OMI
10 years

Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

The First Decade of OMI Observations

Pepijn Veefkind
Pieternel Levelt &
the KNMI OMI team

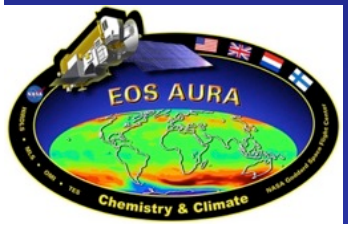

NASA
AURA
NASA

The Antropocene

- Ozone Layer
- Air Quality
- Climate

OMI Science Questions

- Is the ozone layer recovering as expected ?
- What are the sources of aerosols and trace gases that affect global air quality and how are they transported?
- What are the roles of tropospheric ozone and aerosols in climate change?
- What are the causes of surface UV-B change?



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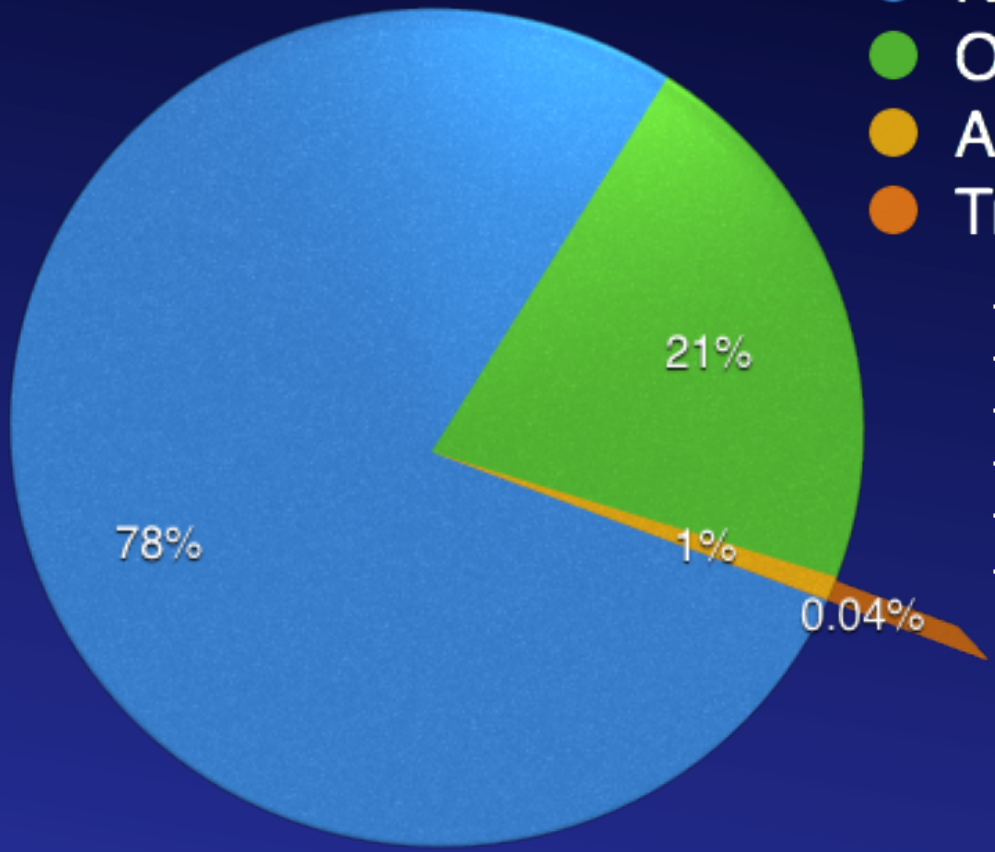
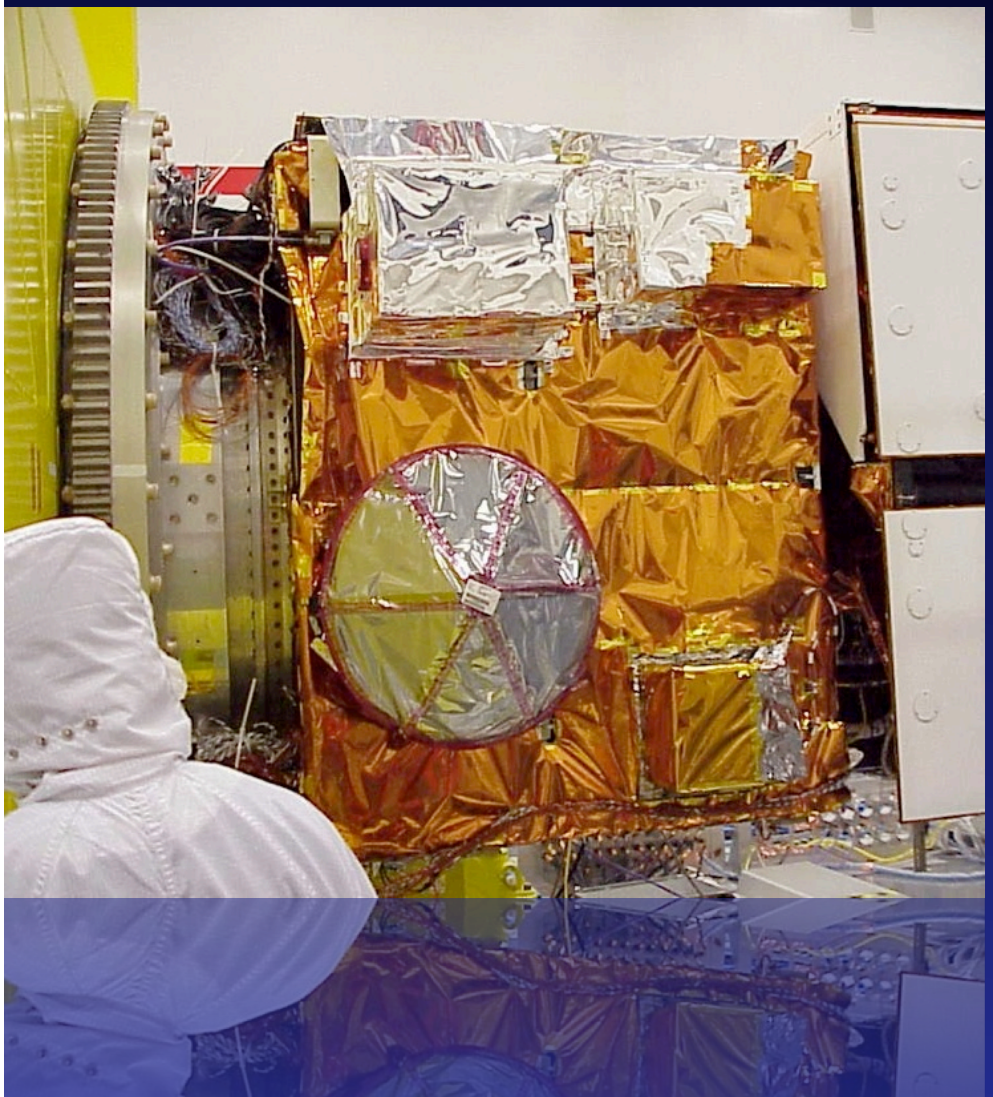
Atmospheric Composition



- Nitrogen
- Oxygen
- Argon
- Trace Gases

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Ozone (O_3)
- Nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- ……

