The cloud cover vertical distribution and its diurnal cycle observed from Multi-Geostationary data

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CONTEX

A coherent cloud mask, cloud type classification and cloud top pressure maps with a high spatial and temporal resolution in the tropical belt using geostationary satellite data (GEO: GOES-E, GOES-W, MTSAT and MSG) has been elaborated in the frame of the MEGHA-TROPIQUES experiment.

HERE

The diurnal cycle of the GEO cloud cover and cloud cover type occurrence over ocean and land for one summer and one winter north hemisphere season.

Comparison with the 0130 AM and PM AIRS and CALIOP measurements and the 0930 AM and PM IASI measurements

Background : a detail comparative analysis between the GEOs and CALIOP already performed for the same summer season (Sèze et al., QJRMS, 2014)

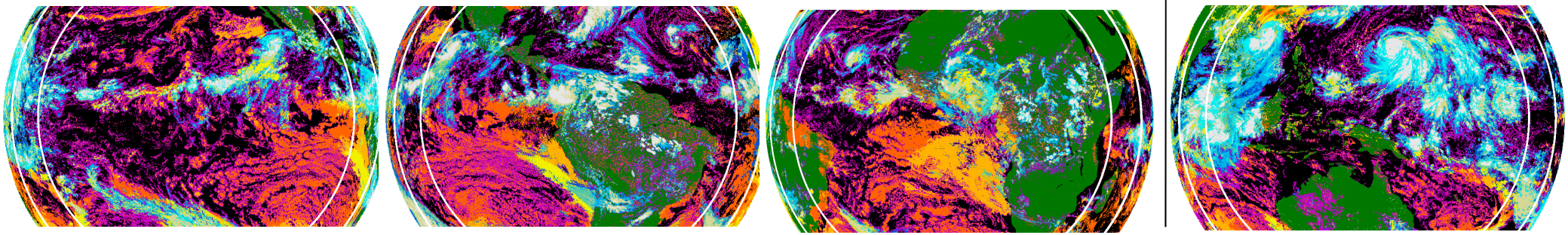
Elaboration of cloud cover maps over the tropical belt using geostationary satellite data

➔ **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, 2009)**

➔ **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

GOES-W 4 channels | GOES-E 3 channels | SEVIRI 6 channels | MTSAT 4 channels



Land | Sea | Very Low | Low | Medium | High | Very Hig. | Th. Cir. | Cirrus | Thk. Cir. | Th. Above | Partial

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.

The CALIOP, IASI and AIRS cloud cover

- The version 3 of the cloud layer operational product for the CALIOP 5km average profil and 333m profile are used.

The CALIOP cloud cover includes all the thin high cloud with optical depth above 0.1 and all the small clouds detected at scale smaller than 5km.

- The AIRS and IASI cloud cover are obtained both with the LMD algorithm and using the ERA interim atmospheric profils.

DAY to NIGHT CHANGES IN THE DATA:

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.

Limitation of the field of view of each GEO to VZA < 55°.

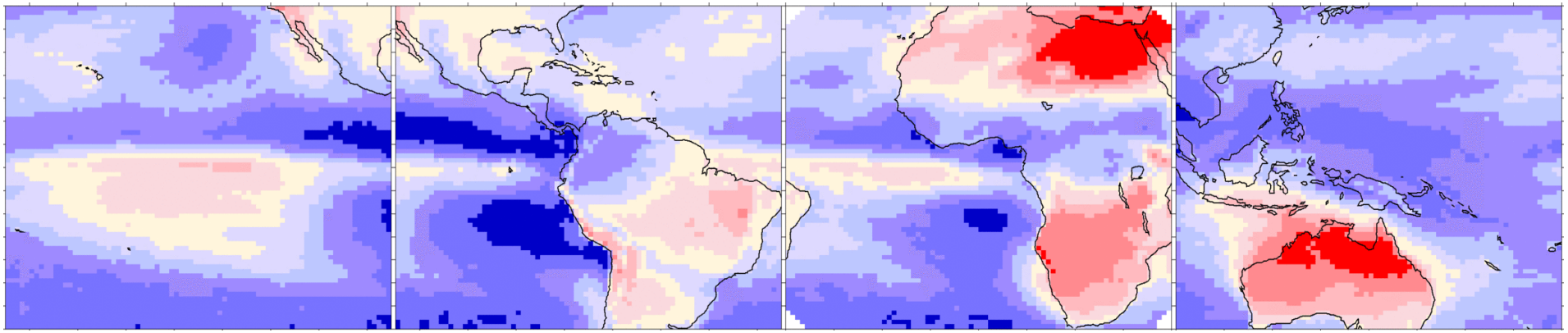
CLOUD OCCURRENCE FREQUENCY MAP

Average over the diurnal cycle (16 time steps)

