System 4 versus System 5

May 2015

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Introduction

The operational EUROSIP forecast is a multi-model combination of 4 « forecast systems » produced by ECMWF, Met Office, Météo-France and NCEP. Météo-France System 4 was launched in January 2012. System 5 has started in May 2015, and will replace System 4 in autumn 2015. A detailed documentation of System 4 (in French) is available upon request to:

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A more synthetic description is also available at:

http://old.ecmwf.int/products/forecasts/seasonal/documentation/eurosip/index.html

As far as System 5 is concerned, the documentation (in English, except one appendix) is available at:

http://www.cnrm.meteo.fr/IMG/pdf/system5-technical.pdf

In this document, we list the main differences between the two systems and display various diagnostics calculated from the hindcast period.

Basic facts

The table below is adapted from ECMWF system documentation. It compares the main features of the two forecast systems. The reference publications are just below this table

	System4	System5
1. Ensemble version		
Ensemble identifier code:	CNRM-CM 5.2	CNRM-CM 6.0
Short Description	Global ensemble system that simulates uncertainties using a lagged-average scheme. Based on 51 members, run once a month up to 7 months	Global ensemble system using a lag-averaged and a stochastic scheme to simulate initial state and model uncertainties using a lagged-average scheme. Based on 51 members, run once a month up to 7 months
Research or operational	Operational	Operational
Data time of first forecast run	01/01/2013	01/05/2015
2. Configuration of the EPS		
Is the model coupled to an ocean model ?	Yes from day 0	Yes from day 0
If yes, please describe ocean model briefly including frequency of coupling and any ensemble perturbation applied:	Ocean model is NEMO3.2 with a 1 degree horizontal resolution, 42 vertical levels, initialized from unperturbed MERCATOR-OCEAN Ocean Analysis. Frequency of coupling is 24-hourly.	Ocean model is NEMO3.2 with a 1 degree horizontal resolution, 42 vertical levels, initialized from unperturbed MERCATOR-OCEAN Ocean and Sea-ice Analysis. Frequency of coupling is 24-hourly
Is the model coupled to a sea Ice model?	No	Yes
If yes, please describe sea-ice model briefly including any ensemble perturbation applied:	NA	Sea-ice model is GELATO v5 (Salas y Melia (2002) , embedded in the ocean model. It is initialized from unperturbed 1 degree resolution MERCATOR-OCEAN Ocean and Sea-ice Analysis
Is the model coupled to a wave model?	No	No
If yes, please describe wave model briefly including any ensemble	NA	NA

perturbation applied:		
Ocean model:	NEMO 1 degree resolution	NEMO 1 degree resolution
Horizontal resolution of the atmospheric model:	TL127	TL255
Number of model levels:	31	91
Top of model:	10 hPa	0.01 hPa
Type of model levels:	hybrid sigma-pressure	hybrid sigma-pressure
Forecast length:	7 months	7 months
Run Frequency:	once a month	once a month
Is there an unperturbed control forecast included?	No	No
Number of perturbed ensemble members:	51	51
Integration time step:	30 minutes	15 minutes
3. Initial conditions and perturbations		
Data assimilation method for control analysis:	4DVAR	4D Var
Resolution of model used to generate Control Analysis:	TL1279L137 (IFS operational analysis)	TL1279L137 (IFS operational analysis)
Ensemble initial perturbation strategy:	Lagged-average with distinct pairs of ocean+atmosphere initial conditions	Lagged-average + in-run perturbations
Horizontal and vertical resolution of perturbations:	NA	NA
Perturbations in +/- pairs:	NA	NA
4. Model Uncertainties perturbations:		
Is model physics perturbed?	No	No
Do all ensemble members use exactly the same model version?	Yes	Yes
Is model dynamics perturbed?	No	Yes (Batté and Déqué 2012)
Are the above model perturbations applied to the control forecast?	NA	Yes
Additional Comments	None	None

5. Surface Boundary perturbations:		
Perturbations to sea surface temperature?	No	No
Perturbation to soil moisture?	No	No
Perturbation to surface stress or roughness?	No	No
Any other surface perturbation?	No	No
Are the above surface perturbations applied to the Control forecast?	NA	NA
Additional comments	None	None
6. Other details of the models:		
Description of model grid	Reduced Gaussian Grid	Reduced Gaussian Grid
List of model levels (pressure in Pa from top to bottom when surface pressure is 100000Pa)	1000, 3000, 5000, 7000, 9008, 11064, 13232, 15560, 18077, 20801, 23735, 26876, 30217, 33746, 37450, 41317, 45332, 49484, 53757, 58136, 62602, 67131, 71689, 76233, 80704, 85023, 89088, 92768, 95896, 98263, 99614	1, 3, 6, 10, 17, 28, 43, 64, 92, 130, 178, 238, 312, 402, 509, 634, 780, 947, 1137, 1350, 1588, 1852, 2141, 2457, 2799, 3167, 3563, 3985, 4433, 4907, 5407, 5931, 6480, 7051, 7643, 8257, 8896, 9561, 10258, 10988, 11758, 12572, 13435, 14352, 15325, 16358, 17452, 18613, 19842, 21144, 22523, 23982, 25526, 27158, 28885, 30709, 32637, 34674, 36824, 39094, 41488, 44011, 46651, 49386, 52190, 55035, 57895, 60746, 63574, 66368, 69115, 71801, 74413, 76939, 79368, 81690, 83892, 85965, 87904, 89700, 91347, 92841, 94182, 95368, 96400, 97280, 98035, 98678, 99198, 99595, 99882
What kind of large scale dynamics is used?	Spectral semi-lagrangian	Spectral semi-lagrangian
What kind of boundary layer parameterization is used?	Ricard and Royer (1993)	Ricard and Royer (1993)
What kind of convective parameterization is used?	Bougeault (1985)	Bougeault (1985)
What kind of large-scale precipitation scheme is used?	Smith (1990)	Smith (1990)
What cloud scheme is used?	Ricard and Royer (1993)	Ricard and Royer (1993)
What kind of land-surface scheme is used?	Noilhan and Mahfouf. (1996)	Masson et al. (2013)

How is radiation parametrized?	Long Wave Radiation: Mlawer et al. (1997) Short Wave radiation: Morcrette (1990)	Long Wave Radiation: Mlawer et al. (1997) Short Wave radiation: Morcrette (1990)
Other relevant details?	None	None
7. Re-forecast Configuration		
Number of years covered	20 years (1991-2010)	24 years (1991-2014)
Produced on the fly or fix re-forecasts?	Fix re-forecasts	Fix re-forecasts
Frequency:	monthly	monthly
Ensemble size:	15 members	15 members
Initial conditions:	ERA interim (T255L60) for Atmosphere and Land surface + MERCATOR-OCEAN reanalyses for ocean PSI2G2R3	ERA interim (T255L60) for Atmosphere and Land surface + MERCATOR-OCEAN reanalyses for ocean PSI2G2R4
Is the model physics and resolution the same as for the real-time forecasts:	Yes	Yes
If not, what are the differences:	NA	NA
Is the ensemble generation the same as for real-time forecasts?	Yes	Yes
If not, what are the differences	NA	NA

References:

Batté, L. and Déqué, M. (2012). A stochastic method for improving seasonal predictions. *Geophysical Research Letters*, *39*(9).

Bougeault, P. (1985). A simple parameterization of the large-scale effects of cumulus convection. *Monthly Weather Review*, *113*(12), 2108-2121.

Masson, V., Le Moigne, P., Martin, E., Faroux, S., Alias, A., Alkama, R., Belamari, S., Barbu, A., Boone, A., Bouyssel, F., Brousseau, P., Brun, E., Calvet, J.-C., Carrer, D., Decharme, B., Delire, C., Donier, S., Essaouini, K., Gibelin, A.-L., Giordani, H., Habets, F., Jidane, M., Kerdraon, G., Kourzeneva, E., Lafaysse, M., Lafont, S., Lebeaupin Brossier, C., Lemonsu, A., Mahfouf, J.-F., Marguinaud, P., Mokhtari, M., Morin, S., Pigeon, G., Salgado, R., Seity, Y., Taillefer, F., Tanguy, G., Tulet, P., Vincendon, B., Vionnet, V., and Voldoire, A. (2013). The SURFEXv7.2 land and ocean surface platform for coupled or offline simulation of earth surface variables and fluxes, Geosci. Model Dev., 6, 929-960, doi:10.5194/gmd-6-929-2013.

Mlawer, E. J., Taubman, S. J., Brown, P. D., Iacono, M. J., & Clough, S. A. (1997). Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave. *Journal of Geophysical Research: Atmospheres (1984–2012)*, *102*(D14), 16663-16682.

Morcrette, J. J. (1990). Impact of changes to the radiation transfer parameterizations plus cloud optical. Properties in the ECMWF model. *Monthly Weather Review*, *118*(4), 847-873.

