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

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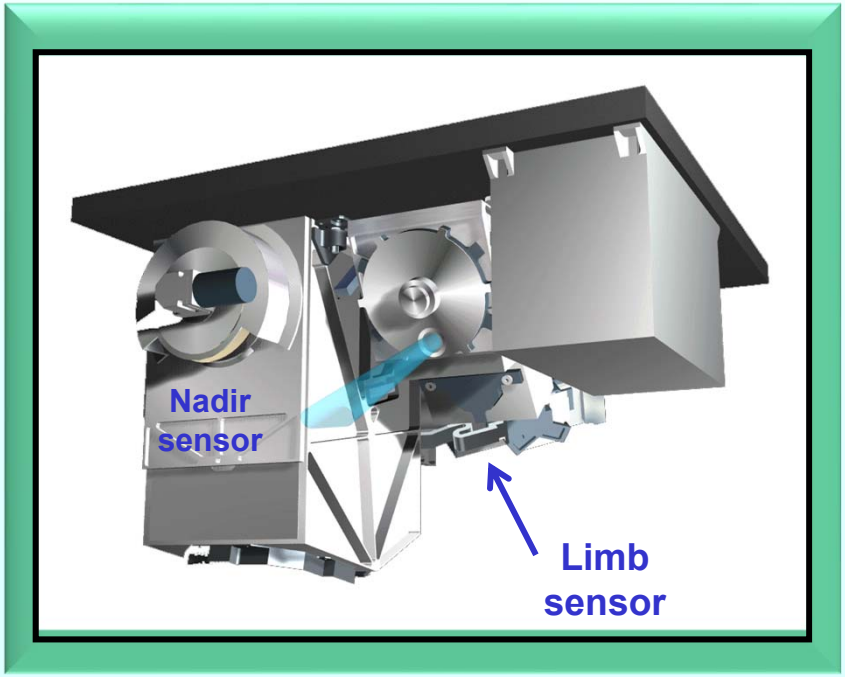
OMPS
Ozone Mapping and Profiler Suite

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

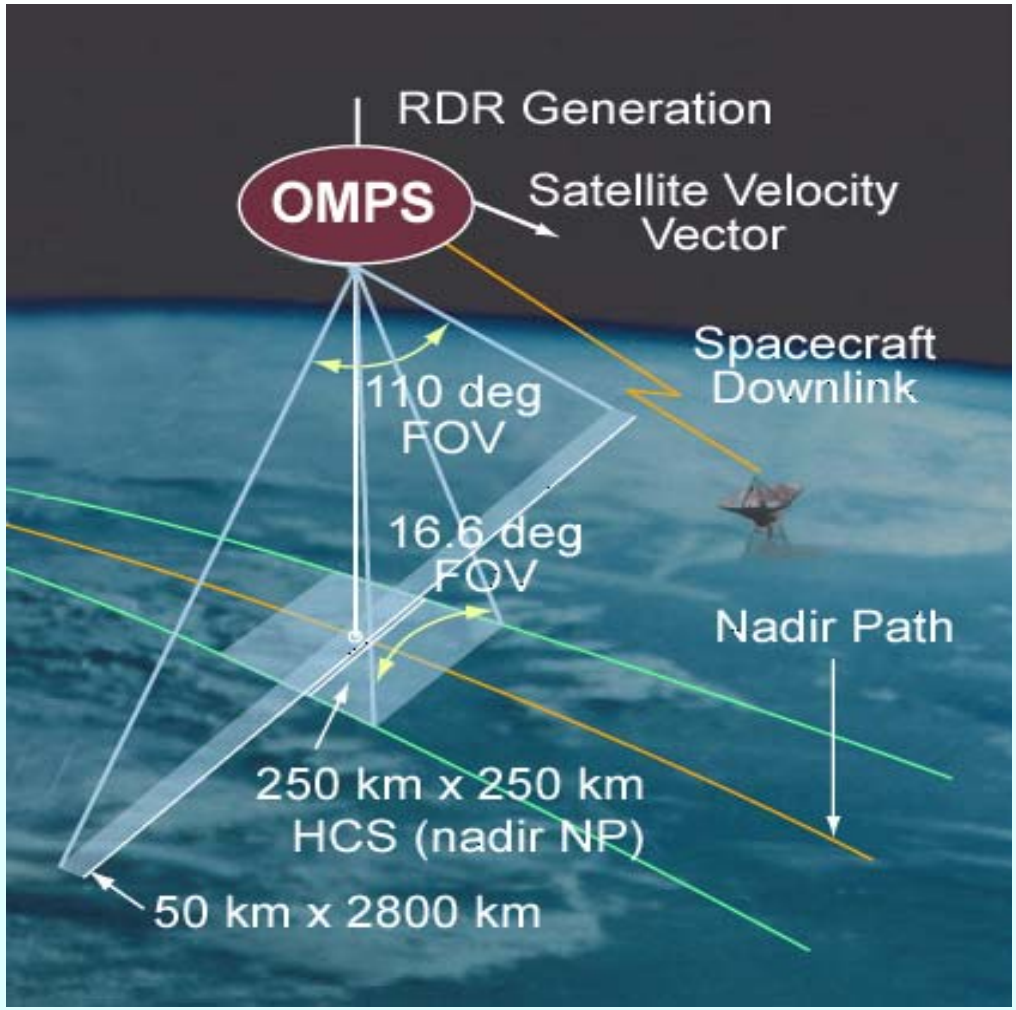
110° cross-track swath

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

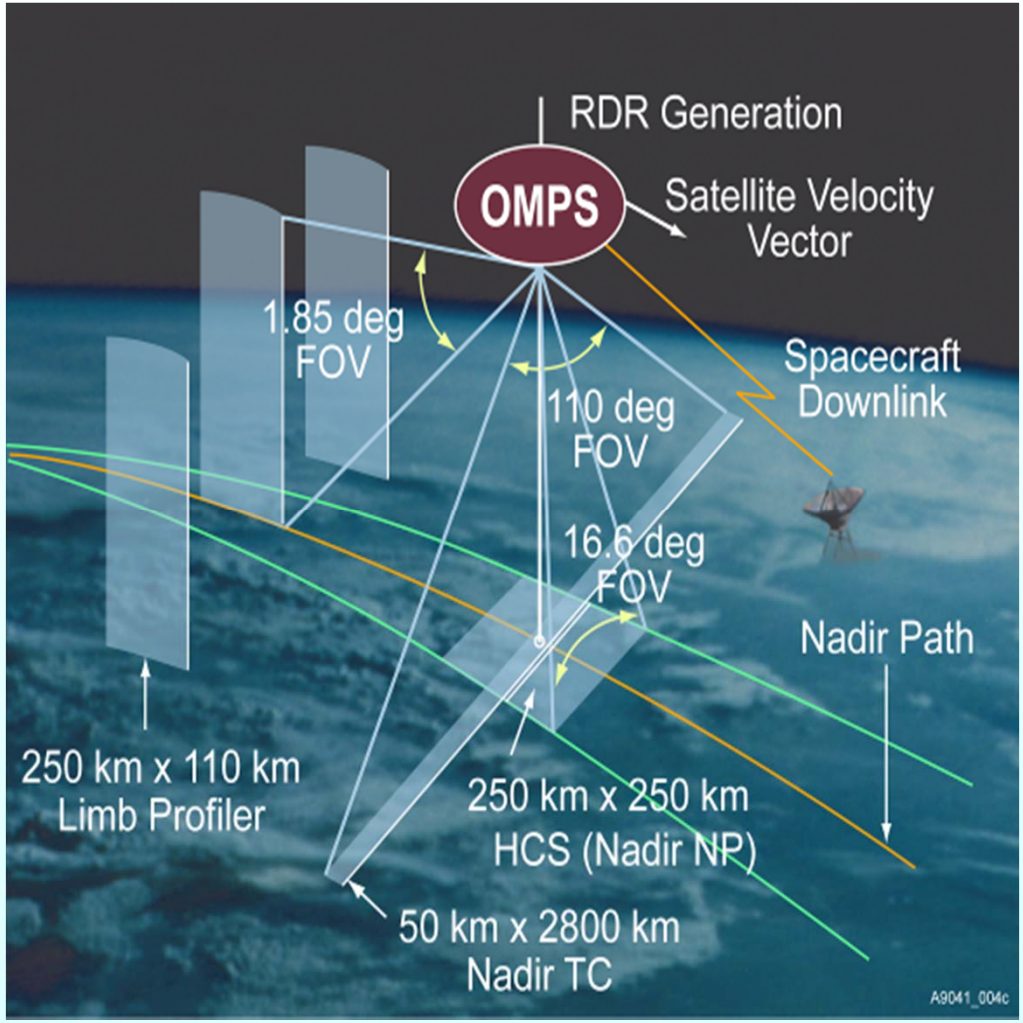
Vertical range: 105 km (5 - 80 km consistently)

