Remote Sensing of Clouds and Aerosols from POLDER

Recent Development in the A-Train Framework and Perspectives for New Mission Concept

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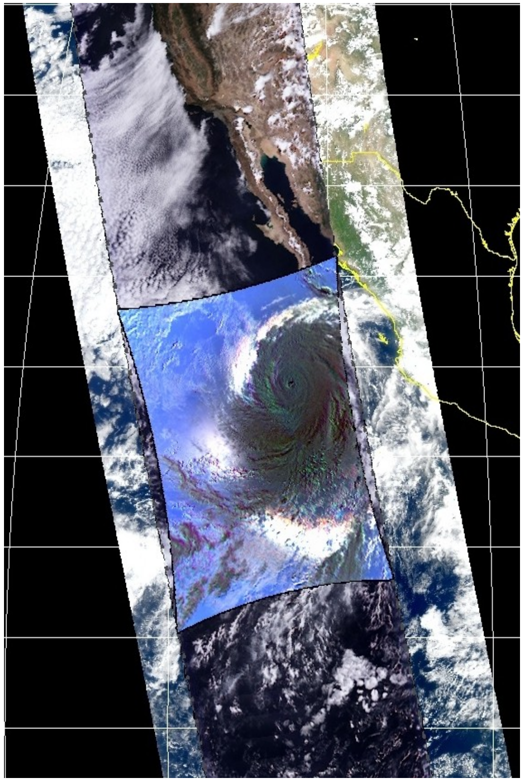


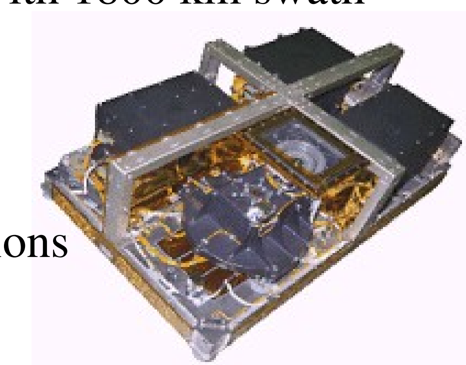
Hurricane Ileana - 23 August 2006

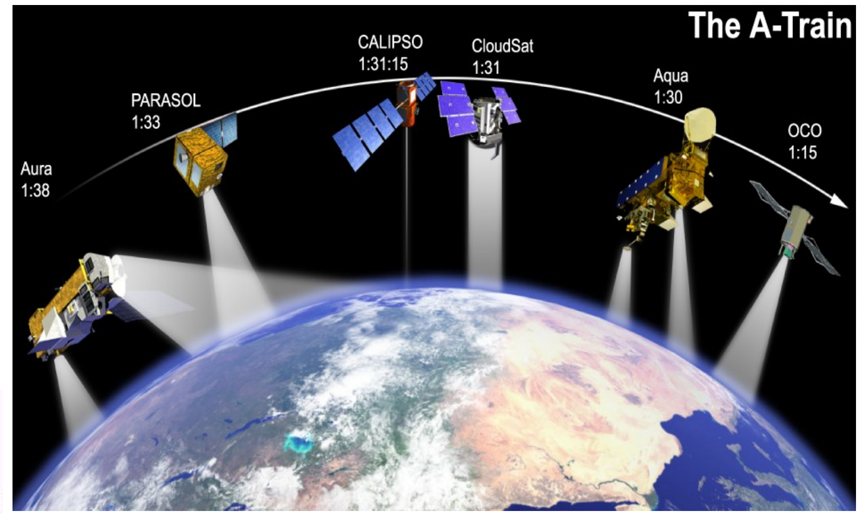
OUTLINE

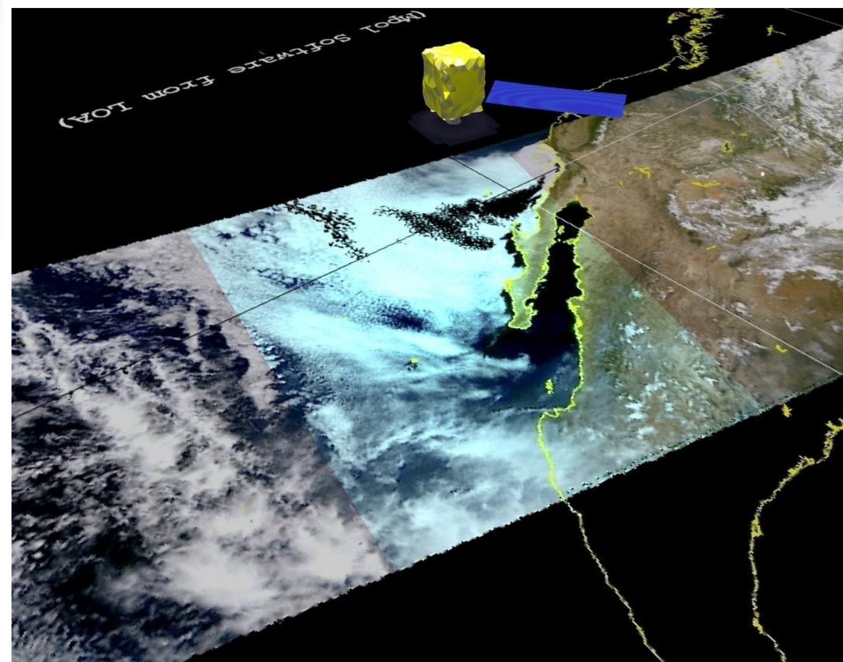
Context
Contribution from POLDER/Parasol
Multi-sensor Analysis
Perspective

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

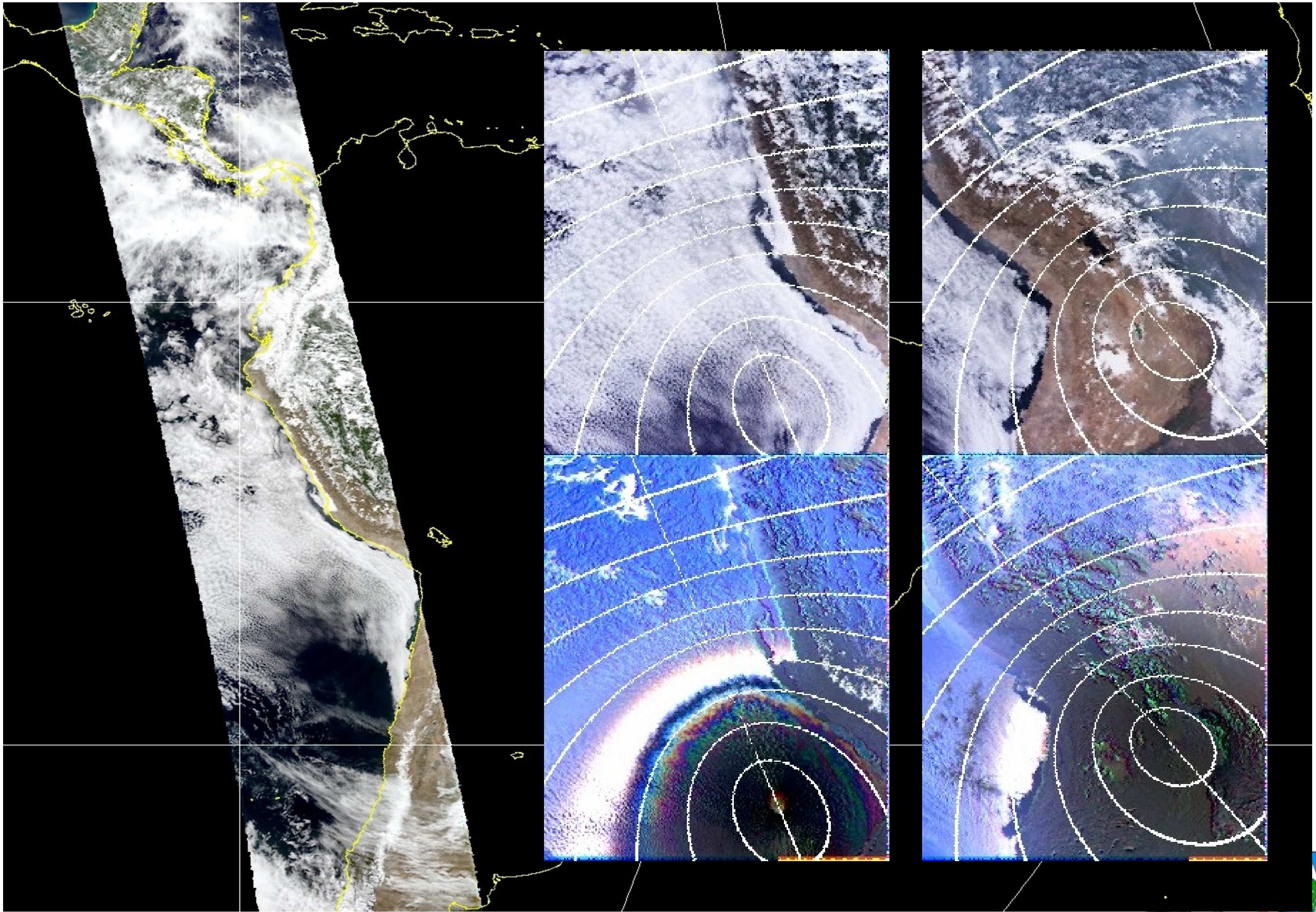






Contribution of POLDER/PARASOL to the A-Train

Almost 2 years of POLDER3/Parasol data already available



POLDER3/Parasol Products availability

Data available since March 2005.

Level1 : calibrated georeferenced data
Level2 : daily products – one file per orbit swath
Level3 : monthly products
Joint Atmosphere product (selected daily and monthly products)

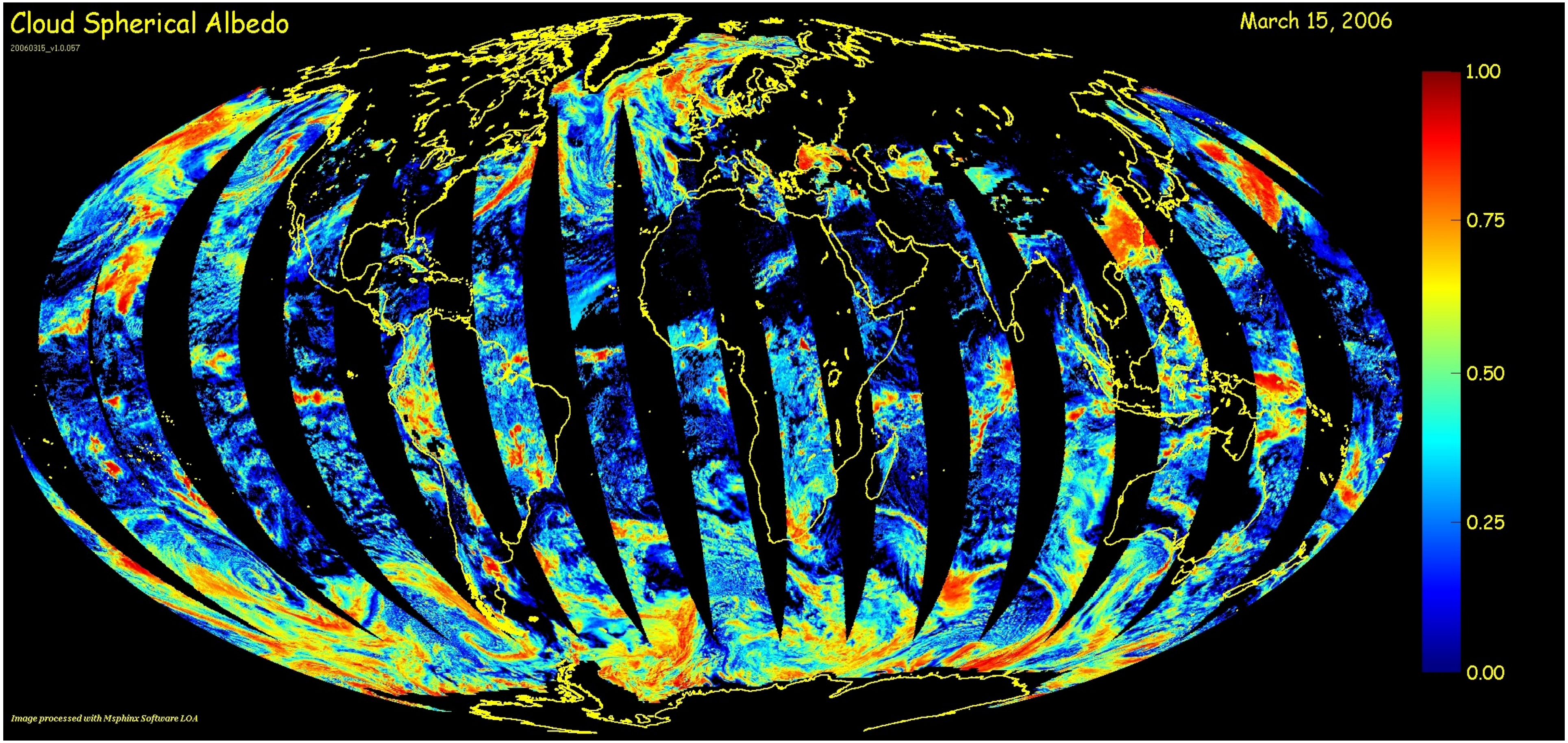
Data processed with collection 2 algorithms (heritage from POLDER1 and POLDER2 mission)

POLDER L1 data and products together with MODIS/Aqua, Caliop, IIR, ... available online from the ICARE data center

http://www.icare.univ-lille1.fr/

Contribution of POLDER/Parasol to the A-Train

Benefits from multiangle observations : Application for clouds



Cloud spherical albedo is retrieved under up to 16 directions

Directional product provided at λ = 670nm (land) and 865 nm (ocean)

Contribution of POLDER/Parasol to the A-Train

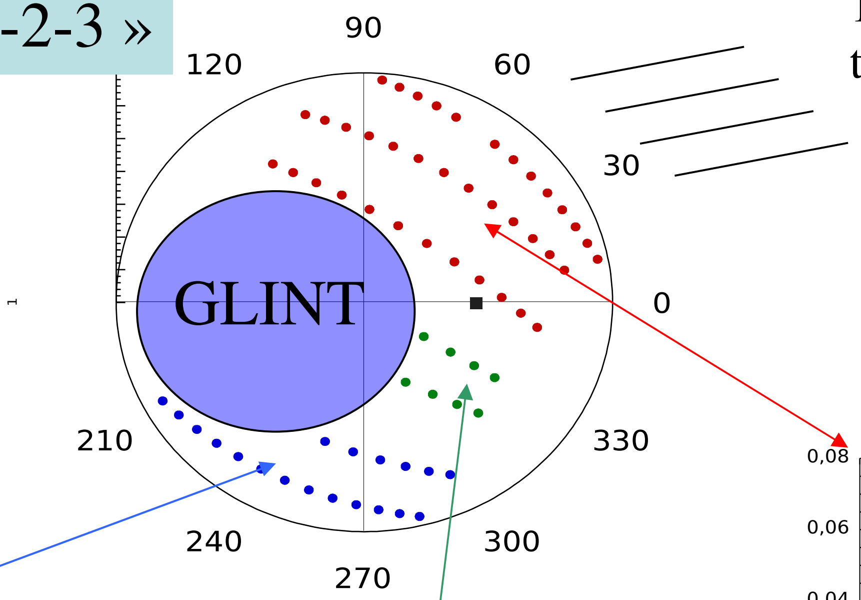
Benefits from multiangle observations : Application for aerosols

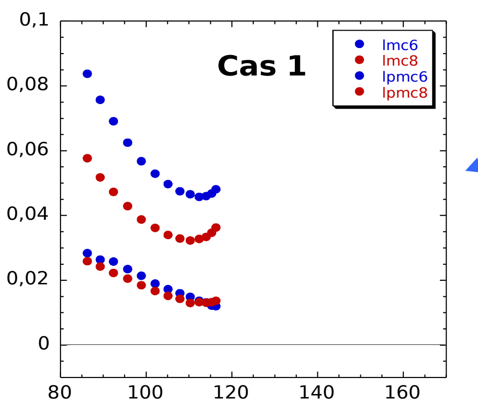
Over Ocean « Cases 1-2-3 »

