

Multiangle cloud remote sensing from POLDER3/PARASOL

Cloud detection and altitude information

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Instrumental Background



- CNES/LOA instrument, Parosol launched Dec. 2004

- ~ 705 km polar orbits, ascending (13:30 a.m.)

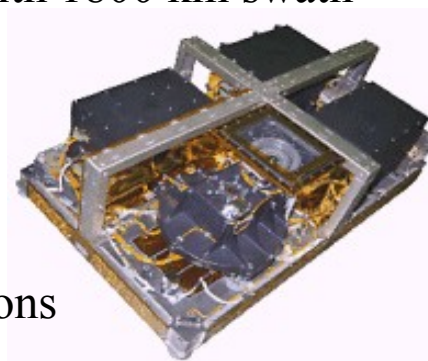
**Data available from March 2005 to Jan 2010
within A-TRAIN and more**

- 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

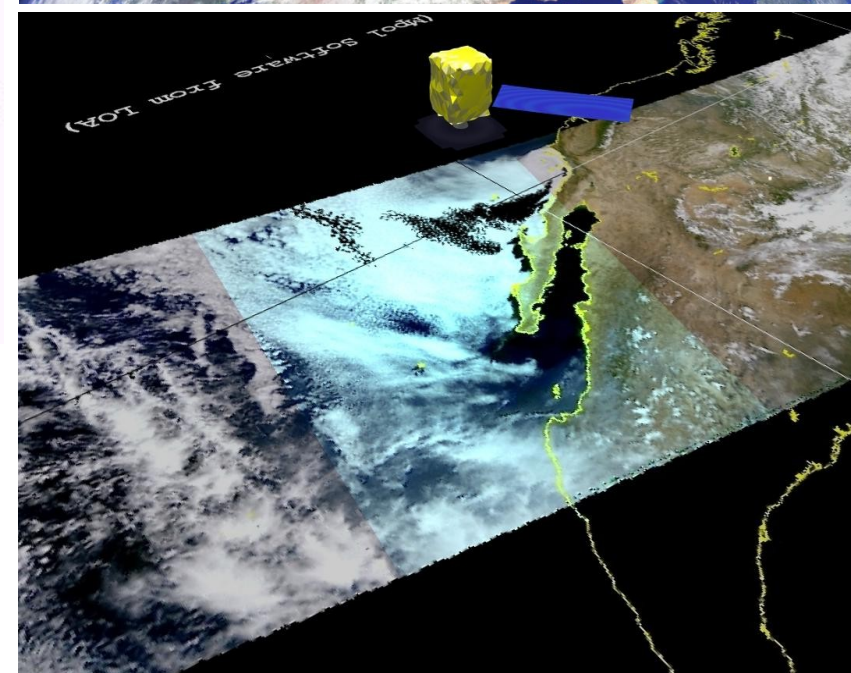
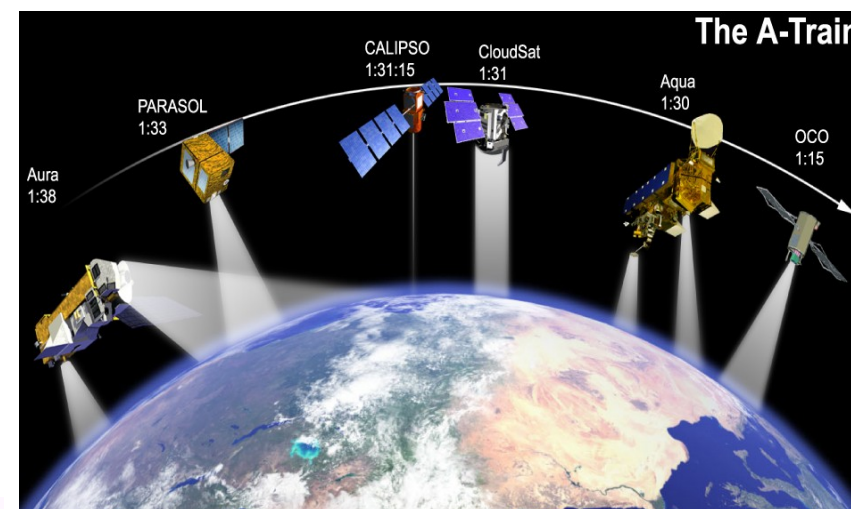


- Multidirectionnal observations (up to 16 directions)

- Spatial resolution : 6x7 km

- No onboard calibration system - Inflight vicarious calibration :

- 2-3% absolute calibration accuracy
- 1% interband – 0.1% interpixel over clouds



ERB, WV and Clouds Level 2 processing scheme

Level 1 georeferenced data – Int. Sinusoidal grid 6km x 6km

Gaseous absorption correction

Apparent pressure determination

Cloud detection

*Clear sky
only* ↓

Water vapor content

Cloud phase

Ice only

Cloud Optical Thickness
and spectral albedo

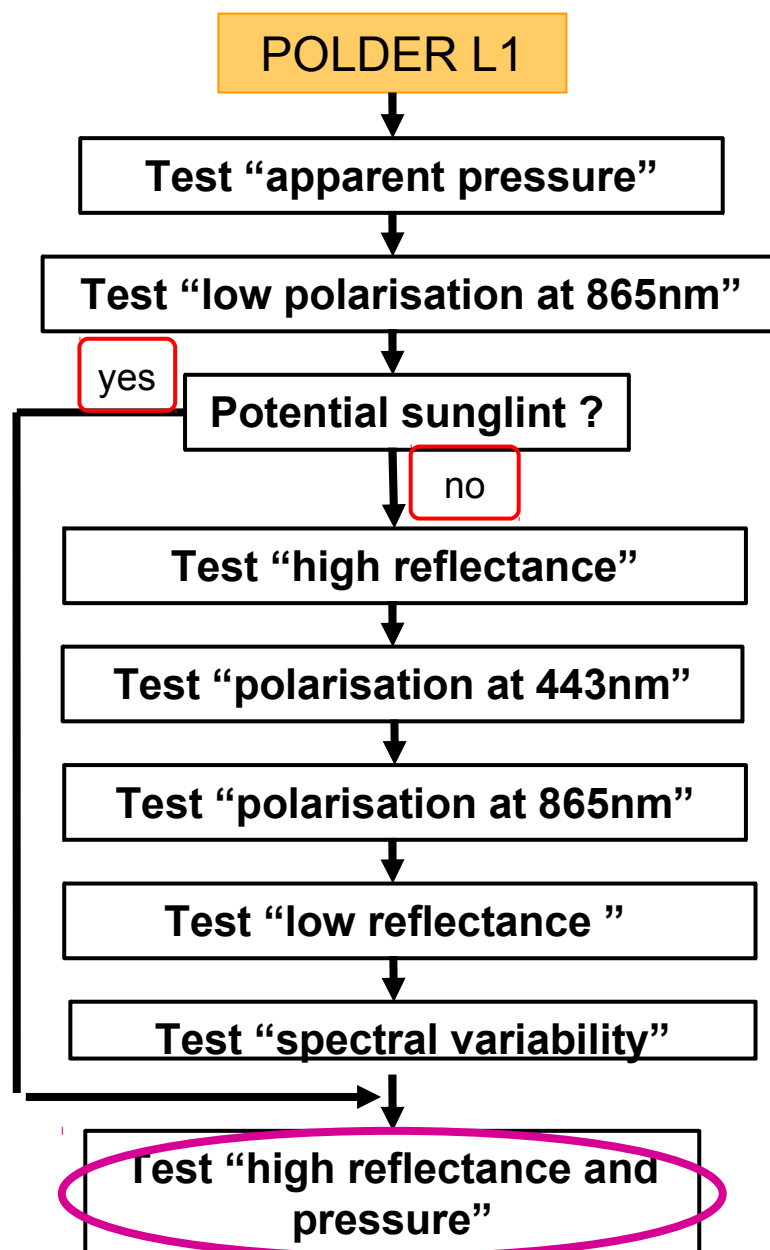
Microphysical index
from polarisation

SW albedo integration

Rayleigh and Oxygen
cloud pressure

Level 2 gridded product
Int. Sinusoidal 20km x 20km

Multiangle measurements and Cloud detection



All tests are performed (outside sun glint)

Cloud detection uses surface BRDF maps (15 days composite) from the POLDER land surface processing output and ancillary data from ECMWF.

Cloud fraction is computed for 3x3 pixels boxes from results obtained over directions and individual L1 pixels.
QA index is computed from proportion of tests giving opposite information and number of tests actually used

Specific to snow/ice surface (snow index from ECMWF)

