Hyperspectral SCIAMACHY measurements and their application for cloud research

A. A. Kokhanovsky, J. P. Burrows, C. Martinecz, L. Lelli,
V. V. Rozanov, M. Vountas, W. Lotz

Institute of Remote Sensing, Bremen University
P. O. Box 330440 Bremen, Germany

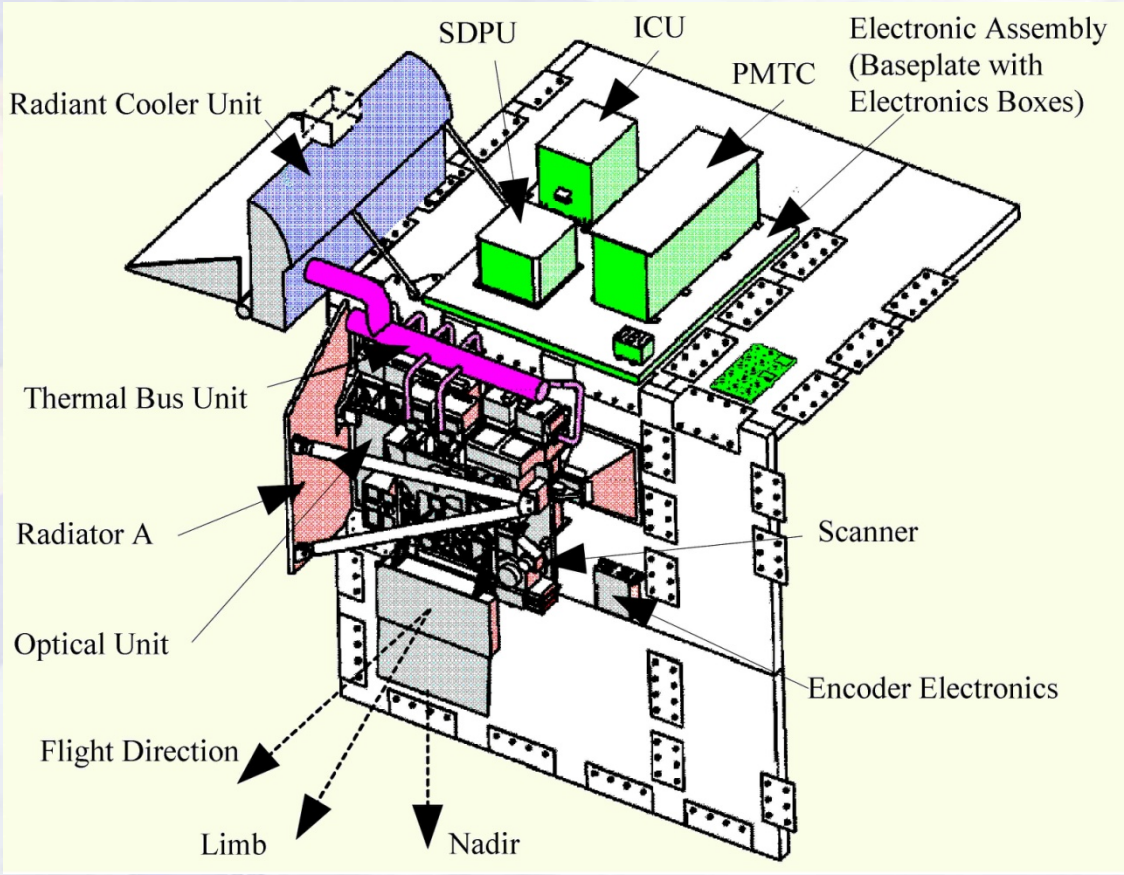
alexk@iup.physik.uni-bremen.de

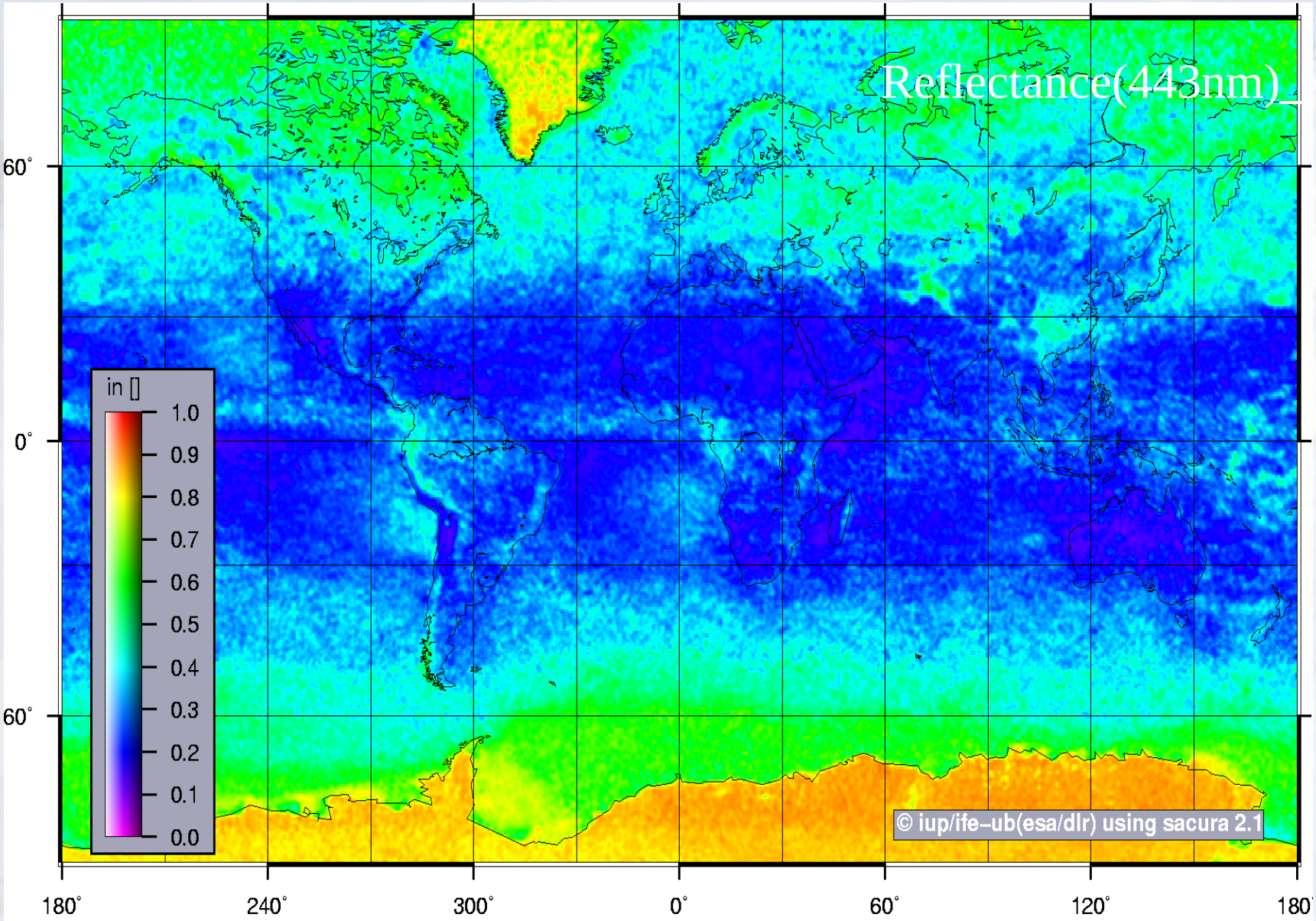
I. SCIAMACHY

SCIAMACHY = **SC**anning **I**maging **A**bsorption spectro**M**eter for **A**tmospheric **CH**artograph**Y**

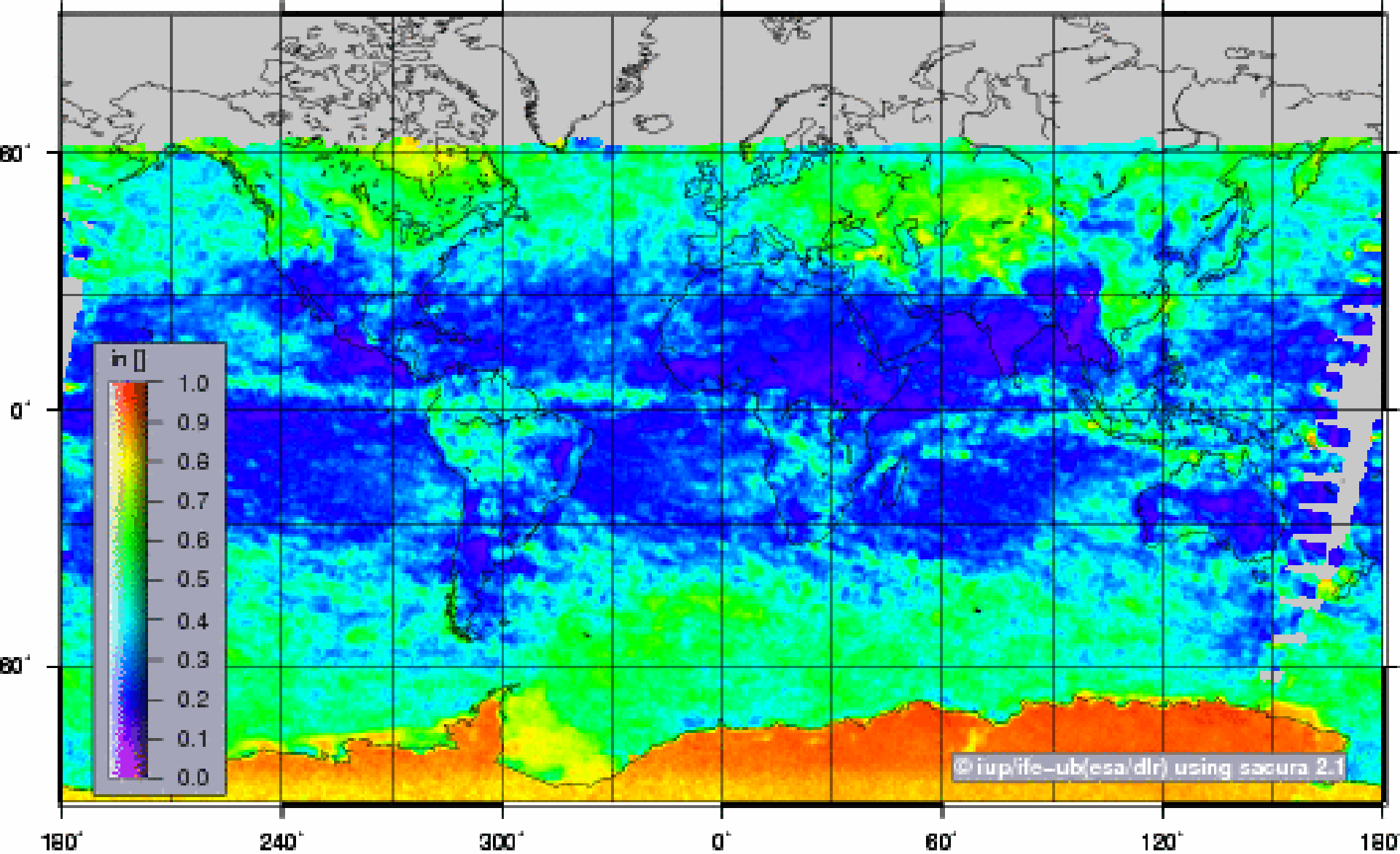
Characteristics:

- UV/Vis/NIR Spectrometer: 240 - 2380 nm
- Spectral resolution: 0.2 – 1.5 nm
- 8000 spectral points
- SCIAMACHY measures:
  - **Reflected solar light (nadir)**
  - Scattered solar light (limb)
  - Transmitted solar/moon light (occultation)
  - Solar Irradiance





Reflectance at 443 nm from SCIAMACHY data (01. January 2006 – 31. December 2006)



Reflectance at 443 nm from SCIAMACHY data (01. January 2006 – 31. January 2006)

Universität Bremen ife Bremen

ENVISAT SCIAMACHY

II. ALGORITHMS

CLOUD PARAMETERS to be retrieved:

Cloud optical thickness /5-100/.....R(443nm)

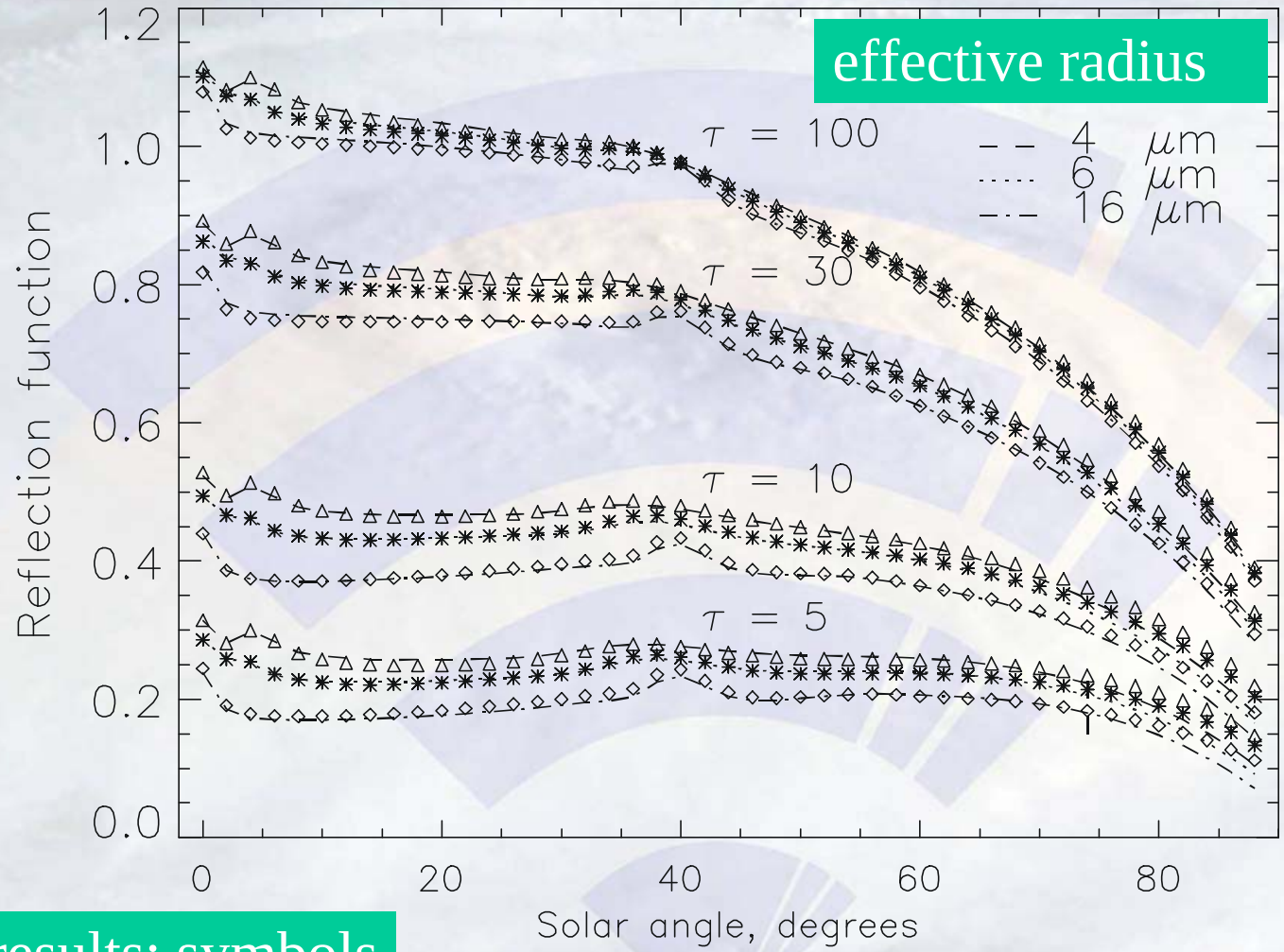
Cloud top height /0.5-15km/.....R(758-770nm)

Thermodynamic phase
/ice or water clouds/.....R(1550nm)/R(1670nm)

$$R = \frac{\pi I_{refl}}{\cos(\vartheta_{sun}) E_0}$$

The cloud optical thickness determination

The physical principle behind the retrievals



$\lambda = 0.65 \mu m$

Rozenberg et al, 1978 (KOSMOS 320)

