Beyond (pretty) spectra – Measuring plant chlorophyll fluorescence from a UAS

Juliane Bendig[1], Arko Lucieer[1], Deepak Gautam[1], Richard Ballard[1], Rhys Wyber[2], Zbyněk Malenovský[1] and Sharon Robinson[2]

[1]University of Tasmania, Private Bag 78, Hobart TAS 7001, Australia, juliane.bendig@utas.edu.au
[2]University of Wollongong, Northfields Avenue, Wollongong NSW 2522, Australia

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Abstract:
An up-and-coming area of remote sensing research is Sun-Induced chlorophyll Fluorescence (SIF), as it is a direct measure of photosynthetic activity in vegetation. Current vegetation indices only provide a hint of potential photosynthesis by exploiting the passive reflectance of the canopy. Chlorophyll fluorescence is light that is emitted from plants after absorbing solar radiation from 400 to 700 nm, the so-called photosynthetically active radiation. SIF makes up only 1-2% of the total radiance of plants with peaks at 690 and 740 nm. It can be measured passively within two narrow oxygen absorption features at 680 and 740 nm, where the incoming irradiance is strongly reduced through the gas absorption. The signal relates to the photosynthetic activity in the plant tissue, enabling detection of plant stress; even before changes show in the visible and near-infrared reflectance. The passive measurement of SIF from space will be a major advance for satellite systems. However, measuring SIF requires precise and accurately calibrated spectroradiometers, as the SIF signal is relatively low and limited to very narrow spectral bands compared to the amount of light reflected by vegetation. With the European Space Agency's Fluorescence Explorer (FLEX) satellite mission under development, questions remain about the remotely sensed SIF signal particularly on different scales and over complex canopies. Unmanned Aircraft Systems (UAS) are well suited to help answering these questions because they enable capturing highly detailed hyperspectral data (from which SIF is retrieved) quickly and flexibly. Thus, the objectives of this study are to describe how to measure the SIF signal with a UAS-based spectroradiometer and how to relate the data to the plant canopy. A description of the platform and the spectroradiometer setup is given, followed by an outline of the calibration procedure, data capture and its validation in a field experiment. The system has been spectrally and radiometrically calibrated and data in the field is validated against a calibrated LED panel emitting at 680 and 750 nm. SIF has been retrieved from a test flight over different kinds of grass and a black tarp, using Standard Fraunhofer Line Descrimination (sFLD) and 3FLD methods. First results show that SIF can be reliably captured with this system as supported by rigorous experimental methodologies.

References:

ESA. Report for Mission Selection: FLEX, ESA SP-1330/2 (2 volume series). European Space Agency, Noordwijk, The Netherlands.

Joiner, J., Yoshida, Y., Vasilkov, A.P., Yoshida, Y., Corp, L.A., Middleton, E.M., 2011. First observations of global and seasonal terrestrial chlorophyll fluorescence from space. Biogeosciences 8, 637–651. doi:10.5194/bg-8-637-2011

Malenovský, Z., Ač, A., Olejníčková, J., Gallé, A., Rascher, U., Mohammed, G., 2014. Knowledge gap analysis assessing steady-state chlorophyll fluorescence as an indicator of plant stress status, in: Proceeding of the 5th International Workshop on Remote Sensing of Vegetation Fluorescence. European Space Agency, pp. 1–5.

Mohammed, G.H., 2016. FLEX/Sentinel-3 Tandem Mission FLEX Bridge Study – Final Report, ESA ESTEC Contract No. 4000112341/14/NL/FF/gp.