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POSTERS

Decadal climate predictions with the CMCC-CM coupled OAGCM initialized with ocean analyses (WP6)

Bellucci, Alessio (1), Silvio Gualdi (1,2), Enrico Scoccimarro (2), Antonio Navarra (1,2), Simona Masina (1,2), and Andrea Storto (1)
(1) Centro Euro-Mediterraneo per i Cambiamenti Climatici
(2) Istituto Nazionale di Geofisica e Vulcanologia

The effects of realistic oceanic initial conditions on a set of decadal climate predictions performed with a state-of-the-art coupled ocean-atmosphere general circulation model (OAGCM) are investigated. The decadal predictions are performed in both retrospective (hindcast) and forecast mode. Specifically, the full set of prediction experiments consists of 3-members ensembles of 30-years simulations, starting at 5-years intervals from 1960 to 2005, using CMIP5 historical radiative forcing conditions (including greenhouse gases, aerosols and solar irradiance variability) for the 1960-2005 period, followed by RCP4.5 scenario settings for the 2005-2035 period. The ocean initial state is provided by ocean syntheses differing by assimilation methodologies and assimilated data, but obtained with the same ocean model. The use of alternative ocean analyses yields the required perturbation of the full three-dimensional ocean state aimed at generating the ensemble members spread. A full-value initialization technique is adopted. The predictive skill of the system is analysed at both global and regional scale as well as the processes underlying the enhanced predictability exhibited over specific regions.

Global Water Vapor variations in the Upper Troposphere and Lower Stratosphere in a coupled stratosphere-troposphere-ocean model (WP3)

Cagnazzo[1], C. E. Manzini[2], and P.G. Fogli[1]
1 Centro EuroMediterraneo per i Cambiamenti Climatici, Bologna, Italy
2 Max Planck Institute for Meteorology, Hamburg, Germany

Water vapor and ice are known to exert a key influence on the radiative and dynamical balance of the upper troposphere and lower stratosphere (UTLS). Recent research has demonstrated that observed variations of the global water vapor into the lower stratosphere are an important driver of decadal global surface climate change. Therefore, variations of the water vapor into the lower stratosphere can provide a source of decadal variability for the climate system. However, there is still a need to improve the representation of the UTLS water vapor distribution and its variations in climate models. The interannual and inter-decadal variability of the water vapor in the UTLS is examined in a long-term simulation performed with a coupled troposphere-stratosphere-ocean model. The model has a well-resolved

stratosphere with a high vertical resolution and is fully coupled to a dynamical ocean model. The long-term pre-industrial simulation (more than 100 years) is not subject to external forcings and is therefore analysed for investigating the internally driven long-term variability in the global UTLS water vapor. The evaluation will focus on the impact of the ocean coupling, the high vertical resolution and the representation of the tropical stratospheric dynamics on the modeled UTLS water vapor distribution and its interannual to inter-decadal variability, the representation of the cold-point tropopause temperature and its variations, the representation of tropical clouds and their impact on the tropical tropospheric variability.

Role of stratospheric ozone changes, as simulated by the CMCC-ESM (WP3)

Cagnazzo[1], C., E. Manzini[2], P.G. Fogli[1] and M. Vichi[1,3]
1 Centro EuroMediterraneo per i Cambiamenti Climatici, Bologna, Italy
2 Max Planck Institute for Meteorology, Hamburg, Germany
3 Istituto Nazionale Geofisica Vulcanologia, Bologna, Italy

Observed large changes in the Southern Hemisphere (SH) climate over the past decades are reported as a shift in the Southern Annular Mode, especially during SH summer. Model studies have found that during austral summer these changes can be mostly attributed to stratospheric ozone depletion. Coupled-climate-carbon-model simulations have reported that associated trends in surface winds can have an impact on the air-sea CO2 fluxes over the Southern Ocean through ventilation of carbon rich deep water. It is expected that summer SH circulation changes will be weaker or even reversed for the next 50 years due to stratospheric ozone recovery partially offsetting changes due to greenhouse gases increase. In this work two sets of simulation reproducing the historical climate and one future scenario including stratospheric ozone changes are performed and analysed. The simulations are performed with the CMCC Carbon Earth System Model (ESM) that includes processes related to the biological and geochemical parts of the carbon cycle. One set of simulations is done with the high-top version of the model, which includes a well-resolved stratosphere and has top at 80km; the second set uses the low-top version of the same ESM (top at 10km). The high-top model is able to fully reproduce the observed tropospheric circulation patterns in the SH during austral summer whilst the low-top version not. By comparing the two sets of simulations, we discuss the impact of imposed stratospheric ozone changes to the surface circulation patterns through troposphere-stratosphere coupling.

Influence of stratospheric dynamics on the extra-tropical circulation: Comparison of High-top/Low-top versions of a climate model (WP3)

Christiansen, Bo and Shuting Yang
Danish Climate Center, Danish Meteorological Institute

Recently, it has become clear that the stratosphere impacts the surface/troposphere system on time-scale ranging from seasonal to climatic. In this study we investigate to what extend this downward coupling is already represented in current climate models and if it could be improved by including a better resolved stratosphere. The difference between two versions of the newly developed global climate system model, EC-Earth, has been studied. The two versions, a low-top and a high-top, differ in their representation of the stratosphere. The components of EC-Earth are IFS, NEMO and LIM for the atmosphere, ocean and sea-ice, respectively. The low-top version is the standard configuration of EC-Earth with 62 vertical levels (top at 1 hPa) and T159 horizontal resolution for the atmosphere. The high-top version has a better resolved stratosphere with a total of 91 vertical layers and the top at 0.01 hPa. CMIP5 type experiments (1850-2005) with the two versions are intercompared and compared to ERA40/ERA-Interim reanalyses. Our focus is on extra-tropical circulation described by annular modes, blockings, EP-flux etc. Preliminary results show that in comparison with the reanalysis the high-top version has the most realistic stratosphere both regarding climatology and variability. The latter is demonstrated in, e.g., stronger and more pronounced winter warmings. These improvements are probably connected to an improved representation of the EP-flux coupling the stratosphere and the troposphere. Both the high-top and the low-top simulations show a realistic downward propagation of zonal mean zonal wind anomalies from the stratosphere to the troposphere/surface.

