A NAO-based subsampling approach for winter seasonal predictions

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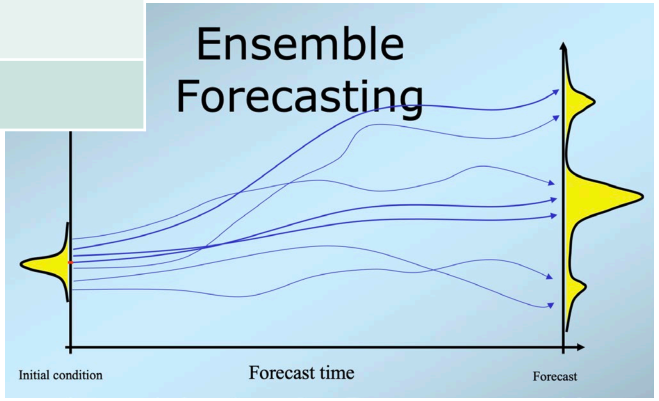
Introduction

esa

Weather forecasts | **Seasonal forecasts** | **Decadal forecasts** | **Climate scenarios**

few hours → **2 weeks** → **1 year** → **30 years**

WHAT A SEASONAL FORECAST IS
Information about average seasonal conditions
Forecast over a large region
Shifts in probabilities



Seasonal forecasts provide a range of possible climate changes that are likely to occur in the season ahead. It is a **probabilistic forecast** based on the production of an **ensemble of simulations**.

To forecast the conditions for the upcoming season compared to a given reference period, every month a set of simulations is produced, and the resulting probability distribution is compared with the reference climatological one produced by the same system for the same season (*i.e.* **hindcast climatology**).

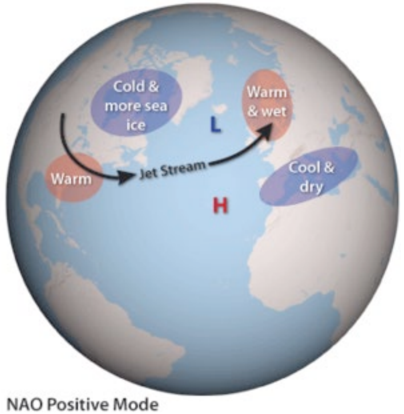
Introduction

The idea is to propose a subsampling methodology designed to **improve the quality of the winter seasonal forecast** over the Euro-Mediterranean sector, in principle **applicable in real-time operations**:

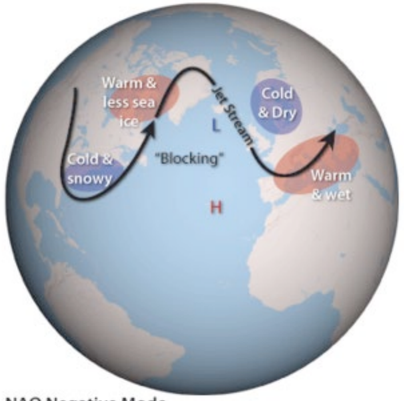
- ✓ Rely on the ensemble itself (e.g. in decadal framework, Smith et al., 2020)
- ✓ Rely on external sources of information (e.g. observational predictors; Dobrynin et al., 2018; Dobrynin et al., 2022)

Which is the subsampling criterion?

Since the known impact of the **North Atlantic Oscillation** on winter weather condition over Europe, we aim at finding the ensemble **members more reliable in NAO representation** under the hypothesis that the improvement in NAO will be reflected also in terms of “observables of interest” (e.g. T2m and precipitation)



NAO Positive Mode



NAO Negative Mode

Subsampling approaches

- **Ensemble mean NAO subsampling:** we select the ensemble members with NAO closest in sign and amplitude to the value of the **ensemble mean NAO at the beginning of the forecast (lead season 0)**

- **Empirical NAO subsampling:** we select the ensemble members with NAO closest in sign and amplitude to the value of an **independent estimate of NAO for the target season**

✓ In both cases we retain 1/3 of the full ensemble

✓ NAO computed following Li and Wang (2003) definition

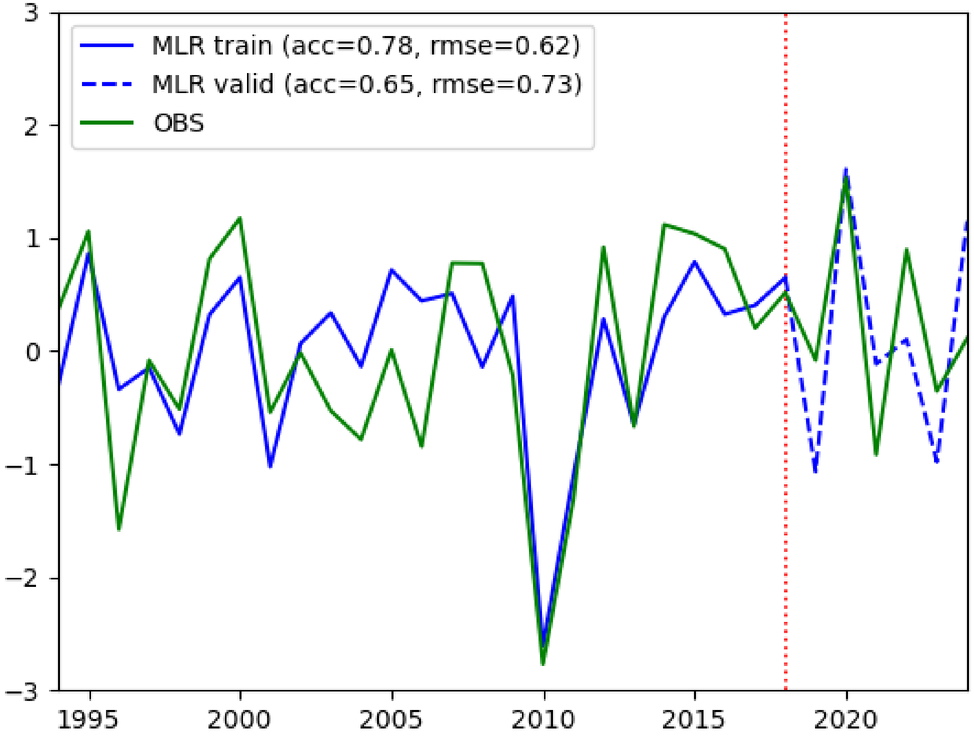
✓ **November initialization**: target season **DJF**

Both the approaches have been applied in C3S multi-system ensemble and for CMCC-SPS3.5

C3S multi-system ensemble	hindcast size	initialization strategy
CMCC-SPS3.5	40	burst
DWD-GCF2.1	30	burst
ECMWF-SEAS5	25	burst
METEO-FRANCE System 8	25	lagged
UK-MetOffice- GloSea6v02	28	lagged
JMA- CP3	10	lagged
NCEP-CFSv2	20	lagged
ECCC-CanAM4	10	burst
ECCC-GEM5-NEMO	10	burst

Empirical NAO definition

DJF NAO OBS and MLR - (1993/1994-2023/2024)

