ESA Contract Report

SMOS ESL contract 4000130567/20/I-BG

Contract Report to the European Space Agency

Quarter 3 2024: Operations Service Report

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Abbreviations

BUFR ..... Binary Universal Form for the Representation of meteorological data
CCU ..... Central Computer Unit
CESBIO ..... Centre d'Etudes Spatiales de la Biosphère
DPGS ..... Data Processing Ground Segment
ECFS ..... ECMWF's File Storage system
ECMWF ..... European Centre for Medium-range Weather Forecasts
ESA ..... European Space Agency
ESAC ..... European Space Astronomy Centre
ESL ..... Expert Support Laboratory
FTP ..... File Transfer Protocol
MIRAS ..... Microwave Imaging Radiometer using Aperture Synthesis
NetCDF ..... Network Common Data Form
NRT ..... Near Real Time
NWP ..... Numerical Weather Prediction
SAPP ..... Scalable Acquisition and Pre-Processing system
SEKF ..... Simplified Extended Kalman Filter
SMOS ..... Soil Moisture and Ocean Salinity

1. Introduction

This document summarises the production and dissemination status of the European Space Agency (ESA) Soil Moisture and Ocean Salinity (SMOS) neural network (NN) nominal soil moisture product for the third quarter of 2024. The NN nominal product is produced at the European Centre for Medium-range Weather Forecasts (ECMWF) and it processes raw SMOS BUFR files within 30 minutes of their arrival via the Scalable Acquisition and Pre-Processing system (SAPP). The SMOS BUFR files should be available to ECMWF less than 165 minutes from the initial observation time and the NN product NetCDF files should be delivered to ESA less than 240 minutes from the initial observation time in the corresponding source BUFR file. Statistics of the production and timeliness of the delivered product are presented, reasons for the lack of completeness and/or failure to meet the timeliness deadline are given and corrective actions (if possible) are described in this report.

2. Quarterly statistics of completeness and timeliness of the SMOS NN product

Figure 1 shows the time series of daily file completeness and timeliness as defined by files that are delivered to ESA within 240 minutes of the initial observation time in the corresponding input BUFR file. The percentages are calculated by dividing the total time covered in the output files by the 24 hours in any single day. For example, for a single day if there are 30 BUFR files covering 48 minutes of data each and 1 file is not produced and 1 file is delivered late then the completeness percentage is 96.67% and the timeliness percentage is 93.33%. The time series covers the third quarter of 2024, 1st July to 30th September 2024. The data shows that for quarter 3 the completeness is 100% except for two days in September. The average timeliness is above 90% for all months. A more detailed explanation of the periods where completeness drops below 95% and timeliness drops below 80% can be found in section 3.

Table 1 shows the monthly and entire quarter mean statistics of completeness and timeliness. The completeness is 100% for July and August but drops to 98.8% in September. Thus, the resulting entire quarter averages is 99.6%. The timeliness is 98.0% for July, 94.7% for August and 91.3% for September, respectively, resulting to entire quarter average of 94.7%.

Month	Completeness	Timeliness
July	100.0%	98.0%
August	100.0%	94.7%
September	98.8%	91.3%
Quarter	**99.6%**	**94.7%**

Table 1: Monthly mean statistics of completeness and timeliness of SMOS NN nominal soil moisture product delivery

