RESEARCH DEPARTMENT
MEMORANDUM

To:	HR,HMD,HMAS,HMOS,RD divisions and sections heads
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Subject: Sensitivity of ASCAT soil moisture first guess departure to incidence angle.

1 Introduction

The use of ASCAT soil moisture data at ECMWF in the Integrated Forecasting System (IFS) has been developed and tested at T159 (∼125km) for May 2007 (Drusch et al. , 2008; Scipal et al., 2008). ASCAT soil moisture monitoring has been implemented in the e-suite 35r3 in passive mode on 22 July 2009. The use of ASCAT soil moisture data relies on a Cumulative Distribution Function (CDF) matching approach based on the ERS scatterometer data base and developed by Scipal et al. (2008). CDF matching transforms normalised surface soil moisture data into model equivalent surface soil moisture. In this research memorandum CDF matching parameters are shown at T799 (∼25km) and at T1279 (∼16km). Two ASCAT monitoring experiments have been conducted to validate the CDF parameters and their use at these resolutions. A more detailed validation is then performed at T799 for which characteristics of ASCAT soil moisture first guess (FG) departure are investigated. For this study the recently reprocessed ASCAT soil moisture data, distributed by EUMETSAT since 4 May 2009, are used. ASCAT instruments cover two swaths separated by 336km and gridded into nodes. Left swath corresponds nodes 1-21 while right swath corresponds to nodes 22-42. The ASCAT incidence angle ranges from 25° to 65° depending on the node number. A recent report provided by the University of Vienna (TU-Wien) pointed out some inconsistencies between ASCAT and ERS data as well as calibration issues in the ASCAT soil moisture data for nodes corresponding to high incidence angles (IPF report , 2009). ECMWF is concerned by inconsistencies between ERS and ASCAT soil moisture products since they might affect the accuracy of the CDF matching that is based on ERS data, when ASCAT data are used. In order to use ASCAT data for soil moisture data assimilation it is of crucial importance to evaluate the accuracy of the CDF matching approach at the operational resolution T799. It is also important to investigate possible incidence angle issues with ASCAT data in order to refine ASCAT soil moisture data screening and blacklisting. In this research memorandum the sensitivity of ASCAT soil moisture first guess departure to the incidence angle is investigated in IFS cycle 35r3 T799.

2 ASCAT soil moisture CDF matching parameters at T799 and at T1279

ASCAT soil moisture data are provided by EUMETSAT within the H-SAF (Satellite Application Facility on support to operational hydrology and water management) project. ASCAT soil moisture is expressed as an index normalised between 0 (dry soil) and 100 (saturated soil). To use the ASCAT soil moisture data in the

IFS, normalised ASCAT soil moisture ($ascatsm_{data}$) are first rescaled to model equivalent ASCAT absolute soil moisture ($ascatsm_{wsa}$), based on a CDF matching approach (Scipal et al., 2008):

$$ascatsm_{wsa} = MAX(0, a + b\,\frac{ascatsm_{data}}{100}) \qquad (1)$$

ASCAT absolute soil moisture $ascatsm_{wsa}$ is a volumetric quantity ranging between 0 m^3/m^3 and 0.76 m^3/m^3 depending on the soil texture type. The CDF matching parameters a and b (both in m^3/m^3) are derived for each model grid point from the CDF matching moments (mean and variance) of ERS soil moisture data and ERA-Interim surface soil moisture for 1992-2000. They are rescaled to account for soil texture dependent soil moisture ranges in HTESSEL as described in Balsamo et al. (2008) and in `http://www.ecmwf.int/products/changes/soil_hydrology_cy32r3/`. This linear CDF matching corrects differences in mean and variance between ASCAT data and ECMWF soil moisture (Scipal et al., 2008).

