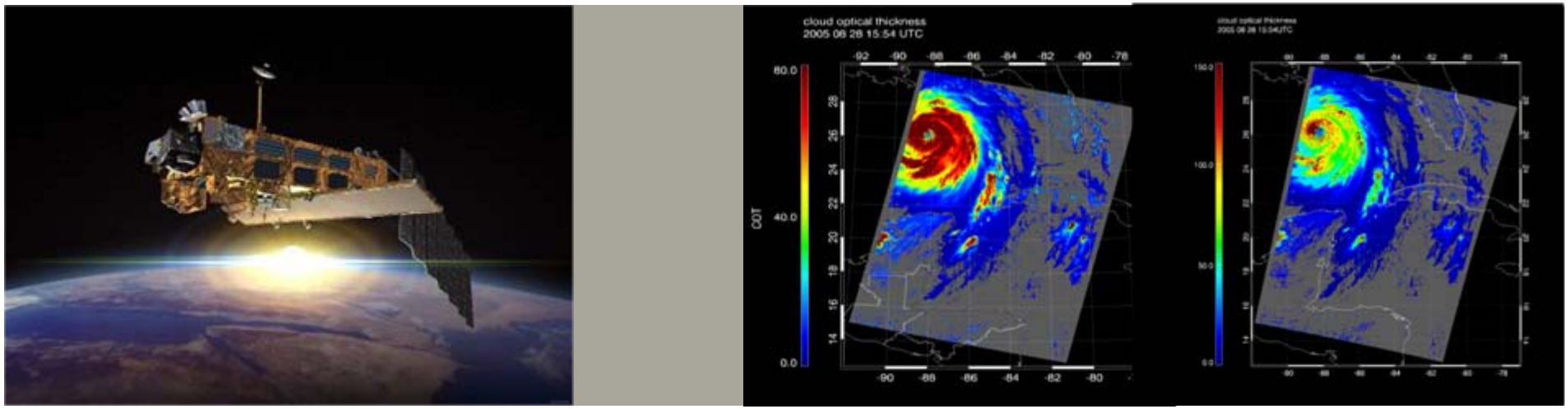
Freie Universität Berlin



MERIS cloud products

Jürgen Fischer, Rasmus Lindstrot and Rene Preusker
Institut für Weltraumwissenschaften, Freie Universität Berlin

GEWEX cloud assessment meeting, 22-25 September 2010

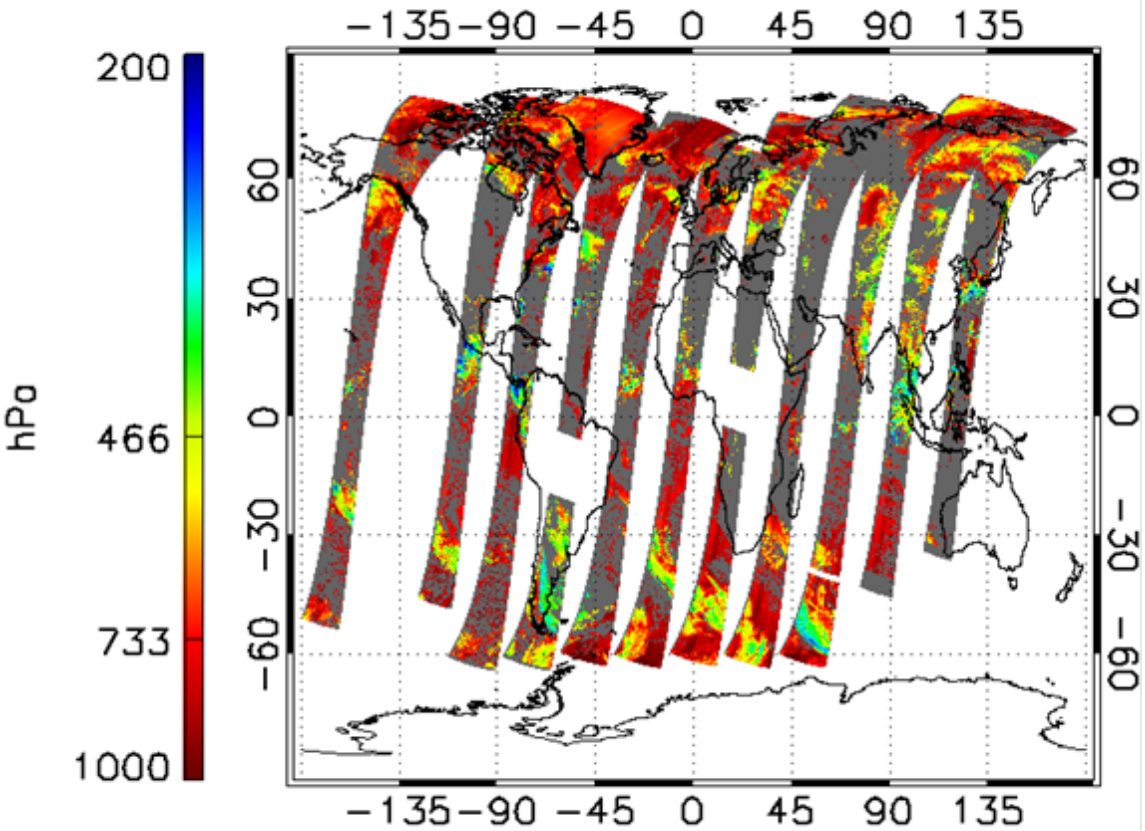
MERIS

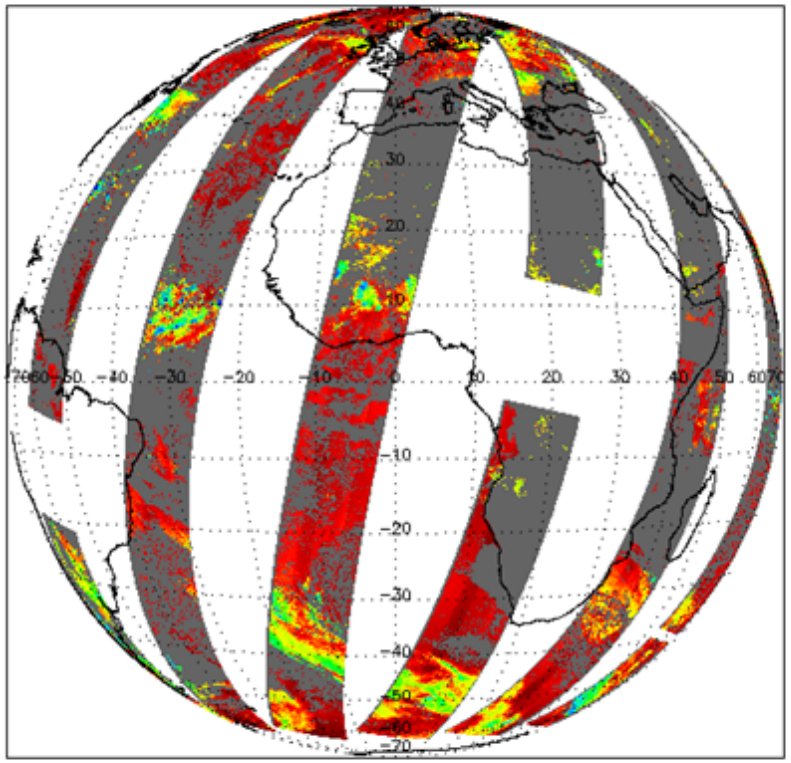
Medium **R**esolution **I**maging **S**pectrometer onboard ENVISAT (2002 - ...)

- Pushbroom Imager
- Spatial resolution 1*1 km² (RR, globally), ~ 300 * 260 m² (FR, land and coastal areas)
- Swath width ~1150km
- 15 spectral channels:

1	412.5 ± 10	Yellow substance and detrital pigments
2	442.5 ± 10	Chlorophyll absorption maximum
3	490 ± 10	Chlorophyll and other pigments
4	510 ± 10	Suspended sediment, red tides
5	560 ± 10	Chlorophyll absorption minimum
6	620± 10	Suspended sediment
7	665± 10	Chlorophyll absorption and fluorescence reference
8	681.25 ± 7.5	Chlorophyll fluorescence peak
9	708.75 ± 10	Fluorescence reference, atmospheric corrections
10	753.75 ± 7.5	Vegetation, cloud
11	760.625 ± 3.75	Oxygen absorption R-branch
12	778.75 ± 15	Atmospheric correction
13	865 ± 20	Vegetation, water vapour reference
14	885 ± 10	Atmospheric correction
15	900 ± 10	Water vapour

MERIS spatial coverage





- Polar-orbiting, sun-synchronous orbit
- Global coverage: 2-3 days
- Orbit repeat cycle: 35 days
- Daytime-only due to spectral range!

MERIS cloud products

MERIS was not designed for remote sensing of clouds!

- No thermal IR → daytime-only observations
- No CO_2 slicing
- No shortwave IR → no cloud microphysics

BUT:

+ almost unique selling point: O_2 A absorption at a high spatial resolution.

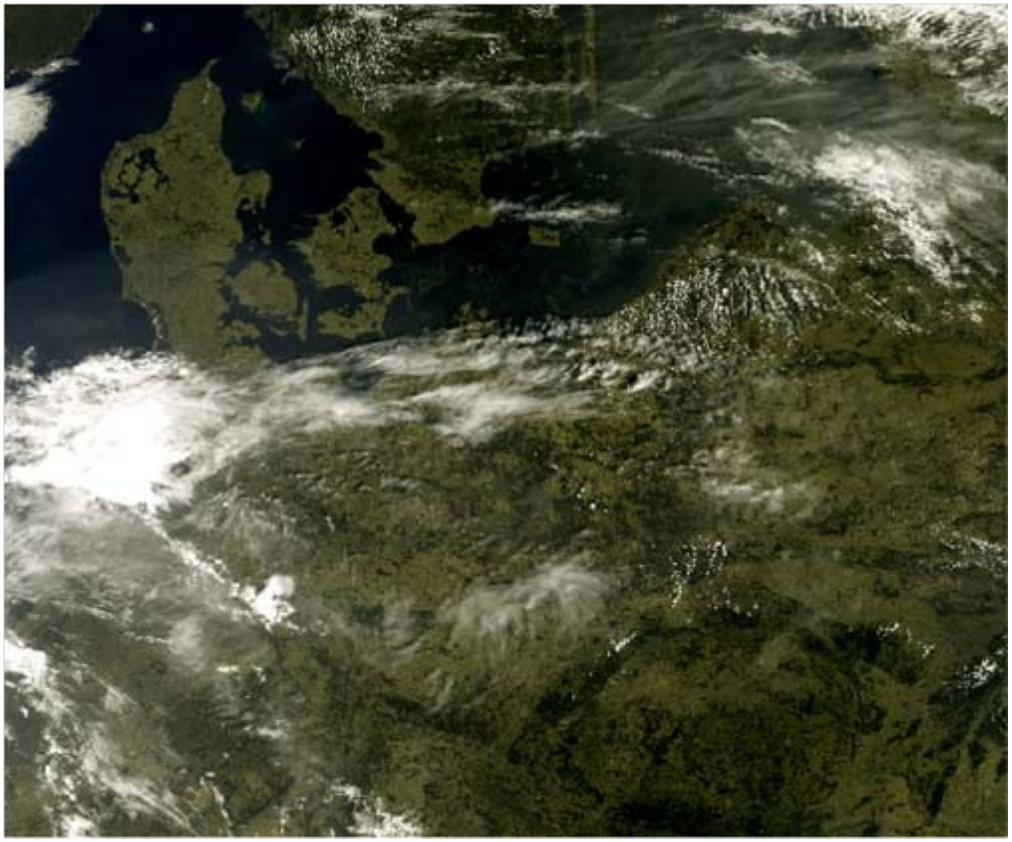
  → Accurate retrieval of **cloud-top pressure** (especially for low clouds).

