WCRP/SPARC workshop:
"Challenges for Climate Science - Synergies between SPARC and the WCRP Grand Challenges"

Harnack House, Berlin, Germany
31 October – 01 November 2016

Program and Abstracts

Scientific Organizing Committee:
Neil Harris, Katja Matthes, Judith Perlwitz, Hauke Schmidt, and Fiona Tummon

Agenda (as of Oct, 14, 2016)

Mon pm		
1300	Welcome/Aims of the workshop	Workshop SOC
1310	WCRP priorities for next 5-10 years	Guy Brasseur
1330	GC1: Clouds, circulation & climate sensitivity	Ted Shepherd
1400	Ice formation in clouds - small-scale uncertainties and their relevance for large scales	Corinna Hoose
1420	The role of changes in MA circulation for chemistry and climate	Hella Garny
1440	The role of stratospheric water vapor for climate	Gabi Stiller
1500	Discussion: SPARC/GC1 links	
	TEA	
1550	GC6: Near-term climate prediction	Judith Perlwitz
1620	Predictability after volcanic eruptions	Claudia Timmreck
1640	Lessons from the SNAP activity	A. Charlton-Perez
1700	Miklip – Assessment of decadal climate prediction	Wolfgang Müller
1720	Solar variability and climate predictability	Katja Matthes
1740	Discussion: SPARC/GC6 links	
	Posters & Ice breaker	
2000	CLOSE	

Tues am		
0900	Seasonal prediction and the involvement of the stratosphere	Daniela Domeisen
0920	GC3: Climate extremes	Olivia Romppainen
0950	Extremes	Dim Comou
1010	HiWeather project	George Craig
1030	Discussion: SPARC/GC3 links	
	COFFEE	
1120	GC7: Carbon feedbacks in the climate system	Tatiana Ilyina (skype)
1150	Atmosphere ocean coupling through trace gases	Susann Tegtmeier
1210	Short-lived climate forcers	Bill Collins
1230	Discussion: SPARC/GC7 links & Final discussion	
1300	CLOSE	

30’ slots: 20’ presentation + 10’ discussion
20’ slots: 15’ presentation + 5’ discussion

Abstracts

Oral Presentations (ordered by time schedule)

Clouds, circulation and climate sensitivity

Theodore Shepherd
University of Reading, United Kingdom

The CCCS Grand Challenge has identified four major science questions to focus its activities. Two relate to the long-standing problem of global climate sensitivity, where the uncertainty mainly results from cloud feedbacks. The other two relate to central features of atmospheric circulation relevant to climate impacts, extratropical storm tracks and tropical rain belts. Whilst the role of cloud feedbacks is an emphasis here as well, the questions raise a number of broader issues. This talk will discuss the nature of these challenges for atmospheric circulation and some ways forward in which SPARC could contribute.

Ice formation in clouds - small-scale uncertainties and their relevance for large scales

Corinna Hoose
Karlsruhe Institute of Technology (KIT), Germany

Significant progress has been made in the last years in the quantification, understanding and parameterization of primary ice formation. Nevertheless, its role in different cloud regimes is still unclear, in particular compared to secondary ice formation. I will briefly review the current state of research on heterogeneous ice nucleation from laboratory experiments and high resolution modelling; and will provide links to cloud dynamics, large-scale dynamics and radiative budgets.

Changes in the large-scale circulation of the middle atmosphere and its role for chemistry and climate

Hella Garny
Institut für Physik der Atmosphäre, DLR, Oberpfaffenhofen, Germany

The role of the middle atmosphere in the climate system is increasingly being appreciated, and it is known that the circulation of the middle atmosphere can significantly influence surface climate and weather. The fate of the large-scale circulation of the middle atmosphere in a changing climate is a much discussed topic in the last years. Progress has been made on the understanding of the mechanisms of the general acceleration of the circulation in response to climate change as simulated by models. However, observational evidence on circulation changes is still not reconciled with model simulations and with our mechanistic understanding. The key open questions on large-scale circulation changes and their possible impact on the climate system, that will be discussed during this talk, are:
(1) Process understanding: How is tracer transport (that is detectable from observations) coupled to the concept of the wave-driven mean mass circulation, the residual circulation?
(2) Reconcile observations, models and reanalysis: Is decadal-scale variability causing the differences between observational records and models, or are relevant processes not captured properly in the models?
(3) Role of Gravity waves: Do gravity waves contribute to circulation trends in a different manner than simulated by current simplified gravity wave parameterizations used in climate models?
(4) Downward coupling: How do changes in the large-scale middle atmospheric circulation impact tropospheric and surface climate?
In particular the last question presents a challenge closely linked to the WCRP grand challenges. While evidence exist that strong changes or anomalies in the middle atmosphere can impact surface climate and weather pattern locally both through direct dynamical coupling and through radiative coupling, it remains to be quantified how large the impact of middle atmospheric change in response to climate change is on surface climate.

The role of stratospheric water vapor for climate

Gabriele P. Stiller
Karlsruhe Institute of Technology (KIT), Germany

Water vapour is the most potent greenhouse gas. Observations over 20 to 30 years at the end of the 20th century indicated a continuous increase of lower stratospheric water vapour. CCMs extrapolated this positive trend into the future and gave rise to concerns regarding the global warming impact. However, during recent years new analyses of observational data records indicated a somewhat different picture on the long term evolution of water vapour and its link to tropospheric and lower thermospheric temperature. The talk will give an overview on recent literature and discuss what we think to know about water vapour and its role within climate change, and what we do not yet understand.

