Towards soil moisture retrieval based on radar and optical satellite imagery. First results of ESA EXPRO project on Sentinel-1 validation in Biebrza wetlands.

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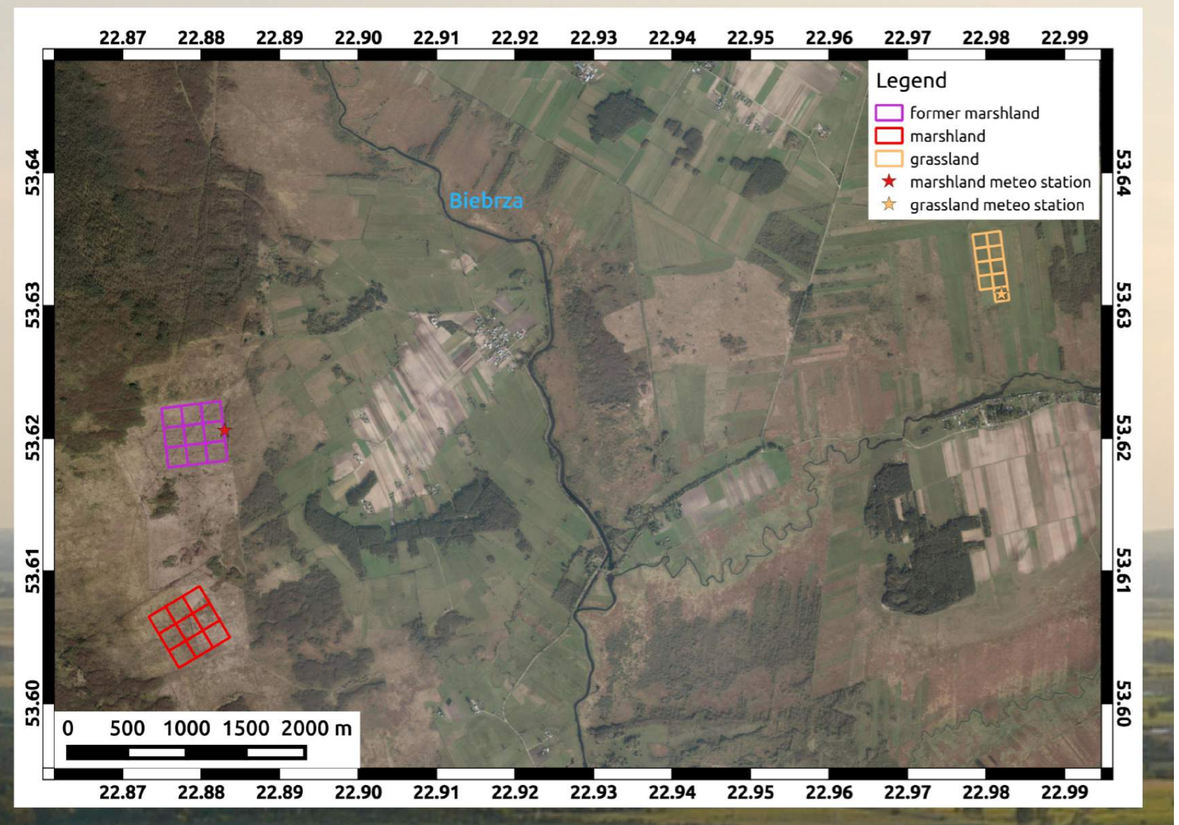
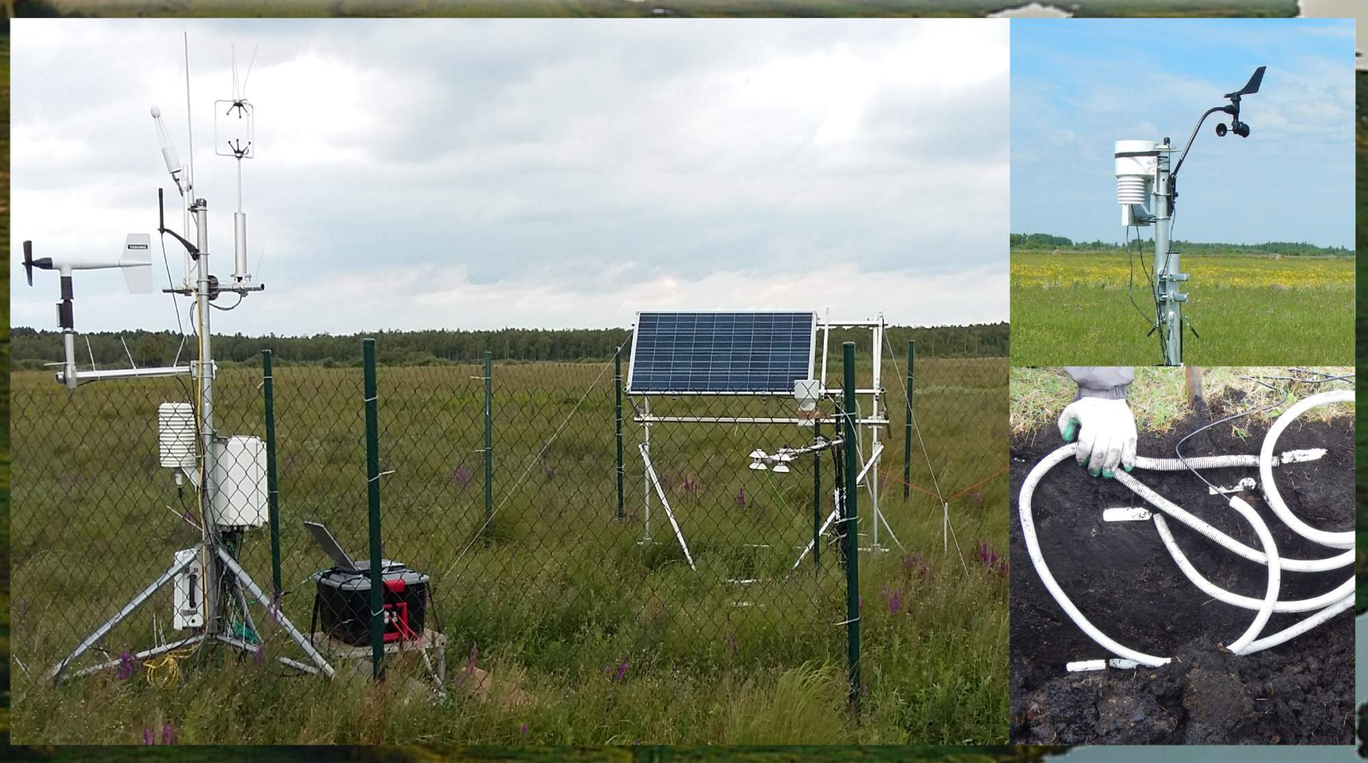
Project summary

