SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2013
Project Title:	Sensitivity of decadal forecast to atmospheric resolution and physics
Computer Project Account:	spfrguer
Principal Investigator(s):	Jean-François Guérémy
Affiliation:	CNRM-GAME/GMGEC
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	01 January 2013
Expected end date:	31 December 2015

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			11600000	6074573
Data storage capacity	(Gbytes)			40000	0 (everything on frtodcli)

Summary of project objectives

(10 lines max)

The main objective of the project is to investigate the sensitivity of decadal predictability to atmospheric resolution and physics. Two earlier projects dealing with decadal forecasts (i.e., CMIP5 and EPIDOM) made use of our present model CNRM-CM5 with different atmospheric spatial resolutions, Tl127l31 for the former and Tl63l62 together with Tl63l91 (including for the latter. In the present project, we will use a more recent version of the CNRM-CM model including a new atmospheric physical package (non orographic gravity wave drag, turbulence, convection and microphysics). In the last year of the project, prognostic aerosols might be included in the model to perform the decadal forecasts. Moreover, different atmospheric spatial resolutions will be considered in the course of the project, all including the stratosphere to take advantage of our simulated QBO, starting from Tl159l91.

Summary of problems encountered (if any)

(20 lines max)

Summary of results of the current year (from January to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

This first half year has been mainly devoted to the definition and evaluation of the atmospheric component of a new coupled version of CNRM-CM (hereafter called CNRM-CM5+), using cycle 37t1 of ARPRGE-IFS (and NEMO 1° as in CNRM-CM5). First, it has been decided to deal with the following new atmospheric physical package: turbulence (Cuxart et al., 2000), microphysics (Lopez, 2002) and convection (Guérémy, 2011 and Piriou, 2012, personal communication for the prognostic convective microphysics following Lopez, 2002). Given this new physics, several coupled mode preliminary tests have shown that a linear truncation of Tl159 provided better results than Tl127 in terms of the equatorial Pacific SST pattern and also in terms of the PNA response pattern (as shown in Fig. 1).

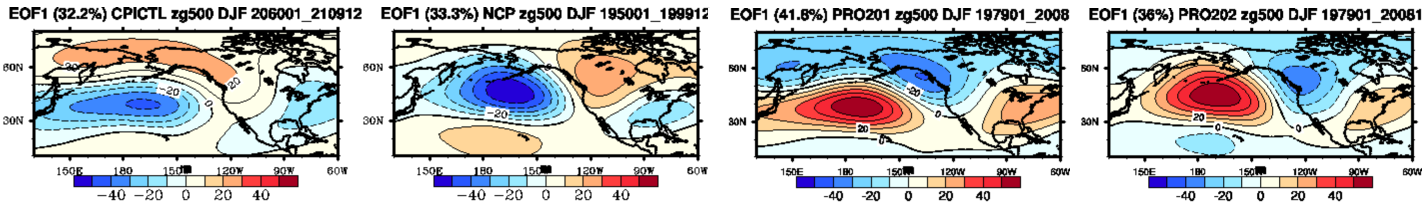

Fig. 1. First EOF of the North Pacific Z500 for CNRM-CM5 (Tl127l31), NCEP reanalysis, CNRM-CM5+ (Tl127l70 and Tl159l62), from left to right.

Moreover, the vertical resolution l62 (tropospheric part of the ECMWF l91) provided better results than the CNRM l70 resolution (including the stratosphere) due to thinner layers in the tropospheric low levels. Finally, a Tl159l91 resolution has been chosen; it includes the stratosphere with a new non orographic gravity wave drag parameterization (Lott, 2012, personal communication) simulating a realistic QBO simulation.

CNRM-CM5+ using a Tl159l91 resolution has been assessed in terms of its ability to simulate the observed climate and also of its skill in seasonal predictions. This exercise has been performed in comparison with CNRM-CM5 using a Tl127l31 resolution (being 3.8 less expensive in SBU than our target model using a 15 mn time step instead of 30 mn). CNRM-CM5+ has been integrated over 30 years starting in 1979. Figure 2 shows the biases of the zonal averaged temperature. These biases are significantly reduced, notably in the tropics thanks to the new convection scheme.

