A satellite image of Earth showing the continent of Africa and parts of Europe. The image is in a false-color composite, with Africa appearing in shades of green and brown, and Europe in shades of blue and white. The text is overlaid on the image.

Evaluation of rainfall retrievals from SEVIRI VIS/NIR reflectances over West Africa and Europe

Erwin Wolters – Climate Observations

Bart van den Hurk – Global Climate/IMAU

Rob Roebeling - Weather Research

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- ✓ Hydrological cycle
- ✓ Retrieval of precipitation from satellite instruments - history

✓ CPP-PP algorithm

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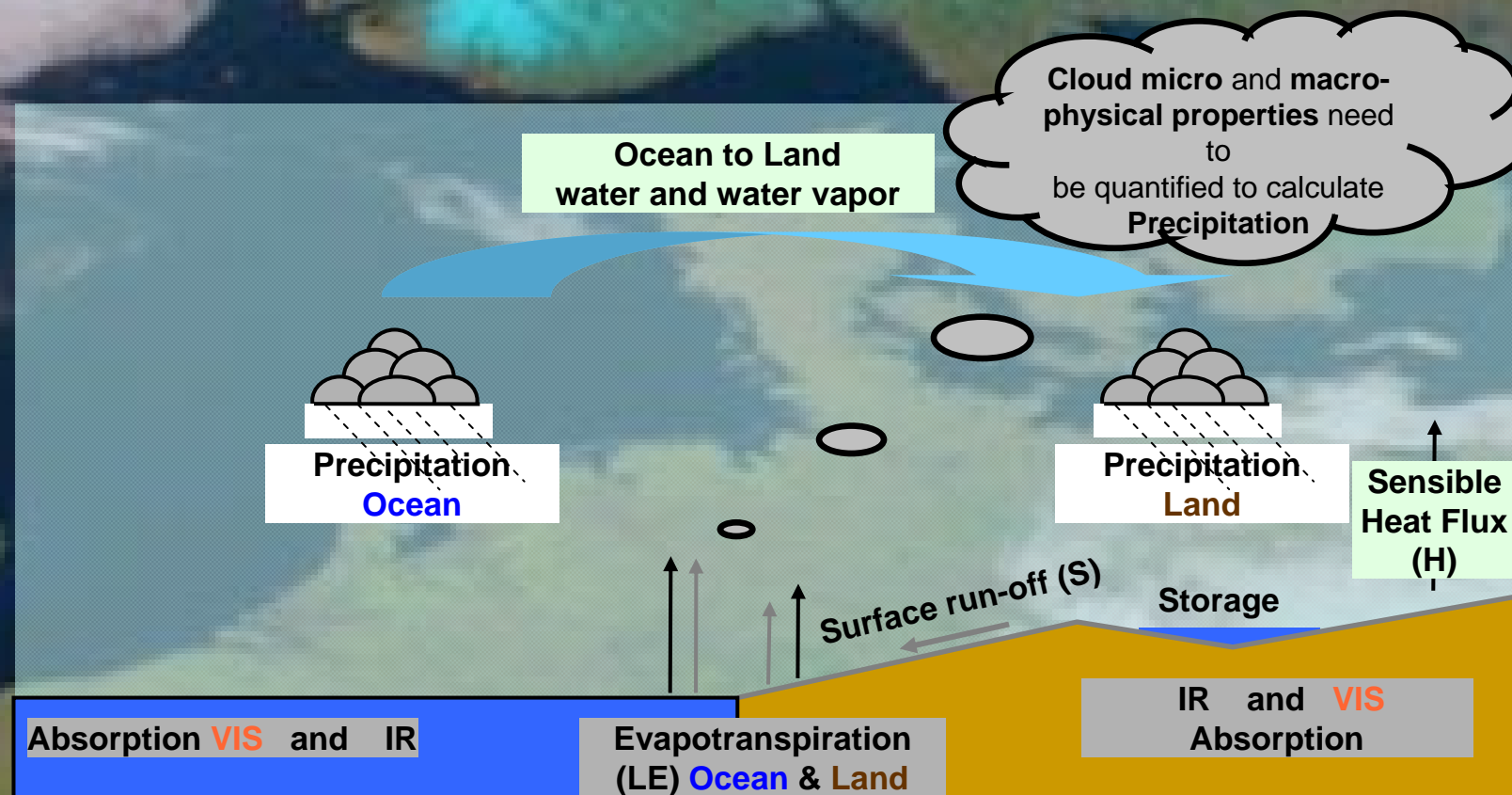
- ✓ TRMM-PR and CMORPH

✓ Results

- ✓ Instantaneous
- ✓ Seasonal scale
- ✓ Daytime cycle
- ✓ Model evaluation

✓ Conclusions and outlook

Introduction - hydrological cycle



Schematic representation of the role of clouds in the water balance

Precipitation measurements...

- ✓ Rain gauges perform point observation
- ✓ If densely distributed, areal average can be accurately calculated
- ✓ Most oceanic and tropical land areas have sparse rain gauge network
- ✓ Satellite instruments well-suited to monitor rainfall
- ✓ Efforts ongoing since 1970s

