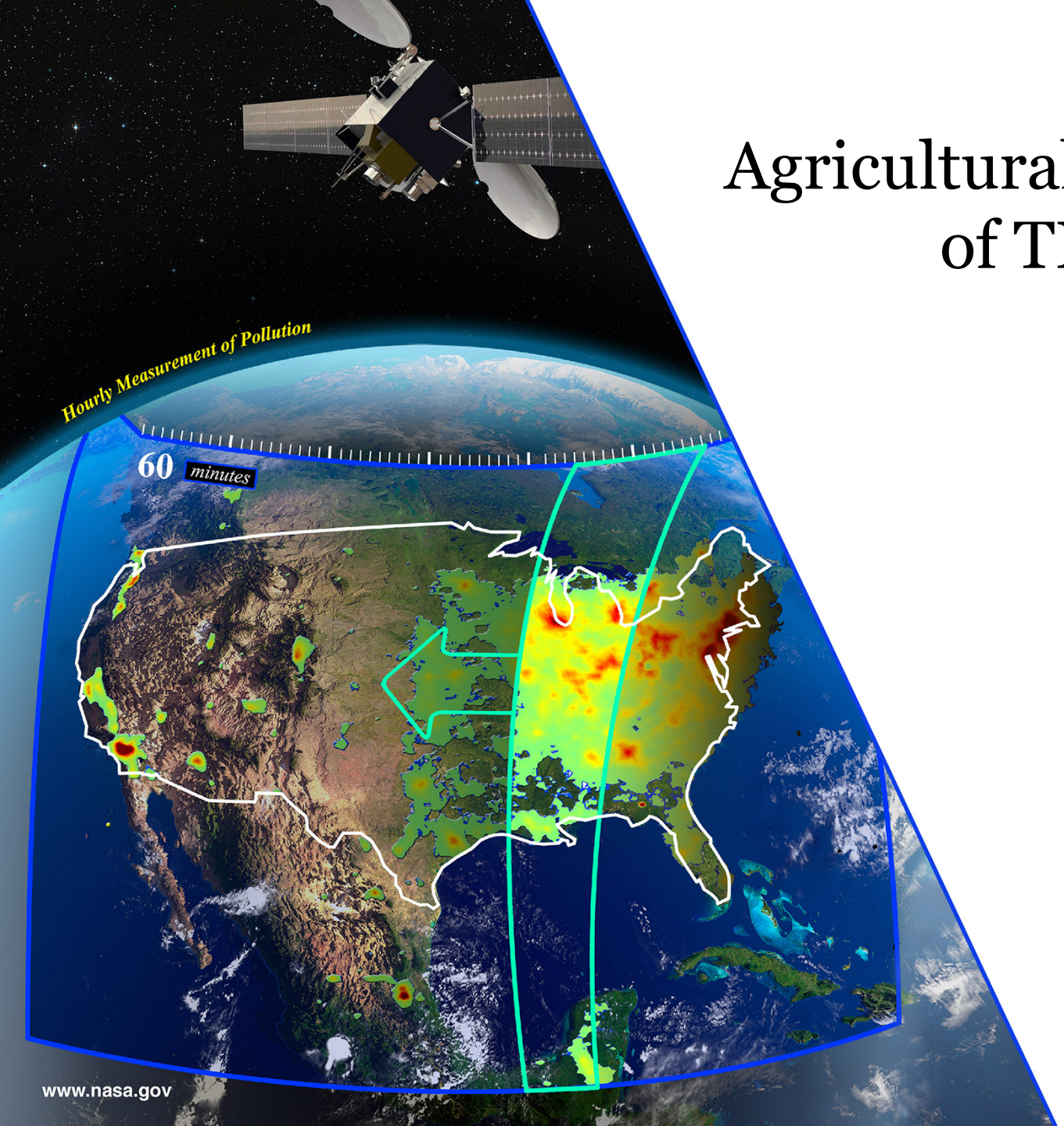

Agricultural Applications of TEMPO

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Minerva Schools at KGI

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Harvard University

Chris Chan Miller
Harvard-Smithsonian
Center for Astrophysics

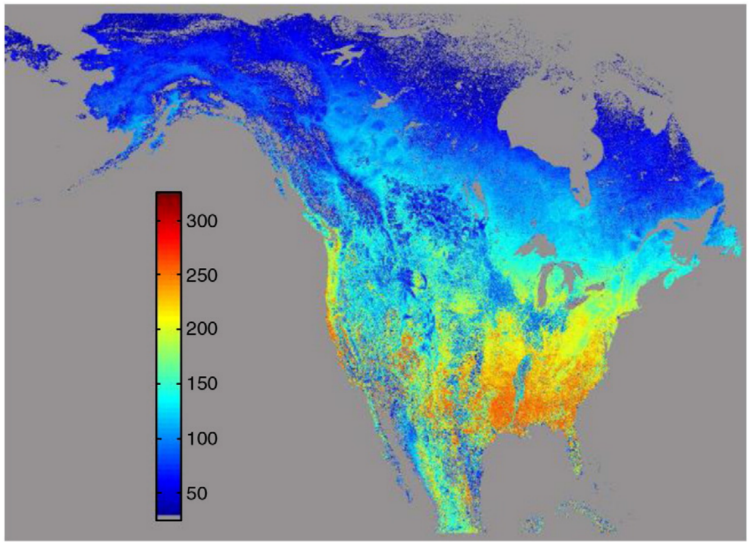
TEMPO
Science Team Meeting
June 7, 2018

Overview and Opportunities

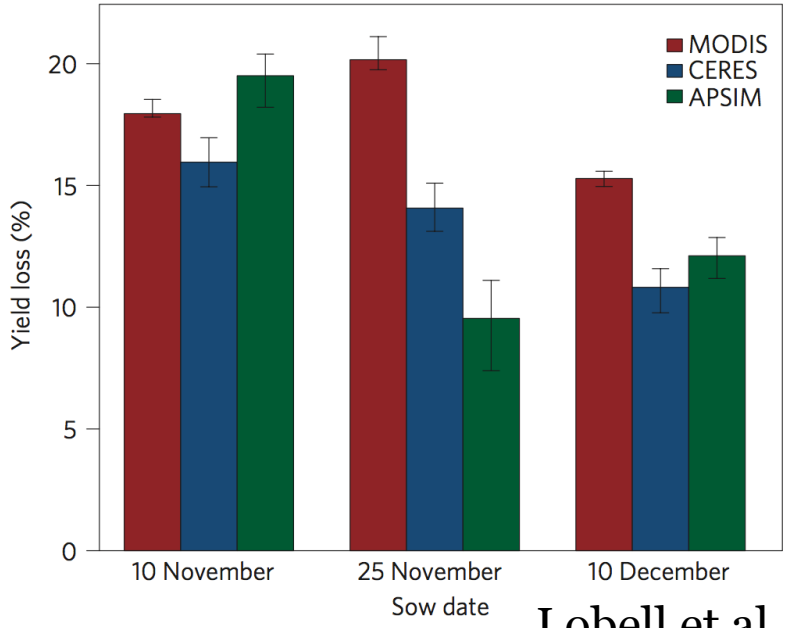
- Yield gaps requires measures on both the size of the gaps and underlying causes