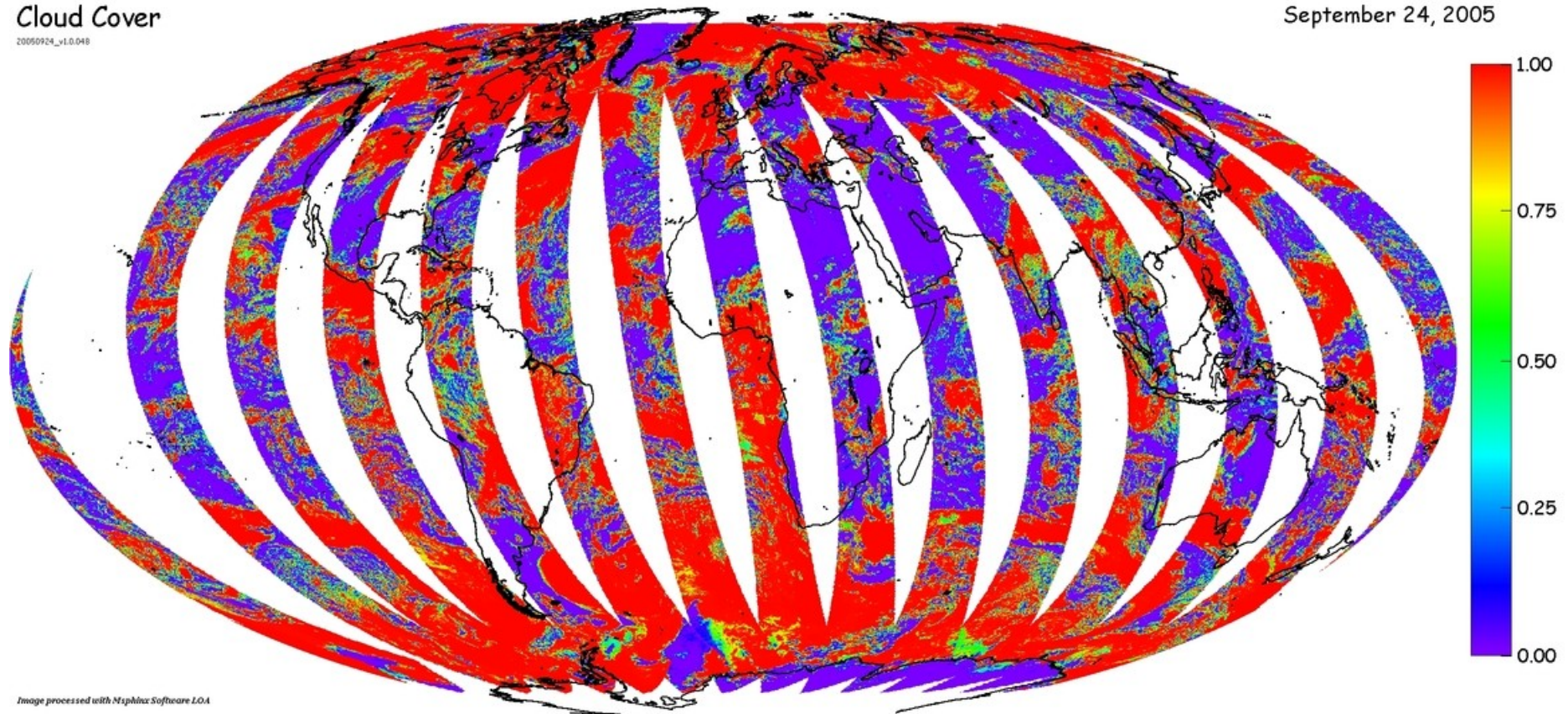


Multangle measurements and Cloud detection

Cloud Cover

20050924_v1.0.048

September 24, 2005



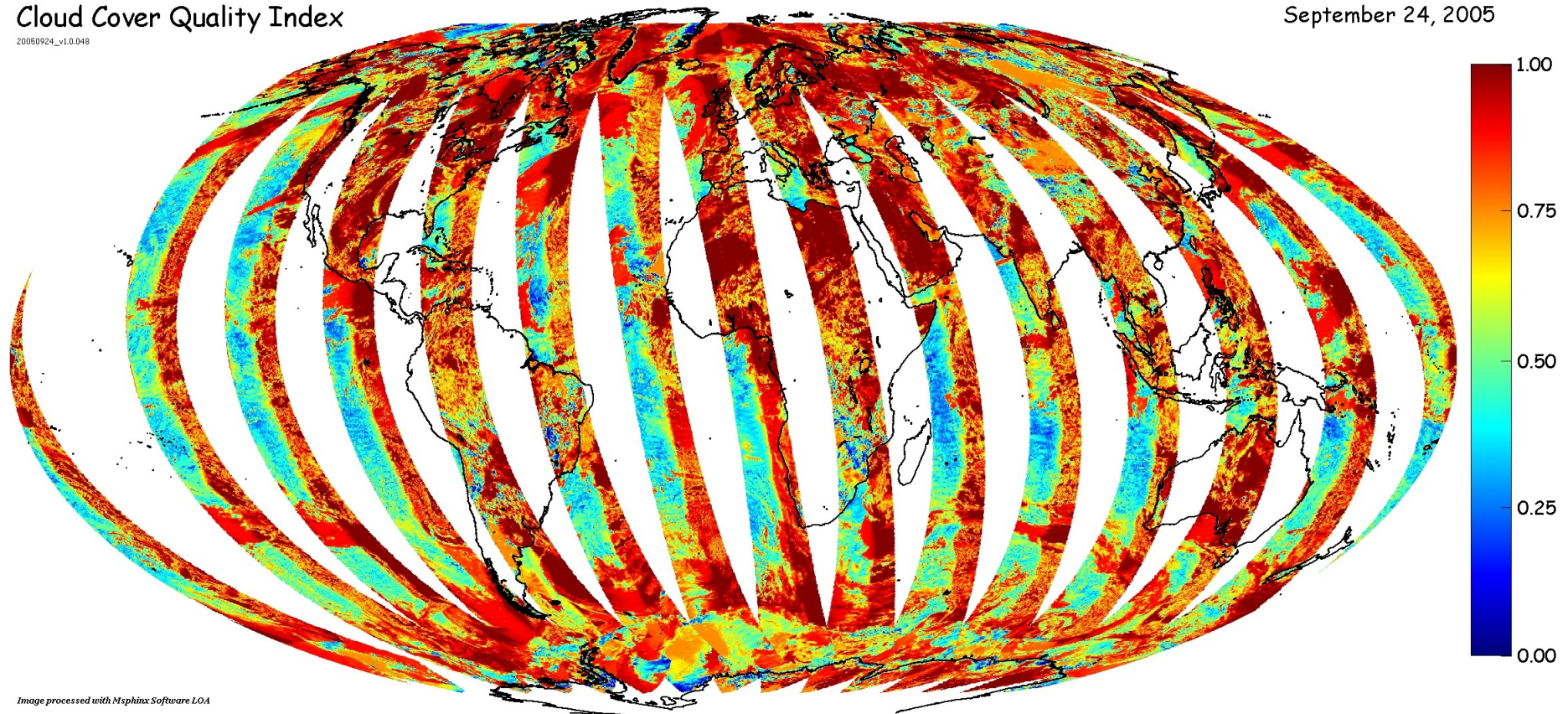
Cloud fraction at 20x20 km resolution

Multiangle measurements and Cloud detection

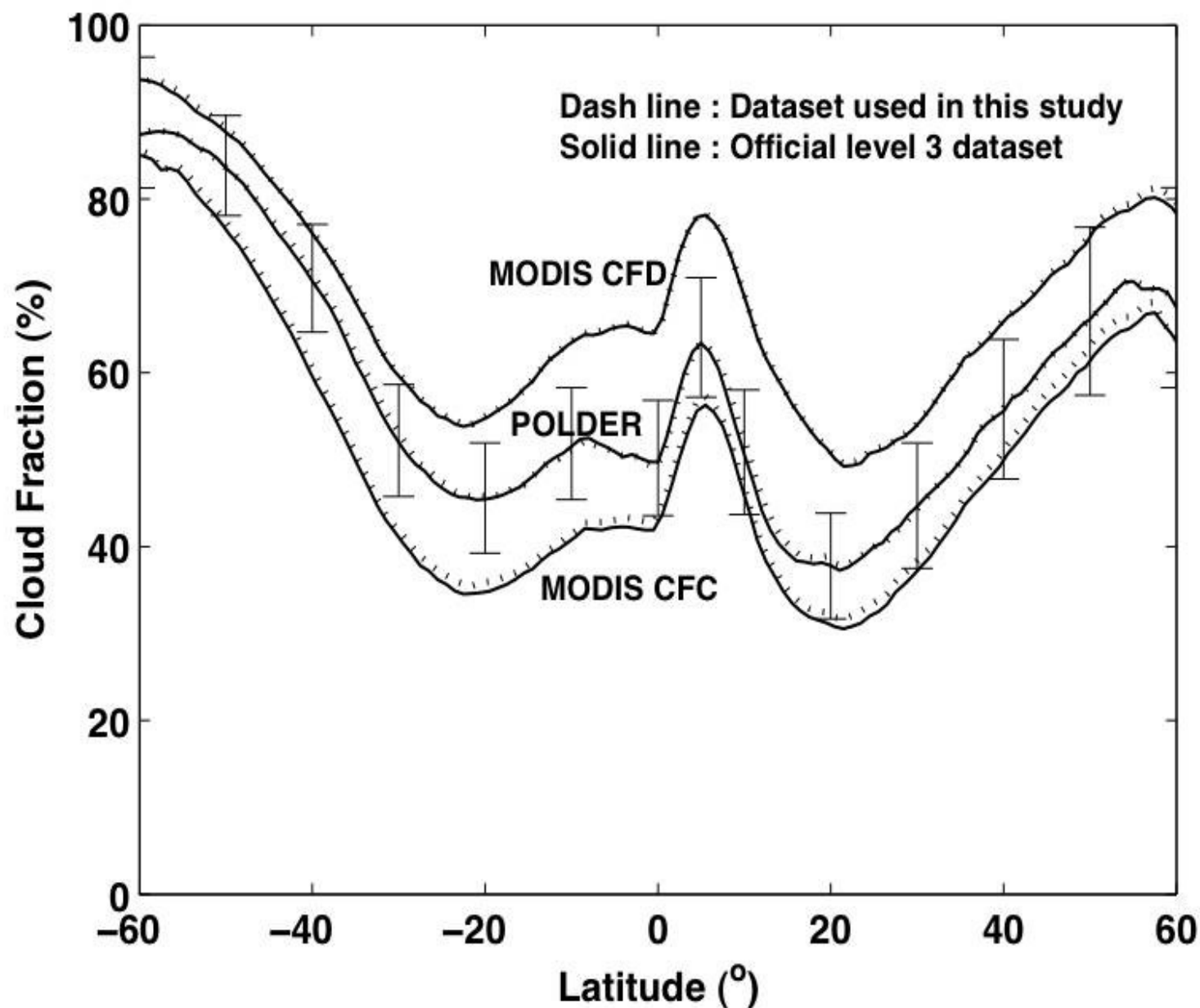
Cloud Cover Quality Index

20050924_v1.0.048

September 24, 2005



Cloud fraction quality index at 20x20 km resolution



Zeng et al, 2010 (submitted)