Arking Childs,1985

Twomey Cocs, 1989

Nakajima King, 1990

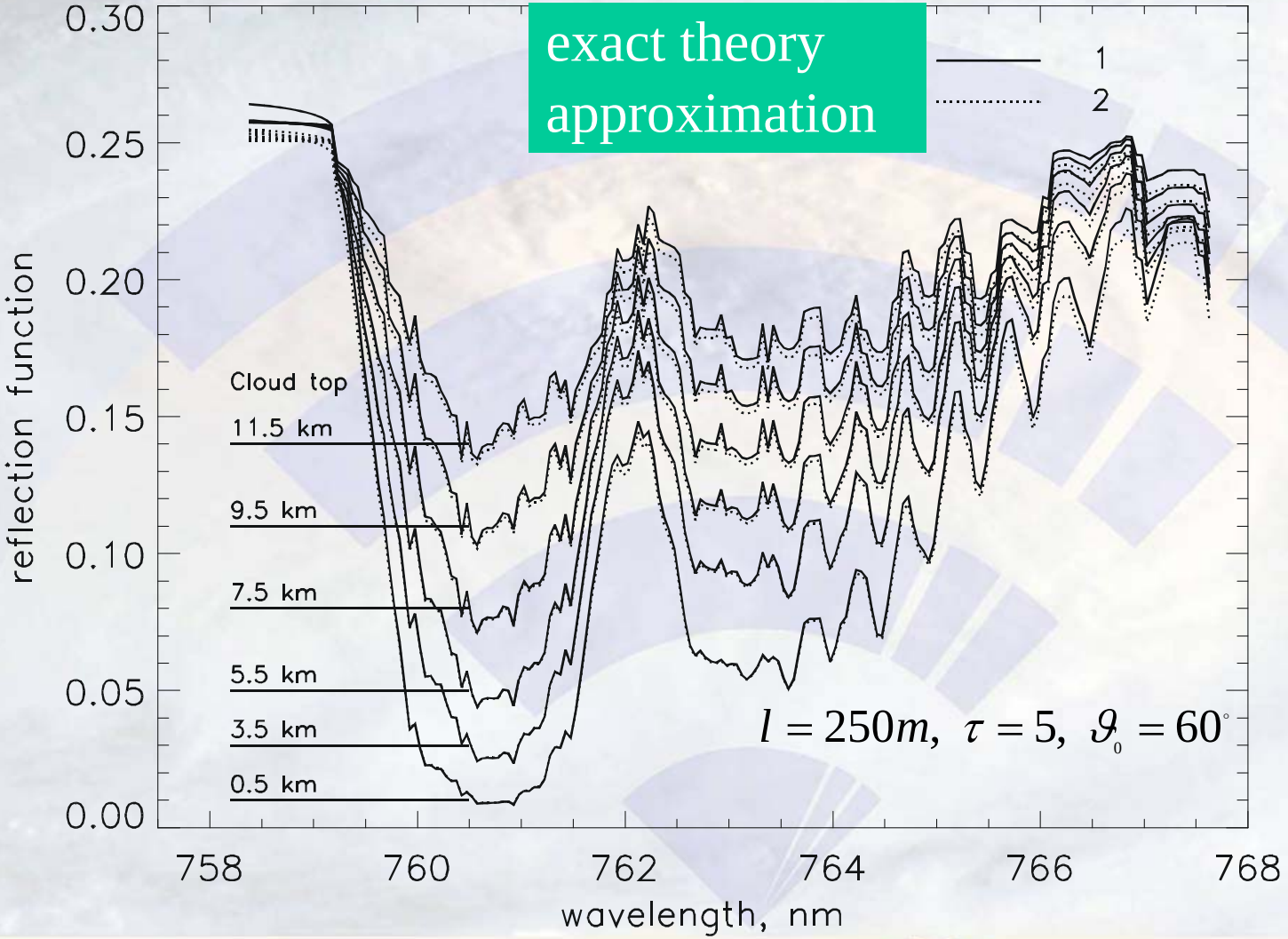
Exact results: symbols

Lines: asymptotic radiative transfer theory for thick layers(Kokhanovsky et al., JGR, 2003)

r_ef→NIR

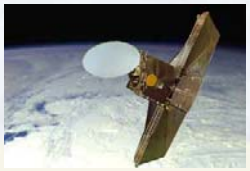
The cloud top height determination

The physical principle behind the retrievals



Yamomoto and Wark, 1961

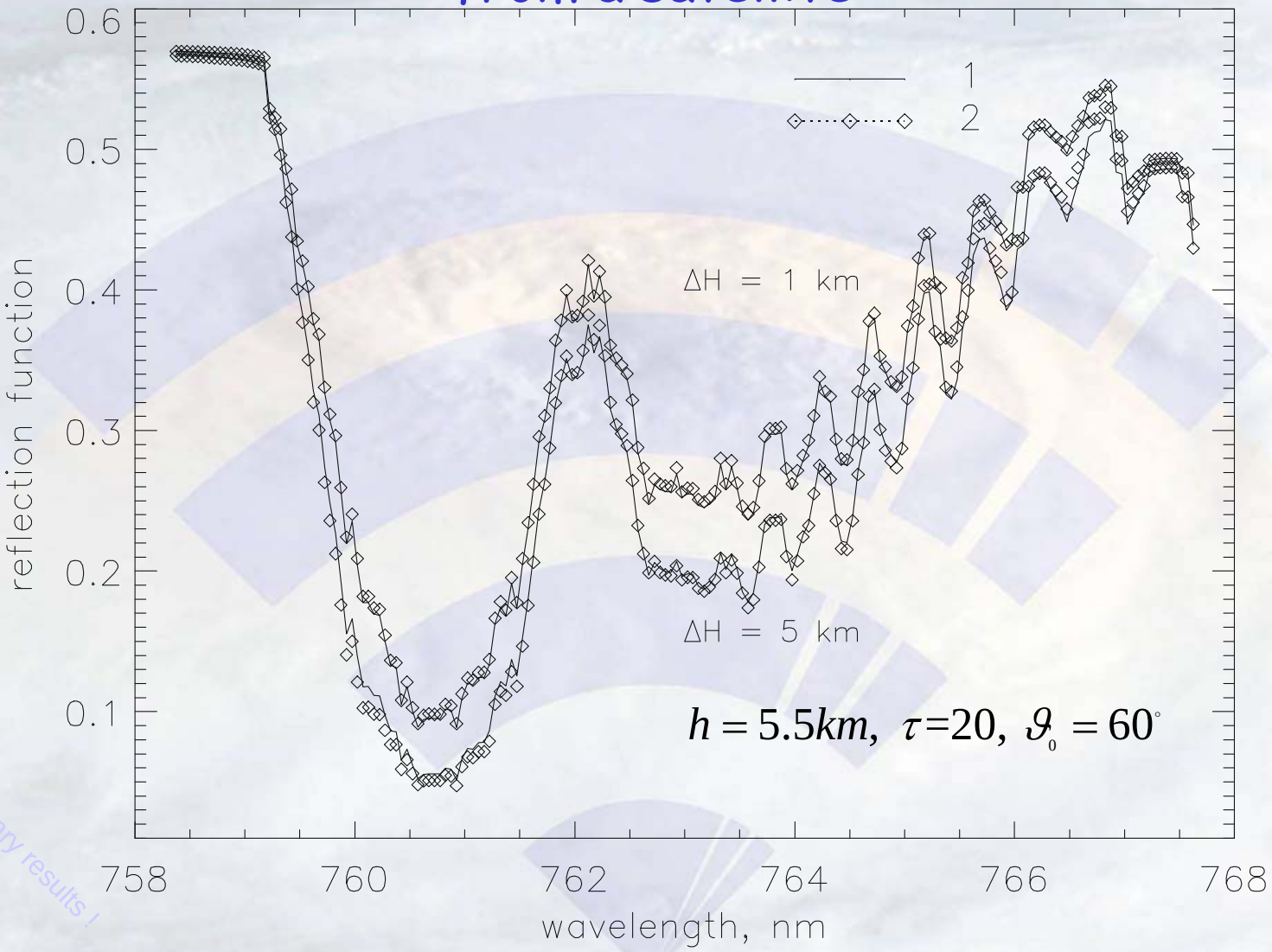
Fischer and Grassl, 1991



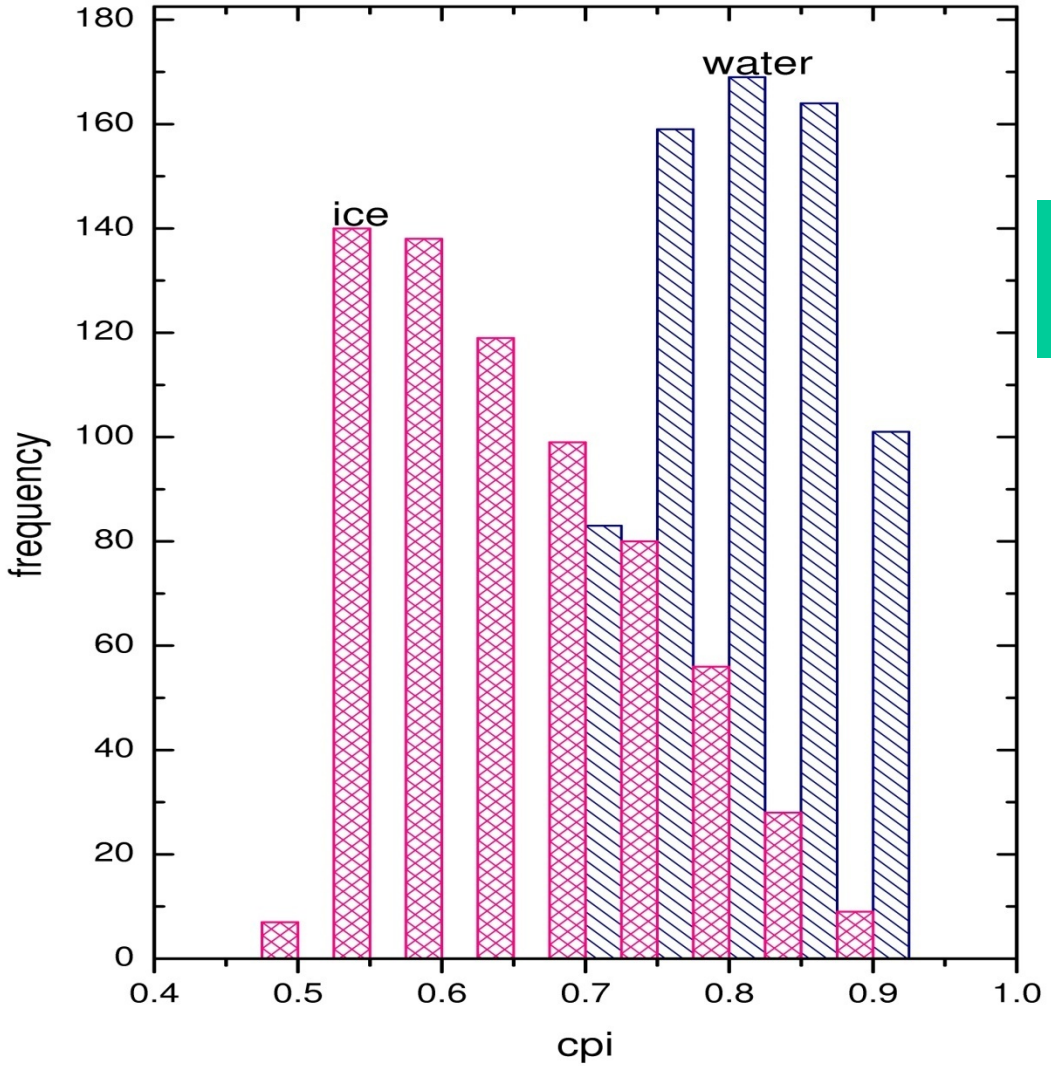
Universität Bremen ife Bremen

ENVISAT SCIAMACHY

Cloud geometrical thickness/bottom height determination from a satellite



The cloud phase discrimination



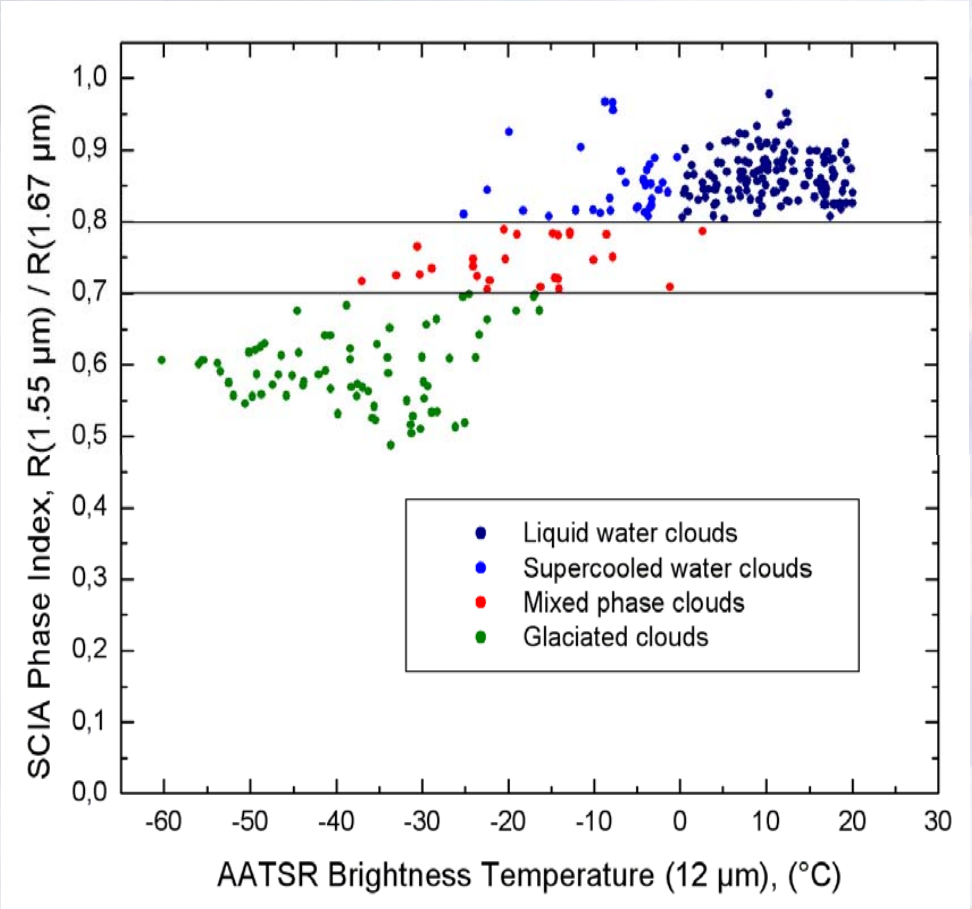
R(1550nm)/R(1670nm)

Radiative transfer calculations

COT: 5-30

a_ef: 5-30 micron

The cloud phase discrimination : (P,T) diagram (Kokhanovsky et al., IEEE Trans. Geosci. Rem Sens., Letters, 2006, v.3, p.103-106)

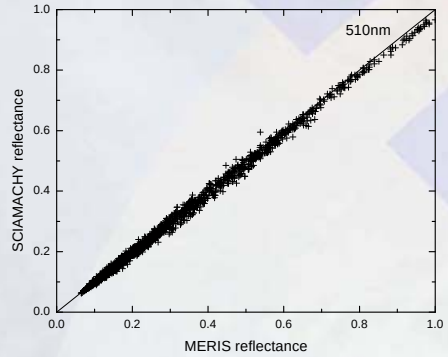


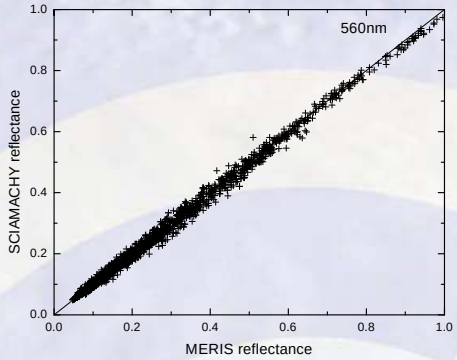
- **Cloud cover inferred from AATSR (cc=100%)**
- **Ratio of two IR reflectance can be used to roughly distinguish liquid from ice phase clouds (SCIA)**
- **BT measurements validate and refine the classification based on SCIA phase index**
- **Supercooled and mixed phase clouds can only be accurately identified from the synergy of SCIA and AATSR**

