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Synergistic estimation of surface parameters from jointly using optical and microwave observations in EOLDAS

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The large amount of remote sensing data nowadays available provides a huge potential for monitoring crop development, drought conditions and water efficiency. This potential however not been realized yet because algorithms for land surface parameter retrieval mostly use data from only a single sensor. Consequently products that combine different low-level observations from different sensors are hard to find.

The lack of synergistic retrieval is caused because it is easier to focus on single sensor types/footprints and temporal observation times, than to find a way to compensate for differences. Different sensor types (microwave/optical) require different radiative transfer (RT) models and also require consistency between the models to have any impact on the retrieval of soil moisture by a microwave instrument. Varying spatial footprints require first proper collocation of the data before one can scale between different resolutions. Considering these problems, merging optical and microwave observations have not been performed yet.

The goal of this research was to investigate the potential of integrating optical and microwave RT models within the Earth Observation Land Data Assimilation System (EOLDAS) synergistically to derive biophysical parameters. This system uses a Bayesian data assimilation approach together with observation operators such as the PROSAIL model to estimate land surface parameters. For the purpose of enabling the system to integrate passive microwave radiation (from an ELBARRA II passive microwave radiometer), the Community Microwave Emission Model (CMEM) RT-model, was integrated within the EOLDAS system.

In order to quantify the potential, a variety of land surface parameters was chosen to be retrieved from the system, in particular variables that a) impact only optical RT (such as leaf water content and leaf dry matter), b) only impact the microwave RT (such as soil moisture and soil temperature), and c) Leaf Area Index (LAI) that impacts both optical and microwave RT.

The results show a high potential when both optical and microwave are used independently. Using only RapidEye only with SAIL RT model, LAI was estimated with R=0.68 with p=0.09, although estimating leaf water content and dry matter showed lower correlations |R|<0.4. The results for retrieving soil temperature and leaf area index retrievals using only (passive microwave) Elbarra-II observations were good with respectively R=[0.85, 0.79], P=[0.0, 0.0], when focusing on dry-spells (of at least 9 days) only the results respectively [R=0.73, and P=0.0], and R=0.89 and R=0.77 for respectively the trend and anomalies.

Synergistically using optical and microwave shows also a good potential. This scenario shows that absolute errors improved (with RMSE=1.22 and S=0.89), but with degrading correlations (R=0.59 and P=0.04); the sparse optical observations only improved part of the temporal domain. However in general the synergistic retrieval showed good potential; microwave data provides better information concerning the overall trend of the retrieved LAI due to the regular acquisitions, while optical data provides better information concerning the absolute values of the LAI.