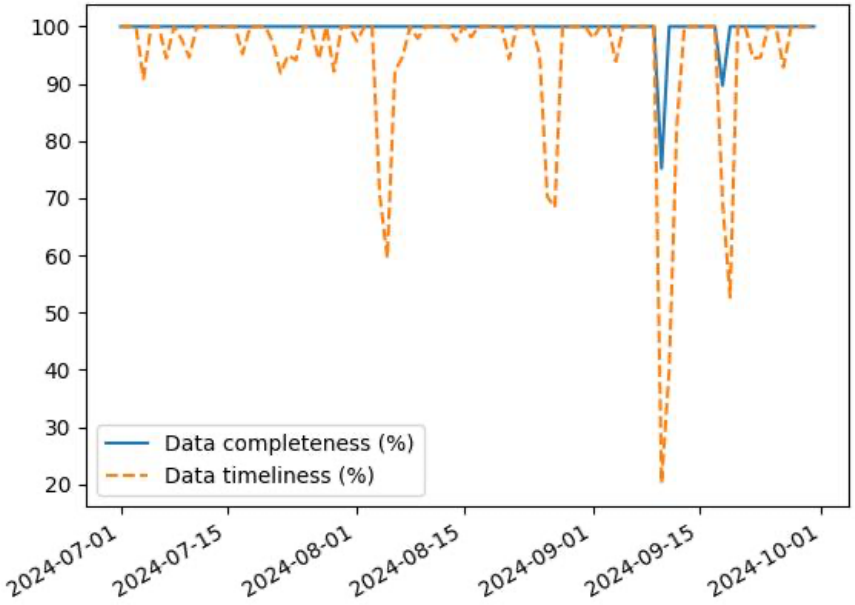

Figure 1: Daily SMOS NN nominal soil moisture production completeness and delivery timeliness percentages (see text for how these are calculated) for the third quarter of 2024: 1st July to 30th September 2024

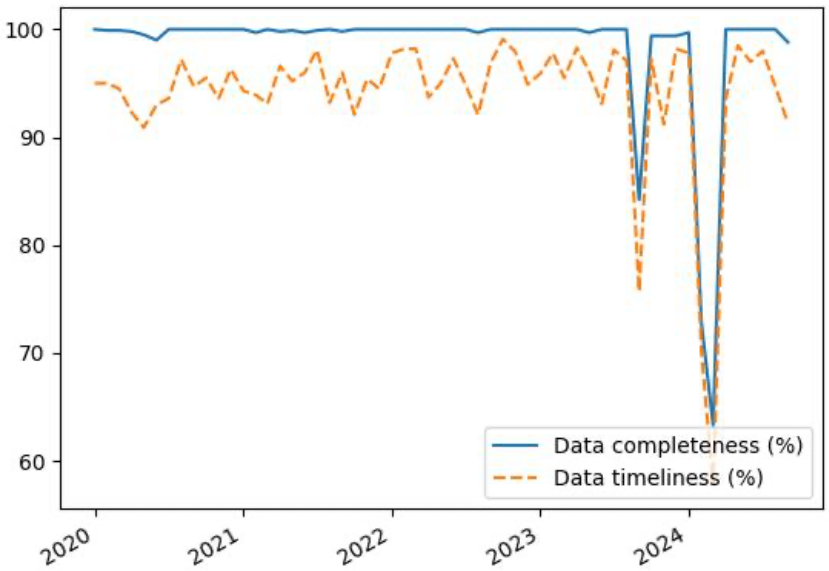

Figure 2: Monthly SMOS NN nominal soil moisture production completeness and delivery timeliness percentages (see text for how these are calculated) for the period January 2020 to September 2024

Figure 2 shows the monthly statistics of completeness and timeliness since January 2020. After September 2023 the level of completeness slightly dropped compared to previous years but for the latest six months it is 100% or very close to it. The drop is a result from a change how the completeness is calculated. The calculation after the change takes into account the missing BUFR files. Previously if the time covered in the NetCDF files matched the time covered in the BUFR files, regardless of how much of the day was covered by the BUFR files, then the completeness would be 100%. With the new behaviour the statistics are sensitive to any missing BUFR files and this behaviour is a more accurate representation of completeness. In February and March 2024 both the completeness and timeliness dropped significantly due to SMOS being in the safe hold mode. The data became available for users again on 12th of March and the statistics have returned to the normal levels in April 2024. The notable drop in the completeness and timeliness in September 2023 was caused by the on-board GPS anomaly.

3. Operational anomalies in this quarter

Figure 1 shows that there are two days where the completeness dropped below 95% during quarter 3 of 2024. Namely 10th and 18th of September. In both cases the reason has been that not all BUFR files have been delivered. On 10th September the missing files are 6.28 – 11.10 UTC and the reason is related

likely to the network issues which started at 8.10 UTC and continued until 11.9 8.38 UTC affecting also timeliness of the data. On 18th September one BUFR file covering an entire orbit was not delivered.

There were eight days in quarter 3 of 2024 where the timeliness dropped below 80% as seen in Fig. 1, namely 4th, 5th, 26th and 27th August and 10th, 11th, 18th and 19th September. On 4th and 5th August the timeliness was 70.6% and 59.5%, respectively. On both days the reason was CCU reset. On 26th and 27th August the timeliness dropped to 70.2% and 68.4%, respectively, due to problems with the distribution in the NRTP production. During 10th September 8.10 UTC and 11th September 8.38 UTC the NRTP production had degraded performance due to network issues and this dropped the timeliness to 20.1% and 40.0% on those days. The reason for the drop in timeliness on 18th and 19th September was caused by delays in the ground segment production.

