Rob Roebeling, Anke Thoss (SMHI) and Andi Walther (SSEC)

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Andrew Heidinger for scientific support
MeteoSwiss for hosting (Igor Giunta)
EUMETSAT for co-funding
All research groups for providing their data

Outcome of EUMETSAT Cloud Workshop 2009, Locarno

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Introduction

- Introduction
- Groups, Products and Satellites
- Evaluation method
- First results
- Conclusions

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Introduction: 1st Cloud Workshop

KNMI

History

First workshop was held in 2006 in Nörrkoping, Sweden.

Objective

To asses the differences between algorithms to detect clouds and retrieve cloud properties from SEVIRI.

Method

For a single observation SEVIRI cloud mask and cloud properties of 12 algorithms were inter-compared

Recommendations

- To validate passive imager cloud retrievals against CLOUDSAT/CALIPSO data;
- To include cloud products from polar satellites (e.g. MODIS, AVHRR);
- To organize next workshop within 2 year.

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Introduction: 2nd Cloud Workshop

Place and date

2nd workshop was hosted by MeteoSwiss and held from 3 till 5 February 2009 in Locarno, Swiss

Objectives

- To inter-compare SEVIRI cloud properties retrievals from different retrieval algorithms;
- To inter-compare cloud properties retrievals from different satellites;
- To compare passive imager cloud properties retrievals to an independent set of cloud property measurements with superior quality.

Response

- About **50** participants from research groups in Europe and North America
- Datasets from **16** algorithms to the comparison study

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Groups, Products and Satellites

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Introduction: 2nd Cloud Workshop

Data:

i)	13 June 2008	(12:00 -15:30 hr)*
ii)	17-18 June 2008	(22:00 - 01:45 hr)
iii)	22 June 2008	(10:00 – 12:30 hr)
iv)	3 July 2008	(10:00 - 12:00 hr)

Algorithms:

- 16 algorithms

Satellites (Passive Imagers):

- SEVIRI, MODIS, AVHRR, AIRS and POLDER

Satellites used for validation:

- Cloudsat, Calipso and AMSR

** used for comparison study*

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Groups

Table: *List of groups that provided data for the comparison*

Acronym	*Group*	*Contact*	*Satellite Inst.*
CMS	Climate Monotoring SAF	R. Hollmann, K. Karlsson, R. Roebeling	SEVIRI, AVHRR and MODIS
EUM	EUMETSAT	H. Lutz	SEVIRI
OCA	EUMETSAT	P. Watts	SEVIRI
MPF	EUMETSAT	S. Joro	SEVIRI
FUB	Free University Berlin	R. Preusker	SEVIRI
DLR	DLR	L. Bugliaro	SEVIRI
MFR	Nowcasting SAF	H. Legleau	SEVIRI
RMB	Royal Meteorological Inst. of Belgium	A. Ipe	SEVIRI
UWM	University of Madison	A. Walther, A. Heidinger	SEVIRI, AVHRR
UKM	UK MetOffice	P. Francis	SEVIRI
SMI	NWC-SAF	A. Dybroe, A. Thoss	AVHRR
GSF	NASA Goddard	S. Platnick, G. Wind	MODIS, SEVIRI
LAR	NASA Langley	P. Minnis	SEVIRI
CNR	CNRS	C. Stubenrauch	AIRS
ULI	University of Lille	J. Riedi	POLDER
UMW_2	University of Madison	Ralph Bennartz	AMSR

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Products

Table: *List of products included in the comparison study*

Acronym	*Description*	*Unit*
CMB	Cloud Mask	[%]
CTH	Cloud Top Height	[m]
CTP	Cloud Top Pressure	[Hpa]
CTT	Cloud Top Temperature	[K]
COD	Cloud Optical Depth	[-]
REF	Partical Effective Radius	[μm]
LWP	Liquid Water Path	[g m^{-2}]
IWP	Ice Water Path	[g m^{-2}]
CPH	Thermodynamic Phase	[water, ice, mixed]
CTY	Cloud Type	[-]

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Overview of provided data

Table: *List of products provided by each group*

Acronym	CMB	CTH	CTP	CTT	COD	REF	LWP	IWP	CPH	CTY
CMS	xao	xao	xao	xao	xo	xo	xo	xo	xo	x
EUM	x		x	x					x	
OCA	x		x		x	x				
MPF	x		x	x						
FUB	x		x							
DLR	x		x	x	x	x				
MFR	x	x	x	x						x
RMB	x				x				x	
AWG	a	a	a	a	a	a	a	a	a	
UKM	x	x	x	x	x	x			x	
GSF	xo		xo	xo	xo	xo	xo	xo	xo	
LAR	x	x	x	x	x	x	x	x	x	
CNR	ai		ai	ai						
ULI	p				p					
SMI	a	a	a	a						a
REF	cc	cc	cc	cc	cc		am	cc	cc	cc

x = MSG; o = MODIS; a = AVHRR; p = POLDER; ai =AIRS

(REFerence data: cc = Cloudsat/Calipso; am = AMSR)

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Evaluation Method

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Evaluation Method

SEVIRI Inter-comparison

- Full disk images and statistics
- Scatterplots and Frequency distributions

Comparison against MODIS Level 2 data

- Scatterplots and statistics

Comparison with A-Train sensors

- Selection 5 region CUTs representing different conditions
- Statistics of cloud properties from satellite for the region CUTs
- CTH passive imagers (MSG, MODIS, AVHRR, AIRS) against Calipso
- LWP passive imagers (MSG, MODIS, AVHRR) against AMSR

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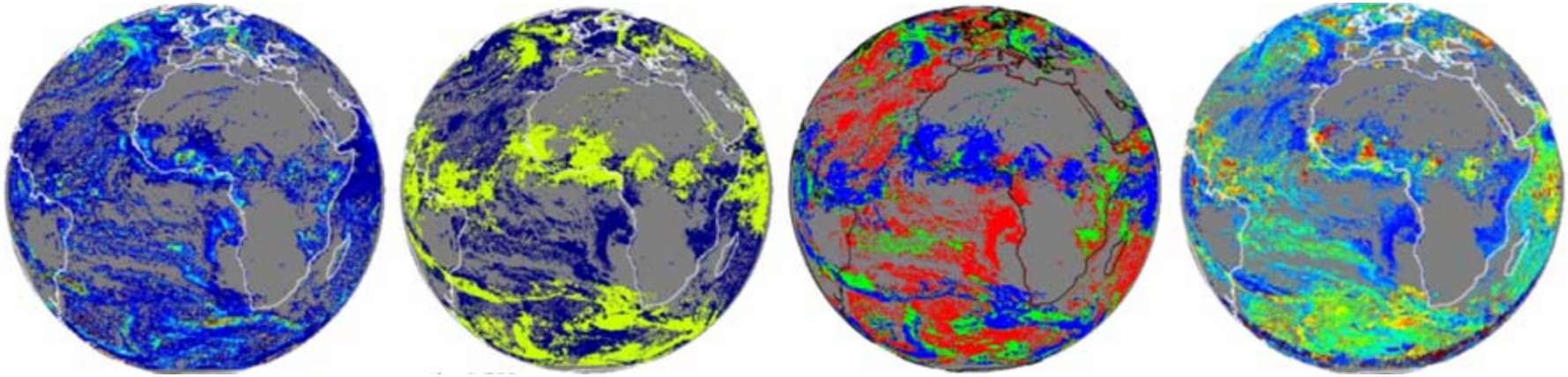
Example: MSG inter-comparison



