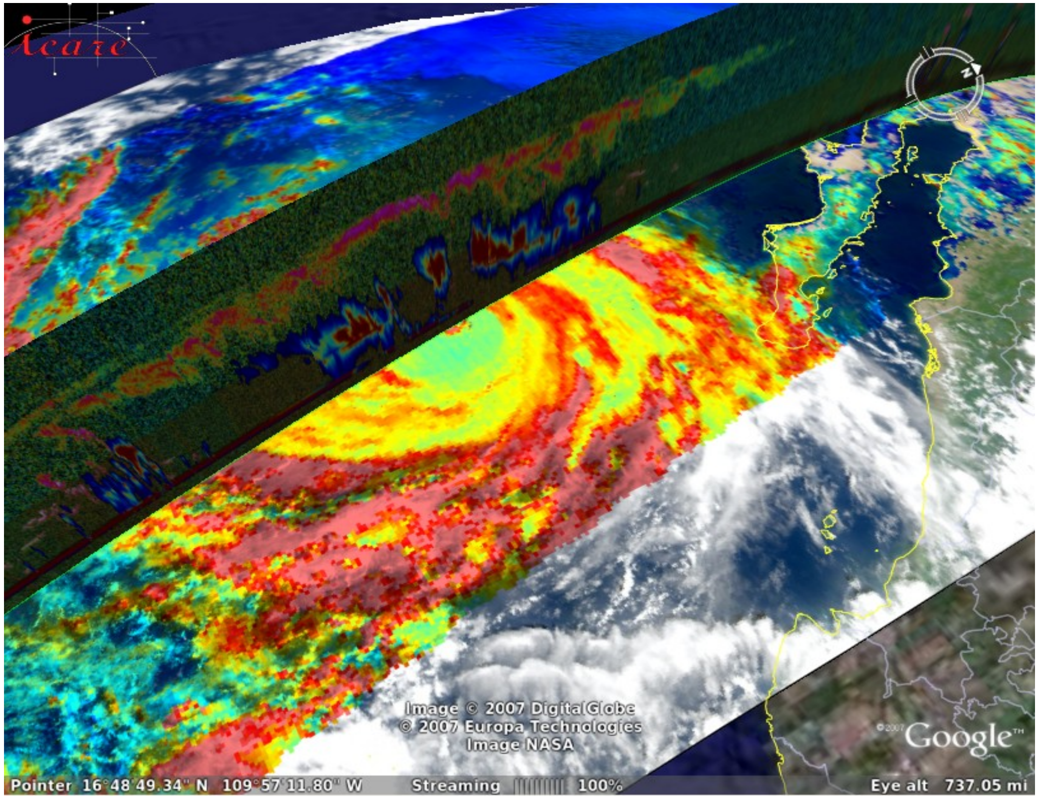
Remote Sensing of Cloud Properties from POLDER3/PARASOL and MODIS/AQUA in the A-TRAIN

The Cloud POLDER3/PARASOL science team.
Laboratoire d'Optique Atmosphérique, USTL, Lille, France

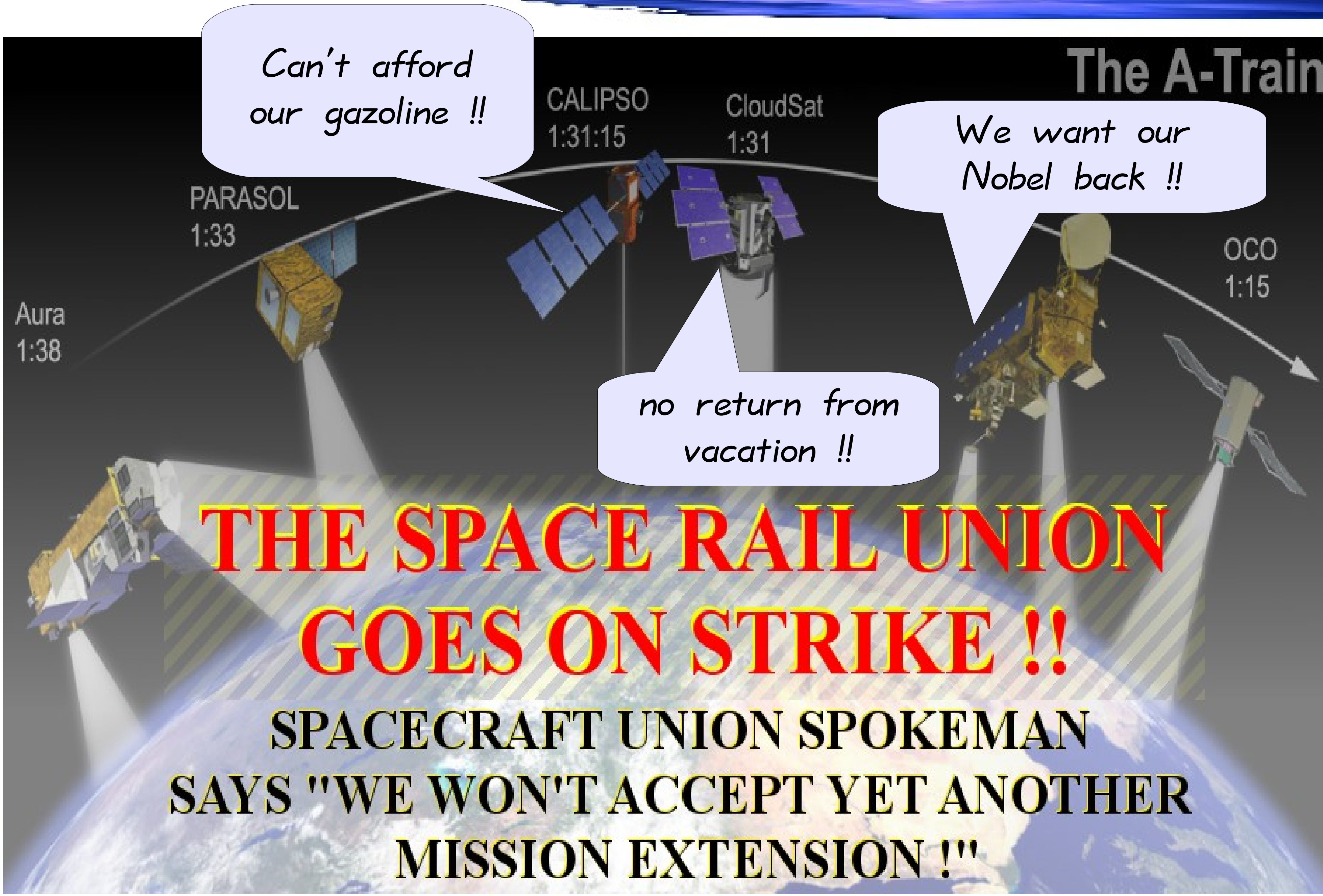
J. Riedi, F. Parol, F. Thieuleux, L. Labonnote, C. Vanbauce, B. Marchant,

OUTLINE

Context
POLDER/MODIS products
Multi sensors synergy
cloud phase
cloud/aerosols
Perspective



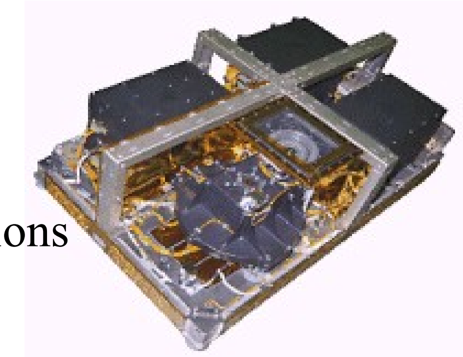
Hurricane Ileana - 23 August 2006

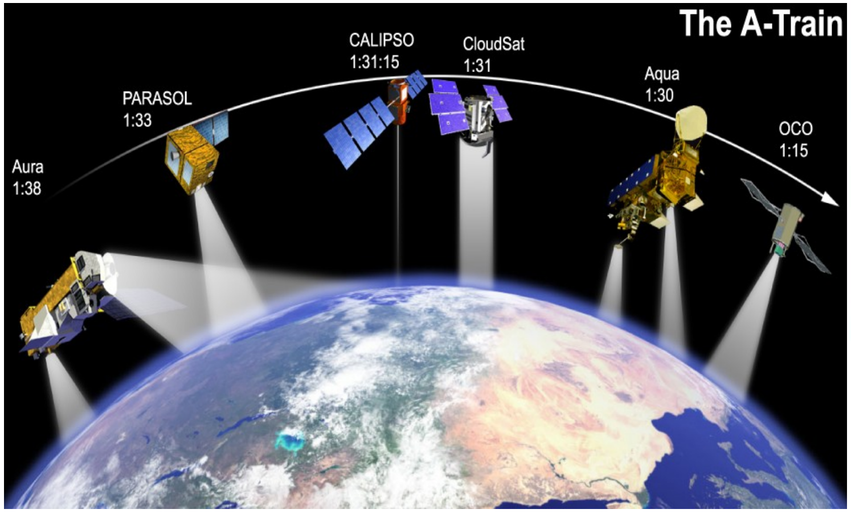


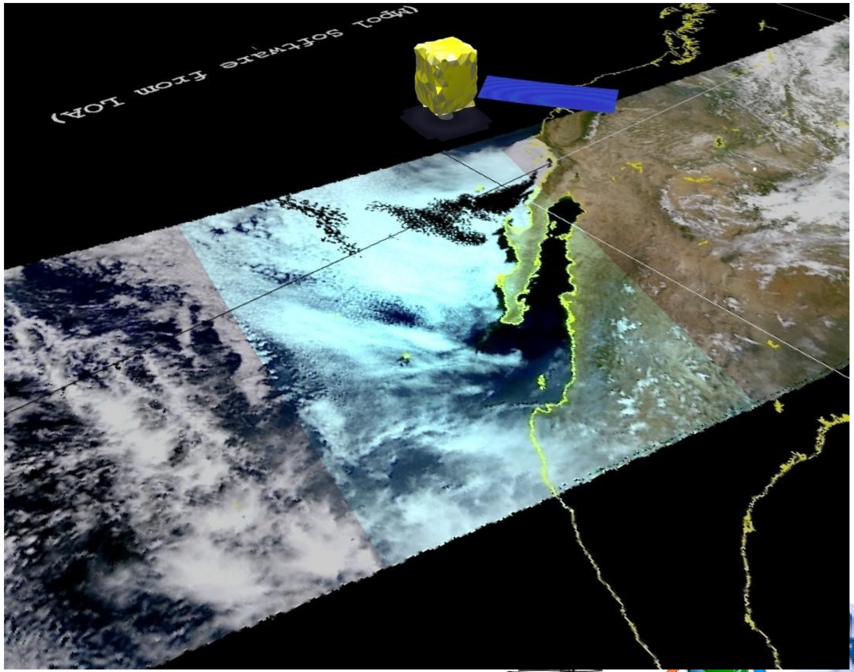
Can't afford our gazoline !!
The A-Train
CALIPSO 1:31:15
CloudSat 1:31
We want our Nobel back !!
PARASOL 1:33
Aura 1:38
OCO 1:15
no return from vacation !!
THE SPACE RAIL UNION GOES ON STRIKE !!
SPACECRAFT UNION SPOKEMAN SAYS "WE WON'T ACCEPT YET ANOTHER MISSION EXTENSION !"

Context & Instrumental Background

- CNES/LOA instrument, Parasol launched Dec. 2004
  - ~ 705 km polar orbits, ascending (13:30 a.m.)
- Sensor Characteristics
  - 10 spectral bands ranging from 0.443 to 1.020 µm
  - 3 polarised channels
  - Wide FOV CCD Camera with 1800 km swath width
  - +/- 43 degrees cross track
  - +/- 51degrees along track
  - Multidirectionnal observations (up to 16 directions)
  - Spatial resolution : 6x7 km
  - No onboard calibration system - Inflight vicarious calibration :
    - 2-3% absolute calibration accuracy
    - 1% interband – 0.1% interpixel over clouds



