The Met Office Unified Model (MetUM) is used for prediction of tropical cyclones from days ahead, through seasonal and climate timescales. The Met Office has a number of collaborative partners undertaking research into the MetUM's performance for tropical cyclones including the Korean Meteorological Agency, the Centre for Australian Weather and Climate Research and the University of Reading. This talk will summarise recent evaluation of the MetUM's performance across the timescales in tropical cyclone prediction drawing upon work being undertaken both at the Met Office and by its collaborative partners. Results will be presented on the impact of recent and proposed changes to the model's dynamics, physics, resolution and initialisation and will summarise research plans for tropical cyclone prediction in the MetUM.
**Abstract title**  
Convective processes and improving their representation in models *(INVITED)*

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Parameterizations of deep convection are often designated as responsible for many persistent biases of climate models. A major concern is that they are not able to capture properly the diurnal cycle of precipitation over land. Key processes driving the life cycle of convective systems are known for a while, highlighted in the seventies during field campaigns such as GATE. However, nowadays, most of those processes are still mis-represented in parameterizations of deep convection for climate models. This is particularly true for precipitating downdrafts and associated cold pools but also for mesoscale updrafts. One reason for this is that observations can not provide all information that would be needed to understand the key mechanisms involved in the initiation and development of such structures. In the development team of the general circulation model LMDZ (the atmospheric component of the IPSL Earth System Model), a thorough research effort has been undertaken to include a physical representation of such missing processes, relying on LES and CRM process studies. This includes boundary-layer thermals, at the top of which shallow cumulus clouds form, and that contribute to precondition deep convection; and cold pools driven by the evaporation of precipitation that contribute to sustain it. This leads to a better representation of the diurnal cycle of continental convection, in the mid-latitudes as well as in the Tropics. The impact of this better representation of local and small-scale processes on the simulation of precipitation mean and variability at longer time-scales is investigated further.
Atmospheric tide as a proxy to diagnose parametrisation error: an intercomparison of semi-diurnal tides represented in TIGGE models (INVITED)

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Presenter name Daisuke Hotta

Data assimilation (DA) is the process to estimate the most likely atmospheric state by comparing model's forecast with the observations. Thus, monitoring of a DA system can be a valuable source of information on model errors. Through the monitoring of the JMA's DA system, we found that the analysis increments exhibit a systematic error in surface pressure which oscillates twice a day with a clear zonal wavenumber-2 structure, which suggests the model's misrepresentation of semi-diurnal tides. Thus motivated, we investigated discrepancies of the observed and modeled atmospheric tides. Atmospheric tides are the dynamical response of the atmosphere to diabatic heating. In particular, solar semi-diurnal tides are forced mainly by diabatic heating in the tropics. Hence, investigation of them can be an effective tool to diagnose tropical parametrisations which are considered to be still uncertain. In this study, we assessed the atmospheric solar semi-diurnal tides in surface pressure simulated in TIGGE models by comparing them with the observations. It was found that only four models (ECMWF, NCEP, UKMO and JMA) out of 8 models represent realistic amplitude. However, the JMA model, while successfully reproducing the amplitude, exhibits a phase lead of ~10 degrees. According to the classical tidal theory, theoretical predictions of semi-diurnal tides forced by long and short wave radiation agree with the observation in the amplitude but exhibit a phase error, just like the JMA model does. Lindzen (1978) showed that this discrepancy can be accounted for by incorporating tropical latent heating to the forcing. From this, we suspect that the underestimation of semi-diurnal tropical precipitation is a likely culprit. In fact, we confirmed that it is substantially weaker in JMA than in the other successful models. Our study can be viewed as an example of the 'top-down' approach where diagnostics of a DA system yields insights into parametrisation errors.
A Joint Research Activity by the WCRP-WWRP/THORPEX MJO Task Force & Year of Tropical Convection (YOTC) and the GEWEX Atmosphere System Study (GASS) is in progress to characterize, compare and evaluate the heating, moistening and momentum mixing processes associated with the MJO that are produced by global weather and climate models, with a particular focus on their vertical structure. Three sets of experiments are conducted i) twenty-year climate simulations ii) a series of daily initialized 2-day hindcasts for two successive MJO events during boreal winter 2009-10 which focuses on detailed model output over a select near-equatorial Indian Ocean / western Pacific Ocean domain and iii) 20-day hindcasts to assess the performance of the models MJO as a function of forecast lead time. Analysis of the 2-day hindcast component focuses on processes that control transition from suppressed to active convective phase over the Indian Ocean. 12-36 hours of the forecast has been analysed to provide a balance between minimizing the spin up effects and minimizing the differences in the large scale evolution. Results from the analysis of vertical humidity structures, cloud variables and heating and moisture budgets will be presented.
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<th>Abstract title</th>
<th>Deep moist convection as a governor of the West African Monsoon (ORAL)</th>
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<td>Cathryn Birch</td>
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Climate models struggle to capture monsoons and fail to represent the water cycle in West Africa with sufficient accuracy to provide confidence in even the sign of projected rainfall change. Global models all use parameterisations of deep convection and struggle to represent both the diurnal cycle and the upscale organisation of the convection. Here, we use 10-day continental-scale convection-permitting simulations over summertime West Africa to evaluate how the representation of convection affects the modelled synoptic-scale meteorology and the implications for weather and climate prediction. The convection-permitting simulations give a more realistic distribution and diurnal cycle of convection with upscale organisation and a more realistic monsoon flow.

The impact of representation of convection on the monsoon is explained by the differences between the heating from parameterised and explicit convection and the representation of cold-pool outflows, which in explicit runs form an important component of the monsoon. The convective storms act as a governor to the WAM system: the monsoon provides moisture for convection, while the convection weakens the monsoon flow and delays its diurnal cycle. The explicit versus parameterised differences are consistent with the forecast bias exhibited in this region by global model forecasts. Improved parameterisations of convection that capture storm structures, their diurnal cycle and rainfall intensities will substantially improve weather and climate predictions of the WAM and many varied aspects of Earth system modelling.
The Effect of an Increased Convective Entrainment Rate on Indian Monsoon Biases in the Met Office Unified Model (ORAL)

Primary author: Stephanie Bush
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Abstract:

Global circulation models (GCMs) are a key tool for understanding and predicting monsoon rainfall, now and under future climate change. However, many GCMs show significant, systematic biases in their simulation of monsoon rainfall and dynamics that spin up over very short time scales and persist in the climate mean state. We describe several of these biases as simulated in the Met Office Unified Model and show they are sensitive to changes in the convective parameterization's entrainment rate. To improve our understanding of the biases and inform efforts to improve convective parameterizations, we explore the reasons for this sensitivity. We show the results of experiments where we increase the entrainment rate in regions of especially large bias: the western equatorial Indian Ocean, western north Pacific and India itself. We use the results to determine whether improvements in biases are due to the local increase in entrainment or are the remote response of the entrainment increase elsewhere in the GCM. We find that feedbacks usually strengthen the local response, but the local response leads to a different mean state change in different regions. We also show results from experiments which demonstrate the spin-up of the local response, which we use to further understand the response in complex regions such as the Western North Pacific. Our work demonstrates that local application of parameterization changes is a powerful tool for understanding their effect on rainfall biases.
Errors in climatological mean precipitation (P) over the central-eastern equatorial Pacific are often related to the well-known double-ITCZ problem, which is still seen in the CMIP5 multi-model ensemble (MME). The biases in P over the above area arise not only from errors in mean SST and parameterized convective processes but from errors in the strength of El Nino-Southern Oscillation (ENSO), which rectifies P through a phase asymmetric nature of ENSO. We investigate the causes of diversity in P and its possible coupling with the ability of ENSO simulation using CMIP5 MME and perturbed physics ensembles (PPEs) based on single models. We found a linear relationship between the ENSO amplitude and P over the Nino 3 region in PPEs, which is explained both by the mean state control of ENSO and the ENSO feedback to the mean state. However, Nino 3 P in the CMIP5 MME does not show a linear relationship with ENSO; the diversity in the ENSO amplitude thus cannot explain the errors in P, which are rather due to large bias in mean in-situ SST. Further, ensemble of the CMIP5 historical experiments suggests a remote influence of the Southern Ocean SST bias to P via an atmospheric bridge.
Realistic representation of the tropical Atlantic remains a challenging problem for coupled general circulation models (GCMs). This is particularly evident on the equator, where simulations participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5) continue to suffer from serious biases. Out of 33 models examined, 29 produce an equatorial zonal sea-surface temperature (SST) gradient whose sign is opposite to observations, with SSTs simulated in the eastern equatorial cold tongue region warmer than in the west. Previous studies have shown that these SST biases are closely related to weaker than observed equatorial easterlies in boreal spring and their influence on upper ocean stratification. Such errors also affect the southeastern tropical Atlantic through Kelvin wave-induced adjustment along the equatorial-coastal waveguide. Here we show that the simulated equatorial surface winds are linked to both continental convection and the latitudinal position of the Intertropical Convergence Zone (ITCZ). Particularly the latter has a strong influence on equatorial zonal winds, which is evident over a wide range of temporal scales from daily to interannual. This simulated relation compares well with observations. GCMs, however, place the ITCZ south of the equator far more often than observed, particularly during boreal spring, and thus their equatorial easterlies are too weak in that season. The tendency for south-equatorial ITCZ latitudes is clearly evident even when the GCMs are forced with observed SSTs, which suggests that errors in simulated deep convection are a root cause of equatorial Atlantic SST biases, rather than the other way round. This underscores the need to understand better the processes that trigger or inhibit deep convection in the region and to find ways of representing these processes in convective parameterizations.
Most global climate models (GCMs) suffer from biases of a reversed zonal gradient in sea surface temperature and weak surface easterlies (the westerly bias) in the equatorial Atlantic. These biases exist in atmospheric GCMs (AGCMs) and are amplified by air-sea interactions in atmospheric-oceanic coupled GCMs. This problem has persisted despite of considerable model improvements in other aspects. We propose a hypothesis that there are two possible root causes for the surface westerly bias. The first is insufficient low-level diabatic heating over the Amazonia. The second is erroneous zonal momentum flux (entrainment) across the top of the boundary layer. The base of this hypothesis comes from an analysis of a simple model of a well-mixed tropical boundary layer and diagnoses of simulations from eight AGCMs. The weakest easterlies in the AGCMs tend to occur when diabatic heating at low-levels (850 - 600 hPa) over the Amazonia is relatively weak for a given amount of precipitation. Deficient low-level heating weakens the zonal gradient of sea-level pressure (SLP) along the Atlantic equator. In addition, the westerly bias can be aggravated when the momentum entrainment is weak for a given zonal gradient of SLP.
Systematic Error of the Asian Summer Monsoon in CMIP5 and CMIP3 Simulations of the Late 20th Century *(ORAL)*

**Abstract title**
CMIP5 and CMIP3 Simulations of the Late 20th Century

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The boreal summer Asian monsoon has been evaluated in 25 Coupled Model Intercomparison Project-5 (CMIP5) and 22 CMIP3 GCM simulations of the late 20thCentury (Sperber et al. 2012). Diagnostics and skill metrics were used to assess the time-mean, climatological annual cycle, interannual variability, and intraseasonal variability. Numerous systematic errors have been identified; including a pronounced rainfall dry bias over India in the time mean state, and a poor representation of the annual cycle of rainfall as related to the development of the oceanic and continental tropical convergence zones over the Indian longitudes. Importantly, shortcomings in the simulation of the boreal summer intraseasonal variability remain prevalent. A goal of this study is to provide a more holistic view of simulating the monsoon by evaluating the interdependence of the errors across the multitude of time and space scales analyzed. One of the key aspects to be investigated is the late onset of the monsoon, and how this is related to the intraseasonal and annual cycle errors in the models. The relationship to other aspects of the integrations, including the simulation of sea-surface temperature, land-sea thermal contrast, and moisture transports, will be explored to understand the development of the monsoon systematic error. Acknowledgements. K. R. Sperber was supported by the Office of Science (BER), U.S. Department of Energy through Lawrence Livermore National Laboratory contract DE-AC52-07NA27344. H. Annamalai was supported by the Office of Science (BER) U.S. Department of Energy, Grant DEFG02-07ER6445, and also by three institutional grants (JAMSTEC, NOAA and NASA) of the International Pacific Research Center.

Simulating Large-Scale Teleconnections to Africa: What is the State of the Art?

Dave Rowell
Met Office Hadley Centre

This study provides an overview of the state-of-the-art of modelling SST teleconnections to Africa, and begins to investigate the sources of error. Data is obtained from the Coupled Model Intercomparison Project, CMIP3 and CMIP5, using the '20C3M' and 'historical' coupled model experiments. A systematic approach is adopted, with the scope narrowed to 6 large-scale regions of Sub-Saharan Africa within which seasonal rainfall anomalies are reasonably coherent, along with 6 SST modes known to affect these regions. No significant non-stationarity of the strength of these 6x6 teleconnections is found in observations. The capability of models to represent each teleconnection is then assessed (whereby half the teleconnections have observed SST-rainfall correlations that differ significantly from zero). A few of these teleconnections are found to be relatively easy to model, whilst a few more pose substantial challenges to models, and many others exhibit a wide variety of model skill. Furthermore, some models perform consistently better than others, with the best able to at least adequately simulate 80-85% of the 36 teleconnections. No improvement is found between CMIP3 and CMIP5. Analysis of atmosphere-only simulations suggests that the coupled model teleconnection errors may arise primarily from errors in their SST climatology and variability, although errors in the atmospheric component of teleconnections also play a role. Last, no straightforward relationship is found between the quality of a model's teleconnection to Africa and its SST or rainfall biases or its resolution. Perhaps not surprisingly, the causes of these errors are complex, and will require considerable further investigation.
The Madden-Julian Oscillation (MJO) is a dominant source of intraseasonal variability precipitation and is a subject of strong interest to the climate modeling community. In an attempt to understand and improve the typically poor simulations of MJO by climate models, we have performed perturbed-parameter hindcasts and long-term AMIP type of free-running simulations with the fifth version of the Community Atmosphere Model (CAM5). We would like to first use the hindcasts to define the ranges of parameter space that yield improved MJO simulation and physically understand why parameter changes yield improved simulations. Then we would like to know if improved simulation in hindcasts can yield an improved simulation of the MJO in climate mode. The goals of this study are (1) to provide guidance to model developers on how to better represent the MJO, (2) to provide some insight as the critical MJO process. Research has shown that the observed MJOs are influenced by the interactions of a number of processes such as shallow and deep convection, stratiform heating, surface fluxes and radiation. The dependencies of CAM5's MJO simulation on uncertain physical parameters are being explored in this study using MJO Metrics, which include the real-time multivariate MJO Index (RMM) that is computed from the 20 daily values of OLR, U200 and U850 averaged from 15S to 15N and projected onto a pair of EOF's, as well as daily fields of precipitable water, OLR and rainfall that were averaged from 15N to 15S retaining only the first three global wavenumbers. Pattern correlation and RMS statistics were computed over 60E to 210E for the model and observations to provide additional metrics. Detailed results from this study will be presented in the meeting. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.
The Mexican southern area is located in the tropics and the northern one in the extra-tropics; the great surface variability observed in the Mexican territory is associated to tropical and extra-tropical processes and a combination of both affected by abrupt orography. The reproduction of these complex dynamics by global models is a big issue. 15 General Circulation Model (GCMs) of the Coupled Model Intercomparison Project phase 5 (CMIP5) were evaluated, weighted and ensemble for the Mexican area in the historical period from 1961 to 2000. This was done applying the Reliability Ensemble Averaging (REA) method, evaluating the grade of reliability of each of the 15 global models used. The GCMs outputs were interpolated on a regular geographical grid with 0.5 degree horizontal resolution using a bilinear interpolation; this grid matches the observed gridded precipitation and temperature dataset of the Climatic Research Unit (CRU) of the University of East Anglia. Using statistical analyses of several metrics (root mean squared error (RMSE), mean absolute error (MAE), standard deviation (STD), and temporal correlation (r)) we evaluated the performance of these models based on monthly data for two surface variables: air temperature and precipitation. These analyses were applied for two sub-regions in Mexico: Northwest (extra tropics) and Southeast (tropics). We made comparisons between the models used in the Fourth Assessment Report (AR4) and the models used in the Fifth Assessment Report (AR5), identifying the models limitations to reproduce the tropical regional variability, analyzing possible models errors and evaluating the methods of reduction the uncertainties. The implications of these results are discussed in terms of the observed atmospheric regional processes.
Abstract title  The West African water budget: An analysis using the Cascade simulations

