ACE Ocean Ecology Sensor (OES) Requirements

ACE Mission Status Review
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NASA Ocean Biogeochemistry Derived Products & CDRs

- CDRs drive sensor stability and derived product accuracy requirements
- Ocean Products
  - **Multispectral normalized water-leaving radiances (±5%)**
  - **Chlorophyll-a (± 35%)**
  - **Diffuse attenuation coefficient (490 nm)**

Current OBB CDRs

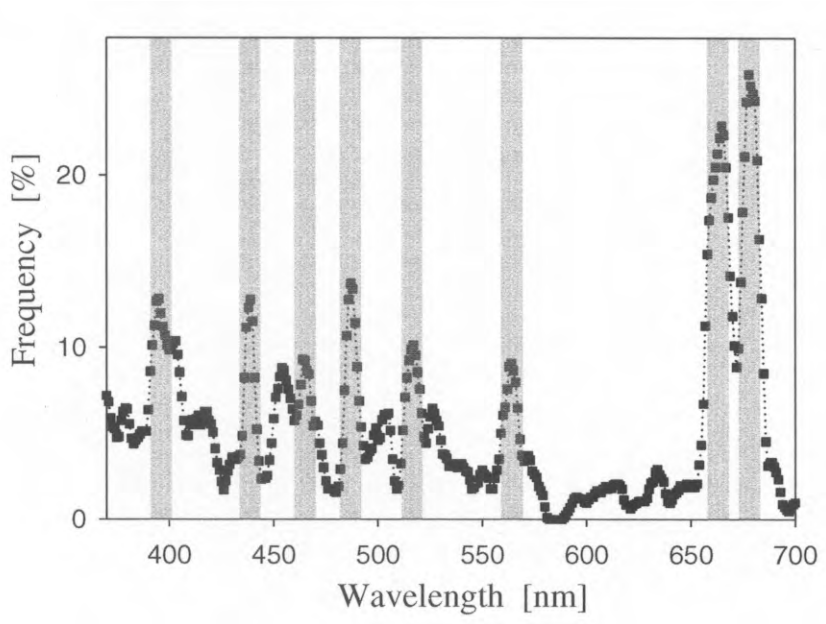
  - **Primary production**
  - **Inherent optical properties (IOPs; spectral absorption & scattering coefficients)**
  - **Spectral diffuse attenuation**
  - **Spectral remote sensing reflectance (pending a hyperspectral sensor)**
  - **Particulate organic carbon concentration**
  - **Calcite concentration**
  - **Colored dissolved organic matter (CDOM)**
  - **Photosynthetically available radiation (PAR)**
  - **Fluorescence line height (FLH)**
  - **Euphotic depth**
  - **Total suspended matter**
  - **Trichodesmium concentration**

Candidate OBB CDRs

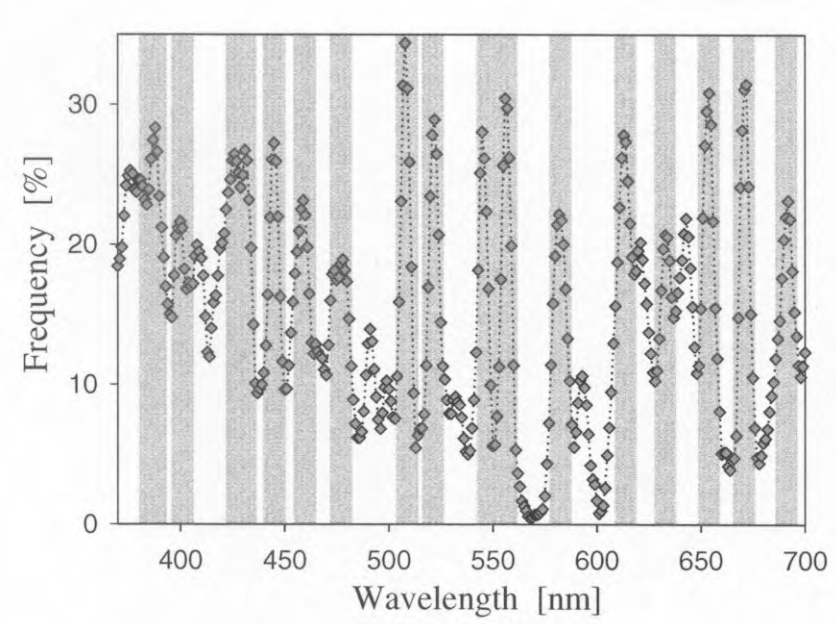
  - Particle size distributions & composition (biogenic, mineral, etc.)
  - Functional/taxonomic group distributions
  - Phytoplankton carbon
  - Dissolved organic matter/carbon (DOM/DOC)
  - Physiological properties (e.g., C:Chl, fluorescence quantum yields, growth rates)
  - Other plant pigments (e.g. carotenoids)
  - Export production

