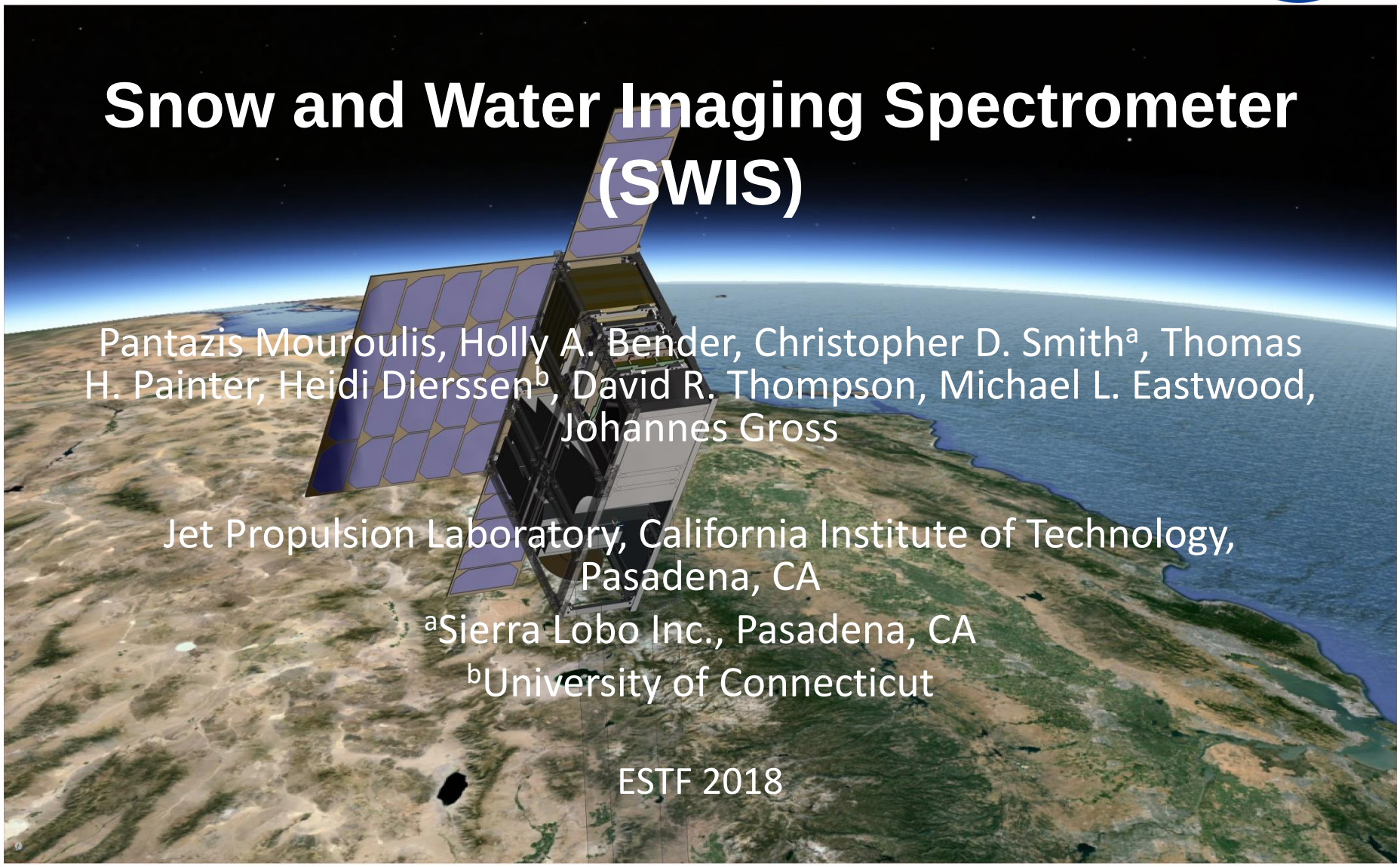

Snow and Water Imaging Spectrometer (SWIS)

Pantazis Mouroulis, Holly A. Bender, Christopher D. Smith[a], Thomas H. Painter, Heidi Dierssen[b], David R. Thompson, Michael L. Eastwood, Johannes Gross

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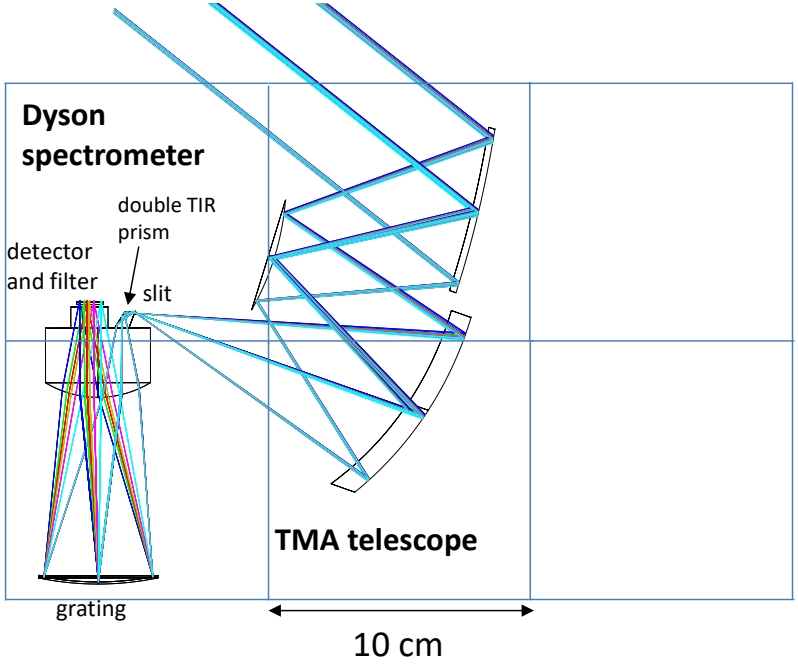
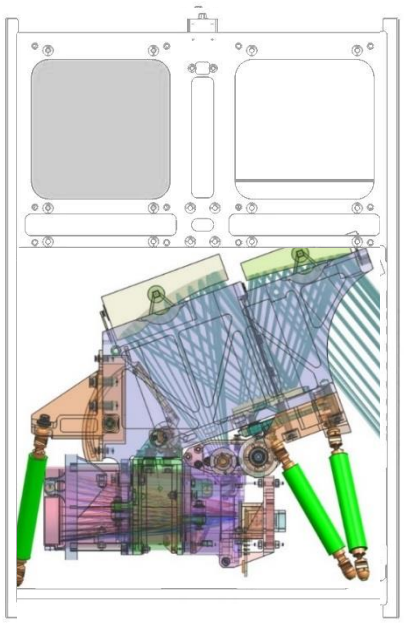
[b]University of Connecticut

