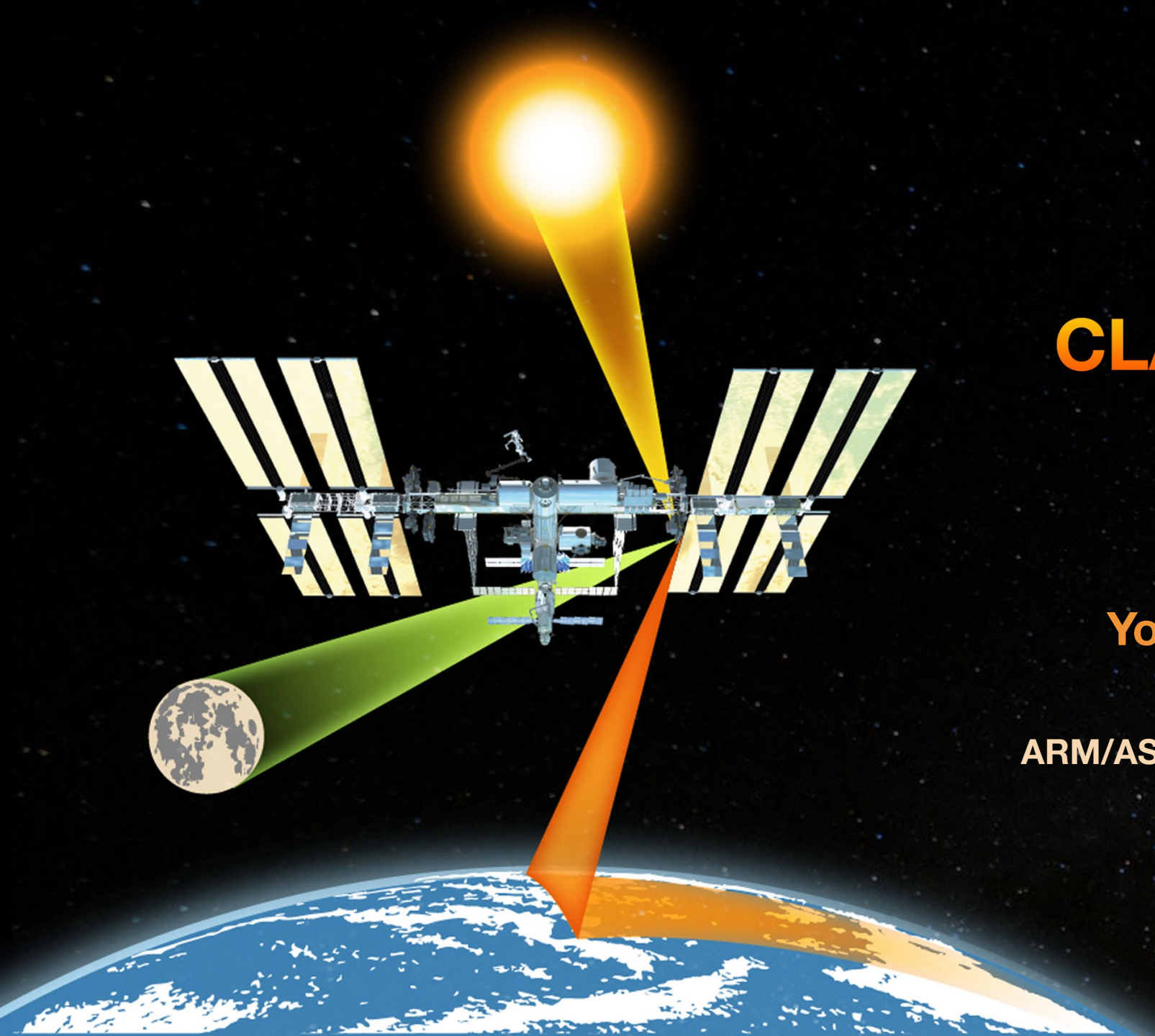
National Aeronautics and
Space Administration



