Electromagnetic Interactions with Vegetated Soils: An Integrative Modeling Approach

I. Baris[1], T. Jagdhuber[1], F. Jonard[2,3], J. Judge[4], H. Anglberger[1]

[1] German Aerospace Center, Microwaves and Radar Institute, Münchner Str. 20, 82234 Wessling
[2] Forschungszentrum Jülich GmbH, Institute of Bio- and Geosciences: Agrosphere (IBG-3), 52425 Jülich, Germany
[3] Université catholique de Louvain, Earth and Life Institute, Croix du Sud 2, 1348 Louvain-la-Neuve, Belgium
[4] Center for Remote Sensing, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, USA
E-Mail: {ismail.baris,thomas.jagdhuber, harald.anglberger}@dlr.de, f.jonard@fz-juelich.de, jasmeet@ufl.edu

I. Abstract

Many attempts have been made and are undertaken to model the electromagnetic (EM) interaction with vegetation-covered soils at different frequencies. The modelling concepts and architectures range from empirical correlations to simple and sophisticated physical models [1, 2]. However, a general understanding of the physical properties and interactions along frequency and for a wider part of the EM spectrum is difficult if the different models are treating the single frequencies and acquisition characteristics (e.g. active or passive recording) separately. Due to the increasing fleet of earth observation sensors operating in multiple frequency bands, demand for a spectrum-overarching EM modelling is becoming increasingly important. An integrative modeling approach offers the chance that the different insights into biophysical and biochemical processes can be considered consistently including the respective dielectric properties and structural characteristics. With this objective we developed a kernel-driven electromagnetic interaction model using vector radiative transfer (VRT), called SPIN (Spectrum Invariant Interaction) model, which represents an integrated model approach for active and passive microwaves and passive optical as well as thermal signatures [3]. Preparatory research for this study was the development of the RadOptics Model [4]. The main advantage of a kernel-driven approach is its analytical invertibility and the representation of the VRT as sum of linear equations, which leads to an enlargement of the information by including multiple frequencies. In addition, the model does not require semi-empirical or statistical calibration (i.e. all model parameters have physical meaning and none just for model adjustment.).

L- (active & passive) and C-band (passive) measurements along the growing cycle from the Eleventh Microwave, Water, and Energy Balance Experiment (MicroWEX-11) have been used for first forward model validations including in situ data of the experiment [5]. The first results for sweet corn signatures during different stages of growth showed that the modelled values represent actual measurements with Pearson's correlations up to 0.83. An example result for the comparison of SPIN forward model results with passive C-band observations can be found in Fig. 1. In the further course of our research we have the chance to look to other test sites of the MicroWEX-11 campaign which include optical and thermal observations. Nevertheless, if one compares the model results with the results of other models (PROSAIL), a very high correlation can also be observed (Pearson's correlations 0.99).

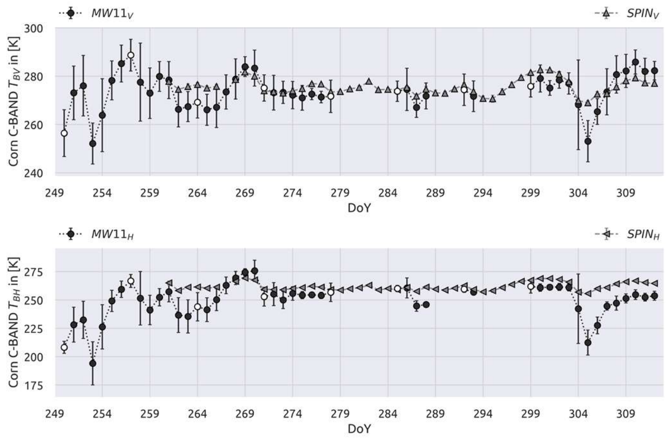

Fig. 1: T_B-Measurements from MicroWEX-11 compared with the SPIN-modelled T_B for C-band.
Top: Modelled and measured T_B for vertical polarization (Pearson 0.73, R^2=0.53, RMSE=9.49). Bottom: Modelled and measured T_B for horizontal polarization (Pearson 0.73, R^2=0.53, RMSE=10.41) along growing season (DoY) of 2011. White dots: In-situ measurements of plant parameters. Linear interpolation of some input variables (e.g. Vegetation Water Content) for modelling was performed between these DoY.

However, the simulations are still not optimized in some ways (e.g. mismatch between observation time of sensors and in situ measurements), which give reason why the error bars of some individual measurements are distinct. Therefore, our current effort is to refine the validation in order to draw more precise conclusions. Moreover, to also include higher-order solutions of VRT, far-reaching analyses are currently carried out to determine the kernel-based formulation of these solutions. For instance, we focus on the thermal infrared region (TIR). Different options are also currently examined to include optical acquisition traits, like the so-called *hotspot* or the *shadowing* effect in optical regions [6]. Additionally, we will include other plant species, investigated during MicroWEX-11 in the validation of SPIN to assess its applicability.

II. References

1. Mishchenko MI, Travis LD, Mackowski DW (1996) T-matrix computations of light scattering by nonspherical particles: A review. Journal of Quantitative Spectroscopy and Radiative Transfer 55(5): 535–575. doi: 10.1016/0022-4073(96)00002-7
2. Jacquemoud S, Baret F (1990) PROSPECT: A model of leaf optical properties spectra. Remote Sensing of Environment 34(2): 75–91. doi: 10.1016/0034-4257(90)90100-Z
3. Chandrasekhar S (1960) Radiative transfer. Dover Publications, New York
4. Baris I, Jagdhuber T, Anglberger H et al. (2018) Semi-Physical Integration of Scattering Models for Microwaves and Optical Wavelengths. In: IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium. IEEE, pp 345–348
5. UF IFAS Extension, University of FLORIDA (2015) Field Observations during the Eleventh Microwave Water and Energy Balance Experiment (MicroWEX-11): from April 25, 2012, through December 6, 2012: AE514
6. Ross J (1981) The radiation regime and architecture of plant stands. Tasks for vegetation science, vol 3. Junk, The Hague