ESTF 2018

Instrument specifications

Spectrometer and telescope inside 6U CubeSat frame (20 x 30 x 10 cm)





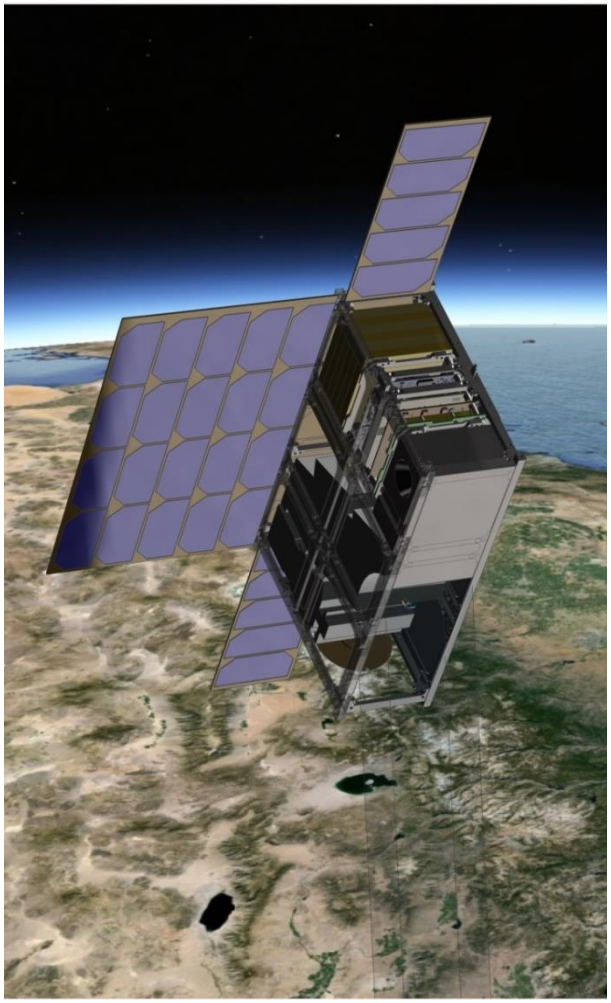
Optomechanical design within 6U CubeSat structure

SWIS specifications	
Spectral range	350 – 1700 nm, single FPA
Spectral sampling	5.7 nm
Cross-track spatial elements	600 (+40 monitor)
Cross-track FOV	10° (±20° pointing)
Resolution	0.3 mrad
Detector pixel size	30 µm
Focal length	100 mm
F/#	1.8
Uniformity	95%

Mouroulis et al, Proc. SPIE 9222, (2014)
Bender et al, Proc. SPIE 9611, (2015)

Mission requirements

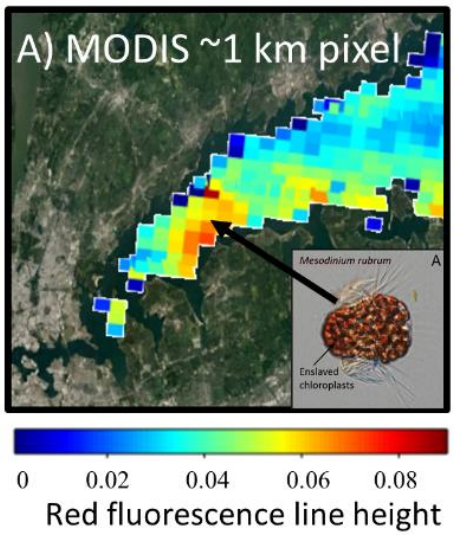
- **High spectral resolution** for detecting subtle changes in the spectral signature of aquatic habitats.
- **High radiometric sensitivity / SNR** to tease out subtle spectral features from on-orbit radiance dominated by the intervening atmosphere.
- **Near IR spectral coverage** for discriminating between atmospheric and surface water signatures.
- **High spatial resolution** to limit spectral mixing and resolve signals from ecologically important features.
- **Maneuverability** for viewing off-nadir targets and higher repeat coverage of key locations.
- **Calibration** using solar radiance and lunar views.



