CFOSAT SCAT activities for NWP in Météo-France

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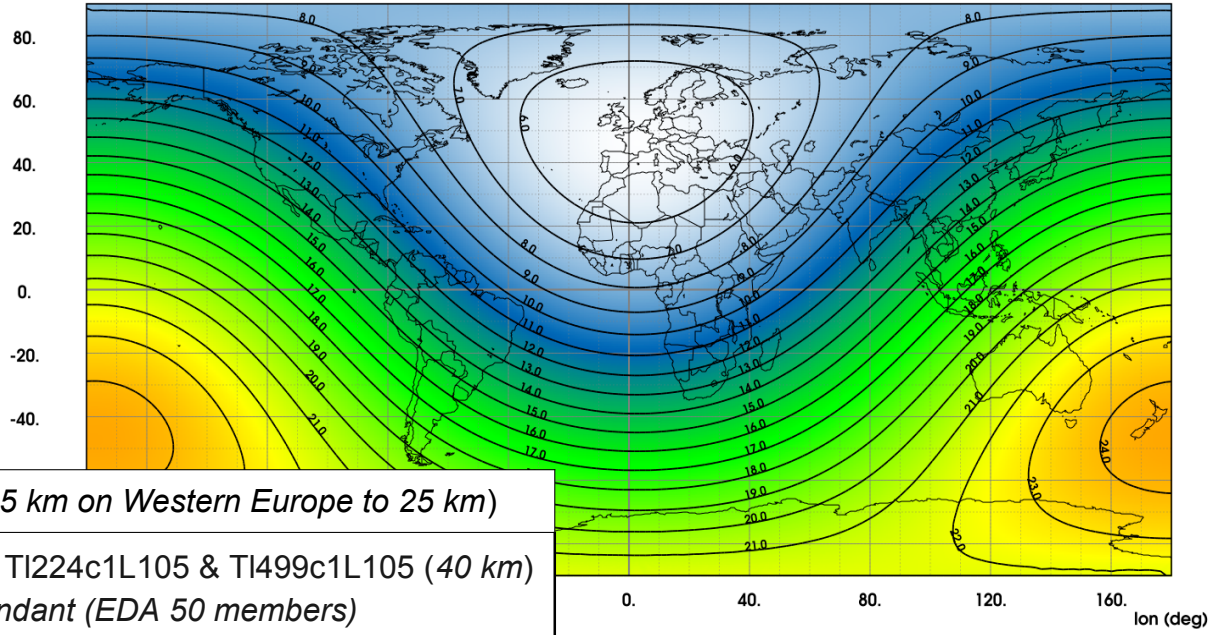
Plan

- The global model ARPEGE (some characteristics and evolution)
- Scatterometer wind datasets
- Monitoring configurations
- CFOSAT monitoring results
- Conclusions

The global model ARPEGE



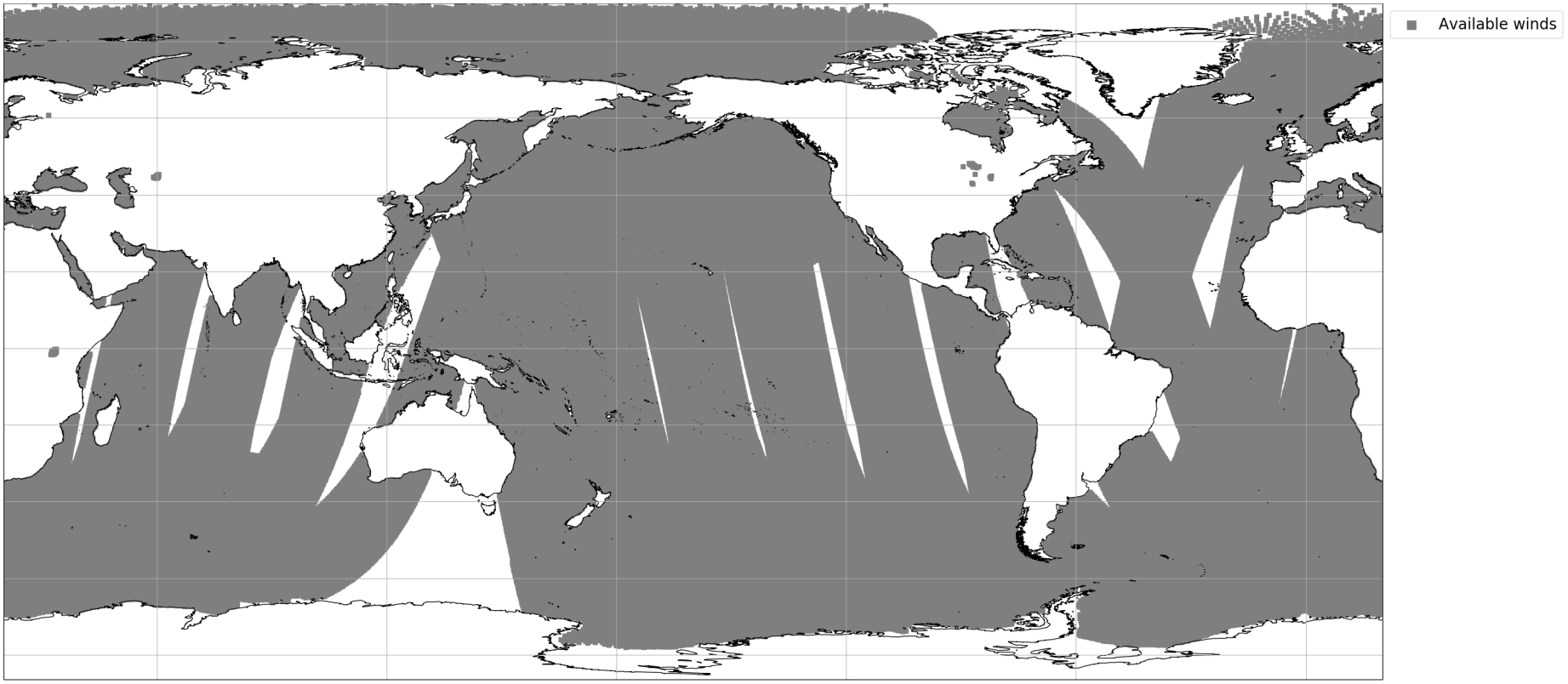
Operational configuration:
(43T2 version)

resolution	*Stretched grid* TI1798c2.2 L105 (*5 km on Western Europe to 25 km*)
assimilation	*4DVar* (6 h cycle) 0, 6, 12, 18 UTC: TI224c1L105 & TI499c1L105 (*40 km*) *Full B-matrix flow dependant (EDA 50 members)*
forecast	4 forecasts per day up to 114h