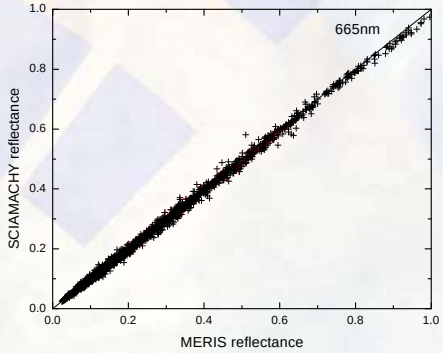
Only combined measurements from SCIA and AATSR allow proper cloud top phase discrimination

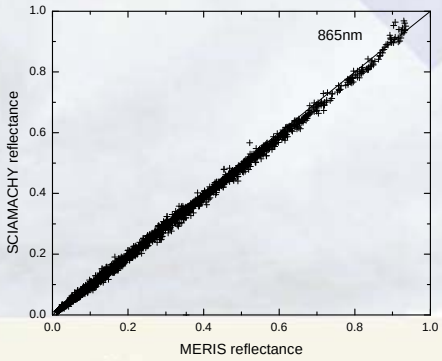
SCIAMACHY calibration

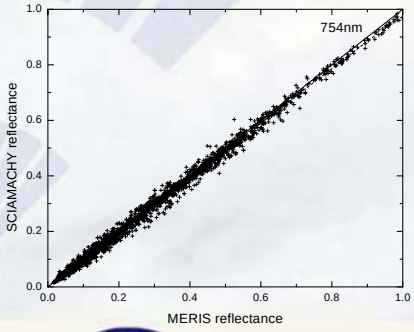
The intercomparison of MERIS and SCIAMACHY reflectances











VALIDATION: CTH

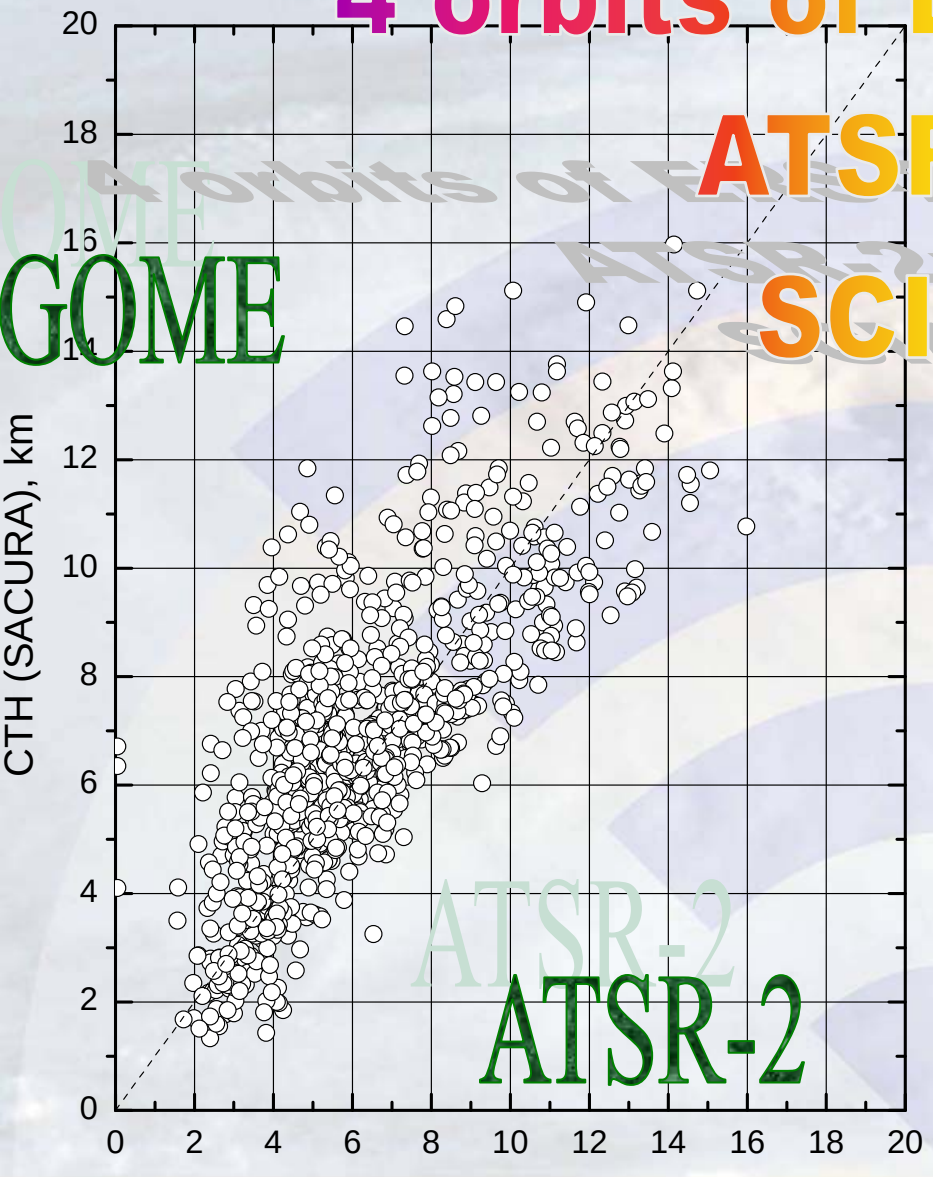
4 orbits of ERS-2, 931 pixels

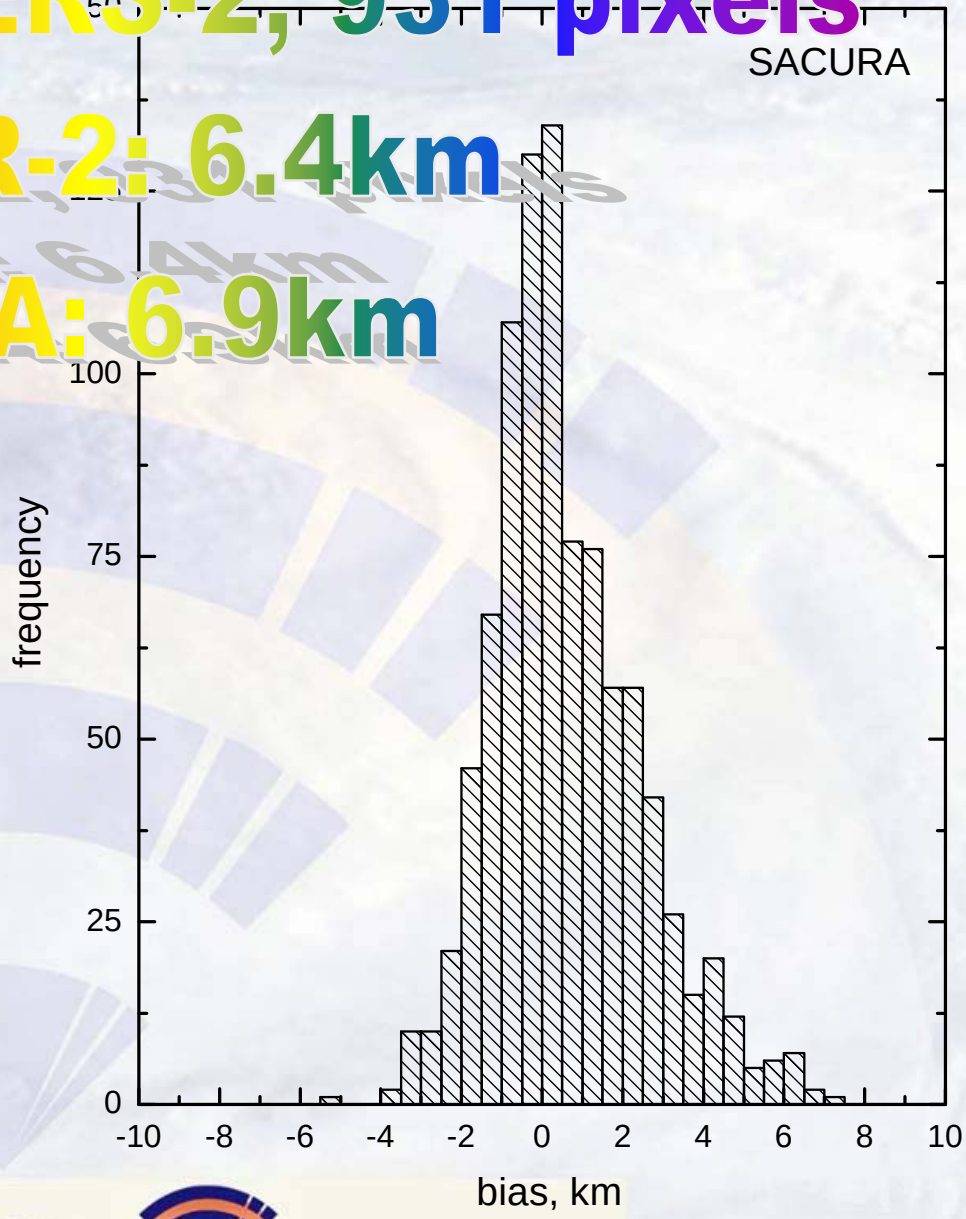
ATSR-2: 6.4km

SCIA: 6.9km

GOME

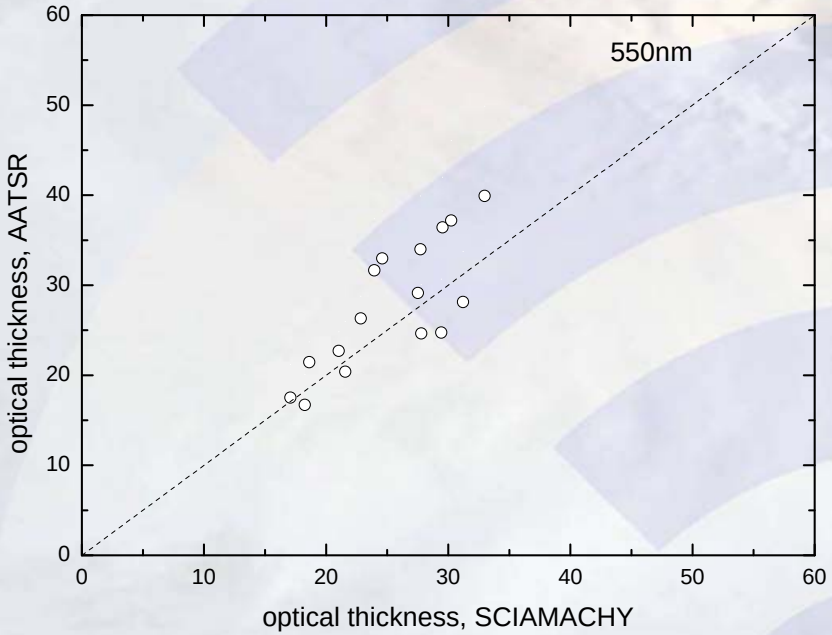
ATSR-2





Rozanov et al., 2006, Remote Sens. Env., v.102, 186-193.

Cloud optical thickness: inter-comparisons with AATSR, MERIS



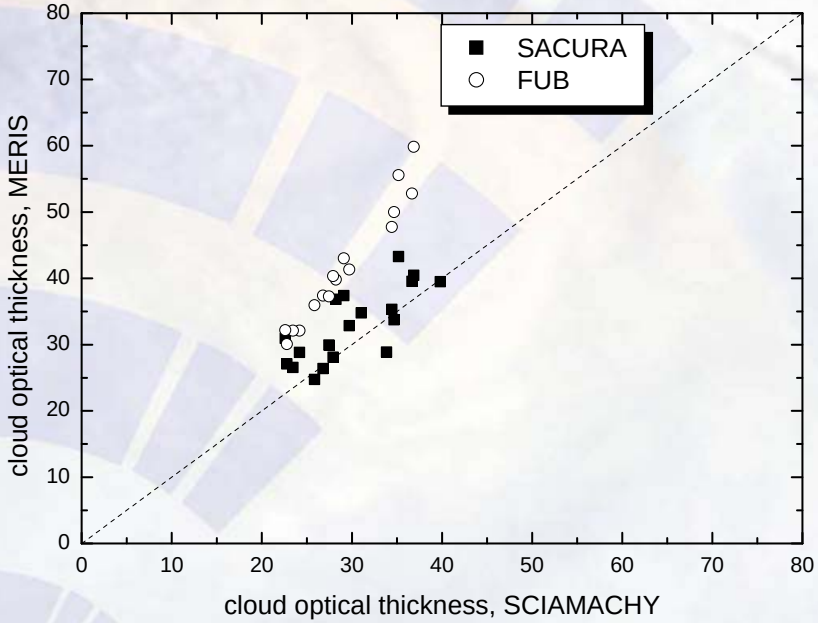
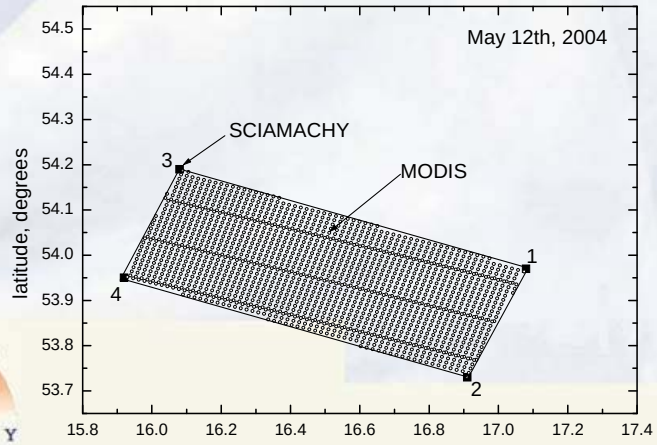


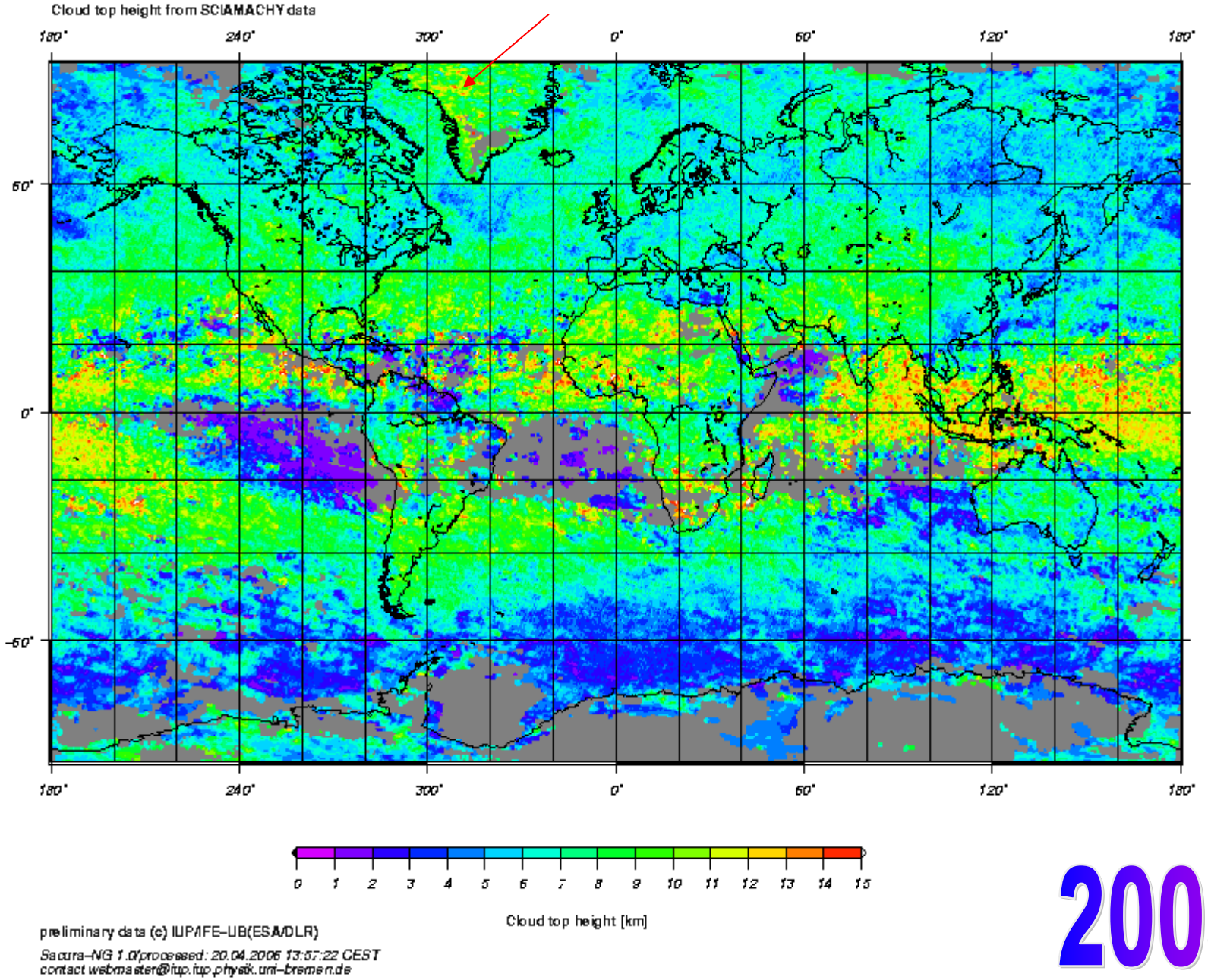
Table 1. Cloud parameters retrieved using SCIAMACHY and MODIS. The center of the SCIAMACHY pixel is located at (16.49E, 53.96N). Corners are located at the following positions: 1- (17.08E, 53.97N) 2-(16.91E,53.73N), 3-(16.08E, 54.19N) , 4 - (15.92E, 53.95N)

