Regionally Improved Seasonal Forecast of Precipitation through Best Estimation of Winter NAO

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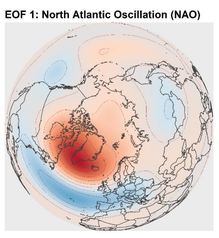
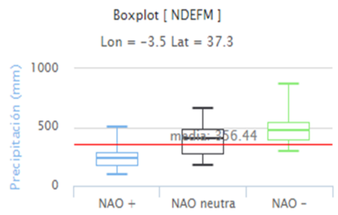
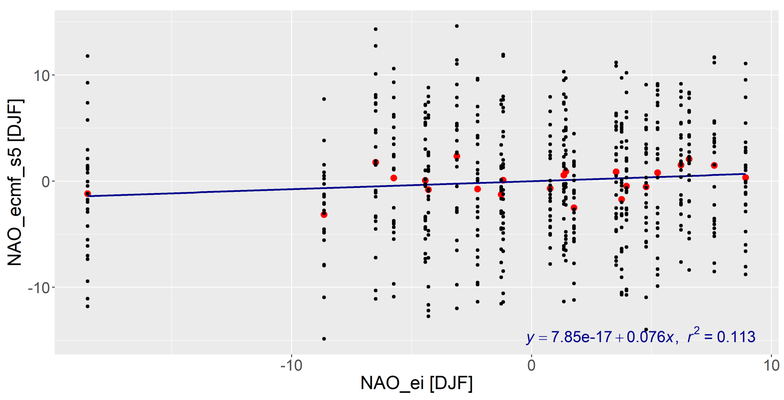
1.- Introduction



Although operational seasonal forecasting systems (SFSs) have shown little or no skill in European mid-latitudes, recent work has demonstrated that some SFSs based on dynamical models show remarkable skill in predicting winter NAO (e.g., Scaife et al. 2014), which, in turn, is known to have influence on the climate of the Southwestern European façade. On the other hand, Cohen and Jones (2011) have shown that part of NAO wintertime variability may be externally forced by the autumn boreal snow cover advance. Dobrynin et al. (2018) has also shown that SFS skill can be significantly improved by refining a dynamical ensemble through subsampling based on empirical NAO prediction. This work makes use of a *Best* winter NAO estimate (combining NAO information both from dynamical SFS and from empirical relationships) as a metric to modify weighting to different members of a SFS ensemble. We compare skill of a SFS ensemble using both weighted and customary unweighted ensemble members.



2.- How do seasonal forecasting systems predict the winter NAO?



Scatter plot: predicted NAO vs ERAI NAO of individual members (black dots) and ensemble mean (red dots) for ECMWF-S5 SFS

SClimWaRe, an empirical forecasting system of the winter NAO developed in AEMET and based on autumn snow cover teleconnection (Voces et al. 2016) has been also verified against ERAI NAO. The hindcast common period for the whole NAO characterization is restricted to 1997-2015 due to the availability of S-ClimWaRe input satellite snow cover products.

ECMWF-S5 and the empirical S-ClimWaRe system present the highest correlation with ERAI winter NAO over the hindcast period. However, ECMWF-S5 seems to be slightly over dispersive.

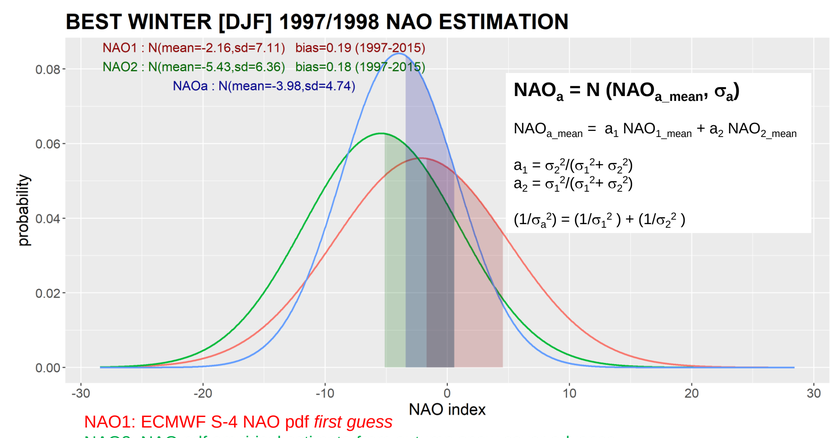
The ability to simulate the winter NAO by four operational SFSs stored in the Copernicus Climate Data Store has been analyzed.

ERA-Interim (ERAI) reanalysis has been used to obtain EOF patterns and NAO index time series similarly to Butler et al. (2016). For every SFS, the NAO index for each ensemble member has been obtained by projecting the 1st EOF onto the member Z500 gridded anomaly. Time series of the mean NAO index of the SFS ensemble has been compared to that of ERAI to assess the SFS NAO performance. Some results are presented in figure to the left for ECMWF S-5, and for all SFSs considered in table below.