+ all other MERIS algorithms require an ahead cloud detection.

  → A lot of effort is put into this field. Global **cloud amount** can be derived.

+ **cloud optical thickness** is derived (assuming fixed r_{eff})

MERIS cloud detection



Clouds are

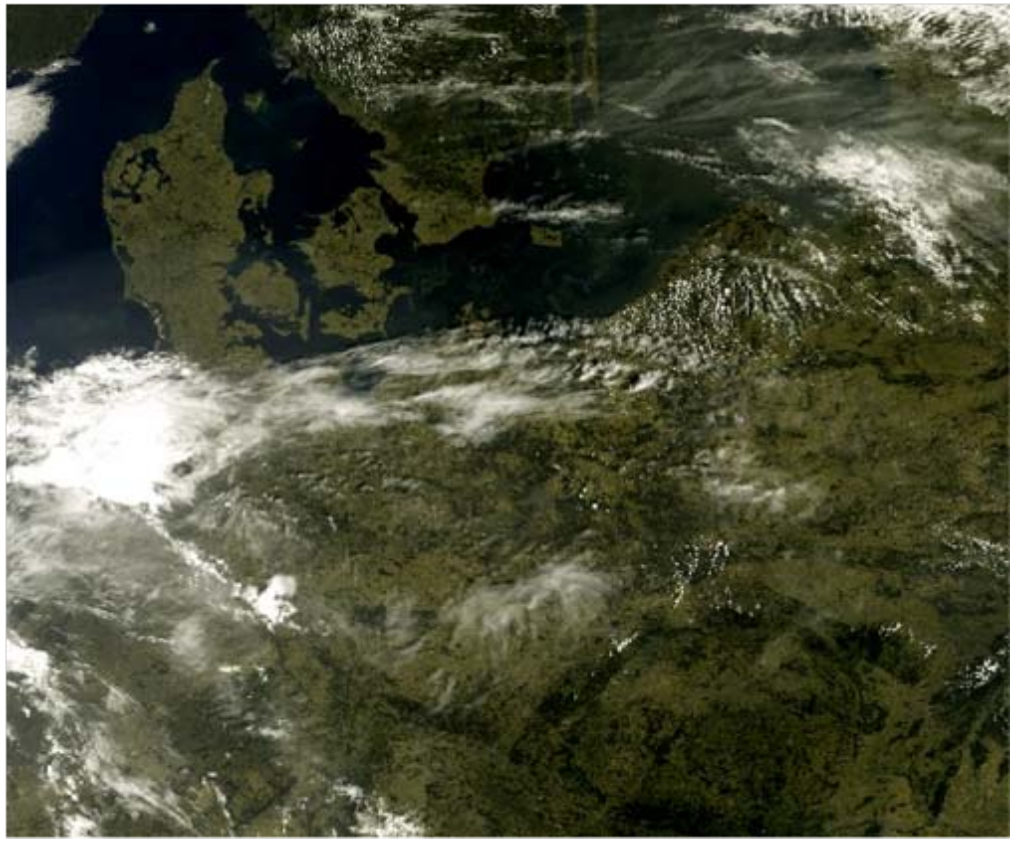
- bright
- white
- elevated
- cold
- ...

- none of these criteria is always true and none is singular
  - there are clouds that are not very bright
  - there are clouds that are close to the surface
  - there are warm clouds
  - etc

MERIS cloud detection

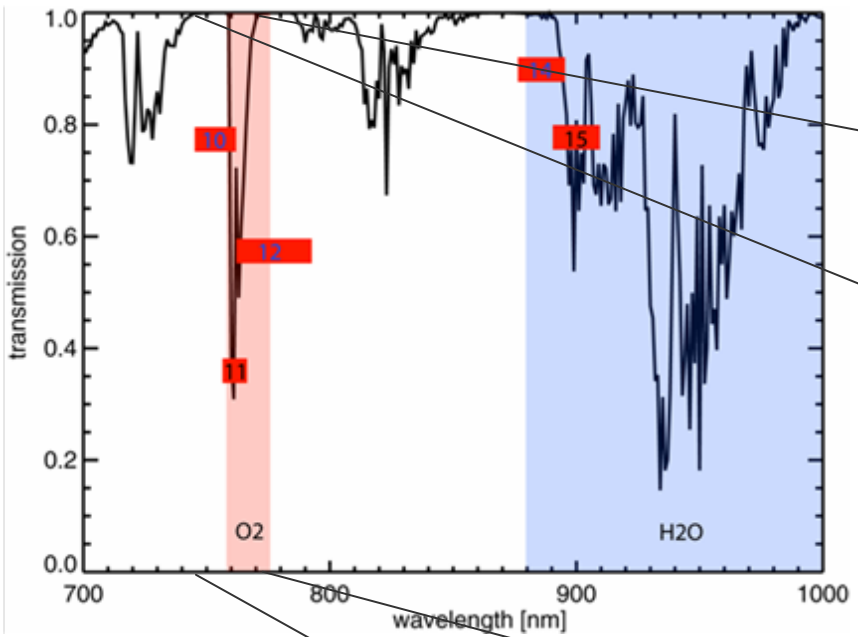
Clouds are

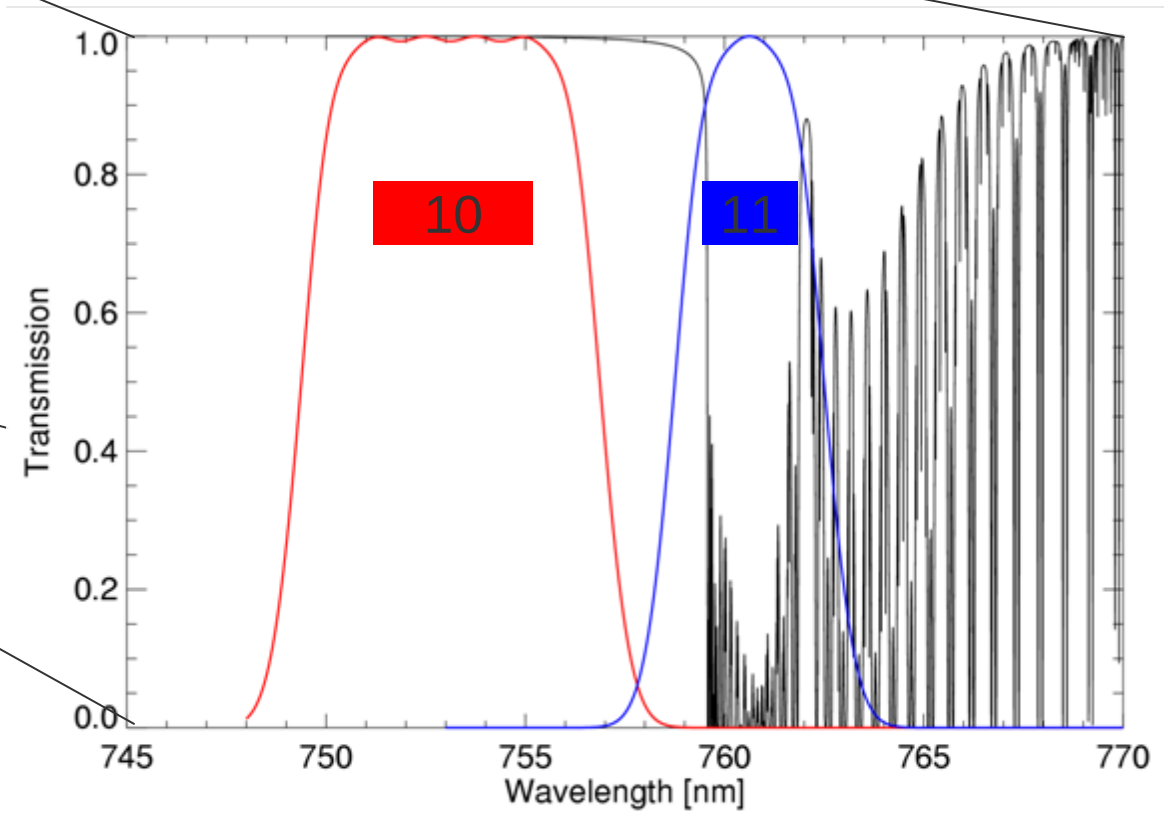
- bright → full spectrum
- white → full spectrum
- elevated → O_2 A band
- cold
- ...



