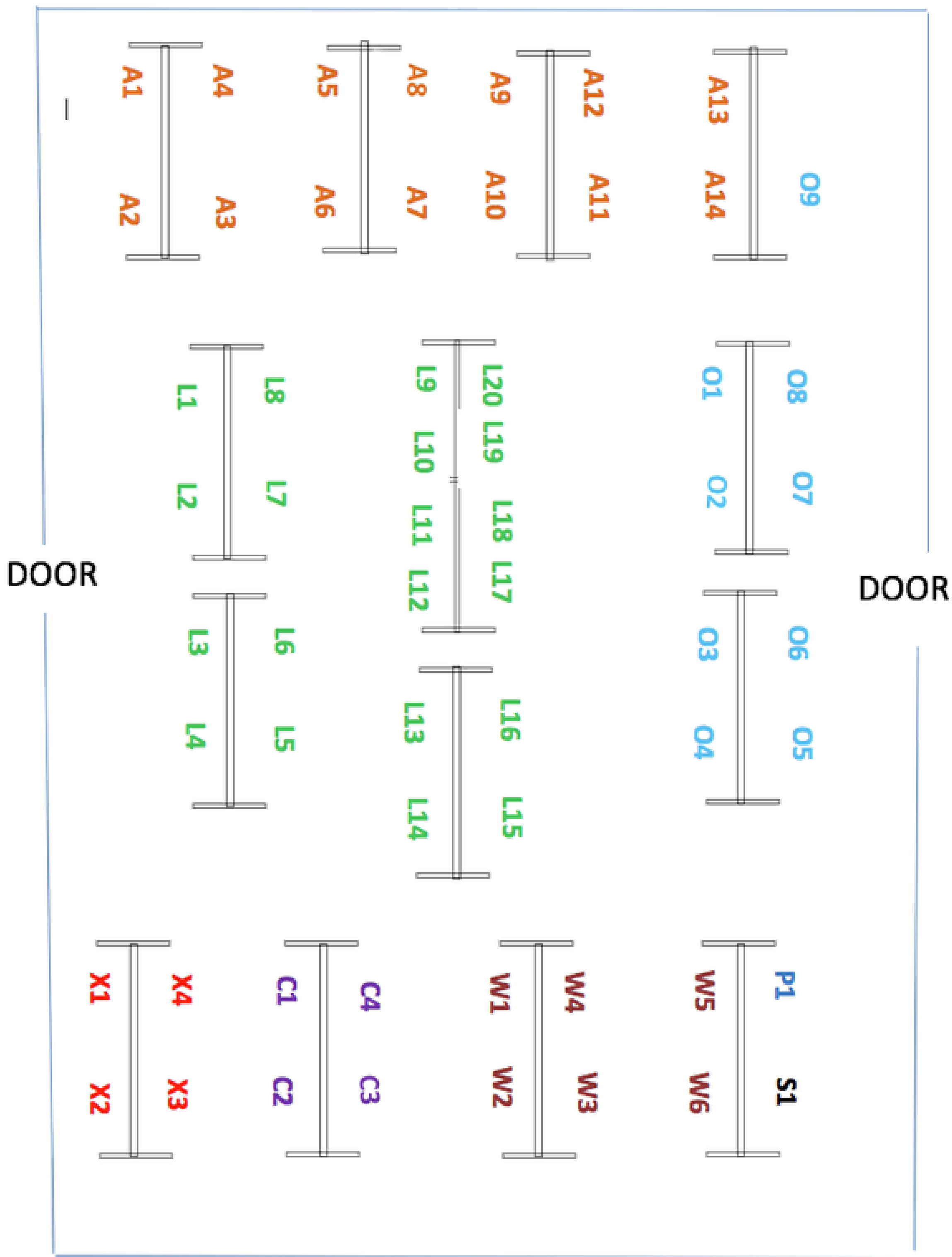
Posters Layout

Layout for the 2017 ACME All-Hands meeting



#A01 Cloud analysis using COSP

Poster Title	Validation of ACME simulated clouds and their sensitivity to model resolution with satellite and ground-based simulators
Authors	Yuying Zhang, Shaocheng Xie, Wuyin Lin, Po-Lun Ma, Phil Rasch, and Steve Klein
Group	Atmosphere
Experiment	
Poster Category	Early Result
Submission Type	poster
Poster Link	

Abstract

The poster uses the CFMIP (the Cloud-Feedback Model Intercomparison Project) Observation Simulator Package (COSP) and the Atmospheric Radiation Measurement (ARM) radar simulator to evaluate clouds simulated by the US DOE Accelerated Climate Modeling for Energy (ACME) atmosphere model version 1. COSP is used to evaluate model clouds from ACME AMIP simulations at 1 degree and 0.25 degree resolutions, while the ARM radar simulator is used to evaluate model clouds in its day 2 hindcasts at the ARM sites. Model biases on cloud amount and properties are quantified and impacts of the model resolution on the simulated clouds are discussed. The radiative effect of errors in cloud properties for the AMIP runs is examined using cloud radiative kernels

#A02 CAPT simulations with ACME v1 CONUS RRM grid

Poster Title	Understanding the Cloud and Precipitation Biases in ACME v1 over the Central US with the CONUS RRM Grid
Authors	Xue Zheng, Chris Golaz, Shaocheng Xie, Wuyin Lin, Qi Tang, Erika Roesler
Group	Atmosphere
Experiment	
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

Simulating precipitation processes, clouds, and hydrologic cycle at regional scale over the central US remains challenging for global climate models. ACME v1 atmosphere model has implemented many new features in the physical parameterizations. It is important to assess the persistent model biases over the central US in ACME v1 and exam how the biases respond to different model settings. This study conducts ACME v1 5-year AMIP simulations and several sets of short-term hindcasts (i.e. CAPT simulations) for the summer of 2011 with the regular grid and the CONUS RRM grid. Based on observations, especially ARM observations, the evolution of cloud and precipitation biases over the central US with various model parameter settings is analyzed in this study.

#A03 Convective gustiness and tropical precipitation biases

Poster Title	The Role of Convective Gustiness in Reducing Seasonal Precipitation Biases in the Tropical West Pacific
Authors	Bryce Harrop, Po-Lun Ma , Phil Rasch, Rich Neale, Cecile Hannay
Group	Atmosphere
Experiment	Watercycle
Poster Category	Early Result
Submission Type	poster (or presentation pending simulations completing in time)
Poster Link	

Abstract

Convective gustiness reduces the precipitation bias to the north of the maritime continent in the Tropical West Pacific (TWP). The gustiness enhances surface evaporation proportional to the amount of convective precipitation reaching the surface, which can be treated as an increase in the energy forcing into the atmosphere. Coupled with a relatively constant normalized gross moist stability, this increase in energy forcing demands an increase in precipitation to maintain an atmosphere close to equilibrium. The increase in tropical precipitation owing to convective gustiness is favored in regions where the large-scale circulation is weak and thus, the evaporative flux without gustiness is weak. The increase in precipitation north of the maritime continent initiates a feedback process that results in improvements to the Southeast Asian monsoon.

#A04 Dust Aerosols in ACME and Sensitivity to Model Resolution

Poster Title	Dust Aerosols in ACME and Sensitivity to Model Resolution
Authors	Yan Feng, Hailong Wang, Kai Zhang, Wuyin Lin, Po-Lun Ma, Jasper Kok, and Natalie Mahowald
Group	Atmosphere
Experiment	
Poster Category	Early Results
Submission Type	Either
Poster Link	

Abstract

Dust aerosols affect Earth's climate through direct and indirect perturbations of global energy balance, and interactions with atmospheric chemistry and biosphere. Therefore, it is important to quantify the model representation of dust aerosols for implications on both coupled water cycle and biogeochemical simulations with ACME. Here we present dust simulations from the low-res (ne30) and high-res (ne120) F2000 runs, evaluation with observations, and discuss sensitivity of dust predictions to model resolution.

Compared to the low-res model, increase of model resolution (by 4 times) leads to higher dust emissions (+29%) and increases dust aerosol optical depth (AOD) from 0.03 to 0.037, shifting to the higher end of the current estimates of dust AOD [0.02~0.04]. In the meantime, total aerosol wet removal is enhanced in the high-res model, which compensates for the increase of dust AOD, resulting in a global mean AOD (0.145) similar to that by the low-res model (0.143). After tuning dust emissions to match the low-res model, the total AOD decreases by 16% (sea salt emissions are also reduced). This could potentially change the estimate of total aerosol forcing between the two model resolutions. We will present the resulting changes in spatial distribution of aerosol optical properties and compare with observations.

