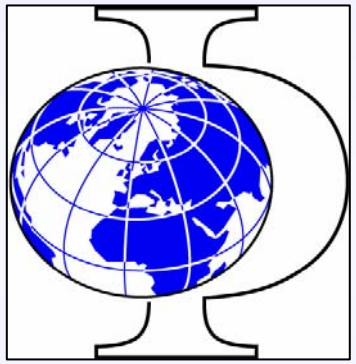
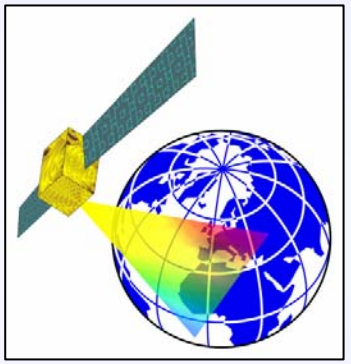
Cloud retrieval from SCIAMACHY using broad band spectrometers and absorptions of O_2 and O_4



Michael Grzegorski, Steffen Beirle, Tim Deutschmann, Ulrich Platt and Thomas Wagner



Institute of Environmental Physics, University of Heidelberg
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Overview

- The Heidelberg Iterative Cloud Retrieval Utilities (HICRU): an overview
  - Retrieval of effective cloud fraction
- DOAS evaluation of O_2 and O_4 at 630 nm
- Interpretation of O_2 and O_4 results with respect to the retrieval of cloud top height

PMD cloud algorithm (HICRU)

- PMDs: broad band spectrometer.
- Higher spatial resolution than spectral high resolution channels
- Effective cloud fraction (= cloud coverage and cloud albedo)

Basic concepts:

cloudy pixel

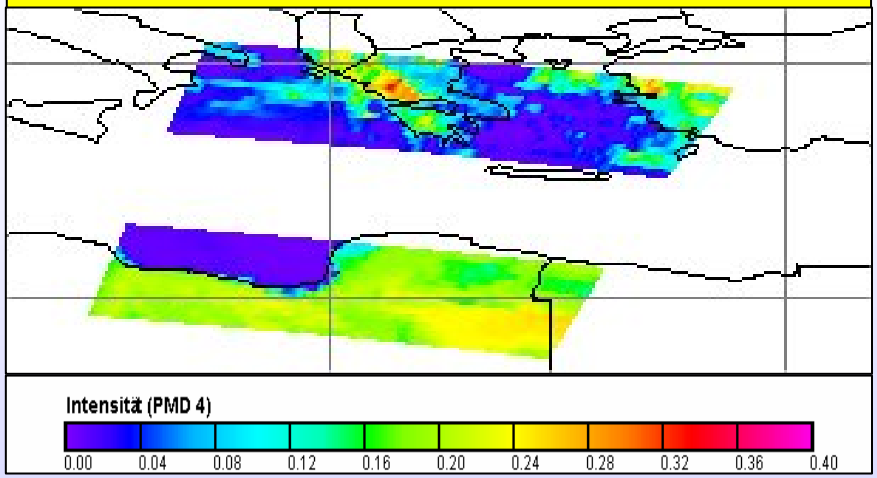
upper threshold

fractional cloudy

lower threshold

cloud free pixel

PMD 4 (805-900nm SCIA)



HICRU algorithm: Retrieval method

Upper threshold: iterative determination as function of solar zenith angle and scan angle of the satellite.

lower threshold: iterative algorithm using image sequence analysis.

- Seasonal variation of the albedo is taken into account
- Algorithm detects pixels with persistant cloud cover to avoid overestimation of the lower threshold.

PMDs on SCIAMACHY

channel	spectral range [nm]
1	310-377
2	450-525
3	617-705
4	805-900
5	1508-1645
6	2265-2380

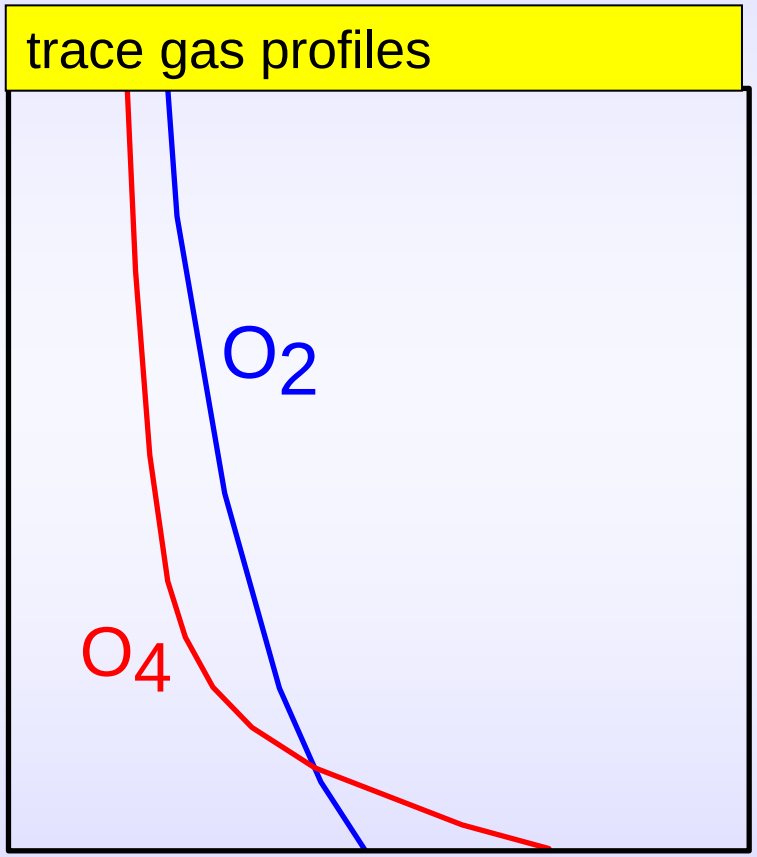
RGB image of the cloudfree earth:
Red (PMD3: 617-705), Green (PMD4: 805-900), Blue (PMD2: 450-525)

Heidelberg Iterative Cloud Retrieval Utilities (HICRU)

Grzegorski et al.,
The Heidelberg Iterative Cloud Retrieval Utilities (HICRU) and its application to GOME data, ACPD, 2006

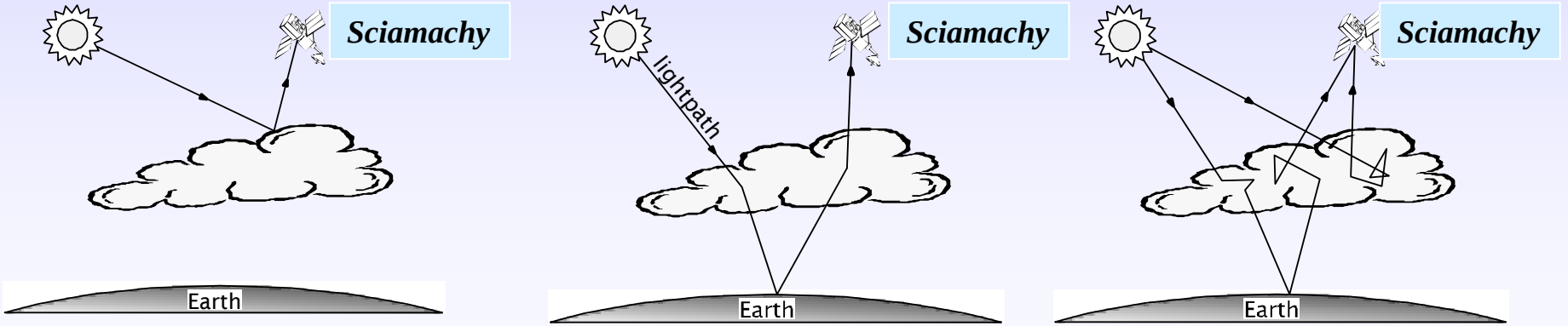
- The current algorithm determines cloud fraction successfully from PMD 3 (617-705 nm)
- Registered product at http://www.SCIAMACHY.org
- Data (SCIAMACHY and GOME) can be downloaded free of charge from: http://satellite.iup.uni-heidelberg.de

