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New algorithm for mapping soil moisture by coupling Sentinel-1 and Sentinel-2 images

Nicolas Baghdadi (1), Mohammad El Hajj (1), Mehrez Zribi (2), and Hassan Bazzi (1)

(1) Irstea, UMR TETIS - Maison de la Télédétection, Montpellier Cedex 5, France (nicolas.baghdadi@teledetection.fr), (2) CESBIO (CNRS/UPS/IRD/CNES), 18 Avenue Edouard Belin, 31401 Toulouse CEDEX 9, France;

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Nicolas Baghdadi1, Mohammad El Hajj1, Mehrez Zribi2, Hassan Bazzi1

1 IRSTEA, University of Montpellier, UMR TETIS, 34093 Montpellier CEDEX 5, France;
2 CESBIO (CNRS/UPS/IRD/CNES), 31401 Toulouse CEDEX 9, France;
nicolas.baghdadi@teledetection.fr (N.B.); mohammad.el-hajj@teledetection.fr (M.E.H.) ;
mehrez.zribi@ird.fr (M.Z.); hassan.abdel-nasser-bazzi@teledetection.fr

Soil moisture is a key parameter regulating the earth water cycle since it is a function of the rates of soil evaporation and precipitation. SAR data in the C- and X-bands were widely and primarily used to estimate soil moisture (mv) over bare soils and soils covered with vegetation. The arrival of Sentinel-1 (S1) and Sentinel-2 (S2) satellites have encouraged the development of an operational algorithm for soil moisture mapping over agricultural areas with high revisit time and high spatial resolution (up to plot scale).
The aim of this study is to develop an operational approach for mapping soil moisture at high spatial resolution (up to the plot scale) in agriculture areas by coupling S1 and S2 images. The proposed approach is based on the inversion of the Water Cloud Model (WCM) using the neural network (NN) technique. The use of the new S1 and S2 data for operational soil moisture mapping in agricultural areas with high revisit time and at the plot scale is an innovative use of spatial imageries.
NNs were trained in using the noisy synthetic training database generated from the parameterized WCM and the modified Integral Equation Model (soil contribution). To improve the soil moisture estimates, a priori knowledge on the soil moisture state is introduced. Indeed, it is easily to define from the weather forecasts (precipitation and temperature) if the soil is either dry to slightly wet (no precipitation for many days before SAR acquisition) or very wet (heavy rainfall preceding SAR acquisition). The integration of a priori information constrains the range of possible soil moisture parameter values estimated by the neural networks and thus leads to a better estimation of the soil moisture.
Three inversion SAR (Synthetic Aperture Radar) configurations were tested: (1) VV polarization, (2) VH polarization, and (3) both VV and VH polarization, all in addition to the NDVI information extracted from optical images. Neural networks were validated using synthetic and real databases. The results showed that the soil moisture could be estimated in agricultural areas with an accuracy of approximately 5 vol.%.

Keywords: soil moisture, Sentinel-1, Sentinel-2, neural networks, agricultural areas