Global Analysis of Cloud Properties or what the EUMETSAT SAF for Climate Monitoring can provide

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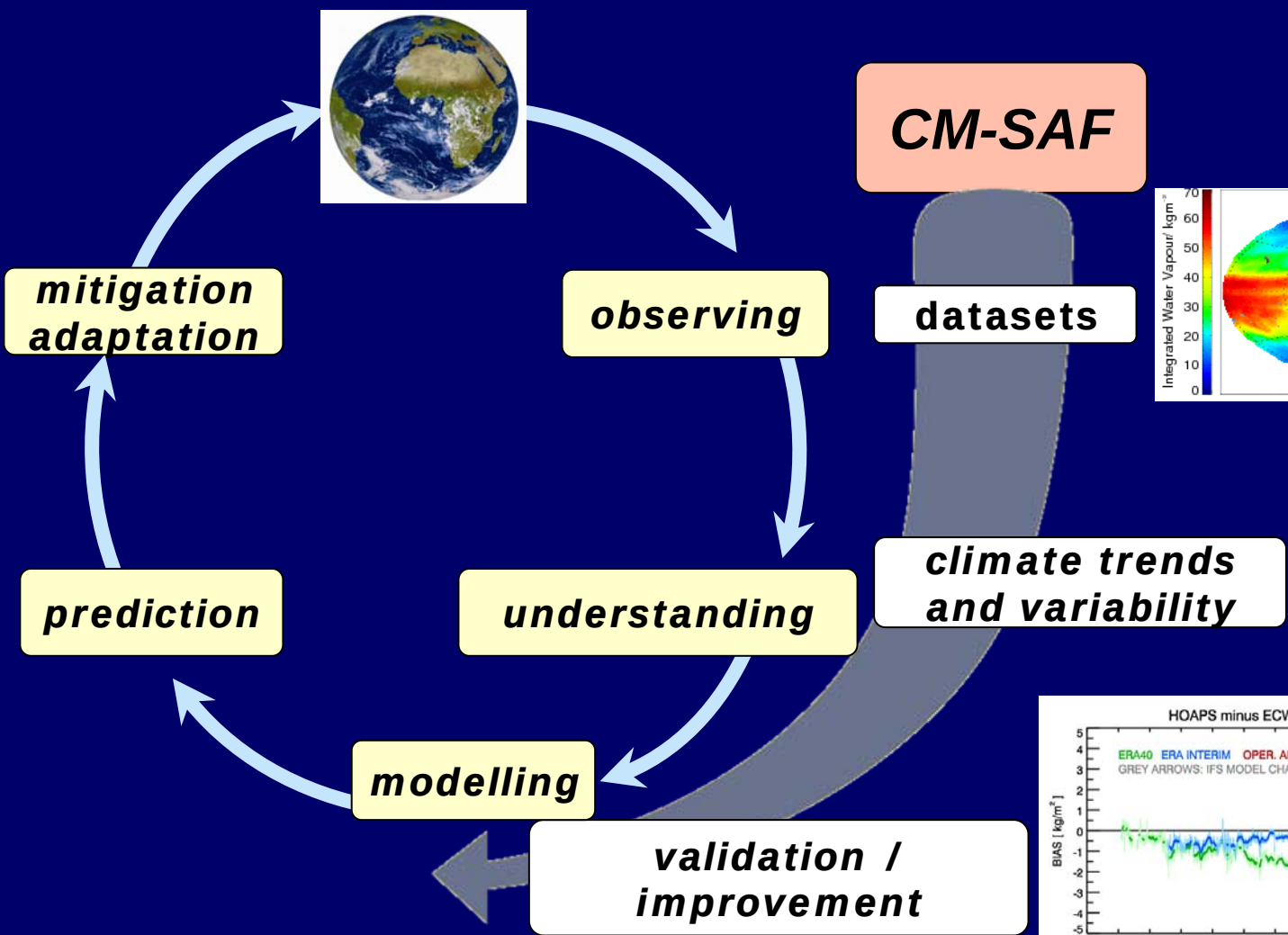
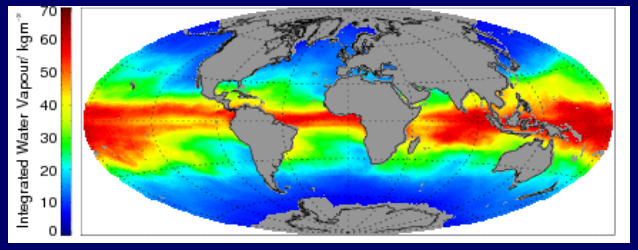
Content

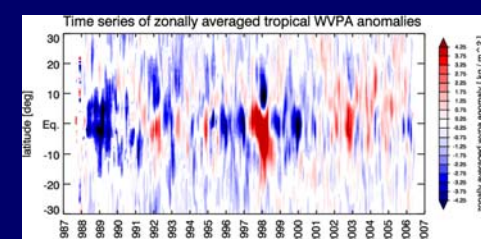
- CM-SAF Approach
- AVHRR cloud products
- Usage of SEVIRI products
- Passive Microwave LWP
- Validation of data products: see posters from Rainer Hollmann and Maarit Lockhoff as well as Jan Fokke Meirink
- Conclusions

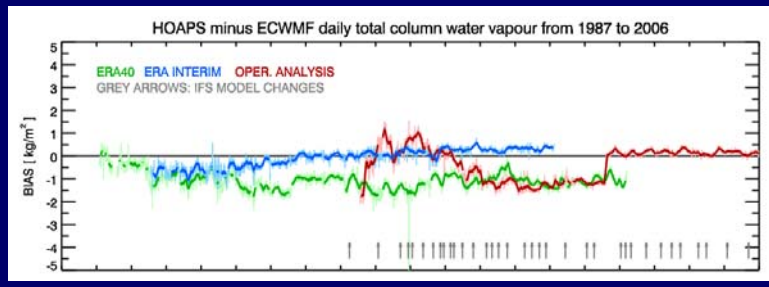
CM-SAF Approach

CM-SAF's role in climate monitoring and research

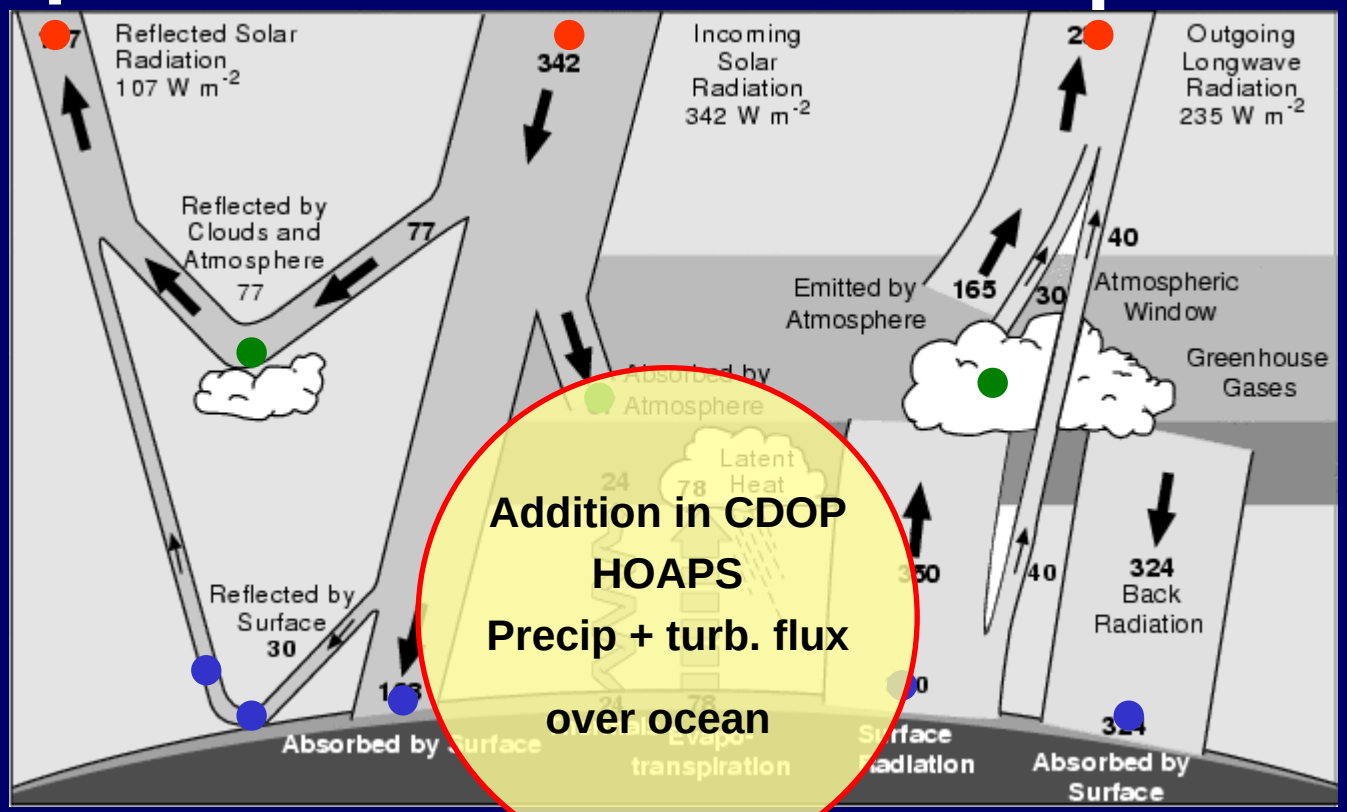




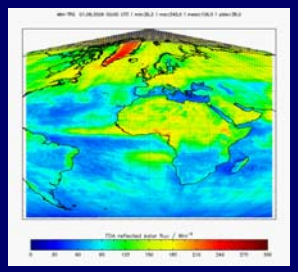


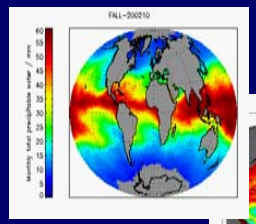


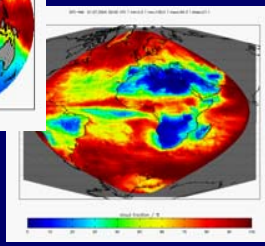
Energy and Water Cycle

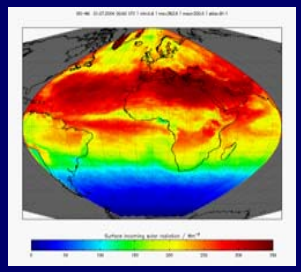


Kiehl und Trenberth (1997)



