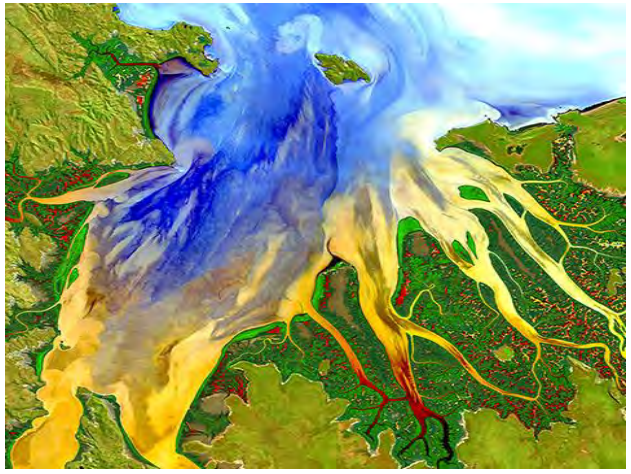

CHPS: The Compact Hyperspectral Prism Spectrometer for Sustainable Land Imaging

Tom Kampe
Ball Aerospace & Technologies

SLIT-15
Earth Science Technology Forum 2020
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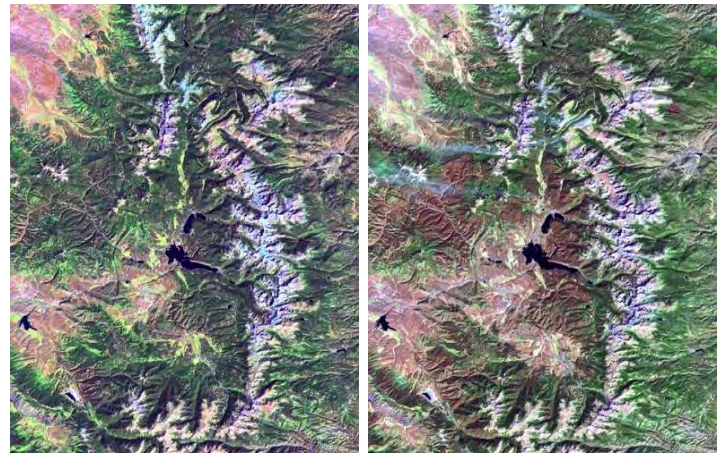
Sustainable Land Imaging-Technology Program

Targeted at developing technologies that

- *Reduce the risk, cost, size, volume, mass, and development time for the next generation **Sustainable Land Imaging (SLI)** instruments while meeting or exceeding the current **Landsat** land imaging capabilities;*
- *Enable new SLI measurements that can improve operational efficiency and reduce overall costs*
- ***Maintain continuity with heritage Landsat instrument to continue 40+ year data series***
- *Improve temporal, spatial, and **spectral resolution and sampling of SLI measurements***

- **The CHPS Program was awarded in 2016**
- **We are now in the final year of the project**



NASA

Ball Aerospace

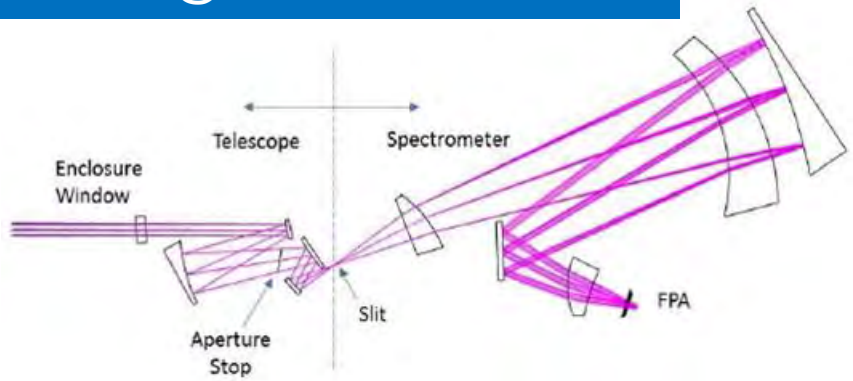
Compact Hyperspectral Prism Spectrometer (CHPS)

