Royal Netherlands
Meteorological Institute
Ministry of Transport, Public Works
and Water Management

The Ozone Monitoring Instrument on EOS-Aura: Lessons Learned

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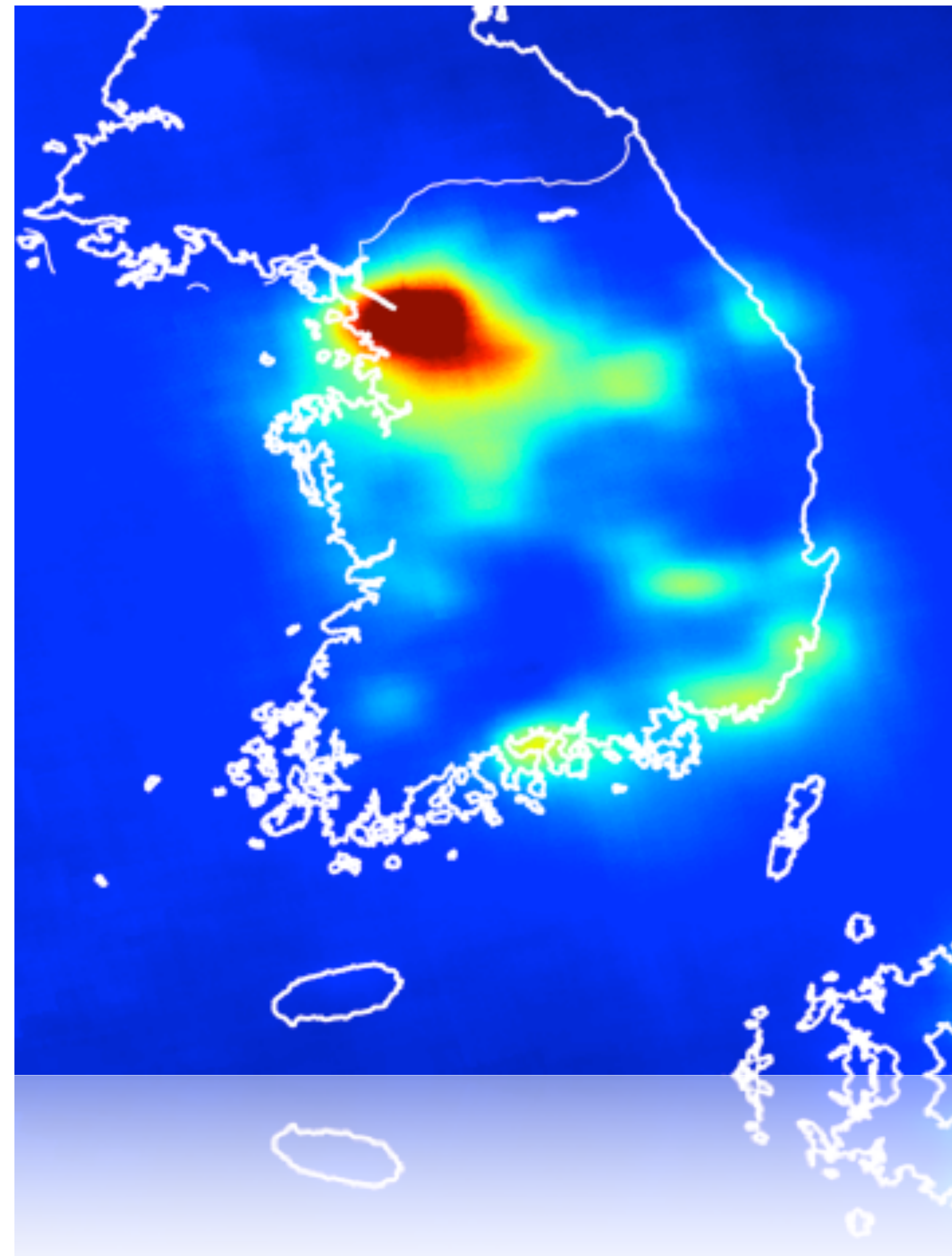
OMI 2005-2009



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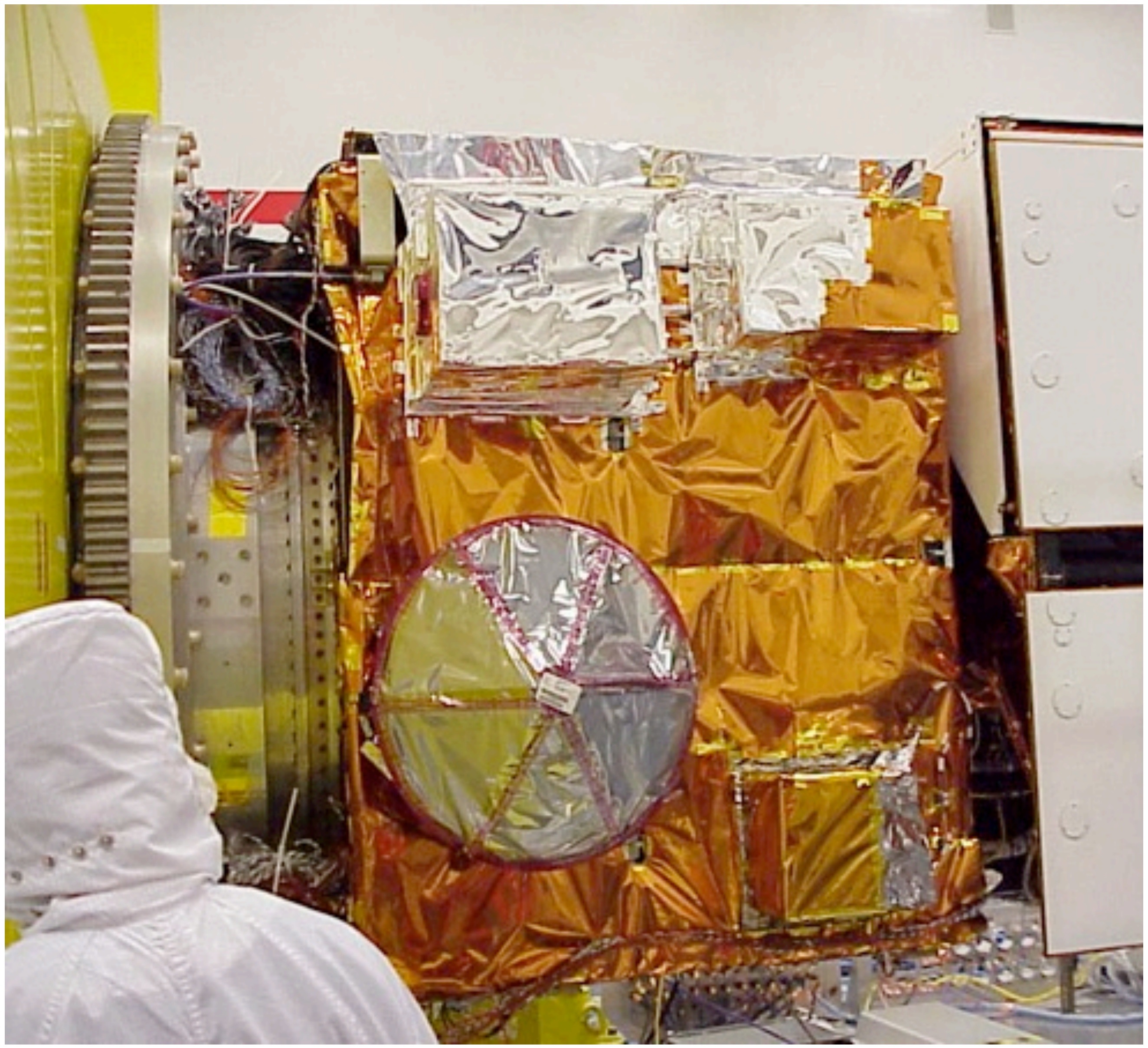
Ozone Monitoring Instrument



