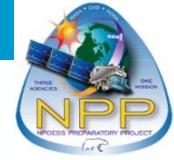




Initial sensor performance and product status of the Suomi-NPP OMPS Limb Profiler



Glen Jaross, P.K. Bhartia

NASA Goddard Space Flight Center

Mark Kowitt, Grace Chen, Zhong Chen,
Michael Haken, Jeremy Warner

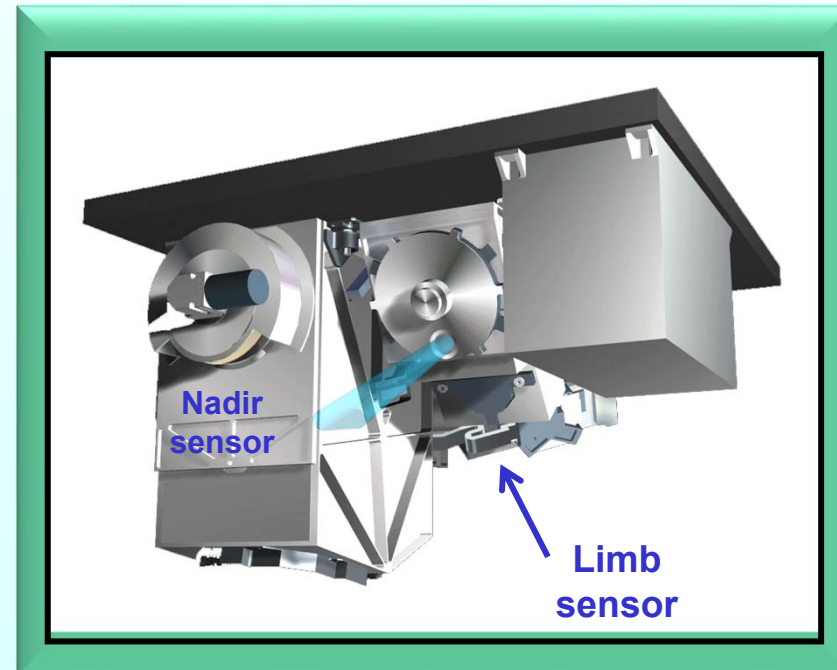
Science Systems & Applications, Inc.

Ghassan Taha

Universities Space Research Association

OMPS
Ozone Mapping and
Profiler Suite

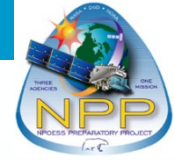
SNPP Launch
October 28, 2011



Courtesy of Ball Aerospace and Technology Corporation



OMPS Nadir sensor



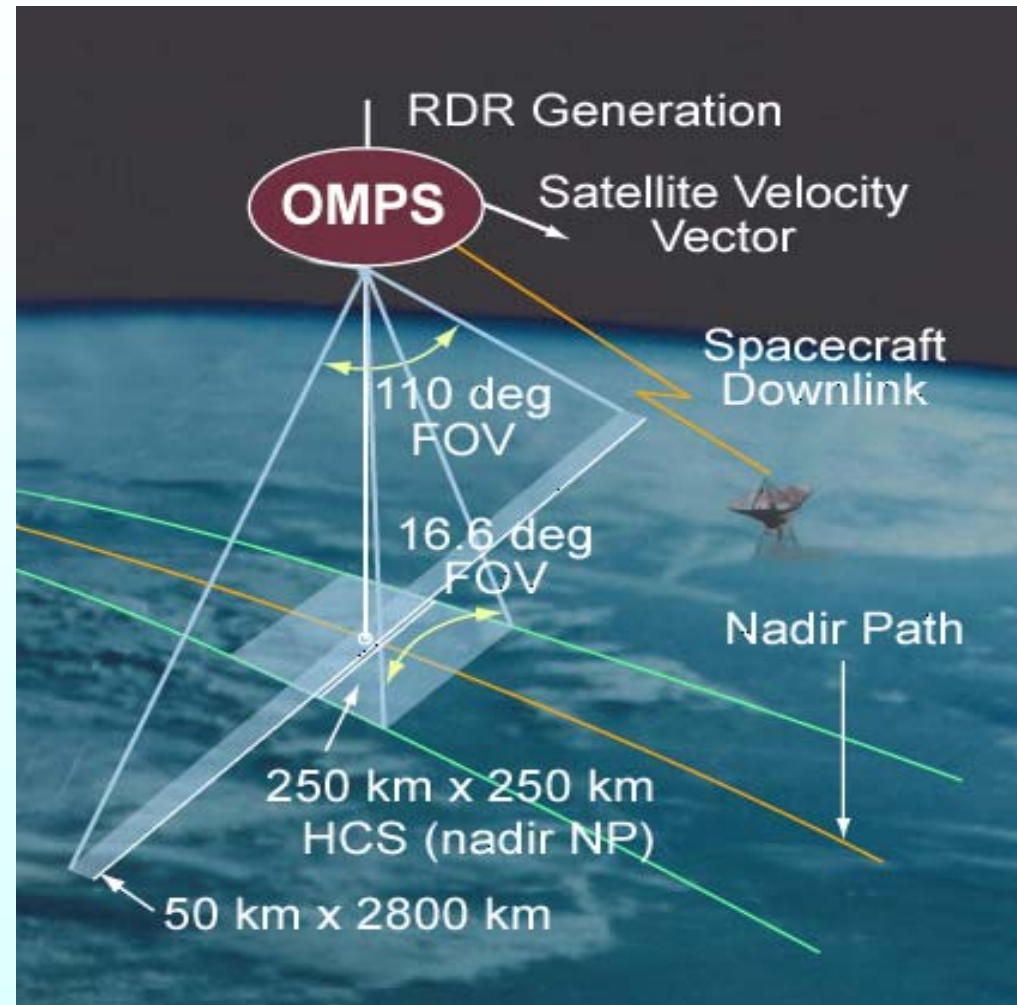
Nadir sensor has 2 spectrometers with a shared telescope:

Nadir Mapper

Heritage: TOMS, OMI, GOME, GOME2
300 – 380 nm
110° cross-track swath

Nadir Profiler

Heritage: SBUV2, OMI, GOME, GOME2
250 – 310 nm
16° FOV





OMPS Limb sensor



Limb Profiler

Heritage: SOLSE / LORE, OSIRIS, SCIAMACHY, GOMOS

Wavelength: 280 –1000 nm

Vertical range: 105 km (5 - 80 km consistently)

