



# Status of satellite winds use in the Météo-France NWP system

---

Christophe Payan

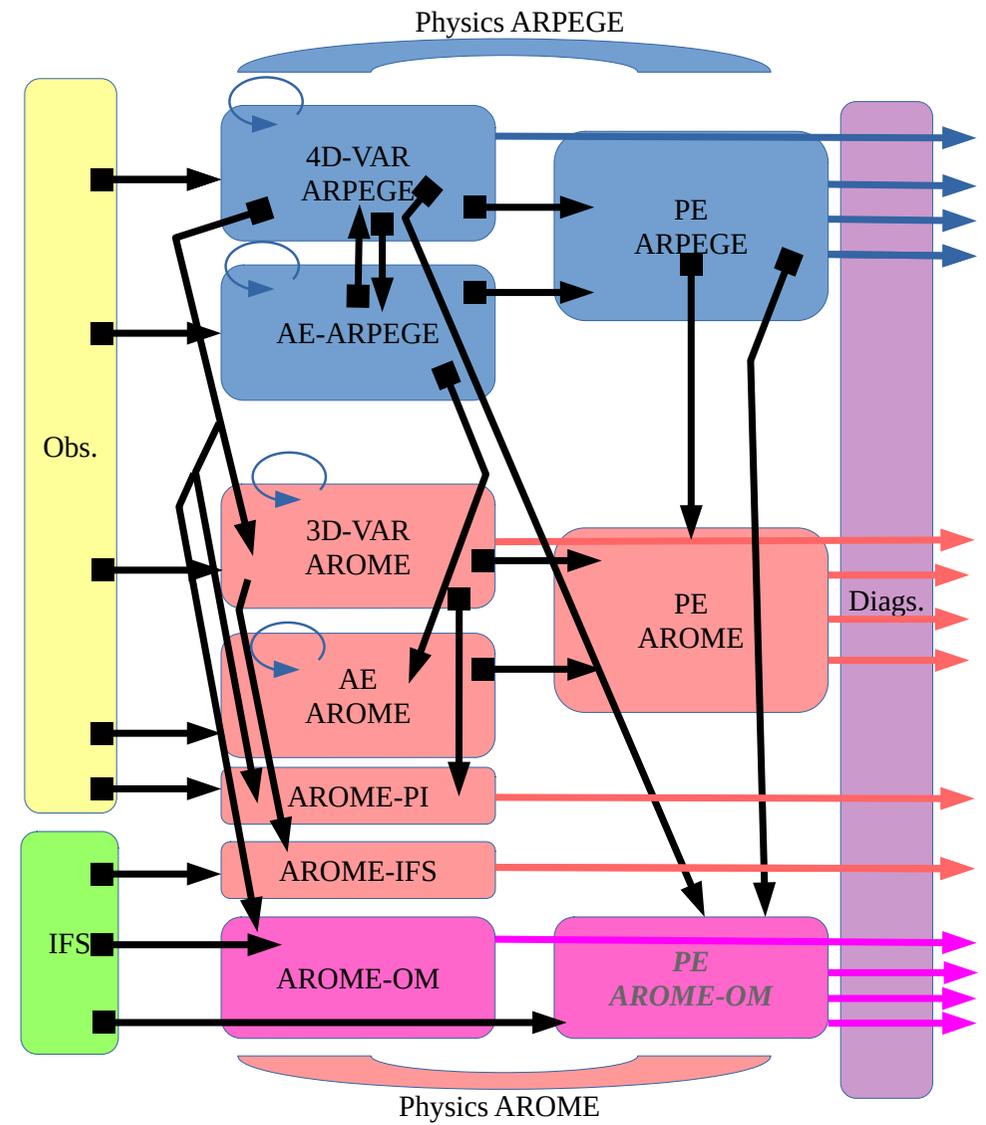
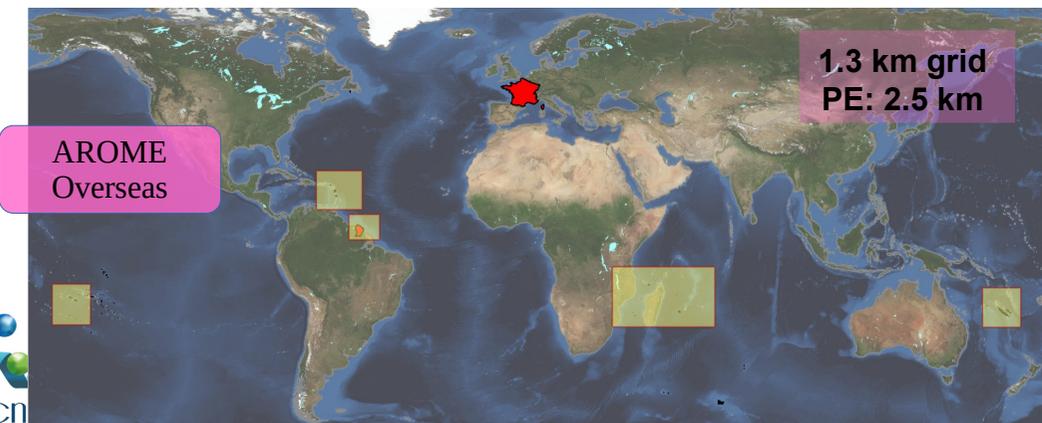
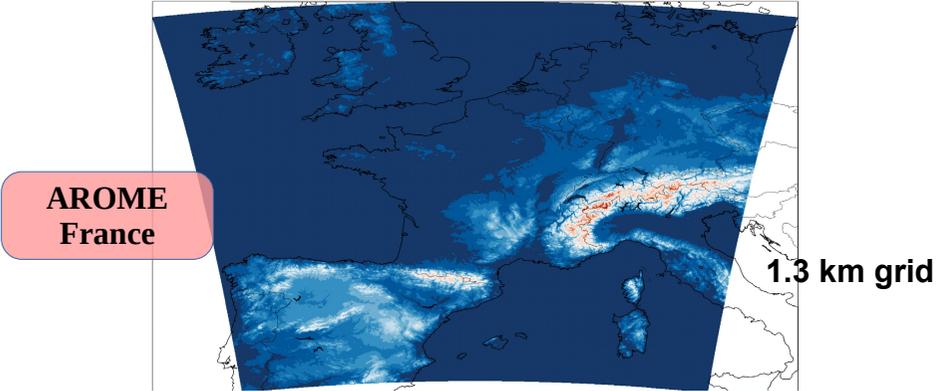
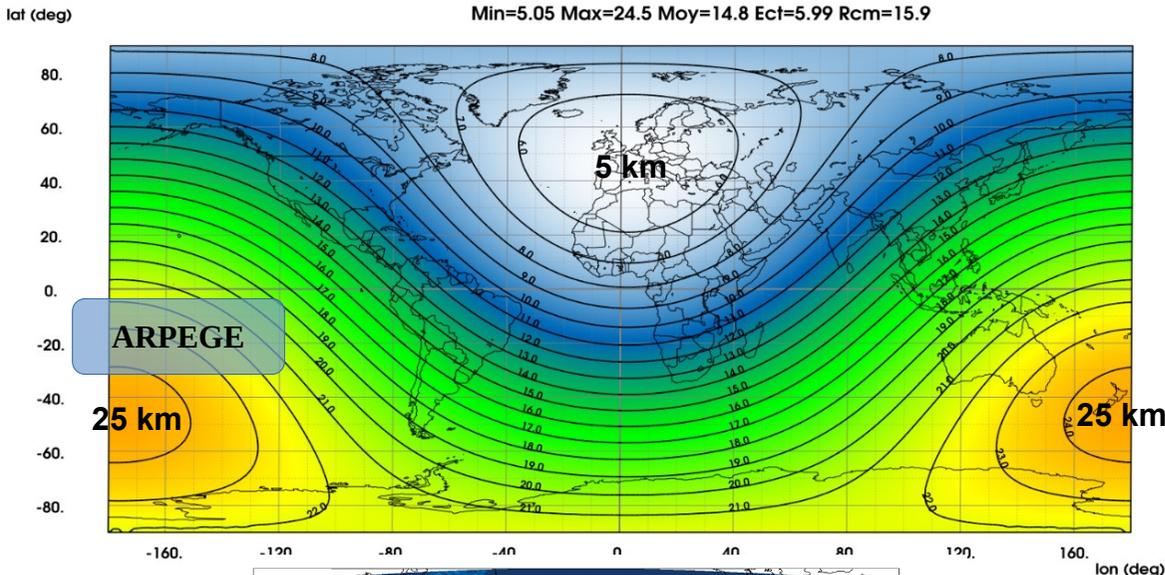
CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France

# Outline

---

- The NWP configuration
- Scatterometer upgrade
- AMV upgrade
- Summary

# Operational NWP system



# Last upgrade on 29/06/2022

## Major changes regarding the global model (ARPEGE) :

	<i>previous (version CY43T2)</i>	<i>now (version CY46T1)</i>
<b>deep convection</b>	Geleyn/Bougeault scheme with anti-gps v3 (Marquet et al 2019)	New scheme based on <i>Tiedtke</i> 1989, <i>Bechtold</i> et al. 2004, 2008, 2014 (IFS scheme)
<b>air-sea fluxes</b>	ECUME scheme (Belamari and Pirani, 2007)	<i>ECUME</i> V6 (Belamari et al, 2016)
<b>solar radiation</b>	SW 6 bands from Foucart and Bonnel (1980) modified by Morcrette et al. (2008)	SRTM from Mlawer et al. 1997 with Mclca solver (Pincus et al 2003)
<b>sea-ice</b>	analysis update (from OSTIA)	<i>1D scheme GELATO</i> (Salas y Melia 2002)

