GOBIERNO DE ESPAÑA
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA
AEMet
Agencia Estatal de Meteorología

MEDSCOPE
MEDiterranean Services Chain based On climate PrEdictions

Combination and weighting of seasonal forecasting information

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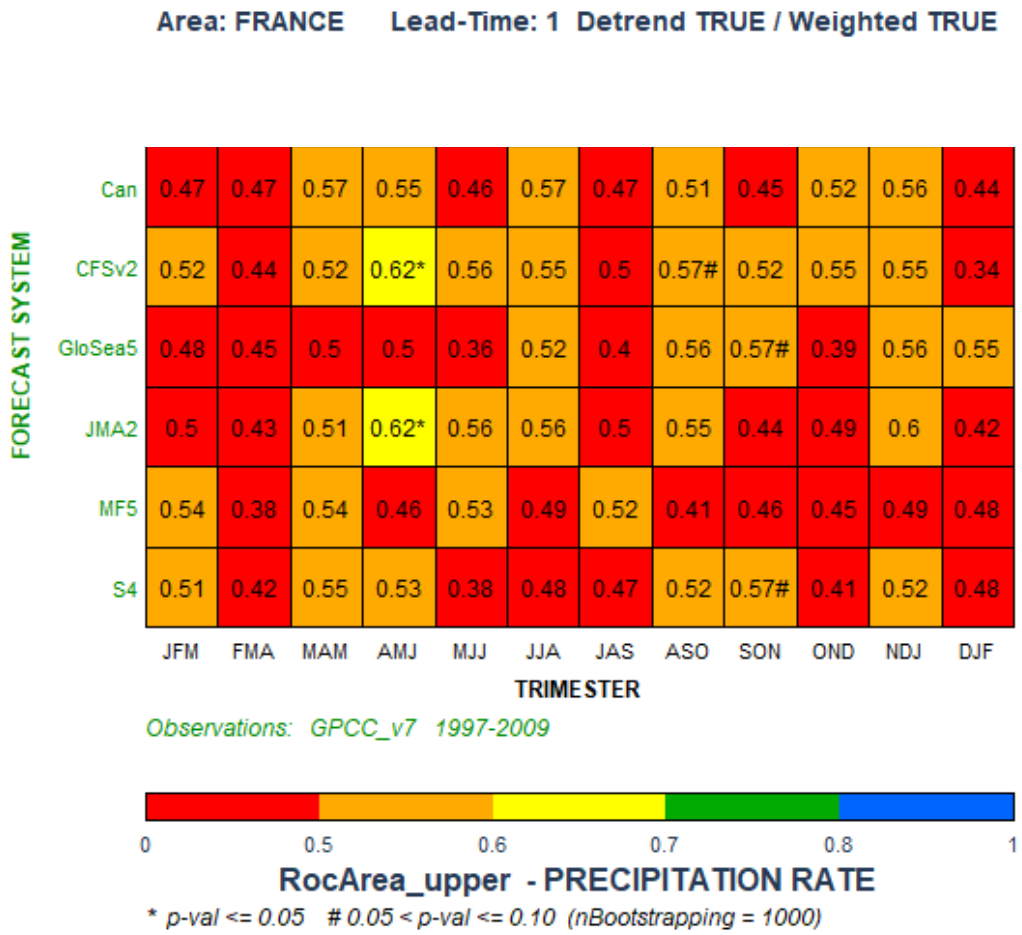
AEMET

Calibration and combination of different SFSs

- Because of difference in model construction **seasonal forecasts differ** between centres.
- A consolidated, single climate prediction can be obtained by **combining all contributing model predictions** to obtain a unified view.
- An essential step is to interpret each model's prediction in light of its **past performance (calibration).**
- So **combining predictions from different and complementary models helps improve** our predictive ability without needing to know in detail the ability dependencies of all models, which is very complex. All these facts, plus the **empirical evidence that on average it is better** to use multiple sources, makes the combination of different climate model predictions advantageous and advisable.

