Improving Cloud Climatology analysis using Space Lidar observations:

comparison of SEVIRI/MSG with GLAS and CALIPSO

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CLOUD Climatology

A better characterisation of Cloud and Aerosol radiative parameters is needed at the global scale to better understand climate feedback (albedo change, heating rates, dehydratation of the TTL, …)

Cloud cover and cloud types are the first parameters of importance

analyze frequency of occurrence
diurnal Cycle

GLAS provides a first lidar data set over several week periods

CALIPSO is now providing data since June 2006 and offers a unique opportunity to better characterize vertical cloud and aerosol vertical structure (CALIOP) and microphysics (CALIOP/IIR, to come later)

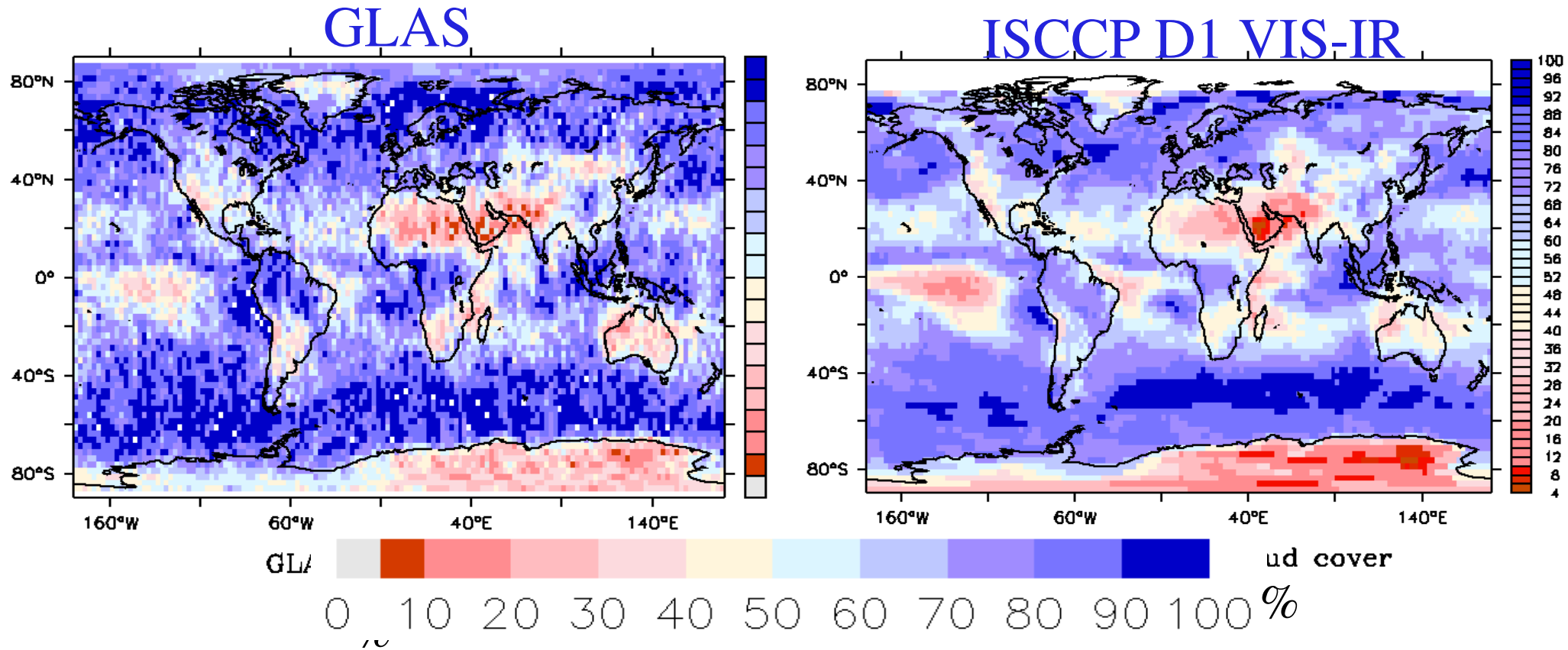
general overview

Geostationary (SEVIRI over Europe and Africa) satellites observations will help to get better global/regional analyses of the cloud cover, its time evolution and its diurnal cycle

t comparative analysis

GLAS and ISCCP Total Cloud Cover

29 September to 18 November 2003



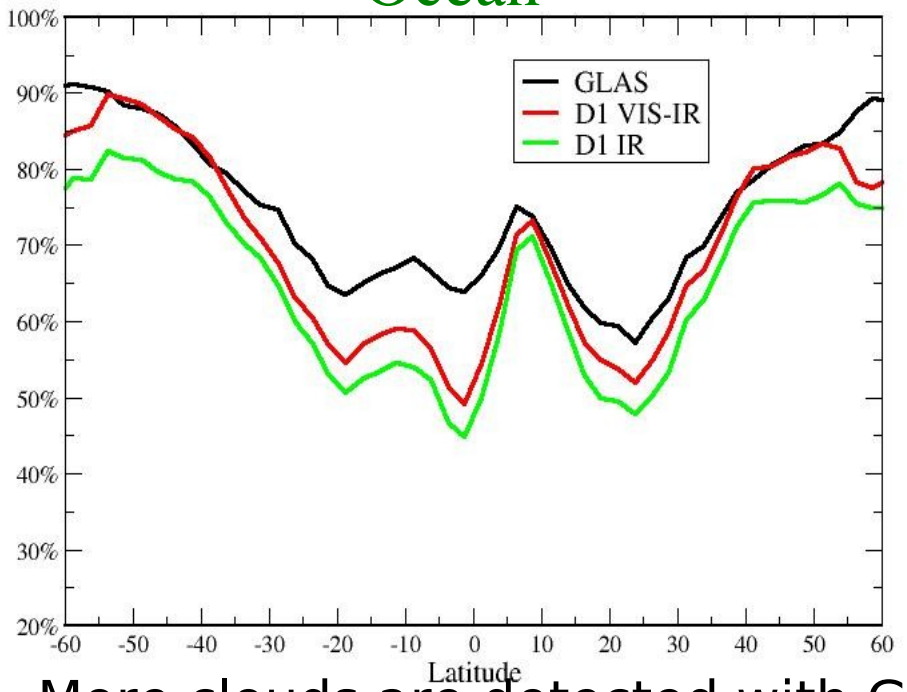
GLAS: night and day data **ISCCP**: 7h , 8h, 9h, 10h30, 12h, 15h, 16h, 17h local time average

Minimum of Cloud cover well observed over desert areas, south pole, and west side of oceanic subsidence areas linked to tropical convection

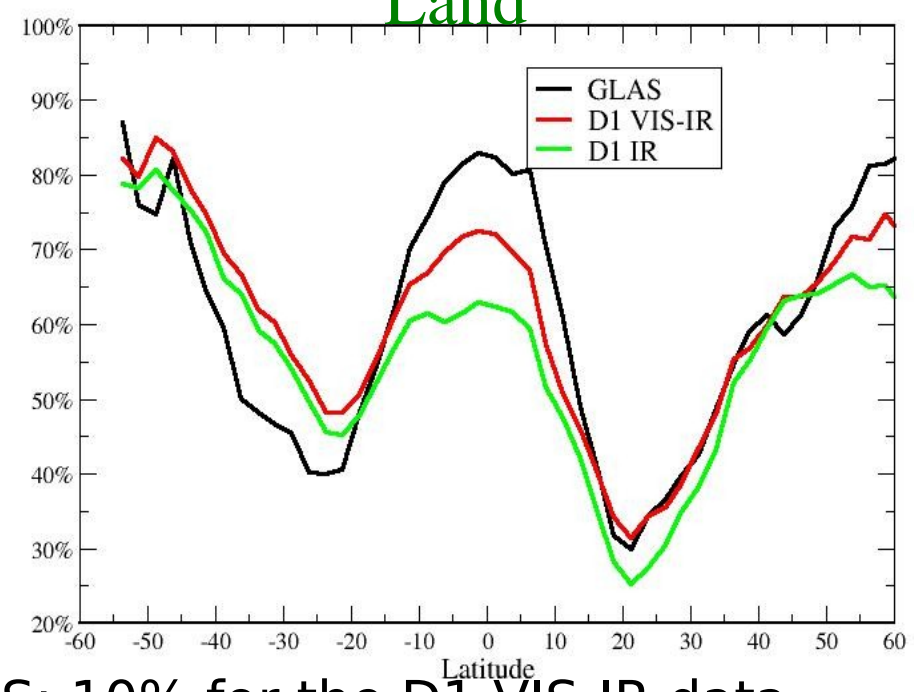
GLAS and ISCCP D1 CLOUD COVER

29 September to 18 November 2003

Ocean



Land

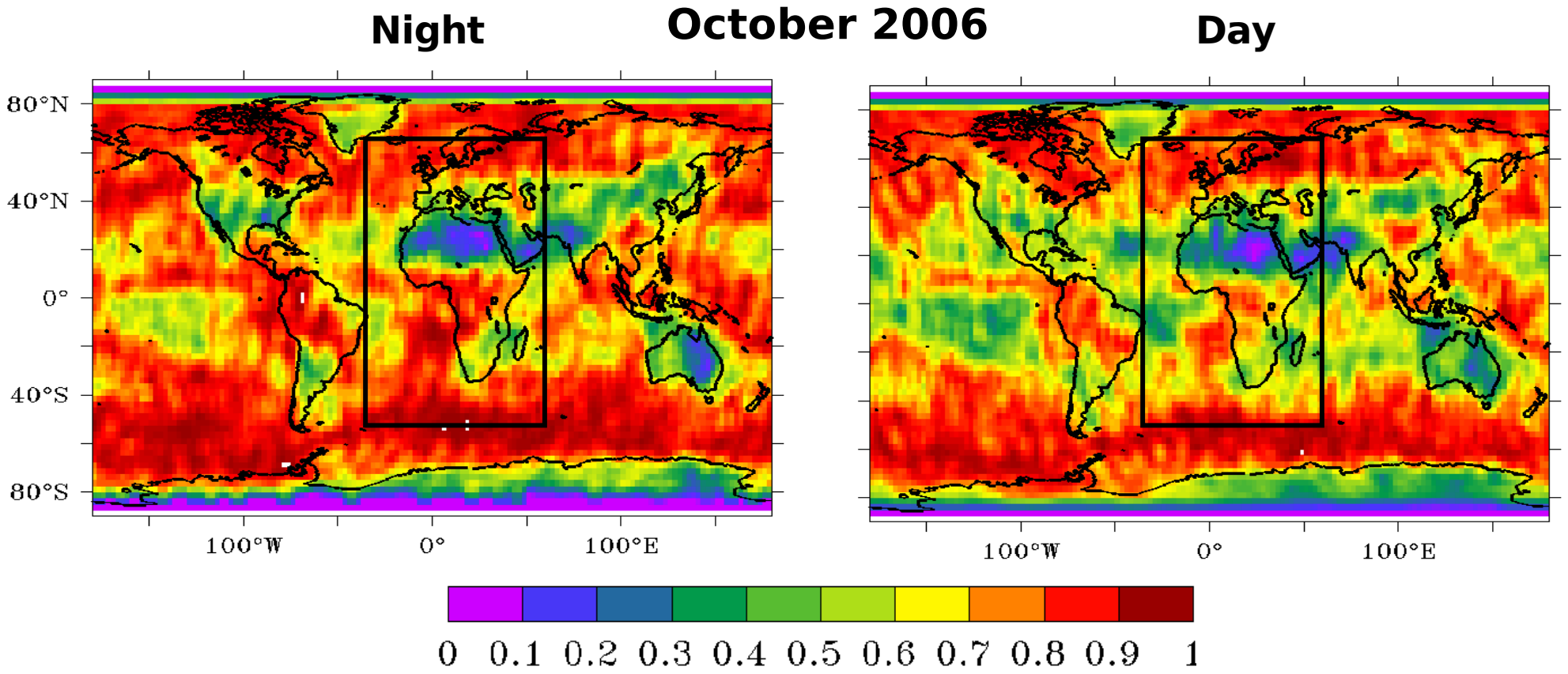


More clouds are detected with GLAS: 10% for the D1 VIS-IR data, 15% for the D1 IR data.

Differences vary with latitude. Large differences are found at the equator over land and in the south tropical region over ocean.

Differences between the DI VIS/IR and IR cloud cover vary also with latitude.

CALIPSO CLOUD COVER

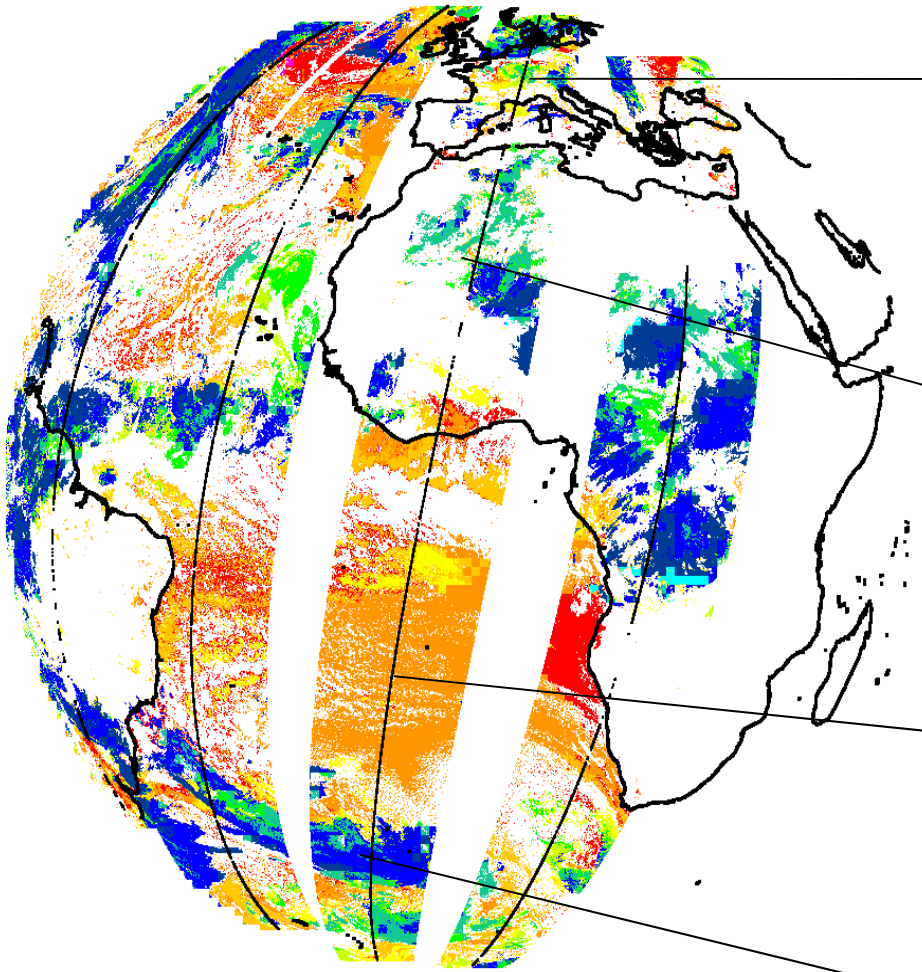


Importance of diurnal cycle (> 20 % change at tropical and mid-latitudes in southern hemisphere –low clouds-)