A framework for quantifying biogeochemical feedbacks in an Earth System model (WP7)

Collins, Bill, Olivier Boucher, Chris Jones, Ian Totterdell, Paul Halloran, Stephanie Woodward, and Nicola Gedney.
Met Office Hadley Centre

Many of the climate simulations for the CMIP5 project have been performed using Earth System models. These go beyond the physical climate models by including representations of biogeochemical components of the Earth System such as terrestrial and ocean ecosystems, and chemically reactive gases and aerosols. These components are coupled to each other through the impacts of composition changes on ecosystems and through the emission and removal of species from and to the biosphere. The components are also coupled to the physical climate system thus introducing feedback loops. Feedbacks involving interactions between the atmospheric composition and the biosphere can act to amplify or dampen climate change and hence affect the climate sensitivity. These feedbacks will be implicitly included in the CMIP5 predictions generated by Earth System models. Here we present a framework for comparing biogeochemical feedbacks in Earth System models to quantify their relative importance and to compare them to physical feedbacks. We separate the steps in the feedback chain into: sensitivity of composition to climate change, cross impacts of one atmospheric constituent on another, and the radiative effects of composition change. The first two steps can involve interactions with the terrestrial and ocean biospheres. We apply the above methodology to analysis of results from the HadGEM2 Earth System model which is used by the Met Office Hadley Centre in its submission to CMIP5. We quantify here the biogeochemical feedbacks in HadGEM2, for example the carbon cycle feedback, the wetland methane feedback, the CLAW hypothesis and many others. Apart from the carbon cycle feedback itself, the most important biogeochemical feedback in HadGEM2 is through wetland methane emissions. The least important is the CLAW feedback, which is shown to be negligible. Biogeochemical feedback strengths (in W/m2/K) are summed to calculate the overall impact of the Earth System components on the HadGEM2 climate sensitivity.

Climate sensitivity and radiative feedbacks in the CNRM climate model (WP7)

Geoffroy, O., D. Salas-Mélia, A. Voldoire, D. Saint-Martin

We give an analysis of changes in temperature and in the Earth's radiative budget in response to an increase of atmospheric CO_2 concentration levels in the CNRM climate model. We compare estimates of the Climate Sensitivity and the Transient Climate Response between the versions CNRM-CM3 and CNRM-CM5. Changes in radiative fluxes at the bottom and the top of the atmosphere and changes in some components of the climate system are analysed jointly. This provides insight of the respective contributions of some radiative feedbacks. Finally, estimates of the climate radiative feedbacks (water vapour, lapse rate, clouds and surface albedo) are given using the Partial Radiative Perturbation method and the validity of the relationship between the cloud radiative feedback parameter and the change in global Cloud Radiative Forcing already observed in the CMIP3 dataset is evaluated for the CNRM climate model.

Tropical wave in climate simulations using MPI-ESM with different vertical resolutions (WP3)

Giorgetta, Marco, Traute Crüger and Thomas Krismer
Max Planck Institute for Meteorology

This study compares the simulated tropical waves in the troposphere and in the stratosphere in CMIP5 simulations differing in the vertical resolution in the upper troposphere and in the stratosphere, but using the same vertical domain. The used vertical grids have 47 (L47) and 95 layers (L95), respectively, which has immediate effects on the representation of the vertical structure of prominent tropical waves like the MJO, Kelvin waves, Rossby-gravity waves and inertial gravity waves. In the stratosphere the L95 model allows the representation of the major wave types and hence simulates the quasi-biennial oscillation (QBO). In the L47 model the vertical structure of waves cannot be resolved in the stratosphere and hence no QBO is simulated. This work compares the wave number frequency spectra of the gravest tropical waves at levels in the troposphere, near the tropical tropopause and in the stratosphere.

Frozen soils in a land surface scheme: modelling challenges and first results (WP4)

Gouttevin[1], I, G. Krinner[1], P. Ciais[2], J. Polcher[3]
1 CNRS/Université Joseph Fourier – Grenoble
1 LGGE, Saint Martin d'Hères, France
2 CEA/CNRS, LSCE, Saclay, France
3 CNRS/Ecole Normale Supérieure, LMD, Paris, France

Permafrost underlies around 25% of northern hemisphere terrestrial surfaces while more than 50% of them are subject to seasonal freezing. Despite this extent, permafrost and seasonal freezing are not systematically accounted for in land surface and global climate models. We here present how soil freezing in implemented in the land surface model ORCHIDEE, part of the global climate model IPSL-CM4, and investigate the consequences of such developments for the modelling of the Arctic. Latent heat effects lead to a fair improvement in the representation of the soil thermal regime, with implications for the active layer, the uppermost part of the soil, which thaws on an annual basis in permafrost environments and hosts key microbiological processes. The hydrological regime is also thoroughly affected by soil freezing, with a distinct signature in the hydrographs of the major Arctic rivers. Simulation results point out the need of a subgrid variability approach in the treatment of surface infiltration and runoff, and underline the primary role of snow in our ability to model any hydrological or thermal variable.

Does the integration of dynamic N cycle in land surface model improve the long-term trend of LAI? (WP1)

Guenet [1], B., Cadule[1], P., Zaehle[2], S., Piao[3], S., Peylin[1], P., Maignan[1], F., Ciais[1], P., Friedlingstein[4], P.

1 Unité mixte de recherche CEA-CNRS-UVSQ, laboratoire des sciences du climat et de l'environnement, 91191 Gif-sur-Yvette, France.
2 Max Planck Institute for Biogeochemistry, Department for Biogeochemical Systems, Hans-Knöll-Str. 10, 07745 Jena, Germany.
4 Departement of Ecology, College of Urban and Environmental Sciences, Peking University, Beijing 100871, China.
4 QUEST, Department of Earth Sciences, University of Bristol, Bristol BS8 1RJ, UK.

The nitrogen (N) cycle is known to act as a feedback on the carbon (C) cycle. Thus, the C storage capacities of ecosystems could be at least partially controlled by its capacities to provide the N needed by the primary producers. Despite the several experimental evidences, which underline the importance of the N cycle on the land C dynamic, only few land surface models that integrate the N cycle exist. Thanks to satellite data, it is now possible to benchmark the models against long-term data and to evaluate the capacities of the models to reproduce long-term trend of vegetation growth. Here we used two versions of a land surface model with a dynamic representation of N cycle (O-CN) or without (O-C) and a satellite-derived Leaf Area Index (LAI) dataset based on the products defined by the Global Inventory Monitoring and Modeling Studies (GIMMS) group. The O-CN version better represented the long-term trend of LAI compared to the O-C version at global scale. This is particularly due to an improvement for the boreal regions. Our results suggest that the N availability might control the C storage capacities of the boreal ecosystems.

Differences in surface climate in a CMIP5 historical simulation due to the inclusion of a well resolved stratosphere (WP3)

Hardiman, Steven C (1), Neal Butchart (1), Scott M Osprey (2), Lesley J Gray (2)
1 Met Office Hadley Centre, Exeter, Devon, UK
2 National Centre for Atmospheric Science, University of Oxford, Oxford, UK
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Results are presented from the CMIP5 historical simulation using the stratosphere resolving Met Office climate model, run by the Met Office and NCAS. The results are compared against those from an equivalent low top model differing only in vertical extent and vertical resolution. Several examples of where the inclusion of a well resolved stratosphere impacts significantly on the simulated surface climate are shown, including: trends in the Southern Annular Mode, the influence of El-Nino teleconnections on northern hemisphere winter, and the direct influences of the Quasi-Biennial-Oscillation and stratospheric sudden warmings on surface temperature and pressure.

