

# Multi-model seasonal hindcast skill of the North Atlantic

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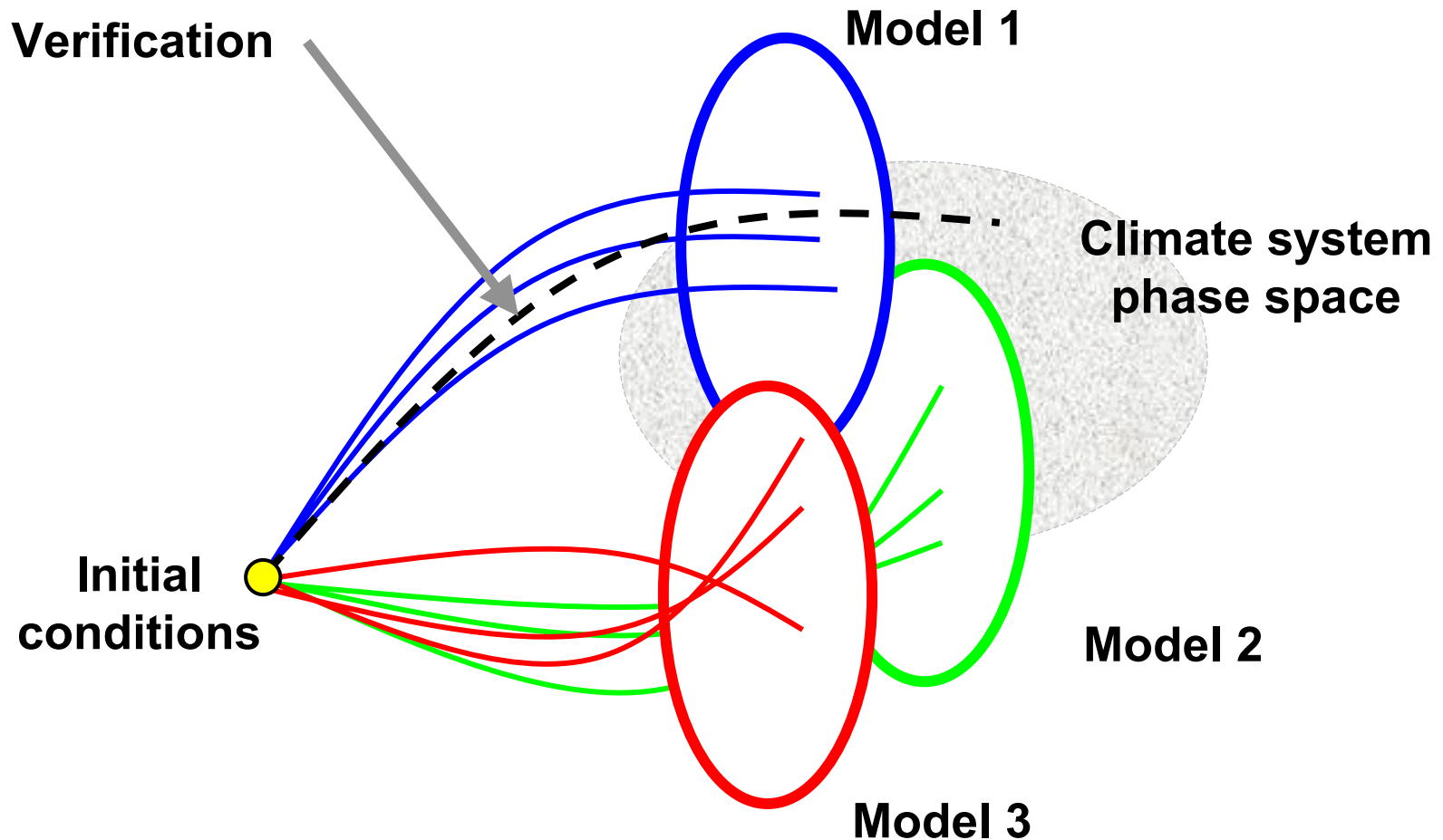
# Outline

- **PROVOST: Introduction and scope**
- **Multi-model: verification for grid-point and NAO hindcasts**
- **DEMETER: Introduction, scope, and status**