13 views of the same target

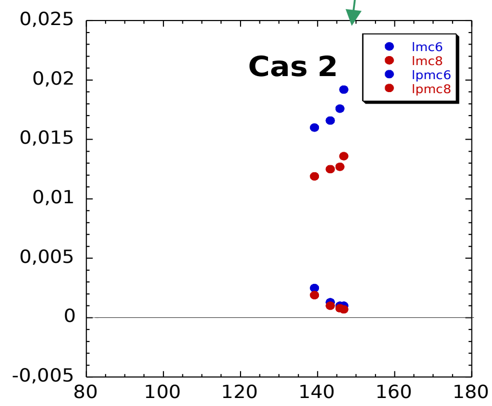
West

East

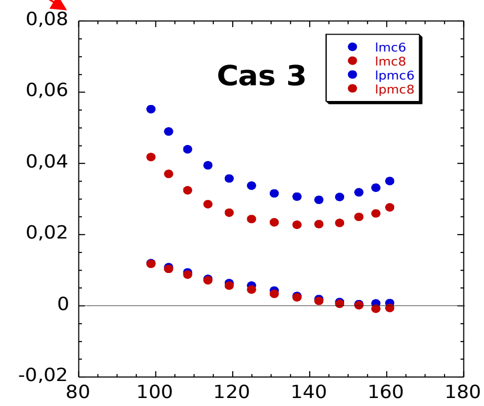




δ, δ_{Acc}, r_{Acc}, m_{Acc}, α



δ, δ_{Acc}, α



δ, δ_{Acc}, r_{Acc}, m_{Acc}, m_{coarse}, α

$NSI = \delta_{ns}/(\delta_{cs}+\delta_{cns})$

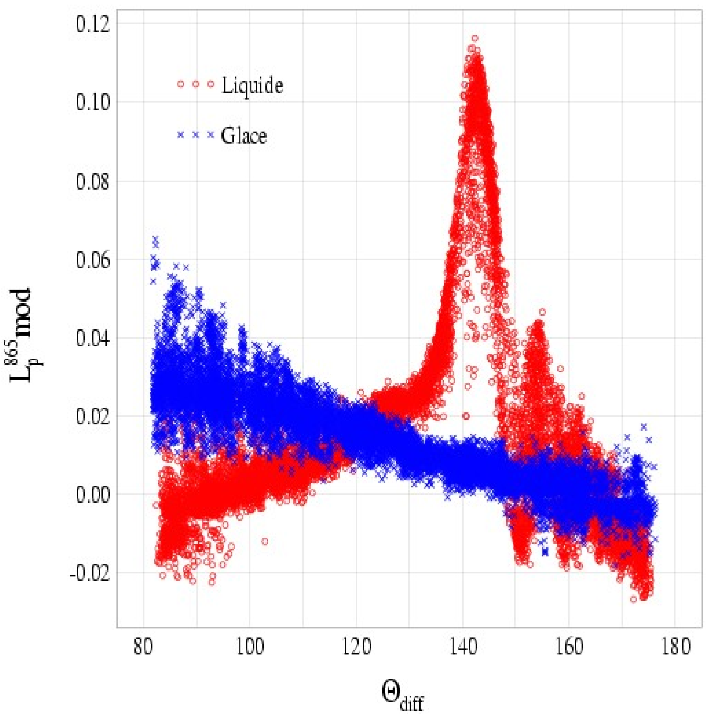
(Herman et al., J.G.R. 2005)

USTL

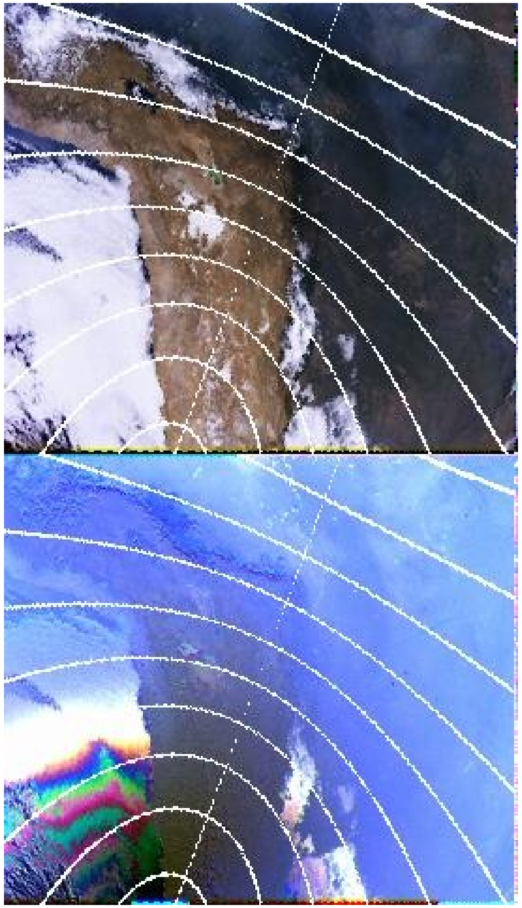
Contribution of POLDER/Parasol to the A-Train

Benefits from polarization observations : Application for clouds

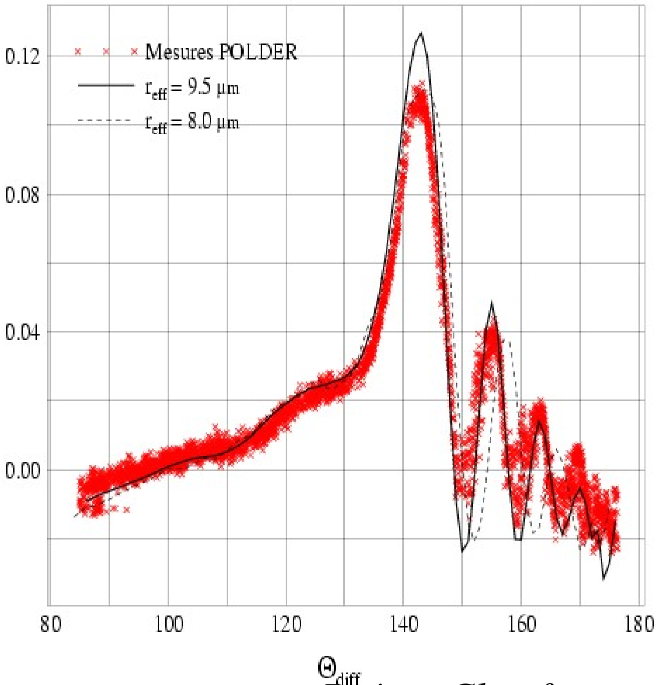
Cloud Phase



Riedi et al



Cloud microphysics

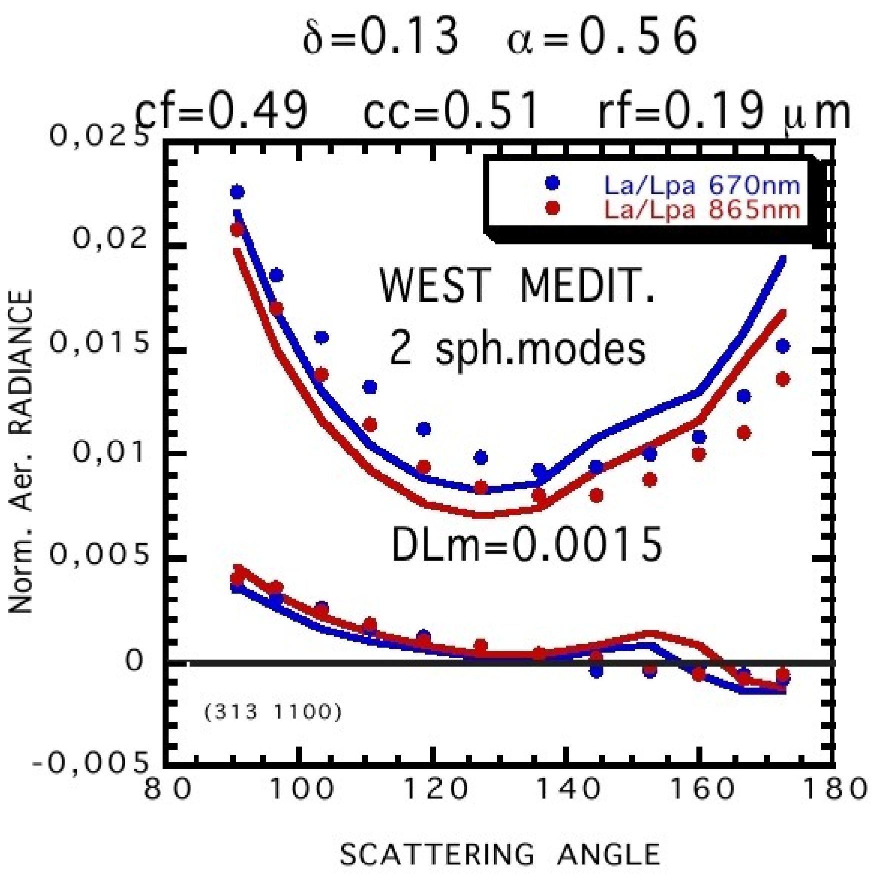


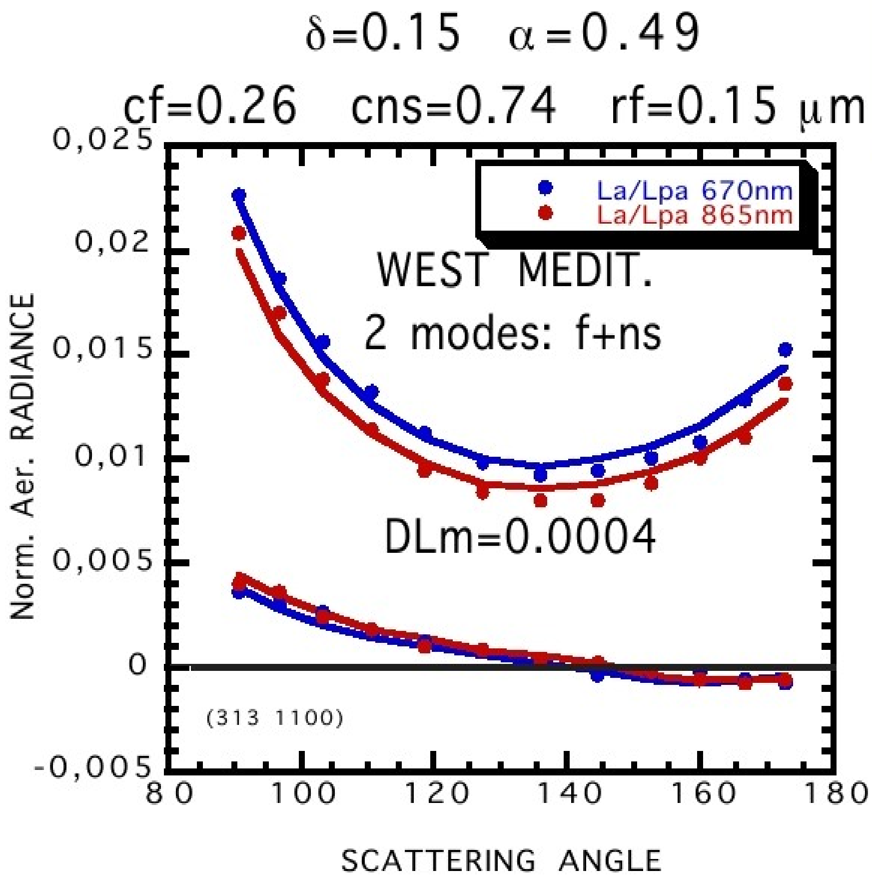
Bréon, Chepfer et al

Contribution of POLDER/Parasol to the A-Train

Benefits from polarization observations : Application for aerosols

Discrimination between spherical and non-spherical aerosols

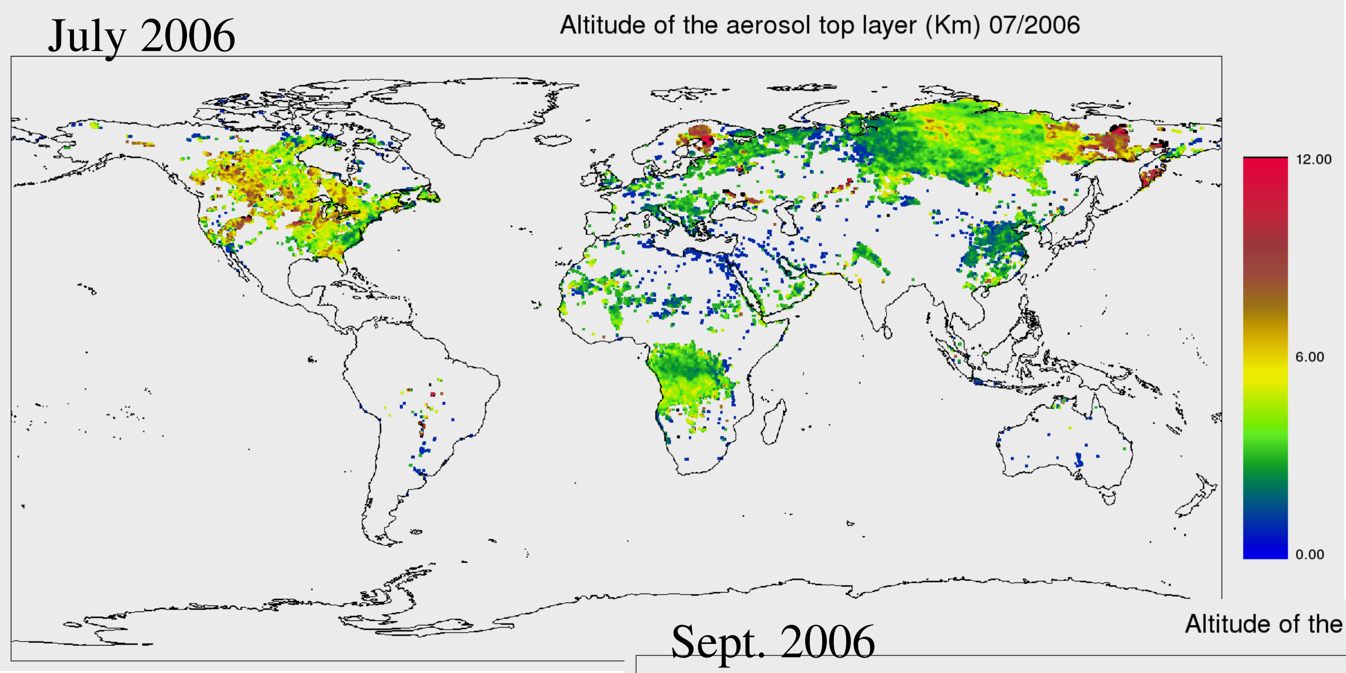




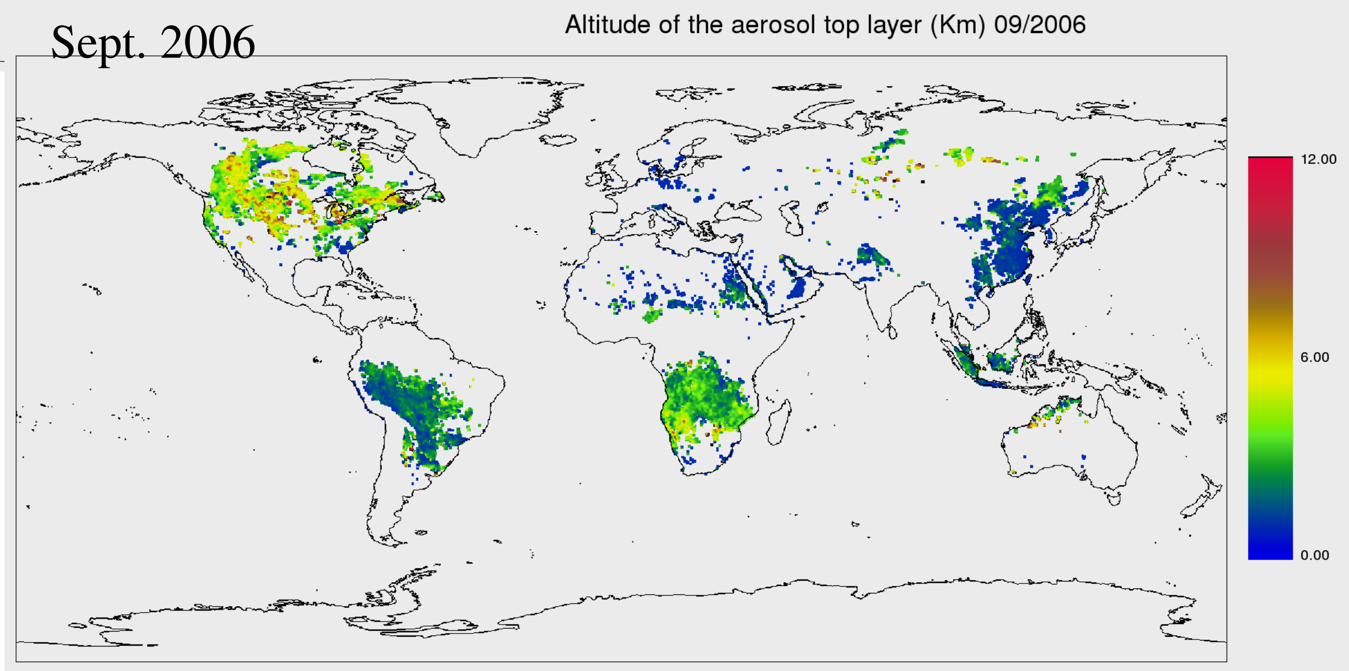
Deuzé, Herman et al

LEVEL 3

July 2006



Sept. 2006



Altitude of the aerosol top layer from PARASOL

(Derived for $\tau_{490} > 0.5$)

