Results from a new approach for albedo calibration on OMPS

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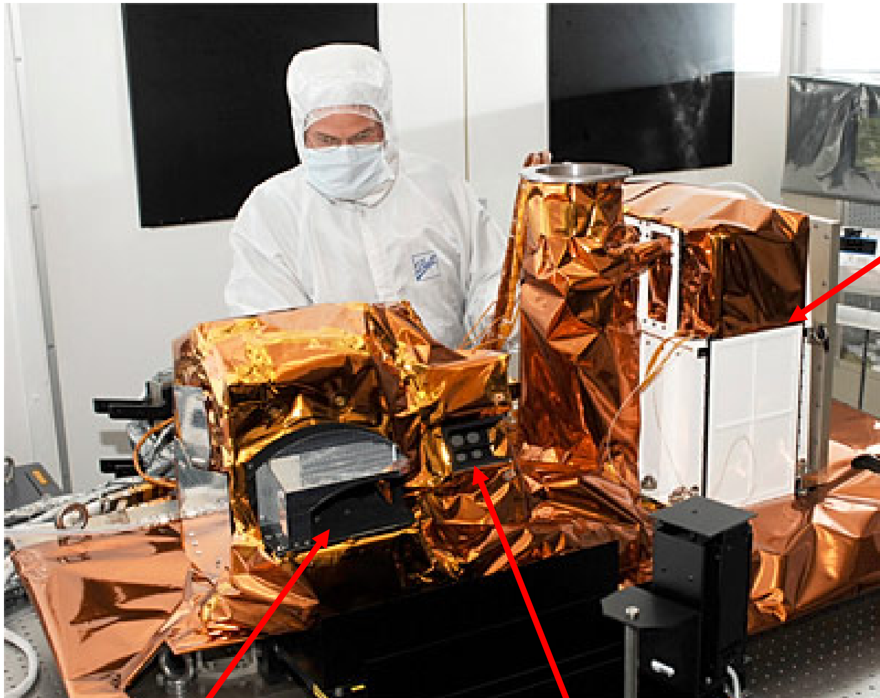
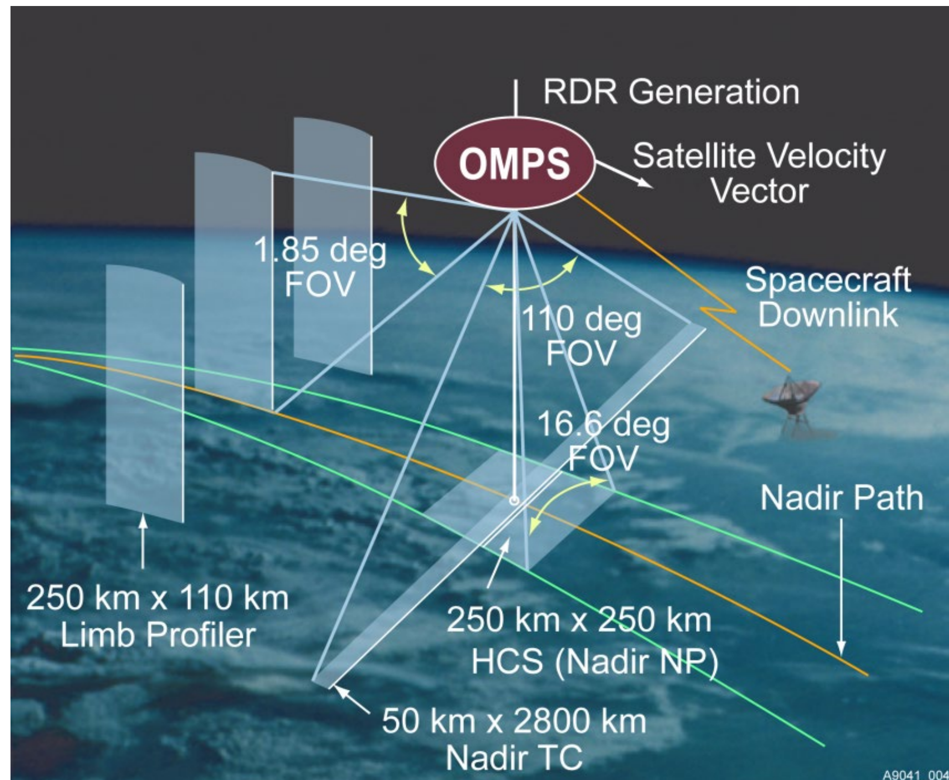
Ozone Mapping and Profiler Suite



Main electronics box (MEB)