# PROVOST Project

- **PROVOST: European (EU-funded) multi-model hindcast experiment with SST-forced atmospheric models.**
- **Three different atmospheric GCMs: The Met Office, ECMWF, and Météo-France (an additional version of Météo-France model just for winter with higher-resolution).**
- **Four hindcasts per year (verifying from 1st Dec, Mar, Jun, Sep), fifteen years, 120-day long simulations, same initial conditions (ERA-15), lagged initialization, 9-member ensembles, prescribed SST and sea-ice extent. Data are available at ECMWF and (partially) on CD-ROM.**
- **Multi-model seeks to provide skill improvement by sampling model uncertainty.**

# Multi-model: Forecasting an Event

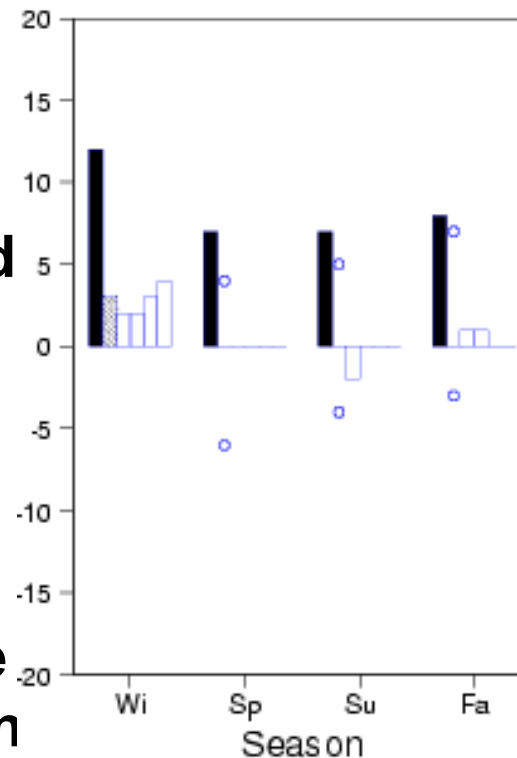


# Skill: Multi-model vs Individual Models

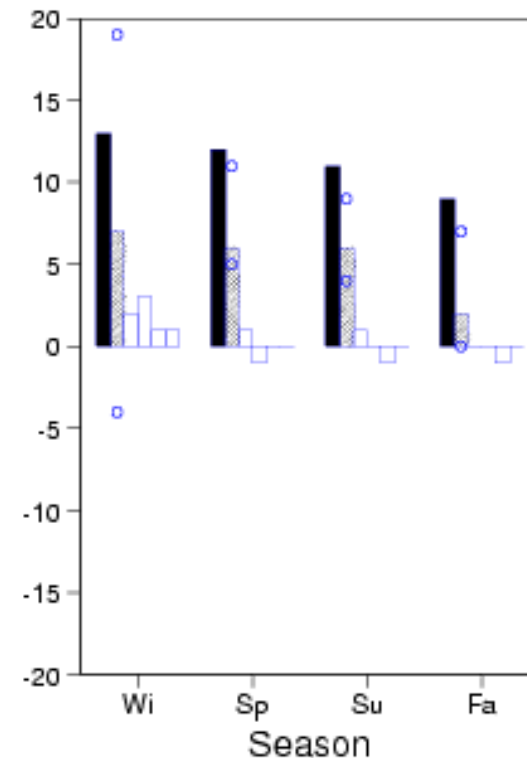
- **Black bars: multi-model; grey bars: reduced ensemble (9 members) multi-model; white bars: individual models.**
- **Dots are the 5th and 95th RPSS percentiles computed by scrambling the reduced multi-model hindcasts.**
- **Multimodel approach provides skill improvement over the tropical band: note the 5th percentile above 0 in Sp, Su, and Fa.**

**Grid point skill  
RPSS for precipitation 1-month lead probability  
hindcasts with three categories**

**Northern Hemisphere**



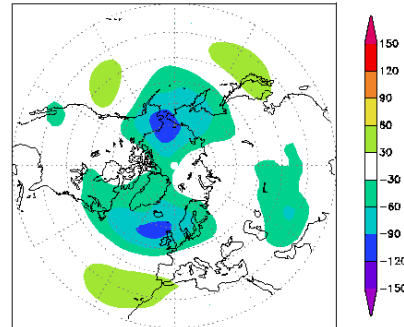
**Tropics**



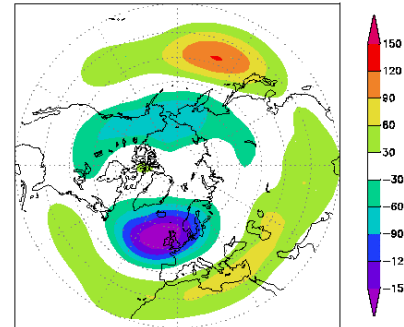
# Winter Model Biases: Z500 and Blocking (1)

