CLARREO Pathfinder Overview

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CLARREO Pathfinder Overview: Presentation Outline

- Inter-calibration of sensors: background
- Mission Requirements & Success Criteria
- On-orbit pointing approach for inter-calibration
- Instrument Field-of-Regard from ISS location
- Other Inter-calibration opportunities
- Inter-calibration event prediction & sampling
- Inter-calibration data products
- Publications
LEO and GEO data matching when available (e.g. MODIS and GOES-13).
Uniform and stable surface sites.
Instrument stability by observing the Moon (e.g. SeaWIFS).
Deep Convective Clouds, clear ocean & deserts: involve RT modeling.
Inter-Calibration of Sensors in RS: Current

Inter-calibration of gain:
✧ Type A uncertainty (random) is 5.11% (k=1): due to data matching.
✧ Type B uncertainty (not random) is defined by the MODIS accuracy of 2% (k=1) [pre-launch].
✧ Spectral Type B uncertainty: due to difference in spectral response.

Results from the GSICS

GOES-12/Terra-MODIS
July 2003

Gain = 0.68
29 published count offset

GOES-12 gain based on Terra-MODIS

Fundamental limitation of current approach
CLARREO Pathfinder is a directed mission through the NASA Science Mission Directorate – Earth Science Division

_NASA Langley has overall project management responsibility_

CLARREO Pathfinder is a _risk reduction mission_ for a potential future full CLARREO Mission

_Two primary mission objectives:_

1. Demonstrate on orbit, high accuracy, SI-Traceable calibration
2. Demonstrate ability to transfer this calibration to other on-orbit assets

Project scope consists of formulation, implementation, launch, operation, and analysis of measurements from a Reflected Solar (RS) Spectrometer, launched to the International Space Station (ISS)

- Category 3 (NPR 7120.5E) / Class D Mission (NPR 8705.4), nominal 1-year mission life + 1 year science data analysis
- Targeted for launch in late CY2020 – early CY2021
- Authority to Proceed received April 11, 2016
Inter-Calibration Requirements & Objectives

CERES / RBI and VIIRS are the **required** instruments for demonstrating inter-calibration capability:

- CERES / RBI Short Wave Channel
- VIIRS Reflectance Bands
- Inter-Calibration possibilities include CERES / VIIRS on Suomi NPP and JPSS-1, and RBI / VIIRS on JPSS-2

CLARREO Pathfinder project **objective** is to have the capability to acquire the data necessary to demonstrate inter-calibration with other Earth-observing instruments:

- The objective is intended to get as much scientific value out if this risk reduction mission as possible within the available budget and schedule
- **Acquisition of data** for demonstrating inter-calibration with instruments other than CERES/RBI and VIIRS will be as events of opportunity
- **Processing the data** for demonstrating inter-calibration with instruments other than CERES/RBI and VIIRS is not within current CLARREO Pathfinder project scope / budget

We welcome the opportunity to work with other projects to arrange / advocate for the necessary funding
**Draft Level-1 Requirement Summary**

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<tr>
<th>Demonstration Parameter</th>
<th>Baseline Objective*</th>
<th>Threshold Requirement**</th>
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<tr>
<td><strong>Spectrally-Resolved Earth Reflectance (350 – 2300 nm):</strong> SI-Traceable, referenced to spectral solar irradiance</td>
<td>≤ 0.3% (k = 1)</td>
<td>≤ 0.6% (k = 1)</td>
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<tr>
<td><strong>Spectrally-Integrated Earth Reflectance (350 – 2300 nm):</strong> SI-traceable broadband (350 - 2300 nm) spectrally-integrated Earth reflectance with spectral accuracy weighted using global average Earth spectrally reflected energy</td>
<td>≤ 0.3% (k = 1)</td>
<td>≤ 0.6% (k = 1)</td>
</tr>
<tr>
<td><strong>On-Orbit Inter-Calibration</strong>*: Demonstrate the ability to Inter-Calibrate with CERES/RBI short wave channel and VIIRS reflectance bands</td>
<td>≤ 0.3% (k = 1)</td>
<td>≤ 0.6% (k = 1)</td>
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* Baseline Objective is within a factor of 2 of full CLARREO Tier-1 Decadal Survey Mission Requirements

** Threshold requirement is a factor of 2 (CERES) to 4 (VIIRS) better than current capabilities.

*** Inter-calibration uncertainty are contributions from data matching noise.
CLARREO Pathfinder Project Status

CLARREO Pathfinder is currently in Formulation Phase A:

- *Successful Mission Concept Review on August 24-26, 2016*
- *Key Decision Point-A (KDP-A) gate review passed on January 12, 2017*

CLARREO Pathfinder is a recognized International Space Station (ISS) payload and is listed on the MiPROM (MiPROM = ISS payload schedule planning tool):