Predictability after large volcanic eruptions

Claudia Timmreck
Max Planck Institute for Meteorology, Hamburg, Germany

The possibility of a large volcanic eruption provides arguably the largest uncertainty concerning the evolution of the climate system on the time scale of a few years; but also the greatest opportunity to learn about the behavior of the climate system, and our models thereof. When the next volcano erupts, large changes in the earth system are to be expected. For instance, as a response to the 1991 eruption of Mt. Pinatubo, in the Philippines, global surface cooling with a maximum of about 0.4K was observed. But how predictable is the response of the earth system to future eruptions? And how much will the response depend on factors such as the ocean state, or the season, location, and strength of the event? The talk will give an overview on the current state of art and discuss further research needs.

Miklip – Assessment of decadal climate prediction

Wolfgang Müller
Max Planck Institute for Meteorology, Hamburg, Germany

Milkip (from the German Mittelfristige Klimaprognose; mid-term climate forecast), is a German national project which aims at the assessment of the climate prediction on a 10-year time horizon and which is transferred to the German Weather Service for operational use by the end of the project. It is organized around a global prediction system comprising the Earth System model MPI-ESM together with an initialization procedure and a model evaluation system. An overview is given summarizes the lessons learned from MiKlip so far; some are purely scientific, such as what are best practices for initializing this system and what skill can currently be expected, others concern strategies and structures of research that targets future operational use. Additionally, Miklip is participating to international programs such as on an European level or to WCRP as an example via the Decadal Climate Prediction Project (DCPP). The current focus of DCPP is a coordinated experiment setup for decadal predictions for CMIP6. This approach and its linkage to the MiKlip are briefly summarized.

Seasonal prediction and the involvement of the stratosphere

Daniela Domeisen
GEOMAR, Kiel, Germany

The prediction of seasonal weather and climate variability has been significantly improved over the past decade with the increasing availability and operational use of seasonal prediction models. However, several gaps remain, especially in the extratropical atmosphere. Due to its comparably slow movement as compared to the troposphere, the stratosphere has been shown to have a significant influence on seasonal variability at the Earth's surface in the extratropics. The stratosphere acts as a modulating intermediary for remote influences from the tropics during winter, while during summer, tropospheric processes are the main drivers of seasonal variability. The talk will give an overview of the main predictors and challenges for seasonal forecasting and relate them to the role of the stratosphere and the Grand Challenges.

Short-lived climate forcers

Bill Collins
University of Reading, United Kingdom

Short-lived climate forcers (SLCFs) are well known to have large climate impacts. The route from emission of a pollutant to climate impact involves a chain of many processes and spans many academic fields (chemistry of multiple phases, aerosol physics, cloud physics, climate dynamics). Research into the last of these (climate dynamics of short-lived forcers) has increased recently. IPCC AR5 recommended a definition of Effective Radiative Forcing that includes "rapid adjustments" such as the change in atmospheric stability, and hence cloud cover, due to changes in absorbing SLCFs such as black carbon and ozone. These adjustments may dramatically reduce the ERF of black carbon. The surface temperature response to SLCFs is also a hot topic – responses seem to be largest in the broad latitude band where the forcing is applied. Shindell (2014) suggested that a forcing concentrated in the northern mid-latitudes may give a larger global temperature rise than the equivalent forcing applied globally. I will summarise the latest research on SLCF climate impacts and outline future challenges for the climate community.

Posters (alphabetically by first author)

Simulation of upper-tropospheric African-Asian jet and of its response to global warming in the CMIP5 Models

Shahin Alimzadeh, Alireza Mohebalhojeh, Farhang Ahmadi-Givi, Daniel Yazgi
Institute of Geophysics, University of Tehran

In this study, models from phase 5 of the Coupled Model Intercomparison Project (CMIP5) are used to examine the simulation of upper tropospheric subtropical African-Asian jet and of its response to global warming. ERA-Interim reanalysis data is used here to assess the model biases in representing the seasonal-mean jet features in historical period. We analyze the geometric parameters of the jet including “latitude”, “speed” and “width” in each season and for two separate sectors of the jet region: “North-Africa” and “South-West Asia” which is briefly named “Africa” and “Asia” hereafter.
The main features of observed seasonal cycle of the jet in reanalysis data, is well captured in ensemble multimodel mean historical simulations: jet latitude increase (decrease) from clod (warm) to warm (cold) season and vice versa is true for jet speed and width. In addition, in all seasons Jet latitude and speed is greater in Asia than Africa except for springtime jet speed. Despite the large intermodel spread in historical jet projections, the models do not show large systematic biases in most cases (seasons). However, systematic biases in each of geometric jet indices are found in some seasons: most models exhibit equatorward jet biases in summertime and wintertime Africa (about 1.8° and 0.9° of latitude respectively, in multimodel mean), positive biases in jet width in summertime Asia (0.9° in multimodel mean), negative biases in jet speed in summertime Asia and wintertime Africa (approximately 2.9 m/s) and positive jet speed biases in autumn-time Africa (1.8 m/s).
In almost all seasons and for all geometric jet indices, the multimodel mean jet reponse to climate change is stronger in RCP8.5 than RCP4.5 integrations. Robustness and valu of the multimdoel mean jet response in each of the jet indices, varies among different seasons and sectors. In winter months, we found no robust response in any of the geometric jet indices nor in Africa neither in Asia sector except for a slight and relatively robust increase in jet width (0.2° of latitude in RCP8.5) in Africa. However, in other seasons we found robust multimodel mean changes in jet indices between historical period and the end of twenty first century in the RCP8.5 scenario: In spring, models predict a robust increase in jet width of about 0.5° and 0.2° of latitude in Africa and Asia respectively and also a robust increase in jet speed of 1.1 m/s for Asian sector. In summer, the African jet speed is found to decrease (0.7 m/s), whereas the Asian jet speed will increase (0.4 m/s) and it will move equatorward by 0.8° of latitude. Finally, the models show a consistent and considerable decrease in autumn-mean African jet speed of 1.39 m/s and with this change, the jet position is found to shift slightly poleward by 0.3° of latitude.
These changes in the jet in response to climate change have interesting and important implications for changes in surface air temperature and precipitation over North-Africa and South-West Asia region, because the position and intensity of the subtropical jet is closely related to the Hadley cell and also the equatorward propagating waves from mid-latitude to this region. There is large spread across the models in historical jet projections and also in jet response to climate change. Finding the sources of this spread and also the dynamical causes of the seasonality of the jet response remain as important challenges, which is beyond the scope of this study and would be analyzed in our future work.