Research products

Phytoplankton Functional Groups: Spectral Derivative Analyses



Spectral distribution of the frequency where the 1st-order derivative of ocean reflectance = 0.



Spectral distribution of the frequency where the 2nd-order derivative of ocean reflectance = 0.

Lee, Z-P., K. Carder, R. Arnone, & M-X. He, Determination of primary spectral bands for remote sensing of aquatic environments, *sensors*, 7, 3428-3441, 2007.

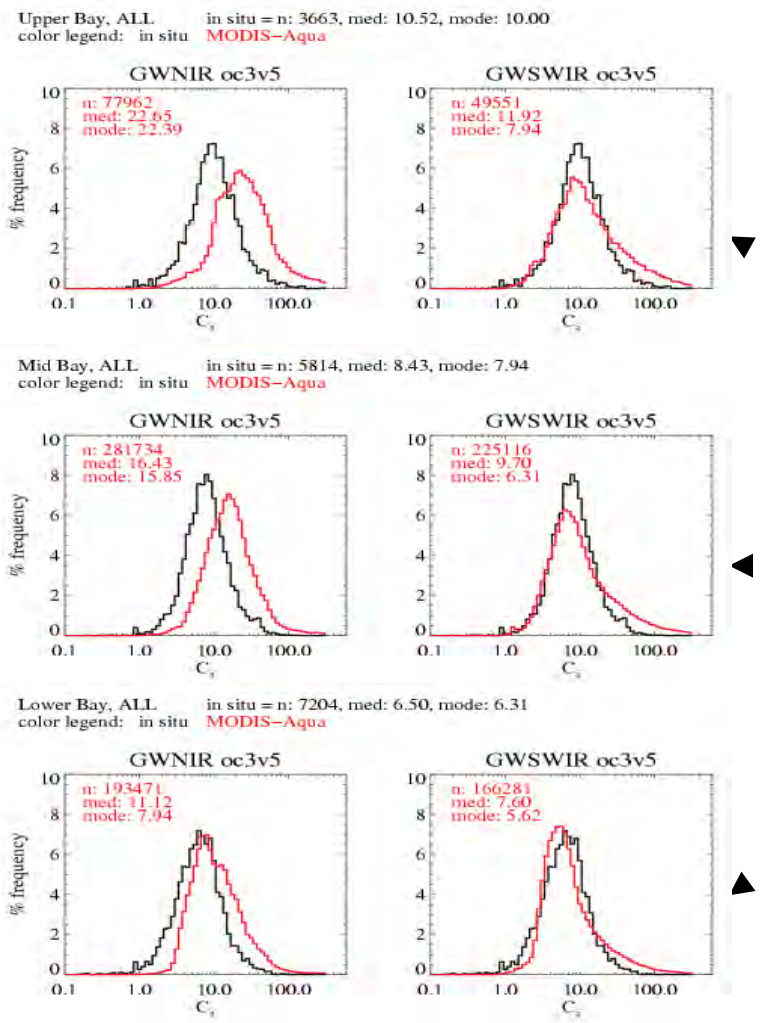
SWIR-based Corrections: Impact on Chlorophyll Retrievals

