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Effects of heat wave on sun induced fluorescence and underlying physiology in citrus trees

Amnon Cochavi, Madi Amer, Rafael Stern, fedor tatrinov, and Dan Yakir
Weizmann Institute of Science, Earth and Planetary Science, Israel (amnon.cochavi@weizmann.ac.il)

Heat wave events ('Hamsin') are a common phenomenon in the Mediterranean basin during springtime. It is important to understand plant response to such extreme events as their frequency and severity is increasing with global climate change. Sun induced fluorescence (SIF) offers a new intrinsic indicator of the functioning of the photosynthetic apparatus at the canopy scale that complement conventional flux measurements, and can be measured in two specific wavelengths, 687 nm (SIF_B) and 760 nm (SIF_A). Previous reports show correlation between ecosystem SIF_A and gross primary production (GPP). This suggests that chlorophyll fluorescence is linked to electron transport in the photochemical pathway, but the effects of different environmental factors on this signal and the details of its relation to GPP is still unclear.

We studied the effect of 10 days seasonal heat wave in a citrus orchard in Israel from May to mid-June, when the maximum temperature ranged between 37-42ºC (compared with 23-28ºC in normal days), and vapor pressure deficit (VPD) values were 3-8 KPa (compared to 0.5-2 in normal days). In addition, we defined several days between consecutive heat waves, with intermediate VPD values. continues eddy covariance and SIF measurements were conducted, complemented with Pulse Amplitude Modulated fluorescence measurements (PAM).

Midday net ecosystem exchange (NEE) and GPP decreased by $\sim$50% during heat waves, compared to the prestressed values. Midday SIF_A signal decreased to the same extent. However, in the intermediate days SIF_A values were as low as during the heat-wave and the CO_2 fluxes fully recovered to the pre-stressed values. Electron transport rate (ETR) estimated with mini-PAM demonstrated similar patterns to the SIF_A signal (overall correlation R2>0.8). The estimated non-photochemical quenching (NPQ) values based on both methods was also consistent with SIF_A and ETR, and generally increased during the day with the increasing VPD.

The results demonstrated a correlation between both SIF_A and ETR and CO_2 fluxes under severe stress, but decoupling between SIF and CO_2 fluxes under intermediate stress conditions. These results demonstrate the complexity in the SIF vs GPP relationships, but also the potential of SIF_A in providing additional, intrinsic, information on physiological processes underlying ecosystem response to stress.