DEMETER and Beyond

Scientific Results, Technical Lessons, Future Perspectives

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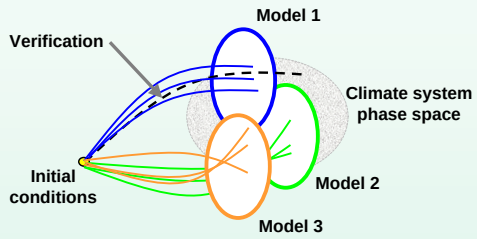
Motivation and project structure

Motivation: Recent years have shown a growing demand for reliable seasonal to interannual climate predictions. There are many ways in which the quality of life, health and safety can be improved by such probability forecasts. A wide range of applications from agriculture, energy, health, insurance up to the financial sector would benefit from reliable predictions. In particular, warnings of the likelihood of extreme climate situations would be of great benefit for the whole society.

Objective: The over-arching objective of DEMETER is to develop a well-validated European seasonal forecast system and assessing its potential for end-user applications. To account for the two main sources of error, model formulation and initial conditions, DEMETER uses the so-called multi-model ensemble concept. Here model error is represented by applying different models and running these models from sets of initial conditions.



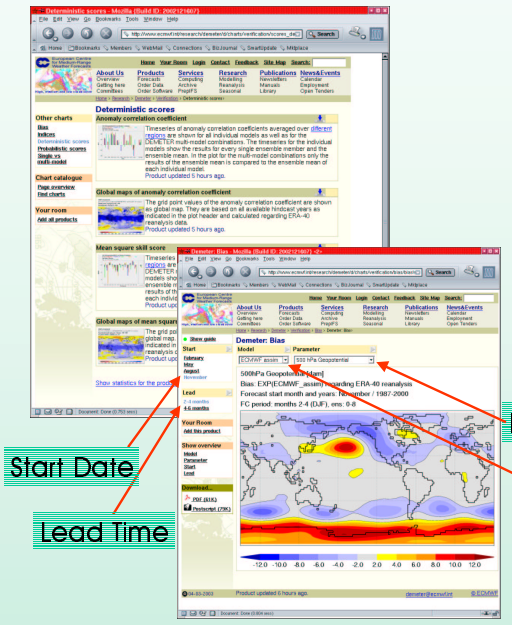
Project Structure: The DEMETER project consists of two main components:

- Development of the multi-model ensemble system, including
  - installation of seven coupled global circulation models in a common framework
  - production of extensive set of hindcasts
    main focus: 1987 - 1999 (7 models), extended period: 1958 - 2001 (4 models)
  - verification of model output
  - downscaling of model output
- Application of (downscaled) model output for
  - agricultural predictions (crop modelling in Europe)
  - disease related predictions (malaria modelling in Africa)

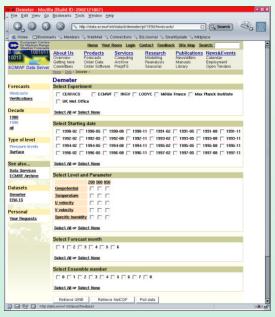
Partner	Atmosphere	Ocean
ECMWF	IFS	HOPE
LODYC	IFS	OPA 8.3
CNRM	ARPEGE	OPA 8.1
CERFACS	ARPEGE	OPA 8.3
INGV	ECHAM-4	OPA 8.2
MPI	ECHAM-5	MPI-OM1
UKMO	HadCM3	HadCM3

Monitoring – Archiving - Dissemination

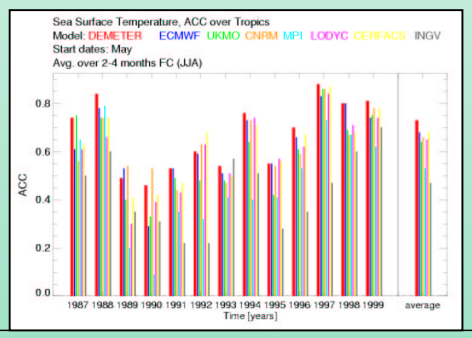
Monitoring: A comprehensive verification system to evaluate all DEMETER single models as well as the multi-model DEMETER ensemble system has been set up at ECMWF. It is run periodically to monitor hindcast production, to quality control the data (and correct archival) and to calculate a common set of diagnostics. Results are online available via a user friendly display tool developed at ECMWF: **http://www.ecmwf.int/research/demeter/verification**



