COMBINE GENERAL ASSEMBLY
10 June 2010, 13:30- 15:00 POSTER SESSION

CAB building, Universitätstr. 6. Foyer, Floor G (Zurich, Switzerland)

ABSTRACTS

How well do we know the state of the ocean in the last decades?

Balmaseda, MA, K Mogensen and F Molteni (ECMWF Reading, United Kingdom)

A new ocean re-analysis, based on NEMOVAR, has been completed. It will be use to provide ocean initial conditions to the COMBINE decadal forecasts. The climate variability from this reanalyses is compared with the results from the current operational re-analyses (ORA-S3). The main changes are illustrated in table 1. Differences include the ocean model, data assimilation system, forcing fluxes and in-situ data. The impact on climate variability arising from these different aspects is discussed. Specific Climate Features discussed are trends in the Equatorial thermocline, the impact on forcing fluxes in the low frequency climate variability and recent changes in the ocean heat uptake.

Coupling GELATO sea-ice model to NEMO3.2/OPA9 - A new ocean/sea-ice model for global climate studies at CNRM

Chevallier, M, and D Salas-Y-Melia (CNRM Toulouse, France)

A new configuration of the ocean/sea-ice model in use at CNRM is presented. It includes the dynamic-thermodynamic multicategory sea-ice model GELATO, coupled to the NEMO3.2 global ocean mode in its 1°-configuration. Model performance is evaluated by performing a hindcast of the Arctic sea-ice cover, forced by an ERA40-based atmospheric forcing (DFS4) during the 1958-2001 period. To test the impact of a more refined description of melting sea-ice albedo, a new albedo scheme including melt ponds evolution, was also implemented in GELATO.

The simulated mean sea-ice state and year-to-year variability of ice extent are realistic. Areal Fram Strait export of ice is also well reproduced when compared to observations. Although sea-ice is overall too thin, the ice thickness field structure is reasonable. This could be partly explained by the radiative forcing. Comparison with other data set suggests that DFS4 incoming solar radiation could be biased in polar regions. Simulated Arctic sea-ice is younger than expected (~2 years). Introduction of "dynamic" melt ponds allows a more realistic representation of ice albedo evolution, but enhances the ice-albedo feedback.

Preindustrial climate: Results from the CMCC model with a well resolved stratosphere

Fogli, PG(1), C Cagnazzo(1), E Manzini(1,2,*)
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There is growing evidence that the state and the variability of the lower stratosphere affect tropospheric climate and that climate change may impact on the circulation of the stratosphere. This two-way stratosphere-troposphere coupling therefore needs to be represented in models of the global Earth system.

In this work, results from a 300-year preindustrial simulation with the new generation CMCC climate model with incorporated a stratosphere-resolving component are presented. The model has 95 vertical levels from the surface to the 80 km, T63 horizontal resolution and is coupled to a general circulation ocean model with an average horizontal resolution of 2 deg and 31 vertical levels. The evaluation includes the examination of surface climatology, the analysis of top of the atmosphere radiation balance, the estimation of possible climate drifts, and the stratospheric climate. Preliminary results on stratospheric variability are also included.

The characteristics and performances of the model demonstrate that the CMCC model is a suitable tool for evaluating and quantifying the role of the stratosphere-troposphere dynamical coupling on surface climate predictability on seasonal to decadal timescales by means of long-term climate integrations.

Inhomogeneities of clouds – A statistical scheme for large-scale models

Jess, S, P Spichtinger, P and U Lohmann (ETH Zurich, Switzerland)

Clouds play a key role in our climate system, since they influence both the radiation budget as well as the hydrological cycle. Global climate models used for simulating the future climate are limited to a coarse resolution on the order of 100 km horizontal grid space due to computational costs. Hence, most clouds are not resolved in these models and must be parameterized. One key issue is the inhomogeneity of clouds: General circulation models (GCM) use grid mean quantities of cloud properties to calculate cloud microphysical processes i.e. representing homogeneous layers of clouds. In nature, however, clouds are inhomogeneous in terms of microphysical and radiative properties, which must be represented by using subgrid-scale parameterizations. Errors in simulations occur due to the nonlinearity of all processes inside a cloud.