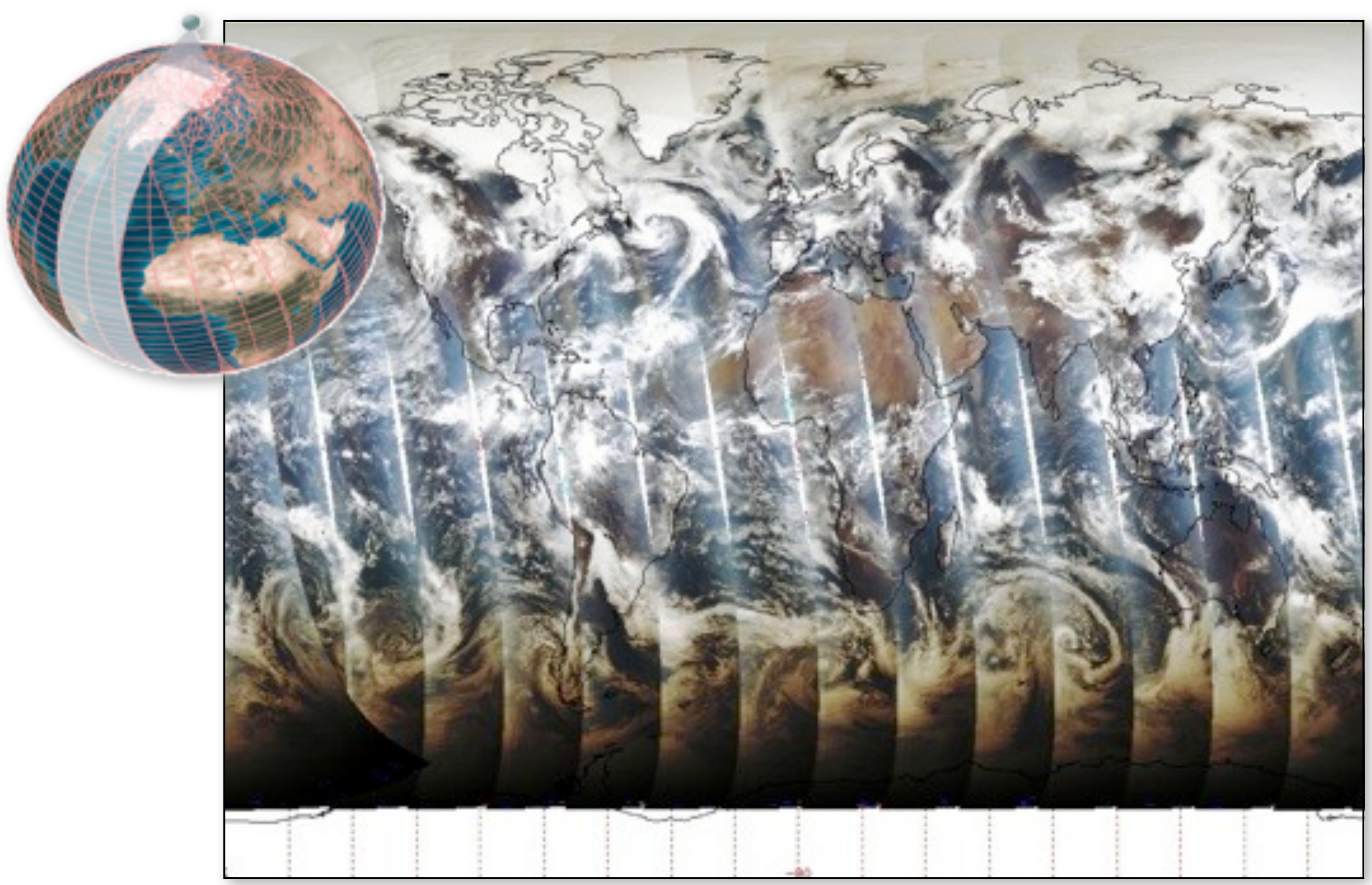
Ozone Monitoring Instrument

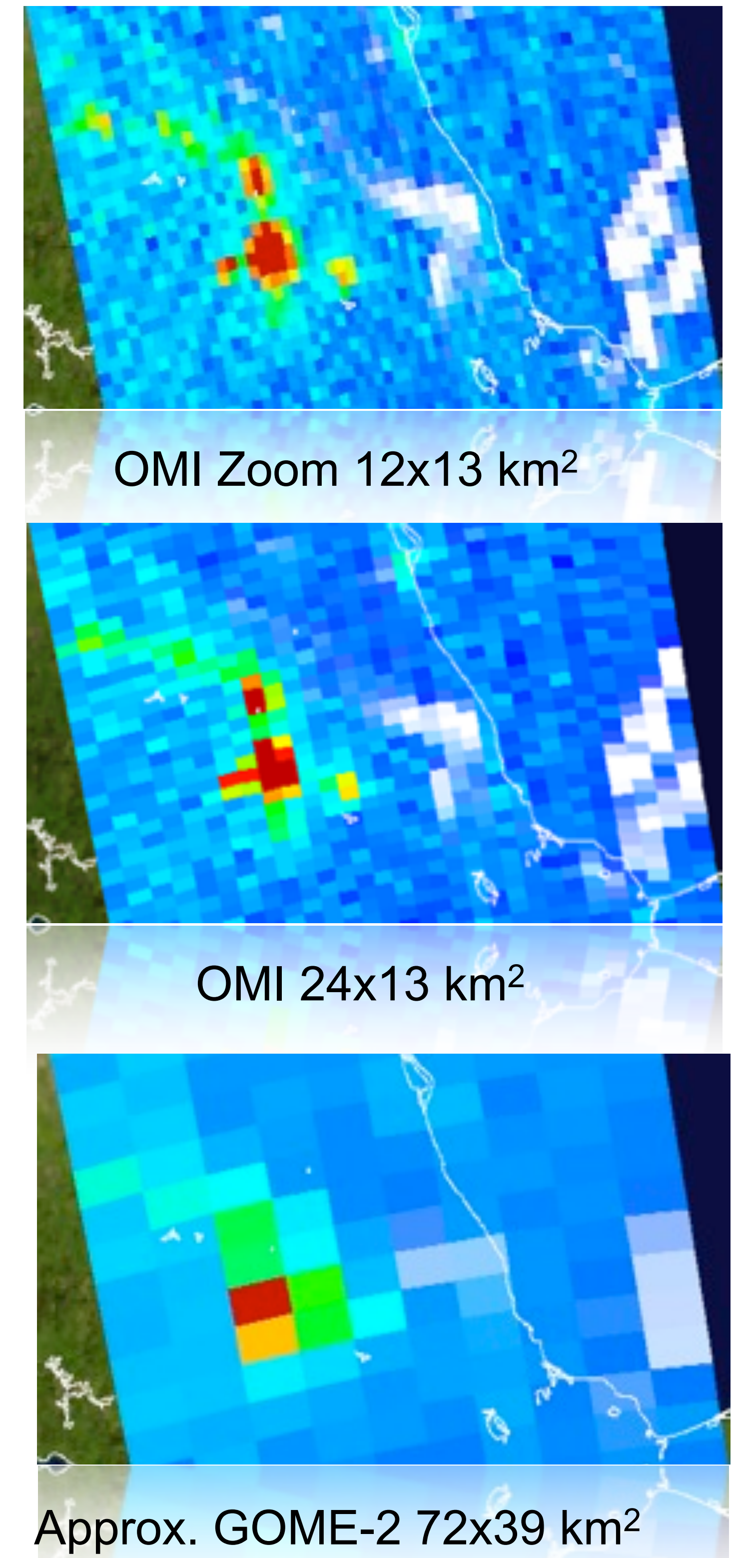
Instrument	Imaging spectrometer
Spectral Range	270 - 500 nm
Spectral Resolution	0.45 - 0.63 nm
Spectral Sampling	0.15 - 0.30 nm
Spatial Resolution	13x24 km^2 (nadir)
Swath Width	2600 km
Mass	65 kg
Size	50 cm × 40 cm × 35 cm
Power	66 W
Data rate	0.8 Mbps (average)
Spacecraft	NASA EOS-Aura
Launch Date	15 July 2004
Orbit	Sun synchronous, 13:30 hr
Altitude	705 km
Agencies	NSO (NIVR), FMI
PI Institutes	KNMI, FMI

OMI is the Dutch-Finnish contribution to the NASA EOS-Aura Mission and is developed by an international consortium led by Dutch Space and TNO.

Innovative Aspects of OMI

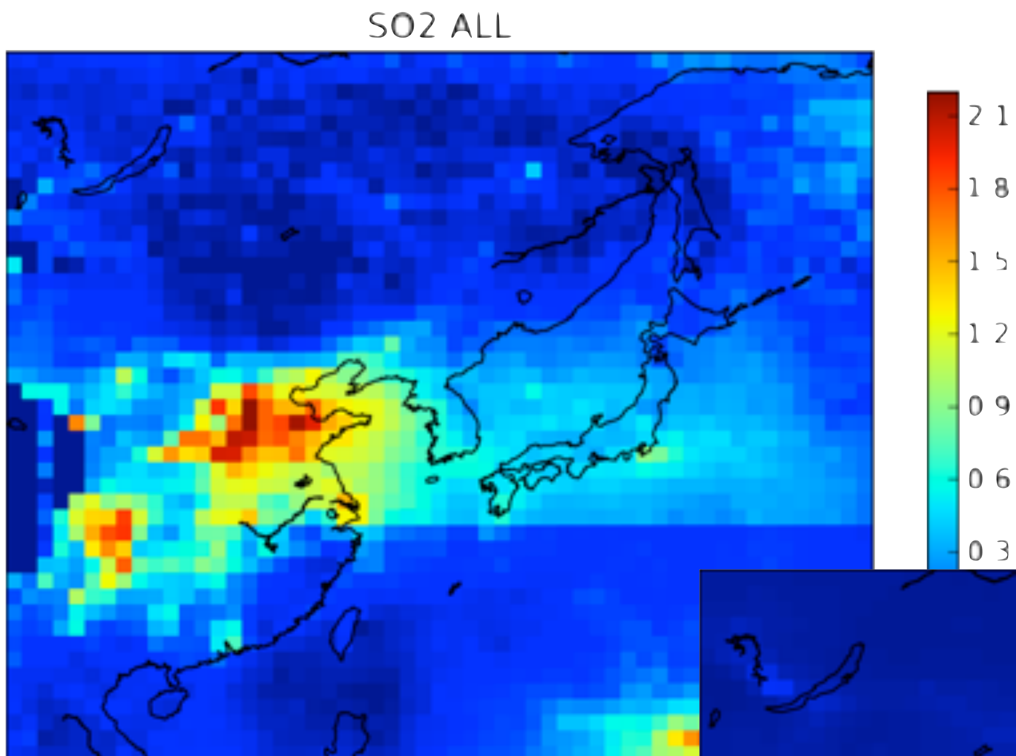
- Daily global coverage
- High spatial resolution
- Polarization insensitive instrument