CLARREO Pathfinder

Mission Update & Overview

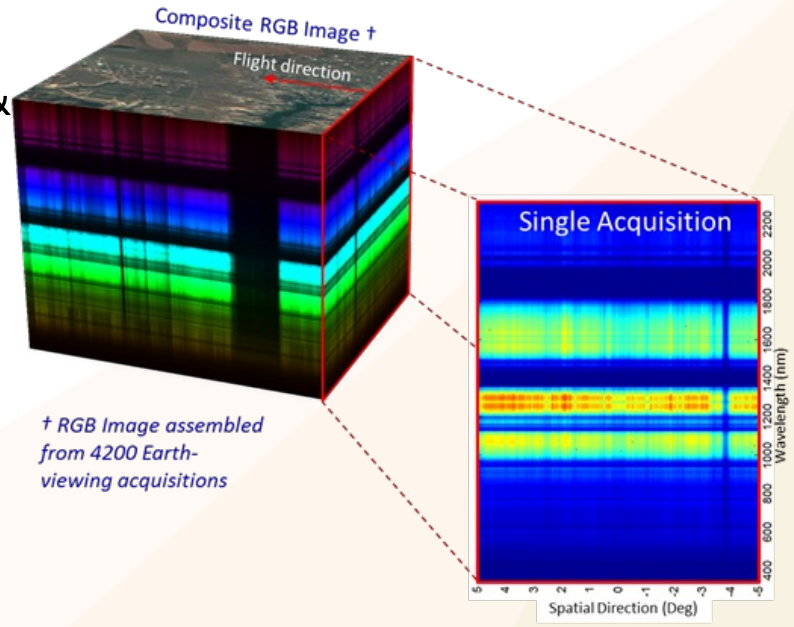
Yolanda Shea & the CPF Team

ARM/ASR Joint User Facility/PI Meeting 2023
August 7, 2023

CLARREO Pathfinder on ISS: Summary

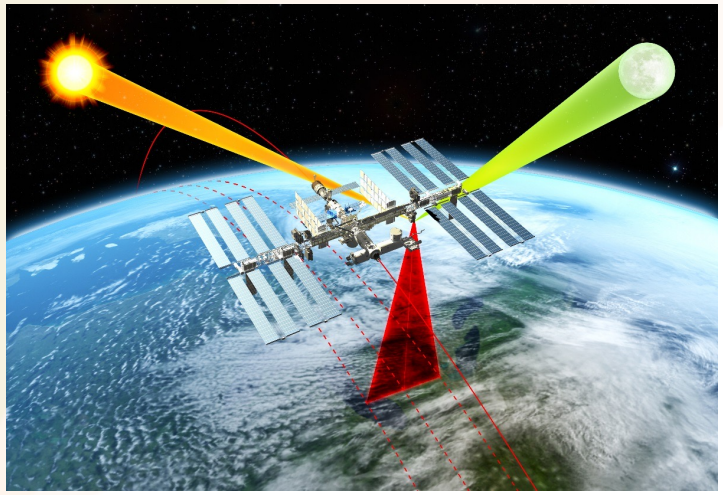
- **Mission Purpose:** Take climate-critical high accuracy measurements of Earth reflectance and intercalibrate with CERES (broadband) & VIIRS (multi-spectral) shortwave channels
- LASP-Led Reflected Solar Spectrometer (350 – 2300 nm) & Payload
- Nominally 1-year mission operations (but hopefully more!) + 1-year science data analysis
- Launch Readiness: ~Spring/Summer 2024
- Launch: TBD (ISS "Traffic Jam") – active work with NASA's Earth Science Division

Spectrally-Resolved Earth Reflectance



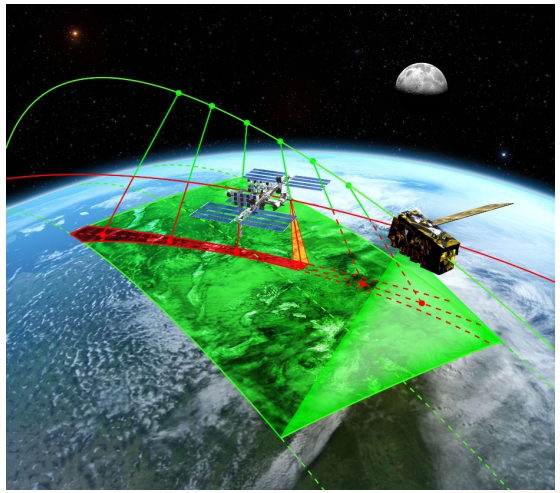
https://clarreo-pathfinder.larc.nasa.gov/

Objective #1: **High Accuracy SI-Traceable Reflectance Measurements**



Demonstrate on-orbit calibration ability to reduce reflectance uncertainty by a factor of ***5-10 times*** compared to the best operational sensors on orbit.

