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*Supplement of*

## **A double peak in the seasonality of California’s photosynthesis as observed from space**

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## Introduction

This supporting information contains two additional sections of text and seven figures. Figure S1 shows the bias correction that is applied to the TROPOMI SIF data. Figure S2 is an expanded version of main text Fig. 2. Figure S3 shows a scatterplot comparison of TROPOMI SIF and AmeriFlux GPP. Figure S4 shows the time series of AmeriFlux CO<sub>2</sub> fluxes, as opposed to GPP from the main text. Figure S5 shows eigenvalue spectrum for the EOFs from main text Fig. 9. Figure S6 is the same as main text Fig. 6 but using MODIS NIR<sub>v</sub>. Figure S7 is the same as main text Fig. 8 but using MODIS NIR<sub>v</sub>.

## Text S1. SIF, NIR<sub>v</sub>, and PAR

The two peaks in the California photosynthesis seasonal cycle coincide with a slight decline in PAR inferred from ERA Interim, a time when the MODIS vegetation indices (e.g., NIR<sub>v</sub>) remain nearly constant. If part of the difference between the SIF seasonal cycle and NIR<sub>v</sub> seasonal cycle is indeed due to a clear sky bias as we mention, then comparing SIF with NIR<sub>v</sub>×PAR would be the more appropriate comparison. However, the all-sky PAR dataset used in our work (ERA Interim) has a known issue that makes it unreliable (see known issue number 2: “<https://confluence.ecmwf.int/display/CKB/ERA-Interim+known+issues>”). The clear sky PAR from ERA Interim is reliable and, as such, we have applied a correction to the statewide PAR based on the reliable clear sky PAR but we are hesitant to draw any conclusions using this scaling at finer scales. All this is to say, the PAR data presented in main text Figure 6 is illustrative of potential reductions in PAR during May when there is a difference in the seasonal cycles from SIF and NIR<sub>v</sub>, but we are wary of using it to directly scale NIR<sub>v</sub> and/or compare with SIF. Further study of SIF and NIR<sub>v</sub> in other regions is obviously needed.

## Text S2. Gap filling and interpolation for state-wide means

Main text Figure 2 (the scatterplot comparison) is a direct comparison between MODIS observations at the same location on the same day. This figure serves as a one-to-one comparison of the different products and supplemental Figure S2 is expanded to include comparison with the downscaled SIF products. For main text Figure 6, we interpolate the MODIS data in time for gap-filling purposes and then compute a statewide mean. The same number of points go into the statewide mean for both SIF and MODIS but there is more gap filling for MODIS. The statewide mean SIF and VIs represent our best attempt at producing a statewide mean for the different variables. The MODIS data will have gaps that need to be filled via interpolation during cloudy scenes, leaving only clear-sky conditions to build a statewide mean. TROPOMI will observe more scenes with low-to-moderate cloud cover, thus potentially inducing a clear-sky bias in the inferred statewide seasonal cycle. As such, the inferred seasonal cycle is different when using SIF vs VIs and part of that difference is likely due to the lack of data in cloudy periods from MODIS.