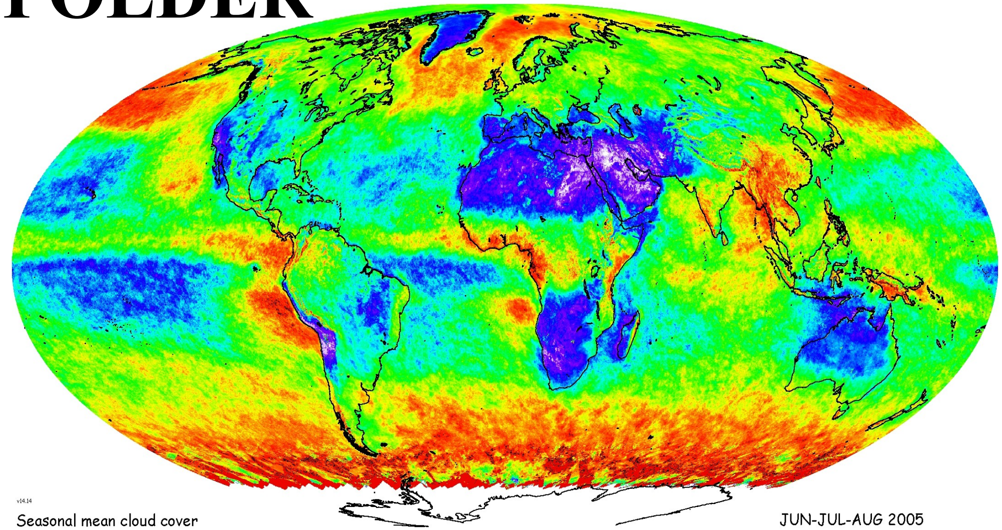


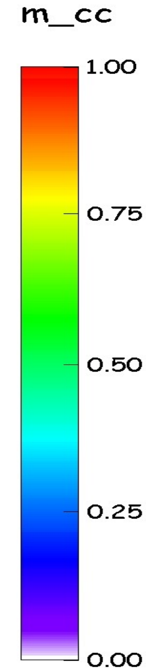


Cloud products comparisons

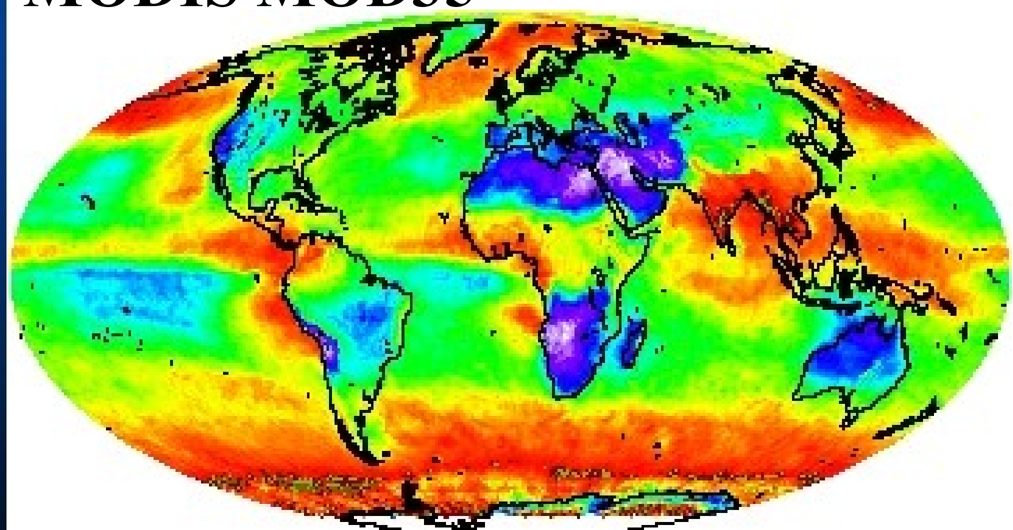
Mean Cloud Fraction Day JJA 2005

POLDER

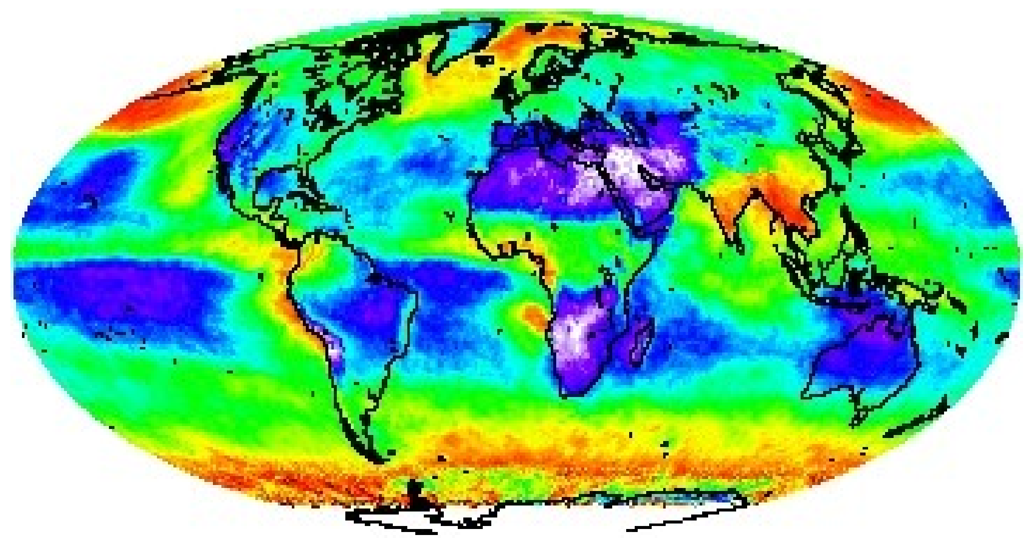




MODIS MOD35



MODIS MOD06 OP



See poster Parol et al, P088

Cloud thermodynamic phase

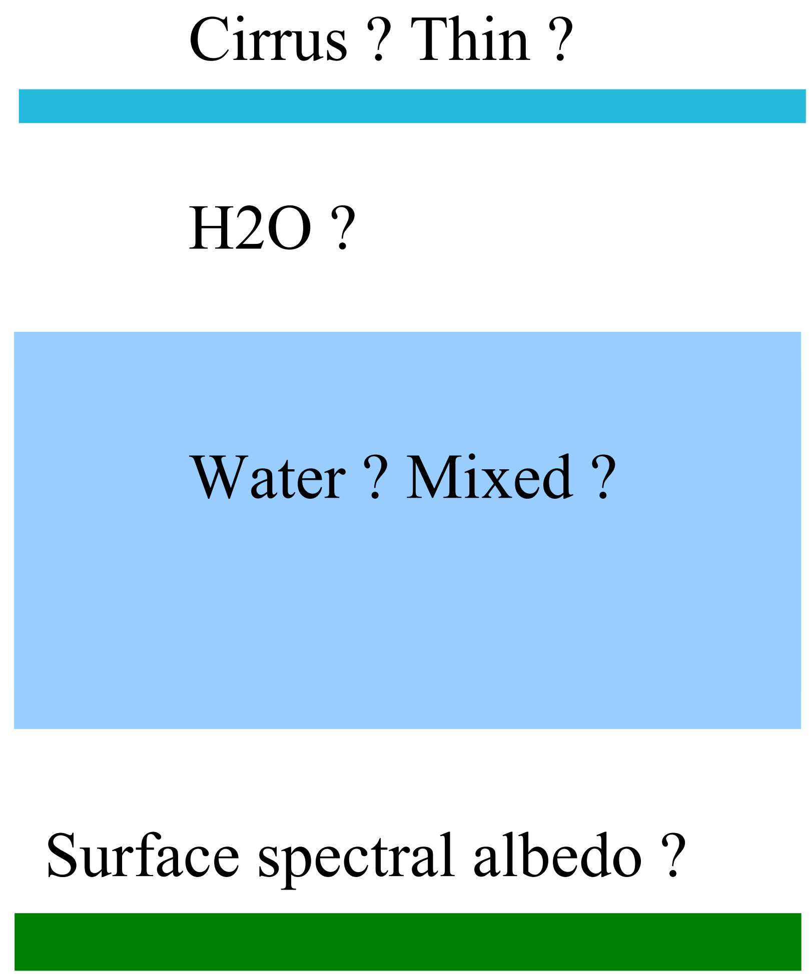
Combination of information on particle shape and absorption properties

Basis

Polarization
mostly single scattering
sensitive to particle shape
Top of cloud but see through it if very thin

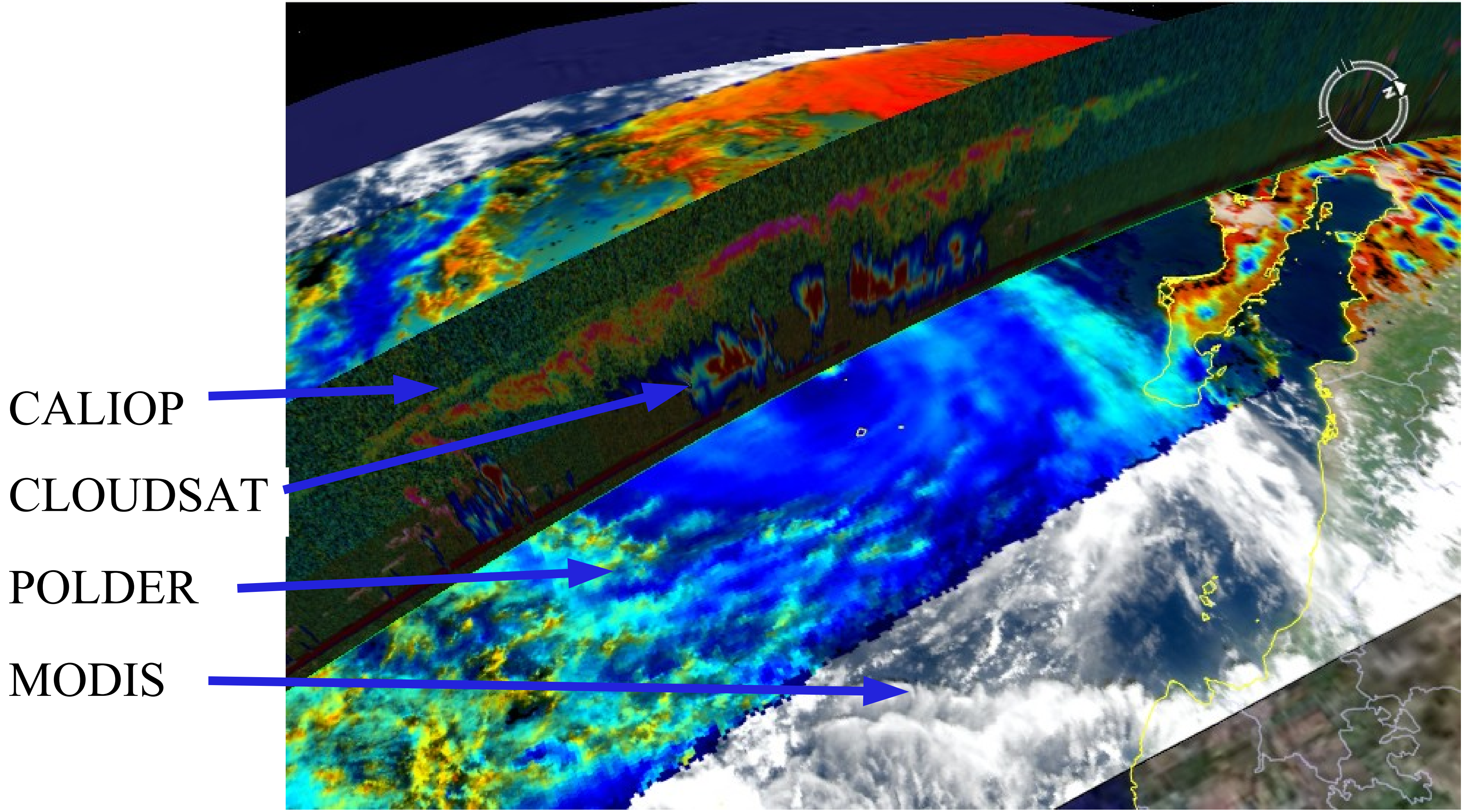
SWIR
Differential Water/Ice Absorption
sensitive to particle size
Some depth in the cloud

Thermal IR
Diff. Water/Ice,
also sensitive to surf. emissivity, H_2O
Some depth in the cloud except thin cirrus



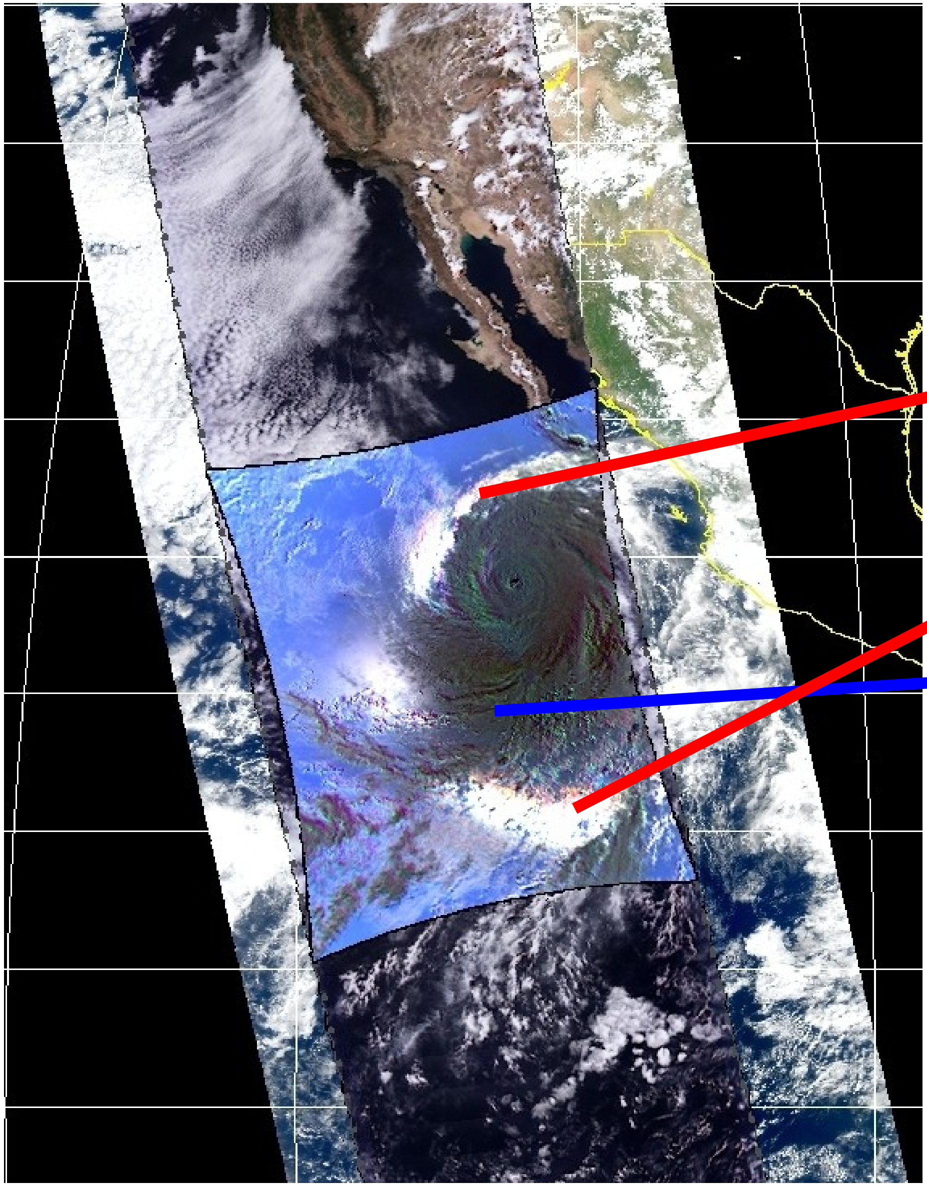
Cloud thermodynamic phase

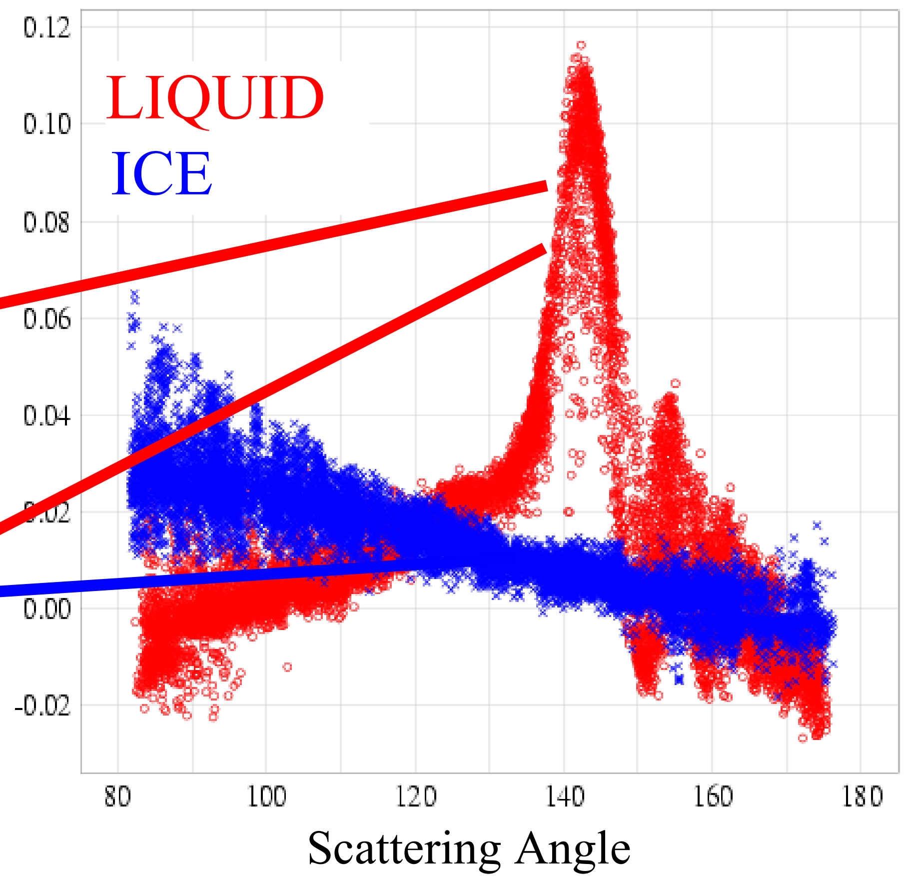
Combination of information on particle shape and absorption properties



