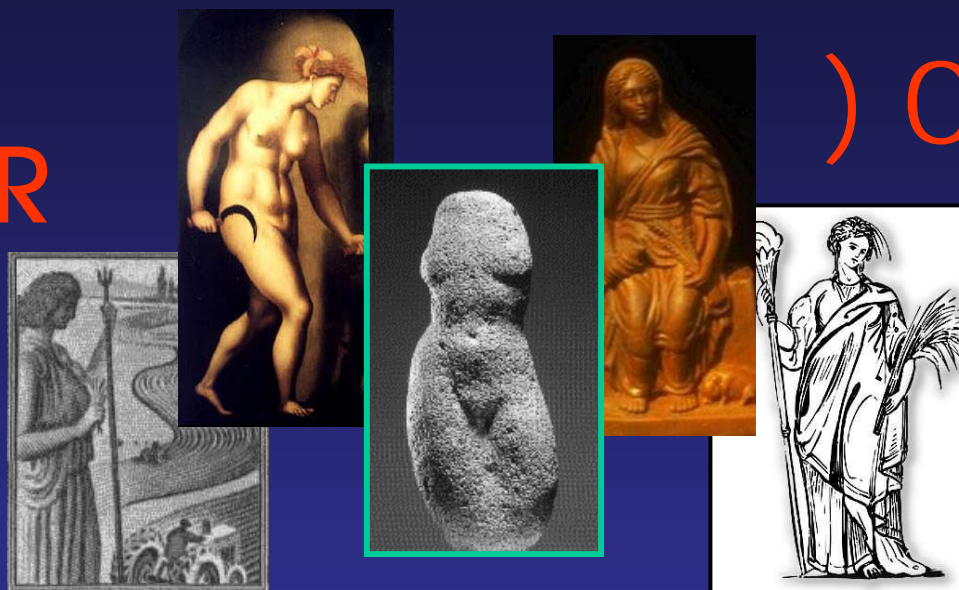


Development of a European Multi-Model Ensemble System for Seasonal to Interannual Climate Prediction

DEMETER



) 0: OJOD

Francisco Doblas-Reyes
Renate Hagedorn
Tim Palmer

European Centre for Medium-Range Weather Forecasts (ECMWF)

The Idea behind DEMETER

- Growing demand for reliable seasonal
- Two main sources of uncertainty
 - X error in initial conditions
 - X error in model formulation
- Install a Multi-Model Ensemble System
- Evaluate the skill and potential utility

Multi-model ensemble system

- DEMETER system: 7 coupled global circulation models

Partner	Atmosphere	Ocean
ECMWF	IFS	HOPE
LODYC	IFS	OPA 8.3
CNRM	ARPEGE	OPA 8.1
CERFACS	ARPEGE	OPA 8.3
INGV	ECHAM-4	OPA 8.2
MPI	ECHAM-5	MPI-OM1
UKMO	HadCM3	HadCM3

4 start dates per year

6 months hindcasts

9 member ensembles

3 ocean analyses, 4 \pm SST pert

ERA-40: ocean forcing and

atmospheric initial conditions

- Hindcast production for: 1980-2001 (1958-2001)