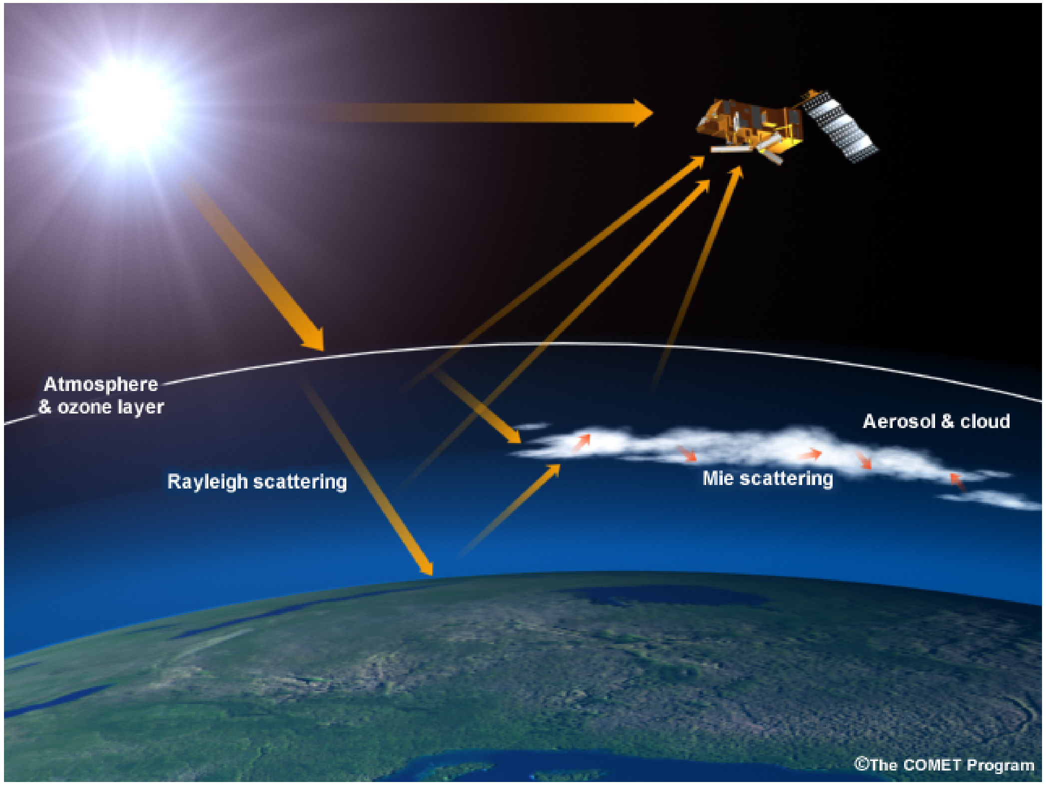
Nadir sensor:
Total Column (TC) spectrometer
&
Nadir Profiler (NP) spectrometer

Limb profiler (LP) sensor



OMPS measurements

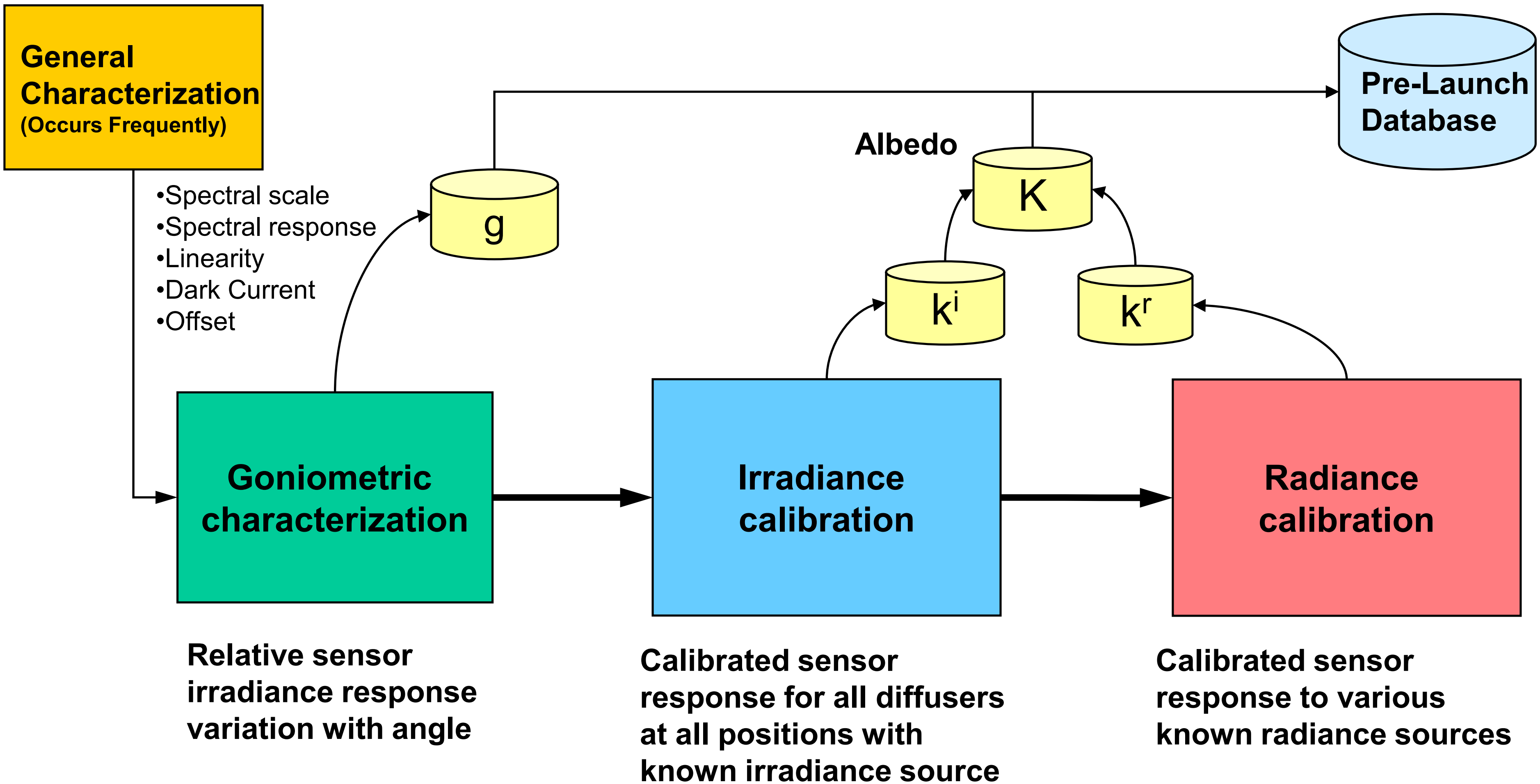
- **Backscattered or scattered radiances**
  - **Nadir sensor views back-scattered solar light from Earth's atmosphere**
  - **Limb sensor views solar light scattered by Earth's limb**
- **Measures ratio of Earth radiance to solar irradiance**
- **Working (reference) diffusers for weekly (semi-annual) solar calibration**



