REQUEST FOR A SPECIAL PROJECT 2015–2017

Amended version

MEMBER STATE:	Germany
Principal Investigator[1]**:**	Prof. Dr. Richard J. Greatbatch
Affiliation:	GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel
Address:	Düsternbrooker Weg 20, 24105 Kiel
E-mail:	rgreatbatch@geomar.de
Other researchers:	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 Dr. Hansen will carry out the experiments and lead the data transfer and analysis. Dr. Gollan, Herr Wolff and Dr.Wahl will assist with the data transfer and analysis. The role of coupled ocean/atmosphere interactions in the tropics for seasonal and decadal prediction

If this is a continuation of an existing project, please state the computer project account assigned previously.	SPDEGREA	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2015	
Would you accept support for 1 year only, if necessary?	YES - 2017	

Computer resources required for 2015-2017: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2017.)		**2015**	**2016**	**2017**
High Performance Computing Facility	(units)	11.600.000	1.800.000	9.240.000
Data storage capacity (total archive volume)	(gigabytes)	62.600	5.6	29.400

An electronic copy of this form ***must be sent*** *via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

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[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Prof. Dr. Richard J. Greatbatch

Project Title: The role of coupled ocean/atmosphere interactions in the tropics for seasonal and decadal prediction

Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Amendments:

This is an amended version of a proposal submitted in June 2014. The amendments from the original proposal are as follows:

(i) Dr. Serrar is no longer involved in the project.

(ii) Dip. Met. Gollan has now successfully defended his Ph.D. and is now Dr. Gollan.

(iii) Dr. Felicitas Hansen, a GEOMAR-funded Research Scientist working with Prof. Dr. Greatbatch, is now running the model experiments and leading the analysis. This change was noted in the Progress Report submitted in June 2015.

(iv) Herr Ole Wulff is a Masters student at Kiel University and is working on the project for his Masters thesis.

(v) The list of experiments has been modified slightly from those proposed originally, as noted in the Progress Report submitted in June 2015. However, whereas in June 2015, we proposed experiments using global relaxation in the stratosphere, we are now proposing to replace this by a coupled model experiment using relaxation in the extratropics in both hemispheres, more in keeping with the original proposal. One reason for this is the technical difficulty of carrying out global relaxation in the stratosphere due to the latitudinal variation in the height of the tropopause. However, there are good reasons for wanting to do an experiment using the coupled model with relaxation in the extratropics in order to study feedbacks from the extratropics on the tropics.

(vi) The main reason for the amendment is that Dr. Hansen is on leave for the remainder of 2016. As such, we would like to transfer some of the resources originally requested for 2016 to 2017, extending the project to a 3rd year. The plan outlined in June 2015 was that 2016 would be devoted to running coupled model experiments. So far, only test runs have been carried out in 2016.

Introduction (as in the request submitted in 2014 with minor updates):

A meeting of the Royal Meteorological Society was held in London in March 2013 on the topic of long-range weather forecasting. The meeting was prompted by the 50th anniversary of the unusually severe European winter of 1962/63 (see, for example, Greatbatch et al., 2015). As a result of the severe weather, the UK Met Office introduced the “Monthly Weather Survey and Prospects“” that started in November 1963. Since that time there has been enormous progress in the area of monthly and seasonal forecasting as well as a growth of interest in decadal prediction, for example as part of the activities of the Climate Model Intercomparison Project (CMIP5) of the World Climate Research Programme. An example in Germany is the BMBF MiKlip project that aims to provide a decadal prediction system with a focus on needs and requirements in Germany and in which Professors Greatbatch and Matthes participate.