MODIS cloud fraction for total swath 2% higher than if limited to POLDER swath

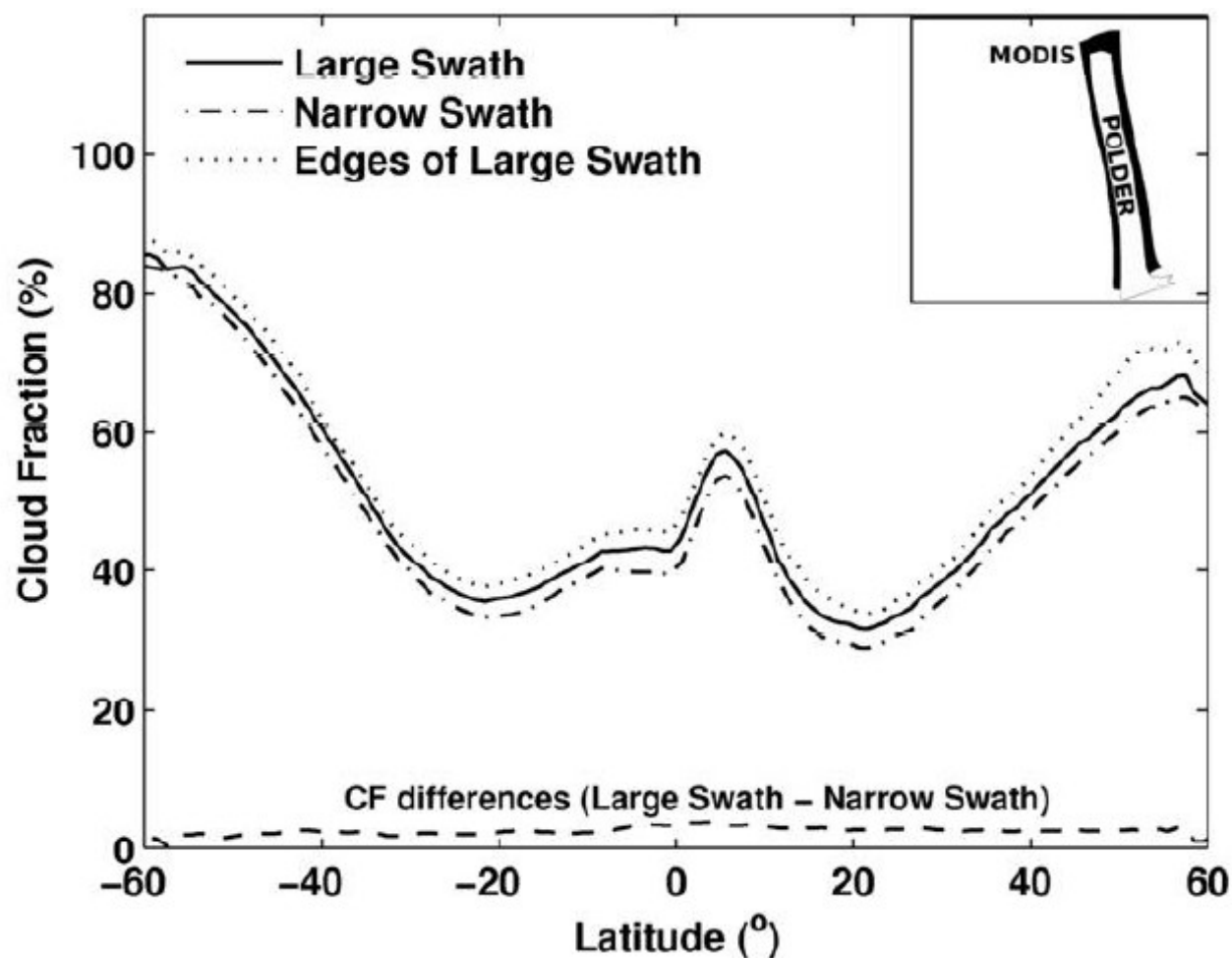
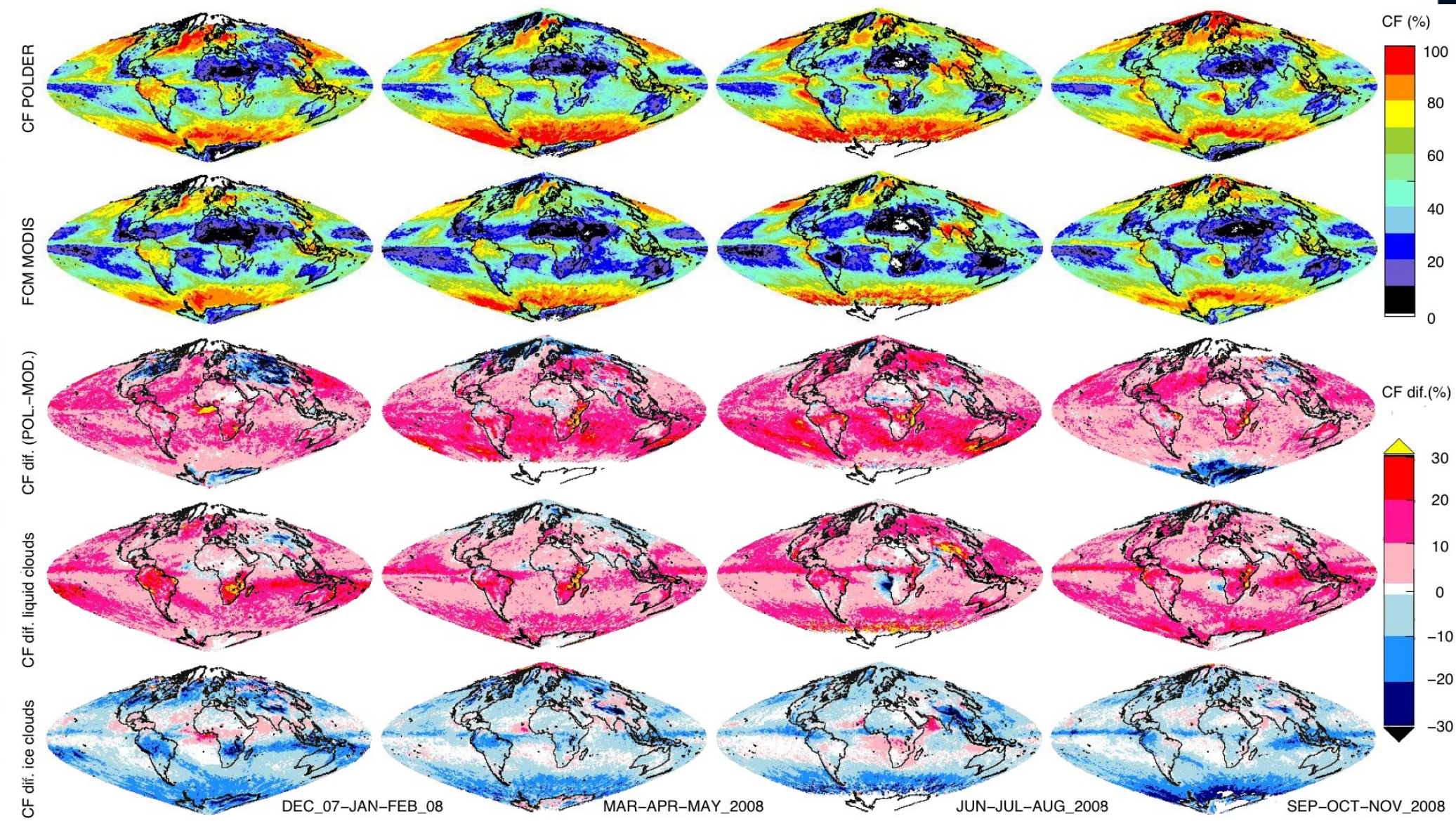
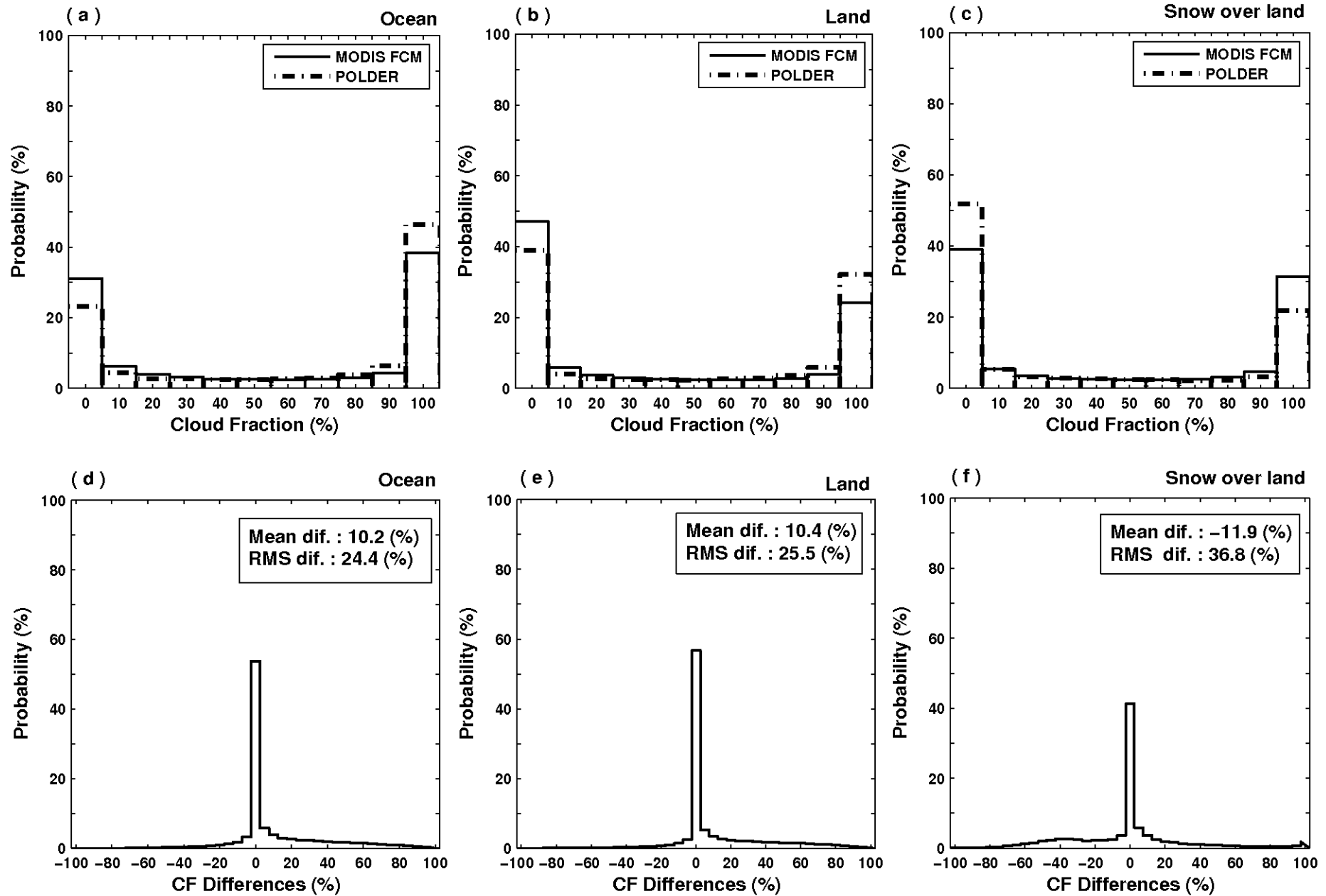


