i-Geostationary Satellite Data Set At Full Space and Time Resol n

To Observe Tropical High Cloud Cover:

Evaluation with Lidar and IR soundeurs onboard Polar Orbiting Satellites

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Context

The **visible and infrared imaging radiometers on-board GOES, MTSAT, Meteosat (1-st and 2-nd generation) geostationary satellites** can observe high clouds and their environment on a time scale from a quarter-hour (over Africa and Atlantic) to about an hour. **High temporal sampling and spatial resolution provided by geostationary instruments is essential for the study of cumulonimbus towers spatial distribution, extension and altitude of cirrus anvils, and overshoot frequencies during the life cycle of convective systems.**

The information retrieved from visible/infrared radiometric observations needs to be evaluated and corrected/supplemented by more accurate measurements of the cloud top height and cloud optical and geometric thickness. Moreover, sub-visual cirrus with optical thickness smaller than < 0.3 are below the detection threshold of the visible/infrared imaging radiometers.

from Multi-Geostationary Satellite Data

Context (2)

Active measurements from the CALIOP lidar, CloudSat radar and from the AIRS sounders of the A-Train mission on board polar orbiting satellites give insight both on the thin cirrus occurrence frequency and on their vertical distribution. However, **these instruments observe the same region just twice a day** (at 1:30 AM/PM local time) and the lidar/radar field of view is small, so their picture of the convective system life cycle is incomplete. **Two additional observation times are available by including IASI observations** aboard the Metop satellites with 9:30 AM/PM local time at equator crossing.

Present study

For a summer and a winter season high cloud occurrence frequency in the tropics observed with geostationary (GEO) data is shown and compared with the AIRS/IASI sounder observations. For the summer season the GEO high cloud cover is compared with CALIOP lidar and sounder AIRS observations to quantify its ability to detect high clouds and retrieved its cloud top altitude. Both mean and instantaneous statistics are used in this analysis.

Thanks to SATMOS(INSU-METEO-France), ASDC(NASA) and ICARE (CNES) for the DATA Provsion

THE MULTI-GEOSTATIONARY DATA SET

Cloud Type Classification and Cloud Top Pressure from June 2009 Until Present

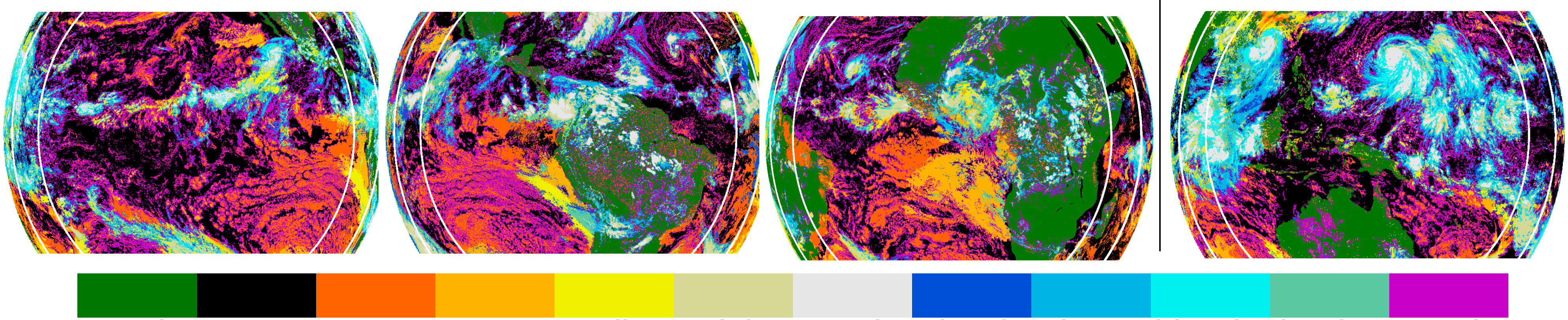
➔ Multi-spectral threshold technique developed for the radiometer SEVIRI on board MSG by the *Satellite Aplication Facility for NoWCasting* (Marcel Derrien and Hervé Legleau, 2005, 2010)

➔ 5 satellites in the minimal configuration with at least one visible channel, two IR channels (10.8µ, 3.9µ), one WV or CO2 sounder channel (Sèze et al. 2015)

For the moment one missing satellite

No 12µ channel

GOES-W 4 channels **GOES-E** 3 channels **SEVIRI** 5 channels **MTSAT** 4 channels



Land Sea VeryLow Low Medium High VeryHig. Th. Cir. Cirrus Thk. Cir.Th. AbovePartial

The white curves indicate for each satellite the 72.5° VZA and 55° VZA.

For partial cloud cover and for some GOES and MTSAT cirrus cloud top pressure is not available.

Day and Night differences in the data: VIS radiance data during daytime, solar contribution in the 3.7µ radiance.

The Indian ocean and Meteosat-7

Undergoing work

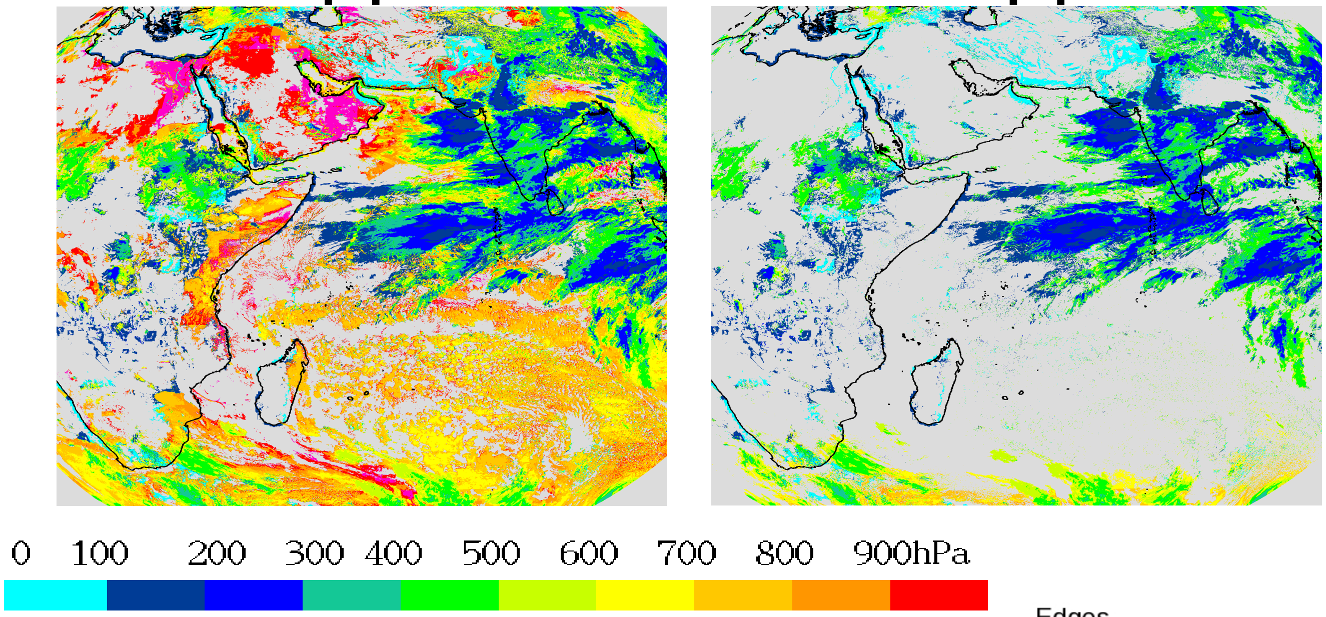
➔Application of the ISCCP algorithm (Rossow and Shiffer, 1991) at full spatial resolution and each half hour (G. Sèze- collaboration with W-B Rossow)

➔Application of the **Dynamic Cluster Method** using VIS, IR and WV radiances in the aim to detect cirrus during nigh-time and improve cirrus detection during daytime (Sèze and Pawlowska, 2001)

15 july 2009 - 0900UTC

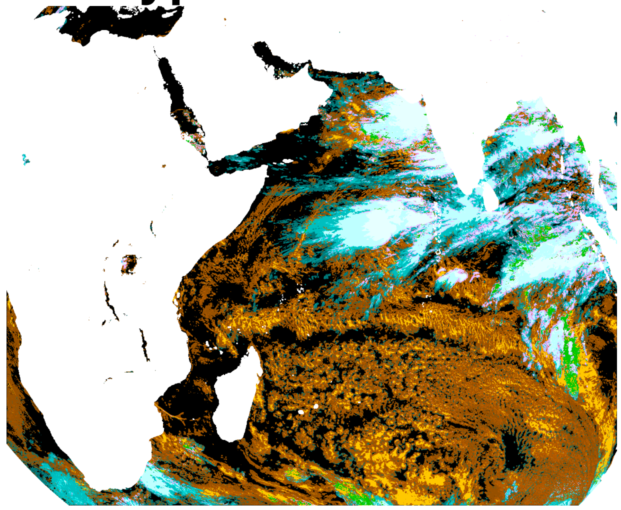
ISCCP

Cloud top pressure **Ice cloud top pressure**



Dynamic Cluster Method

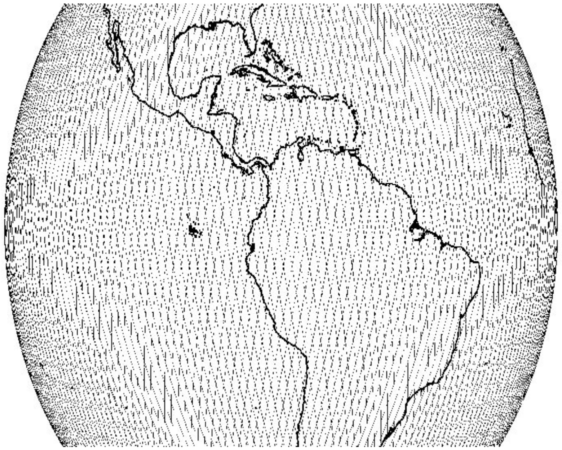
Cloud Type Classification



COINCIDENT GEOSTATIONNARY/ LIDAR/SOUNDER DATA

For a four month period (June to September 2009) the **SEVIRI, GOES-E, GOES-W and MTSAT** cloud classification and cloud top pressure data have been collocated on The **CALIOP** foot print. (Sèze et al., 2015).

orbit tracks for GOES-E



CALIOP DAY and **NIGHT** overpass time:
1h30 AM/PM local time. Mean lag between the GEO and CALIOP observation depends on the GEO.