Instrument	a_ef, micron	LWP, g/m^2	COT	CTH, km
SCIAMACHY	10.08	87.26	13.51	3.30
MODIS	9.7	102.38	16.65	2.76
Difference	**+0.38**	**-15.12**	**-3.14**	**+0.54**

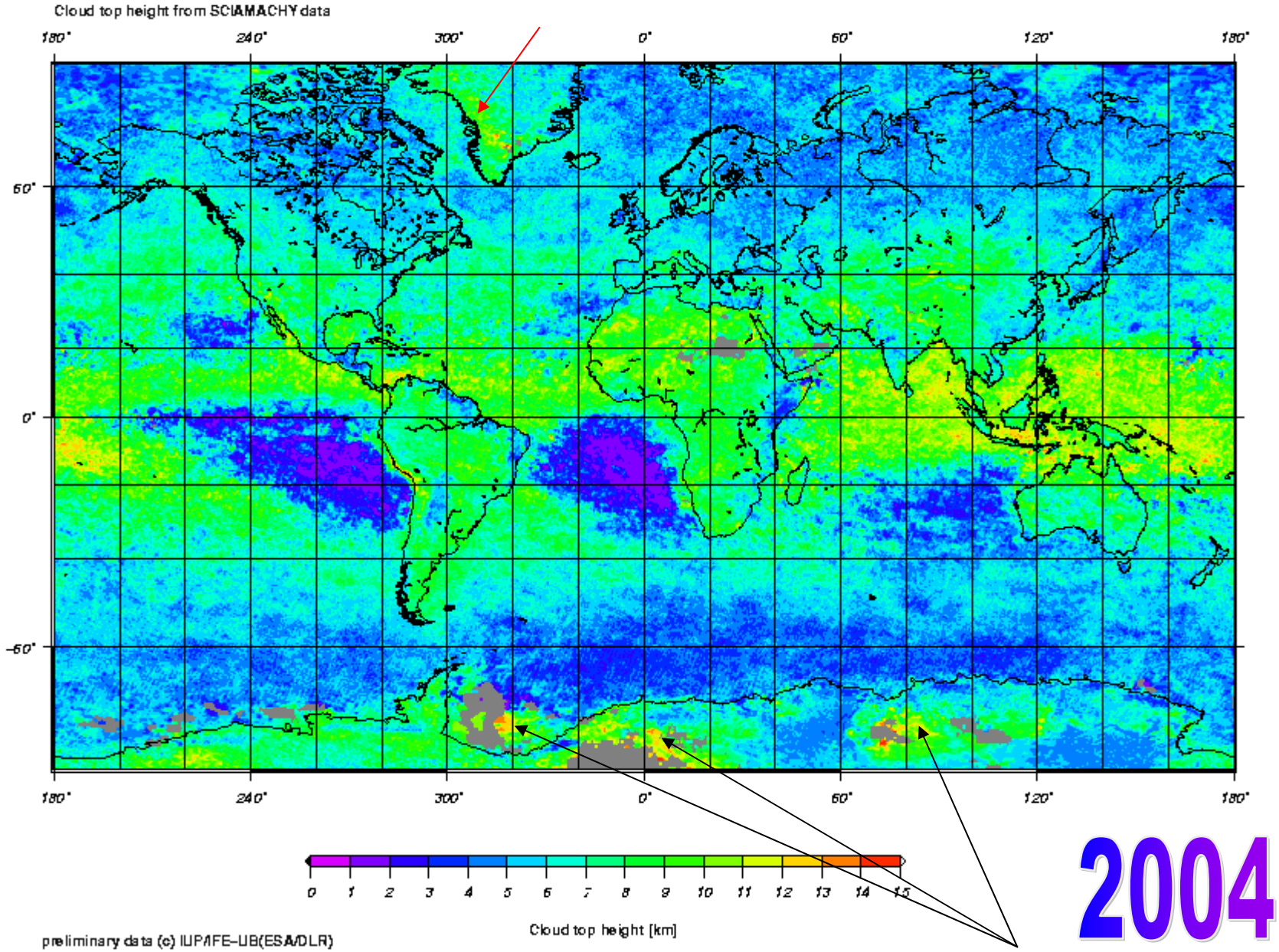
MODIS

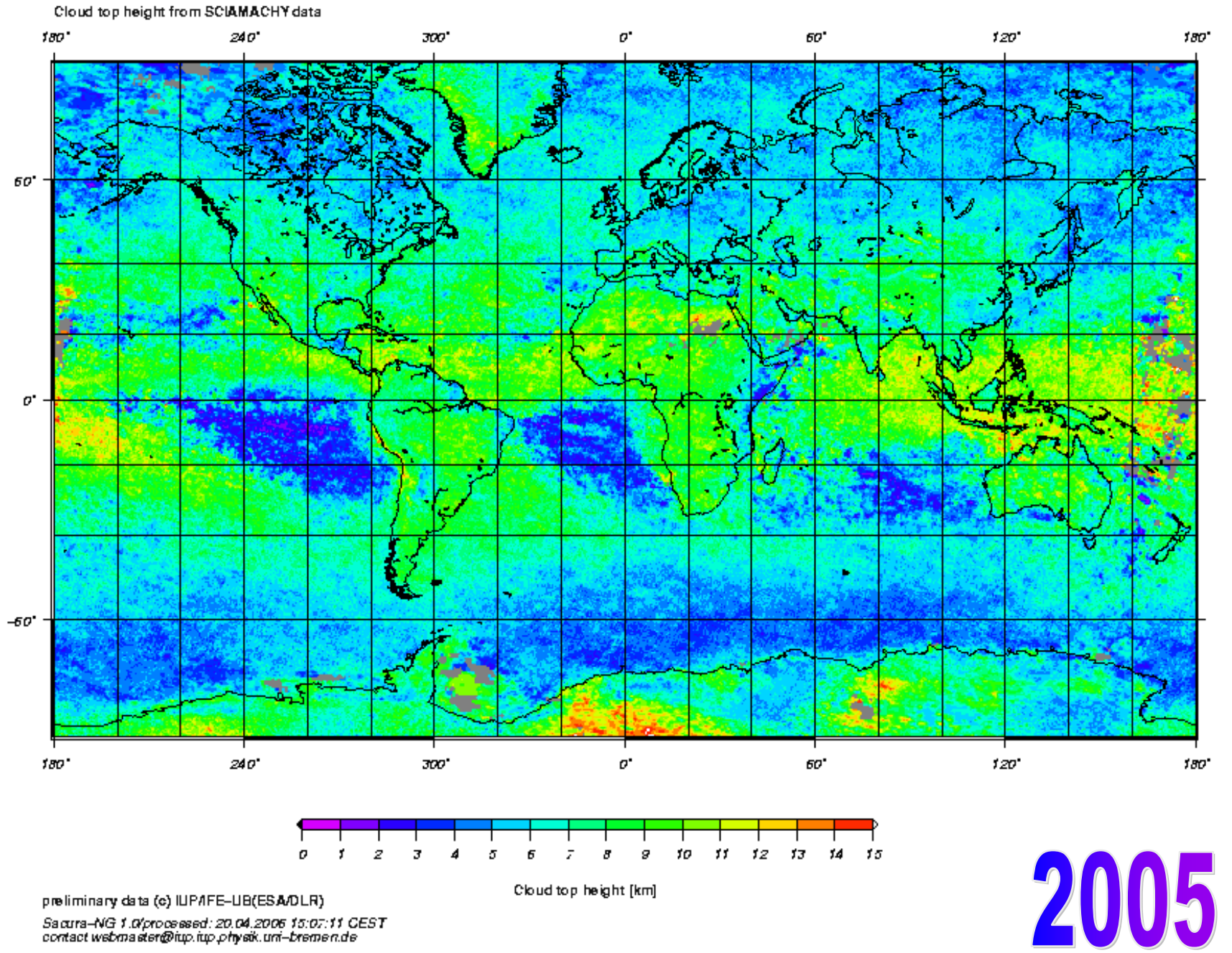


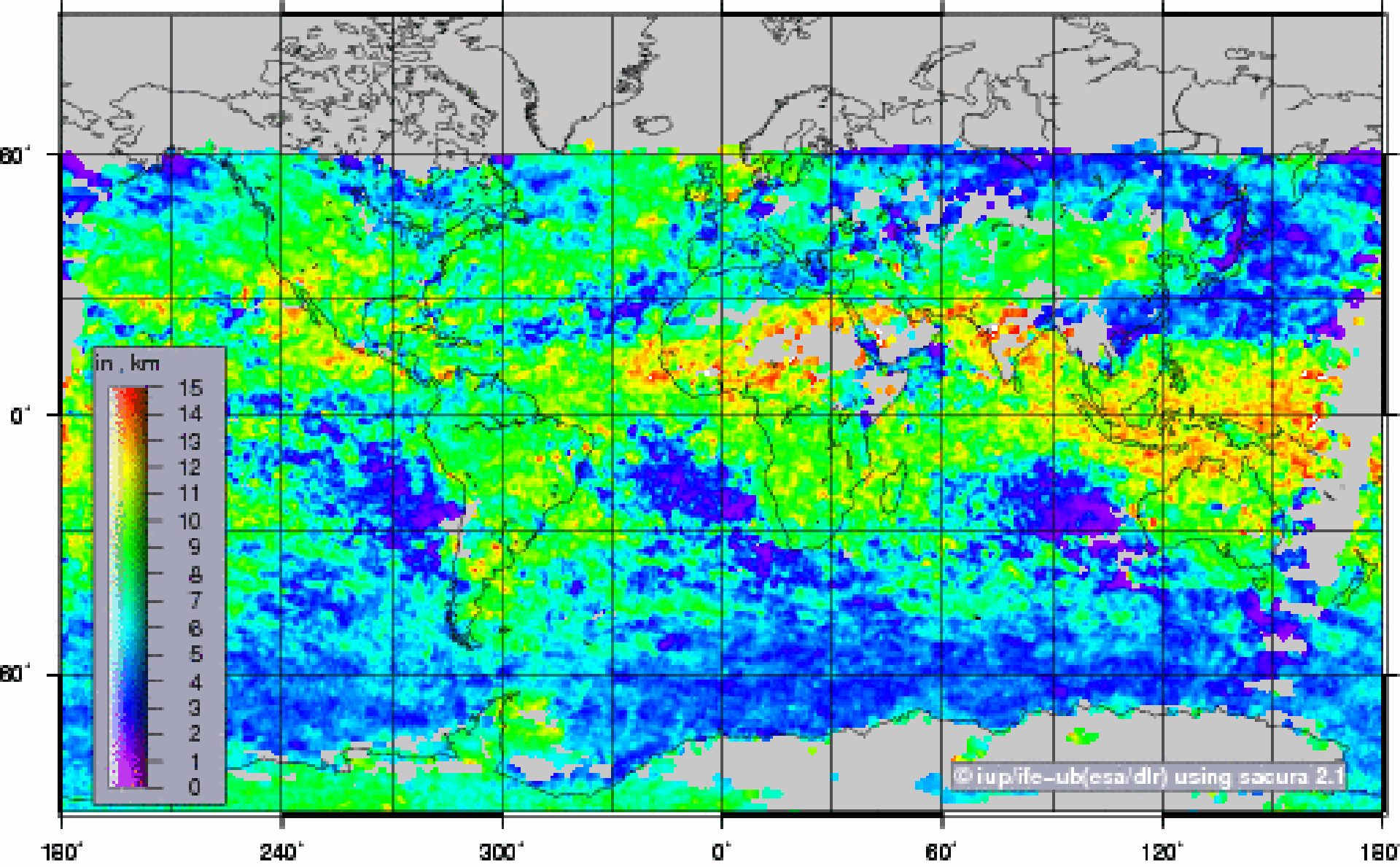
III. GLOBAL RESULTS



2003


Cloud top height from SCIAMACHY data
180°
240°
300°
0°
60°
120°
180°
60°
0°
-60°
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Cloud top height [km]
2004
preliminary data (c) IUP/IFE-UB(ESA/DLR)
Sacura-NG 1.0/processed: 20.04.2006 14:24:42 CEST
contact webmaster@iup.iup.physik.uni-bremen.de

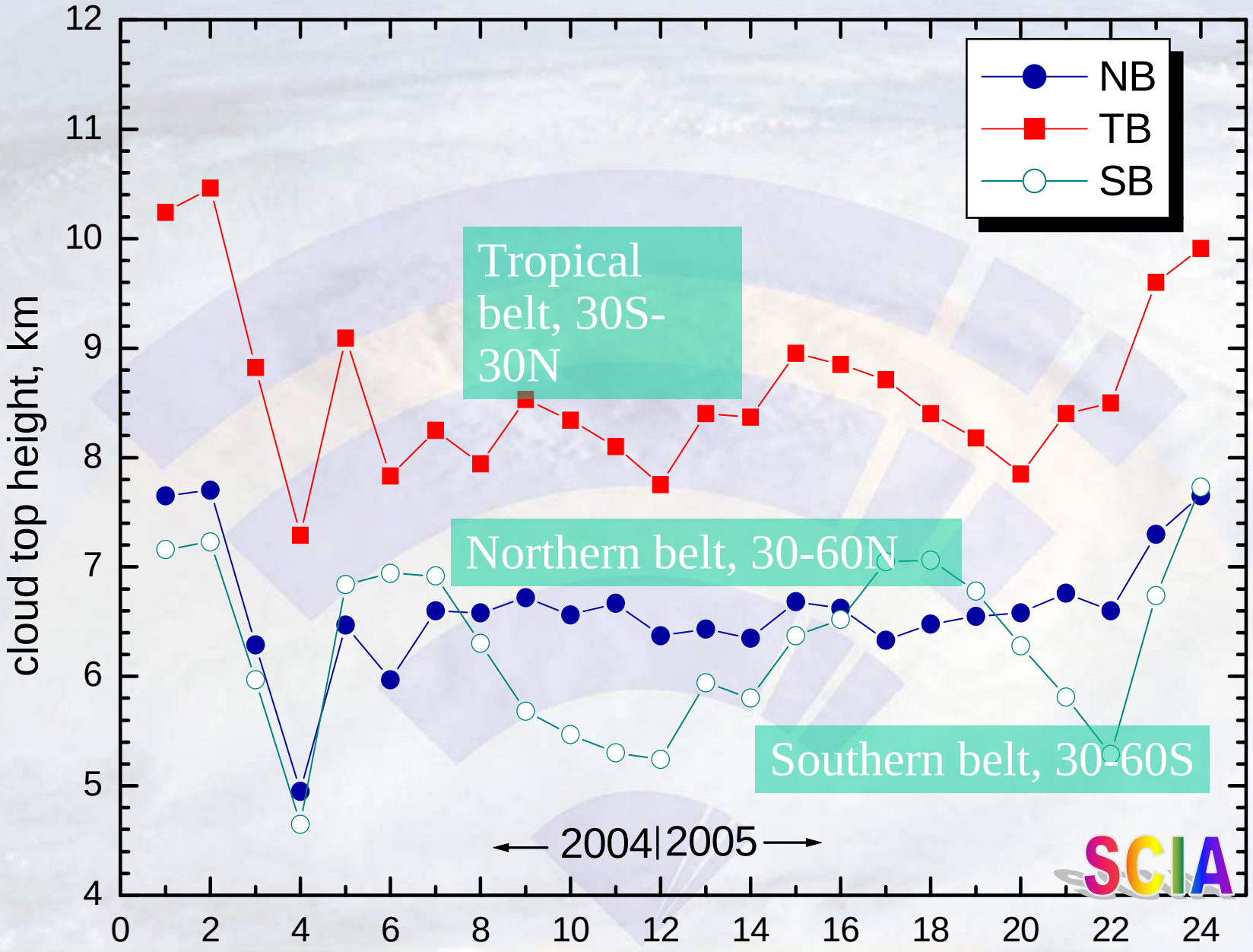

Cloud top height from SCIAMACHY data
180°
240°
300°
0°
60°
120°
180°
60°
0°
-60°
180°
240°
300°
0°
60°
120°
180°
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Cloud top height [km]
preliminary data (c) IUP/IFE-UB(ESA/DLR)
Sacura-NG 1.0/processed: 20.04.2006 15:07:11 CEST
contact webmaster@iup.iup.physik.uni-bremen.de
2005



