Representation of Low-Level Clouds in West Central Africa in a convection-permitting regional climate simulation

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Dynamics, Variability and Bioclimatic Effects of Low Clouds in Western Central Africa

https://dyvalocca.osug.fr/

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Introduction

In Western Equatorial Africa (WEA), low level clouds (LLC) in the dry season (June-September) extremely **important for the Forest**.

Analyses of ground **observations, satellites** and **ERA5 reanalyses** in the **DYVALOCCA** project show:

- **Cloudy days** on the **windward side** of the low mountains range but **strong afternoon clearing** on the **leeward side** (Aellig et al. 2022, EGU, AS 1.10).
- **"Cloudy" days** favored by **cold sea surface temperature** (SSTs) over the near Atlantic Ocean and a **warm El Niño**. (Moron et al. 2022, submitted in JoC).
- Large **deficiencies of CMIP6** in simulating **LLC in WEA** (Camberlin et al., 2022, submitted to Climate Dynamics), likely due to **the parametrization of convection** (Lucas-Picher, 2021).

CP4-Africa is a **convection-permitting regional climate model (CPRCM),** run in Africa in 1997-2006 (Stratton et al. 2018) but **no studies done on LCC in WEA.**

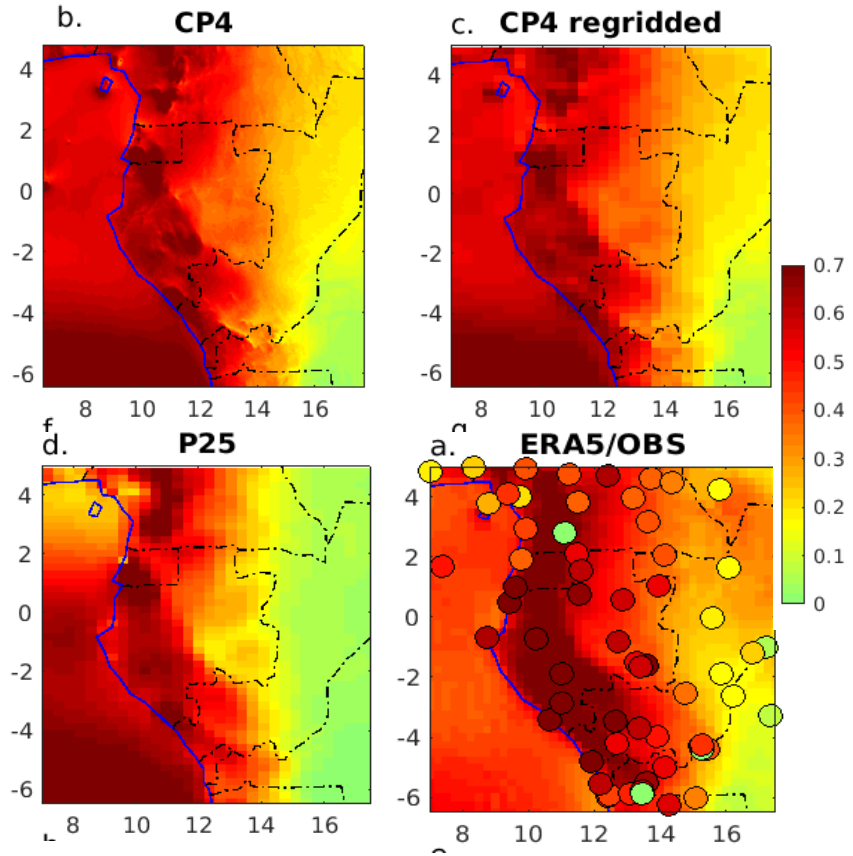
Are low-level-clouds in WEA well represented in the CP4-Africa convection-permitting regional climate model?

West Equatorial Africa (Raffael Aellig, 2022)

Data and Methods

DATA: Low cloud cover from diverse sources:

- **CP4 Africa (1997-2006):** (**4km** horizontal res. and reggrided to 25km) forced with N512L85 **global model run in 1988-2010** and **daily sea surface temperature** (SST, Reynolds 1988)
- **P25-Africa (1997-2006): (25km** resolution**)** Regional climate model with **same resolution and settings as the global model** (convection **parametrized**). Aerosols and soil surface similar as CP4.
- **Concatenated** low level clouds **in situ observations (1971-2019).**
- **Low cloud cover from ERA5 reanalyses** data (1979-2019).