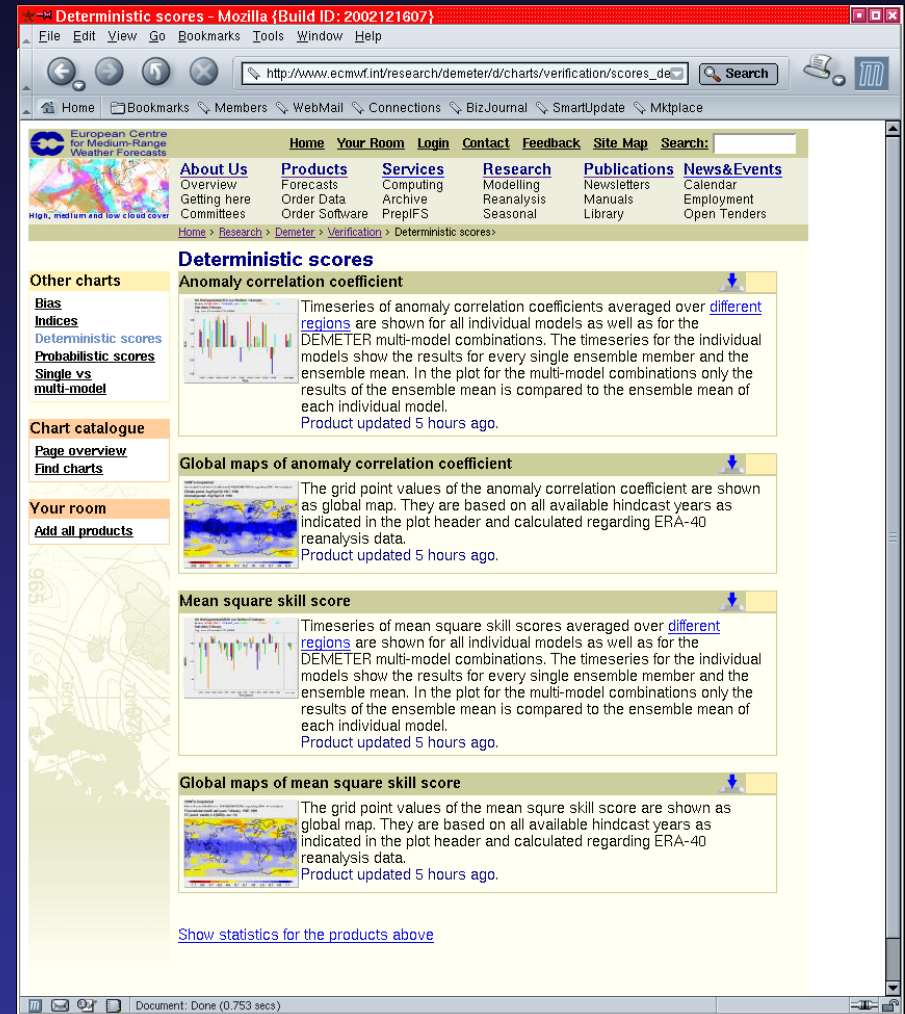
<http://data.ecmwf.int/data>

	Period	# Years
ECMWF	1958 - 2001	44
CNRM	1958 - 2001	44
UKMO	1959 - 2001	43
MPI	1969 - 2001	33
INGV	1973 - 2001	29
LODYC	1974 - 2001	28
CERFACS	1980 - 2001	22

Retrieve
NetCDF

Verification

- Bias
- Indices
- Deterministic Scores
- Probabilistic Scores
- Single vs. multi-model
- 54-single vs. multi-model
- Ocean diagnostics



<http://www.ecmwf.int/research/demeter/verification>

Verification

Start date



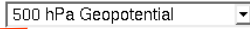
Lead time



Parameter



Model



Brier score and its decomposition

- Measures the quadratic distance between forecast and verification probabilities for binary events (negatively oriented)

$$BS = \frac{1}{N} \sum_{n=1}^N (p_n - o_n)^2$$

- The Brier score can be split into three terms that measure different aspects of the forecast quality

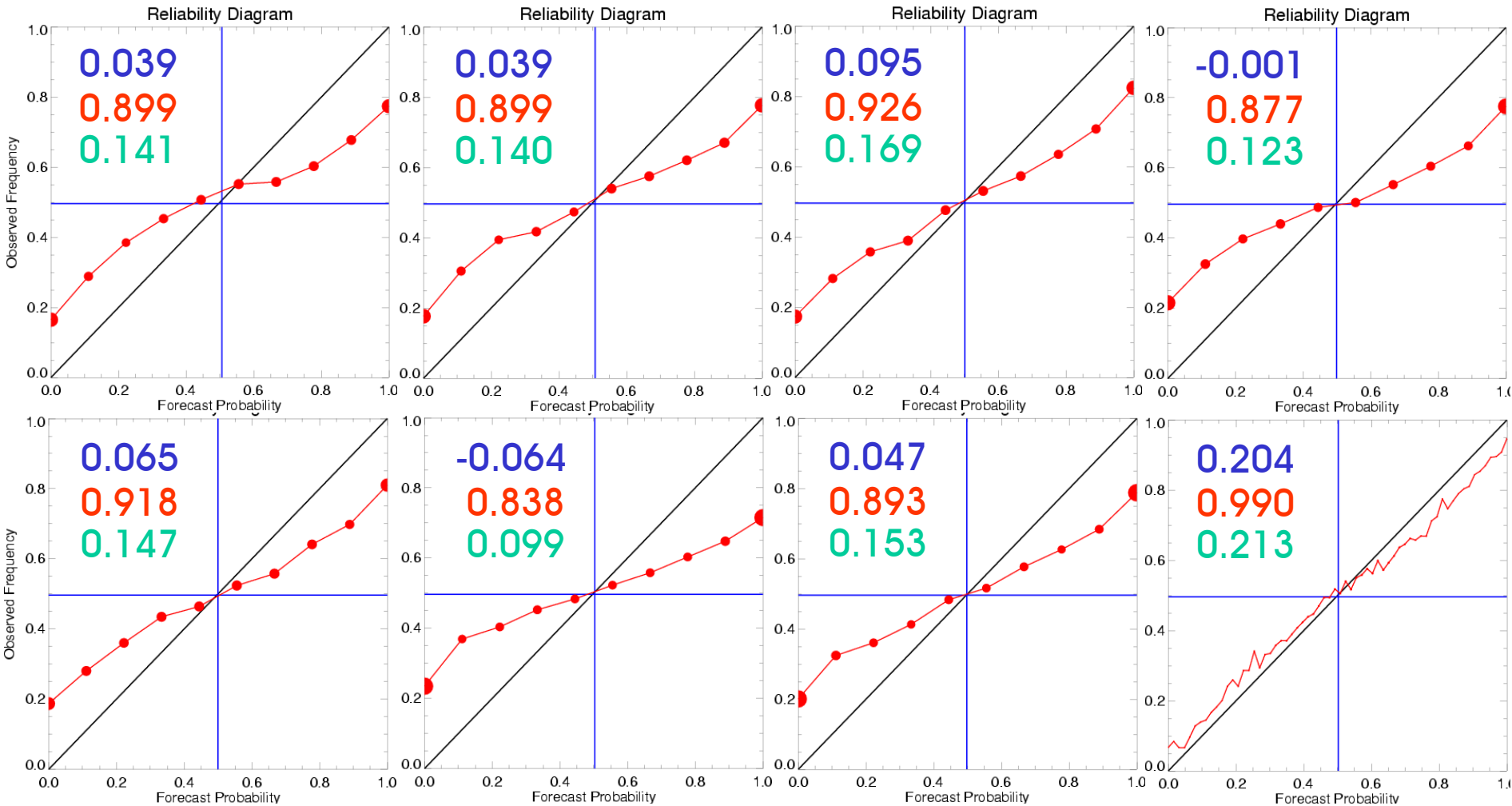
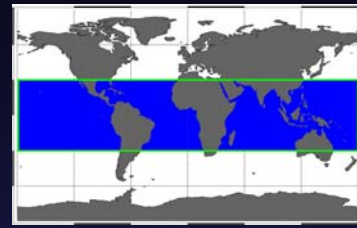
Brier Score = Reliability – Resolution + Uncertainty