Vertical Sampling: 1 km

Vertical resolution: ~2 km

Along-track sampling: 125 km

Detector: 0.25 megapixel CCD at -45 ºC

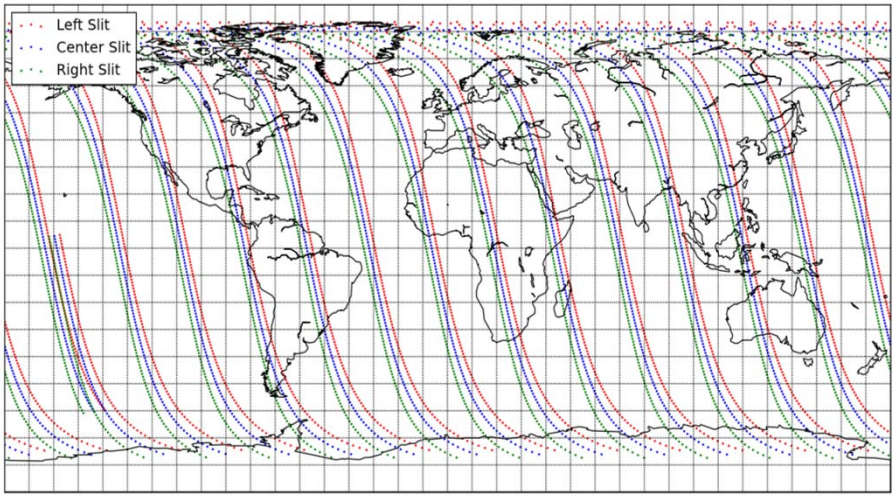


Known sensor challenges

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

OMPS Limb data coverage

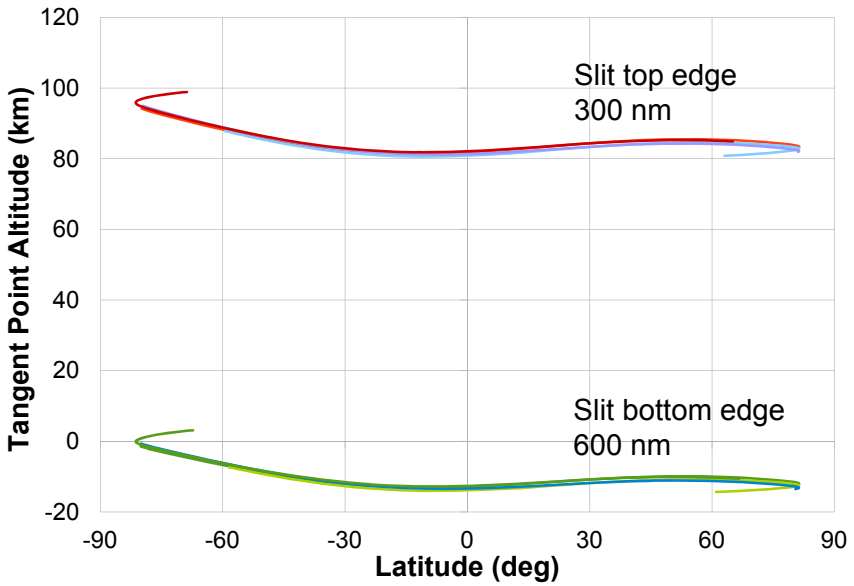
Daily Ground Track (typical)



Local Time at Ascending Node : 1335

Max. solar zenith angle: 100 deg.

