I.1 A brief history of AOGCM tuning methods over the past 30 years or so

Ronald J Stouffer
GFDL/NOAA

Thirty years ago, when the first global AOGCMs were being developed, the atmospheric component when run with observed SST and sea ice distributions typically had globally averaged radiative imbalances of more than 10 w/m**2 at the top of the model atmosphere. Many of these models also had large internal sources/sinks of heat and/or water. Modelers quickly discovered that these atmospheric models, when coupled, experienced large climate drifts due to these imbalances. Modelers started to tune their cloud schemes, changing the cloud distribution and cloud radiative properties, to achieve a better radiation balance. Several modeling groups also started to use flux adjustment schemes to account for the remaining radiation imbalances.

As the AOGCMs have improved over the years, the need for flux adjustments has diminished. Higher resolution models are able to have realistic AMOCs (and associated realistic meridional heat transports). Also modelers have addressed many of the heat and water sinks/sources present in the early models. One area of continuing challenge is clouds. As the cloud schemes have become more complex, tuning the model radiatively has become more difficult. There are many more observations of the relating to the detailed processes in modern cloud schemes. Often, it is difficult to tune these cloud schemes to obtain a better radiation balance and at the same time, have the cloud processes be realistic. This can create a tension between the process scientists and those building the AOGCM.

In this talk, I will be using the GFDL models as an example. However, most if not all of the modeling groups have had similar experiences.

I.2 Distress and dilemmas in developing and tuning models

Hideaki Kawai
Meteorological Research Institute, JMA

Based on my many years of experience in developing and tuning cloud parameterization in our climate model (MRI-CGCM3) and operational global model (JMA-GSM), my perspective on model tuning is quite pessimistic.

Limitations for parameter ranges from observation are too loose in most cases, and so we can tune the parameters almost as we like. Not only tuning the model parameters but also thresholds or lower limits of the parameters can drastically change the model performance in a lot of cases. Sometimes, coding bugs play significantly important roles for model performance, time-step dependency is very large, and numerics including discretization methods, especially vertical resolution, are critical for representations of phenomena or climatologies in models. In such cases, model tuning compensates such inappropriate behaviors or performances in models whether consciously or unconsciously. I will show various related examples in the talk. Additionally, examples of dilemmas in model tuning will be also introduced.

I hope that information on model tuning is shared more (and more honestly) among modeling centers because model tuning is almost the most time-consuming and important part of model development substantially.

I.3 Tuning Strategy in the Community Earth System Model

Gokhan Danabasoglu, Jean-Francois Lamarque, Andrew Gettelman
National Center for Atmospheric Research

We describe the integration and tuning strategy used in the Community Earth System Model (CESM) framework to obtain pre-industrial control and subsequent twentieth-century simulations. First, component models, e.g., atmosphere, ocean, land, and sea-ice, are finalized independently using forced stand-alone integrations as well as short fully-coupled simulations with near-final versions of all other components. Then, all model components are coupled to produce an 1850 pre-industrial control simulation. At this stage, the only parameter settings that are usually allowed to change are the sea-ice albedos and a variable controlling the relative humidity threshold above which low clouds are formed in the atmospheric model. The latter is used to balance the top-of-the-atmosphere (TOA) heat flux. We then perform several century-long coupled experiments to find the optimal values for these parameters based on the sea-ice thickness, particularly in the Arctic, and an acceptable (order 0.1 W m^-2) TOA heat balance. With the exception of these two parameters, the CESM strategy is to have the individual components use the same parameter settings in their stand-alone and coupled integrations. The reason behind this approach is that it is inappropriate to change a parameter value in a component to compensate for errors in other components or forcing. We then perform a long (> 1000 years) pre-industrial control simulation. This is followed by a twentieth-century (1850-2005) experiment, initialized from a later date from the pre-industrial control. A decision on whether this twentieth-century integration is acceptable is made based primarily on two comparisons with observations: globally-averaged surface temperature time series and the September Arctic sea-ice extent for the 1979 – 2005 period. If these comparisons are judged to be unacceptable and if resources and time are not constrained, the process of setting up the pre-industrial control and twentieth-century experiments can be repeated. In our last released control simulation, this process was not repeated. The presentation will include our latest updates to the above strategy.