- ▶ Reliability: forecast prob. vs. observed relative
- ▶ Resolution: ability to issue reliable forecasts close to 0% or 100%
- ▶ Uncertainty: variance of observations frequency in sample

Reliability: 2m-Temp. > 0

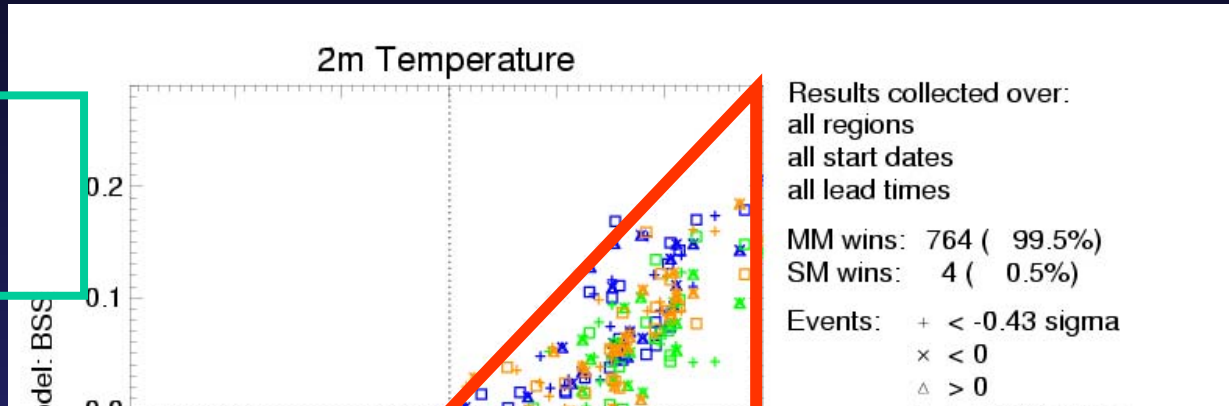
BSS
Rel-Sc
Res-Sc