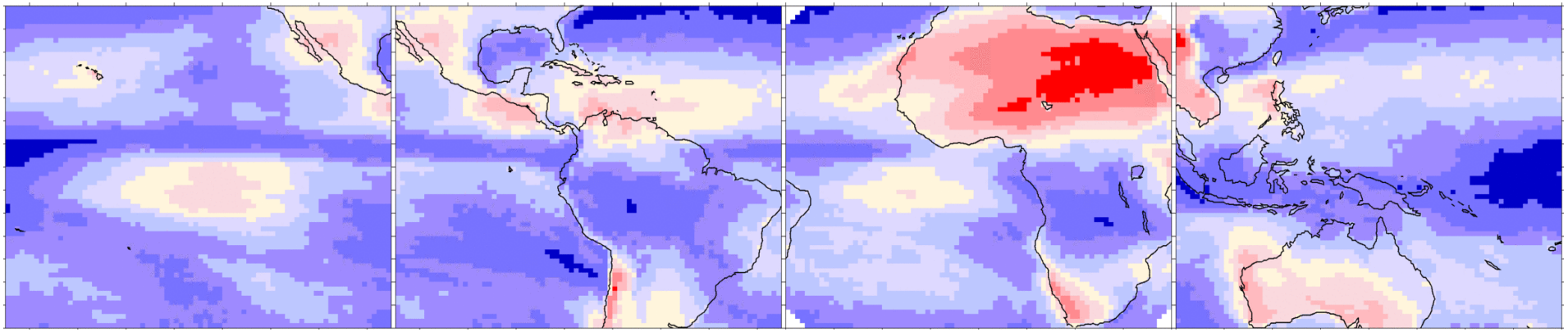
GEO VZA < 55°.

June, July, August, September 2009 (JJAS)

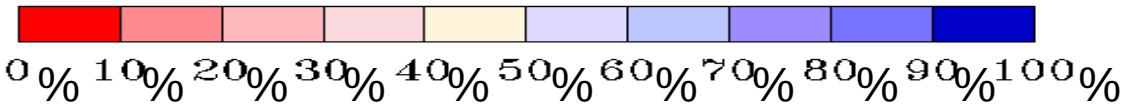
GOES-W **GOES-E** **SEVIRI** **MTSAT**



December 2009, January, February 2010 (DJF)

