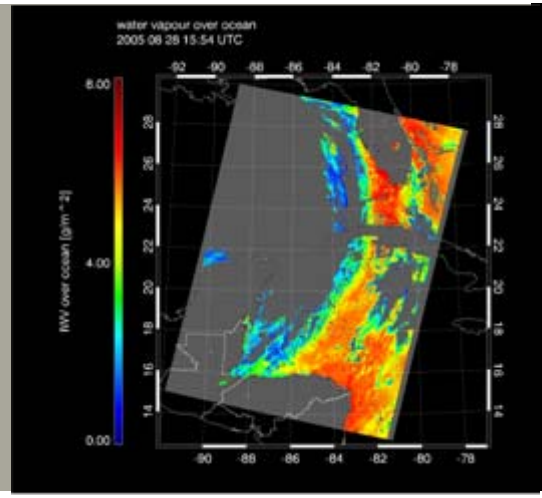
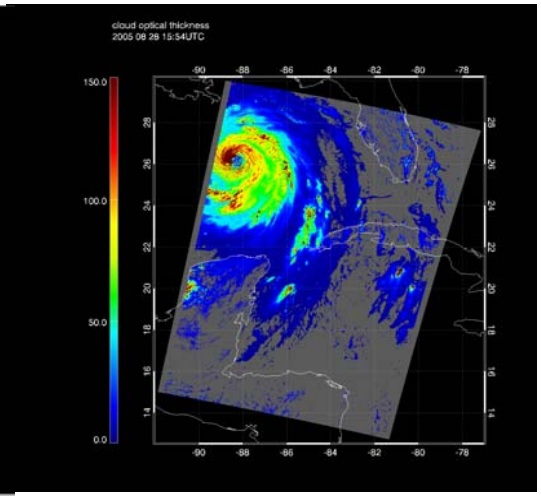
Freie Universität Berlin





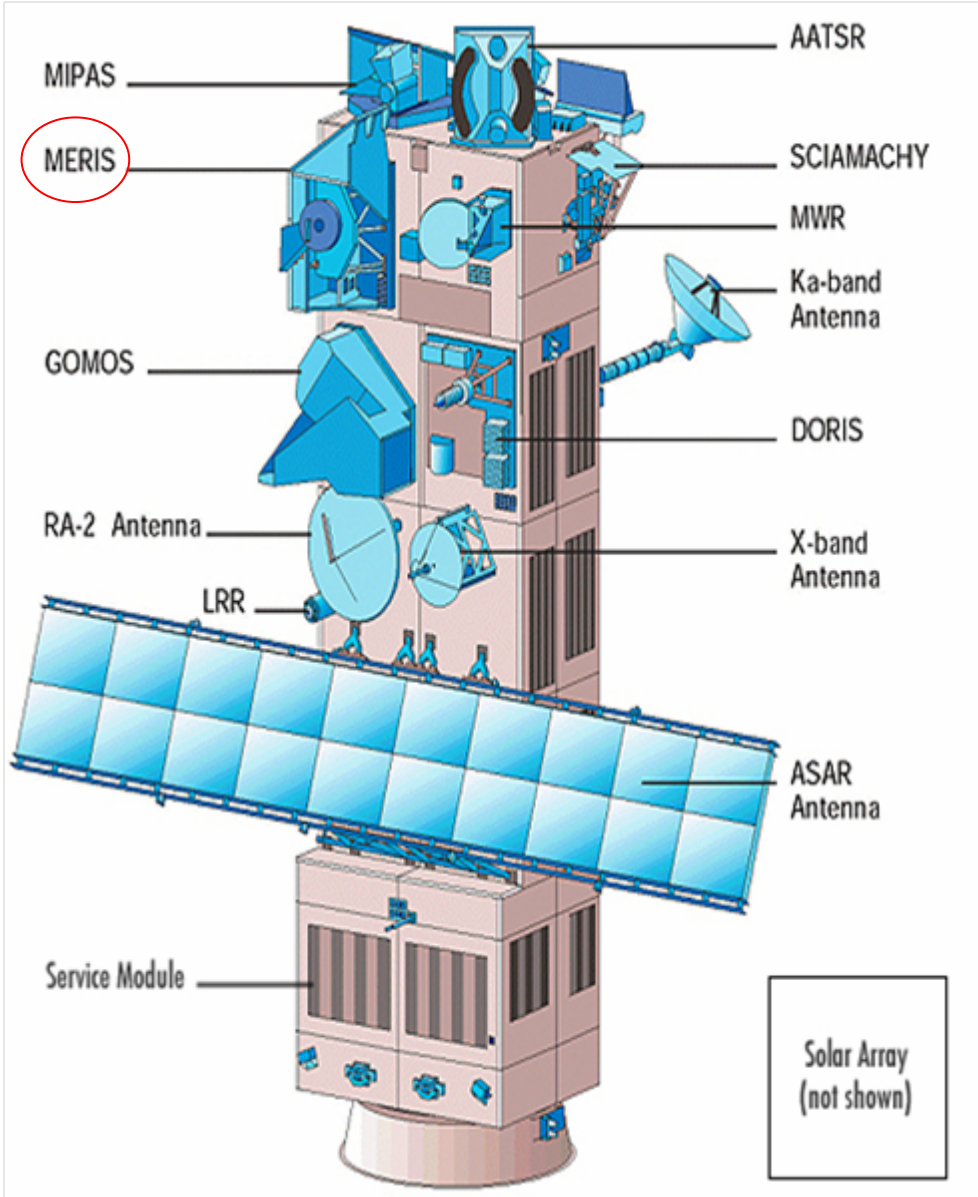
MERIS cloud products
(and Sentinel 3 perspective)

Jürgen Fischer, Rene Preusker, Rasmus Lindstrot

MERIS and ENVISAT

MERIS:

- (Medium Resolution Imaging Spectrometer)
- 68.5 FoV (1200 km swath)
- Pixel: 300m (FR) / 1200m (RR)
- 15 programmable bands between 400 und 1000 nm (>1.8 nm)
- coverage: 3 days
- Objectives:
  - **Ocean**
  - Atmosphere
    - Clouds (O2A)
    - Aerosols
    - Water vapour
  - Land



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"MERIS is certainly a great instrument but it is not very well suited for the remote sensing of clouds!"

(undisclosed scientist)

But why do serious scientists still work on MERIS cloud products?

But why do serious scientists work on MERIS cloud products?

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

BUT:

+ almost "**unique selling point"**: O2A absorption together with a high spatial resolution.

+ all other MERIS algorithms require an ahead **cloud detection**.

Cloud Detection

"Compressed" take home messages from the cloud session talks:

1. Cloud detection for MERIS is an issue!
2. Cloud detection for MERIS is an issue!
3. Cloud detection for MERIS is an issue!

The cloud detection bias:

Let $\boldsymbol{p}$ be a remotely sensed atmospheric/oceanic/... parameter and <> any kind of statistical mean. If a prepend cloud detection $\boldsymbol{cd}$ is variable (e.g. if it is improvable), you will find in many cases:

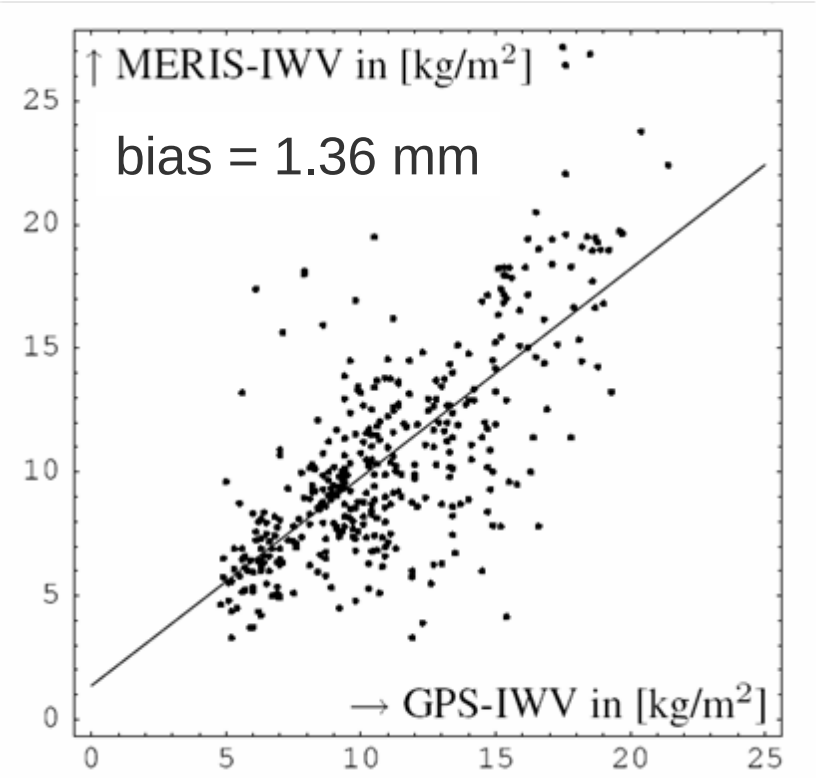
$$\frac{d\langle p\rangle}{d\,cd} \neq 0$$