4. Comparisons between the ESA nominal and ECMWF assimilation neural network products

In this section the retrieved soil moisture from both the nominal neural network product delivered to ESA and the assimilation neural network product used at ECMWF will be compared. The month chosen for the comparison is August 2024 which is the middle month of the quarter.

Figure 3 shows that data is missing over large areas of Ukraine, Russia, China, Myanmar and the Middle East for the ECMWF assimilation product due to extensive radio frequency interference (RFI) in the SMOS brightness temperatures over those regions. To large extent, these areas are not missing for the ESA nominal product due to a different use of RFI flags in the training of the nominal and assimilation products. However, compared to the same month a year ago, August 2023 (Salonen et al., 2023) also the ESA nominal product has now some areas without data in Ukraine, Russia, Myanmar and China where the RFI is strong.

Figure 3 also shows that the two products continue to have significant differences, with the ECMWF assimilation soil moisture product generally moister than the ESA nominal product in August 2024. The maps show that the differences are largest in the tropics (over South America, central Africa and the maritime continent in particular) and the Northern mid latitudes (USA and Europe). The products are in better agreement over the extra-tropical Southern hemisphere as well as in arid regions. The differences are due to the different datasets which the two neural networks are trained on. The nominal ESA product is trained on historical values of SMOS level 2 soil moisture whereas the ECMWF assimilation product is trained on the ECMWF model soil moisture. These datasets have different characteristics and represent different soil depths which lead to the differences in figure 3. The SMOS level 2 soil moisture represents the top most 2-3cm of soil whereas the ECMWF model soil moisture represents the top most 7cm of soil.