Vertical Sampling: 1 km

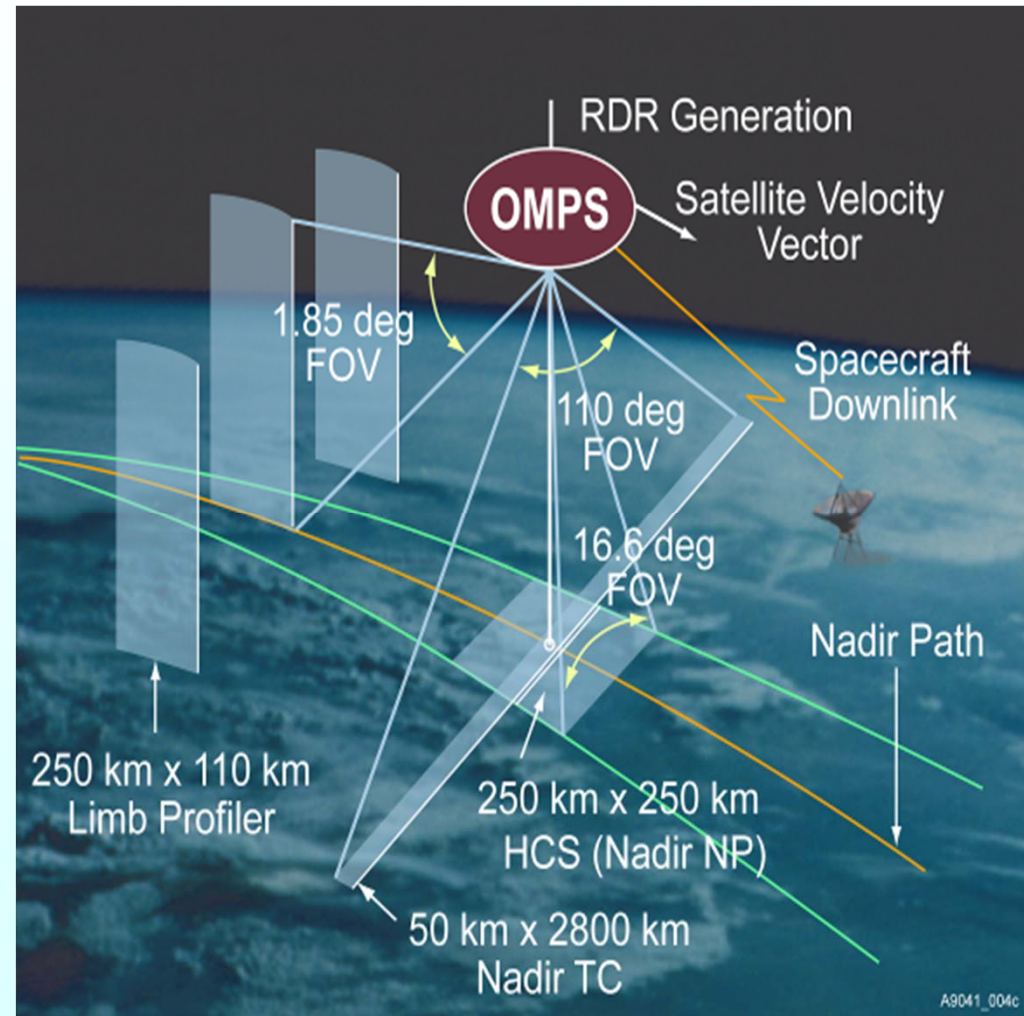
Vertical resolution: ~2 km

Along-track sampling: 125 km

Detector: 0.25 megapixel CCD at -45 °C

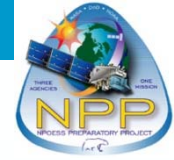
Known sensor challenges

- *Pointing*
- *Internal stray light*
- *Gain matching*

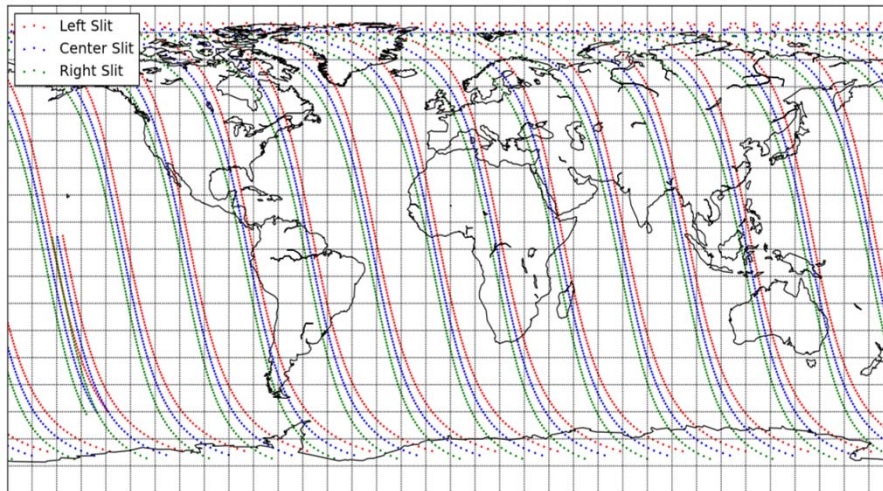




OMPS Limb data coverage



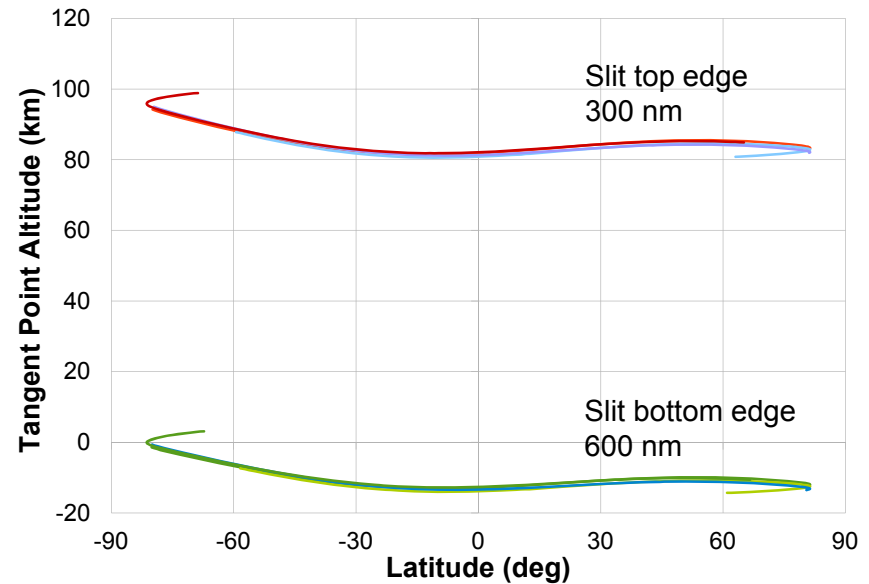
Daily Ground Track (typical)



Local Time at Ascending Node : 1335

Max. solar zenith angle: 100 deg.

Vertical Range

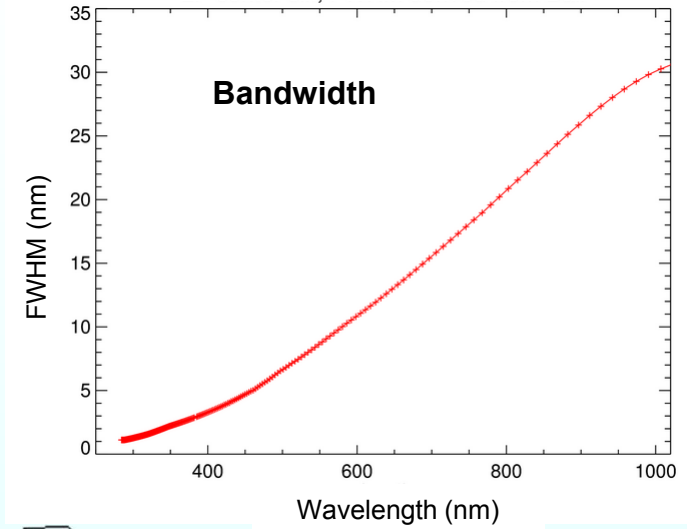
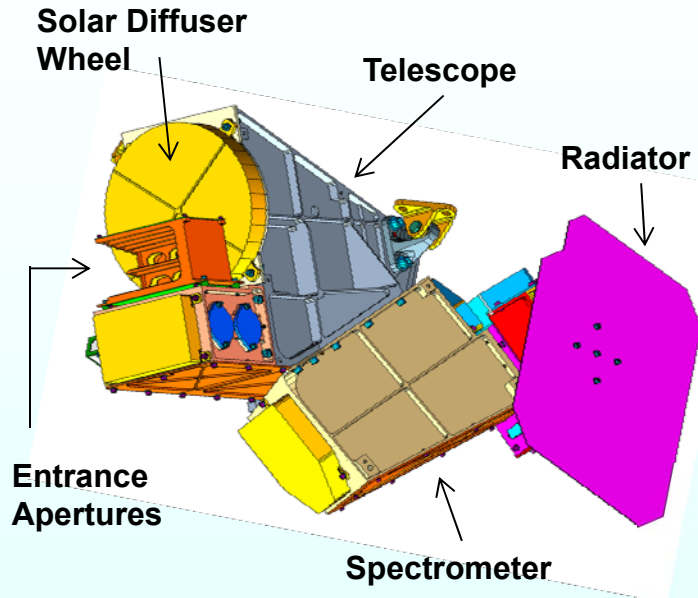


Vertical coverage governed by

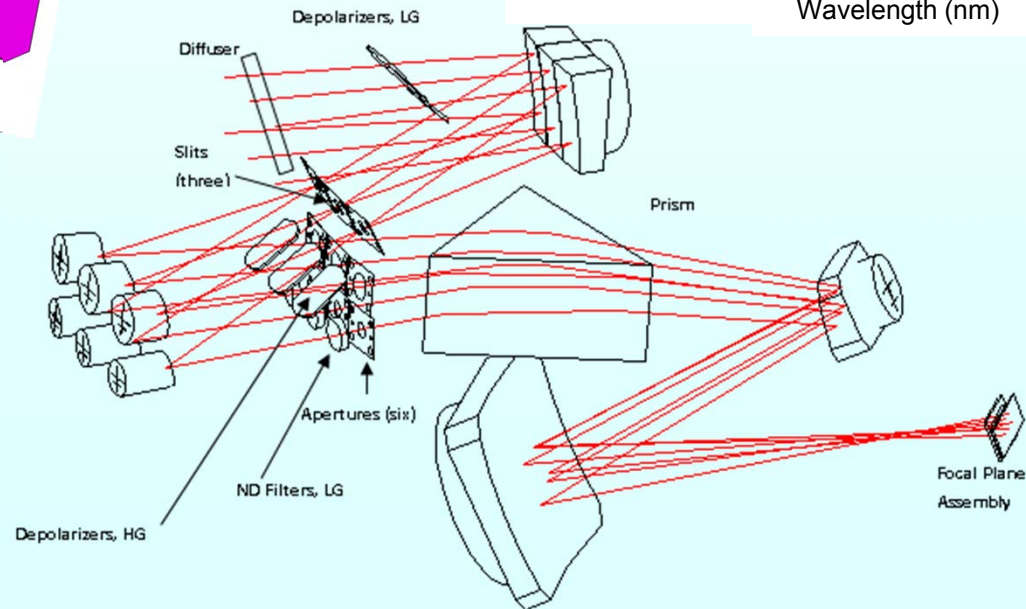
- Time of year
- Geodetic pointing of satellite