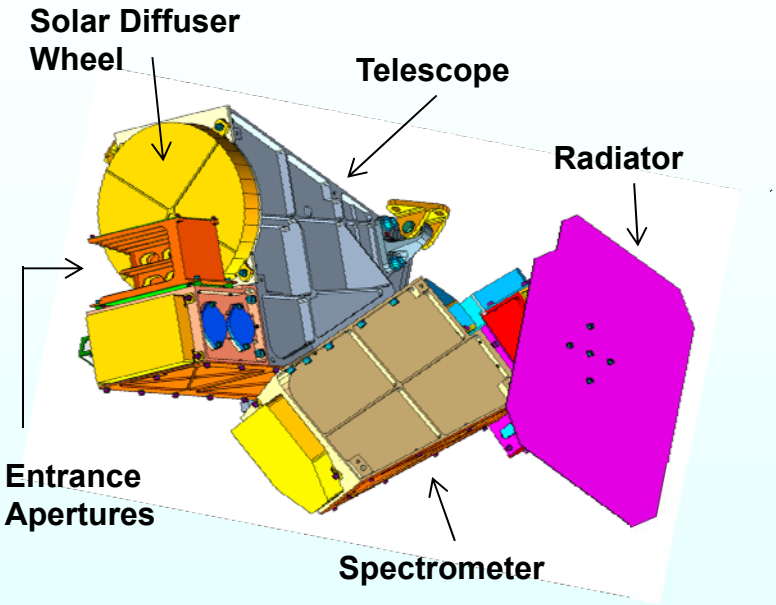
Vertical Range

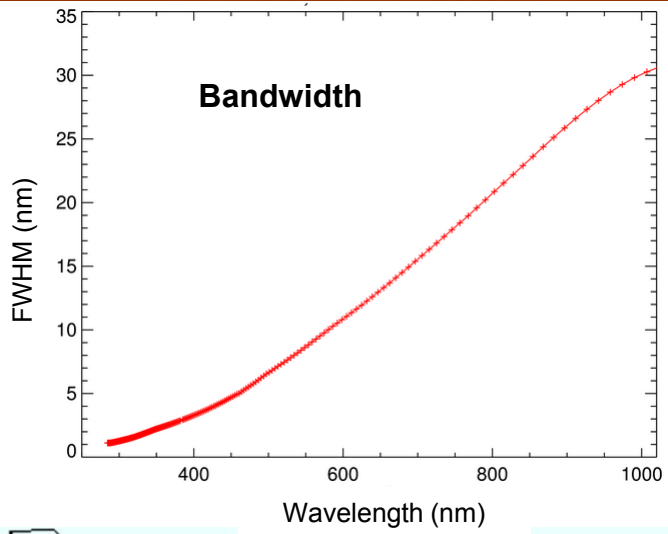


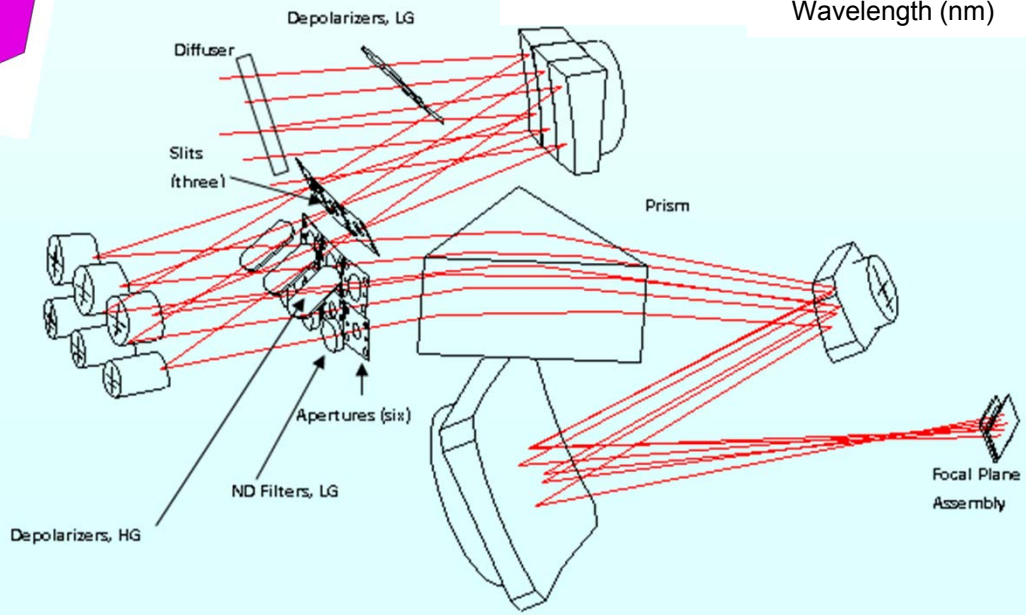
Vertical coverage governed by

- Time of year
- Geodetic pointing of satellite

Prism disperser matched to measurement needs

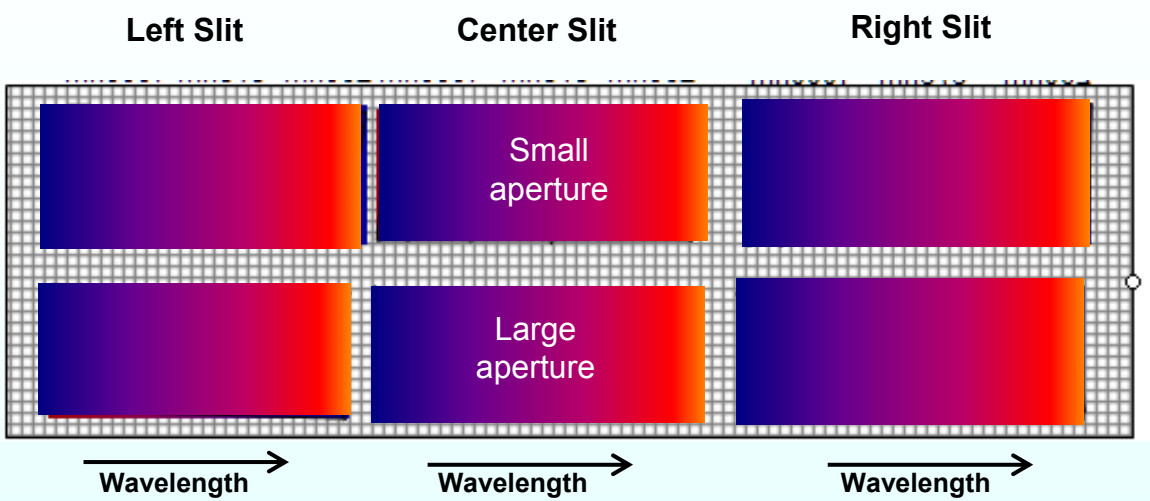




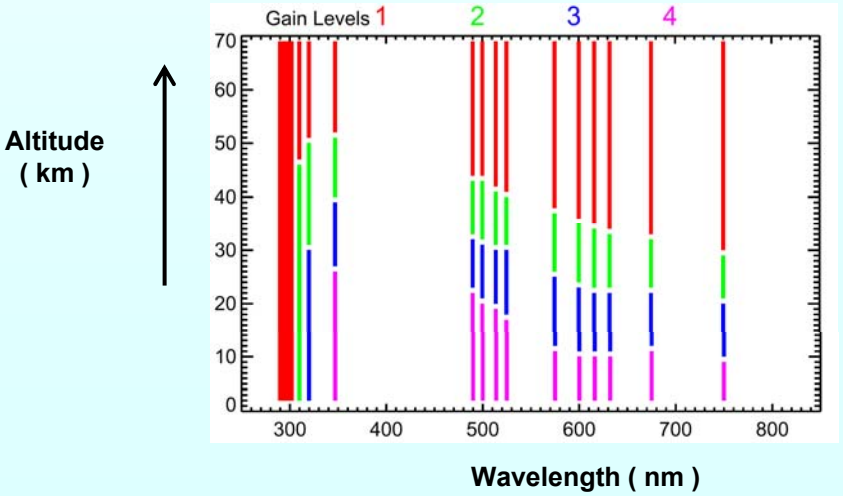


Each slit has a large and a small aperture to enhance the dynamic range

6 images collected on CCD detector



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



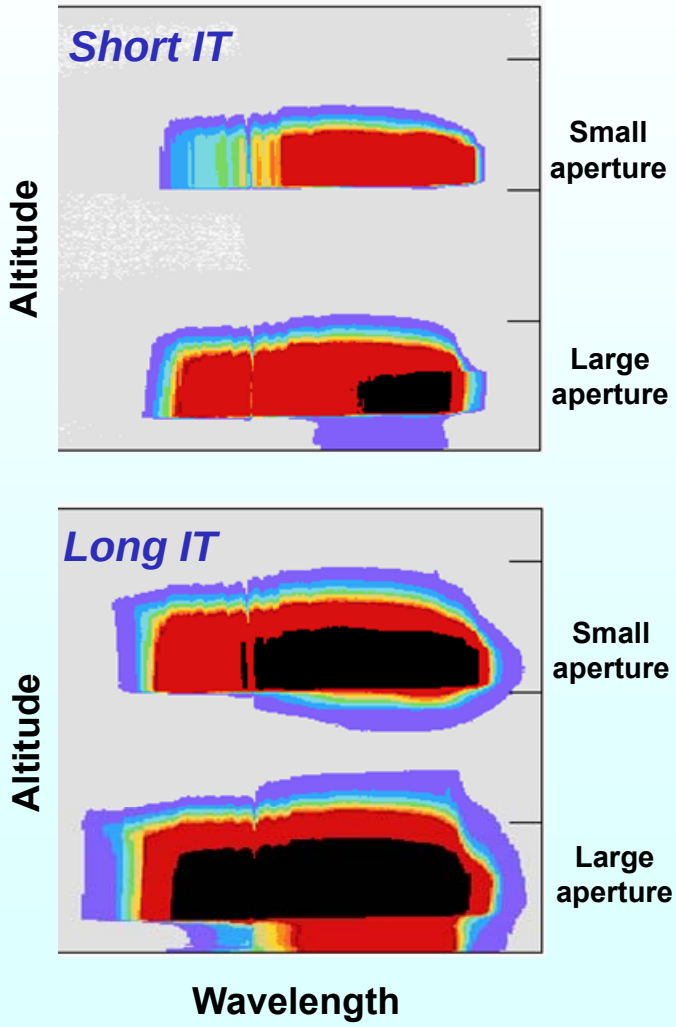
Gain 1 = 140
Gain 2 = 31
Gain 3 = 4.5
Gain 4 = 1

14-bit A/D converter

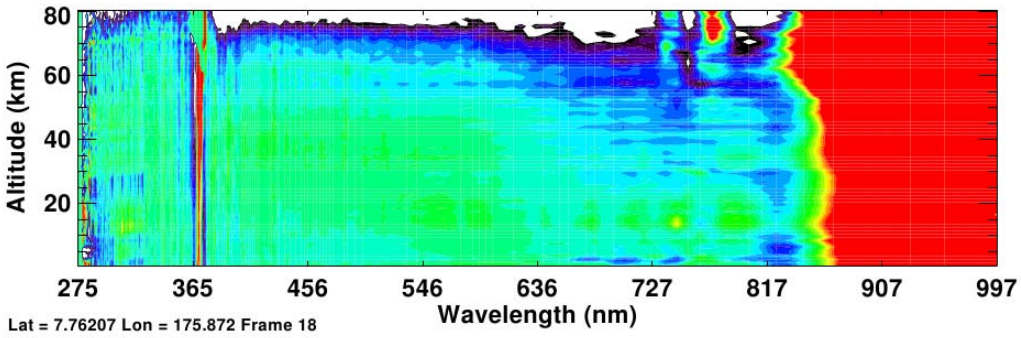
Total detector dynamic range ≈ $2 \cdot 10^6$
(need 10^4)