Noilhan, J., and Mahfouf, J. F. (1996). The ISBA land surface parameterisation scheme. *Global and planetary Change*, *13*(1), 145-159.

Ricard, J. L., and Royer, J. F. (1993). A statistical cloud scheme for use in an AGCM. In *Annales Geophysicae,* Vol. 11, pp. 1095-1115.

Salas y Mélia D (2002) A global coupled sea ice-ocean model. Ocean Model 4:137–172

Performances of the hindcast

These diagnostics are based on Eurosip operational hindcasts available at ECMWF on the MARS archiving system. They have been calculated on 1993-2012 period (20 hindcasts) for the 1st May and 1st November start date. The MARS archive contains data from 1991 to 2014 and the 12 calendar months. Each hindcast is made of 15 individual members. Since 20 years and 15 members do not provide a high statistical accuracy to compare the two systems, we restrict here to ENSO predictability and model bias. The latter diagnostic is not directly connected to predictability, because the model systematic error is subtracted from the forecast. It is however an indicator of misfunctionings in the model, and is statistically more robust than unbiased forecast scores. Further evaluations based on 1979-2012 period and 30-member ensembles are not reported here as they use NEMOVAR ocean initial conditions. They indicate a general improvement of the hindcast scores by the new system.
The verification data used here are ERA interim reanalyses over the same period 1993-2012.

ENSO scores

We consider here time correlation between predicted and observed mean sea surface temperature in the Nino 3.4 area (5°S-5°N by 170°W-120°W). The correlation is calculated with 20 pairs.

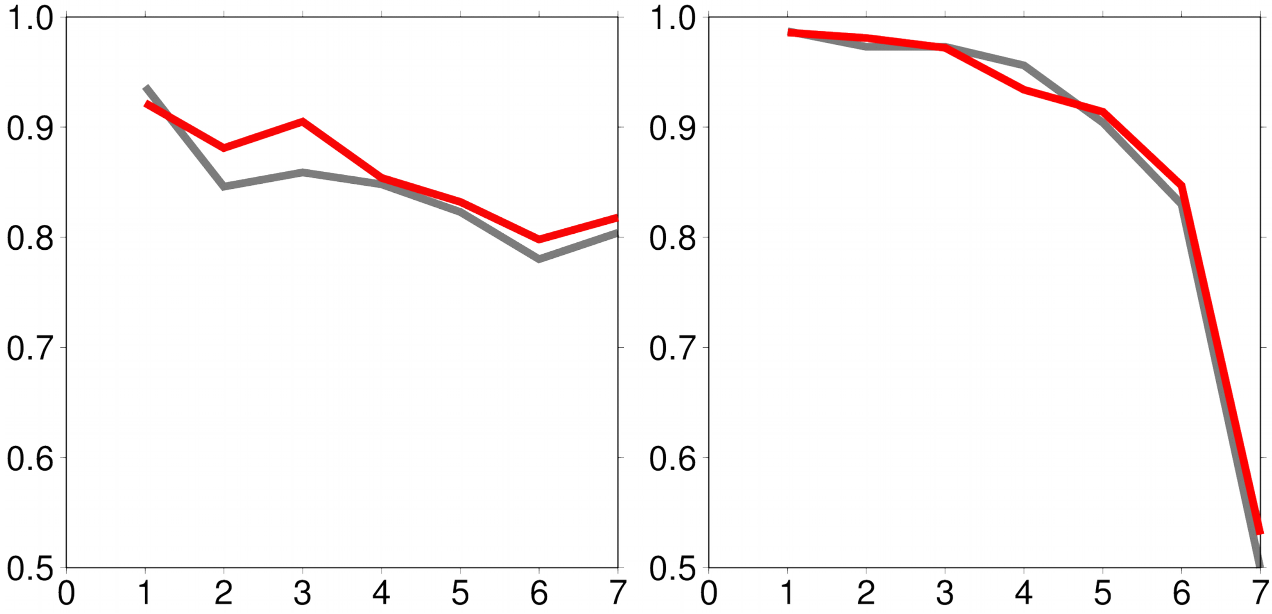
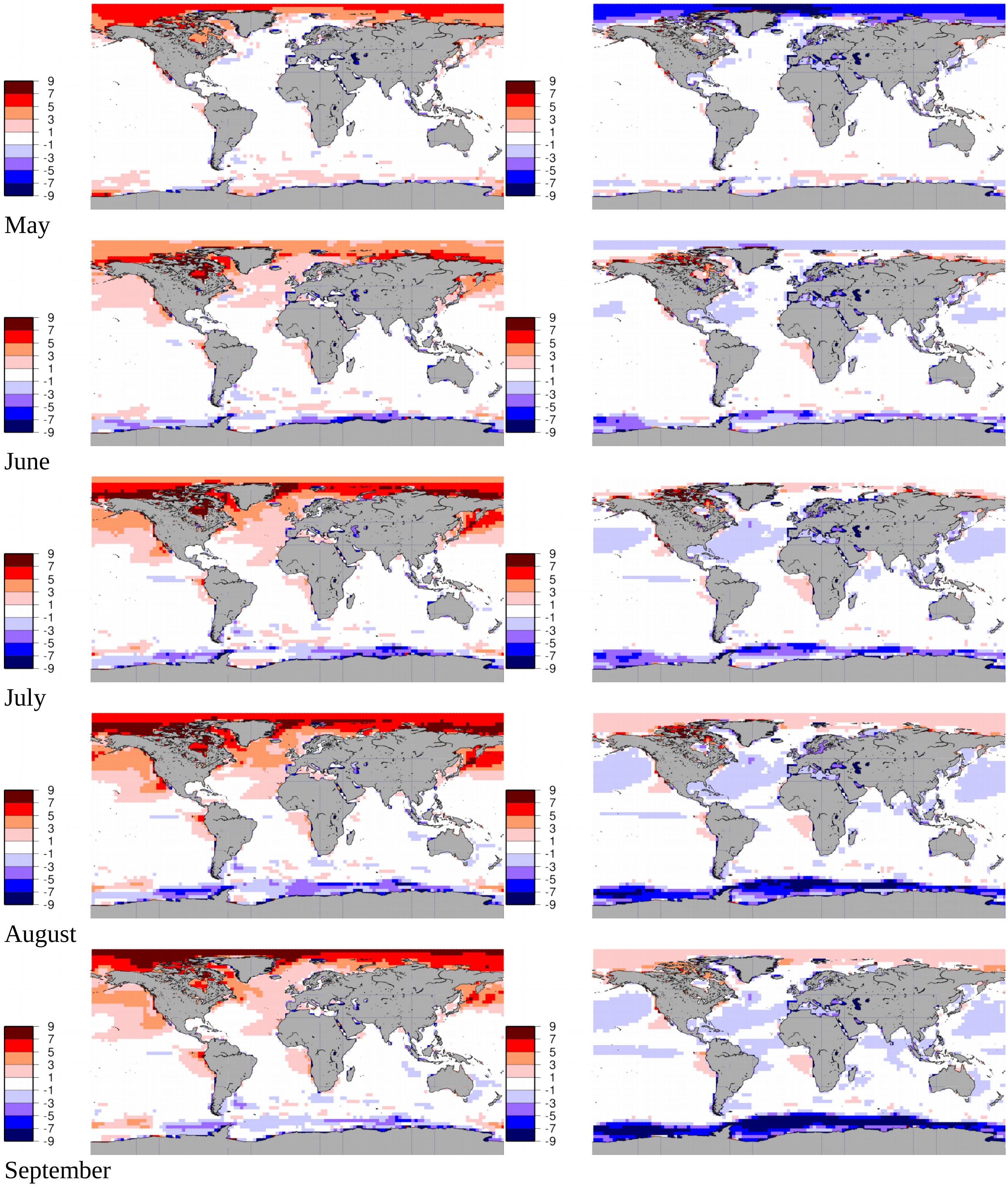


Figure 1 : Nino 3.4 SST time correlation for system 4 (grey) and system5 (red) as a function of forecast range (month); 1 May start (left) and 1 November start (right)

Sea Surface Temperature bias

In polar regions, the actual field is sea-ice surface temperature, not ice-melting temperature (271 K).



