

Occurrence and Vertical Distribution of Tropical High Clouds from Multi-geostationary Satellite Data Evaluation with Lidar and IR sounders data onboard Polar Orbiting Satellites



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INTRODUCTION

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 timescale from a quarter-hour (over Africa and Atlantic) to about an hour. High temporal sampling and spatial resolution (< 5km) 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.

Active measurements from the CALIOP lidar, CloudSat radar and from the AIRS sounders of the A-Train mission on board the polar orbiting satellite Aqua have given a new 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

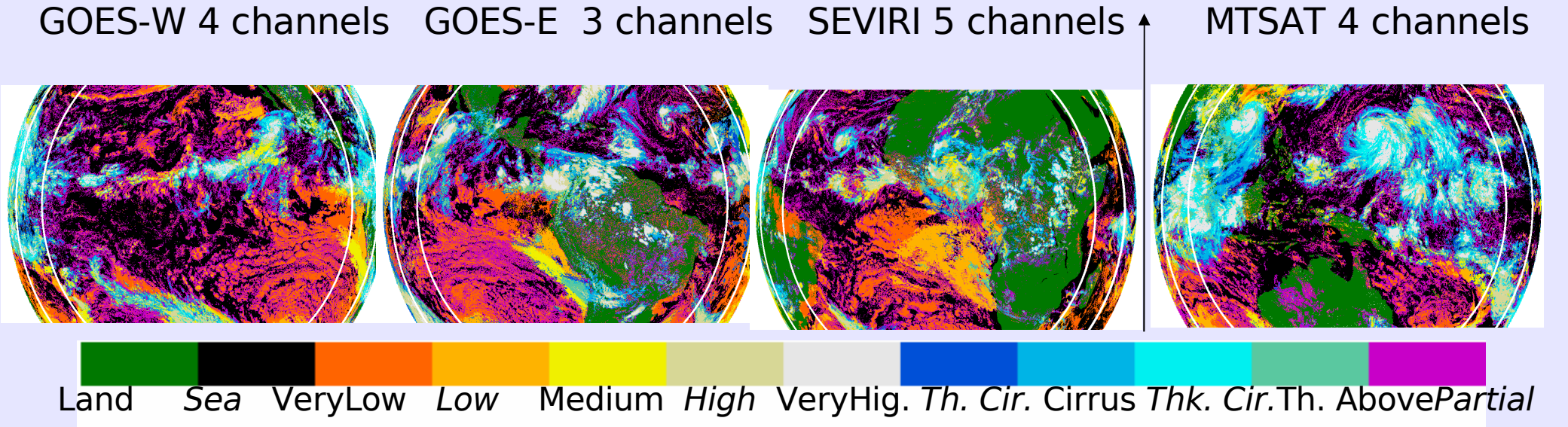
For a summer and a winter season high cloud occurrence frequency in the tropics observed with geostationary (GEO) data is shown and compared with the AIRS/IASI sounder observations. For the summer season the GEO high cloud cover is compared with CALIOP lidar observations to quantify its ability to detect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

THE GEOSTATIONARY DATA - THE SAFNWALGORITHM

➔ **Multi-spectral threshold technique** developed for the radiometer SEVIRI on board MSG by the *Satellite Application 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