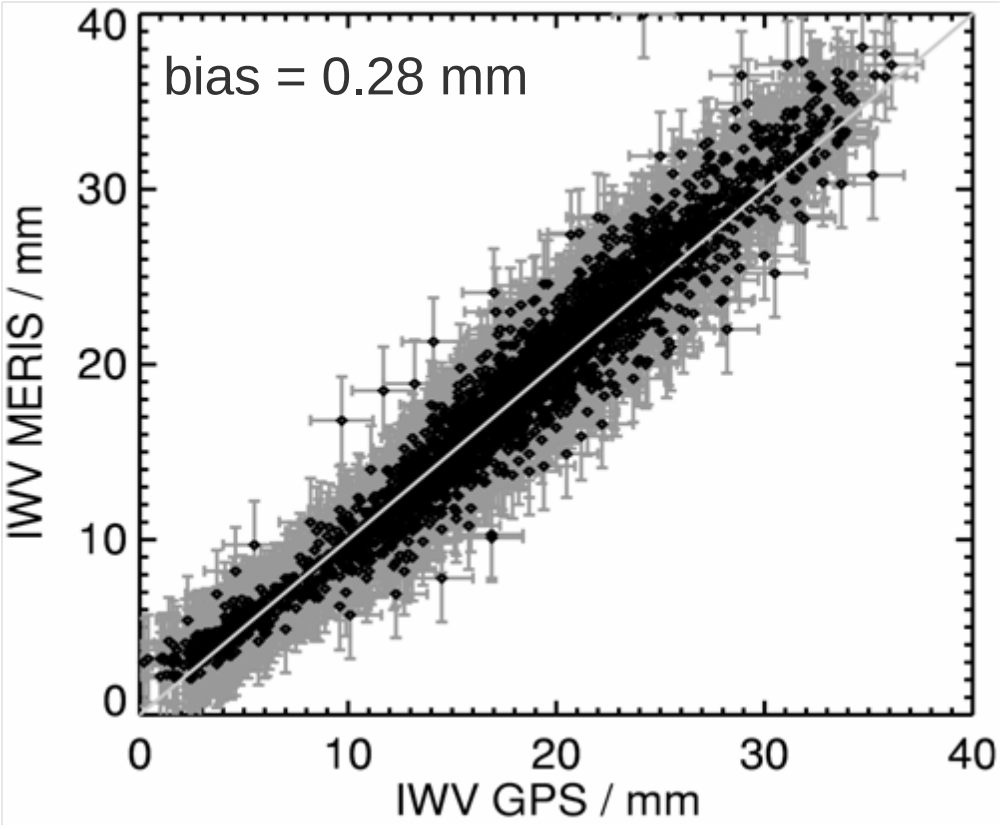
→Huge interest of the MERIS community on a reliable cloud detection and

→Non-binary cloud detection to enable the user to estimate the upper quantity by themselves

→Consequently large effort to detect clouds with an instrument which was not made for it.

Importance of cloud detection: Validation of water vapor above NL and GER





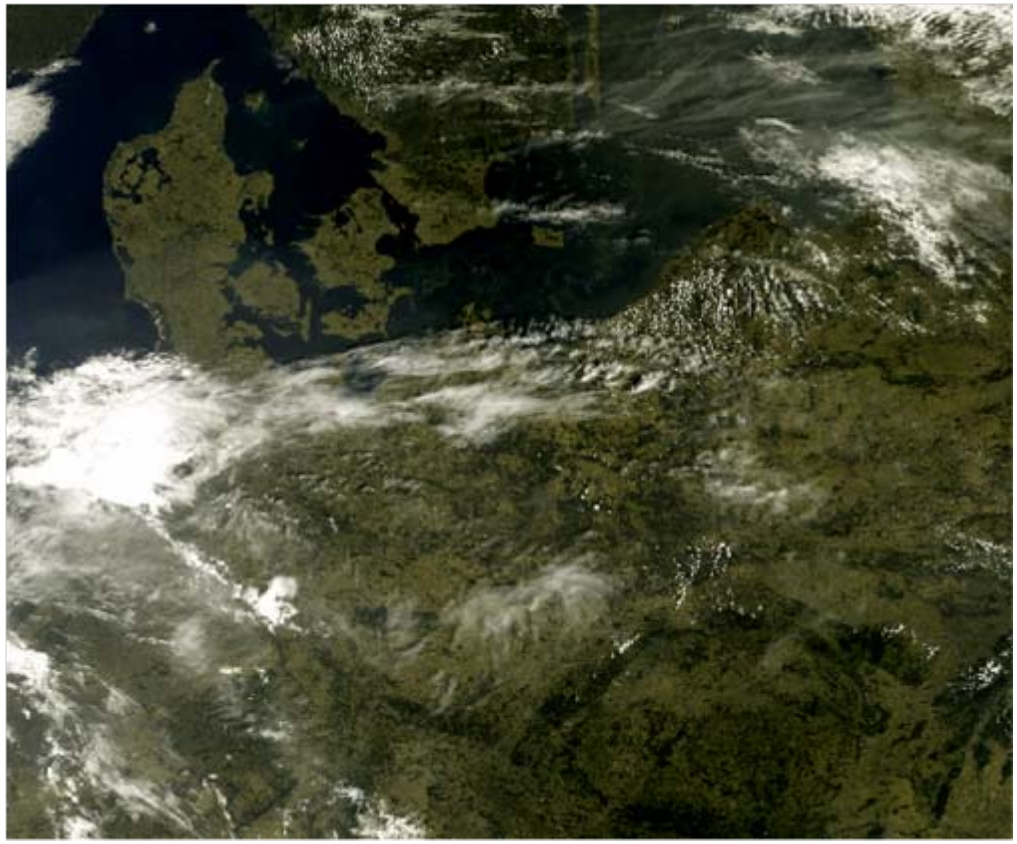
standard (2007) MERIS cloud detection

improved MERIS cloud detection

Roderik Lindenbergh1**, Hans van der Marel**1**, Maxim Keshin**2**, and Siebren de Haan**3

Cloud characteristics

- bright
- white
- higher than surface
- cold
- spatial radiation variability



- none of these criteria is always true and none is singular
  - there are clouds that are not very bright
  - there are clouds that are at the surface (e.g. mountains)
  - there are warm clouds
  - etc

Cloud characteristics

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- white
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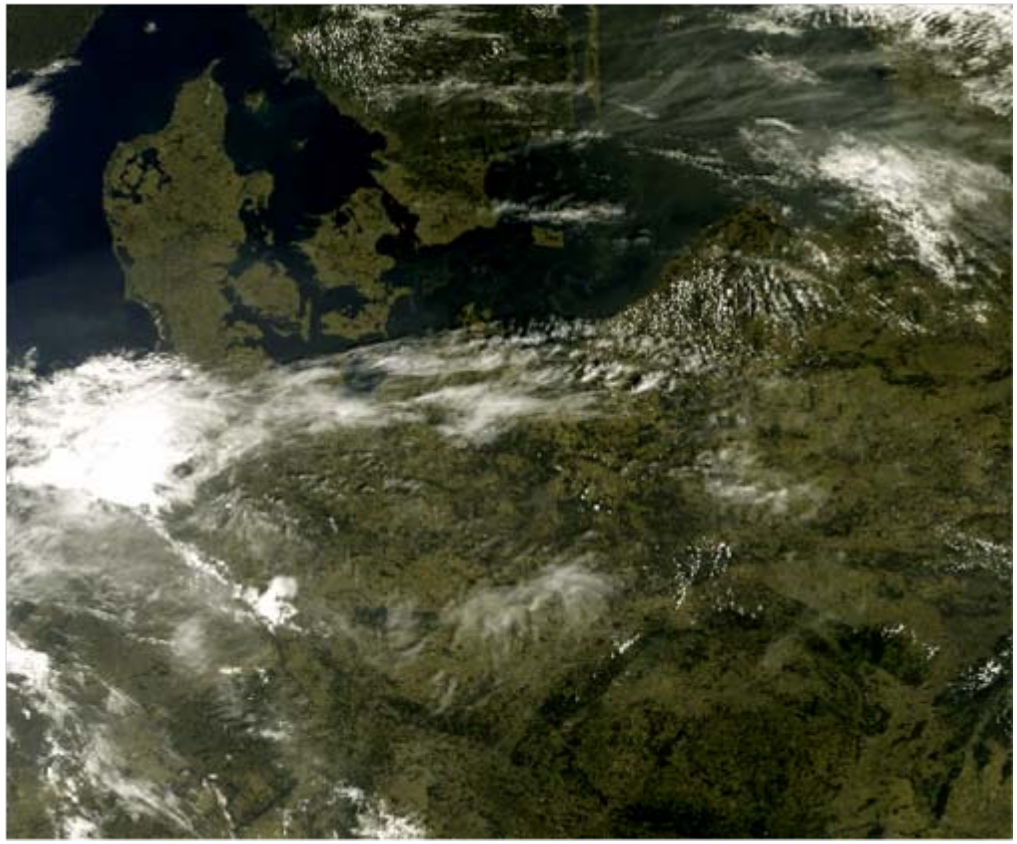