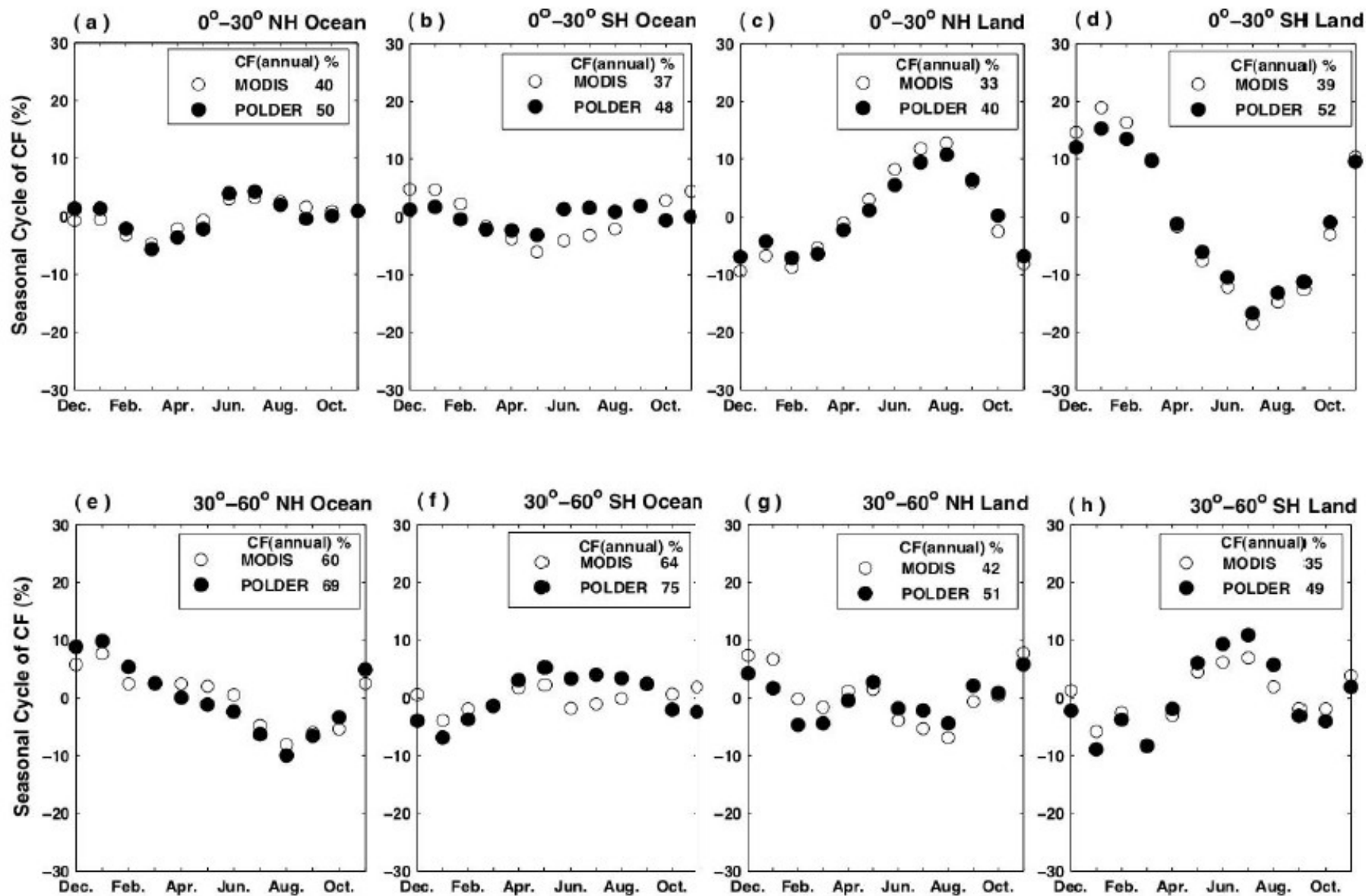
Figure 2. Latitudinal variations of CFC cloud fraction from wide swath (MODIS swath), narrow swath (POLDER swath) and edge of the large swath (POLDER swath subtracted from MODIS swath), and the differences of cloud fraction between MODIS and POLDER swath.

Zeng et al, 2010 (submitted)



Zeng et al, 2010 (submitted)



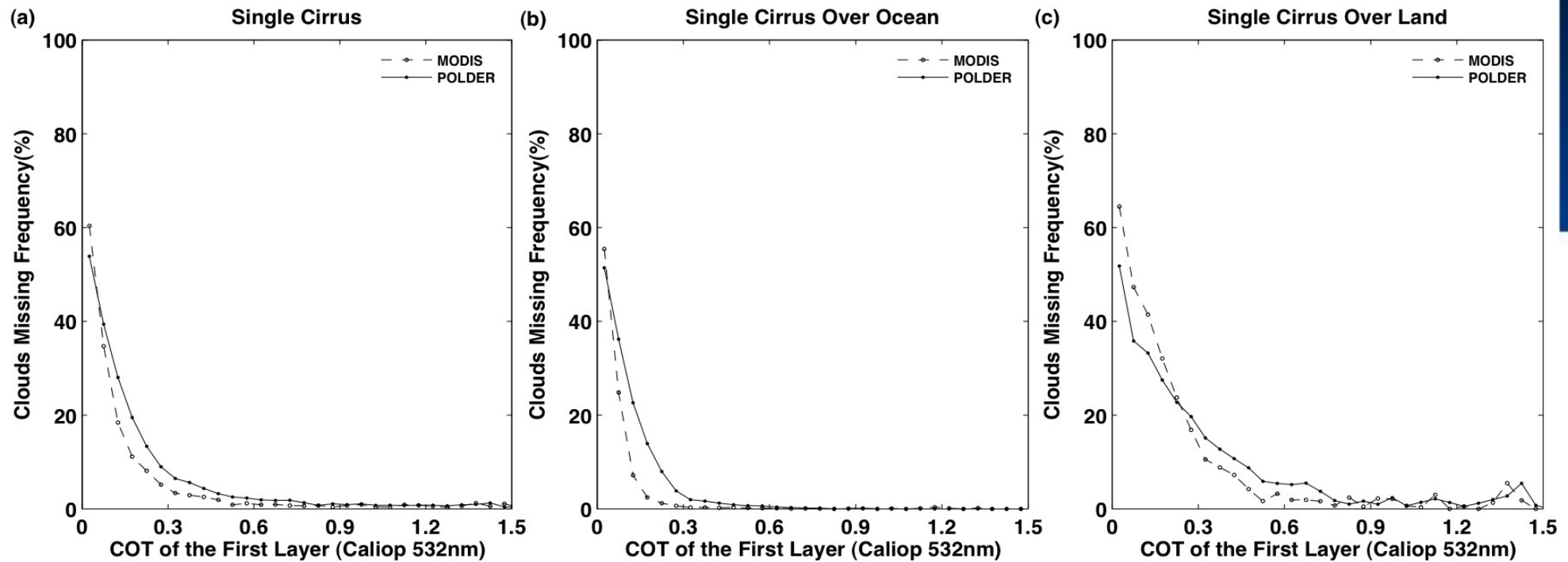


Zeng et al, 2010 (submitted)



Université
Lille1
Sciences et Technologies

Sensitivity to thin cirrus



Frequency of « missed cirrus » for POLDER and MODIS (MOD35) as a function of CALIOP optical thickness.

Cloud altitude information

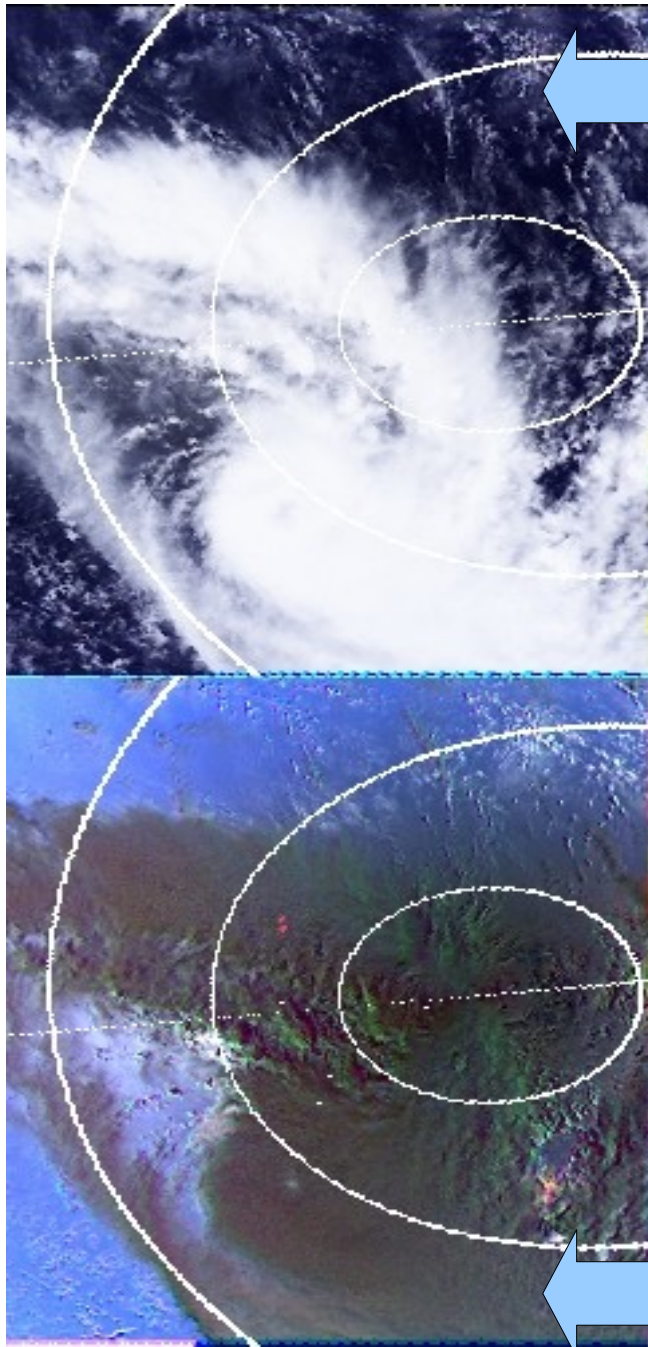
[1] Cloud top Rayleigh pressure

[2] Oxygen A-Band apparent pressure
(reported in GEWEX netcdf)

!! Official product reports CP for cloud albedo > 0.3 !!



POLDER instantaneous field of view



True color total reflectance RGB composite (490 – 670 – 865 nm)

Basis for the Rayleigh scattering technique :

Single scattering by molecules highly polarizes the signal in the side scattering direction where clouds introduce very little polarization.

Differences between polarized reflectance in the blue (490nm) and the red (865nm) can be related to the Rayleigh optical thickness above the cloud, from which we can infer an apparent cloud top pressure.

Approximation is good as long as :

- cloud is spectrally neutral in polarized reflectance
- cloud is thick enough to block contribution from Rayleigh scattering below it

False color polarized reflectance composite (490 – 670 – 865 nm)