For the moment one missing satellite

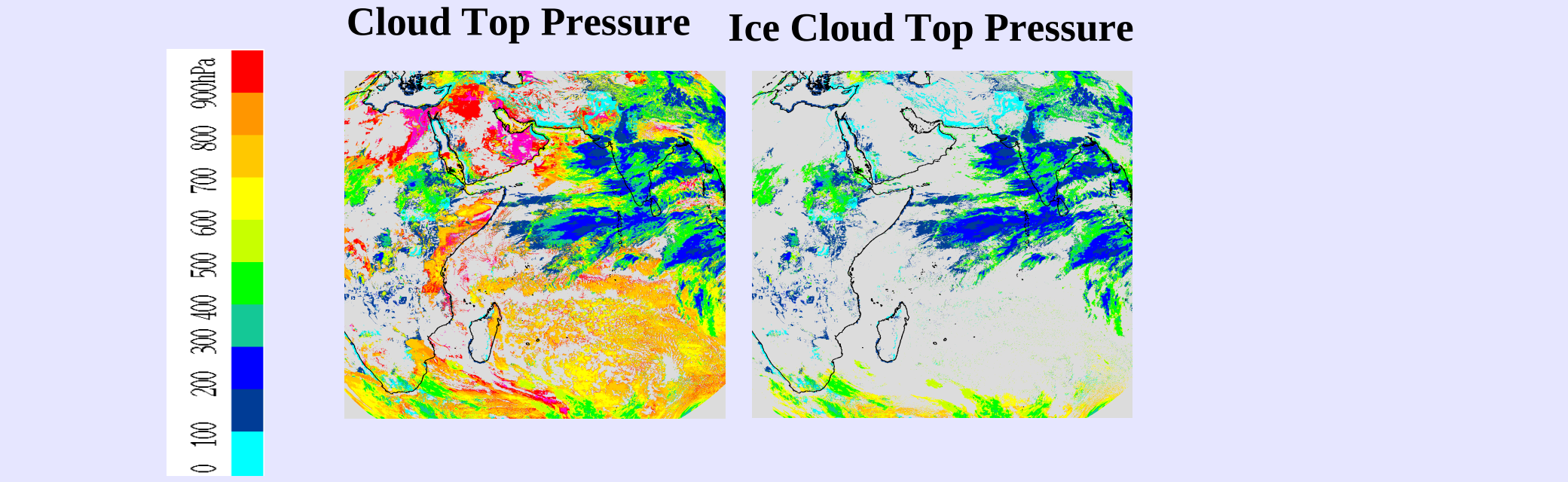


The white curves indicate for each satellite the 72.5° VZA and 55° VZA.
For partial cloud cover and for some GOES and MTSAT cirrus cloud top pressure is not available.

INDIAN OCEAN – METEOSAT-7 THE ISCCP ALGORITHM

Undergoing work to complete the tropical belt:

➔ Application to METEOSAT-7 data of the **new ISCCP software** to each 5 km pixel and each half hour data **using the VIS and IR channel**. (G. Sèze, collaboration with W-B Rossow).

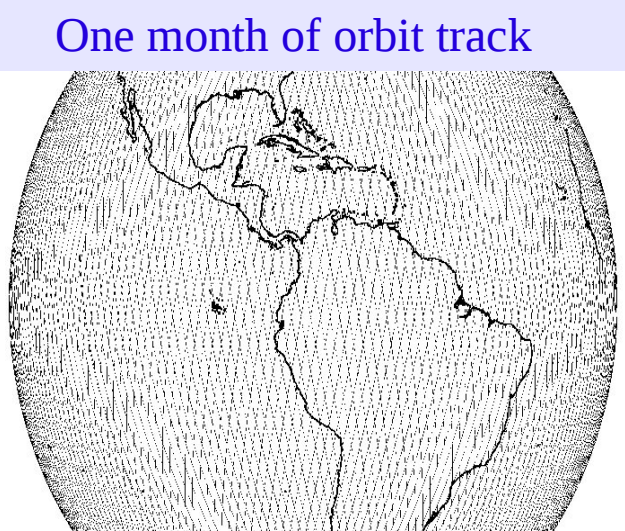


COINCIDENT GEOSTATIONNARY/ LIDAR DATA

For a four month period (June to September 2009) the SEVIRI, GOES-E, GOES-Wand MTSAT cloud classification and cloud top pressure data have been collocated on the CALIOP foot print. About 300 CALIOP orbits for one month period (Sèze et al., 2015).

The cloud layer operational product for the CALIOP 5km average profile is used.