In addition to dust optical properties, model resolution also affects dust deposition. In the high-resolution model with similar dust emissions (also dust AOD), wet removal of dust is more efficient and its contribution to global dust deposition increases from 22% to 28%. Regional and seasonal changes of dust deposition are more significant especially over the open ocean and high latitudes, with implications on predictions of soluble iron flux and snow/ice albedo. We will perform one-year runs with meteorology nudged to the reanalysis data, and evaluate the model predictions of dust emissions, AOD, surface concentrations and deposition with observations or observationally constrained model estimates.

#A05 High Resolution Modeling and Measurements in the Arctic

Poster Title	High Resolution Modeling and Measurements in the Arctic
Authors	Erika Roesler, Ben Hillman, Matthew McChesney, Peter Bosler, Oksana Guba, Mark Taylor, Lauren Dennis, Qi Tang
Group	Atmosphere
Experiment	n/a
Poster Category	Future Direction
Submission Type	poster or presentation
Poster Link	

Abstract

We present results from a variety of simulations targeted at understanding mixed-phase low clouds in the Arctic, particularly over the North Slope of Alaska. We will show the resolution sensitivity and phase partioning of cloud amount in the Department of Energy's ACME model with uniform low, uniform high, and variable resolutions with active atmosphere and land components. These results are compared with observations. The modeled cloud profiles differ substantially between the resolutions with potential for convergence. We also present results from simulations with a Large Eddy Simulation (LES) model, the System for Atmospheric Modeling (SAM), and a super-parameterized version of the atmospheric model in ACME. The stand-alone LES gives us insight into the phase partitioning of the cloud when compared with sensors mounted on a tethered balloon system taking in situ cloud measurements during various campaigns at Oliktok Point, Alaska. We find that the constrained ice crystal concentration plays a large role in the amount of liquid cloud produced when compared to observations. Synergistically, we will show work on detecting and tracking Arctic storms in the variable-resolution ACME configuration with the Stride Search software. We have expectations that this work will aid in informing the future ACME-Arctic regionally refined grid configuration.

#A06 Light-absorbing particles in snow and ice

Poster Title	Deposition and radiative impact of light-absorbing particles in snowpack and sea ice
Authors	Hailong Wang, Rudong Zhang, Mark Flanner, Nicole Jeffery, Susannah Burrows, Balwinder Singh, Yun Qian, Phil Rasch
Group	Atmosphere, land and ocean
Experiment	Watercycle and Cryosphere
Poster Category	Early Results
Submission Type	Poster or Presentation
Poster Link	

Abstract

Light-absorbing particles (LAPs) such as black carbon (BC) and dust in snowpack and sea ice can reduce the surface albedo and increase the speed of snow/ice melting, leading to a surface warming in the Arctic as well as lower latitudes across the northern hemisphere. To improve the compatibility between the treatment of atmospheric aerosols and the treatment of LAPs in snow over land and snow/ice over ocean, the ACME model has been modified to separately treat BC mixed internally within hydrometeors and externally with hydrometeors and to use size-dependent BC optical properties (i.e., depending on snow grain size and BC particle size). These modifications along with changes to the atmospheric aerosol transport and deposition have a substantial influence on the concentration and radiative impact of LAPs in snow/ice. Here we use one-year nudged low-resolution (ne30) F-2000 simulations to quantify the deposition rate and concentrations of LAPs and their radiative impact in ACME. Under the present-day conditions, LAPs in snow/ice have an annual mean positive clear-sky radiative forcing of up to 20 W m^{-2} over areas covered by snow/ice. There is a strong seasonal cycle in the forcing magnitude determined by changes in insolation and snow/ice cover. Under the all-sky conditions, the LAPs-induced radiative forcing ranges from 2 to 10 W m^{-2} in the boreal spring and summer over the Arctic, having great implications for the role of LAPs in melting snow/ice and warming the Arctic. We will discuss these results as well as further model developments needed for a more accurate/comprehensive representation of LAPs in snow/ice.

#A07 Parametric sensitivity and tuning for ACME-V1 atmosphere model based on short PPE simulations

Poster Title	Parametric sensitivity and tuning for ACME-V1 atmosphere model based on short Perturbed Parameters Ensemble (PPE) simulations: Method, application and limitations
Authors	Yun Qian, Hui Wan, Phil Rasch, Wuyin Lin, Kai Zhang, Shaocheng Xie, Po-Lun Ma, Balwinder Singh, Hailong Wang
Group	Atmosphere
Experiment	Water Cycle
Poster Category	Early results
Submission Type	Poster
Poster Link	

The ACME V1 (NE30_L72) atmosphere model has included many new features in the physics parameterizations. Complex nonlinear interactions between those new features create a big challenge for understanding the model behaviors and tuning. Using the one-at-a-time method, we often encounter cases where the tuning of one parameter leads to an offset of the accomplishment from the tuning of another parameter, or the improvement in one target variable leads to degradation of model fidelity in another target variable. The PPE simulations provide an opportunity to evaluate and optimize model fidelity in a comprehensive and systematic manner. We have finished 256x12 5-day simulations, in which 18 carefully-selected parameters in various physical processes were perturbed simultaneously using the Latin Hypercube sampling method. In this poster we will briefly introduce the framework of PPE simulations and present the results from the analysis that aimed at quantifying the model response to the most sensitive parameters and estimating the maximum likelihood of model parameter space for a number of important fidelity metrics. We also present the results focusing on a few issues related to model tuning using short PPE simulations, such as model parametric sensitivity with different spatial resolution, simulation lengthy, and skill score function i.e. global mean bias, root mean square error, spatial pattern correlation coefficient, and Taylor score. Finally we discuss a few limitations in using PPE simulations for global model tuning. Results from this analysis provide a more complete picture of the model behavior and improve our understanding of model physics associated with model parameters and their interactions.

Abstract

#A08 Regionally Refined ACME v1 model over the Contiguous United States

Poster Title	Regionally Refined ACME v1 model over the Contiguous United States
Authors	Qi Tang, Erika Roesler, Wuyin Lin, Xue Zheng, and Mark Taylor
Group	Atmosphere
Experiment	
Poster Category	Early Results
Submission Type	Poster
Poster Link	

Abstract

A key goal of the Accelerated Climate Modeling for Energy (ACME) project is to develop a high resolution, fully coupled Earth system model for the climate simulation and prediction. However, the globally uniform high resolution model is computationally intense. The regionally refined model (RRM) is developed as an economic tool for high resolution model development and studies. In this work, we document the performance of the ACME v1 Contiguous United States (CONUS) RRM with emphasis on longstanding climate model biases over the fine portion (i.e., CONUS) of the grids that are shared by the ACME v1 model, such as convection diurnal cycle, and summertime warm biases. We will examine the results from the free-running and nudging simulations and compare them with the uniformly low and high resolution simulations and observations.

#A09 The ACME spectral finite element non-hydrostatic dynamical core

Poster Title	The ACME spectral finite element non-hydrostatic dynamical core
Authors	Mark Taylor , Oksana Guba , David Hall , Andrew Steyer , Paul Ullrich
Group	Atmosphere
Experiment	
Poster Category	Early Result
Submission Type	poster or presentation
Poster Link	

Abstract

We will describe the development of a non-hydrostatic dynamical core for the Department of Energy's (DOE) Accelerated Climate Model for Energy (ACME) program. Our non-hydrostatic core is being developed in ACME's verison of HOMME and shares many of the underlying computational kernels including full support for variable resolution meshes. We use the Laprise mass coordinate formulation of the equations with the shallow atmosphere approximation. The Laprise system supports both hydrostatic and non-hydrostatic formulations. The hydrostastic formulation is nearly identical to ACME's existing hydrostatic dynamical core and the nonhydrostatic formulation adds two additional prognostic variables (vertical velocity and geopotential height). The discretization relies on mimetic methods: spectral finite elements in the horizontal and finite differences in the vertical, with both vertically Lagrangian and Eulerian options. We use a horizontally-explicit vertically-implicit (HEVI) IMEX approach for the time discretization. We introduce a moist potential temperature as a prognostic variable, and formulate the equations so that total energy are conserved through the use of mimetic discretizations. Initial results will be presented from several of the DCMIP idealized test cases.

