Seasonal predictions of summer precipitation over West Africa using the CNRM-CM5 GCM

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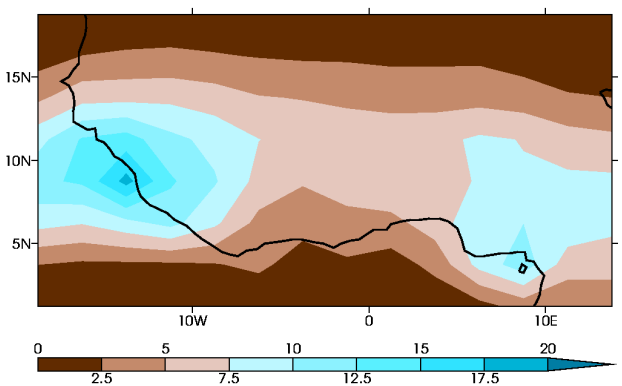
Purpose of our study

Assessment of the CNRM-CM5.1 climate model for seasonal predictions

- GCM developed for IPCC AR5
- Ensemble seasonal re-forecasts for 1979-2010 (different ensemble methods)
- Scores vs. GPCP v2.2 data for precipitation (Huffman et al. 2009), ERA-Interim for other fields (Dee et al. 2011)
- Comparison with a former version (used in FP6-ENSEMBLES)

West African region

Geographical definition : latitude $\in \{0°\text{N}, 20°\text{N}\}$; longitude $\in \{20°\text{W}, 15°\text{E}\}$
Scores are calculated over the 27-year common period for June-July-August (JJA)



JJA 1979–2005 climatology (GPCP v2.2) (mm/day)

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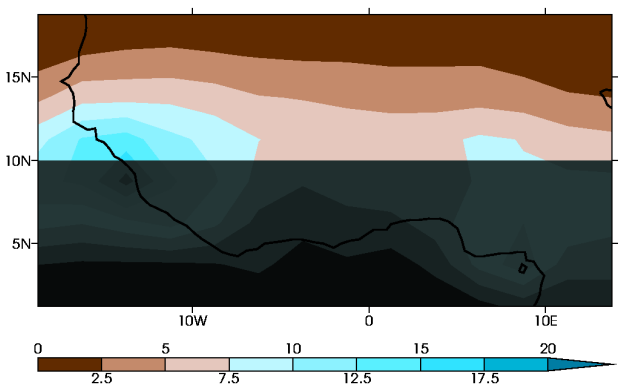

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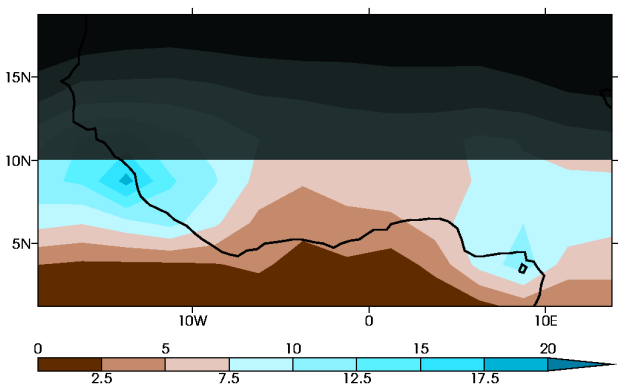