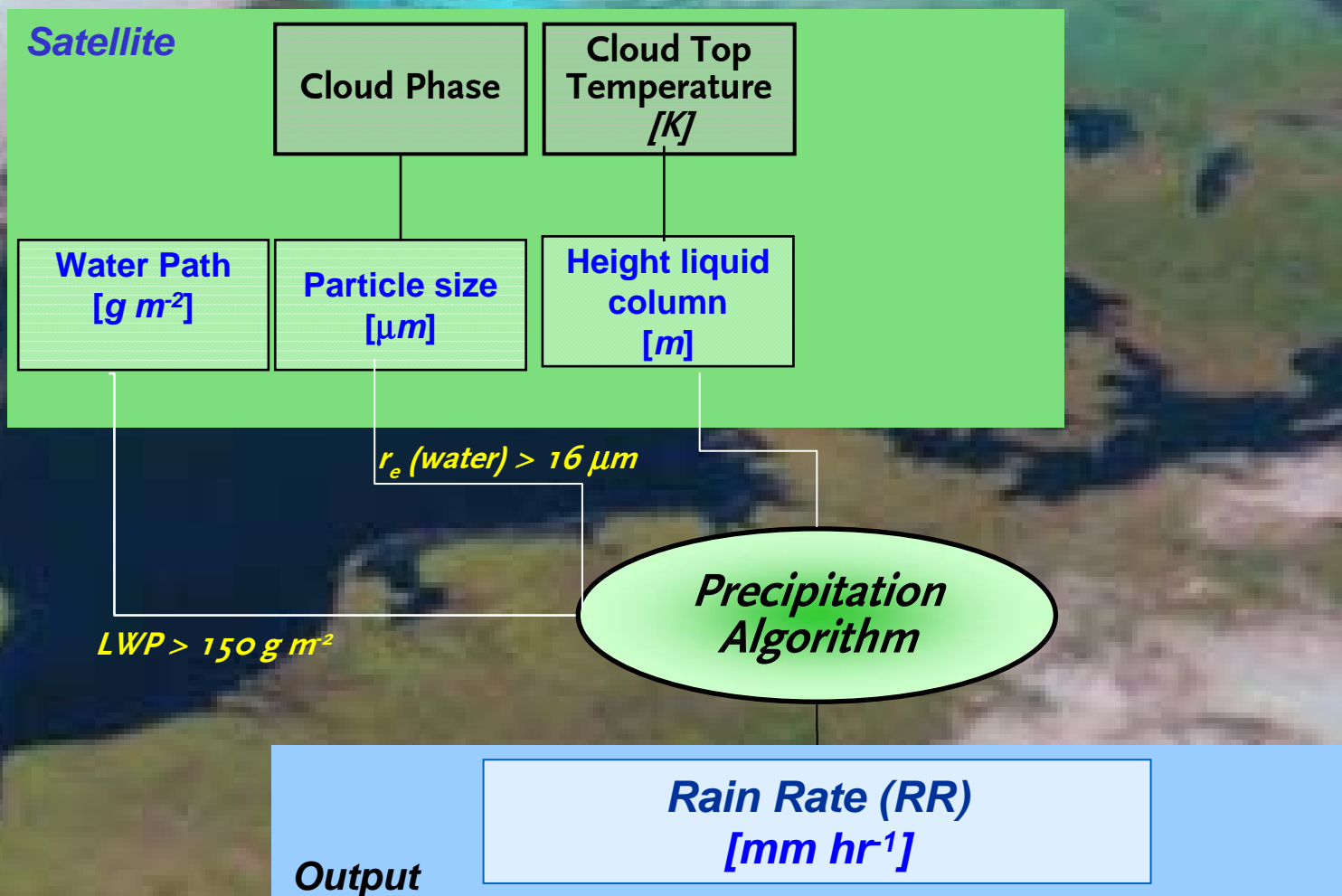
...from space

- ✓ 1970s and 1980s: Cold Cloud Duration techniques -> attribute (fixed) rain rate to cloud-flagged pixel with e.g. $T < 235 \text{ K}$
- ✓ From 1980s onward: PMW techniques → *Rain rate* ~ *LWP*
- ✓ Recent years: multi-satellite algorithms (PMW+IR); calibration against rain gauges over land
- ✓ CPP-PP: rain occurrence and rain rate from cloud-top properties retrieved from SEVIRI

Cloud Physical Properties – Precipitation Properties

- ✓ Not dependent on satellite data merging and calibration to rain gauges
- ✓ More physically based than e.g. CCD technique
- ✓ Condensed water path, effective radius, and cloud phase most important parameters
- ✓ Most information retrieved from 0.6 μm and 1.6 μm spectral channels
- ✓ High spatial (3x3 km² at nadir) and temporal resolution (15 minutes)

CPP-PP retrieval algorithm



CPP-PP retrieval algorithm

1) **Based on Wentz and Spencer (1998)**
(Parameterization developed for SSM/I)

2) **Roebeling and Holleman (2009)**
(Parameterization modified for SEVIRI)

$$\Delta H = \frac{(CTT_{max} - CTT_{pix})}{6.0} + dH$$
$$R = \frac{1}{\Delta H} \left(\frac{CWP - CWP_t}{CWP_t} \right)^{1.6}$$

CWP : Condensed Water Path [g m⁻²]

R : Rain Rate [mm hr⁻¹]

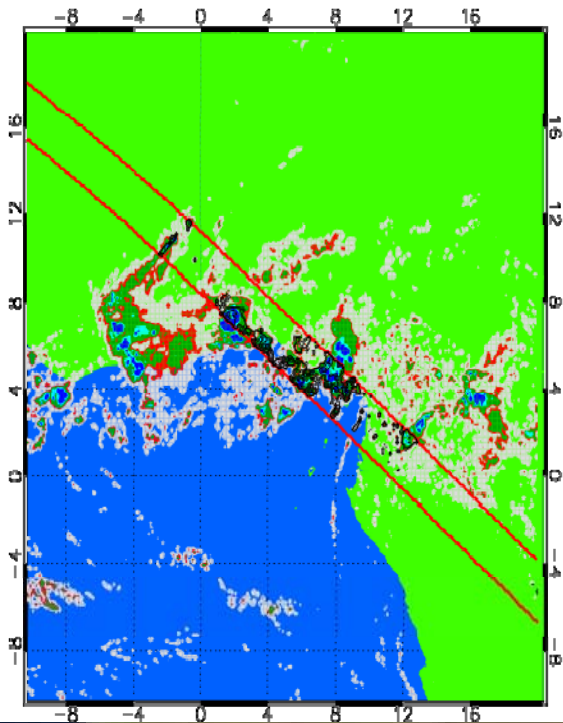
ΔH : Height of rain column [km]

CTT : Cloud Top Temperature [K]

dH : Offset height rain column [km]

Roebeling and Holleman (2009), J. Geophys. Res.

Evaluation: Overview



TRMM-PR and CMORPH over West Africa

Instantaneous statistics

Seasonal evolution of West African monsoon

Daytime cycle over Europe and West Africa

Datasets West Africa

A satellite image of West Africa, showing the continent's coastline and major river systems like the Niger and Benue rivers. The land is depicted in shades of brown and green, while the surrounding oceans are dark blue.

CPP-PP on SEVIRI:

- ✓ 3 x 3 km resolution, 15 minutes
- ✓ Only available during daytime (8:30 – 16:30 UTC)

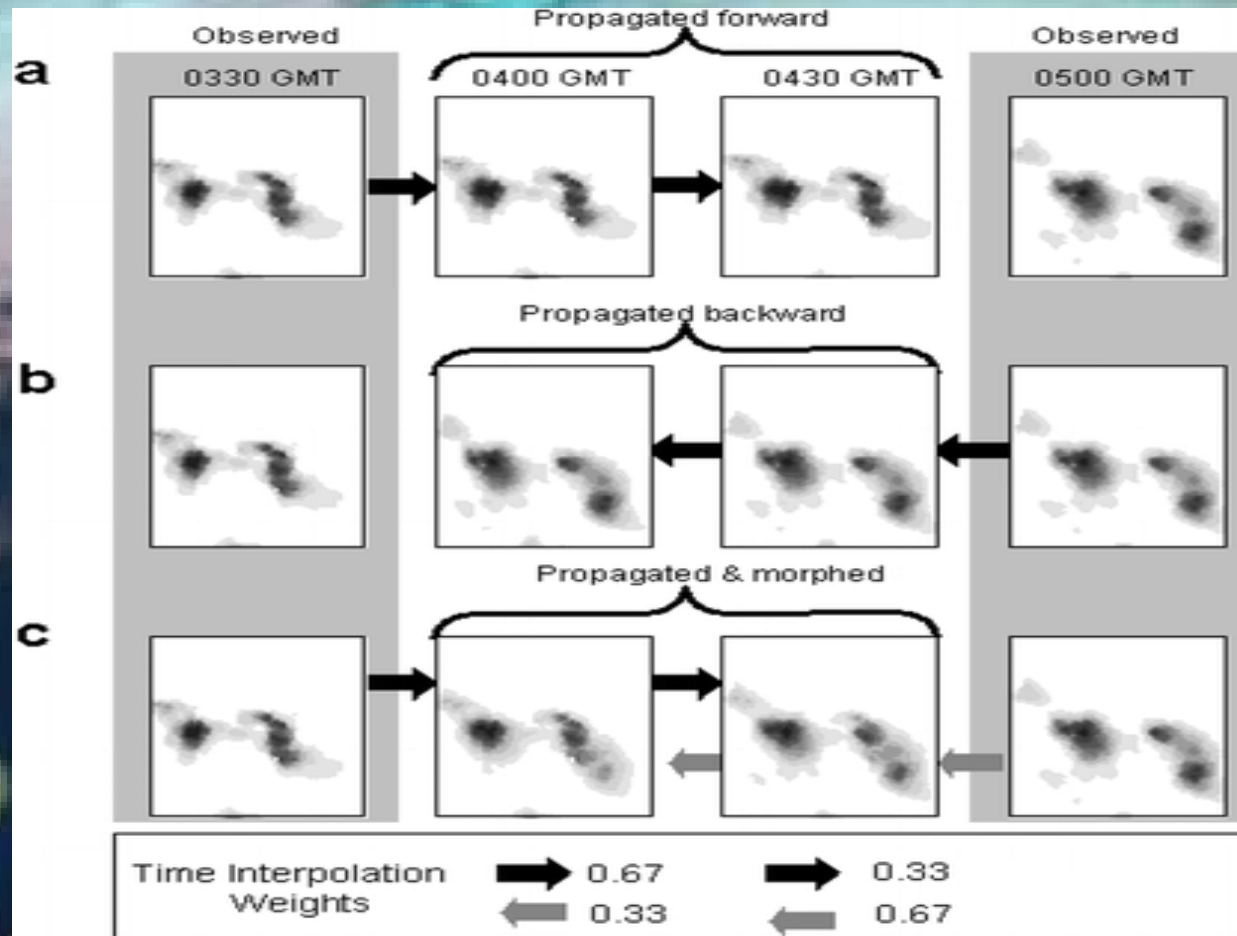
TRMM-PR:

- ✓ ~4.5 x 4.5 km resolution
- ✓ active sensor, Low Earth Orbit between 37°S and 37°N

CMORPH:

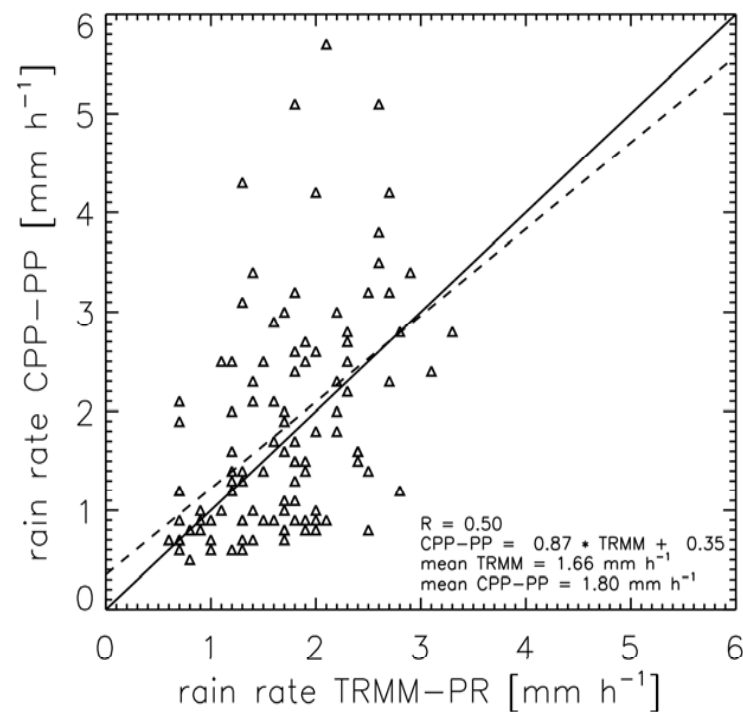
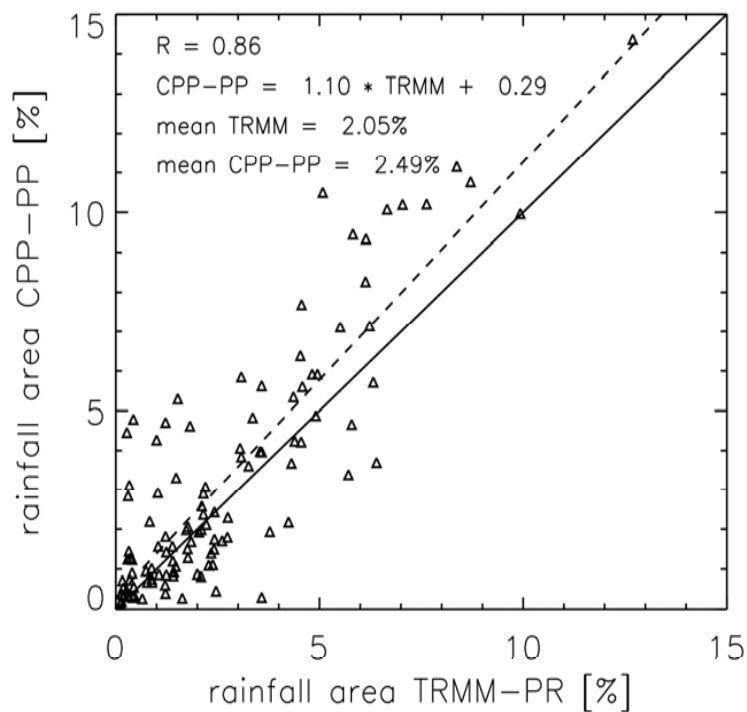
- ✓ blended PMW and Geo-IR
- ✓ Forward and backward interpolation between 2 overpasses
- ✓ 3-hr, 0.25° x 0.25° product available from 2002 onwards

CMORPH algorithm

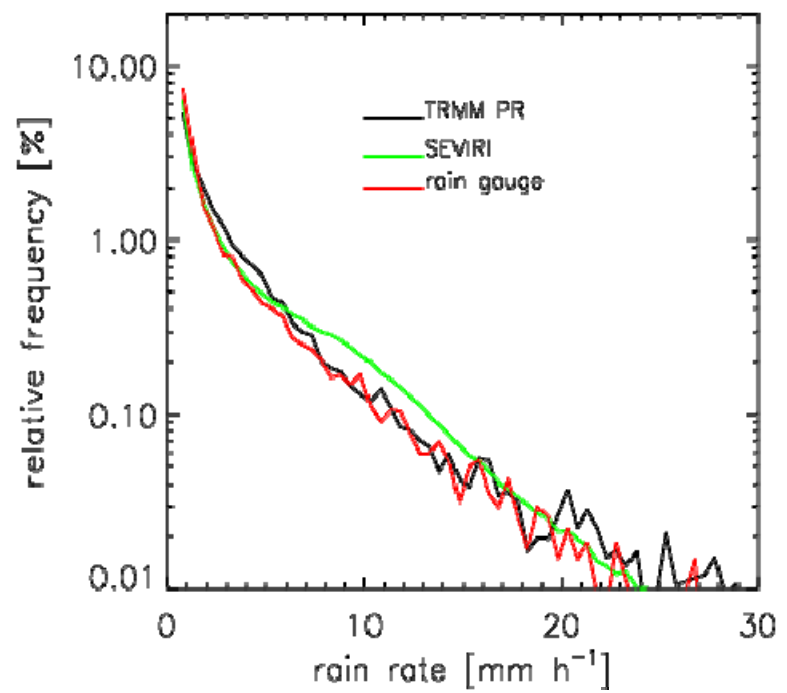
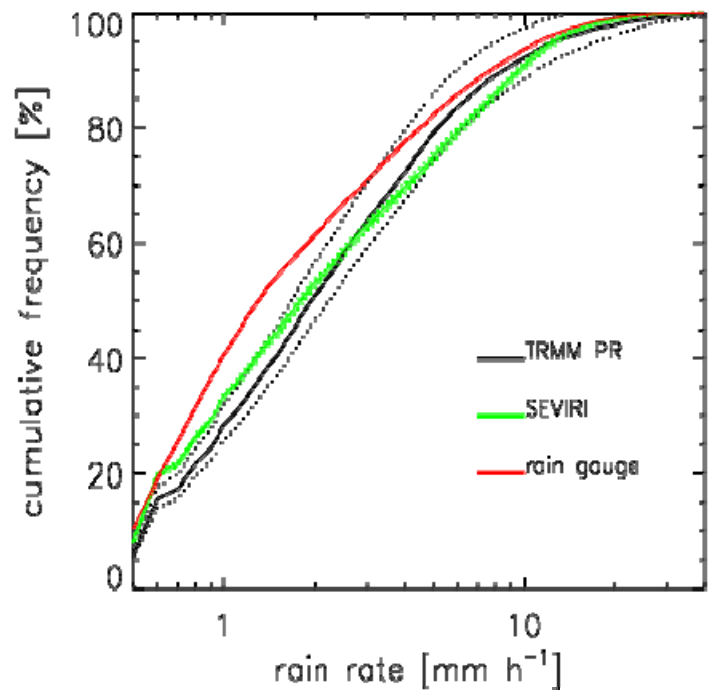


Depiction of the propagation and morphing process. The analyses at 03:30 and 05:00 UTC are actual passive microwave estimates, i.e., no propagation or morphing has been applied to these data. The 04:00 and 04:30 UTC are (a) propagated forward in time, (b) propagated backward in time, and (c) propagated and morphed (from Joyce et al., J. Hydrometeorol., 2004).