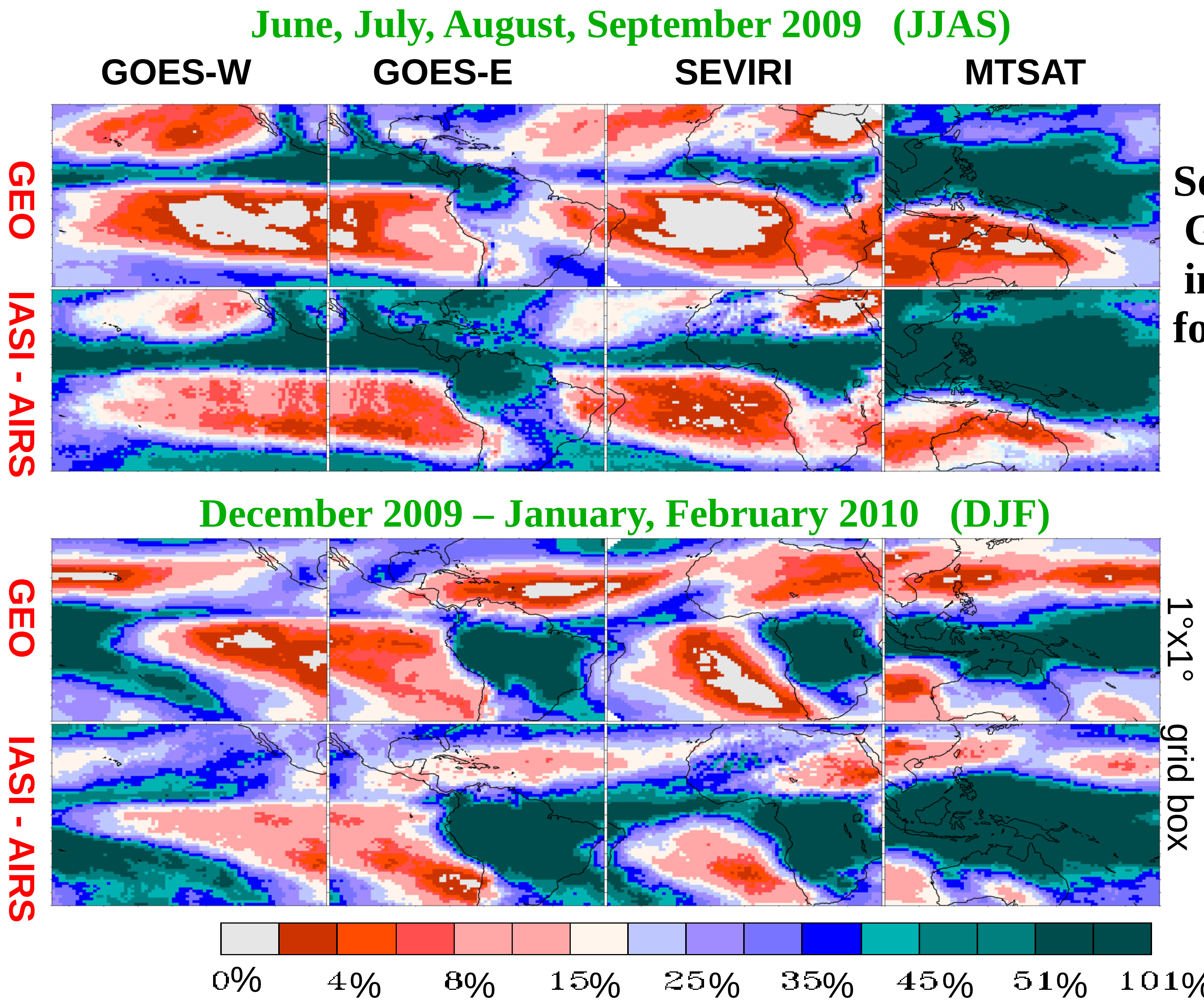
Version 3 of the cloud layer operational product for the CALIOP 5km average profile is used.
The CALIOP cloud cover include all the thin cloud with optical depth above 0.1.

AIRS and IASI SOUNDER DATA

The AIRS (1h30 AM/PM) and IASI (9H30 AM/PM) cloud cover are obtained both with the LMD algorithm (Stubenrauch et al., 2008) and using the ERA interim atmospheric profiles. A data set giving access four time a day to the cloud top altitude and emissivity in a large part of the tropics with no change in sensitivity of the measurements between day and night .

GEO and SOUNDEURS HIGH CLOUD OCCURRENCE FREQUENCY
AVERAGE OVER THE DIURNAL CYCLE

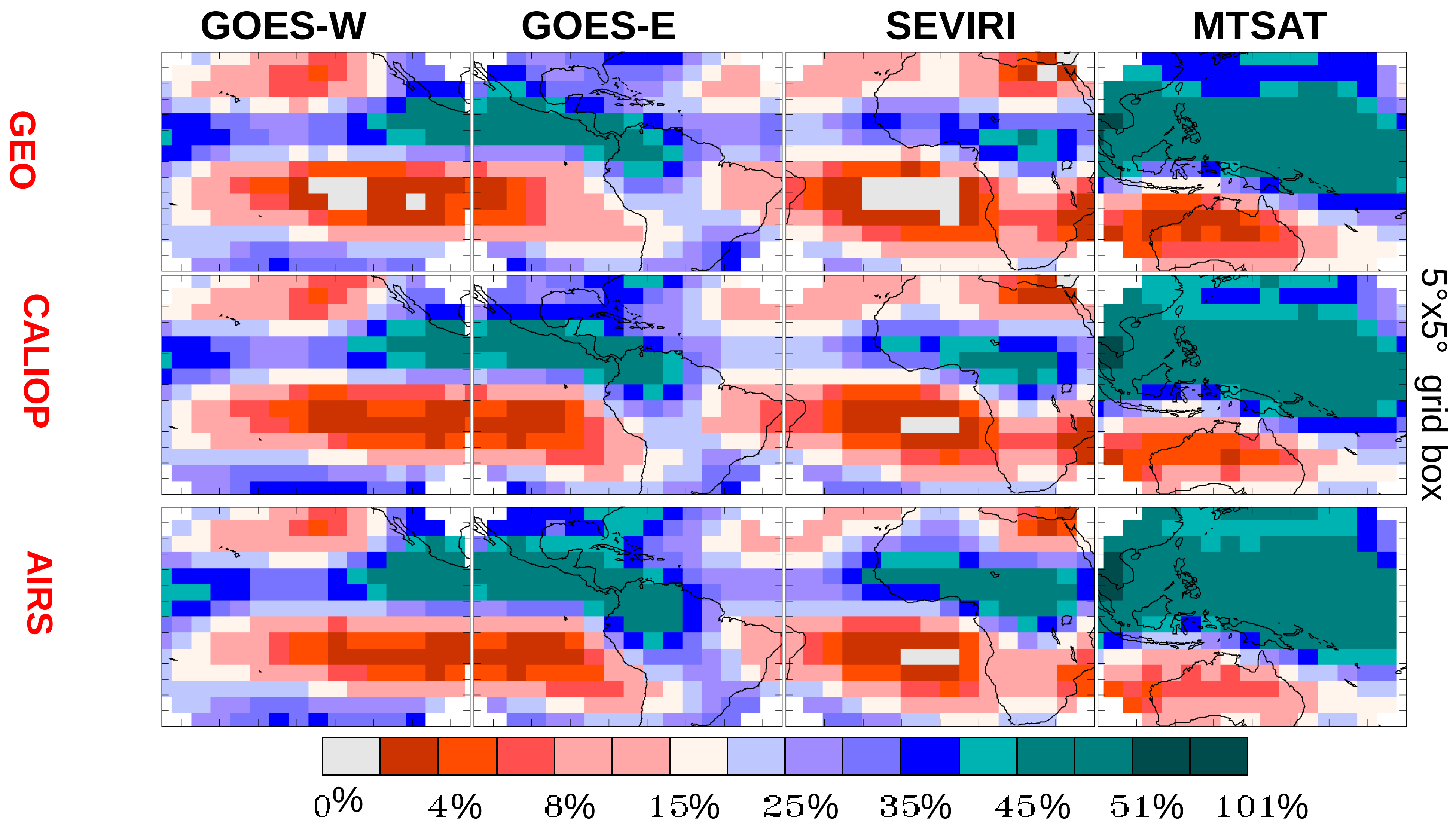
GEOs each 01h30, IASI-AIRS 9h30 and 1h30 AM/PM