Objective #2: **InterCalibration Capabilities**

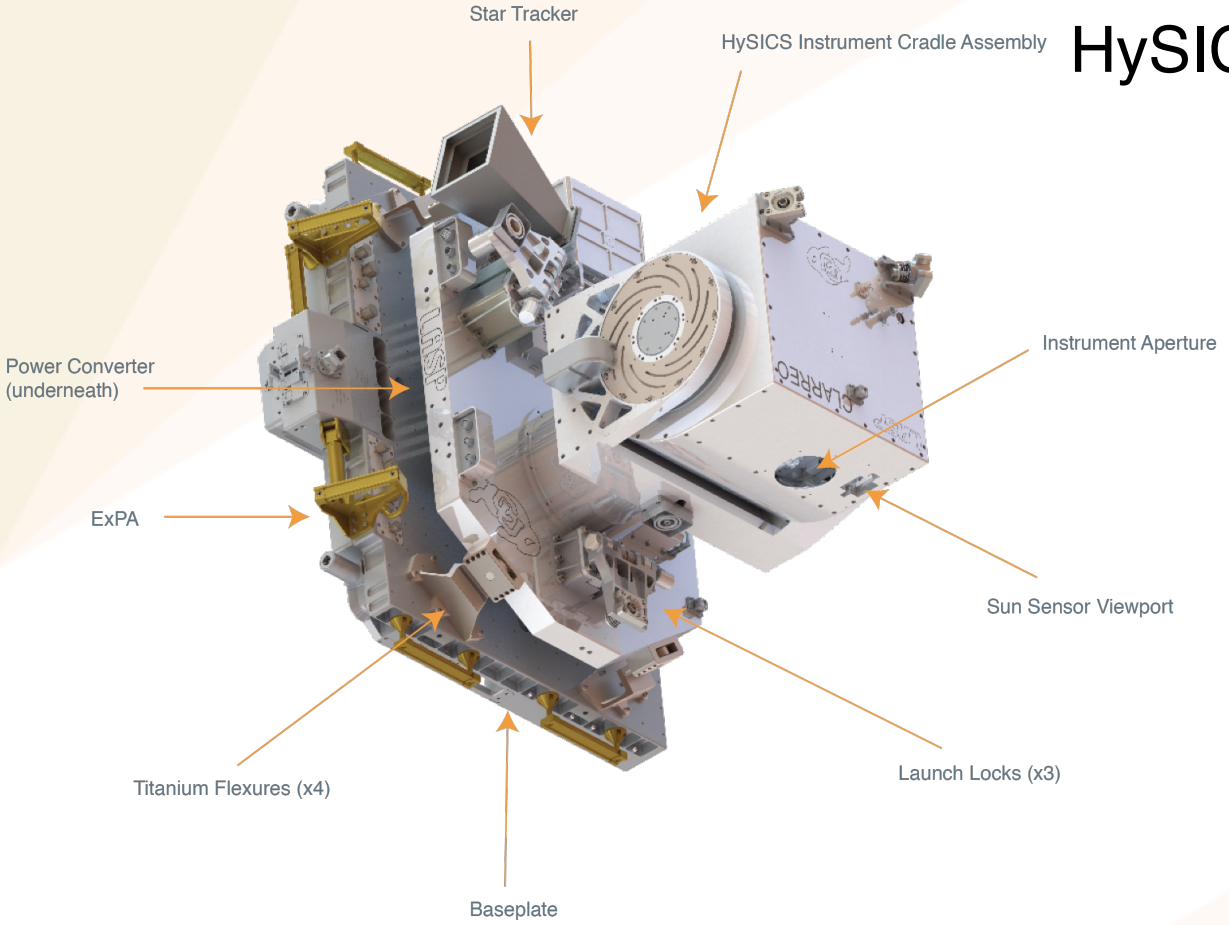


Demonstrate ability to transfer calibration other key RS satellite sensors by intercalibrating with CERES & VIIRS.

