Seasonal predictions of summer precipitation over West Africa using coupled GCMs: skill of the ENSEMBLES project multi-model forecasts

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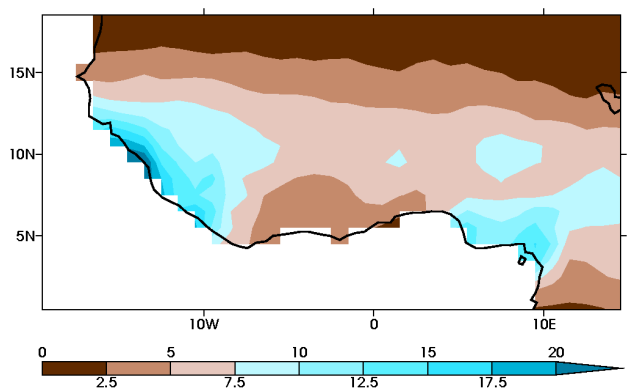
Purpose of our study

Goals and purpose

- Study the predictability of precipitation over West Africa at a seasonal timescale
  - Early warnings (drought, disease...)
  - Economic applications
- Assess the FP6-ENSEMBLES multi-model seasonal forecasts
- Ensemble prediction : allows for deterministic and probabilistic assessment

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 a 46-year period for the June-July-August season (JJA)



JJA 1960–2005 climatology (GPCC) (mm/day)

Data

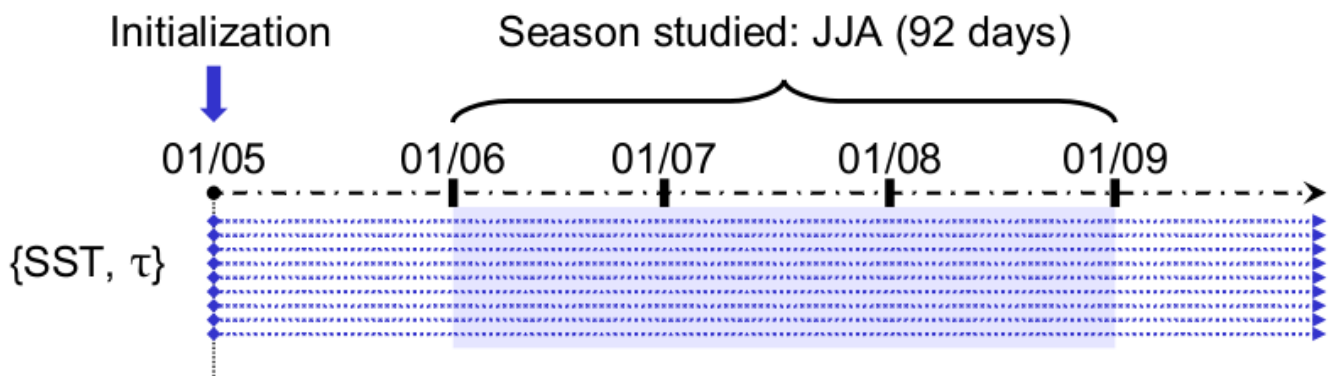
FP6-ENSEMBLES stream 2 forecasts (Weisheimer et al., 2009)

5 coupled models
(ECMWF, IFM-G, MF, UKMO, CMCC)
9 members per model
} 45-member multi-model ensemble (MME)

- **Time period studied :** 1960–2005

Observations : GPCC (Schneider et al., 2008)

- GPCC Full Data Reanalysis version 4 dataset, monthly reanalysis of in-situ data