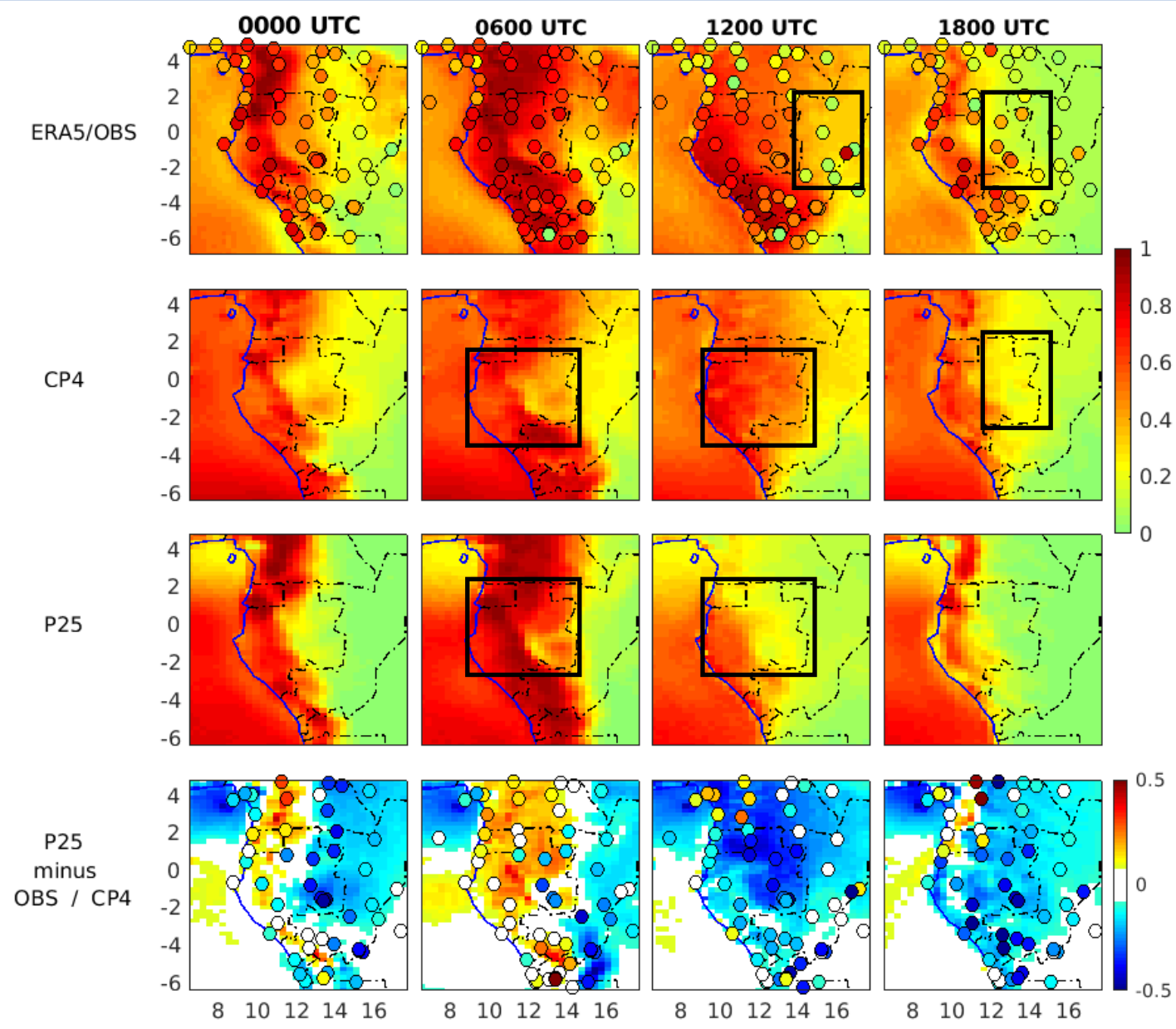
Low cloud fraction from diverse data sources

METHOD: Comparison of LLC dataset in term of:

(1) **The spatial variability of the diurnal cycle**

(2) **The temporal variability of these diurnal cycles** (**Diurnal types** identified from in situ observations (points) using k-means algorithm).

Diurnal change of low level clouds



Average low-level cloud fraction (3 top rows) and difference P25 - OBS (points) and P25 – CP4 fields (bottom row) from diverse data sources in JJAS

- **Clearing early in OBS** (pojnts) compared to ERA5 (shade) **in Cameroon and RC** (**see 1200 UTC)**
- **Clearing not occurring in eastern Gabon in OBS** (**see 1800 UTC)**