Next configuration in preparation (2021), major changes:
(46T1 version)

	operational (43T2)	***double (46T1)***
deep convection	Geleyn/Bougeault scheme with anti-gps v3 (Marquet et al 2019)	New scheme based on *Tiedtke* 1989, *Bechtold* et al. 2004, 2008, 2014 (IFS scheme)
air-sea fluxes	ECUME scheme (Belamari and Pirani, 2007)	*ECUME V6* (Belamari et al, 2016)
solar radiation	SW 6 bands from Fouquart and Bonnel (1980) modified by Morcrette et al. (2008)	SRTM from Mlawer et al. 1997 with Mclca solver (Pincus et al 2003)
sea-ice	analysis update (from OSTIA)	*1D scheme GELATO* (Salas y Melia 2002)

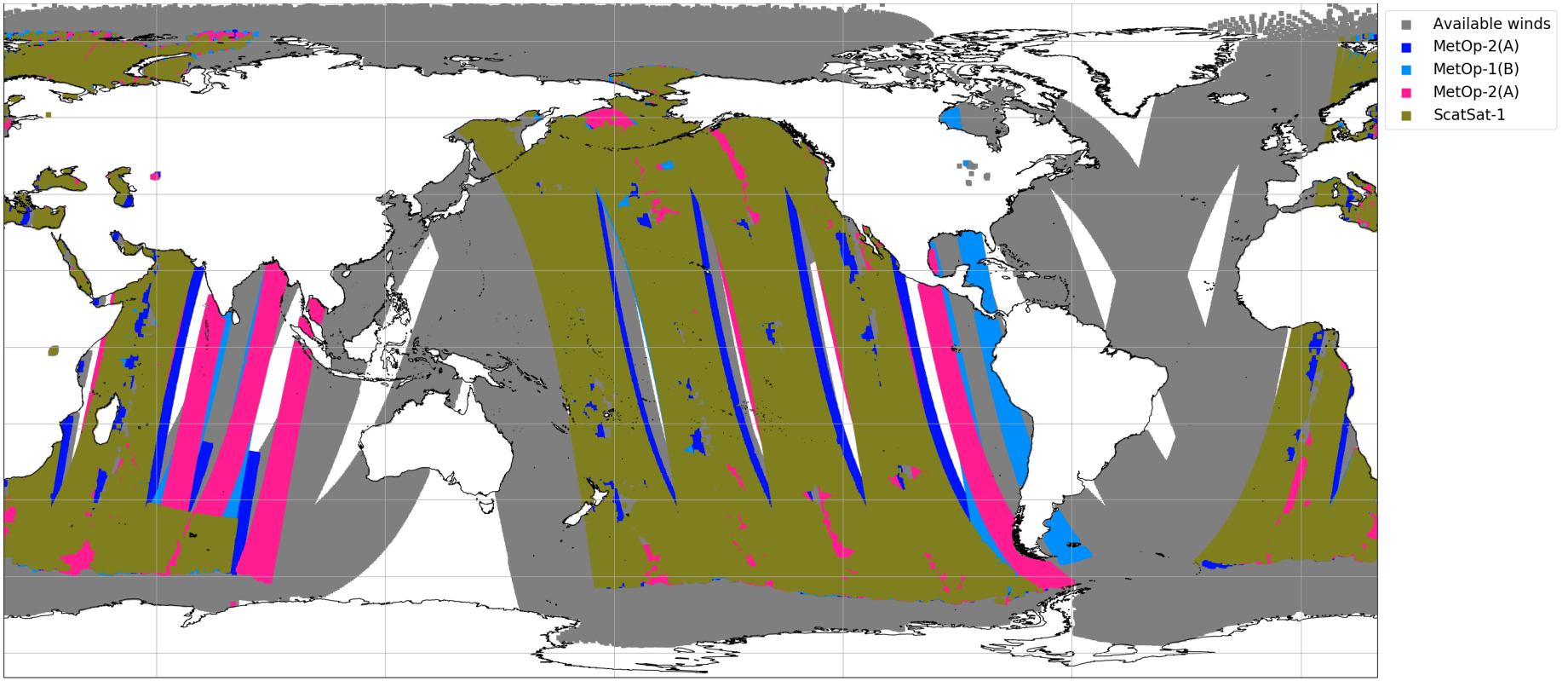
Scatterometer winds datasets



- Now, wind datasets from 7 scatterometers can be processed in NWP system of Météo-France

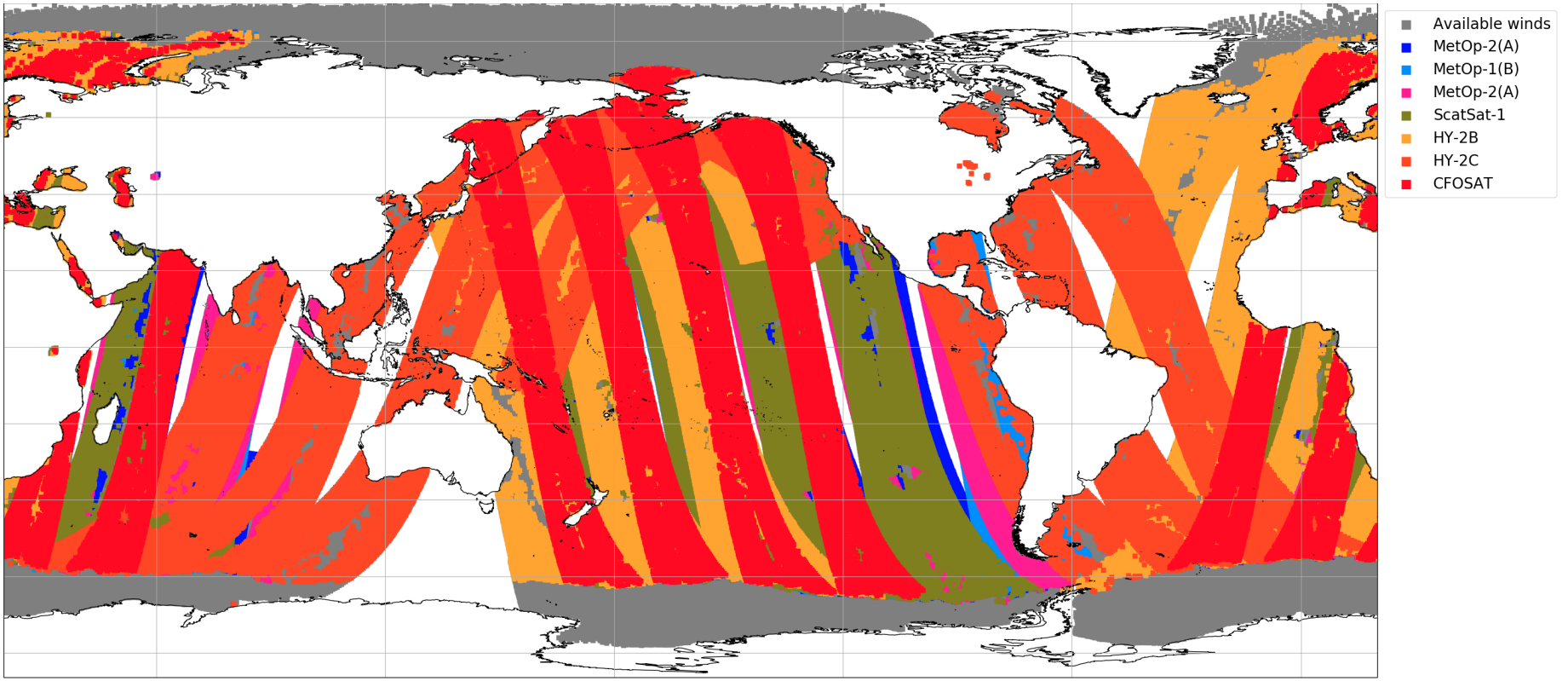
- Above, example of coverage on an assimilation window of 6 hours with EUMETSAT SAF Ocean and sea Ice products (KNMI)

