SCIAMACHY cloud products

Alexander Kokhanovsky, V. V. Rozanov,
M. Vountas, W. Lotz, K.-U. Eichmann, J. P. Burrows

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

alexk@iup.physik.uni-bremen.de

Universität Bremen ife Bremen ENVISAT SCIAMACHY

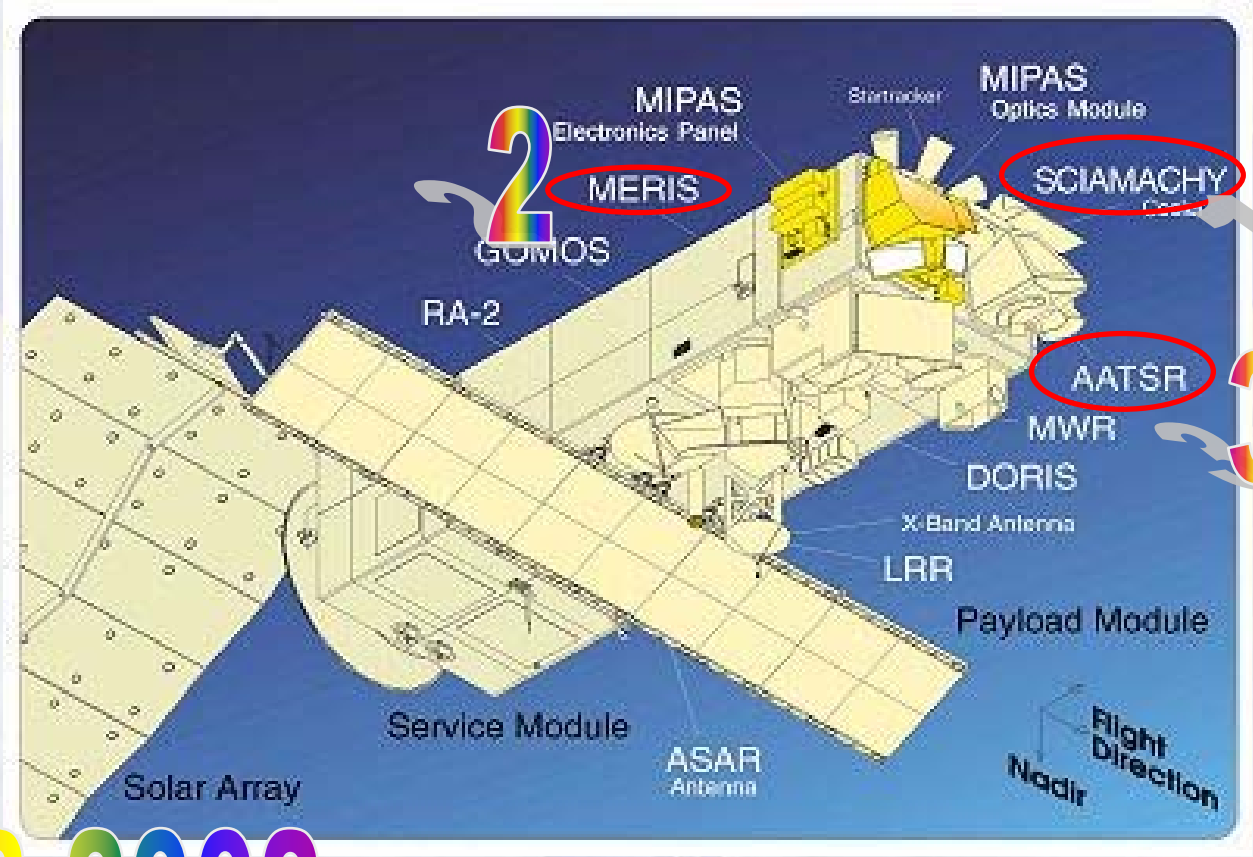
AGENDA

1. SCIAMACHY instrument
2. Algorithms
3. SCIMACHY cloud retrievals
4. Problems to be solved

ENVISAT INSTRUMENTS

10

SCIAMACHY/MERIS/AATSR



2

1

3

01.03.2002

Credit: ESA

Universität Bremen ife Bremen

ENVISAT SCIAMACHY

INVIDIA

ENVISAT Start: 01.03.2002

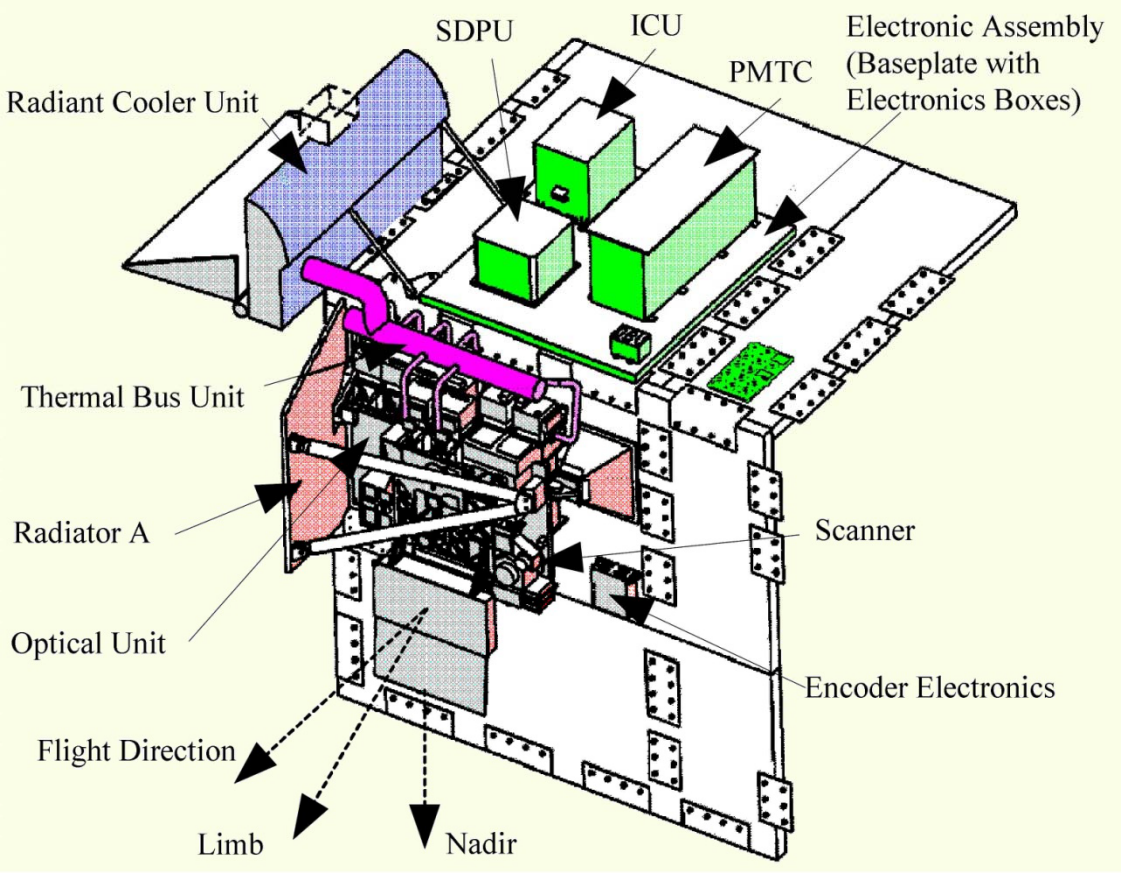
7 years

SCIAMACHY Instrument

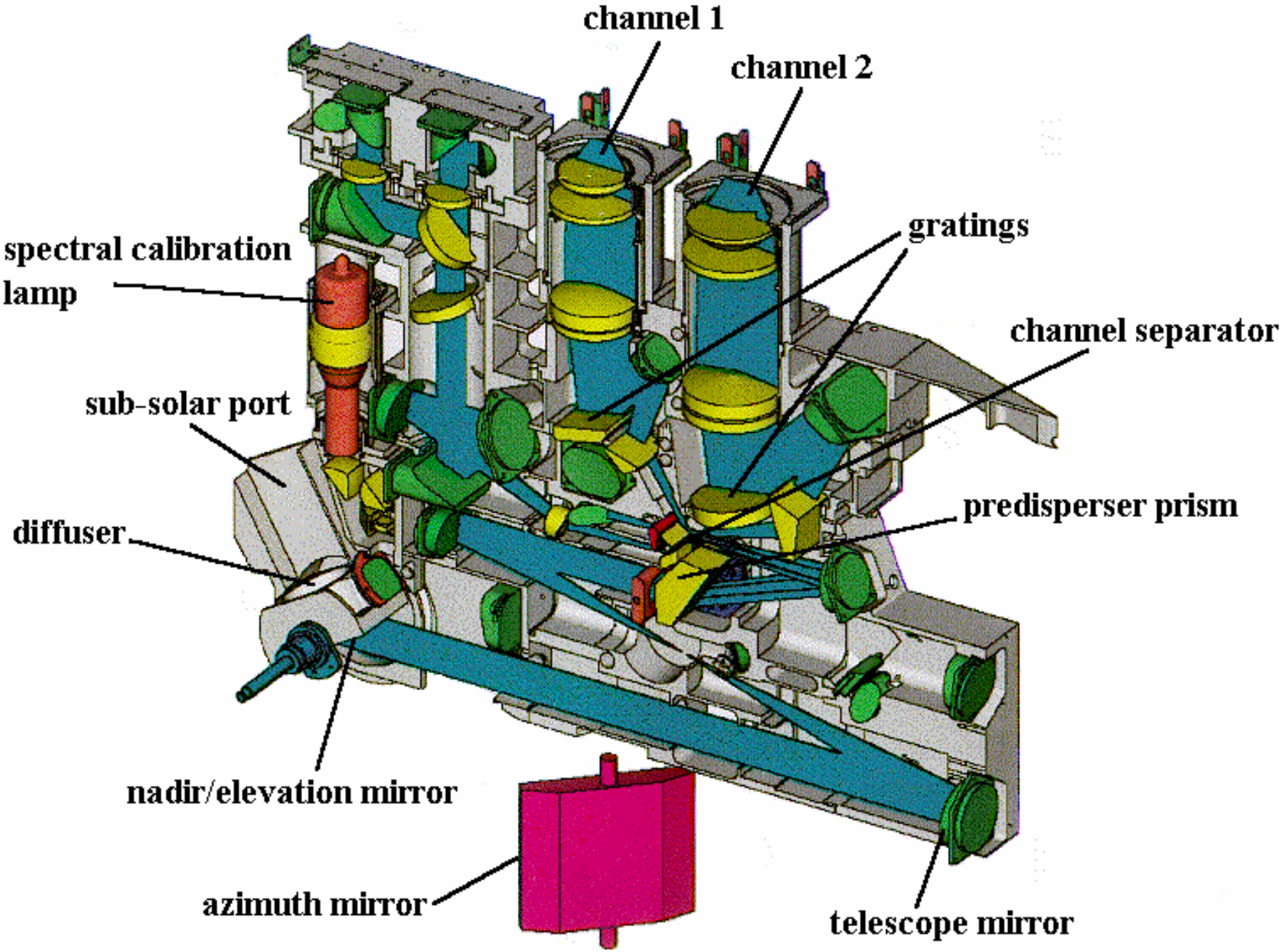
SCIAMACHY = **SC**anning **I**maging **A**bsorption spectro**M**eter for **A**tmospheric **CH**artograph**Y**

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



30km*60km


channel 1
channel 2
gratings
spectral calibration lamp
channel separator
sub-solar port
predisperser prism
diffuser
nadir/elevation mirror
azimuth mirror
telescope mirror

SCIAMACHY channels(nm)

440-314(0.24nm)

309-405(0. 26nm)

394-620(0.44nm)

604-805(0.48nm)

785-1050(0.54nm)

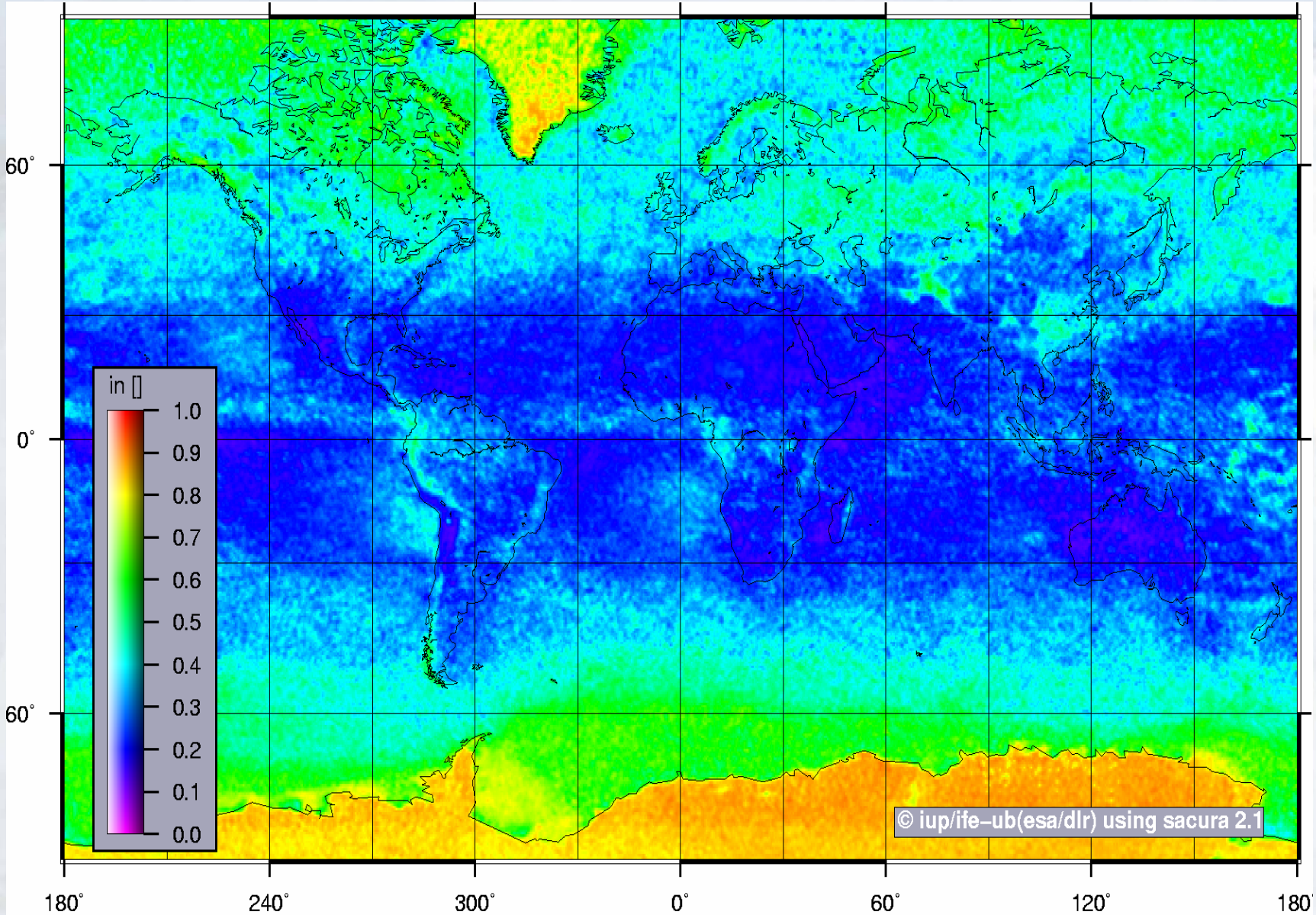
1000-1750(1.48nm)