Lidar SNR larger during nigh-time than day-time

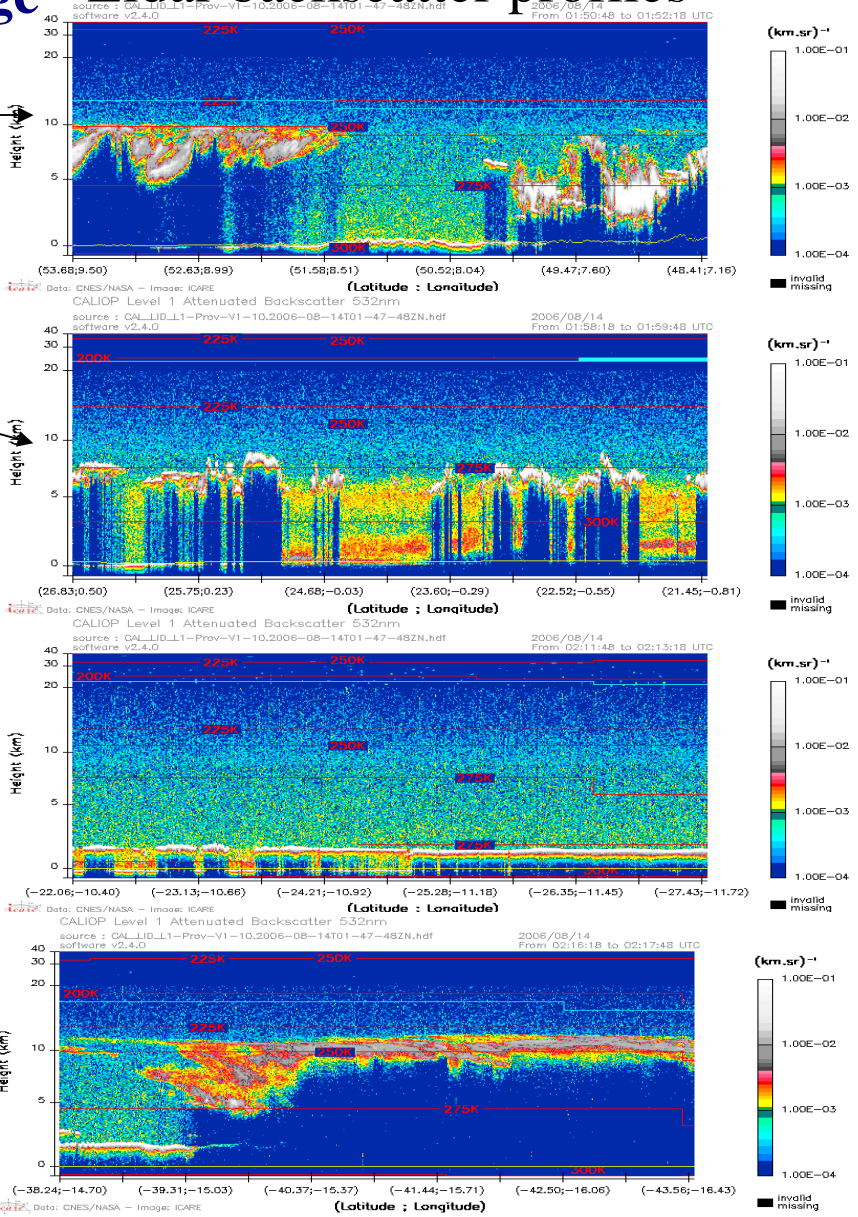
Coincident SEVIRI and LIDAR DATA Analysis

SEVIRI cloud top pressure composite image



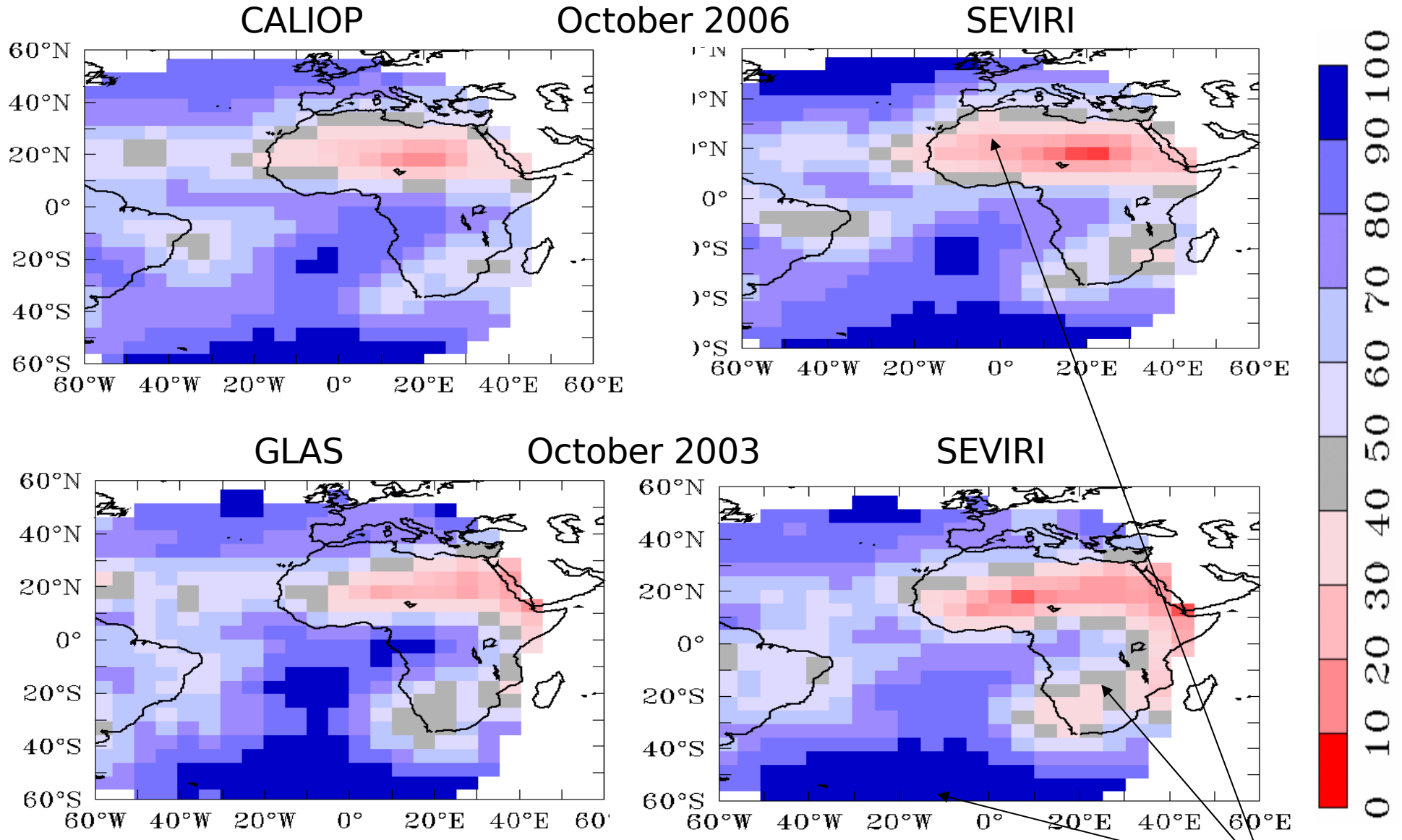
August 14th 0130 local time

Lidar backscatter profiles



METEOSAT SAF NFC Analyses Legleau & Derrien, 2005

SEVRI, GLAS and CALIOP CLOUD COVER



Some differences between the two years apparent both in the SEVIRI and lidar data

GLAS and SEVIRI CLOUD COVER

October 2003 at 7h30am - 7h30pm SEVIRI viewing angle restricted to 55°

	SEVIRI	GLAS (All)	GLAS (OT>0.1)	GLAS (OT>0.2)	ISCCP DX IR/VIS-IR
Ocean Night	70	80	74(-6)	72(-8)	62
Ocean Day	76	69	65(-4)	62(-6)	63/69
Land Night	46	64	54(-10)	50(-14)	45
Land Day	40	50	44(-6)	39(-11)	42/48

The GLAS cloud cover is larger that SEVIRI cloud cover, excepted over ocean during day time.
The mean GLAS cloud cover after application of a threshold on OT of 0.2 is close from the SEVIRI one.

The IR DX cloud cover is close from the SEVIRI one over land but there is a large underestimation over ocean. During daytime over ocean, DX VIS/IR and GLAS mean cloud cover are close.

With SEVIRI from night to day (19h30 to 7h30), the cloud cover over land/ocean increases/decreases. In both cases, GLAS CC decreases.

SEVIRI and CALIOP CLOUD COVER

October 2006 at 1h30am - 1h30pm

	SEVIRI	CALIOP (All)	CALIOP (OT>0.1)	CALIOP (OT>0.2)	ISCCP DX IR/VIS-IR
Ocean Night	72	75	72(-3)	68(-7)	??
Ocean Day	70	63	60(-3)	56(-7)	??
Land Night	41	56	52(-4)	48(-8)	??
Land Day	44	53	50(-3)	45(-8)	??

As between GLAS and SEVIRI, the CALIOP cloud cover is larger that SEVIRI cloud cover, excepted over ocean during day time.

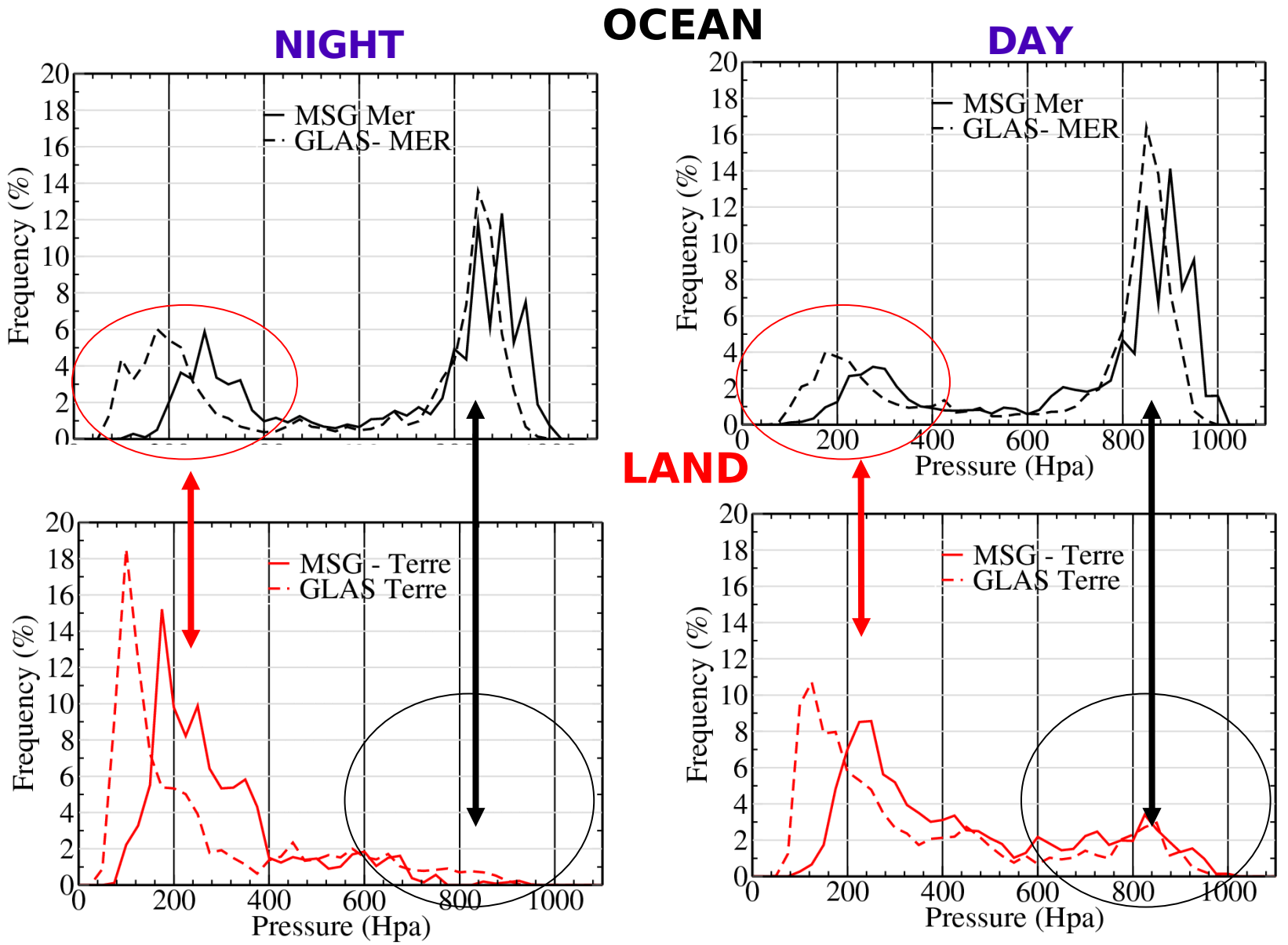
Over ocean at night, the differences observed are smaller than between GLAS and SEVIRI.

The decrease of CALIOP cloud cover with an increasing OT threshold is smaller than those observed for GLAS.

With SEVIRI, from 1h30 to 13h30, the cloud cover over land/ocean increases/descreases. In both cases, CALIOP CC decreases.

GLAS-SEVIRI CLOUD COVER

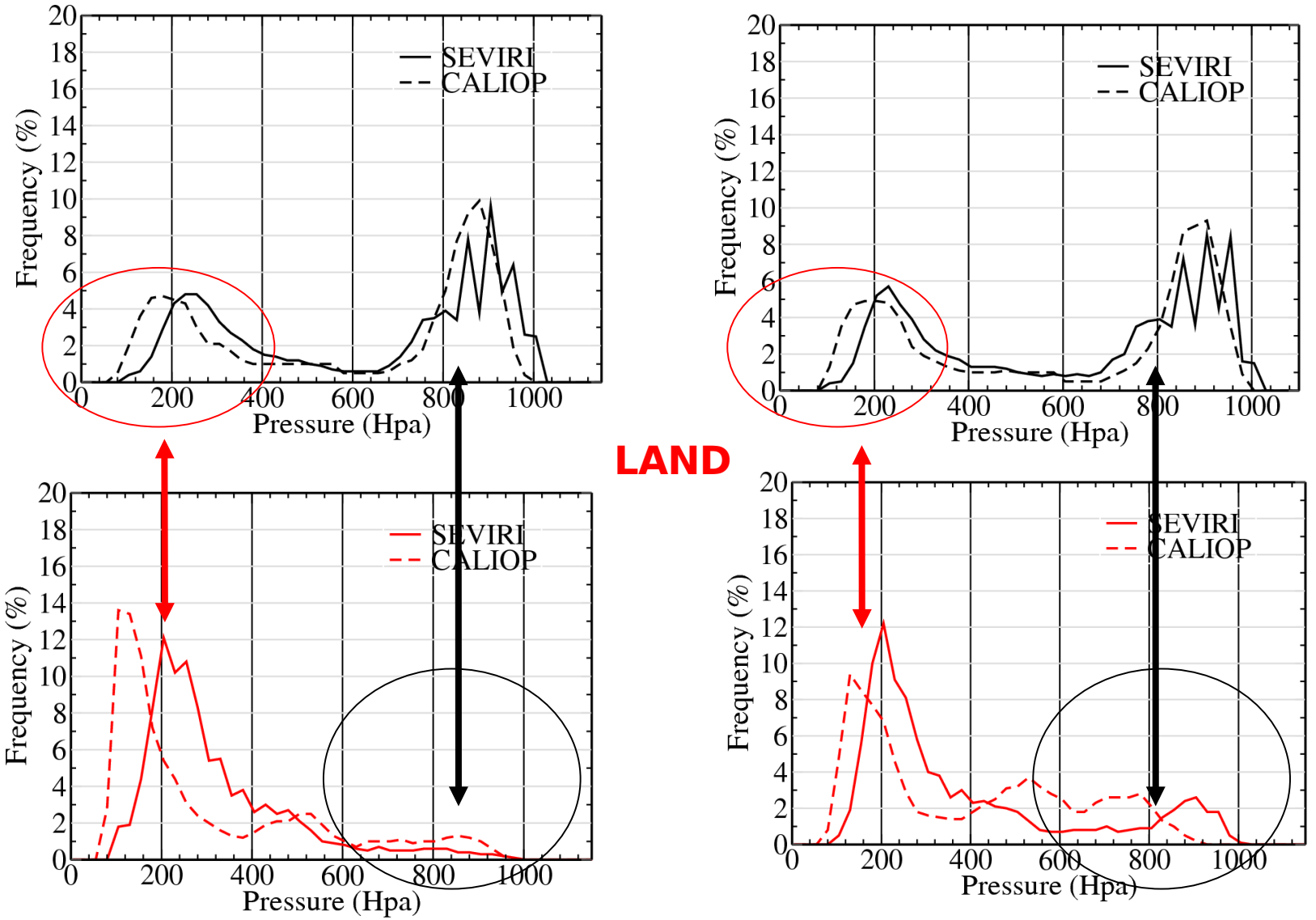
October 2003 OVER ALL MSG-COVERED AREA



CALIPSO-SEVIRI CLOUD COVER

October 2006 OVER ALL MSG-COVERED AREA

NIGHT **OCEAN** **DAY**



LAND

MAIN CLOUD TYPES OVER OCEAN

GLAS/GLAS OT<0.2/GLAS ALL LAYERS/SEVIRI/DX IR/DX VIS-IR

	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	36/20 21 20/9	6/7/10 4	38/45/54 29	16
	10	14	38	
Day	25/16 18 9/4 6	5/6/8 5	38/40/43 32	21
	10/18	15/16	39/35	

Decrease of the high cloud cover from night to day. Increase of the low cloud amount for SEVIRI.
SEVIRI and DX VIS-IR high cloud close from GLAS OT>0.2.
Large amount of partially covered pixels for SEVIRI.