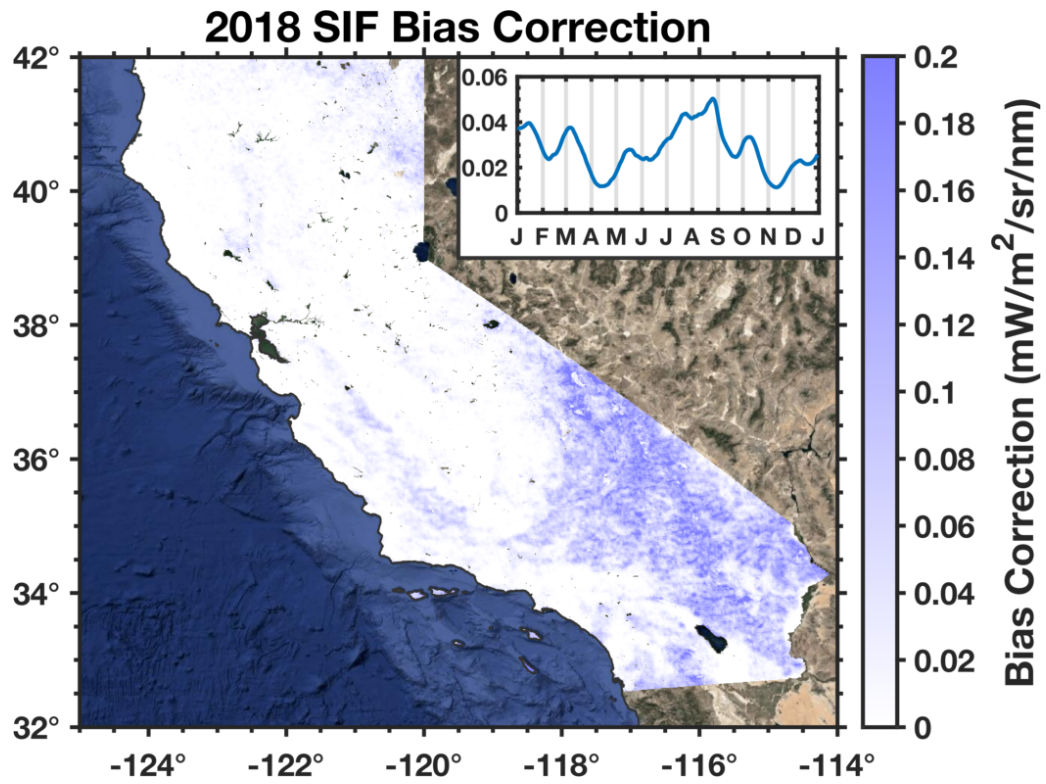


Figure S1: Bias correction applied to the TROPOMI SIF data as described in the main text.

