Initial look at the results from the prelaunch characterization campaign of OCI on the PACE mission

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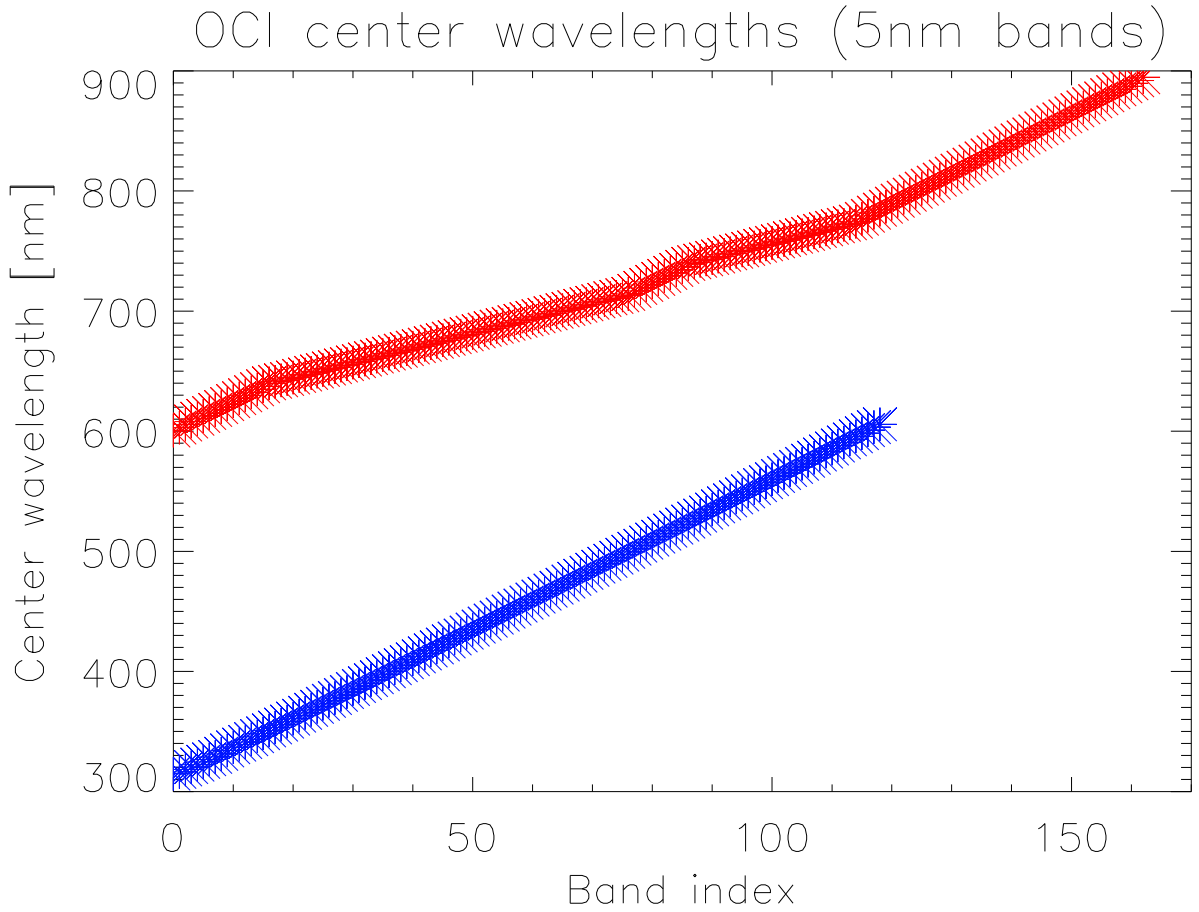
OCI Spatial Performance (GSD, IFOV, FoR)

- Ground Sampling Distance (GSD) along scan/track: 0.0888deg/0.0881 deg (distance between pixel centers)
- Instantaneous Field of View (IFoV) along scan/track: 0.0889deg/0.0929deg (area imaged by a pixel)
- Effective spatial resolution for PACE orbit including 20deg tilt at 'nadir': **1.2km** (similar to SeaWiFS, larger than MODIS (1km))
- Field of Regard (FoR) : **- 56.0deg to +56.5deg**
- Swath width on the ground: ~**2700km**
- 2-day global coverage (almost daily global coverage)
- Tilt (-19.9deg and +19.9deg) will be staggered (like SeaWiFS)

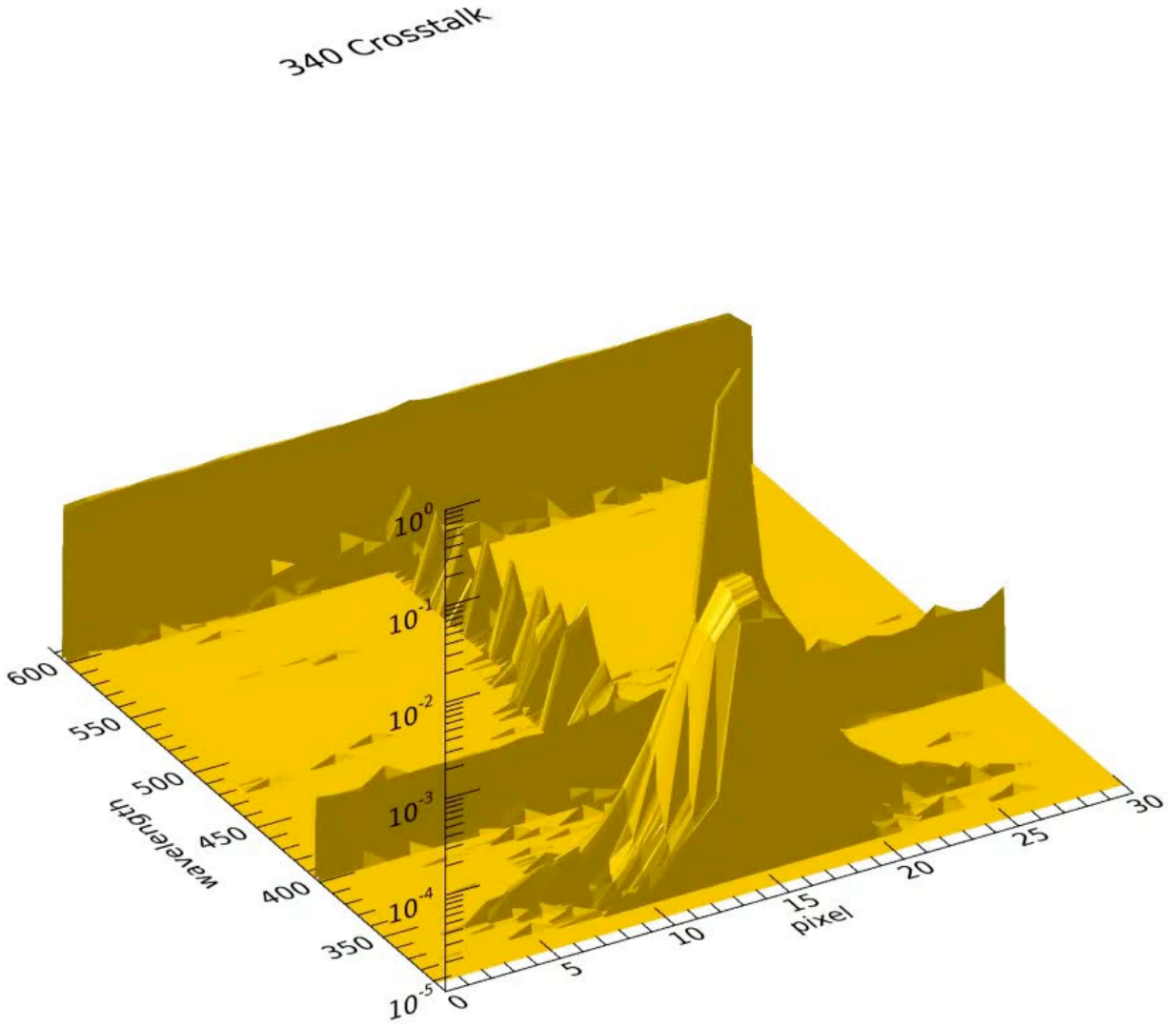
Hyperspectral bands: spectral coverage

- Blue FPA baseline aggregation: 119 L1B bands from **314.9nm to 605.7nm**
  - 116 L2 bands up to 598.3nm
  - Bands below 340nm have reduced radiometric accuracy (TBD on-orbit)
  - Bandwidth: ~5.1nm
- Red FPA baseline aggregation: 163 L1B bands from **600.5nm to 894.6nm**, bandwidth ~5.0nm
- 9 SWIR bands at 7 wavelengths from **940nm to 2260nm**
- See following presentation for details on SWIR bands, bandwidth, out-of-band, etc.



