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ECMWF

ESA Contract Report

SMOS ESL contract 4000130567/20/I-BG

Contract Report to the European Space Agency

Quarter 4 2020: Operations Service Report

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January 2021

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Abbreviations

BUFR .... Binary Universal Form for the Representation of meteorological data

CESBIO .... Centre d'Etudes Spatiales de la Biosphère

DPGS .... Data Processing Ground Segment

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

SAPP .... Scalable Acquisition and Pre-Processing system

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 fourth quarter of 2020. 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 fourth quarter of 2020, 1st October 2020 to 31st December 2020. The data shows that for the vast majority of days the completeness is 100% or very close to 100% and the timeliness is greater than 90%. An 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 above 99% for all months and the entire quarter average is 100.0%. The timeliness is 93% or above for all months and the entire quarter average is 95.1%.

Month	Completeness	Timeliness
October	100.0%	95.5%
November	100.0%	93.6%
December	100.0%	96.3%
Quarter	**100.0%**	**95.1%**

Table 1: Monthly mean statistics of completeness and timeliness of SMOS NN nominal soil moisture product delivery.
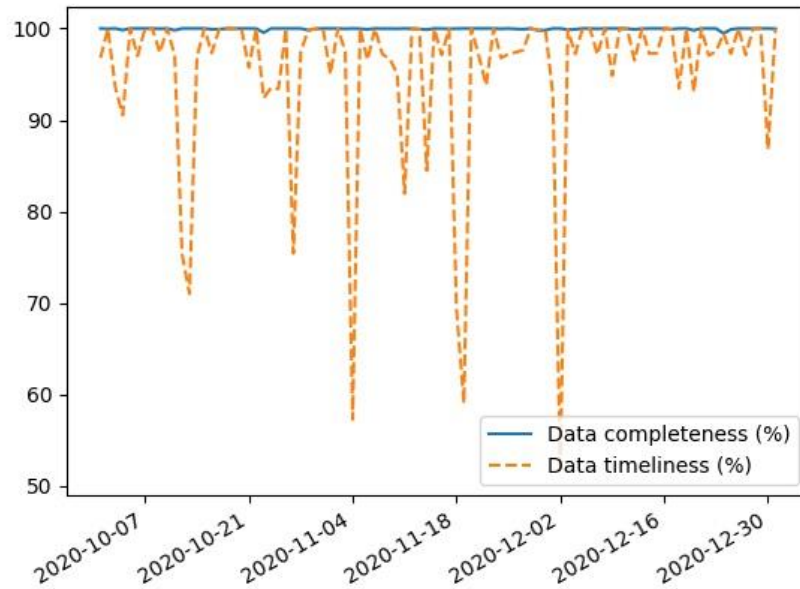
Figure 1: Daily SMOS NN nominal soil moisture production completeness and delivery timeliness percentages (see text for how these are calculated) for the fourth quarter of 2020: 1st October to 30th December 2020
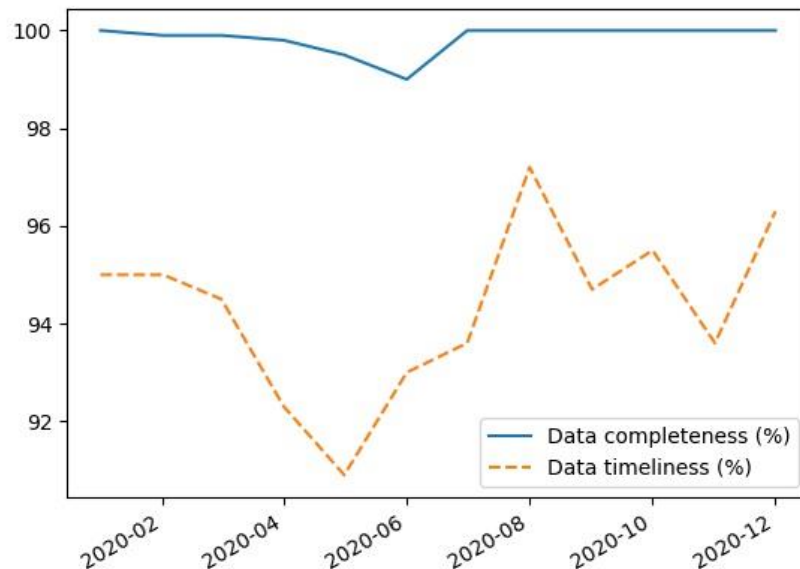

Figure 2: Monthly SMOS NN nominal soil moisture production completeness and delivery timeliness percentages (see text for how these are calculated) for the period January 2020 to December 2020

Figure 2 shows the monthly statistics of completeness and timeliness since January 2020 and shows that the they have remained fairly constant in quarter 4 of 2020 compared to quarter 3.