Regional Variability in Tropical Precipitation and Gravity Waves, and Relation to Circulation in the Upper Troposphere and Lower Stratosphere

M. Joan Alexander, David Ortland, Alison Grimsdell, Ji-Eun Kim, Claudia Stephan

Atmospheric gravity waves generated by tropical convection influence large-scale winds in the upper troposphere and stratosphere. Winds at these levels guide Rossby wave propagation and teleconnection patterns that strongly influence the simulation of regional-scale climate and skill of long-range weather forecasts. Most climate and weather forecasting centers have raised their model lids in recognition of the importance of these upper level winds and the importance of simulating the processes that control them. At seasonal forecast model resolutions, small-scale waves remain severely under-resolved, yet the influence of their drag forces on the circulation in the upper troposphere and stratosphere make them key players in predictability. Gravity wave drag parameterizations are used to tune both climate and forecast models with demonstrated effects on bias reduction and forecast skill. The tropical lower stratosphere quasibiennial oscillation, in particular, has demonstrated influence on seasonal predictability, and this circulation is forced in large part by non-orographic gravity waves emanating from tropical convection. The El Nino Southern Oscillation (ENSO) and Madden-Julian Oscillation (MJO) are two major modes of tropical precipitation variability, and the small-scale rain events within these oscillations are major sources of tropical gravity waves. We present results of idealized models with realistic gravity waves generated by observed precipitation variability to examine regional changes in gravity wave generation and gravity wave drag and relationships to ENSO and MJO precipitation and circulation patterns.

Climatology, structure and formation mechanisms of local ozone anomalies in Europe

S. Barodka (1,2), A. Krasouski (1,2), P. Lapo (3), A. Svetashev (1,2), T. Shlender (2), L. Turishev (2), Y. Yakautsava (1), V. Zhuchkevich (2), I. Bruchkouski (1,2)

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(3) Center of Hydrometeorology, Radioactive Contamination Control and Environmental Monitoring of the Republic of Belarus, Minsk, Belarus

Local ozone anomalies, defined as synoptic-scale deviations in the total ozone column field with a characteristic lifetime of about a week or a few days, constitute an important component of the stratospheric ozone variability. The present study is devoted to investigation of the statistics, dynamical structure and formation mechanisms of local ozone anomalies. First, we process observational and reanalysis data to obtain statistics of all cases of negative and positive anomalies over the territory of Europe during the last two decades, paying attention to the definition of anomalies, their possible classification, and algorithms for their objective identification. Furthermore, we investigate several prominent cases of both negative and positive anomalies, focusing on the underlying dynamical processes. For that purpose, we combine observations and reanalysis with global-scale numerical simulations by ECMWF OpenIFS model and regional simulations by WRF model, treating ozone as a tracer. Special attention is paid to the cases of deepest negative ozone anomalies (e.g., the 1997-1998 ozone mini-hole, which is responsible for the minimal TOC value ever observed over Belarus – 163 DU), and of springtime and summertime ozone mini-holes, when sufficiently low TOC values coincide in time with intense solar irradiation. Finally, we discuss the connection of local ozone anomalies with surface weather phenomena, their predictability in numerical weather modelling, and the role of local ozone anomalies in the broad context of stratosphere-troposphere interactions research.

PALEOSTRAT: PALEOmodelization from a STRATospheric perspective

David Barriopedro (1,2), Natalia Calvo (1), Ricardo García-Herrera (1,2)
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(2) Instituto de Geociencias (CSIC, UCM), Madrid, Spain

Recent studies have demonstrated the influence of the stratosphere on the climate. However, the limited period of instrumental observations prevents us from obtaining a clear picture of role of the stratosphere in modulating the climate responses to internal (e.g., El Niño Southern Oscillation) and external (e.g., volcanic) forcings, and its contribution to explain anomalous periods before the industrial era.
PALEOSTRAT (PALEOmodelization from a STRATospheric perspective) is a funded project by the Spanish government which will investigate the impact of the stratosphere on the climate of the Last Millennium (LM), with focus on the preindustrial era (850-1850 CE). This will be addressed by means of a suite of LM simulations with the CESM model which only differ in the representation of the stratosphere, so that their comparisons will unambiguously quantify the impact of the middle-atmosphere on the surface climate.
Uncertainties related to external forcings will also be addressed by comparing business-as-usual LM model simulations with LM runs forced with novel external forcing histories and innovative model implementations, which include an explicit representation of volcanic aerosols and their evolution following major eruptions. PALEOSTRAT will also offer an unprecedented opportunity to explore the vertical coupling on multidecadal and longer time scales.