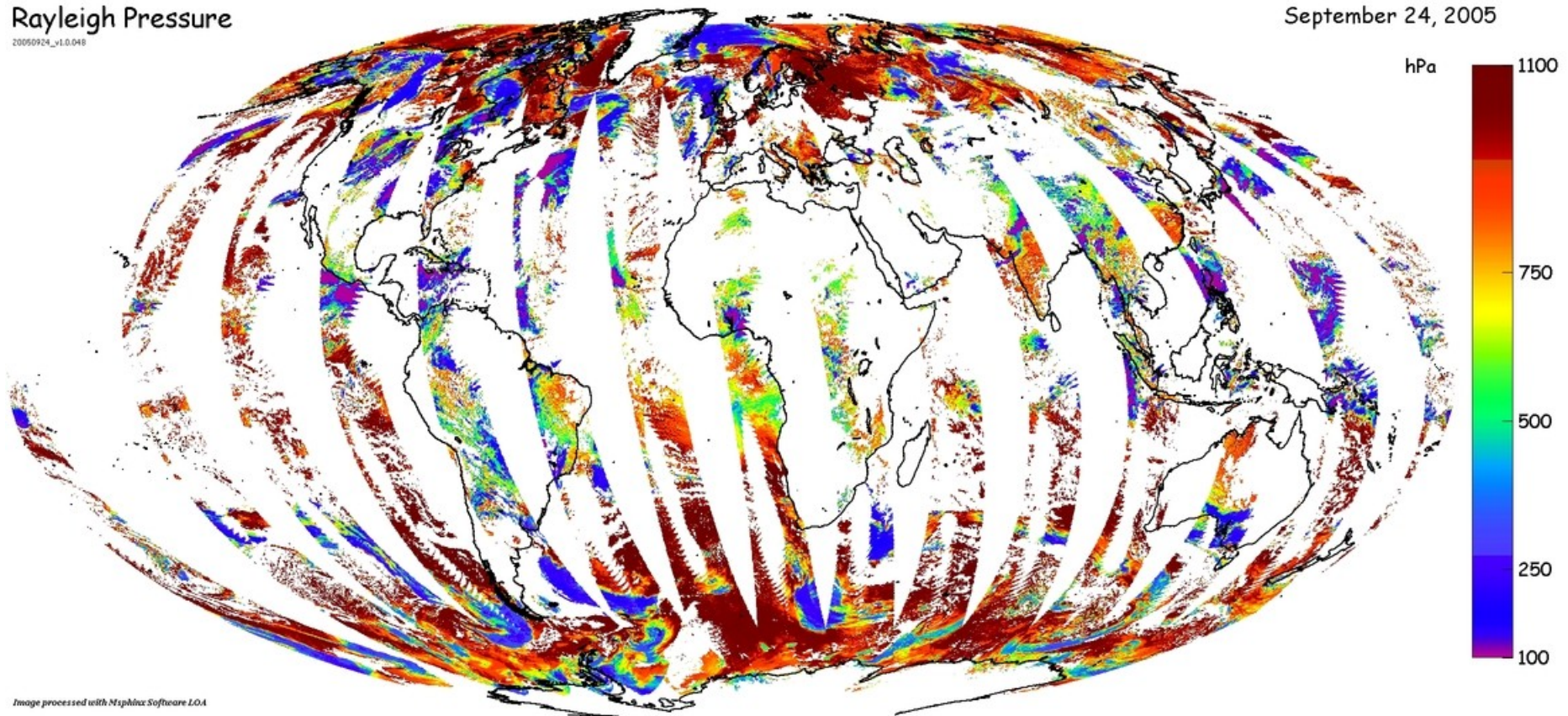


Multiangle multispectral measurements

Rayleigh Pressure

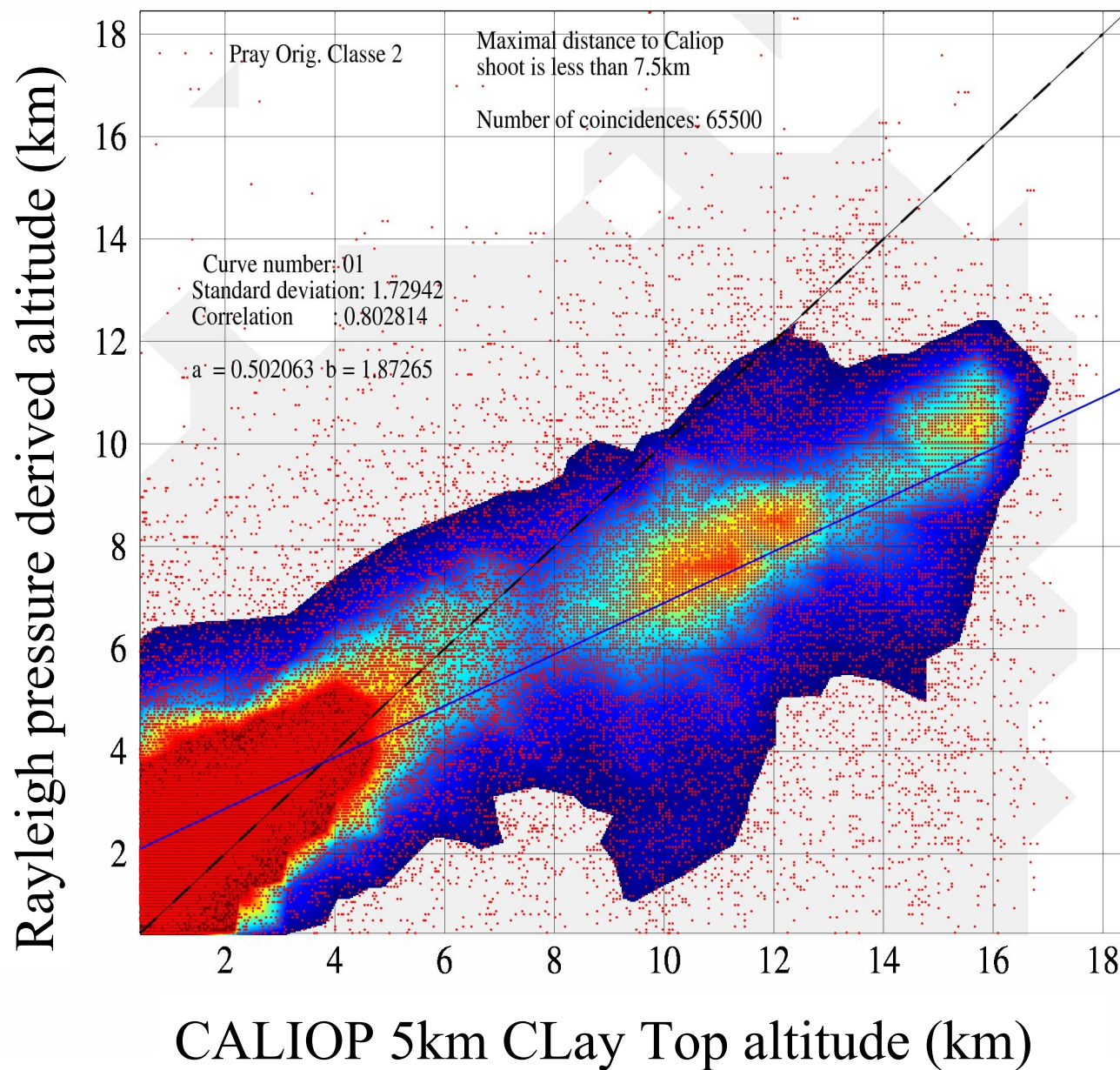
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September 24, 2005



Polarised reflectances at 490 nm and 865 nm are used to infer cloud top pressure via determination of rayleigh optical thickness above cloud.

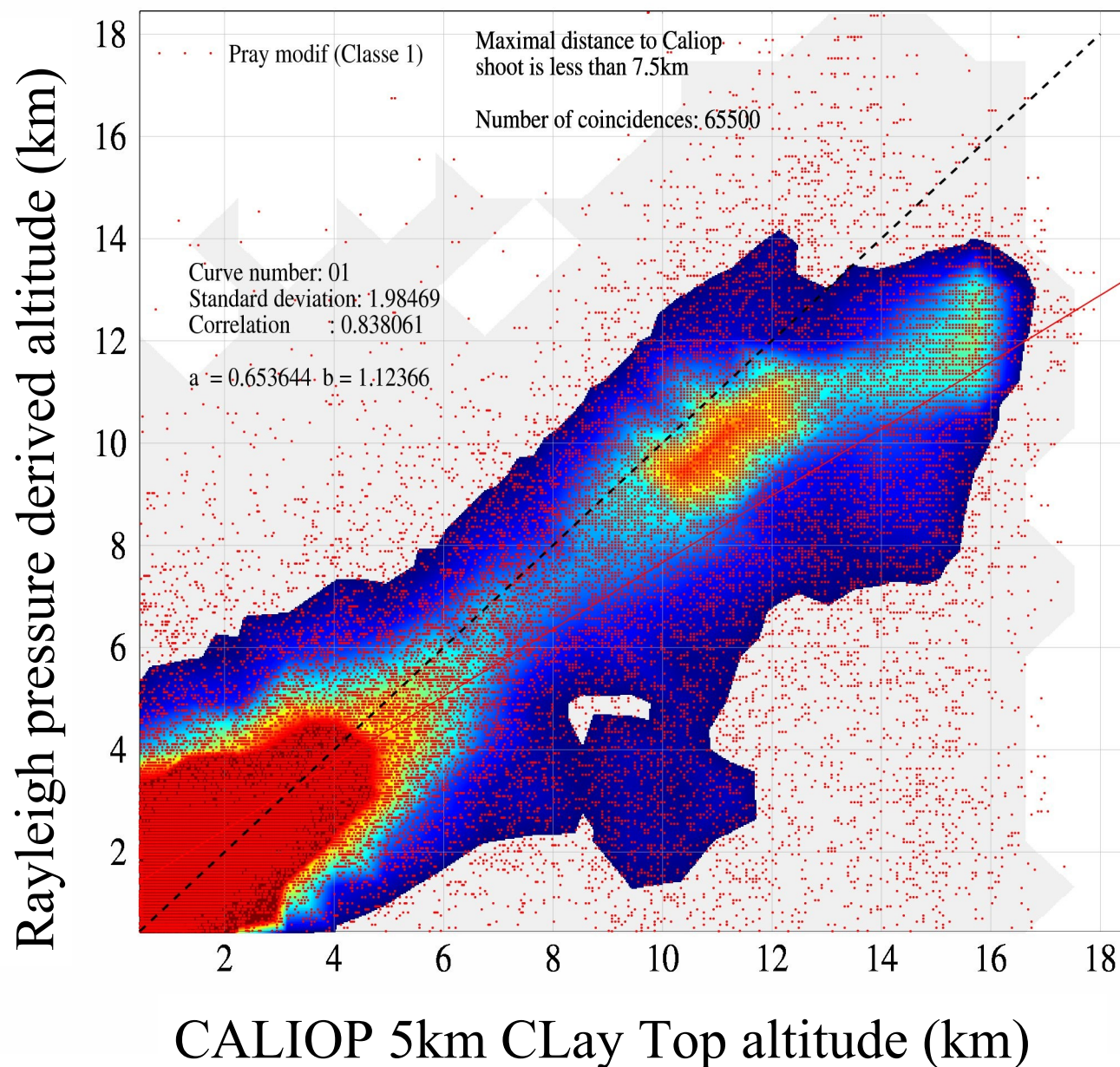
June 2008



Altitude from
Rayleigh pressure
Vs
Caliop altitude

OLD VERSION :
Way too much
middle clouds

June 2008



Altitude from
Rayleigh pressure
Vs
Caliop altitude

NEW VERSION :
Higher high clouds
Lower low clouds

Basis for O₂ A-band technique :