1 month lead, start date May, 1980 - 2001

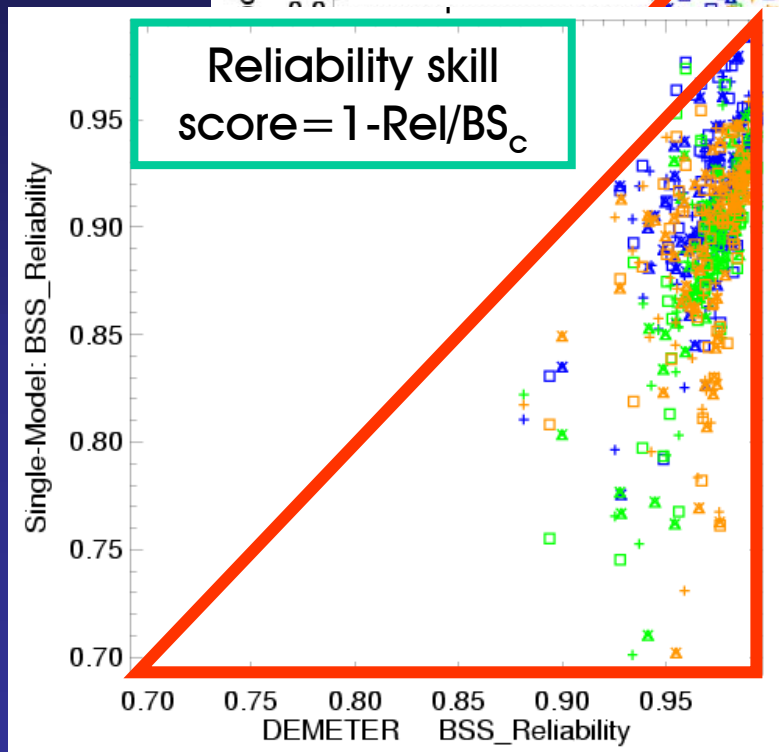


Single vs. multi-model: Brier score

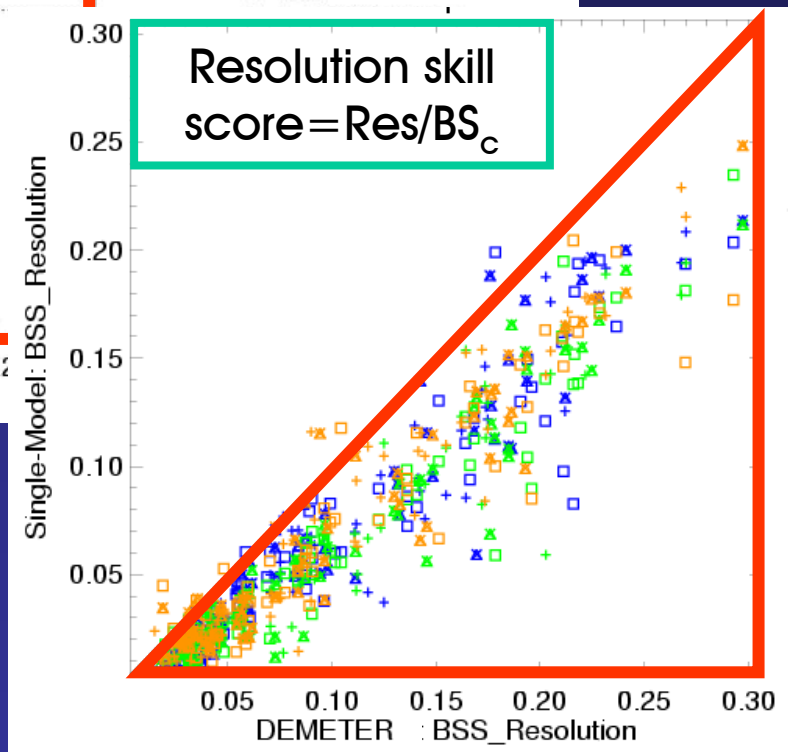
Brier skill score = $1 - BS / BS_c$



Reliability skill score = $1 - Rel / BS_c$

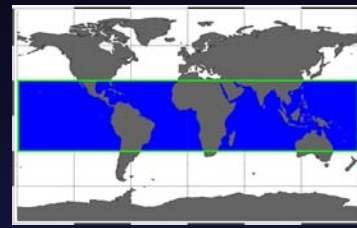


Resolution skill score = Res / BS_c

