Generalized mapping-based precipitation calibration methodology for impacts modelling: a special look at the African regions

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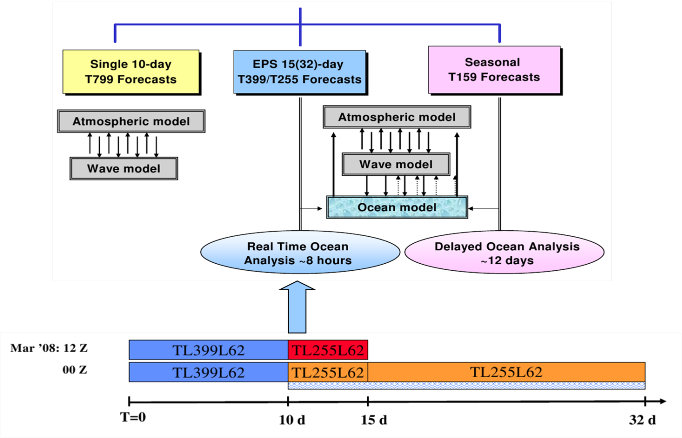
ECMWF main duty for QWeCI

To develop a seamless prediction system from medium-range to seasonal scales. Final aim is to provide the best ("unbiased") possible forecast at any lead time independently of the forecast systems (short-range, varEPS /monthly, seasonal)

ECMWF forecasting system



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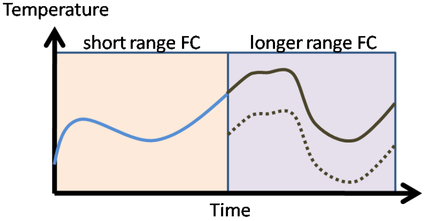
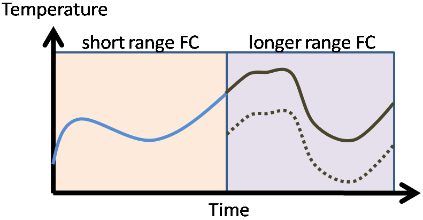


time

In accessing products from different sources we ideally want .... seamlessly in



time

space

outline

Main questions

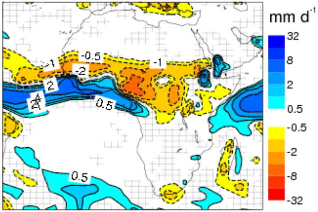
- What are IFS problems over Africa and do we see them in the short-range, varEPS/monthly and seasonal farecast systems SYS3/SYS4?
- How are the performances of ERA-Interim ove Africa?
- In other words, how “seamless” is the ECMWF over Africa?

SYS3 (31R1) against GPCP-2.1

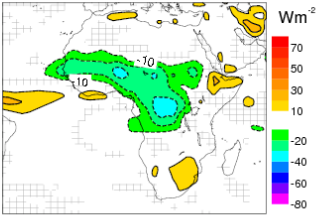
Precipitation Bias for JAS 2006 from SYS3 Hindcast. Verification against GPCP-2.1

- Rainfall displaced South
- Confirmed by negative bias in TOA IR radiation (lack of stratocumulus clouds?)

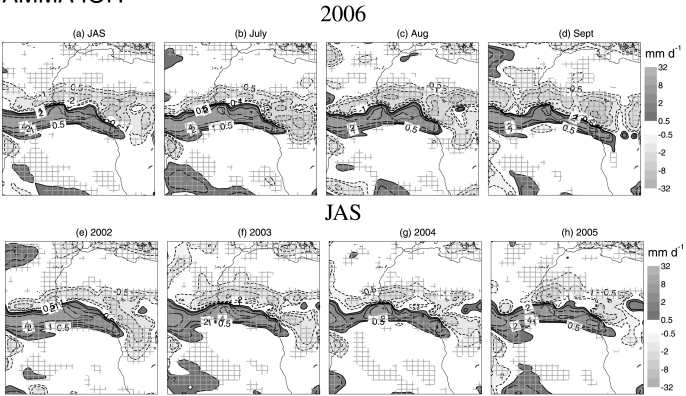
Precip Bias: SYS3 (31R1) - GPCP



IR bias: SYS3 (31R1) - GPCP



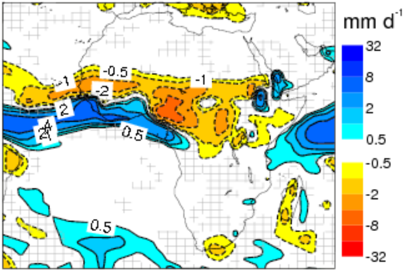
The bias is robust, month by month, and year by year. This for the 2006 AMMA IOP.