Gérard, Deuzé, Herman et al

Potential Synergy for Clouds

Cloud detection

Cloud detection can be tricky under many circumstances (heavy aerosol loading, glint, bright surfaces : desert, snow/ice)

Cloud layers height

Deriving multiple cloud top pressure (O2, Rayleigh, CO2 slicing, H20) to detect multilayer clouds and better describe vertical structure

Cloud thermodynamic phase

Combination of information on particle shape and absorption properties help

Improved cloud retrievals

ex : Using Size retrieval from MODIS to improve multidirectionnal OT retrievals from POLDER

Cloud Heterogeneities

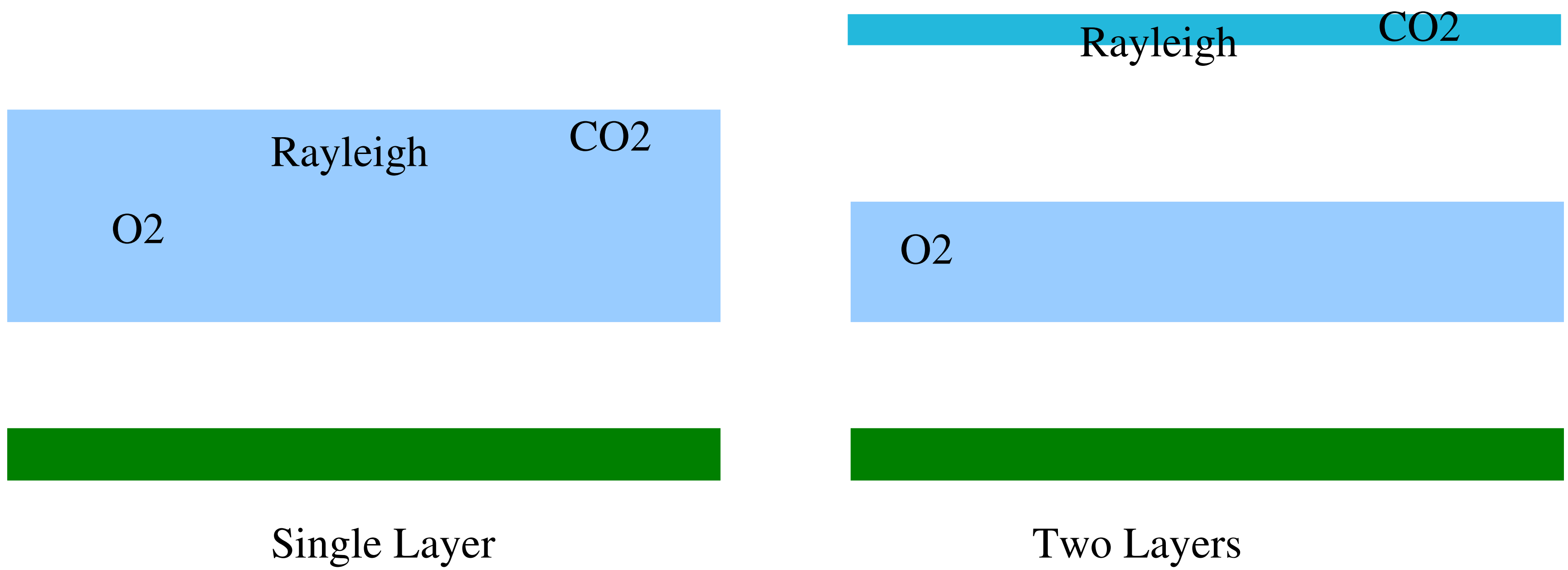
Using MODIS 250m information to understand angular behavior in POLDER measurements and separate 3D effect from subpixel heterogeneities

Cloud layers height

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

Basis

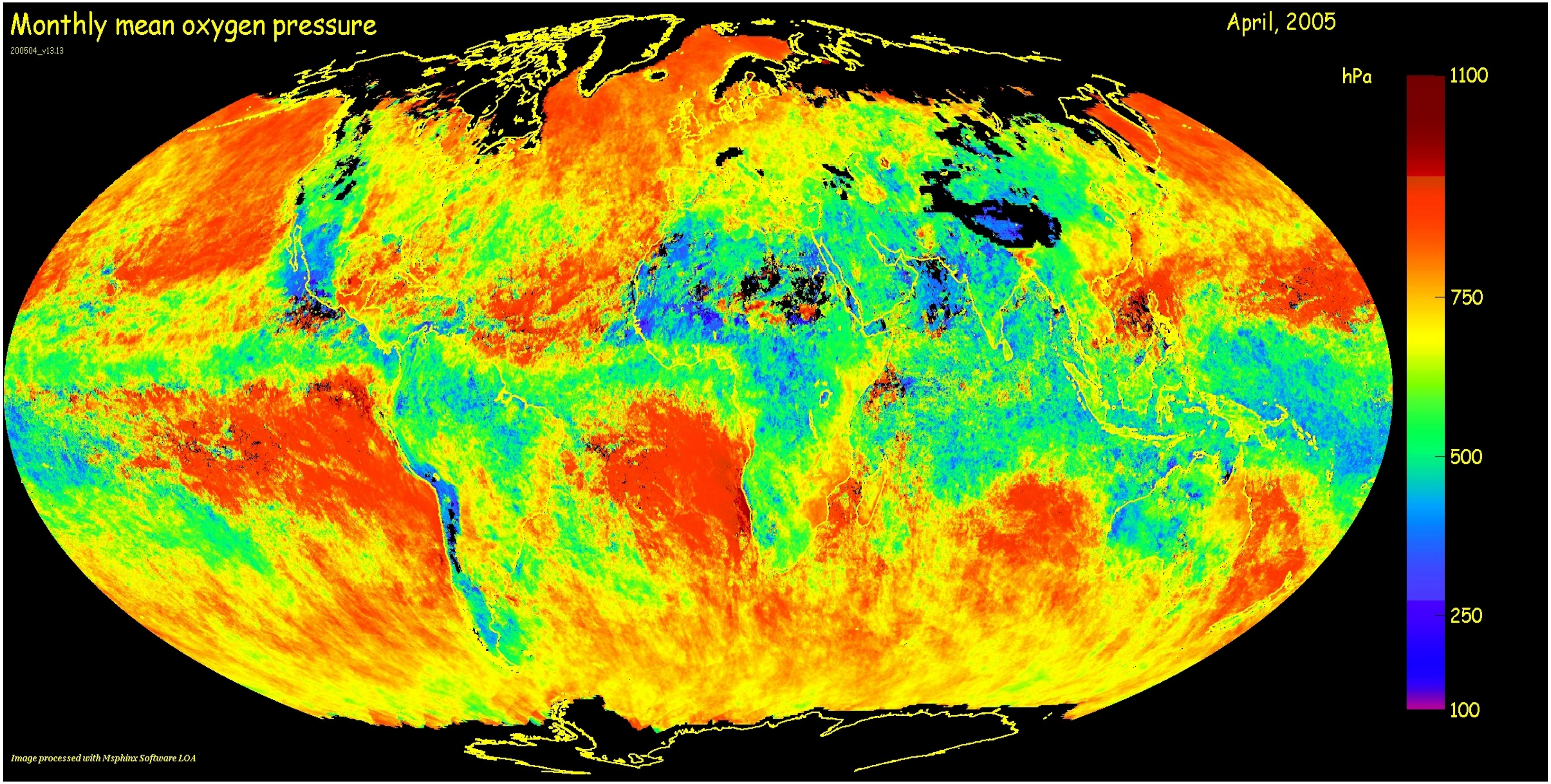
We do expect differences in pressure due to resp. sensitivities and we also expect increasing differences in case of multilayer situations



O_2 : Oxygen band differential absorption (*Vanbauce et al*)
Rayleigh : Polarization Rayleigh Scattering absorption
CO_2 : CO_2 Slicing (IR)

Cloud layers height

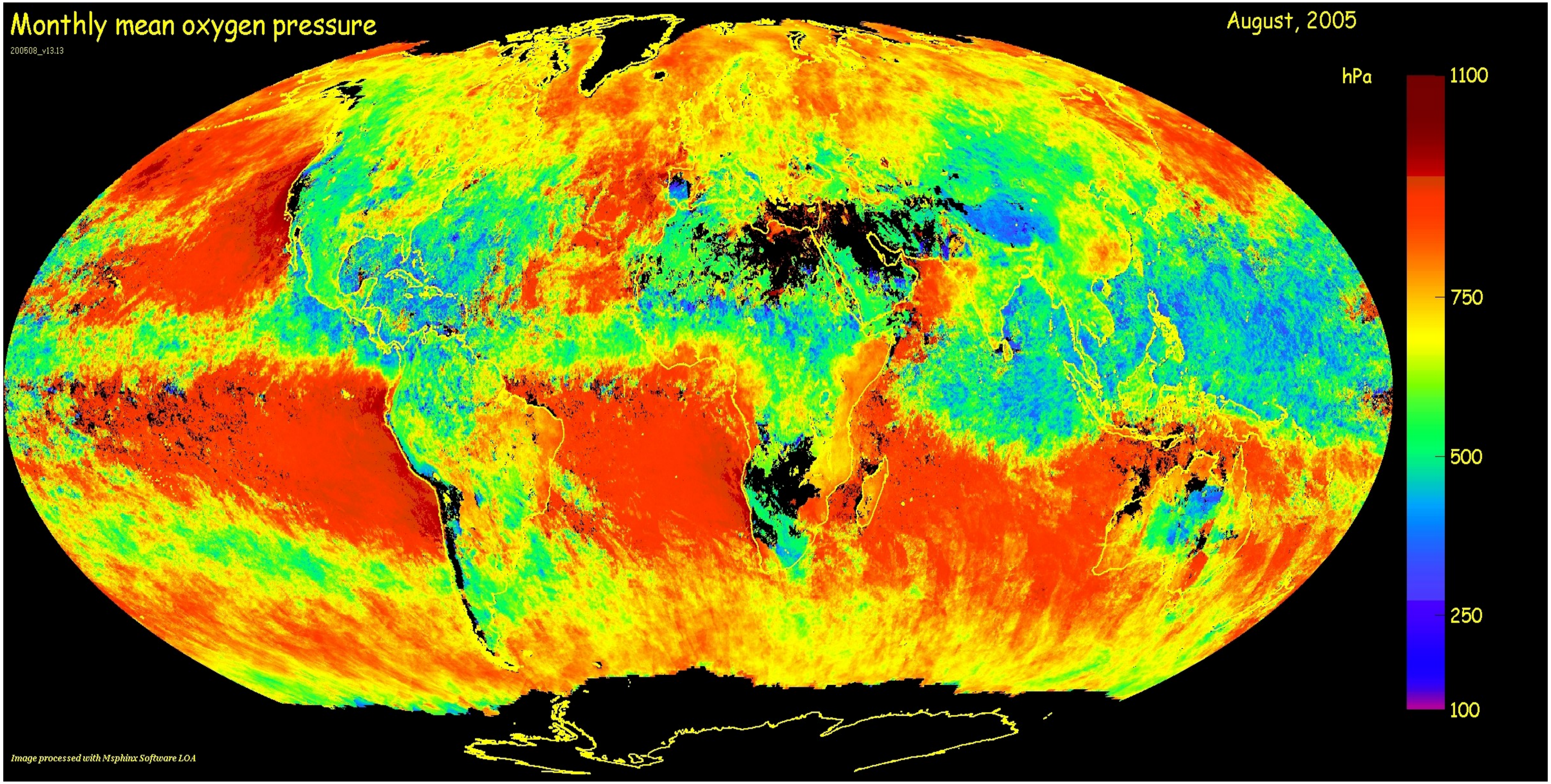
Cloud Top Pressure retrieval from O2



(*Vanbauce et al*)