DOAS evaluation of O_2 and O_4



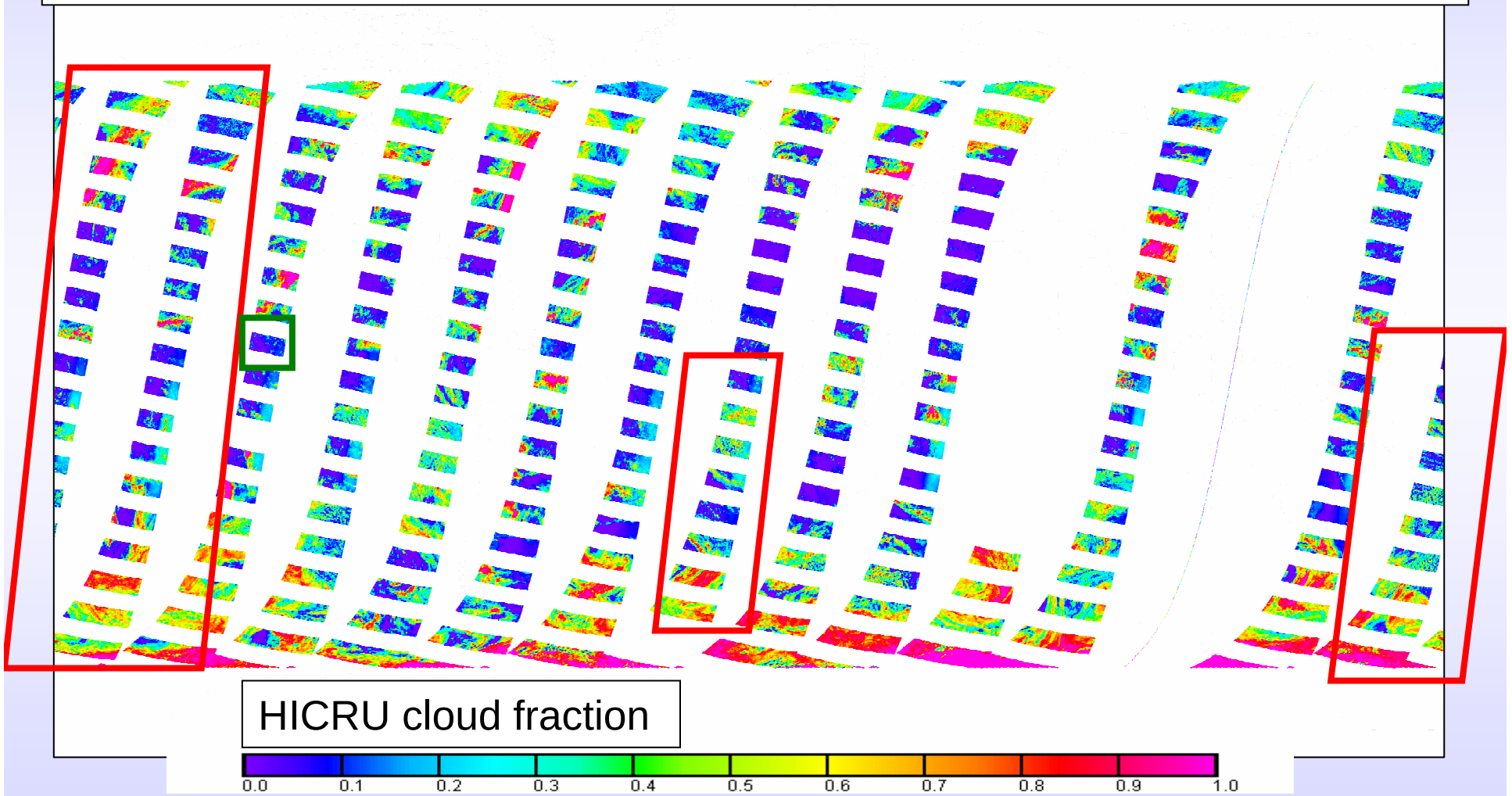
- PMD broad band intensities mainly depend on cloud coverage and cloud albedo
  - Retrieval of effective cloud fraction by HICRU
- Absorptions of O_2 and O_4 should mainly depend on cloud coverage, cloud albedo and cloud top height
- DOAS evaluation of O_2 and O_4 implemented around 630 nm.
  - Earthshine spectra instead of solar reference spectra