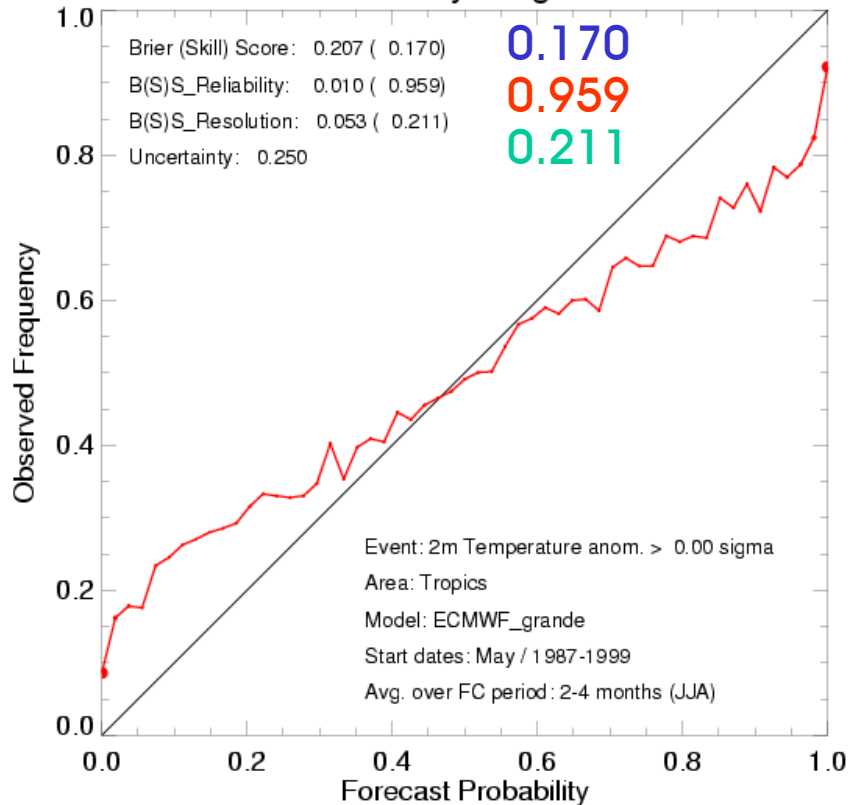


Reliability: 2m-Temp. > 0

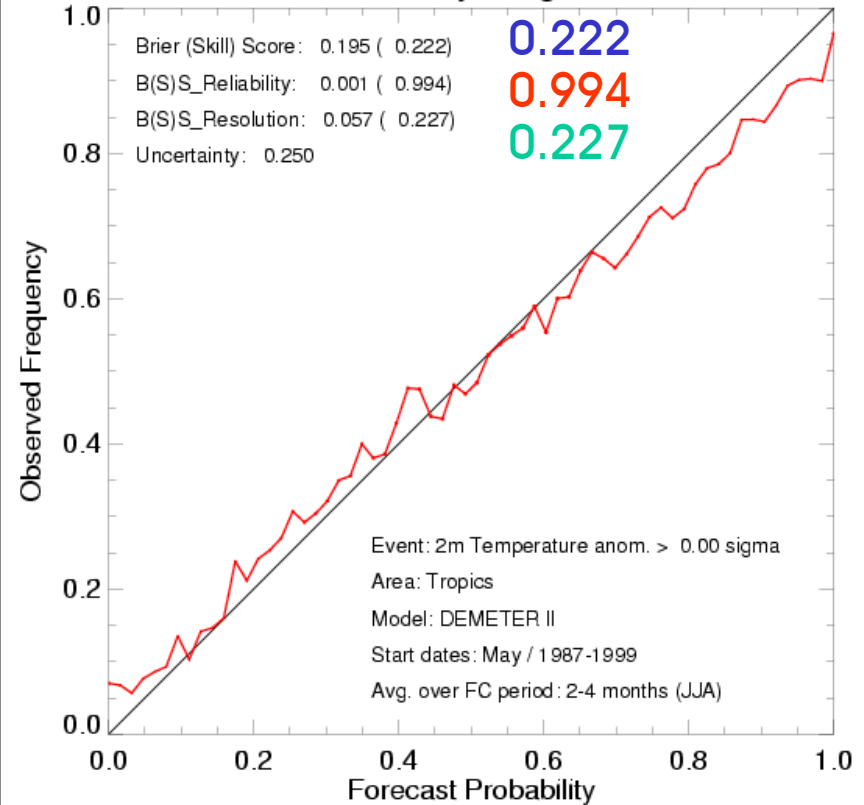
1 month lead, start date May, 1987 - 1999



Reliability Diagram



Reliability Diagram

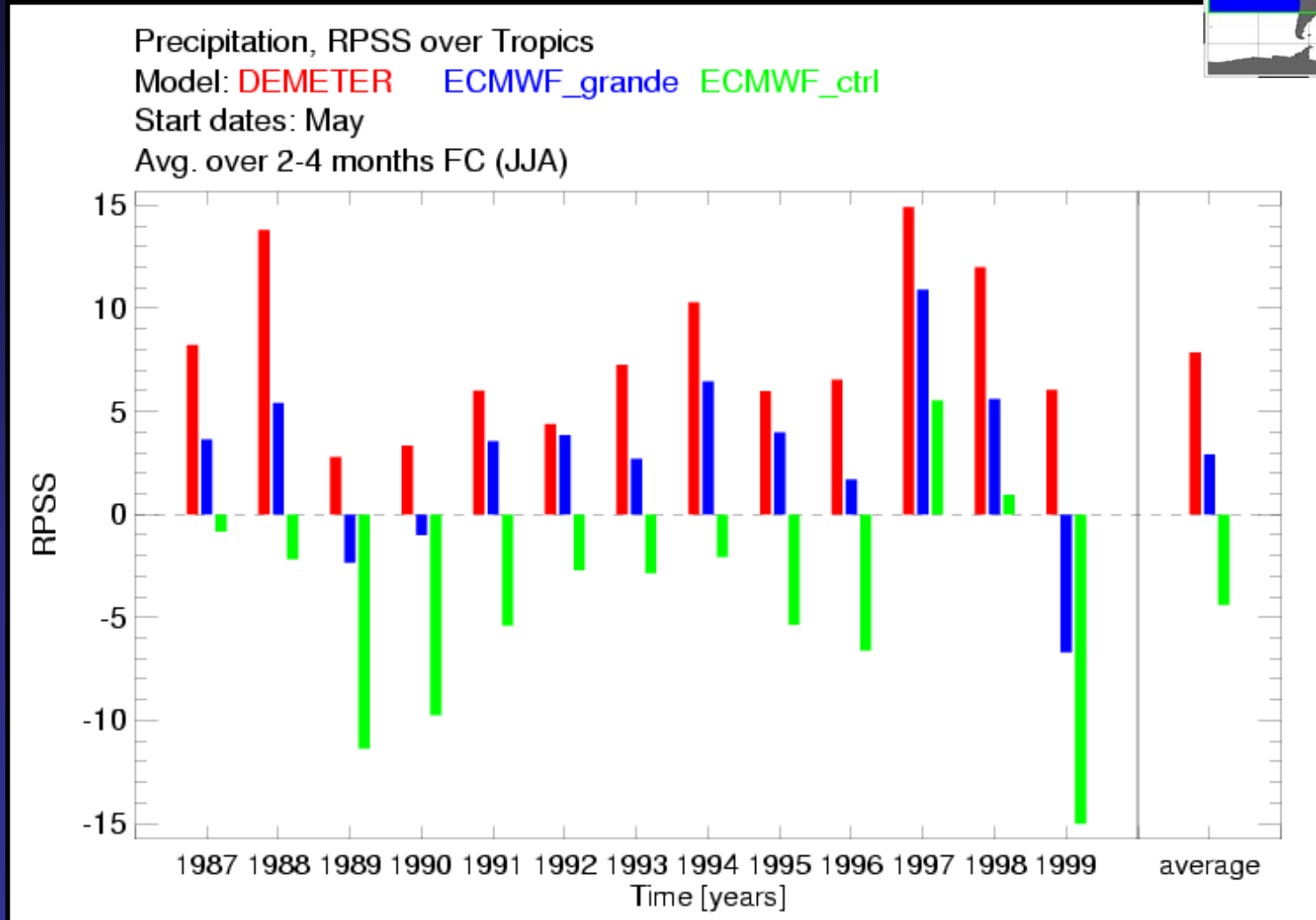
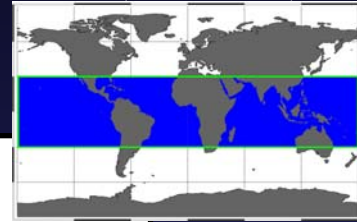