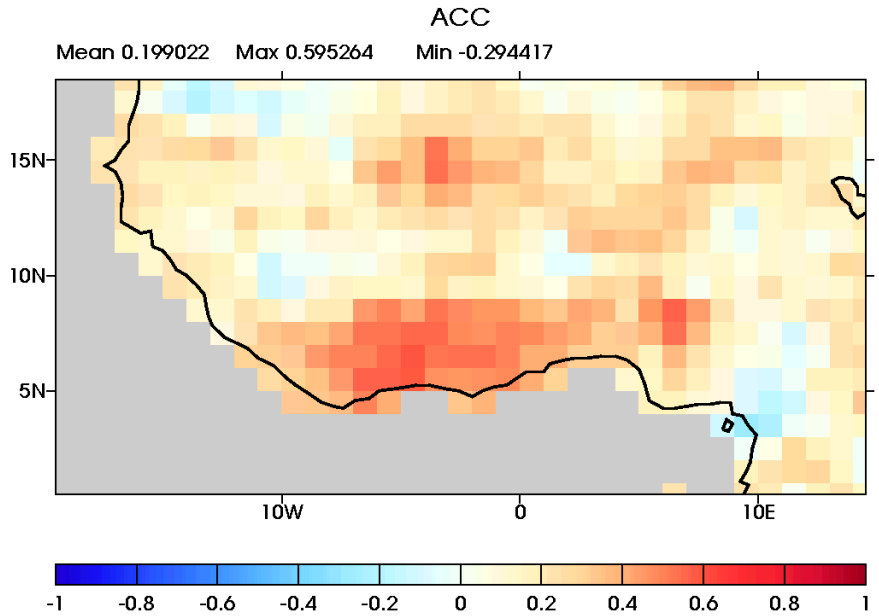
Outline

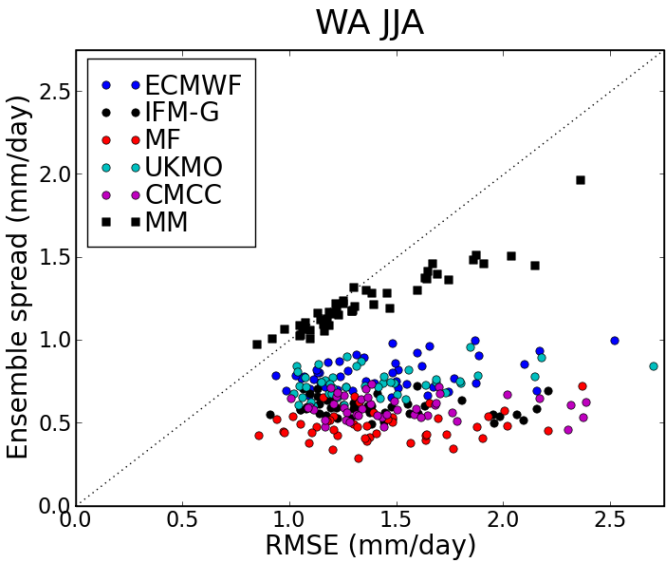
Deterministic scores

Anomaly correlation coefficient

$$\mathrm{ACC} = \frac{\overline{(o_i - \overline{o})(p_i - \overline{p})}}{\sqrt{\overline{(o_i - \overline{o})^2 (p_i - \overline{p})^2}}}$$

o : observations ; p : predictions ;
$i = 1, .., N_{years}$





Spread VS skill (RMSE)

- Individual models are underdispersive
- Multi-model increases spread without increasing RMSE

Deterministic scores

"mean-ACC" coefficient

- mACC : space and time anomaly correlation (Déqué et Royer, 1992)

$$\mathrm{mACC} = \frac{\overline{\langle (o_i - \overline{o}) \cdot (p_i - \overline{p}) \rangle}}{\sqrt{\overline{\langle (o_i - \overline{o})^2 \rangle} \cdot \overline{\langle (p_i - \overline{p})^2 \rangle}}}$$

Region	mACC MME
West Africa	0.223
"Sahel" (lat > 10° N)	0.160
"Guinea" (lat < 10° N)	0.249

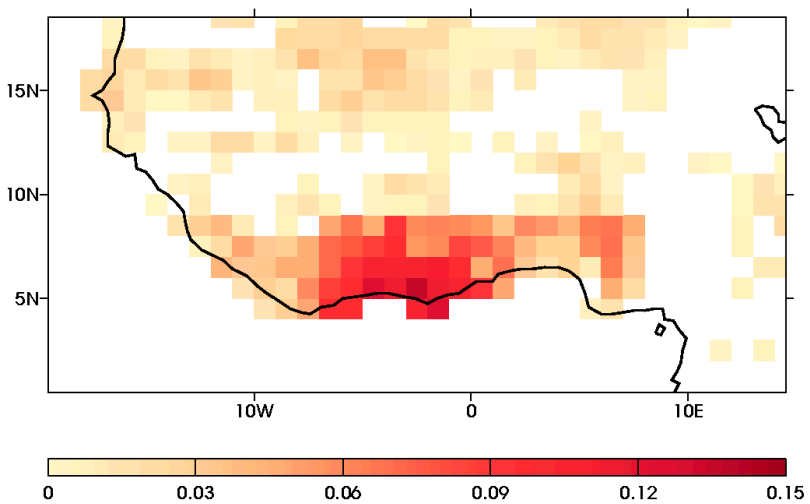
- Multi-model ensemble (MME) : improves most individual model scores
- Improvement due to
  - the larger ensemble size (10-member multi-model : 0.198)
  - individual model error compensation

Probabilistic formulation of an ensemble forecast

Forecasting a probabilistic event E

For each year of the 1960–2005 time period :

- Quantile-quantile calibration of precipitation amounts for the MME 45 members and 3 months (JJA)
- Fraction of forecast outputs predicting the event E : probability forecast $y = n_E/n$



RPSS West Africa : 0.98%

Ranked probability skill score (RPSS) (Epstein, 1969)

