

MÉTÉO-FRANCE STATUS

RECENT OPERATIONAL CHANGES AND SHORT TERM PLANS

26TH NAEDEX AND 14TH APSDEU DATA EXCHANGE
MEETINGS

MONTRÉAL (CANADA) – 6 OCTOBER 2015



J.-F. MAHFOUF (and many colleagues)

Outline

- Computing platform
- Model configurations
- Use of observations
- Recent operational changes
- Ongoing developments and future plans

Recent changes at Météo-France

3

- New HPC computers at Météo-France since mid-2013 : **BULLX 710DLC**
- Two clusters (research and operations)
- About 50 000 Intel processors (Ivy Bridge) – 1 Pflops (peak performance)

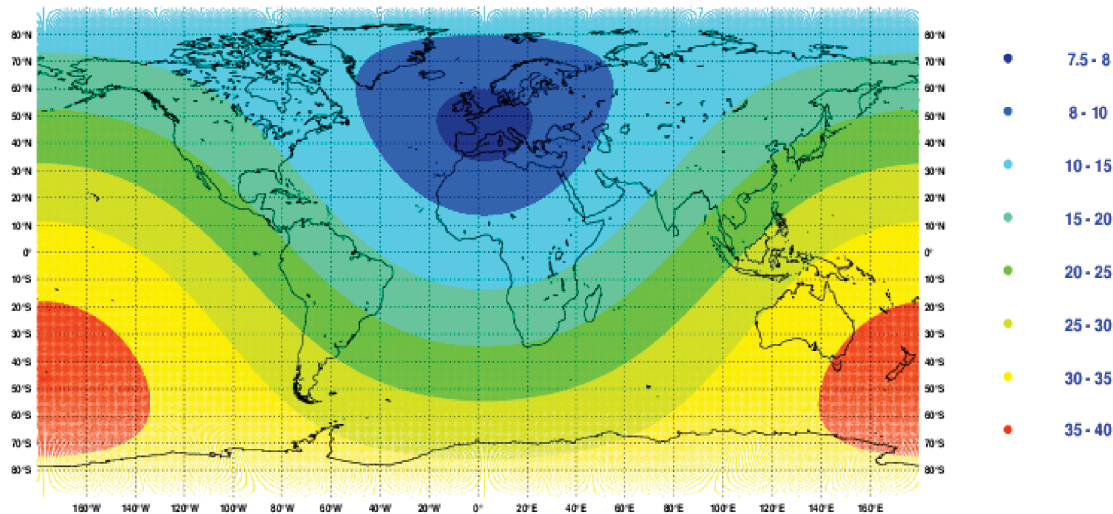


14 January 2014 : Migration of the Numerical Weather Prediction (NWP) suites on the new HPC

13 April 2015 : Significant upgrade of the NWP suites : increases in horizontal and vertical resolutions of the models + changes to the data assimilation systems + more observations

Global model ARPEGE

Spectral model with variable resolution : $T_L1198c2.2L105$
 (resolution from 7.5 km to 36 km, 105 levels from 10 m to 0.1 hPa)
 Forecasts up to 104 hours



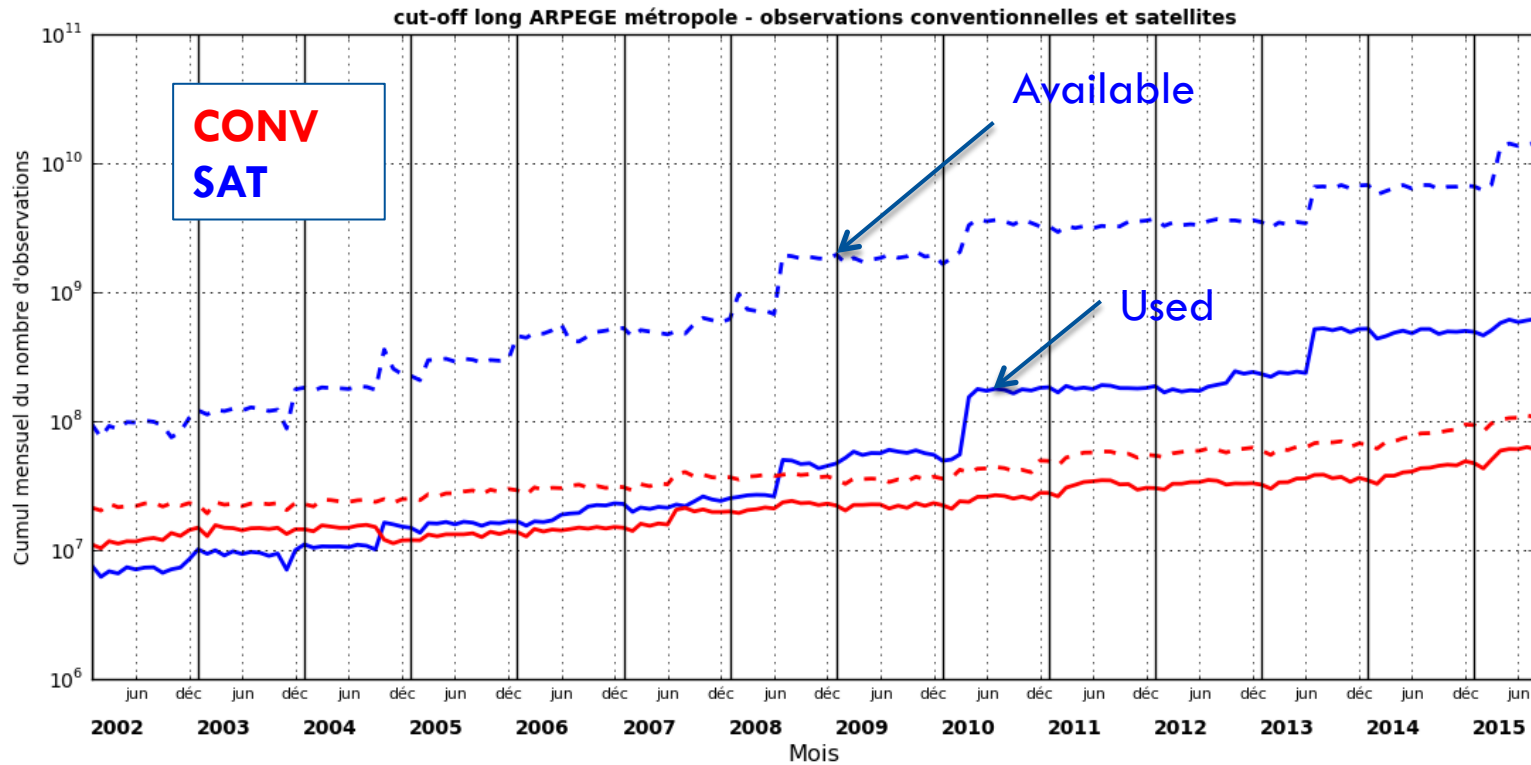
Previous configuration:
 $T_L798c2.4L70$
 4D-Var 1 hour time slots
 Minimisation (25/25)
 EDA : 6 members