- *Instrument payload is planned to be accommodated on the ISS at Express Logistics Carrier #1 (ELC-1) Site #3*
- *ISS has planned for an 18-month occupancy for the CLARREO Pathfinder payload (October 2020 through March 2022)*
- *Includes 2-month commissioning period + 12 months prime mission operations*

Project is currently performing the necessary work to establish contracts and partnerships during the Formulation phase of the project.
CLARREO Pathfinder Instrument provides high-accuracy reference on orbit.
CLARREO Pathfinder Instrument has 2D pointing ability for real-time data matching.
CLARREO Pathfinder data matching with CERES and VIIRS on JPSS: temporal matching within 10 minutes, on-orbit angular/spacial matching.
CLARREO Pathfinder location on ISS: ELC-1 Site 3.
Gimbal configuration: pitch - roll
Approximate gimbal range of motion at ISS ELC-1 Site 3.
Not all pointing angles are available due to ISS accommodation.
Refine analysis for ISS components affecting RS instrument view in Phase-A.

Accommodation studies by the NASA LaRC
Inter-Calibration Event Prediction

- **Approach:** Inter-calibration by real-time pointing off-nadir!
- **Inter-calibration on-orbit operations are planned ahead of time!**

(1) Inter-calibration of Sensors:
- Prediction by orbital modeling
- Filter out events with instrument FOV obscured by ISS fixed and rotating structures
- Assess the value for every event by modeling
- Deliver event parameters to instrument operations team

(2) Calibration of Lunar Spectral Reflectance:
- Prediction of Moon viewing by orbital modeling
- Filter out events with instrument FOV obscured by ISS fixed and rotating structures
- Assess the value for every lunar geometry by modeling
- Coordinate with the instrument calibration team
- Deliver event parameters to instrument operations team

(3) Characterization of Surface Sites:
- Prediction by orbital modeling
- Filter out events with instrument FOV obscured by ISS fixed and rotating structures
- Assess the value for every event by modeling
- Deliver event parameters to instrument operations team
Inter-Calibration Events: Geolocation

Results from C. Roithmayr

Geolocation of the ISS ground track during each opportunity to take measurements for inter-calibrating JPSS cross-track sensors (CERES and VIIRS).

- Instrument FOV = 10°
- Time matching +/- 10 minutes
- 1308 inter-calibration opportunities over 1 year
Simulation ISS ELC-1 Site 3:
- 10 minutes time matching
- Instrument field-of-regard
- Instrument FOV = 10°
- Instrument FOV obscuration = 0%
- Event duration > 30 seconds
- SZA < 75°
- N good events = 1163

VIIRS:
100 samples every 5 seconds
(imager re-sampling)

CERES:
3 FOVs every 5 seconds
(large FOV)

Margin at 44% for operations not-available on average!
Other Inter-Calibration Opportunities

**CALIBRATION TARGETS:**
- Instrumented and not-instrumented Surface Sites (deserts)
- Moon: improve accuracy of lunar spectral reflectance

**SENSORS:**
- GEO imagers:
  - NOAA ABI on GOES-16
  - EUMETSAT
  - ESA GERB
- Land imagers:
  - USGS Landsat
  - ESA Sentinel-2A/B
## Inter-Calibration Data Products

<table>
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<tr>
<th>Product</th>
<th>Contents</th>
<th>Resolution</th>
<th>Granule</th>
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<tr>
<td>Level-1 Products for VIIRS CERES GEO (NOAA, ESA, etc.) Landsat (USGS) Surface Sites Moon</td>
<td>Calibrated and geo-located CPF observations.</td>
<td>Full spectral and spatial resolution of the CPF RS Instrument.</td>
<td>Each granule contains single CPF inter-calibration event.</td>
</tr>
<tr>
<td>Level-4 Products for VIIRS CERES</td>
<td>Collections of CPF (Level-1), VIIRS, and CERES matched data (Level-1 &amp; Level-2).</td>
<td>CLARREO (Level-11) and VIIRS (Level-1 &amp; Level-2, Clouds and Aerosols) data spatially convolved over IC sample. CLARREO Spectral re-sampling. CLARREO (Level-1) spatially convolved over CERES FOV’s PSF. CLARREO conversion to broadband reflectance. Scene ID from the CERES SSF.</td>
<td>Data processed by the CPF inter-calibration events.</td>
</tr>
<tr>
<td>Level-4 Products for VIIRS CERES</td>
<td>Inter-calibration results: Constraints on effective offset, gain, non-linearity, sensitivity to polarization, and spectral degradation.</td>
<td>N/A</td>
<td>N/A</td>
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- Additional data analysis – by a separately funded science team
CLARREO Inter-Calibration: Key Publications