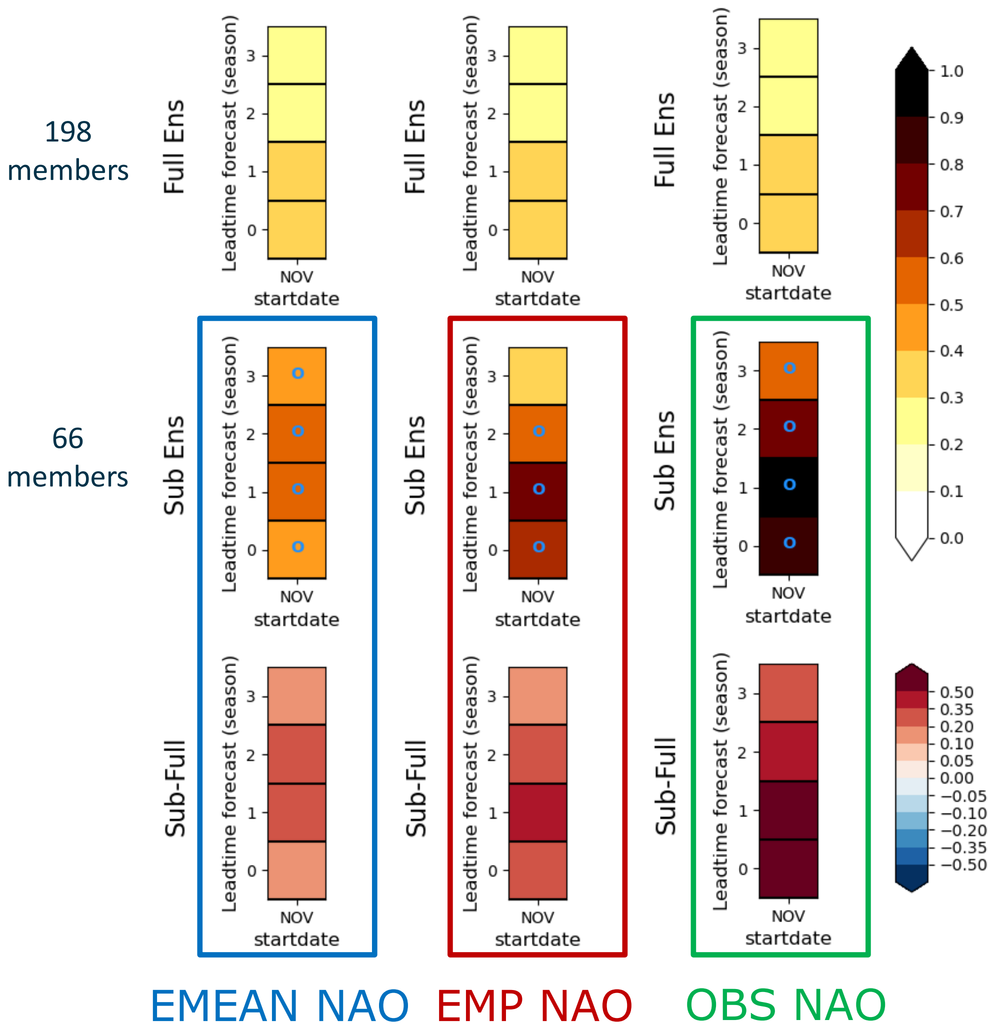


Empirical DJF NAO produced following multiple linear regression (MLR) approach as in *Wang et al.* (2017):

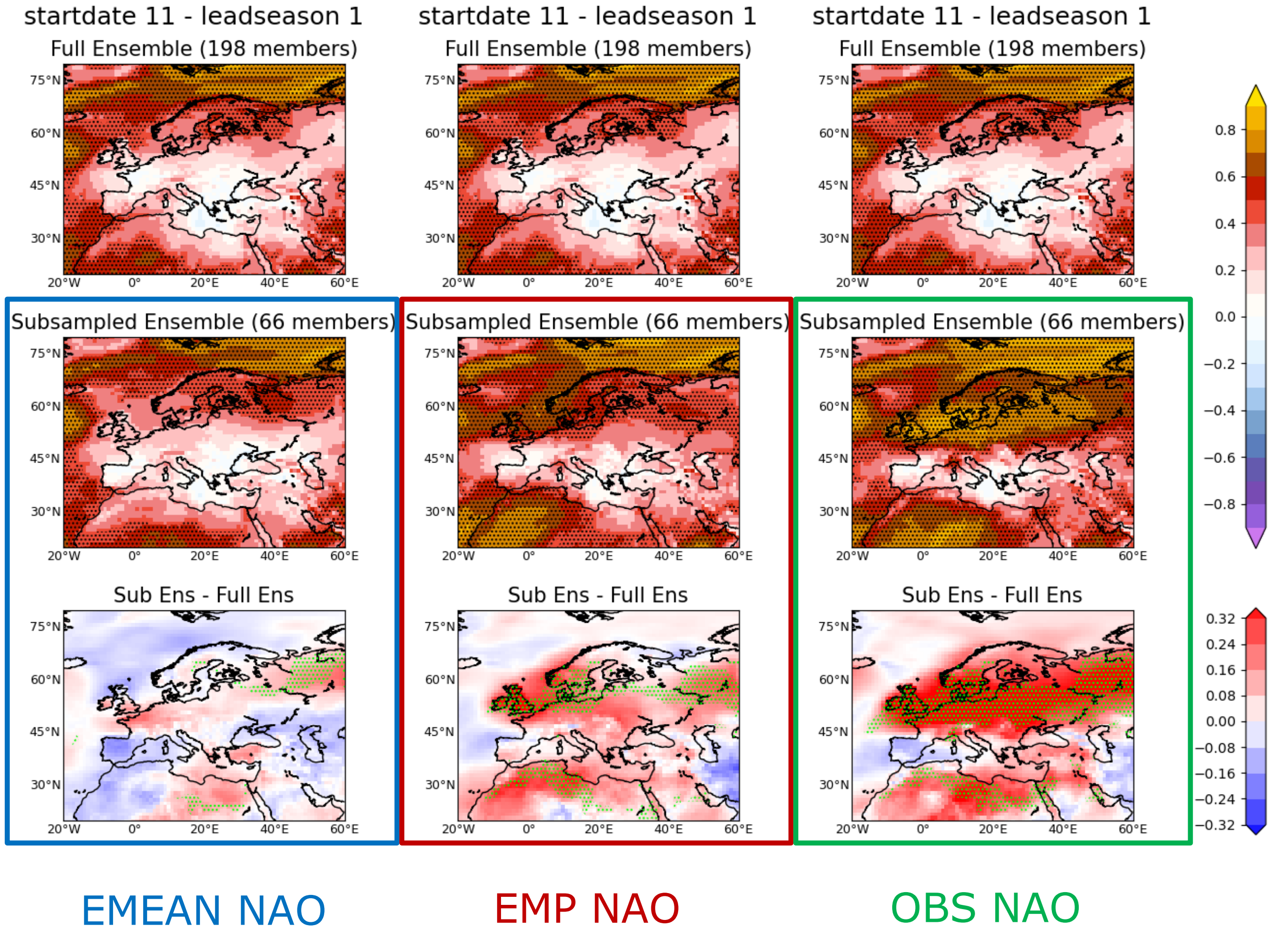
- Predictors: ERA5 sea-ice cover, sst, 70hPa geopotential height (September and October PCs)
- First three EOFs retained for each predictor and PCs computed over September and October (18 predictors: 3 fields x 3 PCs x 2 month)
- NAO ACC over the training period (DJF 1993/1994-2016/2017): 0.78
- NAO ACC over the evaluation period (DJF 2017/2018-2023/2024): 0.65

