



Can sun-induced chlorophyll fluorescence track variations of photosynthesis over the senescence period in an evergreen needle leaf forest?

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The emerging technique of remotely sensed Sun-Induced chlorophyll Fluorescence (SIF) has advanced our ability to estimate plant photosynthetic activity. However, continuous observations of SIF and Gross Primary Productivity (GPP) at the canopy scale in evergreen needle leaf forests have been lacking so far. Here, we report continuously observed far-red canopy SIF, GPP and Absorbed Photosynthetically Active Radiation (APAR) during the senescence period in an evergreen needle leaf forest. We installed a high-spectral-resolution spectrometer combined with a rotating prism system, which measures up- and down welling irradiance with a single fiber, 20 m above the canopy. We investigated the relationships between SIF, APAR and GPP separately for the following three periods; 1) before and 2) after understory vegetation leaf fall, 3) after the temperature drops below zero. In addition, we examined the effects of diffuse light on the relationships. We found that the slope of the half-hourly SIF-APAR relationship was distinctly different in each period but this was not the case in the APAR-GPP and SIF-GPP relationships: while the APAR-GPP relationship showed a similar slope difference as APAR-SIF in the third period, the other two periods had a more similar slope value; the SIF-GPP relationship, in contrast had similar slope values in the last two periods but a very different value in the first period. In addition, the half-hourly SIF-APAR relationship showed the highest correlation over the three periods ($R^2 = 0.83$). On the other hand, regardless of sky condition, we confirmed that for daily mean values, SIF-GPP relationship (cloudy: $R^2 = 0.83$, clear: $R^2 = 0.76$) was stronger than the SIF-APAR relationship (cloudy: $R^2 = 0.66$, clear: $R^2 = 0.69$). Overall, our results indicate that relationships between canopy SIF, GPP and APAR can vary depending on the presence of understory vegetation, temperature and the sky condition in an evergreen needle leaf forest. These findings will help improve canopy-level SIF-based GPP estimation across multiple temporal scales.