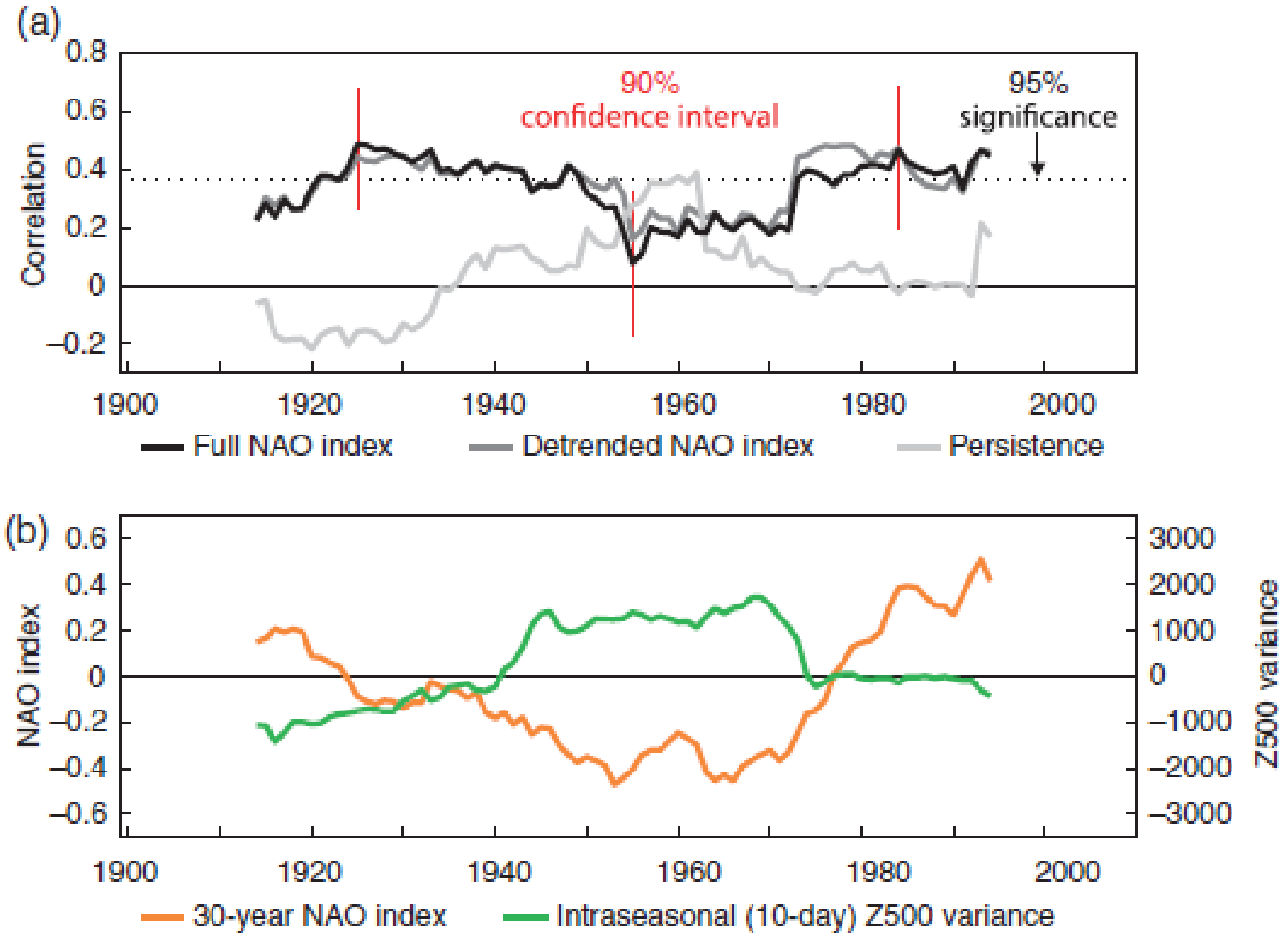
(SPECS Report http://www.specs-fp7.eu/sites/default/files/u1/SPECS_D53.1.pdf)

The best model is not always the same model



Different models have different abilities to predict the observed climate in distinct climate situations and regions (i.e. models prediction abilities can be complementary). **The best model is not always the same model** (i.e. prediction ability depends on many factors).

Performance of seasonal models depends on hindcast period.

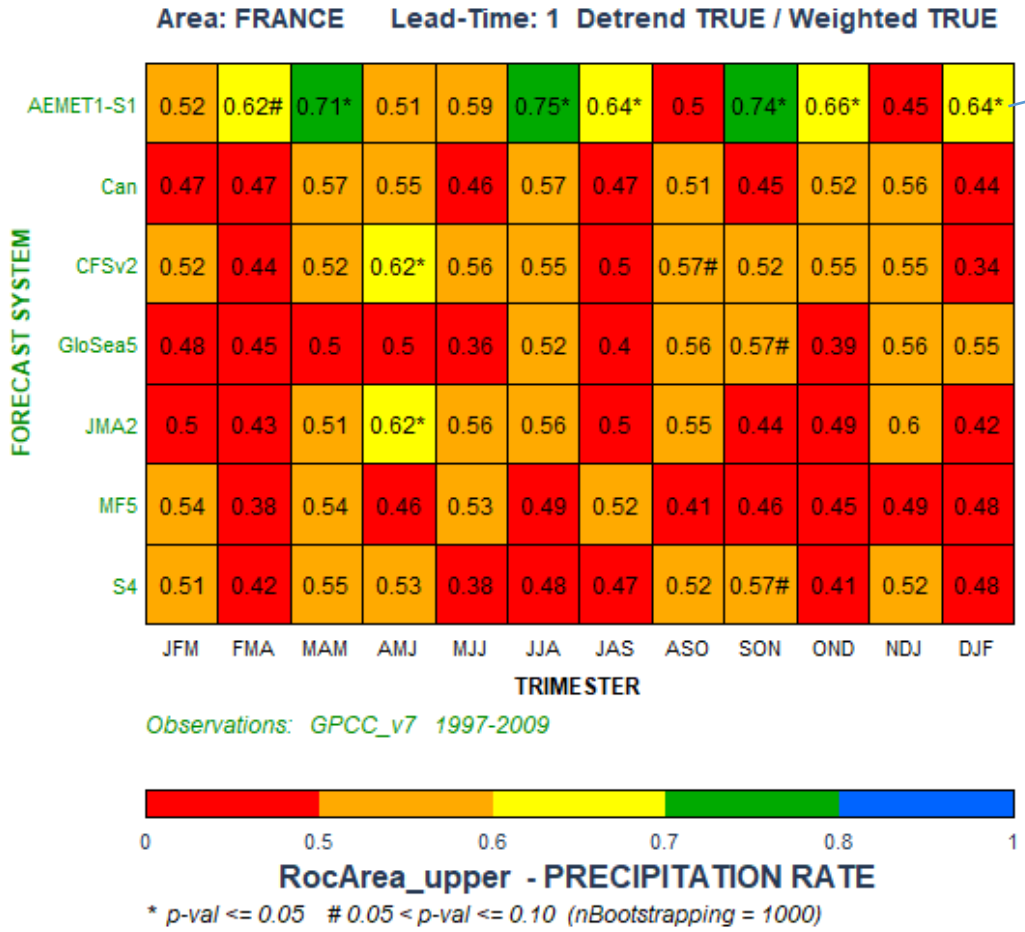


Mid-century period of low forecast skill coincides with a negative NAO phase but the relationship between the NAO phase/amplitude and forecast skill is more complex than linear (Weisheimer et al. 2017, doi:10.1002/qj.2976)