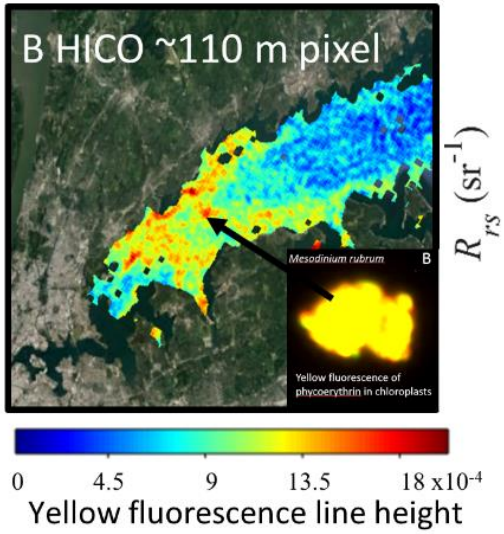
SWIS CubeSat, artist's concept

Bloom monitoring and assessment

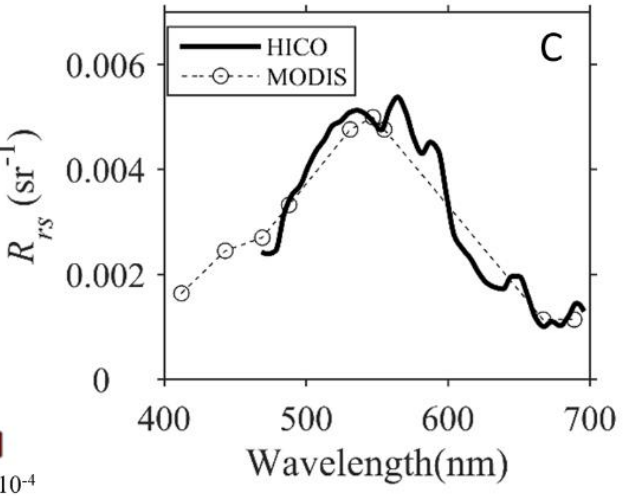
- Assess location, frequency, and formation conditions for bloom occurrence
- Mechanisms for bloom initiation, growth, aggregation, demise
- Monitoring multiple and widespread events not possible from in-situ data



MODIS Terra map of dense *Mesodinium rubrum* bloom, Long Island Sound



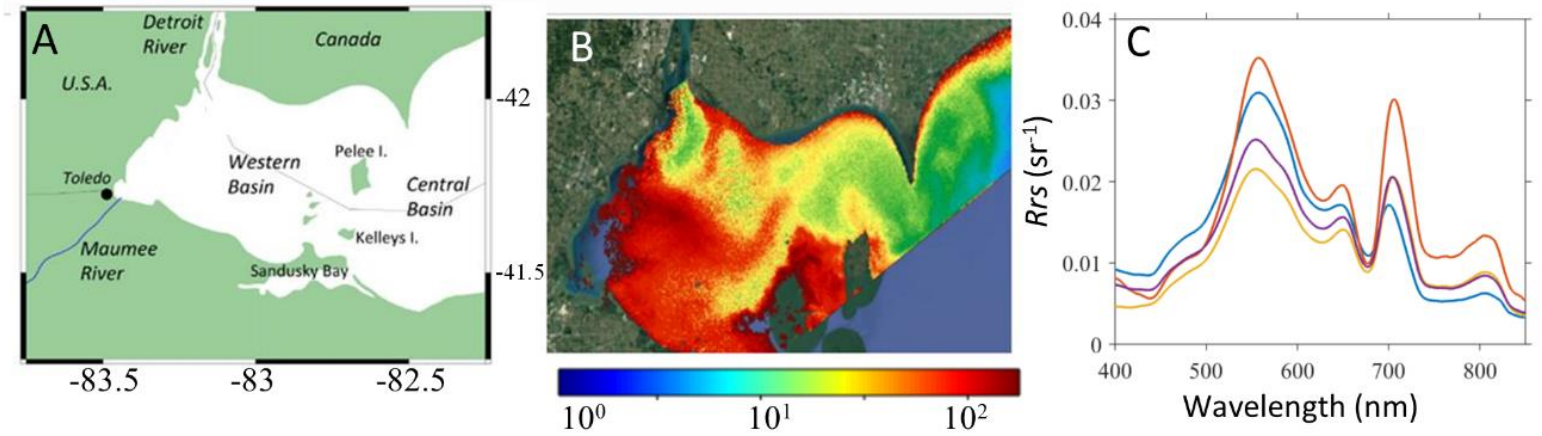
HICO map of fluorescence line height from the phycoerythrin accessory pigment within M. rubrum



Distinctive spectral features of the bloom

Dierssen et al Proc. Natl. Acad. Sci. 2015

Bloom monitoring and assessment



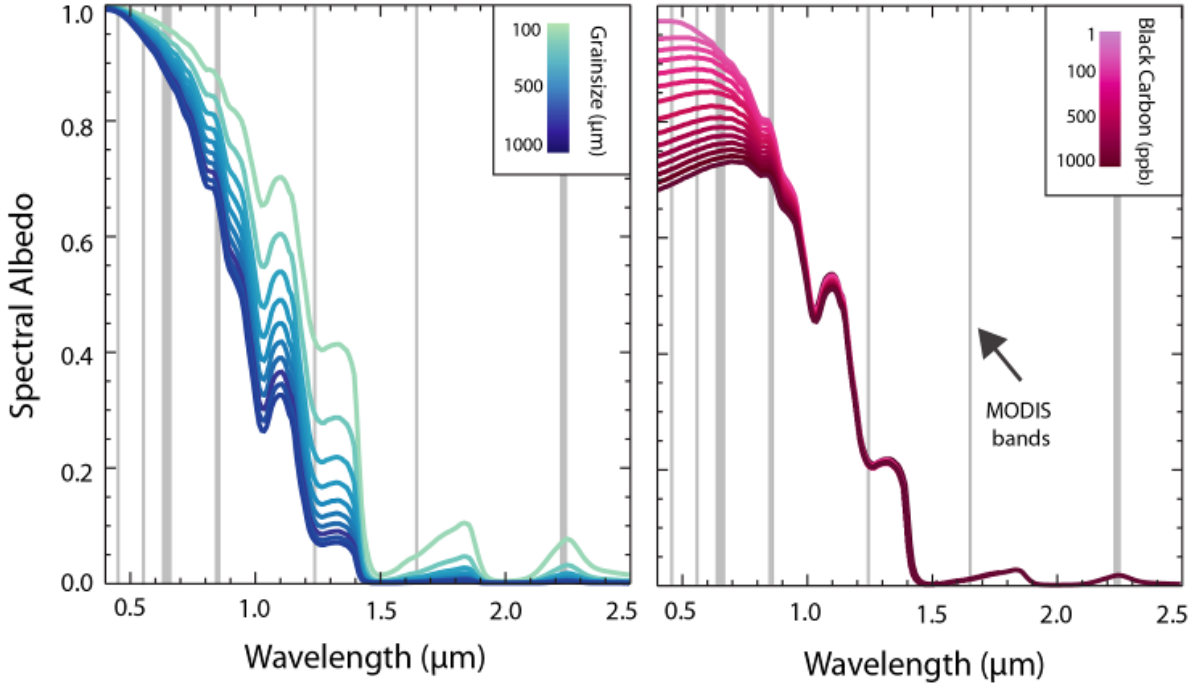
HICO map of Chlorophyll-a (mg/m^3) of Lake Erie reveals patchy distribution of surface cyanobacteria bloom, common to this area.