1940-2040(0.22nm)

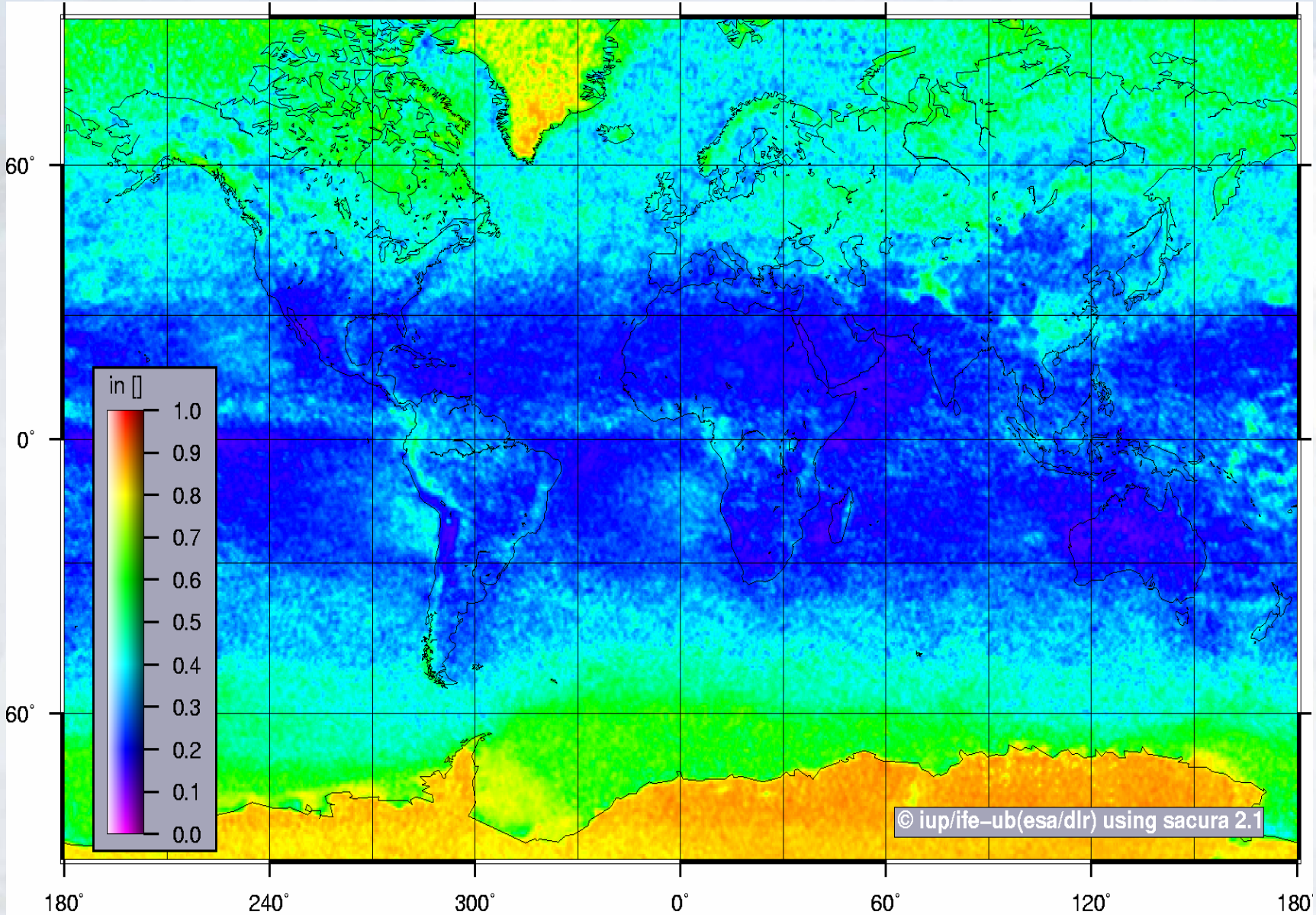
2265-2380(0.26nm)

8000 spectral measurements

pixel size 30km*60km, swath: 960km



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



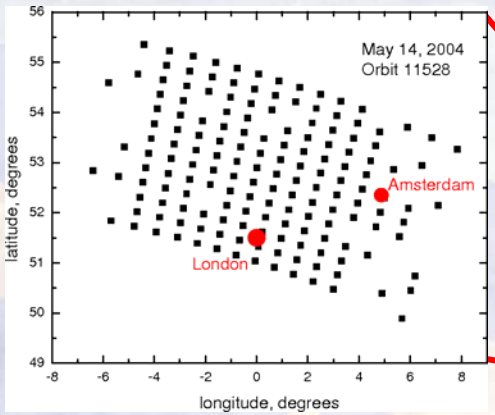
Reflectance at 443 nm from SCIAMACHY data (01. January 2006 – 31. December 2006)

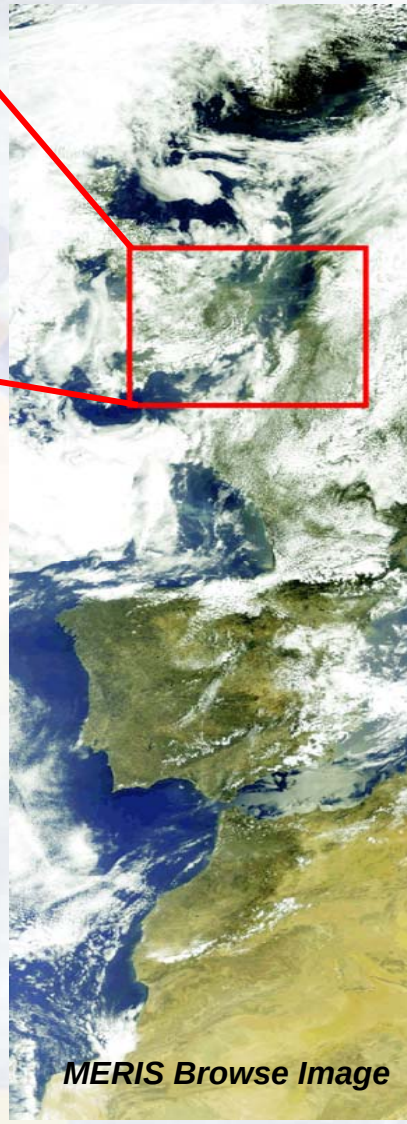
VICARIOUS CALIBRATION of SCIAMACHY USING MERIS MEASUREMENTS

Comparisons with MERIS (1)

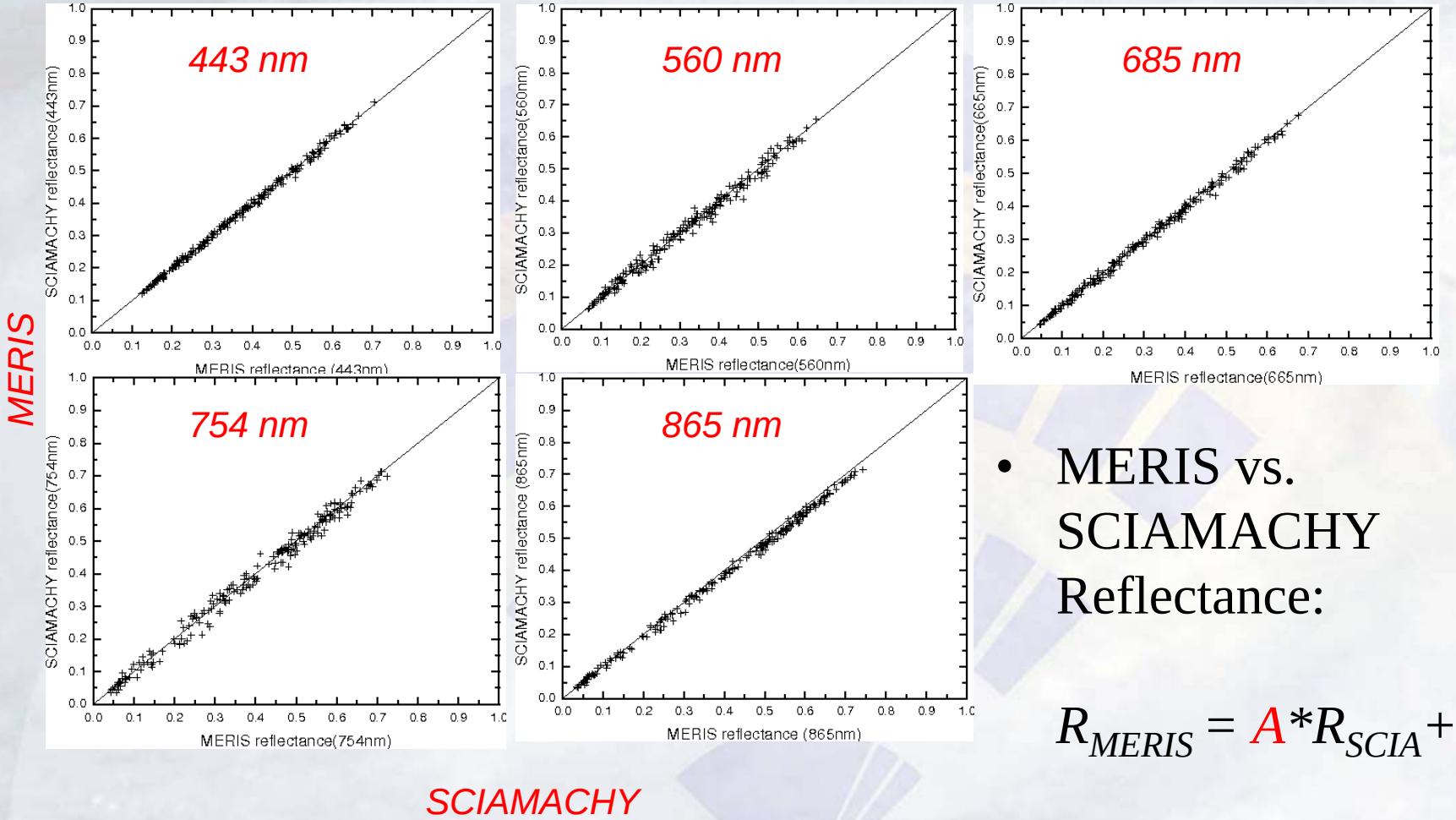
- Analysed data:
  - One state of orbit 11528 (14 May 2004)
    over Western Europe / UK
    - Broken clouds
    - Over ocean and land

    ⇨ Covers almost entire range of reflectance variability
  - MERIS reflectances are averaged over larger SCIAMACHY ground pixels (~1200 MERIS pixels per SCIAMACHY pixel)
  - SCIAMACHY spectral data are averaged over MERIS filter bands





Comparisons with MERIS (2)



- MERIS vs. SCIAMACHY Reflectance:

$$R_{MERIS} = A * R_{SCIA} + B$$

- Results:

  A, B and Correlation Coefficient

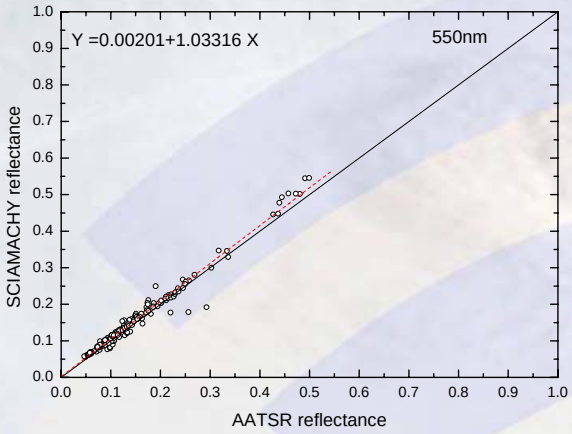
Summary: Comparisons with MERIS

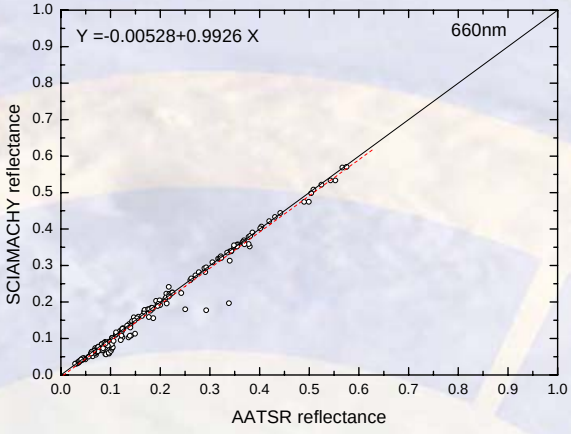
Wavelength, nm	*A* slope	*B* bias	Corr. Coeff.
443	1.0017	0.0010	0.9975
560	1.0135	-0.0016	0.9890
665	1.0106	0.0008	0.9966
754	1.0099	0.0002	0.9899
865	1.0375	-0.0007	0.9978

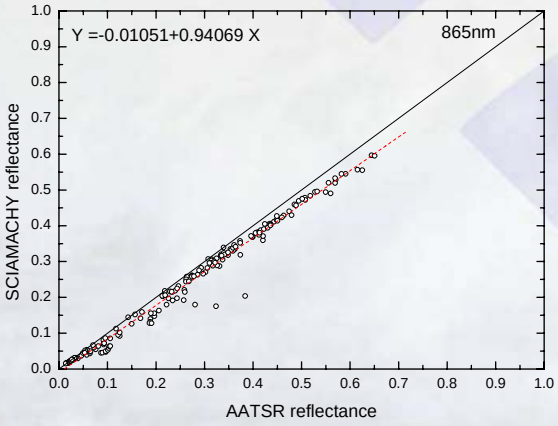
- Good agreement between SCIAMACHY and MERIS
- Bias negligible
- Only 1% difference of reflectances in the visible
- SCIAMACHY reflectance at 865 nm by 4% lower than that of MERIS