Case study : Hurricane Ileana - 23 August 2006

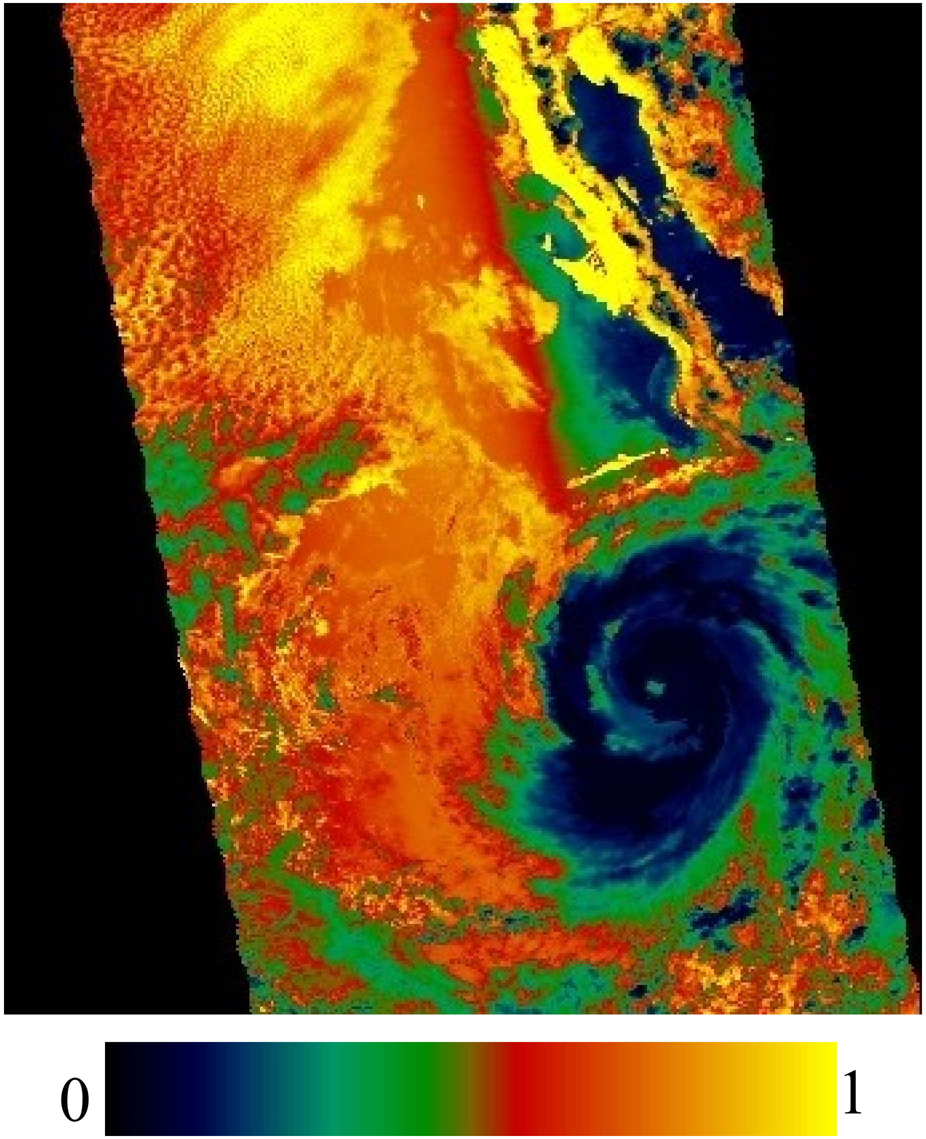
Cloud thermodynamic phase



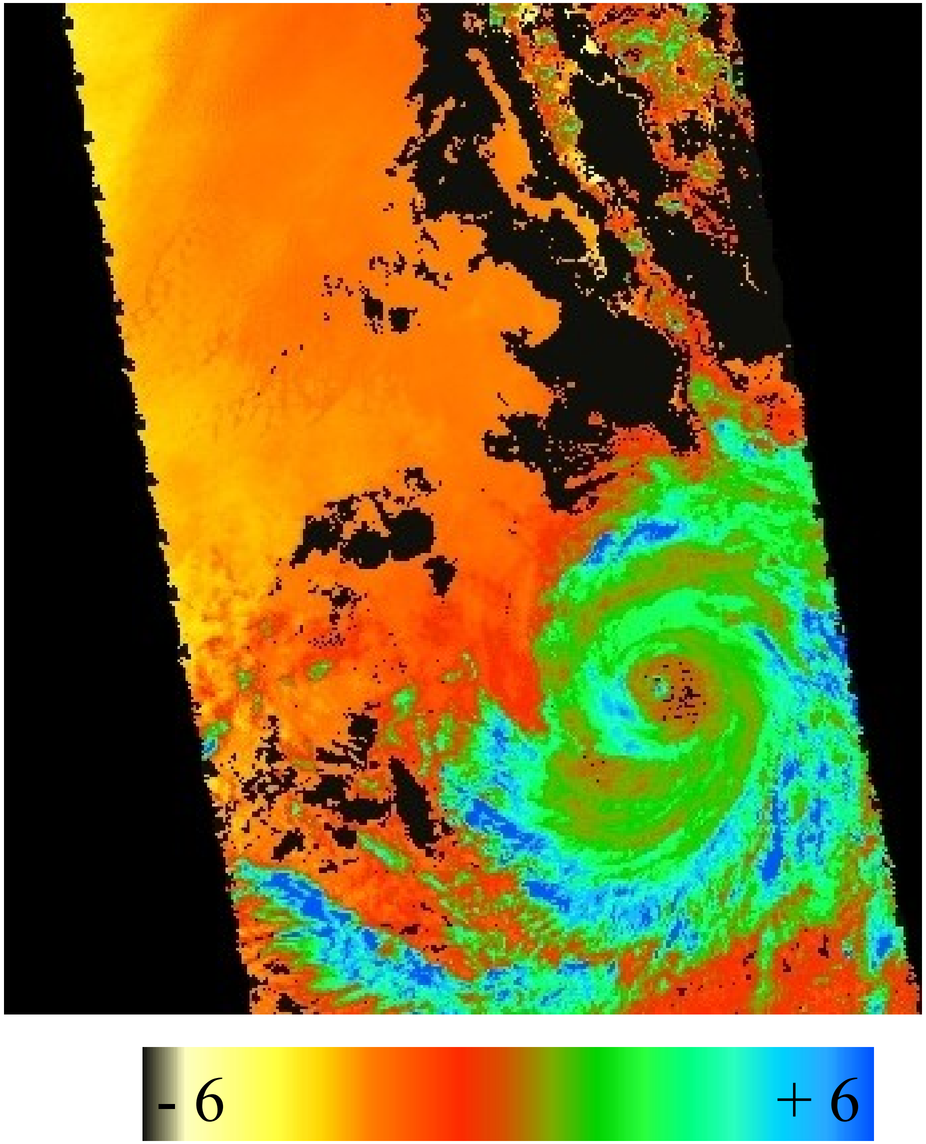


Hurricane Ileana - 23 August 2006

Cloud thermodynamic phase



SWIR over VIS ratio
(MODIS bands 2 and 7)

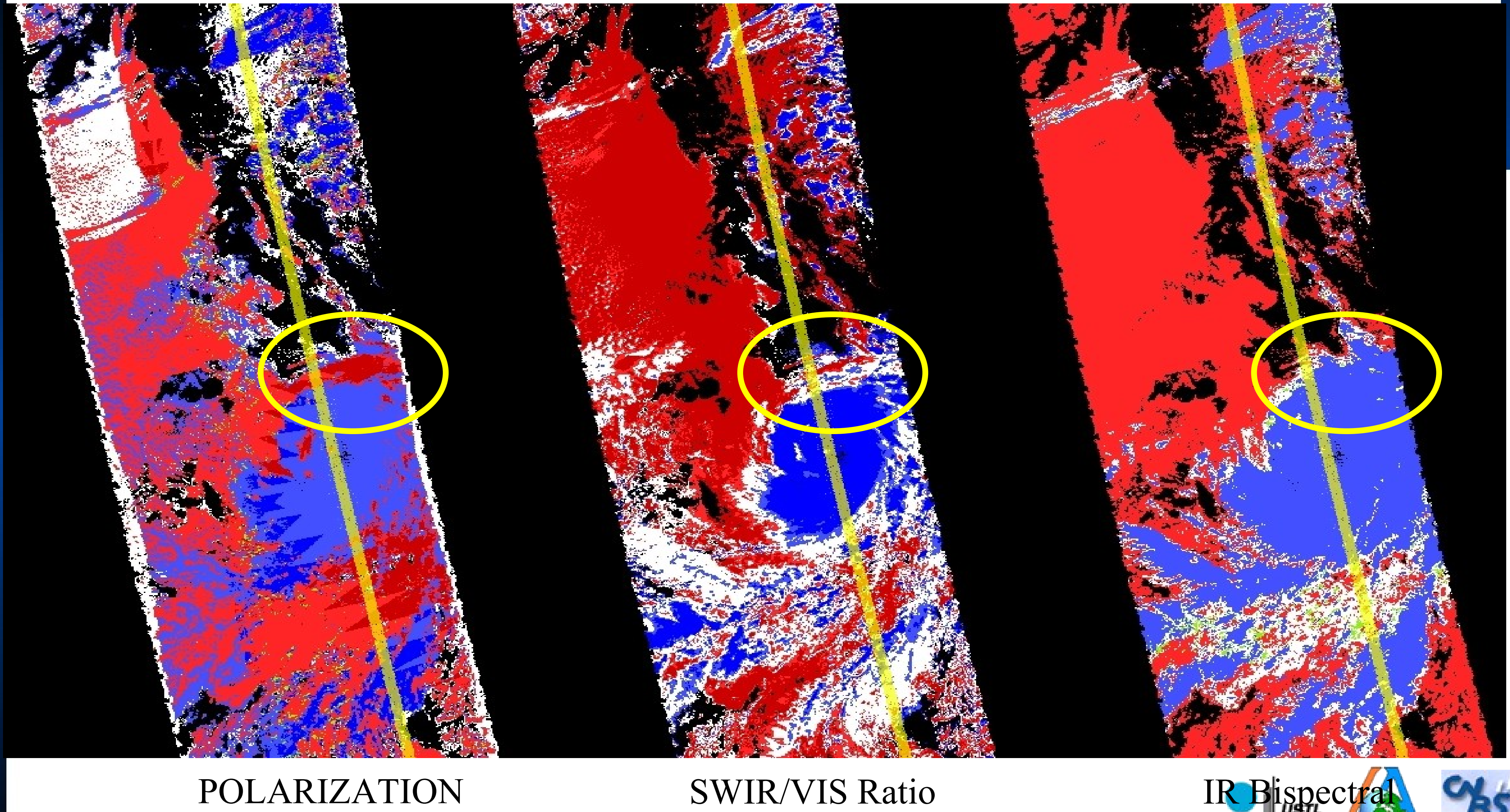


BTD 8 – 11 microns

Cloud thermodynamic phase

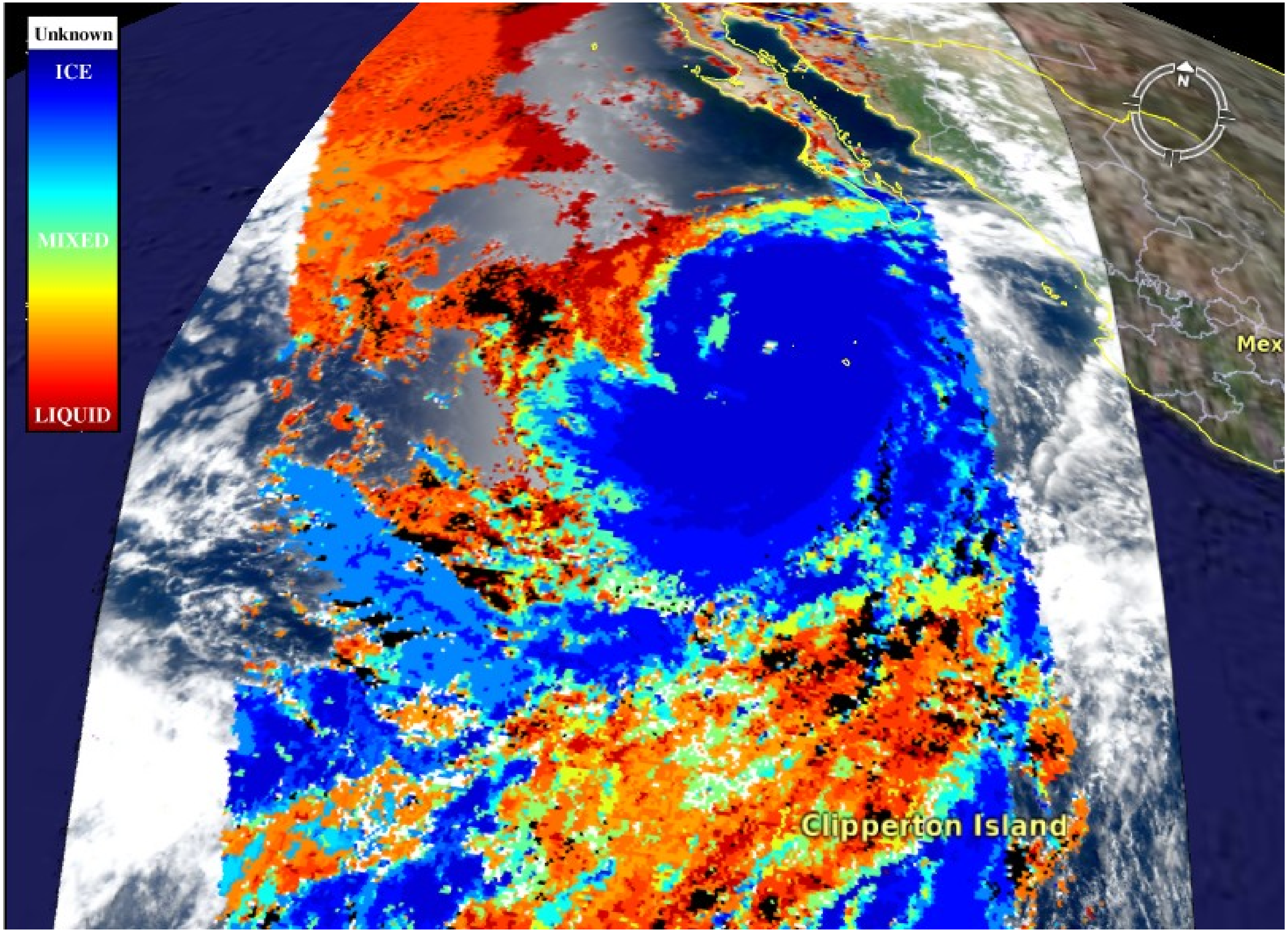
Combination of information on particle shape and absorption properties help