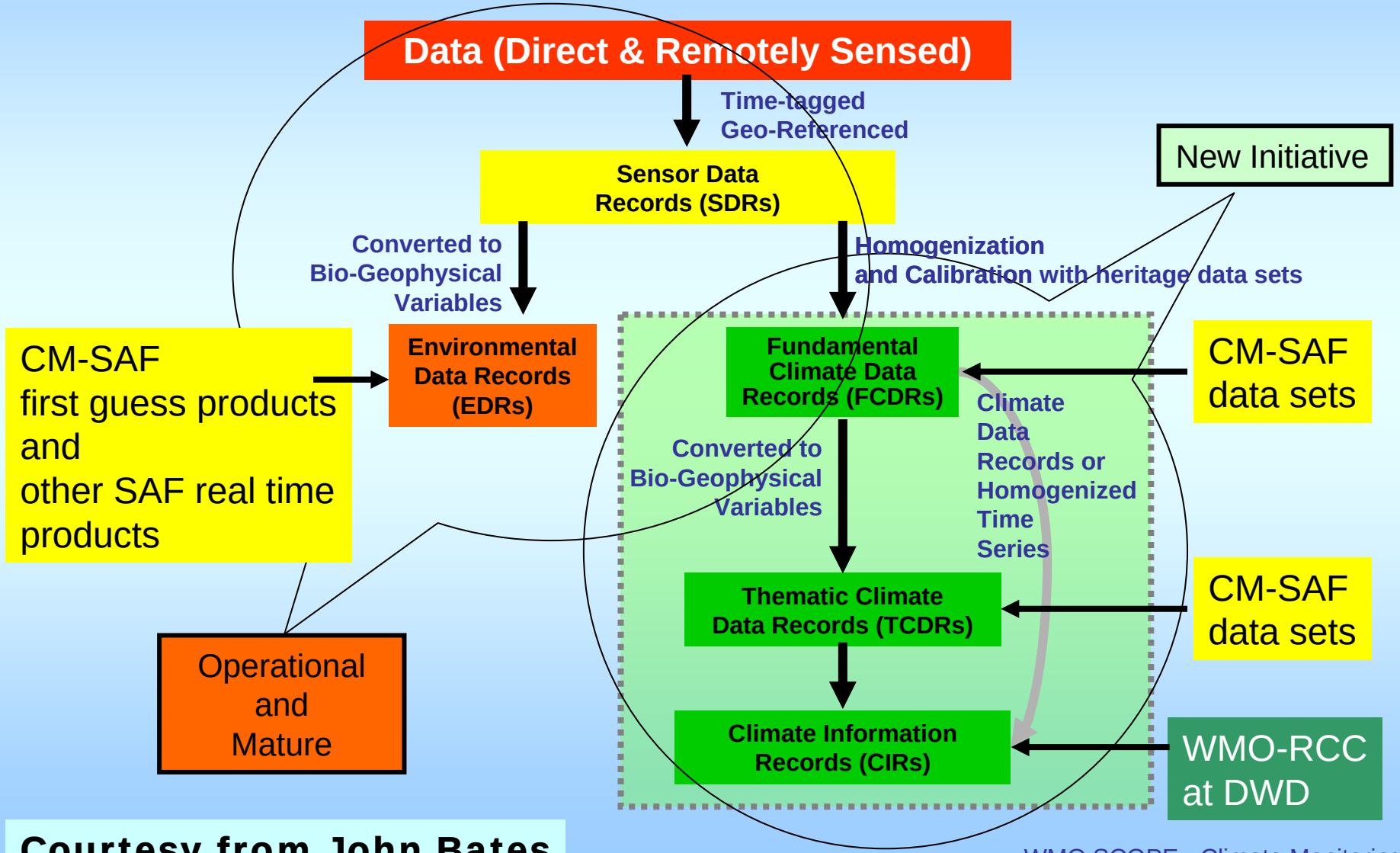






Weather vs. Climate Processing

Distinct Paths, Technologies, and Timelines



Courtesy from John Bates

CM-SAF CDOP Data Set Portfolio

Products	Data Coverage	Available	Satellite Data
GEOSTATIONARY DATA			
Cloud Products / TOA / Surface Radiation / Water vapour	2004 – 2010	2011	SEVIRI and GERB
Surface radiation Products (SIS, SAL, SDL)	1983 – 2010	0° 2009	MVIRI/SEVIRI
Free Tropospheric Humidity **(LMD)** (Cloud Mask also included)	1983 – 2010	IODC 2009 0° 2010	MVIRI/SEVIRI
POLAR ORBITER DATA			
Cloud Products / Surface Radiation Products **(NOAA)**	1982 – 2010/2001-2010 (CPP)	2011	AVHRR
HOAPS (Liquid Water Path, Latent Heat Flux, Precipitation, etc.) **(MPI-HH, NOAA-STAR)**	07/87 – 12/2007	2010	AVHRR/SSM/I (Ocean)
Other humidity products		2011	ATOVS

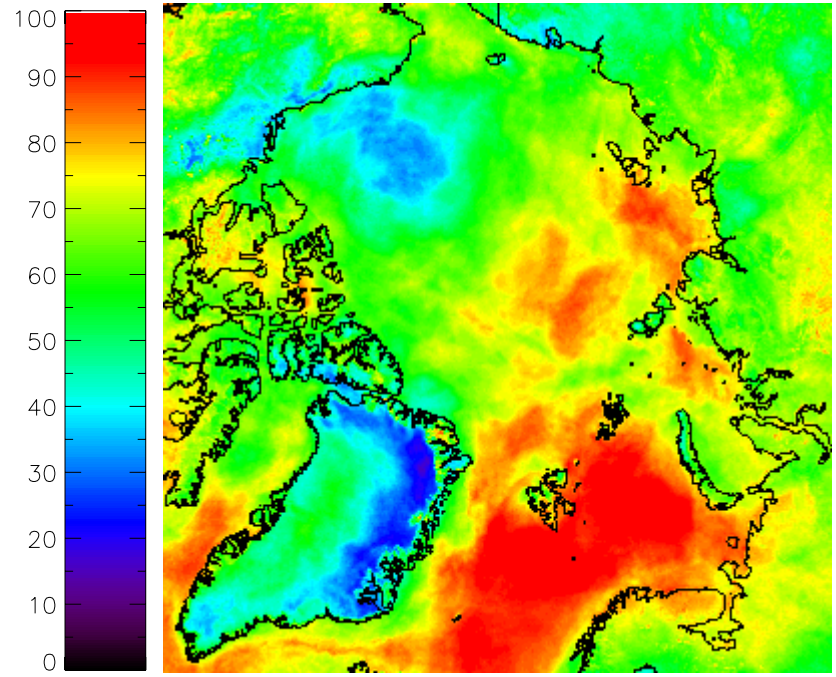
- IODC = Indian Ocean Data Coverage.
- All products derived from geostationary satellites shall cover full disc.
- All other products shall be global (microwave products only over ice-free ocean).
- All products will be available in full sensor resolution, i.e., VIS/IR provides high spatial resolution.

Conclusion

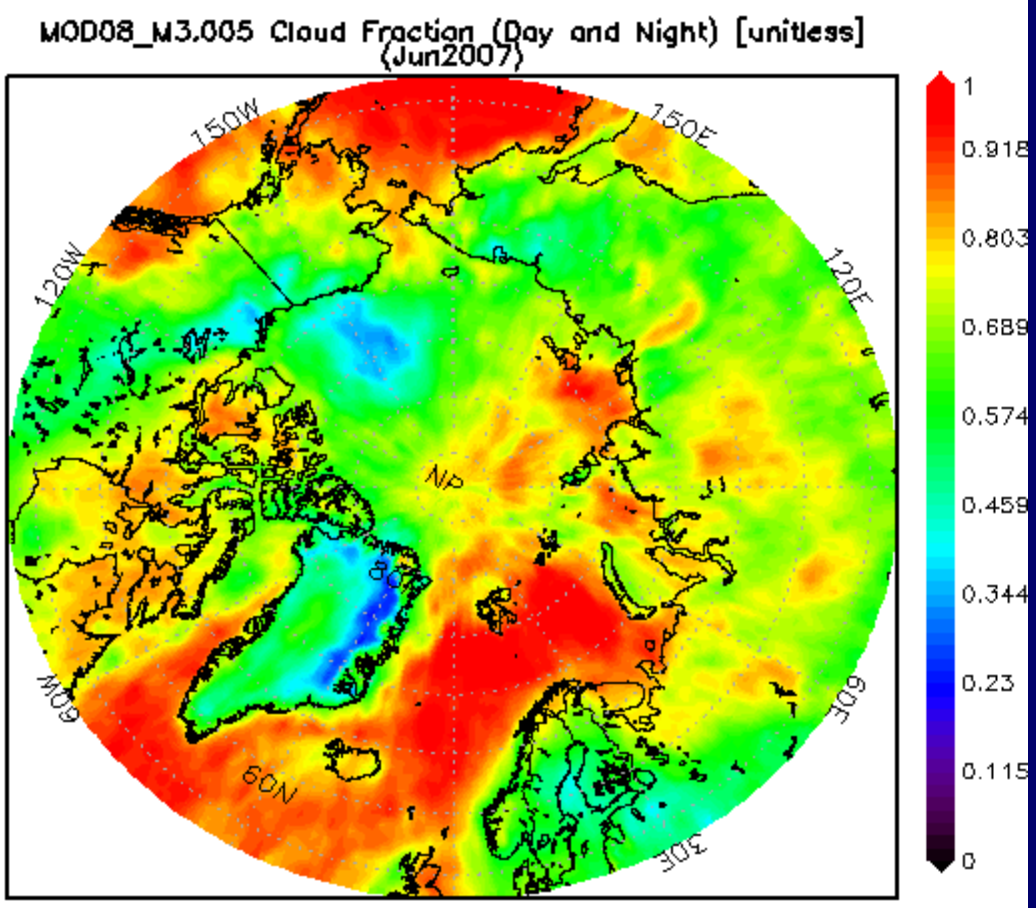
- CM-SAF is producing so called first guess products and long time series of cloud properties with improved accuracy.
- We use AVHRR, ATOVS/IASI, MVIRI/SEVIRI (MTG will have sounding capability in geostationary orbit, 2016) and SSMI class instruments because of its either existing long series or committed long series.
- Other instruments as (A)ATSR(2), MERIS, GOME type also come into focus.
- The multitude of different observational techniques should be used to cross compare and potentially combine sensors alleviating systematical weaknesses in single sensor approaches, e.g., PMW vs. visible spectral range LWP estimates.
- New data as CloudSat and Calipso provide much better validation capabilities than ever before. Can also be utilised to improve algorithms assumptions.

