Flux correction and seasonal predictability

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Numerical models of the atmosphere and the ocean are approximations to the reality, and are thus not expected to fit exactly to it, even on long time averages. The difference between the multi-year average model variables and the corresponding observed values is named the systematic error. In numerical climate scenarios, this error is seldom shown (e.g. in IPCC reports) because modellers exhibit the difference between a future climate and a reference climate, both produced by the same model. The hidden assumption is that the systematic error change is smaller than the mean climate change. This difference is sometimes added to observed values in impact studies. This way of proceeding is named the delta method (Déqué, 2007a). In the earlier coupled scenarios, the systematic error in surface fluxes was so big that the ocean drifted toward an unrealistic climate. To avoid this, a constant empirical term was added to the coupling interface. This term was named flux correction (Cubasch et al., 1992). Progresses in developing and calibrating flux parameterizations have made this technique obsolete in recent coupled long integrations.

Systematic errors also exist in seasonal forecasting. Their amplitude may be larger than the predicted signal, in particular when ensemble means are considered. However, they do not appear in forecasts, as scientists produce a series of hindcasts to evaluate the model climatology and consider the anomaly, i.e. the difference between a model forecast and the hindcast climatology. This anomaly is compared with the difference between an observed variable and its climatology. However, this *a posteriori* correction does not prevent the model to badly simulate large-scale teleconnections which contribute to the predictability of the system. Guldberg et al. (2005) proposed to apply an *a priori* correction to the model to improve the seasonal predictability. The aim was not to prevent the ocean from drifting, but to maintain the atmosphere in a mean state close to the observed one. To this purpose, the error must be corrected at its source: a surface flux error can originate in a lack of cirrus clouds. The technique consisted in adding to the model equations, at each level and time step, a correction of the tendency error. This tendency error was calculated in a previous model simulation nudged toward a reanalysis. The long term average of the nudging term (the difference between model and reanalysis multiplied by the relaxation factor) was considered as the mean tendency error of the model. Subtracting this term in the model equations in a seasonal hindcast experiment did not lead to the expected improvement. The systematic error was weakly reduced and no impact on the forecast scores was observed.

The experiment we present here is an attempt to improve the above method. The systematic error is a statistical concept, because the model error is not systematic but changes according to the situation. Because the model is highly non-linear, applying every day the same correction is not the best way to proceed. The experiment is based on three hindcasts of the 1979-2010 period with a version of CNRM-CM5. (Arpege TL127 with 91 vertical levels, Nemo 1° with 42 vertical levels). The hindcasts start on November 1st, and we focus on the DJF period.

- E1: a 32 NDJF hindcast with 4 members in which a weak nudging toward ERA interim above 850 hPa (10 days for vorticity, 30 days for temperature and moisture) is applied every 6 hours. The daily nudging terms are stored.
- E2: a 32 NDJF hindcast with 15 members in which the initial situations are perturbed (as in E1).
- E3: a 32 NDJF hindcast with 60 members in which every 6 hours a nudging term is randomly selected among the E1 saved terms (same calendar month leaving the current year). The correction is linearly interpolated in time between two consecutive 6h steps.

E2 is a control experiment, E3 is an experiment in which we attempt to correct the model by using the probability distribution of past errors. The terms saved in E1 help estimate the model error statistics in forecast mode. E1 is not an actual hindcast since it uses verification data: its forecast scores for seasonal means (not shown) are obviously very high.

Figure 1 shows that the mid-latitude bias is significantly reduced. Table 1 shows the anomaly correlations of the DJF period for a few parameters. In order to properly evaluate the improvement due to the correction technique, 15 members are randomly drawn out of the 60 members, and we show the score quantiles (based on 500 series) corresponding to 5%, 50% and 95%. When the score of E2 is below the 5% quantile of E3, we can consider the score improvement as significant. This is the case for most variables, except for NAO which is however generally improved. The bias and score improvements are mainly due to the mean term of the perturbation, as shown by later experiments at lower resolution. However the random part does not reduce this positive effect and increases the intraseasonal as well as the seasonal intra-ensemble variability which is a further improvement when evaluating probability prediction.

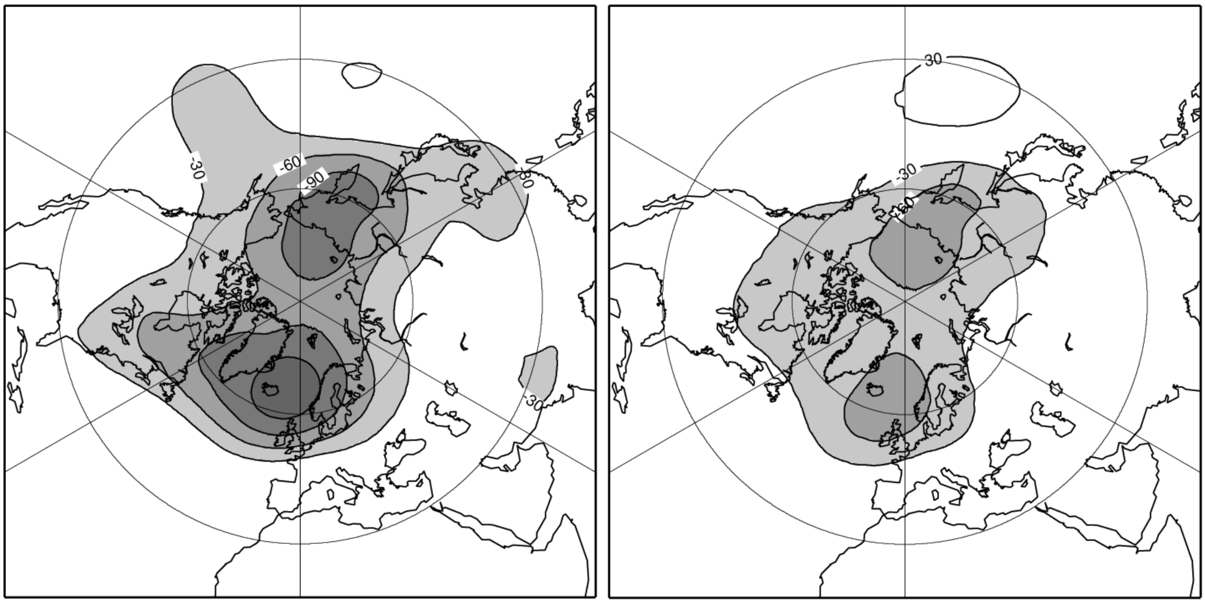

Figure 1: DJF mean error in E2 (left) and E3 (right) for 500 hPa geopotential height ; contour interval 30m, shading below -30 m

	30N-90N Z500	NAO	NAM	Nino3.4 SST	30S-30N Prec.
E2	0.27	0.24	0.13	0.89	0.54
E3 Q5%	0.30	0.23	0.39	0.90	0.54
E3 Q50%	0.35	0.43	0.52	0.91	0.56
E3 Q95%	0.40	0.60	0.64	0.92	0.57

Table 1: Anomaly correlation over 32 DJF for 500 hPa height (30N-90N), North Atlantic Oscillation (NAO), Northern Annular Mode (NAM), Nino3.4 sea surface temperature and precipitation (30S-30N)

References:

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