Prism disperser matched to measurement needs

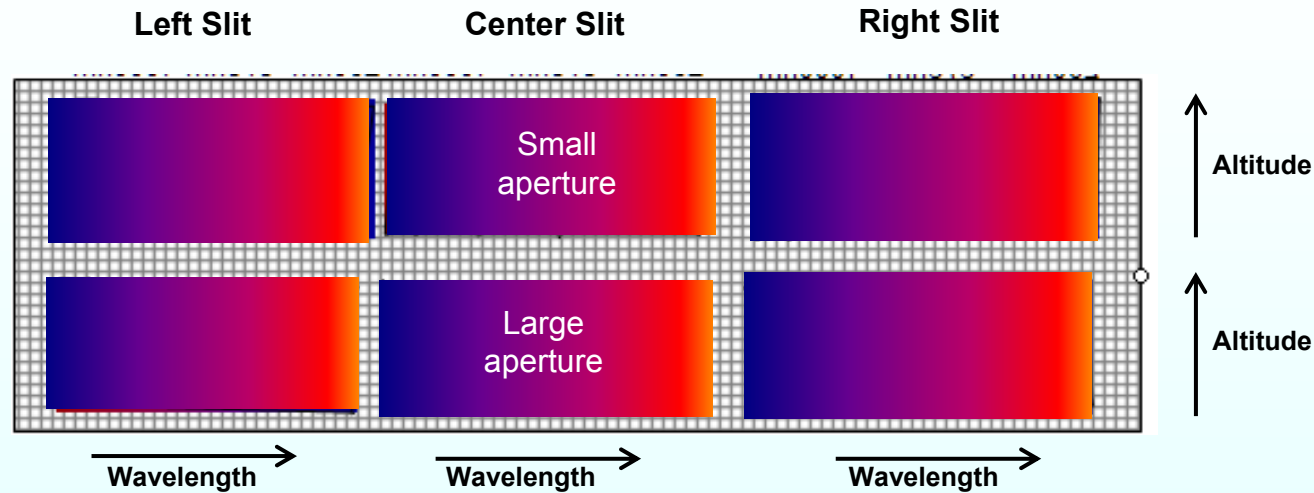


Each slit has a large and a small aperture to enhance the dynamic range

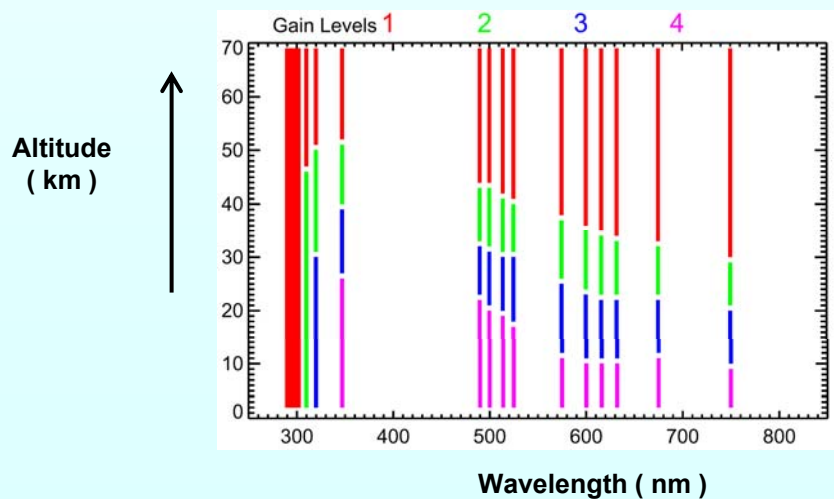




6 images collected on CCD detector



Each image collected twice:
Long = 1.25 sec
Short = 0.04 sec



Gain 1 = 140
Gain 2 = 31
Gain 3 = 4.5
Gain 4 = 1

14-bit A/D converter

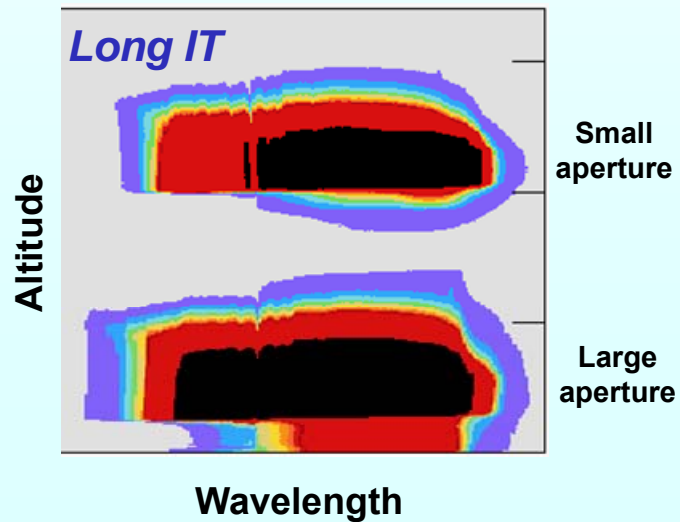
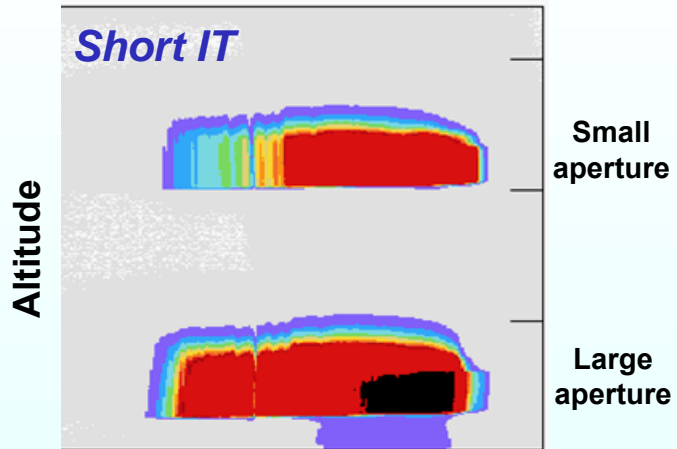
**Total detector dynamic range $\approx 2 \cdot 10^6$
(need 10^4)**



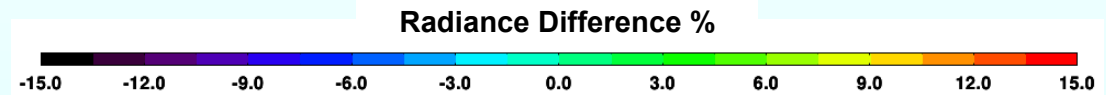
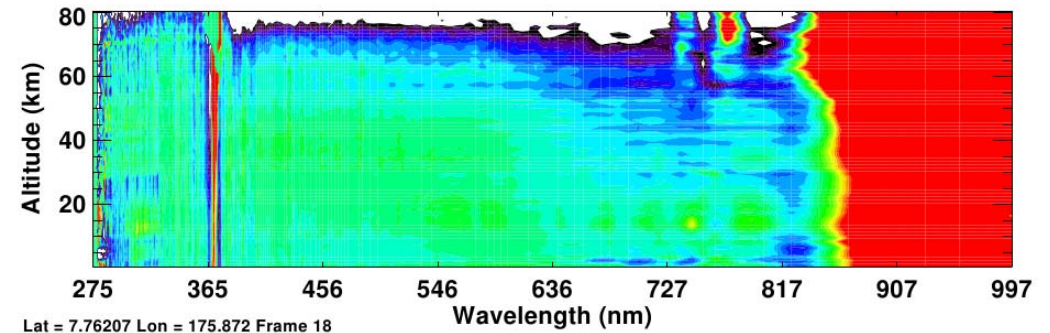
Radiances from different apertures never match



Detector Signal
(Black = saturated)



Large – Small aperture radiance difference



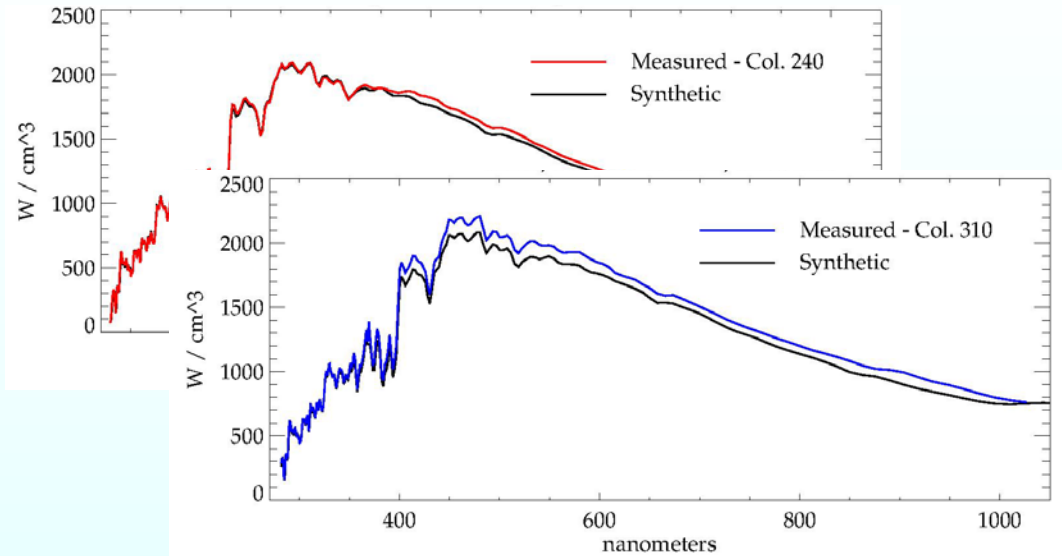
Future plans :