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



AIRS and IASI SOUNDER DATA

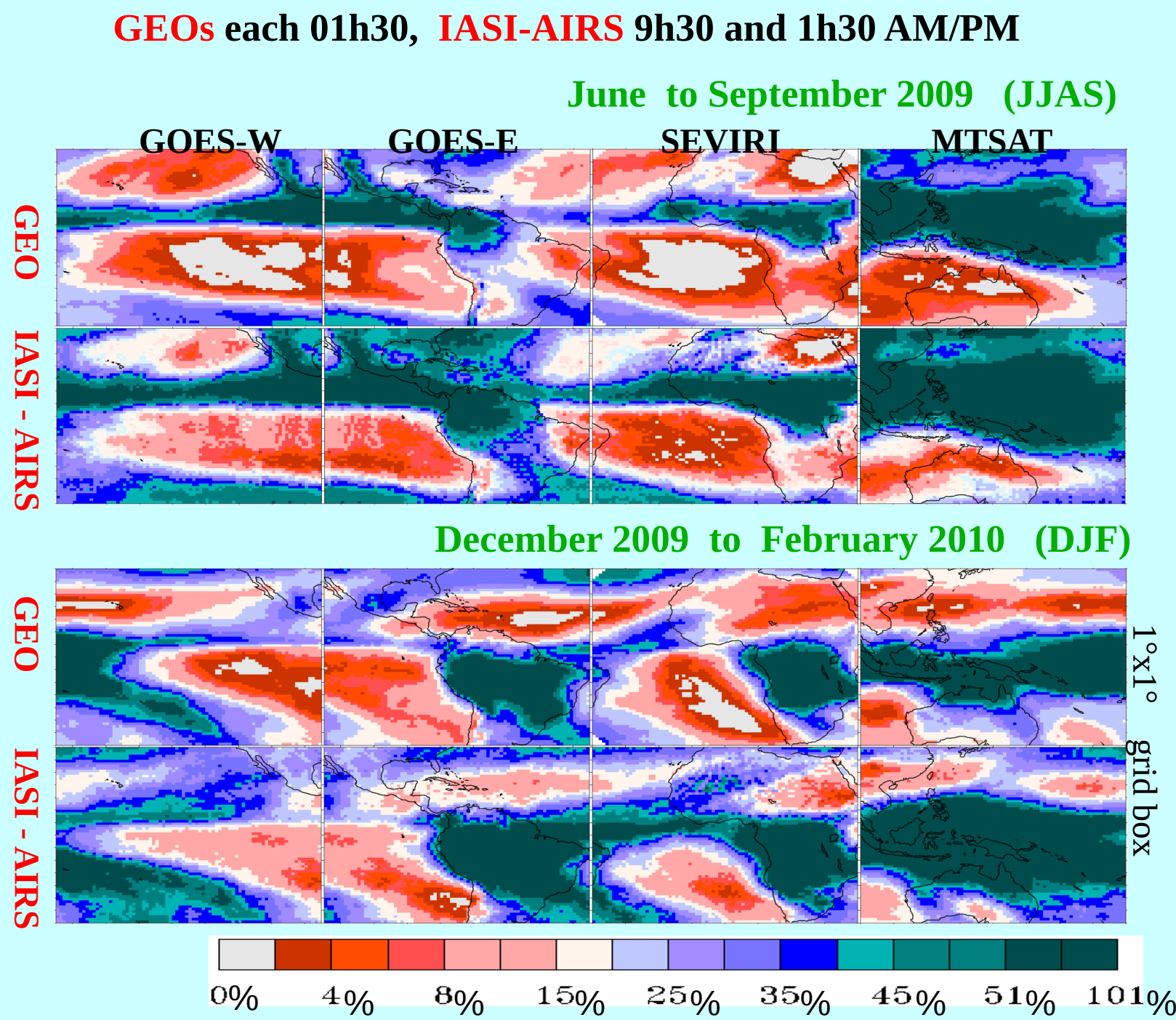
The AIRS (1:30AM/1:30PM) and IASI (9:30AM/9:30PM) cloud cover are obtained both with the LMD algorithm (October 2014 version; Stubenrauch et al. 2008) and using the ERA interim atmospheric profiles. Spatial resolution of the order of 13km. OD threshold of 0.1 for detection of thin Cirrus. (See poster S7-14)