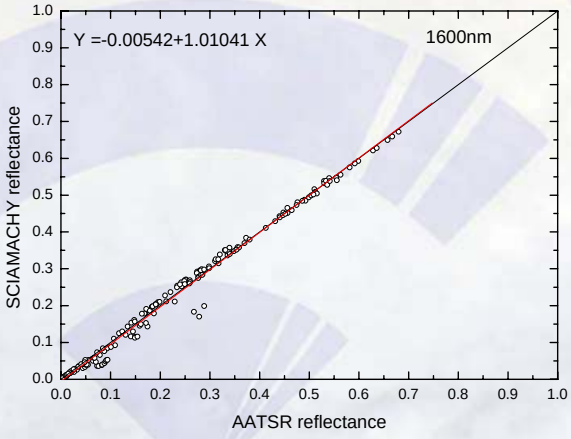
⇨ Within specified MERIS reflectance accuracy

Calibration: AATSR









Algorithms

CLOUD PARAMETERS to be retrieved:

thick clouds only

30kmx60km

Cloud optical thickness /5-100/ →443nm, 1630nm(bi-spectral algorithm)

Cloud top height /0.5-10km/ →758-778nm

Cloud bottom height/0.5-10km/→758-778nm (+IR)

Cloud cover /0-1/ PMD-algorithm, MERIS G-POD algorithm

Cloud albedo/0.3-0.8/→443nm

Liquid water path /50-200 g/m**2 /→443nm, 1630nm

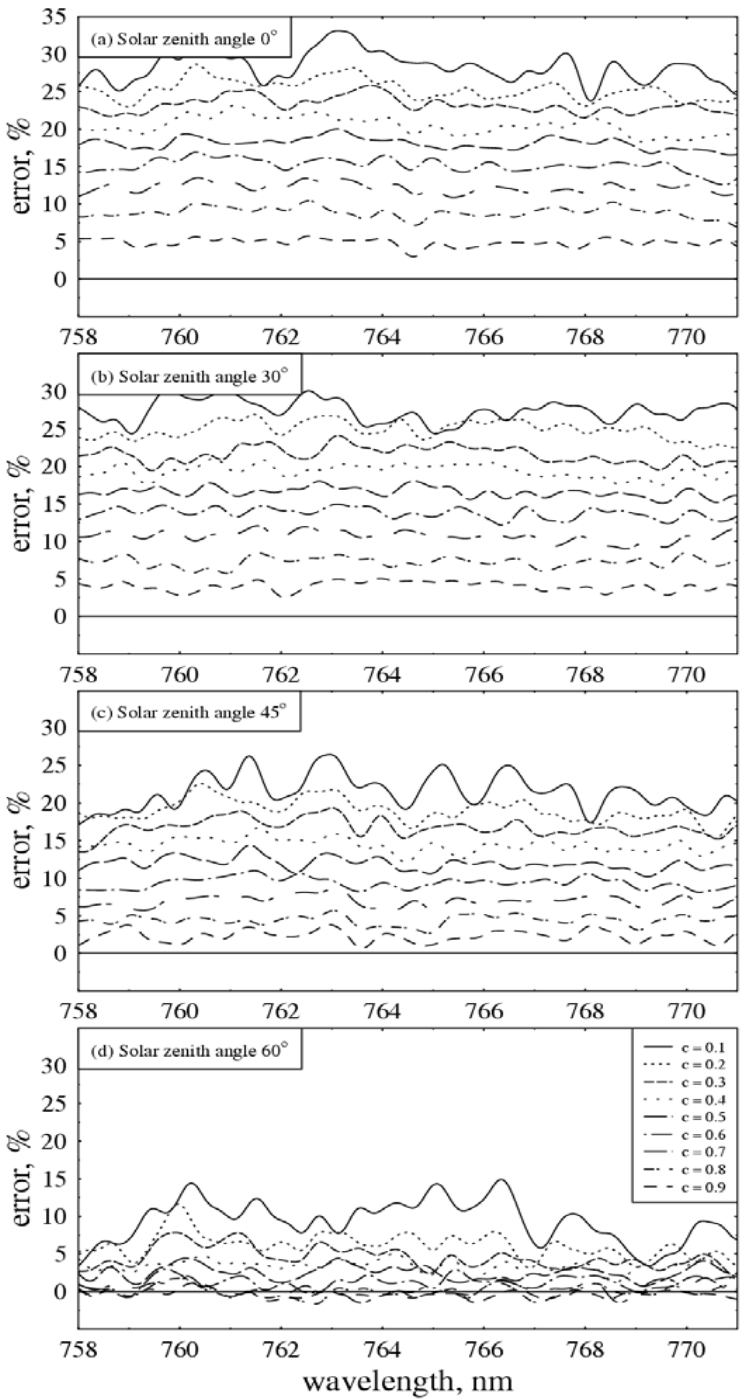
Thermodynamic phase /ice, water or mixed clouds/ Phase index=R(1550)/R(1670)

Average size of droplets/crystals → 443, 1630nm

two modes:

1.completely cloudy pixels

2. broken cloud fields(R=cR_cloud+(1-c)*R_clear)



Broken clouds

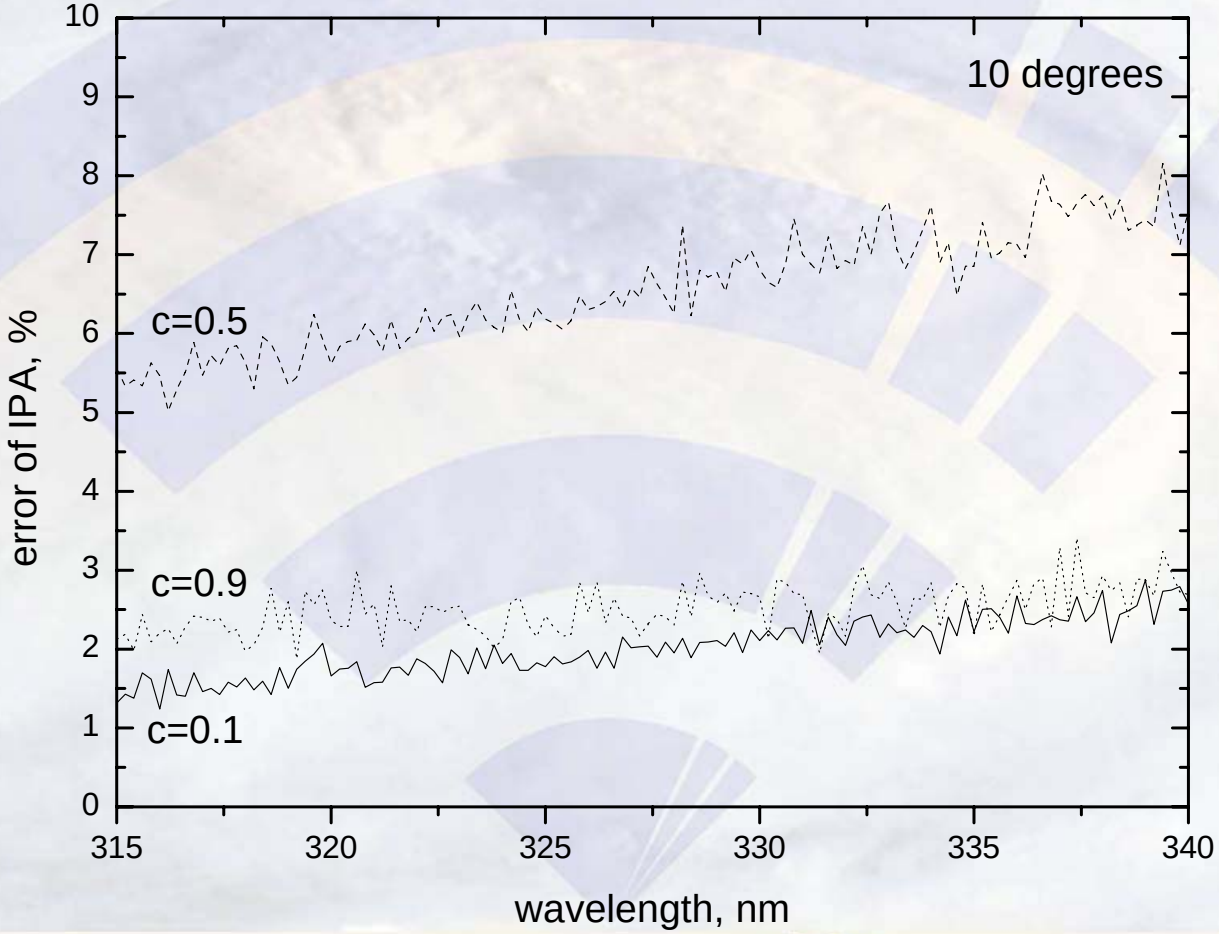
Errors of IPA:

R=cR_cloud+ (1-c)R_clear

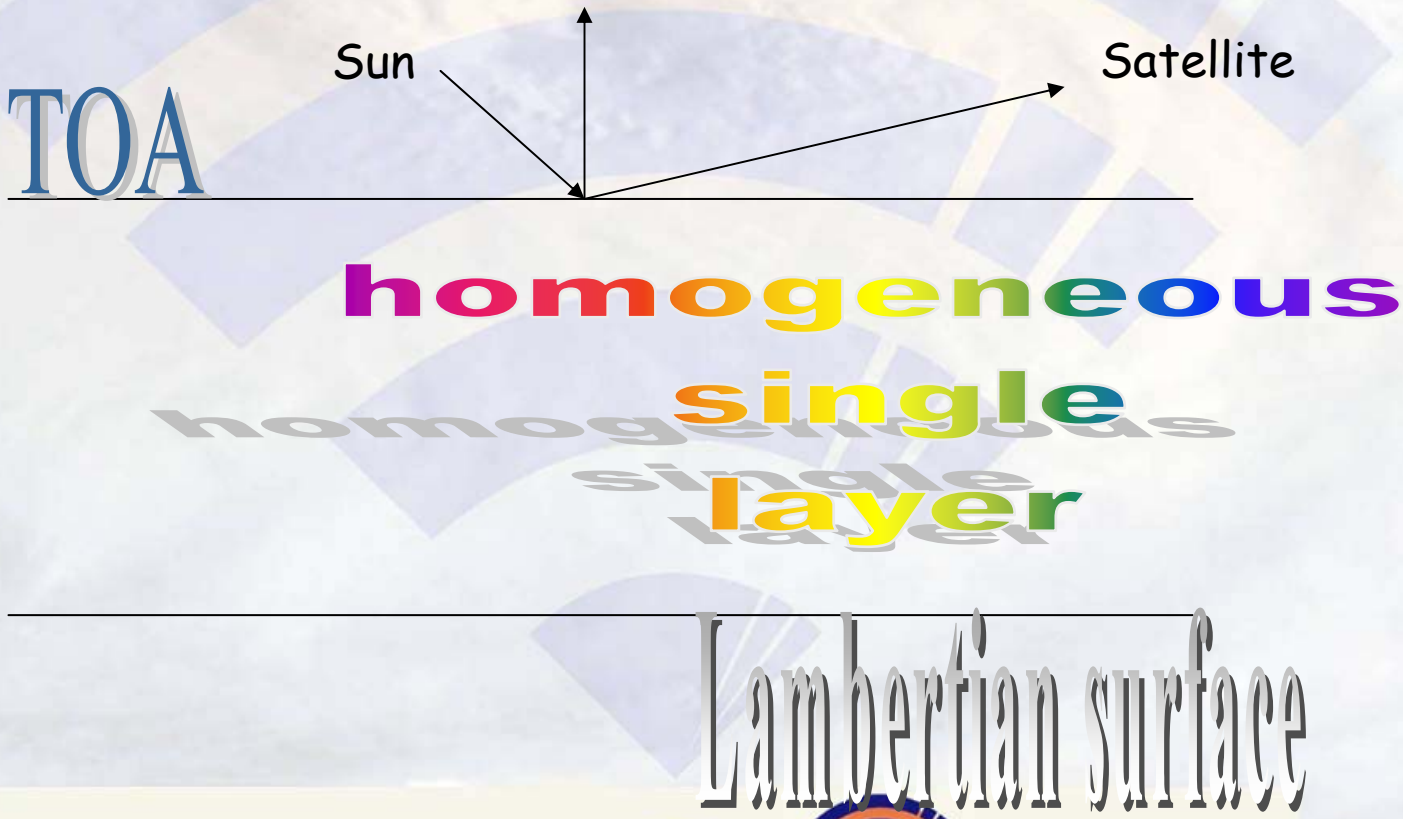
Kokhanovsky et al., JQSRT, 2007, 3D RT

VZA=0 degrees

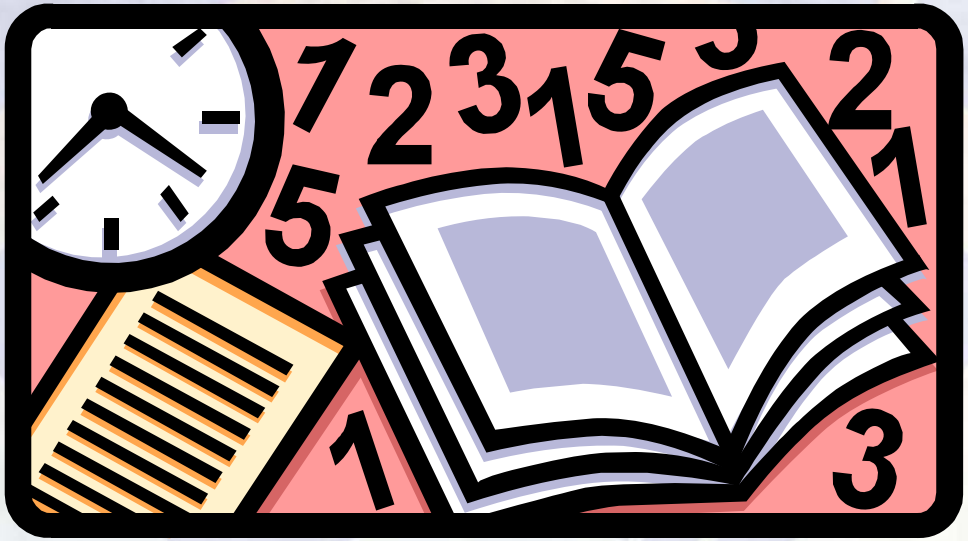
Errors in UV region: IPA



Assumptions: macro-geometry



Assumptions: mathematical model



asymptotic theory

$$\cos\vartheta \frac{\mathrm{d}I(\vartheta_0,\vartheta,\phi)}{\mathrm{d}\tau} = -I(\vartheta_0,\vartheta,\phi) + \mathrm{B}(\vartheta_0,\vartheta,\phi)$$

