

CLARREO Pathfinder: Mission Overview

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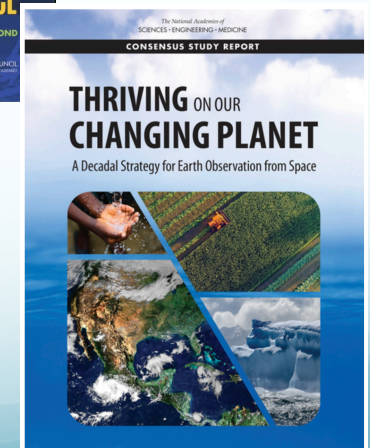
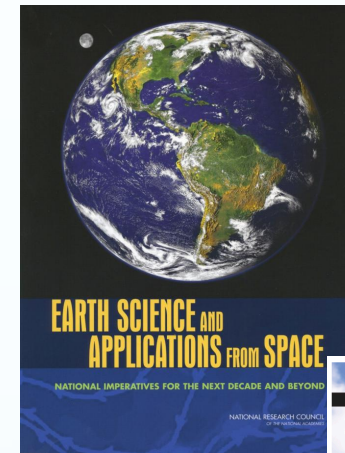
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Climate Absolute Radiance and Refractivity Observatory

- **CLARREO Mission:** Tier 1 recommended mission in 2007 Decadal Survey
- **Purpose:** To address critical need of...
 1. Sufficient accuracy for climate change observations and improved confidence in observing the small climate change signals over decadal and longer time scales
 2. Sufficient information content for attribution.
- **2017 Decadal Survey:** Radiance Inter-calibration recommended to address *Most Important* science priority of reducing climate sensitivity uncertainty.
 - Recommended that NASA execute Program of Record - ***Including CLARREO Pathfinder***

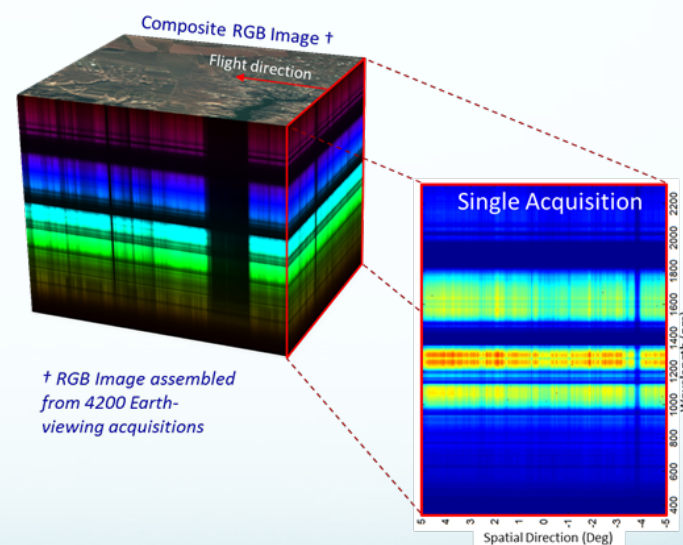


- **Mission Purpose:** Demonstrate ability to achieve unprecedented accuracy measurements of Earth reflectance and inter-calibration with CERES (broadband) & VIIRS (multi-spectral)
 - Aligned with recommendations made in 2007 and 2017 Earth Science Decadal Surveys

