PACE Science & Application Team Meeting
Ocean Color Instrument Development Status
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10/6/2021

Plankton, Aerosol, Cloud, ocean Ecosystem
PACE Ocean Color Instrument

- hyperspectral scanning radiometer
- 340 – 890 nm, 5 nm resolution, 2.5 nm steps
- plus, 940, 1038, 1250, 1378, 1615, 2130, and 2250 nm
- 1 day global coverage
- ground pixel size of 1 km² at nadir
- ± 20° fore/aft tilt to avoid Sun glint
- twice monthly lunar calibration
- daily on-board solar calibration
- built at NASA Goddard Space Flight Center
How Do You Transform Science Questions into an Operational Observatory?

Q’s

Science Questions
Requirements & Trades
Prototype Testing
Flight Component Build

Integration & Testing
Ground Calibration
Launch
Commissioning & Operations
How Do You Transform Science Questions into an Operational Observatory?

Q’s

Science Questions

Commissioning & Operations
Agree on the science questions that are worth perusing

How & why are ocean biogeochemical cycles & standing stocks changing? How do they influence the Earth system?

How do physical ocean processes affect ocean ecosystems? How do ocean biological processes influence ocean physics?

What is the distribution of both harmful & beneficial algal blooms & how is their appearance & demise related to environmental forcing?

What are the long-term changes in aerosol & cloud properties & how are these properties correlated with inter-annual climate oscillations?

What are the magnitudes & trends of direct radiative forcing components?

How do aerosols influence ocean ecosystems & biogeochemical cycles? How do ocean biological & chemical processes affect the atmosphere?
Determine the measurements that are required to answer the science questions

Core ocean data products
- concentration of chlorophyll-a
- diffuse attenuation coefficients
- phytoplankton absorption
- non-algal + CDOM absorption
- particulate backscattering
- photosynthetic available radiation
- concentration of particulate carbon

Advanced ocean data products
- phytoplankton community structure & biomass
- phytoplankton physiological parameters
- photosynthetic pigments
- primary/community production
- dissolved carbon pools
- particle abundances & size distributions
- carbon fluxes & export
- water quality & clarity

*MODIS on Terra (2000-)
does not yet provide science-quality data
**MODIS/VIIRS short-wave infrared bands are not optimal
Engineers and scientists leverage heritage data, instruments, and data products to agree on science requirements that will enable instruments measurements to answer mission science questions.

GSD of 1 ± 0.1 km² at nadir

Twice-monthly lunar calibration & onboard solar calibration (daily, monthly, dim)

Spectral range from 350-865 @ 5 nm 940, 1038, 1250, 1378, 1615, 2130, 2260 nm

Instrument performance requirements

Varied optical properties

Varied contrasts

Multi-angle polarimetry

Different algal groups

Image stripes

Absorbing aerosols

Dark ocean vs. bright land & clouds

Sun glint

Tilt ± 20°

Spectral range goal of 320-865 @ 5 nm

8/16/22

PACE OCI UMBC Class
How Do You Transform Science Questions into an Operational Observatory?

Q’s

Science Questions

Requirements & Trades

Commissioning & Operations
Iterate engineering requirements and system design trades

- Mission Concept Review
  - S/C Location
- System Requirements Review
  - Detailed System Trades
- Calibration & Noise
- Tilt Trades
- Thermal Trades
- Optics and Detector Trades

- Mass
- Power
- Volume
- Optics and Detector Trades

8/16/22 PACE OCI UMBC Class
Iterate engineering requirements and system design trades
What is OCI & how does it work?

**Main Optical Bench**
- RTA Mechanism (6 Hz)
- RTA Launch Locks
- Depolarizer (6 Hz)
- Flat mirror (6 Hz)
- Half-Angle Mirror (3 Hz)
- Collimator/Slit Assembly
  - Slit
  - Field lens
- Optical Module
  - Collimator
  - Dichroic
  - Primary (6 Hz)
  - Half-Angle Mirror (3 Hz)
- Solar Calibration Assembly
  - Daily Bright Target (QVD)
  - Monthly Bright Target (QVD)
  - Monthly Dim Target (Fractal Black)
- Fiber Optic Micro-Lens Assembly
  - Fiber Optic Bundle (16 fibers)
- Main Optical Sub Bench
  - Dichroic
  - Re-Imaging Optic
  - Aperture
  - Grating
  - Lens Assembly
  - UVVIS Subassembly
    - UVVIS 342.5-607.5 nm
  - VISIR Subassembly
    - VISIR FPA 597.5-887.5 nm
- Thermal Control Subsystem
  - Radiators: MCE, DAU, ICDU, FPA
  - Heaters / Temp Sens / MLI
  - Loop Heat Pipes/Earth Shield
- Instrument Structure
  - IDS
  - Machine Plates
  - RSS & ES
  - AIS
- Mech Control Electronics
  - RTA/HAM Controller
  - HAM Mechanism (3 Hz)
  - HAM Mechanism (3 Hz)
- Instrument Command and Data Unit
  - Processor
  - SW
  - HK
  - Thermal (TCC)
  - OM
  - H/M x2
  - LVPC
- Data Acquisition Unit
  - DAU
  - Digital Controller
  - Bias x 2
  - Dark Star x3
- SWIR SIDEAR Module
  - Star Camera Head (S/C DIL)