I.4 Towards Credible and Transparent Model-Based Climate Science

John Scinocca
CCCma

A climate model, or GCM, can be characterized by its numerics, discretization, resolution, dynamics and physical parameterizations. A particular model version, GCM_X, is defined by the additional specification of a state vector of free parameters employed by all of its parameterizations. Ideally, each free parameter will have a physical interpretation and be constrained to a prescribed range of acceptable values. In principle, changing the value of even one of the free parameters in this state vector will imply a different model version. From this perspective, model tuning may be viewed most simply as the exercise by which the values in the state vector are selected. Once finalized, the state vector fixes all model behaviour and properties of GCM_X (eg its climatic biases, natural variability such as ENSO and MJO, extremes, and its response to external forcings - both natural and anthropogenic).

How are the properties of GCM_X discovered and documented? Initially, there will be a suite of standard simulations and diagnostics employed by the modelling centre to provide basic insight. Over time a deeper understanding of GCM_X will be revealed through participation in MIPs and individual scientific applications. Finally, following the legacy of the CMIP3 and CMIP5 archives of model results, individual and collective model properties will be uncovered by the analysis and scrutiny of the entire climate community. The ability to harness the expertise of the community in this way is arguably one of the most important advances in climate science. It offers a path towards more transparent and credible climate-model applications as well as provides insight into model behaviour, which feeds back naturally onto model development.

There is a ongoing tension between the desire to constantly adjust, or tune, a model and the need to fix a model version for as long as possible to best understand and document its properties. A model that undergoes continual tuning, producing a new model version for each application, offers very limited insight into the properties of those model versions. This reduces the transparency and credibility of its scientific results and limits the potential feedback on its future development. At CCCma, we have implemented a new more structured model development strategy that emphasizes the importance of physics development and the documentation of model behaviour of each new model version relative to the exercise of model tuning.

I.5 Tuning the GISS climate model to the past climate

Larissa Nazarenko
NASA Goddard Institute for Space Studies

NASA Goddard Institute for Space Studies (GISS) climate model (denoted GISS-E2 in the CMIP5 archive) is 2º by 2.5º horizontal resolution and 40 vertical layer model, with the model top at 0.1 hPa. We use three different treatments of the atmospheric composition. The simplest is a version with Non-INTeractive (NINT) composition i.e. using prescribed three-dimensional distributions of ozone and aerosols interpolated from the decadal concentrations. The aerosol indirect effect on clouds is included as a simple parameterization for increasing the low cloud cover in response to increasing aerosols. This parameterization is based on an assumed relation between aerosol number concentrations and clouds and tuned to produce a roughly -1.0 W/m2 TOA radiative imbalance in 2000 relative to 1850.

The second version (TCAD) has fully interactive Tracers of Aerosols and Chemistry (including Direct effects) (TCAD) both in the troposphere and stratosphere. All chemical species are simulated prognostically consistent with atmospheric physics in the model. The indirect effect of aerosols is parameterized in the same way as in the NINT version. The third version additionally includes a parameterization of the first indirect aerosol effect on clouds (TCADI).

Each atmospheric version is coupled to two different ocean general circulation models: the Russell ocean model (GISS-E2-R) and HYCOM (GISS-E2-H).

Before starting the coupled models, the tuning of the atmosphere-only model is performed through alterations of cloud parameters, such as low cloud critical relative humidity, high cloud critical relative humidity, and the parameter affecting the shortwave and longwave cloud radiative forcings. The main goal of tuning in our climate model is to maintain the global radiative balance at the top of the atmosphere for the pre-industrial (1850) atmospheric composition while we are making the comparison of some basic quantities to available observational data for the present (1970s-1980s) conditions.