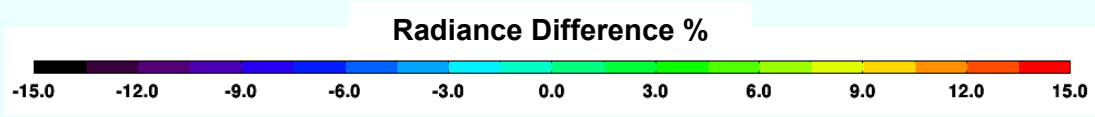
Radiances from different apertures never match

Detector Signal
(Black = saturated)



Large – Small aperture radiance difference



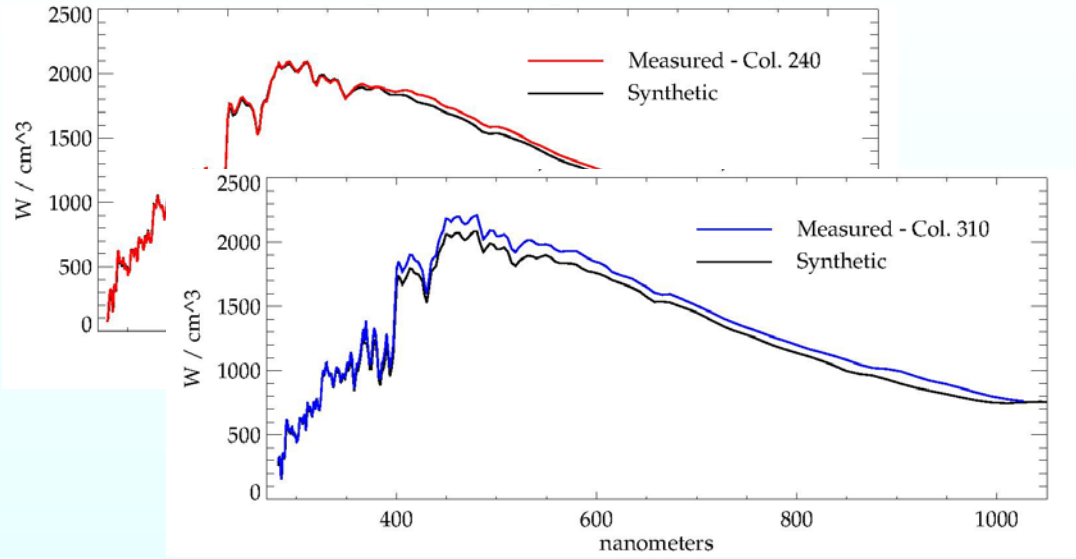


Future plans :

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

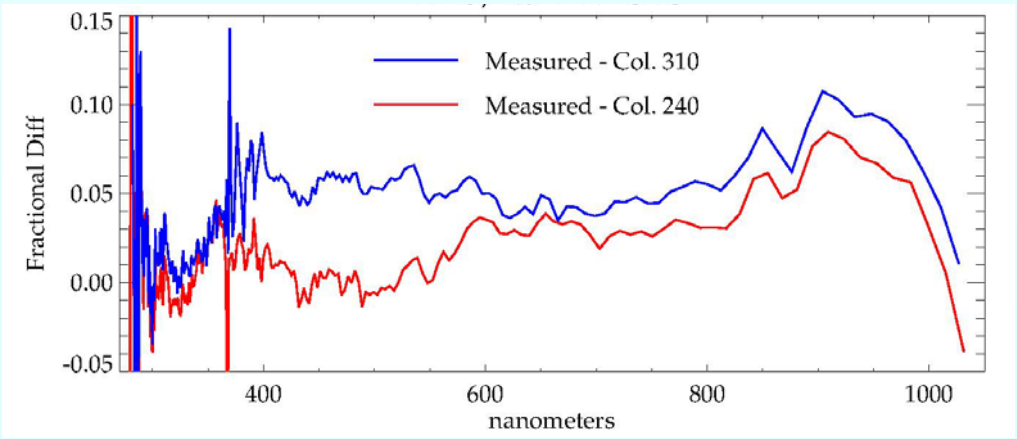
We trade mid-altitude S/N for smoother gain transitions

Solar measurements used for spectral calibration and to monitor sensor changes



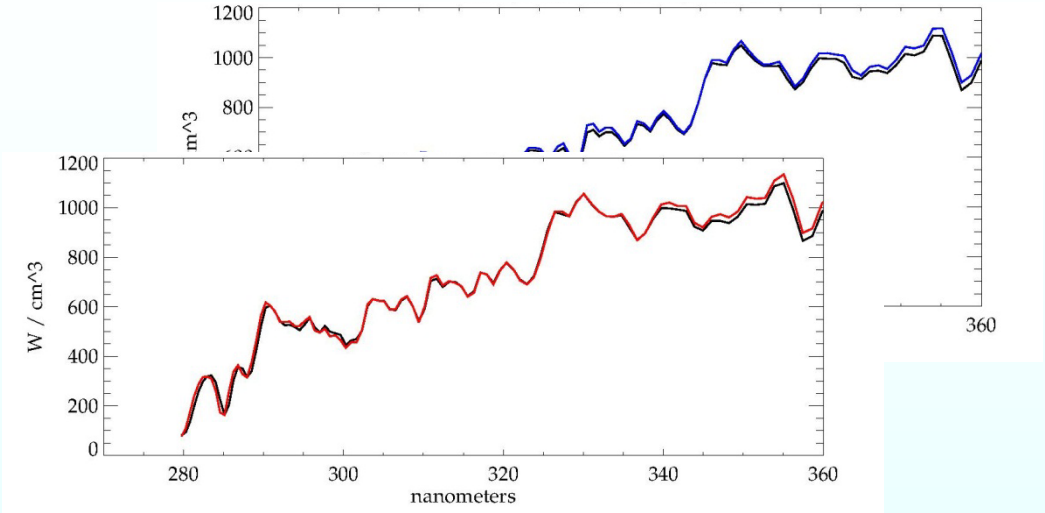
600 OMPS solar spectra (1 for each spatial location) are measured every week

OMPS compared to SUSIM-based spectrum



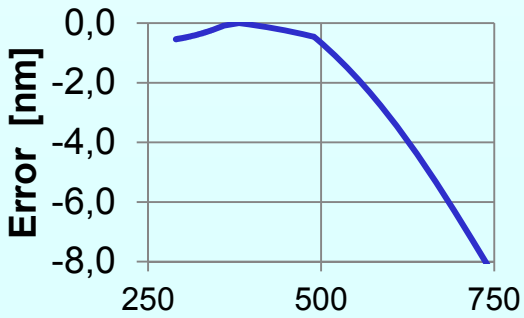
Spatial variations are indicative of radiance calibration errors at different tangent heights