Cloud top height from SCIAMACHY data (01. January 2006 – 31. January 2006)

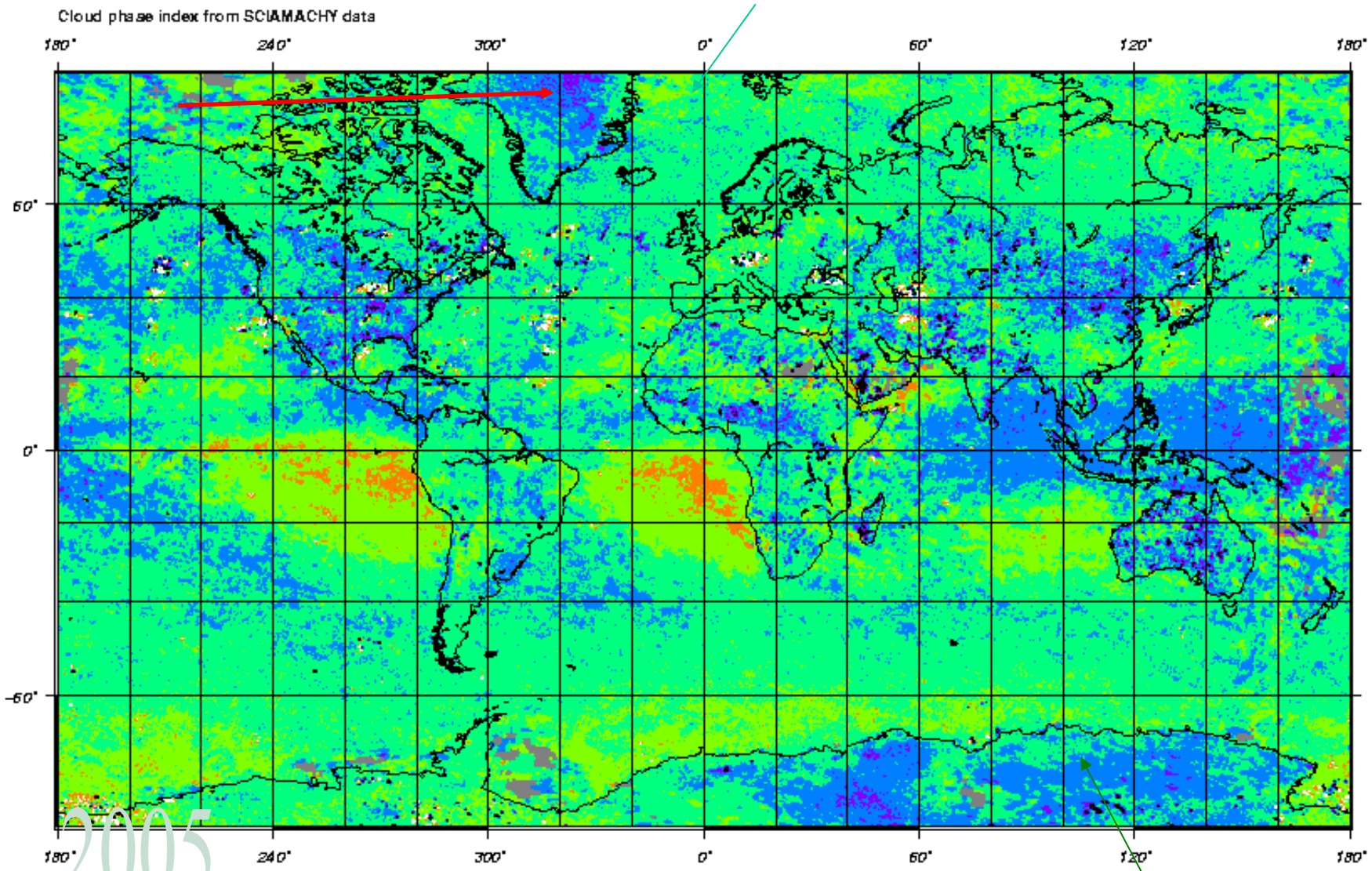
Universität Bremen ife Bremen

ENVISAT SCIAMACHY



Universität Bremen ife Bremen

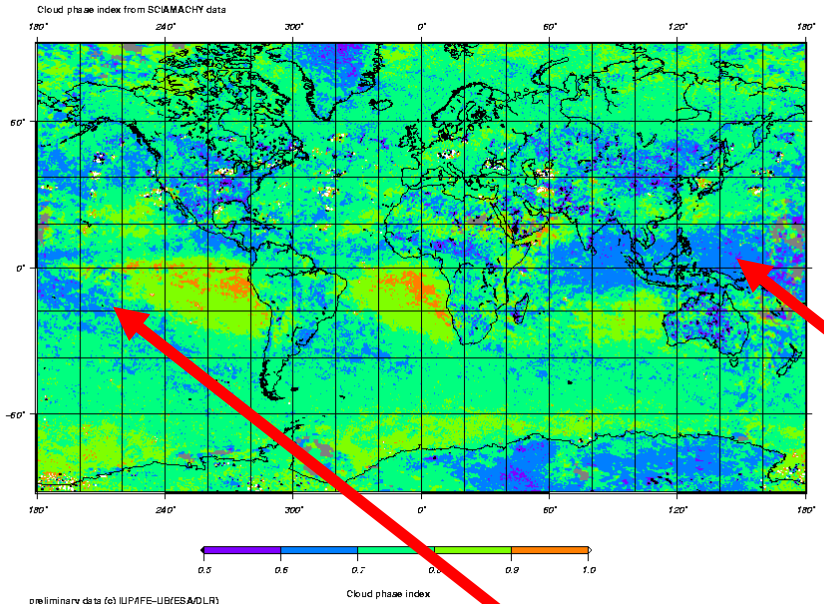
ENVISAT SCIAMACHY



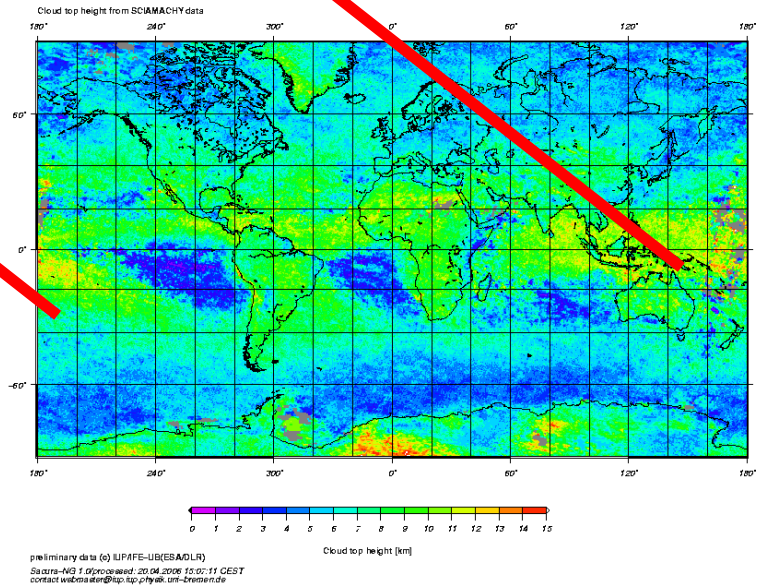
2005

R 1570/R 1660

PHASE INDEX

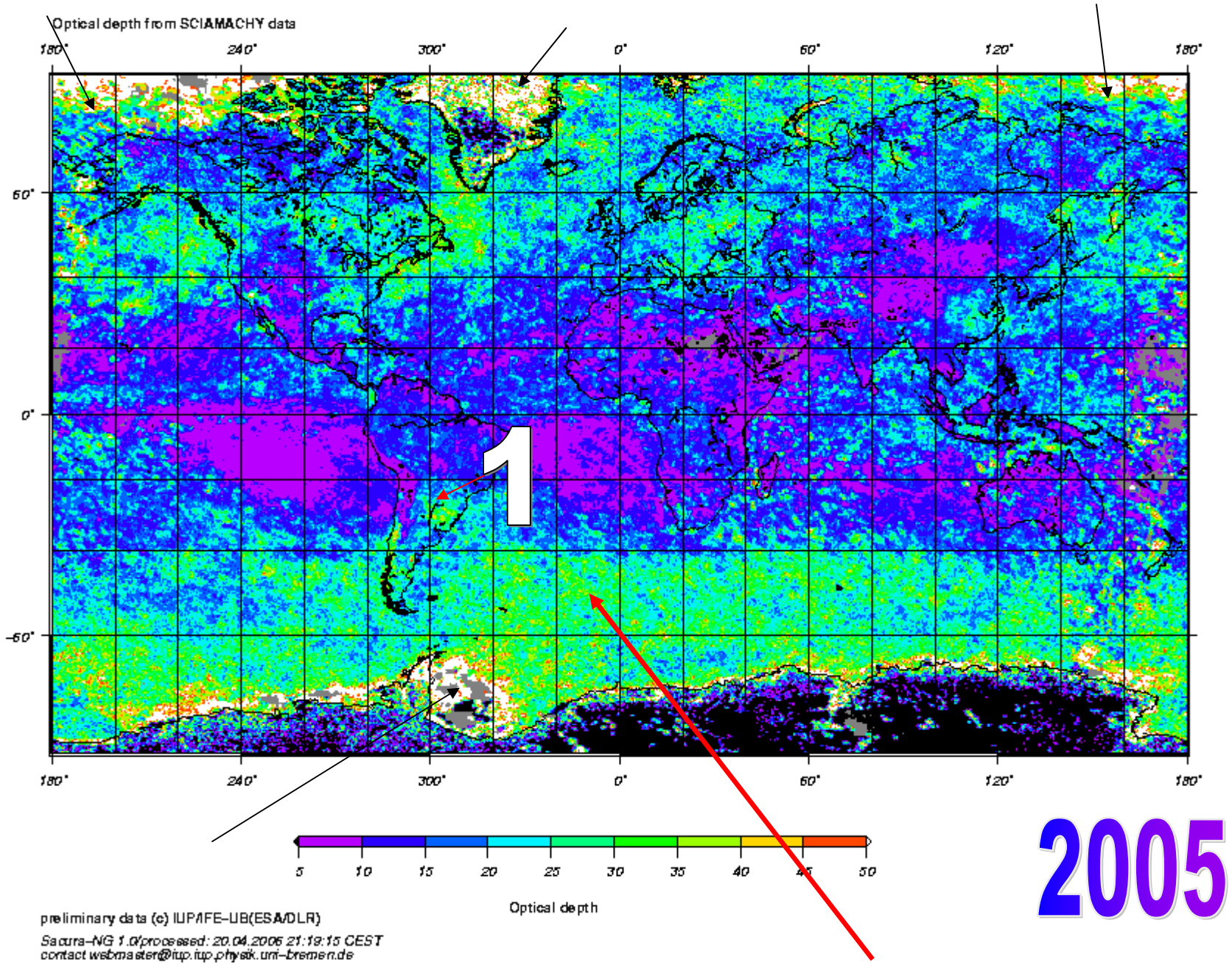


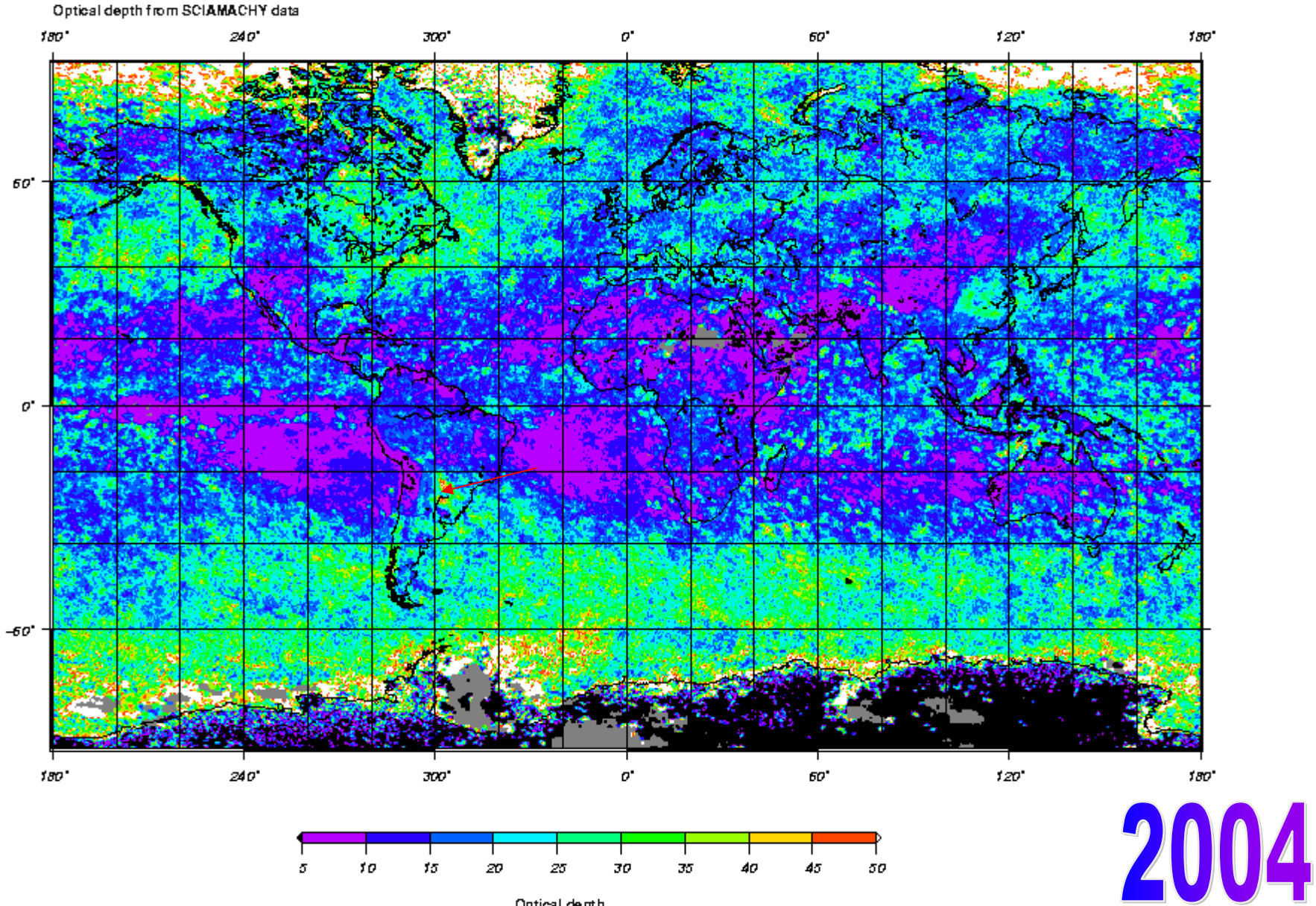
CTH

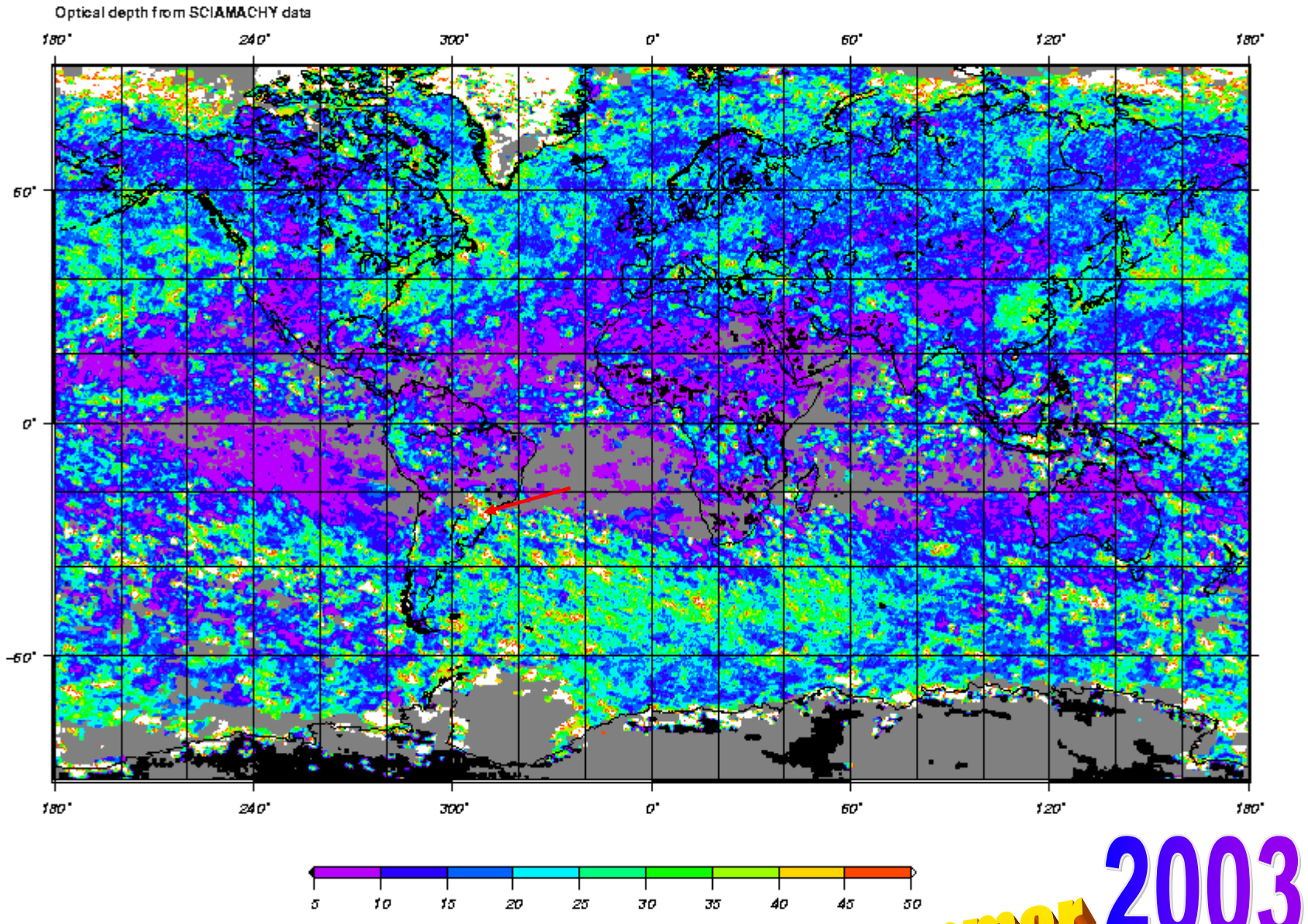


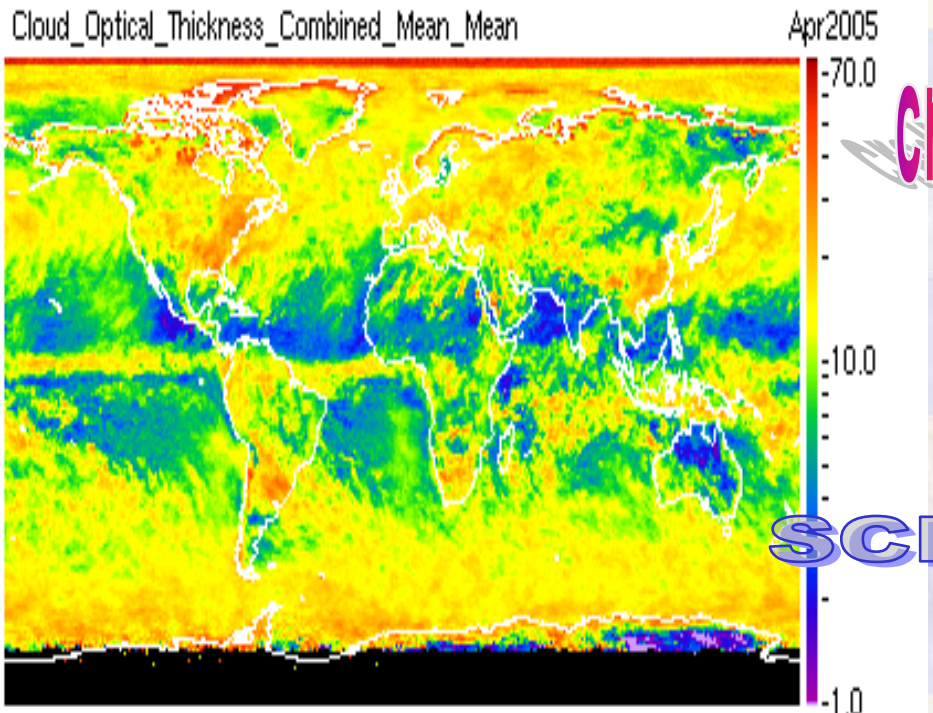
Universität Bremen ife Bremen

ENVISAT SCIAMACHY


Optical depth from SCIAMACHY data
180°
240°
300°
0°
60°
120°
180°
60°
0°
-60°
1
5
10
15
20
25
30
35
40
45
50
Optical depth
preliminary data (c) IUP/IFE-UB(ESA/DLR)
Sacura-NG 1.0/processed: 20.04.2006 21:19:15 CEST
contact webmaster@iup.iup.physik.uni-bremen.de
2005


Optical depth from SCIAMACHY data
180°
240°
300°
0°
60°
120°
180°
60°
0°
-60°
180°
240°
300°
0°
60°
120°