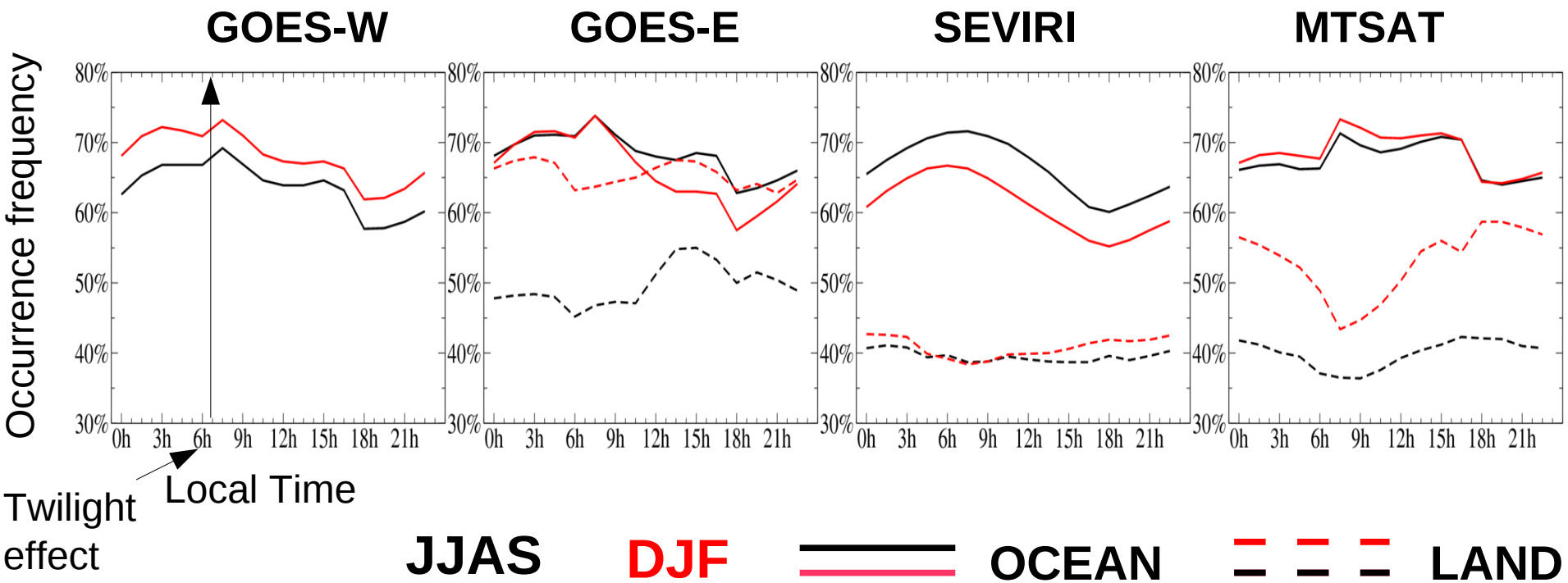


1°x1° grid box



DIURNAL CYCLE of CLOUD OCCURRENCE FREQUENCY

JJAS and DJF - 1H30 time step



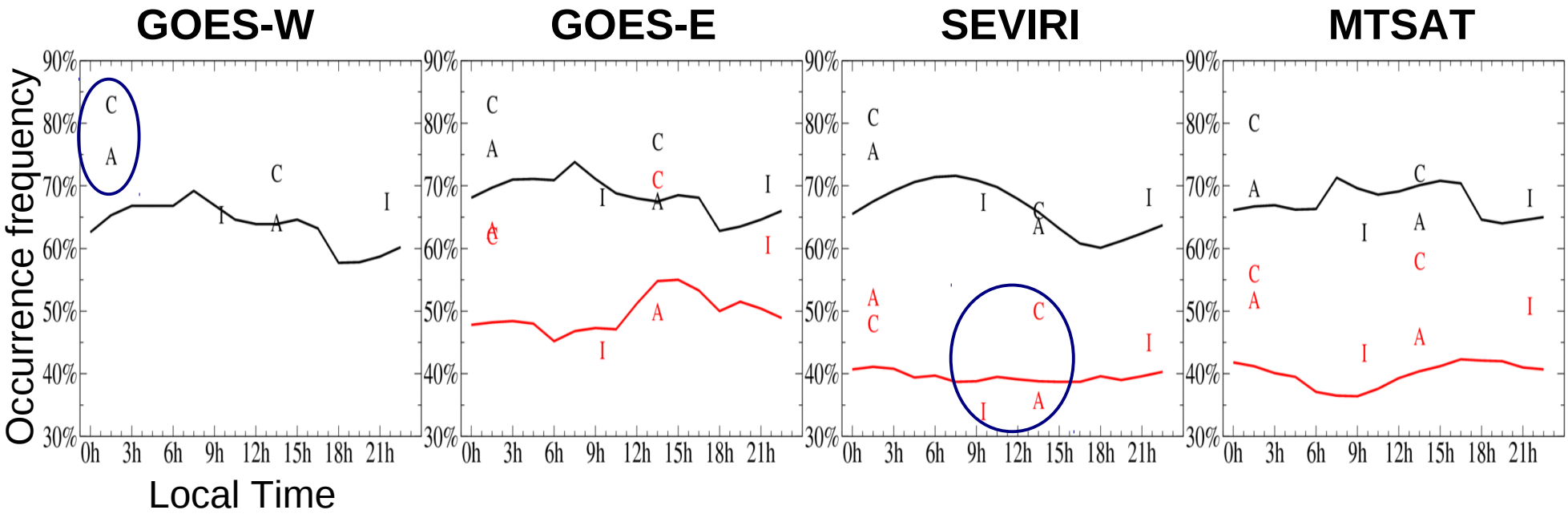
Over ocean COF maxima in the early morning
Over land COF minima in the morning

Over ocean no change in the diurnal cycle COF curve shape between JJAS and DJF
Over land large increase in COF in DJB in relation with the ITCZ southward shift.