AVHRR Cloud Products

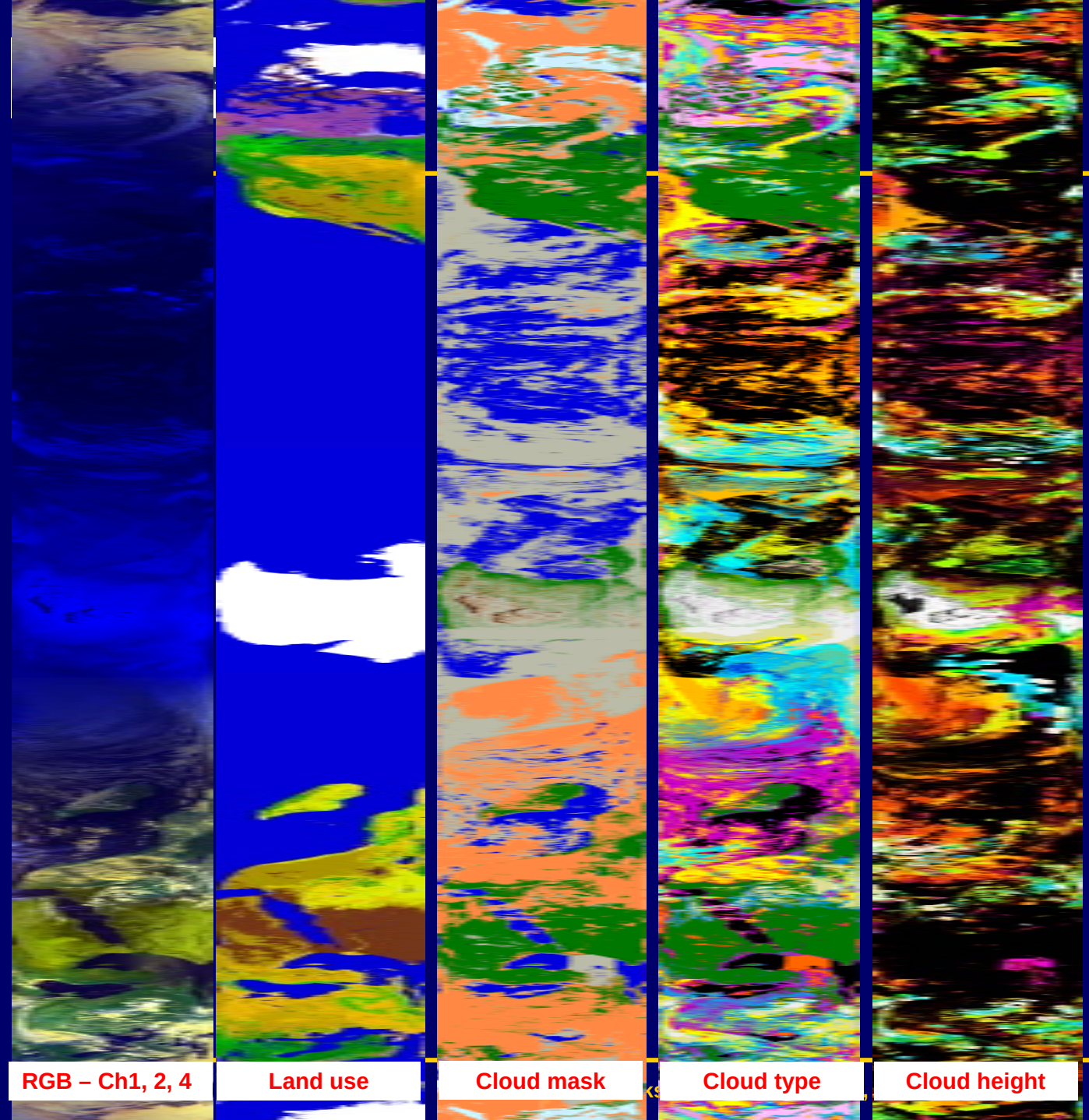
Mean cloud cover (%) in June 2007 compared to MODIS



CM-SAF cloud cover



(MODIS data extracted from the Giovanni online data system, http://g0dup05u.ecs.nasa.gov/Giovanni/ developed and maintained by the NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC))



AVHRR/NOAA-14
Year: 1998
Day: 181
Time: 10:37 UTC

Cloud Mask

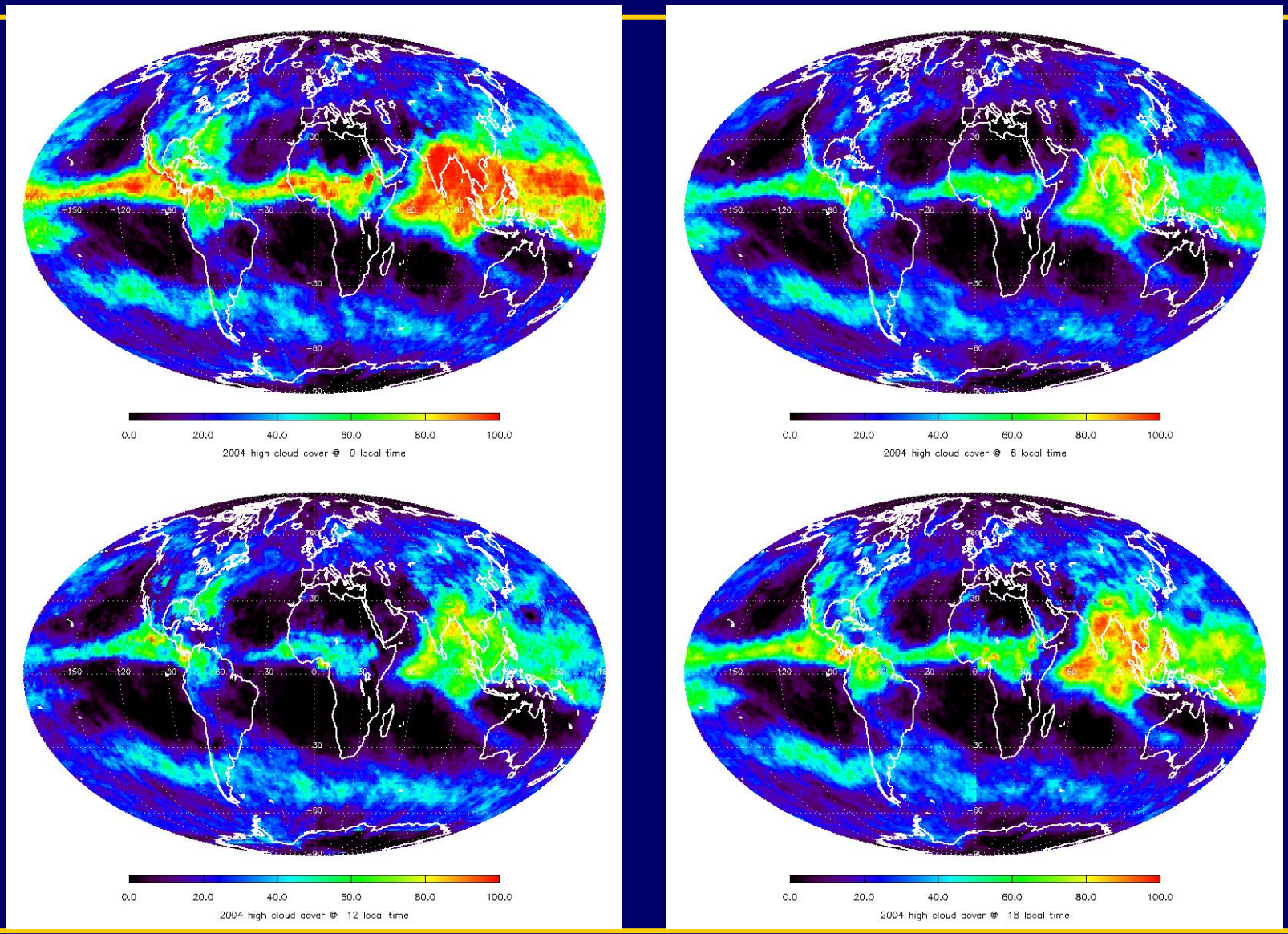
- Unprocessed
- Cloud free land
- Cloud free sea
- Cloud contaminated
- Cloud filled
- Snow/Ice contaminated
- Unclassified
- Low quality

Cloudtype

Cloud free	Very high
Cloud free	Very thin cirrus
Snow	Thin cirrus
Snow/Ice	Thick cirrus
Very low	Cirrus above
Low	Fractional
Medium	Unclassified

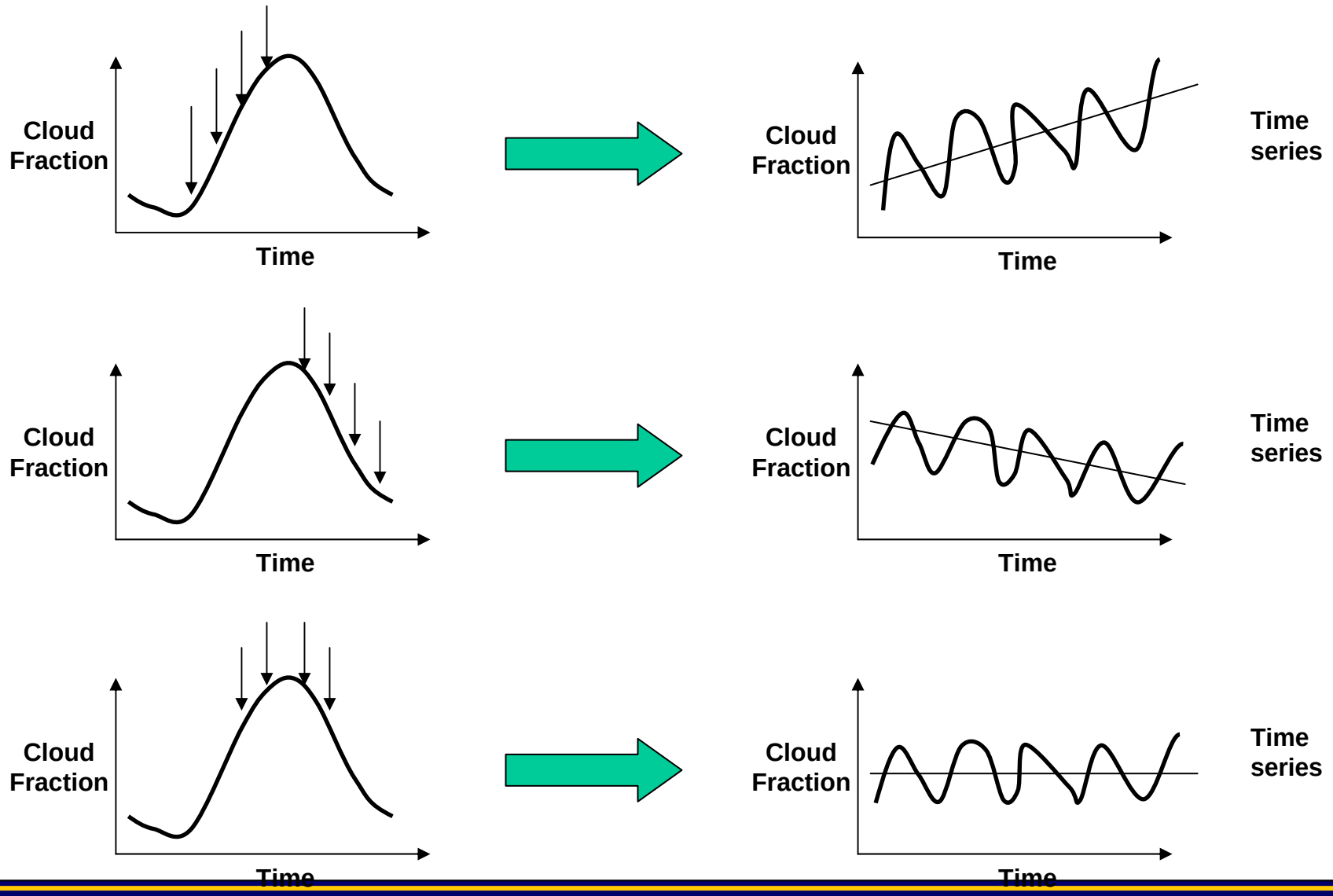
Unprocessed	4500-5000m
0-500m	5000-5500m
500-1000m	5500-6000m
1000-1500m	6000-6500m
1500-2000m	6500-7000m
2000-2500m	7000-7500m
2500-3000m	7500-8000m
3000-3500m	8000-8500m
300-4000m	8500-9000m
4000-4500m	

Diurnal Cycle of High Cloud for July 2004 produced at 0, 6, 12, and 18 local time.