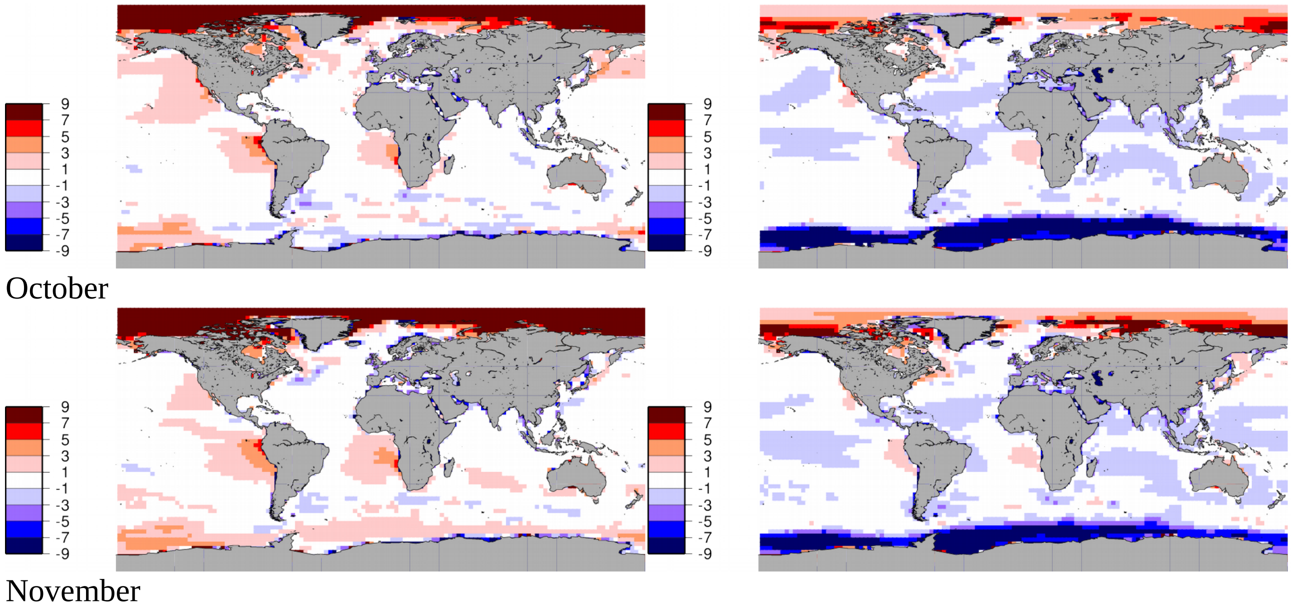
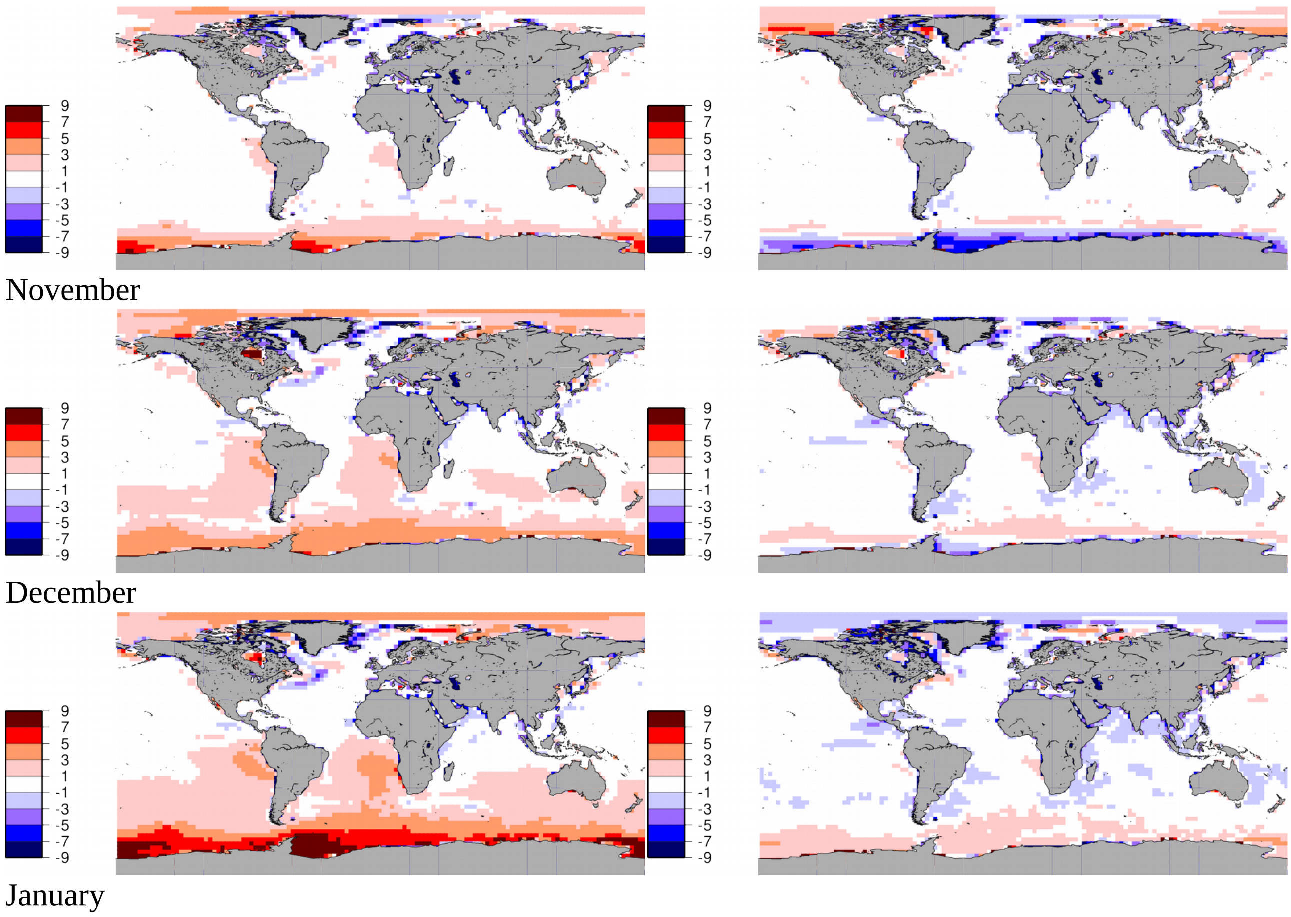
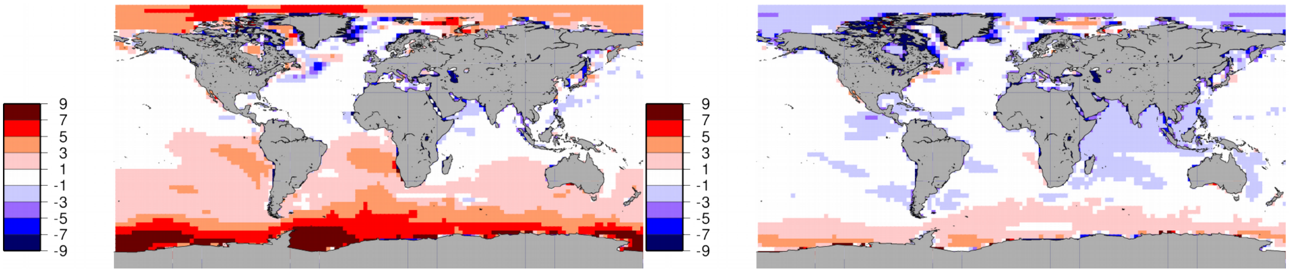


Figure 2 : Monthly SST bias (°C) for a 1st May start ; system 4 (left) vs system 5 (right)





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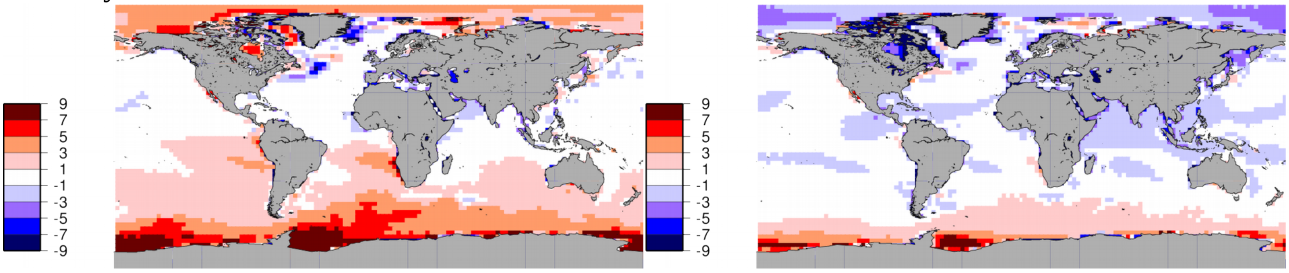

