Workshop on CMIP5 Model Analysis and Scientific Plans for CMIP6

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SESSION 5: Friday 23rd October (morning)

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Robust assessment of the expansion and retreat of Mediterranean climate in the 21st century

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Abstract

The warm-temperate regions of the globe characterized by dry summers and wet winters (Mediterranean climate; MED) are especially vulnerable to climate change. The potential impact on water resources, ecosystems and human livelihood requires a detailed picture of the future changes in this unique climate zone. Here we apply a probabilistic approach to quantitatively address how and why the geographic distribution of MED will change based on the phase five of the Coupled Model Intercomparison Project (CMIP5) climate projections for the 21st century. Our analysis provides, for the first time, a robust assessment of significant northward and eastward future expansions of MED over both the Euro-Mediterranean and western North America. Concurrently, we show a significant 21st century replacement of the equatorward MED margins by the arid climate type. Moreover, future winters will become wetter and summers drier in both the old and newly established MED zones. Should these projections be realized, living conditions in some of the most densely populated regions in the world will be seriously jeopardized. This work is published in Nature Scientific Reports and can be accessed at following link www.nature.com/articles/srep07211

Keywords: Mediterranean climate, climate change, climate projection

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Strengthening of Amazonian dry season as projected by constrained climate model simulations

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Abstract

Reducing the large uncertainties of the regional precipitation response to anthropogenic climate forcing is a crucial challenge in the assessment of the future climate and water resources availability. Even though the main mechanisms driving the large-scale changes in precipitation simulated by climate models (GCMs) are known, a convergence of the model projections is not expected in the near term. How the rain-bearing South American Monsoon will evolve across the 21st century is a question of particular interest, given the local and global implications of changes in the functioning of Amazonian rainforest. Extensive savanization, with its loss of forest carbon stock and uptake capacity, represents an extreme pathway within a very uncertain scenario.

The precipitation changes across the Amazon basin are addressed using both an observational data set and an ensemble of simulations (historical and RCP8.5 projections) from 36 GCMs participating in Phase 5 of the Coupled Model Intercomparison Project (CMIP5). A major dynamic influence on the Amazonian rainfall changes is observed across the GCMs, consistent with earlier studies pointing out circulation as a strong control of regional patterns of precipitation change, and as a major uncertainty source in the modelled response to elevated atmospheric CO2 concentration. We show that the contrasted Amazonian rainfall projections simulated by GCMs can be reproduced with empirical models, established with historical GCM data as functions of the large-scale circulation. A set of these simple models was therefore calibrated with an observational data set and used to constrain the GCM projections.

In agreement with the current hydrological trends, the resulting precipitation prognosis towards the end of the 21st century is for a strengthening of the monsoon seasonal cycle,

*Speaker

and a dry-season lengthening in southern Amazonia. With this approach, the increase in the area subjected to lengthy - savanna-prone - dry seasons is substantially larger than the GCM-simulated one. Our projections confirm then the dominant picture shown by the state-of-the-art GCMs, but suggest that the 'model democracy' view of these impacts can be significantly underestimated.

Keywords: Precipitation projections, Amazonia, dry season length

Cooling biogeophysical effect of large-scale tropical deforestation in three Earth System models

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Abstract

Vegetation cover in the tropics is limited by moisture availability. Since transpiration from forests is much greater than from grasslands, the sensitivity of precipitation in the Amazon to large-scale deforestation has long been seen as a critical parameter of climate-vegetation interactions. Most Amazon deforestation experiments to date have been performed with interactive land-atmosphere models but prescribed sea surface temperatures (SSTs). They reveal a strong reduction in evapotranspiration and precipitation, and an increase in global air surface temperature due to reduced latent heat flux. We performed large-scale tropical deforestation experiments with three Earth system models (ESMs) including interactive ocean models, which participated in the FP7 project EMBRACE. In response to tropical deforestation, all models simulate a significant reduction in tropical precipitation, similar to the experiments with prescribed SSTs. However, all three models suggest that the response of global temperature to the deforestation is a cooling or no change, differing from the result of a global warming in prescribed SSTs runs. Presumably, changes in the hydrological cycle and in the water vapor feedback due to deforestation operate in the direction of a global cooling. In addition, one of the models simulates a local cooling over the deforested tropical region. This is opposite to the local warming in the other models. This suggests that the balance between warming due to decrease in cloud cover, change in latent heat flux decrease and cooling due to albedo increase is rather subtle and model-dependent. Last but not least, we suggest using large-scale deforestation as a standard idealized experiment for model intercomparison within the land-use MIP (LUMIP) in the CMIP6 framework. Both, biogeophysical and biogeochemical effects, of large-scale land surface perturbation could be evaluated.