single-model (54 members)

multi-model

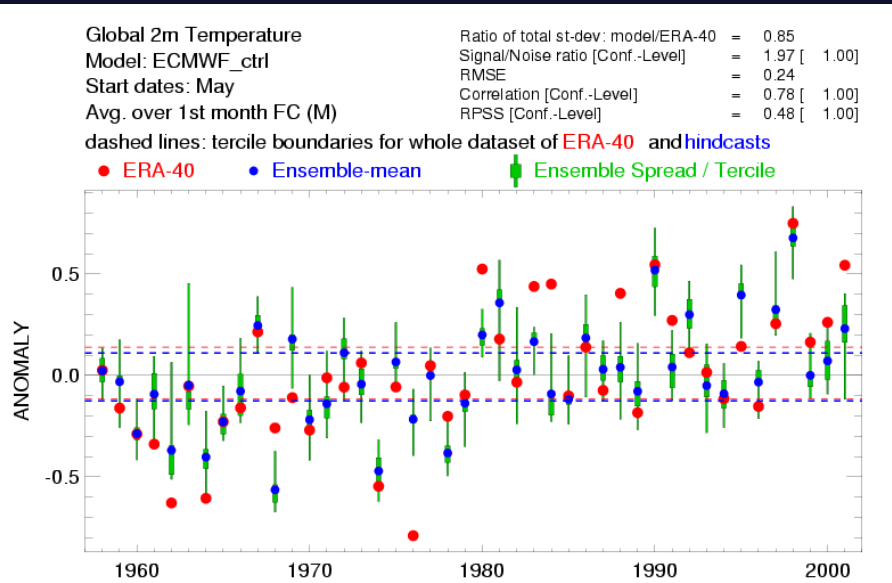
Impact of ensemble size: Precip (JJA)

Multi-model (54 members) single model (54) single model (9)



