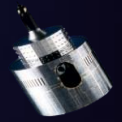
PRECIPITATION ESTIMATE FROM MSG

Marie Doutriaux-Boucher
Rob Roebeling
Phil Watts



EUMETSAT

Who am I ?

Who am I ?

Together with my colleagues, we are working at EUMETSAT, the European Organisation for the Exploitation of Meteorological Satellites.

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Outline

- Introduction
- Multi sensor Precipitation Estimate principle
- OCA cloud microphysical products
- Towards updating MPE using OCA

MPE EUMETSAT operational product overview

Multi-Sensor **P**recipitation **E**stimate

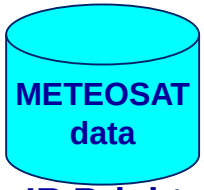
- **Heritage product**: Same algorithm for MFG (Meteosat 7) & MSG (Met 8,9,10)
- Combines passive microwave rain-rates from polar orbiting satellites (SSMIS) with IR data from geo-stationary satellites (Meteosat).
- Instantaneous rain rate data are produced every 5/15/30 min in original Geo-satellite pixel resolution
- Processing is done in near-real time mode with a time delay of < 10 minutes between image acquisition and data dissemination.
- Data are provided on the internet and via EUMETCAST in GRIB-2 data format and in addition visualised on the EUMETSAT web-page.

Why to combine IR versus MW data for precipitation retrieval?

	Spatial/temporal resolution	Retrieval accuracy
IR	XX	
MW		XX

It’s beneficial to combine both types of measurements.

MPE Blending Algorithm Overview



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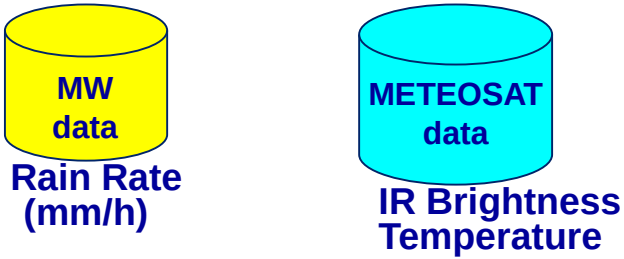

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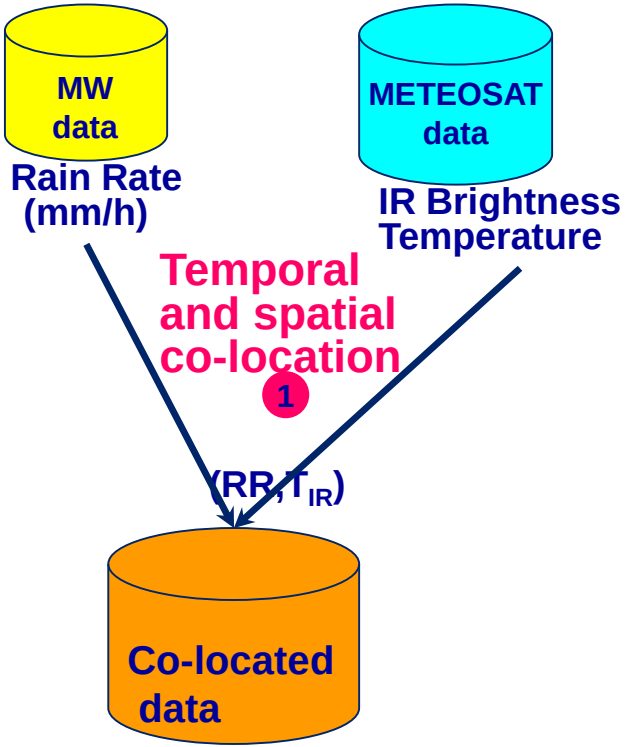

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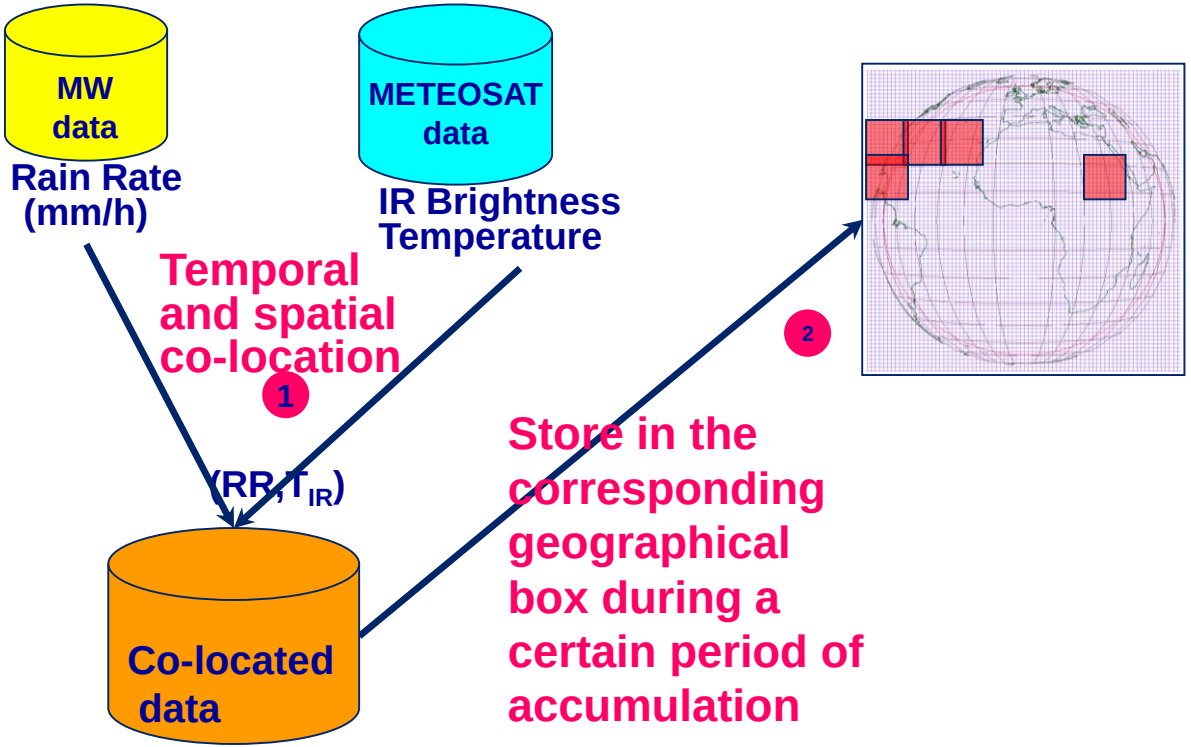

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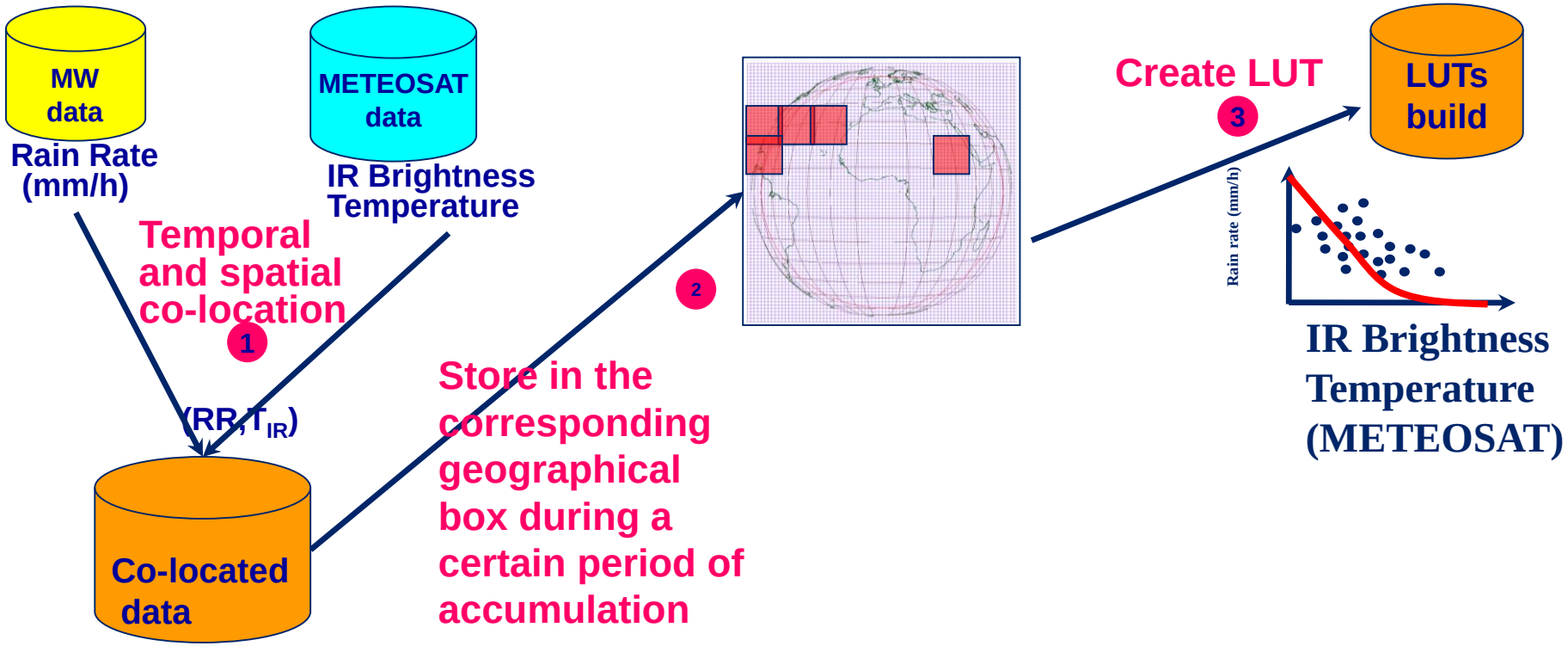