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Explicit global simulation of gravity waves up to the lower thermosphere

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Increased computer facilities allow to run general circulation model (GCMs) with significantly higher resolution and/or higher complexity than several years ago. Nevertheless, the closure problem of unresolved dynamical scales remains an issue, especially when the scales of parameterized gravity waves (GWs) and resolved GWs become comparable. In addition, turbulent diffusion must always be parameterized along with other subgrid-scale dynamics. A practical solution to the combined closure problem for GWs and turbulent diffusion is to dispense with a parameterization of GWs, apply a high spatial resolution, and to represent the unresolved scales by a macro-turbulent diffusion scheme such as to account for damping of resolved waves in a self-consistent fashion. This is the approach of a few GCMs that extend from the surface to the lower thermosphere and simulate a realistic GW drag and the associated summer-to-winter-pole residual circulation in the upper mesosphere. In this presentation we describe such a model, namely a new version of the Kuehlungsborn Mechanistic general Circulation Model (KMCM), which includes explicit (though idealized) computations of radiative transfer and the tropospheric moisture cycle. Particular emphasis is spent on the possible role of secondary GWs in the Austral winter mesosphere.

Stratospheric nitrogen dioxide: some peculiarities of its retrieval procedures and its possible effects on the total ozone column

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This work is dedicated to the analysis of measured differential slant column densities (DSCD) of nitrogen dioxide and ozone. The measurements have been performed by a self-developed MAX-DOAS instrument and took place in Belarus (Minsk urban area and Narachanski National Park), Germany (Mainz), Netherlands (Cabauw) and Antarctica (Larsemann Hills). The instrument has successfully passed two international inter-comparison campaigns and has been characterized by its good stability, high rate of spectra registering and high quality of retrieved DSCD trace gases data.

The work is aimed at finding a relationship chain between the stratospheric nitrogen dioxide and the state of the ozone layer employing ground-based MAX-DOAS measurements. Since ozone is one of the climate-forming factors and the formation of ozone layer depends essentially on the nitrogen dioxide condition, there is a possibility of indirect influence of nitrogen dioxide on the Earth climate.

Series of obtained ground-based measurements data along with satellite and MACC reanalysis data and their analysis and interpretation will be presented.

Future trend of the lower stratospheric ozone column at tropical latitudes from SPARC-CCMI model simulations

Irene Cionni, Giovanni Pitari, Daniele Visioni, Eva Mancini and SPARC-CCMI model PIs

Chemistry-climate coupled models (CCMs) are used to study the future evolution of ozone as concentrations of ozone-depleting substances (ODSs) decrease and greenhouse gases increase, cooling the stratosphere. Model uncertainty in tropical column evolution is high (Eyring et al. 2010, Charlton-Perez et al., 2010, Douglass et al. 2014), mostly related to the large spread that is simulated in the magnitude of tropical upwelling among the models. Following WMO 2014, "the uncertainty in future lower stratospheric ozone trends in the tropics precludes a confident assessment of the sign of future stratospheric ozone radiative forcing", keeping the question open about "how the coupling between changes in atmospheric dynamics and chemical composition affect future climate" (Science question about the SPARC theme: "Chemistry Climate").

Projections of stratospheric ozone from a suite of CCMs that participated in the coordinated model inter-comparison organized by the SPARC Chemistry Climate Model Initiative (CCMI-1) have been analyzed. In the tropical upper stratosphere, all CCMI simulations following the REF-C2 scenario indicate decreasing annual mean ozone between 1960 and 2000 followed by a steady increase until the end of the 21st century, while in the tropical lower stratosphere a continuous ozone decrease from 1960 to 2100 is simulated in almost all models, due to the predicted intensification of the Brewer-Dobson circulation, namely the tropical upwelling.

Diagnostics for the evaluation of tropical O3 (tropospheric, lower stratospheric and upper stratospheric columns) and of dynamical drivers (w*, age of air, latitudinal age gradient, lower stratospheric tropical N2O profiles) are carried out to better understand differences in model behavior. We take advantage of the SPARC Data Initiative (SPARC theme: Long-term Records for Climate Understanding) for valuable information on data quality.

References

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The linkage between Arctic sea ice changes and mid-latitude atmospheric circulation - The role of tropo-stratospheric coupling

Dörthe Handorf[1], Ralf Jaiser[1], Erik Romanowsky[1], Klaus Dethloff[1], Tetsu Nakamura[2,3], Jinro Ukita[4], Koji Yamazaki[2,3]
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Observed global warming trends have their maximum in Arctic regions, a phenomenon referred to as Arctic Amplification. Consequently, Arctic sea ice shows a strong decreasing trend. These changes imprint modifications on atmospheric flow patterns not only in Arctic regions themselves. Changes of teleconnections and planetary scale motions like Rossby waves affect mid-latitude climate as well.
We identified mechanisms that link recent Arctic changes through vertically propagating planetary waves to weakening events of the stratospheric polar vortex. Related anomalies then propagate downward and lead to negative AO-like situations in the troposphere. These results based on ERA-Interim reanalysis data do not allow to entirely dismiss other potential forcing factors leading to observed mid-latitude climate changes. More importantly, properly designed Atmospheric General Circulation Model (AGCM) experiments with AFES and ECHAM6 are able to reproduce observed atmospheric circulation changes if only observed sea ice changes in the Arctic are prescribed. This includes the potential mechanism explaining how Arctic Amplification can lead to a negative AO response via a stratospheric pathway.

Arctic Stratosphere Dynamical Response to Global Warming

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(2) Max-Planck-Institute for Meteorology, Hamburg, Germany

Climate models often simulate dynamical warming of the Arctic stratosphere as a response to global warming in association with a strengthening of the deep branch of the Brewer-Dobson circulation. However until now, no satisfactory mechanism has been suggested to explain the stratospheric dynamical warming, casting doubts to the realism of the response. Here we analyse runs by twelve atmosphere-only CMIP5 models and show that all models simulate Arctic stratosphere dynamical warming in association with increased upward wave flux from the troposphere mainly due to the quasi-stationary wavenumber 1. We propose a mechanism which relates stratospheric warming and increased wave flux to the stratosphere with an eastward shift of quasi-stationary tropospheric waves, in particularly the low in the North Pacific, and ultimately with the strengthening of the zonal winds near the tropopause. Our results suggest that a weaker polar vortex is a more likely state of the future Arctic stratosphere.

