The satellite winds in the operational NWP system at Météo-France

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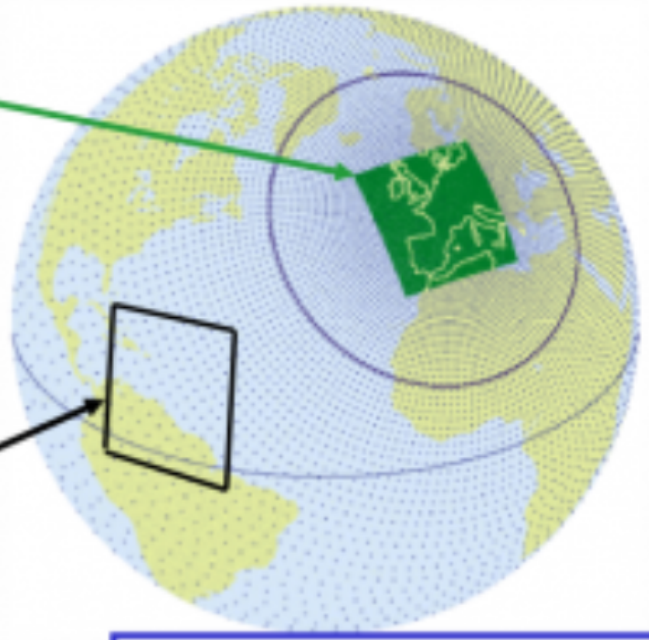
Outline

- Operational NWP configuration upgrades
- AMVs: results with Himawari-8
- Scatterometry: impact of RapidSCAT winds
- RapidSCAT instrumental event
- Summary / Future work

Operational NWP configuration

AROME:
non-hydrostatic
3DVAR
coupled with ARPEGE

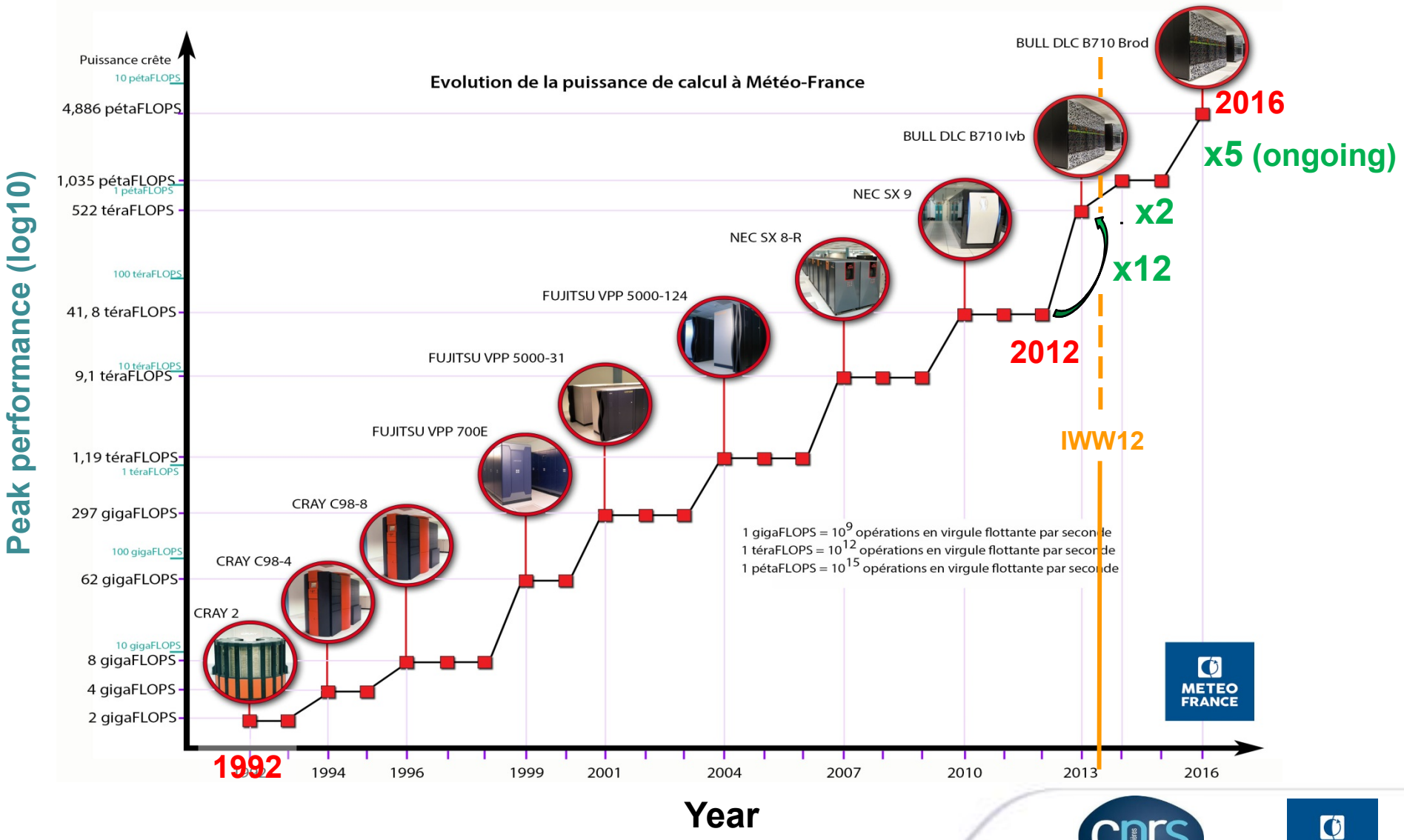


4 ALADIN-OM:
3DVAR

ECMWF or ARPEGE coupling

ARPEGE & PEARP (global):
stretched grid
4DVAR coupled with AEARP

An ever-increasing computing power



cnrs

METEO FRANCE

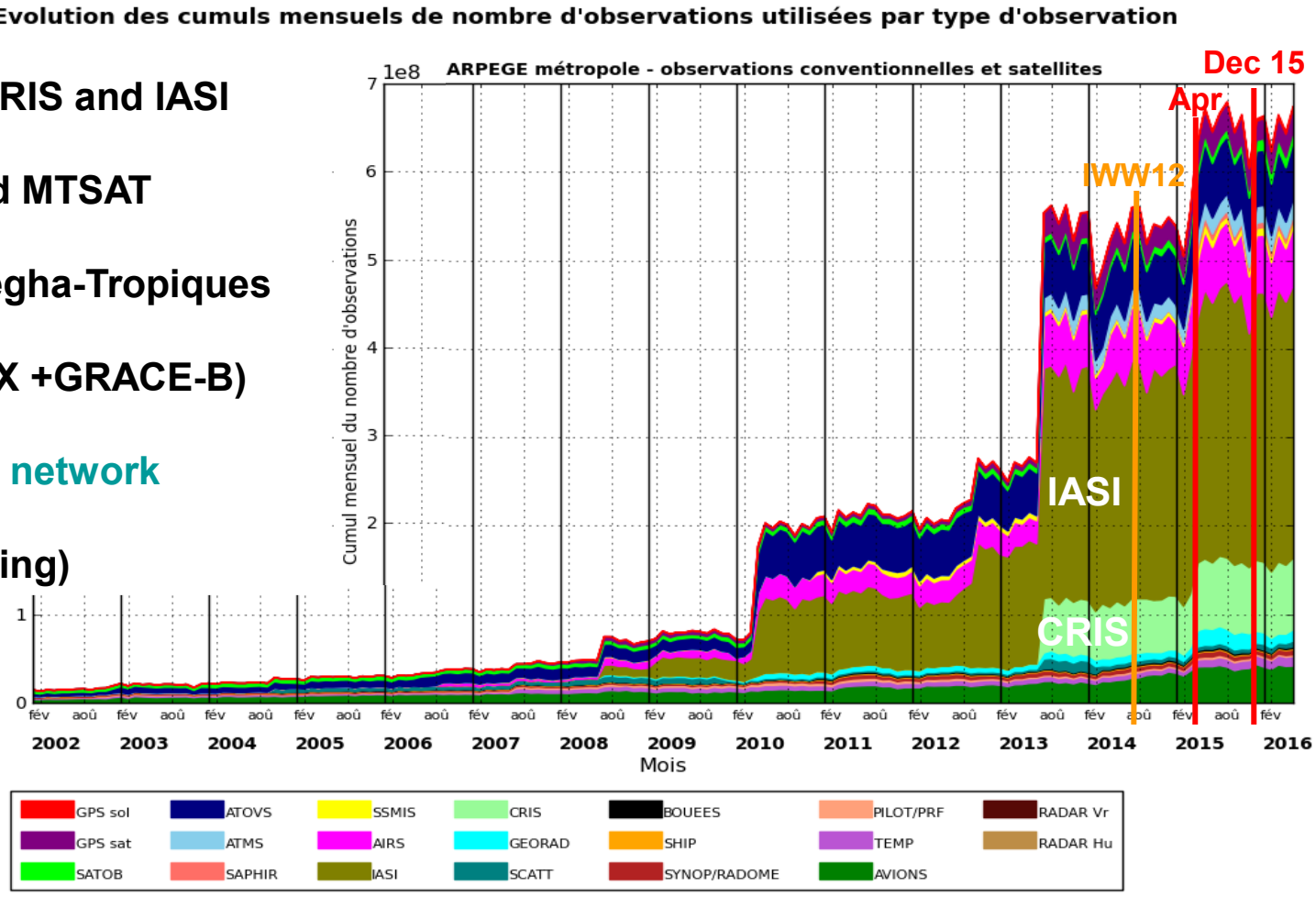
ARPEGE (and AEARP) observations upgrade

April 2015 (+20%):

- Additional channels from CRIS and IASI
- CSR from METEOSAT-7 and MTSAT
- SAPHIR (microwave) on Megha-Tropiques
- More GNSS (use +Tandem-X +GRACE-B)
- ASCAT-B winds from EARS network
- Dual-MetOp AMVs (monitoring)

December 2015:

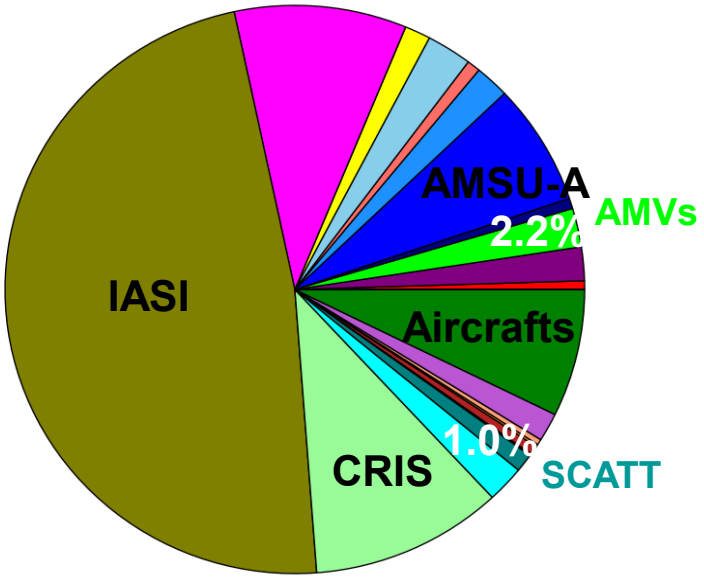
- Additional CRIS channels
- Himawari-8 AMVs
- RapidSCAT winds
- NPP AMVs (monitoring)



Monthly number of used observations in ARPEGE (monitored excluded)

Number of observations (Dec 2015 upgrade)

Observation number by type (%)

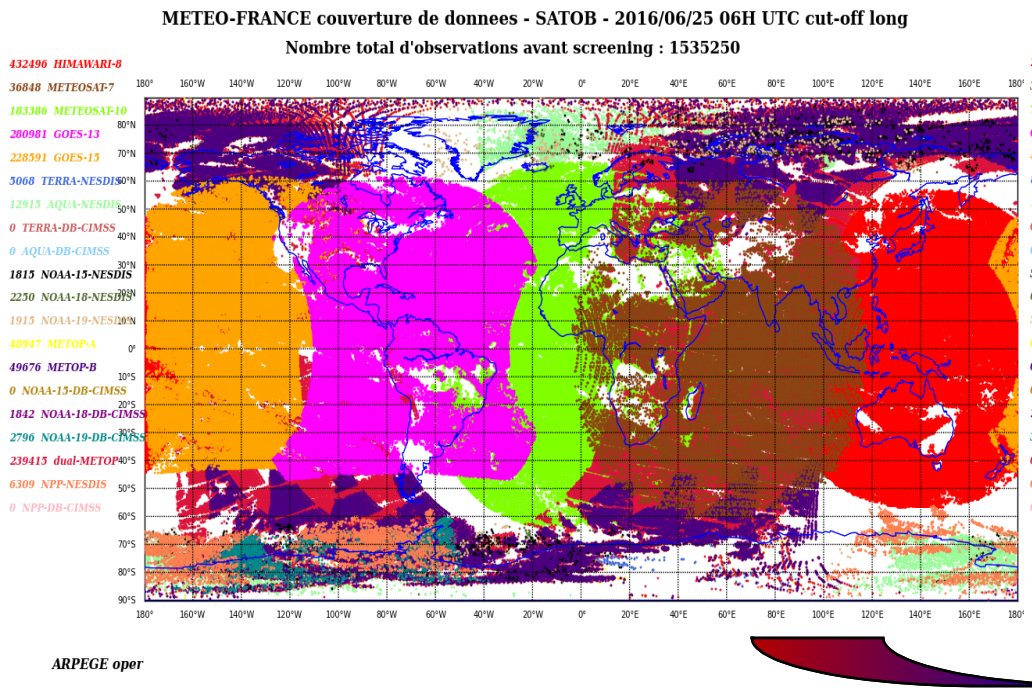


GPS ground	0.49%	SSMIS	1.44%	SYNOP/SYNOR/RADOME	0.50%
GPS sat	1.91%	GMI	0.00%	SHIP	0.14%
SATOB	2.20%	AIRS	9.60%	PILOT/PRF	0.32%
ATOVS HIRS	0.60%	IASI	47.84%	TEMP	1.61%
ATOVS AMSU-A	6.93%	CRIS	10.73%	AIRCRAFTS	7.25%
ATOVS AMSU-B	1.92%	GEORAD	2.10%	RADAR Vr	0.00%
SAPHIR	0.74%	SCATT	1.04%	RADAR Hur	0.00%
ATMS	2.53%	BUOY	0.10%	BOGUS	0.00%

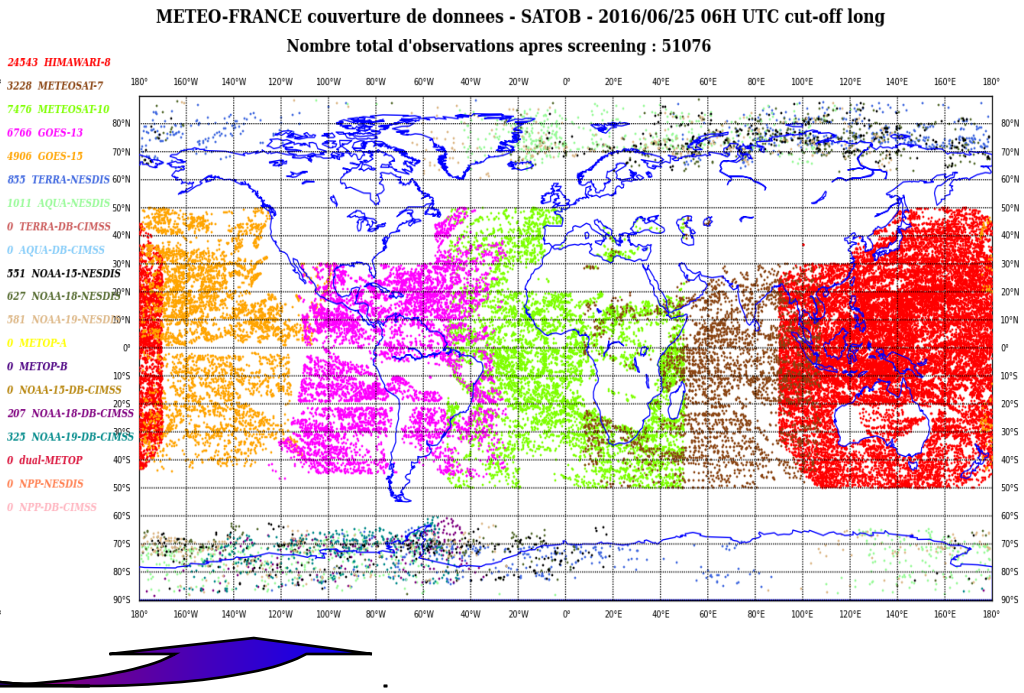
- **IASI data dominates (almost 50%)**
- **Radiances (all instruments), 85%!**
- **Satellite winds (AMVs +SCATT) represent only 3% of total**

AMVs coverage

Available AMVs on 6 hours



Used AMVs



ARPEGE oper

QC + thinning

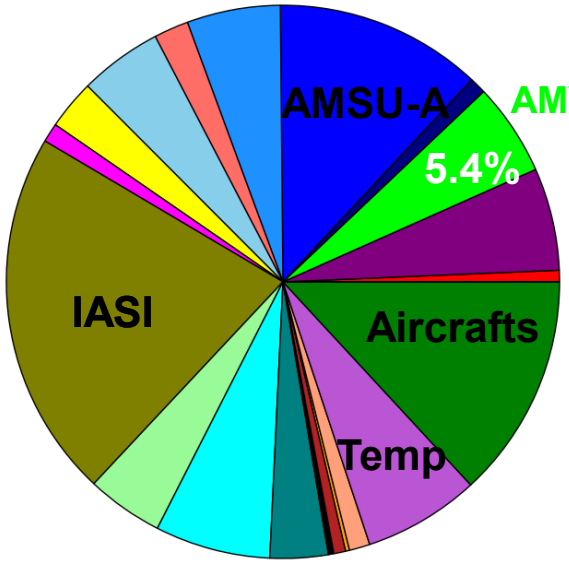
- A large amount of AMVs is available (until 1.5 M by 6h assimilation window)
- Only around 3/4% are used after QC and thinning, or not still tested

AMVs impact in ARPEGE analysis

Degrees of Freedom for Signal (DFS) by obs. type (%)

Before Dec 2015

observations conventionnelles et satellites
cumul du DFS sur la période 2015120100 - 2015120118 : 463672

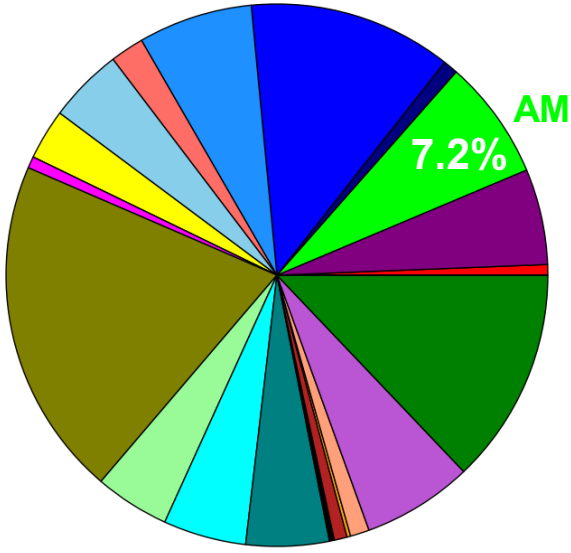


GPS ground	0.67%	SSMIS	2.90%	SYNOP/SYNOR/RADOME	0.69%
GPS sat	5.99%	GMI	0.00%	SHIP	0.23%
SATOB	5.41%	AIRS	1.11%	PILOT/PRF	1.21%
ATOVS HIRS	0.97%	IASI	21.52%	TEMP	6.80%
ATOVS AMSU-A	12.10%	CRIS	4.48%	AIRCRAFTS	13.12%
ATOVS AMSU-B	5.47%	GEORAD	6.74%	RADAR Vr	0.00%
SAPHIR	2.02%	SCATT	3.39%	RADAR Hur	0.00%
ATMS	4.84%	BUOY	0.32%	BOGUS	0.00%