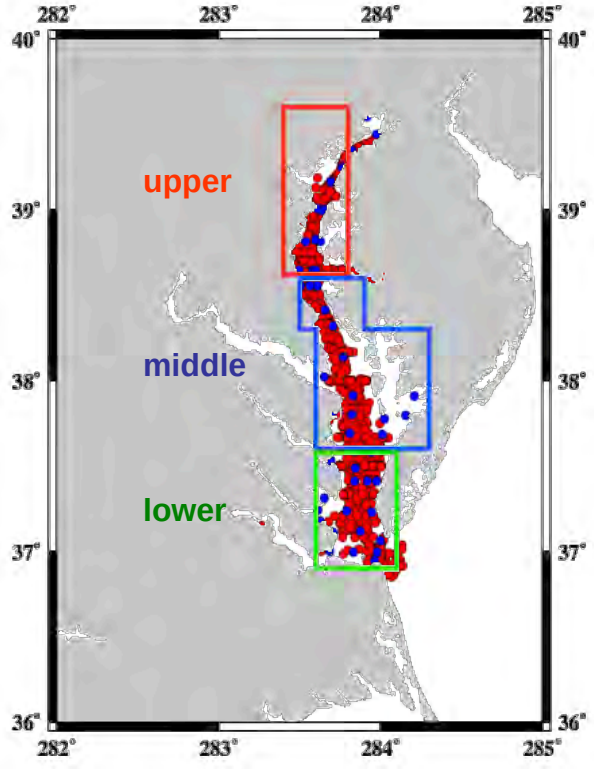
Chlorophyll (mode)

Field: 10 mg/m^3
w/o SWIR: 22 mg/m^3
w/ SWIR: 8 mg/m^3

Field: 8 mg/m^3
w/o SWIR: 16 mg/m^3
w/ SWIR: 6 mg/m^3

Field: 6 mg/m^3
w/o SWIR: 8 mg/m^3
w/ SWIR: 6 mg/m^3





Chesapeake Bay

ACE Ocean Ecosystem Radiometer Minimum Requirements

- 5 nm resolution 350 to 775 nm (functional group derivative analyses)
- 26 required multispectral bands (see next slide for details)
- Stability
  - 0.1% radiometric stability knowledge (mission duration)
  - 0.1% radiometric stability (1 month prelaunch verification)
- 2-day global coverage
  - ±58.3^{o} cross track sampling (116.6^{o} total swath): Constrained by atmospheric path length & pixel size at swath edges
- Sensor tilt (±20^{o}) for glint avoidance
- Polarization: < 1.0% sensor radiometric sensitivity,
  < 0.2% prelaunch characterization accuracy
- < 2% prelaunch radiance calibration accuracy (minimum)
  - Goal: 0.5% prelaunch calibration accuracy
- 1 km spatial resolution @ nadir
- No saturation in UV to NIR bands
- 5 year minimum design lifetime