An important source of predictability on seasonal and decadal time scales is the tropics. Ding et al. (2013) give an example in which information stored in the tropical oceans leads to predictability in the Pacific sector of two major decadal climate shifts, those in 1976/77 and 1998/99. It is also known that the extratropics can significantly influence the tropics, e.g. El Nino Southern Oscillation (ENSO) (see, for example, Fedorov et al., 2003) and the Madden Julian Oscillation (MJO; Lin et al., 2009; Vitart and Jung, 2010) and that both ENSO and the MJO can, in turn, exercise an important influence on the extratropics that is important for seasonal predictability (Trenberth et al., 1998; Cassou, 2008; Lin et al, 2009; Folland et al., 2012; Greatbatch et al., 2012). Greatbatch et al. (2015) have noted an important role for the tropics in the dynamics of the severe European winter of 1962/63, a topic that has been investigated more closely by Gollan and Greatbatch (2015). Of particular importance was the extreme easterly state of the zonal mean zonal wind in the upper equatorial troposphere that winter (see Figure 1). It is known that the zonal mean zonal wind is, in turn, strongly influenced by the MJO (Slingo et al., 1996; Hoskins et al., 1999; Gollan and Greatbatch, 2015) and indeed, the MJO was remarkably suppressed during winter 1962/63. Greatbatch et al. (2015) speculate that the strongly anomalous state of the extratropical atmosphere could itself have been a factor in influencing the MJO in 1962/63 leading to the intriguing possibility of a two way interaction in which both the tropics and the extratropics influence each other through a positive feedback. We have also found that the zonal mean zonal wind in the upper equatorial troposphere is a useful predictor for European winter anomalies; for example, the strong westerly phase during winter 2013/14 appears to have been a factor in the mild conditions experienced over the UK and Europe during that winter.

It is also becoming increasingly recognized that the impact of changes in radiative forcing on the atmosphere can be amplified in their effect on the troposphere though coupled ocean/atmosphere interactions in the tropics (e.g. Meehl et al., 2009). At the same time, there is increasing evidence that the tropics have a major impact on the interannual variability and trends of the Southern Annular Mode (SAM; Ding et al., 2012; Ding et al., 2014, 2015). These studies offer an alternative to the generally accepted view that the recent decadal trends in the SAM are a product of anthropogenic forcing, especially ozone depletion (Thompson et al., 2011). However, it is quite possible that the forcing from the tropics that is influencing the SAM is, itself, being driven by changes in the stratosphere that are a consequence of changes in radiative forcing. We are also finding evidence that the zonal mean zonal wind in the upper equatorial troposphere is influenced by the solar cycle (Gereon Gollan, Remi Thieblemont, personal communication) offering a possible mechanism by which the solar cycle can influence winter weather in Europe (Lockwood et al., 2010; Gollan and Greatbatch, 2015).

