Royal Netherlands
Meteorological Institute
Ministry of Transport,
Public Works and Water Management

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Weather Research

Thanks to:
Hartwig Deneke, Bastiaan Jonkheid, Wouter Greuell ,
Jan Fokke Meirink and Erwin Wolters (KNMI)

MSG-SEVIRI
cloud physical properties for model evaluations

Cloud Assessment Workshop
22-25 June 2010, Berlin, Germany

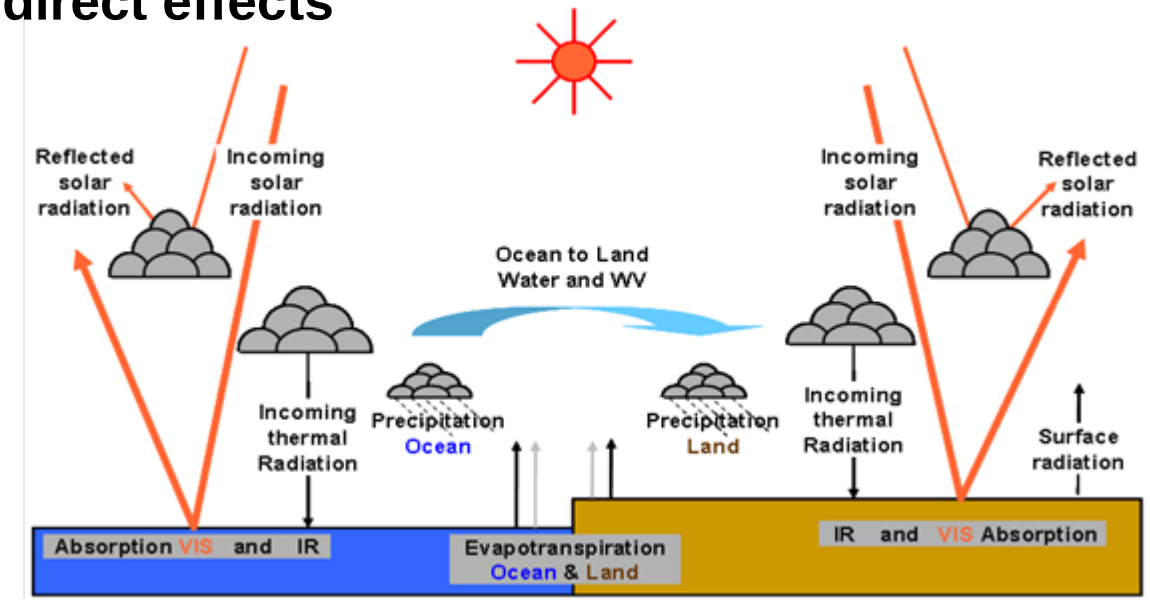
Introduction

- Motivation
- Retrieval of cloud and precipitation properties
- Validation and inter-comparison studies
- Model evaluation
- Conclusions

Motivation

Motivation

- **Trend studies (*annual, seasonal and* ***diurnal*****)**
- **Evaluation of model parameterisations**
- **Studies of feedback mechanism**
- **Studies of aerosols indirect effects**
- **Closure studies**



Cloud Physical Properties

Retrieval: Cloud Physical Properties

Algorithm

- *Satellites* : **MSG**(SEVIRI), **NOAA**(AVHRR), **Terra & Aqua**(MODIS)
- *Channels* : ***VIS*** (*0.63 μm)* and ***NIR*** (*1.6 μm*) and ***IR*** (10.8 *μm)*
- *Products CM-SAF* : **CPH, COT, LWP, IWP**
- *Products KNMI* : **CFC, CTT, REF, Precip, SSI, DCLD, DnDv**

Models

- Doubling Adding KNMI model (DAK) & SHDOM

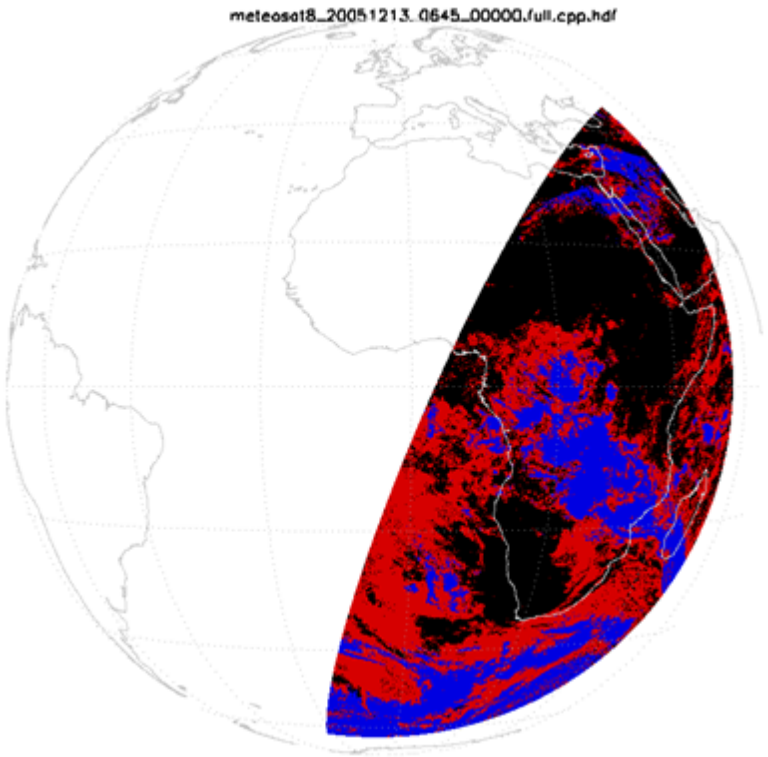
Auxiliary

- Surface reflectance(MODIS white sky albedo)
- Viewing geometry

Product Overview

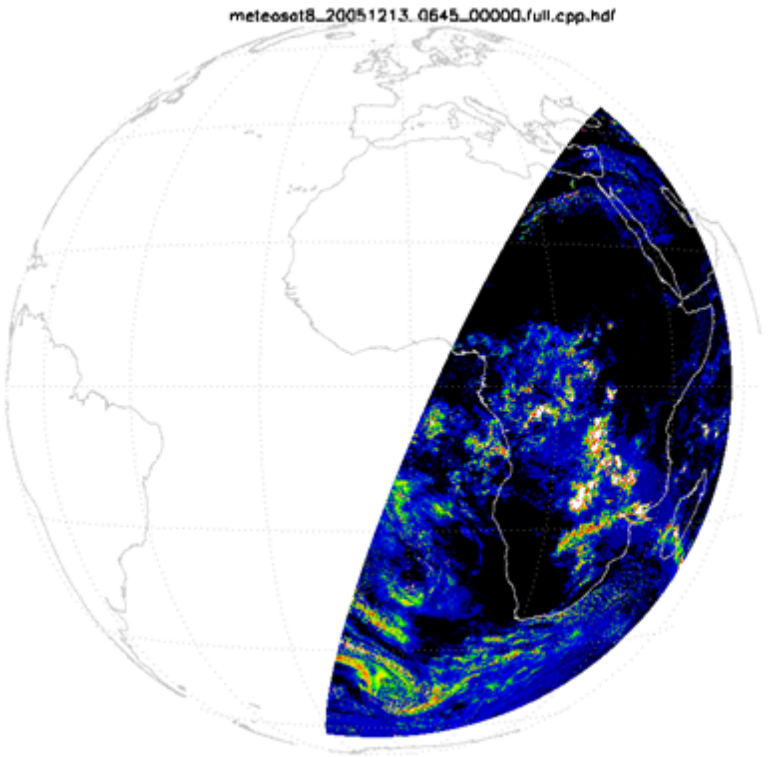
	Product	Unit	Note
CFC	Cloud Fraction	[%]	
COT	Cloud Optical Thickness	[-]	
REFF	Particle size	[μm]	
CPH	Cloud Thermodynamic Phase	[-]	
CTT	Cloud Top Temperature	[K]	
CTH	Cloud Top Height	[hPa]	
LWP	Liquid Water Path	[g m^{-2}]	
IWP	Ice Water Path	[g m^{-2}]	
CGT	Geometrical Depth	[m]	Water clouds only
CDNC	Droplet Number Concentration	[cm^{-3}]	Water clouds only
IRR	Surface Solar Irradiance	[W m^{-2}]	
PRECIP	Rain Rate	[mm hr^{-1}]	