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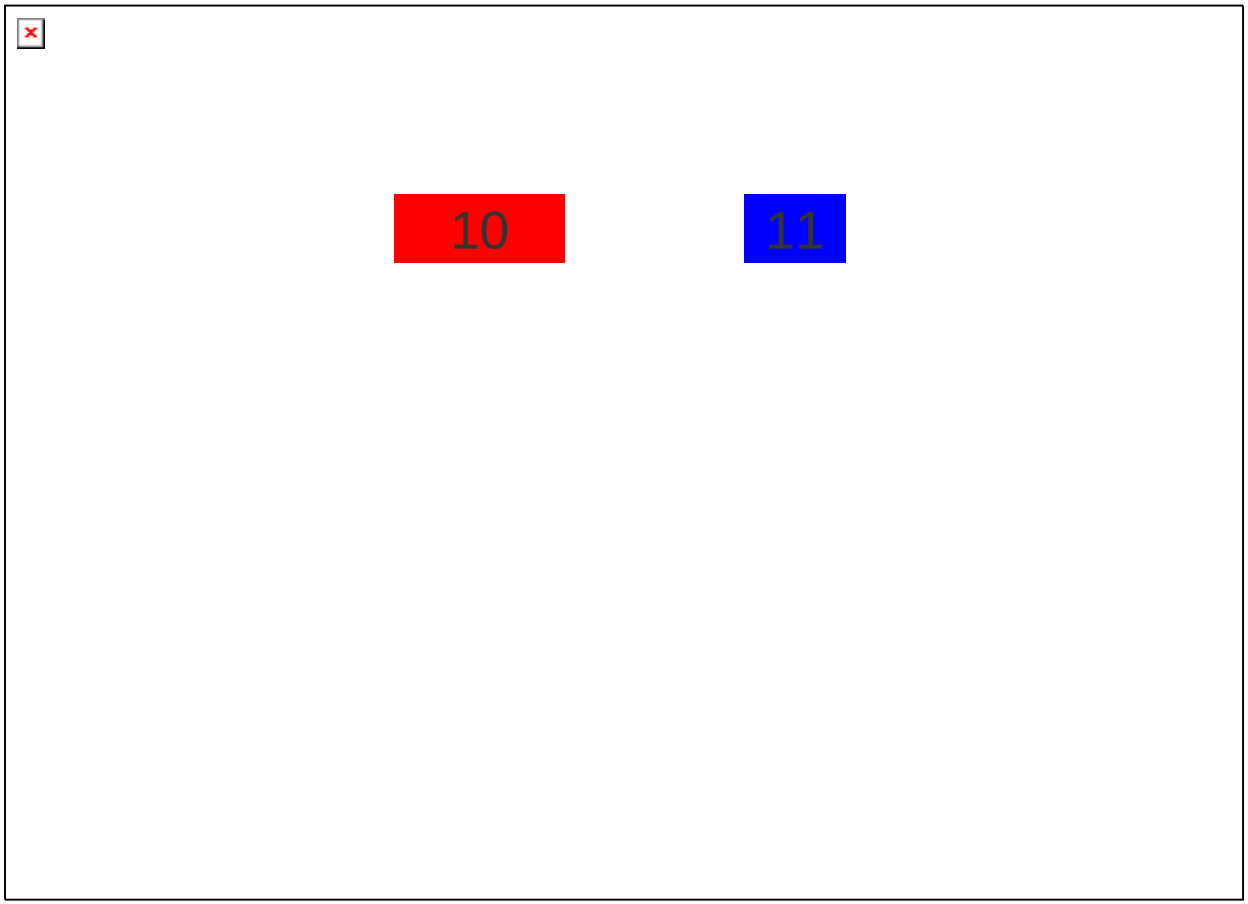
DIFFERENTIAL ABSORPTION with MERIS



Differential Absorption

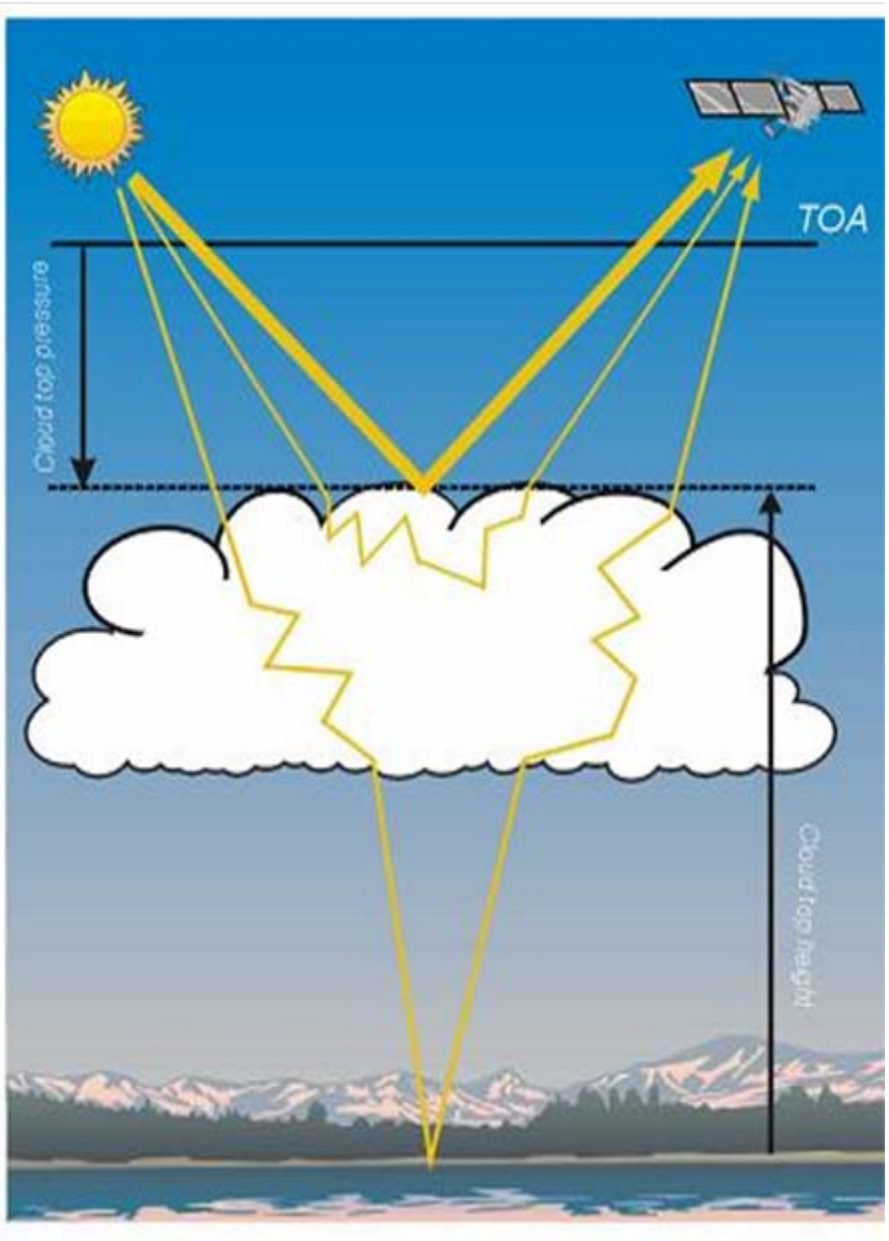
$$\ln(Transmission) \propto absorbing\ mass$$

- For O_2 (well mixed and constant concentration) the *absorbing mass* equals the photon path length
- The photon path length can be related to **cloud height**

- Almost independent from surface temperature and emissivity and from temperature profile. But:
- biased by multiple scattering.

