Short Term Scientific Mission Report

COST Action OPTIMISE: ES1309

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STSM topic: Integration of a low-weight hyperspectral system with a UAV platform for the estimation of solar-induced chlorophyll fluorescence

STSM reference number: COST-STSM-ES1309-050317-083185

STSM type: Regular (from United Kingdom to Finland)

Period: from 2016-03-05 to 2016-03-12

Host: Dr. Albert Porcar-Castell, joan.porcar@helsinki.fi
Department of Forest Sciences, University of Helsinki, Finland

Purpose of the STSM;

This purpose of this STSM was to support my participation in a major field campaign taking place this growing season that will contribute significantly to the goals of WG3 of the OPTIMISE COST Action. The Hyytiälä 2017 Multiscale Campaign, lead by Dr. Albert Porcar-Castell (University of Helsinki) and involving numerous international collaborators, will quantify the impact of physiological, ecological, physical, and methodological factors on the seasonal variation of the solar-induced chlorophyll fluorescence signal (SIF), and other optical indices, over a boreal forest ecosystem. A series of measurement campaigns will be made at the SMEAR-II site at the Hyytiälä Forest Research Station (Finland) at multiple spatial scales between March and July, to capture the spring recovery and resumption of photosynthetic activity in the forest. As part of this campaign, I am contributing a low-weight hyperspectral system for SIF measurements (Piccolo Doppio) that will be mounted on a UAV for canopy-scale SIF measurements. This STSM enabled a week-long visit to Helsinki and Hyytiälä to assist with Piccolo-UAV integration with Dr. Porcar-Castell, Dr. Jon Atherton (U. Helsinki) and Teemu Hakala (Finnish Geospatial Institute), and to participate in the first measurement campaign. Specific goals of the STSM were to:
1) test the validity of the Piccolo Doppio system for UAV-based SIF measurements;
2) evaluate the challenges of measuring spectral and fluorescence properties during winter and in the presence of variable snow.
3) Develope and test a measuring protocol for drone-based multiscale measurements of SIF ranging from tree canopy level (pixel size of a few meters) to the satellite-pixel level (pixel size of hundreds of meters)

Description of the work carried out during the STSM;

During the STSM we installed and updated the Piccolo Doppio control software, making code modifications to allow continuous measurement and logging during the flights (Figure 1). We mounted the complete system of spectrometers, fiber optics and sensor heads aboard the UAV and completed a successful first test flight of the Piccolo Doppio aboard the UAV, collecting reflectance spectra from a height of about 30 m both over trees and snow (Figure 2). This involved running a sequence of 1 initial dark reading, 5 repeat scans of each of the upwelling and downwelling radiation from the two spectrometers mounted on the UAV, and a second dark reading at the end of the sequence. This sequence took 30 seconds to complete, and was repeated 20 times during the test flight. We planned the full flying protocol for the canopy to pixeld level measurements, but due to issues with integration with the GPS unit and windy conditions we were unable to fly a full protocol a this point. We also made parallel measurements between the Piccolo system used on the UAV and the tower-based system that is making continuous point measurements through the season (Figure 3), to provide an initial cross-comparison and to ensure data from the two systems are comparable. A rigorous cross-calibration will be conducted post-campaign.

Figure 1 | Kadmiel MAseyk, Jon Atherton and Teemu Hakala preparing the Piccolo Doppio system aboard a UAV.

Figure 2 | The test flight of the Piccolo Doppio aboard the UAV. The fibre optic heads of the Piccolo system can be seen on the left hand side of the UAV in (a). The system in the air (b) and above the trees (c).

Description of the main results obtained;

The main result of this STSM was a successful demonstration that reliable spectra of both down-welling and up-welling radiation for deriving the SIF signal can be obtained using the Piccolo Doppio system aboard a UAV. A clear difference was observed between the measurements taken above the snow and above trees (Figure 4). There was also low variation in repeated scans from the stationary UAV, indicating averaging of a repeated scans will ensure high accuracy measurements necessary for calculation of SIF indices. These mesurements also gave us useful information on the integration times required to avoid saturation of the signal and maintain good signal-to-noise over forest vs snow. Subsequent to the STSM, issues with integration with the GPS were resolved, and the first complete

Figure 3 | the tower-based Piccolo Doppio system and field ov view, showing evergree pine and spruce and deciduous birch with snow background

flight was conducted with measurements above the forest canopy. Three flights were made: the first flight was a 9 pixel grid at 200 m; the second was a vertical profile that included acquisitions at 30m, 80m, 200m and 500m; and the third was sub grid measurements over pure birch, pine and spruce stands. These measurements represent a significant step forward in proximal sensing of forest canopy SIF, and bode well for the rest of the campaign. The same protocol will be reapeated a few times during the campaign to assess the impact of snow, phenology, and spring recovery of photosynthesis on the SIF at multiple scales. Ongoing work is focussed on the processing of the data and precise positioning of the data within the 3D-spatial domain.