Scatterometer winds datasets



- 4 used operationally:
  - ASCAT-A and B (9:30 desc.), since 2008 and 2013
  - ScatSat-1 (8:30 desc.) added in July 2019
  - ASCAT-C (9:30 desc.) activated in January 2020

Scatterometer winds datasets



- 4 used operationally:
  - ASCAT-A/B/C (9:30 desc.), assimilated since 2008, 2013 and 2020
  - ScatSat-1 (8:30 desc.), since 2019
- 3 in research mode:
  - HY-2B (6:00 desc.), since Feb 2019, assimilation tests
  - CFOSAT (7:00 desc.), since Jun 2019, monitoring
  - HY-2C (prograde orbit), since Nov 2020, monitoring

Monitoring configurations
new instruments (including CFOSAT) + operational

Monitoring configurations versus operational: (use and quality control)

	variables	*wvc resol.*	thinning	quality flags (producer)	sea-ice/land masks	too high speed	azimuth check (rotating beams)
monitoring	ambiguities *selected sol.***	?*	?*	used	SST < -1°C land fraction > 0	O or B > 35m/s	?*
operational	ambiguities	50 km	100 km	//	//	C-band > 35 m/s Ku-band > 25 m/s	used

*: depending on monitoring experience
**: statistics from producer's selected solution in the following slides

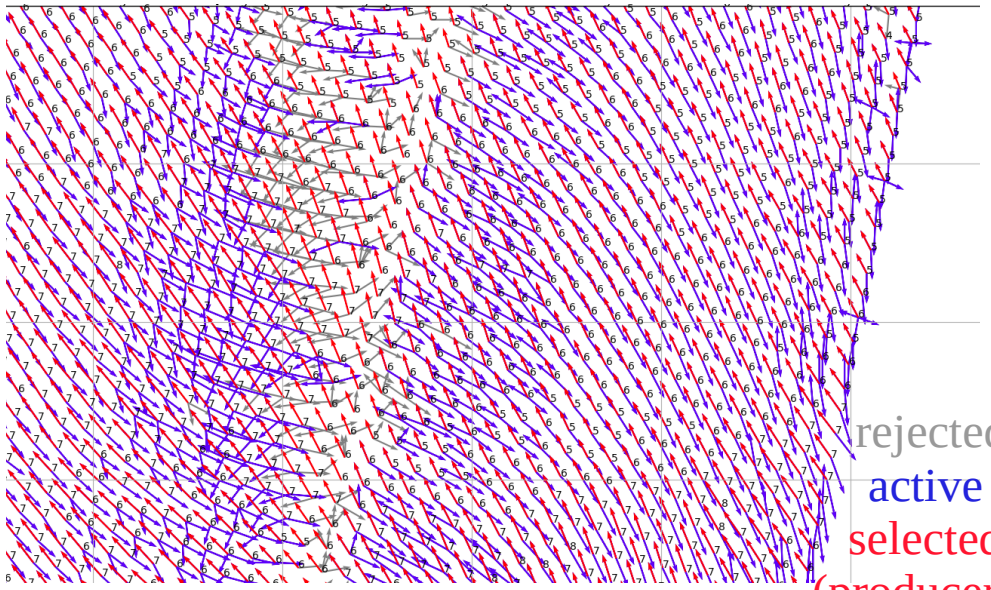
Monitoring configurations (datasets, QC and periods):

experience id.	G75A (1)	G6XC (2)	G71P (3)	G7IO (4)	G71S (5)
CFOSAT product	KNMI	KNMI	KNMI	KNMI	CNES (NSOAS V3.0)
wvc resol./thinning	50 km	50 km	25 km	25 km	25 km
azimuth check (dir1,dir2) < 135° rejected (rotating beams)	used	used	used	not used	not used
model background	operational	double	double	double	double
period	10/09/20 to 10/02/21	10/09/20 to 28/02/21	10/09/20 to 28/02/21	01/12/20 to 28/02/21	10/09/20 to 28/02/21

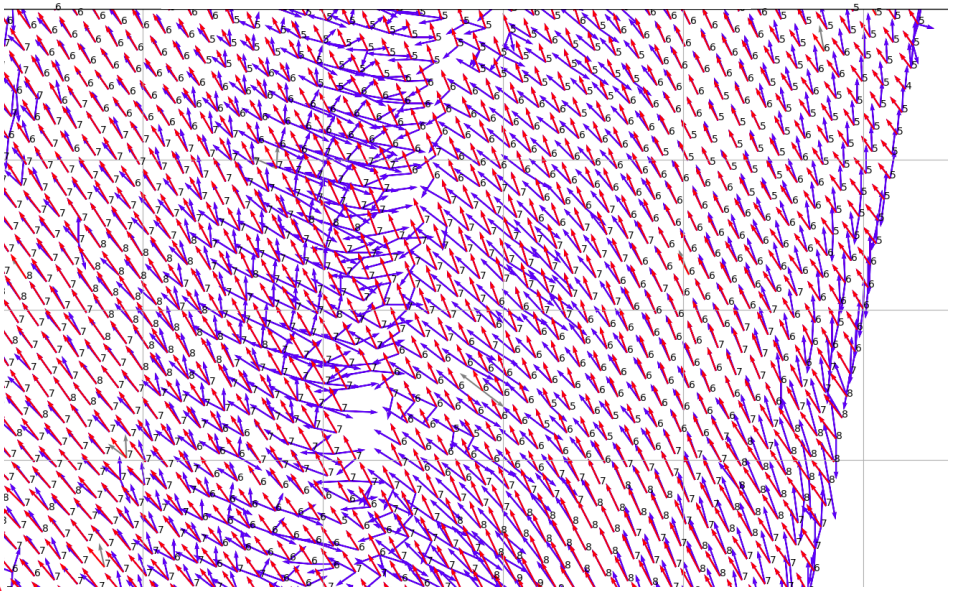
CFOSAT 25 km, ambiguities production
(5) CNES versus (3) KNMI with azimuth check

