Retrieval of the global water vapor distribution from satellite observations in the blue spectral range

MAX-PLANCK-INSTITUT FÜR CHEMIE

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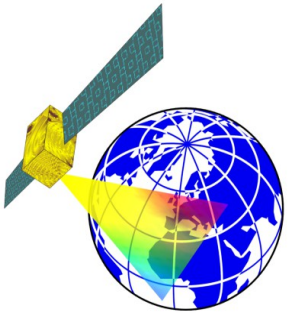
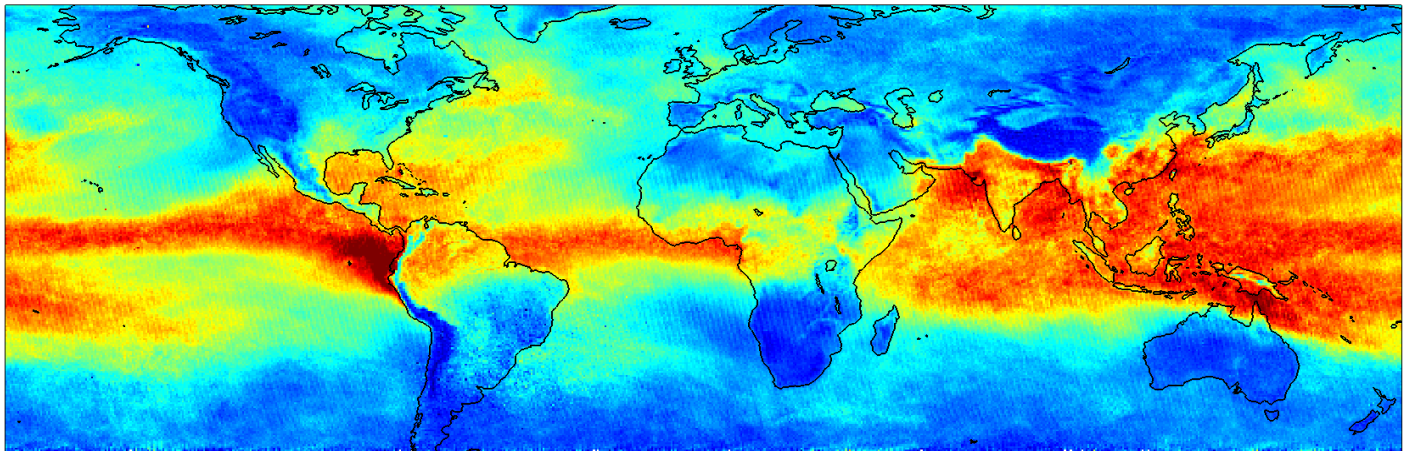




H_2O from OMI, June 2007

- Existing methods
- What is different in the blue spectral range?
- Results from GOME, GOME-2 & OMI

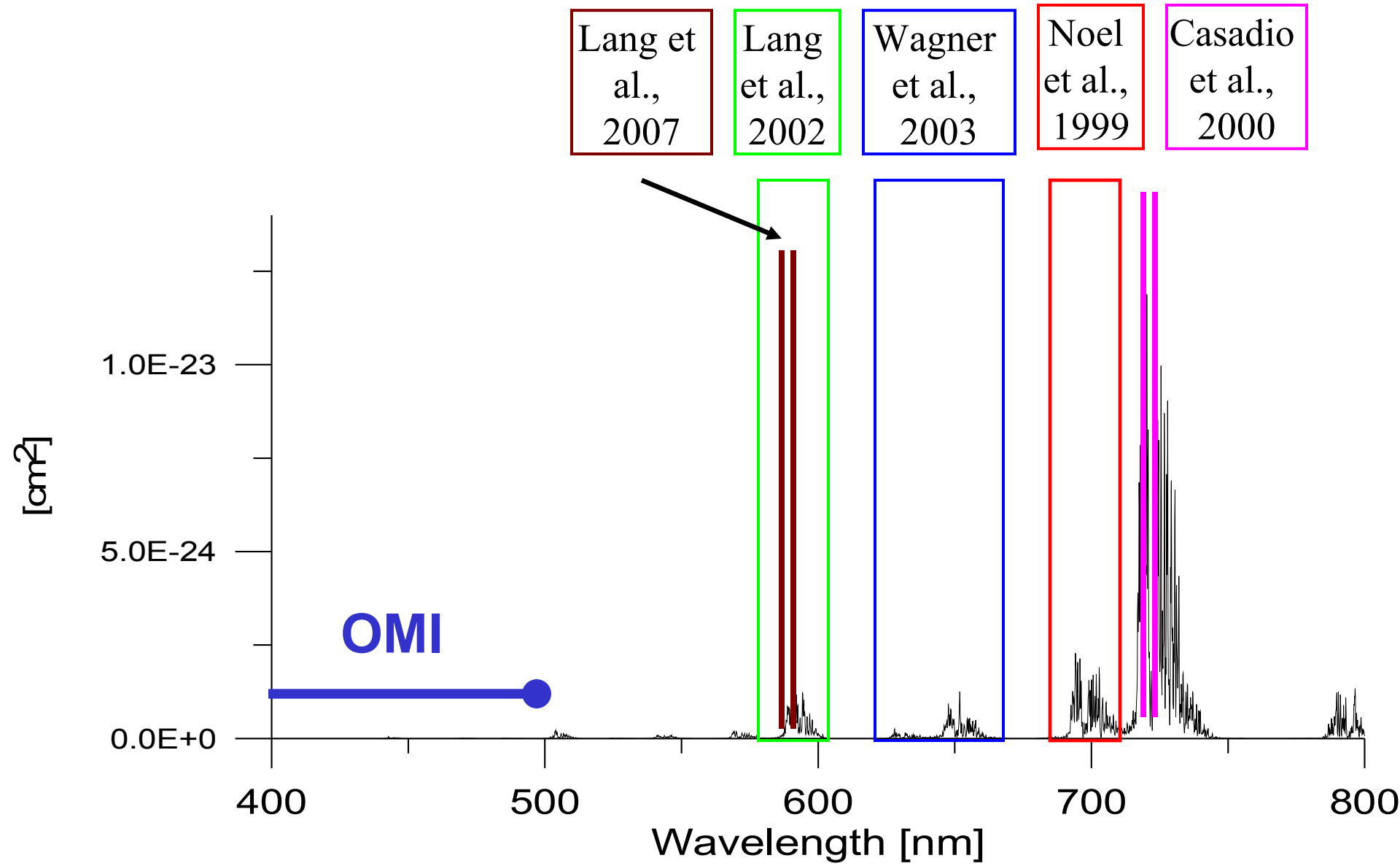
H_2O retrievals from different satellite instruments:

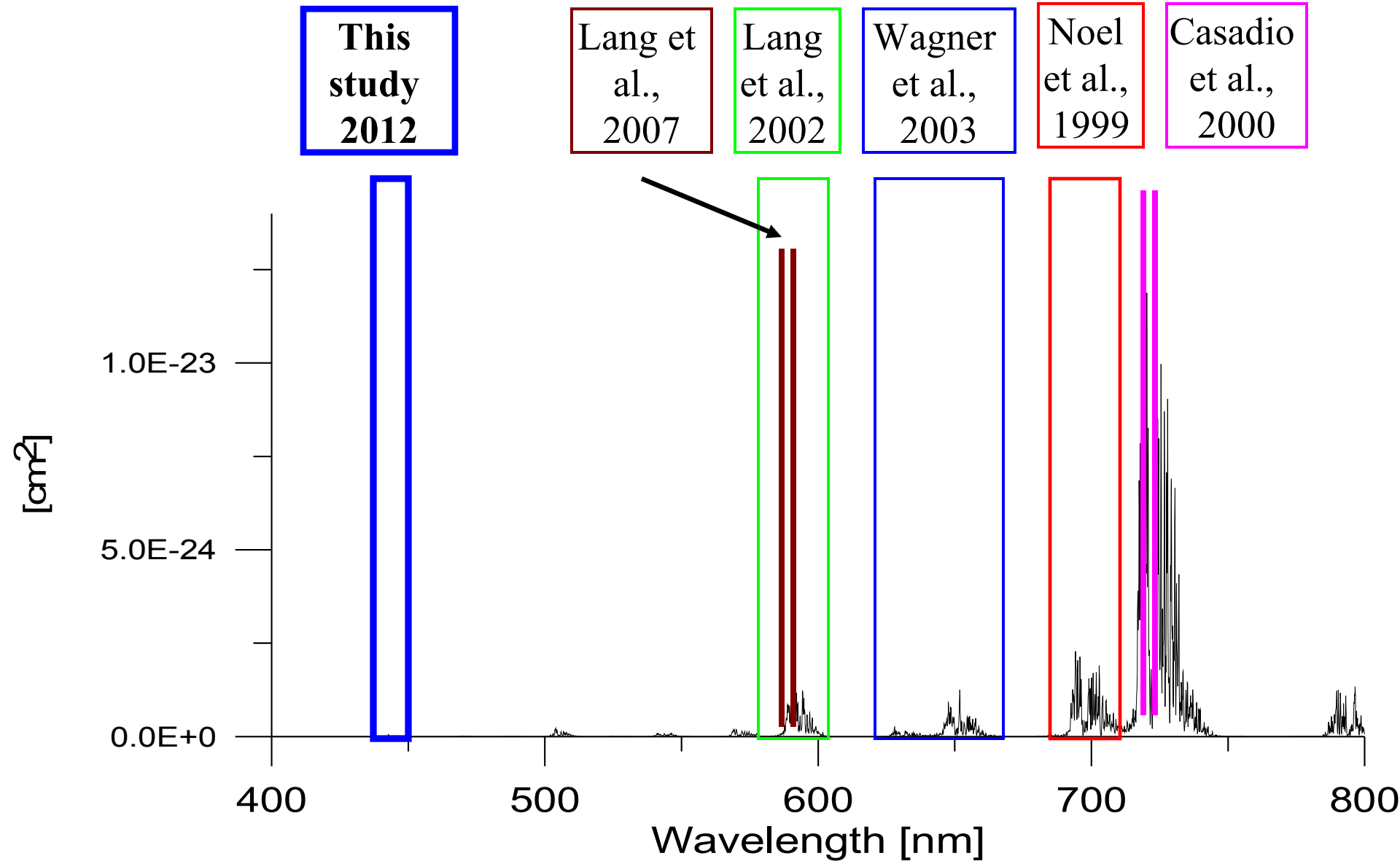
-Microwave (e.g. SSM/I): total column
Advantage: not affected by clouds
Disadvantage: only over ocean

-Thermal IR (e.g. TOVS, TES, IASI): partial columns
Advantage: over land and ocean, vertical profile information
Disadvantage: not sensitive to near surface, strong cloud effects

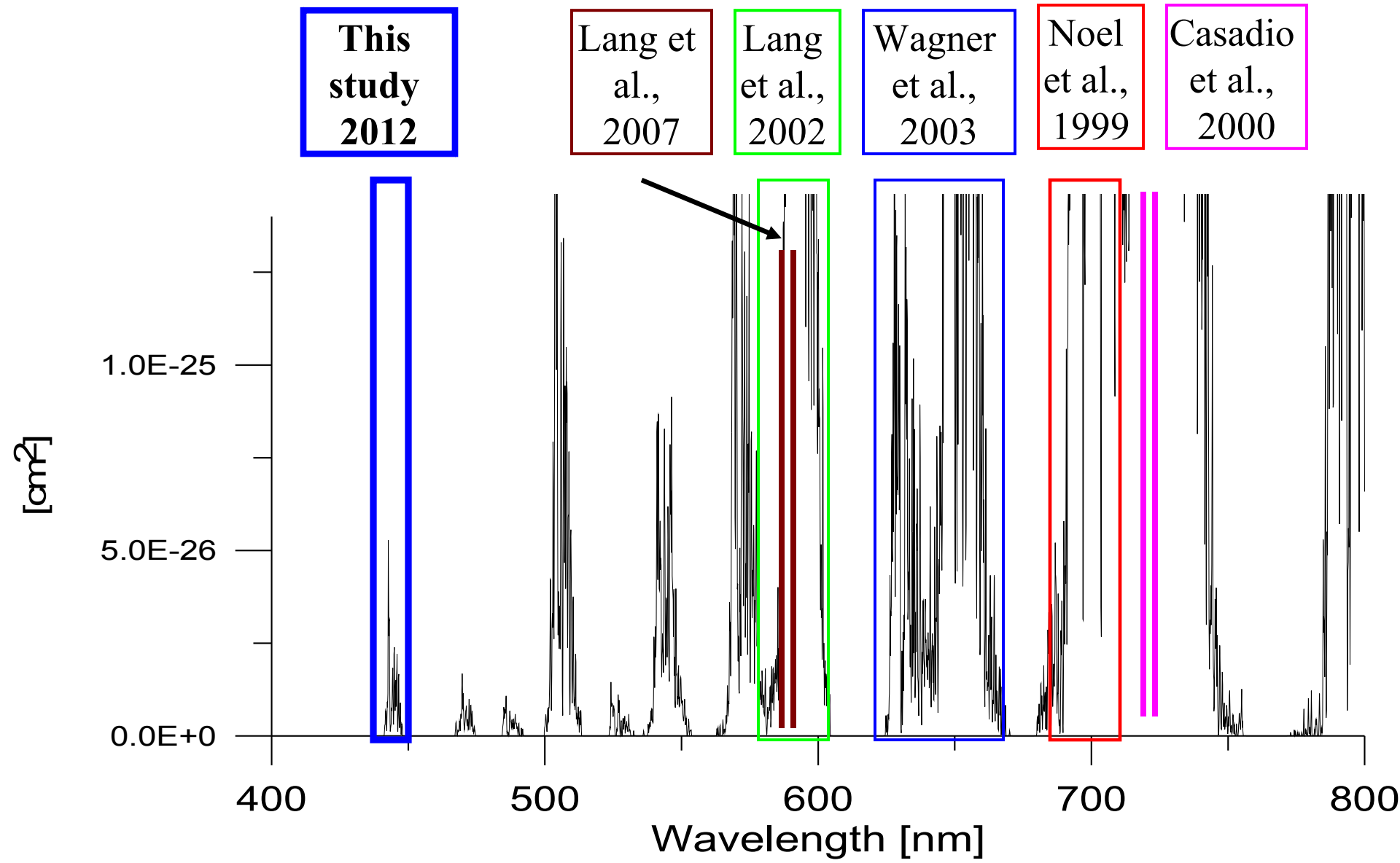
-Vis/NIR (e.g. GOME, SCIAMACHY): total column
Advantage: over land and ocean, high sensitivity to troposphere
Disadvantage: strong cloud effects, only at day-time