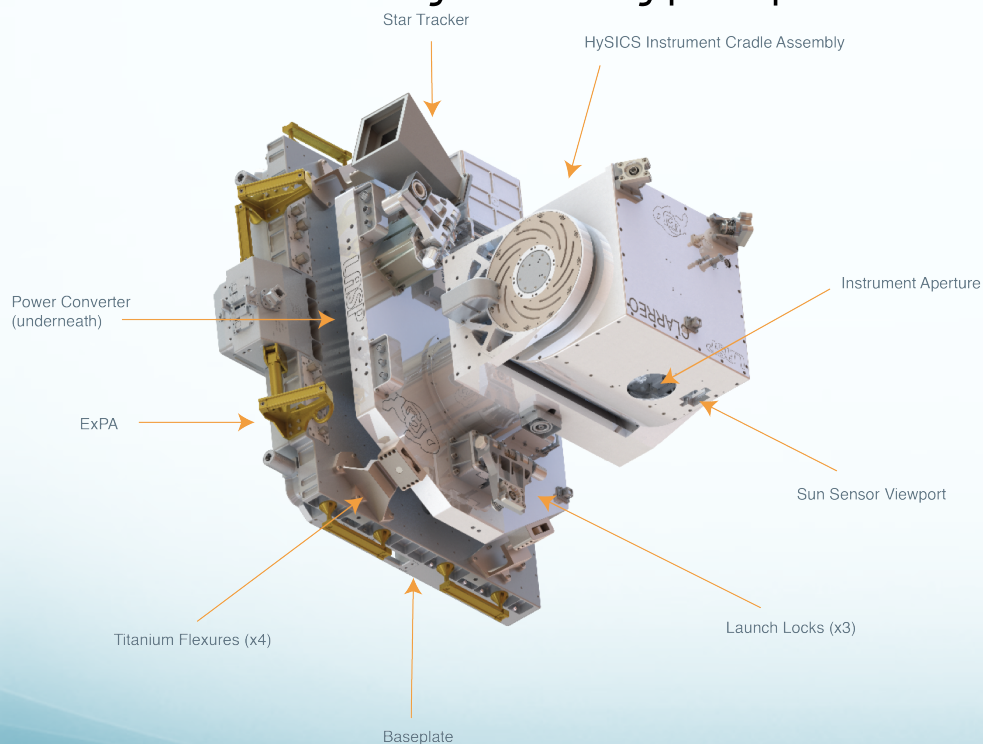
Mission Summary

- LASP-Led Reflected Solar Spectrometer (350 – 2300 nm)
- Platform: International Space Station
- Nominal 1-year mission life + 1-year science data analysis
- Launch Readiness: 2023
- Purpose: Advance and demonstrate on-orbit calibration and inter-calibration technologies and approaches for improved climate change observations