+ Himawari-8 AMVs

Dec 2015 upgrade

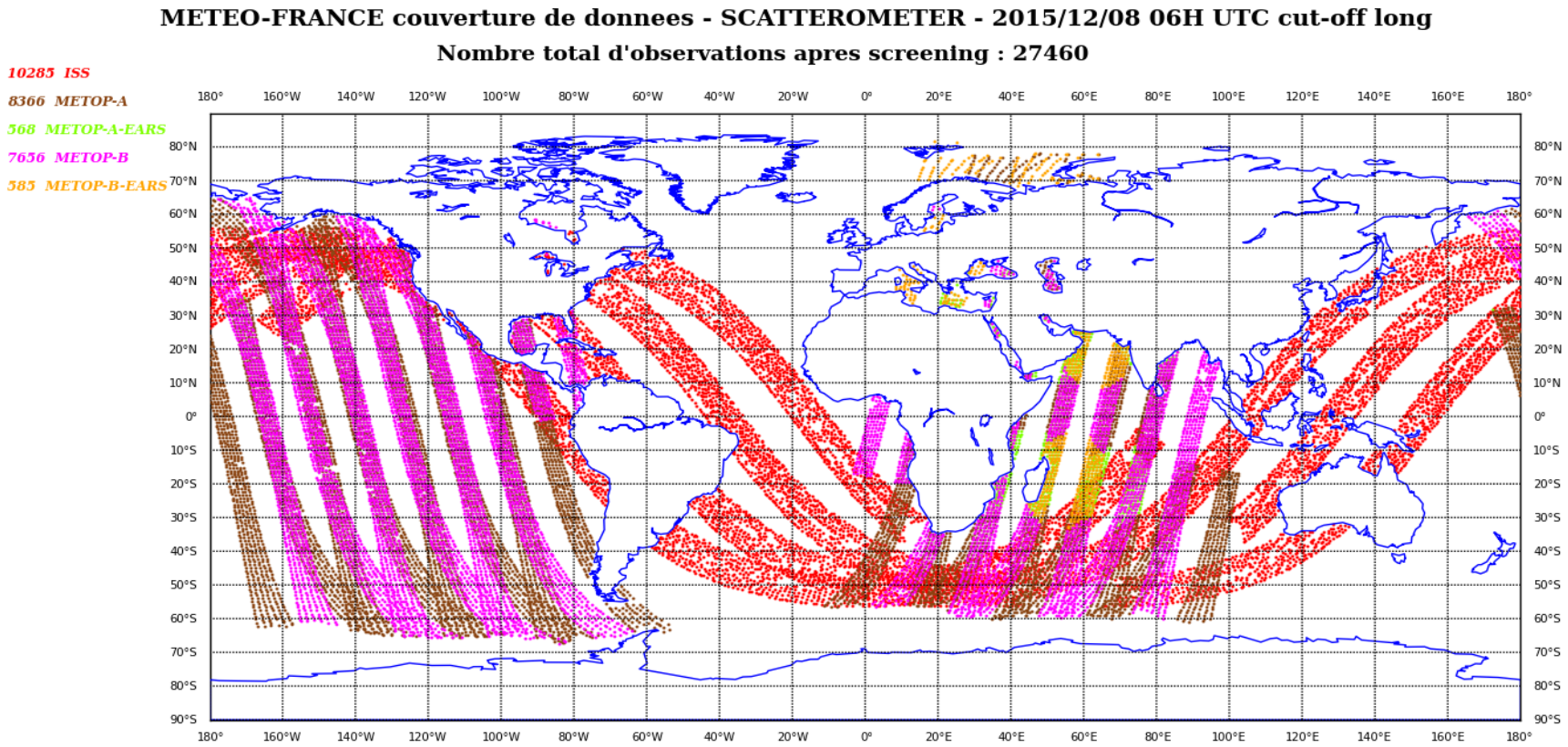
observations conventionnelles et satellites
cumul du DFS sur la période 2015120100 - 2015120118 : 481780



GPS ground	0.63%	SSMIS	3.02%	SYNOP/SYNOR/RADOME	0.77%
GPS sat	5.71%	GMI	0.00%	SHIP	0.21%
SATOB	7.15%	AIRS	0.69%	PILOT/PRF	1.14%
ATOVS HIRS	0.88%	IASI	20.23%	TEMP	6.59%
ATOVS AMSU-A	12.14%	CRIS	4.46%	AIRCRAFTS	12.89%
ATOVS AMSU-B	6.82%	GEORAD	4.95%	RADAR Vr	0.00%
SAPHIR	2.01%	SCATT	4.96%	RADAR Hur	0.00%
ATMS	4.46%	BUOY	0.29%	BOGUS	0.00%

- 0.7 % of used data
- 1% of used data

Scatterometer winds coverage

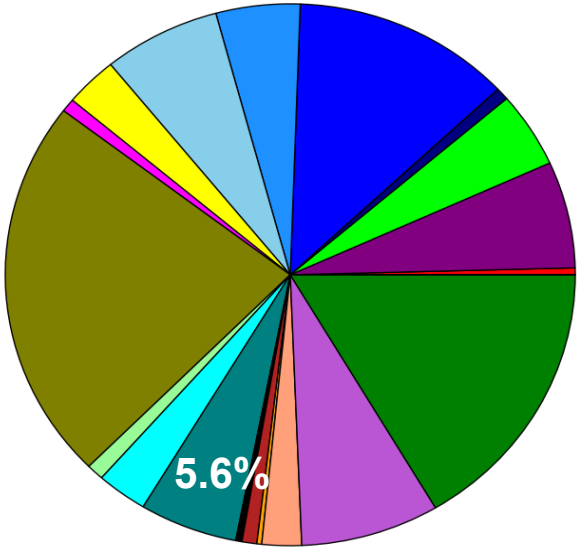


- First RapidSCAT winds assimilated operationally (on 8 Dec 2015)
- May complete the ASCAT coverage, as here, depending on ISS orbit

Scatterometer winds impact in ARPEGE analysis

Degrees of Freedom for Signal (DFS) by observation type in %

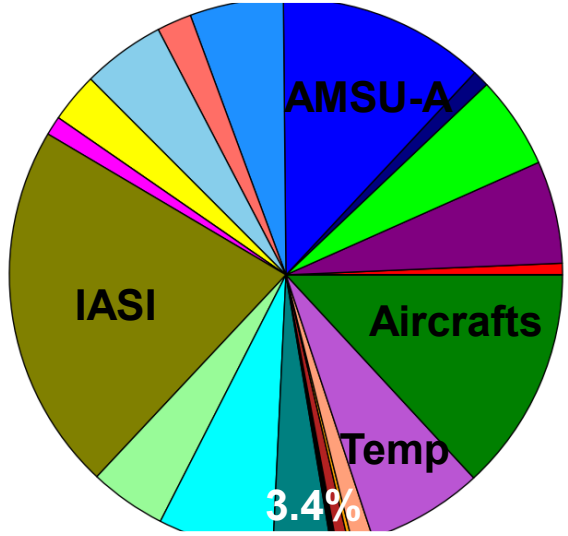
2013
ASCAT-A & B + OSCAT



GPS ground	0.41%	AIRS	0.79%	SHIP	0.27%
GPS sat	6.37%	IASI	22.86%	PILOT/PRF	2.24%
SATOB	4.50%	CRIS	0.98%	TEMP	7.87%
ATOVS HIRS	0.74%	SEVIRI	2.88%	AIRCRAFTS	16.48%
ATOVS AMSU-A	12.43%	SCATT	5.57%	RADAR Vr	0.00%
ATOVS AMSU-B	4.77%	BUOY	0.36%	RADAR Hur	0.00%
ATMS	6.65%	SYNOP/SYNOR/RADOME	0.84%	BOGUS	0.00%
SSMIS	3.00%				

- 2% of used data

2014 to 2015
ASCAT-A & B



SCATT DFS

GPS ground				SYNOP/SYNOR/RADOME	0.69%
GPS sat	5.99%	GMI	0.00%	SHIP	0.23%
SATOB	5.41%	AIRS	1.11%	PILOT/PRF	1.21%
ATOVS HIRS	0.97%	IASI	21.52%	TEMP	6.80%
ATOVS AMSU-A	12.10%	CRIS	4.48%	AIRCRAFTS	13.12%
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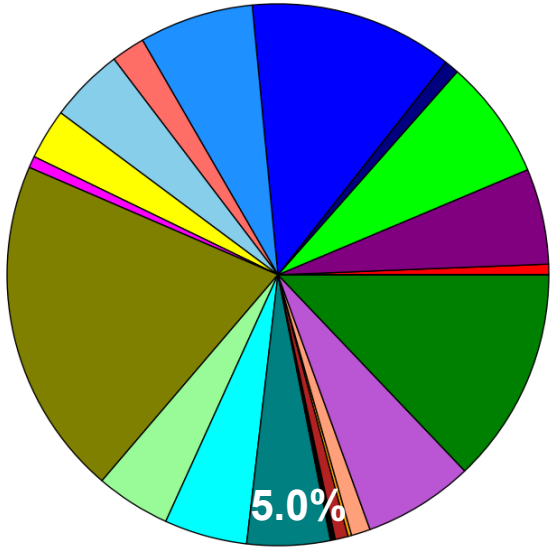
SAPHIR	2.02%	SCATT	3.39%	RADAR Hur	0.00%
ATMS	4.84%	BUOY	0.32%	BOGUS	0.00%

- 0.7 % of used data

2015 upgrade
ASCAT-A & B + RapidSCAT



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ATOVS AMSU-B	6.82%	GEORAD	4.95%	RADAR Vr	0.00%
SAPHIR	2.01%	SCATT	4.96%	RADAR Hur	0.00%
ATMS	4.46%	BUOY	0.29%	BOGUS	0.00%