ICE UNKOWN LIQUID



Cloud thermodynamic phase

Results from the combined POLDER/MODIS phase algorithm



Cloud thermodynamic phase

Atmos. Chem. Phys. Discuss., 7, 14103–14137, 2007
www.atmos-chem-phys-discuss.net/7/14103/2007/

Atmospheric Chemistry and Physics Discussions

Cloud thermodynamic phase inferred from merged POLDER and MODIS data

J. Riedi[1], B. Marchant[1], S. Platnick[2], B. Baum[3], F. Thieuleux[1], C. Oudard[1], F. Parol[1], J-M. Nicolas[4], and P. Dubuisson[1]

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ACPD

7, 14103–14137, 2007

Cloud phase from POLDER and MODIS data

J. Riedi et al.

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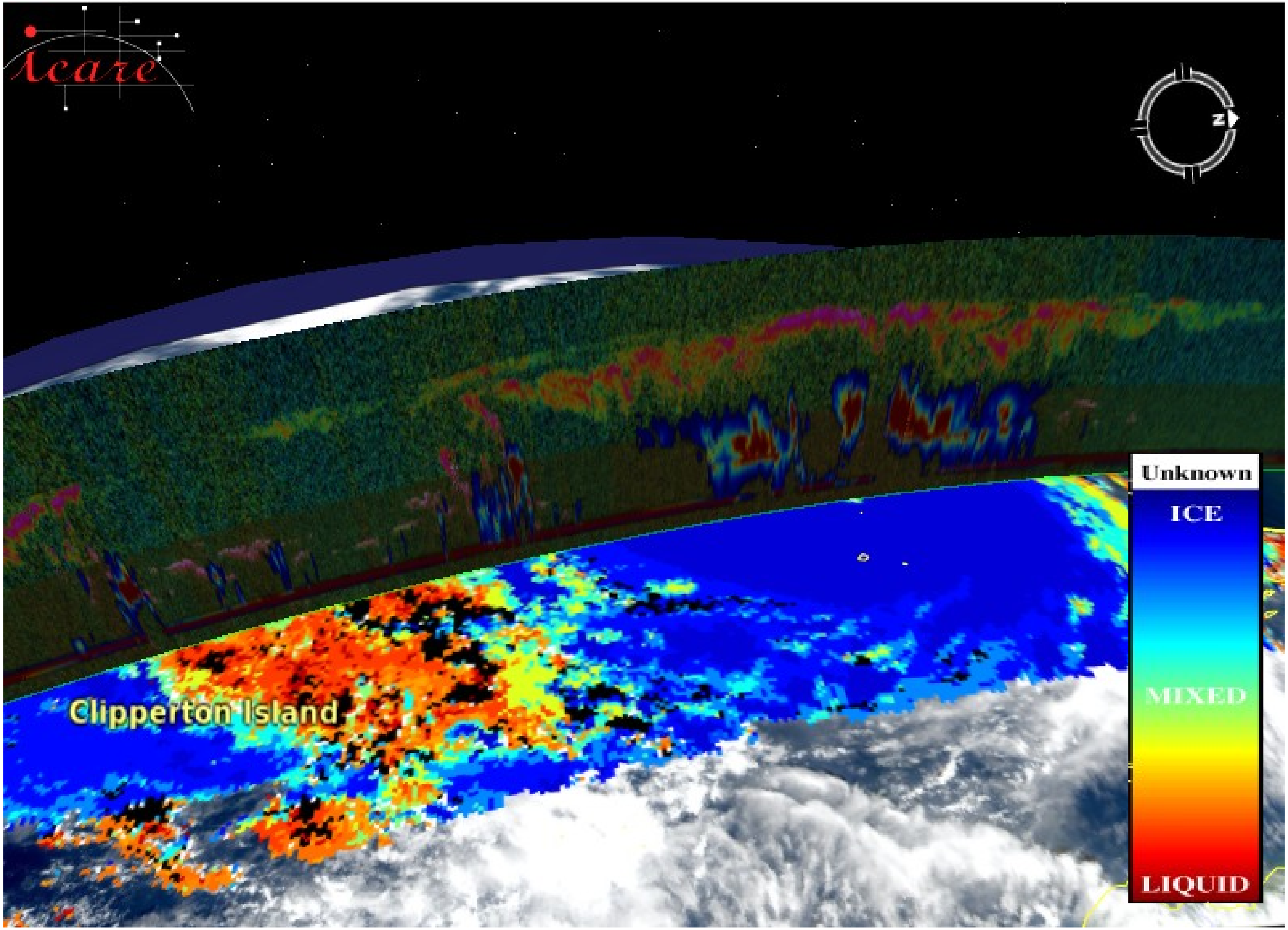
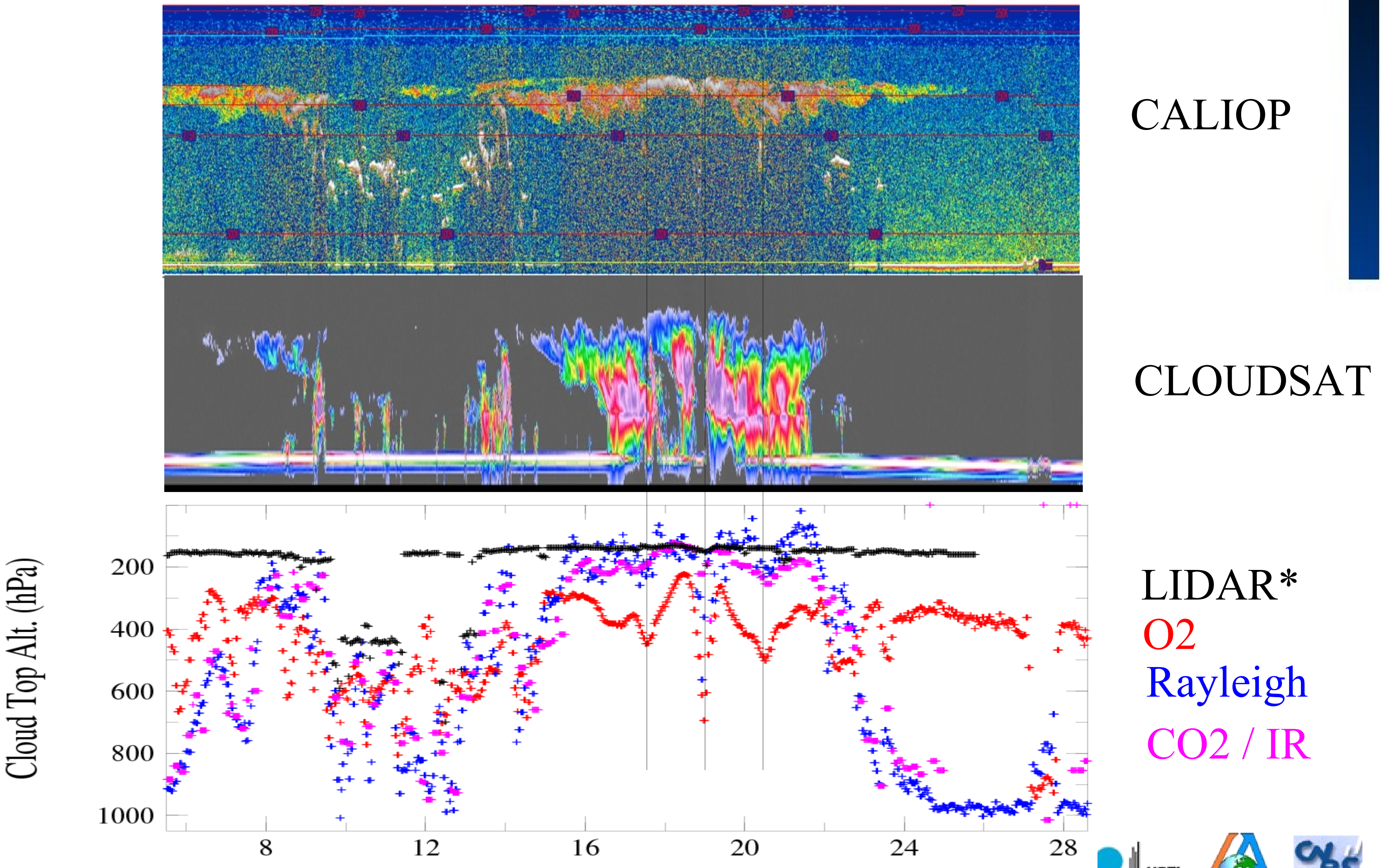
Cloud thermodynamic phase

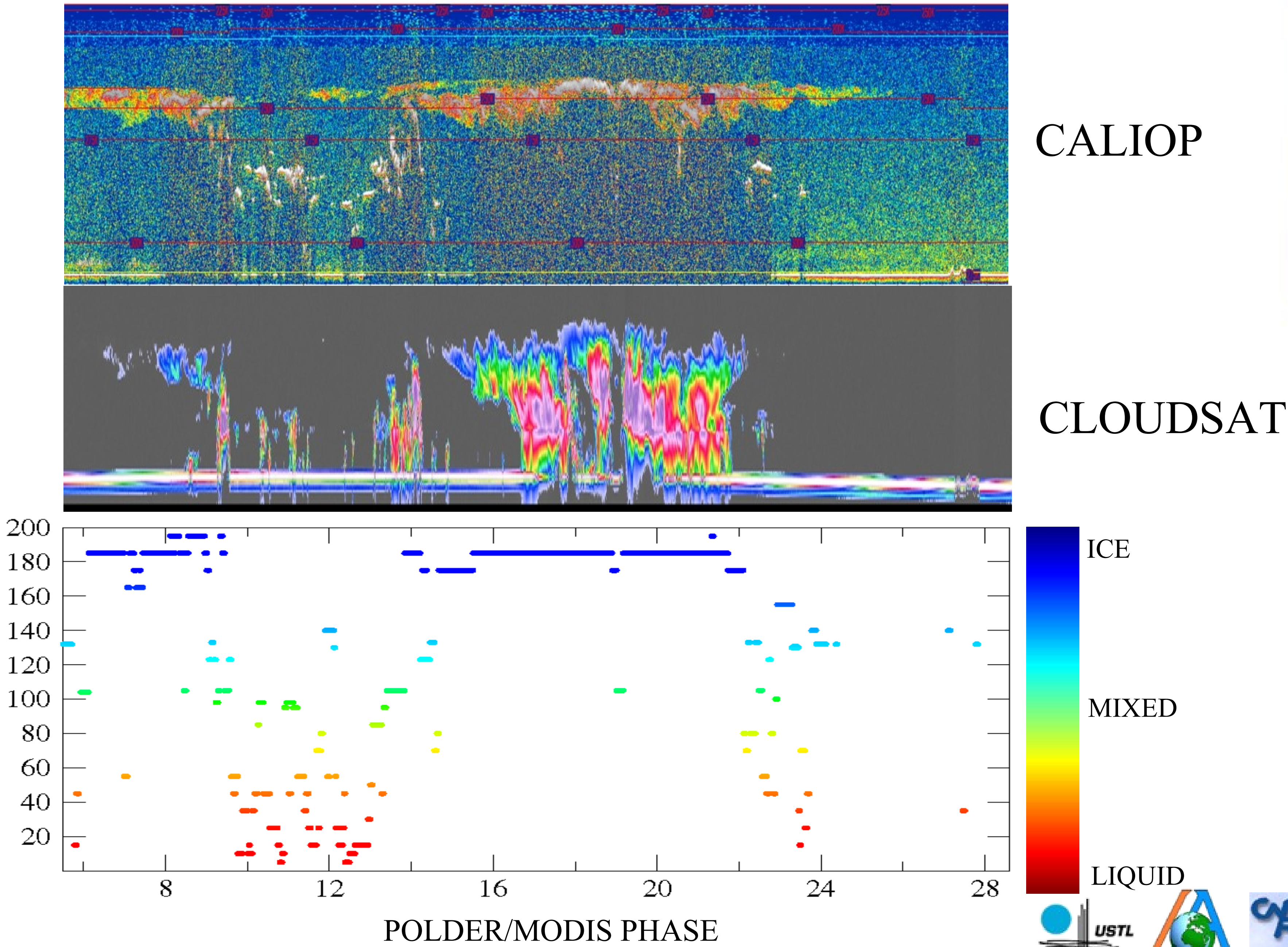
Results from the combined POLDER/MODIS phase algorithm



Cloud thermodynamic phase



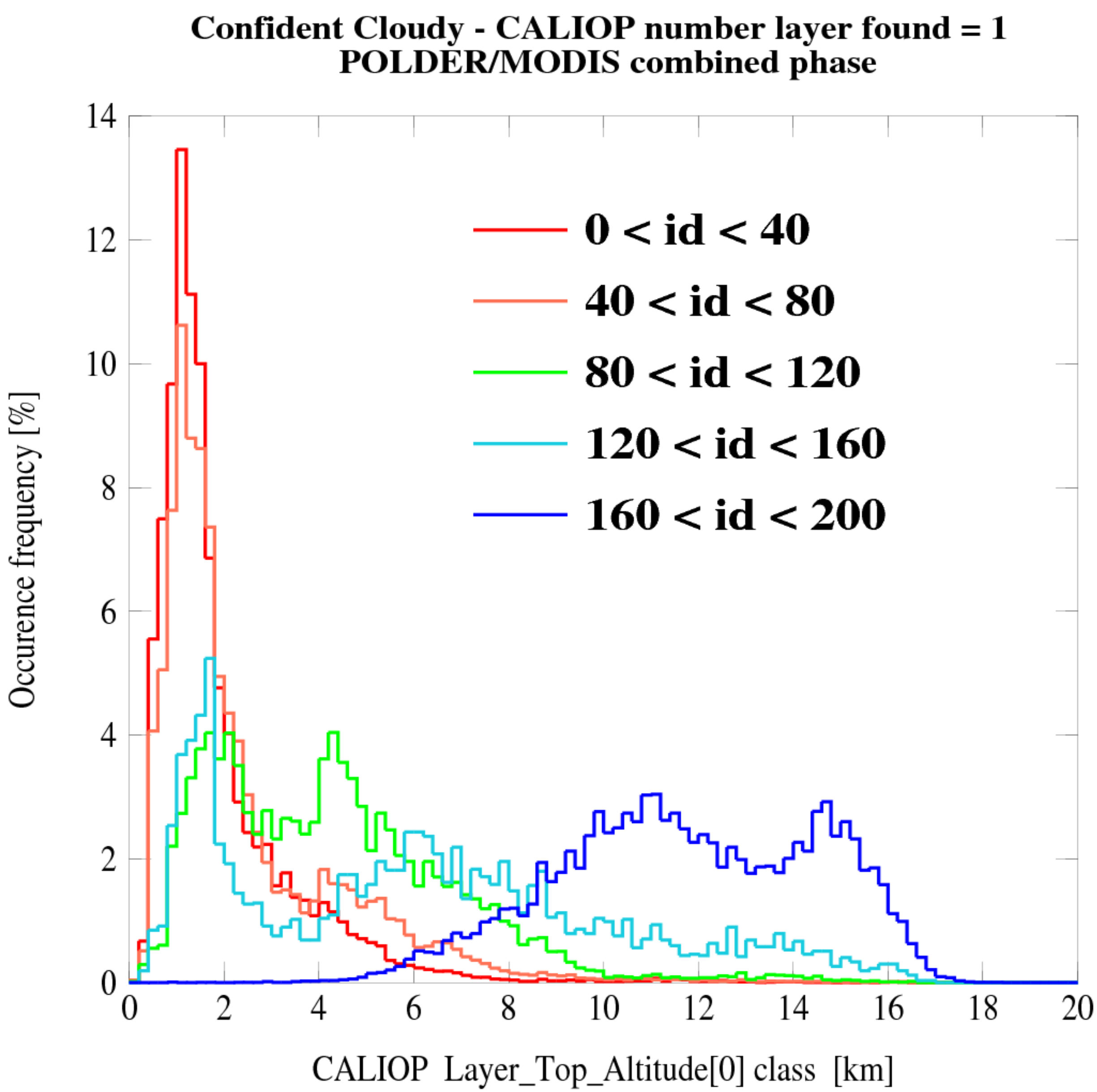
Cloud thermodynamic phase



Cloud thermodynamic phase

PDF of cloud top layer altitude from CALIOP function of cloud phase
Case of single layer

