RESEARCH DEPARTMENT MEMORANDUM

To:	DR, HMD, HMAS, RD division and Section Heads, DA section
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From:	Patricia de Rosnay, Giovanna De Chiara, Ioannis Mallas
Date:	August 15, 2011 — File: R43.8/PdR/11100
Subject:	**Use of ASCAT soil moisture: revised bias correction and test of improved ASCAT product in IFS cycle 37r2.**

1 Introduction

An improved version of the ASCAT (Advanced SCAtterometer) level 1 and level 2 soil moisture products was developed at EUMETSAT. It is planned for release on August 18th, 2011.

This was announced by EUMETSAT on 8 July 2011, together with the delivery of a 1-month test data set of the level 1 and level 2 products. The level 2 test product delivered by EUMETSAT was downloaded and pre-processed at ECMWF. It is available for 27 March 2011 to 21 April 2011 on ECFS (ECMWF File Storage system).

The level 2 ASCAT product is used in operations at ECMWF for wind analysis and soil moisture monitoring. It is also used for soil moisture analysis developments and for H-SAF (Satellite Application Facility on support to operational hydrology and water management) activities.
The use of ASCAT surface soil moisture (SSM) data relies on a Cumulative Distribution Function (CDF) matching approach which rescales, for each model grid point, the scatterometer SSM index to fit the model SSM climatology. ASCAT CDF matching is based on (i) the ERS scatterometer (ERS/SCAT) data base, which provides a long data set consistent with ASCAT data, and (ii) the ERA-Interim soil moisture for 1992-2000 (Scipal et al., 2008). In this memorandum a revision of the ASCAT soil moisture bias correction approach is proposed, as suggested in de Rosnay et al. (2011b). The revised CDF matching still relies on ERS/SCAT data for 1992-2000. However it matches ERS/SCAT surface soil moisture CDF to that of the recent cycle 36r4 of the ECMWF land surface model H-TESSEL (Hydrology Tiled ECMWF Scheme for Surface Exchanges over Land). H-TESSEL climatology was obtained from offline simulations forced by ERA-Interim corrected by GPCP (Global Precipitation Climatology Project) Balsamo et al. (2011, 2010). The revised ASCAT CDF matching accounts for a seasonal cycle correction.

The objective of this memorandum is two-fold. First, the content and structure of the new improved ASCAT data, that will replace the currently operational data from 18 August 2011, is investigated and compared to that of the current ASCAT product. Second, the revised ASCAT soil moisture CDF matching approach is presented and results of the CDF matching using both the ASCAT operational product and ASCAT improved products are shown. Data assimilation experiments were conducted to address the impact of both the improved data and the revised CDF matching.

2 Modification of ASCAT product

The ASCAT level 2 multi parameter (backscattering coefficient, wind and soil moisture) 25km product is used at ECMWF since February 2011 de Rosnay (2011a). It is preprocessed and archived per 6-hour periods on ECFS in the emos directory: ec:/emos/ALWS/. It will be replaced on 18 August by the improved product for which the test data set (available for 27 March 2011 to 21 April 2011) is on ECFS ec:/emos/e/ALWS/.

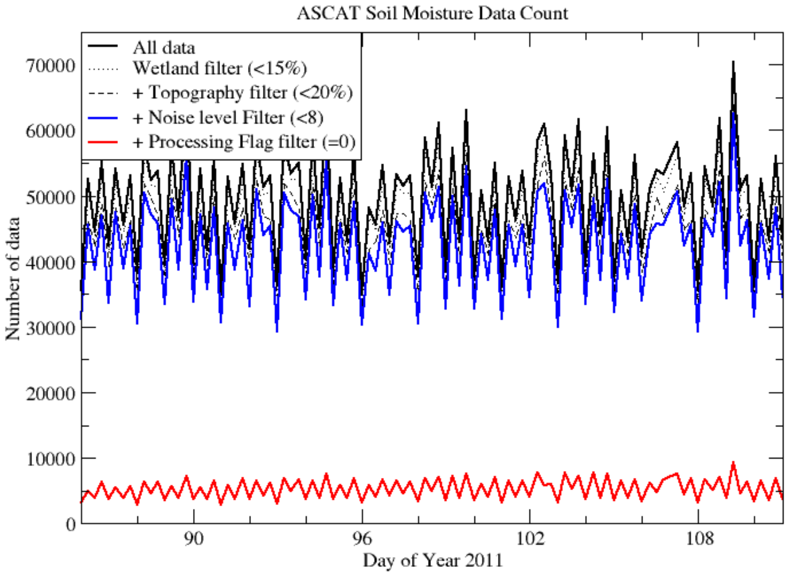
Improvements in the ASCAT soil moisture product relies on:

- Improved backscatter calibration: antenna gain patterns have been derived, reducing small incidence angle dependent oscillations observed in the ASCAT backscatter products over the ocean and the rainforest. A sudden small calibration change in the instrument, observed in September 2009, is compensated for with this new antenna gain patterns. This calibration update reduces the backscatter levels by 0.1 dB on average, for FORE and AFT LEFT beams and for the FORE, MID and AFT RIGHT beams, and by 0.2 dB for the MID LEFT beam. Another improvement expected with this processor upgrade is a more realistic set of Kp values, following an algorithm revision. The Kp values will see an increase of 0.5-0.7 % on average, depending on beam and incidence angle.

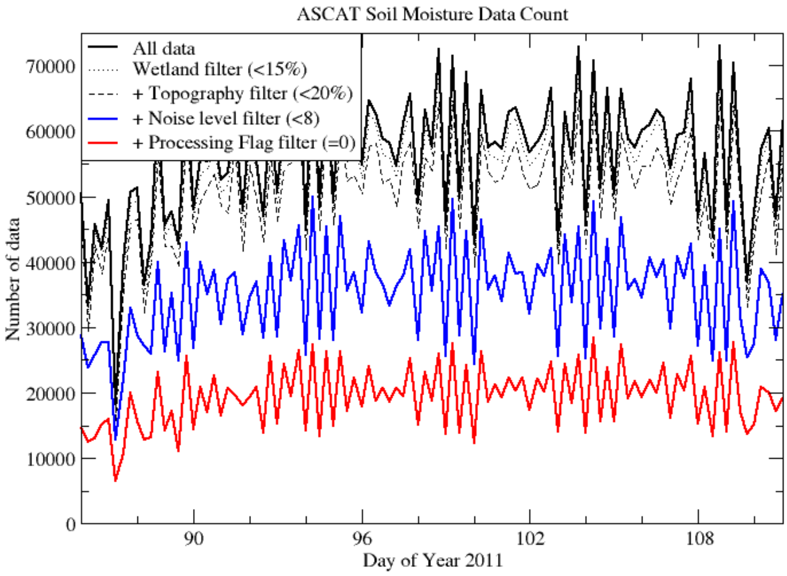
- Improved soil moisture retrieval algorithm: the new reference parameter database has been trained exclusively on ASCAT re-processed backscatter values, corresponding to the years 2007 and 2008. This new configuration has been provided by the Institute of Photogrammetry and Remote Sensing of the Vienna University of Technology. Among other improvements, the currently observed noise of the soil moisture values in mid to far swath will be reduced, thanks to a better interpretation of backscatter slope along incidence angle. Furthermore, a more adequate backscatter azimuthal correction is expected to reduce the currently artificial wetness observed around urban areas