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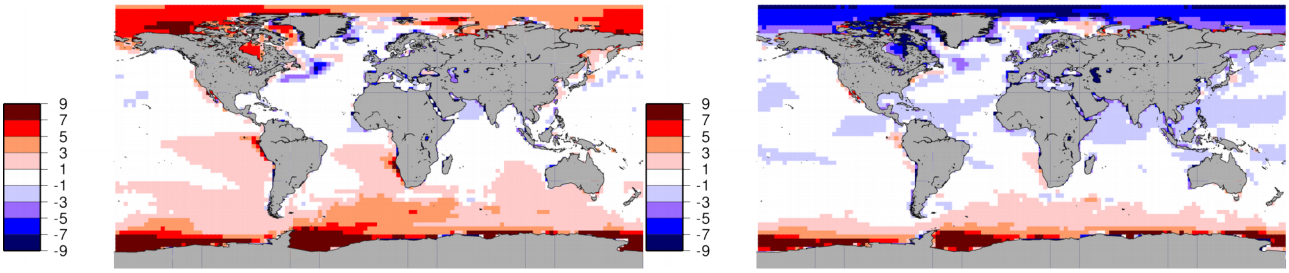

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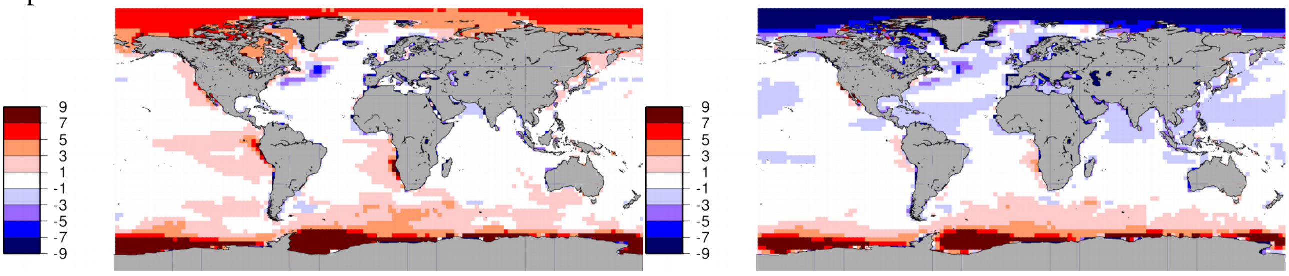
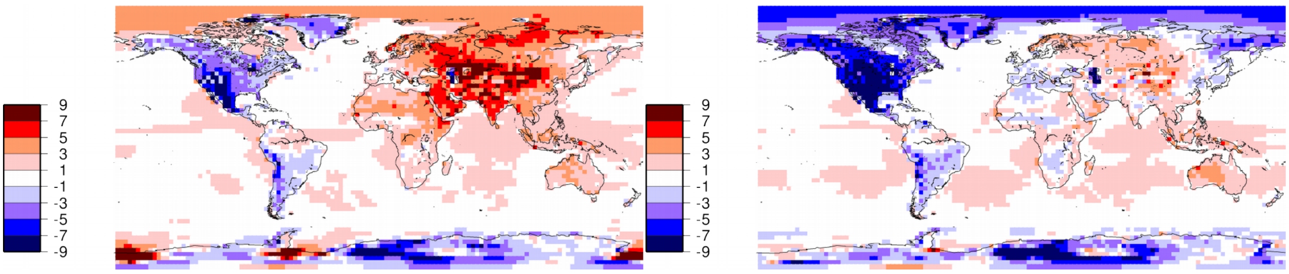


May

Figure 3 : Monthly SST bias (°C) for a 1st November start ; system 4 (left) vs system 5 (right)

2m Temperature bias

Surface elevation not is corrected, which explains some differences in mountainous regions, as system 5 has higher mountains due to its higher resolution.



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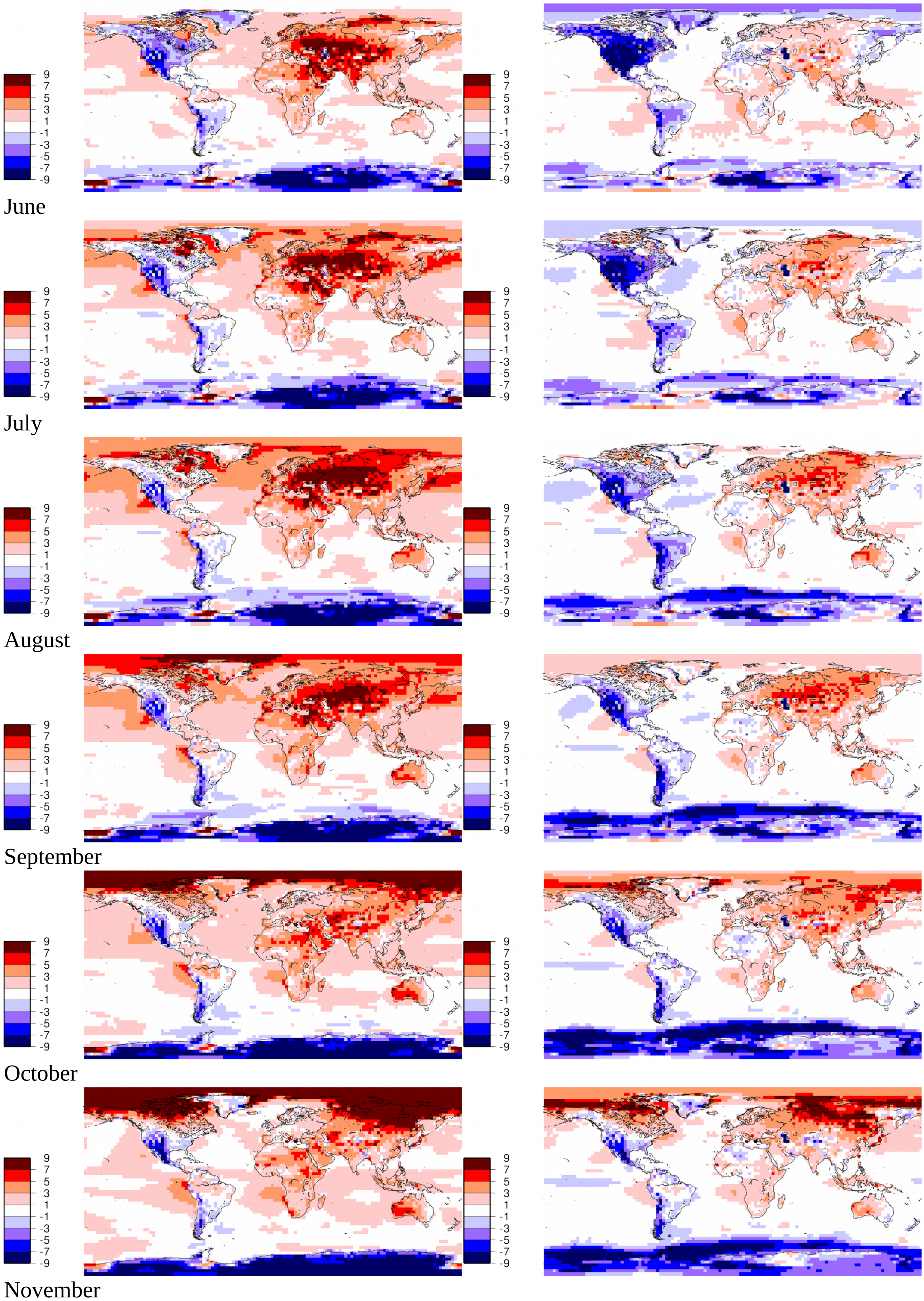
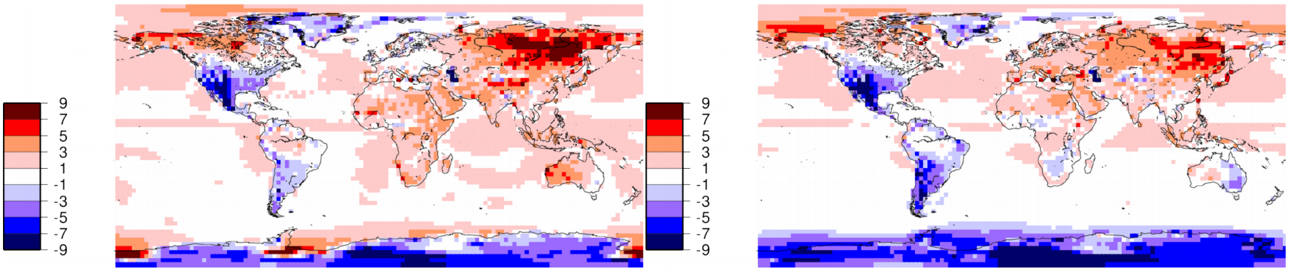


Figure 4 : Monthly 2m temperature bias (°C) for a 1st May start ; system 4 (left) vs system 5 (right)