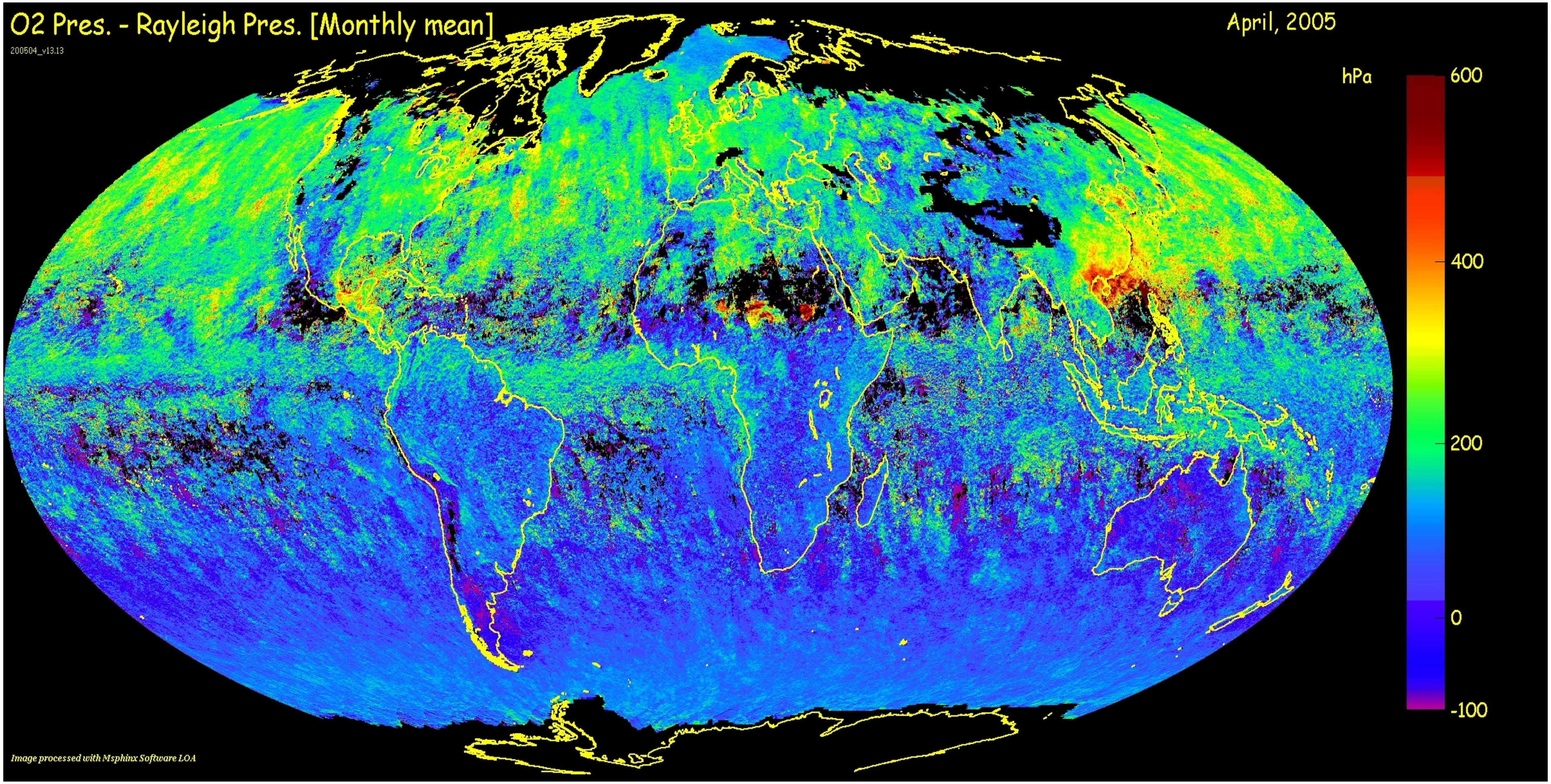
Cloud layers height

Cloud Top Pressure retrieval from O2



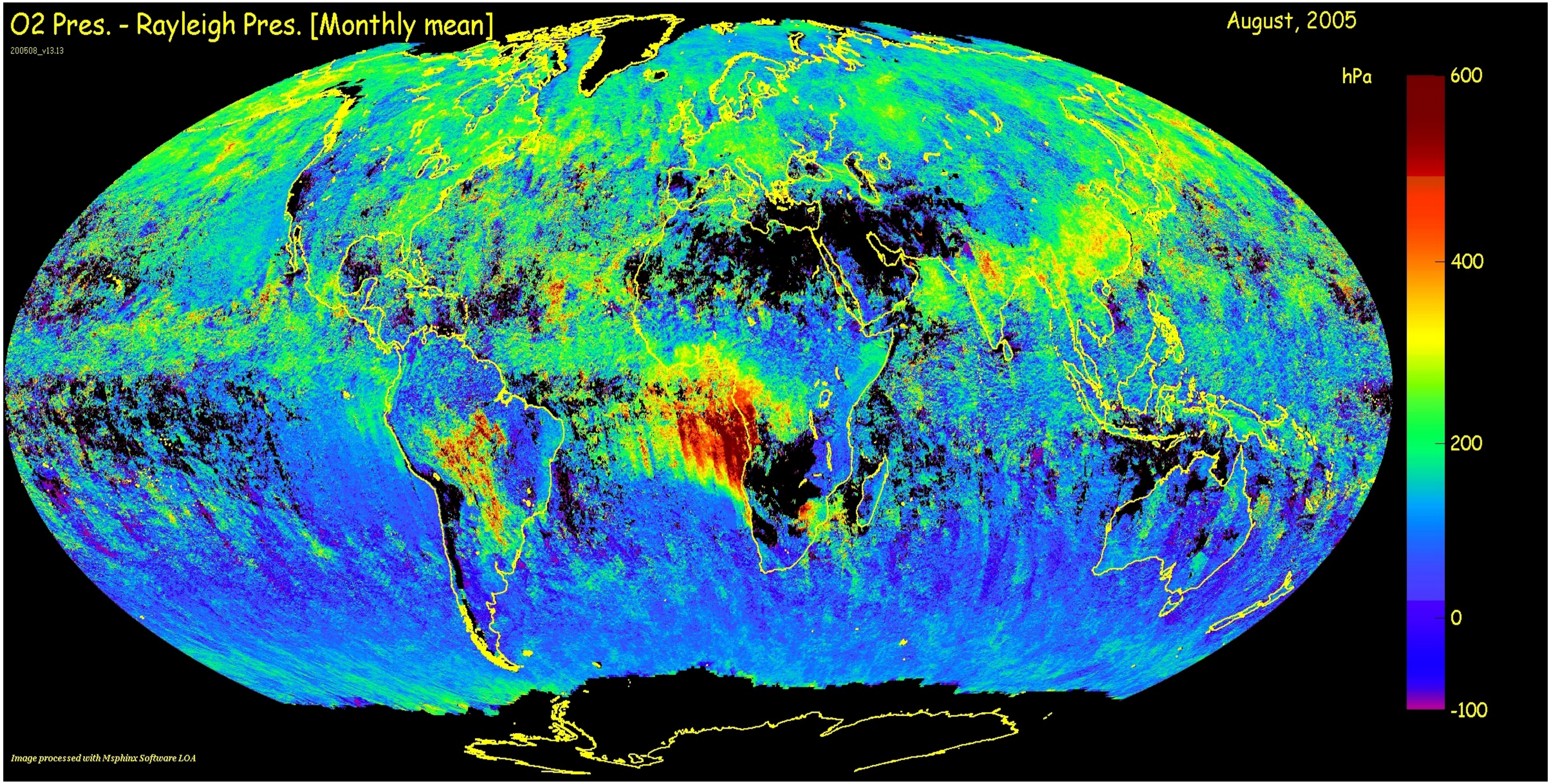
Cloud layers height

Difference in Cloud Top Pressure retrieval from O2 and Rayleigh Scattering.



Cloud layers height

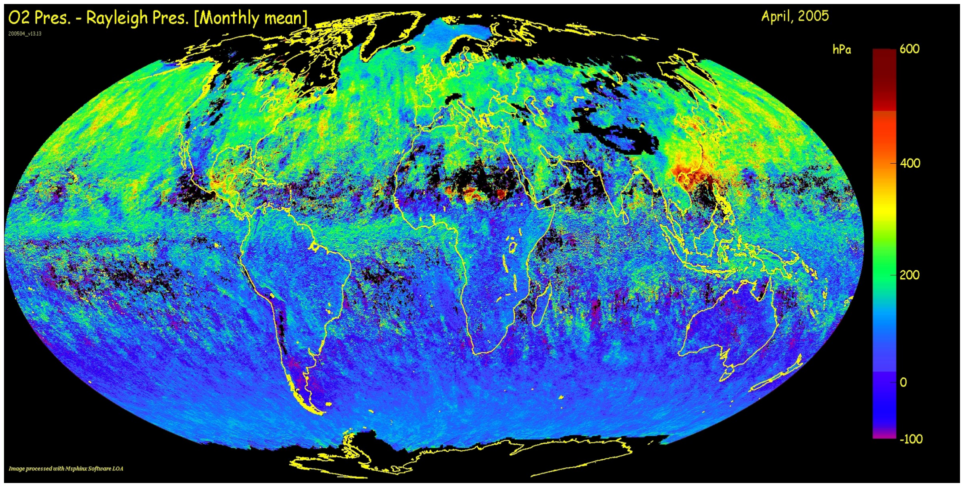
Difference in Cloud Top Pressure retrieval from O2 and Rayleigh Scattering.



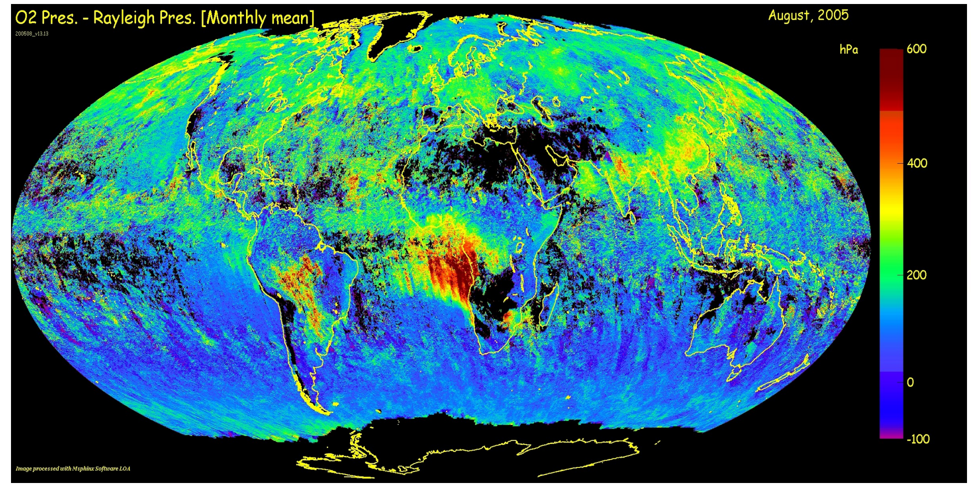
Cloud layers height

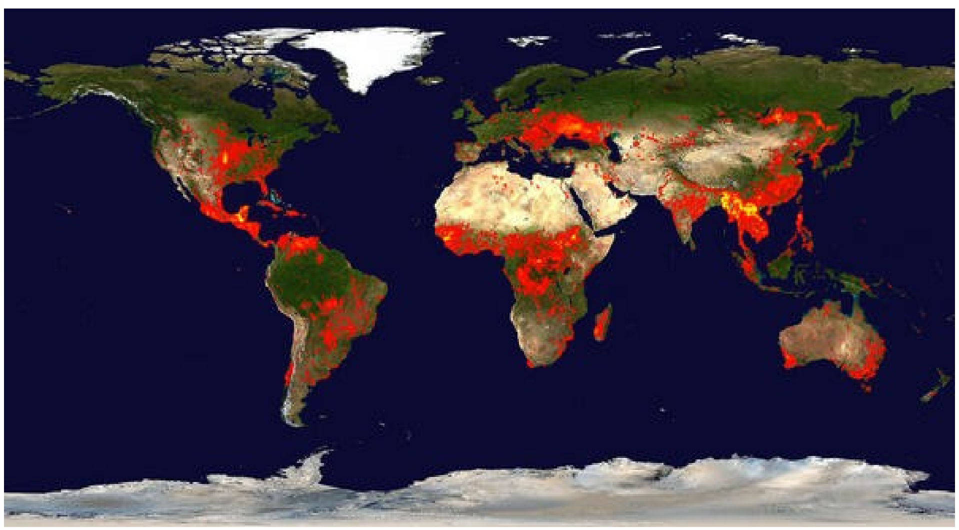
Difference in Cloud Top Pressure retrieval from O2 and Rayleigh Scattering.