Evaluation West Africa: SEVIRI vs TRMM-PR



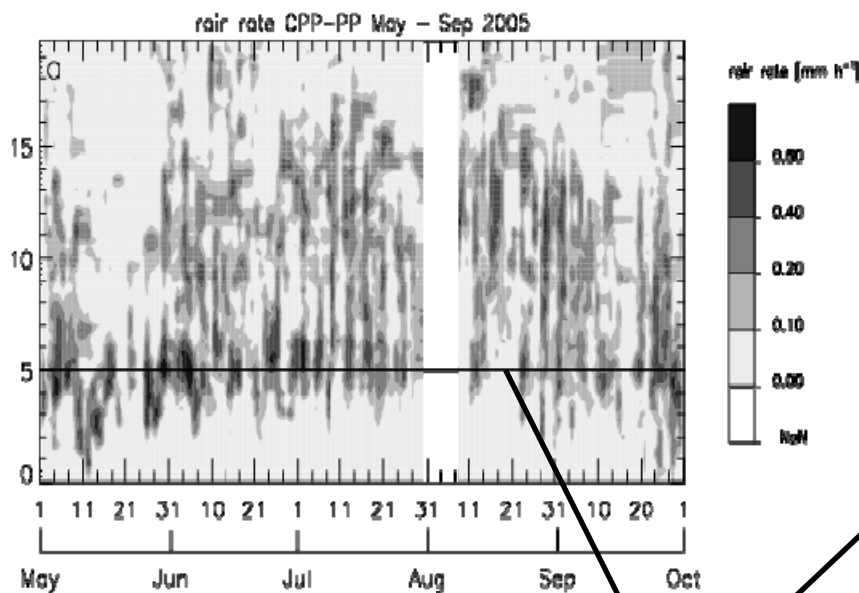
(Left) Rainfall area per TRMM overpass and (right) median rain rate per overpass for TRMM PR and CPP-PP on SEVIRI



(left) Cumulative and (right) relative distribution function for SEVIRI, TRMM PR, and CMORPH. All datasets at 0.25° x 0.25°, daytime data only.

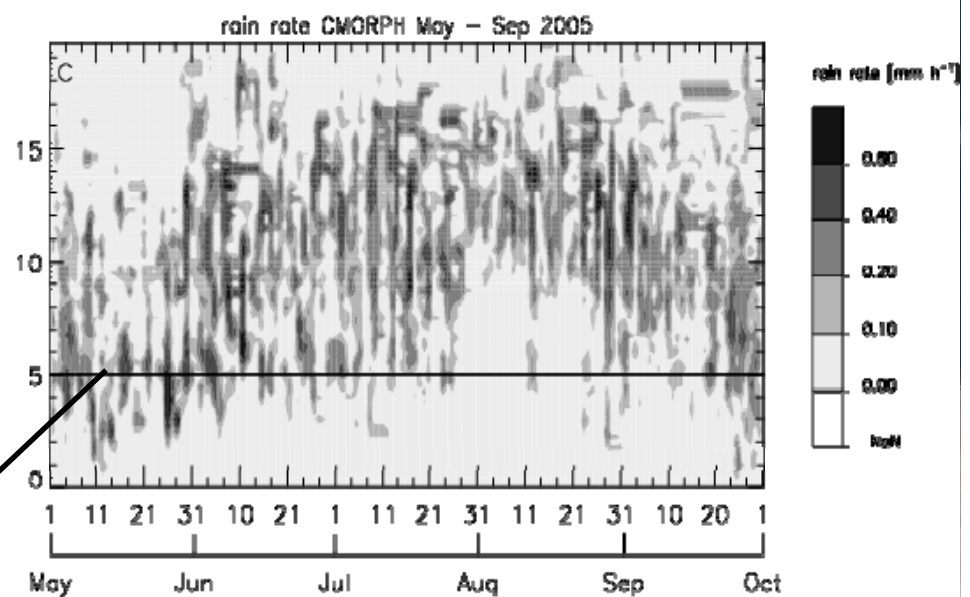
Evolution of West African Monsoon 2005

CPP-PP



coastline

CMORPH

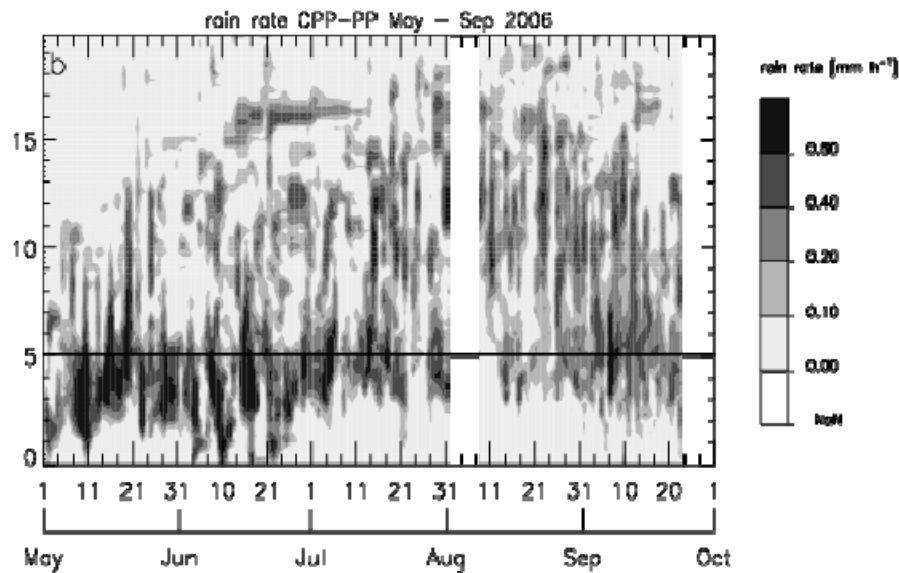


(Left) CPP-PP and (right) CMORPH $0.25^\circ \times 0.25^\circ$ daytime latitudinal Hovmüller diagrams for rain rate, May - September 2005