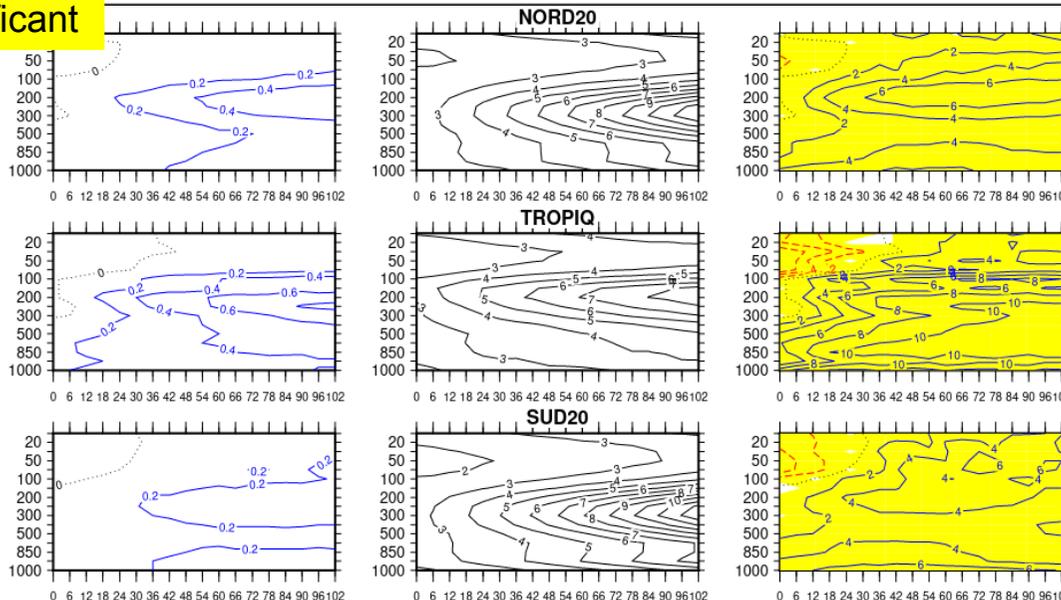
## 0 UTC wind forecast scores against ECMWF analysis (330 cases) :



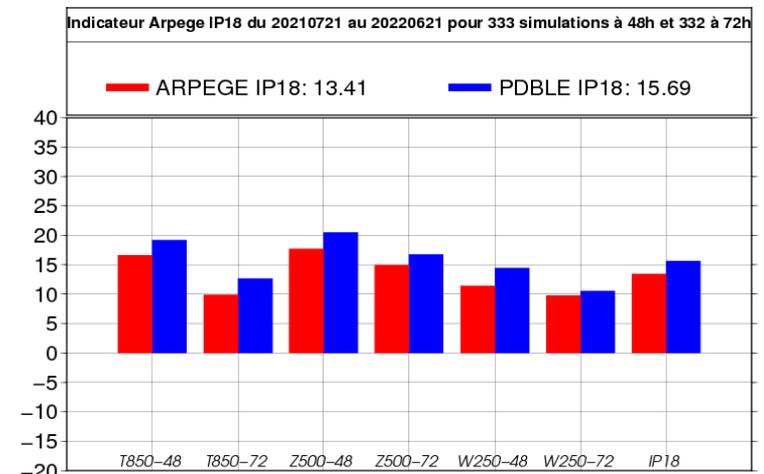
Différences d'EQM – EQM – Scores normalisés par rapport aux analyses  
Période de validité du 20210721 au 20220621 330 simulations contrôlées à 102 heures

— Amélioration — Dégradation --- Valeur EQM ou Neutralité Significativité à 95 % (bootstrap)

significant



## Synthetic score against radiosondes over Europe, based on T850, Z500, Wind250, +48 and +72 h (+2.28) :

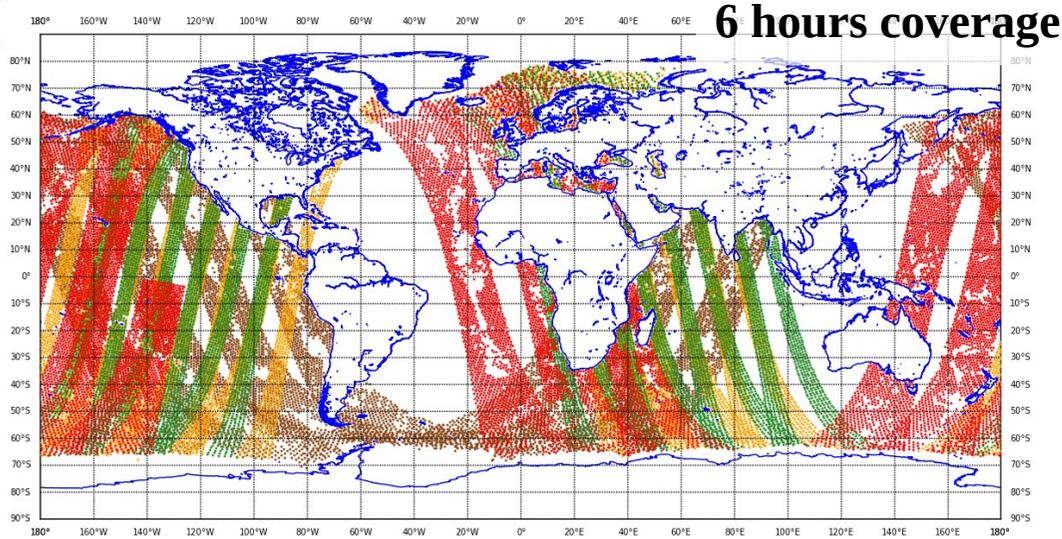


# Upgrade, on the satellite winds side: HY-2B and HY-2C added and ASCAT error revision

- **HY-2B** at 6:00 desc., **HY-2C** not sun-synchronous

11347 HY-2B  
11894 HY-2C  
8230 METOP-B  
0 METOP-B-EARS  
8686 METOP-C  
0 METOP-C-EARS

METEO-FRANCE data coverage - SCATTEROMETER - 2023/04/30 18H UTC long cut-off  
Total number of observations after screening : 40157



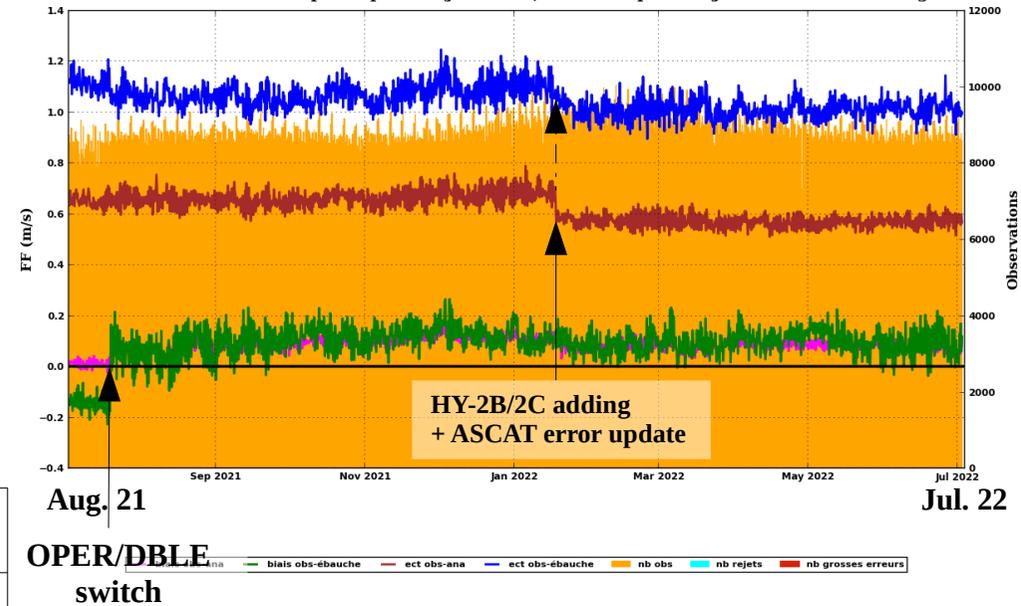
- Observation error revision (based on Desroziers diagnostic) :

Obs. error /Instr. (m/s)	ASCAT	HSCAT
New tuning (U/V)	1.00/1.05	0.95/0.90
Former	1.39/1.54	
(O-B)	1.30/1.40	1.20/1.20

## ASCAT-B wind speed monitoring with the new ARPEGE version :

STD(O-B) STD(O-A) bias(O-B) bias(O-A) Nobs(right scale)

METOP B - ARPEGE oper depuis 03-JUL-2021, double depuis 20-JUL-2021 - cut-off long

