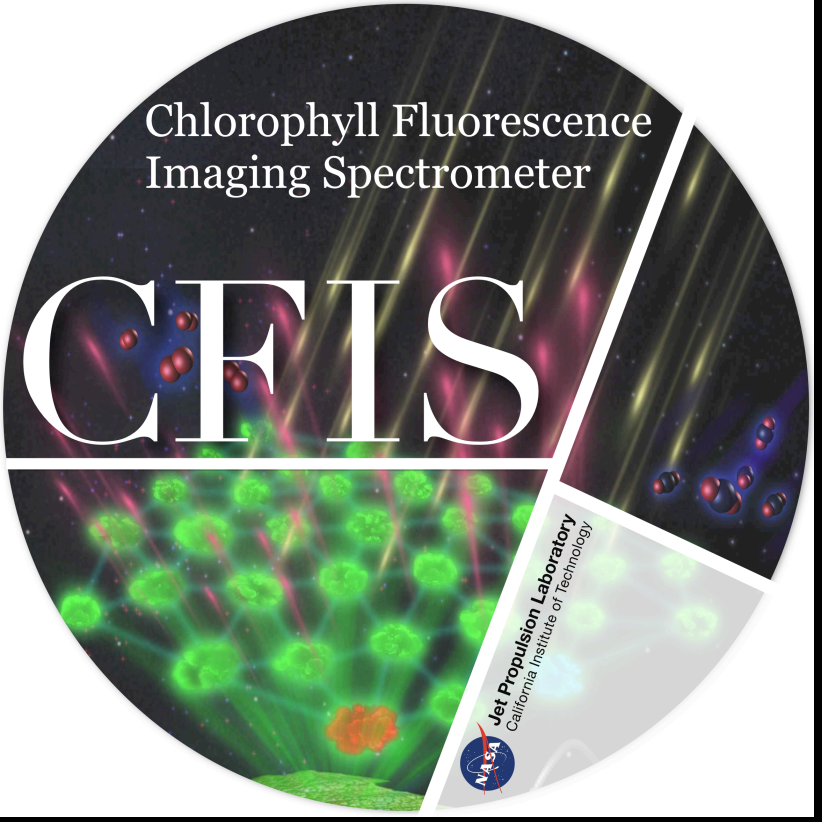

Airborne Solar Induced Chlorophyll Fluorescence to Characterize Arctic Boreal Zone Phenology and Productivity

Darren Drewry, Christian Frankenberg, David Schimel, Nicholas Parazoo

Syndonia Bret-Harte, Eugenie Euskirchen, Adrian Rocha, Charles Miller

Ryan Pavlick

- **Objective 1**: Acquire CFIS data in ABoVE domain in summer 2017
  - Acquire data over systems with contrasting productivity
  - Maximize spatial coincidence with other optical sensors and radars
  - Sample active flux towers in the region

- **Objective 2**: Analyze CFIS SIF Level 2 retrievals to characterize gradients in ecophysiological activity as functions of variation in:
  - Canopy chemistry, photosynthetic capacity, chlorophyll & water contents (AVIRIS-NG)
  - Plant functional type
  - Canopy / Ecosystem Structure (LVIS)
  - Disturbance history
  - Subsurface hydrology

- **Objective 3**: Demonstrate the utility of high resolution SIF data to constrain simulated GPP estimates over flight transects.
  - Integrate SIF biochemistry into the Community Land Model (CLM)
  - Utilize relationships between SIF and GPP to constrain biochemical parameters, applying a SIF constraint on simulated GPP estimation.