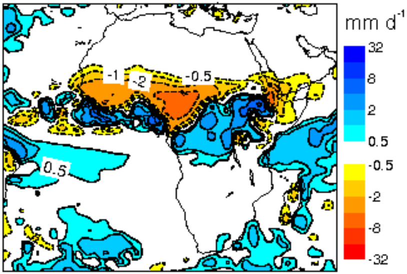
Tompkins and Feudale, 2010: Seasonal Ensemble Predictions of West African Monsoon Precipitation in the ECMWF System 3 with a Focus on the AMMA Special Observing Period in 2006. Wea. Forecasting, 25, 768â788.

An amalgamation of day 1 forecasts shows the same southerly shift for operational forecasts of JAS 2006 (recall cycle 31r1)

Precip Bias SYS3

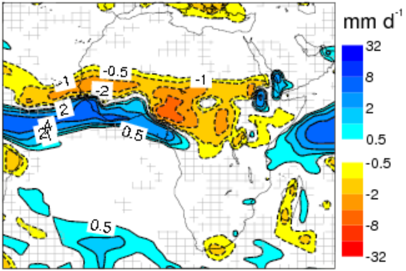


Precip Bias OPER DAY 1

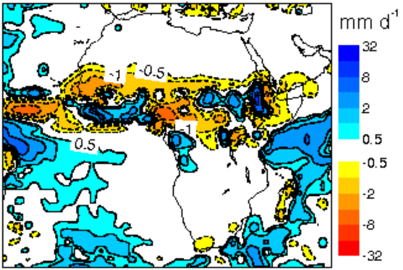


However, it is seen that the rainfall shifts northwards in the medium range: here at day 5.

Precip Bias SYS3



Precip Bias OPER DAY 5

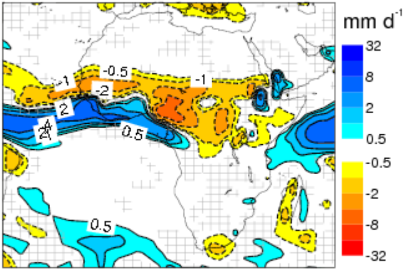


However, it is seen that the rainfall shifts northwards in the medium range: here at day 10.

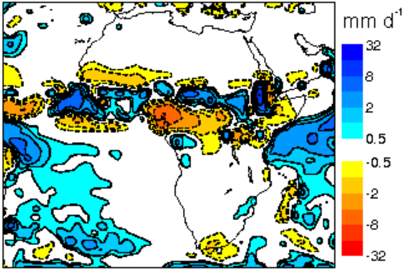
Note that....

The shift in rainfall as a function of the short range forecast indicates an imbalance between model climate and its analysis (spin-up/down)