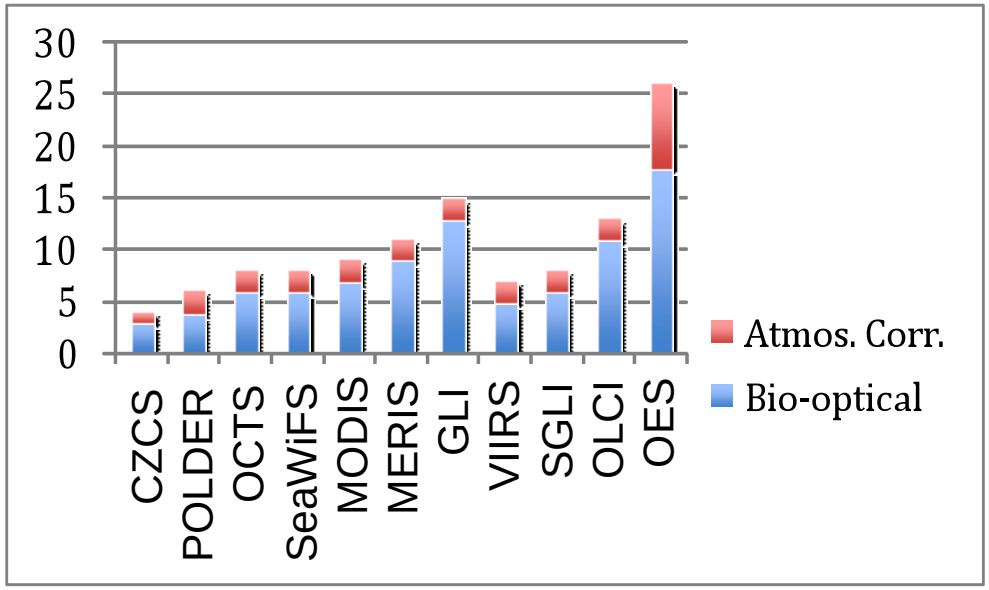
ACE OES Multispectral Bands

λ	∇λ	Ltyp	Lmax	SNR-spec
350	15	7.46	35.6	300
360	15	7.22	37.6	1000
385	15	6.11	38.1	1000
412	15	7.86	60.2	1000
425	15	6.95	58.5	1000
443	15	7.02	66.4	1000
460	15	6.83	72.4	1000
475	15	6.19	72.2	1000
490	15	5.31	68.6	1000
510	15	4.58	66.3	1000
532	15	3.92	65.1	1000
555	15	3.39	64.3	1000
583	15	2.81	62.4	1000
617	15	2.19	58.2	1000
640	10	1.90	56.4	1000
655	15	1.67	53.5	1000
665	10	1.60	53.6	1000
678	10	1.45	51.9	1400
710	15	1.19	48.9	1000
748	10	0.93	44.7	600
765	40	0.83	43.0	600
820	15	0.59	39.3	600
865	40	0.45	33.3	600
1245	20	0.088	15.8	250
1640	40	0.029	8.2	250
2135	50	0.008	2.2	100

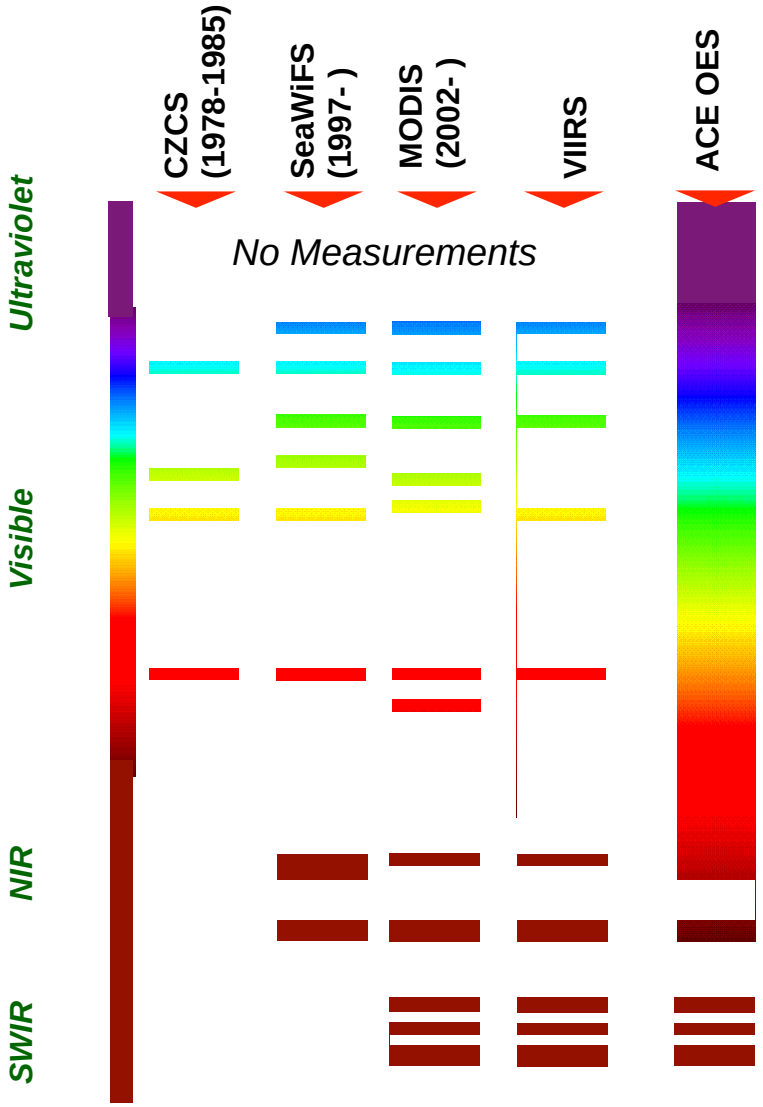
Minimum SNR values based on sensitivity studies of impacts of noise-induced atmospheric correction errors and subsequent errors in 3 key geophysical products (chlorophyll-a, particulate backscattering coefficient, and colored dissolved organic matter).