τ – optical thickness

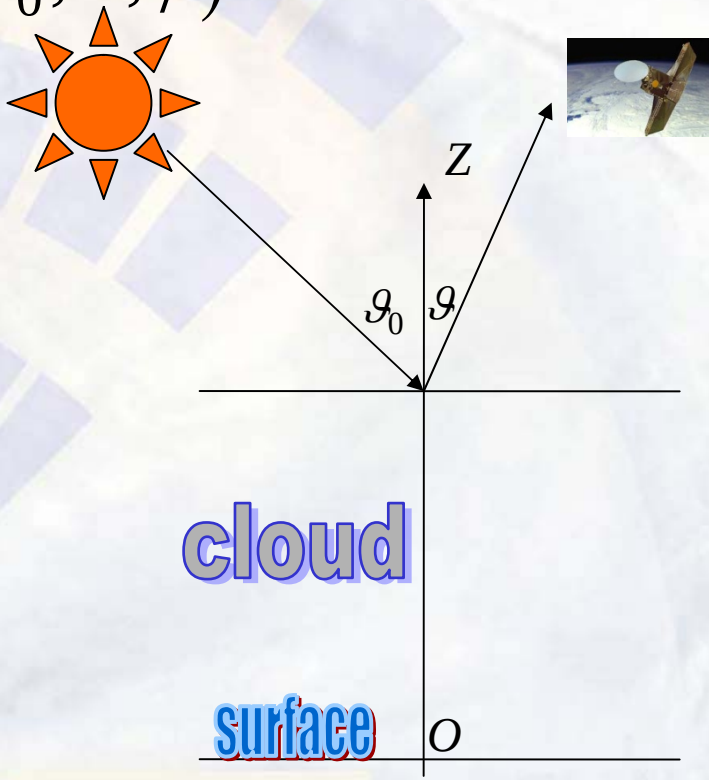
ϑ_0 – zenith solar angle

ϑ – zenith observation angle

ϕ – relative azimuth

I – reflected light intensity

B – source function



Assumptions in cloud retrievals

- No absorbing aerosols present
- Plane-parallel homogeneous layer
- Shape of particles: spheres (option: crystals, PAL/JGR 2005)

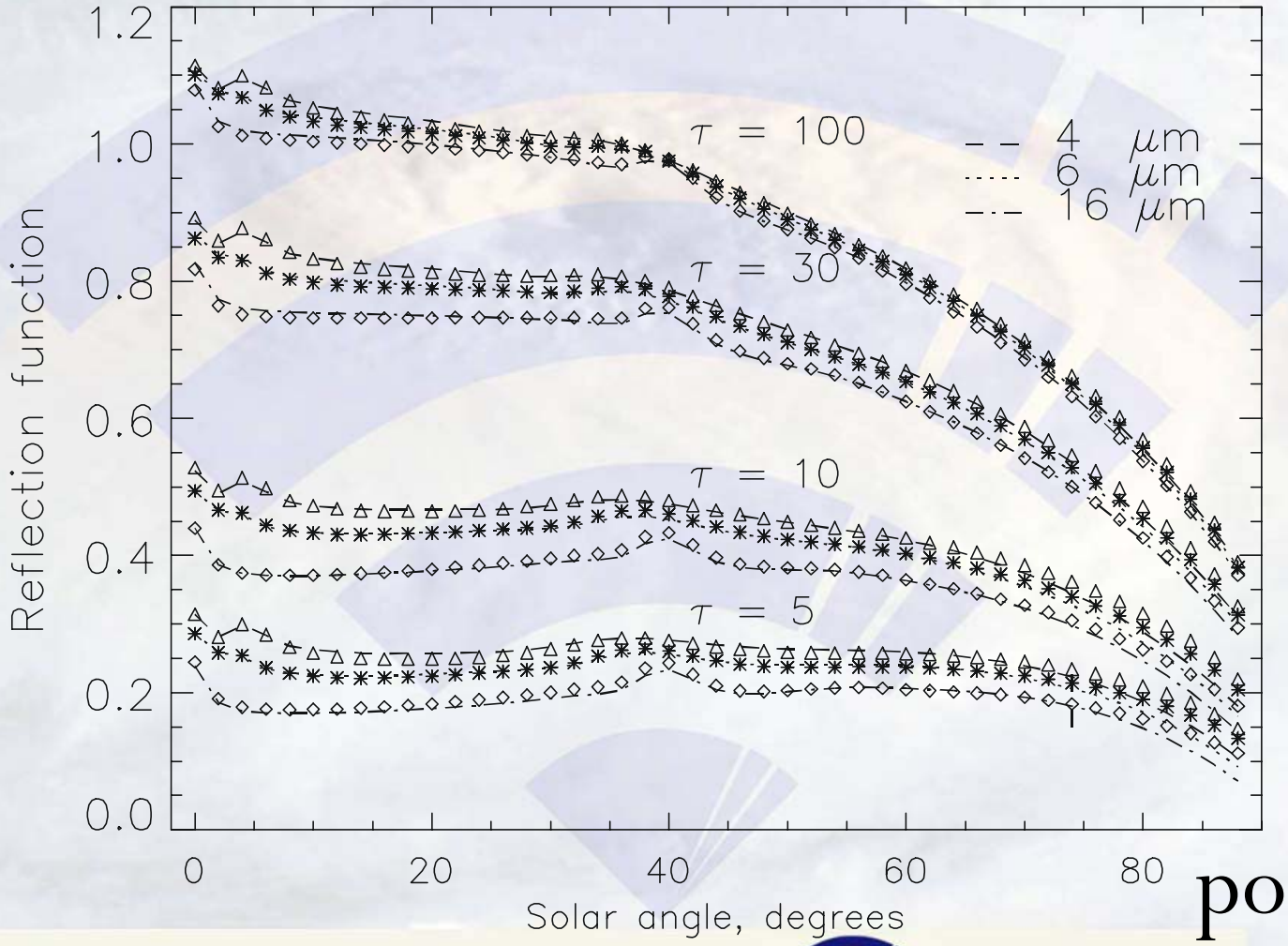
2 channels: VIS, NIR→LWP, ER

O2 A-band: CTH (CBH-?)

PHYSICAL BACKGROUND

The cloud optical thickness determination: the physical principle

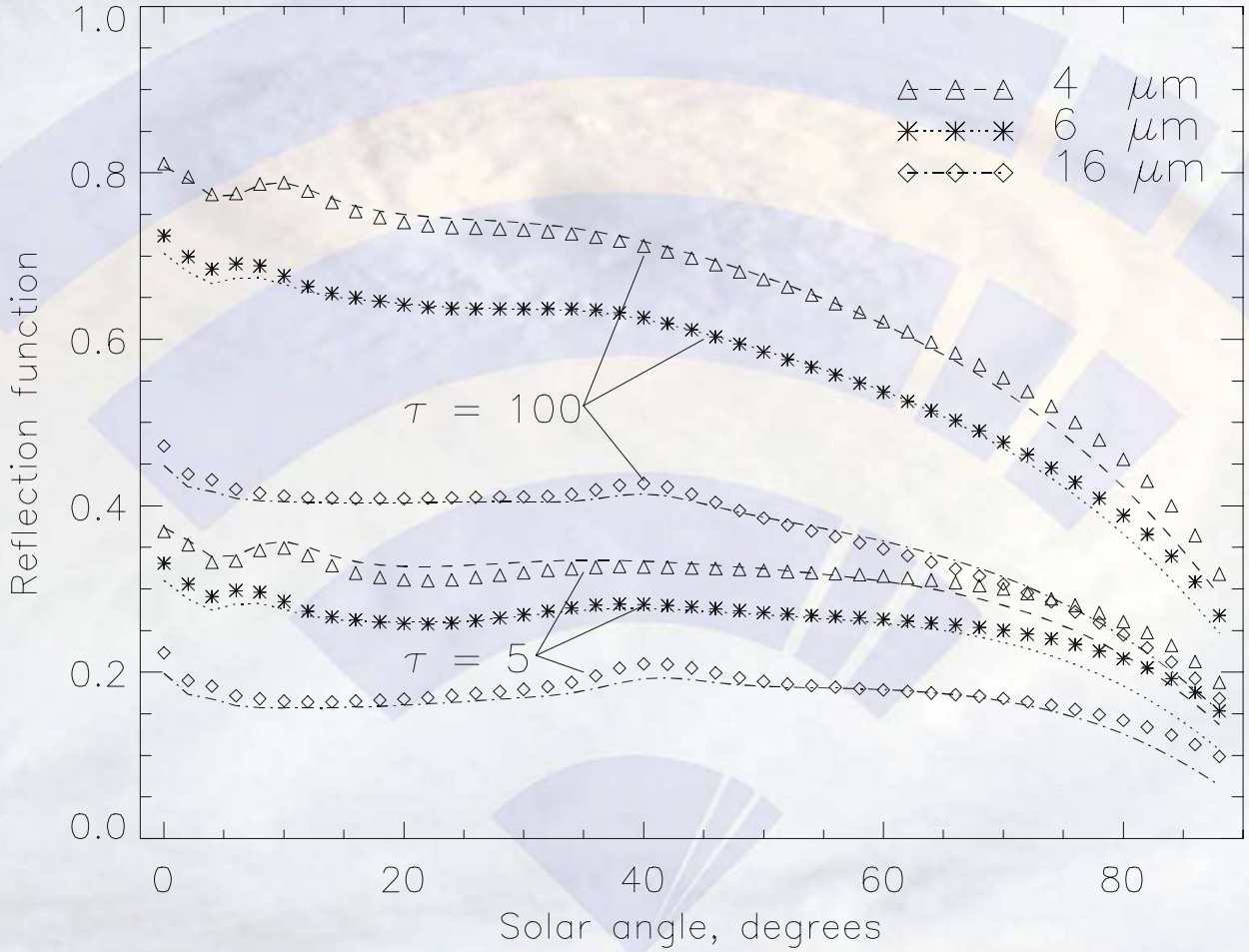
Kokhanovsky and Rozanov, 2003 $\lambda = 0.65\,\mu m$



points-SCIATRAN

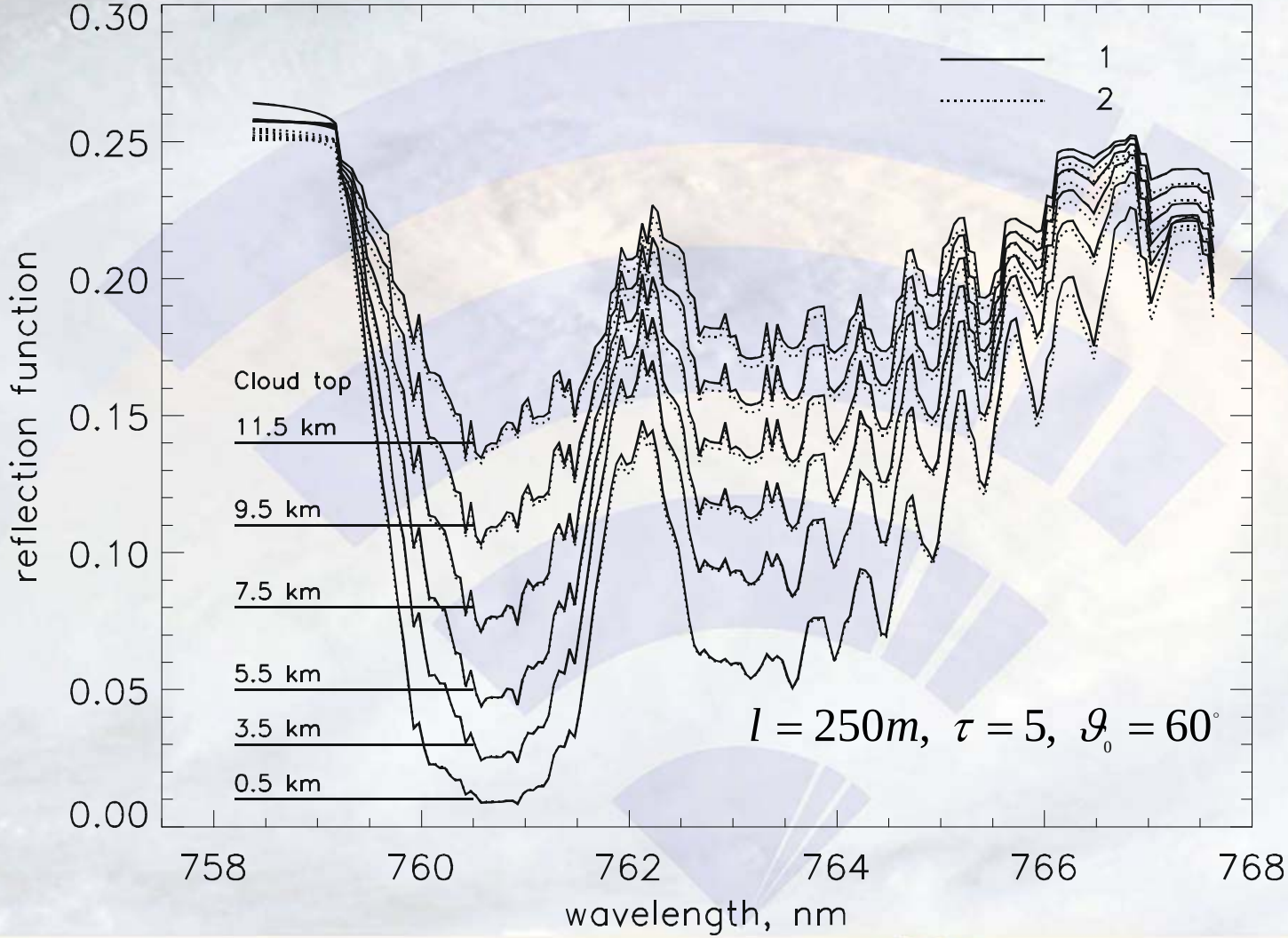
The effective radius determination from a satellite

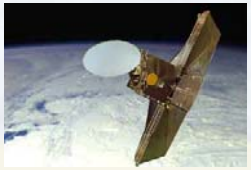
Kokhanovsky and Rozanov, 2003 $\lambda = 1.55 \mu m$