Seasonal Forecasting System	R (NAO Ensemble Mean forecast - NAO ERAI) (1997-2015)	spread/RMSE (1997-2015 excluding extreme NAO 2009)
ECMWF System 5	**0.37**	**1.16**
ECMWF System 4	**0.14**	**1.09**
Met Office System 12	**0.09**	**1.01**
Météo-France System 5	**0.12**	**1.04**
S-ClimWaRe empirical model	**0.31**	**1.03**

3.- Best winter NAO estimate

Using this climate pattern performance by SFSs, statistical estimation theory (e.g. Kalnay, 2003) is applied to obtain an optimal estimation of winter NAO pattern and its uncertainty. The NAO *first guess* from operational SFSs can be corrected *assimilating* other NAO estimates, as e.g., those obtained from empirical relationships or teleconnections. Known errors characteristics (Gaussian errors are assumed here) of all *a priori* estimates are employed to retrieve the *best* estimation of NAO pdf. The method is similar to the Bayesian approach used by Coelho and Pezulli (2004) to estimate ENSO index seasonal forecast distribution.

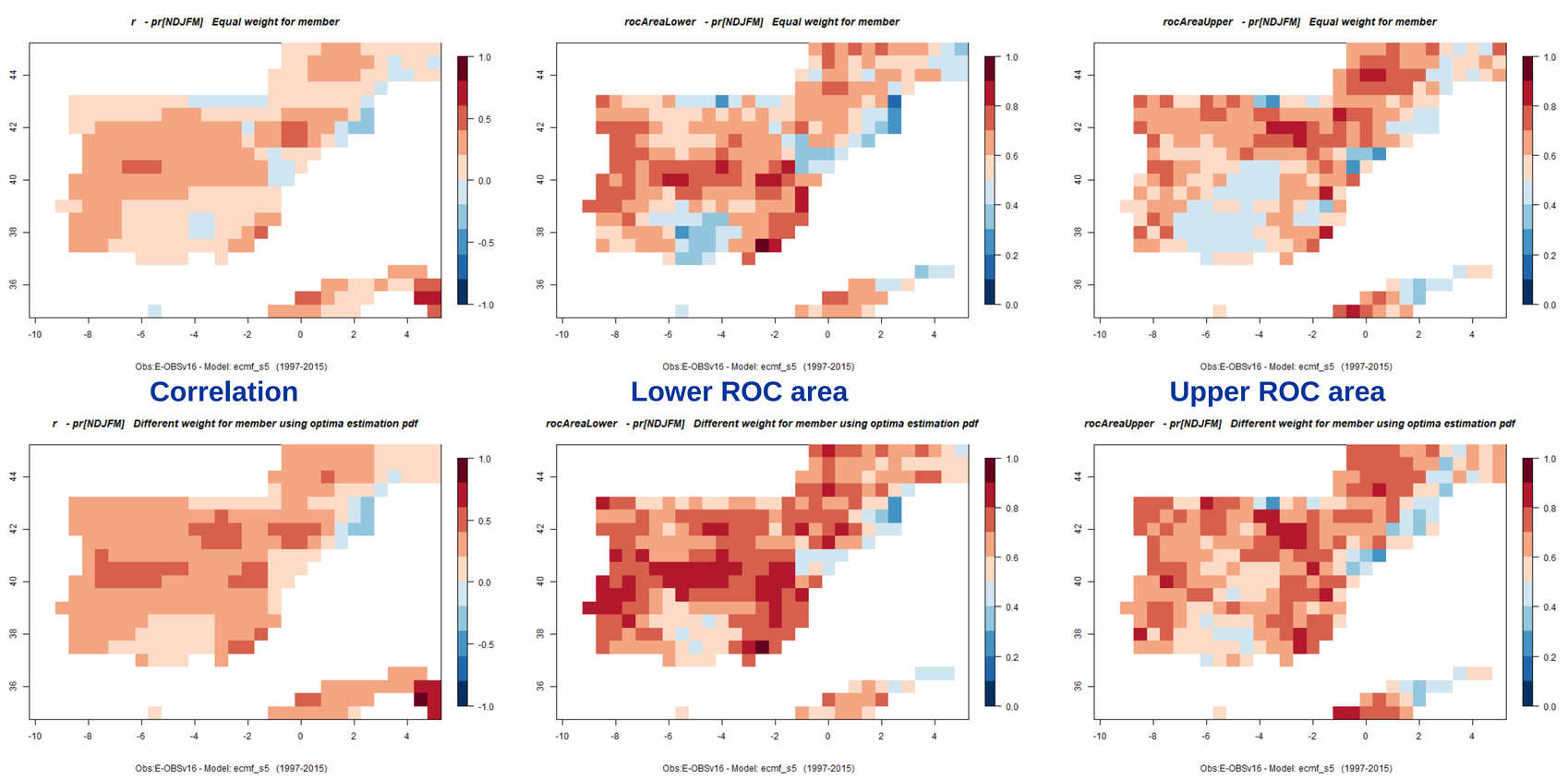


4.- Consistent seasonal EPS precipitation with Best Winter NAO estimate

In a latest step, the *first guess* precipitation pdf (equal weight for each SFS ensemble member) is consistently modified by correcting the different ensemble members weight, using a metric based on each member NAO and the *Best estimation* of NAO pdf.