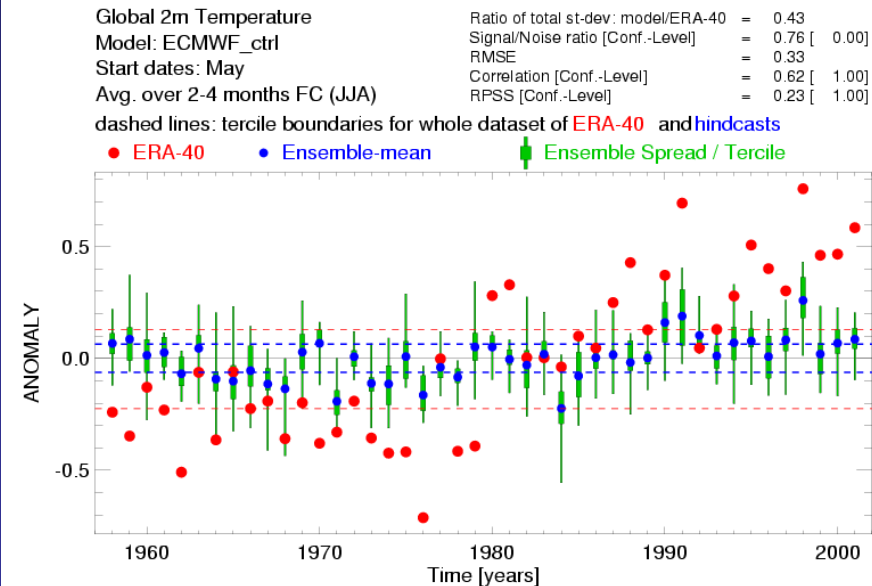
1st PC global 2m temperature

Lead 0

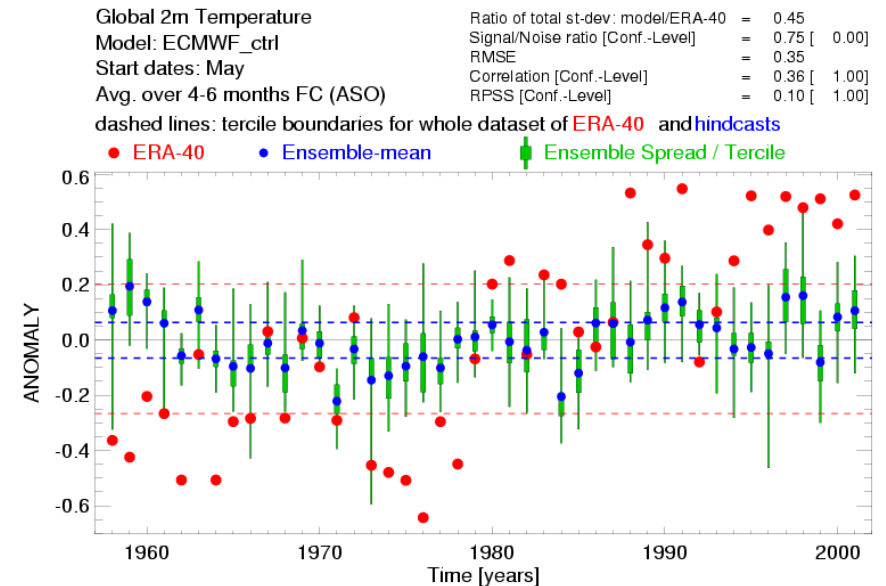


ECMWF vs ERA-40

Lead 1



Lead 3

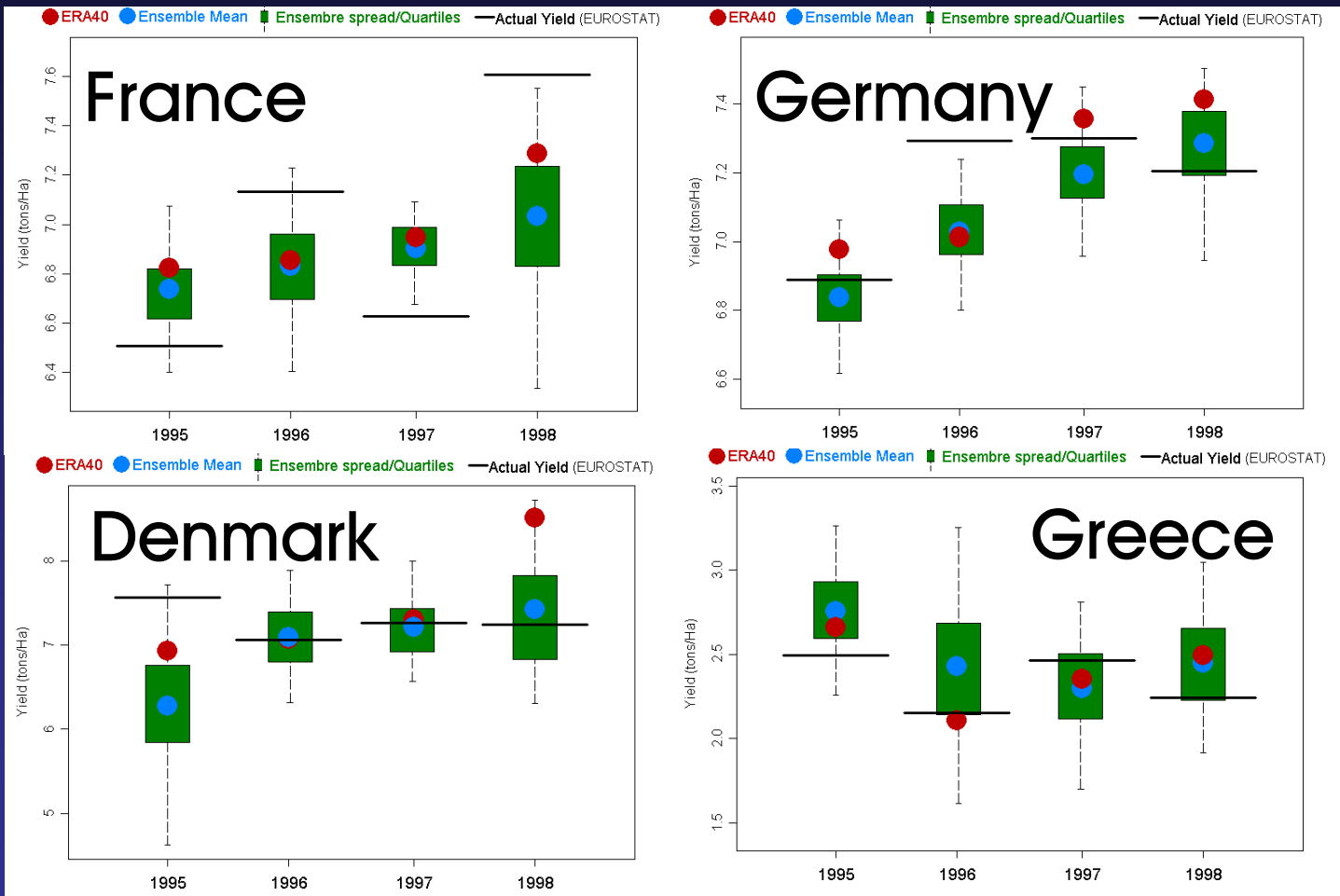


End-user modelling

- DEMETER ensemble hindcasts input for
 - health application (malaria model)
 - agriculture application (crop model)
- Basic idea:
 - explore utility of DEMETER hindcasts
 - give range of uncertainty
- Main problems:
 - sparse data to validate malaria in Africa
 - need of downscaled data