Atlantic blocking in climate simulations with a well resolved stratosphere (WP3)

Hinton, Tim, Neal Butchart, Steven Hardiman, Adam Scaife Met Office Hadley Centre and Lesley Gray, Scott Osprey NCAS-Climate, University of Oxford.

Previous climate change projections have suggested that the Atlantic will see a reduction in blocking frequency associated with a poleward shift of the storm track. This has been done with models that lack a good representation of the stratosphere

and therefore are unable to properly simulate sudden stratospheric warming (SSW) events. Here we use a model with a well resolved stratosphere, which indicates a poleward shift in the preferred area of Atlantic blocking and an equatorward shift in the mean storm track. We also look at the relationship between SSW events and blocking in this model.

Decadal prediction experiments using a Japanese AOGCM, MIROC (WP6)

Masahide Kimoto
Atmosphere and Ocean Research Institute, The University of Tokyo

We finished initial sets of CMIP5 near-term prediction experiments using MIROC AOGCM. A quick assessment of multi-version ensemble of MIROC models indicates that impacts of ocean subsurface initialization are seen up to 10 and about 5 yrs in the Atlantic and Pacific Oceans. The versions of the model used are MIROC3 (T42 atmosphere + 1deg oceans), MIROC4 (T213 + eddy permitting oceans) and MIROC5 (T85 + 1deg oceans, but with updated physics package). Decadal prediction is a new challenge in climate studies and comparisons with COMBINE and CMIP5 models will be of great interest.

Potential decadal predictability and its sensitivity to sea ice albedo parameterization in a global coupled model (WP6)

Koenigk, Torben, Christof König Beatty, Mihaela Caian, Ralf Döscher, Klaus Wyser
SMHI

This study analyzes the upper limit of climate predictability on decadal time scales and its dependency on sea ice albedo parameterization by performing two perfect ensemble experiments with the climate model EC-Earth. The first experiment uses the standard albedo formulation of EC-Earth, the second experiment reduced sea ice albedo. The decadal potential predictability of the atmospheric circulation is small. The highest predictability was found in air temperature at 2 m height over the northern North Atlantic and the southern South Atlantic. Over land, only a few areas are significantly predictable. The predictability for continental size averages of air temperature is relatively good in all northern hemisphere regions. Sea ice thickness is highly predictable along the ice edges in the North Atlantic Arctic Sector. The meridional overturning circulation is highly predictable in both experiments and governs most of the decadal climate predictability in the northern hemisphere. The experiments using reduced sea ice albedo show some important differences like higher predictability of atmospheric variables in the Arctic or higher predictability of temperature in Europe.

Interactions between climate, nitrogen availability and plant transpiration: Insights from scenario simulations with JSBACH/ECHAM6 (WP1)

Kracher, D., C.H. Reick, B.R. Parida.
Max-Planck-Institute for Meteorology, Hamburg

Future climate depends not only on the amount of future fossil fuel emissions, but also on the carbon (C) sink and source strengths of the oceans and the terrestrial biosphere. _As for the terrestrial biosphere, N availability commonly limits C sequestration directly via biochemical processes. There are also indirect impacts on the ecosystems by modifying plant transpiration, thereby affecting the hydrological cycle. _To study these indirect impacts, the land component JSBACH of the MPI

Earth system model was applied. In JSBACH, N dynamics were recently coupled to the C cycle. To quantify the effect of N limited transpiration on future climate, we ran two simulation scenarios (1850-2100), one with and the other without N availability affecting transpiration. JSBACH was run coupled to the climate model ECHAM6, i.e. N limited transpiration influences soil moisture via precipitation and limited water uptake. By comparing the two scenarios, the effect of N limited transpiration on several ecosystem processes is quantified at global scale. As also soil respiration and N2O emissions are affected and thus the release of greenhouse gases, transpiration is shown to be - in addition to C sequestration - another pathway through which N limitation and therefore N dynamics interact with climate.

Fidelity and Predictability of Decadal Climate Variations in ECHAM/MPIOM: Impact of Different Ocean Reanalyses (WP6)

Kroeger, Juergen, Wolfgang Mueller, and Jin-Song von Storch
Max-Planck-Institut fuer Meteorologie Hamburg

We study the impact of three ocean state estimates (GECCO, SODA, [ECMWF]-ORA-S3) on decadal predictability in one particular forecast system, the Earth system model from the Max Planck Institute for Meteorology (MPI-M) in Hamburg. The forecast procedure follows two steps. First, anomalies of temperature and salinity of the observational estimates are assimilated into our coupled model. Second, the assimilation runs are then used to initialize 10-year-long hindcasts/forecasts starting from each year between 1960 and 2001. The impact of the individual ocean state estimates is evaluated both by the extent to which climate variations from the ocean state estimates are adopted by the forecast system (`fidelity') and by the prediction skill of the corresponding hindcast experiments. The evaluation focuses on North Atlantic (NA) sea surface temperature (SST), upper-level (0-700~m) NA ocean heat content (OHC) and the Atlantic meridional overturning circulation (MOC). The ORA-S3 reanalysis gives the best results for our forecast system as measured by both the overall fidelity of the assimilation procedure and the predictions of upper-level OHC in the North Atlantic.

Improving the representation of sea ice physics in NEMO-LIM: snow thermodynamics and pancake ice formation (WP4)

Lecomte, O, M Vancoppenolle and T Fichefet
Centre for Earth and Climate Research, Earth and Life Institute,
Université catholique de Louvain (UCL)

UCL has recently improved the representation of sea ice processes in LIM (Louvain-la-Neuve Sea Ice Model), a large-scale sea ice model which is part of the ocean modelling system NEMO (Nucleus for European Modelling of the Ocean) and included in several climate general circulation models (e.g., IPSL-CM and EC-Earth). These developments involve (1) snow physics and (2) pancake ice formation. The new snow scheme implemented in the last version of the model is multi-layer, with vertically varying snow density and thermal conductivity. This model structure has been tested in a one-dimensional framework by means of sensitivity experiments. Besides, a parameterization of the impact of pancake ice formation on the ice growth rate has been developed. The latter is based on two components. First, wave propagation in sea ice is treated as exponentially decaying with ice thickness. Second, the ice growth in open water is enhanced due to the more frequent exposure of the ocean to atmospheric cooling in wave-affected regions. Both new components significantly affect the large-scale characteristics of sea ice, in particular volume and extent. This work was done within COMBINE WP4.