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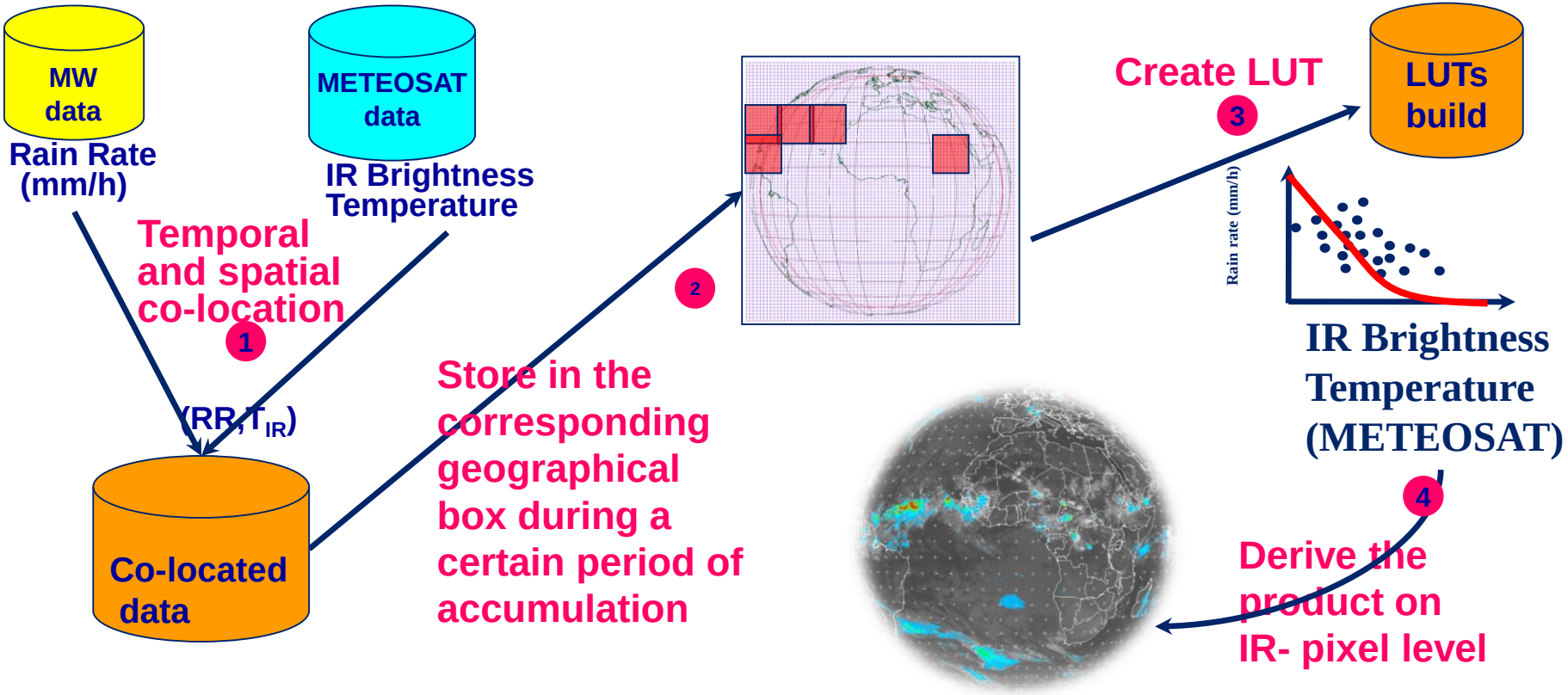
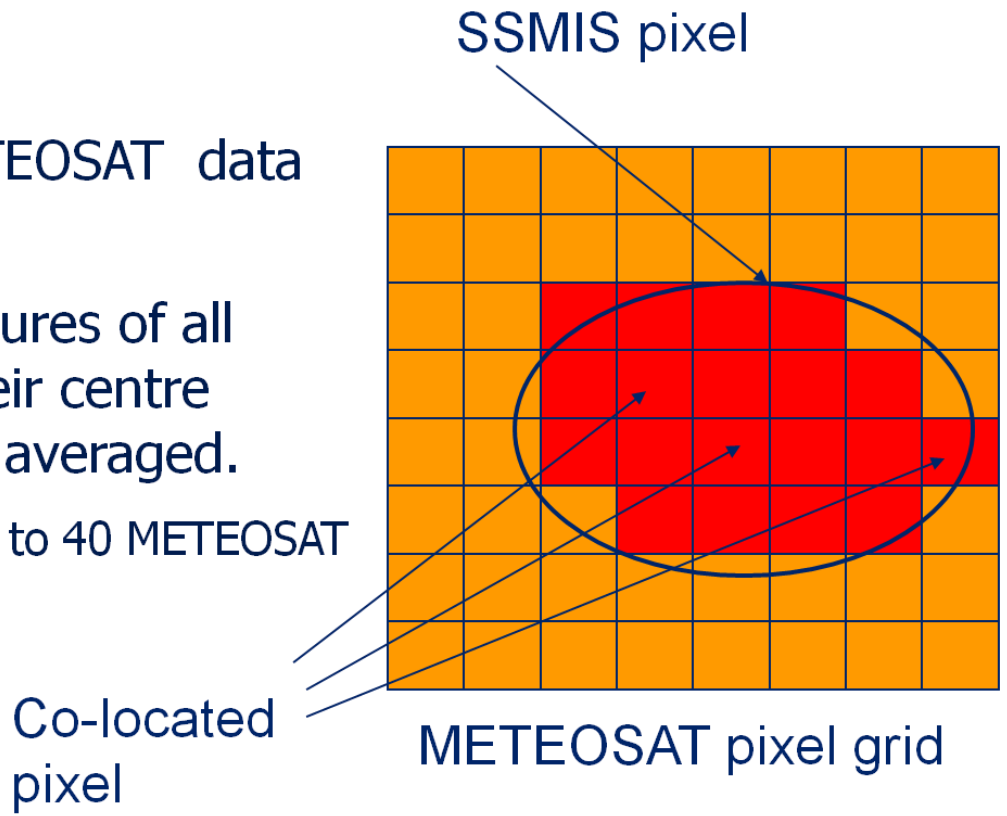


Algorithm overview: spatial co-location

Spatial averaging of METEOSAT data to the SSMIS resolution:

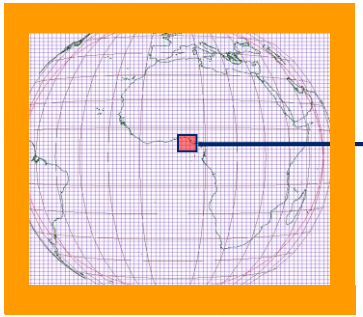
The Brightness temperatures of all METEOSAT pixel with their centre within a SSMIS pixel are averaged.

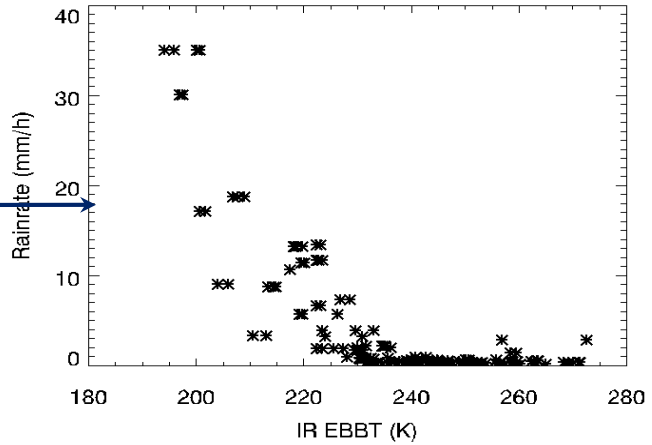
- One SSMIS pixel contains 5 to 40 METEOSAT pixels



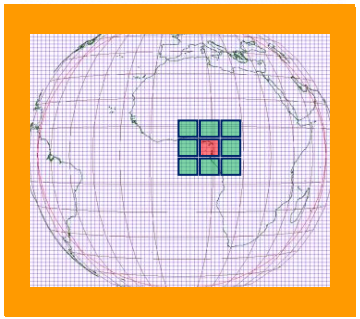
Lookup Tables LUT (combining IR and MW)

- To represent the synoptic weather scale, co-located points are sampled over a specific time period (6 to 24 hours) and in geographical grid boxes (5° x5°).



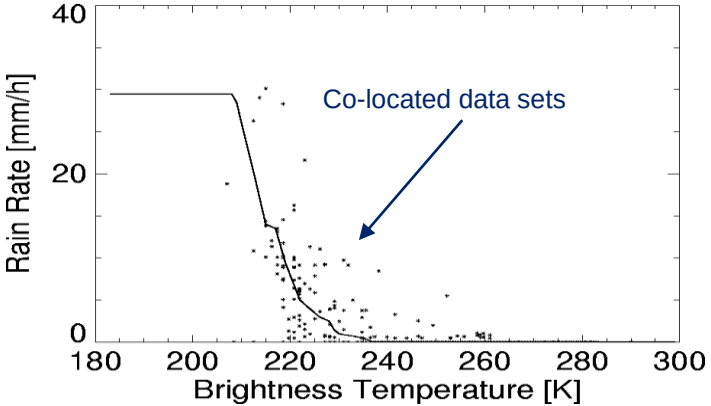


- To obtain a smooth rainrate, the estimation of instantaneous rainrate is performed for each cloudy pixel in real time using up to 9 processing boxes.



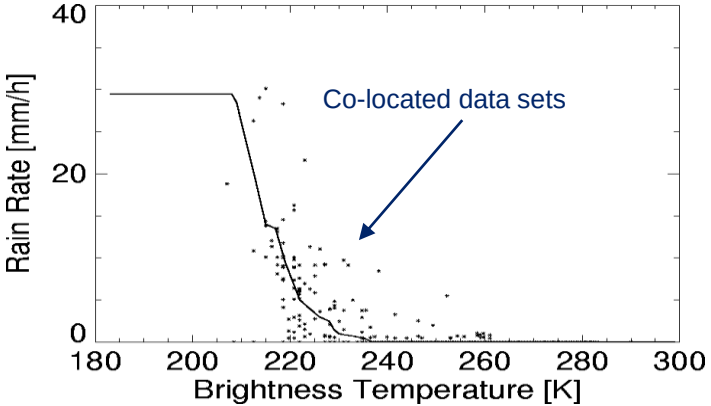
$$R_i = \frac{\sum_{i=1}^{9} w_i r_i}{\sum_{i=1}^{9} w_i}$$

Where is the MPE more reliable?