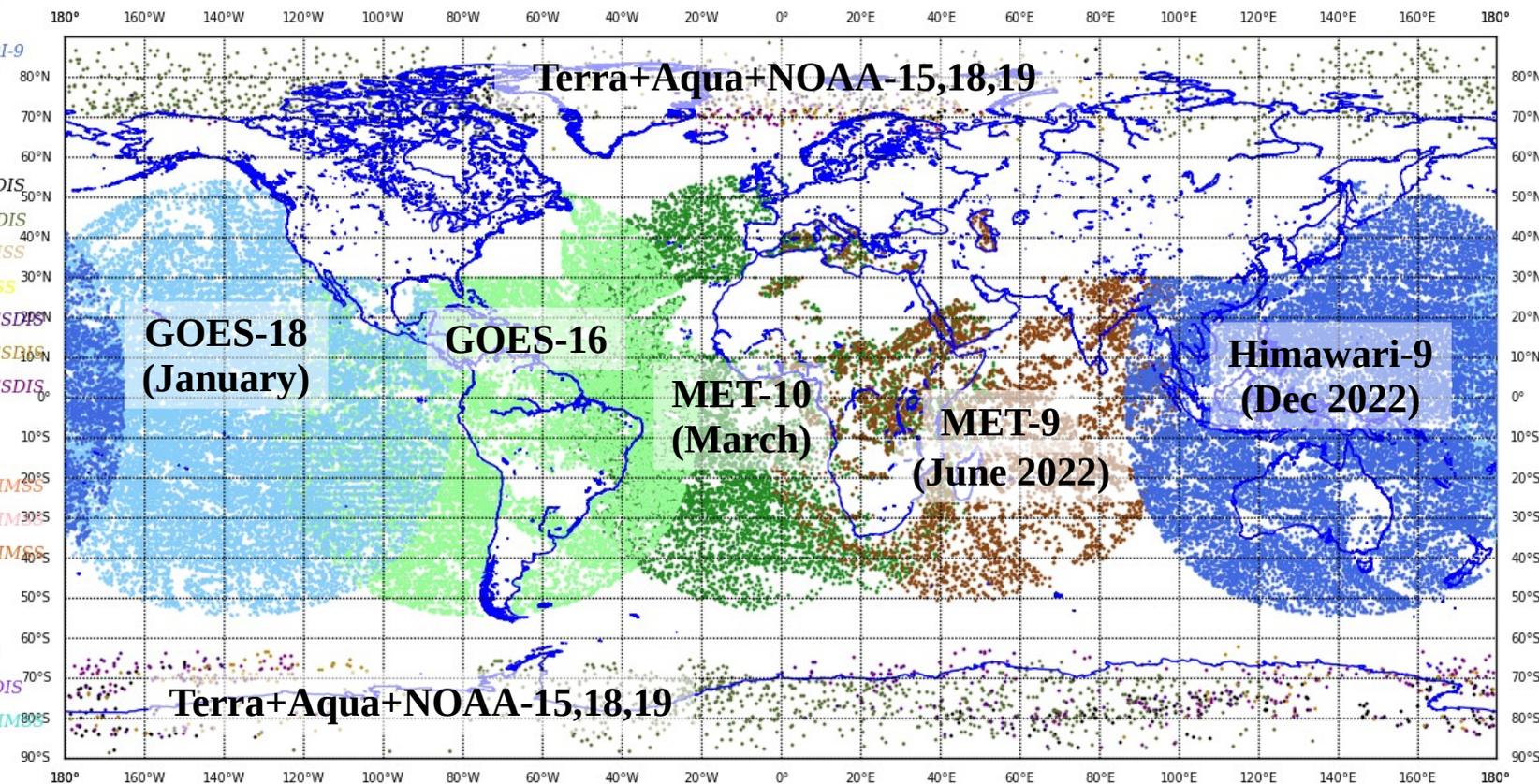


# Upgrade, on the satellite winds side (off NWP upgrade): geostationary satellite changes

- 0 METEOSAT-8
- 5445 METEOSAT-9
- 9680 METEOSAT-10
- 0 METEOSAT-11
- 0 HIMAWARI-8
- 21584 HIMAWARI-9
- 19585 GOES-16
- 0 GOES-17
- 21590 GOES-18
- 441 TERRA-NESDIS
- 1472 AQUA-NESDIS
- 0 TERRA-DB-CIMSS
- 0 AQUA-DB-CIMSS
- 215 NOAA-15-NESDIS
- 313 NOAA-18-NESDIS
- 275 NOAA-19-NESDIS
- 0 METOP-B
- 0 METOP-C
- 0 NOAA-15-DB-CIMSS
- 0 NOAA-18-DB-CIMSS
- 0 NOAA-19-DB-CIMSS
- 0 dual-METOP
- 0 NPP-NESDIS
- 0 NPP-DB-CIMSS
- 0 NOAA-20-NESDIS
- 0 NOAA-20-DB-CIMSS

**METEO-FRANCE data coverage - SATOB - 2023/04/30 18H UTC long cut-off**

**Total number of observations after screening : 80600**



ARPEGE oper

**Datasets monitored: MetOp-B,C, NPP, NOAA-20**



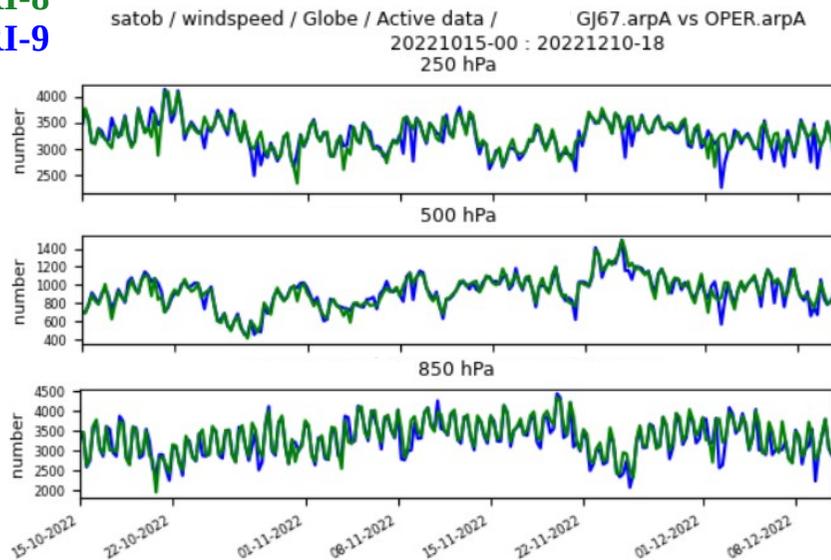
16<sup>th</sup> International Winds Workshop, Montreal, Canada, 8 - 12 May 2023



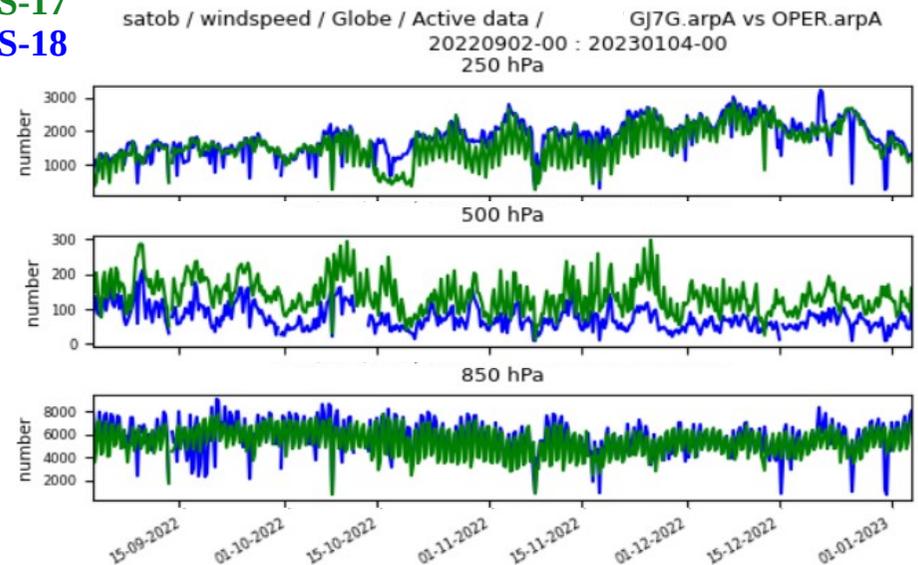
# Upgrade, on the satellite winds side: geostationary satellite changes

- In the frame of these satellite changes, experiments were made for checking the impact of new satellites in the case where the old ones were no longer available, for:
  - Himawari-9
  - GOES-18
- Periods of data evaluation (retrieved off-line):
  - Himawari-9 from 15 October to 11 December (switch H8 → H9 the 13<sup>th</sup>), JMA server
  - GOES-18 from 2 September to 4 January (switch G17 → G18 the 4<sup>th</sup>), NESDIS server

