Seasonal forecast skill increase due to vertical resolution

Michel Déqué and Jean Philippe Piedelievre
Météo-France/CNRM Toulouse, France. deque@meteo.fr

Evaluation of the skill of seasonal forecasts is a computationally expensive exercise, as the number of years must be at least 10 for tropics and 30 for midlatitudes. The size of the ensembles must be at least 3 for the tropics and 9 for midlatitudes. Otherwise, the accuracy of the scores is too poor (Déqué, 1997). The choice of horizontal and vertical resolution is a compromise between the expected improvement and the cost of a reliable evaluation experiment. In the PROVOST European project (Doblas-Reyes et al., 2000), an attempt to introduce high resolution in the stratosphere was not successful in terms of score improvement. Possible reasons were the number of stratospheric levels (20), the absence of coupling with the ocean, the poor quality of the ERA15 analyses in the stratosphere.

In the DEMETER European project (Palmer et al., 2004), the conditions are more favorable: the 44 years of ERA40 offer a good dataset for stratospheric initial conditions, and the forecast exercise is carried out in coupled mode. The experiment we present here is based on a revisit of the winter forecasts with a more recent version of one of the participating models. We used version 4.4 of ARPEGE-Climate (Déqué, 2003). The initial atmospheric conditions are obtained from ERA40 data, whereas the ocean is initialized by an uncoupled run of the model forced by the daily ERA40 surface fluxes. Nine members, obtained by lagging by using the last 9 days of October as an atmospheric initial condition, have been produced for 44 winters (starting at 1st November 1958 through 2001). The standard simulation uses 31 vertical levels, as in DEMETER. Although the model has undergone a few improvements since the original DEMETER exercise (the forecast scores are improved in uncoupled mode), this new version is generally below the original one in terms of scores.

A stratospheric version has been built by using 91 levels and letting ozone evolve as a prognostic variable (it is prescribed from a multi-year average of the same field in the 31L version). In addition the time step is divided by two to maintain time stability. As a result of the quadratic increase of the radiative calculations, the 91L version is ten times more expensive than its 31L counterpart. Table 1 indicates the average pressure in the middle of each layer for both resolutions. The anomaly correlation of both models has been calculated for the DJF (month 2-4) averages with respect to the ERA40 values. Except in the southern hemisphere, the scores are significantly improved. This result is in agreement with recent findings of Baldwin et al. (2003) about stratospheric memory.

References:

Baldwin, M.P., Stephenson, D.B., Thompson, D.W.J., Dunkerton, T.J., Charlton, A.J. and O'Neill, A., 2003: Stratospheric memory and extended-range weather forecasts. Science, 301, 636-640.

Déqué, M., 1997: Ensemble size for numerical seasonal forecasts. Tellus, 49A, 74-86.

Déqué, M., 2003: Documentation of ARPEGE-Climate version 4. Available electronically in 3 volumes upon request to the author.

Doblas-Reyes, F.J., Déqué, M. and Piedelievre, J.P., 2000: Model and multimodel spread in the PROVOST seasonal forecasts : application to probabilistic forecasts. Quart. J. Roy. Meteor. Soc., 126, 2069-2088.

Palmer, T.N., Alessandri, A., Andersen, U., Cantelaube, P., Davey, M., Délécluse, P., Déqué, M., Díez, E., Doblas-Reyes, F.J., Feddersen, H., Graham, R., Gualdi, S., Guérémy, J.F., Hagedorn, R., Hoshen, M., Keenlyside, N., Latif, M., Lazar,A., Maisonnave, E., Marletto, V., Morse, A.P., Orfila, B., Rogel, P., Terres,J.M. and Thomson, M.C., 2004: Development of a European Multi-Model Ensemble System for Seasonal to Inter-Annual Prediction (DEMETER). Bull. Am. Meteorol. Soc., 85, 853--872.

0.01	0.03	0.06	0.10	0.17	0.28	0.43	0.64	0.92	1.30
1.78	2.38	3.12	4.02	5.09	6.34	7.80	9.47	11.37	13.50
15.88	18.52	21.41	24.57	27.99	31.67	35.63	39.85	44.33	49.07
54.07	59.31	64.80	70.51	76.43	82.57	88.96	95.61	102.58	109.88
117.58	125.72	134.35	143.52	153.25	163.58	174.52	186.13	198.42	211.44
225.23	239.82	255.26	271.58	288.85	307.09	326.37	346.74	368.24	390.94
414.88	440.11	466.51	493.86	521.90	550.35	578.95	607.46	635.74	663.68
691.15	718.01	744.13	769.39	793.68	816.90	838.92	859.65	879.04	897.00
913.47	928.41	941.82	953.68	964.00	972.80	980.35	986.78	991.98	995.95
998.82									
10.00	30.00	50.00	70.00	90.08	110.64	132.32	155.60	180.77	208.01
237.35	268.76	302.17	337.46	374.50	413.17	453.32	494.84	537.57	581.36
626.02	671.31	716.89	762.33	807.04	850.23	890.88	927.68	958.96	982.63
996.14									

Table 1: Vertical discretization (hPa) of the 91L version (row 1-10) and of the 31L version (row 11-14)

		Globe	NH	SH	Tropics	Nino3.4
Z500	31L	.20	.12	.17	.64	.25
	91L	.25	.20	.16	.67	.41
Precip.	31L	.45	.14	.07	.47	.58
	91L	.51	.19	.04	.53	.72
S Temp.	31L	.25	.16	.22	.40	.47
	91L	.30	.23	.23	.42	.51

Table 2: Anomaly correlations of 500 hPa height, precipitation and surface temperature in the two vertical resolutions. The verification domains are the globe, the northern hemisphere (30°N-90°N), the southern hemisphere (30°S-90°S), the tropics (30°S-30°N) and the Nino3.4 box (5°N-5°S, 120°E-170°E).