LUT for a grid box with large scale tropical convection

Where is the MPE more reliable?



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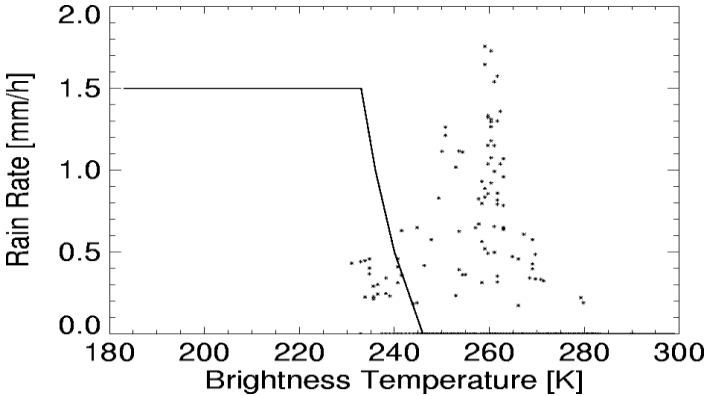

LUT for a grid box with frontal precipitation

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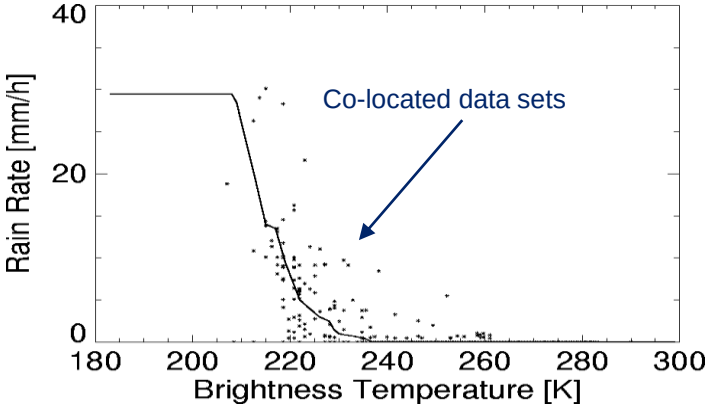

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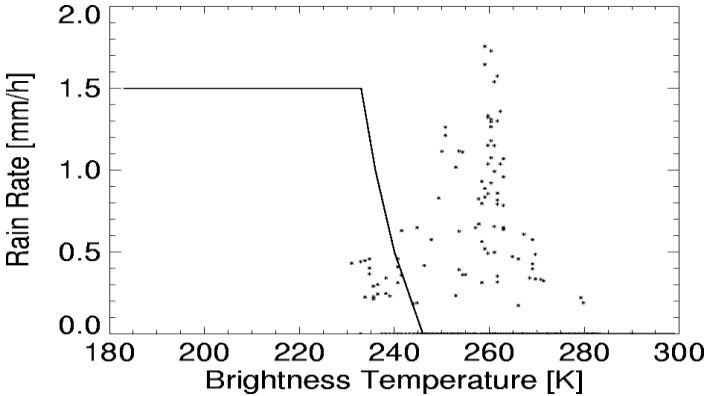
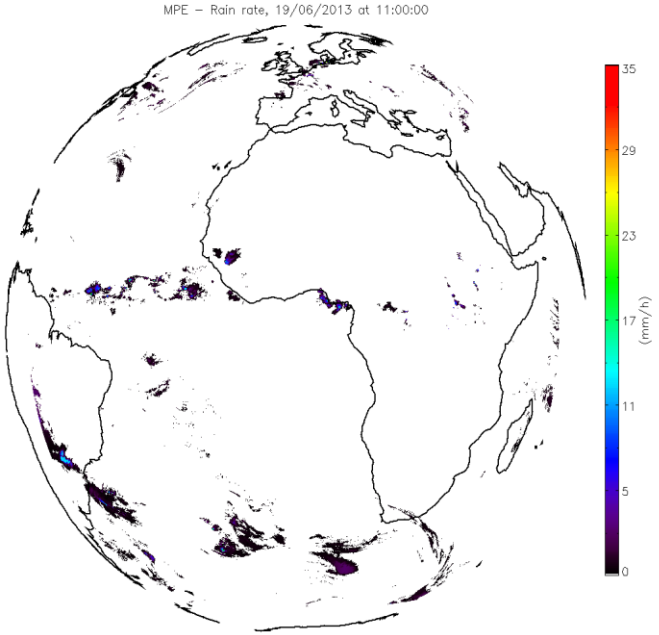


LUT for a grid box with frontal precipitation

Keep in mind that MPE is more appropriate for convective precipitation.

MPE product – every 15 minute, at pixel level –

Rain rate (mm/h)



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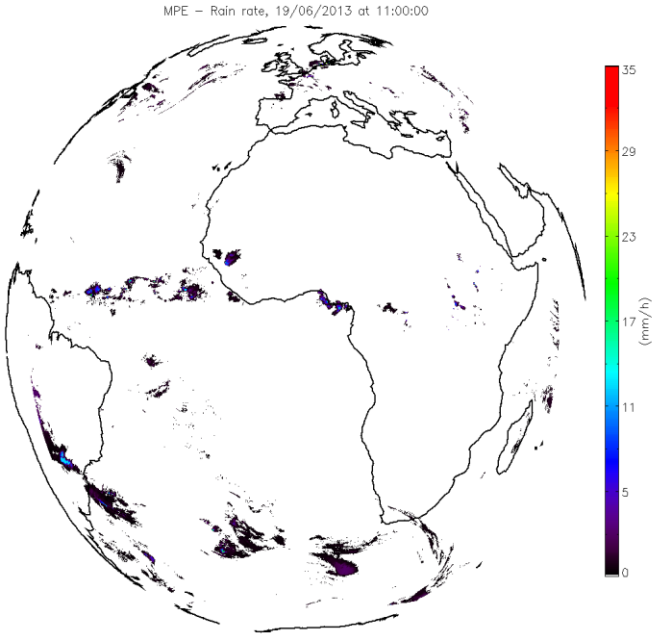
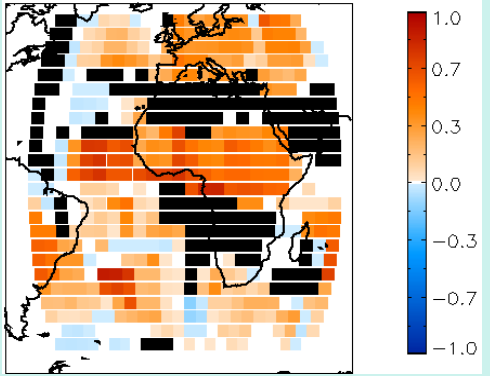
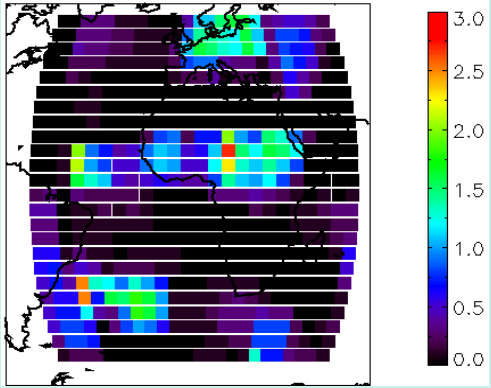