## Z500 Bias

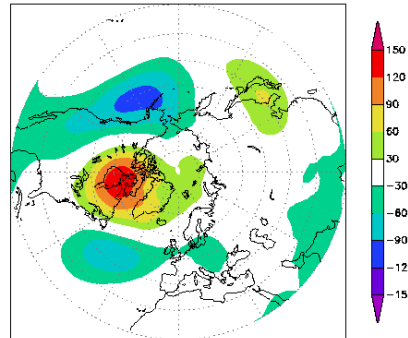
a) ECMWF



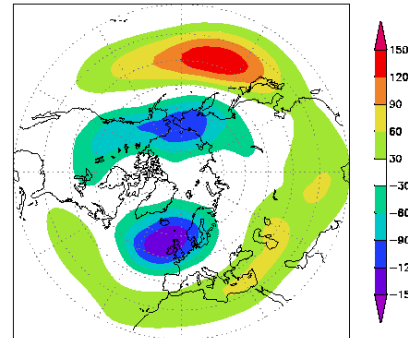
b) ARP 42



c) UKMO



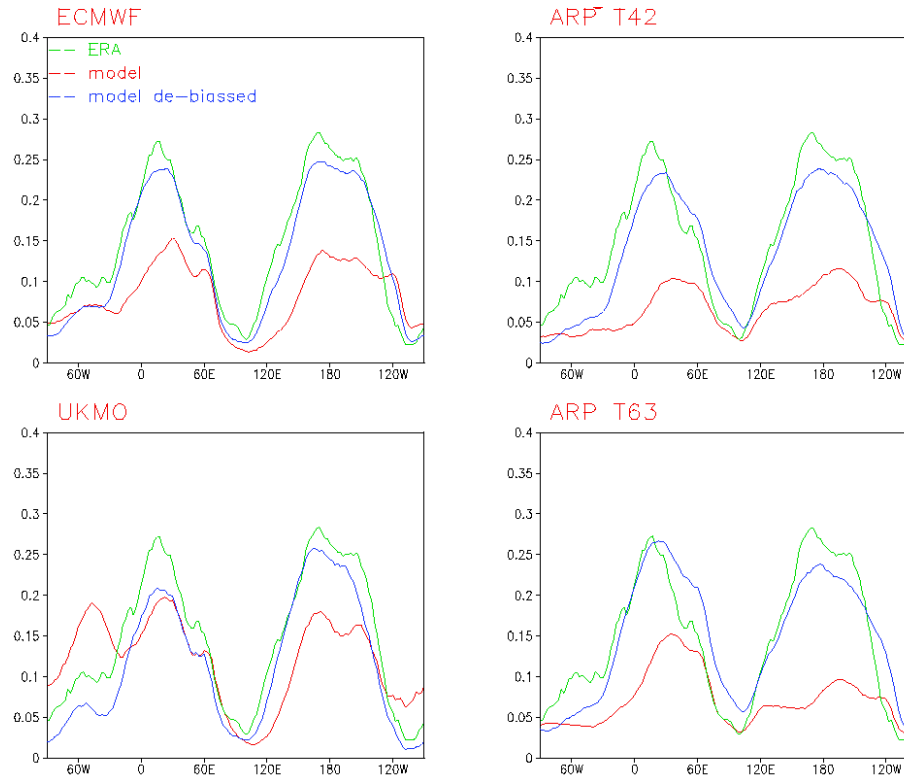
d) ARP 63



- Three of the models have similar biases.
- Bias has similar magnitude as interannual standard deviation