MERIS	Sciamachy
- 1 channel at 760 nm	- ~ 10 channels at 760 nm
- 250mx250m o. 1kmx1km pixel size	- 30km x 30km (60km) pixel size
- Main objective was the cloud height itself. - Naïve assumptions of “real” vertical cloud structures	→ Many pixel are cloud contaminated → Need for quantitative measures that allow accurate trace gas retrievals for cloud contaminated pixel → *fresco, sacura* with all its assumptions (Piet’s and Alex presentations)

MERIS ctp algorithm



- assumptions about the vertical structure of liquid/ice water (single layer clouds with LWC=c*h)
- assumptions about the droplet effective radius
- cloud fraction = 1
- surface albedo from MERIS monthly statistics
- US standard atmosphere
- plan parallel atmosphere

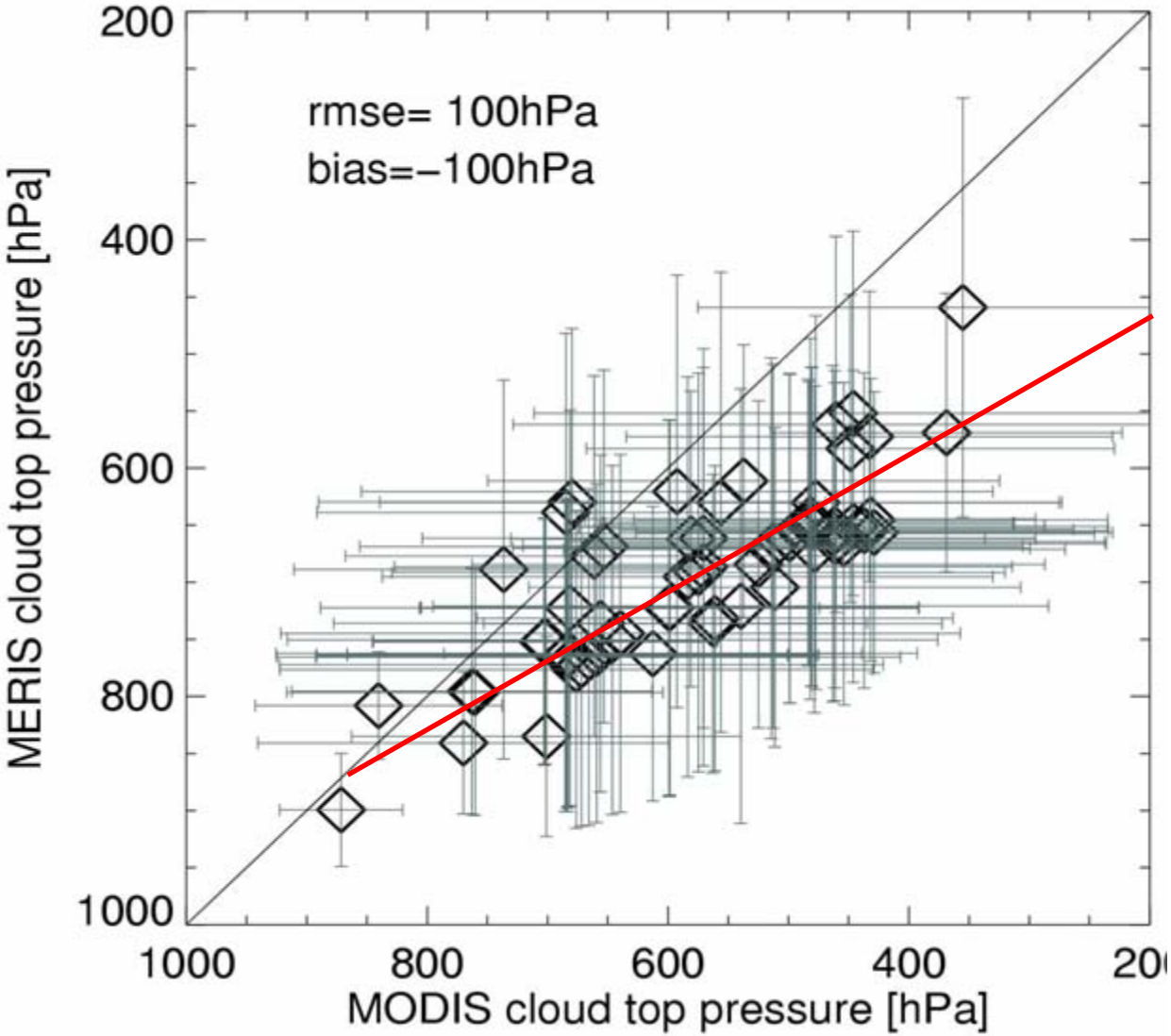
- Difficult spectral characterisation of MERIS!

Validation of cloud top heights

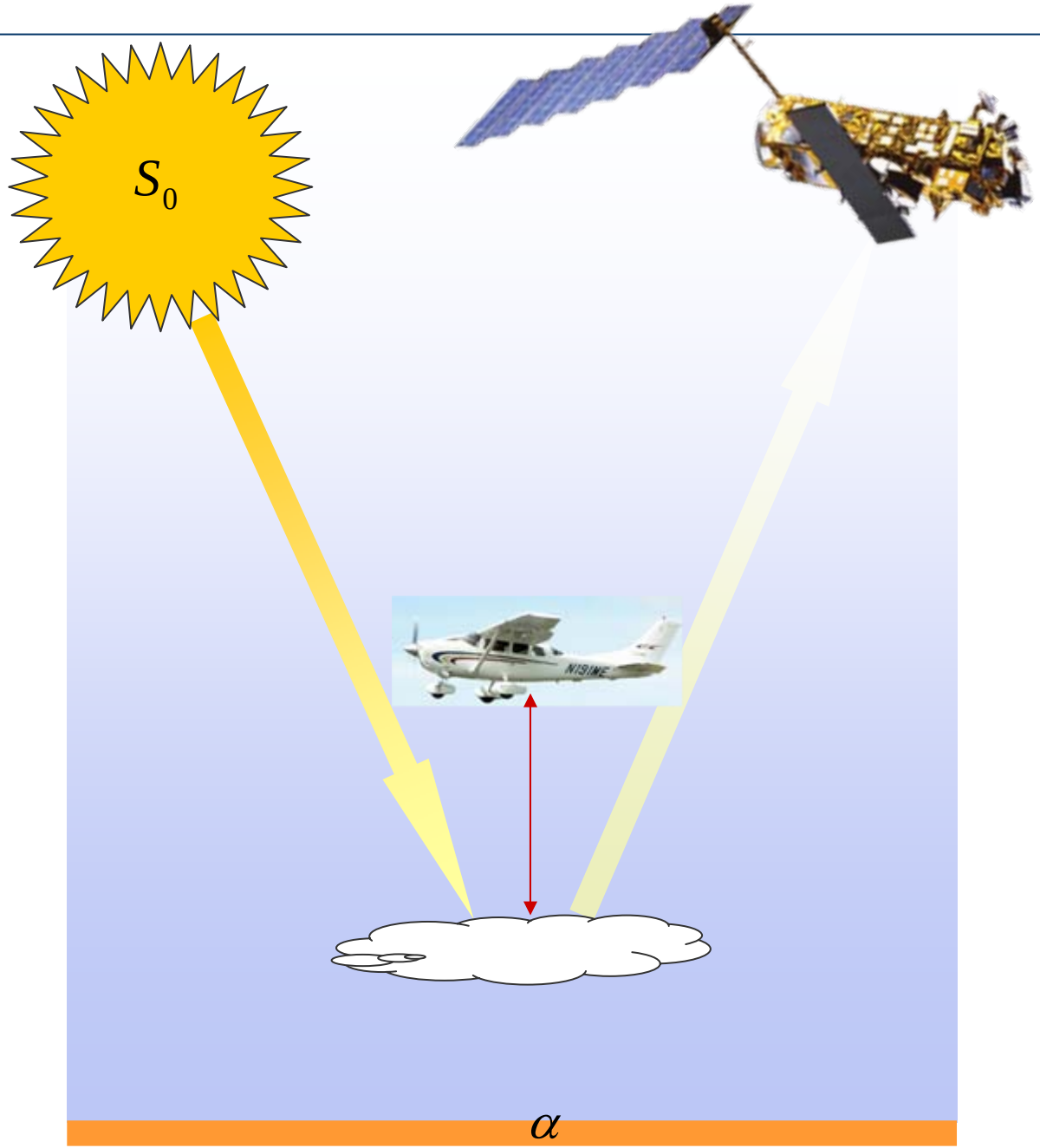
1. Comparison with other Satellites (MODIS CO2 slicing)
2. Comparison with airborne LIDAR

Comparison of MERIS CTP and MODIS

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 CO2, and we know why.



