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

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• **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)

\[
GPP = PAR \cdot fPAR \cdot \phi_p \\
SIF = PAR \cdot fPAR \cdot \phi_f \\
GPP = SIF \cdot \phi_p / \phi_f
\]
**Reflectance**

- Chlorophyll fluorescence (-)
- Solar induced fluorescence
- O₂ absorptions
- H₂O absorptions
- Fraunhofer lines

**wavelength / nm**

**reflectance**

- 0.35
- 0.30
- 0.25
- 0.20
- 0.15
- 0.10
- 0.05
- 0.00

**Chlorophyll fluorescence (-)**

- 0.6
- 0.5
- 0.4
- 0.3
- 0.2
- 0.1
- 0.0