## HIMAWARI-8 HIMAWARI-9



## GOES-17 GOES-18



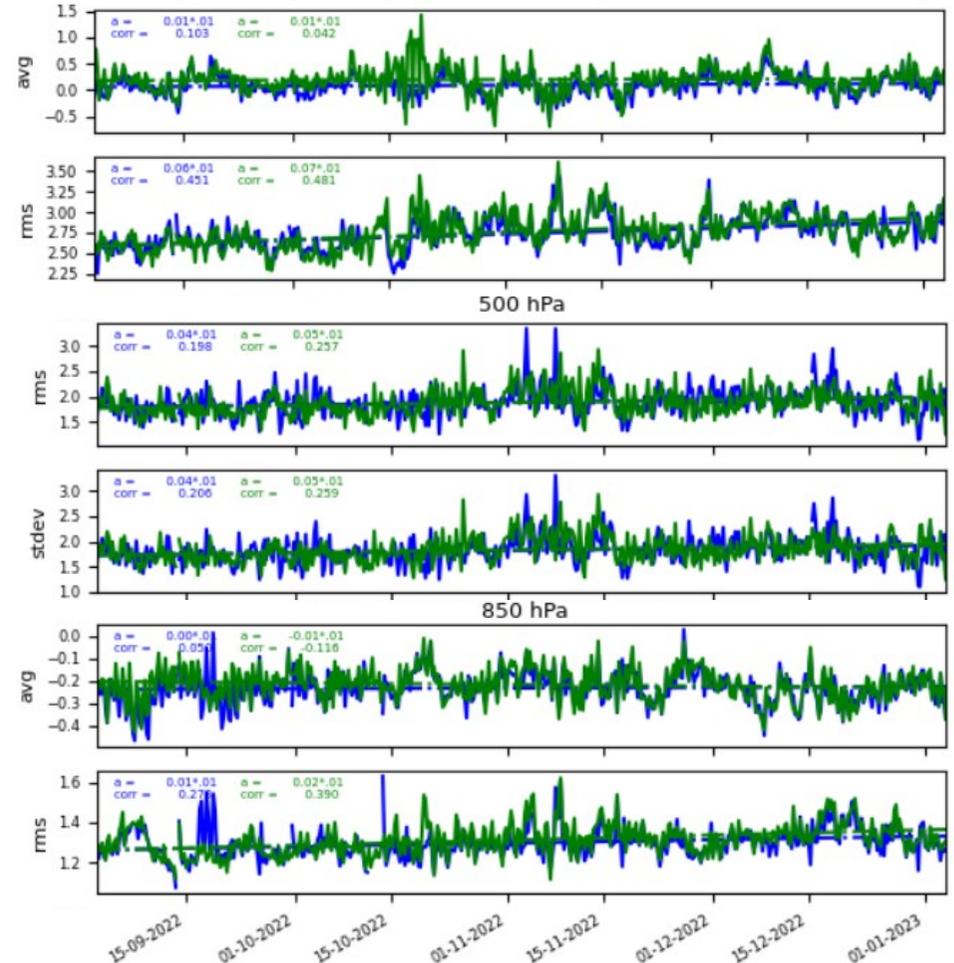
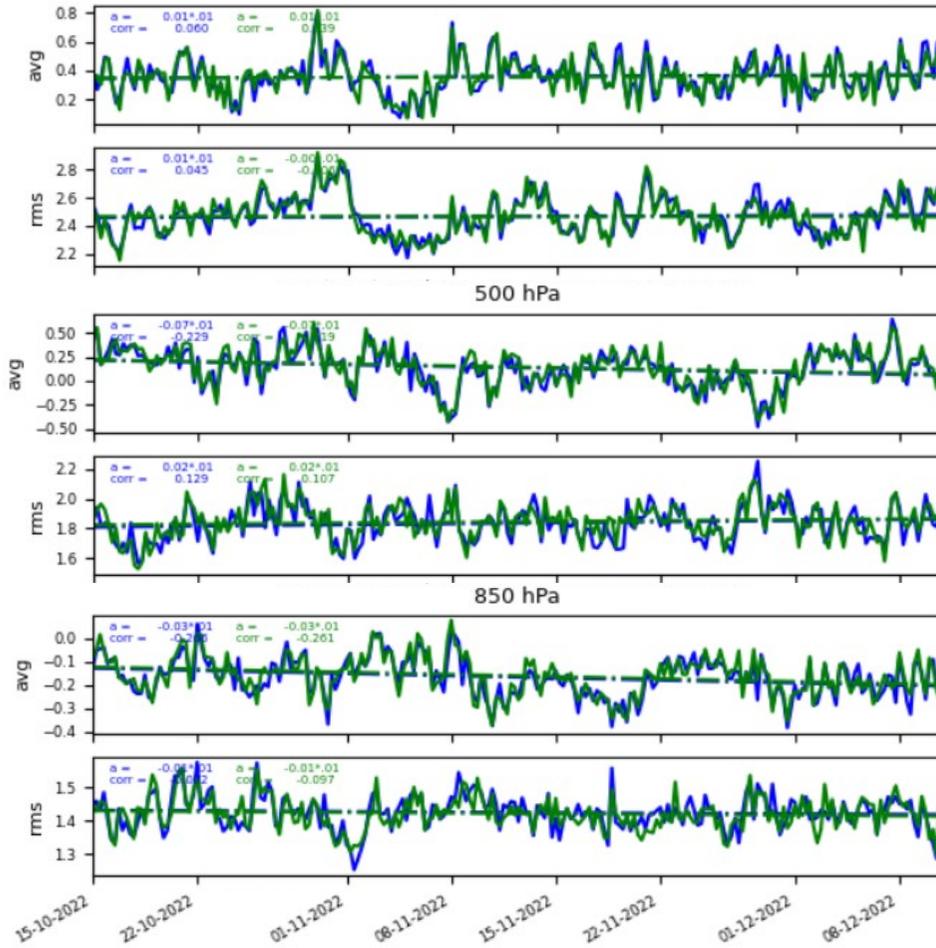
# Upgrade, on the satellite winds side: geostationary satellite changes

HIMAWARI-8  
HIMAWARI-9

windspeed / Globe / Active data / fgdep / GJ67.arpA vs OPER.arpA  
20221015-00 : 20221210-18  
250 hPa

GOES-17  
GOES-18

windspeed / Globe / Active data / fgdep / GJ7G.arpA vs OPER.arpA  
20220902-00 : 20230104-00  
250 hPa



# Upgrade, on the satellite winds side: geostationary satellite changes

## ANALYSIS change

HIMAWARI-9

TEST: with the new satellite    REF: without the former

GOES-18

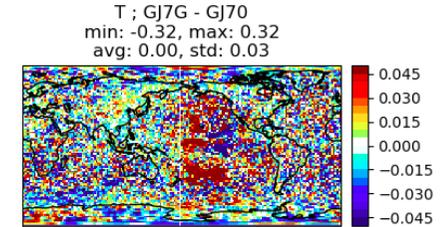
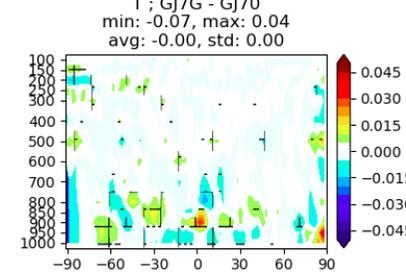
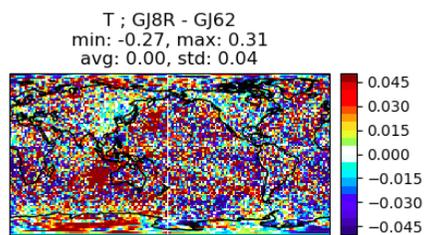
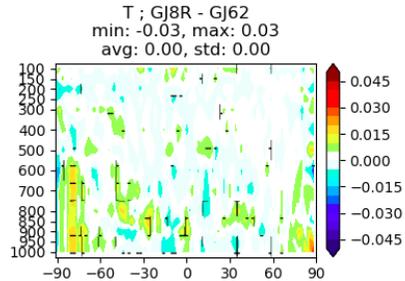
Zonal mean

Level 850 hPa

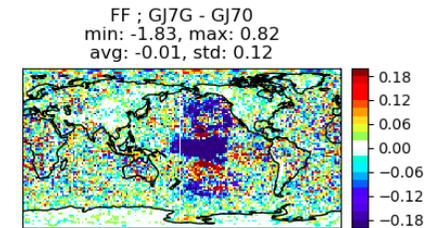
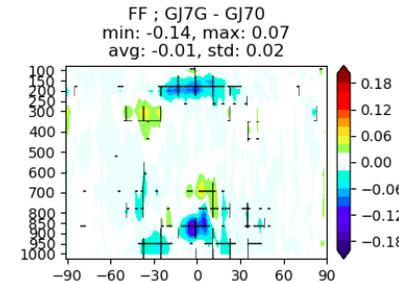
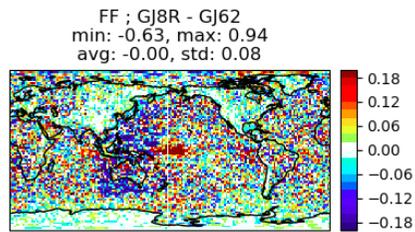
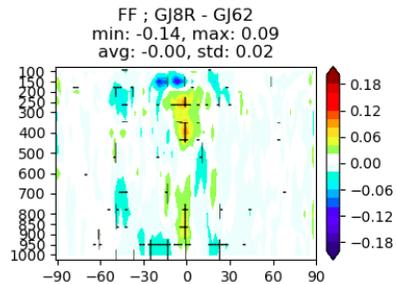
TEST - REF

Zonal mean

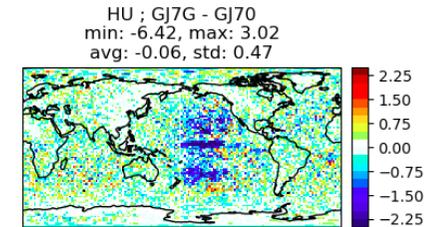
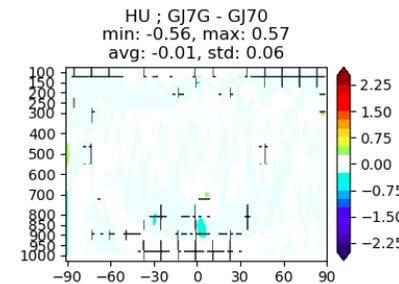
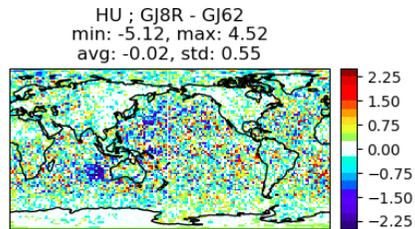
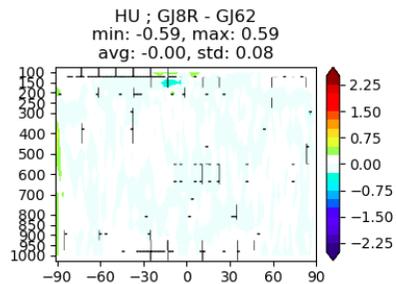
Level 850 hPa