Besides, the **relatively short historical model predictions** currently available prevent an unequivocal identification of the best model.

http://seasonal.meteo.fr/sites/data/Documentation/doc_general/AEMET_MEDCOF_model_verification.pdf

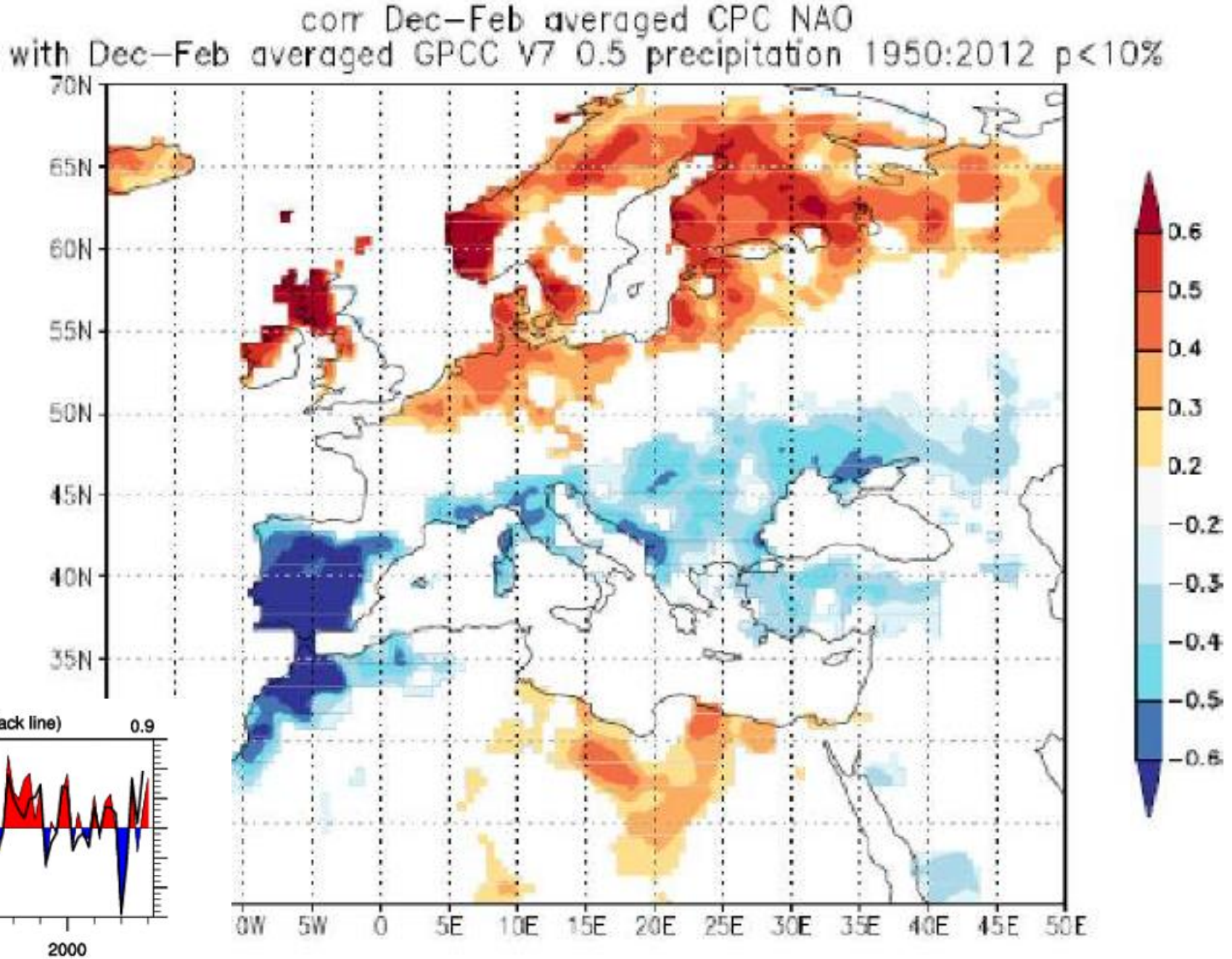
How can we regionally improve forecast of precipitation at seasonal timescale?

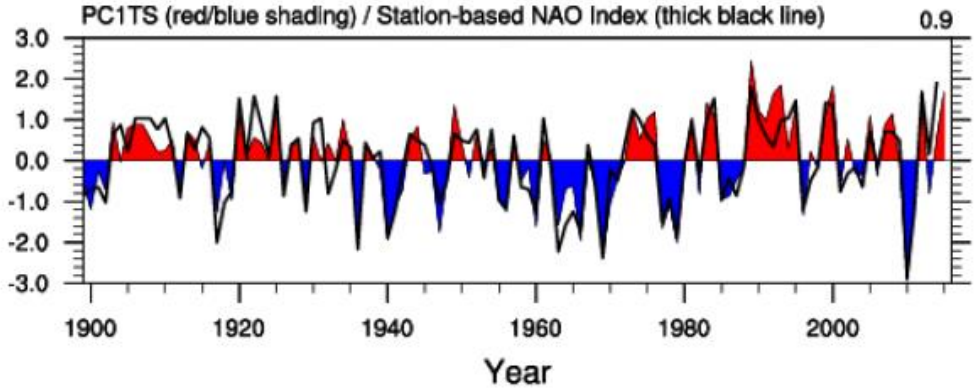


First version of the empirical system developed for the Mediterranean region in the frame of the ERA4CS MEDSCOPE Project

Different models have different abilities to predict the observed climate in distinct climate situations and regions (i.e. models prediction abilities can be complementary). **The best model is not always the same model** (i.e. prediction ability depends on many factors).