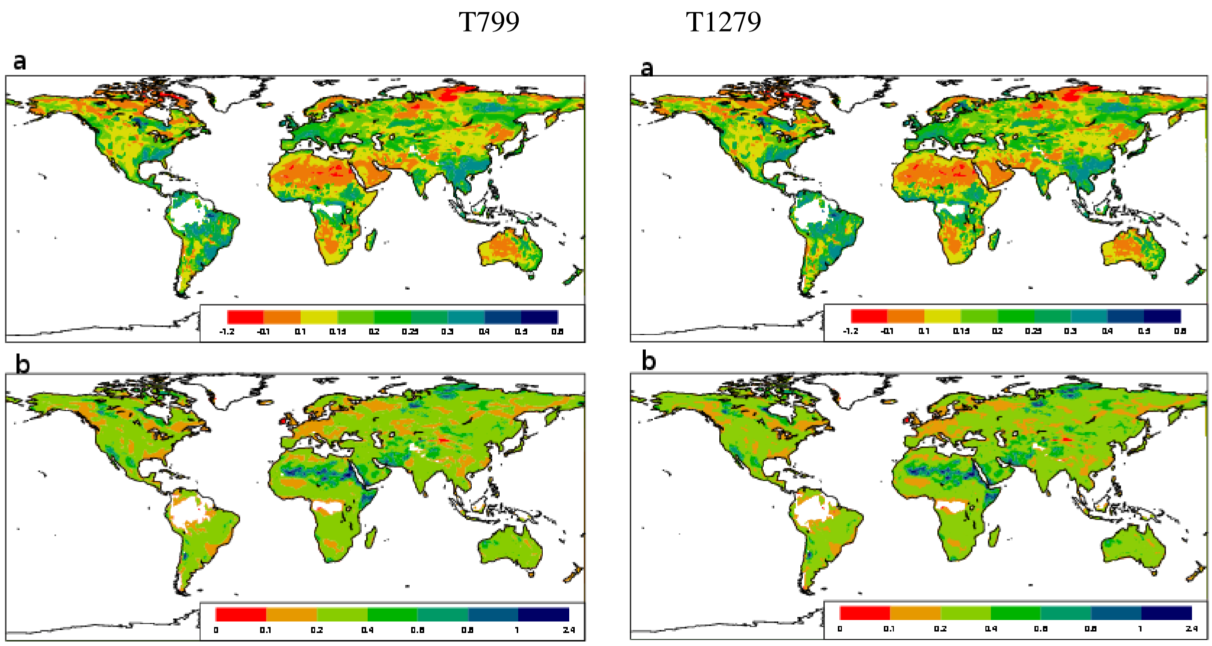

Figure 1: ASCAT CDF matching parameters at T799 and and at T1279. The parameter a (top) and the parameter b are expressed in m^3/m^3.

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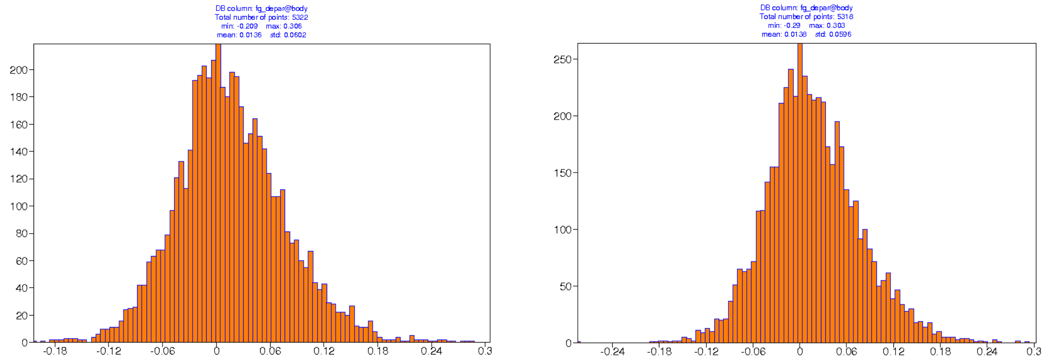
An experiment (f7mi) has been conducted for two days in June 2009 in order to test the use of these parameters at T1279. The control experiment at T799 is f7lb. Figure2 shows the histogram of ASCAT surface soil moisture first guess departure (rescaled observation - FG) obtained for the first three cycle at T799 (f7lb) and at T1279 (f7mi).

