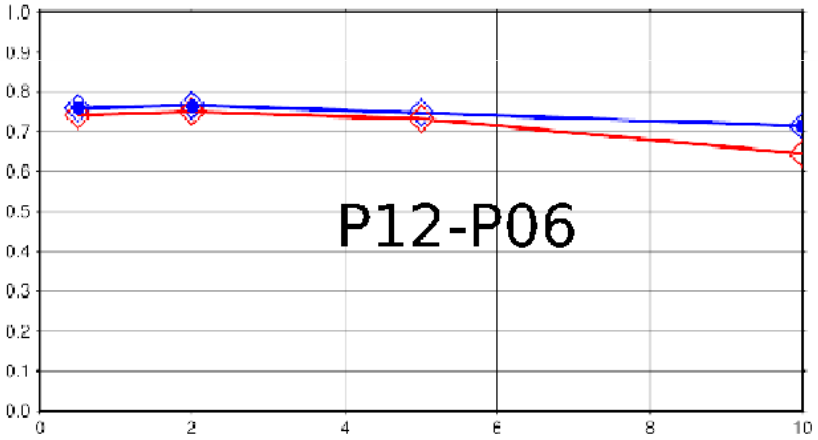
obs-analysis

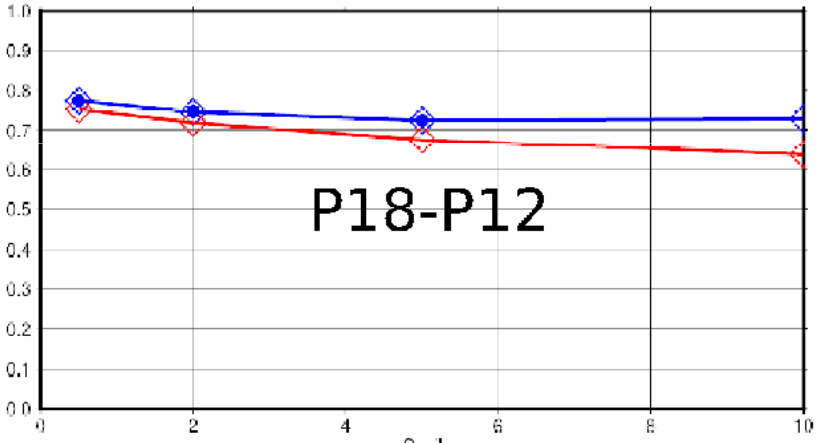
obs-guess

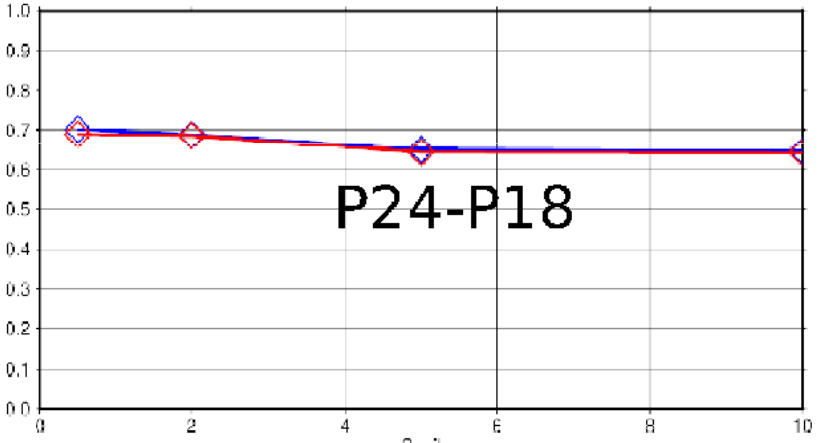
1-h assimilation cycle (P. Brousseau)

- 3-h cycle B matrix with REDNMC=0.5 (versus 1.2 in the 3-h cycle)
- No initialisation technique (IDFI or IAU) requested w/r to spin-up
- 2.5 months assimilation experiment (2.5 km)
- Brier Skill Scores for 6-h cumulative precipitation, neigbourhood of 50 km (15/07/2013-30/09/2013)









Threshold (mm) 0.5 2 5 10 0.5 2 5 10

1h cycle 13 UTC **VS** **3h cycle 12 UTC**

Plans in overview: NWP and DA systems based on Arome

- **Arome nowcasting (aka Arome-PI)** and SESAR applications (Arome-airport): mid- or 2nd half of 2015
- **Arome EPS**: daily experimental tests under OLIVE in 2015; operations in 2016
  - 10 members; BC from PEARP (clustering); IC = Arome analysis + PEARP pert. (later from EnDA); surface pert = specific surface and physiographic fields; model error by SPPT
- **Arome EnDA**: pert of obs (3D-Var); model error by time varying inflation; 2.5km; 6 members (at present)
- Spatial objective filtering of error variances; filtering of localization function lengthscales (Ménétrier, Michel, Montmerle, Berre)
- Daily varying (spatially homogeneous) background error variances derived from the Arome EnDA
- Porting to **OOPS** (Object-oriented prediction system with a top-layer of OO code in C++ / with ECMWF) and development of **EnVar** (ensemble B, hybrid solutions, no TL/AD models): pre-operational assimilation in 2016 ?

Und zum guten Schluss,

Er ist noch weit vom Schluß entfernt,
Er hat das Ende nicht gelernt.

Johann Wolfgang von Goethe (1749 - 1832)