COT (mean 5.9) ***CPH (water 58%)*** ***CTH (low, mid, high)*** ***R_e mean 19 μm)***

Fig. : *Example of full disk cloud products NASA Langley (13 June 2008, 12 hr UTC)*

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Region CUTs

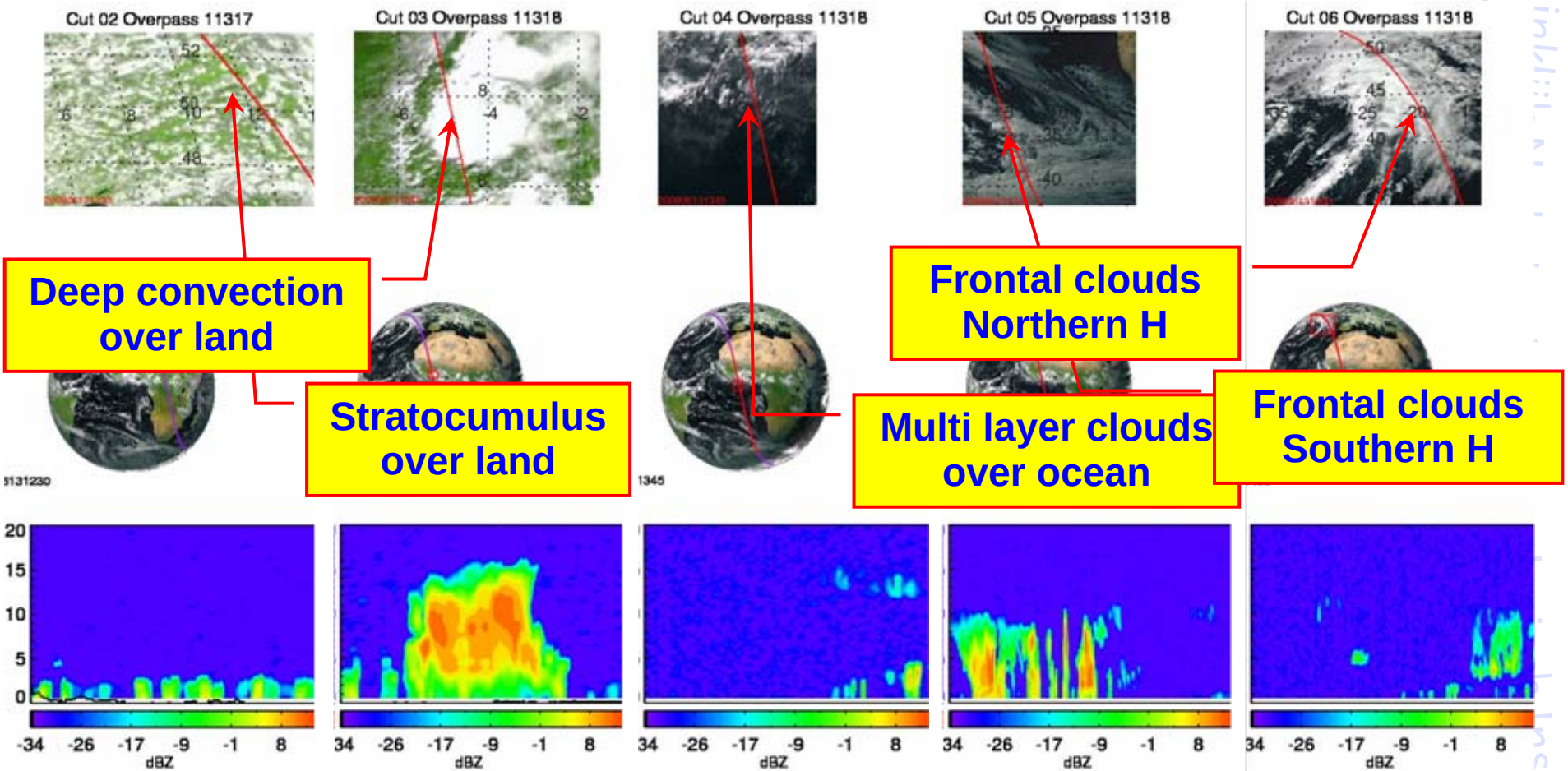

Fig. : *Region CUTs selected to the comparison against A-Train sensors*

A-Train Calipso and AMSR comparison

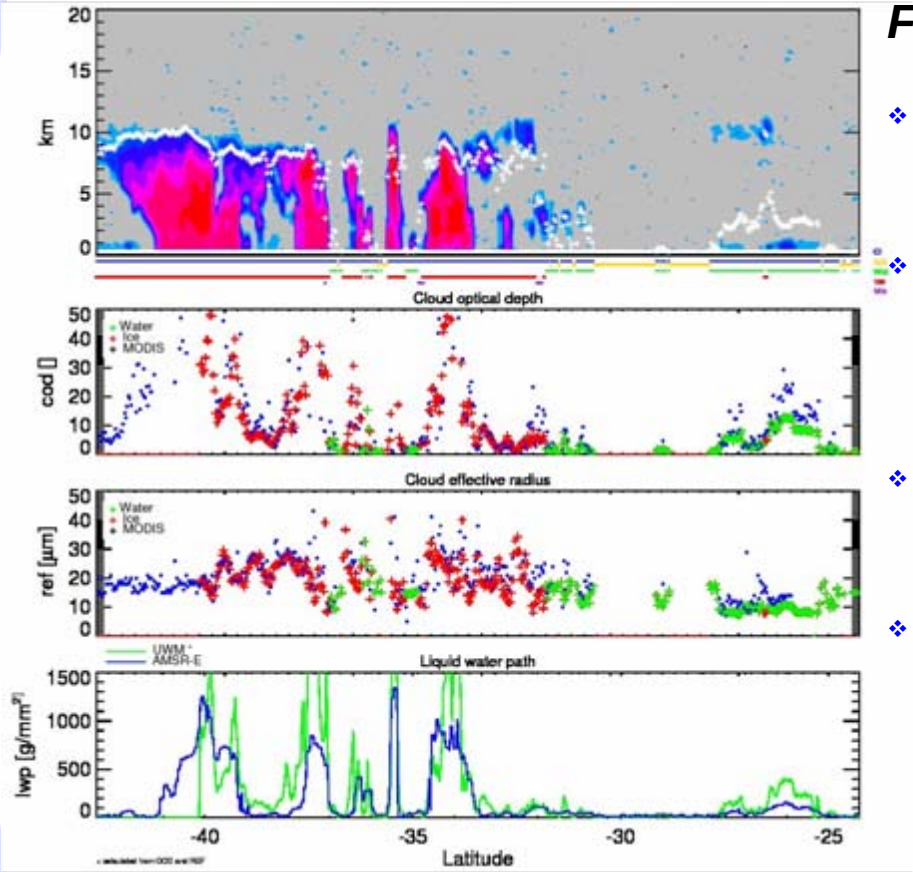

Fig. : *Comparison of UWM and Calipso and AMSR cloud properties (CUT-05)*

For each region CUT

- Visual inspection of Cloudsat profiles vs. passive imager cloud properties