Keywords: land use, deforestation, ESM, EMBRACE

*Speaker

Understanding processes and uncertainty in regional circulation and precipitation change

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Abstract

Despite substantial efforts in model development, uncertainty in CMIP5 projections of regional precipitation and circulation change remains stubbornly large. In order for this uncertainty to be reduced, the processes which cause these regional changes must first be better understood. The CFMIP contribution to CMIP6 includes a set of atmosphere-only time-slice experiments, which decompose the regional circulation and precipitation responses of each coupled model into separate responses to each aspect of CO2 forcing and warming (uniform SST warming, pattern SST change, direct effect of increased CO2, plant physiological effect). As well as allowing regional responses in each individual model to be examined, this set of experiments should prove especially useful for understanding the causes of model uncertainty in regional climate change.

We present the results of a pilot study, in which these experiments have been run by several modeling groups using their CMIP5-class models, and their regional climate responses (e.g. rainfall change over West Africa) compared. These results demonstrate the benefits of this experimental design, and we encourage other modeling groups to participate by adding to this pilot study, and/or taking part in these experiments for CMIP6. The key science questions to be answered are:

• How do regional climate responses (of e.g. precipitation) in a coupled model arise from the combination of responses to different aspects of CO2 forcing and warming (uniform SST warming, pattern SST warming, direct CO2 effect, plant physiological effect)?
• Which aspects of forcing/warming are most important for causing inter-model uncertainty in regional climate projections?
• Can inter-model differences in regional projections be related to underlying structural or resolution differences between models through improved process understanding, and could this help us to constrain the range of regional projections?
• What impact do coupled model SST biases have on regional climate projections?

Keywords: Precipitation, Circulation, Regional Climate Change

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Present and Future Projected Changes of Asian Summer Monsoon Evolution and Intensity in CMIP Models

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Abstract

The evolutions of Asian summer monsoon (ASM) are detected and evaluated based on the models in Couple Model Intercomparison Projects Phase-3 and Phase-5 (CMIP3 and CMIP5) for the 20th Century climate simulation (20c3m and Historical runs, respectively). Considering that the individual models have various biases in rainfall amount simulation, instead of applying a fixed rainfall criterion as used in observation, we use model-dependent rainfall criteria to identify the simulated ASM onset, retreat, and duration. This model-dependent criterion is defined as the height in cumulative distribution function (CDF) of simulated precipitation that the observed criterion occurs. Based on this method, the multi-model ensembles (MMEs) of CMIP3 and CMIP5 both show a delayed monsoon onset but an earlier retreat relative to the observations, indicating that models tend to underestimate the monsoon period. The MME results show a skill in capturing the ASM domain which features monsoon rainfall characteristics, whereas a large spread is found among individual models. Overall, the state-of-the-art CMIP5 models show slightly improvements from the CMIP3 models in the simulations of ASM domain and evolutions. Models with a hybrid method based on bulk mass flux and CAPE closure schemes perform better than models with other types of convection parameterization. For the future projections of ASM evolutions under RCP4.5 and RCP8.5 scenarios, the CMIP5 model tends to show earlier onset and delayed withdraw. Therefore, one would expect a increase of the length of ASM season. CMIP5 model also project a larger ASM domain and increase in the mean rainfall intensity near the end of 21 century. The circulation variation and related physical processes lead to the projected changes will be discussed. The potential implication on the regional water resources availability from these future monsoon changes will also be examined.