For a better representation of clouds we propose a new statistical scheme. We are implementing a sub-column algorithm into the ECHAM5 GCM to account for a distribution of cloud condensate and number concentration instead of one mean value of each. Cloud cover is then distributed over the sub-columns depending on the diagnosed cloud amount and the number of chosen sub-columns. The sub-boxes in each layer are either clear or completely cloudy. Therefore the vertical cloud overlap is explicitly defined using a maximum-random overlap assumption. Mass and number concentration of cloud droplets and ice crystals are distributed randomly over the sub-columns according to frequency distributions obtained from aircraft observations conserving the mean. All microphysical processes are then calculated independently for all sub-columns. At the end of each time step the average grid-mean cloud properties are calculated and passed on to the rest of the model. This procedure introduces subgrid-scale variability in the microphysical properties of the clouds, which then affect the cloud processes (e.g. rain formation). Due to the better representation of cloud inhomogeneities using this statistical scheme, a more physical treatment of microphysical interactions inside clouds and sub-cloud layers as well as of their radiative properties can be achieved.

Simulations with the Single Column Model version of ECHAM5 for the EPIC campaign (East Pacific Investigation of climate) and the MPACE campaign (Mixed-Phase Arctic Cloud Experiment) were performed. Both cases show that the inhomogeneities lead to an earlier precipitation formation and therefore consequently a decrease in cloud lifetime for the initial cloud. For the MPACE campaign precipitation was enhanced by accretion a multi-layer cloud. Changes in the distribution width of the mass and number concentrations show a lower sensitivity than changes between the original model version and the sub-column scheme.

Met Office Hadley Centre CMIP5 simulations

Jones, C, J Hughes, S Liddicoat, M Doutriaux-Boucher (METO Exeter, United Kingdom)

As part of our ongoing project to perform HadGEM2-ES centennial climate change simulations for IPCC AR5 (CMIP5) we have completed the historical (1860-2005) simulation and the 1% CO2 rise up to 4xCO2 (140 years). Future scenario runs ("RCP"s) are also complete for RCP4.5 and 8.5 and ongoing for RCP2.6. We will present early results from these simulations including an initial feedback analysis of the carbon cycle in the "coupled" and "uncoupled" simulations. We will also look at the role of land-cover change, which has been implemented for the first time to interact with a dynamic global vegetation model in a GCM. Hence the prescribed changes in land-cover cause consistent physical and biogeochemical impacts on the simulation.

Sea-ice data assimilation in NEMO-LIM2 and -LIM3 using the Ensemble Kalman Filter

König Beatty, C, P Mathiot, F Massonnet, T Fichefet, H Goosse (TECLIM, Earth Life Institute, UCL Belgium)

We use the Ensemble Kalman Filter (EnKF) to assimilate either sea-ice concentration or sea-ice thickness data into the coupled ocean sea-ice models NEMO-LIM2 and -LIM3. Output from our data assimilation system is intended to be used to initialize decadal forecasts within the EU-project COMBINE. For now assimilated data is model generated (twin experiments). We find that assimilation of data of one variable in NEMO-LIM2 does not only improve the assimilated variable but also non-assimilated variables. Such cross-variable improvement is very promising considering the scarcity of polar data, particularly of sea-ice thickness. We also show preliminary results of data assimilation experiments into the new version of our sea-ice model, NEMO-LIM3, where data assimilation does not yet lead to the expected results.

Impact of Different Ocean Reanalyses on Decadal Climate Prediction

Kröger, J, W Müller and J-S von Storch (MPI-M Hamburg, Germany)

Decadal or near-term climate prediction needs to take into account both external forcing and internal climate variability. Much of the memory of variations on decadal and longer time scales in the Earth system is thought to lie in surface and subsurface layers of the ocean. Hence, in a forecast system accurate initialization of the ocean is crucial when aiming at better skill with respect to pure climate projection efforts. We apply a recent version of the Earth system model from the Max Planck Institute for Meteorology (MPI-M) in Hamburg to study the impact of different ocean state estimates (GECCO, SODA, ECMWF-ORA-S3) on decadal predictability. Anomalies of the observational estimates are assimilated into our coupled model. The assimilation runs are then used to initialize 10-year-long hindcast from 1959 to 2001 (43 hindcasts for each state estimate). Here, we present prediction skill for various climate parameters such as sea surface temperature and upper-levels heat content. In addition, we compare variations in the Atlantic meridional overturning circulation (MOC) within the model experiments, that is, between assimilation run and respective hindcasts of each reanalysis product. Results are compared to available observations and other initialization techniques performed at the MPI-M.