Tropical variability and stratospheric equatorial waves in the IPSLCM5 model (WP3)

Lott, François, Pauline Maury and Lionel Guez (WP3)
Laboratoire de Météorologie Dynamique, Ecole Normale Supérieure,
24 rue Lhomond, 75231 Paris Cédex 05, France

The variability of precipitations in the Equatorial regions is analysed in the 1000yrs control simulations done with the ESM of IPSL in the framework of COMBINE. We find that the model has reasonable mean values and has an intra-seasonal ENSO-like variability, but the model ENSO signal stays too confined to the western Pacific. At the inter-annual periods, the model is almost devoid of Madden-Julian Oscillation, with one MJO-like events occuring every 10 winters typically. At shorter time-scale the spectra of velocities and precipitations reveal the presence in the model of Convectively Coupled Equatorial Waves (CCEWs).
As the spectral signature of the CCEWs is not far from that of the slowest freely propagating stratospheric equatorial waves, we could expect the model to under-represent the latter. For the Kelvin waves, we show that it is not entirely the case, the ones in the model being of reasonable amplitude. It seems that in the model, the excitation of the waves by the mid-latitudes compensates for the lack of forcing by the tropical convection. The very long duration of the run also permit to analyse the action the individual waves on the zonal mean-flow as well as on the water content at the tropopause.

Forecast strategies in presence of systematic model errors (WP5)

Magnusson, L., M. Alonso-Balmaseda, F. Molteni
ECMWF

Systematic model error has been and still is a difficult problem for seasonal forecasting and climate predictions. If a state close to the observed state (analysis) is used to initialise the model, the result will drift towards the model climate. The time scale of the drift is different in different parts of the climate system, from a few days for fast atmospheric processes to multi-decadal time scale in the deep ocean. In this presentation we will assess three different forecast strategies applied for seasonal and decadal forecasts in order to deal with the model drift. Full initialisation start the model from the analysed state and the model drift is afterwards removed by a lead-time dependent bias correction. Anomaly initialisation uses observed anomalies that are added to the model climatology in order to initialise the model close to its climatology. The results are post-processed by using a bias correction in order to map back the results to the climatology of the nature. The third option investigated here is to apply flux correction in order to avoid model drift. In the presentation we will compare the results both in terms of variability and predictability.

Global sea-ice data assimilation in NEMO-LIM: towards systematic biases reduction in modelled sea-ice concentration and thickness (WP5)

Massonnet, François, Pierre Mathiot, Christof König Beatty, Thierry Fichefet, Hugues Goosse, Martin Vancoppenolle.
Georges Lemaître Centre for Earth and Climate Research, Earth and Life Institute, Université Catholique de Louvain, Louvain-la-Neuve, Belgium

We first examine the performance of two sea-ice models (LIM2 and LIM3) coupled to NEMO in global hindcast simulations for the period 1983-2007. The differences in skill are assessed with a comprehensive set of metrics for sea ice. In the Arctic, we find that the representation of sea-ice physics is critical for simulating realistic ice thickness and concentration fields, in terms of both mean state and intra-to-inter-annual variability. In the Southern Hemisphere (SH), the two models are found to perform lower than in the Northern Hemisphere, with no particular outstanding model. We suggest that the coarse resolution of our experiments (~1°) is the main limiting factor to the models' performance in the SH. To overcome the systematic biases of the simpler model, an Ensemble Kalman Filter (EnKF) is implemented. We assimilate daily global observations of sea-ice concentration between 1979 and 2005. We note a clear improvement in the reproduction of the observed ice edge and in the reduction of the biases in ice thickness, highlighting the multivariate nature of the EnKF and its underlying cross-correction mechanisms. The resulting sea-ice reanalysis can be used to initialize decadal climate hindcasts and predictions with ESMs.

Interannual predictions of the Atlantic Meridional Overturning Circulation at 26.5ºN (WP6)

Matei[1], Daniela, Johanna Baehr[2], Johann Jungclaus[1], Helmuth Haak[1], Wolfgang Müller[1] & Jochem Marotzke[1]
1Max Planck Institute for Meteorology, Bundesstrasse 53, 20146, Hamburg Germany. 2Institute of Oceanography, KlimaCampus, University of Hamburg

The Atlantic Meridional Overturning Circulation (AMOC) is an important contributor to European climate, which implies that the future strength of the AMOC is of considerable scientific and societal interest. In the near term (interannual to decadal), AMOC variations are influenced by both anthropogenic forcing and natural variability, and therefore near-term predictions need to be initialized from the current ocean state. We perform interannual AMOC predictions with the state-of-art coupled climate model ECHAM5/MPI-OM and compare these predictions with the only continuous observations of the AMOC at 26.5ºN, which are provided by the RAPID/MOCHA project over the period April 2004 to March 2009. Our predictions are initialized from an ensemble of ocean-only experiments forced by NCEP-NCAR atmospheric reanalyses. We show that the interannual AMOC variations at 26.5ºN are predictable up to 4 years in advance, with considerably increased skill compared to both non-initialized simulations and persistence forecasts. Investigating the predictability of different AMOC components, we find that the predictive skill arises predominantly from the basin-wide upper-mid-ocean geostrophic transport, which in turn receive its predictive skill through the upper-ocean zonal density gradient. Ensemble forecasts initialized in January 2008 indicate that the AMOC will remain stable over the next five years, with some interannual modulation of the seasonal cycle.

Stratosphere and Climate in HadGEM2 Simulations of the 20th Century (WP3)

Osprey[1], Scott M, Steven C Hardiman[2], Lesley J Gray[1], Tim Hinton[2] and Neal Butchart[2]
1 National Centre for Atmospheric Science, University of Oxford, Oxford, UK
2 Met Office Hadley Centre, Exeter, Devon, UK

Here we present results compiled by the Met Office and NCAS from the CMIP5 historical simulations using the stratosphere resolving global climate model, HadGEM2. We compare against an equivalent low top model with a model lid at 3hPa, which is otherwise identical. We highlight a number of examples where an improved representation of the stratosphere impacts on 20C climate and variability. These include: a spontaneously generated Quasi-Biennial Oscillation, improved upwelling and water vapour concentration in the tropical lower stratosphere and age-of-air at mid-latitudes and a realistic frequency of disturbed Northern Hemisphere winters.

When Chaos Reigns: Evidence Against a Stochastic Description of Northern Annular Mode High Frequency Variability (WP3)

Osprey[1], Scott M, Maarten Ambaum[2]
1 National Centre for Atmospheric Science, University of Oxford, Oxford, UK
2 Department of Meteorology, University of Reading

Future projections of climate change are dependent on understanding the origin and character of external forcings, e.g. future GHG emissions, solar irradiance, land-use etc; and modes of internal variability. Concerning the latter, the North-Atlantic Oscillation (NAO), and Northern Annular Mode (NAM) are key to describing low frequency internal variability on regional and hemispheric scales. Our understanding of these has relied, in part, on statistical descriptions of near-surface height and pressure fields. Specifically, seasonal NAM variability has been described using low order stochastic models, e.g. first order autoregressive (Marchov) processes, which are characterised by an exponential fall-off in predictability. However, on timescales of days to weeks, it is not evident how applicable these models are. We assess the relevance of power-law representations of near-surface annular mode variability (1000hPa Z), with a particular critique of the AR-1 representation. We claim that power law behaviour does not and can not readily explain the wintertime NAM on timescales shorter than 40 days, but rather deterministic chaos provides a more suitable paradigm. We conclude by outlining the relevance of our results to NAM variability in the stratosphere.