Archiving: To enable a fast and efficient post-processing and analysis of the complex DEMETER data set, much attention was given to the definition of a common archiving strategy for all models; the ECMWF's Meteorological Archival and Retrieval System (MARS) was used for this purpose. A large subset of atmosphere and ocean variables , both daily data and monthly means has been stored into MARS. Special attention was given to the time-consuming task of ensuring that all model output complies with agreed data formats and units. To ensure a widespread dissemination of the DEMETER data set a significant part of the data (monthly averages of a large subset of surface and upper-air fields in Grib or NetCDF format) is freely available for research purposes through an online data retrieval system installed at ECMWF: **http://data.ecmwf.int/data**



Tropical and Extra-Tropical prediction skill

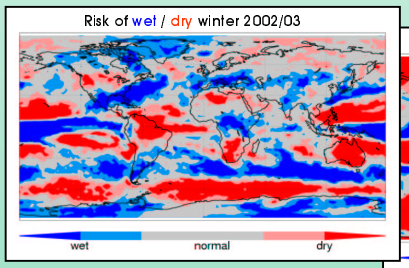


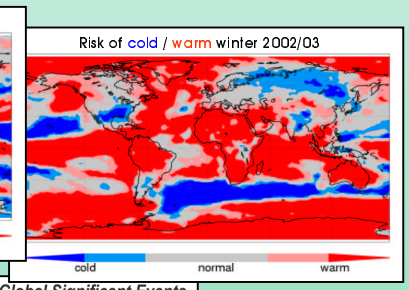
Time series of the ensemble mean sea surface temperature anomaly correlation coefficient for the multi-model (thick red bars) and all individual models (thin bars; ECMWF: blue, Met Office (UKMO): green, Météo-France (CNRM): orange, Max-Plank-Institute (MPI): cyan, LODYC: pink, CERFACS: yellow, INGV: grey. Results are shown for the 1-month lead summer (JJA) SST in the tropics (latitudinal band of 30ºS - 30ºN). Additionally, the average over the whole period 1987-1999 is shown at the end of the plot.

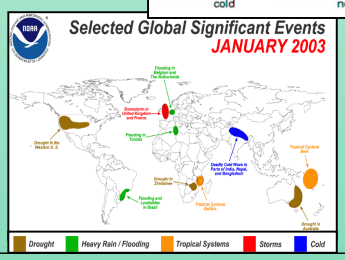
	Multi-Model	ECMWF	LODYC	CNRM	CERFACS	INGV	MPI	UKMO
ACC: PNA	**0.75**	**0.80**	**0.75**	0.20	0.19	**0.57**	**0.68**	**0.62**
ACC: NAO	**0.68**	0.43	0.49	0.44	0.48	0.37	0.23	0.31
RPSS: PNA	**19.3**	**21.8**	**27.3**	26.9	1.8	4.6	**37.5**	0.9
RPSS: NAO	**23.5**	**21.3**	**18.5**	**17.1**	**15.3**	**7.4**	7.9	8.8

Ensemble-mean correlation and ranked probability skill score for the Pacific North American (PNA) and North Atlantic Oscillation (NAO) indices calculated from the 1-month lead hindcasts started in November (DJF seasonal average) for the years 1987-1999. Statistically significant values (95% confidence level) are printed in bold letters.

The world's first real-time dynamical multi-model seasonal forecast

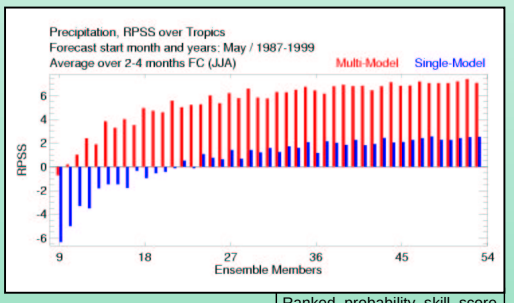






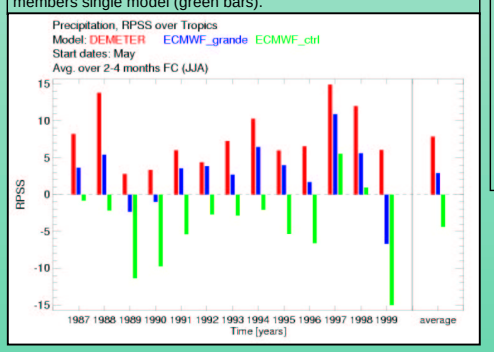
As a result of the success of DEMETER, real-time multi-model ensemble forecasting is now being established as part of the operational seasonal forecast suite at ECMWF.In November 2002, the world's first real-time dynamical multi-model seasonal forecast was presented at the European Research forum in Brussels. The qualitative comparison of the probability maps with selected global significant events demonstrates the potential of seasonal forecast. The maps are representing the probability of the forecast to be in the upper/lower tercile of the climatological distribution (blue/red colors). The subdivision within the upper/lower tercile represents certain probability levels, to indicate the level of confidence in forecasting that particular tercile. The light color marks probabilities above 40%, while the dark color indicates probabilities above 50%. The grey color represents situations with no preferred upper/lower tercile, i.e. cases in which the probability to be in the upper or lower tercile is below 40%.