- **Albedo requirements**

  2% λ-independent
  0.5% λ-dependent

Calibration design schematic

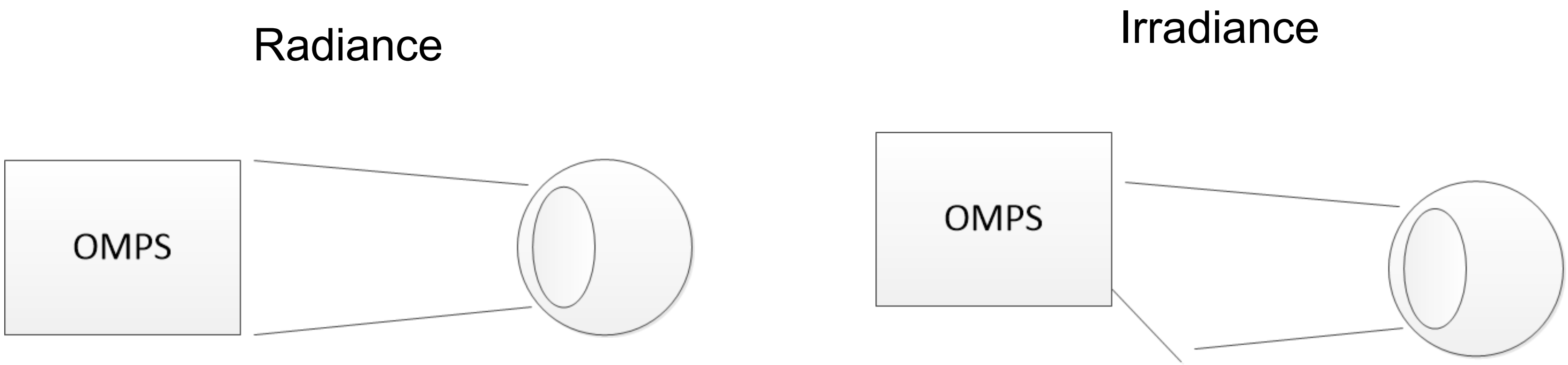


Heritage vs new calibration methods

- Heritage OMPS calibration program relied on calibrating the absolute radiance and irradiance response of the sensors
  - Derive albedo calibration from the ratio of absolute calibrations
- Desire to measure and characterize the sensor albedo directly
  - Eliminate test uncertainties and calibration transfers.
  - Leverage geometrical relations in the test setup to negate the need for a source known absolutely.

Experimental setup

- Measure radiance and irradiance in close succession
  - Same test setup
  - Same light source
  - Same lamp strike for radiance and irradiance on both diffusers
- Use a 'sun-like' source, leverage test setup geometry
  - Source terms cancel in ratio
  - Source has ~1 to ~2.25 degree FOV



Albedo measurement

- **Radiance Method**

$$Q^r(j,k) = L_{sphere} s^r(j,k)$$

Signal on CCD equals light from sphere times the radiance sensitivity of the sensor

- **Irradiance Method**

$$Q^i(j,k) = E_{sphere} g(\theta,\varphi) s^i(j,k)$$

Signal on CCD equals light from sphere times goniometry times the irradiance sensitivity of the sensor

- **Walker equation**

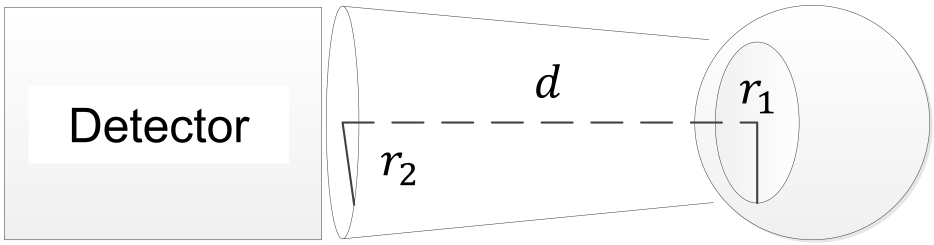
$$E_{sphere} = \frac{\pi r_1^2}{d^2 + r_1^2 + r_2^2} L_{sphere}$$

d is distance to sphere, r_1 is sphere aperture, r_2 is detector aperture

- Walker & Cromer, "Improving the accuracy of sphere-source calibrations," 1991.

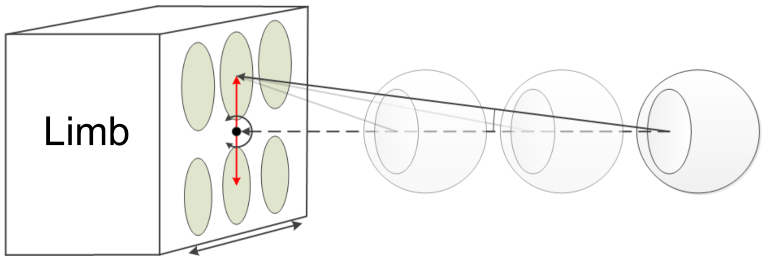
- **Albedo**

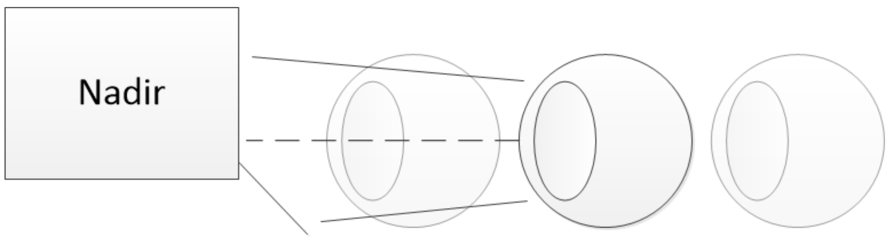
$$K = \frac{s^i}{s^r} = \frac{Q^i(j,k)}{Q^r(j,k)} \frac{d^2 + r_1^2 + r_2^2}{g(\theta,\varphi)\pi r_1^2}$$