Subsampling on C3S multi-system ensemble

NAO ACC (Nov 1993-2016) C3S vs ERA5

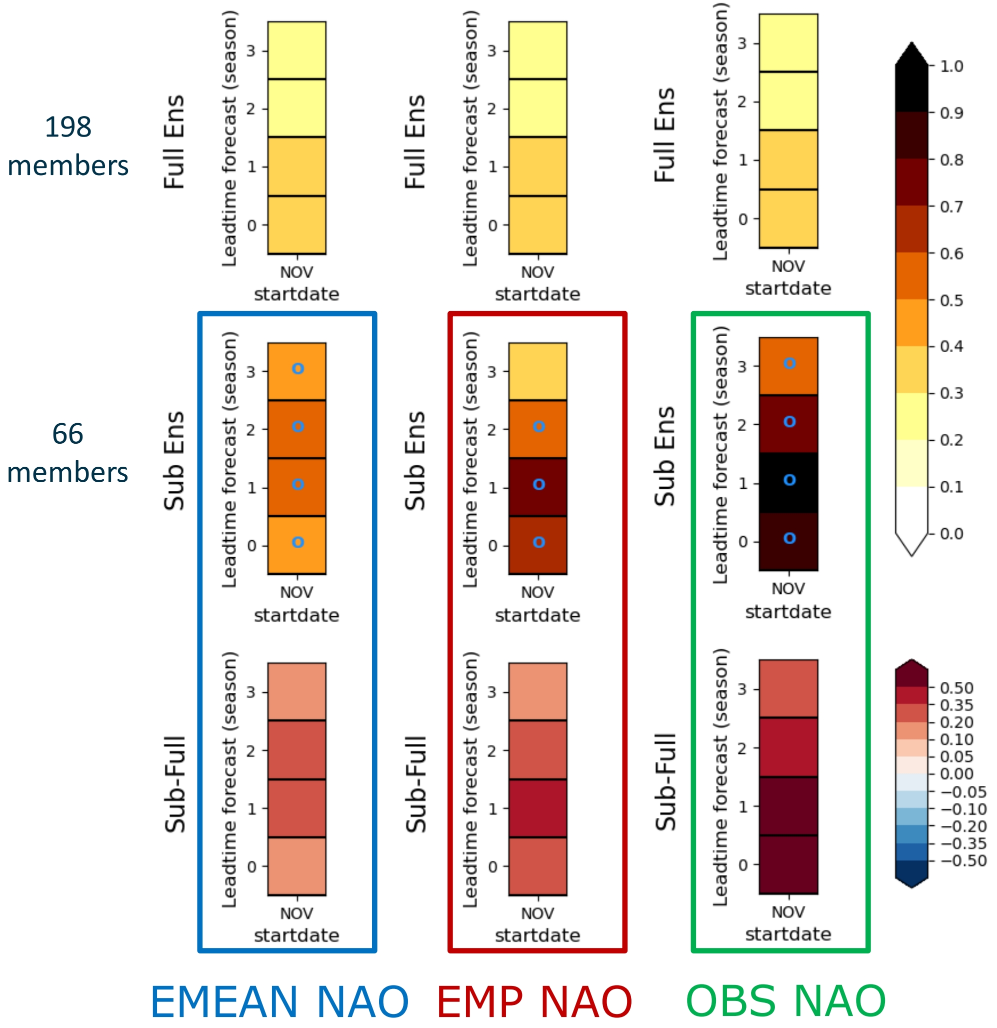


T2m ACC (Nov 1993-2016) C3S vs ERA5

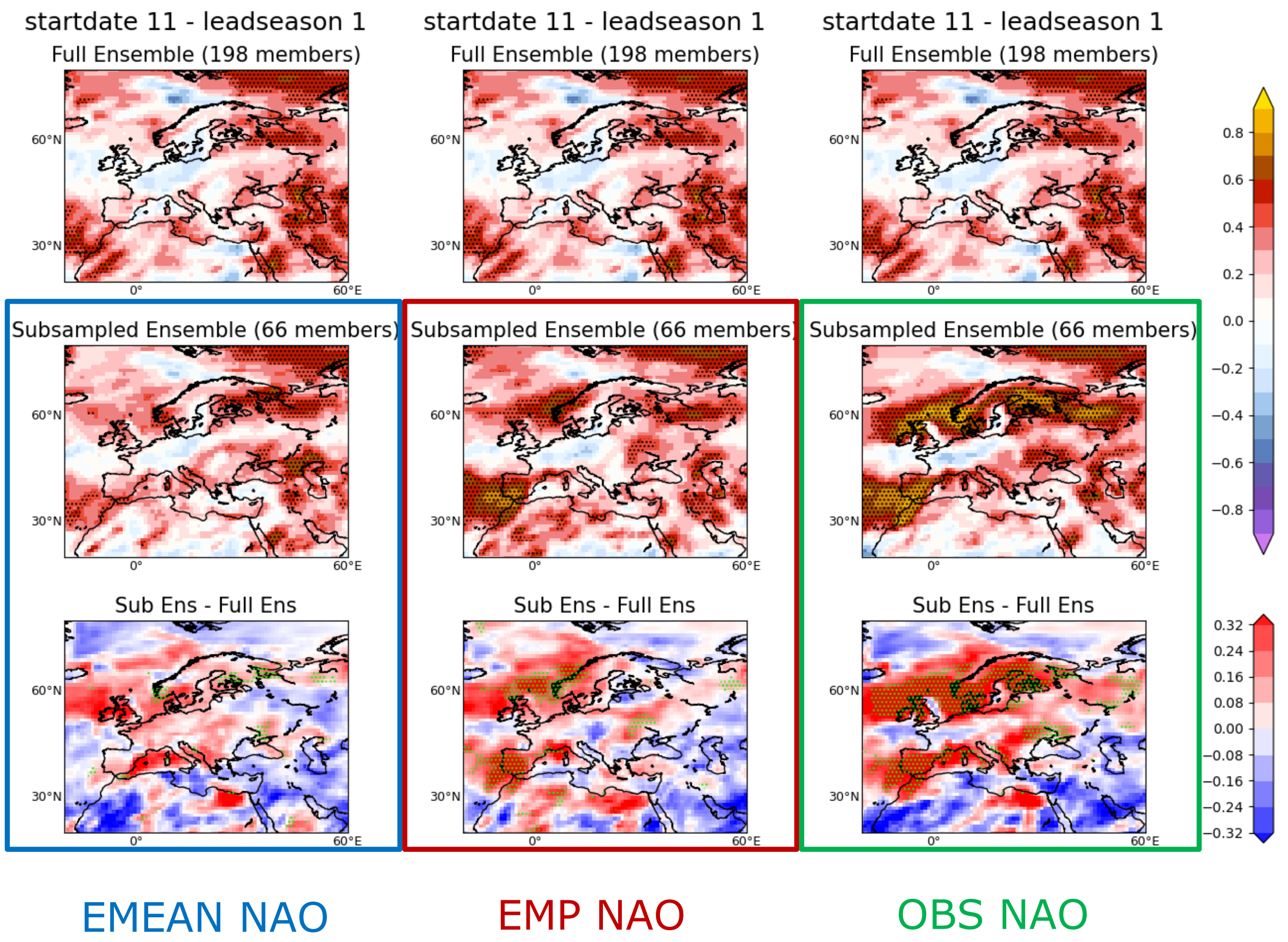


Subsampling on C3S multi-system ensemble

NAO ACC (Nov 1993-2016) C3S vs ERA5

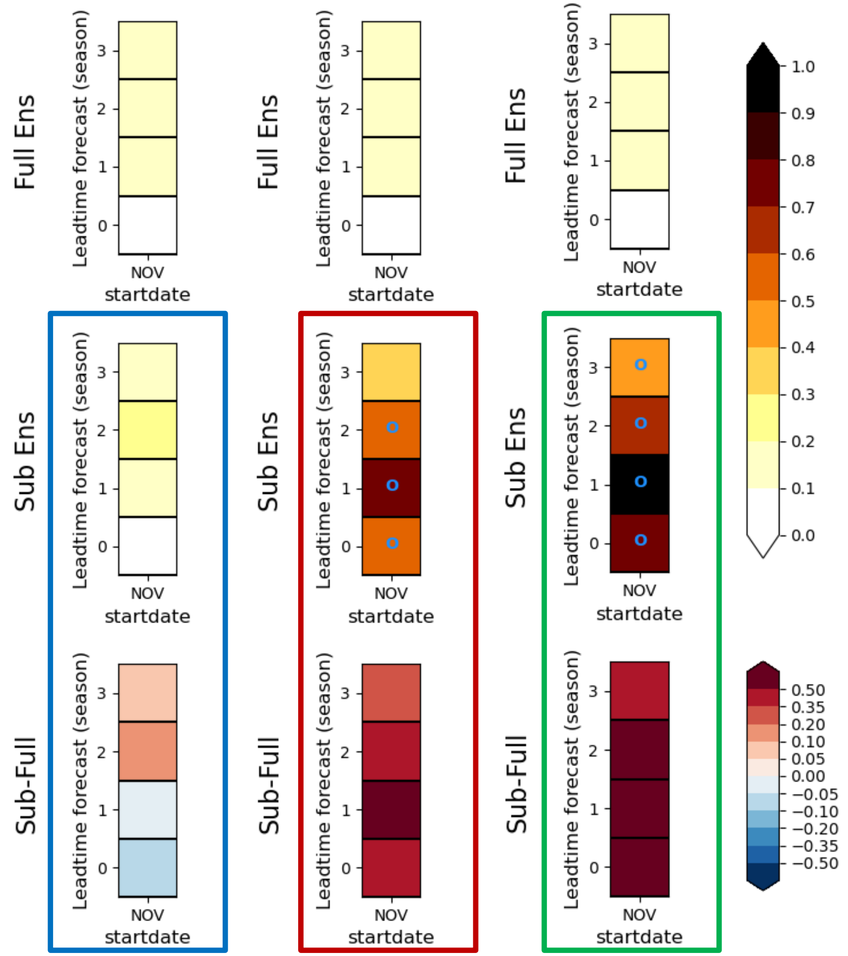


Prec ACC (Nov 1993-2016) C3S vs GPCP



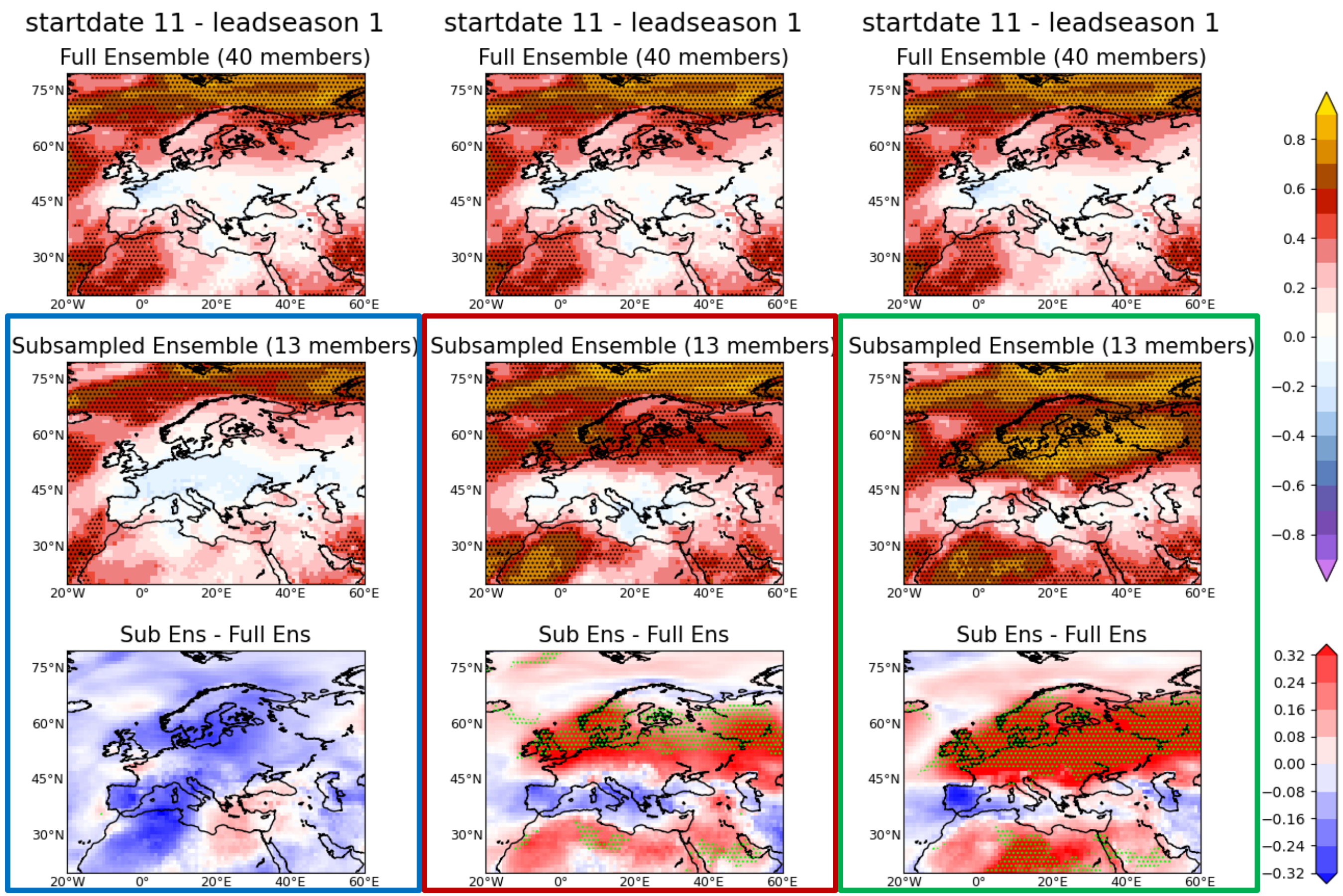
Subsampling on CMCC-SPS3.5