I.6 CNRM-CM coupled model tuning protocol

David SALAS Y MELIA
METEO-FRANCE / CNRM-GAME

The tuning stategy of the CNRM-CM5 AOGCM, which contributed to CMIP5, was to tune its components (ocean, sea ice, atmosphere and land surface) in forced mode. This tuning essentially aimed at correctly representing mean states, plus a realistic NAO. Some examples of the sensitivity of the obtained simulations will be given in this talk. Once every component has been tuned, they are all coupled together. No significant tuning was applied to the coupled system, in order to avoid compensating errors, even if this is probably at the expense of e.g. the global mean state of the model. This technique does not seem to completely hold for CNRM-CM6, probably because this new model includes new atmospheric physics, hence more degrees of freedom. In particular, ocean-atmosphere turbulent fluxes, which are key in a coupled climate system model, are now tuned in coupled mode.

I.7 On the development, tuning procedure, and parameter sensitivity of the climate model MIROC

Hiroaki Tatebe
JAMSTEC, Japan

We have been developing the latest version of the climate model MIROC (MIROC5.2) for the contribution to CMIP6 and the next IPCC report. Improved parameterizations for cumulus convection, cloud-micro physics, sea-ice process in MIROC5.0 led to better representation of internal climate variability on seasonal-to-decadal timescales and reduced model systematic biases in the tropics and around the Arctic Ocean. However, much (less) cloud over the subtropical ocean (Eurasian continent and the Southern Ocean) and resultant cold (warm) SST biases, and thus weaker meridional gradient of the surface temperature in MIROC5.0 than observations, which have been recognized as common biases among IPCC-class models, are still found. To solve these biases and associated biases such as stronger trade winds and deeper thermocline along the equator, we are trying to implement shallow convection scheme and a few land schemes and to tune the model climate, paying attention to global maps of typical variables, strength of aerosol-cloud interactions, and TOA imbalance. In my presentation, we will give a talk on a brief description on MIROC5.2 and its biases, sensitivity of the model to the parameters often used to control cloud-radiative feedback, tropical variability (e.g., ENSO behavior), and the typical global-mean metrics. Along with these topics, we will introduce our system operated on a wiki site for monitoring model state, biases, and drifts on tuning stages.

I.8 Approach for the tuning of the radiative balance in the IPSL climate model

Frédéric Hourdin, Jean-Yves Grandpeix, Catherine Rio, Sandrine Bony, Arnaud Jam, Frédérique Cheruy, Nicolas Rochetin, Laurent Fairhead, Abderrahmane Idelkadi, Ionela Musat, Jean-Louis Dufresne, Marie-Pierre Lefebvre, Alain Lahellec, Romain Roehrig
LMD/IPSL/CNRS/UPMC, Paris, France

In the preparation phase of IPSL-Coupled Model configurations for the CMIP exercises, a significant amount of human and computer resources is dedicated to the selection of configurations and tuning of free parameters like ocean mixing, snow albedo, cloud properties, to try to match key features of the present day climatology with a focus on radiative balance, surface temperature and precipitation patterns, ... If changes in horizontal resolution tend to improve the model climatology and variability systematically (at least for the rather coarse grids used at IPSL for CMIP exercises), without affecting the radiative balance too much, changes in vertical resolution as well as in the parameterization of cloud processes, turbulence and convection, significantly affect the radiative balance. A tuning of free parameters is then required, without which improvements in specific parameterizations or grid refinement would result in a strong deterioration of the model climatology. We will describe this tuning processes which we claim is an intrinsic and fundamental aspect of climate modeling. At IPSL, a particular care is given to the radiative balance, not only globally but also in terms of latitudinal distribution, contrasts between convective and subsidence regions in the tropics, or between clear sky and cloud radiative effect, both for the solar radiation and thermal infra-red. This tuning is done at IPSL based on series of Amip-Like simulations with the LMDZ atmospheric component as well as Aqua-planet simulations with reduced horizontal grid used to estimate the sensitivity to cloud parameters. At regular interval, a given parameter set is tested in the coupled ocean-atmosphere IPSL model. During this tuning process, simulations are also performed with zoomed and nudged (by reanalyzes) configurations compared to site or campaign in situ observations as well simulations of test cases with the single column of LMDZ compared with Large Eddy Simulations, in order to get a more "process oriented" evaluation and control of the tuning process.