Basically, product error becomes asymptotically insensitive to noise as SNR increases. The SNR-spec values are estimates of this asymptote.

OES vs. Other OC Sensors



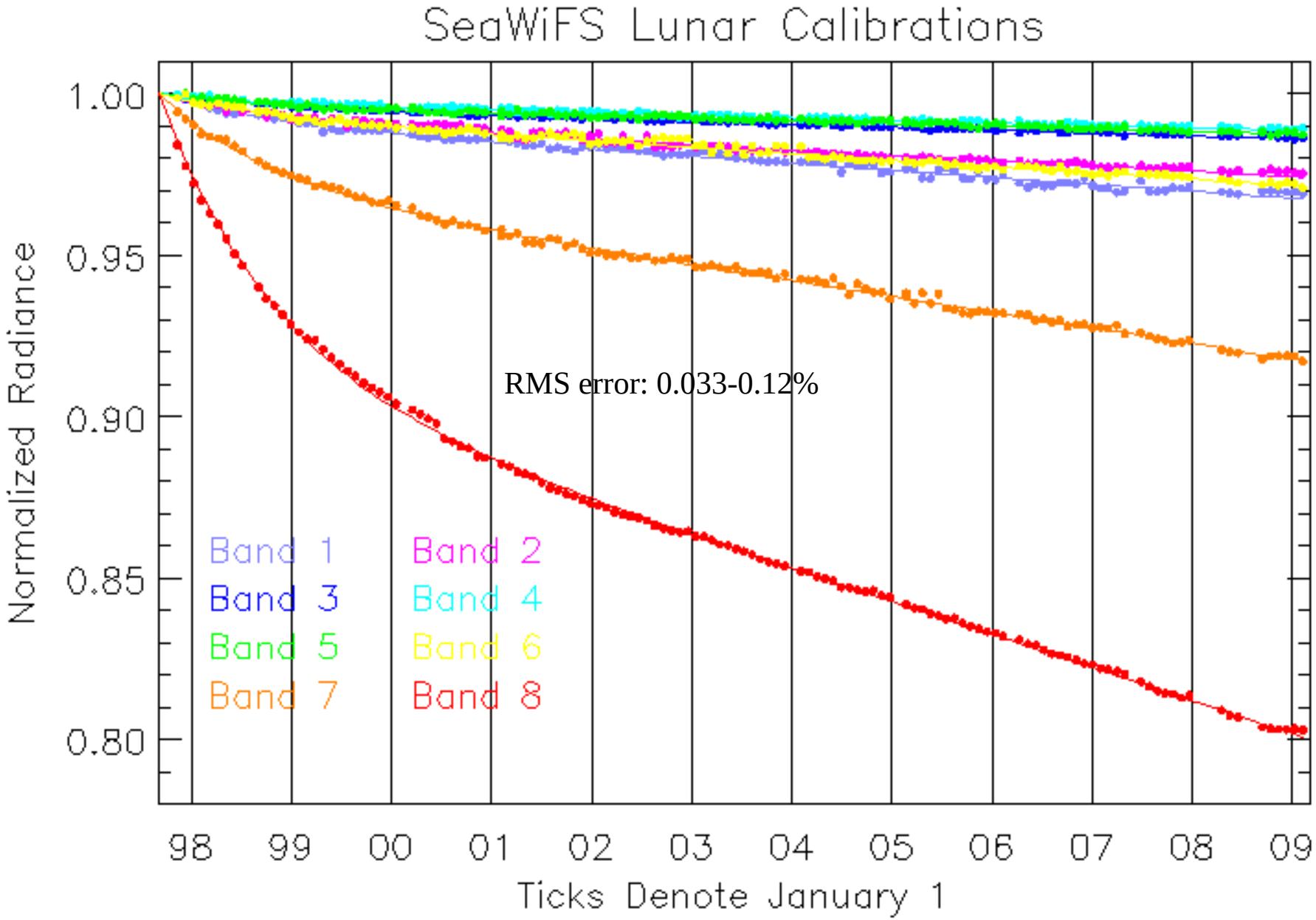
Number of OC multispectral bands



Platform Requirements

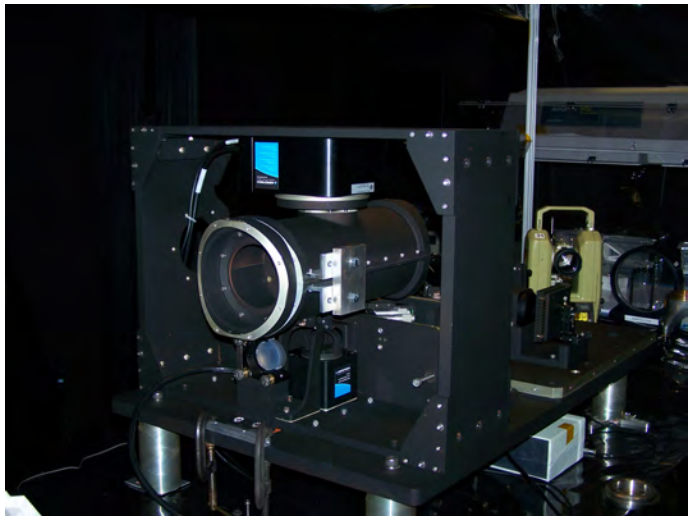
- Orbit permitting 2-day global coverage of ocean radiometer measurements
- Sun-synchronous orbit with crossing time between 10:30 a.m. & 1:30 p.m.
- Storage and download of full spectral and spatial data
- Monthly lunar calibration at 7^{o} phase angle through Earth observing port