- Brier score for event E and JJA year i : $(y_i - o_i)^2$; $o_i = 0$ or 1
- Ranked probability score (RPS) : mean of Brier scores for precipitation deciles
- Reference : RPS of climatological distribution (leave-but-one mode)
- Skill score :

$$RPSS = 1 - \frac{RPS_{\text{MME}}}{RPS_{\text{clim}}}$$

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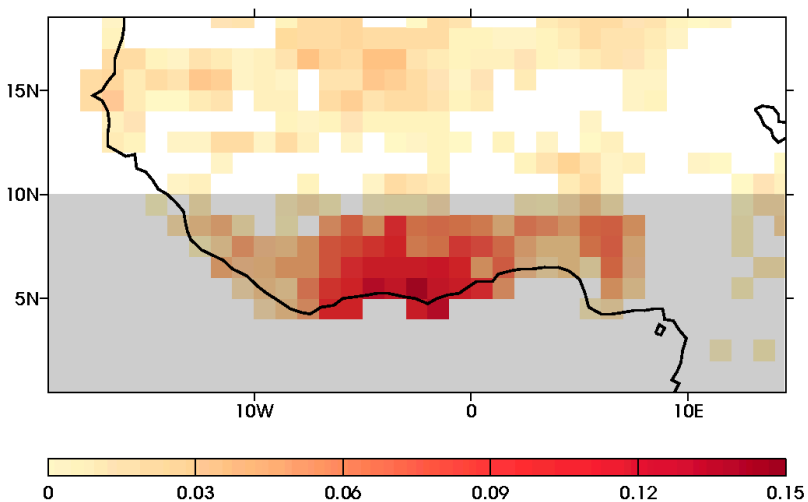

RPSS West Africa : 0.98%
RPSS "Sahel" : 0.25%

Ranked probability skill score (RPSS) (Epstein, 1969)

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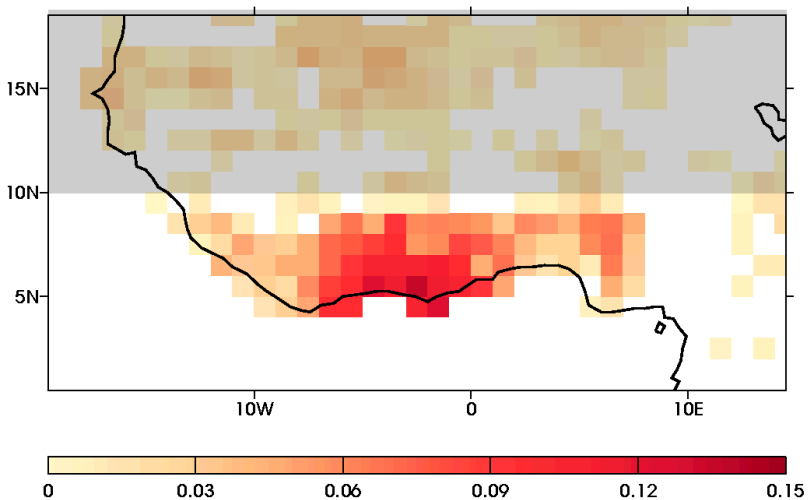

RPSS West Africa : 0.98%
RPSS "Sahel" : 0.25%
RPSS "Guinea" : 2.15%

Ranked probability skill score (RPSS) (Epstein, 1969)

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$$RPSS = 1 - \frac{RPS_{\text{MME}}}{RPS_{\text{clim}}}$$