Example: Cloud Phase and Cloud Optical Thickness



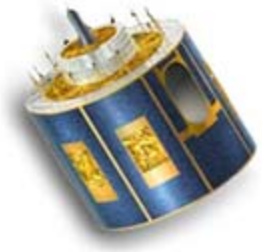
Cloud Thermodynamic Phase

Water **Ice** **Clear**



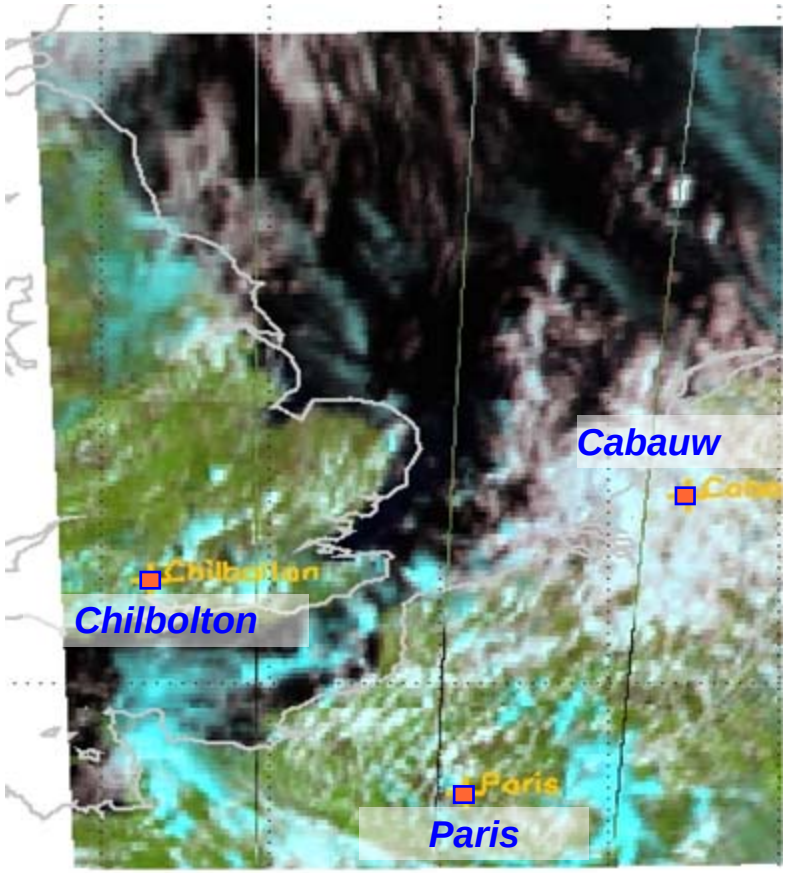
Cloud Optical Thickness

0 7 14 21 28 35 42 49 56 63 70



Validation
&
Inter-comparison

Validation: Overview



CloudNET validation sites

Validation activities

- Comparison against ground-based observations;
- Comparison against retrievals of other providers;
- Comparison against other A-Train instruments (Cloudsat, Calipso, AMSU)

Validation Overview

Product	*Unit*	*Acc.*	*Prec.*	*Ref*
Cloud Optical Thickness	[-]	~15%	~25%	
Particle size (***Water (ice)***)	[μm]	2 (10)	5 (30)	
Cloud Thermodynamic Phase	[%]	5	15	*Wolters et al. (2008), JAMC*
Cloud Top Temperature	[K]	5	10	*Feijt et al. (1999),Phys. Chem.of the Earth*
Liquid Water Path	[g m^{-2}]	5	25	*Roebeling et al. (2008), JAMC* *Greuell and Roebeling (2009), JAMC* *Schutgens and Roebeling (2009), JTECH*
Geometrical Depth *(water cloud)*	[m]	50	120	*Roebeling et al. (2008), GRL*
Droplet nr. Conc. *(water cloud)*	[cm^{-3}]	-	-	*Roebeling et al. (2008), GRL*
Surface Solar Irradiance	[W m^{-2}]	5	20	*Deneke et al. (2008), RSE*
Rain Occurrence	[%]	1	10	*Roebeling and Holleman (2009), JGR*
Rain Rate	[mm hr^{-1}]	0.1	1.0	*Roebeling and Holleman (2009), JGR* *Wolters et al. (in concept), HESS*

EUMETSAT algorithm inter-comparison activity

Objective

To quantify the differences between cloud properties algorithms to for passive imagers (e.g. SEVIRI, MODIS, AVHRR)

Method

- To inter-compare SEVIRI cloud properties retrievals of different algorithms;
- To inter-compare cloud properties retrievals from different satellites;
- To compare passive imager cloud properties to independent measurements.