CFOSAT scene with all ambiguities (arrows)

KNMI



CNES (NSOAS)



rejected
active
selected
(producer)

- **KNMI**:
  - ambiguities given by MLE residual in inversion (CFOSAT user manual)
  - more diversity in azimuth for directions
- **CNES** (NSOAS):
  - ambiguities given by 2DVAR with a multiple solution scheme (MSS), Portabella and Stoffelen 2004
  - less diversity in azimuth for directions

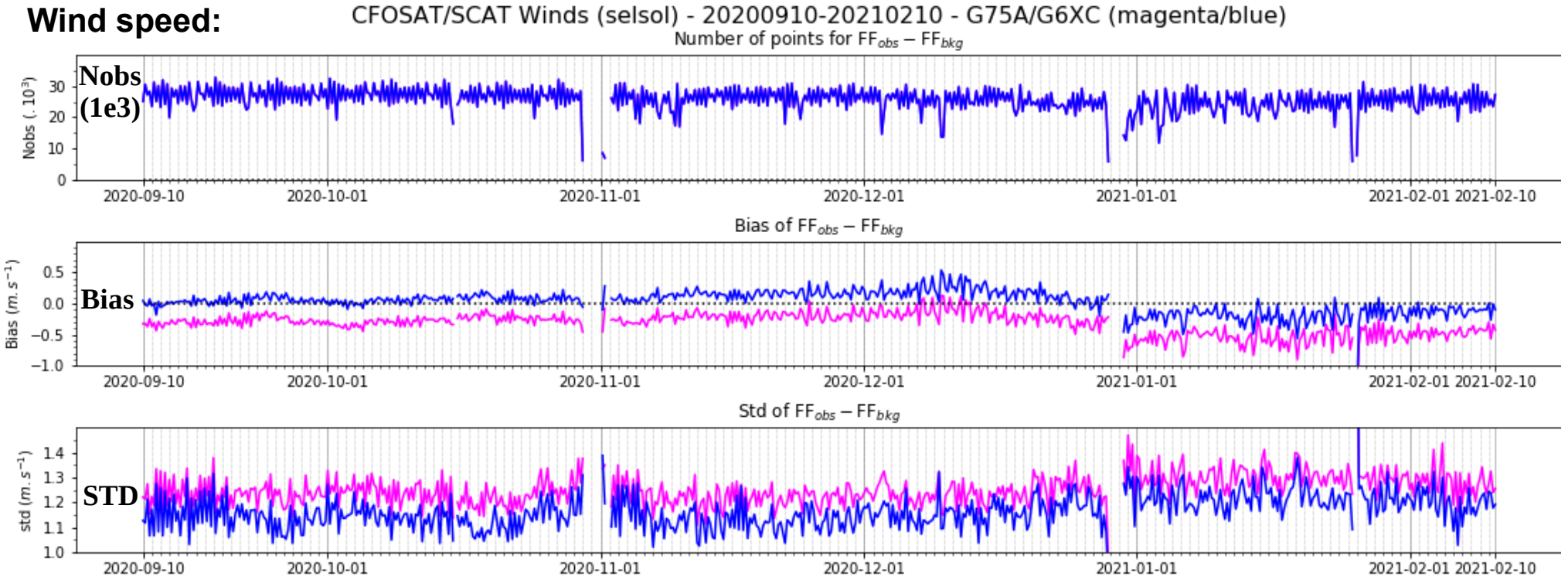
- **Azimuth check** (rejection if less than 135° between the 2 first solutions):

KNMI: **~ 15 % of rejections**, mainly in the nadir part

CNES: **no check** otherwise **85 % of rejections**

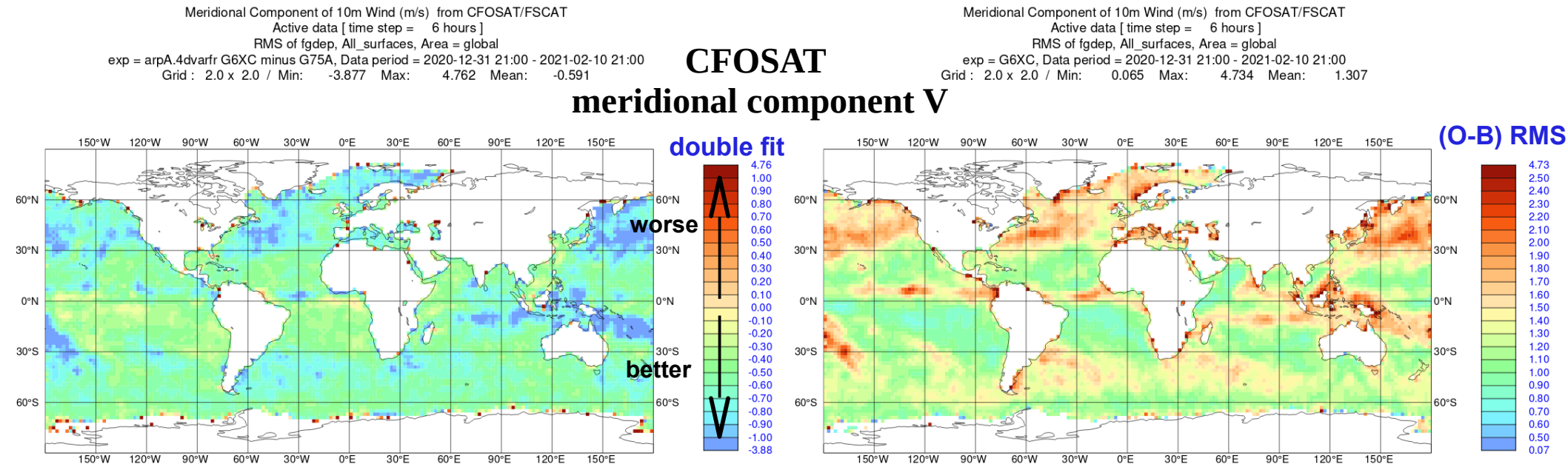
KNMI 50 km, time series 10/09 to 28/02/2021, 6 h step
Model background double (2) versus oper (1)

Wind speed:



- Around 100e3 observations per day
- With the double, speed bias closer to 0 and smaller standard deviation
- The same for the standard deviation in wind direction (bias equal)
- Change in bias in end of December (observed in all CFOSAT datasets)
- From this point on, focus on January-February 2021 period

KNMI 50 km, monitoring map, Jan-Feb 2021
Model background double (2) versus oper (1)