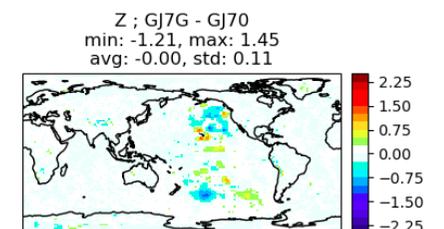
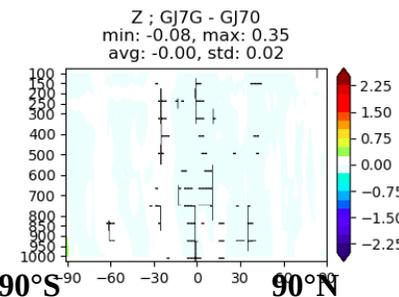
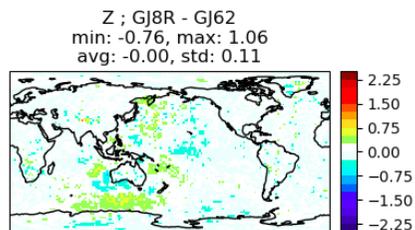
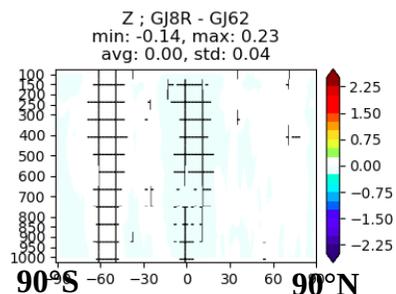
Temperature



Wind speed



Humidity



Geopotential

QUE  
ISE

# Upgrade, on the satellite winds side: geostationary satellite changes

HIMAWARI-9

GOES-18

## FORECAST impact

Control: ECMWF analysis

RMS  
(TEST - REF)/REF  
(%)

Temperature

Wind speed

Humidity

Geopotential

FC+24 hours

FC+72 hours

FC+ 24 hours

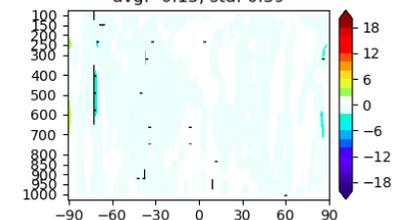
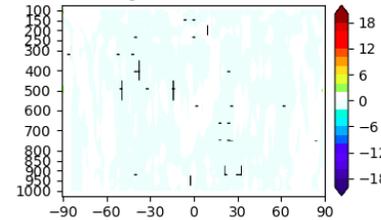
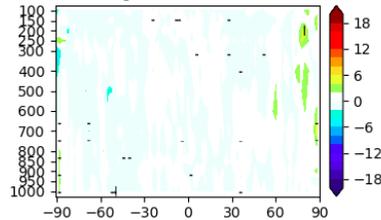
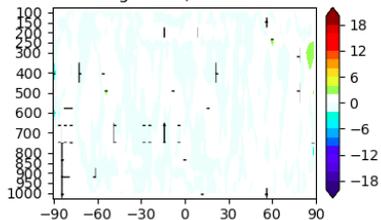
FC+72 hours

T ; (GJ8R - GJ62)/GJ62\*100  
min: -8.31, max: 3.47  
avg: -0.02, std: 0.48

T ; (GJ8R - GJ62)/GJ62\*100  
min: -7.14, max: 5.42  
avg: -0.09, std: 0.54

T ; (GJ7G - GJ70)/GJ70\*100  
min: -2.13, max: 3.18  
avg: -0.16, std: 0.37

T ; (GJ7G - GJ70)/GJ70\*100  
min: -3.79, max: 6.57  
avg: -0.15, std: 0.39

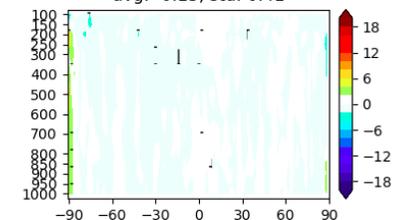
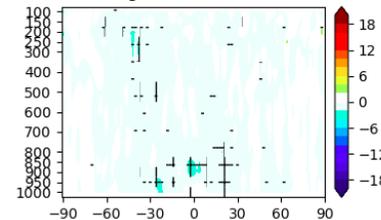
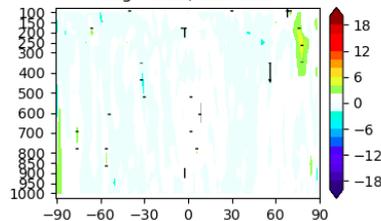
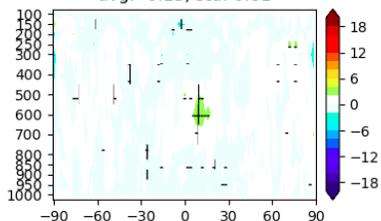


FF ; (GJ8R - GJ62)/GJ62\*100  
min: -9.80, max: 4.50  
avg: -0.13, std: 0.61

FF ; (GJ8R - GJ62)/GJ62\*100  
min: -7.74, max: 5.87  
avg: -0.09, std: 0.58

FF ; (GJ7G - GJ70)/GJ70\*100  
min: -3.66, max: 2.71  
avg: -0.31, std: 0.55

FF ; (GJ7G - GJ70)/GJ70\*100  
min: -7.59, max: 6.92  
avg: -0.13, std: 0.41

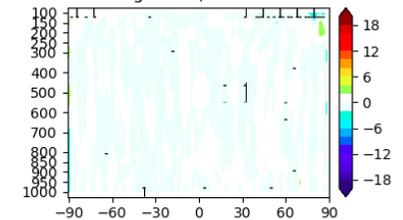
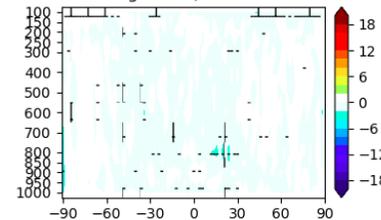
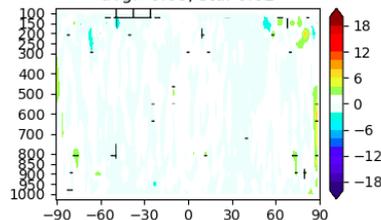
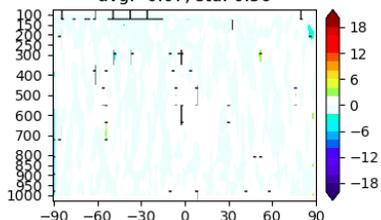


HU ; (GJ8R - GJ62)/GJ62\*100  
min: -8.59, max: 2.96  
avg: -0.07, std: 0.56

HU ; (GJ8R - GJ62)/GJ62\*100  
min: -7.02, max: 7.55  
avg: -0.08, std: 0.62

HU ; (GJ7G - GJ70)/GJ70\*100  
min: -7.35, max: 1.93  
avg: -0.19, std: 0.48

HU ; (GJ7G - GJ70)/GJ70\*100  
min: -4.47, max: 4.41  
avg: -0.11, std: 0.41

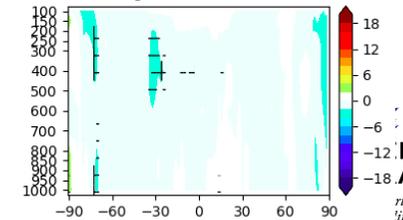
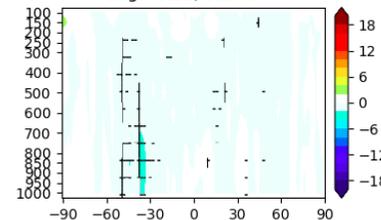
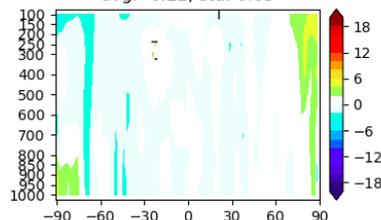
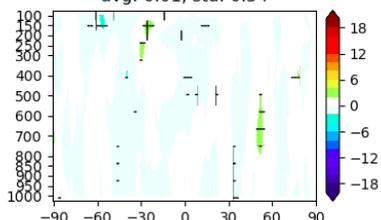


Z ; (GJ8R - GJ62)/GJ62\*100  
min: -2.50, max: 2.72  
avg: 0.01, std: 0.54

Z ; (GJ8R - GJ62)/GJ62\*100  
min: -5.97, max: 5.34  
avg: -0.22, std: 0.65

Z ; (GJ7G - GJ70)/GJ70\*100  
min: -2.95, max: 2.47  
avg: -0.29, std: 0.44

Z ; (GJ7G - GJ70)/GJ70\*100  
min: -4.08, max: 3.69  
avg: -0.35, std: 0.48



# Summary

---

- HY-2B and -2C added in addition to ASCAT-B and -C, when upgrading the operational NWP configuration in June last year
- MET-9, GOES-18, HIMAWARI-9 and METEOSAT-10 were activated on the fly, after at least a period of monitoring and also impact studies for Himawari-9 and GOES-18
- From these examples, analysis modified over areas not already covered by AMVs of other satellite, with positive impacts on the forecast scores, but relatively small, less than 2% of reduction in RMS, and rather in the first forecast ranges
- In agreement with DFS or FSO diagnostics (see the backup slides)
- Lot of informations regarding the observations (model departures, DFS, FSO) available on the external operational monitoring website:  
<http://www.meteo.fr/special/minisites/monitoring/menu.html>
- More details about the impact of observations in ARPEGE: Chambon, P., and Coauthors, 2023: Global Observing System Experiments within the Météo-France 4D-Var Data Assimilation System. *Mon. Wea. Rev.*, 151, 127–143, <https://doi.org/10.1175/MWR-D-22-0087.1>.

