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	2015
Project Title:	Seasonal hindcasts of the atmosphere in the 20th Century: Attribution, reliability and the impact of stochastic perturbations
Computer Project Account:	spgbawsf
Principal Investigator(s):	Antje Weisheimer, Nathalie Schaller
Affiliation:	University of Oxford
Name of ECMWF scientist(s) collaborating to the project (if applicable)	(not applicable)
Start date of the project:	01.01.15
Expected end date:	31.12.16

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)	NA	-	25 000 000	55 195
Data storage capacity	(Gbytes)	NA	-	24 000	

Summary of project objectives
(10 lines max)

This special project was requested in order to perform extended seasonal re-forecast (or hindcasts) sets and sensitivity experiments for the entire 20th Century. Being in possession of such an unprecedented dataset will allow us to assess the reliability of seasonal forecasts in the context of the attribution extreme weather event to anthropogenic influence, but also to investigate the impact of stochastic perturbations on the model performance. In addition, it will be possible for the first time to quantify whether the skill of seasonal forecast changes throughout the century, as studies showed that, for example, there is higher skill in predicting the North Atlantic Oscillation for the 1980-2000 period than for the 1960-1980 period (*Shi et al, 2015, GRL*).

Summary of problems encountered (if any)
(20 lines max)

Because of the delay in the operational model cycle CY41R1, we were not able to start extensive testing before May 2015 as CY41R1 is the first cycle supported for research-type longrange experiments after the switch off of the old IBM supercomputer. However, we envisage that we will still be able to run experiments as planned later this year and thus use the allocated SBU.

Summary of results of the current year (from July of previous year 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

The first six months of this project (the project started in January 2015) were dedicated to the validation of the modelling setup that will be used to produce the over 100 re-forecasts of the 20th Century winter seasons. The time period considered for this validation is 1981-2009 and 51 ensemble members were calculated for four months, with November as starting date. There are a number of settings that need to be changed compared to the operational model version in order to perform the 100-year long hindcast:

a) Use of prescribed Sea Surface Temperatures (SSTs) instead of the atmospheric model coupled to the ocean model
b) Upgrade of the model version from CY36R4 to CY41R1
c) Use, or not, of stochastic parametrization
d) Use of different reanalyses datasets for the prescribed SSTs
e) Use of different land initial conditions
f) Use, or not, of singular vectors to create initial ensemble data

a) Performing hindcasts for the whole 20th Century is only feasible by prescribing the SSTs, as there are no ocean reanalysis available yet to initialize the model in the first part of the Century. To quantify the impact of prescribing or not the SSTs, we compared the skill and reliability between an experiment run with ERA-Interim SSTs prescribed and one with the ocean coupled. In general, the biases in 2m temperature (2mt) over the oceans, in particular the warm bias along the eastern North America coast, become negligible when SSTs are prescribed. Similarly, the correlation of the model 2mt anomalies with observed anomalies becomes almost perfect over the oceans. However, over land, both the biases and correlation coefficients are very similar between both experiments, indicating that even when the state of the oceans is perfectly known, the model errors over land are

mostly caused by the atmosphere and land surface components of the model. For precipitation, the biases and anomalies only improve marginally in some ocean regions when SSTs are prescribed, but in a few regions, they worsen, suggesting again that the ocean has only a small impact in the representation of precipitation in the model. However, for mean sea level pressure (mslp), prescribing the SSTs increases the biases over the Pacific, North Atlantic and North Africa, but decreases them over the equatorial Atlantic, Siberia, the maritime continent and Antarctica. In terms of reliability, for the region of interest in our project, Europe, we find improvements for both the lower and upper terciles of 2mt and mslp, but no difference for precipitation.