Confident cloudy pixels over land and ocean.
August 2007



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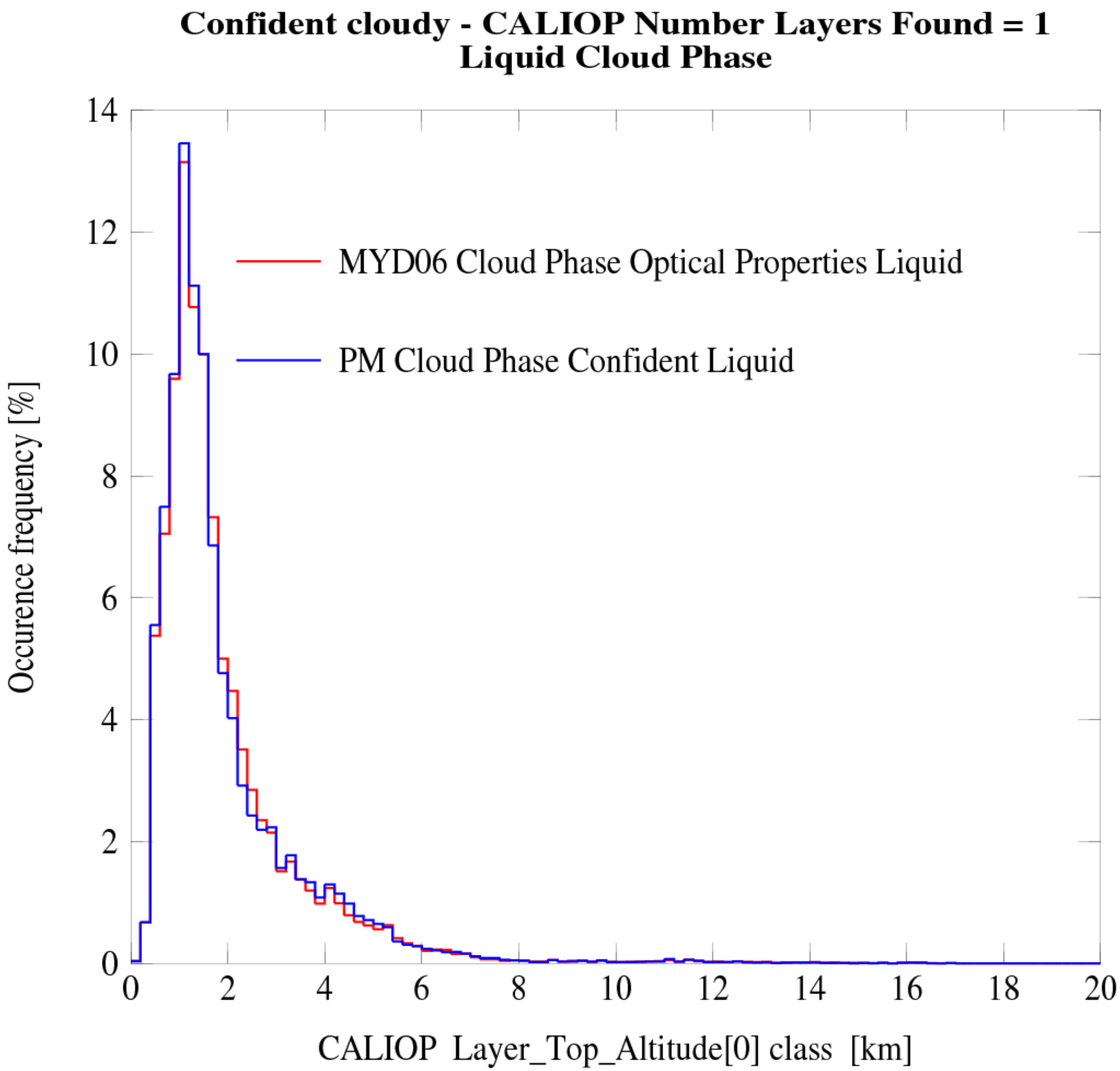

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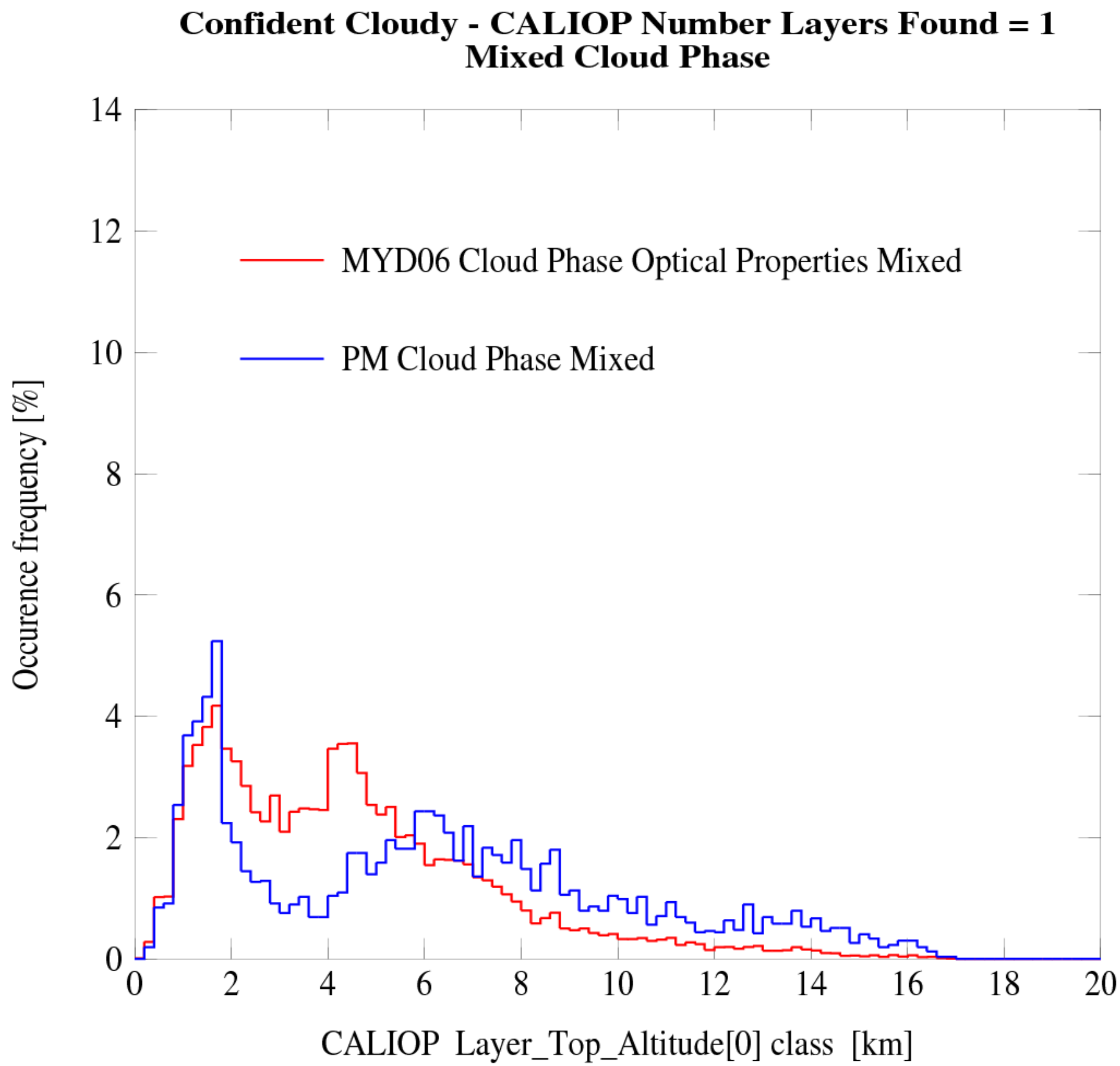

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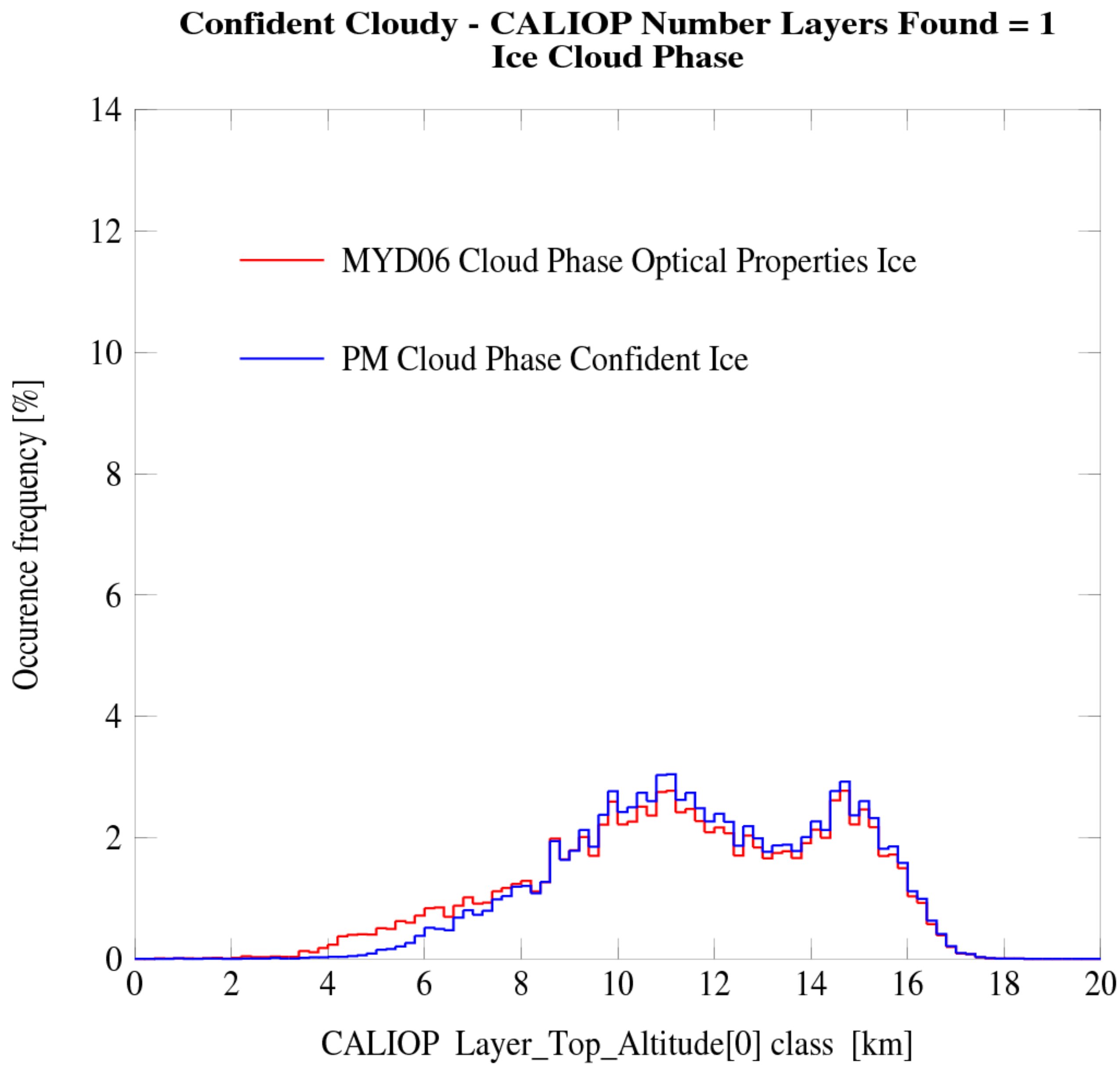
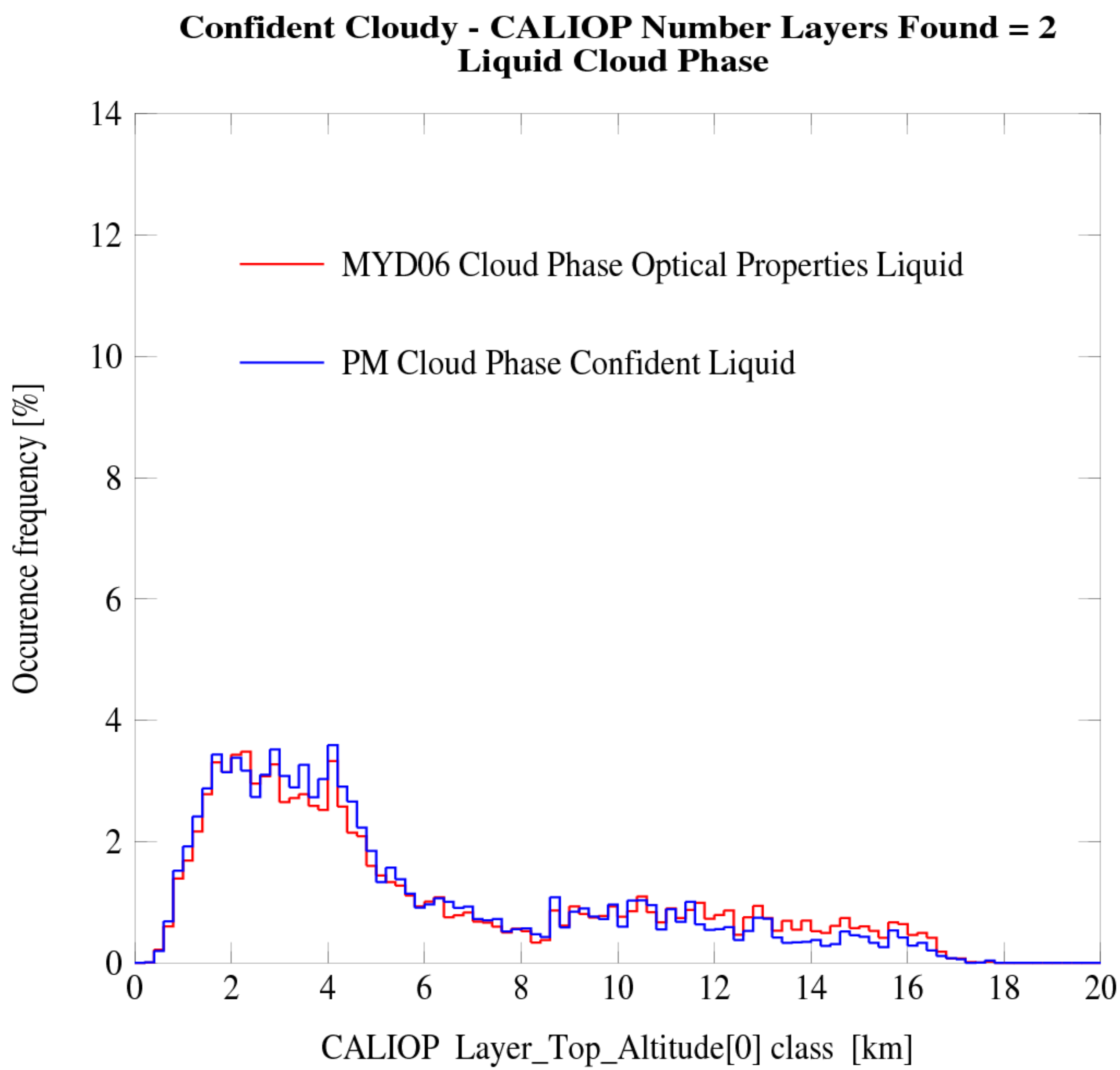