- Growing challenges with changes in climate, more frequent extreme events, and increasing background ozone
- These challenges demand better information sources on plant and crop health to inform best practices

Broadband Methods

Response of ecosystems to climate: Mean growing length derived from MODIS vegetation index (2001-2006)



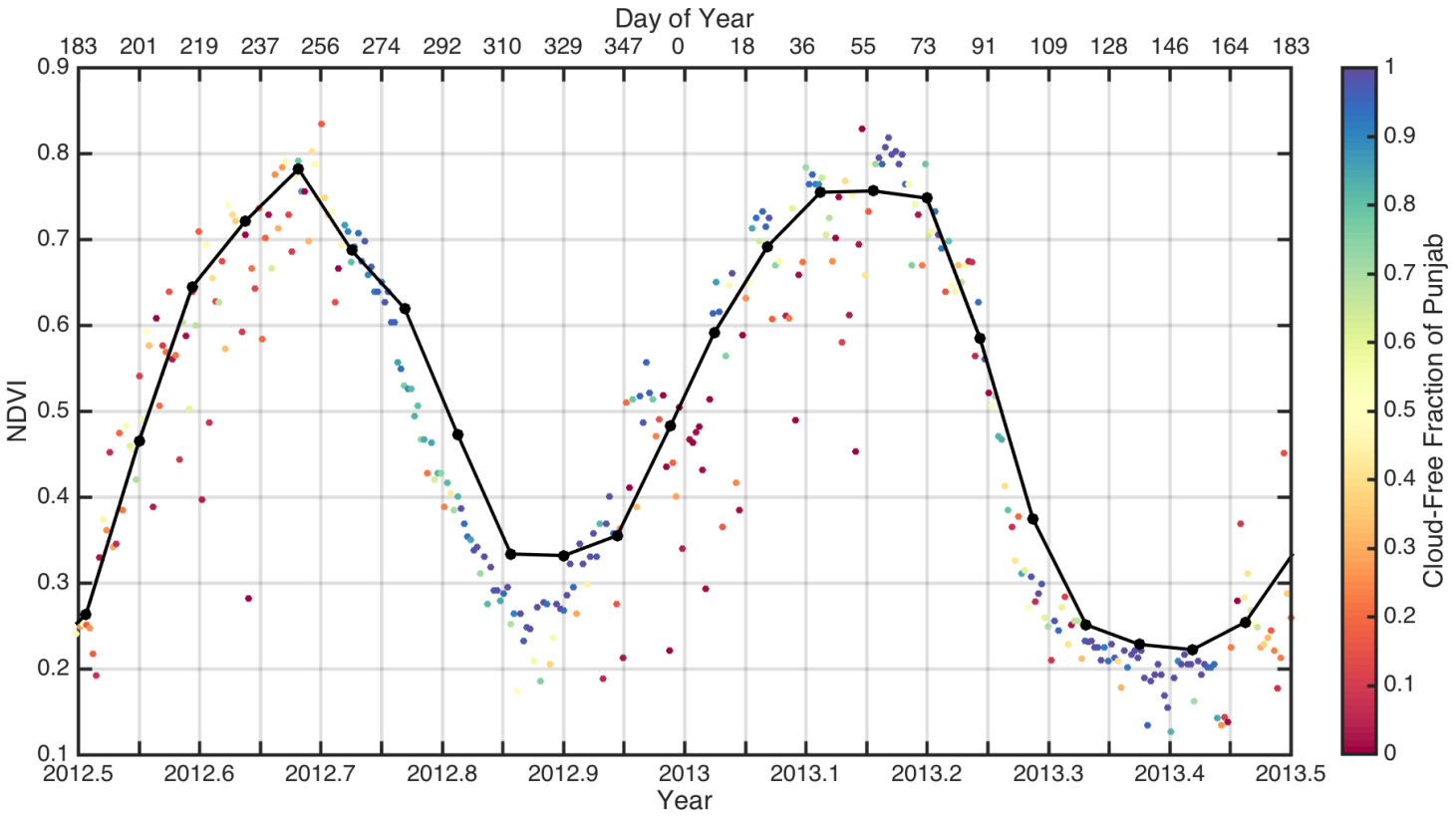
Ganguly et al. [2010]



Lobell et al. [2012]

This type of information is critical for agricultural decisions (e.g. maximizing yield)

