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State of art of the ground-based optical measurements at European flux sites: current status and future directions

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Understanding and predicting the impact of climate change on ecosystems is one of science's great challenges. With a changing global climate, it is critical to understand the dynamics of ecosystem carbon fluxes in response to environmental drivers such as water, temperature, light and nutrient availability. Present approaches to understanding ecosystem carbon exchange have been made possible through the direct measurement of CO2 and H2O fluxes and through models that rely on meteorological data as inputs for predicting photosynthetic function. However, these methods reveal problems related with their restricted spatial representativeness and a lack of driving variables collected at required spatial and temporal scales. It has been recognized that the deployment of ground-based remote sensing instruments offers a means of monitoring ecosystems at synoptic temporal and spatial scales, permitting observation and understanding of ecosystem carbon-related spectral responses at flux tower sites.

There is a necessity to improve the quality and reproducibility of spectral measurement standards at eddy covariance networks in Europe, and for this reason the COST Action ESO903 – "Spectral Sampling Tools for Vegetation Biophysical Parameters and Flux Measurements in Europe" was funded in 2009 by the European Science Foundation. The main aim of the Action is to define common and standardized protocols and to develop new instruments for optical measurements at flux tower sites. In this context, the Action sets out to join together scientists and industries to improve the methodologies for proximal optical sampling. During the first year of the Action, specific activities have been accomplished to analyze the limits and opportunities of the current spectral measurement tools, to identify a low-cost standard sensor to continuously monitor biophysical characteristics, and to promote the collaboration between the remote sensing and eddy covariance communities. One of the main objectives of the first year of activities was to design and disseminate an online questionnaire to collect information about the current state of the art of optical sampling activities carried out in Europe (available on http://tinyurl.com/cost-questionnaire). The information has provided a complete view on spectral sampling activities carried out within the different research teams in European countries. This information will allow collaborating scientists in the action to address further activities on standardization and across-site comparability issues.

The objective of this presentation is to convey the key findings from the online survey and to review and identify all of the currently available tower-based optical methods for reflectance measurements at European eddy covariance sites. This review is based on the responses obtained from researchers working at 33 flux towers located in the COST countries and includes information about the skills of research groups in optical sampling, a detailed description of protocols and methodologies used and report of sensors used for both in situ and at tower site optical measurements.

The responses to the online survey showed that except for the in situ hyperspectral measurements, made manually and sporadically during specific field surveys, the majority of spectral measurements are taken regularly in time (e.g. every 30 min), largely by two-band sensors mounted at the top of the flux tower. The survey showed that many such measurements were spatially discrete, measuring a single "spot" below the flux tower and recording its spectral trajectory through time. Some groups also use portable radiometers to collect measurements along a linear transect or randomly over the sampling footprint of the flux tower. In both cases, the responses show that each group follows an individual strategy for optical sampling of vegetation and there is currently no accepted or standardized measurement protocol for deployment of optical systems, for checking the data quality and

spatio-temporal consistency of the data set. Consequently, spectral measurements protocols vary from site-to-site, lack traceability, and do not provide useful datasets for cross-comparison studies, or for scaling-up observations. Therefore a current scientific challenge remains the design of a standardized procedure for optical sampling which will allow for collection of reproducible optical spectroradiometric measurements for comparison to fluxes and biophysical data collected at eddy covariance sites.