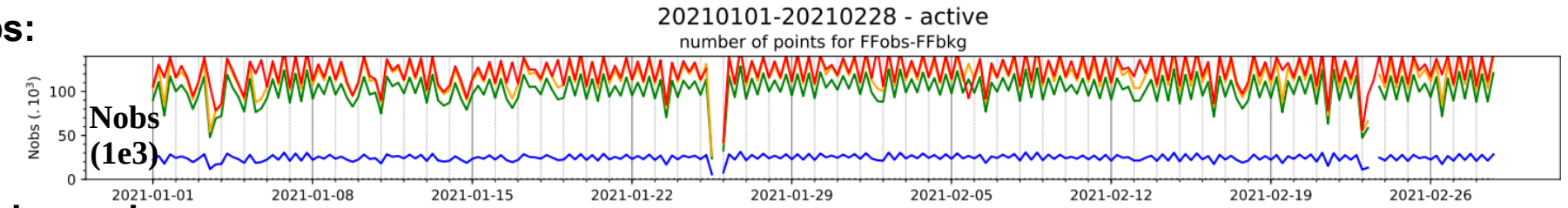
RMS (O-B) difference (2)-(1)

RMS (O-B) in (2)

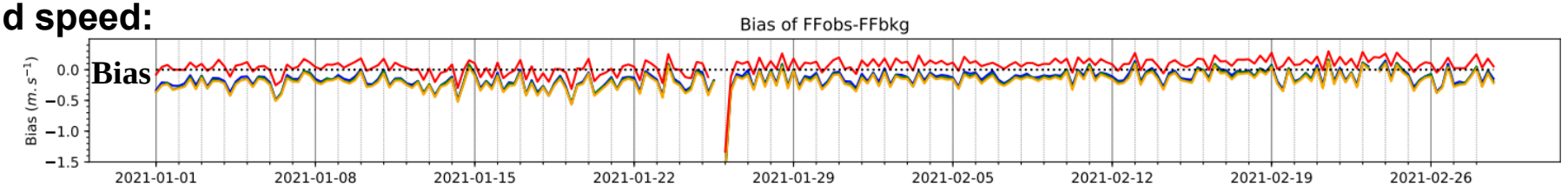
- Almost better fit of ARPEGE double to CFOSAT winds everywhere w.r.t ARPEGE oper
- With regional differences larger, where (O-B) RMS are the largest:
  - mainly in the areas of deep convection (SPCZ, ITCZ)
  - along the storm track of northern hemisphere (winter period here)
  - also some improvements along the north pole ice pack
- So statistics will be now w.r.t ARPEGE double

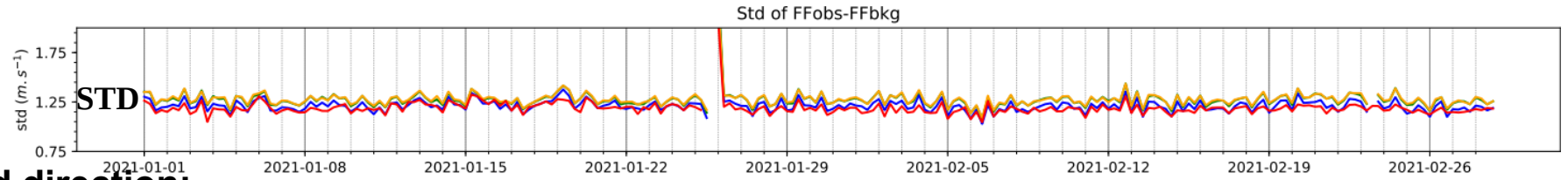
Time series with ARPEGE double, Jan-Feb 2021, 6 h step
(2) KNMI 50 km (3) 25 km (4) no azimuth check (5) CNES

Nobs:

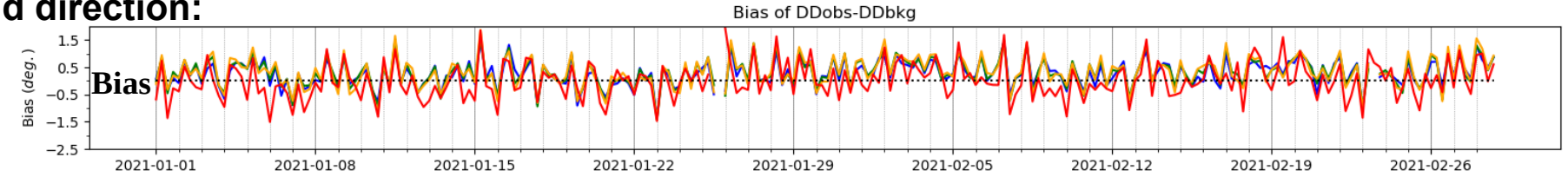


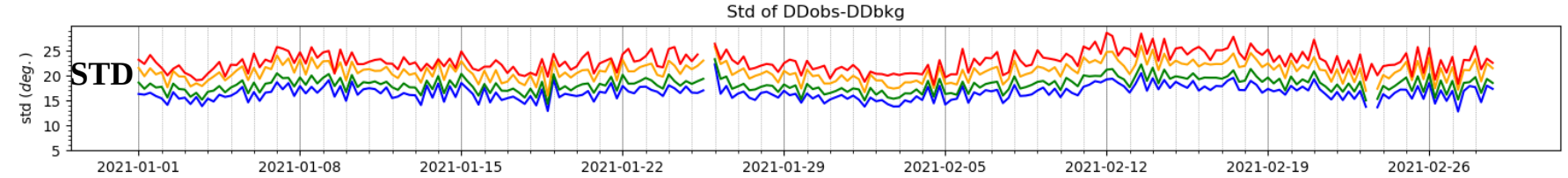
Wind speed:





Wind direction:

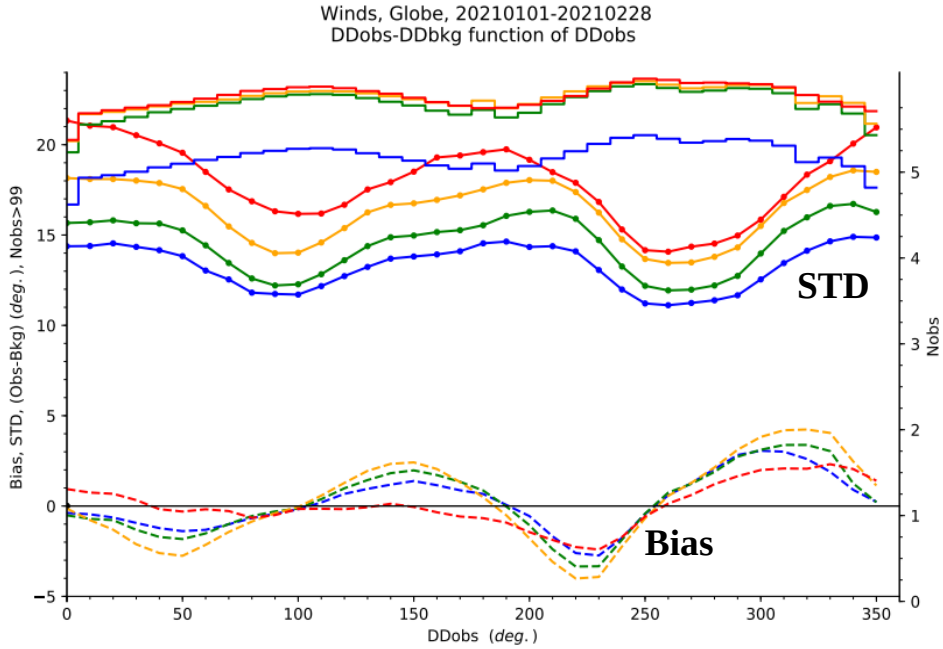




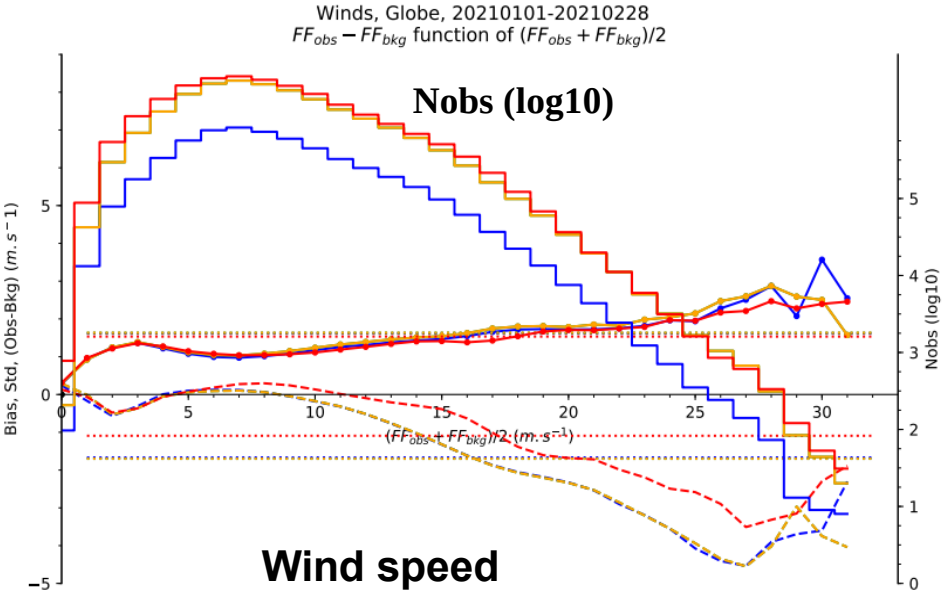
- 25 km wvc ((3),(4),(5)) ~ 450e3 observations per day depending on QC, (3) ~ 4 x (2), 50 km wvc (same QC)
- Reliable statistics over the period, “each” dataset keeps its rank

(O-B) statistics (bias, STD), by direction and speed

(2) KNMI 50 **(3) KNMI 25** **(4) KNMI 25 w/o azi. check** **(5) CNES 25**



Wind direction



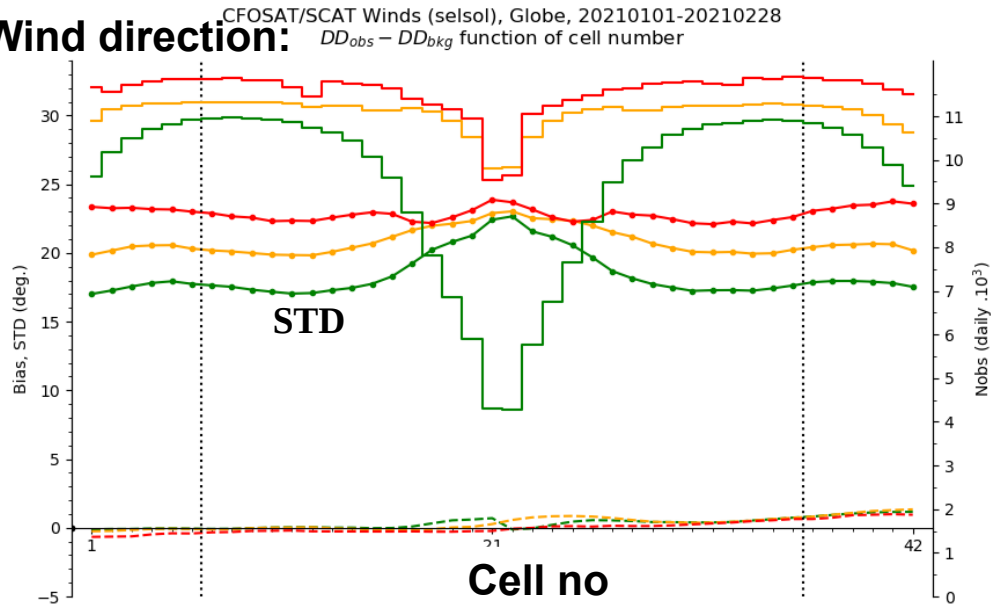
Wind speed

- Direction: rise of the STD without the azimuth check ((4),(5) against (2),(3)) and with the wvc resolution increase ((3) against (2))
- Speed: negative bias closer to 0 for CNES product (5) when this one increases. No difference for KNMI products ((2),(3),(4)), independently of wvc resolution and the QC.

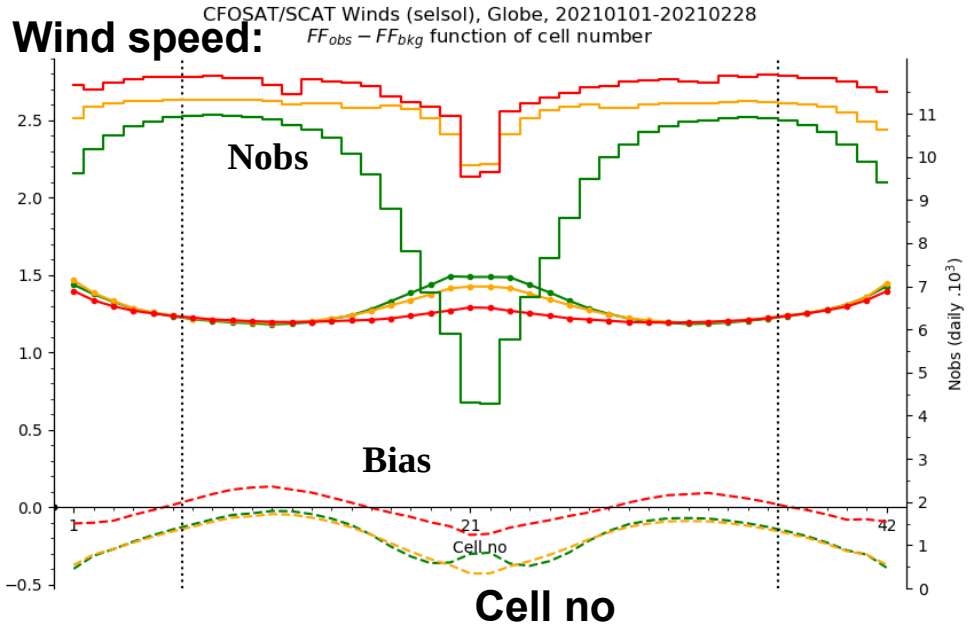
(O-B) statistics (bias, STD) cross-track