Courtesy Andrew Heidinger

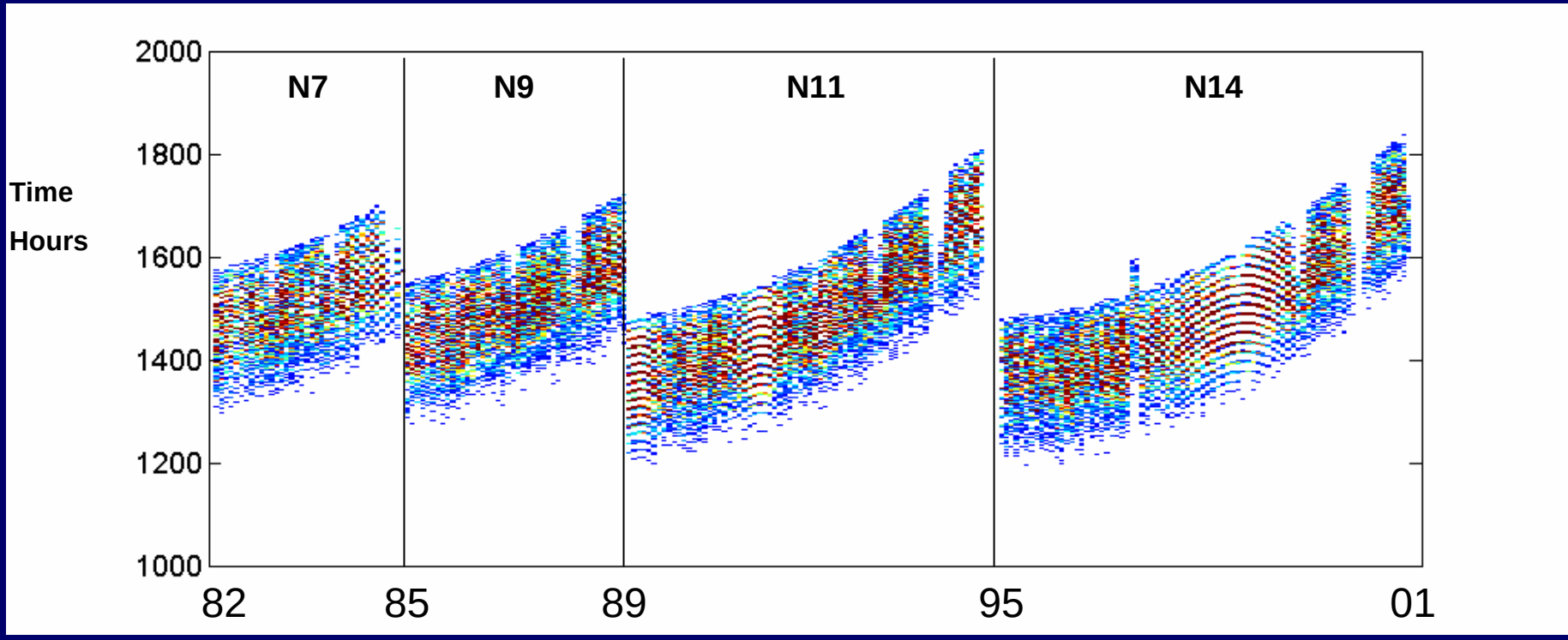
Relevance for cloud climatology – its all about diurnal cycle !!!



Drifting of NOAA satellites

Example: Data over Indian subcontinent:

How the time of observation has changed for AVHRRs



Time

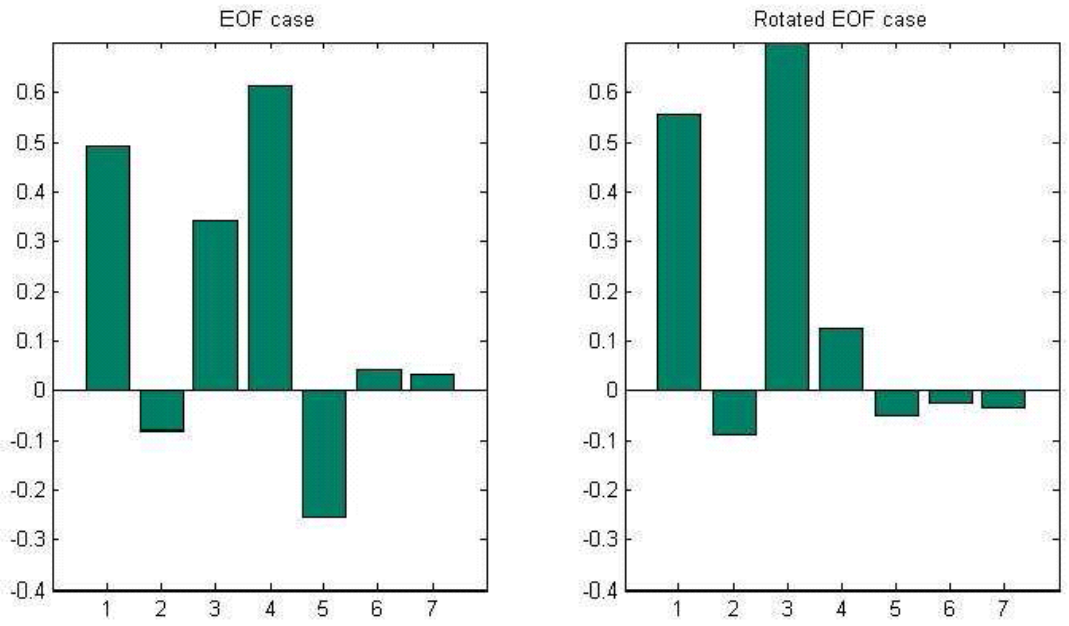
Demonstrating usefulness of REOFs

Methodology (conceptually based on Waliser and Zhou, 1997)

1) Detrend the data.
2) Calculate EOFs.
3) Rotate EOFs (varimax).
4) Identify modes with orbital drift influence.
5) Calculate synthetic modes.
6) Calculate synthetic dataset.
7) Calculate EOFs again (for checking).

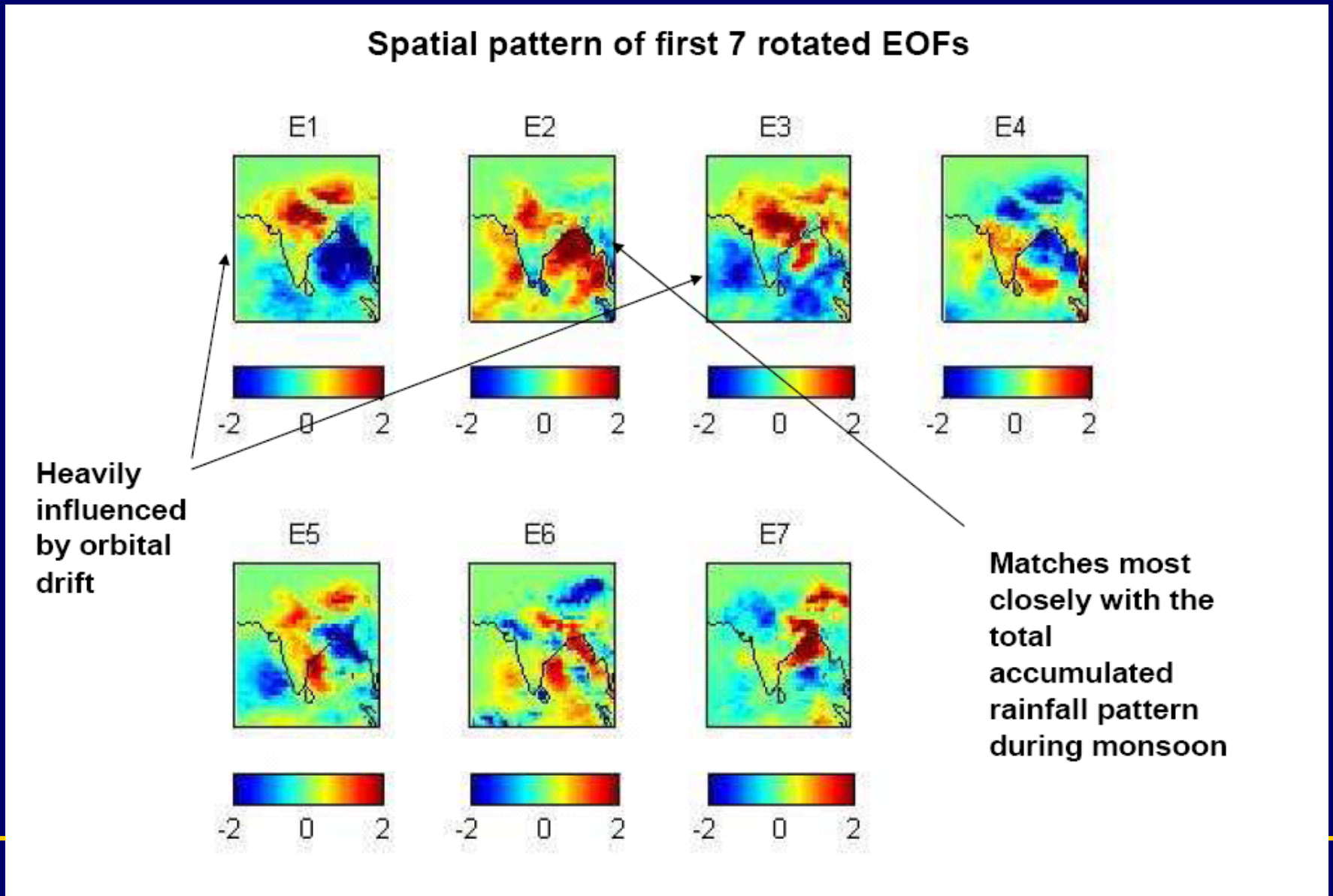
Usefulness of REOFs

Correlation of the first 7 principal components with the TOB for unrotated and rotated EOF cases