Confident cloudy pixels over land and ocean.
August 2007

Cloud thermodynamic phase

PDF of cloud top layer altitude from CALIOP function of cloud phase

Case of two layers



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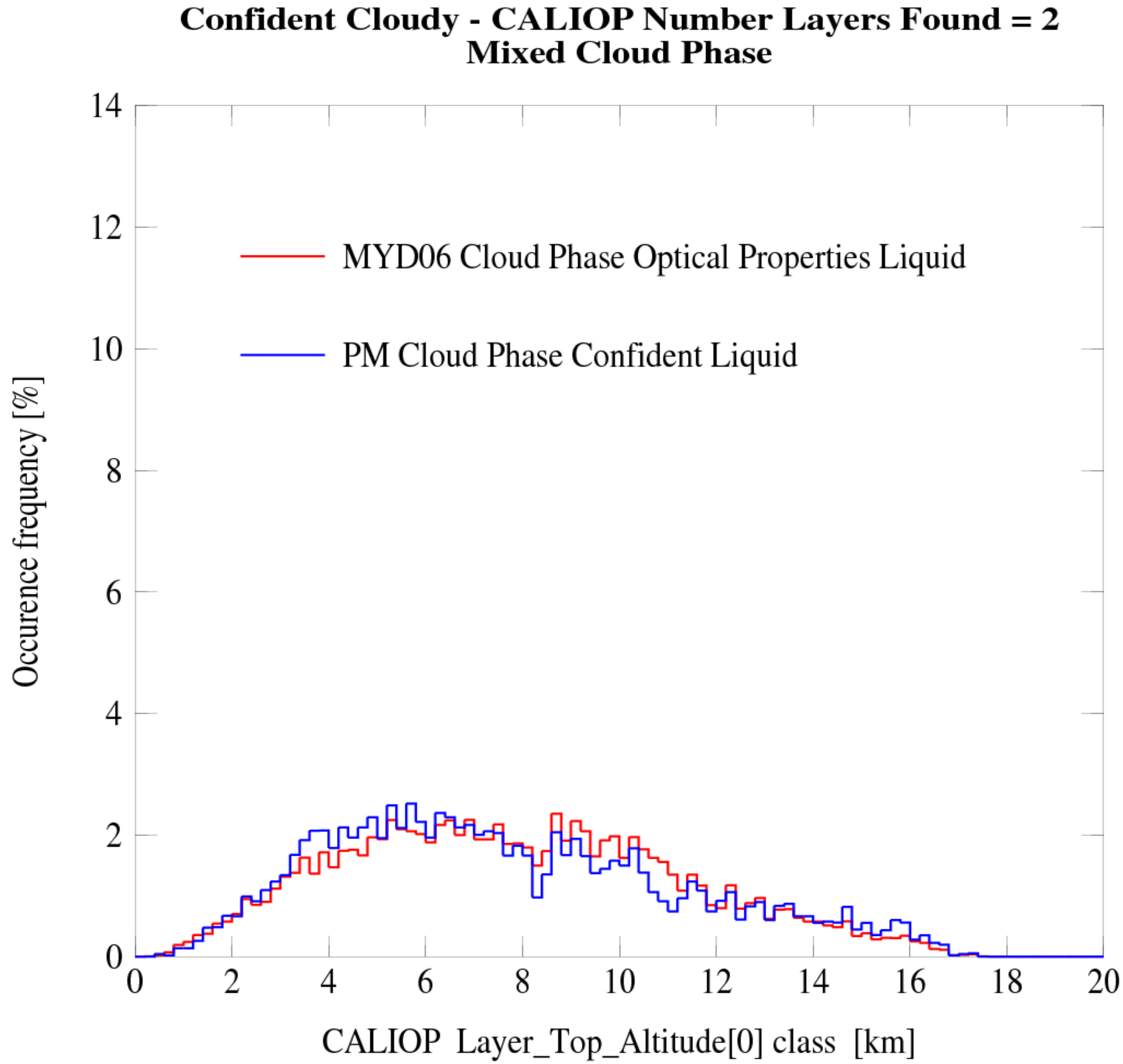

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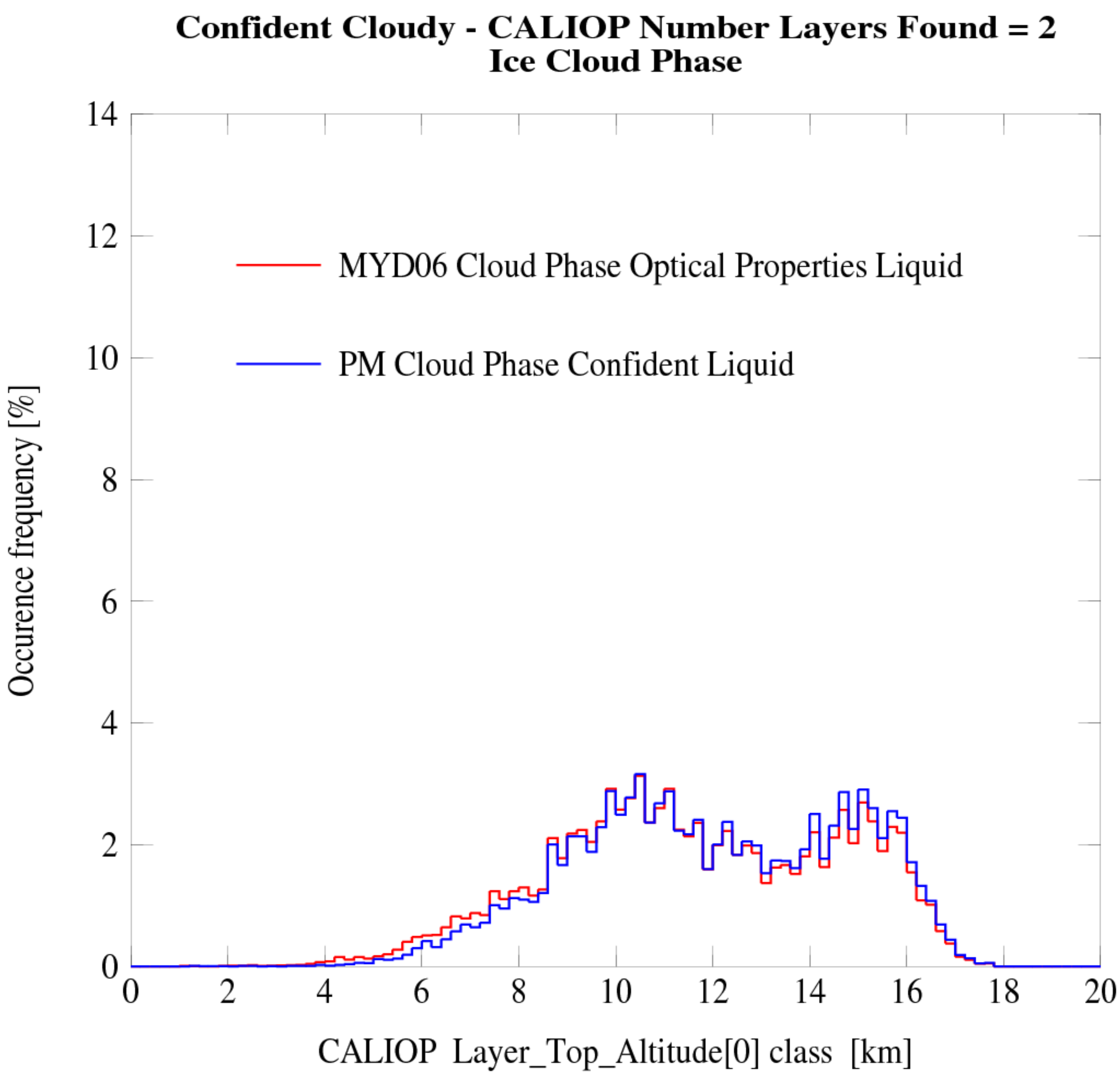
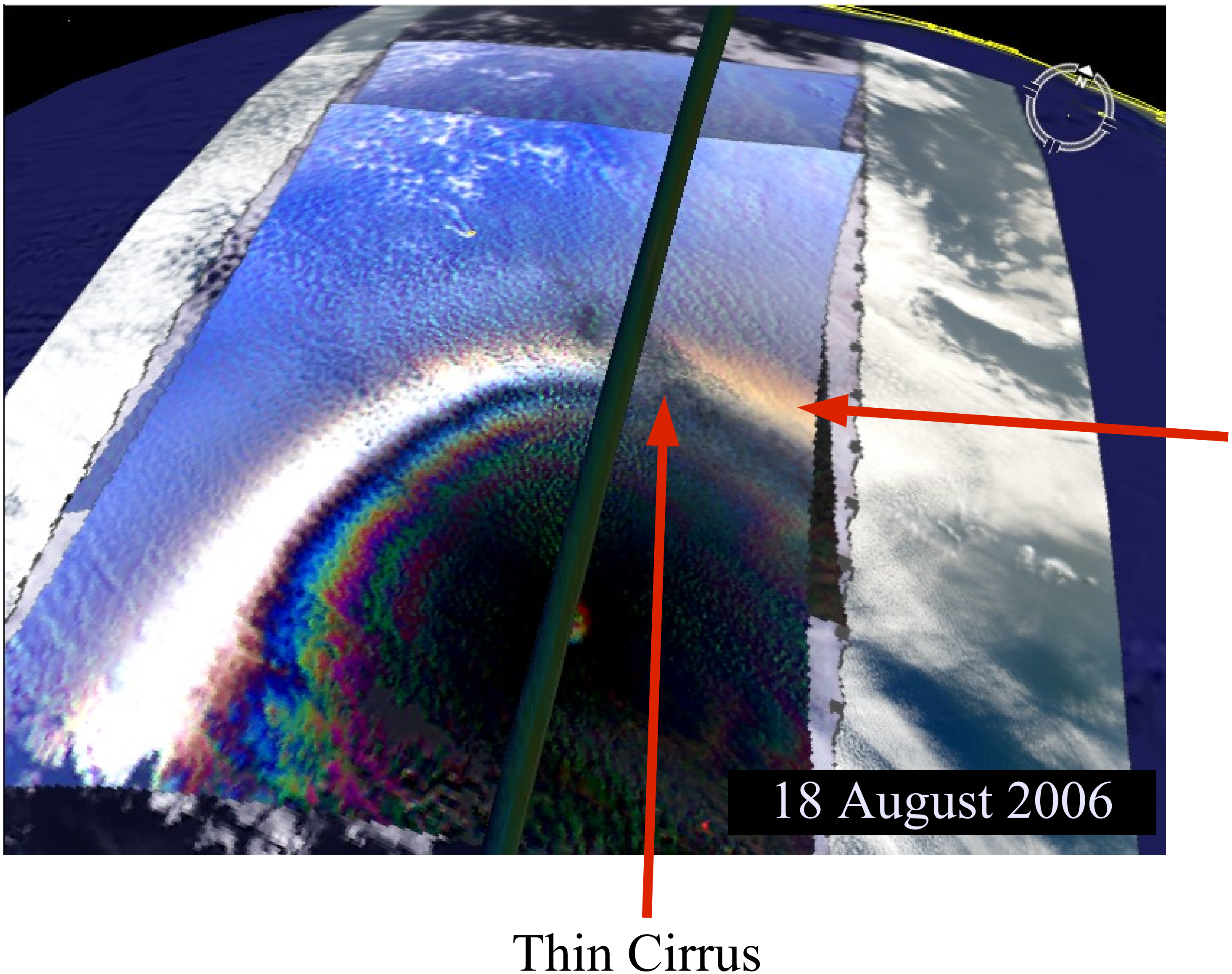


Aerosols over clouds : a case study

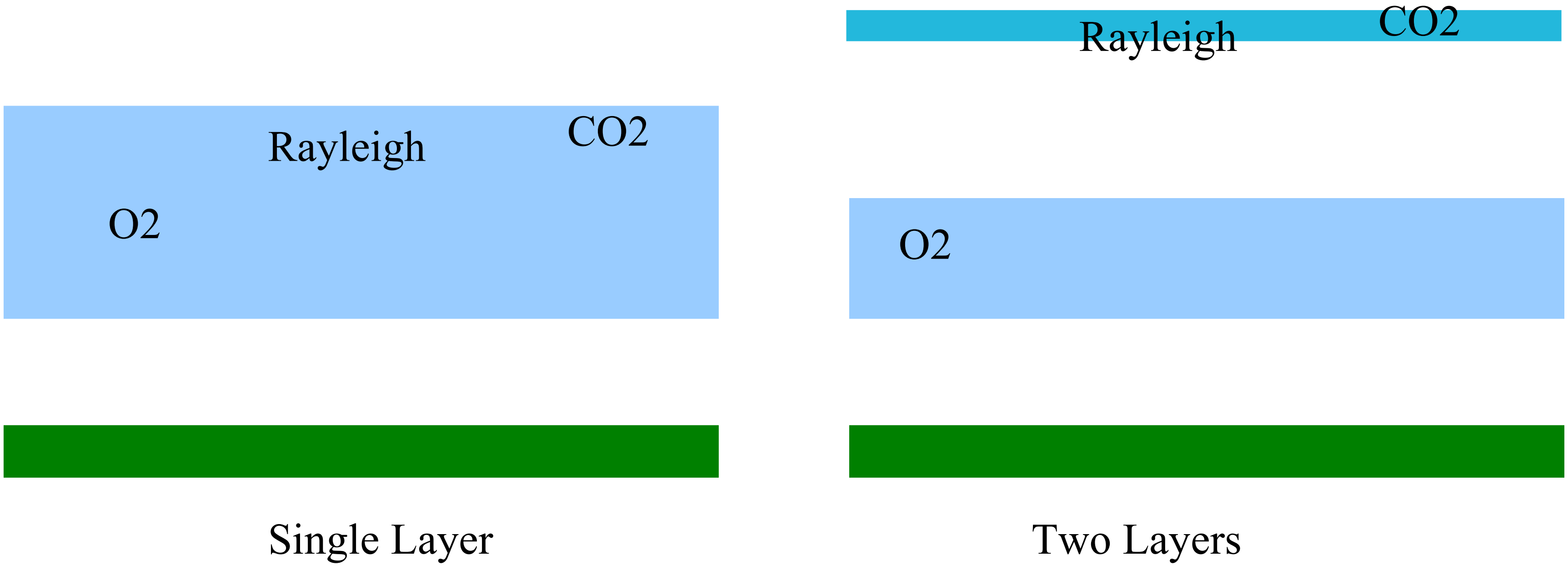


Cloud layers height

Deriving multiple cloud top pressure (O_2, Rayleigh, CO_2 slicing) to detect multilayer clouds and better describe vertical structure