OMPS albedo calibration

- Ideally we can use the Walker equation to eliminate source term
- Irradiance and albedo calibrations project view of flight diffuser normal to the sensor aperture
  - Accounts for pixel foreshortening
  - BRDF/BTDF of the diffuser inherent to the calibration
- Practically the test setups deviate from the ideal
  - Diffusers off-axis and viewed at angles
- Must carefully consider test geometry
  - Use numerical integral for corrections
  - Take data at multiple distances to check for systematics
  - Take data with multiple apertures to check for systematics

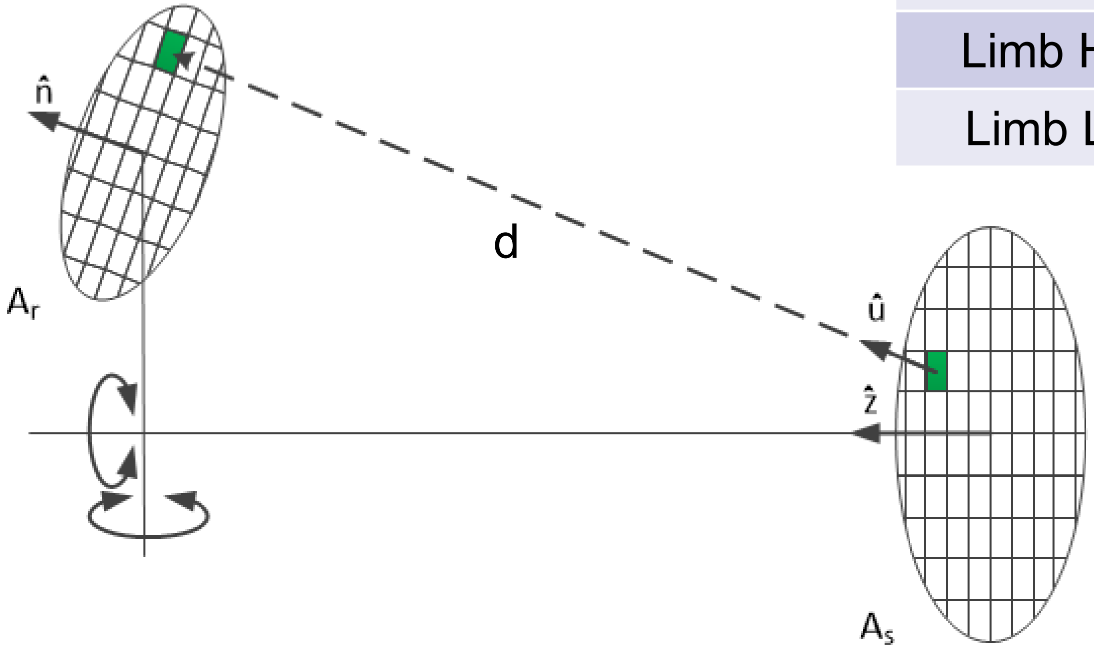




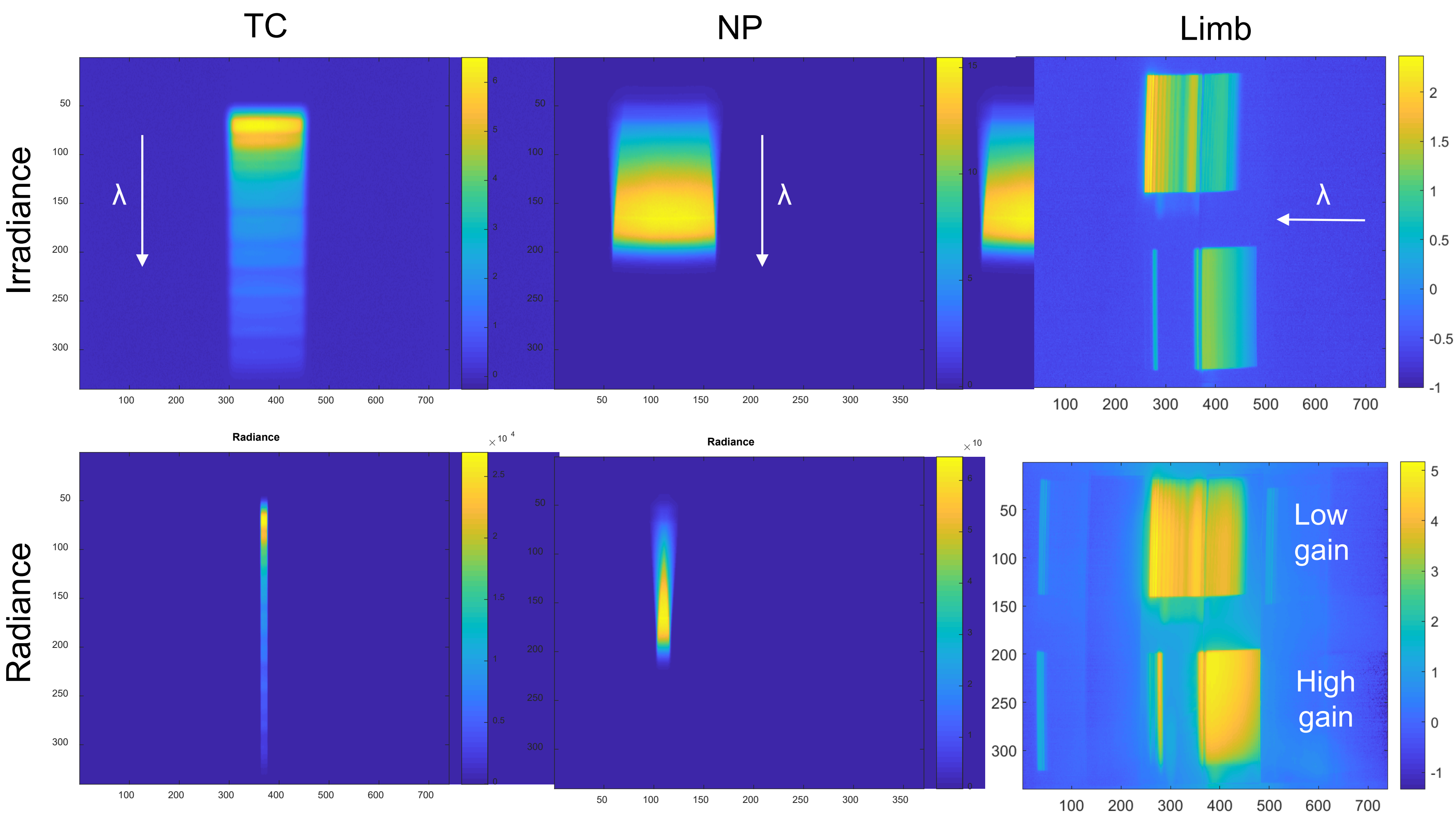
Correction factors