Anomaly versus full-field initialized DePreSys CMIP5 simulations (WP5)

Pohlmann, Holger & Doug M. Smith
Met Office Hadley Centre, Exeter, UK

The upcoming fifth assessment report (AR5) of the Intergovernmental Panel of Climate Change (IPCC) will focus additionally to the traditional climate projections undertaken over the coming century also on near-term climate predictions over the coming years to decades (10 to 30 years). The reason to perform the near-term experiments is to explore the degree to which future climate predictions depend on the initial climate state, focusing in particular on whether we can more accurately predict the actual trajectory of future climate if we initialize the models with the observed initial state. These simulations are coordinated by the World Climate Research Programme's Coupled Model Intercomparison Project (CMIP5). One of the goals of the COMBINE project (WP5) is to analyze the methodologies for initializing the decadal climate predictions. We therefore present here a comparison of two identical sets of near-term hindcasts with the DePreSys CMIP5 system using anomaly and full-field initialization methods.

Modelling surface mass balance on Greenland in a GCM: Impact of model resolution for modern day and differences for Eemian and glacial inception conditions (WP4)

Punge, Heinz Jürgen (1), Masa Kageyama (1), Gerhard Krinner (2), Hubert Gallée (2), and Aurélien Quiquet (2)
(1) Laboratoire des Sciences du Climat et de l'Environnement (LSCE), IPSL, CEA-CNRS-UVSQ, Gif-sur-Yvette, France
(2) Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE), CNRS–UJF Grenoble, Saint-Martin-d'Hères, France

A realistic modelling of Surface Mass Balance (SMB) is essential for coupling of ice sheets to climate models. Having improved the snow scheme SISVAT into the atmospheric model recently, we compare the results to the previous version of the model and show the impact of atmospheric resolution, both horizontal and vertical, on the SMB. Furthermore, we study SMB in past climate conditions, notably the Eemian (126ka BP) and the following glacial inception (115ka BP). The warmer summers in the Eemian lead to a lower than preindustrial mass balance, while the impact of cooler climate during inception on mass balance is not very pronounced. For the Eemian, the model predicts lower mass balance on the central ice sheet but a higher mass balance towards the coast compared to a PDD method based on temperature and precipitation calibrated under present conditions. A physical representation of snow processes can hence be essential for modelling the ice sheet response to changing climatic conditions.

Influence of different prescribed scavenging ratios on global aerosol and cloud properties in ECHAM5-HAM (WP2)

Reutter, Philipp and Ulrike Lohmann
Institut for Atmospheric and Climate Science, ETH Zurich, Switzerland

The standard version of the general circulation model ECHAM5-HAM (Lohmann and Hoose, 2009) uses prescribed aerosol scavenging ratios (percentage of removed particles per aerosol mode) for in-cloud scavenging. The benefit of prescribed scavenging parameters lies in the low computational costs, which are markedly increased when more sophisticated approaches like physically detailed size-dependent aerosol scavenging fractions (e.g. Croft et al., 2010) or prognostic aerosol cloud processing schemes (Hoose et al., 2008a,b) are used.
Using different prescribed aerosol scavenging ratios, we investigate their effects on the global aerosol and cloud properties. The results show that the cloud droplet number burden is decreased when the scavenging of aerosol particles is reduced as compared to the standard scavenging parameters of ECHAM. The reduced cloud droplet number concentration can be explained by the reduced formation of aerosol particles due to the higher aerosol concentration initially. The presence of more aerosol particles in the beginning leads to more condensation of sulfuric acid and organic vapors onto existing particles. Hence the nucleation of new aerosol particles is suppressed and coagulation of existing aerosol particles to form larger aerosol particles is more important. Therefore, the overall cloud droplet number concentration is reduced but the aerosol mass mixing ratio is increased when the scavenging ratios are reduced.

Coupling ocean, ice and atmosphere in a climate model (WP4)

Ridley, Jeff, Tony Payne, Chris Harris, Rupert Gladstone, Stephen Conford, and Ian Culverwell

The challenge in climate models is to depict the physical mechanisms, which might result in a 'collapse' of the West Antarctic ice sheet, as the consequential rate of sea level rise is of considerable interest to policy makers. Thus, a comprehensive model of the Antarctic ice sheet, which couples ice dynamics to the ice shelves and ocean is required. Here we describe the development of the components intended for inclusion in the Met Office Hadley Centre model HadGEM3. These include the GLIMMER ice sheet model with ice shelves coupled to the ocean model NEMO. The surface mass balance is calculated through the multilayer snow model in HadGEM3 and downscaled to GLIMMER using a subgrid statistical orography scheme. Updates to the orography and land mask, and associated issues relating to grounding line migration will be discussed.

First results of the newly coupled ice sheet-earth system model (WP4)

Rodehacke, Christian and Uwe Mikolajewicz
Max-Planck Institute for Meteorology, Hamburg, Germany

Since ice sheets belong to the slowest climate components, they are usually not interactively coupled in climate models. Therefore, climate projections are incomplete and only the consideration of ice sheet interactions allows to reduce projections' uncertainties. The inclusion of ice sheet interactions in climate models is also indispensable to tackle fundamental questions; How did ice sheets shape and how did they contribute to abrupt climate changes in the past? The earth system model at the Max-Planck Institute for Meteorology (MPI-ESM) is a fully coupled atmosphere (ECHAM6), vegetation (JSBACH), and ocean (MPI-OM) model. This model system has been bi-directionally coupled to a modified version of the Parallel Ice Sheet Model (mPISM). The coupling from the earth system model to the ice sheet model is accomplished by evaluating 6-hourly atmospheric output fields to compute the energy balance with an explicit snow layer scheme. The computed surface mass balance and temperature below the seasonal varying snow layer drive the ice sheet model. The resulting changes of the spatial distribution and elevation of the ice sheet are feed back into the earth system model. In addition, melting ice sheets release fresh water that ultimately flows into the ocean. Our coupling scheme closes the hydrological cycle by accounting for surface melt and calving losses, which are routed to appropriate ocean locations. We present preliminary results of our first fully coupled ice sheet-earth system model runs: The response of the entire system to instantaneously skyrocketing atmospheric carbon dioxide concentration is shown. Our main focus highlights the response of the Greenland ice sheet and the immediate strong consequences of, for example, changing ice sheets in the earth system.