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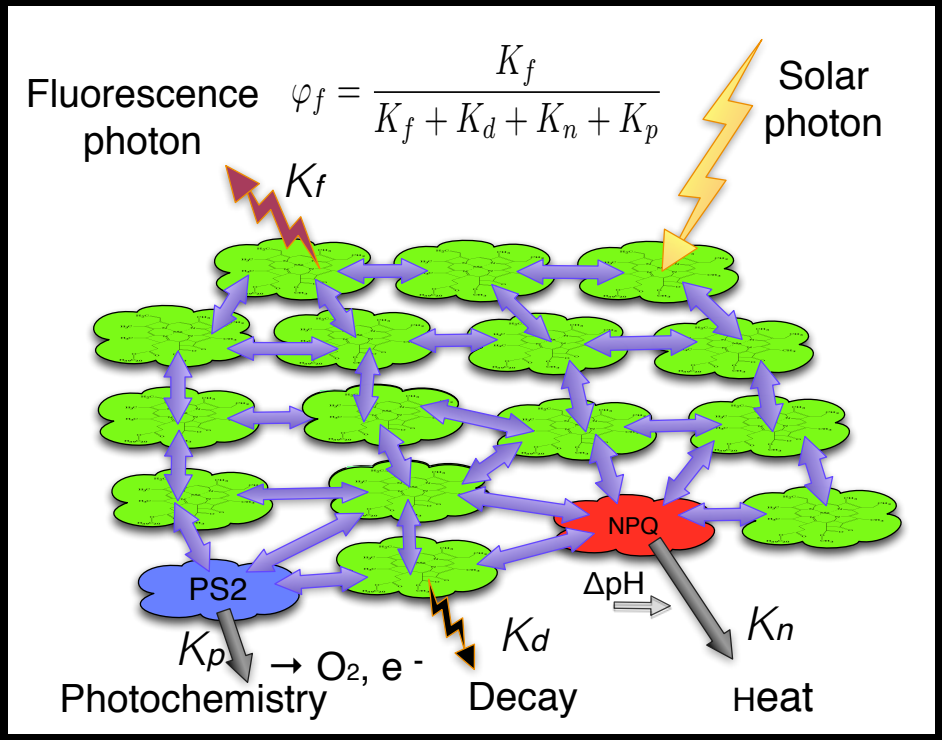
CFIS Overview

- Chlorophyll Fluorescence Imaging Spectrometer (CFIS), optimized for retrieving SIF
  - Pushbroom grating spectrometer
  - 11 degrees FOV
  - Spectral Range: 737 – 772 nm
  - ~2K spectral bands; ~2K spatial bands
  - High Spectral Resolution
    - <0.01nm FWHM; sampling ~0.017 nm/pixel
  - Signal-to-Noise Ratios exceeding 500
- Built for OCO-2 SIF validation
- Initial flight campaigns (engineering and science) in 2015, 2016

What is Solar Induced Fluorescence (SIF)?



- Solar Induced chlorophyll Fluorescence (SIF) is a direct by-product of photosynthesis
- SIF provides a unique dynamic proxy for gross primary production GPP
- SIF is only ~1-2% of continuum radiance

Retrieval approaches use filling-in of Fraunhofer lines (solar absorption features)

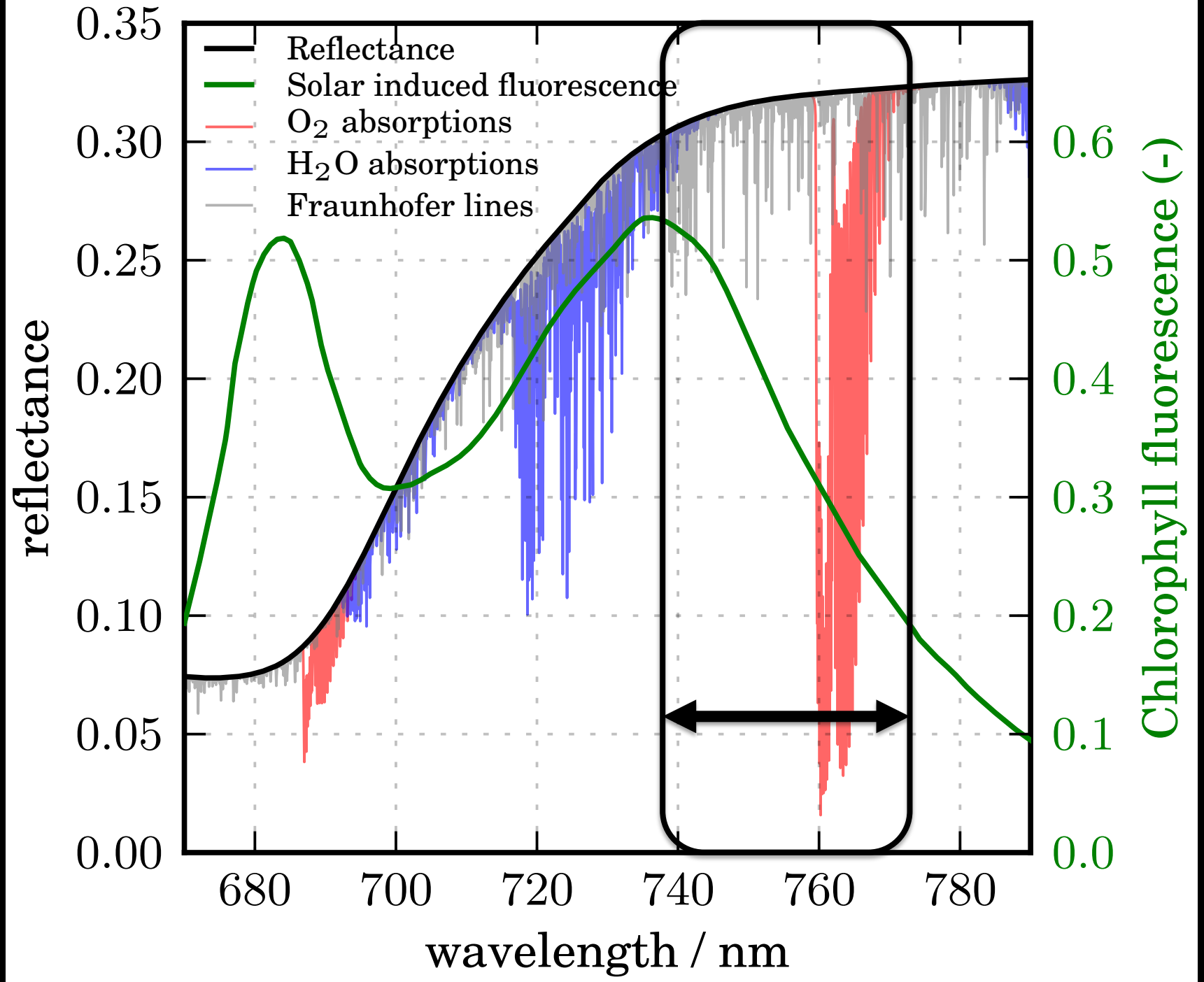
- High spectral resolution allows SIF retrievals not affected by atmospheric interference (Frankenberg et al, 2011; Joiner et al, 2011)