Keywords: Monsoon, Climate Change

*Speaker

CMIP5 model intercomparison of freshwater budget and circulation in the North Atlantic

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Abstract

Abrupt climate changes in the past 20,000 years are, in part, explained by switches of the Meridional Overturning Circulation (hereafter MOC), associated with fluctuations in freshwater content in the North Atlantic, the circulation being reduced when freshwater content was maximum. Moreover, recent reconstructions of trends in the MOC during the last century and climate models suggest an ongoing reduction in the MOC related to the freshening of high latitude North Atlantic, in part due to melting of the Greenland Ice Sheet. On the other hand, observations and hindcast simulations suggest that from the early 1970s to the mid-1990s the North Atlantic subpolar gyre became fresher while the gyre and meridional circulations intensified. This is opposite to the relationship of freshening causing a weakened circulation ! We hypothesize that both these configurations exist but dominate on different time scales: a fresher subpolar gyre when the circulation is more intense at interannual frequencies, and a saltier subpolar gyre when the circulation is more intense at longer periods. This hypothesis is tested in five climate models from CMIP5 which are intercompared for their freshwater budget and circulation changes. Lag correlations and cross-spectral analysis between freshwater content changes and circulation indices validate our hypothesis, suggesting that the driving role of salinity on the circulation depends on frequency. Overall, this analysis underscores the large differences among state-of-the-art climate models in their representations of the North Atlantic freshwater budget.

Keywords: MOC, freshwater, interannual to multidecadal variability, CMIP5 intercomparison

*Speaker

A mid-Holocene constraint for future projections of the North Atlantic Oscillation?

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Abstract

The North Atlantic Oscillation (NAO) is the main mode of atmospheric variability over the North Atlantic region, with important effects on weather patterns, explaining a large part of the variance of winter temperatures over Europe. Even though current climate models represent the NAO reasonably well for the recent period, they show little agreement in their future projections of winter NAO in response to large changes in radiative forcing. To gain insight into this uncertainty, the use of paleoclimate periods with different radiative forcing and large data coverage seems very promising.
Multiple studies have suggested that winter in the mid-Holocene (MH, around 6000 years BP) was characterized by a positive NAO-like mean state. This period has a different insolation and therefore radiative forcing than present-day climate. A recent pollen-based reconstruction of European MH climate (Mauri et al. 2014) confirms that MH winter temperature and precipitation anomalies have patterns consistent with modern positive NAO conditions. We propose to use this new reconstruction to provide constraints on projections of winter NAO in CMIP5 models.

In a first step, we will quantitatively compare the MH winter surface temperature patterns as simulated by PMIP3 models with the reconstructed data by Mauri et al. (2014). The obtained metrics will allow us to assign weights to the different models based on how well they represent these MH temperature patterns over Europe. In a second step, we will apply

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these weights in CMIP5 projections of winter NAO. This analysis will propose an estimate of NAO future behaviour, including precise paleoclimatic constrains from the MH period.

Finally, the analysis of key factors (e.g., model differences in meridional temperature gradients in the lower vs. higher troposphere, sea-ice cover, the representation of Atlantic multidecadal variability) involved in the simulated winter atmospheric circulation for MH and future projections will further our understanding of the mechanisms at play in response to large changes in external radiative forcing in CMIP5 models.

Reference:

Mauri, A., B. A. S. Davis, P. M. Collins, and J. O. Kaplan (2014), The influence of atmospheric circulation on the mid-Holocene climate of Europe: a data-model comparison, Clim. Past, 10, pp. 1925-1938, doi: 10.5194/cp-10-1925-2014.

Keywords: NAO, mid, Holocene, CMIP5, PMIP3, paleoclimatic constraints

Multi-resolution modeling with the AWI-CM in CMIP6

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Abstract

Especially in the ocean there are key regions such as the Gulf Stream and North Atlantic current regions, the Agulhas retroflection zone, the Weddell Sea, and coastal areas which are insufficiently resolved in state-of-the art climate models. Our novel approach to gain higher resolution in those key regions while leaving the resolution unchanged in other regions is to use a finite element dynamical core. We have successfully run FESOM (Finite Element Sea ice Ocean Model), which was developed at AWI (Alfred Wegener Institute), in a coupled configuration with ECHAM6, which was developed at the Max Planck Intitute for Meteorology. In a first set-up of this model, the AWI Climate Model (AWI-CM), we achieved a similar performance regarding the realistic simulation of basic atmospheric and oceanic quantities compared to state-of-the-art CMIP5 climate models in a long control simulation of 1500 years. However, in this first set-up we have not yet exploited the potential of the ocean model since we have only applied moderate resolution of about 25 km in key areas. Furthermore, the atmosphere model has only been run in T63 corresponding to about 200 km in this set-up.