DAY to NIGHT CHANGES IN THE OBSERVATIONS

Lidar SNR smaller during daytime than nighttime. Use of visible channels in the GEO retrievals during daytime. Solar contribution in the 3.7 channel during daytime. For GOES-E no 12.0 channel. No change in the sensitivity of the AIRS and IASI measurements between day and night.

HIGH CLOUD OCCURRENCE FREQUENCY (HCOF) MAP

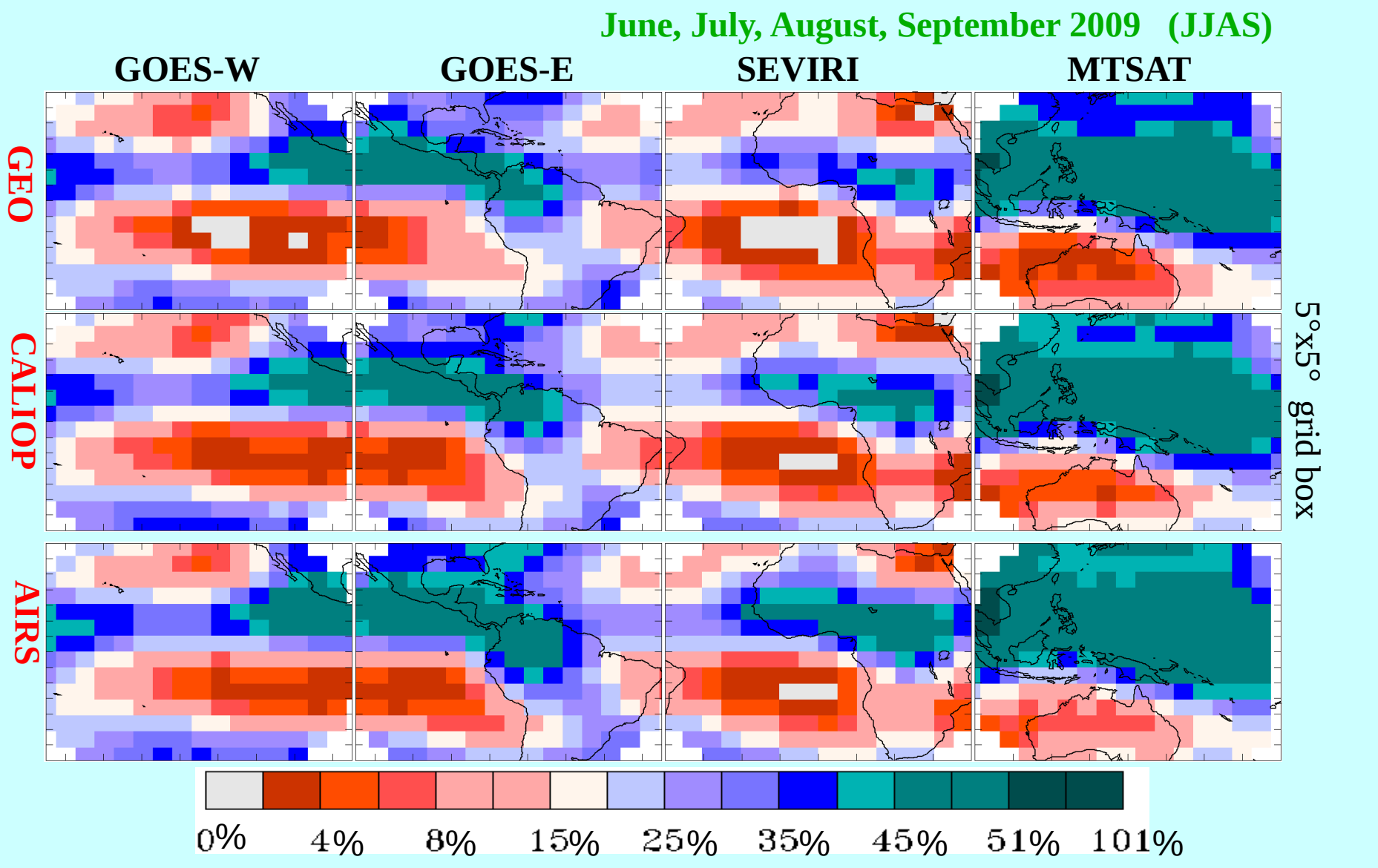
GEO and SOUNDEUR HCOF AVERAGE OVER THE DIURNAL CYCLE



Same patterns of high and low HCOF observed in the sounder and GEO data sets. Sounder HCOF > GEO HCOF in all the regions and for the two seasons.