The European Space Agency project no. 4000112578/14/NL/MP lead by the Remote Sensing Centre of the Institute of Geodesy and Cartography was established to retrieve and validate soil moisture products derived from Sentinel-1 SAR satellite data. In April 2015 two permanent validations sites have been set up covering grassland and marshland environments located in the Biebrza wetlands, Northeastern Poland. Both sites feature dense soil moisture measuring network (less than 200 m distance between stations) that fits high spatial resolution of the Sentinel-1 data. Apart from soil probes, the sites are equipped with two meteorological stations, one eddy covariance system and net-radiometer to measure carbon, water and energy fluxes within the marshland environment. On a monthly basis field campaigns are conducted to measure various biophysical parameters such as: biomass, leaf area index (LAI), leaf chlorophyll content, vegetation height , soil moisture, and PAR. Such a comprehensive dataset allows not only for soil moisture retrieval and validation based on SAR data but also for complex analysis of satellite optical products. In this respect, the Biebrza wetlands were included in the SPOT-5 Take5 experiment, that collected over 20 usable scenes covering the validation sites from 8th April till 10th September 2015. This creates an unprecedented opportunity to develop algorithms for soil moisture retrieval based on combined Sentinel-1 and SPOT-5 data.



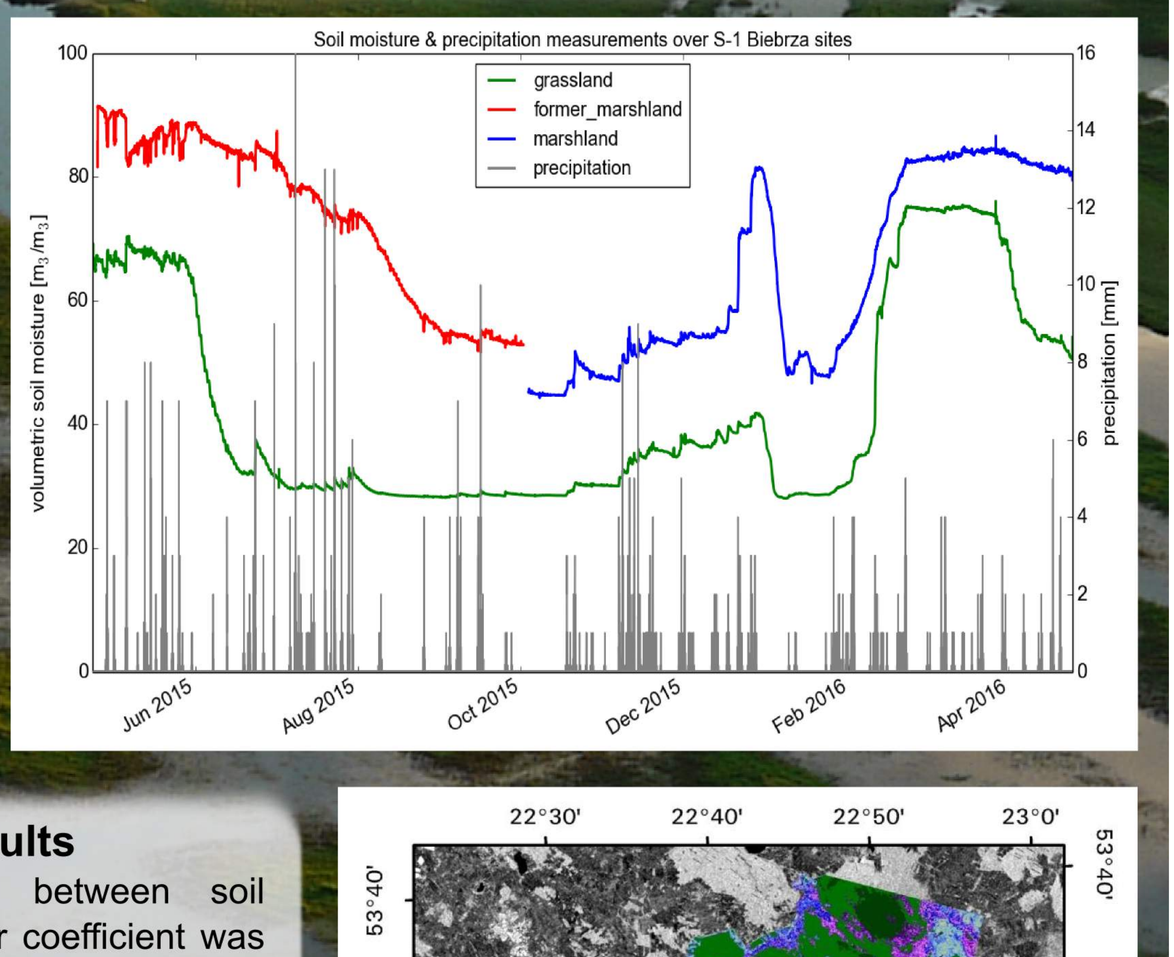
Sentinel-1 validation sites setup

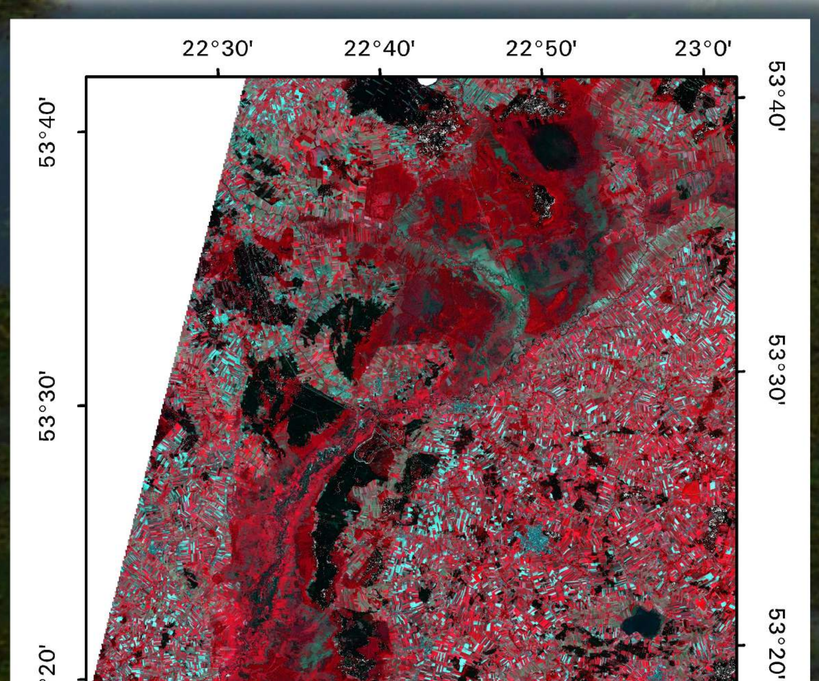
Grassland and marshland Sentinel-1 validation sites are located in the Biebrza National Park (BNP) that is also protected by the Ramsar and Natura 2000 conventions. The marshland site has a regular 500 x 500 m measuring grid composed of 9 soil moisture stations equipped with 5 probes each, measuring at depths of 5 (2 probes), 10, 20, 50 cm. The grassland site has analogous instrumentation with the stations arranged in two rows (230 x 580 m). Distance between the sites is 7 km . Due to inhomogeneous management of the marshland site its location has changed on 26.09.2015 around 1 km southwards (see purple vs red grid on the above Figure). The grassland site is under intensive management and it is covered by semi-organic, drained soil. The new marshland site is unmanaged and it is covered by natural peat. The measuring network consists of DECAGON GS3 soil moisture probes, that have been additionally calibrated in laboratory to specific soil properties at different vertical levels. All of the measurements are transmitted through a cellular network to IGiK's servers, screened for outliers, and distributed further to ESA and International Soil Moisture Network (ISMN).