H_2O bands used in previous studies




This study 2012
Lang et al., 2007
Lang et al., 2002
Wagner et al., 2003
Noel et al., 1999
Casadio et al., 2000
1.0E-23
5.0E-24
0.0E+0
[cm2]
400
500
600
700
800
Wavelength [nm]

H_2O absorption at 440nm: **two orders of magnitude weaker!**



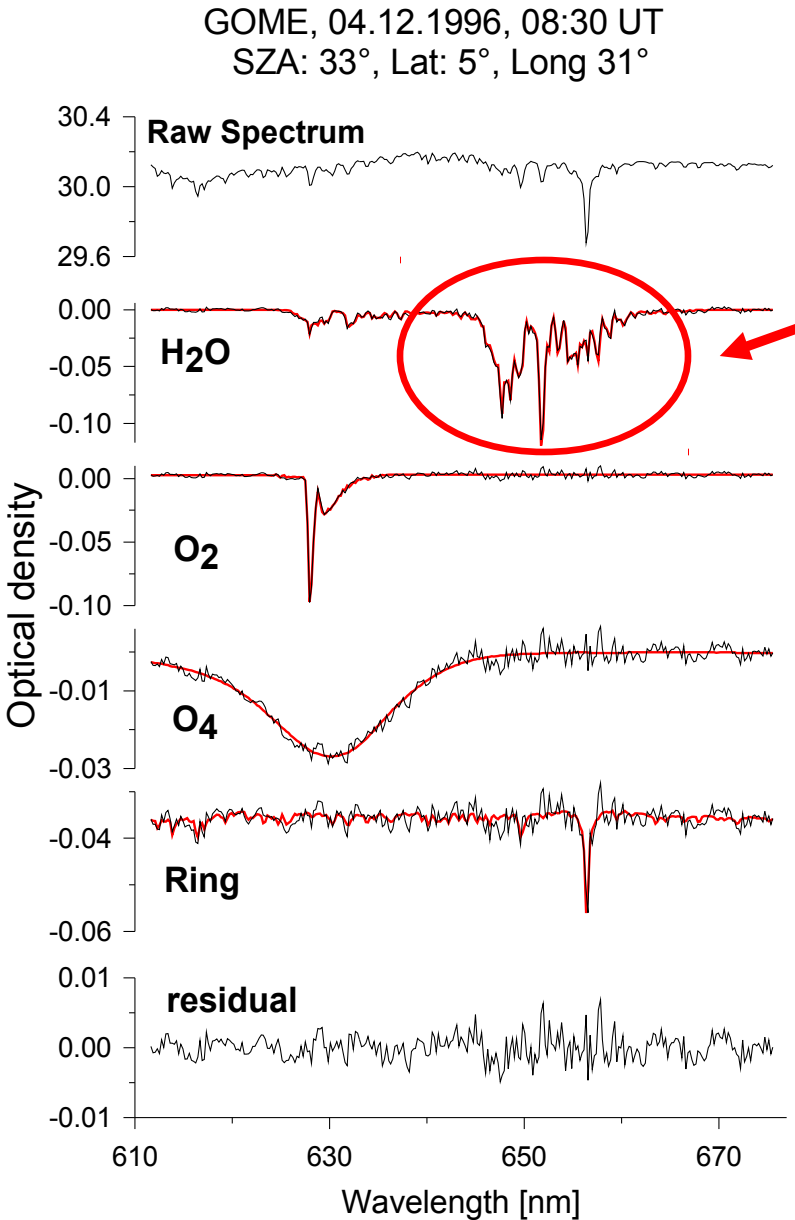
What is the optical depth under typical atmospheric conditions?

A) Tropics,	H_2O VCD: 1.5e23,	AMF = 1	
	=> H_2O SCD: 1.5e23,	**OD: 7.5e-3**	√
B) Mid latitudes	H_2O VCD: 3e22,	AMF = 2	
	=> H_2O SCD: 6e22,	**OD: 3e-3**	√
C) Polar regions	H_2O VCD: 1e21,	AMF = 10	
	=> H_2O SCD: 1e22,	**OD: 5e-4**	**???**

Interesting question:

=> What is the detection limit?

H_2O analysis in the red spectral range



Strong and clear absorption signal

Analysis Details:

Wavelength range: 611.6 - 675.4 nm

Shift and squeeze:
spectra linked to sun spectrum.

Reference spectra:

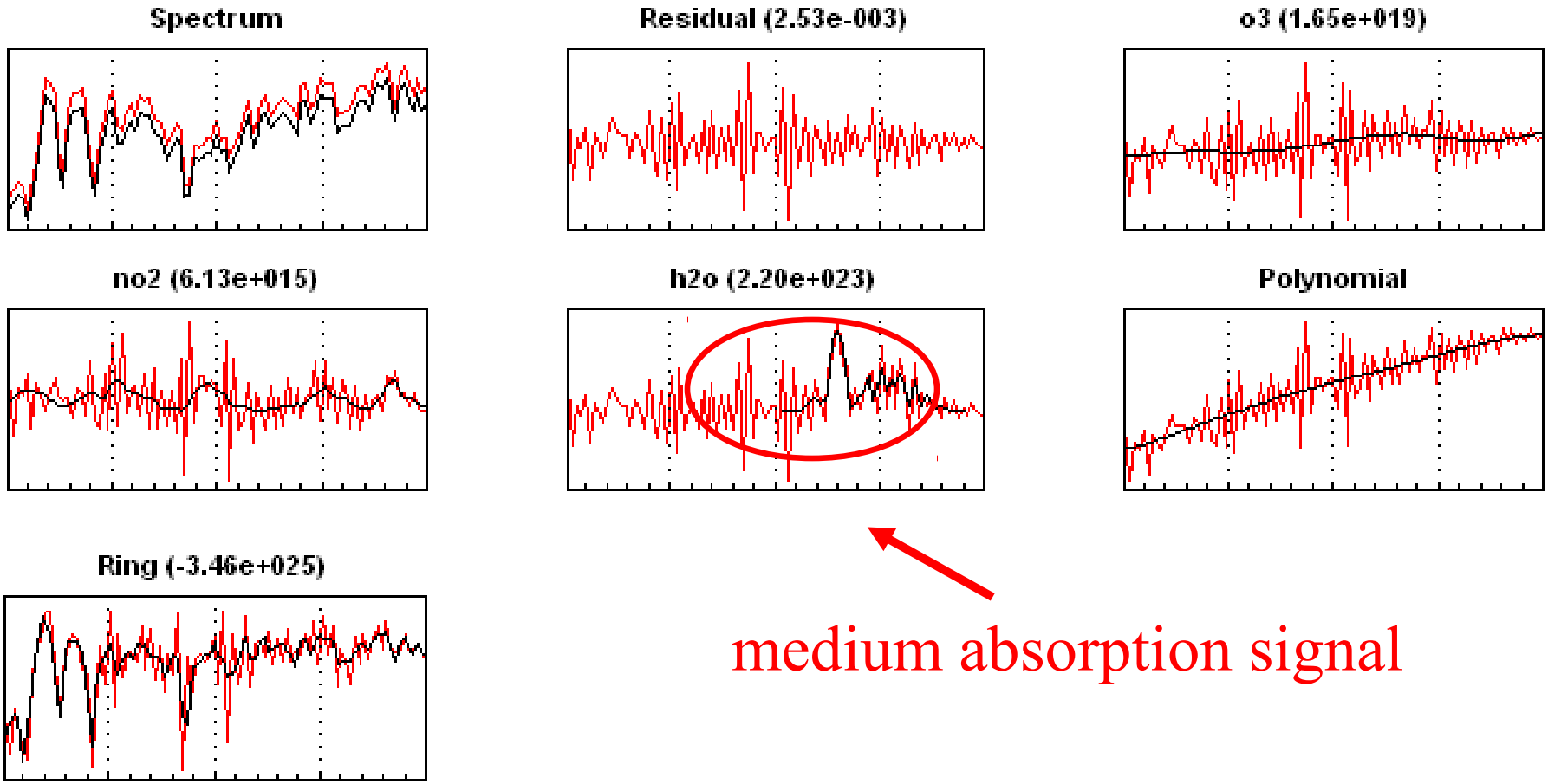
O2:	**Hitran, 273 K**
H2O:	**Hitran, 280 K**
O4:	**Greenblatt, 293 K**
Ring:	**calculated from sun spectrum (01.06.1997)**

[Wagner et al., 2003]

H_2O analysis in the blue spectral range

GOME analysis at low SZA

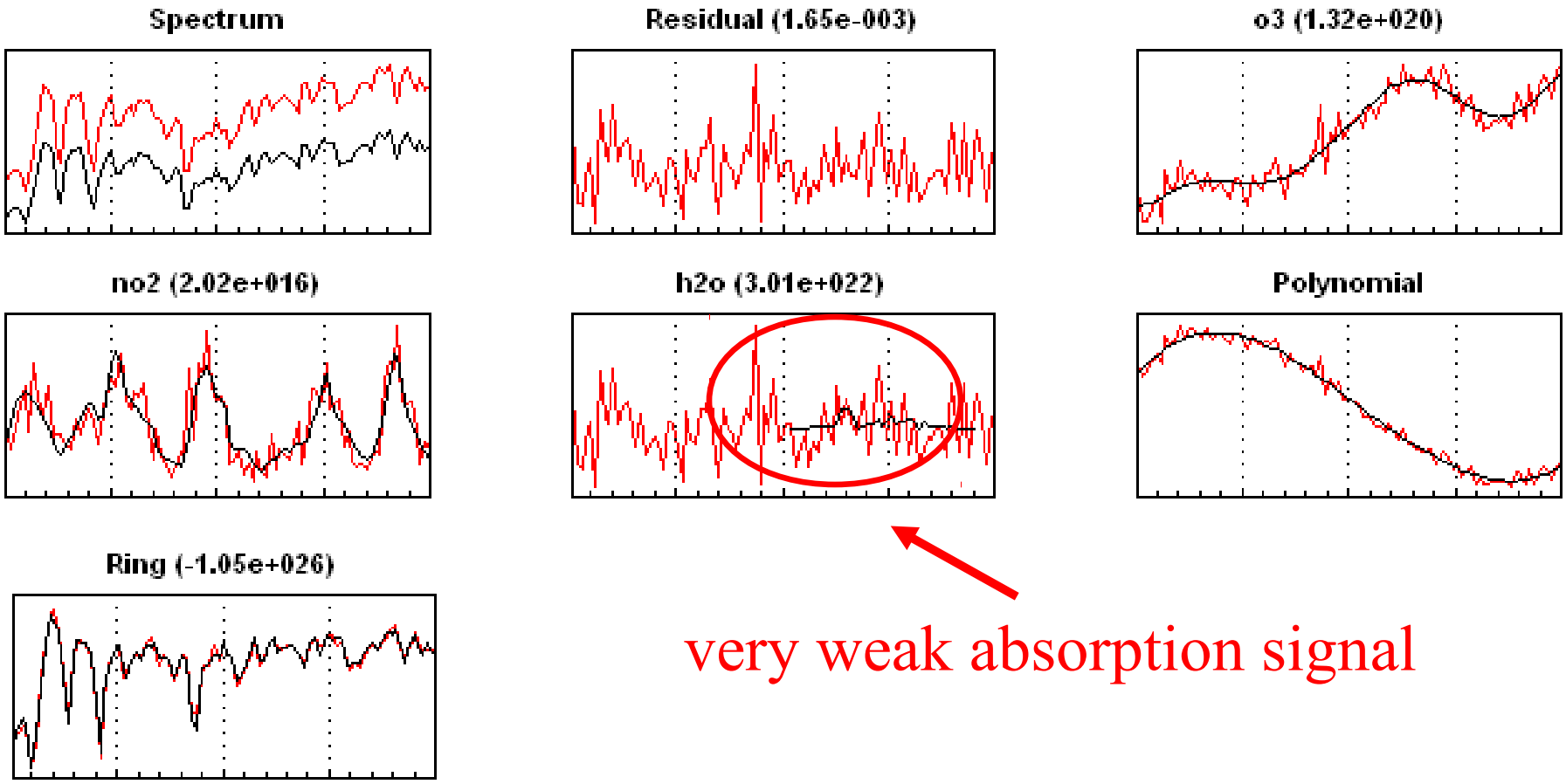
(high H_2O VCD)



H_2O analysis in the blue spectral range

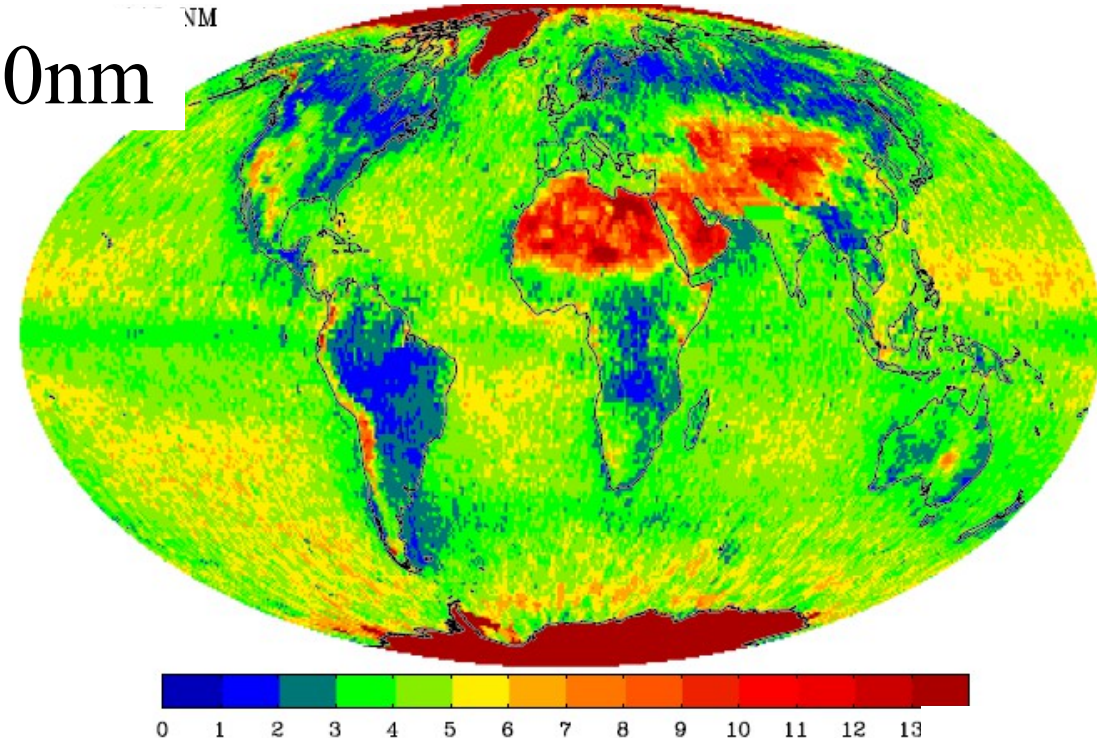
GOME analysis at high SZA

(low H_2O VCD)