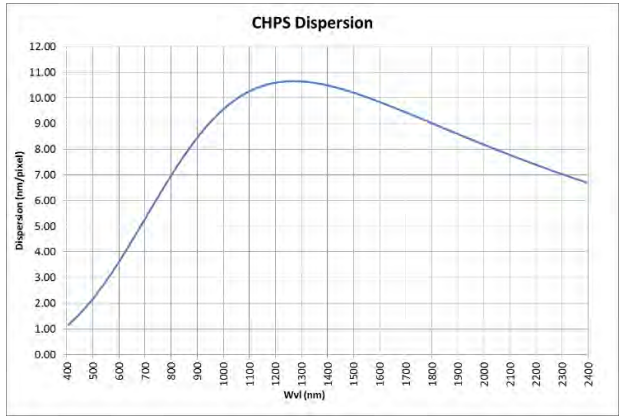
- **Objectives**
  - Provide improved science return with continuous VSWIR spectroscopic data in compact instrument form-factor
  - Provide high SNR performance comparable with OLI
  - Ensure high-quality spectral data with low stray light design
  - Provide low polarization sensitivity for inland and coastal water science
  - Maintain continuity with legacy Landsat instruments

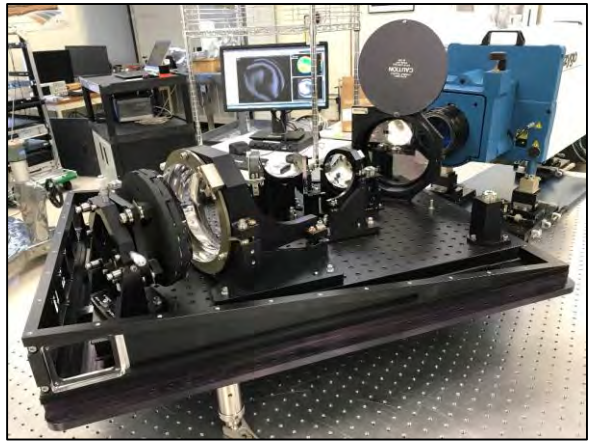
- **Approach**
  - Developed prism imaging spectrometer design to eliminate stray light issues due to grating scatter & grating/order-sorting filter issues
  - Developed an airborne instrument to demonstrate feasibility of approach
  - Conducted airborne campaigns to collect data over range of ecosystems for comparison to Landsat
  - Developed spaceborne instrument concepts

Airborne CHPS Optical Subsystem

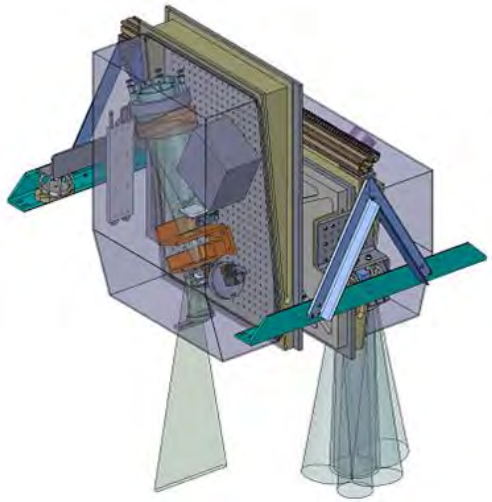
- F/3.0 Pushbroom system
- 20^0 Field of View
- Spectral range: 400 – 2500 nm
- Spectral Sampling: 1.3 to 13 nm/pixel
- 2.5 m GSD @ 4000 m Altitude