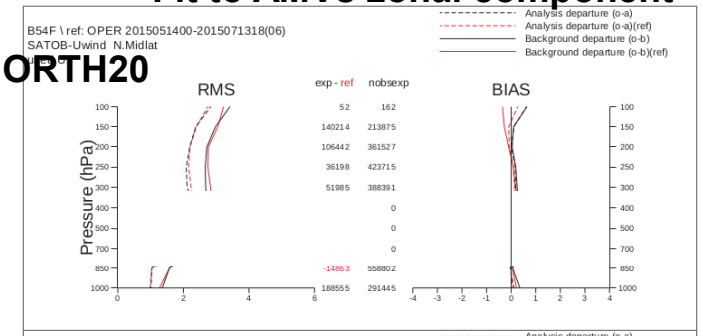
- 1% of used data

Himawari-8 AMVs assimilation

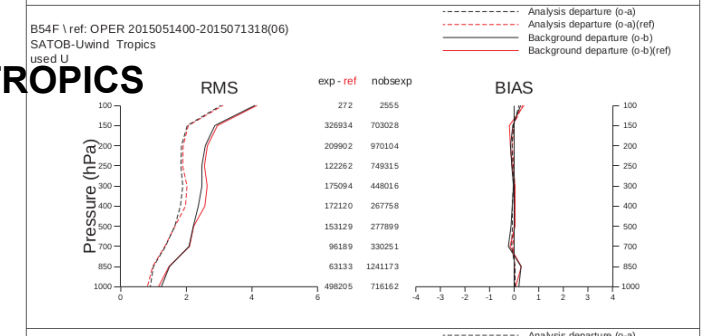
- Himawari-8 AMVs volume: available around 5xMTSAT-2, used 3xMTSAT-2 (same QC), +35% of AMVs in the system

Fit to AMVs zonal component

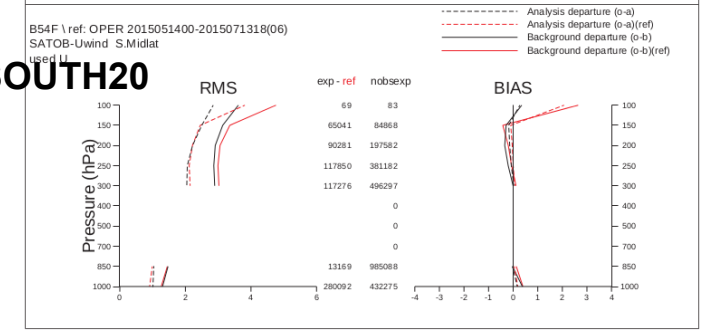
NORTH20



TROPICS



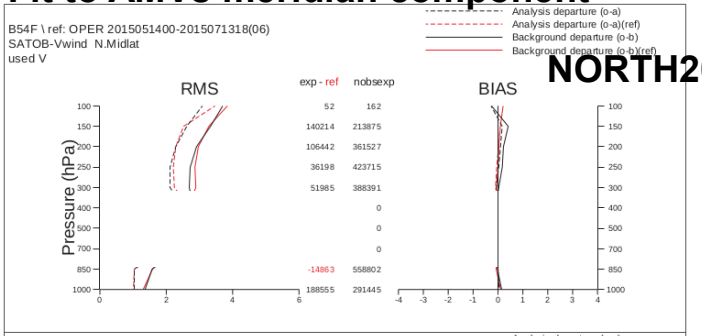
SOUTH20



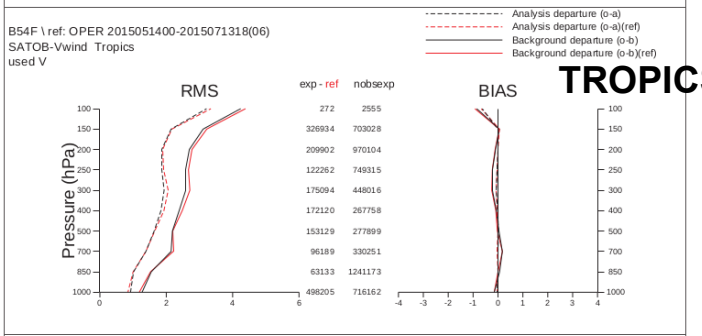
- Better fit of **model background to AMVs, MTSAT discarded , H8 included,** versus OPER
- some differences on bias, not always in the right direction
- Improves the fit to the drop winds above 500hPa, degradation below 700hPa (not shown)