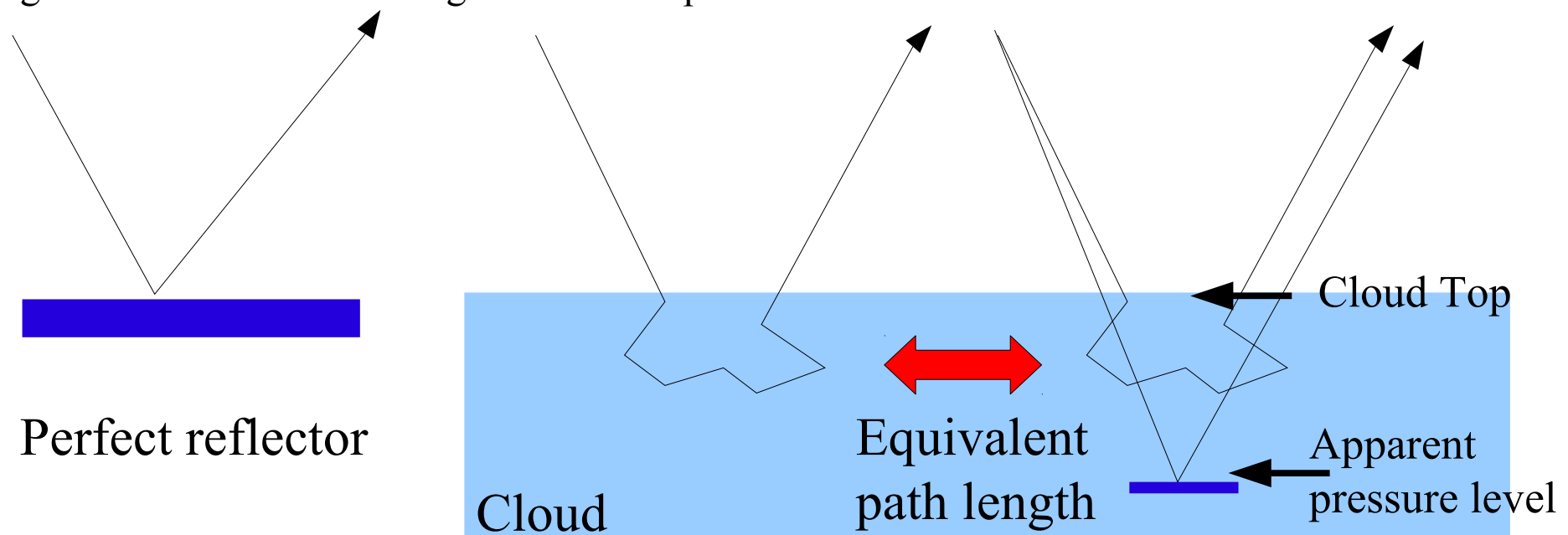
Ratio of the reflectance in 2 two channels (an absorbing and a non absorbing) is approximately equal to the ratio of O₂ transmission (two ways) for the two channels.

O₂ transmission (a measure of the mean photon path length) can then be related to a pressure level (Vanbauce et al).

Pressure level would correspond to target top only for purely reflective bright target such as bright surfaces, sun glint but NOT clouds.

Approximation is good as long as :

- photon penetration is small (almost never the case)
- target reflectance is much larger than atmospheric reflectance

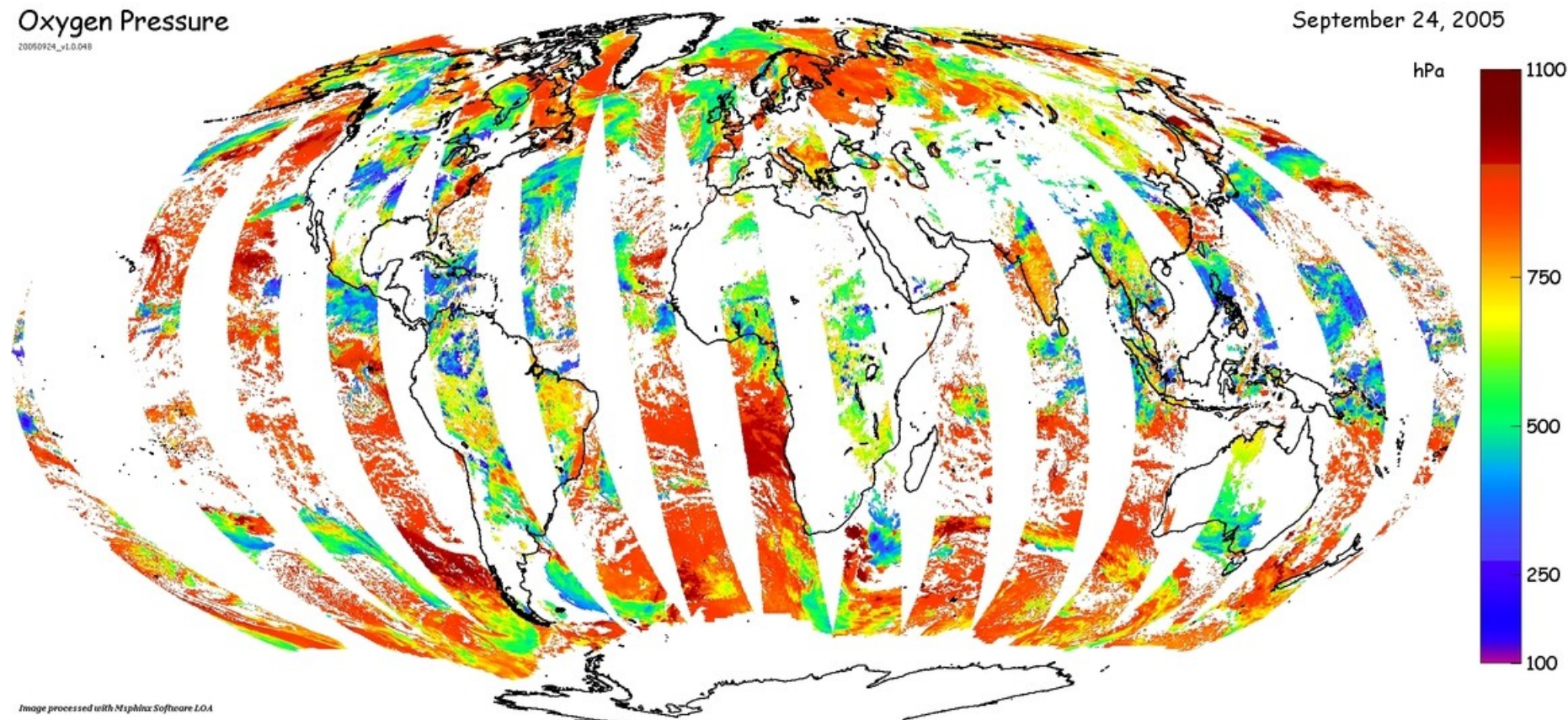


Multiangle multispectral measurements

Oxygen Pressure

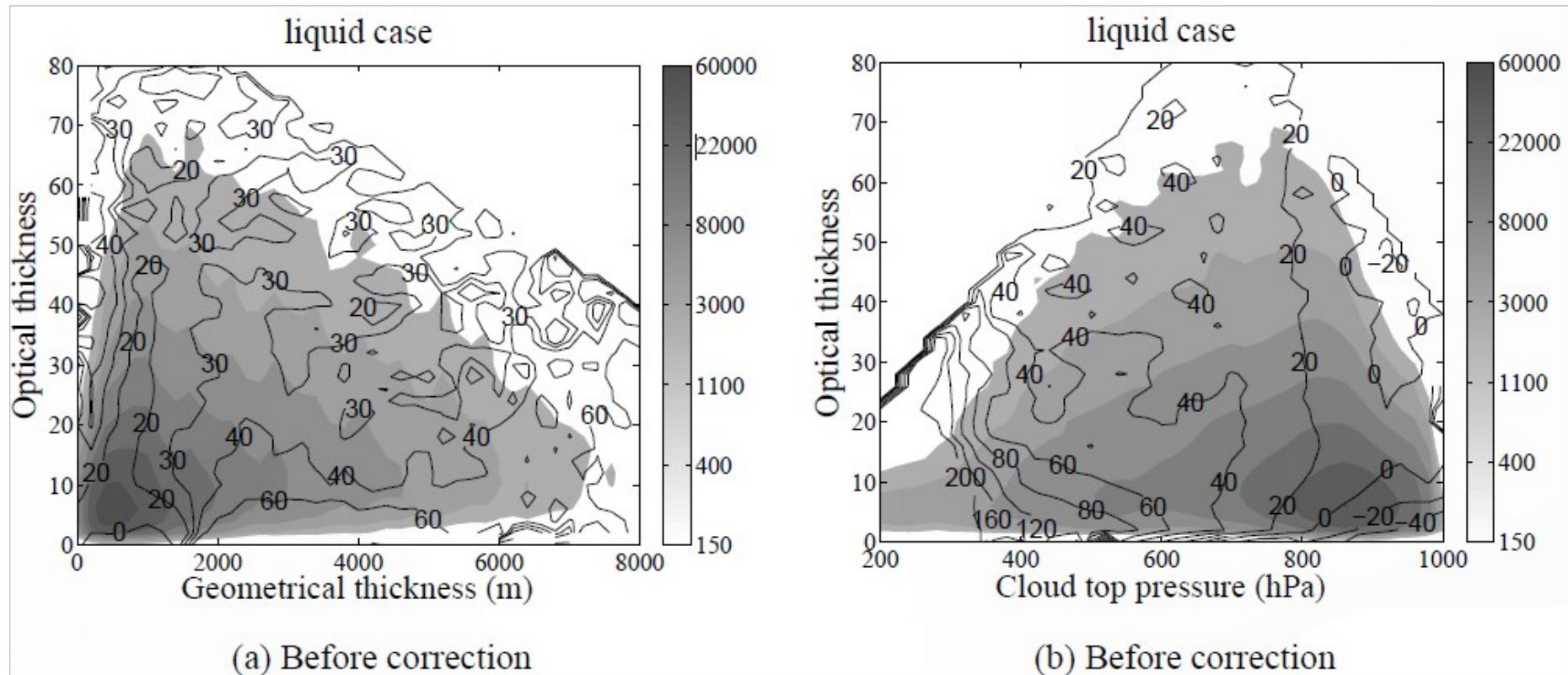
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September 24, 2005



Differential absorption is used to infer cloud apparent pressure - 763nm and 765 nm
Directional product – Retrieval is performed in up to 16 directions