NAO ACC (Nov 1993-2016) CMCC vs ERA5



EMEAN NAO EMP NAO OBS NAO

T2m ACC (Nov 1993-2016) CMCC vs ERA5



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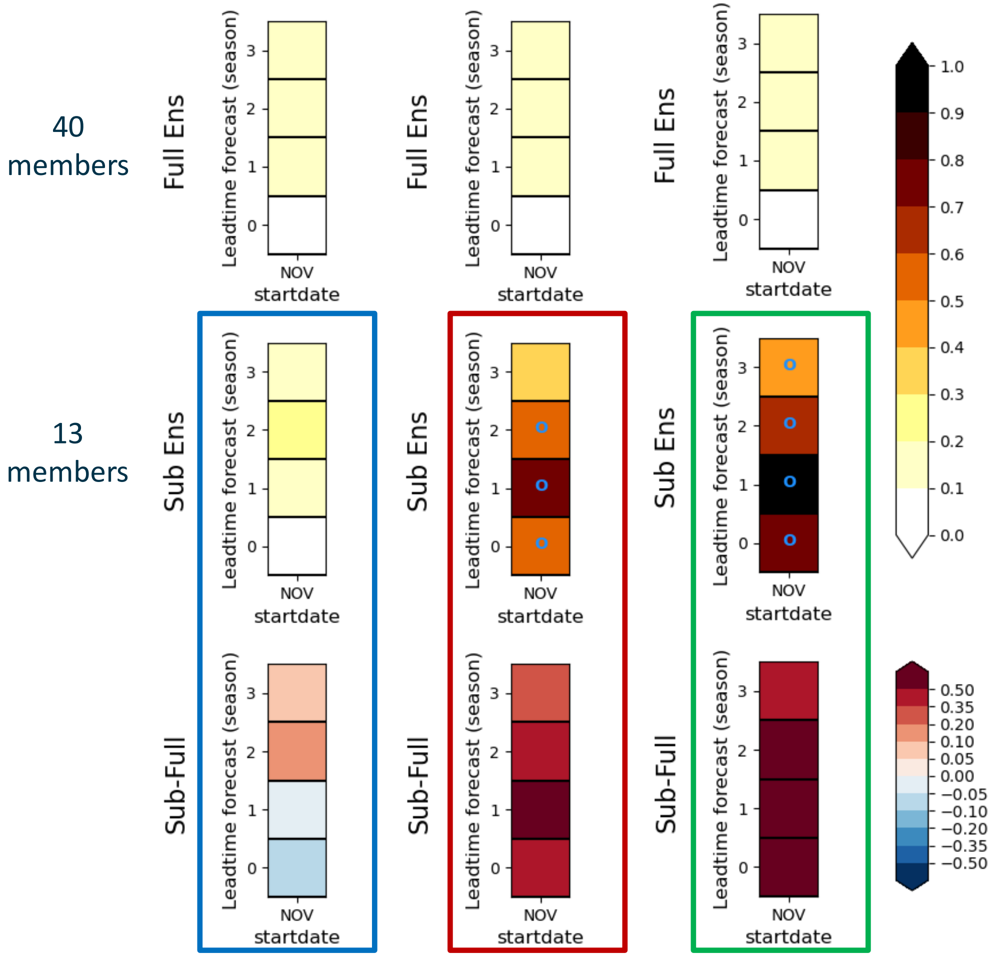
Subsampling on CMCC-SPS3.5

NAO ACC (Nov 1993-2016) CMCC vs ERA5



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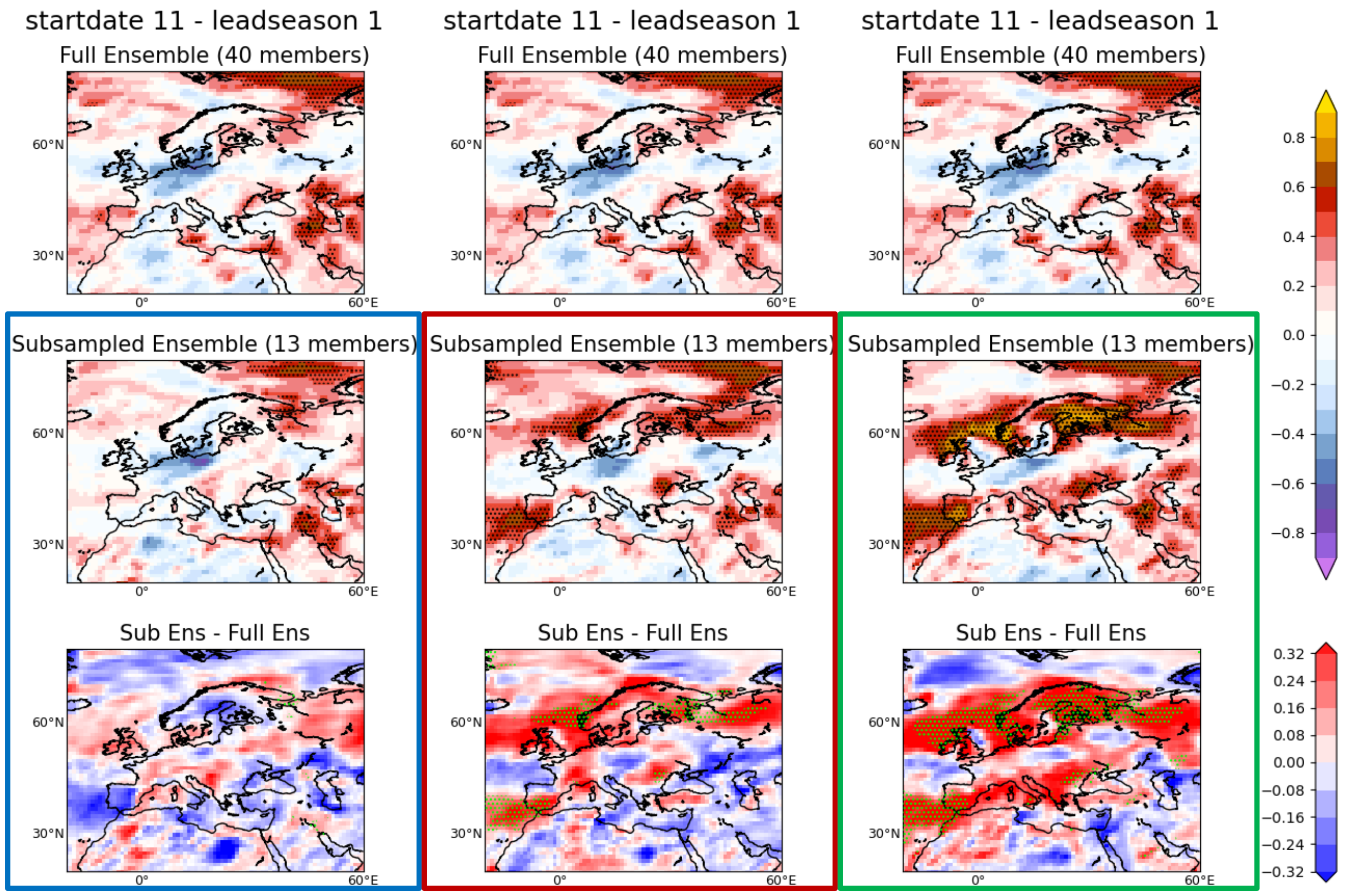
Prec ACC (Nov 1993-2016) CMCC vs GPCP



EMEAN NAO EMP NAO OBS NAO

Summary and conclusions

- Two different subsampling approaches have been tested, both potentially applicable in a real-time operational framework
- In C3S multi-system ensemble, both approaches enhance NAO skill and consequently 2m temperature and precipitation one
- In single system framework, as expected the improvement depends on the system skill on NAO: the subsampling relying on an independent estimate of NAO has a strong beneficial impact on the system skill

What's next?