MAIN CLOUD TYPES OVER OCEAN

GLAS/GLAS OT>0.2/GLAS ALL LAYERS/SEVIRI 7h30 – 19h30

	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	36/20 21 20/9	6/7/10 4	38/45/54 29	16
Day	25/16 18 9/4 6	5/6/8 5	38/40/43 32	21

SAME BEHAVIOuR OF GLAS and CALIOP VS SEVIRI

Some differences : GLAS high cloud before application of an OT threshold is larger, High cloud, same behaviour than in 2003. SEVIRI low cloud opposite behaviour.

CALIOP/CALIOP OT>0.2/CALIOP ALL LAYERS/SEVIRI 1h30 – 13h30

	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	28/19 22 14/8	6/6/10 4	41/42/51 29	17
Day	24/19 18 7/7 4	5/5/9 4	33/31/40 24	24

MAIN CLOUD TYPES OVER LAND

GLAS/GLAS OT>0.2/GLAS ALL LAYERS/SEVIRI/DX IR/DX VIS-IR

	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	53/34 37 19/11	9/12/18 4	3/4/8 2	3
	20	16	11	
Day	36/22 26 10/4 8	8/10/13 5	7/8/9 6	4
	10/17	16/16	16/15	

SAME BEHAVIOUR OF GLAS and CALIOP VS SEVIRI

Some differences : GLAS high cloud before application of an OT threshold is larger, CALIOP mid-cloud amount is larger during day time

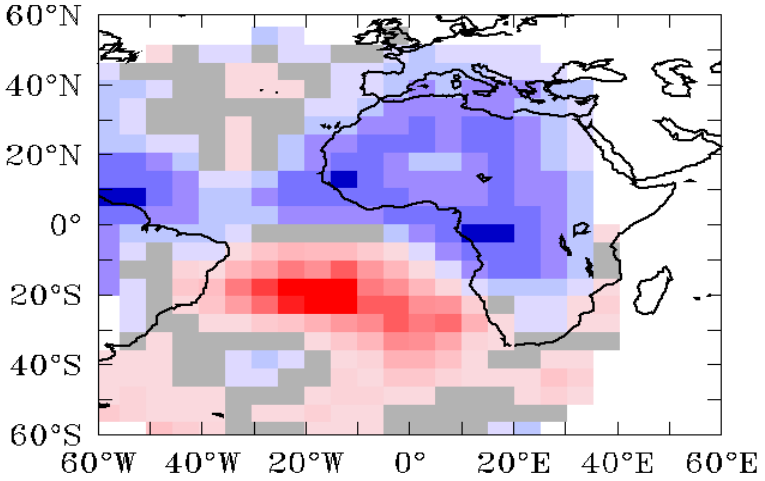
CALIOP/CALIOP OT>0.2/CALIOP ALL LAYERS/SEVIRI 1h30-13h30

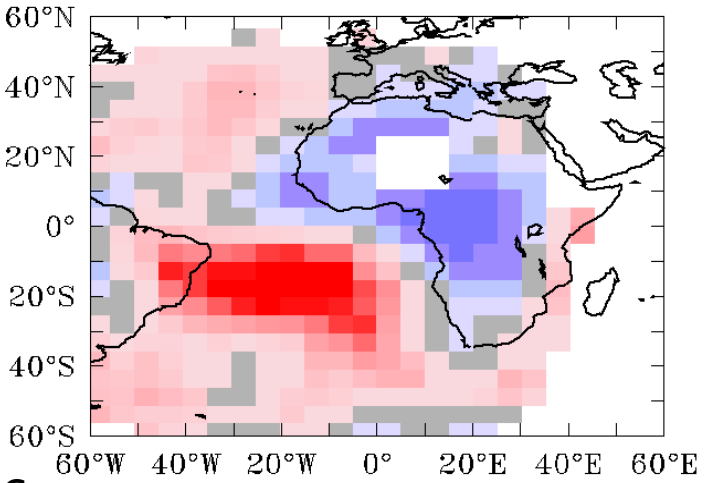
	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	40/30 32 16/10	9/11/19 5	6/7/10 2	3
Day	30/23 26 9/6 6	14/13/19 4	9/9/12 5	9

HIGH CLOUD COVER
DAY and NIGHT (total)

October 2003

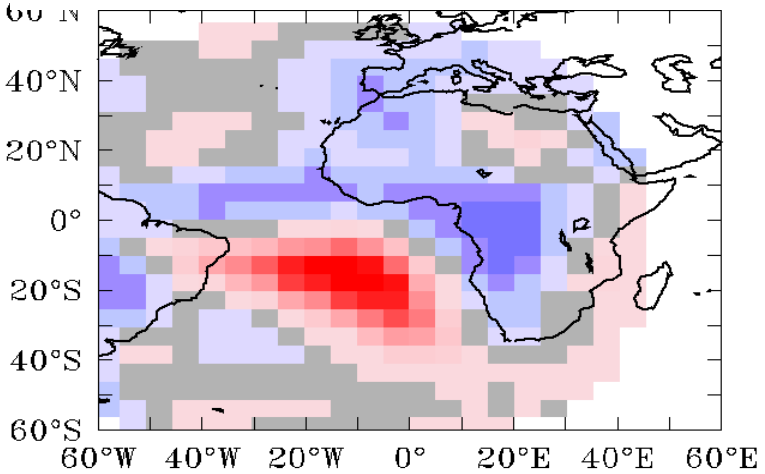
GLAS



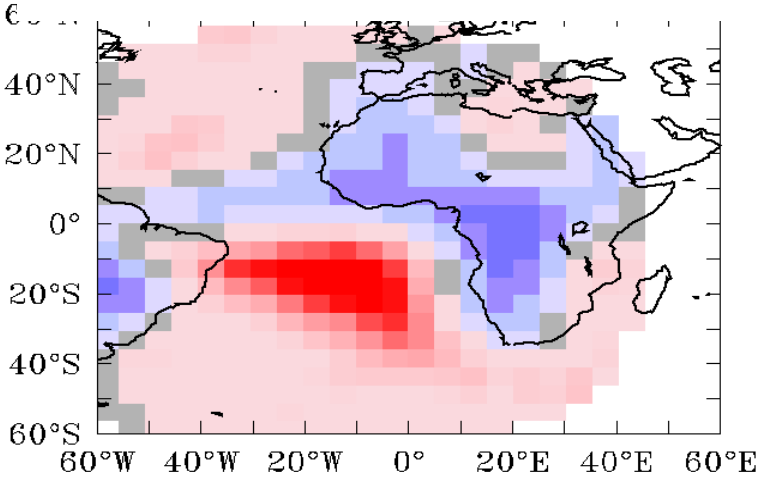


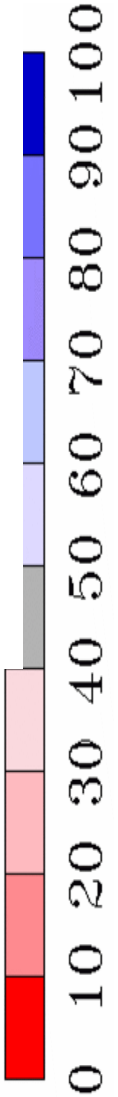
October 2006

CALIOP



SEVIRI



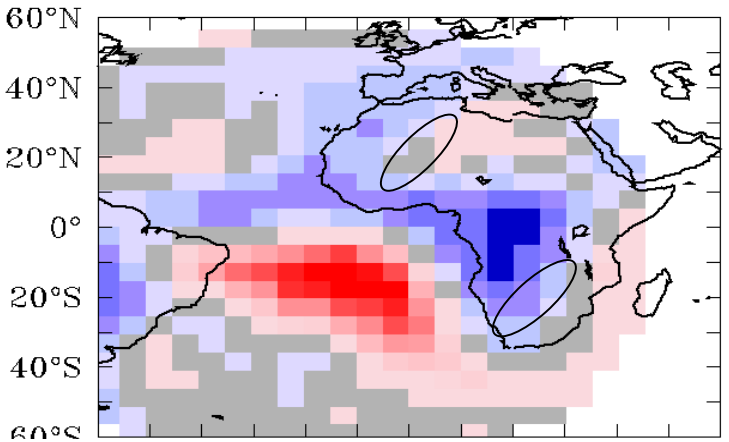


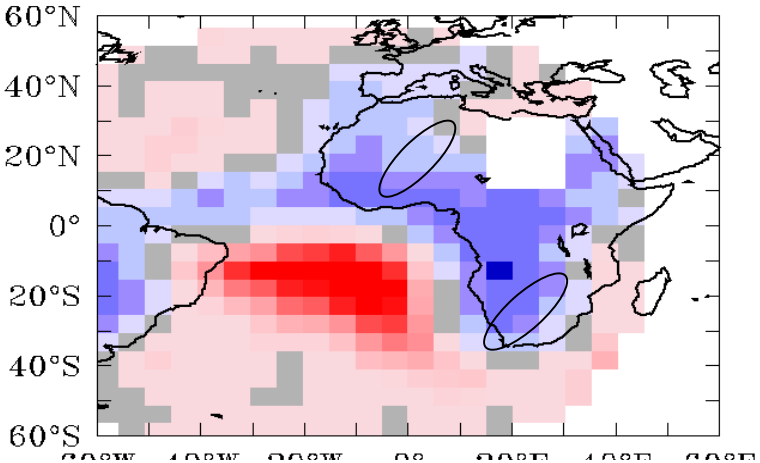
HIGH CLOUD
DAY and NIGHT (sep.)

CALIOP

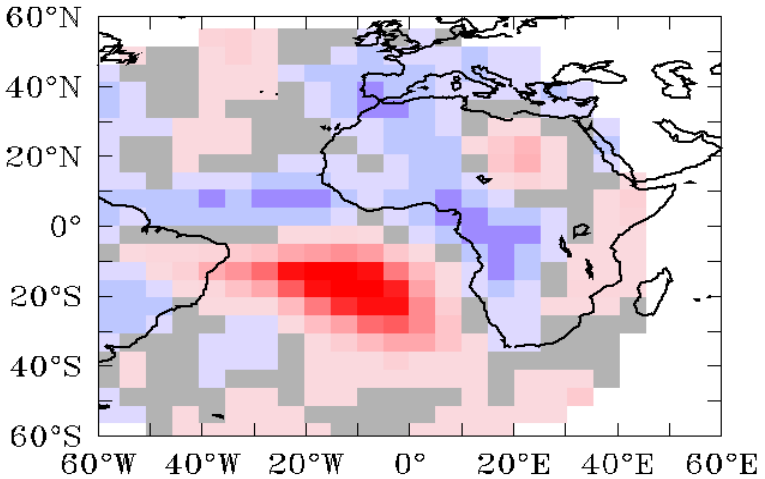
SEVIRI

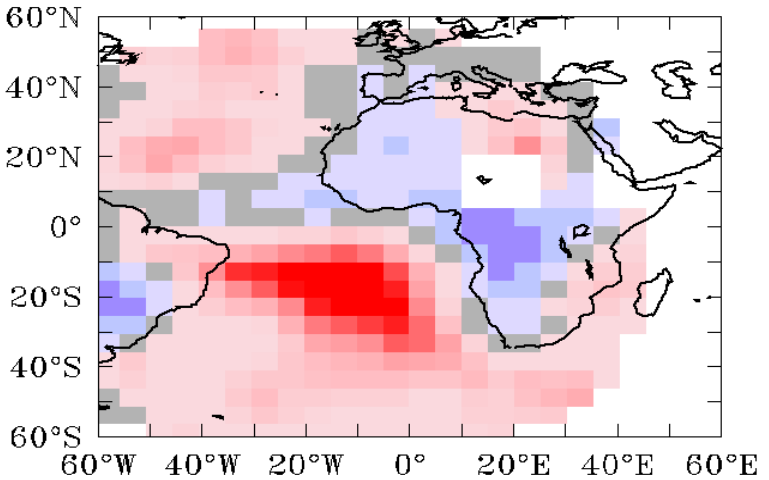
Night

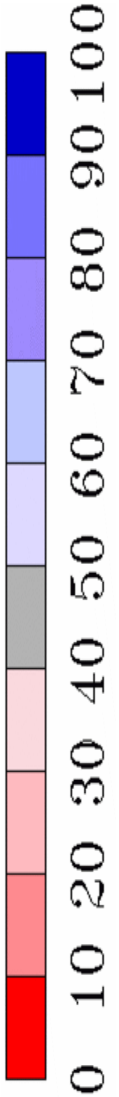




Day



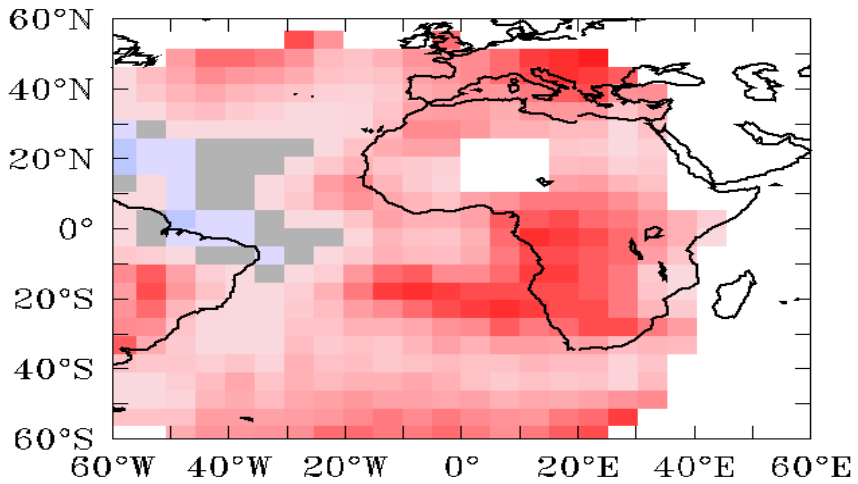




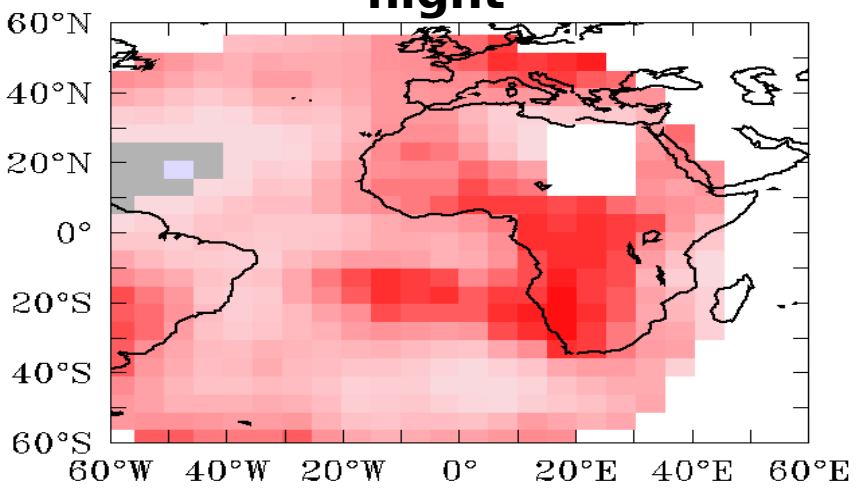
For some regions SEVIRI high cloud frequency larger than CALIOP one's