#A11 Soluble iron model development within the ACME

Poster Title	**Soluble iron model development within the ACME**
Authors	**Douglas Hamilton, Rachel Scanza, Natalie Mahowald**
Group	Atmosphere
Experiment	BGC
Poster Category	Early Science
Submission Type	Poster
Poster Link	

Abstract

An intermediate complexity soluble iron is currently being incorporated into the atmospheric part of the Accelerated Model for Climate and Energy (ACME) model in order to better understand the role of dust and combustion sources of iron to be processed in the atmosphere to become more soluble and impact ocean biogeochemistry. Currently the ocean model include iron limitation and links between the iron and nitrogen cycle, and thus including a prognostic iron cycle is an important step in coupling the land to the ocean via the atmosphere. This model is more complicated than first generation models, and incorporates recent advances in atmospheric processing and differential source solubility, but allows soluble iron processing to occur without complicated chemistry or thermodynamic models. The overall scheme follows that of the previously implemented addition of soluble iron tracer to the bulk aerosol model.

To determine which modelling uncertainties dominate the potential supply of soluble iron to remote ocean regions, particularly those with a high nutrient low chlorophyll profile, a series of source attribution and atmospheric processing and deposition sensitivity studies are being undertaken. The dominant source of soluble iron to each ocean basin is defined, along with the sensitivity of that flux to modelled uncertainties in the atmospheric pH, chemical processing, and wet and dry deposition.

#A12 How can we make model tuning less laborious and more transparent?

Poster Title	How can we make model tuning less laborious and more transparent? Putting human expertise in the loop in visualization design and expert judgement.
Authors	Susannah Burrows, Aritra Dasgupta (PNNL), Sarah Reehl (PNNL), Lisa Bramer (PNNL), Kyungsik ("Keith") Han (PNNL), Po-Lun Ma, Phil Rasch, Yun Qian
Group	Atmosphere
Experiment	
Poster Category	Future Direction
Submission Type	poster
Poster Link	

Abstract

Climate model calibration ("tuning") is a complex and laborious task, requiring many thousands of hours of effort by experienced model developers for each new version of a component or coupled model. Two key obstacles to efficient model fidelity analysis are: (1) comparisons of model fidelity across multiple simulations are time-consuming, and (2) there is limited consensus on the relative importance of different model variables to evaluating overall fidelity. We address these challenges through a unique, close collaboration among climate modellers, visual analytics researchers, and statisticians, as part of an LDRD project at Pacific Northwest National Laboratory.

To address the first challenge, we have empirically tested four possible visual designs for the task of comparing model fidelity across many (>10) models and many (>10) variables (Dasgupta, et al., ACM SIGCHI, 2017). This study demonstrated that a visualization called the "slope plot" was preferred and perceived as more efficient for these tasks by climate model developers and users, compared with alternative visual displays (heatmaps, bar charts, and Taylor plots). This preference was exhibited by both highly experienced and less experienced scientists, and objective task completion accuracy was as good or better with the "slope plot" compared to other plots.

As a first step towards addressing the second challenge, we conducted a broad survey of the climate modelling community (with ca. 100 participants from four continents) to elicit expert judgments about the importance different variables in evaluating model fidelity. We present community-mean importance ratings for concise sets of variables. We quantify how community-mean importance ratings vary in response to the driving science question, quantify the degree of consensus on the importance of different model variables, and show that the distribution of responses does not differ significantly between less-experienced (median 10 y experience) and more-experienced (median 20.5 y experience) climate modelers. While we found a general lack of consensus with respect to importance ratings of particular variables, our results also suggest that once a certain level of expertise is acquired, additional experience in model evaluation currently may not necessarily lead to differences in assessments of model fidelity by individual experts.

In follow-on work, we are developing a visual analytic tool which will allow scientists to interactively adjust weights assigned to different model metrics and see how these impact model rankings, and to explore how model parameters impact model fidelity in a perturbed physics ensemble.

Dasgupta, Aritra, Susannah Burrows, Kyungsik Han, and Philip J. Rasch. "Empirical Analysis of the Subjective Impressions and Objective Measures of Domain Scientists' Visual Analytic Judgments." In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pp. 1193-1204. ACM, 2017.

#A13 Advances in the application of parallel split physics and dynamics

Poster Title	Advances in the application of parallel split physics and dynamics
Authors	Aaron Donahue Peter Caldwell
Group	Atmosphere
Experiment	
Poster Category	Problem/Solution
Submission Type	poster
Poster Link	

Abstract

Progress towards separating physics and dynamics onto separate computational cores will be presented. With an eye towards the future in high performance computing, the climate modeling community has been focusing on how to improve performance on a growing number of computational cores. The two most costly components of the atmosphere model, dynamics and physics, are both perfectly scalable up to the total number of elements and physics columns, respectively. However, the current coupling framework of sequential tendency splitting, by which the tendencies from physics are passed to the SE-dycore to advance the model state lead to a bottleneck in overall performance at the limit of the number of elements. With 9 times more physics columns than dynamics elements, a vast potential for performance enhancement is left untapped. Our hypothesis is that by switching to a parallel split architecture between physics and dynamics and solving each component on separate cores it is possible to extend the scalability of the model past the current limit. Early progress in applying a parallel-split architecture on separate cores will be presented as well as some promising results.

#A14 Impact of physics parameterization ordering in a global atmosphere model

Poster Title	Impact of physics parameterization ordering in a global atmosphere model
Authors	Aaron Donahue Peter Caldwell
Group	Atmosphere
Experiment	
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

Because weather and climate models must capture a wide variety of spatial and temporal scales, they rely heavily on parameterizations of sub-grid scale processes. The goal of this study is to demonstrate that the assumptions used to couple these parameterizations have an important effect on the climate of version 0 of the ACME model. Parameterizations in ACME are sequentially split in the sense that parameterizations are called one after another with each subsequent process feeling the effect of the preceding processes. This coupling strategy is non–commutative in the sense that the order in which processes are called impacts the solution. By examining a suite of 120 simulations with deep and shallow convection, macrophysics, microphysics and radiation parameterizations reordered, process order is shown to have a big impact on predicted climate. In particular, reordering of processes induces differences in net climate feedback that are almost as big as the inter–model spread in phase 5 of the Coupled Model Inter-comparison Project (CMIP). One reason why process ordering has such a large impact is that the effect of each process is influenced by the processes preceding it. Timing of where output is written is also an important indicator of diagnosed behavior. Application of K–means clustering demonstrates that the positioning of micro and macro physics plays a critical role on the model solution.

#A15 Improving Radiative Transfer Efficiency and Coupling in ACME

Poster Title	Improving the Efficiency and Coupling of Radiative Transfer in the ACME Earth System Model
Authors	Robert Pincus, Eli Mlawer, Jennifer Delamere, Mike Iacono, Rick Pernak, Brian Eaton
Group	Atmosphere
Experiment	
Poster Category	Future Direction
Submission Type	Poster
Poster Link	

Abstract

Compared to previous generations of Earth System Models, ACME has increased complexity, a greater degree of coupling among parameterizations, and higher spatial resolution, each of which leads to substantial increases in the computational demands. Realizing improved accuracy and efficiency in ACME, as well at its component parameterizations, is essential. While radiative transfer is fundamental to climate and weather prediction, the computational cost of this component remains a significant fraction of the total cost of model integration. Optimizing the efficiency and coupling of radiative transfer in ACME is the objective of this project. Although widely used for its accuracy, the RRTMG radiation code, which was developed at AER and is currently in ACME, is insufficient to meet the demands of modern parallel computing techniques. Under separate funding, the PIs of this project are developing a high-performance broadband radiation code for modern computer architectures called RRTMGP, which combines the strengths of RRTMG (high accuracy and the k-distribution treatment of gas absorption) with completely redesigned code to enable highly parallel processing across a range of platforms. This project supports the integration of RRTMGP into ACME through our collaboration with the ACME team.

#A10 The path to a well-tuned high-resolution ACME V1 atmosphere model and initial results

Poster Title	The path to a well-tuned high-resolution ACME V1 atmosphere model and initial results
Authors	Wuyin Lin, Shaocheng Xie, Phil Rasch, Po-Lun Ma, Yun Qian, Qi Tang, Chris Golaz, Peter Caldwell, Yuying Zhang, Hui Wan, Kai Zhang, Hailong Wang, Vince Larson, Rich Neale, Julio Bacmeister, Mark Taylor
Group	Atmosphere
Experiment	
Poster Category	Early Results
Submission Type	Poster
Poster Link	

Abstract

The atmosphere group has delivered a reasonably well-tuned high-resolution ACME V1 atmosphere model. This presentation is to document the pathway from the best well-tuned low resolution configuration, which however exhibits large biases at high resolution if without further tuning. A strategy heavily relying on the Cloud Associated Parameterization Testbed (CAPT) framework is adopted for the tuning at high resolution. As described in previous report, it is efficient in terms of computational cost and effective in terms of identifying and reducing model biases. The physical parameter tuning is guided by the Perturbed Parameter Experiments (PPE) at low-resolution, with successive fine tuning to narrow the perturbation range at high resolution using CAPT-type short-term hindcasts. High number of short-term hindcasts were performed, involving one or more parameters at a time, to gauge the sensitivity response. The best configuration is selected after taking into account overall model performance in various metrics at both global and regional scales. It produces consistent performance in both short-term hindcasts and climate simulations, with respect to other configurations. Initial results in cloud, precipitation, radiation, and large-scale thermodynamics will be shown, in comparison with observations and low-resolution simulations. The performance of high-resolution model is comparable to that of low-resolution in all essential metrics, with some notable improvements. The CAPT based tuning strategy can be extended to include more critical metrics, such as applicable variability characteristics and important regional features, and automated in continuing development of the ACME model to speed up the process and optimize the performance.