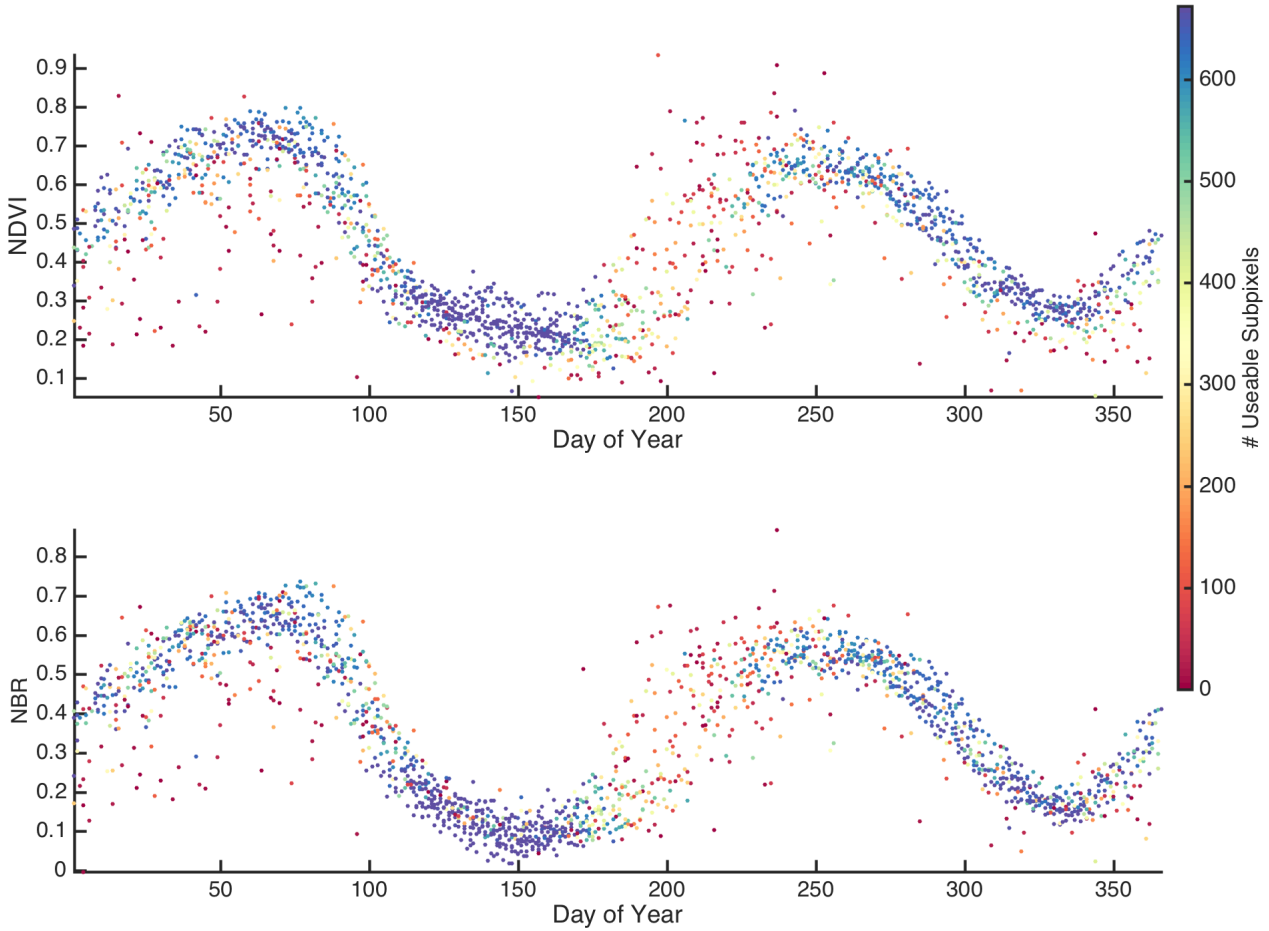
Importance of temporal resolution



Aggregation in standard MODIS product results in temporal and magnitude errors in vegetation indices

Lin et al. [*in prep*]