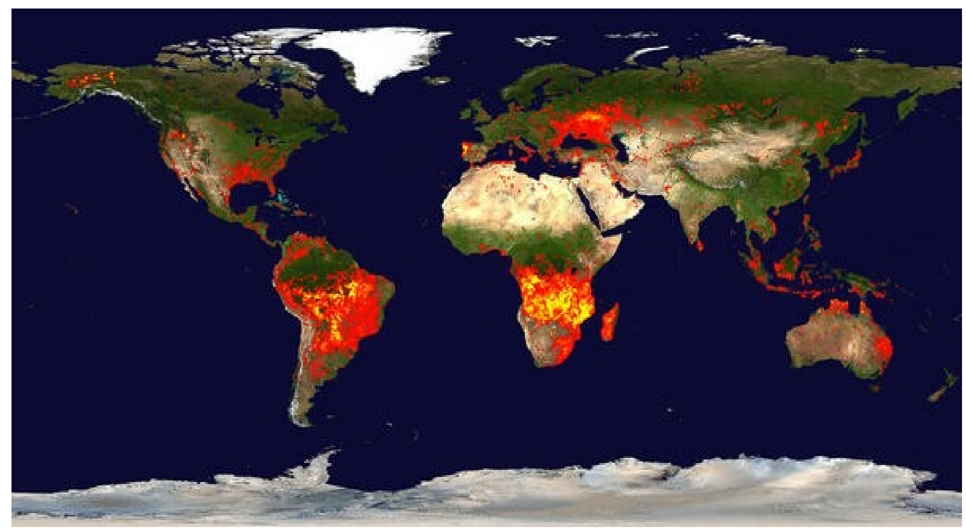
April



August

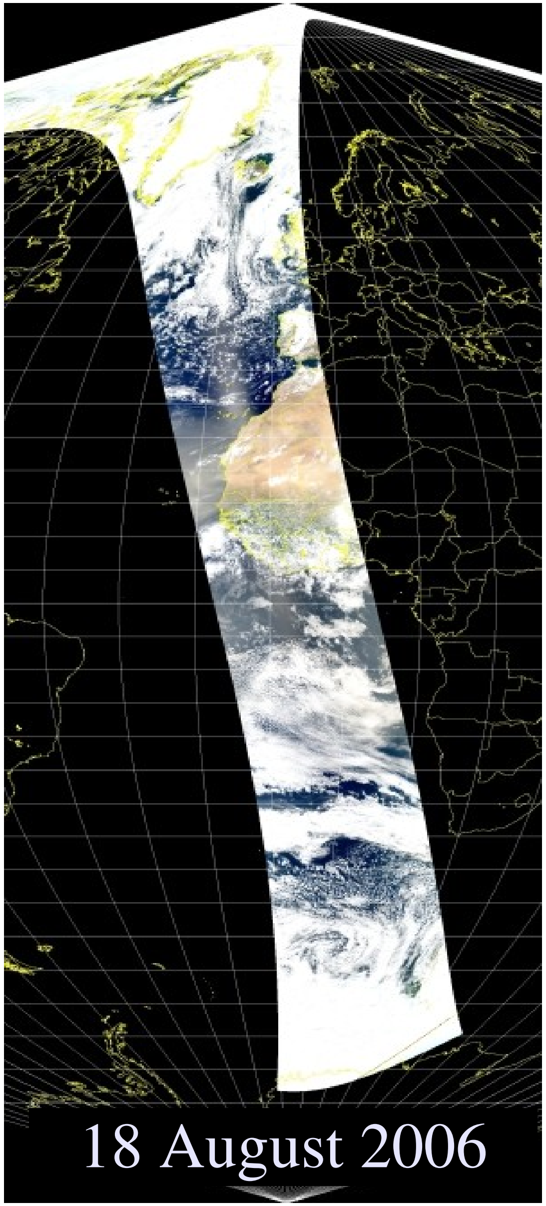


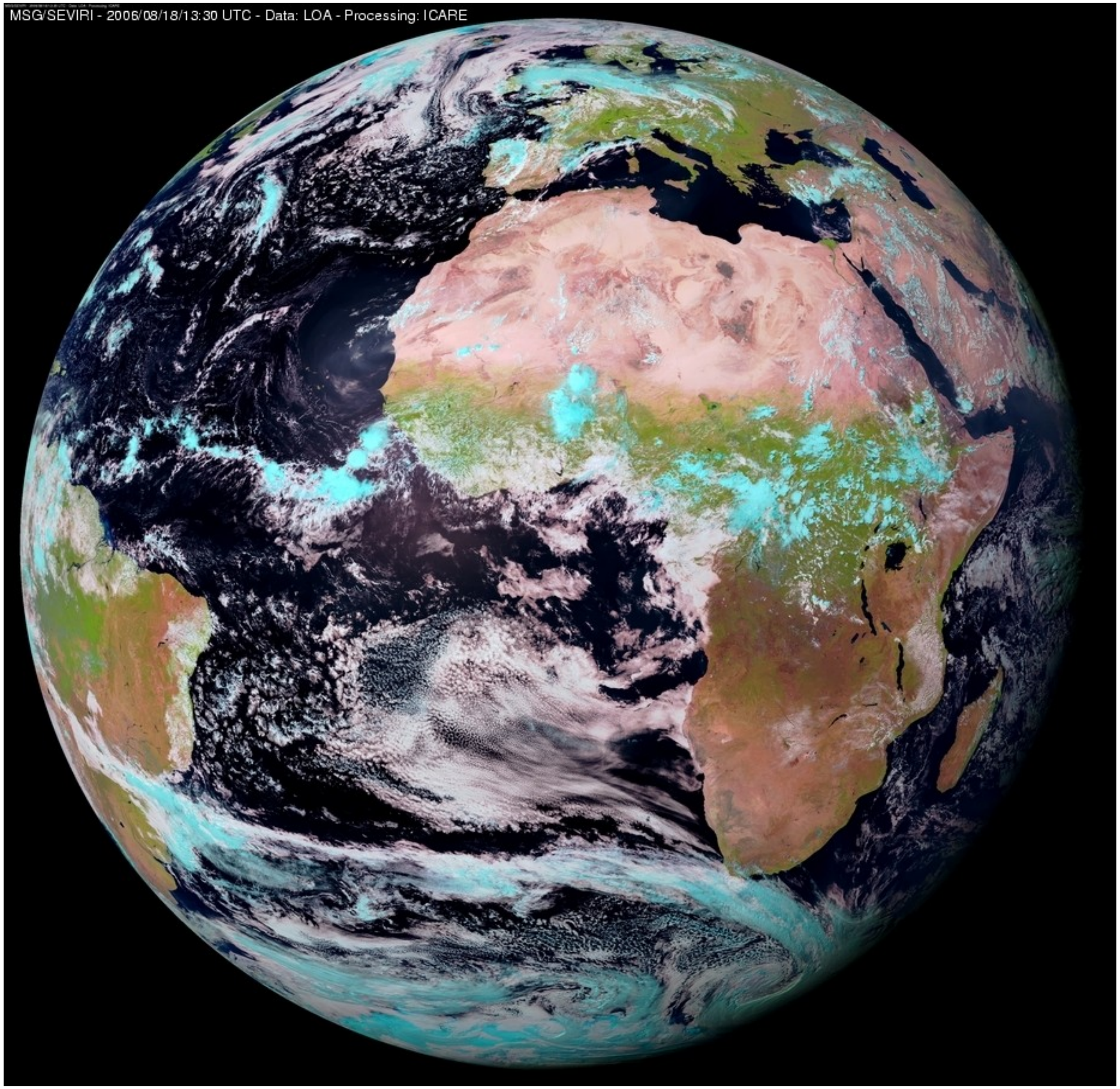




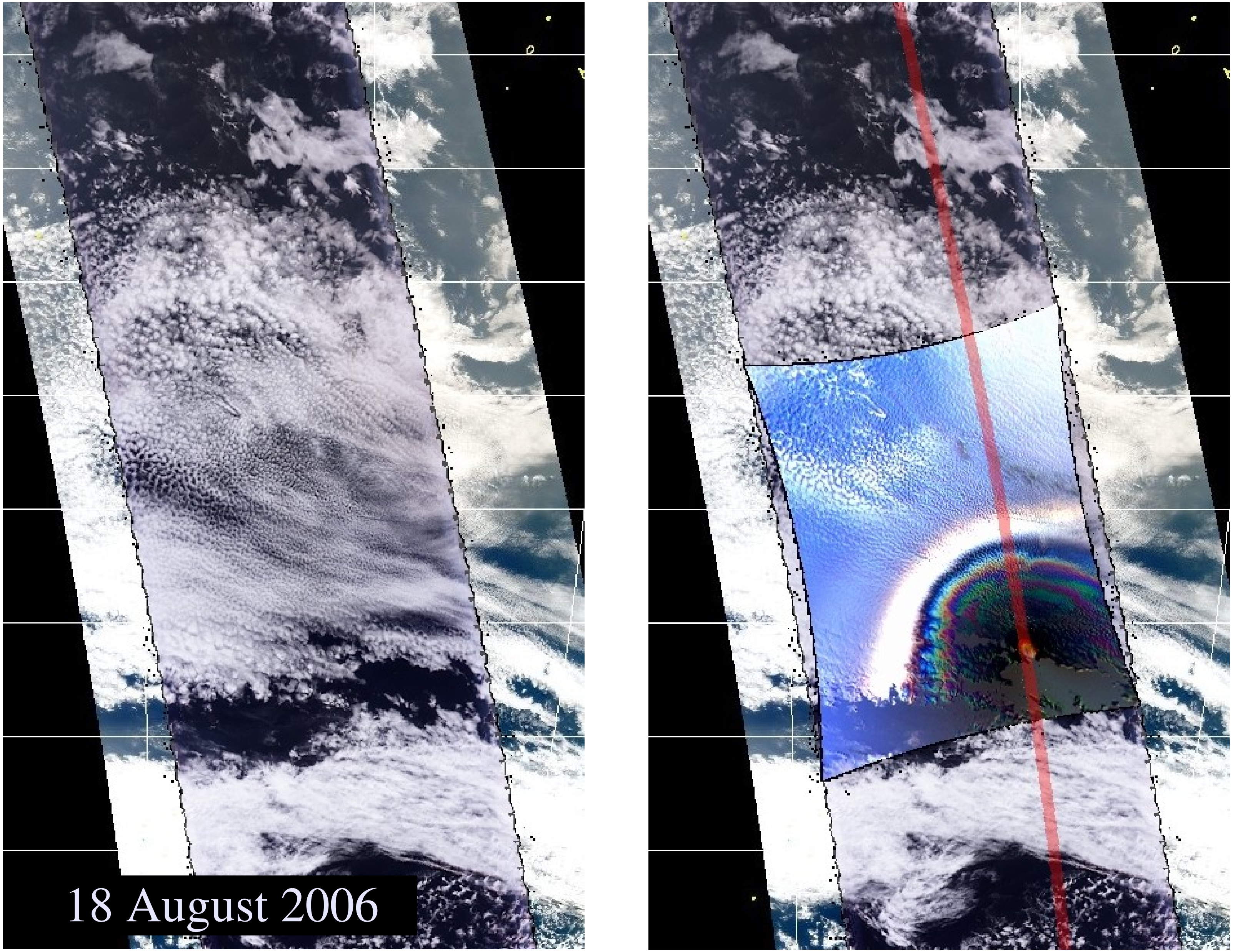
Active fire detection (Rapid Response System)