The BUFR file contents of the operational (ASCAT Oper) soil moisture and the improved (ASCAT new) soil moisture data were compared. The data quality is substantially different in the two products. Figure 1 shows the data count of the operational and the test products, for different use of flag conditions given in the BUFR file. Flag conditions are used at ECMWF for the data Quality Control (QC), before the ASCAT soil moisture data it is used for monitoring and data assimilation. Figure 1(a) shows that the operational ASCAT product contains about 50000 SSM data per 6 hour (black line). Any SSM value associated to a non-zero processing flag is potentially corrupted, so, it is rejected at the QC level. Figure 1(a) shows that the use of this flag considerably reduces (by a factor of about 10) the number of data for the operational product. Figure 1(a) also shows that the count of data is not very sensitive to the noise level flag for ASCAT Oper.
In contrast, Figure 1(b) shows that the improved ASCAT product does a very different usage of the flags than the operational product. The noise level filtering (blue line) seems to be more strict than for the operational product: a noise level lower than 8 leads to reduce by about one-third the total number of data (instead of by about one-tenth for ASCAT Oper). The improved product ASCAT new, has a much reduced count of potentially corrupted data compared to the operational product, as shown by the total data count of data after the processing flag QC (red lines).

In 2010 EUMETSAT delivered a preliminary version of the improved ASCAT level2 soil moisture product. Although this test product was not considering the improved backscatter calibration, it was using the new configuration of the soil moisture retrieval algorithm. It was provided for the entire 2009 year. Figure 2 shows the data count for the different flags for the operational product and the improved product for a few days in July 2009. Results and improvements with respect to the operational product, are well in line with those obtained for the 2011 improved product. The same procedure was repeated for other periods of 2009, showing consistent

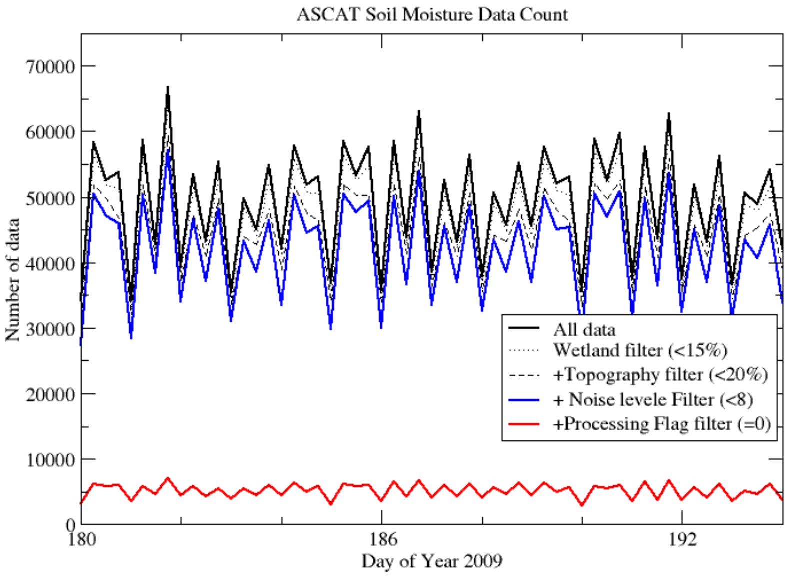


(a) ASCAT operational product

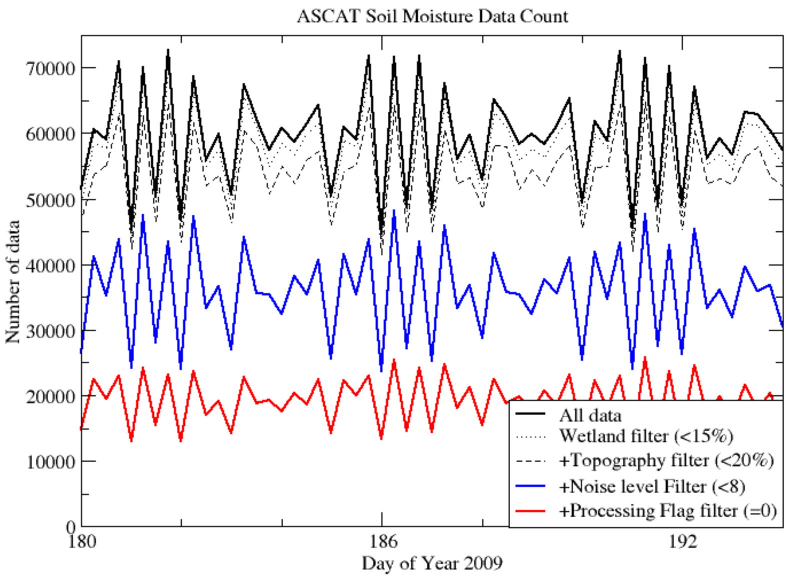


(b) ASCAT improved product

Figure 1: ASCAT level 2 soil moisture product data content and count (per 6 hours) for the test period (27 March 2011 - 21 April 2011), for (a) the ASCAT operational product (used in operations at ECMWF for soil moisture monitoring), (b) the ASCAT improved product that will be released on 18 August 2011. The black line shows the total soil moisture data count per 6 hour, the dotted-black line shows the data count after data from pixels with wetland fraction larger than 15% is rejected. The dashed line is the count after removing data from pixel with a topographic complexity larger than 20%. A noise level quality control (noise level ¡ 8) is applied resulting to the blue line. The ASCAT soil moisture data is used only when the processing flag is set zero, ensuring that the data is not corrupted. The total soil moisture data count available after quality control is the red line.



(a) ASCAT operational product



(b) ASCAT improved product

Figure 2: Same as figure 1, for a few days in July 2009 from the operational ASCAT product and the first test data set provided for 2009 and accounting for the new soil moisture retrieval algorithm.

results (not shown).

Overall the new product provides a larger amount of reliable data and it uses a more strict indication of the noise level of the data than the current operational product. This increased number of non-corrupted data combined with a better flag usage is of great interest for data assimilation activities.

3 ASCAT Soil Moisture bias correction revision

3.1 Motivation

ECMWF uses ASCAT soil moisture for operational monitoring (`http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite/slmoist/ascat/`) and for research data assimilation experiments. ECMWF have been continuously producing (back from July 2008) a root zone soil moisture profile based on ASCAT soil moisture data assimilation (`http://www.ecmwf.int/research/EUMETSAT_projects/SAF/HSAF/ecmwf-hsaf/index.html`).

The use of ASCAT soil moisture index data relies on a Cumulative Distribution Function (CDF) matching approach based on the ERS/SCAT data base and developed by Scipal et al. (2008). ERS/SCAT provides a long time series of consistent quality surface soil moisture. Intercalibration between ERS/SCAT and ASCAT ensures a good consistency between the two products. CDF matching transforms ASCAT normalised surface soil moisture index into model equivalent volumetric surface soil moisture. The CDF matching parameters were derived for each model grid point from the CDF matching moments (mean and variance) of ERS/SCAT soil moisture data and ERA-Interim surface soil moisture for 1992-2000. They were rescaled from TESSEL to H-TESSEL to account for soil texture dependent soil moisture ranges in H-TESSEL. This CDF matching is referred to as CDF1 in the following of this memorandum.