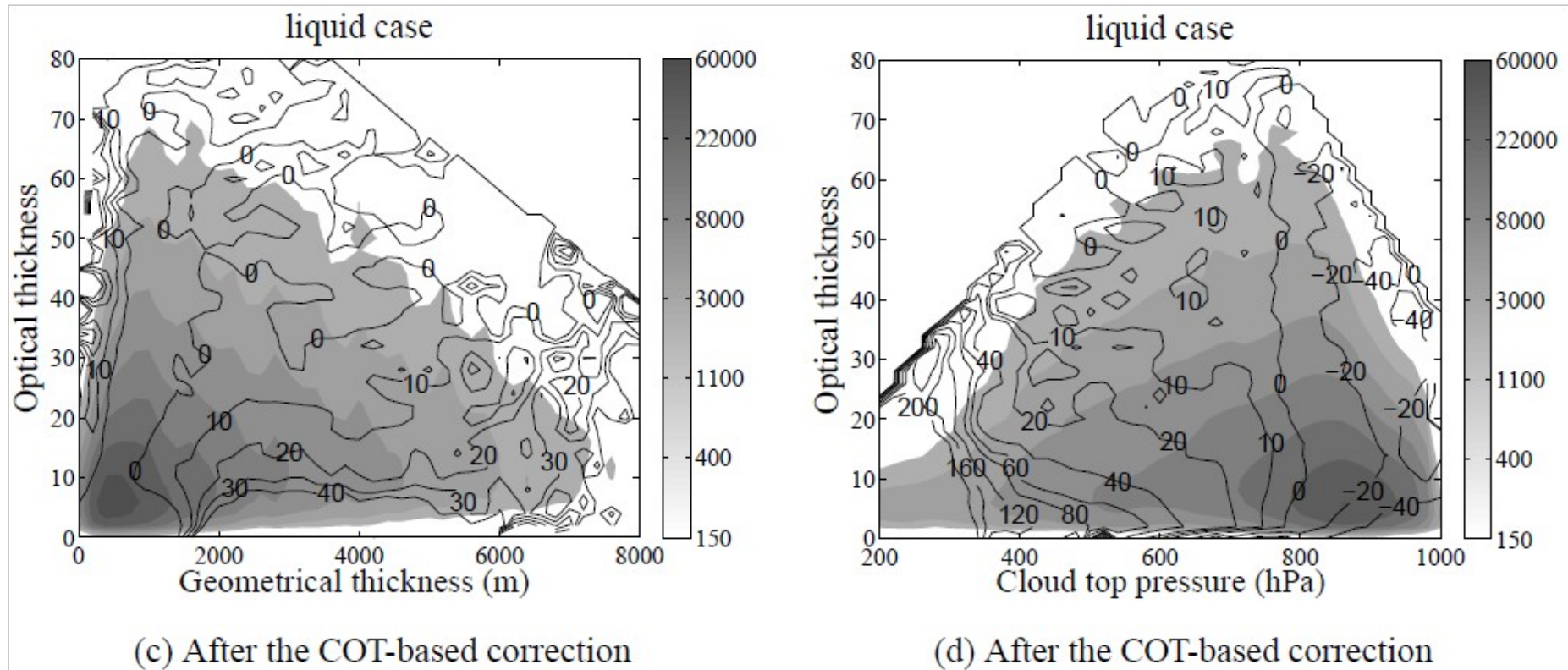
Difference between O₂ apparent pressure and mid-cloud pressure derived from Combined Cloudsat/Calipso GEOPROF product (hPa).



Ferlay et al , 2010 (submitted)

Liquid clouds – single layers – uncorrected pressure

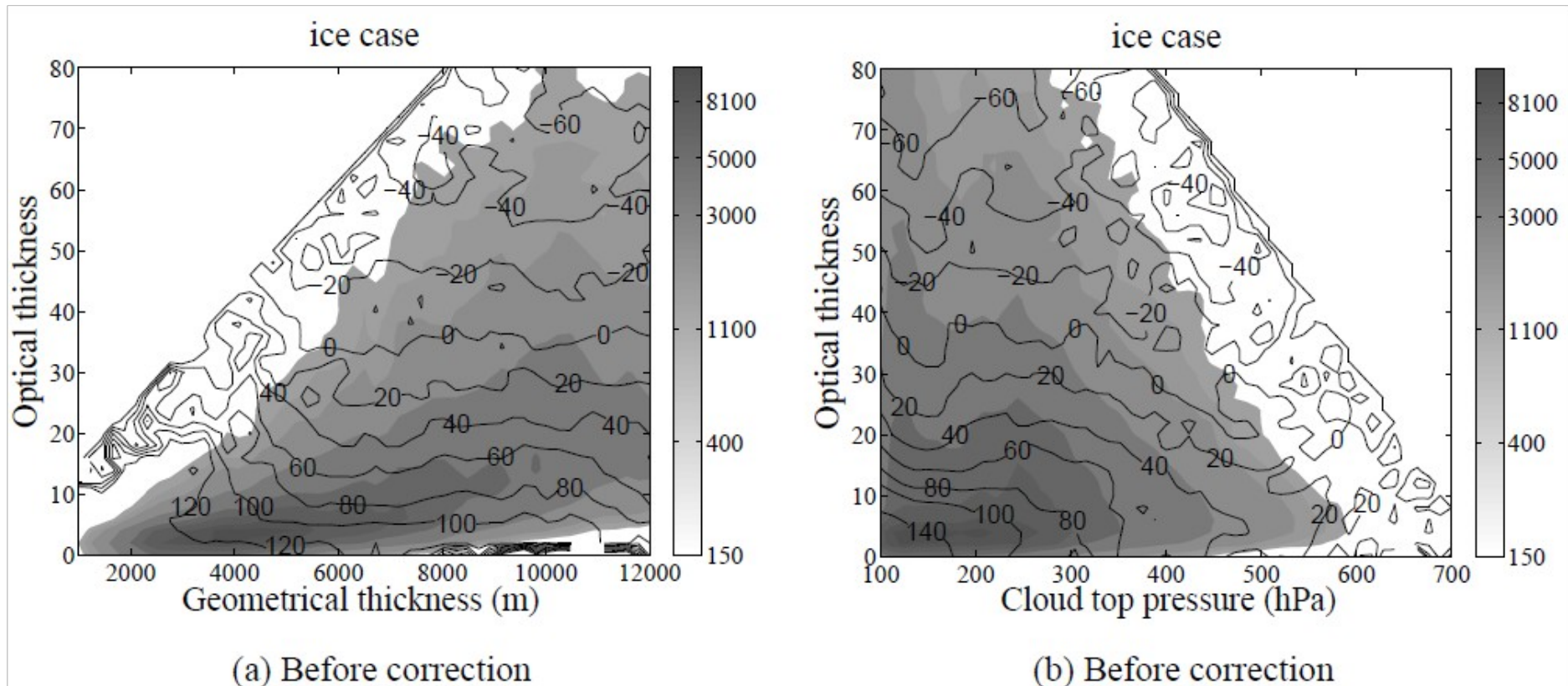
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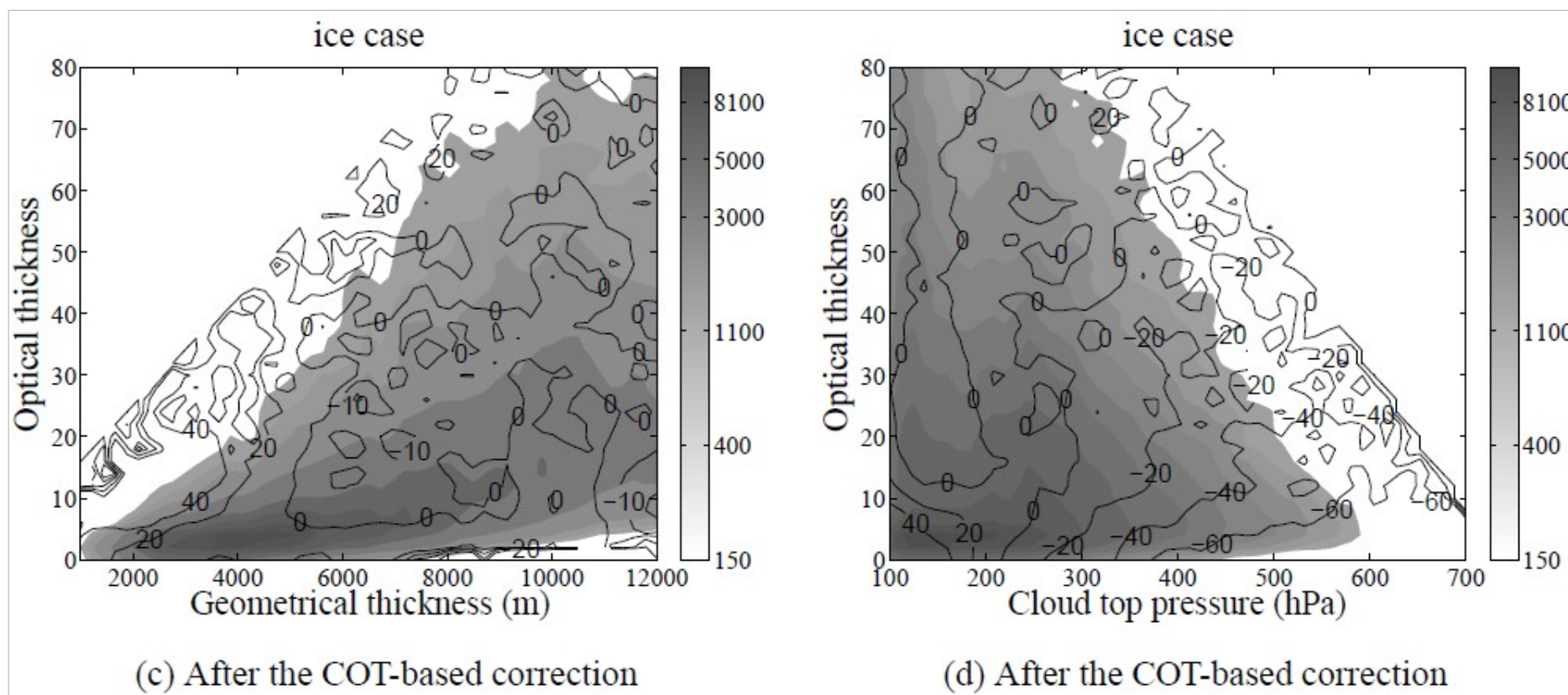
Difference between O₂ apparent pressure and mid-cloud pressure derived from Combined Cloudsat/Calipso GEOPROF product (hPa).



Ferlay et al , 2010 (submitted)