Using response-guided causal effect networks to predict the stratospheric polar vortex

Marlene Kretschmer, Dim Coumou
Potsdam Inst. f. Climate Impact Research, Germany

Analyzing and predicting climate phenomena are usually based on known correlations of climate indices. For example, ENSO indices are used to predict seasonal rainfall and temperatures around the globe. There exist different data driven approaches (e.g. EOF, correlation networks) to identify and improve relevant climate indices but these are usually not considering a response variably of interest. Therefore, previous studies introduced the concept of response-guided community detection. However, these do not account for spurious correlations due to common drivers or auto-correlation and are thus limited in their interpretability. Combining response-guided clustering and causal discovery algorithms we overcome this problem and present an approach to objectively identify indices which help to analyze a variable of interest. We apply this method to the stratospheric polar vortex and identify potential drivers at different time-lags which influence stratospheric variability and therefore are also of interest for mid-latitude winter weather.

Heavy rain forecasts in mesoscale convective system in July 2016 in Belarus

Palina Lapo
Hydrometeological Center of Belarus

The research work is focused on study of the microphysical processes of mesoscale convective system occurred on the 13th of July 2016 over The Republic of Belarus.
July 13, 2016 the weather on the Republic of Belarus was defined by the wave cyclone. The formation of the wave cyclone was due to large temperature gradients between the polar and tropical air masses. In addition, cold advection was observed on the isobaric surface of 850 hPa. Differences between the two air masses were not only in temperature, but is also seen in the reserve of moisture in the high atmospheric level. According to the isotachs analysis the jet stream took place on the isobaric surface of 300 hPa over the northern part of Belarus. It speed was about 30 m / s. This condition created the possibility for the development of strong convective clouds on the border of air masses. Within hours, strong mesoscale convective storm was formed over the north-west part of Belarus. On the HRV RGB satellite product overshooting top can be observed.
Moreover, «hook echo» radar echo form was recognized on Doppler weather radar "Minsk-2".
It was the most powerful convective U storms over the past few years on the territory of Belarus. Over last few years the number of heavy convective rains has increased in Belarus, it is connected with climate changes. These convective storms produced strong winds, rainfall, hail and vortex, like tornado. As a result of the convective storm a lot of crops and forest were damaged.
The precipitation quantitative for this case have been performed by using different microphysic parameterizations in WRFV3.7 model.
The results of study show underestimation of the precipitation amount and spatial distribution of the precipitated area. The main object in this research is to find the best variant of model configuration for this extraordinary case. For that purpose a simulation of atmospheric phemomena with different microphysic configuration have been conducted. The results indicate that the microphysical process defined amount of water, graupel, snow and hail and such processes as particle growth in cloud. In addition, microphysics configuration determines the difference in time and the quantity of precipitation. WRF-ARW v3.7 model has shown some advantage in simulation of the physical processes responsible for production and initiation of heavy rainfall compared to other model runs. Thus, the choice of microphysics determines the accuracy of the forecast of heavy rains. In such way WRF model can resolve convective storms which, in extreme cases and help in predictions of early warnings of convective mesoscale phenomenas.

Eurasian winter cooling in the warming hiatus of 1998-2012

Chao Li[1], Bjorn Stevens[1], and Jochem Marotzke[1]
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In this study, we investigated the relative magnitudes of the contributions of surface temperature trends from different latitude bands to the recent warming hiatus. We confirm from five different global datasets that the global-mean surface temperature trend in the period 1998—2012 is strongly influenced by a pronounced Eurasian winter cooling trend. This cooling trend was not reproduced in an influential model study attributing most of the hiatus to cooling in the tropical Pacific (Kosaka and Xie, 2013) and hence might have different causes. Arctic sea ice loss over interannual time scales has previously been shown to influence Eurasian winter temperatures (Kim et al., 2014; Mori et al., 2014), but whether such an influence exists for the concrete hiatus period has remained unclear. To understand the drivers of this winter–cooling trend, we perform three twenty-member ensembles of simulations with different prescribed sea surface temperature and sea ice in the atmospheric model ECHAM6. Our experimental results suggest that the Arctic sea-ice loss does not drive systematic changes in the northern-hemisphere large-scale circulation in the past decades. The observed Eurasian winter cooling trend over 1998–2012 arises essentially from atmospheric internal variability and constitutes an extreme climate event. However, the observed reduction in Arctic sea ice enhances the variability of Eurasian winter climate and thus increases the probability of an extreme Eurasian winter cooling trend.

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Mori M., M. Watanabe, H. Shiogama, J. Inoue, and M. Kimoto, 2014: Robust Arctic sea-ice inuence on the frequent Eurasian cold winters in past decades, Nature Geoscience, 7, 869—873, doi:10.1038/ngeo2277.

The extraordinarily strong and cold polar vortex in the early northern winter 2015/16

Vivien Matthias[1], Andreas Dörnbrack[2] and Gunter Stober[1]
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2: Institut für Physik der Atmosphäre, DLR Oberpfaffenhofen, 82230 Oberpfaffenhofen, Germany

The Arctic polar vortex in the early winter 2015/16 was the strongest and coldest of the last 68 years. Using global reanalysis, satellite observations, and mesospheric radar wind measurements over northern Scandinavia we investigate the characteristics of the early stage polar vortex and relate them to previous winters. We found a correlation between the planetary wave (PW) activity and the strength and temperature of the northern polar vortex in the stratosphere and mesosphere. In Nov/Dec 2015, a reduced PW generation in the troposphere and a stronger PW filtering in the troposphere and stratosphere, caused by stronger middle latitudes zonal winds, resulted in a stronger polar vortex. This effect was strengthened by the more equatorward shift of PWs due to the strong zonal wind at polar latitudes resulting in a southward shift of the Eliassen-Palm flux divergence and hence inducing a decreased deceleration of the polar vortex by PWs.

