Monitoring of Ecosystem Metabolisms through Remotely and Proximally Sensed High-frequency Data toward Enhanced Sinks and Reduced Sources of Greenhouse Gases

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Ecosystem

T e ability to predict the biogeochemical consequences of our actions for global climate failed as with the case of predicting many major natural, social, political or f nancial events throughout the human history. T ese unforeseen changes have been triggered by the interaction of many root causes such as unpredictable stochastic events, epistemological uncertainty, and lack of data to gauge the potential for changes to take place. In its constant and systematic search to be less wrong, however, the science strives for integrative and quantitative metrics and signals to better understand, monitor, predict and manage interdependencies and interconnections among society, environment, and economy.

Whether be terrestrial or aquatic, ecosystem metabolisms are a measure of ecosystem-scale input-output balances of energy budgets or stoichiometrically coupled biogeochemical budgets (e.g. solar radiation, carbon—C, nitrogen—N, water—H_2O, and oxygen—O) as a function of natural and anthropogenic degrading and aggrading processes. T ey are an ecosystem-level measure as they encompass all the related spheres (atmosphere, biosphere, hydrosphere, and pedosphere) of a terrestrial or aquatic ecosystem (Table 1). Ecosystem metabolisms for biogeochemical budgets are governed simultaneously by natural and human-induced production and loss rates of photosynthetic organic C (POC) and soil/sedimentary organic C (SOC), and ecosystem respiration rates. Ecosystem respiration rate (R_e) is the sum of heterotrophic (R_h) and autotrophic (R_a) e f uxes of carbon dioxide (CO_2) to the atmosphere. Biological production can be expressed at the three organization levels of plant, ecosystem, and biome with and without accounting for respiratory C losses, a 2ℵ o]î

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Table 1:

complicates the quantification of ecosystem metabolisms is the necessity of high-frequency (HF) data/signals to cover longer periods, bigger areas, and faster sampling rates and filtering techniques to extract useful information out of noisy HF data. The continuous monitoring of spatiotemporal changes in NEE through the use of HF eddy covariance (flux tower) data was made possible owing to many scientific and technological achievements reviewed chronologically by Baldocchi [1] and was first published by Monteith and Szeics [2] for a short period of time, and by Wofsy et al. [3] for a year. Data collected by multi- and hyper-spectral remote and proximal sensors have been related to flux tower and/or diel DO datasets for the purposes of interpolation, verification, and validation of terrestrial and aquatic ecosystem metabolism dynamics since the late 1990s.

Recent interests in ecosystem metabolism characterization have led to improvements in HF sensor data (e.g. Surface Water and Ocean Topography satellite mission to be launched in 2020) [4], technology (e.g. diel oxygen probes, and high-resolution digital cameras) [5], network (e.g. the Global Lake Ecological Observatory Network, the National Ecological Observatory Network, and the Ocean Observatory Initiative) [6] and data-filtering (e.g. continuous and discrete wavelet transforms) [7]. Denoised data from HF sensors play a pivotal role in not only better understanding and modeling of how ecosystem metabolisms work but also in better decision-making under uncertainties/stochastic conditions about how ecosystem metabolisms respond to and are affected by policy and management decisions. Any attempt at climate change resolution and mitigation involves the multiscale harmonization (or trade-offs