- large aperture only for UV
- large or small only for VIS
- small aperture only for IR

We trade mid-altitude S/N for smoother gain transitions

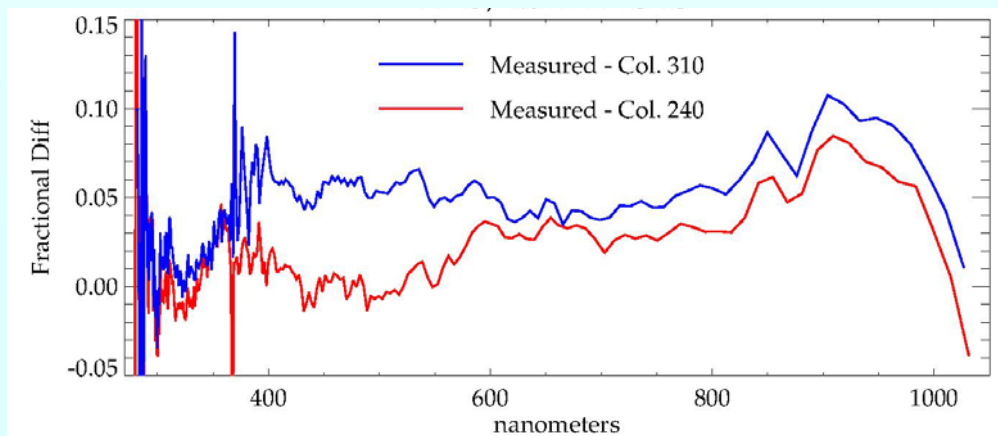


Solar measurements used for spectral calibration and to monitor sensor changes



600 OMPS solar spectra
(1 for each spatial location)
are measured every week

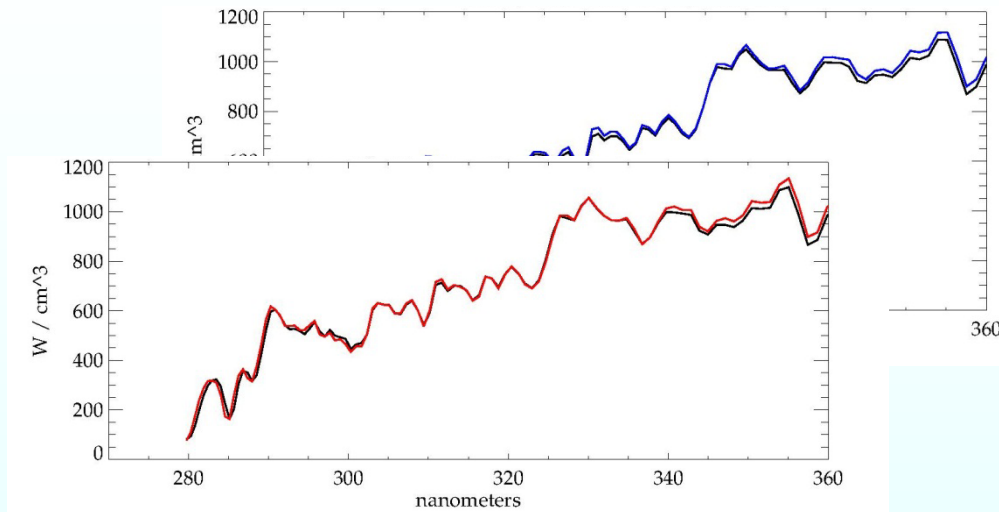
OMPS compared to SUSIM-based spectrum



Spatial variations are
indicative of radiance
calibration errors at
different tangent heights

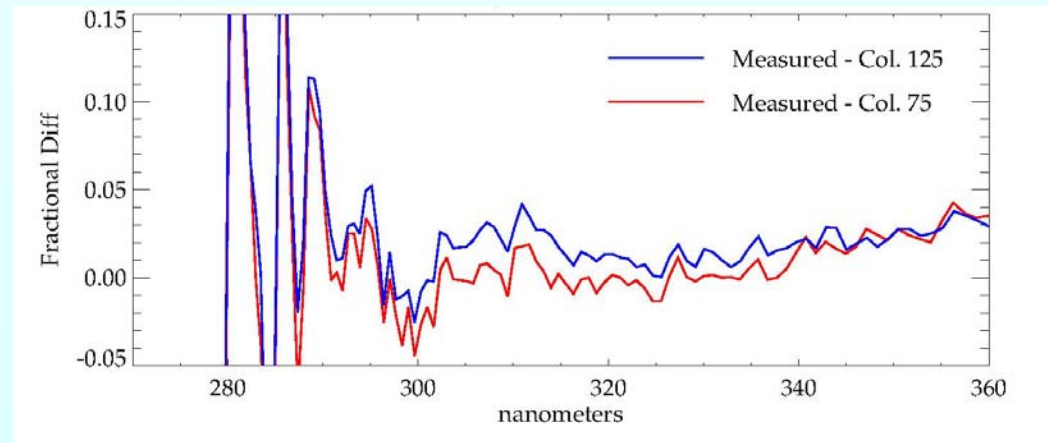
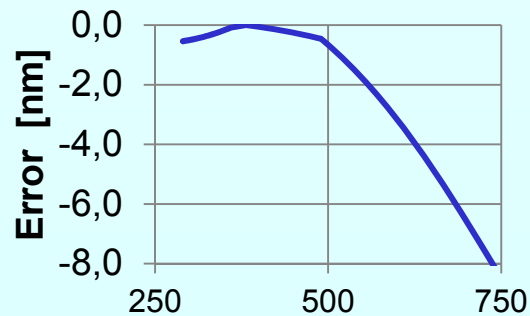


Spectral calibration from solar data



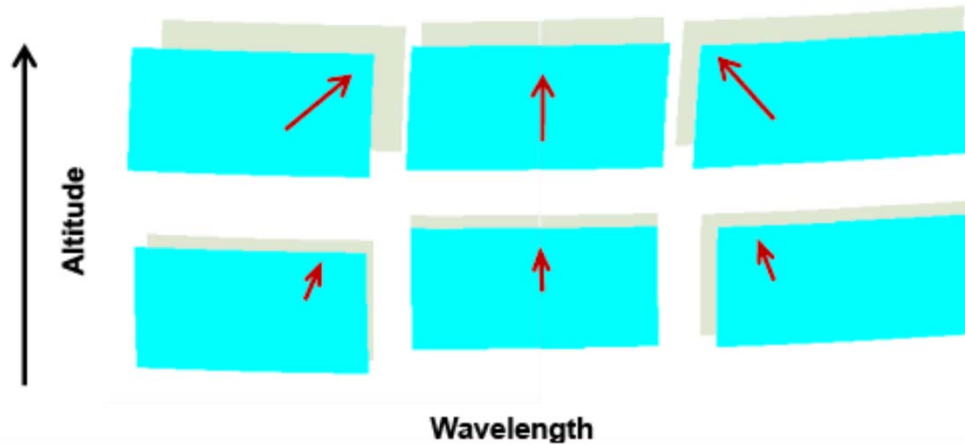
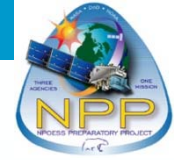
- 3 primary fitting windows
 - 290 – 320 nm
 - 320 – 360 nm
 - 370 – 435 nm
- wavelengths outside the fitting windows derived by extrapolation
- anomalous dispersion caused by optical distortion at focal plane