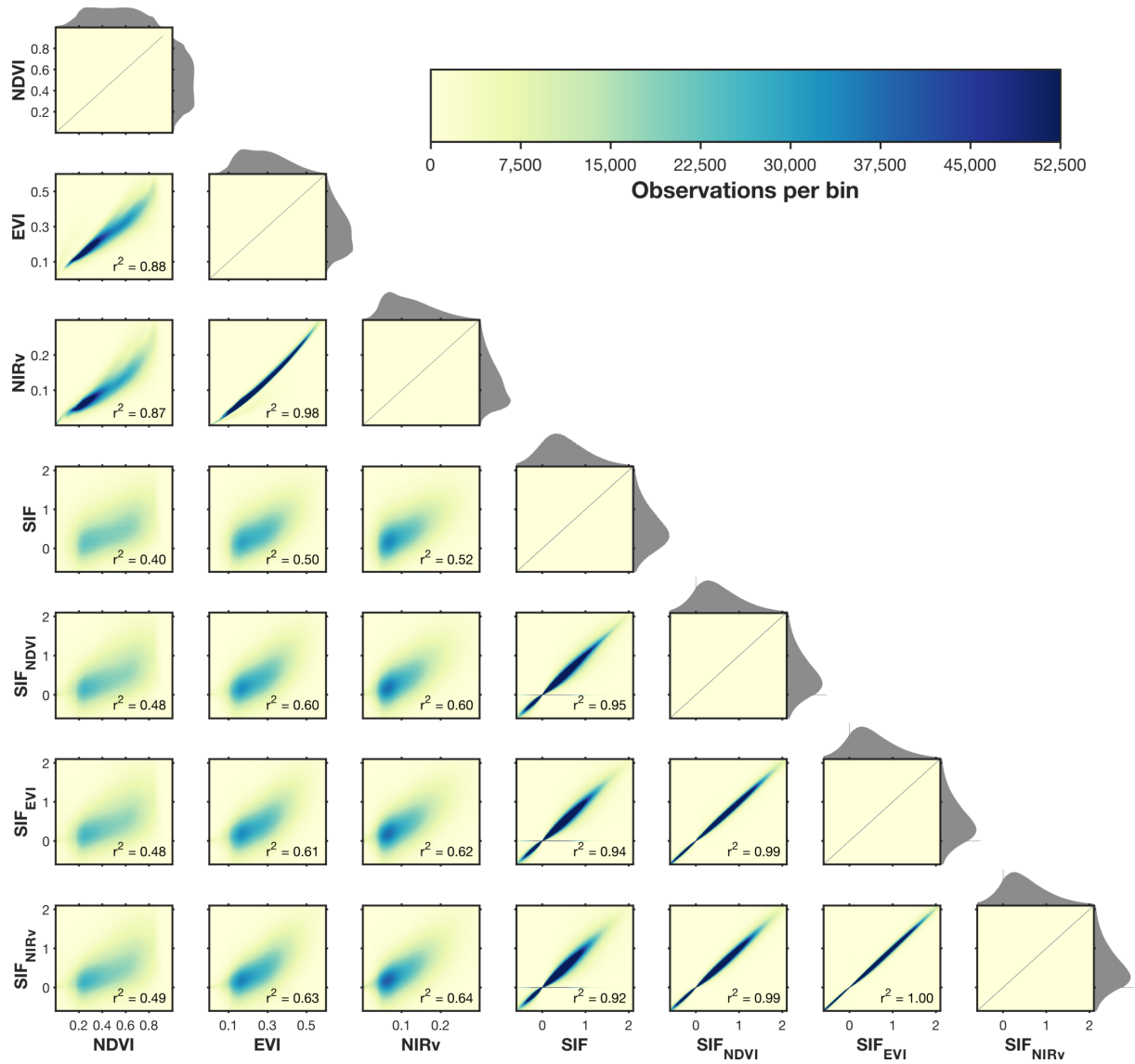


Figure S2: Same as main text Fig. 2, but includes the downsampled SIF data in rows 5, 6, and 7.



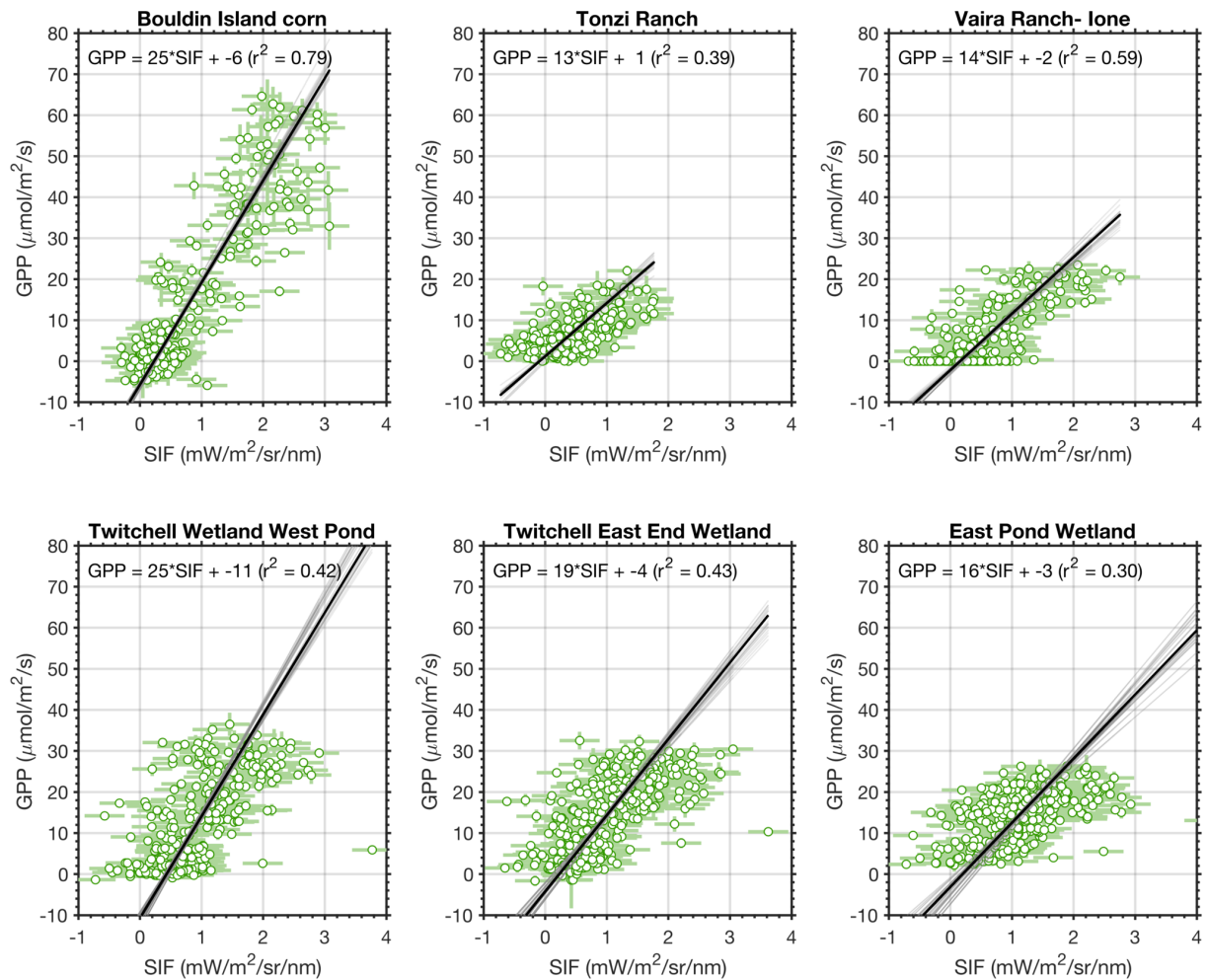


Figure S3: Scatterplot comparison of TROPOMI SIF data with AmeriFlux GPP from main text Fig. 5. Lines are York fits. Solid black line uses all data and light gray lines are bootstrapped fits.