For CMIP6 we plan to use eddy-resolving resolutions in key ocean areas (1/12 corresponding to 9-10 km) to contribute to HighResMIP within the EU project PRIMAVERA. In fact, short test simulations with very high resolution in the Gulf Stream and North Atlantic current surroundings as well as in the Agulhas current area already show clear improvements in the simulation of the location of these currents. Regarding the atmosphere resolution, the plan is to use T255 corresponding to about 50 km globally. Furthermore, we plan to contribute to OMIP, PMIP, and SIMIP.

We are currently working on a finite volume version of the ocean model code which would be numerically more efficient and could be two to three times faster than the current finite element version when applying the same number of grid points and when using the same number of computational nodes. This version of the code is planned to be ready for use in CMIP6.

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Keywords: coupled modeling, eddy, resolving ocean simulation, reduction of common biases, finite element, finite volume

Decadal predictions of the oceanic carbon uptake

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Abstract

The ocean has been a major sink for the anthropogenic carbon during the industrial era. The strength of the oceanic carbon uptake determines the airborne fraction of CO2 and thus affects climate change. The oceanic uptake of anthropogenic CO2 also perturbs the biogeochemical state of seawater. The modern decadal prediction systems focus on the predictions of physical state of the ocean and suggest robust predictive skills for a number of phenomena, such as Atlantic multi-decadal variability, Atlantic meridional overturning circulation, the Earth's temperature. Until now, predictability of variations in the oceanic carbon uptake and the corresponding ocean biogeochemical variables has received only little attention. In an earlier study, multiyear predictability of tropical marine productivity has been explored and a prediction skill of 3 years was found (Séférian et al., 2014). Our ongoing work based on the MPI-ESM decadal prediction system (Hongmei Li et al. submitted) reveals significant interannual and decadal variations of CO2 uptake in the western subpolar gyre of the North Atlantic. Moreover, we demonstrate that the potential prediction skill of the North Atlantic carbon uptake variability is up to 4 years and that there is evidence confirmed by observational data for establishing predictive skill of CO2 uptake. We show that beside a trend due to rising CO2 emissions, near-term projections of the oceanic uptake and storage of carbon are largely affected by decadal variations. Predictions of oceanic carbon sink in the next several years considering variations and variability in the ocean circulation, thermal state, and atmospheric forcing are crucial for projections of climate and ocean acidification. They are also beneficial for informing science-based management decisions and guiding monitoring programs aimed at understanding the present and future oceanic carbon sink. Our work provides first steps towards earth system predictions. There are still open questions related to the predictability of the oceanic carbon uptake and associated underlying mechanisms including a combination of physical, biological and chemical processes. We hope that CMIP6 will provide a platform for systematic studies addressing some of these open questions.

Keywords: decadal predictions, oceanic carbon uptake, sources of decadal variability

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A more productive, but different, ocean after mitigation

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Abstract

Warming of the ocean surface under greenhouse gas (GHG) accumulation has been projected to enhance ocean stratification, exacerbate nutrient limitation of phytoplankton, and decrease marine net primary production (NPP) over the next century. Studies of the reversibility of warming further suggest a lagged recovery of global mean sea surface temperatures after GHG mitigation, suggesting that oceanic NPP may also be slow to rebound. In this study, we employ a mitigation scenario in which projected Representative Concentration Pathway (RCP8.5) forcings are applied out to 2100, and then reversed over the course of the following century in a fully coupled carbon-climate earth system model, and find an unexpected rapid increase in global mean NPP, including an "overshoot" to values above contemporary means. The 5.5% NPP overshoot is driven by a similar overshoot (11.8m) in the maximum monthly mixed layer depth arising from a transient imbalance between the cooling surface ocean and waters at intermediate depths (_~100-400m) that still carry strong legacy effects of warming in the 21st century. Residual warm subsurface waters at these depths weaken upper ocean density gradients, resulting in deeper mixing and enhanced surface nutrients despite the continued presence of significant legacy warming and freshening in surface waters. Enhanced surface nutrients combine with the positive effects of residual warming on phytoplankton growth and nutrient recycling to drive a global mean NPP overshoot. Regional variations in NPP reversibility exist however, and some regions experience prolonged suppression of NPP. We also find a marine ecosystem regime shift as stark depletion of silica at intermediate depths over the 21st century warming and mitigation period results in increased prevalence of large, non-diatom phytoplankton.