I.9 Tuning climate model INMCM

Evgeny Volodin
Institute of Numerical Mathematics, Russia

Strategy of INM climate model tuning is presented. Main features that usually should be adjusted in a new model version are follows: global mean temperature, spatial distribution of annual mean temperature error, Arctic and Antarctic sea ice area, amplitude of diurnal cycle of surface temperature, maximum of Atlantic overturning streamfunction, parameters of equatorial stratospheric quasi-biannual oscillation. Model parameters responsible for these features are presented.

I.10 Your name Tuning with expensive model physics: MPI-ESM-HAM, a progress report

Doris Folini
ETH Zurich

Our goal is to study aerosol effects on sea surface temperatures. To do so, we start from the global coupled climate model MPI-ESM (Max Planck, Hamburg) and replace its prescribed AOD fields (S. Kinne) and cloud micro-physics with corresponding physics from HAM (Hamburg Aerosol Module).

Replacing part of the physics of MPI-ESM requires re-tuning of the model. Meanwhile, the comparatively detailed treatment of aerosol effects comes at the price of high CPU costs. Given these high costs, our re-tuning goal is to come as close as possible to the climate of the MPI-ESM piControl_LR experiment from CMIP5 (without HAM), in order to profit as much as possible from the already spun up ocean of this experiment.

The talk is a status report on this endeavor. It also raises some general questions. How to best deal with model physics that is too complex (expensive!) for a 5000 year model spin up? Does it make sense at all to replace part of the physics of a model and then tune against an existing experiment?

S1.1 Tuning the climate sensitivity of MPI-ESM1.1

Thorsten Mauritsen
MPI

After CMIP5 the MPI atmospheric model received a series of bug-fixes addressing energy conservation in the physics and an error in the cloud fraction scheme. After this, however, the models climate sensitivity which had been stable decades of development was roughly doubled from 3.5 to an estimated 6-7 K due to a strong increase in tropical low-level cloud shortwave feedback. This was considered unacceptable and a subsequent re-tuning of the model was successful in reducing cloud feedbacks foremost by increasing the lateral entrainment rate for shallow convection. This contribution describes how we used Cess-experiments (AMIP+4K) to monitor feedbacks during the model development process, what we learned about the controls of cloud feed-back, and what we think about the activity.

S1.2 Why it could make sense to transparently tune the climate sensitivity range of ESMs

Florian Rauser
MPI for Meteorology

It has been shown in the last years that it is possible to find multi-model correlations between climate sensitivity and a variety of observable quantities, mostly cloud-related. This could - given trust in those multi-model correlations and their underlying physics - help to constrain the ECS / TCR range which is highly desirable from a stakeholder point of view.

Still, I believe that those literature correlations are currently too contradictory to be trusted in this way and that the scientific knowledge they contain should better be used in the tuning process towards models that better represent observational best estimates of ECS/TCR.

I argue that if we openly use response properties as ECS or TCR in the tuning process, we gain confidence and do not have to go into the difficult explanation process if they are or are not truly independent, emergent quantities of the ESMs.

This mini-talk would be advocating in favor of including response properties to GHG forcing changes in the tuning process and could be part of the general discussion as to for which experiments this might be helpful and for which it definitely does not.