Sounder HCOF > GEO HCOF in all the regions and for the two seasons

High Cloud Occurrence Frequency at 1H30 AM+PM
Coincident GEOs, AIRS and CALIOP observations

June, July, August, September 2009 (JJAS)



When very thin cirrus with OD<0.1 not taken into account:

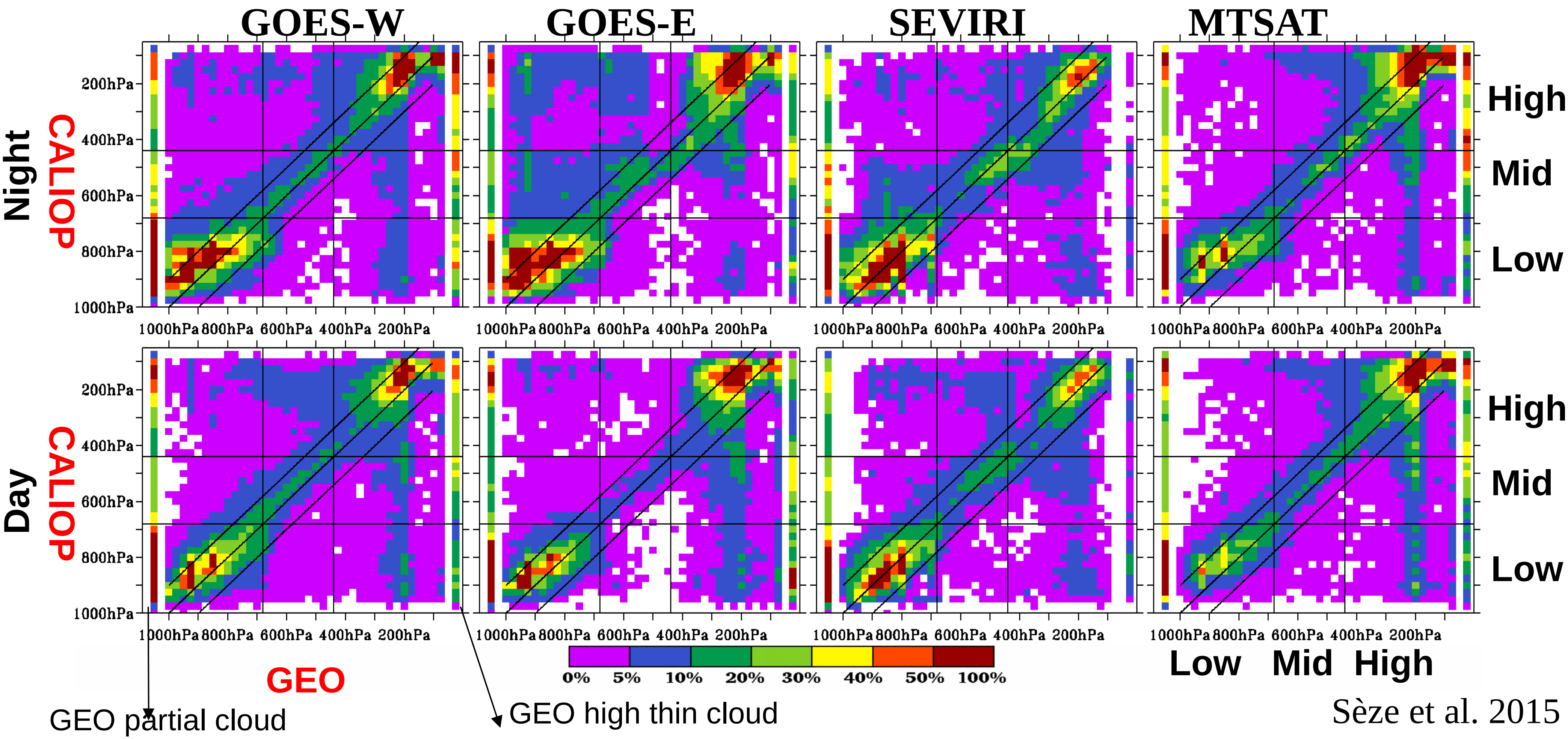
→ sounder HCOF > CALIOP HCOF

→ GEO HCOF in +/- 5% of CALIOP HCOF (Sèze et al. 2015)

GEO and CALIOP INSTANTANEOUS MEASUREMENTS COMPARISON

GEO versus CALIOP cloud top pressure distributions for nightime and daytime

OCEAN



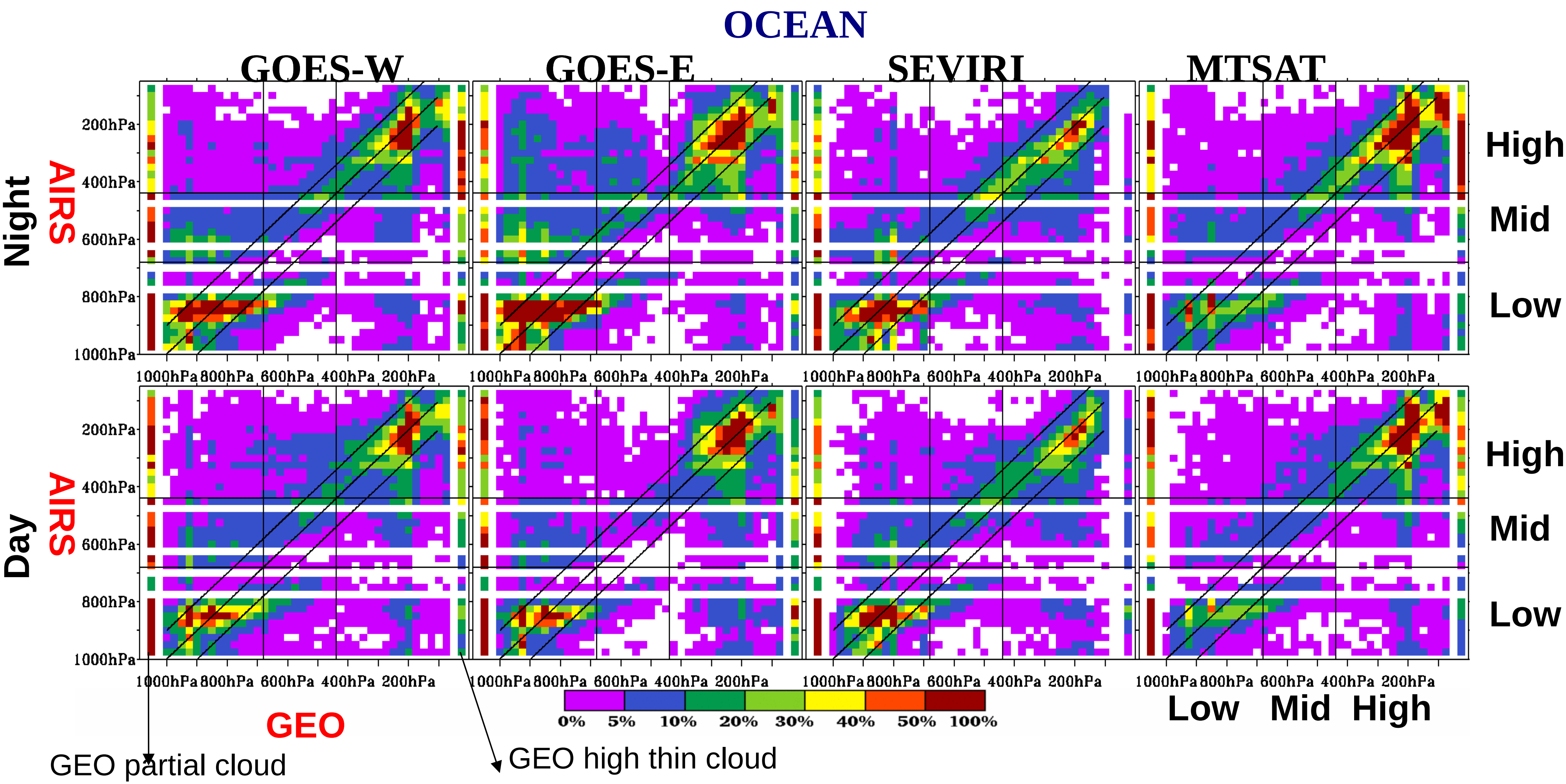
Sèze et al. 2015

Agreement between CALIOP and the GEOs on the detection of high cloud including high cloud over another layer between 75% and 85%.