A mistake in wavelength calibration exists in the current released product

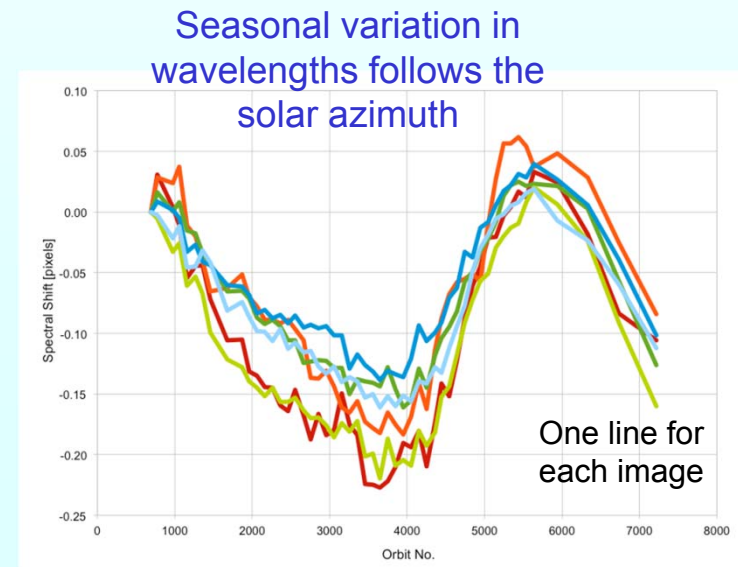
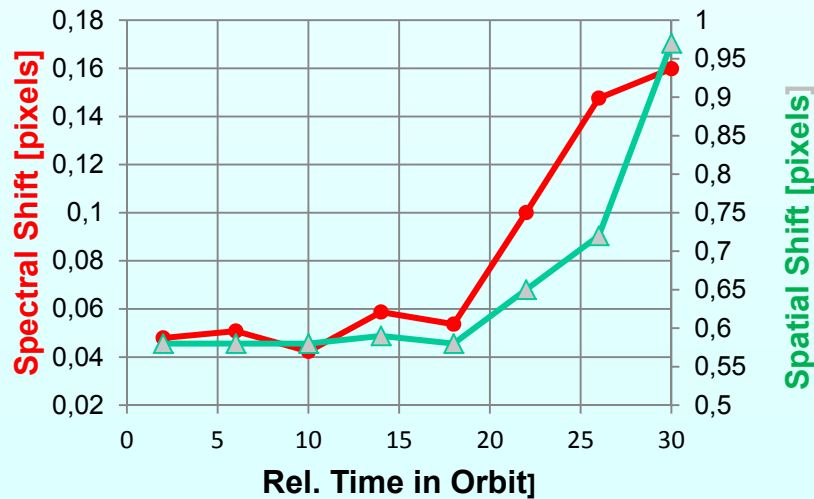




Thermal sensitivity of instrument

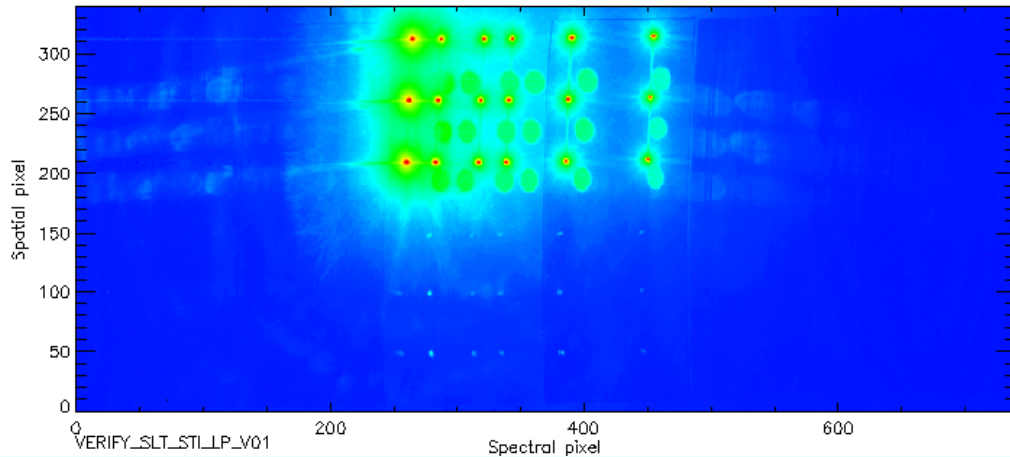


Images shift on focal plane as sun heats the sensor. Wavelength and vertical pointing shift every orbit.





Detailed characterization with tunable laser leads to simple stray light correction

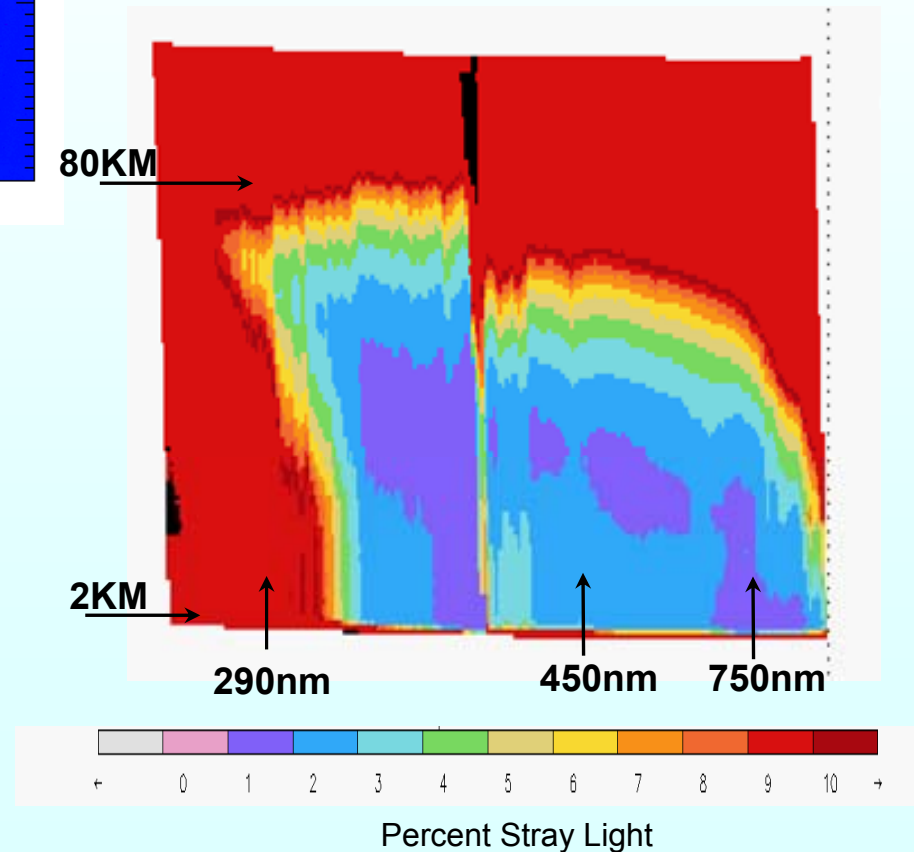


Test data was separated into a combination of PSFs and ghosts

Stray light is mainly a high altitude problem

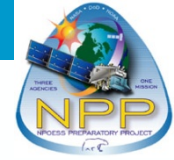
1 μ m has large stray light at all altitudes

Computed stray light as fraction of measured radiance (orbit 1449)