- Along track statistics of Calipso and Cloudsat observed and passive imager retrieved CTH,
- Along track statistics of AMSR observed vs, passive imager retrieved LWP
- Evaluation of algorithms agreement for:
  - *water or ice clouds*
  - *single or multiple layer clouds and*
  - *plane parallel or 3D cloud fields*
  - *Filled or broken cloud fields*

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Results

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Example: MSG inter-comparison

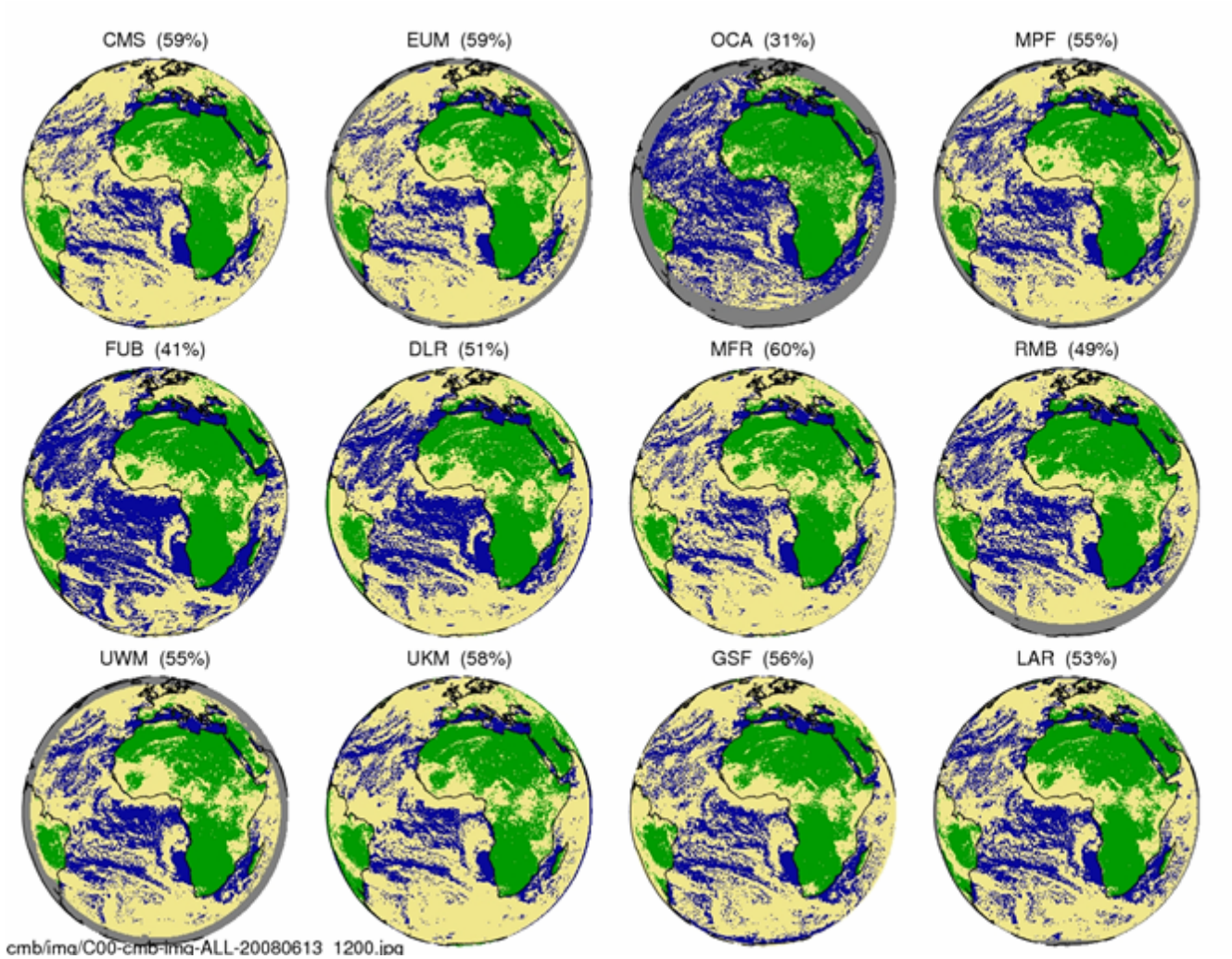

Fig. : *Cloud masks of 12 MSG algorithms*

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Example: MSG inter-comparison