What consequences can have small changes in heterotrophic respiration on the global carbon cycle? (WP1)

Roelandt , Caroline and Jerry Tjiputra
University of Bergen, Department of Geophysics

Soil is the largest global pool of terrestrial C and the soil organic C pool (Davidson and Janssens, 2006). The heterotrophic respiration (RH), depends on organic matter recalcitrance, on soil temperature and moisture. Because of its strong sensitivity to temperature, it is believed that the carbon transfer of from soils to the atmosphere could counterbalance the global NPP. The terrestrial biosphere would then become a net source of carbon. We explore here the impact of changes in decomposition rates on the behavior of the “Bergen Climate Model – Carbon” (BCM-C, Tjiputra et al., 2010). The BCM-C consists of global atmospheric and oceanic general circulation models coupled to oceanic and terrestrial carbon cycle models (Tjiputra et al., 2010). We modified the SOM decomposition dependence to soil temperature by a constant factor: R: ±15%, ±10%, and 0%. Two series of multi-century simulations were realized with the different values of R: 1) Simulations with pre-industrial climate forcings (i.e., atmospheric CO2 concentration at 284.7 ppm). 2) Fully interactive simulations based on historical and SRES-A2 emission scenario (only for 0% and ± 5% sensitivity factor). These 10 simulations will show us how a small change in RH can have consequences on the global carbon cycle.

References:

Davidson, E. A., and I. A. Janssens (2006), Temperature sensitivity of soil carbon decomposition and feedbacks to climate change, Nature, 440, 165-173.

Lloyd, J. and J. A. Taylor (1994), On the Temperature Dependence of Soil Respiration, Functional Ecology, 8(3), 315-323

Portner, H., Bugmann, H., and A. Wolf (2010), Temperature response functions introduce high uncertainty in modelled carbon stocks in cold temperature regimes, Biogeosciences, 7, 3669–3684.

Sitch, S., et al. (2003), Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model, Global Change Biol., 9, 161–185.

Tjiputra, J.F. et al., (2010), Bergen Earth system model (BCM-C): model description and regional climate-carbon cycle feedbacks assessment, Geosci. Model Dev., 3, 123–141.

Progress in sea-ice modelling in CNRM-CM5 ESM : first results from CMIP5 centennial and decadal experiments (WP4)

Salas y Mélia, D., M. Chevallier, C. Cassou, E. Sanchez, S. Sénési and A. Voldoire

Gelato is a multi-category and multi-layer enthalpy sea-ice model coupled with NEMO1° and ARPEGE-Climat, within CNRM-CM5 ESM. Several improvements were introduced in Gelato before CMIP5 simulations were carried out with CNRM-CM5 ESM, like prognostic sea ice salinity, a new snow albedo scheme and a new formulation of the ocean/sea-ice heat flux. A 10-member set of 1850-2012 long-term simulations was carried out with this improved version of Gelato. A comparison of modeled sea ice with satellite data reveals that CNRM-CM5 tends to simulate too little sea ice in Southern Seas, due to atmospheric and oceanic biases, whereas the model performs rather well in the Arctic. The modeled trend in Arctic summer sea ice cover varies significantly from one member to another, showing that using just one member to evaluate such a simulated trend would be questionable. The spread of trends is however compatible with observations, an improvement compared to the previous version of the model, CNRM-CM3. Decadal hindcast and forecast experiments were also run with CNRM-CM5, suggesting the model has some skill in forecasting summer sea ice a few years in advance. However, it seems that the initialisation technique must be improved in order to reduce the initial model drift that arises during the winter season.

Recent modifications in CNRM-CM5 ESM: basic evaluation from CMIP5 centennial simulations (WP7)

Salas y Mélia, D., E. Sanchez, B. Decharme, E. Fernandez, O. Geoffroy, C. Cassou, S. Sénési and A. Voldoire

The new global coupled climate model CNRM-CM5 is based on the ocean-atmosphere core formed by the most up-to-date versions of NEMO (IPSL, Paris) and ARPEGE-Climat (Météo-France). SURFEX v5, Gelato v5 and TRIP models respectively represent surface-atmosphere exchanges, sea ice and river routing. This new model was developed in close collaboration with Cerfacs (Toulouse). The atmospheric component has a horizontal resolution of 1.4° and 31 levels, and includes the new radiation scheme RRTM. This new model includes many developments compared to CNRM-CM3 (IPCC-AR4 version), particularly in ocean, sea ice and surface modelling. CMIP5 runs are now complete, and preliminary analyses of these simulations show that the model temperature drift is much reduced in preindustrial control (about 0.03K/century, compared to -0.1K/century for CNRM-CM3). An ensemble of 10 simulations of the 20th century climate shows that simulated global mean temperature changes are now correctly reproduced by the model. Some variability patterns, like NAO, PDO and ENSO, as well as teleconnections (tropics/extratropics, ENSO/African and Indian monsoons) also appear to be fairly realistic. However, some radiative biases tend to persist in CNRM-CM5, particularly over Eurasia and the Southern Oceans.

First results of the CNRM-CERFACS "near-term" forecast exercise (WP6)

Sanchez-Gomez, Emilia, Christophe Cassou, Elodie Fernandez, Laurent Terray, Aurore Voldoire, Stephan Senesi, David Salas (CNRM-CERFACS CMIP5 team)
CERFACS-SUC URA 1875, Toulouse, France
CNRM/METEO-France, Toulouse, France

In climate predictability studies, earth-system models are affected by important drifts at the beginning of the forecast that may alter the performance of the model in terms of skill. Several approaches have been proposed to reduce the model drift in decadal forecast integrations such the anomaly initialization and surface initialization. The goal is to find initial conditions (ICs) as close as possible to the model attractor but also compatible with the observations. In this work we present a methodology to obtain the initial conditions for decadal forecast experiments using the CNRM-CERFACS coupled system. The method is based on a three-dimensional newtonian damping in temperature and salinity of the ocean component towards the NEMOVAR_COMBINE ocean reanalysis beyond the mixed layer, while surface temperature and salinity are restored towards reanalysis using a flux derivative term. The rest of the components (atmosphere, sea-ice, continents) are freely coupled.

Several tests on the choice of the newtonian damping parameters have been performed. Finally, the initial condition are taken from a experiment in which no nudging is applied within [15°S, 15°N] (EXTROP experiment). Following the CMIP5 protocol, 10 members are performed for each initial date from EXTROP initial conditions. The preliminary results concerning the CNRM-CERFACS decadal integrations are shown, in terms of model drift and skill of forecast for several ocean variables.

The oceanic nitrogen cycle as part of the MPI Earth System Model: Basic features and first results (WP1)

Segschneider, Joachim, Katharina Six, and Ernst Maier-Reimer
Max-Planck-Institute for Meteorology, Hamburg, Germany

The oceanic nitrogen cycle is intimately interwoven with the marine carbon cycle, and therefore interacts with the climate system both directly and indirectly. First, nitrogen is a major nutrient for marine phytoplankton. Therfore, nitogen has an impact on the biological carbon pump and hence air-sea carbon fluxes. Second, N2O, a greenhouse gas, is released as a by-product during remineralization of organic matter. Further, the nitrogen budget is strongly linked to the oxygen minimum zones in the ocean, where NO3 is lost during denitrification when the oxygen required for remineralization of organic matter is taken from nitrate. This loss is counteracted by N-fixation from the atmosphere by cyano bacteria. It should be noted, however, that these processes are independent of each other, and therefore it is not a priori evident that the nitrogen budget in the ocean is balanced. All the above processes are simulated in the global marine biogeochemical model HAMOCC as part of the MPI-ESM (Earth system model), which is used in the current IPCC AR5 effort. We will present first results from these model experiments and changes of the nitrogen budget as a result of climate change will be discussed for idealized experiments like a 1%/yr atmospheric CO2 increase.

