

# CLARREO Pathfinder: A New Perspective of Earth

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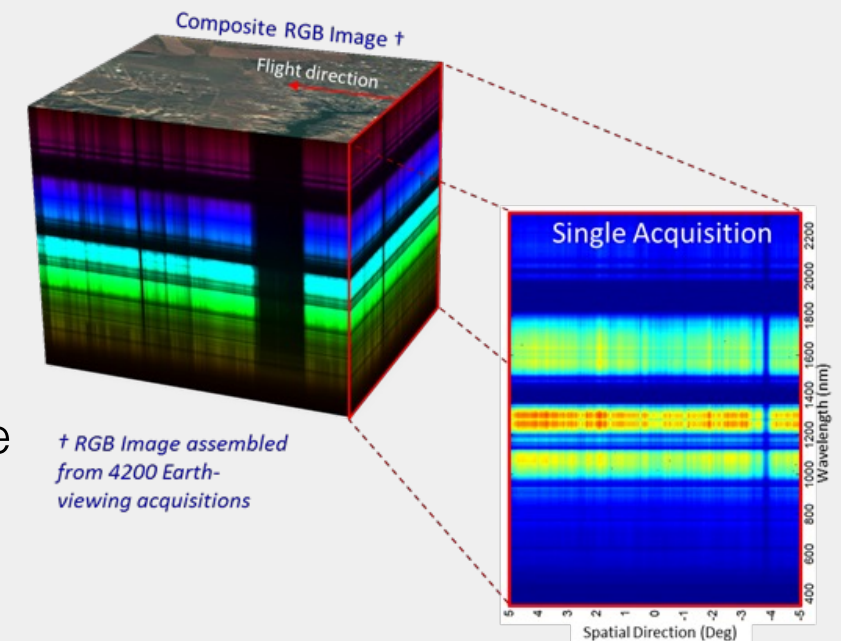
<sup>3</sup>NASA Goddard Space Flight Center

And THANK YOU to all CPF Science Workshop Participants!

## Climate Absolute Radiance and Refractivity Observatory

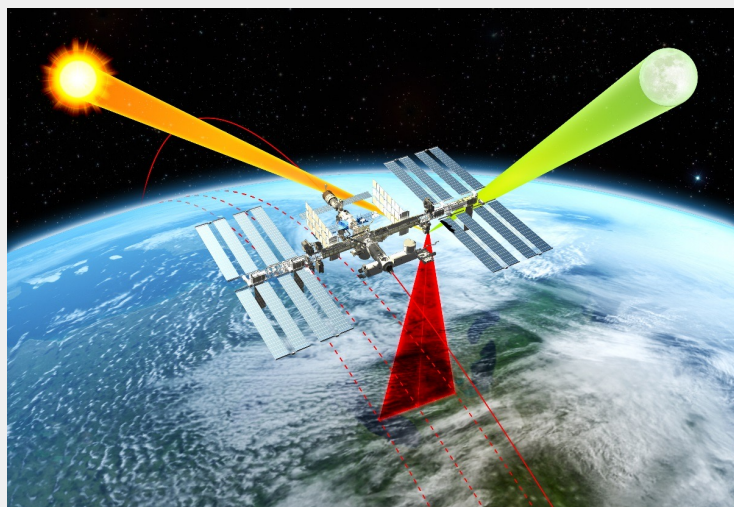
- **Core Mission Objectives:** Take climate-critical high accuracy measurements of Earth reflectance and inter-calibrate with CERES (broadband) & VIIRS (multi-spectral)
- LASP-Led Payload & Reflected Solar Spectrometer (350 – 2300 nm)
- Hosted on International Space Station
- *Nominal* 1-year mission operations + 1-year science data analysis
  - But wait there will be more! On ISS schedule through end of ISS life (2030)!
- Launch: December 2023

