Last update of scatterometer winds usage at Météo-France

Christophe Payan – CNRM (Météo-France/CNRS)

Assimilation overview

The scatterometer winds have been assimilated in the operational Numerical Weather Prediction (NWP) system of Météo-France since 2004. 2008 onwards, the products provided by the Royal Netherlands Meteorological Institute (KNMI) in the frame of the EUMETSAT Ocean Sea Ice Satellite Application Facility (OSI-SAF) are used, first ASCAT on MetOp-A, then MetOp-B in 2013, OSCAT on OceanSat-2 between 2013 and 2014, and lastly RapidSCAT, since last December (2015) on an upgrade of the NWP system. The considered products are at 50km of resolution (25km grid for ASCAT data) and assimilated after miscellaneous quality checks and a spatial 100km-thinning.

Météo-France run different models, depending on their application (Figure 1). The model ARPEGE is used for the global predictions, computed on a stretched grid (8km resolution over the Western Europe until 35km). PEARP is its ensemble version (35 members) with a slightly degraded resolution. The analysis uses a 4DVAR algorithm, updated every 6 hours, coupled with an ensemble assimilation AEARP (25 members), which allows to provide a flow-dependant B-matrix. Over France, AROME is a non-hydrostatic model, 1.3km of resolution. It uses a 3DVAR assimilation, every hour, and is coupled with ARPEGE for its boundary layer conditions. For the overseas territories, as the New-Caledonia or the Lesser Antilles and the French Guyana, limited-area versions of ARPEGE are used, the ALADIN-overseas, with a 6h 3DVAR assimilation and a coupling with the ECMWF's model IFS, except for the La Réunion domain still linked to ARPEGE. These models will be replaced this year by AROME versions with an higher resolution (2.5 km instead of 8 km) but on smaller domains.

The adding of RapidSCAT, delayed stream, in last December has allowed to complete the ocean vector winds coverage assured only by the both ASCAT on MetOp-A and B, shifted by an half-orbit (coverage on a 6h assimilation window Figure 2). The computation of Degrees of Freedom for Signal shows that this addition allows to scatterometers to contribute to the total information provided by the assimilation almost at the same level as before the loss of the instrument OSCAT (in February 2014), now around 5% whereas they represent only 1% of used data (Figure 3).

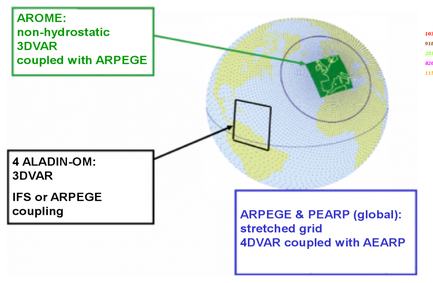

Figure 1: NWP system at Météo-France

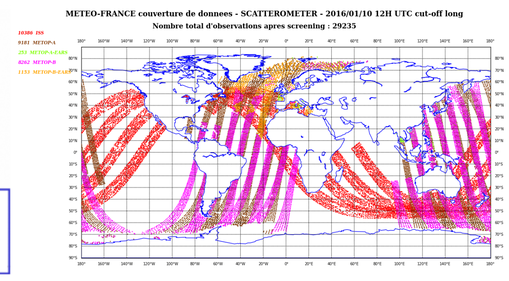

Figure 2: Coverage of scatterometer winds used in an ARPEGE 6h assimilation window, 10/01/2016 12 UTC analysis

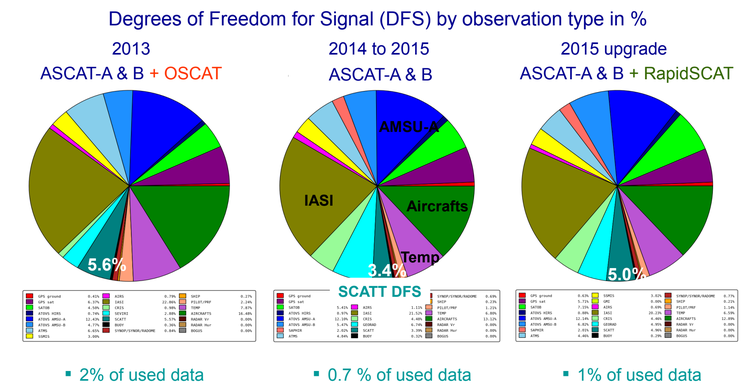

Figure 3: DFS by observation type in ARPEGE at different dates (with different scatterometers constellation)