Multi-Model vs. Single-Model skill



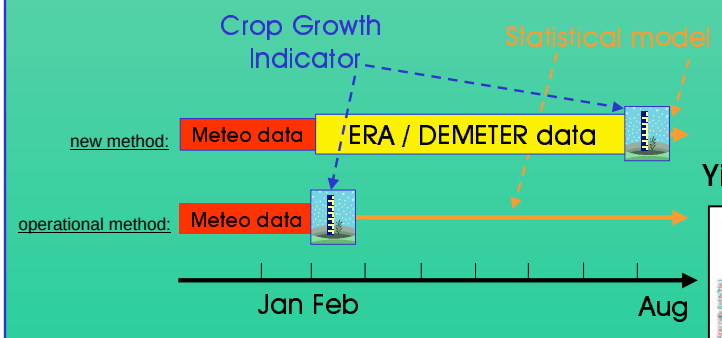
Ranked probability skill score of the multi-model (red bars) and the ECMWF model (blue bars) for precipitation over the tropics for JJA (start date 1st of May, forecast period 2-4 months) as a function of the ensemble size. For each set of hindcasts, an ensemble of the size indicated in the abscissa has been randomly picked out of the whole ensemble of 54 members. Three equiprobable categories defined by the corresponding terciles in each grid point have been used to compute the RPSS.

Time series of the ranked probability skill score for tropical summer precipitation (JJA, start date 1st of May, forecast period 2-4 months). Shown are the results for the 54-members multi-model (red bars), the 54-members single model (blue bars) and the 9-members single model (green bars).

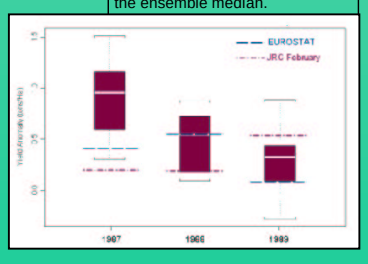


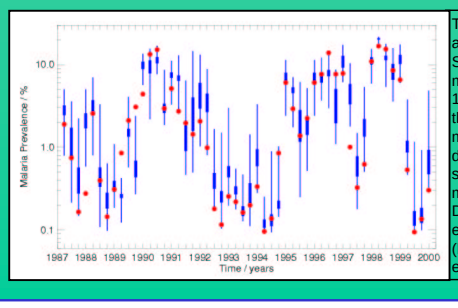
End-user applications

Illustration of the operational and new JRC crop growth monitoring tool to obtain yield predictions. In the traditional method a statistical regression model is used to predict the yield in August based on crop growth indicators which depend on meteorological data available in February. The new method utilises seasonal forecasts for the period February to August to obtain improved crop growth indicators which in turn can improve the statistical yield prediction.



Distribution (25% quantile) of wheat yield anomaly predictions for Spain utilising downscaled multi-model ensemble data (new method). The blue dashed line corresponds to the reference value (Eurostat), the red dash-dotted line to the JRC operational system prediction issued at the end of February. The white solid line inside the central box marks the ensemble median.





Time series of 3-month average (MAM, JJA, SON, DJF) modelled malaria prevalence for 1987 – 1999. Shown are the results of the malaria model forced by ERA-40 data (red dots) and the spread of the malaria model when forced by DEMETER multi-model ensemble members (blue box-and-whisker, ensemble terciles).

Summary FP-5 project DEMETER

Conclusions: The evaluation and application of the DEMETER data demonstrates

- the importance of a coordinated data monitoring, archiving and dissemination strategy
- the potential of seasonal forecasts due to significant skill in tropical Pacific SST-predictions
- skill for extra-tropical forecasts can be found in certain regions and at certain times
- multi-model results are generally superior to single-model results
- increasing the ensemble size adds skill, but multi-model is still superior
- seasonal forecasts can be used to improve end-user application model results

Towards the FP-6 project ENSEMBLES

Outlook: It is proposed to extend the DEMETER system to

- build an integrated prediction system for time scales from seasons to decades and beyond
- include additional components of the earth system (bio-geo-chemistry etc.)
- incorporate a greater diversity of end-user models focussing on climate changes applications
- evaluate the reliability of ensemble systems used to make scenario assessments

For more information on DEMETER please visit our website http://www.ecmwf.int/research/demeter