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Controls on Leaf-Level Chlorophyll Fluorescence Properties in a Boreal Forest During Spring Recovery of Photosynthesis

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For decades, Chlorophyll Fluorescence (ChlF) has been used as a tool for tracking photosynthetic activity variations. The continuous ChlF spectrum (i.e. 650 - 850 nm) can be measured in vivo at leaf-level. At the same time, the ChlF induced by Sun (or Sun Induced Fluorescence, SIF) can be retrieved from remote sensing platforms or even satellites, but only within narrow spectral bands. An interpretation of remotely sensed SIF, or finding the connection between ChlF spectral bands and physiological functionality of leaves, is difficult without investigating the factors controlling ChlF spectral variation at leaf-level. Each of the ecosystem elements – from a leaf to a whole forest – has its own, distinctive set of optical properties. Simultaneously, the remotely sensed ChlF is a composition of signals arising from all the elements of the measured area.

The leaf-level ChlF spectra can vary across species, stress factors, and canopy light gradients. Sum of these variations will further affect the observed remote sensing retrieval. Therefore, analysis of ChlF at all scales is needed to approach physiological properties of plants from the perspective of remote sensing. To address this need, the main goal of this study was to characterize the controls on ChlF spatiotemporal variation.

“Fluorescence Across Space and Time” (FAST) campaign was carried out in Hyytiälä Forest Station (SMEAR II), Southern Finland, from February to July 2017. In order to fully illustrate the boreal forest ecosystem, 5 boreal species were examined: two conifer trees, Pinus silvestris and Picea abies; one broadleaf tree, Betula Pendula; and 2 dwarf shrubs, Vaccinium vitis-idaea and Vaccinium myrtillus. Samples were acquired from two different heights (top and low) to address the variability in ChlF across light regimes present within a forest canopy profile. We measured seasonal variation in: leaf-level ChlF spectral properties and reflectance, leaf absorption, Fv/Fm, NPQ and PQ, as well as photosynthetic assimilation and pigments concentrations. Last but not least, we estimated the light environment using Digital Hemispherical photography in order to investigate the role of light environment.

Here we present the preliminary results of correlating the ChlF spectra with other at-leaf-level measurements. Distinctions between canopy positions, thus light conditions, and between species of different leaf-morphologies were examined. We hypothesize that a combination of environmental, structural, biochemical and physiological factors affect the spatiotemporal dynamics in the intensity and shape of ChlF spectra.