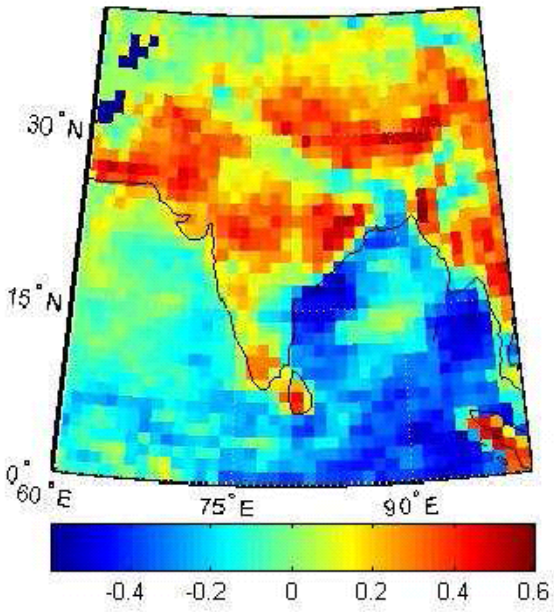
Notice how rotated case un-mixes the effect of the drift (only 2 modes affected instead of 4 in unrotated case).

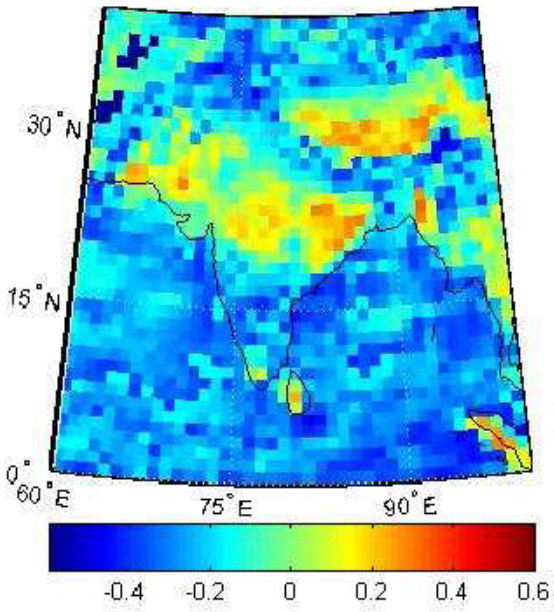
Usefulness of REOFs



Usefulness of REOFs

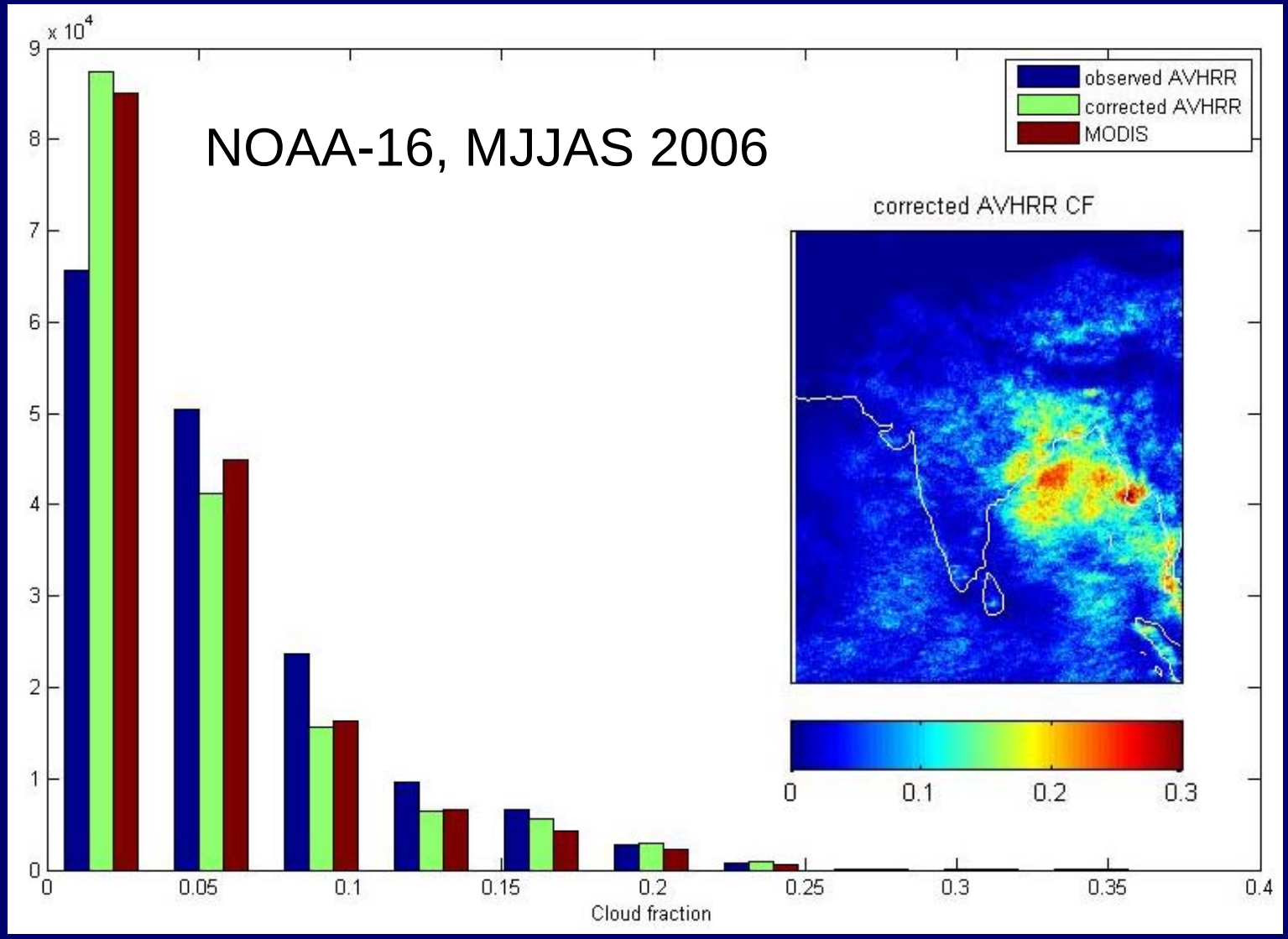
Correlation of original and synthetic datasets with the TOB





Range of correlation coefficients reduced from +/- 0.6 to +/- 0.3 over most of the area.

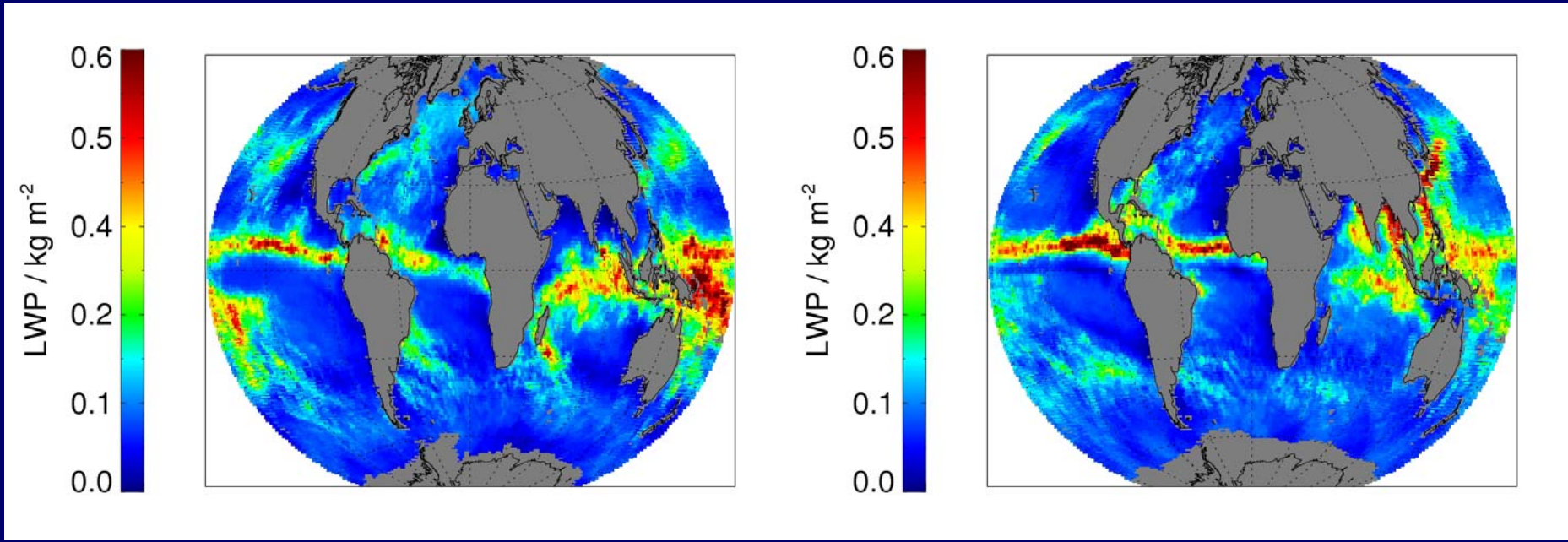
High Cloud Fraction AVHRR vs. MODIS



Passive Microwave LWP

Example from HOAPS

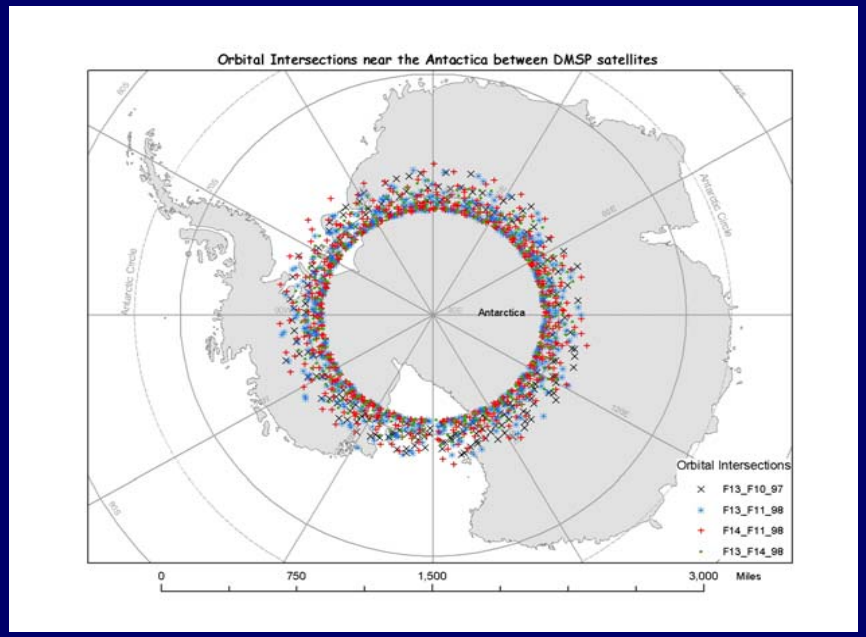
January 2005 June 2005



Experienced much higher values compared to others in GEWEX cloud assessment. Most likely a problem of distinction between rain and cloud water. -> need to renovate our retrieval.