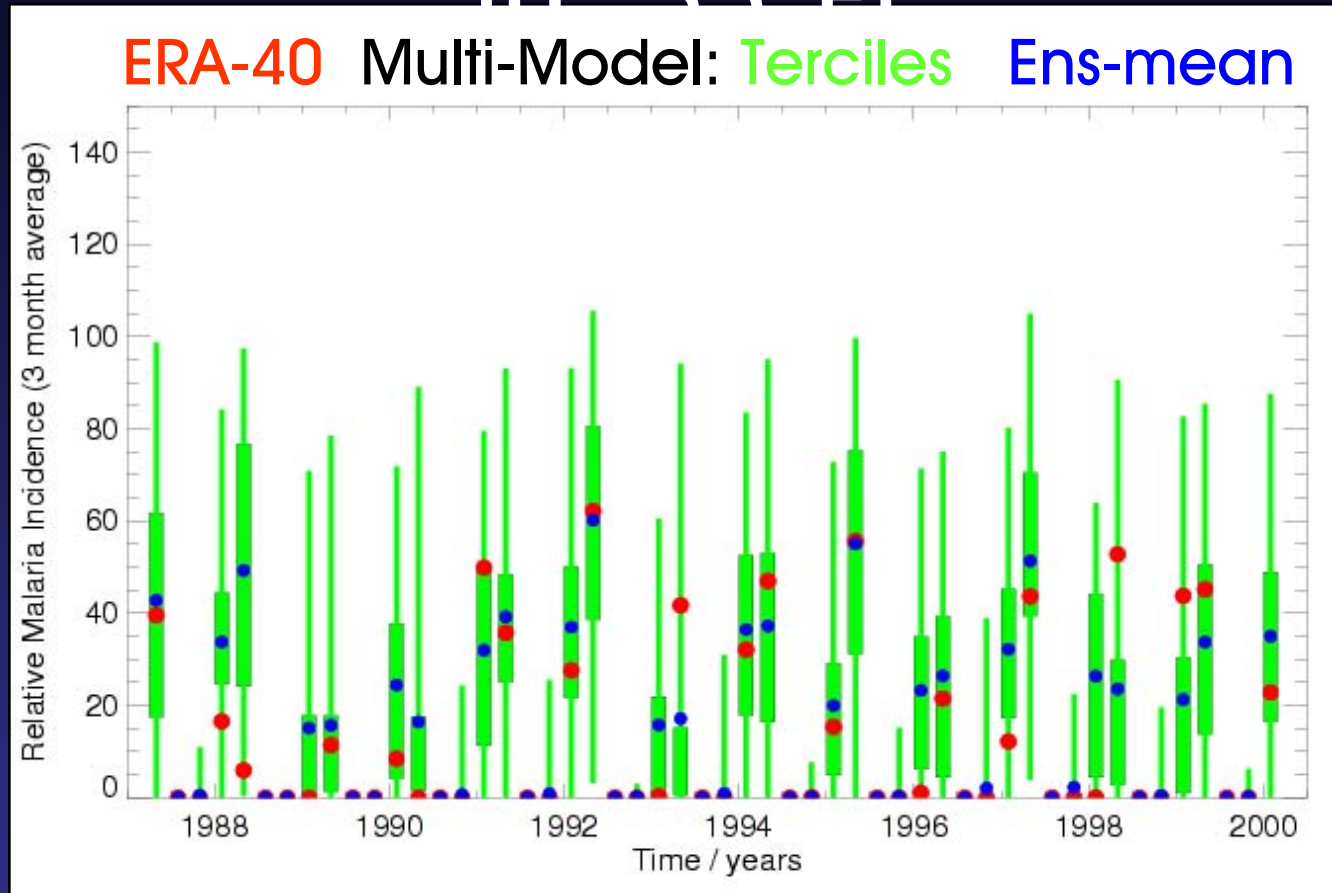
Wheat yield predictions

using downscaled DEMETER multi-model data



Malaria Incidence predictions

(n° 350E)



	Multi-Model	CERFACS	CNRM	ECMWF	INGV	LODYC	MPI	UKMO
Correlation	0.50	0.51	0.52	0.34	0.35	0.29	0.03	0.36
RPSS	0.30	0.23	0.23	0.24	0.27	0.26	-0.25	-0.01

Summary

- DEMETER multi-model hindcasts data set:
 - 22 years available for 7 models (1980 – 2001)
 - 28-44 years available for 5 models (1958 – 2001)
 - Extensive diagnostics and data publicly available
- Multi-model improves over single-model ensembles:
 - main improvement due to reliability
 - skill also improves because of increase in resolution
 - impact of low-frequency variability in skill and calibration
- Applications:
 - end-to-end systems for seasonal prediction -> actual
 - feasibility of *skilful* predictions: malaria incidence, crop yield
- The future:
 - EU-funded ENSEMBLES project (starts April 2004)