A first impact demonstration of ERS/SCAT soil moisture data assimilation using a nudging scheme was performed by Scipal et al. (2008). They showed that compared to the Optimum Interpolation soil moisture analysis (using screen level data), assimilating ASCAT data was slightly degrading the forecast scores. They recommended to use ASCAT data in an Extended Kalman Filter (EKF) analysis to account for observation errors and to combine ASCAT data with screen level proxy information. ASCAT soil moisture data assimilation in the EKF soil moisture analysis was shown to have a neutral impact on soil moisture and screen level parameters analysis and forecasts (de Rosnay et al. , 2011b). The impact of ASCAT data assimilation was limited by the quality of the ASCAT product, using non-appropriate processing and noise level flags as shown in the previous section, which was reducing considerably the number and the quality of data used in the analysis. In addition a large angular bias of ASCAT soil moisture was shown in de Rosnay (2009), resulting in rejecting data at large incidence angles and reducing further the amount of data available for data assimilation. An other issue was related to the main assumption in CDF1, which is that the systematic differences between observations and model are stationary. There are actually potentially large differences in the seasonal cycles of the ASCAT and ECMWF soil moisture. In a previous study, Draper et al. (2009) showed that for the AMSR-E (Advanced Microwave Scanning Radiometer) SSM data and the Météo-Frances Aire Limiteée Adaptation Dynamique développement InterNational (ALADIN) SSM, it is crucial to account for seasonal correction in the CDF matching. Not accounting for seasonal discrepancies between observations and model climatologies might affect the matching at both short time scale and seasonal scale.

Major modifications were implemented in November 2010 in the land surface model in IFS cycle 36r4 (Balsamo et al. , 2011). The bare soil evaporation parameterisation was improved by removing the lower wilting point limit for bare soil areas and by accounting for Lea Area Index seasonal cycle (Balsamo et al. , 2011;

Boussetta et al. , 2011). These modifications had a significant impact on the soil moisture range (Albergel et al. , 2011). So, the TESSEL to H-TESSEL CDF moments rescaling used in CDF1 is not any longer valid from H-TESSEL cycle 36r4. Limitations in the CDF matching and important changes in H-TESSEL justify a revision of the ASCAT soil moisture CDF matching at ECMWF.

3.2 Revision and evaluation using 2009 data sets

The revised ASCAT index rescaling approach matches ERS/SCAT SSM climatology to that of ECMWF (H-TESSEL cycle 36r4) for 1992-2000. ECMWF soil moisture climatology was generated for 1989-2009 from offline simulations, with atmospheric forcing obtained from ERA-Interim corrected by Global Precipitation Climatology Project (GPCP) product Balsamo et al. (2010). The revised CDF matching is referred to as CDF2 in the following of this memorandum.

In addition to CDF2, a further improved CDF matching is investigated, by correcting for the seasonal cycle differences between ASCAT and ECMWF SSM climatologies. It is referred to as CDF2 seasonal. CDF2 seasonal was computed separately for each month, using a three month moving window, based on the 1992-2000 ERS/SCAT and H-TESSEL cycle 36r4 climatologies.

For all the CDF matching approaches described above, moments are computed based on observations and model SSM values in snow free and for two-meter air temperature above 0 $^\circ$C (in the model). CDF moments are computed at the ERA-Interim resolution (T255, ie 80km). They are interpolated to each resolution (ranging from T42 to T1279) used at ECMWF to run the Integrated Forecasting System (IFS). CDF matching coefficients are then computed at each resolution from interpolated moments.

The revised CDF matching approaches (without and with seasonal correction) were applied to rescale the ASCAT 2009 improved test data set provided by EUMETSAT. Rescaled ASCAT SSM data was compared to H-TESSEL cycle 36r4 SSM for 2009.

	Min	Max	Mean	StD
ECMWF (m^3m^{-3})	0.066	0.439	0.317	0.080
ASCAT Index (-)	0.000	0.998	0.450	0.207
ASCAT rescaled CDF1 (m^3m^{-3})	0.191	0.428	0.326	0.050
ASCAT rescaled CDF2 (m^3m^{-3})	0.103	0.500	0.316	0.065
ASCAT rescaled CDF2 seasonal (m^3m^{-3})	0.069	0.511	0.321	0.072
ASCAT CDF 1 - ECMWF (m^3m^{-3})	-0.11	0.198	0.010	0.054
ASCAT CDF 2 - ECMWF (m^3m^{-3})	-0.176	0.204	-0.001	0.056
ASCAT CDF2 seasonal - ECMWF (m^3m^{-3})	-0.124	0.200	0.005	0.041

Table 1: Characteristics (minimum value, maximum value, mean and standard deviation) of ASCAT data and ECMWF SSM (H-TESSEL 36r4), and their difference for the improved ASCAT data rescaled with CDF1 and CDF2 without and with seasonal correction. Statistics were computed for a small region (12 pixels) in south west of France for the entire year 2009 (sample size after temporal collocation between ASCAT ECMWF SSM is 1972 elements).

Figure 3 illustrates, for one location in south west of France, an example of surface soil moisture time series obtained for 2009 for ECMWF (H-TESSEL cycle 36r4) and for ASCAT data, before (top panel) and after (middle panel) CDF matching. The middle panel shows that the current CDF matching (green) is not appropriate to be used with the current version of the land surface model at ECMWF as discussed above. Mean and variance

