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ENSEMBLES

Deliverable M4.4.4

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Due: month 30

Assessment of the importance of including variable GHGs in seasonal forecasts/hindcasts to guide construction of the ENSEMBLES Stream 2 simulations

1. Introduction

Studies of historical temperature records provide evidence for global atmospheric warming since the early 20th century, especially for the last two decades. Long-term simulations reveal the important role of increasing greenhouse gas (GHG) concentrations in explaining this warming. In spite of this evidence, it has been assumed that the effect of long-term variations in GHG concentrations may be rather small in shorter time scale simulations such as those performed in seasonal forecasting. This is because dynamical seasonal forecasts have been considered as a problem mainly determined by ocean initial conditions and, hence, been produced with models using constant GHG concentrations. However, the need of long sets of integrations for forecast calibration and forecast quality assessment, along with the sharp recent increase in GHG concentrations suggest that this forcing might also play a significant role. This report describes the main results of an experiment undertaken to assess the impact of variable GHG concentrations in short-term climate forecasts and the consequences derived from the conclusions of the experiment.

2. The impact of GHG concentrations in short-term climate forecasts

The ECMWF coupled general circulation model has been used in the experiment. The model consists of IFS cycle 23R4 and HOPE-E as atmospheric and ocean components, respectively. A set of 88 9-member ensembles 6-month long seasonal integrations started from realistic ocean, land and atmosphere initial conditions on the first of May and November of each year over the period 1958-2001 were carried out.

The integrations used realistic initial conditions for the ocean, atmosphere and soil. A control experiment (CONS henceforth) with greenhouse concentrations of the gases CO2, N2O, CH4, CFC11 and CFC12 fixed to their 1990 concentrations (353 ppmv, 1.72 ppmv, 310 ppbv, 280 pptv and 484 pptv, respectively) was performed. The experiment mimics the setup used to produce ECMWF's operational seasonal forecasts. A similar experiment was carried out with concentrations updated every year (VARI). The GHG concentration values were taken from IPCC's TAR until 2000 and then completed beyond that year with the scenario A1B. No seasonal cycle was used.

While biases are similar for both experiments, an improvement in probabilistic forecast quality of temperature and tropical cyclone frequency is found when using realistic variations of GHG concentrations. The improvement is the result of a substantial increase in the resolution component of the Brier score. This is achieved simultaneously improving the reliability. In fact, given an appropriate method, ensemble predictions can be calibrated to produce reliable probability forecasts, while no method can increase the resolution of the forecasts, unless additional information is merged into the prediction. Given that seasonal forecast skill tends to be relatively low, even marginal improvements can prove very useful.

The increase in forecast resolution is a consequence of a better representation of temperature trends and of decadal variability of tropical cyclone frequency in the VARI experiment. In CONS, with constant GHG forcing, the global change signal imprinted to the initial conditions fades out during the first 1-2 months, the temperature trends tend towards zero and the decadal variability of tropical cyclone frequency is out of phase in several basins. VARI partially improves this misrepresentation. The effect seems to take place through changes in net solar and longwave radiation in the case of temperature and in a better representation of vertical wind shear for tropical cyclones. The lack of realistic long-term trends in surface and tropospheric temperatures in the CONS experiment indicates that ocean initial conditions do not properly constrain this long-term variability beyond the first month of the simulation. Using realistic GHG concentrations partially alleviates this problem, which is an additional indication of the impact on climate of anthropogenic changes in atmospheric composition.

The results of the experiment are summarized in three papers:

Doblas-Reyes, F.J., R. Hagedorn, T.N. Palmer and J.-J. Morcrette (2006). Impact of increasing greenhouse gas concentrations in seasonal ensemble forecasts. Geophysical Research Letters, 33, L07708, doi:10.1029/2005GL025061 (available from http://www.ucm.es/info/climast/paco/abstr/grl06_1.htm).

Liniger, M.A., H. Mathis, C. Appenzeller and F. J. Doblas-Reyes (2007). Realistic greenhouse gas forcing and seasonal forecasts. Geophysical Research Letters, 34, L04705, doi:10.1029/2006GL028335 (available from http://www.ucm.es/info/climast/paco/abstr/grl07_1.htm).

Vitart, F. and F.J. Doblas-Reyes (2007). Impact of an increase of greenhouse gas concentrations during the past 50 years on tropical storms in a coupled GCM. Tellus A, in press (draft available from http://www.ucm.es/info/climast/paco/abstr/tellus07_1.htm).

3. Outcome and future work

The positive consequences of the outcome of this experiment are as follows:

- While improved seasonal forecasts are linked to progress in coupled modelling, ocean and land-surface initialization and ensemble generation, it has been demonstrated that an adequate treatment of atmospheric composition makes for more realistic simulations, increasing simultaneously their forecast quality. The experiment illustrates the benefits of linking the seasonal forecast and climate change modelling communities.
- All the forecast systems participating in the Stream 2 s2d simulations already include time-varying GHG concentrations.
- Calibration and combination of single-model forecasts are methods considered by operational seasonal forecasting centres to improve forecast quality. All methods used to calibrate and combine forecasts require long time series of past forecasts and, hence, to correctly reproduce past climate variability in coupled simulations. It has been recommended to include time-varying forcings into operational seasonal forecast systems as enhanced long term trends will result in a better model calibration. Several operational institutions have already adopted this recommendation.
- A thorough analysis of the impact of other atmospheric components will be undertaken. In particular, the impact of anthropogenic and volcanic aerosols will be investigated during the second part of ENSEMBLES.

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