Ozone Monitoring Instrument

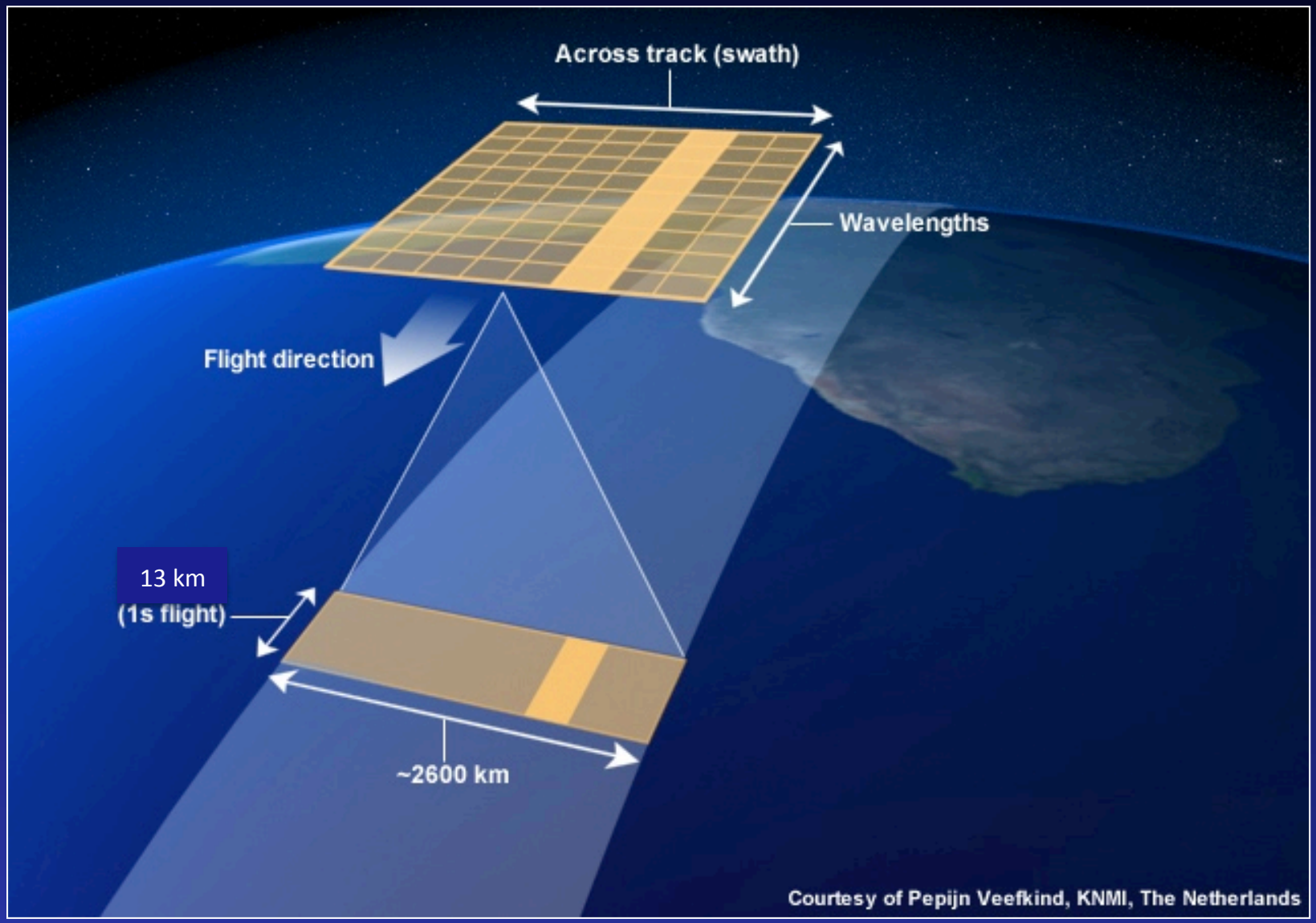


Ozone Monitoring Instrument

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, 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.

Measurement Principle



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Instrument Design

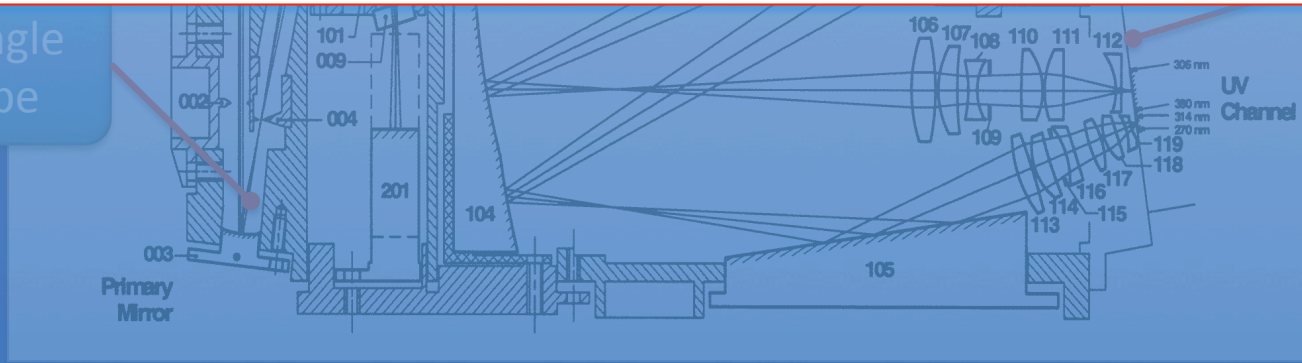
Polarisation Scrambler

Quartz Volume Diffuser

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

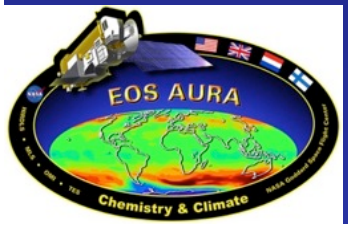
Wide Angle Telesope



Flexible Electronics

OMI Stability

- OMI has never been switched off
- Near-perfect temperature control:
  - Detector trend 0.05 K/decade
  - Optical bench +1.2 K/decade
  - Electronics +1 K/decade
- Bad pixels ~7% after 10 years
- Radiance port optical degradation -0.5 – 1.0%



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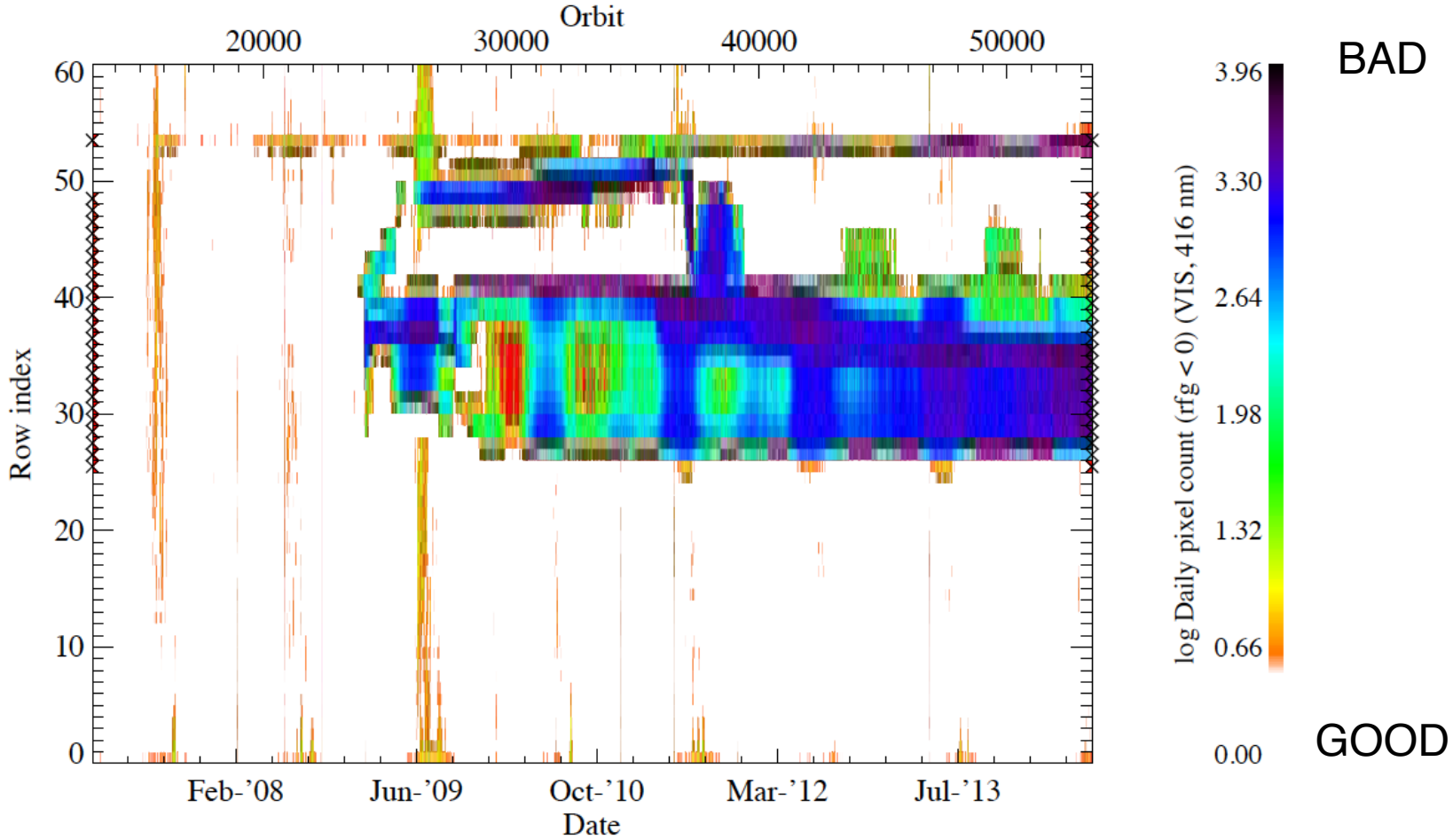
Number of negative reflectances (VIS, 416 nm) (Blockage)



