ESA CONTRACT REPORT

Contract Report to the European Space Agency

SMOS Hurricane wind speed analysis

Authors: Giovanna De Chiara and Stephen English

Report for ESA contract
4000101703/10/NL/FF/fk CCN5

European Centre for Medium-Range Weather Forecasts
Europäisches Zentrum für mittelfristige Wettervorhersage
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Abbreviations

ECMWF .... European Centre for Medium-range Weather Forecasts
IFREMER .... Institut français de recherche pour l'exploitation de la mer
GMF……………..Geophysical Model Function
NetCDF…………..Network Common Data Format
ODB……………..ECMWF Observational DataBase
QC .... Quality Control
SMOS……………Soil Moisture and Ocean Salinity
TC………………..Tropical Cyclone

Abstract

The European Centre for Medium-Range Weather Forecasts (ECMWF) has been contracted by the European Space Agency (ESA) to perform a preliminary evaluation of the Soil Moisture and Ocean Salinity (SMOS) wind speed products. This report presents the results of the work done in the framework of the ESA contract 4000101703/10/NL/FF/fk CCN5, WP4060.

1. Introduction

The European Space Agency (ESA) Soil Moisture and Ocean Salinity (SMOS) mission was launched in 2009. It provides multi-angular L-band (1.4 GHz) brightness temperature images of the Earth [Mecklenburg et al., 2009; Kerr et al., 2010]. The goals of SMOS are soil moisture and ocean salinity but other applications, such as marine wind speed at high wind speed and thin sea ice, have the potential to provide useful information. In this short report we examine the characteristics of a new wind speed product. As L-band measurements are less affected by the atmosphere than higher frequencies, and also because the emissivity of saline water is very low at low frequency, L-band measurements have the potential to provide all-weather wind (near surface) information, even at very high wind speed. Crucially this can be achieved without loss of sensitivity due to atmospheric absorption and scattering and without the sensitivity saturating at moderately high wind speed, as occurs for scatterometer and higher frequency passive observations. Therefore they can be very useful to provide observations in case of extreme events such as Tropical Cyclones (TC) and extra-tropical storms which are characterized by the presence of clouds and rain.

In the framework of the *SMOS+ STORM* and *SMOS+ STORMS Evolution* ESA projects, a consortium led by IFREMER started exploiting the capability of using SMOS brightness temperature measurements for retrieving wind speed in TCs and storms. The rationale behind the product is to exploit the large difference between the emissivity of foam by breaking waves and the emissivity of the foam-free ocean. The projects were aimed to assess SMOS measurements capabilities for wind speed retrieval, to develop a Geophysical Model Function (GMF) to relate the brightness temperature to surface wind speed and to generate SMOS oceanic wind products and TC and Extra-Tropical Cyclone events database.

The European Centre for Medium Range Weather Forecasts (ECMWF) was contracted by ESA to perform a preliminary assessment of the SMOS wind data. The analysis is aimed to assess the quality of SMOS winds by comparing them to ECMWF model wind fields.

2. SMOS wind data acquisition and description

SMOS wind data were provided by IFREMER. The High Wind Speed Database, version 2 released in January 2016. Data from 2010 to 2015 were accessible and downloaded from the following ftp link: ftp://ftp.ifremer.fr/ifremer/cersat/cercache/users/nreul/HWS_DB_version_jan_2016/. A brief description of the file content were provided as well. Each SMOS wind file corresponds to a half orbit of SMOS retrieved winds using SMOS-STORM 2nd GMF [Reul et al., 2015]. Example of the filename is the following:

HWS_REPR_MIR_SC_F1B_20110201T192458_20110201T201856_621_001_1-V02.0_fv01.0

SMOS products are available in NetCDF format. The NetCDF files contain, for each observation, the following parameters:

1) Wind speed (in m/s);
2) Latitude (in deg);
3) Longitude (in deg);
4) Acquisition time;
5) Cross-track distance;
6) Quality Control (QC) flags. Nine bit flags are available:
   a) Flag 1 is set to 1 if the distance to coast at pixel is less than or equal to 150 km;
   b) Flag 2 is set to 1 if distance to coast at pixel is in between 150 and 800 km;
   c) Flag 3 is set to 1 if distance to coast at pixel is greater than 800 km;
   d) Flag 4 is set to 1 if temporal standard deviation of SSS > 0.8 pss (practical salinity scale);
   e) Flag 5 is set to 1 if SST less than or equal to degrees;
   f) Flag 6 is set to 0 if the pixel is located in zone with low statistical contamination by Radio Frequency Interference; it is set to 1 otherwise;
   g) Flag 7 is set to 1 if the pixel is located in zone with moderate statistical contamination by Radio Frequency Interference. It is defined by an average monthly RFI probability greater than 0 and less than or equal to 25%; it is set to 0 otherwise;
   h) Flag 8 is set to 1 if the pixel is located in zone with high statistical contamination by Radio Frequency Interference. It is defined by an average monthly RFI probability greater than 25%;
   i) Flag 9 is set to 1 if the pixel shows a multi-angular variability of the brightness temperature greater than 5 K. This flag potentially indicate RFI or rain contaminated signal.

It is recommended to filter out the wind observations with the flags 1, 4, 5, 6 set to 1.

3. Comparison with ECMWF winds

The preliminary assessment of the SMOS Storm Wind database was done comparing SMOS observations to ECMWF analysis winds. The comparison was performed using a tool developed internally at ECMWF which was originally designed for SSMI and MTVZA observations in Observational Database (ODB) format. The tool computes the departure between the observations and ECMWF analysis or background.

To be able to use this tool for our purposes, the SMOS data were converted from NetCDF format to ODB format. Hence, the tool was adapted to process SMOS wind speed data. Once the tool was successfully tested, two sets of nine days were processed. The analyzed periods are 1-9 February 2012 and 1-9 August 2012, to verify any seasonal variability. SMOS winds were compared to ECMWF analysis and for each observation the analysis departure was computed. In Figure 1 the scatterplots of SMOS winds versus ECMWF analysis winds are shown for the periods 1-9 February 2012 (top panel) and 1-9 August 2012 (bottom panel). There is overall a fair good agreement between the two datasets for both periods with most of the observations having an analysis departure within +/- 5 m/s. However many SMOS observations show large departure ranging from 10 to 30 m/s. Some other observations show very high values, up to 75 m/s, which do not find correspondence in the model fields. The amount of these outliers is slightly larger for the second dataset (Southern Ocean winter).