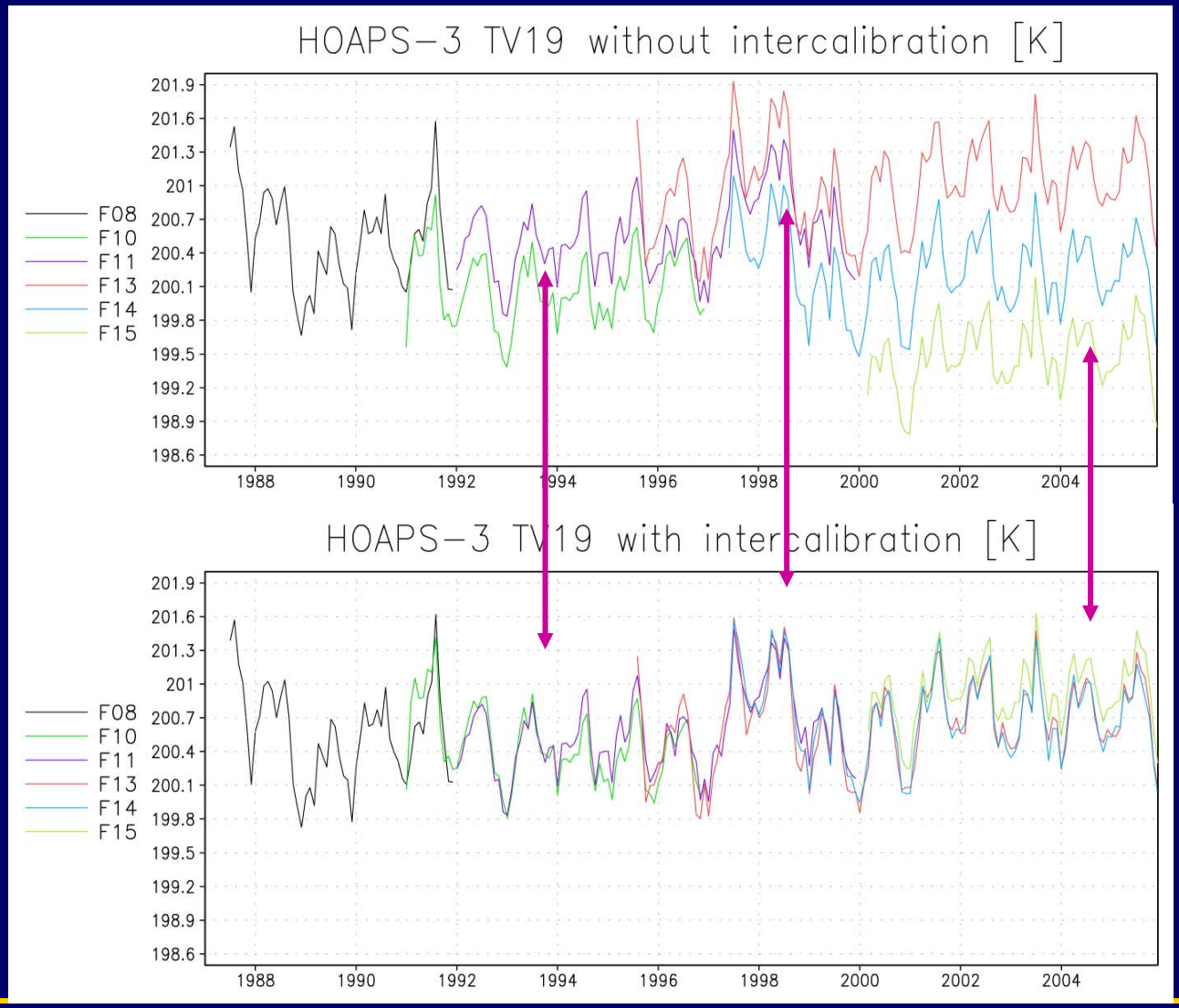
SSM/I Intersensor Calibration

- NOAA: Developed unique technique for matching SSM/I obs from two DMSP satellites
  - Simultaneous conical over-passing
  - Characterize biases according to surface type
- EUMETSAT CM-SAF
  - Statistical intercalibration (histogram equalisation)
  - Intercomparison
- Work with CSU (Kummerow) and RSS (Wentz)
  - Independent calibration approach
  - Intercomparison
- Work with NASA GPM Cross-Calibration team
  - TMI and SSM/I
  - Windsat and SSM/I



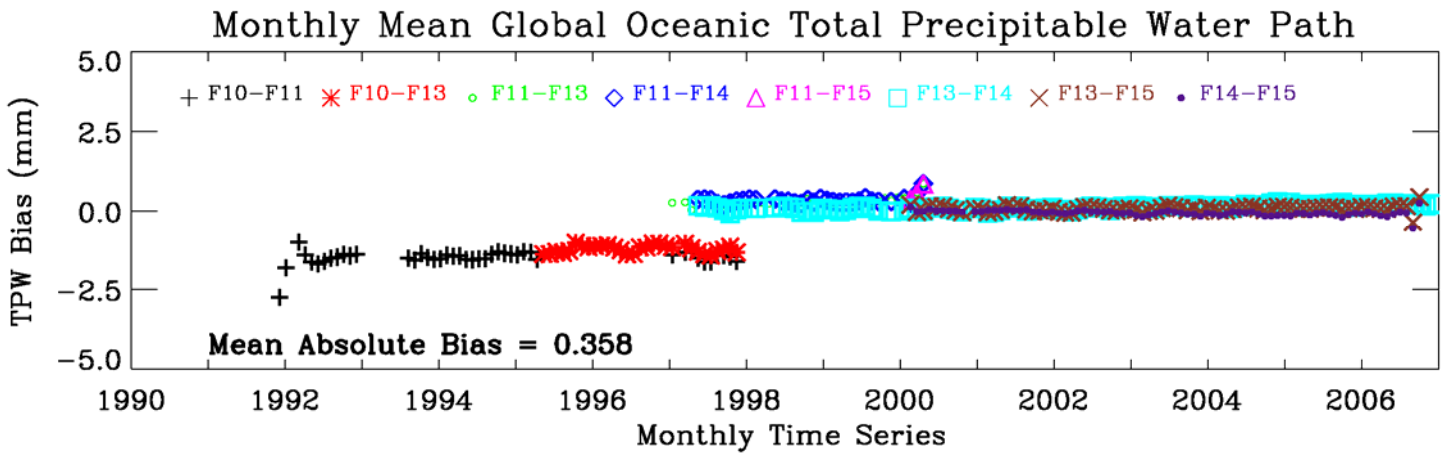
Simultaneous observations from DMSP F10 and F11 satellites over Antarctic continent

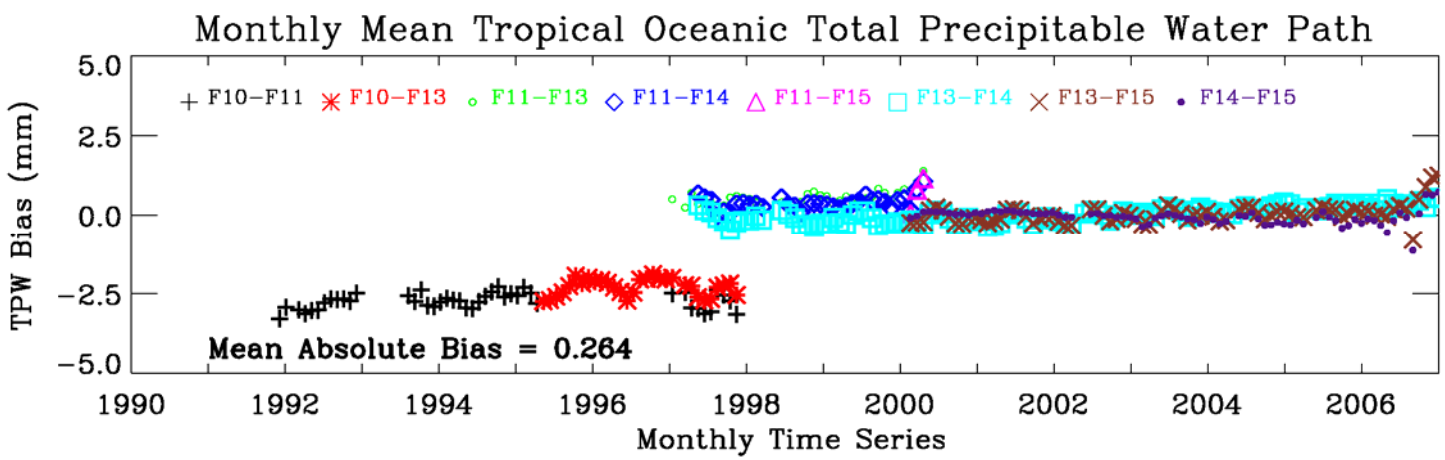
CM-SAF Intersatellite Homogenisation Example