Cloud influence on O_2 and O_4

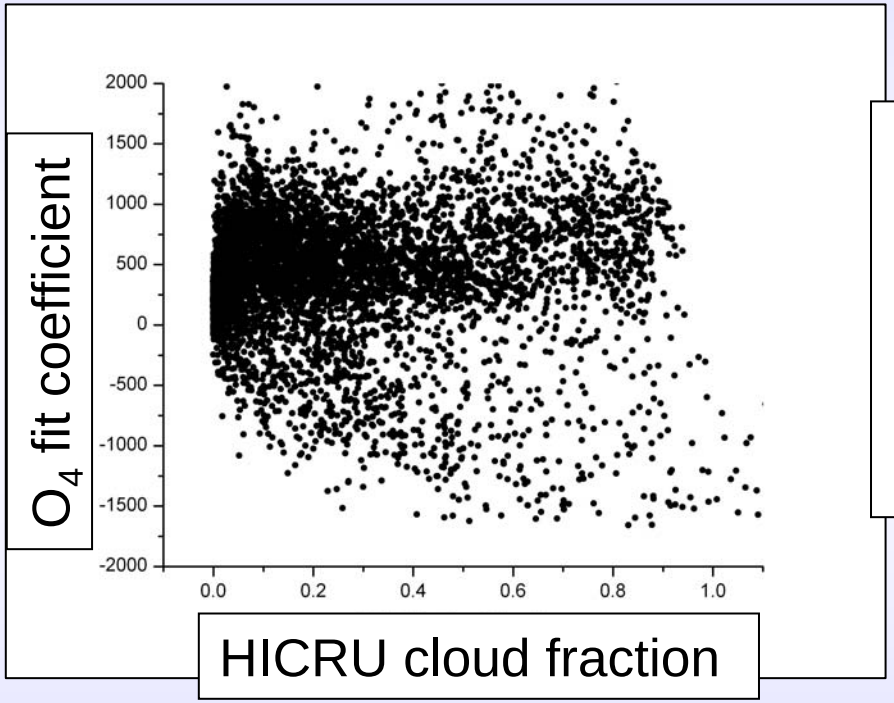


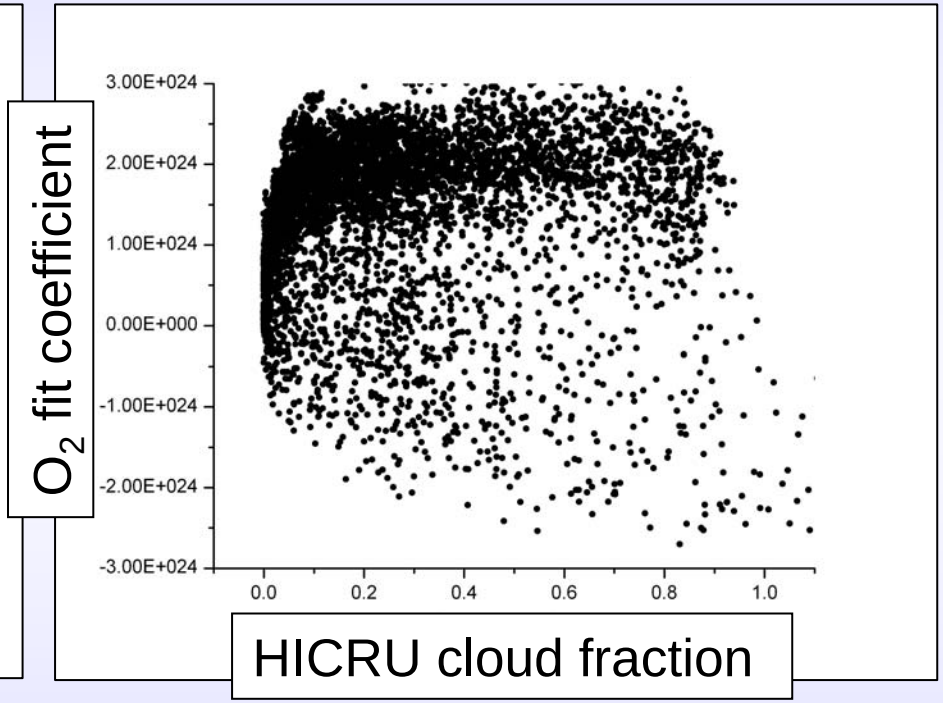
- shielding effect for O_2 and O_4 below the cloud
- albedo effect for O_2 and O_4 above the cloud
- absorptions can depend on further effects (e.g. photon path length)
  - T. Wagner: Probing internal cloud properties from space, today, 12:30

Analysis: Selection of 3 orbits over ocean (11/26/04)

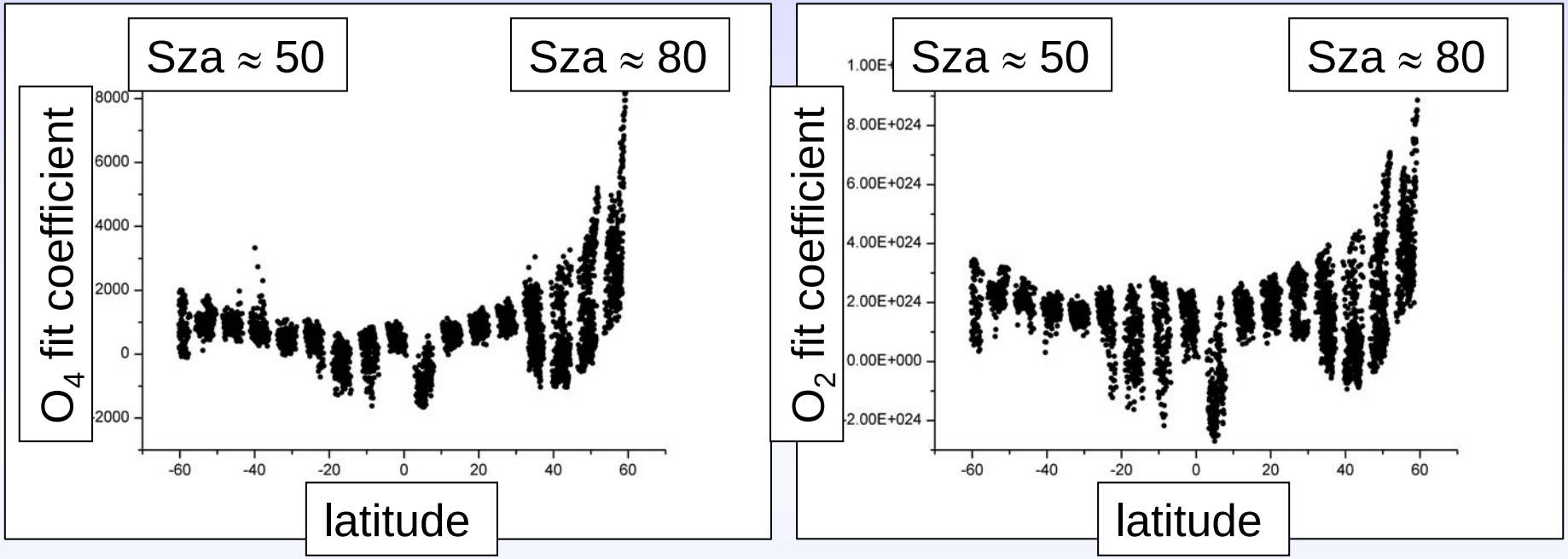


Correlation with HICRU (sza < 45)



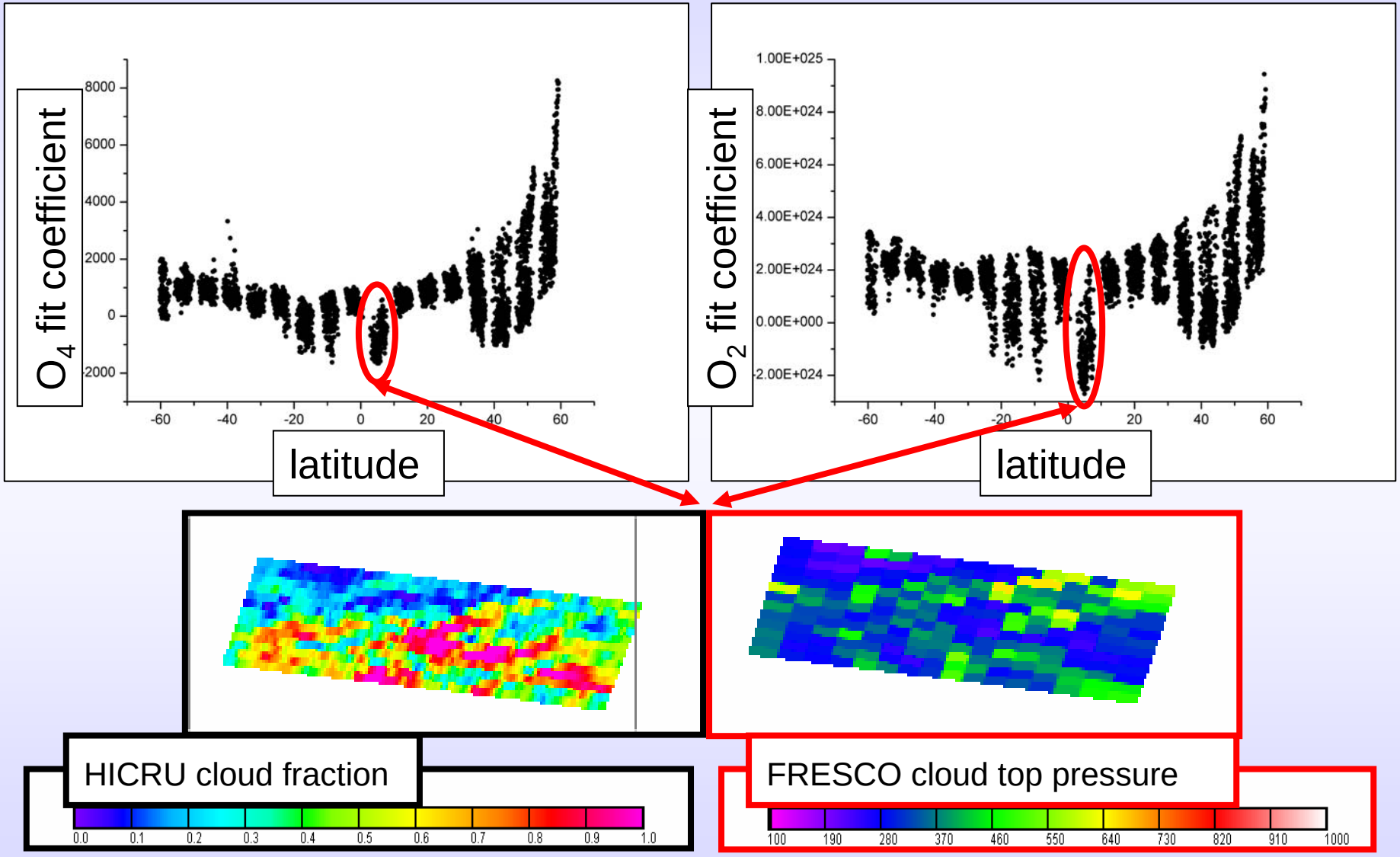


Orbit 14340: O_4 and O_2 (Pacific Ocean)