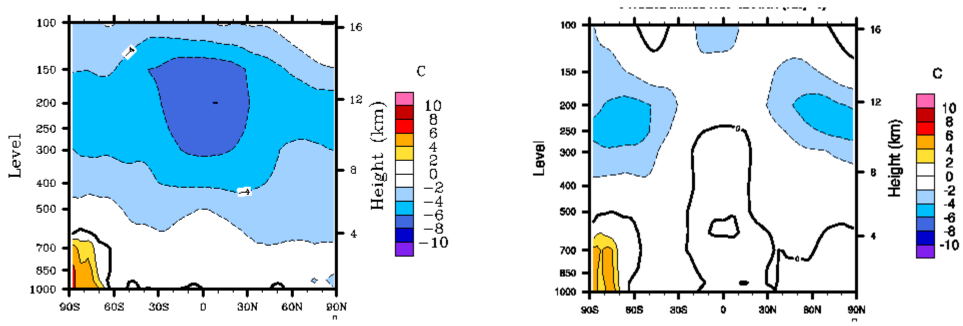

Fig. 2. Zonal averaged temperature biases for CNRM-CM5 and CNRM-CM5+, from left to right.

The SST biases are reduced, notably in the tropical oceans as presented in Fig. 3.

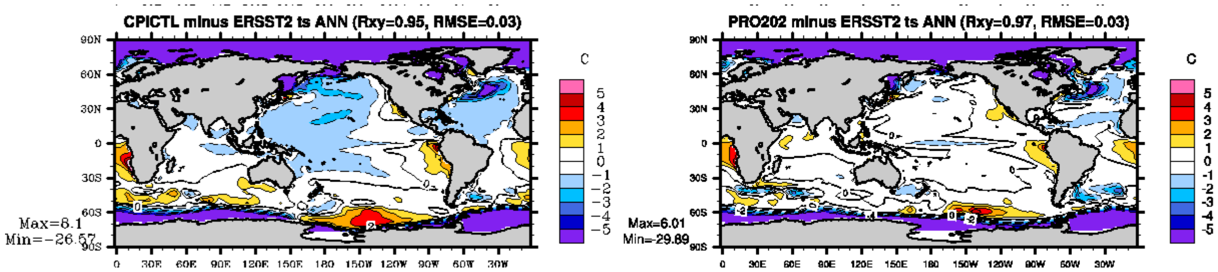

Fig. 3. SST biases for CNRM-CM5 and CNRM-CM5+, from left to right.

The precipitation biases are also reduced, as shown in Fig. 4. The latitudinal spread of the tropical biases are particularly smaller, due to both the new convection scheme and the increase of resolution. A negative bias is still notably present in the equatorial Western Pacific, coherently to the negative SST bias (see Fig. 3). This bias should diminish with the increase of atmospheric horizontal resolution, as it appears in some preliminary tests (not shown).

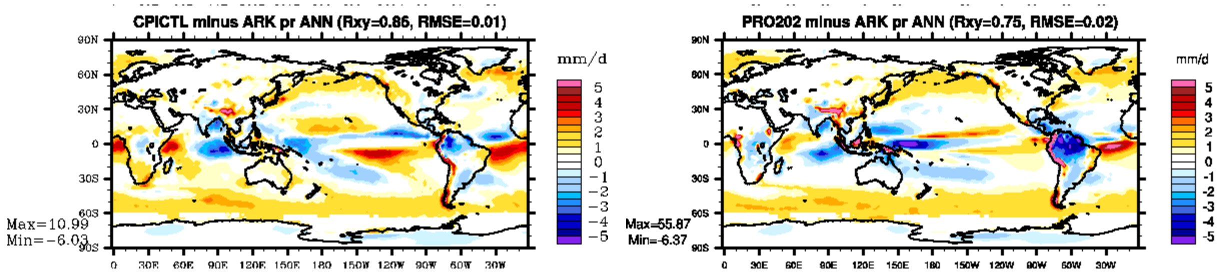

Fig. 4. SST biases for CNRM-CM5 and CNRM-CM5+, from left to right.

Further to the mean climate, the simulated variability has also been improved with the new version of CNRM-CM. Figure 5 shows the first EOF and the time spectrum of the corresponding principal component of the tropical Pacific SST in DJF, for the observation and both versions of CNRM-CM. The EOF patterns of both simulations are similar to that of the observation, the one of CNRM-CM5+ being the closest. Furthermore, the observation time spectrum is characterised by two local maxima, one around 0.4 (2.5 years) and another one between 0.16 and 0.3 (3.3 and 6.3 years). CNRM-CM5 and CNRM-CM5+ also exhibit a double maximum, but with lower periods (2.4 and 3.3 years) for the former and more proper periods (2.5 and 5 years) for the latter. The PNA response to ENSO has been presented in Fig. 1. The time spectrum of this mode from CNRM-CM5+ is closer to the one of the observation, because of the better similarity obtained by the ENSO mode.