BAD

GOOD

OMTMRAMRFGDP multiple day visualization
Orbit range: 13103 - 53412

From: 2007-01-01
To: 2014-07-31

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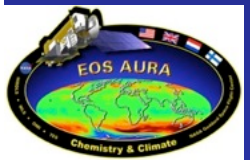
OMI Data products

Product	Application
Ozone column	Ozone layer monitoring / NWP / UV index
Ozone profile	Ozone layer monitoring / Tropospheric ozone
Surface UV	UV index
NO_2	Air quality / Emission monitoring
SO_2	Volcanic eruptions / Air quality / Emission monitoring
Formaldehyde	Air quality / Emission monitoring
BrO	Air quality
OClO	Ozone layer monitoring
Aerosol	Absorbing aerosol plumes / Volcanic ash
Cloud	Cloud fraction and height variability
Surface reflectivity	Climatology
Solar irradiance	Solar variability



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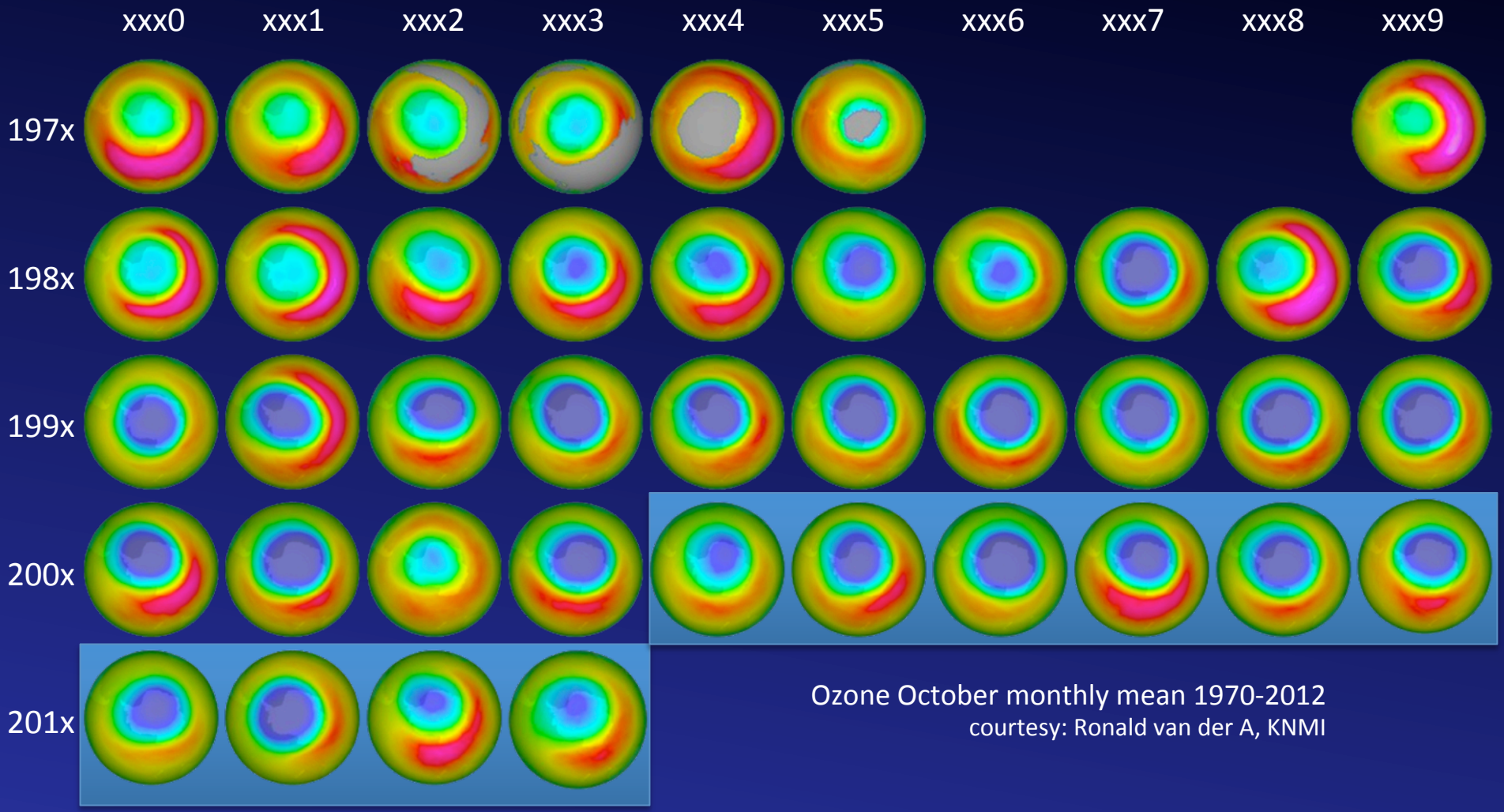
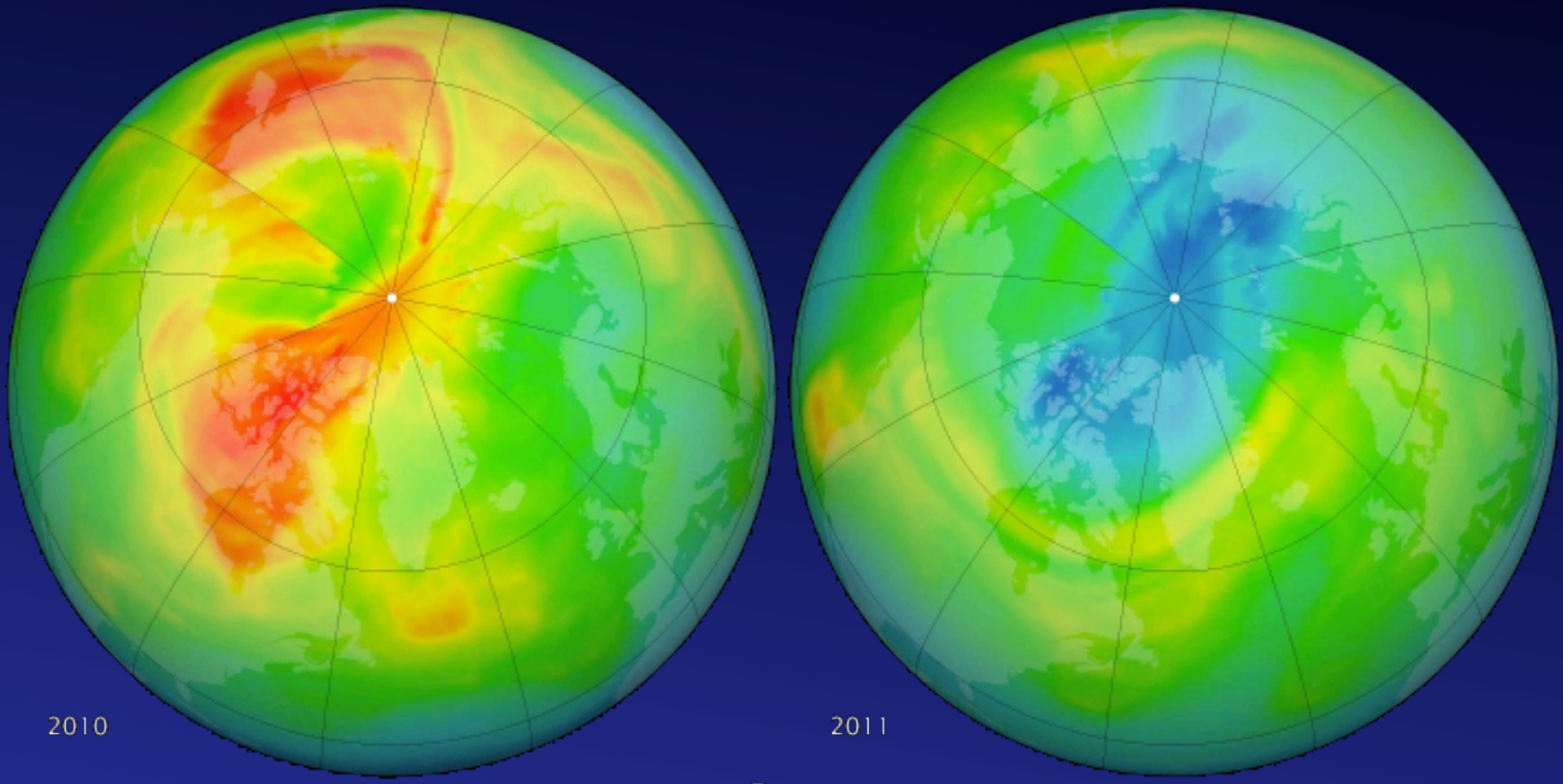
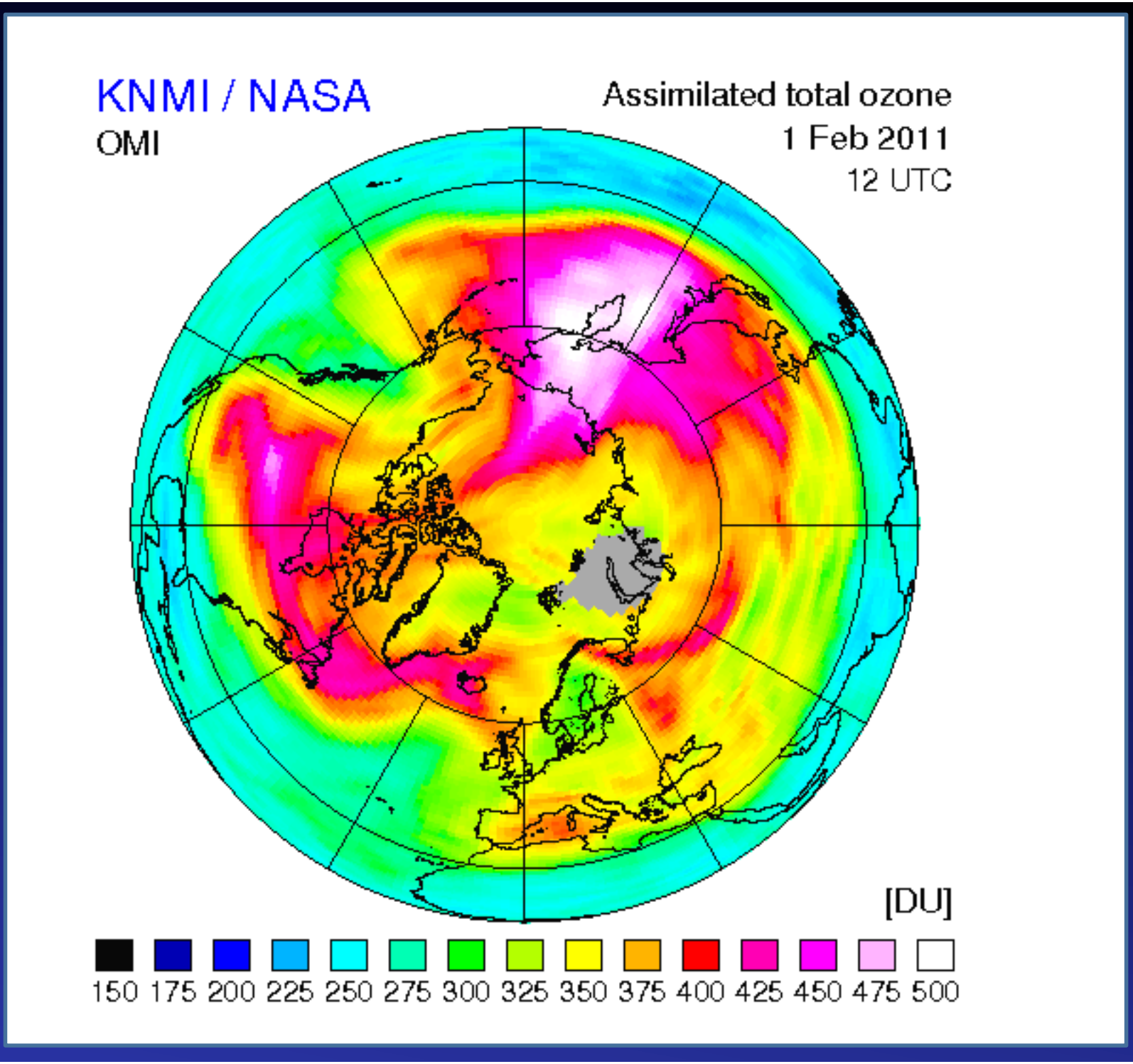
Multi Sensor Reanalysis -2 (MSR)

