Seasonal forecasts of temperature and precipitation anomalies in the Mediterranean region

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1. Aim of the study

Skillful seasonal forecasts are of interest for water management, energy and tourism sectors. This analysis compares three major seasonal forecast models [1,2,3] to test their ability to forecast summer (JJA) and winter (DJF) temperature and precipitation anomalies over the extended Mediterranean region (18°W-60°E; 18°N-55°N) at 1-month lead time.

2. Anomaly correlations

Despite the probabilistic nature of the seasonal predictions, the anomaly correlation of the ensemble mean forecast with respect to observations (deterministic skill measure) is commonly investigated [1].
Ensemble mean summer temperature anomalies are generally correlated with observed anomalies over the Mediterranean and North Africa, suggesting that a simple deterministic skill measure such as the ensemble mean of the forecasts can provide forecast skills. For other seasons and variables correlations are lower.

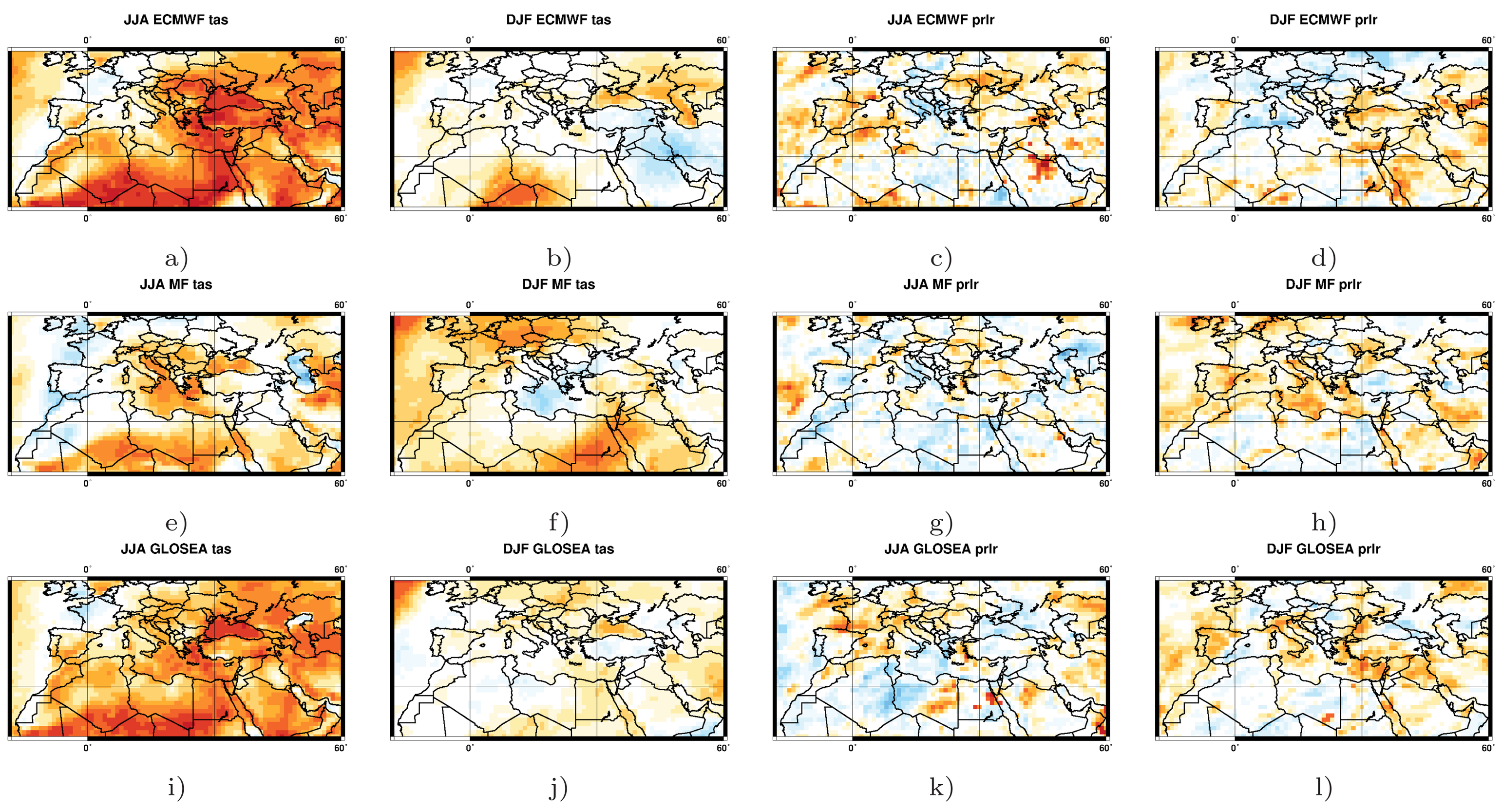

Figure 1. Anomaly correlation map of the ensemble-mean mean (a,b,e,f,i,j) 2m air temperature and (c,d,g,h,k,l) precipitation forecasts for JJA and DJF at 1 month forecast lead for ECMWFS5 (25 members), Meteo-FranceS5 (15 members) and GLOSEA5 (14 members) forecast models. Anomalies are calculated over 21 seasons (1994-2014) using ERA5 as a reference.