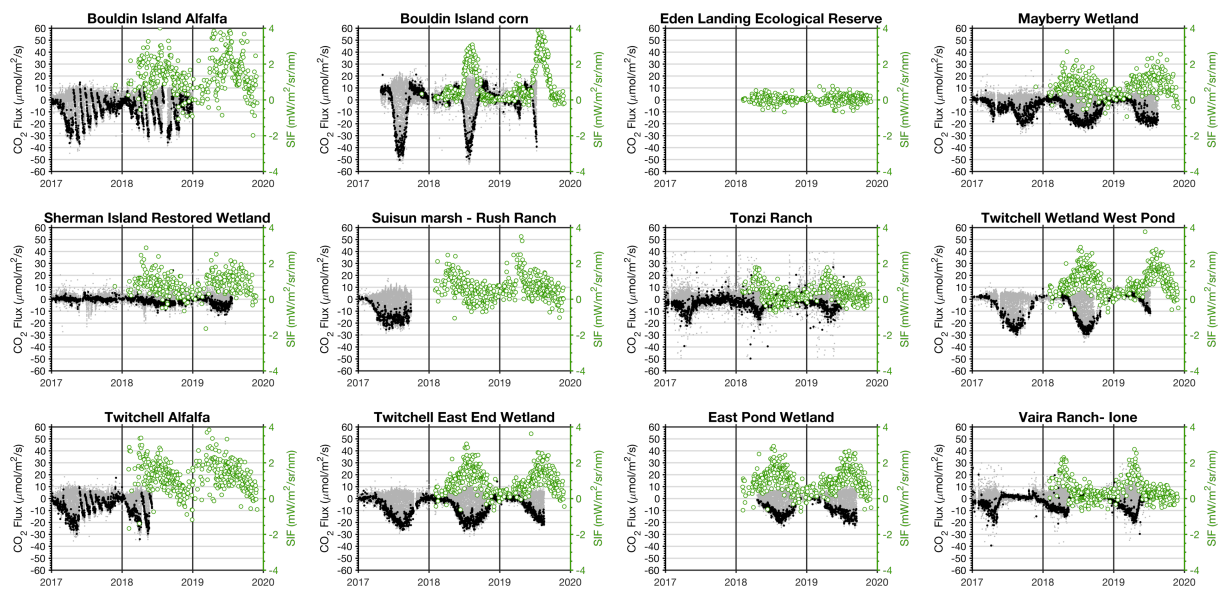


Figure S4: Shows AmeriFlux  $\text{CO}_2$  flux measurements (gray) and TROPOMI SIF (green). Black dots are AmeriFlux measurements between 13:00 and 14:00 PST. Timeseries begins in January 2017 and ends in December 2019.