SEVIRI PARTIAL CLOUD COVER

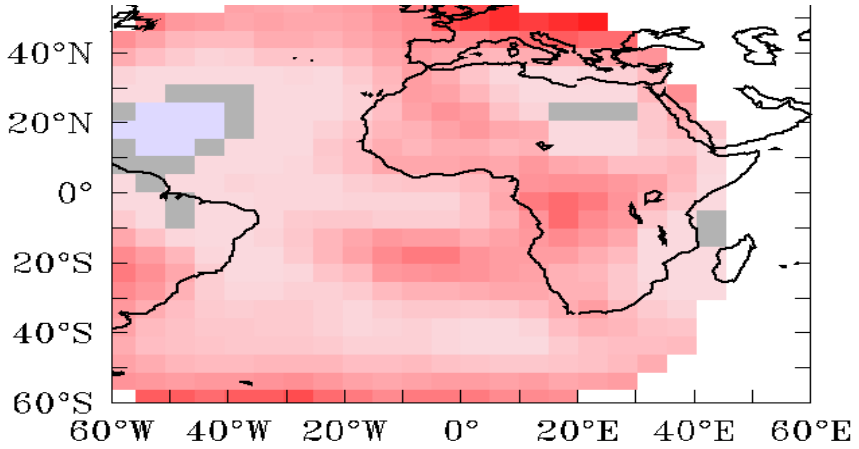
day and night
October 2003



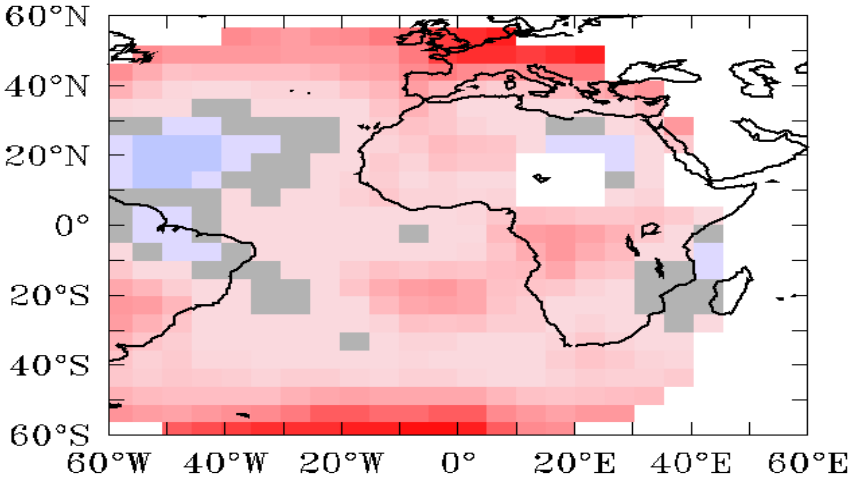
October 2006
night

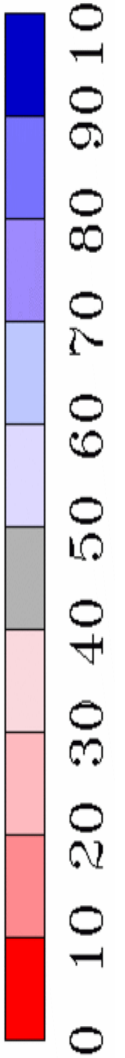


October 2006



day





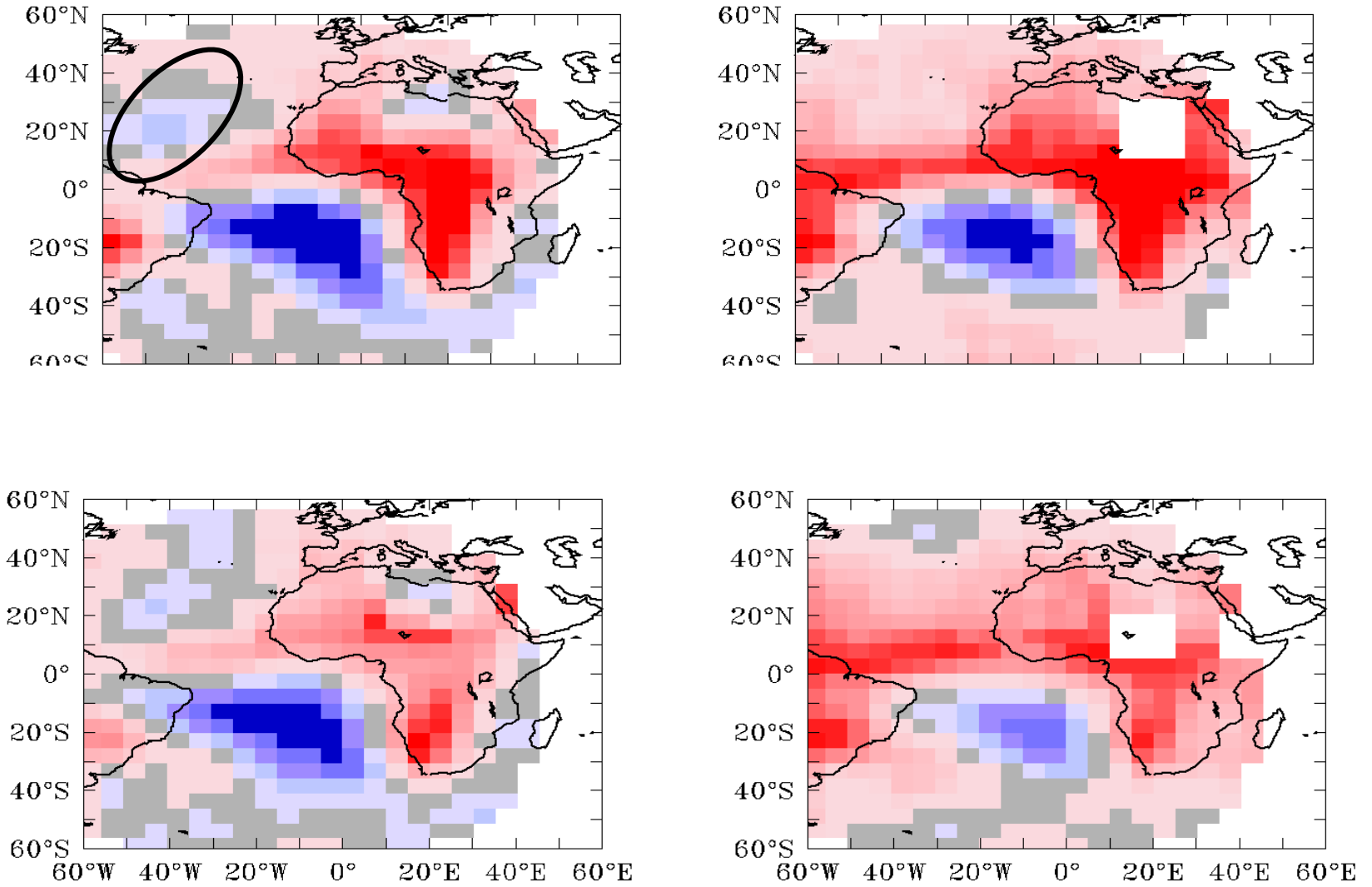
LOW CLOUD
DAY and NIGHT (sep.)

CALIOP

SEVIRI

Night

Day



COMPARISON AT PIXEL LEVEL: CLOUD COVER CO-OCCURENCE MATRIX

		83%/89%			82%/92% SEVIRI			83%/92%			81%/94%		
		Ocean Night			Land Night			Ocean Day			Land Day		
CALIO		clear	cloud	par	clear	cloud	part	clear	cloud	part	clear	cloud	part
	cle.	18/25	8/4	4/2	43/55	1/1	0/0	24/32	13/7	10/5	42/60	6/34	3/0
	clo.	10/6	65/64	13/3	16/7	40/37	2/0	5/2	58/60	14/5	14/5	39/35	7/0

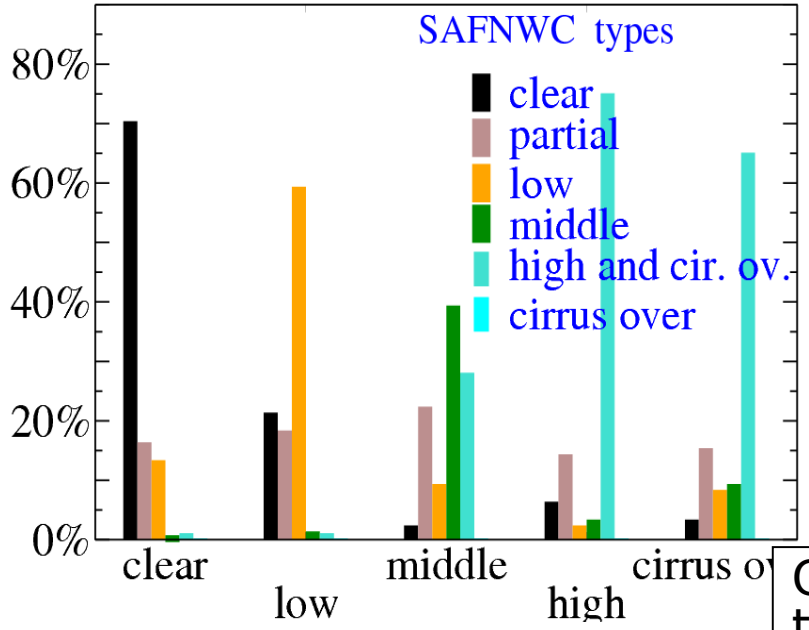
SAME BEHAVIOR OF GLAS and CALIOP VS SEVIRI

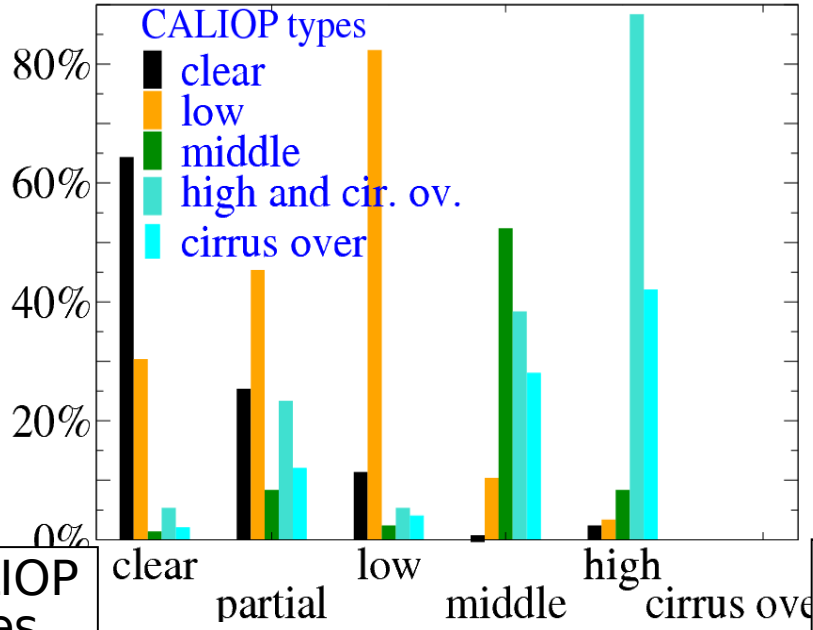
Partial cloud coverage included in SEVIRI CC

Application of a spatial homogeneity test on SEVIRI data and excluding the cloud layer with optical thickness smaller than 0.2 increase the agreement in all cases.