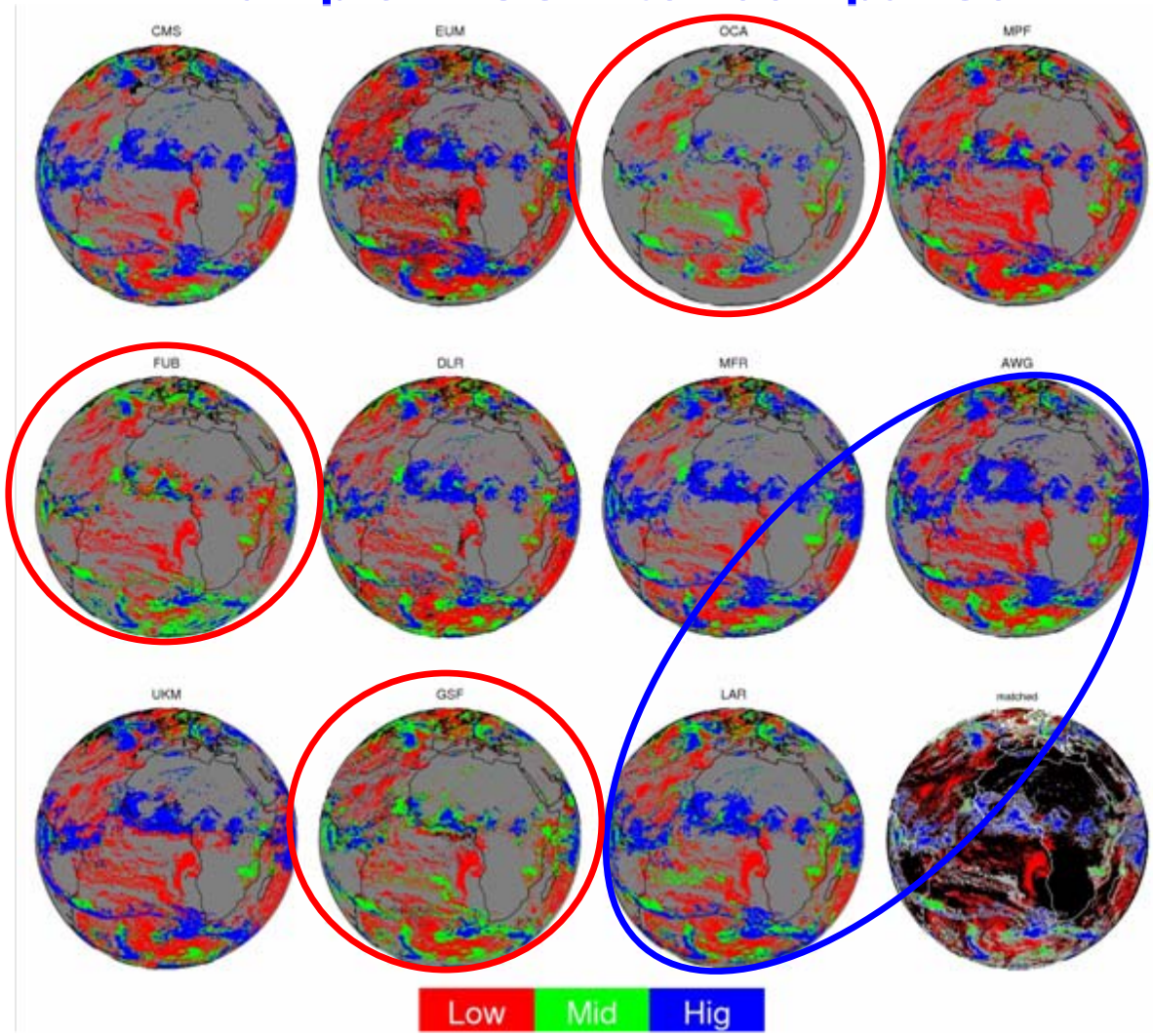

Fig. : *Cloud top pressure of 12 MSG algorithms*

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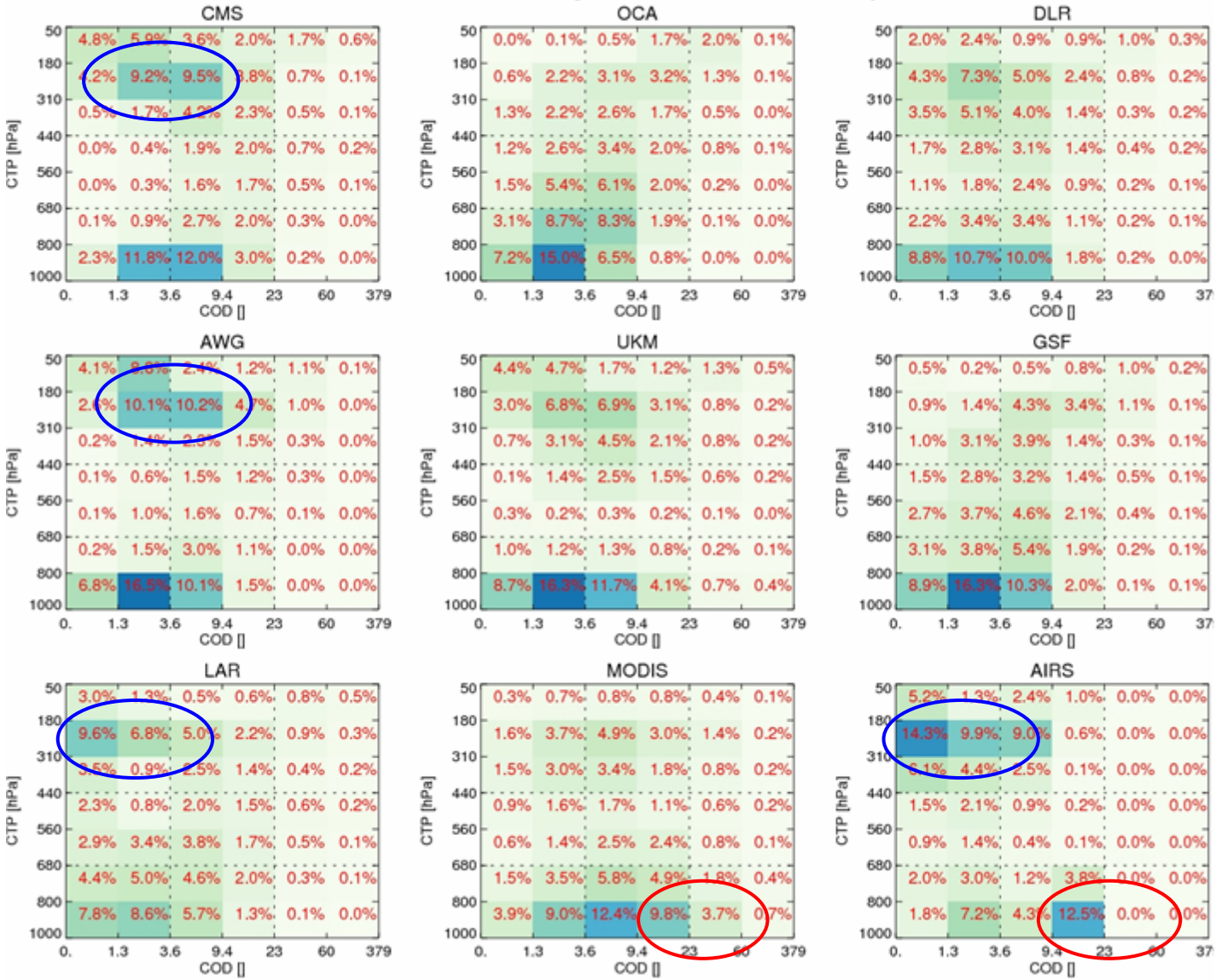
COD-CTP ISCCP-style cloud classes Tropics



d/isccp/C00-cod-isccp-ALL-IND-20080613 1200 Tropics.jpg

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Example: A-Train Calipso and AMSR comparison