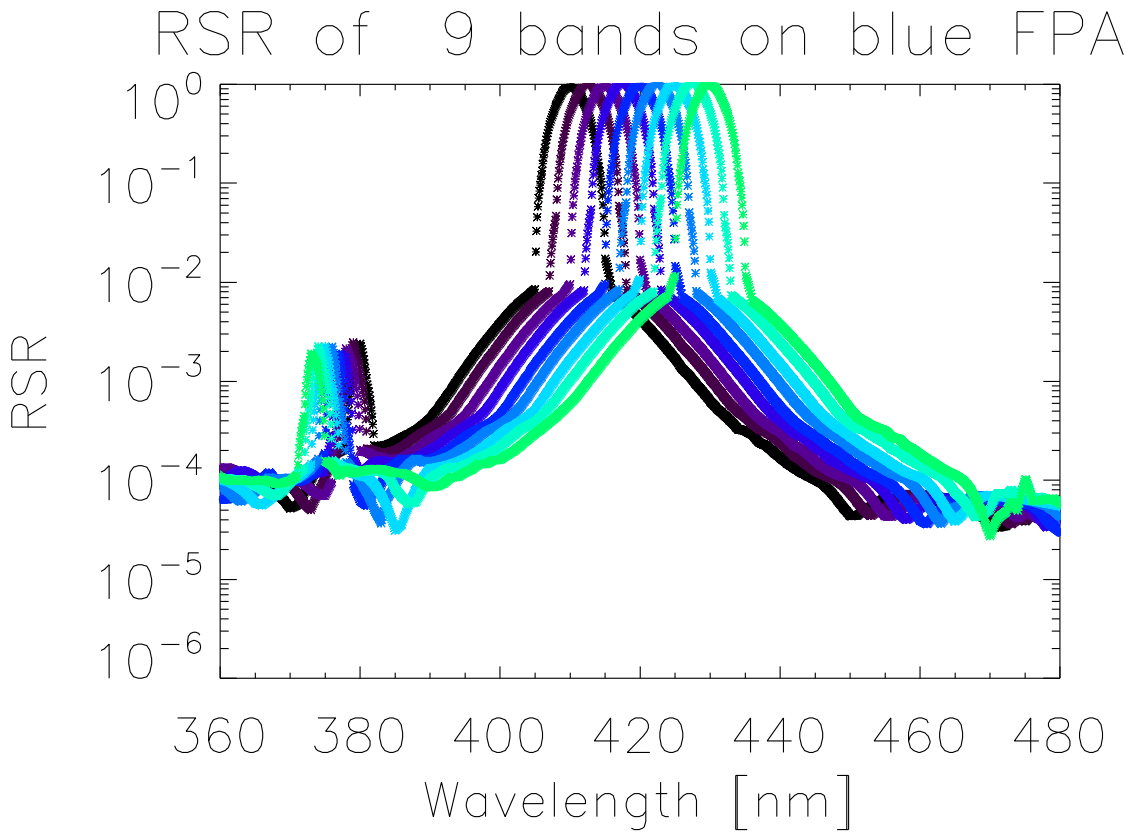
‘Ghosts’ in blue spectrograph

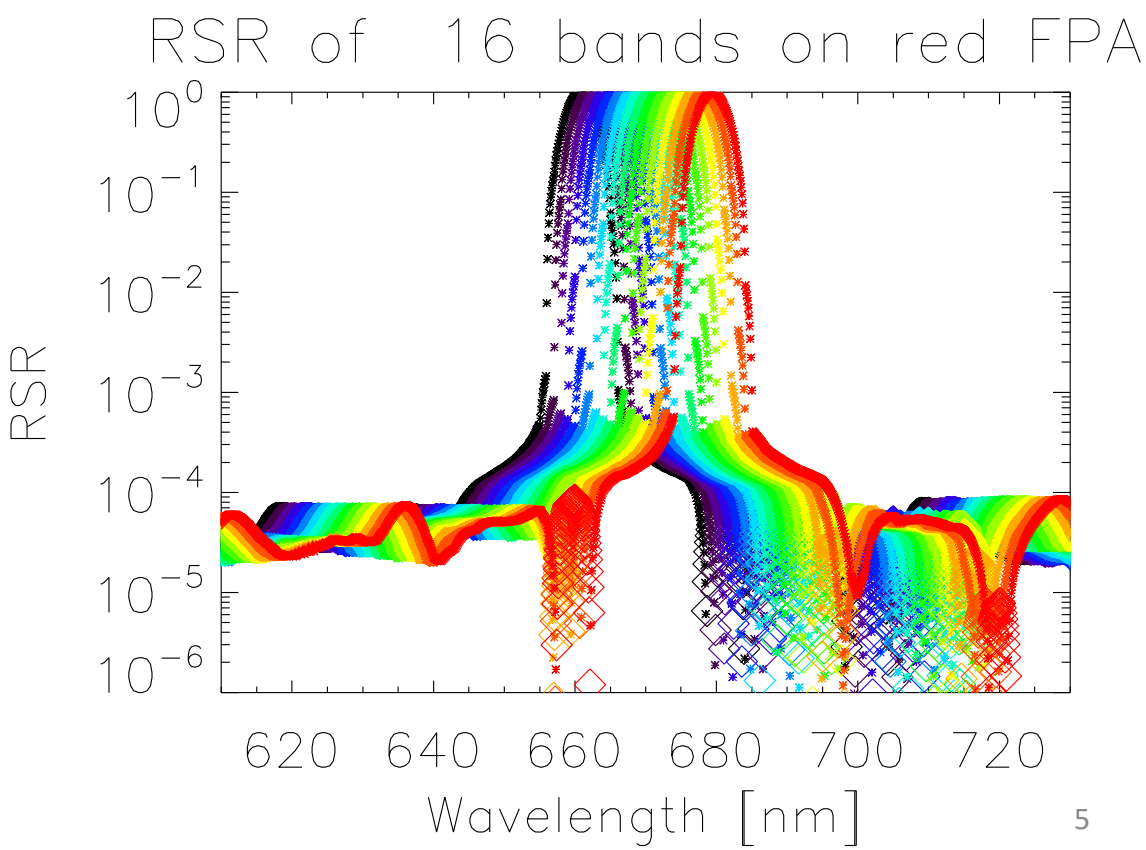
- Identified as reflections of various optical surfaces via raytracing model
- We derived a model based on measurements
- Animation shows modelled crosstalk from +/- 15 1km pixels (x-axis) and sender wavelengths (y-axis) into receiving band (function of time)
- We have derived a correction that removes the ghosts (two ‘walls’ in picture on the right) and along-scan and spectral straylight (remaining features in picture on the right). No correction is applied for adjacent 1km pixels or adjacent 5nm bands.
- Along-track straylight is smaller (limited by telescope aperture) than along-scan and not corrected for.



OCI relative spectral response: red FPA

- More RSR variation (electronic crosstalk) on red FPA, but at very low level (often negative)
- Decline from peak to <1e-3 much faster than in blue FPA
- Ghosts much smaller than in blue FPA