Automatic Quality control

Correlation coefficient

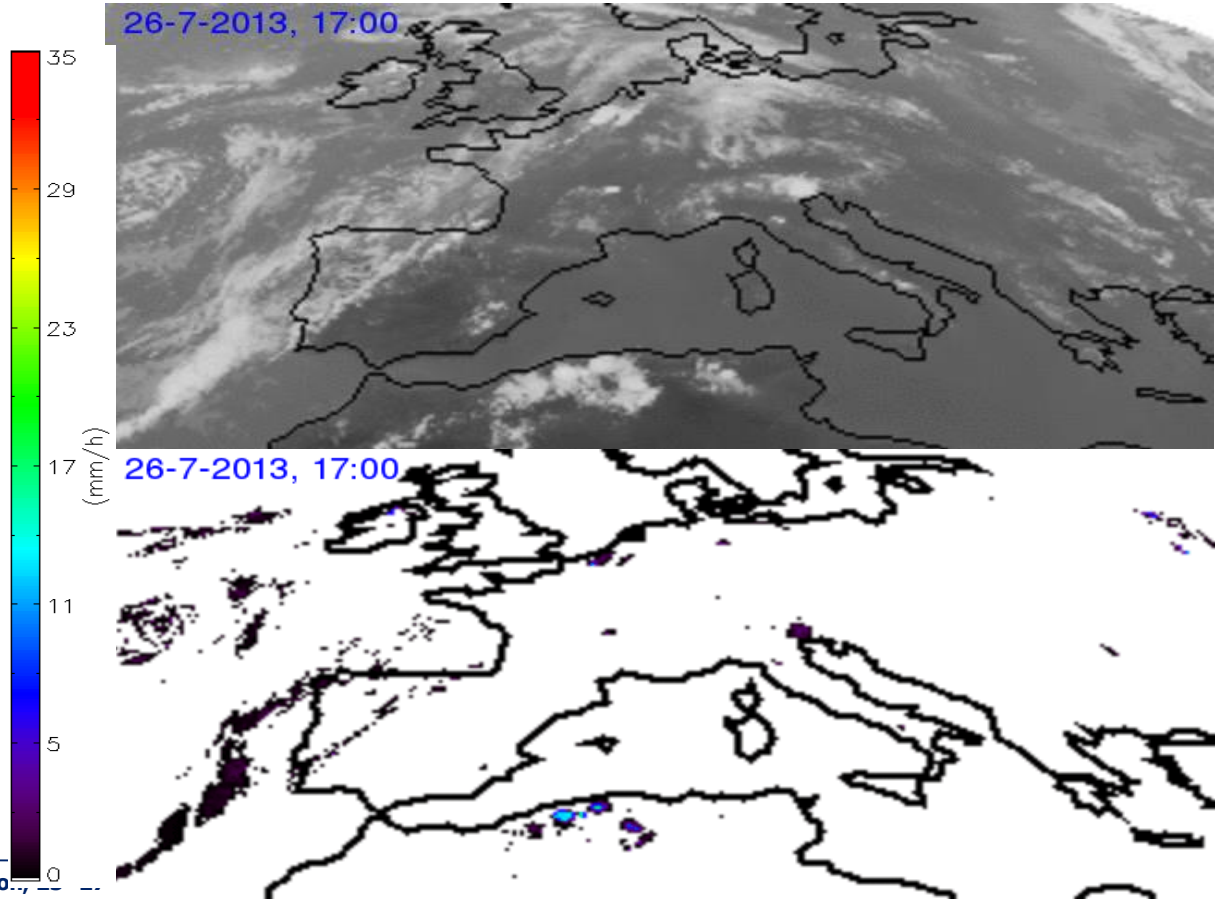


Standard deviation



MPE product – an example on the 26-27 of July 2013

The animation shows a huge convective precipitation cell crossing France during the night of the 26 and 27 July 2013. The precipitation rain-rate (mm/hr) is retrieved by combining the infrared brightness temperature derived from the SEVIRI instrument onboard Meteosat-10 satellite and the passive microwave data coming from the SSMIS instrument on board the polar orbiting



Precipitation from Cloud Microphysical Products

- Recently EUMETSAT began to provide cloud microphysical properties from the Optimal Estimation scheme (OCA). OCA is a demonstrational product since June 2013.

- Recent research shows that cloud microphysics can be related to precipitation detection and rain rate estimate successfully during daytime.

- We are exploring if an OCA based retrieval can improve the current MPE product and provide rain rates with associated errors.

Watts, P. D., R. Bennartz, and F. Fell (2011), Retrieval of two-layer cloud properties from multispectral observations using optimal estimation, J. Geophys. Res., 116, D16203, doi:10.1029/2011JD015883

Cloud layer L1

Cloud layer L2

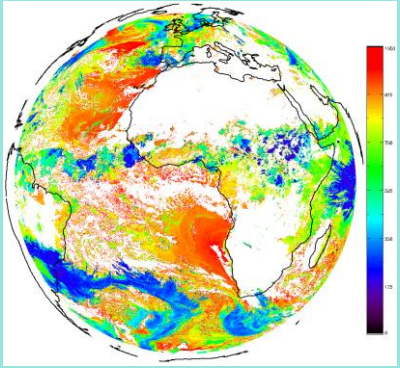
Surface

Cloud layer L1

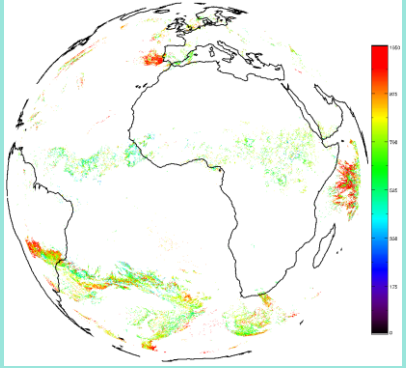
Cloud layer L2

Surface

Cloud top height (L1)



Cloud top height (L2)



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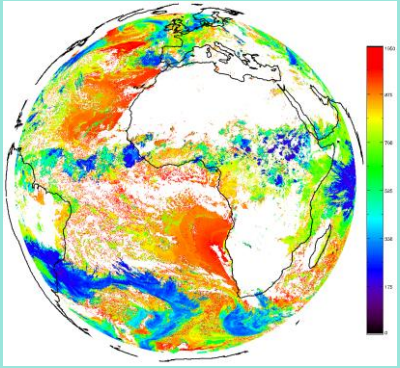
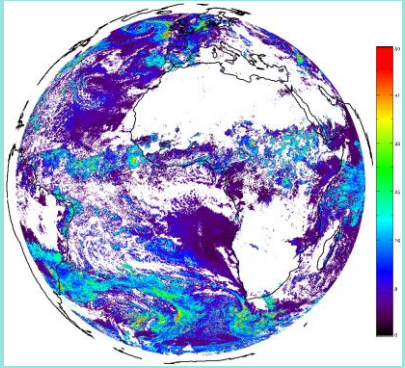
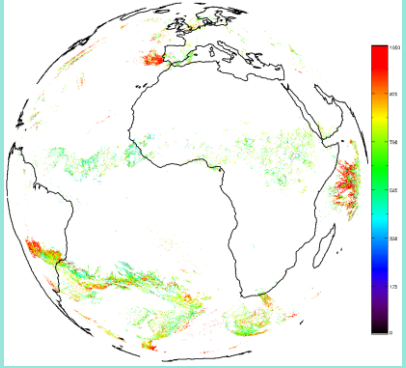


Cloud effective radius (L1)



Cloud top height (L2)



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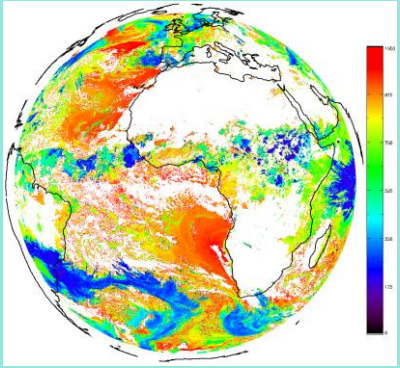

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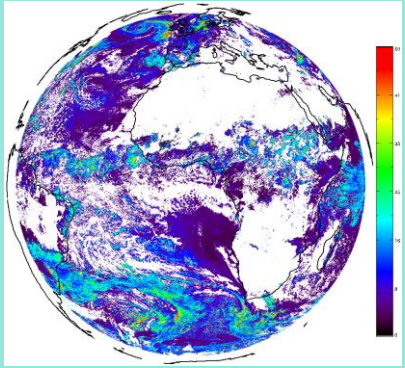
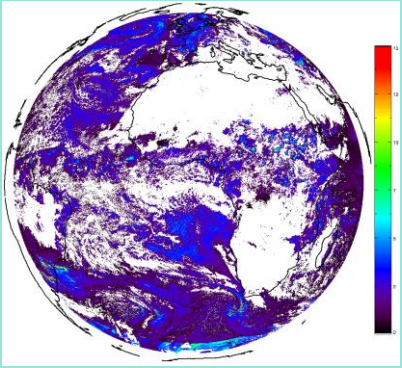
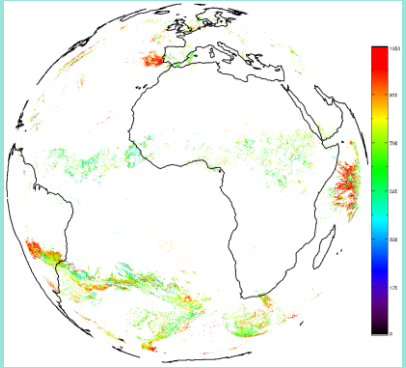


Cloud optical depth (L1 and L2)



Cloud top height (L2)



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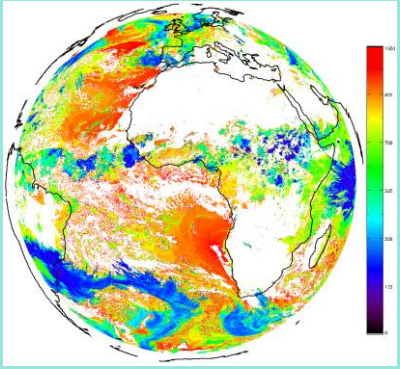

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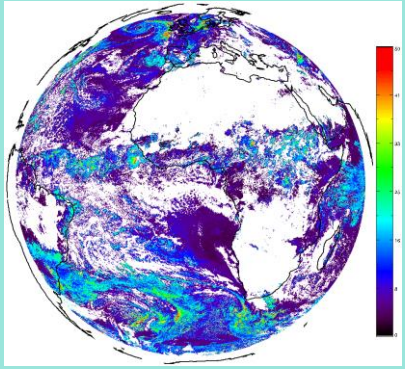

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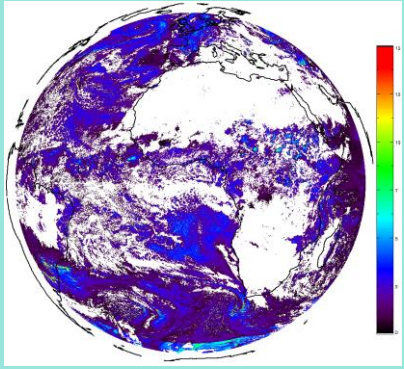

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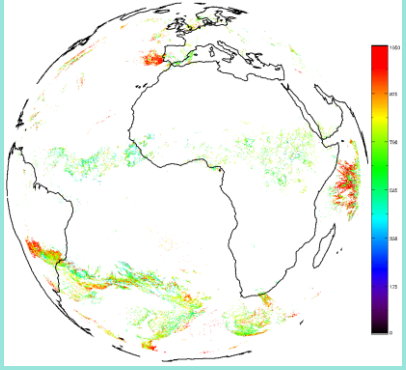
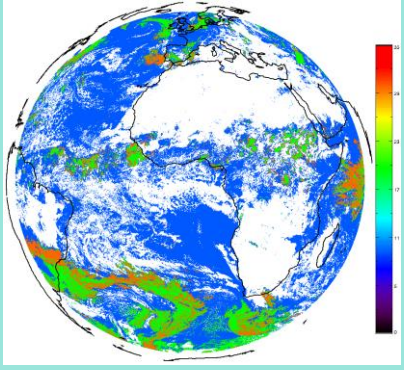


Cloud phase



First attempt to derive precipitation using OCA cloud properties based on the CPP/KNMI algorithm

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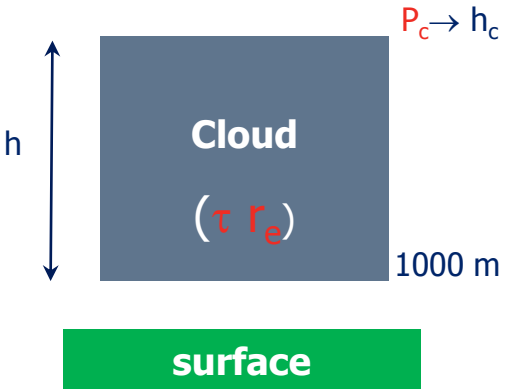
Roebeling et al., J. of Hydrol, 2012.