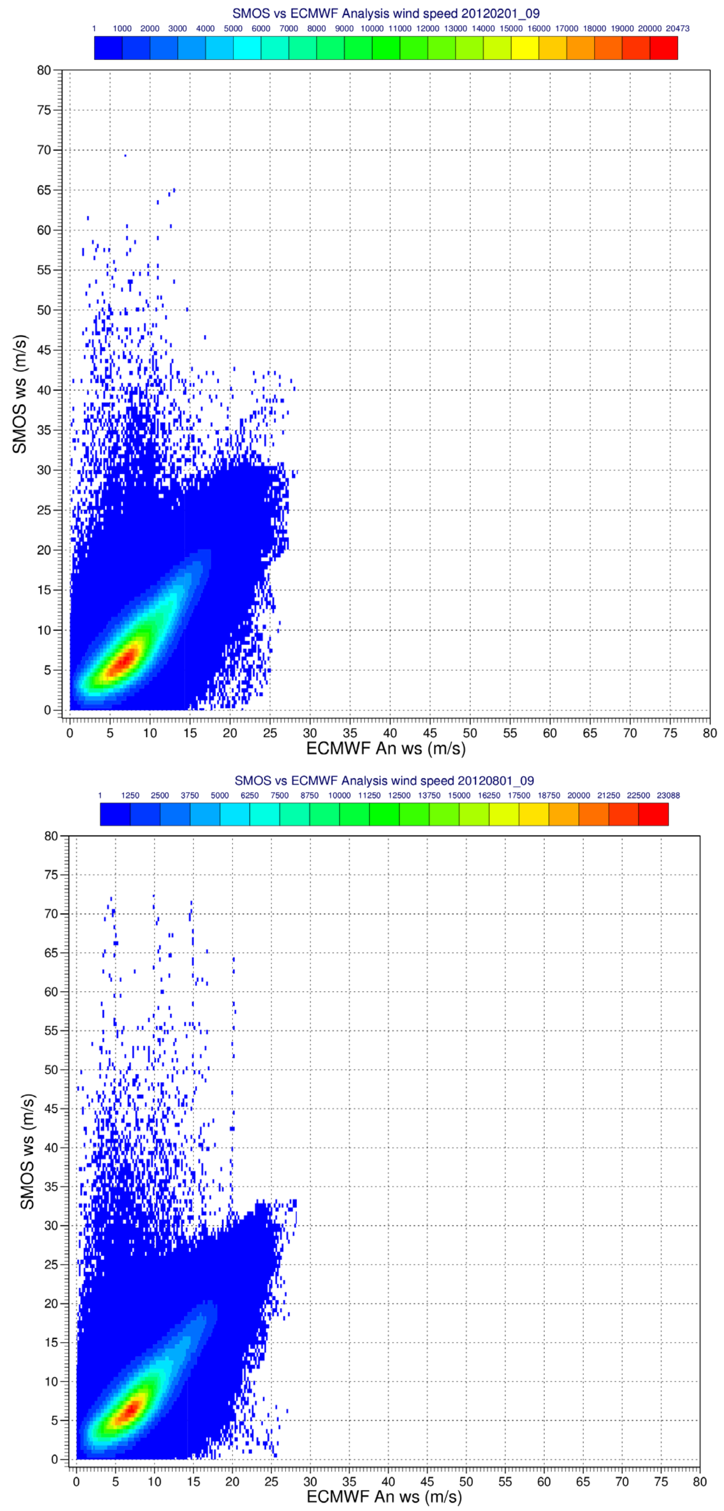

Figure 1: Scatterplots of SMOS winds versus ECMWF Analysis winds for the period 1-9 February 2012 (top panel) and the period 1-9 August 2012 (bottom panel).

To better analyze data with large departure, maps of all the SMOS with analysis departure larger than 10 m/s measured at any time during the two periods under investigation observations (no gridded averaging applied) are shown in Figure 2.