On-Orbit Sensor Stability Traceability

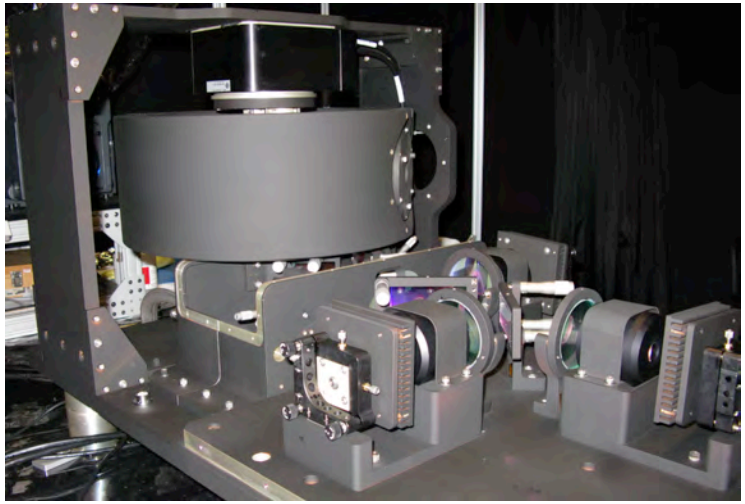


ESTO Contribution: Ocean Radiometer for Carbon Assessment

- **IIP (FY09-11: $3.35M)**
  - Flight-like prototype layout
  - Complete fore and aft optics with scan mechanisms
  - Commercial off the shelf detectors and electronics
  - GSFC & NIST characterization
- **IIP (FY11-13: pending)**
  - Custom-manufactured focal planes, electronics, & data system
  - Synchronization of telescope & half-angle mirror assemblies with detector array outputs @ flight scan rates (~ 6 Hz).