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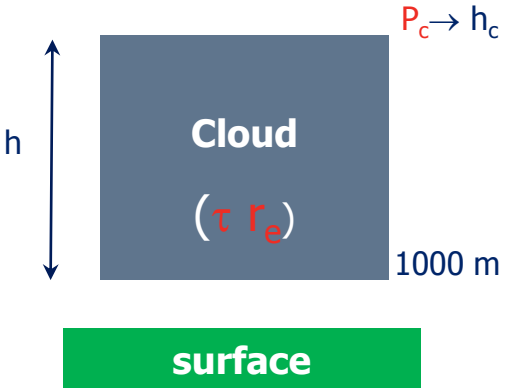

OCA microphysical parameters of cloud

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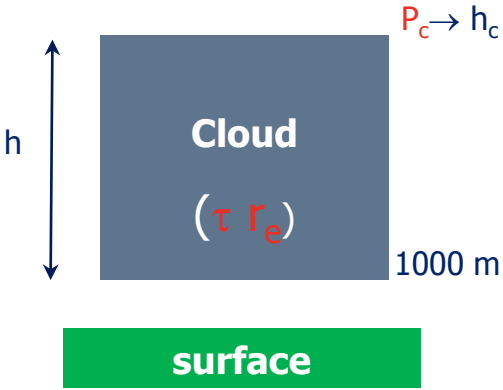

OCA microphysical parameters of cloud

Cloud top pressure

ECMWF forecast

Cloud liquid water path

$$LWP = \frac{2}{3} \tau\ r_e$$

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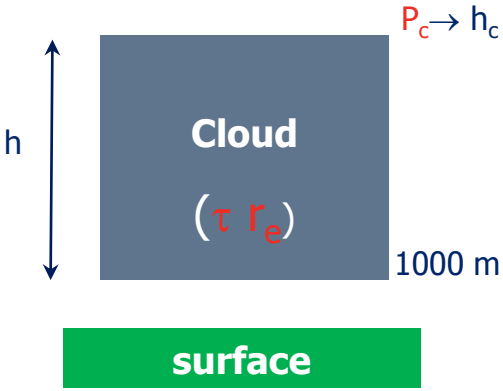

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Cloud top height

Assuming bottom =1000m

Cloud depth (h)

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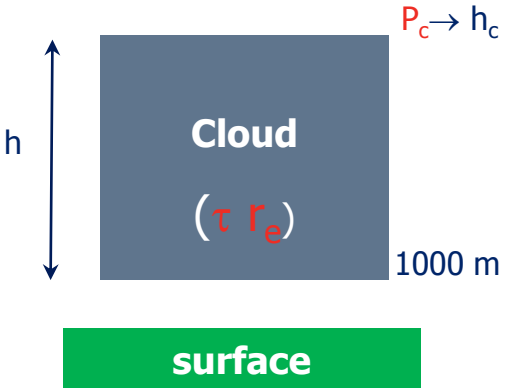

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IF LWP > 150 gm^{-2} & (Re > 15 μm or CPH = ice)

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Assuming bottom =1000m

Cloud depth (h)

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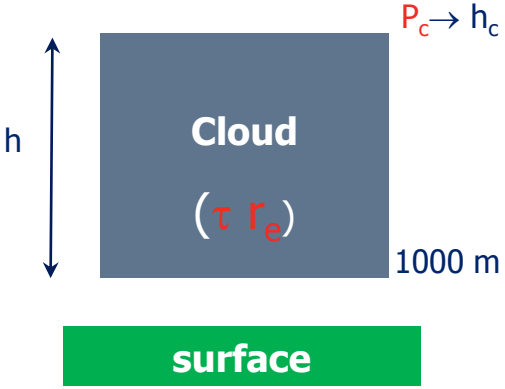

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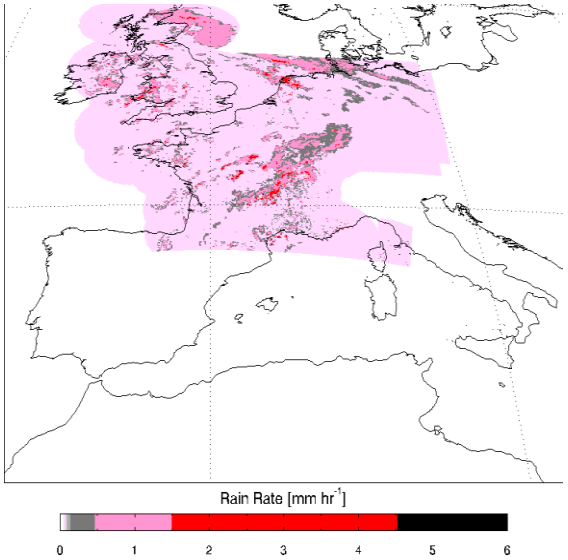
Cloud top height

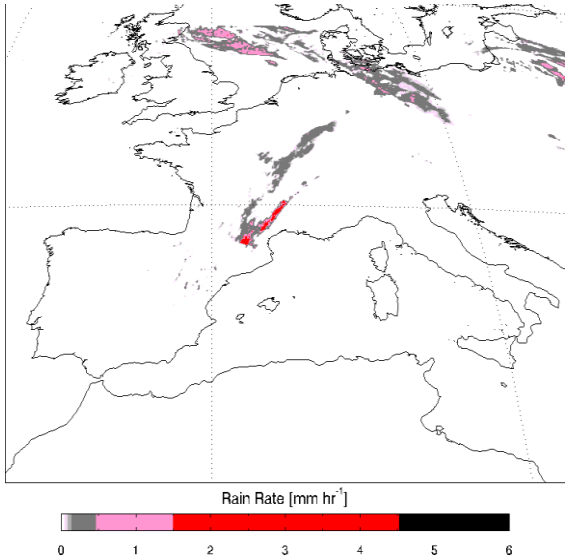
Assuming bottom =1000m

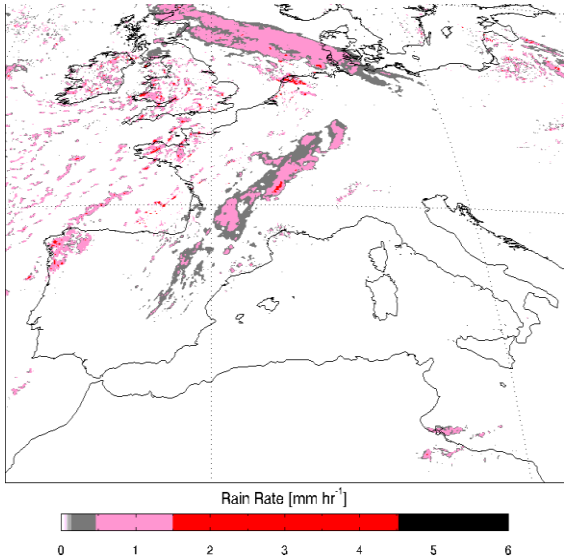
Cloud depth (h)

Rain rate

$$RR = \frac{c\left(\frac{LWP}{120} - 1\right)^{1.6}}{h} \quad and \quad RR_{max} = 5 + \left(\frac{h}{c_2}\right)^{1.6}$$

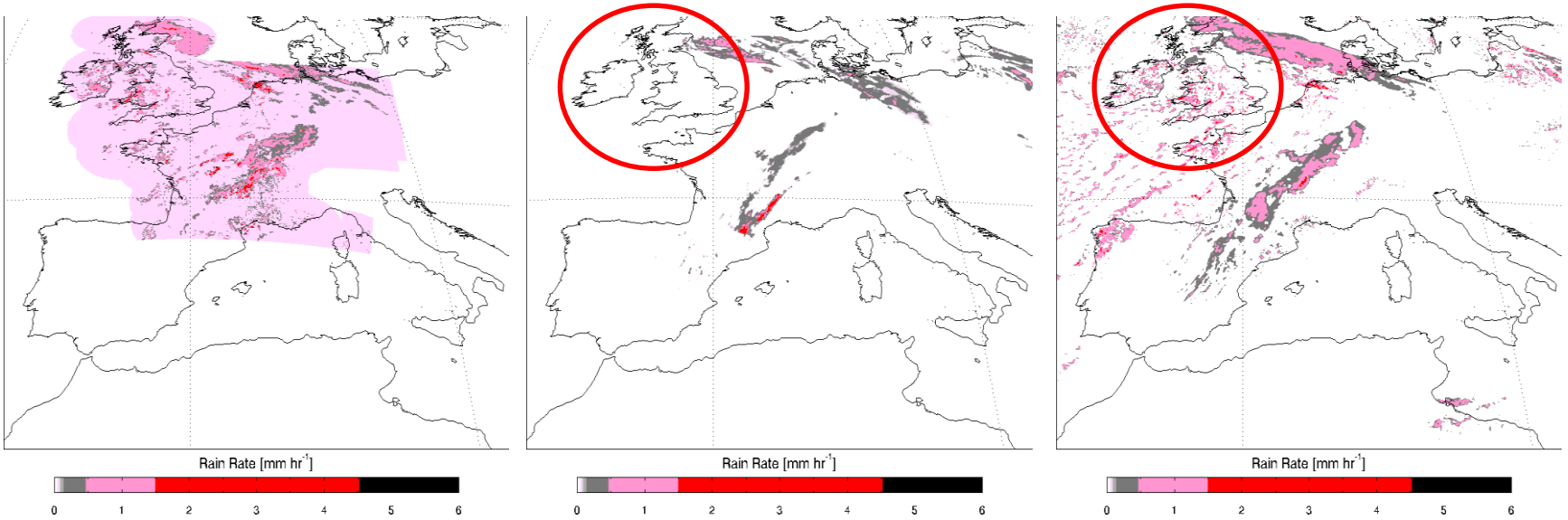






Weather Radar ***EUMETSAT-MPE (MSG)*** ***Microphysical based product (MSG)***

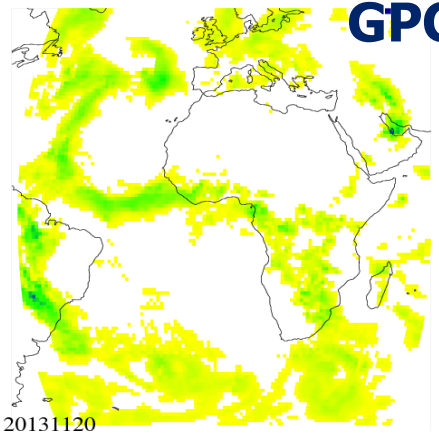
(diurnal cycle 1 July 2007)