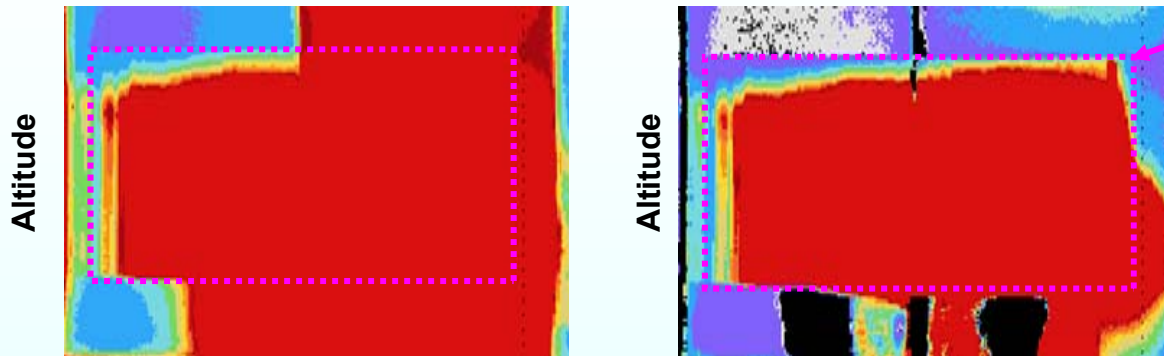


Stray light correction can be evaluated and tuned



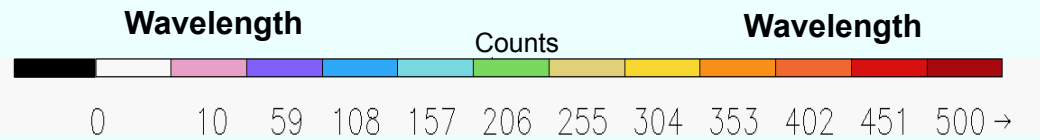
Stray Light Uncorrected

Stray Light Corrected

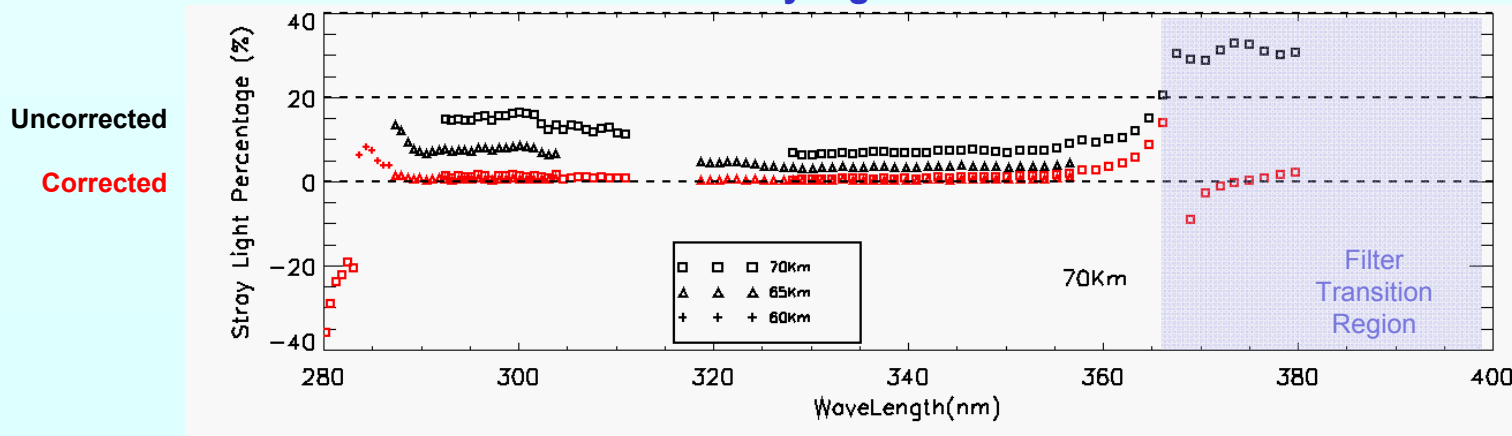


Optical Region Boundary

Stray light correction evaluated using non-optical regions on detector



Stray Light in UV





Status of released products



Corrections in Version 1

- tangent height adjustments (plus relative large-small aperture pointing)
 - Left slit: 1.0 km
 - Center slit: 1.4 km
 - Right slit: 2.0 km
- post-launch wavelength assignment (static)

Planned corrections in Version 2 (release in late 2013)

- geolocation in Right Slit
- improved S/N estimates
- static, seasonal, and intra-orbital wavelength registration
- solar irradiance adjusted to spectral scale
- addition of IR wavelengths in gridded radiance product
- intra-orbital altitude correction: 200 - 400 m
- ozone vertical smoothing
- atmospheric temperatures above 45 km

Remaining issues

- apparent tangent height error (~0.5 km) at VIS wavelengths
- undersampling errors in gridded radiances
- lacking 1 μ m radiances



Data distribution



- Distribution through ozoneaq.gsfc.nasa.gov/omps

- Individual files or gzip bundles

- Version 1

Gridded (wavelength-altitude) Radiances – all 3 slits

Gridded (altitude) ancillary data (NCEP Temp. & Pres.)

Daily O₃ (14 orbits; Center Slit only)

Orbital O₃ curtain image

- Version 2 (late 2013)

Same as above

Daily Aerosol Extinction (14 orbits; all 3 slits)

- Other products available upon request

Level 1B (ungridded)

Calibration data (including solar)

Orbital O₃ and aerosol retrievals

Date	Measurement Type	Filename
20130607 14:40:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607144012-e08346-2013m0611131307...
20130607 12:58:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607125842-e08345-2013m0611131019...
20130607 11:17:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0607111712-e08...
20130607 11:17:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607111712-e08344-2013m0611131033...
20130607 09:55:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607095542-e08343-2013m0611103055...
20130607 09:55:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0607095542-e08...
20130607 07:54:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607075412-e08342-2013m0611092702...
20130607 06:12:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0607061242-e08...
20130607 06:12:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607061242-e08341-2013m0611044652...
20130607 04:31:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607043112-e08340-2013m0611030343...
20130607 04:31:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0607043112-e08...
20130607 02:49:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607024942-e08339-2013m0611012226...
20130607 02:49:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0607024942-e08...
20130607 01:08:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0607010812-e08...
20130607 01:08:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0607010812-e08338-2013m0610234400...
20130606 23:28:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606232842-e08337-2013m0610220111...
20130606 23:28:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606232842-e08...
20130606 21:45:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606214512-e08336-2013m0610201916...
20130606 21:45:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606214512-e08...
20130606 20:03:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606200342-e08335-2013m0610182738...
20130606 20:03:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606200342-e08...
20130606 18:22:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606182212-e08334-2013m0610165609...
20130606 18:22:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606182212-e08...
20130606 16:40:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606164042-e08333-2013m0610151457...
20130606 16:40:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606164042-e08...
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20130606 14:59:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606145912-e08...
20130606 13:17:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606131742-e08331-2013m0610115207...
20130606 13:17:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606131742-e08...
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20130606 09:54:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606095442-e08329-2013m0610082959...
20130606 09:54:42	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606095442-e08...
20130606 08:13:12	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606081312-e08328-2013m0610054726...
20130606 08:13:12	LP_EDR_ORBITAL_PLOT_O3_curtain...	OMPS-NPP-LP_EDR_ORBITAL_PLOT_O3_curtain_p06-v1.0-2013m0606081312-e08...
20130606 06:31:42	LP_SDR_EV_GRID	OMPS-NPP-LP_SDR_EV_GRID-v1.0-2013m0606063142-e08327-2013m0610050505...



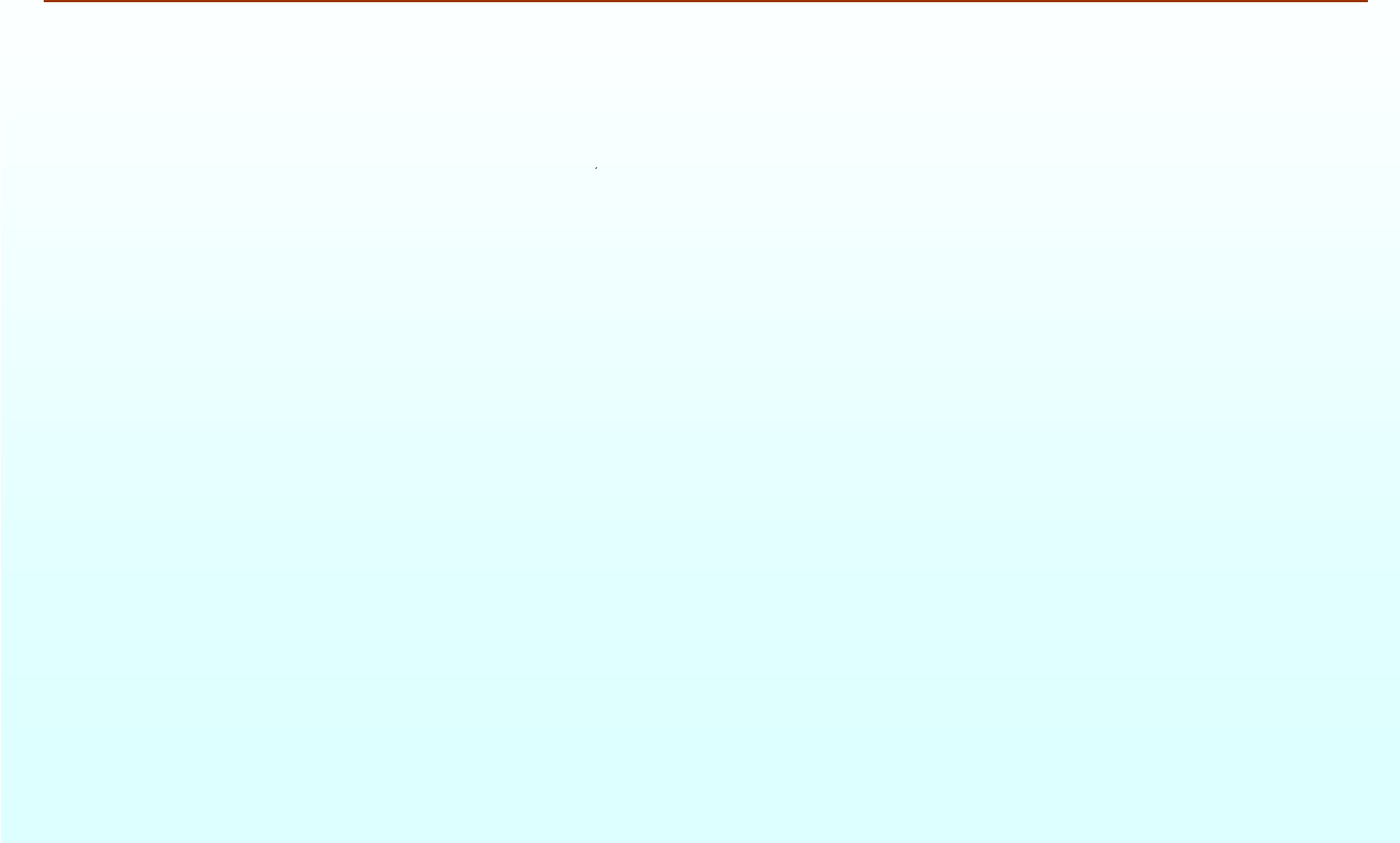
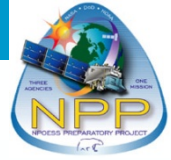
Summary