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Presenter name  Cathryn Birch

The amount and variability of rainfall is crucial for people living in West Africa. Presently our ability to predict West African rainfall on NWP, seasonal and climate scales is relatively poor. As part of the Cascade project large-domain simulations were performed with the Met Office Unified Model over West Africa. The 40-day simulations are at various horizontal resolutions, with both parameterised and explicit convection and are long enough to allow a statistical approach to the analysis. This study (AMMA-UK) uses these simulations to analyse the components of the water budget over West Africa. Over most regions in West Africa the simulations with explicit convection reproduce the diurnal cycle of rainfall better than the models with parameterised convection. In the simulations with explicit convection the daytime peak in rainfall is later in the day and the westward propagation of complex systems is reproduced. Unlike most regions in West Africa, the peak in rainfall over Niamey (southwest Niger) is overnight due to the westward propagation of MCS’s that initiate in the mountains to the east. Even the explicit models are unable to reproduce this peak because the simulated daytime rainfall from locally generated convection is far too large, which overwhels the nocturnal signal. The feedbacks of the different rainfall regimes (i.e. diurnal timing, propagation and intensity) on other parts of the model water cycle are also explored.
Abstract title: Systematic biases in energy budget due to errors in the diurnal cycle representation

Primary author:
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- Surname: Taylor
- Organisation: NASA Langley Research Center

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Abstract:
Many geophysical variables including temperature, clouds, and precipitation exhibit robust diurnal cycles in response to the daily cycle of solar insolation. Due to the fundamental nature of this variability, it is critical that weather and climate models adequately represent the diurnal cycle. However, numerical model physics have difficulty reproducing this behavior and as a result this may lead to systematic errors in model representation of earth energy budget terms: including TOA and surface radiation, precipitation, and surface latent and sensible heat fluxes. This study evaluates the regional diurnal cycle in the Tropics within reanalysis models (ERA-Interim, NCEP, and MERRA) and quantifies systematic errors in simulated TOA flux and precipitation due to biases in the diurnal cycle representation. The focus of this study is to quantify the importance of diurnal cycle simulation to systematic bias in numerical models.
The vertical distributions of cloud water content (CWC) and cloud fraction (CF) over the tropical oceans, produced by 13 coupled atmosphere-ocean models submitted to the Phase 5 of Coupled Model Intercomparison Project (CMIP5), are evaluated against CloudSat/CALIPSO observations as a function of large-scale parameters. Available CALIPSO simulator CF outputs are also examined. A diagnostic framework is developed to decompose the cloud simulation errors into large-scale errors, cloud parameterization errors and co-variation errors. We find that the cloud parameterization errors contribute predominantly to the total errors for all models. The errors associated with large-scale temperature and moisture structures are relatively greater than those associated with large-scale mid-tropospheric vertical velocity and lower-level divergence. All models capture the separation of deep and shallow clouds in distinct large-scale regimes; however, the vertical structures of high/low clouds and their variations with large-scale parameters differ significantly from the observations. The CWCs associated with deep convective clouds simulated in most models do not reach as high in altitude as observed, and their magnitudes are generally weaker than CloudSat total CWC, which includes the contribution of precipitating condensates, but are close to CloudSat non-precipitating CWC. All models reproduce maximum CF associated with convective detrainment, but CALIPSO simulator CFs generally agree better with CloudSat/CALIPSO combined retrieval than the model CFs, especially in the mid-troposphere. Model simulated low clouds tend to have little variation with large-scale parameters except lower-troposphere stability, while the observed low cloud CWC, CF and cloud top height vary consistently in all large-scale regimes.
Impact of the surface flux parametrisation on the precipitation bias over the tropical ocean in the global atmospheric model ECHAM5

Compared with data from the Global Precipitation Climatology Project (GPCP) the general circulation model ECHAM5 of the Max Planck Institute for Meteorology in Hamburg, Germany produces too much precipitation in the warm pool area of the tropical Pacific and the north eastern part of the Indian ocean. In addition, simulated surface latent heat fluxes show significant biases when compared with the Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite data (HOAPS3) that for the central Pacific match the sign of the precipitation bias. In this work we analyse the role that surface latent heat fluxes and their parametrisation play towards these biases. A reduction of surface fluxes for low windspeeds acts predominantly in the tropical Pacific and results in a significant decrease of precipitation biases. The precipitation anomaly in the warm pool area w.r.t. GPCP data is reduced by up to 50% in the annual and seasonal mean while for other regions precipitation is affected to a much lesser extent. However, bias patterns remain pronounced for the summer months and a small dry bias is introduced.
Deep convection triggering by boundary layer thermals: the stochastic triggering formulation and parametrization in LMDZ GCM

Abstract

This work proposes a stochastic approach for representing the deep convection triggering by boundary layer thermals in a GCM grid cell. It may be divided in two parts: (i) first the stochastic triggering formulation of the transition process, and (ii) second the stochastic triggering parametrization for the LMDZ GCM. The first part is mainly dedicated to the statistical analysis of a LES cloud field (Couvreux et al. 2011) in a case of transition from shallow to deep convection over a semi-arid land (Niamey, NIGER). We first propose a new computation of the Available Lifting Energy (ALE) that must exceed CIN for triggering. Another triggering condition is required to make triggering effective, which is based on the comparison between the distribution law (or PDF) of the maximum sizes of the domain and a prescribed threshold cross-section. The surpassing of this threshold cross-section is explicitly represented through a random number that has to exceed a no-trigger probability. This new, stochastic formulation, integrates the whole transition process from the first cloud to the first convective cell, and can be decomposed in 3 steps: (i) the appearance of clouds, (ii) the inhibition layer crossing and (iii) the effective triggering. The second part consists in the implementation in the LMDZ GCM through a stochastic triggering parametrization. It is tested over 4 various cases in a single column model (SCM) framework, and the impact of the new triggering is analyzed. As compared with the standard, deterministic triggering, the present parametrization (i) delays deep convection triggering over lands, (ii) suppress it over trade wind cumulus zones, and (iii) increases the day-to-day convective variability. The scale-aware nature of this parametrization is also discussed.
Large-scale Processes Influencing the East Asian Monsoon based on Observational Data and CMIP5 Model Outputs

Primary author: Jinqiang Chen

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Additional authors: Simona Bordoni