Distinctive spectral signature of the bloom

- Single SWIS satellite can study isolated bloom
- 2-3 satellites can perform systematic assessment

Moore et al, Front. Mar. Sci. 2017

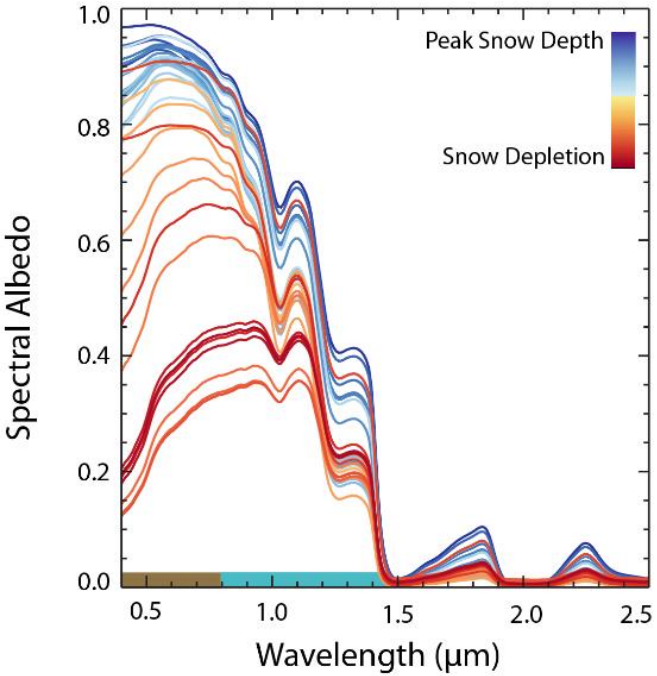
Snow surface and properties



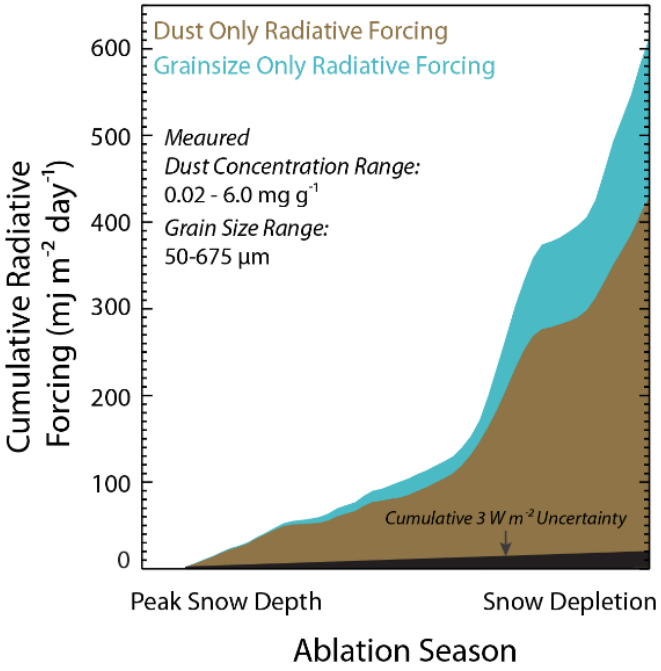
NIR/SWIR snow spectral albedo is sensitive to snow grain size

VIS/NIR wavelengths sensitive to concentrations of impurities such as black carbon or dust

Seasonal data



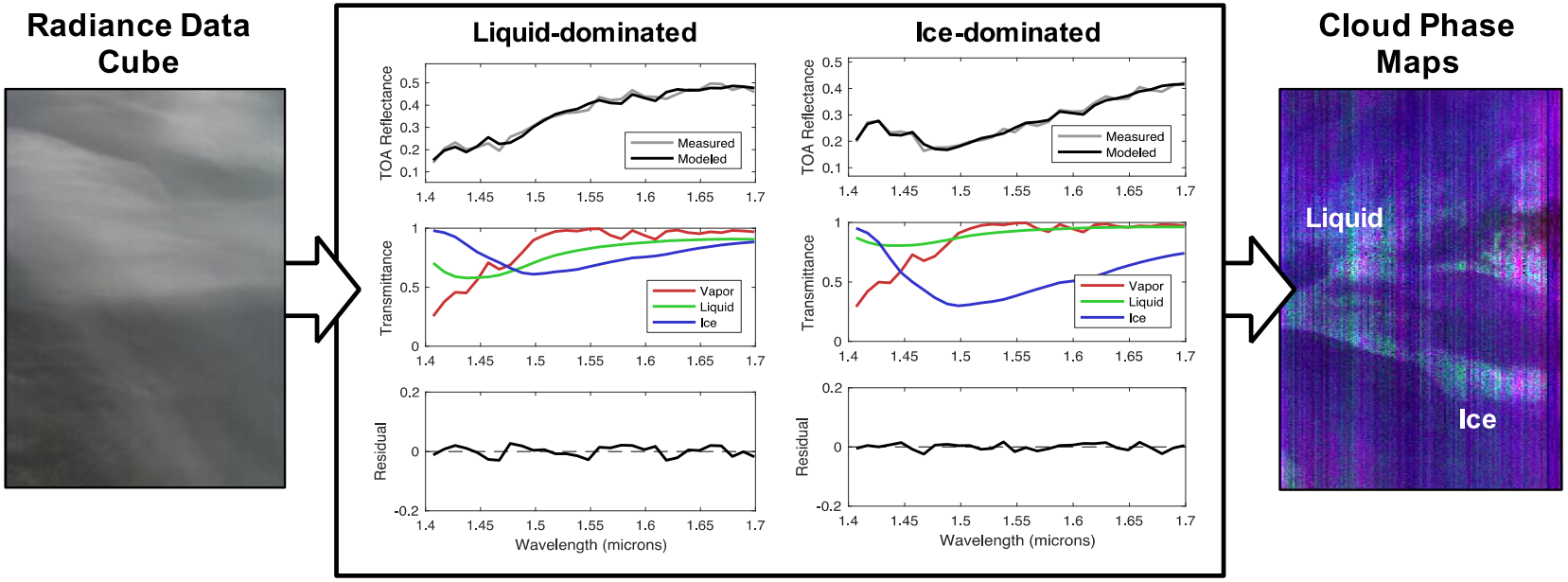
Time series of measured spectral evolution over entire melt season, Rocky Mountains, CO