- Predict offset factor from Walker equation due to off-axis source and tilted/rotated diffuser using numerical integration
- Compare to predicted Walker albedo
- Must consider goniometric effects

	Near	Middle	Far
NP/TC small	0.994	0.996	0.996
NP/TC large	0.980	0.986	0.987
Limb HG	0.986	0.990	0.993
Limb LG	1.009	1.007	1.005

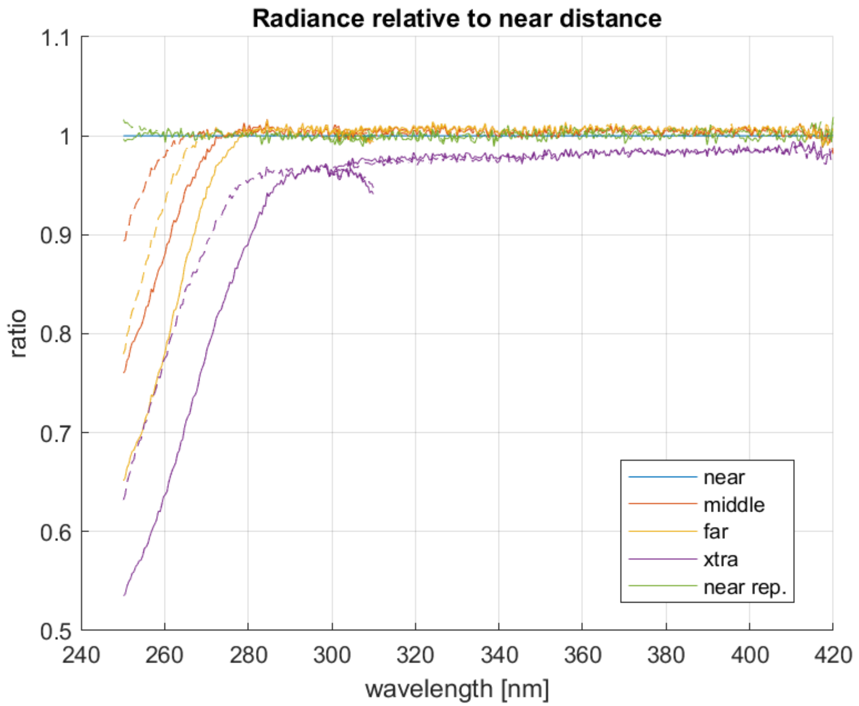


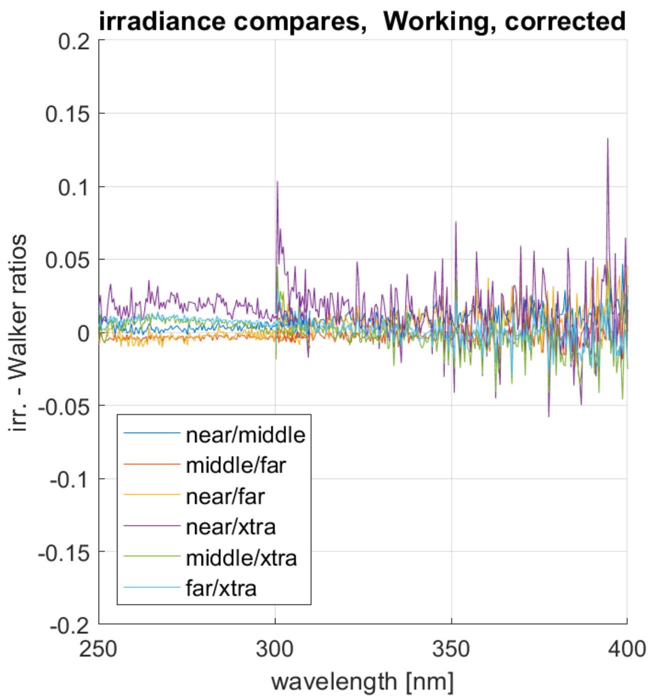
Representative images



Test setup verification

- **Two verification steps**
  - **Radiance is constant, ratios of radiance images at different distances should yield unity. Deviations indicate issue with straylight or test setup.**
  - **Irradiance scales with Walker equation. Deviations indicate issue with test setup and can be used to adjust parameters within reason.**