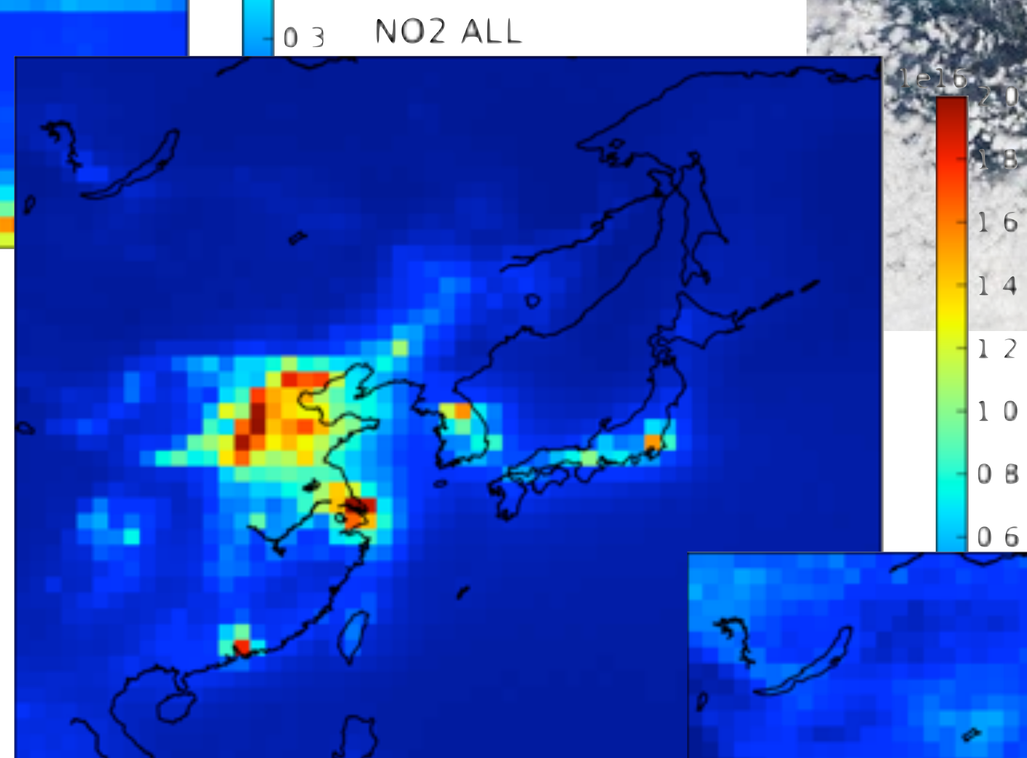


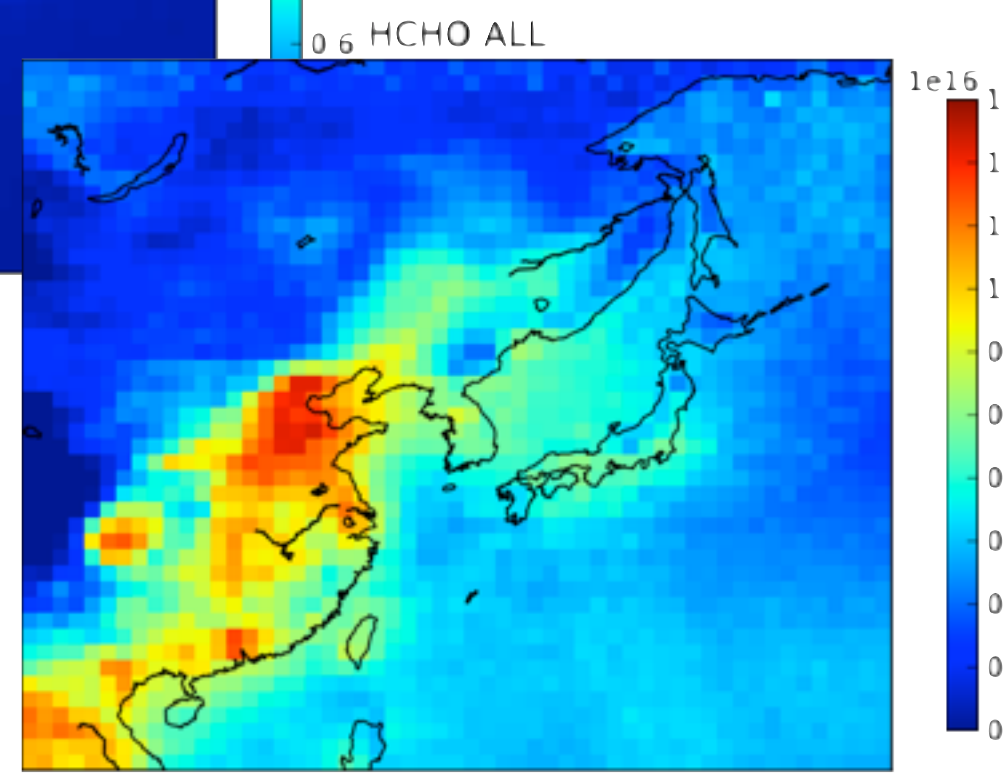


Mexico City
January 20, 2005

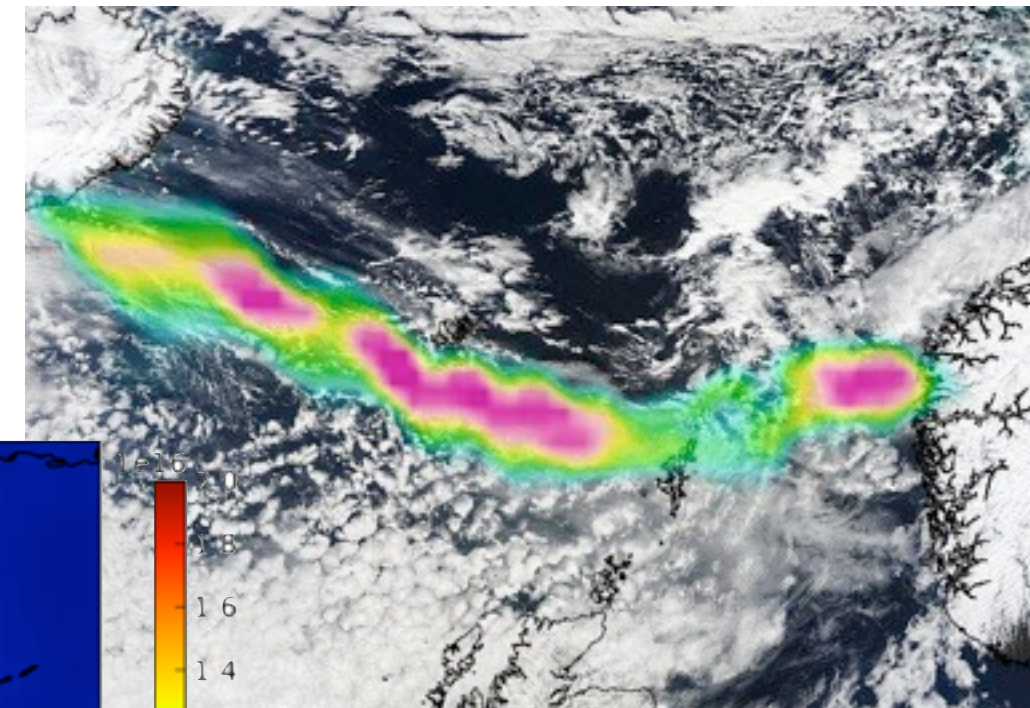
OMI Data Products





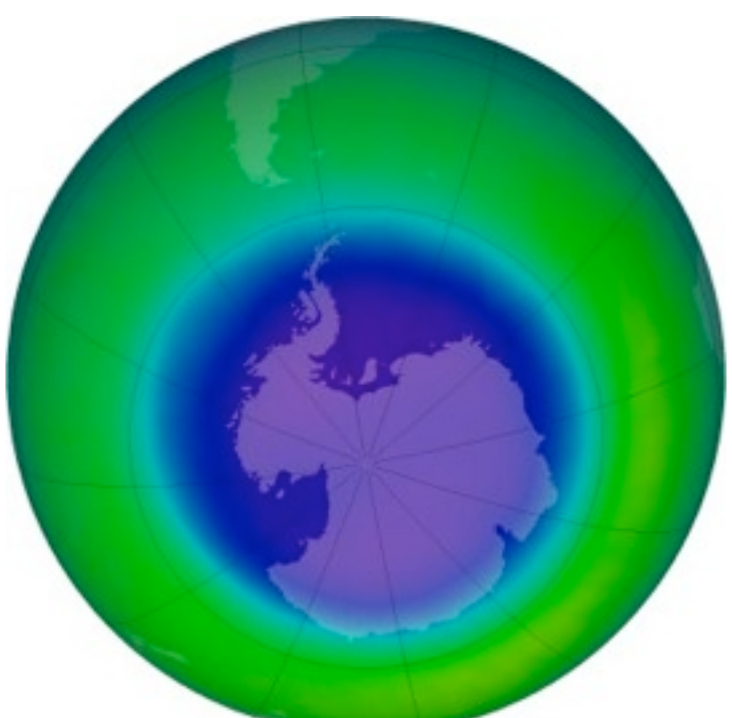


Volcanic Ash, April 2009



Colin Seftor, SSAI

Ozone Sep. 2009



OMI Super Zoom
~3x13 km^2 Sampling

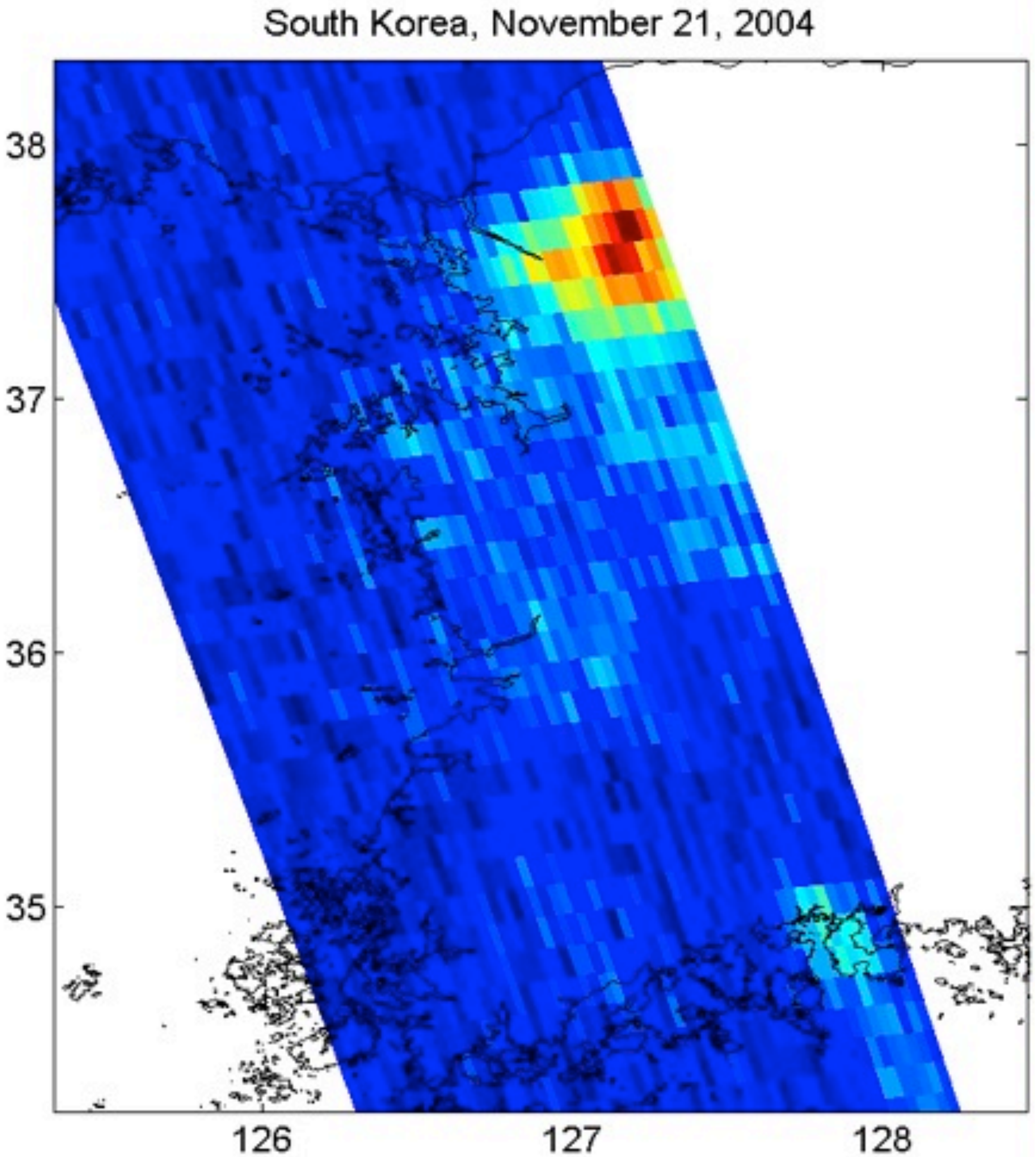
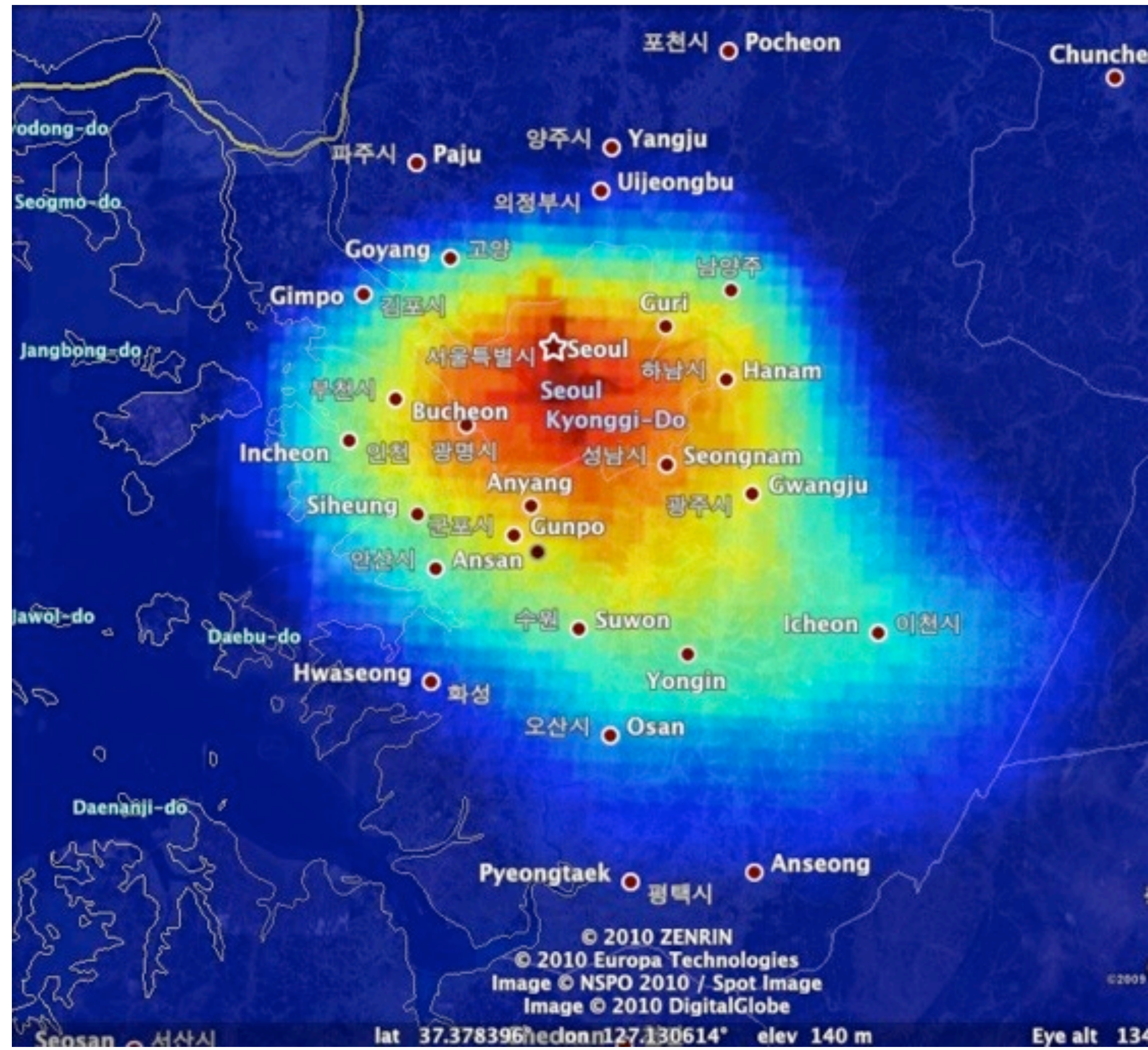