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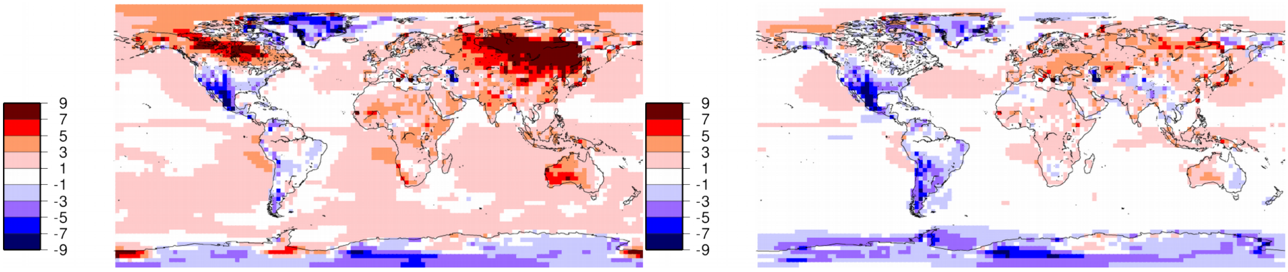

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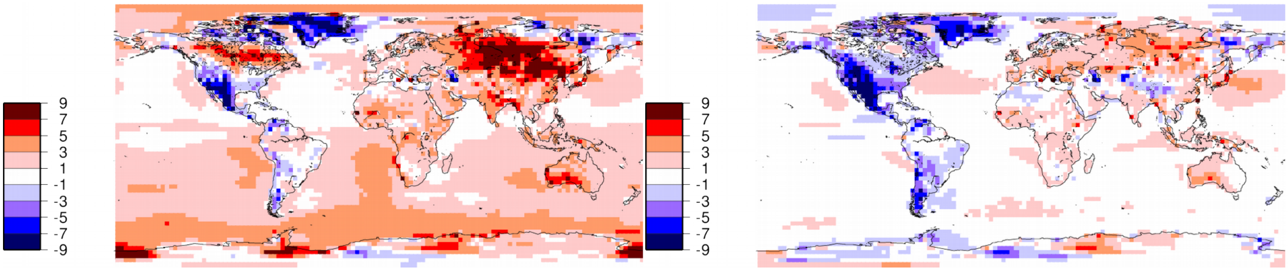

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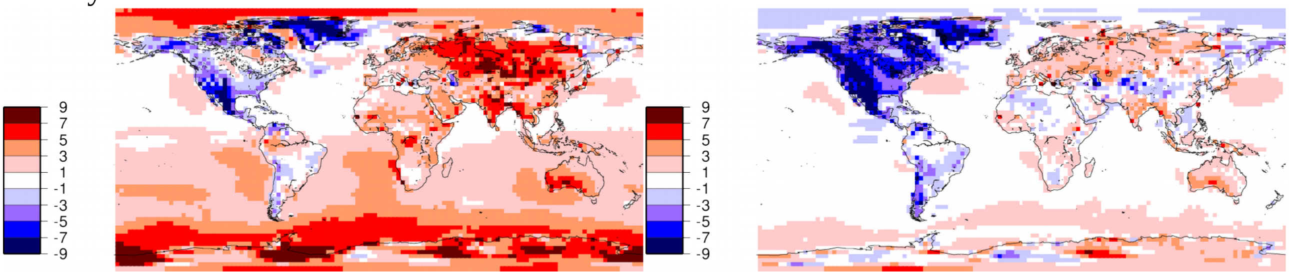

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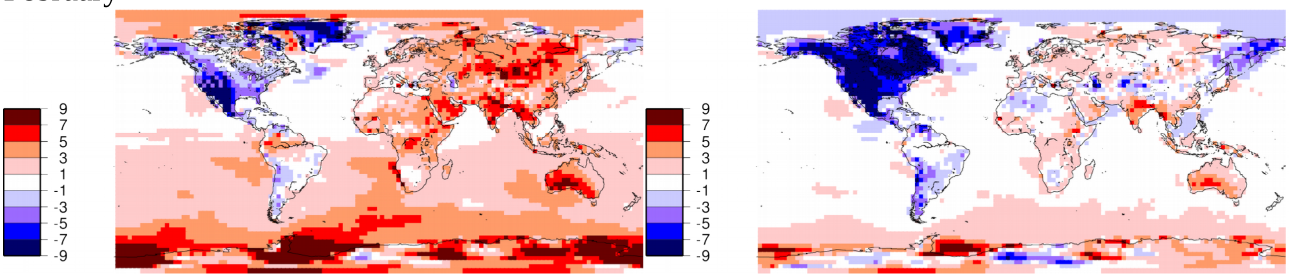

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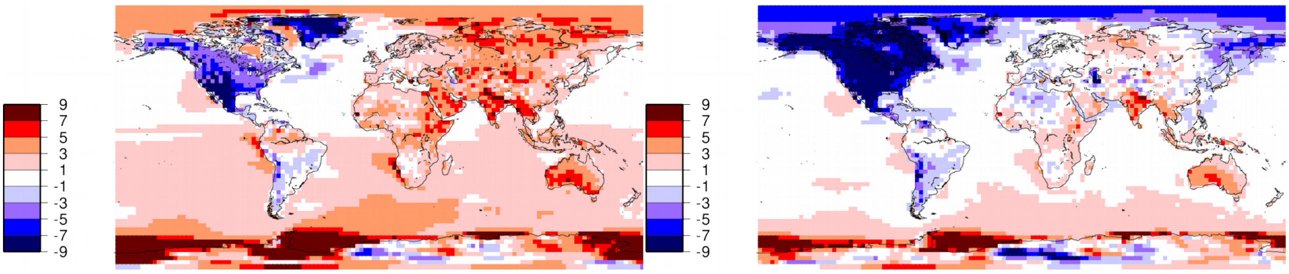

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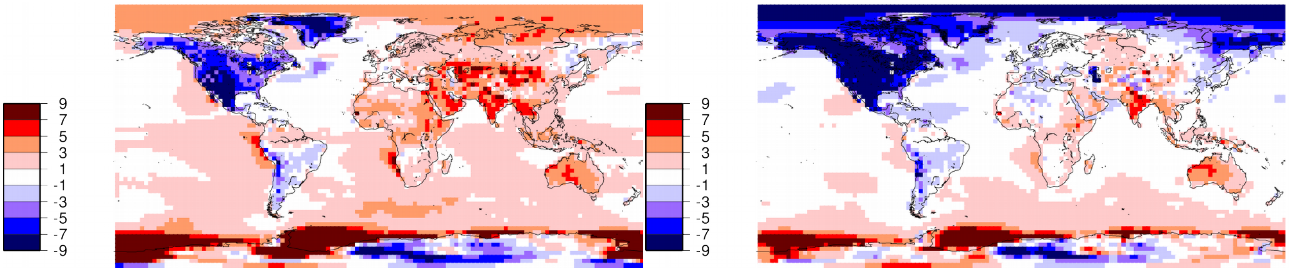
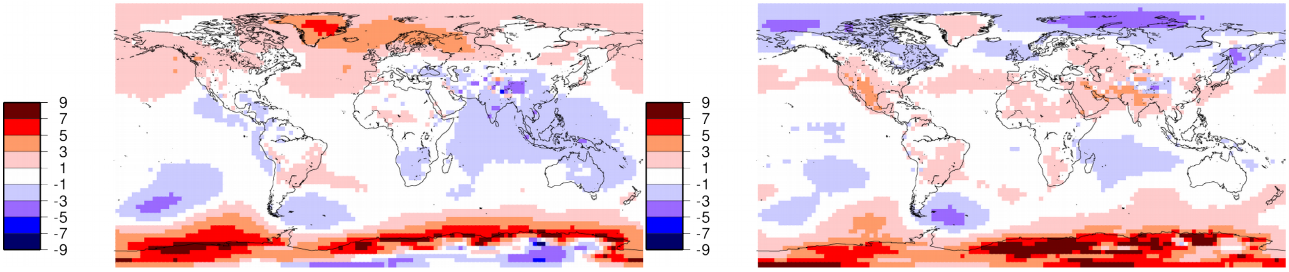


May

Figure 5 : Monthly 2m temperature bias (°C) for a 1st November start ; system 4 (left) vs system 5 (right)

Mean sea level pressure bias



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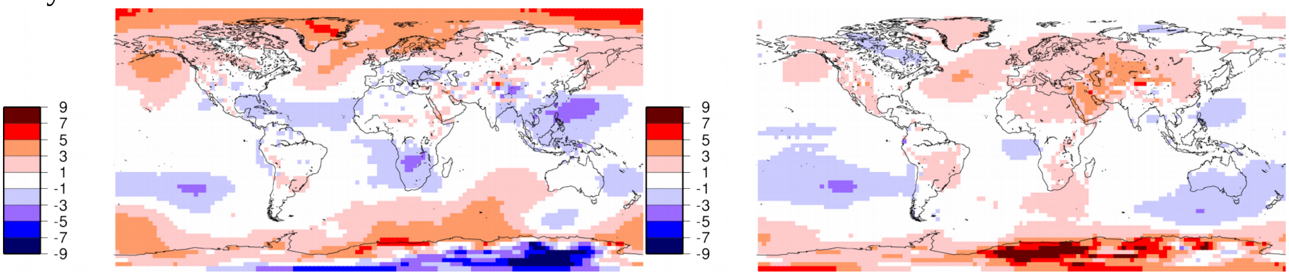