Resulting radiative forcing

SWIS will produce similar data sets, although on a global scale instead of single-point research stations.

Cloud and atmospheric science

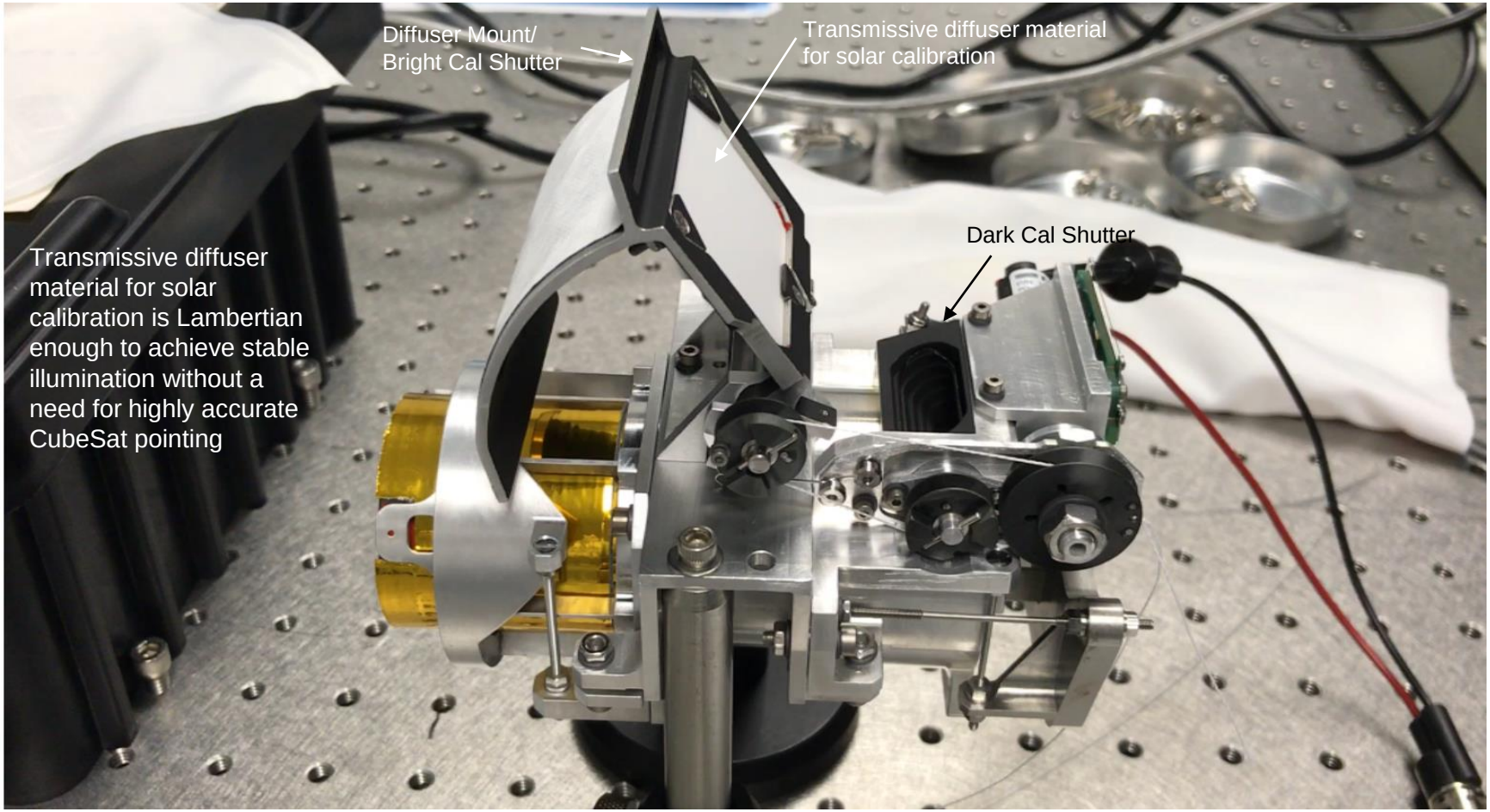


- Example spectroscopic fits using Hyperion data (EO1H2221282005350110KF)
- Spectral fitting algorithm, applied to the SWIS 1400 – 1700 nm interval recovers variable ice and liquid absorptions.