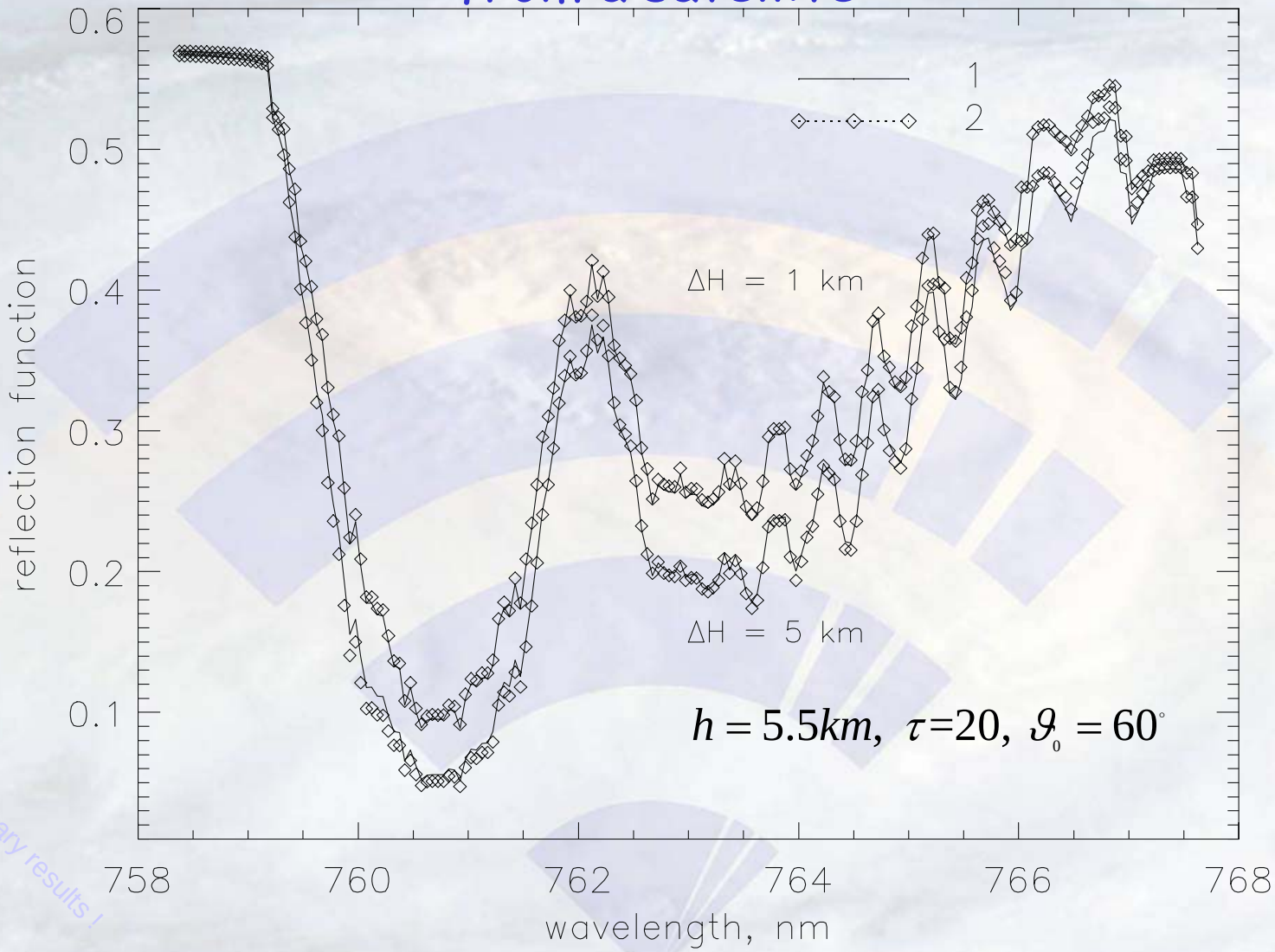
Cloud top height determination from a satellite

The physical principle behind the retrieval





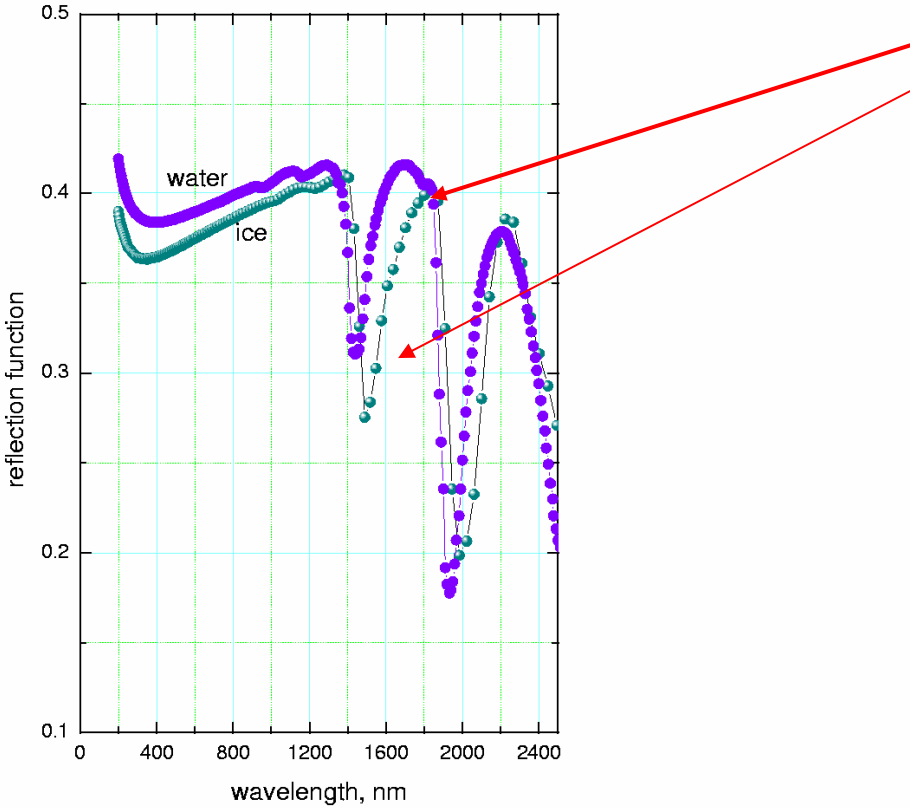
Cloud geometrical thickness/bottom height determination from a satellite

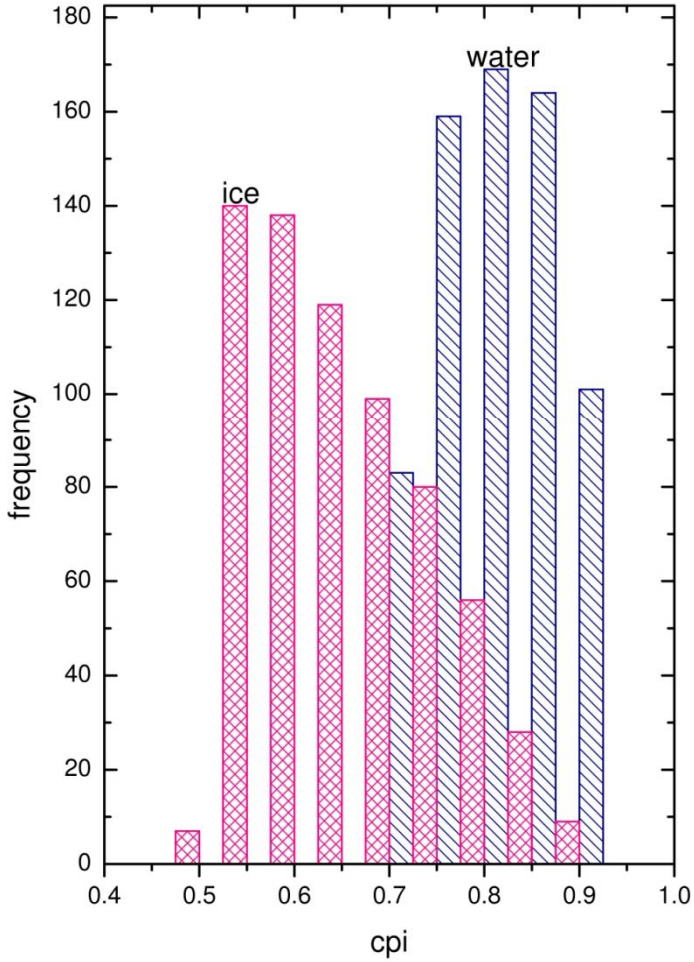


Preliminary results !

Cloud Phase

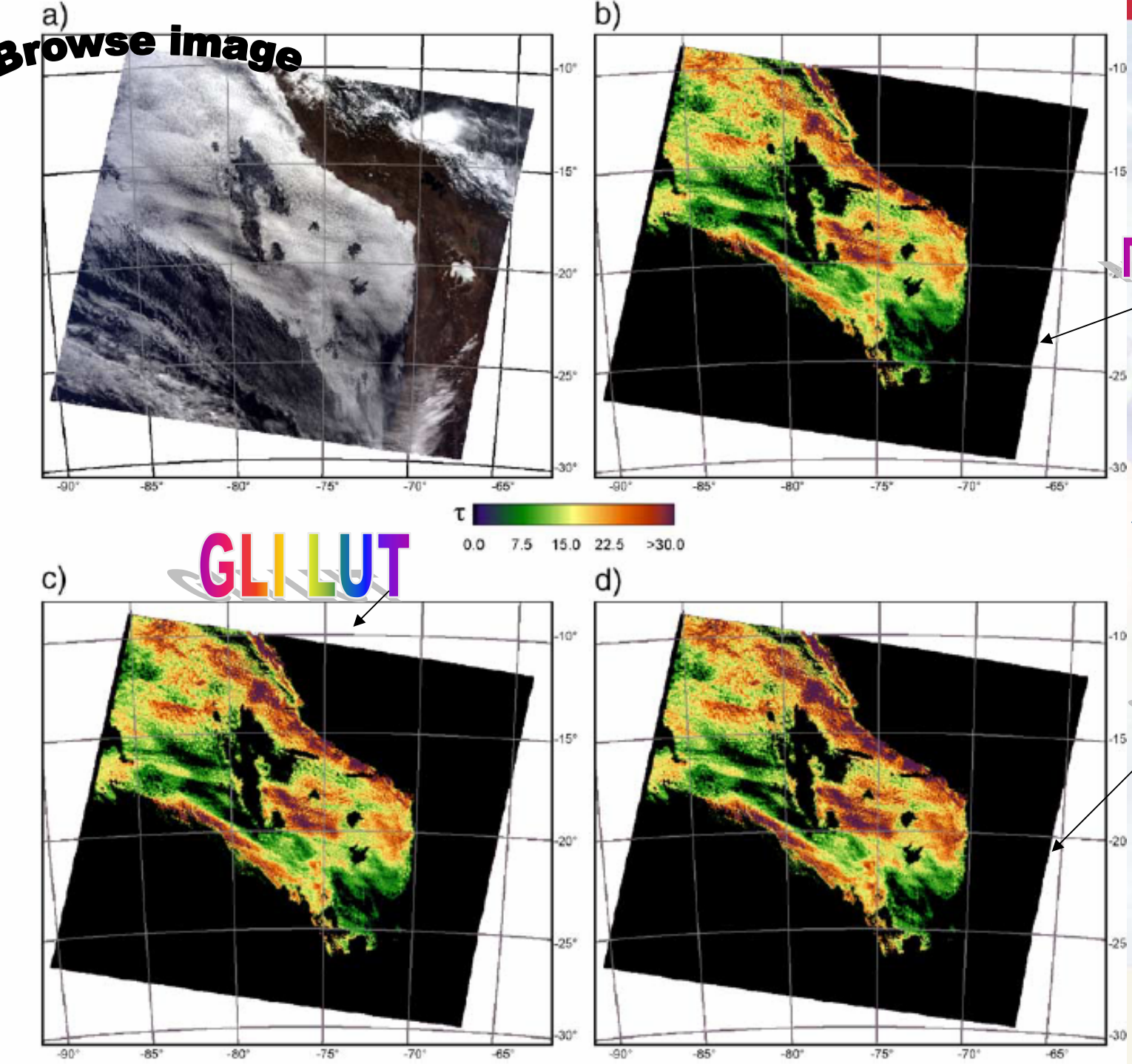
CPI=R(1550nm)/R(1670nm)