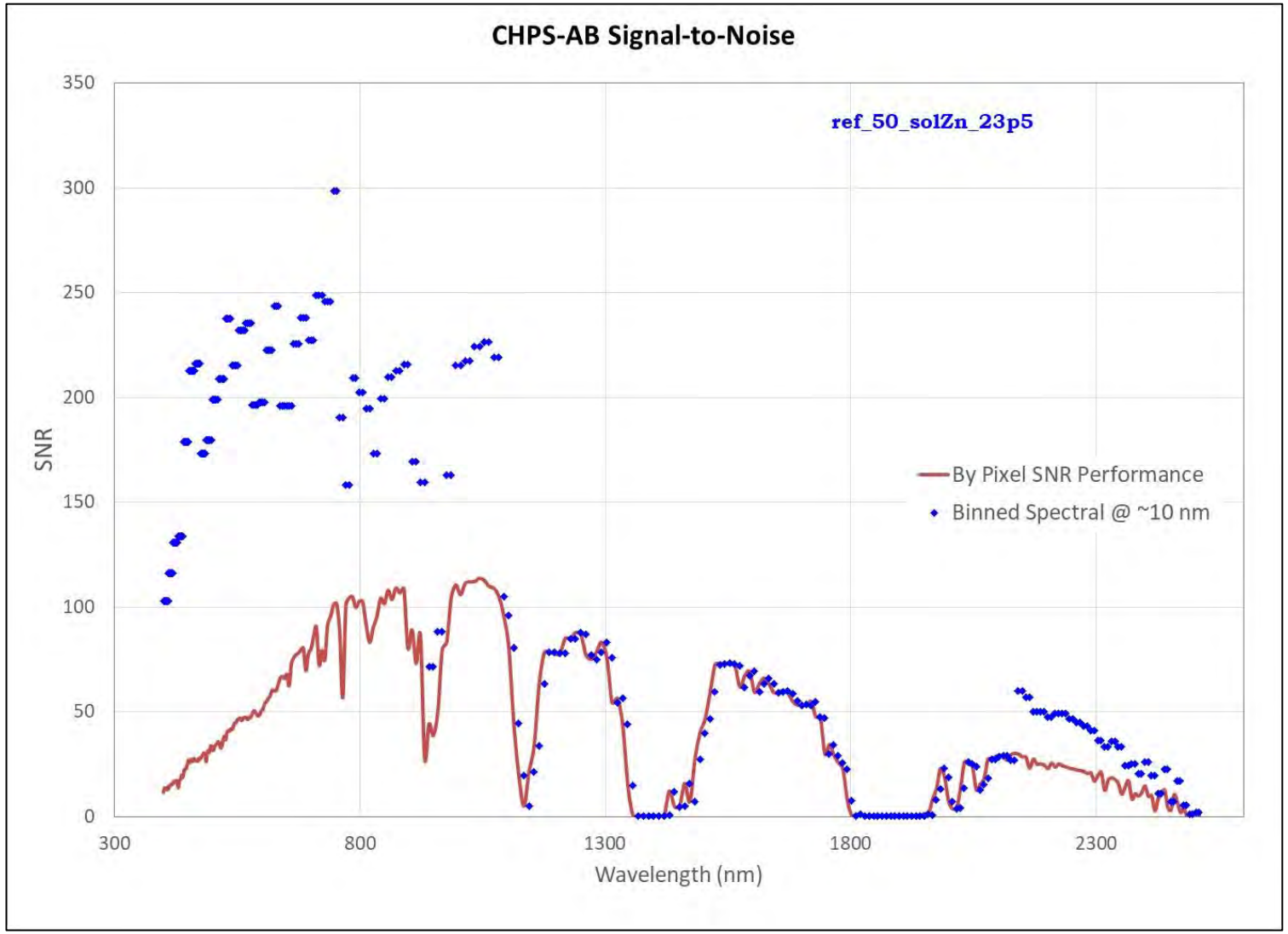




- 4-Mirror Telescope
- Prism spectrometer
- Fused Silica refractive elements
- Protected silver coated mirrors
- Optical system housed in thermally-controlled enclosure backfilled with dry nitrogen
- Integral on-board calibration sub-system