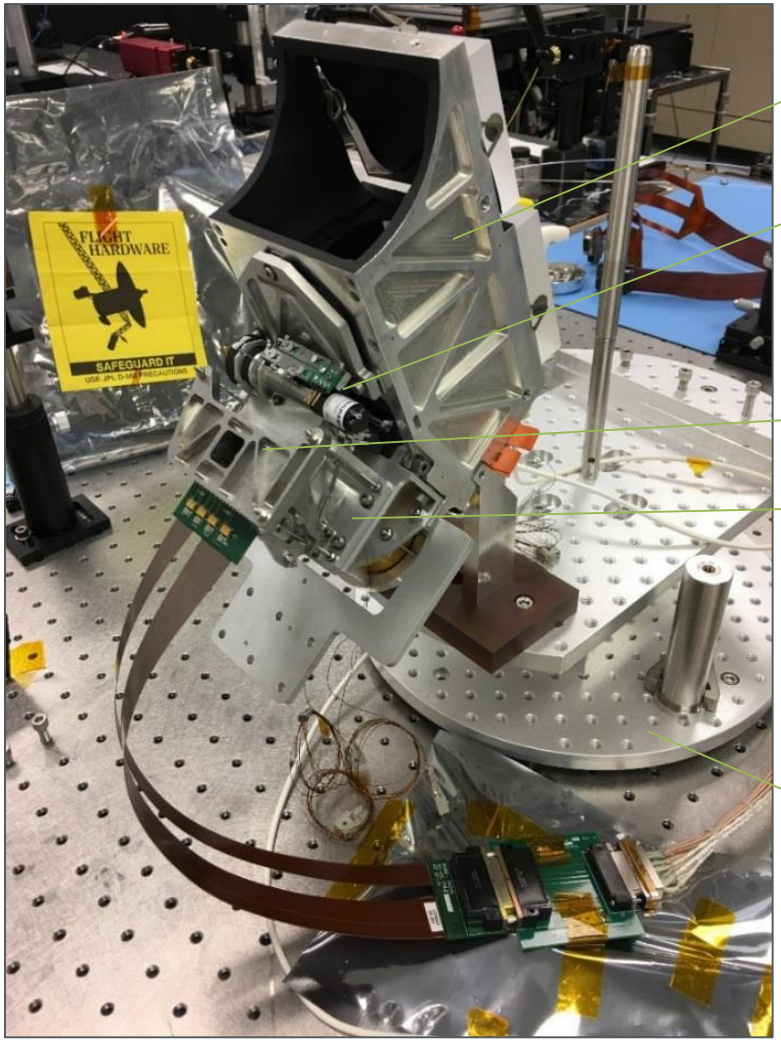
Thompson et al, Atmospheric Measurement Techniques 2018

Spectrometer and calibration mechanism

Single drive on-board calibration mechanism performs the dual function of positioning the on-board calibrator and providing a shutter for dark frames



Full system for testing



telescope

calibration mechanism

detector

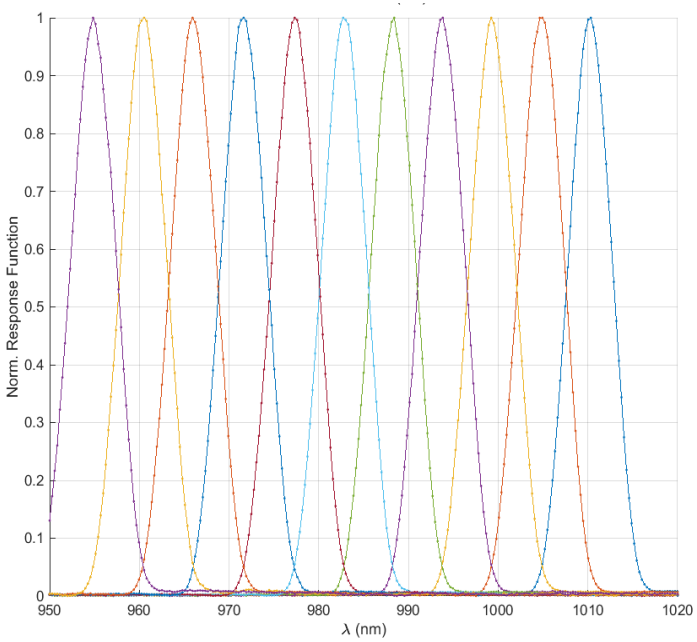
spectrometer

rotation stage (for thermal chamber tests)

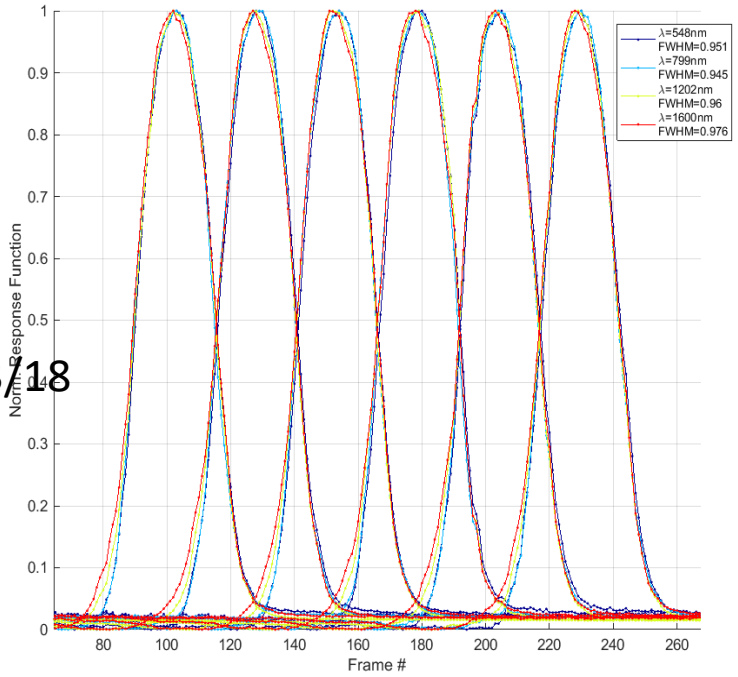
Measured performance of SWIS spectrometer

Parameter	Value
Spectral resolution (FWHM, typical)	1.1 x sampling
SRF FWHM variation with field (worst-case)	2.5%
Spectral error (worst case, all wavelengths)	4% (pixel unit)
ARF resolution (FWHM, typical)	1.1 x sampling
ARF FWHM variation with wavelength (worst case)	6%
CRF resolution (FWHM, typical)	1.0 x sampling
CRF FWHM variation with wavelength (worst case)	2%
Spectral/IFOV alignment error (worst case, all fields)	3% (pixel unit)