4D-Var assimilation (6-h window and 30 min time-slots) :

- 2 loops of minimization : $T_L149c1L105$ (40 iterations) + $T_L399c1L105$ (40 iterations)
- Background error variances and correlation lengths from an Ensemble Data Assimilation system (4D-Var at lower resolution: T_L479/T_L149) with 25 members

Observations in ARPEGE 4D-Var

Evolution des cumuls mensuels de nombre d'observations disponibles et utilisées pour l'analyse



Sounding radiance usage

Satellite	HIRS	AMSU-A ATMS	AMSU-B/MHS ATMS	AIRS/IASI/ CriS
NOAA15	✗	✓	✗	⊖
NOAA18	✗	✓	✓	⊖
NOAA19	✗	✓	✓	⊖
AQUA	⊖	✓	⊖	✓
MetOp-A	✓	✓	✓	✓
MetOp-B	✗	✓	✓	✓
Suomi-NPP	⊖	✓	✓	✓

⊖ : not relevant

✗ : not available

✗ : received but blacklisted

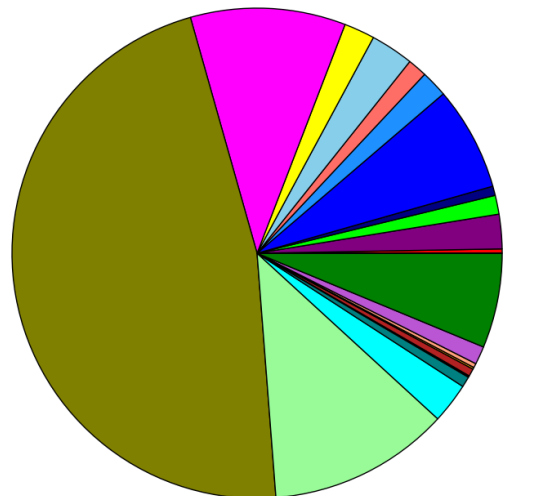
✓ : used

Local acquisitions

- Lannion
- EARS
- RARS

Information content in ARPEGE

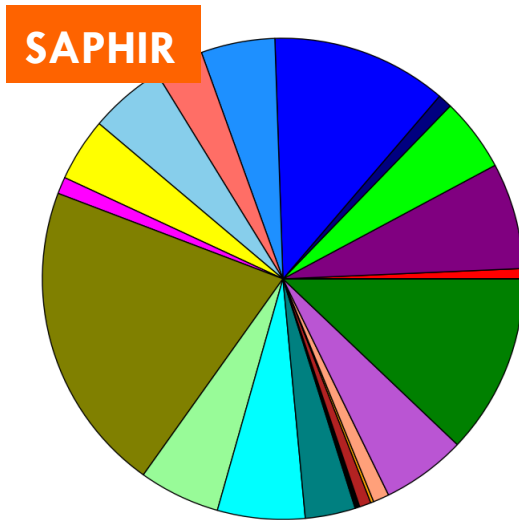
cumul du nom



GPS ground	0.28%	SSMIS	2.03%	SHIP	0.12%
GPS sat	2.27%	AIRS	10.23%	PILOT/PRF	0.28%
SATOB	1.24%	IASI	46.84%	TEMP	1.19%
ATOVS HIRS	0.62%	CRIS	11.96%	AIRCRAFTS	6.25%
ATOVS AMSU-A	6.86%	GEORAD	2.66%	RADAR Vr	0.00%
ATOVS AMSU-B	1.76%	SCATT	0.70%	RADAR Hur	0.00%
SAPHIR	1.27%	BUOY	0.10%	BOGUS	0.00%
ATMS	2.84%	SYNOP/SYNOR/RADOME	0.50%		

After
04/2015

IASI
AIRS
CRIS
ATMS
ATOVS
GPS-RO
AIRCRAFTS

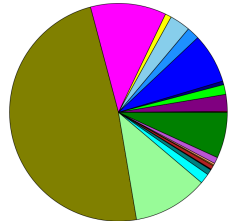


GPS ground	0.69%	SSMIS	4.25%	SHIP	0.20%
GPS sat	7.14%	AIRS	1.13%	PILOT/PRF	1.08%
SATOB	4.94%	IASI	20.93%	TEMP	5.67%
ATOVS HIRS	0.96%	CRIS	5.45%	AIRCRAFTS	12.10%
ATOVS AMSU-A	11.81%	GEORAD	5.88%	RADAR Vr	0.00%
ATOVS AMSU-B	4.96%	SCATT	3.37%	RADAR Hur	0.00%
SAPHIR	3.27%	BUOY	0.33%	BOGUS	0.00%
ATMS	5.07%	SYNOP/SYNOR/RADOME	0.78%		

Proportions des nombres d'observations utilisées par type de données
analysées en cas d'usage "ARPEGE météorologie opérationnelle"
observations conventionnelles et satellites
cumul du nombre d'observations utilisées sur la période 2015021300 - 2015021310 : 17800300

Part des DFS par type d'obs
analysées en cas d'usage "ARPEGE météorologie opérationnelle"
observations conventionnelles et satellites
cumul du DFS sur la période 2015021300 - 2015021310 : 233984

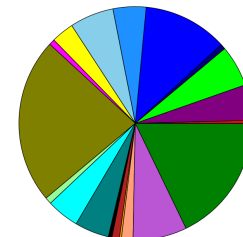
Number of
observations



GPS ground	0.11%	SSMIS	4.14%	SHIP	0.11%
GPS sat	2.10%	AIRS	11.20%	PILOT/PRF	0.24%
SATOB	1.14%	IASI	46.84%	TEMP	0.93%
ATOVS HIRS	0.62%	CRIS	11.96%	AIRCRAFTS	6.25%
ATOVS AMSU-A	6.86%	GEORAD	2.66%	RADAR Vr	0.00%
ATOVS AMSU-B	1.76%	SCATT	0.70%	RADAR Hur	0.00%
SAPHIR	1.27%	BUOY	0.10%	BOGUS	0.00%
ATMS	2.84%	SYNOP/SYNOR/RADOME	0.50%		