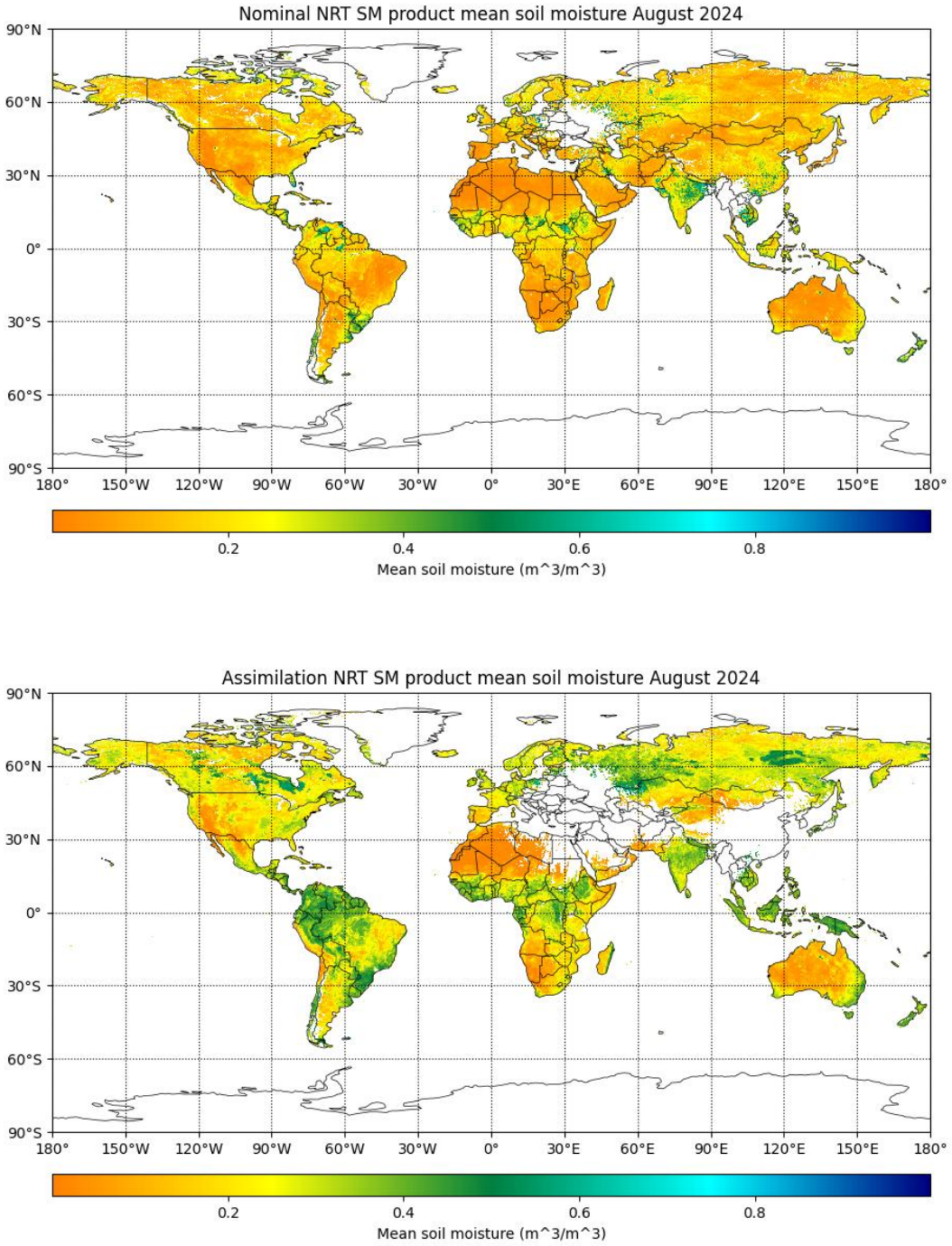

Figure 3: Mean retrieved soil moisture (m^3/m^3) for August 2024 for the nominal NRT product (upper) and assimilation NRT product (lower)

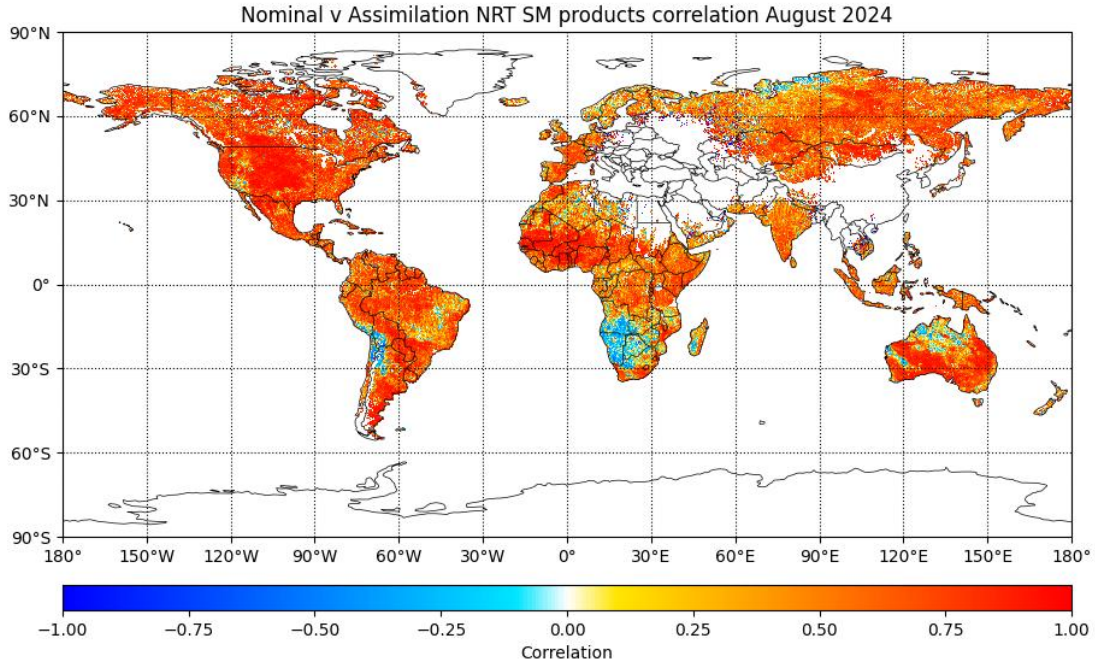

Figure 4: Correlation between the ESA nominal neural network product and the ECMWF assimilation neural network product in August 2024

Figure 4 shows that the two products have the strongest correlations in South America, North America, Central Africa, Australia and Western Europe. There are moderate correlations in the remainder of the Northern mid-latitudes and tropics with the weakest (and sometimes negative) correlations over arid regions such as the Sahara desert, Northern Australia and the Andes.

References

Salonen, K., Weston, P., de Rosnay, P., 2023. Quarter 3 2023: Operations Service Report. Available from https://www.ecmwf.int/en/publications