ASCAT CDF matching parameters have been computed at several resolutions for which they are available on the climate data base (for example at T799 for cycle 35r3: /home/rd/rdx/data/35r3/climate/799l_2/ascatsm_htessel). To this end CDF matching moments were first computed at T255 from ERA-interim and ERS data interpolated at T255. Then CDF matching parameters were computed for each resolution from the interpolated CDF matching moments and finally rescaled according to HTESSEL soil texture properties. This operation was repeated here at T1279 to prepare for the next high resolution cycle implementation.

Figure 1 shows the CDF matching parameters a and b at T799 and those obtained at T1279. They are very



(a) T799 (b) T1279

Figure 2: Histograms of the ECMWF FG departure of rescaled ASCAT surface soil moisture, $ascatsm_{wsa}$, at T799 (left, mean 0.0136 m^3/m^3, std 0.0602 m^3/m^3) and at T1279 (leftright, mean 0.0138 m^3/m^3, std 0.0596 m^3/m^3) for 3 cycles (2009060100-2009060200).

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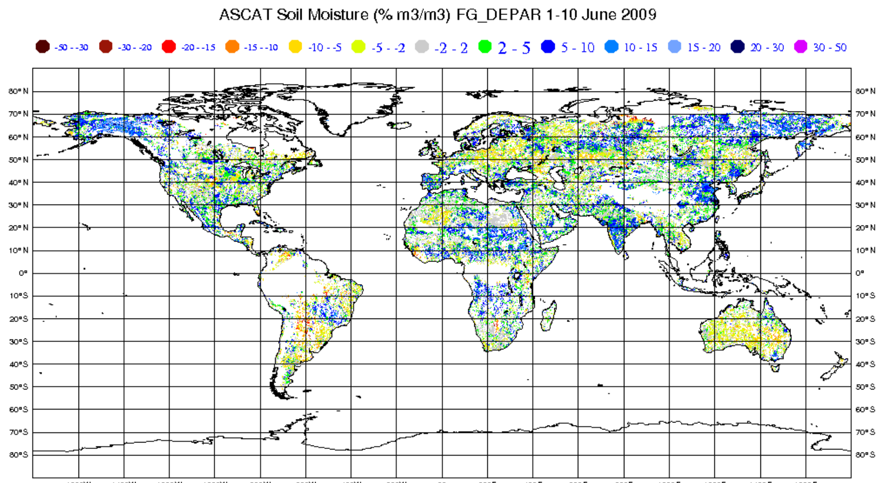
similar.
The experiments f7lb and f7mi validate from a technical point of view the use of ASCAT CDF matching parameters at T799 and at T1279, respectively. Results of Figures 1 and 2 indicate that CDF matching parameters are consistent at T799 (mean 0.0136 m^3/m^3, std 0.0602 m^3/m^3) and at T1279 (mean 0.0138 m^3/m^3, std 0.0596 m^3/m^3) for the considered period. They also show that first guess departure characteristics are very similar at T799 and at T1279.

3 ASCAT first guess departure: sensitivity to observing configuration

The use of ASCAT soil moisture data for monitoring and data assimilation experiments relies on the CDF matching approach, which rescales ASCAT soil moisture indexes into model equivalent soil moisture values. As indicated in the previous section the CDF matching as used in the IFS is based on the ERS scatterometer data and the ERA interim soil moisture for 1992-2000. The consistency of the CDF matching between ERA interim, using TESSEL, and the current IFS, using HTESSEL, is ensured by a rescaling of the CDF matching parameters according to the soil moisture range associated to each soil texture type (Balsamo et al. , 2008). Therefore it is expected that first guess surface soil moisture is unbiased, provided that ASCAT and ERS data are consistent.