8/16/22
PACE OCI UMBC Class
OCI Telescope Ground Coverage

- 1 Science Pixel = 1000m x 1000m at Nadir
  - Elongates at all other cross track and along track angles
- The OCI rotating telescope projects 16 science pixels at once onto a slit
  - This results in 16,000m x 1000m of instantaneous ground area imaging
- The slit image is re-imaged onto the detectors of the OCI detection system
- If you stop the telescope from rotating, OCI will only see 16 science pixels on the ground
- The rotating telescope continuously moves the 16 science pixels across the slit so that it scans across the full field of regard in the cross track direction

* Science Pixels are shown to approximate scale

16 Science Pixels: 1000m Each, 16,000m
The rotating telescope continuously moves the image of the 16 science pixels in the cross track direction across a slit to cover the full field of regard. The slit is continuously reimaged onto a detector.

The telescope rotates fast enough so there are no gaps in coverage per scan.

Telescope Rotation Rate = Ground Velocity / Ground Sample Distance
Rotating Telescope and Half Angle Mirror Fundamentals

- Rotating Telescope (RT)
  - Continuous 360°
  - 6 Hz
  - Primary Mirror

- Half Angle Mirror (HAM)
  - Continuous 360°
  - 3 Hz
  - Double Sided

Field of Regard +/- 56.5°
SCA Rotating Telescope and Half Angle Mirror Fundamentals

Field of Regard +/- 56.5°
OCI is a Slit Grating Hyperspectral Spectrograph in the UVNIR

The optics are designed with a grating that splits the incoming light from each 1000m x 1000m ground scene into individual wavelengths.

Each 1000m x 1000m ground scene is comprised of over 100 science pixels.

Ultraviolet to Near Infrared in 5nm increments

Each science pixel has the spectral content of 1 wavelength at a 1000m x 1000m resolution
The rotating telescope allows the same science pixel to be imaged on the detector 16 times.

The CCD detector uses time delay integration (TDI) to transfer the charge from pixel to pixel at the same rate of the rotating telescope. This occurs in analog charge space to avoid noise introduced by reading, amplifying, and digitizing the signal.

This allows the detection system to view the same ground scene for an extended time and build up enough signal to meet SNR while eliminating image striping due to detector pixel gain offsets.
The detector uses TDI to transfer the charge from pixel to pixel at the same rate of the rotating telescope allowing the same ground scene to be viewed by every pixel.
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Science Questions

Requirements & Trades

Prototype Testing

Commissioning & Operations
Its time to cut metal

Building & testing a prototype enables the team to improve design, testing, and build process for flight.

You don’t know what you don’t know until you build and learn.
Assembly of prototype focal planes, optics, and electronics
Testing the prototype OCI

Ambient System Testing

Thermal Vacuum Testing

Tunable Lasers for Calibration

SWIR Detection Assembly
Ocean Color Instrument (OCI)

Engineering Test Unit
Covid-19 Restart Activities

September 2020 – February 2021
How Do You Transform Science Questions into an Operational Observatory?

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Science Questions

Requirements & Trades

Prototype Testing

Flight Component Build

Commissioning & Operations
How do you build a flight instrument that will reliably operate in space?
Break it into smaller pieces & test test test

Mechanism Control Electronics (MCE)
Inst. Command & Data Handling Unit (ICDU)
Structure
Main Optics Sub Bench (MOSB)
Main Optics Bench (MOB)
Solar Calibration Assembly (SCA)

Data Acquisition Unit (DAU)

Radiator, Earth Shield & Support Structure

Multi Lens Assembly (MLA)/Fiber
Red Focal Plane Array (FPA)
Blue Focal Plane Array (FPA)

SWIR Detection Assembly (SDA)

UVNIR Loop Heat Pipes (LHP)/Radiators
Test as you fly & fly as you test

- SWIR Detection
- Assembly
- Vibration

Optics Characterization

- RT/HAM Actuator
- Thermal
- Vacuum Testing

ICDU EMI Testing

8/16/22
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Science Questions  Requirements & Trades  Prototype Testing  Flight Component Build

Integration & Testing  Commissioning & Operations
Flight Ocean Color Instrument (More I&T Details In Veronica's Section)
How Do You Transform Science Questions into an Operational Observatory?

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Commissioning & Operations
The OCI Team Has Spent Years Preparing for Pre-Launch Calibration
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