b) For this project, we also want to use the newest available version of the model, CY41R1. We therefore compared experiments with the old and new cycle, both for SSTs prescribed and ocean coupled. The results are almost identical for the both cases, which is why we are reporting the results without discriminating between both. For 2mt, the biases over the oceans decrease in the new cycle. Improvements in bias are also seen over North America, Europe, South America, North Africa and Australia, but the biases increase over Antarctica (cold bias gets stronger) and in the Arctic (warm bias increases slightly). However, in terms of precipitation, the biases appear to mostly amplify, in particular the dry bias of South America, the dry/wet dipole in the maritime continent and the dry bias in the South Pacific. One improvement appears to be the wet bias in the western Indian Ocean. While the contrary is true for the experiments with prescribed SSTs, when the ocean is coupled, the wet/dry biases across the equator are amplified in the new version. In contrast, for mslp, the biases are clearly reduced in the new model version, especially in the North Pacific, over Europe, Australia and Antarctica. In terms of reliability for the European region, the use of the new cycle does affect much the forecast for both the lower and upper terciles of 2mt and precipitation, but there is again a significant improvement for mslp, especially in the upper tercile.

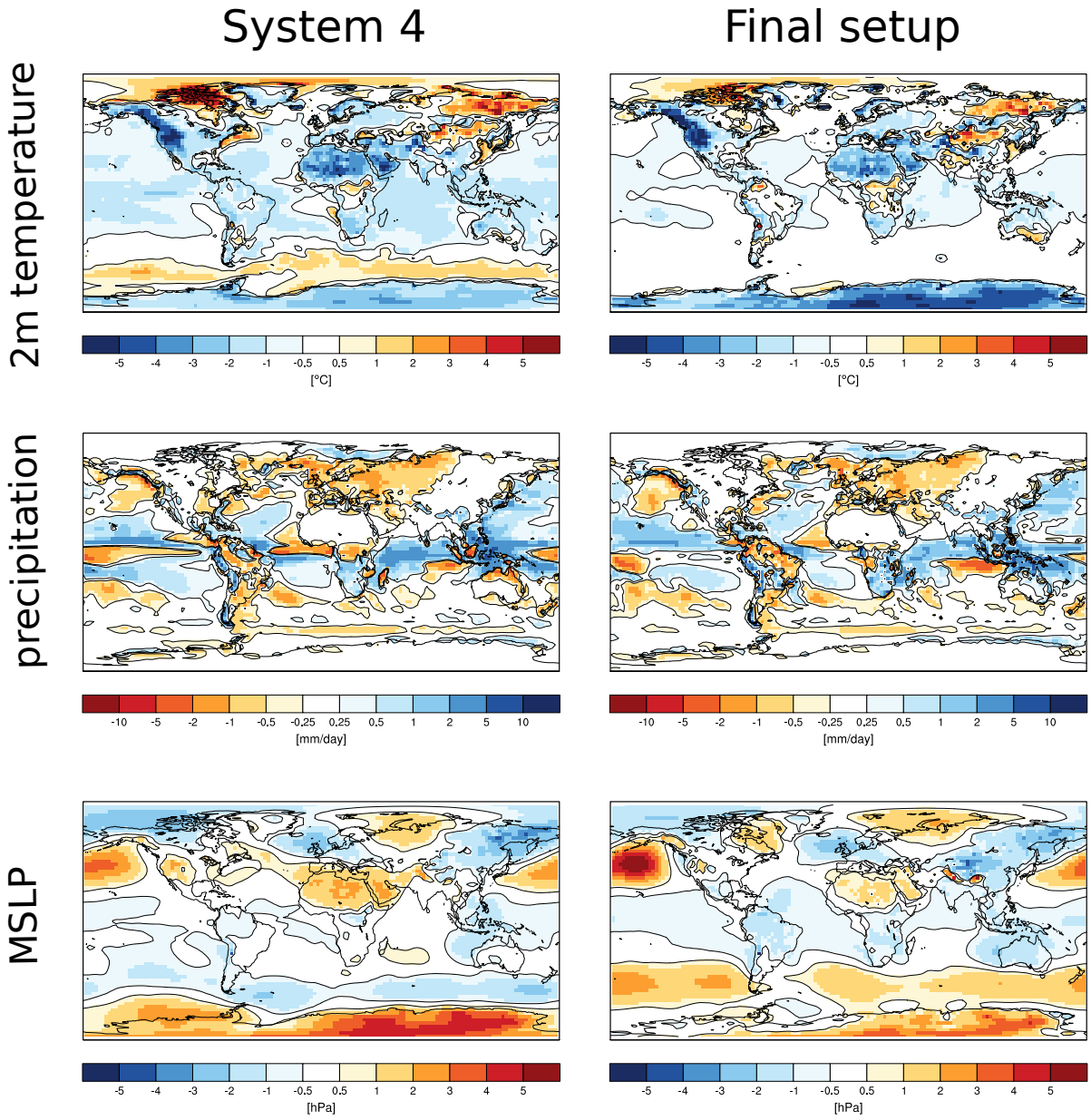
c) For the 20th Century re-forecasts, the stochastic parametrization scheme will be active, but this was a good opportunity to test its effect on the re-forecasts nevertheless. Having this scheme on or off does not affect much the modelled representation of 2mt. Both the biases and anomaly correlation coefficients, as well as the reliability over Europe, are very similar. The spread is nevertheless reduced over the Tropics when the scheme is not active. For precipitation, the biases and anomaly correlations are also similar between both setups, but for this variable, the reliability of the forecasts over Europe clearly decreases. Again, the largest differences are seen for mslp, where both the biases and anomaly correlation coefficients in the mid-latitudes are improved by having the scheme on. This is again reflected in the reliability over Europe, especially for the upper tercile.