Fit to AMVs meridian component

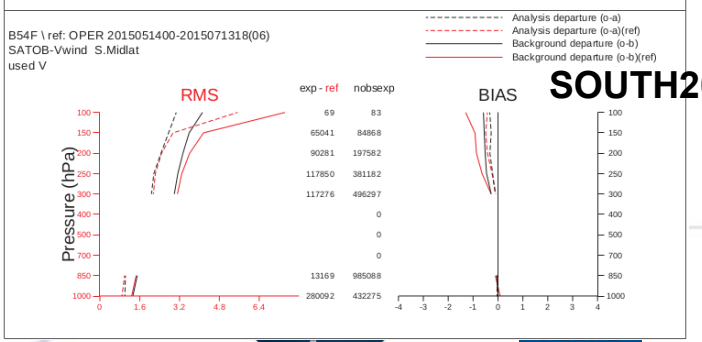
NORTH20



TROPICS

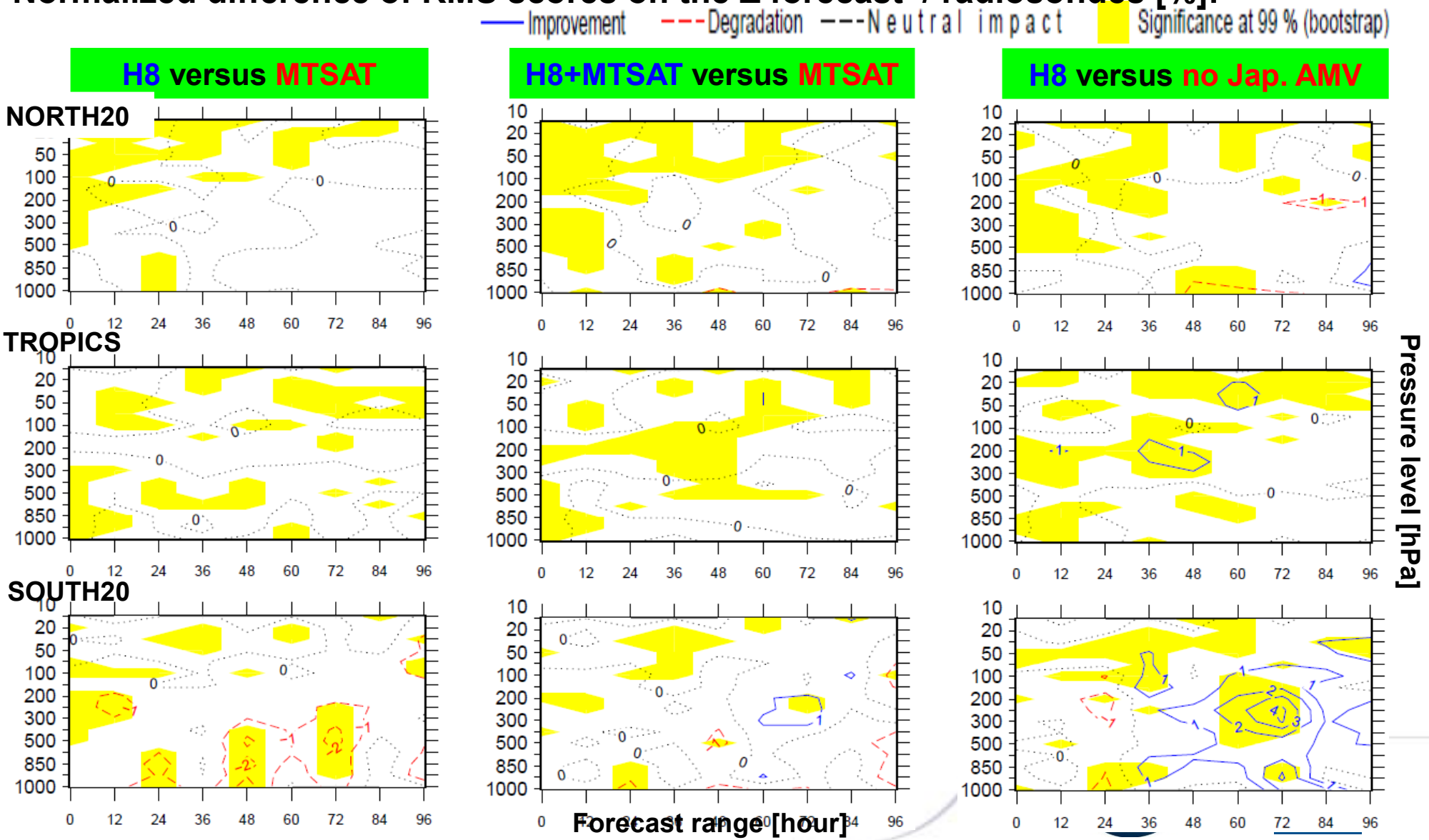


SOUTH20

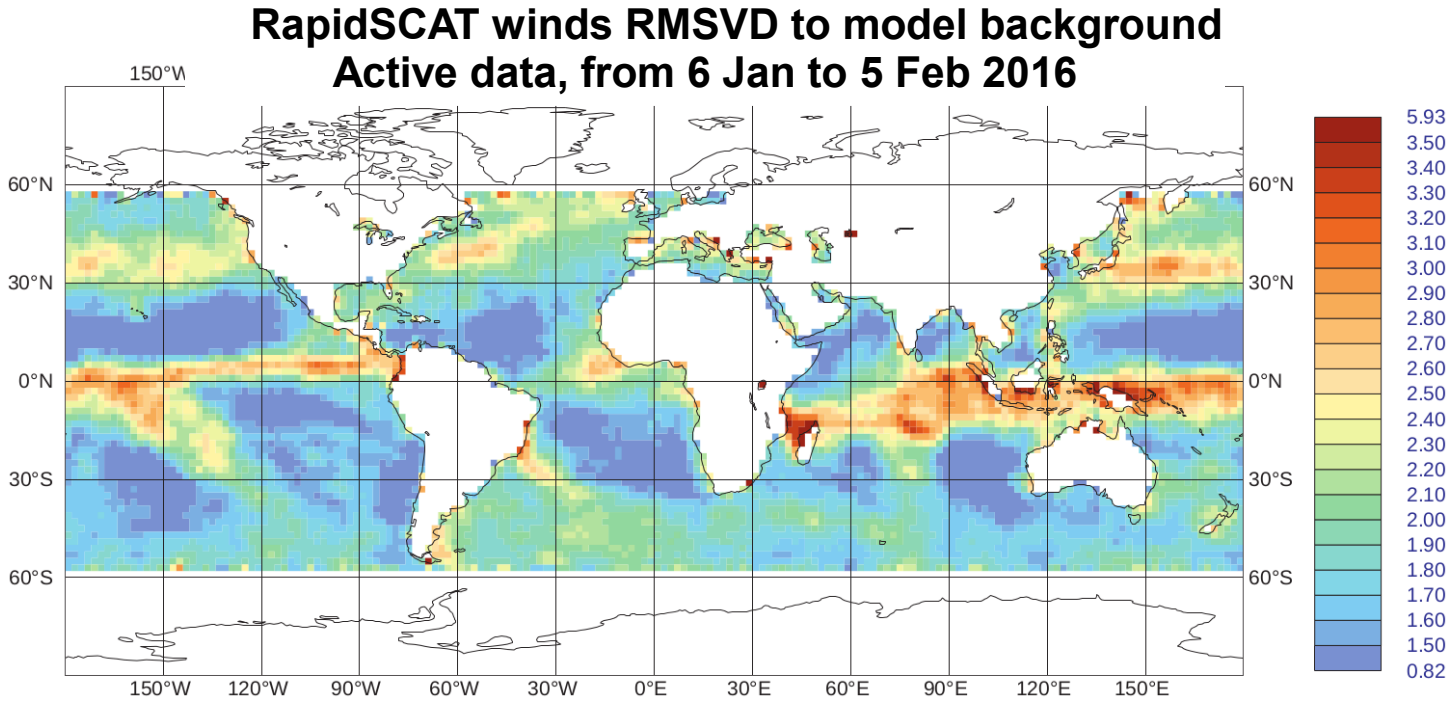


Himawari-8 AMVs assimilation tests
45 forecasts at 0 UTC, from 14/05 to 01/07/2015

Normalized difference of RMS scores on the Z forecast / radiosondes [%]:



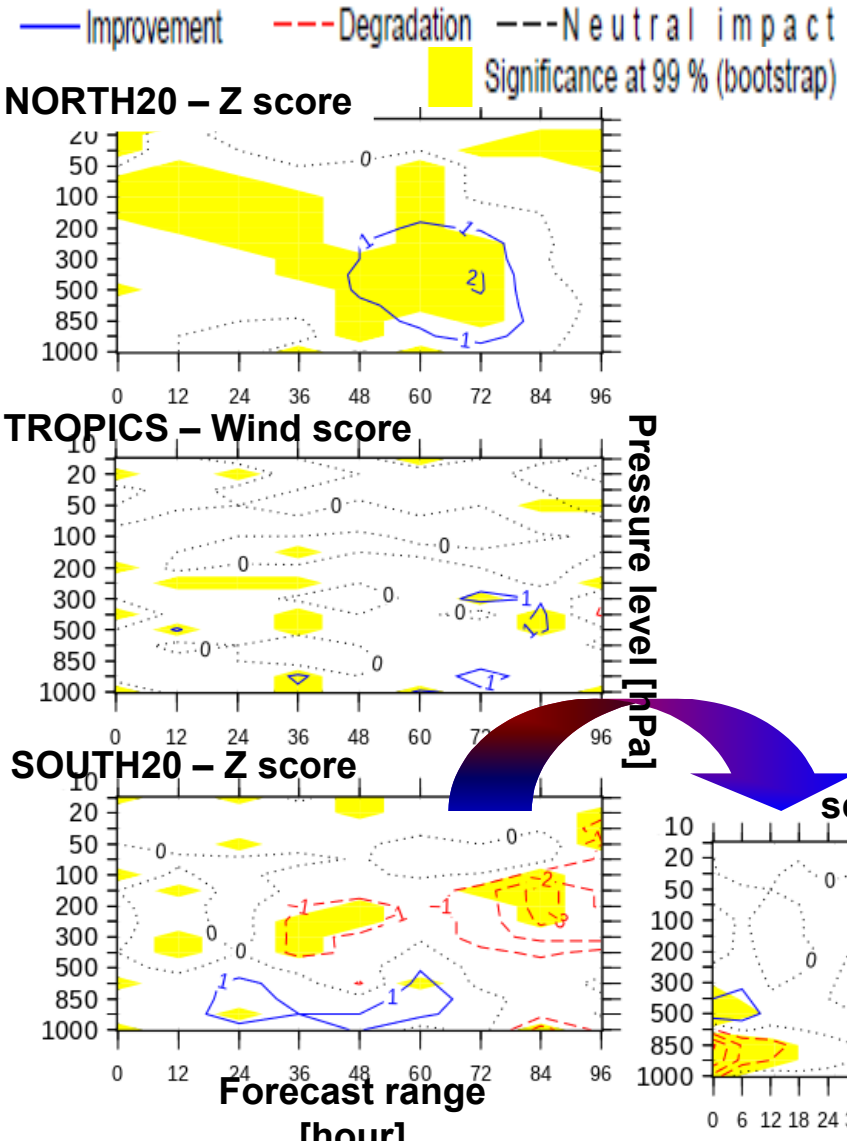
50km RapidSCAT winds (EUMETSAT OSI SAF)



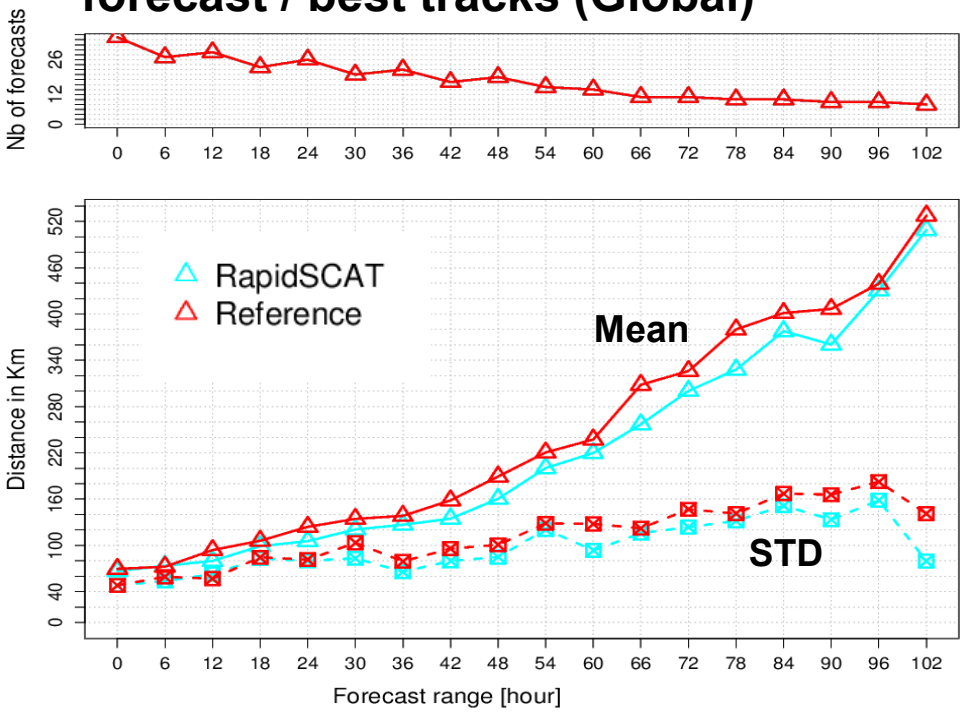
- RMSVD to model bkgrd similar to ASCAT statistics (after QC, mainly rain effect removal)
- Highest differences along the ITCZ, the Gulf Stream and the Kuroshio
- On average, RapidSCAT RMSVD is now close to 2.0 $m.s^{-1}$, 19° for direction RMS, 1.3 $m.s^{-1}$ in speed

RapidSCAT assimilation
47 forecasts at 0 UTC, from 10/12/2014 to 29/01/2015

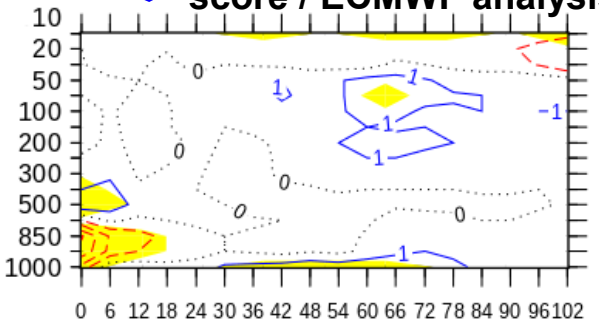
Normalized difference of RMS on fc. scores / radiosondes [%]



Position error of Tropical Cyclones forecast / best tracks (Global)

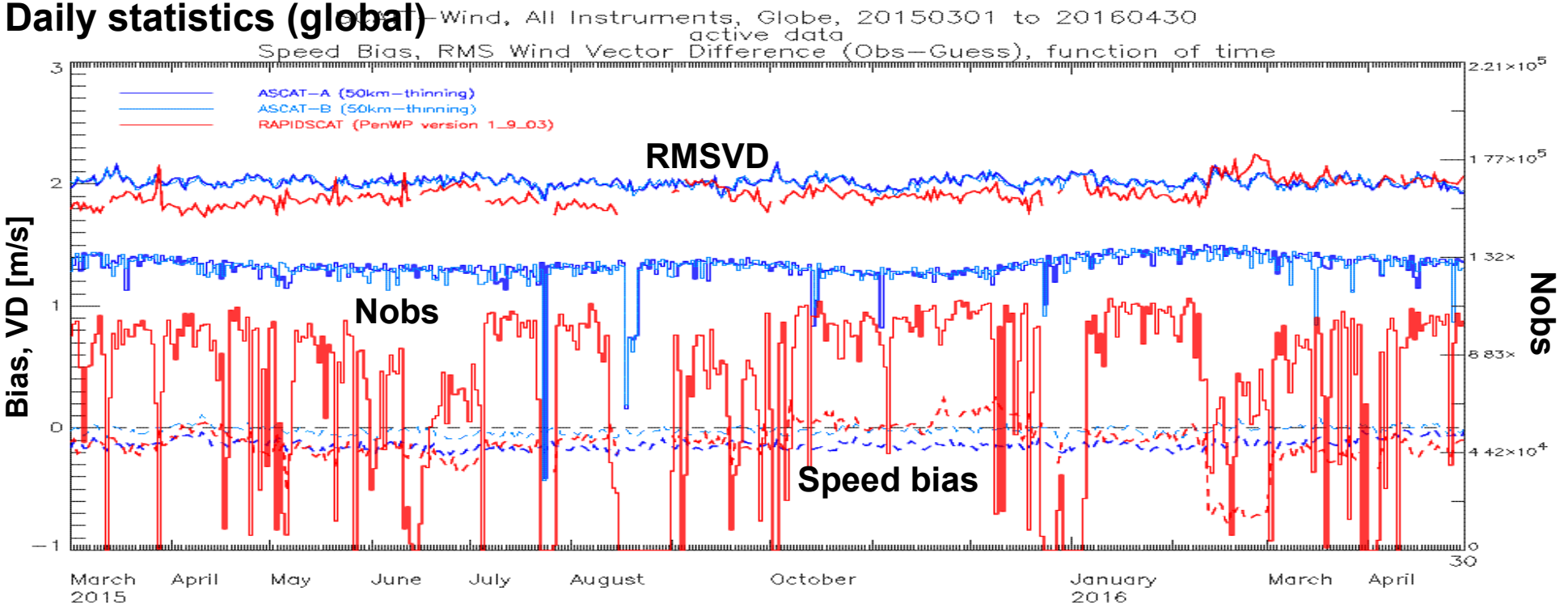


score / ECMWF analysis



50km SCAT winds (EUMETSAT OSI SAF)