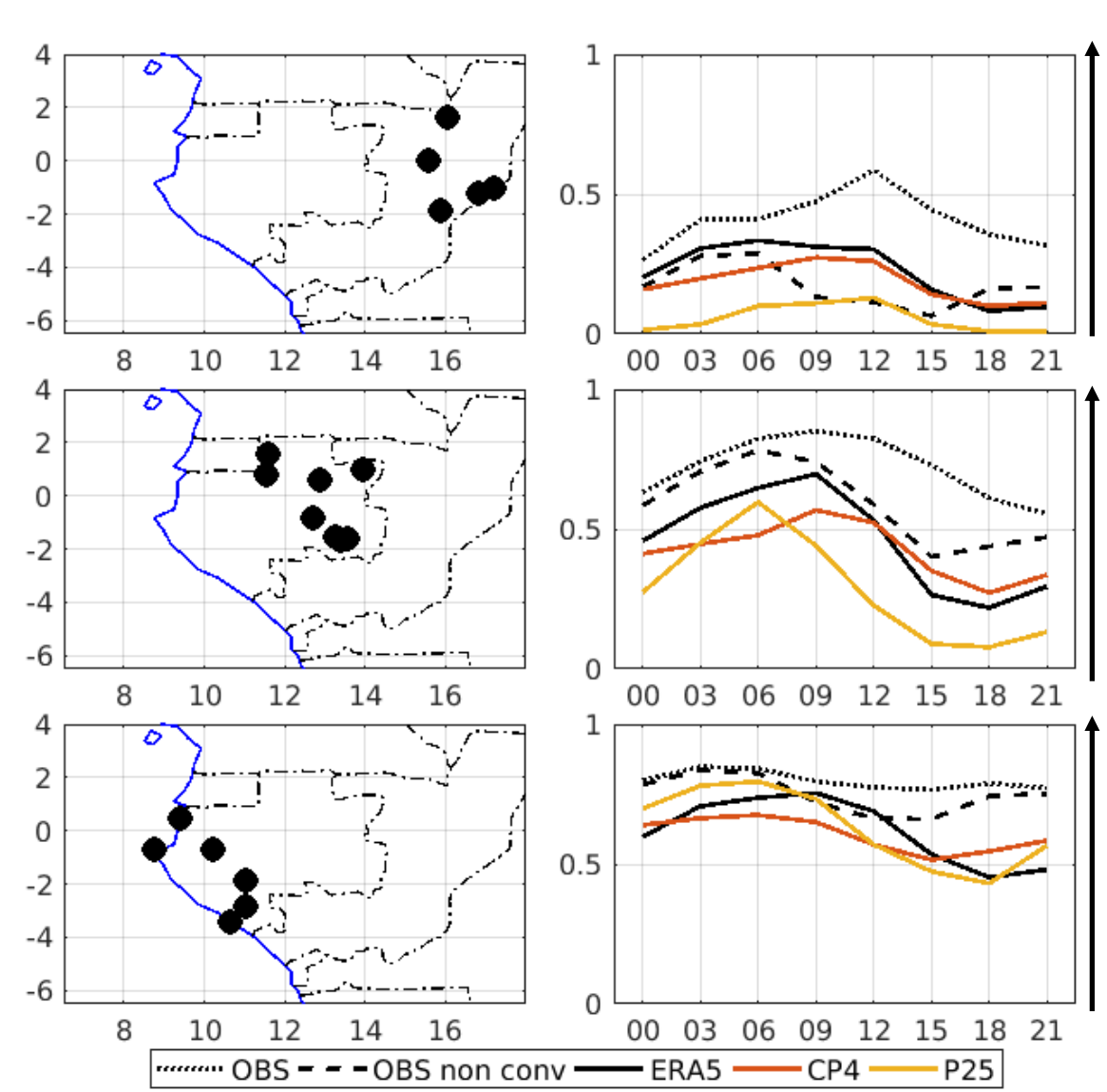
In **CP4 diurnal persistence**/increase of LCC in **Gabon**.
Strong clearing in the afternoon in the east (similar to ERA5)

In **P25 stays clear in NE RC** and **clearing early in Cameroon and eastern Gabon**

How CP4 improves P25?

P25 shows a large underestimation of Low level cloud mainly in eastern Gabon (blue points).
CP4 reduce this underestimation (blue shade) mainly in afternoon
But not enough clouds in the morning