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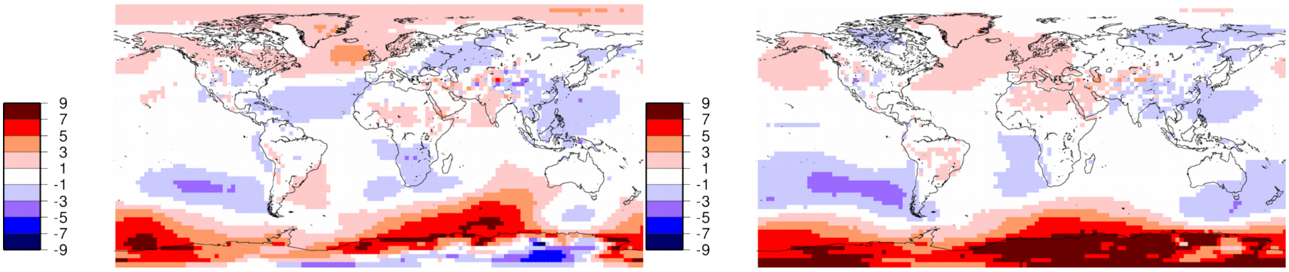

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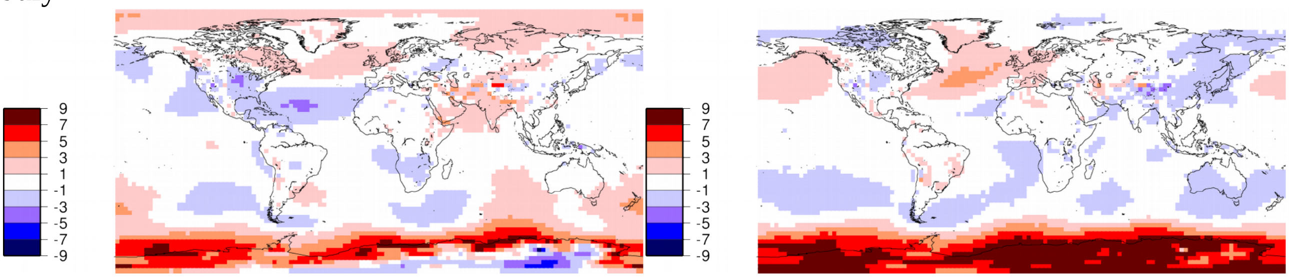

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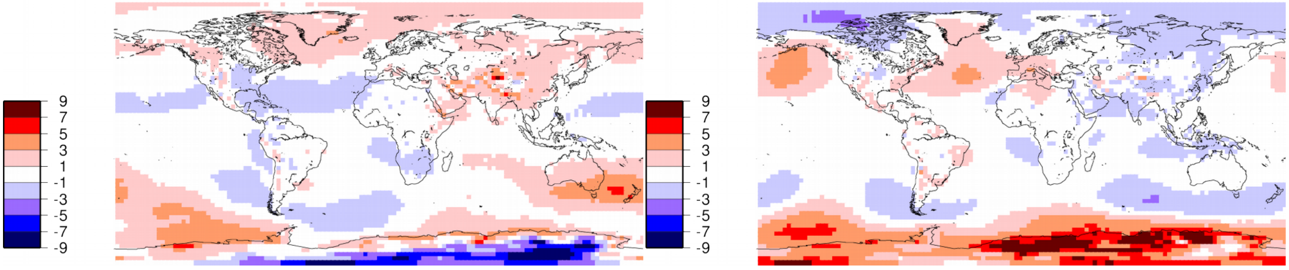

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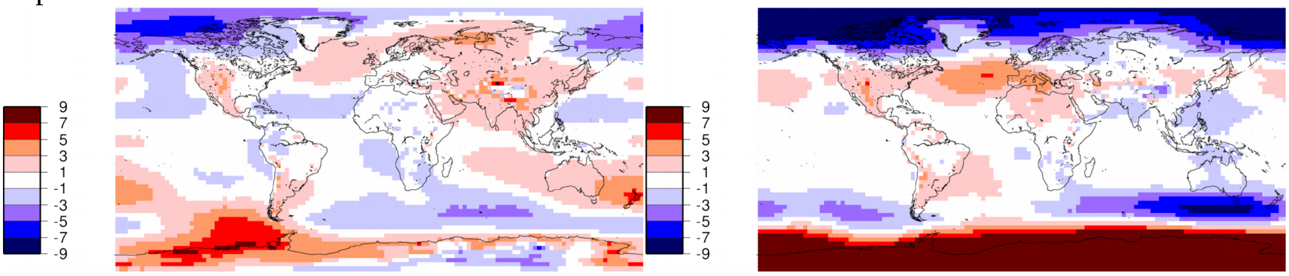

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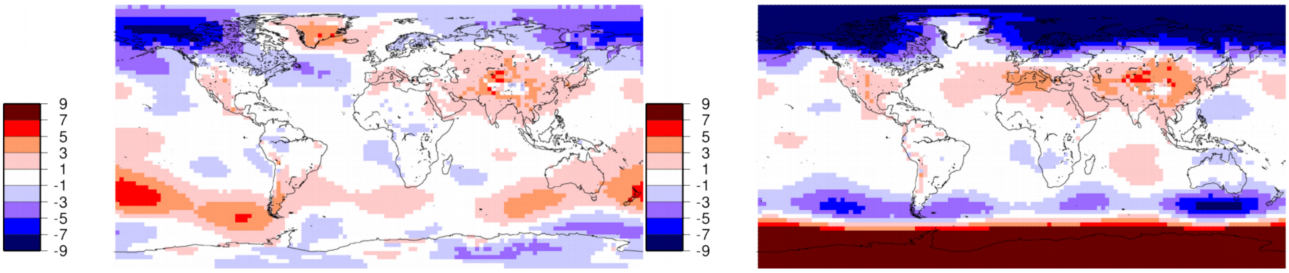
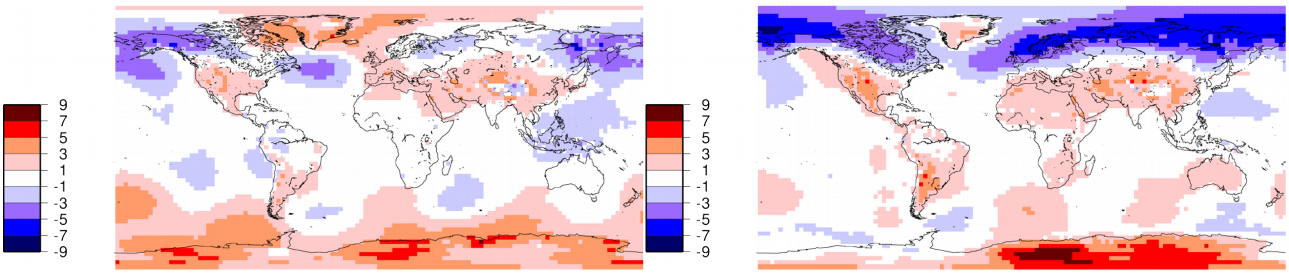


November

Figure 6 : Monthly Sea level pressure bias (hPa) for a 1st May start ; system 4 (left) vs system 5 (right)



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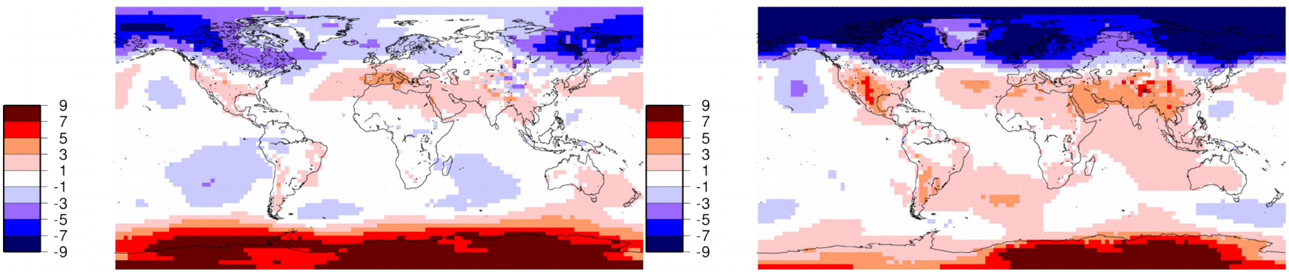