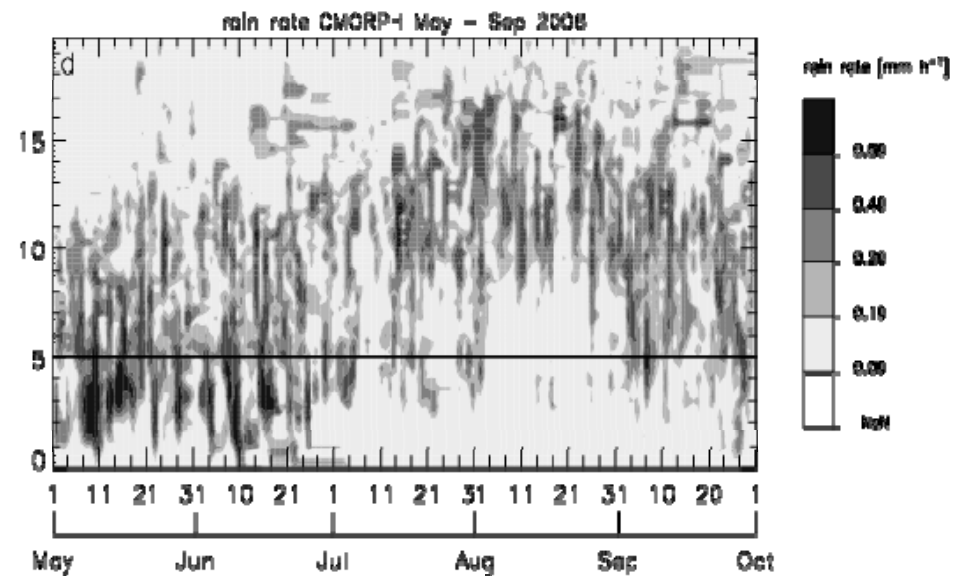
AK/CK Science Talk, 2 Feb 2011

Evolution of West African Monsoon 2006

CPP-PP

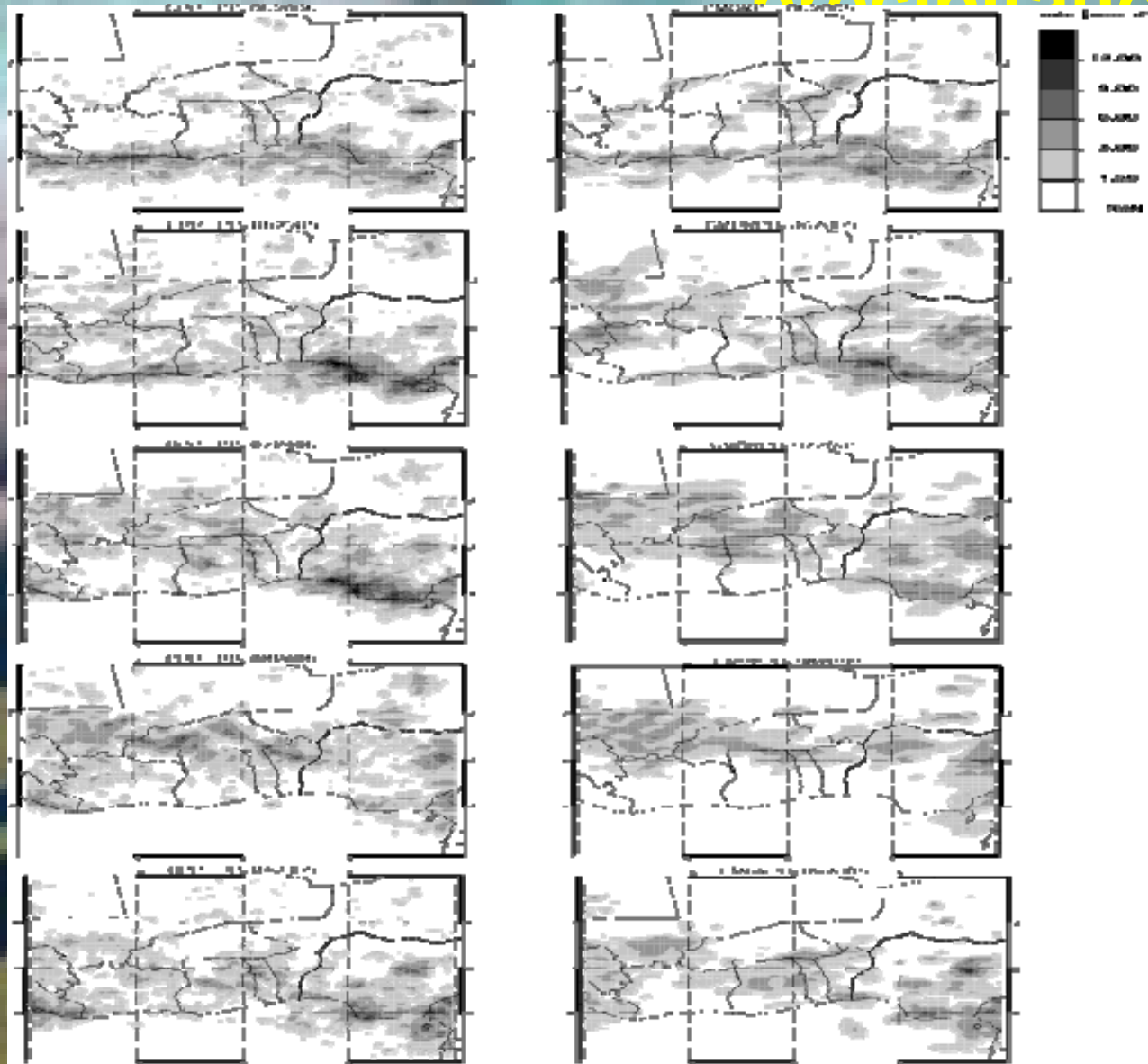


CMORPH



(Left) CPP-PP and (right) CMORPH $0.25^\circ \times 0.25^\circ$ daytime latitudinal Hovmöller diagrams for rain rate, May – September 2006