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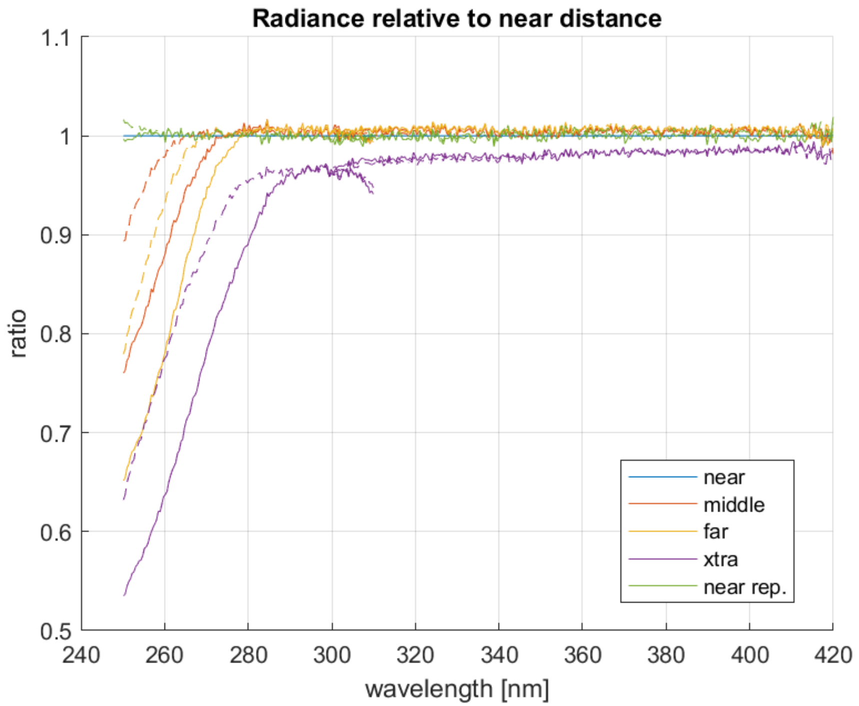
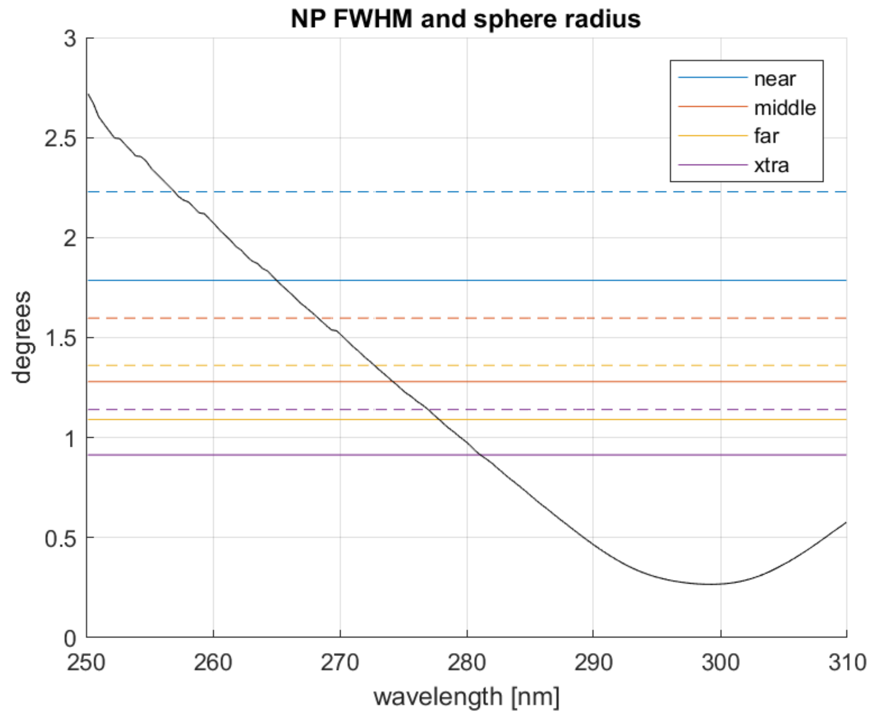
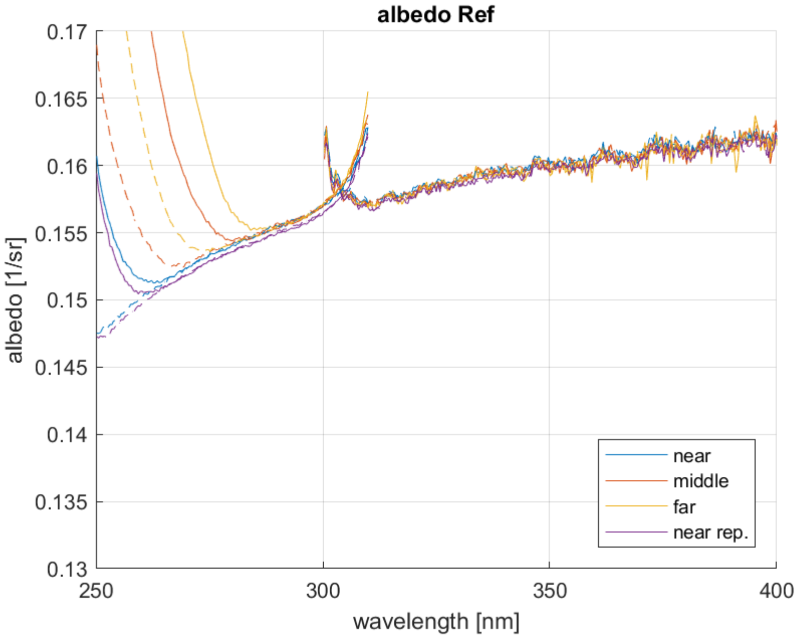
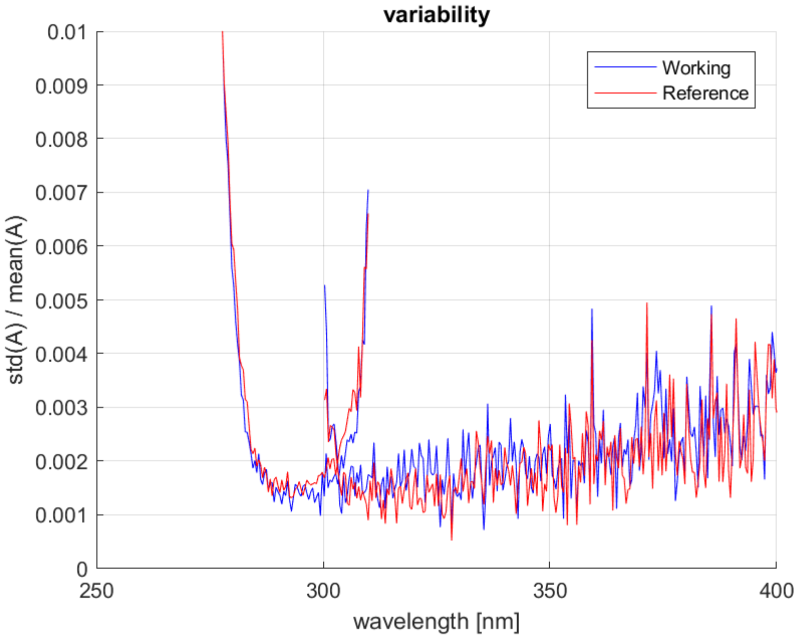