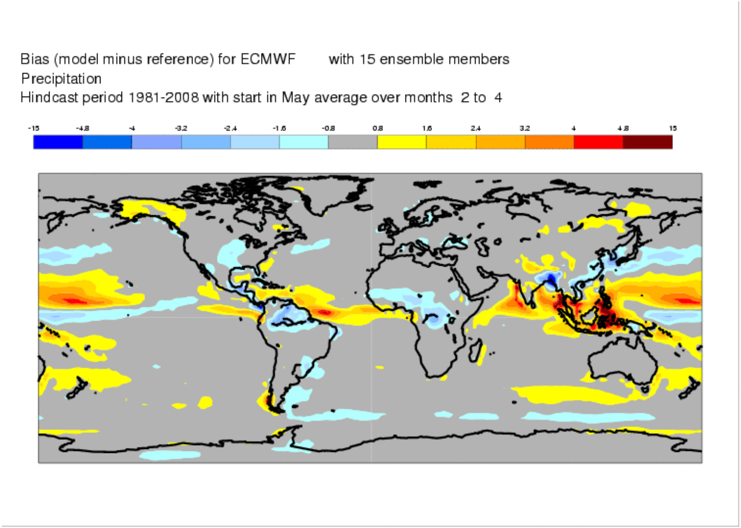
Precip Bias SYS3



Precip Bias OPER DAY 10

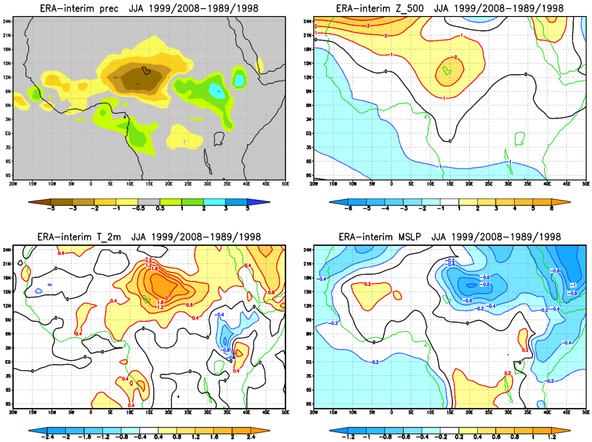


Precip Biases in SYS4 (36R4)



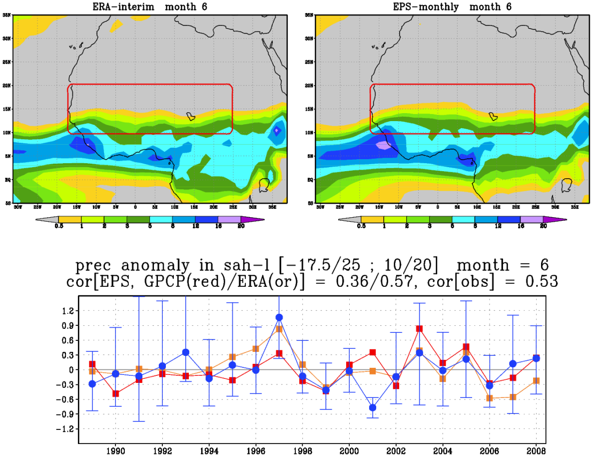
Precipitation Bias for JJA 1981-2006. SYS4 against GPCP-2.1 (*Courtesy of Laura Ferranti*)

ERA-Interim over Africa: JJA



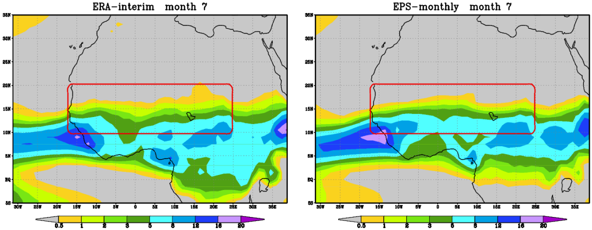
from Franco Molteni

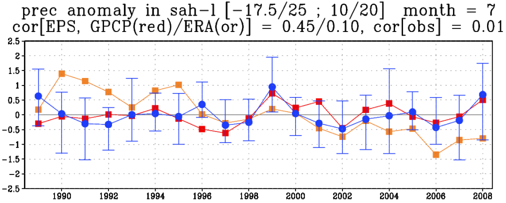
ERA-Interim over Africa: June



from Franco Molteni

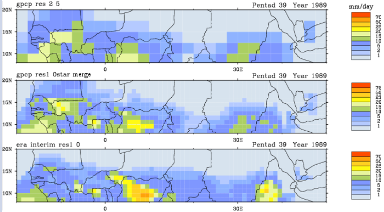
ERA-Interim over Africa: July





from Franco Molteni

The GPCP-merge dataset



$$G(1.0) = \mathcal{F}(r)G'(1.0)$$

where:

$$r = (\mathcal{E}(1.0) + \epsilon)/(\mathcal{E}'(1.0) + \epsilon).$$

$$\epsilon = max[0.1\langle\mathcal{E}'(1.0)\rangle, 0.2mm/day].$$

$\mathcal{E}(1.0)$	ERA-interim at 1^oresolution (on daily-GPCP grid)
$\mathcal{E}(2.5)$	ERA-interim aggregated on 2.5^o grid
$\mathcal{E}'(1.0)$	ERA-interim bi-linear interpolated from 2.5^o onto 1.0^o
$\mathcal{G}(2.5)$	GPCP original pentade data on 2.5^o grid (original dataset)
$\mathcal{G}'(1.0)$	GPCP bi-linear interpolated from 2.5^o onto 1.0^o
$\mathcal{G}(1.0)$	Merging of GPCP and ERA-interim on 1.0^o grid

Recap!