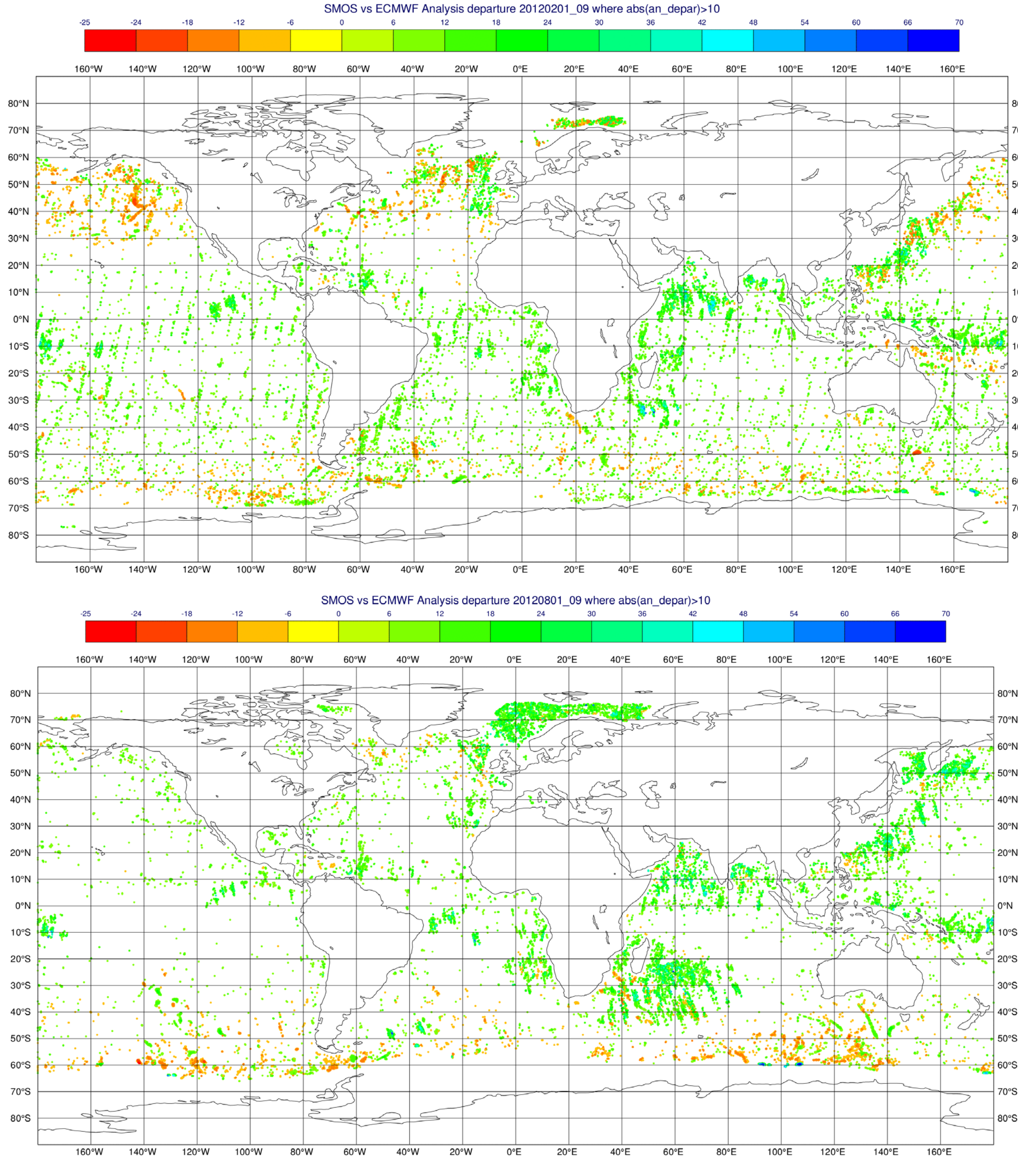

Figure 2: Maps of SMOS winds analysis departure for departure larger than 10 m/s for the period 1-9 February 2012 (top panel) and the period 1-9 August 2012 (bottom panel).

On average the observations are stronger than the analysis and the departure values range from -25 m/s to about 65 m/s. Observation with large positive departure are generally globally spread with areas of major concentration in the Tropical Western Pacific, Indian Ocean and North Atlantic. Observations with large negative departure, instead, are located mostly in the northern extra-tropical areas in February and in the southern ocean in August. Some observations show a very large departure (above 40 m/s) and are located in the Indian Ocean and Tropical Western Pacific. In October, some of these outliers are seen in the Southern Ocean close to the area masked as sea-ice which might be due to a sea-ice contamination. Features related to the satellite swath are evident, in both maps, which might be related to the position of the observations in the swath.

4. Conclusions

In this report results of a preliminary assessment of the SMOS Storm database were presented. SMOS winds were compared to ECMWF analysis. Overall SMOS winds look promising. Most of the observations show analysis departure within 10 m/s but there are still many points with very large departures. Some of them might be related to sea-ice contamination or poor quality of the information retrieved due to the distance from the centre of the swath and further investigations are needed. A detailed analysis of the quality of the observations in the area of TC and extra tropical storms will be performed in the follow-on project.

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http://www.smosstorm.org/Presentation/Project-Overview