Comparison with airborne LIDAR



Rasmus Lindstrot in cooperation with Thomas Ruhtz, Birgit Heese[2], Matthias Wiegner[2],

[2]:Meteorologisches Institut, LMU München

POLIS on a Cessna T207A

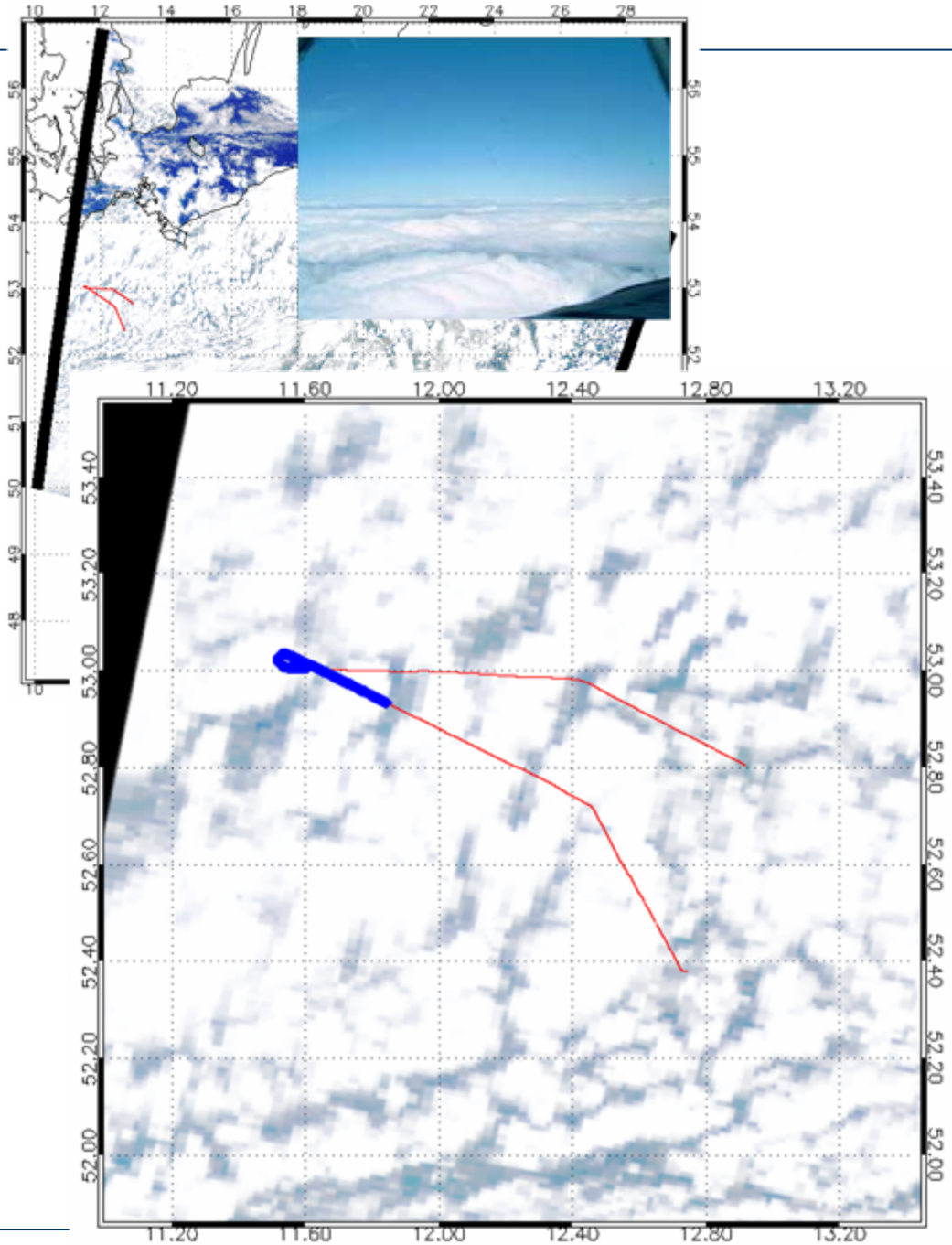
- max. flying altitude: 6000m (3000m during validation campaign).
- max. cruising speed: 110 knots
- POLIS: Portable Lidar System (LMU) Vertical resolution: 7.5m. Horizontal resolution: ~10m (at aircraft speed of 50 m/s).

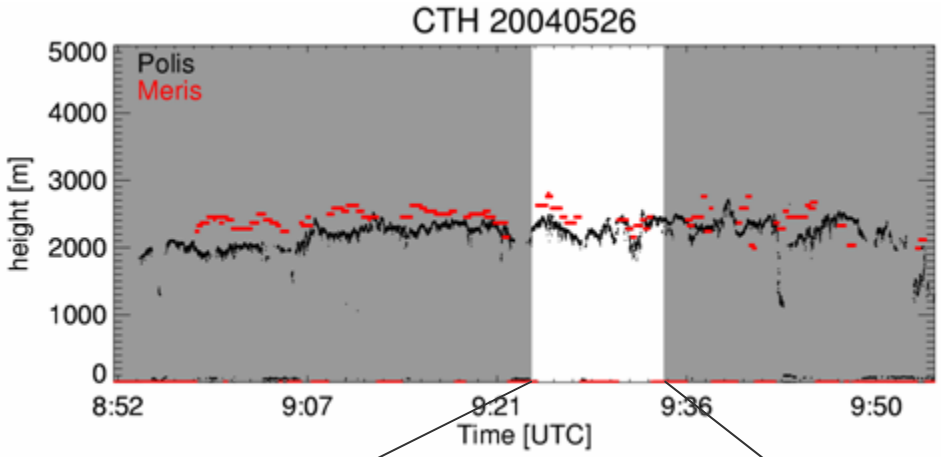
Flights

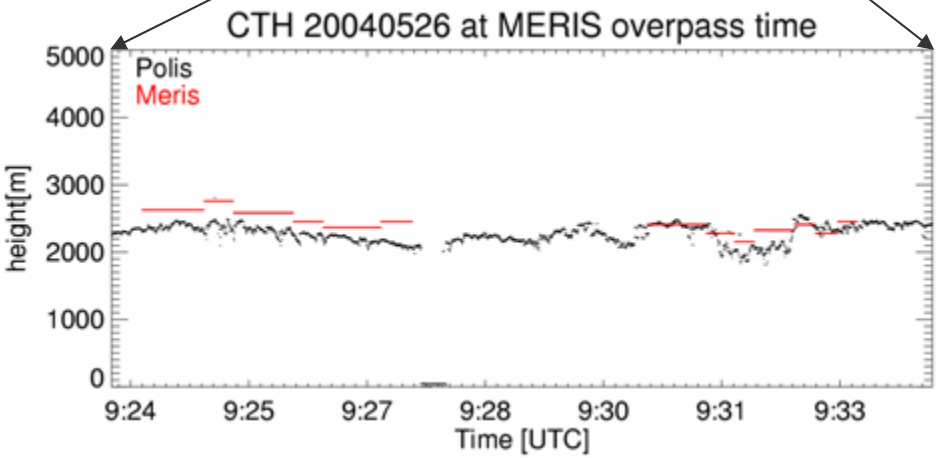
12 measurement flights over various surfaces between April and June 2004 :

Date	Clouds
2004 04 20	scattered Cumulus + Cirrus
2004 05 03	Stratocumulus + Cumulus
2004 05 06	scattered Cumulus + Cirrus
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