CALIOP and SEVIRI over OCEAN
Ver. 2 October 2006

Night

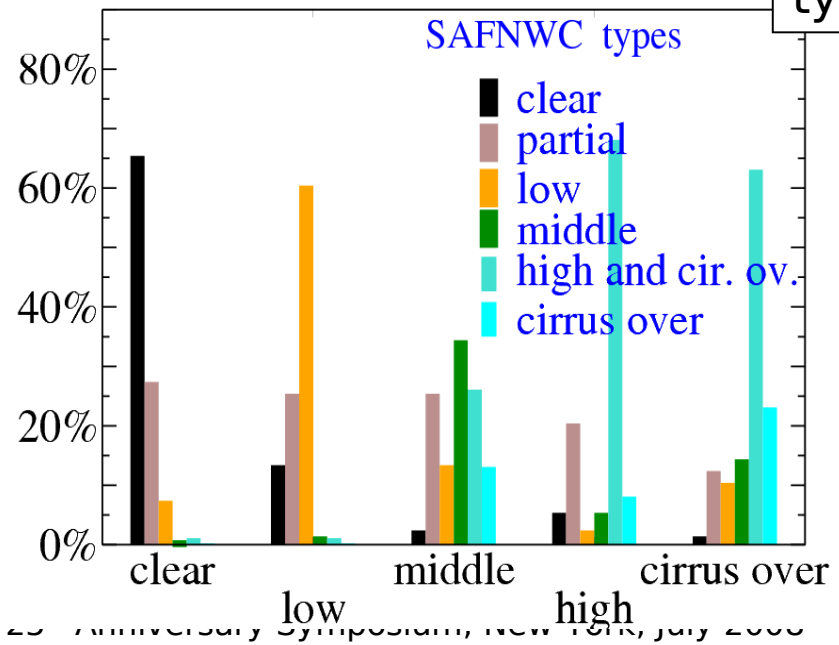


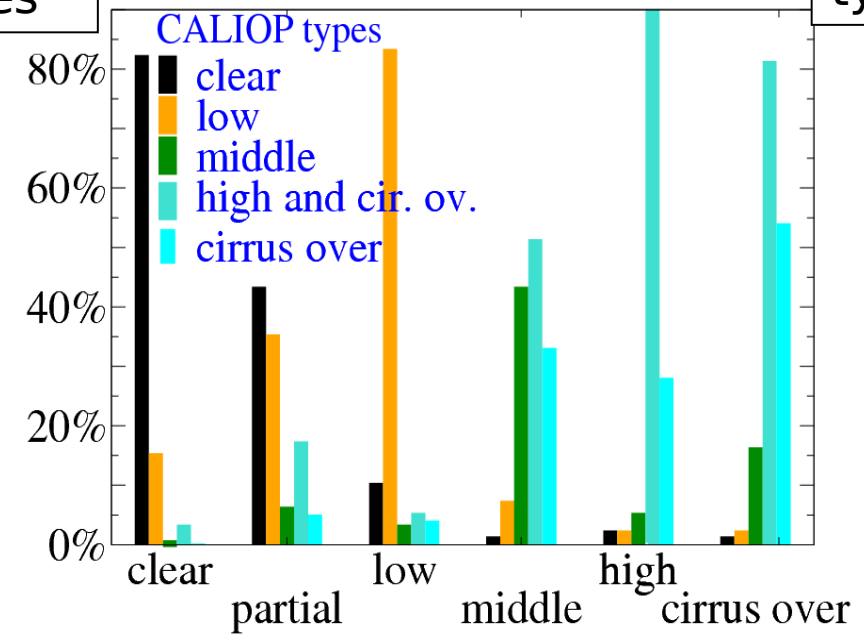


CALIOP types

SEVIRI types

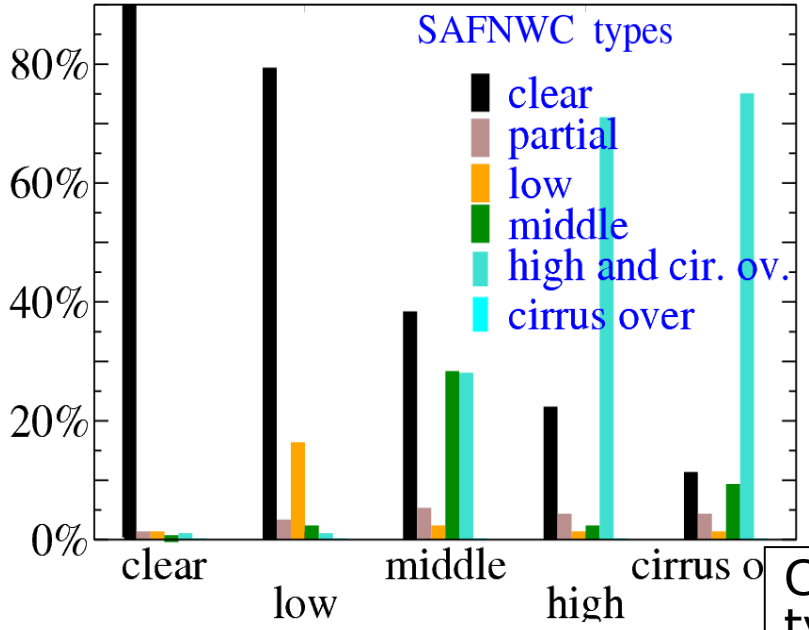
Day

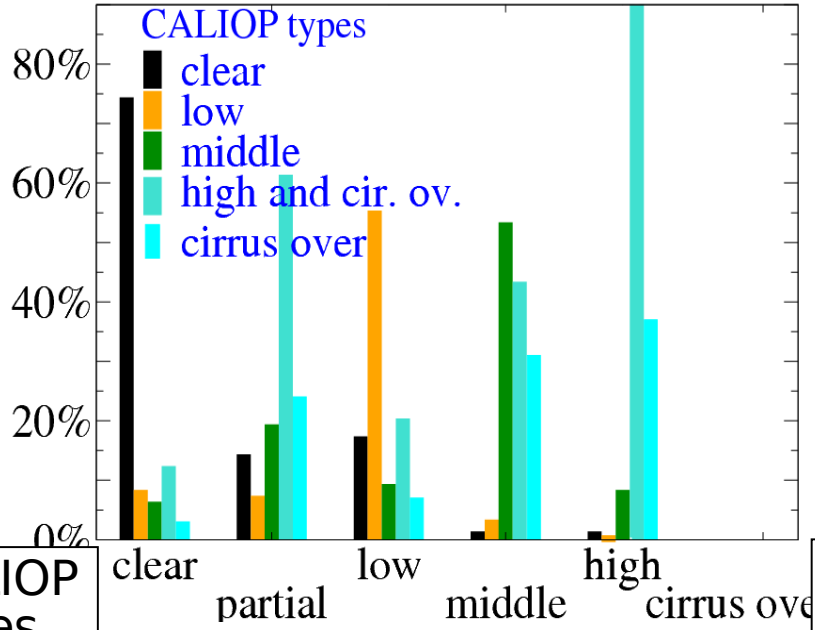




CALIOP and SEVIRI over LAND new October 2006

Night

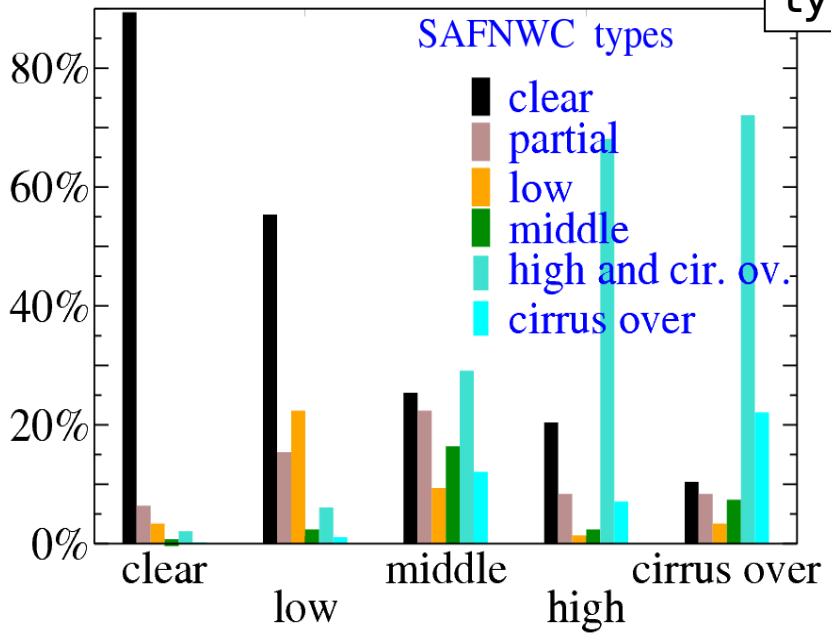


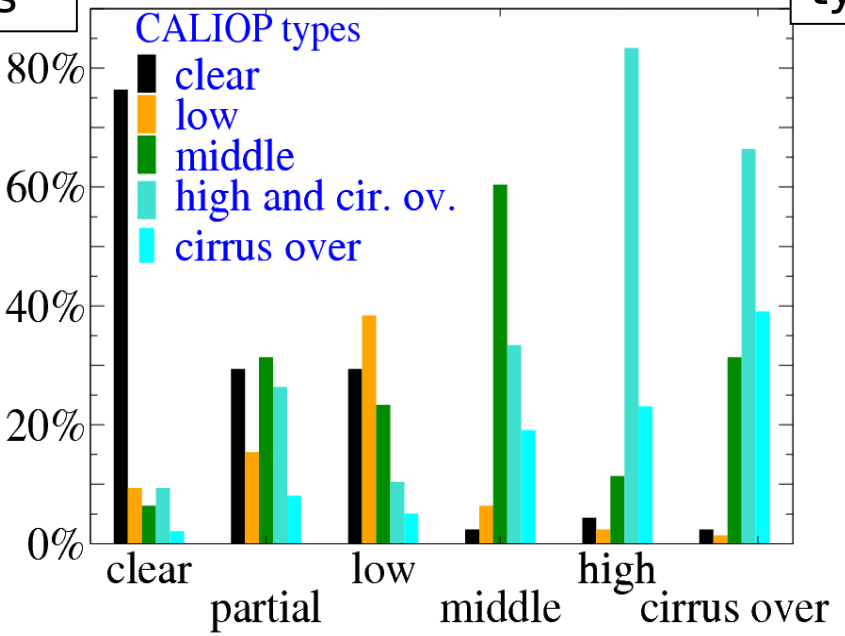


CALIOP types

SEVIRI types

Day





ISCCP

CONCLUSION

SEVIRI cloud cover and cloud frequency types have been compared with October 2003 GLAS data and October 2006 CALIOP data for land and ocean night and day data separately.

The same behaviour of GLAS and CALIOP versus SEVIRI is found.

The agreement at pixel scale is above 79%. For CALIOP when a spatial homogeneity test (SEVIRI) plus an 0.2 OT threshold (lidar) are applied the agreement is above 89%.

High SEVIRI clouds are classified high cloud by the lidar in more than 80% of the cases. The agreement for mid-level cloud is poor and also over land for low cloud.

The better detection of small or broken low clouds over ocean during day-time by SEVIRI must increase the frequency of lidar clear profils detected cloudy by SEVIRI.

Some differences, not large for the CALIOP/SEVIRI comparison, are observed between night and day in the behavior of the lidar data and SEVIRI data. More investigations are required.

FURTHER WORK

Pursue the comparison between SEVIRI and CALIOP on a longueur data set and as a function of latitude and cloud systems in the aim to improve the cloud diurnal and life cycle obtained with the geostationnary data.

Do the same type of analyses for other geostationnary data set in the frame of the MEGHA-TROPIQUE experiment.

Analyses the results in order to improve the existing ISCCP climatology.

THANKS TO ASDC(NASA) AND ICARE(CNES) FOR THE DATA PROVISION

CONCLUSION

- check of coherence and complementarity with other sensors (existing climatologies from passive sensors): GLAS, CALIOP differences with SEVIRI comparable.
- DX....
- looking at cloud types separating land and ocean...
- Importance of diurnal cycle (vertical structure and CC),
- Low cloud occurrence much larger over ocean (subsidence areas)
- Larger occurrence of multiple cloud layers including low clouds over land

Future work

- Refine algorithm to minimize error and false detection (aerosol-cloud separation- ....) to analyse time evolution?
- Pursue the study using other geostationnary satellites in the frame of the MEGHA-Tropique experiment.
- Improve the analyses of the ISCCP climatology

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- DX....
- looking at cloud types separating land and ocean...
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- Larger occurrence of multiple cloud layers including low clouds over land

GLAS-ISCCP differences depend on cloud types and of their diurnal cycle

Future work

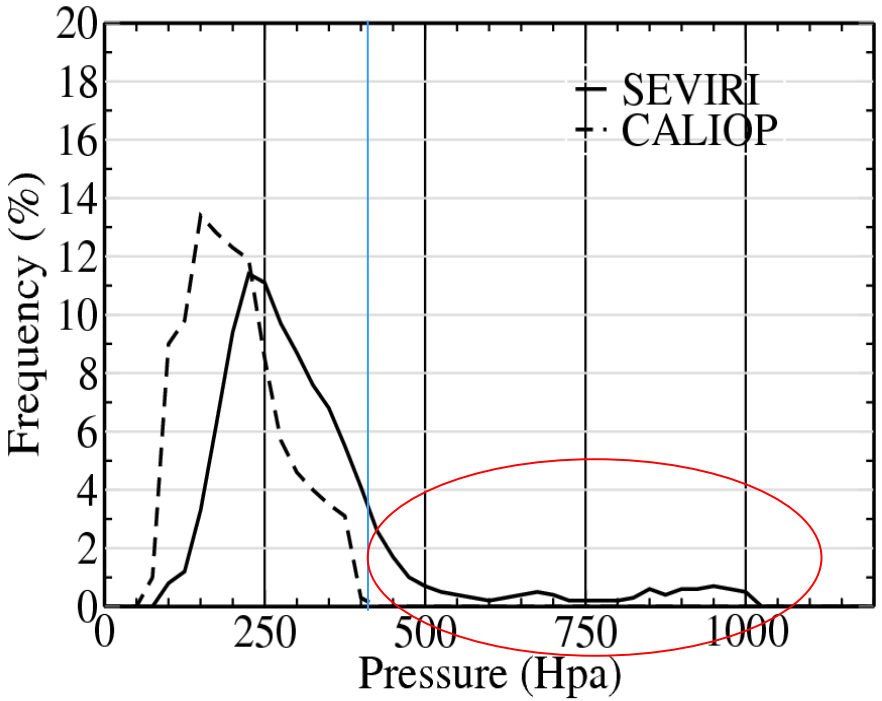
- Refine algorithm to minimize error and false detection (aerosol-cloud separation- ....) to analyse time evolution?
- Pursue the study using other geostationnary satellites in the frame of the MEGHA-Tropique experiment.
- Improve the analyses of the ISCCP climatology