Ice clouds – single layers – uncorrected pressure

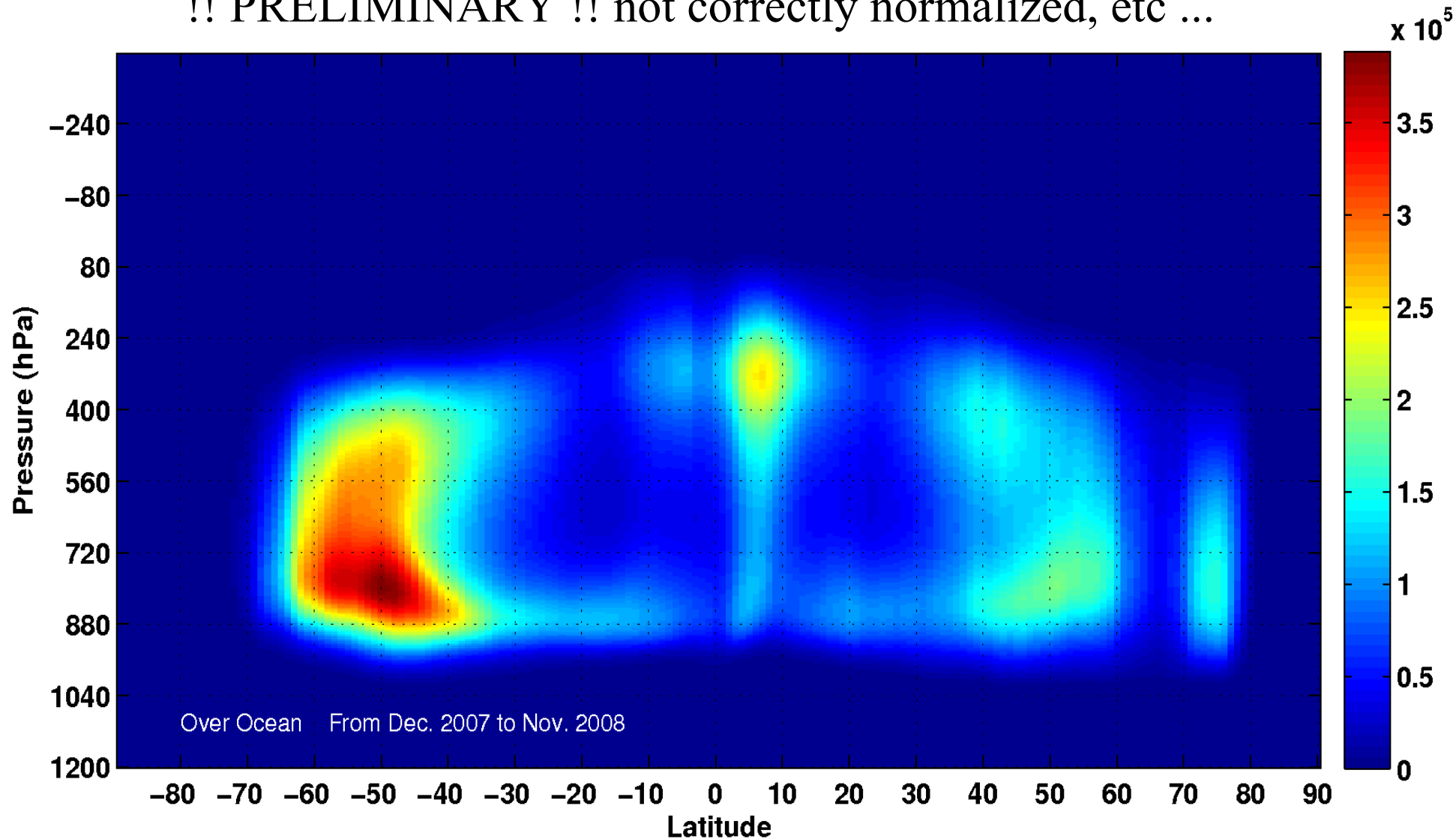
Difference between O₂ apparent pressure and mid-cloud pressure derived from Combined Cloudsat/Calipso GEOPROF product (hPa).



Ferlay et al , 2010 (submitted)

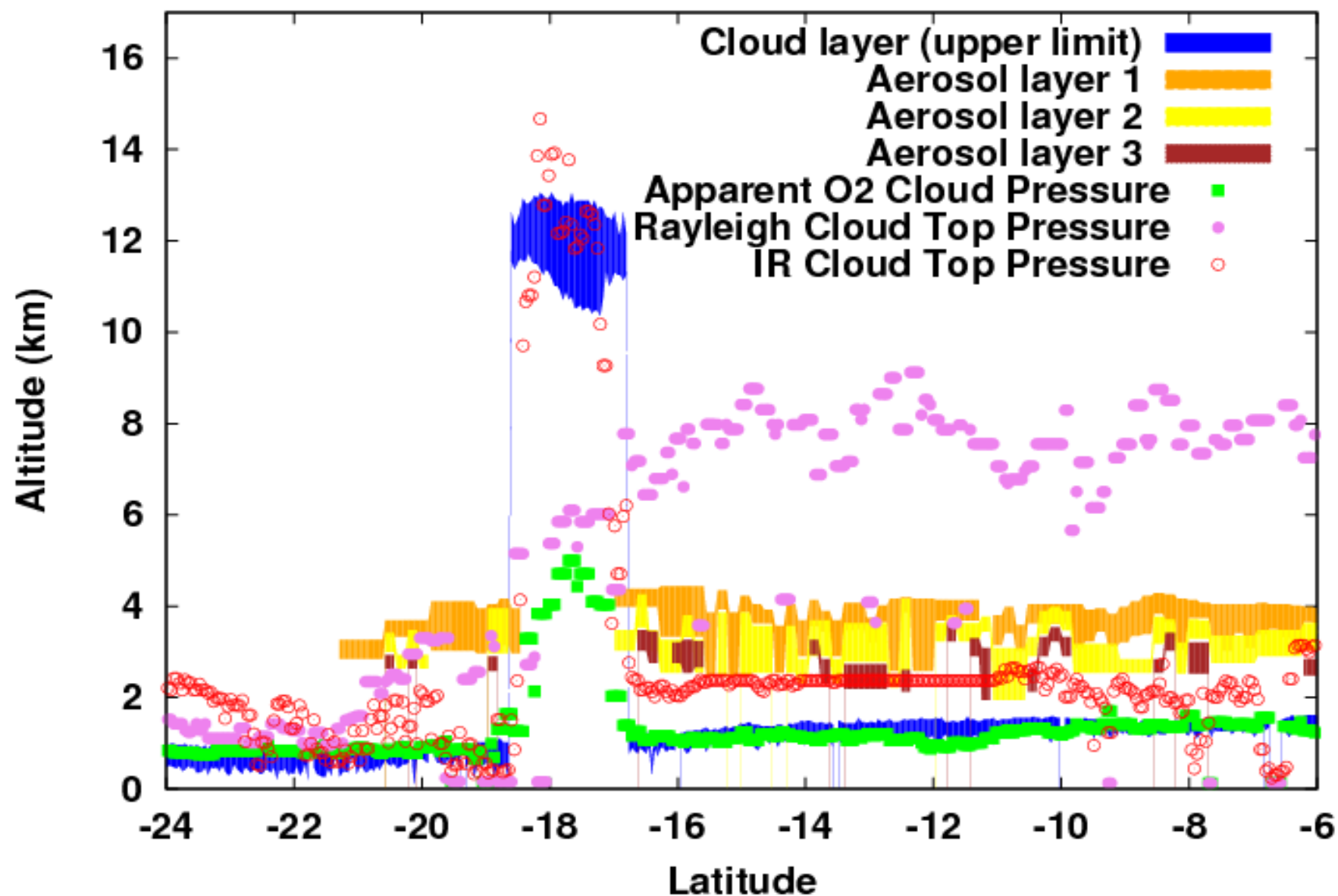
Ice clouds – single layers – corrected pressure

!! PRELIMINARY !! not correctly normalized, etc ...



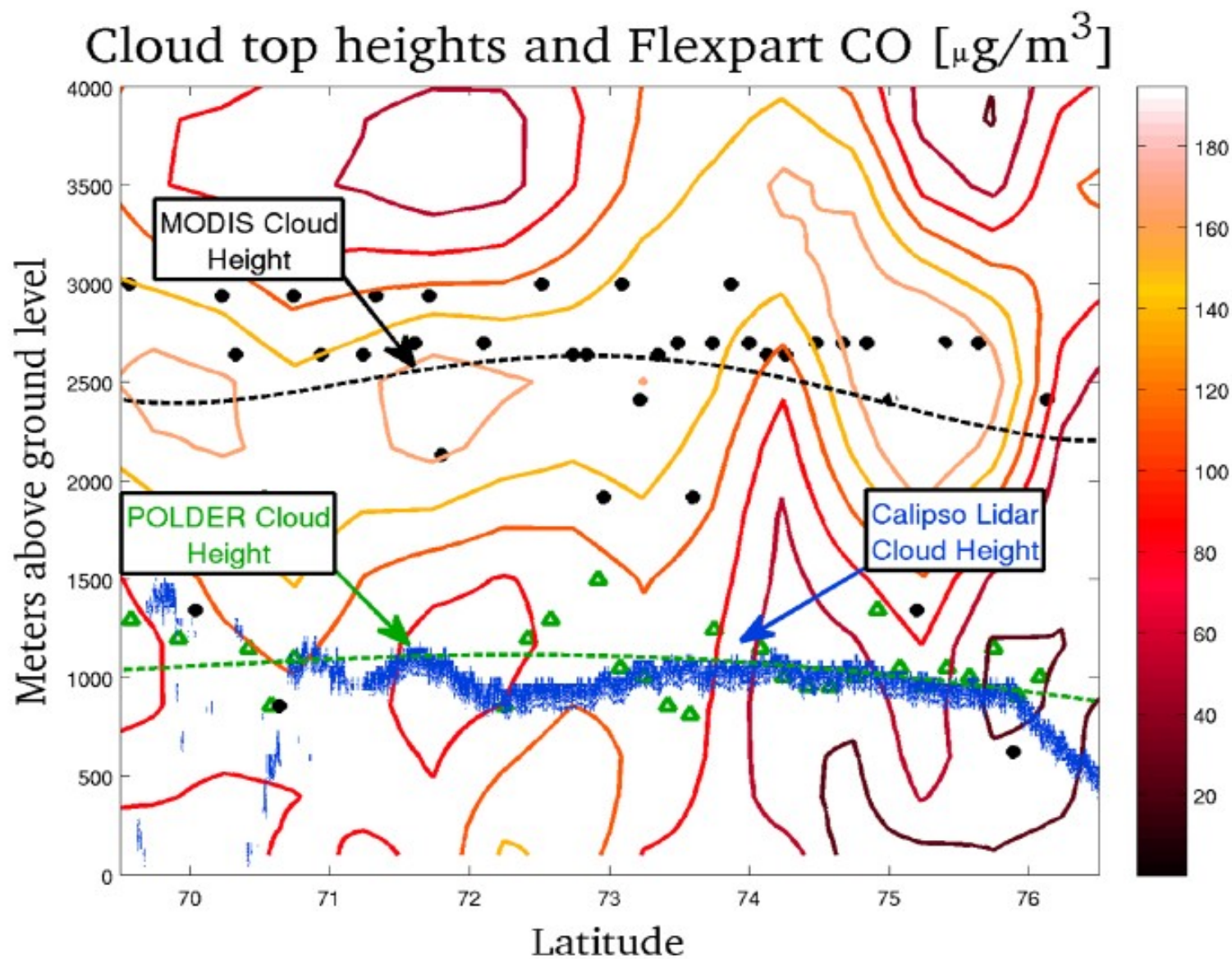
Use O2 as midlevel and Pray as top level and estimate a vertical extent of cloud layers.

Cloud top altitude in presence of aerosols



Waquet et al, 2009 (JAS)

Cloud top altitude in polar regions



Tietze et al, 2009 (presented at IAMAS)

Summary (1/2)

Cloud detection skills of POLDER algorithm are limited for

- thin (high) clouds due to limited spectral range (no IR channels)
- small broken clouds due to relatively coarse resolution
- Clouds over snow/ice except liquid clouds when rainbow can be observed.



- Multiangle measurements allow easier cloud/clear sky discrimination under sun glint condition.
- Quality index (confidence) of cloud detection is provided by the multiple viewing geometries
- Polarisation is very useful for aerosol/cloud discrimination

Summary (2/2)

- O2 A-Band apparent pressure derived from POLDER observation DOES NOT correspond to cloud top
- Rayleigh derived pressure from polarization is much closer to cloud top but can be biased by presence of aerosols above clouds.
- Combination of O2 A-Band and Rayleigh pressure carries information on cloud vertical extent → we're getting there.
- O2 performs well for lower clouds where the MODIS CO2 is not sensitive and the IR can be biased by temperature inversion.