- Analysis of the orbit with respect to HICRU and FRESCO.
- Cloud top pressure from FRESCO
  - O_2-A-Band, based on SCIAMACHY data
  - Reference: Koelemeijer et al, JGR, 2001; Fournier et al., ACP, 2006
  - http://www.temis.nl

Orbit 14340: O_4 and O_2 (Pacific Ocean)



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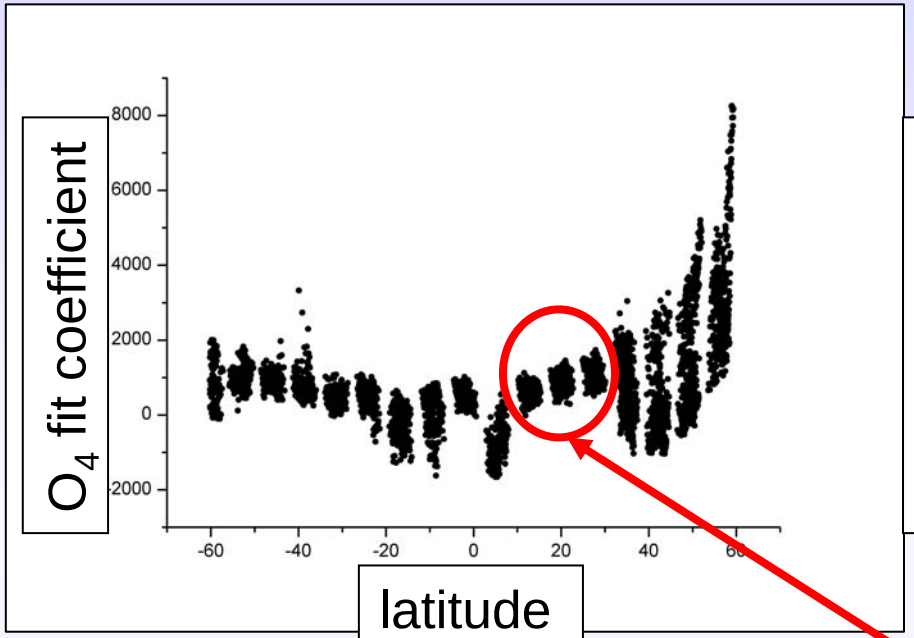
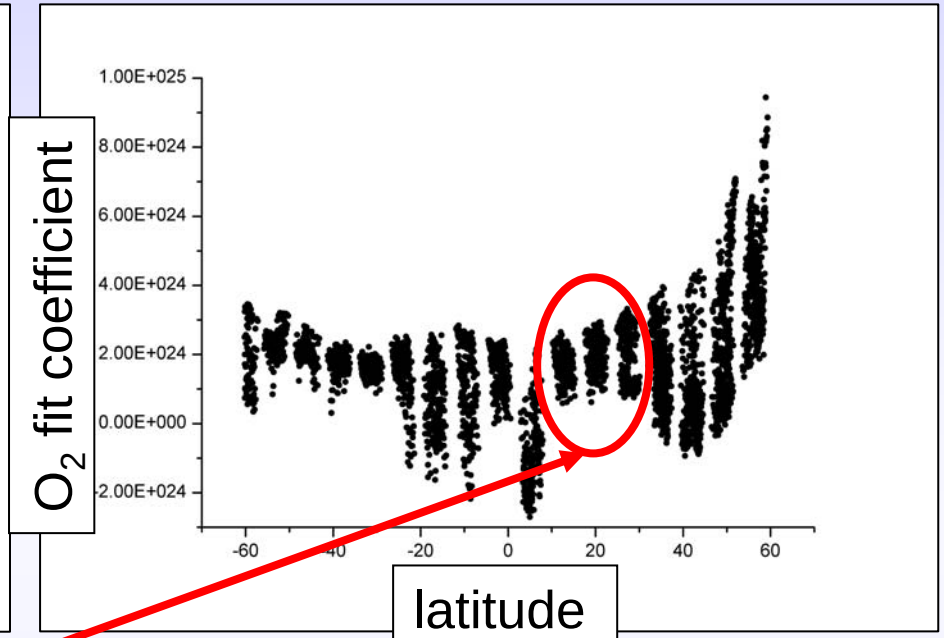
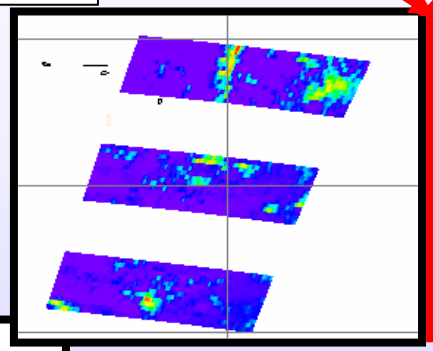
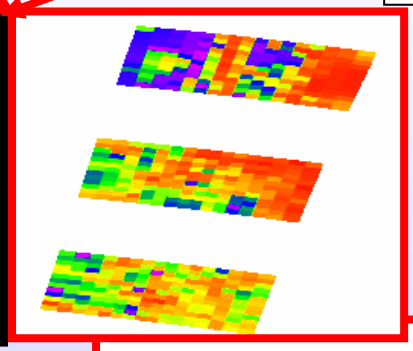
Orbit 14340: O_4 and O_2 (Pacific Ocean)