- **Areas of future emphasis**
 - Evaluate accuracy of radiances and TOA reflectance
 - Work on improving TOA reflectance measurements, especially in IR
 - Improved methods for evaluating pointing errors (including lunar measurement)
- **We need to optimize pixel selection**
 - Limited data rate – shared between Limb and Nadir
 - Fill gaps in spectrum
 - Eliminate redundant pixels in large and small apertures
 - Do we need all three slits in UV ?
- **1 μm measurements are the most difficult**
 - Low signals in ground cal. – poor radiometry
 - Vertical signal gradient creates stray light problems
 - Detector internal scattering – poorly characterized

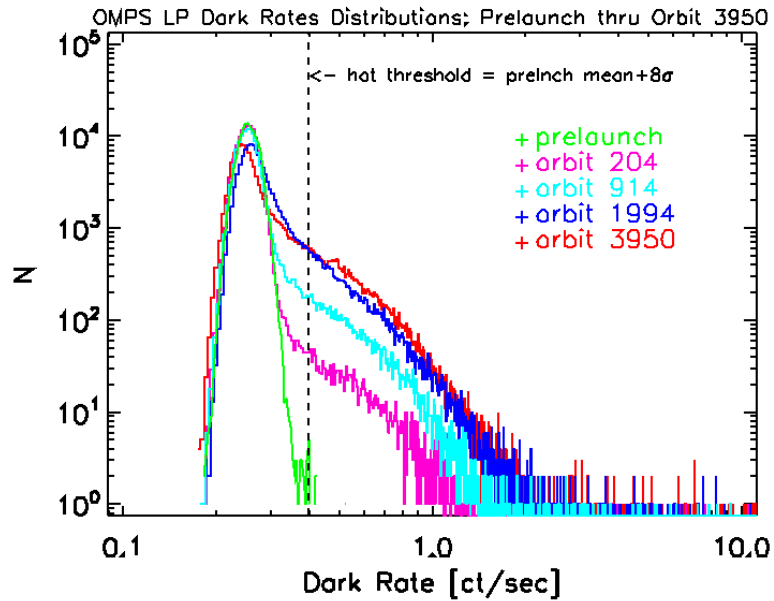


Extra slides

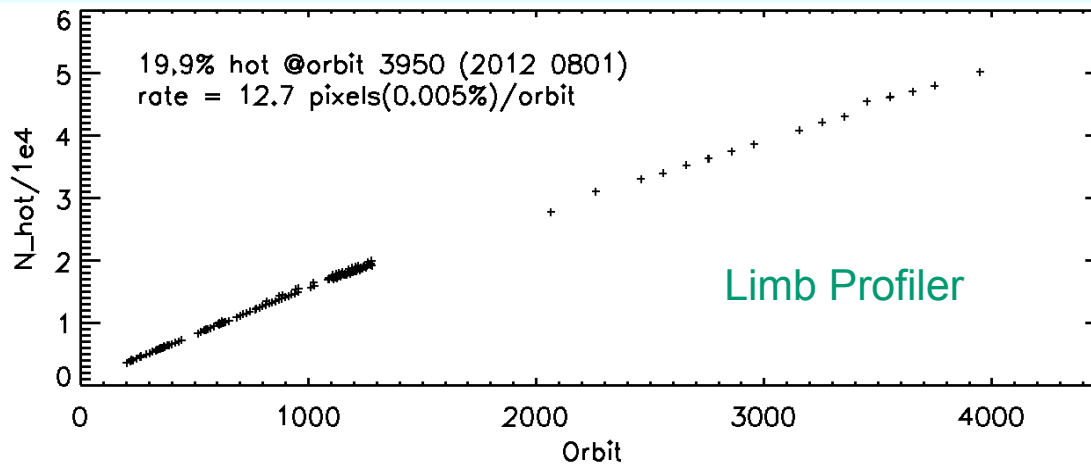




CCD detectors subject to radiation damage

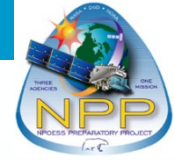


Dark currents are increasing as expected

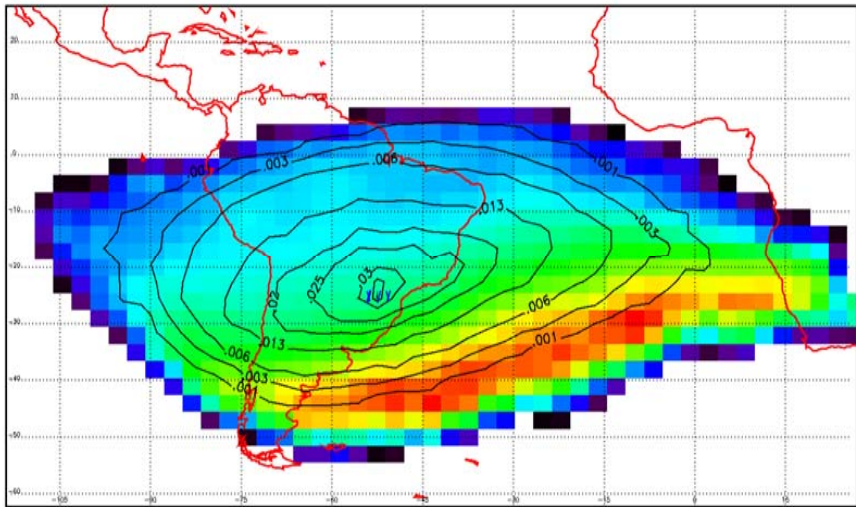