Response

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

Example: inter-comparison cloud masks

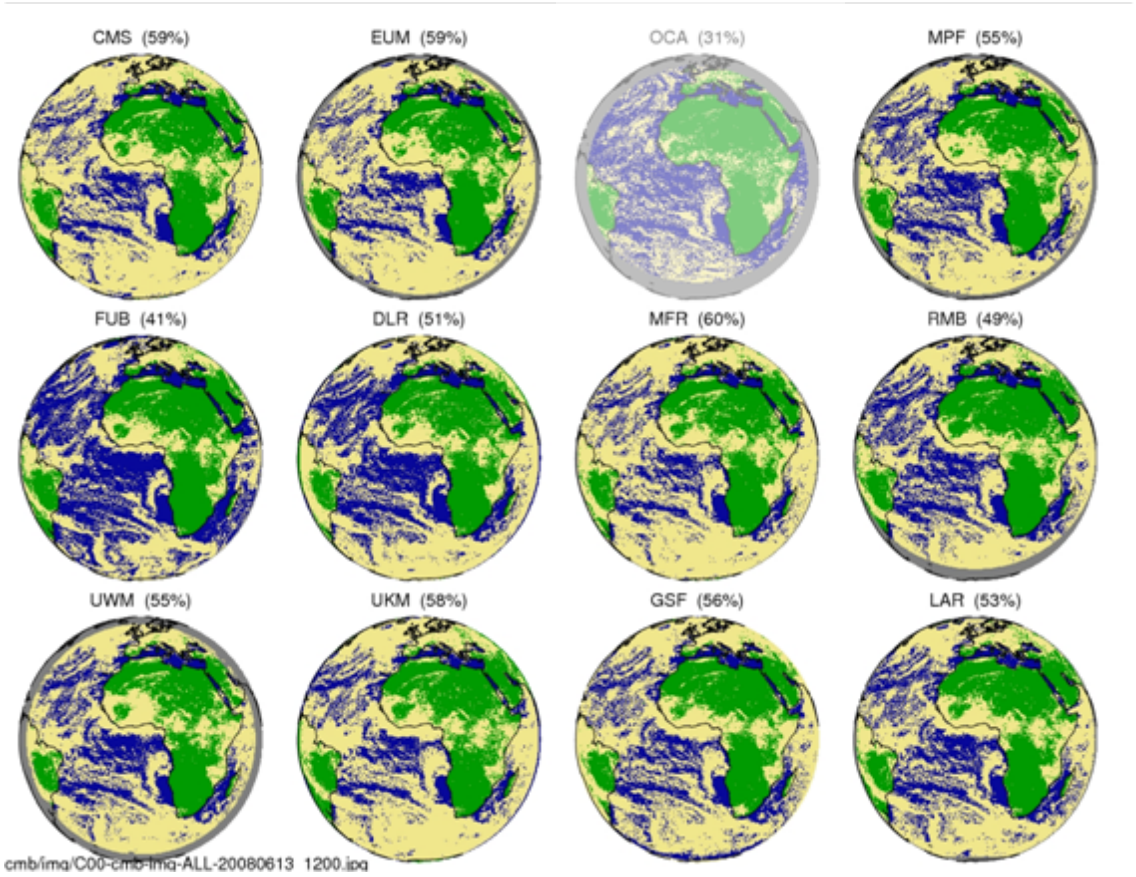
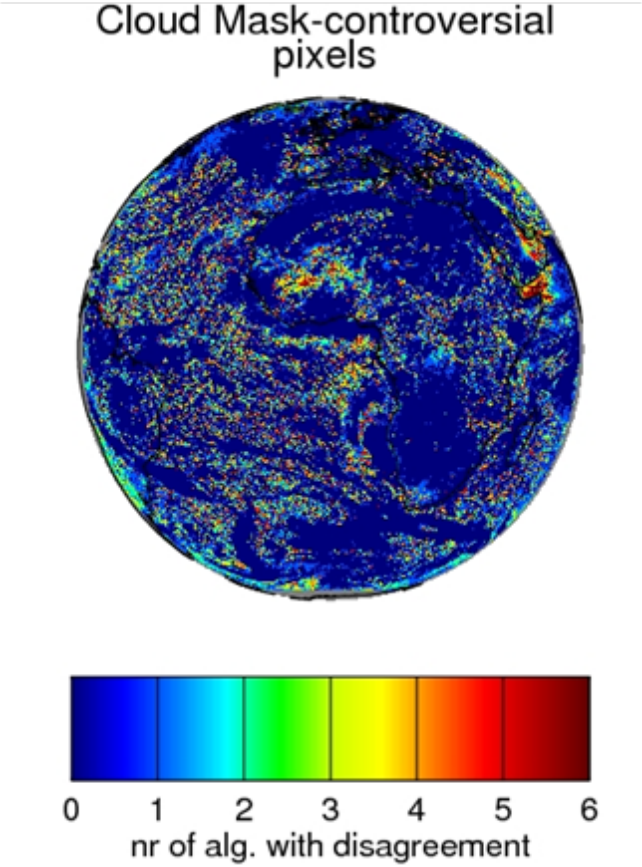