# Winter Model Biases: Z500 and Blocking (2)

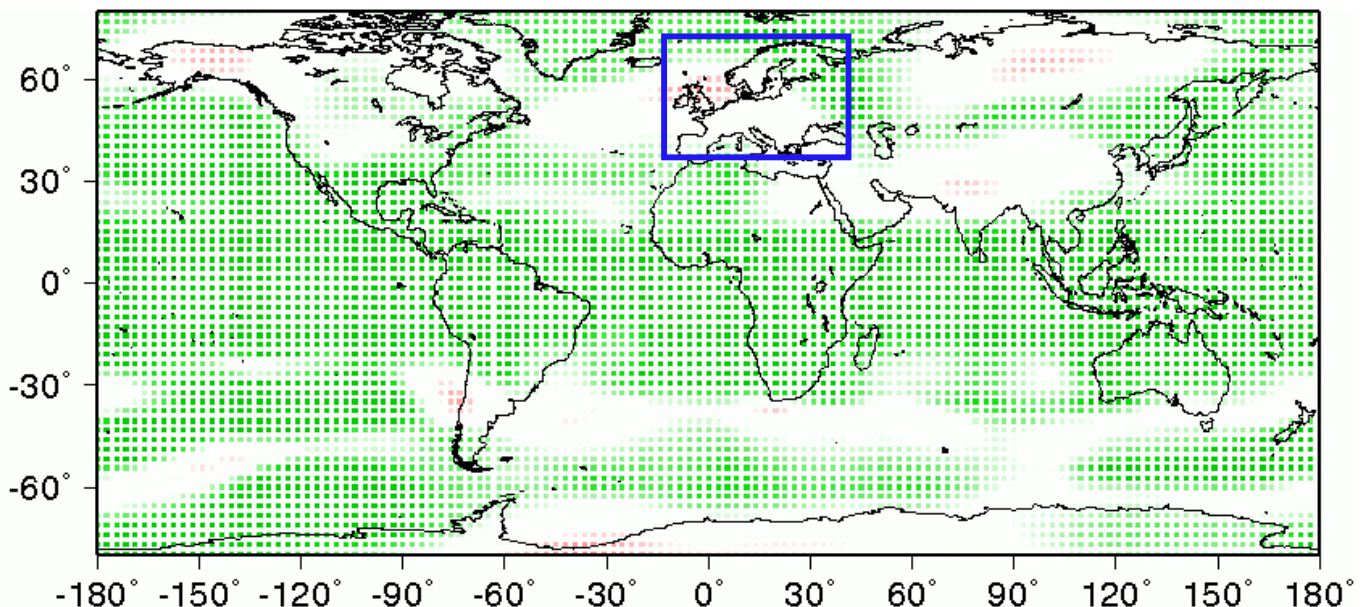
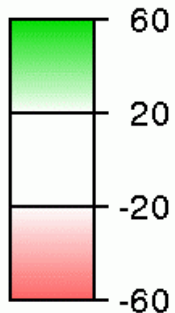
## Blocking Frequency (Tibaldi and Molteni index)



- Blocking frequency, as most of the extratropical variability, tends to be underestimated.

# Ensemble Mean Skill (JFM)

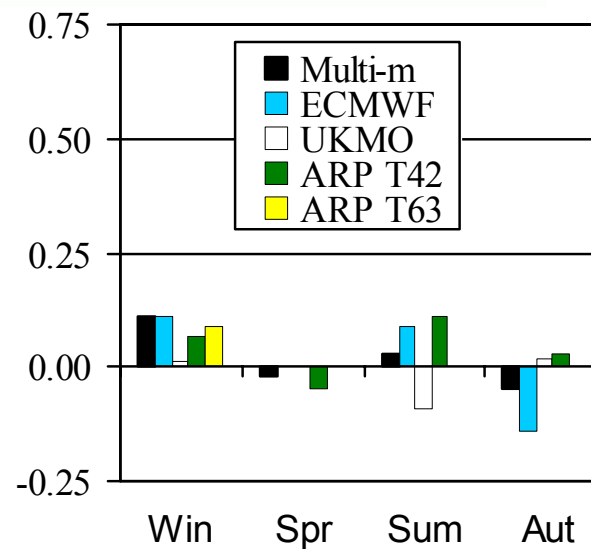
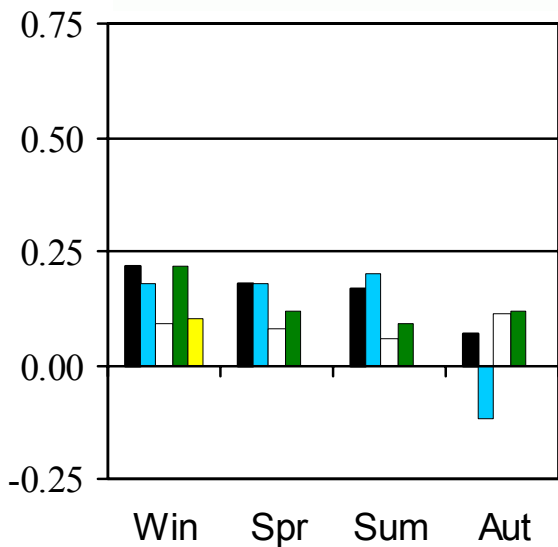
Z500 ensemble mean (grid point time correlation)