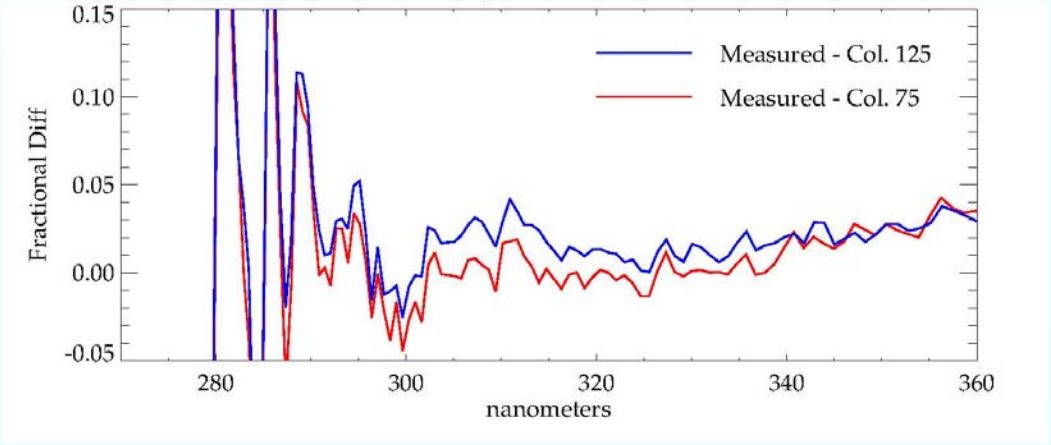
Spectral calibration from solar data



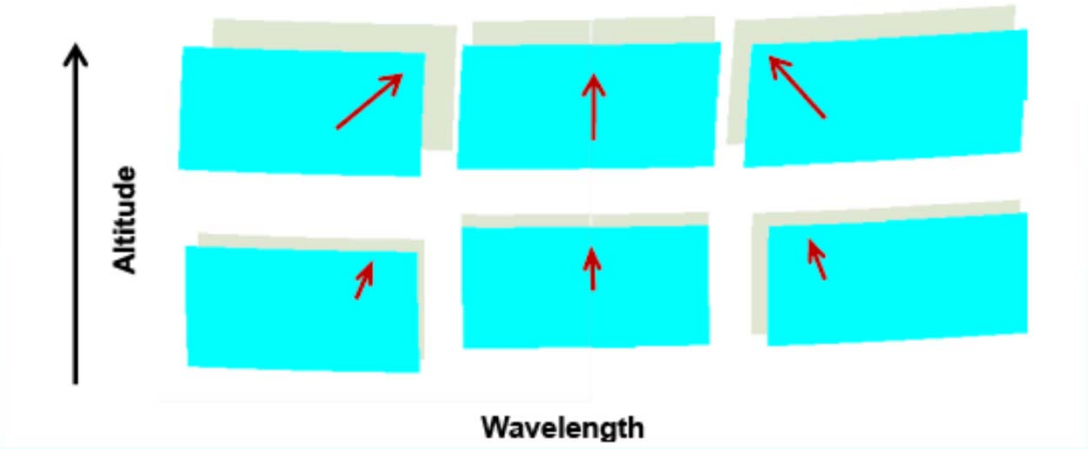
- 3 primary fitting windows
  - 290 – 320 nm
  - 320 – 360 nm
  - 370 – 435 nm
- wavelengths outside the fitting windows derived by extrapolation
- anomalous dispersion caused by optical distortion at focal plane

A mistake in wavelength calibration exists in the current released product

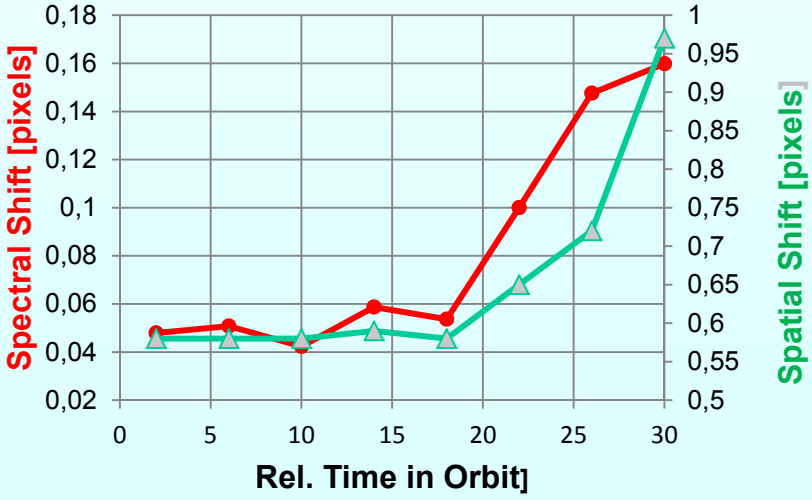




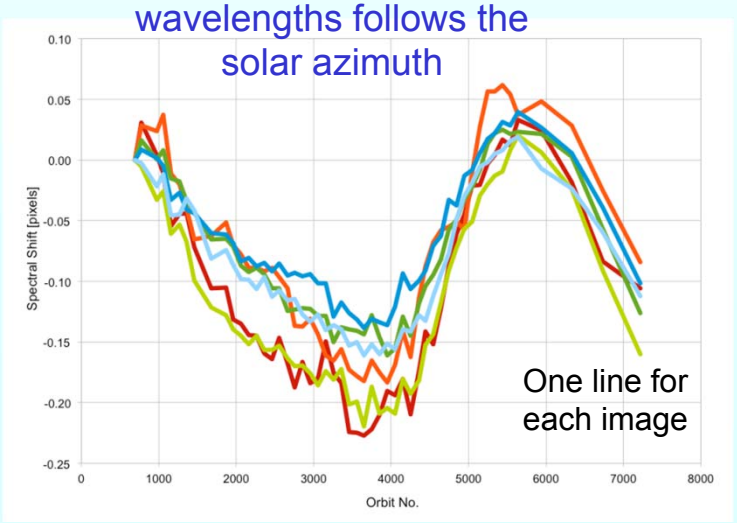
Thermal sensitivity of instrument



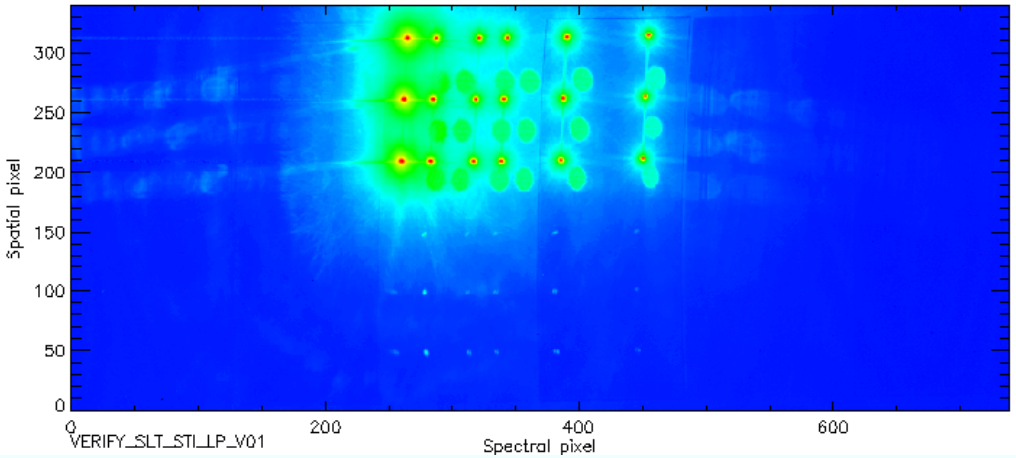
Images shift on focal plane as sun heats the sensor. Wavelength and vertical pointing shift every orbit.



Seasonal variation in wavelengths follows the solar azimuth



Detailed characterization with tunable laser leads to simple stray light correction