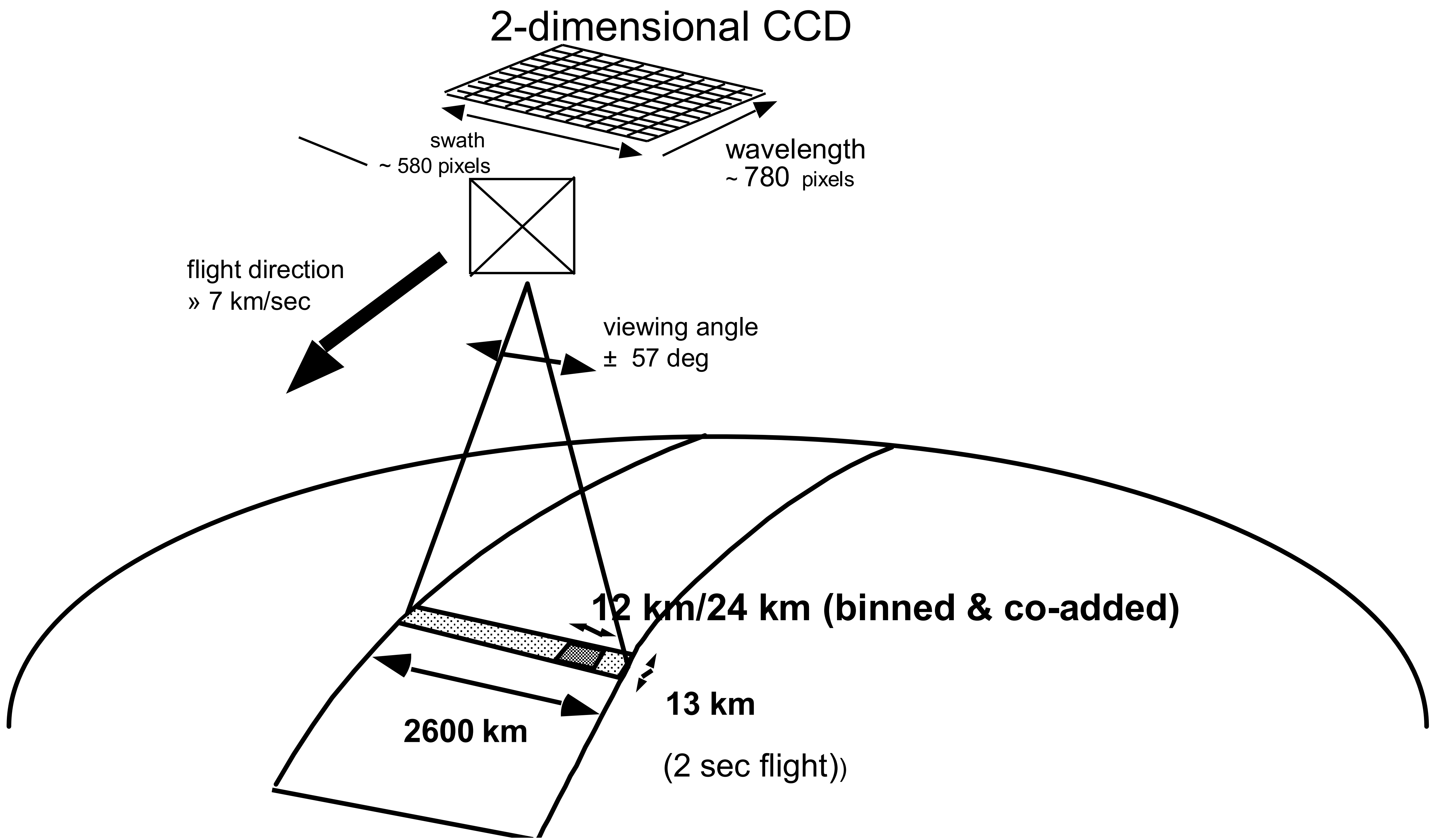
Image courtesy of Ron Cohen

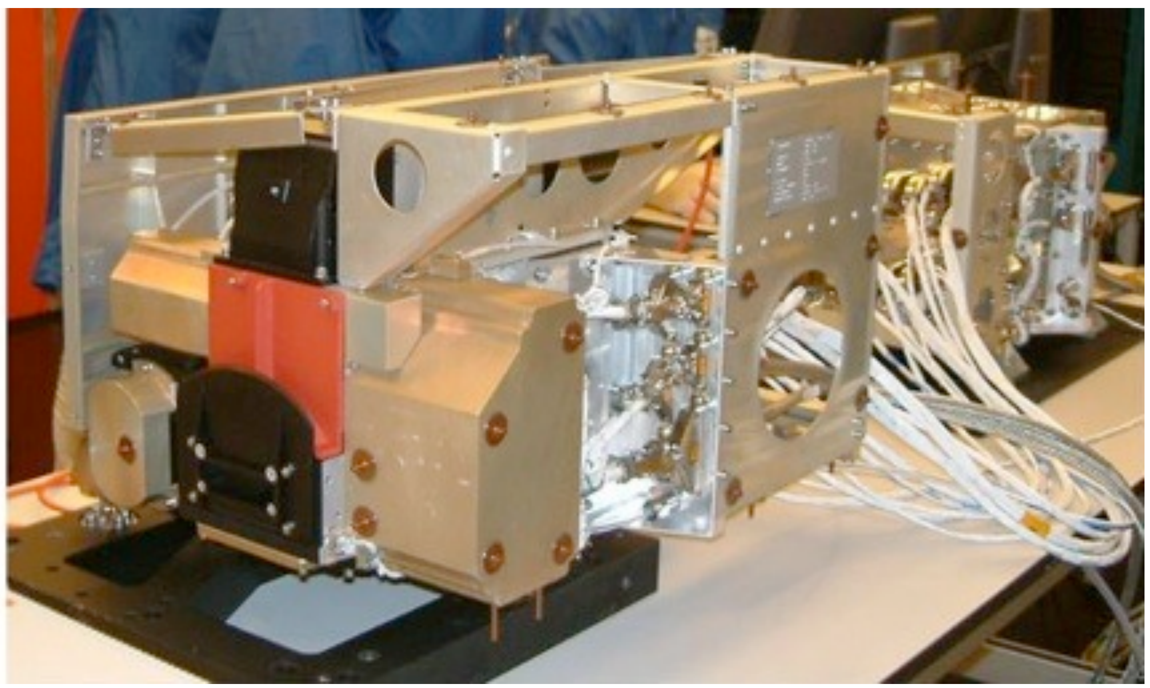
OMI 2005-2009
2.5x2.5 km^2 grid

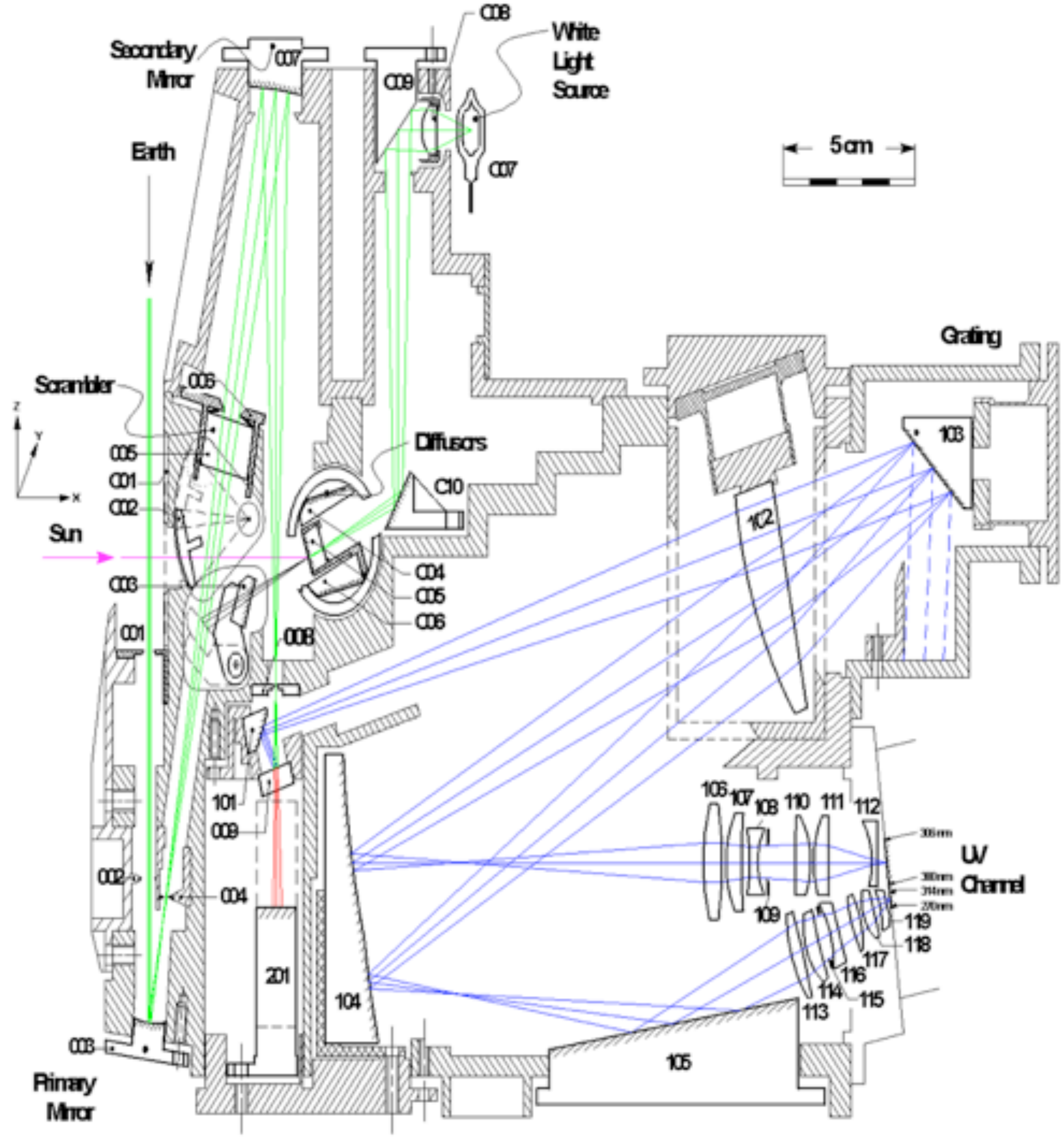


~100 km

OMI Measurement Principal





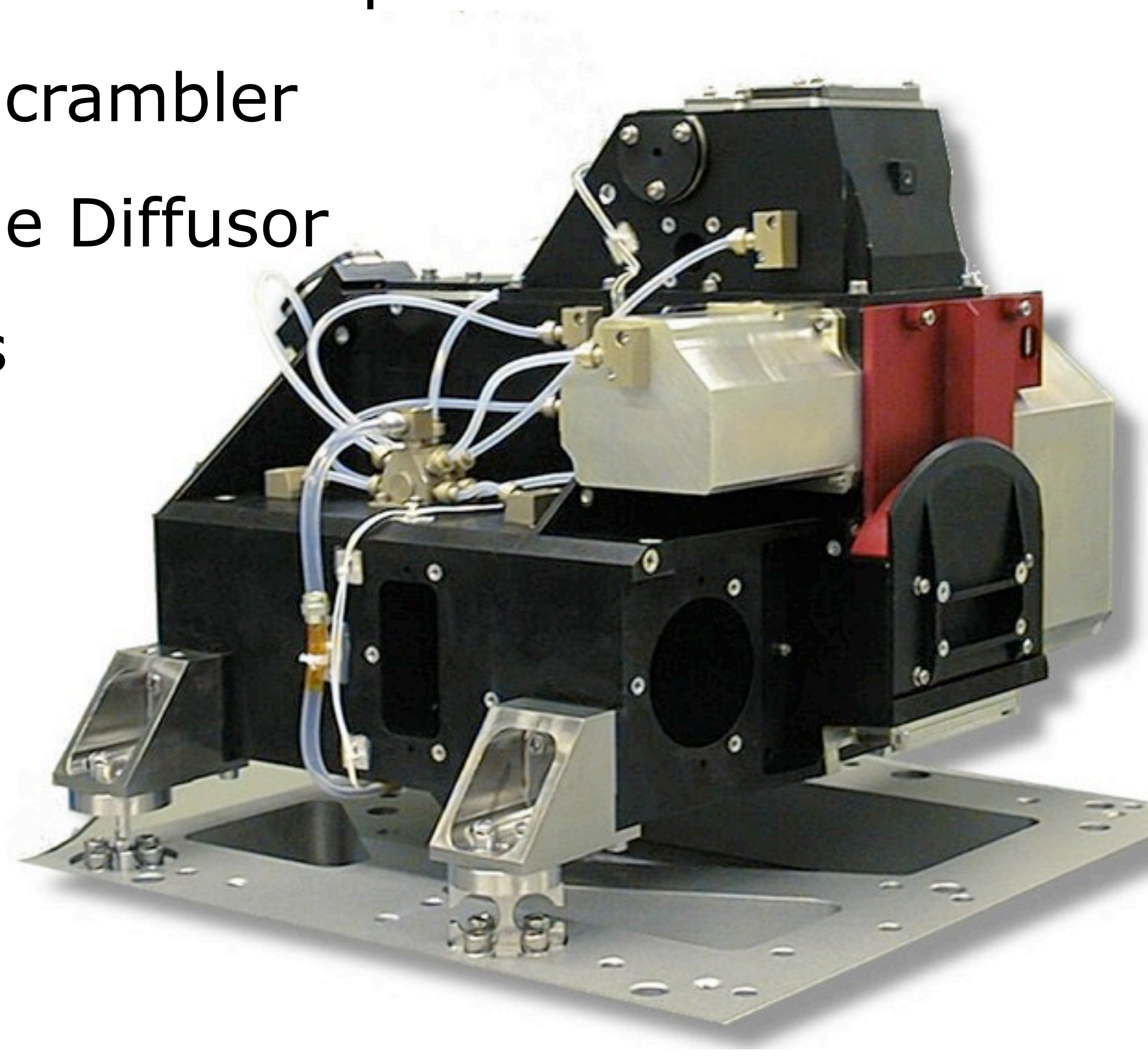


Spectral range, resolution and sampling distances

Channel	Total Range	Full Performance Range	Average Spectral Resolution (FWHM)	Average Spectral Sampling Distance
UV-1	264 - 311 nm	270 - 310 nm	0.63 nm	0.33 nm/pixel
UV-2	307 - 383 nm	310 - 365 nm	0.42 nm	0.14 nm/pixel
VIS	349 - 504 nm	365 - 504 nm	0.63 nm	0.21 nm/pixel