Daytime accumulated precipitation



May 2005

Jun 2005

Jul 2005

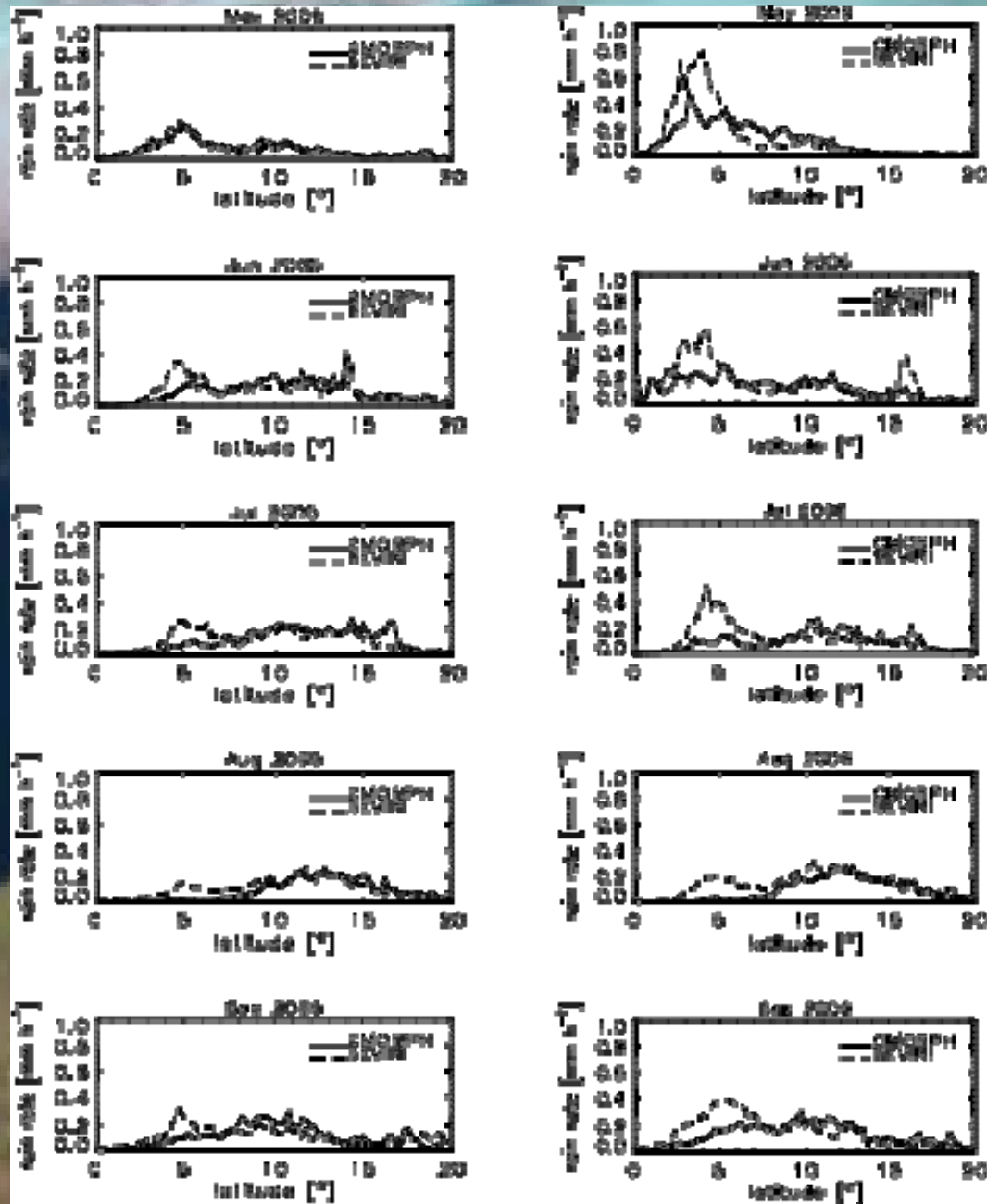
Aug 2005

Sep 2005

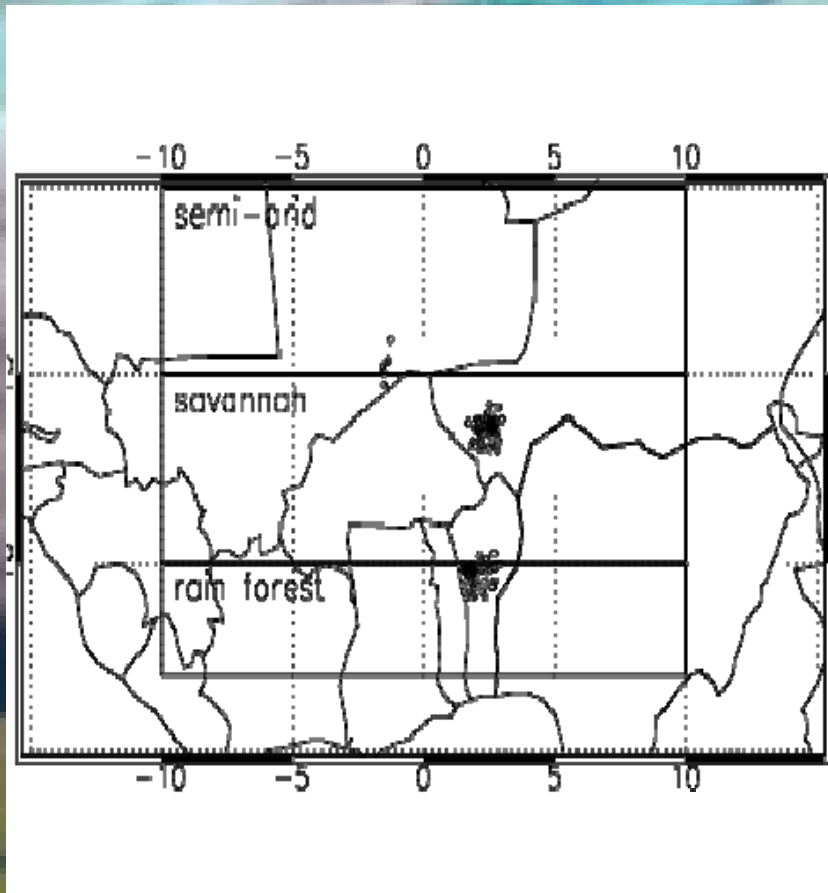
CPP

CMORPH

Latitudinal cross section



Daytime cycle of rainfall West Africa

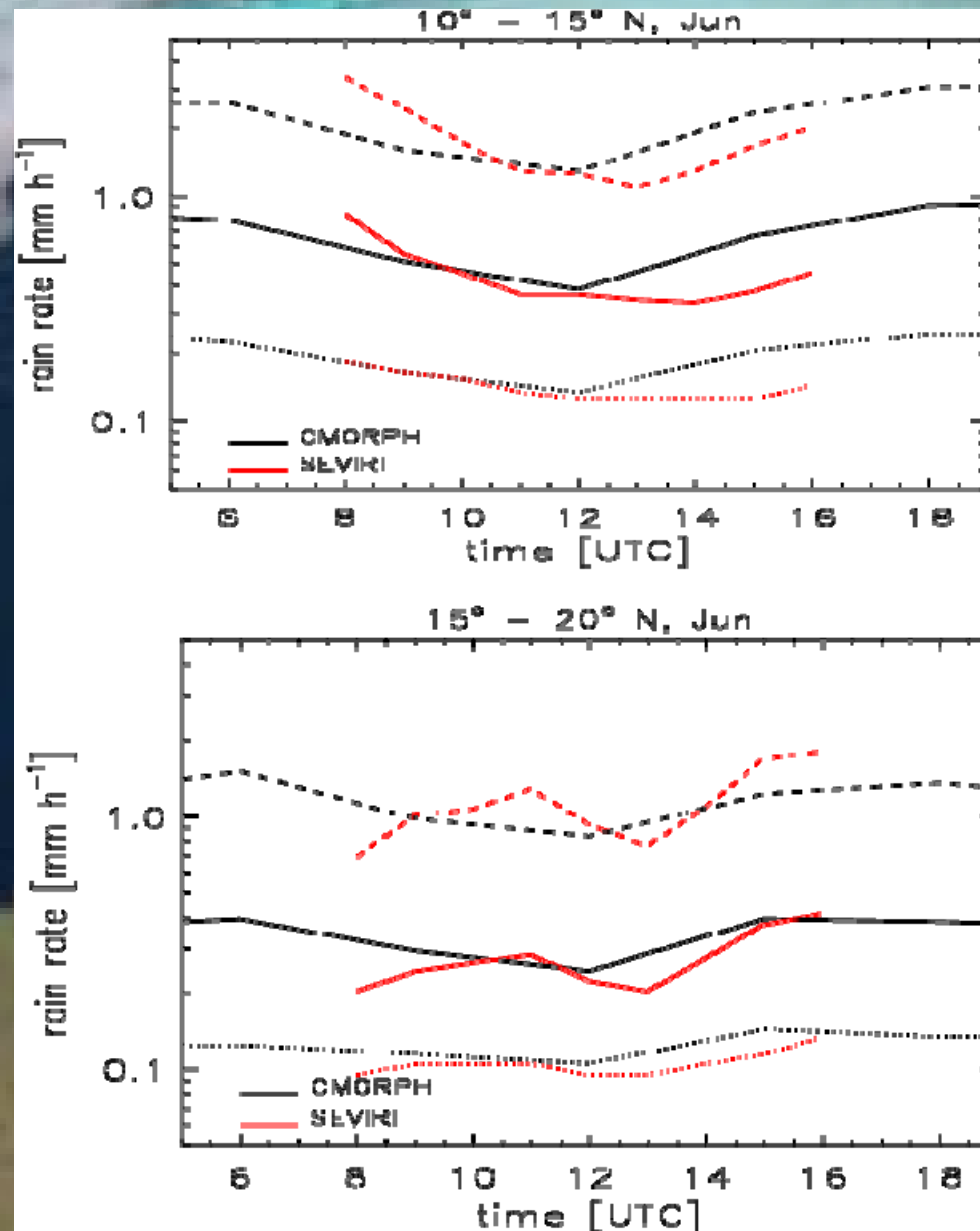


- SEVIRI rain rates reprojected to $0.25^\circ \times 0.25^\circ$ grid

- Observations from 8:30 – 16:30 UTC are collected into hourly bins

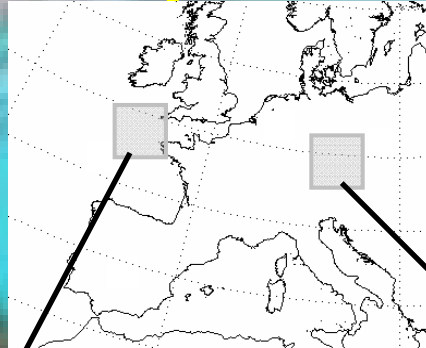
- Daytime cycle calculated for 3 latitudinal bands