The Deep South National Science Challenge: Clouds and Ozone?

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Southern-Hemisphere climate projections are subject to persistent climate model biases affecting the large majority of contemporary climate models, which degrade the reliability of these projections.
Southern-Hemisphere specific problems include the fact that satellite-based observations show that model output cloud occurrence above the Southern Ocean is underestimated, with consequences for the radiation balance, sea surface temperatures, sea ice, and the position of storm tracks. Stratospheric ozone depletion and in particular the Antarctic ozone hole has also been shown to modulate the strength of the Southern Annular Mode in the stratosphere and at the surface. This also potentially leads to variations in surface temperatures, sea ice and the position of the storm tracks.
In recognition of these Southern-Hemisphere specific problems within climate models, the New Zealand Government has launched the Deep South National Science Challenge, whose purpose is to develop a new Earth System Model which hopefully represents these physical processes more faithfully, thereby reducing model bias. The Deep South programme plans to conduct targeted observations in the Southern Ocean region and around Antarctica to develop improved process level understanding. But, these new observations will also be used with existing, mostly satellite, records to develop a rigorous framework for evaluating and tuning the New Zealand Earth System Model. This presentation describes three projects within the Deep South programme focussed on NZESM model developments, cloud and aerosol observations and model evaluation.

The “Study of water vapor in the polar atmosphere” (SVAAP) project and its 2016 measurements campaign at Thule Air Base, Greenland

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The “Study of water VApor in the polar AtmosPhere” (SVAAP) project, funded by the Italian Program for Antarctic Research, is aimed at investigating the surface radiation budget in relation to atmospheric water vapor concentration and clouds. The project includes the realization of an intensive field campaign which was held from 5 to 28 July, 2016, at Thule Air Base (76.5° N, 68.8° W), Greenland. The atmospheric observatory at Thule is devoted to stratospheric ozone research and climate change studies since the 90’s, and is being maintained through an international effort by the DMI (Denmark), NCAR (U.S.A.), ENEA (Italy), INGV (Italy), and the University of Rome (Italy) (http://www.thuleatmos-it.it). Instruments currently installed at the observatory are capable of measuring chemical and physical parameters of the middle atmosphere (two microwave spectrometers, a lidar system, a FTIR spectrometer (NCAR), and UV-Vis Spectrometers (DMI)), of the troposphere (a RPG-HATPRO radiometer, the lidar, the FTIR, and sky cameras), and the surface radiation budget (downward and upward looking radiometers in the shortwave and longwave ranges). A few of these instruments are enlisted in the Network for the Detection of Atmospheric Composition Change (NDACC). During the SVAAP campaign, a new 22 GHz spectrometer (VESPA-22) was also installed at Thule with the aim of starting a long-term monitoring program of water vapor stratospheric vertical profiles and column contents. Additionally, during the campaign 23 radiosondes were launched in order to obtain vertical profiles of pressure, temperature, relative humidity, and wind direction and speed up to about 30 km altitude. The same Vaisala hardware is regularly used by DMI to launch ozonesondes during winter and spring.
The poster presentation will show the dataset acquired during the campaign and will discuss comparisons of water vapor column contents, vertical profiles, and preliminary results on the dependence of the surface radiation budget on water vapor content and cloud cover.

Self-excited oscillations in the atmosphere (0-100 km) with bi-annual to multi-centennial periods

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Several multi-annual oscillations have been detected in lower to upper atmosphere temperatures (SABER) and other parameters. They are similarly found in GCM model calculations (HAMMONIA, WACCM, HSC010). They also exist if the boundaries of the models are fixed, i.e. if sun, SST and trace gas densities are kept constant. This suggests that they are non-linear, self-generated (self-sustained) atmospheric oscillations. Such oscillations are characterized by robust periods and the capability of synchronization. Structures and impacts of these oscillations are analyzed, and some results are presented.
1. Structures: Many oscillation periods have been found in three different model runs: HAMMONIA (30 year run), WACCM (150 year run), HSC010 (400 year run). The longest period is 346 years. The periods of the oscillations in the different models are very nearly the same though the models are rather different. This demonstrates the robustness of the periods. The data are analyzed in altitude layers of 2-3 km thickness from the ground to 100 km. The oscillation phases are frequently found to be the same in adjacent layers. This is possibly a synchronization effect.
2. Impacts: The oscillation amplitudes are relatively small. Impacts are therefore expected in cases of small atmospheric trends. A prominent example is the "climate effect", i.e. the longterm increase of ground temperatures. Recently the IPCC has suggested that the origin of the climate effect might be not entirely anthropogenic , but some fraction might be natural. Analysis of the 235 year temperature record at Hohenpeißenberg suggests that superposition of three self-sustained oscillations can simulate part of the climate effect at this place. This natural fraction is about one third.

An Unprecedented Disruption of the Quasi-Biennial Oscillation

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We will describe the recent unique evolution of the atmospheric quasi-biennial oscillation, detailing the nature of the disruption, its dynamical origins, predictability and possible recurrence under a warming climate.