Diurnal cycles of low level clouds



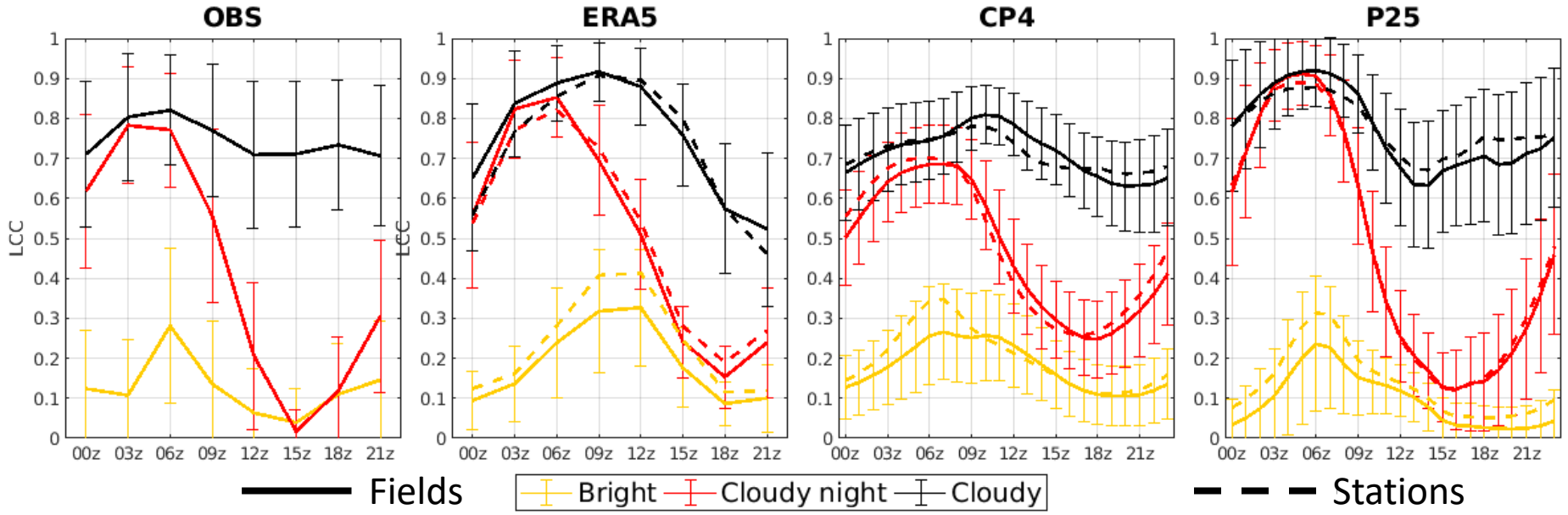
Diurnal cycle of low-level cloud fraction from 3 regions and diverse data sources in JJAS

In NE Republic of Congo:
- CP4 (red) decreases the P25 negative bias (yellow)
- All products fail to recreate OBS diurnal cycle (likely due to convective clouds counted as LCC in EEA5 and CP4)

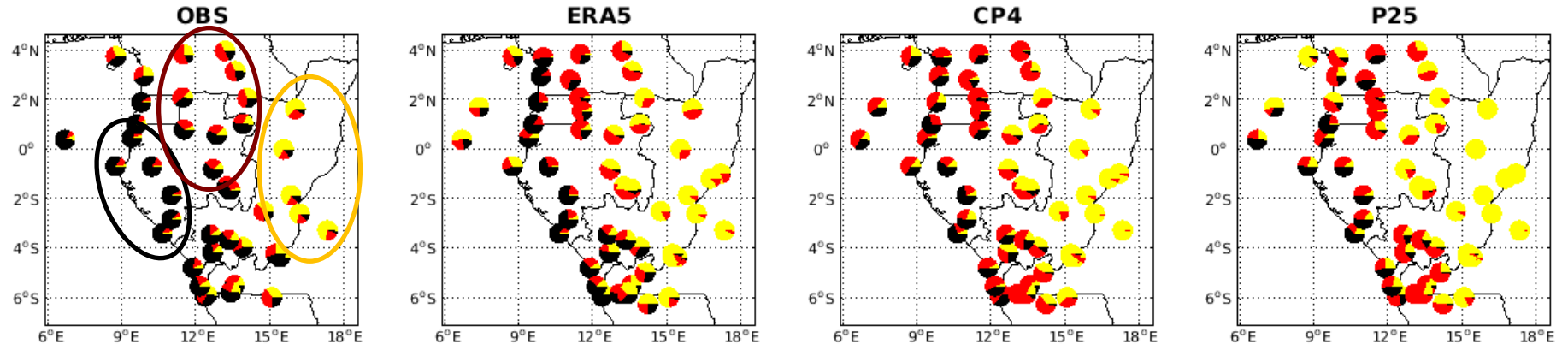
In Eastern Gabon:
- CP4 improve the P25 negative bias
- Better representation of diurnal cycle in all models
- CP4 underestimate the diurnal amplitude
- P25 overestimate the diurnal amplitude

Coastal Gabon:
- CP4 does not improve the overall P25 negative bias
- P25 still overestimate the diurnal amplitude