Underestimation of cloud top altitude by the IR radiometry compared to CALIOP lidar as already observed in other studies

GEO and AIRS INSTANTANEOUS MEASUREMENTS COMPARISON

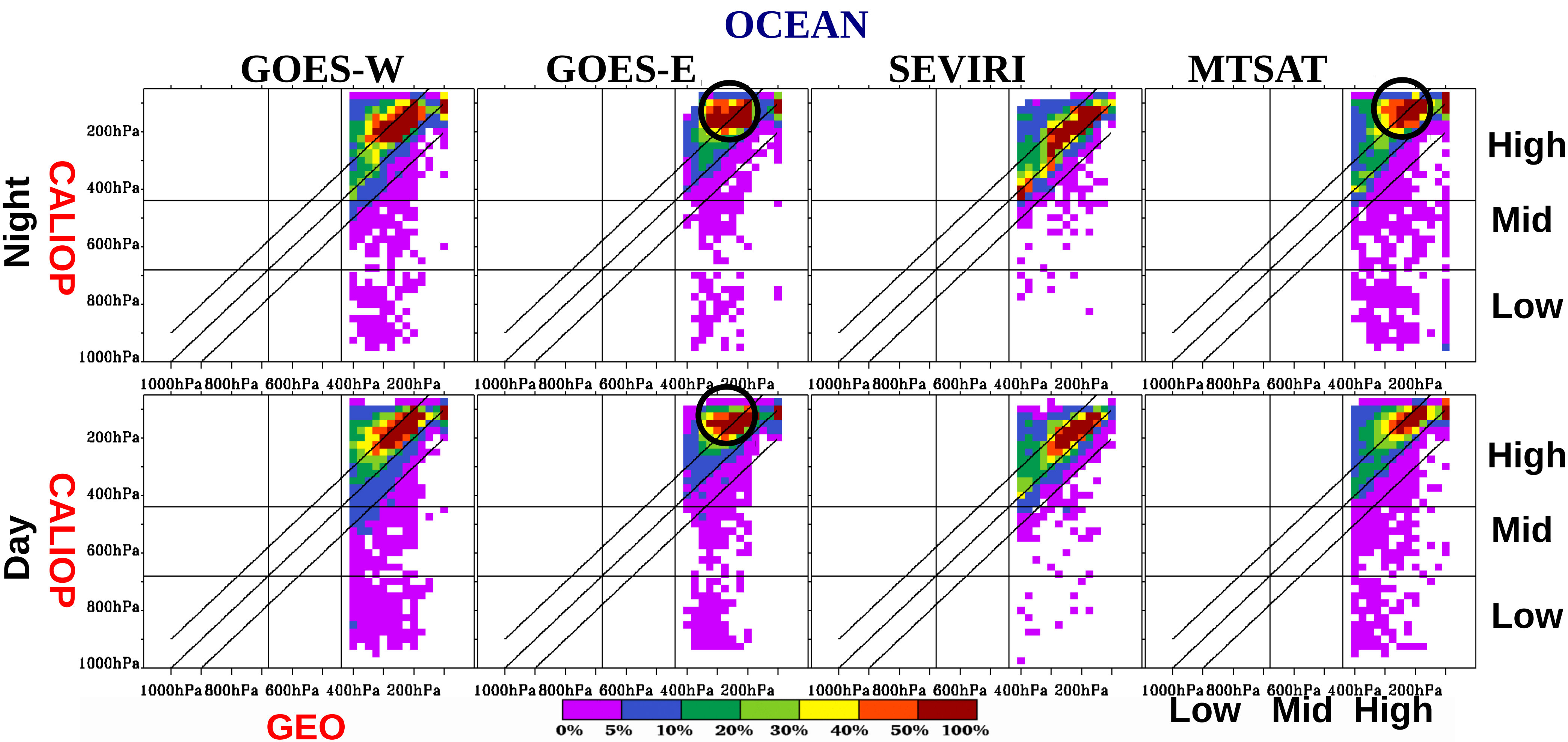
GEO versus AIRS cloud top pressure distributions for nightime and daytime



No systematic bias between the GEO and AIRS sondeur high cloud top pressure

GEO and CALIOP CLOUD TOP PRESSURE

Thick High Clouds in the GEO field of view

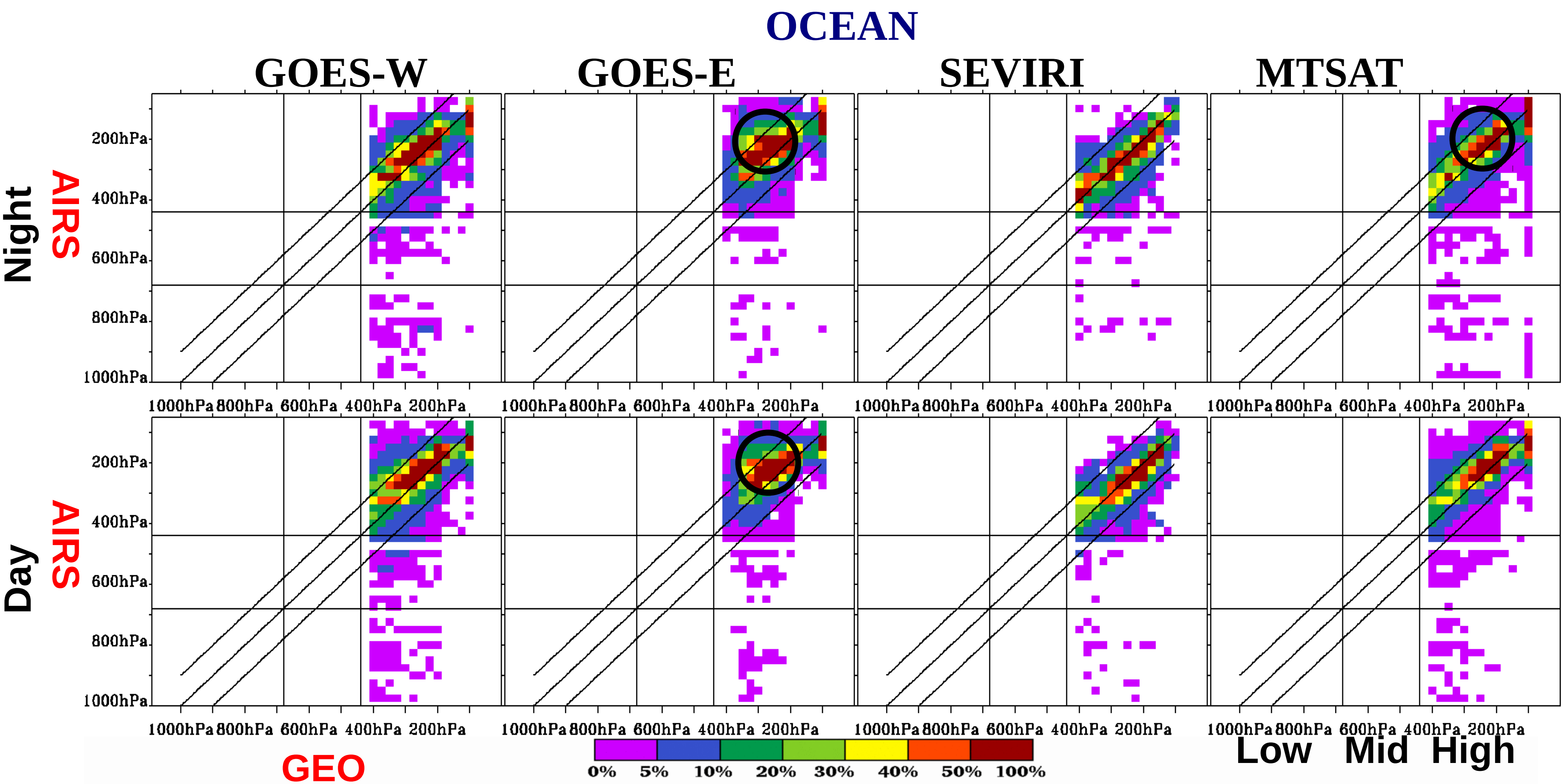


As well over land than over ocean the best agreement between CALIOP and GEO cloud top pressure is found for SEVIRI

The largest discrepancy are observed for GOES-E but for MTSAT during night-time.