Strong correlation btw winter NAO and precipitation over IP and N Morocco

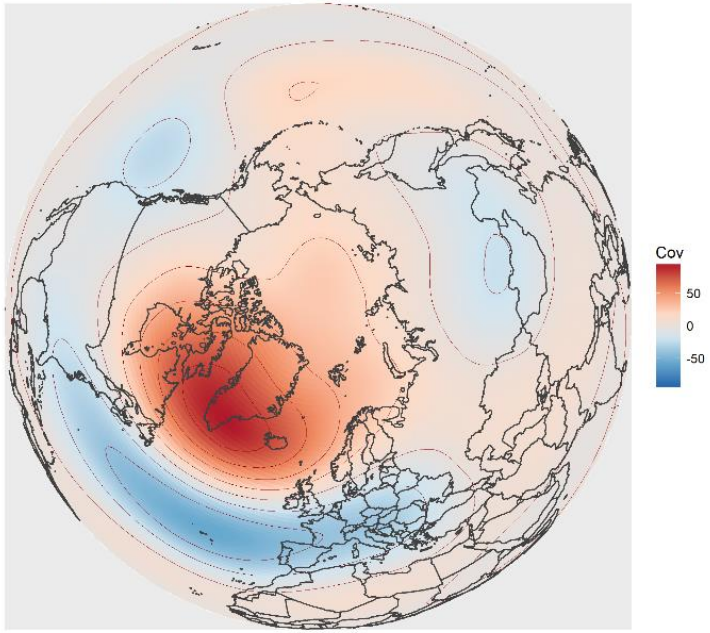




Regionally improved forecast of precipitation at seasonal timescale through the best estimation of winter NAO

- Although operational 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)
- Part of **NAO wintertime variability** may be externally forced by the autumn boreal **snow cover advance** (Cohen and Jones 2011)
- SFSs skill can be significantly improved by refining a dynamical ensemble through **subsampling based on empirical NAO** prediction (Dobrynin et al. 2018)
- **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.

EOF 1: North Atlantic Oscillation (NAO)



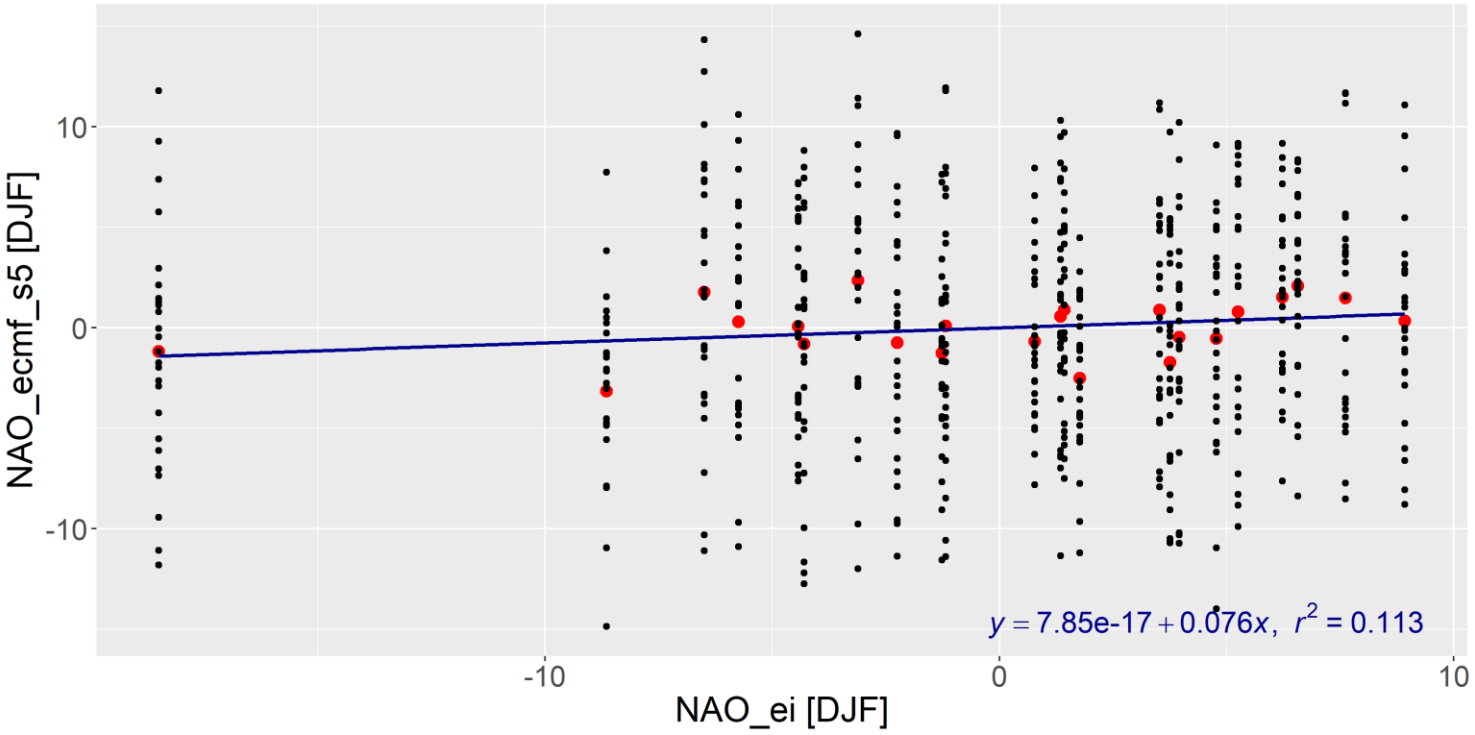
How well is NAO forecasted by SFSs?