Keywords: mitigation, reversibility, marine primary production, regime shift

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Future Arctic Sea Ice and Climate Projections from RCP Scenarios

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Abstract

Recent studies showed that the Arctic is experiencing pronounced environmental changes such as reduced spring-summer snow cover, declining sea ice, and altered ecosystems by a decades-long warming trend (Hegseth and Sundfjord 2008; Batt et al. 2010; Brown et al. 2010). There are still large uncertainties in the projections of the Arctic region, but it is well agreed between various CMIP3 and CMIP5 models that the Arctic is the most climatically sensitive region in the world (IPCC 2007, 2014). The impending Arctic climate change and its vulnerability to the climate change increases the needs for more profound and reliable information and comprehensive studies. Projection on future sea ice is a prerequisite for understanding the future climate change in the Arctic region as sea ice is one of the major components of controlling the Arctic climate. Although there are uncertainties in the sea ice projections, most CMIP5 models project the reductions and changes in seasonal variations of sea ice in the future. This study aims to relate sea ice changes and their impacts on the Arctic climate in the future based on the RCP scenarios, which NIMR has produced for CMIP5. Sea ice reductions are expected to continue and seasonally ice free Arctic Ocean would appear around 2050s for RCP 4.5 and 2040s for RCP 8.5. Only 22.8% of sea ice of this century is projected to remain at the end of the 21st century. The locations of large sea ice changes are well matched to the regions covered with thin ice (Holland and Bitz 2003). Changes of sea ice extent seem to be strongly correlated with surface temperature and downward longwave radiation as a result of weakening of ice albedo feedback. As a whole, global warming in the future would result in a stormy Arctic climate: increases in surface temperature, downward longwave radiation, precipitation, and cloudiness and decrease in surface pressure. It is also noticeable that the late formation of sea ice as a result of surface warming seems to result in the late autumn in the Arctic. Changes in sea ice cover over the Arctic Ocean lead to the increases in heat and moisture transfers from the ocean to the atmosphere, and lead to decreases in the lower clouds and increases in the upper clouds, i.e., the vertical profiles of Arctic Ocean atmosphere would become more favorable to the convections. It is projected that heat budget would be redundant over the Arctic Ocean, and most of heat redundancy can be explained by increases in downward longwave radiation and latent heat fluxes. Increase of freshwater transports through Fram strait and CAA and decrease of brine rejection with less sea ice formation also are projected to contribute to the weakening of AMOC in the future.

Keywords: Arctic, sea ice, climate change, RCP, CMIP5

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The biogeophysical effects of deforestation on mean and extreme temperature in temperate regions from 1850 to present

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Abstract

During the industrial period, the extent of forest was reduced in favour of the expansion of agriculture in most temperate regions. This has impacted local climate conditions through the so-called biogeophysical effects, i.e. by modifying the physical properties of the land surface such as the albedo and the evapotranspiration rate. Previous modelling studies suggest that these historical land-use and land-cover changes (LULCC) have had a cooling effect annually, in some regions of a similar magnitude as the temperature changes driven by increasing greenhouse gas (GHG) concentrations, but with large differences in the magnitude and the seasonal pattern of the temperature response among models1,2. However, these studies considered simulations which were run with global non-coupled models using fixed Sea Surface Temperatures (SSTs).
Here, our goal is to reassess these findings using a larger number of fully coupled historical simulations from the Coupled Model Intercomparison Project phase 5 (CMIP5). We include only CMIP5 models providing at least three ensemble members, in order to take interannual variability into account. These historical simulations were driven by both natural (volcanoes) and anthropogenic forcings (GHG, land-use, aerosols). In order to disentangle the effect of LULCC from that of other forcings, we compared climate changes in neighbouring grid cells in which surface temperature is assumed to respond similarly to GHG and other large-scale forcings, but which differ in terms of land-use forcing.
Our analysis confirms that the biogeophysical effects of the reduction in forest cover lead to a local cooling in winter, with all of the 8 models taken into account indicating such a behaviour, and it also suggests that this response was primarily driven by increases in albedo. However, the results reveal a higher model disagreement than what was previously found regarding the impact on summer temperature changes, with four models out of 8 showing a warming effect of LULCC, against only one out of seven in a previous inter-model comparison1,2. Furthermore, we show that this lack of agreement is even higher for the hottest extremes. This is largely related to the inter-model spread in evapotranspiration changes following the conversion from primary vegetation to cropland. On average, we calculate that the magnitude of the impact of LULCC on near-surface temperature from 1850 to present was about 30% as big as that of the cumulated effect of other forcings over areas of North America