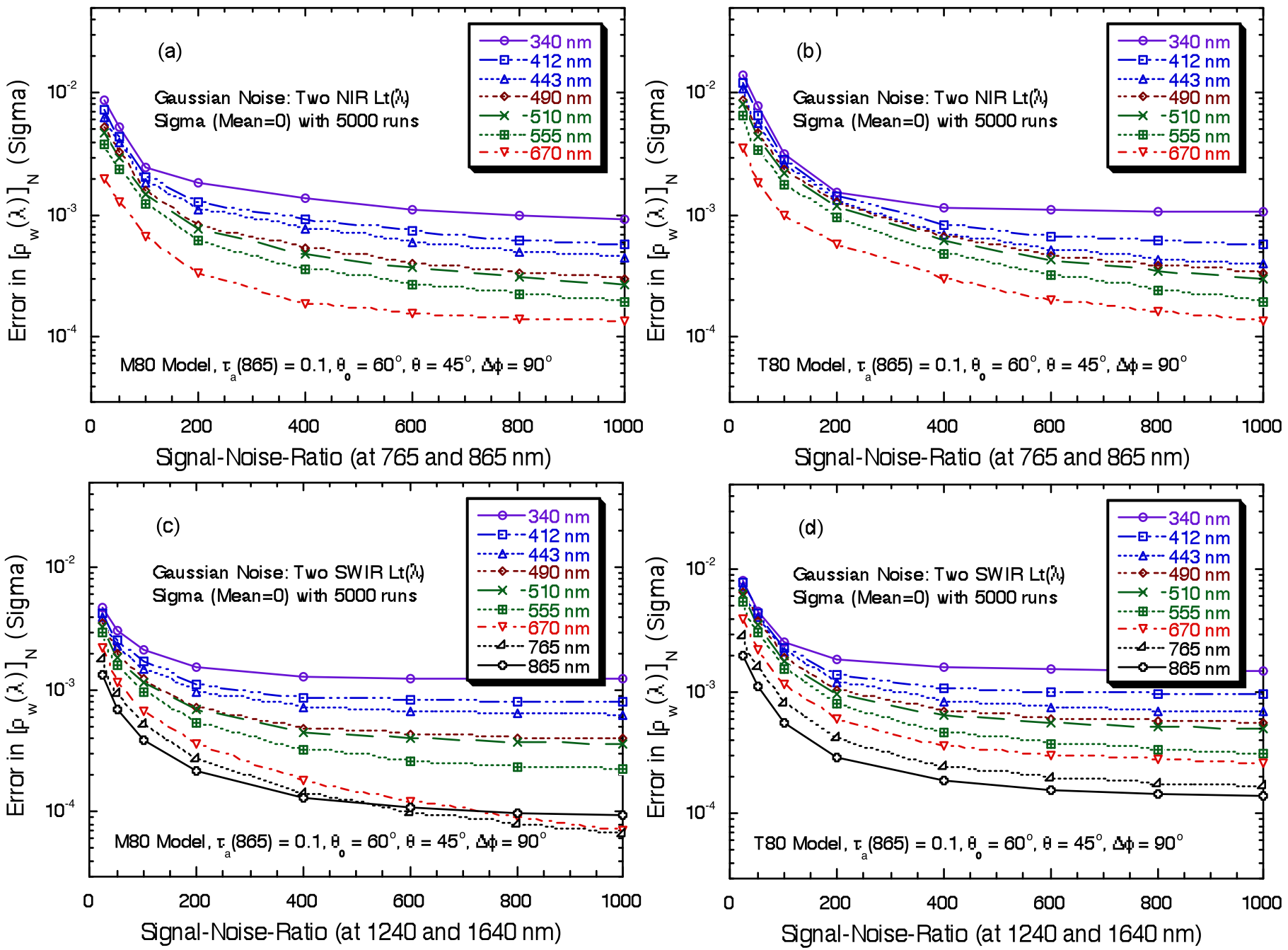


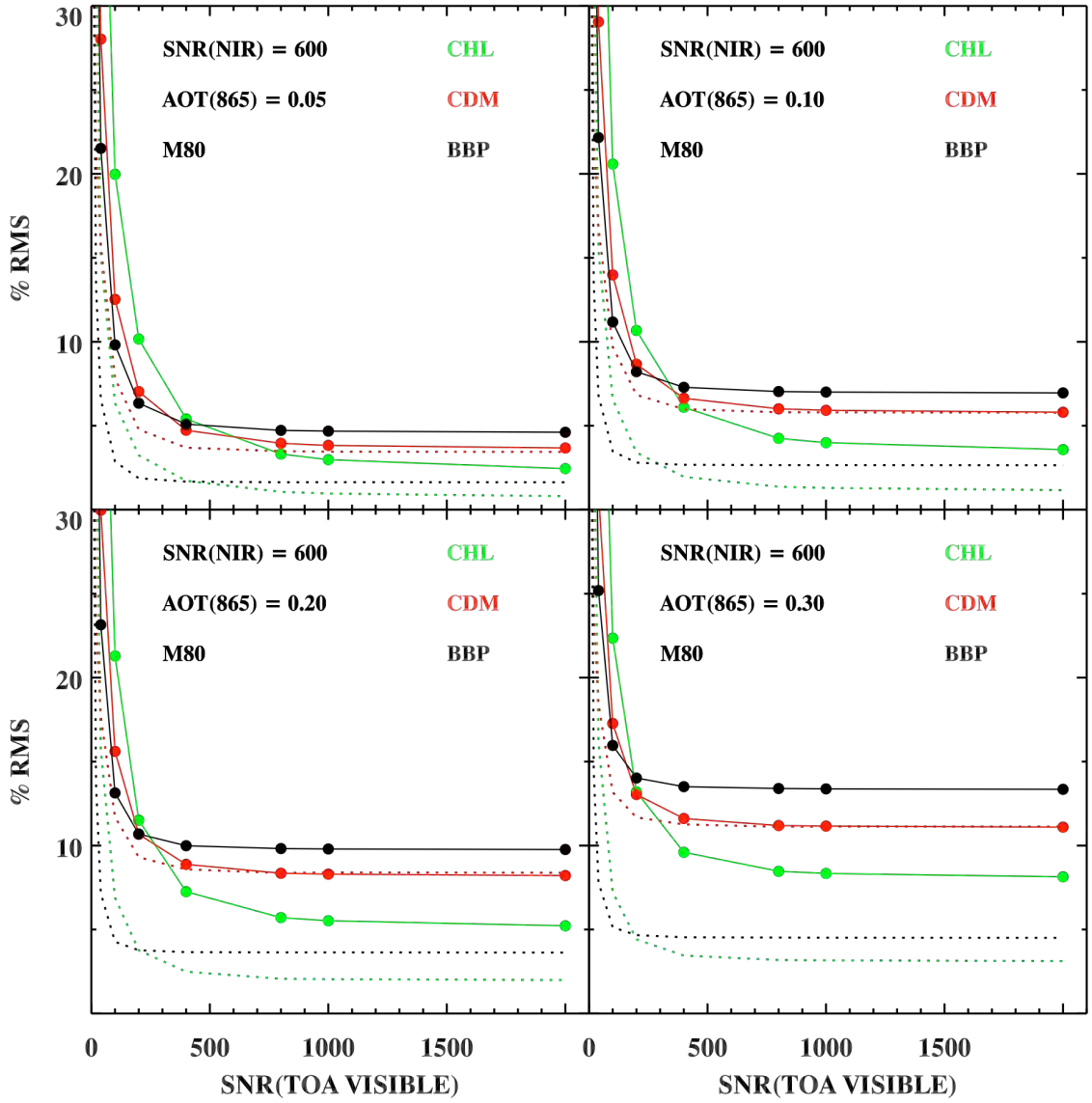
Front view:Telescope, Motor & Collimator



Rear view: Telescope with Internal Shield, 3 discrete SWIR Band Assemblies

BACK-UP


(a)
Gaussian Noise: Two NIR Lt(λ)
Sigma (Mean=0) with 5000 runs
340 nm
412 nm
443 nm
490 nm
510 nm
555 nm
670 nm
M80 Model, τa(865) = 0.1, θ0 = 60°, θ = 45°, Δφ = 90°
Error in [ρw(λ)]N (Sigma)
Signal-Noise-Ratio (at 765 and 865 nm)
(b)
Gaussian Noise: Two NIR Lt(λ)
Sigma (Mean=0) with 5000 runs
T80 Model, τa(865) = 0.1, θ0 = 60°, θ = 45°, Δφ = 90°
(c)
Gaussian Noise: Two SWIR Lt(λ)
Sigma (Mean=0) with 5000 runs
765 nm
865 nm
M80 Model, τa(865) = 0.1, θ0 = 60°, θ = 45°, Δφ = 90°
Signal-Noise-Ratio (at 1240 and 1640 nm)
(d)
Gaussian Noise: Two SWIR Lt(λ)
Sigma (Mean=0) with 5000 runs
T80 Model, τa(865) = 0.1, θ0 = 60°, θ = 45°, Δφ = 90°



Average ocean retrieval AOT ~ 0.1, so an SNR ~ 1000 in the visible is an adequate minimum requirement. Fluorescence bands need a higher SNR.