SFS	R (For NAO – ERA-I NAO) (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

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

S-ClimWaRe, an empirical forecasting system of the winter NAO 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

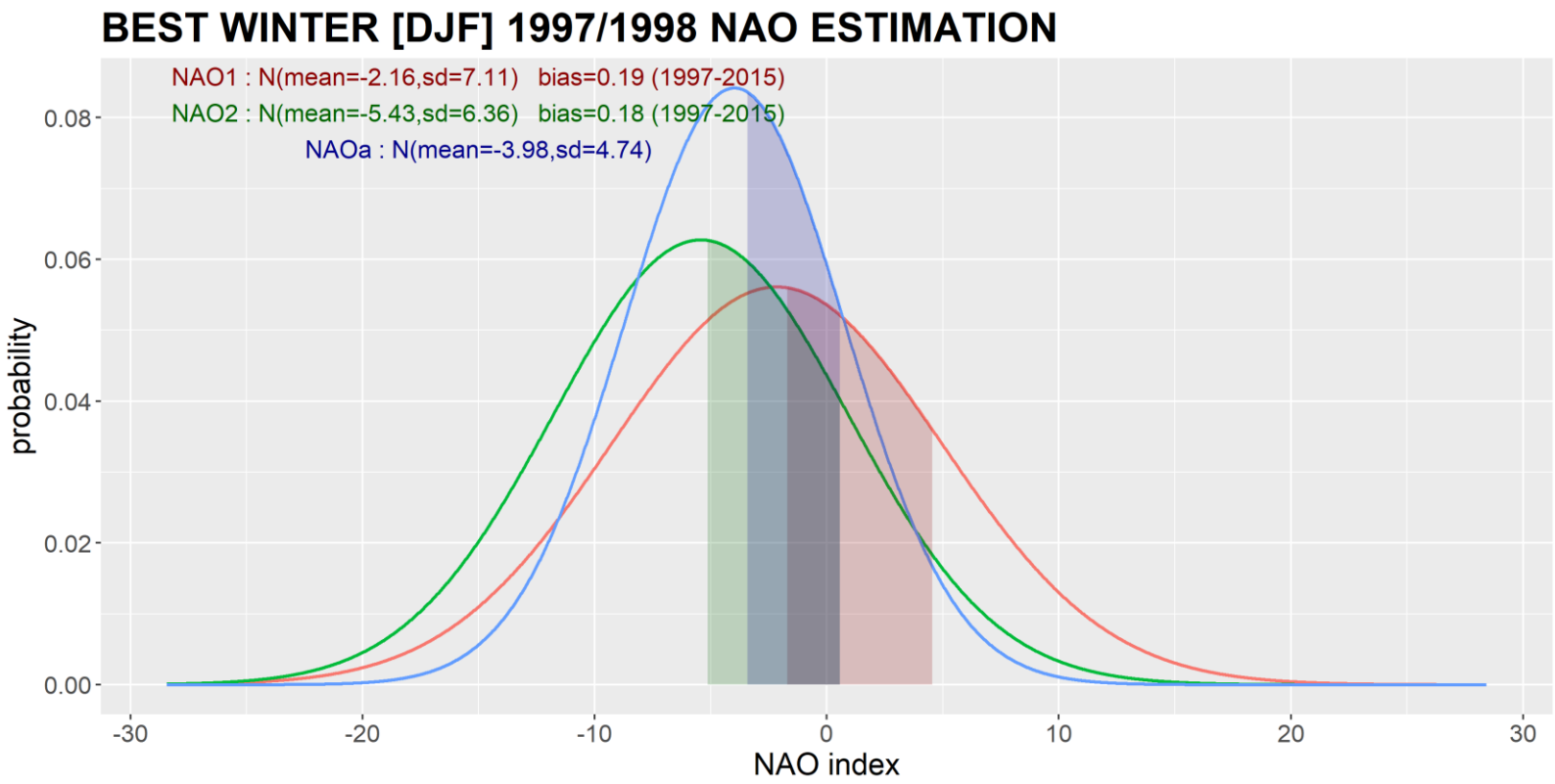
Comparison of NAO index: SFS vs ERA-Int



- ERA-Int used to obtain EOF patterns and NAO index time series (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 ERA-Int to assess the SFS NAO performance.