Presenter name: Jinqiang Chen

The Meiyu-Baiu (MB) is a stationary front in the seasonal march of the East Asian Monsoon (EAM). The MB front starts developing in late May, reaches maturity around mid-June, and then dissipates around mid-July. Large-scale mechanisms controlling the location and seasonal evolution of this front are still unclear. We use ten years (2000-2009) of ECMWF ERA Interim reanalysis data to study the energetics of the MB system in the context of the moist static energy (MSE) budget. We find that horizontal advection of MSE sustains the front in a region of otherwise negative net energy input into the atmospheric column. The spatial pattern of horizontal MSE advection coincides remarkably well with the region of intense precipitation thus providing a simple framework within which model performances in simulating the MB front can be assessed. AMIP, rcp45 runs in the CMIP5 archive are analyzed and compared with observed data (e.g., GPCP v1.1 precipitation). Most models do not simulate correctly the spatial and/or temporal distribution of the MB rainfall. This deficiency results from an inaccurate simulation of the horizontal temperature (or MSE) advection. This arises because of a poor simulation of the mean position and strength of the subtropical westerly jet. Future work will assess how different mechanisms arising from the interaction of the Tibetan Plateau and the westerly jet, such as advection of anomalous temperatures over the Plateau and mechanically-driven convergence downstream of the Plateau, can affect the mean position and evolution of the MB front. The projected response of the EAM to future scenarios will also be studied within the simple framework highlighted above. The fast response of the EAM to doubling CO2 and +4 K SST will be studied to separate the effects due to temperature gradient and water vapor.
To examine the role of four dimensional data assimilation (FDDA) on prediction of two Severe Cyclonic Storms [Aila (23-26 May 2009) and Jal (4-8 Nov. 2010)], four numerical experiments are performed using Weather Research and Forecasting (WRF-ARW) model with three nested domains (60, 20 & 6.6km) having two-way interaction and physical parameterization schemes as CPS-BMJ, MP-WSM6 and PBL-YSU. In each experiment, the model integration is started prior to the formation of depression and continued till the observed landfall. For the experiment without FDDA, NCEP-FNL data alone is used as initial & boundary conditions and for the experiments with FDDA, additional observations (from NCEP ADP Global Upper Air & Surface data which include radiosondes, pibals, aircraft, and satellite data) are used. In all the experiments, FDDA is considered only in the outer domain up to 24hrs of integration and then the inner domain is introduced. The results are examined in terms of surface circulation, vorticity, CSLP, MSW and surface track error. FDDA produced surface circulation and vorticity showed well organized structure. For the case of Aila, the surface track (maximum track error=281km) and landfall position (88E/21.73N) in FDDA experiment is predicted better than without FDDA experiment (track error=445km and landfall position= 87.13E/20.37N) whereas the landfall time without FDDA experiment is closer to observations (between 09-12UTC of 25th May) than that of with FDDA experiment (06UTC of 25th May). When CSLP & MSW are examined, the overall intensity is well predicted with FDDA experiment except near to the landfall time. For Jal cyclone, FDDA played significant role to improve the landfall position (80.16E/13.67N) with a time lead of ~10hrs but other parameters remain more or less unchanged.
The ability of coupled ocean-atmosphere general circulation models (CGCMs) to simulate the El Nino Southern Oscillation (ENSO) has largely improved over the last decades. Nevertheless, the diversity of model simulations of present-day El Nino characteristics, and the lack of significant progress from CMIP3 to CMIP5, indicate current limitations in our ability to model this climate phenomenon and therefore anticipate changes in its properties on short and long time scales. A recent body of studies shows that the atmosphere GCM may lie at the heart of these limitations and that ENSO in CGCMs is extremely sensitive to the representation of atmospheric convection and of tropical clouds. Nevertheless the diversity and complexity of the processes involved has so far been a severe limiting factor for the understanding of this sensitivity. In this context we provide a review of the different methods proposed to understand ENSO shortcomings in GCMs ranging from simple performance metrics to process-based analysis or fully developed experimental strategies. We discuss them in the light of observation limitations, both in quality and in record length, and theoretical frameworks and propose some new pathways to make progress.
The present and future of the West African monsoon: a process-oriented assessment of CMIP5 simulations along the AMMA transect

Abstract title

Abstract

The present comprehensive assessment of the West African monsoon in the models of the fifth phase of the Coupled Model Intercomparison Project (CMIP5) indicates little evolution since CMIP3 in terms of both biases in present-day climate and climate projections. The outlook for Sahel precipitation in twenty-first-century coupled simulations remains uncertain, as models still disagree on the sign of the trends. This contrasts with the relatively robust spring and summer warming of the Sahel, larger by 10 to 50% compared to the global warming. CMIP5 coupled models underestimate the monsoon decadal variability, although simulations with imposed sea surface temperatures (SSTs) succeed in capturing the recent partial recovery of monsoon rainfall. Coupled models still display major SST biases in the equatorial Atlantic, inducing a systematic southward shift of the monsoon. Because of these strong biases, further evaluation of the African monsoon is performed in SST-imposed CMIP5 simulations along the AMMA meridional transect, across a range of timescales ranging from seasonal cycle, intraseasonal fluctuations and diurnal cycle. Our emphasis is on the comprehensive set of observational data now available to evaluate in depth the monsoon representation across those scales and on the promising usefulness of high-frequency outputs provided by some CMIP5 models at selected sites along the AMMA transect. Most of CMIP5 models capture many features of the African monsoon with varying degrees of accuracy. In particular, the top-of-atmosphere and surface energy balances, in relation with the cloud cover, and the intermittence and diurnal cycle of precipitation, demand further work from modelling centres to achieve a reasonable realism.
Sensitivity of tropical convection and extreme precipitation in GEOS-5 to resolution, time-step, and convective parameterization options.

The role of deep convective parameterization remains one of the great uncertainties in global atmospheric models as horizontal resolution increases to cloud-permitting scales. The Goddard Earth Observing System model (GEOS-5) is designed to selectively adjust the influence of deep convective parameterization with increasing resolution. GEOS-5 uses the Relaxed Arakawa-Schubert (RAS) convection scheme modified by a stochastic Tokioka (STK) limiter to reduce the influence of deep convective parameterization as resolution increases. At the same time, the deep convective adjustment time-scale remains substantially long at 12-hours further reducing the influence of deep plumes from RAS in GEOS-5. These modifications improve the representation of tropical processes in GEOS-5, in particular the intensity and inter-seasonal variability of tropical cyclones. Despite these improvements, there is a tendency for extreme precipitation events to become too intense and too frequent. This problem is exacerbated with increasing resolution, and decreasing time-step. There is great sensitivity in GEOS-5 to the choice of the convective adjustment time-scale, and the lower limit on the plume entrainment by the STK limiter. In this study we will present results from a series of sensitivity studies using GEOS-5. The first is a suite of runs for the JJA period of 2006 at 25-km resolution varying the model time-step, the STK limiter and the convective adjustment time-scale. Tropical precipitation results are evaluated against observations from TRMM, looking at mean patterns, frequency and intensity of extreme precipitation, and the diurnal cycle. The 25-km results are used to select a combination of parameters evaluated at resolutions of 14- to 7-km for the same period. The sensitivity to increasing resolution is revealed in comparisons with TRMM observations, IR observations from composite geostationary satellite imagery, and cloud properties using MODIS.
A regional climate model, reanalysis and satellite observations are used to study the evolution of vertical moist thermodynamic structure associated with Indian summer monsoon. This synergised approach is first of its kind to the best of our knowledge. The model simulated fields (pressure, temperature, winds and precipitation) are comparable with the respective in-situ and reanalysis fields, both in intensity and geographical distribution. The correlation coefficient between model and observed precipitation is 0.5 and the RMSE is 4.8 mm d⁻¹. Inter-comparison of model simulated surface and midtropospheric temperature (Water vapour mixing ratio (WVMR)) with satellite observations reveals that the midtropospheric temperature (WVMR) has RMSE of 0.5K (1.6 g Kg⁻¹) whereas the surface temperature (WVMR) has RMSE of 3.4 K (2.2 g Kg⁻¹). The analysis reveals that the midtropospheric temperature sensitivity to rainfall is better captured by the model compared to the surface temperature. Similar sensitivity nature is found in the case of WVMR. Temporal evolution of vertical structure of temperature with rainfall over central Indian region reveals that the baroclinic nature of the monsoon is found in all the three products. The associated midtropospheric warming with rainfall is captured by the model but surface response to high and low rainfall events is not well captured by the model. Analysis for WVMR reveals that the model has strong water vapour loading in the whole troposphere but weaker coherence with rainfall compared to observations. Thus strong water vapour loading, large discrepancy in the boundary layer and over estimation of rainfall are reported in model simulation compared to observations. Overall model performance with satellite observations is found to be better than reanalysis. This study put forward that the discrepancy in the model simulated structure may be reduced by assimilation of satellite observations.
The representation of South Asian Summer Monsoon in CMIP5 dataset is evaluated over 20 GCMs. These evaluations include surface temperature gradient, precipitation, and large-scale circulation over South Asia. Observations used to compare with model results are global surface temperature dataset (HadCRUT3), precipitation from India Meteorological Department (IMD), Aphrodite precipitation, ERA-40 re-analysis. The results are diverse. The observed positive precipitation trend during June over central India only appears in half of the models. The South Asian Summer Monsoon is sensitive to changes in physical parametrization. Local aerosol loadings (Sulphate, Black carbon, Organic carbon, Mineral dust, Sea salt) are compared with observations and satellite data (SeaWiFS). Single anthropogenic aerosol forcing runs available from some models are also used to explore the response of South Asian Summer Monsoon to aerosol forcing. Different aspects of response are explored. The response of surface temperature shows a consistent decrease in the second half of 20th century. However, the precipitation does not show such consistent responses. Further evaluations will focus tropospheric temperature gradient and monsoon circulation changes.
While the Madden-Julian Oscillation (MJO) exerts pronounced influences on global climate and weather systems, current general circulation models (GCMs) exhibit rather limited capability in representing this prominent tropical variability mode. Meanwhile, the fundamental physics of the MJO are still elusive. Given the central role of the diabatic heating for prevailing MJO theories and demands for reducing the model deficiencies in simulating the MJO, a global model inter-comparison project on diabatic processes and vertical heating structure associated with the MJO has been coordinated through a joint effort by the WCRP-WWRP/THORPEX YOTC MJO Task Force and GEWEX GASS. In this presentation, progress of this model inter-comparison project will be reported, with main focus on the climate simulation component (Project Component 1 of 3). Analyses based on about 20 participating GCMs from this component in simulating vertical structures of heating and diabatic processes associated with the MJO will be presented along with their reanalysis and satellite estimate counterparts. Model physics for the MJO will also be discussed based on various process-oriented diagnostics.
### Abstract