GEO and AIRS CLOUD TOP PRESSURE

Thick High Clouds in the GEO field of view



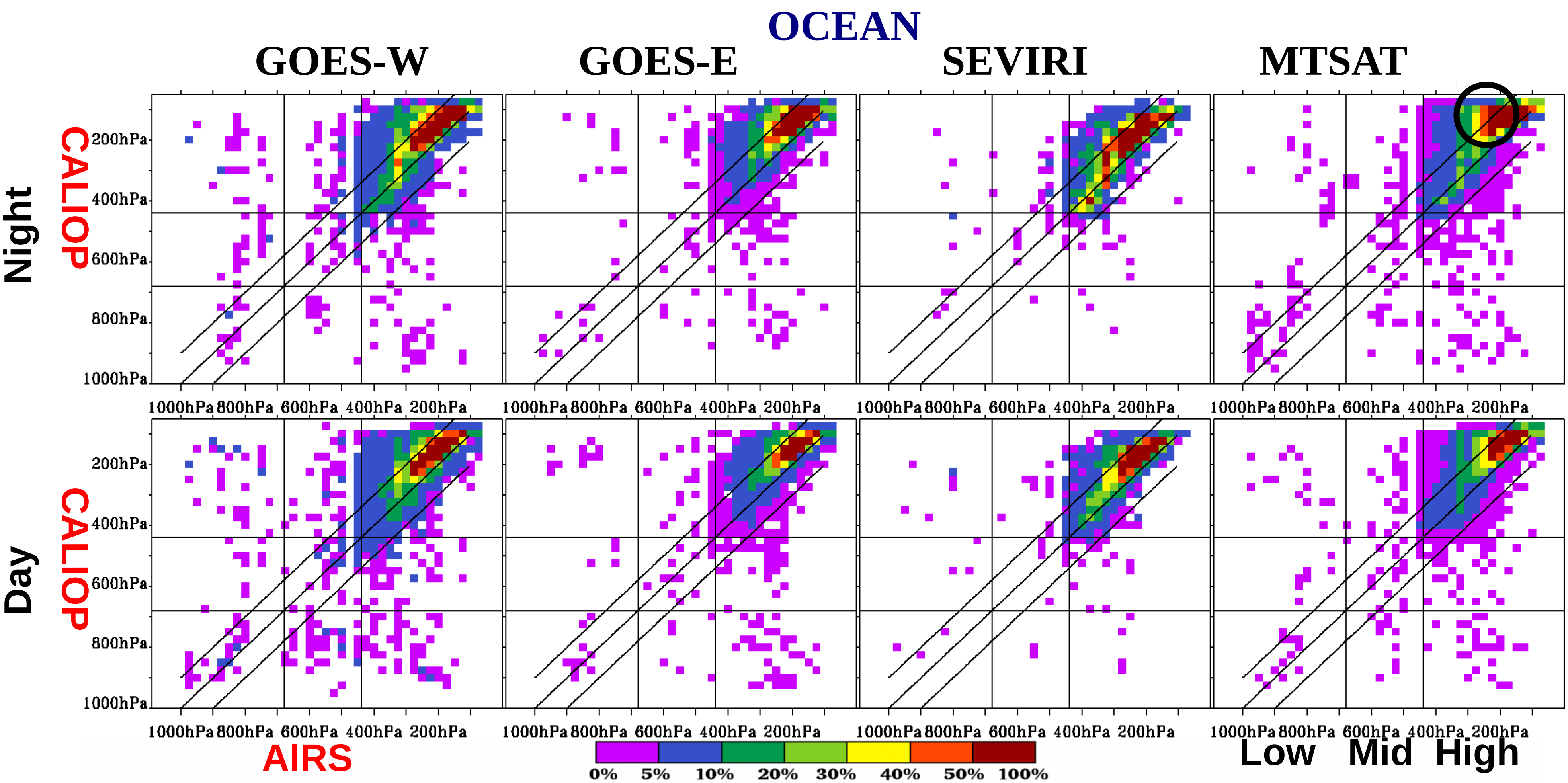
As well over land than over ocean the best agreement between AIRS and GEO cloud top pressure is found for SEVIRI.

The largest discrepancies are observed for GOES-E. Lack of 12μ channel leads to a less better separation between thick cirrus and high thick clouds?

The agreement between AIRS and MTSAT is good.

AIRS and CALIOP CLOUD TOP PRESSURE

Thick High Clouds in the GEO field of view

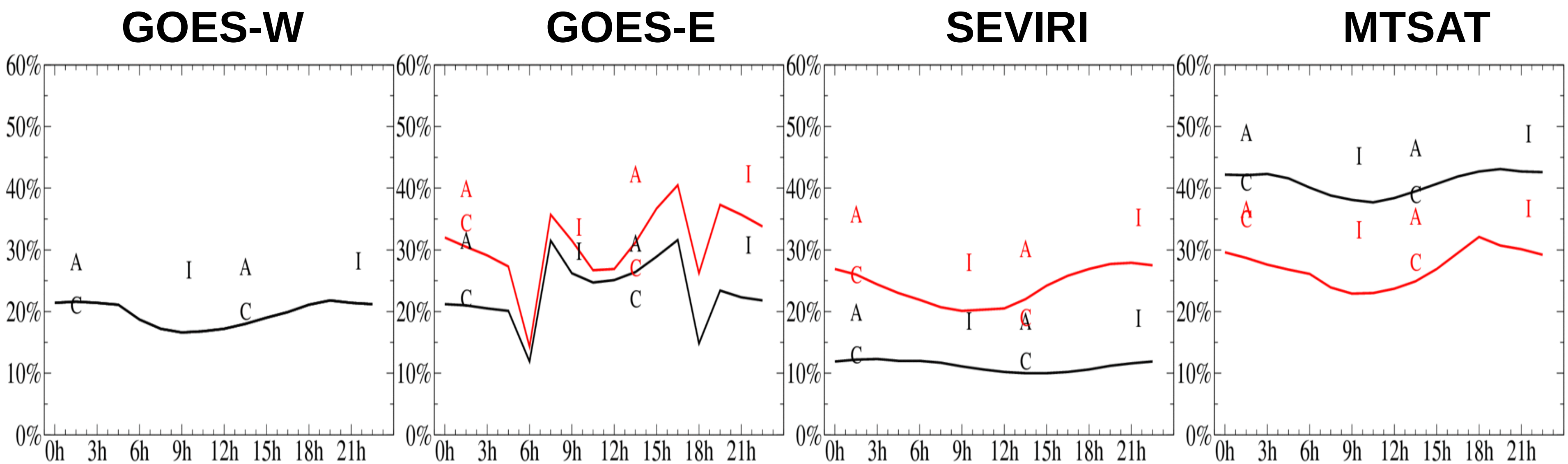


In the MTSAT field of view the highest CALIOP cloud are also underestimated by AIRS.

HIGH CLOUD OCCURRENCE FREQUENCY DIURNAL CYCLE

June, July, August, September 2009

GEO : 1h30 time step - CALIOP and AIRS : 0130 AM and PM – IASI : 0930 AM and PM



C: CALIOP A : AIRS I : IASI — OCEAN — LAND

Taking CALIOP as reference GEO do not underestimate high cloud OFs. The AIRS and IASI high cloud OFs are larger.

The sign of diurnal variations of sounder HCOF and GEO HCOF are in agreement.

Diurnal variations of HCOF below 5% over ocean and 10% over land.

For GOES-E: lack of 12µ channel, at twilight large underestimation of HCOF, during daytime some thin middle clouds or small low clouds classified thin cirrus.

Institut Pierre Simon Laplace

CONCLUSION

LMD

When the field of view of each GEO is limited to VZA < 55° and CALIOP cloud layer with optical thickness smaller than 0.1 or detected at a scale larger than 5km are not taken into account GEOs and CALIOP HCOF are close. CALIOP high thin clouds are very well detected over ocean. The GEO's and CALIOP high clouds are in agreement in more than 80% of the cases. This is reduced to 70% for the cirrus over another layer.

Compared to CALIOP, as expected the GEOs under-estimates the cloud top altitude.

AIRS and IASI HIGH COF are larger than the GEOS HIGH COF. In this recent version of the LMD AIRS/IASI cloud products the bias can reach 10%. No systematic bias is observed between GEO and AIRS cloud top pressure.

➔ Near Future

Go further in the comparative analysis between GEOs high cloud cover and CALIOP AIRS and IASI high cloud cover using instantaneous measurements.

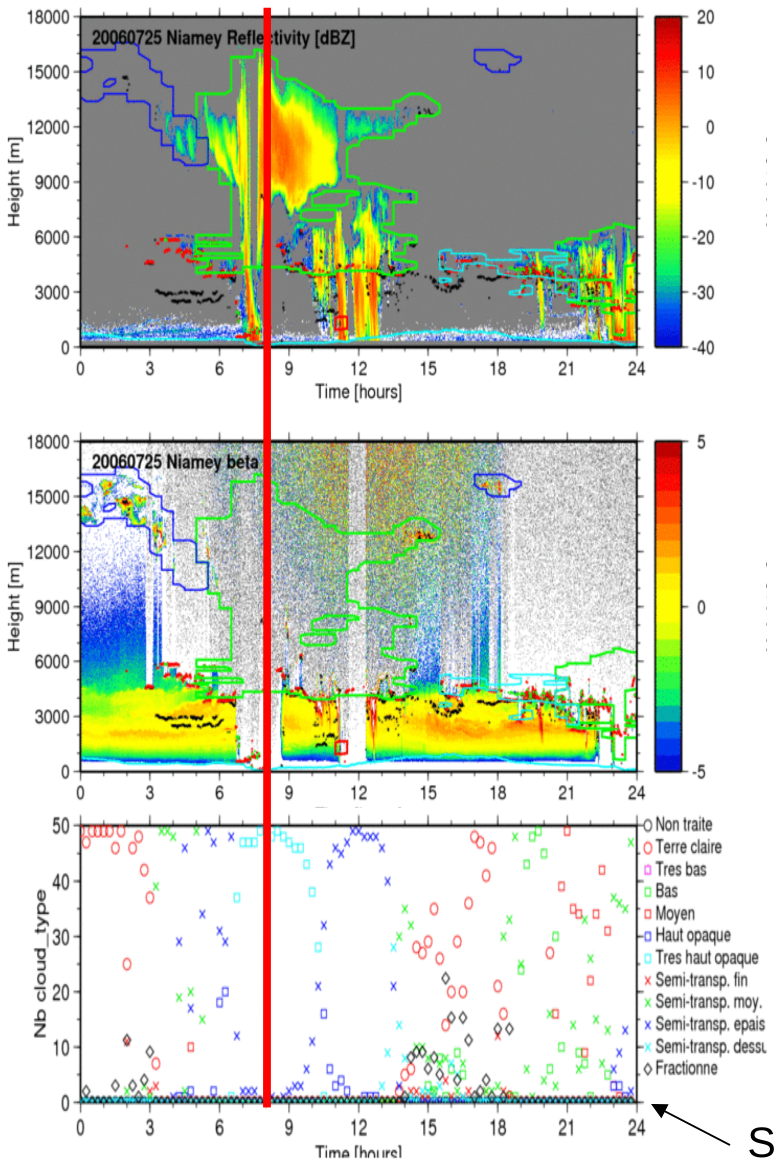
Quantify the frequency and altitude of CALIOP very high thin cloud layers (OD<0.1) not detected by the GEOs and detected or not detected by the sounders.