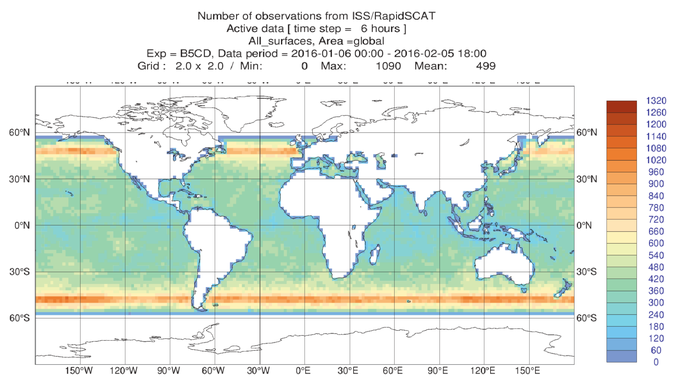

Figure 4: RapidSCAT winds number by 2°x2° boxes, active for the assimilation, January 2016

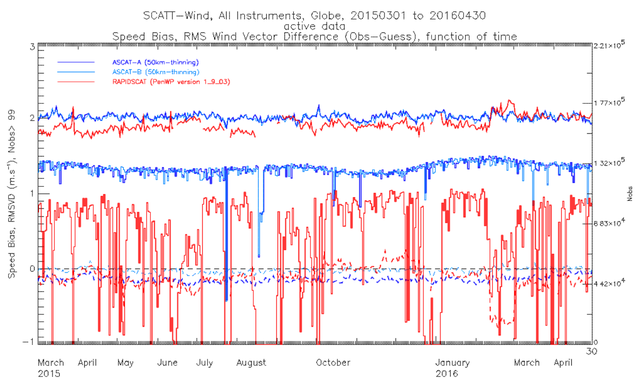

Figure 5: daily time series of RMSVD, speed bias and Nobs on ASCAT-A, ASCAT-B and RapidSCAT, after QC and 50km thinning

RapidSCAT contribution

The ISS progrid orbit with a 51.6° inclination allows de facto a frequent revisit of the mid-latitudes, with a maximum around 1000 data per month and per 2°x2° box along the 55th degrees of latitude, available for the assimilation, after quality control and a 100km thinning, whereas the global average is of 500 observations. The tropical Indian Ocean is now better covered, even though a little lower than in the other tropical basins (January 2016, Figure 4). The assimilation of this data in an optimal configuration, after various tuning, improves significantly the forecast scores, mainly on the geopotential in the northern hemisphere or on the wind in the tropics, until 1-2% of reduction on the RMS error, with radiosondes as control. The positive impact is clearer in the southern hemisphere, when the ECMWF's analysis is used as control (Figure 6). This dataset reduces also the position error of tropical cyclones at all forecast ranges, 14 events on the test period of one month and half, early 2015. The daily statistics after QC and with a common 50km-thinning, over more than one year show generally a RMSVD for RapidSCAT lower than for ASCAT instruments, and a speed bias a little more negative. This is because RapidSCAT data are discarded where the departures to the model are usually higher as in the rainy areas or towards the poles. The speed bias in the southern hemisphere is also more negative for RapidSCAT. Moreover, this time series shows some variations due to the ISS management or to the instrument behaviour, as the event of February (Figure 5).