The changes in coverage by arid climate and intensity of the Hadley circulation during the second half of the 20th century were examined using observations and the multi-model ensemble (MME) mean of 20C3M simulations of CMIP3. It was found that the area of dry climate, which comprises steppe and desert climates following the Koppen climate classification, expanded to an appreciable extent in observation and, to a lesser degree, in MME simulation. The areal extent of steppe climate (the outer boundary of arid climate) tends to encroach on the surrounding climate groups, which, in turn, feeds desert climate (the inner part of arid climate) and causes it to grow. This result indicates the importance of accurate prediction for climate regimes that border steppe climate. Concomitant with the expansion of drylands, the observed intensity of the Hadley cell is persistently enhanced, particularly during boreal winter, suggesting the validity of a self-induction of deserts through a positive bio-geophysical feedback (also known as Charney's cycle). In comparison, the simulated Hadley circulation in the MME mean remains invariant in time. The climate models in CMIP3, therefore, disagree with the observation in the long-term linkage between desertification and Hadley cell. For a more reliable assessment, it is necessary to compare the results in CMIP5 with the representation of biophysical processes such as vegetation-albedo feedback. It is discussed as a possible guidance to improve models.
Minimizing errors in models used for weather and climate prediction by improving initially and boundary condition

Abstract

Goitom Kelem

Abstract. The NWP model has error on initially condition then to improve this error it is mast to make correction on the assimilation of satellite data and correction on the surface data ,topography data and mesoscales data as well as skims, but highly recommended make correction on satellite data simulations since it used as input for NWP and Satellite observations have revealed a remarkably strong positive correlation between sea-surface temperature (SST) and surface winds on oceanic mesoscales of 10-1000 km. While this SST influence on the atmosphere had previously been identified from several in situ observational studies, its widespread existence in regions of strong SST gradients throughout the World Ocean and the detailed structure of the surface wind response to SST have only become evident over the past decade from simultaneous satellite measurements of SST and surface winds. This has stimulated considerable scientific interest in the implications of this air-sea interaction to the large-scale and mesoscale circulation of the atmosphere and ocean. Convergence and divergence of surface winds in regions of spatially varying SST generate vertical motion that can penetrate deep into the atmosphere. Spatial variability of the SST field also results in a curl of the wind stress and its associated upwelling and downwelling that feeds back on the ocean and alters the SST itself. And investigation the effect of ENSO on atmosphere dynamic circulation, downscale and reanalysis the impact of El Nino and La Nina on mesoscale circulation.
High-resolution (up to 1.5 km grid size) limited-area simulations of large tropical domains are analyzed as part of the Cascade project. Model versions with explicit convection and sufficient vertical mixing are found to show significant improvements in the representation of the MJO; this is accompanied by an improved relationship between free-tropospheric moisture and precipitation. Simulations with 12 km grid length and parameterized convection have too many occurrences of very light rain and too few of heavier rain when interpolated onto a one-degree grid and compared with TRMM data. There are also significant differences in the vertical heating and moistening profiles, strength of large-scale vertical motions, and available potential energy generation and conversion. This has important potential implications for the maintenance and propagation of large-scale waves and circulations.
This paper evaluates the performance of a suite of state-of-art coupled atmosphere-ocean general circulation models (AOGCMs) in their representation of regional characteristics of hydrological cycle and temperature over South Asia. Based on AOGCM experiments conducted for two types of future greenhouse gas emission scenarios (RCP4.5 and RCP8.5) extending up to the end of 21st century, scenarios of temperature and hydrological cycle are presented here. The regional climate change scenarios of temperature (T), atmospheric water balance components, precipitation, moisture convergence and evaporation (P, C and E) up to the end of the 21st century based on CMIP-5 modelling experiments conducted for (RCP4.5 and RCP8.5) indicate marked increase in both rainfall and temperature into the 21st century, particularly becoming conspicuous after the 2050's. While the scenarios presented in this study are indicative of the expected range of rainfall and water balance changes, it must be noted that the quantitative estimates still have large uncertainties associated with them.
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<th>Abstract title</th>
<th>Systematic winter SST biases in the northern Arabian Sea in HiGEM and the CMIP3 models</th>
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Analysis of 20th century simulations of the High resolution Global Environment Model (HiGEM) and the CMIP3 models shows that most have a cold SST bias in the northern Arabian Sea during boreal winter. The association between Arabian Sea SST and the South Asian monsoon has been widely studied in observations and models, with winter cold biases having been shown as detrimental to rainfall simulation during the subsequent monsoon in coupled GCMs. However, the causes of these SST biases are not well understood. The models show anomalously strong north-easterly winter monsoon winds and cold air temperatures in north-west India, Pakistan and beyond. This leads to the anomalous advection of cold, dry air over the Arabian Sea. The cold land region is also associated with an anomalously strong meridional surface temperature gradient during winter, contributing to the enhanced low-level convergence and excessive precipitation over the western equatorial Indian Ocean seen in many models.
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<th><strong>Abstract title</strong></th>
<th>The role of peninsular India in the South Asian monsoon</th>
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Several studies have examined the role of the Tibetan Plateau and Himalayas in the initiation and maintenance of the South Asian summer monsoon. In this study we describe the results of a series of novel experiments with the Met Office Unified Model HadGEM3 run in atmosphere-only configuration, in which the role of the Indian peninsula is assessed in order to understand biases in the model. The contributions of the topography, orography and land surface properties to the monsoon circulation and distribution of precipitation in the tropical Indo-Pacific region are examined. While the model usually features a wet bias over the Western Ghats and Himalaya and a dry bias over the northern part of the peninsula, initial results examining the effect of topography suggest a large impact on the distribution of summer monsoon precipitation in the northern Indian Ocean, with increasing rainfall. The impacts of the topography on the boundary layer, partitioning of surface fluxes and the diurnal cycles of temperature and precipitation are assessed.
Mayer et al (2012) carried out comprehensive quantitative diagnostics of atmospheric energy budgets employing third generation reanalyses. They described robust anomaly patterns in zonally resolved fields such as the divergence of total, dry-static and latent energy transports as response to ENSO. These results provide a basis for exploration of the variability of tropical atmospheric energy budgets in climate model runs from the CMIP5 (Coupled Model Intercomparison Project 5) archive. For this purpose, we adopt the indirect method presented in Mayer and Haimberger (2012) to compute energy divergences. While recent studies have addressed fields such as ENSO-related SST or windstress anomaly patterns shown by the CMIP5 models, we compare patterns of anomalous energy transports from models (atmosphere-only and fully coupled historical runs) to those from reanalyses. Anomalies of the energy divergence fields, especially those of total energy, are tightly coupled to SST and consequently also reflect SST biases. As a result, a biased energy budget response to ENSO leads to flawed variability of tropical energy export and ocean to land transports. We also started to study the variability of energy budget quantities from ocean reanalyses such as surface energy fluxes and oceanic heat content in order to explore the quantitative relationship to the atmospheric budgets. We hope that we can quantify budget anomalies associated with important mechanisms known from ENSO theory (e.g. ocean heat discharge during El Nino) with these novel datasets. In return, results will provide an excellent testbed for coupled runs from the CMIP5 archive.