- none of these criteria is always true and none is singular
  - there are clouds that are not very bright
  - there are clouds that are close to the surface
  - there are warm clouds
  - etc

MERIS O_2 A bands





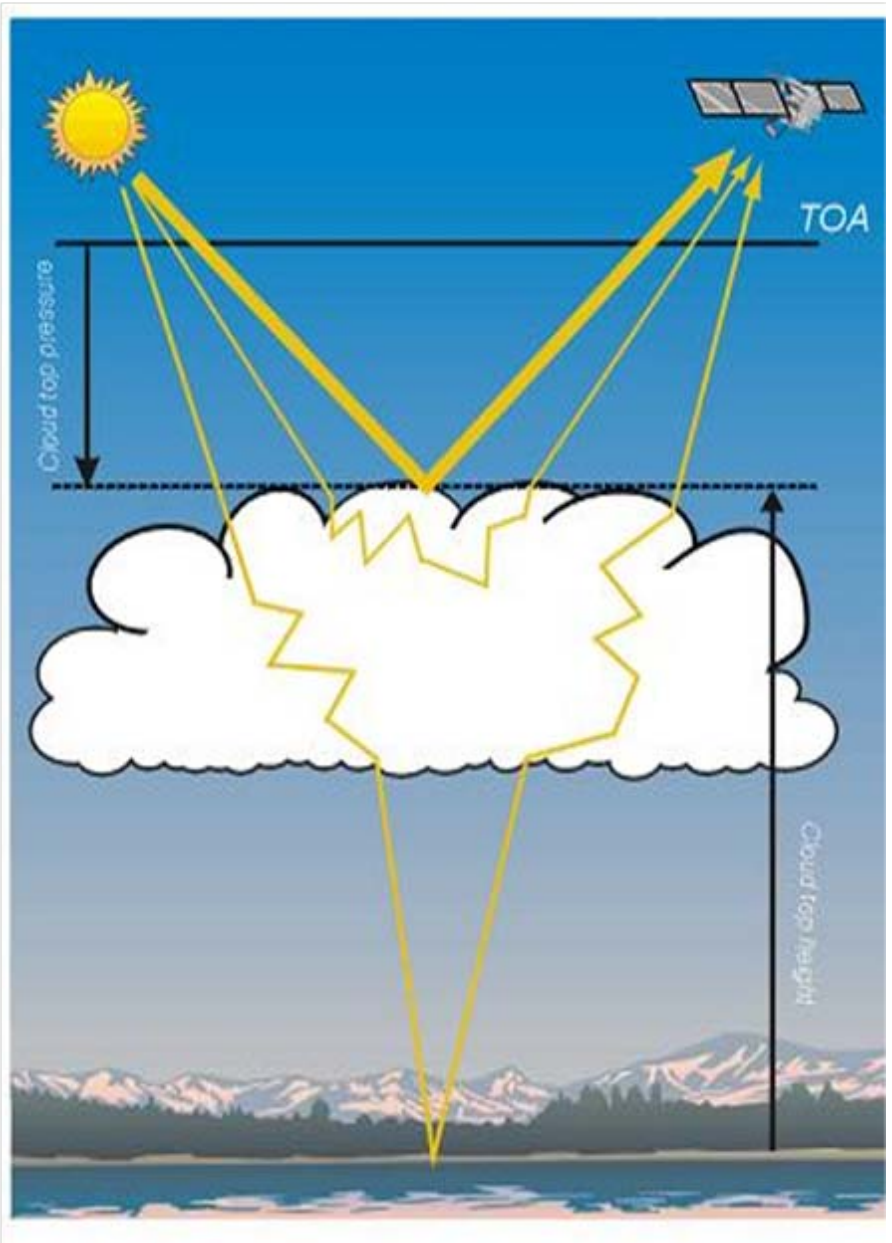
Window channel 10 @ 753 nm, (fwhm ~ 7.5nm)

O2A band channel 11 @ 761nm , (fwhm ~ 3.75nm)

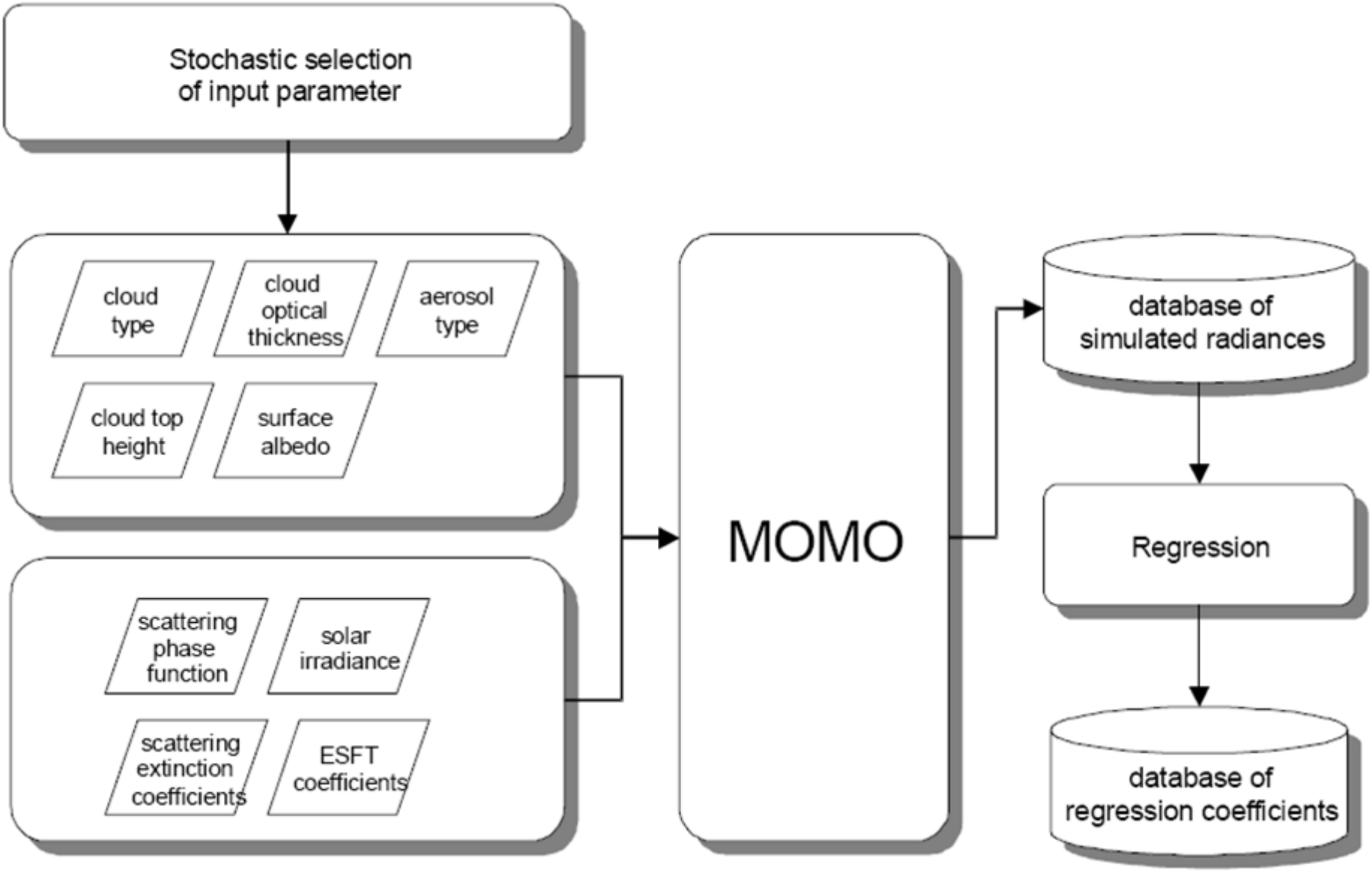
CTP - Approach

- Ratio of radiances of channels 11 and 10 (→ transmittance) depends on traversed air mass, mainly determined by cloud-top pressure (and viewing geometry).

- Impact of multiple scattering within cloud and between cloud and surface is estimated by
  - cloud optical thickness from window band 10,
  - surface albedo from MERIS Albedomap.



Radiative transfer simulations



CTP validation campaign

- Flight campaign between April and June 2004.

- Cessna 207 T (FUB)

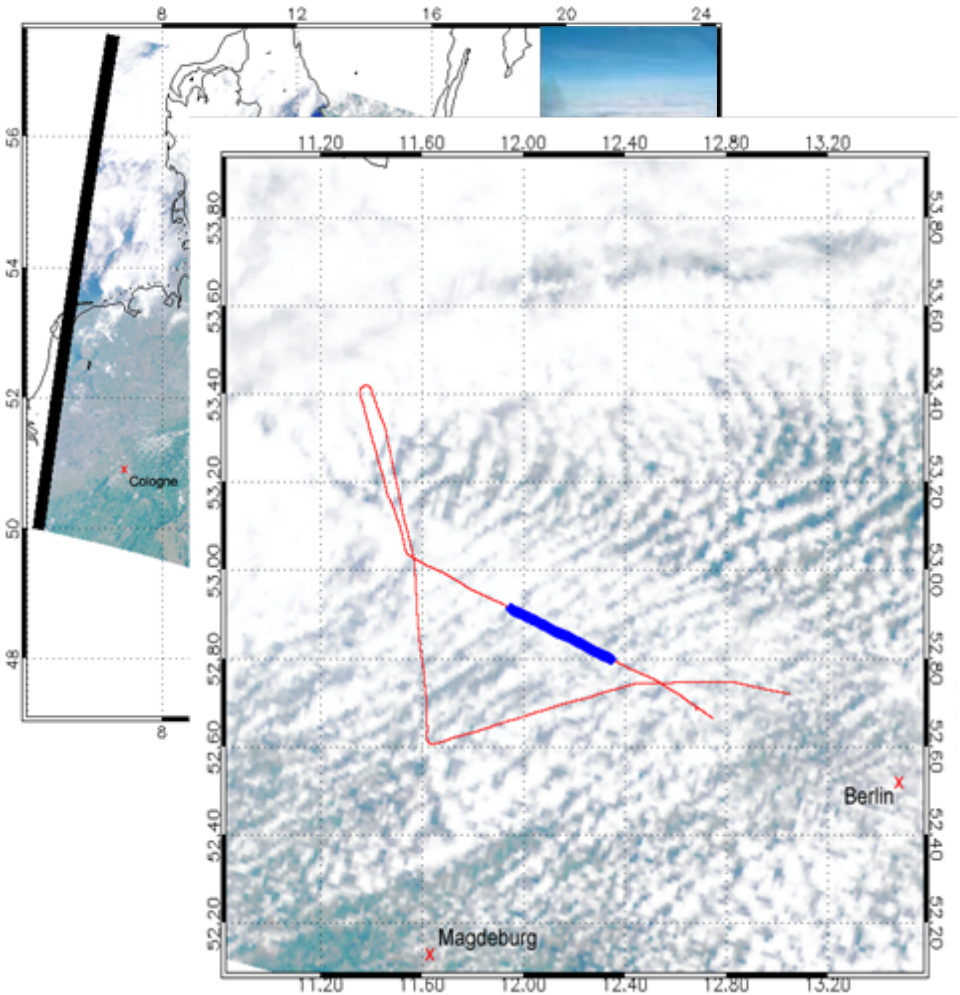
- Instrument: POLIS (LMU München), **Po**rtable **Li**dar **S**ystem.