- Ongoing analysis on the added-value of the selected members: insight on possible sources of predictability for NAO at the seasonal timescale

The results shown for CMCC SPS are based on the current operational system (CMCC-SPS3.5) but we are currently running the new set of hindcasts for the new CMCC-SPS4 system (operational in Nov 2024)

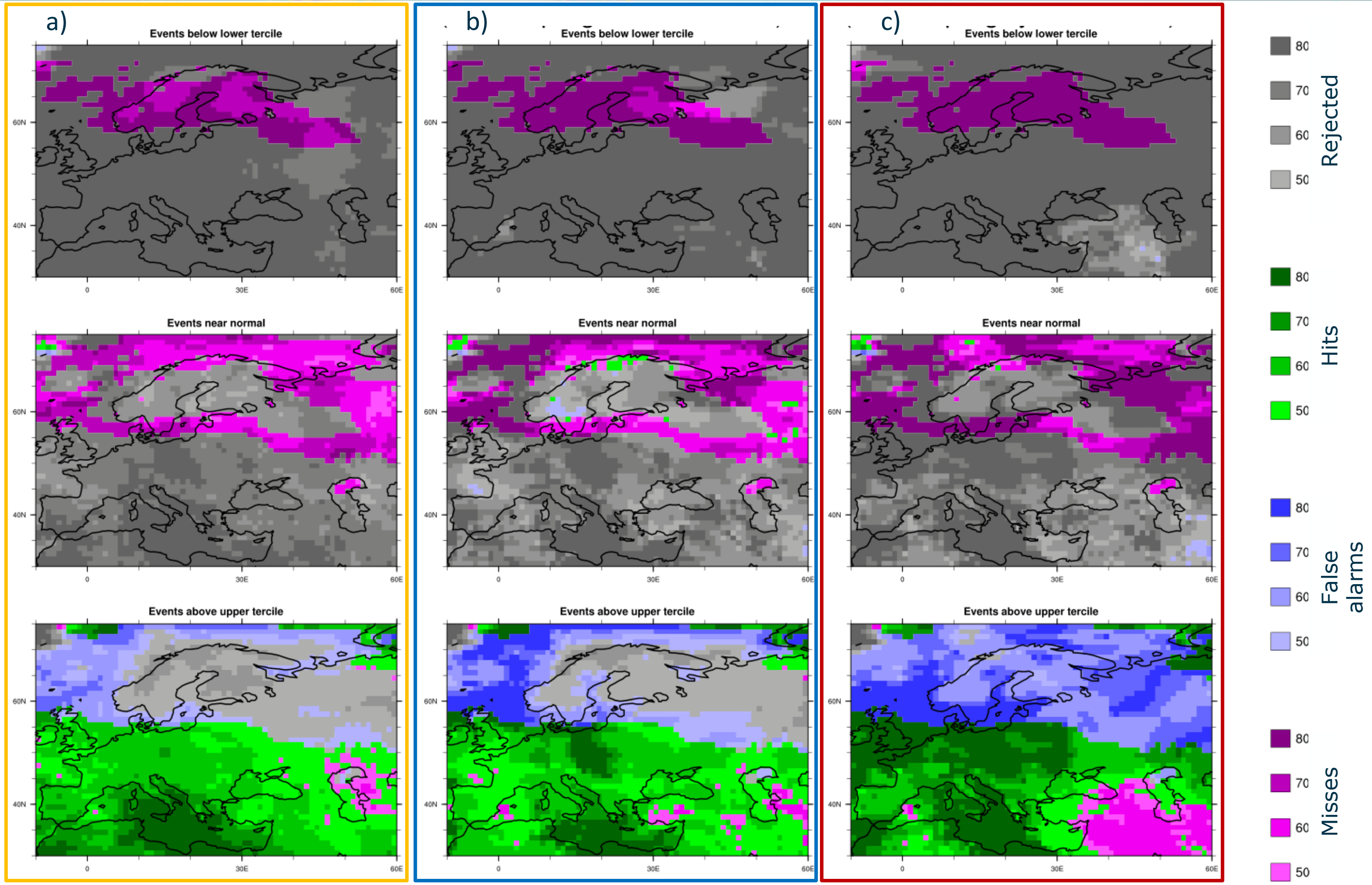
- Comparison btw the two systems: given the longer hindcast period (1993-2022) we want to keep 1993-2016 for ACC/skill analysis (as SPS3.5) and use the extra years 2017-2022 for independent evaluation

- Application of subsampling in real-time operational chain from November 2024

THANKS FOR YOUR ATTENTION

Grid-point contingency table for **2m temperature over the Euro-Mediterranean** domain for winter (DJF) 2023/2024

(**forecast initialized in November 2023** evaluated against ERA5 data)