Monthly TPW Bias between Overlapped Sensors

Before Calibration

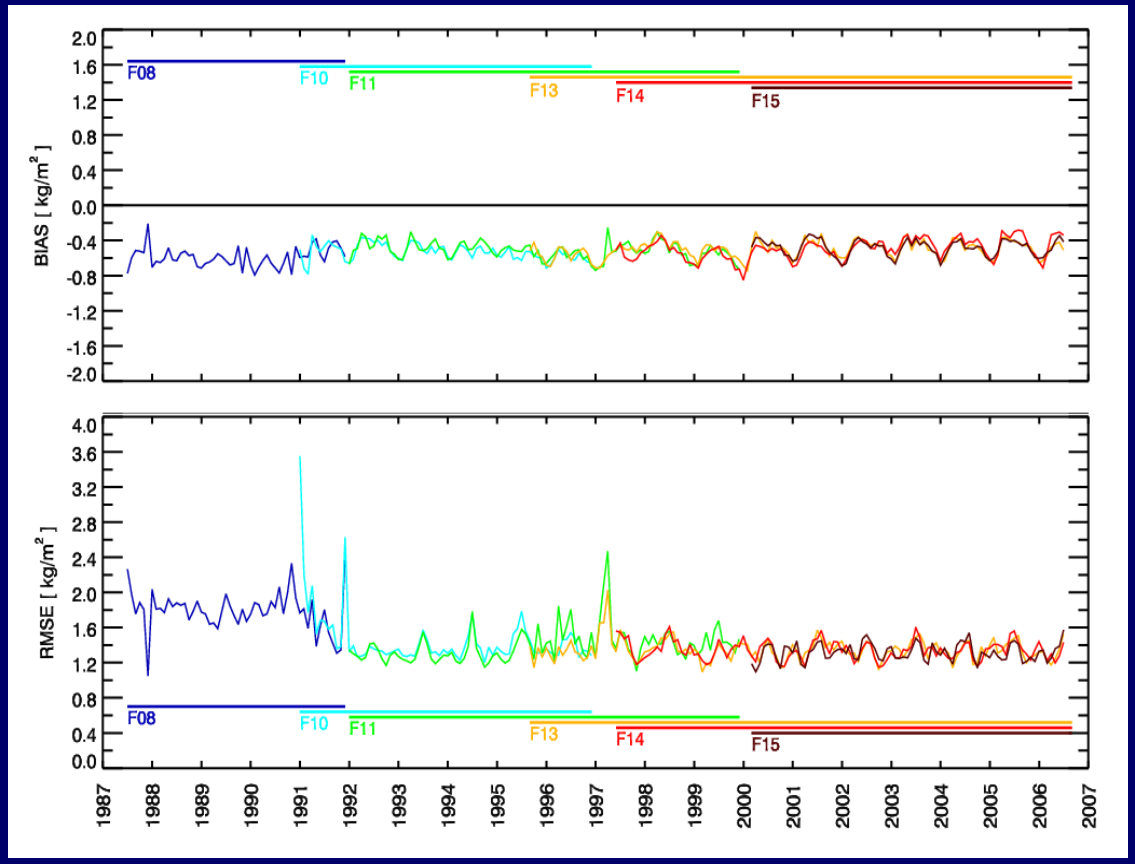




Monthly total precipitable water path (TPW) bias between any overlapped SSM/I sensors for F10, F11, F13, F14, and F15. Large biases between F10-F11 and F10-F13 are obvious. Since TPW = 232.89-.1486*TV19-.3695*TV37-(1.8291-.006193*TV22)*TV22, (Alishouse et al., 1991), any radiance biases in lower SSM/I frequencies will be directly translated into TPW biases

CMSAF-IWV vs. RSS-IWV

Check for quality of homogenisation



- CMSAF: merged product (all satellites),
- RSS: individually for each platform.

- Homogenisation of CMSAF works well, if bias in overlap periods is stable.

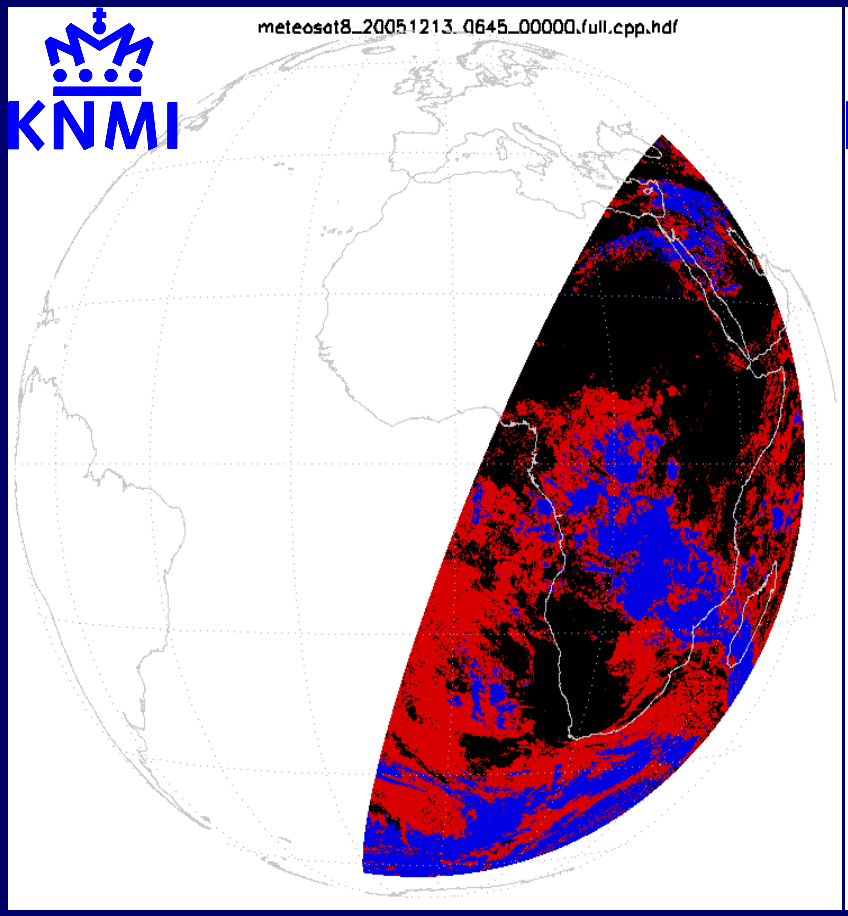
- RSS uses all channels for retrieval simultaneously,
- DMSP F-08, 86 GHz channel is synthesized: may lead to enhanced bias and rmse,
- Compensated by homogenisation when F-10 appears.

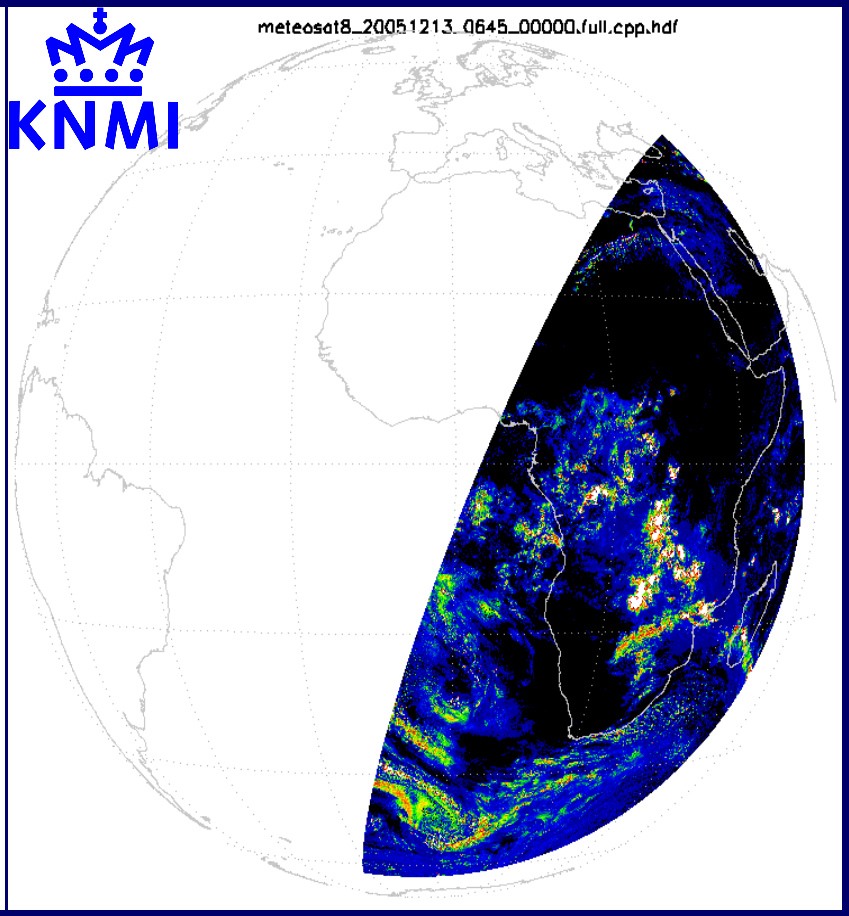
Conclusion intercalibration and drift

- Successful intercalibration of successive sensors and correction of diurnal satellite drift are essential to produce a meaningful climate product.
- Currently, drift corrections are mostly applied to derived products – should try application to radiances to be consistent with intercalibration.
- REOFs are only one way to correct drift - should also try others.
- Need carefully to consider not to eliminate climate variability by this.

SEVIRI Usage in Model Evaluation

Cloud Properties - Meteosat-8

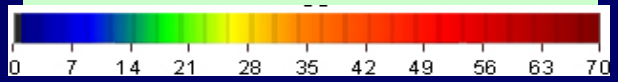




Phase

Water	Ice	clear

Optical Thickness



Model Evaluation

Objective

Evaluate diurnal cycles of Cloud Properties from the Regional Atmospheric Climate Model (RACMO) with corresponding cycles derived from SEVIRI.

RACMO (version 3)

- Limited area hydrostatic model,
- Physics based on ECMWF,
- HIRLAM forecast component.

Method

- Hourly RACMO and SEVIRI data over Europe (May – September 2004),
- Comparison to Cloudnet ground-based observations,
- Evaluation of daylight cycles for four climate regions.