Test results



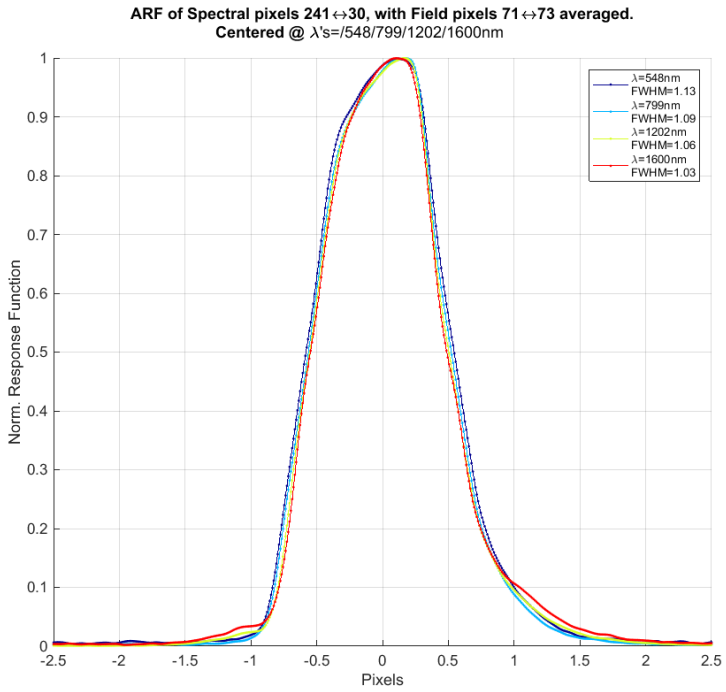
Spectral response functions



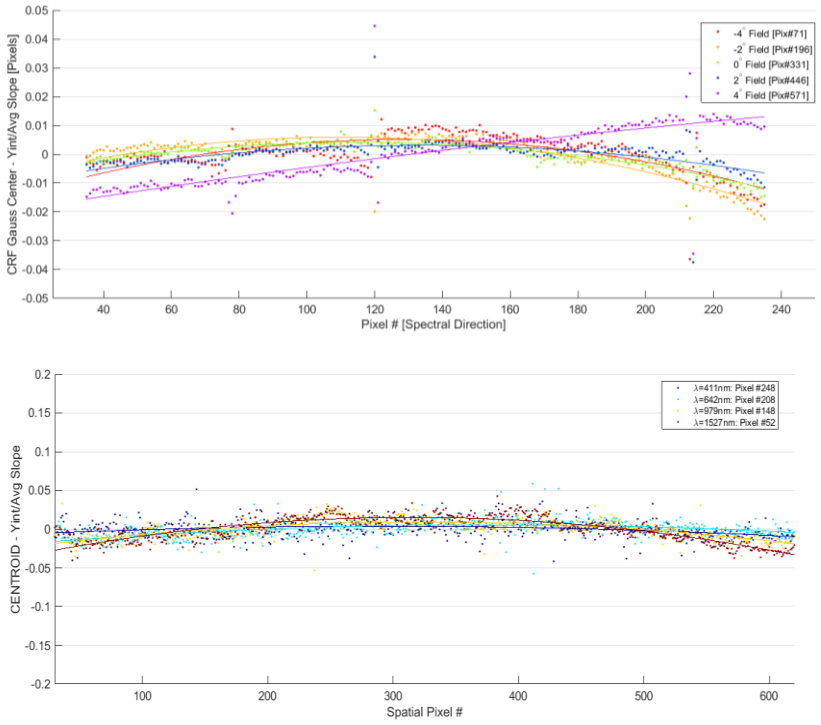
Cross-track spatial response functions for multiple wavelengths

Test results

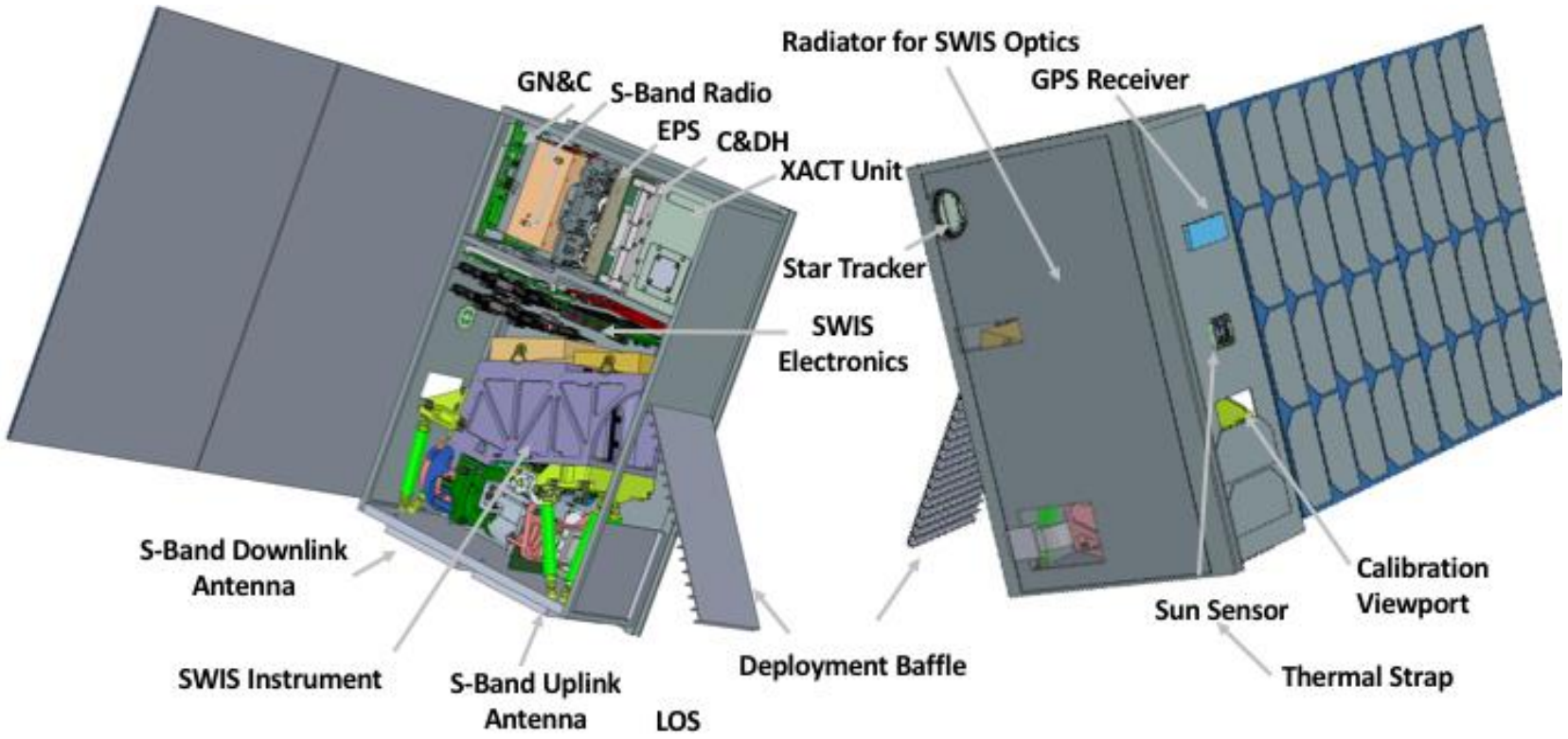
Along-track spatial response function for various wavelengths