Fig. : *Cloud masks of 12 MSG algorithms*



Variations in mean cloudiness 41% - 60%

SEVIRI–CTH vs. Calipso/Cloudsat-CTH

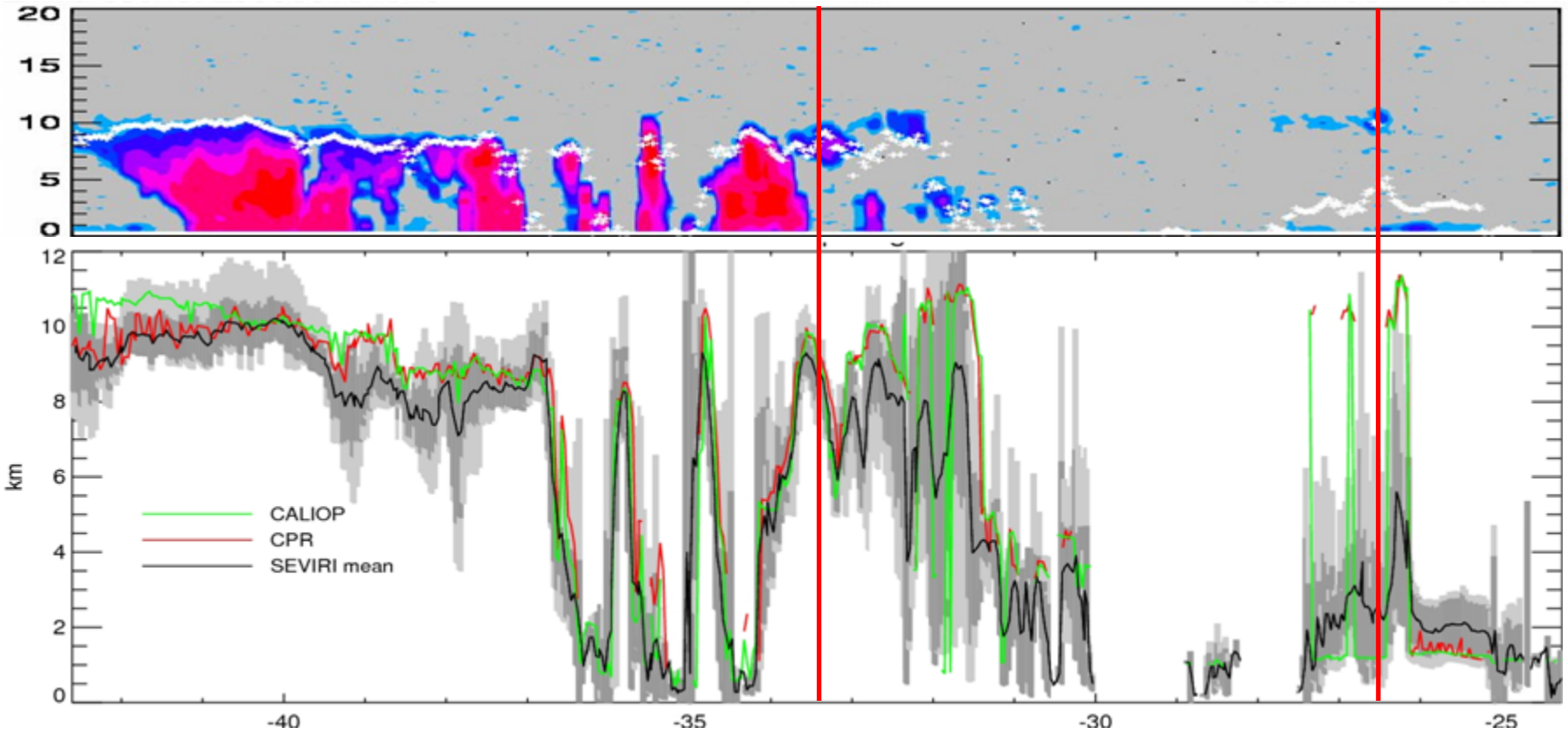
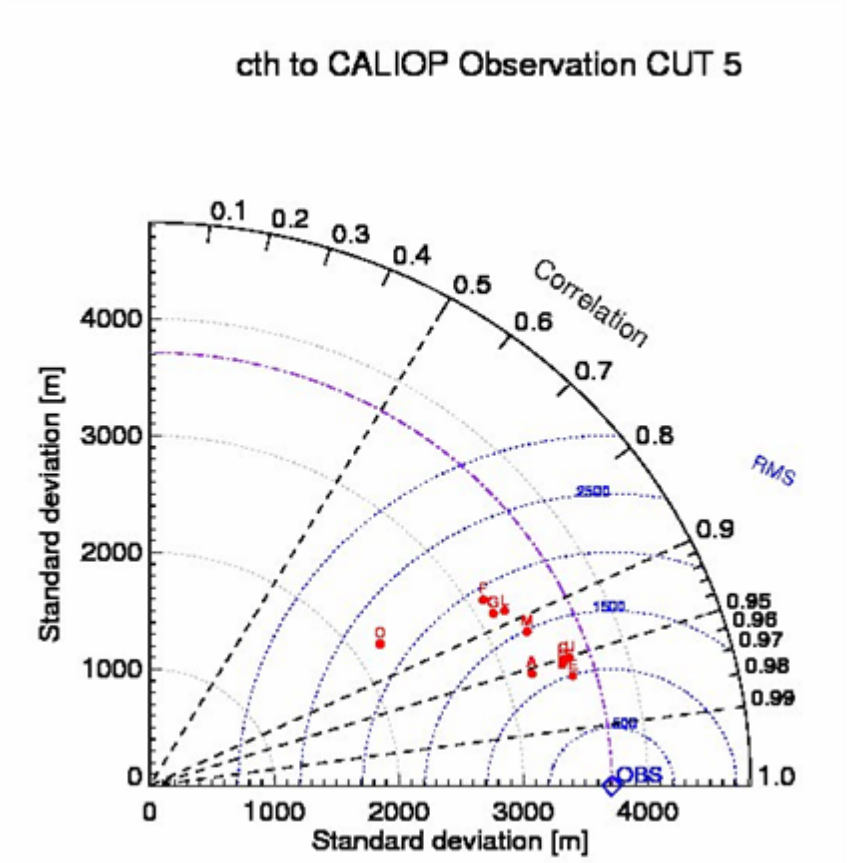
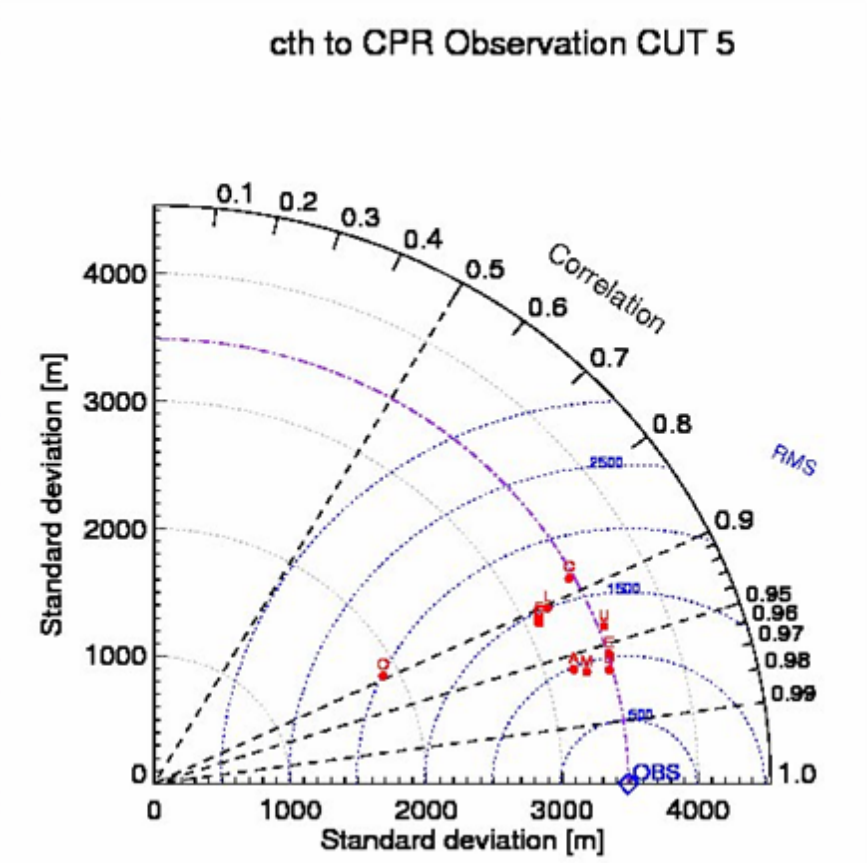


Fig: *Comparison of Cloud Top Heights. The grey areas indicate the variance of 11 SEVIRI retrievals*

Taylor diagrams Cloud Top Height

SEVIRI vs. Calipso and Cloudsat





Level 2 vs. Level 3

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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

Individual cloud mask | Common cloud mask