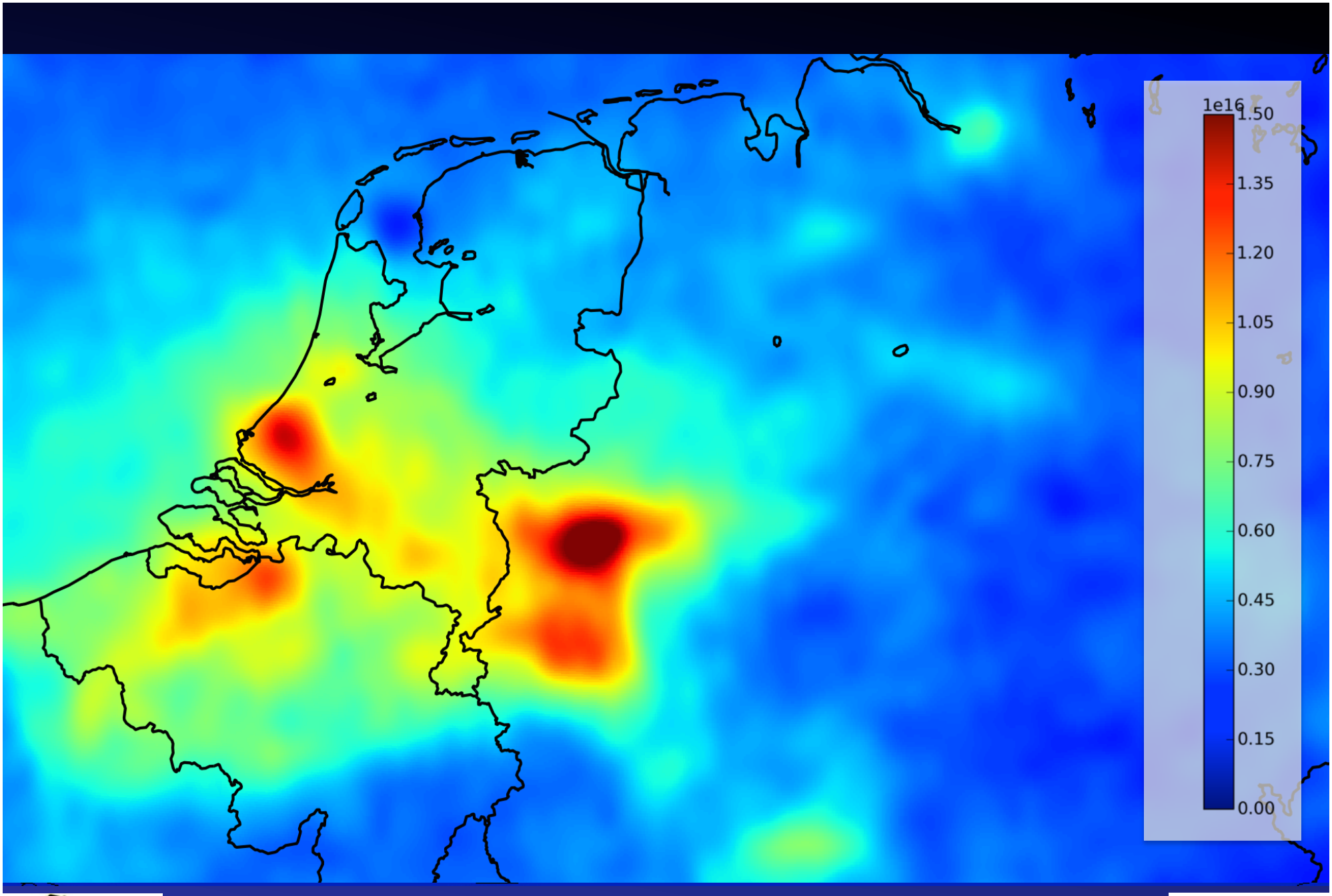


Ozone October monthly mean 1970-2012
courtesy: Ronald van der A, KNMI

Arctic Ozone Loss




KNMI / NASA
OMI
Assimilated total ozone
1 Feb 2011
12 UTC
[DU]
150 175 200 225 250 275 300 325 350 375 400 425 450 475 500