Before
04/2015

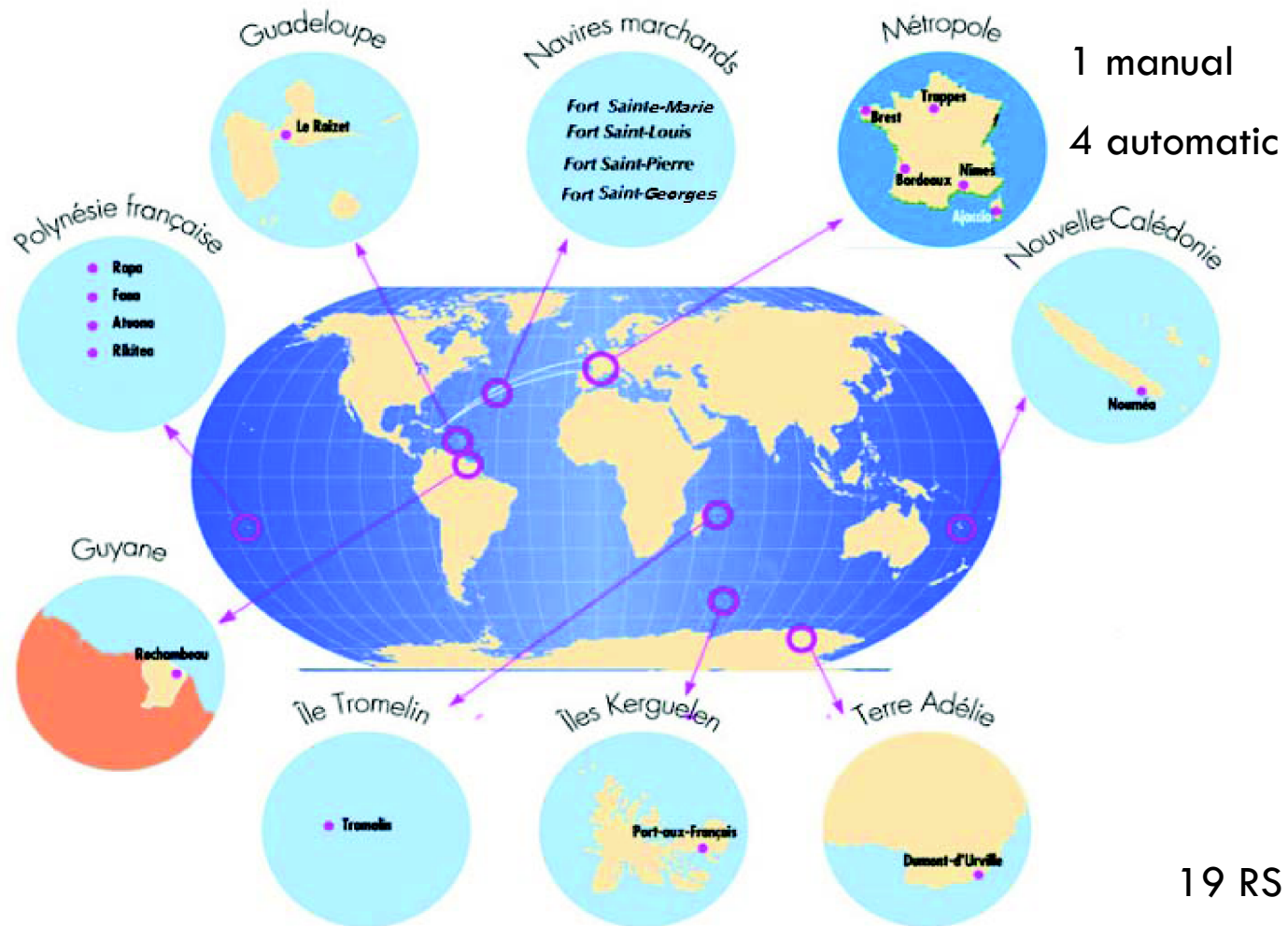
Information
content
DFS = $\text{Tr}(I - AB^{-1})$



GPS ground	0.69%	SSMIS	4.25%	SHIP	0.20%
GPS sat	7.14%	AIRS	1.13%	PILOT/PRF	1.08%
SATOB	4.94%	IASI	20.93%	TEMP	5.67%
ATOVS HIRS	0.96%	CRIS	5.45%	AIRCRAFTS	12.10%
ATOVS AMSU-A	11.81%	GEORAD	5.88%	RADAR Vr	0.00%
ATOVS AMSU-B	4.96%	SCATT	3.37%	RADAR Hur	0.00%
SAPHIR	3.27%	BUOY	0.33%	BOGUS	0.00%
ATMS	5.07%	SYNOP/SYNOR/RADOME	0.78%		

The MF upper air network (2015)