THANKS TO ASDC(NASA) AND ICARE(CNES) FOR THE

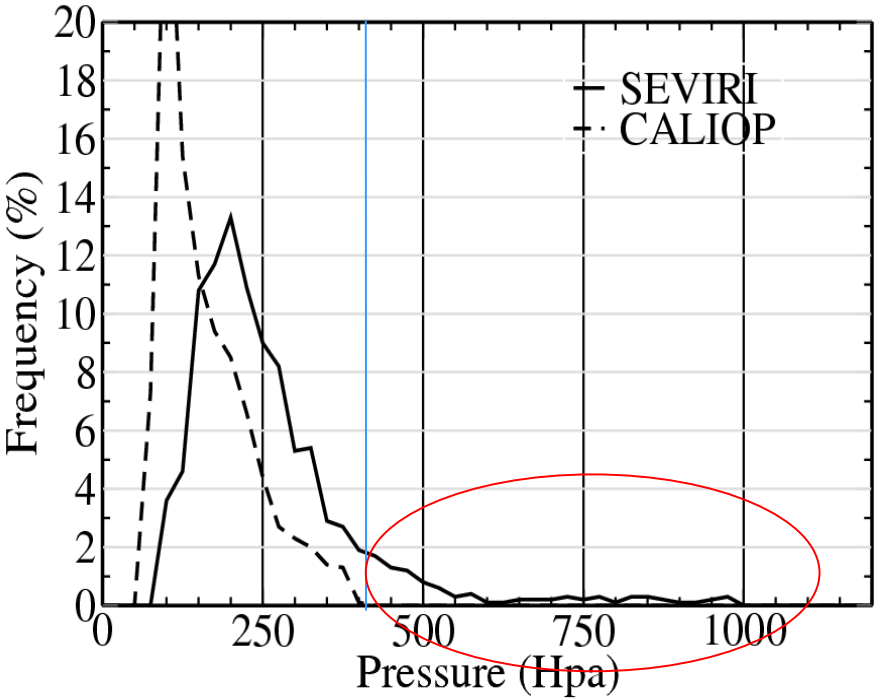
BACK-UP SLIDES

DISTRIBUTION OF SEVIRI CLOUD TOPS

FOR CALIOP high clouds tops below 400 hPa Night data



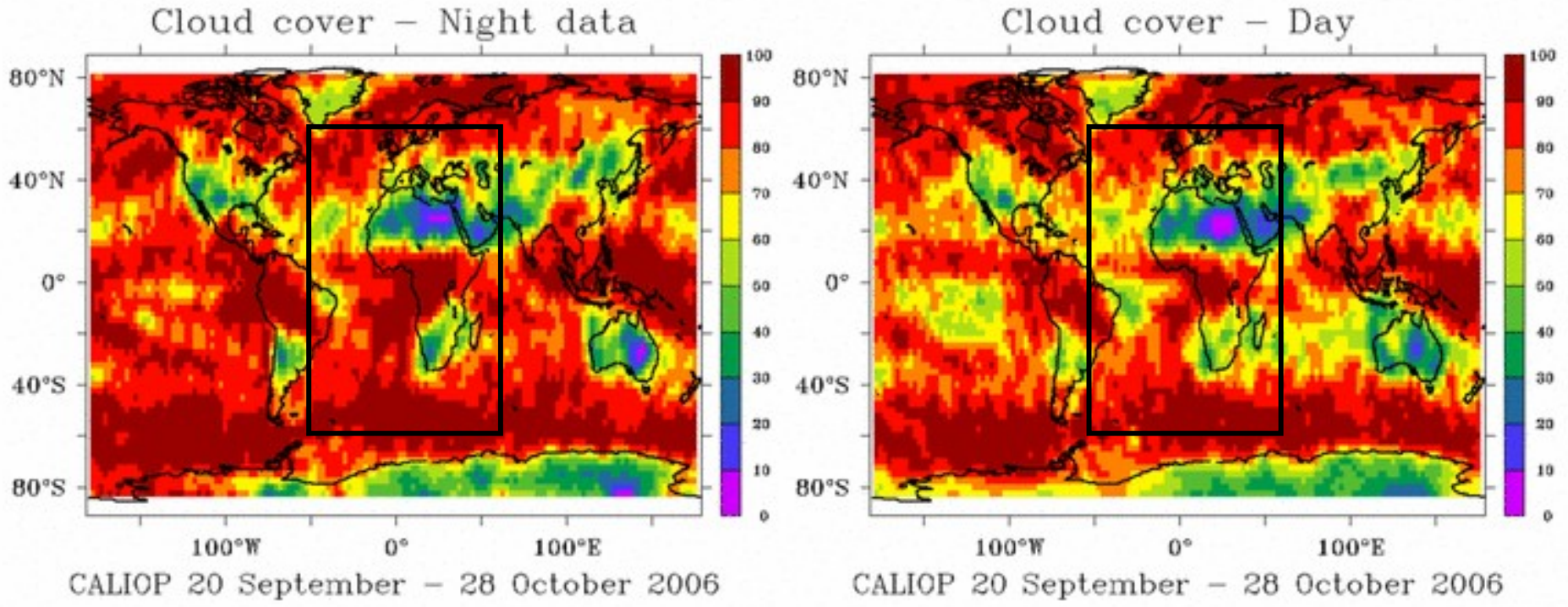
OCEAN



Land

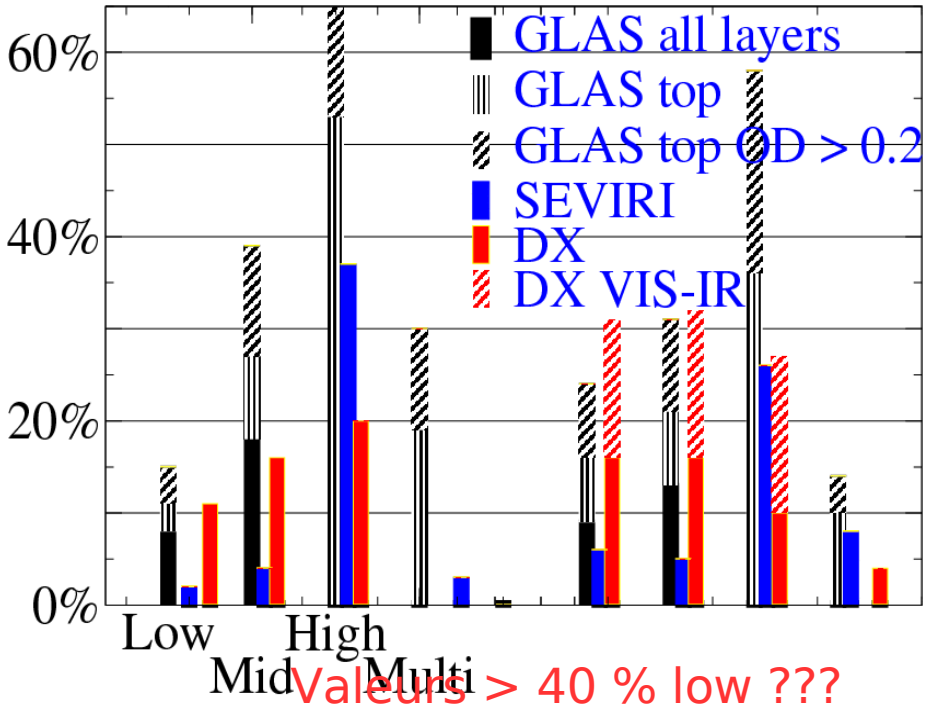
CALIPSO CLOUD COVER

September-October 2006

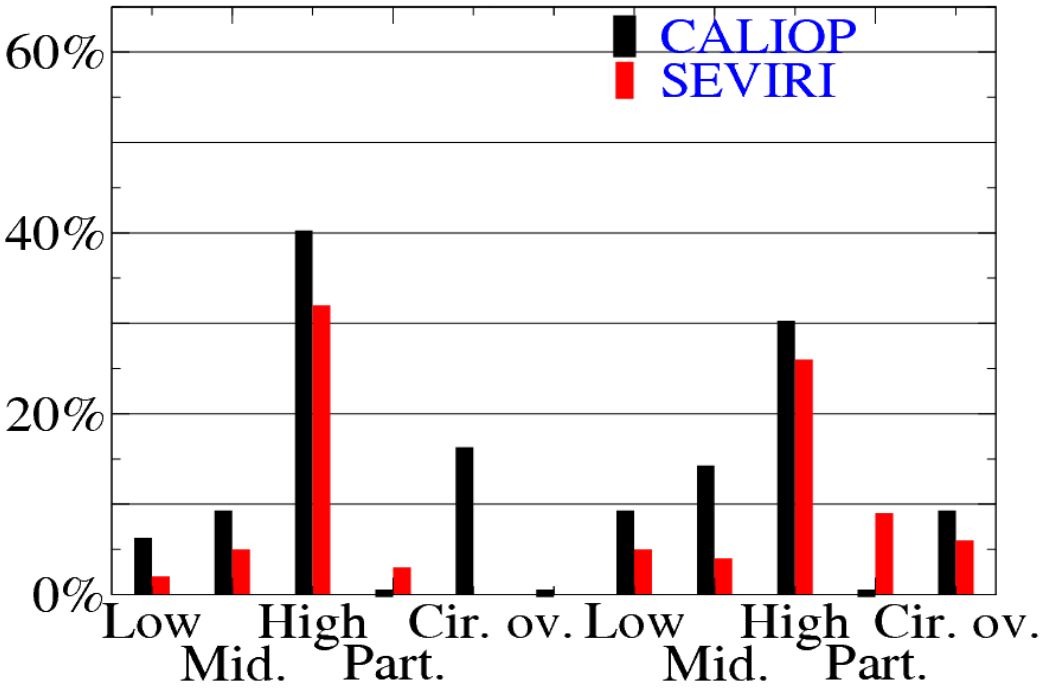


- **Importance of diurnal cycle (> 20 % change at tropical and mid-latitudes in southern hemisphere –low clouds-)**
- **Minimum of Cloud cover well observed over desert areas, south pole, and subsidence areas linked to tropical convection**

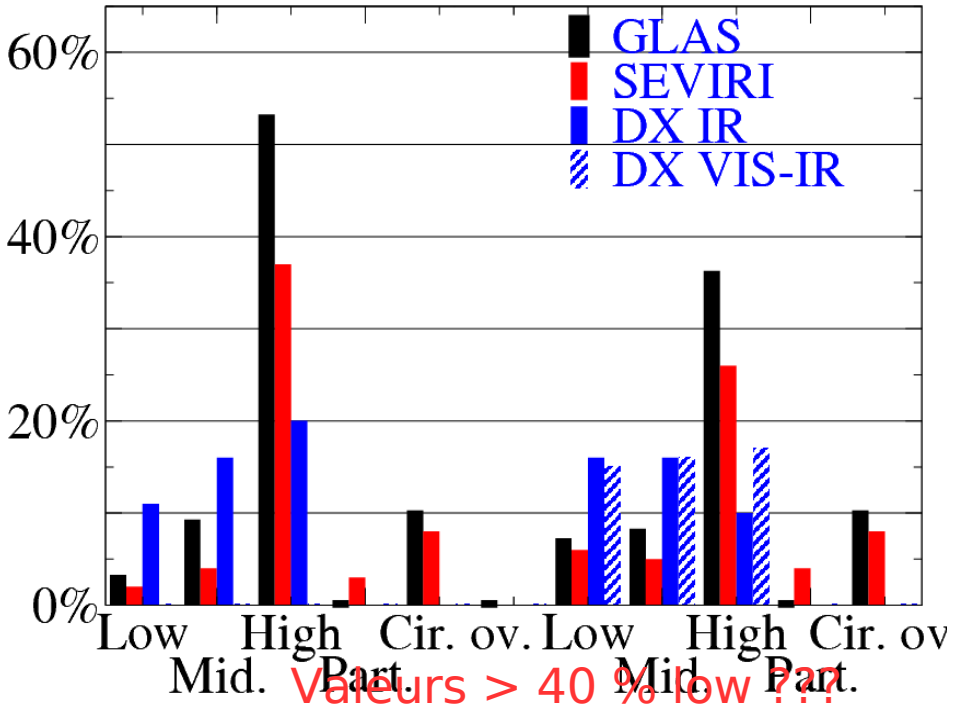
MAIN CLOUD TYPES



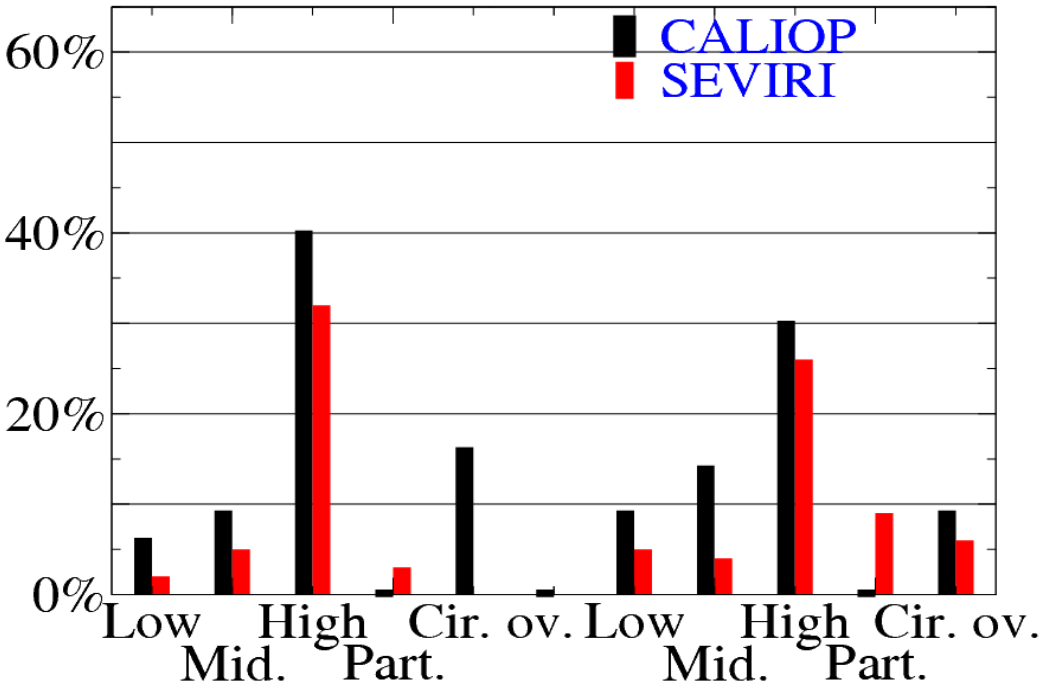
Valeurs > 40 % low ???

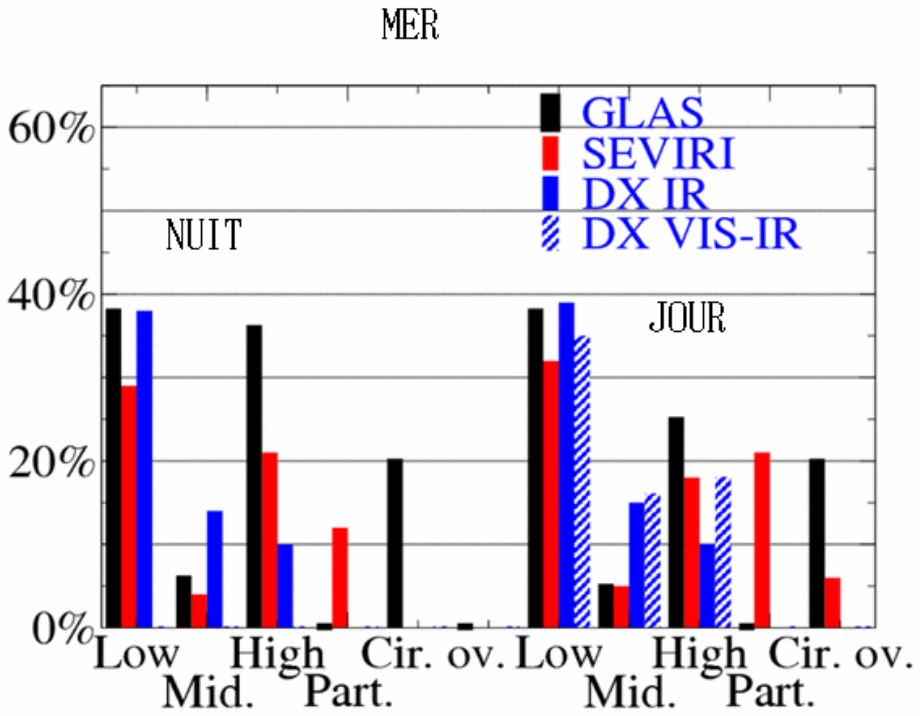


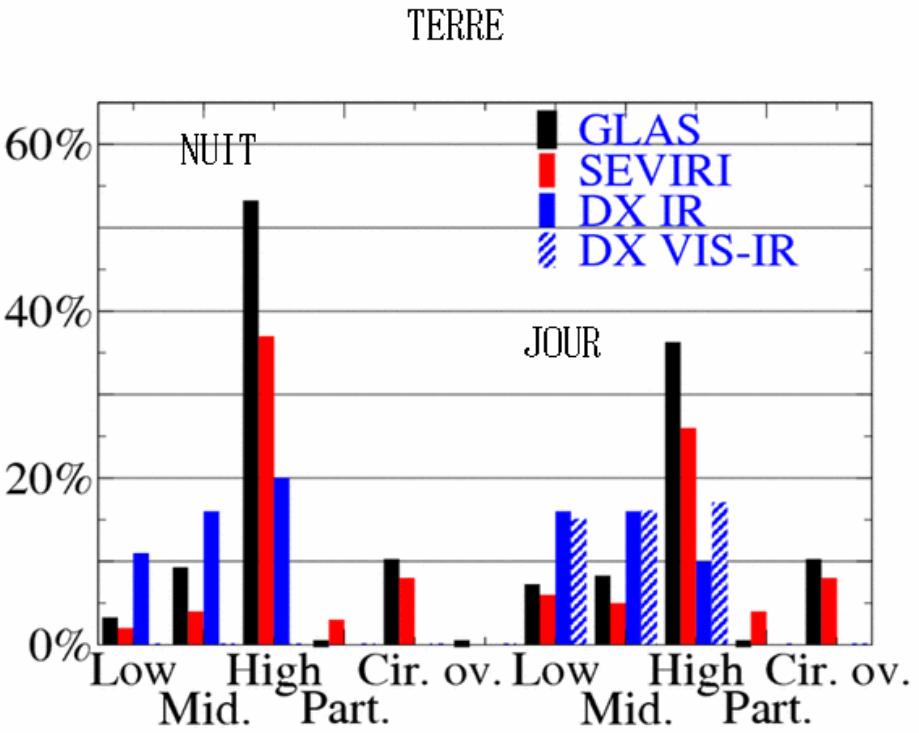
MAIN CLOUD TYPES

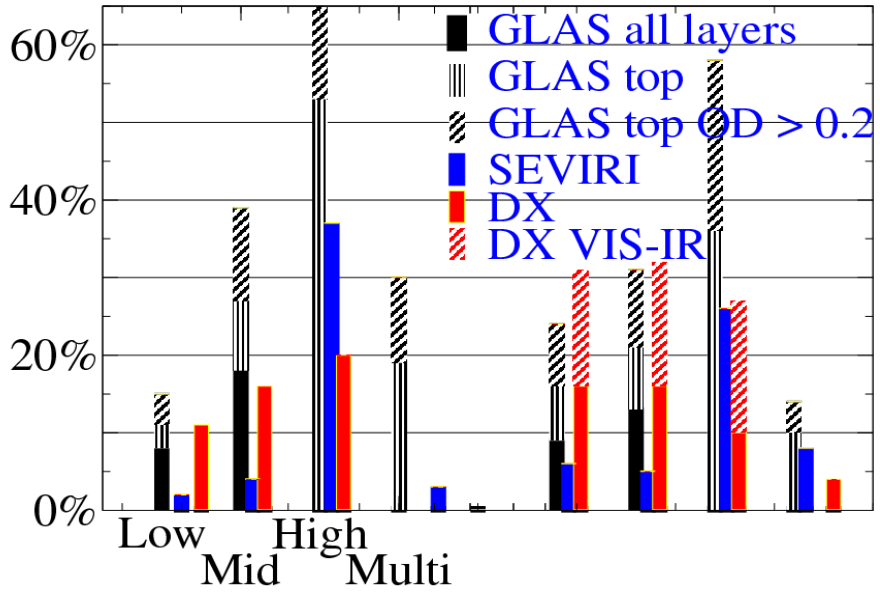


Valeurs > 40 % low ???



