SMOS-IC: CURRENT STATUS AND OVERVIEW OF SOIL MOISTURE AND VOD APPLICATIONS

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ABSTRACT

In 2017, the new SMOS-IC retrieval product of soil moisture (SM) and L-band Vegetation Optical depth (L-VOD) was developed. This product relies on a two-parameter inversion of the L-MEB model (L-band Microwave Emission of the Biosphere) which requires little ancillary information and was found to be accurate, making it very well-suited for application in agriculture, hydrology, climate and vegetation monitoring. In this communication we present recent improvements in the SMOS-IC retrieval algorithm and recent applications using the soil moisture or VOD retrievals from the SMOS-IC data set. SMOS-IC SM is available at the French CATDS center.

Index Terms— SMOS-IC, SMOS, soil moisture, VOD, biomass, carbon stocks

1. INTRODUCTION

Soil moisture (SM) over the land surfaces is currently monitored by two L-band passive microwave missions: SMOS (Soil Moisture and Ocean Salinity) [1,10] and SMAP (Soil Moisture Active Passive) [5]. To retrieve SM and VOD from SMOS, several algorithms have been developed: the SMOS official Level 2 (L2) & Level 3 (L3) [9,10], the LPRM [16] and SMOS-IC algorithms [8], etc..

The SMOS-IC algorithm corresponds to a two-parameter inversion of the L-MEB model (L-band Microwave Emission of the Biosphere) as defined in [17,19]. It is based on an approach aiming at (i) minimal use of ancillary data and (ii) optimal use of the space-borne observations by exploiting the multi-angular and dual polarization TB signatures and the relatively low amplitude in the trend of VOD.

The main features of SMOS-IC are as follows:

1) SMOS-IC is, as much as possible, independent of auxiliary data: it does not use (i) modelled ECMWF SM data nor (ii) vegetation data estimated from optical observations. Currently it only uses ECMWF temperature fields to compute the effective surface temperature [19].

2) Presently SMOS-IC considers pixels as homogeneous as done in the AMSR-E, AMSR-2, SMAP retrieval algorithms.

3) Simple and efficient filtering methods are used (threshold on the cost function, available TB angular range, number of available TB inputs, etc.) as defined in [17].

4) Processing is very fast, allowing quick optimization tests and Near Real Time (NRT) applications

5) Simple soil roughness and vegetation model parameterizations are used [11]

SMOS-IC provides global gridded (EASE grid 2) daily SM (m3/m3) and VOD in the NetCDF format with a ~25 km cylindrical projection (ascending and descending overpasss at 0600 a.m. and 0.600 p.m. Local Solar Time, respectively). The current version is V105 (processed end of 2017) and has a global coverage. The latest version of the SMOS-IC SM product is available as a scientific product at the Centre Aval de Traitement des Données SMOS (CATDS) at ftp://ext-catds-cecsm:catds2010@ftp.ifremer.fr/Land_products/L3_SMOS_IC_Soil_Moisture/

3. THE SMOS-IC ALGORITHM

The two-parameter inversion of the L-MEB model requires defining soil and vegetation input parameters [20]. As noted above, the objective was to derive this information directly from the SMOS TB observations as a function of the land use classification scheme of the International Geosphere-Biosphere Programme (IGBP), which is composed of 17 classes.

A large optimization study based on the ISMN (International Soil Moisture Network) showed there is a low dependence of the soil and vegetation model parameters on the IGBP classes [7]. So, a complex parameter optimization is not required in SMOS-IC and model parameters are mainly distinguished for two vegetation classes: forest and low vegetation. Note that considering [6], when evaluating SM retrievals, a higher priority was put on correlation (R) and Ub-RMSE), a lower one on bias (SMOS-IC SM is slightly "drier" by 0.01-0.03 m^3/m^3 globally than some other SMOS products).

