COST Action ES1005 “TOSCA"

Report for the Short-Term Scientific Mission

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Host: K. Matthes, GEOMAR, Kiel, Germany

Title: Preliminary assessment of the 11-year solar cycle effect in the CMIP5 climate models

Purpose and Objectives of STSM

Climate Models, mainly General Circulation Models interactively coupled with Ocean Circulation Models, based on well-established physical principles are the most advanced tools today available for climate simulations and predictability (e.g. IPCC reports). As stratospheric changes played a minor role for climate predictions in the past, climate models did not take into account stratospheric processes and in particular ozone changes due to solar UV absorption. Today stratospheric processes and their role in climate are gaining a lot of interest and importance. Not only the effect of ozone recovery and its relationship to climate but also stratosphere-troposphere dynamical coupling and its role for predictability from days to decades have been recognized and are important issues for further climate studies (e.g., Gerber et al., Bulletin of the American Meteorological Society, 2012). Therefore, and in order to fully assess the solar cycle impact on the atmosphere it is very important to use climate models that are resolving the stratosphere, either interactively coupled with stratospheric chemistry codes (Chemistry-Climate Models-CCMs), or properly accounting for the solar-induced stratospheric ozone variability. Today, coupled ocean-atmosphere climate models include the stratosphere, so that fully coupled ocean-troposphere stratosphere climate and Earth system models have become available in the scientific community from the runs performed for CMIP5 (the 5th Climate Model Intercomparison Project, run under WCRP, in order to promote a new set of coordinated climate model experiments). A number of these models have included in their basic set of forcing the solar cycle variations, using as input the NRLSSI data sets.

The objective of the STSM was to work closely and coherently on the exploration of the 11-year solar cycle signal in the troposphere as depicted first in simulations carried out in the framework of the CCMVal-2 initiative, and further progressing with the CMIP5 climate model simulations, taking into account the results and expertise gained from the detailed CCMVal-2 analysis of simulations. Moreover, primary purpose of the STSM is to set the strategic planning for the future work, the final aim being to assess direct solar effects in the stratosphere, as well as the indirect dynamical effects, the modulation with the tropical oscillations and finally the extension of the signal into the troposphere. The STSM is tightly linked to the TOSCA WG4 Activities as well as the SPARC/SOLARIS-HEPPA activity.

Description of work

This scientific mission is the follow-up of a visit that took place in February 2013 (own funding). We have continued work on the estimation of the 11-year solar cycle effects in the stratosphere and the troposphere using output from CCMVal model simulations, employing various statistical tools, such as multi-linear regression and EOF analysis. Analysis of observational ozone, temperature and zonal winds data sets was also carried out using the same tools, and a detailed comparison of the results was performed. A series of discussions took place on the results...
achieved so far with a tentative assessment for the stratospheric signal and more emphasis on the tropospheric response.

At the early stage of the STSM, a survey was started, aiming at the expression of interest and collaboration of all modelling groups that have performed 11yr-solar–cycle-forcing simulations in the framework of CMIP5 (Climate Model Intercomparison Project) to initiate an intercomparison of the modelling results in order to assess the effects of solar variability (11 – year solar cycle) as depicted in climate models. This initiative, taken under SOLARIS/HEPPA auspices, falls directly within the TOSCA WG4 activities, with L. Gray as a key-person in the initiative, tentatively named SolarMIP (Solar cycle Model Intercomparison Project). A tentative analysis regarding the model set-ups and simulation details was initiated, so that an initial selection of models and diagnostics to be analysed is facilitated.

In addition, we had the chance for meetings, discussions and close collaboration among the WG4 leaders (H. Schmidt and K. Tourpali) together with the Action’s co-chair K. Matthes on future plans on the analysis, planned meetings and actions to be taken in the framework of TOSCA and for the second half of the project.

Results Obtained

The analysis of 11-year solar cycle effects in the stratospheric ozone and temperatures from the CCMVal-2 model simulations was concluded, as an update of the work previously carried out by Austin et al. 2008. The propagation of the signal from the stratosphere to the troposphere was investigated in the ERA-40 and NCEP zonal winds reanalysis. Furthermore, the relationship between the solar cycle and the Northern Annular Mode in the troposphere was analysed using observations and model simulations. The extension of the signal from the stratosphere into the troposphere was investigated.

Results from this work are presented at a talk during the Stratospheric Chemistry and Dynamics session at the IAGAC-CCMI workshop in Boulder held in May 2013.

The SolarMIP project has been initiated, with close collaboration between TOSCA experts (K. Matthes, H. Schmidt, K. Tourpali and S. Misios) and collaborators of TOSCA (L. Gray and D. Mitchell from the UK). Based on our own survey of the CMIP5 data base, as well as the preliminary replies on the questionnaire that was sent out, a tentative analysis of the model set-ups and simulation details of stratosphere-resolving (high-top) climate models with interactive ocean that provided simulations for the CMIP5 has started. To pursue this issue further, a workshop is planned to be held in October 2013 at Thessaloniki, Greece.

Building on the experience gained from the CCMVal-2 analysis, the appropriate multi-linear regression tool was selected, using a number of proxies based on the forcings used by the models. For the solar cycle variation the solar proxies recommended by SPACR/SOLARIS and applied by the modelling groups will be used. Relevant software and source code is currently adapted and further developed for future use also in the host Institute.

Relevance to TOSCA

The proposed STSM is directly relevant to understanding the impact of solar variability on the Earth’s climate, the key subject of TOSCA. The work is part of the WG4 activities, and the planning and discussions that were held during the STSM are essential to the future planning
and progress of the Action

Future Collaboration with the host Institute

The long-time collaboration that exists between the host researcher at the GEOMAR Institute and the applicant is expected to continue in the coming years closely tied to both TOSCA and the SOLARIS/HEPPA Project of SPARC. The applicant and the applicants’ home Institute have and will continue to benefit from the visit to GEOMAR in various ways, especially in the coming months with the finalising of the scientific papers that are foreseen as outcome of the STSM.

Foreseen publications/articles related to the STSM

There are currently three joint papers planned in relation to the STSM

a) A publication on the stratospheric and tropospheric effects of the 11-year solar cycle as seen in the CCMVal-2 model simulations, jointly with the model PIs
b) 2 papers planned for the analysis of the CMIP5 results, on the stratospheric/tropospheric signal of the 11-year solar cycle and the ocean/lower tropospheric effects