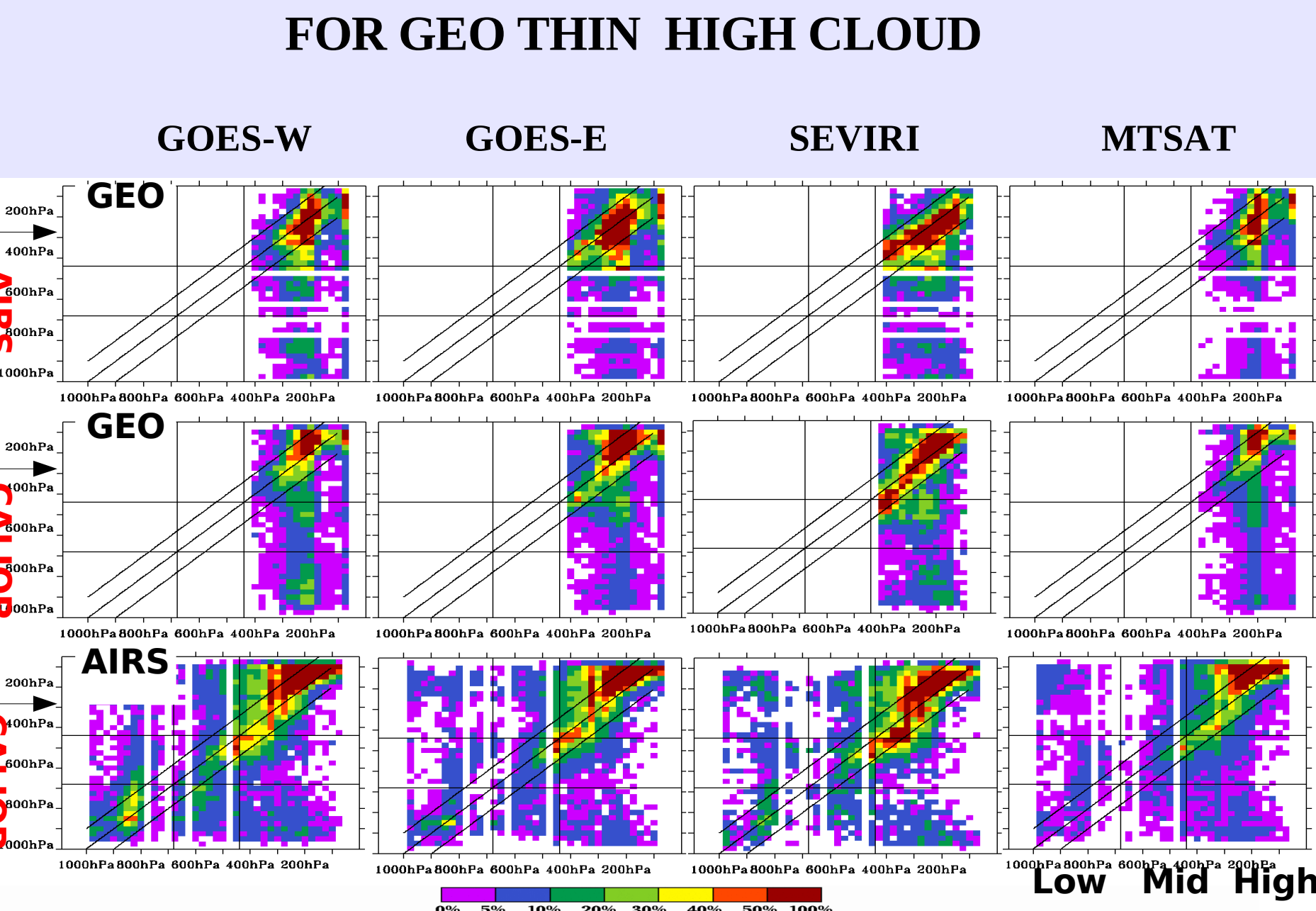
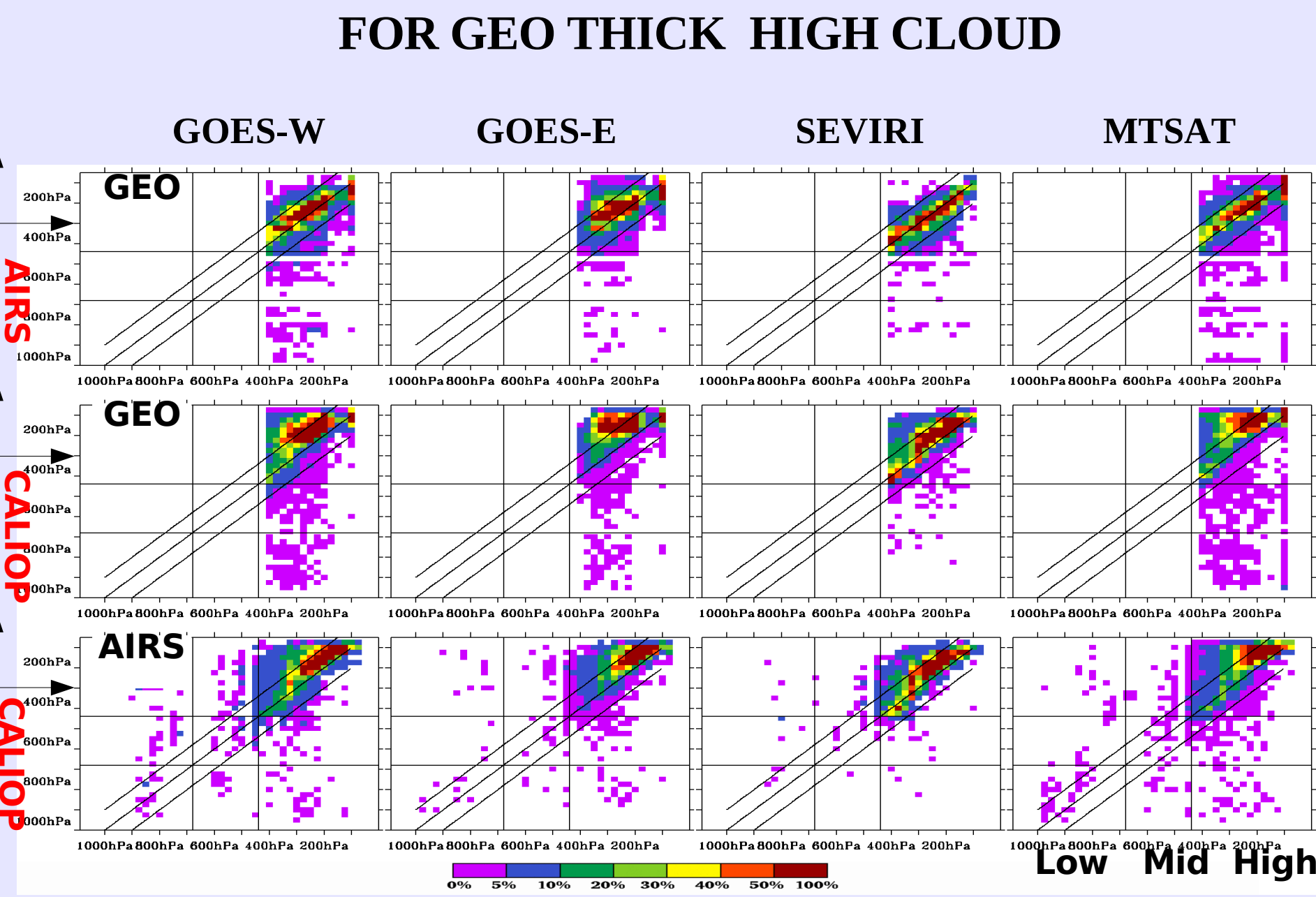
Comparison for 0130 AM and 0130 PM CALIOP, GEO and AIRS HCOF shows that when the very thin cirrus with OD < 0.1 detectable by CALIOP are not taken into account:
➔ sounder HCOF > CALIOP HCOF
➔ GEO HCOF in +/- 5% of CALIOP HCOF (Sèze et al. 2015)