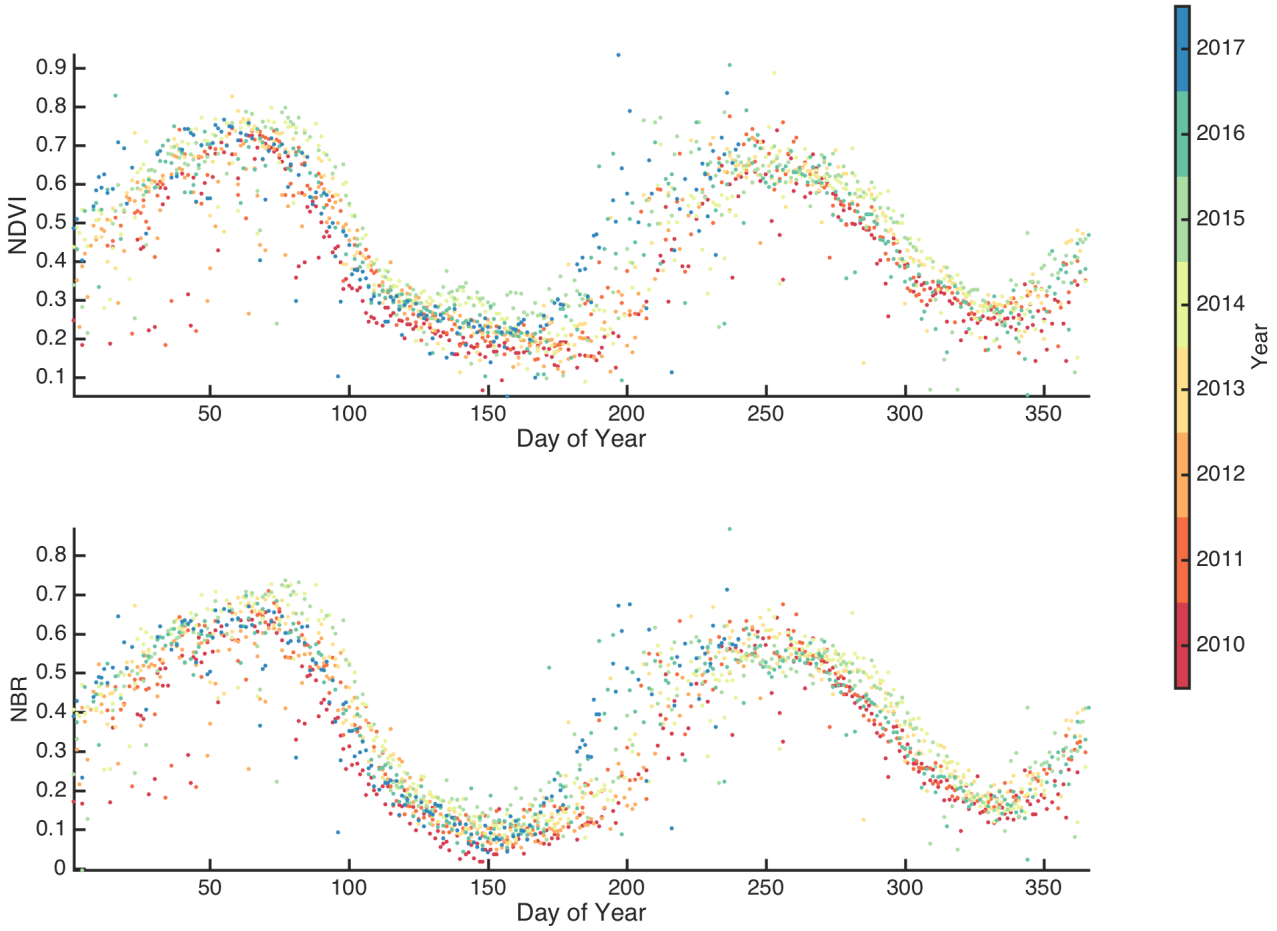
Importance of temporal resolution



Blue pixels (high observation count) show smooth evolution of ground cover characteristics.

Lin et al. [*in prep*]

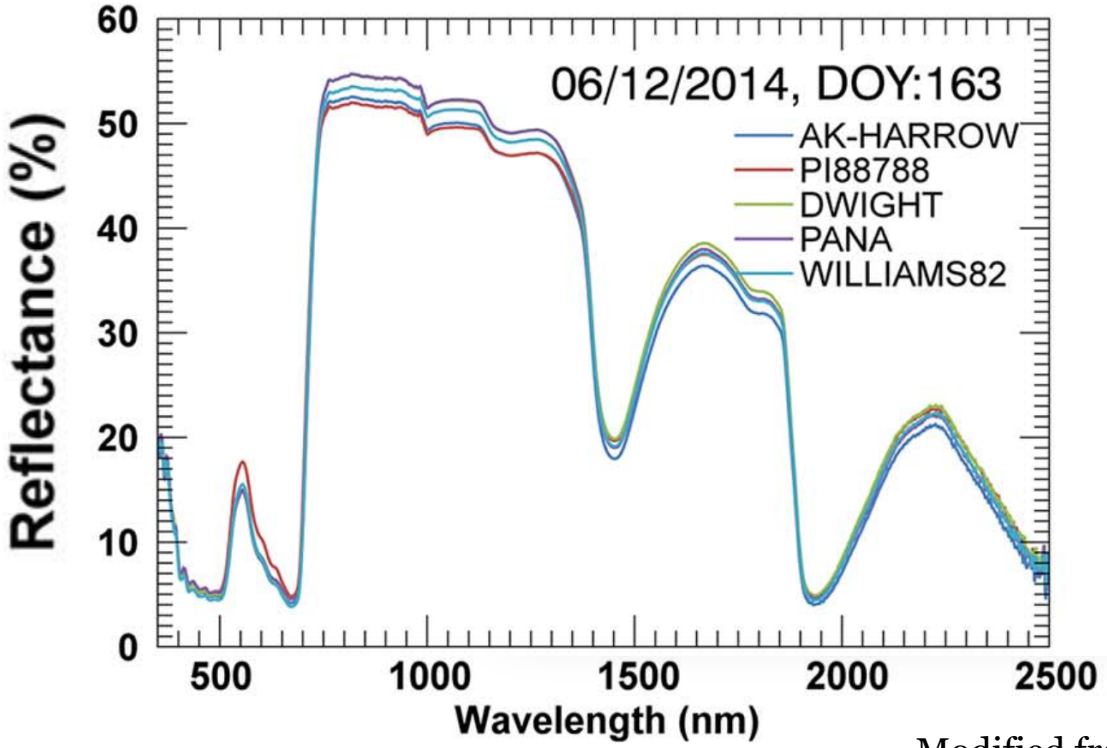
Importance of temporal resolution



Coloring by year demonstrates ability to compare inter-annual changes. These may be due to human decisions on planting or harvesting and/or environmental conditions.