3.   Operational anomalies in this quarter

Figure 1 shows that there are no days where completeness drops below 95% this quarter. There are some days where the percentage drops very slightly below 100% and these are due to a small number of input SMOS BUFR files containing only ocean points. When the neural network processor encounters such a file it skips the file because the neural network product is only validly produced over land.

Figure 1 also shows that there are several days in the past three months where the timeliness drops significantly below 80%, namely 12th October, 13th October, 27th October, 4th November, 18th November, 19th November and 2nd December, where it drops to 75.3%, 71.0%, 75.4%, 57.3%, 69.3%, 59.0% and 51.4% respectively. Most of these significant drops were caused by ESA delays to the delivery of the BUFR files due to a degraded near-real time (NRT) dissemination service. On the 12th and 13th October this was due to an unspecified hardware issue. On 4th November this was due to a network intervention. On 18th and 19th November this was due to a Microwave Imaging Radiometer using Aperture Synthesis (MIRAS) Central Computer Unit (CCU) reset and network intervention at Tromso. These events are out of ECMWF's control, so no corrective action can be taken to stop these events happening in the future. On the 27th October there was a 4 hour delay in the processing at ECMWF between 18:00 and 22:00 due to an unforeseen ECMWF network outage. Other than those events described above there were no other operational anomalies this quarter.

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. Figure 3 shows that the two products have significant differences with the ECMWF assimilation soil moisture product generally moister than the ESA nominal product in November 2020. 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 (over Europe and central Asia). The products are in better agreement over Scandinavia, Eastern North America 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 ECNWF model soil moisture. These datasets have different characteristics and represent different soil depths which lead to the differences in figure 3. The data is missing at high latitudes due to snow

cover and frozen surfaces where the retrieval of soil moisture is not possible. Data is also missing over China and the Middle East due to extensive radio frequency interference (RFI) in the SMOS brightness temperatures over those regions.
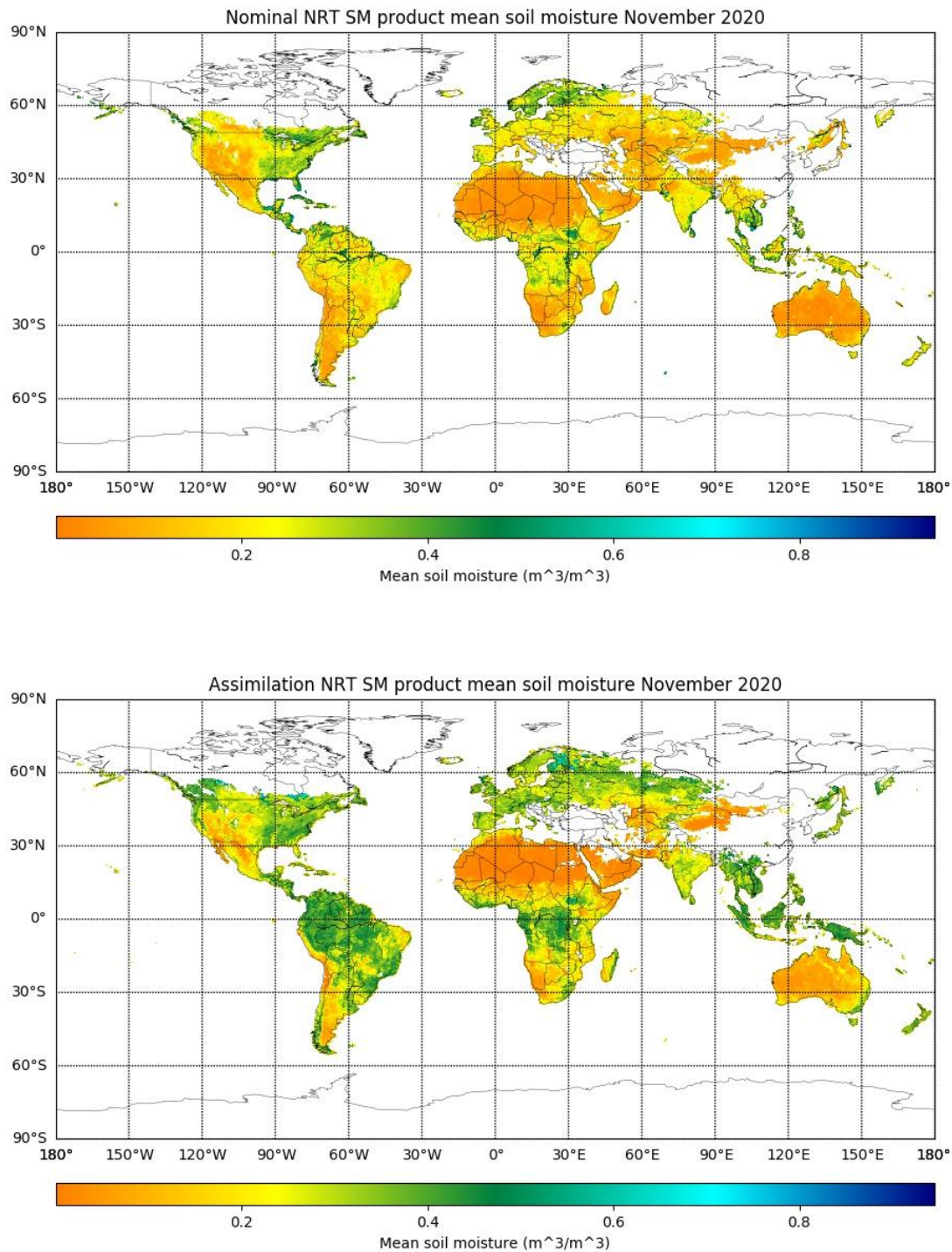