	Objective #1	Objective #2
Uncertainty	Spectrally-resolved & broadband reflectance: ≤0.3%-0.6% (1σ)	Intercalibration Methodology Uncertainty: ≤0.3% (1σ)
Data Product	Level 1A: Highest accuracy, best for intercal, lunar obs Level 1B: Approx. consistent spectral & spatial sampling, best for science studies using nadir spectra	Level 4: One each for CPF-VIIRS & CPF-CERES intercal. Merged data products including all required info for intercal analysis

CLARREO Pathfinder Payload

Novel Measurements: CLARREO Pathfinder will be ***the first*** Earth Science mission with its ***combination*** of high accuracy, spectral range, spectral resolution, and spatial resolution.

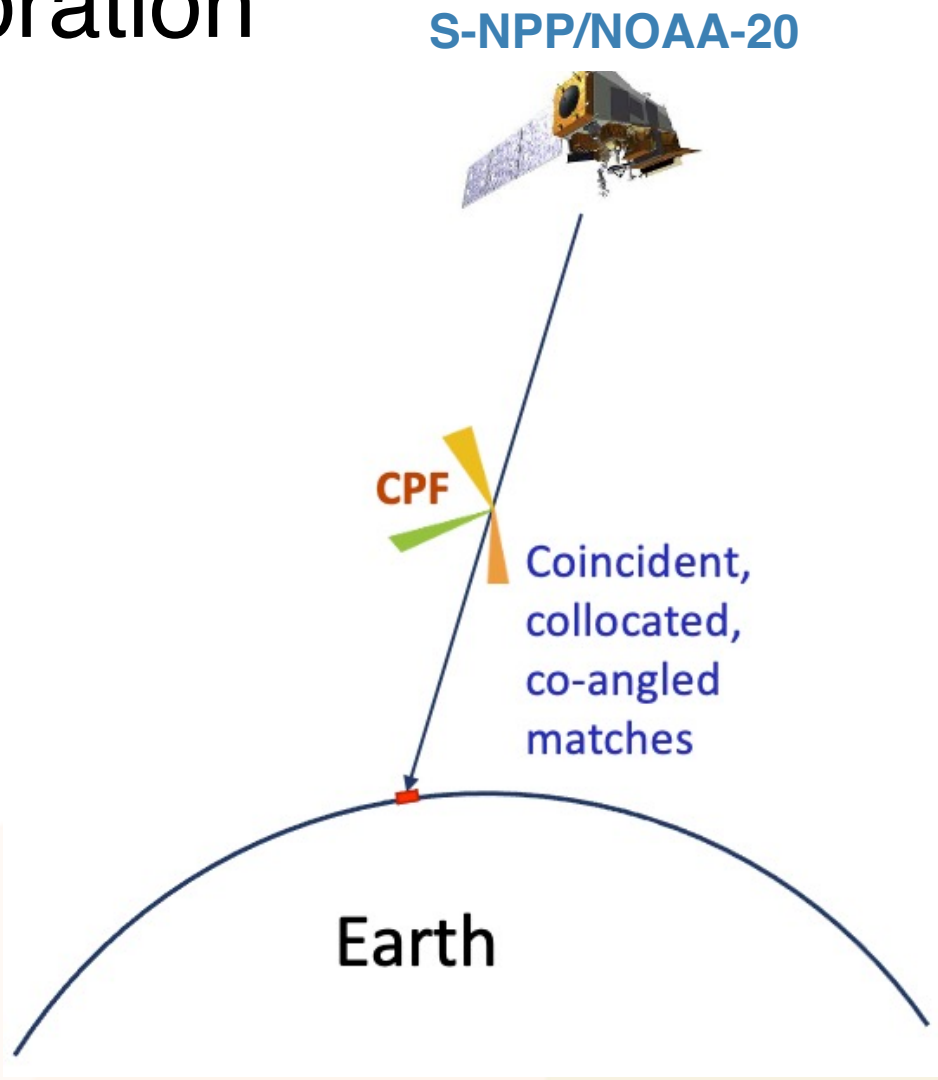


HySICS: Hyperspectral Imager for Climate Science