VALIDATION and comparisons

COT



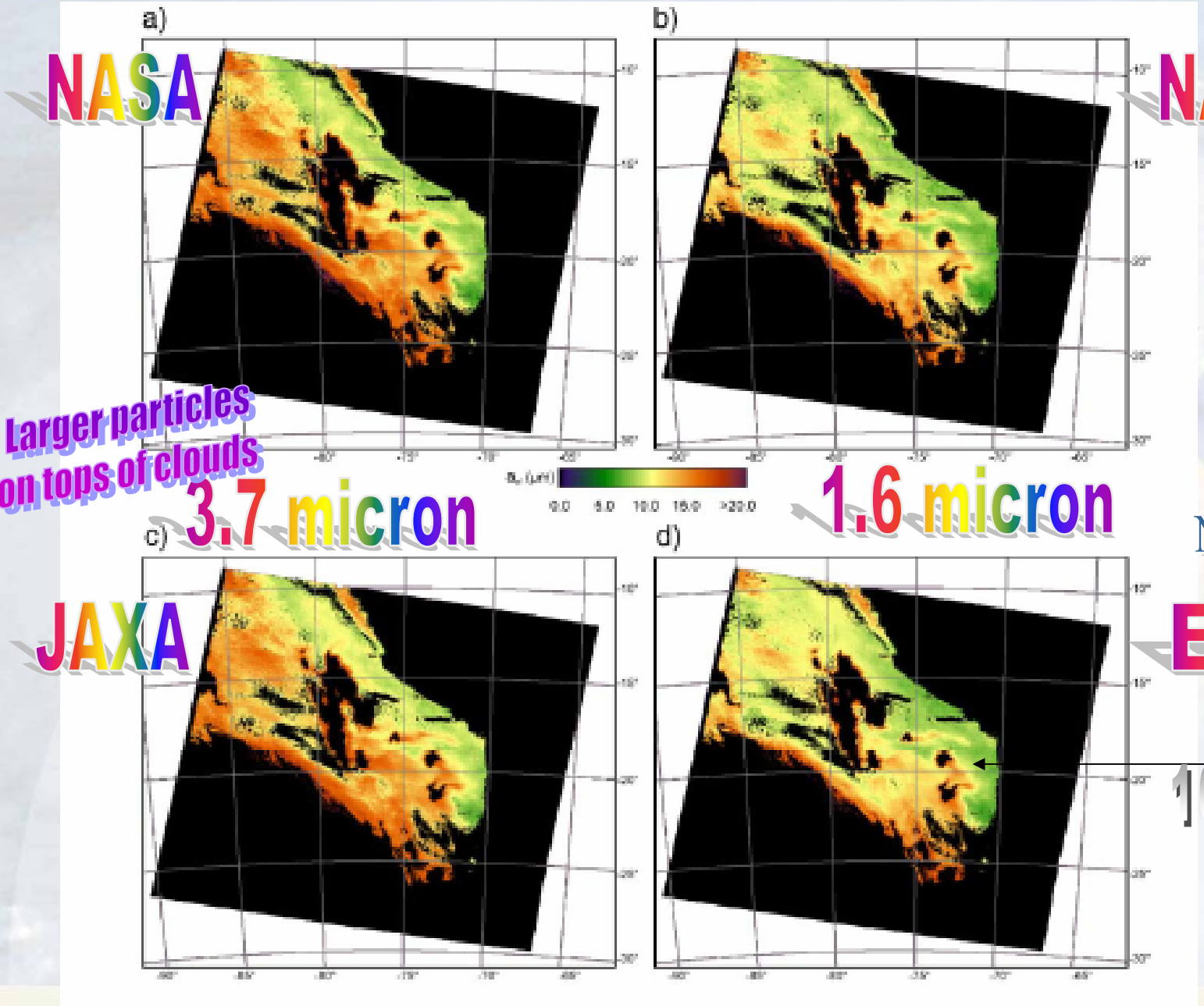
Nauss et al., 2005

SACURA

860nm

MODIS

a_ef



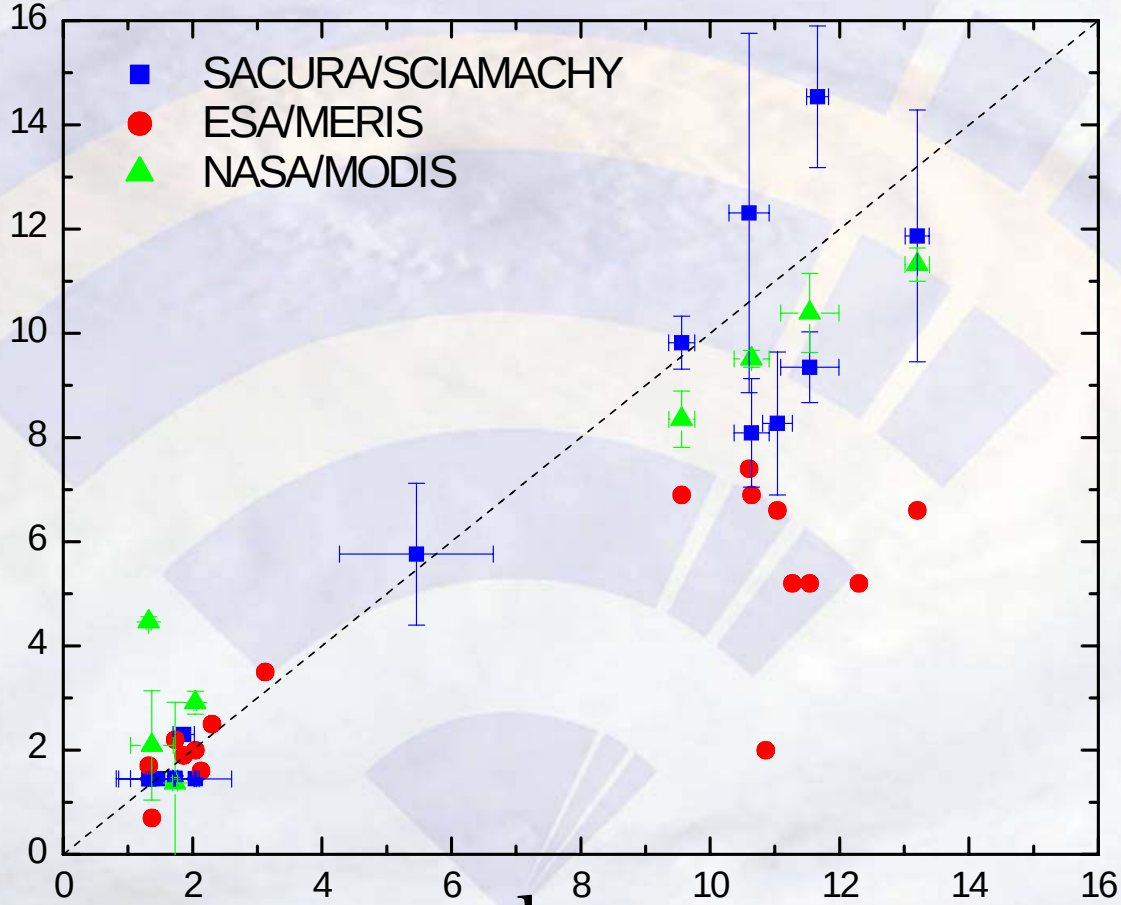
Nauss et al., 2005

IEEE TGRS 2009, in press

The comparisons satellite and radar (ARM) cloud top heights

CTH

sat



radar

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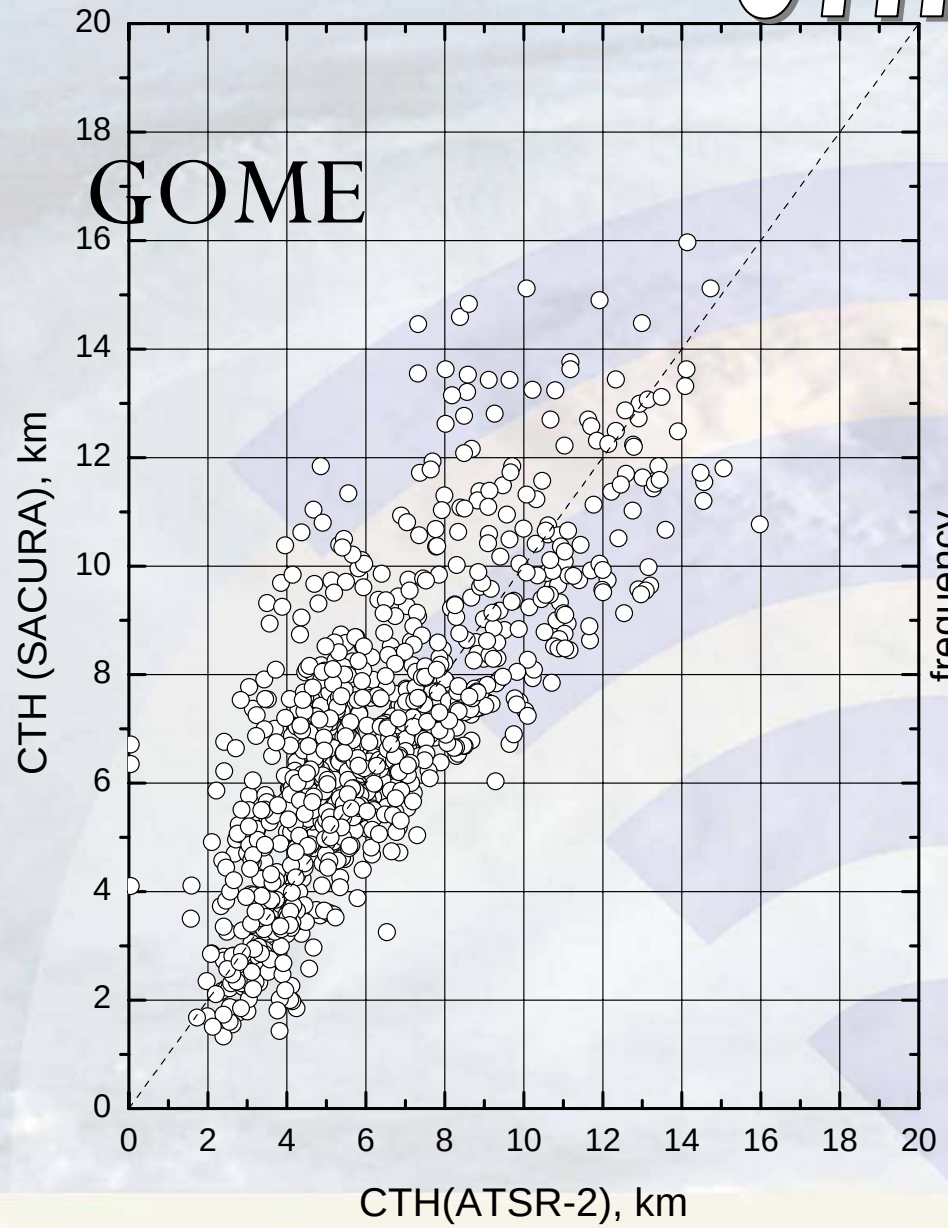
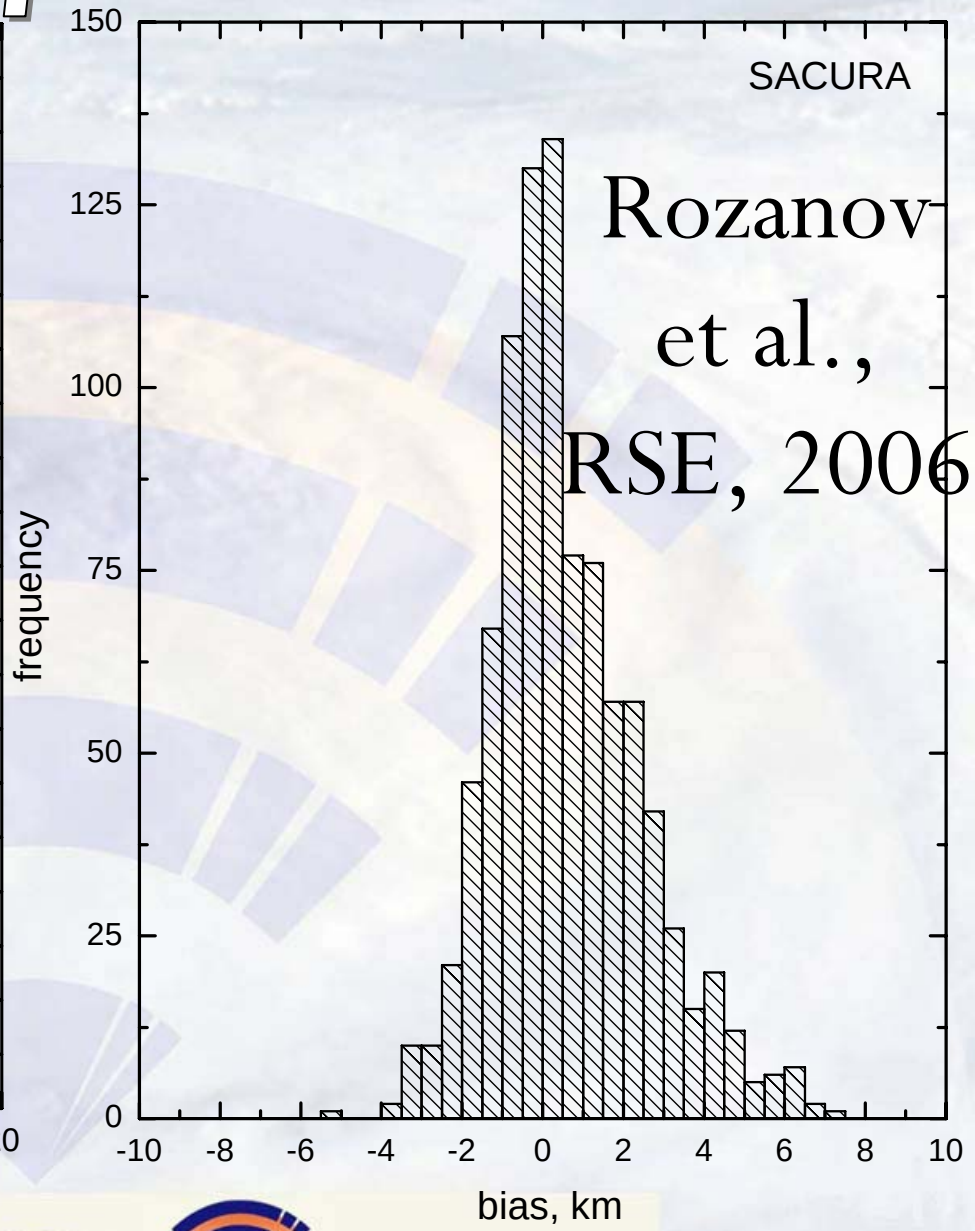
CTH





Rozanov et al., RSE, 2006

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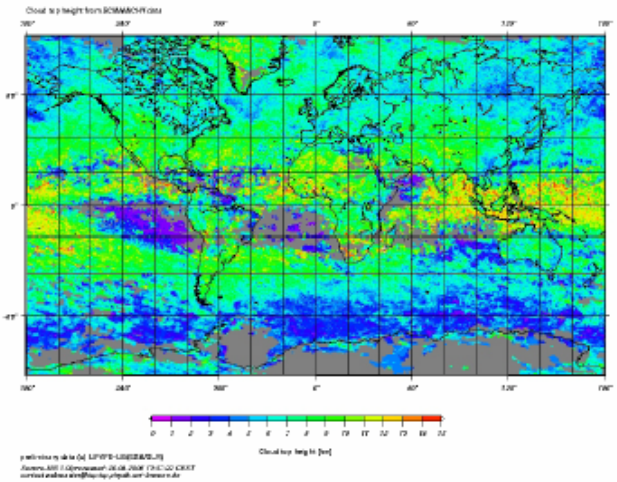
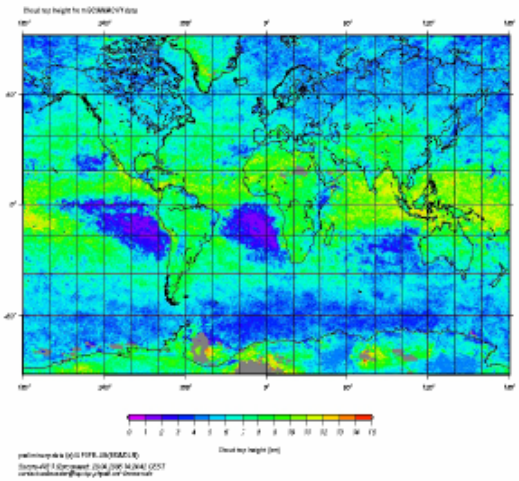
RESULTS of RETRIEVALS