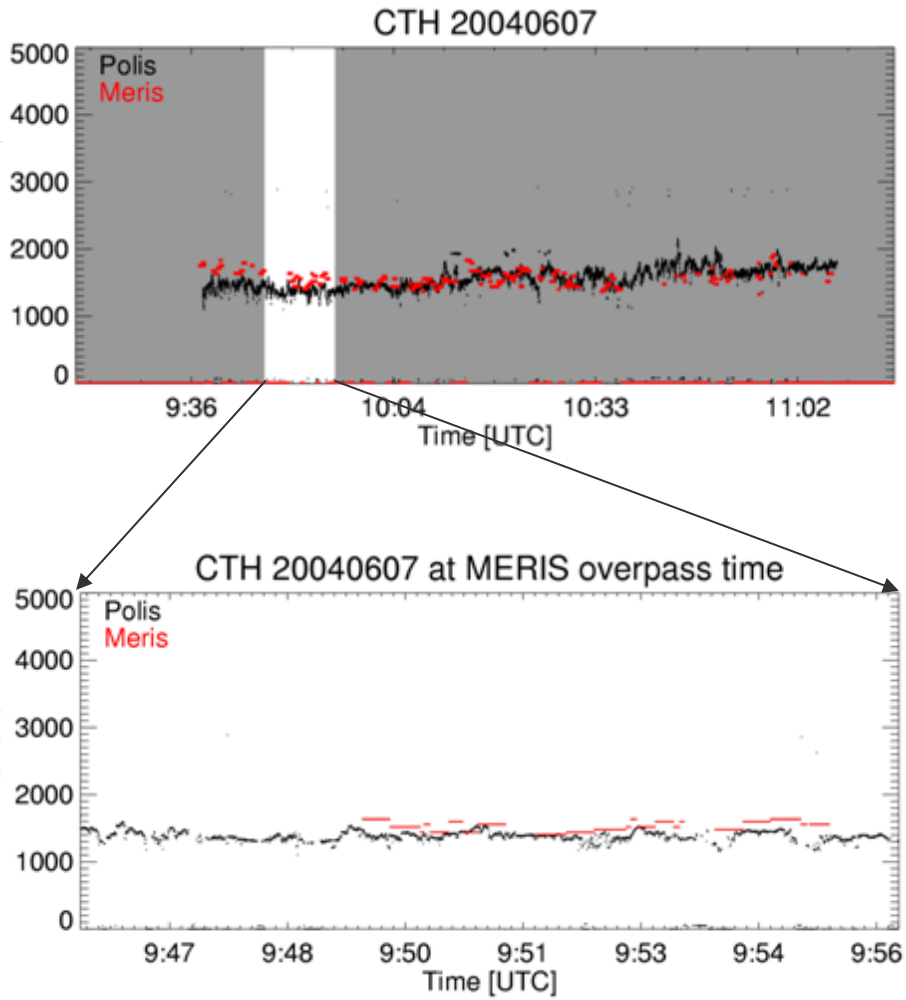
- limited to observation of low clouds (CTH ≤ 3000m).

CTP validation campaign

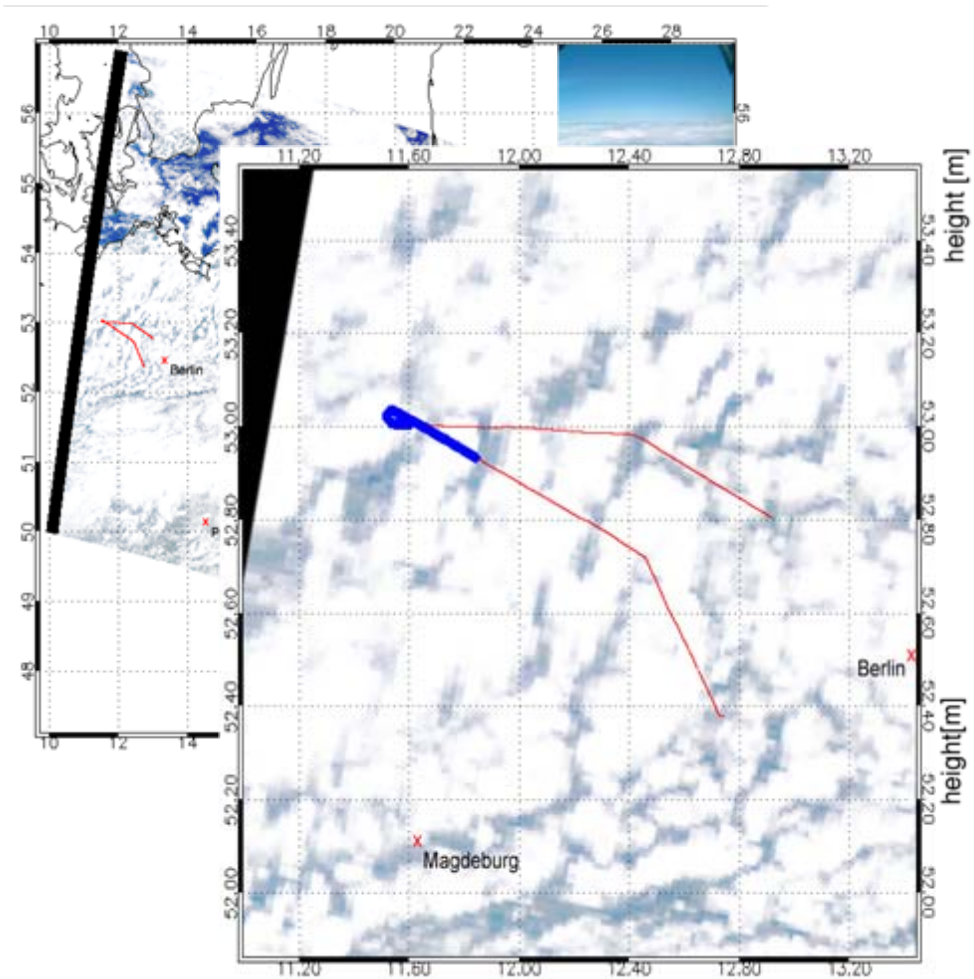
Date	Clouds
2004 04 20	scattered Cumulus + Cirrus
2004 05 03	Stratocumulus + Cumulus
2004 05 06	scattered Cumulus
2004 05 12	Stratocumulus
2004 05 18	Stratocumulus
2004 05 24	Stratocumulus
2004 05 25	Stratocumulus
2004 05 26	Stratocumulus + Cumulus
2004 06 03	scattered Cumulus
2004 06 07	Stratocumulus
2004 06 11	Cumulus + Cirrus
2004 06 16	Stratocumulus + Cumulus