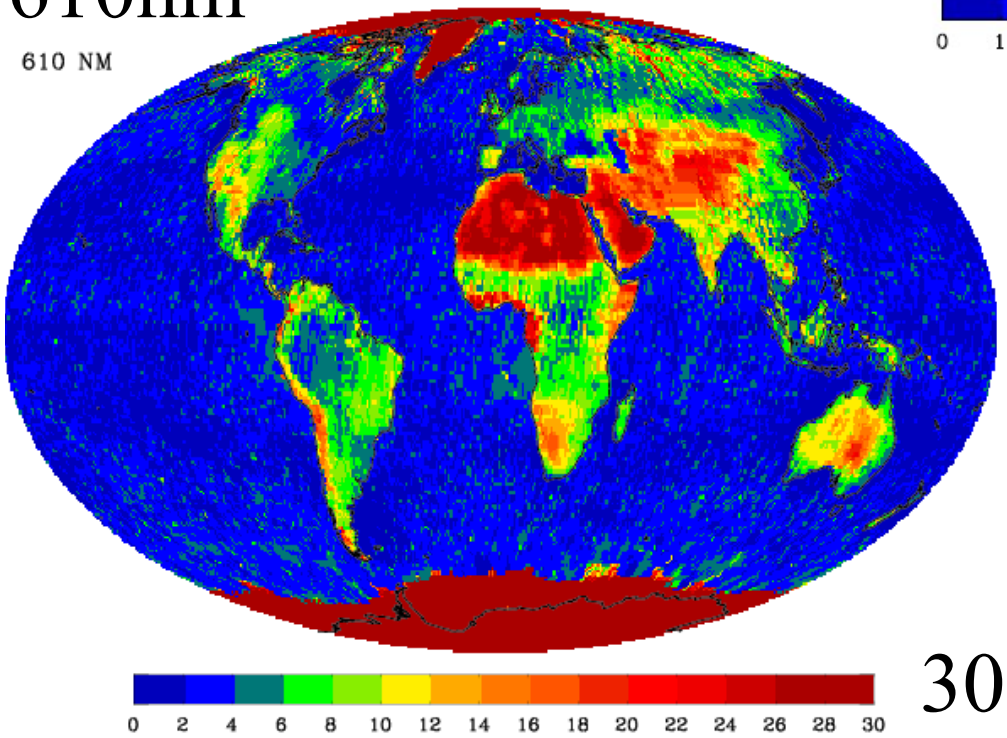
Surface albedo maps from Koelemeijer et al., 2002