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



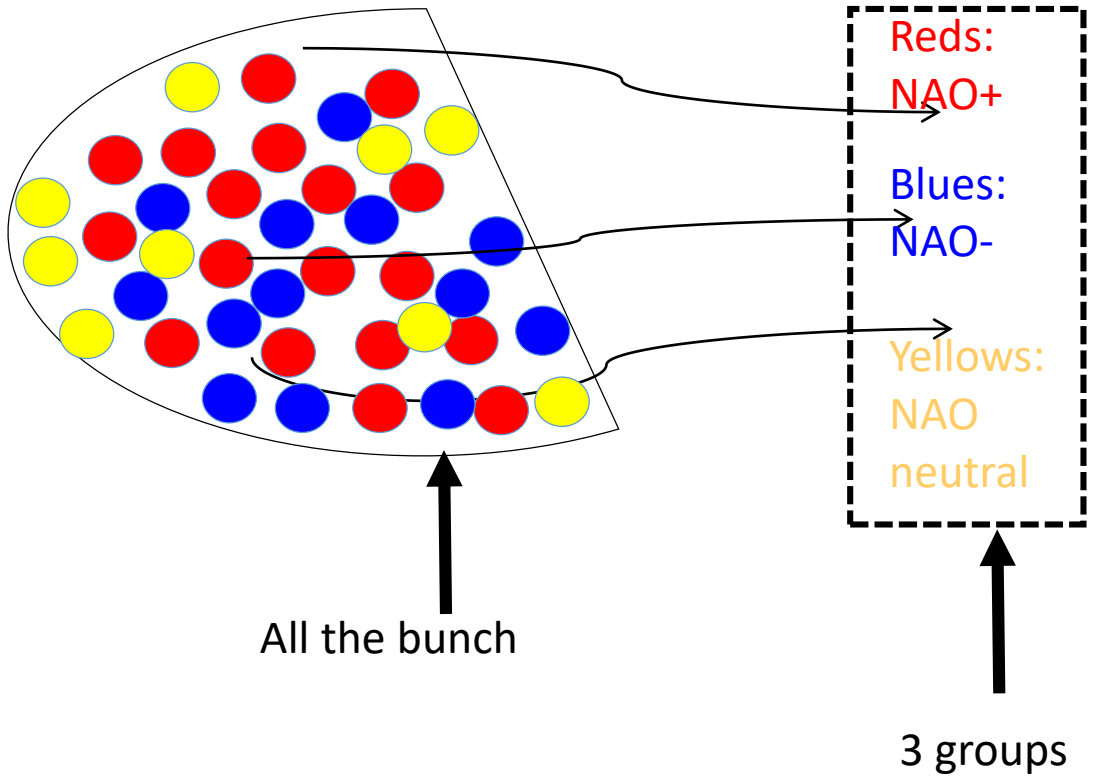
NAO1: ECMWF S-4 NAO pdf *first guess*

NAO2: NAO pdf empirical estimate from autumn snow cover advance

NAOa: *a posteriori best* NAO pdf obtained by statistical linear estimation

Objective tools for combining and synthetizing information:
ensemble subsampling or weighting

Contribution of AEMET to MEDSCOPE Task 3.4 [Forecast system combination and selection of sub-ensembles for applications]



- We will work on an approach of ensemble **members selection based on their consistent evolution with known drivers** (Dobrynin et al. 2016).
- The selection/weighting of ensemble members will be **applied to the tailored service for water reservoirs management** developed in task 4.2.
- Is our **ensemble member evolving according to the canonical response** of winter NAO to October Siberian snow advance?

Consistent seasonal EPS precipitation with Best Winter NAO estimate (I)

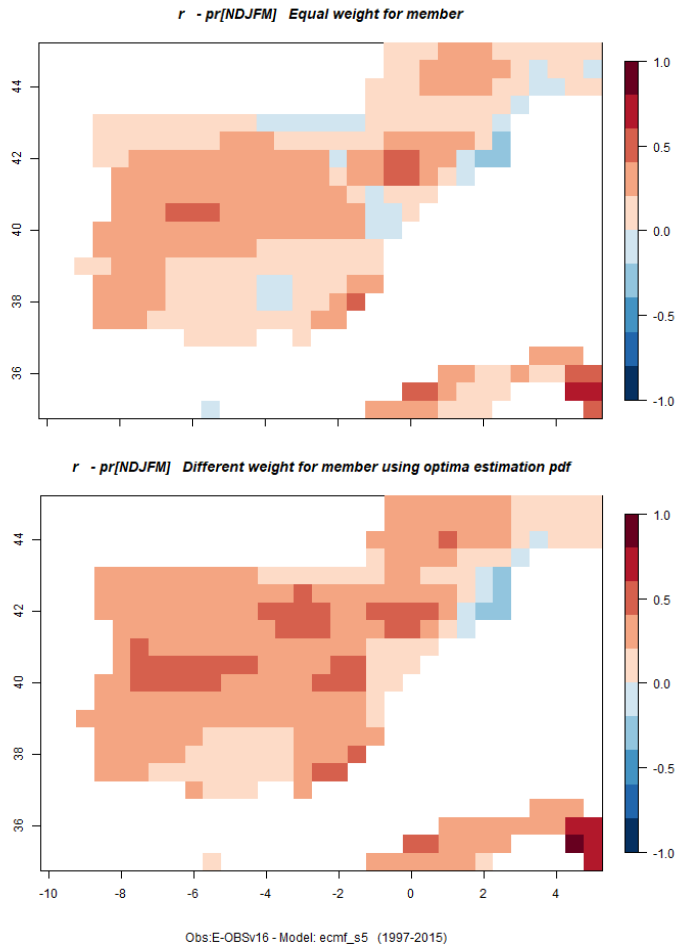
- *First guess* precipitation pdf (equal weight for each SFS ensemble member) is consistently modified by correcting the different ensemble members weight, using a metric based on each member NAO and the *Best estimation* of NAO pdf.

- The procedure produces a noticeable improvement of the extended winter (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.

Correlation Coef.