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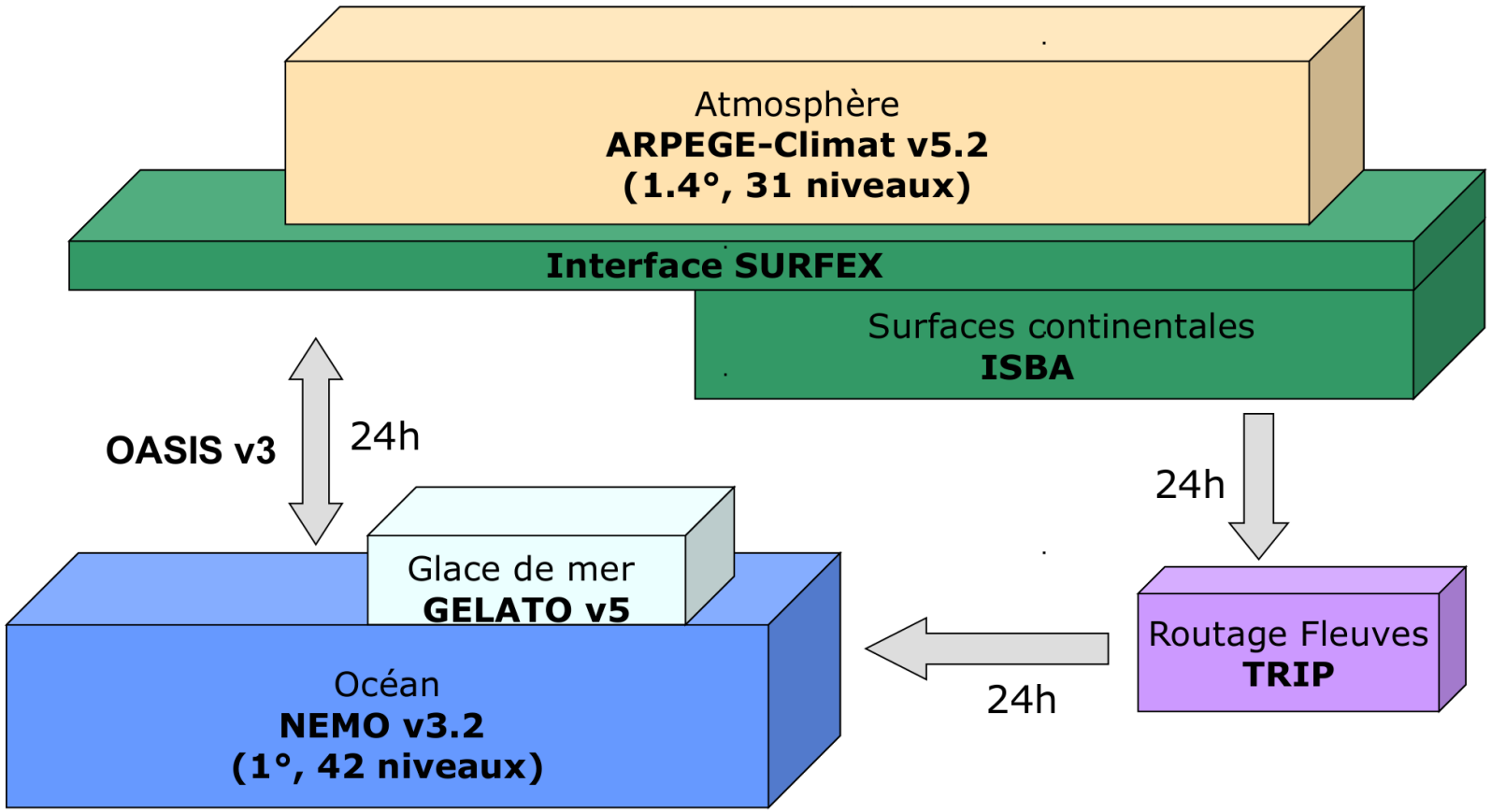
Guinea : latitude $\in \{0°\text{N},\ 10°\text{N}\}$

Seasonal predictions with CNRM-CM5.1



Voldoire et al. 2012

Stochastic dynamics technique

Additive stochastic perturbations of the ARPEGE-Climat model (Batté and Déqué 2012)

$$\mathbf{X}(t + \Delta t) = \mathbf{X}(t) + \mathbf{M}(\mathbf{X}(t), t) + \delta\mathbf{X}$$