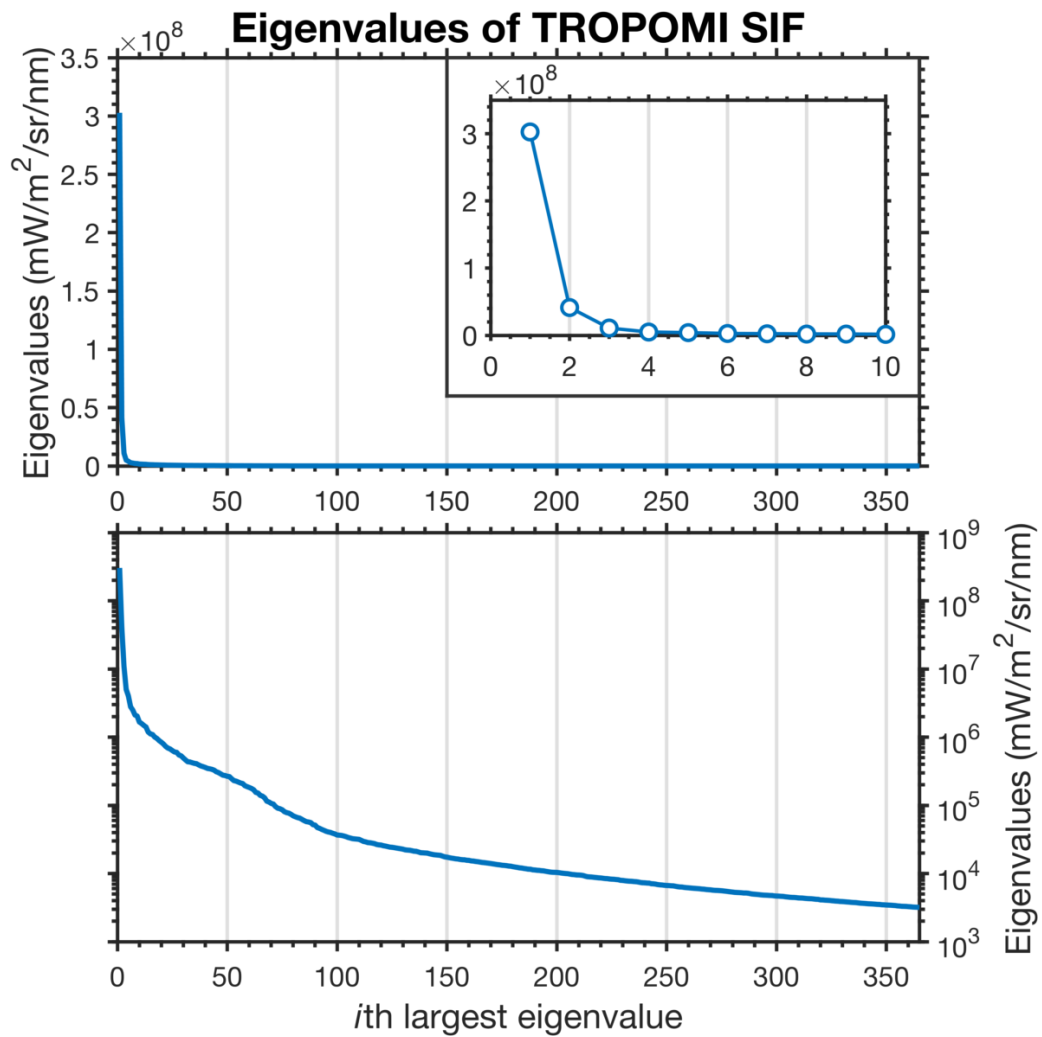


Figure S5: Eigenvalue spectrum of TROPOMI SIF data over California. Shows the spectrum of eigenvalues values of SIF data from March 2018 through September 2019 over California. Top panel is on a linear-scale and bottom panel is a log-scale. Inset shows the first ten eigenvalues.