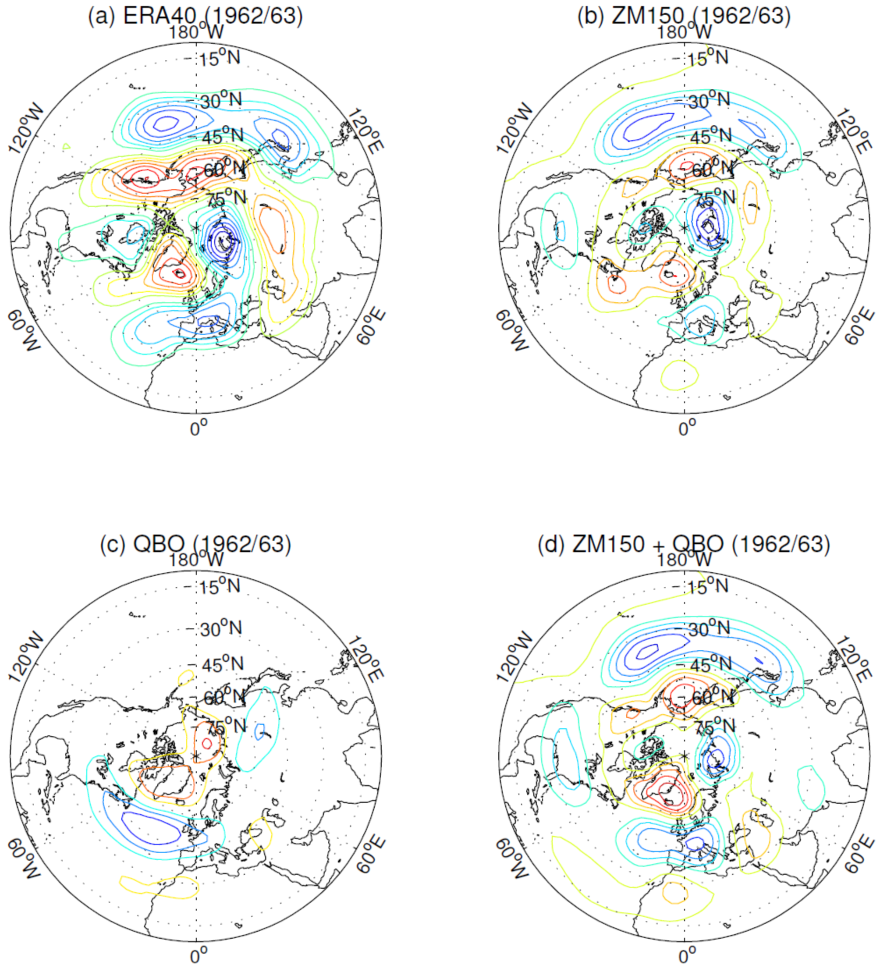

Figure 1: Z500 DJF mean anomalies for winter 1962/63. (a) is the ERA-40 anomaly with respect to the winter mean from 1960/61 to 2001/02; (b) is the component associated with the zonal mean zonal wind along the equator at 150 hPa; (c) is the component associated with the QBO and (d) is the sum of (b) and (c). Both (b) and (c) are computed using the patterns obtained from a regression analysis applied to the 42 winters in ERA.40 between 1960/61 and 2001/02 and multiplied by the values of the corresponding indices for winter 1962/63. Contour intervals are 16 m for (a) and 8 m for (b) to (d), with yellow to red (blue) shadings indicating positive (negative) values It is clear that the pattern (d), while not capturing the full amplitude of the observed anomalies, nevertheless captures the basic features characterizing winter 1962/63..

In this proposal we plan to investigate the influence of both the extratropics and the stratosphere on the tropics and, in particular the role of coupled ocean/atmosphere interactions in the tropics. To do this, we plan a series of relaxation experiments using both the ECMWF coupled model and a version of the ECMWF atmospheric model without ocean coupling. By comparing the two sets of experiments we can assess the importance of coupled ocean/atmosphere dynamics in the tropical regions. When using the relaxation technique, parts of the model domain are constrained close to reanalysis (e.g. as in Jung et al., 2010), a technique implemented by Thomas Jung during his time at ECMWF. Greatbatch et al. (2012) describe an analysis of such experiments using a recent version of the ECMWF operational model and covering all winters from 1960/61 to 2001. For the new experiments planned here, the relaxation technique will be used to draw the model towards the reanalysis in the extratropics and the stratosphere in separate sets of experiments using both the ERA-40 and the ERA-Interim reanalysis. The experiments in which the extratropics are relaxed will be used to access the importance of extratropical influences and feedbacks on the tropics. Topics of particular interest are the impact of the extratropics on ENSO, for which it is known that such influences impose a limit on predictability (Fedorov et al., 2003), and feedbacks involving the MJO and the zonal mean zonal wind in the equatorial region (Gollan and Greatbatch, 2015).