(3) KNMI 25 (4) KNMI 25 w/o azi. check (5) CNES 25

Wind direction:



Wind speed:



- Same patterns as with previous results (rotating beams): (O-B) dependence on the cross-track position
- Here comparison of various 25 km datasets:
  - direction: higher STD for the CNES product (~+4° wrt to (3) KNMI 25 km with azimuth check), but smaller differences in the nadir part (higher rejection rate in (3) due to azimuth check), (4) intermediate
  - speed: better bias and STD in the nadir part for the CNES product (after speed bias jump of end Dec)

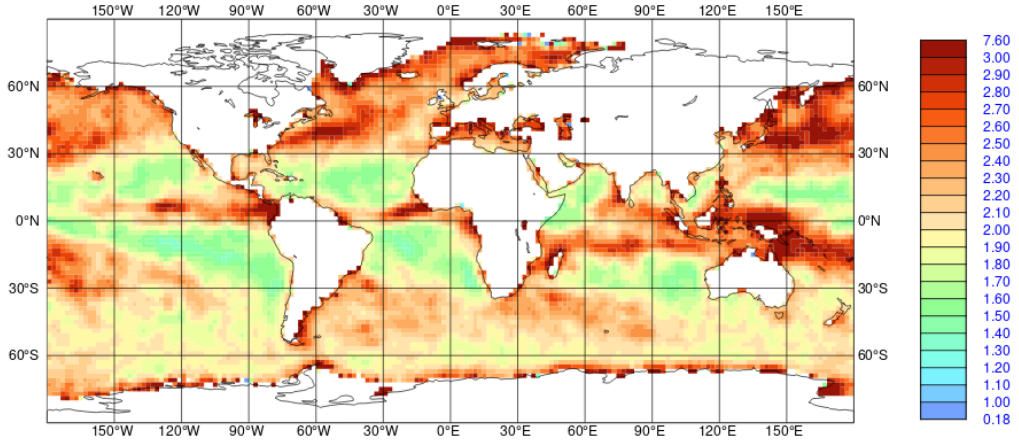
WVC 25 km
CFOSAT (5) CNES, (4) KNMI (azi. check off) & ASCAT-B

10m Wind Vector (m/s) from CFOSAT/FSCAT
Active data [time step = 6 hours]
RMS of fgdep, All_surfaces, Area = global
exp = G71S, Data period = 2020-12-31 21:00 - 2021-02-28 21:00
Grid : 2.0 x 2.0 / Min: 0.181 Max: 7.599 Mean: 2.126

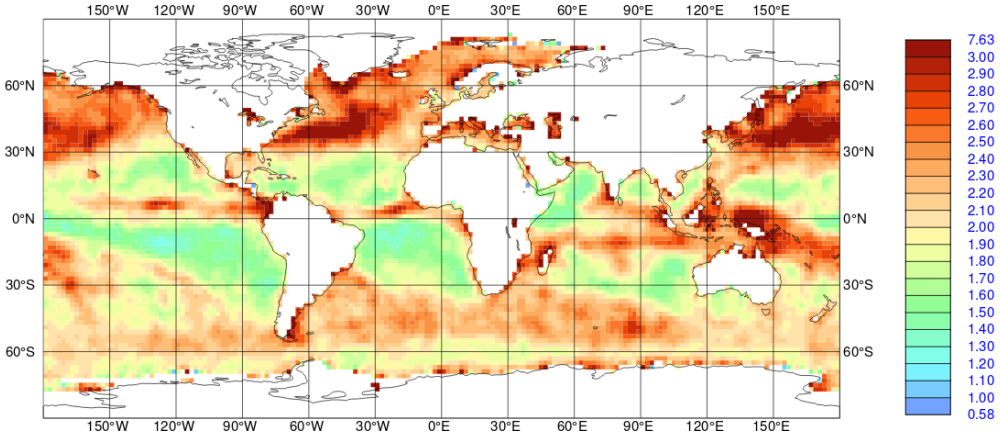
RMS (O-B) vector difference

10m Wind Vector (m/s) from CFOSAT/FSCAT
Active data [time step = 6 hours]
RMS of fgdep, All_surfaces, Area = global
exp = G7IO, Data period = 2020-12-31 21:00 - 2021-02-28 21:00
Grid : 2.0 x 2.0 / Min: 0.584 Max: 7.627 Mean: 2.107

CFOSAT CNES

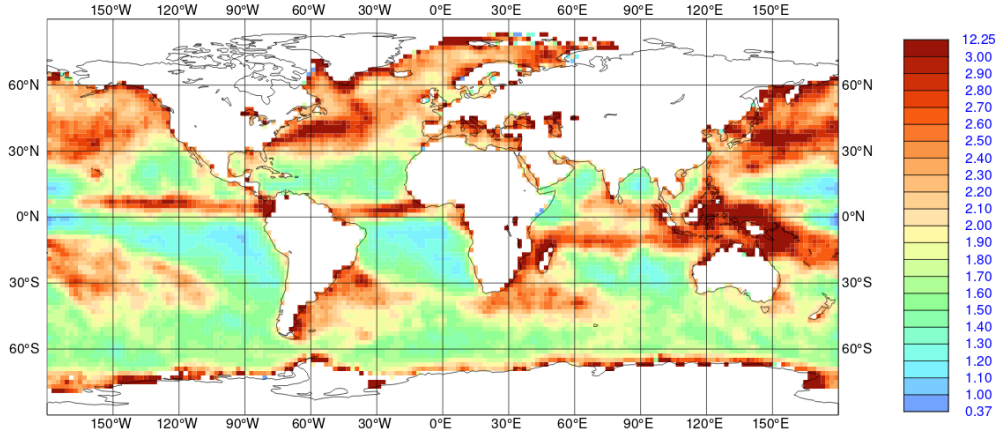


CFOSAT KNMI



10m Wind Vector (m/s) from MetOp-1(B)/ASCAT
Active data [time step = 6 hours]
RMS of fgdep, All_surfaces, Area = global
exp = G71S, Data period = 2020-12-31 21:00 - 2021-02-28 21:00
Grid : 2.0 x 2.0 / Min: 0.374 Max: 12.251 Mean: 1.964