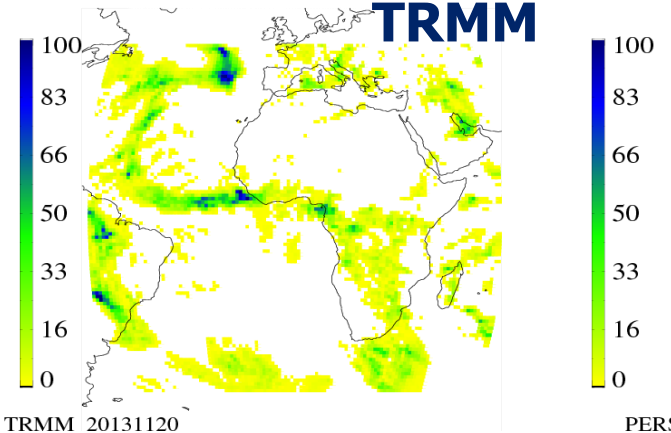


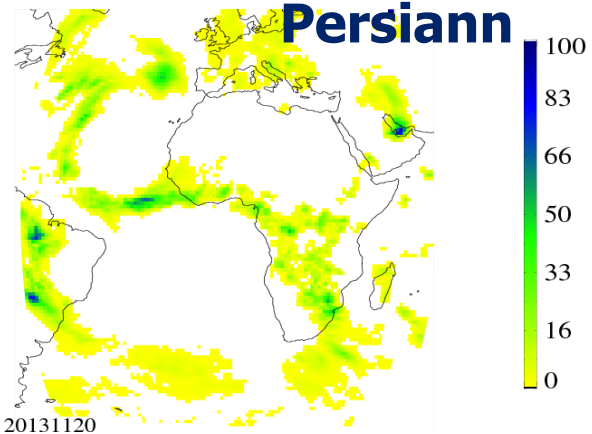
Weather Radar ***EUMETSAT-MPE (MSG)*** ***Microphysical based product (MSG)***

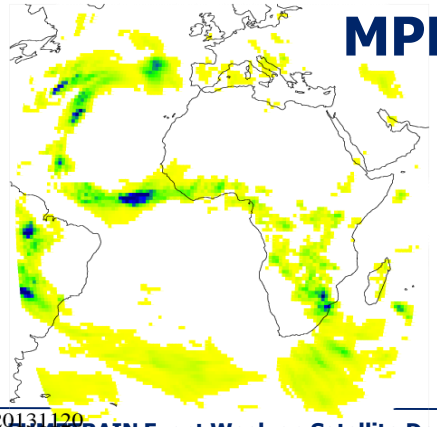
(diurnal cycle 1 July 2007)

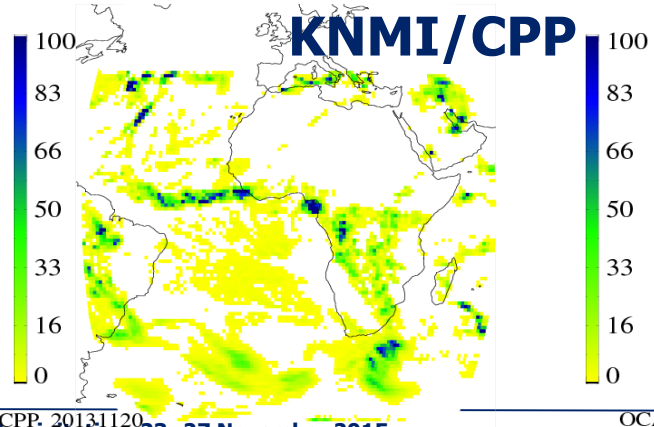
20 November 2013, daily rain rate (mm/day)