HICRU cloud fraction

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

FRESCO cloud top pressure

100 190 280 370 460 550 640 730 820 910 1000

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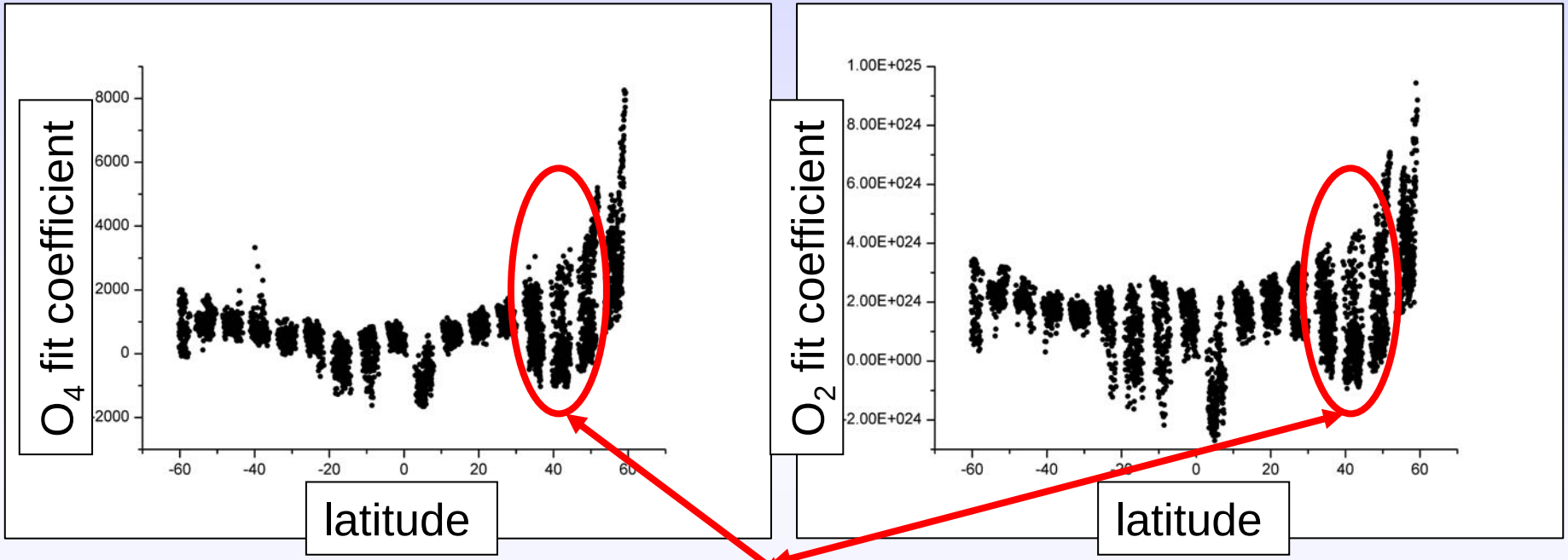
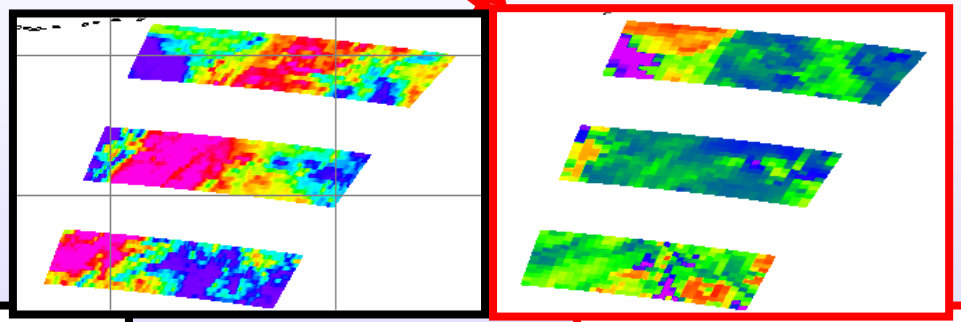
Orbit 14340: O_4 and O_2 (Pacific Ocean)





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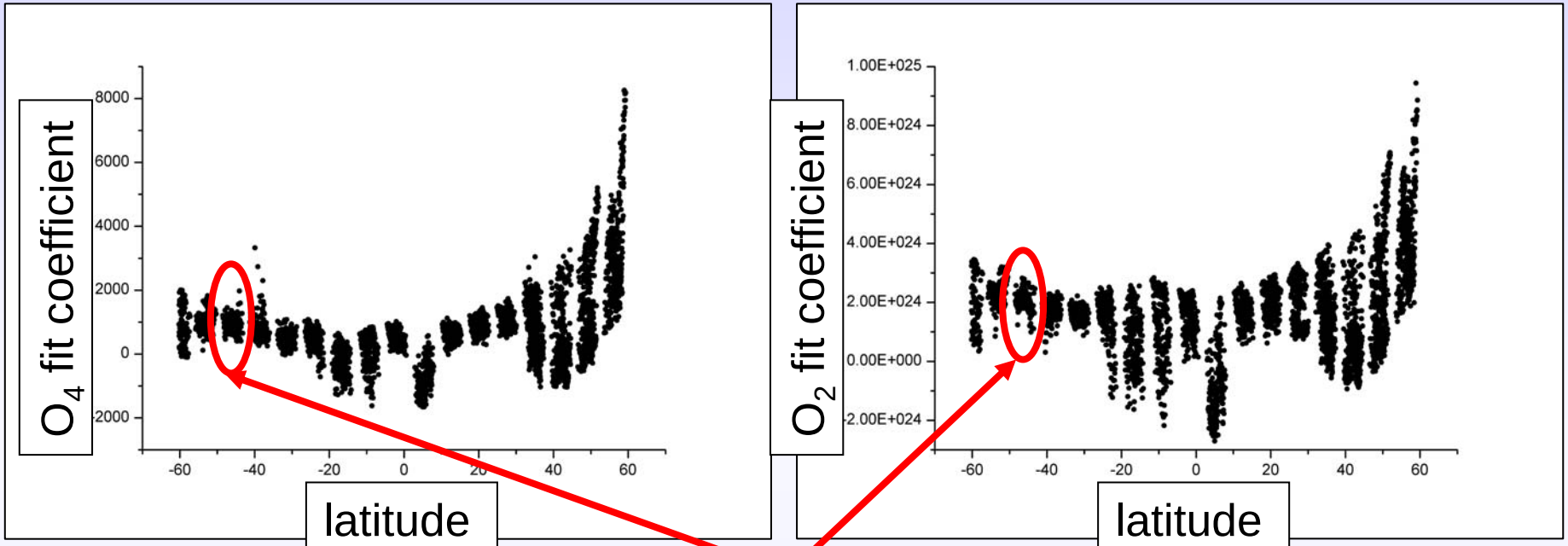
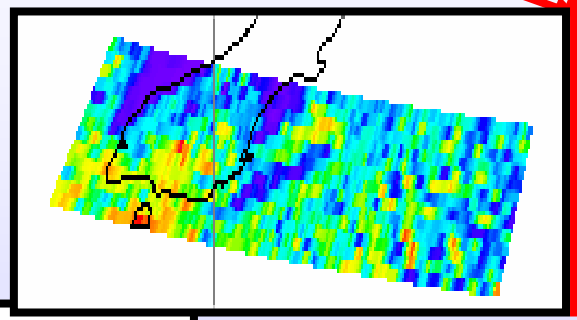
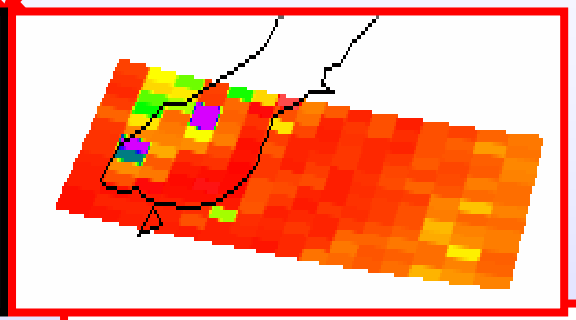
Orbit 14340: O_4 and O_2 (Pacific Ocean)







HICRU cloud fraction

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

FRESCO cloud top pressure

100 190 280 370 460 550 640 730 820 910 1000

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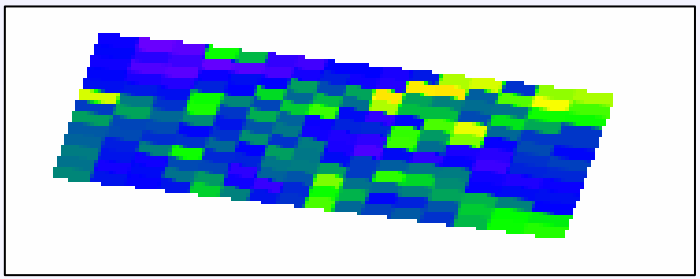
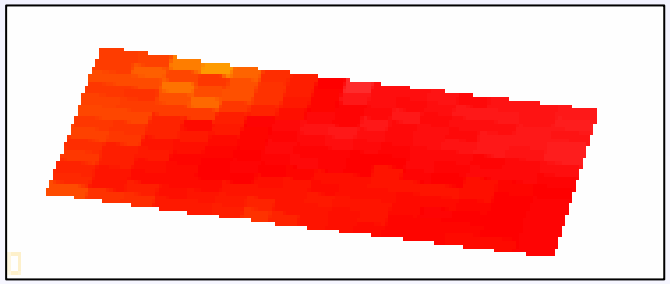
Case study I: Low and high clouds