S1.3 Tuning aerosol in-direct effect. Include new processes or tune old

Øyvind Seland
Norwegian Meteorological Institute

Cloud adjustments due to aerosols, i.e. aerosol in-direcet effect, stands out as the forcing with lowest level of understanding in IPCC AR5. Also the best estimate of aerosol in-direct effect is the most negative of all forcing processes. At the same time it has been shown that including an advanced treatment of aerosol-cloud interactions, often also have the best representation of recent observed temperature trends. Despite being a critical forcing for understanding 20th century climate change a large part of the uncertainty may be connected to natural aerosols and not as one may suspect the anthropogenic contribution This talk will give an example on how including more information natural aerosols can have as large effect as tuning cloud doplet number concentrations.

S1.4 Cloud tuning and twentieth century warming

Chris Golaz
NOAA Geophysical Fluid Dynamics Laboratory

Cloud parameterizations are often tuned to best reproduce specific aspects of the observed climate, such as the energy balance at the top of the atmosphere. Starting with the CMIP5 GFDL CM3 coupled climate model, we construct alternate model configurations that achieve the desired energy balance using different, but plausible, combinations of parameters. The present-day climate is nearly indistinguishable in all configurations, but the evolution of the surface temperature over the course of the twentieth century differs markedly due to a large spread in the magnitude of the aerosol indirect effect.

CloudSat and A-Train satellite observations are employed to construct the statistical "fingerprint" process-level signatures of the cloud-to-rain processes. They demonstrates that the model predictability of twentieth-century temperature trends contradicts the process-based constraint on tunable cloud parameters. This implies the presence of compensating errors at a fundamental level, and underscores the importance of observation-based, process-level constraints on model microphysics uncertainties for more reliable predictions of the aerosol indirect effect.

Note: this contribution could also take the form of a brief (5 min) presentation instead of a short one (10-12 min). It's important to leave enough time during the session for discussion.

S2.1 Simulation of East Asian-Western Pacific Summer Monsoon: From CMIP3 to CMIP5

Tianjun ZHOU
Institute of Atmospheric Physics, Chinese Academy of Sciences

The complex East Asian – western Pacific Summer Monsoon system has provided a rigorous test bed for climate models. However, how to reliably reproduce the climatological rainfall and inter-annual variation of the monsoon remains to be a challenge for climate modeling community. The improvements of East Asian – western Pacific Summer Monsoon simulation from CMIP3 to CMIP5 are assessed. The crucial dynamical processes that determine the model performance in reproducing the inter-annual variability of EASM are revealed. We show evidences that there is a skill dependence on Indian Ocean-western Pacific anticyclone tele-connection, viz. the tropical eastern Indian Ocean (IO) rainfall response to local warm SST anomalies in El Nino decaying year summer and the associated Kelvin wave response over the Indo-western Pacific region are important to maintain the Western Pacific anticyclone (WPAC). A successful reproduction of inter-annual EASM pattern depends highly on the IO-WPAC tele-connection. A further comparison of offline AGCM and fully coupled CGCM simulations of CMIP5 models indicate that the inter-annual EASM pattern is better simulated in CGCMs than that in AGCMs, thus the air-sea coupling process significantly improves the simulation.

S2.2 On the effectiveness and limitation of parameter tuning

Tomoo Ogura
National Institute for Environmental Studies

Model development often aims at reducing systematic errors in the simulated climate compared to observations by 1) tuning the uncertain parameter values and/or 2) improving the uncertain equations representing physical processes in the model. Given the two approaches, we need to make a decision as to which one should be given higher priority to effectively achieve the aim. In the development process of MIROC5.2 AOGCM, a Perturbed Parameter Ensemble (PPE) experiment was utilized to address this issue. For each member of the PPE, climatology of the pre-industrial control run was compared with observation, focusing on the radiation bias at TOA. Large biases were found in shortwave cloud component, especially over low latitude oceans and Southern Oceans. Analysis showed that the biases could be reduced by parameter tuning, but they could not be eliminated altogether, which pointed to the need for improving model physics parameterizations. Motivated by the analysis of the PPE, we implemented a shallow convection parameterization to MIROC5 AGCM. At the workshop, we will discuss effectiveness and limitation of parameter tuning, based on the results of the PPE, which helped us form the decision in the model development process. We will also discuss impact of the shallow convection parameterization and implication of a new ensemble experiment which considers uncertainties in parameter values and model structures.