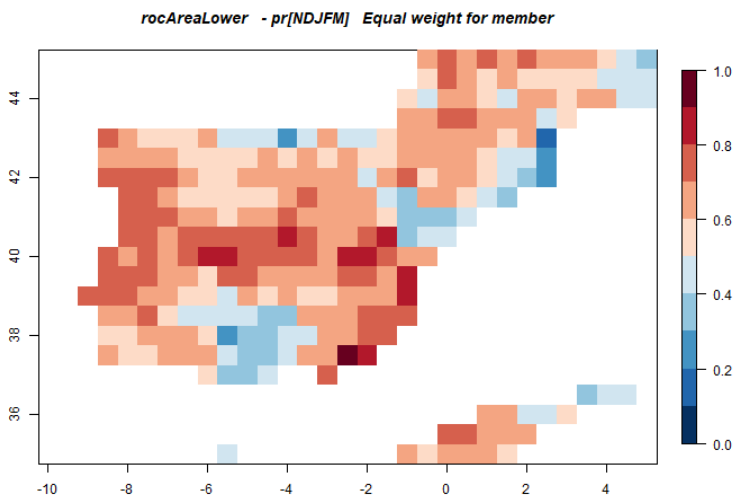


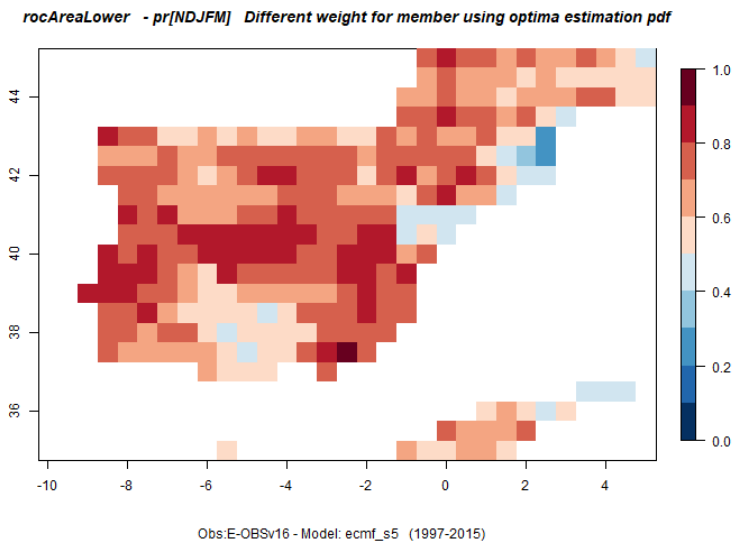
without weighting

with weighting (using a metric based on each member NAO and the Best estimation of NAO pdf)

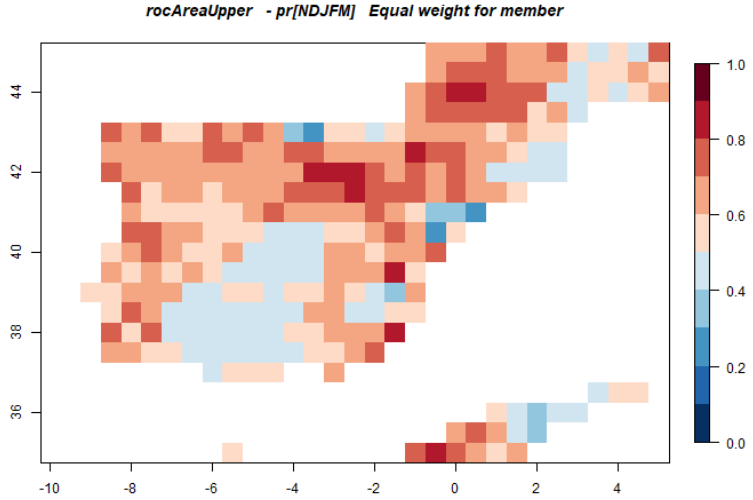
Consistent seasonal EPS precipitation with Best Winter NAO estimate (II)