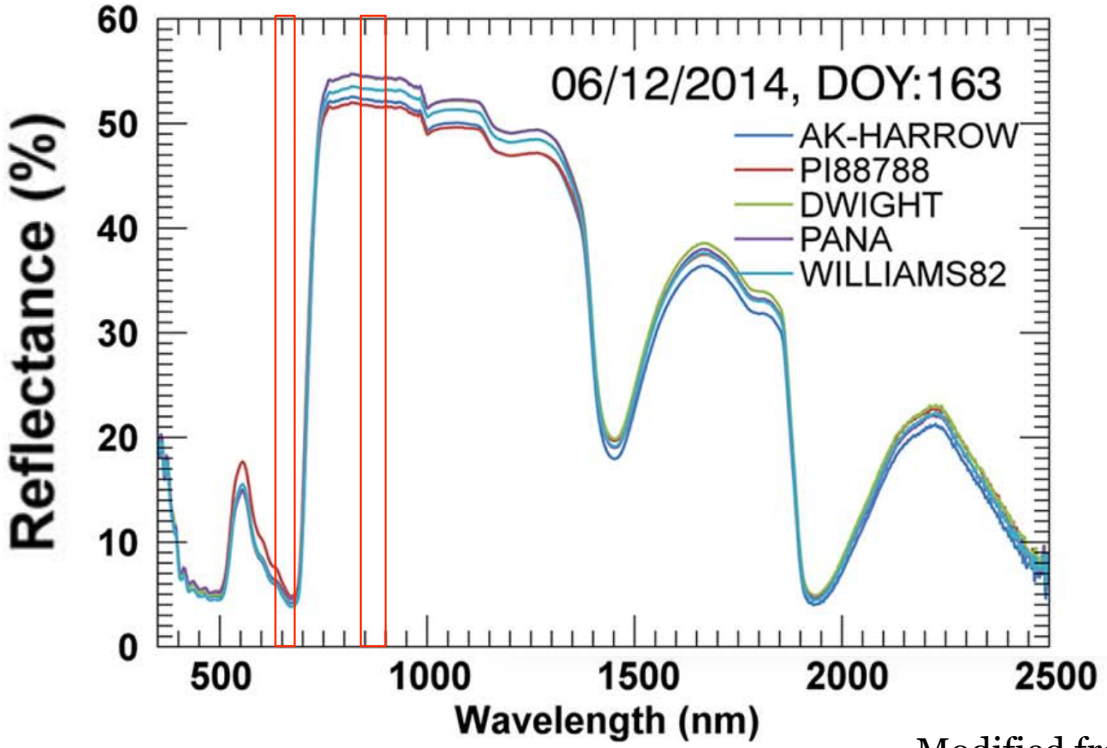
Lin et al. [*in prep*]

TEMPO in context



Modified from Ghulam et al. [2015]

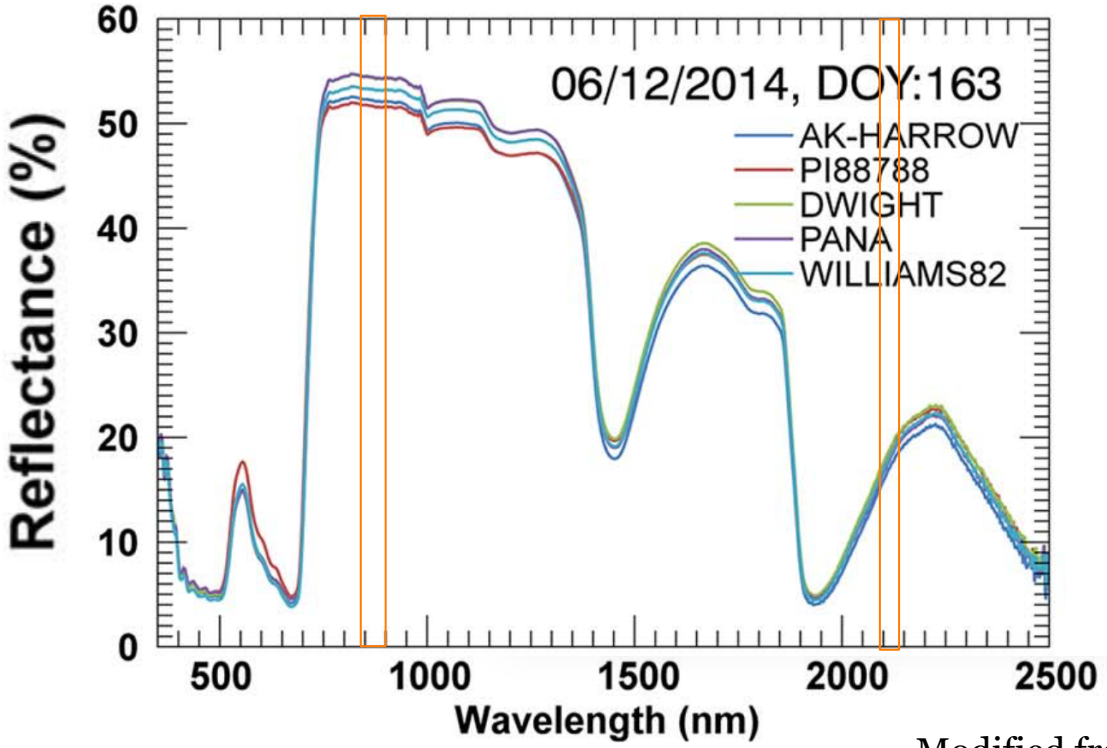
TEMPO in context



Modified from Ghulam et al. [2015]

NDVI = (NIR – Red) / (NIR + Red)