Diurnal types of low level clouds



The amplitude of diurnal types is underestimated in CP4, overestimated in P25



in NE-RC **Bright type** more hegemonic in all products and mainly in P25

In Eastern Gabon **Cloudy night** and **Bright** becomes hegemonic

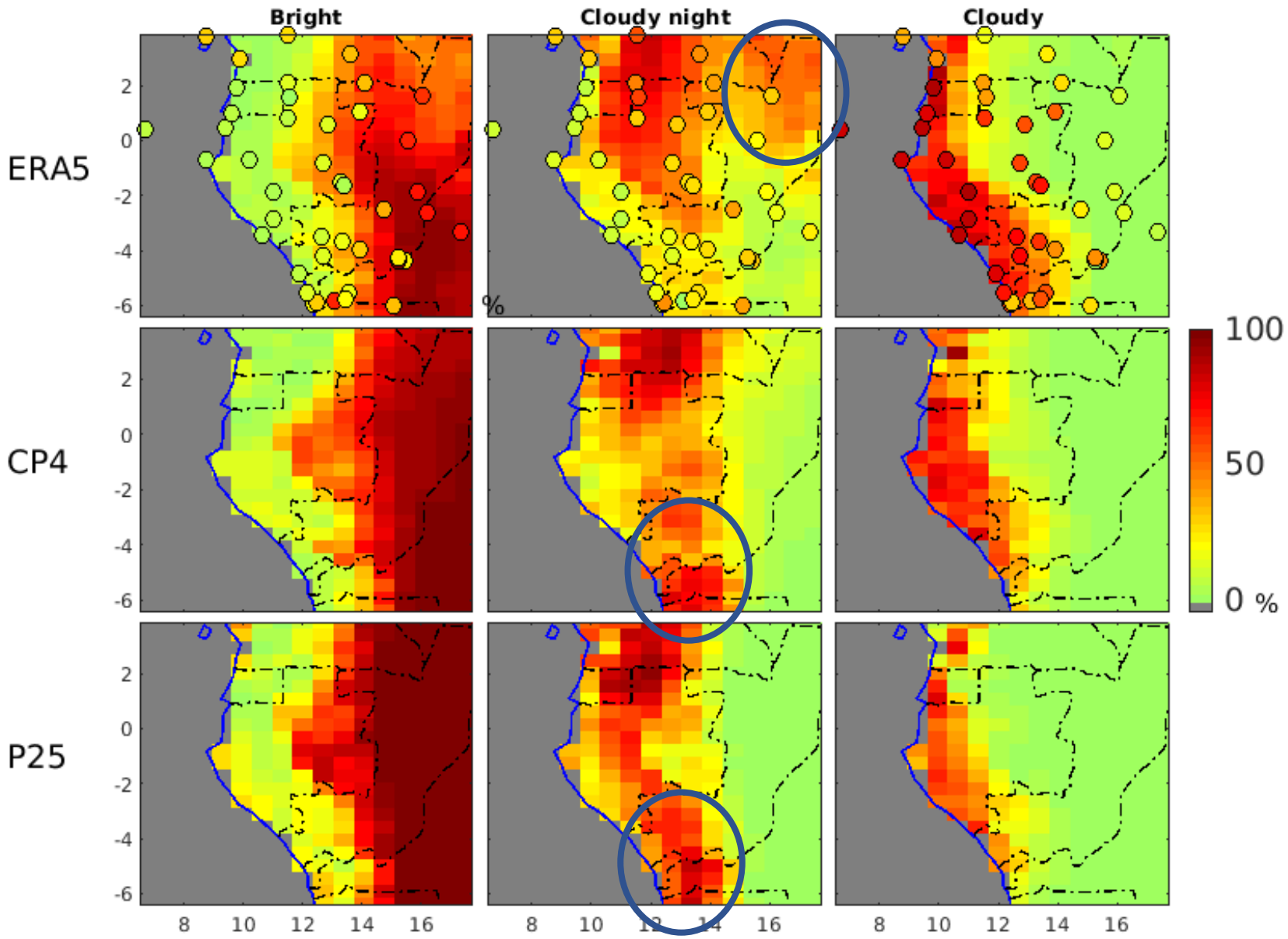
In coastal Gabon **Cloudy** stays dominant but **cloudy night** is also present

Diurnal types calculated from OBS

- **In the NE RC Type 'Bright' dominant,**
- **In Eastern Gabon mix between Type 'Cloudy night' and 'Cloudy'**
- **In coastal Gabon Cloudy is dominant**

