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Using hyperspectral sensors on the ground for satellite validation. A focus on the Fluorescence Explorer mission

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The validation of optical satellite data products is a central but challenging component of the space missions. In order to validate the satellite images, ground data is used for reference and allows also the assessment of the associated total uncertainty budget. Overall, when comparing ground data and satellite measurements three main uncertainty sources need to be considered: i) instrument characterisation, ii) algorithm retrieval performances and iii) spatial representativeness. These key components affect the proper comparison of ground measurements with satellite data and, thus, have to be carefully examined.

JB devices (FloX and RoX) are hyperspectral instruments acquiring optical field data with standardized hardware and routines. They have collected a legacy of data for over half of a decade using a comprehensive and readily implemented open-source data processing chain, considering the individual laboratory characterization of each instrument's optical performance. Thus, the instruments are capable of providing valuable data products for the purpose of satellite validation. In particular, the FloX (Fluorescence BoX, JB Hyperspectral Devices GmbH) is the first commercially available device for the measurement of solar-induced chlorophyll fluorescence (SIF). The instrument was developed with the support of the scientific community following the specification of the Fluorescence Explorer mission (FLEX) by the European Space Agency (ESA), expected to be launched in 2024. The FloX features a high performing spectrometer (FWHM: 0.3 nm, SSI: 0.15, SNR: 1000) and allows stand-alone measurement of SIF emission at canopy level on the ground. Furthermore, the FloX enables the continuous measurements of spectral down-welling and up-welling radiance in the VIS-NIR range using an additional spectrometer to cover a larger spectral range and allows the automatic computation of reflectance as well as various vegetation indices (VIs). The instrument synchronously acquires upwelling and downwelling radiance during each measurement cycle, automatically optimizes the integration time according to light conditions and acquires the dark current and internal quality flags to ensure high quality data products. In addition to SIF and VIs, the FloX produces time series of high-resolution radiometric parameters, suitable for the investigation of the optical properties from the monitored targets. In the last years over 60 FloX units have been deployed worldwide.

Within a current ESA project, we are investigating the instrument uncertainty sources, with the final aim of defining a preliminary version of the FLEX validation plan. At the same time, currently deployed instruments in 10 location around the world were used to examine the agreement of the ground measurements with available satellite product (i.e. Sentinel-2). This approach reversed the common practice of validating satellite data with ground measurements by using the globally available, standardized L2A products of Sentiel-2 evaluating the conformance of ground-measured data products across a network of standardized instruments. An unprecedented alignment of satellite and ground data was achieved, confirming high validity of data products from the network of automated field spectrometers around the globe.

In summary, in this contribution we provide an overview of how field spectroscopy systems can be used in the framework of specific activities with the purpose of satellite validation.