References:
Hurricane and Typhoon are the major contributors to the annual damage and economic lost due to natural disaster around the world. How the characteristics of these high-impact weather extremes will change in a warming climate has attracted considerable interests from research community. For proper assessments, the reliability of simulated TC genesis, tracks and intensity and how they respond to the large scale climate conditions are very crucial. Limited by computational resources, until now, only a few very high resolution (1/4deg or less) global climate models can produce more realistic intense TCs and at the same time have long enough integration to sample the climate-TC interactions without further dynamical downscaling. Here we examined and compared the statistics and characteristics of TC tracks simulated explicitly in the very high resolution global climate models with the observational track data archive from IBTrACS. The hurricane genesis locations shifted toward southeast direction over tropical north Atlantic in CAM5 model as compared to the observation. On the other hand, the typhoon genesis occurrences in both CAM5 and MRI models are more poleward over the northwest Pacific than the observation. The impact of model systematic biases of necessary conditions for TC genesis (e.g. favorable wind shear, moist mid-troposphere, conditionally unstable atmosphere, etc.) on the errors of basin-scale seasonal TC activities will be discussed. The detailed statistics on lifetime evolution of tracks and their intensities suggest that the simulated TCs tend to decay much faster after their peak intensity as compared to the observation.
The Madden-Julian Oscillation dominates intra-seasonal climate variability in the Tropics, plays an important role in the El Nino Southern Oscillation, and influences weather around the world. Despite its importance, uncertainties exist in the mechanism for the MJO and it is poorly simulated and predicted by models. Although ocean-atmosphere interaction is believed important to the MJO, no consensus exists. The aim of this study is to increase understanding of atmospheric intraseasonal variability involving the upper few meters of the ocean. We improve its simulation and reduce model bias over the warm pool area using an AGCM coupled to one-column ocean model (ECHAM5-SIT). In contrast to other state-of-the-art climate models, the model simulates the MJO with a high degree of fidelity, in terms of intensity, f-frequency, zonal wave number and eastward propagation speed. Comparison among observations and models with different degrees of ocean-atmosphere interaction indicates that resolving temperature variations of only the upper few meters of the ocean is essential to accurately simulate the eastward movement of the MJO over Indo-Pacific warm pool. This result may lead to better prediction of intra-seasonal variability, through better representation of the MJO.
Abstract title
Observational evidence for the role of convective cold pools on model biases in the Sahara

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Presenter name Luis Garcia-Carreras

Radiosonde data from Bordj Badji Mokhtar (Algeria) in the central Sahara have been used to confront for the first time model behaviour in the remote Sahara with regular in-situ profile observations. We evaluate the impact of data assimilation on model analyses and in particular assess how cold pool outflows contribute to model biases. Model predictions are too warm and dry, with cold pools contributing the majority of the mean bias. Although cold pools uplift dust, the sign of the errors is inconsistent with radiative impacts of dust and can therefore be directly attributed to advective cooling from cold pools. Cold pools cause 29% of the meridional humidity flux, but this contribution is missing both in the forecast and analysis, thus affecting the large-scale water cycle of the monsoon/heat low system. Although assimilating the radiosondes reduces the errors, significant temperature and meridional humidity-flux biases remain at night. The model biases are consistent with the larger-scale heat-low biases in the operational UM, and can be linked to known issues with parameterisations of convection that are used in all global weather and climate models. This study suggests that the upscale impact of the misrepresentation of moist convective processes significantly affects continental-scale biases, altering the West African monsoon circulation.
The double-ITCZ syndrome in CMIP5 models: the role of large-scale vertical circulation regimes.

Alessio Bellucci

Centro EuroMediterraneo sui Cambiamenti Climatici

P. Athanasiadis, S. Gualdi, E. Scoccimarro

The double-ITCZ (DI) systematic error in the multi-model CMIP5 ensemble is examined. Aim of this study is to quantify the DI error on precipitation in the tropical Pacific, with a specific focus on the relationship between the DI error and the representation of large-scale vertical circulation regimes in climate models. The DI rainfall signal is analysed using a sorting approach in which precipitation events are sorted according to different regimes of large-scale vertical motions, as represented by the mid-tropospheric lagrangian pressure tendency (w500). This methodology allows the partition of the total model precipitation into deep and shallow convective components. Following this regime-sorting diagnosis, the total DI bias is partitioned accordingly into an error related to the intensity of precipitation of individual convective events, and an error related to the frequency of occurrence of particular convective regimes. The results from this analysis are compared with a previous assessment based on CMIP3 simulations (Bellucci et al., 2010).
At ECMWF, systematic model errors are evaluated for each model version at the seasonal time scale with an extensive diagnostic package. In this presentation we will present the methodology of the evaluation and highlight some of the current issues regarding systematic model errors. One example is the wind bias in the tropical Pacific that gives rise to erroneous ENSO variability on the multi-year time-scale.
Abstract title          Uncertainty in the CMIP5 Projections over South Asia
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We analyze Global Climate Models (GCMs) simulations from the fifth phase of the Coupled Model Intercomparison Project (CMIP5) to investigate the response of South Asian summer monsoon to increases in greenhouse forcing. The analysis covers 1970-1999 as the baseline period and 2010-2039 as the near-term, 2040-2069 as the mid-term and 2070-2099 as the long-term future periods under the Representative Concentration Pathway (RCP) 8.5. Our analysis suggests an increase in the South Asian summer monsoon precipitation in the ensemble mean of GCMs in all future periods. However, not only do most of the GCMs disagree on the sign of the precipitation change, the inter-model spread is also much larger than the multi-model mean. The disagreement is particularly significant over the western and northeastern parts of South Asia. This uncertainty in monsoon projections is partly associated with the fact that many GCMs show substantial biases in the simulation of spatial and temporal distribution of seasonal precipitation, as well as in the representation of local and large-scale processes that govern precipitation variations at intra-seasonal to inter-annual time-scales. Given the uncertainty in the CMIP5 ensemble mean projections, a skill-based analysis approach is necessary to improve the reliability of 21st century climate projections over the monsoon region.
An objective tracking technique has been used to assess the representation of African Easterly Waves (AEWs) in the Met Office Unified Model (MetUM) at NWP, seasonal and climate timescales. Model waves are compared to ERA-Interim reanalysis and GPCP rainfall data. The waves are inspected from a dynamical perspective and also from a rainfall-coupling perspective. MetUM is able to capture AEW features at weather forecasting and climate timescales but has issues with rainfall coupling/ enhancement to trough passage. The strength and frequency of AEWs is also generally underestimated in the GCMs. The potential causes of forecast deficiency will be shown along with sensitivity tests with different parameterisations. Despite these deficiencies, the seasonal forecasts of wave strength show good skill in the hindcast data. The implications of this will be discussed along with future plans for forecast improvement.
Although populations affected by the Australian monsoon are much smaller than for south or east Asia, regional impacts of any such changes are nevertheless likely to be large particularly on vulnerable indigenous populations and on ecosystems. In this study, large-scale aspects of the Australian rainfall and tropical climate are analyzed in the CMIP5 models, including means and seasonal variations of temperature, mean sea level pressure, winds, and precipitation as well as inter-annual variability of precipitation. Features such as the seasonal reversals of low-level easterlies into Westerlies and the reverse aloft, and skill in the location, orientation, and seasonal progression of the low-level monsoon 'shear line' are investigated. Broad-scale features of winds between the equator and the continent in the Australian region are analyzed. We have earlier found (Colman et al., 2011) that for CMIP3 simulations, precipitation biases in models were related to differences in occurrence of convective/suppressed vertical motion, and to related precipitation amounts. Our new analysis will investigate if CMIP5 simulations provide a better relationship between the occurrence of convective regimes and associated rainfall amounts. We will also present results from our CMIP5 based assessment of Australian regional rainfall changes under enhanced greenhouse conditions together with a specific focus on the monsoon. For the latter, we will again focus on the analysis of rainfall changes using regime-sorting techniques which previously has shown for the tropical Australian region offsetting tendencies from thermodynamic changes associated with enhanced atmospheric moisture and dynamic changes associated with a weakened overturning circulation. Early results show a significant improvement in the representation of Australian regional rainfall in some models, particular across the tropical region during the summer season.
Abstract