#C01 ACME Priority Metrics: A-PRIME

Poster Title	ACME Priority Metrics: A-PRIME
Authors	Kate Evans Milena Veneziani Salil Mahajan Xylar Asay-Davis Marcia Branstetter Phillip J. Wolfram Mark Petersen Susannah Burrows Charlie Zender Luke Van Roekel (not in a particular order right now)
Group	Coupled
Experiment	Watercycle
Poster Category	Early Result
Submission Type	Either
Poster Link	

Abstract

Developers of the ACME model must quickly determine if large-scale, coupled configurations of ACME are providing good results across global and local areas of interest. This allows developers to identify issues and attributes before major computer and personnel time is spent. The model's complexity requires that many eyes of developers covering a wide range of scientific expertise be able to view and assess model quality quickly. The python-based ACME Priority Metrics (A-PRIME) software has been developed to address these requirements. It is designed for mostly autonomous execution, targeting the leadership computing centers and Livermore National Lab's ACME1 clusters. Although A-PRIME provides only a wide view of model performance, it has been designed as a platform to hook up more substantial software that performs more robust analysis of specific model features. An example of this modular expansion is the ability to include analysis of atmospheric dynamics and extremes events, which is a scientific topic of interest by the software developers.

#C02 ENSO in ACME coupled runs

Poster Title	Possible causes of the weak ENSO in the ACME coupled runs
Authors	Jack Reeves Eyre , Xubin Zeng , Michael Brunke
Group	Coupled
Experiment	
Poster Category	Problem/Solution
Submission Type	Poster
Poster Link	

Abstract

El Niño Southern Oscillation (ENSO) is unrealistically weak in the latest ACME coupled model runs. This is manifest in both atmosphere and ocean variables; for example, sea surface temperatures (SSTs) and precipitation both show too little inter-annual variability in the central equatorial Pacific. With the aim of attributing the ENSO simulation deficiencies to the relevant model components – atmosphere, ocean, or coupler – we look at surface fluxes and associated atmosphere and ocean variables in the tropical Pacific from various coupled and un-coupled ACME runs. To gain additional insights, comparisons are made with ERA-Interim and CESM.

In the atmosphere, the main finding is a positive bias in the west Pacific net shortwave, even in runs where the total cloud amount is close to ERA-Interim. This issue is also present in CESM, pointing to possible problems with CAM5's cloud and radiation schemes. Mean wind stress and latent heat flux are biased in the central and east Pacific, even in an AMIP-like ACME atmosphere-only model run. The result of these biases in ACME coupled runs is that net surface heat flux is too large in the west Pacific.

In the ocean, we find that SSTs in coupled runs are too low across the tropical Pacific, despite the positive net heat flux biases mentioned above. Ocean mixed layer depth is too shallow in the east Pacific. In the west Pacific, near-isopycnal conditions exist in a deeper layer than in CESM, but the diagnosed mixed layer depth is much smaller, as strictly isopycnal conditions occur only in a very shallow (~10 m) layer.

Based on these analyses using coupled and un-coupled ACME runs, our hypothesis is that the most likely source of the weak ENSO in the ACME coupled runs is the unrealistic representation of vertical mixing in the ocean model caused by very high vertical resolution near the ocean surface.

#C03 Fully Coupled High-Resolution ACME V0.1 Approximate Present Day Transients

Poster Title	Fully Coupled High-Resolution ACME V0.1 Approximate Present Day Transients
Authors	Julie McClean, David C. Bader, Mark Taylor, Mathew Maltrud, Milena Veneziani, Qi Tang, Jack Ritchie, Detelina Ivanova, Marcia Branstetter, Kate Evans, Salil Mahajan
Group	Coupled
Experiment	
Poster Category	Early Result
Submission Type	Poster
Poster Link	

To provide a baseline for comparisons with subsequent ACME simulations, a 130-year 1850 pre-industrial control (PICNTRL) simulation and a 6-member ensemble of idealized present day (PD) transient simulations approximating 1970-2010 climate change, were carried out using fully coupled high-resolution ACME V0.1. This model has enhanced horizontal resolution in each of its components relative to standard coupled climate model resolution, and consists of the 1/4° Community Atmosphere Model 5 - Spectral Element (CAM5-SE) /Community Land Model 4 (CLM4), and 1/10° Parallel Ocean Program 2 (POP2)/CICE4 (sea ice model). The initialization protocol of branching present day transients off a multi-century PICNTRL and then running from 1850 to present day is precluded at these horizontal resolutions by lack of computer power. Consequently, our PD ensemble was initialized in three ways to test the viability of alternative approaches. Two members are branched off the PICNTRL at years 20 and 90, while three others were initialized from an atmospheric reanalysis-forced 0.1° POP2/CICE4 simulation run for 1948-2009 that was configured in the same framework as the fully coupled model. These latter initial conditions were selected to represent a spread in climate mode variability from the late 1960s to the late 1970s. Finally, a sixth transient was initialized from a two-year spun-up state of POP2/CICE, the same initial condition that was used to initialize the PICNTRL. All the PD transients started in 1970 and were run through 2000; the three started from the 60-year POP2/CICE4 continued through 2015. All transient ensemble member TOA imbalances reduced to roughly the observed present-day value during the last decade of the simulations. The simulated climate system was also assessed in terms of drift and bias, especially focusing on comparisons of present-day observations and the transient ensemble. Particularly, we examined sea surface temperature biases, meridional ocean heat transport and overturning circulation, sea ice thickness and concentration biases, and simulated climate mode variability.

#C04 Solar-J: Improved Solar-Heating

Poster Title	**An efficient and accurate model of sunlight for use in all ACME components**
Authors	Michael Prather (UCI), Juno Hsu (UCI), Alex Veidenbaum (UCI), Alex Nicolau (UCI), Philip Cameron-Smith (LLNL)
Group	Coupled
Experiment	All
Poster Category	Future Direction
Submission Type	Poster or presentation
Poster Link	

Abstract

An alternative module for solar heating is being developed and implemented into ACME by UC Irvine (Earth System Science and Information & Computer Science) and LLNL. Based on the recently published Solar-J code (Geosci.Model Dev., doi:10.5194/gmd-2017-27), it represents a high-accuracy solar heating module alternative to RRTMG-SW, providing also a photolysis module for aerosol and gas-phase chemistry. The increased accuracy comes with increased computational costs (15x), and thus a core part of this proposal is the computer science effort to optimize the backbone code for multi-stream scattering on the new DOE HPC systems. We have identified several opportunities for 3x to 10x speedups using GPUs and even reduced precision arithmetic. In parallel, we are pursuing alternative radiation-science optimizations with fewer visible-infrared wavelength bins but lower fidelity (possible 5x speedup).

Solar-J takes RRTMG-SW's spectral data as the gold standard for solar heating at visible-infrared wavelengths (0.7-12 µm), but it keeps the UCI Fast-J cross sections for O_2 and O_3 at uv-visible wavelengths (0.18-0.7 m) because UCI has a long history of optimizing radiative transfer in the stratosphere. For clear sky, overhead sun, both models agree to within 1-2% on tropospheric heating rates, as they should since we copied the RRTMG code for water vapor and other trace gas absorption. We found errors in RRTMG heating rates for large solar zenith angles (>84), becoming very large near the terminator. For the stratus cloud, RRTMG has a 3% low bias in planetary albedo across most solar zenith angles due to its 2-stream scattering vs. 8-stream scattering of Solar-J. Discrepancies with the cirrus cloud using any of RRTMG's three different parameterizations are larger than for stratus, less systematic. Averaging over cloud structures within a grid cell with RRTMG is by Monte Carlo (MC) selection of independent column atmospheres (ICAs) for each wavelength bin (RRTM MCICA paper describes rms errors >10% per column), while Solar-J uses cloud quadrature over those same ICAs using the same ICAs for all wavelengths (errors ~ 1%).