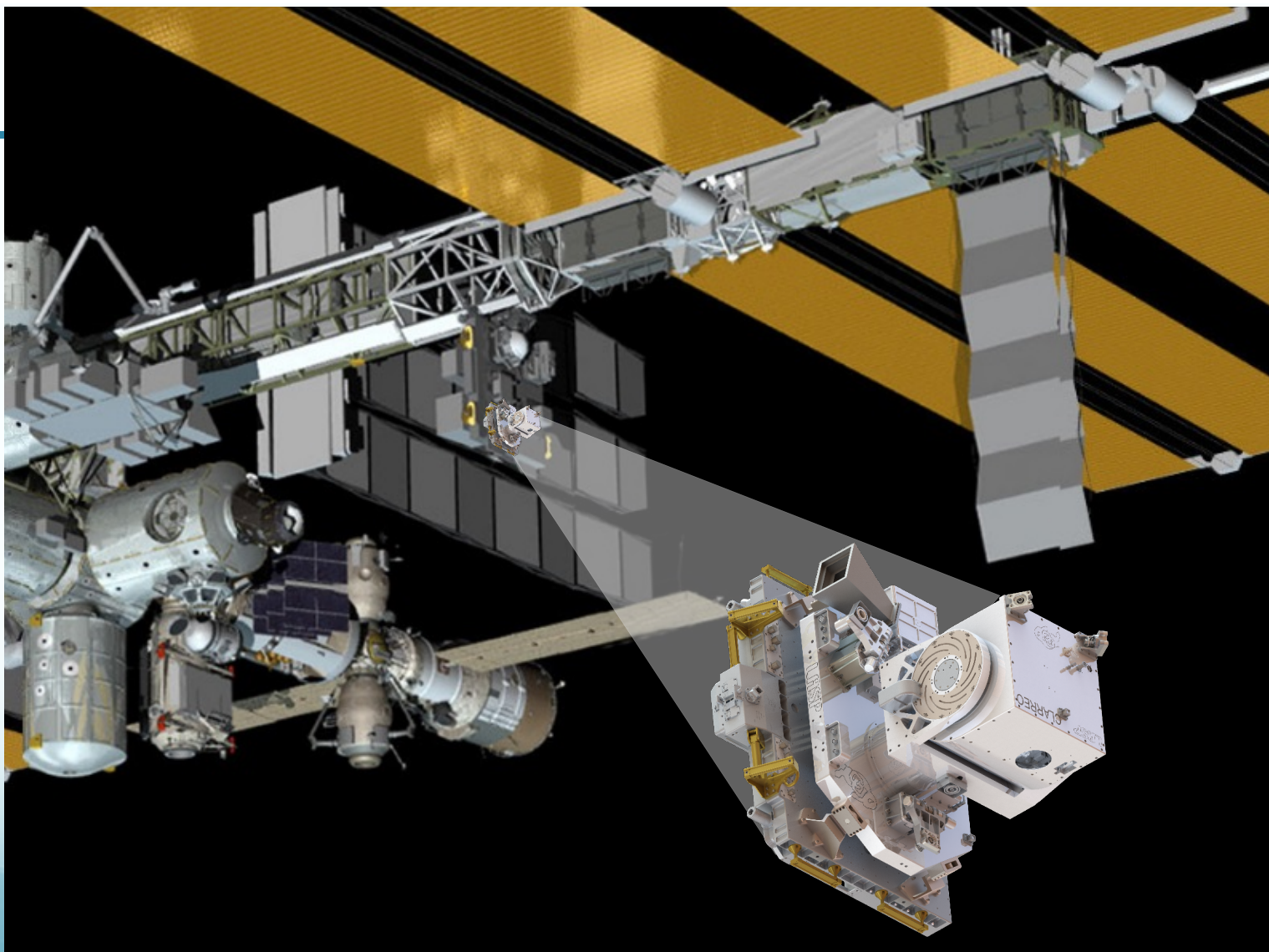
Spectrally-Resolved Earth Reflectance



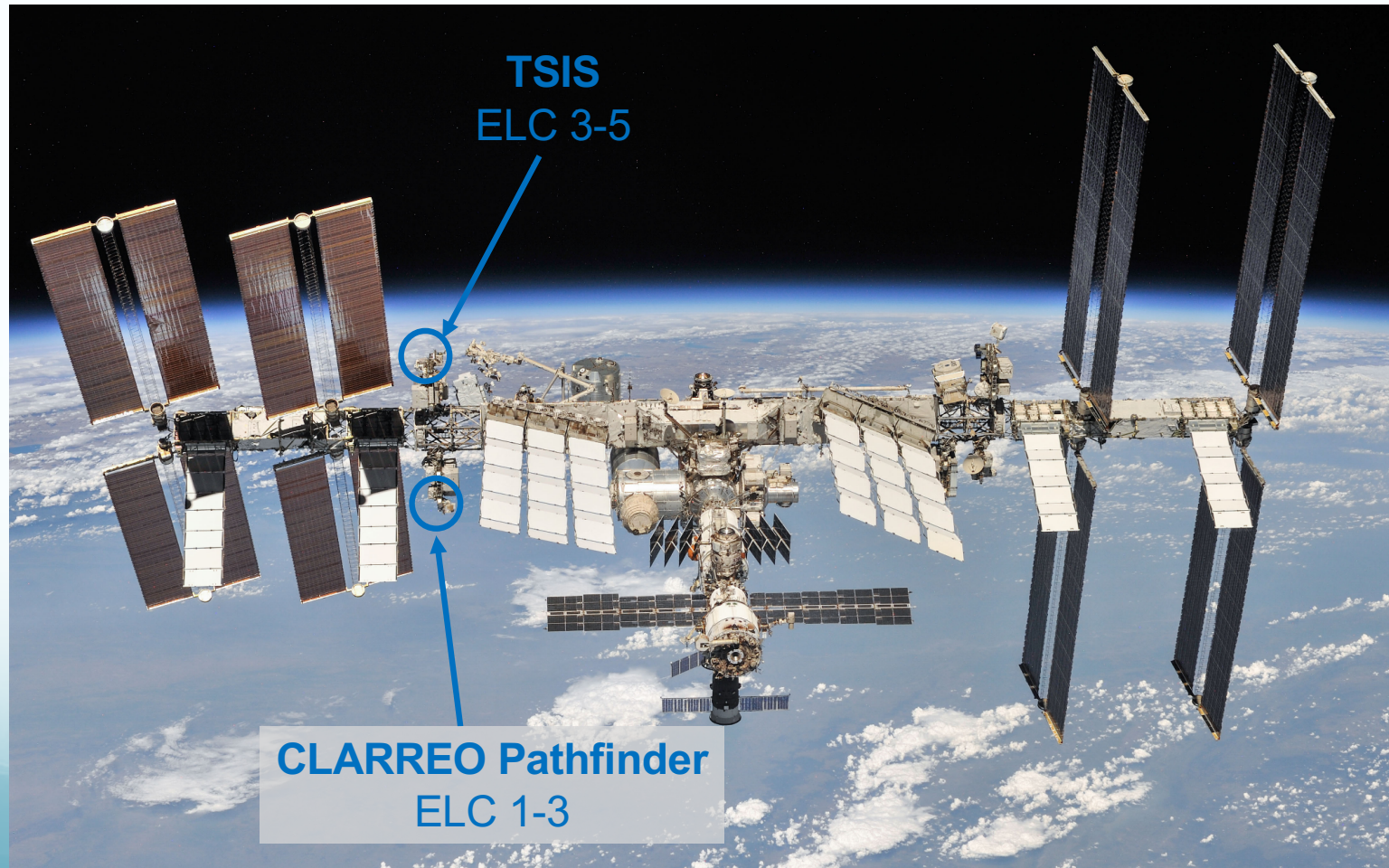
HySICS: Hyperspectral Imager for Climate Science