Figure 3: Mean retrieved soil moisture (m^3/m^3) for November 2020 for the nominal NRT product (upper) and assimilation NRT product (lower)
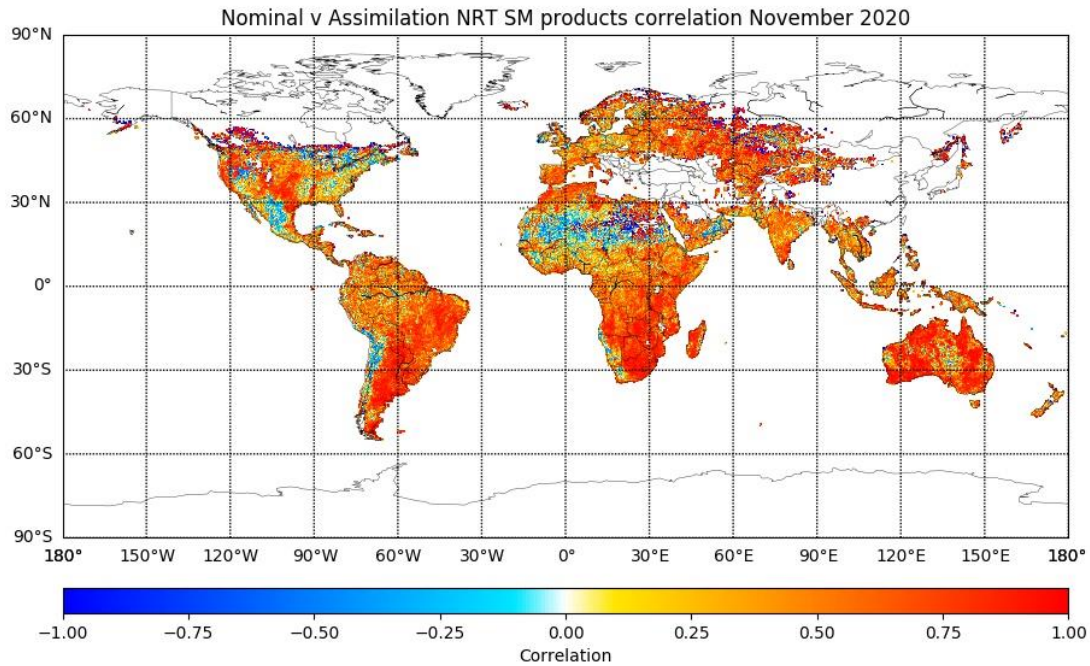
Figure 4: Correlation between the ESA nominal neural network product and the ECMWF assimilation neural network product in November 2020

Figure 4 shows that the two products have the strongest correlations in the Southern extra-tropics. There are moderate correlations in the Northern mid-latitudes and tropics with the weakest (and sometimes negative) correlations over arid regions such as the Sahara desert, Western US and the Andes. There are also weak or negative correlations in the North-Eastern US and Southern Canada which may be due to contamination from frozen surfaces during a time of year of rapid seasonal change in those parts of the world.