When ACME has solar-heating models that can be run with a range of accuracies, we can assess how such uncertainty maps onto climate simulations. Solar-J's resolved scattered light field at the surface can improve the fidelity of land/ocean biogeochemistry. Long-term goals are a single solar module providing a more coherent linkage with the biogeochemistry and surface heating.

#L01 Soil-Plant-Atmosphere Continuum model for ALM

Poster Title	Implementation of a rigorously verified, vertically resolved biophysics model in ALM to simulate transport of water, energy, and carbon along the soil-plant-atmosphere continuum
Authors	Gautam Bisht, Bill Riley and Ryan Knox
Group	Land
Experiment	Watercycle
Poster Category	Future direction
Submission Type	Poster
Poster Link	

Abstract

The land-atmosphere exchange of water, energy, and carbon fluxes plays a critical role in the evolution of the terrestrial water cycle. Several recent studies have demonstrated the need for explicitly resolving the vertical light and thermal regimes within the vegetation canopies and the surrounding air space to accurately capture vegetation response to future climate perturbations. Additionally, estimation of the hydraulic gradients through the soil-root-plant system is crucial for estimating transpiration. The ACME Land Model version 1.0 (ALM-v1.0) uses big-leaf and diagnostic canopy air modules to simulate fluxes of water, energy, and carbon exchanged between land and atmosphere. Moreover, ALM-v1.0 directly links stomatal responses to soil moisture instead of accounting for the stem water potential.

The overall objective of this research is to develop a rigorously verified, vertically-resolved soil-plant-atmosphere continuum (SPAC) model to simulate transport of water, energy, and carbon along the soil-plant-atmosphere continuum. The SPAC model will include: (i) extension of the ALM-v1.0’s VSFM formulation to simulate transport of water across the soil-root-xylem system; (ii) inclusion of a roughness sublayer model to account for turbulence within canopies; (iii) development of a vertically resolved shortwave and longwave radiation scheme; and (iv) development of models for conservation of water, energy, and carbon within the SPAC. To deliver this new capability to ALM, we will use the Portable, Extensible Toolkit for Scientific Computation (PETSc) library for the numerical solution of the discretized equations. Automated Verification & Validation will be performed to build trust-worthiness of the high-fidelity SPAC model by comparing numerical solution for multiple benchmark problems with known and manufactured solutions.

#L02 Development and testing of ALMv1-ECA-CNP

Poster Title	Development and testing of ALMv1-ECA-CNP
Authors	QING ZHU. Bill Riley, Jinyun Tang
Group	Land
Experiment	BGC
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

We describe here model development and benchmarking for one of the two land model versions integrated in ALMv1 that will participate in the BGC Inter-comparison: ALMv1-ECA-CNP. ALMv1-ECA-CNP is unique in several ways that strongly affect the model's estimates of terrestrial C budgets: (1) plants have a flexible CNP stoichiometry; (2) plant allocation and storage are dynamic and respond to nutrient, water, and light stresses; (3) a multi-element co-limitation concept replaces Liebig's law of the minimum for nutrient controls on photosynthesis; (4) multiple substrate & nutrient competition is based on the Equilibrium Chemistry Approximation (ECA); and (5) BeTR vertically-resolved multi-phase reactive transport solver is used for numerically robust solutions. This poster describes the model assumptions, implementation, benchmarking, and predictions of global C, N, and P dynamics.

#L03 Evaluation of two decomposition schemes in ALM

Poster Title	Evaluation of two decomposition schemes in ALM against LIDET, C14 observations and global soil carbon maps
Authors	Xiaojuan Yang Daniel Ricciuto Peter Thornton
Group	Land
Experiment	
Poster Category	Early Results
Submission Type	poster
Poster Link	

Abstract

Soils contain the largest pool of carbon in terrestrial ecosystems. Soil carbon dynamics and associated nutrient dynamics play significant roles in regulating global carbon cycle and atmospheric CO2 concentrations. Our capability to predict future climate change depends to a large extent on a well-constrained representation of soil carbon dynamics in ESMs. Here we evaluate two decomposition schemes - converging trophic cascade (CTC) and Century - in ACME Land Model using data from the long-term intersite decomposition experiment team (LIDET), radiocarbon (14C) observations, and Harmonized World Soil Database (HWSD). For the evaluation against LIDET, We exercise the full ACME land model, including seasonal variability in nitrogen limitation and environmental scalars (temperature, moisture, O2), in order to represent LIDET experiment in a realistic way. We show that the proper design of model experiments is crucial to model evaluation using data from field experiments such as LIDET. We also use ^{14}C profile data at 10 sites to evaluate the performance of CTC and CENTURY decomposition scheme. We find that the ^{14}C profiles at these sites are most sensitive to the depth dependent decomposition parameters, consistent with previous studies.

#L04 System Engineering for ALM

Poster Title	A System Engineering perspective on the ACME Land Model development effort
Authors	Peter Thornton
Group	Land
Experiment	
Poster Category	Problem/Solution
Submission Type	Poster
Poster Link	

Abstract

The evolution of a climate model, considered as a whole or as a collection of components, takes place through an iterative process of conceptualization, design, development, application, analysis, and re-conceptualization. It is possible for this evolution to proceed "organically", depending on the changing passions and proclivities of the group of developers that happen to be engaged over time. It is also possible to conceive a more mission-oriented approach that takes explicit account of the objectives of various stakeholders, including science drivers but potentially also policy applications. Here I use the ACME Land Model as an example to illustrate how a System Engineering approach might be applied to the iterative model development process to help identify requirements, guide designs, quantify risks and uncertainties, and deliver mission-specific outcomes for stakeholders. I examine the extent to which the current ACME process already follows a System Engineering approach, and outline some suggestions for how modest recasting of processes could result in a higher likelihood for successful mission outcomes (meeting stakeholder needs). A central recommendation is to consider the model as a system of systems, where a common process for requirements gathering, design, prototyping, implementation, deployment, and analysis can be applied recursively at multiple levels in the system hierarchy. This approach borrows extensively from lessons learned by NASA engineering centers through their experience with multi-component missions with deep system hierarchies. Examples for ALM provided here could serve as a springboard for discussion in relation to other ACME components, and to the ACME coupled system as a whole.

#L05 Exploring the Capability of Topography-based Subgrid Structures

Poster Title	**Exploring the Capability of Topography-based Subgrid Structures to Capture Variability of Soil Properties in Global Datasets**
Authors	Teklu K Tesfa ; Ruby Leung
Group	Land, CMDV-Land
Experiment	
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

Topography is an important factor in soil formation, exerting dominant control on the spatial patterns of soil properties such as soil depth over watersheds. For example, soils are deeper and finer in texture over valleys compared to the shallower and coarser texture over ridges of watersheds. As an effort to improve representation of the effect of topographic heterogeneity in land surface processes, recently, a new topography-based subgrid structure has been developed and evaluated for its capability to capture spatial variability of climate and land cover over topographically heterogeneous region of the western United States. In this study, the capability of the new subgrid structure is evaluated for its capability to capture spatial pattern of various soil properties. For this purpose, global datasets of soil properties such as depth to bedrock are mapped to the new topography-based subgrid structure. Results are compared against the current subgrid structure of the ACME land model using various statistical metrics.

#L06 Forward and Inverse Uncertainty Quantification for ALM Single Point Model

Poster Title	Forward and Inverse Uncertainty Quantification for ALM Single Point Model
Authors	Khachik Sargsyan, Daniel Ricciuto
Group	Land
Experiment	
Poster Category	Early Result
Submission Type	poster
Poster Link	

Abstract

The poster will highlight recent advances and results relevant to uncertainty quantification (UQ) method development and application to ACME Land Model (ALM). We are developing and applying two broad categories of UQ algorithms:

- *Forward UQ* encompasses input parameter uncertainty representation, propagation, as well as global sensitivity analysis (GSA), otherwise known as variance-based decomposition. We will highlight Polynomial Chaos (PC) expansions and Bayesian compressive sensing (BCS) for high-dimensional model surrogate (proxy, metamodel, emulator) construction as the main ingredient of any forward UQ study.
- *Inverse UQ* is essentially parameter estimation (calibration, tuning) given observational data. We will highlight Bayesian machinery, and a recently developed model error embedding approach for simultaneous estimation of physical parameters and structural errors.