---

Thank you for your attention!



16<sup>th</sup> International Winds Workshop, Montreal, Canada, 8 - 12 May 2023

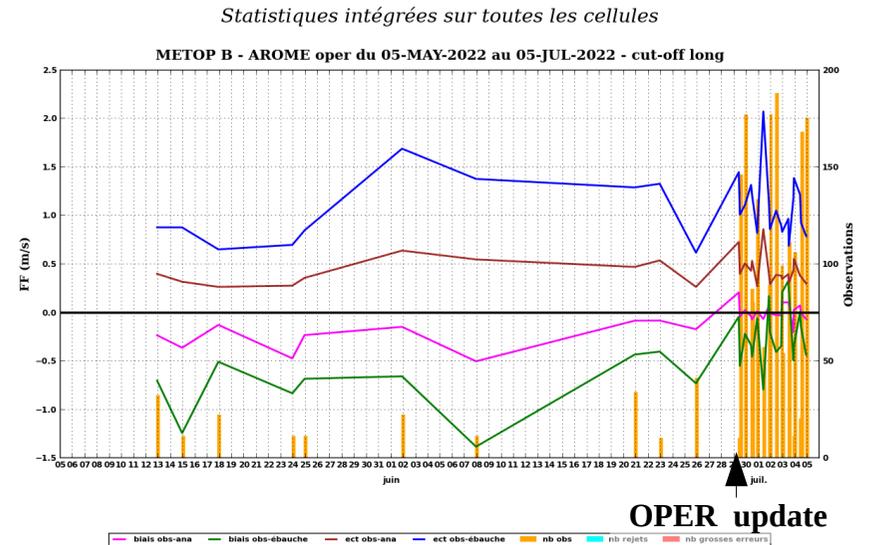
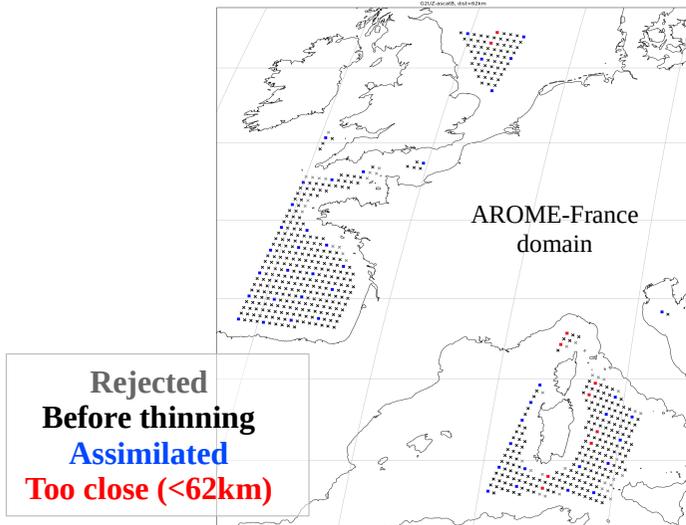


---

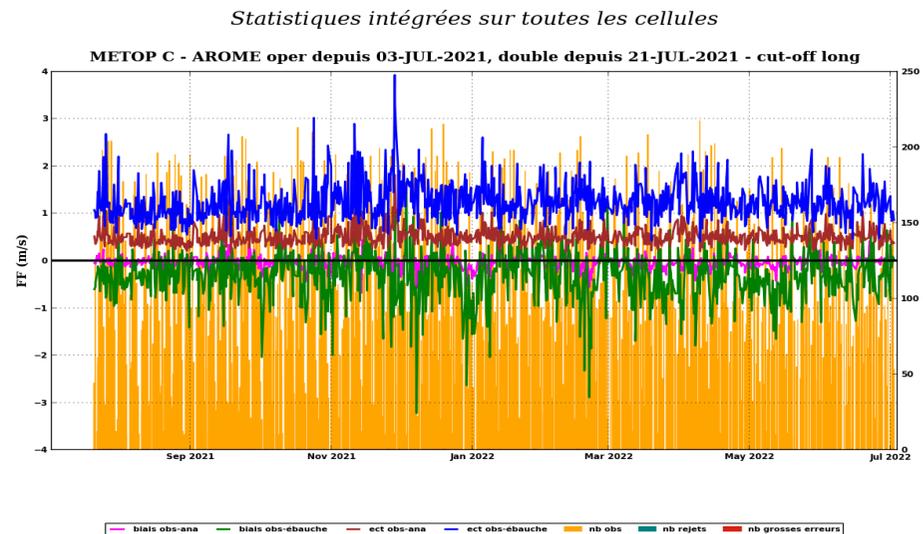
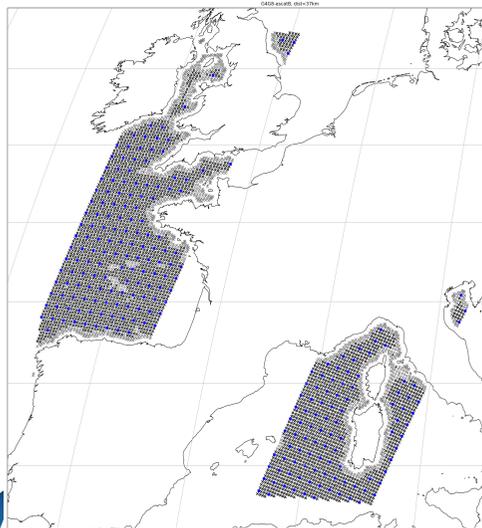
# Backup slides

# Upgrade, on the satellite winds side: HR ASCAT winds in AROME + ASCAT-C

- Former : 25 km grid ASCAT with the legacy thinning, only ASCAT-B used



- New : 12.5 km grid ASCAT with the obs grid thinning, ASCAT-C added



HR + ASCAT-C

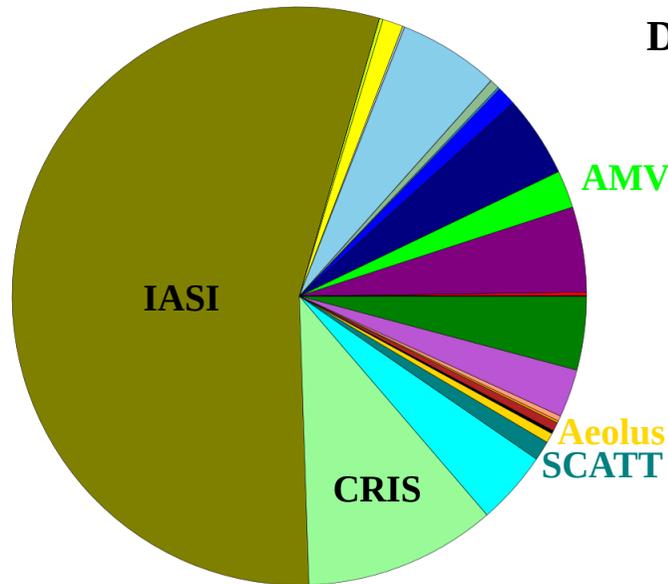


4 times more  
assimilated data in  
AROME

# Satellite winds weight in ARPEGE assimilation: DFS

## Observation number by type (%)

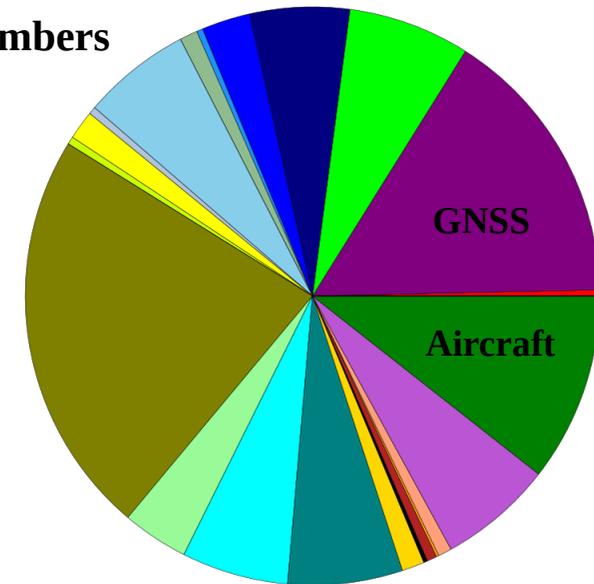
Proportions of used observations numbers for each observation type conventional and satellite observations over the period 2022020500 - 2022020518 : 27041524



ground GPS	0.21%	SSMIS	1.15%	BUOY	0.17%
sat GPS	4.77%	GMI	0.21%	SYNOR/SYNOR/RADOME	0.49%
SATOB	2.10%	AMSR2	0.00%	SHIP	0.13%
AMSU-A	4.56%	MWRI	0.00%	PILOT/PRF	0.29%
AMSU-B Tb	1.07%	AIRS	0.00%	TEMP	2.69%
AMSU-B Hu	0.11%	IASI	55.03%	AIRCRAFTS	4.13%
MWHS2	0.54%	CRIS	10.80%	RADAR Vr	0.00%
MWTS2	0.00%	GEORAD	4.13%	RADAR Hur	0.00%
ATMS Tb	5.65%	SCATT	1.10%	BOGUS	0.00%
ATMS Hu	0.12%	LIDAR	0.55%		