Trends in the stratospheric Brewer-Dobson circulation and related effects on age of air

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The global stratospheric Brewer-Dobson circulation (BDC), with upwelling in the tropics and sinking motion above the poles, is expected to change with rising Greenhouse gas concentrations. A changing BDC, in turn, changes the stratospheric trace gas composition providing an important feedback on climate change via radiation and dynamics. However, trends in the BDC are largely uncertain, hitherto. Current climate models simulate a strengthening residual mean mass circulation, resulting in decreasing mean age of air, the average transit time for an air parcel since entering the stratosphere across the tropical tropopause. Balloon-borne measurements collected over the last decades, on the other hand, show weakly increasing mean age in the Northern hemisphere (NH). Moreover, satellite observations from the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) show a challenging inhomogeneous increase/decrease change pattern in the NH/SH over 2002-2012.
We present mean age and its trends from updated balloon- and satellite-based datasets and from recent model simulations with the Lagrangian transport model CLaMS driven by reanalysis meteorology. Comparison between observed and CLaMS simulated age of air shows good agreement from a climatological point of view, as well as regarding inter-annual variability related to the QBO and decadal trends. In particular, we focus on the hemispheric pattern in the decadal mean age change during 2002-2012 as seen by MIPAS and simulated by CLaMS, with increasing mean age in the NH and decreasing mean age in the SH. Our analysis shows evidence that the processes involved include a southward shifting stratospheric circulation pattern, manifesting in a southward shift of subtropical transport barriers. Furthermore, we separate the effects of residual circulation and eddy mixing on the mean age changes using a continuity equation based approach.
This separation analysis reveals a crucial effect of mixing on mean age and its decadal change pattern, suggesting that differences between climate models and observations are likely resulting from differences in the representation of mixing in climate models and in observations. Investigation of age of air spectra simulated with CLaMS is consistent with these findings.

Ozone radiative feedback and climate sensitivity

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Occurence of an ozone radiative feedback has been demonstrated in CO2-driven global warming simulations with coupled chemistry climate models. In some models, this ozone feedback is associated with changes of other feedbacks like the stratospheric water vapour feedback or the cloud feedback. While the direct ozone radiative feedback is negative in all models simulations available so far, the coupling to other feedbacks shows considerable inter-model variability. Hence, in some models the climate sensitivity is substantially reduced by the presence of interactive chemistry, while in others the climate sensitivity is left almost unchanged.
If the forcing is provided by perturbations other than CO2 increase, the picture may become even more complex. We sshow that in a simulation driven by enhanced ozone precursor emissions at the Earth's surface, the climate sensitivity is enhanced in spite of a negative ozone radiative feedback. This counter-intuitive effect can again be explained by changes in other feedbacks in response to interactive model ozone.
We will also address the necessity of methodical advances, especially in case of simulations driven by non-CO2 forcings. A reasonable compromise has to be found between a signal to noise ratio large enought to identify significant feedback changes (requiring sufficiently large forcing and response), and a scaling of the forcing low enough to avoid the occurence of spurious non-linearities that prevent sensible interpretation of feedback differenced for different forcings.

Spatiotemporal variability of the GW drag in the stratosphere - new perspectives for the middle atmospheric research

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In the lower and middle atmosphere, the most natural, immediate and fastest way for communication of information in the vertical are gravity waves (GWs). Although GWs induce highest accelerations in the mesosphere, lower thermosphere region, the imposed drag force is much bigger in the stratosphere.
In our study we present results from idealistic model sensitivity simulations showing an important role of the spatial distribution of GW activity for the polar vortex stability, formation of planetary waves and for the strength and structure of the zonal mean residual circulation.
Using multiple linear regression and conditional analysis we study the relation between spatial distribution of the GW drag in the stratosphere and selected atmospheric phenomena (ENSO, NAO, QBO) showing possible implications for the stratospheric circulation.

Orographic drag uncertainties impact forecast skill

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Despite their importance for the large-scale circulation, to date the representation of drag processes remains a major source of uncertainty in global models. Among the different drag processes the representation of orographic drag is particularly challenging. This has been recently highlighted by the WMO Working Group on Numerical Experimentation (WGNE) 'Drag project' which demonstrated that the main NWP and climate models differ significantly in representation of the total parameterized surface stress and in the partitioning of surface stress among various physical processes, particularly in regions with orography.
Here we discuss how uncertain is the representation of orographic drag in models, and we illustrate how this uncertainty affects the skill of medium range weather forecasts. Namely we show how different is the representation of the resolved orography even in models with similar headline horizontal resolution. We also use the results of the WGNE 'Drag project' to illustrate how much models differ in terms of the total parameterized surface stress and its partition among various processes. Finally, we use the Integrated Forecasting System of ECMWF to demonstrate how much these intermodel differences either in the resolved orography or the representation subgrid drag affect the forecast skill.

Characteristics of the Stratospheric Ozone Influence on Tropospheric Circulation

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The paper is aimed at studying cause-and-effect relations between space-time variations in the stratospheric ozone and tropospheric air masses dynamics. We proceed from the observational data, which suggests a clear relation of the ozone field to air masses boundaries and circulation processes in the troposphere, and perform the analysis using ground-based observations, atmospheric reanalyses, satellite data and numerical simulations (WRF model). In addition, we apply the theory of atmospheric elementary circulation mechanisms classification by Dzerdzeevsky. We present statistical analysis results, which demonstrate a stable correlation between temperatures in the atmospheric surface layer and total ozone over the territory of Belarus, particularly for the warm season (from May to the end of August). It is revealed that some features of the stratospheric ozone dynamics can be associated with fluctuations in the repeatability of circulation processes in the middle latitudes of the Northern Hemisphere. Finally, we investigate the evolution of stationary atmospheric fronts and jet streams, which may be treated as boundaries of global air masses, in relation to the tropopause height field and stratospheric ozone distribution. For that purpose we elaborate an algorithm of objective automated identification of jet streams, stationary fronts and tropopause surface from gridded reanalysis and modelling data. Finally, attempts are made to estimate the time lag between the variations in stratospheric ozone and tropospheric circulation.