COINCIDENT GEOs, AIRS and CALIOP OBSERVATIONS HCOF at 1H30 AM+PM



COMPARISON OF GEO, CALIOP AND AIRS INSTANTANEOUS HIGH CLOUD COVER

CLOUD TOP PRESSURE COMPARISON OVER OCEAN AT 01H30 AM



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

Miss detection of CALIOP thin high clouds by the GEO the largest over land during night-time due to confusion by the GEO with partial cloud cover.

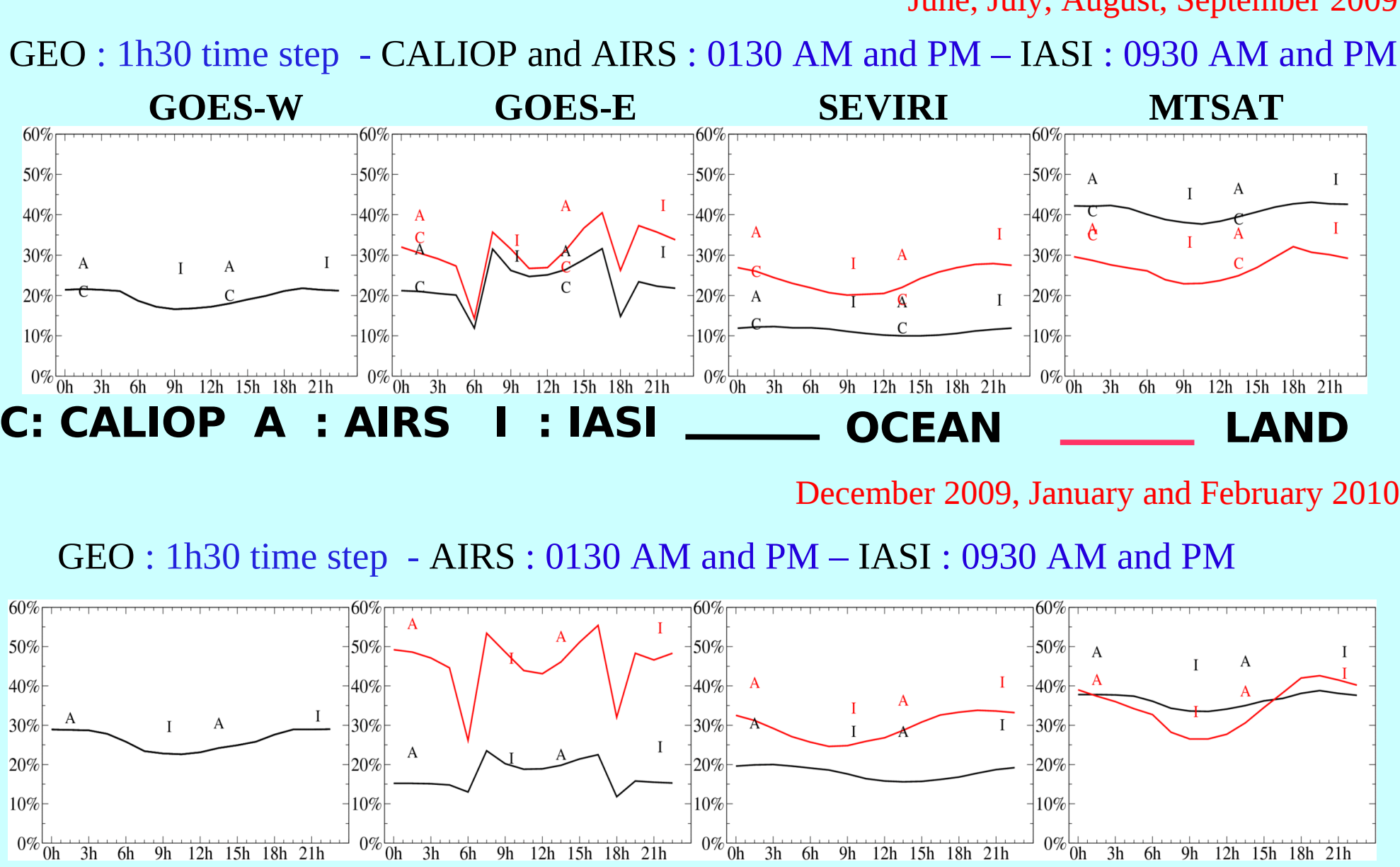
Miss detection of AIRS thin high clouds by the GEO the largest over land during daytime in part to non detection of these clouds by the GEOs and over ocean confusion with partial cloud cover.