TEMPO in context

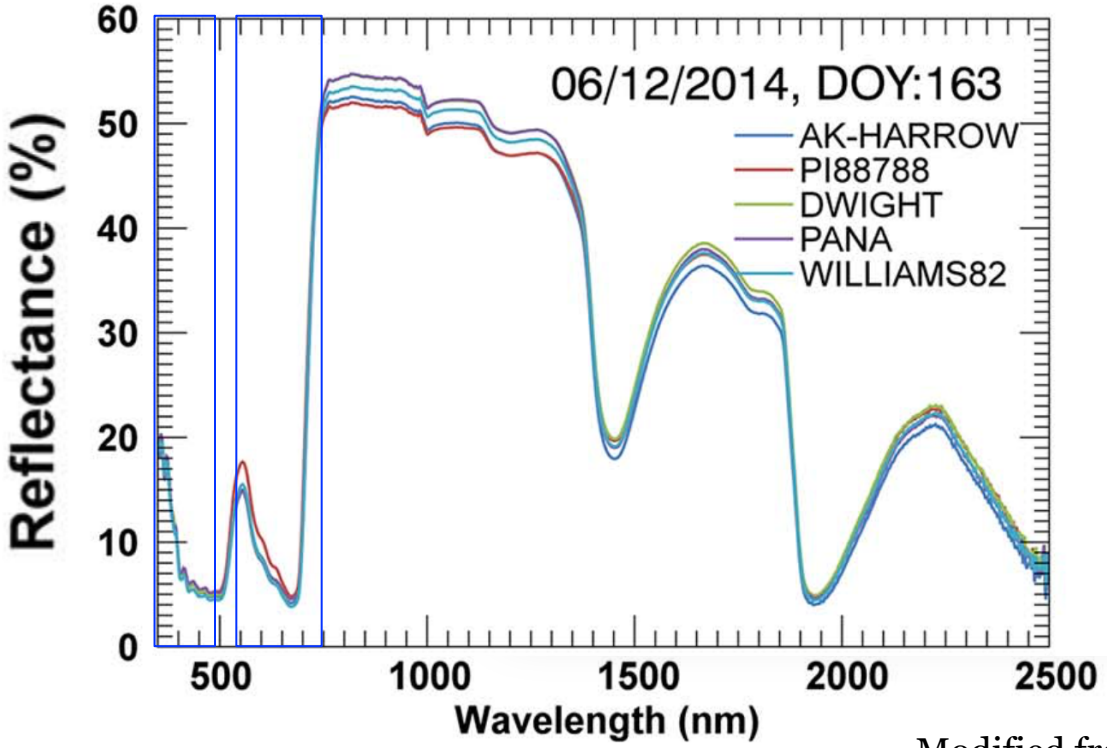


Modified from Ghulam et al. [2015]

NDVI = (NIR – Red) / (NIR + Red)

NBR= (NIR – SWIR) / (NIR + SWIR)

TEMPO in context



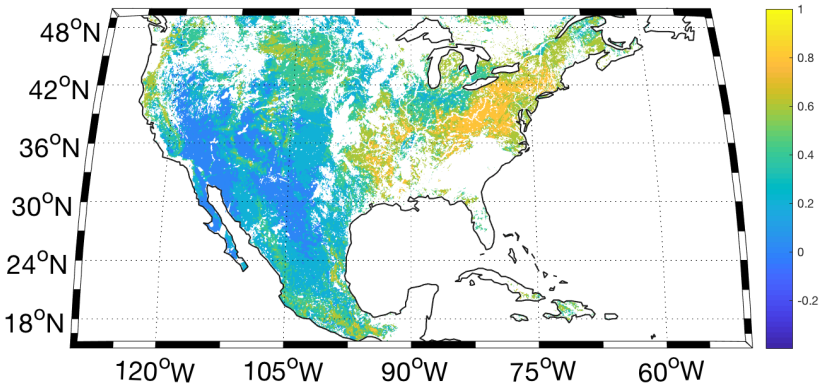
Modified from Ghulam et al. [2015]

NDVI = (NIR – Red) / (NIR + Red)
NBR= (NIR – SWIR) / (NIR + SWIR)

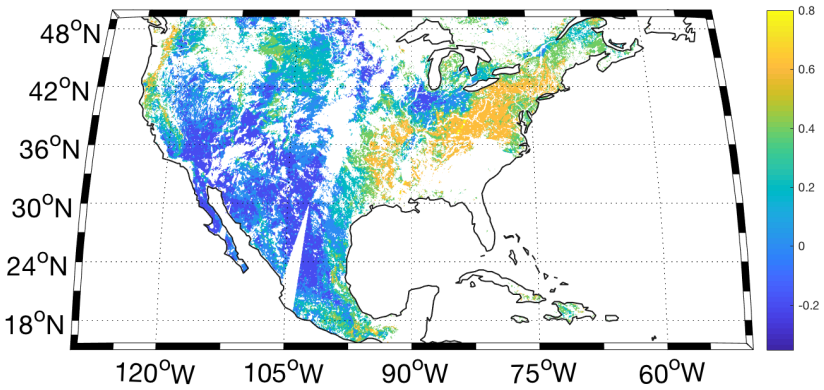
TEMPO bands see chlorophyll absorption/reflection and significant portion of red edge