DIURNAL CYCLE of CLOUD OCCURRENCE FREQUENCY

JJAS

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



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

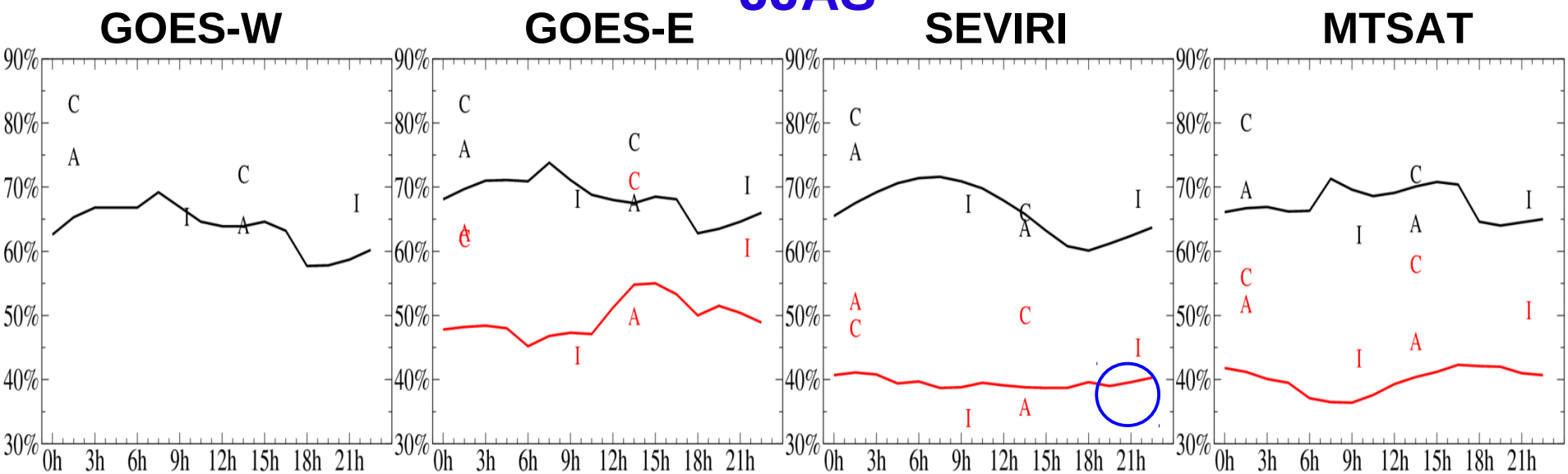
GEOs underestimate COFs with respect to CALIOP by more than 10% at 0130AM. At 0130 PM, the bias increases over land and decreases over ocean.

GEOs underestimate COFs with respect to AIRS or IASI COFs in the night data. It is not the case in the daytime data. The largest bias are over land during nighttime.

The changes in COFs between 0130AM and 0130PM for CALIOP and AIRS are comparable over ocean. This is not the case over land.

