Using Sun Induced Chlorophyll fluorescence (SIF) and pigment composition to detect spring activation in evergreen conifers

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Northern hemisphere evergreen forests assimilate a significant fraction of global atmospheric CO^2. Conifers undergo winter-downregulated photosynthetic activity and spring-onset photosynthetic activation. Currently, increased temperatures are leading to shifts in photosynthetic phenology (early spring-onset, longer growing season), which has important implications for annual CO^2 global budget. Still, the role of conifer forests in the increase in northern hemisphere photosynthesis is highly uncertain. One of the reasons is that their needles remain green year-round, making the photosynthetic transition between spring and winter "invisible" to classical remote sensing (RS) monitoring techniques such as Normalized Difference Vegetation Index (NDVI). However, conifers increase and decrease their carotenoid and chlorophyll pigments content between seasons, to modulate photosynthesis and relieve excess energy.

These changes can be detected using RS techniques such as the Photochemical Reflectance Index (PRI), the Chlorophyll/Carotenoid Index (CCI) and the sun induced chlorophyll fluorescence signal (SIF). To better understand the mechanisms and timing of this invisible transition, we conducted two experiments to explore the link between SIF, PRI, CCI and chlorophyll/carotenoid pigment quantification. The first experiment was conducted under natural outdoors conditions (NC) and the second one was developed under an increased-temperature controlled environment (TC) on two conifer species: Lodgepole pine (*Pinus contorta*) and Black Spruce (*Picea mariana)*. Preliminary results from NC experiment showed that PRI and CCI captured the seasonal transition of chlorophyll/carotenoid ratio changes and clear positive relationships were observed between PRI, CCI and SIF emission. TC experiment results displayed a positive correlation between temperature CCI, PRI and SIF. This study showed that alternative RS techniques based on spectral reflectance of carotenoids and spectral monitoring of the SIF emission can track the regulation of evergreen trees' spring-onset photosynthetic activity. Additionally, we are certain that these metrics combined may offer a powerful method to monitor photosynthesis and phenology across boreal northern evergreen vegetation types via RS.

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