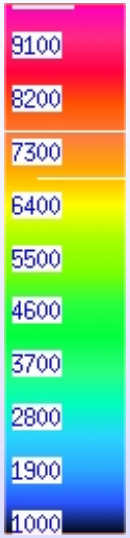
High clouds heterogenic state

Low clouds homogeneous state

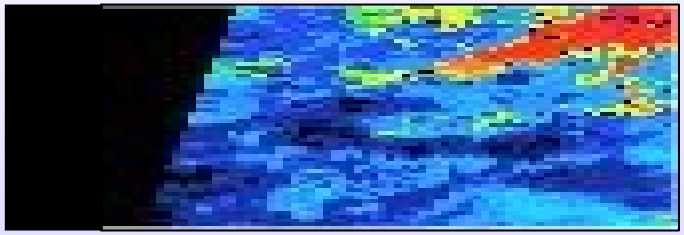


FRESCO cloud top pressure

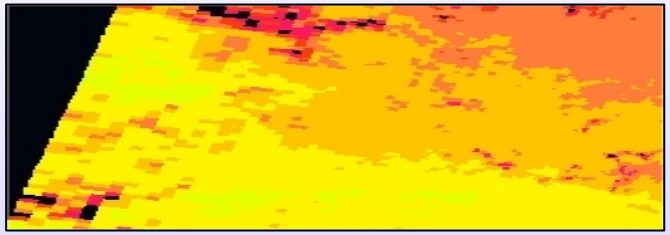




FRESCO cloud top pressure



MODIS cloud top pressure

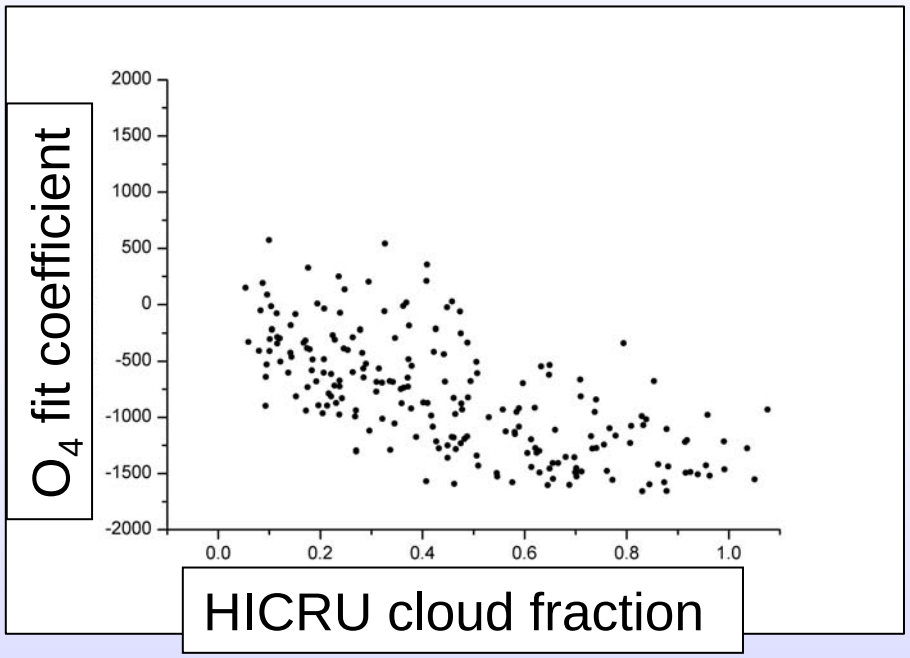


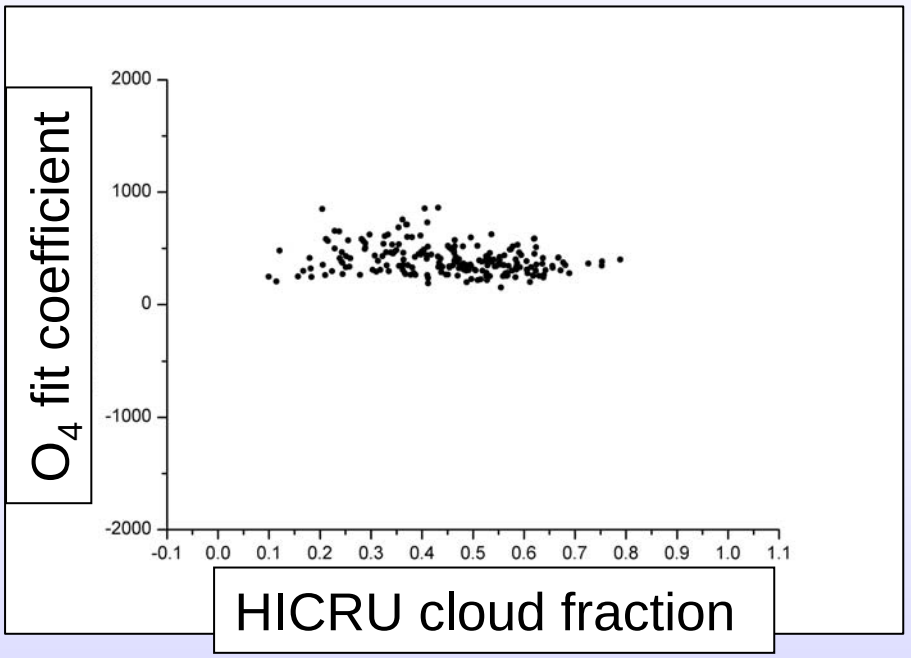
http://modis-atmos.gsfc.nasa.gov

Case study I: O_4 evaluation

High clouds heterogenic state

Low clouds homogeneous state

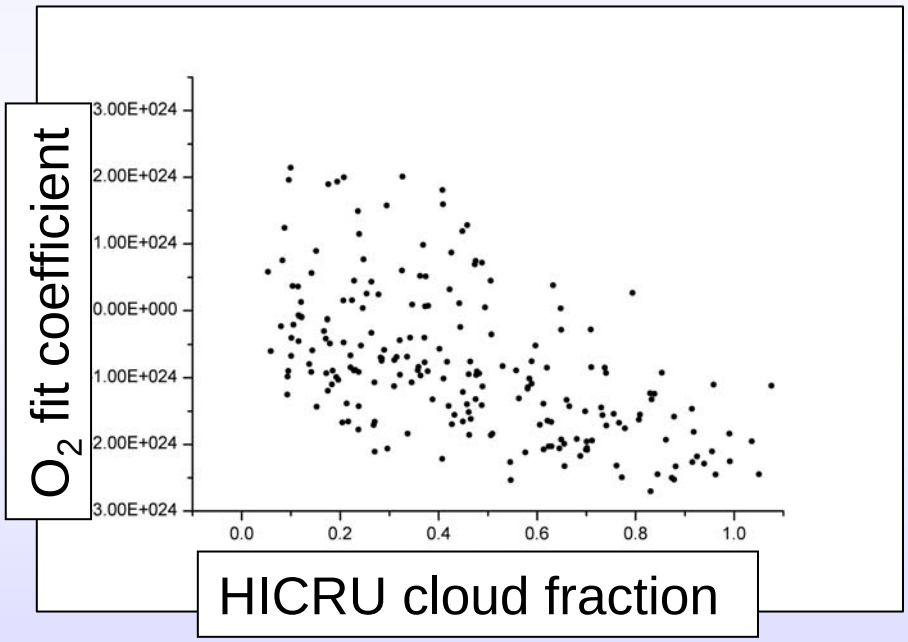


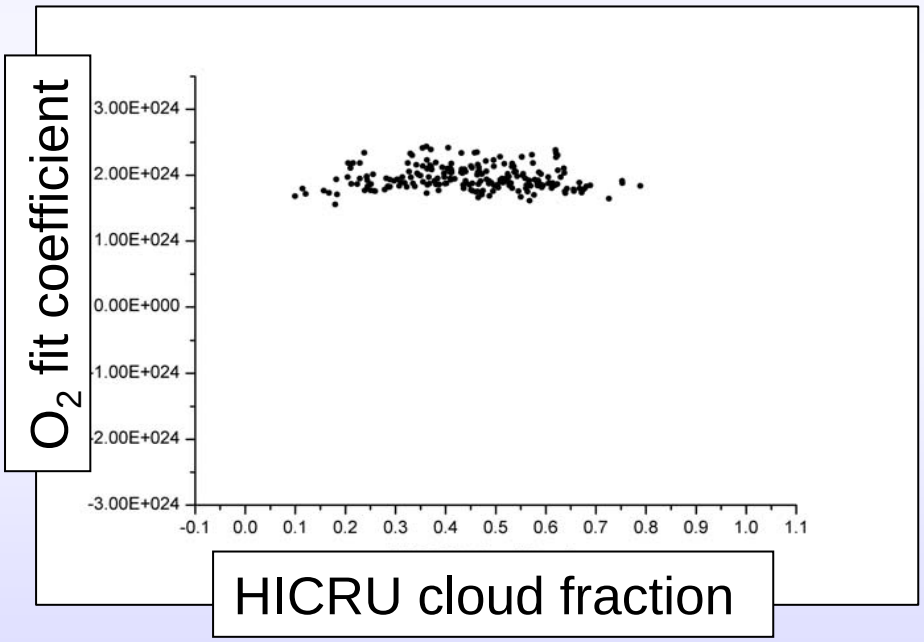


Case study I: O_2 evaluation

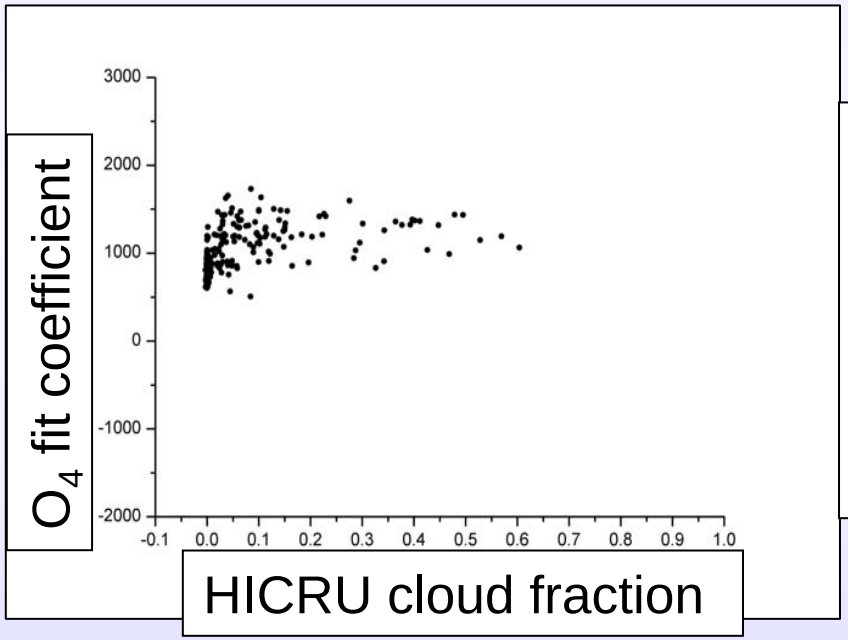