A new snow thermodynamic scheme for the Louvain-la-Neuve Sea Ice Model (LIM)

Lecomte, O, T Fichefet and M Vancoppenolle (UCL Louvain-la-Neuve, Belgium)

The Louvain-la-Neuve sea Ice Model (LIM) is a three-dimensional global model for sea-ice dynamics and thermodynamics that has been specifically designed for climate studies and that is fully coupled with the oceanic general circulation model OPA on the modelling platform NEMO. This study assesses the skills of a new one-dimensional snow model developed for the thermodynamic component of LIM, by comparison with the former model thermodynamics and observations.

Snow is a key element in sea-ice physics and in the interactions between sea ice and atmosphere. Owing to its low thermal conductivity and high albedo, the snow cover is a very efficient insulator and it contributes directly and indirectly to the sea-ice mass balance. Given the high variability and heterogeneity of the snow cover above sea ice, it is necessary to represent different types of snow, depending on their characteristics. A multilayer approach has been chosen for the model, with time varying temperature, density and thermal conductivity for each layer. Vertical heat diffusion, surface and internal melt, precipitation, snow-ice formation and a parameterization for melt-pond albedo are included in the model. The model is validated at Point Barrow (Alaska) and at the Ice Station POLarstern (IS- POL) in the western Weddell Sea (Southern Ocean).

The new snow thermodynamic scheme leads to better snow and ice internal temperature profiles, with a setup-dependent increase in the correlation between modelled and observed temperature profiles. The model ability to reproduce observed temperatures improves with the number of snow layers, but stabilizes after a threshold layer number is reached. This threshold is different at Point Barrow and ISPOL. Ice ablation rate is quite insensitive to snow thermal conductivity in summer because almost all the variability at the surface is absorbed by snow, making the temperature gradient in the ice relatively small and steady. Nevertheless, during winter, when the air temperature falls far below the freezing point, thermal conductivity plays a larger role as temperature gradients steepen and drive the heat loss transmitted to the ice. Overall, for a given simulation, the consistency between observed and simulated snow and sea-ice mass balances seem to depend more on the handling of the snow stratification in the model than on any other parameter.

Strategies for dealing with systematic errors in a coupled ocean-atmosphere forecasting system

Magnusson, L, MA Balmaseda and F Molteni (ECMWF Reading, United Kingdom)

In this project we compare different strategies aimed at dealing for systematic errors in a coupled ocean-atmosphere forecasting system. In the presence of model error, the current data-assimilation methods produce initial conditions far from the model attractor, which cause the forecast to drift towards the attractor of the model. The drift could introduce non-linear effects that have a negative impact on the forecast quality.

We are comparing three different strategies for compensating for systematic error. The methods are a posteriori bias correction, flux correction and anomaly initialisation. The first alternative is to correct the bias as a post processing of the forecast. The second alternative is to use flux correction in order to avoid model drift and keep the model state close to the attractor of the nature. The third one is aimed to initialise the forecast on the model attractor, while keeping the information of the present anomalies.

Here we will show some preliminary results in order to demonstrate some advantages / disadvantages with the different methods. The focus of the presentation will be on the prediction of El Nino, but also with an outlook toward the decadal prediction of MOC.

Coupled nitrogen - carbon cycle simulations for the 21st century with JSBACH-CN

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Nitrogen availability potentially limits carbon assimilation in most terrestrial ecosystems. So arguably, many coupled carbon cycle-climate models without nitrogen cycle significantly overestimate carbon sequestration and its future trend under a changing climate. The aim of the present study is to investigate in simulations the interactions between global carbon and nitrogen cycles in a changing climate. To this end, we incorporated the nitrogen cycle into the process-based carbon cycle model JSBACH. Our simulations show that the CN coupling is likely to have a fundamental impact on land carbon uptake during the 21st century: Land carbon sensitivity to increasing atmospheric CO_2 concentration decreases, and projected land carbon uptake is reduced by a factor of 2 by 2100 (as compared to 3.7 found by Thornton et al; 2007). In particular we investigate the so called Progressive Nitrogen Limitation (PNL) hypothesis by Luo et al. (2004), proposing that elevated CO_2 enhances plant N uptake, reducing the concentration of mineral N in soils so that plants run into an N shortage. Our simulated plant N annual demand shows an increase over time with increasing CO_2, causing a decrease in simulated total soil mineral N until 2050 (like PNL). However, around 2050 due to warming N availability starts increasing (unlike PNL). These results suggest that during the 21st century the positivity of the climate carbon cycle feedback is first strengthening, but starts lowering once more after the middle of the century.