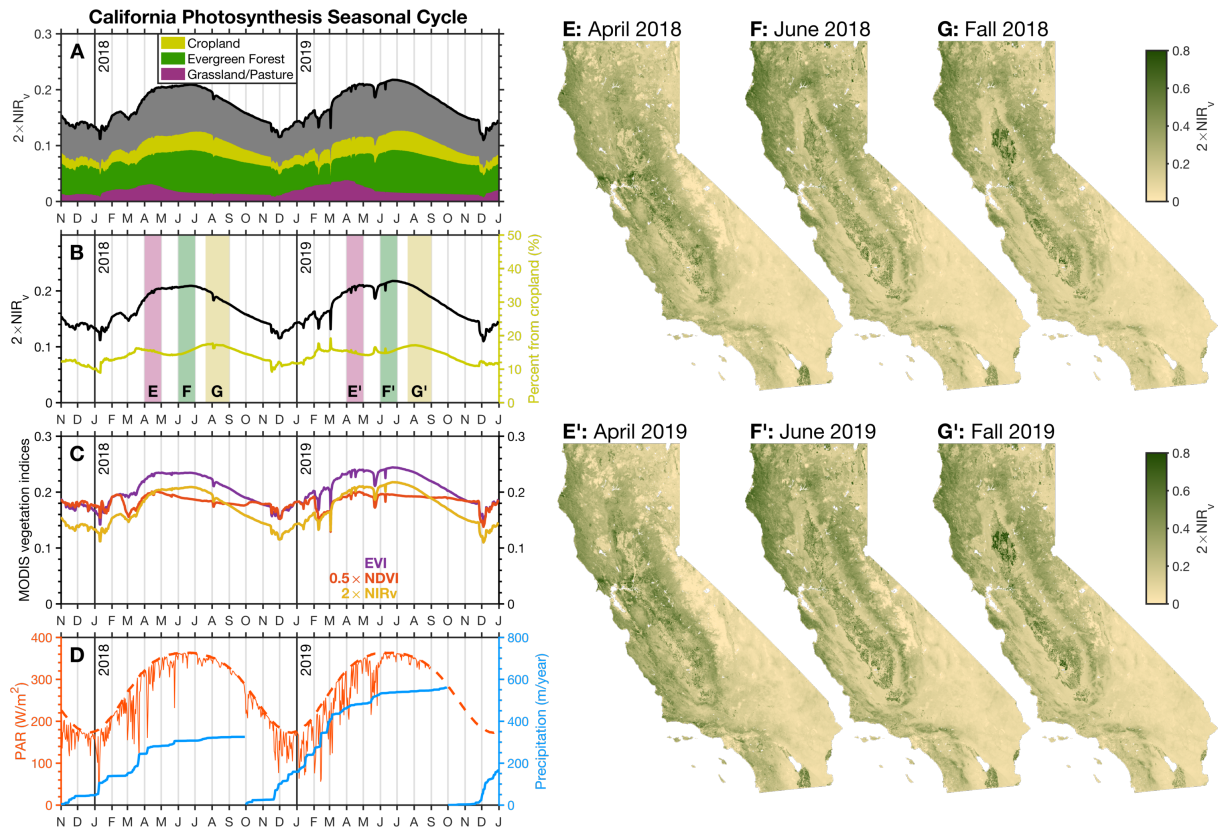


Figure S6: Same as main text Fig. 6 but for MODIS  $NIR_v$ .

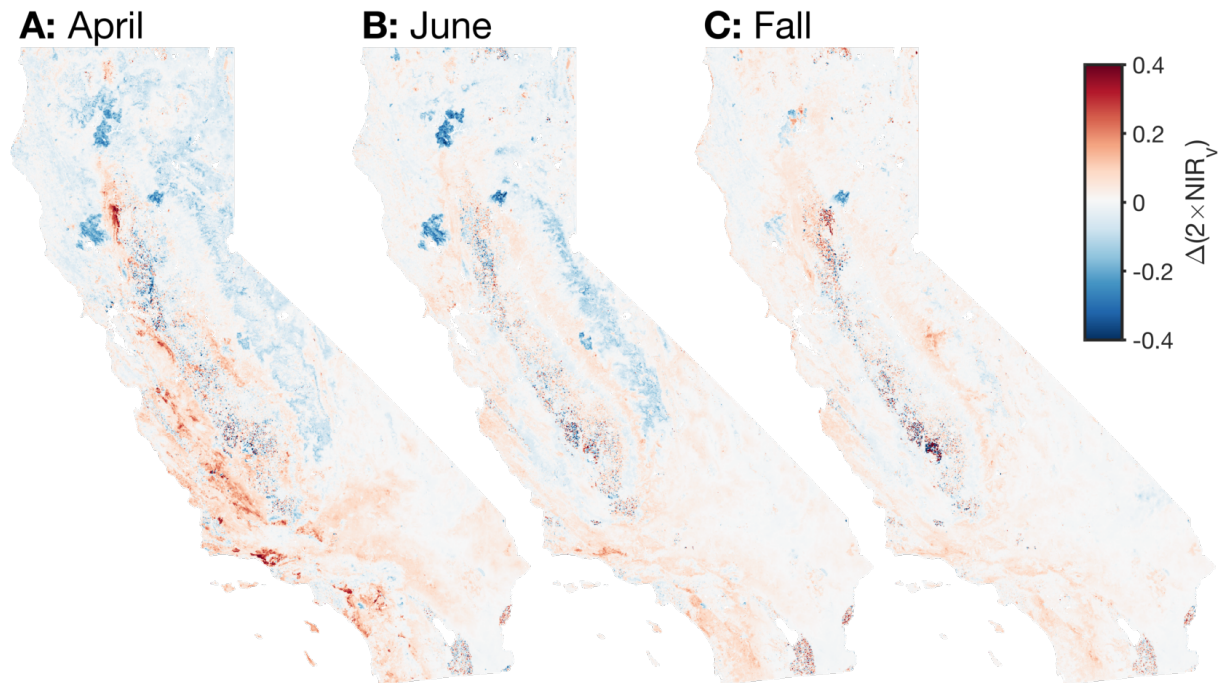


Figure S7: Same as main text Fig. 8 but for MODIS  $NIR_v$ .