The experiment f7lb has been conducted with IFS cycle 35r3 default version at T799 in early delivery mode for 01 to 10 June 2009. In this experiment the variable LASCATSM is set to .true. in prepIFS in order to activate the feedback of soil moisture first guess departure to the ODB (ECMA.scatt). The experiment f7lb is bit identical to the experiment f7lc in which the feedback to the ODB is scwitched off (LASCATSM=.false.). So it has been safely activated in the 35r3 e-suite.

Figure 3 shows mean first guess departure of volumetric surface soil moisture represented for 1-10 June 2009. It represents the difference between the observation, transformed in absolute soil moisture using CDF matching approach of Scipal et al. (2008), and the model first guess (FG). In Figure 4 we plot the histograms results of ASCAT first guess departure for 1-10 June 2009, for all nodes (a). A slight positive bias is shown in the FG departure (0.00917 m^3/m^3), indicating slightly higher soil moisture values for the observation than for the



(a) All nodes

Figure 3: First guess departure (rescaled observation - FG) of surface soil moisture in % m^3/m^3 for the period 1-10 June 2009.

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model. However this bias is lower than 1% m^3/m^3 so it indicates a very good agreement between observations and model. The standard deviation obtained of 0.064 m^3/m^3 at global scale also indicates a good accuracy which validates the CDF matching approach at T799. The small bias obtained might be due to the short period considered or to a seasonal effect. However, based on the document sent by TU-Wien (IPF report , 2009), which shows that ASCAT has a positive bias compared to ERS (in particular at high incidence angles), characteristics of the FG departure needed to be further investigated. Figure 4 shows the histograms obtained for the left swath (b), the right swath (c) of ASCAT and for different particular nodes at low and high incidence on left and right swath.

Figure 4 (b-c) clearly shows that the mean bias is larger for the right swath (0.0139 $m3/m3$) than for the left swath (0.00296 m^3/m^3). Figure 5 (a) shows the relation between the first guess departure and the node. In Figure 5 (b) the sensitivity of the standard deviation of the FG departure is shown and in Figure 5 (b) the incidence angle is represented for the different nodes. Figure 4 (d-g) and Figure 5 show that bias and standard deviation are larger for high incidence angles than for low incidence angles. These results are preliminary and only based on 6 days of monitoring. They need to be confirmed for longer period including seasonal contrasts. However the dependencies of the FG departure bias and standard deviation to observing configuration (incidence angle and swath) are not expected to be much affected by seasonal cycle. The general positive bias noted here is consistent with the results shown in IPF report (2009) for the right swath they investigated. We show here that both bias and standard deviation seem to be lower on the left swath.

4 Conclusion

In this research memorandum ASCAT soil moisture CDF matching parameters are presented at T799 and at T1279 in order to prepare ASCAT monitoring and data assimilation activities at high resolution. The use of ASCAT soil moisture CDF parameters at these resolution is validated and parameters values and first guess departures are shown to be consistent at T799 and at T1279.

Furthermore the sensitivity of ASCAT soil moisture first guess departure to ASCAT incidence angle has been investigated for ten days in June 2009. The objective was two-fold: to validate the CDF matching approach at T799 and to investigate the use of reprocessed ASCAT soil moisture data that are received in operation since 4 May 2009. Preliminary results showed an incidence angle dependency of the first guess departure bias and standard deviation. It is recommended that further tests are conducted to investigate the impact ASCAT incidence angle on the first guess departure. Blacklisting of ASCAT soil moisture data at high incidence angles will most likely be considered for ASCAT soil moisture data use in the IFS.