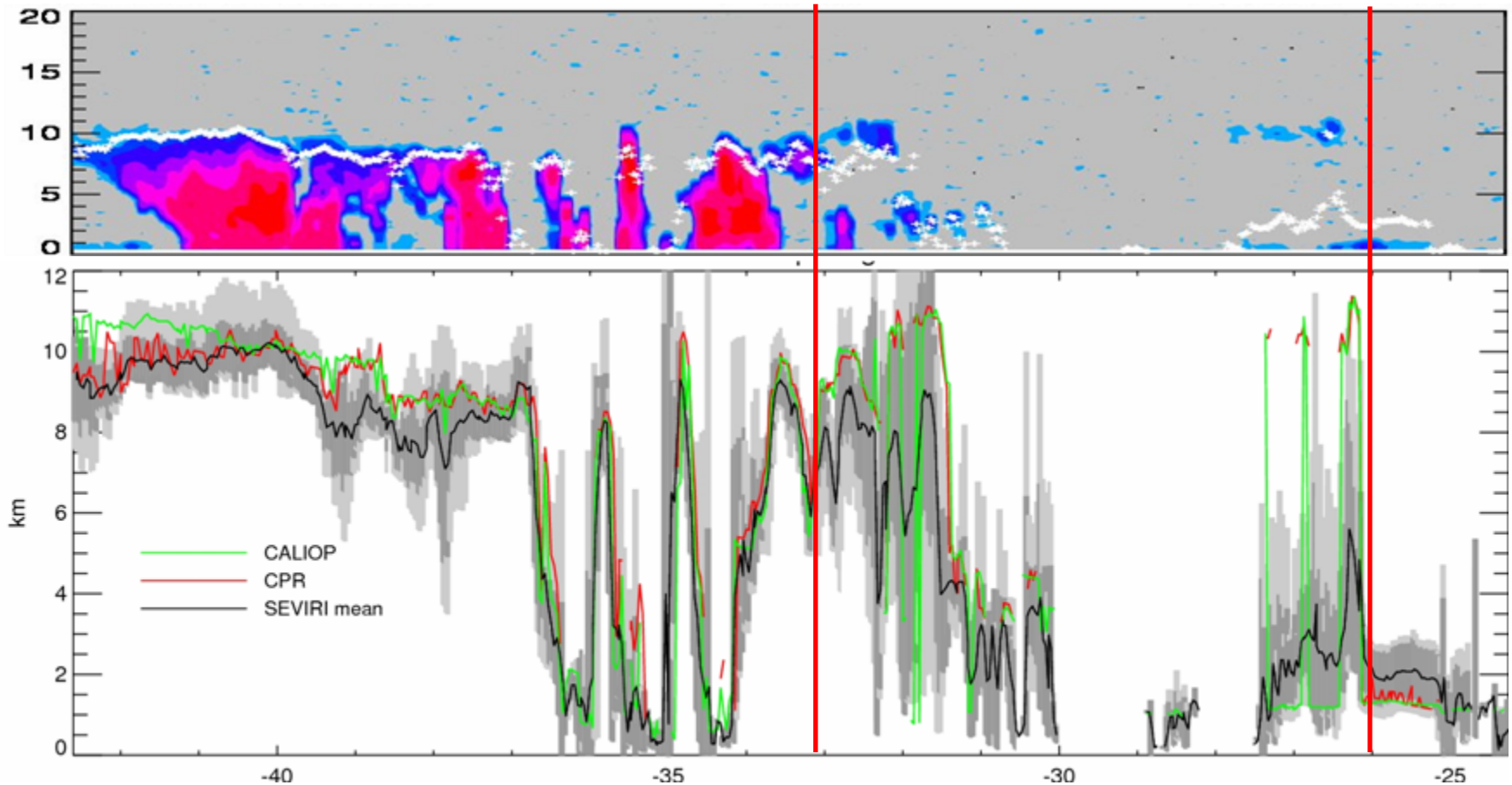

Fig. : *Comparison of* ***Calipso*** *and* ***CLOUDSAT*** *Cloud Top Height against the* ***SEVIRI mean****. The grey areas indicate the min/max of 12 SEVIRI retrievals (CUT-05)*

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Statistics region CUT 05

	CTT [K]	CPH [% wtr]	CTH [m]	CTH[m] Seviri vs CPR			CTH [m] Seviri vs Calipso		
Mod	*Median Seviri*	*Seviri*	*Median Seviri*	*Bias*	*RMSE*	*Corr*	*Bias*	*RMSE*	*Corr*
CMS	256.0	44.2	7434	-1061	2504	0.75	-527	1801	0.88
EUM	234.8	41.1	8264	-647	2260	0.75	-98	1726	0.87
OCA		96.7	6802	-1183	2347	0.77	-573	1712	0.90
MPF	240.9	30.1	7789	-1138	2486	0.78	-633	1591	0.91
FUB	-	-	5665	-991	2916	0.70	-463	2098	0.85
DLR	250.8	23.8	6043	-1676	2794	0.75	-1156	1922	0.90
MFR	235.9	42.6	7965	-942	2574	0.72	-402	1941	0.85
AWG	238.8	31.2	7784	-631	2165	0.75	-97	1592	0.90
UKM	237.5	37.1	7732	-742	1881	0.86	-56	1862	0.86
GSF	tbc	tbc	tbc	tbc	tbc	tbc	tbc	tbc	tbc
LAR	244.3	40.7	7751	-1090	2464	0.76	-516	1849	0.87

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Example: MSG inter-comparison