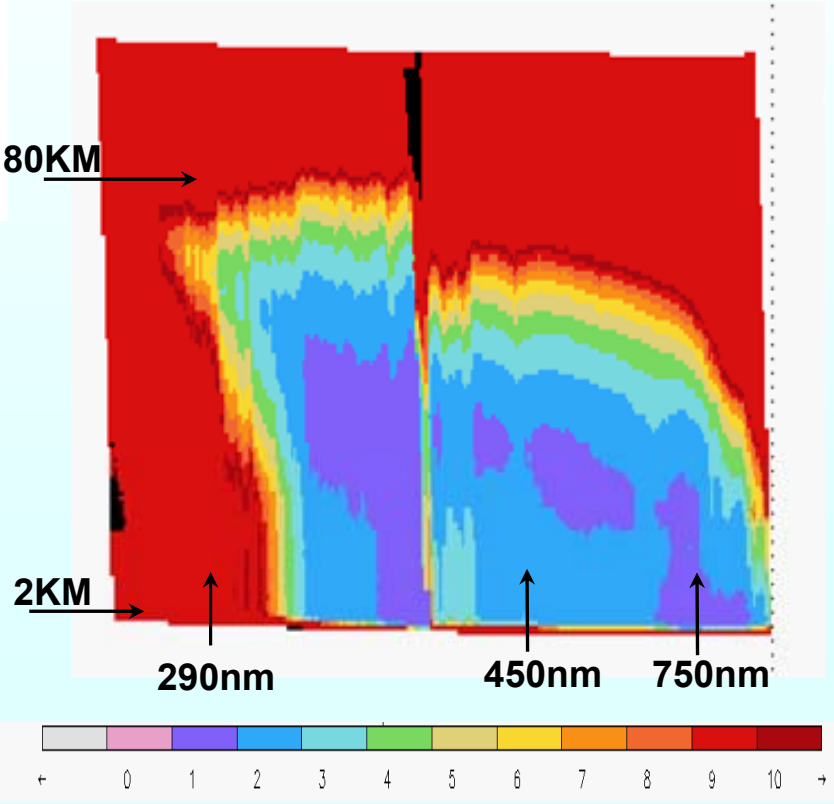


Test data was separated into a combination of PSFs and ghosts

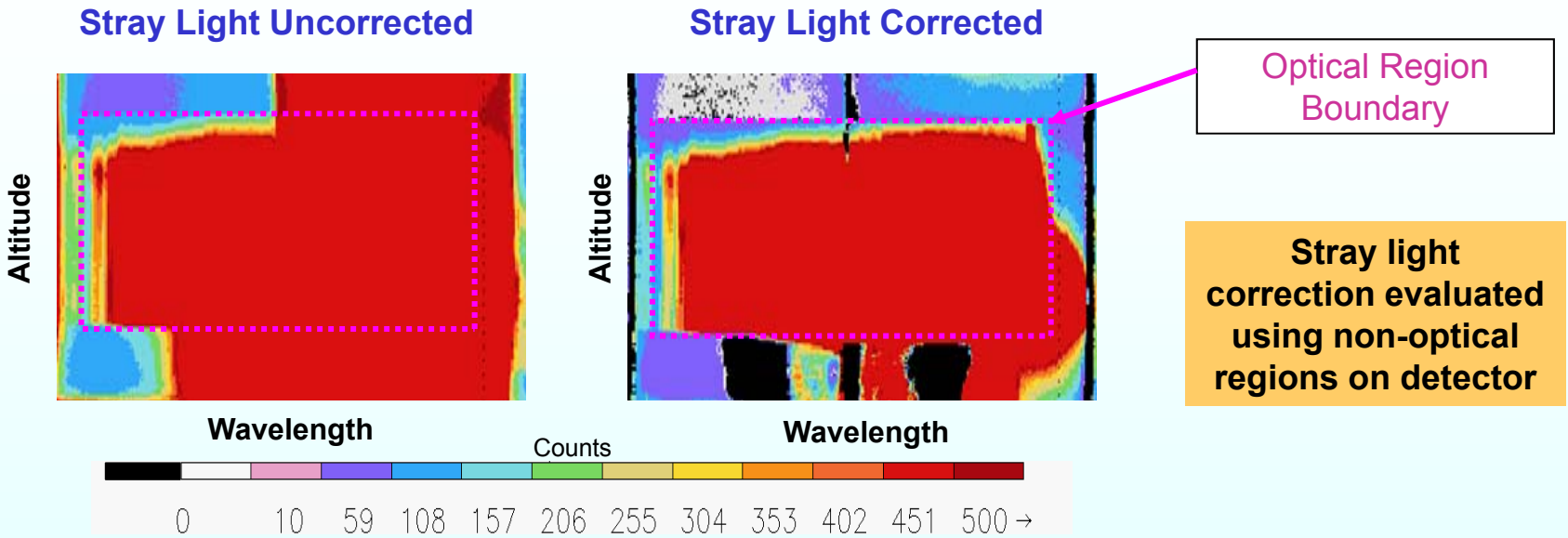
Stray light is mainly a high altitude problem

1µm has large stray light at all altitudes

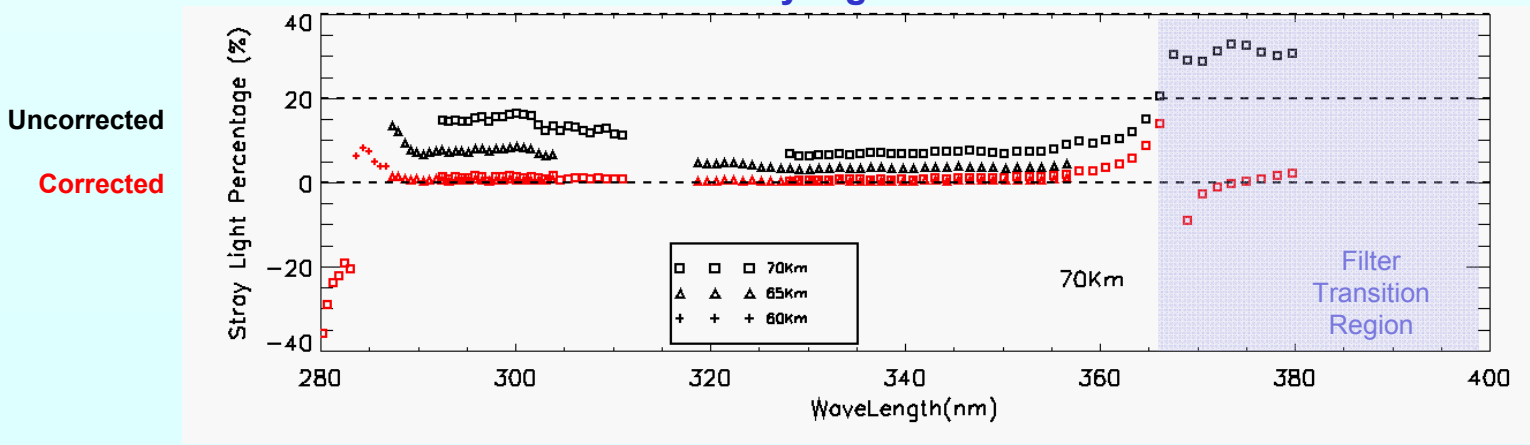
Computed stray light as fraction of measured radiance (orbit 1449)



Stray light correction can be evaluated and tuned



Stray light correction evaluated using non-optical regions on detector



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)

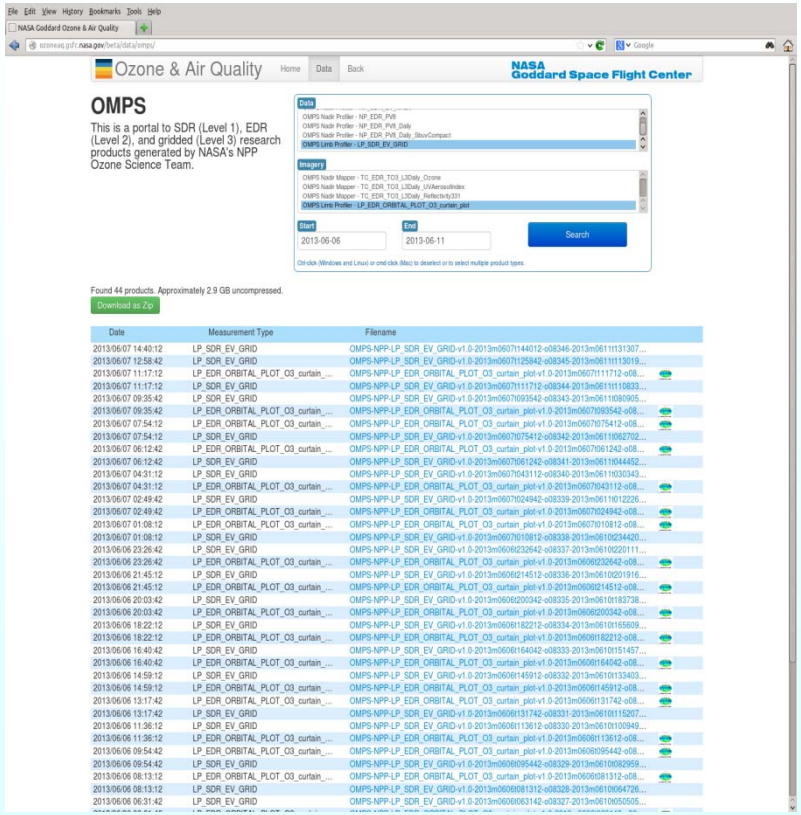
- geolocation in Right Slit
- improved S/N estimates
- static, seasonal, and intra-orbital wavelength registration
- solar irradiance adjusted to spectral scale
- addition of IR wavelengths in gridded radiance product
- intra-orbital altitude correction: 200 - 400 m
- ozone vertical smoothing
- atmospheric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

Remaining issues

- apparent tangent height error (~0.5 km) at VIS wavelengths
- undersampling errors in gridded radiances
- lacking 1μm 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 O_3 (14 orbits; Center Slit only)
  - Orbital O_3 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 O_3 and aerosol retrievals