*Speaker

where at least 15% of the forest was removed, although this value highly depends on the considered model. 1 Pitman, A. J., et al. (2009), Uncertainties in climate responses to past land cover
change: First results from the LUCID intercomparison study, Geophys. Res. Lett., 36, L14814, doi:10.1029/2009GL039076.
2 de Noblet-Ducoudré, N., Boisier, J., Pitman, A., Bonan, G., Brovkin, V., Cruz, F., et al. (2012). Determining robust impacts of land-use-induced land cover changes on surface climate over North America and Eurasia: Results from the first set of LUCID experiments. Journal of Climate, 25, 3261-3281. doi:10.1175/JCLI-D-11-00338.1.

Keywords: biogeophysical effects, LULCC

Slowdowns and accelerations of surface global warming due to tropical Pacific internal variability: A multimodel intercomparison

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Abstract

Despite the ongoing increase in atmospheric greenhouse gas concentrations, the hiatus in global warming has been reported for the past decade or so, for which various mechanisms have been proposed. With the Pacific Ocean-Global Atmosphere (POGA) climate model experiment forced by radiative forcing and tropical Pacific sea surface temperature variability, Kosaka and Xie (2013) showed that La Nina-like decadal cooling offset radiatively forced warming and caused the current hiatus.
Here, we extend the POGA experiment from the late 19th century to present in a multimodel framework.
All the models show accelerations and deceralations of global warming due to tropical Pacific decadal warming and cooling. By comparing the results with sets of CMIP5 experiment forced solely by radiative forcing, we (1) quantify contribution of tropical decadal variability to individual acceleration and hiatus events of global warming since late 19th century, and (2) assess uncertainty of the tropical Pacific influence on global climate.

Keywords: POGA, tropical Pacific, uncertainty

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Stochastic parameterization of gravity waves from convection and fronts: theory, validation, and impacts on the middle atmosphere climate

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Abstract

A recently developed stochastic parameterization of gravity waves (GWs) is used and adapted to represent the GWs produced by convections and mid-latitude fronts in General Circulation Models. For the fronts, the parameterization uses a theory of the spontaneous adjustment that relates directly the GWs field to potential vorticity anomalies. With relatively little modification to the theory, we show that the spontaneous adjustments occurring in the troposphere can well be used to predict the right amount of waves in the mesosphere. The relation with the sources also gives to the GWs predicted an intermittent character that is quite realistic when compared to the constant level balloon measurements done during the Concordiasi campaign in the low stratosphere.
The impacts on the climate is then addressed, with a particular emphasis on the annual cycle in the stratosphere, because with sources the launched GWs now have an annual cycle. We also address the significance of including the GWs sources on the middle atmosphere responses to the changing climate. In preparation for CMIP6, we show that including GWs sources strongly impact our predictions of the climate change, at least in the middle atmosphere.

Keywords: Gravity waves parameterization, convection, climate change in the middle atmosphere, CMIP6 models

*Speaker

Probabilistic uncertainty assessment of multi-centennial sea-level rise projections consistent with climate targets