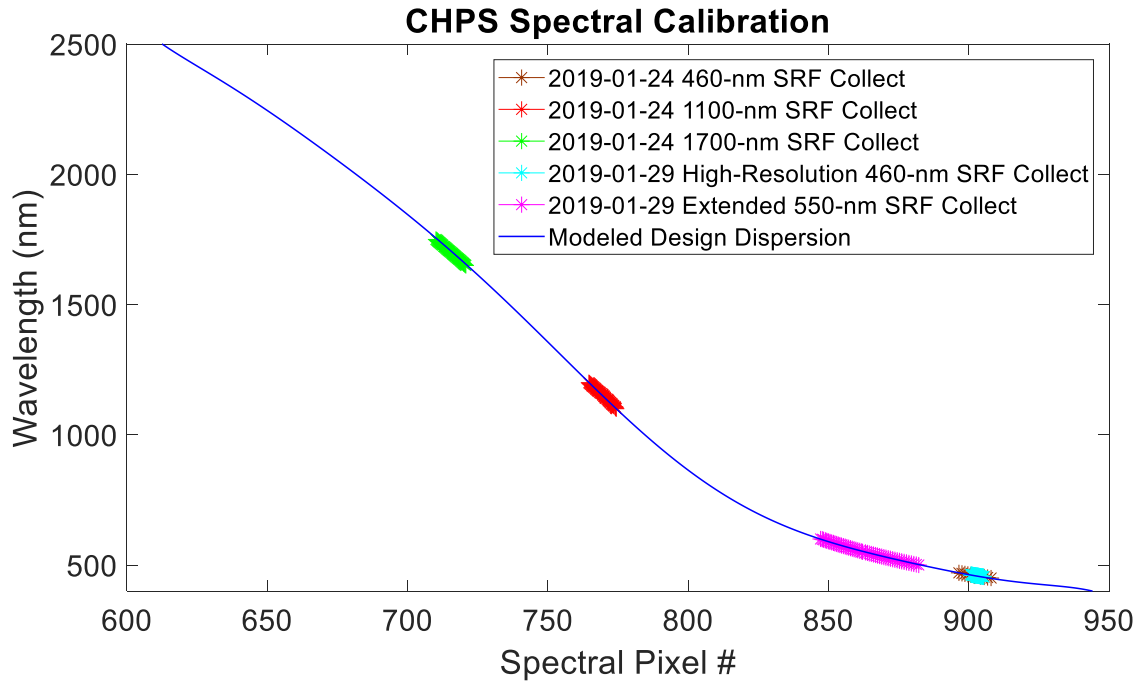


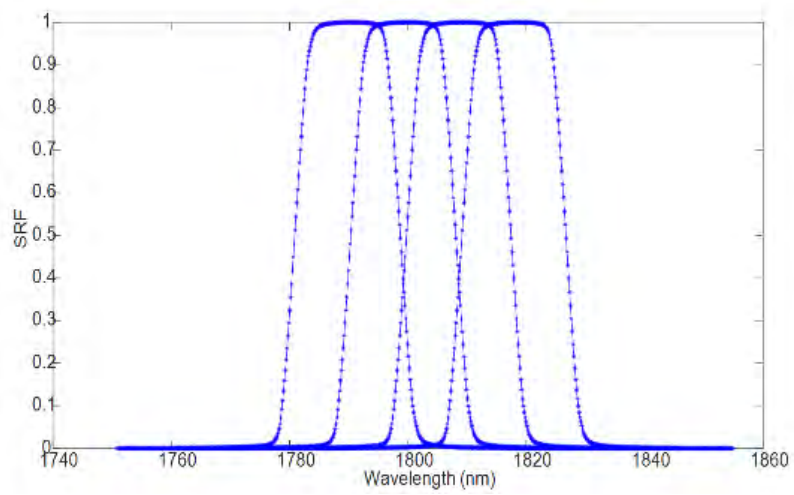
SNR Performance



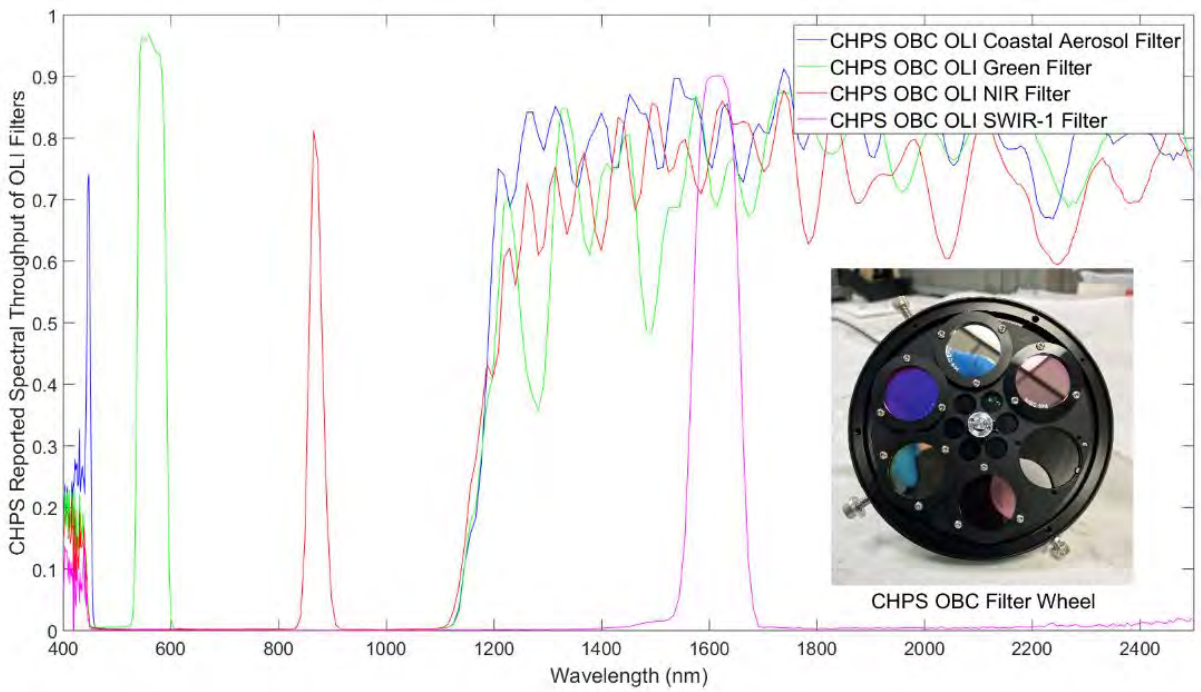
CHPS Spectral Calibration

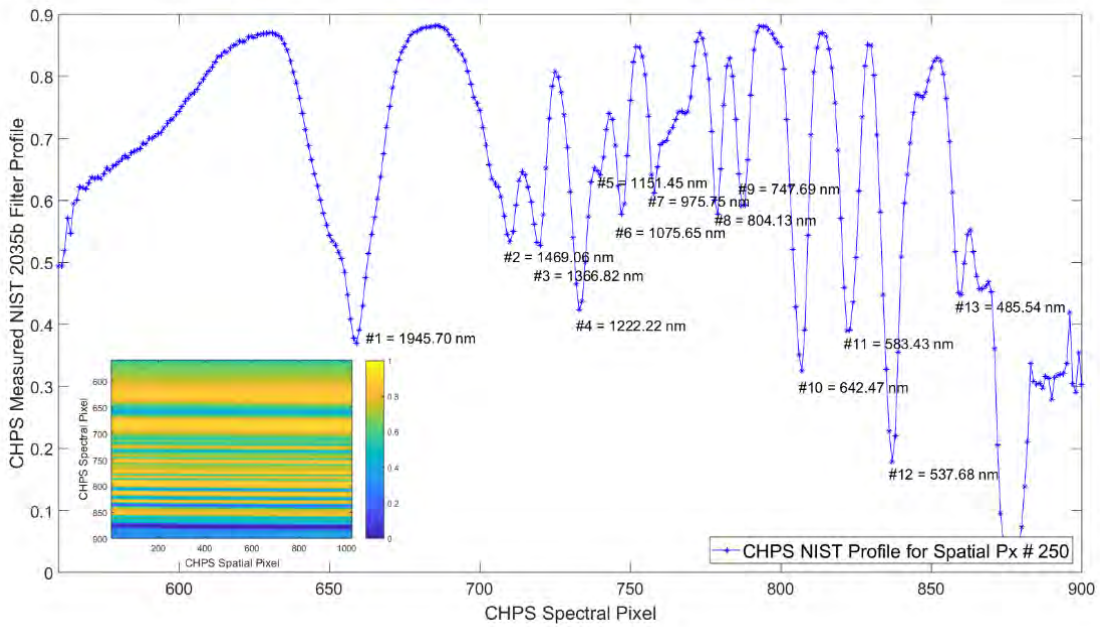
- Tunable Laser utilized to illuminate CHPS at select wavelengths
  - Spectral Mapping
  - Instrument Line Shape and Spectral Response Function
- Excellent correlation between measured Spectral Mapping and the designed Dispersion Model