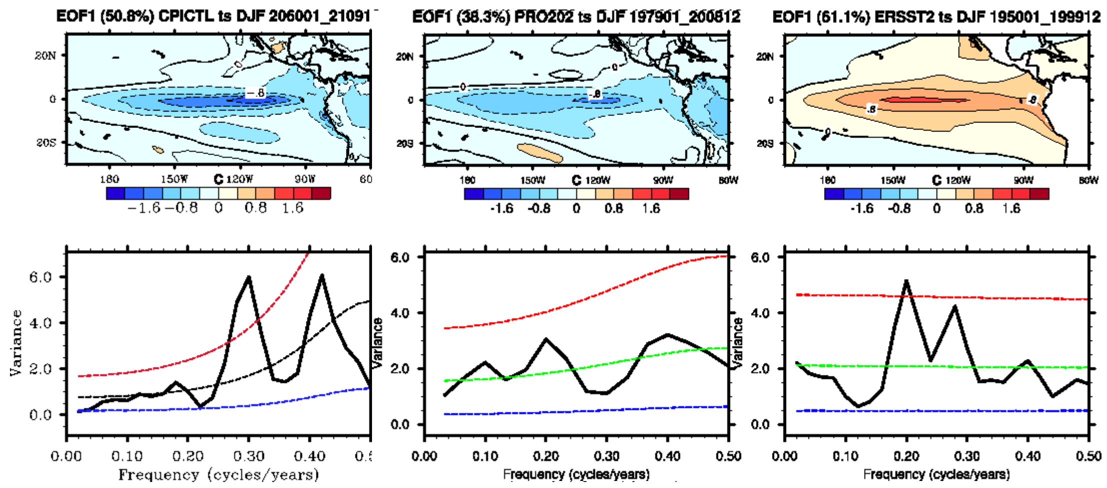

Fig. 5. First EOF and time spectrum of the corresponding principal component of the tropical Pacific SST in DJF, for CNRM-CM5, CNRM-CM5+ and the observation, from left to right.

Figure 6 shows the first EOF and the time spectrum of the corresponding principal component of Z500 over the Northern Atlantic in DJF, for the observation and both versions of CNRM-CM. This NAO pattern is reasonably reproduced by the both versions of the model, while being somewhat shifted to the West compared to NCEP reanalysis. In terms of time spectrum, the new version is providing better results with a small spectral peak located around 0.38 (2.6 years) as in the NCEP reanalysis, whereas the old version is producing a large peak at 0.32 (3.1 years).

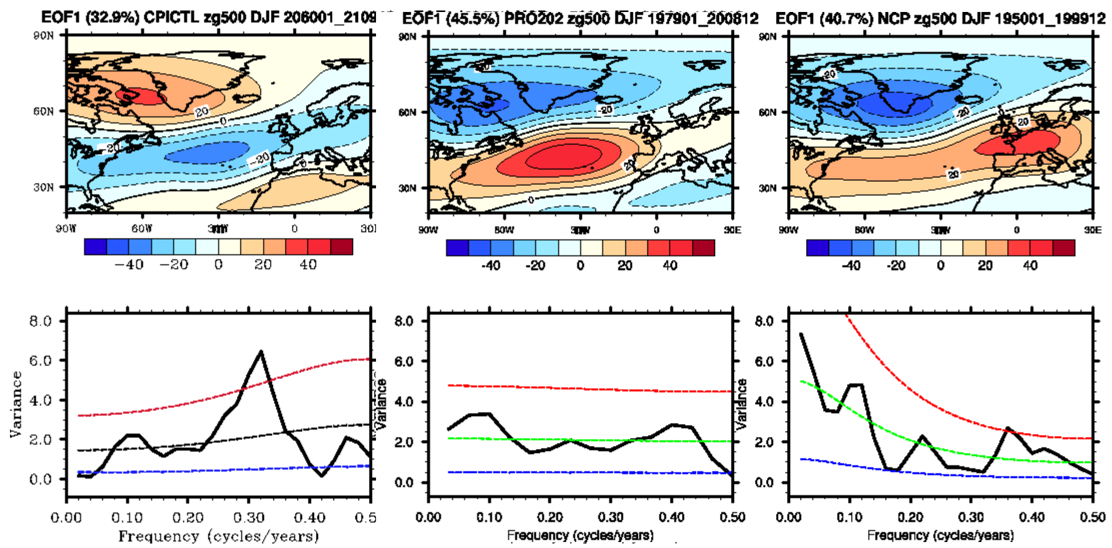

Fig. 6. First EOF and time spectrum of the corresponding principal component of Z500 over the Northern Atlantic in DJF, for CNRM-CM5, CNRM-CM5+ and NCEP reanalysis, from left to right.