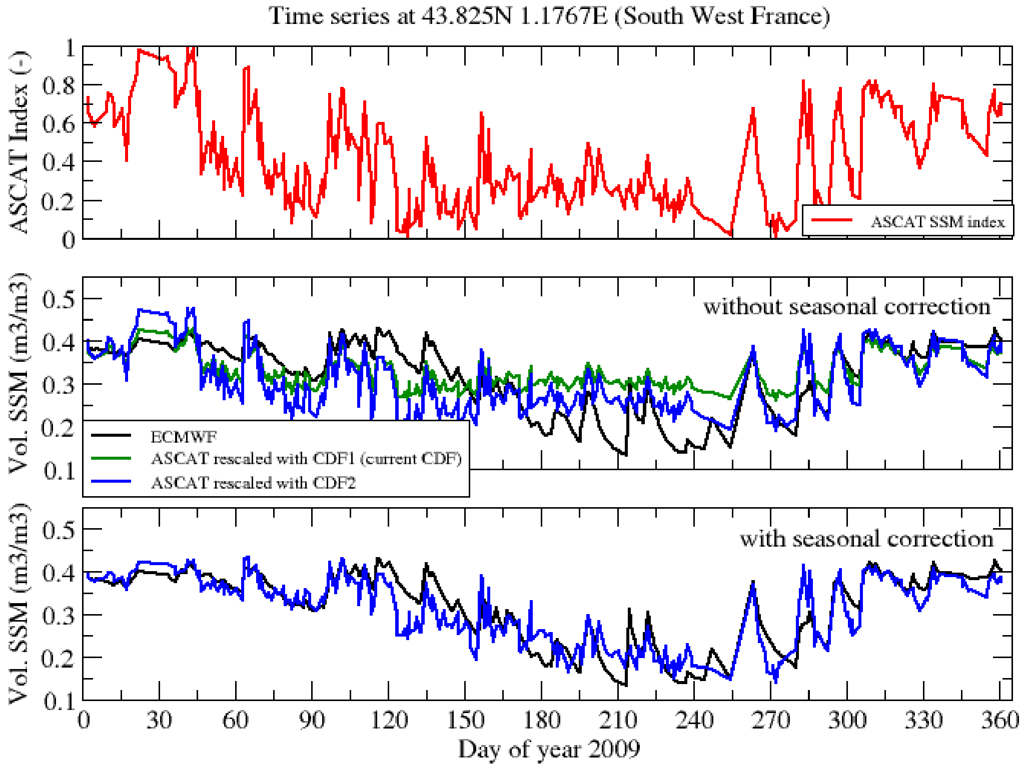


Figure 3: Surface soil moisture time series for 2009, for one location in South West of France, for ASCAT data (top) and for ECMWF (H-TESSEL cycle 36r4) and ASCAT data rescaled without (middle) and with (bottom) seasonal cycle correction.

of ASCAT data rescaled using CDF1 does not fit those of ECMWF land surface model. As expected using CDF2 (matching to H-TESSEL 36r4), improves the fit between rescaled ASCAT and ECMWF SSM compared to CDF1 (middle panel). However there are still large discrepancies related to the seasonal cycle differences between ASCAT and ECMWF soil moisture. Accounting for a seasonal correction (CDF2 seasonal, bottom panel) allows to obtain a much improved match, at short time scale at well as at seasonal and annual scales, between rescaled ASCAT data and ECMWF soil moisture (bottom panel).

Table 1 summarises, for a small region in south west of France (location above extended to 12 pixels), characteristics of ASCAT and ECMWF surface soil moisture and their difference (observation-model), for CDF1 and for CDF2 without and with seasonal correction. CDF1 rescales ASCAT to H-TESSEL version older than 36r4 (without the improved bare soil evaporation parameterisation and Leaf Area Index seasonal cycle). So, SSM range and SSM standard deviation (StD) is much lower when ASCAT is rescaled with CDF1 than with CDF2. Miminum soil moisture value of ASCAT data rescaled with CDF1 is 0.191 m^3m^{-3}, while it is 0.066 m^3m^{-3} for H-TESSEL cycle 36r4. Accordingly, the difference between ASCAT CDF1 and ECMWF shows a large positive bias of rescaled observations. Mean difference between observations and model drops from 0.01 m^3m^{-3} for CDF1 to -0.001 m^3m^{-3} for CDF2. Bias reduction between CDF1 and CDF2 shows the importance of using an updated version of the land surface model for the CDF matching. However the StD is not improved in CDF2 (0.056 m^3m^{-3}) compared to CDF1 (0.054 m^3m^{-3}). Accounting for the seasonal cycle correction is necessary to improve the fit between ASCAT and ECMWF SSM variance, as shown by reduced StD in observations minus model for CDF2 seasonal (0.041 m^3m^{-3}) compared to CDF2 (0.056 m^3m^{-3}). CDF2 seasonal also makes it possible to fit minimum soil moisture values to that of the model with a better accuracy than CDF2 (0.103 m^3m^{-3} for CDF2, 0.066 m^3m^{-3} for H-TESSEL and 0.069 m^3m^{-3}) for CDF2 seasonal).

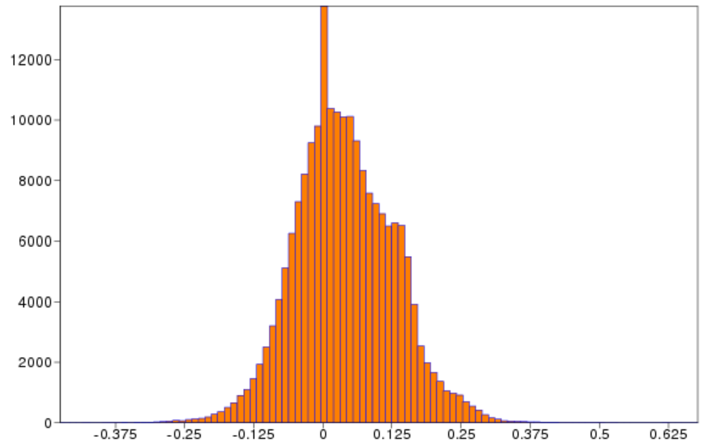
3.3 Evaluation of the CDF matching for April 2011 data sets

Figures 4 and 5 show histograms of the global scale differences between ASCAT soil moisture after CDF matching and ECMWF operational soil moisture for the period 01 April 2011 to 21 April 2011, for the ASCAT operational product and the improved test product, respectively. Table 2 summarises statistics of the differences between observations and model for both the current and the improved ASCAT soil moisture products, for different configurations of CDF matching. Results show that:

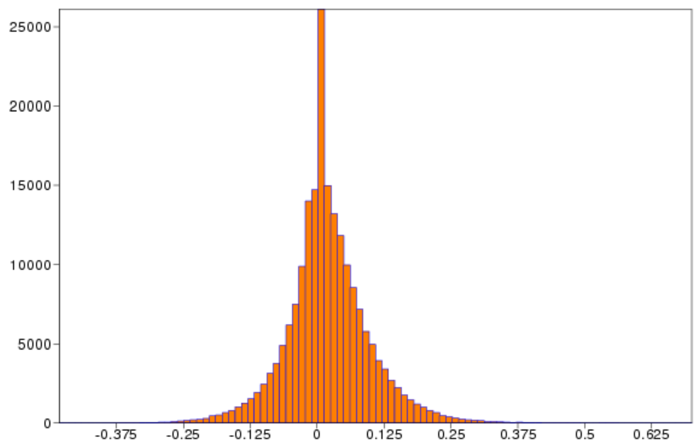
- The improved ASCAT soil moisture product is in better agreement with ECMWF soil moisture, than the operational ASCAT product, as shown in Table 2, with systematic lower mean and StD of the difference between observations and model, for all CDF matching approaches. For example for CDF2, StD is reduced from 0.08 m^3m^{-3} for the operational product to 0.074 m^3m^{-3} for the improved product.

- Compared to CDF1, the improved matching CDF2 reduces the observations bias for both the operational ASCAT product (0.033 m^3m^{-3} for CDF1 and 0.014 m^3m^{-3} for CDF2) and the improved ASCAT product (0.034 m^3m^{-3} for CDF1 and 0.011 m^3m^{-3} for CDF2). Bias is slightly larger with the seasonal correction than without it. As for the regional case study above, accounting for seasonal correction in the CDF matching improves the match between observation and model variances, with StD values of 0.087 m^3m^{-3}, 0.074 m^3m^{-3} and 0.071 m^3m^{-3} for CDF1, CDF2 and CDF2 seasonal, respectively.