Visible Vegetation Indices

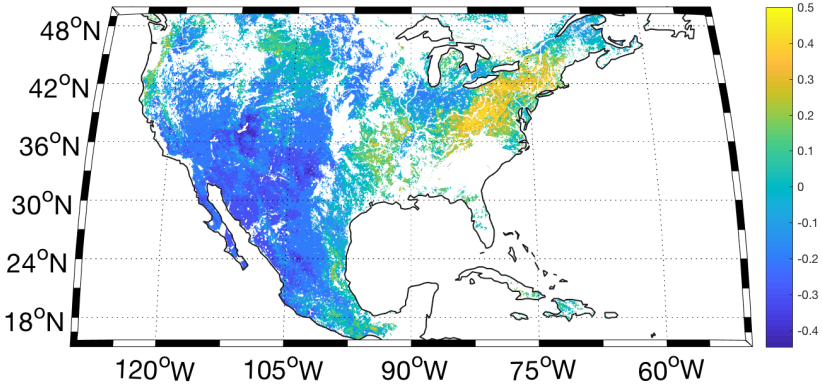
NDVI



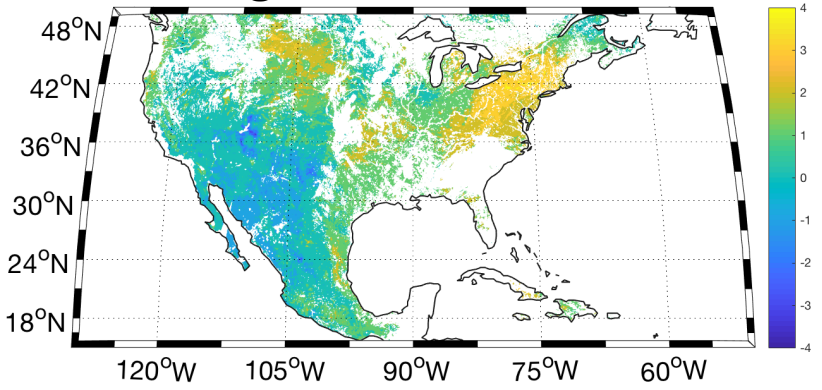
NBR



Visible Atmospherically Resistant Index



Triangular Greenness Index

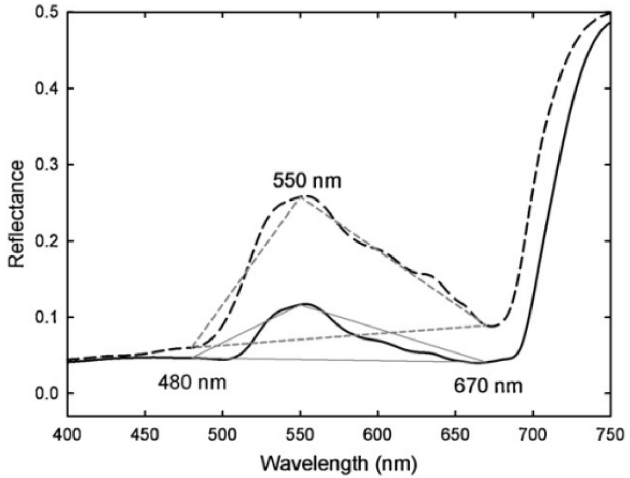


Visible indices of vegetation from MODIS (May 27, 2018) display similar spatial distribution to traditional IR indices

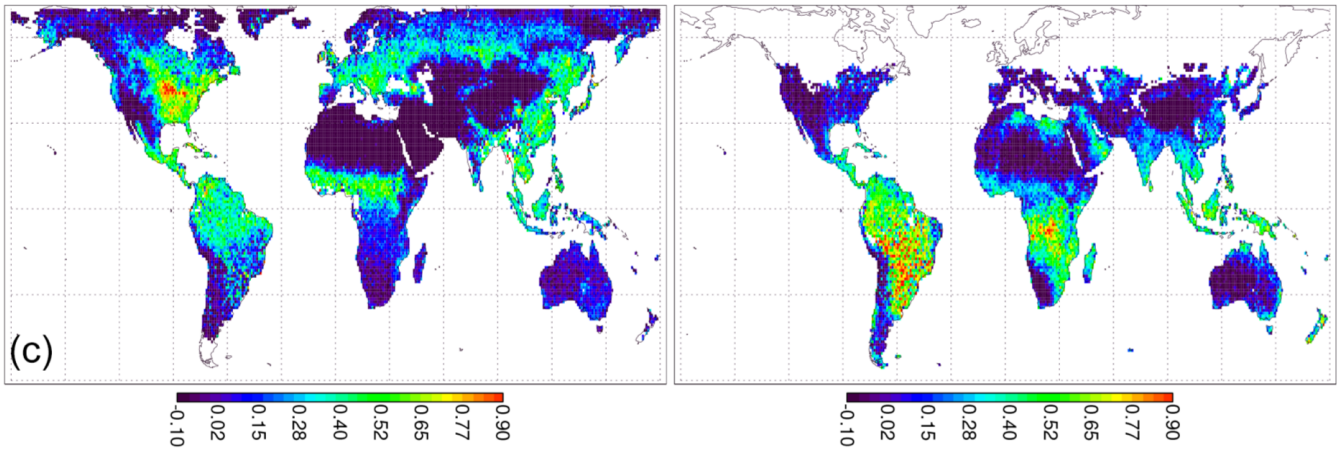
Spectrally resolved indicators

TGI is an approximation of chlorophyll reflectance that we could quantify more precisely with TEMPO

→ more efficient fertilization



Hunt et al. [2013]