The poster will demonstrate surrogate model construction and GSA (forward UQ) based on ensemble of simulations of ALM point model for a select set of FLUXNET sites, as well as initial exploratory results of calibration (inverse UQ) with structural errors given monthly latent heat flux data at the Missouri Ozark flux tower.

#L07 Global LCLUC drivers

Poster Title	Spatiotemporally dynamic drivers of global land cover and land use change in the past century
Authors	Atul Jain Xiaoming Xu Katherine Calvin
Group	*Land*
Experiment	
Poster Category	Early Result
Submission Type	Presentation
Poster Link	

Abstract

Uncovering the historical land cover and land use change (LCLUC) drivers is vital for projecting the future LCLUC. Due to the differences from spatiotemporal scales, methods and LCLUC datasets, previous studies have not reached a consensus regarding the global LCLUC drivers in terms of biophysical and socioeconomic aspects. Here we present a global scale estimation of the biophysical and socioeconomic drivers of several dominant LCLUC types, e.g. deforestation, agriculture intensification, and urbanization over the past century (1900~2015). The LCULC drivers are extremely complicated with great variances in both spatial and temporal scales. More advanced models are needed to account for the spatial and temporal heterogeneities. We first use a time-series segmentation technique to identify different periods for each LCLUC type, and analyze the key LCLUC features within each period globally. Then we detect the hotspot regions in term of Agro Ecological Zones (AEZs) for each LCLUC type. Finally, we employ the geographically weighted logistic regression to assess the spatially explicit drivers of LCLUC in each period.

The spatial and temporal patterns of major LCLUC types revealed by our study can provide a perspective in the overall global LCLUC characters at a centennial time scale. The spatially and temporally explicit LCLUC drivers also promote the understanding of the complex LCLUC processes. The identified biophysical and socioeconomic components will be coupled with an ACME to improve the accuracy of future projections of LCLUC. The methodology developed in this study will also serve as a comprehensive example for LCLUC studies at different spatiotemporal scales.

#L08 Vegetation dynamics under water stress

Poster Title	**Toward better predictions of vegetation dynamics under water stress in ACME**
Authors	Chonggang xu, Bradley Christoffersen, Wei Liang, Daniel Johnson, Devin Goodsman, Minzi Wang, Sanna Sevanto, Ryan Knox, Nate McDowell, Charlie koven
Group	Land
Experiment	Water Cycle, BGC
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

Water is a key regulator of vegetation growth and mortality. Currently, the impact of water stress on growth and mortality in ACME are simulated based on simple empirical adjusting factors, which may fail under future novel climate conditions. In this study, we developed more process-based representations of water limitation functions, mortality, and insects toward better predictions of vegetation dynamics. To test these models, we have also compiled sap fluxes and leave water potential observations, drought-induced tree mortality from forest inventory and insect productivity for model evaluations. We showed promising impact of incorporating these process-level representations at the site level. In the next step, we will test these models at the regional and global scales. We expect that these process-based model, parameterized and benchmarked at the global scales, can make robust predictions of future vegetation dynamics under water stress.

#L09 Evaluating CMIP5 and CMIP6 land use forcings for ACME v1

Poster Title	**Evaluating CMIP5 and CMIP6 land use forcings for ACME v1**
Authors	ritvik sahajpal, George Hurtt, Louise Parsons Chini
Group	Land
Experiment	
Poster Category	Early result
Submission Type	poster
Poster Link	

Abstract

Land-use activities have influenced the Earth's climate system by significantly altering biogeochemical and biogeophysical properties at local to planetary scales. Yet the precise magnitude and character of land-use effects on climate remains uncertain, and this uncertainty in turn limits the accuracy of future projections. To address this issue, we have developed a new set of global gridded land-use forcing datasets to link historical land-use data and future projections in a standard format required by climate models. For CMIP6, land-use has become a required forcing and use of the land-use harmonization dataset is designated as an entry card for participating in CMIP6 experiments. The second generation land-use harmonization (LUH2) product expands on the land-use forcing dataset generated for CMIP5 and includes new land-use states (and all transitions between them), updated inputs, and new management layers.

As a first step towards understanding the impacts of different land-cover datasets on the Earth climate system, we compared the land-cover information and surface datasets generated from two versions of the land-use harmonization products (LUH1 and LUH2). This process involved converting the latest version of the land-use harmonization dataset (LUH2) into the land-use harmonization (LUH1) dataset format by mapping the thematically and spatially more resolved LUH2 land use states and transitions to the LUH1 land use states (primary, secondary, crop, pasture and urban). The dataset in LUH1 format was processed through a land use translator to produce a surface dataset. We assessed the two land-use datasets across a suite of diagnostics, including global comparisons at different time-periods for the following metrics: net and gross transitions, land use area for different land use states, secondary age profile, increase in secondary land due to human impacts, wood clearing estimates, and potential biomass and forest area estimates. To assess the land-cover and surface datasets produced from the land-use datasets, we compared the changes in cropland and forest plant functional types between the datasets. Implications of differences in the two datasets on carbon cycle simulations will also be presented.

#L10 Integrating the Functionally Assembled Terrestrial Ecosystem Simulator (FATES) into the Accelerated Climate Model for Energy (ACME)

Poster Title	Integrating the Functionally Assembled Terrestrial Ecosystem Simulator (FATES) into the Accelerated Climate Model for Energy (ACME)
Authors	Ryan Knox, Gautam Bisht, charlie koven, Benjamin Andre, Bill Riley, Rosie Fisher, Jennifer Holm, Junqi Yin, Robert Jacob, Lara Kueppers and Jeffrey Chambers
Group	Land, CMDV-Land
Experiment	
Poster Category	Early Result
Submission Type	poster
Poster Link	

Abstract

The Functionally Assembled Terrestrial Ecosystem Simulator (FATES) represents processes related to the demographics and dynamics of aboveground natural vegetation. It serves as a focal component of the Model-Experiment (MODEX) approach to the Next Generation Ecosystem Experiment (NGEE-Tropics). The Accelerated Climate Model for Energy (ACME) represents the vast super-set of processes of an earth simulation model. As such, it utilizes models such as FATES to simulate specific components of the earth system. Here we describe the process of coupling FATES into the ACME software framework, describe some of our testing methodologies, and evaluate some output of ACME-FATES simulations from scientific and software perspectives.

#L11 Migrating PFLOTRAN into ACME Land Model

Poster Title	Migrating PFLOTRAN Reaction Network from NGEE-Arctic into ACME through a Generic Biogeochemistry Interface
Authors	Gangsheng Wang ; Fengming Yuan ; Peter Thornton
Group	Land
Experiment	BGC
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

Explicit representation of microbial communities and functions in soil biogeochemistry (BGC) processes is a major task in the ACME Land Model (ALM) development. The microbe-enabled BGC module will be implemented in the PFLOTRAN-BGC framework, which has been developed under the NGEE-Arctic project. PFLOTRAN can solve a system of nonlinear partial differential equations describing multi-phase, multi-component and multi-scale 3-D flow and reactive-transport in porous media. We have developed a generic BGC-Interface in ACME to facilitate the migration of NGEE-PLFOTRAN to ACME. The ultimate objective of this interface is to enable flexible and fast development and evaluation of soil BGC modules and their coupling to various thermohydrology and aboveground vegetation modules. The BGC-Interface includes a generic data-structure to pass data between submodels (i.e., vegetation, vegetation and BGC) and allows a selection of multiple instances (e.g., ALM-BGC and PFLOTRAN-BGC for BGC-submodel) for each submodel. We test ALM-PFLOTRAN and compare it to the original ALM and NGEE-PLOTRAN at the Barrow site, AK. Global-scale test of the ALM-PFLOTRAN will also be conducted through this collaboration between ACME and NGEE-Arctic projects.

#L12 MOSART-BGC in ACME

Poster Title	MOSART-BGC in ACME: Model development and preliminary results
Authors	Hong-Yi Li ; Jinyun Tang ; Ruby Leung
Group	Land
Experiment	
Poster Category	Early Results
Submission Type	Poster
Poster Link	

Abstract

Representing riverine biogeochemistry is a critical step to fill the missing links between land and aquatic interfaces and the biogeochemistry cycling in the atmosphere-land-river-ocean continuum. As such, we here extend the Model for Scale Adaptive River Transport (MOSART) to include the riverine transportation and transformation of biogeochemical fluxes, and hence denote the model as MOSART-BGC. MOSART-BGC integrates the existing riverine modules, MOSART-Water, MOSART-heat and MOSART-sediment, and the Biogeochemical Transport and Reaction (BeTR) module version 2 of land biogeochemistry. Our preliminary global simulation results will demonstrate the transport of dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) from ALM-BeTR2 to rivers, through the networks and into the ocean, and riverine transformation of DOC into DIC and evasion of DIC into atmosphere (CO2) as a simple function of DOC, DIC concentrations and water temperature. Finally, we will discuss current limitations and next steps to achieve the coupled modeling of river and land biogeochemistry.