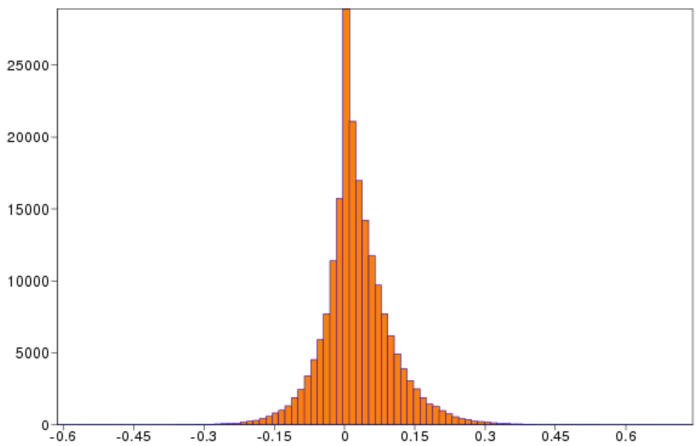
Both regional and global scale results confirm the suitability of the revised CDF matching approach. They show the relevance of both the seasonal bias correction and the improved ASCAT soil moisture product. Further investigations will be conducted when the improved ASCAT soil moisture is operational from 18 August 2011.



(a) ASCAT CDF1 (currently used)

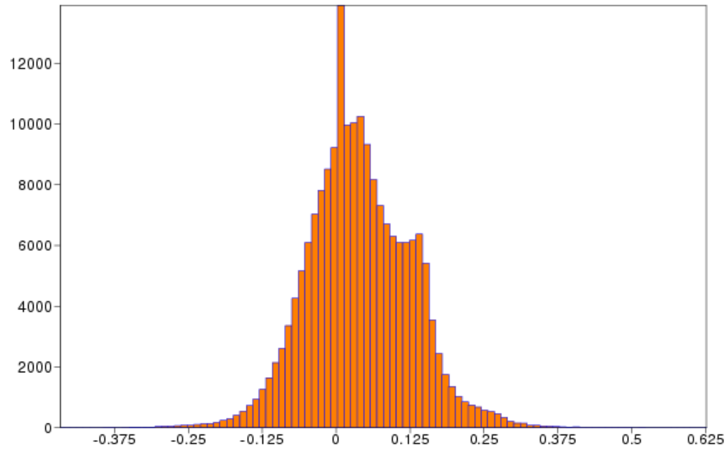


(b) ASCAT CDF2

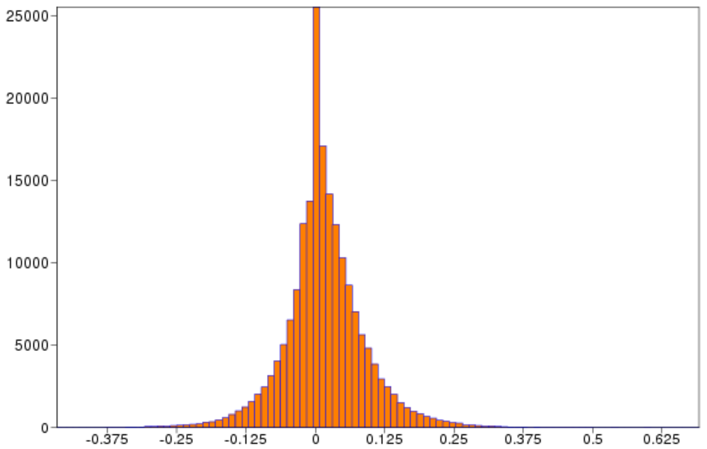


(c) ASCAT CDF2 with seasonal correction

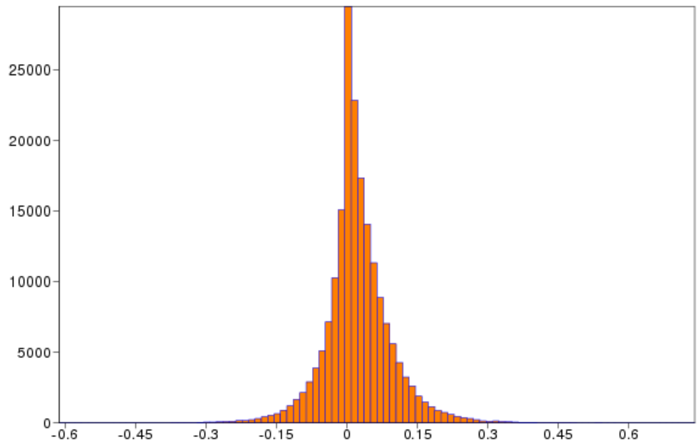
Figure 4: Histograms of global scale differences between ASCAT and ECMWF surface soil moisture (in m^3m^{-3}), for the **operational ASCAT product** *after CDF matching, with the current CDF matching (a) and with the revised CDF matching without (b) and with (c) seasonal correction. Note that axis are different for the 3 figures.*



(a) ASCAT CDF1 (currently used)

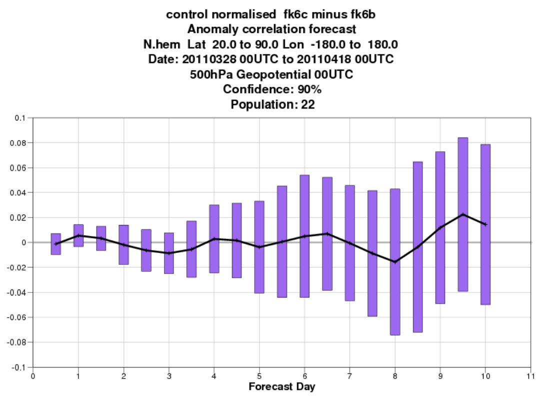


(b) ASCAT CDF2

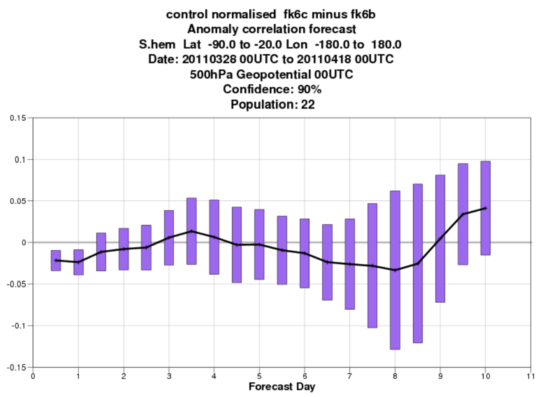


(c) ASCAT CDF2 seasonal

Figure 5: Same as Figure 4 for the **improved ASCAT product***.*



(a) ASCAT operational product



(b) ASCAT improved test product

Figure 6: Impact of the improved backscatter product used for ocean wind analysis, on the anomaly correlation forecasts (500hPa geopotential), for 28 March 2011 to 18 April 2011 (experiments fk6b and fk6c in Table 3).

	Operational ASCAT SSM		New ASCAT SSM	
	Mean	StD	mean	StD
CDF1	0.033	0.090	0.034	0.087
CDF2	0.014	0.080	0.011	0.074
CDF2 seasonal	0.020	0.074	0.017	0.071

Table 2: Global scale statistics of the difference (in m^3m^{-3}) between ASCAT observations after CDF matching and ECMWF operational soil moisture, for 01-21 April 2011, for different configurations of ASCAT bias correction. Sample size after ASCAT and H-TESSEL quality control and CDF matching is 200228.