The separate processing of in-wake and off-wake boundary layers and its effect on the low cloud cover in the LMDZ GCM.

In the LMDZ GCM, moist convection is represented by a set of three parametrizations, namely the thermal scheme (representing boundary layer thermals), the wake scheme (representing density currents) and the Emanuel scheme (representing deep convection); the first two parametrizations are coupled with the convective scheme through two variables, the ALE (Available Lifting Energy, used in the convective trigger) and the ALP (Available Lifting Power, used in the convective closure). This set of parametrizations coupled through the ALE/ALP system made it possible to improve largely the simulation of the diurnal cycle of convection over land and of its variability over ocean (Rio et al., 2009, Rio et al., 2012). However, the current set up yields an underestimation of the low level cloud cover. One of the reasons is that, because the boundary layer schemes see average profiles of temperature and humidity, the thermal plumes disappear as soon as density currents appear, contrary to observations which show that deep convection and shallow cumulus do co-exist in domains the size of a GCM grid-cell. In order to deal with this problem, we modified the physics of the LMDZGCM. In the new version the boundary layer is split into two parts (inside and outside the wakes), each part having its own temperature and humidity profiles and its own surface fluxes. With this new set up, the off-wake boundary layer is very unstable and displays numerous thermal plumes. We present the new model, its workings and how it performs in a few 1D cases and in global simulations. Emphasis is led on the consequences for wake properties, surface fluxes and cloud clover.
Does convective aggregation need to be represented in cumulus parameterizations?

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For a given mean precipitation rate and given large-scale forcings, relationships between the degree of aggregation of convection, water vapor, cloudiness and radiation have been revealed in observations above tropical oceans, over domain sizes typical of a General Circulation Model (GCM) gridbox size. Consistent relationships have been found in the Met Office Cloud-System Resolving Model. These findings suggest that the aggregation state of convection constitutes a degree of freedom which modulates the interactions between convection and the large-scale atmosphere. Convective aggregation, however, is likely not to be represented in cumulus parameterizations. The adjustment and testing of cumulus parameterizations by comparing Single Column Model states against observations or high resolution models regardless the aggregation state of convection may induce bias in GCM simulations.
A realistic simulation of Nino-Southern Oscillation (ENSO), the dominant mode of interannual climate variability, in Coupled GCMs is a key indicator of their overall performance. However, despite the substantial progress made over the last decade or so, the CGCMs still experience a significant challenge in simulating the key features of ENSO. For example, CGCMs have difficulty in correctly simulating the spatial structure and amplitude of ENSO, its phase locking to the annual cycle, the El Nino-La Nina a-symmetry, and the ENSO feedback processes, among other things. Considering the importance of ENSO in climate variability and change, it is imperative that efforts are continued to improve the ENSO fidelity in state-of-the-art climate models, such as those participating in the CMIP phase 5. Here, we examine the key features of simulated ENSO variability using a subset of the CMIP5 experiments contributed by two versions of the Australian Community Climate and Earth System Simulator (ACCESS), ACCESS1.0 and ACCESS1.3. The two versions of the ACCESS model have essentially the same ocean and sea-ice components, but differ in atmospheric physics parameterisations, most notably in the cloud and land surface parameterisation schemes. Both versions of the model do a good job in simulating the main ENSO features, such as the spatial structures, amplitude, and the time scale of variability. However, ACCESS1.0 outperforms ACCESS1.3 in the simulation of the annual cycle of the tropical basic state and of the ENSO variance (i.e., the ENSO phase locking). There are also significant differences between the ENSO related ocean-atmosphere feedbacks in the two models. We attempt to understand the differing performances of ACCESS1.0 and ACCESS1.3 in simulating the key ENSO properties in terms of the simulated feedback processes. Among other things, we investigate the role of the Bjerknes' and thermodynamic feedbacks in detail, which will be discussed in the presentation.
Evaluation of Climate Models with Radio Occultation Observations - Tropical Convection Regimes in the HadGEM Model

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Bettina C. Lackner, Mark A. Ringer, and Gottfried Kirchengast

Andrea K. Steiner

The evaluation of climate models requires high-quality observational data sets. Global Positioning System (GPS) Radio Occultation (RO) measurements provide a global and continuous data record of key climate variables for the upper troposphere and lower stratosphere (UTLS) since 2001. The measurements are based on precise atomic clocks and feature long-term stability, consistency, and accuracy. Best data quality is achieved at about 5 km to 30 km altitude.