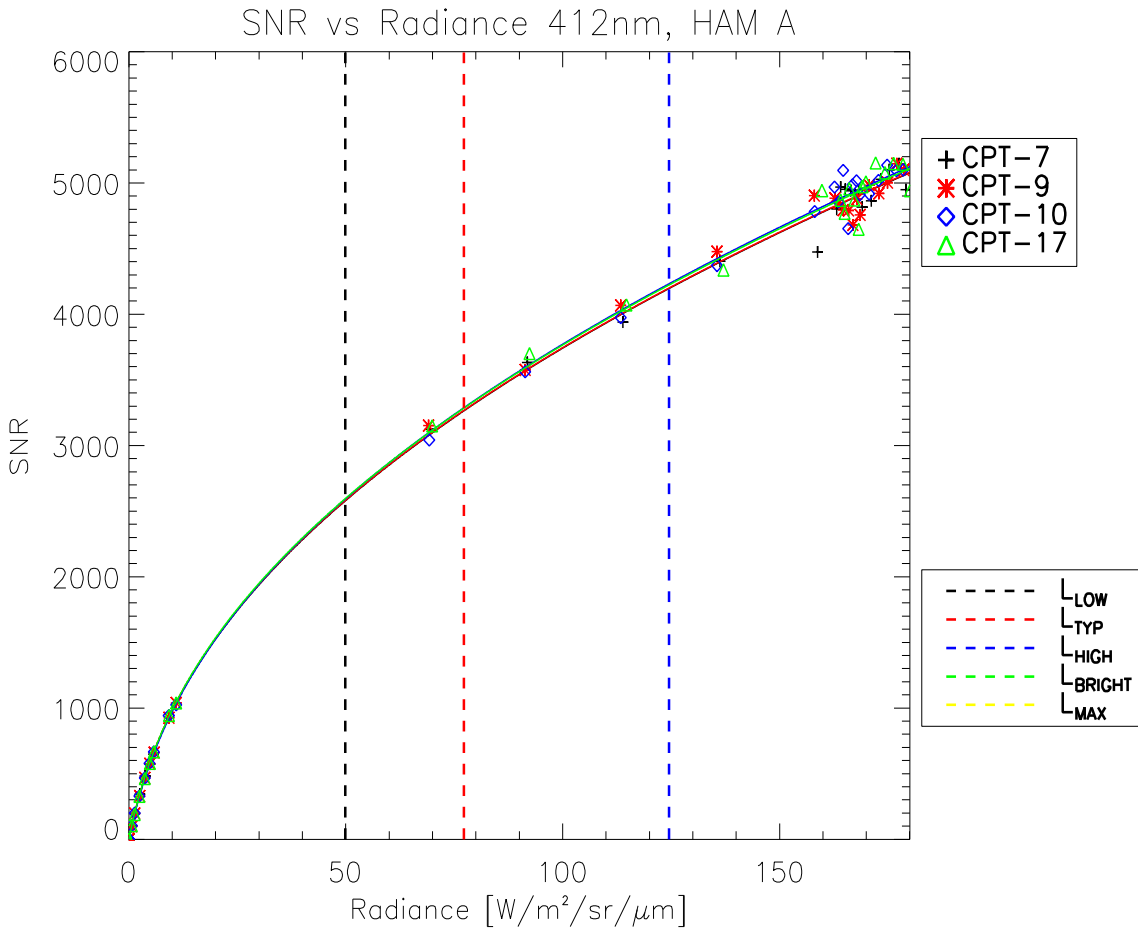
SNR Evaluation

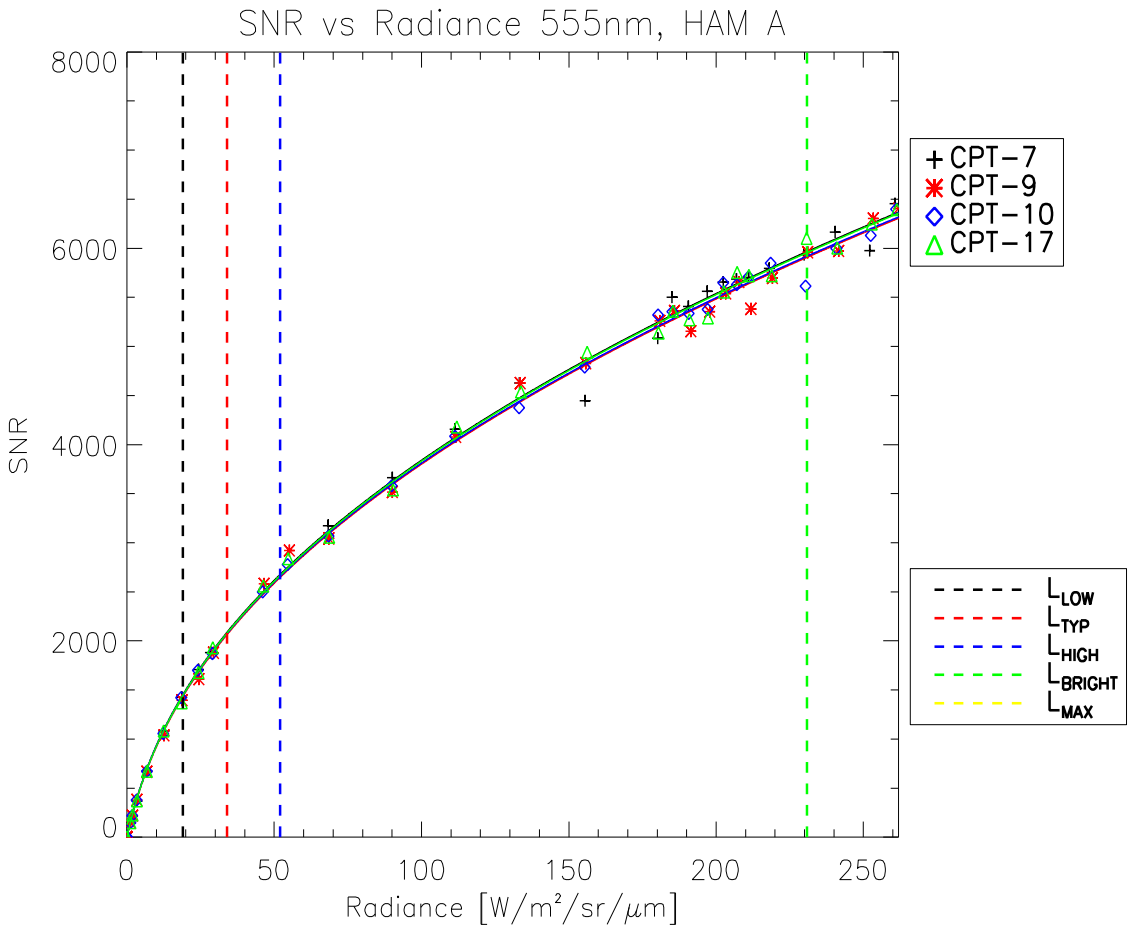
SNR (412 nm and 555 nm)

Measured SNR plotted versus radiance (different lamp levels).

Data – symbols; Colors – TVAC temperatures (nominal, hot op, cold op)

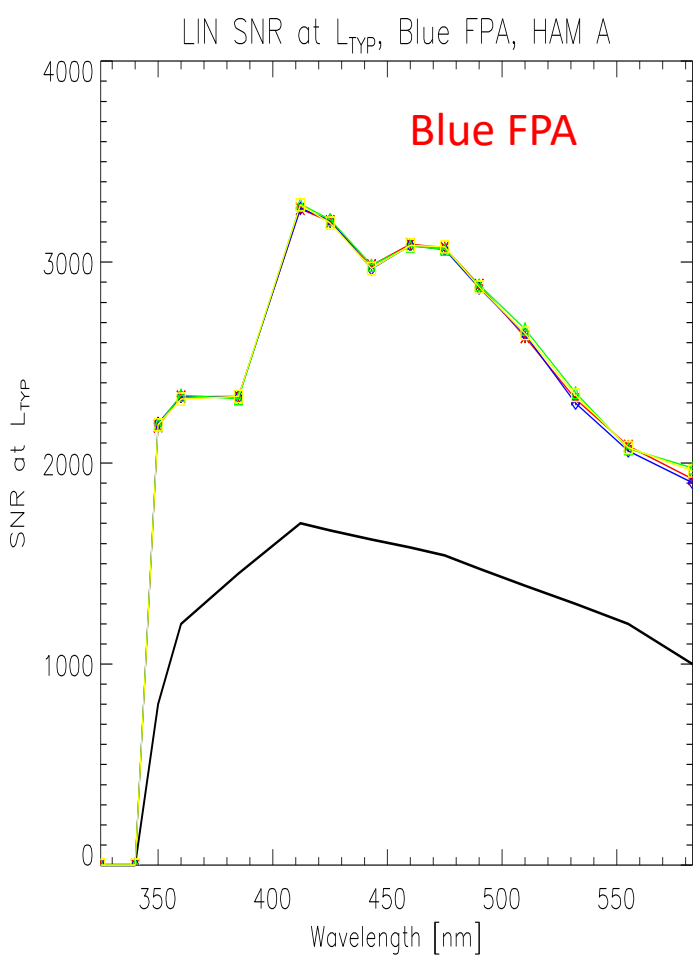
Solid lines – Fit to data; Dashed vertical lines – TOA radiance levels (from requirements)

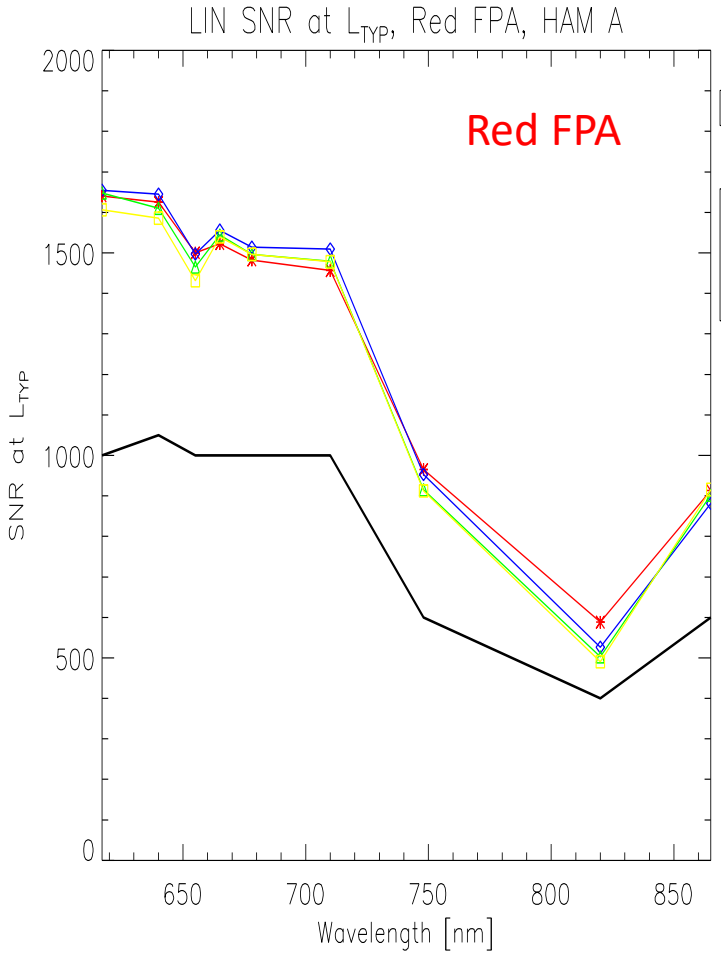


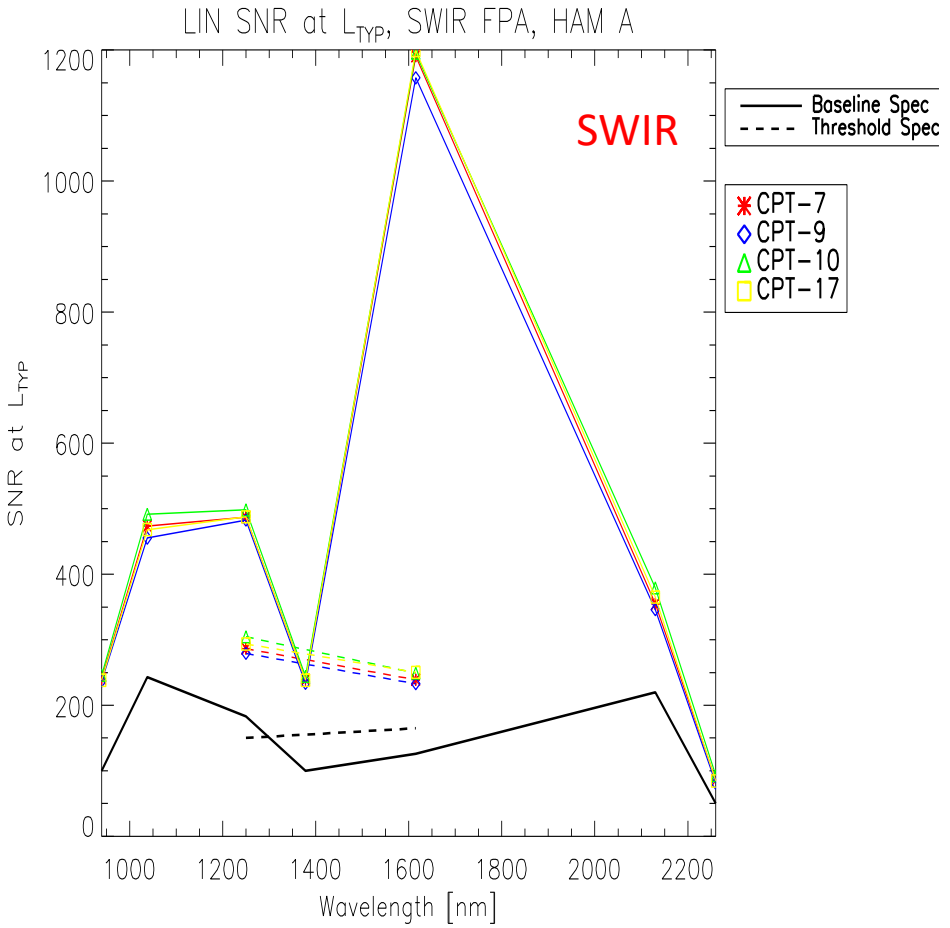


SNR at L_{TYP} for multispectral bands

Comparison of different SNR estimates over TVAC tests (HAM A shown; HAM B is consistent).
All multispectral and SWIR bands well above the baseline requirement.