CLOUD TOP HEIGHT

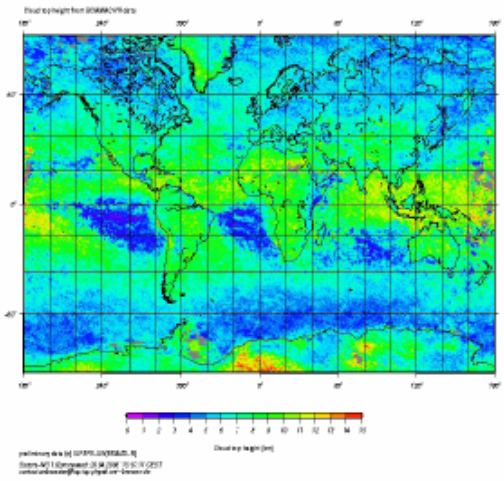
2003



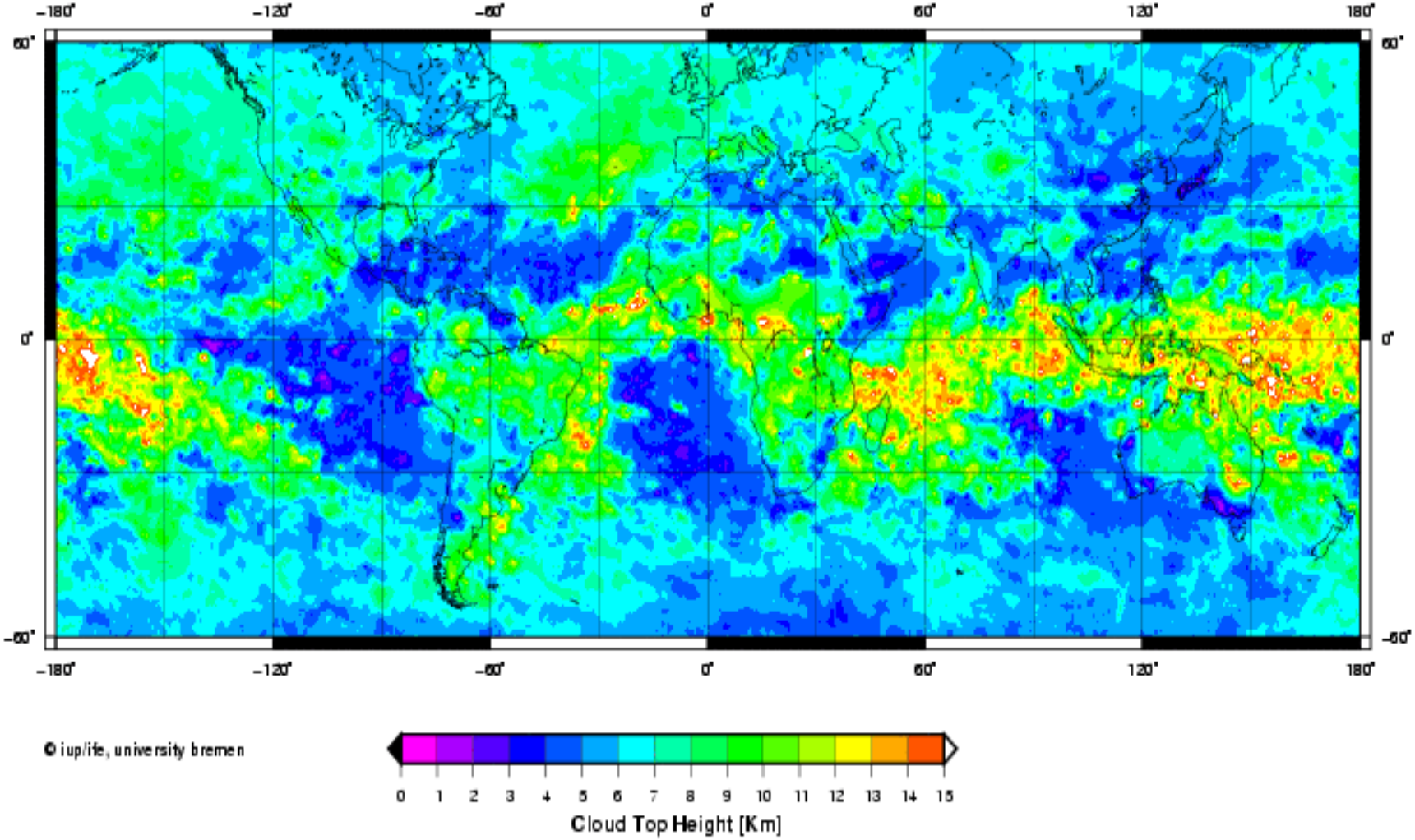
2004

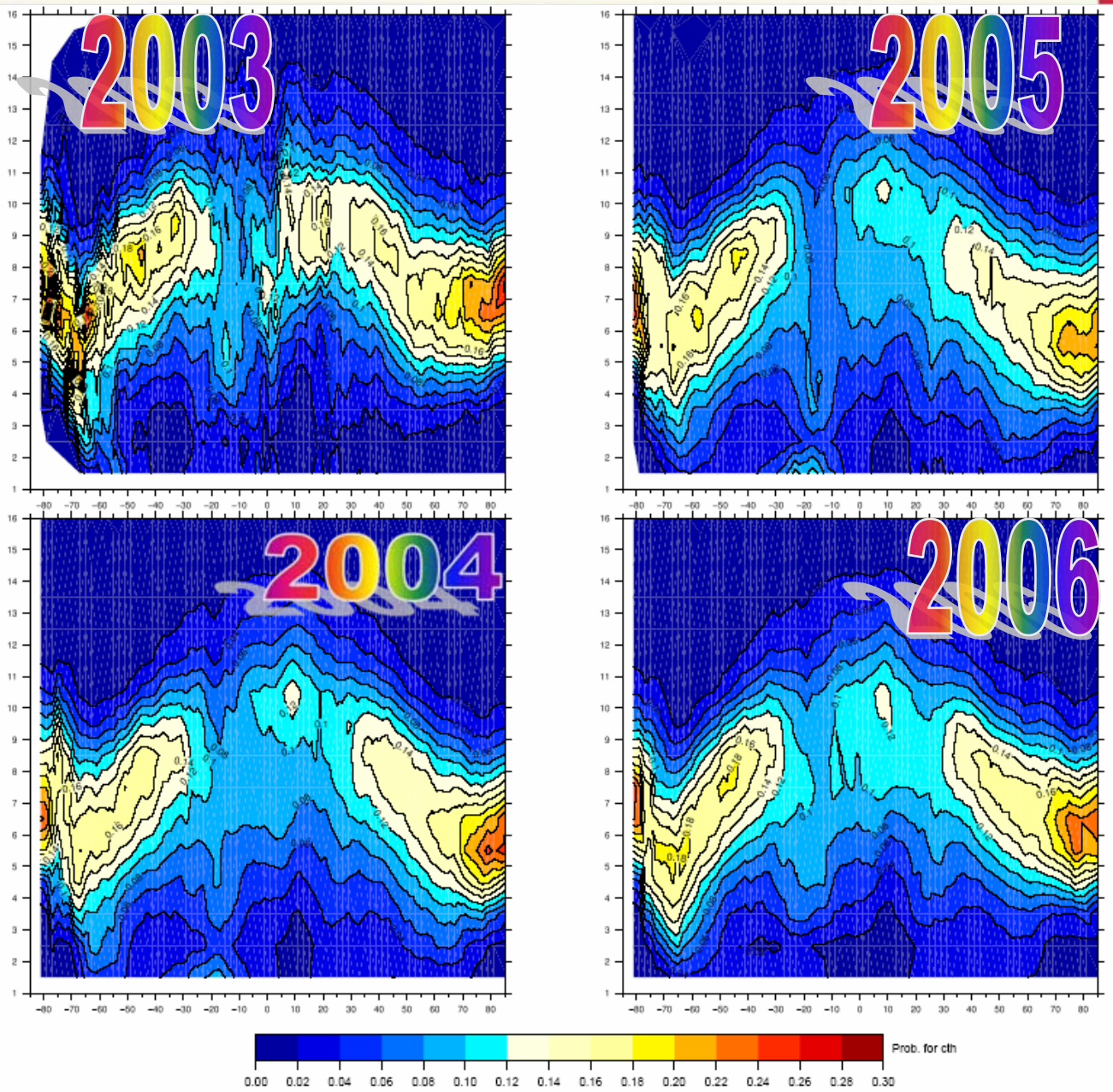


2005

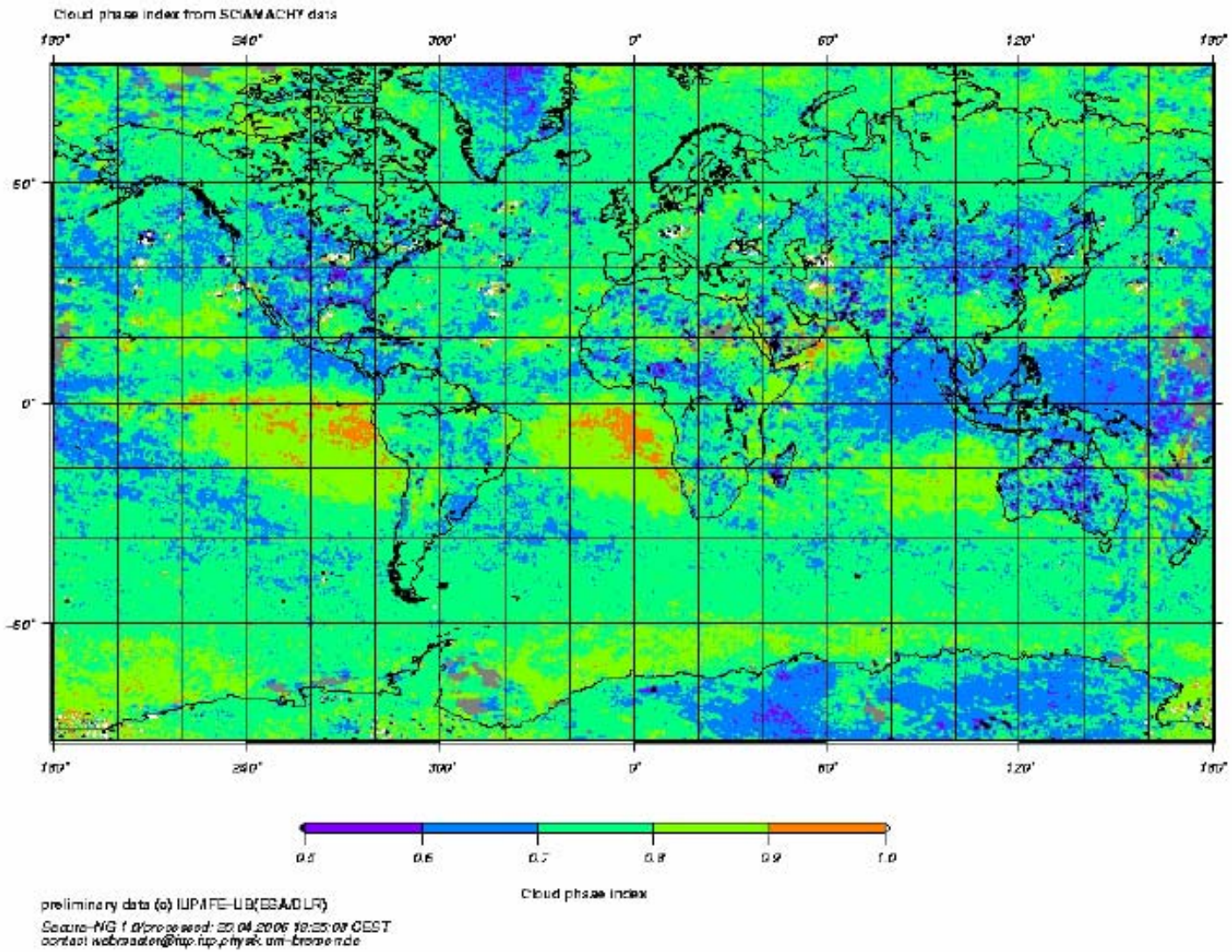


Cloud Top Height from SACURA (01–Jan–2004 – 31–Jan–2004)




2003
2005
2004
2006
Prob. for cth
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22 0.24 0.26 0.28 0.30

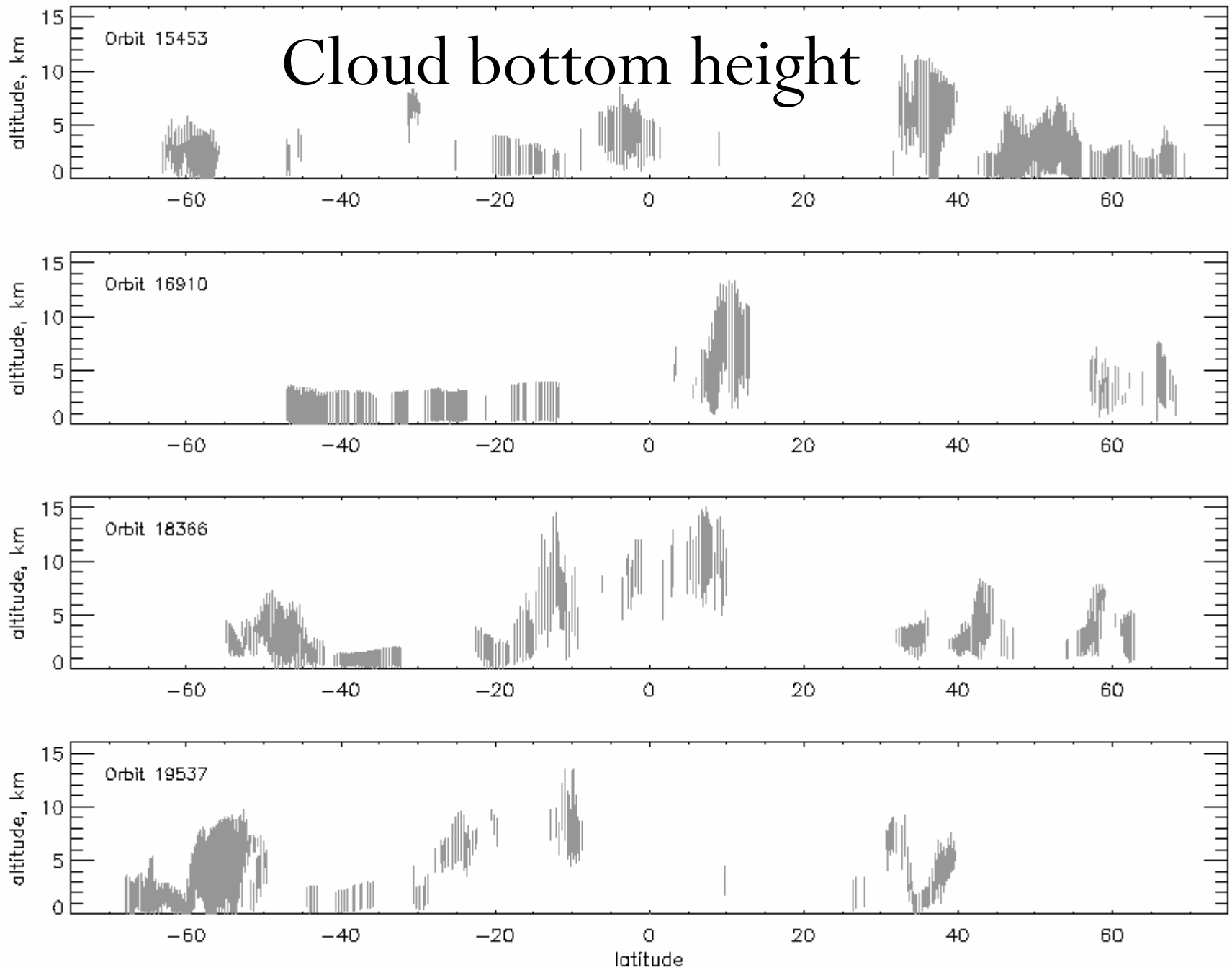
Phase Index


Cloud phase index from SCIAMACHY data
180°
240°
300°
0°
60°
120°
180°
60°
0°
-60°
0.5
0.6
0.7
0.8
0.9
1.0
Cloud phase index
preliminary data (c) IUP/IFE-UB(EGA/DLR)
Secure-NG 1.0(processed: 25.04.2006 19:25:07 CEST
contact: webmaster@iup.iup.physik.uni-bremen.de