Mechanisms leading to cold European winter extremes and the role of troposphere-stratosphere interactions (WP3)

Tomassini, Lorenzo, Marco Giorgetta, and Elisa Manzini
Max Planck Institute for Meteorology, Hamburg, Germany

The study aims at investigating driving factors of European winter climate variability with a focus on cold winter extremes. Despite the general warming trend due to increased levels of greenhouse gas concentrations, several severe northern continental winters have been observed in recent years. The results of past studies provided evidence that Atlantic sea surface temperatures and arctic sea ice concentrations partly govern European winter climate variability. Ensemble simulations with climate models of different vertical resolutions also suggest that the stratosphere plays a role in propagating anomalies related to continental cold spells in the higher mid-latitudes. In the present work we take advantage of a newly performed long pre-industrial control run in order to examine processes which drive European winter climate variability. The investigation centers on the role of troposphere-stratosphere interactions in the development of European extreme cold spells. Sensitivity experiments with different vertical resolutions of the climate model are analyzed. Statistics of major stratospheric warming and weak polar vortex events are presented and related to cold European winter extremes.

Decadal prediction skill in a multi-model ensemble (WP6)

van Oldenborgh, Geert Jan ,Francisco J. Doblas-Reyes, Bert Wouters and Wilco Hazeleger

Decadal climate predictions may have skill due to predictable components in boundary conditions (mainly greenhouse gas concentrations but also tropospheric and stratospheric aerosol distributions) and initial conditions (mainly the ocean state). We investigate the skill of temperature and precipitation hindcasts from a multi-model ensemble of four climate forecast systems based on coupled ocean-atmosphere models. Regional variations in skill with and without trend are compared with similarly analysed uninitialised experiments to separate the trend due to monotonically increasing forcings from fluctuations around the trend due to the ocean initial state and aerosol forcings. In temperature most of the skill in both multi-model ensembles comes from the externally forced trends. The rise of the global mean temperature is represented well in the initialised hindcasts, but variations around the trend show little skill beyond the first year due to the absence of volcanic aerosols in the hindcasts. The models have non-trivial skill in hindcasts of North Atlantic SST beyond the trend. This skill is highest in the northern North Atlantic in initialised experiments and in the subtropical North Atlantic in uninitialised simulations. A similar result is found in the decadal ENSO region in the (sub) tropical Pacific, although the signal is less clear. The initialised experiments show some skill in the eastern Pacific, whereas the uninitialised simulations have good skill beyond the trend in the western North Pacific. The models also show some skill in forecasting 4-yr mean Sahel rainfall at lead times of 1 and 5 years, in agreement with the observed teleconnection from the Atlantic Ocean. However, uninitialised simulations have similar skill, so part must also be ascribed to the prescribed boundary forcing. We conclude that the ocean initial state contributes substantially to skill in forecasting in some regions, but that variations in boundary forcings are also important in decadal forecasts. The main source of skill in temperature is due to the trend forced by rising greenhouse gas concentrations.

Inclusion of monoterpene emissions in JSBACH-ECHAM-HAM (WP2)

Vuollekoski, H (1), S Smolander (1), T Bergman (2), R Makkonen (1) & A Asmi (1)
1) University of Helsinki, Department of Physics, Helsinki, Finland
2) Finnish Meteorological Institute, Kuopio Unit, Kuopio, Finland

In order to find more accurate estimates for the radiative forcing effect of aerosols; their formation and growth must be more profoundly understood. While recent development of the ECHAM-HAM climate model has included e.g. nucleation of organic compounds [Makkonen et al., 2011], monoterpene emissions remain unaccounted for. And yet several studies suggest these to be the main drivers of particulate growth [e.g. Iida et al., 2008; Paasonen et al., 2009]. We aim to include monoterpene emissions in the JSBACH vegetation model by applying the parameterization of Schurgers et al. [2009]. Monoterpene oxidation products will then be directed to ECHAM-HAM, where the vapors can contribute to secondary organic aerosol (SOA) formation according to O'Donnell et al. [2011]. We will also apply a scheme where monoterpene oxidation products are able to participate in particle nucleation and the growth of newly formed particles. We intend to run the new scheme on a development version of ECHAM6, and find whether the total effect is significant enough to be included in longer model runs, which would then determine its usability in the IPCC scenarios.

Iida et al., J. Geophys. Res., 2008
Makkonen et al., manuscript in preparation, 2011
O'Donnell et al., Atmos. Chem. Phys. Discuss., 2011
Paasonen et al., Boreal Env. Res., 2009
Schurgers et al., Atmos. Chem. Phys., 2009

Recent developments in background- and observation-error covariance modelling for NEMOVAR (WP5)

Weaver, A., I. Mirouze and T. Pangaud (CERFACS), M. Balmaseda and K. Mogensen (ECMWF)

NEMOVAR is a variational ocean data assimilation system for NEMO. It has been used to produce a 5-member ensemble 3D-Var reanalysis for a global 1-degree configuration (ORCA1). This reanalysis has been used by participants in WP6, for the production of decadal forecasts. This poster will outline recent developments to NEMOVAR aimed at improving the estimation and representation of the background-and observation-error covariances. Three developments will be described: 1) the use of assimilation statistics to diagnose the variances of observation error for temperature and salinity profiles; 2) the use of ensembles to estimate background-error variances and directional length-scales of background error; and 3) the representation of the directional length-scales in a correlation model based on an implicit diffusion equation. Results using the NEMOVAR ORCA1 system will be presented.

Does potential predictability and predictive skill improve with seasonal vegetation? (WP6)

Weiß,Martina, Bart van den Hurk, Reindert Haarsma K
NMI, De Bilt, Netherlands

Recent studies found potential predictability of temperature mainly over mid- to high latitude oceans (e.g. Boer, 2004; Boer and Lambert 2008), and in the North Atlantic region (Pohlmann et al., 2004), with very weak signals (of e.g. T2M) over land. The question therefore is how the signal over land could be increased. One possibility might be a better representation of vegetation, as its phonological development influences canopy resistance, evapotranspiration, interception, throughfall, soil moisture, albedo, and roughness length. The overarching question is to which extent can the land surface communicate past and prevailing anomalies back to the atmosphere and thus have an impact on subsequent climate (anomalies). In this study we try to answer this question by analysing the impact of an improved representation of land surface properties on monthly and seasonal potential predictability of various climate parameters. We use the EC-Earth earth system model to carry out perfect model experiments for the decade 2000-2010 with an ensemble of 10 members for prescribed SST conditions using MODIS LAI data to identify the variation in signal to noise ratios. Gain in predictive skill is thereafter quantified by comparison with the ERA interim dataset.