- In-run perturbed variables : T, Ψ, Q ; vertical profile (no perturbation at the surface)
- $\delta\mathbf{X}$: initial tendency error correction term drawn from a given population $\{\delta\mathbf{X}\}$
- Coherence between perturbations of T, Ψ and Q : corrections refer to a given date in a nudged hindcast run (Guldberg et al. 2005), in leave-but-one mode

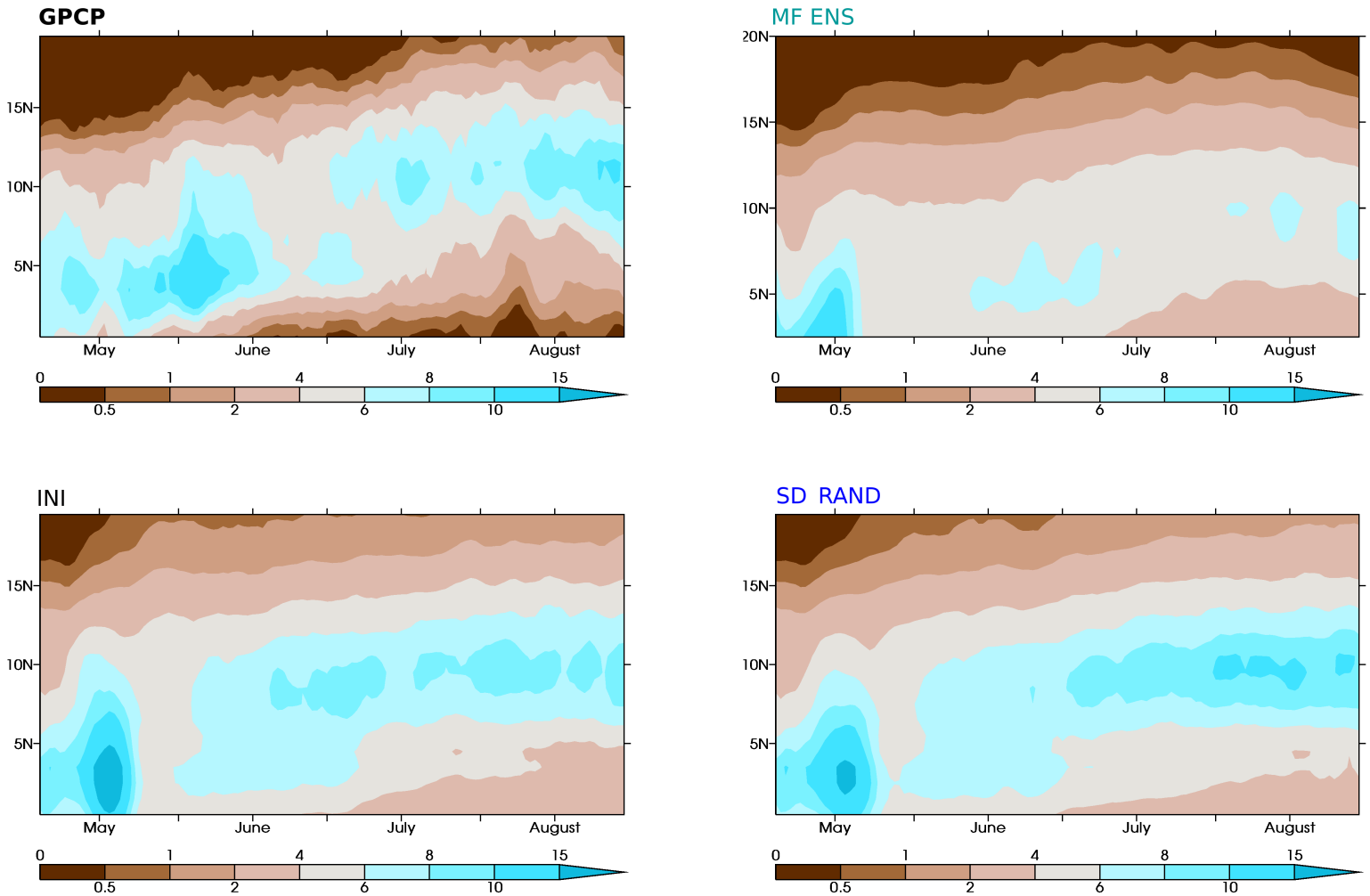
Ensembles tested

Characteristics : 15-member ensembles, JJA re-forecasts initialized on May 1st over the 1979-2010 ERA-Interim time period