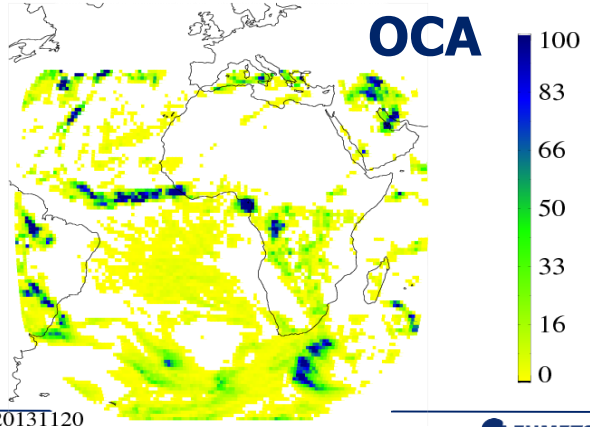




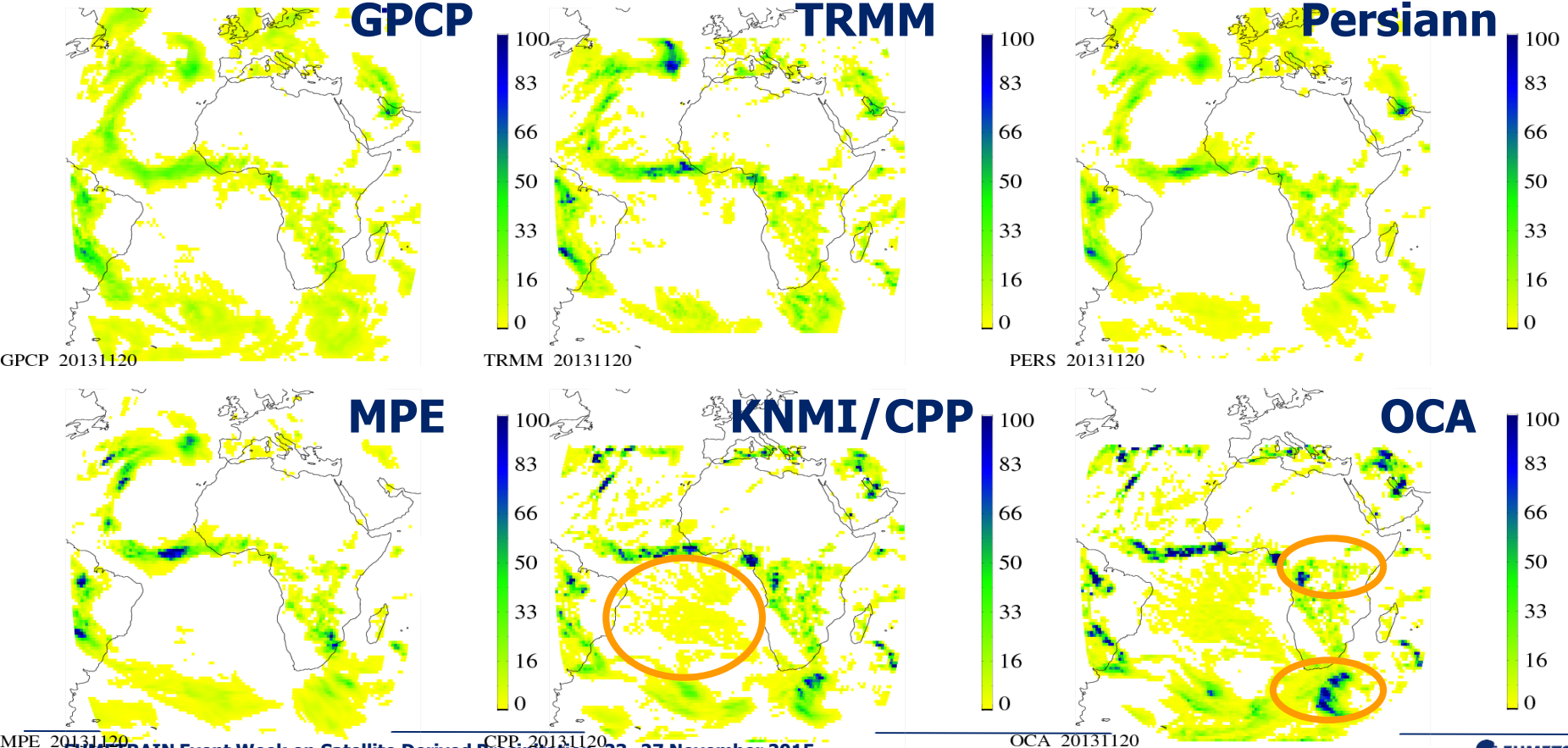




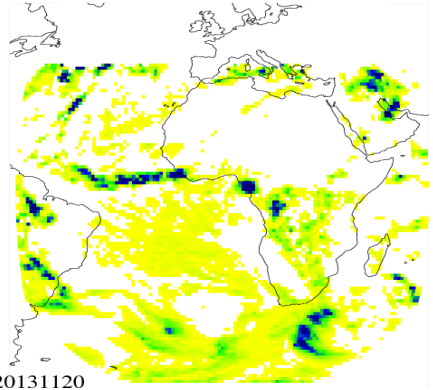




20 November 2013, daily rain rate (mm/day)



Stratiform precipitation



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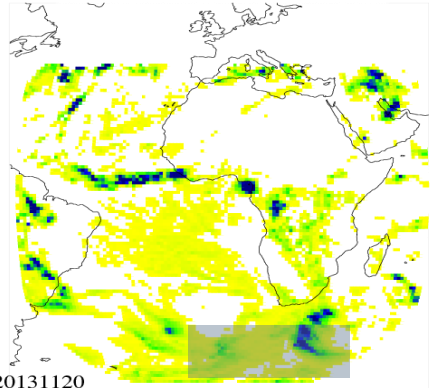
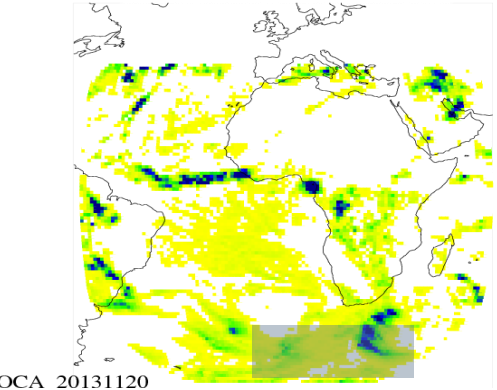
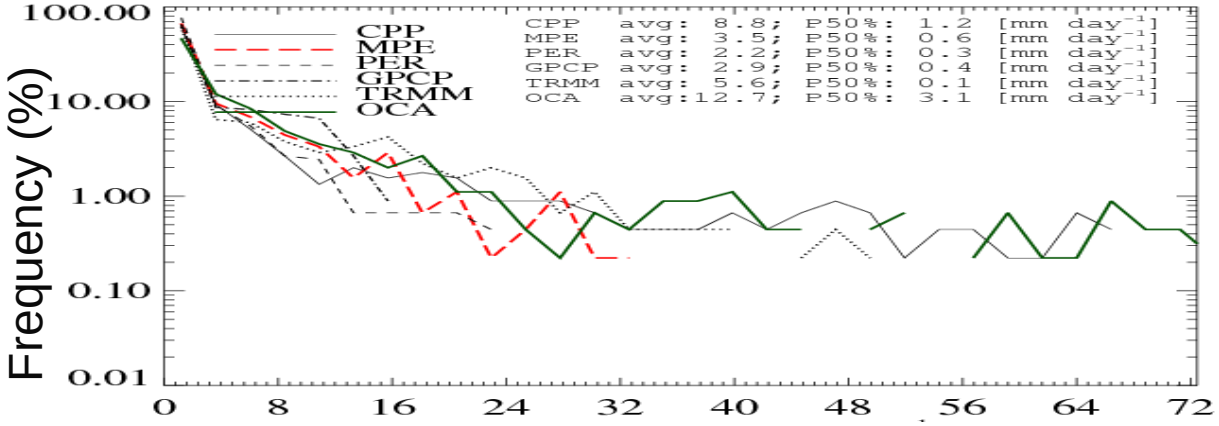
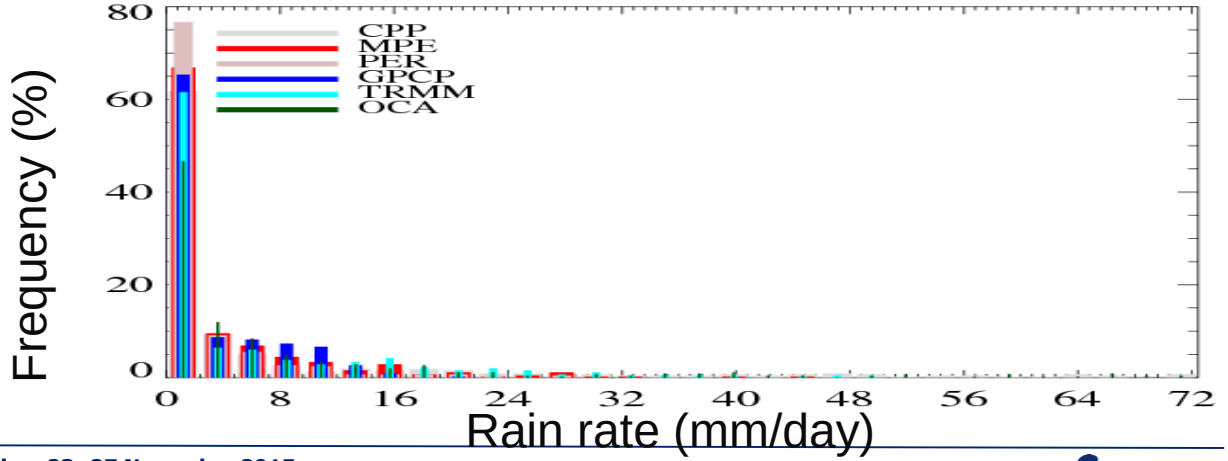
Stratiform precipitation



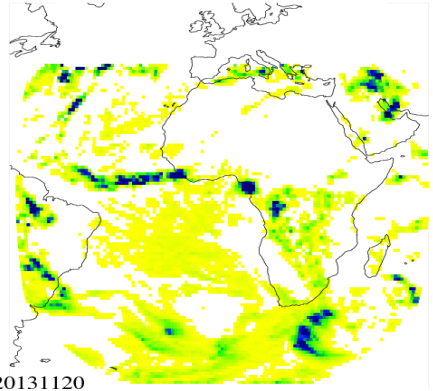
Stratiform precipitation





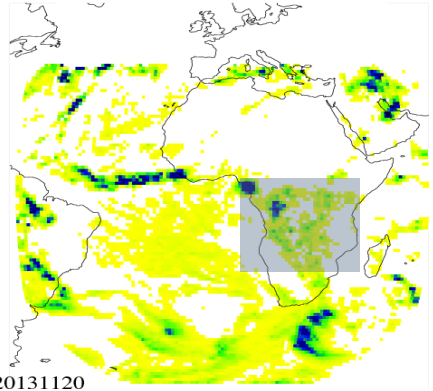


ITCZ



OCA 20131120

ITCZ



OCA 20131120

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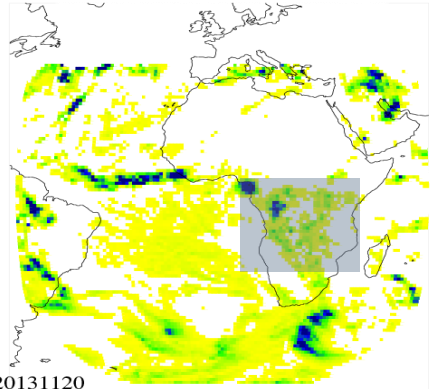
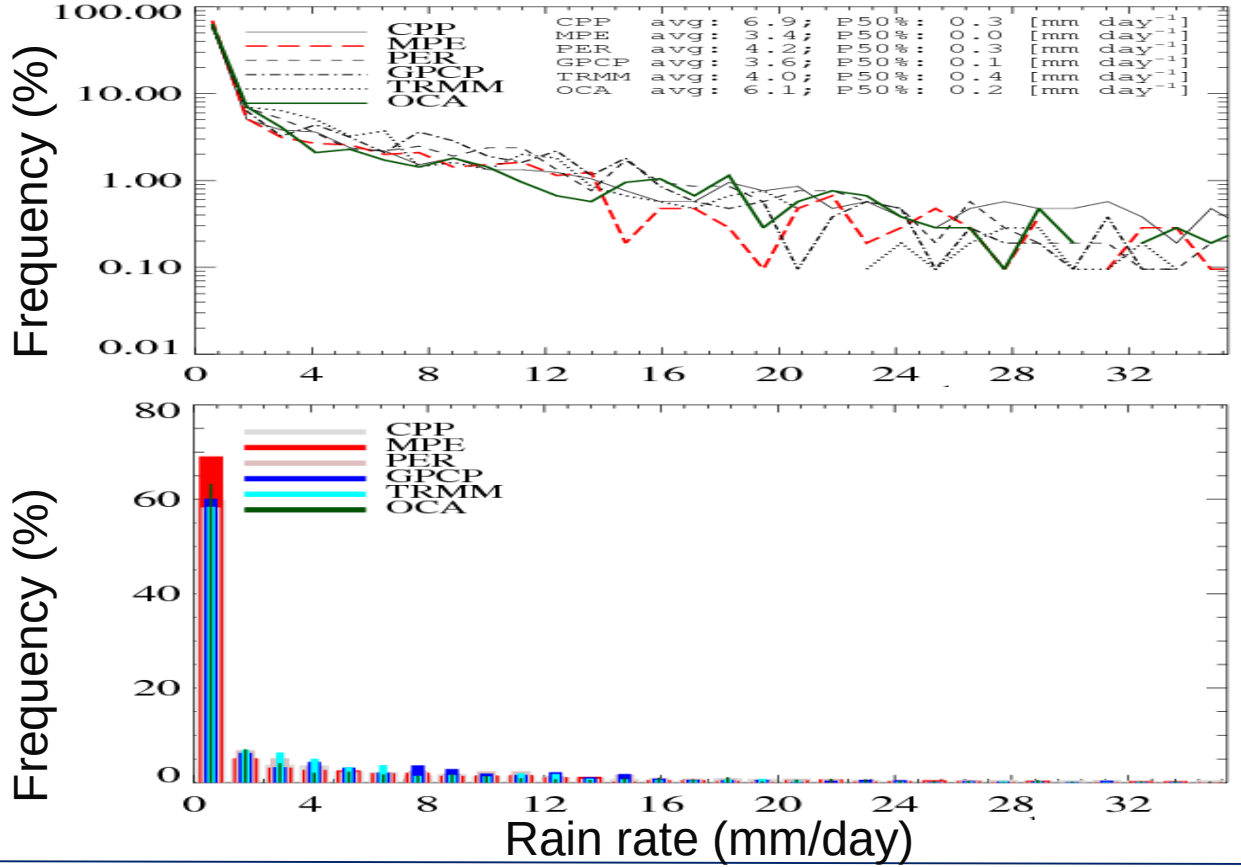
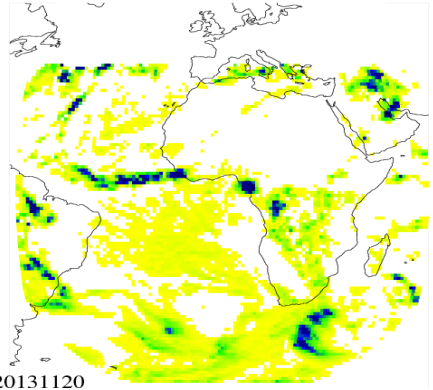

