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	July 2015 – June 2016
Project Title:	The role of coupled ocean/atmosphere interactions in the tropics for seasonal and decadal prediction
Computer Project Account:	spdegrea………………………………………………….... .
Principal Investigator(s):	Prof. Dr. Richard J. Greatbatch (GEOMAR), Dr. Felicitas Hansen (GEOMAR), Dr. Gereon Gollan (GEOMAR), Prof.Dr.Thomas Jung (AWI), Prof. Dr. Katja Matthes (GEOMAR), Dr. Sebastian Wahl (GEOMAR), Herr Ole Wulff
Affiliation:	GEOMAR Helmholtz Zentrum für Ozeanforschung Kiel
Name of ECMWF scientist(s) collaborating to the project (if applicable)	N/A
Start date of the project:	January 1 2015
Expected end date:	December 31 2017

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)	11.600.000	6.115.183	11.300.000	1.781.929
Data storage capacity	(Gbytes)	62.600	not known	41.628	not known

Summary of project objectives
(10 lines max)

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To determine factors that are important for seasonal and decadal predictions in the mid-latitudes, especially over Europe. Of particular interest are influences from the tropics and the stratosphere. But we are also interested in how the mid-latitudes influence the tropics and whether a positive feedback can sometimes exist between anomalies in the tropics and anomalies in the mid-latitudes, a possible example being during the winter of 1962/63.

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

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(i) As noted in the progress report submitted in June 2015, the experiments are now being carried out by Dr. Felcitas Hansen, a Research Scientist working with Prof. Dr. Richard Greatbatch in Kiel and funded by GEOMAR. Herr Ole Wulff has joined the project and will help with the analysis.

(ii) As noted in the Progress Report submitted in June 2015, the focus in 2015 was on atmosphere-only experiments.

(iii) Dr. Hansen is on leave for the rest of 2016. We are therefore asking to have our proposal extended to the end for 2017 so that the coupled model experiments can be carried out in 2017. Some resources have already been used in 2016 to test running the coupled model. An amended "Request for a Special Project" is being submitted with this report

(iv) The experiments planned for 2017 are given in the table at the end of the report.

(v) In the event, the experiments carried out in 2015 were for the two seasons of boreal summer and boreal winter only and not continuous runs, covering the whole of the reanalysis period, as previously envisaged. This is the reason we used only 40% of the requested resources. It turns out that technically, it is much easier to carry out experiments for single seasons and we have abandoned the plan to do continuous runs.

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

We have now run many experiments using a relaxation technique (e.g. Jung et al., 2010; Greatbatch et al., 2012) in which certain parts of the model domain are relaxed towards reanalysis, typically the tropics within 20 degrees either side of the equator and, in separate experiments, the stratosphere and, more recently, the extratropics. We increasingly use the ERA-Interim reanalysis for the relaxation, rather than ERA-40 as previously, based on the period 1979-present. Analysis of these experiments is on-going. Generally speaking, our preliminary analysis of the experiments carried out for boreal summer show little skill at capturing events in the northern hemisphere during summer, even during the years of exceptional heatwaves such as 2003, 2006 or 2010, suggesting a large role for internal atmospheric variability in summer. On the other hand, we have found a significant impact from the tropics on the southern hemisphere in boreal summer (austral winter). In Ding et al. (2016), we identified a mode of variability in the southern hemisphere winter that is being driven by the diabatic heating anomalies associated with the East Asian Summer Monsoon in the northern hemisphere, in addition to the well-known ENSO signal. The dynamics of this mode of variability require further analysis, in particular concerning the diabatic heating source that drives the anomalies.

For boreal winter, we have carried out an analysis of our atmosphere-only experiments using relaxation to ERA-Interim and compared the performance with that of the ECMWF coupled model using experiments carried out by Antje Weisheimer at the University of Oxford, UK. The results are summarised in Figure 1. What is interesting here is the overall improved performance of the coupled model with tropical relaxation compared to the uncoupled model versions. These results appear in a manuscript submitted to the QJRMS (Hansen et al.., 2016) in which we also look at the model skill at predicting stratospheric sudden warmings (SSWs) and the impact of this skill on the predictability of the NAO. We found that the coupled model exhibits a bias in which the westerly winds in both the troposphere and the stratosphere are too strong over the Atlantic sector, similar to what is discussed by Keeley et al. (2012) in the case of the Hadley Centre Model and probably related, as shown in that paper, to the development of North Atlantic cold bias during the seasonal forecasts (see Drews et al., (2015) for a discussion on the North Atlantic cold bias). However, when a correction is made for the bias, it was still found that the coupled model has the best performance at forecasting (SSWs). The impact of the SSWs on the NAO is also noted, with winters in which SSWs occur (do not occur) favouring the negative (positive) NAO.