- Reference run : initial perturbations only ; ***INI***
- Random stochastic dynamics : classification of $\{\delta\mathbf{X}\}$ population according to the current month (May to August), new $\delta\mathbf{X}$ drawn each 6 hours ; ***SD_RAND***
- Sequential stochastic dynamics : set of consecutive $\delta\mathbf{X}$ drawn every 5 days ; ***SD_SEQ***

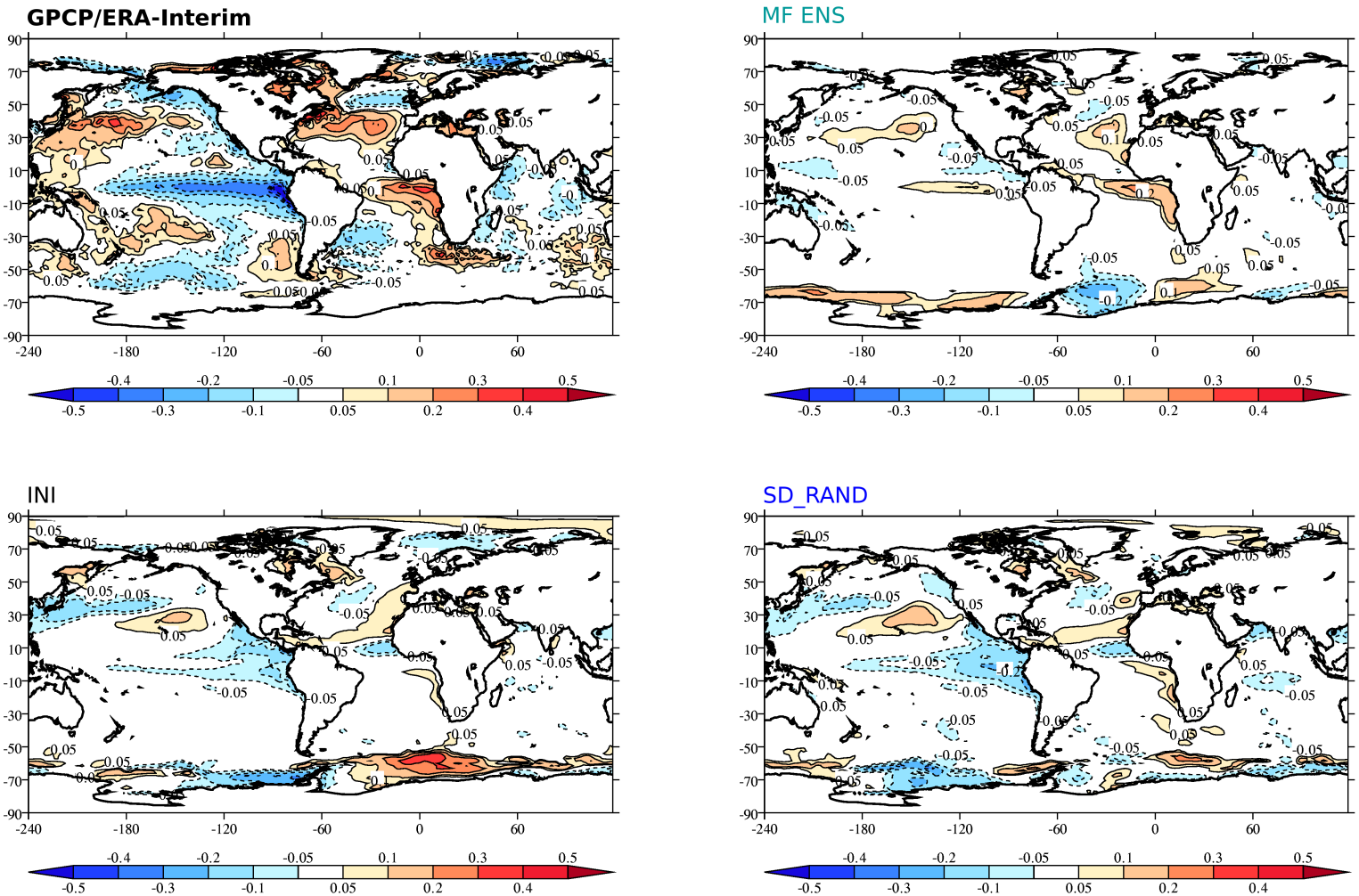
Compared to the CNRM contribution to ENSEMBLES : ***MF ENS***