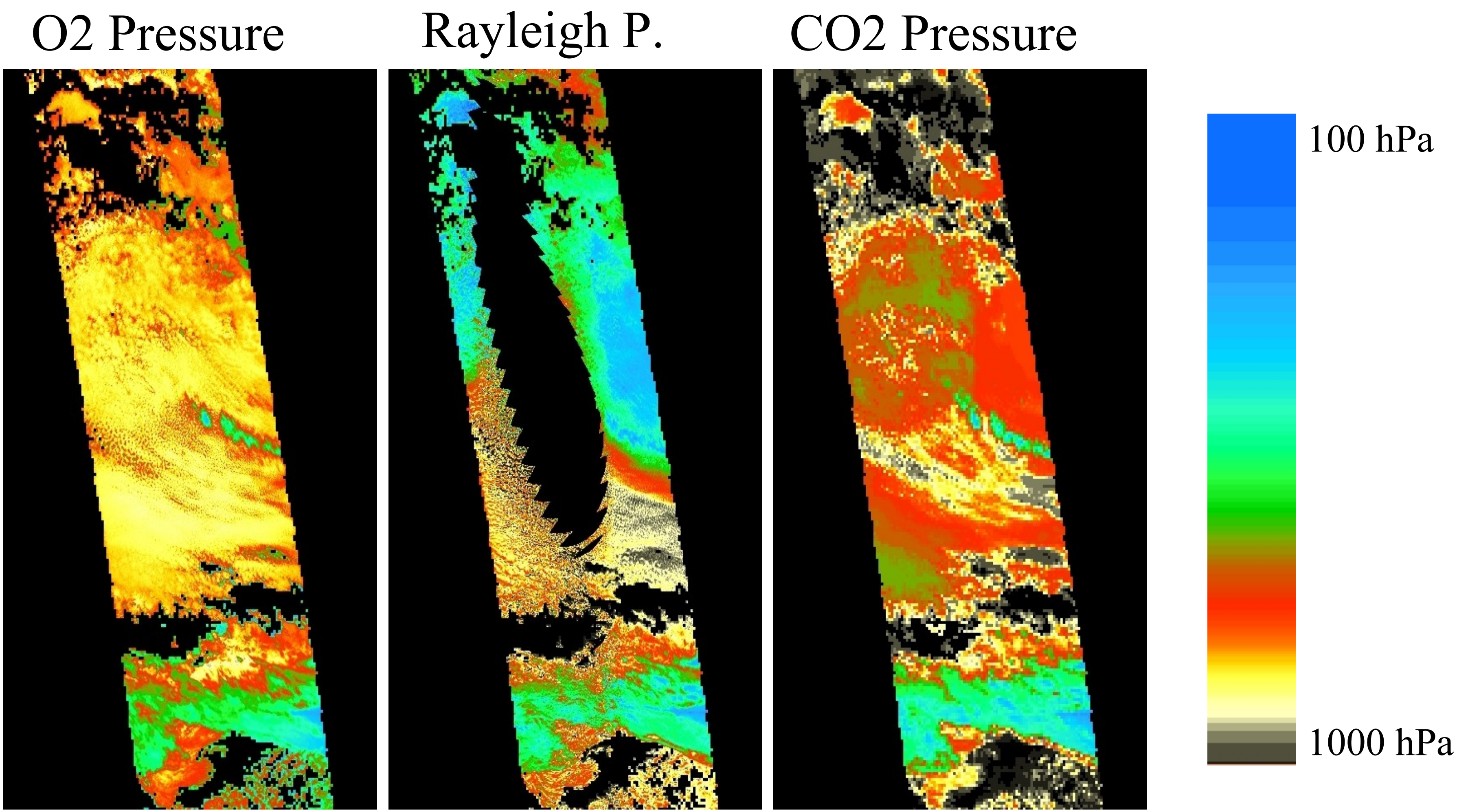
Basis

We do expect differences in pressure due to resp. sensitivities and we also expect increasing differences in case of multilayer situations



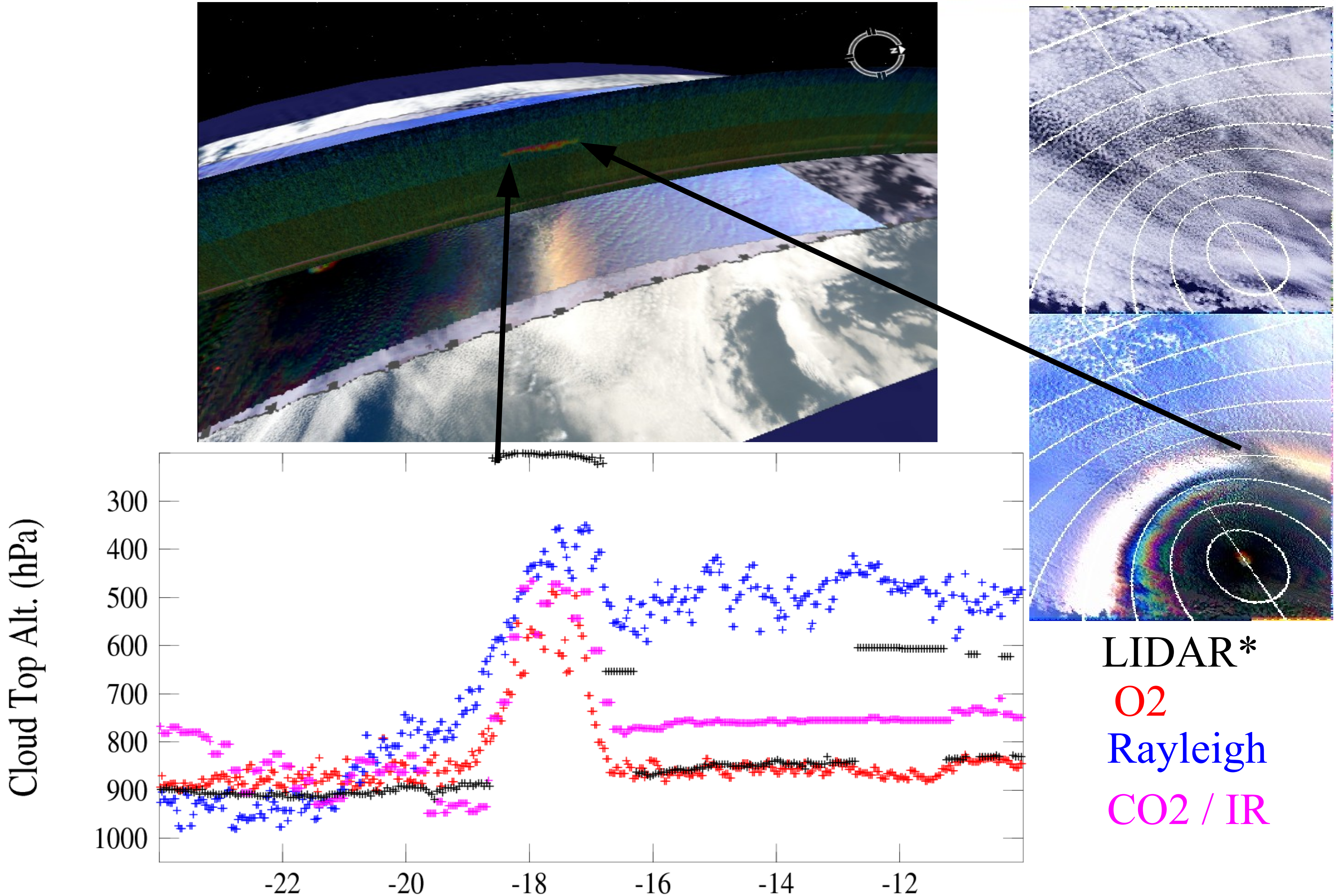
O2 : Oxygen band differential absorption (*Vanbauce et al*)
Rayleigh : Polarization Rayleigh Scattering absorption
CO2 : CO2 Slicing (IR)

Example : aerosols over cloud

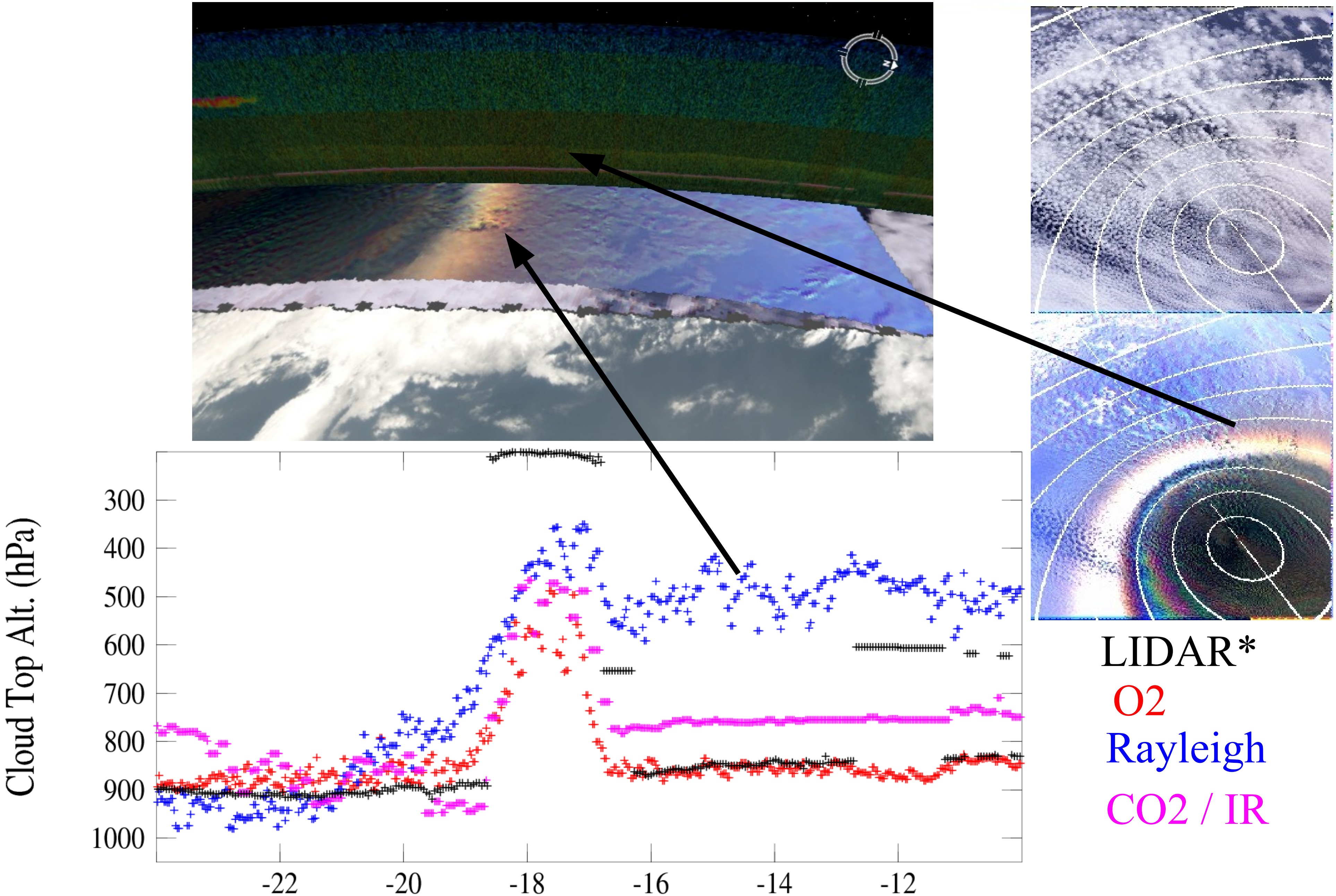


Usually with single layer : O_2 > Rayleigh > CO_2 with small differences

And here we have : O_2 > CO_2 >> Rayleigh due to presence of aerosol in the upper layer

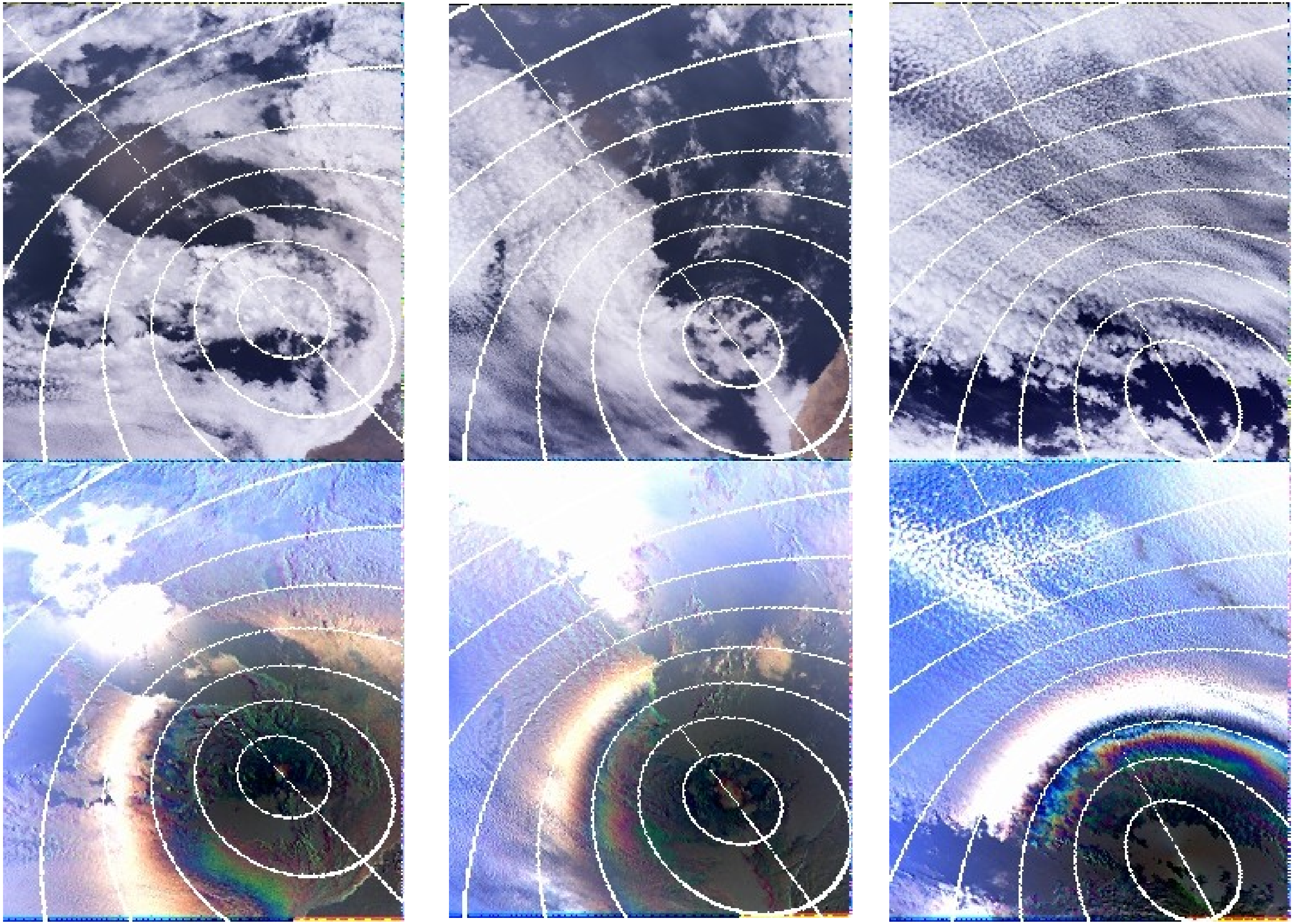


*LIDAR Alt from 5km
Cloud Layer product



*LIDAR Alt from 5km
Cloud Layer product

About aerosols over cloud



Polluted Polluted Clean

Aerosol layers over extended cloud fields

Can we derive information on aerosols using cloud as a « source » of polarized light ?