Analyse the separation in cirrus and thick high clouds given by the GEOs with that is observed with CALIOP, AIRS/IASI. Add CLOUDSAT in the analysis in order to differentiate thick cirrus anvils from the convective part in convective systems.
Use these information to improve the GEO products by analysing the spatial and temporal variations of the IR spectral signatures.

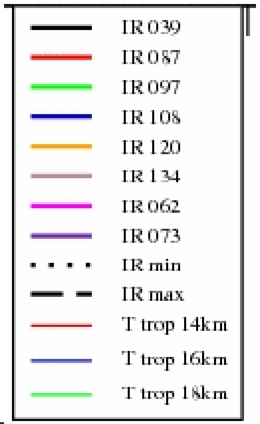
Overshooting cloud top observed with the MSG geostationnary satellite and the radar and lidar of the Niamey ARM station during AMMA

25 July 2006

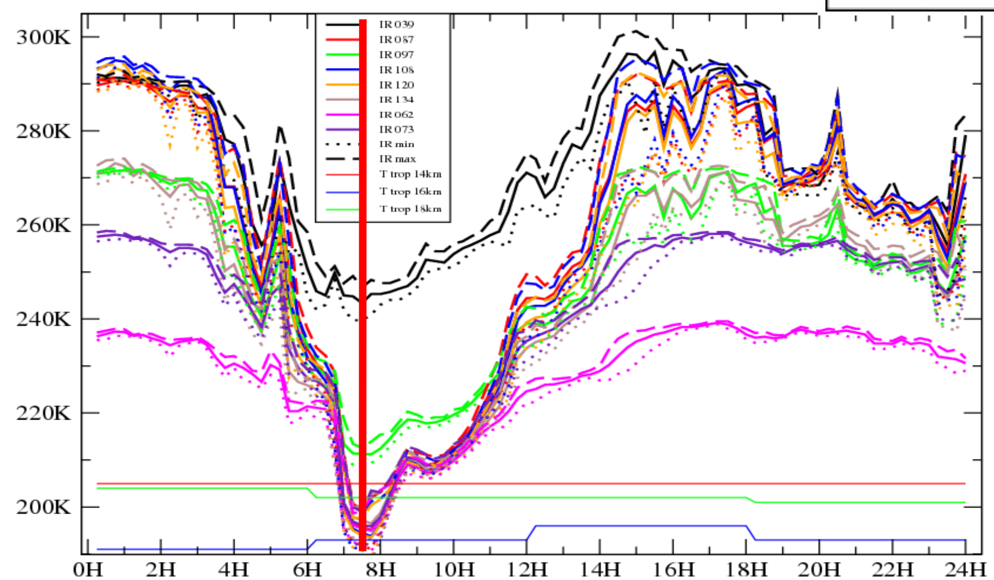
Radar and lidar profils from 00GMT to 24GMT



SEVIRI/MSG radiometer brightness temperature
8 IR spectral bands, 15' repeat cycle, 3km resolution.
And 14, 16 et 18 km ECMWF temperature