The global mapping of the soil roughness H_R parameter was derived from the SMOS observations as described in [12]. The value of the N_{RP} parameter was distinguished only for forested (N_{RV} = -1, N_{RH} = 1) and non-forested (N_{RP} = -1) vegetation classes (very similar results were obtained by using $N_{RV} = 0$ and $N_{RH} = 2$). The value of the effective scattering albedo (ω) was distinguished for 16 land use classes. But this can be simplified over low vegetation and barren by setting ω = 0.1 (constant value). In that case, the values of the roughness parameters (H_R and N_{RP}) mainly impact bias (they have a low impact on correlation and unbiased-RMSE). Over forests, the value of ω was set to 0.06 based on the analysis of SMOS observations [13]. The initial guess of VOD in the minimization process of the cost function was set to the yearly average value of VOD retrieved in a preliminary inversion step (independently of LAI data). Simple and efficient filters were applied to improve the quality of the retrieved SM and VOD data considering:

-sufficient amplitude in the angular signature (minimum = 10°) and restricting the angle range to 20-55° [8, 17]

-relatively low values of the Root Mean Square Error between the observed and modelled TB data (RMSE-TB). Note that the L-MEB model is able to fit very well the TB signatures over all kind of surfaces (up to levels of RMSE ~ 1-3 K). So RMSE-TB values larger than about 3 K mainly reveal RFI (man-made interferences in protected bands) effects and thus RMSE-TB is very well correlated to RFI. We used a threshold values of 12 K above which we considered retrieved data should be filtered out [18]. Recent tests with V105 showed this value should be decreased to 8-10 K. In regions with strong RFI effects (Asia, part of China and India), a compromise has to be found: increasing the RMSE-TB threshold lead to obtain more data, but the obtained data might be noisier. Scene flags are set to indicate the presence of moderate topography, strong topography, polluted scene (if water, urban and ice fractions represent more than 10% of the pixel according to the IGBP classification) and frozen conditions (soil temperature < 273 K). If one of these flag is set, retrievals are made in the V105, but a quality flag is set to 1 to indicate the data are not recommended. So, except for very specific use, the users should use only recommended data (quality flag = 0). In the V105, no filters are applied to take off negative SM and VOD values as these values are useful. For instance, negative SM & VOD values are numerically possible in desert areas and should be used when computing long term averages.

Note that it can be interesting to combine the L-VOD and SM products retrieved from both the ascending (ASC, 6 am) and descending (DESC, 6 pm) data, as the observations made from both orbits do not have the same sensitivity to RFI effects. This can be explained by the fact the boresight of the SMOS antenna is forward tilted by 32.5° with respect to nadir to enable multi-angular measurements over a large range of incidence angles. When monitoring pixels located in the southern hemisphere from DESC orbits, the SMOS antenna is tilted towards southern areas (including Antarctica and Southern Ocean) barely affected by RFI effects (symmetrically this may be true when monitoring pixels in the northern hemisphere from ASC orbits). As a result, pixels located in the southern (northern) hemisphere may be less impacted by RFI effects for descending (ascending) orbits. Optimal combination of ASC and DESC data can be done simply by using the RMSE-TB criteria which will automatically select (ASC, DESC or both ASC & DESC data) which are least affected by RFI effects.

4. APPLICATIONS

The SMOS-IC data set is very well suited for applications. There are two main reasons for this:
1) The SMOS-IC data is very accurate in terms of both SM and VOD data. A number of inter-comparison analyses have been carried out to date and all results obtained so far indicated that SMOS-IC performs very well. These above-mentioned studies considered evaluation based on:
- the ISMN in situ networks, global study [2, 7]
- modelled ECMWF SM data, global study [8]
- new in situ SM networks in Brazil
- the core SMAP SM cal-val sites [2, 14]
- spatial correlation between L-VOD and above-ground biomass (AGB) data and other indices (tree height, NDVI, etc) [3, 8, 15], etc.
-current ongoing studies to be published (see this issue)
2) SMOS-IC considers the pixel as homogeneous (no use of decision tree) and thus retrievals are independent of modelled SM data and optical vegetation indices. This feature is quite important for applications.

5. CONCLUSIONS

The communication will review recent application results based on SMOS-IC, in terms of:
-monitoring of carbon stocks and vegetation water content using the SMOS-IC L-VOD product [3]
-monitoring of SM in link with climate modelling (CMIP5)
-synergy between the SMOS and SMAP observations [4]
We will also present an overview of past and ongoing inter-comparisons between the SMOS-IC, SMAP, CCI SM data sets [2, 7, 8, 14, etc]

6. REFERENCES

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