EGU2020-4656
https://doi.org/10.5194/egusphere-egu2020-4656
EGU General Assembly 2020

A simple method for soil moisture calculation using data from ELBARA III passive radiometer and thermal inertia

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The soil is a heterogonous substance consists of three phases: solid, gas and liquid, where the latter is mainly water – the natural solvent with very high heat capacity. Due to this physical property and the fact that water is a common substance on our planet, it has a significant impact for stability of the climate on Earth. Another water property, the dielectric constant much higher than in other soil ingredients, is often used to determine soil water content. As an example, the Time Domain Reflectometry (TDR) technique for in situ soil moisture measurements may be mentioned. For soil moisture assessments at global scale, the satellite-based instruments were designed and launched into space, e.g. Soil Moisture and Ocean Salinity (SMOS) or Soil Moisture Active Passive (SMAP). Those satellites are measuring brightness temperature of soil in microwave (L-band) domain. The algorithms that retrieve soil moisture from L-band measurements by nonlinear optimisation engage several parameters such as soil temperature, its roughness and vegetation cover. In the presented work, we introduce a much simpler method that base on three facts: i) a high water heat capacity cause that, during the diurnal night/day cycle, the soil with higher water content cools down and heats up slower than dry soil. This phenomenon was quantified by thermal inertia; ii) brightness temperature is related to the effective temperature of the surface and iii) plants are generally semi-transparent for L-band microwaves, what gives a possibility for probing soil properties underneath vegetation. Due to iii) we assumed that L-band soil albedo (needed in thermal inertia computations) is constant. The proposed approach seems to be reasonable, as both variables, brightness temperature and thermal inertia, strongly depend on soil water content. The method was evaluated using ELBARA (European Space Agency L-band Radiometer) instrument operating at Bubnow test site in Poland. The ELBARA is a directional receiver at 1.4 GHz frequency (the same as received by SMOS satellite), installed on the Earth's surface, at 6-meter tower. In the years 2016-2019, we conducted 16 field campaigns – we measured surface soil moisture in situ using TDR, and interpolate it to semi-continuous grid using geostatistics. Then, the driest and the wettest points (in space and time) were chosen and assigned to, respectively, maximum and minimum thermal inertia. Basing on that, the model retrieving soil moisture was built, and the other measurements served as validation assembly. Simple regression methods revealed good or moderately good agreement between modelled and measured data. Some outliers, probably induced by meteorological phenomena disturbing stable soil cooling and heating such as rain or wind, have been noticed.

Research was partially conducted under the project “Water in soil - satellite monitoring and improving the retention using biochar” no. BIOSTRATEG3/345940/7/NCBR/2017 which was financed by Polish National Centre for Research and Development in the framework of “Environment, agriculture and forestry” – BIOSTRATEG strategic R&D programme.