## DFS fraction by type (%)

DFS part for each observation type conventional and satellite observations accumulation of DFS over the period 2022020500 - 2022020518 : 912228



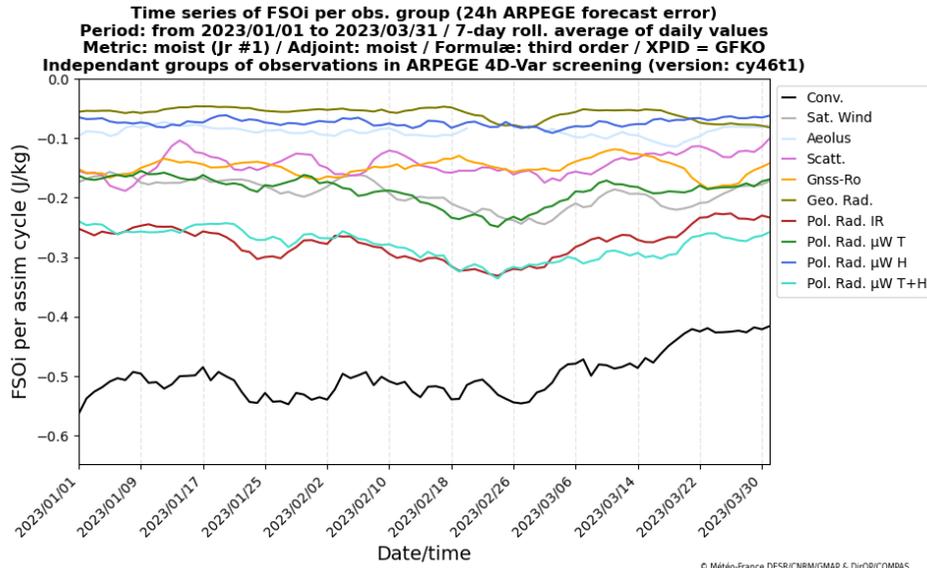
ground GPS	0.34%	SSMIS	1.62%	BUOY	0.22%
sat GPS	15.72%	GMI	0.43%	SYNOR/SYNOR/RADOME	0.55%
SATOB	6.85%	AMSR2	0.00%	SHIP	0.14%
AMSU-A	5.61%	MWRI	0.00%	PILOT/PRF	0.76%
AMSU-B Tb	2.74%	AIRS	0.00%	TEMP	6.42%
AMSU-B Hu	0.35%	IASI	22.71%	AIRCRAFTS	10.57%
MWHS2	1.00%	CRIS	3.72%	RADAR Vr	0.00%
MWTS2	0.00%	GEORAD	6.00%	RADAR Hur	0.00%
ATMS Tb	6.10%	SCATT	6.46%	BOGUS	0.00%
ATMS Hu	0.42%	LIDAR	1.26%		

DFS ~ 6 perturbed members  
5 Feb 2022

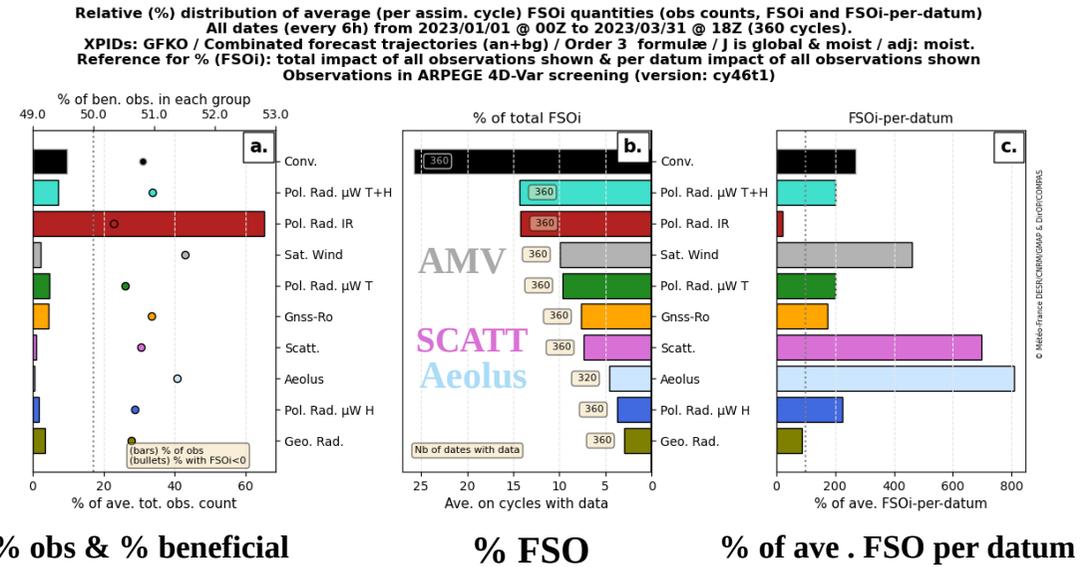
Obs type	AMV	SCATT	Aeolus	All sat. winds
% Nobs	2.10	1.10	0.55	3.75
% DFS (ratio DFS/Nobs)	6.85 (x 3.3)	6.46 (x 5.9)	1.26 (x 2.3)	14.57 (x 3.9)

# Satellite winds contribution to FSO in ARPEGE (24 h fcst error reduction, moist adj. & energy norm)

## Global view, in the 1<sup>st</sup> quarter 2023



**FSO per assim, timeseries, 7-day roll**



**Average on the period**

Obs type	AMV	SCATT	Aeolus	All sat. winds
% FSO	10.0	7.4	4.8	22.2
Per datum / ave. FSO	x 4.7	x 7.0	x 8.1	x 6.3

# Satellite winds contribution to FSO in ARPEGE (24 h fcst error reduction, moist adj. & energy norm)

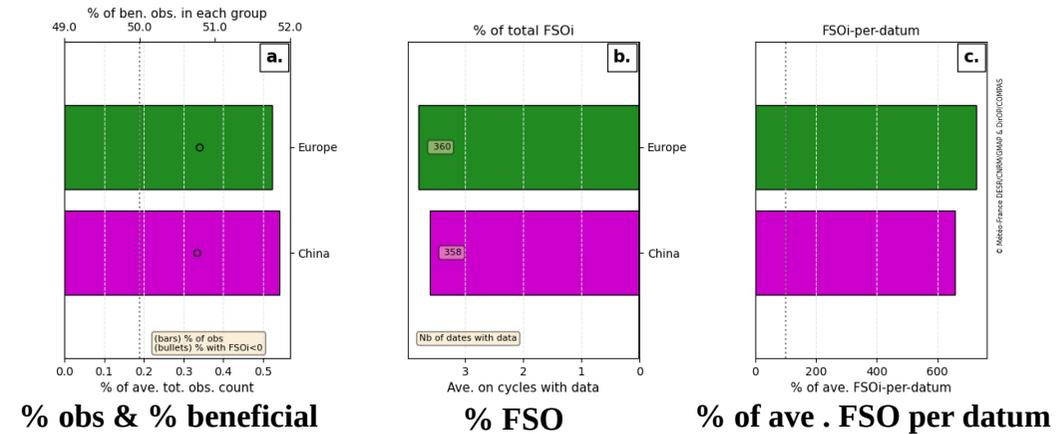
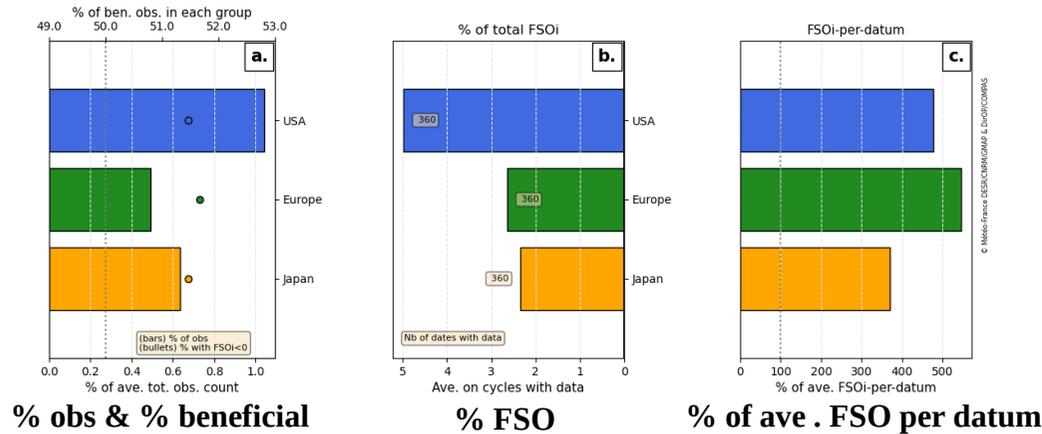
## By obstype and provider country (sensor)