Aerosols over clouds : a case study

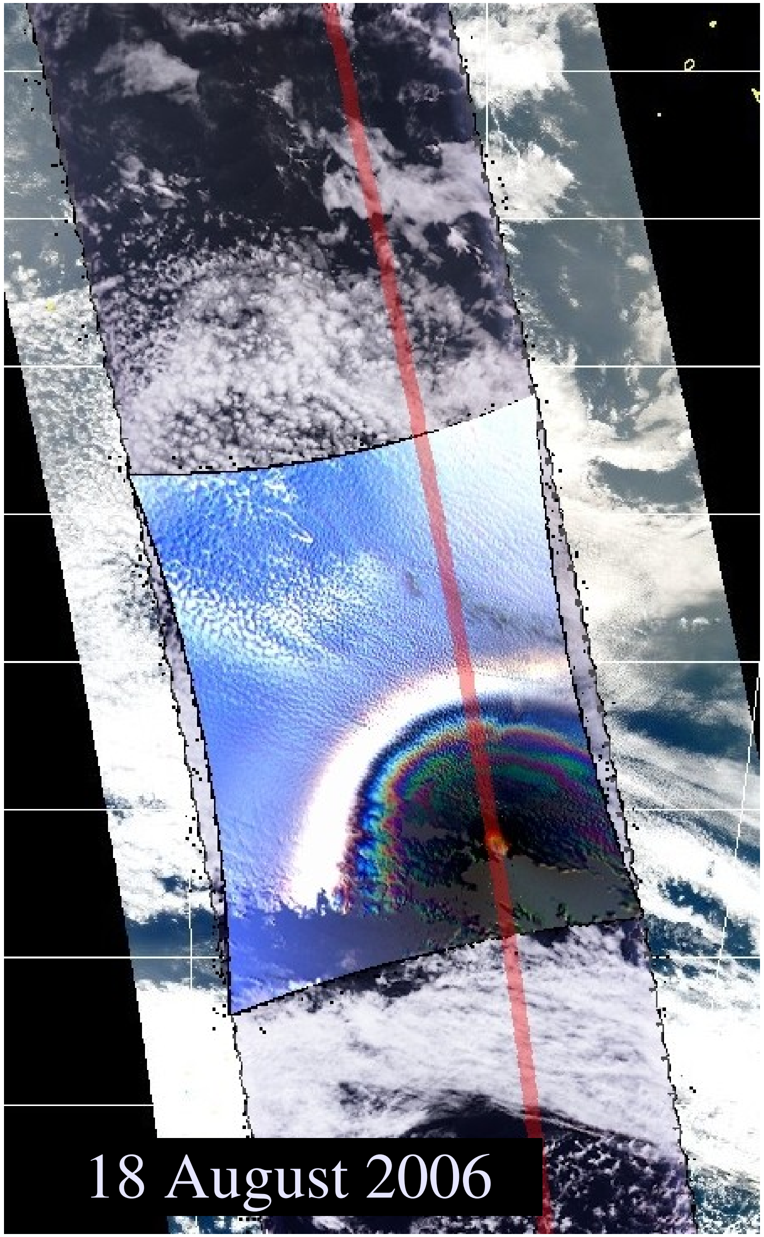


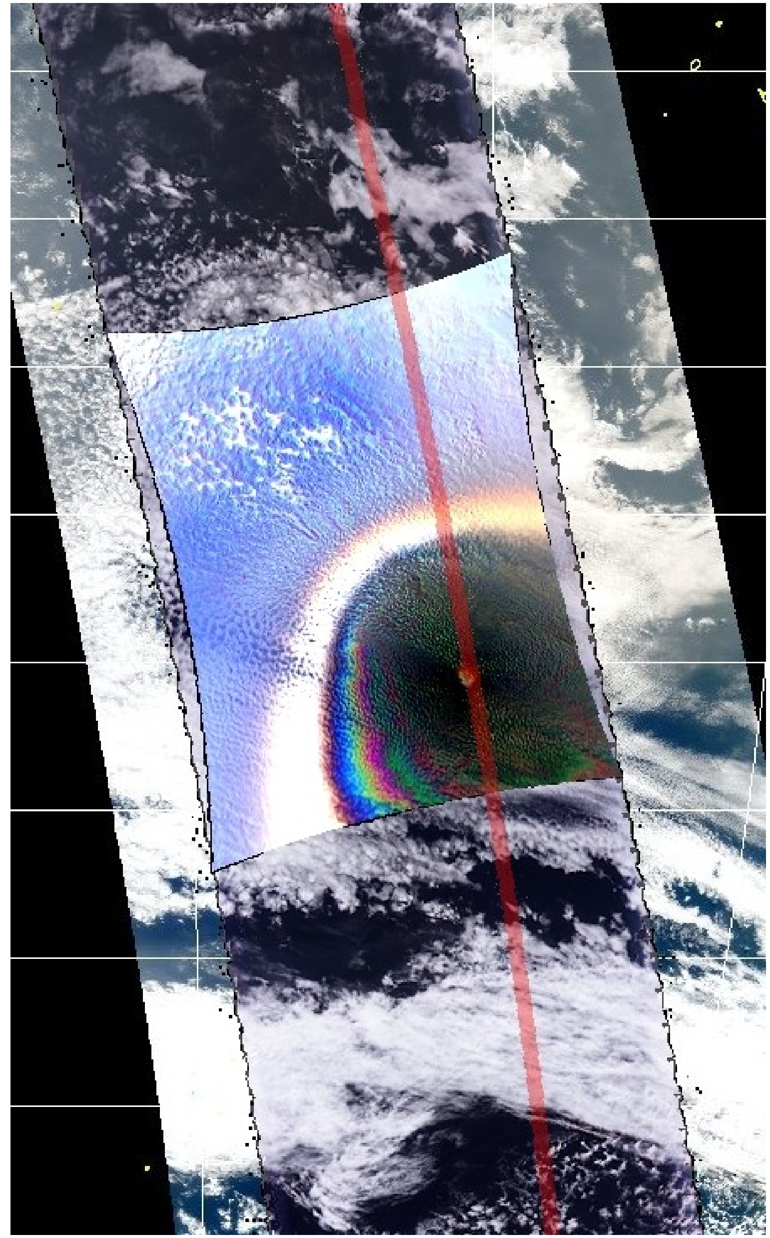


Aerosols over clouds : a case study

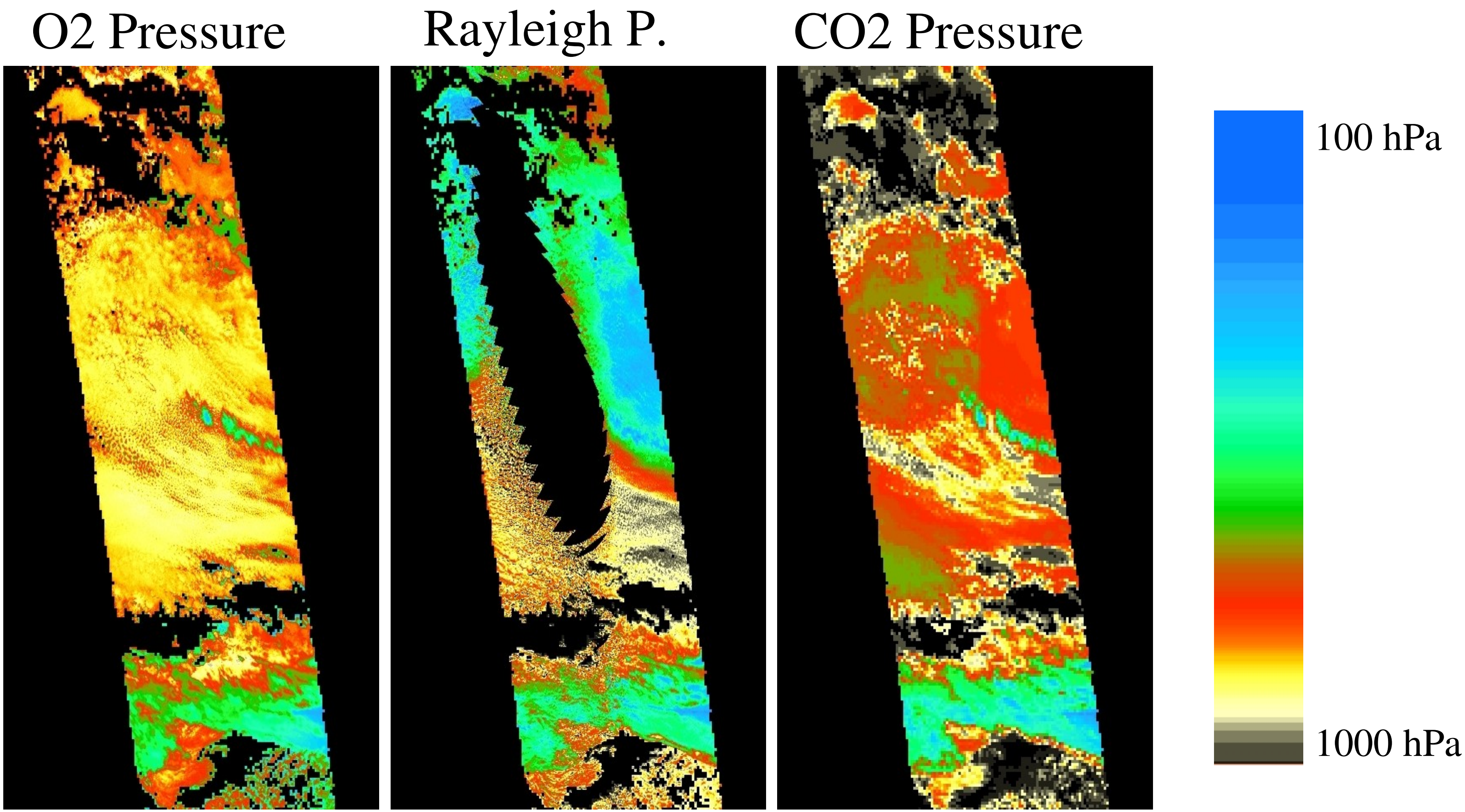


Aerosols over clouds : a case study





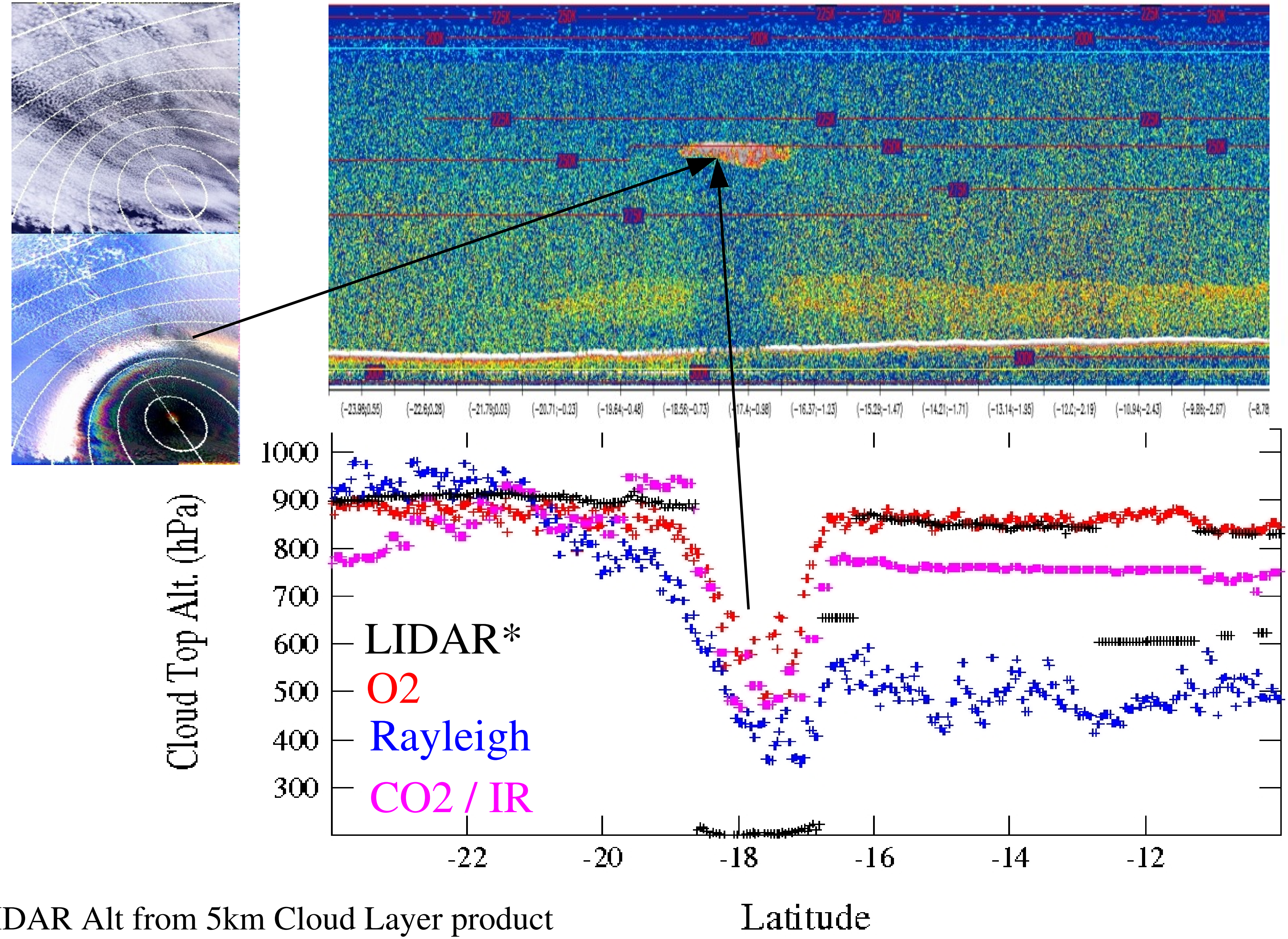
Example : aerosols over cloud



Usually with single layer : O2 > Rayleigh > CO2 with small differences

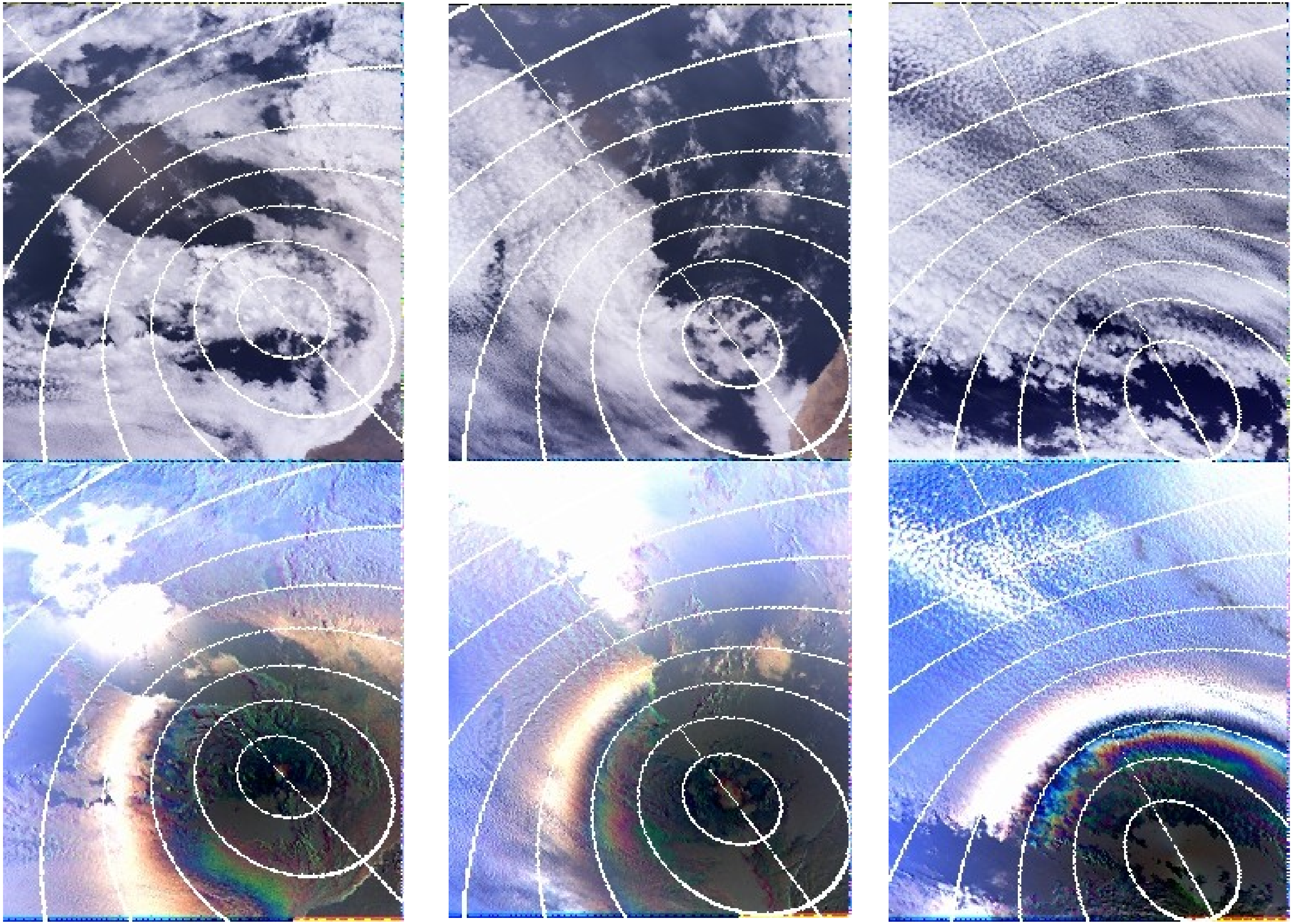
And here we have : O2 > CO2 >> Rayleigh due to presence of aerosol in the upper layer

Example : aerosols over cloud



*LIDAR Alt from 5km Cloud Layer product

Example : aerosols over cloud



Polluted Polluted Clean

Cloud thermodynamic phase

Combination of information on particle shape and absorption properties

Basis

Polarization

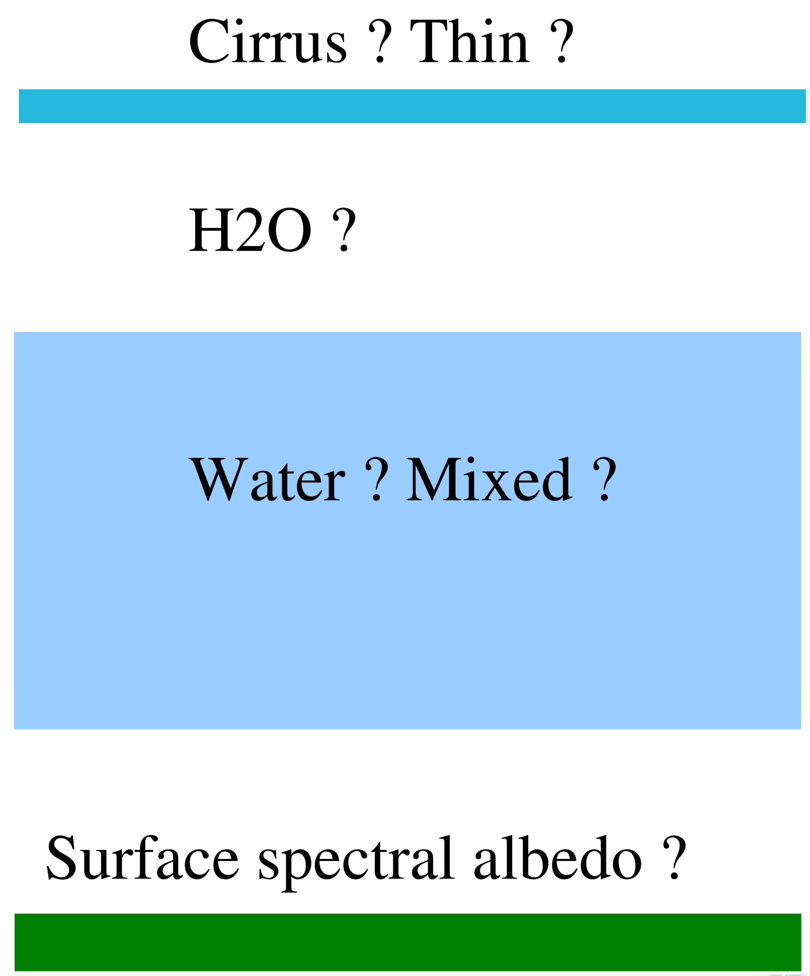
mostly single scattering
sensitive to particle shape
Top of cloud but see through it if very thin

SWIR

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

Thermal IR

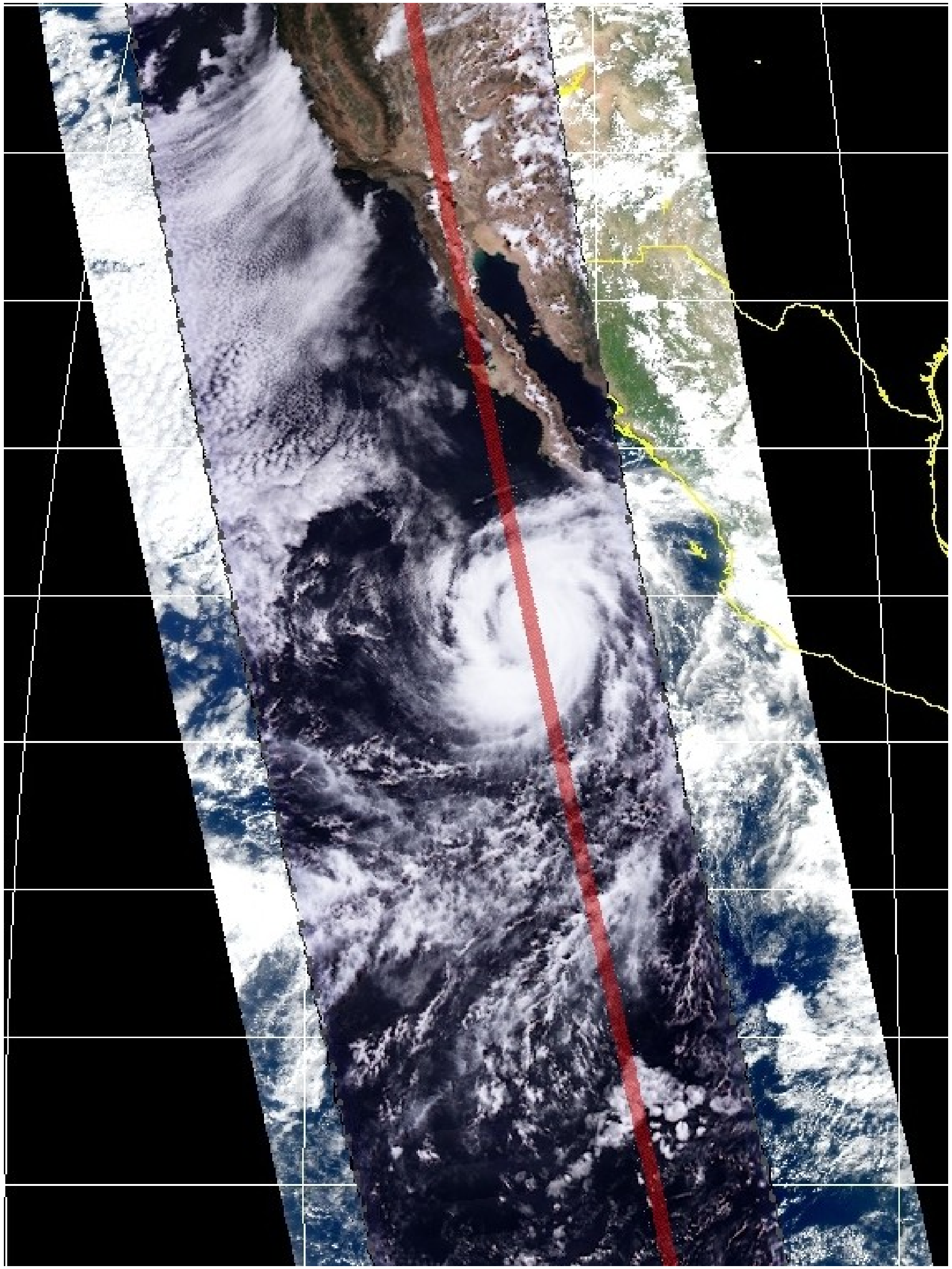
Diff. Water/Ice,
also sensitive to surf. emissivity, H_2O
Some depth in the cloud except thin cirrus



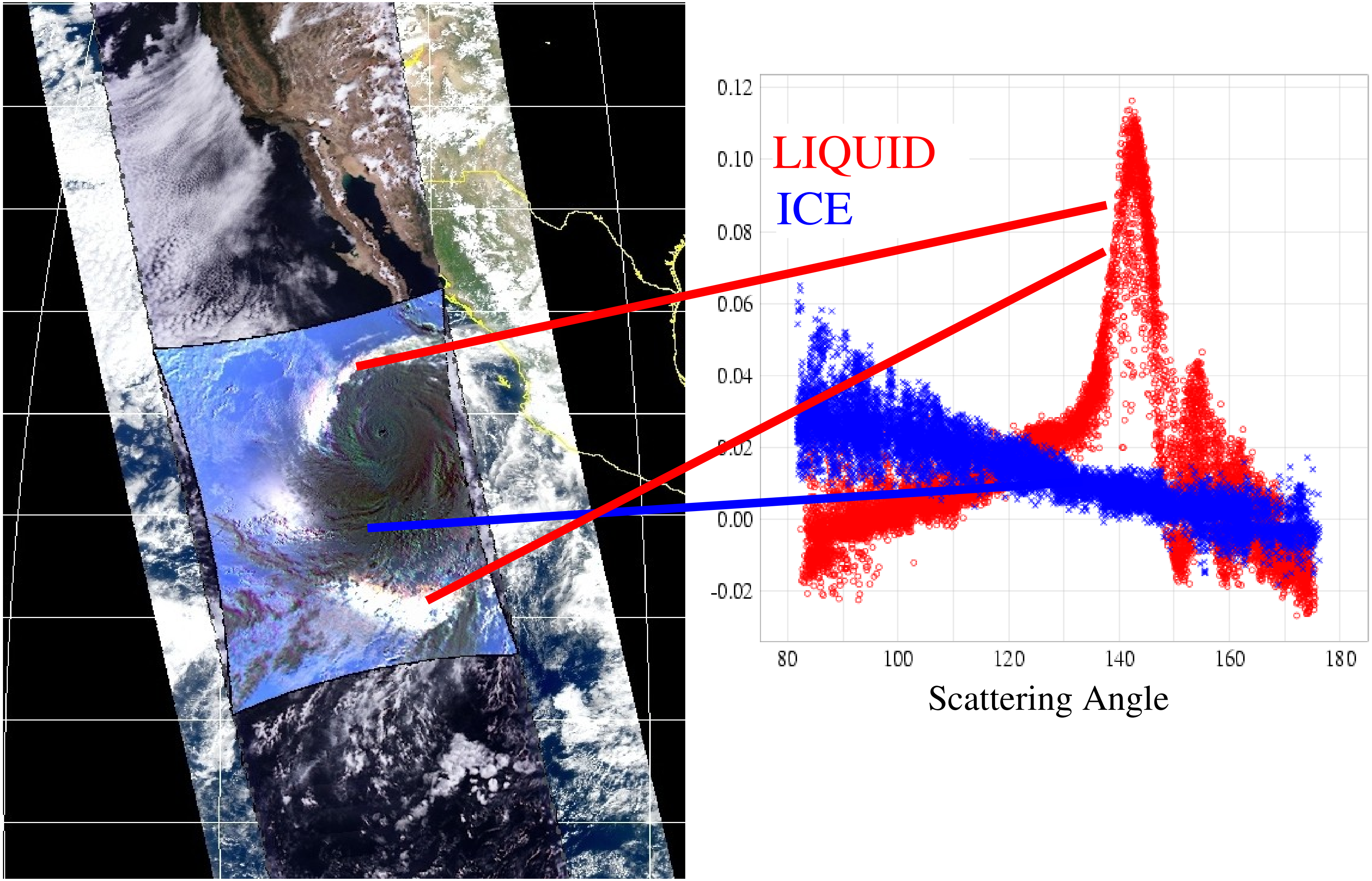
Cloud thermodynamic phase

Case study :