ACC Averaged on the blue area

← Z500

PREC →



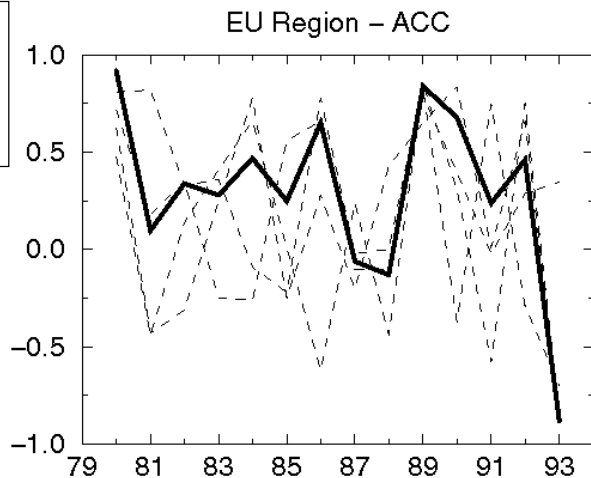
# Euro-Atlantic Skill (JFM)

Z500 ensemble mean and RPSS (areal average skill)

95% confidence intervals in parenthesis

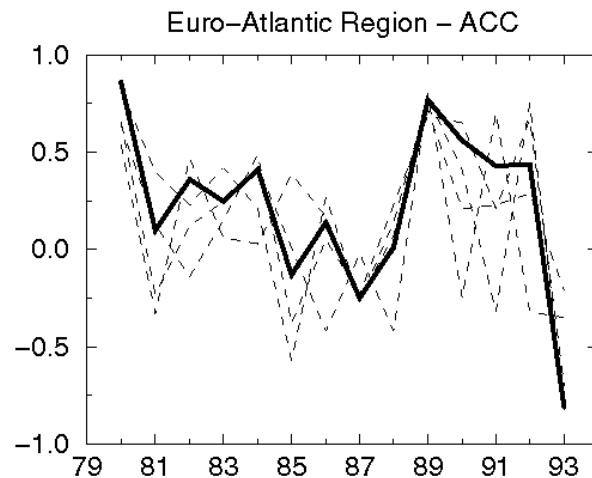
35N, 75N  
12.5W, 42.5E

**0.33**  
**(-0.19,0.12)**

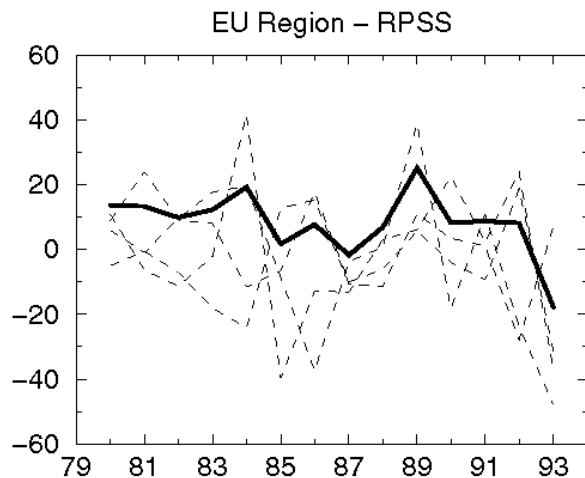


35N, 88N  
60W, 50E

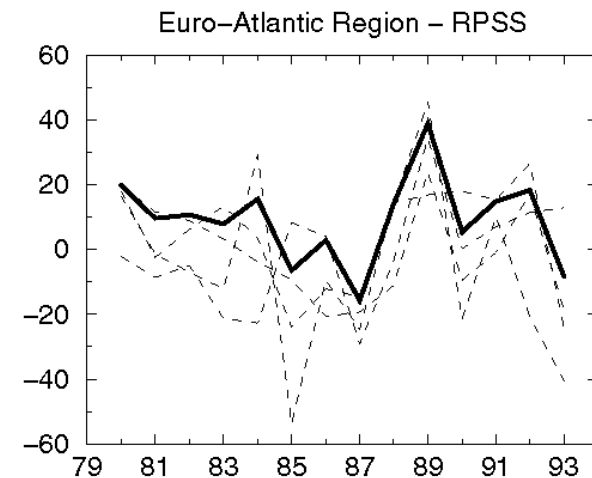