MJJA precipitation



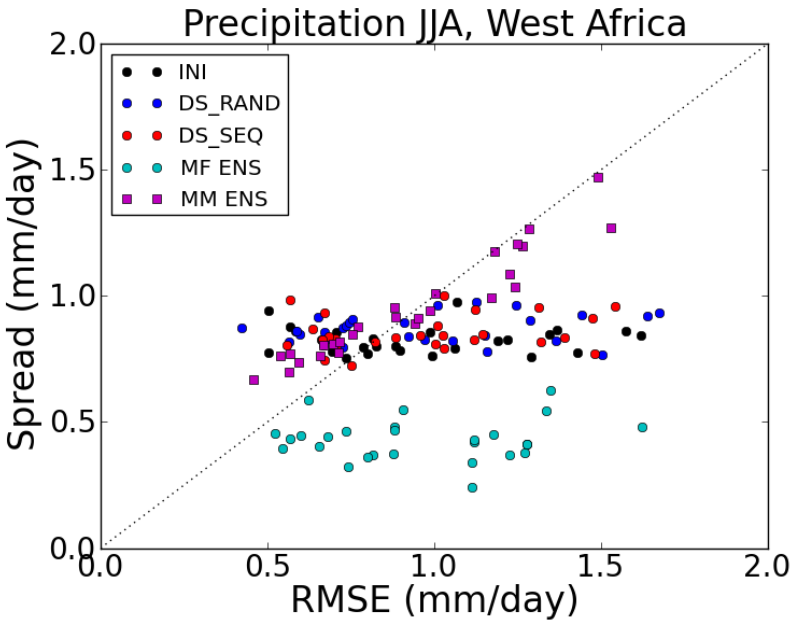
Hovmöller diagrams of average precipitation (mm/day) between 10° W and 10° E for MJJA 1979-2005 in GPCP and runs MF ENS, INI and SD_RAND.