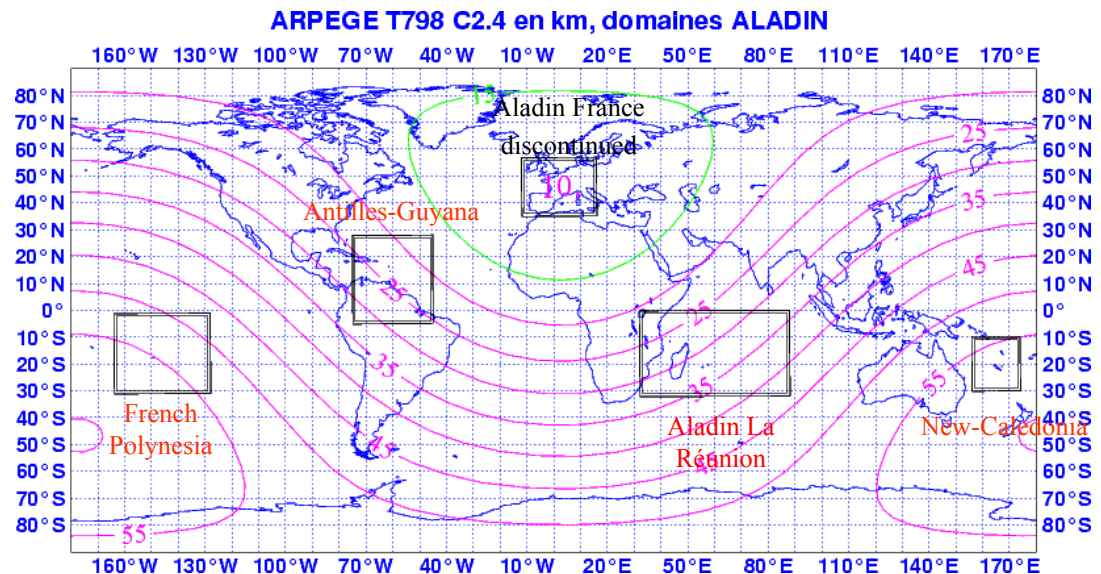
EUMETNET-ASAP



19 RS

Regional models ALADIN

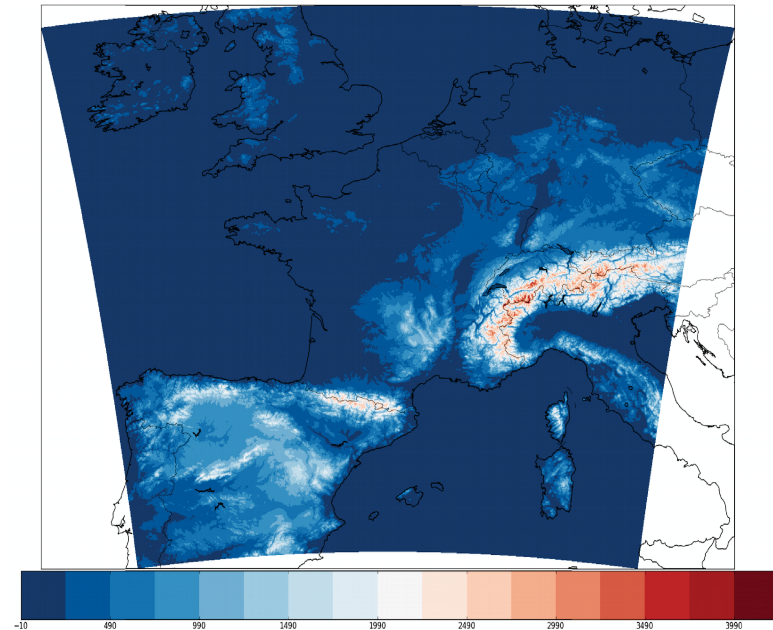
- Spectral limited area model : E199x199L70
 - 105 levels from 10 m to 0.1 hPa, horizontal resolution 7.5 km
- 3D-Var assimilation (6h window) :
 - Same data as ARPEGE plus wind bogus
- Current operational domains :



Forecast range up to 84 hours

Regional model AROME

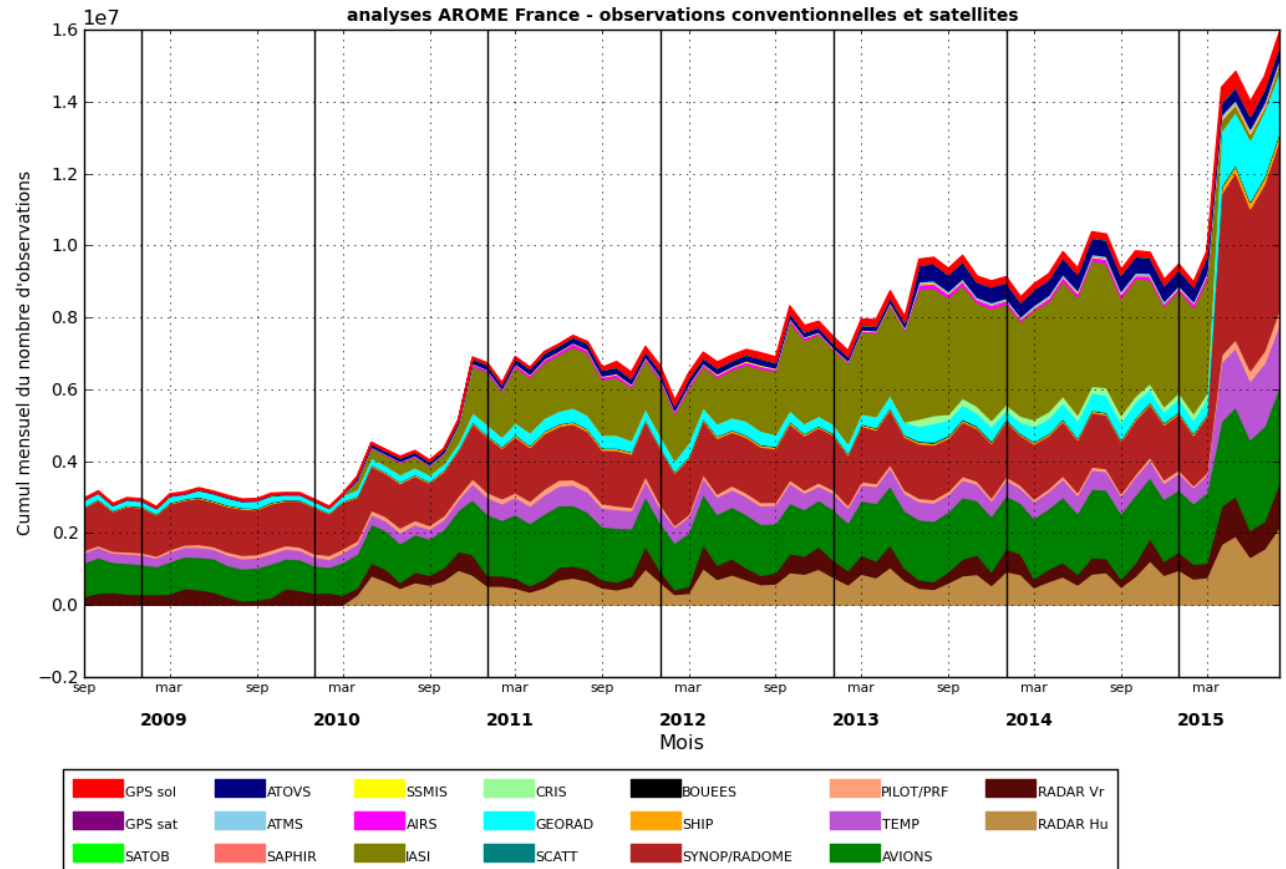
- Spectral limited area non-hydrostatic model with explicit moist convection (since 12/2008)
- Horizontal resolution : 1.3 km
- 90 vertical levels (from 5 m up to 10 hPa)
- 3D-Var assimilation (1-h window)
- Observing system : same as ARPEGE (+) 5 SEVIRI/MSG radiances (with Ts inversion) (+) radar DOW and Z (RH) (-) GNSS RO (+) IR and MW sounders with a different set of channels
- Coupling files : hourly forecasts from global model ARPEGE
- Forecast range : up to 42 hours