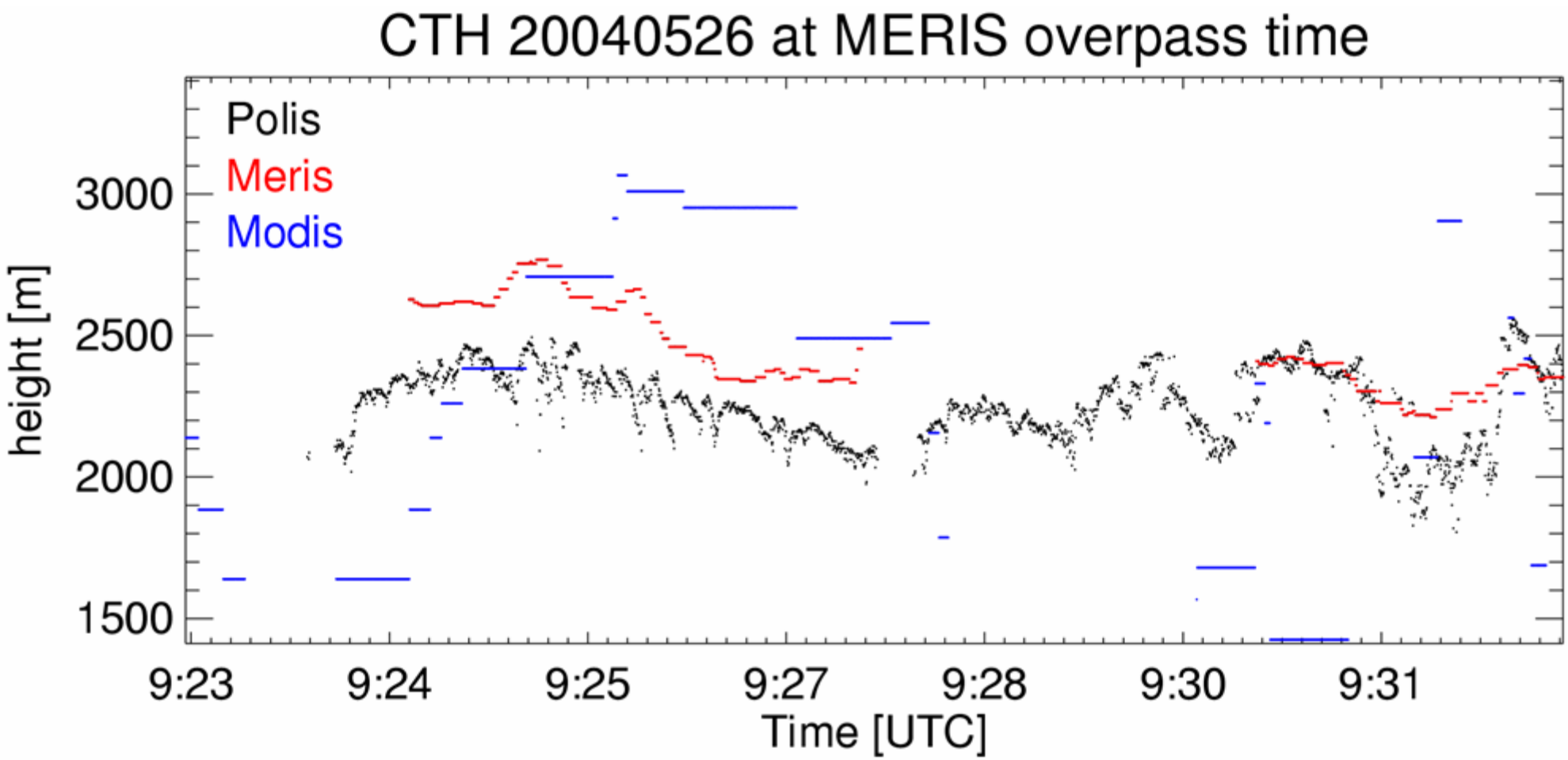
2004/05/26, Stratocumulus + Cumulus

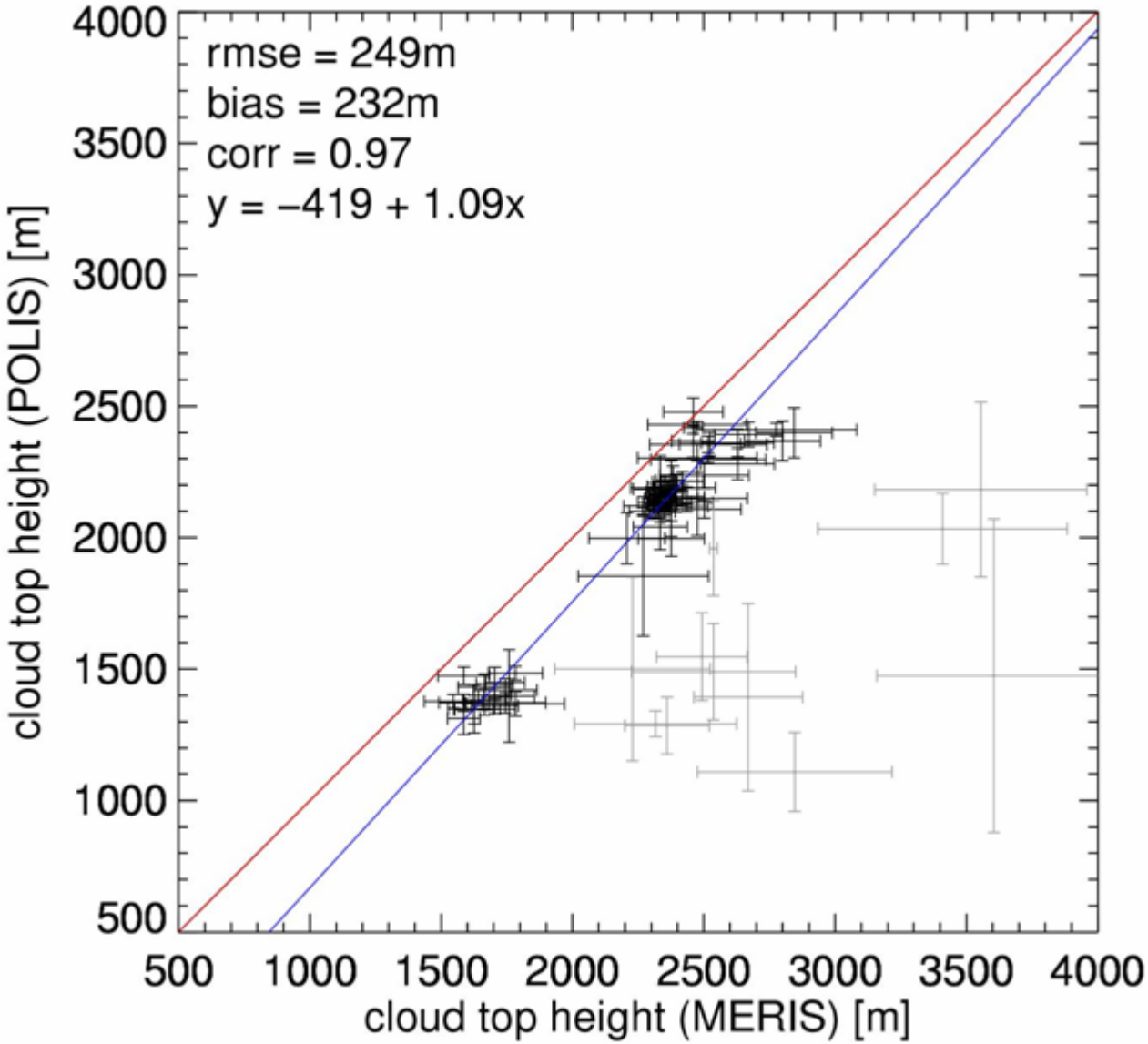






CTP-validation




rmse = 249m
bias = 232m
corr = 0.97
y = −419 + 1.09x
cloud top height (POLIS) [m]
cloud top height (MERIS) [m]
500
1000
1500
2000
2500
3000
3500
4000