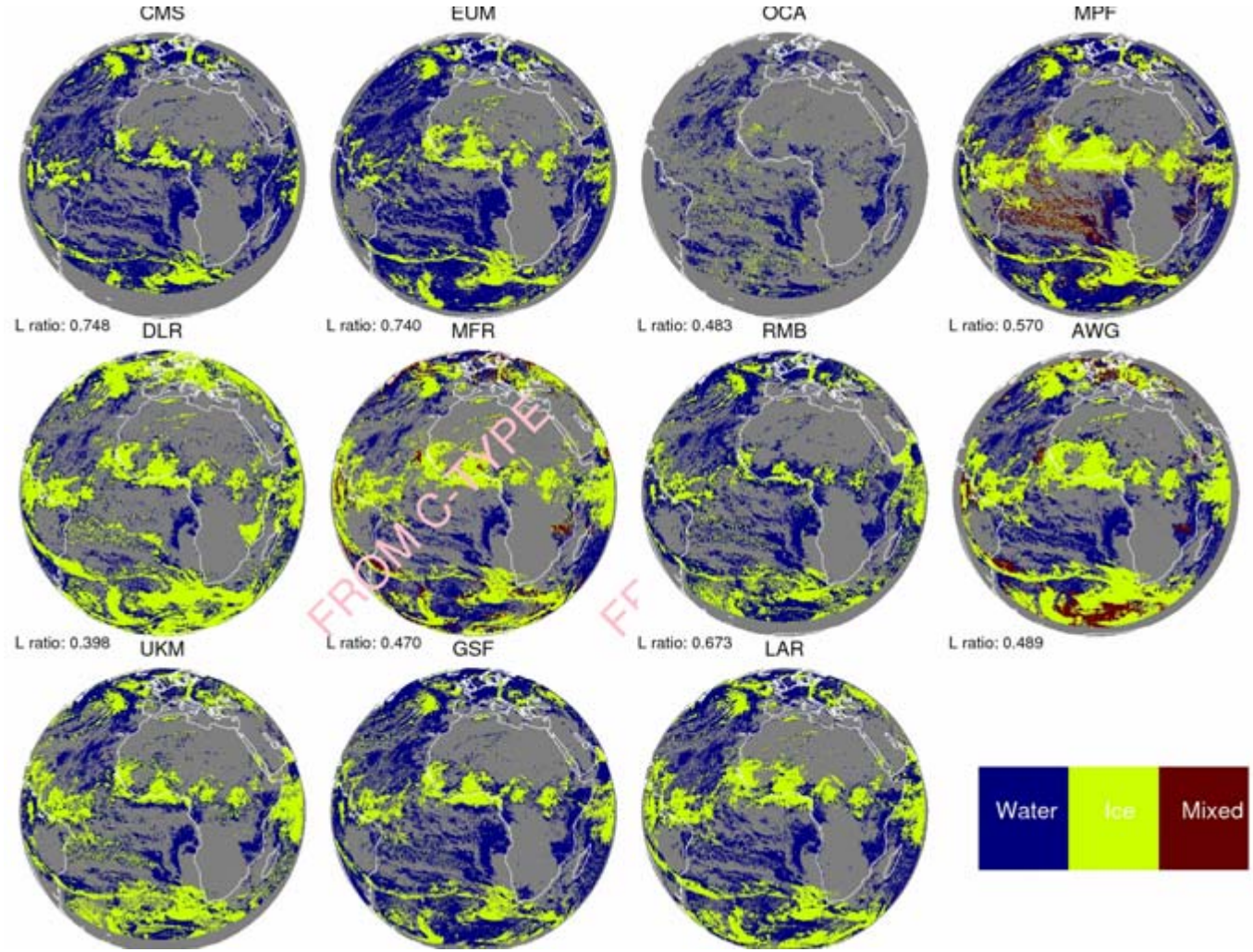

Fig. : *Cloud thermodynamic phase of 11 MSG algorithms*

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Example: A-Train Calipso and AMSR comparison