S2.3 How Bright is a Cloud? Parametric Tuning in the Model Development and Evaluation Process

Andrew Gettelman
NCAR

Tuning as an integral part of model development and evaluation. One definition is the adjustment of uncertain parts of a model given larger scale constraints on the system. The scale of model development and evaluation goes from the details of a single processes, through to global metrics, up to the performance in a coupled climate simulation. Model evaluation and tuning occurs on all levels. The link between parameter tuning and climate simulation performance (mean state, climate forcing and feedbacks, climate sensitivity) will be explored with examples from the atmosphere and cloud physics parameterizations. Some ideas about why certain parameters are critical and many are not important will be presented. Parameters and processes that are critical in more than one model may provide unique areas for trying to constrain the earth system, and some examples will be presented as questions and perhaps critical challenges.

S2.4 The “process-oriented” tuning strategy of the LMDZ model

Catherine Rio, Frédéric Hourdin, Arnaud Jam, Fleur Couvreux
CNRS/IPSL/LMD

In the final stage of tuning of the atmospheric component of the IPSL coupled model, LMDZ, ten or so parameters are being used. They are some of the less-constrained ones, for which a range of values can be explored, trying, insofar as possible, to keep them realistic. They are mostly parameters related to cloud processes or sub-grid scale distributions of temperature and humidity. A way to help constraining those parameters is to rely on process-studies comparing simulations in 1D mode with observations or cloud resolving models on specific case-studies.

One example is the prescription of entrainment and detrainment rates used in the thermal plume model for dry and shallow convection. One way to go is to tune them to some constant values in order to reproduce the observed mean environmental variables. An other way is to develop a sub-model to express them as a function of thermal properties, in which new parameters are involved, which are tuned to reproduce the entrainment and detrainment rates deduced from explicit models. This way, the physical realism of the model is increased, while the tuning process is pushed back to a lower level inside the model.

This strategy was also applied to develop a parameterization of the variance of the saturation deficit used in the shallow cumulus cloud scheme. Therefore, remaining tuning parameters also highlight where increased physical realism is still needed in the model, as for example regarding the representation of the fall speed of ice crystals, the precipitation efficiency of convective clouds or the variance of total water used in the large-scale condensation scheme in LMDZ.

While explicit models can be used to constrain transport by mass-flux schemes or cloud fraction, there is still a gap between this 1D approach and the tuning of the radiative balance in 3D mode. Here, we will discuss if we think this gap can be filled or not.

S2.5 Designing a Sensitivity Model Intercomparison Project (SensMIP)

Peter Gleckler / David Neelin
PCMDI / UCLA

Many modeling groups are currently undertaking parameter sensitivity studies but there has not yet been a systematic Sensitivity Model Intercomparison (SensMIP). One reason for this is that a one-to-one comparison of parameter dependence is not generally possible because models have different representations of parameterized physical processes. However, there is a high premium on establishing key properties such as degree of sensitivity and nonlinearity in parameter dependence associated with particular physical processes across the ensemble of models. Simplicity of design and physical interpretability are important factors in a proposed initial SensMIP design. The experiments would be potentially usable by each group for tuning, while permitting estimation of a range around each model's standard parameter setting associated with uncertainty in particular physical processes as parameterized in that model and identification of common processes associated with high sensitivity and/or nonlinearity.

S3.1 High-Resolution Tuning Overview and ACME Tuning Plans

Peter Caldwell
LLNL

In this talk I will summarize tuning practices from previous high-resolution climate experiments and general thinking on tuning for ongoing and future high-resolution runs. Particular emphasis will be placed on plans for tuning the US Department of Energy's new ACME model. Novel approaches such as 1). using ensembles of short forecasts to tune in lieu of more expensive climate length simulations, 2). using a regional model or a global model with regional refinement for tuning, or 3). using coarse-resolution simulations to guide tuning at finer resolution will be explored.