**0.27**  
**(-0.15,0.11)**



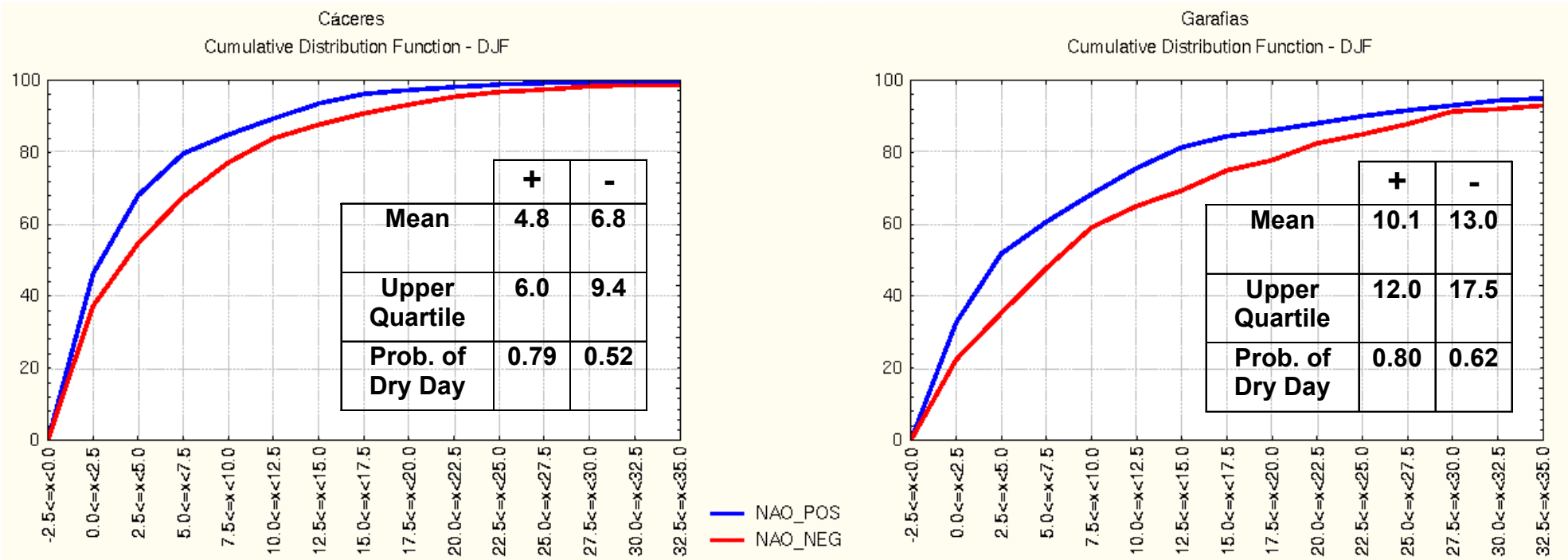
**8**  
**(-2,4)**



**9**  
**(-1,5)**

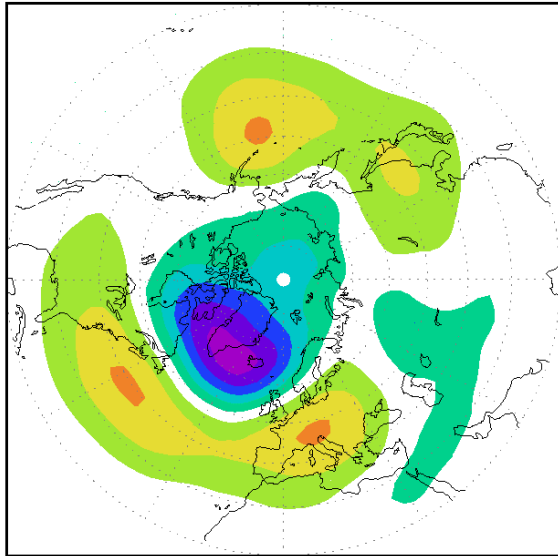


# NAO Impact on Daily Precipitation



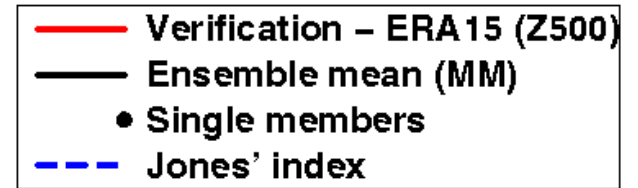
- Different phases of the NAO imply strong differences in Spanish precipitation CDF.
- A way to introduce this information into water management models is still needed.