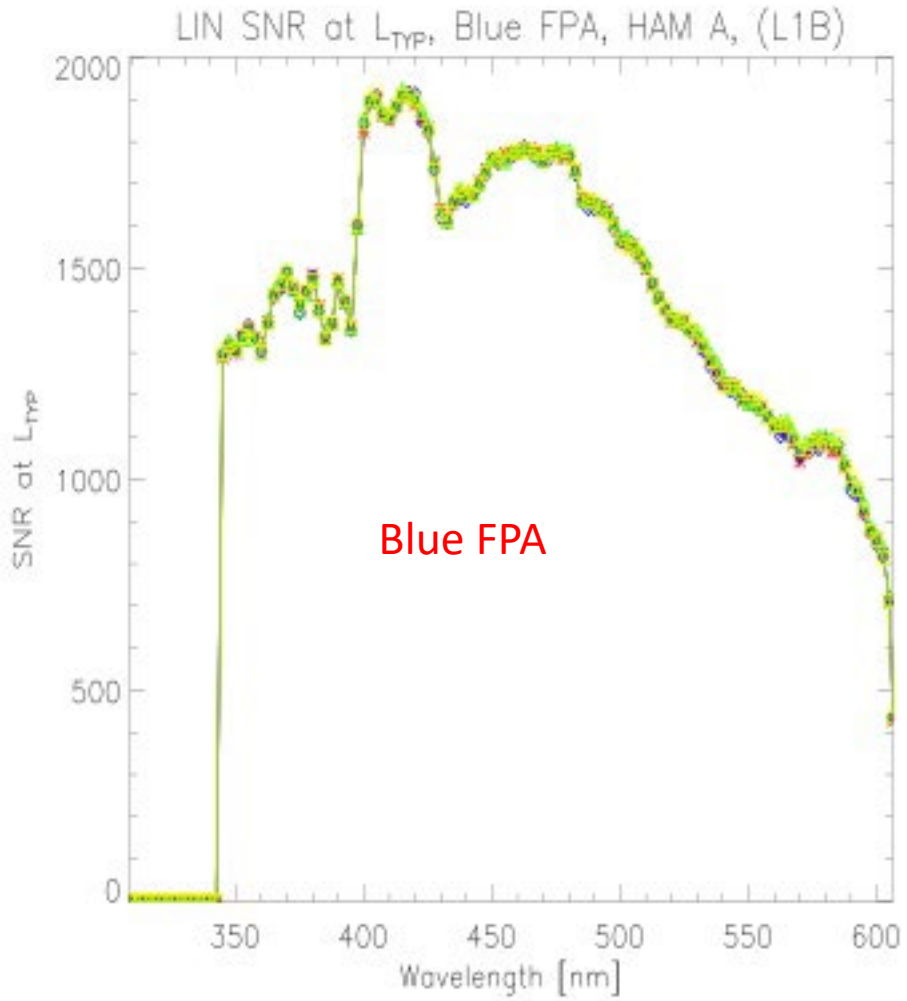


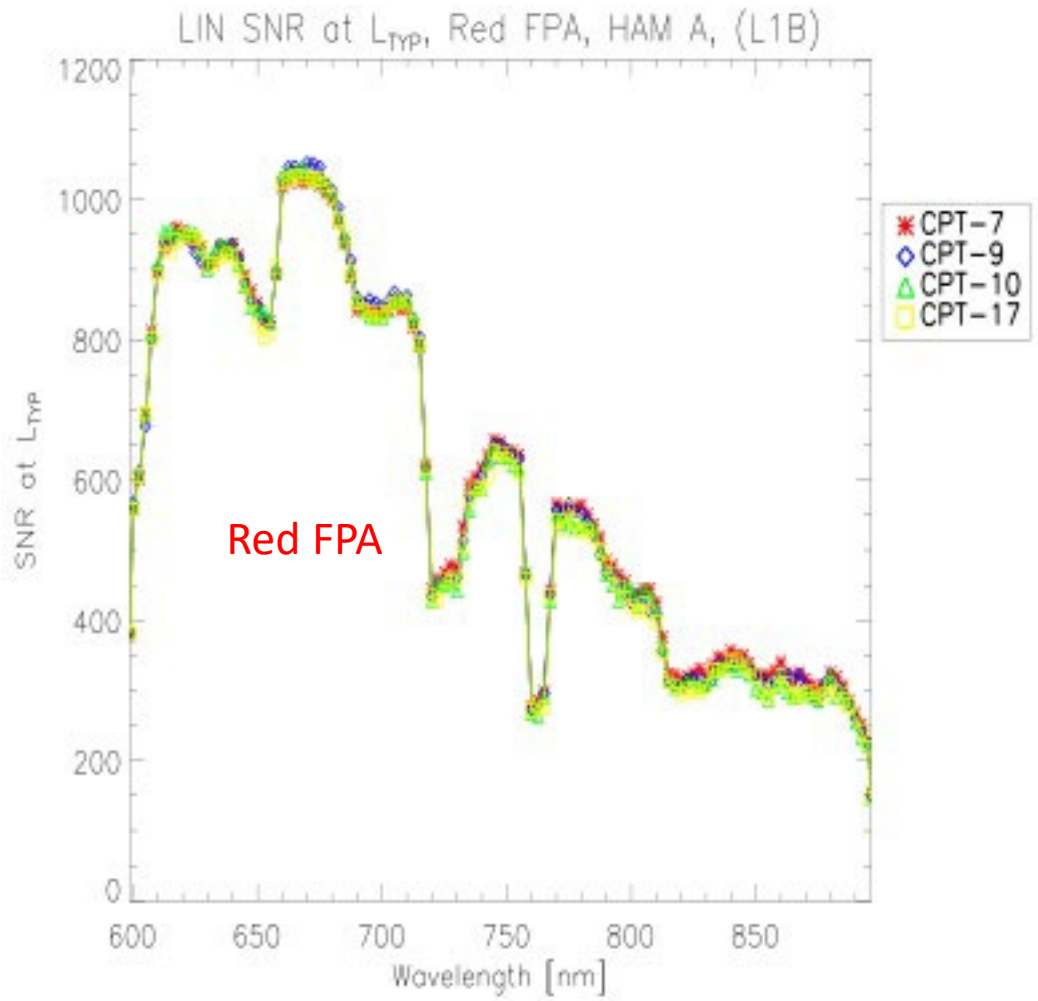




SNR at L_{TYP} for hyperspectral bands

Comparison of different SNR estimates over TVAC tests (HAM A shown; HAM B is consistent).
Very high SNR even for hyperspectral bands (spectral aggregation needed above 800nm).





Radiance Calibration Equation

$$Lt = K1*K2(t)*(1-K3(T-Tref))*K4(\theta) *K5(dn)*Kp*dn$$

- Lt = Radiance, unit: W /(m^2 µm sr)
- K1 = absolute gain factor; unit: (W /(m^2 µm sr))/dn
- K2(t) = relative gain factor as a function of time t; unitless
- K3 = temperature correction [(deg C)$^{-1}$] (vector)
- T = Temperatures measured at relevant locations [deg C] (vector)
- Tref = Reference Temperature [deg C]
- θ =scan angle [deg]
- K4 = (θ) response versus scan ; unitless
- K5 = nonlinearity factor ; unitless
- dn = dark-corrected instrument counts

Kp: polarization correction applied in Level-2 code (correction needs TOA radiance polarization information)