440nm



14%

610nm

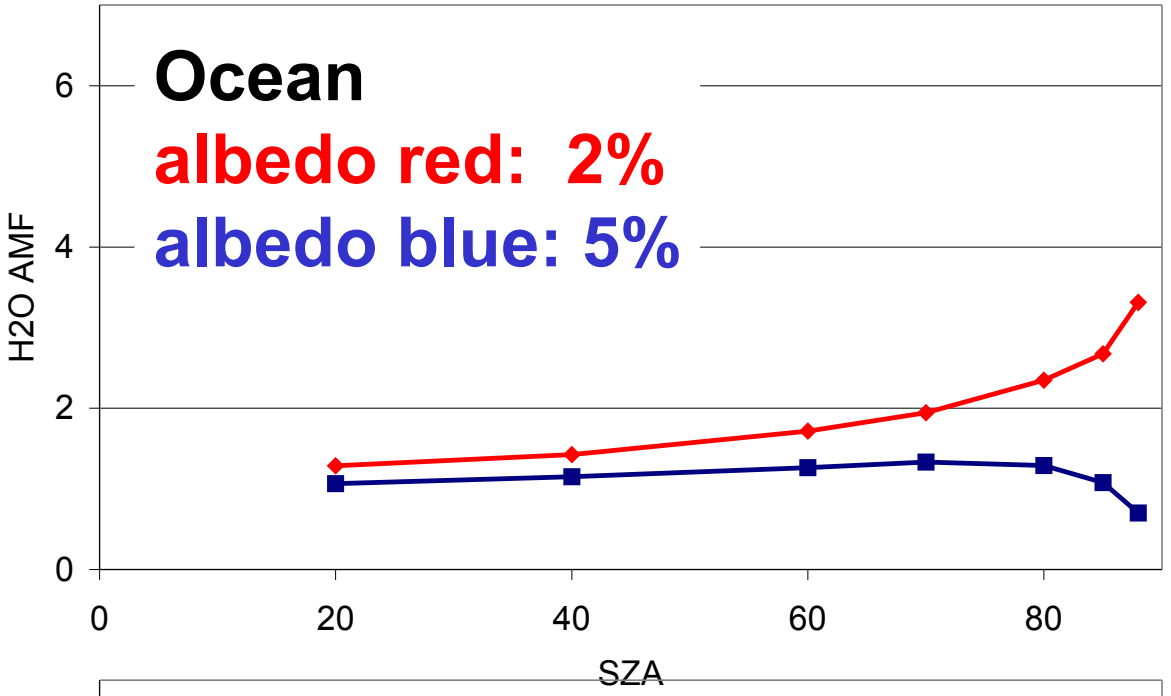


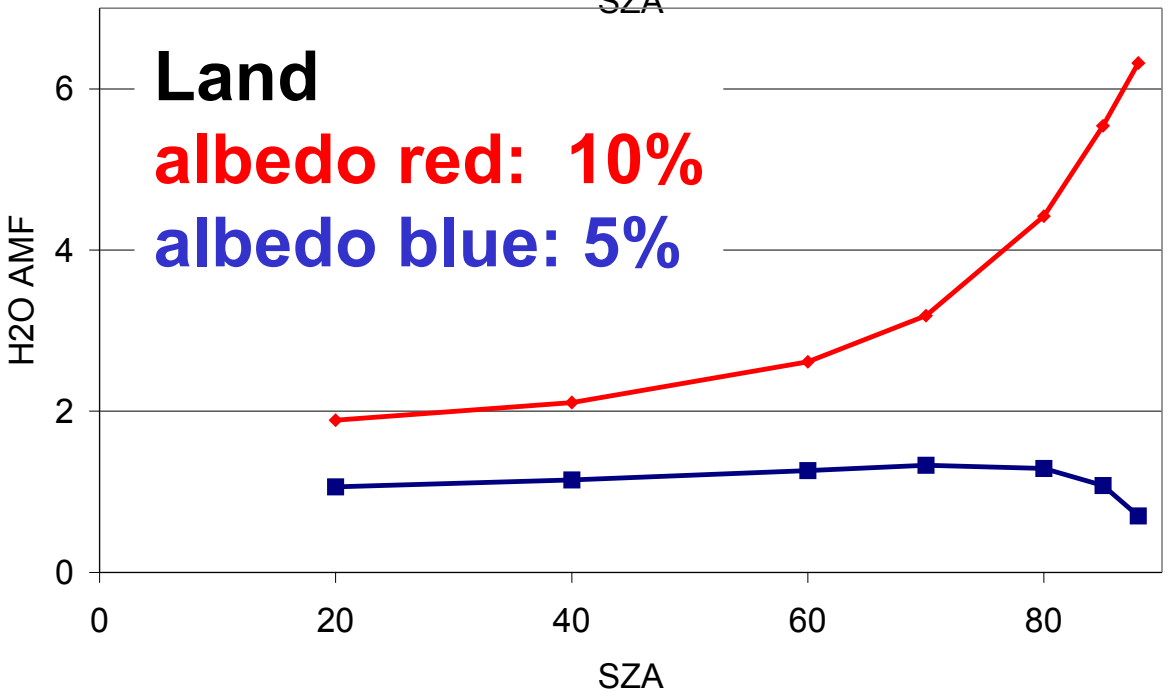
30%

In the blue spectral range, the surface albedo has weaker gradients

SZA dependence of total AMF for clear sky conditions

=> sensitivity is higher in red spectral range

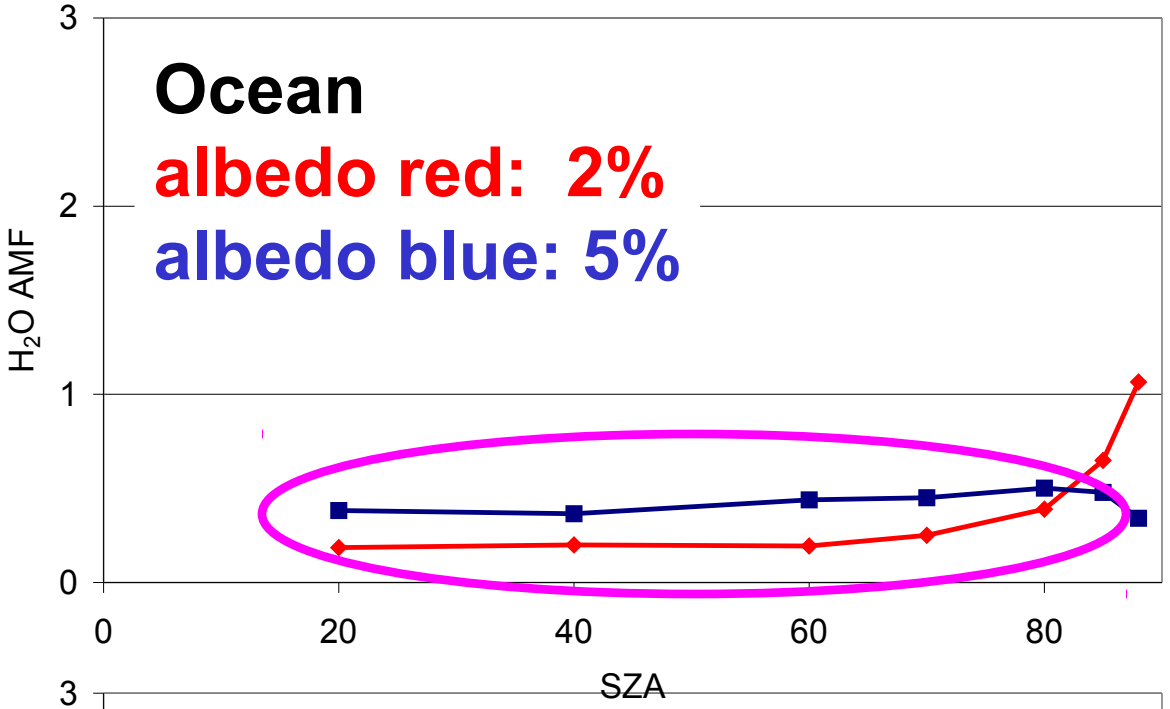


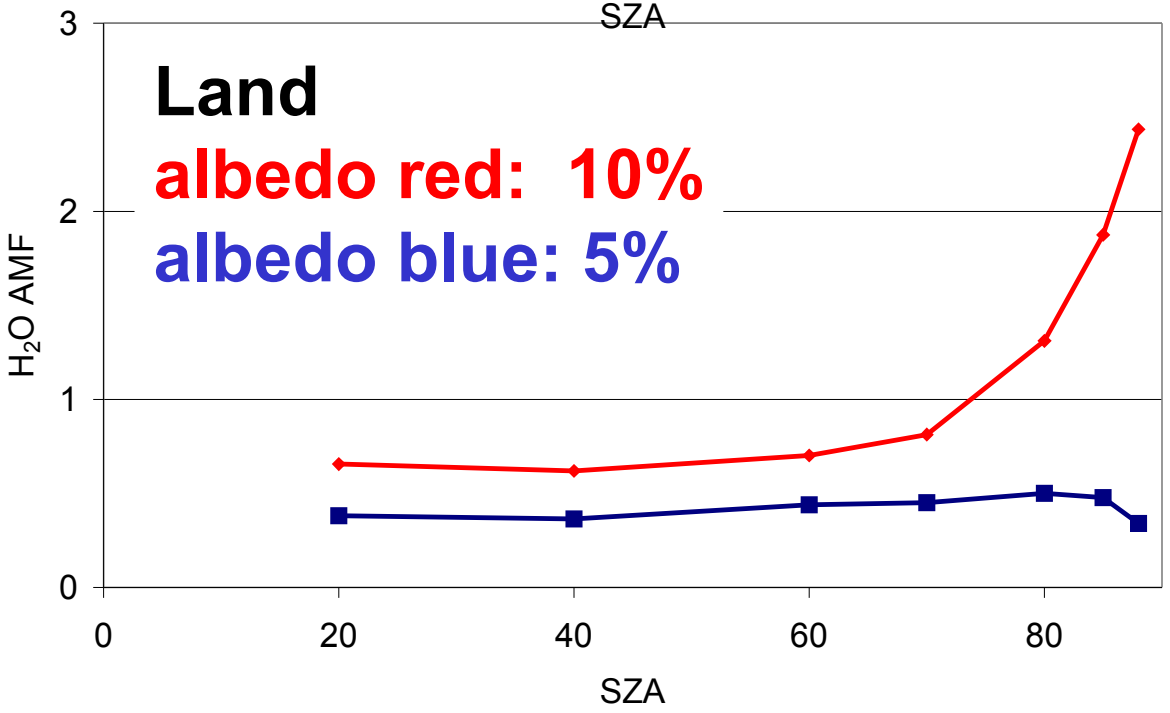


SZA dependence of total AMF for cloudy conditions

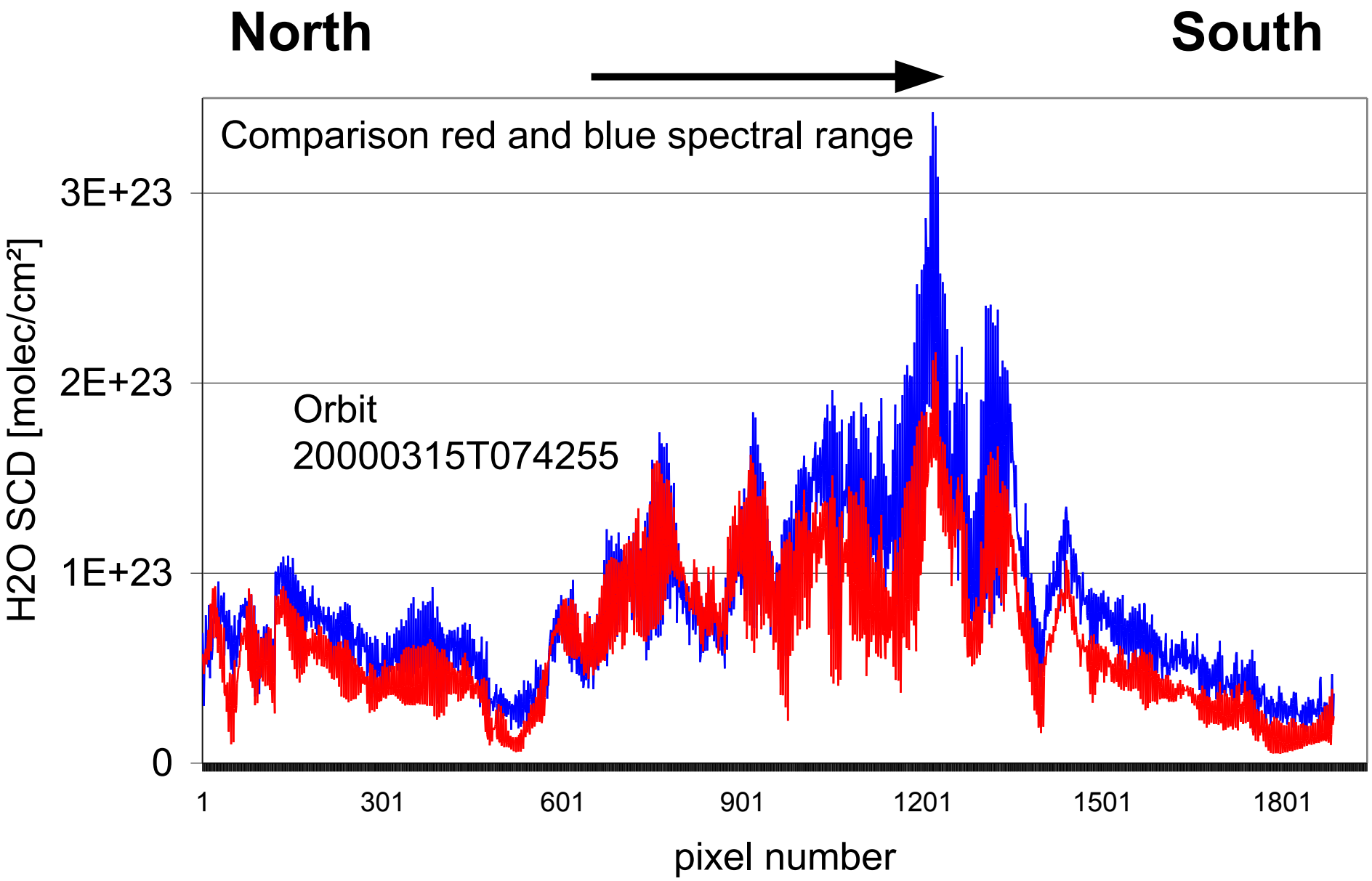
=> Over ocean, sensitivity can be higher in blue spectral range