Daily statistics (global)



RapidSCAT instrumental events

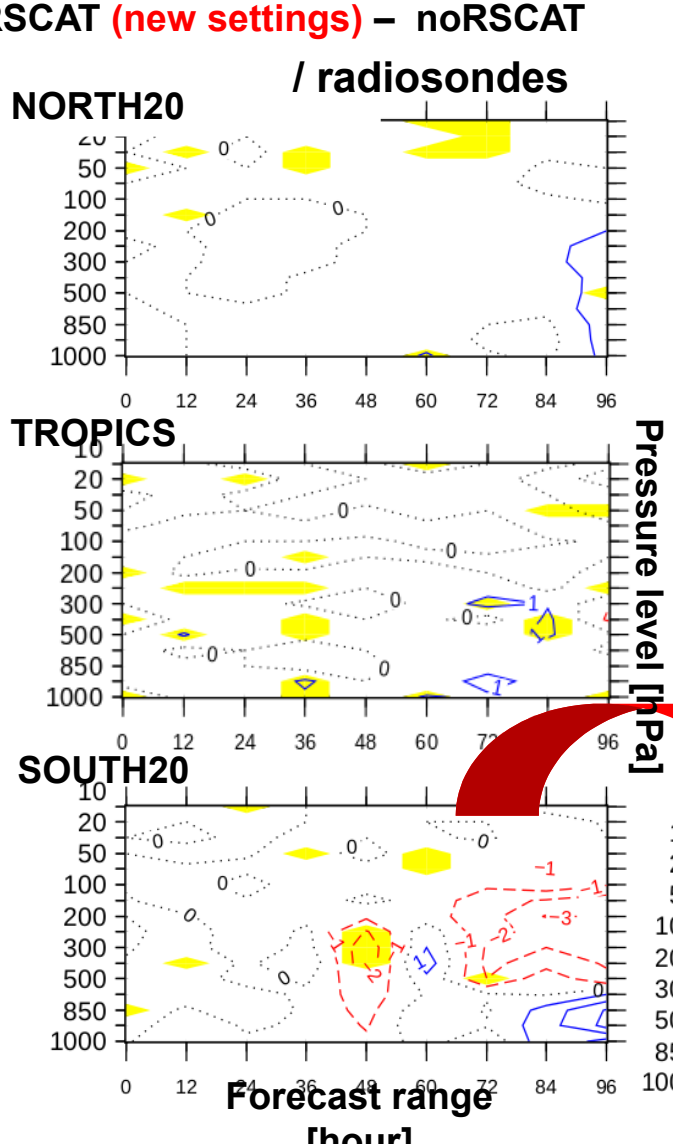
Low SNR1 | Low SNR2 | Low SNR3 | Low SNR4

- ASCAT-A&B availability and their departure to FG very stable in time
- More variations with RapidSCAT due to ISS management (attitude, docking) or low SNR events (since Aug. 2015)
- During the **low SNR3** event (Feb to Apr), RapidSCAT blacklisted

RapidSCAT low SNR3 event
26 ARPEGE forecasts at 0 UTC (March 2016) with new settings (obs error)

Normalized difference of RMS scores on the Z forecast [%]

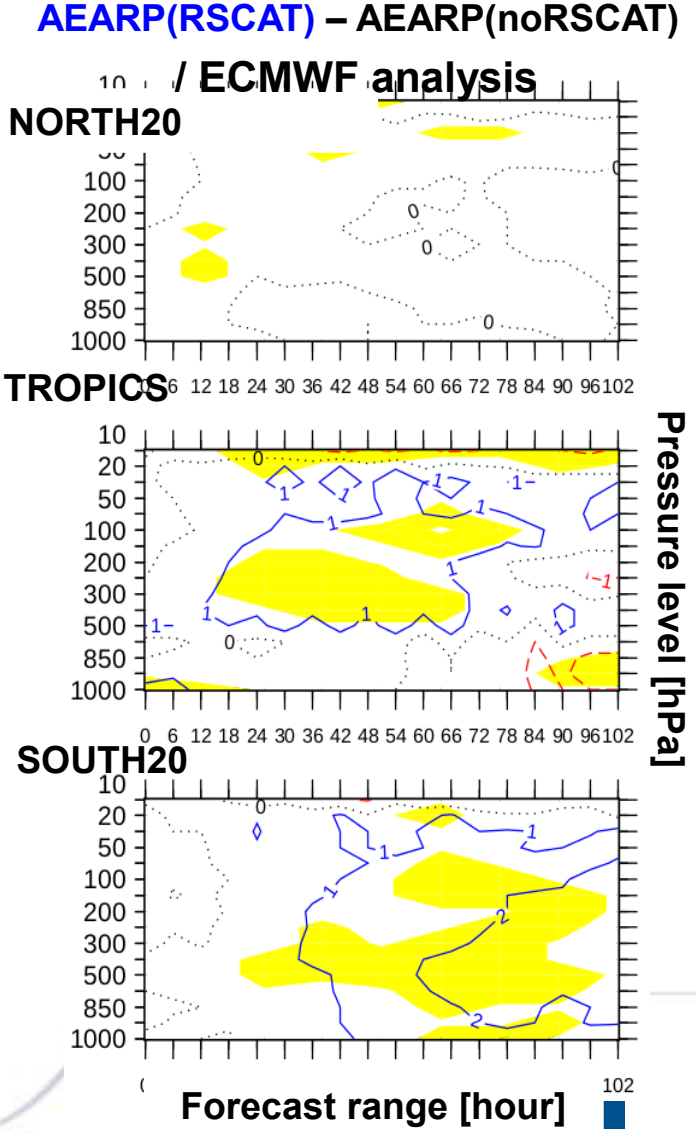
RSCAT (new settings) – noRSCAT / radiosondes



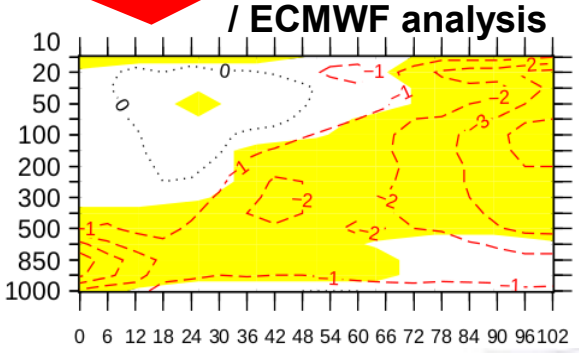
Improvement
Degradation
Neutral impact
Significance at 99 % (bootstrap)

+ RSCAT in AEARP

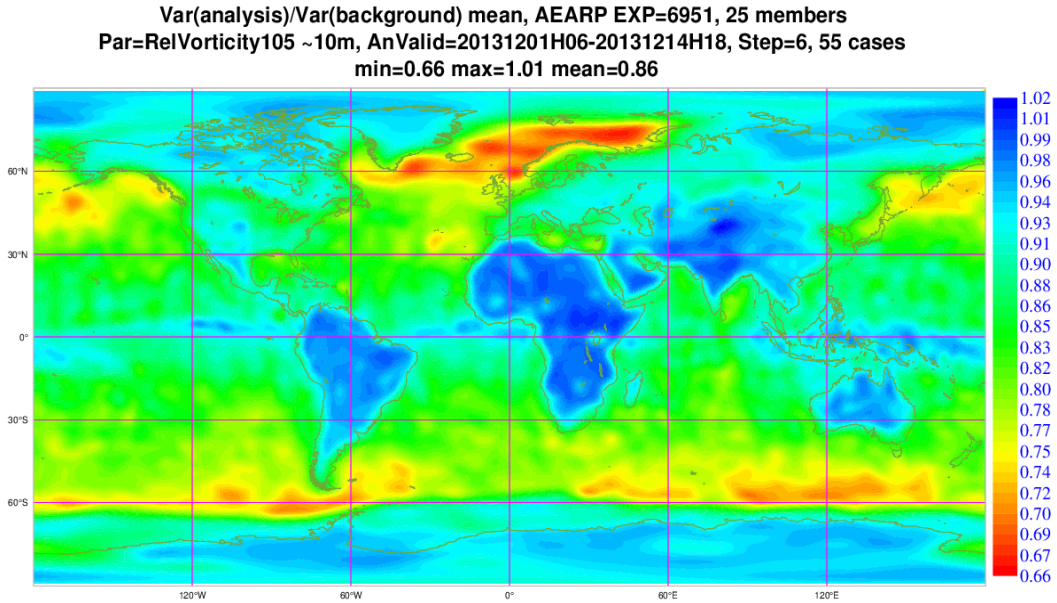
AEARP(RSCAT) – AEARP(noRSCAT) / ECMWF analysis



/ ECMWF analysis



Scatt. winds impact in ensemble assimilation AEARP



10m relative vorticity error variance reduction in AEARP

HPC resources / Configuration	4DVAR alone	4DVAR + AEARP
Requested processor cores	243 960	1M374 (x5.6)
Run time (real)	9 days	15 days (x1.7)
Output volume	20 Tb	100 Tb (x5)