Daytime cycle of rainfall West Africa

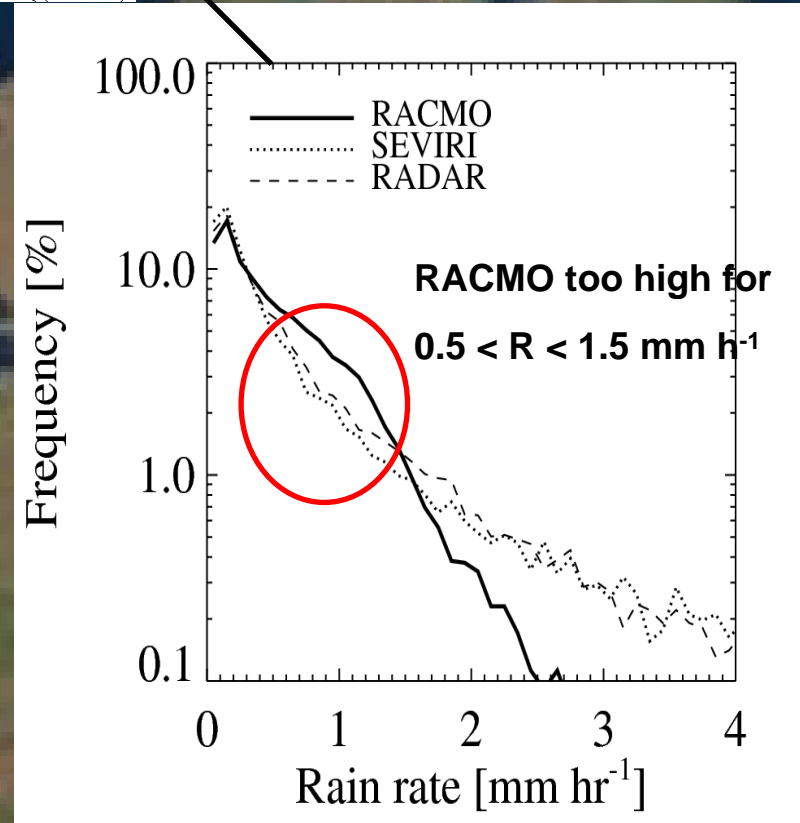
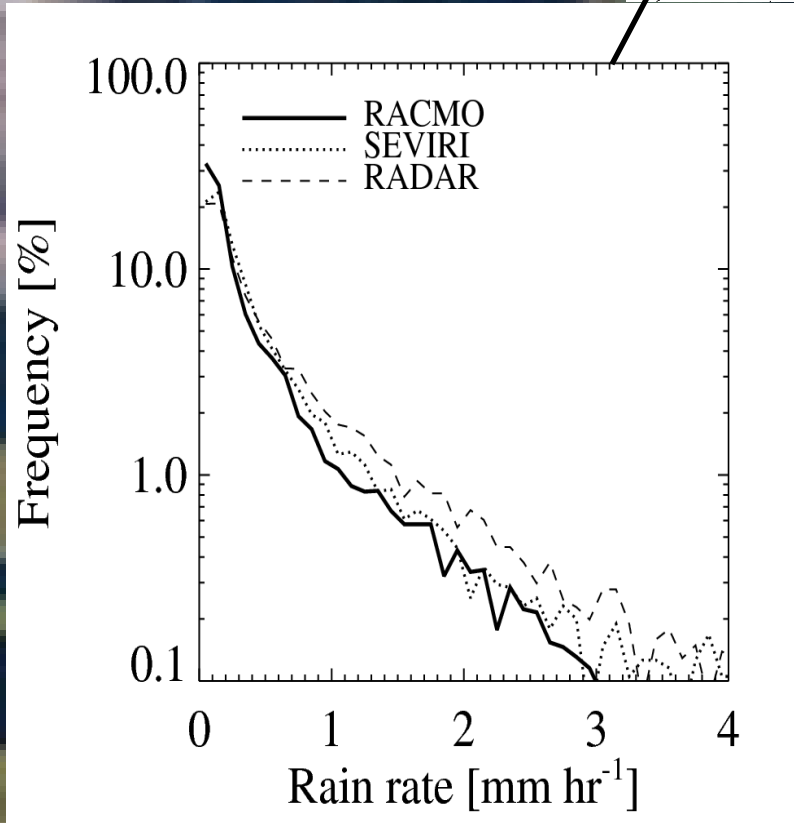


Evaluation: precipitation parameterization

Atlantic Ocean
May – Sep 2006



Continental Europe
May – Sep 2006



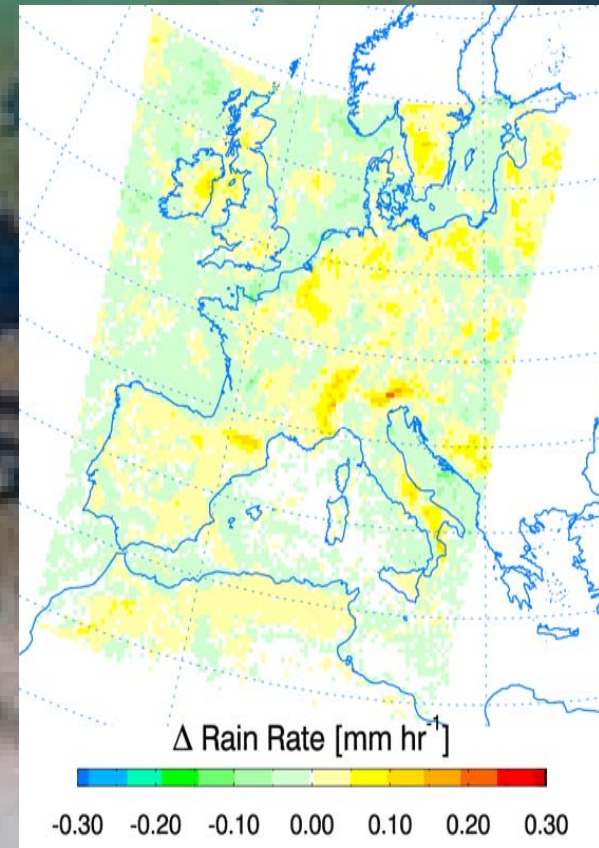
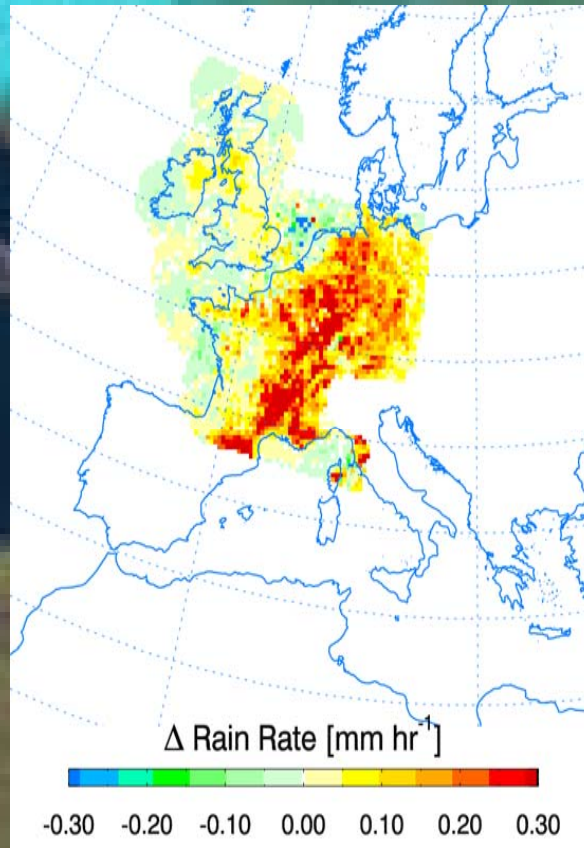
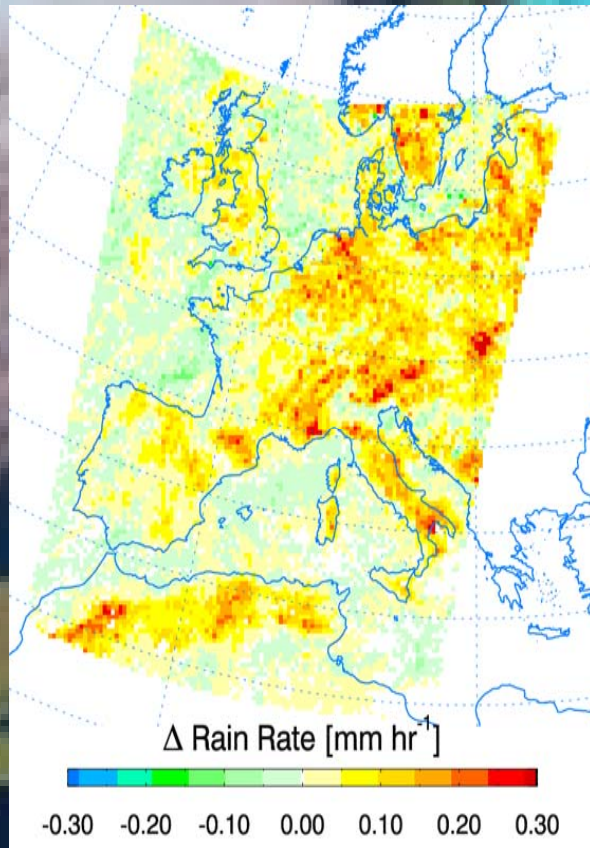
Frequency distributions of RACMO, Weather Radars and SEVIRI Rain Rate for two regions in Europe, May – Sep 2006