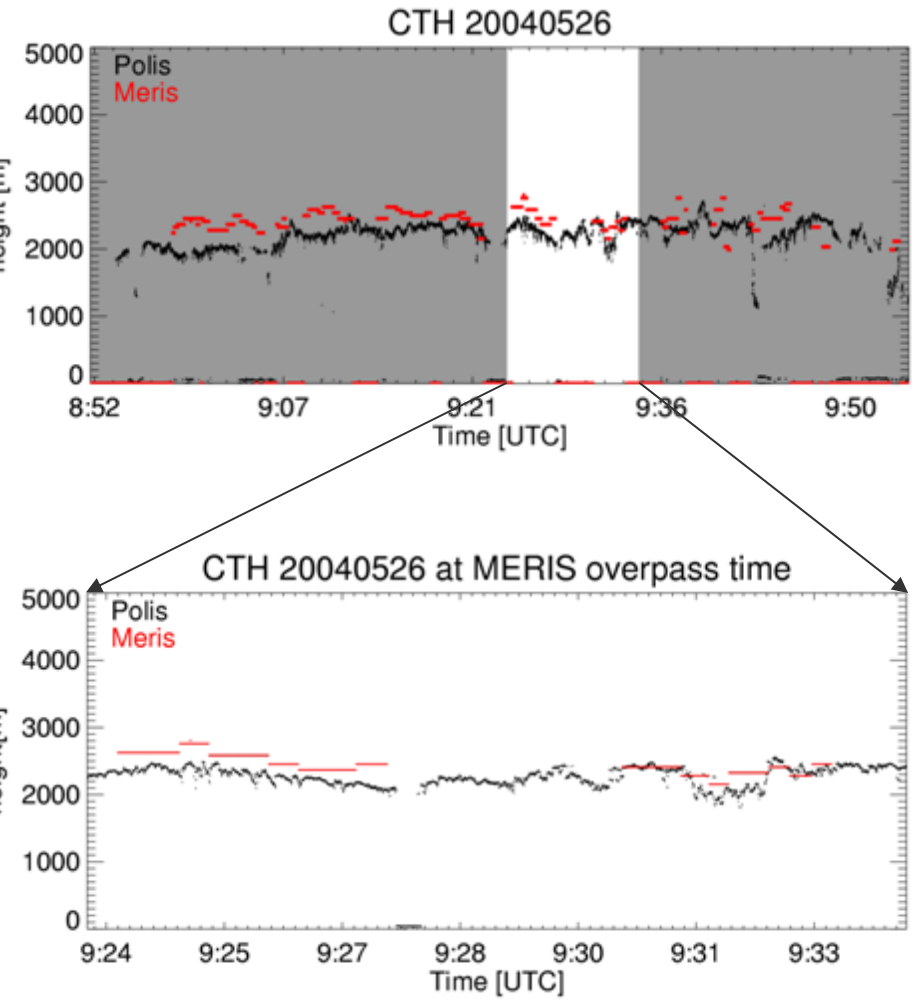
2004/06/07, Sc


Cologne
Berlin
Magdeburg

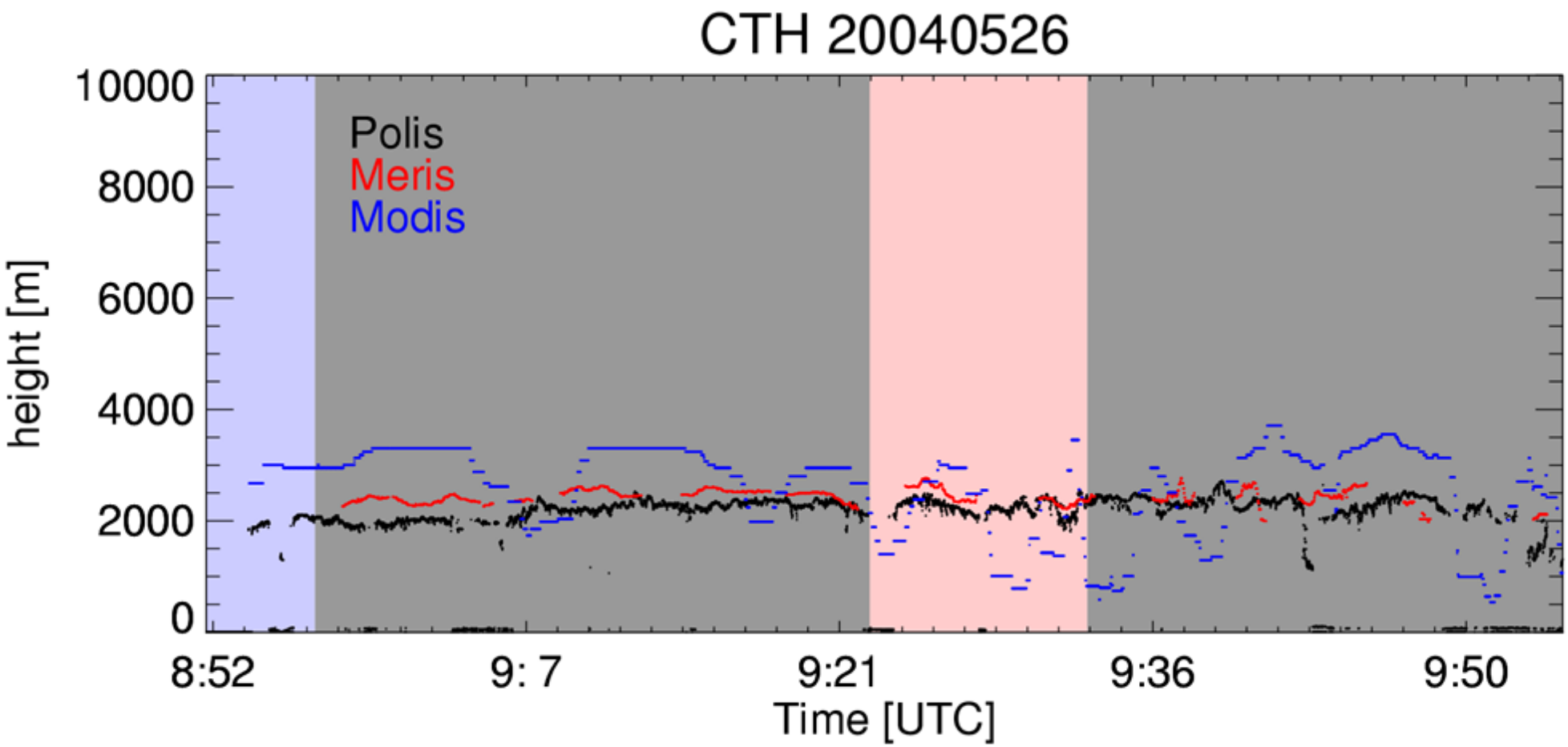

CTH 20040607
Polis
Meris
Time [UTC]
CTH 20040607 at MERIS overpass time
Polis
Meris
Time [UTC]

2004/05/26, Sc + Cu

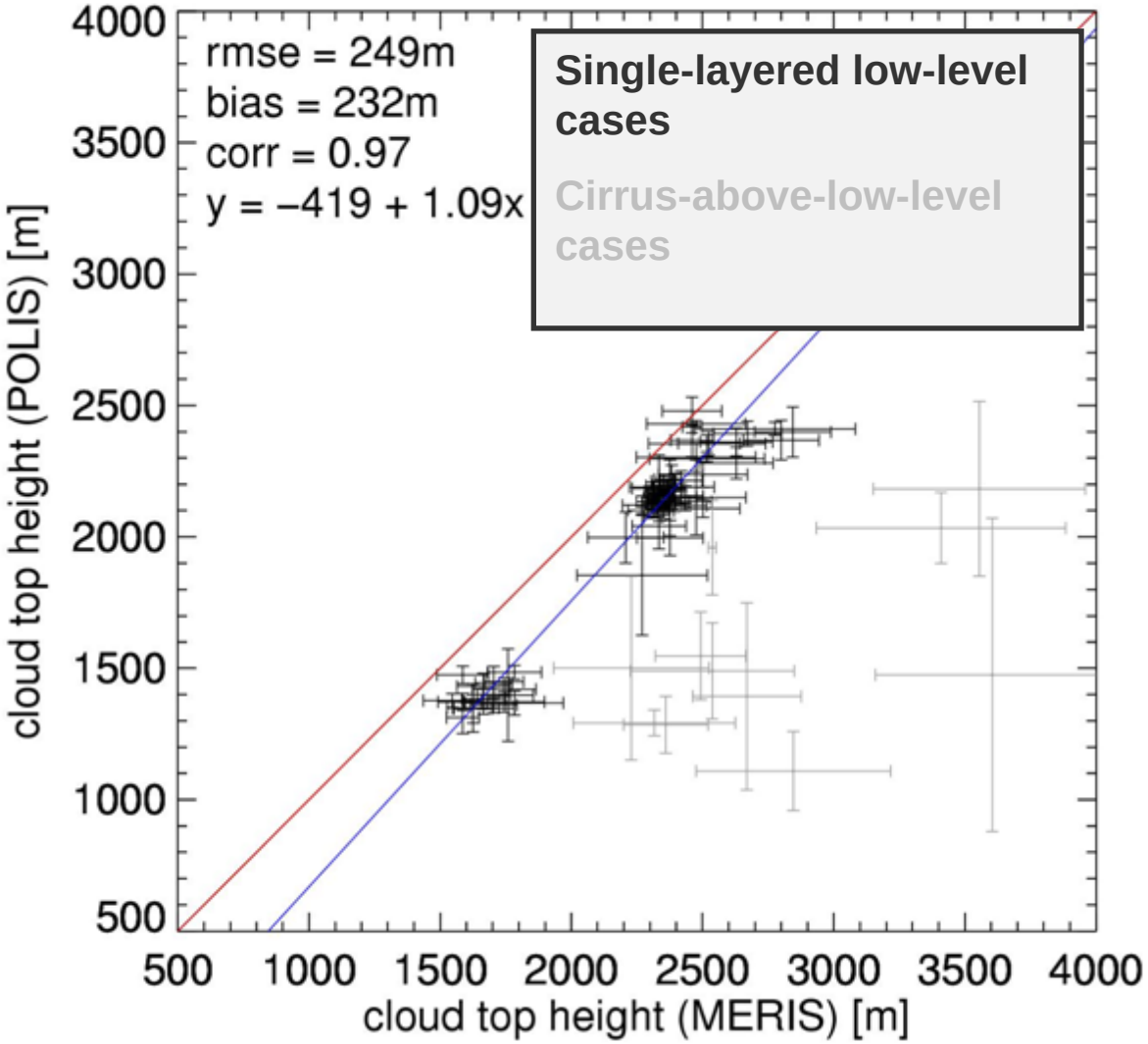




MODIS/MERIS/LIDAR



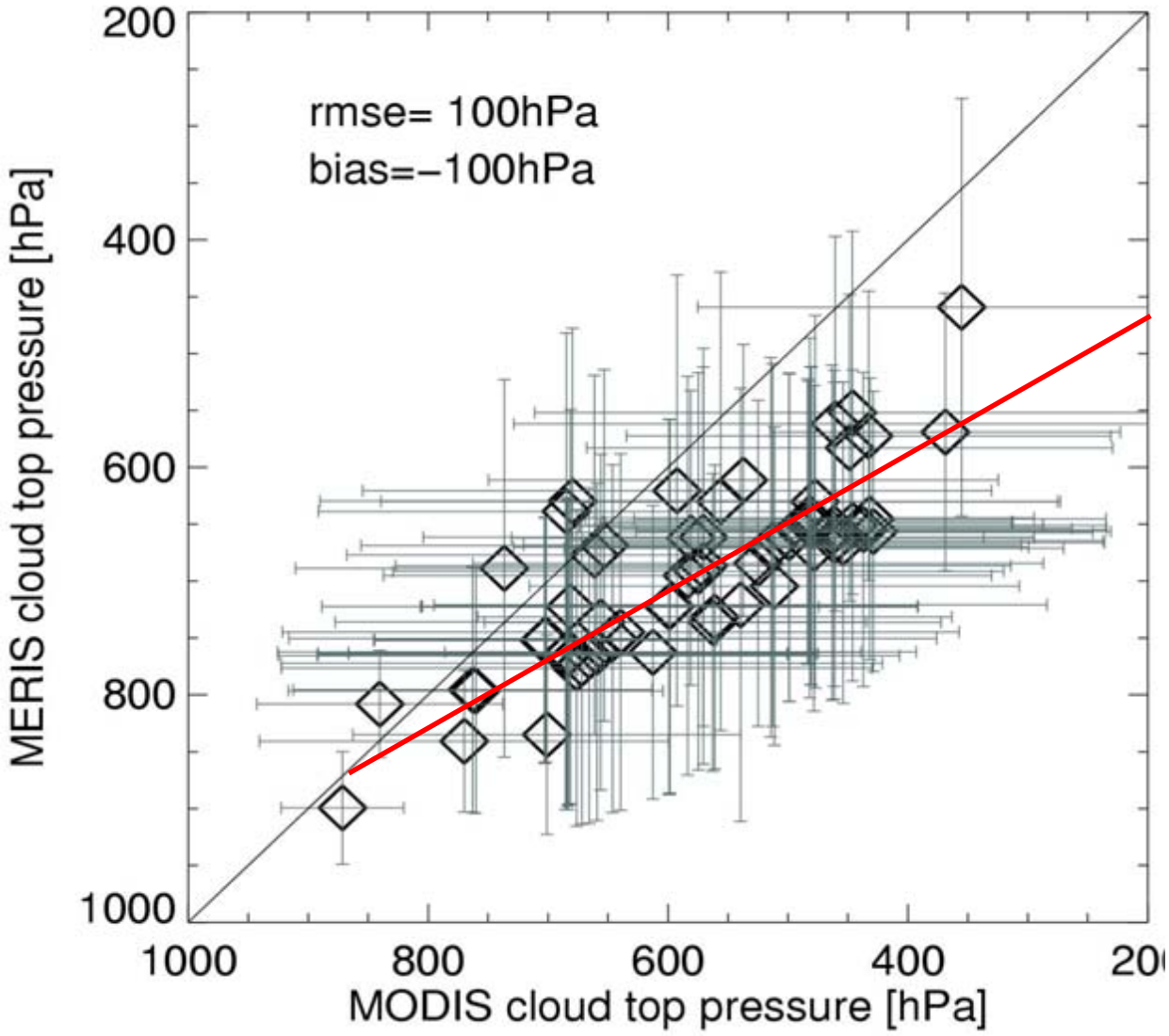
Validation



MERIS CTP provides 25 hPa accuracy for single-layered low-level cases!