### Spectrally-Resolved Earth Reflectance



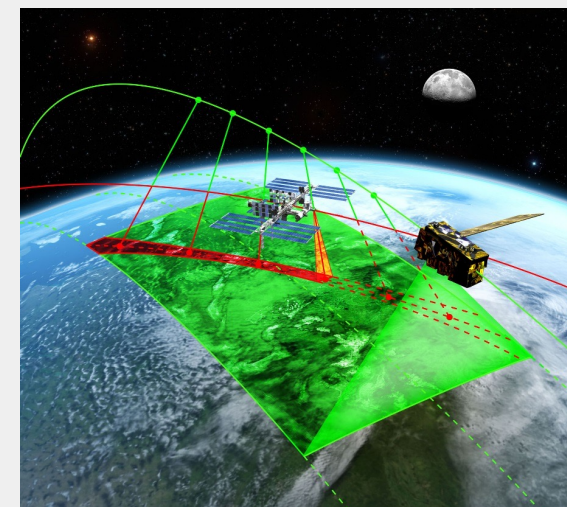
# CPF Science Objectives

## 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.

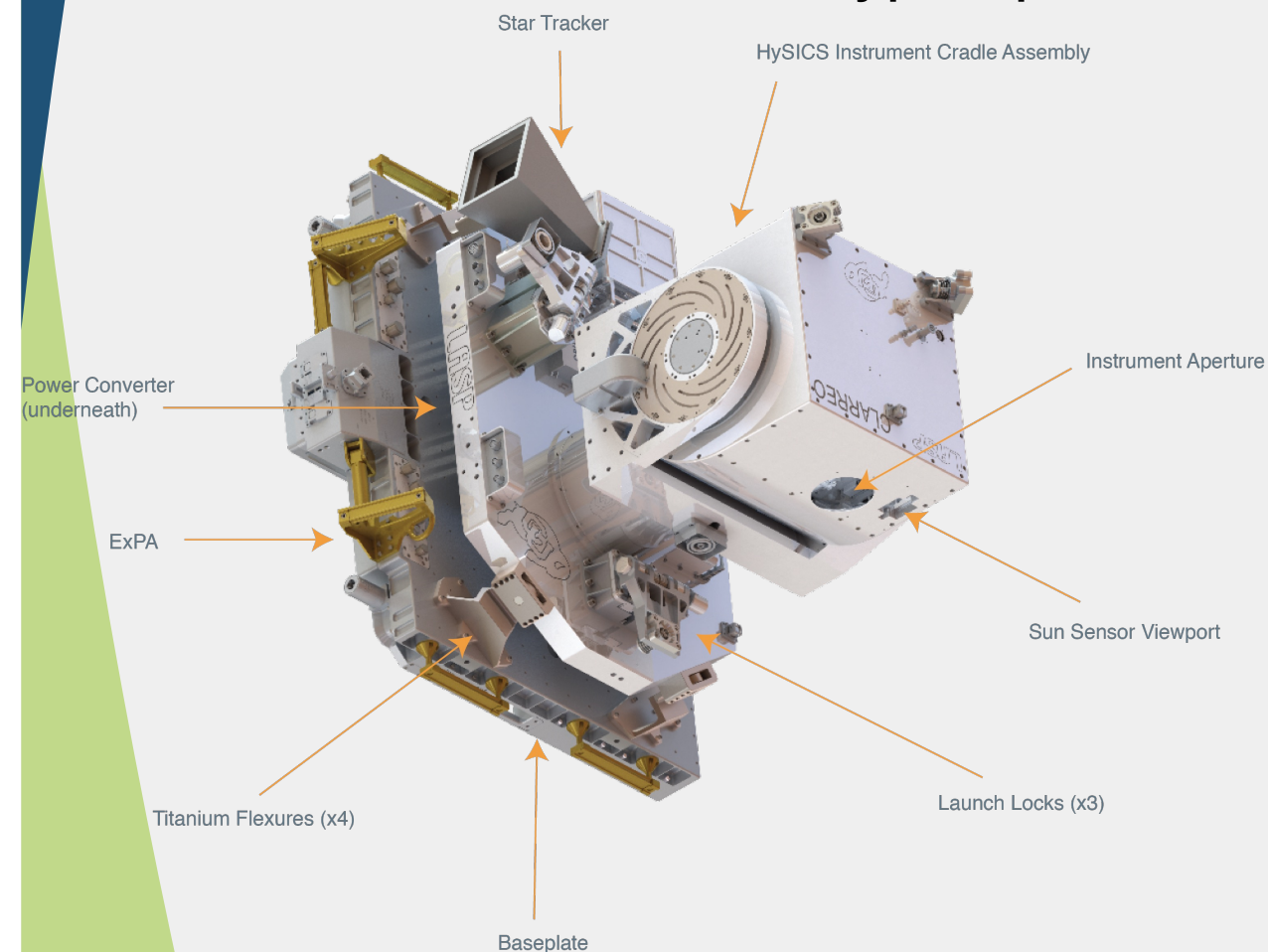
## Objective #2: Inter-Calibration Capabilities