OMI Innovative Components

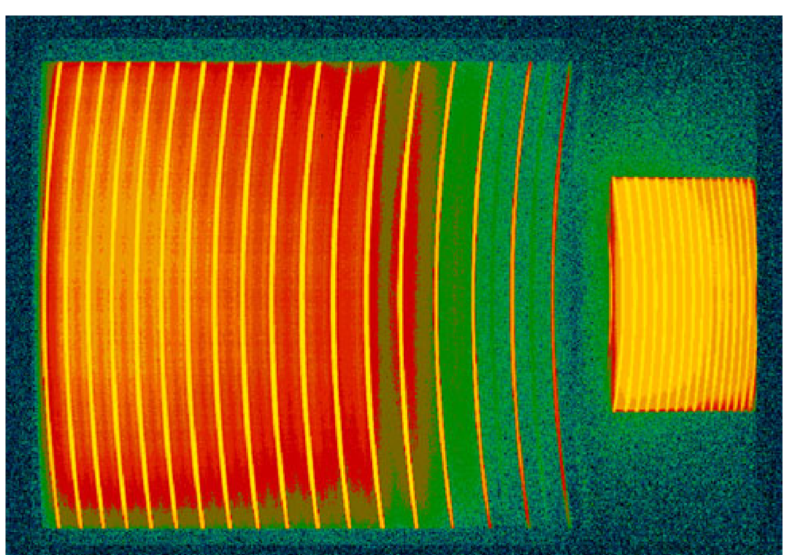
- Wide angle 114° telescope
- Polarization Scrambler
- Quartz Volume Diffusor
- 2-D detectors



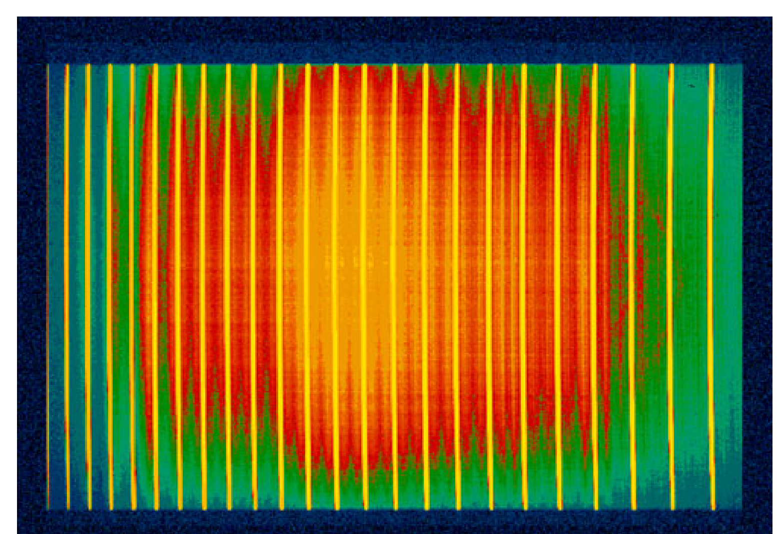
OMI CCD Detectors

- OMI has 2 Frame Transfer CCDs of 780 rows by 576 columns.
- Around the detector modules 10 kg of aluminum shielding has been applied.
- On the CCD 8 detector pixels are binned in the across track direction into one ground pixel.
- In the flight direction 1-4 CCD exposures are co-added.
- Detector temperature is -8 °C.