180°
5
10
15
20
25
30
35
40
45
50
Optical depth
2004
preliminary data (c) IUP/IFE-UB(ESA/DLR)
Sacura-NG 1.0/processed: 20.04.2006 20:38:20 CEST
contact webmaster@iup.iup.physik.uni-bremen.de

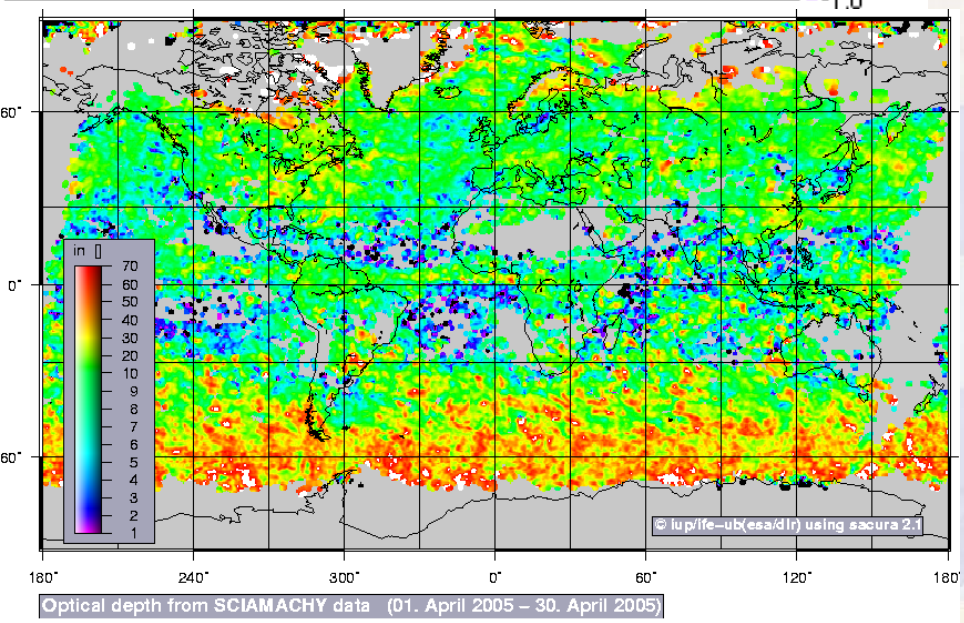

Optical depth from SCIAMACHY data
180°
240°
300°
0°
60°
120°
180°
60°
0°
-60°
180°
240°
300°
0°
60°
120°
180°
5
10
15
20
25
30
35
40
45
50
Optical depth
preliminary data (c) IUP/IFE-UB(ESA/DLR)
Scatra-NG 1.0/processed: 20.04.2006 20:11:25 CEST
contact webmaster@iup.iup.physik.uni-bremen.de
hot summer
2003



credit: NASA

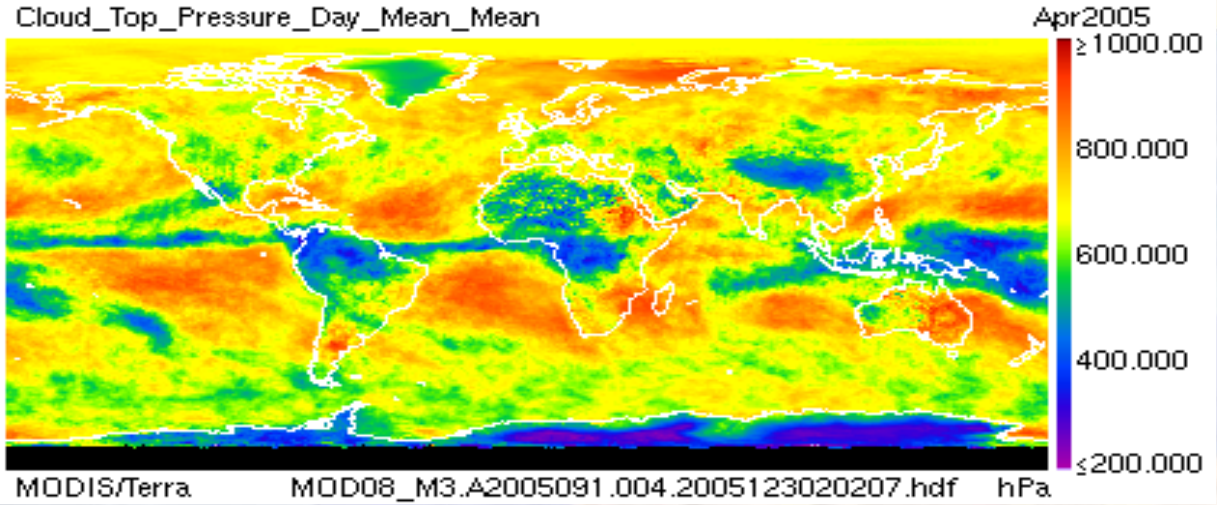
SCIAMACHY/ENVISAT and MODIS/TERRA

April 2005



Universität Bremen ife Bremen

ENVISAT SCIAMACHY

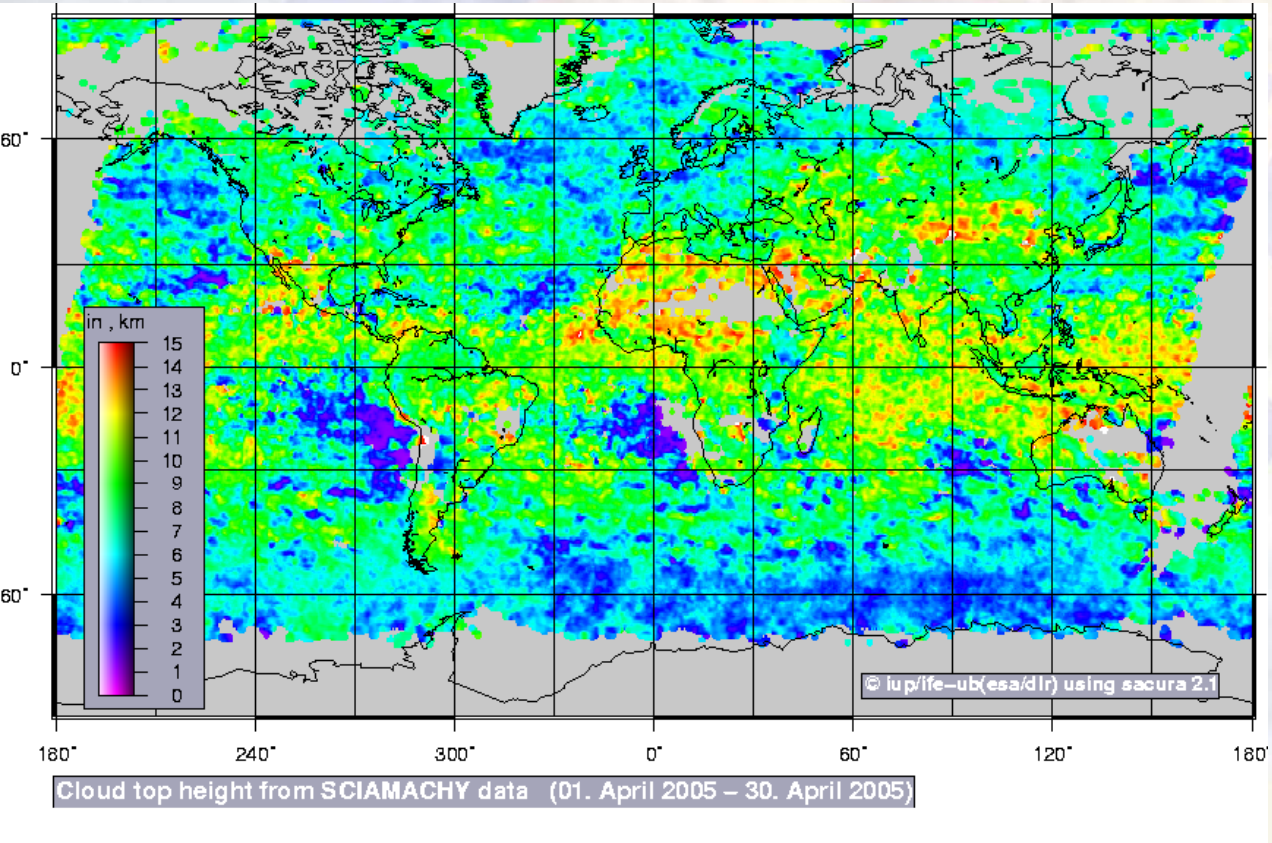


credit: NASA

blue

green

green

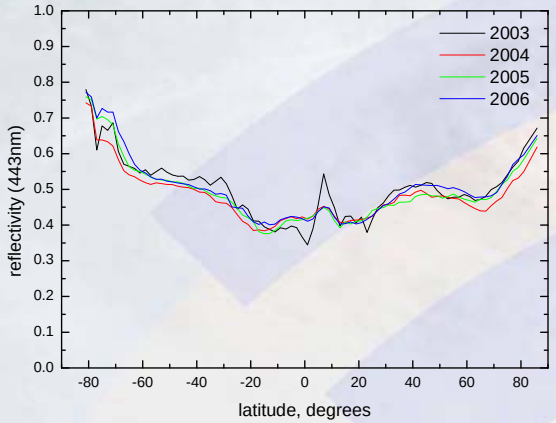


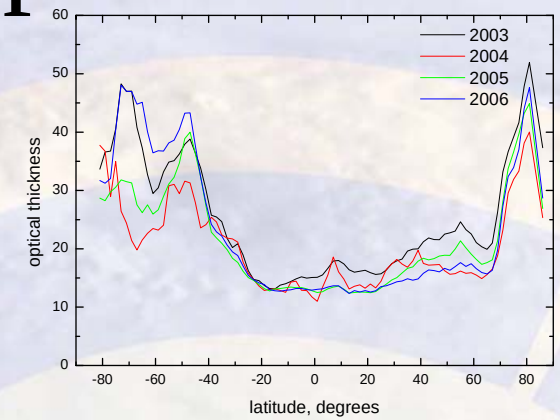
Cloud top height from SCIAMACHY data (01. April 2005 – 30. April 2005)