Radiometric Uncertainty	0.3% (1-sigma)
Spectral Range	350 nm – 2300 nm
Spectral Sampling	3 nm
Swath Width	10° (70 km nadir)
Spatial Resolution	0.5 km
Sampling Rate	15 Hz

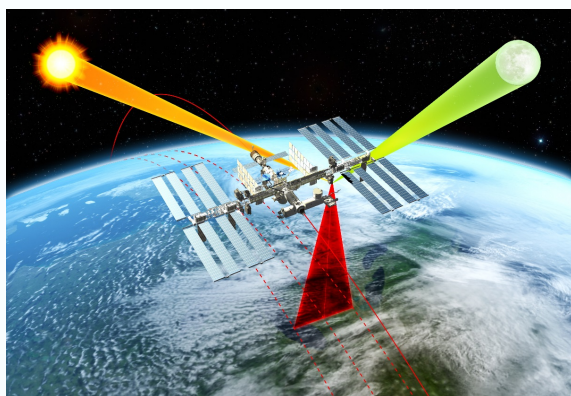


Our Future Home on ISS



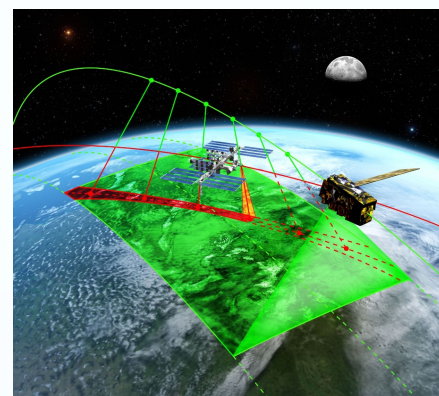
CLARREO Pathfinder Objectives

Objective #1: High Accuracy SI-Traceable Reflectance Measurements



Demonstrate on-orbit calibration ability to reduce radiance uncertainty by a factor of **4-8 times** compared to the best operational sensors on orbit.