GEO thick high clouds -> underestimation of cloud top altitude by the GEO IR radiometry and sounder IR measurements compared to CALIOP lidar measurements.

25hPa bias between GEO and AIRS cloud top pressure for GOE-E, GOE-W and MTSAT. For SEVIRI no bias and differences < 50hPa for 85% of cases.

The best agreement between CALIOP and GEO cloud top pressure and AIRS and GEO cloud top pressure is found for SEVIRI.

HIGH CLOUD OCCURRENCE FREQUENCY DIURNAL CYCLE



The sign of diurnal variations of sounder HCOF and GEO mean HCOF are in agreement. Diurnal variations of mean HCOF are below 5% over ocean and 10% over land when both thick and thin high clouds are taken into account. For GOES-E: lack of 12μ channel, at twilight leads to large underestimation of HCOF, during daytime some thin middle clouds or small low clouds are classified thin cirrus.

CONCLUSION

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 between AIRS and the GEOs on the detection of high clouds can reach 10%.

AIRS and IASI HIGH COF are also larger than CALIOP HCOF 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. In particular CALIOP high thin clouds are very well detected over ocean by the GEOs. 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.

Between AIRS and the GEOs, the agreement on high cloud detection at pixel scale is also between 75% and 85%. For GOES-E the lack of 12μ channel leads to difficulty in the separation between thin cirrus and the other cloud types at twilight and during day-time.

Compared to CALIOP, as expected the GEOs and AIRS under-estimates the cloud top altitude of high thick clouds. Between AIRS and the GEOs a small 25hPa bias exists for GOES-E, GOES-W and MTSAT. The best agreement between CALIOP and GEO cloud top pressure and AIRS and GEO cloud top pressure is found for SEVIRI.

The AIRS/IASI and GEO mean HIGH COF diurnal variability are in relatively good agreement.

➔ Near Futur

Go further in the comparative analysis between GEOs high cloud cover and the CALIOP and 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. 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.