Decadal predictability of the North-Atlantic region in the EC-Earth model (WP6)

Wouters, Bert, Geert Jan van Oldenborgh, Wilco Hazeleger and Rein Haarsma
KNMI, De Bilt, Netherlands

We present an analysis of predictability of the ocean and atmosphere conditions in the EC-Earth model, anew global climate model based on the seasonal prediction system of ECMWF, focusing on the subpolar North-Atlantic region. In the model, this region is characterized by low-frequency variations, implying a certaindegree of potential predictability. This is being verified by means of a set of hindcast experiments for the period1960-2005. We initialize the ocean using NEMOVAR re-analysis data and sea-ice is obtained from a forcedocean-only model run. The model shows skill in predicting observed variations in sea surface temperature upto 6 to 9 years ahead. A good skill is found both in hindcasting the observed trends in the regions, as well asin capturing the interannual variability. Marginal predicitability is found over land, although regions under theinfluence of the Atlantic Multidecadal Oscillation appear to have some skill. Finally, we compare the subpolargyre strength in the model to a 20 year record of satellite altimetry observations, and discuss its predictability in our model, and the consequences thereof.

Initialization of sea-ice for decadal predictions with EC-EARTH (WP5)

Wyser, Klaus, Mihaela Caian, Torben Königk Rossby Centre, SMHI

The Rossby Centre at SMHI is working on a decadal prediction system based on the EC-EARTH model with anomaly initialization of the ocean. Decadal predictions require initial conditions for ocean and atmosphere that are close to the observed state. Re-analysis products are available for the atmosphere and the ocean, but not for the sea-ice component. Within the COMBINE project, we have investigated several methods for the initialization of sea-ice. The performance of the different methods is tested in a series of experiments and the results compared to observed sea-ice cover and SST. We find that the different initialization methods show minor differences in the Arctic sea-ice or the North Atlantic SST after the first forecast year. In the first forecast year, the simulation that started with a constant but not unrealistic sea-ice thickness resulted in larger differences to the observations than any of the other methods that show very similar performance. We conclude that for our decadal prediction system the anomaly initialization of sea-ice concentration, thickness and temperature is slightly better than the initialization with climatological sea-ice, and much better than the initialization with constant sea-ice thickness. However, the differences resulting from the different initialization methods diminish with increasing forecast length because of the short memory in the sea-ice.

Sensitivity of the aerosol 1st indirect effect: Impact of mitigation on clouds properties (WP2)

Yan, N [1], Y. Balkanski[1] and M. Schulz[2] (WP2)
1-Laboratoire des Sciences du Climat et de l'Environnement / IPSL, Gif-sur-Yvette, France
2- Norwegian Meteorological Institute, Oslo, Norway

This study focuses on the impacts that aerosol mitigation has on cloud properties and how such reductions affect clouds over the 21th century. We aim to distinguish these effects for different activity sectors and evaluate whether mitigating one activity sector can have a significant effect or not. The period of focus is the 2050 period when CO2 levels will be close to twice its preindustrial value and after the peak in aerosol emissions, which occurs emission between 2010 and 2030. We consider the BC, OC and sulphate emissions issued from the Representative Concentration Pathways (RCPs) which are consistent with long term socio-economic scenarios. This projection considers 10 different activity sectors, and we focus on the 3 main sulphate-emitting sectors (Energy, Industry, and International Shipping). The LMDz-INCA model is used in this study, it consists of a GCM coupled to an interactive aerosol chemistry module. This model is also coupled to ORCHIDEE, a vegetation module, in order to better constrain the surface fluxes. The interaction between aerosols and climate is calculated online. In Particular, the 1st indirect effect is represented using an updated formulation of the empirical relationship between cloud droplet number concentration and aerosol mass of Boucher and Lohmann (1995). The sea surface temperatures are prescribed from an IPSL ESM simulation for 2050 according to greenhouse gases concentrations corresponding to the RCP 8.5 projection. We estimate the first indirect effect from sulphate only for shipping, industrial and energy power, to respectively: -0.144 W/m2, -0.151W/m2 and -0.170W/m2. We also focus our study on the liquid water path (LWP), on the liquid cloud cover (LCC) and on the cloud droplet number concentration (CDNC), which are relevant diagnostics of the 1st indirect effect. Furthermore, we present 4 sensitivity studies of the 1st indirect effect to the preindustrial aerosol levels considered. We show that the 1st indirect effect is very sensitive to preindustrial levels and depends mostly upon the volcanic aerosol emissions and to a lesser extent upon the aerosol loads from biomass burning over continents. Considering present-day sulphate conditions, the radiative forcing for 1st indirect effect presents variations from -0.58 to -1.18 W/m2 in these 4 simulations.

Boucher, O., and U. Lohmann: The sulfate-CCN-cloud albedo effect: A sensitivity study with two general circulation models, Tellus, 47B, 281-300, 1994.
Twomey, S.: Pollution and planetary albedo, Atmos. Environ., 8, 1251-1256, 1974.

Simulating the Greenland Ice Sheet in the climate model EC-Earth: Sensitivity of the Greenland Ice Sheet (WP4)

Yang, Shuting, Marianne Sloth Madsen and Gudfinna Adalgeirsdottir
Danish Climate Center, Danish Meteorological Institute.

Ice sheet is an important component in the Arctic climate system that is intricately linked to the surface energy budget, the water cycle and sea level rise. The challenge when including an ice sheet model in an Earth System Model (ESM) is to reproduce the present day ice sheet as closely as possible while the ice sheet is in equilibrium with the modelled climate under the present day conditions. We address this by coupling the state-of-the-art ice sheet model PISM (Parallel Ice Sheet Model) with the ESM EC-Earth. In this fully coupled system the ice sheet model PISM is driven by the surface mass balance and the surface temperature from the atmosphere-ocean modules. Meanwhile the ice melt and surface albedo, as well as the changes in ice-extent and topography simulated by PISM feedback simultaneously to the atmosphere-ocean modules. Different climate forcings to Greenland ice sheet are obtained from EC-Earth simulations using preindustrial and present day conditions and evaluated with the reanalysis data ERA40/ERAInterim as well as with observations. PISM is run both in off-line mode driven by the various sets of forcings to equilibrium state, and in coupled mode in the full EC-Earth. The sensitivity of the Greenland ice sheet to different climate forcings as well as in the coupled system is quantified. The importance of snow parameterization in the atmospheric module for mass balance of the ice sheet is examined. The presence of fast processes in the ice sheet model is also explored.
