Open PhD position for years 2020-2023

Title: Airborne remote sensing of laser-and-sun-induced fluorescence for the study of carbon and water functions of terrestrial ecosystems.

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Description of the subject:
Natural and anthropized terrestrial ecosystems play a fundamental role in the Earth's climate, in particular through their interactions with biogeochemical cycles such as the water and carbon cycles. However, the representation of the water and carbon functions (WCF) in these ecosystems remains one of the main sources of uncertainty in climate models. Remote sensing data from space offers promising perspectives for the improvement of WCF models. In recent years, new spatial observations (GOME-2, OCO-2, TROPOMI/Sentinel5 missions, as well as FLEX/S3 from ESA and MicroCarb from CNES in the future) of the emission of sun-induced chlorophyll fluorescence (SIF) showed new opportunities to constrain gross primary production (GPP) in photosynthesis models.
However, the relationships between SIF and photosynthesis involve complex mechanisms for managing the competition between the three deactivation pathways that utilize absorbed energy, namely photochemistry, fluorescence and heat dissipation. These later processes still remain poorly understood in particular during abiotic stress (water, thermal, light). Although significant work has been devoted to fluorescence at the leaf scale, the understanding of these mechanisms at time and space scales compatible with spaceborne observations remains limited due to the controversial role of endogenous (pigment content, leaf index, angular orientation of leaves, etc.) and exogenous (solar angle, proportion of direct *vs* diffuse radiation) factors. Another issue is the difficulty of taking into account the intra-pixel heterogeneity.
Airborne remote sensing remains a powerful tool for filling the gap between field data (fluorescence coupled with ecophysiological functioning measured by exchanges of CO_2, H_2O and energy) and space observations. In this perspective, LMD has developed an airborne fluorescence lidar (LASVEG) as part of the ECOFLUO project (CNES/TOSCA funding, partnership between ESE, LMD, LSCE, CESBIO and SAFIRE). This tool is designed to sample on the very same target laser-induced fluorescence (LIF), sun-induced fluorescence (SIF), the three-dimensional structure of the canopy and the visible reflectance, including the spectral region of the Photochemical Reflectance Index (PRI). By using controlled lighting conditions, LIF opens the possibility to overcome the exogenous confounding factors mentioned above, and to access the dynamics of fluorescence yield linked to physiology. A first flight campaign is planned for 2020/2021.
This thesis project will exploit the data produced by the LASVEG instrument, focusing on two objectives: 1) to better assess the effect of scale changes in the relationships between photosynthesis and optical variables, and in particular the role of spatial heterogeneity in the transition from in-situ measurements to the satellite pixel, 2) to separate, in the SIF-PRI signals, the component linked to the photosynthetic efficiency from those linked to structural or exogenous factors. This project will also rely on data collected by passive fluorescence sensors developed by LMD, ESE and CESBIO. Active fluorescence measurements will also be carried out with a fluorescence micro-lidar developed at LMD. We will study the diurnal and seasonal fluorescence dynamics (SIF, LIF), in relation to the carbon fluxes observed by eddy covariance, and the airborne LIF-SIF co-variations in relation to the canopy structure characterized by the back-scattered lidar waveform and visible reflectance. Finally, the results obtained will be compared with the state of the art of canopy fluorescence models (e.g. SCOPE, DART).

Applicant profile:
We are looking for applicants with good knowledge in plant sciences (ecophysiology, agronomy, ...) and a strong interest in remote sensing and physical approaches for the observation of vegetation (radiative transfer, optical measurements). Skills in programming with a high level language (Matlab, R, Python, ...) and in data analysis and processing is required.

Keywords:
vegetation, plant ecophysiology, photosynthesis, remote sensing, radiative transfer, fluorescence, bioclimatology, biosphere, vegetation stress.