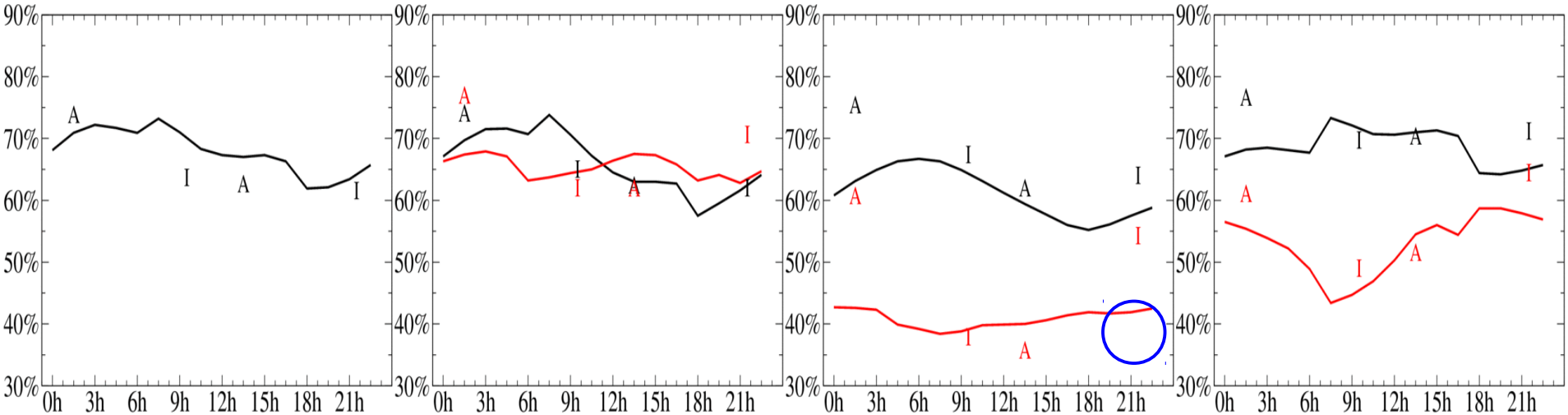
DIURNAL CYCLE of CLOUD OCCURRENCE FREQUENCY

JJAS



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

DJF



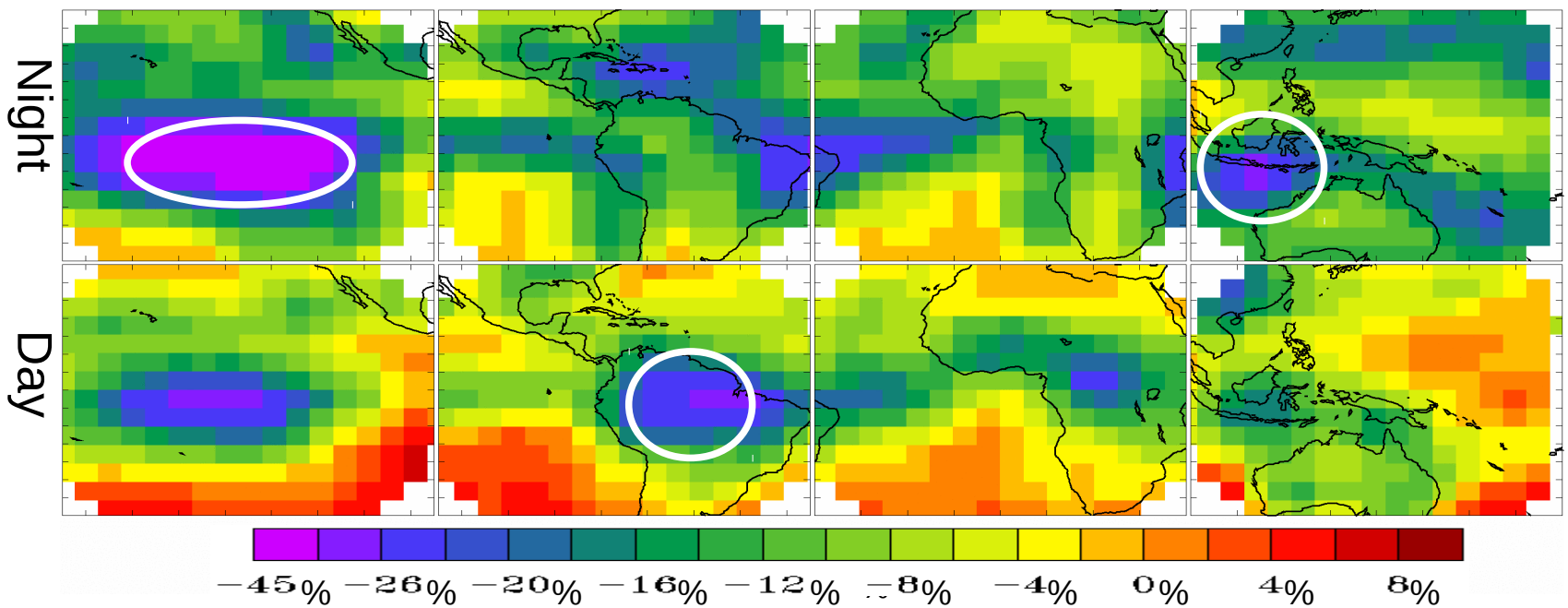
Between the two seasons the change in bias can be larger than the change in COFs

0130 AM and 0130 PM GEO and CALIOP COFs
the 2009 JJAS period

	GOES-W			GOES-E			SEVIRI			MTSAT		
	G-W	CAL	Bias	G-E	CAL	Bias	SEV	CAL	Bias	MTS	CAL	bias
Ocean night	66%	83%	-17%	71%	83%	-12%	69%	81%	-12%	67%	80%	-13%
Ocean day	65%	72%	-7%	66%	70%	-4%	61%	66%	-5%	70%	72%	-2%
Land night				48%	62%	-14%	38%	48%	-10%	43%	56%	-13%
Land day				53%	71%	-18%	39%	50%	-11%	40%	58%	-18%