Comparison of MERIS and MODIS CTP

Scatter diagram of the median MODIS and the median MERIS cloud top heights for a set of scenes. The error-bars are the standard deviations within each scene. There is a clear and strong tendency to retrieve lower cloud tops than MODIS CO_2 Slicing, and we know why.



Cloud Optical Thickness

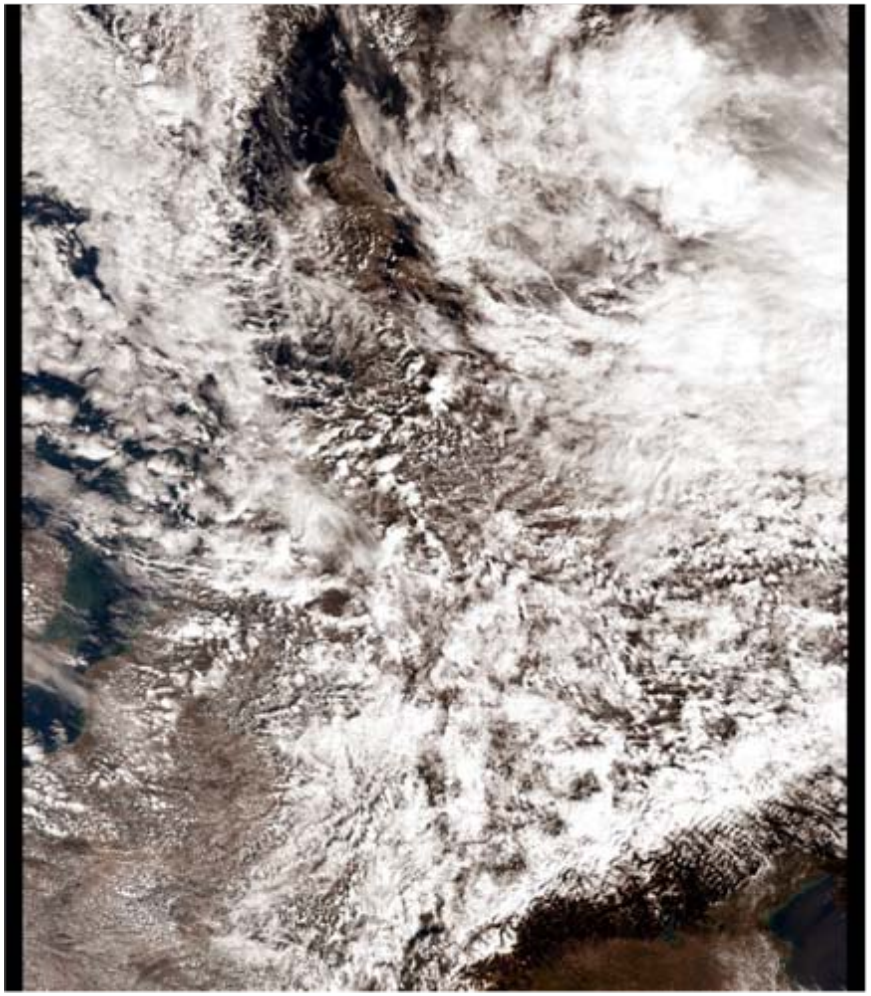
Freie Universität Berlin

- MERIS radiance at 754nm allows estimation of cloud optical thickness.

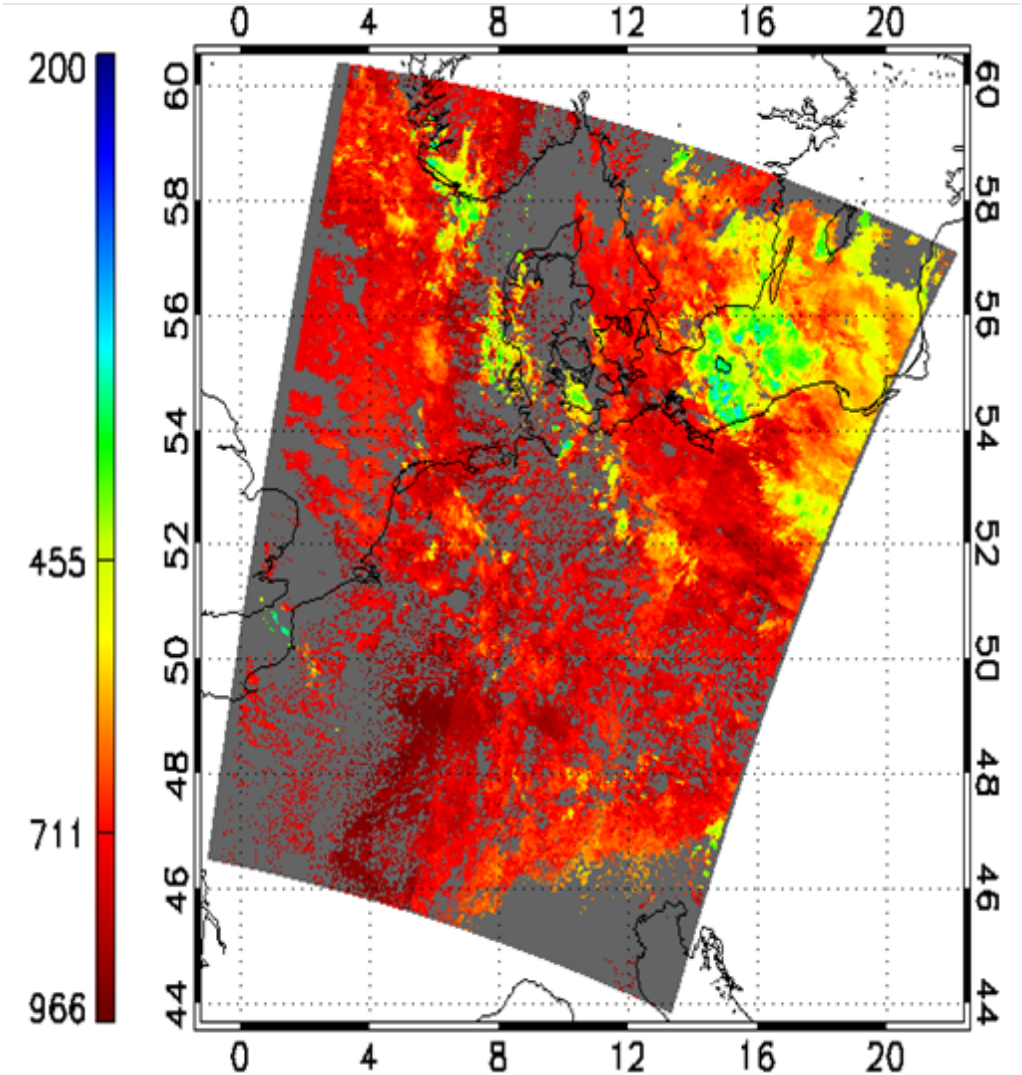
BUT:

- MERIS does not provide SWIR measurements
- Common Nakajima-King-approach can not be applied with MERIS alone
- Fixed effective radius instead