South Atlantic Anomaly has significant effect on most radiances

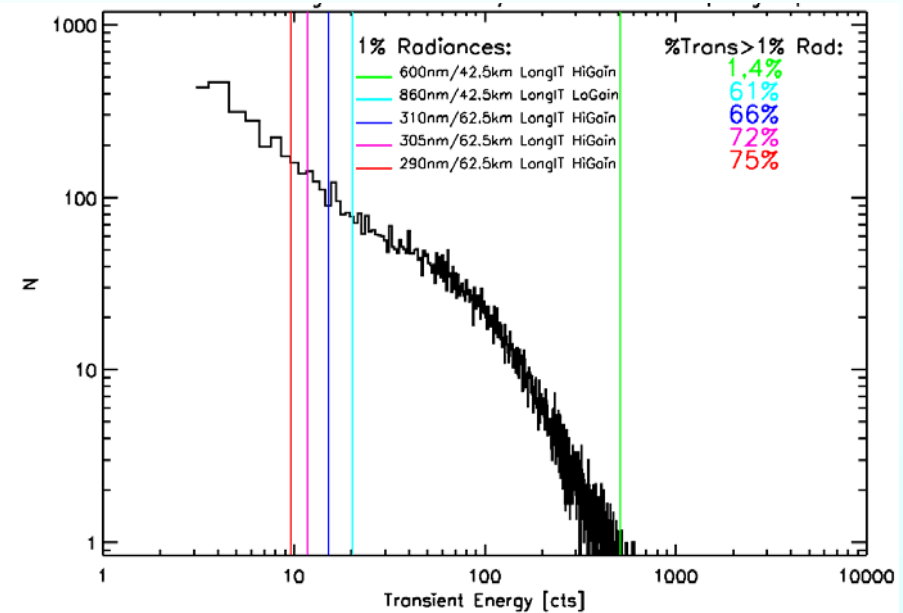


Number of detector transients and mean transient energy



Results from closed door data

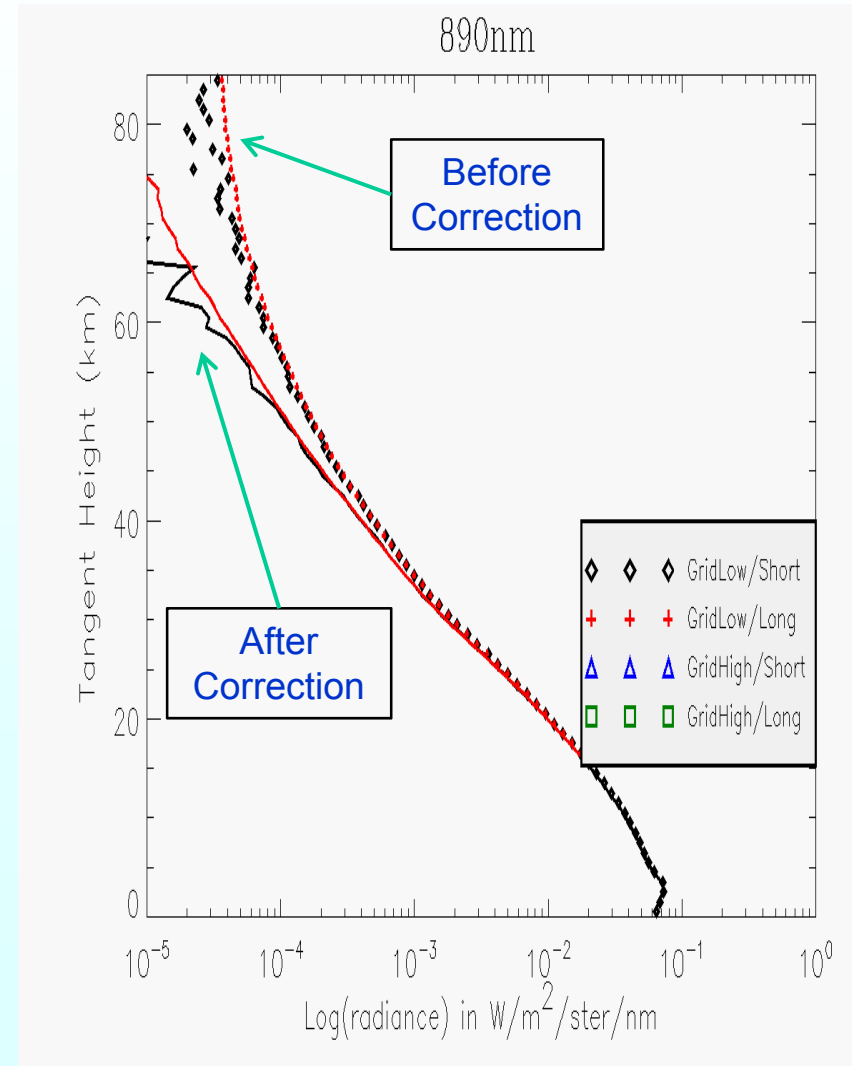
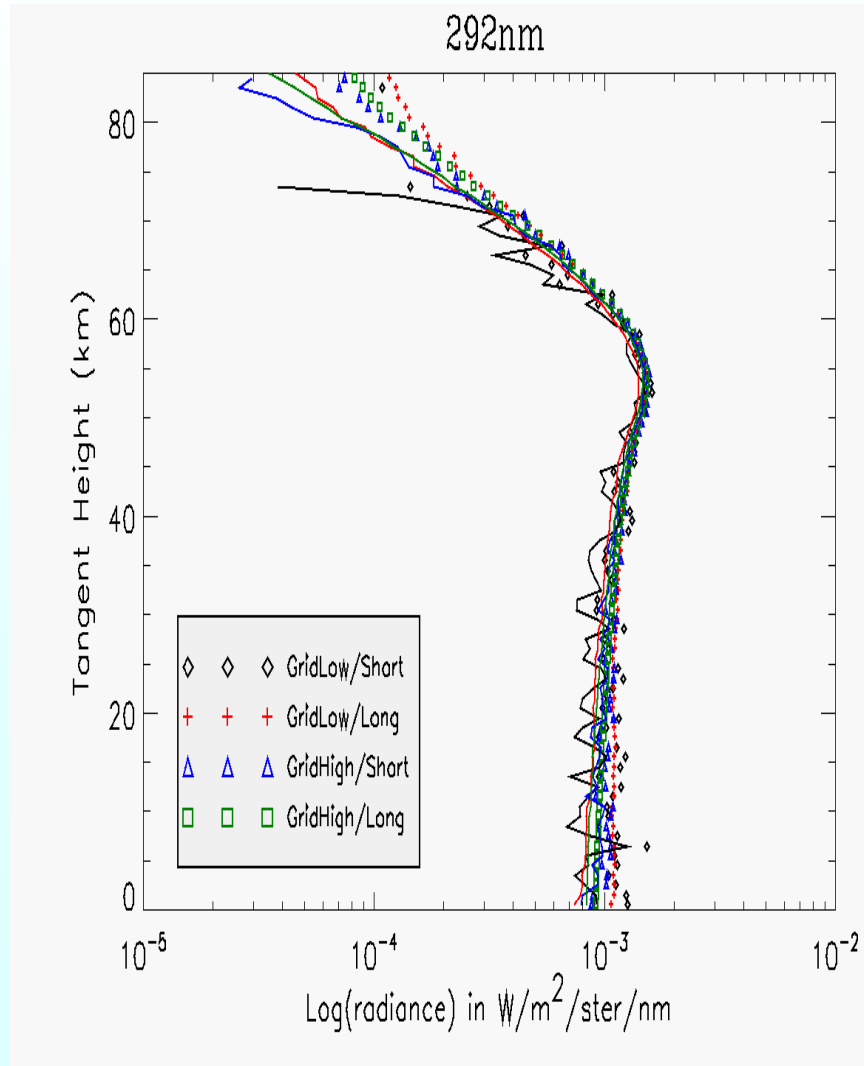
Transient energy distribution at SAA peak



Transient detection not operating in current product



Stray light residuals mainly in high altitude IR



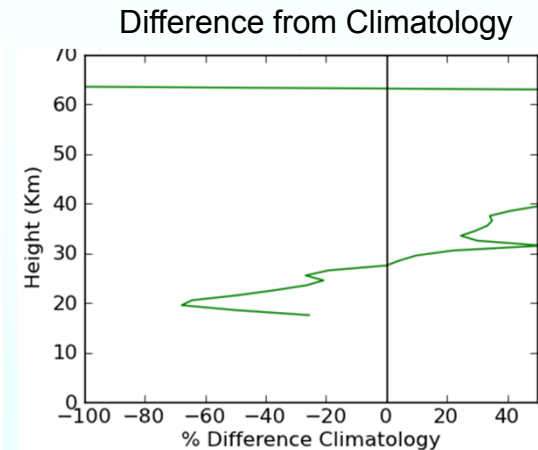
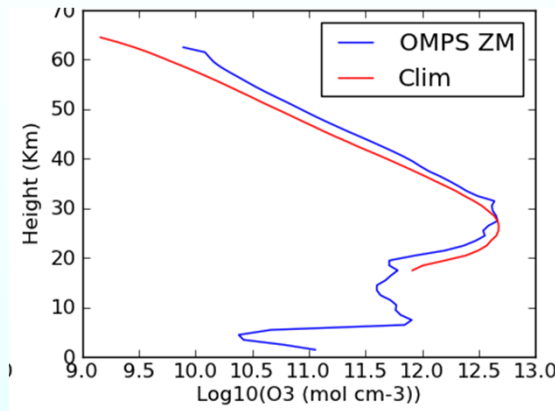


Vertical Shift confirmed through comparisons with ozone climatology

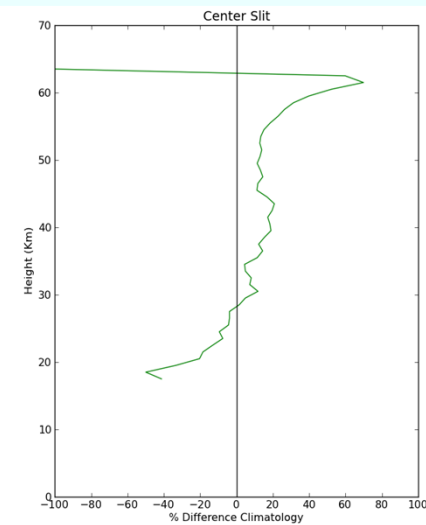
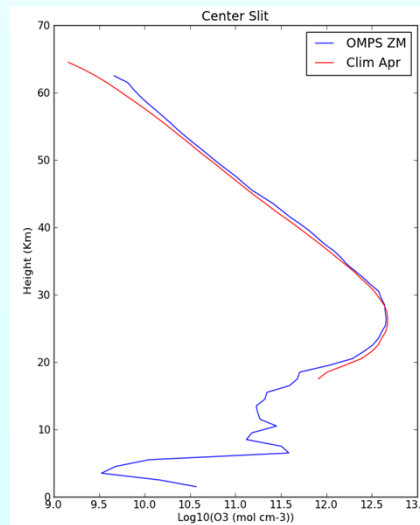


Mean Ozone: 22-28 April, 2012
20 South – 20 North

Before
vertical
adjustment

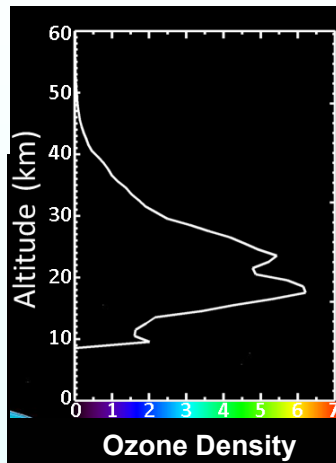


After 1.3 km
adjustment





OMPS Limb data available Nov. 1 at <http://ozoneaq.gsfc.nasa.gov/omps>



October 4, 2012