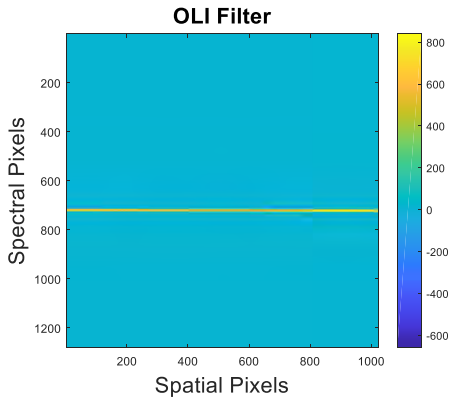




CHPS On Board Calibration Sequence



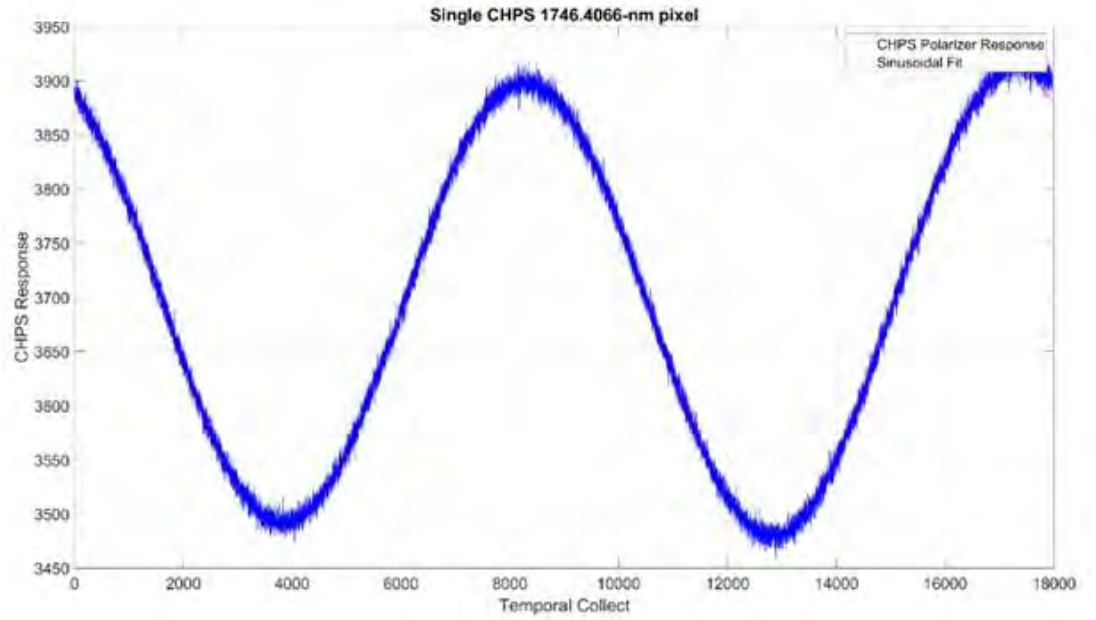


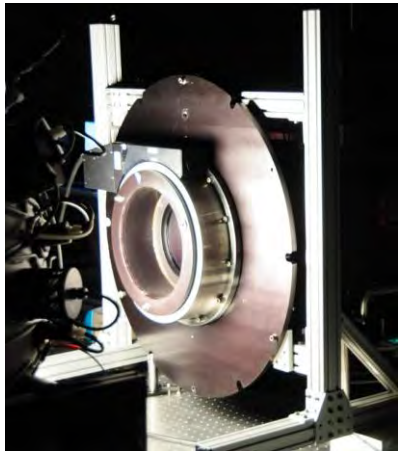


- **CHPS performance during flight is monitored using:**
  - **Broad-band Source**
  - **Shutter for dark collects**
  - **OLI filters**
  - **NIST 2035b Wavelength standard**
- **Calibration collects conducted for each flight line for sensor trending**

Low Polarization Sensitivity Provides Capability for Monitoring Near-Shore Waters

Landsat 8 “natural color" image using coastal/aerosol band 1 of Lake Erie (https://landsat.usgs.gov/)