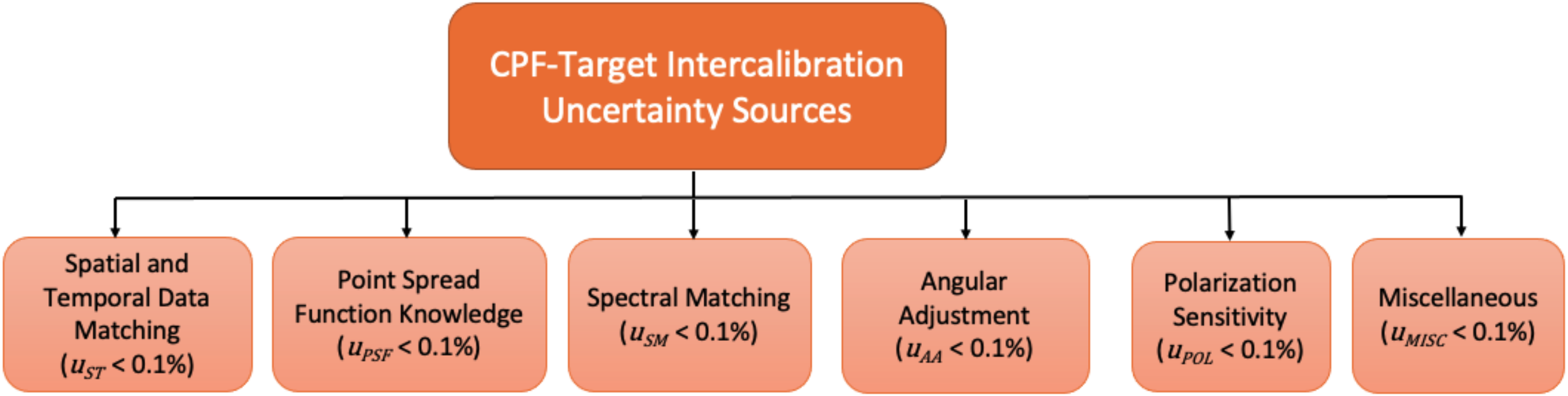
Radiometric Uncertainty	0.3%-0.6% (1-sigma)
Spectral Range	350 nm – *2261* nm
Spectral Sampling	3 nm
Swath Width	10° (70 km nadir)
Spatial Sampling	0.5 km
Sampling Rate	15 Hz

CPF-Target Instrument Intercalibration

- An idealized intercalibration setup has perfectly matched data in **time**, **space**, **angles**, and **wavelengths**
- Realistic intercalibration measurements have finite differences in sampling, thereby resulting in several sources of uncertainty
  - *Spatial mismatch*
  - *Angular differences (SZA, VZA, and RAA)*
  - *Spectral band differences*
- CPF will demonstrate a state-of-the-art intercalibration methodology mitigating the uncertainties from imperfect data matching
  - *2-axis pointing capability*

