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Towards developing a framework of global evapotranspiration and drought product for the Sentinel-3 mission

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Abstract

Here we propose a novel concept to develop global evapotranspiration (*E*) and drought product using the thermal infrared (TIR) and optical bands of the future SLSTR (Sea and Land Surface Temperature Radiometer) and OLCI (Ocean and Land Colour Instrument) payload on-board Sentinel-3 mission scheduled to be launched in mid-2015.

This multi-instrument mission will measure sea- and land-surface temperature, ocean colour and land colour with high-end accuracy and reliability in terms of better spatial, temporal and radiometric resolution as compared to those achieved by the Envisat Advanced Along Track Scanning Radiometer (AATSR) and Medium Resolution Imaging Spectrometer (MERIS). This makes Sentinel-3 mission as an ideal to develop global terrestrial *E* and surface moisture condition products by exploiting the multiple TIR and optical bands. Radiometric surface temperature (T_R) through TIR remote sensing serves as a direct metric for the land surface moisture status and vegetation ecophysiological conditions, which in turn influences the surface energy fluxes and their partitioning. Similarly, vegetation and leaf area indices retrieved from the shortwave optical bands offer information on the biophysical controls of *E*. Allied to these, the multiple radiance channels in the shortwave and longwave spectrum of Sentinel-3 can be used to retrieve the shortwave and longwave radiative fluxes required to drive the *E* models.

Having retrieved the information of all the core radiative, biophysical and ancillary variables necessary, a comprehensive approach will be further adopted to determine *E* by employing four different process-based algorithms and creating an ensemble product and drought indices derived from the evaporation ratios. The four algorithms are Surface Temperature Initiated Closure (STIC) (Mallick et al., 2013, 2014), Two Source Energy Balance (TSEB) (Norman et al., 1995), Maximum Entropy Production (MEP) (Kleidon et al., 2014), and Surface Energy Balance System (SEBS) (Su, 2002). STIC is an analytical model which physically integrates the radiometric surface temperature into the Penman-Monteith equation. The method combines T_R data with the standard surface energy balance equations and a modified advection–aridity hypothesis in order to derive a hybrid equation closure that does not require specifications of the surface to atmosphere conductance terms; instead the conductances are analytically retrieved. STIC is formed by the simultaneous solution of four state equations. On the contrary, SEBS (Su, 2002) and TSEB (Norman et al., 1995) require explicit estimates of the surface to atmospheric conductance terms. Both are land surface parameterization-based approaches proposed for the estimation of atmospheric turbulent fluxes using satellite observations of biophysical variables (T_R, fractional vegetation cover, albedo), in combination with ancillary meteorological information (air temperature, relative humidity and wind speed). These models rely on the measurements of T_R to directly estimate the sensible heat flux and indirectly obtain *E* as a residual of surface energy balance. To estimate aerodynamic conductances they determine the roughness length of heat and momentum transfer; but while SEBS is a single-source scheme using the energy balance at extreme dry and wet cases to solve the evaporative fraction, TSEB is a two source soil-vegetation model which requires partition of T_R into soil and vegetation. This partition can be better achieved via angular estimates of T_R or with single observations via an iterative process. Thus, TSEB will greatly benefit from the multi-angular capabilities from Sentinel-3 –SLTSR and will reduce the uncertainty from approaches based on single-angle T_R observations. MEP is also another novel physical approach which is built on constraining the land-atmosphere exchanges based on the thermodynamic limit of maximum power to derive analytical expressions for the partitioning of the terrestrial surface energy and water balances based on the information of T_R, radiation and rainfall. Once retrievals of *E* from these four process-based models are obtained, we shall adopt a Simple Averaging (SA) as well as Bayesian model averaging (BMA) method to improve satellite-based global terrestrial *E* estimation by merging the algorithms. Surface moisture availability will be simultaneously estimated using multiple approaches, such as, employing day-night T_R and radiative flux information (Mallick et al., 2015), using the ratio of evaporation to potential evaporation, psychrometric principles and Budyko aridity principle. Here also a SA and BMA method will be followed by merging the multiple surface moisture estimates from different algorithms.

Using the combination of geophysical land surface data from MERIS and AATSR in conjunction with atmospheric data from other satellites, we will develop a proof of concept for Sentinel-3 (OLCI/SLSTR) data and a synthetic framework to simultaneously retrieve global E and surface moisture status at 1 km spatial resolution. Upon the availability of the land and atmosphere data from Sentinel-3 the framework to estimate E and surface moisture would likely be adapted to demonstrate the potential of SLSTR and OLCI channels for near real-time mapping of terrestrial E and drought. This will not only greatly benefit the climate studies but a consistent thermal remote sensing satellite based E, surface moisture and drought data record will also be established for the post NOAA and MODIS era.