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Large uncertainties still remain in the modeling of Gross Primary Production (GPP) in terrestrial biosphere models (TBM). Chlorophyll fluorescence has been estimated recently by satellites (Frankenberg et al., 2011; Guanter et al., 2012; Joiner et al., 2013) and measured at field stations (Daumard et al., 2010; Porcar-Castell, 2011) and shown to be related to GPP. It could potentially be used to constrain photosynthesis parameters and the model structure by forcing a match between model simulations and observations. We use the TBM ORCHIDEE (ORganizing Carbon and Hydrology in Dynamic Ecosystems Environment, Krinner et al., 2005) to simulate GPP at two flux sites: Hyytiälä in Finland for 2008-2009 and Avignon in France for 2010. Those simulated GPPs and supplemental eddy flux-derived GPPs are compared to in-situ measurements of fluorescence at leaf-level and/or canopy-level.

The main purpose of this research is to investigate the relationship between GPP and fluorescence for diurnal and seasonal cycles during the field campaigns at both sites. One objective is to derive a robust 'observational operator', potentially based on new functions to relate model carbon assimilation and canopy structure to in-situ/satellite fluorescence measurements in order to assimilate such information into ORCHIDEE. The difference in ecosystem structure between both flux sites: a Boreal Needleleaf Evergreen forest in Hyytiälä and Cereal Crops in Avignon, could, in particular, give us some insights for scaling-up the simulated fluorescence from leaf level to canopy level. We may also show preliminary results of single-leaf simulation of fluorescence, which is going to be undertaken soon, by implementing the processes of the SCOPE model (Van der Tol et al., 2009) into ORCHIDEE.

S1.8 Diurnal Dynamics and Phenological Changes in Vegetation Fluorescence, Reflectance, and Temperature Indicative of Vegetation Photosynthetic Properties and Function

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Current remote sensing techniques rely on reflectance (R) data to estimate vegetation vigor. While R has been related to Chl content, the emission of fluorescence from plant chlorophyll provides a more direct measure of photosynthesis that has not been fully exploited by remote sensing. It still remains to be determined how: 1) the dynamics in temperature and illumination affect the relationships between fluorescence and photosynthesis, especially at canopy level, 2) how these relationships may vary for different species (C₃ vs. C₄), and 3) how these relationships change during the growing season. Our goal is to better understand the dynamic relationships between vegetation photosynthetic function and its spectral fluorescence, reflectance and thermal properties at both leaf and canopy level.

This study compares key phenological periods, such as vegetative vs. tassling for corn, and/or maximum vs. reduced photosynthetic function for loblolly pine. During the last two growing seasons NASA's automated FUSION system (described in <ftp://fusionftp.gsfc.nasa.gov/FUSION/>) collected diurnal measurements (at 15-20 minutes) of complimentary canopy reflectance, solar induced fluorescence and surface temperature over corn (*Zea mays*, summers of 2012 and 2013) and loblolly pine (*Pinus taeda*, fall of 2013) canopies, providing. FUSION solar induced canopy chlorophyll fluorescence (SIF) was retrieved at the atmospheric oxygen absorption bands centered at 688 and 760 nm bands using the Fraunhofer Line Depth method. Changes in magnitude of fluorescence were clearly seen throughout the day and with viewing geometry. For example, SIF at 760 nm varied for corn between 2-8 W·m⁻²·μm⁻¹·sr⁻¹ and for loblolly pine between 0.5-3.5 W·m⁻²·μm⁻¹·sr⁻¹.

FUSION measurements were augmented at each of the targeted growth stages with field measurements of canopy leaf area index, leaf pigments, chemical constituents, photosynthetic

function and the associated fluorescence kinetic and steady state parameters (collected with LI6400, Lincoln, NE, US and Monitoring -PAM, Walz, Effeltrich, Germany). We evaluated the statistical relationships between the bio-physical parameters and SIF. Both leaf and canopy fluorescence measurements were strongly related (correlation coefficients range: $r = 0.65 -- 0.90$) to photosynthetic pigment levels and functional parameters. Canopy SIF was also strongly correlated ($r = 0.70 -- 0.80$) to canopy leaf area index and foliar structural compounds. Statistical models describing these parameters at leaf to canopy scale were developed and the preliminary results of these analyses will be summarized in the present contribution.

We simulated the ChlF signal at the top of the canopy using the SCOPE (Soil Canopy Observation, Photochemistry and Energy fluxes) model. SCOPE's model output includes estimates of the rate of photosynthesis and the spectrum of reflected radiation, thermal emissions, and chlorophyll fluorescence. A special routine is dedicated to the calculation of photosynthesis rate and chlorophyll fluorescence at the leaf level as a function of net radiation and leaf temperature. For both canopies of corn and pine we will present the results from scaling the leaf measurements to canopy level and simulated seasonal dynamics in vegetation fluorescence. By comparing the in situ spectral and bio-physical measurements within the SCOPE modeling approach we examined, with various successes, the physiological mechanisms underlying the captured canopy spectral responses and compared SIF estimates at leaf and canopy scale under various viewing geometry.

We aim to contribute toward improving the ability to monitor/model reflected radiation, chlorophyll fluorescence and rate of photosynthesis. Potentially, this study will expand to corn under nitrogen and water deficiency/excess and to other species, for which we have collected bio-physical measurements.

S1.9 Remote Sensing of Sun Induced Fluorescence over Urban Areas. Lessons Learnt from the BIOHYPE Project

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The BIOHYPE project aimed to find a link between air quality and chlorophyll fluorescence, such that would allow producing maps of urban air pollution from remotely sensed fluorescence. In order to fulfill this objective an extensive field campaign took place at the city of Valencia, Spain, where numerous trees of four different species were sampled and from which solar-induced fluorescence was measured among other relevant parameters, while hyperspectral airborne images were collected by an ITRES CASI-1500i imaging spectroradiometer.

The CASI-1500i system presents some technical characteristics, with ~ 1 nm spectral resolution and ~ 1.5 m spatial resolution, that in principle make it suitable for the retrieval of chlorophyll solar-induced fluorescence of vegetation using the in-filling of the O₂-A band of single trees. However, the processing of this data is far from straight forward, since there are a number of issues that must be taken into account in order to properly separate the fluorescence signal from other sources. Mainly the passage of light through the atmosphere and how it is modified by atmospheric properties and constituents, together with all the geometric aspects that result in different optical paths across the image. Not to forget sensor noise.

The experimental setup included ground measurements of aerosol optical thickness to properly model the atmospheric effects at the spectral region of interest, and the imaging system carried a solidary IMU with differential GPS that accurately captured the true position and orientation of the optical head to accurately address the geometry of acquisition of each single image line.

With all these aspects (atmospheric, geometric, and instrumental) covered hopes were high that a good fluorescence map would be produced, if not an air quality one. However, some aspects were overlooked that have a great impact on the quality of the data acquired, such as an precise knowledge of the modulated transfer function (MTF), or straylight that might translate in an artificial