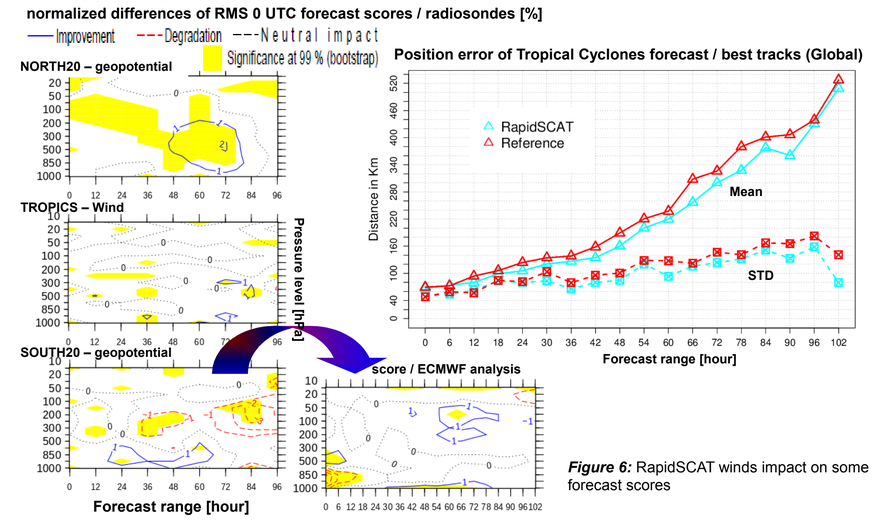

Figure 6: RapidSCAT winds impact on some forecast scores

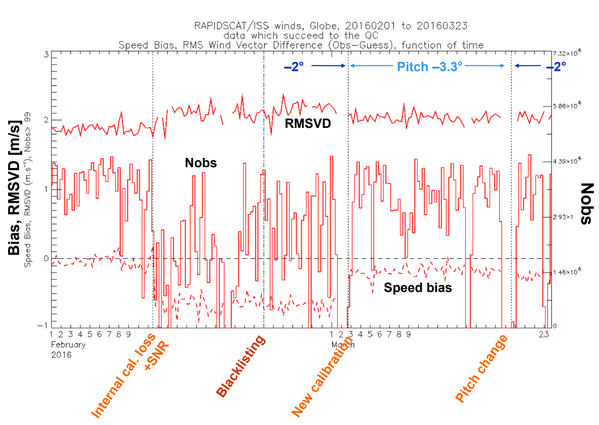

Figure 7: 6h assimilation window time series of RMSVD, speed bias and Nobs on RapidSCAT, after QC, during the instrumental event of February

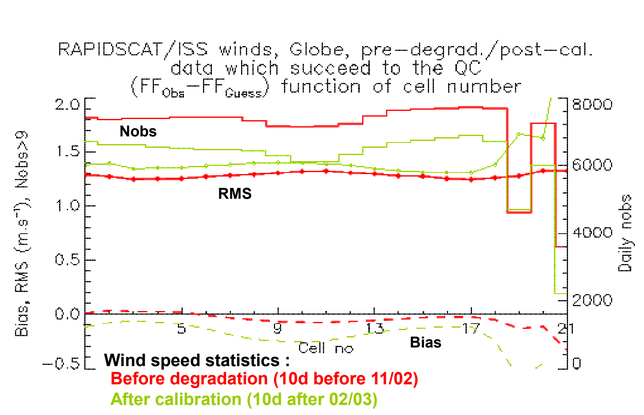

Figure 8: RapidSCAT cross-track index statistics, speed parameter (bias, RMS and Nobs)

RapidSCAT instrumental event

An internal calibration loss, conjugated to a SNR reduction, occurs at the instrument level on 11/02/16. This translates into the data monitoring against the model background by a negative speed bias and an higher RMSVD. In accordance with the Operations, RapidSCAT is blacklisted on 23/02. A new JPL calibration, implemented on 02/03, reduces the speed bias, and also the RMSVD (Figure 7). But the wind speed statistics across the track indicate more important departures (in bias and RMS) for cell idx > 17 (Figure 8). The switch to a more optimal pitch of ISS on 19/03, -2° against -3.3° previously, does not improve these ones.
Various scenarios with ARPEGE are studied for using again RapidSCAT, tested on one month period (March). First, only tests with the operational AEARP, so without RapidSCAT, are done, as this is much less costly in term of HPC resources (Table 1). To use the data without any change (B5T5) or with revised errors (B5T7) is neutral or degrades the forecasts in the southern hemisphere. The best result is with gross errors for cell idx > 17 (B5T6), with a light positive impact on the geopotential forecast score in the northern hemisphere and in the tropics. But a common feature to the 3 tests remains a degradation in the southern hemisphere, mainly with the ECMWF's analysis as control, a result opposite to this one one year before (Figure 9).
A new test, based on B6T6 but this time by playing its own ensemble assimilation using RapidSCAT, improves significantly this point. Even if in this last test, the impact on the forecasts against the operational run, with RapidSCAT blacklisted, is now only neutral in the southern hemisphere, the scores are still improved in the both other large domains.
This result agrees with the scatterometers contribution in the assimilation ensemble to the reduction of the ratio analysis variance on background variance of the 10m relative vorticity, detailed in the 2014 IOVWST meeting presentation (Portland), and mainly in the southern hemisphere, where the sea fraction dominates and the other observations are rarer (Figure 10).
But in ultimate, a last JPL's calibration early April allows to back to statistics close to these ones before 11/02 and RapidSCAT is again used by the Operations on 19/04, without any change.

ARPEGE tests	RapidSCAT use	AEARP coupling	cores / run time / archive (1 month test)
B5T5	settings unchanged (as before 11/02)	OPER (w/o RapidSCAT)	243 960 / 9 days / 20 Tb
B5T6	new obs. errors based on (o-b) statistics, gross errors for cell idx>17	idem	idem
B5T7	new obs. errors based on (o-b) statistics	idem	idem
7EYP	as B5T6	7EYQ (with RapidSCAT)	1M374 / 15 days / 100 Tb

Table 1 : various scenarios for using again RapidSCAT winds after calibration on 02/03/16, and HPC resources used