Objective #2: Inter-Calibration Capabilities

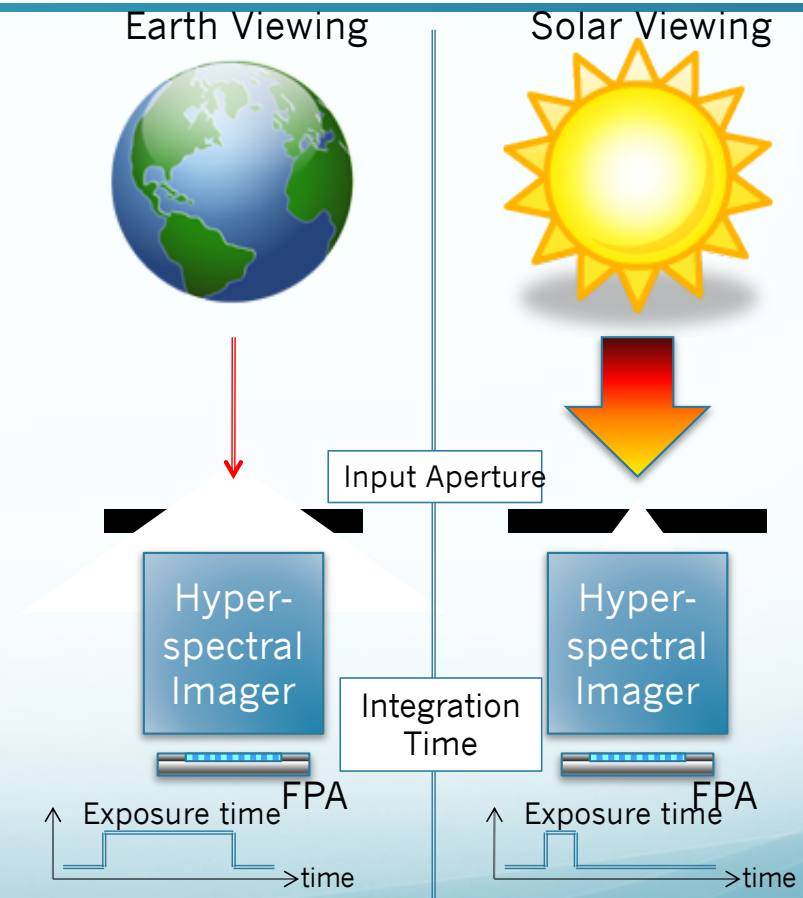


Demonstrate ability to transfer calibration other key RS satellite sensors by inter-calibrating with CERES & VIIRS.

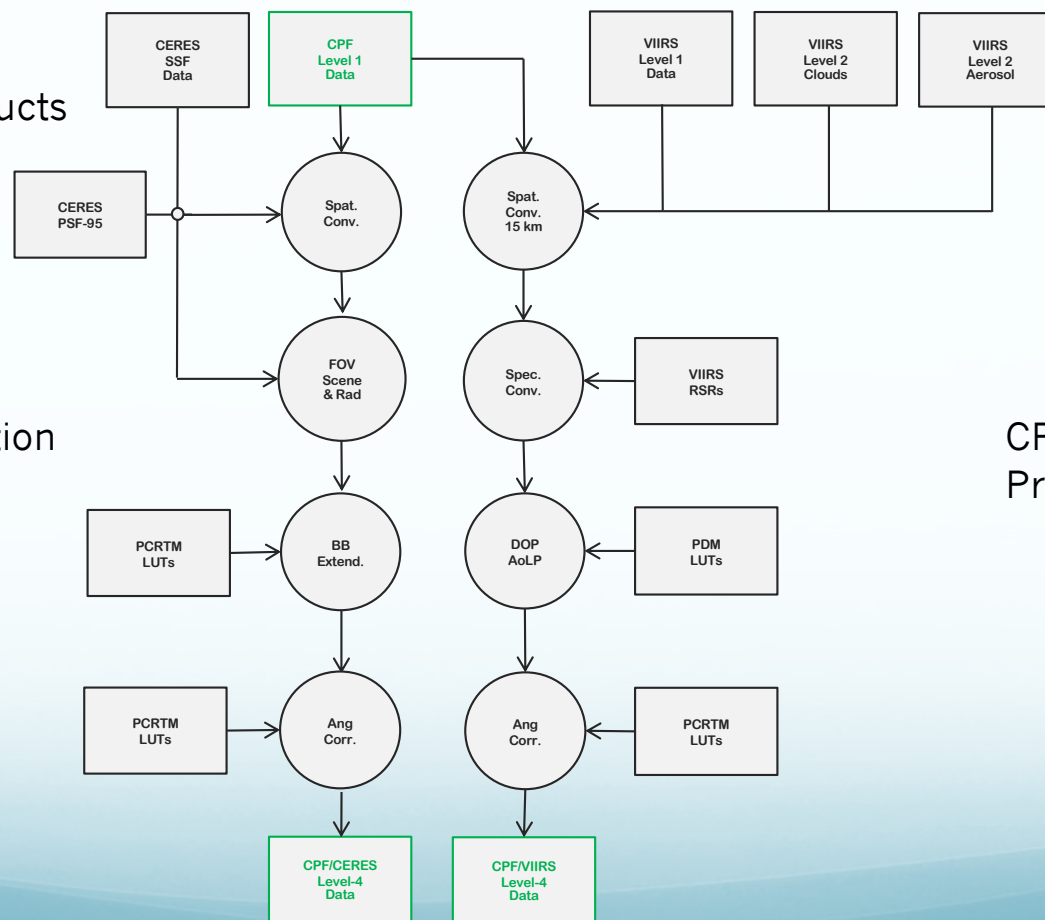
	Objective #1	Objective #2
Uncertainty	Spectrally-resolved & broadband reflectance: $\leq 0.3\%$ (1σ)	Inter-calibration Contribution: $\leq 0.3\%$ (1σ)
Data Product	Level 1A: Highest accuracy, best for inter-cal Level 1B: Approx. consistent spectral & spatial sampling, best for science studies using nadir spectra	Level 4: One each for CPF-VIIRS & CPF-CERES inter-cal. Merged data products including all required info for inter-cal analysis