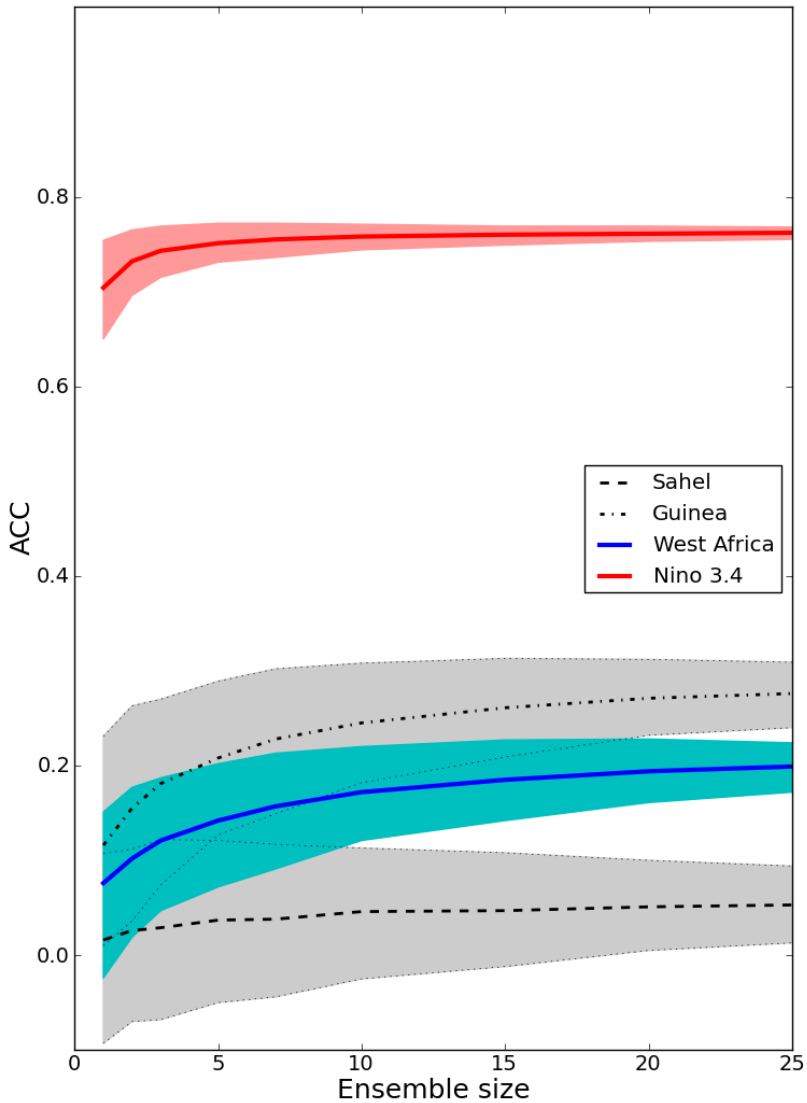
Anomaly covariance WA precipitation - SST



Anomaly covariance (in degrees) between West Africa precipitation and SST in reference datasets (GPCP and ERA-Interim SST) and runs MF ENS, INI and SD_RAND.

Spread-to-skill ratio and anomaly correlation





Impact of ensemble size on ACC →

- CNRM-CM5 45-member ensemble with stochastic dynamics
- JJA precipitation ACC scores for random subsets over different regions
- 5% - 95% score interval
- Increase in ensemble size mainly improves Guinea precipitation ACC

