Seasonal-to-decadal climate probabilistic forecasts in the ENSEMBLES project

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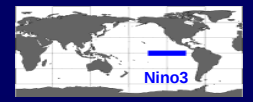
http://www.ecmwf.int/research/EU_projects/ENSEMBLES/



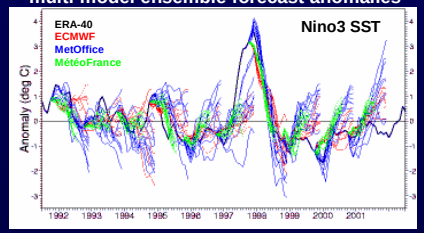
Every physical model of the climate system is wrong. In ENSEMBLES we try to address the problem of coupled model uncertainty using different approaches. Here we present recent results obtained with a multi-model ensemble and an ensemble including stochastic parametrizations of sub-grid physical processes. We focus on predictions of seasonal, interannual and decadal time scales.

Seasonal multi-model ensembles

Combining different, quasi-independent dynamical circulation models, each with specific benefits and errors, into a single forecast system is known as a multi-model ensemble.

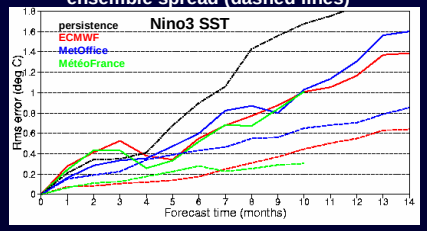
Set up of the simulations:
- Nine-member initial condition ensembles of 3 (so far) global coupled models
- Hindcasts over 7 (May starts) and 14 (November starts) months
- Initialised every year from 1991-2001

multi-model ensemble forecast anomalies



- This plot shows 14-month forecasts of all multi-model ensemble members for the 11 November start dates from 1991-2001
- Depending on the initial state, forecasts from different models spread out into different regions of state space

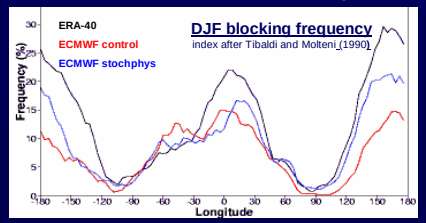
ensemble mean RMSE (solid lines) & ensemble spread (dashed lines)



- In an ideal ensemble system the ensemble spread would match the mean error
- After forecast month 4 all three models are better than a persistence forecast, but underdispersive

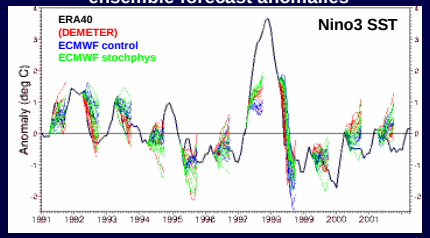
Impact of a new stochastic physics scheme

To account for the effects of unresolved processes the ECMWF model has been integrated with and without a new stochastic physics scheme, which introduces stochastic perturbations to the streamfunction tendencies at each time step.



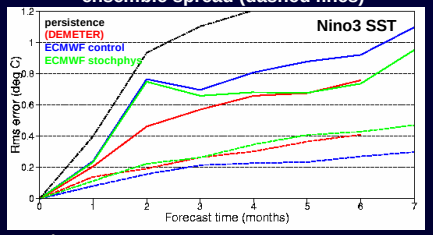
- Blocking, especially over the North Pacific, is improved with stochastic physics

ensemble forecast anomalies



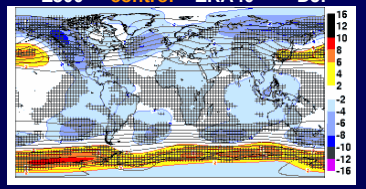
- Stochastic physics ensembles have the potential to sample different directions in state space

ensemble mean RMSE (solid lines) & ensemble spread (dashed lines)

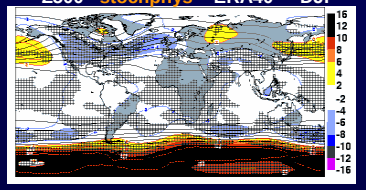


Note the:
- reduction of mean error after two months
- increase of spread on all lead times

Z500 control – ERA40 DJF

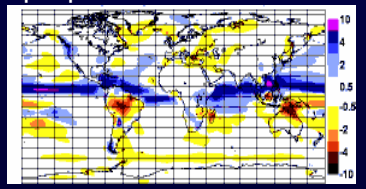


Z500 stochphys – ERA40 DJF

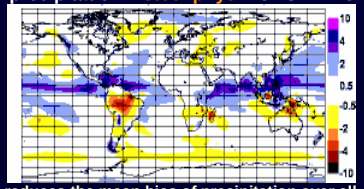


The stochastic physics affects the systematic errors of the atmosphere:
- it improves Z500 over the North Pacific and Siberia

precipitation control – GPCP DJF



precipitation stochphys – GPCP DJF

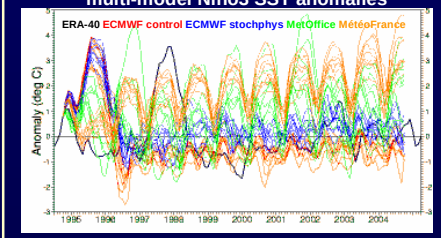


- reduces the mean bias of precipitation over all tropical oceans

Decadal multi-model ensembles

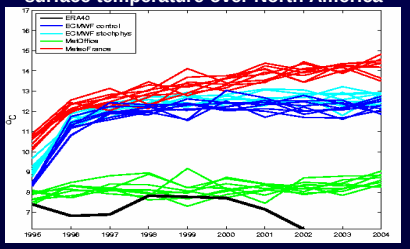
The same global coupled models have been used to make decadal hindcasts, initialised in November 1994. 9-member ensemble simulations have been run with each model.

multi-model Nino3 SST anomalies



- Interannual variability of all ensemble members

surface temperature over North America



- Unrealistic warming over extratropical continents due to soil moisture feedbacks

Conclusions:

- Compared to single-model prediction systems, the multi-model system seems to improve the seasonal and annual hindcasts
- Stochastic physical parametrisation reduces relevant systematic errors
- Decadal predictions remain a challenge for the development of a seamless forecast system