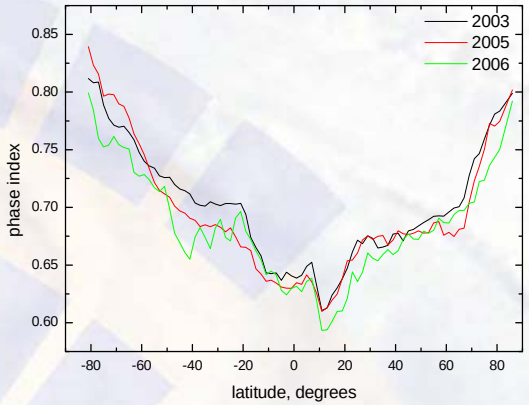
Universität Bremen ife Bremen

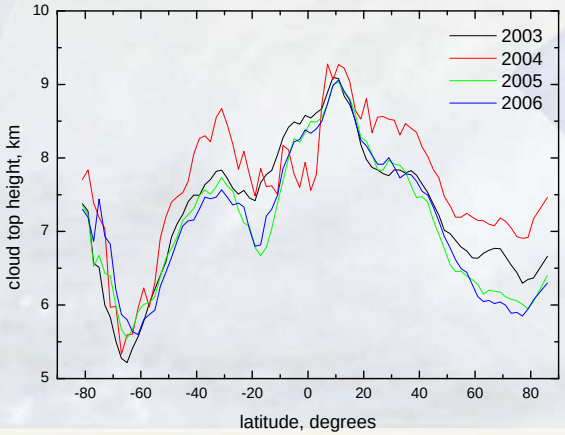
ENVISAT SCIAMACHY

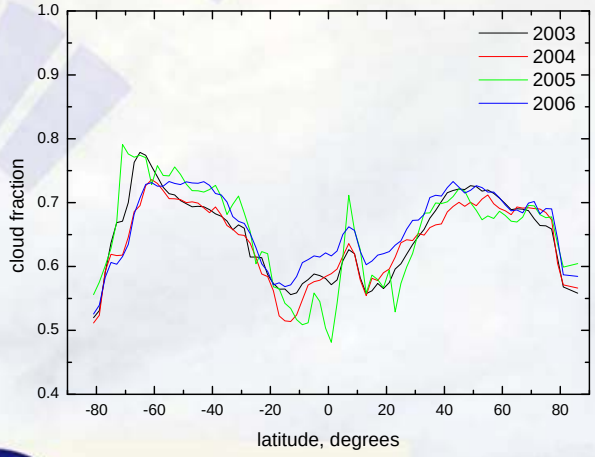
Latitudinal dependence of cloud parameters



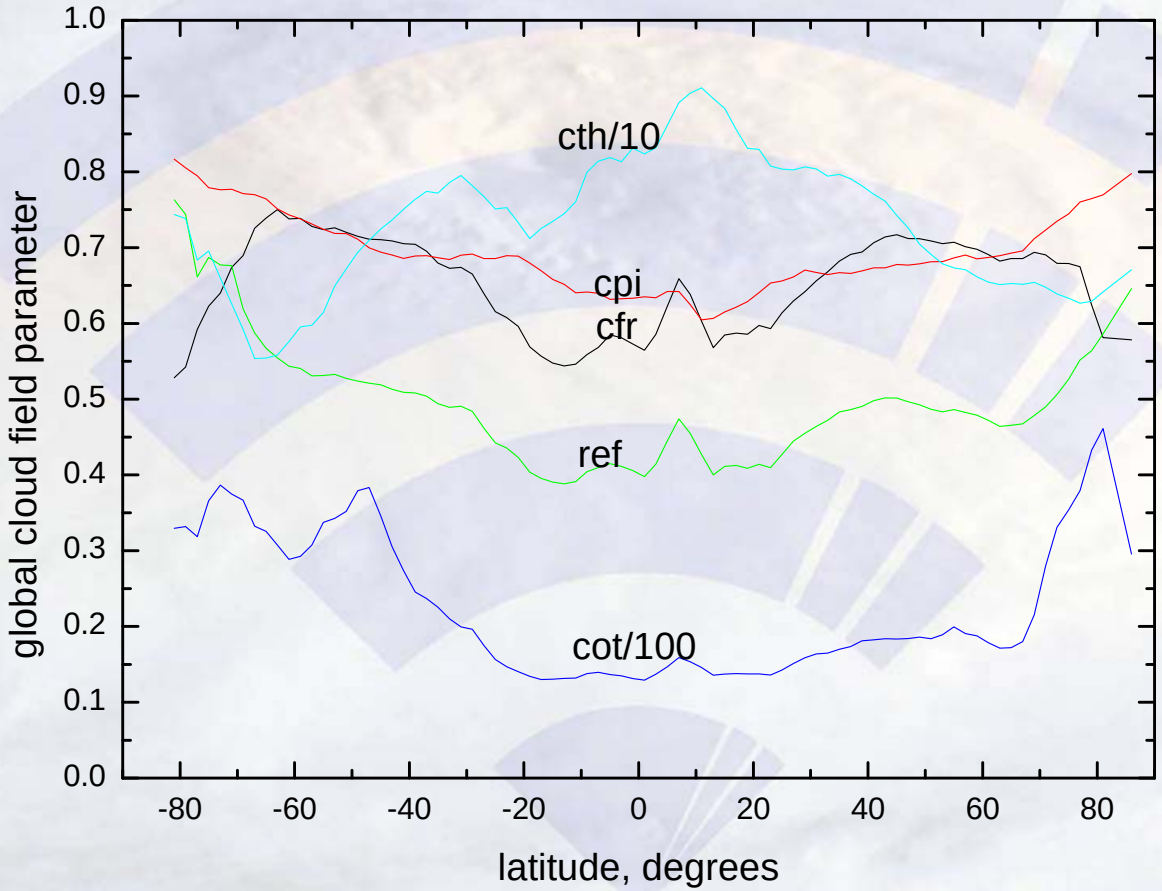






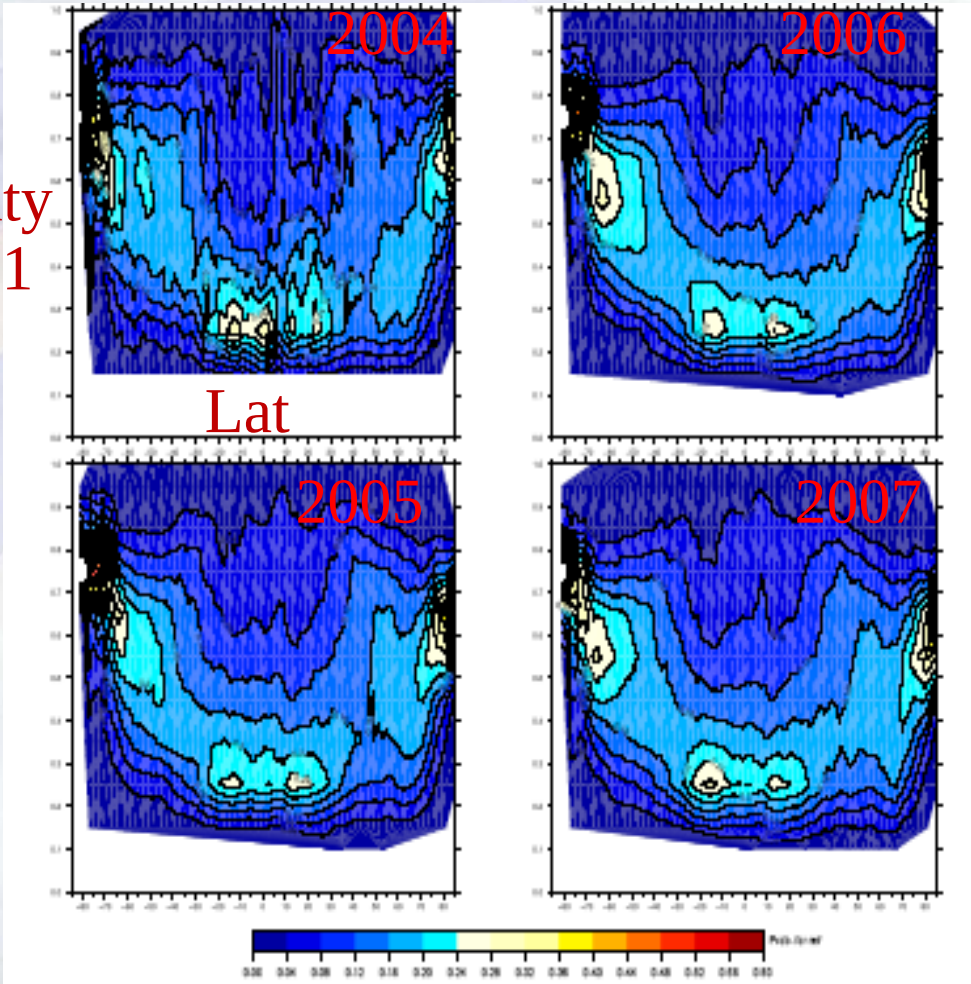


Global statistics: averages for years 2003-3006



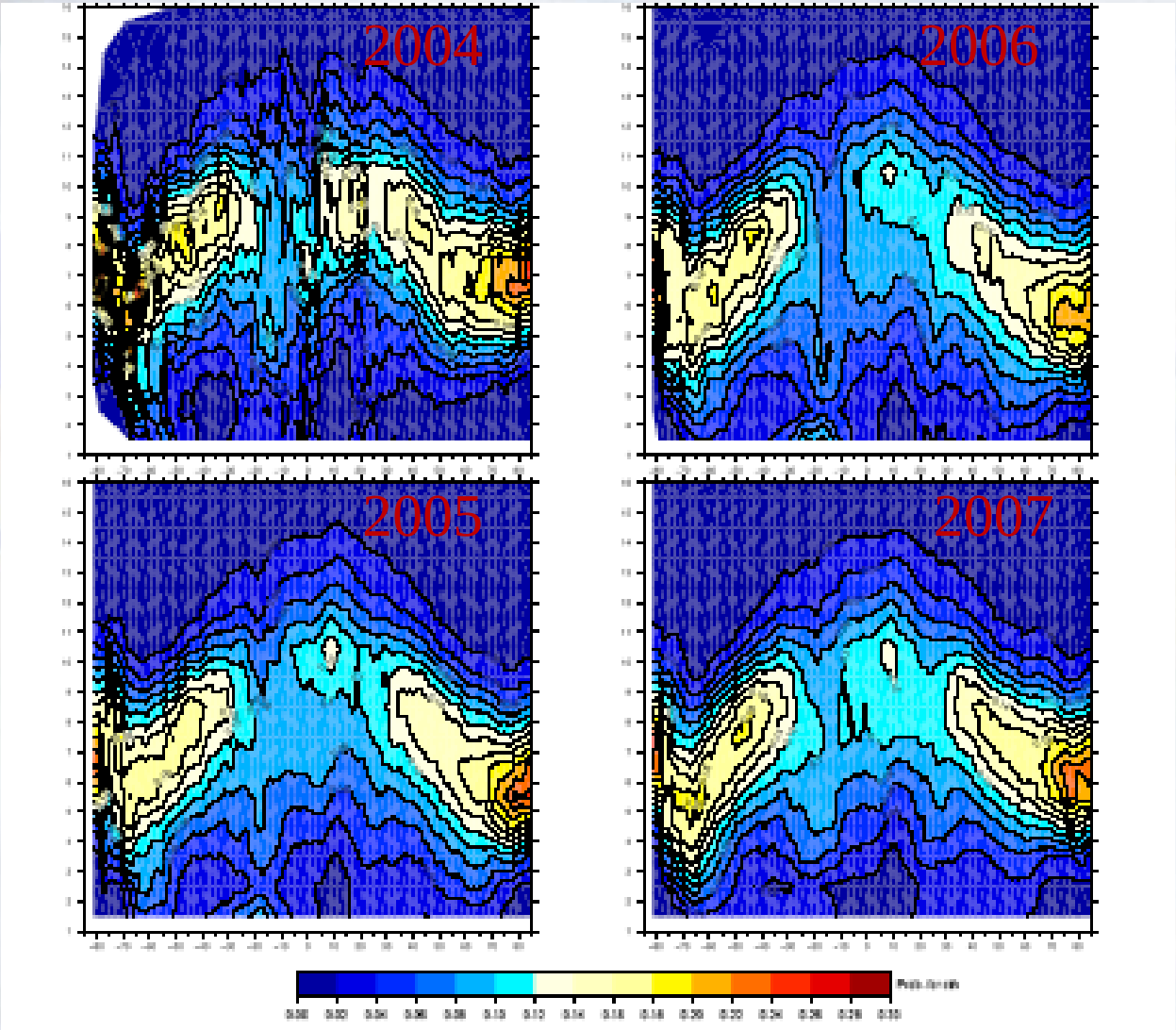
Reflectivity (443nm)