K1, Kp and K3-K5 have been derived for all bands

- K2 will be derived on-orbit from solar diffuser and lunar measurements

- see following presentation for K1 results

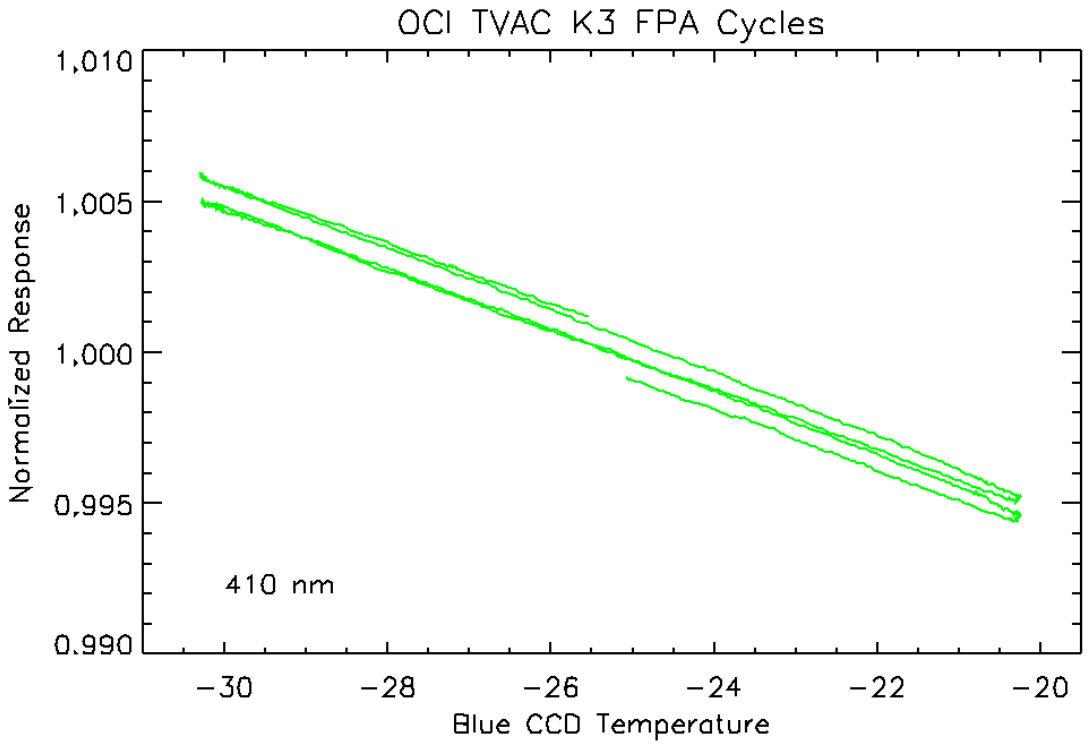
K3: Temperature dependence

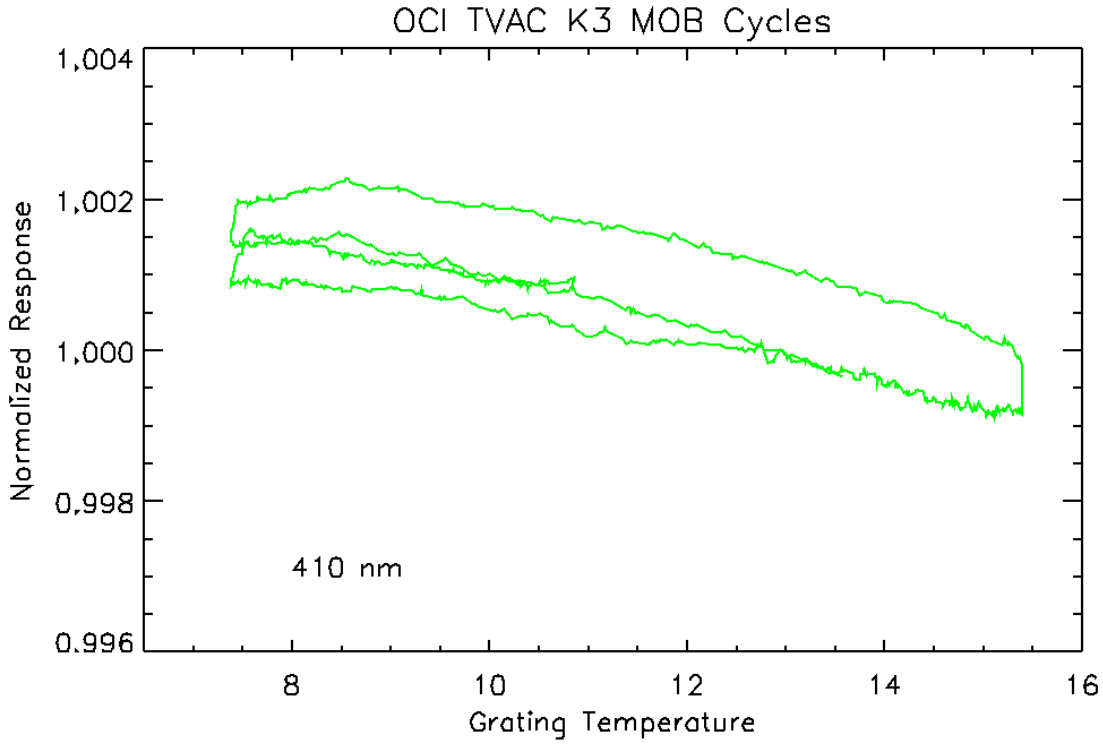
Temperature dependence measured during TVAC testing with white light source:

- variation dominated by detector (FPA) temperature (see e.g. 410nm example below)
- impact of main optical bench (MOB) is minor, no impact from Data Acquisition Unit (DAU)
- very small (unexpected) variation detected with mirror side for red FPA (<0.02%/deg)

Temperature dependence measured during TVAC testing with monochromatic light source:

- 0.02nm/deg wavelength shift (negligible, not corrected) for red FPA



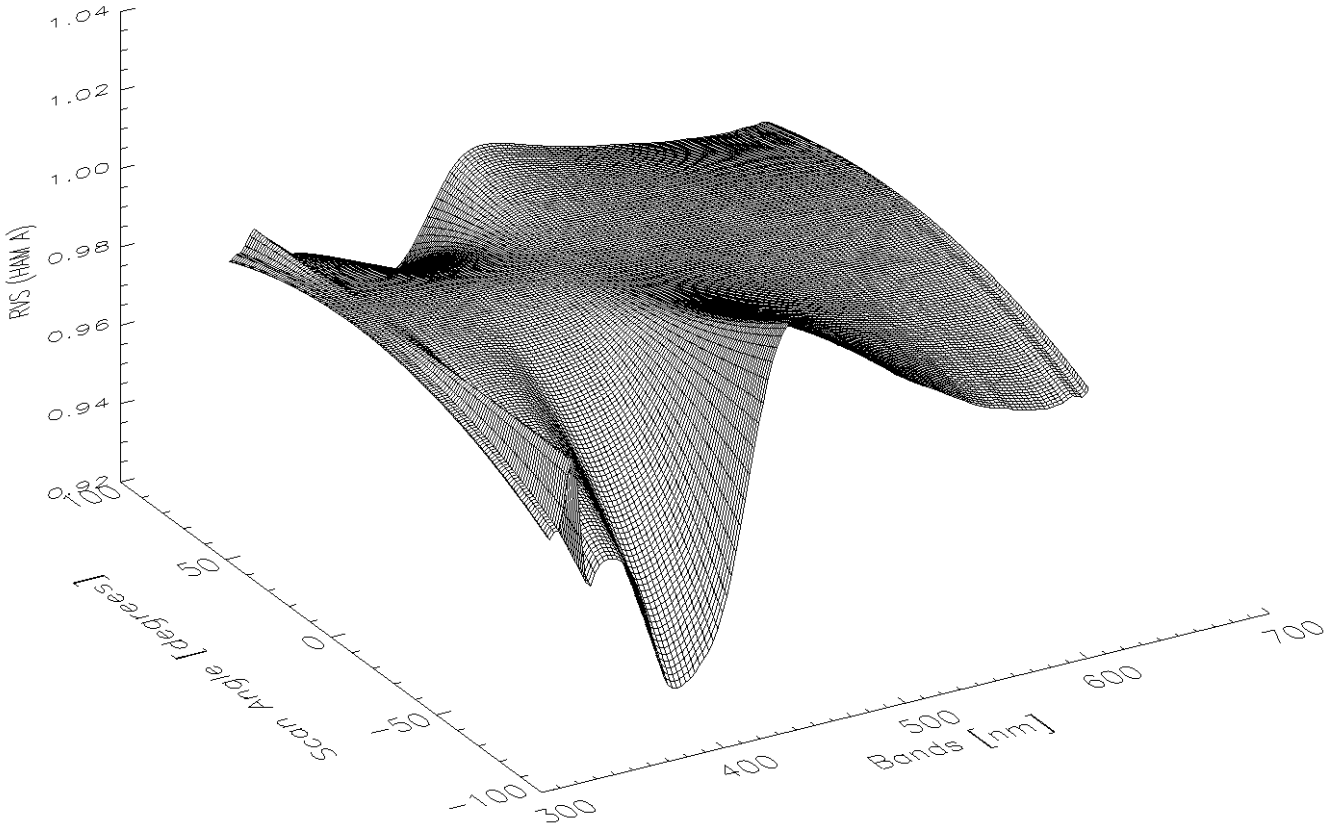


K4: Response Versus Scan Angle (RVS)

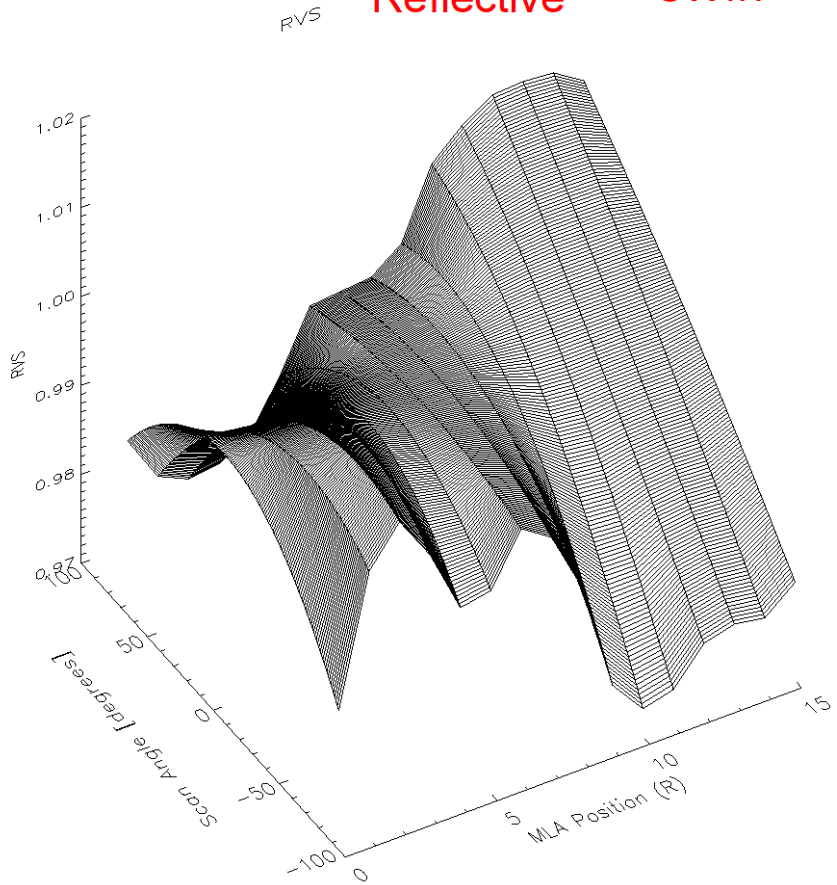
Instrument response to constant radiance measured at different scan angles