Results: Nadir

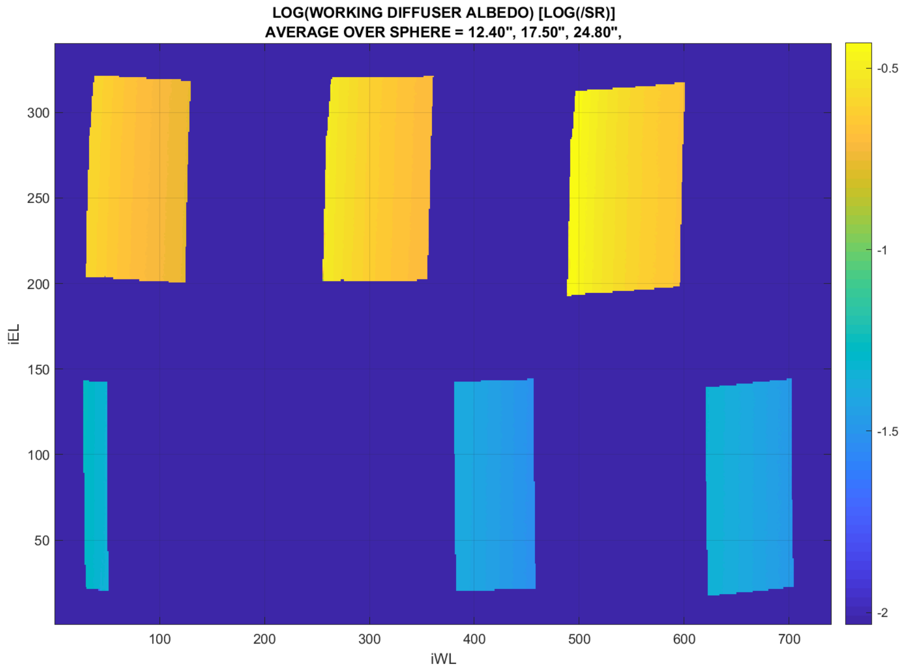
- **Central 6° FOV calibrated with the albedo measurement**
  - **Variability less than 0.4%**