Required HPC resources for 1 month NWP test

- Error variance reduction near the oceanic surface in AEARP (relative vorticity, divergence) directly linked to the scatterometer coverage
- Run a coupled configuration AEARP/ARPEGE much more costly than ARPEGE alone in term of HPC resource but required for a safe evaluation
- But finally, a new JPL processing settings early April allowed to back to statistics close to before the low SNR3 event and RapidSCAT was re-introduced in assimilation, w/o any change

Summary

Since the last IWW

- All models, from global to mesoscale, increased their resolution and they used more observations, thanks a continuous increase of the computing power

- The satellite winds (AMVs and scatterometer) represent a minor amount of used observations, but their weight in the analysis is relatively important

- The RapidSCAT winds improve the global forecasts and the tracking of the TCs, and also through their use in AEARP

- Himawari-8 AMVs results are more mixed: even if this dataset remains required over the Asia area, its negative impact in the southern hemisphere against MTSAT would need further investigation

Future work

Next months

- Scatterometer winds:
  - technical work ongoing for using a new surface analysis model SURFEX in assimilation mode, impacting the scatterometer observation operator
  - to work also on the bias correction and to revisit the 100km-thinning

- AMVs: to start a global revision of their QC and the specified errors, including the use of new datasets (MetOps, NPP, …)

Beyond

- ScatSAT-1, Oceansat-3 (ISRO), CFOSat (NSOAS/CNES)

- GOES-R AMVs

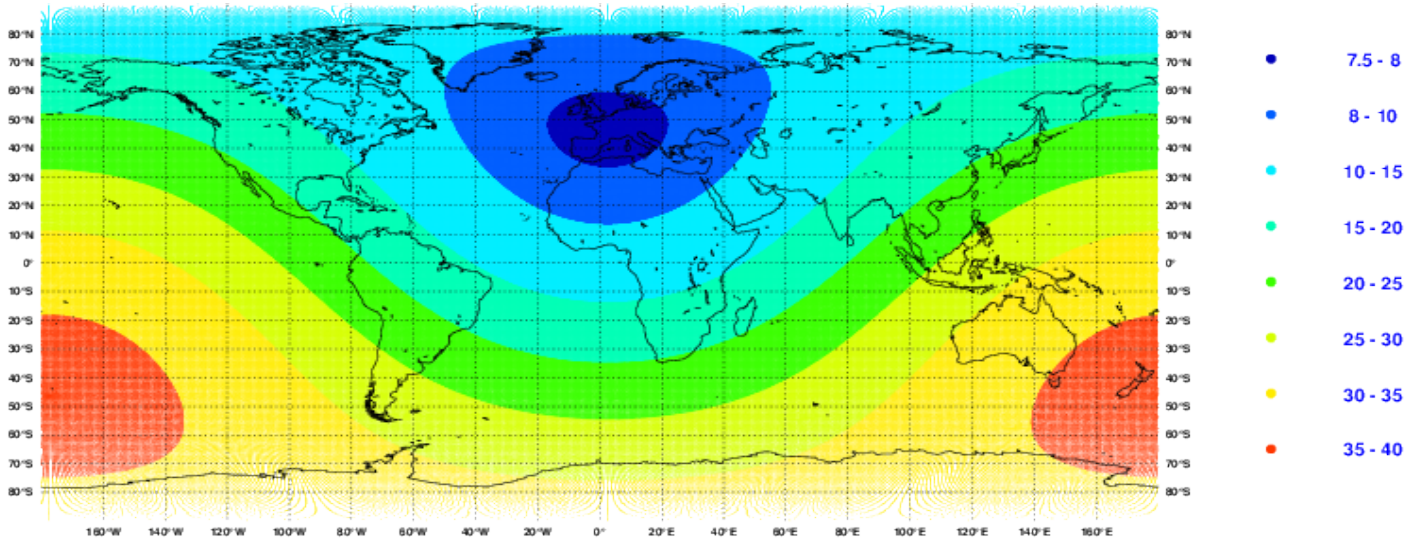
- ADM-Aeolus

Questions?

Backup slides

ARPEGE resolution upgrade (global)

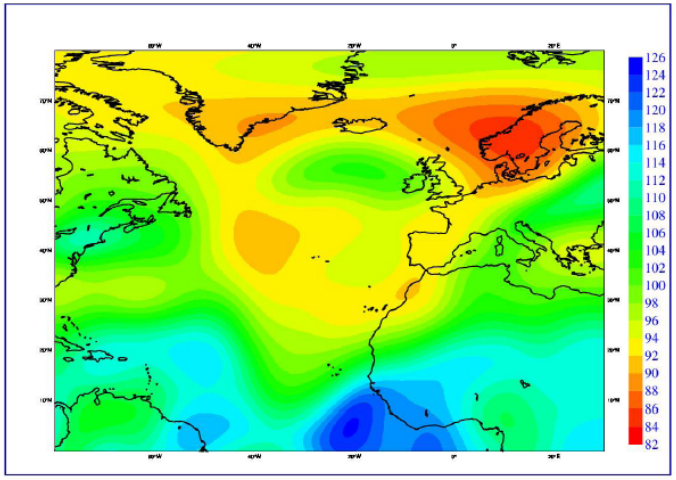
	before	APRIL 2015 after
ARPEGE	T798c2.4 (10km < Δx < 60km) L70 4DVAR 6h@window, 1h@timeslot: -T107c1 (~185km) L70, 25 iterations -T323c1 (~62km) L70, 30 iterations Fc ranges: 102 / 72 / 84 / 60 hours	T1198c2.2 (7.5km < Δx < 37km) L105 4DVAR 6h@window, 30min@timeslot: -T149c1 (~135km) L105, 40 iterations -T399c1 (~50km) L105, 40 iterations Fc ranges: 102 / 72 / 114 / 60 hours



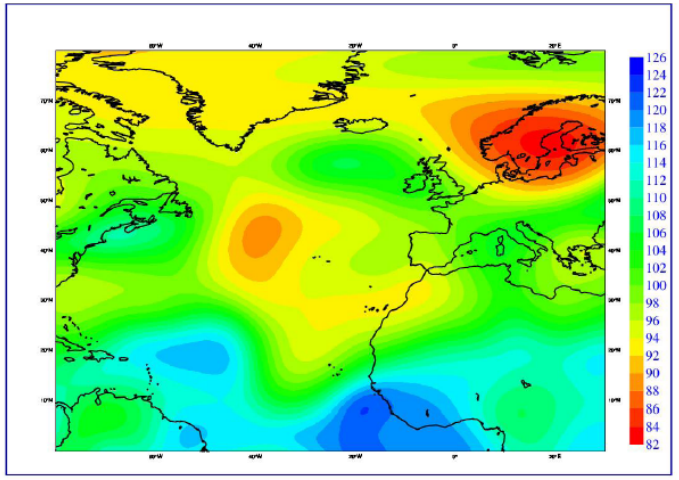
ARPEGE resolution T1198C2.2 in km

AEARP (ensemble assimilation) resolution upgrade

	APRIL 2015 before	APRIL 2015 after
AEARP	**T399c1 (~50km) L70; 6 members** **4DVAR 6h@window, 1h@timeslot:** **-T107c1 (~185km) L70, 25 iterations** **Covariances updated one time per day, averaged on 4 days**	**T479c1 (~42km) L105; 25 members** **4DVAR 6h@window, 30min@timeslot:** **-T149c1 (~135km) L105, 40 iterations** **Covariances updated every 6h, averaged on 1.5 days**



15/11/2013 à 6hTU

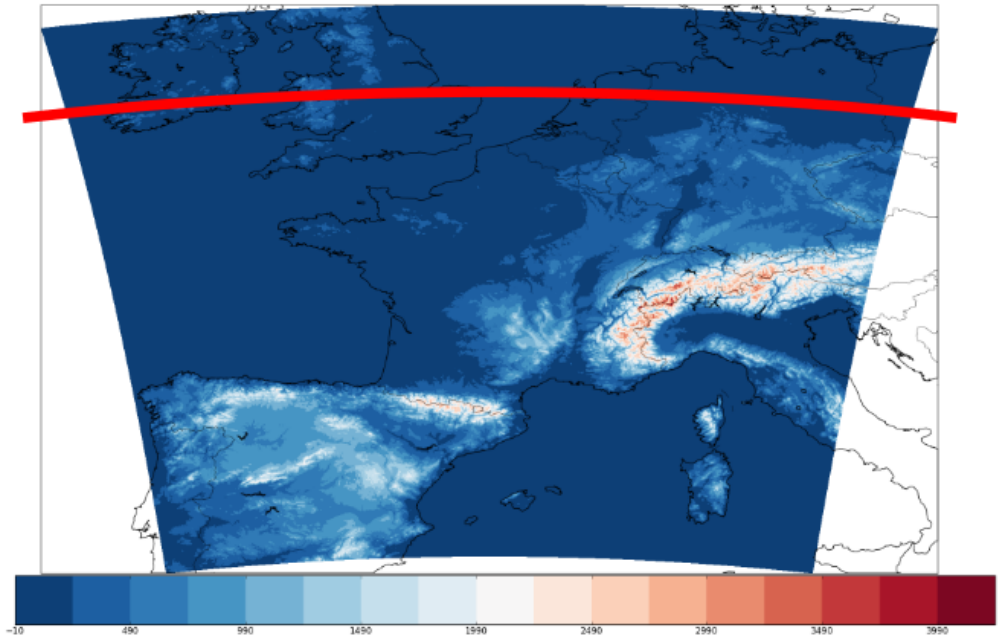


15/11/2013 à 12hTU

Length scale of forecast error correlations for the wind at 500hPa (km), in 2 consecutive assimilation windows

AROME resolution update

	APRIL 2015	
	before	after
AROME	Δx=2.5km L60 750x720 points 3DVAR 3h@window	Δx=1.3km L90 1536x1440 pts + larger area (~ +10%) 3DVAR 1h@window (~ +50% obs)