assumed cloud:
CTH: 6km
CF: 50%
OD: 10

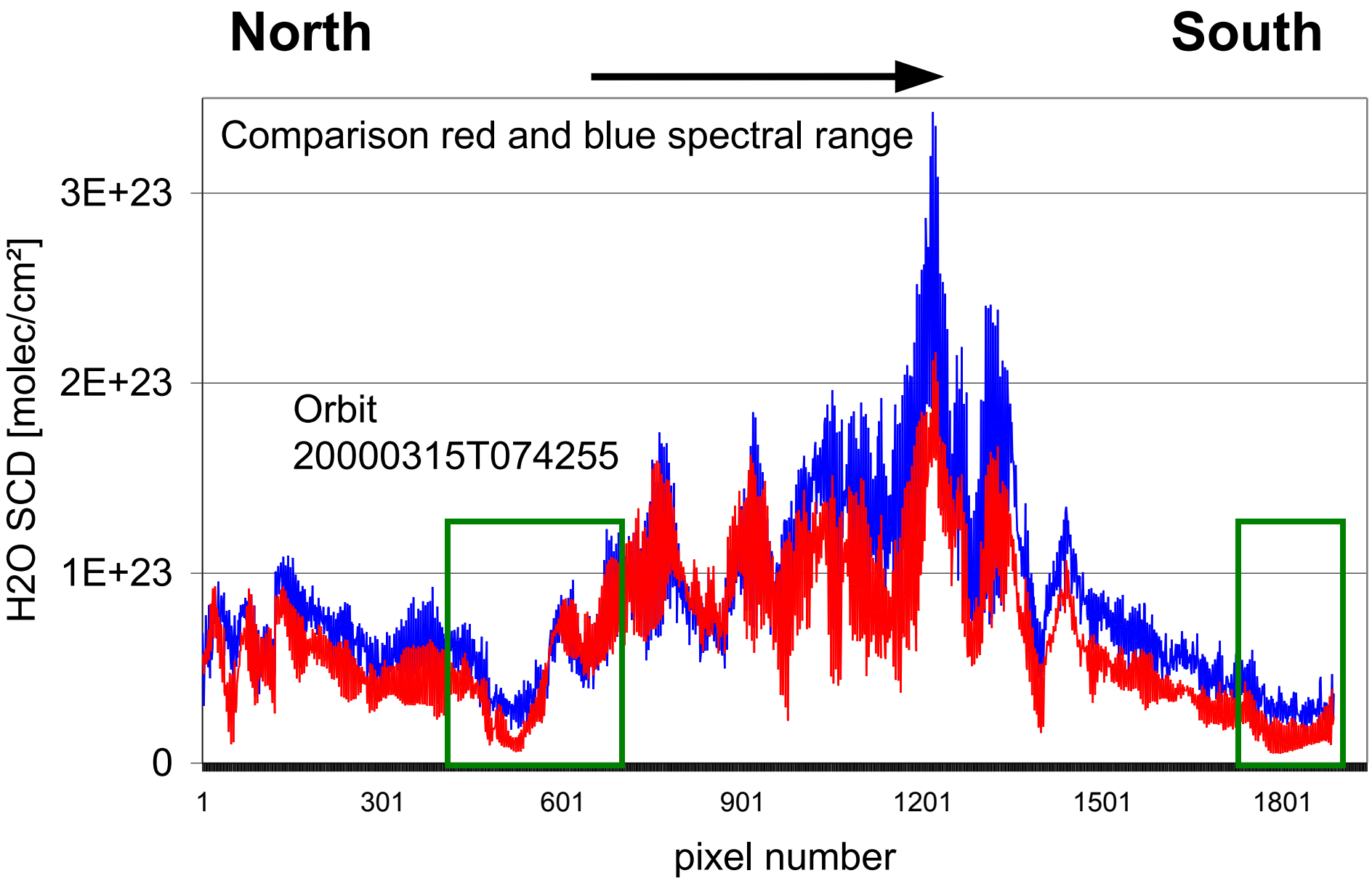


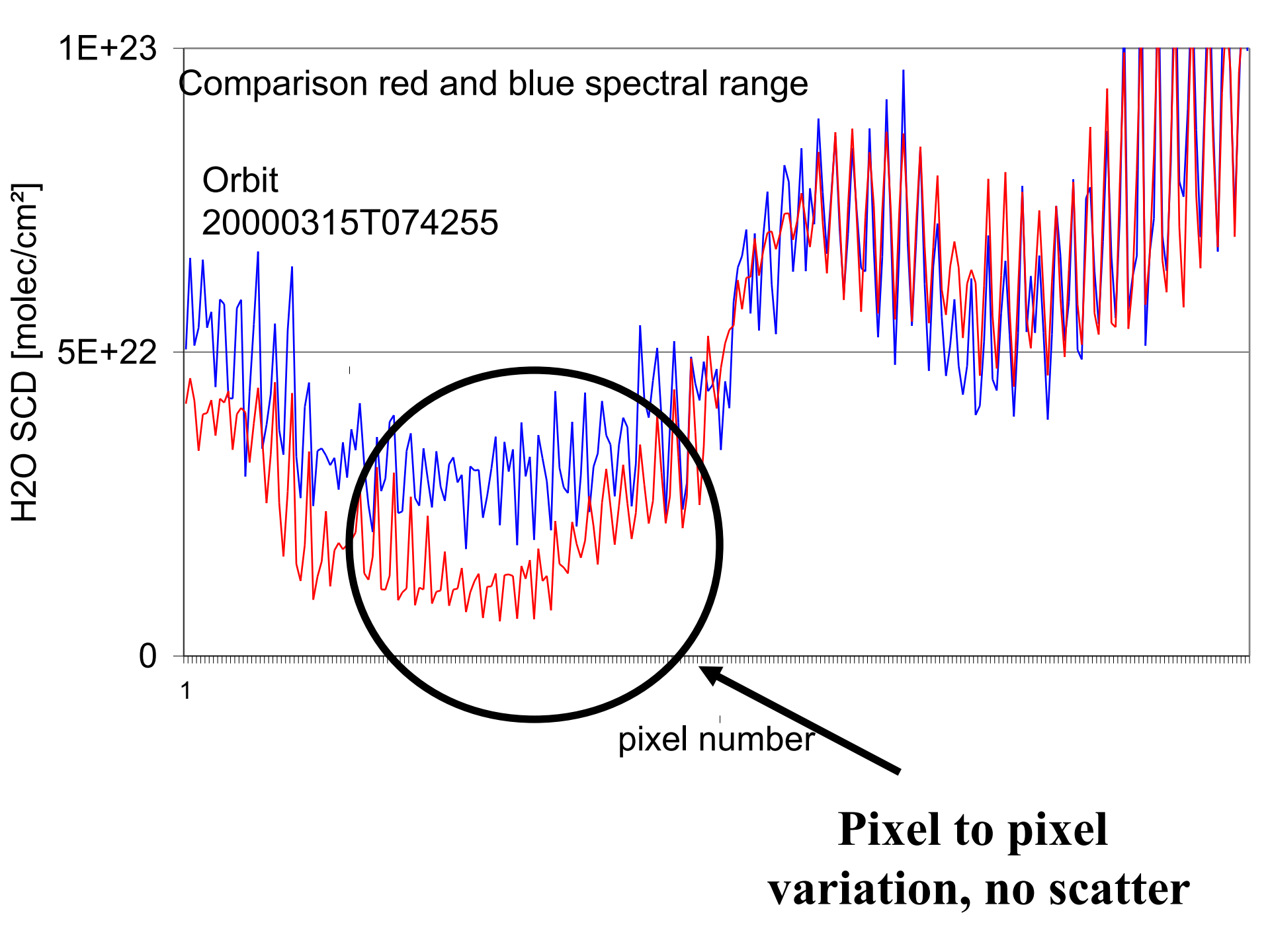


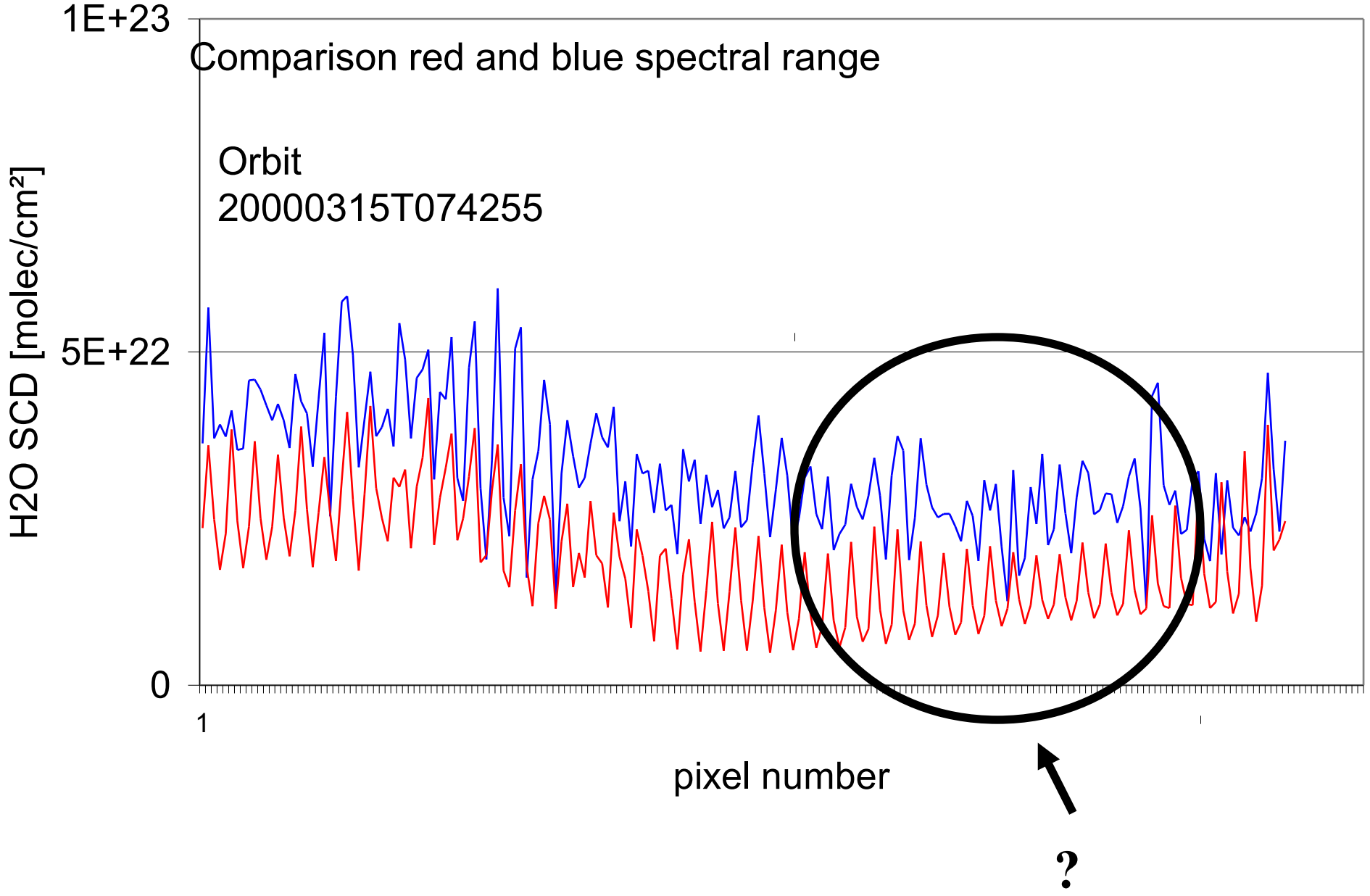
H_2O SCDs for one GOME orbit



H_2O SCDs for one GOME orbit

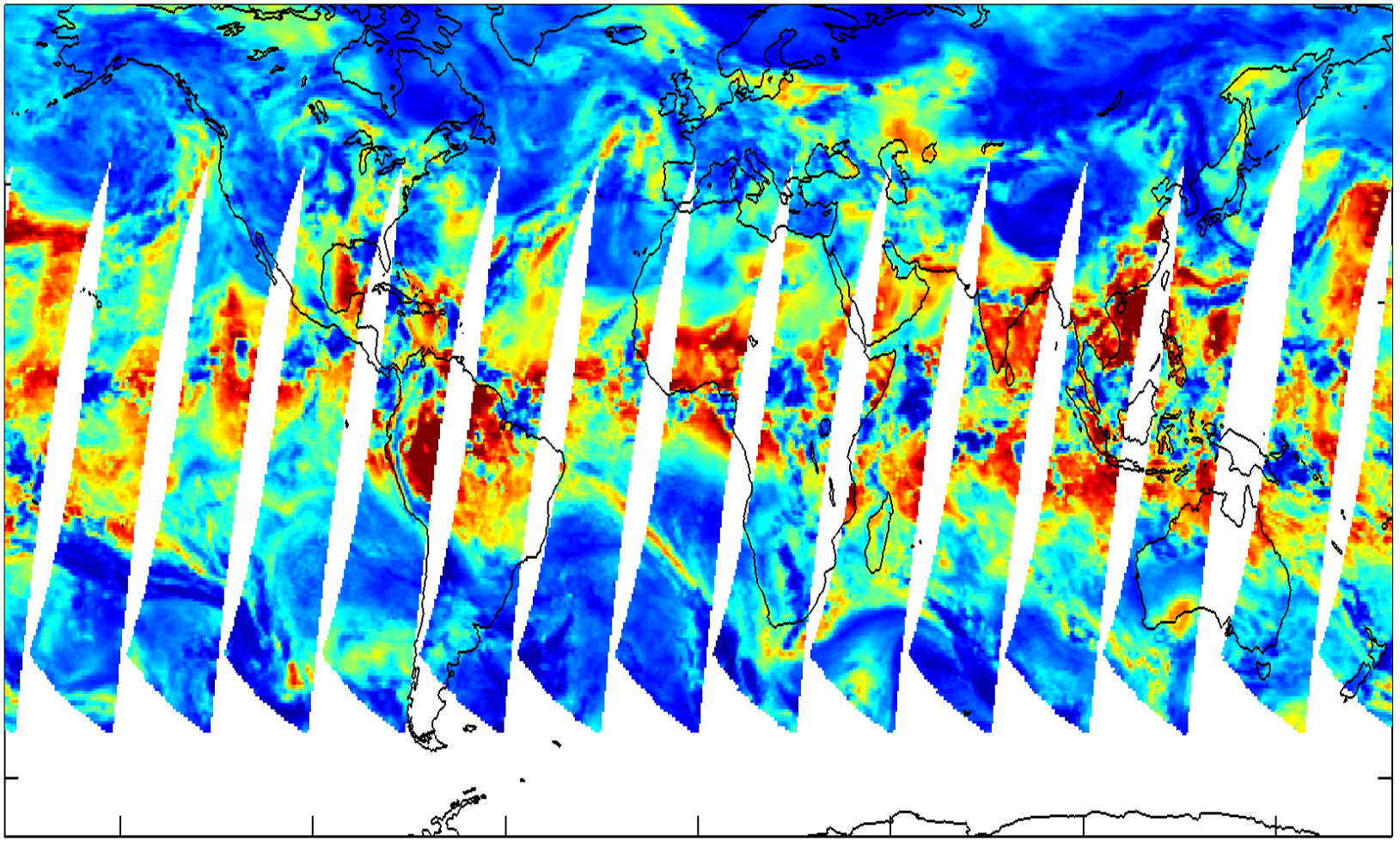


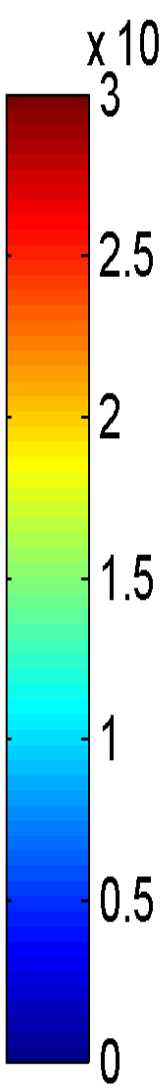

1E+23
Comparison red and blue spectral range
Orbit
20000315T074255
H2O SCD [molec/cm²]
5E+22
0
1
pixel number
Pixel to pixel
variation, no scatter


1E+23
Comparison red and blue spectral range
Orbit
20000315T074255
H2O SCD [molec/cm²]
5E+22
0
1
pixel number
?

H_2O SCD red spectral range

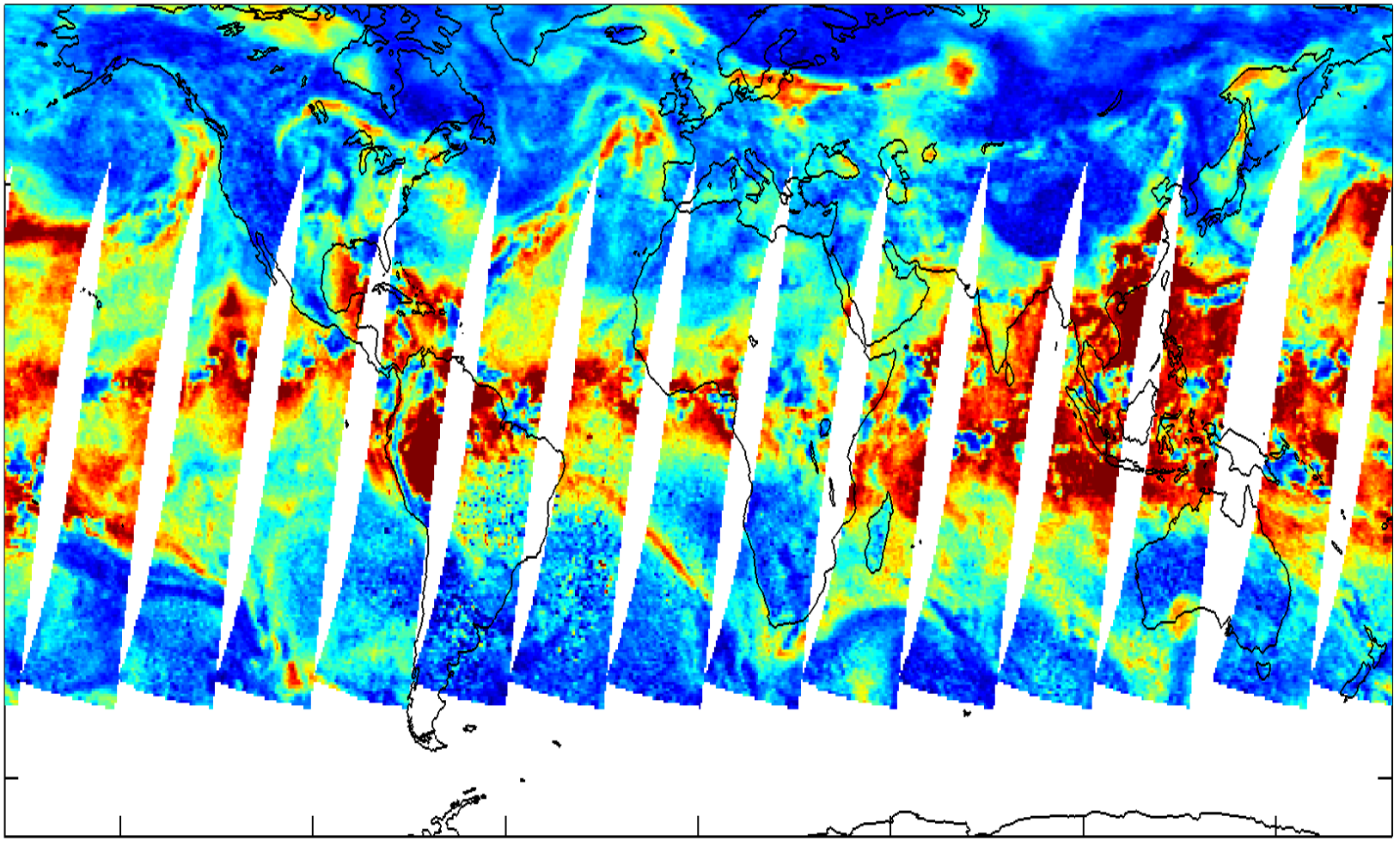
GOME-2, 1 June 2007

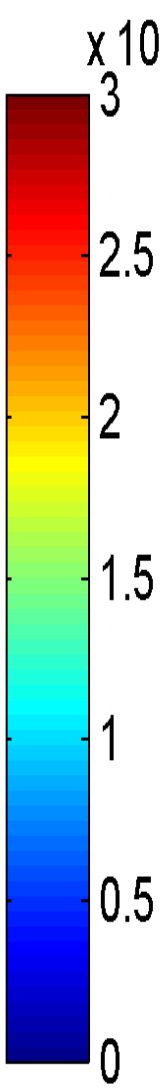




H_2O SCD blue spectral range

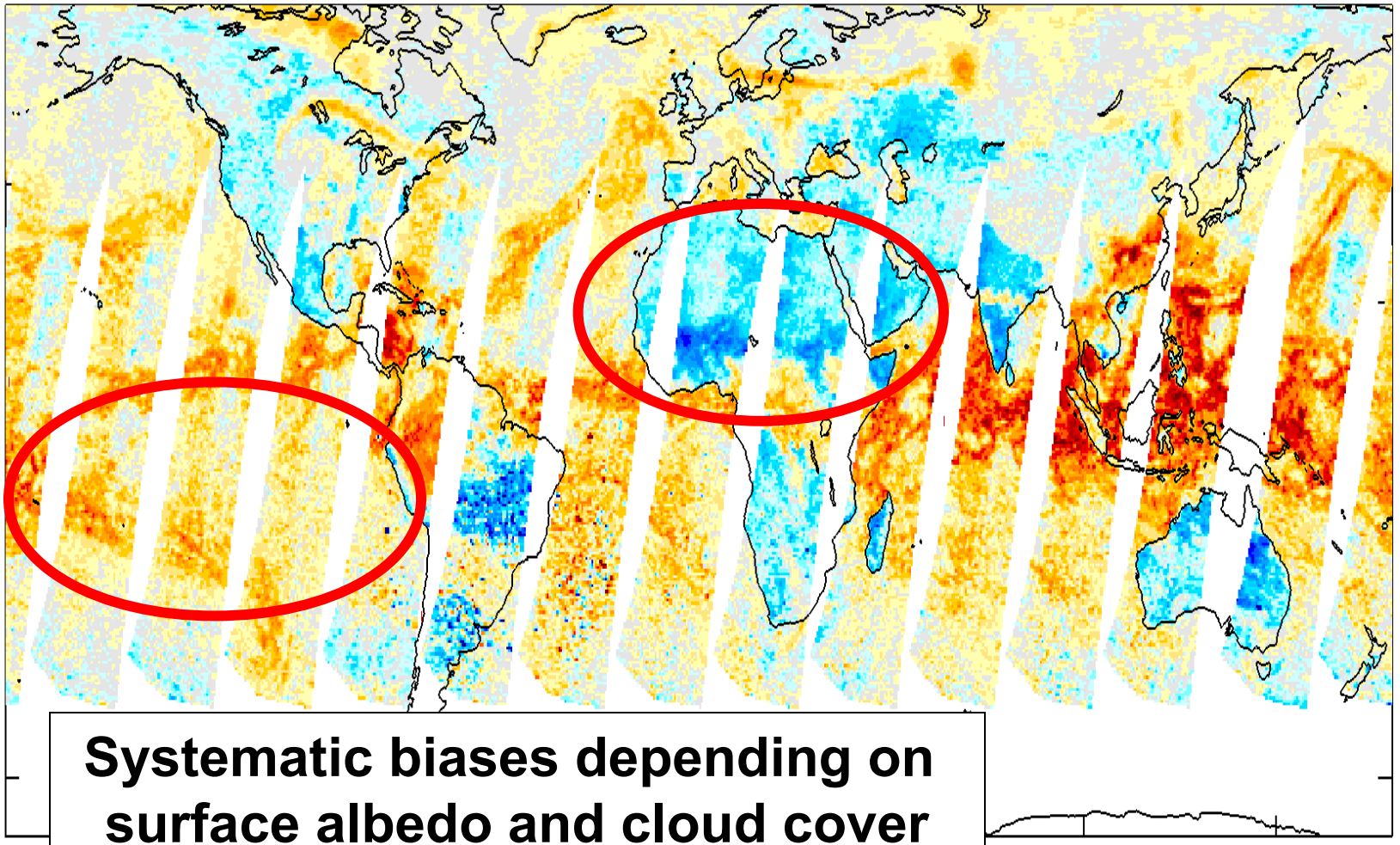
GOME-2, 1 June 2007





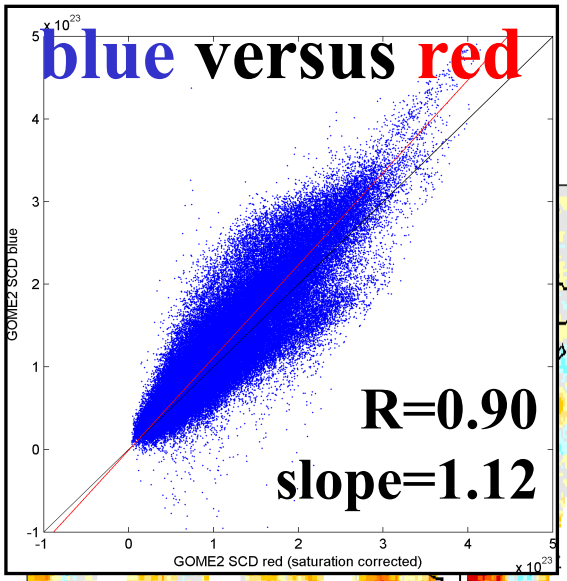
H_2O SCD difference blue minus red spectral range