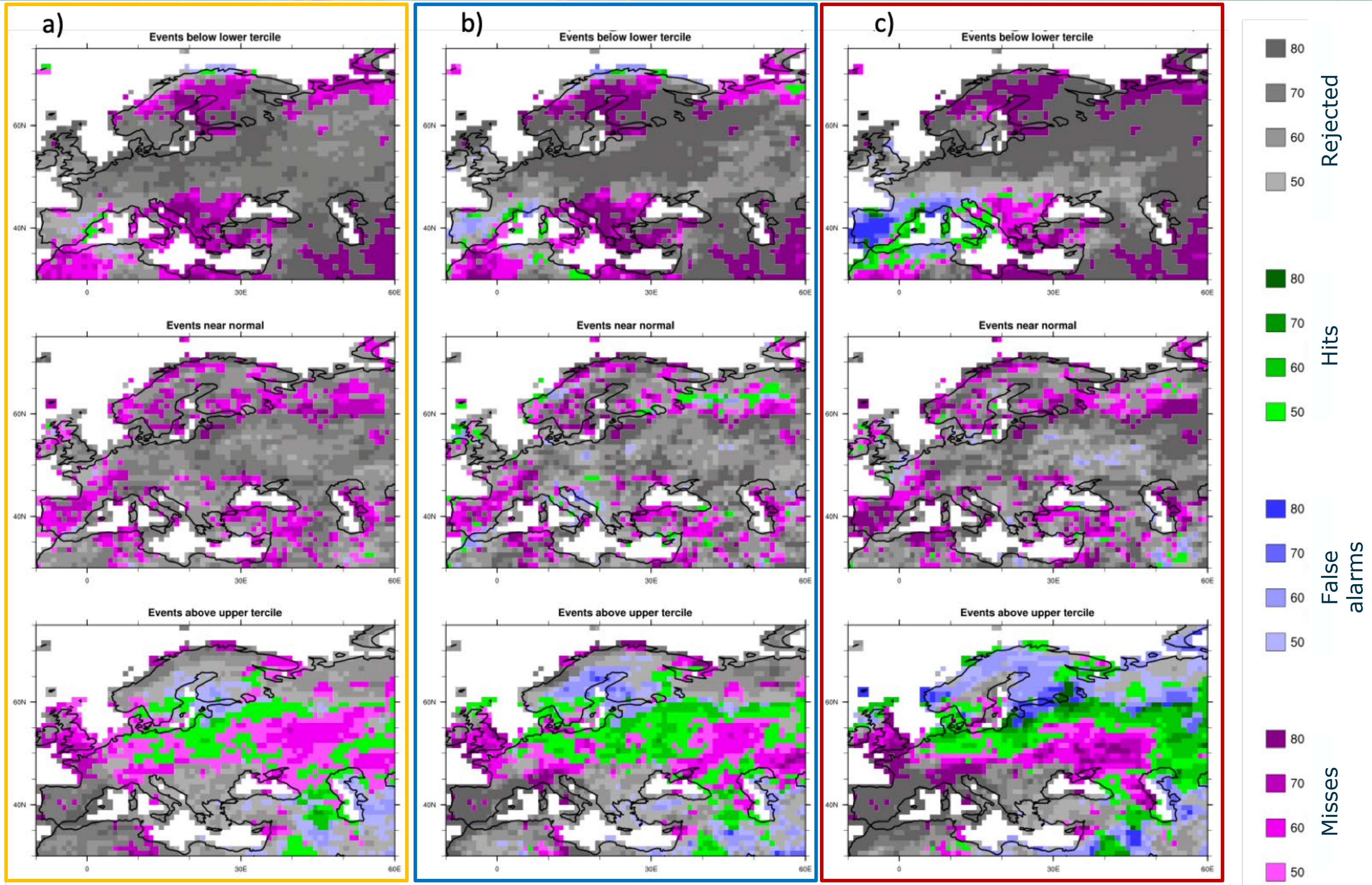
Full Ensemble (50)

EnsMean subsampling (16)

EmpNAO subsampling (16)

Top row shows the percentage of forecast occurrences of events below the lower tercile, mid row shows the percentage of forecast occurrences of events around the average, and the bottom row shows the percentage of forecast occurrences of events above the upper tercile.

Column a) reports results for the **full ensemble** (50 members); column b) reports results for the subsampled ensemble (16 members) using **lead-season 0 ensemble mean NAO criterion**; column c) reports results for the subsampled ensemble (16 members) using **DJF empirical NAO criterion**.



Full Ensemble (50)

EnsMean subsampling (16)

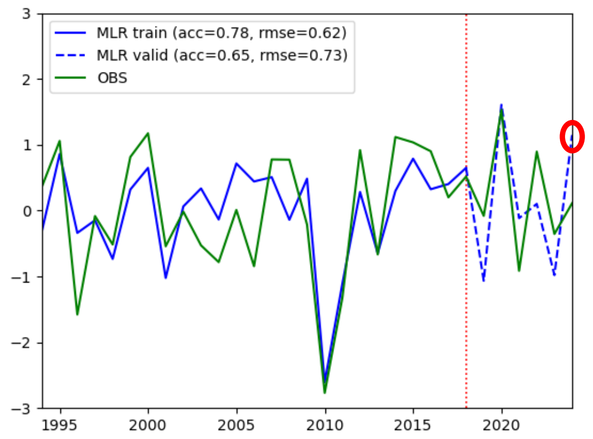
EmpNAO subsampling (16)

Grid-point contingency table for **precipitation over the Euro-Mediterranean** domain for winter (DJF) 2023/2024

(**forecast initialized in November 2023** evaluated against GPCC data)

Column a) reports results for the **full ensemble** (50 members); column b) reports results for the subsampled ensemble (16 members) using **lead-season 0 ensemble mean NAO criterion**; column c) reports results for the subsampled ensemble (16 members) using **DJF empirical NAO criterion**.

DJF NAO OBS and MLR - (1993/1994-2023/2024)



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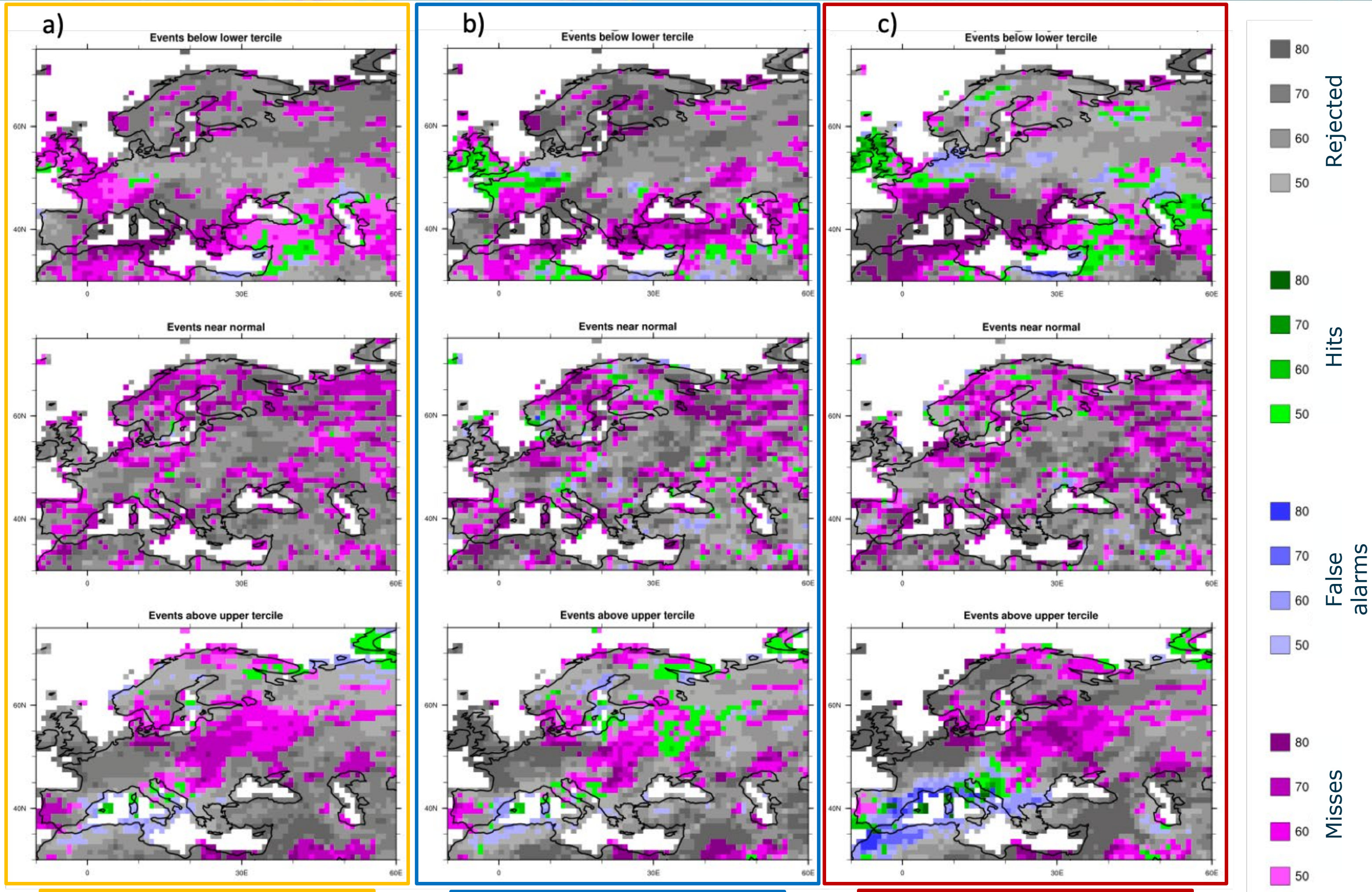
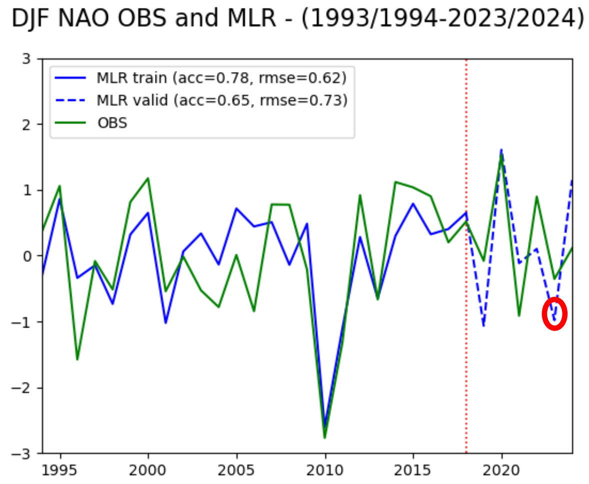