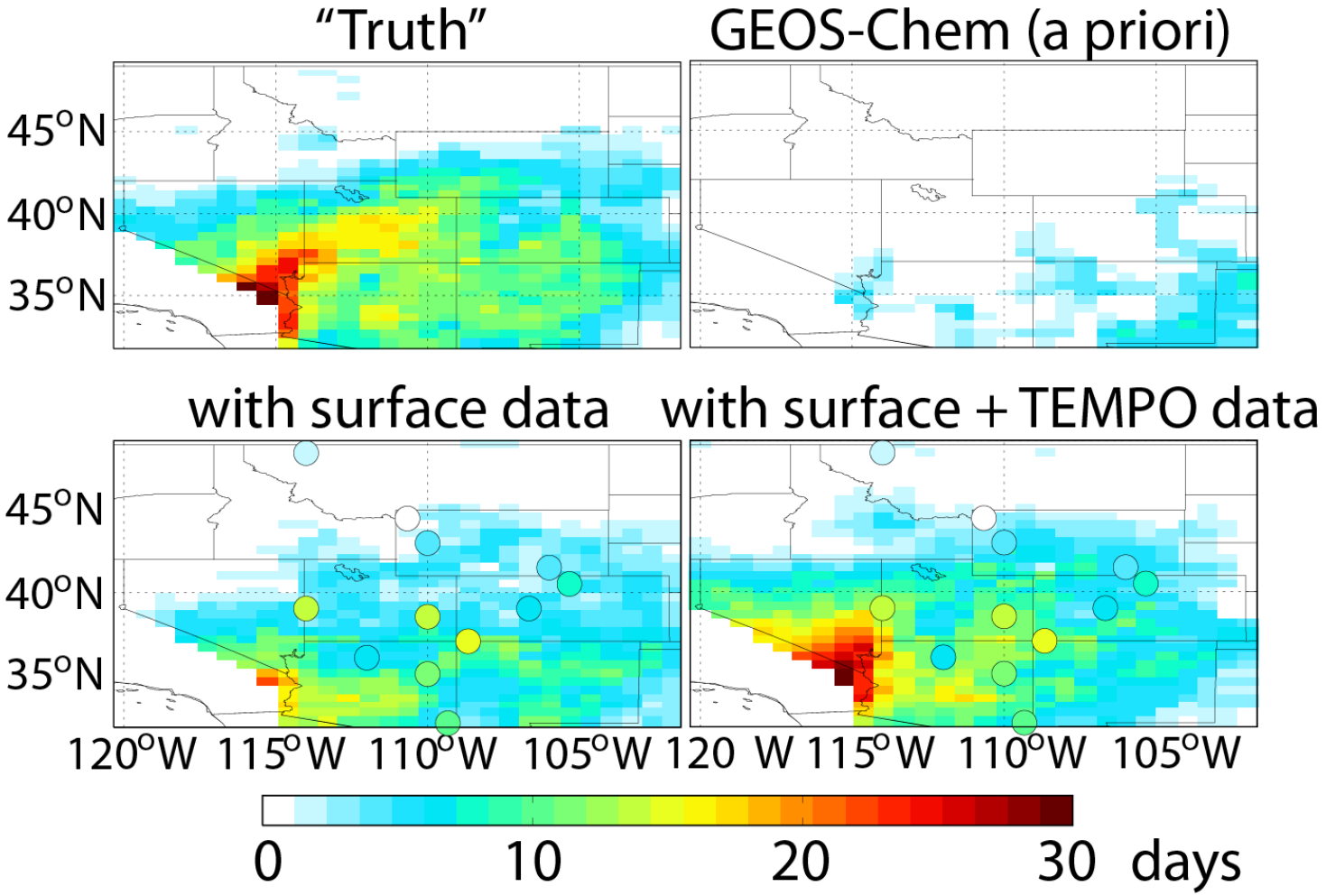


Joiner et al. [2016]

Solar Induced Fluorescence measurements can be used for studies primary productivity, carbon uptake, and drought responses

Observing elevated background ozone

Number of days MDA8 ozone > 70 ppbv

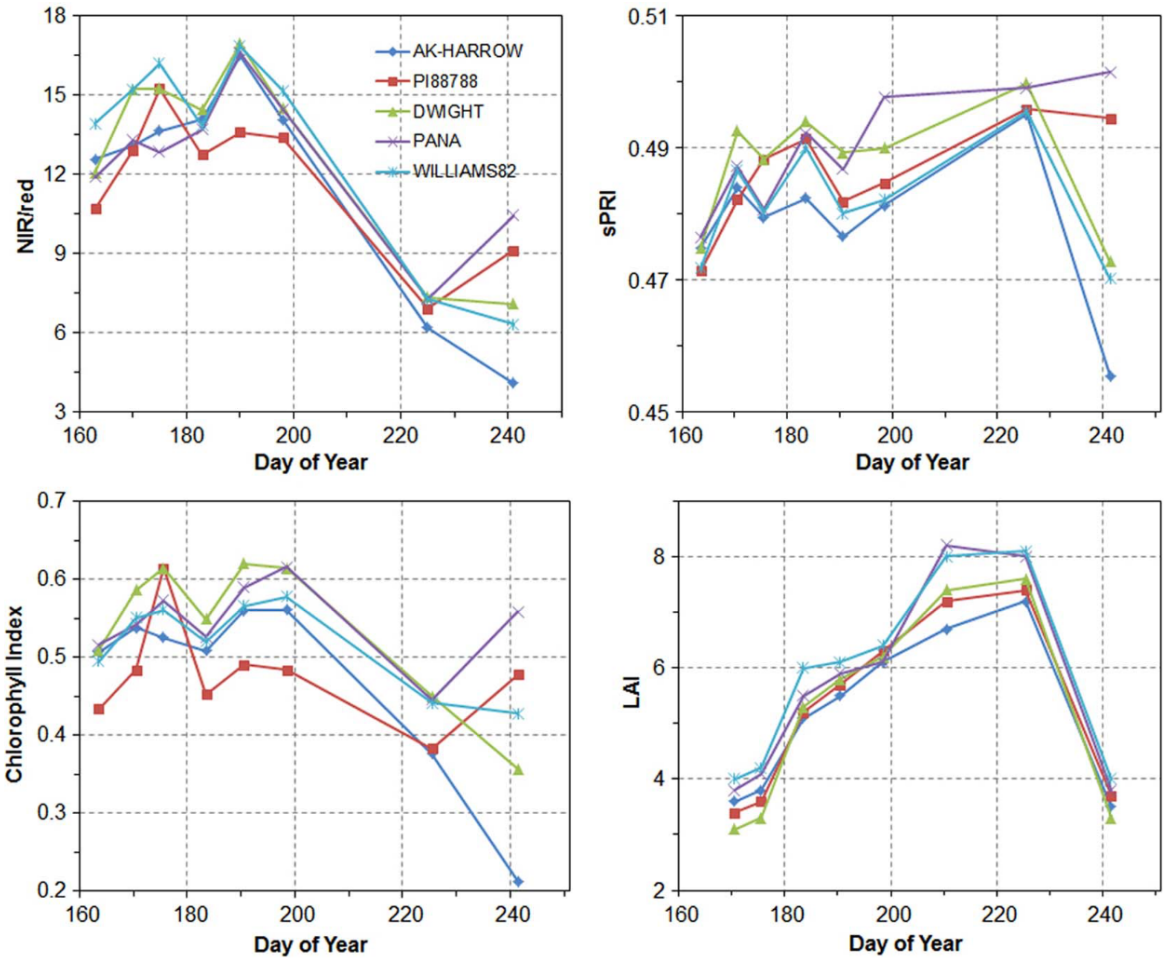


Assimilation of surface measurements does not fully correct bias or spatial pattern
Adding TEMPO observations fully corrects bias and captures most of the distribution

[Zoogman et al. 2014]

Observing Ozone Effects

Fishman et al. [2014]



Ghulam et al. [2015]

Ozone damaged crops exhibit significantly modified visible reflectance spectra

Future Directions

- Ongoing activities to utilize existing platforms for agriculture applications, including both NIR measurements and Vis (e.g. MODIS, GOME-2, TROPOMI)
- Exploit available TEMPO-like data to develop and refine vegetation indices
  - Synthetic TEMPO data
  - GEO-TASO
- Investigate power of TEMPO to quantify effect of atmospheric composition on crops (and the effects of crops on composition!)