GOME-2, 1 June 2007

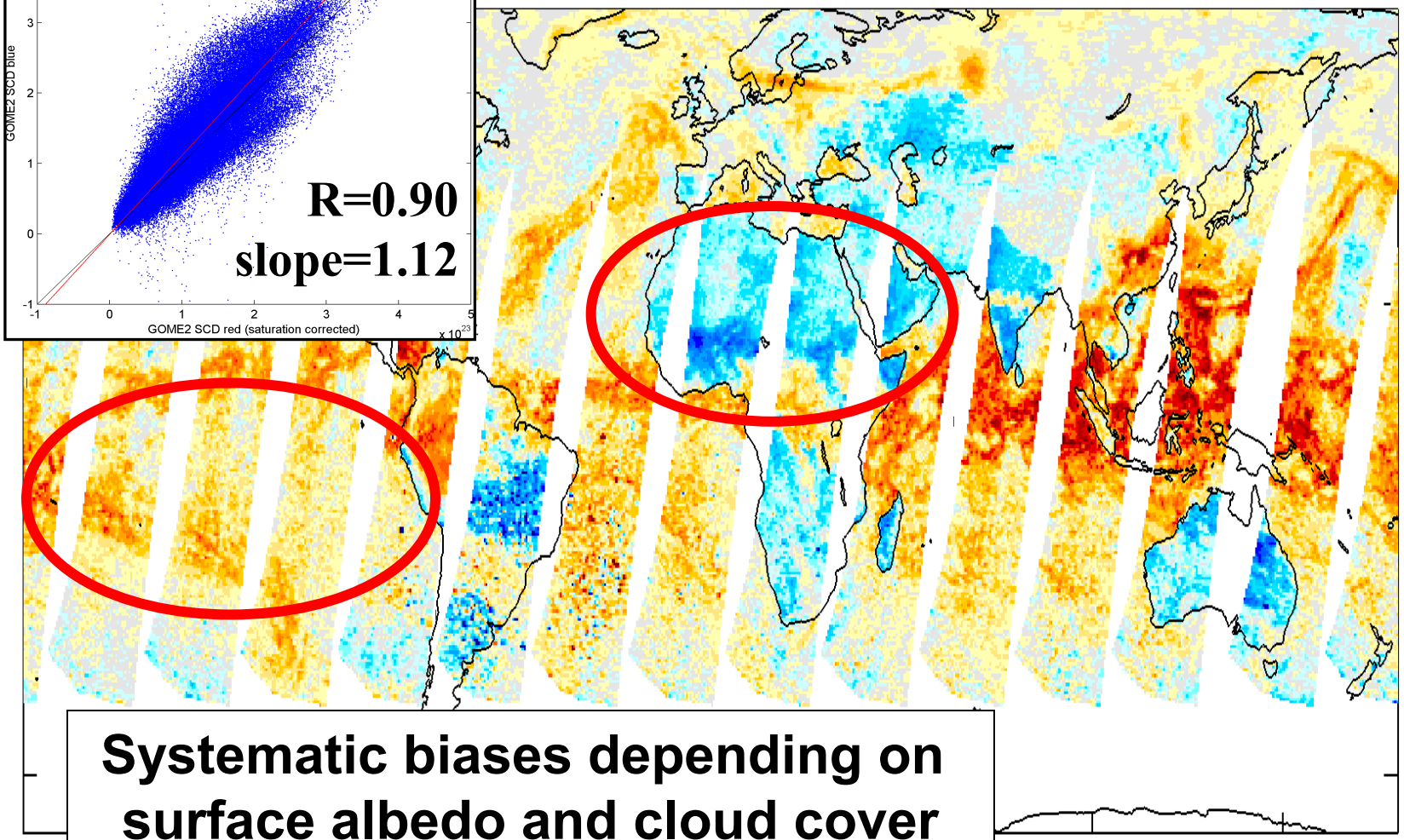


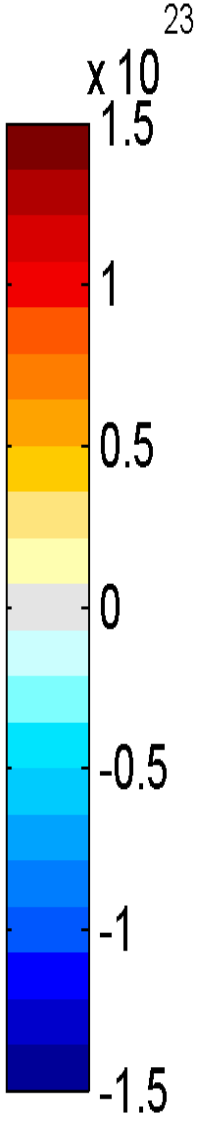
Systematic biases depending on surface albedo and cloud cover

