From Photons to Fluxes: Relating Canopy Structure to Photosynthesis

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There is long history of using remotely sensing to both explain and scale canopy-level measurements of carbon and water fluxes. In terms of photosynthesis, much of this effort has focused on refining measurements of the fraction of incoming radiation absorbed by plants. This approach, however, leaves open the question of how efficiently absorbed sunlight is used to fix carbon dioxide. Measuring and parameterizing this light-use efficiency parameter has been the subject of a large body of research. Here, we present new evidence that measurements of solar-induced chlorophyll fluorescence (SIF) and near-infrared reflectance of vegetation (NIR_V) capture the joint effects of light absorption and light-use efficiency through their relationship with canopy structure.

We develop this argument based on an analysis of daily and hourly fluxes at Harvard Forest (US-Ha1). We show that SIF and NIR_V are more strongly related to canopy fluxes, like the rate of photosynthesis, than to total leaf area. Building from these insights, we demonstrate that NIR_V can explain variations in the daily, weekly, and monthly integrals of hourly GPP fluxes across all sites within the FLUXNET2015 dataset. This indicates that remote sensing can be used to infer canopy light-use efficiency. Based on principles of plant physiology, we argue the observed SIF-GPP and NIR_V-GPP relationships stem from an underlying relationship with canopy architecture.