➢ **Diurnal types are relatively close in ERA5/CP4/P25**

Diurnal types per grids and sources

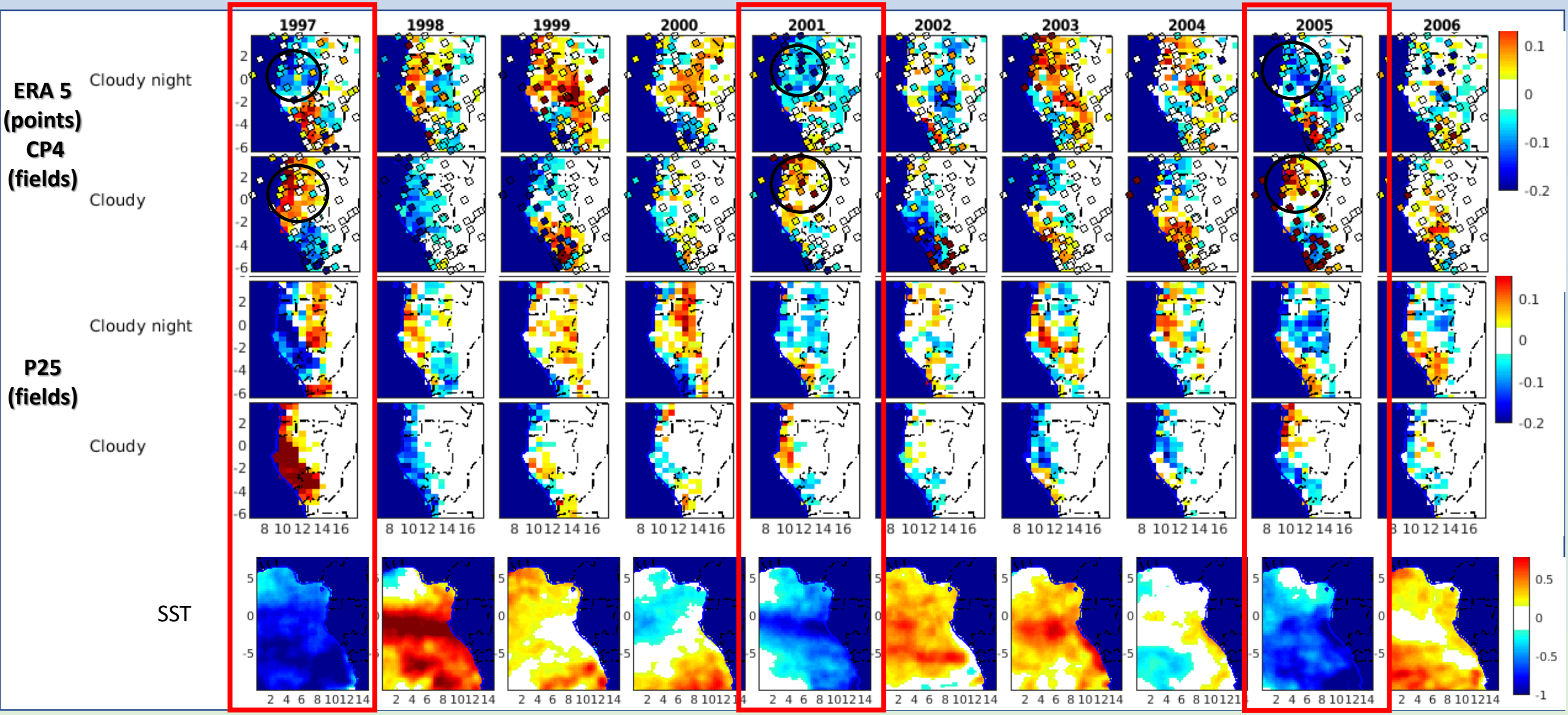


Frequency of each diurnal type per grid points (field) or stations (points) from diverse data sources in JJAS

How CP4 and P25 spatially differ compared to ERA5?

- In **NE RC more cloudy night in ERA5** (More clouds at night) suggesting a **lack of cloud formation at night in CP4 and P25**
- In **SW RC more cloudy night in CP4 and P25** (More clearing during the day)
- **CP4 is closer to ERA5** in term of cloudy days in western Gabon

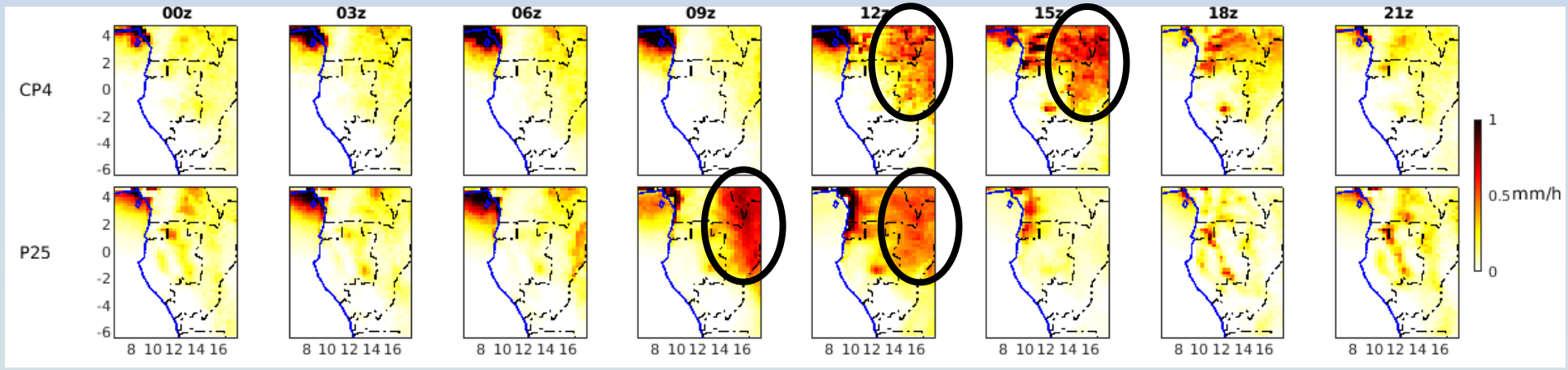
Interannual evolution of Diurnal types occurences