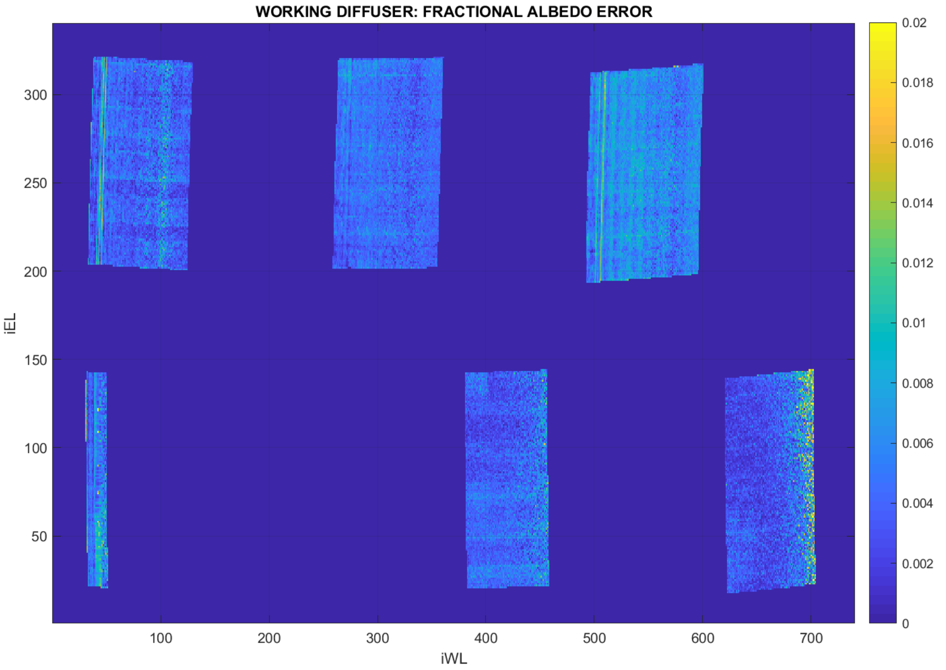




Results: Limb

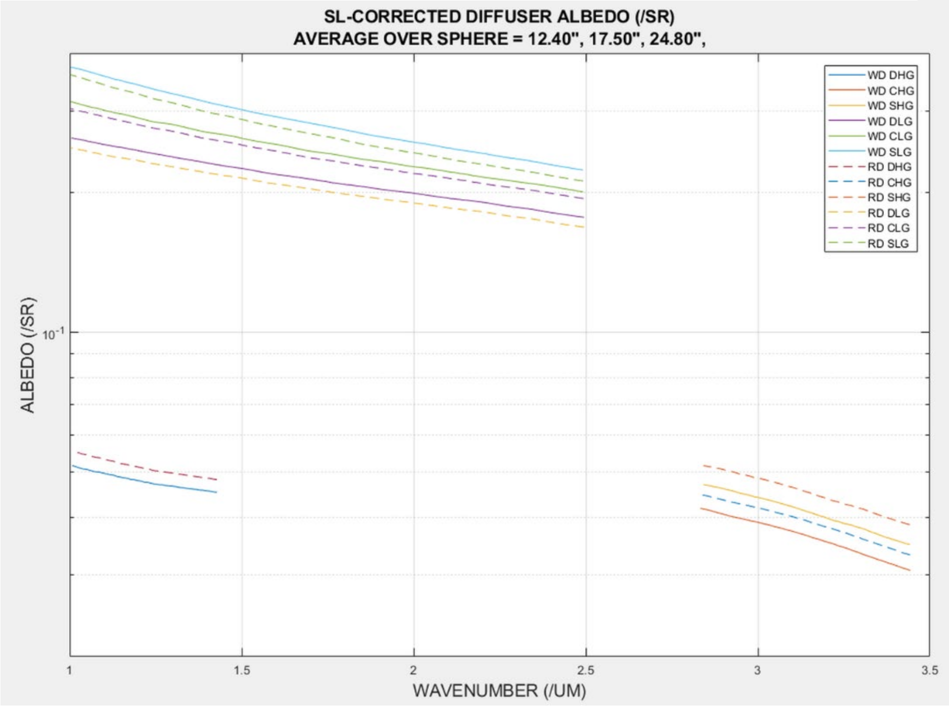
- **Full FOV of all apertures calibrated with the albedo measurment**

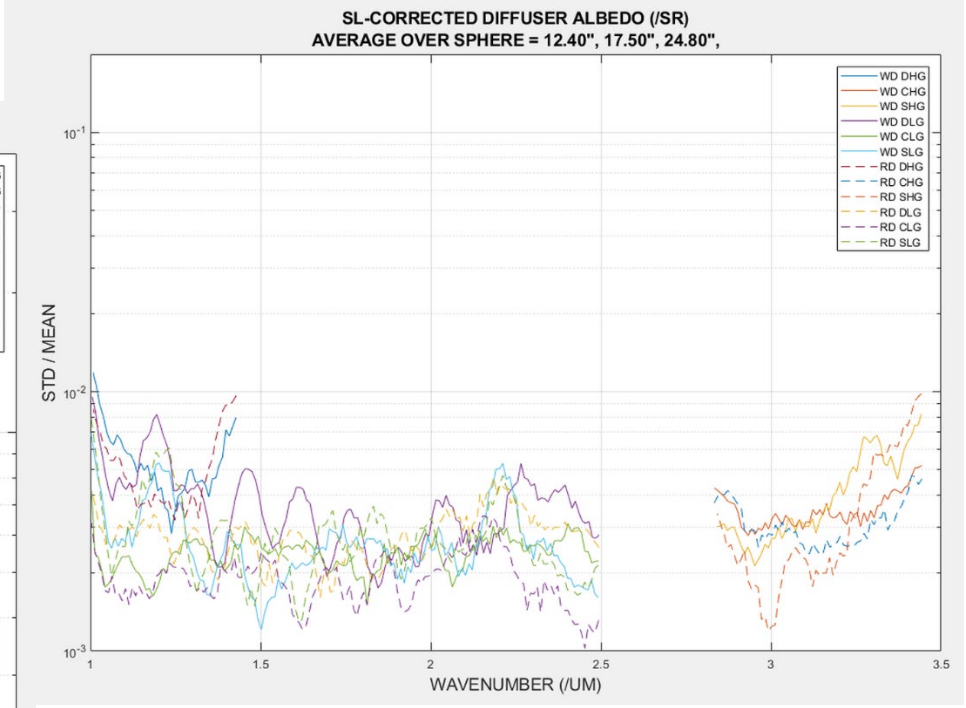




Results: Limb

- Variability less than 0.5% on all apertures except in areas of very low signal or high spectral gradients (UV channels are dim, steep gradient at 1000nm/1μm^{-1}).





Summary

- Ball Aerospace derived a dedicated test setup and procedure to measure the OMPS albedo calibration coefficient
- Minimize sensor changes, eliminate non-common test setups
- Results demonstrate less than 0.5% variability for majority of wavelengths on both Limb and Nadir sensor.
- Albedo requirements met for both sensors.

Thanks to everyone on the OMPS program who has made this possible.

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