3. Continuous Ranked Probability Score

The **Continuous Ranked Probability Score (CRPS)** is a measure of the integrated squared difference between the cumulative distribution function (CDF) of the forecasts and the corresponding cumulative distribution function of the observations (ERA5). **The perfect value is 0**.

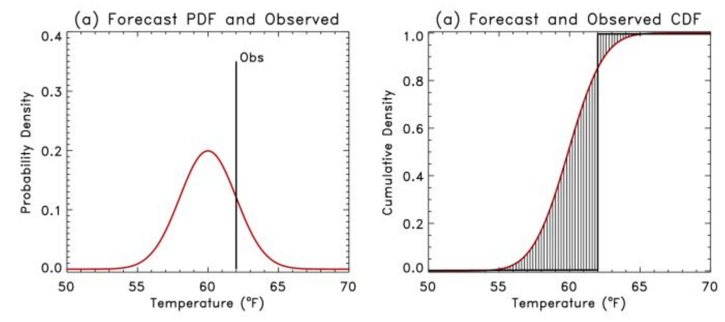

Figure 2. (left) PDF and (right) CDF of the forecast and the observation. CRPS is the total area between the CDF of the forecast and the CDF of the observation.

The three seasonal forecast models show similar skills in all seasons and for all variables. The easiest variable to predict is DJF precipitation anomaly, which is related to North Atlantic Oscillation; comparable skills are obtained for JJA precipitation and temperature anomalies. The most difficult variable to predict is DJF temperature, for which all models show relatively lower skill.

		CRPS			
Model	Ens.Member	TAS anom		PR anom	
		JJA	DJF	JJA	DJF
ECMWFS5 [1]	25	0.38	0.71	0.41	0.35
MFS5 [2]	15	0.44	0.74	0.43	0.35
Glosea5 [3]	14	0.40	0.73	0.45	0.38

Table 1. Seasonal forecast models, ensemble members considered and CRPS for forecasted JJA and DJF temperature and precipitation anomalies using ERA5 as a reference.

4. Rank histograms

The **rank histogram** is used to test the hypothesis that the observation is statistically indistinguishable from the ensemble members. For each observation, we sorted the N corresponding ensemble member forecasts from lowest to highest and then determinate the rank of observation with respect to the forecasts. The rank histogram shows the frequency of the N+1 observation ranks.

Flat histogram → consistent /reliable forecast
U-shaped → ensemble spread too small
Dome-shaped → ensemble spread too large
Asymmetric → model bias to one side

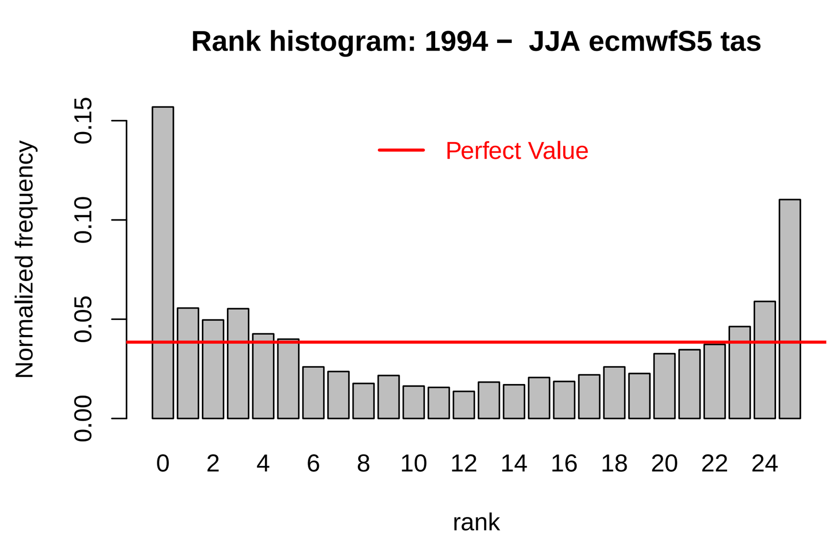

Figure 3. Rank histogram for one forecast, i.e. 1994 JJA temperature from ECMWFS5 model.