Implementation of a new surface scheme for land ice in the LMDZ/IPSL climate model

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In order to prepare the integration of an ice sheet model into the IPSL climate model, a new surface scheme for an improved representation of snow on land ice is implemented in its atmospheric component, the LMDZ model. The SISVAT scheme, used already in the regional model MAR, includes multiple layers of snow and ice characterized by dendricity, sphericity and size of grains, and their evolution due to precipitation, evaporation/sublimation, melting, refreezing, percolation and runoff. Compared to the previous scheme, a more realistic, wavelength-dependent albedo is obtained. First results indicate an over-estimation of the surface mass balance, mainly due to an overestimation of snowfall in the LMDZ model, but probably also related to the underrepresentation of the ablation zone on the coarse GCM grid and a warm bias in winter.

Sensitivity of a Greenland ice sheet model to atmospheric fields

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In the context of global warming, the role of the Greenland Ice Sheet (GIS) is a key issue. Numerical modeling is a major tool to assess the future behavior of this ice sheet and its contribution to sea level change. In this kind of study one must associate an ice sheet model and a climate model that provides atmospheric fields such as precipitation and temperature. However, no model can perfectly represent reality. Before embarking on next century simulations, sensitivity studies are necessary to evaluate the impact of those uncertainties on the predictions. To do so, we compare here several simulations where an ice sheet model is forced with different climate models.

The ice sheet model, GRISLI, is a 3D ice sheet model (Ritz et al. 2001). It is a hybrid model, allowing for the various ice flow regimes found in ice sheets: SIA (shallow ice approximation) for slowly moving ice; SSA (shallow shelf/stream approximation) for ice streams and ice shelves. Using mass conservation, an ice sheet model simulates the evolution of ice thickness in response to climatic conditions. Here, we perform what is usually called a "steady state experiment", where a "climatology" is prescribed constant with time. The objective is to determine the steady state topography that would be consistent with this climatology used as a forcing and compare it with the observed present topography.

We performed the simulations with several sets of climatic conditions, each set being the output of an atmospheric model and supposed to represent the present climatology over the Greenland ice sheet. The atmospheric models used are the following: a atmosphere-ocean global circulation model (AOGCM) with a rather coarse resolution of approximatively 300 km (CNRM); an AGCM with a zooming capability (LMDz) and a 60 km resolution over the Greenland ice sheet (LMDz); A regional atmospheric model (MAR) with a 25 km resolution. Finally we also force the ice sheet model with fields based on observed values and provided by CISM.

Our results indicate that the topography (extension and thickness) is very sensitive to climatological fields. Both precipitation and summer temperature are relevant. The regional model is the one that gives the best agreement between simulated and observed topography. These simulations also reveal an especially strong sensitivity in the northern part of the GIS. We also noticed that in all the simulations, the GIS is slightly shifted to the east.

Global carbon and water cycles inferred from FLUXNET eddy covariance data via integration with global Earth observations

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The current FLUXNET database (www.fluxdata.org) of CO_2, water and energy exchange between the terrestrial biosphere and the atmosphere contains almost 1000 site-years with data from more than 250 sites, encompassing all major biomes of the world and being processed in a standardized way (Reichstein et al 2005; Baldocchi 2008; Papale et al 2006). In this presentation we show that the information in the data is sufficient to derive generalized empirical relationships between vegetation/respective remote sensing information, climate and the biosphere-atmosphere exchanges across global biomes. These empirical patterns are used to generate global grids of the respective fluxes and derived properties (e.g. radiation and water-use efficiencies or climate sensitivities in general, bowen-ratio, AET/PET ratio). For example we revisit global "text-book" numbers such as global Gross Primary Productivity (GPP) estimated since the 70's as ca. 120PgC (Alexander and Fairbridge 1999), or global evapotranspiration (ET) estimated at 65km^3/yr^{-1} (Oki and Kanae 2006) - for the first time with a more solid and direct empirical basis. Moreover climate factors such as radiation, temperature and water balance are identified as regionally varying driving factors for seasonal, inter-annual variations and trends of carbon and water fluxes.

Evaluation against independent data at regional to global scale (e.g. atmospheric CO_2 inversions, runoff data) lends support to the validity of our almost purely empirical up-scaling approaches. Hence, these global fields and relationships of biosphere-atmosphere exchange should be used for evaluation or benchmarking of climate models or their land-surface components, while overcoming scale-issues with classical point-to-grid-cell comparisons.