Bias between 10% and 18% excepted over ocean during daytime

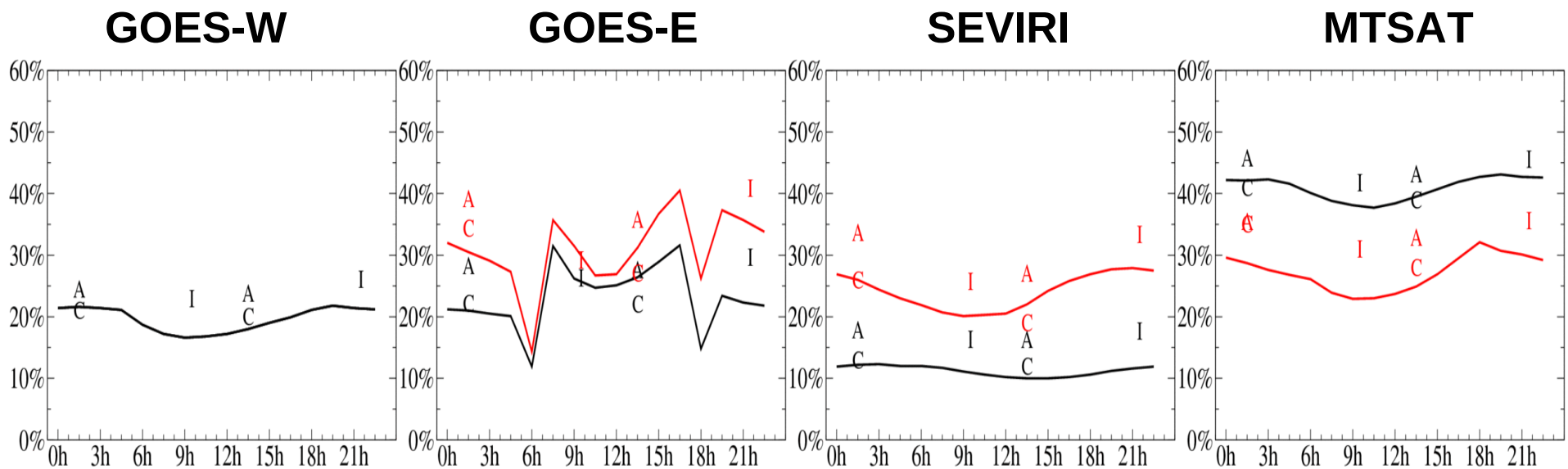
GEO minus CALIOP COF



DIURNAL CYCLE of CLOUD OCCURRENCE FREQUENCY - JJAS

HIGH CLOUD

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 slightly larger.

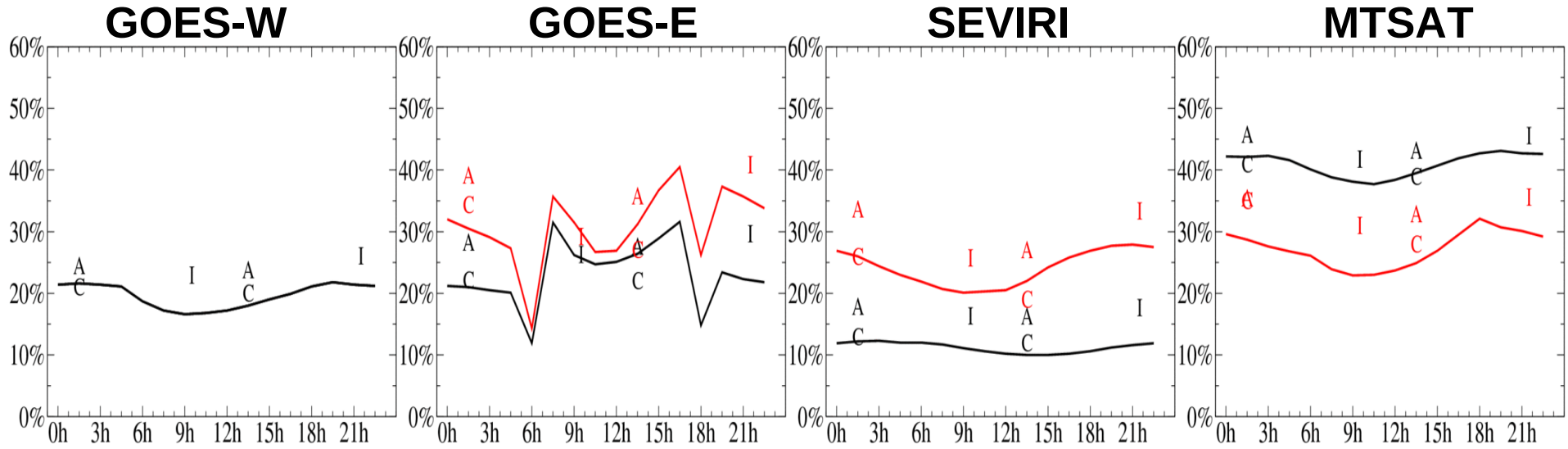
Amplitude of the diurnal cycle below 5% over ocean and 10% over land

For GOES-E during daytime thin middle clouds or small low clouds are classified thin cirrus due to the lack of 12 channel.