Previous configuration:
2.5 km resol. and L60 top at 1 hPa
3D-Var with 3-h assimilation window

Observations in AROME 3D-Var

Evolution des cumuls mensuels de nombre d'observations utilisées par type d'observation

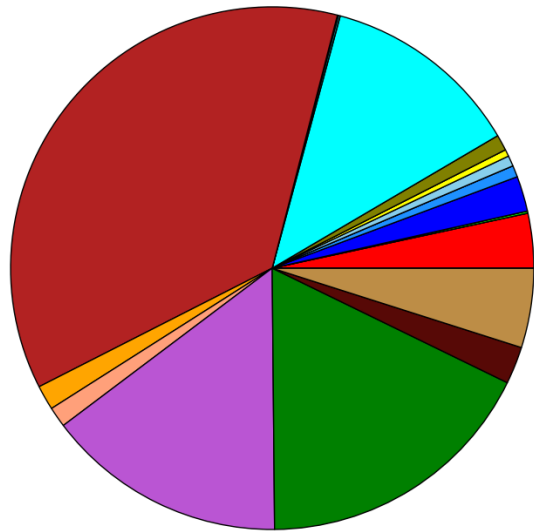


IASI
 AIRCRAFTS
 SURFACE
 RADARS
 SEVIRI
 ATOVS
 TEMP

Number of observations in AROME

Proportions des nombres d'observations utilisées par type d'obs
analyses cut-off AROME - AROME France dbf
observations conventionnelles et satellites

cumul du nombre d'observations utilisées sur la période 2015032300 - 2015032323 : 428623

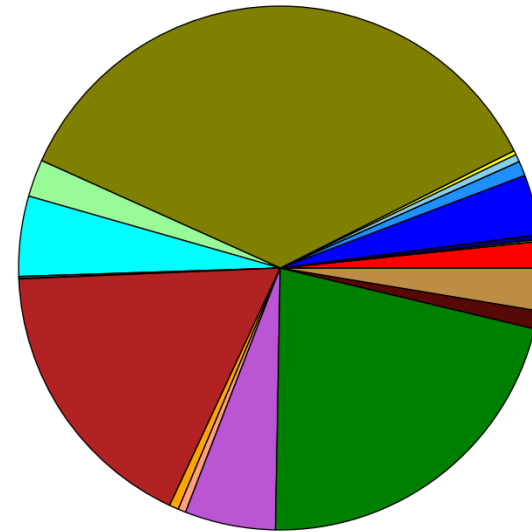


GPS ground	3.38%	SSMIS	0.43%	SHIP	1.53%
GPS sat	0.00%	AIRS	0.00%	PILOT/PRF	1.26%
SATOB	0.14%	IASI	0.98%	TEMP	14.86%
ATOVS HIRS	0.00%	CRIS	0.00%	AIRCRAFTS	17.63%
ATOVS AMSU-A	2.18%	GEORAD	12.35%	RADAR Vr	2.31%
ATOVS AMSU-B	0.72%	SCATT	0.13%	RADAR Hur	4.91%
SAPHIR	0.00%	BUOY	0.05%	BOGUS	0.00%
ATMS	0.65%	SYNOP/SYNOR/RADOME	36.51%		

Since 04/2015

Proportions des nombres d'observations utilisées par type d'obs
analyses cut-off AROME - AROME France oper
observations conventionnelles et satellites

cumul du nombre d'observations utilisées sur la période 2015032300 - 2015032321 : 289162



GPS ground	1.63%	SSMIS	0.26%	SHIP	0.57%
GPS sat	0.00%	AIRS	0.00%	PILOT/PRF	0.48%
SATOB	0.11%	IASI	35.88%	TEMP	5.60%
ATOVS HIRS	0.30%	CRIS	2.30%	AIRCRAFTS	21.56%
ATOVS AMSU-A	3.71%	GEORAD	4.94%	RADAR Vr	1.12%
ATOVS AMSU-B	0.90%	SCATT	0.13%	RADAR Hur	2.61%
SAPHIR	0.00%	BUOY	0.02%	BOGUS	0.00%
ATMS	0.47%	SYNOP/SYNOR/RADOME	17.39%		

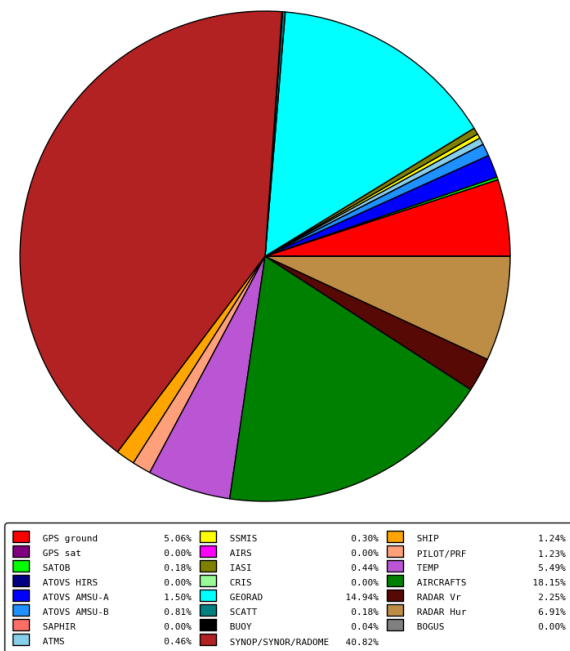
Before 04/2015

Dry day => few radars

Information content in AROME

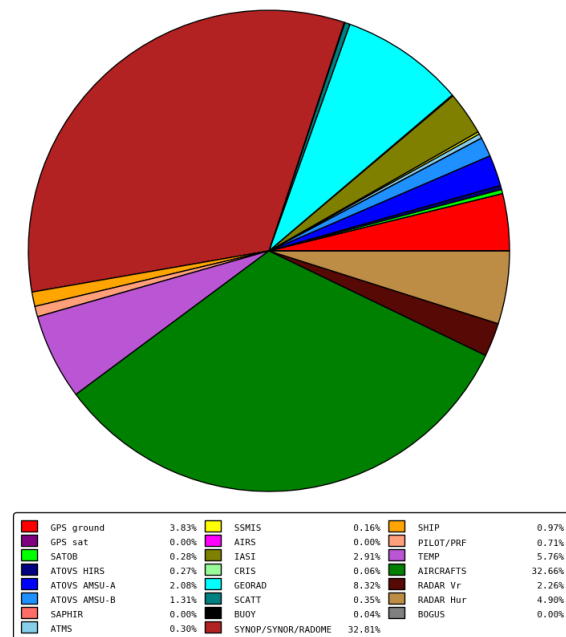
13

Part des DFS par type d'obs
analyses cut-off AROME - AROME France dbl
observations conventionnelles et satellites
cumul du DFS sur la période 2015032300 - 2015032323 : 140630