High clouds heterogenic state

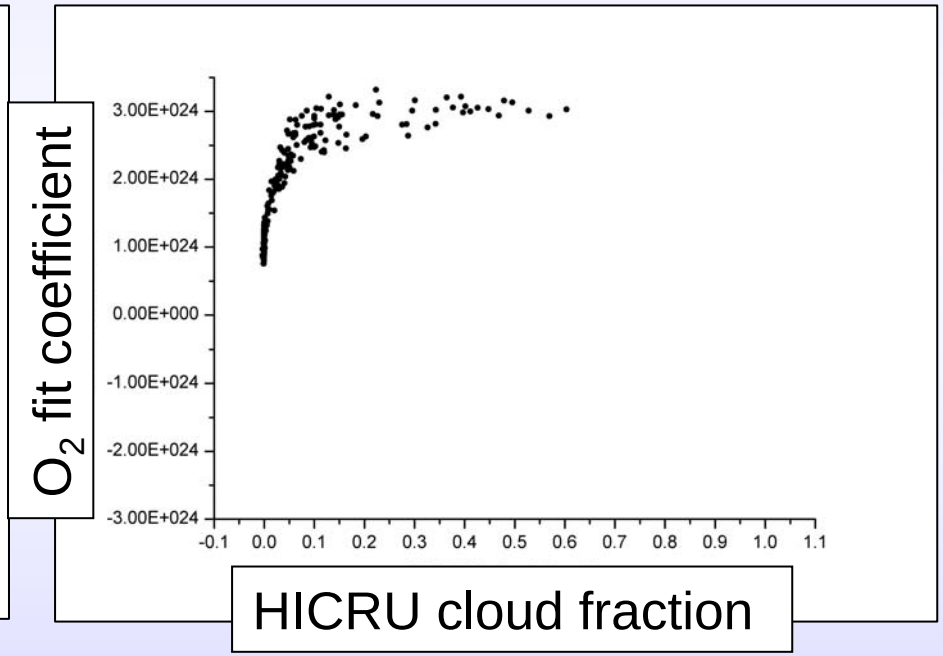
Low clouds homogeneous state





Case study II: O_4 and O_2 evaluation: low effective cloud fraction





Conclusions and outlook I

- HICRU cloud algorithm successfully retrieves effective cloud fraction from PMD 3
- Cloud fraction product available: http://satellite.iup.uni-heidelberg.de
- Successful DOAS evaluation of O_2/O_4 at 630nm
- Absorption of O_2 and O_4 nearly independent from effective cloud fraction for low clouds over ocean with cloud fraction > 0.1
- Significant dependency O_2 and O_4 on effective cloud fraction for high clouds over ocean.