ASCAT-B KNMI



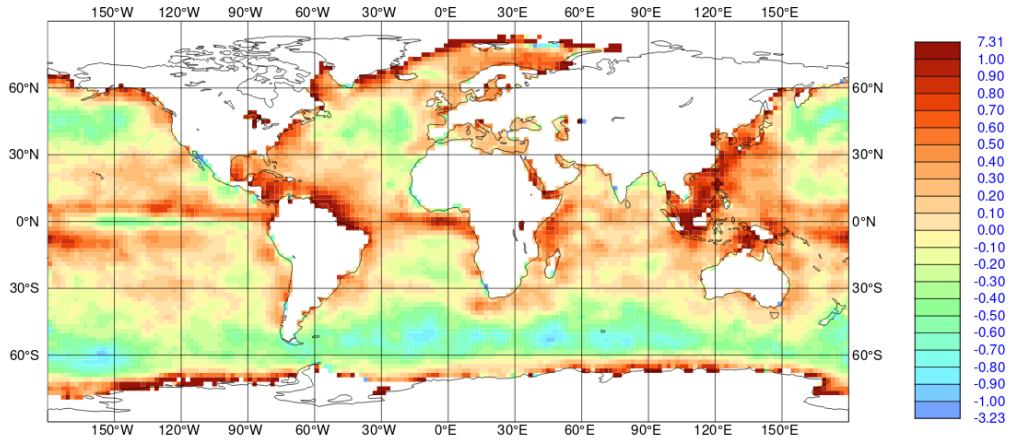
- CFOSAT CNES and KNMI products very similar
- ASCAT-B KNMI (fixes azimuth, lesser sensitivity to rain, SST):
  - better in the subtropical ridges
  - also better along the storm tracks (SH/NH) but with local variations (e.g west-side of south oceanic basins)

WVC 25 km
(5) CFOSAT CNES, (4) HY-2B (azi. check off) & ASCAT-B

Bias (O-B) wind speed

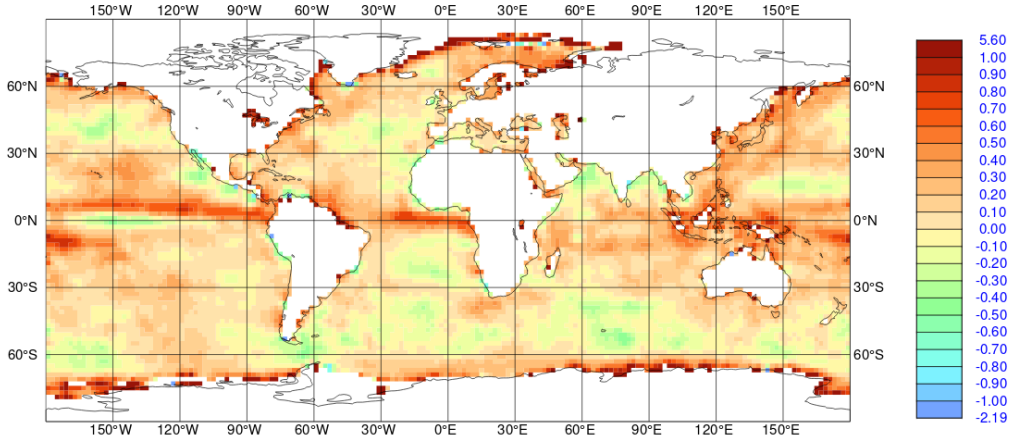
10m Wind Speed (m/s) from CFOSAT/FSCAT
Active data [time step = 6 hours]
MEAN of fgdep, All_surfaces, Area = global
exp = G71S, Data period = 2020-12-31 21:00 - 2021-02-28 21:00
Grid : 2.0 x 2.0 / Min: -3.233 Max: 7.314 Mean: -0.008

CFOSAT CNES



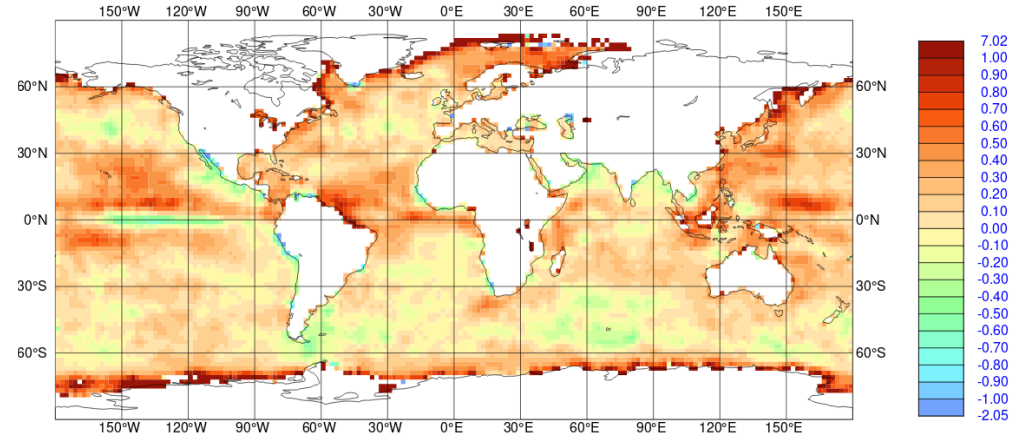
10m Wind Speed (m/s) from HY-2B/HSCAT
Active data [time step = 6 hours]
MEAN of fgdep, All_surfaces, Area = global
exp = G7IO, Data period = 2020-12-31 21:00 - 2021-02-28 21:00
Grid : 2.0 x 2.0 / Min: -2.190 Max: 5.601 Mean: 0.098

HY-2B KNMI



Active data [time step = 6 hours]
MEAN of fgdep, All_surfaces, Area = global
exp = G71S, Data period = 2020-12-31 21:00 - 2021-02-28 21:00
Grid : 2.0 x 2.0 / Min: -2.048 Max: 7.018 Mean: 0.131

ASCAT-B KNMI



- CFOSAT CNES versus HY-2B KNMI: speed bias dependence on SST or high speed higher? Same trend in the KNMI products ((2),(3),(4))
- CFOSAT speed bias farther away to ASCAT than HY-2B

Conclusions

- Next version of ARPEGE in preparation fits better to scatterometer winds
- ASCAT-A/B/C and ScatSat-1 assimilated operationally, HY-2B/C et CFOSAT in evaluation mode or test (ex HY-2B assimilation but impacts remain mixed)
- Capacity to process multi-resolutions of wvc (50 km (oper), 25 km) and the choice between different ambiguity removal schemes (closest to model (oper), a selected solution)
- CFOSAT CNES and KNMI products are very similar to each other at equivalent wvc resolution (25 km) and QC (w/o azimuth check)
- Nevertheless CNES product allows a better fit to ARPEGE in wind speed mostly for the highest values, but without the azimuth check, the wind directions are not as good as KNMI product.
- KNMI 50 km product fits the best to current operational use (BUFR format, resolution)
- So the first assimilation tests will be done with this dataset...
- In the same time, improvement in the assimilation of these data must continue