Probabilistic forecasts : RPSS

Brier Score and RPSS

- Brier Score of binary event A_k : JJA average $<$ k^{th} tercile

$$BS_k = \frac{1}{n}\sum_{i=1}^{n}(y_i^k - o_i^k)^2$$

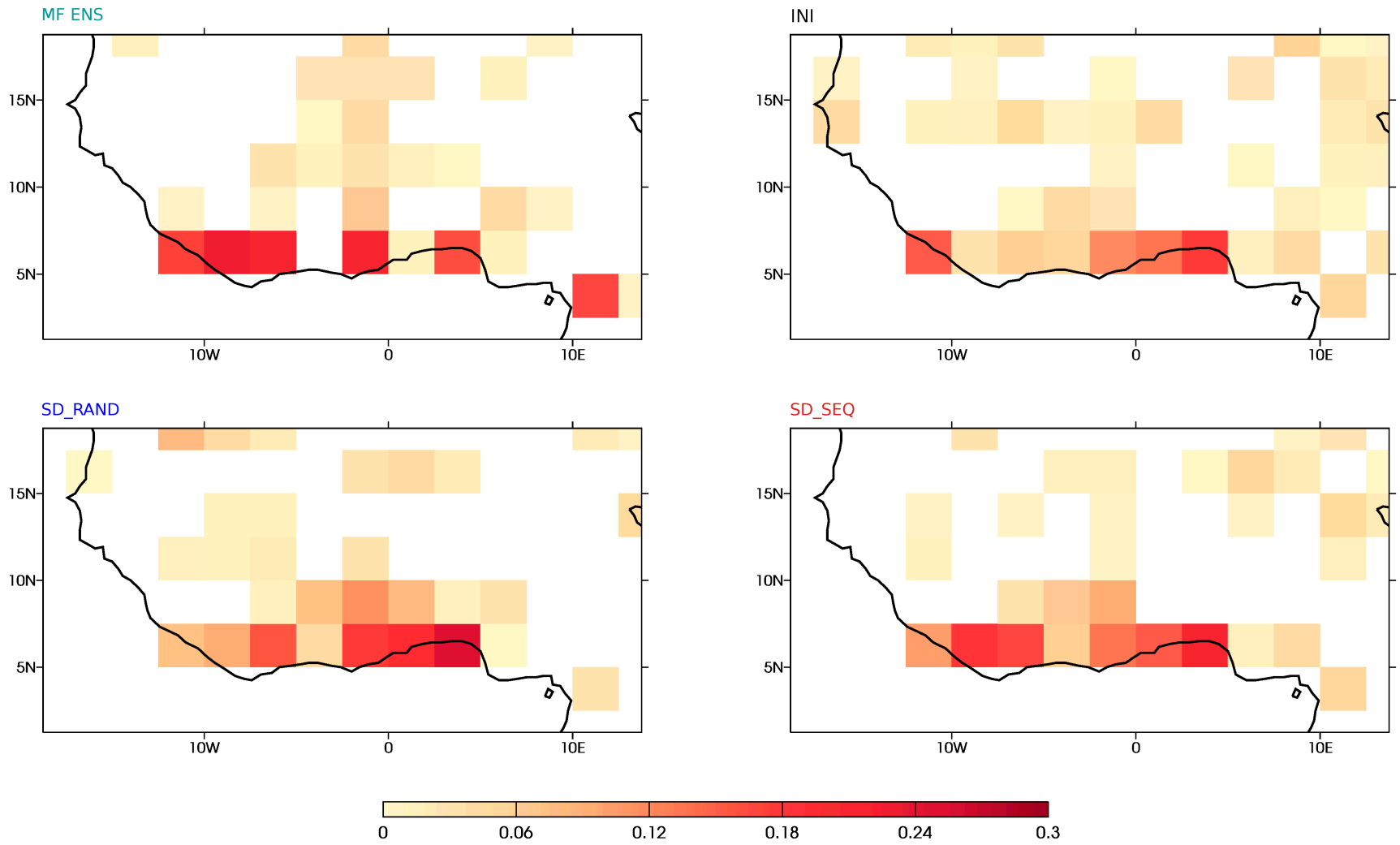
- Ranked Probability Score : BS_k average for first and second precipitation terciles
- $\text{RPS} = \text{Rel} - \text{Res} + \text{Unc}$; $\text{RPSS} = 1 - \frac{\text{RPS}}{\text{RPS}_c}$

Results

West Africa JJA precipitation (over land)				
Ensemble	**Rel/Unc**	**Res/Unc**	**RPS**	**RPSS**
Climatology	0.	0.	0.222	0.
MF ENS	0.491	0.465	0.228	-0.026
INI	0.439	0.443	0.221	0.004
SD_RAND	0.437	0.441	0.221	0.005
SD_SEQ	0.427	0.432	0.221	0.005

- No impact of SD on RPS scores
- Improvement with respect to MF ENS
- Due to better reliability

Probabilistic forecasts : RPSS



Conclusion

Results with CNRM-CM5

- Biases : CNRM-CM5 has a "wetter" monsoon that reaches further north
- Seasonal prediction : similar ACC and RPSS scores, regardless of a better spread
- Little to no impact of stochastic dynamics method over West Africa

Future work

- Ongoing work for improvement of the atmospheric model physics
- West Africa : precipitation far more chaotic than in the Pacific
- Flow-dependent stochastic dynamics technique ?

Thanks for your attention !