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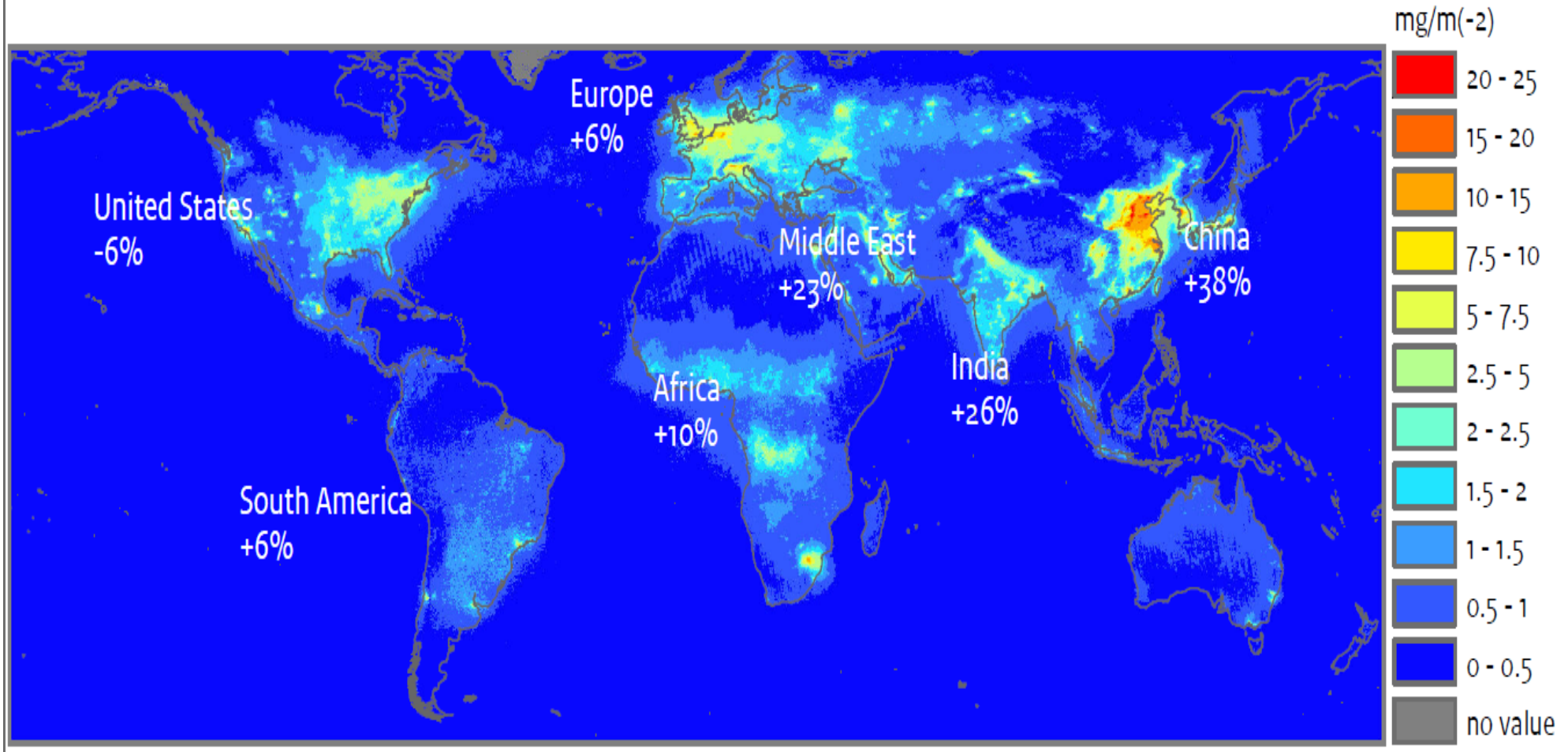
OMI NO_2 average amounts 2012

percentages indicate observed change since 2005



Credits: R.J. van der A, R. Sluiter, M. van Weele (KNMI)