Brigthness temperature time evolution over Niamey



SEVIRI/MSG cloud type classification

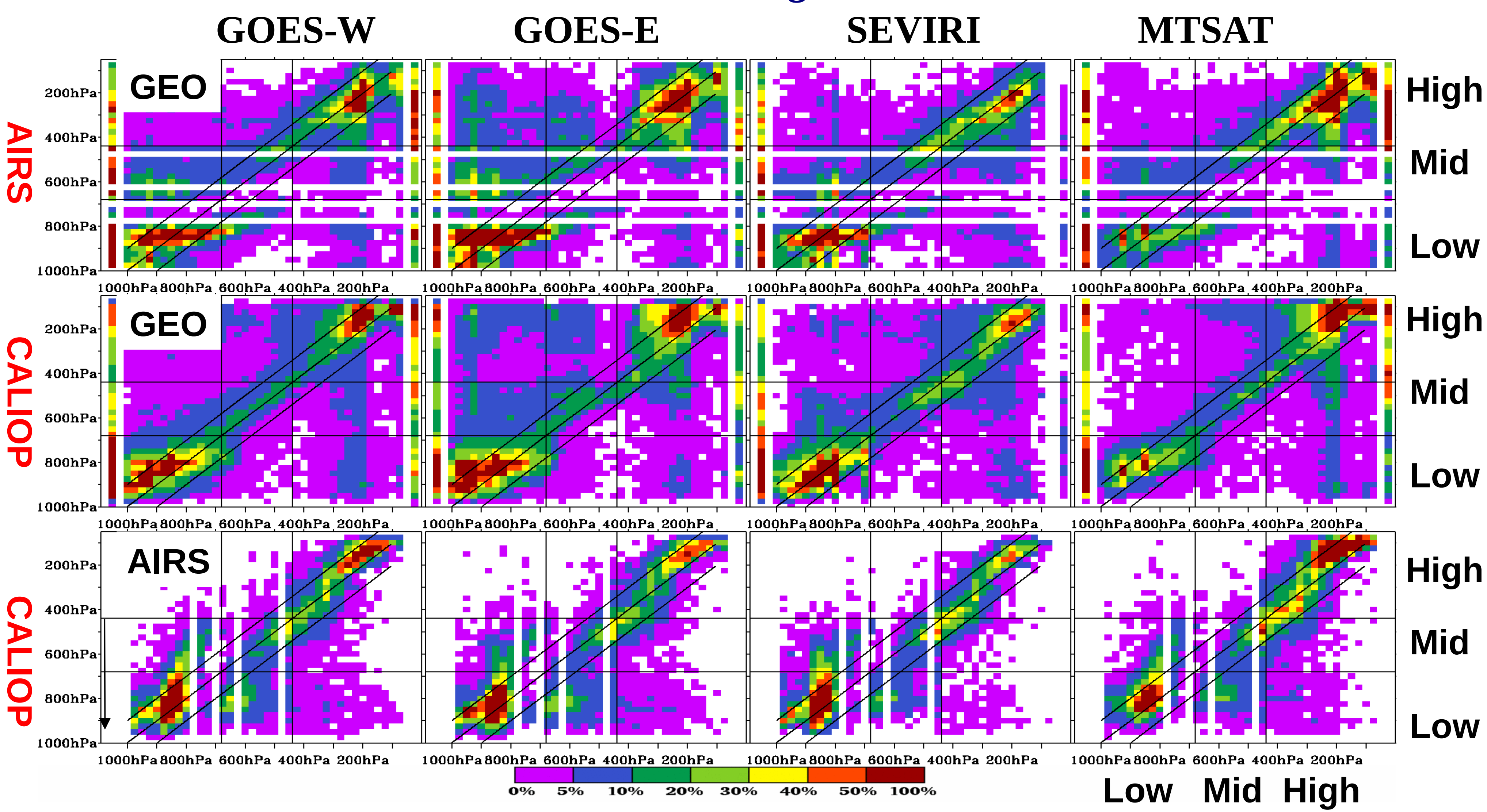
Quick look - D. Bouniol, CNRM

Thibaut Laffineur -Rapport de stage de M2

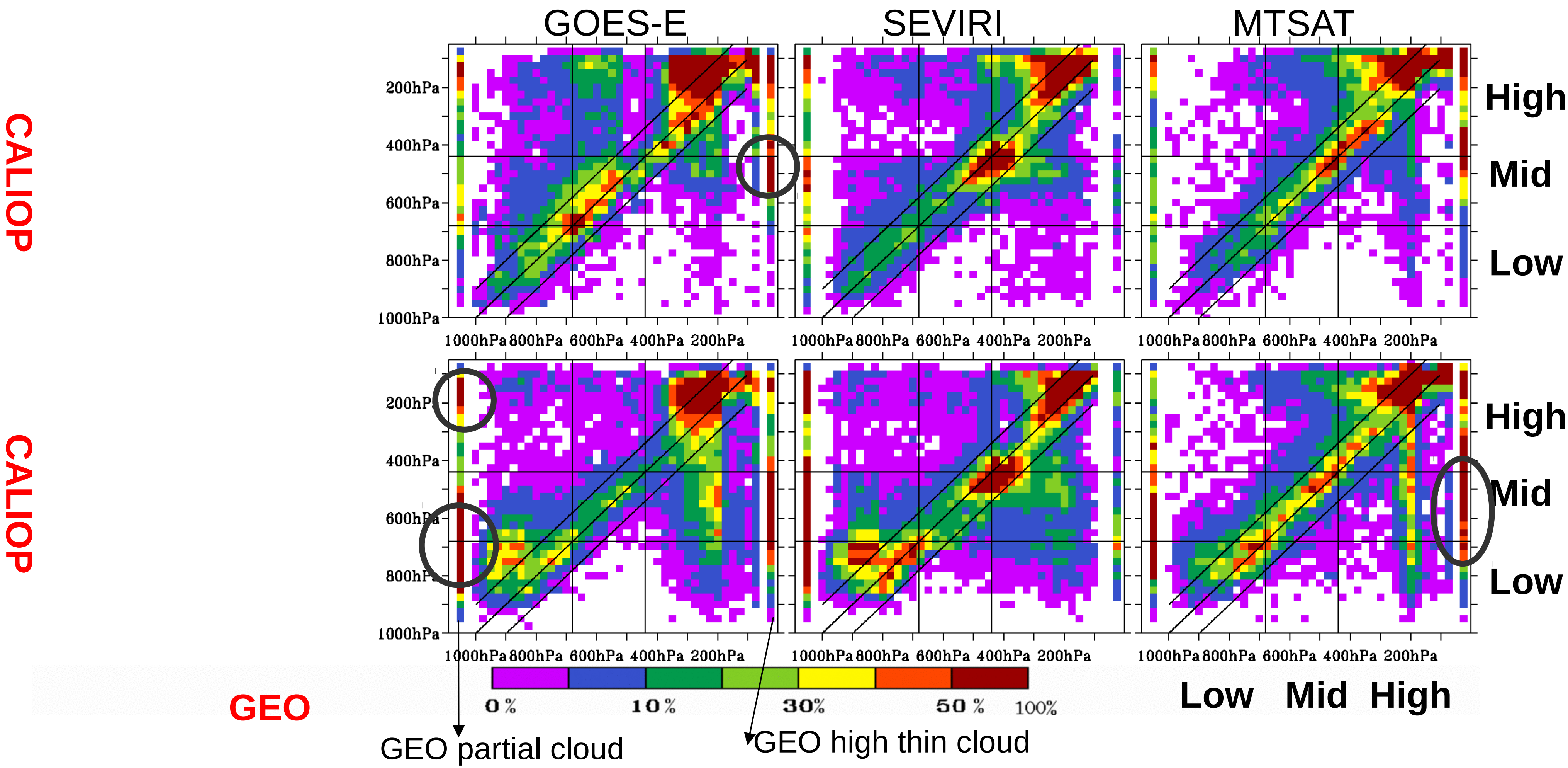
THANK YOU

GEO - CALIOP - AIRS - CLOUD TOP PRESSURE

OCEAN - Night-time

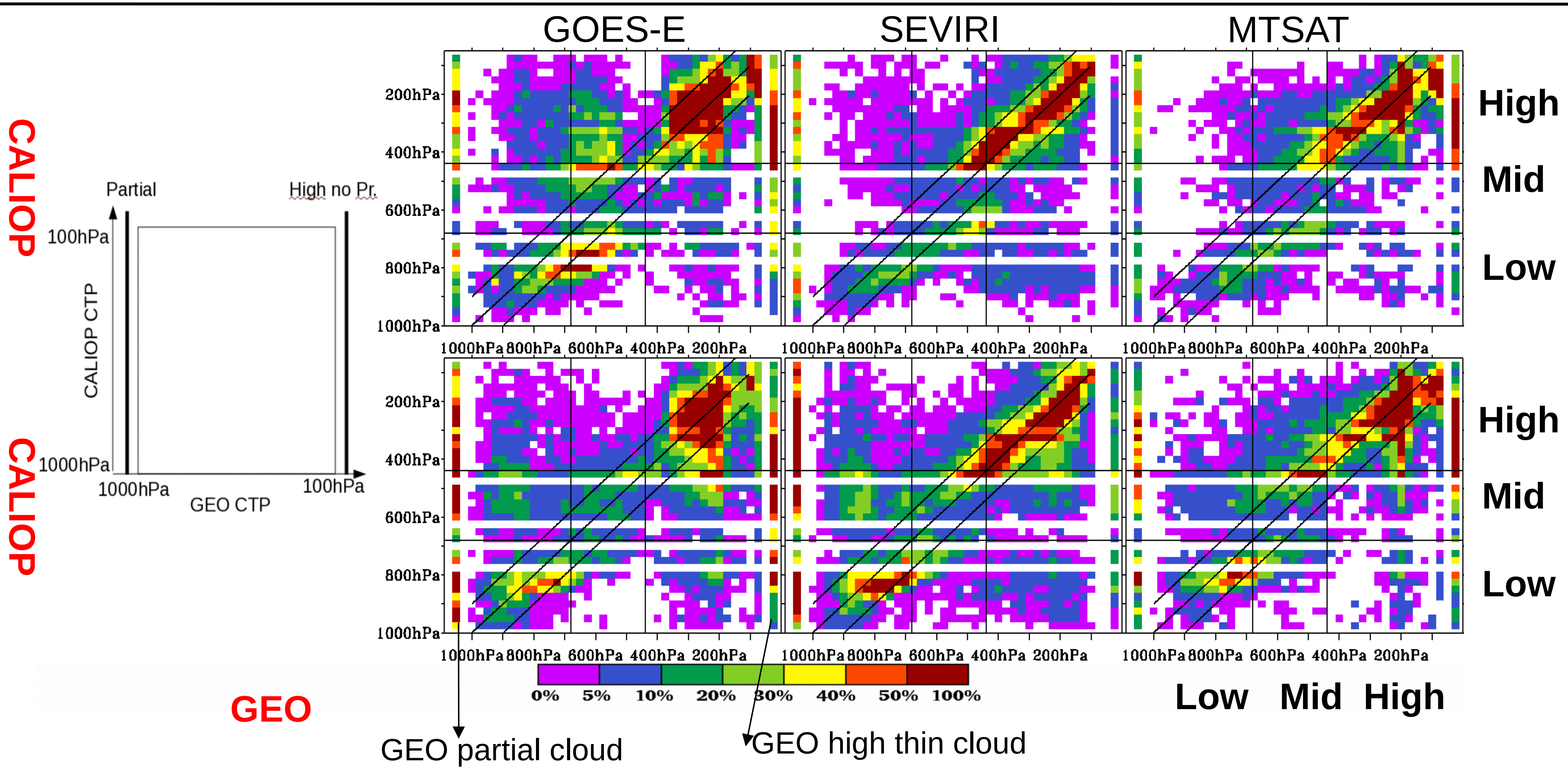


Night and day GEO versus CALIOP cloud top pressure distributions
LAND

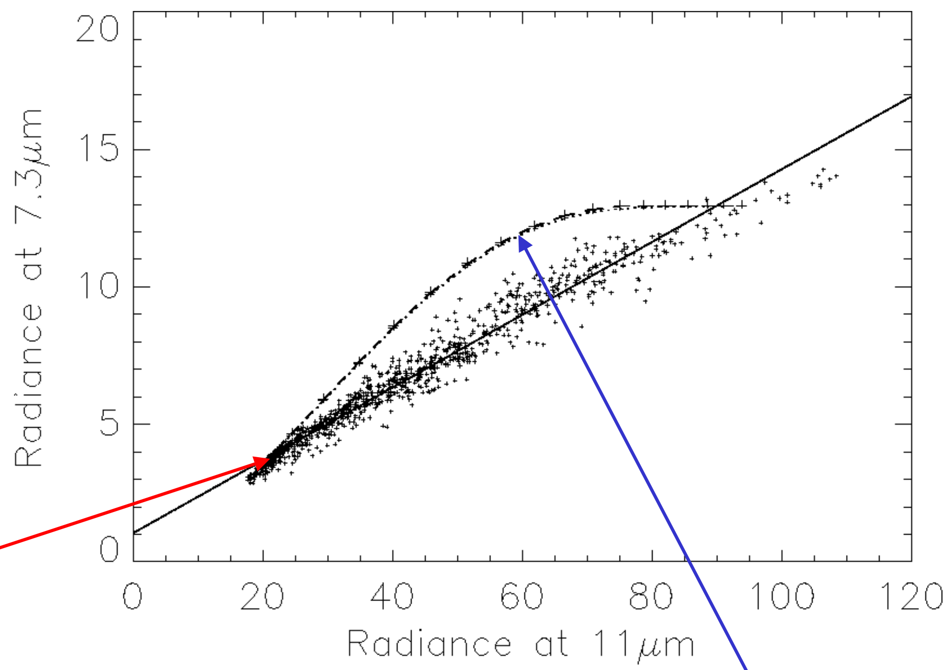


Night and day GEO versus CALIOP cloud top pressure distributions

LAND



Semi-transparent cloud top retrieval: the intercept method



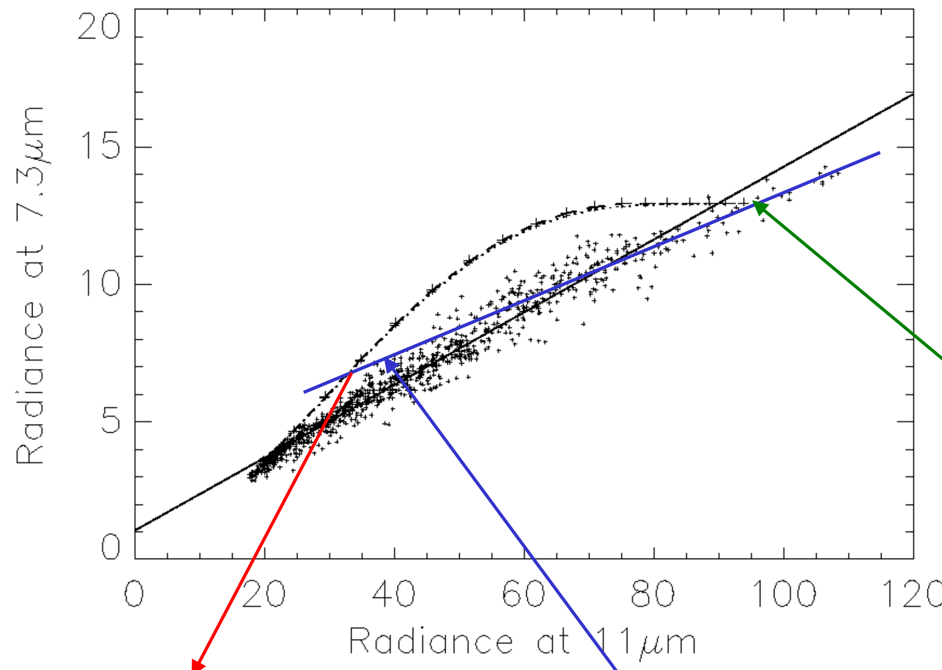
Top pressure of the semi-transparent cloud layer is retrieved from the intersection between:

-Simulated radiances of opaque clouds at various pressure levels.