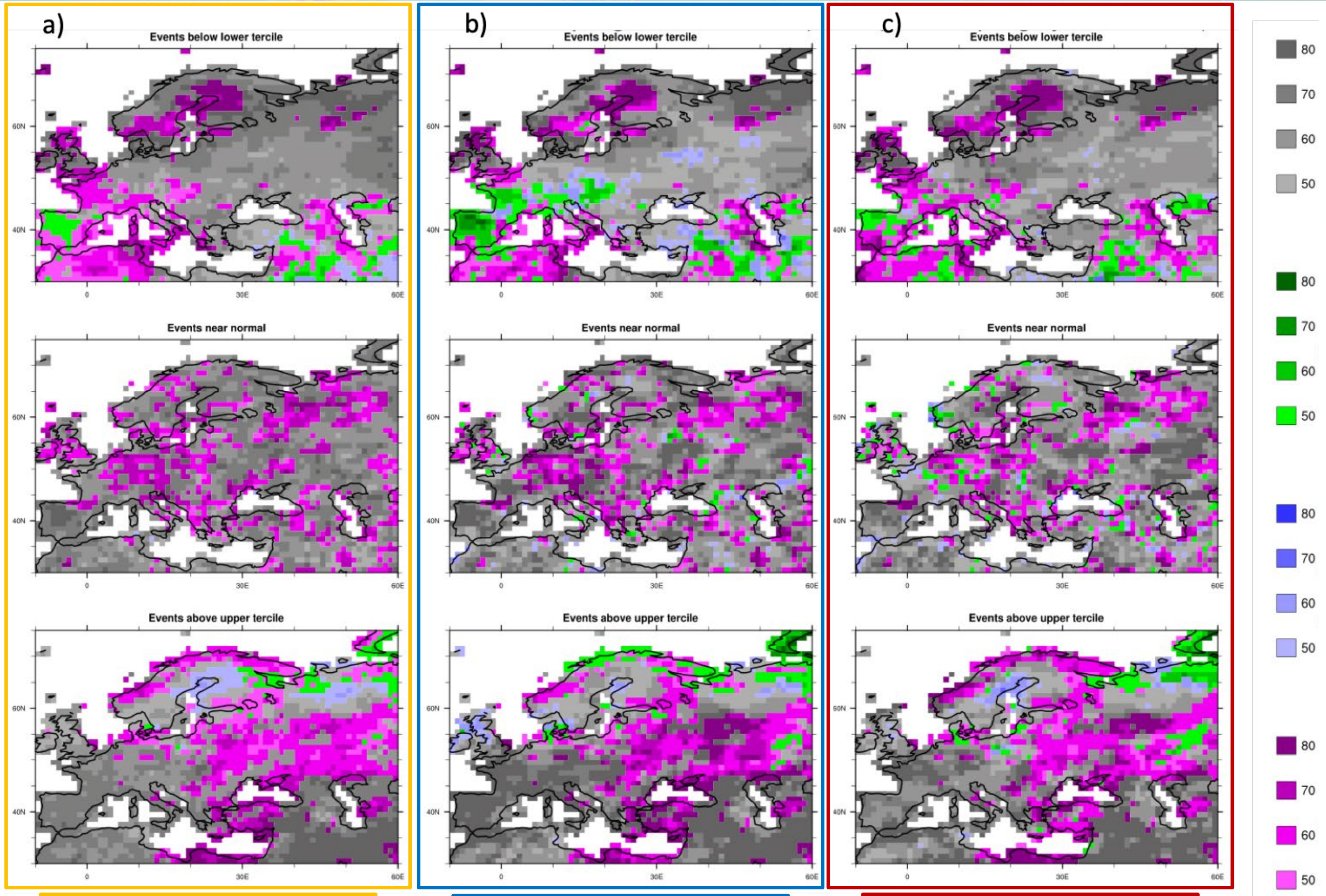
Full Ensemble (50)	EnsMean subsampling (16)	EmpNAO subsampling (16)

Grid-point contingency table for **precipitation over the Euro-Mediterranean** domain for winter (DJF) 2022/2023

(**forecast initialized in November 2022** evaluated against GPCC data)

Column a) reports results for the **full ensemble** (50 members); column b) reports results for the subsampled ensemble (16 members) using **lead-season 0 ensemble mean NAO criterion**; column c) reports results for the subsampled ensemble (16 members) using **DJF empirical NAO criterion**.





Full Ensemble (50)

EnsMean subsampling (16)

EmpNAO subsampling (16)

Grid-point contingency table for **precipitation over the Euro-Mediterranean** domain for winter (DJF) 2021/2022

(**forecast initialized in November 2021** evaluated against GPCC data)

Column a) reports results for the **full ensemble** (50 members); column b) reports results for the subsampled ensemble (16 members) using **lead-season 0 ensemble mean NAO criterion**; column c) reports results for the subsampled ensemble (16 members) using **DJF empirical NAO criterion**.