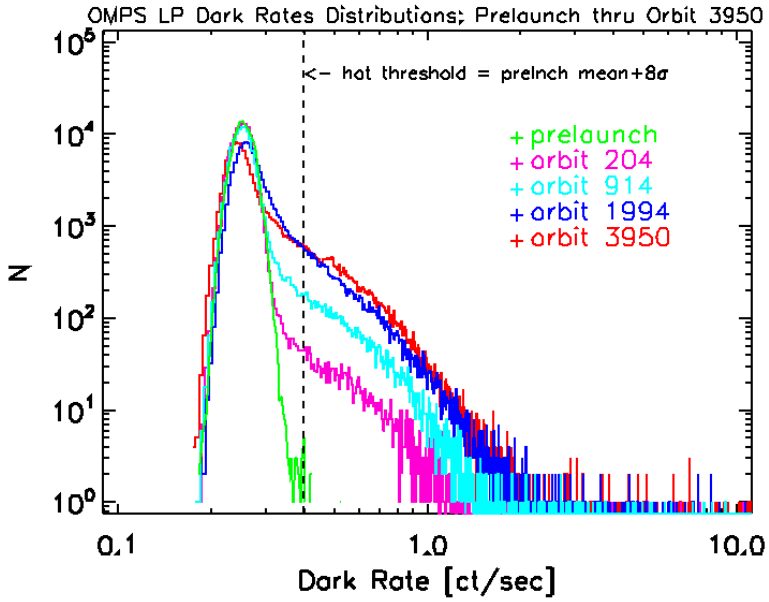


Summary

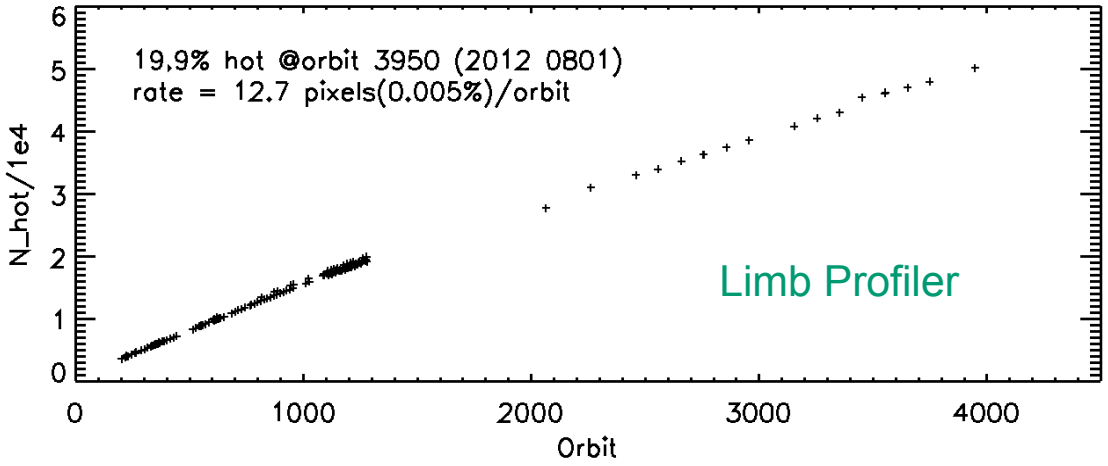
- Areas of future emphasis
  - Evaluate accuracy of radiances and TOA reflectance
  - Work on improving TOA reflectance measurements, especially in IR
  - Improved methods for evaluating pointing errors (including lunar measurement)
- We need to optimize pixel selection
  - Limited data rate – shared 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