# NAO Hindcasts: Definition

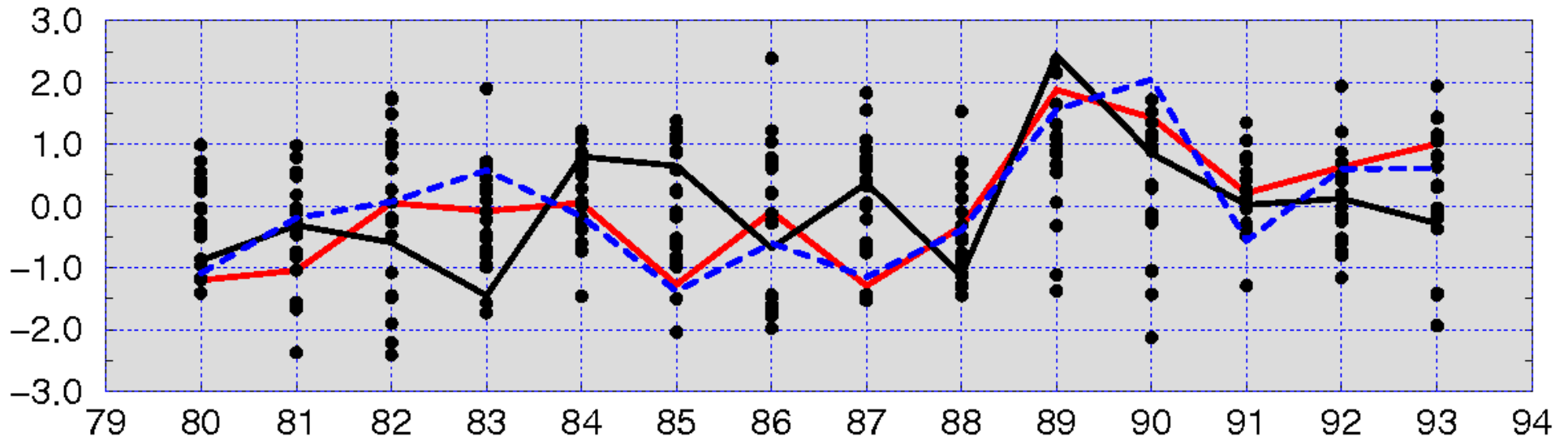


Corr. ERA vs MM ensemble mean	0.48
Corr. Jones vs MM ensemble mean	0.38
Corr. ERA vs Jones	0.90
Corr. MM EOF vs MM areal mean	0.93

← ERA15 Z500 monthly covariance with the 1st NCEP ATL EOF (31%)



JFM (1 month lead) NAO hindcasts



# NAO Hindcast Skill (JFM)

	Multi-M	ECMWF	UKMO	ARPT42	ARPT63
<b>Bias</b>		0.32	-0.62	0.41	0.50
<b>Corr</b>	0.48	0.39	0.48	0.25	0.37
<b>Corr (9)</b>	0.40				
<b>Corr (reg)</b>	0.55				
<b>Corr (reg 9)</b>	0.59				