#L13 Overviews of the NGEE-Tropics Project and FATES, a Demographic Vegetation Model for the ACME ESM

Poster Title	Overviews of the NGEE-Tropics Project and FATES, a Demographic Vegetation Model for the ACME ESM
Authors	charlie koven, Jeff Chambers, Lara Kueppers, Ryan Knox, Rosie Fisher, Gautam Bisht, Benjamin Andre, chonggang xu, Brad Christoffersen, Jennifer Holm, Bill Riley, David Lawrence, Deb Agarwal, Stuart Davies, Michael Keller, Ruby Leung, Nate McDowell, Rich Norby, Alistair Rogers
Group	Land
Experiment	
Poster Category	Future Direction
Submission Type	Poster
Poster Link	

Abstract

In this poster, I will describe an overview of 2 things: (1) The NGEE-Tropics project, including its overview, goals, modeling and measurement activities; and (2) an overview of the Functionally Assembled Terrestrial Ecosystem Simulator (FATES), which is a demographic vegetation model for the ACME ESM. FATES is both a core focus of model development activities in NGEE-Tropics, as well as an integrating tool in the design and scientific organization of the NGEE-Tropics project, and I will highlight some basic theoretical underpinnings and some initial applications of the model.

#L14 Productivity and biomass in Amazon forests using ACME land model

Poster Title	Improving simulated spatial distribution of productivity and biomass in Amazon forests using ACME land model
Authors	Xiaojuan Yang, Peter Thornton, Daniel Ricciuto, Xiaoying Shi, Forrest Hoffman
Group	land
Experiment	BGC
Poster Category	Early results
Submission Type	Poster
Poster Link	

Abstract

Field observations have shown that soil edaphic factors play important roles in affecting productivity and biomass in Amazon tropical forests. Quesada et al. (2012) showed that soil phosphorus is the single most important factors in affecting wood production rates. In addition, observational data suggest that the tree mortality and hence above ground biomass are mainly controlled by soil physical and chemical properties. Here we aim to integrate the insight from these tropical forest observational studies into the development and evaluation of ACME land model (ALM). The implementation of phosphorus cycle in ALM allows us to explore how soil P availability affects the spatial variation in tropical forest productivity. Furthermore, the introduction of the controls of soil property on tree mortality enables us to capture the spatial distribution of above ground biomass in the Amazon region.

#L15 Runoff partitioning and its impact on water and energy budgets in the ACME land model

Poster Title	Runoff partitioning and its impact on water and energy budgets in the ACME land model
Authors	Maoyi Huang , Ruby Leung , Gautam Bisht
Group	Land
Experiment	
Poster Category	'Early Result'
Submission Type	Poster
Poster Link	

Abstract

Soil moisture plays an important role in the coupled water, energy, and carbon cycles. Surface and subsurface runoff are important boundary fluxes that influence soil moisture directly. These fluxes are parameterized in land surface models (LSMs) based on conceptual theories or physical laws, which describe the subgrid heterogeneities of land surface and subsurface runoff using probability distributions derived from subgrid topography or using analytical functional forms with parameters. To date, two runoff parameterizations are widely used in LSMs: the TOPMODEL and Variable Infiltration Capacity (VIC) formulations. The TOPMODEL formulation makes the following assumptions: (1) the saturated zone dynamics could be approximated by successive steady states; (2) the recharge rate to the water table over a catchment is homogeneous; (3) the hydraulic gradient of the saturated zone could be approximated by the local surface slope; and (4) the distribution of downslope transmissivity is assumed to be an exponential function of storage deficit or depth to the water table. In the VIC formulation, surface runoff generation is a function of the mean soil moisture capacity as well as its spatial heterogeneity in the shallow soil layers over a grid cell, and subsurface runoff generation can be approximated by a nonlinear relationship as a function of deep-layer soil moisture Therefore, theoretically TOPMODEL is more suitable under humid climate and mountainous areas with surface saturation and large relief, while VIC is more general but requires calibration of model parameters. However, performance of a LSM in simulating runoff and its partitioning is highly dependent not only on the implementation details of the runoff scheme, but also on its non-linear interactions with other LSM parameterizations. In this study, numerical experiments were conducted using the ACME land model (ALM) with the TOPMODEL and VIC formulations. The model simulations are benchmarked against runoff fields from Global Runoff Data Centre, evapotranspiration datasets derived from FLUXNET and the Moderate Resolution Imaging Spectroradiometer, the terrestrial water storage data from the Gravity Recovery and Climate Experiment, and gridded mean annual base flow indices estimated from streamflow observations globally. Results from this study will be used to guide sensitivity analysis and calibration of ALM runoff parameters in the near future.

#L16 Soil BGC Scaling

Poster Title	Hierarchical scaling of soil biogeochemistry in ALM
Authors	Jinyun Tang ,@Bill Riley
Group	Land
Experiment	
Poster Category	Future direction
Submission Type	Poster
Poster Link	

Abstract

Soil biogeochemistry is one of the dominant uncertainties in predicting carbon-climate feedbacks using earth system models. This uncertainty is partly attributed to the complex network structure that links the many biogeochemical processes in soil, which is not well resolved with existing mathematical framework and model structures. We here propose to implement a hierarchical framework that integrates (1) the network-based SUPECA kinetics for substrate uptake by plants and microbes in soil, (2) a unified growth model for microbes, and the (3) multi-phase reactive transport module BeTR to achieve a consistent scaling of the many soil biogeochemical processes. This new development will also consider the flexible coupling of soil biogeochemistry with different vegetation dynamics. We expect such a develop will enable a flexible and robust assessment of the uncertainty in carbon-climate feedbacks resulting from considering different land biogeochemical processes.

#L17 ACME-FATES: dynamic vegetation and demography

Poster Title	ACME-FATES: Using dynamic vegetation and demography to capture changes in forest carbon cycling and competition
Authors	Jennifer Holm, Ryan Knox, Bill Riley, charlie koven
Group	Land, CMDV-Land
Experiment	Demography
Poster Category	Early Result
Submission Type	Presentation
Poster Link	

Abstract

The inclusion of dynamic vegetation demography in Earth System Models (ESMs) has been repeatedly identified as a critical step in moving ESMs towards more realistic representations of plant ecology, and the processes that govern the climatically important fluxes of carbon, energy, and water mediated by vegetation. Demographic processes have not been represented in the newly developed ACME Land Model (ALM) until the recent integration of the Functionally-Assembled Terrestrial Ecosystem Simulator (FATES). We summarize the first modeling results of ALM-FATES from a single point simulation in Brazil and a globally gridded simulation. We present multiple process approaches to represent plant competition for light, and alterations to the Perfect Plasticity Approximation (PPA) and discretized PPA used in ALM-FATES.

The motivation behind the Brazil simulation is that there is large uncertainty about whether the Amazon will be a carbon sink or source over the next century under a changing climate and rising atmospheric CO_2 levels. To investigate this uncertainty, we simulated the ecosystem dynamics of a lowland moist tropical forest using four models for a detailed model comparison. The four models are ED2, ALM-FATES (structured vegetation models), CLM4.5-BGC, and ALMv1-ECACNP (unstructured vegetation models), driven with local climate and CO_2 forcing from the preindustrial period to 2100. Tree inventory data from a site north of Manaus, Brazil, with repeated demographic measurements from 1996-2011 were compared against simulations from the same time period. Compared to field observations, ED2 and ALM-FATES showed good agreement with observed biomass and forest size structure, but predicted higher growth and mortality fluxes than observed. These biases led to high, continual growth in all size classes and functional groups, whereas the field data indicate that a quarter of canopy trees showed no detectable growth, and the site had neutral biomass accumulation over the 15-year period. With a doubling of CO_2 by 2100, all models predicted an appreciable forest sink, but due to contrasting process representations, different trends in biomass accumulation and opposing responses of vegetation turnover rate emerged. The differences were attributed to phenology response, nutrient constraints, and down-regulation of photosynthesis (native to CLM4.5-BGC and ALMv1-ECA-CNP only), inability to capture accurate density dependent processes (ED2 only), and large woody net primary productivity responses in ED2 and ALM-FATES. Determining appropriate process-level model benchmarks for constraints on carbon accumulation rates with rising CO_2 is an important focus for future research.