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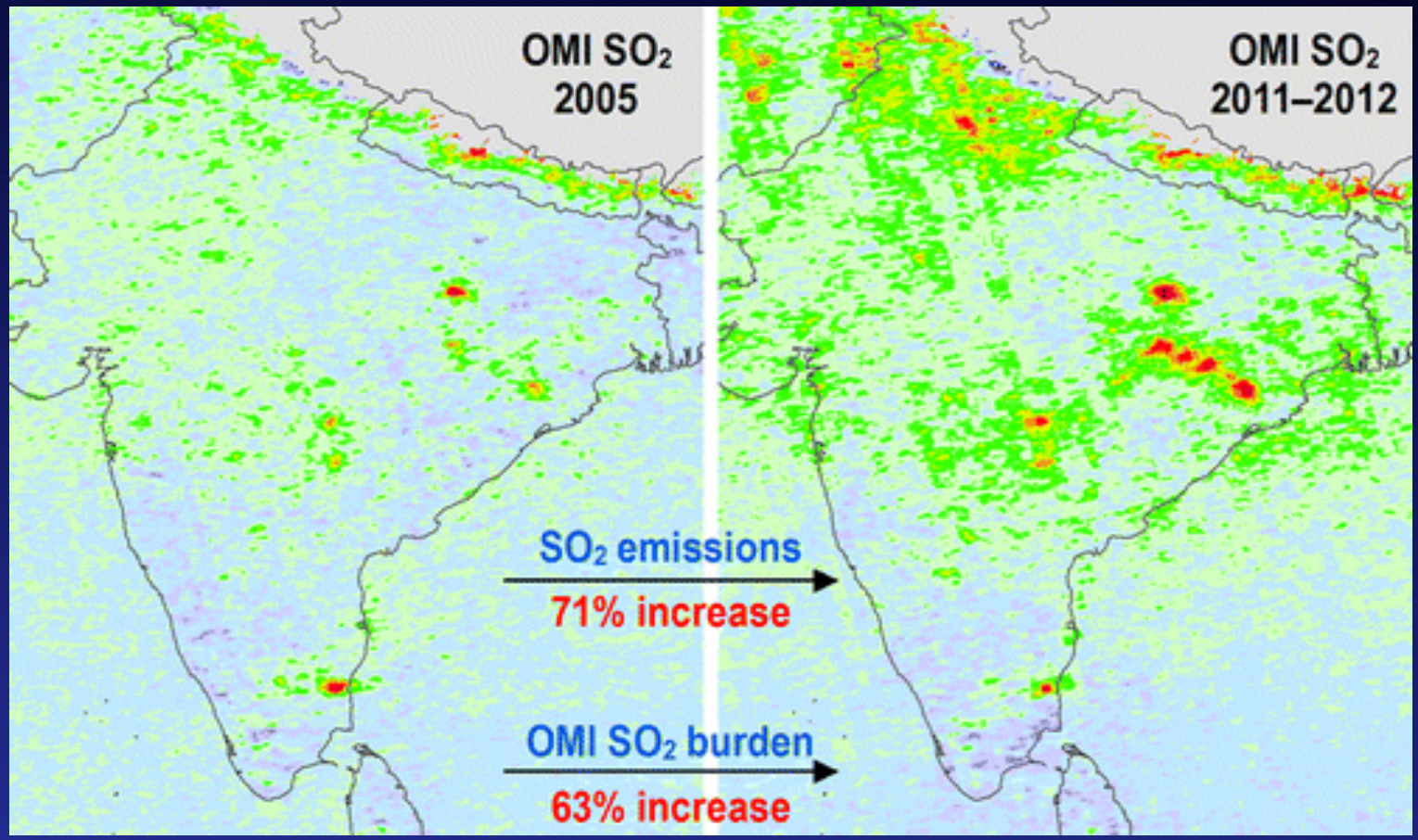
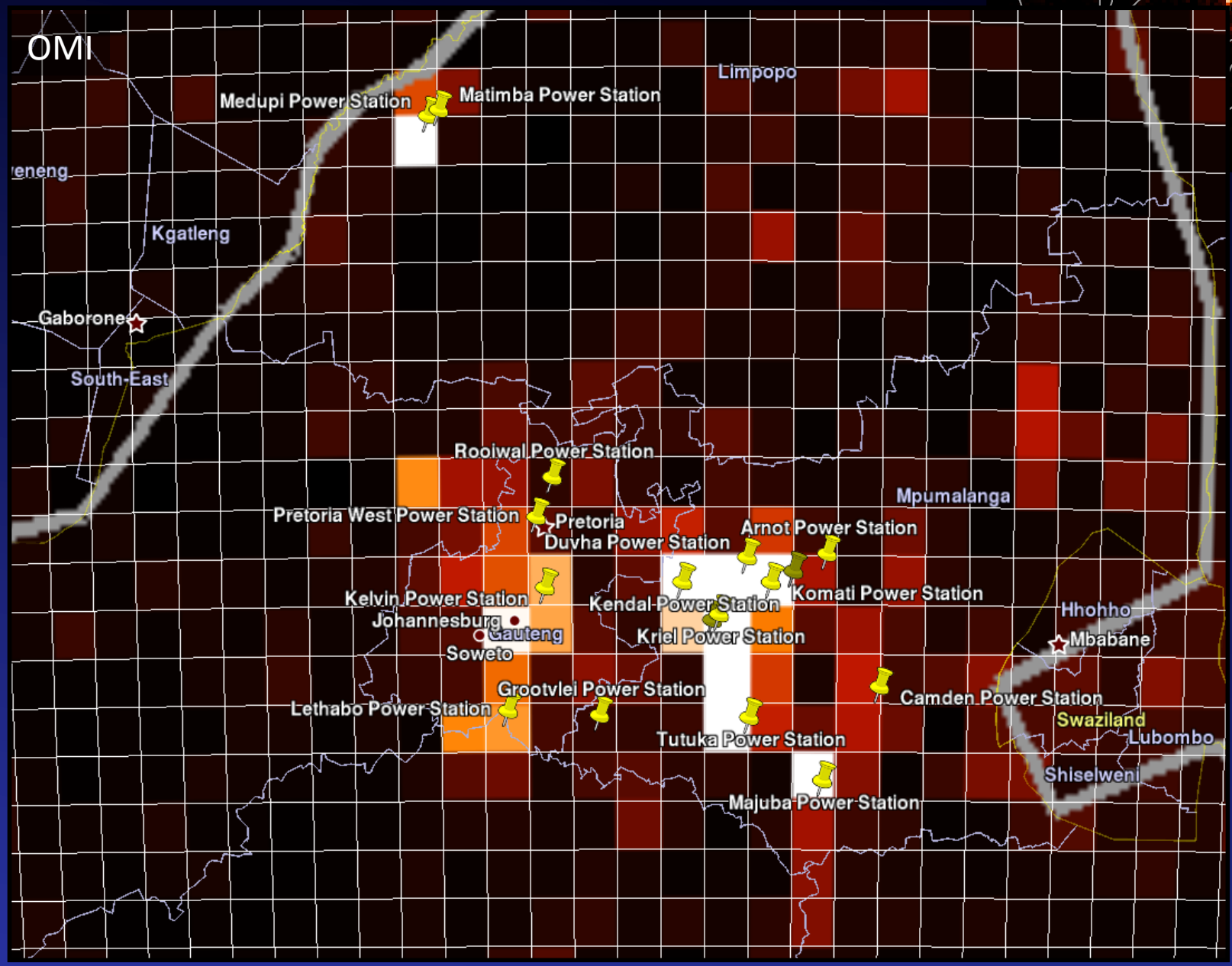
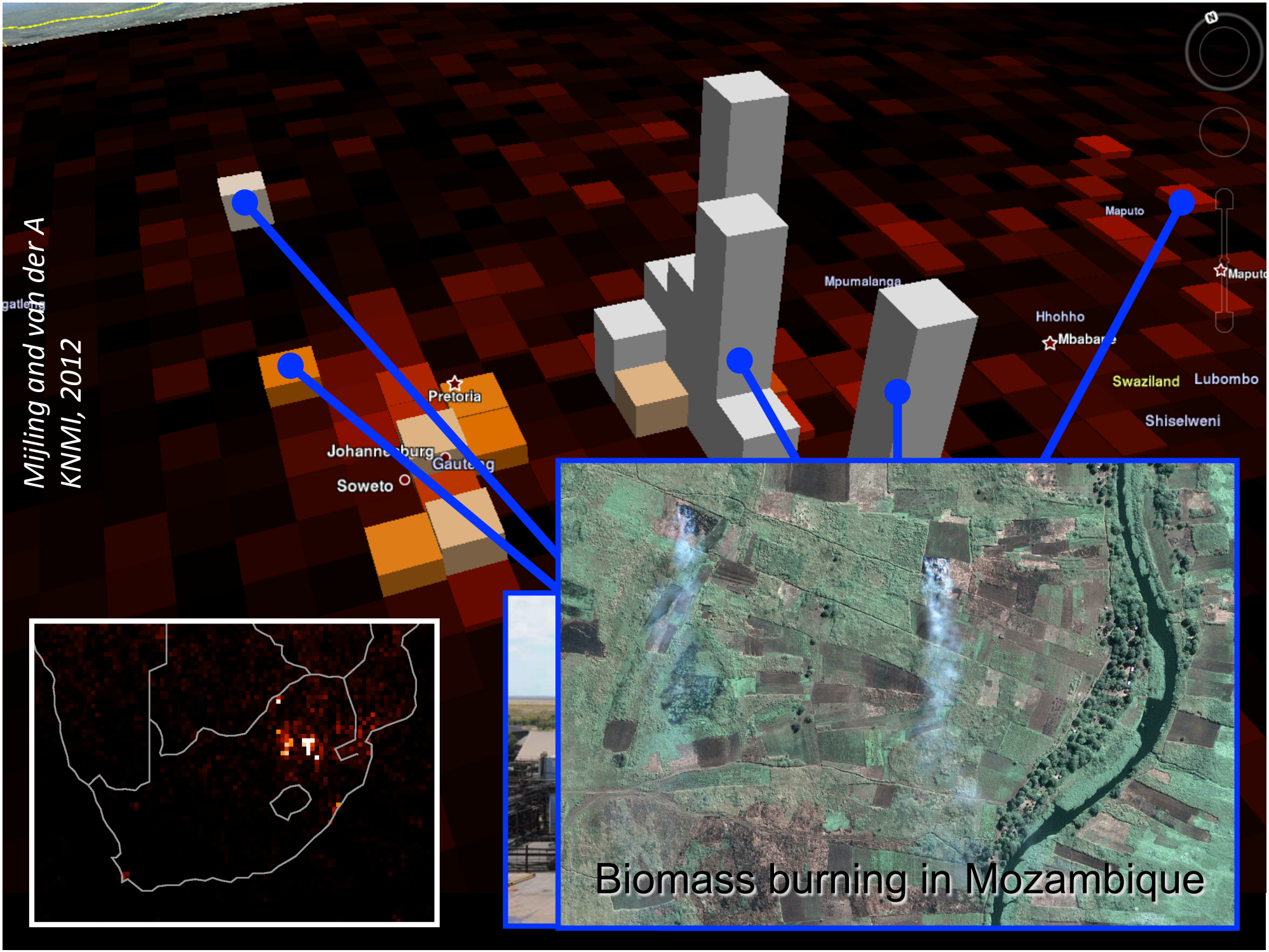
Trend in SO_2 over India



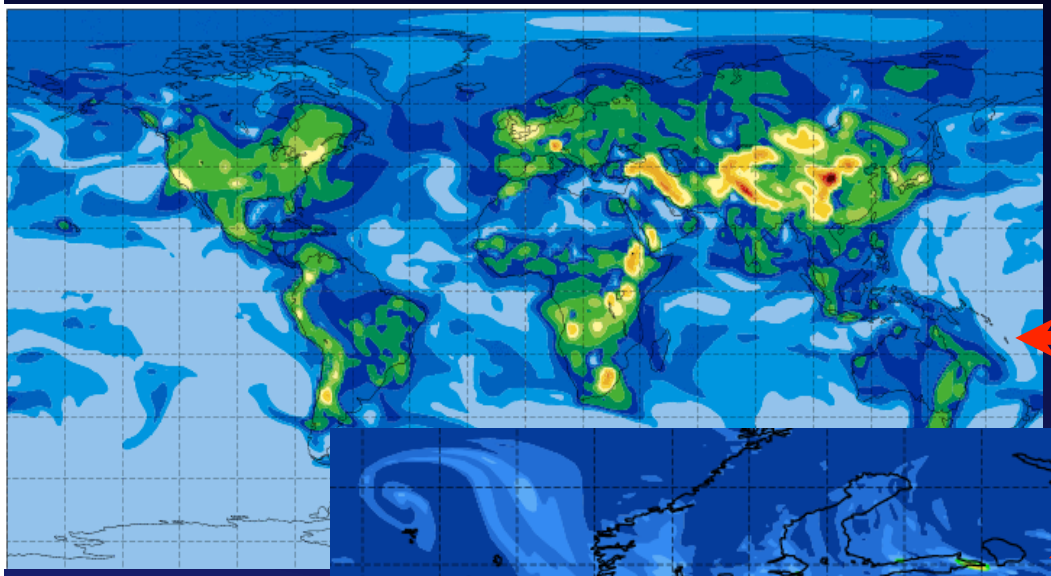
Lu, Zifeng, David G. Streets, Benjamin de Foy, and Nickolay A. Krotkov, Ozone Monitoring Instrument Observations of Interannual Increases in SO2 Emissions from Indian Coal-Fired Power Plants during 2005−2012, Environmental Science and Technology, 2013 ://pubs.acs.org/doi/abs/10.1021/es4039648