In the meantime, analysis is proceeding of our other model experiments with the help of a Masters student (Ole Wulff).

List of publications/reports from the project with complete references

The list of publications given here includes several papers that have appeared in 2015 that use the model output generated from previous special projects.

Ding, H., Greatbatch, R.J., Gollan, G., 2015, Tropical impact on the interannual variability and long-term trend of the Southern Annular Mode during austral summer from 1960/61 to 2001/02, Climate Dynamics, 44 (7-8), 2215-2228, doi:10.1007/s00382-014-2299-x.

Ding, H., R.J. Greatbatch, H. Lin, F. Hansen, G. Gollan and T. Jung, 2016, Austral Winter External and Internal Atmospheric Variability between 1980 and 2014. Geophys. Res. Lett., 43 (5). pp. 2234-2239. dos: 10.1002/2016GL067862.

Drews, A., Greatbatch, R. J., Ding, H., Latif, M. and Park, W., 2015, The use of a flow field correction technique for alleviating the North Atlantic cold bias with application to the Kiel Climate Model. Ocean Dynamics, 65 . pp. 1079-1093. doi: 10.1007s10236-015-0853-7.

Gollan, G., and Greatbatch, R.J., 2015, On the extratropical influence of variations of the upper tropospheric equatorial zonal mean zonal wind during boreal winter J. Climate, 28 (1). pp. 168-185. DOI 10.1175/JCLI-D-14-00185.1.

Greatbatch R.J., Gollan G., Jung T., Kunz T., 2012, Factors influencing northern hemisphere winter mean atmospheric circulation anomalies during the period 1960/61 to 2001/02, Q. J. R. Meteorol. Soc., 138: 1970—1982. doi: 10.1002/qj.1947.

Greatbatch R.J., Gollan G, Jung T., Kunz T., 2015, Tropical origin of the severe European winter of 1962/63, Q. J. R. Meteorol. Soc., 141, 153-165, 10.1002/qj.2346.

Hansen, F., Greatbatch, R.J., Gollan, G., Jung, T. And Weisheimer, A., 2016, Remote control of NAO predictability via the stratosphere, Q.J.R. Meteor. Soc., submitted.

Jung, T., Palmer, T.N., Rodwell, M.J., Serrar, S., 2010, Understanding the anomalously cold European winter of 2005/06 using relaxation experiments, Mon. Wea. Rev., 138, 3157–3174.

Keeley, S., Sutton, R., Shaffrey, L., 2012,. The impact of North Atlantic sea surface temperature errors on the simulation of North Atlantic European region climate, Q.J.R. Meteorol. Soc.,138, 1774-1783.