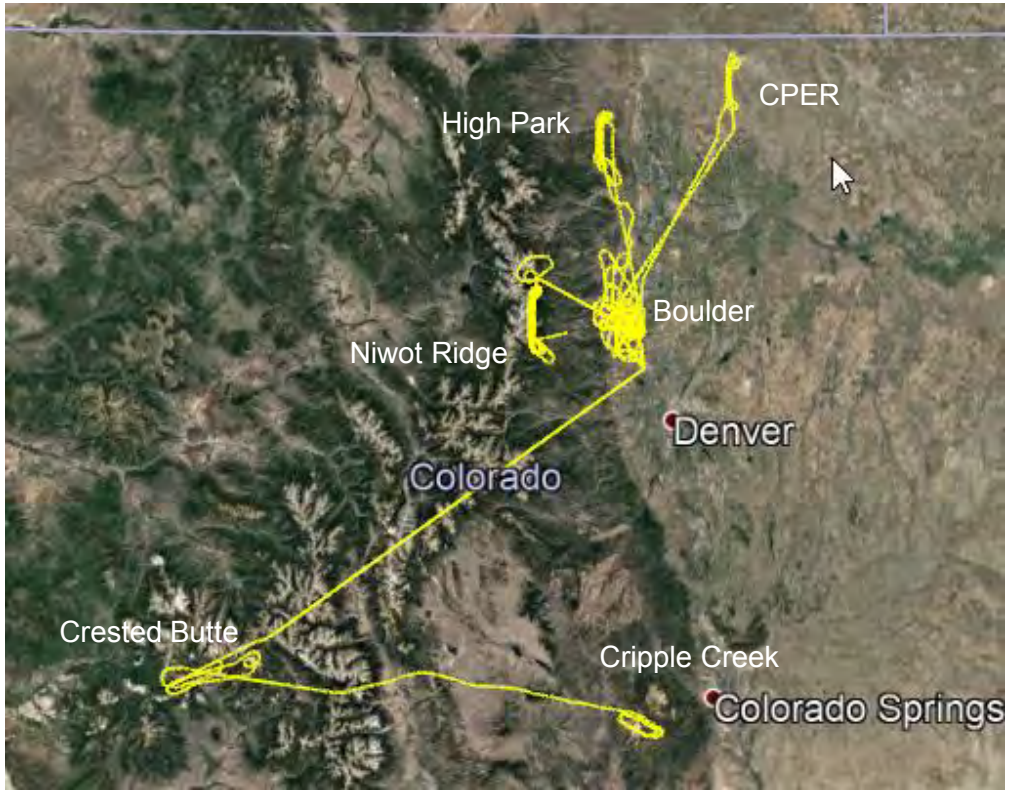
Coastal water science enabled by the addition of the Coastal Water Band on OLI, improved dynamic range, & high spatial resolution (30-m)

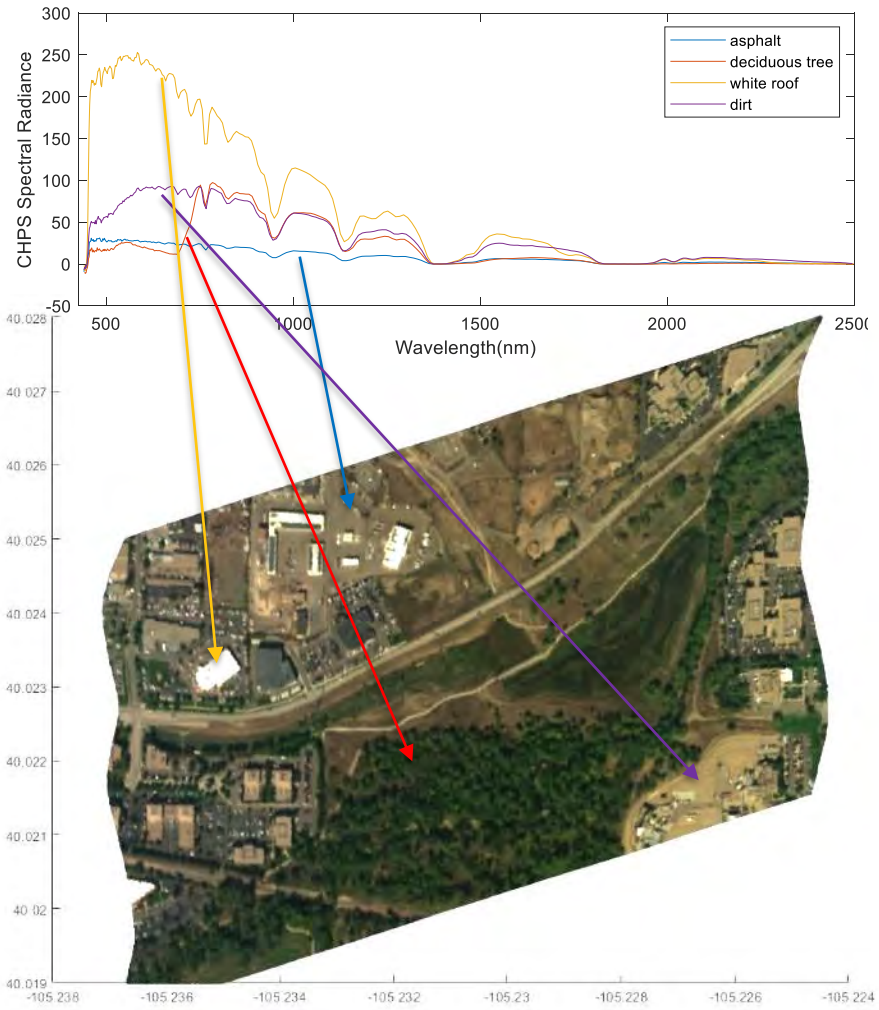
- **Chlorophyll, suspended sediments, colored-dissolved organic matter**
- **phytoplankton and algae blooms**