4 Analysis Experiments

A set of analysis experiments was conducted to evaluate (i) the suitability of the improved product for an operational use at ECMWF from 18 August 2011, (ii) the impact of the improved product on the soil moisture analysis. Since the new product combines modifications in the backscatter and soil moisture products, several experiments were needed to separate the different effects on wind and soil moisture analysis. Table 3 summarises the experiments, using either the operational ASCAT product or the improved product, with or without ASCAT SSM data assimilation. Different ASCAT SSM CDF matching were used and compared in experiments with activated ASCAT SSM data assimilation (fk03, fk04, fk6n and fk6o only). Experiments without ASCAT SSM data assimilation were using CDF1 to rescale ASCAT SSM data for monitoring only. All the experiments but fkb2 were conducted for 27 March 2011 to 21 April 2011 using the branch dap_CY37R2_default_jul18 (default version of IFS cycle 37r2 on 18 July 2011). Experiment fkb2 was conducted with IFS cycle 37r3 using the script branch dah_CY37R2_for37r3, for 25 May 2011 (00z and 12z cycles) to check the esuite reproducibility when the new CDF matching parameters are used for ASCAT soil moisture monitoring.

For all the experiments (except fkb2) the fetchobs script was hacked (from /vol/ifs_sms/rd/dap/) in order to use the ASCAT data from ECFS instead of the MARS combined product. Experiments using the operational product were using the ec:/emos/ALWS product, while the experiments using the improved product were using the ec:/emos/e/ALWS product. All the experiments using the revised CDF matching were hacked to modify the ifstraj script to use CDF matching parameters from /home/rd/dap/cdfpar/37r4/ instead of from /home/rd/rdx/data/37r2/climate.

Comparing fk6b to fk6c shows the forecasts impact of the new backscatter used in the ocean wind analysis (ASCAT SSM analysis not activated). So, differences between the two experiments results are entirely due differences between the operational and improved ASCAT backscatter. To emphasise the sensitivity to the ASCAT backscatter product differences, the use of the ASCAT EARS (Advanced Retransmission Service; stored on ec:/emos/ASEL on ECFS) product, for which we did not receive an improved test data set, was switched off. Scores of geopotential height and temperature forecasts were compared for the two experiments, showing a neutral impact (Figure 6). Wind analysis impact and backscatter bias correction are further investigated in a joint memorandum by Giovanna De Chiara.

Experiments fk68 and fk6o both use the new improved ASCAT product, without and with soil moisture data assimilation, respectively. For fk6o the ASCAT SSM is rescaled using the revised CDF-matching with seasonal correction (CDF2 seasonal). By comparing these two experiments, Figures 7 and 8 show the forecasts impact of ASCAT surface soil moisture data assimilation in theses conditions. They show that activating ASCAT soil moisture data assimilation has a general neutral to slightly positive impact, except in Australia where the impact is slightly negative. However the test period is very short and longer experiments using both the improved product and revised CDF matching will be necessary to evaluate the improved ASCAT soil moisture

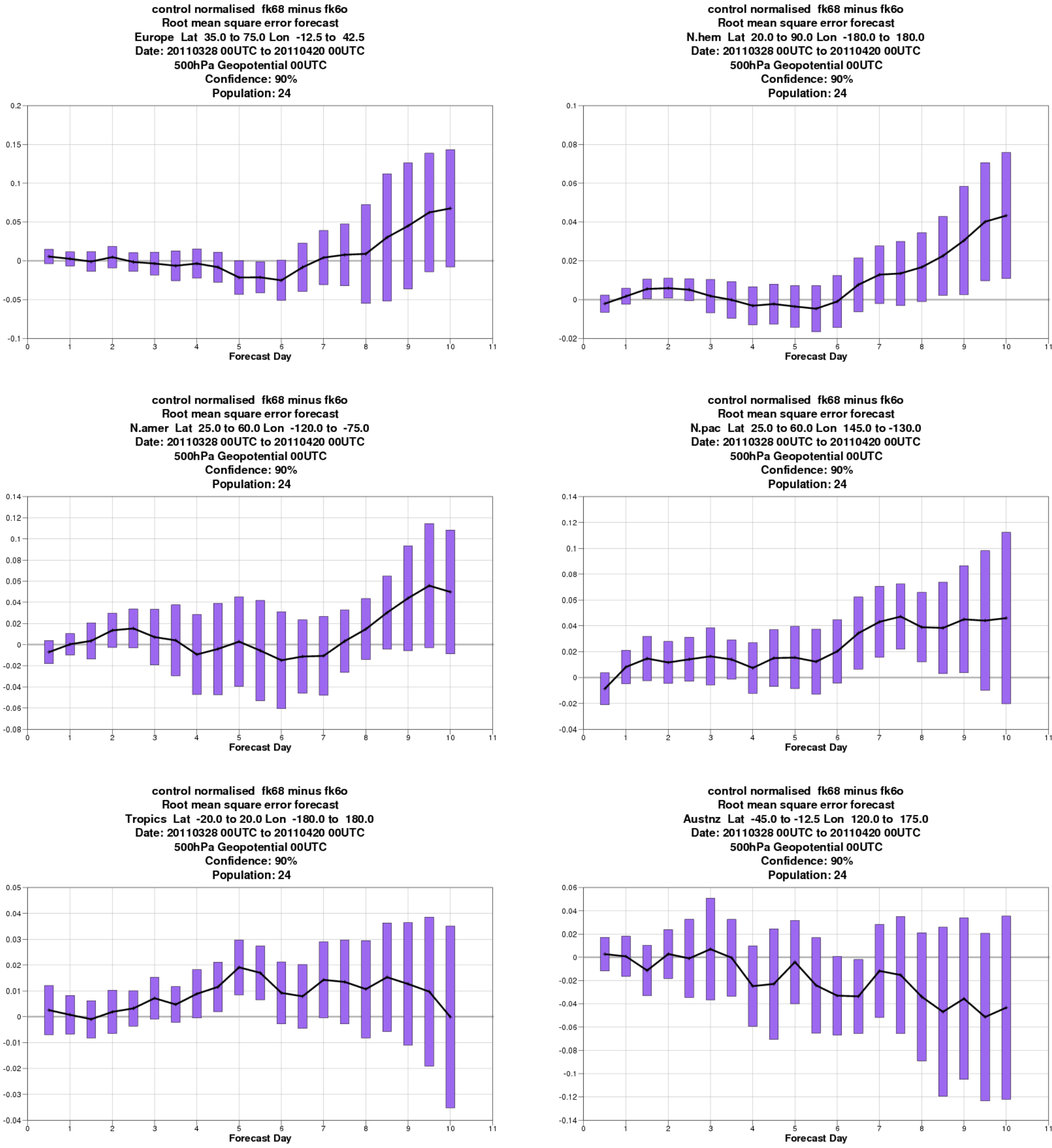


Figure 7: Impact of improved ASCAT SSM product assimilation (experiments fk6o compared to fk68, Table 3) on the 500hPa geopotential root mean square error forecast, for 28 March 2011 to 20 April 2011, for different areas. From top left to bottom right: Europe, North Hemisphere, North America, North Pacific, Tropics, Australia.