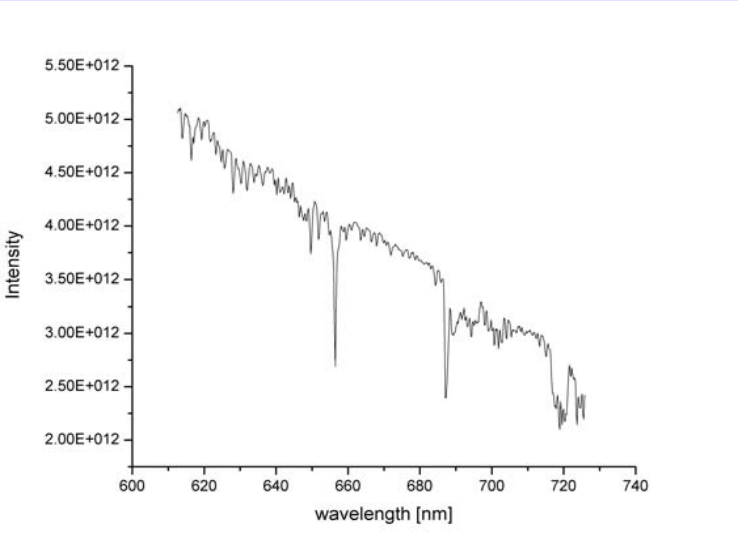
Conclusions and outlook II

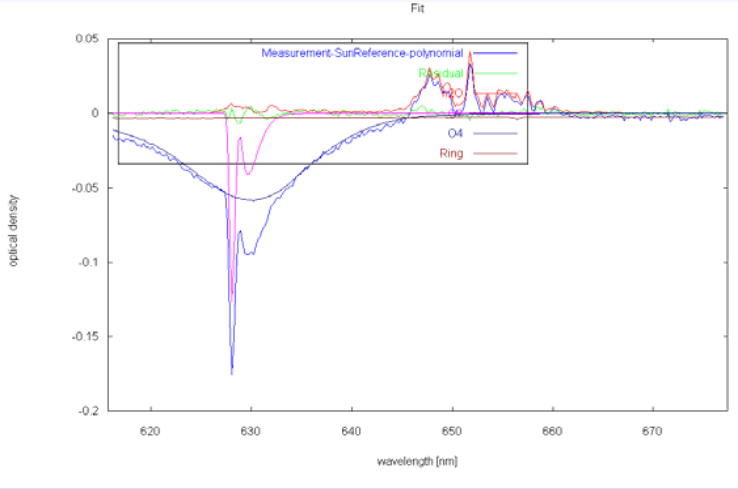
- Results are are good basis for the retrieval of cloud top height
  - Combination of HICRU cloud fraction with O_2 and O_4.
- Additional use of DOAS evaluation of O_4 and Ring effect at 360 nm may allow the retrieval of further cloud parameters

THANKS … …… ….

FOR YOUR ATTENTION

DOAS evaluation of O_2/O_4 at 630nm

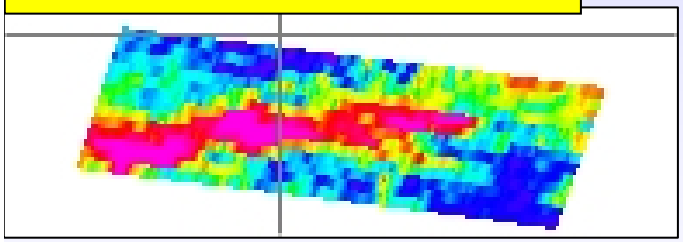




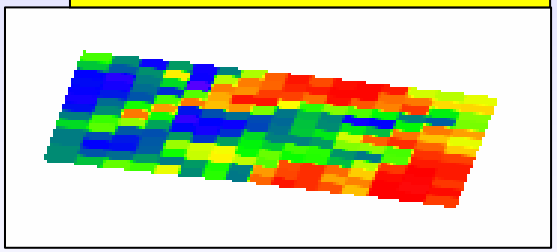
- Fit window: 615nm-676nm
- Earthshine spectra instead of Solar Reference spectra
  - cloud free mesurement over pacific ocean, low sza.
- Reference spectra:
  - O_4 [Greenblatt et. al., 19xx]
  - O_2 [HITRAN]
  - H_2O [HITRAN]
  - Ring [Bussemer et. al., 19xx]

Case study V: O_2/O_4 evaluation

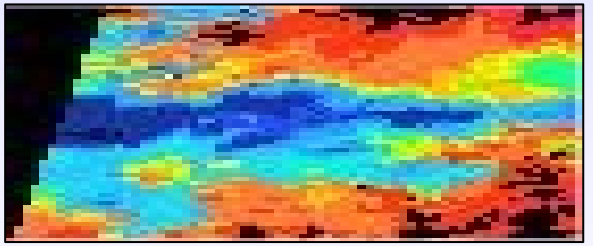
HICRU cloud fraction

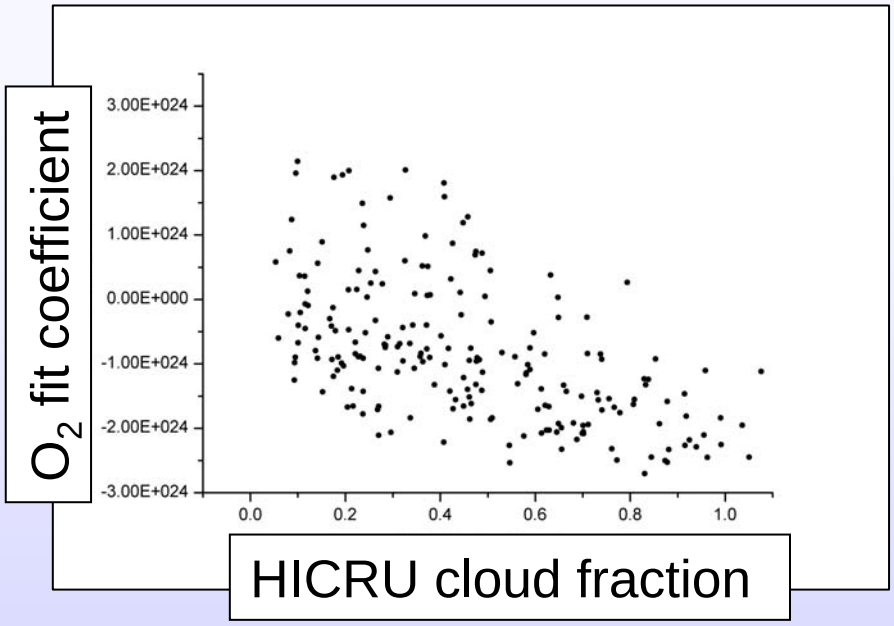


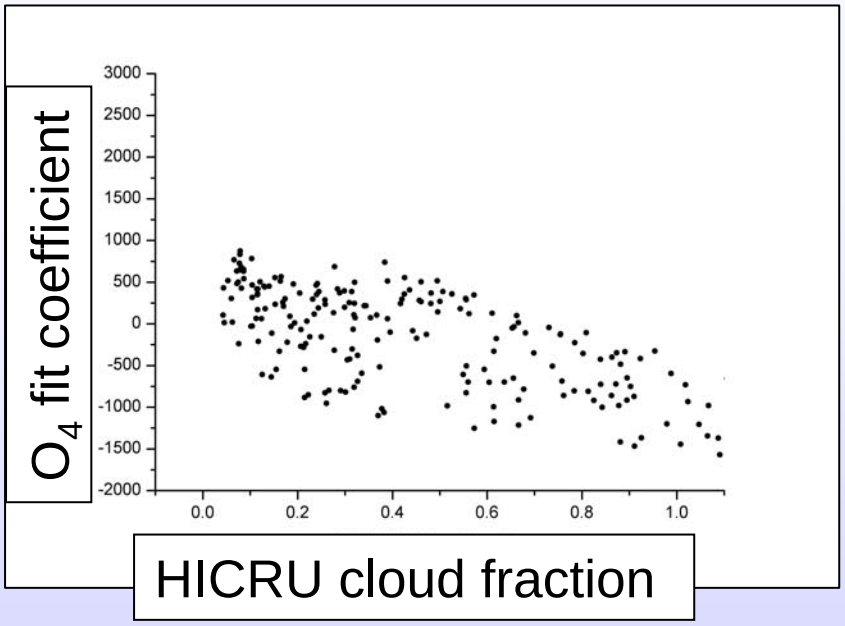
FRESCO CTP



MODIS CTP

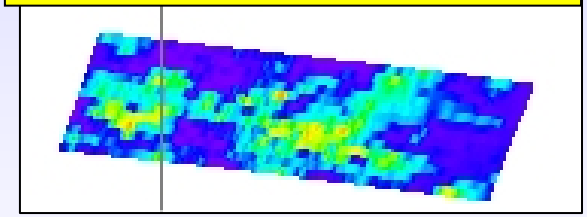






Case study IV: O_2/O_4 evaluation

HICRU cloud fraction



FRESCO cloud top pressure