Acknowledgments
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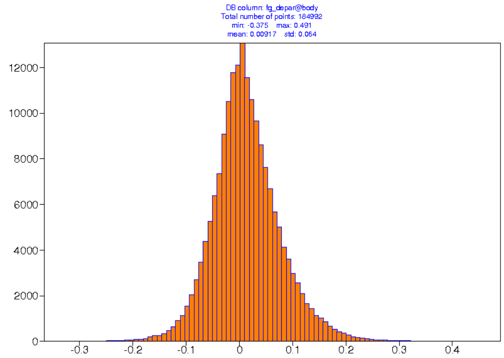
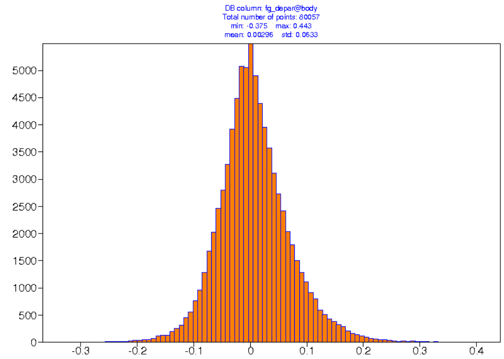


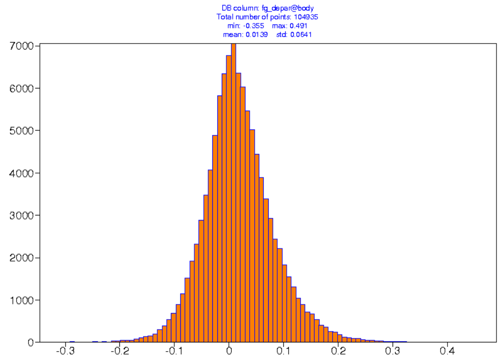
(a) All nodes

mean 0.00917 std: 0.064



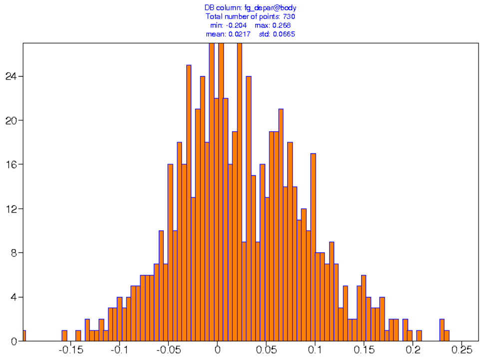
(b) Left swath (nodes 1-21)

mean: 0.00296 std:0.0633



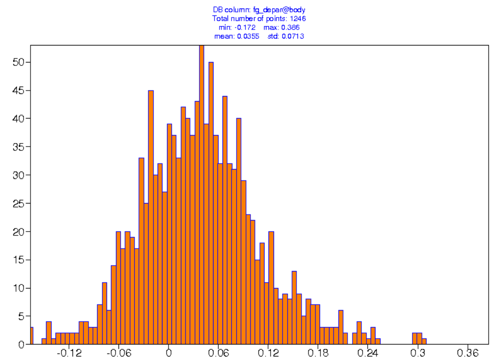
(c) Right swath (nodes 22-42)

mean: 0.0139 std: 0.0641



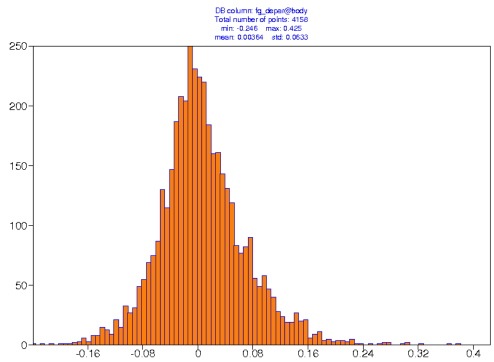
(d) Left swath node 1 (high incidence)