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Abstract

The severe impacts of future sea-level rise (SLR) from global warming call for a robust uncertainty assessment of long-term sea-level projections. Given the complexity of major drivers and the limited process understanding of, for example, the future Antarctic ice sheet response, comprehensive uncertainty analyses have to be carried out for available scenarios and forcings. Process-based models help to advance our understanding of individual contributors to the total sea-level response. However, they are computationally too expensive for joint probabilistic uncertainty assessments. Semi-empirical approaches have been developed to fill this gap but they lack the physical representation of relevant sea-level components. Here, we present a sea-level emulator that is calibrated against long-term CMIP5 and process-based model results for all major sea-level components. We conduct a probabilistic uncertainty assessment of long-term global SLR projections forced by a suite of scenarios that are consistent with the 2C warming target. Thermal expansion estimates are derived from an updated hemispheric upwelling diffusion model (MAGICC), calibrated against CMIP5 ocean temperature profiles. Global glacier contributions are calculated based on transient and equilibrium process-based projections. Long-term estimates for Greenland and Antarctic ice sheets are derived from surface mass balance and solid ice discharge parameterisations that reproduce latest estimates from ice-sheet models and satellite measurements. We also provide SLR projections for scenarios that limit the 2100 global mean temperature increase to 1.5C relative to pre-industrial levels. These projections may serve as a lower bound of future SLR and therefore help to identify minimum adaptation requirements for the 21st century and beyond. Finally, the global SLR estimates provided here can be used to force component-wise sea level patterns for a simplified assessment of regional sea-level responses.

Keywords: sea level rise, sea level projections, climate targets, model response uncertainties

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Tropical Cyclones-Ocean interactions in a high resolution GCM: the role of the coupling frequency

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Abstract

The interaction between Tropical Cyclones (TCs) and ocean is a major mechanism responsible for energy exchange between the atmosphere and the ocean. TCs affect the thermal and dynamical structure of the ocean, but the magnitude of the impact is still uncertain. Very few CMIP5 models demonstrated ability in representing TCs, mainly due to their horizontal resolution. We aim to improve TCs representation in next CMIPs experiments through the new CMCC-CESM-NEMO General Circulation Model, having a horizontal resolution of degree in both atmospheric and ocean components. The model is capable to represent realistically TCs up to Cat-4 Typhoons. The wind structure associated with TCs is responsible for two important atmosphere–ocean feedbacks: the first feedback - positive - is driven by the latent heat associated with the enhanced evaporation rate and leads to an increase of the available energy for TC. The second feedback - negative - is due to the cold water upwelling induced by the increased wind stress at the ocean surface and by the shear-induced mixing at the base of the mixed layer. The second feedback is responsible for a significant cooling of the sea surface, leading to a weakening of the cyclone intensity due to the reduction of the total heat flux into the atmosphere. Furthermore TC intensification, intensity, and lifetime strongly depend on their transitional speed. A good representation of the TC-Ocean interaction strongly depends on the coupling frequency between the atmospheric and the ocean components, especially when simulating fast moving TCs. In this work, we investigate the role of the coupling frequency in representing the two mentioned feedbacks using the new fully coupled General Circulation Model developed at CMCC.

Keywords: Tropical Cyclones, Ocean, Sea Surface Temperature, General Circulation Model

*Speaker

Easy Volcanic Aerosol

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Abstract

Radiative forcing by stratospheric sulfate aerosol of volcanic origin is one of the strongest drivers of natural climate variability. Transient model simulations attempting to match observed climate variability, such as the CMIP historical simulations, rely on volcanic forcing reconstructions based on observations of a small sample of recent eruptions and coarse proxy data for eruptions before the satellite era. Volcanic forcing data sets used in CMIP5 were provided either in terms of optical properties, or in terms of sulfate aerosol mass, leading to significant inter-model spread in the actual volcanic radiative forcing produced by models and in their resulting climate responses. It remains therefore unclear to what degree inter-model spread in response to volcanic forcing represents model differences or variations in the forcing. In order to isolate model differences, "Easy Volcanic Aerosol" will provide an analytic representation of volcanic stratospheric aerosol forcing, based on available observations and aerosol model results, prescribing the aerosol's radiative properties and primary modes of spatial and temporal variability. In contrast to regriddings of observational data, the Easy Volcanic Aerosol module will allow for the production of physically consistent forcing for historic and hypothetical eruptions of varying magnitude, source latitude, and season. Easy Volcanic Aerosol will provide a key tool within CMIP6 (specifically for VolMIP and RFMIP) to perform multi-model experiments with an idealized, consensus volcanic forcing, to allow precise quantification of model uncertainty in the response to volcanic forcing.

