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The prototype SMOS soil moisture Algorithm

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The Soil Moisture and Ocean Salinity (SMOS) mission is ESA's (European Space Agency) second Earth Explorer Opportunity mission, to be launched in September 2007. It is a joint programme between ESA CNES (Centre National d'Etudes Spatiales) and CDTI (Centro para el Desarrollo Tecnologico Industrial). SMOS carries a single payload, an L-band 2D interferometric radiometer in the 1400-1427 MHz protected band. This wavelength penetrates well through the atmosphere and hence the instrument probes the Earth surface emissivity. Surface emissivity can then be related to the moisture content in the first few centimeters of soil, and, after some surface roughness and temperature corrections, to the sea surface salinity over ocean.
In order to prepare the data use and dissemination, the ground segment will produce level 1 and 2 data. Level 1 will consists mainly of angular brightness temperatures while level 2 will consist of geophysical products. In this context, a group of institutes prepared the soil moisture and ocean salinity Algorithm Theoretical Basis documents (ATBD) to be used to produce the operational algorithm.
The consortium of institutes preparing the Soil moisture algorithm is led by CESBIO (Centre d'Etudes Spatiales de la BIOsphère) and Service d'Aéronomie and consists of the institutes represented by the authors. The principle of the soil moisture retrieval algorithm is based on an iterative approach which aims at minimizing a cost function given by the sum of the squared weighted differences between measured and modelled brightness temperature (TB) data, for a variety of incidence angles. This is achieved by finding the best suited set of the parameters which drive the direct TB model, e.g. soil moisture (SM) and vegetation characteristics.
Despite the simplicity of this principle, the main reason for the complexity of the algorithm is that SMOS "pixels" can correspond to rather large, inhomogeneous surface areas whose contribution to the radiometric signal is difficult to model. Moreover, the exact description of pixels, given by a weighting function which expresses the directional pattern of the SMOS interferometric radiometer, depends on the incidence angle. The goal is to retrieve soil moisture over fairly large and thus inhomogeneous areas. The retrieval is carried out at nodes of a fixed Earth surface grid. To achieve this purpose, after checking input data quality and ingesting auxiliary data, the retrieval process per se can be initiated. This cannot be done blindly as the direct model will be dependent upon surface characteristics. It is thus necessary to first assess what is the dominant land use of a node. For this, an average weighing function (MEAN_WEF) which takes into account the "antenna" pattern is run over the high resolution land use map to assess the dominant cover type. This is used to drive the decision tree which, step by step, selects the type of model to be used as per surface conditions.
All this being said and done the retrieval procedure starts if all the conditions are satisfied, ideally to retrieve 3 parameters over the dominant class (the so-called rich retrieval). If the algorithm does not converge satisfactorily, a new trial is made with less floating parameters ("poorer retrieval") until either results are satisfactory or the algorithm is considered to fail. The retrieval algorithm also delivers whenever possible a dielectric constant parameter (using the-so called cardioid approach). Finally, once the retrieval converged, it is possible to compute the brightness temperature at a given fixed angle (42.5°) using the selected forward models applied to the set of parameters obtained at the end of the retrieval process.
So the output product of the level 2 soil moisture algorithm should be node position, soil moisture, dielectric constants, computed brightness temperature at 42.5°, flags and quality indices.
The work around the ATBD also encompasses the making of breadboards and prototype, analysis of specific cases (snow, frozen soil, topography, floods, etc…), the making of data sets and validation verification exercises.

During the presentation we will describe in more details the algorithm and accompanying work in particular decision tree principle and characteristics, the auxiliary data used and the special and “exotic” cases. We will also be more explicit on the algorithm validation and verification approaches together with the making of test data sets from existing and synthetic data. A glimpse of level 3 and 4 products will also be given.