Since 04/2015

Part des DFS par type d'obs
analyses cut-off AROME - AROME France oper
observations conventionnelles et satellites
cumul du DFS sur la période 2015032300 - 2015032321 : 90222



Before 04/2015

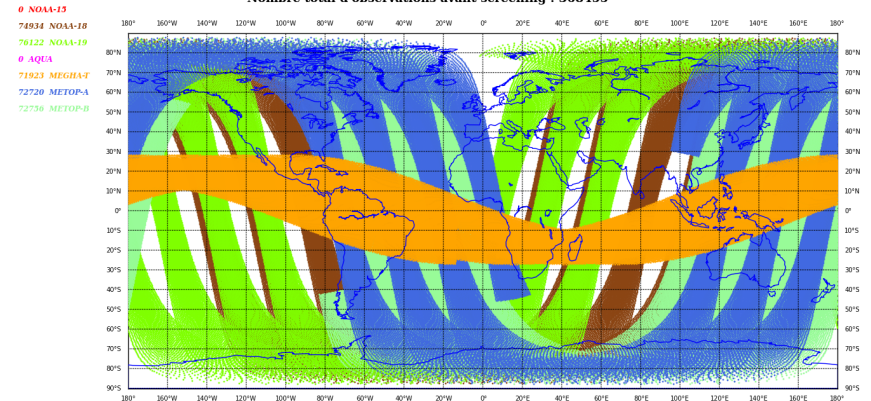
Dry day => few radars

Recent scientific changes (1)

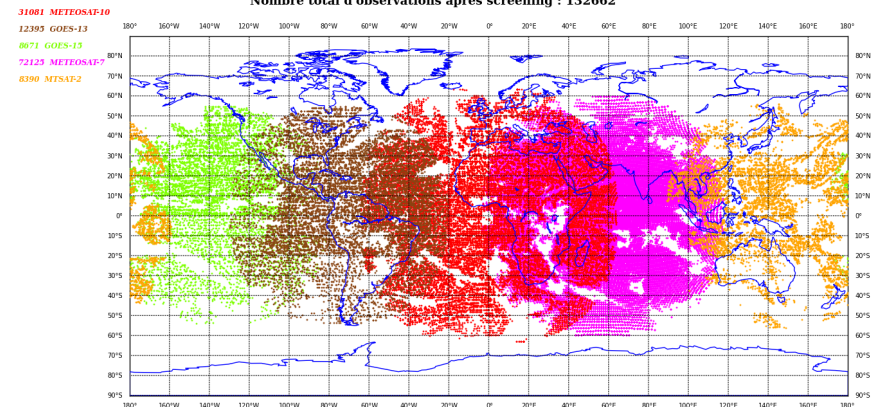
- ARPEGE 4D-Var assimilation : 6-h assimilation window with 30 minute time-slots (instead of 1 hour) => more observations for IASI, AMSU-A, AMSU-B/MHS, profilers, surface, ground based GPS

- Satellite observations (ARPEGE / ALADINs) - New instruments :
 - **SAPHIR**: microwave humidity sounder (AMSU-B/MHS like instrument with 6 channels) on board MEGHA-TROPIQUES (CNES/ISRO)
 - **Tandem-X**: GPS-RO instrument (similar to TerraSar-X)
 - Clear-sky radiances (1 WV channel) from geostationary satellites : **METEOSAT-7**, **MTSAT-2**

METEO-FRANCE couverture de donnees - ATOVS AMSU-B - 2015/04/05 00H UTC cut-off long
 Nombre total d'observations avant screening : 368455



METEO-FRANCE couverture de donnees - CSR - 2015/04/05 00H UTC cut-off long
 Nombre total d'observations apres screening : 132662

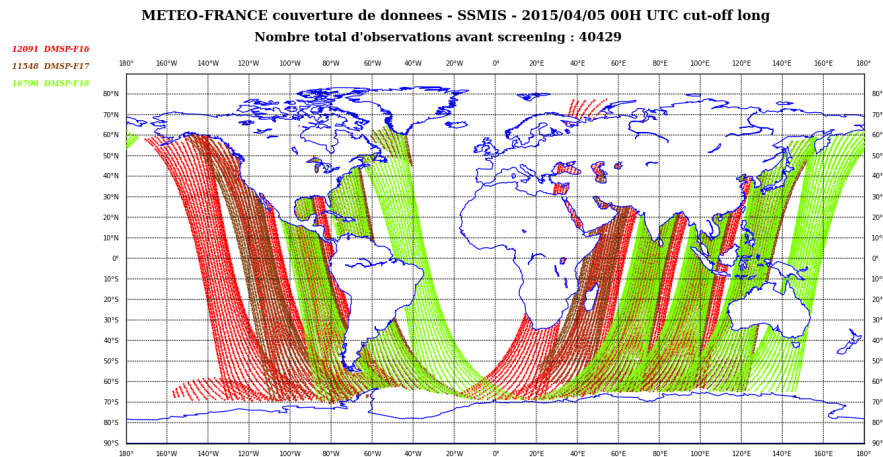


Recent scientific changes (2)

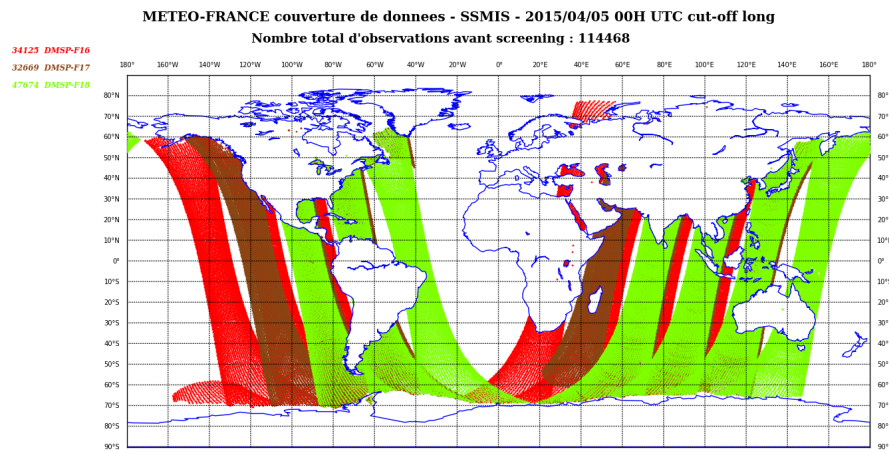
□ Satellite observations (ARPEGE / ALADINs)