EFFECTIVE RADIUS Cut-00 20080613 12:00

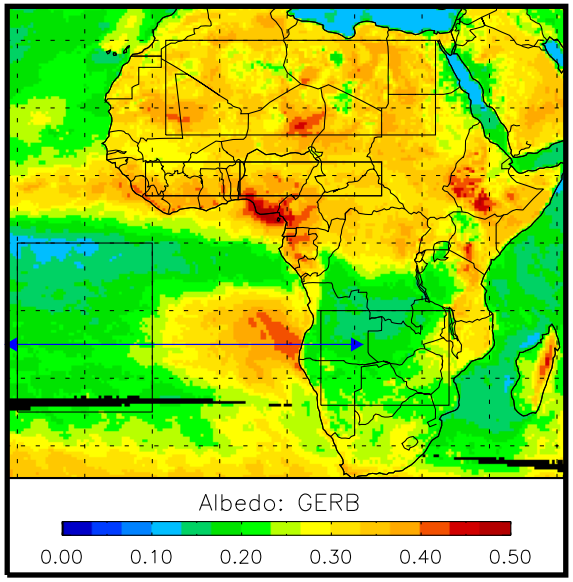
Group	IND Mean	25%_P	Medi	75%_P	COM Mean	25%_P	Medi	75%_P
CMS	13.08	7.89	8.29	18.08	13.77	7.69	8.89	21.47
OCA	19.94	6.10	10.44	34.31	19.92	5.70	8.76	39.17
DLR	11.64	5.99	6.49	14.73	12.51	5.99	5.99	14.98
AWG	17.83	10.41	14.95	21.76	13.19	8.06	11.03	17.60
UKM	15.84	6.79	14.43	22.28	13.87	5.92	11.58	20.71
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

Model evaluation

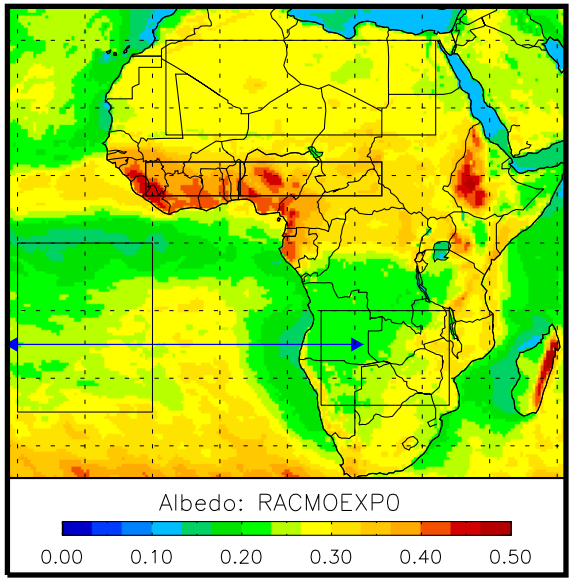
RACMO evaluation using GERB radiation and SEVIRI cloud properties