H_2O SCD difference blue minus red spectral range



GOME-2, 1 June 2007

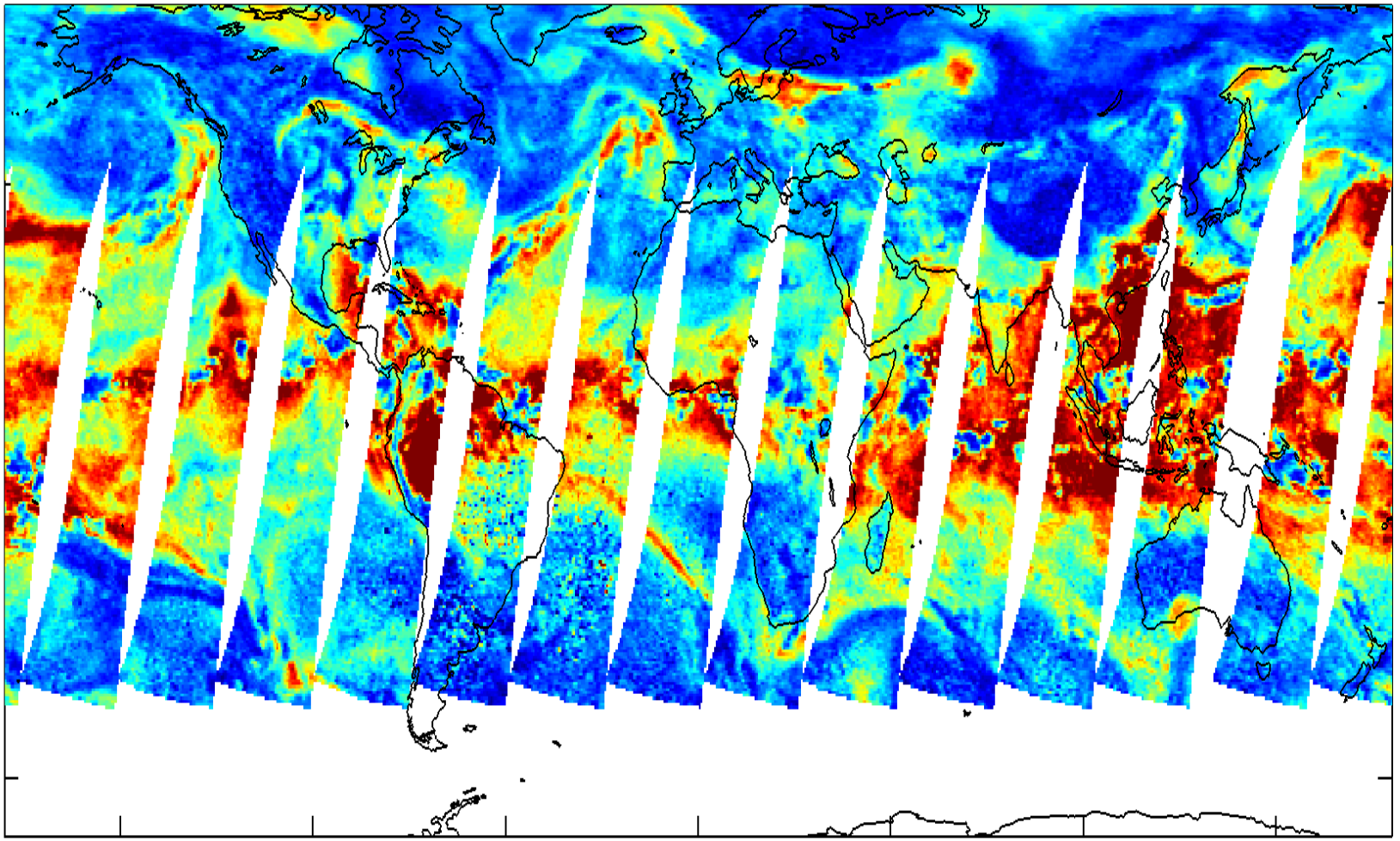


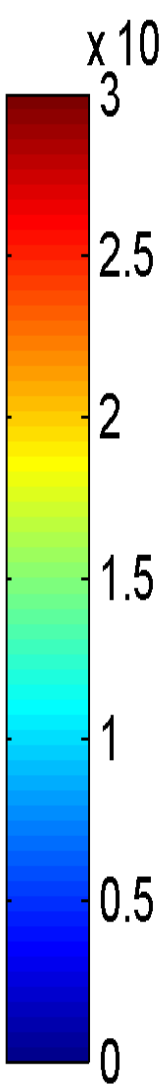


Systematic biases depending on surface albedo and cloud cover

H_2O SCD blue spectral range

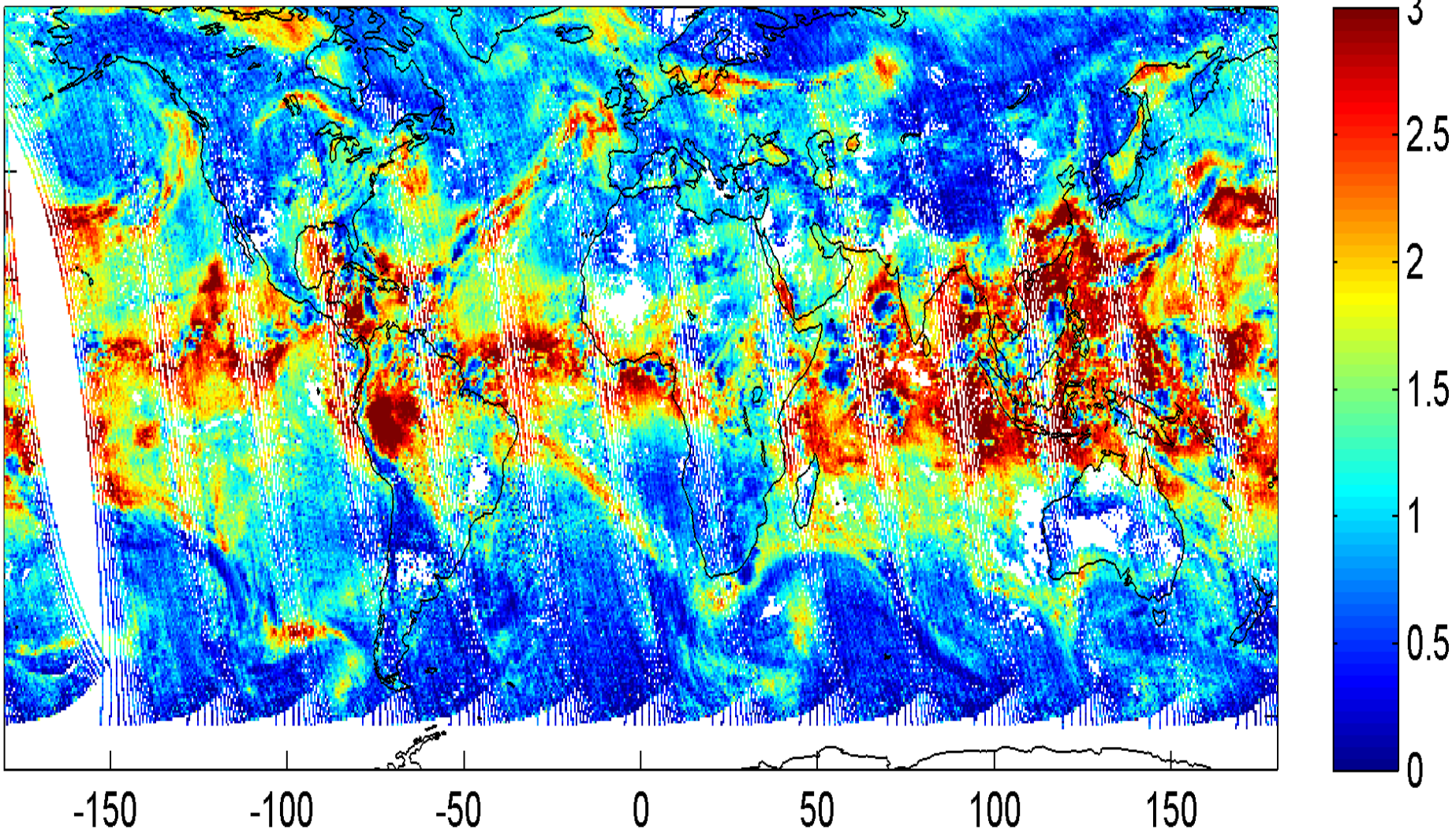
GOME-2, 1 June 2007





H_2O SCD blue spectral range

OMI, 1 June 2007

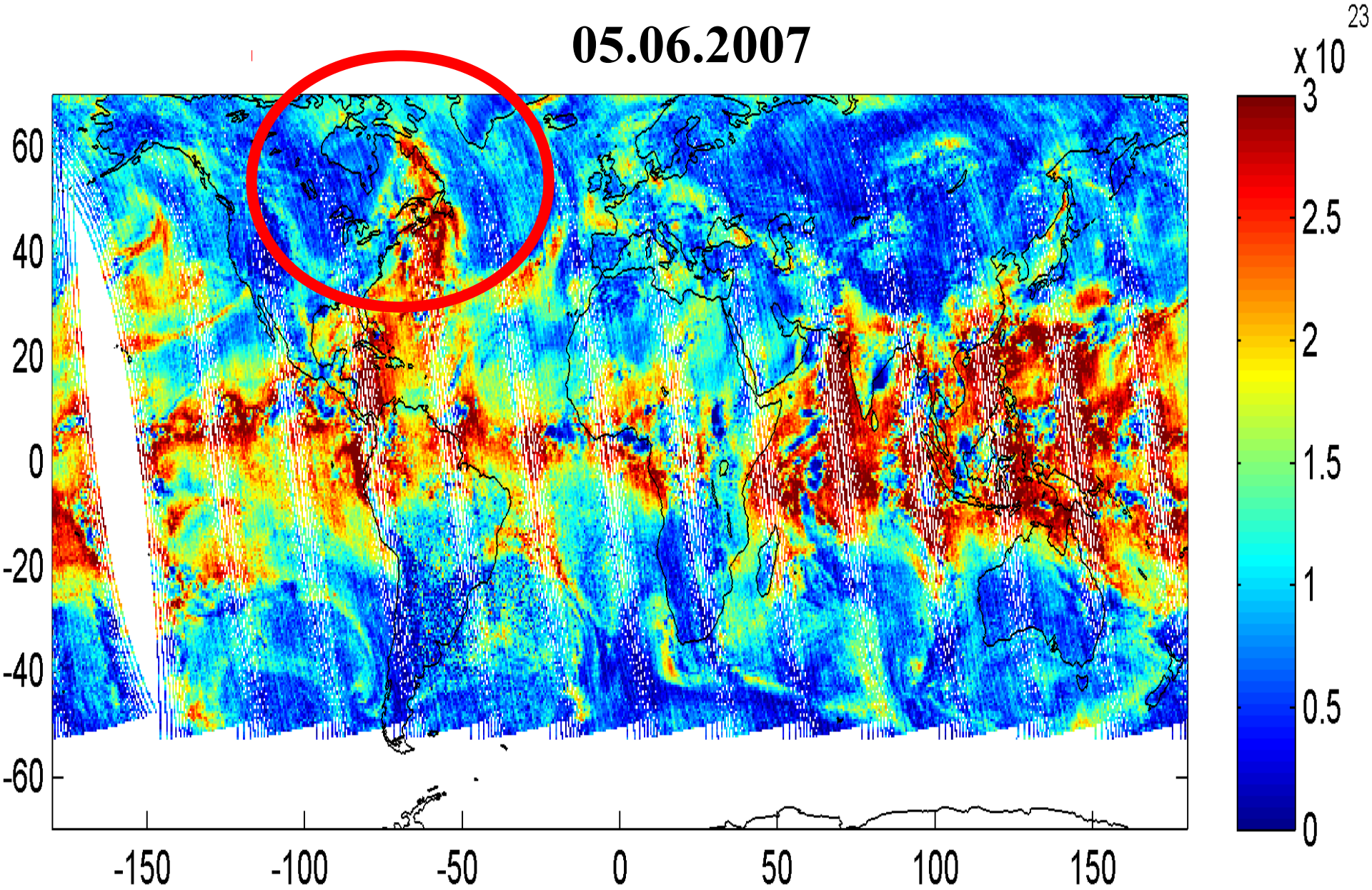


Example result

Transport event

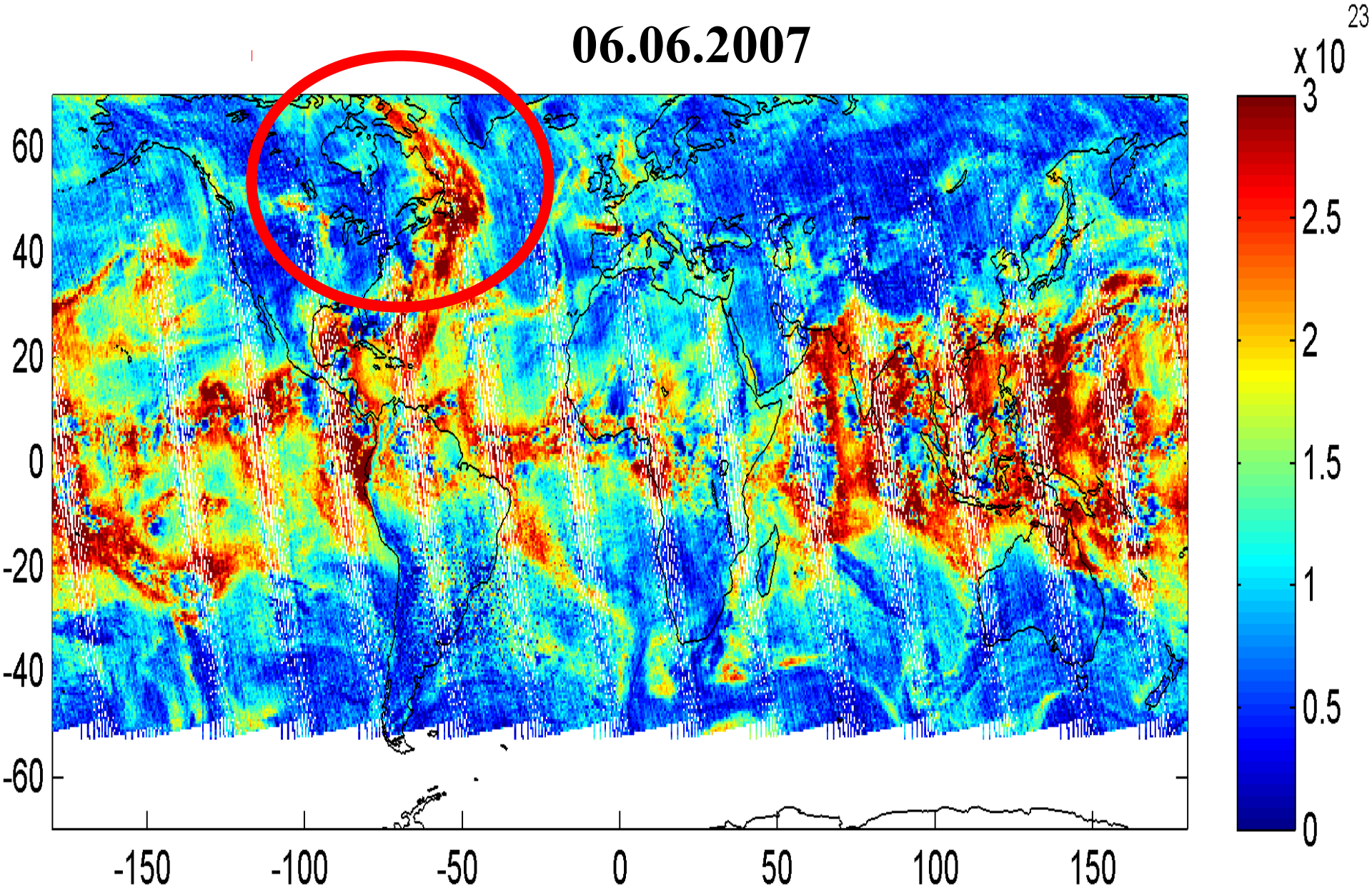
OMI H_2O SCDs

05.06.2007



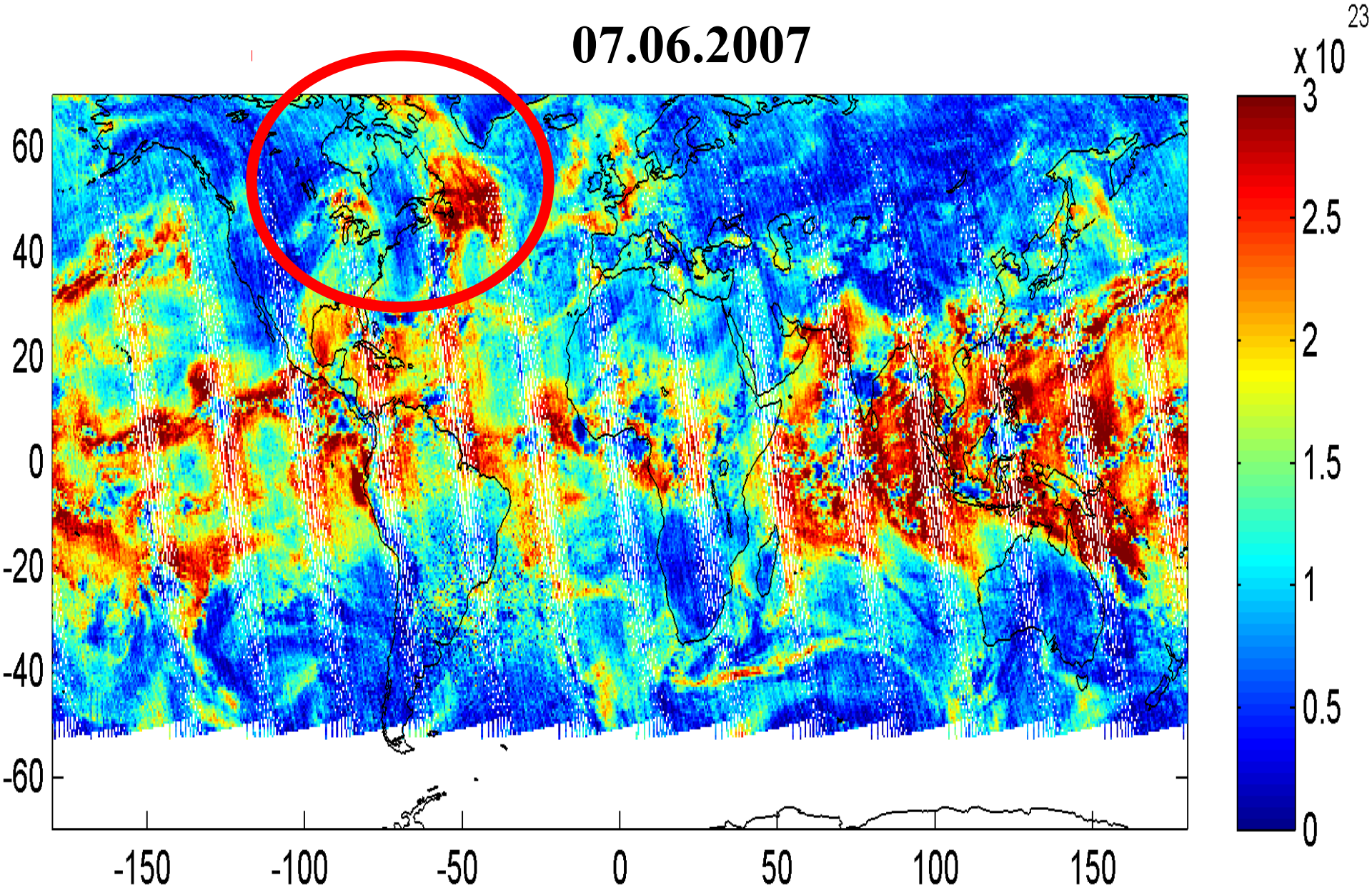
OMI H_2O SCDs

06.06.2007



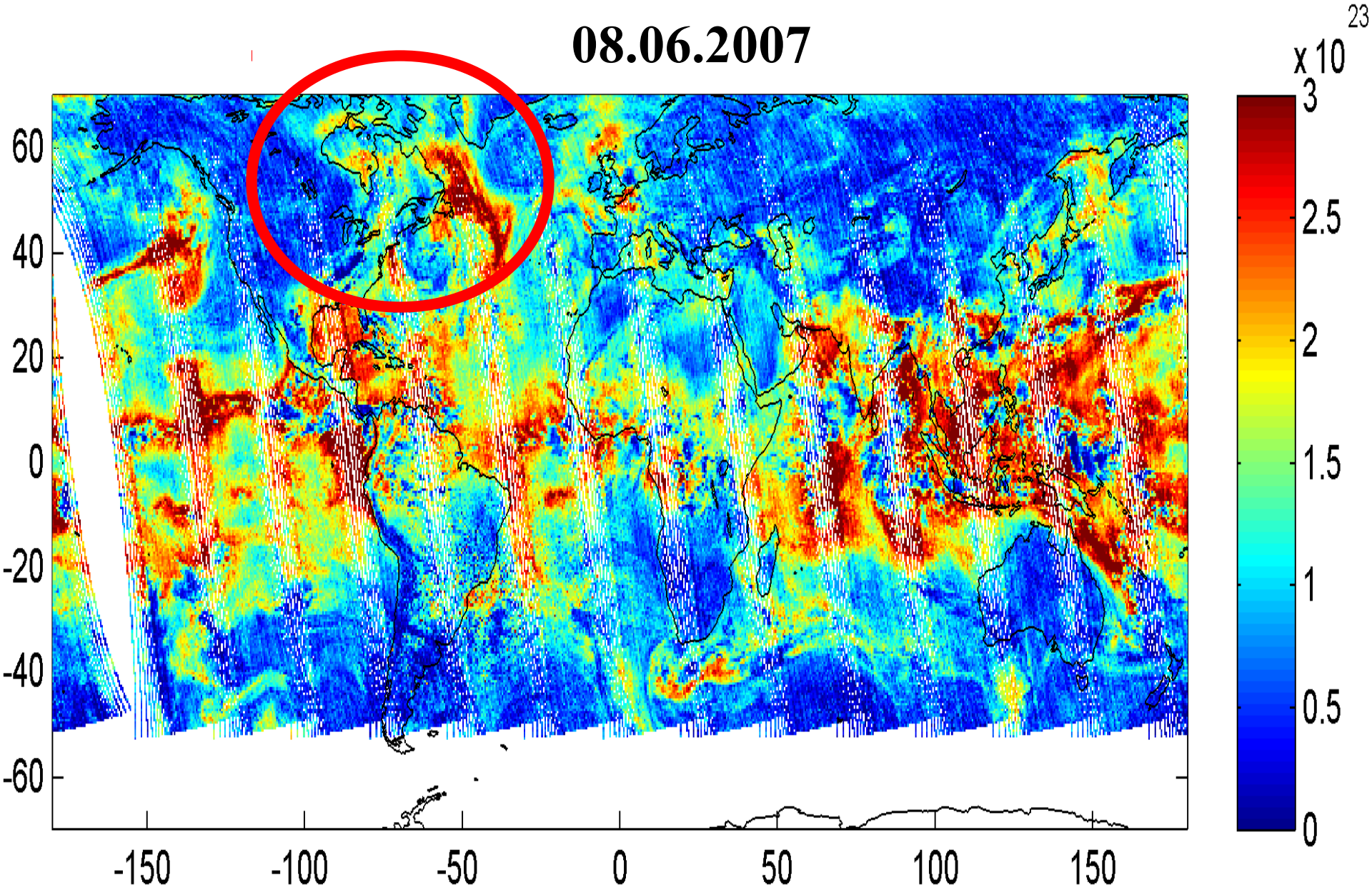
OMI H_2O SCDs

07.06.2007



OMI H_2O SCDs

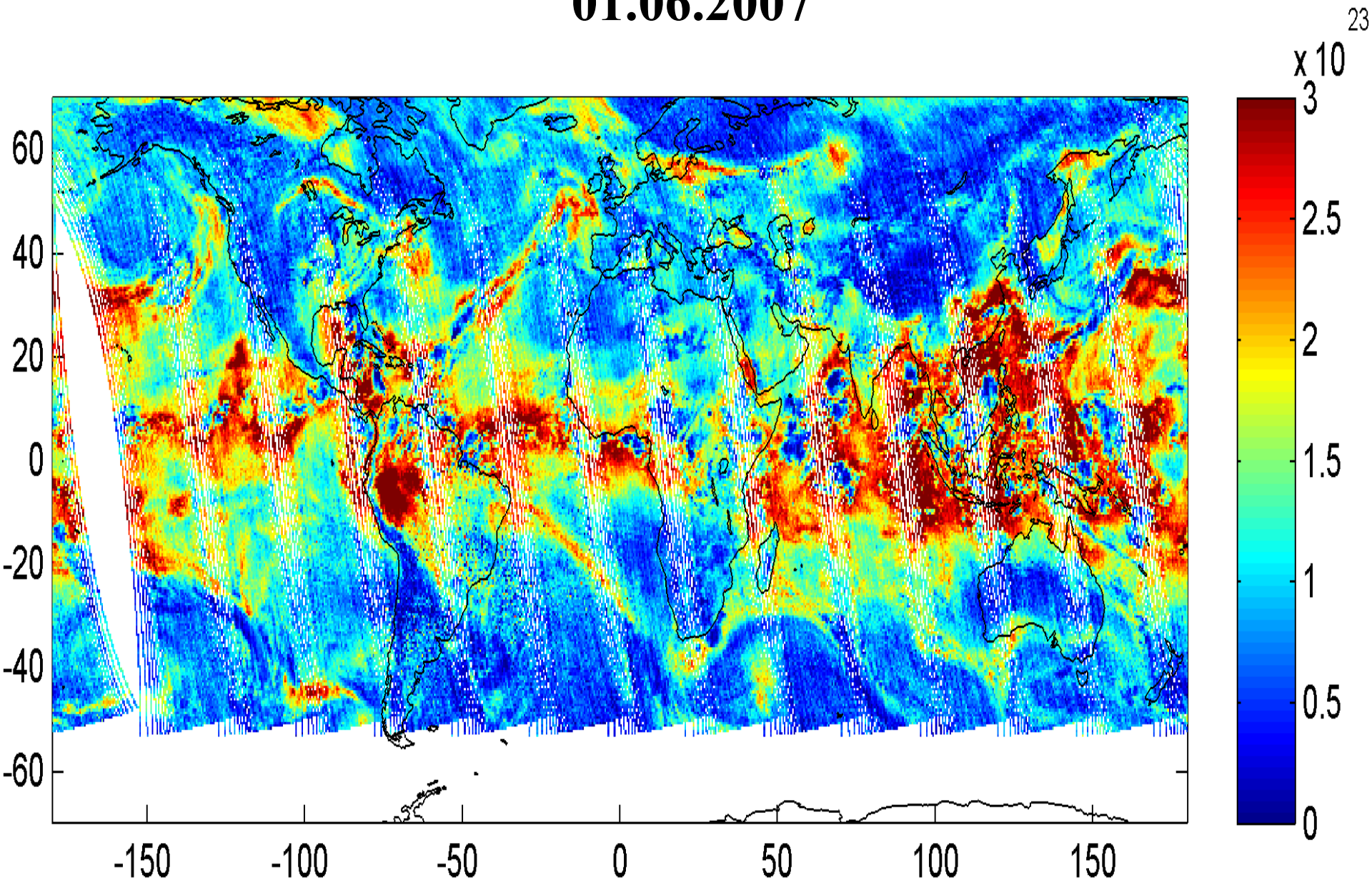