Data & Methods

Sentinel-1 data are automatically downloaded and processed with the S1TBX software to generate microwave backscatter time series. The field measurements are also automatically downloaded and preprocessed (screened, reformatted and archived). Soil moisture retrieval from Sentinel-1 data is based on the water cloud model (Attema and Ulaby, 1978), that was further modified by Dabrowska-Zielinska et al. (2007). Since the microwave dielectric constant of dry vegetative matter is much smaller than the dielectric constant of water, and because vegetation canopy is usually composed of more than 99% air by volume, it was proposed to model canopy as a water cloud where droplets are held in place by the vegetative matter. The modification of the water cloud model proposed by Dabrowska-Zielinska et al. (2007) was to incorporate robust vegetation descriptors retrieved from optical satellite sensors (i.e. SPOT5) such as: leaf area index (LAI), leaf water area index (LWAI), or vegetation water mass (VWM). This allows for correction of vegetation moisture effects within the soil moisture retrieval from SAR data.



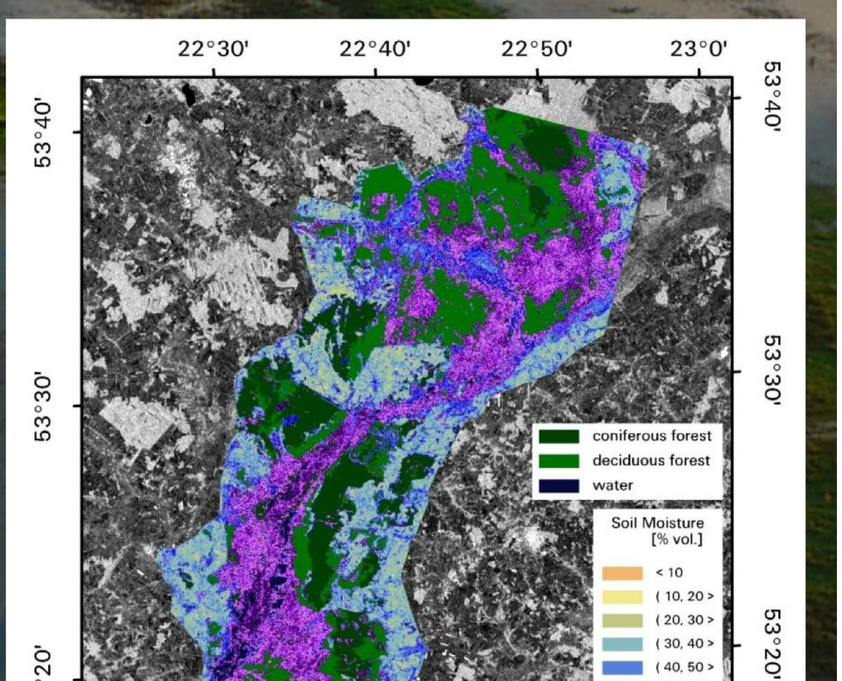


Preliminary results

The qualitative relationship between soil moisture and SAR backscatter coefficient was established using in-situ measurements and linear regression model for various land cover types. Dense vegetation such as forest or shrubs was masked out from the retrieval due to prevailing volume scattering of S-1 C-band signal. The soil moisture map was generated on the basis of aforementioned relationship and water cloud model expanded by vegetation indices derived from SPOT5 imagery. Acquired results prove feasibility of proposed method.

Outlook

The next tasks within the project will be to validate generated soil moisture maps based on field campaigns data. Further an advanced model describing an exchange of water, energy and carbon between wetlands and the atmosphere will be developed using in-situ and S-1, S-2 and SPOT-5 satellite imagery.



esa
International Soil Moisture Network
Warsaw University of Live Sciences
Biebrza National Park