DIURNAL CYCLE of CLOUD OCCURRENCE FREQUENCY - JJAS

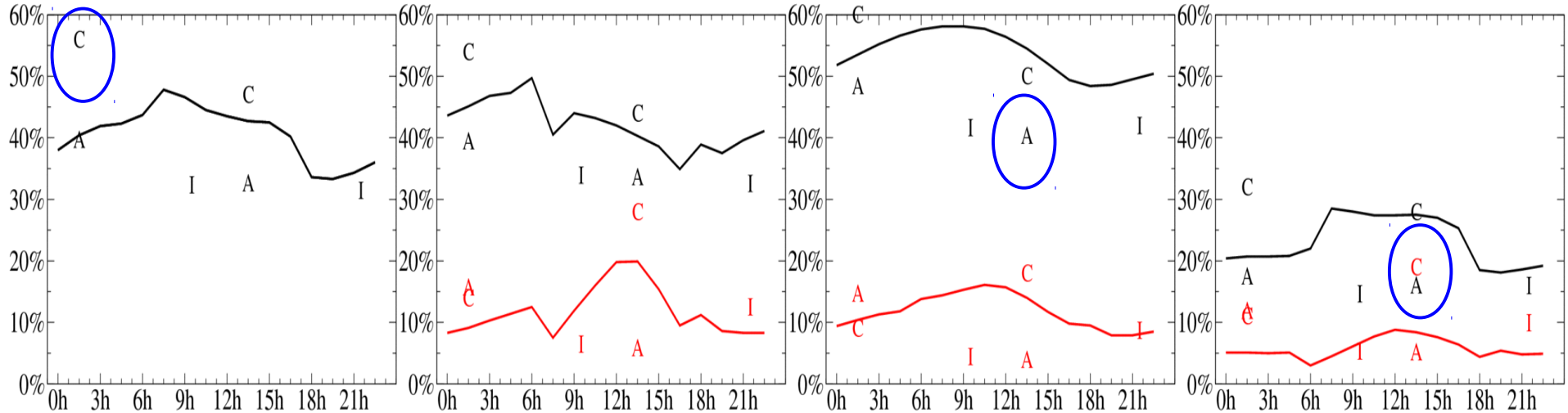
HIGH CLOUD

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



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

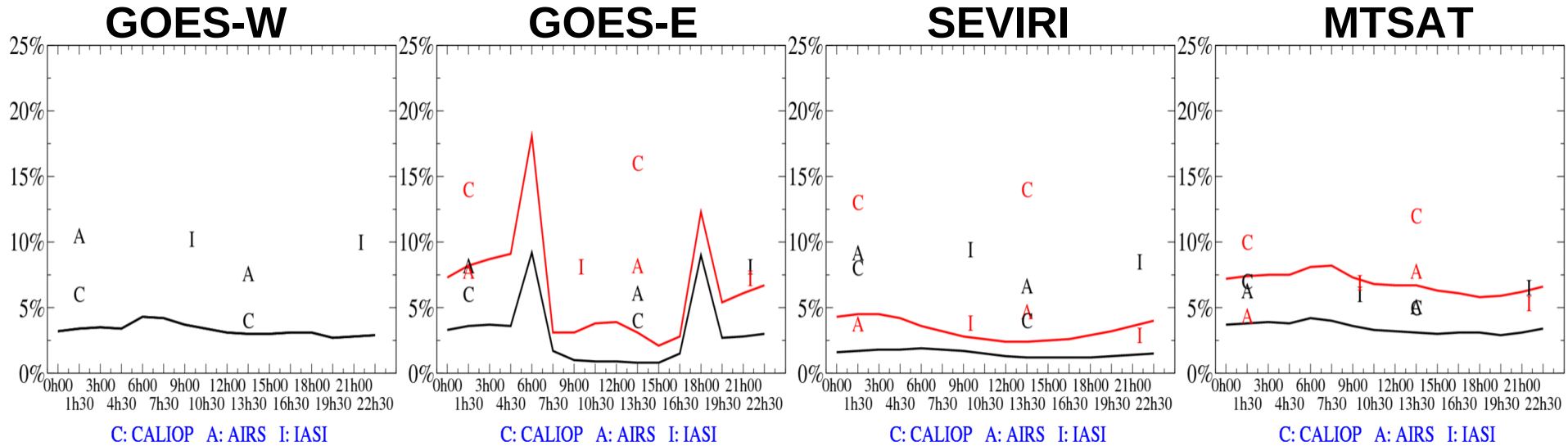
LOW CLOUD



DIURNAL CYCLE of CLOUD OCCURRENCE FREQUENCY - JJAS

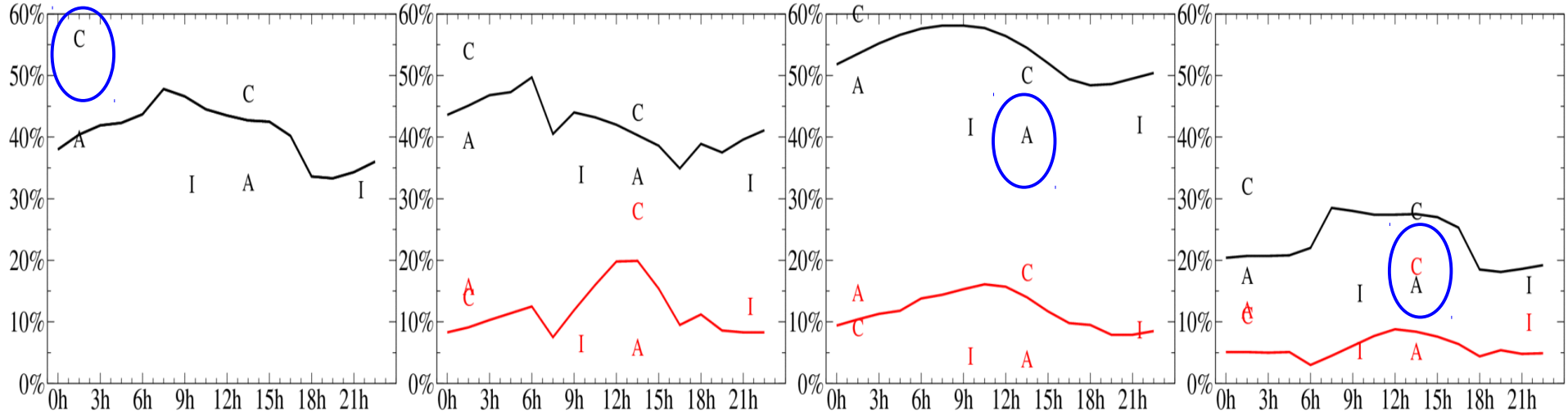
MIDDLE CLOUD

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



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

LOW CLOUD



CONCLUSION (1)

When the field of view of each GEO is limited to VZA < 55° and CALIOP cloud layers with optical thickness smaller than 0.1 or detected at a scale larger than 5km are not taken into account:

➔ **A common behaviour of the GEO against CALIOP depending on cloud type is found when both statistical and pixel to pixel comparison are performed**

Excepted over ocean during daytime, the CALIOP COF's are larger than the GEO COF's by more than 10% . The largest bias (15%-17%) are found for land during daytime for MTSAT and GOES-E and over ocean during nighttime for GOES-W.

The regional variations around these means values are large. These variations are related to the frequency of low clouds and particularly broken low clouds above the regions. The GEO COF negative bias reach 30% at 0130LST in region of small cumulus over ocean. Over land the increase of low clouds during daytime increases the bias between the GEOs and CALIOP.

CONCLUSION (2)

The changes in bias between the GEO and CALIOP COFs depend both in cloud types and change in instrument sensitivity between day and night.

The bias between the GEOs and AIRS and IASI are comparable. The GEOs minus AIRS(IASI) bias is negative during nighttime and is close to null or positive during daytime when the GEO retrieval uses the VIS information.