Teleconnections towards Europe under La Nina

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Previous studies showed that La Nina, the cold phase of ENSO, seems to have an influence on the North Atlantic/ European region. Two case studies are presented in order to identify the mechanisms behind this far-field linkage for summer and winter.
During the summer 2010, Eastern Europe was affected by a long-persistent anticyclone. In climatology, the summer blocking frequency is significantly increased under La Nina conditions.
Multi-scale interaction is further responsible for the maintenance of the anticyclone.
The winter 2009 is characterized by an unexpected sudden stratospheric warming event under moderate La Nina conditions, which occur mainly due to wave 2. The anomalous wave 2 induced eddy heat fluxes are connected with two amplifying anticyclones: over Alaska and over Scandinavia. In climatology, the Scandinavian anticyclone and the related wave 2 eddy heat fluxes seems to be connected with La Nina and MJO phase 7.
These are special cases indicating an influence of La Nina onto Europe. Due to the non-linearity between quasi-stationary waves, transient eddies and mean flow it is expected that some difficulties occur in performing this far-field teleconnection in GCMs. Present-day model simulations of MPIESM (CMIP5 model run) are evaluated regarding the teleconnection towards Europe during winter.

Seasonal-to-Interannual Prediction Skills of Near-Surface Air Temperature in the CMIP5 Decadal Hindcast Experiments

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This study explores the seasonal-to-interannual near-surface air temperature (TAS) prediction skills of state-of-the-art climate models that were involved in phase 5 of the Coupled Model Intercomparison Project (CMIP5) decadal hindcast/forecast experiments. The experiments are initialized in either November or January of each year and integrated for up to 10 years, providing a good opportunity for filling the gap between seasonal and decadal climate predictions. The long-lead multimodel ensemble (MME) prediction is evaluated for 1981–2007 in terms of the anomaly correlation coefficient (ACC) and mean-squared skill score (MSSS), which combines ACC and conditional bias, with respect to observations and reanalysis data, paying particular attention to the seasonal dependency of the global-mean and equatorial Pacific TAS predictions. The MME shows statistically significant ACCs and MSSSs for the annual global-mean TAS for up to two years, mainly because of long-term global warming trends. When the long-term trends are removed, the
prediction skill is reduced. The prediction skills are generally lower in boreal winters than in other seasons regardless of lead times. This lack of winter prediction skill is attributed to the failure of capturing the longterm trend and interannual variability of TAS over high-latitude continents in the Northern Hemisphere. In contrast to global-mean TAS, regional TAS over the equatorial Pacific is predicted well in winter. This is mainly due to a successful prediction of the El Niño–Southern Oscillation (ENSO). In most models, the wintertime ENSO index is reasonably well predicted for at least one year in advance. The sensitivity of the prediction skill to the initialized month and method is also discussed.

SCIAMACHY limb measurements - one decade of observations in the upper troposphere and stratosphere

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SCIAMACHY, an instrument on board Envisat observed the earth atmosphere with different observation geometries for nearly one decade between 2002 and 2012. The limb geometry was used to retrieve profiles of trace gases and aerosols in the altitude regions from the upper troposphere to the stratosphere. Here we show the most recent time series for water vapour, nitrogen dioxide, ozone, and aerosol and present the latest results on their variability and trends and comparisons with other data sets.

Use of SSU/MSU Satellite Observations to Validate Upper Atmospheric Temperature Trends in CMIP5 Simulations

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The tropospheric and stratospheric temperature trends and uncertainties in the fifth Coupled Model Intercomparison Project (CMIP5) model simulations in the period of 1979–2005 have been compared with satellite observations. The satellite data include those from the Stratospheric Sounding Units (SSU), Microwave Sounding Units (MSU), and the Advanced Microwave Sounding Unit-A (AMSU). The results show that the CMIP5 model simulations reproduced the common stratospheric cooling (−0.46–−0.95 K/decade) and tropospheric warming (0.05–0.19 K/decade) features although a significant discrepancy was found among the individual models being selected. The changes of global mean temperature in CMIP5 simulations are highly consistent with the SSU measurements in the stratosphere, and the temporal correlation coefficients between observation and model simulations vary from 0.6–0.99 at the 99% confidence level. At the same time, the spread of temperature mean in CMIP5 simulations increased from stratosphere to troposphere. Multiple linear regression analysis indicates that the temperature variability in the stratosphere is dominated by radiatively-active [m1]gases, volcanic events and solar forcing. Generally, the high-top models show better agreement with observations than the low-top model, especially in the lower stratosphere. The CMIP5 simulations underestimated the stratospheric cooling in the tropics and overestimated the cooling over the Antarctic compared to the satellite observations. The largest spread of temperature trends in CMIP5 simulations is seen in both the Arctic and Antarctic areas, especially in the stratospheric Antarctic.

Internal climate variability in a state space of statistical moments

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Climate variability is often studied in terms of fluctuations with respect to the mean state, whereas the dependence between the mean and variability is rarely discussed. Here, a new climate metric is proposed to measure the relationship between means and standard deviations of annual surface temperature computed over nonoverlapping 100-yr segments. This metric is analyzed based on equilibrium simulations of the Max Planck Institute Earth System Model (MPI-ESM): the last-millennium climate (800–1799), the future climate projection following the A1B scenario (2100–99), and the 3100-yr unforced control simulation. A linear relationship is globally observed in the control simulation and is thus termed intrinsic climate variability, which is most pronounced in the tropical region with negative regression slopes over the Pacific warm pool and positive slopes in the eastern tropical Pacific. It relates to asymmetric changes in temperature extremes and associates fluctuating climate means with increase or decrease in intensity and occurrence of both El Niño and La Niña events. In the future scenario period, the linear regression slopes largely retain their spatial structure with appreciable changes in intensity and geographical locations. Since intrinsic climate variability describes the internal rhythm of the climate system, it may serve as guidance for interpreting climate variability and climate change signals in the past and the future.