UV2



UV1

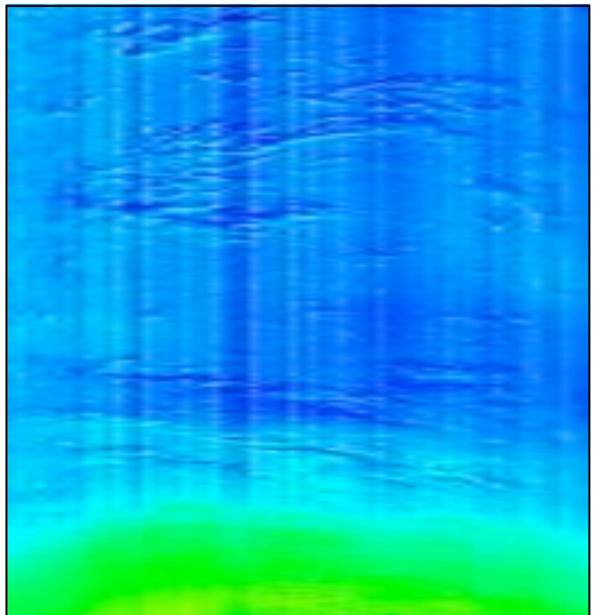


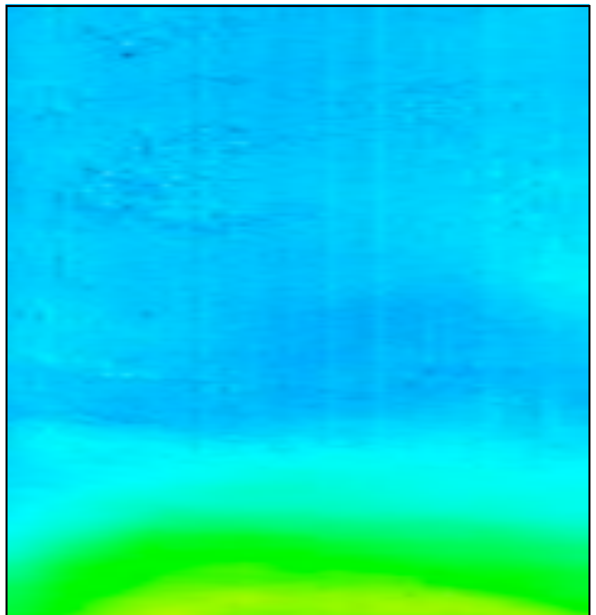
VIS

2-D Detectors and Stripes

- Each cross track pixel has its own characteristics, i.e. slit function, dark current, solar spectrum, etc..
- Random noise in calibration measurements (dark current, solar) translate into systematic errors in the reflectance.
- Because systematic errors vary over the swath, they will result in along track stripes in the Level 2 products, if these errors are of the order or lower as the random noise.
- To avoid stripes the Solar irradiance, dark current maps and other across track varying calibration parameters should be measured with a high precision.

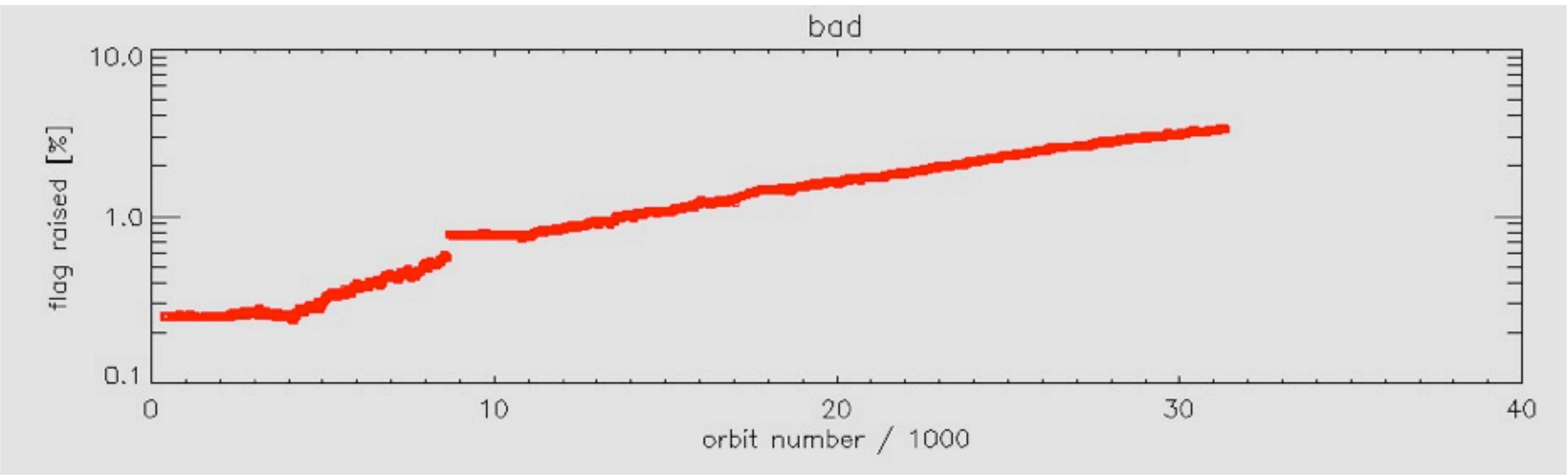
Examples of stripes in DOAS ozone processed at the beginning of the mission. Difference show the impact of an improved dark current correction





CCD detector radiation damage

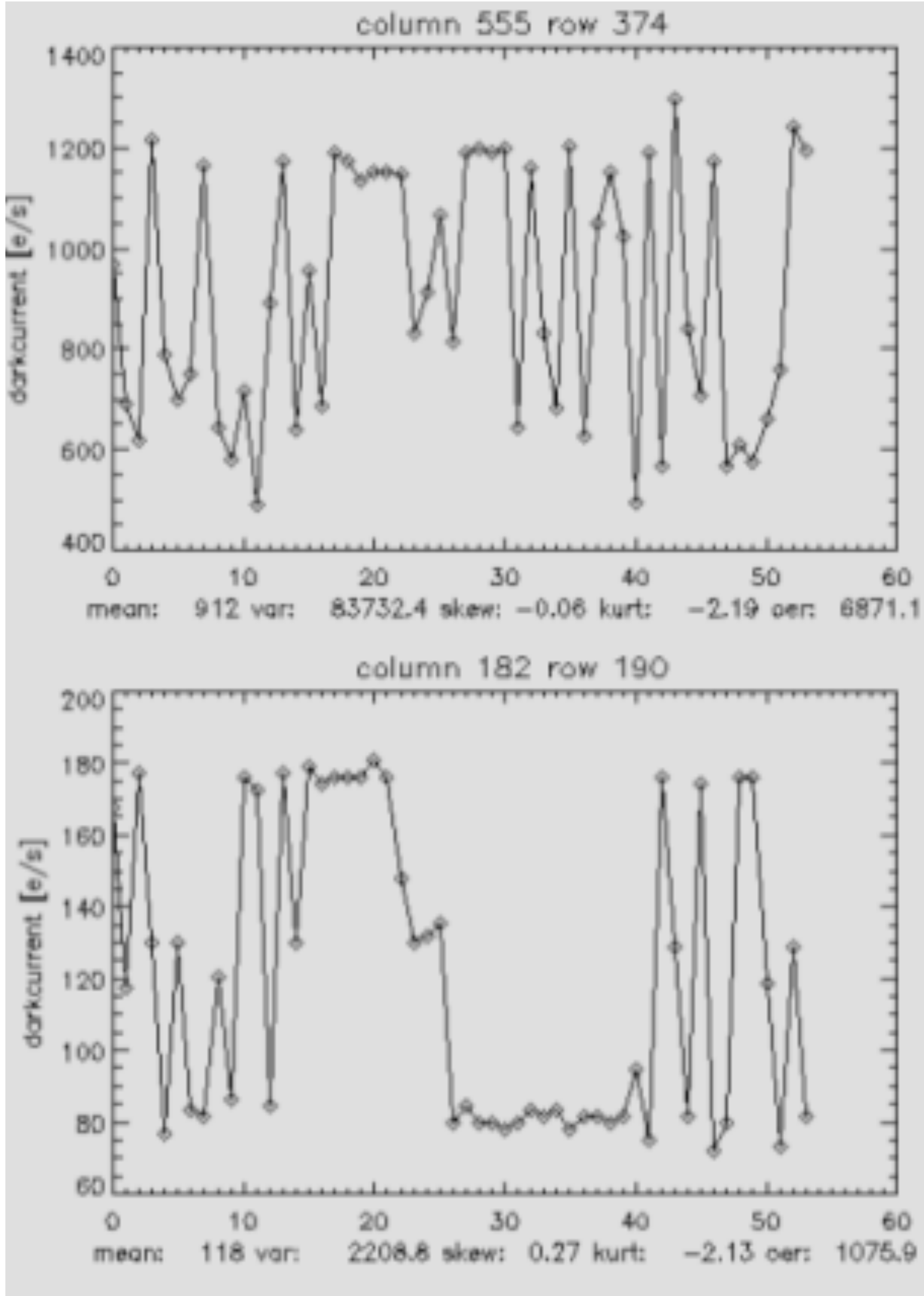
- Overall increase in dark current
- Increase in the number of bad pixels
- Increase in the number of RTS pixels