08.06.2007



Application of cloud filter

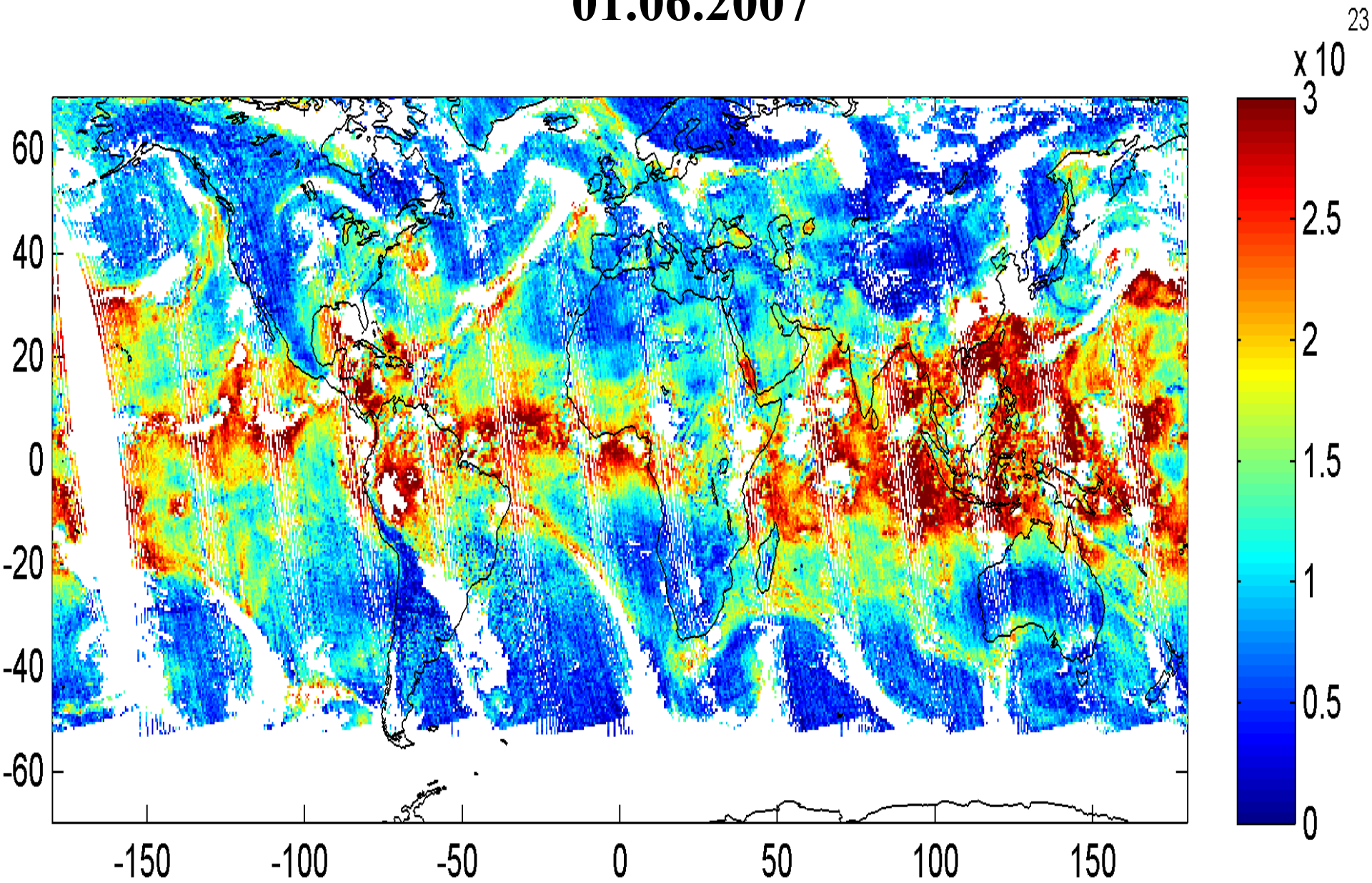
OMI (blue) H_2O SCDs

01.06.2007



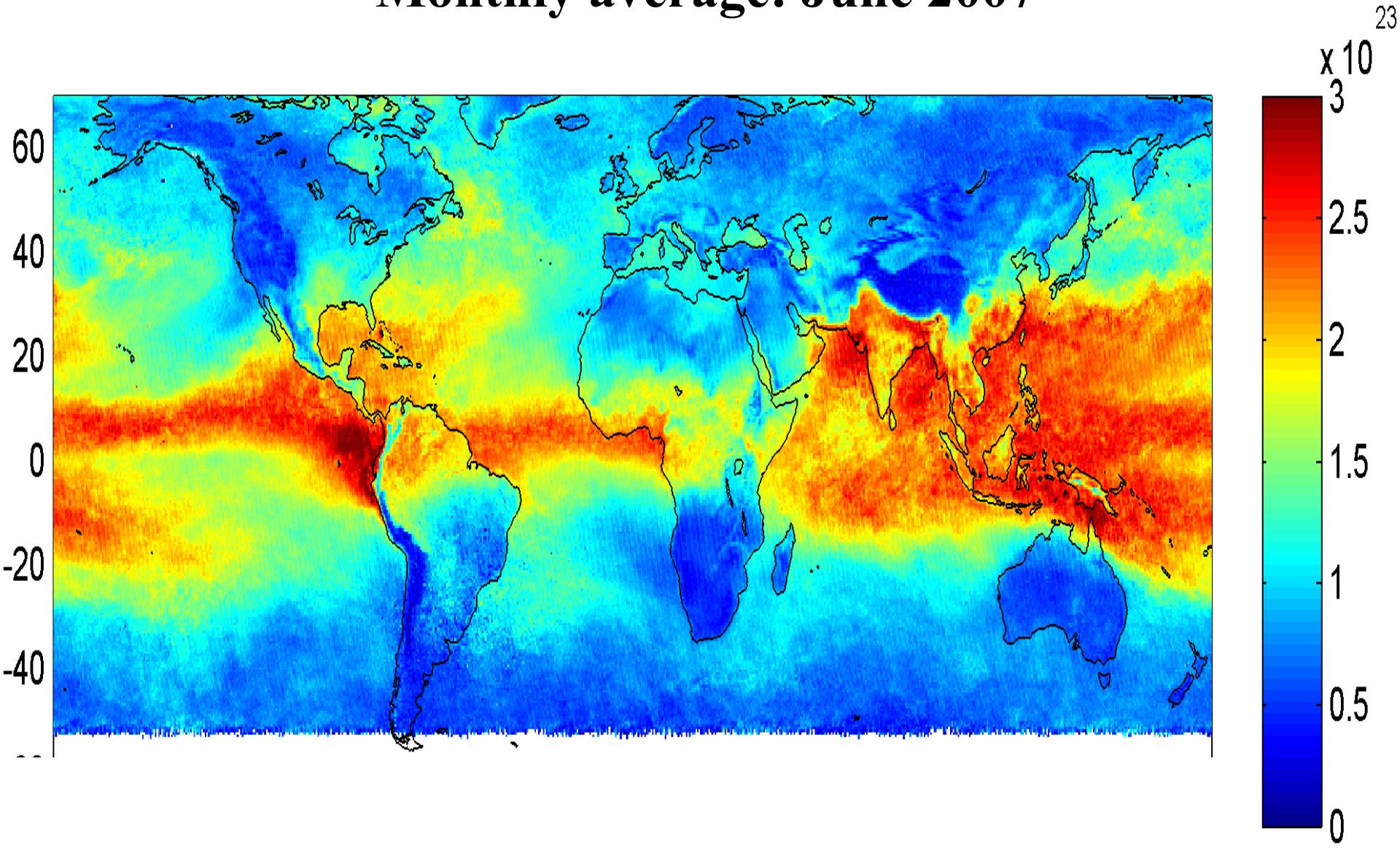
OMI (blue) H_2O SCDs

01.06.2007



OMI H_2O SCD

Monthly average: June 2007



Conclusions

- H_2O analysis in the blue spectral range is possible, even for weak absorptions
- surface albedo is more homogenous in the blue spectral range
- even slightly higher sensitivity for cloudy observations over ocean
- good agreement with existing retrievals (GOME and GOME-2)
- **first daily global maps from OMI**
- similar retrievals possible for SENTINELS

- Many thanks to Maarten Sneep for providing OMI slit function.