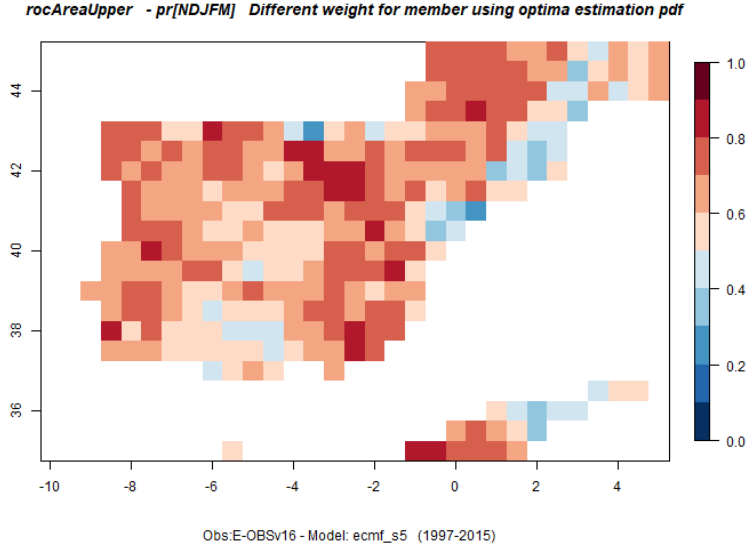
Lower ROC area





Upper ROC area





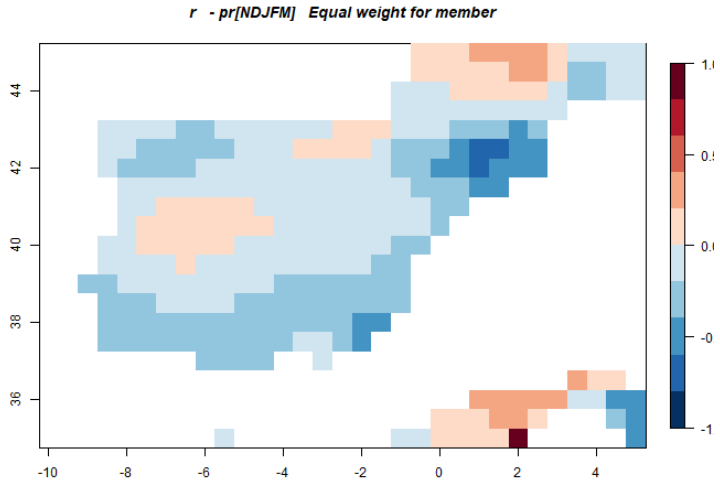
without weighting

with weighting (using a metric based on each member NAO and the Best estimation of NAO pdf)

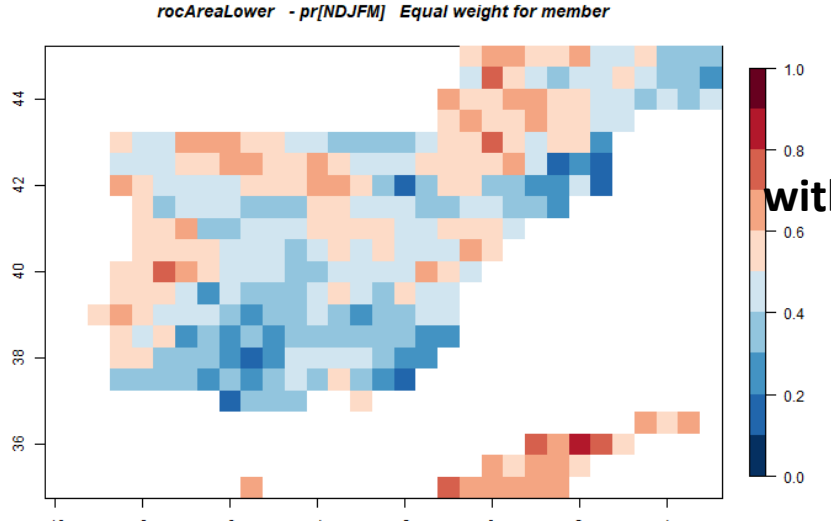
Impact of first guess NAO: ECMWF S4 vs ECMWF S5

Better NAO forecast skill in the *first guess*, like that produced by the recent upgrade of the ECMWF SFS, 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.

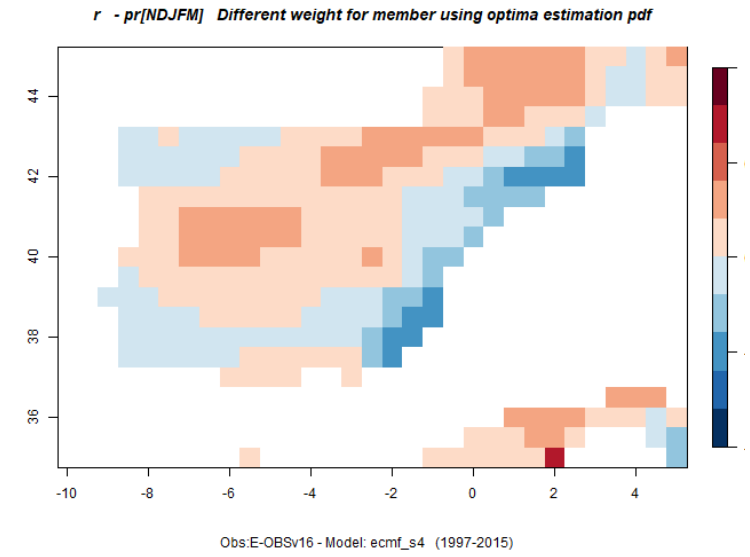
Correlation Coef.

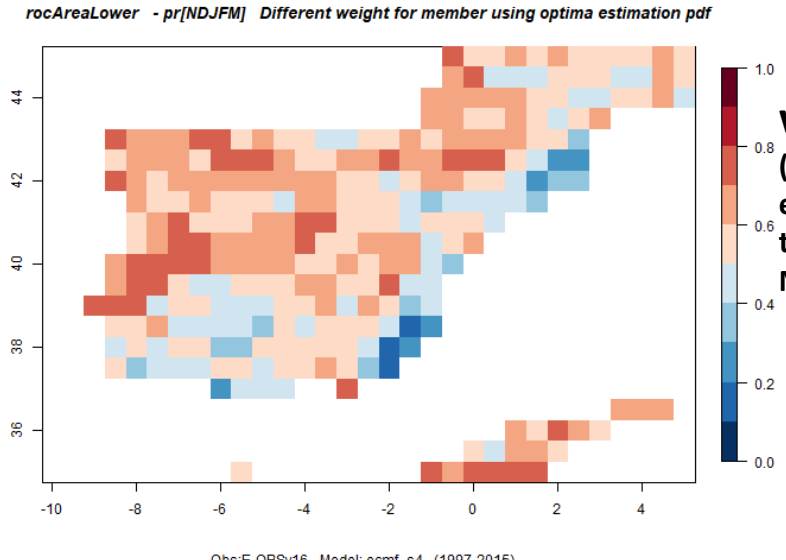


Lower ROC area



without weighting





with weighting
(using a metric based on each member NAO and the Best estimation of NAO pdf)

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 UK Met Office) exhibit the same improvement when their members are weighted (not shown here).
- 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.