Evaluation: precipitation parameterization

SEVIRI

Radars

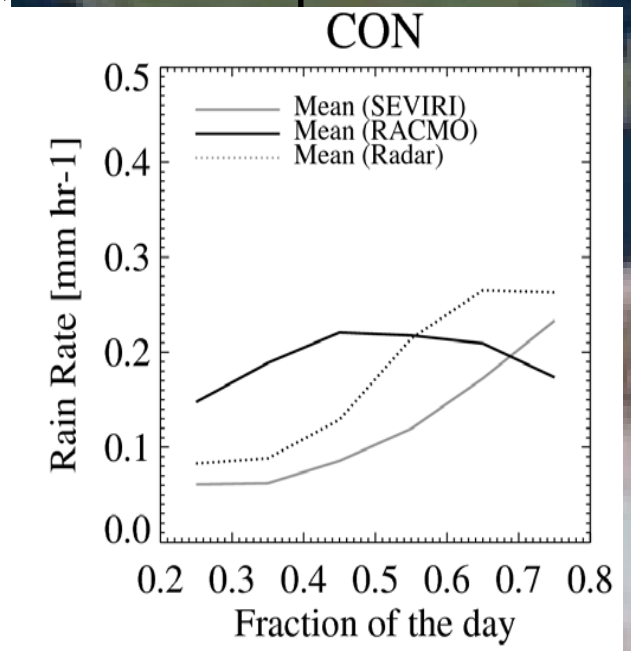
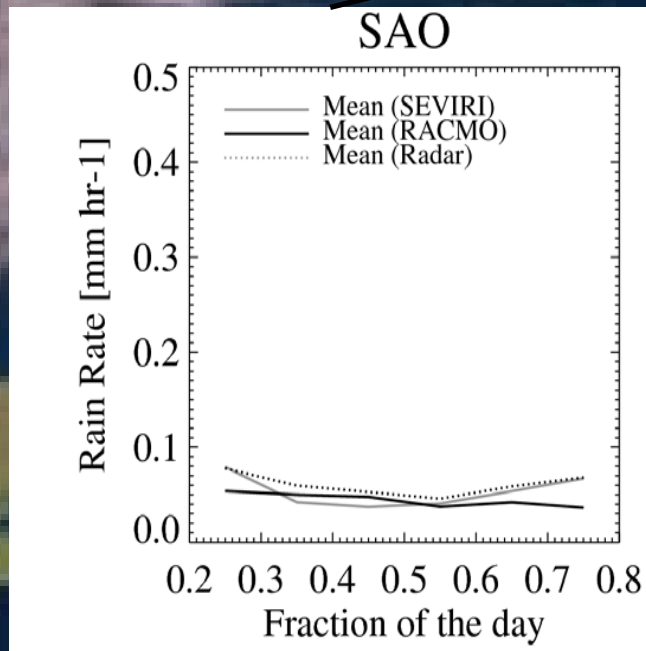
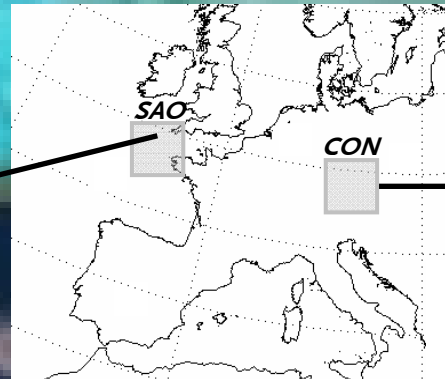
RACMO



Difference between noon and morning rain rates for SEVIRI, Weather Radars and RACMO for May – Sep 2006

AK/CK Science Talk, 2 Feb 2011

Daytime cycle: RACMO vs. SEVIRI



Comparison of daytime cycles of rain rate from RACMO, SEVIRI and Weather Radars for two European regions for May-Sept. 2006

Conclusions and outlook

- SEVIRI enables accurate precipitation retrievals from CPP-PP over various climate regions
- Seasonal progression of West African monsoon can be well followed
- CPP-PP reasonably reproduces the daytime cycle of rainfall over West Africa
- Rainfall retrievals are useful to evaluate precipitation parameterization of RACMO
- Study on soil moisture – precipitation interaction over West Africa is ongoing

Literature

Roebeling, R.A. and I. Holleman: SEVIRI rainfall retrieval and validation using weather radar observations, *J. Geophys. Res.*, **114**, D21202, doi:10.1029/2009JD012102, 2009

Wolters, E.L.A., B.J.J.M. van den Hurk, and R.A. Roebeling: Evaluation of rainfall retrievals from SEVIRI reflectances using TRMM-PR and CMORPH, *Hydrol. Earth. Syst. Sci.*, **15**, in press.

Su, Z. et al.: Earth observation Water Cycle Multi-Mission Observation Strategy (WACMOS), *Hydrol. Earth. Syst. Sci. Discuss.*, **7**, 7899-7956, doi:10.5194/hessd-7-7899-2010

An aerial photograph of a coastal region. A large, dark blue bay is visible on the left side, surrounded by green and brownish land. A prominent, light-colored, rocky peninsula or island extends into the water from the top left. The overall scene is a mix of natural landscape and water.

Thank you!
Thank you!