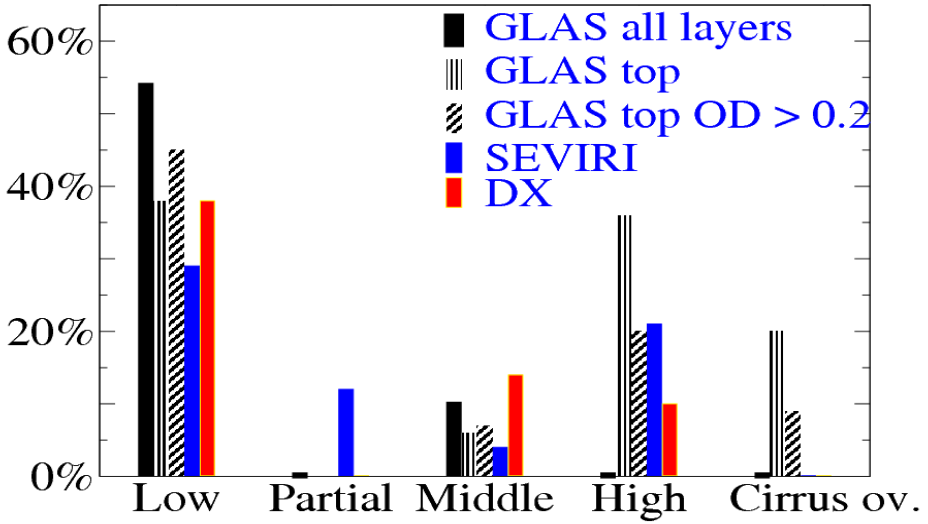

MER
60%
40%
20%
0%
NUIT
JOUR
GLAS
SEVIRI
DX IR
DX VIS-IR
Low
Mid.
High
Part.
Cir. ov.
Low
Mid.
High
Part.
Cir. ov.


TERRE
60%
40%
20%
0%
NUIT
JOUR
GLAS
SEVIRI
DX IR
DX VIS-IR
Low
Mid.
High
Part.
Cir. ov.
Low
Mid.
High
Part.
Cir. ov.

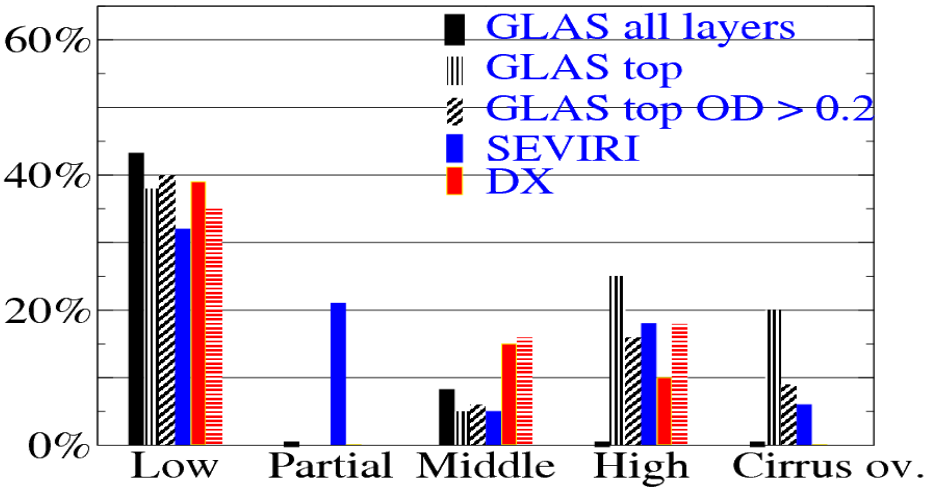

60%
40%
20%
0%
GLAS all layers
GLAS top
GLAS top OD > 0.2
SEVIRI
DX
DX VIS-IR
Low
Mid
High
Multi

GLAS – SEVIRI – DX MAIN CLOUD TYPES

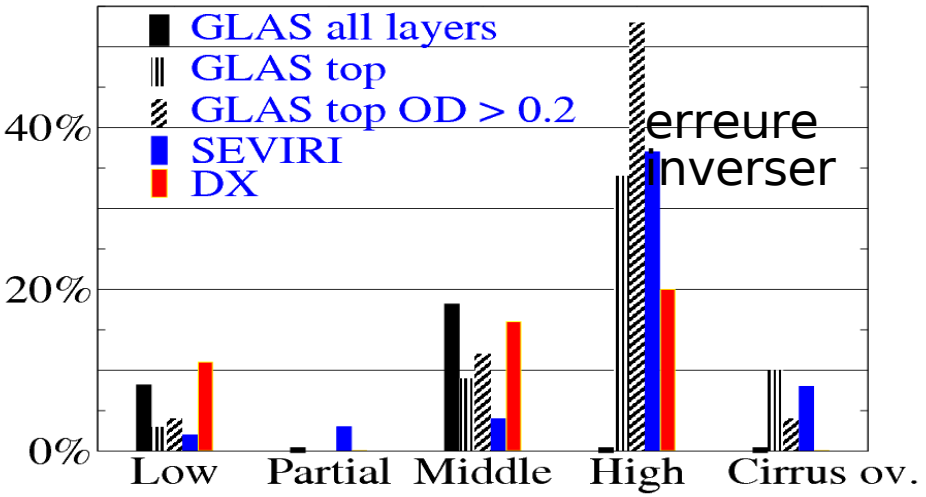
Night OCEAN

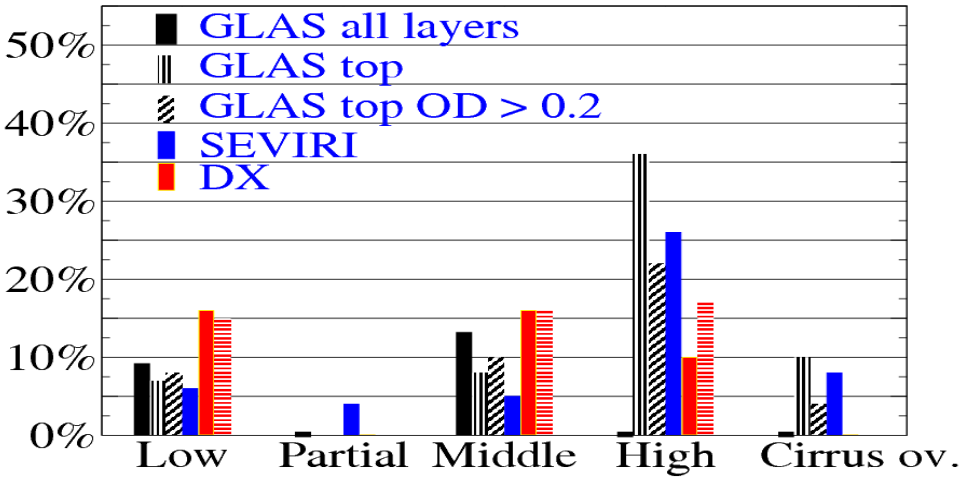


Day



LAND





GLAS, SEVIRI and CALIOP CLOUD COVER

October 2006 at 1h30 - 13h30

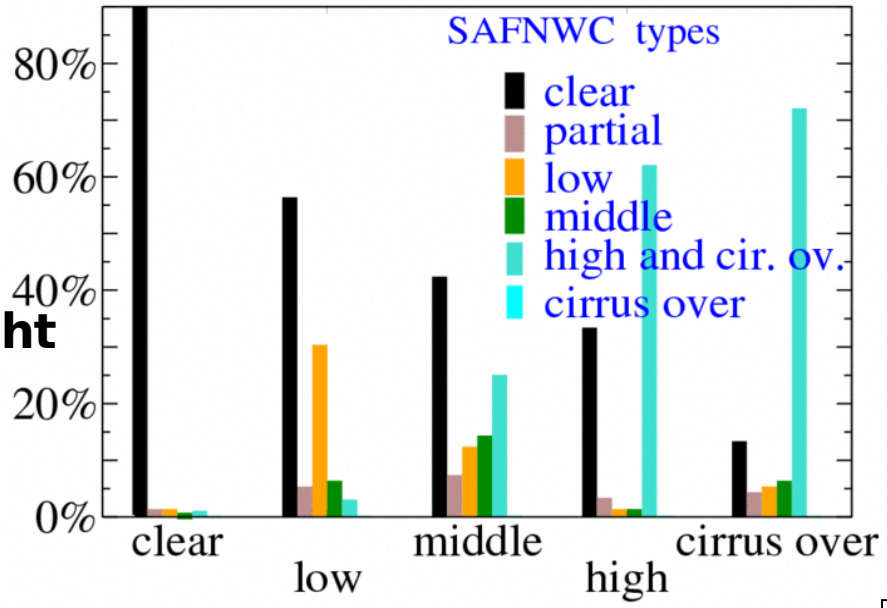
	SEVIRI	GLAS (All)	GLAS (OT>0.1)	GLAS (OT>0.2)	ISCCP DX IR/VIS-IR
Ocean Night	70	80	74(-6)	72(-8)	62
Ocean Day	76	69	65(-4)	62(-6)	63/69
Land Night	46	64	54(-10)	50(-14)	45
Land Day	40	50	44(-6)	39(-11)	42/48

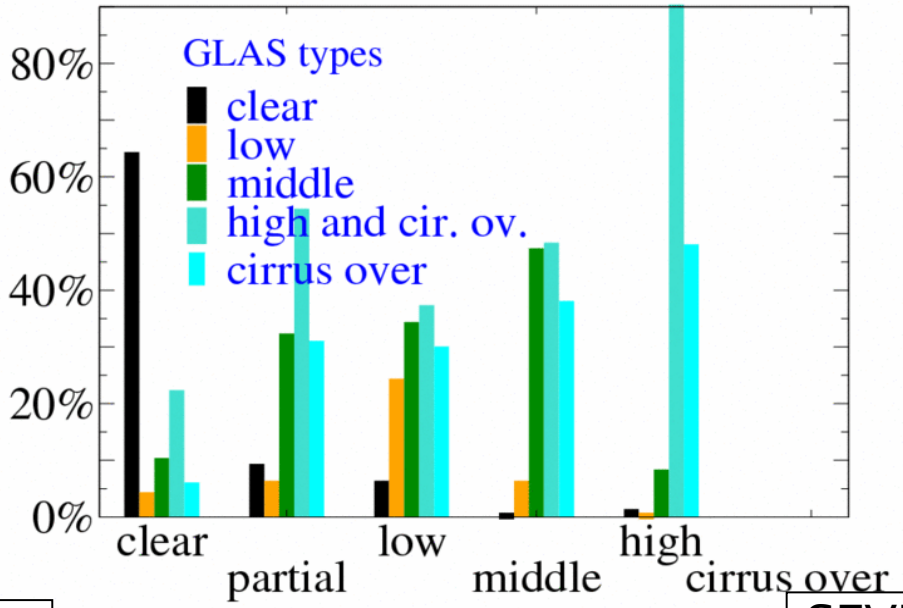
October 2006 at 1h30 - 13h30

	SEVIRI	CALIOP (All)	CALIOP (OT>0.1)	CALIOP (OT>0.2)	ISCCP DX IR/VIS-IR
Ocean Night	72	75	72(-3)	68(-7)	??
Ocean Day	70	63	60(-3)	56(-7)	??
Land Night	41	56	52(-4)	48(-8)	??
Land Day	44	53	50(-3)	45(-8)	??