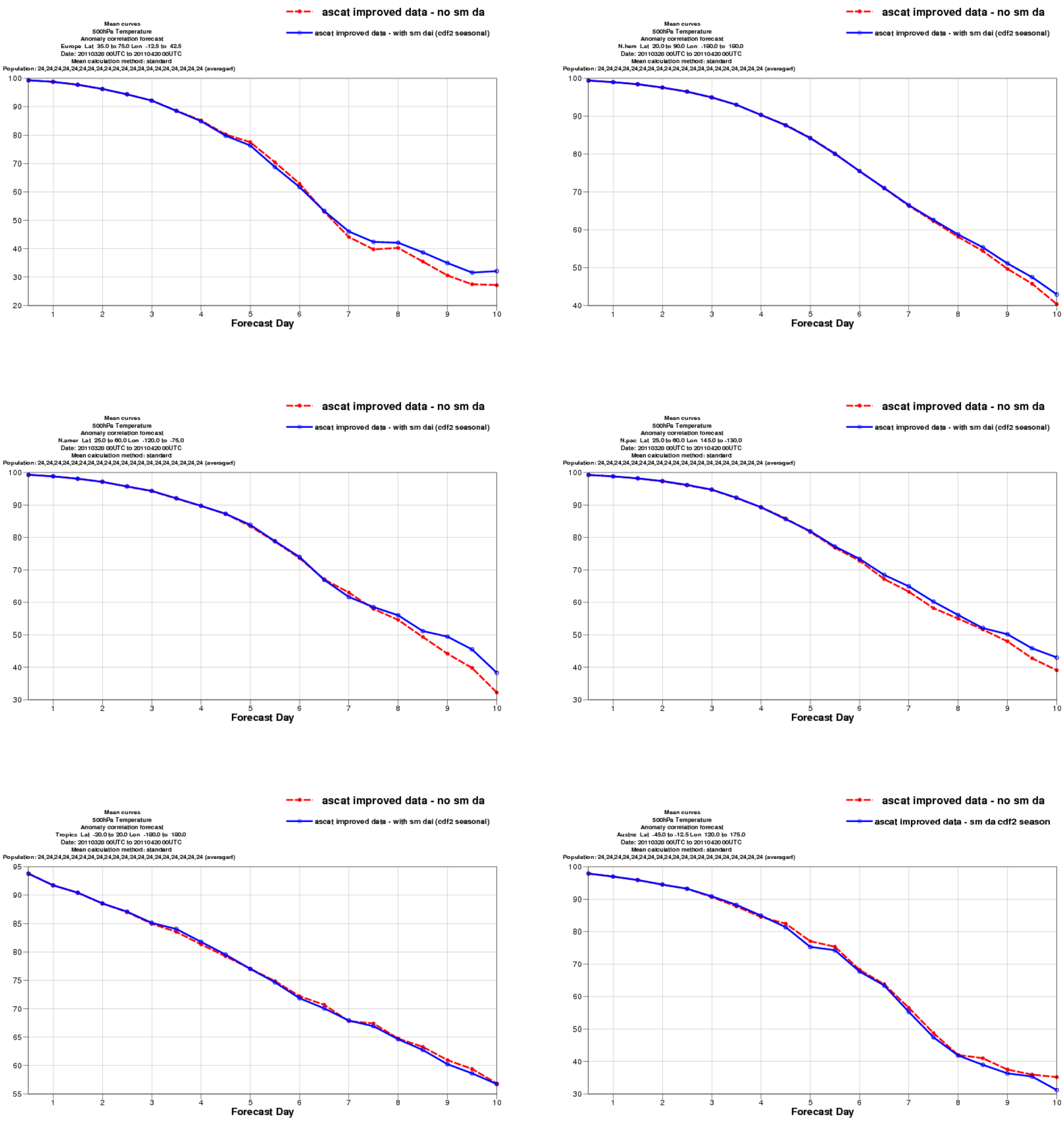
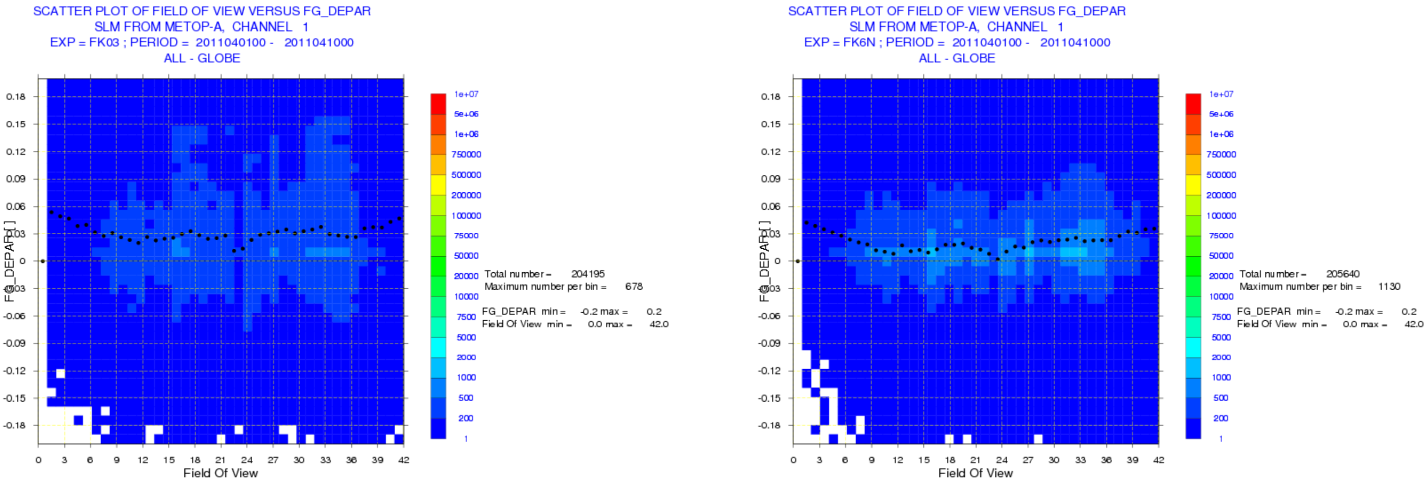
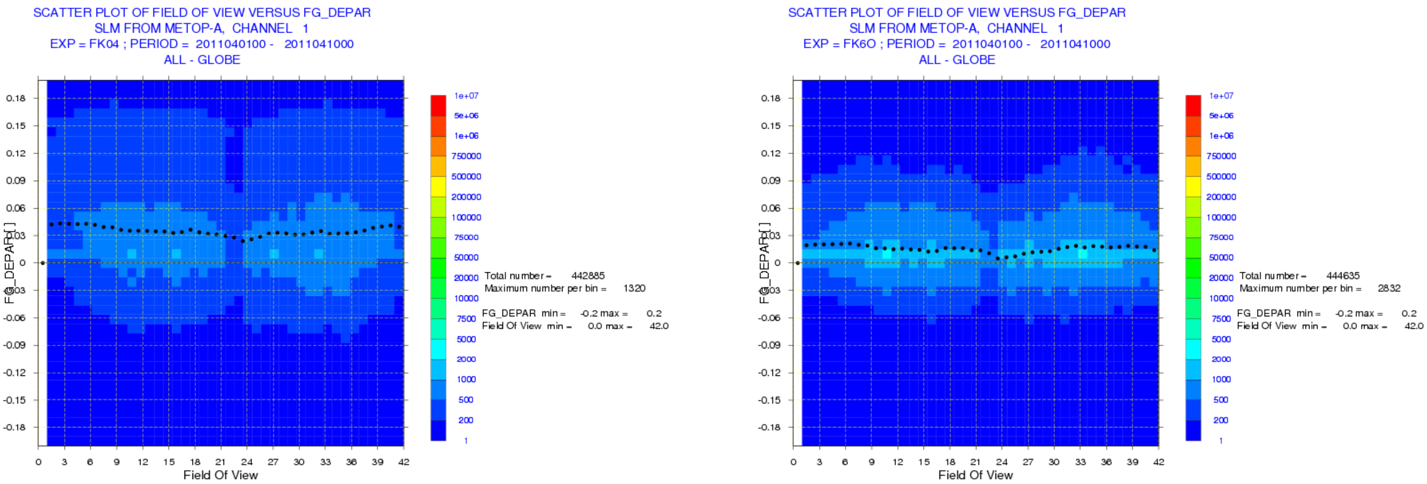