d) While re-forecasts using prescribed SSTs have been performed before using the SSTs form ERA-Interim, for this project we need to make use of the new ERA-20C reanalysis dataset, that extends back to 1900 (versus 1979 for ERA-Interim). Similarly as for the previous setup changes, the biases and anomaly correlation coefficients for 2mt and precipitation are comparable when ERA-Interim or ERA-20C are used and the same is true for the reliability over Europe, for both the upper and lower terciles. Again, the largest change is in terms of mslp. Unfortunately, the high pressure biases over the North Pacific and Siberia amplify when ERA-20C is used. The reliability for the upper tercile in Europe appears unaffected but there is a significant decrease in reliability for the lower tercile. It should however be noted that for this analysis, ERA-Interim is the reference dataset, and the results would likely be different had we used ERA-20C as the reference.

e) Finally, land initial conditions are available only for the period 1981-2009, so there was a need to test how the model behaves when no initial conditions are provided (an available model option). Reassuringly, this model setup change is the one that leads to the smallest differences compared to the ones described above. The biases for 2mt and precipitation are very similar between both experiments for most regions, and the reliability only decreases marginally for the lower tercile of 2mt and the upper tercile of precipitation when no land initial conditions are specified. The reliability of the re-forecasts is not affected for mslp, but intriguingly, the biases in the North and

South Pacific are amplified when no land initial conditions are prescribed, but the high pressure bias in Siberia/Arctic slightly decreases.

Overall, after testing the different setups, its appears that the performance of the model, in particular for Europe, in terms of temperature, precipitation and mean sea level pressure, is not changing dramatically. This is shown in the following Figure: the biases for 2mt, precipitation and mslp for System 4, and the final setup used for this project, i.e. CY41R1, prescribed SSTs from ERA-20C, default land initial conditions and stochastic parametrization scheme on, are comparable in general, except for the differences described in the sub-sections above.



These first results give us confidence that the attribution statements we will obtain are robust and not affected by setup choices. In general, it can be noted that with the setup chosen, the reliability of the re-forecast over Europe is slightly increased compared to the previous cycle and using a coupled ocean. The most striking improvement appears to be for the upper tercile of mslp. This suggests that blocking events might be better represented with this setup, which could have implications for the representation of extreme events in winter.

List of publications/reports from the project with complete references

(none to date)

Summary of plans for the continuation of the project

(10 lines max)

During the remaining period of the project, the hindcasts for the whole of the 20th century will be finalized. The priority for this project is to have a large number of ensemble members (51) per starting month, and therefore, hindcasts for the winter months will be computed first and extended to summer months if enough resources are still available. Currently, we are preparing idealized SSTs of the 20th century. For each day of the century, we are removing the corresponding daily SST anomaly (with respect to 1900-1929) in order to represent the SST conditions that would have prevailed if there had been no human influence. We will then simulate the winter months of the 20th century using these idealized SSTs and keeping atmospheric gas concentrations to 1900 level. Comparing these idealized hindcasts with the ones using observed SSTs would allow us to attribute changes in extreme events during the 20th Century to human influence.