- Increased usage of existing instruments :

- Input to the « screening » : radiances x 2 => 10 % more for assimilation
- SSMI/S : data thinning at 125 km (instead of 175 km), sounding channels (55 and 183 GHz) from F17 and F18 (with a new predictor for VarBC)
- Additional channels from IR hyperspectral sounders: CrIS/NPP (over sea and land, with revised σ_0) and IASI/METOP-A and B



ARPEGE oper



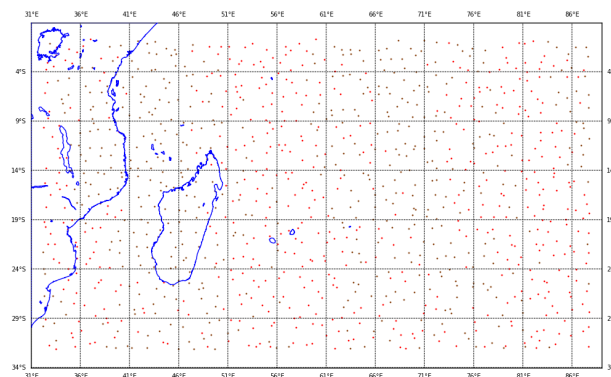
ARPEGE dbi

Recent scientific changes (3)

- Satellite observations (ARPEGE / ALADINs) - Increased usage of existing instruments :
 - Use of GPS-RO bending angles up to 50 km (instead of 46 km) with revised σ_0
 - Additional ATMS radiances at the edge of scan lines
 - Thinning of IASI radiances at 70 km in ALADIN models (instead of 125 km)
 - Early delivery data : ATMS and CriS from Lannion, EARS ASCAT from METOP-B, RARS ATOVS from METOP-B (important for AROME nowcasting with 10 min cut-off)
- Monitoring of new observations : Dual METOP winds + AMVs from METOP-B
- Ground based GPS : additional stations and processing centres (NOAA, METG, IGE2)

METEO-FRANCE couverture de donnees - IASI - 2015/04/04 18H UTC cut-off long
Nombre total d'observations apres screening : 1097

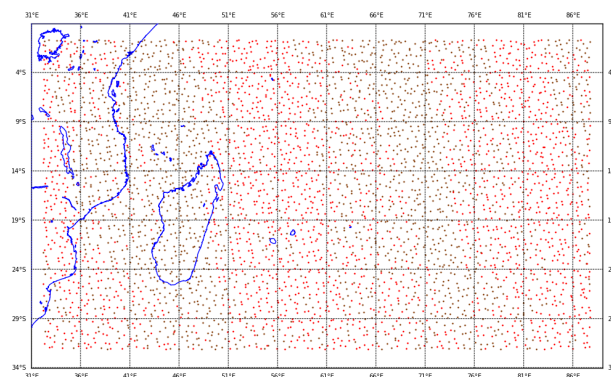
566 METOP-A
531 METOP-B



ALADIN Reunion oper

METEO-FRANCE couverture de donnees - IASI - 2015/04/04 18H UTC cut-off long
Nombre total d'observations apres screening : 4288

2218 METOP-A
2070 METOP-B



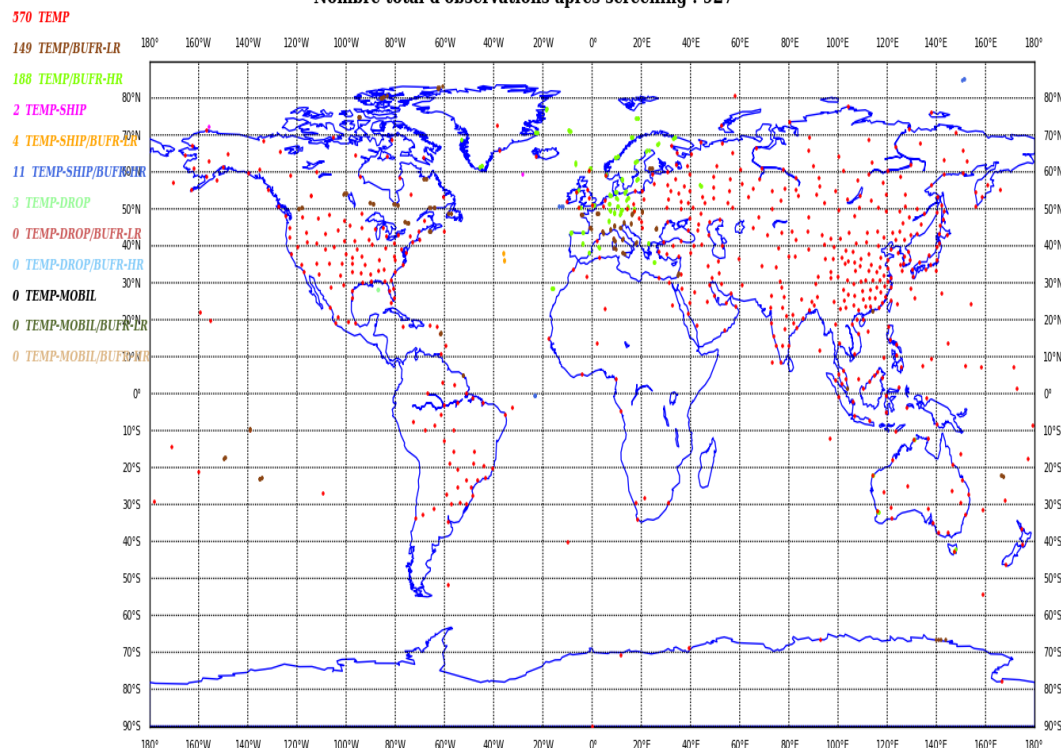
ALADIN Reunion dbl

Technical changes (TAC2BUFR)