$m = Ac + d$

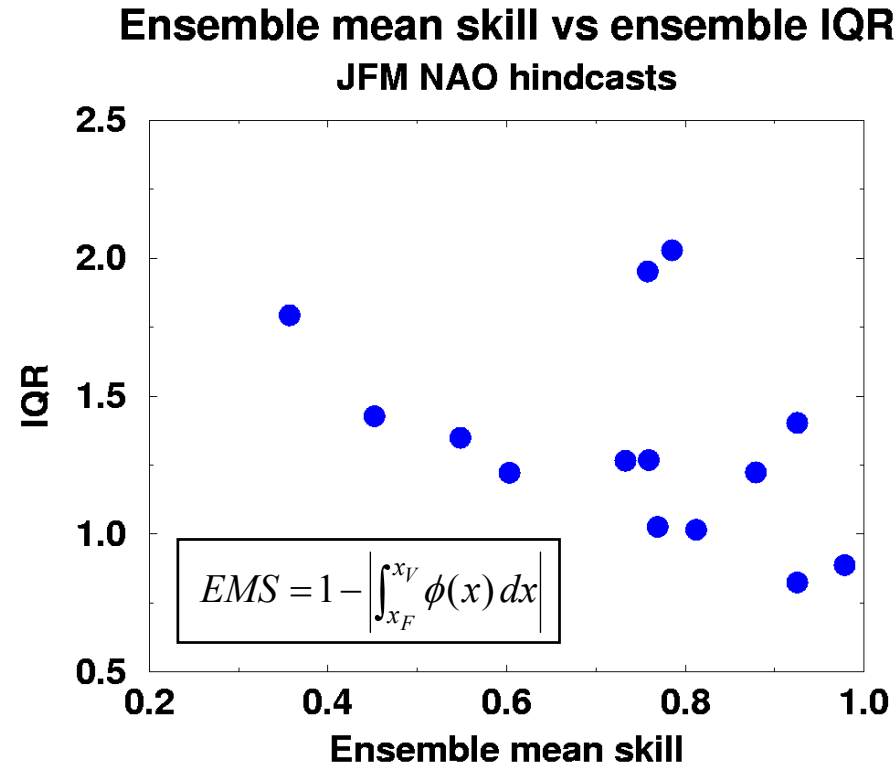
- Multi-model appears in the upper edge of the correlation distribution.
- Multi-model regression estimates are the best (statistically significant).

# NAO Hindcast Skill (JFM): First EOFs

	Multi-M	ECMWF	UKMO	ARPT42	ARPT63
PC1	0.55	0.39	0.48	0.25	0.37
PC2	0.52	-0.14	0.22	0.30	0.20
PC3	0.46	0.39	0.15	-0.15	-0.03
PC4	0.69	0.68	0.07	0.53	0.33

- The improvement also appears in the next principal components. The more important the model biases, the greater the improvement with regard to the simple multi-model estimation.
- The results seem to be quite independent of the ensemble size.

# NAO Hindcast Skill (JFM): Skill vs Spread



- A relationship between ensemble mean skill and spread is observed when spread is measured in terms of IQR and skill as a Gaussian distance to the verification.

# Probabilistic NAO Hindcasts

- Probabilistic skill is positive for some measures, but not statistically significant (Lack of robustness? Ensemble size? Sample size?).

	<b>ERA</b>	<b>Jones</b>
<i>RPSS</i>	-1.0 ( $\mu$ 6.6)	-3.9 ( $\mu$ 6.8)

	<b>ERA</b>			
	<b>3<sup>rd</sup> Quart</b>	<b>Pos</b>	<b>Neg</b>	<b>1<sup>st</sup> Quart</b>
<i>a</i> (ROC)	0.8	0.7	0.7	0.6
<i>ORSS</i>	0.7	0.3	0.5	-0.3

$$ORSS = \frac{\theta - 1}{\theta + 1} \quad \theta = \frac{H}{1-H} \frac{1-F}{F}$$

# Summary

- **The multi-model approach presents significant advantages, mainly over the tropics (where skill is already high).**
- **Significant skill for multi-model ensemble mean NAO hindcasts is just found when combining weighted individual model hindcasts (super-ensemble). The same applies to the first EOFs.**
- **Tentative relationship between ensemble mean skill and spread for NAO hindcasts.**

# DEMETER project

- Multimodel coupled seasonal forecasting experiment (all models run at ECMWF)
- Main focus: 1987-1999, secondary focus: 1969-1986
- 9-member ensembles, 6-month simulations, 4 seasons, SST and wind perturbations, ERA-40 initial conditions
- Downscaling; crop yield and human health applications
- Availability of data (MARS, GRIB format) in quasi-real time.

- Six models:

<i>Atmosphere</i>	<i>Ocean</i>
<i>ECMWF</i>	<i>HOPE</i>
<i>ECMWF</i>	<i>OPA</i>
<i>ARPEGE</i>	<i>OPA</i>
<i>ECHAM</i>	<i>HOPE</i>
<i>ECHAM</i>	<i>OPA</i>
<i>UM</i>	<i>UM</i>

- Website:

[www.ecmwf.int/research/demeter/](http://www.ecmwf.int/research/demeter/)

(with a password protected consortium site)