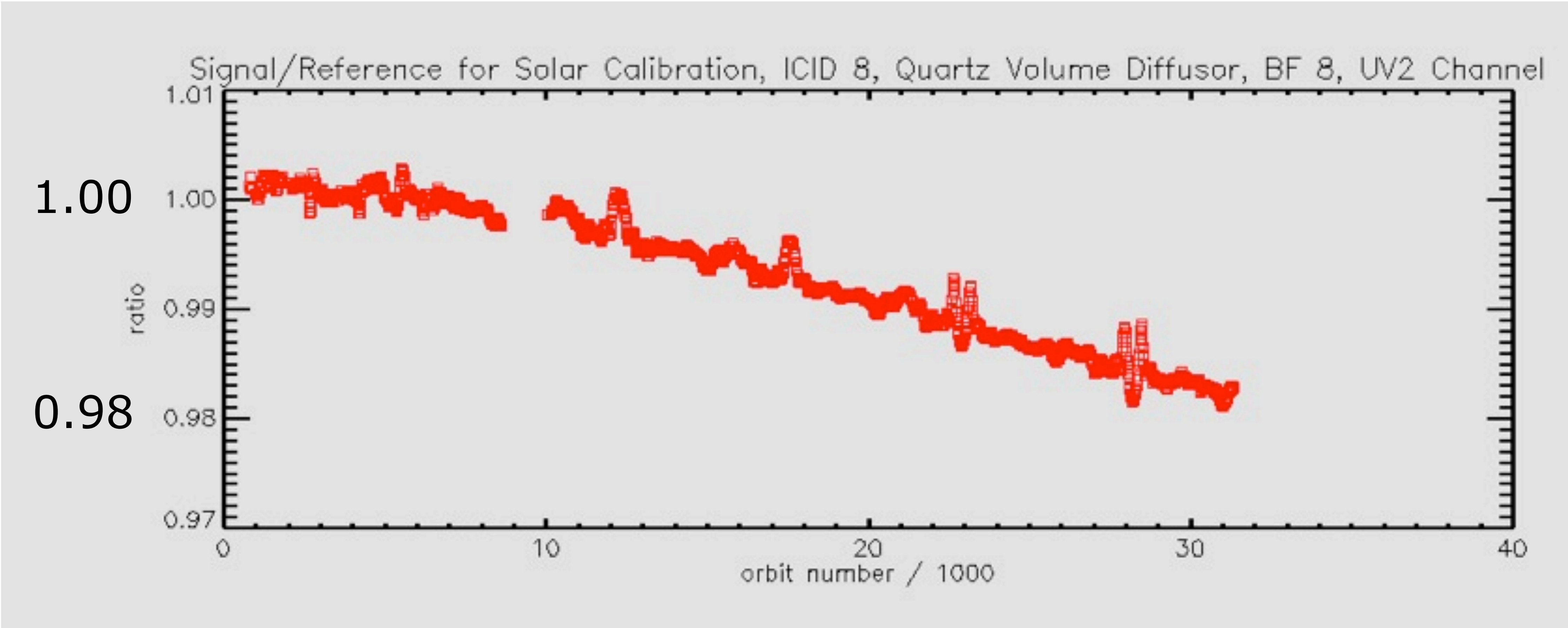
tropical	**UV1**	**UV2**	**VIS**
Bad	4%	3%	3%
RTS	4%	4%	4%

Random Telegraph Signals (RTS)

- RTS is caused by radiation damage.
- RTS is a randomly changing dark current on can be on time scales from seconds to weeks.
- Effects of RTS can be reduced by:
  - Frequently updating the dark current maps (currently for OMI daily)
  - Lowering the dark current, i.e. lowering the CCD temperatures.
- The aluminium shielding doesn't seem to be effective for reducing the RTS.



Optical degradation: sun measurements over on-board diffusers



Absolute degradation	UV1	UV2	VIS
Daily quartz diffuser	3.2%	1.8%	1.5%
Weekly aluminium diffuser	1.7%	1.2%	1.3%
Monthly aluminium diffuser	1.7%	1.2%	1.0%

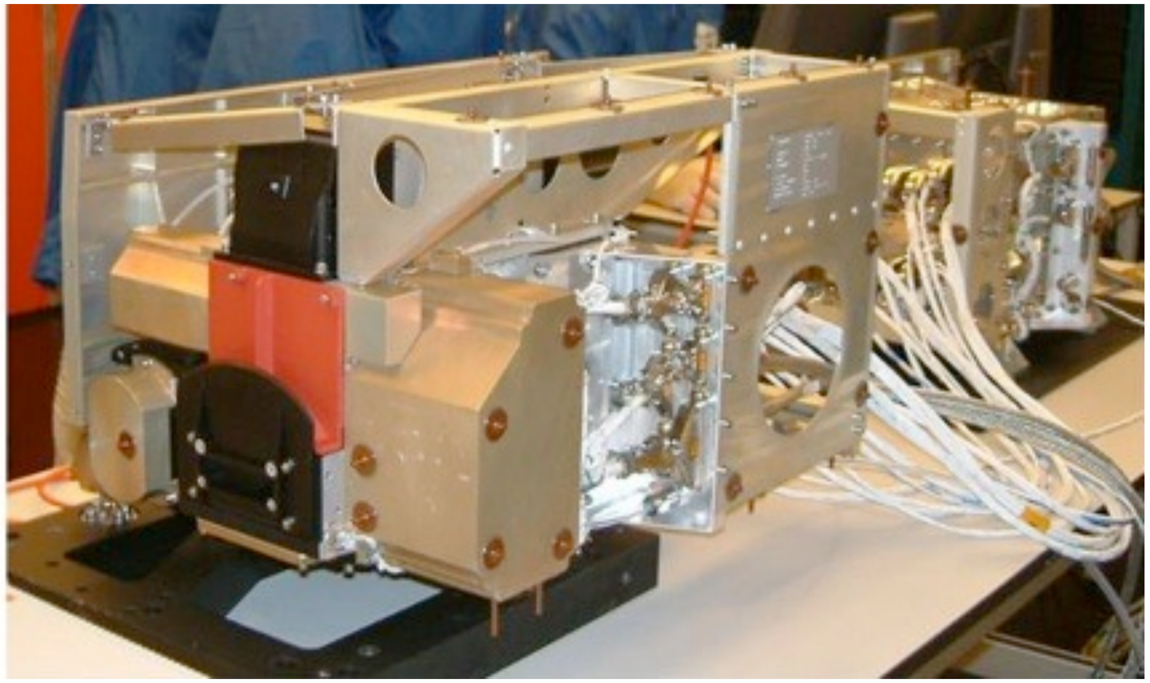
Diffuser degradation	UV1	UV2	VIS
Daily quartz diffuser	1.5%	0.6%	< 0.5%
Weekly aluminium diffuser	0%	0%	< 0.5%
Monthly aluminium diffuser	0%	0%	0%

Low optical degradation

1. First mirror and diffusors are placed deep in the instrument.
2. Early and long outgassing after launch.

Calibration

- The on-ground calibration of 2-D UV spectrometers is a large effort (OMI: 7 months).
- Emphasis should be on parameters that cannot be derived in-flight, e.g. stray light and slit functions.
- On-ground calibration should be performed under flight representative conditions.
- For in-flight calibration of OMI the solar observations and the LEDs are the most important light sources.



OMI

Conclusions

1. OMI successfully demonstrates the use of 2-D detectors for nadir-viewing solar backscatter spectrometers.
2. The optical degradation is the lowest of UV instruments launched.
3. The wide angle telescope, the polarization scrambler and the QVD solar diffusor were all successful.
4. Unique on-ground calibration measurements (i.e. stray light measurement) have to be measured at various angles and for in-flight representative conditions.
5. Measurement of the instrument spectral response (slit) function was successfully performed and has preference over gas cell measurements.
6. Effects of detector degradation (RTS effects) should be decreased by frequently updating dark current maps and lowering the detector temperature.
7. Solar irradiance measurements and other calibration measurements should have a SNR much higher than the radiance data to avoid stripes in the date products.

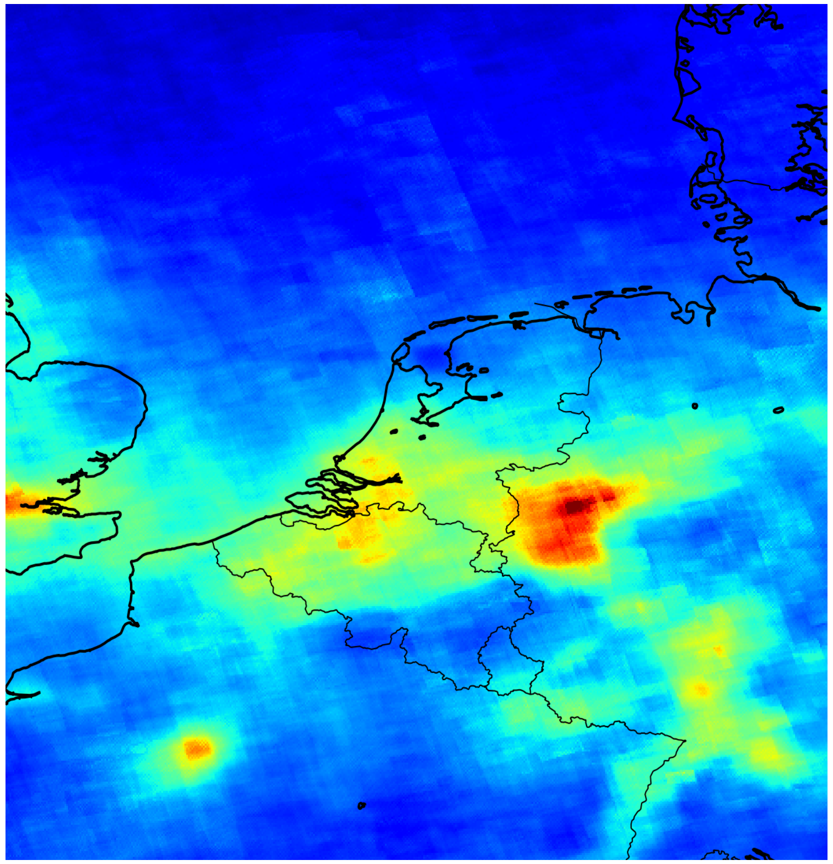
sentinel-5 precursor

GMES ATMOSPHERE MISSION IN POLAR ORBIT

- The ESA Sentinel-5 Precursor (S-5P) is a pre-operational mission focussing on global observations of the atmospheric composition for air quality and climate.
- The TROPOspheric Monitoring Instrument (TROPOMI) is the payload of the S-5P mission and is jointly developed by The Netherlands and ESA.
- The planned launch date for S-5P is 2014 with a 7 year design lifetime.

TROPOMI

- UV-VIS-NIR-SWIR nadir view grating spectrometer.
- Spectral range: 270-500, 675-775, 2305-2385 nm
- Spectral Resolution: 0.25-1.1 nm
- Spatial Resolution: 7x7km^2
- Global daily coverage at 13:30 local solar time.