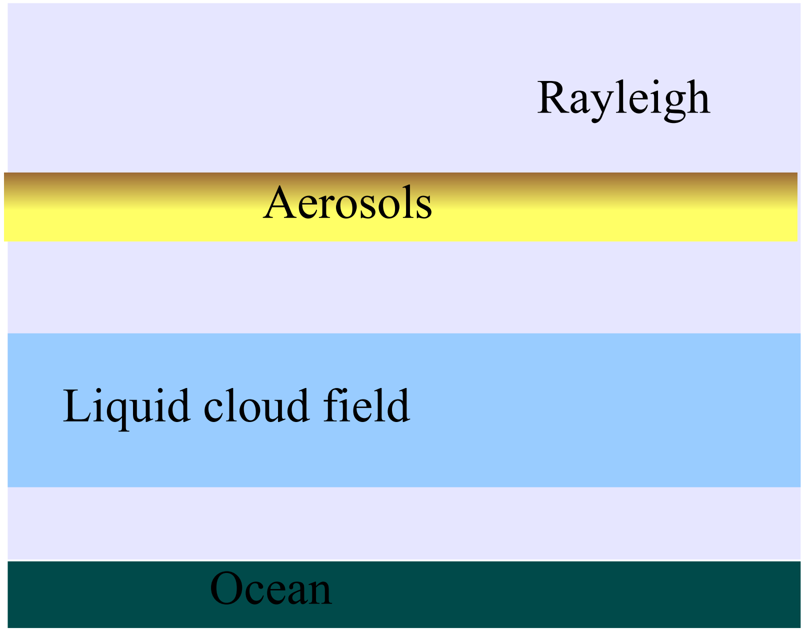
Basis

Use the rainbow as a “source” of polarized light and measure extinction through the aerosol layer

$$R_p^{TOA} = R_p^{Cloud} \exp^{-\tau/\mu} + R_p^{Aerosol+Rayleigh}$$

Use a band where the aerosol contribution is the lowest to retrieve cloud properties and recompute the signal for other 2 bands to get aerosol layer information.

Iterate using aerosol information previously retrieved to improve initial cloud signal estimate.



Advantages

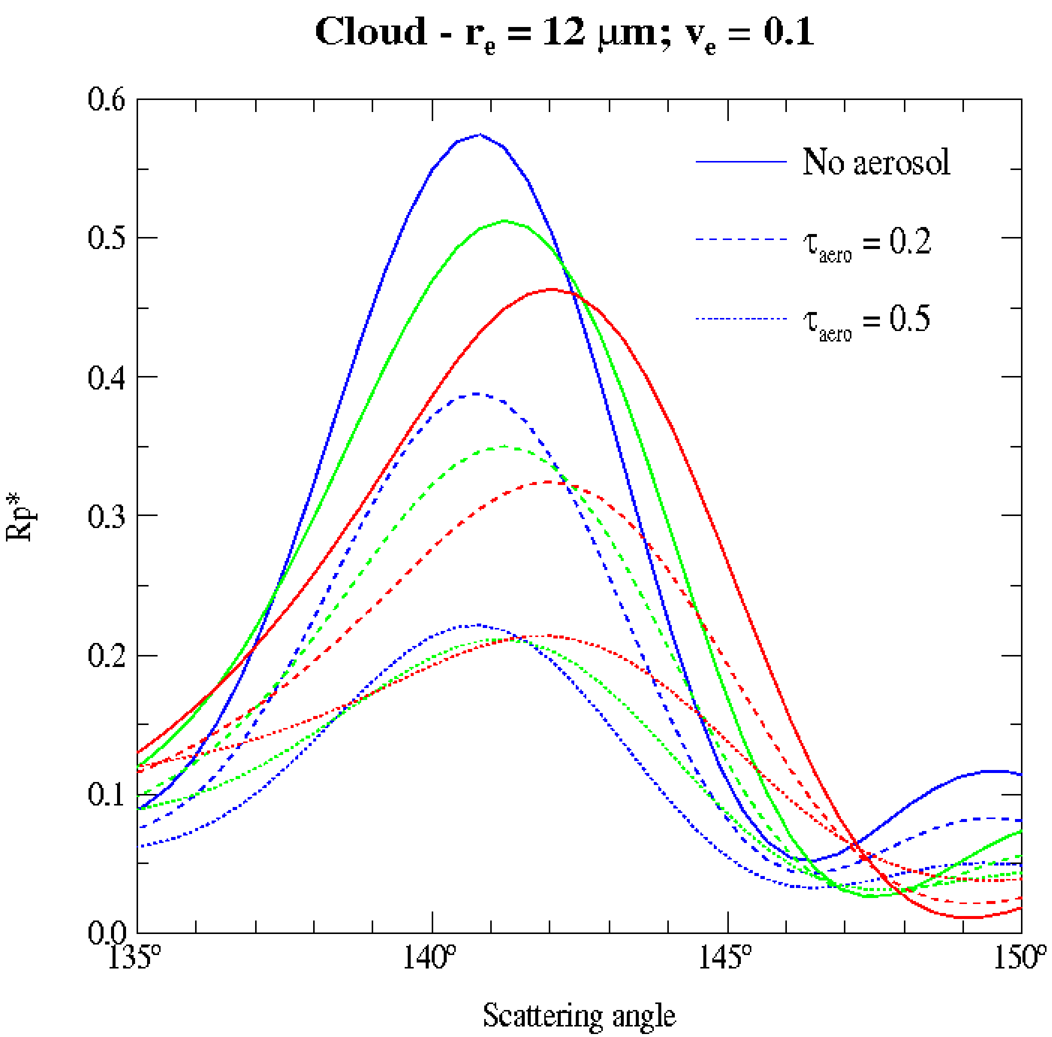
The cloud signal can be determined consistently for the 3 bands.

Rayleigh contribution is reduced in the rainbow region

Knowing the cloud optical thickness is not necessary as long as the cloud is thick enough for polarization signal to saturate (> 2.0)

Aerosol layers over extended cloud fields

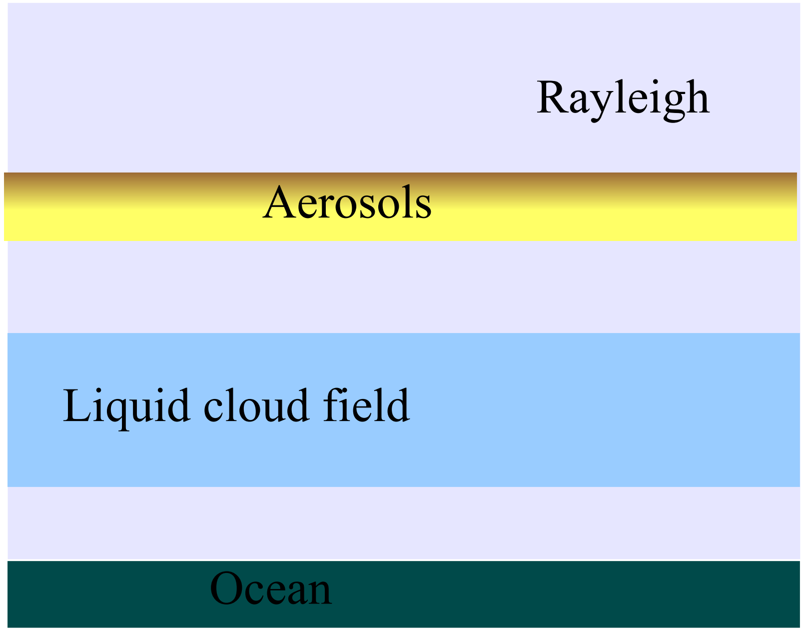
Can we derive information on aerosols using cloud are a « source » of polarized light ?



Why is the primary rainbow turning brown ?

Simulation of an aerosol absorbing layer over a liquid cloud (OT = 5)

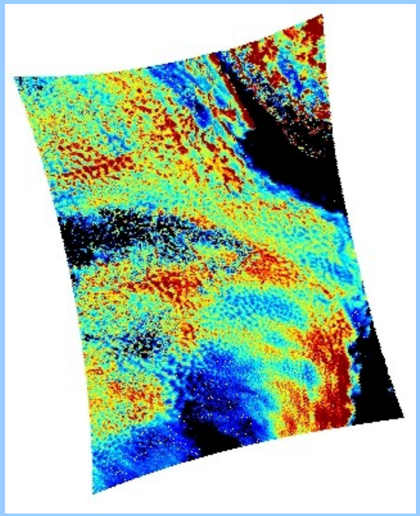
The relative contribution of the red channel increases with aerosol optical thickness



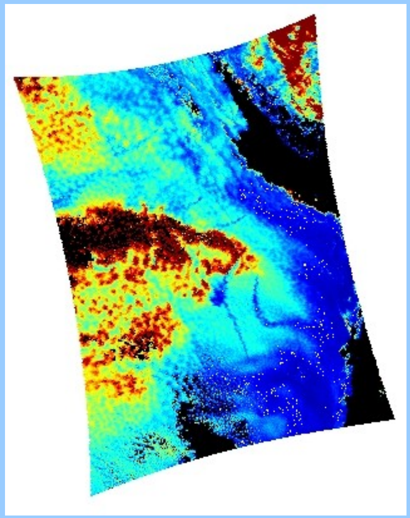
Aerosol layers over extended cloud fields

Can we derive information on aerosols using cloud as a « source » of polarized light ?

INPUT PARAMETERS FOR SIMULATION

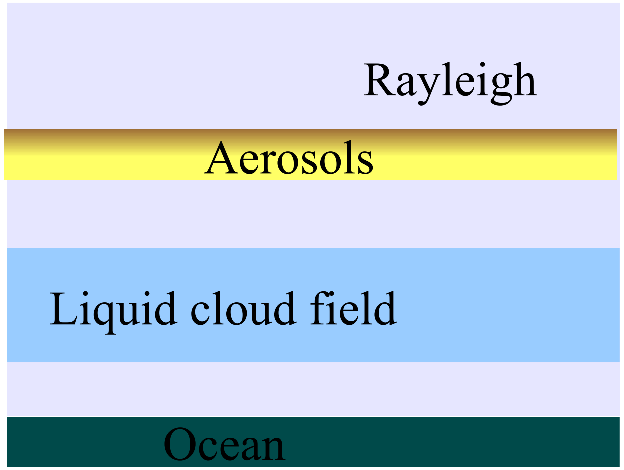


MODIS
Cloud Opt. Thickness

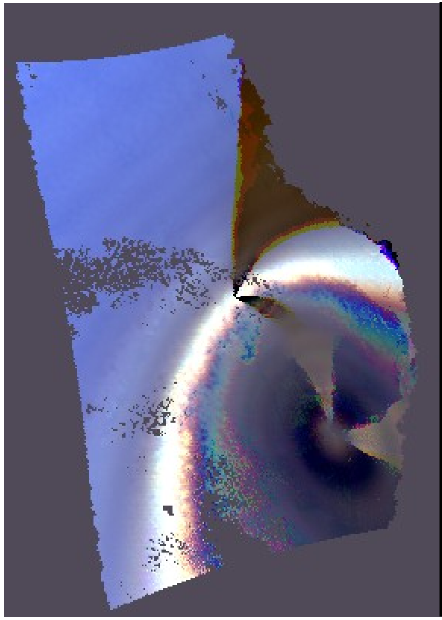


MODIS
Cloud Effect. Radius

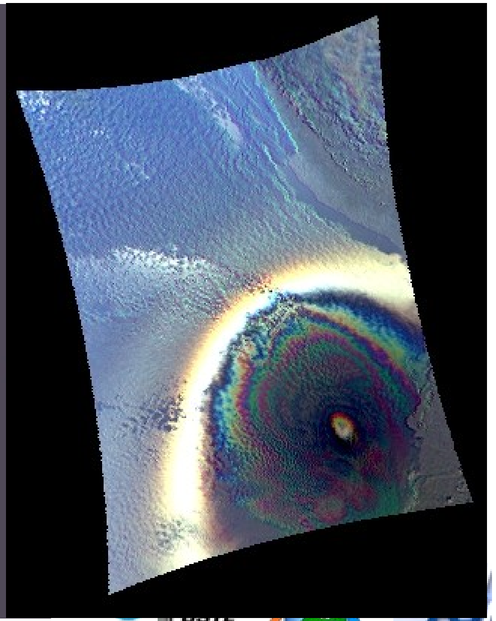
Assume some effective variance $\sigma_{eff} = f(LWC)$



Simulations



Observations



Compute polarized reflectances using
adding doubling code
for corresponding POLDER geometries
Try a multipixels retrieval (Dubovik et al)

Conclusions and Perspectives

GO SEE THE POSTERS ...

Riedi et Labonnote, P095

Labonnote et al, P089

Parol et al, P088

Seze et al, P101

Dubovik et al, P019

Breon, P060

Holz et al, P076

King et al, P083

Sneep et al, P098

Acknowledgement

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- MODIS cloud team members (S. Platnick, B. Baum) for usefull and also numerous useless yet exciting discussions.
- ICARE Data and Services Center for data access and processing support

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