- Use of SYNOP Land data in BUFR format since 04/11/2014 in all operational DA systems
- Use of aircraft data in BUFR format to accommodate the E-AMDR changes in Nov. 2014 (New BUFR WIGOS template)
- Preparation to the use of radiosounding in BUFR format:
 - ▣ Additional information: space and time location of the measurement during the ascent, more measurement points (up to 4000) – thinning at $\Delta z=75$ m
 - ▣ Difficulty : need to accommodate the diversity of messages (TEMP ASCII, BUFR LR, BUFR HR) => possible duplications

METEO-FRANCE couverture de donnees - TEMP - 2015/09/24 00H UTC cut-off long

Nombre total d'observations apres screening : 927



ARPEGE oper

TAC (ASCII) – BUFR LR – BUFR HR

Planned short term evolutions (1)

18

- Increased thinning of radar data in AROME : 8 km (instead of 15 km) with a revised tuning of the Bayesian inversion
- Use of RTTOV-11 with internal interpolation (54/101 levels)
- Assimilation of ocean surface winds from RapidScat/ISS (Ku band scatterometer)
- Assimilation of HIMAWARI-8 AMVs (x4) (and CSRs)
- Assimilation of 5 WV channels from CrIS
- Use of oceanic observations in BUFR format (BUOY, BATHY, TESAC) depending on availability from data producers
- Monitoring of GMI/GPM-Core radiances (very short timeliness !)
- Use of IASI radiances available from the GTS (500 channels)
- Use of « OSI SAF » sea-ice concentration product instead of in-house algorithm based on SSM/I F15 radiances

Planned short-term evolutions (2)

19

- New NWP suites for ARPEGE, AROME, ALADINs, AEARP, PEARP with CY41T1 : operational by the end 2015
- Nowcasting version of AROME (3D-Var with 1-hour assimilation but no cycling) : operational by the end of 2015
- Upgrade of Météo-France HPCs : 1st quarter of 2016 then 3rd quarter of 2016 (CPU power increase : x 3)
- Ensemble Prediction system at convective scale (PEARO)
- Replacement of ALADIN-OMs models by AROME-OMs : finer resolution (8 km -> 2.5 km) but smaller domains
- *Involvement in code developments with ECMWF : OOPS project (data assimilation) and COPE (observation pre-processing)*

Planned for 2016

Longer term evolutions

20

- ❑ Preparation to the use of radar data from OPERA : use of a specific decoder to read ODIM/HDF5 and ODIM/BUFR – issue on the availability of raw reflectivities from data producers for QC (Z+DOW from NL, GB, D, B)
- ❑ Assimilation of MODE-S data in AROME (ftp site from KNMI)
- ❑ New instruments: SSMI/S DMSP F19 (need for data from UPP), MWTS/MWHS on FY-3C (EUMETCast), DPR on GPM Core (validation), Ku band scatterometer on HY-2A (timeliness issues), ADM-Aeolus (need for NRT HLOS from L2B processor)
- ❑ Additional RARS stations : South America (quality to be assessed)
- ❑ Use of VarBC for ground based GPS and aircraft measurements
- ❑ Satellite products for land data assimilation : ASCAT, SMOS, SMAP soil moisture
- ❑ Preparation to the use new hyperspectral IR instruments (MTG/IRS and IASI-NG/EPS-SG) : radiances in principal components and inter-channel error correlations
- ❑ IR radiances over land + IR and MW all-sky radiances

References to recent papers

21

- **Assimilation of radar data in AROME** : Wattrelot E., O. Caumont, and J.-F. Mahfouf, 2014: Operational implementation of the 1D+3D-Var assimilation method of radar reflectivity data in the AROME Model. *Mon. Wea. Rev.*, **142**, 1852–1873.
- **Assimilation of SAPHIR data in ARPEGE** : P. Chambon, L.-F. Meunier, F. Guillaume, J.-M. Piriou, R. Roca and J.-F. Mahfouf (2014) : Investigating the impact of the water-vapour sounding observations from SAPHIR on board Megha-Tropiques for the ARPEGE global model, *Quart. J. Roy . Meteor. Soc.*, DOI: 10.1002/qj.2478
- **FSO impact study during CONCORDIASI** : N. Boullot, F. Rabier, R. Langland, R. Gelaro, C. Cardinali, V. Guidard, P. Bauer and A. Doerenbecher, 2014: Observation impact over the southern polar area during the Concordiasi field campaign. *Quart. J. Roy . Meteor. Soc.*, DOI: 10.1002/qj.2470
- **Impact study on assimilation of GPS ZTD in AROME**: Mahfouf, J.-F., F. Ahmed, P Moll and N.F. Terfele, 2015: Assimilation of zenith total delays in the AROME France convective scale model: a recent assessment. *Tellus A*, **67**, DOI: 10.3402/tellusa.v67.21016
- **Description of the near-real time 3D-Var AROME-WMED system during HYMEX** : Fourrié, N., Bresson, É., Nuret, M., Jany, C., Brousseau, P., Doerenbecher, A., Kreitz, M., Nuissier, O., Sevault, E., Bénichou, H., Amodei, M., and Pouponneau, F.: AROME-WMED, a real-time mesoscale model designed for the HyMeX Special Observation Periods, *Geosci. Model Dev. Discuss.*, **8**, 1801-1856, doi:10.5194/gmdd-8-1801-2015, 2015.

Observation usage summary

Datatype	Contact	Operations	Tests
AMSU/MHS ATMS/SAPHIR	<i>Florian.suzat@meteo.fr philippe.chambon@meteo.fr</i>	NOAA 15,18,19, NPP Aqua Metop	GMI
SSMI/S	<i>Florian.suzat@meteo.fr</i>	F16, F17, F18	F19
Geosat. winds	<i>christophe.payan@meteo.fr</i>	GOES, Meteosat, MTSAT	HIMAWARI-8
Polar winds	<i>christophe.payan@meteo.fr</i>	AVHRR/NOAA MODIS/Aqua, Terra	Dual METOP VIIRS-NPP
Winds : active instruments	<i>christophe.payan@meteo.fr</i>	ASCAT	RapidScat/ISS ADM-AEOLUS
Geosat radiances	<i>patrick.moll@meteo.fr</i>	Meteosat-10, 7 GOES 13, 15, MTSAT-2	HIMAWARI-8
GPS	<i>patrick.moll@meteo.fr</i>	ZTD RO	VarBC
AIRS/IASI CrIS	<i>nadia.fourrie@meteo.fr vincent.guidard@meteo.fr</i>	Aqua, Metop-A and B, Suomi NPP	More channels PC scores

THANK YOU FOR YOUR
ATTENTION !