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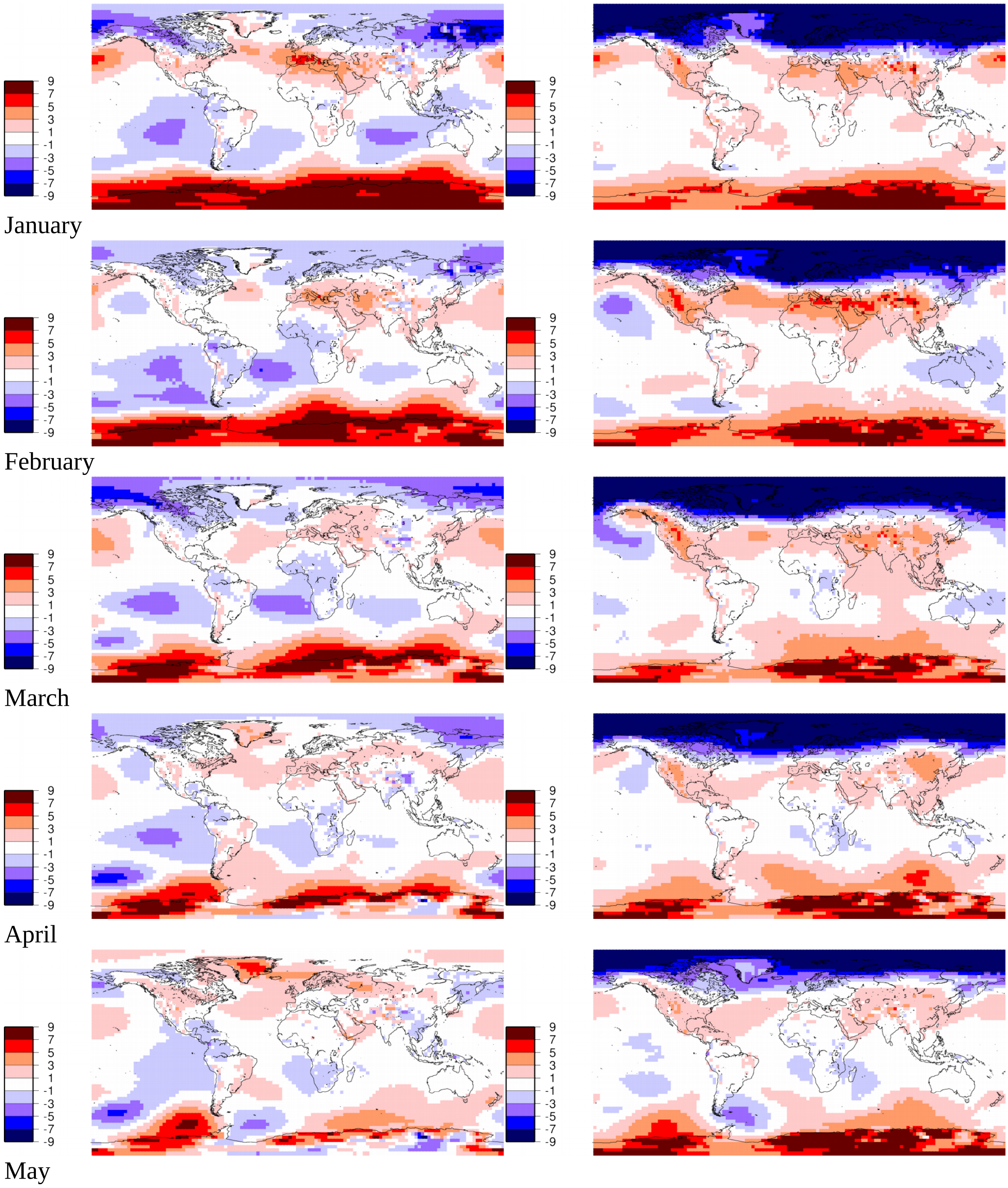
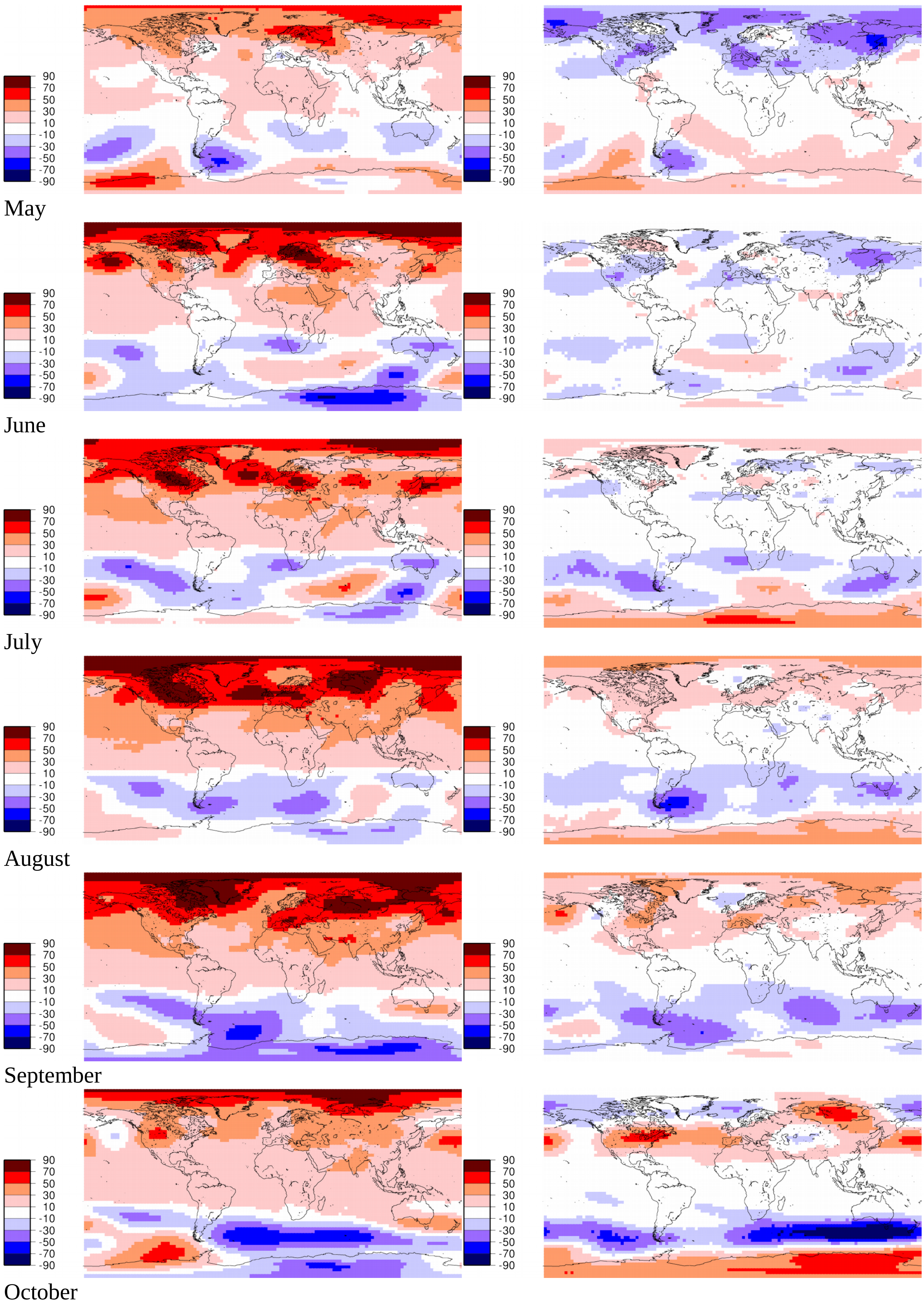


Figure 7 : Monthly Sea level pressure bias (hPa) for a 1st November start ; system 4 (left) vs system 5 (right)