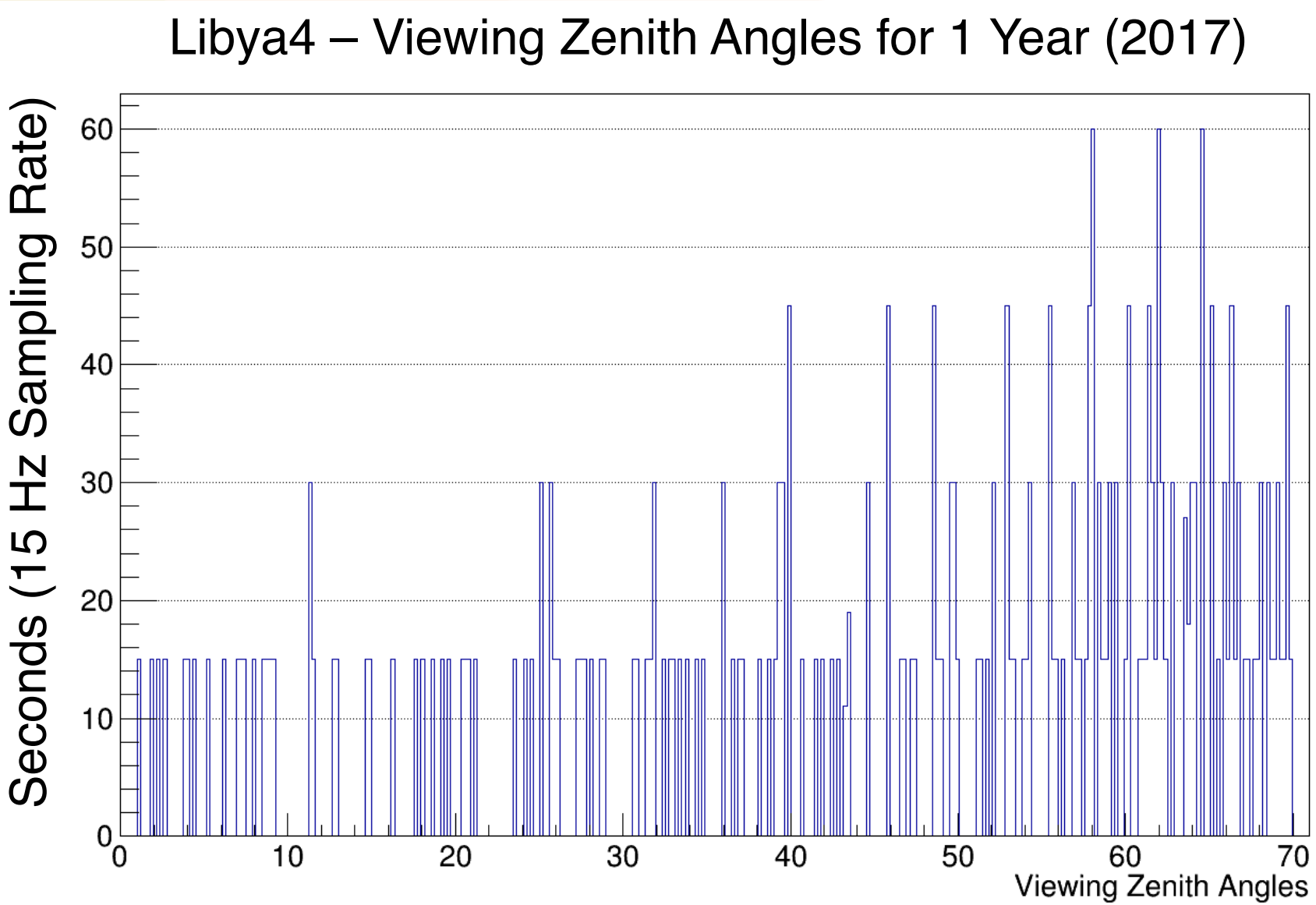


CPF-Target Intercalibration Uncertainty Sources



CPF Intercalibration Benefits

Core Mission Direct Targets (CERES & VIIRS)	Earth Energy Imbalance Spectral Response Calibration evaluation across dynamic range
Independent Verification of Radiometric Consistency between multiple flight models (e.g. CERES, VIIRS)	
Climate Data Record Continued Development, Improved Quality	MODIS-VIIRS Dark Target & Deep Blue Aerosol, Cloud Continuity Products (20+ year records!)
Lunar Reflectance Characterization	Complement to ARCSTONE & airLUSI Supplementing inputs to GIRO, ROLO, SLIMED, etc lunar char. models
Pseudo-Invariant Earth Targets	Deep Convective Clouds Hyperspectral, multi-angle land targets reflectance Improved PICS uncertainty characterization
Augmenting Existing Intercalibration Approaches	GSICS Standard? e.g. All-sky tropical ray matching, Surface PICS, DCCs, etc


Libya4 – Viewing Zenith Angles for 1 Year (2017)
Seconds (15 Hz Sampling Rate)
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
Viewing Zenith Angles

Leveraging the CPF Spectrum

Predecessor & Complement to Several Missions	Decadal Survey Missions PACE TRUTHS/Libra CERES-Libera Connection
Cloud, aerosol, water vapor, and surface hyperspectral retrieval algorithm development	
Developing a Climate Benchmark Prototype	Critical for monitoring geophysical variable changes to provide climate model constraints
Development of Climate Change Attribution Techniques	
Evaluating temporal variability of spectral radiation	e.g. How has spectral reflectance changed in past 20 years?

Dr. Jeff Mast, new LaRC NPP fellow, will be developing hyperspectral ice cloud retrievals.

Reasons to be excited about CPF

- High accuracy measurements critical for detecting climate trends
  - e.g. Development of climate benchmark prototypes
- Wealth of possibilities for additional RS hyperspectral science studies
  - e.g. New and complementary retrieval algorithms
- Reference intercalibration capabilities are far-reaching across Earth Science measurements
  - Intercalibrating (some) concurrently operational RS sensors
  - Support for **GSICS**: Global Space-based Inter-Calibration System
  - Improved characterization of The Moon & pseudo-invariant calibration sites (improving past instruments' calibration)