- variation below 900nm agrees well with model predictions, symmetric around nadir
- RVS in the SWIR bands increases linearly with scan angle (this was unexpected)
- Ray trace model suggests fiber alignment as a possible reason

Blue FPA

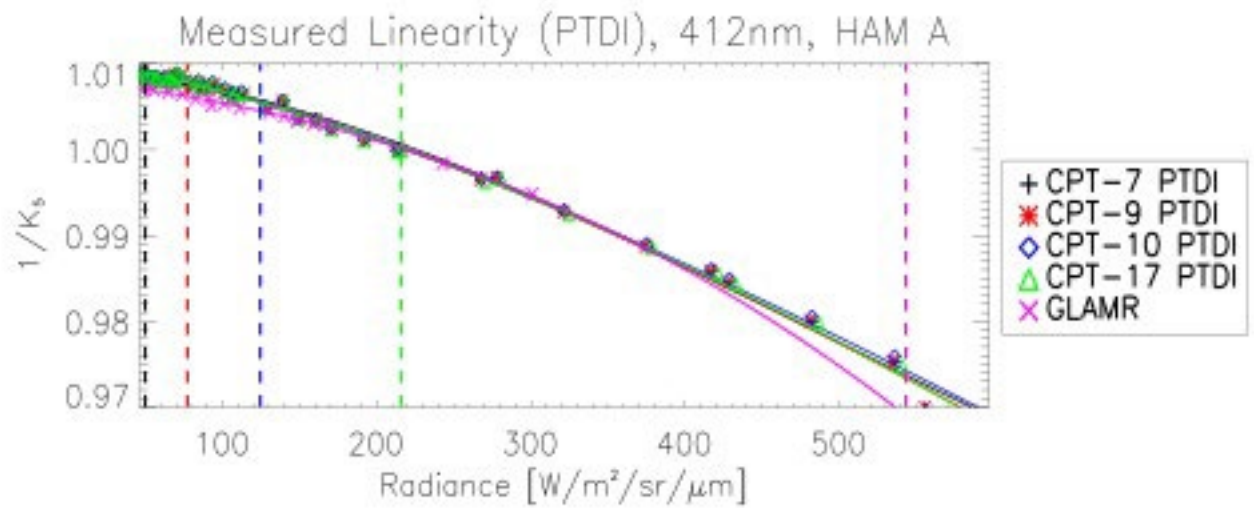


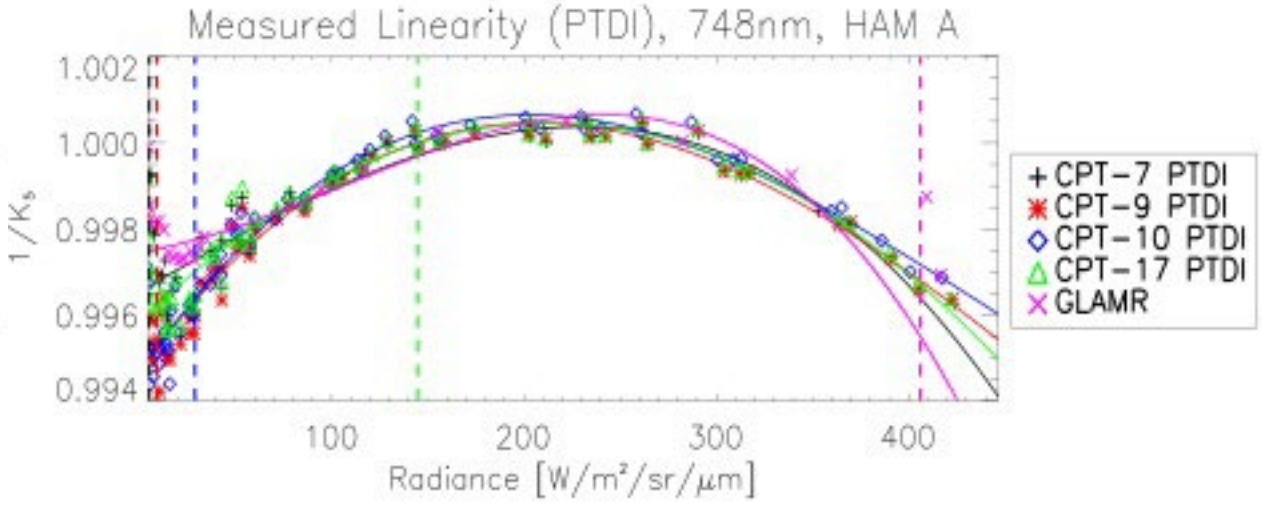
Reflective SWIR

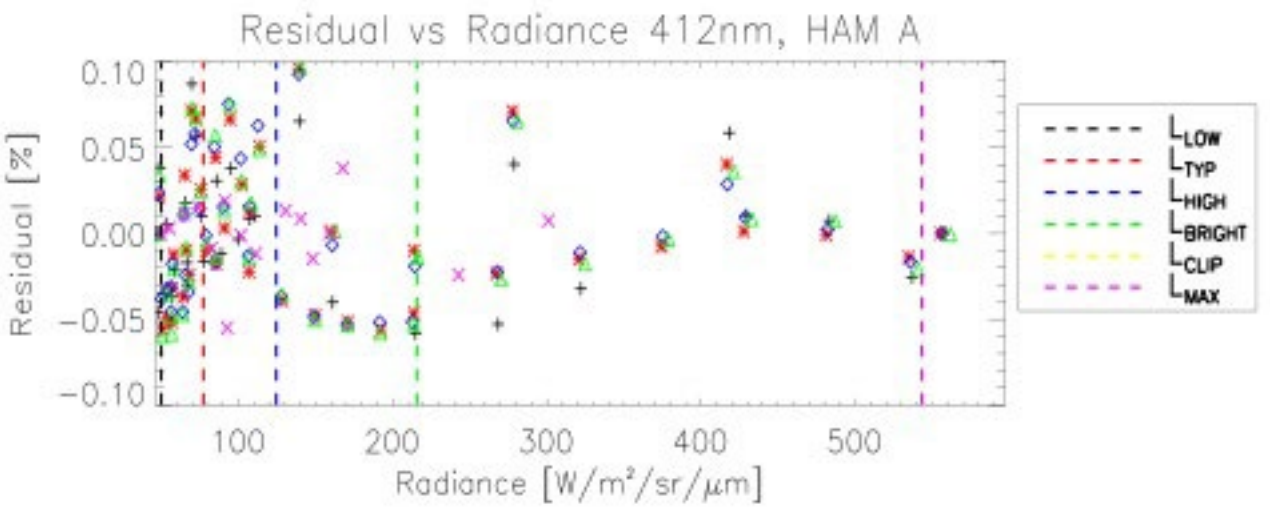


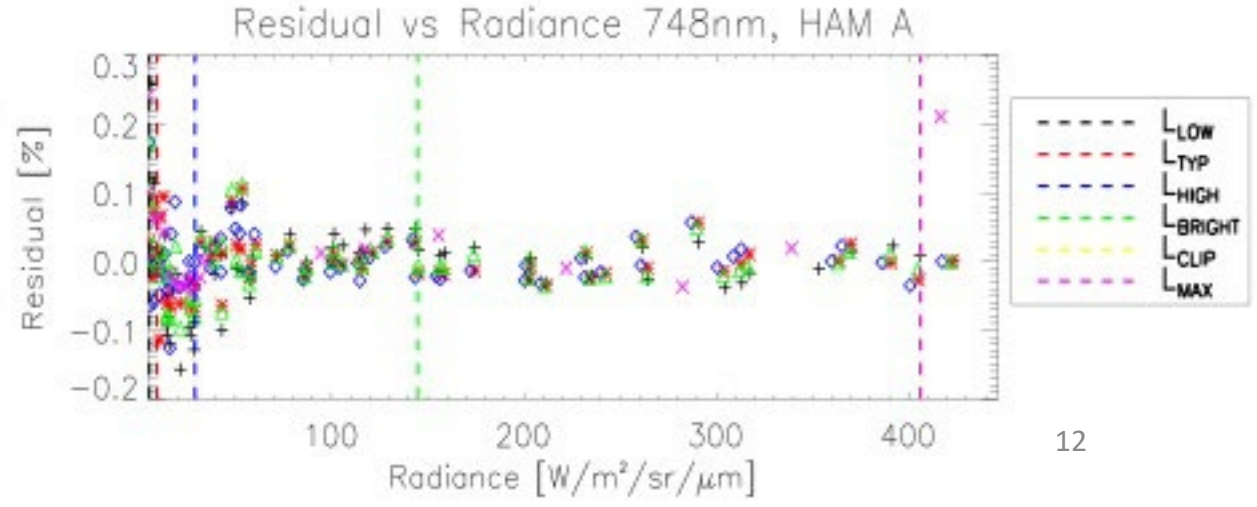
K5: Linearity

Comparison of white light progressive time-delay integration (PTDI) and GLAMR power stepping
- Generally results are comparable for Red and Blue FPAs
- No PTDI for SWIR bands – GLAMR data used