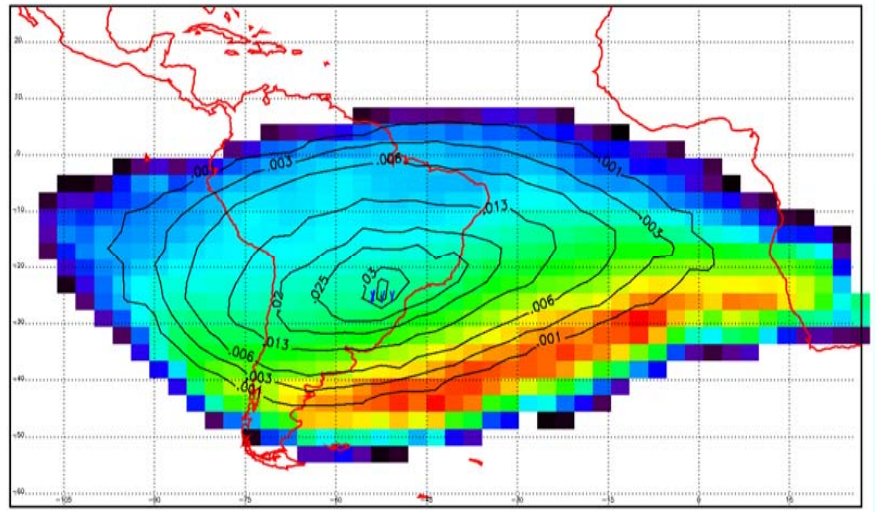


Dark currents are increasing as expected

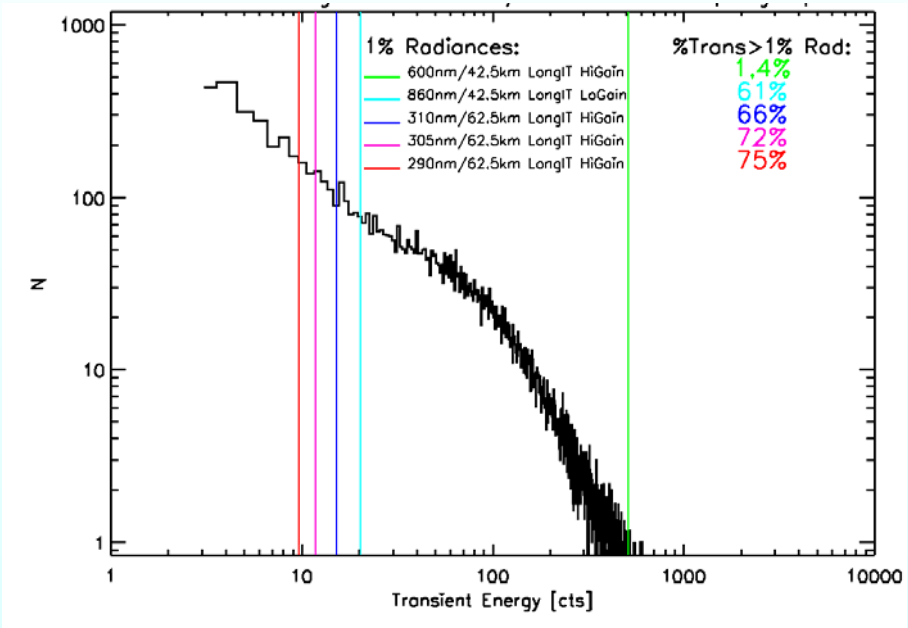


South Atlantic Anomaly has significant effect on most radiances

Number of detector transients and mean transient energy



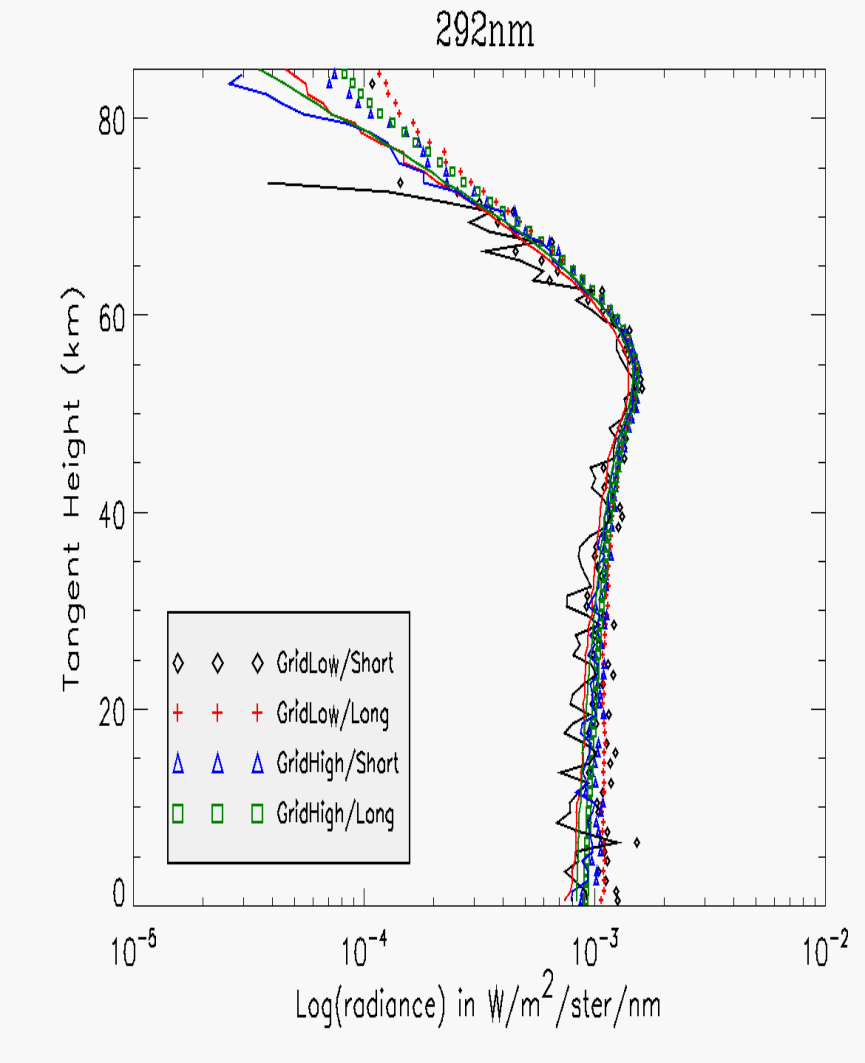
Transient energy distribution at SAA peak

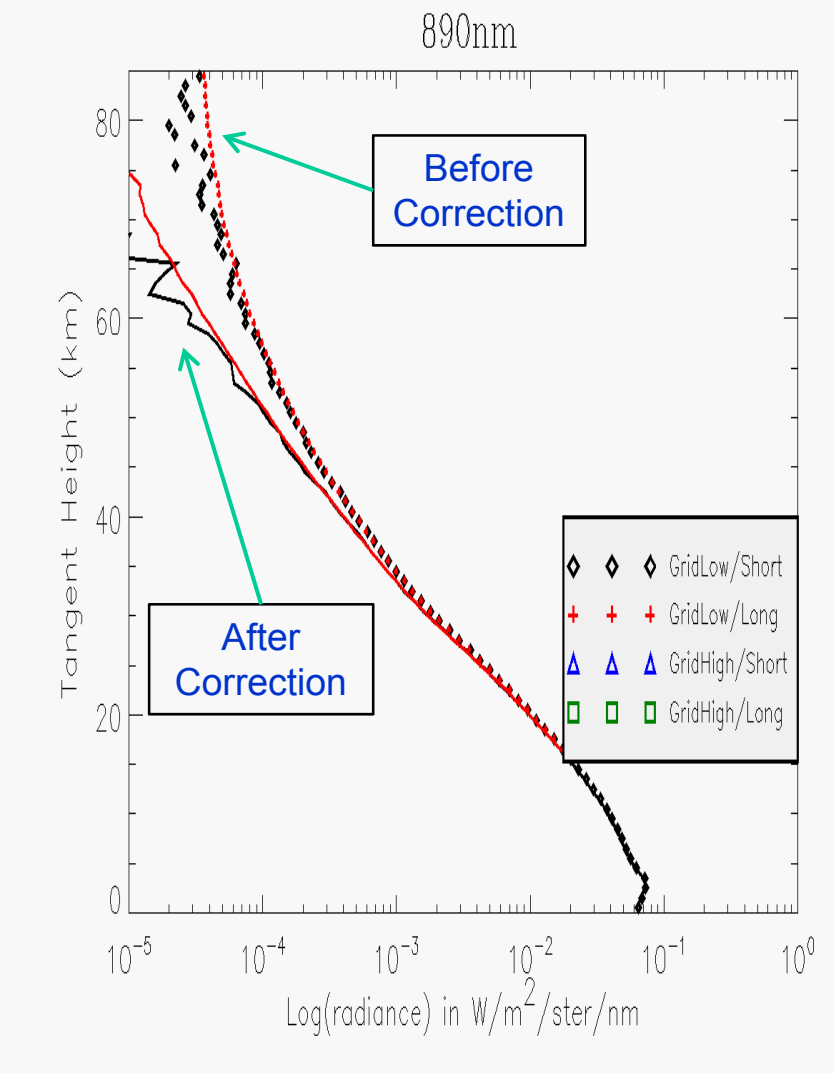


Results from closed door data

Transient detection not operating in current product

Stray light residuals mainly in high altitude IR



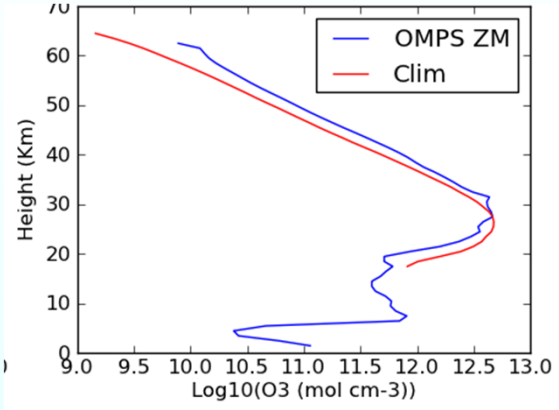


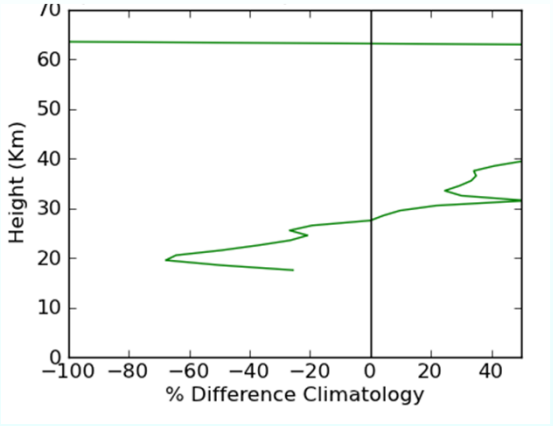
Vertical Shift confirmed through comparisons with ozone climatology

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

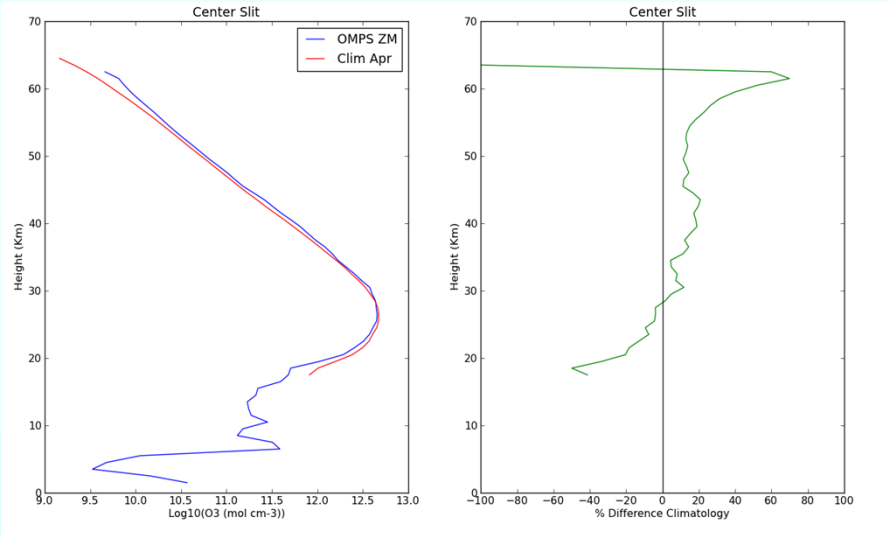
Difference from Climatology

Before vertical adjustment





After 1.3 km adjustment



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