OCA 20131120

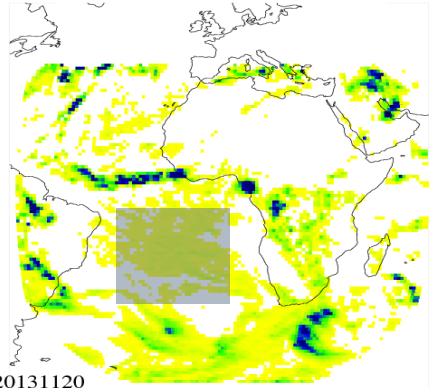

Frequency (%)
100.00
10.00
1.00
0.10
0.01
0
4
8
12
16
20
24
28
32
CPP
MPE
PER
GPCP
TRMM
OCA
CPP avg: 6.9; P50%: 0.3 [mm day-1]
MPE avg: 3.4; P50%: 0.0 [mm day-1]
PER avg: 4.2; P50%: 0.3 [mm day-1]
GPCP avg: 3.6; P50%: 0.1 [mm day-1]
TRMM avg: 4.0; P50%: 0.4 [mm day-1]
OCA avg: 6.1; P50%: 0.2 [mm day-1]
Frequency (%)
80
60
40
20
0
0
4
8
12
16
20
24
28
32
CPP
MPE
PER
GPCP
TRMM
OCA
Rain rate (mm/day)

Ocean

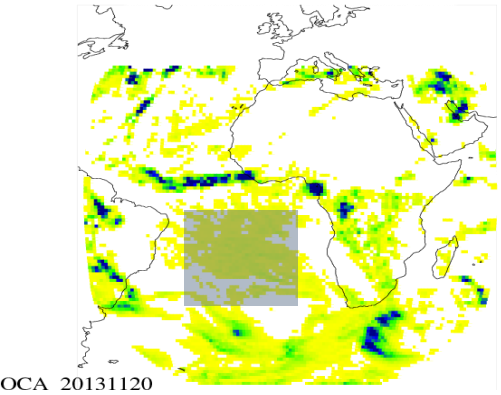


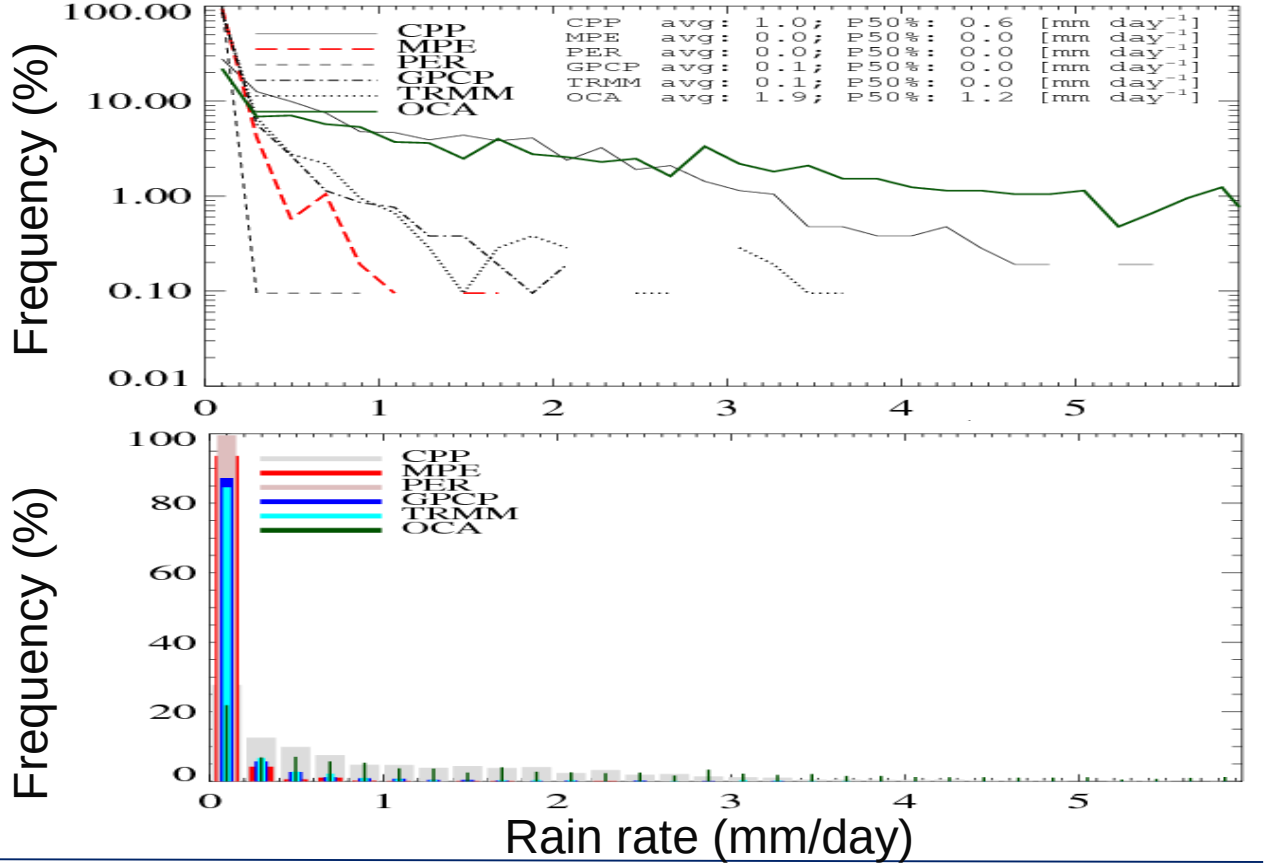
OCA 20131120

Ocean



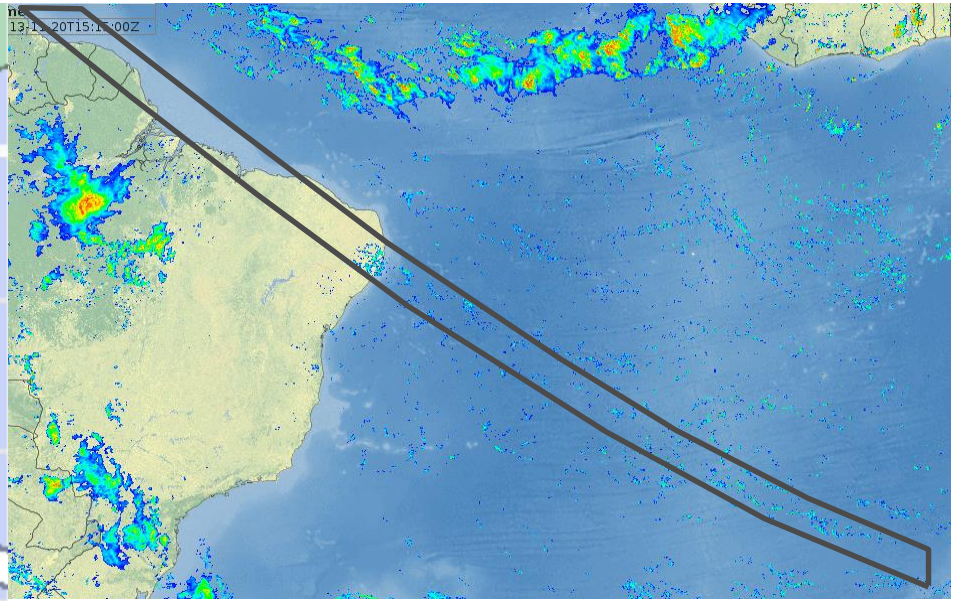
Ocean


OCA 20131120


Frequency (%)
100.00
10.00
1.00
0.10
0.01
0
1
2
3
4
5
CPP
MPE
PER
GPCP
TRMM
OCA
CPP avg: 1.0; P50%: 0.6 [mm day⁻¹]
MPE avg: 0.0; P50%: 0.0 [mm day⁻¹]
PER avg: 0.0; P50%: 0.0 [mm day⁻¹]
GPCP avg: 0.1; P50%: 0.0 [mm day⁻¹]
TRMM avg: 0.1; P50%: 0.0 [mm day⁻¹]
OCA avg: 1.9; P50%: 1.2 [mm day⁻¹]
Frequency (%)
100
80
60
40
20
0
0
1
2
3
4
5
CPP
MPE
PER
GPCP
TRMM
OCA
Rain rate (mm/day)

Ocean

TRMM-PR



OCA

Conclusions (1)

Using geostationary satellite to derive precipitation is interesting due to sampling (every 15 minutes) over 1/5 of the globe

Existing methods to retrieve precipitation differ among each other and show different behaviors over different regions.

It is difficult to decide on 'the' best one. We need a superior reference.

Microphysically-based approaches allow to detect warm rain, light rain and stratiform rain potentially better than IR techniques.

Conclusions (2)

EUMETSAT derived operationally

- MPE
- OCA deriving cloud microphysical properties with uncertainties.

This study is an exploratory attempt to use OCA microphysical properties in order to update the MPE product and make it applicable to warm rain and non convective precipitation.

Conclusions (2)

EUMETSAT derived operationally

- MPE
- OCA deriving cloud microphysical properties with uncertainties.

This study is an exploratory attempt to use OCA microphysical properties in order to update the MPE product and make it applicable to warm rain and non convective precipitation.

Possible improvements:

- OCA provides uncertainties on every parameter - rain rate will have uncertainties
- OCA provides microphysics during the night allowing a 24 hours retrieval.
- Combination of OCA and MPE products will be possible to provide a more robust day and night product over the SEVIRI globe with uncertainties

Thank you!

Questions?