New domain AROME and its relief

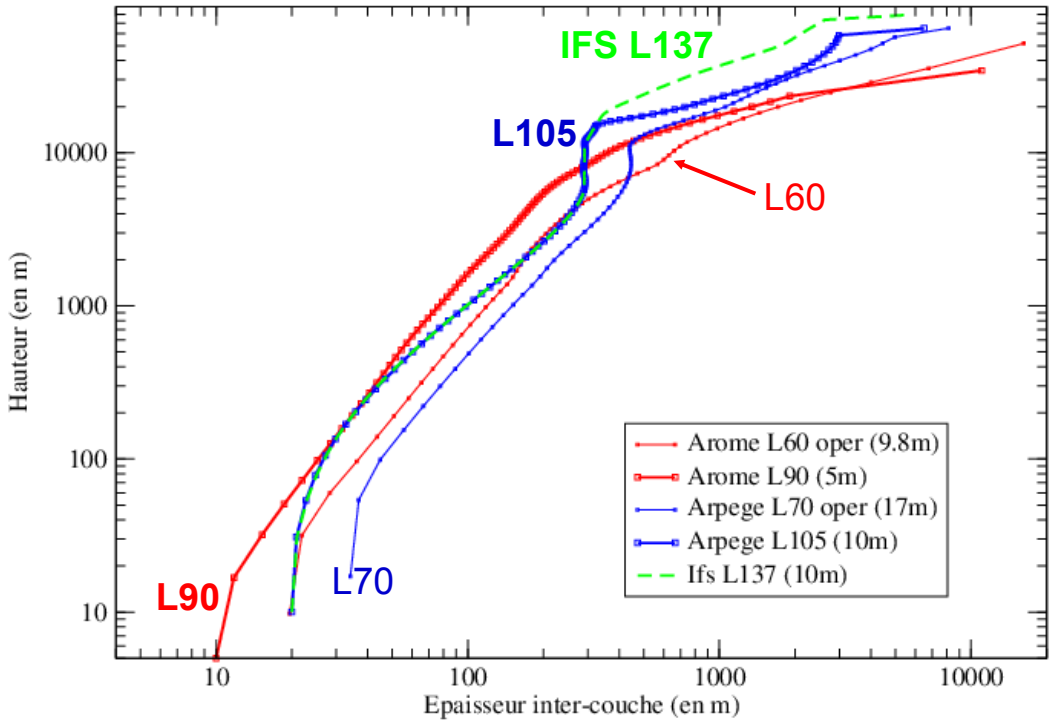
Vertical resolutions ARPEGE and AROME

ARPEGE	APRIL 2015 before	APRIL 2015 after
levels	70	105
model top	0.1hPa (~70km)	idem
lowest level	17m	10m

vertical resolution as IFS L137 <16km

AROME	APRIL 2015 before	APRIL 2015 after
levels	60	90
model top	1hPa (~50km)	10hPa (~32km)
lowest level	10m	5m

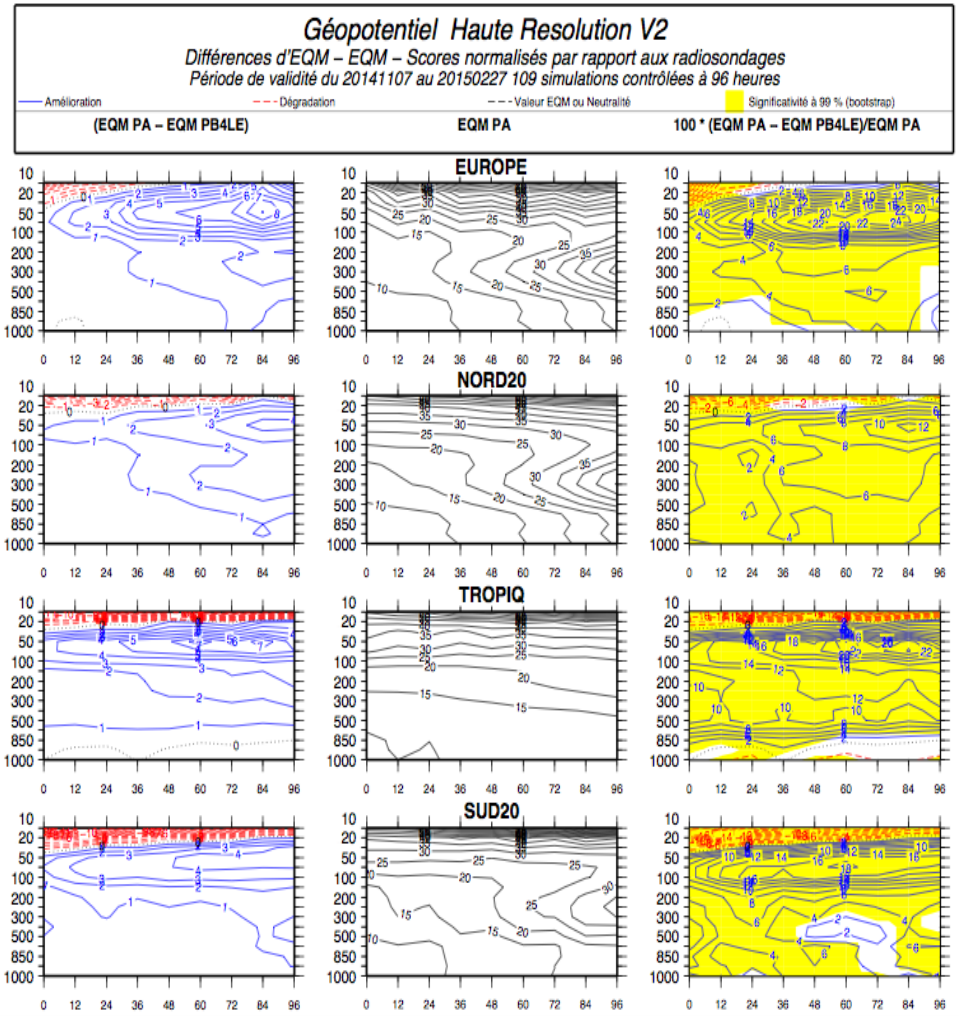
better resolution than ARPEGE L105 <10km



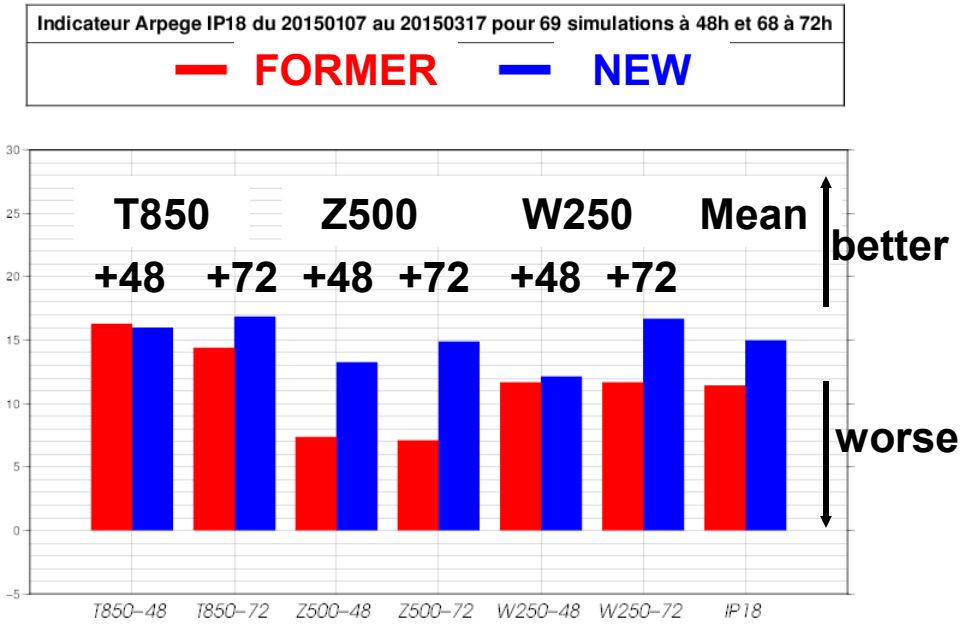
Layer thickness function of altitude (m)

ARPEGE forecast scores: NEW versus FORMER

ARPEGE RMS forecast score to radiosondes on the geopotential:



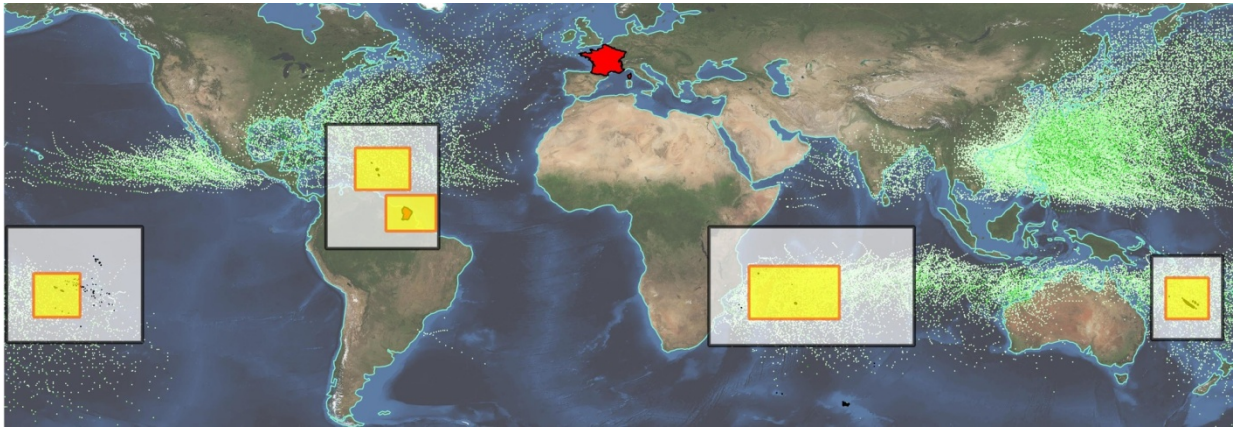
ARPEGE ‘’NWP’’ index:



Index based on the RMS forecast scores against radiosondes on 3 parameters at +48h and +72h over Europe

ALADIN-OM (overseas)

Overseas domains:



Current (ALADIN)

AROME replacement planned in 2016

- ALADIN-OM replacement by AROME-OM versions in 2016 (ongoing)
- Smaller domains but with a 2.5km grid (8km in ALADIN)
- Without assimilation (2nd step)