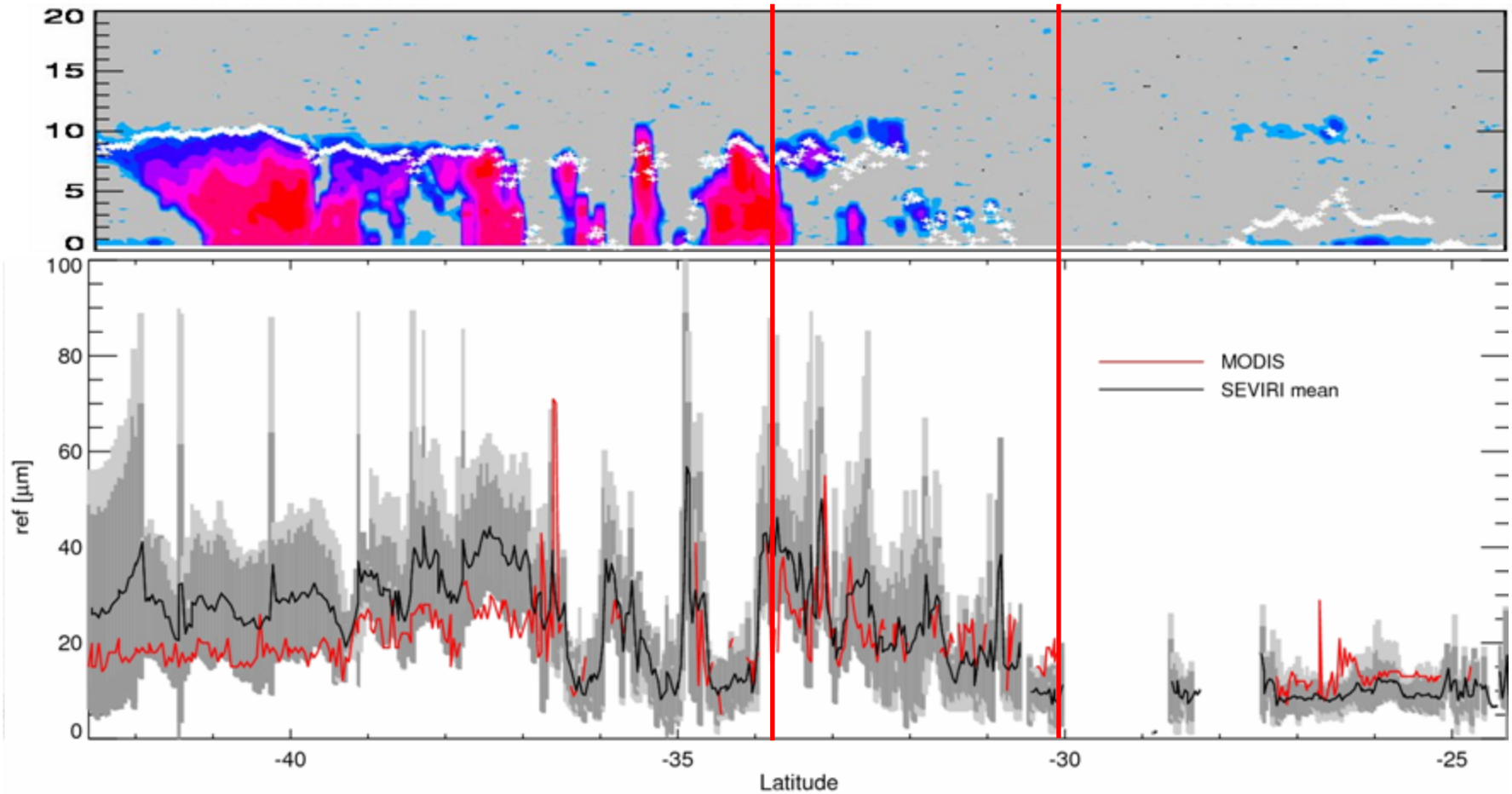

Fig. : *Comparison of* ***Calipso*** *backscatter profile against the* ***SEVIRI mean*** *effective particle radius. The grey areas indicate the min/max of 7 SEVIRI retrievals (CUT-05)*

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Example: A-Train Calipso and AMSR comparison

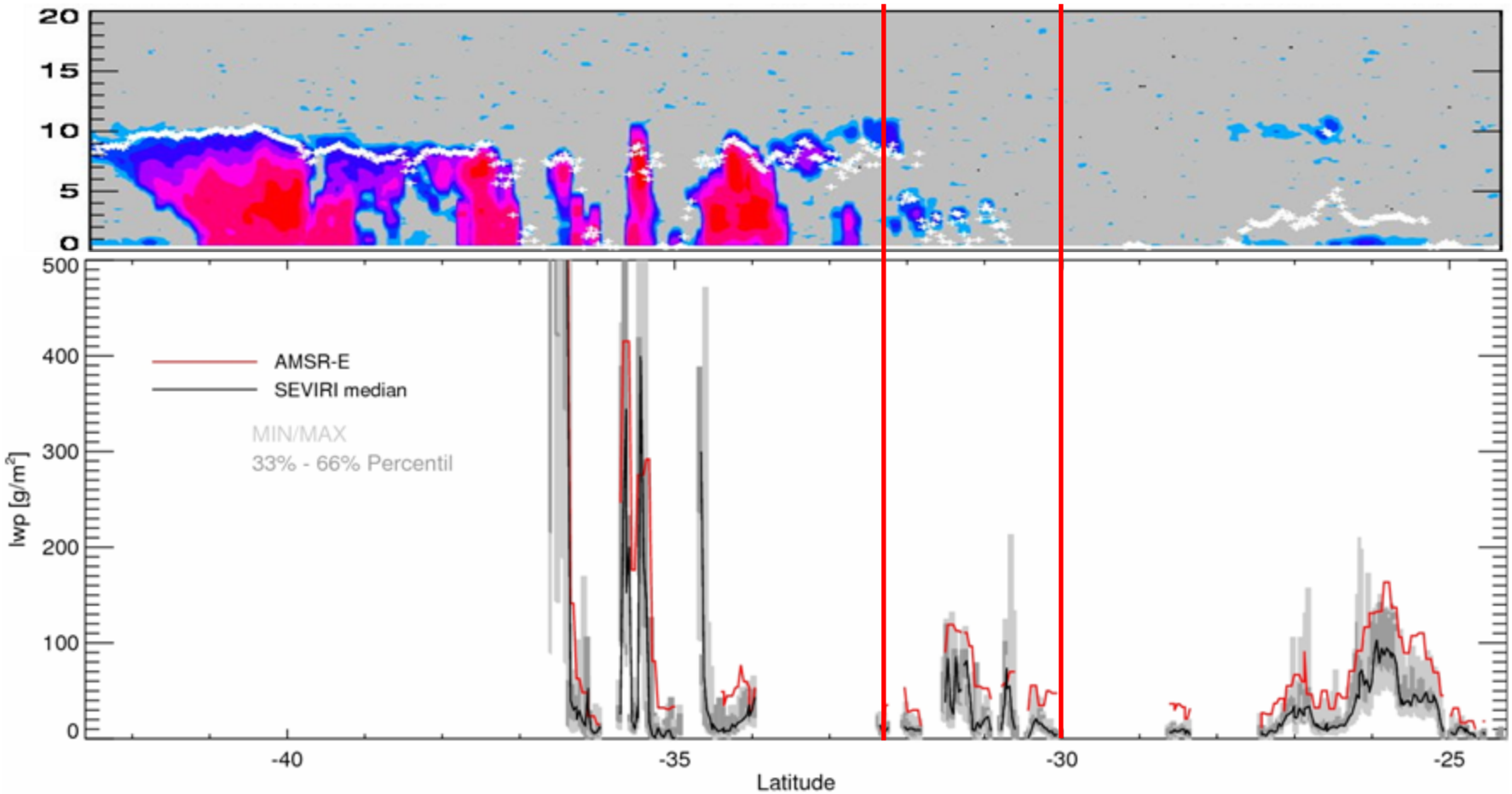

Fig. : *Comparison of* ***AMSR*** *and* ***SEVIRI mean*** *retrievals of LWP. The grey areas indicate the min/max of 4 SEVIRI retrievals (CUT-05)*

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Statistics region CUT 05

	COT [-] Median Seviri	Reff [μm] Median Seviri	LWP [g m^{-2}] Seviri vs AMSR Median Seviri	Bias	RMSE	Corr.
CMS	6.60	8.08	35.19	-28.28	32.73	0.91
OCA	5.48	6.19	16.80	-54.06	60.77	0.90
DLR	6.25	6.24	19.44	-47.16	50.81	0.91
AWG	5.62	9.21	25.48	-44.56	50.89	0.91
UKM	8.01	6.72	31.00	-33.05	38.15	0.89
GSF	tbd	tbd	tbd	tbd	tbd	tbd
LAR	7.25	12.18	61.52	-13.45	22.76	0.90

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Generation of Level 3 products

CLOUD OPTICAL DEPTH Cut-00 20080613 12:00

Group	IND Mean	25%_P	Medi	75%_P	COM Mean	25%_P	Medi	75%_P
CMS	6.27	1.13	2.99	7.12	9.08	2.71	5.27	10.38
OCA	5.67	1.46	2.95	6.43	7.69	2.57	4.59	9.14
DLR	6.77	1.30	3.00	6.75	7.35	2.40	4.40	8.25
RMB	15.94	2.36	5.83	13.73	14.94	4.38	7.91	15.05
UWM	4.63	1.30	2.76	5.79	6.75	2.83	4.78	8.56
UKM	10.41	1.86	4.07	9.43	10.31	3.30	5.85	11.54
GSF	3.24	0.35	1.53	4.20	5.01	1.23	3.13	6.39
LAR	7.85	1.20	3.22	8.01	10.20	3.01	5.53	11.31