Beyond the assessment of the model ability to properly simulate the observed climate, the seasonal forecast skill has been evaluated. Ensembles of 15 seasonal hindcasts have been performed over 4 months starting the first of November during a 32 year period (1979 to 2010), using Tl159l91 CNRM-CM5+. DJF skill scores have been computed and compared to those of Tl127l31 CNRM-CM5 (as already reported in the previous section).Table 1 presents ACCs of selected variables (T850, Z500 and Precipitation) over the Tropics and the Northern Hemisphere. A 95 % confidence interval has been calculated selecting randomly 10 hindcasts among the 15 produced. CNRM-CM5+ performs significantly better than CNRM-CM5 except for the tropical precipitation. Hindcasts carried out using Tl127l91 CNRM-CM5 have shown that the score improvement of T850-Trop is mainly due to the physics, while both the vertical resolution and the physics account for the Z500-NH score improvement (not shown). Tl159l91 CNRM-CM5+ remains significantly better than Tl127l91

CNRM-CM5, except for the precipitation (worse in the tropics and equal in the Northern Hemisphere).

	CNRM-CM5	CNRM-CM5+
T850-Tropics	*0.40* 0.42 *0.43*	*0.46* 0.47 *0.48*
Precip-Tropics	*0.50* 0.51 *0.51*	*0.46* 0.47 *0.47*
Z500-NHemis	*0.15* 0.20 *0.24*	*0.25* 0.29 *0.33*
Precip-NHemis	*0.16* 0.17 *0.19*	*0.17* 0.19 *0.20*

Table 1. CNRM-CM5 and CNRM-CM5+ Anomaly Correlation Coefficients.

Figure 7 shows the global maps of the time correlation between CNRM-CM and ERA-Interim for DJF over the 1979-2010 period. The results presented in this figure corroborate the fact that CNRM-CM5+ performs better than CNRM-CM5. Nevertheless, the skill over Europe has not been really improved.

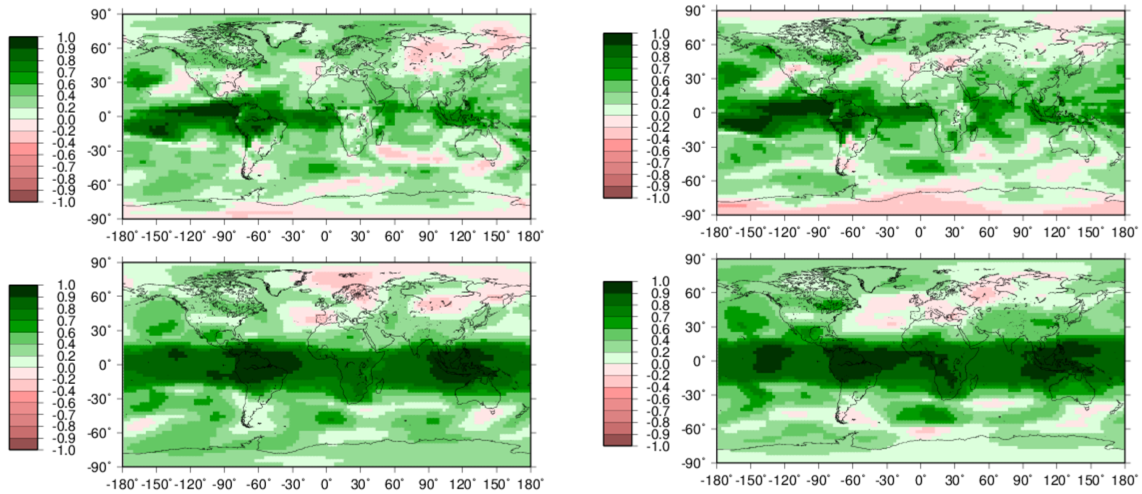

Fig. 7. Time correlation between CNRM-CM and ERA-Interim for DJF over the 1979-2010 period. CNRM-CM5 on the left CNRM-CM5+ on the right and T850 on top and Z500 at bottom.

List of publications/reports from the project with complete references

Summary of plans for the continuation of the project

(10 lines max)

In the second part of the first year, we intend to perform a first set of decadal hindcasts using CNRM-CM5+ with a resolution of Tl159l91. The plan is to consider 11 start dates from 1980 to 2005 every 3 or 2 years (1980, 1983, 1985, ...), similarly to what is expected in the frame of the EU SPECS project. The hindcasts will start from the first of November of the previous year in order to compare with the existing seasonal hindcasts. Each decadal hindcasts will be an ensemble of 10 members over a range of 10 years. The initial conditions will come from a coupled simulation nudged toward NEMOVAR in the ocean and toward the rotational dynamics of ERA-Interim in the stratosphere (as already done in the frame of the French project EPIDOM). During the second year, it is expected to redo the same set of decadal hindcasts, but using a higher horizontal resolution of ARPEGE in order to try to improve both the simulations over the equatorial Pacific and the northern Atlantic.