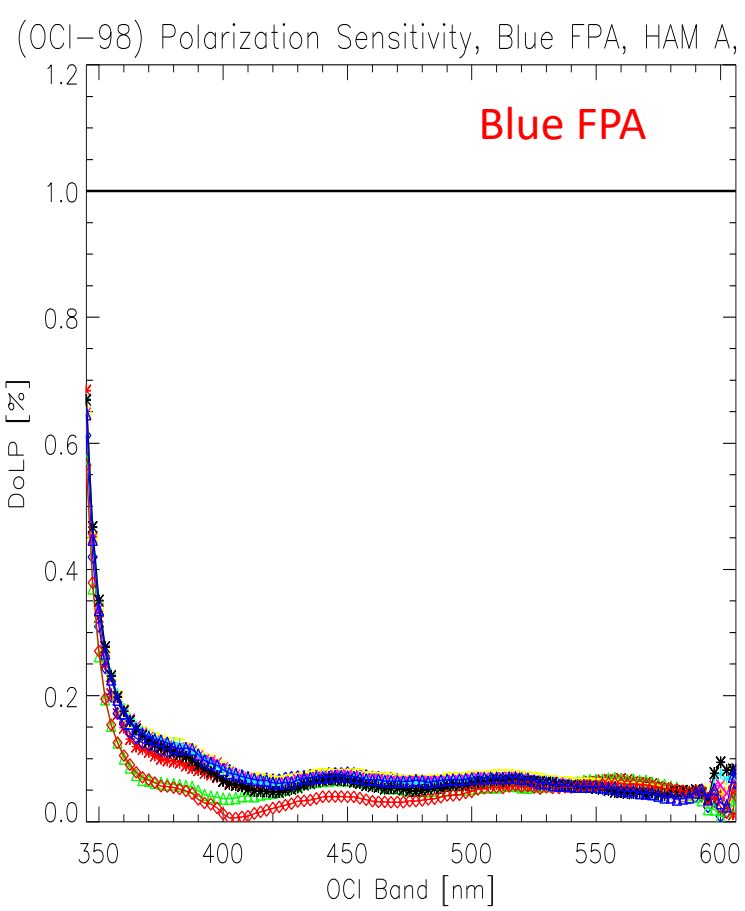


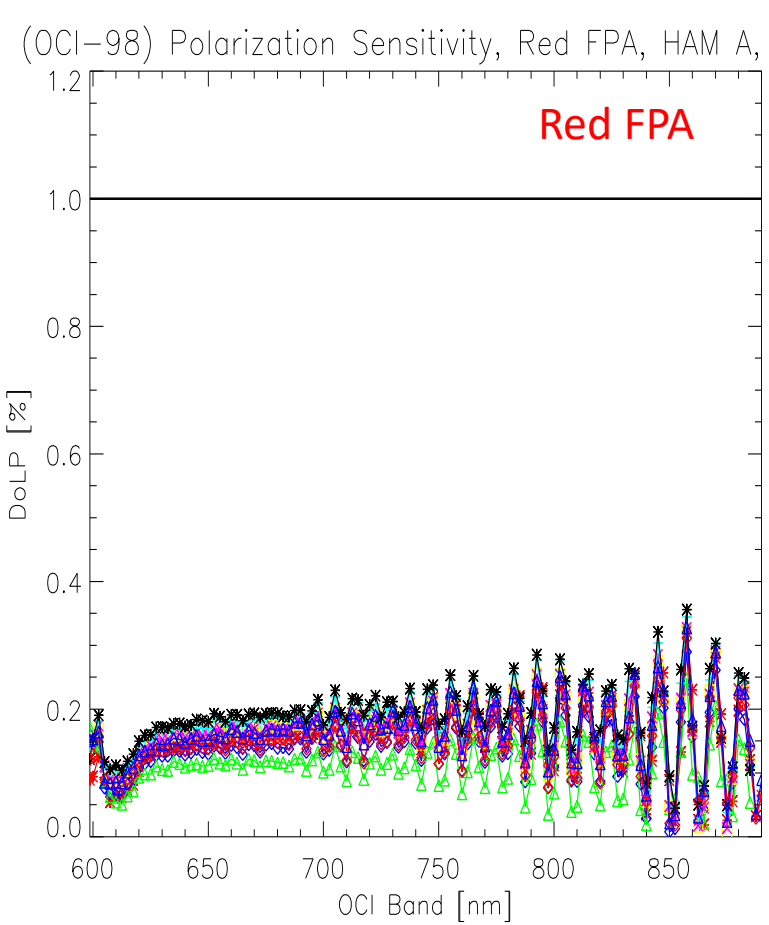


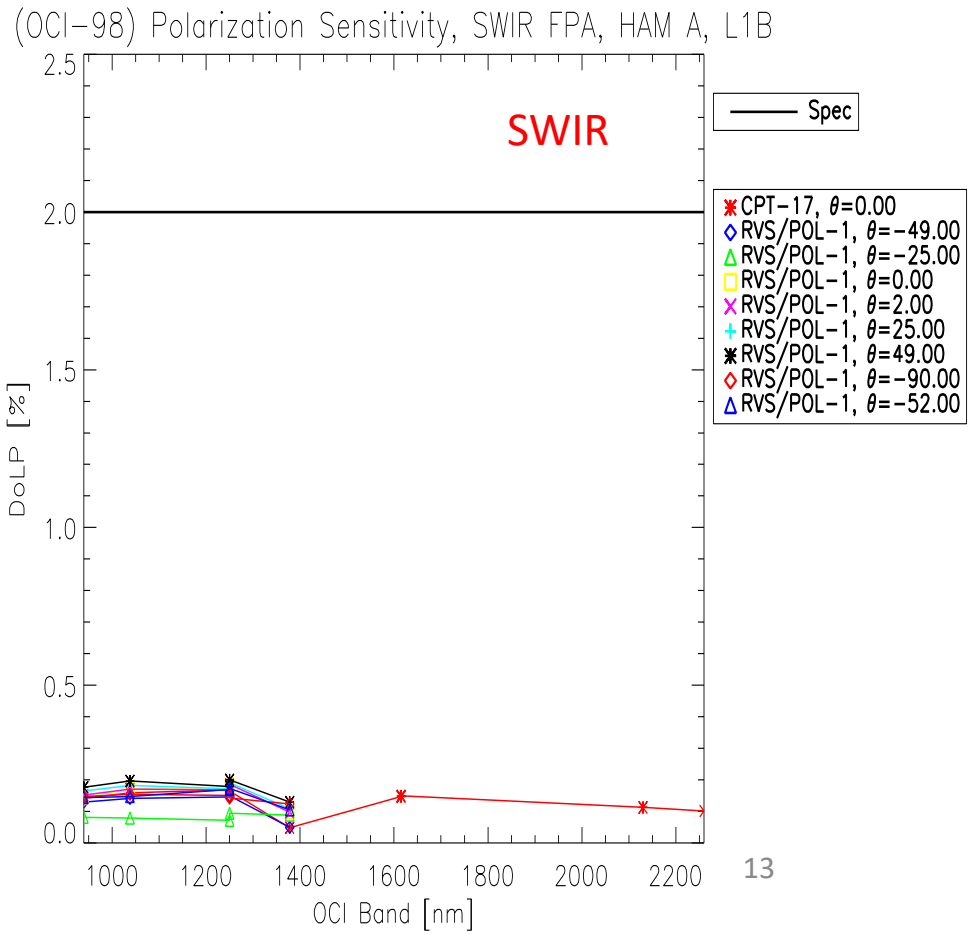


Kp: Polarization Sensitivity

Polarization amplitude measured at different scan angles
- Amplitude generally less than 0.4 % except in UV (below about 350 nm)
- Oscillations in red FPA a feature of the depolarizer
- Phase angle also determined – Mueller matrix components derived from amplitude and phase