- Polarimetric characterization conducted post radiometric calibration with similar configuration
- Polarizer used for OLI characterization was used with Ralph sphere at two integration times
- CHPS polarization sensitivity generally within 2 to 4%

Airborne Campaigns

- 3 Airborne Campaigns successfully completed
  - 2018 Engineering Flight Campaign
  - 2019 Science Flight Campaign
  - May 2020 Science Flight Campaign



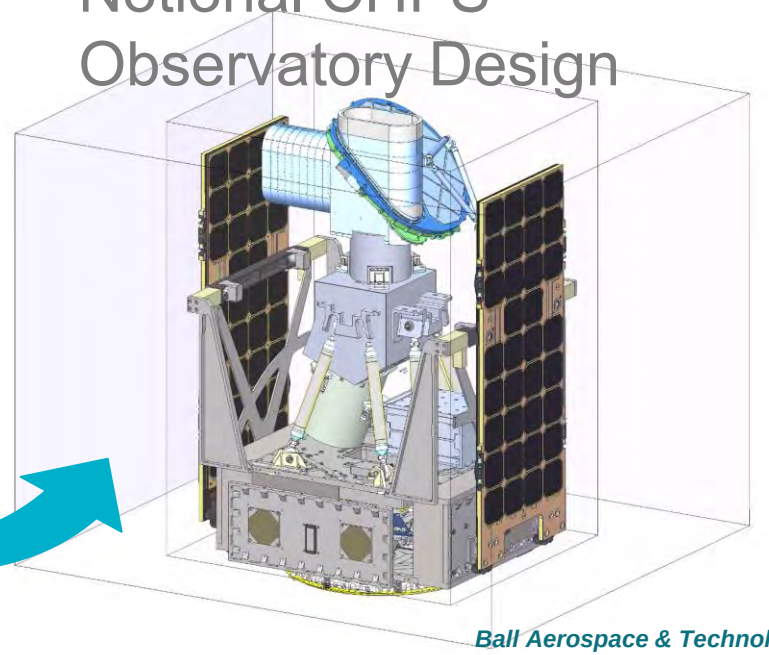


CHPS Hyperspectral Data maintains Landsat Continuity while Providing Target Spectral Information

Future Spaceborne Instrument Concepts Developed

100x reduction
in volume

Notional CHPS
Observatory Design



10x reduction
in mass

Significant Reduction in SWAP over Heritage Instrument

Acknowledgements

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- Ball Team:
  - Tom Kampe, PI
  - Nathan Leisso, Calibration
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  - Maddie Cowell, Data Processing, Flight Team
  - Betsy Farris, Systems Engineering / Flight Team
  - Bob Slusher, AI&T
  - Jerold Cole, Optical Engineering
  - Emily Mrkvicka, Optical Engineering
  - Bob Warden, Mechanical Engineering
  - Kyle Solander, Electronics
  - Jonathan Fox, Software / Flight Team
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