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

	Objective #1	Objective #2
<b>Uncertainty</b>	Spectrally-resolved & broadband reflectance: $\leq 0.3\%$ ( $1\sigma$ )	Intercalibration Methodology Uncertainty: $\leq 0.3\%$ ( $1\sigma$ )
<b>Data Product</b>	Level 1A: Highest accuracy, best for inter-cal, 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 inter-cal. Merged data products including all required info for inter-cal analysis

## HYSICS: Hyperspectral Imager for Climate Science



<b>Radiometric Uncertainty</b>	0.3% (1-sigma)
<b>Spectral Range</b>	350 nm – 2300 nm
<b>Spectral Resolution</b>	6 nm
<b>Swath Width</b>	10° (70 km nadir)
<b>Spatial Resolution</b>	0.5 km
<b>Sampling Rate</b>	15 Hz

# Versatility in CPF Observations

Launch-Ready: Late 2023

Prime Mission Ops

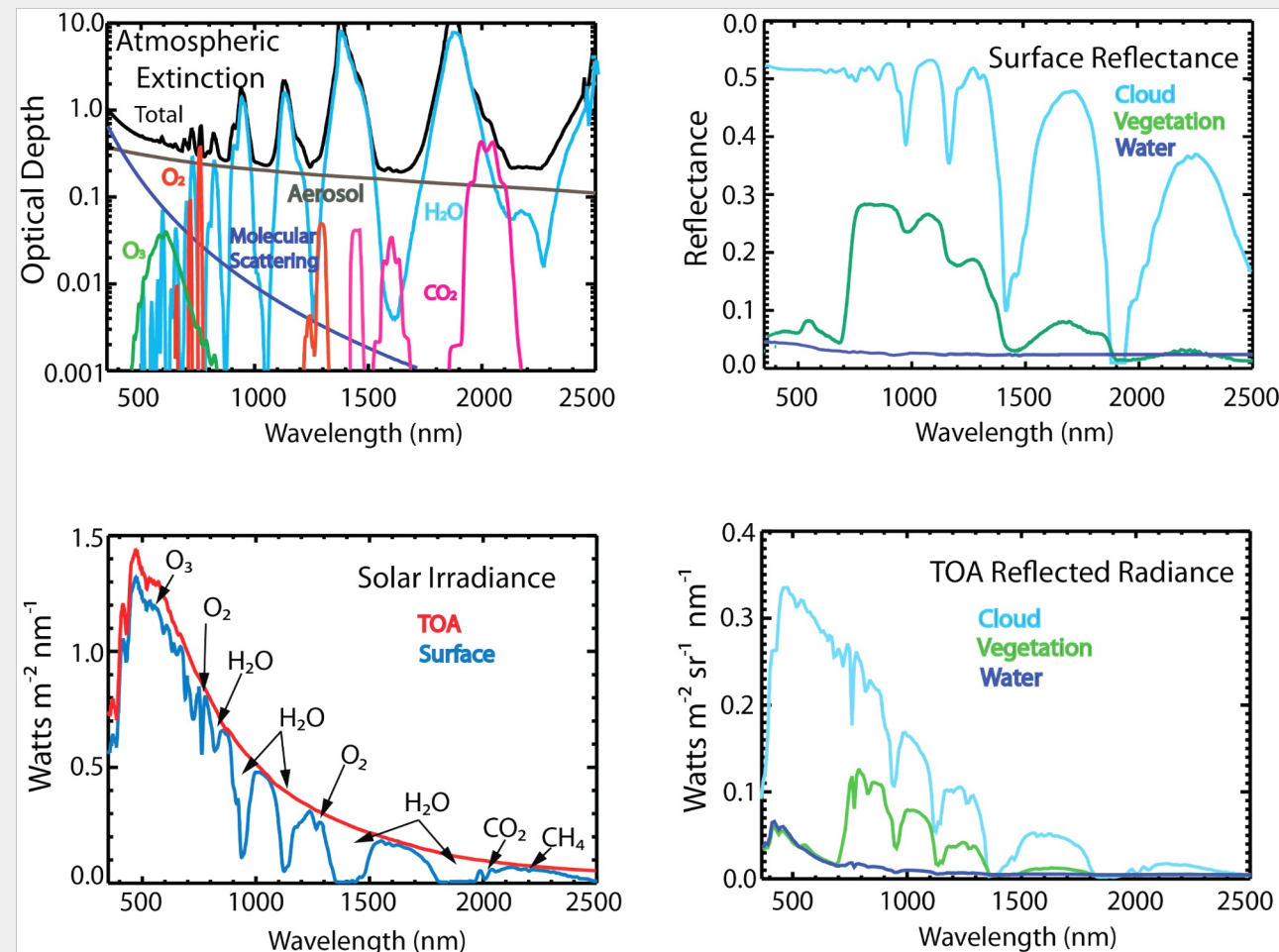
Extended Mission Ops (TBD)