Alexander, R.W. Fairbridge, Encyclopedia of Environmental Science (Springer 1999), pp. 741
Baldocchi, D., Australian Journal of Botany 56, 1 (2008).
Oki, T., and S. Kanae, Science 313, 1068 (Aug 25, 2006)
Papale et al., Biogeosciences 3, 571 (2006).
Reichstein et al., Global Change Biology 11, 1424 (2005).

Aerosol-cloud interactions in the ECHAM5 GCM

Reutter, P and U Lohmann (ETH Zurich, Switzerland)

The aim of WP2 of the COMBINE project is to provide an improved description of subgrid scale aerosol-cloud interactions. This is done by including an aerosol processing scheme based on Hoose et al. (2008a,b) into ECHAM5-HAM, which takes into account that the atmospheric aerosol is changed by clouds through different processes. Included in this scheme among other things are the nucleation and impaction scavenging of aerosol particles and the addition of dissolved material on existing insoluble particles inside cloud droplets during the evaporation of the latter ones. These processes increase the size, reduce the number and change the chemical composition of the aerosol particles and hence have an influence on further cloud and ice nucleation. For instance, after such a cloud cycle the newly formed aerosol particles are larger and more hygroscopic and act therefore more preferably as cloud condensation nuclei than before. Also this cloud cycling permits a more realistic description of heterogeneous freezing in mixed-phase clouds, i.e. in clouds with temperatures between 0 and -35°C, as it limits the number of available ice nuclei. The results of the aerosol processing scheme will be combined with the latest model improvements. The description of the stratocumulus clouds in the boundary layer is going to be improved by adding new model interfaces for a better representation of the cloud base and cloud top of these clouds (Siegenthaler-LeDrian, 2010). Also a new shallow convection scheme that considers the life cycle of shallow cumulus clouds by Isotta et al. (2010) is introduced, which leads to a more realistic frequency of shallow convection on the global scale. For a better representation of the inhomogeneous distribution of cloud particles inside clouds each grid box is divided into 20 sub-columns (Jess et al., 2010).

Hoose, C., U. Lohmann, R. Bennartz, B. Croft and G. Lesins, Global simulations of aerosol processing in clouds, Atmos. Chem. Phys. 8, 6939-6963, 2008a.
Hoose, C., U. Lohmann, P. Stier, B. Verheggen, and E. Weingartner, Aerosol processing in mixed-phase clouds in ECHAM5-HAM: Model description and comparison to observations, J. Geophys. Res., 113, D07210, doi:10.1029/2007JD009251, 2008b.

Isotta, F. A., Spichtinger, P., Lohmann, U., and von Salzen, K.: Improvement and implementation of a parameterization for shallow cumulus in the global climate model ECHAM5-HAM, J. Atmos. Sci., in revision, 2010.
Jess, S., P. Spichtinger and U. Lohmann: A new subgrid-scale algorithm for stratiform clouds in ECHAM5: Part I: Single column model studies, J. Geophys. Res., subm. to, 2010.
Siegenthaler-LeDrian, C.: Stratocumulus clouds in ECHAM5-HAM, PhD thesis, ETH Zurich, 2010.

Bacteria in the ECHAM5-HAM global climate model

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Bacteria are the most active naturally occurring ice nuclei (IN) due to the ice nucleation active proteins on their surfaces, which serve as active sites for ice nucleation. Their potential impact on clouds and precipitation is not well known and needs to be investigated. Bacteria as a new aerosol species are introduced into the global climate model (GCM) ECHAM5-HAM. Their emission and deposition is successfully simulated by ECHAM and leads to results in the same order of magnitude as gained from observations. The inclusion of bacteria acting as contact freezing IN however, did not lead to significant changes in cloud formation and precipitation on a global level, as the interannual standard deviation is larger than the difference due to introducing bacteria as contact freezing IN. Bacteria acting as immersion freezing IN are currently being implemented into ECHAM. Further sensitivity studies will look at the impact of changing bacterial emissions and ice nucleating properties.

Performance of ENSEMBLES RCMs over Crete and Thessaly case study regions

Tsanis, IK and AG Koutroulis (TUC Chania, Greece)

Recent earth's climate change simulations depict a collective picture of a substantial drying and warming of the Mediterranean region. Decreasing annual rainfall trends and rainfall events of shorter periods but of higher intensities are present in most projections from both global and regional climate change models and are consistent across emission scenarios and future time periods. The state-of-the-art regional climate change ENSEMBLES dataset is used to study the impact of the climate change on water resources status of the island of Crete and Pinios river basin. Bias adjusted regional climate model results over the case study areas, reveals an overall decreasing precipitation trend for the period 1970-2100, an increase in the number of days with heavy precipitation and a decrease in the number of months with light precipitation. Late fall/early springs wet periods are becoming drier and the intensity of the maximum daily wintertime precipitation is increasing. Hydrological modelling at river basin scale reveals the potential of an increased risk of severe flooding and prolonged droughts. Water balance analysis at the river basin scale depicts a gradual decrease in water availability till 2100. The new knowledge on the impact of climate change to the extreme events and water availability in the case study areas will be used to improve the existing practices and policies for climate change adaptation in integrated river basin management.