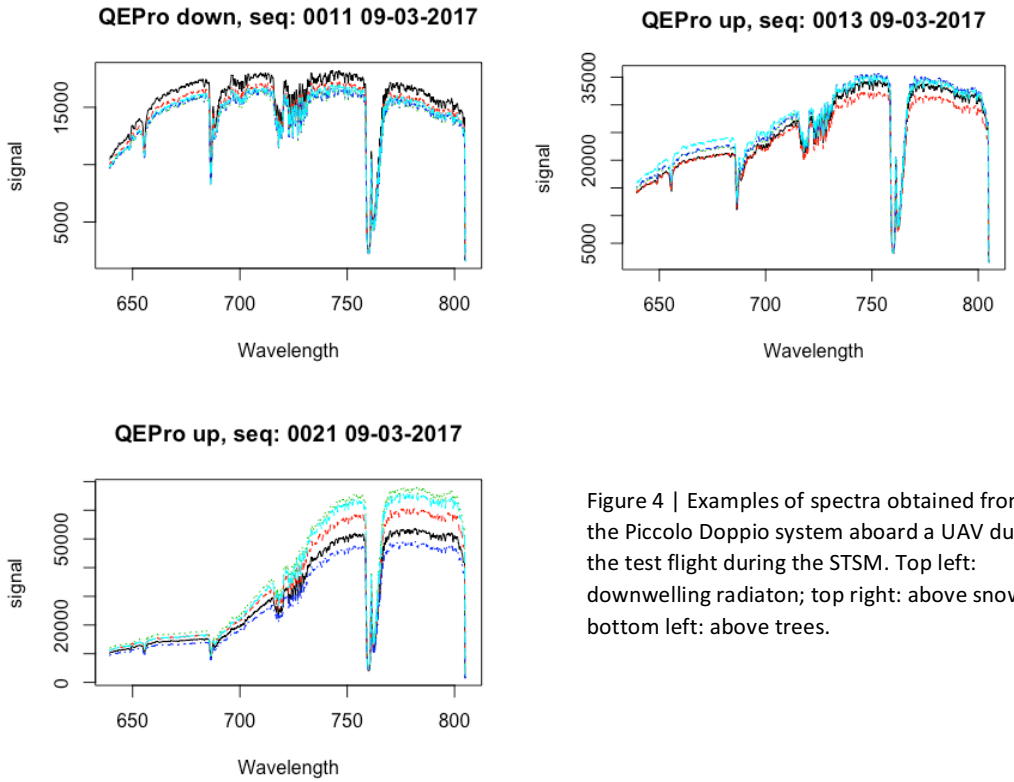

Figure 4 | Examples of spectra obtained from the Piccolo Doppio system aboard a UAV duing the test flight during the STSM. Top left: downwelling radiaton; top right: above snow; bottom left: above trees.

Future collaboration with the host institution (if applicable);

This STSM has initiated a collaboration between Dr's Maseyk and Porcar-Castell that will continue through the duration of this campaign, and betond. A further trip by Dr. Maseyk is planned to participate in another field campaign at the end of May. In addition, this STSM also initiated discussions around another collaboration project linking SIF with other photosynthetic proxies including carbonyl sulphide (COS) that will be developed over the coming months. Dr. Maseyk is actively involved in COS research, including at the Hyytiälä site, and a new project based on existing COS and SIF datasets is being developed.

Foreseen publications/articles resulting from the STSM (if applicable);

Several significant publications are expected from this campaign. Specific to the work related to this STSM, publications are expected on the demonstration of UAV-based SIF measurements above a forest canopy; seasonal variation in SIF signals of the forest canopy and different species; and the integration across scales from leaf to satellite SIF data.

Other comments (if any).

Confirmation by the host institution of the successful execution of the STSM

I hereby confirm that Dr. Kadmiel Maseyk visited us between March 5th to 12th 2017 to contribute to our multiscale and long-term FAST campaign in Hyytiälä (Fluorescence Across Space and Time). His visit was critical for the successful deployment of our UAV measurements since Kadmiel provided access to a Piccolo Doppio spectrometer that was readily configured for drone use and expertise for its implementation.

The system is now operative and we are planning to fly with it and using the protocol developed during Kadmiel's visit throughout our FAST campaign. I expect that the work initiated during Kadmiel's visit will contribute to the preparation of a number of publications where the methods we tested and protocols we planned will be used. OPTIMISE COST action will be duly acknowledged.

With kind regards,
Albert Porcar-Castell