Hurricane Ileana
23 August 2006

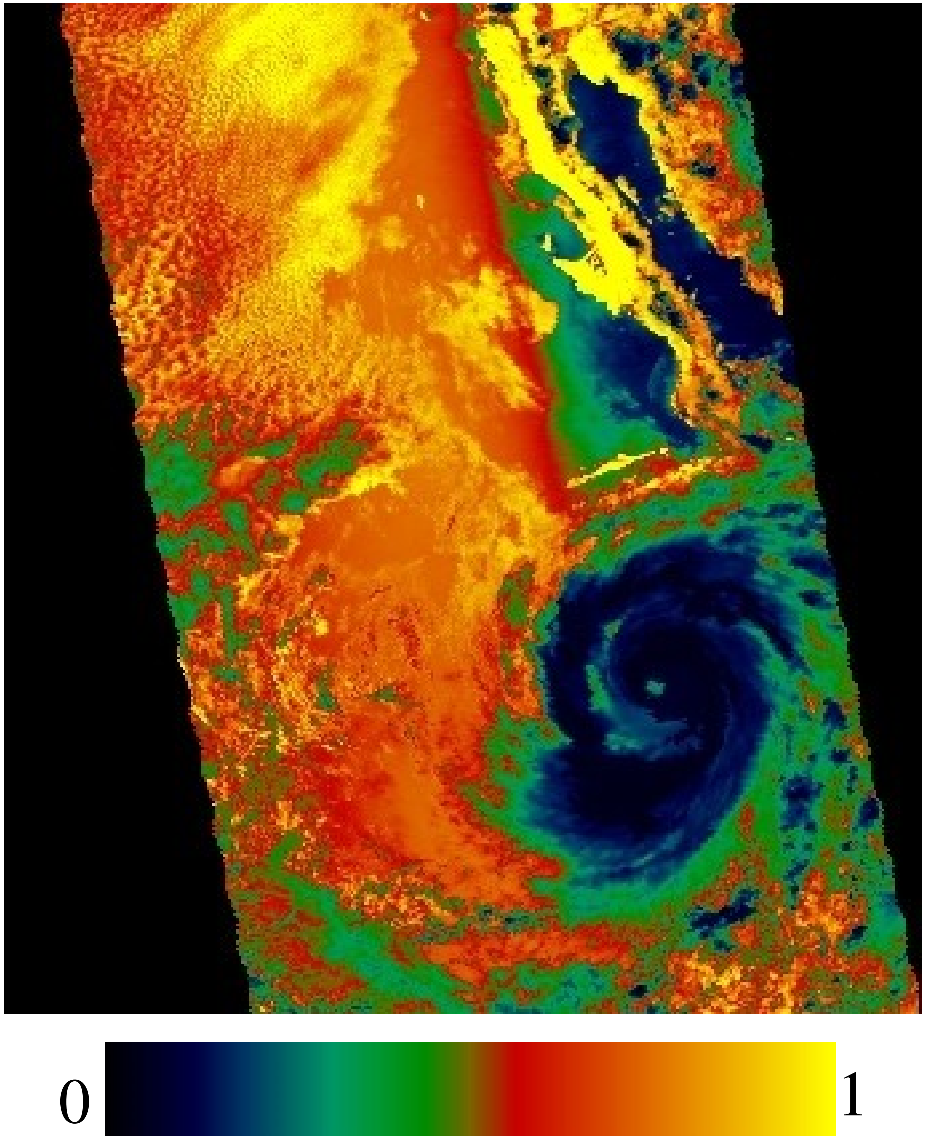


Cloud thermodynamic phase

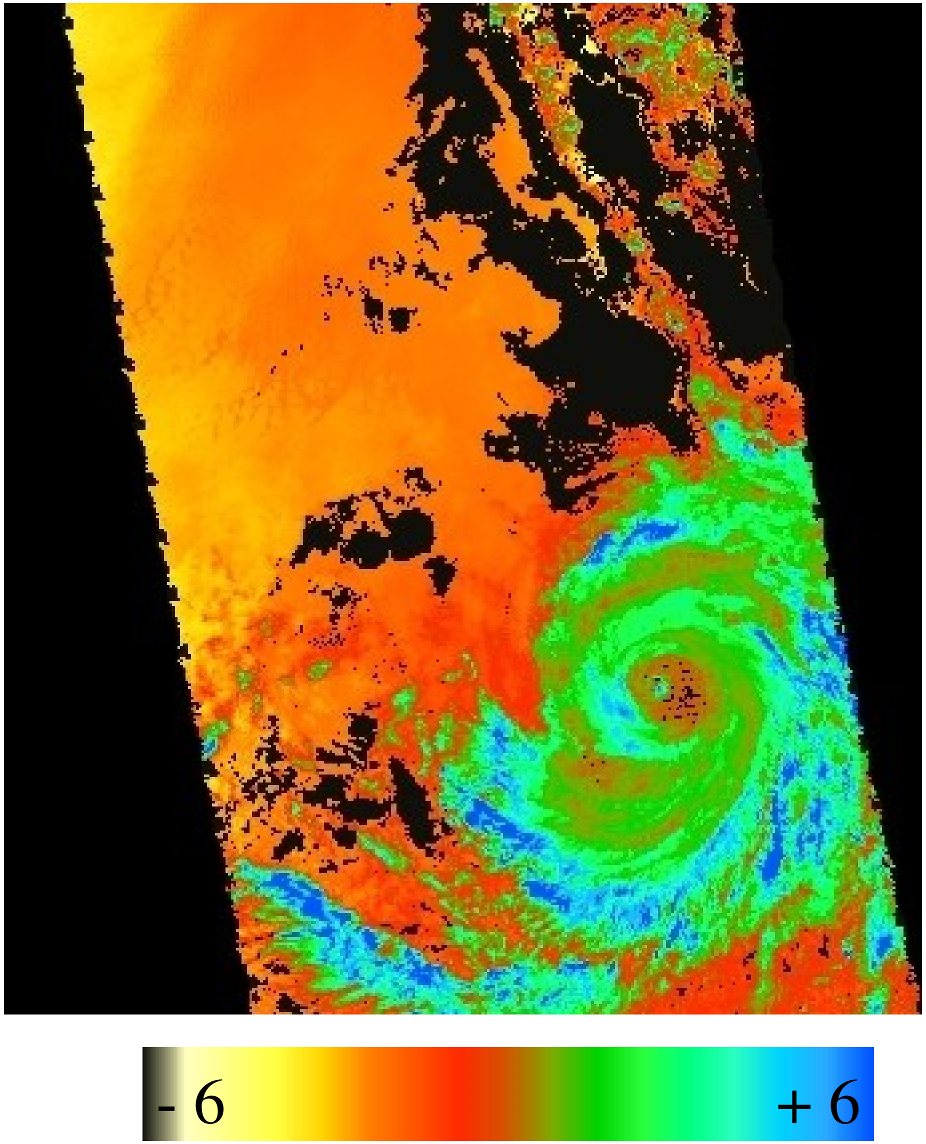


Hurricane Ileana - 23 August 2006

Cloud thermodynamic phase



SWIR over VIS ratio
(MODIS bands 2 and 7)

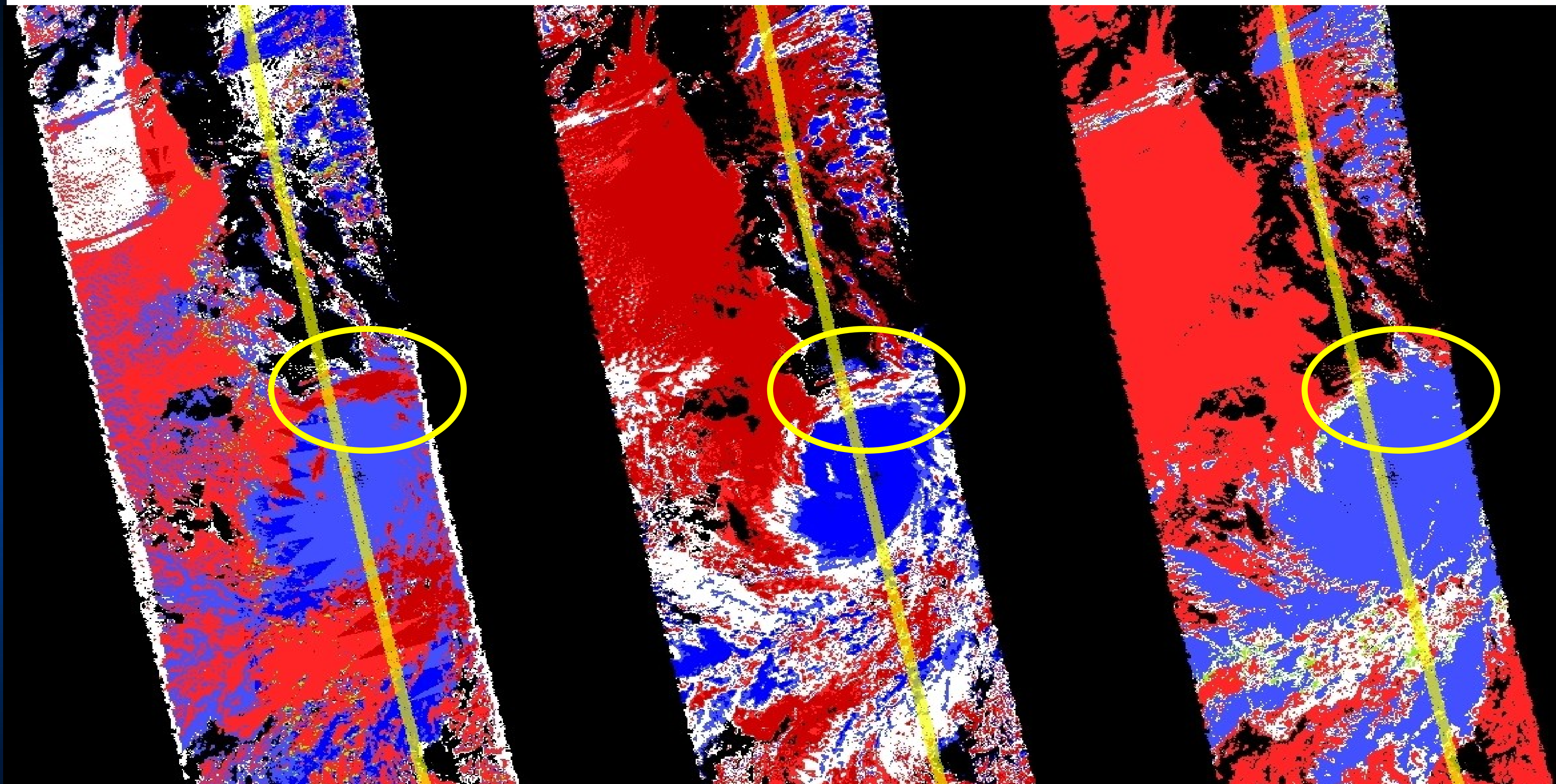


BTD 8 – 11 microns

Cloud thermodynamic phase

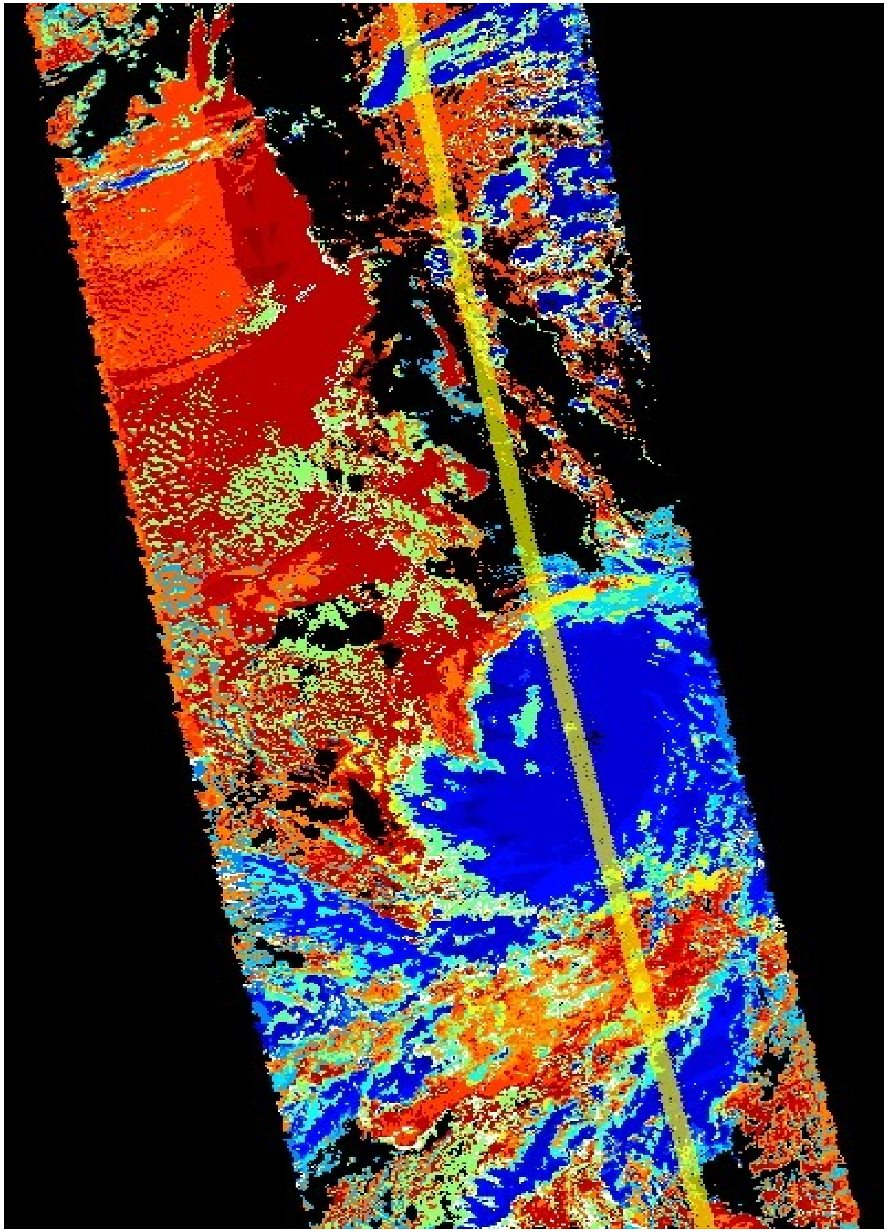
Combination of information on particle shape and absorption properties help