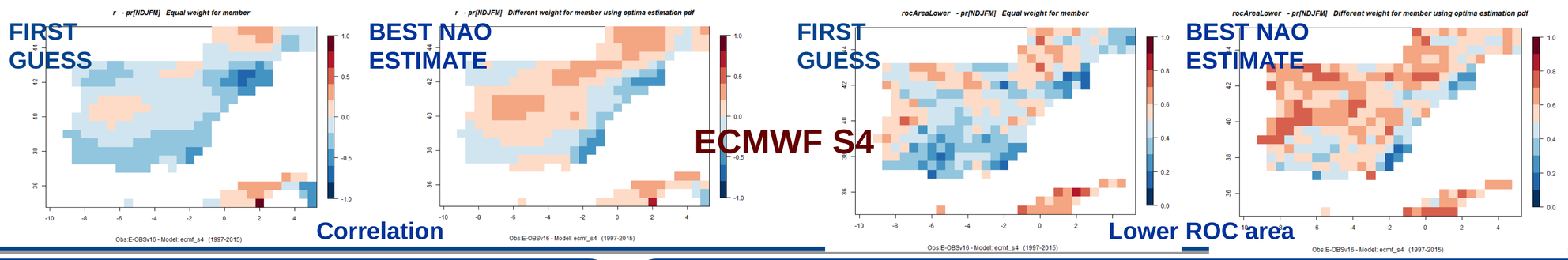
The procedure produces a noticeable improvement of the extended wirnter (NDJFM) precipitation forecasts over the hindcast period (1997-2015) for all the Copernicus seasonal forecasting systems presented above. See the figure to the right for seasonal forecasts of precipitation produced when the *first guess* is the ECMWF-S5. Verification uses E-Obs dataset as observations. Scores shown are deterministic for ensemble mean (r), and probabilistic for lower and upper terciles discrimination (ROC area).

Results confirm that a correct winter NAO distribution prediction is key to obtain skillful precipitation forecasts in this region.



Impact of *first guess* NAO: ECMWF S4 vs ECMWF S5

Better NAO forecast skill in the *first guess*, like that produced by the recent upgrade of the ECMWF Seasonal Forecasting System, has a consistent positive impact not only on the *first guess* precipitation forecasts, but also in the additional improvement produced by this *Best* NAO estimate method.



5.- Conclusions and future

- Members weighting of the ECMWF S5 and S4 SFSs making use of a metric based on each member NAO and the *Best estimation* of NAO pdf (combining NAO information from ECMWF S5 and empirical relationships) improves extended winter (NDJFM) skill scores for precipitation over the Iberian Peninsula.
- Improvement of the ECMWF SFS (S5 versus S4) immediately translates into improvement of the members weighted ECMWF SFS. Other tested SFS (Météo-France and Met Office) exhibit the same improvement when their members are weighted (not shown in this poster).
- Future work includes: i) combination of several dynamical SFSs for a better NAO estimation; ii) further improvements in the empirical model (also covering other seasons); and iii) longer verification periods.

References

- **Butler, A.H. et al. (2016). "The Climate-system Historical Forecast Project: do stratosphere-resolving models make better seasonal climate predictions in boreal winter?". RMetS. Vol. 142, 1413-1427.**
- **Coelho, C.A.S. and Pezzulli, S. (2004). "Forecast Calibration and Combination: A Simple Bayesian Approach for ENSO". J. of Climate, Vol.17, 1504-1516.**
- **Cohen, J., and Jones, J. (2011). "A new index for more accurate winter predictions". Geophys. Res. Lett., 38, L21701, doi:10.1029/2011GL049626.**
- **Dobrynin, M. et al. (2018). "Improved Teleconnection-Based Dynamical Seasonal Predictions of Boreal Winter". Geophys. Res. Lett., Vol.45, 3605-3614.**
- **Kalnay, E. (2003). "Atmospheric modelling, Data Assimilation and Predictability" Cambridge University Press.**
- **Scaife, A.A. et al. (2014). "Skillful long-range prediction of European and North American winters". Geophys. Res. Lett., Vol. 41, 2514-2519.**
- **Voces. J., et al., 2016. Sistema estadístico de predicción estacional para la gestión de los embalses en España. Nota Técnica nº 21 AEMET. http://www.aemet.es/es/conocermas/recursos_en_linea/publicaciones_y_estudios/publicaciones/detalles/NT_21_AEMET.**