TOA albedo

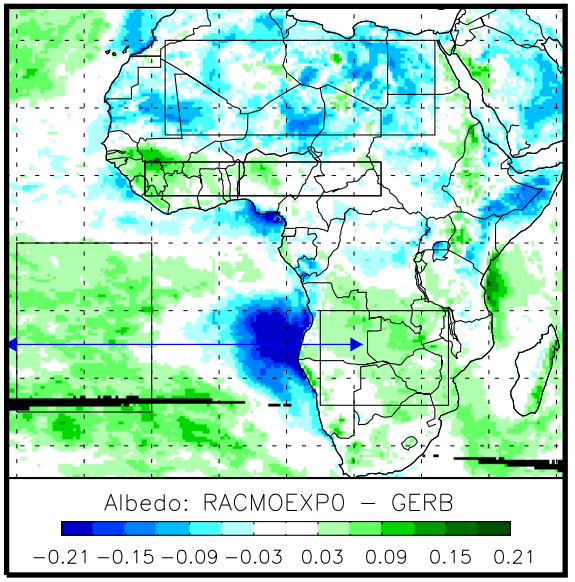
Satellite data



Model simulation

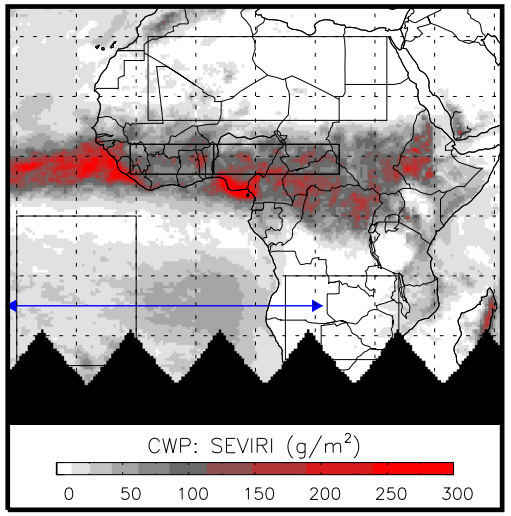


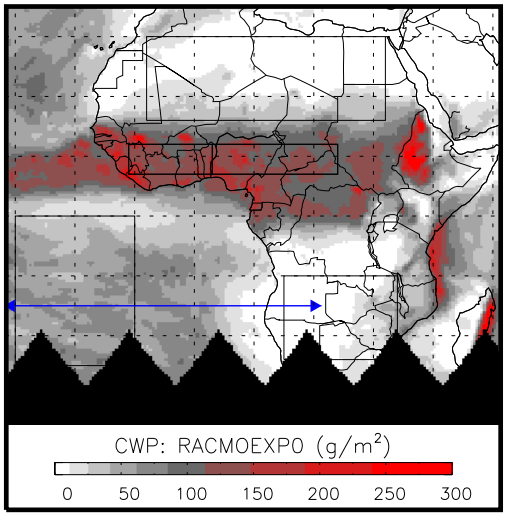
Model - satellite

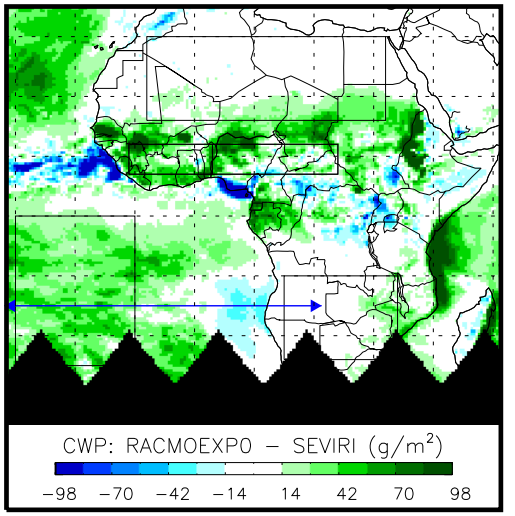


Satellite data | Model simulation | Model - satellite

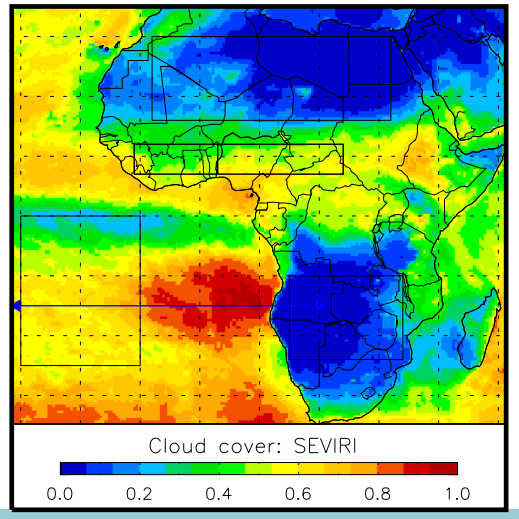
Condensed Water Path

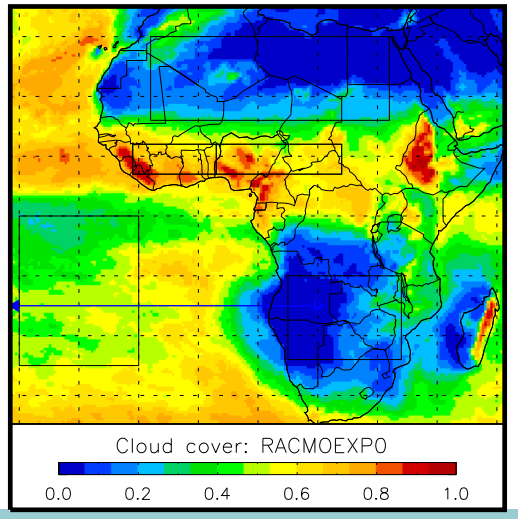


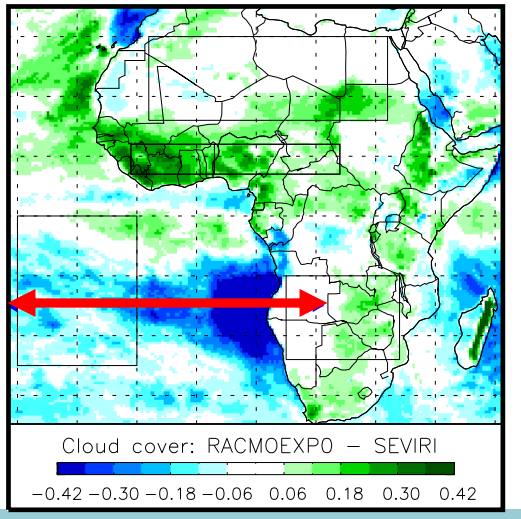




Cloud cover







Greuell et al. (submitted)