GLAS and SEVIRI over LAND October 2003

Night

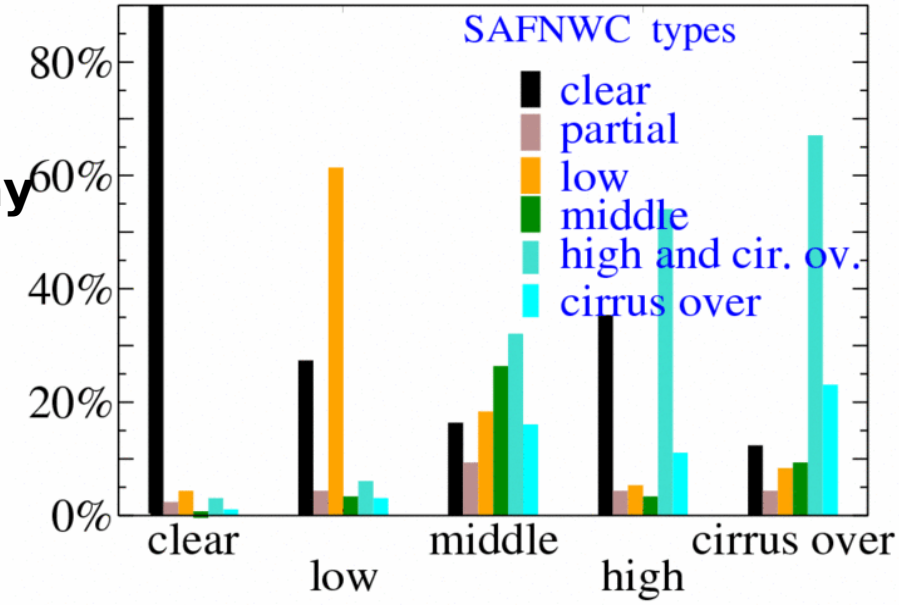


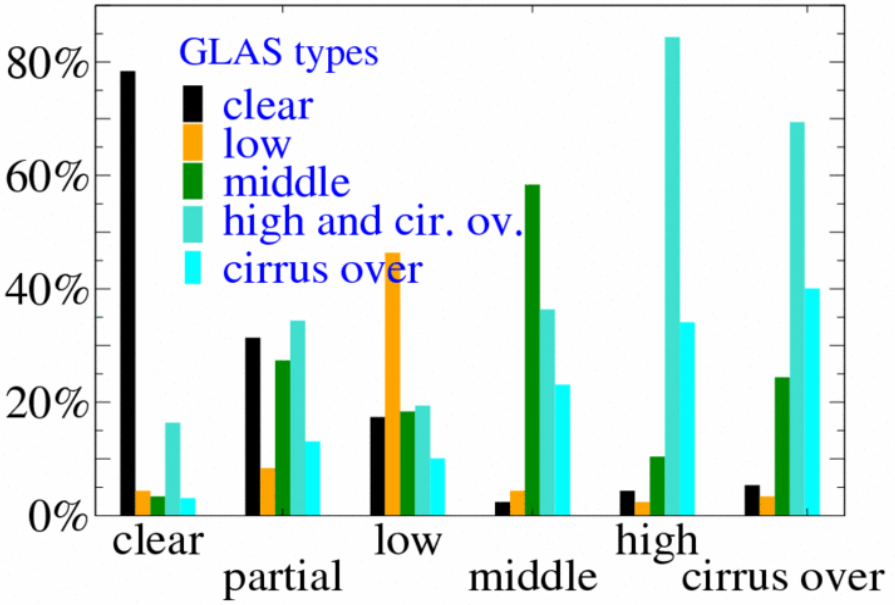


GLAS types

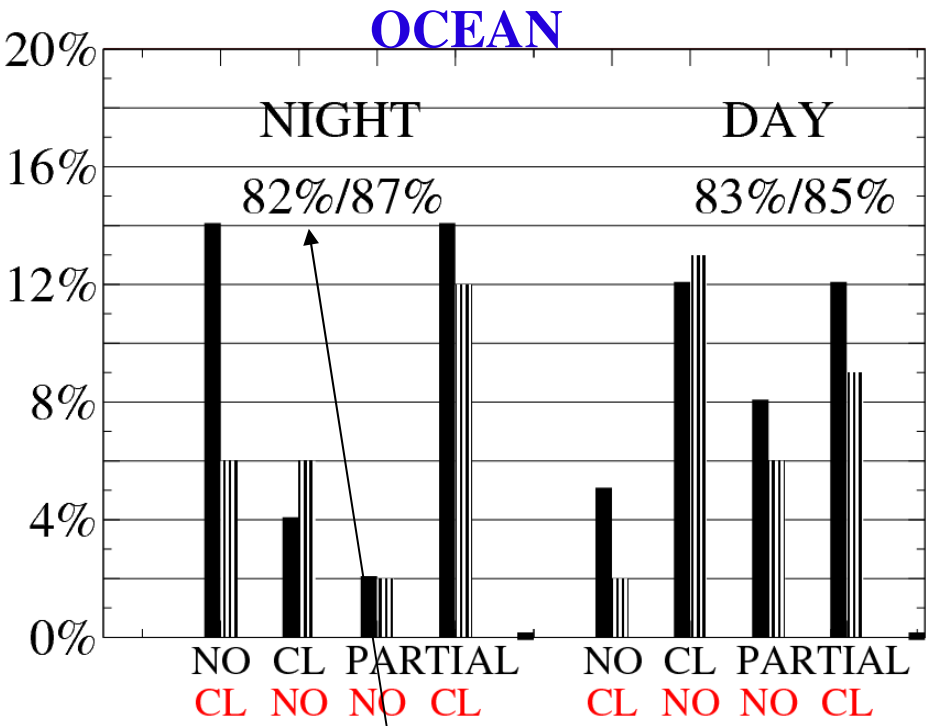
SEVIRI types

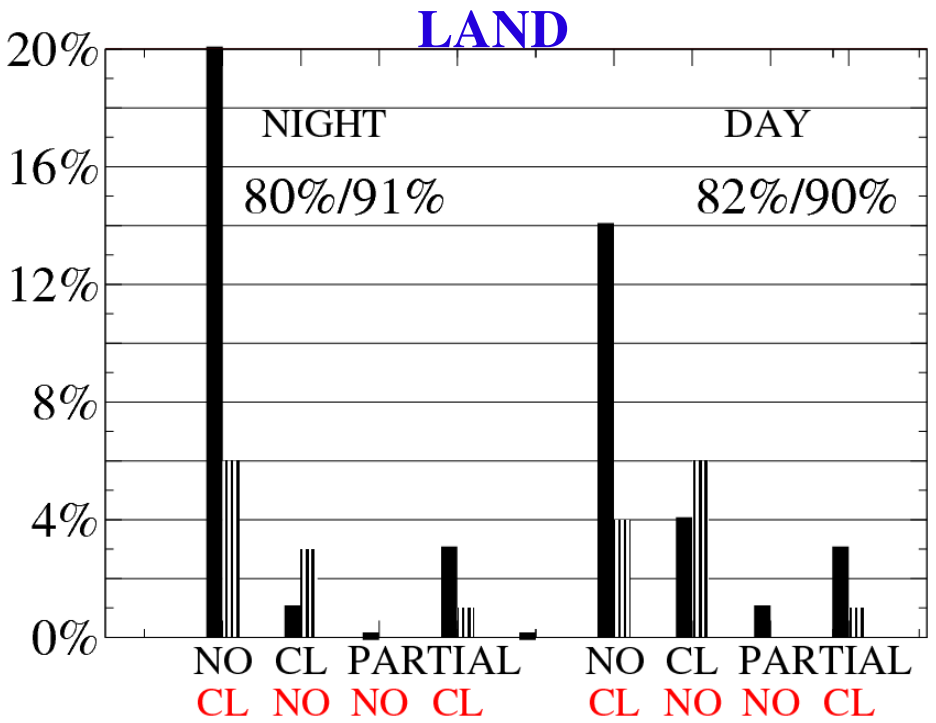
Day





GLAS - SEVIRI CLOUD COVER



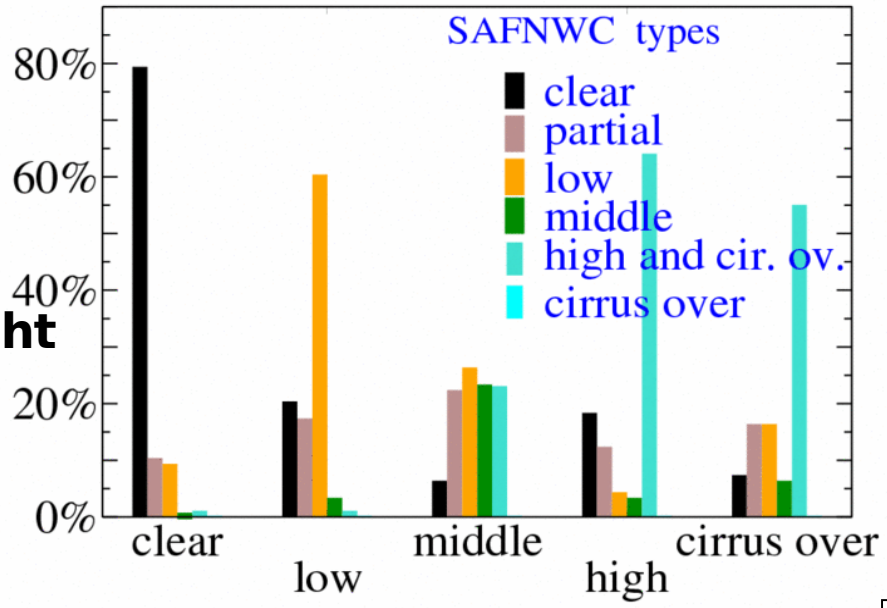


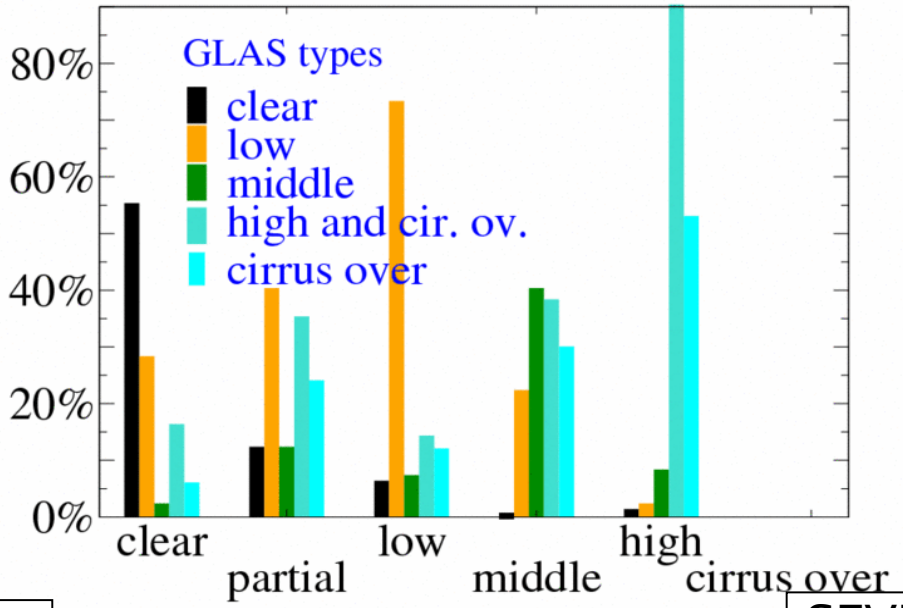
agreement frequency (CL-CL and NOCL-NOCL)

GLAS		SEVIRI											
		Ocean Night			Land Night			Ocean Day			Land Day		
		clear	cloud	par	clear	cloud	part	clear	cloud	part	clear	cloud	part
	clea	16/19	**4/6**	2/2	35/49	**1/3**	0/0	20/18	**12/13**	8/6	46/58	**4/6**	1/0
	clr	**14/6**	66/68	14/12	**20/6**	45/42	3/1	**5/2**	63/67	12/9	**14/4**	36/32	3/1

GLAS and SEVIRI over OCEAN
October 2003

Night

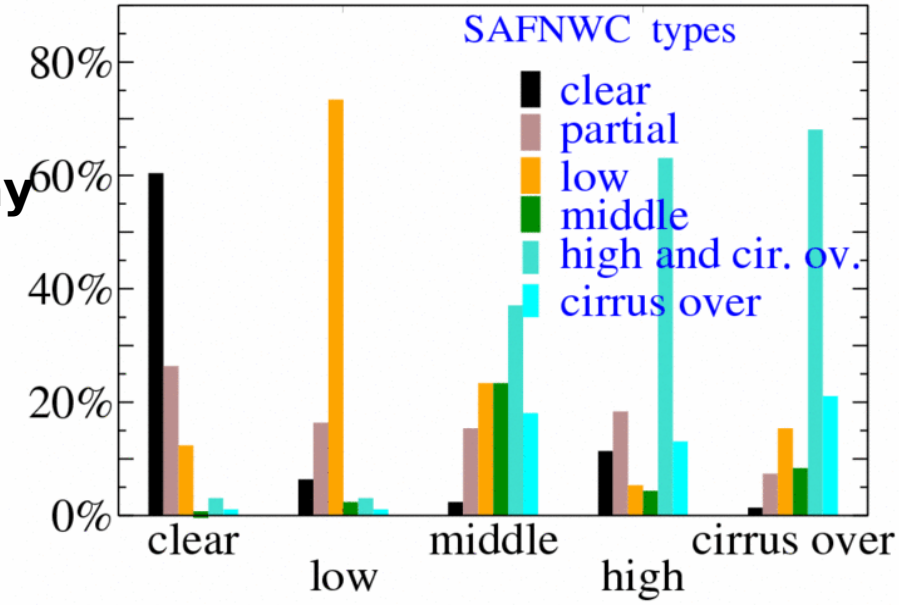


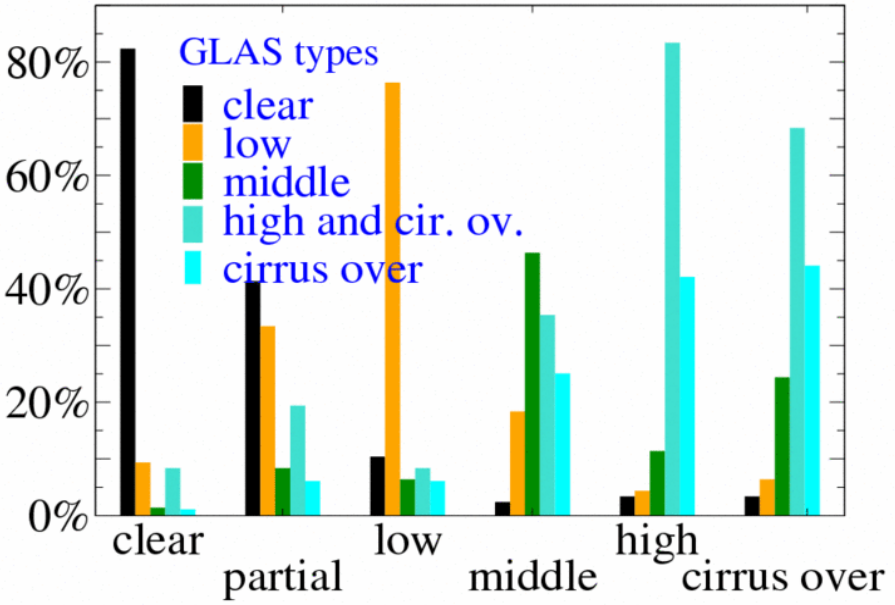


GLAS types

SEVIRI types

Day





MAIN CLOUD TYPES OVER OCEAN

GLAS/GLAS OT>0.2/GLAS ALL LAYERS/SEVIRI

	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	36/20 21 20/9	6/7/10 4	38/45/54 29	16
Day	25/16 18 9/4 6	5/6/8 5	38/40/43 32	21

CALIOP/CALIOP OT>0.2/CALIOP ALL LAYERS/SEVIRI

	HIGH<440hPa (Cir.ov)	Middle	LOW>680hPa	Part
Night	28/19 22 14/8	6/6/10 4	41/42/51 29	17
Day	24/19 18 7/7 4	5/5/9 4	33/31/40 24	24

MAIN CLOUD TYPES OVER

GLAS/GLAS OT<0.2/GLAS ALL LAYERS/SEVIRI/DXIR/DXIR-VIS

	HIGH<440hPa	Middle	LOW>680hPa	Part
Night	36/20 21 10	6/7/10 4 14	38/45/54 29 38	16
Day	25/16 18 10/18	5/6/8 5 15/16	38/40/43 32 39/35	21

GLAS/GLAS OT<0.2/GLAS ALL LAYERS/SEVIRI/DXIR/DXIR-VIS

	HIGH<440hPa	Middle	LOW>680hPa	Part
Night	53/34 37 20	9/12/18 4 16	3/4/8 2 11	3
Day	36/22 26 10/17	8/10/13 5 16/16	7/8/9 6 16/15	4

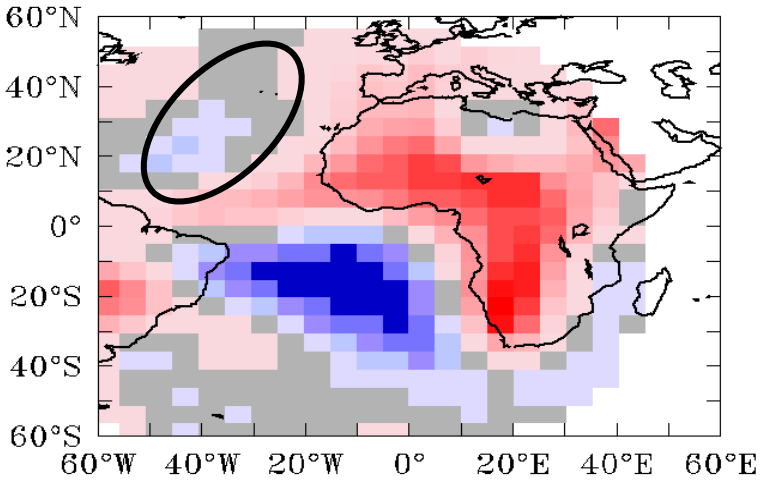
LOW CLOUD COVER

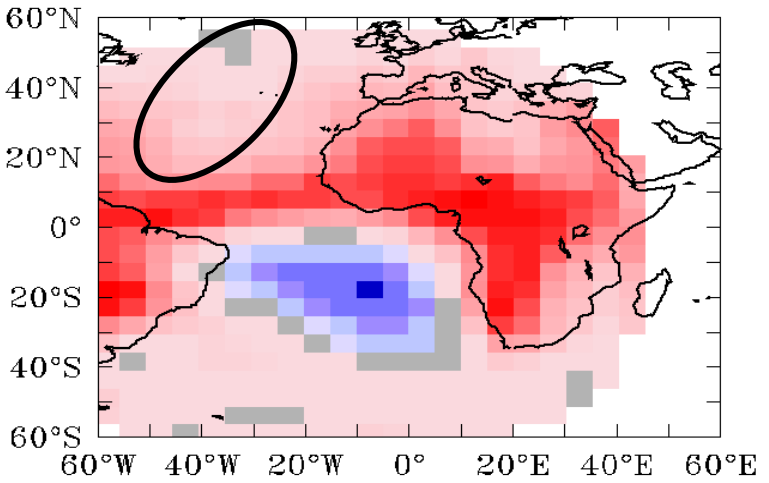
(day + night)

October 2003

SEVIRI

CALIOP





GLAS