-Regression line on measured radiances of clouds at the same height, but with varying thickness.

Le Gleau and Derrien, Meteo-France

Semi-transparent cloud top retrieval: the radiance ratioing method



Clear pixel

Retrieved opaque

Cloud Top Pressure

Semi-transparent

Cloudy pixel

Le Gleau and Derrien, Meteo-France

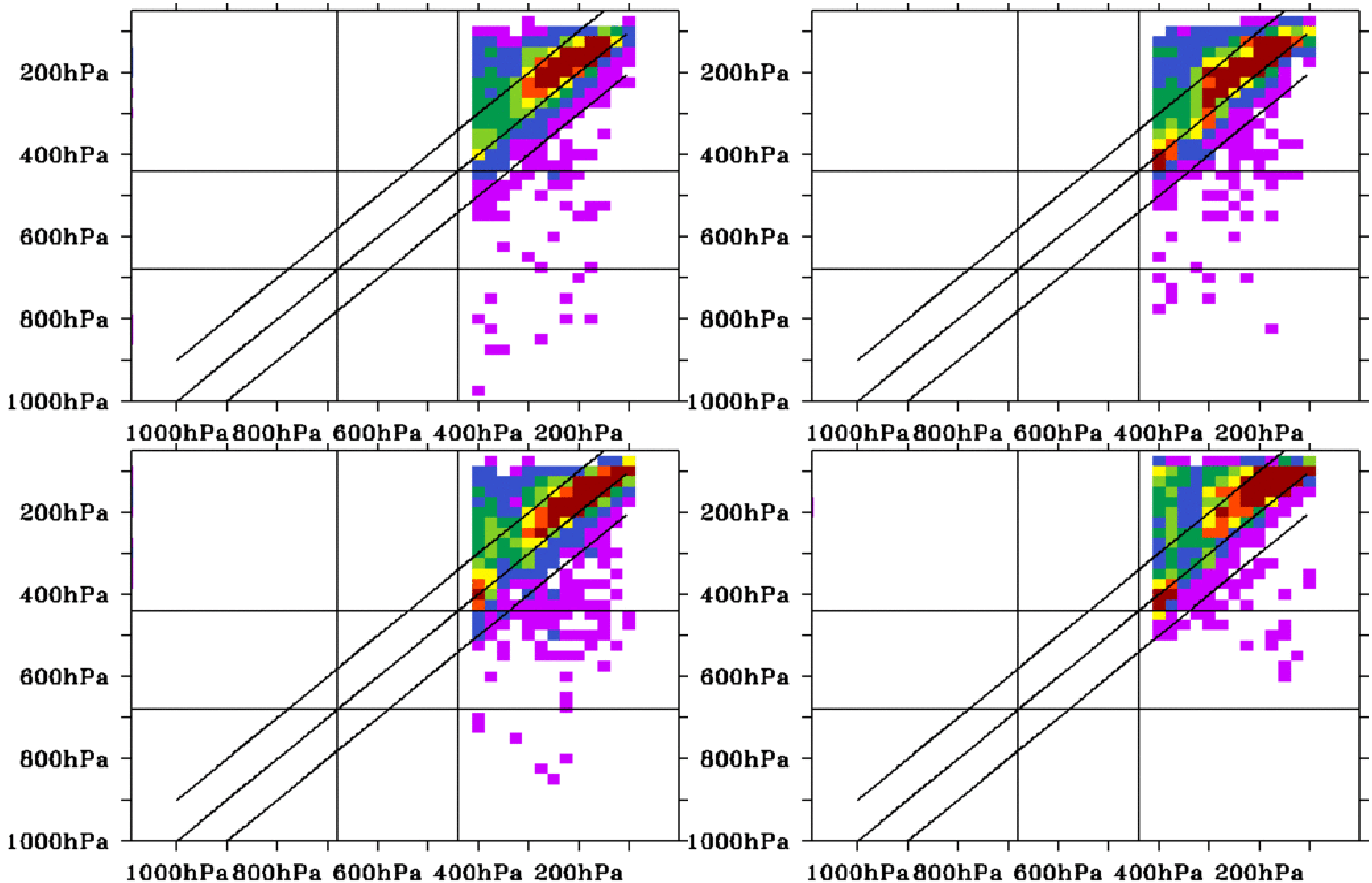
GEO versus CALIOP cloud top pressure distributions Over ocean and land for nighttime and daytime

Thick High Clouds in the SEVIRI field of view

NIGHT | DAY

OCEAN

LAND



HIGH CLOUD OCCURRENCE FREQUENCY DIURNAL CYCLE

June, July, August, September 2009

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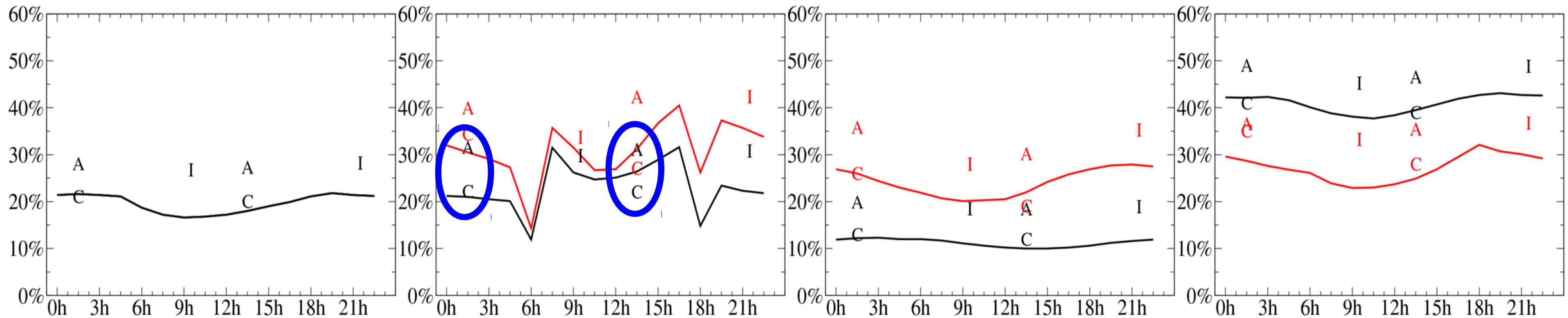
GOES-W GOES-E SEVIRI MTSAT

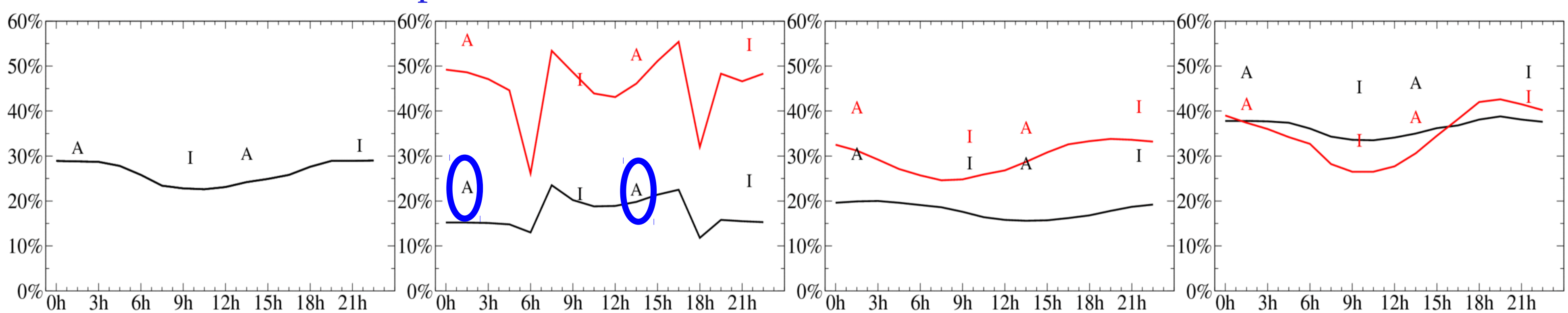


C: CALIOP A : AIRS I : IASI

OCEAN **LAND**

December 2009, January and February 2010

GEO : 1h30 time step - AIRS : 0130 AM and PM – IASI : 0930 AM and PM



Including all the thin cloud layer with OD > 0.1 CALIOP HCOF and GEO HCOF are close

The sign of diurnal variations of sounder HCOF and GEO HCOF are in agreement