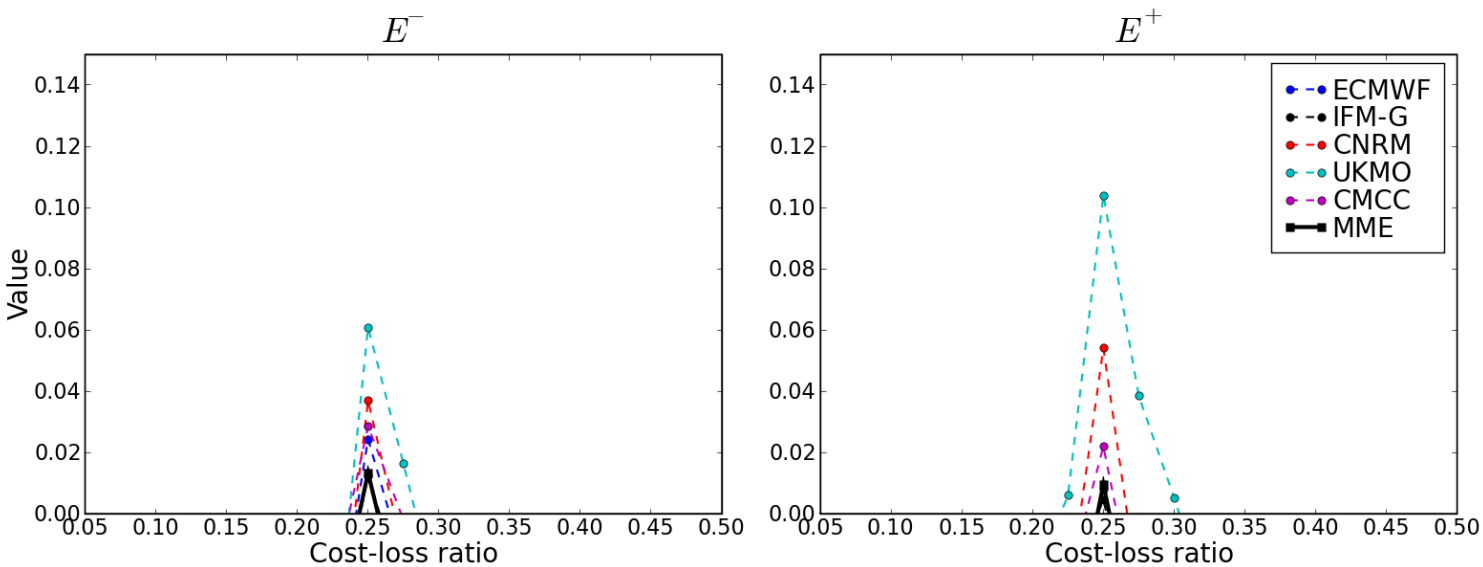
Potential economic value

Computation

- Simple "cost-loss" model (Palmer, 2002) $\Rightarrow$ expenses D due to a probabilistic event E with and without using the multi-model
- Decision thresholds for probability forecasts are optimized
- E^+ : precipitation $> 75\%$; E^- : precipitation $< 25\%$

	E happens: yes	E happens: no
E is forecast	C	C
E isn't forecast	L	0

$$V = \frac{D_{model} - D_{clim}}{D_{perf} - D_{clim}}$$



Links with SST

Why study links with SST ?

- West African region : links with SST are different between "Guinea" and "Sahel" regions
- Aim : check if observed links between precipitation and SST are replicated by the MME

SST data

- Observations : ERA-40 data until 1989, ERA-Interim afterwards (HadISST until 1981, then NOAA-NCEP SST : see Uppala et al., 2005)
- ENSEMBLES multi-model SST : 45 member ensemble mean

Statistic used

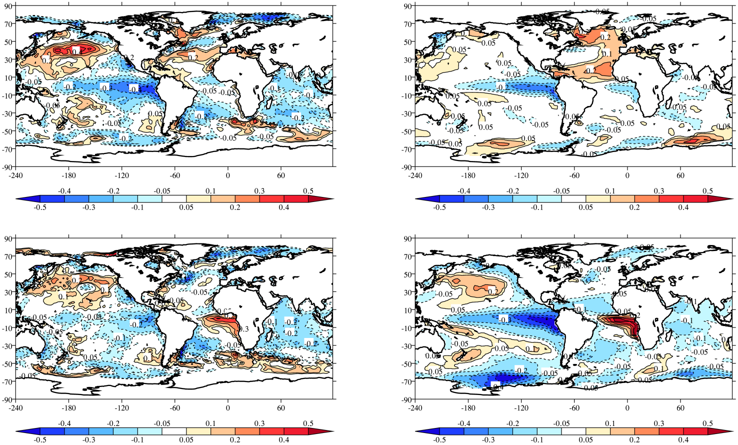
- Covariance between precipitation standardized anomalies over the "Guinea" and "Sahel" boxes and simultaneous global grid-point SSTs

Covariance between precipitation anomalies and SSTs

ERA and GPCC (JJA) | MME (JJA)

"Sahel" (> 10° N)

"Guinea" (< 10° N)



Unit : Kelvin

Concluding remarks

General conclusions

- The ENSEMBLES 45-member multi-model is evaluated over the stream 2 1960–2005 period
- Deterministic forecasts : the MME improves the spread and ACC of individual models
- Probabilistic forecasts : positive but low scores $\Rightarrow$ possible improvement using a better calibration, MOS...

Further research

- High contrast between scores over "Guinea" and "Sahel" regions although the multi-model reproduces in a similar way the observed SST-precipitation covariance patterns : other factors for predictability at this time scale ?
- Scores for the ENSEMBLES MME can be compared with those for other regions and seasons in Africa (Batté and Déqué, 2011. Tellus A, 63 : 283–299)

Acknowledgments

- ENSEMBLES data was produced by the European Commission FP6 Integrated Project ENSEMBLES (contract number 505539)
- GPCC is operated by DWD under the auspices of the WMO
- ERA-40 and ERA-Interim SST data were supplied by ECMWF

Thanks for your attention !