Spatial/IFOV alignment error through wavelength and spectral error through field



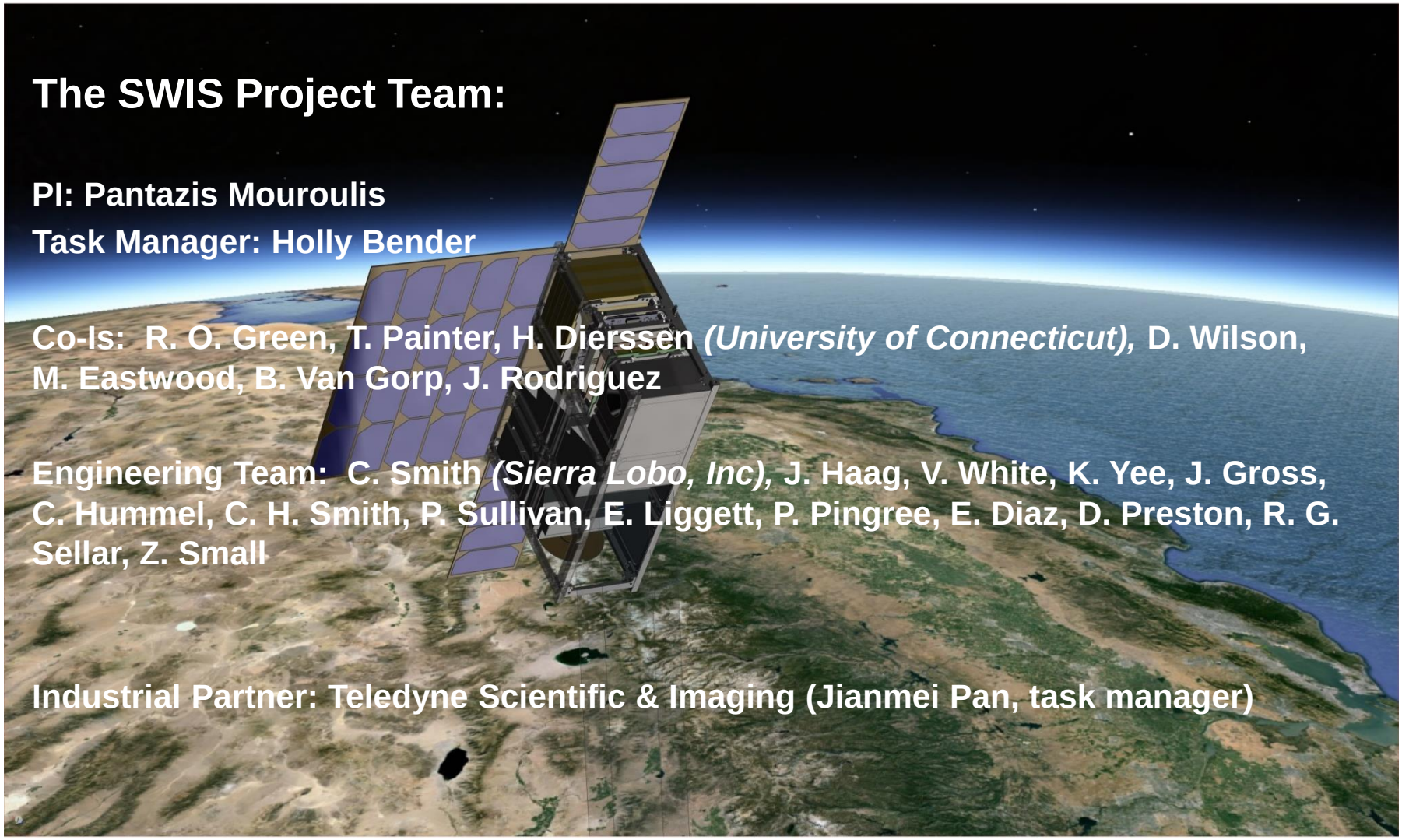
Revised spacecraft configuration



Conclusions

- SWIS Mission is proceeding both in terms of science definition as well as spacecraft configuration
- SWIS has demonstrated its original performance specifications, with confirmation of SNR pending improvements of detector and electronics
- Revised spacecraft configuration shows feasibility
- On-going study with Cal Poly SLO to finalize spacecraft design

Acknowledgments



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Industrial Partner: Teledyne Scientific & Imaging (Jianmei Pan, task manager)