S3.2 Results and Tuning Lessons from High and Variable Resolution Climate Simulations Using the Community Earth System Model

Andrew Gettelman
NCAR

Global climate simulations have been performed with both stand alone and coupled versions of the Community Earth System Model (CESM) at resolutions of ~25km. Variable mesh simulations scaling from 200km —> 25km have also been conducted. Basic results of some of these simulations will be presented, with a focus on some of the issues of tuning a model. Initial experiments have shown that the model physics is sensitive to resolution: both to resolution and to the time steps associated with the resolution. Some methods to address this are being pursued. Some model physics is highly resolution dependent. Variable resolution simulations indicate scale interactions that need to be considered when particular questions are being asked of such models. Coupled experiments generally have performed well with similar tuning to high resolution stand alone experiments. Biases in the mean climate state appear similar between high and low resolution. But some coupling strategies produce different answers at different resolutions: and care needs to be taken to discern differences due to model structure and interpolation from resolution dependencies in the dynamics or physics.

S3.3 Tuning a high resolution AGCM to improve its performances in simulating East Asia Summer monsoon

Jie ZHANG and Tongwen Wu
Beijing Climate Center, China Meteorological Administration

Climate in East Asia is dominated by the monsoon, with abundant rainfall in summer. Due to its particular geographical location and its complex topography, reproducing the East Asia Summer Monsoon is still a big challenge for recent AGCMs. Although increase model resolution can help to improve model performance, two common biases are still evident in high-resolution model: the overestimation along the southern edge of the Tibetan plateau and the underestimation in the low reaches of the Yangtze River valley. To suppress the overestimation, a shape-preserving advection scheme was introduced. It has the advantages of small dispersion error as in upstream scheme and small dissipation error in high-order-accuracy scheme. For general improvement, we optimally tuned eight parameters associated with microphysics, cloud fraction, shallow convection and deep convection. The model reproduces more reasonable seasonal march of East Asia monsoon when eight optimal parameters are used.

S4.1 Using numerical weather prediction methods to improve climate projections
Daniel Klocke
Deutscher Wetterdienst

Uncertainties of model based climate sensitivity estimates are dominated by uncertainties from fast physical processes, which are also important in numerical weather forecasting. Fast processes like clouds and convection act and respond on short time-scales and can be understood and evaluated by performing weather forecasts with climate models. The adaptation of unified modeling approaches at some centers for weather forecasts and climate simulations allows to transfer methodologies for weather forecasting to climate modeling more easily. Some exploratory results will be presented which link short-term forecasts to errors in simulating the climate state and uncertainties in the long-term climate response.

S4.2 How the Met Office develops a global model for timescales from NWP to climate

Alistair Sellar
UKESM / UK Met Office Hadley Centre

The Met Office develops a single global model configuration for use in all its global modelling applications, from NWP, through medium-range and seasonal-decadal prediction, to climate modelling. In the development process, both climate runs and NWP trials/case studies are evaluated to develop a configuration suitable for all timescales. In general, we aim to avoid tuning in the sense of adjusting model parameters to improve the validation. Instead, the approach to "tuning" in the final stages of each development cycle is to try and include physics improvements which have been under development for some time and which improve a bias in the latest configuration. The improvement and the bias may match up by design if the improvement has been developed in response to a long-standing error, or sometimes by good fortune where the improvement has been developed for fundamental improvement of a parameterisation rather than to address a specific bias. The presentation will include examples to illustrate this approach.

S4.3 Is tuning based on hourly forecast range valid at annual range?

Martin Köhler
DWD

The ICON model is unique in it's applicability range in spacial resolution of hundreds of meters (LES) through kilometers (NWP) to hundreds of kilometers (climate). A unified tuning will only be feasible if improvements achieved at diurnal time-scales also improve the model climate. This question will be explored given some examples of gravity wave drag, land surface and cloud parameterizations.

