Solar Induced Fluorescence (SIF) as an Indicator of Photosynthesis
Dalia Tabachnik, Class of 2021

Plants shape the composition of the air we breathe through the process by which they transform sunlight, water, and carbon dioxide gas into oxygen that they release into the air and into sugar that they use to fuel their growth. Information regarding the rate of this process, called photosynthesis, is useful for foresters, farmers, ecologists, and for scientists who study climate change. Current methods to measure rates of photosynthesis of plants are time-consuming, labor-intensive, and do not scale well. This summer, I collaborated with Professor Barry Logan and Jaret Reblin at Bowdoin College, Bowdoin students David Bombard and Elena Sparrow, a team of scientists at the National Institute of Standards and Technology (NIST) in Maryland, and scientists from Boston University to test whether prototype sensors could measure plants' rates of photosynthesis in real-time.

The sensors that I worked with measure a fluorescent signal that plants emit called solar-induced fluorescence (SIF). My research team investigated whether this signal could be a proxy for how much photosynthesis occurs at a given instant in leaves on a select branch. SIF levels have been shown to correlate with the productivity of ecosystems over the course of growing seasons, but the relationship between SIF and photosynthesis had not been investigated at the instantaneous, branch level (Guanter et. al. 2014). SIF can be mapped from sensors on satellites in real-time on a global scale, so it is imperative to comprehend the spatial and temporal scale over which SIF values track with plant productivity in the form of photosynthesis rates in order to obtain the most use from satellite SIF measurements (Guanter et. al. 2014).

During a week-long field campaign at the NIST campus in Gaithersburg, Maryland, I participated in investigating whether SIF can serve as a proxy for instantaneous photosynthesis measurements at the branch scale. We measured the photosynthesis rates and SIF values of leaves on select branches of pin oak and tulip poplar trees along a forest edge. We then measured these variables again after imposing treatments to shut down photosynthesis in leaves on certain branches. I helped to impose these treatments, which involved applying abscisic acid to leaf surfaces with a spray bottle. Abscisic acid is a hormone that plants naturally produce that causes them to close their stomata, small apertures on the leaf surface that enable them to exchange gasses and undergo photosynthesis. We also cavitated branches through pressurizing sections of these branches to shut down photosynthesis. After imposing these treatments, I was involved in using a gas-exchange instrument to measure photosynthesis and a spectrometer to collect SIF data. I also helped collect samples from these select leaves and analyzed their pigment compositions back at Professor Logan's lab at Bowdoin to gain insight about the processes occurring in the leaves.

While data is still being analyzed, preliminary analysis of SIF and photosynthesis rate data suggests that SIF does not track well with instantaneous measurements of photosynthesis at the branch scale. This conclusion is important because it shows that plant ecophysiologists should not use the terms "SIF" and "photosynthesis" interchangeably, which they have been lapsing into since the discovery that that SIF tracks photosynthesis at the forest scale over growing seasons. Future work on this project involves applying additional statistical tests to SIF and photosynthesis rate data to further understand the relationship between these two variables and incorporating information from pigment analyses into the data analysis.

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References:
Guanter, Luis, et. al. 2014. Global and time-resolved monitoring of crop photosynthesis with chlorophyll fluorescence. Proceedings of the National Academy of Sciences. 111(14): E1327-E1333.