Profiles of refractivity, pressure, geopotential height, and temperature are retrieved at a high vertical resolution of about 0.5 km to 1.5 km in the UTLS. Due to these characteristics RO qualifies as climate benchmark data type, which can be used for the evaluation of climate models. In this study we focus on physical processes relevant to tropical water vapor/lapse rate feedback. Water vapor and lapse rate responses are closely coupled in the upper troposphere and models with larger negative lapse rate feedback also have a larger positive water vapor feedback. We show results on the representation of UTLS temperature profiles as well as lapse rates and refractivity gradients in RO observations and in Met Office Hadley Centre HadGEM model data. Moist and dry tropical regimes are classified through distinction between dynamical up- and downdraft regions. The pressure vertical velocity at 500 hPa and surface temperature are used for the classification of these regimes. RO data and co-located HadGEM model profiles are sorted and sampled into classes and a systematic comparison is performed. First results indicate a systematic deviation of the HadGEM2 model from RO observations depending on altitude and atmospheric ENSO conditions. HadGEM2 is found warm biased around the tropopause up to the lower stratosphere and cold biased below and above. A better insight into observation and model behavior in tropical convection regimes will contribute to the development of improved model parameterizations.
Parameterization of cumulus clouds is still a difficult issue for climate models. Many studies have suggested that inappropriate designs of cumulus parameterization (CP) could lead to significant biases of simulated climate states and undermine the credibility of climate projections. On the other hand, CPs used in weather forecasting dedicated on mechanisms that are important for convective activities on weather scales. Thus they may help to avoid the biases caused by incorrect weather-scale variability of climate models. With the goal to improve weather-scale variability in climate models, we implement a CP with weather-focused designs -- the Simplified Arakawa-Schubert (SAS, Pan and Wu 1995) scheme into the community atmospheric model (CAM). SAS has been widely tested in NCEP GFS system, but not in a climate model. This study reports its performance within a series of single-column experiments with original CAM 30-level setup and 60-level setup. Mid-latitude convective events at the ARM South Great Plain site are simulated with single-column version of CAM (SCAM). Study suggests that SAS better capture the timing of surface-driven diurnal cycle and propagating convective complex, compared with the current Zhang-McFarlane (ZM) scheme in CAM. These improvements are attributed to the designs of triggering function, especially that allowing convection originating above PBL, and couple convective intensity with grid-mean vertical velocity. Moreover, when increasing the model vertical resolution up to 60 levels, SAS seems to be able to further improve timing of convective events, while ZM is benefited very little with higher vertical resolution. Current results with a single-column model are promising for our work of introducing SAS scheme into CAM. We plans to conduct AMIP-type and coupled simulations with SAS scheme to better understand its impacts on climate simulations.
Remote diabatic heating in the Indian monsoon region and induced Rossby wave pattern to the west are responsible for dry summers in the Eastern Mediterranean region, through the so-called monsoon-desert mechanism. In this study, by analysing temperature and moisture budgets we investigate the main aspects of this mechanism in a set of CMIP5 coupled models. In the time-mean state, most models are able to correctly simulate the basic structure of the monsoon-Eastern Mediterranean climate relationship. The differences among the models performances are identified in terms of the models' ability in realistically simulating the spatial distribution of the summer mean monsoon rainfall climatology. The analysis is then extended to study the monsoon-desert mechanism at interannual timescales, both in observations/reanalysis and CMIP5 models. In observations, the simultaneous correlation between anomalous precipitation over India and the Eastern Mediterranean sectors is weak but appears to have increased in recent decades. The interannual relationship is investigated in those CMIP5 models having a realistic representation of monsoon precipitation basic state. The role of large-scale phenomena like ENSO is considered as well.
This work investigates the precipitation errors from seasonal climate forecasts using the Eta Model nested in the CPTEC atmospheric general circulation model (AGCM) and compared the errors using the model nested in the CPTEC coupled ocean-atmosphere general circulation model (CGCM). The Eta Model seasonal hindcasts were produced for the years 2001 until 2007. Results are shown for the rainy season of most of South America: December-January-February (DJF). The Eta Model was configured with 40-km horizontal resolution and 38 layers, and covers a domain which includes South America, most of Central America and part of Atlantic Ocean. The forecast length time was 4.5 months. The integrations started on the day 15 of November of each year. The model was carried out using initial and lateral conditions provided by AGCM and CGCM. Anomaly persisted sea surface temperature was daily updated when AGCM conditions was used; for integrations using CGCM conditions the sea surface temperature was updated daily using forecasted sea surface temperature provided by CGCM. In the rainy season, the Inter-Tropical Convergence Zone (ITCZ) is responsible for most of the precipitation over Brazilian Northeast Region. Precipitation, latent heat and shortwave radiation fluxes at surface provided by the Eta Model are compared against observations and Reanalysis data. Results indicate overestimated precipitation over the ITCZ region; however, when the conditions from CGCM were used the amount of precipitation forecasted by Eta Model is significantly reduced. In general, the results from Eta Model using CGCM conditions produced smaller errors than using AGCM conditions.
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<th>Abstract title</th>
<th>Comparisons of observed and modeled water vapor variability to assess hydrological cycle realism in models</th>
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Water vapor is fundamental to climate as the most important greenhouse gas and via its changes in phase that drive much of the atmospheric circulation and are tightly coupled to clouds, precipitation and the lapse rate feedback. To assess hydrologic process representation in models, we compare variability of low latitude, free tropospheric, specific and relative humidity in models with observed variability from GPS RO and AIRS. Comparing the full water vapor distribution from models with observations provides a more stringent evaluation of hydrological realism than low order moments like mean & variance. GPS RO reveals a higher percentage of extremely moist and dry air than ECMWF & NCEP moisture analyses or AIRS. The larger fraction of very dry air in the lower troposphere indicates a larger percentage of freeze dried air from high altitudes is surviving, unmixed, during descent into the lower troposphere than in GCMs.

Saturation-advection model results of Dessler and Minschwaner (2007) produce still more moisture extremes than observed by GPS RO. This combined with the lack of diffusion in this simple model suggests some diffusion is required for realism but apparently less than in present GCMs. Models that reproduce realistic clouds and precipitation patterns while under representing the fraction of high relative humidity air imply parameterizations must be compensating for unrealistically dry moisture distributions. Seasonal and ENSO patterns are evident and reveal interesting patterns of behavior. A cluster analysis reveals significant ENSO-related signatures in GPS RO water vapor data that are not present in moisture analyses or GCMs. Examination of the daily output specific humidity of the CESM 1.0 results agree more closely with the observations than AR4 models indicating improved model realism. While some of this is better resolution, there are other factors as well because the NCEP analyses have comparably fine resolution.
The added value of tropospheric water vapor isotopic measurements for process-oriented evaluation of convective, cloud and transport processes in climate models

Differences between model representations of convective and cloud processes remain the dominant source of inter-model dispersion in climate change projections for a given greenhouse gas scenario. Because of fractionation during phase changes, the water vapor isotopic composition reflects the history of phase changes during the water cycle. The development and availability of a growing number of remote sensing retrievals of isotopic composition provides an opportunity to explore the added value of tropospheric water vapor isotopic measurements for process oriented evaluation of convective, cloud and transport processes in climate models. Three examples will be given. First, in the subtropical free troposphere, isotopic variations are sensitive to vertical diffusion. Comparison between 7 isotope-enabled GCMs and various isotopic datasets suggests that most GCMs suffer from excessive vertical diffusion, and that this problem explains the upper-tropospheric moist bias that has long been noticed in GCMs. Second, in the tropical upper troposphere the latitudinal isotopic gradient reflects the contribution of convective detrainment moistening. Third, in the free troposphere of convective regions, isotopic variations reflect the relative contribution of convection and of large-scale condensation as water vapor sinks.
The Double Intertropical Convergence Zone (DITCZ) syndrome still affects all models of CMIP5. As an ensemble, general circulation models have improved little between CMIP3 and CMIP5 as far as the DITCZ is concerned. A major part of the DITCZ bias of coupled ocean-atmosphere models can be attributed to coupled processes. Another part of the bias in these models, as well as in the atmosphere-only models, is related to the interaction between precipitation and large-scale dynamics. Sensitivity studies to convective entrainment using the CNRM-CM5 hierarchy of models show that the DITCZ bias is associated with an error in the PDF of mid-tropospheric vertical wind resulting from feedbacks between dynamics and convection. Based on this work, a metric of the error on the simulated link between convection and dynamics is proposed and applied to the CMIP5 models.
Abstract title: How well do CMIP models represent ocean surface wind stress climatology?
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Satellite measurements of ocean surface wind and reanalysis products are used to evaluate 18 CMIP3 and 11 CMIP5 models. In terms of annual mean and seasonal cycle, the ensemble averages of CMIP3 and CMIP5 wind stress are surprisingly similar, and thus have similar biases to the satellite observations and reanalysis products. The anticyclonic wind stress curl over the subtropical gyres and the cyclonic wind stress curl over the subpolar gyres are both too strong in CMIP models. These biases are expected to affect the strengths of subtropical and subpolar gyres and thus the meridional heat transport. At high-latitude Southern Ocean, the CMIP models have too weak circumpolar westerly wind and too strong cyclonic wind stress curl, which have important implications to the upwelling, meridional overturning circulation, water mass formation, and CO2 flux. In the equatorial zone, CMIP models have too weak zonal wind stress in the Indian and Atlantic sectors, and too strong (weak) wind stress in western (central) Pacific. These biases have significant consequence on the simulation of climate modes originating in the tropics such as the Indian Ocean Dipole, Atlantic Nino, and ENSO. The CMIP models generally over-estimate the magnitude of seasonal variability of wind stress (by nearly 50% when averaged over the global ocean).