Effect of model modifications

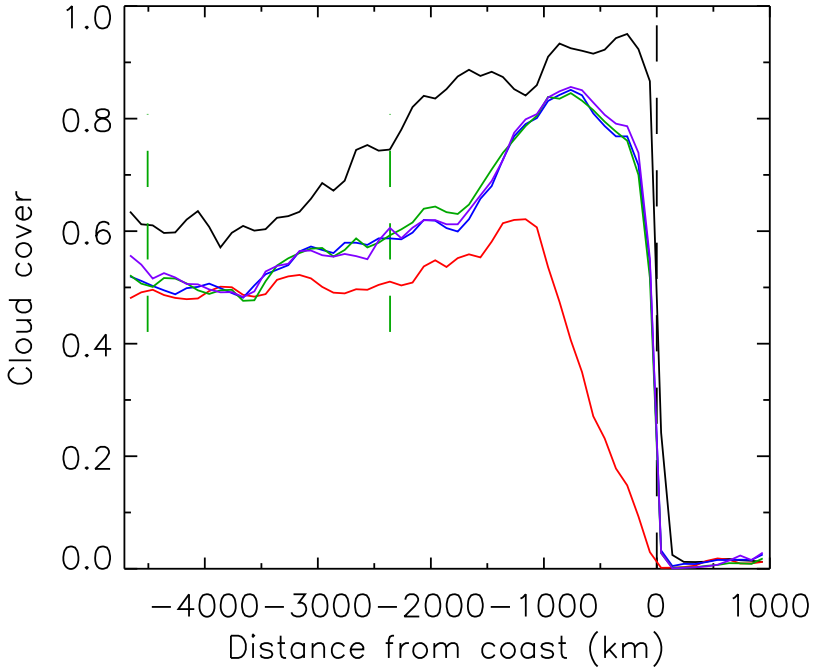


Fig. : *Cloud cover along track through stratocumulus field*

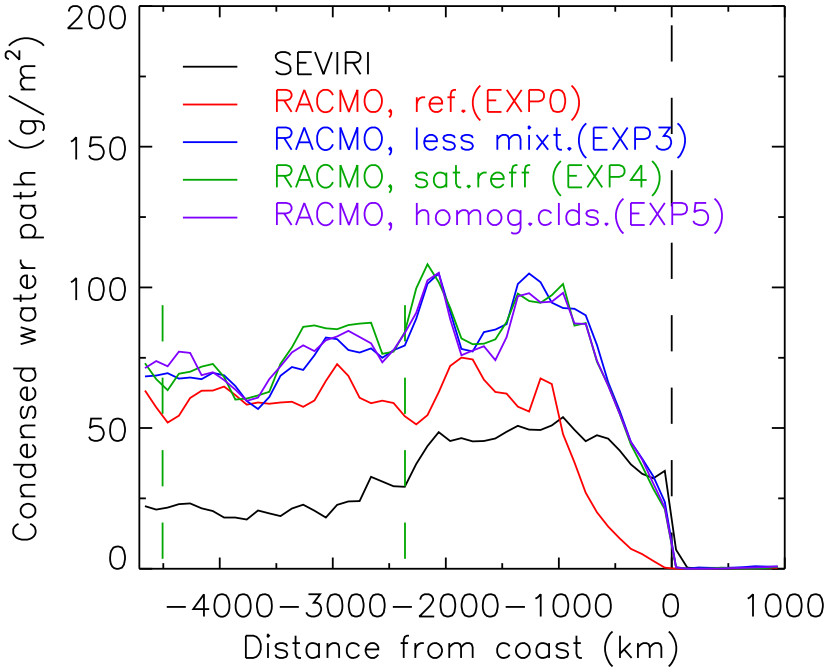
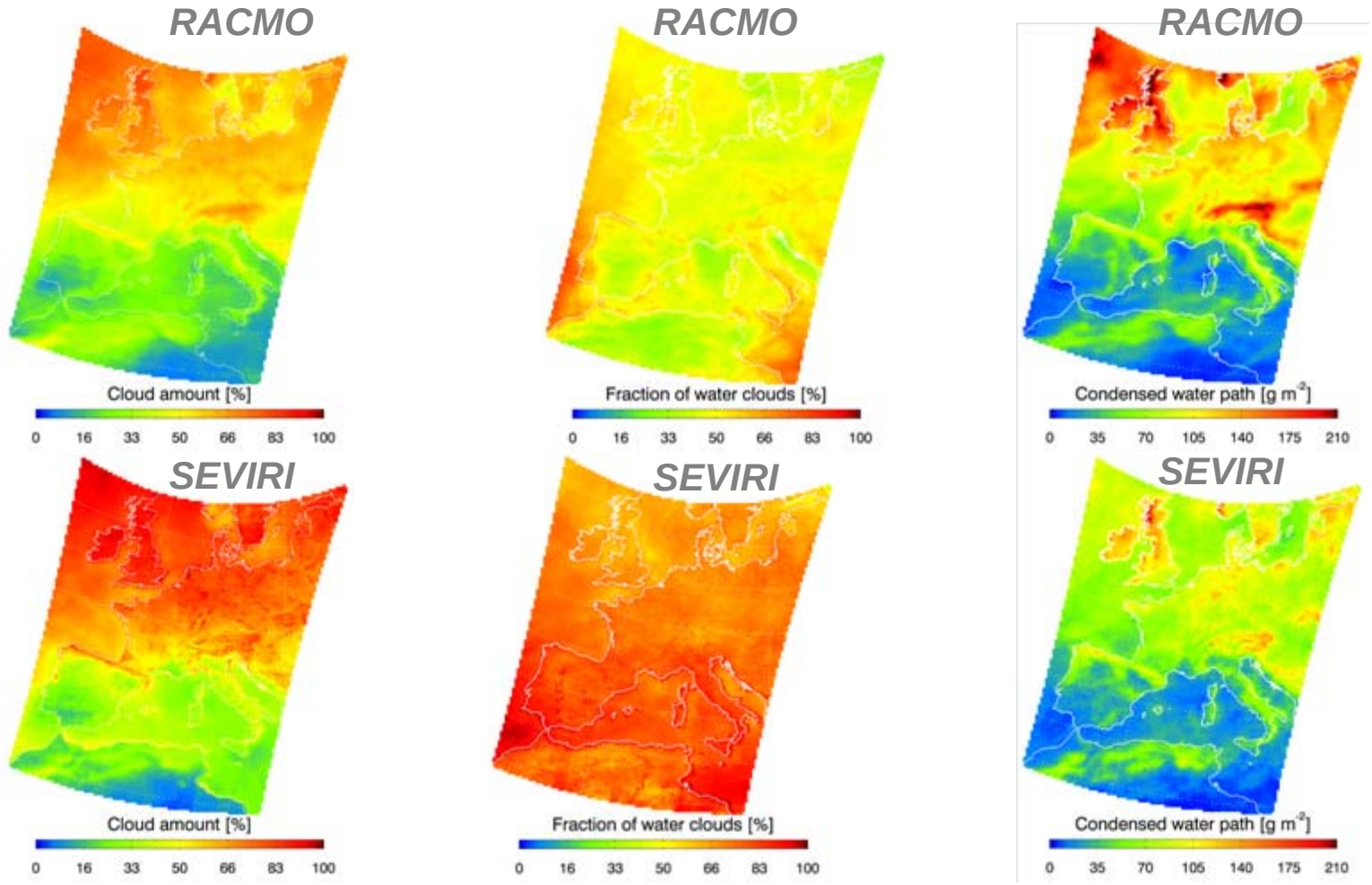
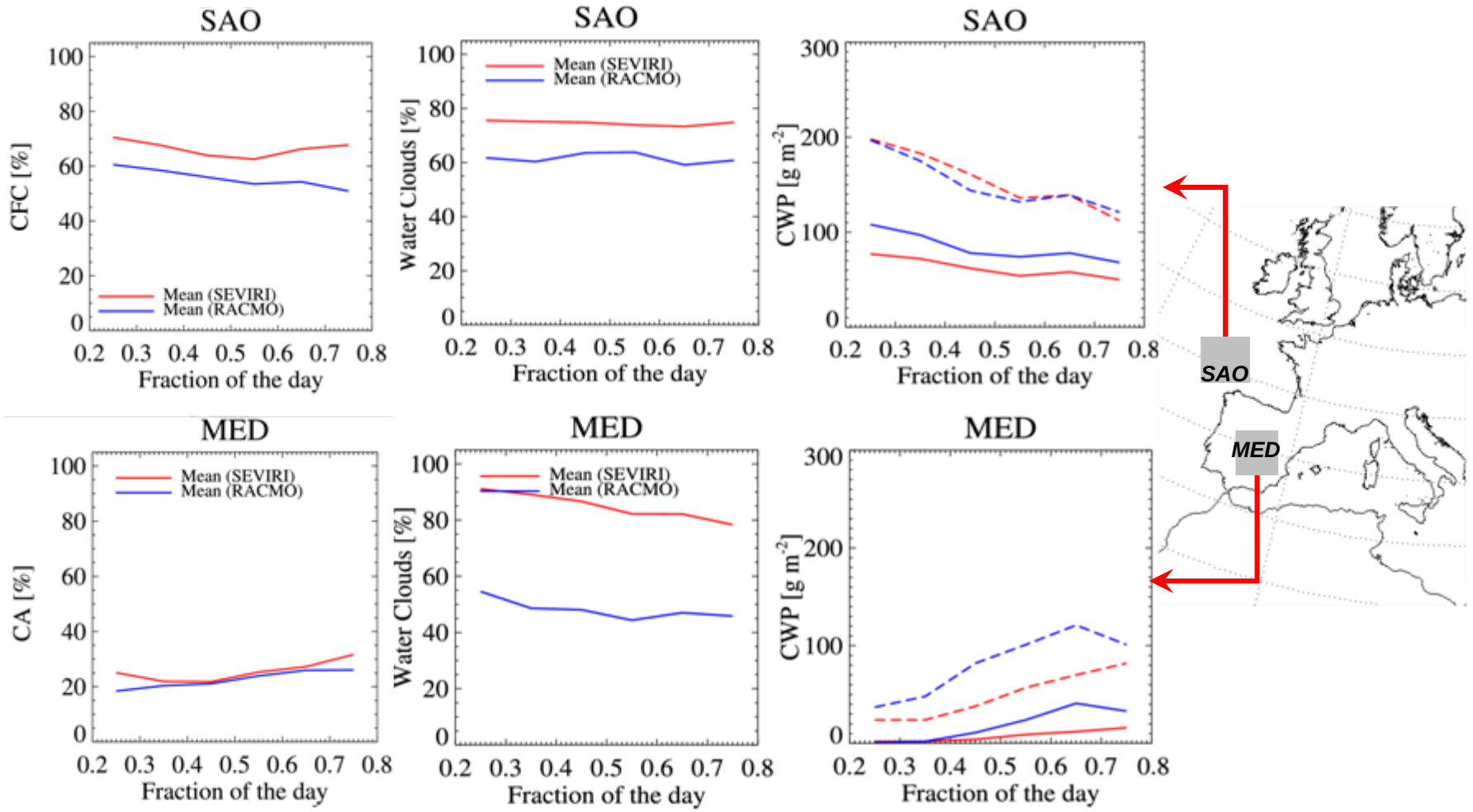