Observation Type	1-Year Prime Mission	2025 – 2030??
On-orbit Instrument Calibration	Confirm success of calibration approach over 1 year	
Earth Reflectance and Radiance Nadir Spectra	Will be used to confirm achieved calibration, geolocation, etc requirements	
LEO On-orbit Inter-calibration	Measurements and data analysis for CERES and VIIRS Only	
GEO On-orbit Inter-Calibration	Demonstration measurements with 1 GEO	
Enhanced Land/DCC Pseudo-Invariant Calibration Site (PICS) Characterization	Measurements over high priority PICS	
Improved characterization of the Moon	Leveraging existing ops mode to cover libration and phase angles available	



# Nadir CPF Hyperspectral Measurements

High accuracy, information-packed measurements are critical for both detecting climate change and identifying what is driving Earth's changing climate (*Shea et al., 2022 [In Press]*).



B. Kindel

# CPF Science Workshop 2021

November 2-3, 2021

CPF Science Workshop

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CC GK DD BK SU AW TS [Profile] KT RL TC ES +25

Changyong ... Gregory A K... Doelling, D... Bruce Kindel Sirish Upret... Aisheng Wu Stone, Tho... Bhatt, Rajen... Kevin Turpi... Ron Lockwo... Taeyoung C... Siman-tov, ...

Shea, Yolanda (LARC-E302)

Kevin Turpie (Guest)

Jucks, Kenneth W. (HQ-DK000)

Platnick, Steven E. (GSFC-6100)

Manik Bali

Wu, Wan (LARC-E303)

Gregory A Kopp

Aisheng Wu

Bhatt, Rajendra (LARC-E302)

Odele Coddington

Peter Pilewskie

Cummings, Cadan R. (LARC-E...)

Liu, Xu (LARC-E303)

Tahersima, Mohammad H. (G...)

Taeyoung Choi

Changyong Cao (Guest)

Adam Thurston

Ron Lockwood (Guest)

# CPF Science Workshop Objectives

1. Educate those external to the CLARREO Pathfinder Project about the mission, payload capabilities, and science objectives.
2. Hear about the science community's interest in how CPF measurements can support their research interests.
3. Support the development of a community interested in using CPF hyperspectral reflected solar measurements.
4. Encourage discussion/coordination among participants.



# Leveraging the CPF Spectrum



Predecessor &  
Complement to Several  
Missions

Decadal Survey Missions  
PACE  
TRUTHS/Libra



Cloud, aerosol, water vapor, and surface remote  
sensing studies and 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?

# 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!)  
Landsat/Land Imagers



## Lunar Reflectance Characterization

Complement to ARCSTONE & airLUSI  
Supplementing inputs to GIRO, ROLO, 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

# Conclusions/Closing

- Science Opportunities Abound!
  - CPF NPP Opportunity – please share!
  - CPF Internship Opportunities too!
- Interested in more detail? See [most] presentations from the workshop on our website
  - <https://clarreo-pathfinder.larc.nasa.gov/meetings-and-workshops/>
- Next CPF Science Workshop: ~Spring 2023
  - Contact me if you'd like to be added to the participant list
- CLARREO Pathfinder scheduled to Launch on SpaceX Launch 29 – December 2023
- CLARREO Pathfinder Science Team Solicitation anticipated in ROSES-24