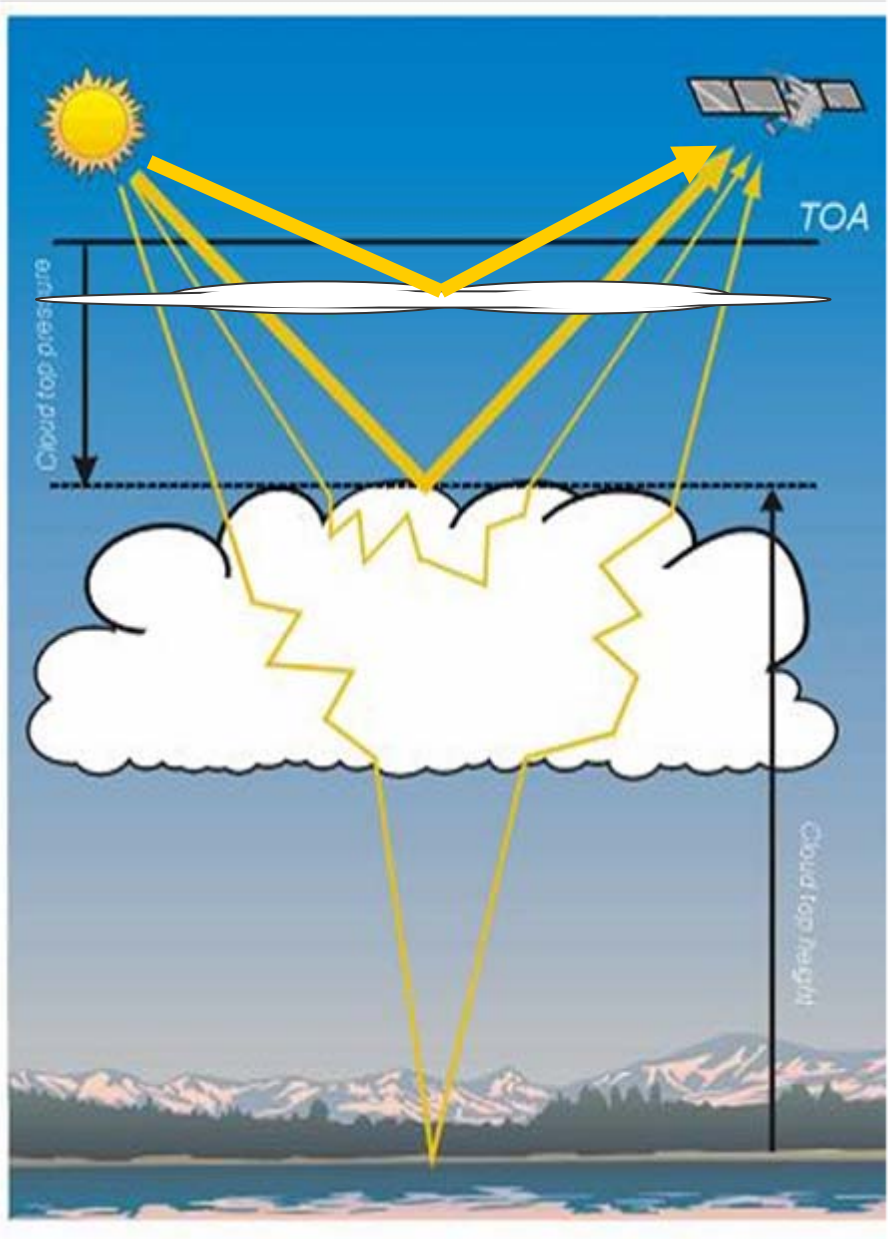
Intermediate Summary:

1. MERIS cloud height is very accurate for low level clouds. This can hardly be achieved with passive thermal (and CO_2) sensors. This will be valuable when investigating aerosol effects on low level clouds.

2. The usage of O2 absorption significantly improves the cloud detection in MERIS (See Poster from Luis Chova). Subsequent algorithms benefit from this improvement!

3. The retrieved height of multilayer clouds (or any clouds with a difficult vertical structure) does not agree with the height retrieved by thermal methods. The reason is clear: The O2 band has a much higher penetration depth than the thermal bands.

Multiple scattering effects for ctp



- Biased by variable multiple scattering within cloud and between cloud and surface.

- Thin high clouds above thick low clouds result in “mixed” cloud top height values.

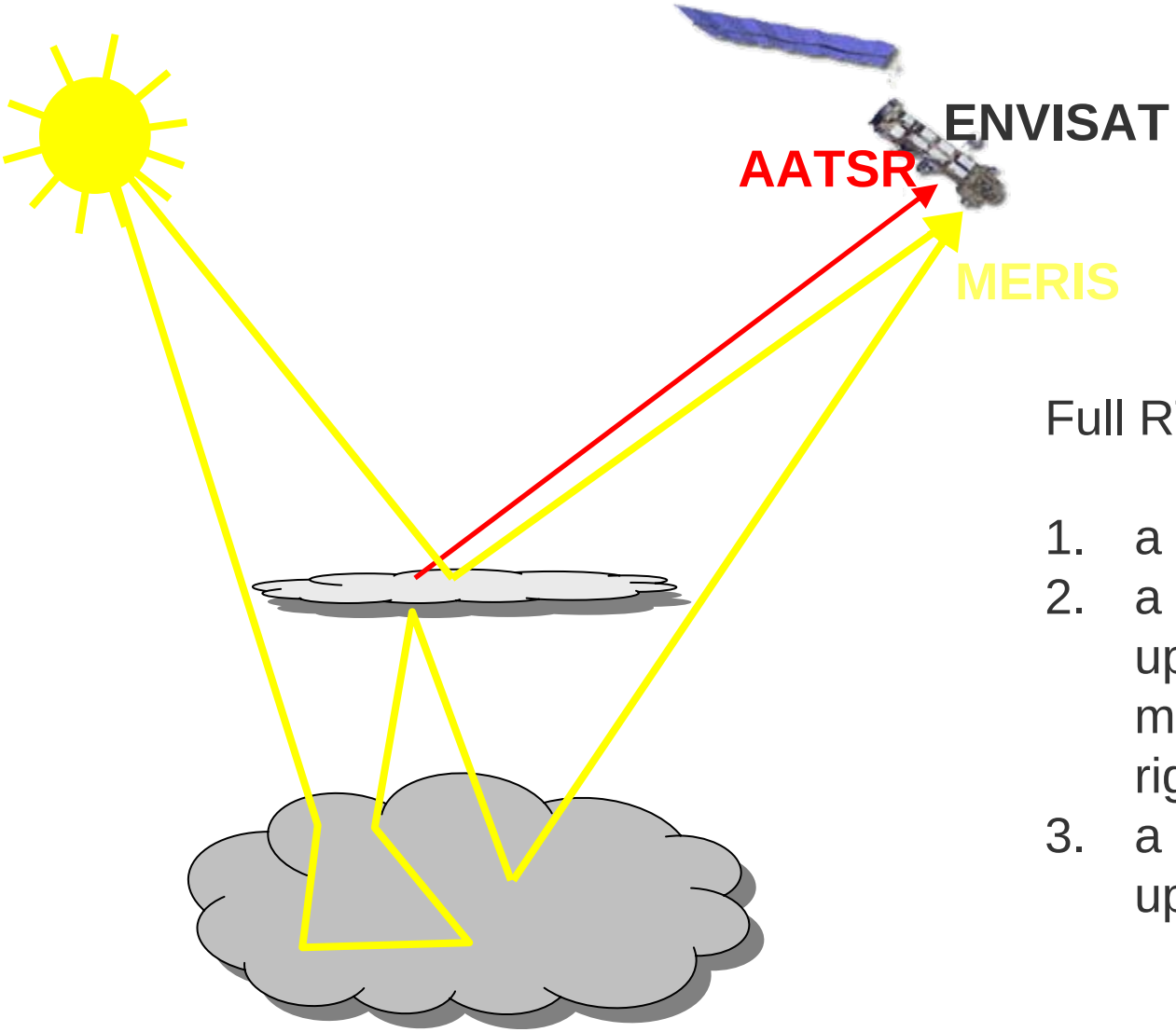
Perspective

One man's meat is another man's poison.

Transposition & Inversion

One scientist’s noise is another scientist’s signal.

