REQUEST FOR A SPECIAL PROJECT 2012–2014

MEMBER STATE: Germany

Principal Investigator[1]: Univ.-Prof. Dr. Ulrike Langematz

Affiliation: Institut für Meteorologie

Address: Freie Universität Berlin
Institut für Meteorologie
Carl-Heinrich-Becker-Weg 6-10
D-12165 Berlin
Germany

E-mail: ulrike.langematz@met.fu-berlin.de

Other researchers: Anne Kubin, Markus Kunze, Janna Abalichin, Andreas Kerschbaumer

Project Title: Simulations with an Atmosphere-Ocean-Chemistry-Climate Model for the development of a decadal climate prediction system

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** DECCMO (new title)	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2012	
Would you accept support for 1 year only, if necessary?	YES X	NO

Computer resources required for 2012-2014: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2014.)	**2012**	**2013**	**2014**
High Performance Computing Facility (units)	2.750.000	550.000	550.000
Data storage capacity (total archive volume) (gigabytes)	8000	2000	2000

*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): 29 April 2011

Continue overleaf

[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.

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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.

Within this project Atmosphere-Ocean-Chemistry-Climate Model (AOCCM) simulations with the MA-ECHAM5/MESSy/MPIOM (EMAC-FUB-O) will be conducted as contribution to the new German research programme "Mittelfristige Klimaprognosen" (MiKlip) which will be funded by the German Federal Ministry of Education and Science from September 2011.

The main focus within this project will lie on the assessment of the importance of stratospheric solar forcing, decadal stratospheric internal variability and the role of atmosphere-ocean interactions in view of the development of a mid-term, i.e. decadal, climate prediction model.

So far most CCMs were not coupled to an ocean model. Therefore, it was necessary to prescribe sea surface temperatures and sea-ice conditions at the lower boundary. This was a limitation as it rendered the reaction of the ocean to any atmospheric changes impossible. It has been shown that the ocean response plays an important role e.g. for the appearance of the 11-year solar signal in the troposphere (Meehl et al., 2009). Furthermore, there is evidence for an influence of the El Niño Southern Oscillation (ENSO) on the occurrence of sudden stratospheric warmings (e.g., Cagnazzo et al., 2009). It has also been shown that anomalies in the Southern Annular Mode have an impact on the southern circumpolar ocean circulation (Gupta and England, 2006) and on the extent of sea ice (Lefebvre and Goosse, 2008) with feedback on atmospheric climate variables. Sea ice loss at high northern latitudes is assumed to affect the atmospheric circulation and weather patterns through changes in the energy exchange between the ocean and the atmosphere (e.g., Francis et al, 2009).

In order to assess the role of the direct tropospheric and indirect stratospheric solar forcing for decadal climate prediction a simulation of sufficient length has to be carried out, covering at least 10 solar cycles. Following the recommendations of the SPARC CCMVal initiative, we plan to perform a transient simulation for the period 1960-2100.

For studies of the solar forcing and the interaction between chemistry and climate it is of great importance to take into account interactions between radiation, dynamics and chemical composition of the atmosphere as well as interactions between the atmosphere and the oceans. Ozone is a major constituent in radiative processes and is also affected by dynamics and transport. Only CCMs can simulate the feedback of chemical processes on dynamics and transport of trace gases. The use of an ocean-coupled CCM opens the possibility for the full range of interactions between a high-top atmosphere and a deep-ocean model to occur.

Model and Experimental Setup

We intend to use the MA-ECHAM5/MESSy/MPIOM (EMAC-FUB-O) AOCCM (Roeckner et al., 2003; Jöckel et al., 2005; Jöckel et al., 2006, Jungclaus et al., 2006), which is a modular system. Depending on the particular object of research EMAC-FUB-O allows for tailor-made configurations by switching on and off respective sub-models for e.g. atmospheric chemistry, radiation, microphysical processes amongst others. Within this project a model version including a spectrally

resolved radiation routine (Nissen et al., 2007), the atmospheric chemistry module MECCA1 (Sander et al., 2005) and the interactive deep-ocean model MPIOM (Jungclaus et al., 2006) will be employed. The coupling of EMAC-FUB to the MPIOM ocean model has been performed at FUB. The new EMAC-FUB-O model has been implemented on the HLRN high performance computer system in Berlin, and is currently run in test-mode. By the time of the special project start a spin-up run will be completed, such that an equilibrated initial state will be available.

The experimental setup of the simulation will follow the recommendations by the SPARC CCMVal group for CCM simulations (Eyring et al., 2008).

The experiment to be carried out is a CCMVal-SCN2d-simulation. It is designed as a sensitivity simulation in addition to the transient REF2 run covering the period from 1960 to 2100. Whereas in REF2 only forcings by emissions of GHGs and ODSs are taken into account, SCN2d in addition considers natural forcings such as solar variability, the quasi biennial oscillation (QBO) and volcanic eruptions. In contrast to previous studies with the atmosphere-only CCM the sea surface temperatures and sea-ice will be modelled interactively in the AOCCM which allows for atmosphere-ocean interactions in response to the applied natural and anthropogenic forcings.

We will use the T42L39 model version with a model top at 0.01 hPa. The ocean model is run in GR15L40 resolution. The simulation will span the period from 1960 to 2100 with two years spin-up prior to 1960.

The results will be analysed to quantify the response of the ocean-troposphere system to the 11-year solar forcing and its two possible mechanisms, i.e. the transfer from the upper to the lower stratosphere and to the troposphere (“top-down”) and/or the direct total solar irradiance changes at the surface (“bottom-up”) as well as interactions of the solar forcing with the QBO. The internal stratospheric variability along with its decadal variability will be evaluated against observations and other model simulations. Aspects of stratosphere-troposphere coupling, i.e. the effects of stratospheric perturbations on the troposphere including the surface climate, will also be the object of research. The role of atmosphere-ocean interactions shall be analysed by comparison of the oceanic and the atmospheric responses to stratospheric external and internal dynamical variability.

The analysis will be done within the approved projects “MiKlip-STRATO – The role of the stratosphere for decadal climate prediction”, “MiKlip-FAST-O3 – Fast stratospheric ozone chemistry for global climate models”, and the approved DFG-Research unit “Stratospheric Change and its Role for Climate Prediction” (SHARP, FOR1095), coordinated by Ulrike Langematz. Subjects within SHARP are interactions between anthropogenically generated climate change and stratospheric dynamics, the future development of water vapour and the ozone layer as well as feedbacks of the stratosphere on climate and weather. Several institutions will jointly evaluate the model data for MiKlip-STRATO, MiKlip-FAST-O3, and SHARP.

Ulrike Langematz, Univ.-Prof. Dr., is Professor at the Institut für Meteorologie of Freie Universität Berlin and head of the working group 'Physics of the Middle Atmosphere'. Her scientific interests are in the fields of radiation, dynamics, and chemistry of the middle atmosphere with focus on stratospheric ozone, the interaction between stratospheric chemistry and climate change, and solar variability. She was/is PI in different national and European projects on climate change modelling (HGF-ENVISAT, EuroSPICE, SCOUT-O3), solar cycle modeling (BMBF-MESA, SOLICE and CAWSES-ProSECCO) and planetary modeling (HGF-Allianz 'Planetary Evolution'). She is coordinating the DFG Research Unit SHARP. Ulrike Langematz is involved in the international climate modeling activity CCMVal. She has been lead and co-author of several international assessments (e.g. the WMO Scientific Assessment of Ozone Depletion: 2006 and 2010).

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