Keywords: volcanic aerosol, tool

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Processes Leading to the Projected Reduction of Tropical Cyclone Activity in the Western North Pacific

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Abstract

The GFDL high-resolution (23-km) AGCM HiRAM was used for AMIP-type time-slice simulations for the present (1979-2008) and the end of century (2074-2100). HiRAM well simulates mean climatology, Asian Monsoon seasonal evolution, frontal activity, and tropical cyclone-intraseasonal oscillation relationship. Strength of simulated extreme precipitation is compatible with TRMM precipitation. The ensemble-mean SST increase projected by CMIP5 CGCMs under RCP8.5 was superimposed on the present SST to force the end-of-century simulation. Tropical cyclone activity in the western North Pacific is projected to be significantly weakened at the end of the 21st century. This is due to the equatorward contraction of convection and the corresponding anomalous subsidence poleward of the equatorial convection belt. Strongest response occurs in the western North Pacific and results in significantly weakened convection and westward extension of the subtropical anticyclone. Vorticity budget analysis finds that the background state decides the amplitude of response. The anticyclonic response is the largest in this monsoon trough (cyclonic) region. This is true even if the low–level divergence anomaly is zonally symmetric. Dynamical Interaction between vorticity and divergence anomalies, the associated thermodynamic components, and the dynamical–thermodynamic interaction likely further enhance the response in the monsoon trough and cyclonic regions. The finding is being applied to examine the CMIP5 projection by various models.

Keywords: high resolutin climate projection, tropical cyclone activity, RCP8.5

*Speaker

Roles of internal and external processes in the Atlantic multidecadal variability

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Abstract

Atlantic multidecadal variability (AMV), as defined by sea surface temperature (SST) anomalies averaged in the North Atlantic basin, is known to fluctuate on interdecadal timescale. A recent study suggests that the time evolution of the AMV is controlled by external forcing due mainly to sulphate aerosol emission, but the mechanism counteracts an existing view of the AMV being generated via internal processes associated with changes in the Atlantic meridional overturning circulation (AMOC) and thus controversy remains. In this study, we performed ensemble historical simulations for 1931-2014 with the MIROC climate model for attributing the AMV to internal and external processes. The historical run with all the radiative forcing drivers reproduced well the time evolution of the AMV index whereas a similar experiment with fixed sulphate aerosol failed, suggesting a crucial role of aerosol-induced radiative forcing in AMV. The externally-forced decadal SST variations dominate in the tropical North Atlantic and the Mediterranean Sea, and significantly increase precipitation over Europe and Sahel during the positive AMV. Consistent with future declining scenario of anthropogenic aerosol emissions, analyses to the Coupled Model Intercomparison Project Phase 5 (CMIP5) climate model simulations show that the North Atlantic decadal SST variability will be generated more by internal processes and confined to high latitudes, suggesting less impact on surrounding land precipitation.

Keywords: Atlantic multidecadal variability, aersol forcing, CMIP5 model

*Speaker

Next generation Earth System Models for informing future climate policy

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Abstract

The next generation of Earth System Models (ESMs) are being developed to address a wider range of policy questions beyond projections of global mean temperature and climate feedbacks. ESMs will now be instrumental in improving our understanding of climate impacts including projections of water resources, food security and air quality that are fully integrated and consistent with climate projections and emissions scenarios. This will involve new representations of processes such as ozone damage on stomatal conductance and land-use change impacts on runoff. Further to this, ESMs will allow us to fully evaluate climate mitigation pathways including co-benefits of following certain multi-gas pathways, for example mitigation of ozone precursors to reduce the impact of air pollution. In addition, many emission pathways include the use of bio-energy crops combined with carbon capture and storage (BECCS) as a carbon removal technology. In which case, the impacts of climate on yield and therefore the magnitude of negative emissions should be represented within the model framework rather than using model forcings. ESMs will also include new processes which are important for more realistic evaluations of mitigation pathways for example the inclusion of nitrogen availability which affects the magnitude and dynamics of the terrestrial carbon sink and thus has implications for allowable emissions in the future.

The next generation of UK Earth System model will be tasked with addressing all these points. In this poster we highlight developments being made for the next generation of UK Earth system models (e.g. UKESM1) that aim to more fully represent multi-component Earth system interactions and thereby allow more robust, policy relevant projections to be made.

Keywords: Earth System Models, Climate Policy, Mitigation

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