### AMVs

### SCATT

Relative (%) distribution of average (per assim. cycle) FSOi quantities (obs counts, FSOi and FSOi-per-datum)  
All dates (every 6h) from 2023/01/01 @ 00Z to 2023/03/31 @ 18Z (360 cycles).  
XPIDs: GFKO / Combined forecast trajectories (an+bg) / Order 3 formulæ / J is global & moist / adj: moist.  
Reference for % (FSOI): total impact of all observations shown & per datum impact of all observations shown  
Sat.Wind observations (SATOB) in ARPEGE 4D-Var depending on agencies (version: cy46t1)

Relative (%) distribution of average (per assim. cycle) FSOi quantities (obs counts, FSOi and FSOi-per-datum)  
All dates (every 6h) from 2023/01/01 @ 00Z to 2023/03/31 @ 18Z (360 cycles).  
XPIDs: GFKO / Combined forecast trajectories (an+bg) / Order 3 formulæ / J is global & moist / adj: moist.  
Reference for % (FSOI): total impact of all observations shown & per datum impact of all observations shown  
Scatt. obs. (sea-surface wind) in ARPEGE 4D-Var dep. on agencies (version: cy46t1)



NESDIS MET-0,-IODC Himawari

HSCAT-2B,-2C ASCAT-B,-C

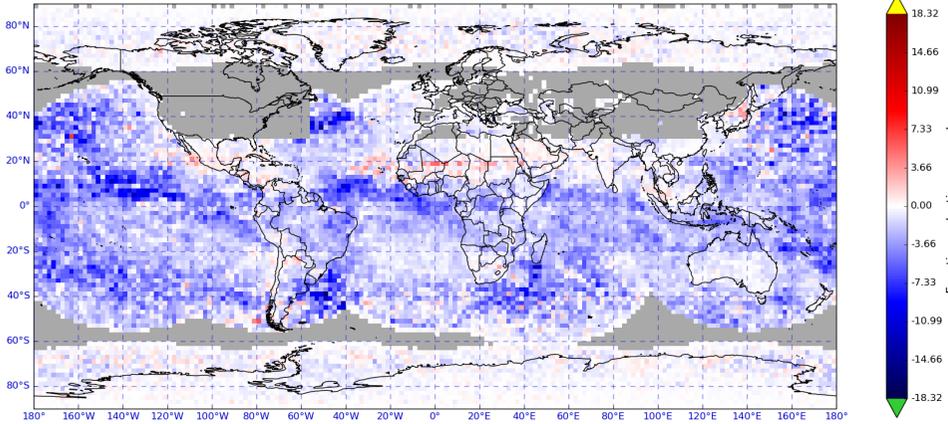
- % FSO ~ in link with Nobs (1<sup>st</sup> NESDIS)
- NESDIS: Nobs from 2 GOES + polar sat.
- METEOSAT serie: Nobs the lowest (rej. over land) but the highest FSO ratio per datum

- Contributions from HSCAT and ASCAT almost equivalent in all terms: same Nobs (2 satellites each), same % beneficial obs, same % FSO and FSO ratio per datum a bit higher for ASCAT



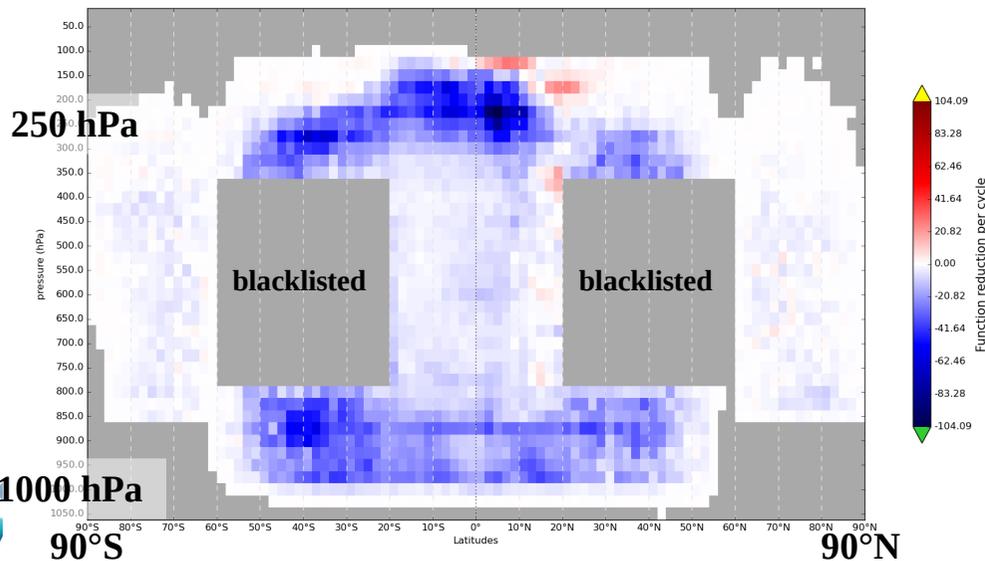
# Satellite winds contribution to FSO in ARPEGE (24 h fcst error reduction, moist adj. & energy norm)

Function reduction per cycle  
 Experiment: GFKO / lat-lon grid: 2.0°x2.0°  
 Period from 2023/01/01@00 to 2023/03/31@18 (360 cycles)  
 Cloud-derived atmospheric motion vectors (polar-orbiting and geostationary satellites)  
 Parameters: wind data



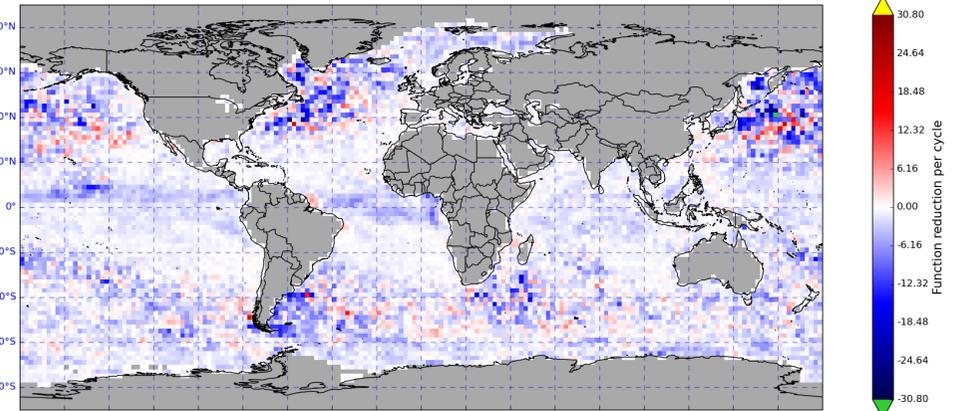
## AMVs

Function reduction per cycle  
 Experiment: GFKO / lat-pressure grid  
 Period from 2023/01/01@00 to 2023/03/31@18 (360 cycles)  
 Cloud-derived atmospheric motion vectors (polar-orbiting and geostationary satellites)  
 Parameters: wind data



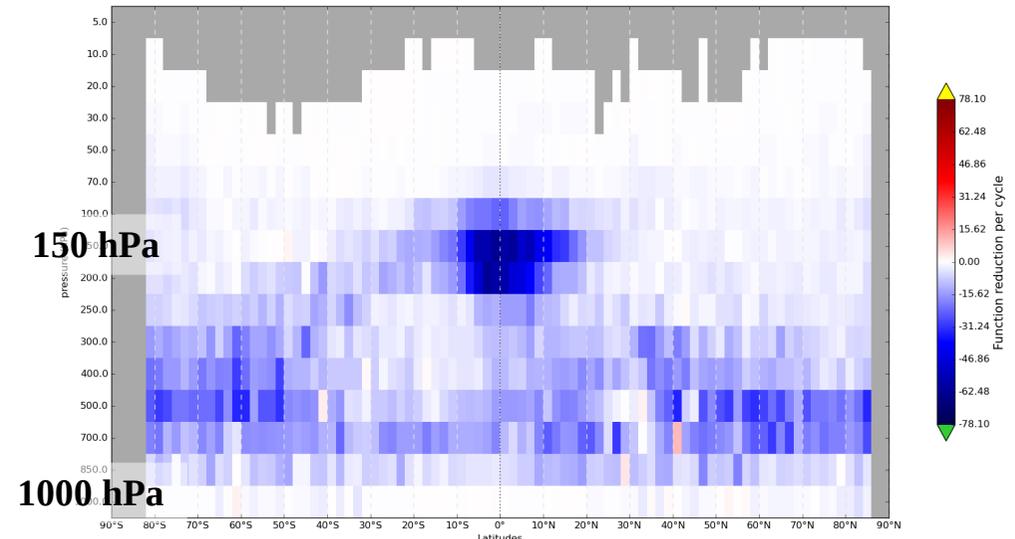
Function reduction per cycle  
 Experiment: GFKO / lat-lon grid: 2.0°x2.0°  
 Period from 2023/01/01@00 to 2023/03/31@18 (360 cycles)  
 Scatterometer data (polar-orbiting satellites)  
 Parameters: Surface ambiguous winds

## SCATT



## Aeolus

Function reduction per cycle  
 Experiment: GFKO / lat-pressure grid  
 Period from 2023/01/01@00 to 2023/03/31@18 (360 cycles)  
 HLOS data (polar-orbiting Aeolus satellite)  
 Parameters: Horizontal line-of-sight wind component



Last quarter! Stopped on 30 April.