Fig. : *Condensed water path along track through stratocumulus field*

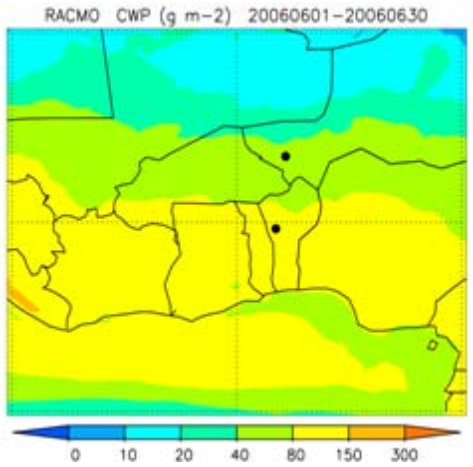
Evaluation: RACMO seasonal means

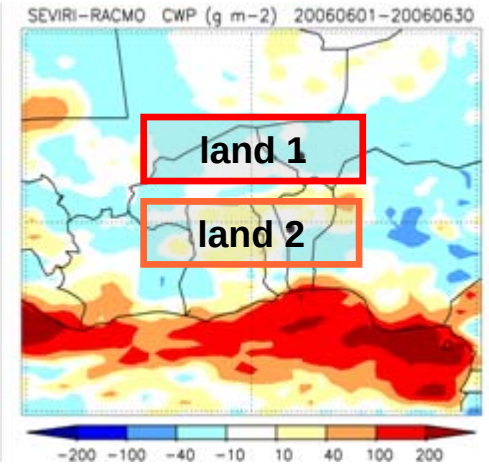


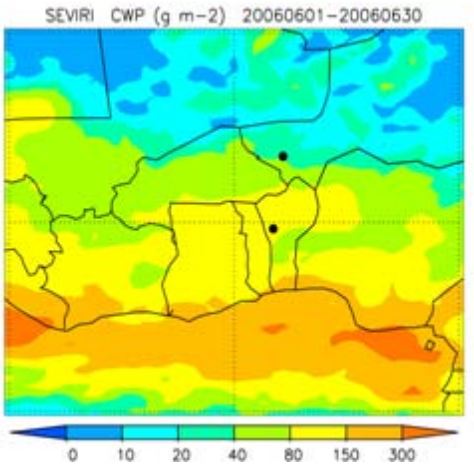
Diurnal cycle over land and ocean

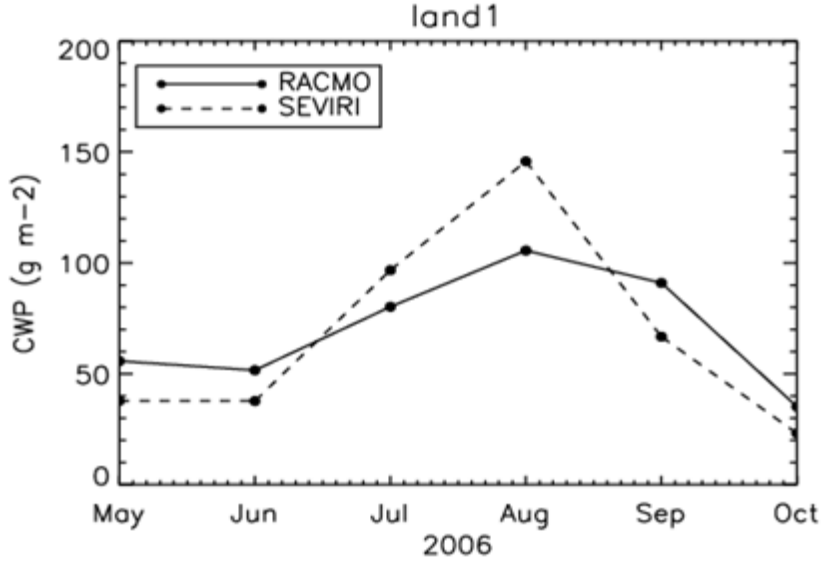


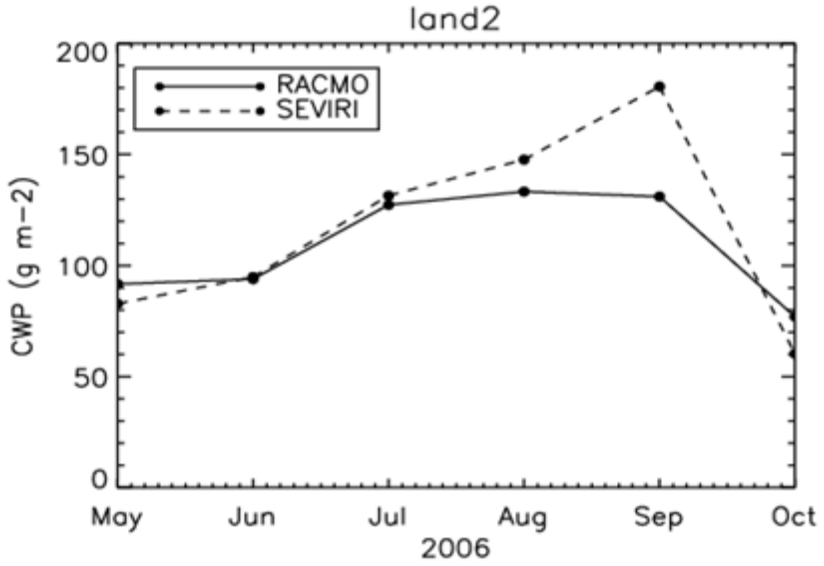
Seasonal cycle



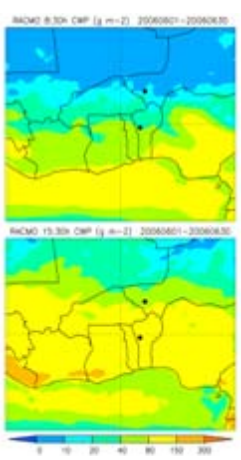


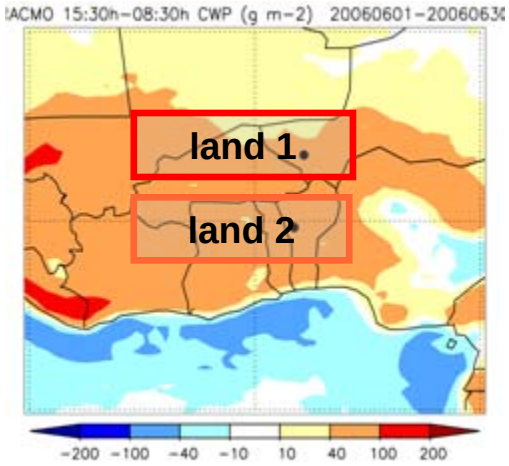


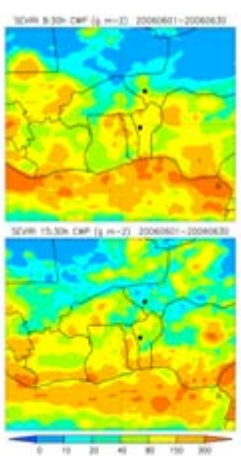


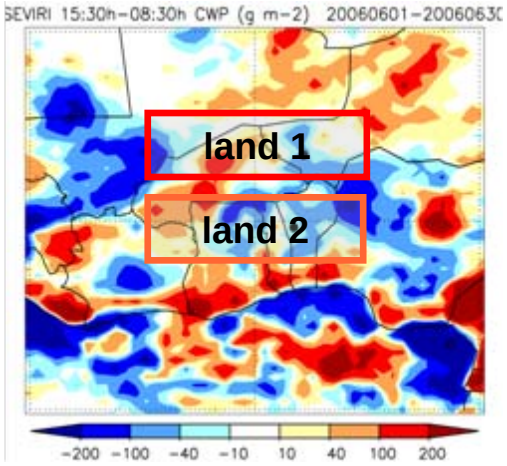


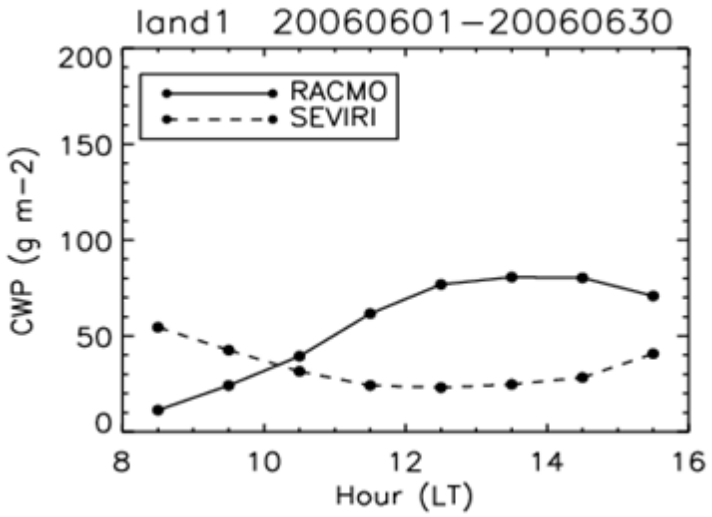
Diurnal cycle

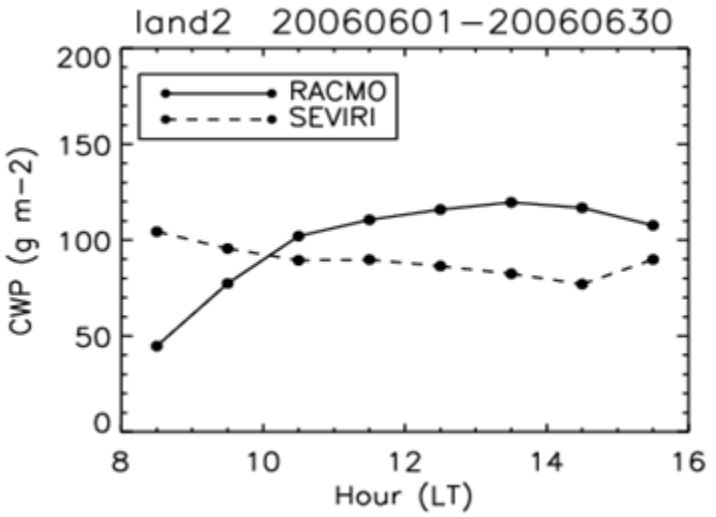












Conclusions

Conclusions

- Very accurate calibration is required for generating climatologies;
- Validation against independent observations confirm accurate and precise radiation, cloud and precipitation properties retrievals;
- SEVIRI derived cloud information is valuable for evaluating **spatial diurnal** and **seasonal** variations weather and climate models;
- Differences in Level3 data partly result from cloud masking, the treatment of cloud free pixels and differences in averaging methods;
- Combination of various available satellite products provide powerful tool to quantify feedback mechanisms.

Thank you !