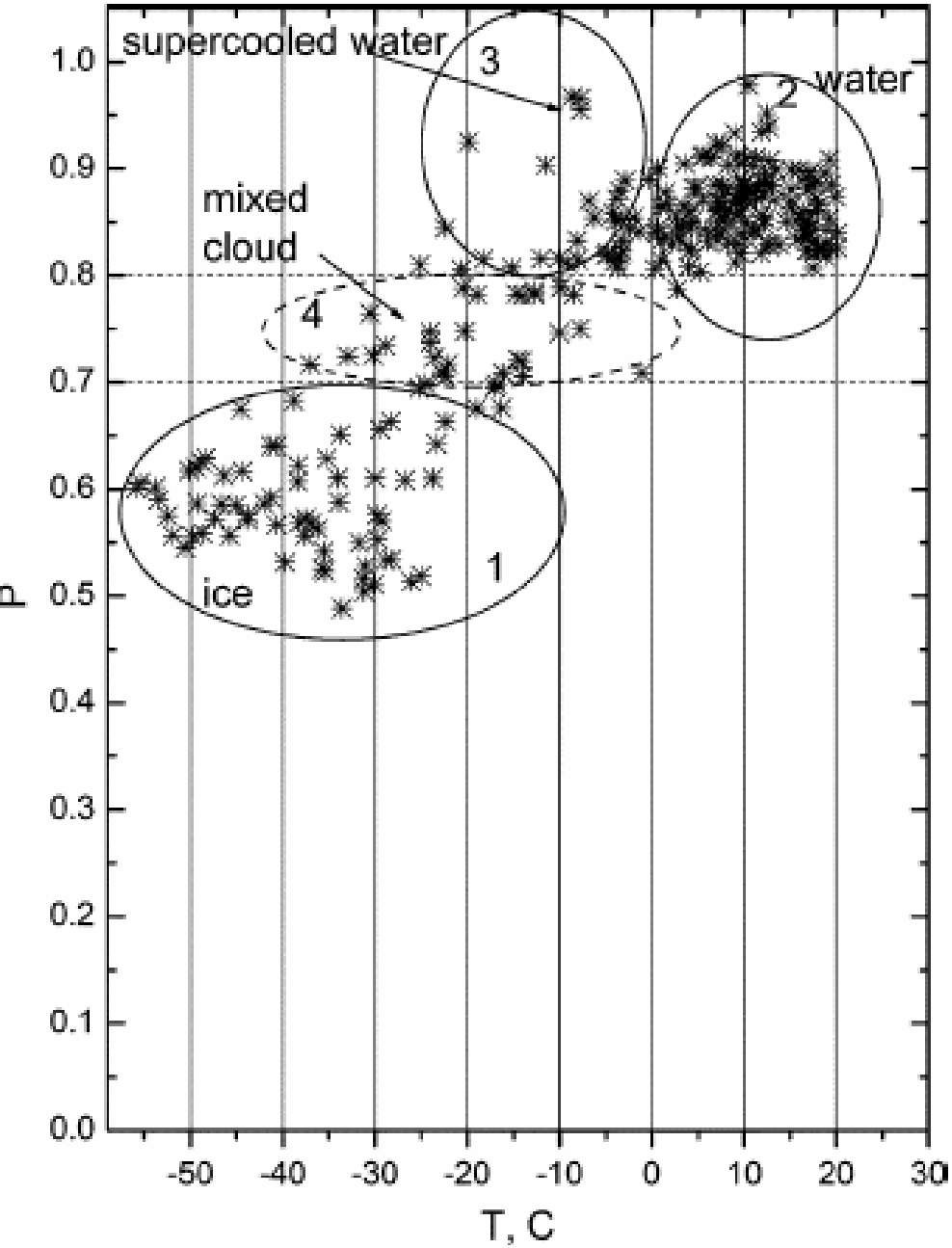
New directions to explore

- CLOUD BOTTOM HEIGHT
- CLOUD THERMODYNAMIC STATE DETERMINATION
- SYNERGY OF SCIAMACHY, MERIS AND AATSR
- LIMB GEOMETRY

Cloud bottom height



A. and V. V. Rozanov, IEEE TGRSL, 2005

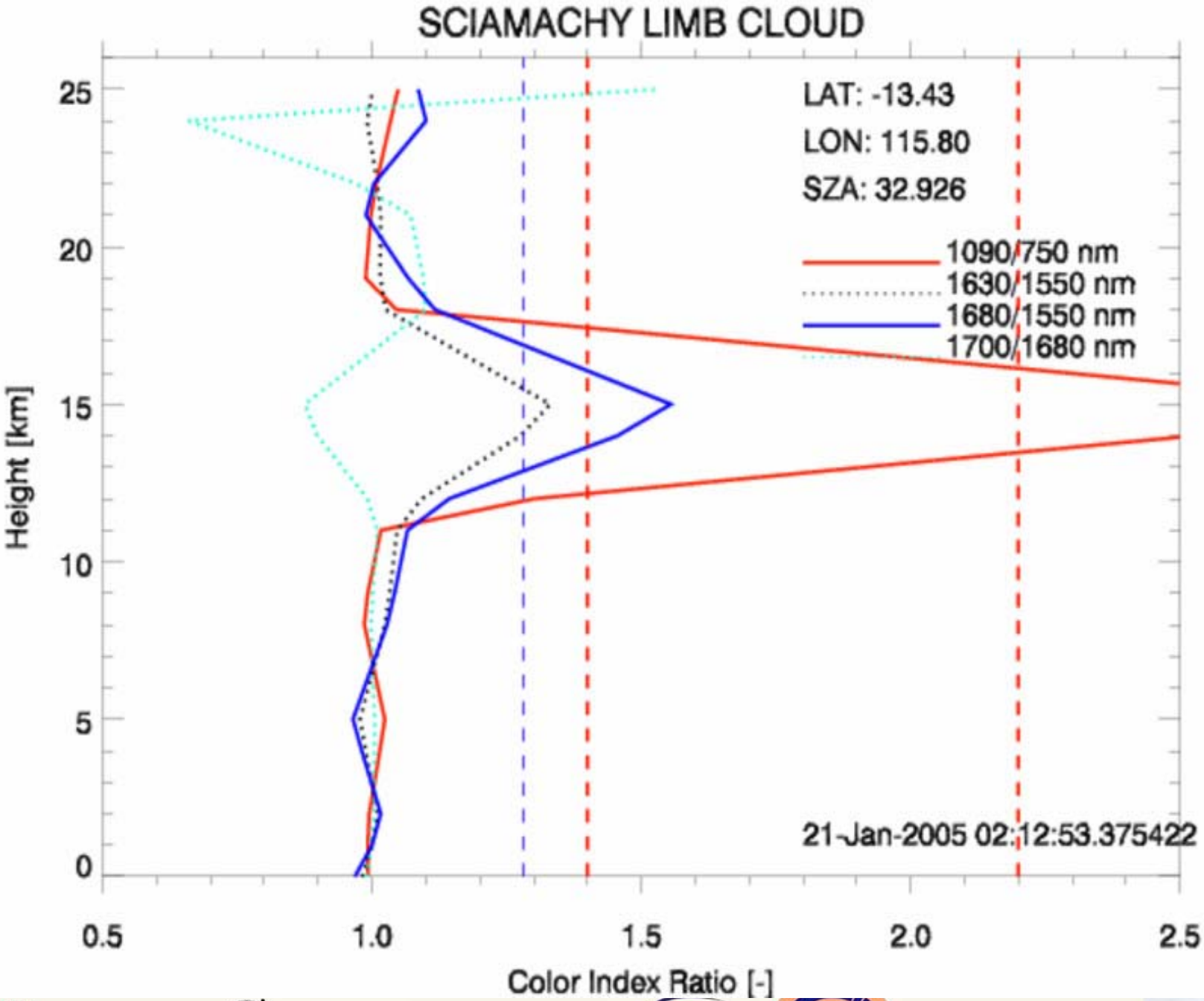


Hurricane Isabel

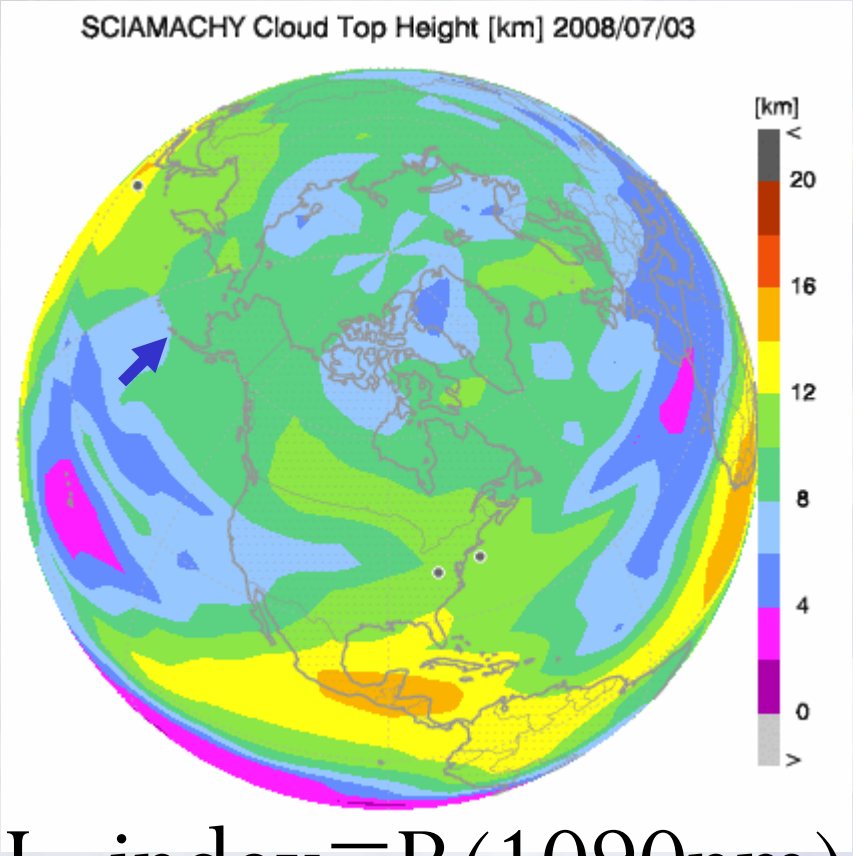
17.09.2003

SCIA/AATSR

ENVISAT


SCIAMACHY LIMB CLOUD
LAT: -13.43
LON: 115.80
SZA: 32.926
1090/750 nm
1630/1550 nm
1680/1550 nm
1700/1680 nm
21-Jan-2005 02:12:53.375422
Height [km]
Color Index Ratio [-]
0
5
10
15
20
25
0.5
1.0
1.5
2.0
2.5

The eruption event as seen by SCIAMACHY

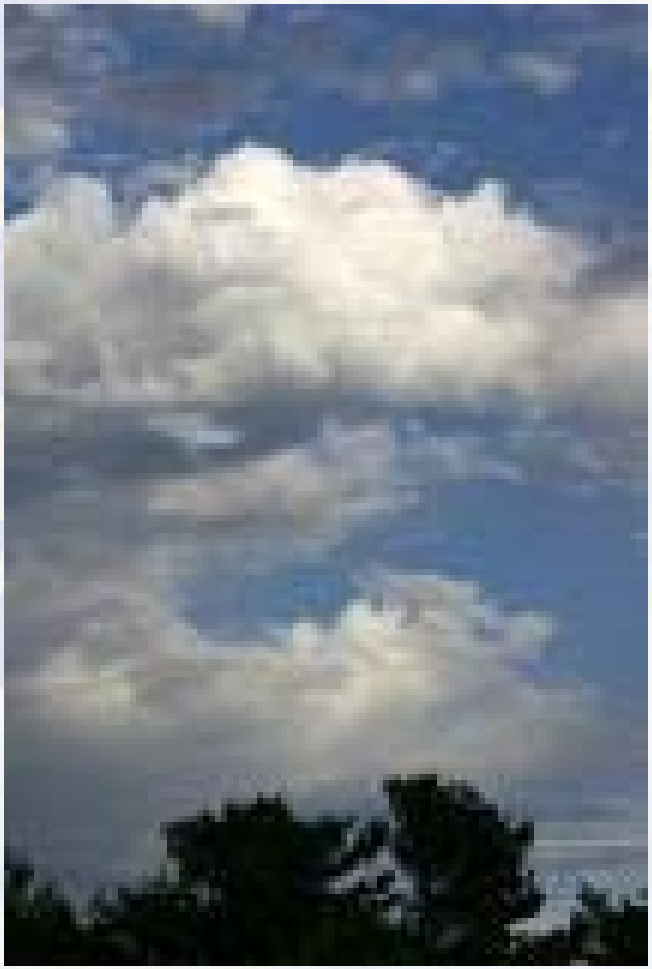


L_index=R(1090nm)/R(750nm)

- Cloud top height animation
- Overplotted are the PSC flags (voulcanic aerosol) when lowering the latitude extent to 35° N.
- It starts at 2008/07/03 and ends at 2008/10/10.
- This intrusion of particles into the stratosphere also effects the CTH detection of SCODA.
- CTH above 16 km were measured over a large part of the northern hemisphere.
- PSC detection lasts till the end of the animation period and seems to be ongoing (needs to be checked!).
- First streamers were seen, that extent the whole polar cap at the end.

Problems: clouds

- 3-D effects, broken clouds
- Vertical inhomogeneity (e.g., cloud layers)
- Polluted clouds
- Mixed clouds
- The account of underlying surface BRDF
- The crystal shape-dependent retrievals of cloud properties



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