Figure 8: Impact of improved ASCAT SSM product assimilation (experiments fk6o compared to fk68, Table 3) on the 500hPa Temperature anomaly correlation forecast, for 28 March 2011 to 20 April 2011, for different areas. From top left to bottom right: Europe, North Hemisphere, North America, North Pacific, Tropics, Australia.



(a) ASCAT Operational Product: CDF1 (fk03, left) CDF2 seasonal (fk6n, right)



(b) ASCAT Improved Product: CDF1 (fk04, left) CDF2 seasonal (fk6o, right)

Figure 9: ASCAT SSM first guess departure (difference between rescaled observation and model first guess, dotted black line), as a function of the ASCAT incidence angle (Field of View on x-axis, ie ASCAT node), for four experiments using the operational (top) and improved (bottom) ASCAT products with the old matching CDF1 (left) and revised matching CDF2 seasonal (right) . Colour scale indicates the number of data used after CDF matching as a function of first guess departure range and Field of View.

Experiment	Resolution	Cycle	ASCAT product	Use EARSL	SSM assimilation	SSM CDF matching
fk6b	T255	37r2	Operational	no	no	CDF1*
fk6c	T255	37r2	Improved	no	no	CDF1*
fk68	T255	37r2	Improved	yes	no	CDF1*
fk03	T255	37r2	Operational	yes	yes	CDF1
fk04	T255	37r2	Improved	yes	yes	CDF1
fk6n	T255	37r2	Operational	yes	yes	CDF2 seasonal
fk6o	T255	37r2	Improved	yes	yes	CDF2 seasonal
fkb2	T1279	37r3	Operational	yes	no	CDF2 seasonal

*Table 3: Data assimilation experiment using either the operational ASCAT product or the improved product, with and without ASCAT SSM data assimilation, for different ASCAT SSM CDF matching for soil moisture monitoring (all experiments) and data assimilation (for fk03, fk04, fk6n and fk6o only). All the experiments but fkb2 were conducted for 27 March 2011 to 21 April 2011. Experiment fkb2 was conducted for 25 May 2011 to check the esuite reproducibility when the new CDF matching parameter are used for ASCAT soil moisture monitoring. *Experiments with ASCAT SSM assimilation not activated are not influenced by the choice of CDF matching (for monitoring only).*

data assimilation impact. Experiments are currently ongoing for summer 2009 based on the first test data set provided by EUMETSAT and using CDF2 seasonal.

Figure 9 presents ASCAT soil moisture monitoring results as produced with the OBSTAT package, for the 4 experiments fk03 (ASCAT Oper, CDF1), fk6n (ASCAT Oper, CDF2 seasonally corrected), fk04 (ASCAT improved, CDF1) and fk6o (ASCAT improved, CDF2 seasonally corrected). It clearly shows an improved usage of the ASCAT data when the improved product is used (bottom) compared to the operational product (top). The angular dependency of the first guess departure for the operational product (black line, top panel) is removed with the new product (black line, bottom panel). Colour scale indicates that more data is used (i) with the improved product (bottom) than with the operational product (top) (ii) with the revised CDF matching (right) than with CDF1 (left). This confirms again the relevance of both the improved ASCAT product and the revised CDF matching.

Experiment fkb2 used the operational ASCAT product and the revised seasonal CDF matching in IFS cycle 37r3. Spectral norms were checked for the 00z and 12z cycles and confirmed that fkb2 was bit-identical to the current esuite (experiment 0055). This shows that using revised CDF matching parameters for ASCAT soil moisture monitoring can be implemented as soon as possible for ASCAT monitoring.

5 Conclusion

A new improved ASCAT data will replace the currently operational data from 18 August 2011. It is based on an improved backscatter calibration and an improved soil moisture retrieval algorithm. The new ASCAT product was compared to the current operational ASCAT product. The improved product provides a larger amount of reliable data and it uses a more strict noise level flag than the current operational product. Increased number of reliable SSM data combined with a better flag usage is of great interest for data assimilation activities. The improved ASCAT soil moisture product is in better agreement with ECMWF soil moisture, than the operational ASCAT product, with systematic lower mean and StD of the difference between observations and model.

In addition, a revised ASCAT soil moisture CDF matching approach was developed. ASCAT CDF matching results were shown, at the point scale, at regional scale and at global scale, for the ASCAT operational product and the ASCAT improved product. Compared to the original CDF matching, the revised CDF matching reduces the observations bias for both the operational ASCAT product and the improved ASCAT product. Accounting for a seasonal correction in the revised CDF matching improves further the match of ASCAT to ECMWF SSM, at short time scale at well as at seasonal and annual scales. At global scale results combining the seasonally corrected bias correction and the improved ASCAT product gave the best agreement in terms of StD between rescaled ASCAT soil moisture and ECMWF operational soil moisture.

Data assimilation experiments were conducted to address the impact of improved ASCAT data assimilation and revised ASCAT SSM CDF matching for monitoring and assimilation of ASCAT SSM. Monitoring results confirmed the relevance of combining the improved ASCAT product and the revised CDF matching. For operational ASCAT soil moisture monitoring, reproducibility of the current IFS cycle 37r3 esuite was checked and confirmed when the new CDF matching parameters are used. So, revised CDF matching can be used as soon as possible in operations for ASCAT SSM monitoring.

Compared to the EKF soil moisture analysis without ASCAT SSM assimilation, activating the assimilation in the EKF of the improved ASCAT product, rescaled with the revised CDF matching, showed a slightly positive impact on the 500hPa geopotential and temperature forecasts, in several regions of the northern hemisphere. A slightly negative impact was however obtained in Australia. ASCAT SSM data assimilation will be further evaluated in research data assimilation experiments when the improved ASCAT soil moisture is routinely available from 18 August 2011.

Acknowledgements

Thanks to Gabor Radnoti for providing the experiment setup to reproduce the esuite and thanks to Mohammed Dahoui for his help with the OBSTAT package. Thanks to Gianpaolo Balsamo for providing the H-TESSEL offline simulations forced by ERA-Interim corrected by GPCP for 1989 to 2009.

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