Example: 30 August 2006, Central Europe

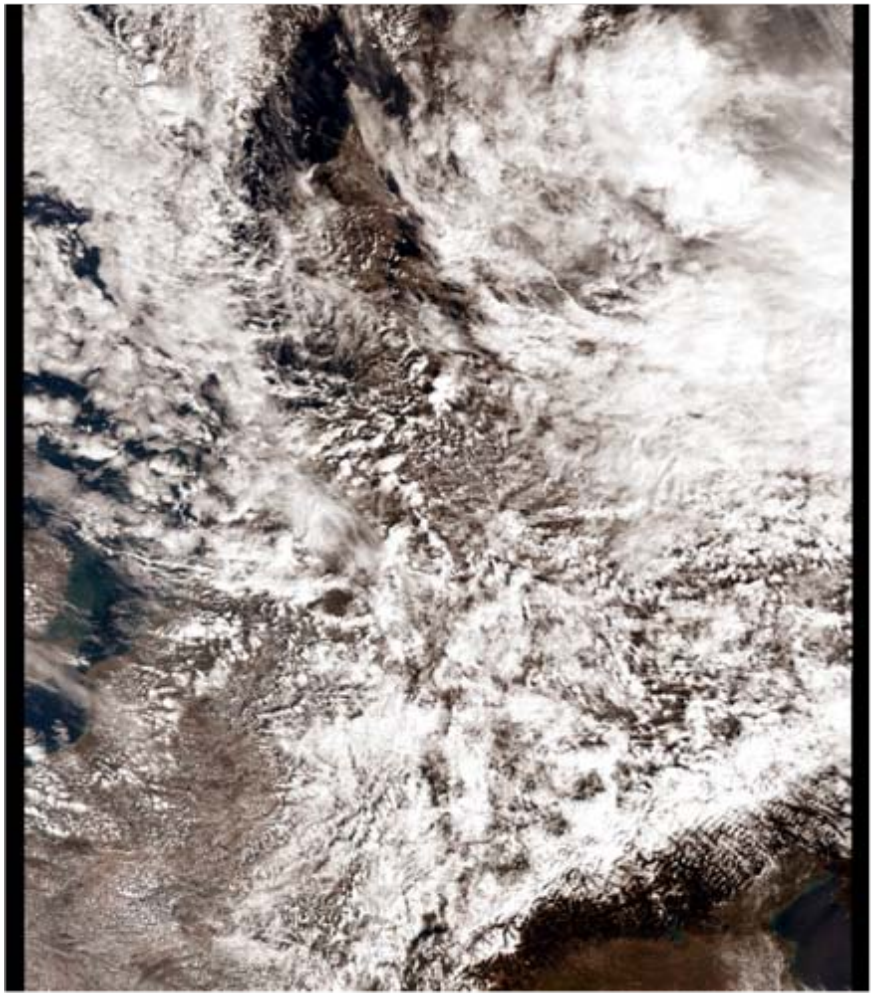


RGB

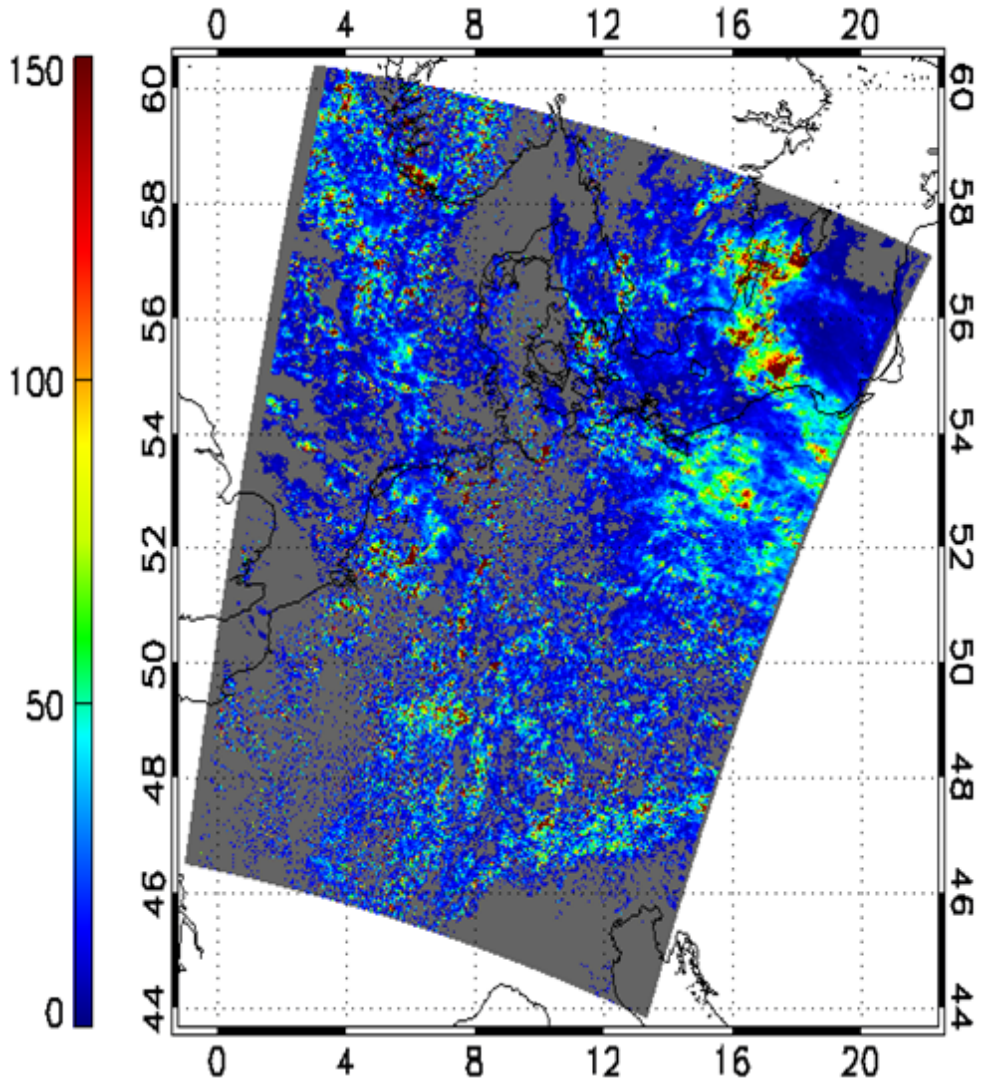


Cloud top pressure

Example: 30 August 2006, Central Europe

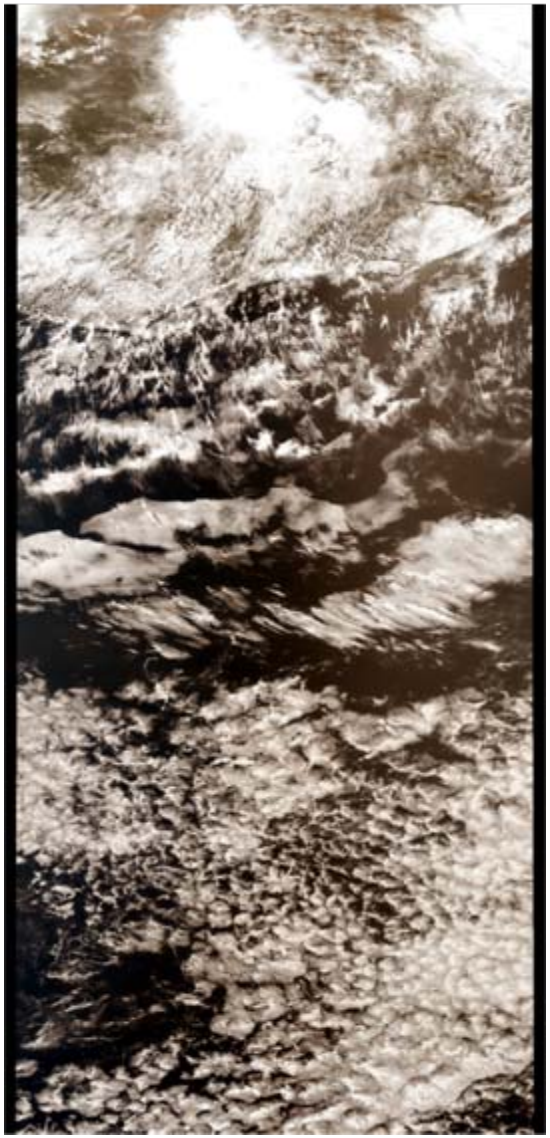


RGB

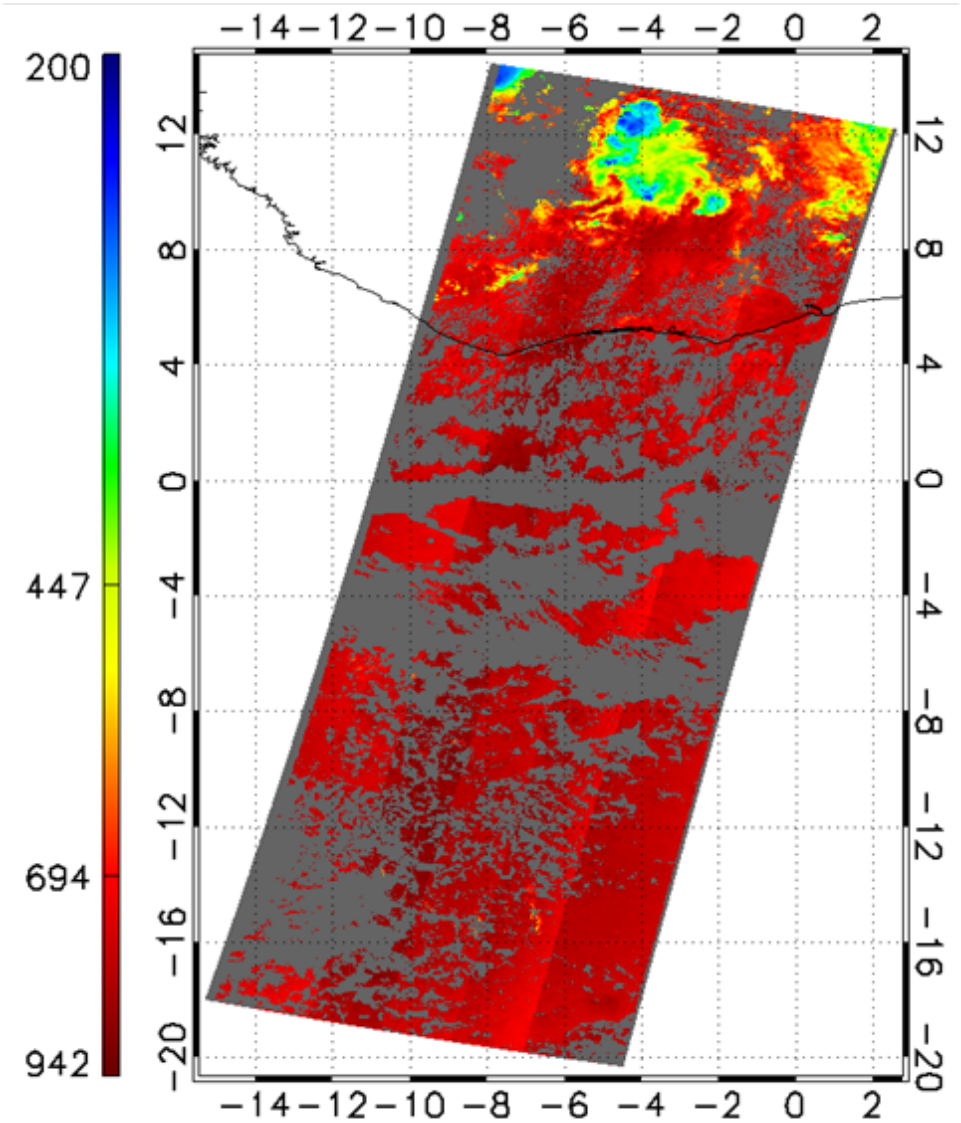


Cloud optical thickness

Example: 30 August 2006, Gulf of Guinea

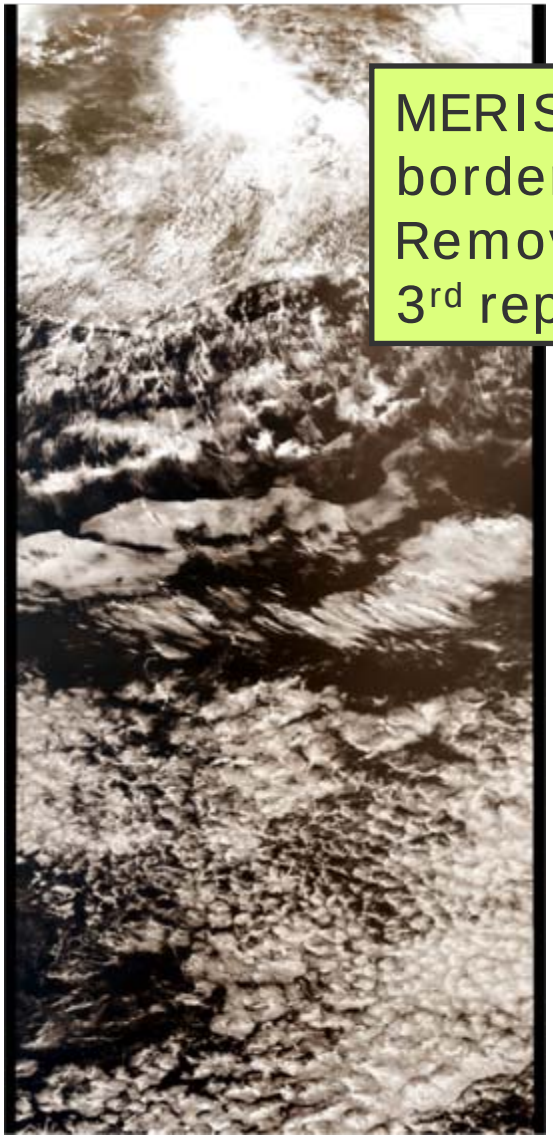


RGB

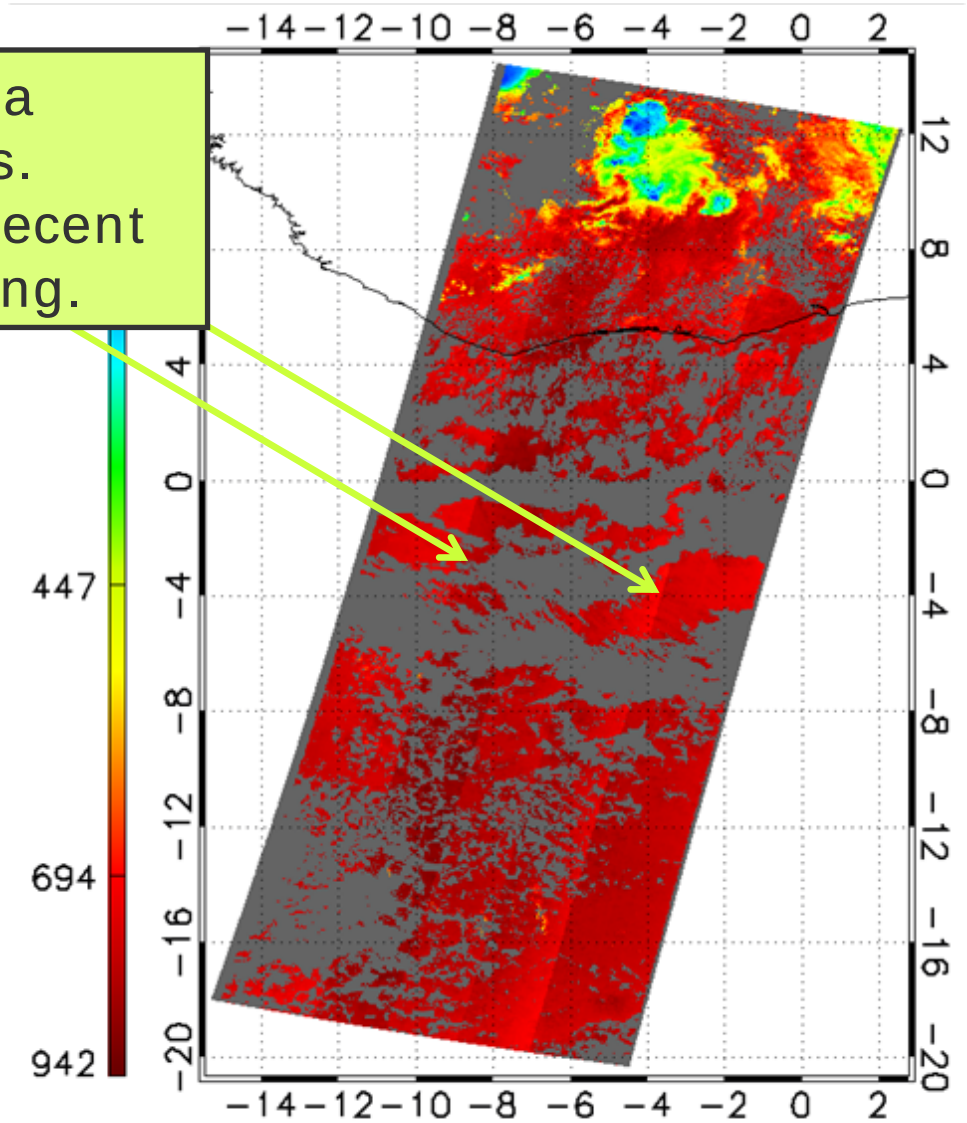


Cloud top pressure

Example: 30 August 2006, Gulf of Guinea



MERIS camera border effects. Removed in recent 3rd reprocessing.

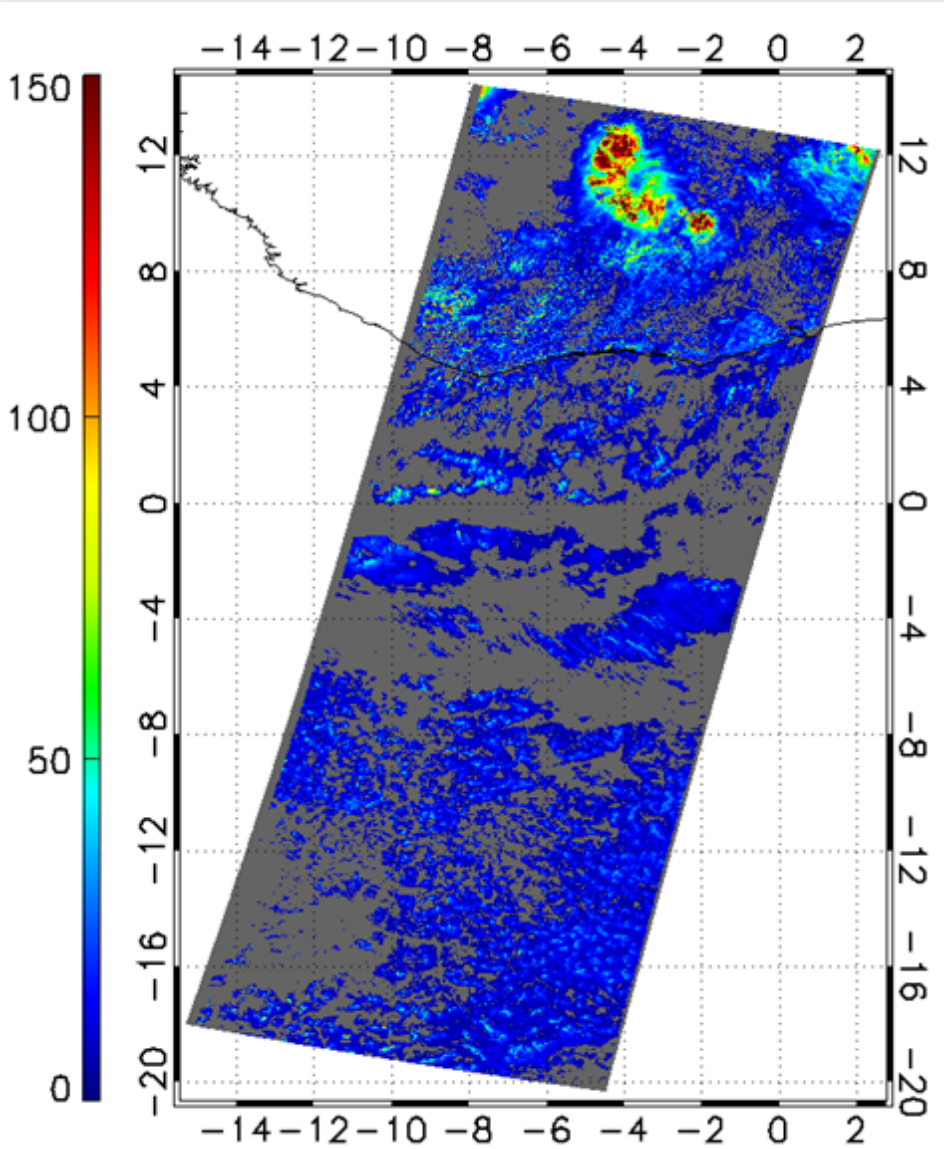


RGB

Cloud top pressure

Example: 30 August 2006, Gulf of Guinea

RGB

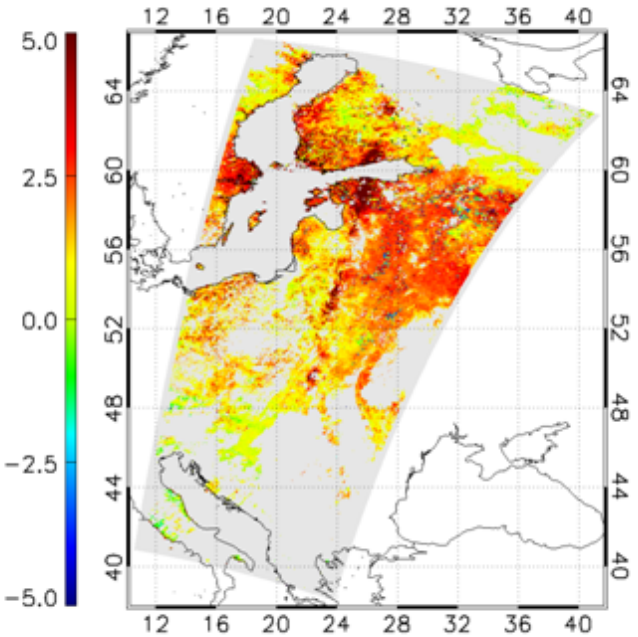