mean: 0.0217 std: 0.0665



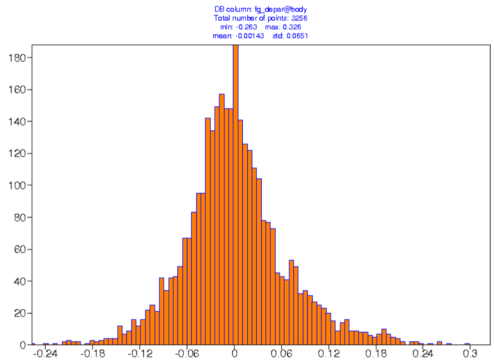
(e) Right swath node 42 (high incidence)

mean: 0.0355 std: 0.0713



(f) Left swath node 21 (low incidence)

mean: 0.00364 std: 0.0633



(g) Right swath node 22 (low incidence)

mean: -0.00143 std: 0.0651

Figure 4: Histograms of the ECMWF FG departure of ASCAT surface soil moisture (x-axis in m^3/m^3) at T799, for 10 days (2009060100 to 2009061000, for different observing configurations (a-g).

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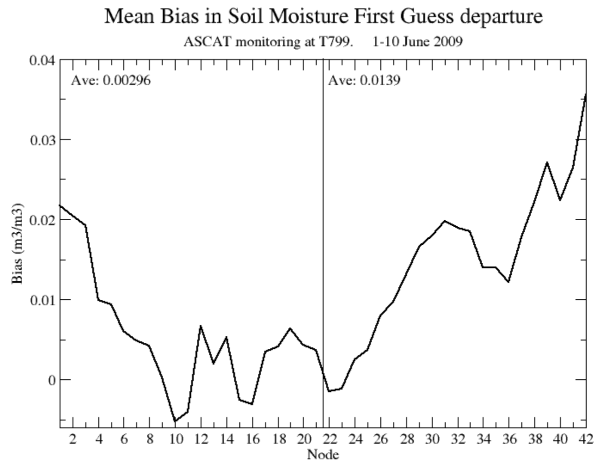
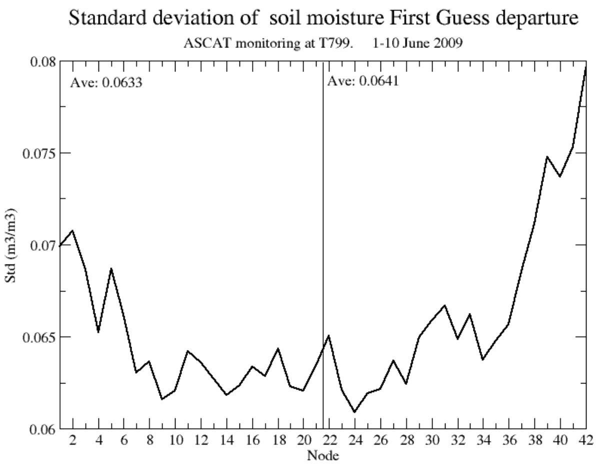
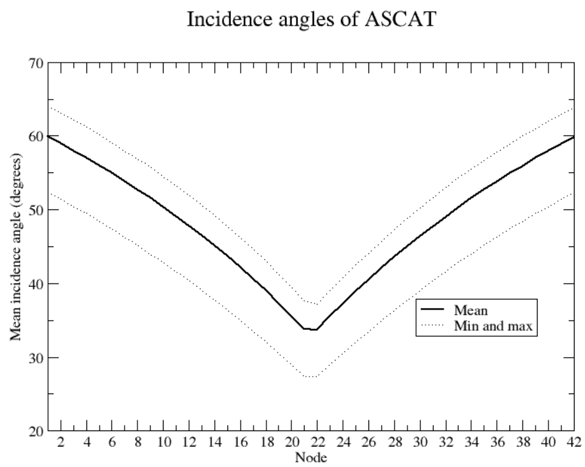


(a) FG departure mean value



(b) FG departure Std



(c) Incidence angle

Figure 5: Relation between FG departure and node: (a) mean value, (b) standard deviation. In (c) the incidence angle is shown.