Likewise, in a second set of experiments, the stratosphere in the models (both coupled and uncoupled) will be relaxed towards reanalysis. For this set of experiments, we shall restrict to the ERA-Interim period and relax the model stratosphere towards the stratosphere in the ERA-Interim reanalysis. We chose to use only the ERA-Interim period for these experiments given the much improved data stream in the stratosphere after 1979 with the advent of satellite data. In these experiments we are looking for the influence of changes in the stratosphere, e.g. due to radiative forcing, on the troposphere and, in particular, on the tropics and associated teleconnections back to the extratropics that are of importance for decadal prediction efforts. The model runs will cover a 30 year period, enough time to capture almost 3 solar cycles, the emergence of the ozone hole over both Antarctic and the Arctic, and a period of significant global warming as well as the recent “hiatus” (Kosaka and Xie, 2013).

Experimental design (with minor updates from the Progress Report submitted in June 2015):

We plan to carry out experiments using both the ECMWF coupled forecast model and versions of the atmospheric model in uncoupled mode. Experiments that use relaxation to ERA-Interim/ERA-40 use the same atmospheric model resolution as is used for the reanalysis in each case. An ensemble consisting of 9 members will be run for each experiment, each ensemble member being initialized using a different atmospheric state (in the case of the coupled model, the ocean state will be initlalised using the ECMWF Ocean Reanalysis (Balmaseda et al., 2013), following Watson et al. (2016)). The groups of experiments labelled EXTRATROPICS will use relaxation in the extratropical atmosphere poleward of 45 N/S with a transition zone of width 20 deg applied between 35 N/S and 55 N/S. Experiments have been run using relaxation in the northern (EXTRATROPICS_NORTH) and southern hemisphere (EXTRATROPICS_SOUTH) separately. These were run for both the ERA-40 (atmosphere-only model) and ERA-interim periods. The stratospheric experiments (STRAT) will be run for the ERA-Interim period only, when much more data was available for the reanalysis, and have used (will use) relaxation only poleward of 35 N/S (STRAT-NORTH and STRAT-SOUTH) . We also plan to carry out a control simulation in which the coupled model will be run without relaxation with 9 ensemble members. This run will be used as a reference for assessing ENSO and the MJO in the coupled model and also model drift.

A summary of all the experiments with the resources required is given in Tables 1, 2 and 3. In 2015, experiments using the atmosphere-only model were carried out. In 2016, some experiments have been carried out in order to test the running of the coupled model, while the main coupled model experiments are planned 2017. Please note that since we have no previous experience running the coupled model, some testing, as we have done so far in 2016, has been necessary. We have allotted some resources for testing in 2017, as well, since the testing is not yet complete. For the coupled model integrations, estimates are based on the assumption that 1 year of integration will require 8.254,000 SBUs and 26 Gb of data storage.

Note on the experimental procedure:

Please note that when the request was originally submitted in 2014, we envisaged carrying out continuous runs using the coupled model initialized in 1980 and run to as close to the present as possible. In reality, such continuous runs are not very practical (for technical reasons) and the atmosphere-only runs we carried out in 2015 were done only for the boreal winter and summer seasons separately. We plan to use the same experimental procedure in 2017 as we did in 2015; that is carry out model runs for the boreal summer and winter seasons only.

Revised list of experiments:

Table 1: Summary of the experiments carried out in 2015 along with the requested computational and mass storage requirements. The experiment names are as in the request for 2015/16.

Experiment	Forecast years	SBU(units of 10^6)	Archive (Gb)
EXTRATROPICS_NORTH Atmosphere-only, ERA-40	360	1.400	5.400
EXTRATROPICS SOUTH Atmosphere-only, ERA-40	360	1.400	5.400
EXTRATROPICS_NORTH Atmosphere-only, ERA-Int	315	2.200	12.950
EXTRATROPICS_SOUTH Atmosphere-only, ERA-Int	315	2.200	12.950
STRAT_NORTH Atmosphere-only, ERA-Int	315	2.200	12.950
STRAT_SOUTH Atmosphere-only, ERA-Int	315	2.200	12.950
Total	1980	11.600	62.600

Table 2: 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 3: 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

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