500 hPa height bias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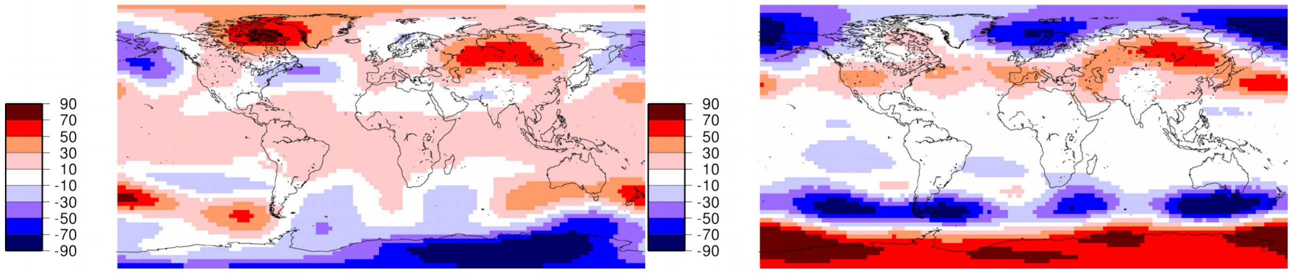
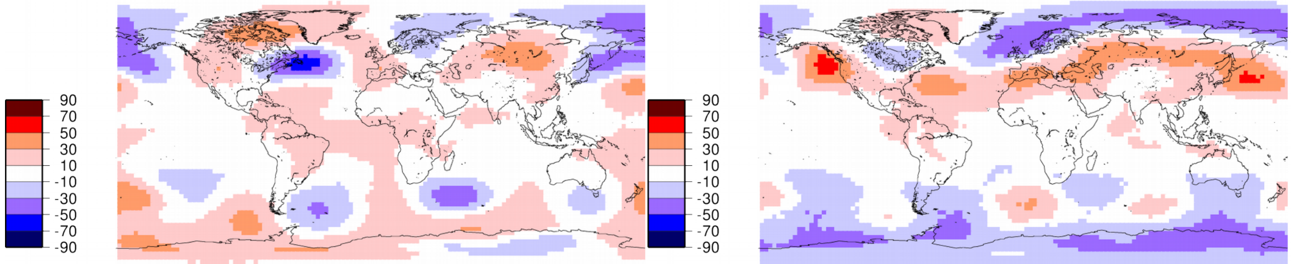


November

Figure 8 : Monthly 500 hPa height bias (m) for a 1st May start ; system 4 (left) vs system 5 (right)



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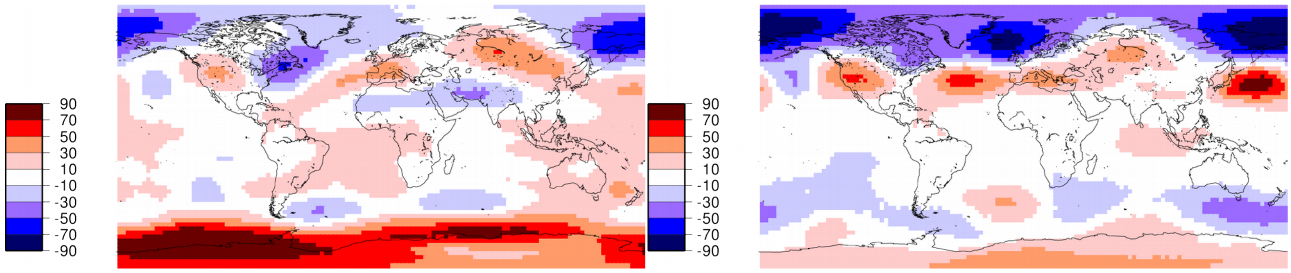

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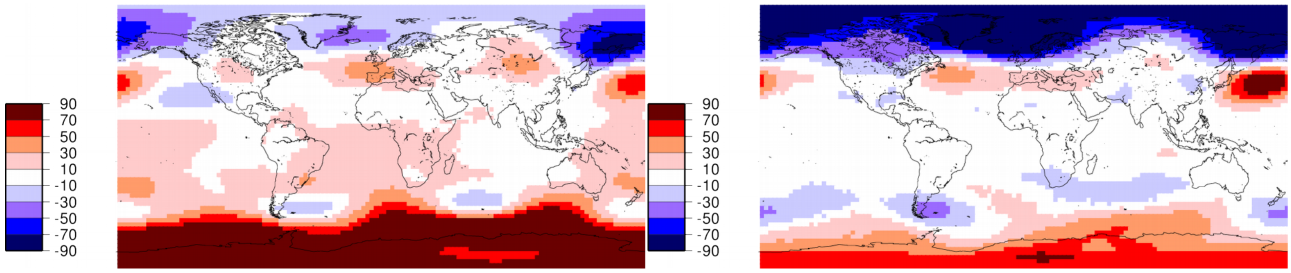

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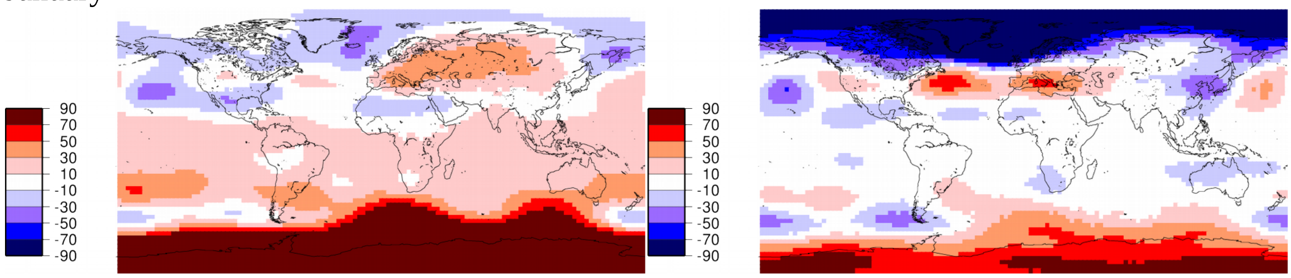

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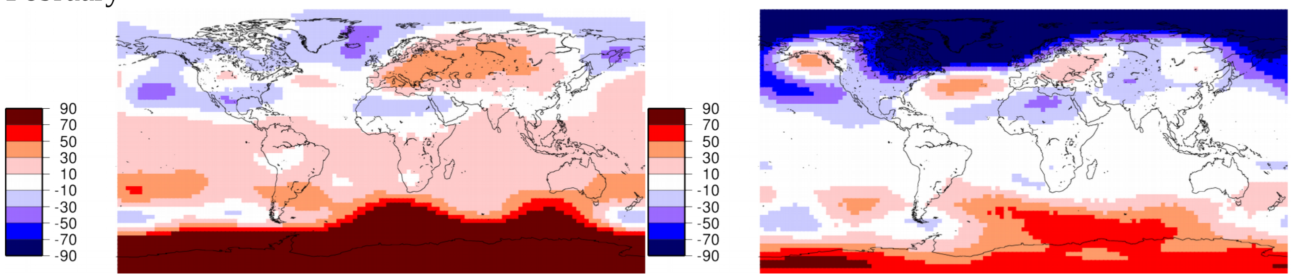

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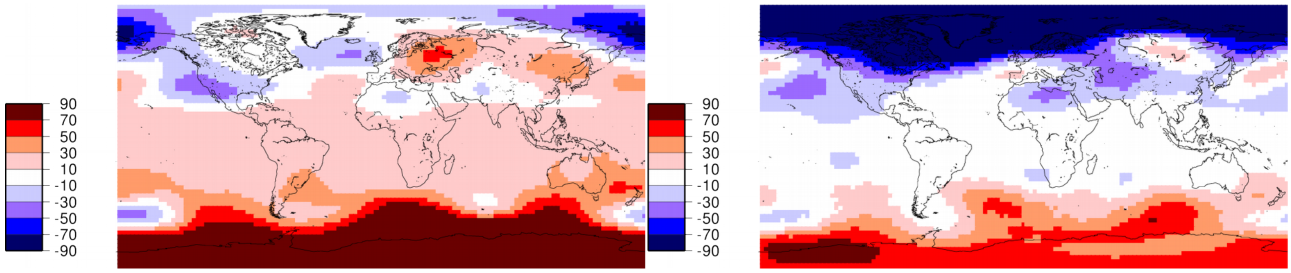

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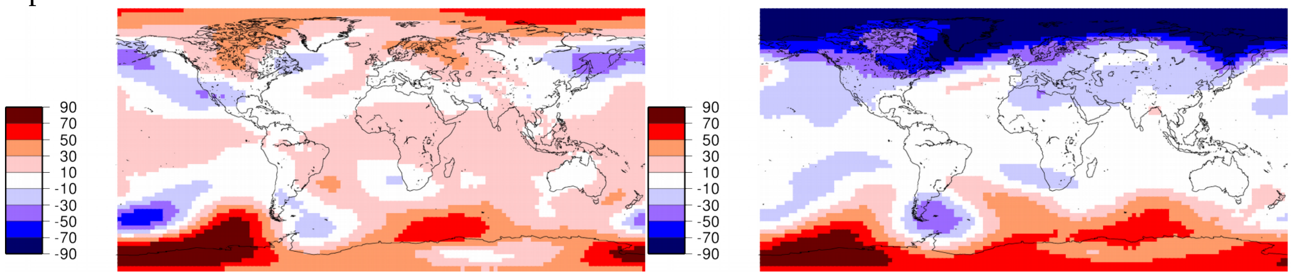

May

Figure 9 : Monthly 500 hPa height bias (m) for a 1st November start ; system 4 (left) vs system 5 (right)