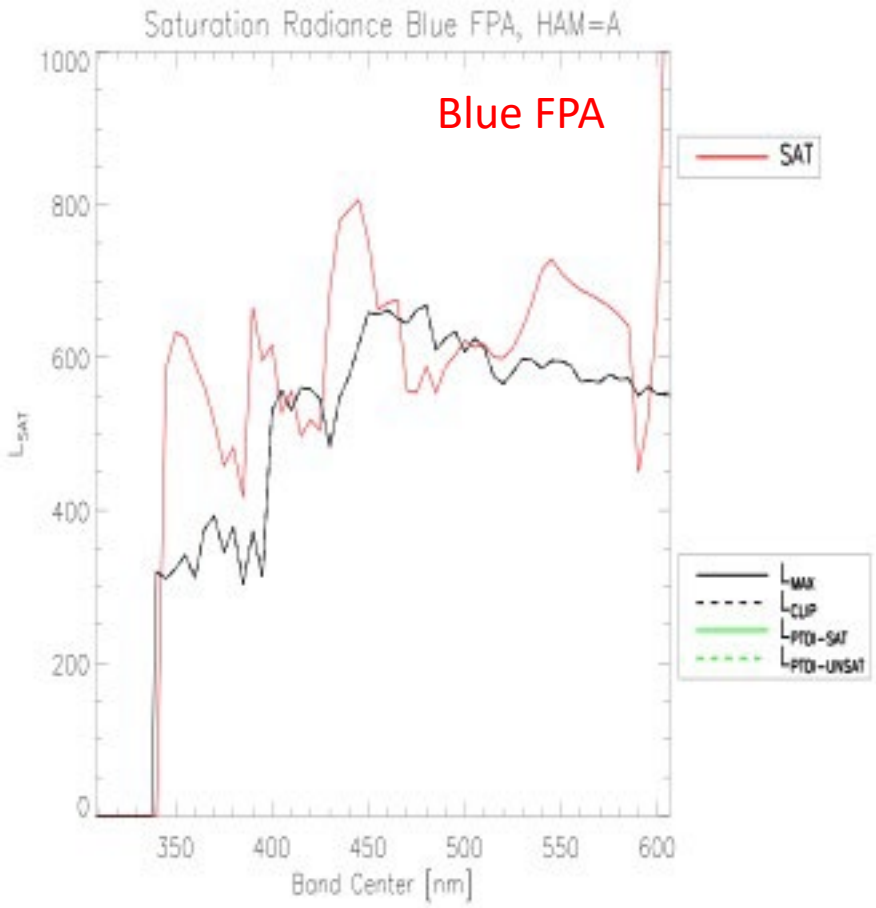


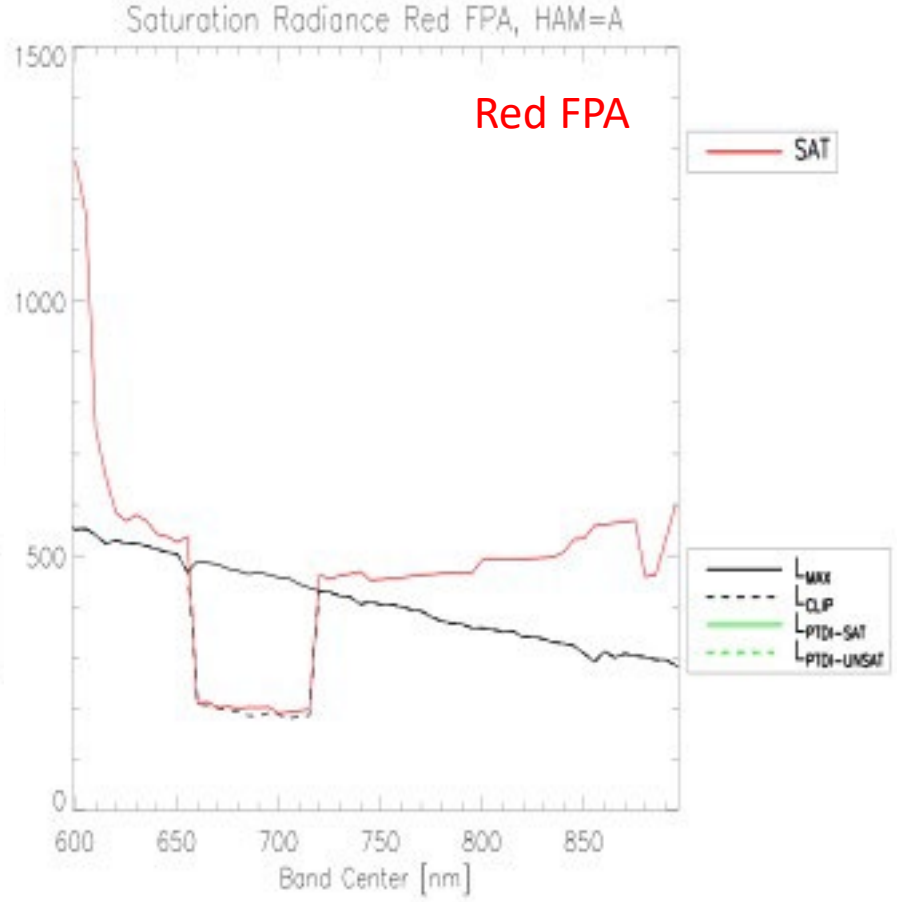


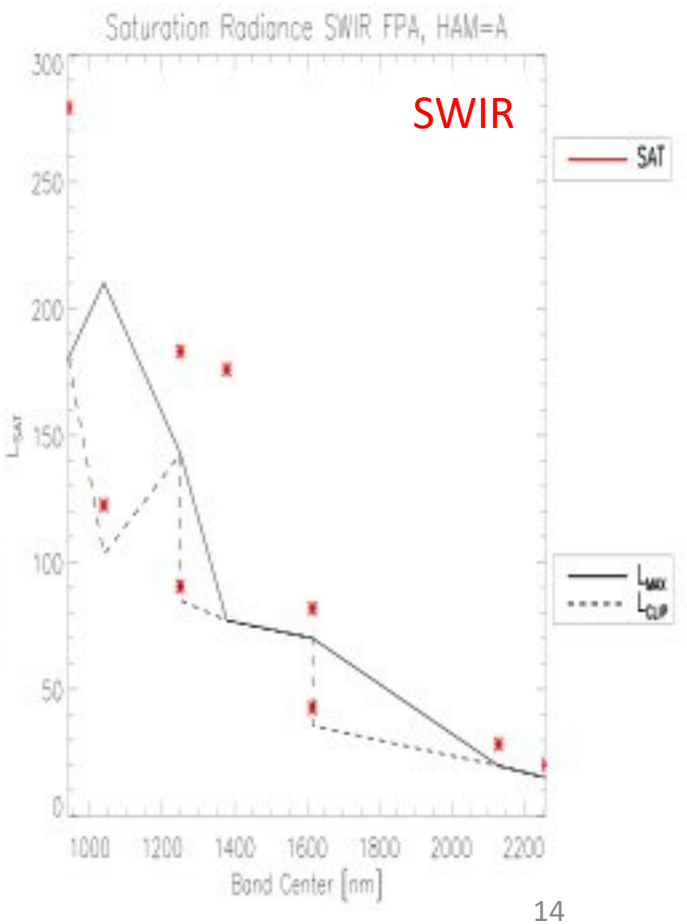


Saturation

- Saturation above L_{MAX} (or L_{CLIP}) for most bands, indicating expected science data range to be met.
- Some bands saturate a little early in blue FPA; this was expected.
- Reduced dynamic range from 660nm-715nm to increase SNR for FLH product (and at 1038nm for atm. cor.).

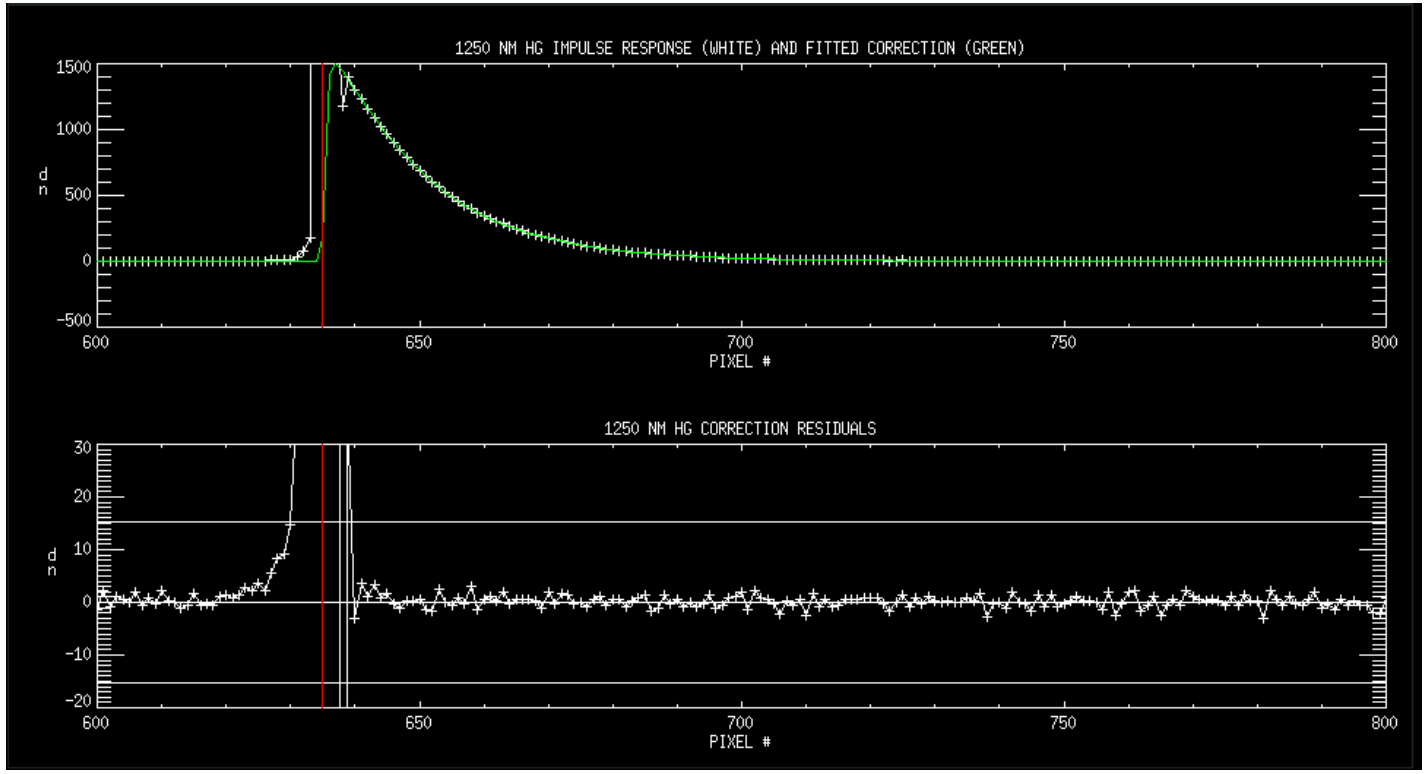






SWIR band hysteresis

- Due to SWIR band detector and electronics characteristics, significant hysteresis is observed after a strong radiance gradient (e.g. cloud/ocean boundary)
- We developed a correction for ETU that reduces the impact to within the noise 3 pixels after the radiance transition (see below for example; red line is 1km x1km stimulus)
- Effect is expected to be linear and to follow the superposition principle, so we expect good performance of the flight unit correction with real on-orbit data



Hysteresis will be monitored on-orbit via lunar measurements (stare mode) and a dedicated on-board device (SPCA: Solar Pulse calibration Assembly)

Summary/Outlook

- Prelaunch calibration of OCI completed successfully in Sep. 2022 – thanks to OCI Systems Engineering, OCI I&T Team, and GLAMR team!
- Performance of OCI passed all requirements, exceeded expectations in many aspects; all calibration LUTs have been created for operational processing of dn to radiances
- Two areas need further evaluation with potential on-orbit adjustments: blue spectrograph stray light and SWIR band hysteresis
- OCI has been integrated to the PACE Observatory, Observatory TVAC testing has started, we are on track for launch early 2024