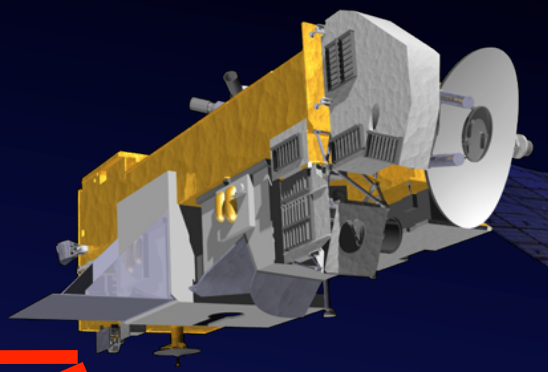


Mijling and van der A
KNMI, 2012


Mijling and van der A
KNMI, 2012
Pretoria
Johannesburg
Gauteng
Soweto
Mpumalanga
Hhohho
Mbabane
Maputo
Swaziland
Lubombo
Shiselweni
Biomass burning in Mozambique

Copernicus Atmosphere: Air Quality product chain

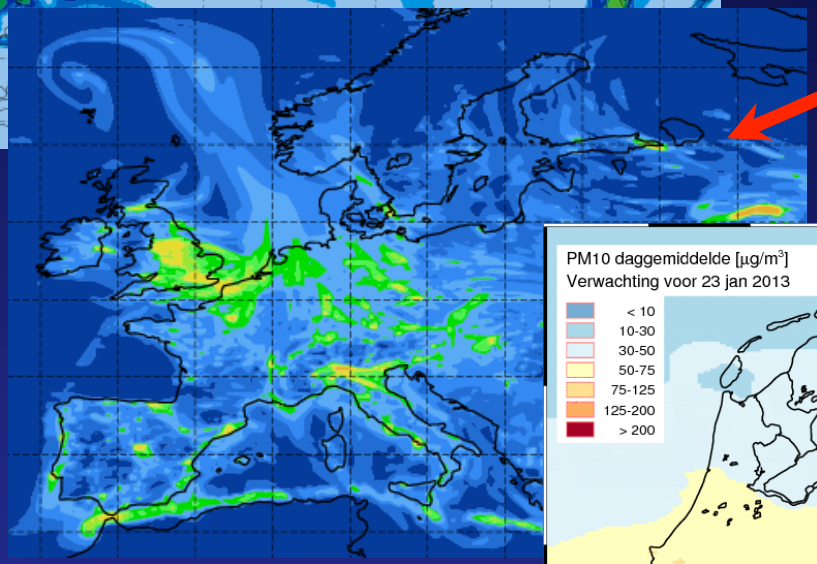


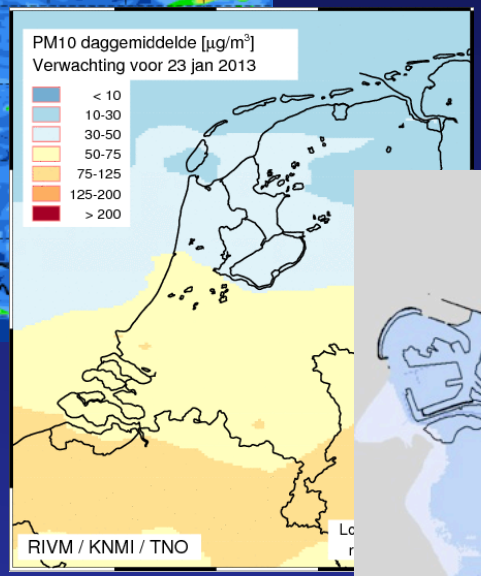


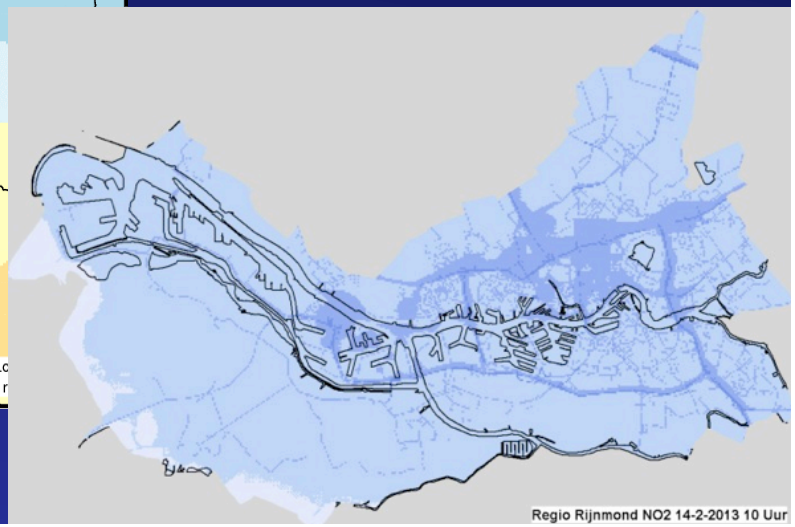
OMI NRT contributions

National forecasts: Nesting in MACC regional

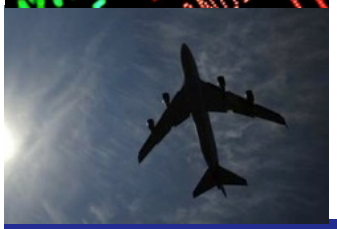
Couple to city-scale models







Use of MACC-global analyses as boundary conditions for MACC-Europe



OMI AAI 15 April 2010

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10 years

TROPOMI

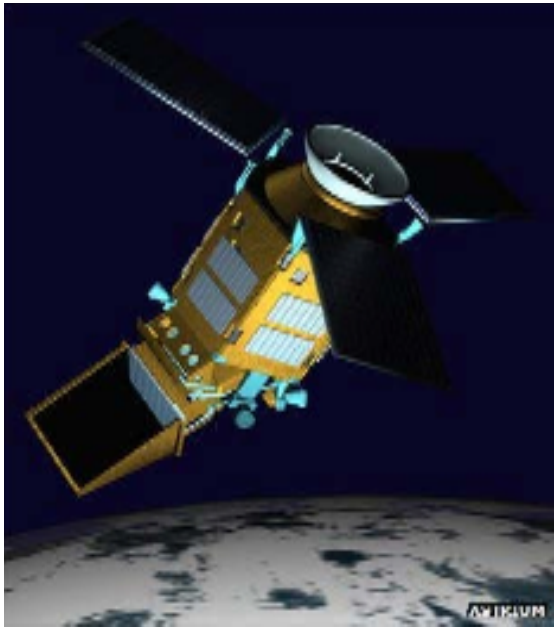
sentinel-5 precursor

COPERNICUS/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 2016 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