$$GPP = PAR \cdot fPAR \cdot \varphi_p$$

$$SIF = PAR \cdot fPAR \cdot \varphi_f$$

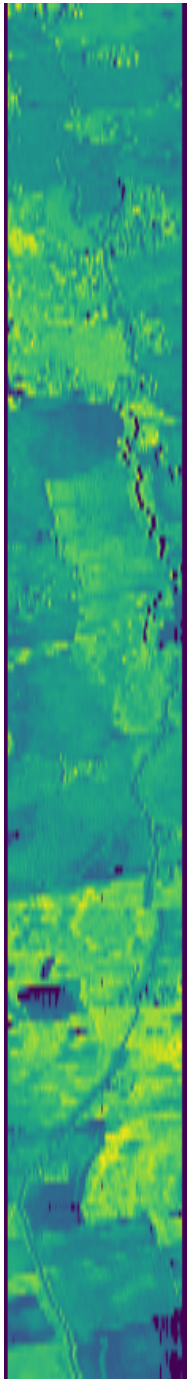
$$GPP = SIF \cdot \varphi_p / \varphi_f$$

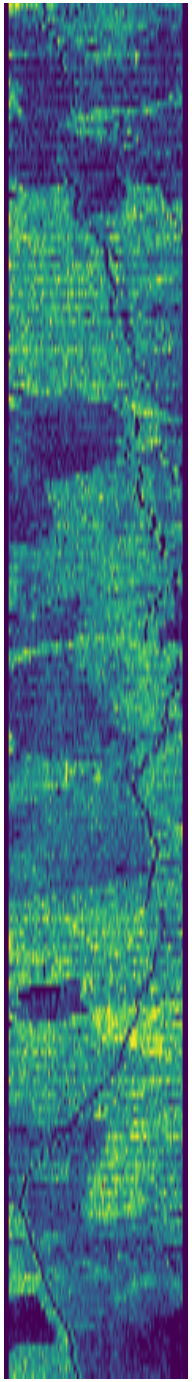
Keck Fluorescence Workshop Report (2013)