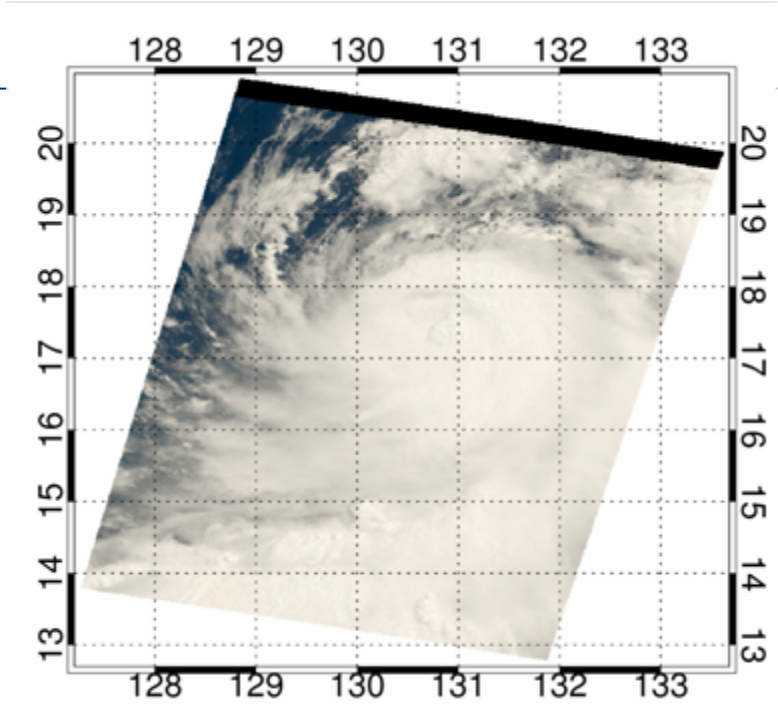
See poster of Rasmus Lindstrot

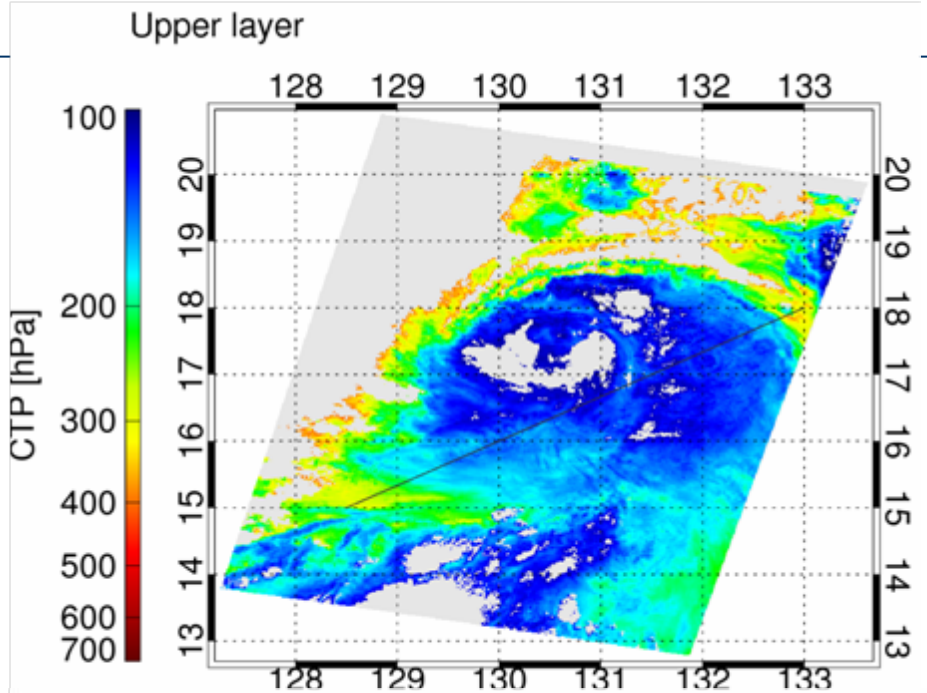


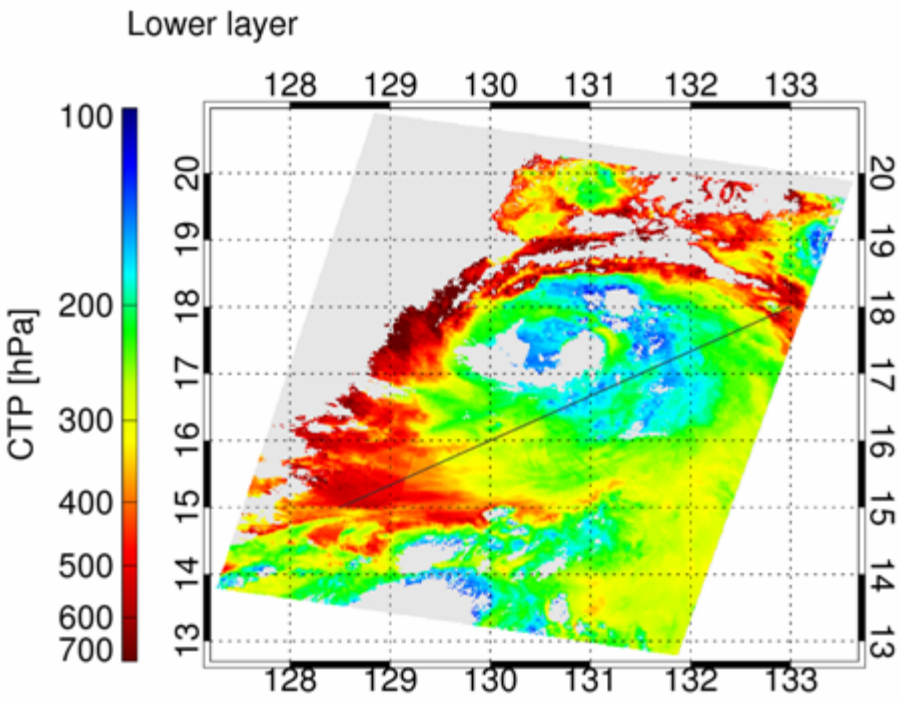
Full RTM OE inversion assuming:

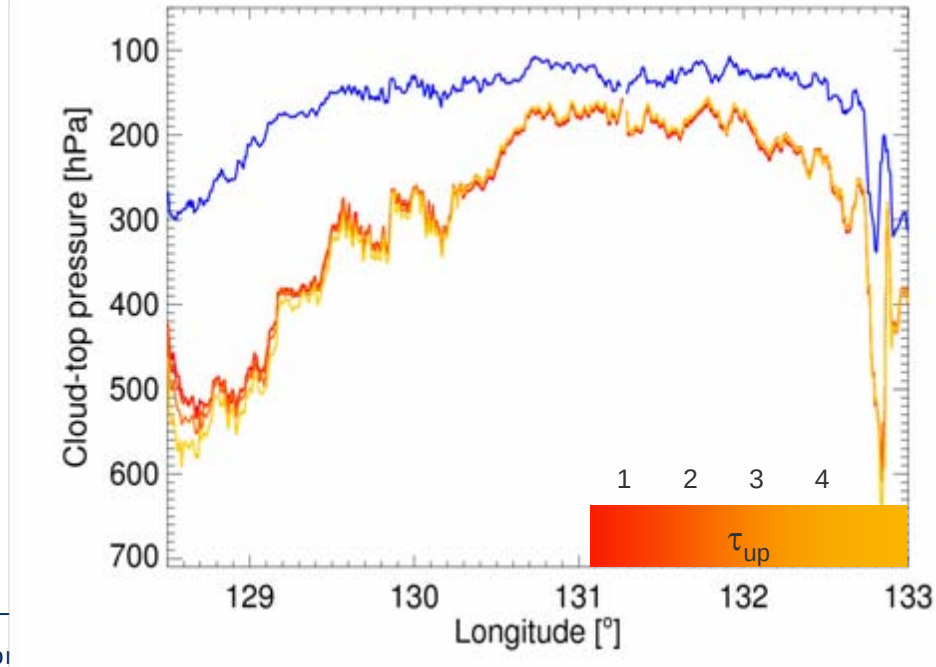
1. a two layered cloud system
2. a cloud top pressure of the upper layer according to the BT measured by AATSR and the right T-profile
3. a cloud optical thickness of the upper layer of 1,2,3,4 or 5

See poster of Rasmus Lindstrot









Intermediate Summary

- O2A band observations will serve investigations of low level clouds, since **they give the most accurate (passive) cloud top heights.**

- O2A band observations can already give us some insights (take this verbatim!) about clouds, **if they are used in synergy with other instruments**.

→ MERIS and AATSR are complementary instruments for advanced cloud remote sensing.

Sentinel 3 perspective

- What is Sentinel 3? "An Operational Oceanography Mission for GMES"

- The satellite will carry :
  1. a topographic system
  2. OLCI = Advanced MERIS (more channels (+O2A), tilted view to avoid glint, …)
  3. SLSTR = A(A(A))TSR (wider FoV, 1.38µm, 2.2µm …)

- OLCI and SLSTR will have the same field of (+ stereo)

→ This will be great! We will exploit synergy for many applications: cloud detection (see poster of Luis Gomez Chova), cloud remote sensing, aerosol remote sensing ...

Appeal to ESA: "operational" + "heritage"+ "fast track" should not set existing algorithms in stone. "Operational" should mean "continuous improvement" and "monitoring" inherits comparison to a "standard" → We will need reprocessing whenever operational algorithms are significantly improved!