EFFECTIVE RADIUS Cut-00 20080613 12:00

Group	IND Mean	25%_P	Medi	75%_P	COM Mean	25%_P	Medi	75%_P
CMS	13.08	7.89	8.29	18.08	13.77	7.69	8.89	21.47
OCA	19.94	6.10	10.44	34.31	19.92	5.70	8.76	39.17
DLR	11.64	5.99	6.49	14.73	12.51	5.99	5.99	14.98
AWG	17.83	10.41	14.95	21.76	13.19	8.06	11.03	17.60
UKM	15.84	6.79	14.43	22.28	13.87	5.92	11.58	20.71
GSF	23.14	11.32	18.67	28.19	21.61	9.99	17.17	27.31
LAR	19.72	10.09	15.58	26.02	18.01	8.89	12.18	25.42

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Conclusions

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Conclusions

- Still large differences between cloud masks
- Best agreement for homogeneous water clouds
- For homogeneous ice clouds good agreement for CTH, but fair agreement for IWP and particle size
- Passive imagers underestimate CTH strongly relative to Cloudsat and moderately relative to Calipso
- Passive imagers underestimate LWP moderately relative to AMSR
- Large differences for multiple layer clouds, some algorithms see top layer while other see the bottom layer.
- Large differences for broken clouds.
- Large differences in Level 3 products due to selection of cloudy pixels.

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Recommendations

- Combining the pro's of different algorithms may possibly help to develop better products for multiple layer clouds
- Use High Resolution visible channel to better resolve broken clouds effects
- Further work out the results of this workshop, in separate side studies. Data are available to all workshop participants.
- Prepare a joint report (or may be publication) on the workshop findings.
- Try to find a common method to prepare level 3 products.
- Next workshop in 2 years.

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Thank you !

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Connection to GlobCloud

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Connection to GlobCloud

KNMI

Which products are most useful

- **Passive imager products may be useful for Kalman Ensemble filtering assimilation techniques**

Which satellite data are missing

- **Profiling from geostationary satellite**

Which global coverage is needed

- **Geostationary satellites are very valuable source of information for regional NWP and Climate models, both for assimilation techniques and model evaluation studies**

Which model improvements are required

- **Using cloud properties observation to improve model parameterization**
- **Workshop provides crucial information on error characteristics.**

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Example: Comparison between SEVIRI and MODIS

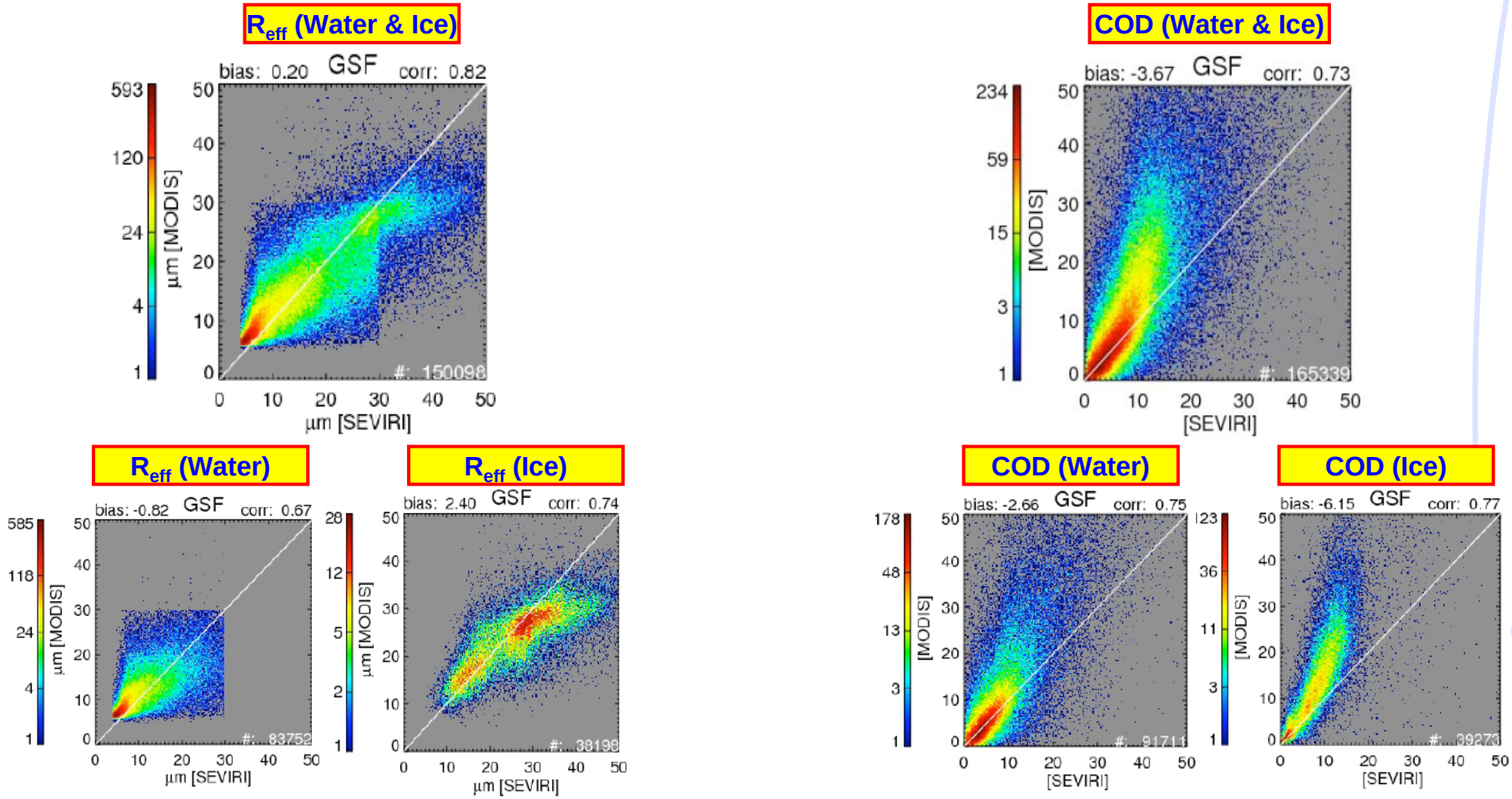

Fig. : *Comparison between GSF_SEVIRI and GSF_MODIS particle size (left panel) and Cloud Optical Depth (right panel)*

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