The AIRS COF bias with respect to the CALIOP COFs depends also on cloud type but is not affected by a change in sensitivity of the instrument between day and night.
The night to day changes in COFS are in agreement with those observed with CALIOP over ocean but not always over land.

As expected, AIRS and IASI HIGH COF are larger than the GEOs HIGH COF but only by few percents. The GEOs LOW COF during daytime can be more than 10% above those of AIRS (IASI). The AIRS/IASI and GEO high cloud OF diurnal cycles are in relatively good agreement.

→ Futur: need to go further in this comparative analysis and combine GEOs and soundeur measurements to describe the cloud cover diurnal cycle.

THANKS TO SATMOS(INSU-METEO-France), ASDC(NASA) AND ICARE(CNES) FOR THE DATA PROVISION

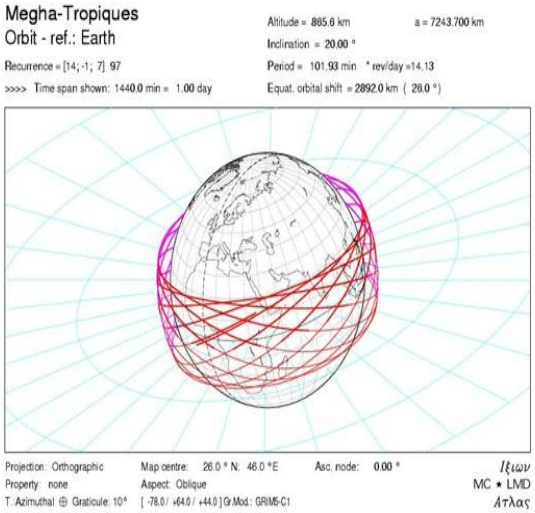
Thank you

MEGHA-TROPIQUES aims to measure with a high repetitivity radiances linked to radiative fluxes, water vapour and precipitation:

The 20 degree orbit at 870km of altitude allows up to six observations by day of the same region.

A MW imager for rain and clouds (MADRAS),
a MW sounder for water vapour (SAPHIR) and
a wide band instrument for radiative fluxes (ScaraB)

The geostationary satellite VIS and IR imagers complete this set of instruments for the cloud scene identification and cloud top pressure retrieval at high spatial scale, the tracking of cloud convective systems the multi-instrument precipitation retrieval.



The cloud scene identification and cloud top pressure will be used:

- **as input in the SAPHIR-MADRAS water-vapour profile retrieval.**
- **for the validation of the ScaraB cloud scene classification**
- **to better characterize clouds associated to convective systems**
- **to observe the low and mid-level cloud cover**