CNRM-CM5 : design and first results

Voldoire, A(1), A Alias(1), C Cassou(2), B Decharme(1), H Douville(1), E Maisonnave(2), D Salas-y-Mélia(1), E Sanchez(2) and S Sénési(1)
(1) CNRM/GAME Toulouse, France (2) CERFACS Toulouse, France

CNRM/GAME and CERFACS have collaborated to design the new AOGCM CNRM-CM5 to perform CMIP5 simulations. The new model is based on the ARPEGE atmospheric model

(CNRM), the NEMO ocean model (LOCEAN), the GELATO sea-ice model (CNRM), the TRIP river routing scheme, coupled through the OASIS system (CERFACS). The SURFEX interface (CNRM) is also embedded in ARPEGE to drive the ISBA land surface model (CNRM). Compared to CNRM-CM3.3, the version used to run the ENSEMBLE-stream2 experiments, all the components have been updated. The resolution has also been increased: the atmospheric and land surface models are run on a 1.5° grid whereas the oceanic and sea-ice components are run on an ORCA 1° resolution grid. The poster will describe the major improvements made to the different components as well as the first results from a pre industrial control run.

Incorporating anthropogenic land cover changes into studies of climate change

Weiss, M, M Brandt, B van den Hurk, R Haarsma and W Hazeleger (KNMI De Bilt, The Netherlands)

In this study, the impact of land cover changes on selected climate parameters for the period 1850 to 2000 is analysed with the earth system model EC-Earth. EC-Earth builds upon the Operational Seasonal Forecast System 3 of the Integrated Forecast System (IFS) of the European Centre for Medium-Range Weather Forecast (ECMWF) and works at a resolution of T159L62. Altered surface parameters due to changes in global vegetation cover are accounted for in the model by adjusting vegetation types, vegetation cover, roughness length and, most importantly, albedo. The impact of past and future land-use activities on climate is potentially significant, since managed croplands and pastures are now among the largest ecosystems on the planet, with a total share of 35% of the ice-free land surface. Their surface parameters differ largely from those of most natural vegetations they replace. The direction of change, however, merits careful analysis, as effects of opposing signs can occur. These largely cancel out on a global basis but can have significant impacts on the regional scale.

Decadal Prediction experiments at KNMI using EC-EARTH

Wouters, B, W Hazeleger, GJ van Oldenborg and R Haarsma (KNMI, The Netherlands)

We present the first results of decadal prediction experiments with EC-EARTH 2.1. The model configuration used consists of the ECMWF IFSc31 model at T159/L62 resolution, the NEMO2 ocean model at 1 degree resolution and the LIM2 sea-ice model. The main purpose is to study and predict decadal variability in the Atlantic Ocean and the resulting predictability in the atmosphere at these time scales. As expected, the model shows a bias in the first years due to the initialization shock from the full initial state (NEMOVAR), but stabilizes afterwards.

Comparison with satellite observations of diagnostics for the 1st aerosol indirect effect

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Aerosols scatter and may absorb solar radiation resulting in the aerosol direct effect. Hydrophylic aerosols can serve as cloud condensation nuclei and thus alter cloud properties. Twomey (1974) suggested that an enhanced cloud droplet number concentration (N_d) at constant cloud liquid water path (L) leads to smaller cloud droplet effective radius (r_e). This is the effect known as the first aerosol indirect effect that we study here. We compare the diagnostics relevant to the 1st aerosol indirect effect from the LMDzINCA model with MODIS observations. LMDzINCA consists of a GCM coupled to an interactive aerosol chemistry module. We also investigate the slope of these variables with respect to variations in aerosol optical depth following the method developed in Quaas et al. (2009).

Quaas, J. et al.: Aerosol indirect effect- general circulation model intercomparison and evaluation with satellite data, Atmos. Chem. Phys., 9, 8967-8717, 2009 - Twomey,S.: Pollution and planetary albedo, Atmos.Environ., 8, 1251-1256, 1974