S5.1 Statistical tuning for GCMs with history matching and emulation

Danny Williamson
University of Exeter

The tuning of climate models with long run times and many parameters and processes presents a considerable challenge to modelling centres who wish to feed into model inter-comparison studies such as CMIP. Though parts of this process must involve the careful judgements of modellers, for example, in specifying the types of target it is sensible to tune to; the search for parameter settings that meet these targets can be automated using the latest statistical methods for quantifying uncertainty using computer experiments. In this talk I will present multi-wave history matching as a method for tuning. I will show how it can be used to find sensible parameter choices as well as for constraining parameter space and quantifying parametric uncertainty for reporting projections. In particular we will show how all parameters must be tuned simultaneously to avoid local minima. We discuss how to apply the method for state of the art models where the model may not be evaluated at a large number of parameter choices. The method will be demonstrated with 2 GCM class models. Firstly, we apply it to HadCM3 to remove a number of biases that were previously thought to be structural. We will then apply the method to the NEMO ocean model.

S5.2 Statistical model validation

Jean-Francois Lamarque
NCAR

I will present a new approach to identify if a simulation is within the expected range of simulated climates. This range is defined from simulations using a previously tested model and relies on short simulations to identify the probability that the new simulation is consistent.

S5.3 Parametric sensitivity and auto-tuning of precipitation in the CAM5

Yun Qian
Pacific Northwest National Laboratory

We investigated the sensitivity of precipitation characteristics (mean, extreme and diurnal cycle) to a set of uncertain parameters that influence the qualitative and quantitative behavior of cloud processes in the Community Atmosphere Model (CAM5). We adopt quasi-Monte Carlo sampling approaches to effectively explore the high-dimensional parameter space and then conduct 1100 5-year of simulations by perturbing 22 parameters related to cloud physics and convections. Six parameters having the greatest influences on the global mean precipitation are identified, three of which (related to the deep convection scheme) are the primary contributors to the total variance of the phase and amplitude of the precipitation diurnal cycle over land. Precipitation does not always respond monotonically to parameter change. The influence of individual parameters does not depend on the sampling approaches or concomitant parameters selected. The total explained variance for precipitation is primarily due to contributions from the individual parameters (75-90% in total) rather than their interactions. The total variance shows a significant seasonal variability in mid-latitude continental regions, but very small in tropical continental regions.

We also applied an auto-tuning technique to improve convective precipitation in the CAM5, in which the convective and stratiform precipitation partitioning is very different from observational estimates. We examined the sensitivity of precipitation and circulation to several key parameters in the Zhang-McFarlane deep convection scheme in CAM5, using a stochastic importance-sampling algorithm that can progressively converge to optimal parameter values. The impact of improved deep convection on the global circulation and climate was subsequently evaluated.

S5.4 The Parametric Sensitivity of CAM5's MJO

Hsi-Yen Ma
PCMDI/LLNL

We systematically explore the ability of the Community Atmospheric Model Version 5 (CAM5) to simulate the Madden-Julian Oscillation (MJO), through an analysis of MJO metrics calculated from an 1100-member perturbed parameter ensemble of 5-year simulations with observed sea-surface temperatures. Parameters from the deep convection scheme make the greatest contribution to variance in MJO simulation quality with a much smaller contribution from parameters in the large-scale cloud, shallow convection and boundary layer turbulence schemes. Improved MJO variability results from a larger lateral entrainment rate and a shorter convective adjustment timescale. Improved variability also results from reductions to the drying tendencies of deep convection that were achieved by a smaller auto-conversion of cloud to rain water and a larger evaporation of convective precipitation. Unfortunately, simulations with an improved MJO also have a significant negative impact on the climatological values of low-level cloud and absorbed shortwave radiation, suggesting that structural in addition to parametric modifications to CAM5's parameterization suite are needed in order to simultaneously well simulate the MJO and mean-state climate.