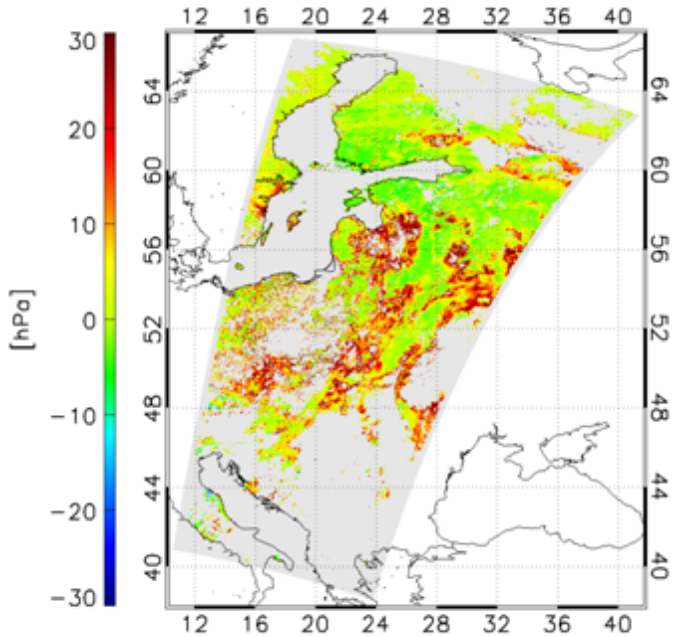
Cloud optical thickness

3rd reprocessing

MERIS cloud products have been improved in 3rd reprocessing by

- instrumental stray light and spectral smile correction
- use of MERIS Albedomap data as lower boundary condition





Change of derived cloud optical thickness (left) and cloud-top pressure (right) due to inclusion of Albedomap data (relative to constant albedo of 0.3)

Conclusions

MERIS cloud products:

- cloud optical thickness
- cloud top pressure

- high spatial resolution (0.26km)
- stable calibration

MERIS plus AATSR:

- improved cloud detection
- cloud microphysics
- multi-layer clouds

Future:

- ESA CCI clouds
- production of global cloud data sets
- contribution to GEWEX