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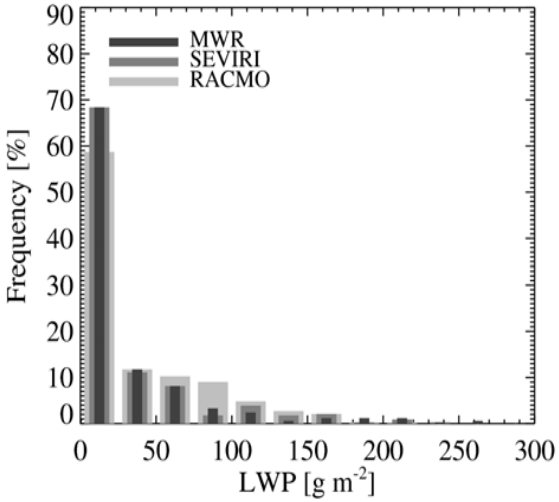
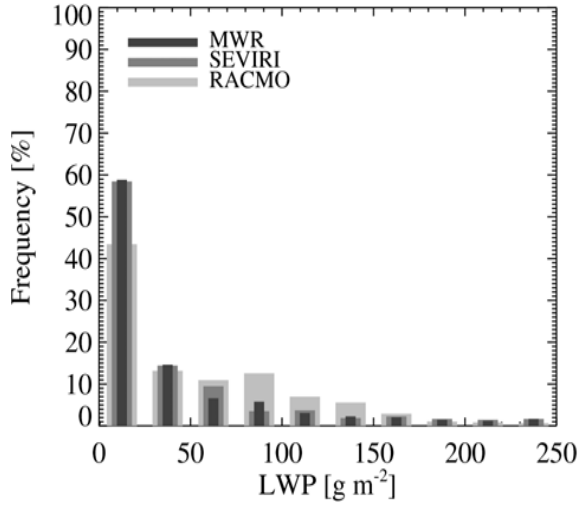
Comparison to MWR observations at Chilbolton

Table *Statistics of LWP values from MWR, SEVIRI and RACMO during May – Sept. 2004*

	RACMO non-precipitating water clouds						*RACMO all water clouds*					
	cloudy & cloud free N = 349			*cloudy N = 99*			*cloudy & cloud free N = 486*			*cloudy N = 163*		
	LWP_m [g m^{-2}]	LWP_{50} [g m^{-2}]	σLWP [g m^{-2}]	LWP_m [g m^{-2}]	LWP_{50} [g m^{-2}]	σLWP [g m^{-2}]	LWP_m [g m^{-2}]	LWP_{50} [g m^{-2}]	σLWP [g m^{-2}]	LWP_m [g m^{-2}]	LWP_{50} [g m^{-2}]	σLWP [g m^{-2}]
MWR	31.0	**8.0**	**56.7**	75.9	**53.3**	**76.1**	44.2	**14.4**	**69.2**	97.8	**75.8**	**87.9**
SEVIRI	33.1	**12.0**	**59.3**	70.5	**52.4**	**70.8**	46.8	**16.7**	**82.2**	87.9	59.5	**81.5**
RACMO	34.1	**10.9**	45.0	53.7	41.9	55.1	58.5	37.8	**83.3**	95.2	**74.2**	117.7



Non-precipitating water clouds



All water clouds

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Evaluation: Spatial variations over Europe

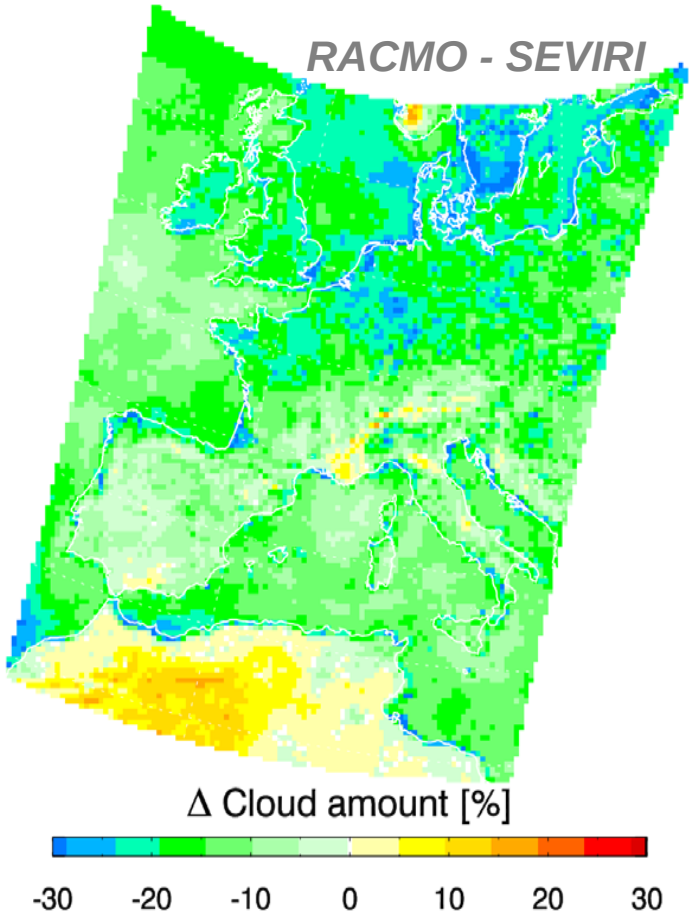

Fig. *Difference between RACMO and SEVIRI Cloud Amounts*

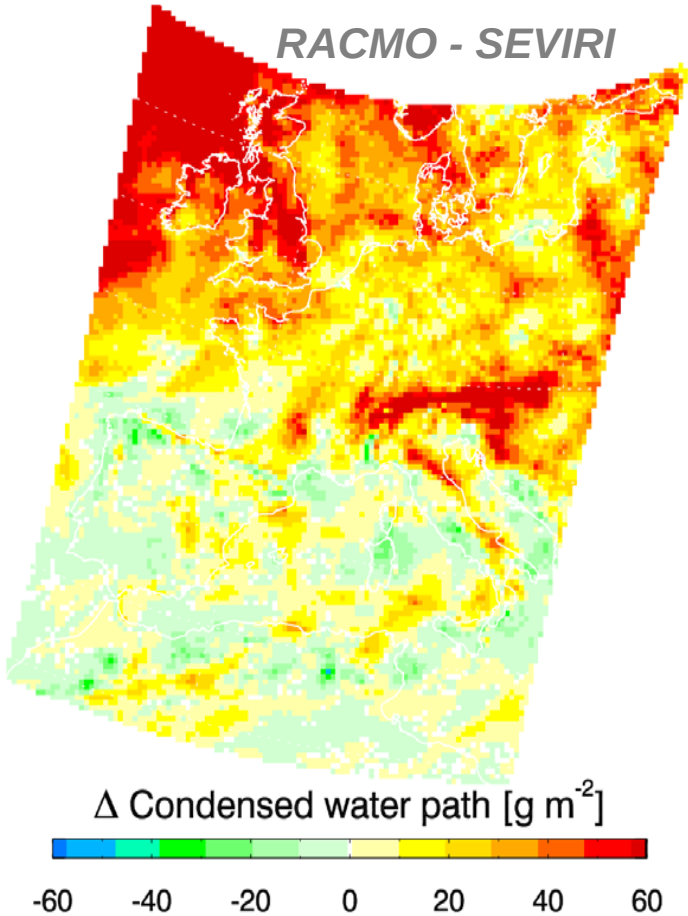

Fig. *Difference between RACMO and SEVIRI Condensed Water Path*

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Evaluation: diurnal cycle of CWP

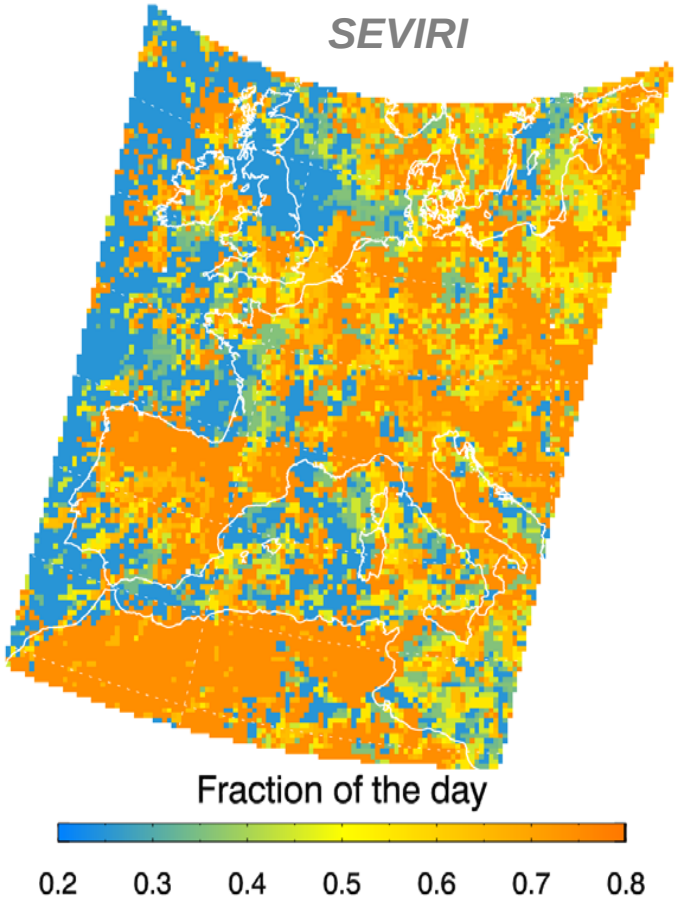

Fig. *Daytime fraction of* ***SEVIRI*** *maximum CWP during May – Sept. 2004*

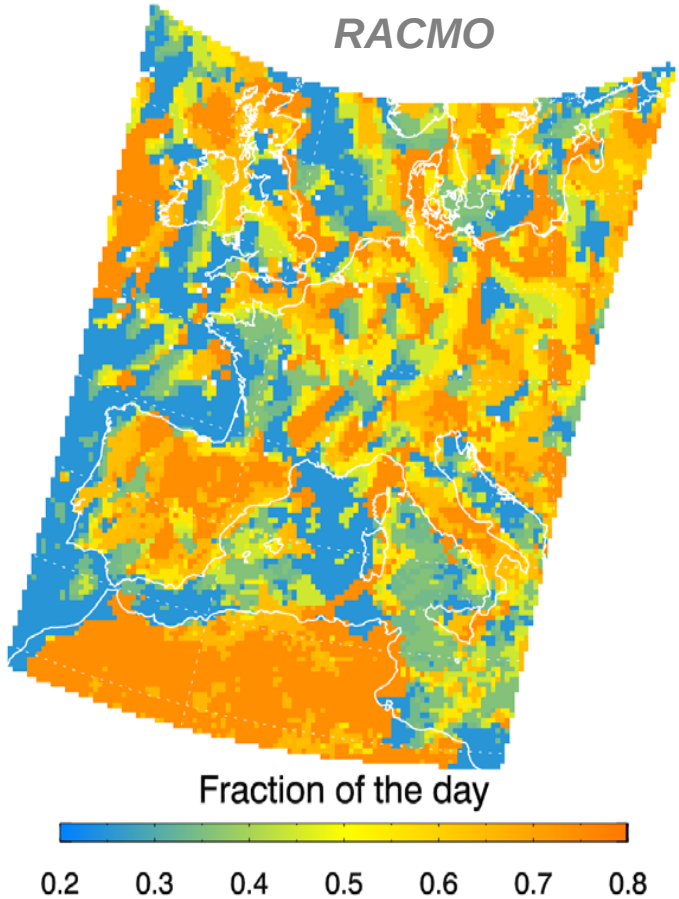

Fig. *Daytime fraction of* ***RACMO*** *maximum CWP during May – Sept. 2004*

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Conclusion model comparison

- Current first guess products are already in use for evaluation of RCMs (RACMO and CLM (see poster of Hollmann and Will et al.).
- Findings for SEVIRI and RACMO-3:
  - Spatial distributions of CA and CWP agree quite well;
  - RACMO underestimates CA ~20% on average;
  - RACMO predicts 50% (up to 100gm^{-2}) higher CWP in Northern Europe. Satellite estimate is not very well validated for thick ice clouds.
  - Daytime fraction of max CWP differ in many places.
- Feedback to the data set producer is essential for further improvements of the data sets.

Thank YOU !

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