sentinel-5 precursor

→ GMES LOW EARTH ORBIT ATMOSPHERE MISSION

2016-2023
daily global coverage

2021 - ~2030
hourly over Europe

sentinel-4

→ GMES GEOSTATIONARY ATMOSPHERIC MISSION

2017 - ...
hourly over SE - ASIA

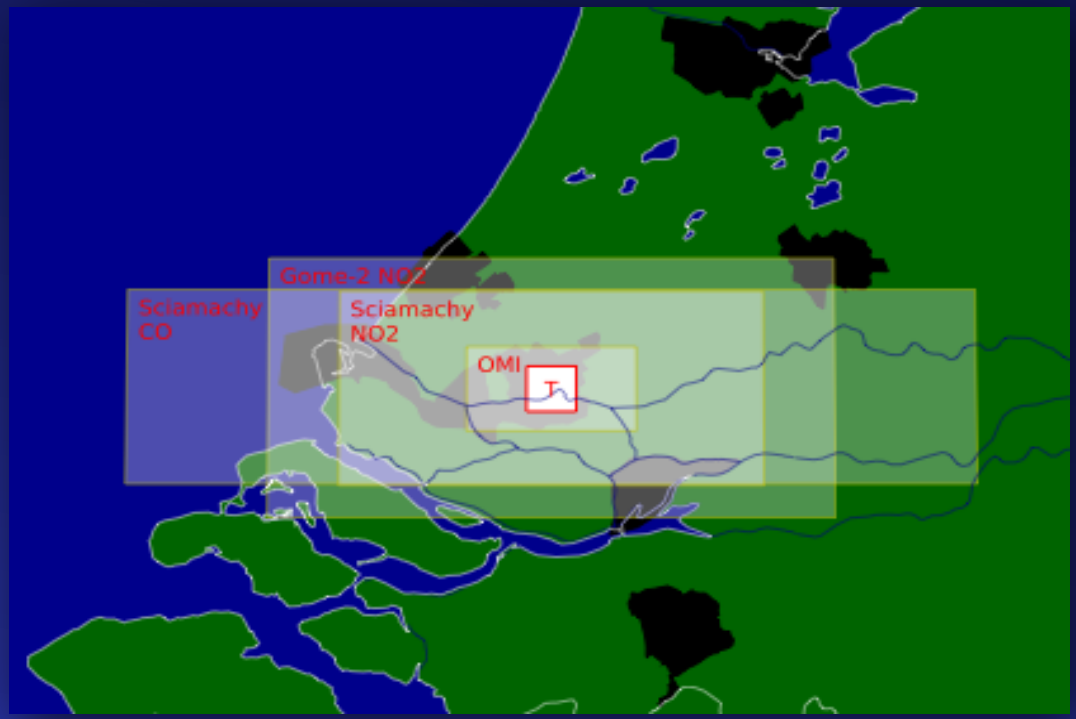
gems | tempo

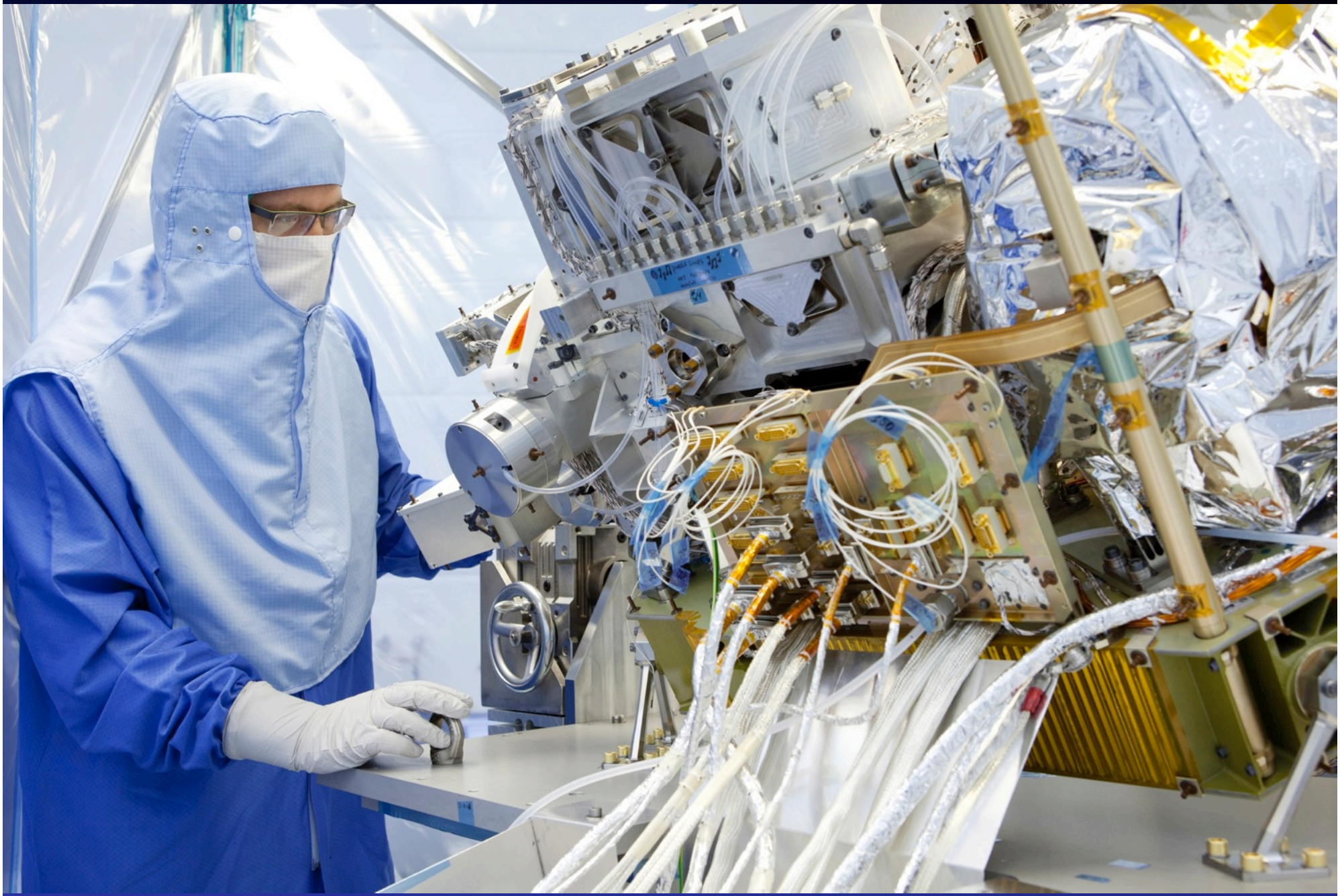
KARI | NASA

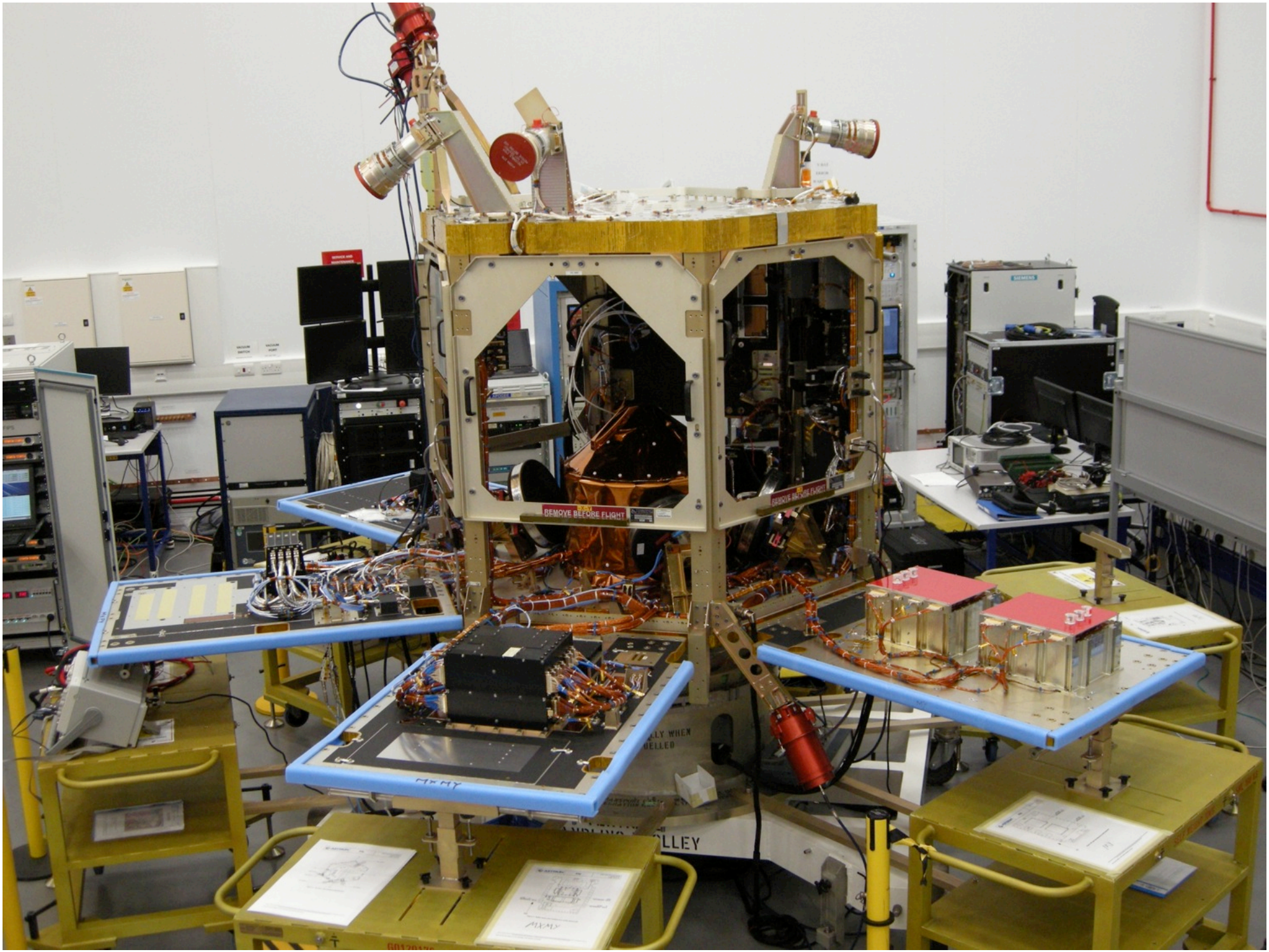
2019 - ...
hourly over N-America

From OMI to TROPOMI

- **6x higher spatial resolution**
  7x7 km^2 vs. 13x24 km^2
- **1-5x higher signal-to-noise**
- **Variable binning scheme**
- **better cloud information**
  from the oxygen A+B bands
- **CO and CH_4 observations**
  from the SWIR band
- **Data rate ~20x OMI**






REMOVE BEFORE FLIGHT
SIEMENS


EOS AURA
Chemistry & Climate
OMI