The inaccuracy of the delivered precipitation estimations needs to be corrected while awaiting for improved models (i.e physics, availability of new observations, improvements in data assimilation ...)
Biases are different across model cycles and at different lead times.
Without any calibration, products could be inconsistent in time.

Note therefore ....

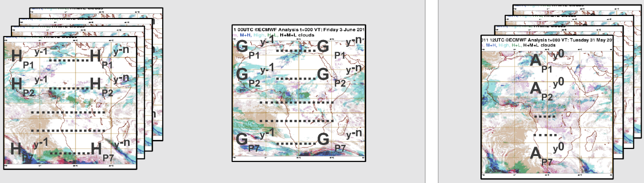
The emphasis is on model ensemble mean bias (and its correction for impacts), not on model skill (which for example improved recently with ocean observation network in Atlantic or improvements in the physical package).

Method Schematic

Monthly Hindcast
(m - ensemble members)

GPCP and Era-Interim
merged dataset

Monthly forecast
(p - ensemble members)



$$H_{anomaly}=\sum_{i=1}^{nEOF} EOF_i^H(x,y)PC_i^H(t)$$

$$G_{anomaly}(x,y,t)$$

$$EOF_i^M(x,y)=\langle G_{anomaly}(x,y,t)\ \ PC_i^H(t)\rangle_t \quad [i=1....nEOF]$$

Training

$$A_{anomaly}=\sum_{i=1}^{nEOF} EOF_i^H(x,y)\ \ PC_i^A(t)$$

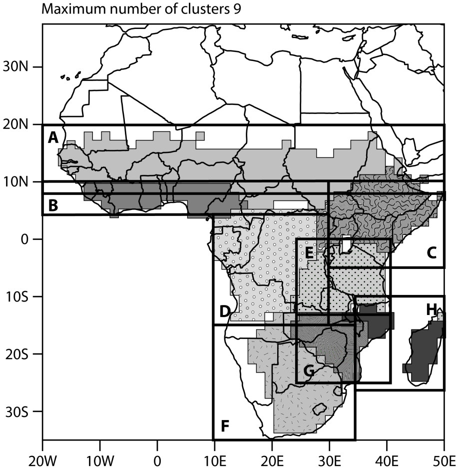
Actual forecast

$$A_{anomaly}^{Mapped}=\sum_{i=1}^{nEOF} EOF_i^M(x,y)\ \ PC_i^A(t)\quad [\forall\ p]$$

Mapping

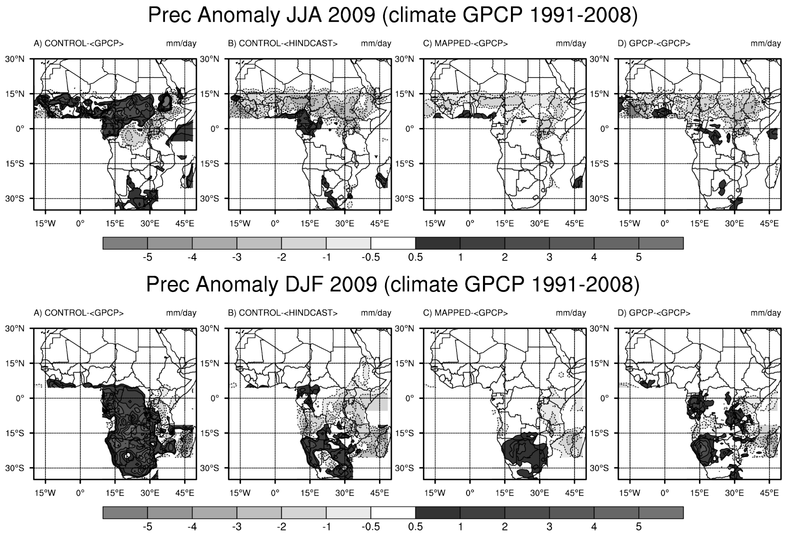
- The mapped EOFs can also be thought as a spatial ”correction” mask.
- Uses a GPCP-based dataset as observation dataset but can use any available dataset.
- It is applied to pentad (5 days average) precipitation anomalies
- it is applied separately to sub-regions “homogeneous” in terms of precipitation synoptic “to maximise” the model skills.