ICE UNKOWN LIQUID

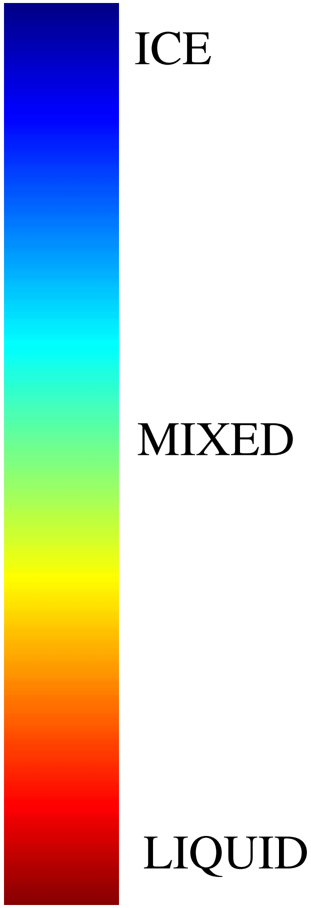


POLARIZATION SWIR/VIS Ratio IR Bispectral

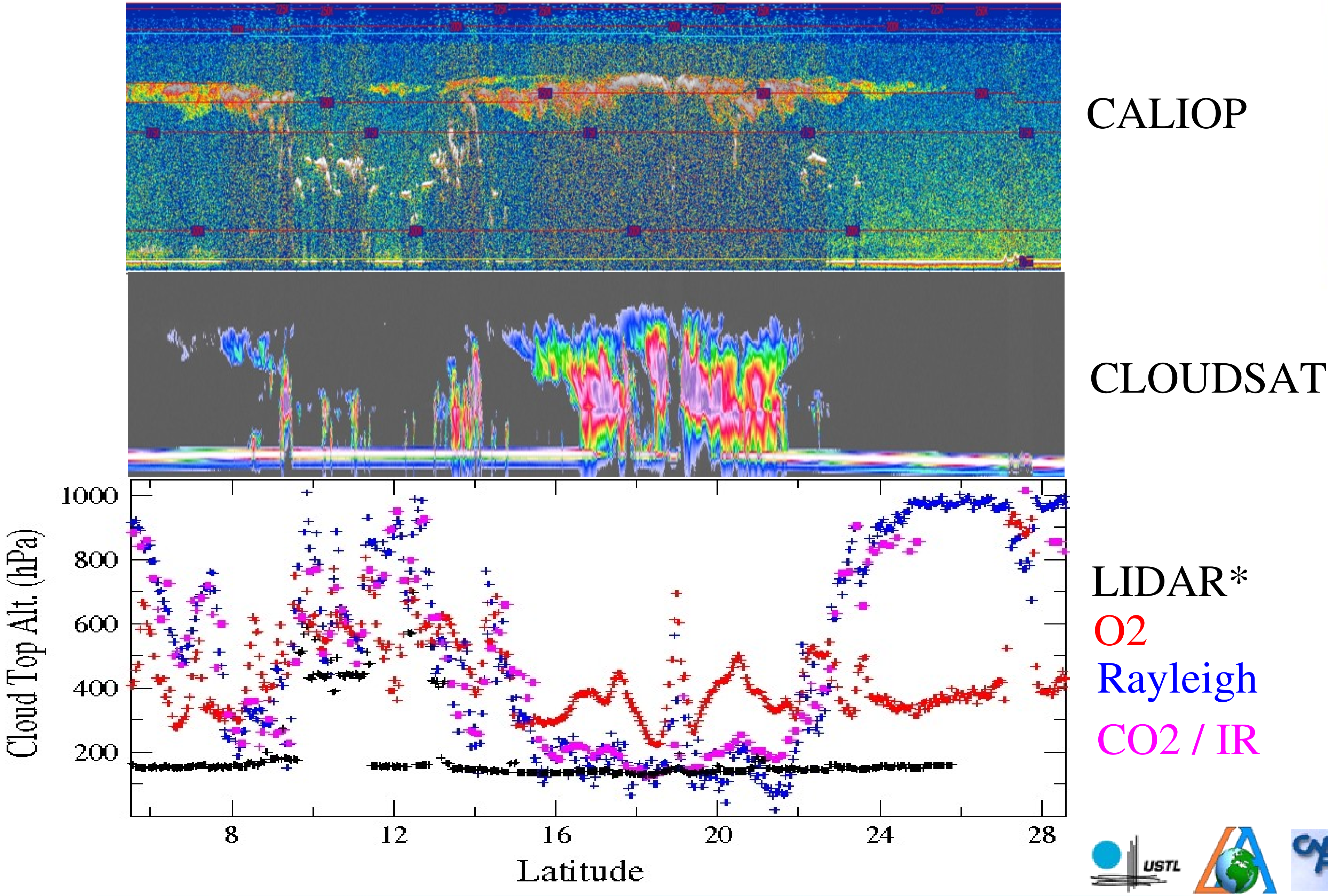
Cloud thermodynamic phase



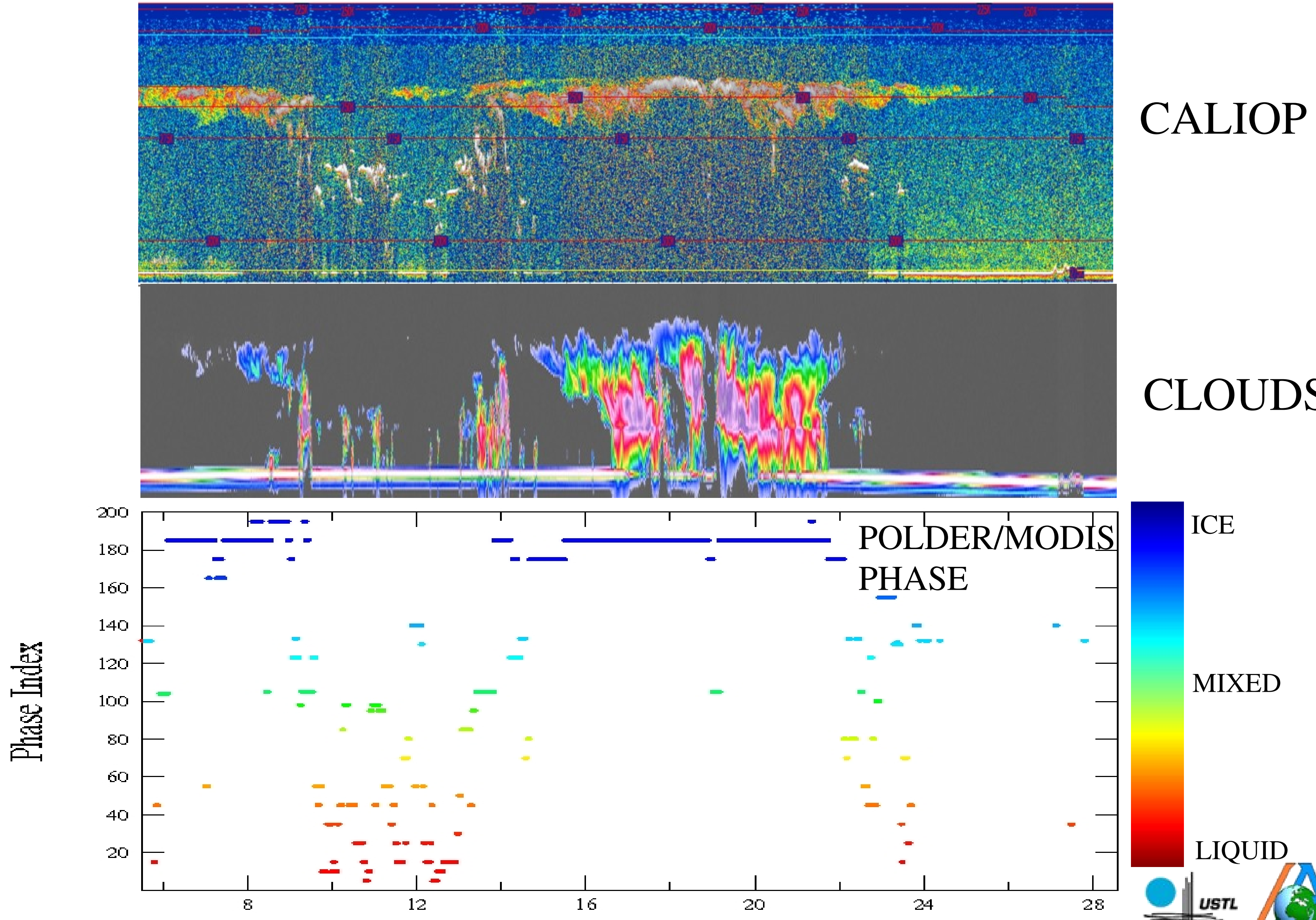
Results from the combined POLDER/MODIS phase algorithm



Cloud thermodynamic phase



Cloud thermodynamic phase



Perspective for New Mission

Lessons learned :

Multiangle measurements applications suffer from non simultaneous acquisition (stereo height retrieval)

Algorithm can prove difficult to design when the range of scattering angle can vary significantly

Microphysical properties retrievals of clouds and aerosols requires a good sampling of the BPDF / BRDF

Observation and analysis of clouds 3D structure could benefit from simultaneous observation of both their bright and dark side.

Perspective for New Mission

CLOUD REMOTE SENSING SCIENCE QUIZZ

What is the difference between LIFE and CLOUDS ?

LIFE : Always look on the bright side of life ...

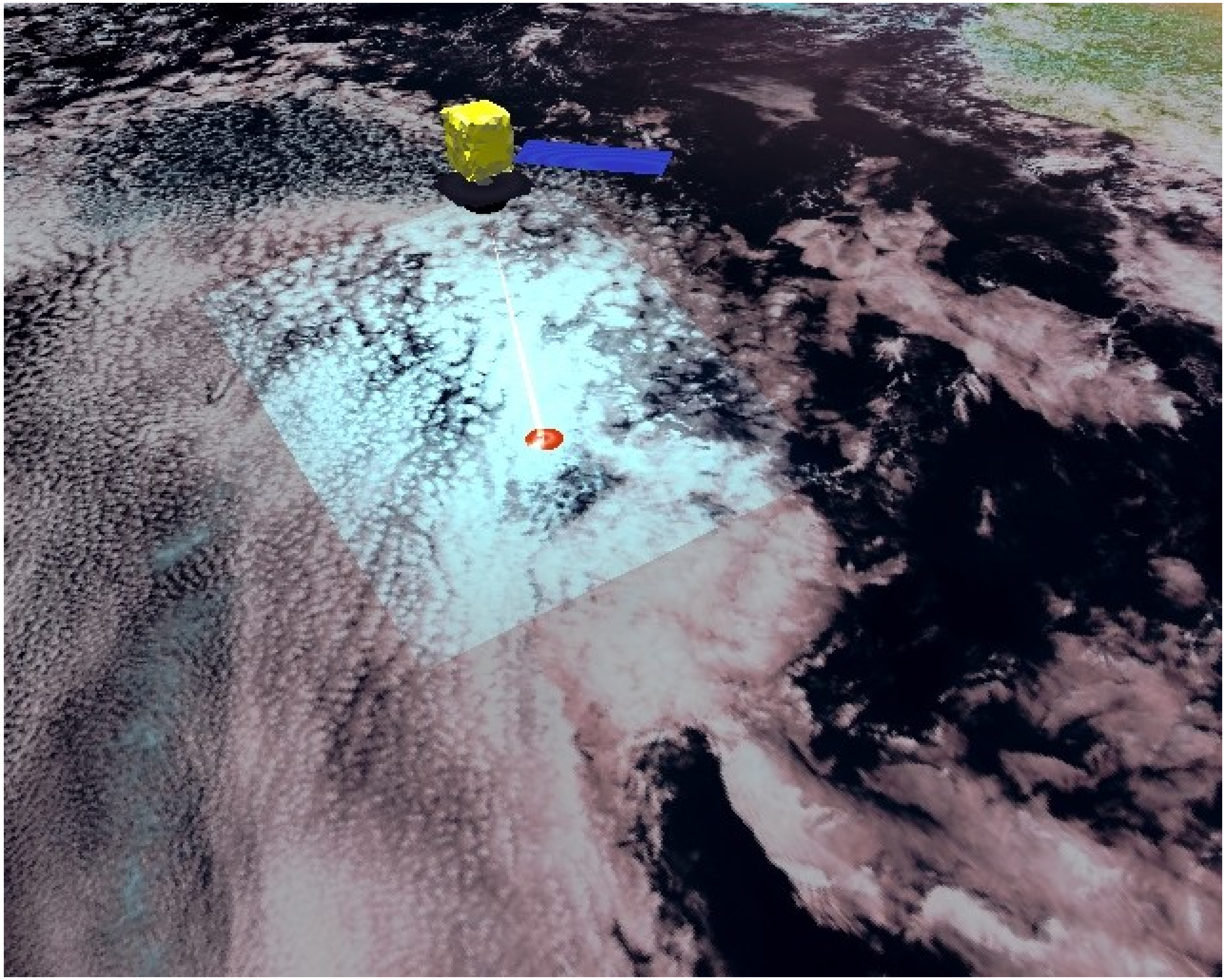
(From Bryan's Life)

CLOUDS : Better look at both the bright and dark side of clouds

(From Marshak's Talk)

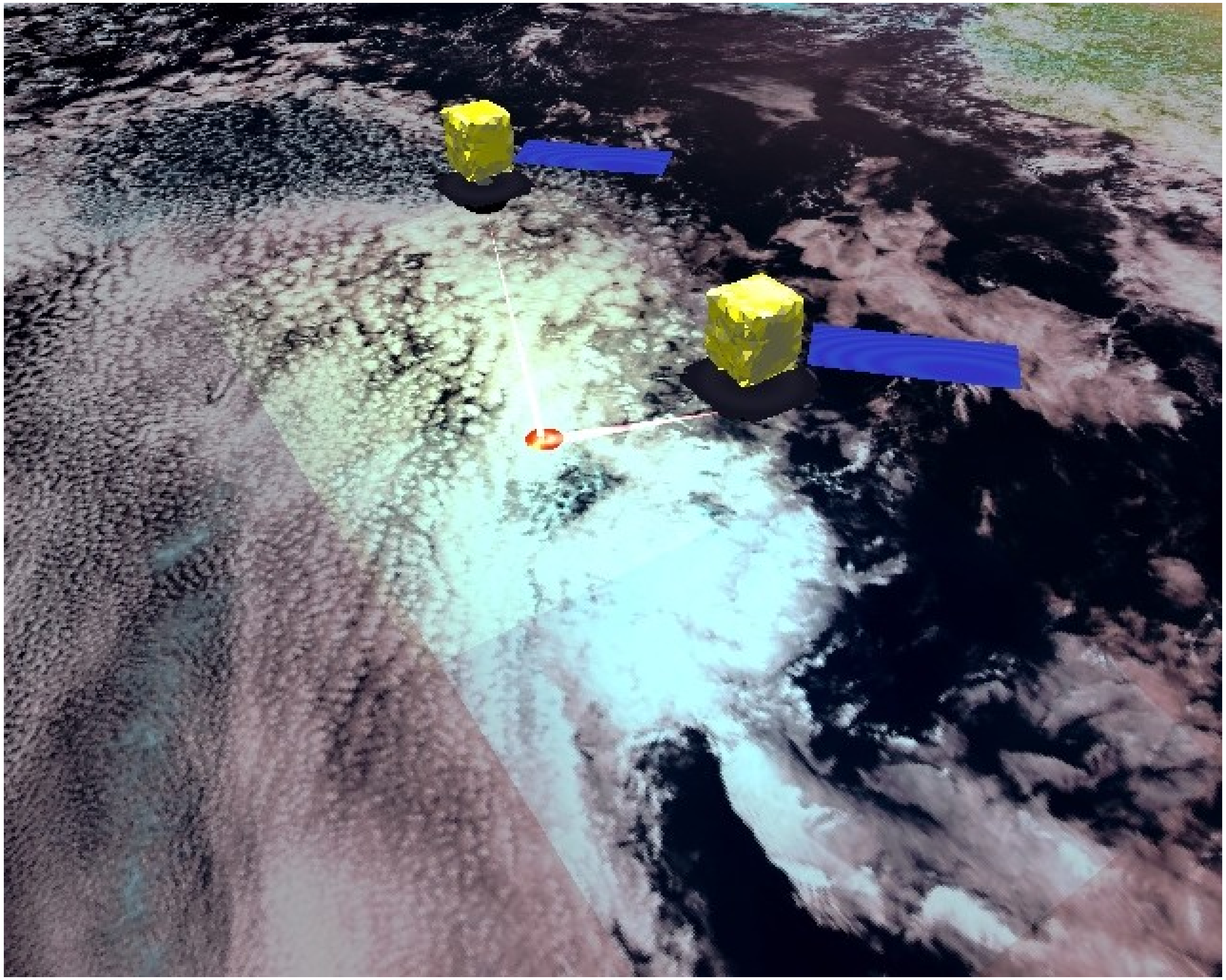
Perspective for New Mission

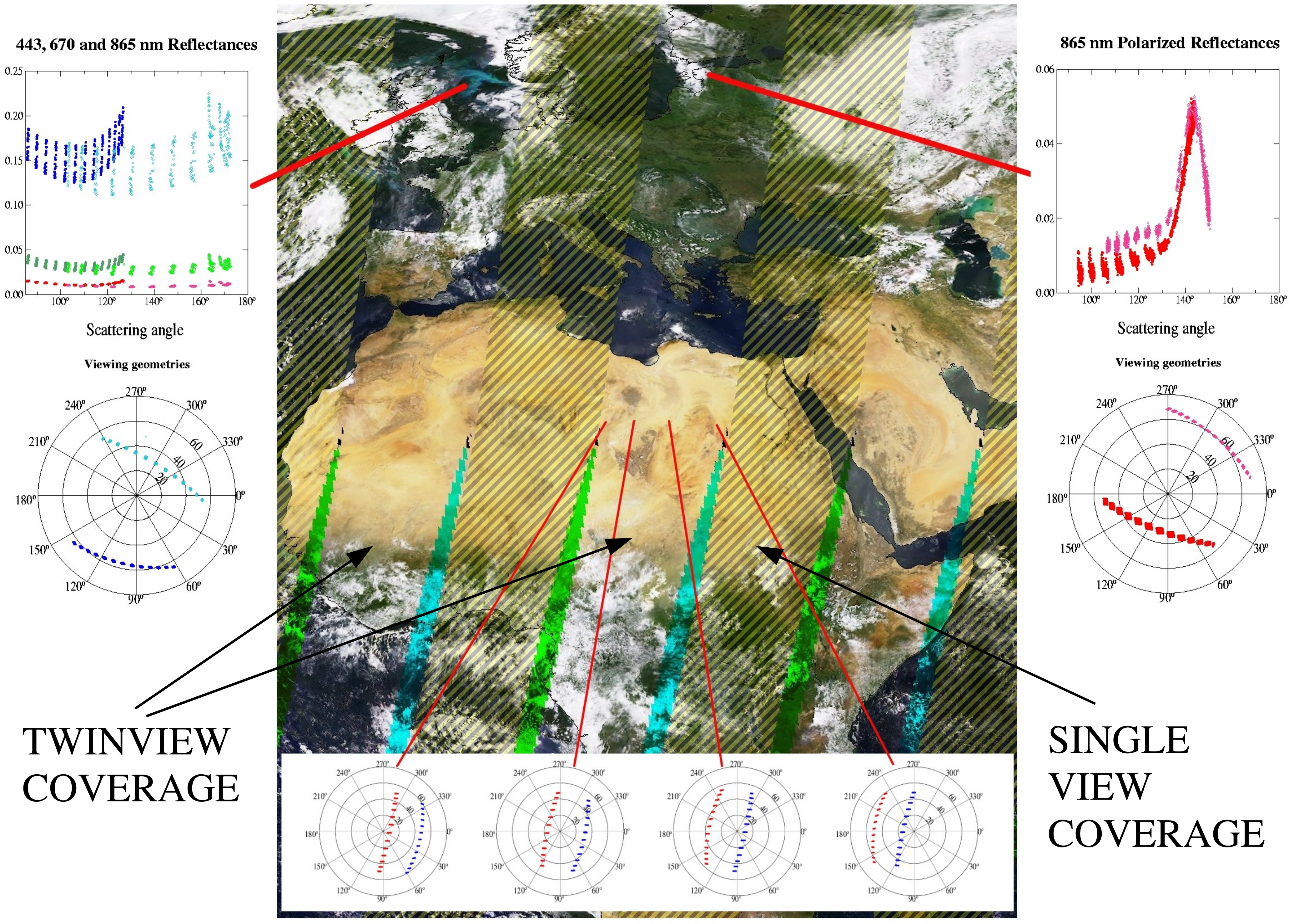
ORIGINAL POLDER vs TWIN VIEW CONCEPT



Perspective for New Mission

ORIGINAL POLDER vs TWIN VIEW CONCEPT




443, 670 and 865 nm Reflectances
Scattering angle
Viewing geometries
865 nm Polarized Reflectances
Scattering angle
Viewing geometries
TWINVIEW
COVERAGE
SINGLE
VIEW
COVERAGE

Summary

PARASOL/MODIS combination is a real opportunity to improve many existing parameters and can help design a next generation sensor

PARASOL/MODIS open perspectives to extend the active sensors observation to the full swath, increasing statistics

PARASOL/MODIS offer a test suite for definition of future cloud/aerosol missions

2 years of POLDER3/Parasol data are available through the ICARE data center : **http://www.icare.univ-lille1.fr/**

Acknowledgement

This work is a common effort from numerous people of the POLDER and PARASOL mission.

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