Reflectivity
Range: 0-1

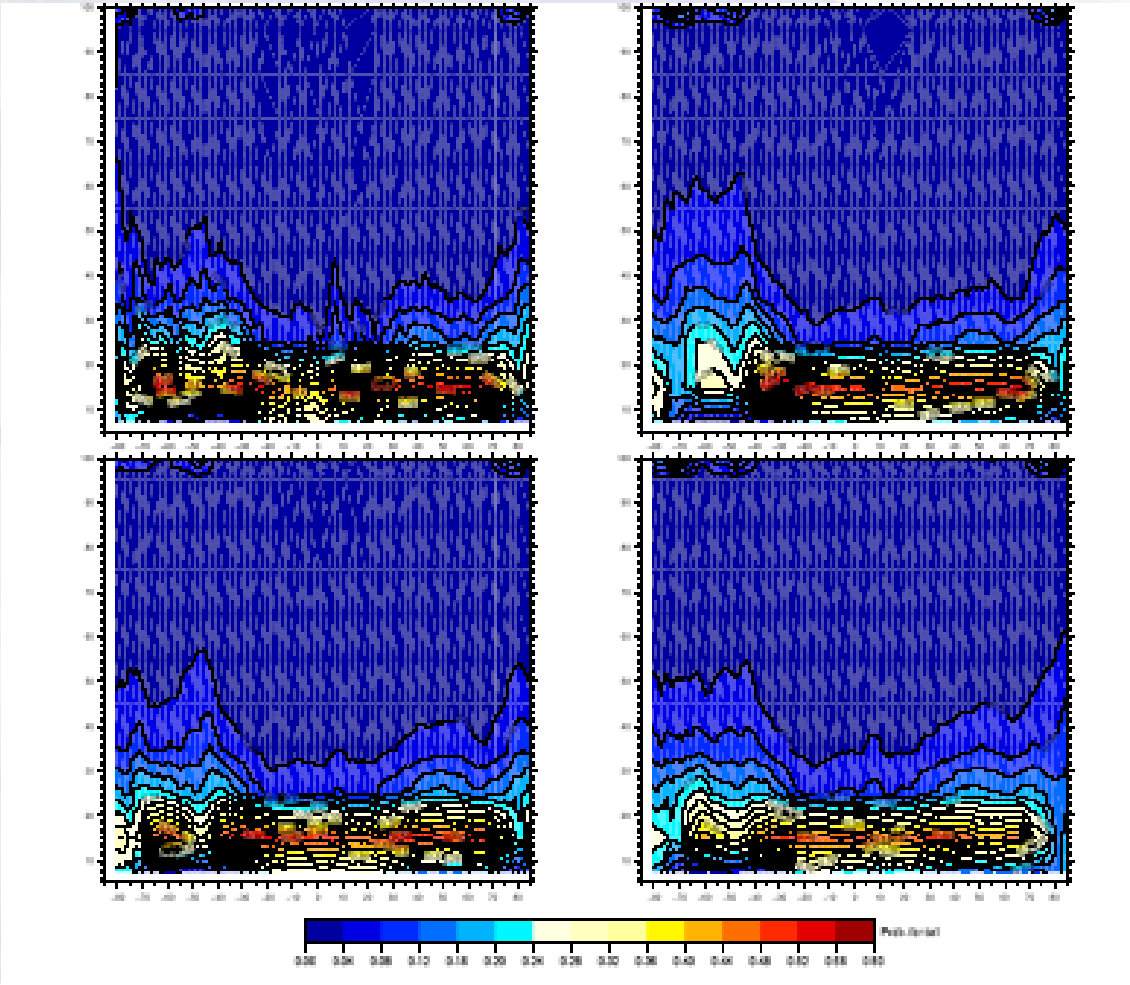


Cloud top height

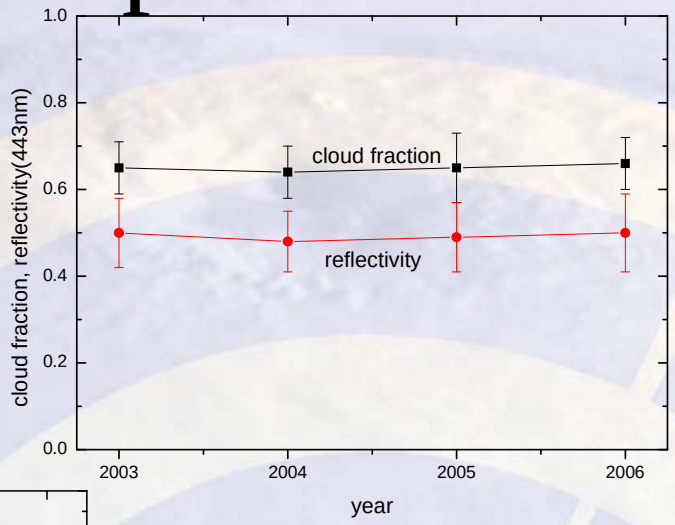
Range:
1-16km

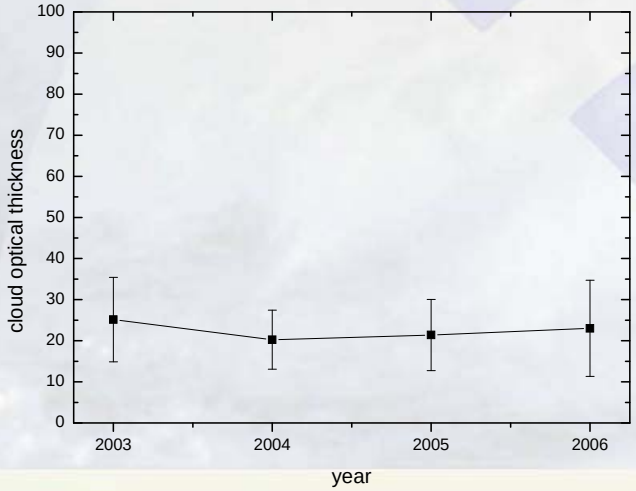


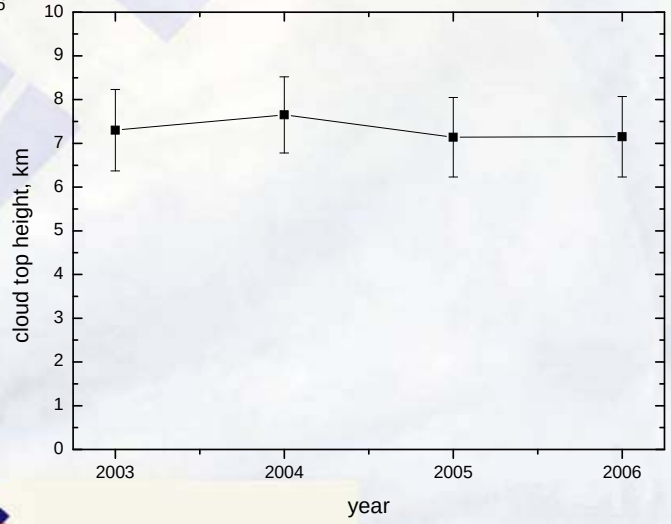
Cloud optical thickness



Annual variations in cloud parameters







Universität Bremen ife Bremen

ENVISAT SCIAMACHY

Conclusions:

- SACURA is capable to derive a number of important cloud parameters on a global scale using SCIAMACHY onboard ENVISAT data

- Further comprehensive validation/ inter-comparison of all derived products is needed

- The results are given as *.pdf files and also as ASCII files at www.iup.physik.uni-bremen.de/sacura 2002-2010

alexk@iup.physik.uni-bremen.de

Further improvements of SACURA:

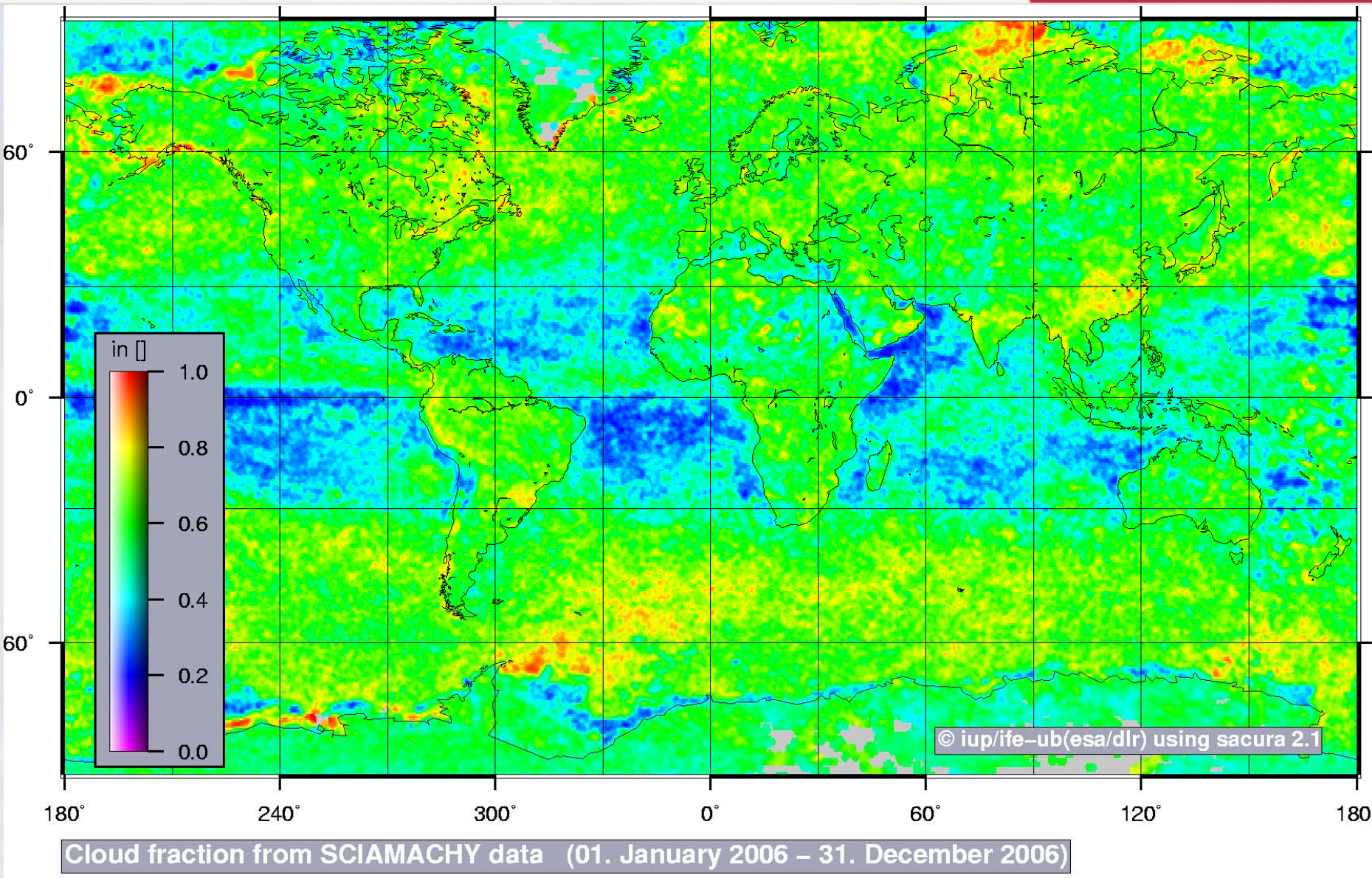
- The snow/cloud discrimination algorithm
- The ice/water cloud separate retrievals
- The MERIS cloud fraction algorithm (G-POD ESA Project)
- The account for thin clouds with LUTs
- The drop of weak absorption assumption
- The improvements of retrievals at high latitudes

Acknowledgements

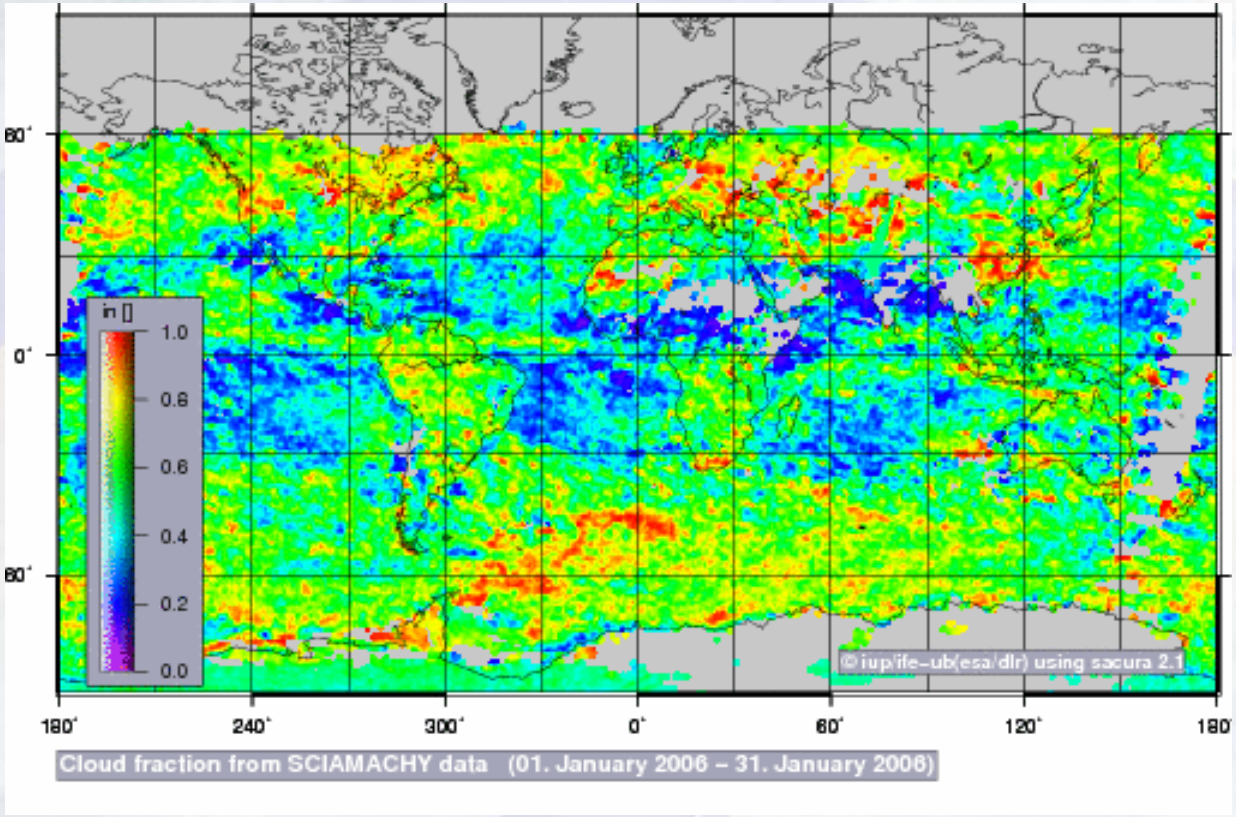
- K. Bramstedt, M. Buchwitz, N. Fournier, O. Jourdan, R. Koelemeijer, B. Latter, D. Loyola, T. Nauss, R. Siddans, P. Stammes, W. von Hoyningen-Huene, E. P. Zege, H. Bovensman, R. Preusker, J. Fischer

- BMBF, DFG, DLR, ESA

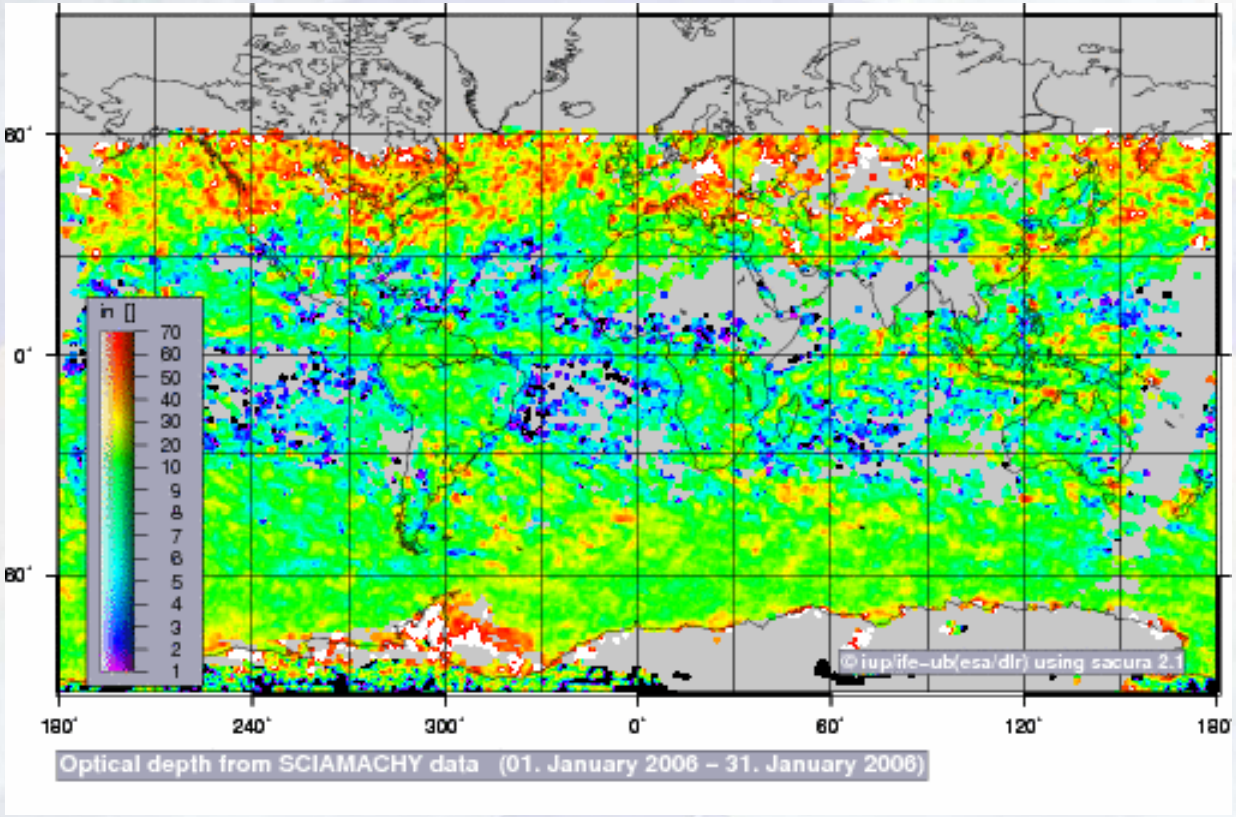
- NASA MODIS team



Cloud fraction from SCIAMACHY data (01. January 2006 – 31. December 2006)



Cloud fraction from SCIAMACHY data (01. January 2006 – 31. January 2006)



Optical depth from SCIAMACHY data (01. January 2006 – 31. January 2006)