Panel Recommendation for CAM5.5 physics – June 2015

This document is an update to the first recommendation that was made by the AMWG assessment panel in February 2015. To reiterate, as with the original recommendation, the intention is to provide an assessment of the best possible path toward providing a skillful and desirable atmosphere model for CESM2 CMIP6 experiments and for the CESM community as a whole. In making this final recommendation the panel has considered, for each scheme, the aspects of performance, desirability and risk, relevant to short-term and longer-term AMWG goals. The assessment has also been carried out with the inclusion of CAM5.4 in mind as a possible fallback configuration if either UNICON or CLUBB were deemed unsatisfactory.

Once again the panel would like to express gratitude to the developers for their effort in addressing the original recommendations and for providing a new set of simulations.

The assessment is based on simulations that can be found here. This includes the configuration and simulation details for CAM5.4:

http://www.cesm.ucar.edu/working_groups/Atmosphere/development/cam6/cam5.5-process/

The panel is encouraged to see that both development teams have made a considerable effort at addressing the primary panel recommendation of improving the ENSO to be competitive with the CESM large ensemble (LE) simulations. Both teams have been largely successful in this exercise. CLUBB simulations show a significant increase in amplitude and a more defined spectral peak. UNICON simulations show a decrease in amplitude and a shift to a longer period. Knowledge of the underlying responsible processes remains unclear, which will make the understanding of ENSO changes when CAM is coupled to new ocean model configurations a challenge. However, based on these new simulation results we are satisfied that both configurations are able to produce an ENSO that will enable useful coupled climate research in the wider CESM community. The panel finds the simulation of ENSO in CAM5.4 to have excessive amplitude that would, in its current configuration, have limited utility for coupled climate research.

Much of the improved skill seen in the original submissions was either maintained or even marginally improved upon. This includes many of the cloud and cloud-radiative properties (especially over tropical land). The tropical precipitation distributions remain competitive with CAM5.3 and CAM5.4, with some seasonal improvement and degradations equally split between UNICON and CLUBB. Sea Surface Temperature Distributions (SSTs) in coupled simulations remain marginally better in UNICON. An area of performance where there remains some concern is in the simulation of equatorially trapped waves in CLUBB. In thermodynamic signatures (OLR, rainfall) there is limited power occupying the equivalent depth mode phase space compared to observations and to a large extent CAM5.4. Simple efforts to elevate the strength of the deep convection scheme have had limited success, pointing to aspects of the moist physics interactions that remain uncertain. On a more fundamental level than just simulation performance the panel found it very challenging to easily identify the elements uniquely within a single scheme that would best fit the most desirable scientific philosophy for moving CAM forward. UNICON has many advantages as a surface to tropopause convective phenomenon-based scheme. It represents a significant enhancement to the legacy Zhang-McFarlane (ZM) scheme with a relaxation of small-plume approximation and an explicit representation of mesoscale organization. It also does away with the inevitable deep and shallow scheme separate philosophical incompatibilities. However, we are still left with the inevitable convective-macrophysics coupling. CLUBB is formulated as a high-order closure scheme for dry and moist turbulence and as such represents a continuum of turbulence with none of the existing arbitrary scheme separation. It also has the advantage of being extensible to represent deep convection processes also, with a consistent representation of microphysics across all cloud types. CLUBB is however a radical change to the paradigm of cloud physics parameterization in CAM. This could transform the validation of cloud processes as phenomena-based towards something of a more statistically based methodology, whereby higher order moments may have to be taken "as is" given the difficulty of validating such quantities outside the realm of Cloud Resolving Models (CRMs).

Both schemes have elements that would be desirable for cross resolution performance, having the potential to provide scale aware responses with reduced resolution dependence. Given that these desirable properties are not unique to just a single scheme, it is not difficult to envisage a combination of several of these factors in future CAM development at high resolution.

When considering risk there are inevitability many unknowns in climate model development that cannot be predicted, however the panel has considered that certain paths should be less risky than others. The essence of CESM is a community-developed model that requires good faith collaboration and acceptance that existing critical-path developments should be used in future model development. It is evident that the CLUBB development team is well placed to support and develop CLUBB within this community collaboration environment. They have actively engaged the Ocean Model Working Group members in order to understand and improve the deficient ENSO, and their code base is already maintained as open-source; available to all CESM developers., and is well integrated into the CESM code hierarchy. Another aspect of the community model paradigm is to develop and maintain a code base following recognized practices and that is readily compatible. This enables codes to be more efficiently advanced in a very rapidly evolving environment where many aspects of the code base can be changed at once.

Although more time is always desirable in the pursuit of ever more improvements and understanding, the panel believes the time has come to select a primary configuration for CAM5.5, both to provide focus for the CESM development and to best allocate the *limited available support and computing resources over the coming months. The panel therefore recommends that the AMWG and CESM primarily move forward with the development of CAM5.5 using the configuration developed by the CLUBB team.*

This recommendation is not without significant advisories. First that the CLUBB team should assemble a larger group to address the obvious shortcomings of certain aspects of the simulation, chief of which is the poor simulation of equatorially trapped wave modes. Insufficient progress was made on this issue, since the original recommendation and any potential improvements should be pursued in the functioning of CLUBB as opposed to cursory changes to the ZM deep convection scheme. This should be CLUBB's number one priority. Secondly, there is still uncertainty as to what the identifiable cloud phenomena are that lead to the climate in CLUBB simulations. Effort should be applied to understand the higher order moment source and sink terms in the context of how cloud types evolve. Currently CLUBB is presented as somewhat of a black box and targeted diagnostics are needed to present future developers and users with more insight into cloud processes. Given the deficiencies in the convectively coupled waves in the CLUBB simulations momentum budgets and vertical heating profiles produced in CLUBB should be investigated and made more transparent.

Once again the panel would like to stress that its primary recommendation applies just to the version of CAM to be used in CESM2 CMIP6 experiments (CAM5.5). We encourage all the developers to continue to move forward with active collaboration among all model developments towards the next version of CAM (CAM6) due June 2016. There are clearly many desirable aspects of the both configurations, and in particular including components of both UNICON and CLUBB that lead to the eventual replacement of the ZM deep convection is highly desirable. The pathway for this will be challenging, but there is a unique opportunity to produce a revolutionary model version for CAM6 over the coming year.

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