Calibration & Measurement Approach

- Earth reflectance will be obtained using a band-ratioing radiometer approach
- CPF will view both Sun & Earth with similar optical paths using
 - Aperture attenuation
 - Over 3 orders of magnitude (20 mm to 0.5 mm)
 - Integration time attenuation
 - Over 2 orders of magnitude (66 ms to 1.17 ms)
- Solar measurements & on-orbit calibration
 - Cross-slit scan
 - Flat fielding for both apertures - along-slit scan
 - Pen-ray lamp measurement



- Green Boxes: CPF-distributed data products



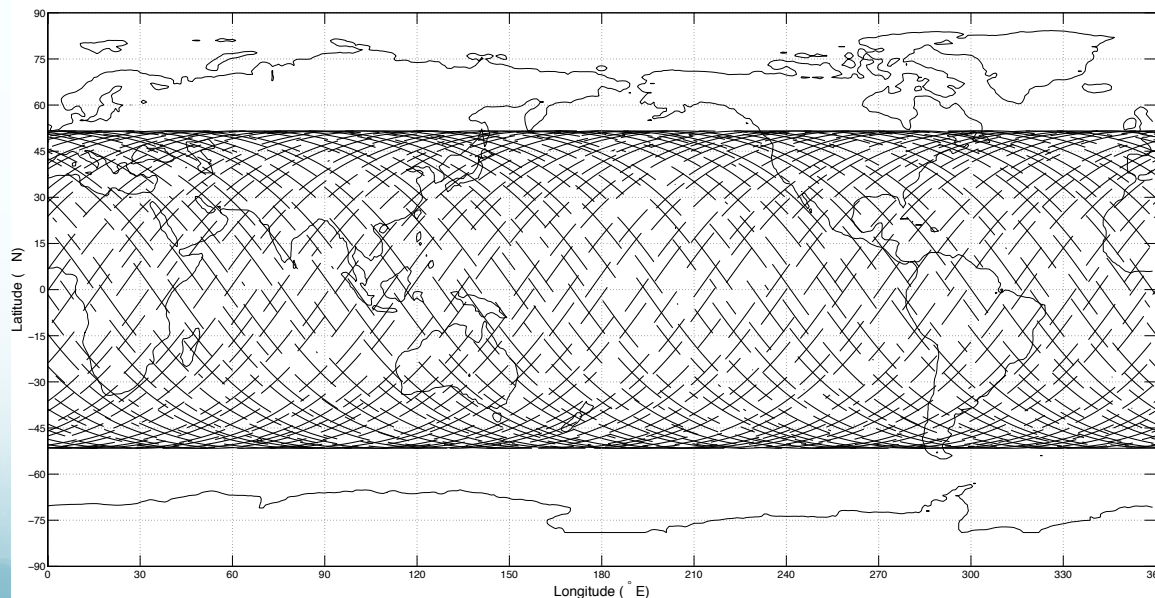
Prior to taking inter-calibration observations, inter-cal events will be predicted using orbital analysis

CPF-VIIRS Inter-calibration Processing

How Inter-Calibration Uncertainty Requirements are Achieved

- Inter-calibration uncertainty requirements are met (in part) by acquiring and analyzing data from an aggregation of inter-calibration events
- More events improves reduction of data matching noise

Predicted inter-calibration events (~1,300) between CLARREO Pathfinder on ISS and NOAA-20 for 1-year of operations



Required Mission Operations	
On-orbit Instrument Calibration	Solar & Lunar Views, Other Calibration Modes
Spectrally-resolved Earth Reflectance and Radiance	High accuracy, geolocated nadir measurements
Inter-calibration with CERES and VIIRS	Earth-views matched in time, space, viewing angle, and spectral band
Additional Mission Opportunities	
Inter-Calibration of Geosynchronous Imagers	Examples: ABI on GOES-16, EUMETSAT's GERB
Inter-Calibration of Low Earth Orbit Imagers	Example: Landsat imagers
Improved calibration of vicarious calibration sites	Spectrally-resolved reflectance over instrumented and non-instrumented sites to calibrate operational and future Earth Science sensors
Improved calibration of lunar radiance	Potential ~10x improvement of current lunar standard, enabling the moon to be used as on-orbit calibration source for current / future Earth Science instruments

Project Status & What's Next?

- Currently in Phase C - Implementation
- Passed Critical Design Review in March 2020
- Launch Readiness: 2023
- CLARREO Pathfinder Science Team solicitation planned but date TBD



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