Ocean Radiometer for Carbon Assessment (ORCA): Design and Testing

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All ORCA IIP Objectives Met

- Refine component specifications and compliance test requirements
- Design & package ORCA in a flight-like optical/mechanical configuration
- Conduct system-level calibration & characterization at NIST
ORCA is a hyperspectral imager with System Design Requirements of:

- Wide spectral range, from 340 nm to 2130 nm
- Spectral resolution of 5 nm in UV & VIS/NIR
- 1 km ground resolution
- SNR >1000 in UV & VIS/NIR
- Scan Angle range +/- 58 deg
- Polarization sensitivity <1% in UV & VIS/NIR
- Low optical crosstalk
ORCA meets scanning, spectral, & SNR requirements

• Large angle scan coverage using a SeaWIFS-like rotating telescope
  • Synchronization of rotation mechanism, electronics, and detectors – implemented in second IIP starting Feb 2011

• Spectral resolution using conventional diffraction gratings in UV & VIS/NIR

• High SNR values achieved using Time Delay Integration (TDI) from UV through NIR
ORCA Scan & TDI Operation

Vertical Summing Register (8x)

Horizontal Output Shift Register (Multiple taps)

Data Output

Register transfer is synchronized to scan speed. (Time Delay Integration)

Wavelength

IFOV

Velocity

16 Science Pixels
ORCA Prototype: Accomplishments over past year

• Final prototype fabrication
• Optical alignment
• Rotary cart design & fabrication
• Optical performance testing
  – Polarization
  – Spectral resolution & linearity
  – Image quality (point spread functions)
  – Straylight
• Second IIP proposed & selected
  – Flight-like focal planes & electronics
  – System synchronization at flight scan/data rates
Views of instrument hardware

Front

Side
Signal-to-Noise Exceeds Requirements

21-23 June 2011 ESTO Conference
ORCA Optical Layout

Blue channel = 340 - 565 nm
Red channel = 575 - 885 nm
ORCA Optical Design

Incoming light → Telescope

Internal Stop

Blue module  Red module  SWIR module
Blue & Red channels show excellent image quality

~3X better than SeaWiFS!

- PSF FWHM (average) = 1.86 detector pixels diameter
  - Note: 1 ground pixel = 8x8 detector pixels
- 80% encircled energy diameter range from 5 to 5.5 detector pixels
- Some broadening at longer wavelengths due to source

Blue (FWHM radius vs \(\lambda\))

Red (FWHM radius vs \(\lambda\))

Note: vertical axis is the radius in pixels of the 1/e point of the PSFs
Similar spectral resolution across Blue & Red channels

• For blue channel, linear dispersion was 0.633 nm/pixel, the FWHM of the slit image was 9.5 detector pixels – **the spectral resolution is 6.0 nm**

• For the red channel, linear dispersion was 0.77 nm/pixel, the FWHM of the slit image was 8.3 detector pixels – **the spectral resolution is 6.5 nm**
Examples of slit images in red channel

RED CHANNEL FULL SLIT IMAGES  07 JUNE 2011
Excellent Red & Blue channel polarization sensitivity

ORCA Polarization Sensitivity calculated for each wavelength band
List of lessons learned

Tests conducted show no significant design issues

• Excellent Image Quality
• Depolarizer ghost
  – solution: wedged front-face
• No other out of field stray light observed
  – measurements and testing continues
• Spectral resolution close to goal
• Continue analysis of dichroic design
  - optimize polarization long wavelength transition
Conclusions

• Optical design is robust
  – Layout, components, and alignment all successfully implemented
  – Polarization, spectral resolution, spatial resolution, and image quality specs met

• Full characterization methodology demonstrated
  – Cooperative assessment done at NIST