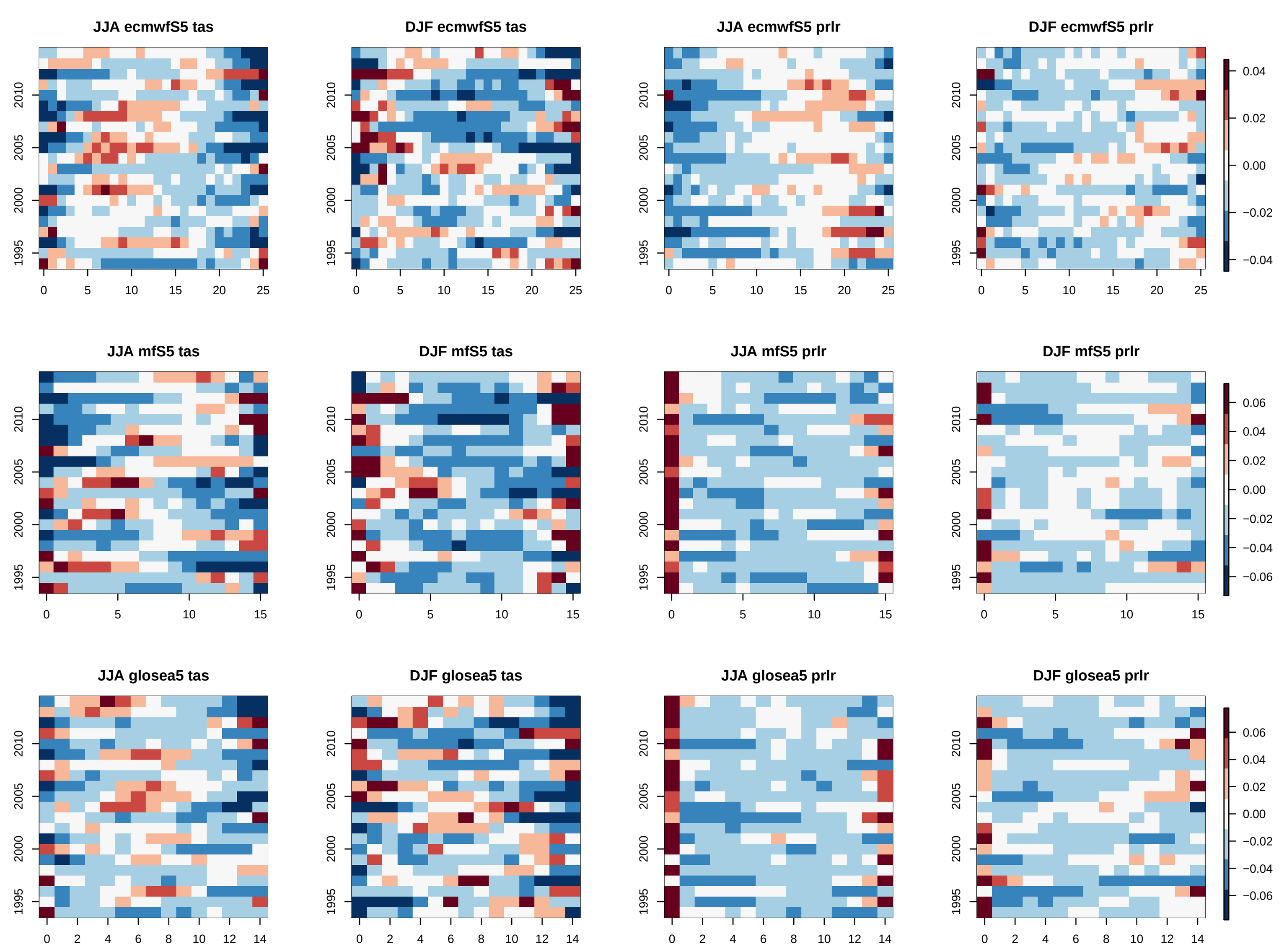

Figure 4. Rank matrices showing for each year (row) and each bin of the rank histogram (column) the deviation of the normalized frequency of the observation ranks with respect to the perfect value (i.e. the value corresponding to a flat histogram, see Fig. 3).

The twenty-one independent simulations (21 seasons) for each model and each variable are analyzed in terms of rank histograms. Figure 4 (column 4) shows that all models nicely reproduce the statistics of the DJF precipitation anomalies (flat histograms). While ECMWFS5 reproduces well also JJA precipitation anomalies, MFS5 and Glosea5 models present a systematic wet bias (histograms peak at rank=0) or a too small ensemble spread (U-shaped histogram). All models show some diffculties in reproducing the statistics of DJF temperature anomalies.

5. Conclusions

Probabilistic verification metrics used in this study allowed to characterize the ability of the seasonal forecasts models to reproduce winter and summer precipitation and temperature anomalies in the Mediterranean area, as well as to determinate their biases and the appropriateness of their ensemble spread.

The metrics employed (CRPS and rank histograms) agree in indicating DJF precipitation as the easiest variable to reproduce, probably owing to its relation with the North Atlantic Oscillation, and DJF temperature as the most difficult one.

Acknowledgments

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References

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