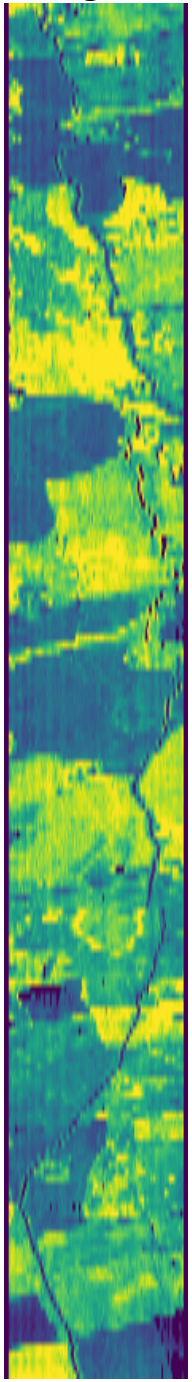

Reflectance
Solar induced fluorescence
O_2 absorptions
H_2O absorptions
Fraunhofer lines
reflectance
Chlorophyll fluorescence (-)
wavelength / nm
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.0
0.1
0.2
0.3
0.4
0.5
0.6
680
700
720
740
760
780

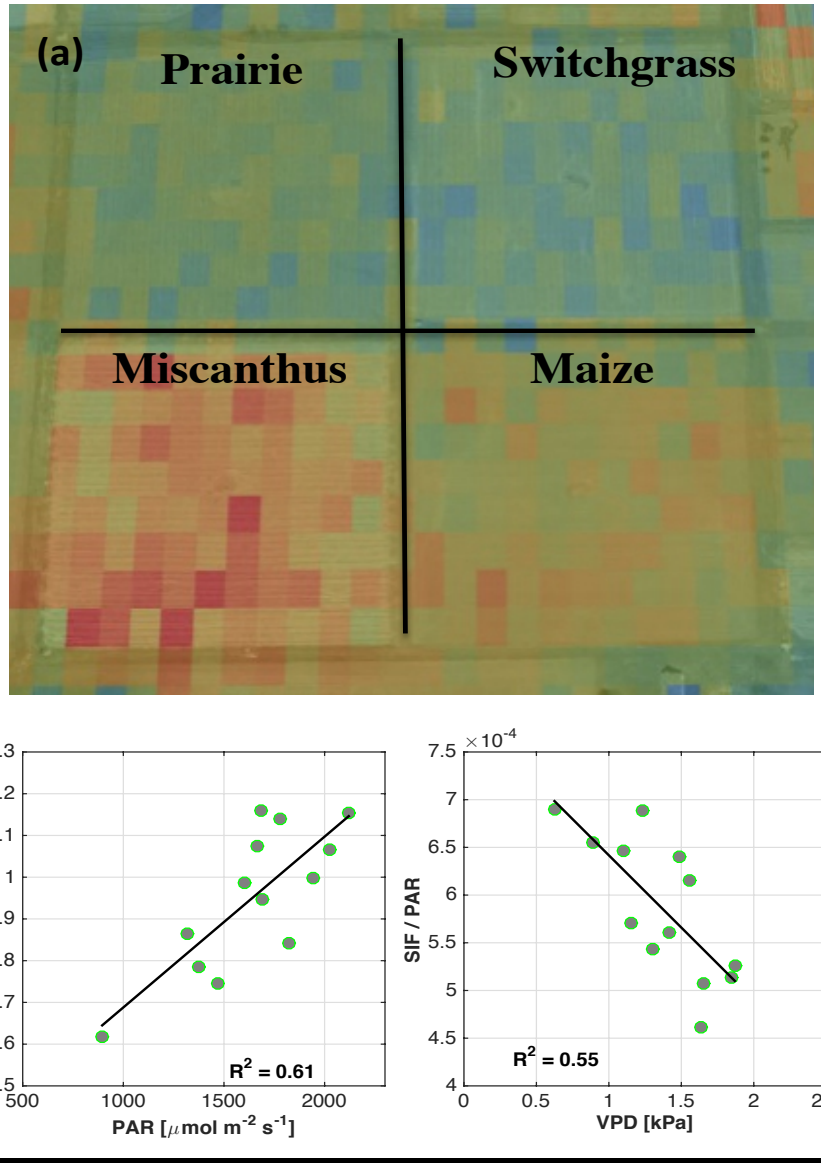

Barrow
Deadhorse
Inuvik
Fairbanks
Yellowknife


Piranha RGB


NIR radiance


SIF (raw)


RedEdge Ratio


(a)
Prairie
Switchgrass
Miscanthus
Maize
SIF [W m-2 sr-1 μm-1]
PAR [μmol m-2 s-1]
R2 = 0.61
×10-4
SIF / PAR
VPD [kPa]
R2 = 0.55