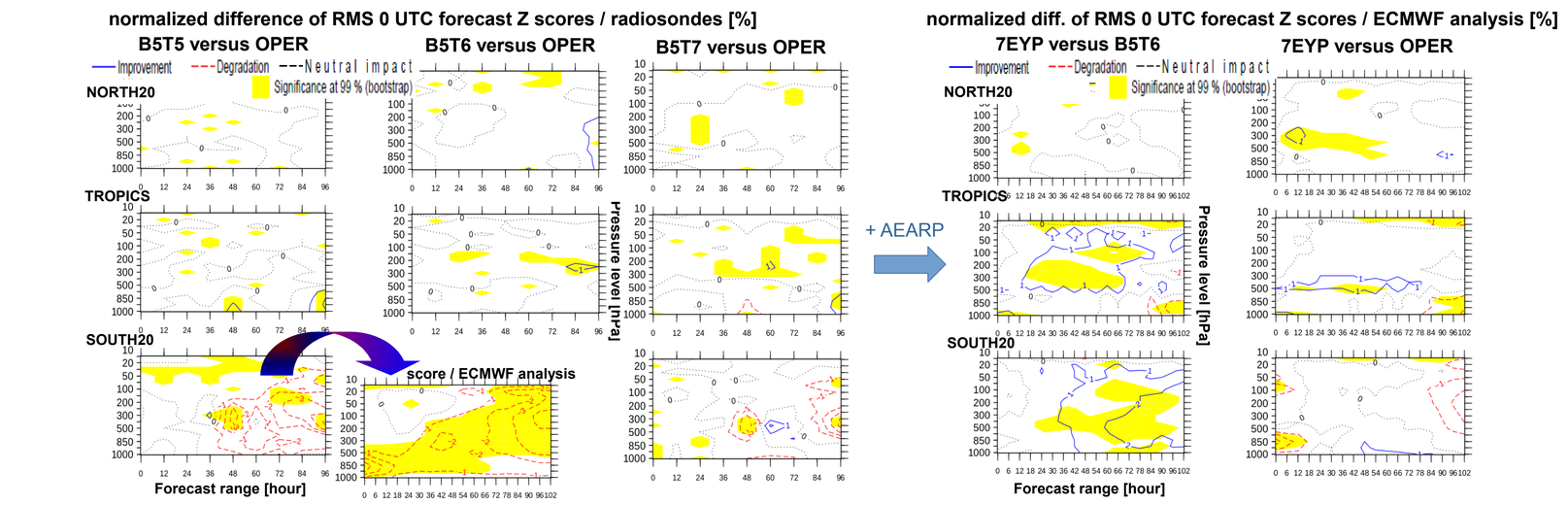

Figure 9: forecast score differences of various ARPEGE scenarios against the operational run or between them for using again RapidSCAT in a degraded mode (after February, 11 event)

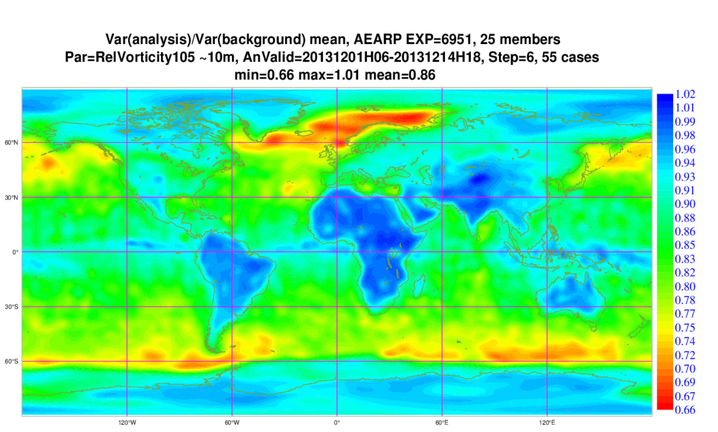

Figure 10: ratio variance(analysis) / variance(background) for the 10m relative vorticity in the ensemble assimilation AEARP, used for providing an updated B-matrix to the deterministic analysis ARPEGE 4DVAR

Conclusion

The addition of RapidSCAT in last December (2015) in the Météo-France operational NWP system, combined with the both ASCAT, allows to mitigate the loss of OSCAT 2 years ago. The chosen final configuration, mainly a spatial 100km-thinning as for ASCAT, allows to improve the global forecast scores and also the tracking of the tropical cyclones in an month and half experiment early 2015.
But the functioning of the instrument is a little erratic, and data is blacklisted between end February and mid-April (2016). Tests with the tuning of new observation errors require to run also a revised ensemble assimilation for proving the beneficial impact of data in a degraded mode. This framework is obviously more costly in term of HPC resources.
Fortunately, a last JPL tuning early April allows to find again (obs – background) statistics close to their magnitude before the February, 11 event and RapidSCAT is back in the operational assimilation on April, 19, with its unchanged settings.

International Ocean Vector Winds Science Team (IOVWST) meeting, Sapporo, Japan, 17-19 May 2016