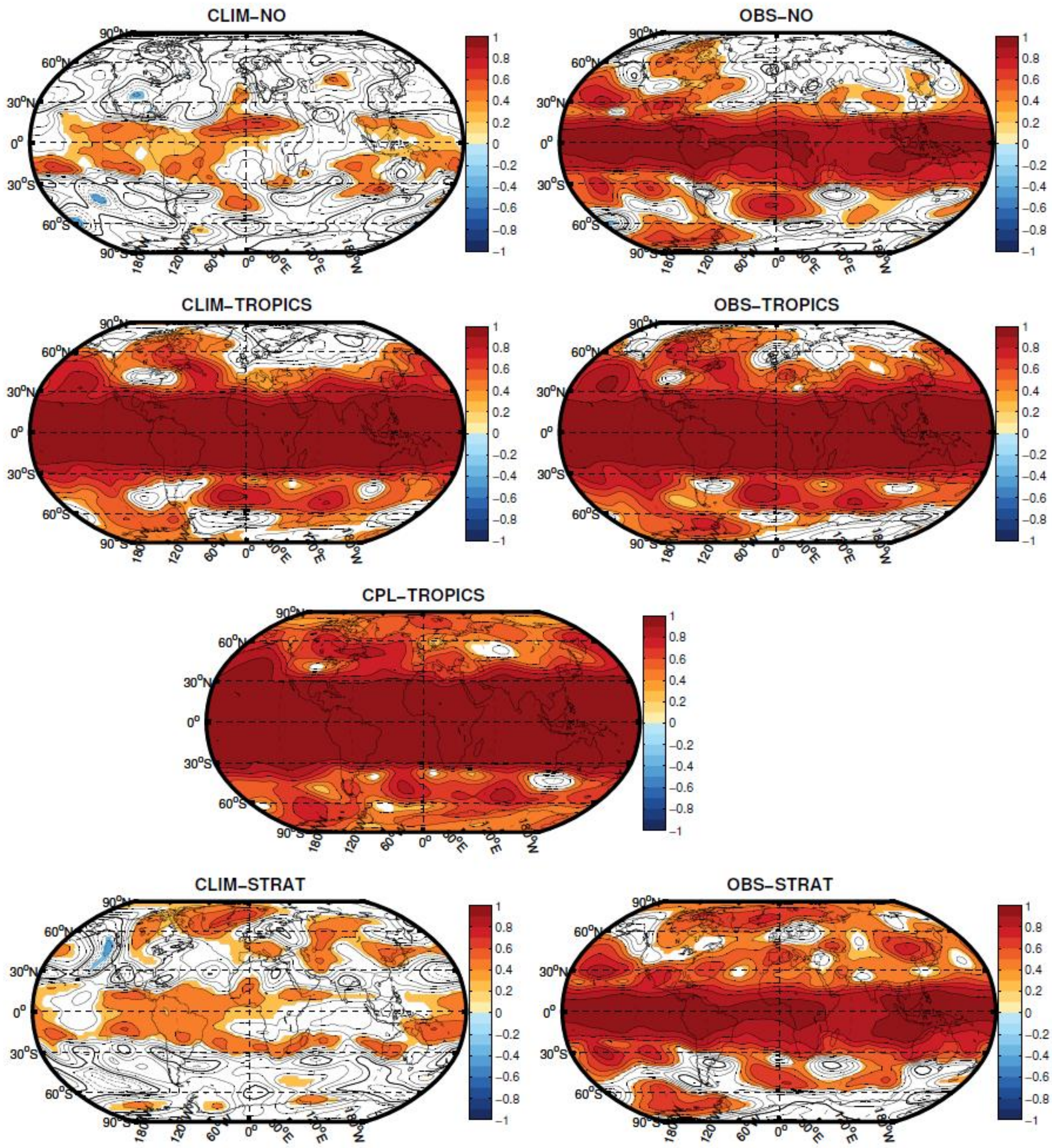

Figure 1: Anomaly correlation coefficient (ACC) for DJF mean Z500, comparing the ensemble mean from the model to ERA-Interim. Contour interval is 0.1, the thick line indicates an ACC of zero; colours indicate 95% statistically significant ACC values as tested with a Student's t-test. In CLIM-NO, no relaxation is used and sea surface temperature and sea-ice (SSTSI) is specified as the climatology for the ERA-Interim period. In this experiment, the only information distinguishing particular winters comes from the initial condition. In OBS-NO, no relaxation is used, but the time series of observed SSTSI is specified at the lower boundary. In CLIM-TROPICS, relaxation to ERA-Interim is carried out in the tropics and SSTSI is taken from climatology, as in CLIM-NO. OBS-TROPICS is the same as CLIM-TROPICS except that the time series of observed SSTSI is used at the lower boundary. Compared to CLIM-TROPICS, this experiment reveals the extra skill coming from specifying the observed SSTST. CLIM-STRAT using climatological SSTSI in combination with relaxation in the northern hemisphere stratosphere, north of 35 N. OBS-STRAT is the same as CLIM-STRAT except that the observed time series of SSTSI is used at the lower boundary. Finally, CPL-TROPICS is the coupled model but using relaxation to ERA-Interim in the tropical atmosphere.

Summary of plans for the continuation of the project
(10 lines max)

Please see the amended resource request for 2016 and 2017 below.

Revised list of experiments for 2016 and 2017:

Table 1: Summary of the experiments already carried out in 2016.

Experiment	Forecast years	SBU (kilo units)	Archive (Gb)
Coupled model testing	215	1.800	5.600
Total	215	1.800	5.600

Table 2: Summary of the experiments planned in 2017 along with the required computational and mass storage requirements. The experiment names are as in the request for 2015/16.

Experiment	Forecast years	SBU (kilo units)	Archive (Gb)
Coupled model testing	160	1.320	4.200
EXTRATROPICS_NORTH Coupled, ERA-Interim	160	1.320	4.200
EXTRATROPICS_SOUTH Coupled, ERA-Interim	160	1.320	4.200
EXTRATROPICS_GLOBAL Coupled, ERA-Interim	160	1.320	4.200
STRAT_NORTH Coupled, ERA-Interim	160	1.320	4.200
STRAT_SOUTH Coupled, ERA-Interim	160	1.320	4.200
CONTROL, Coupled	160	1.320	4.200
Total	1120	9.240	29.400