Africa MacroRegions definition

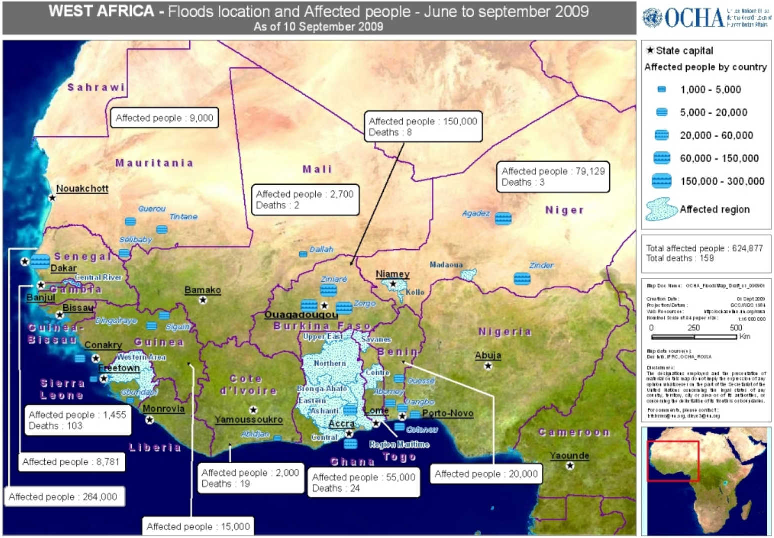


- Each location is represented by a set of 10 coordinates which are the principal componets (PCs) of monthly mean rainfall anomalies over Africa from GPCP-2.1 for all months in years 1979-2008.
- The K-means method uses the 10dimension time dependent coordinates to define clusters of grid points with coherent time variability,
- There is no constraint in the clustering method about geographical proximity, so the geographical boundaries of the cluster regions are only originated by the 'closeness' of the anomaly time series.

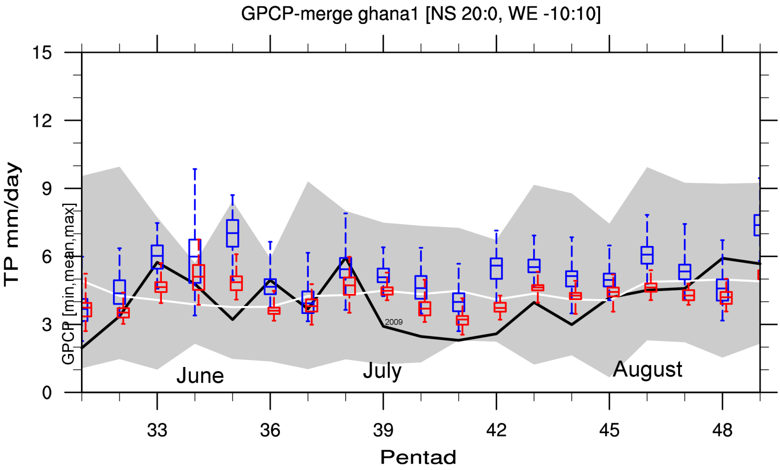
Overview of correction performance



The 2009 Ghana Floods



Comparing the climatology with what happened ...



Conclusions

- highlights needs for automated bias correction for impacts applications, especially considering frequent system updates.
- A new generalised mapping technique has been tested to calibrate precipitation over Africa from 1 to 5 pentade lead time (Monthly time scale) and will be extended to be applied to SYS4
- The technique is constructed to reshape the predicted precipitation anomaly to spatially “map” the observed precipitation
- It has to be stressed that the reshaping takes place only if the model possess some predictive skills.
- Instead being based on EOF mapping and not on PC mapping it cannot corrected for time shift.