CONTRIBUTION TO GMES

- Total column O_3, NO_2, CO, SO_2, CH_4, CH_2O, H_2O, BrO
- Tropospheric column O_3, NO_2
- O_3 profile
- Aerosol absorbing index, type, optical depth

Links & References

Information on the OMI instrument design: www.knmi.nl/omi/instrument

IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 44, NO. 5, MAY 2006 1209

Ozone Monitoring Instrument Calibration

Marcel R. Dobber, Ruud J. Dirksen, Pieternel F. Levelt, G. H. J. van den Oord, Robert H. M. Voors, Quintus Kleipool, Glen Jaross, Matthew Kowalewski, Ernest Hilsenrath, Gilbert W. Leppelmeier, *Member, IEEE*, Johan de Vries, Werner Dierssen, and Nico C. Rozemeijer

www.temis.nl

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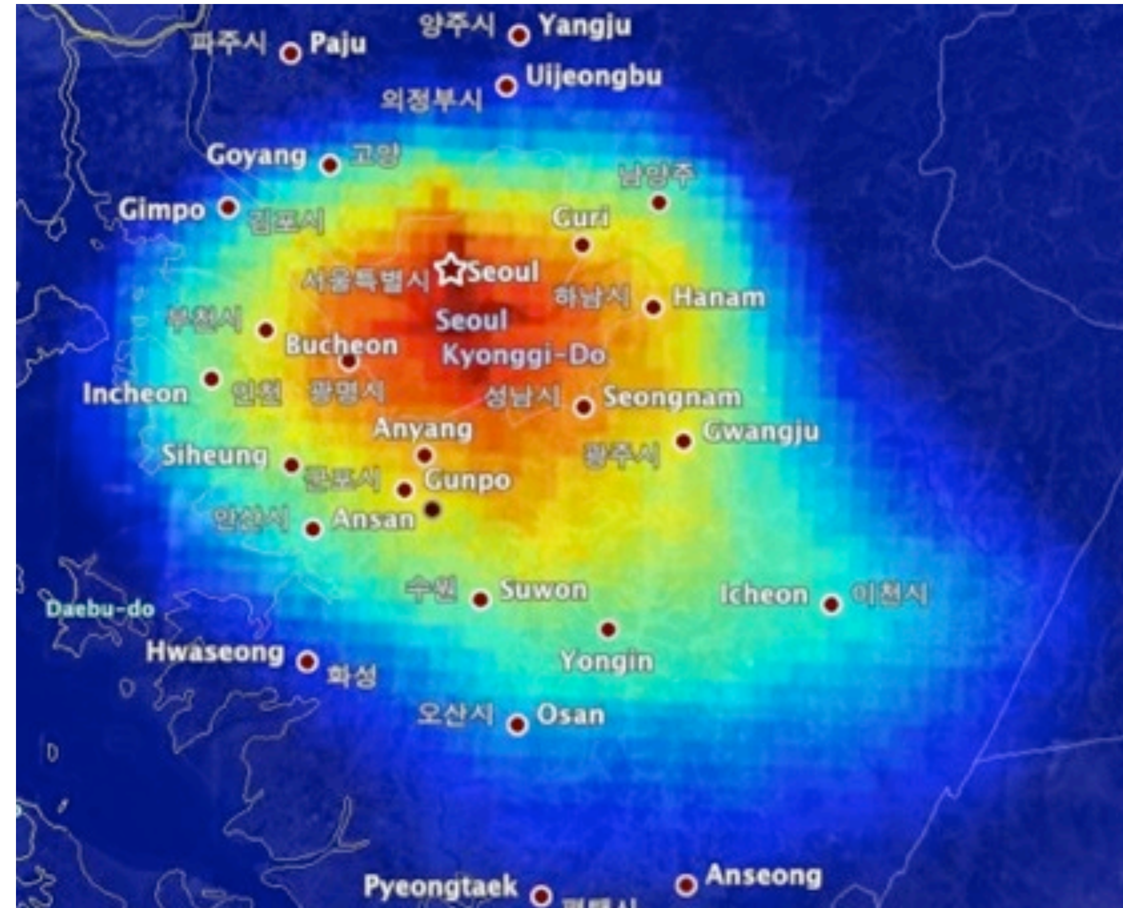
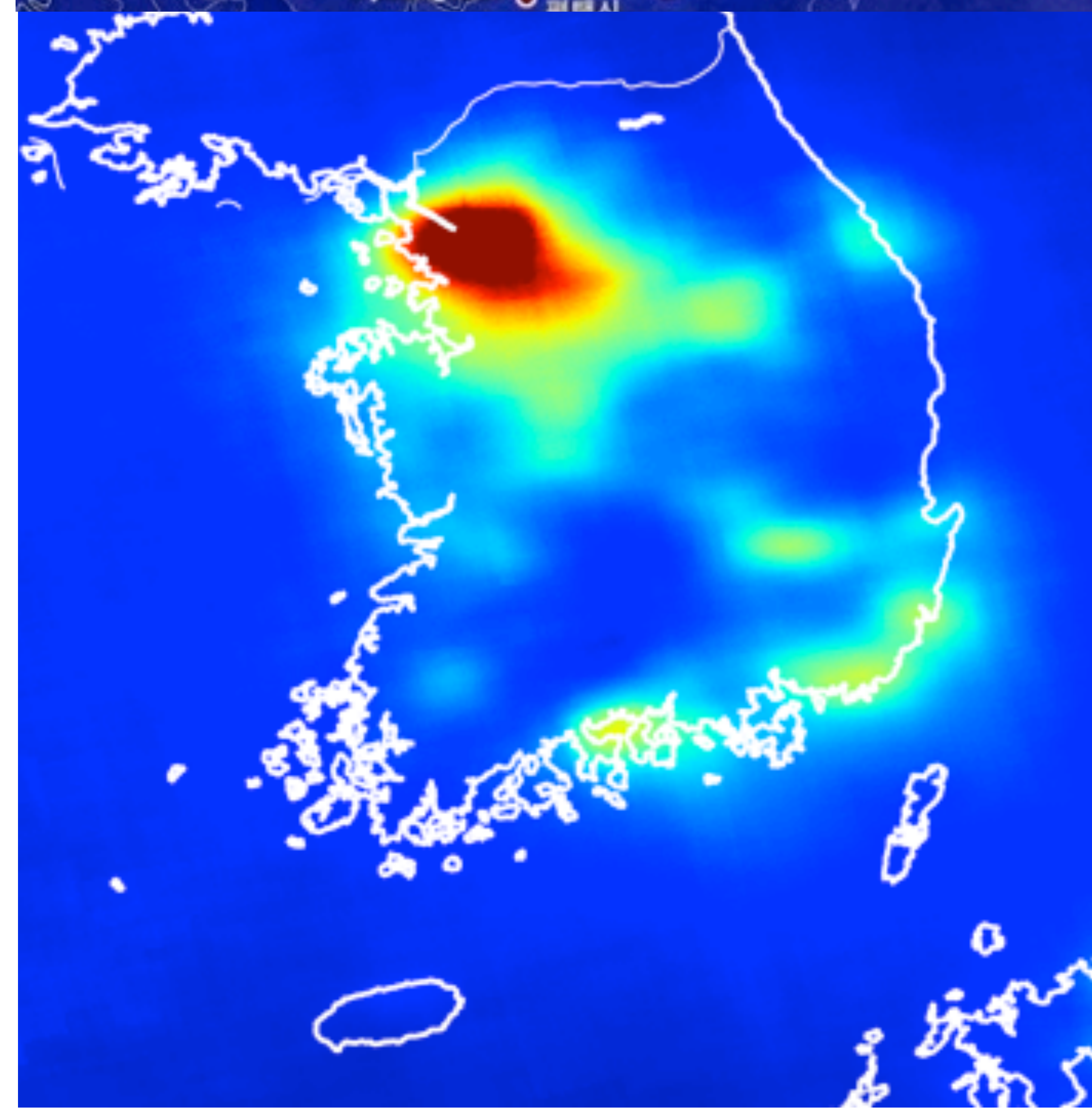
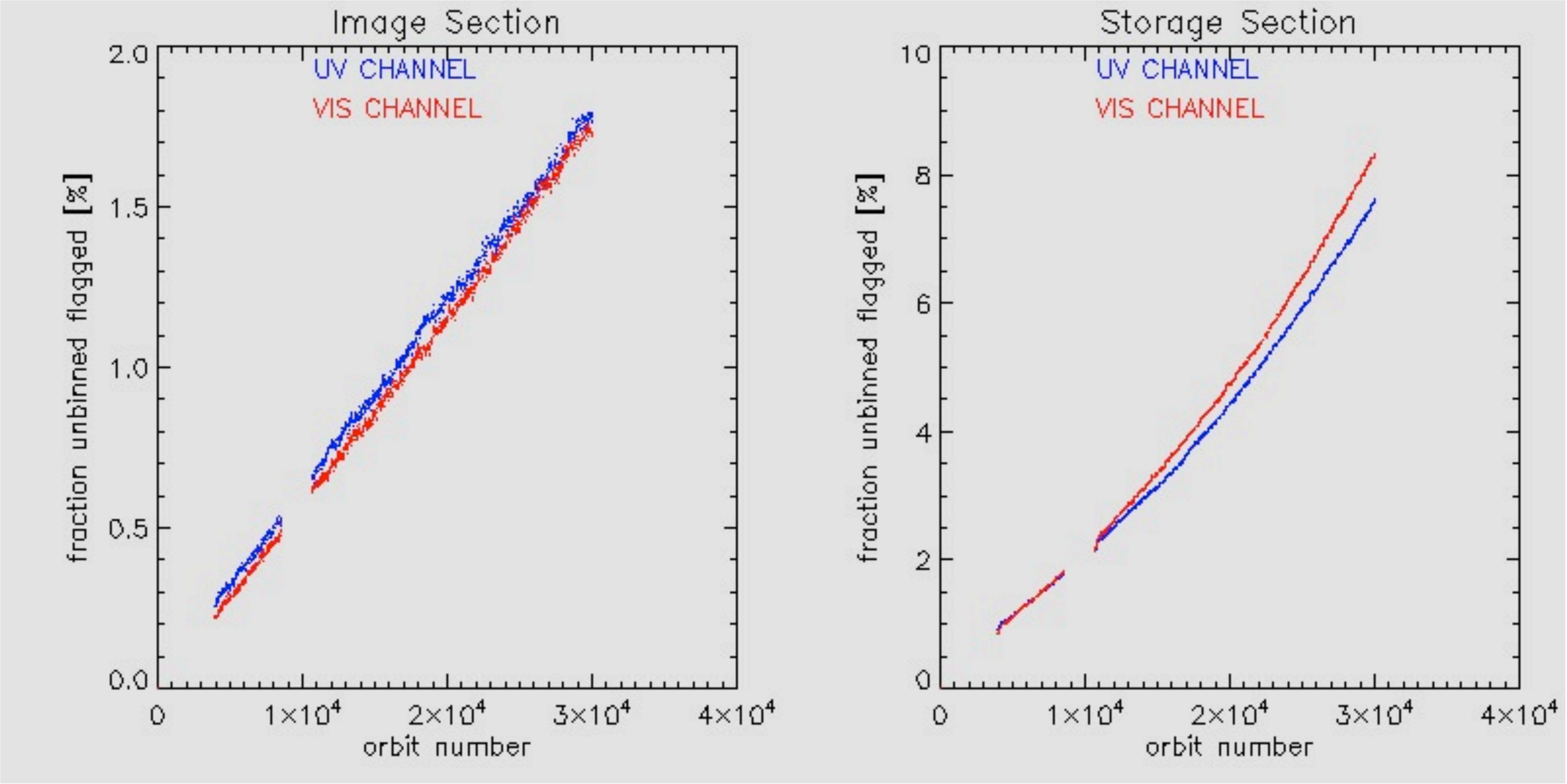
http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI





Evolution of flagged unbinned pixels



OMI Optical Assembly