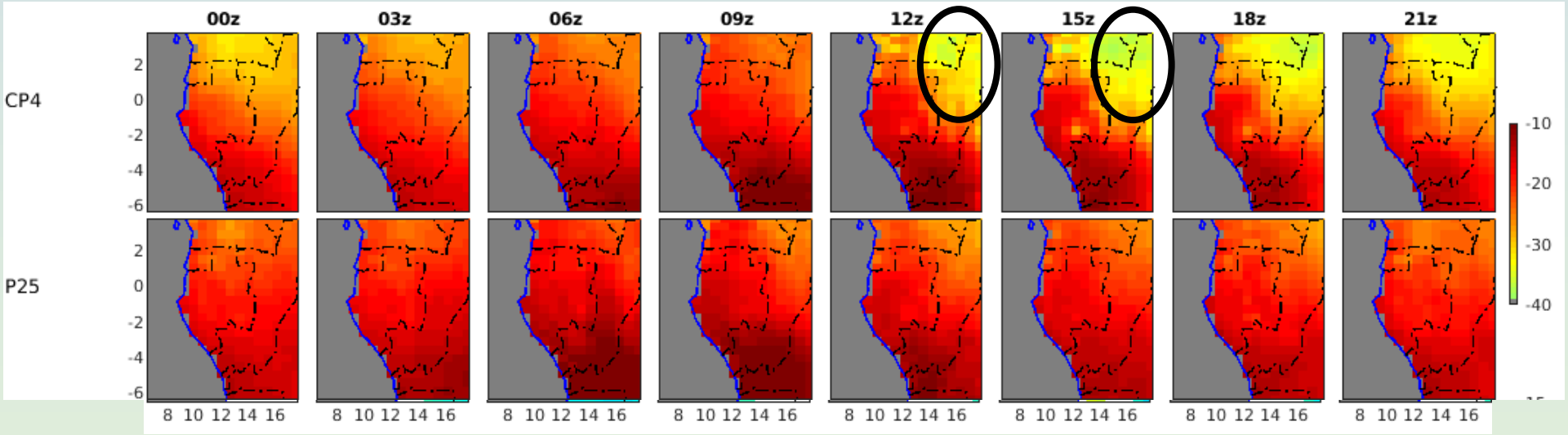
Low SST in the Atlantic ocean decrease (increase) the number of cloudy night (cloudy) types in Gabon (Ex. 1997, 2001, 2005). Signal very strong in 1997 in P25 (El Nino?)

Discussion: Diurnal cycle of Rain and high-level clouds

Average Rain (mm/h):



Cloud top temperature relative to temperature at 650hPa:

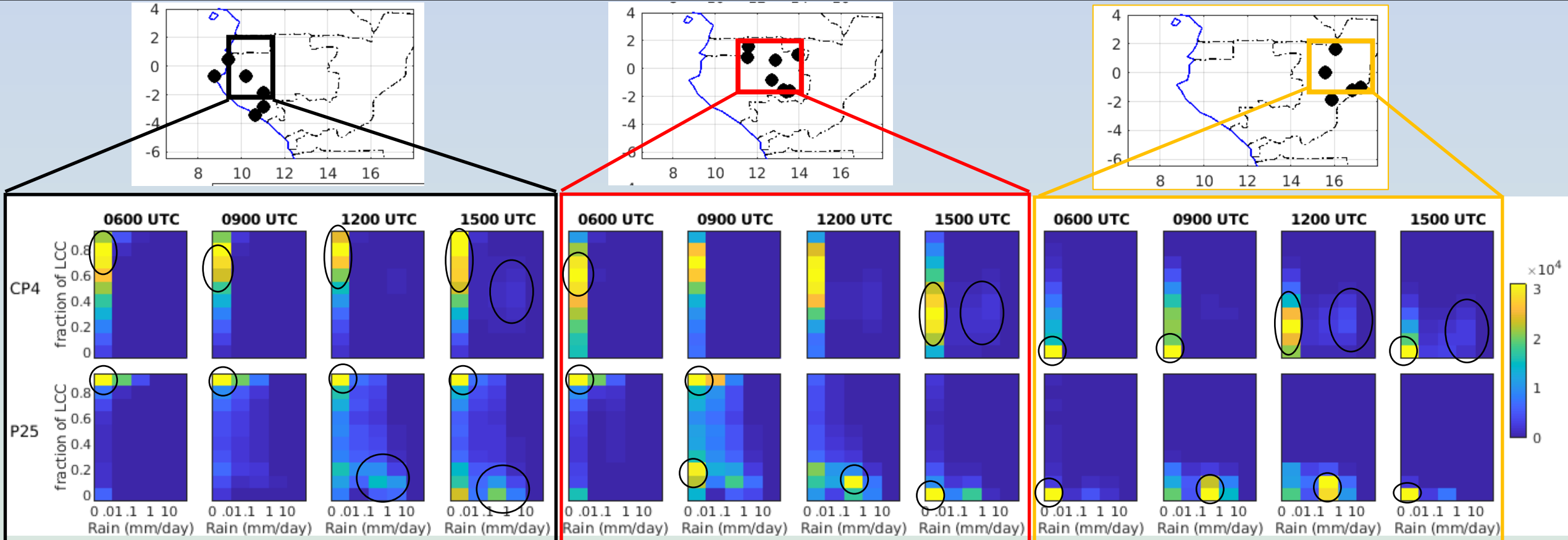


In **CP4: Rain in NE RC** occurs in the **afternoon** and associated with **higher cloud top**.

In **P25: Rain occurs earlier** and **not associated to high clouds** (Not low clouds either, see previous slides)

- P25 creates possibly **convection too early** and create **too sparse clouds** (explaining the afternoon underestimation of convective Low level clouds).

Discussion: Concomitant distribution of Rain and low clouds



- In CP4 no rain and LCC >60%. few clearer and rainy days in the afternoon
- In P25 no rain with LCC>90%. Clearer days with some rain in the afternoon

- In CP4 afternoon clearing with few rainy days
- In P25 no rain with LCC>90% in the morning. Clearer days with some rain in the afternoon

- In CP4 Becomes slightly cloudy with some rain by midday
- In P25 becomes slightly cloudy with rain in the morning

Some rainy days in CP4 associated to partial LCC (20-50%) mainly in the east => Some convection increases LCC
P25 is more extreme (or very high (> 90%) or very low (<30%)) => Could overestimate the diurnal amplitude

Conclusion

- The **low-level clouds** in **West Equatorial Africa** in June-september (1997-2006) from the **convection permitting** model **CP4 Africa** shows:

✓ A **reduction of the underestimation** of low-level clouds seen in P25 in the east

(due to P25 simulating full LCC **OR** no LCC).

X But a Diurnal cycle of low-level clouds still **not matching well the ground observations:** mainly in the **North-east** part of the region:

- **Not enough low level clouds at night (difficulties simulating full cloudy skies)**
- **Too much clouds during the day** in the **North-east** part of the region likely due to **cumuliform clouds**

The **apparent improvement of CP4 from P25** is more **due to a more realistic diurnal cycle of convection** than a real improvement in the representation of stratiform clouds

- For **future research: Medium/high-level clouds** and **other variables** (temperature, wind, pressure, humidity…) should be investigated…

Thank you!

EGU22-5881 | Presentations | AS1.10

Climatology of low-level clouds during the main dry season over Western Equatorial Africa: Comparison between ground observations and satellites

Raffael Aellig et al.

Wed, 25 May, 15:34–15:40 Room F1

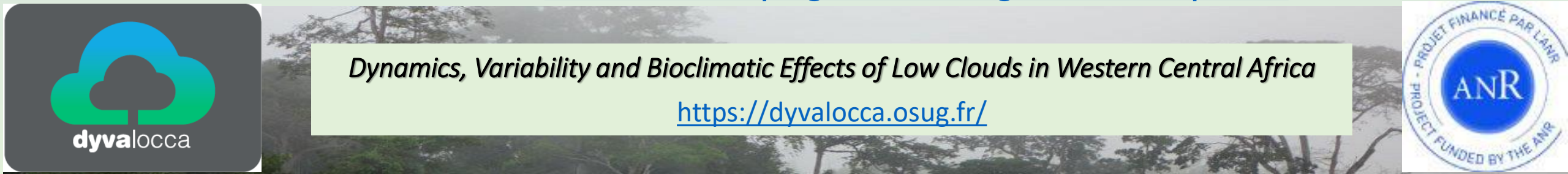
EGU22-13520 | Presentations | AS3.2

Representation of Low-Level Clouds in West Central Africa in a convection-permitting regional climate simulation

Olivier Champagne et al.

Thu, 26 May, 09:28–09:34 Room F1

Contact: Olivier.champagne@univ-grenoble-alpes.fr



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