#L18 Experimental evidence supports Relative Demand hypothesis

Poster Title	Experimental evidence from CO2 enrichment experiments supports the "Relative Demand" approximation for nutrient competition
Authors	Peter Thornton , Daniel Ricciuto , and others
Group	Land
Experiment	BGC
Poster Category	R = Early Result
Submission Type	Presentation or Poster
Poster Link	

Abstract

Using experimental data from two different types of CO2 enrichment experiments, we show that there is empirical evidence to support an approximation for the behavior of multiple plant and microbial players as they compete for common nutrient resources, known as the Relative Demand (RD) approach. The RD approach is founded on the hypothesis that various plant and microbial components of an ecosystem have efficient mechanisms for obtaining nutrient resources, which can be abstracted as varying nutrient sink strengths. To the extent that multiple competitors share space in a common rhizosphere, the relative magnitude of expressed sink strength should correlate with nutrient demands for persistence and growth, given a current ecosystem and organism state, and these relative demand quantities should correlate as well with actual nutrient uptake by each competitor. To take the simple example of two plant species growing growing in a mixed plot, one with a well-developed canopy exhibiting rapid biomass accumulation, and another with a poorly developed canopy and low growth rate: The nutrient demand to maintain growth of the larger, more vigorous species is obviously higher than the nutrient demand to maintain growth of its smaller and less vigorous neighbor. The RD hypothesis is that, through a multitude of biological, physiological, and ecological mechanisms, the more vigorous plant species will be able to compete more effectively than its less vigorous neighbor for the available nutrient resources in the soil, in approximate proportion to the ratio of its own demand to the total demand.

We use experimental and modeling data from a recent intercomparison study based on the long-term Free Air CO2 Enrichment (FACE) experiments carried out at Oak Ridge National Laboratory and at Duke University to demonstrate that observed total plant nitrogen uptake under conditions of increasing nitrogen demand driven by higher rates of photosynthesis is qualitatively and quantitatively consistent with an operational implementation of the RD approach as used in the ACME Land Model. We also show that independent short-term CO2 enrichment experiments under conditions of varying nitrogen availability offer important guidance for how storage pools for carbon and nutrients in plants are likely to regulate short-term carbon and nutrient uptake dynamics, and how those storage pools can influence long-term plant-microbe interactions through competition.

#L19 Global terrestrial nutrient uptake

Poster Title	Half of global terrestrial nutrient uptake occurs in the absence of photosynthetic demand: Implications for the ACME BGC Inter-comparison
Authors	Bill Riley, QING ZHU, Jinyun Tang
Group	Land
Experiment	BGC
Poster Category	Early Result
Submission Type	presentation (or poster if presentation is unavailable)
Poster Link	

Abstract

The ACME BGC inter-comparison has a primary goal of evaluating two ALMv1 representations of nutrient controls on the terrestrial C cycle: ALMv1-ECA-CNP and ALMv1-CTC-CNP. These models take fundamentally different approaches to representing nutrient competition, plant nutrient acquisition, and plant nutrient use, resulting in distinct C cycle dynamics. We focus here on one important aspect of these interactions: nutrient competition and acquisition at the root-soil interface. In this regard, an important distinction between the two model structures is the Equilibrium Chemistry Approximation (ECA) versus Relative Demand (RD) concepts. Decades of observations indicate that plant nutrient uptake is de-coupled from instantaneous photosynthetic nutrient demand in terrestrial systems, contradicting a fundamental basis of the RD approach integrated in ALMv1-CTC-CNP. Our analysis using ALMv1-ECA-CNP indicates that about half of global N and P uptake occur outside of photosynthetically active periods, with non-growing season uptake being particularly important in high latitudes and nighttime uptake being particularly important at lower latitudes. In this presentation, we describe ALMv1-ECA-CNP concepts, benchmarking, and estimates of the implications of non photosynthetically active period nutrient acquisition on global C, N, and P cycles.

#L20 Implementing variable soil thickness in ALM

Poster Title	Variable soil thickness in ALM: Implementation without elevation classes and preparation for implementation with elevation classes
Authors	Michael Brunke, Xubin Zeng
Group	Land
Experiment	Watercycle
Poster Category	Early Result
Submission Type	
Poster Link	

Abstract

Currently, the ACME Land Model (ALM), like most other land surface models, has a constant depth (~3.8 m) that is hydrologically active. To compensate for this constant “soil” depth, a poorly-defined unconfined aquifer somewhere below this depth is included. As an alternative, variable soil thickness based upon our global ~30 arcsec (or ~1 km) estimate of bedrock depth (Pelletier et al. 2016) has been implemented into the ALM for inclusion into ACMEv2. This implementation allows for the removal of the unconfined aquifer when turned on. As seen in Brunke et al. (2016) for CLM4.5, soil moisture profiles are most impacted in locations where the soil column is made shallower than the original 10 layers. Hydrologic fluxes such as surface runoff and baseflow are also impacted. Surface runoff is less affected with small changes to the amplitude of the mean annual cycle at some locations. Baseflow is more affected from changes to annual cycle amplitude and temporal changes to the timing of the annual maximum.

We are furthering the implementation of variable soil thickness by improving the cold start spin-up and supporting the inclusion of elevation classes which will enhance the representation of variable soil thickness in the model. Spin-up with variable soil thickness takes at least 200 years for the soil temperature of deep layers to reach equilibrium. This happens because of the lag needed to move heat from the surface down to deeper layers due to an unrealistic initialization of a constant 274 K for non-urban and non-lake grid cells. We propose to initialize soil temperature based upon the climatological 2-m air temperature at each particular grid cell. We are also investigating the best ways to map atmospheric forcings from grid-average quantities to quantities for the individual elevation classes within grid cells. The quantities that need to be mapped include near-surface temperature, humidity, and wind as well as surface precipitation and surface downward shortwave and longwave radiation.

#O01 A Biogeochemical Modeling Studying on San Francisco Bay

Poster Title	A Biogeochemical Modeling Studying on San Francisco Bay
Authors	Zhengui Wang, Fei Chai, Qianqian Liu, Y. Zhang
Group	Ocean/ICE
Experiment	BGC
Poster Category	Future Direction
Submission Type	poster
Poster Link	

Abstract

In San Francisco Bay, phytoplankton growth is largely influenced by nutrient dynamics and suspended particulate matter (SPM). A biogeochemical model is developed for this area to study the phytoplankton dynamics. This model is based on Carbon, Silicate, and Nitrogen Ecosystem (CoSiNE) model, which is coupled with Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM). A new version of CoSiNE model is developed recently with a better model structure, a separate input file and new functionalities, aimed to facilitate the usage of this model in various water environments including ocean and estuaries. The calibration of this model is done in San Francisco Bay for 2011. We will introduce how different nutrients regulate the phytoplankton growth in San Francisco Bay. Also, we will investigate the influence of SPM on phytoplankton by incorporating SPM into our model. The future development of CoSiNE model involves coupling the model with MPAS-O/biogeochemical model regarding nutrient recycling process, carbon cycle and light filed.

#O02 CICE Consortium

Poster Title	CICE Consortium: Accelerating sea ice model research, development and transfer to operations
Authors	Elizabeth Hunke
Group	Ocean/Ice
Experiment	
Poster Category	Problem/Solution
Submission Type	poster
Poster Link	https://acme-climate.atlassian.net/wiki/download/attachments/127819231/Consortium_Poster_ACME2017.pdf?api=v2

Abstract

The primary developers and stakeholders of the Los Alamos sea ice model, CICE, are forming a new sea-ice modeling consortium to formalize and enhance the collaborative alliance that has fostered the model's development over the past two decades. The CICE Consortium will incorporate and maintain new research and development in collaboration with the larger sea ice modeling community, in order to accelerate the transfer of scientific sea ice model development into operational use and for the wider research community, including ACME. This multi-agency, international Consortium represents a microcosm of larger R&D/operational alliances now developing within the U.S. climate and weather prediction community, for which our experience may provide guidance, including a governance model, intellectual property protection within an open software development environment, and innovative solutions for code confidence and acceptance testing as it advances from research into operations.

#O03 Evaluation of small-scale, nonlinear physical processes in climate simulations

Poster Title	Evaluation of small-scale, nonlinear physical processes in climate simulations: the role of resolution and mixing parameterizations
Authors	Luke Van Roekel Phillip J. Wolfram
Group	Ocean/ice
Experiment	
Poster Category	Result
Submission Type	poster
Poster Link	

Abstract

Secular changes in Earth's climate system are driven by large-scale, long-term sequestration of heat within the deep ocean. Small scale processes, such as mixing occurring due to ocean eddies, interacts via nonlinear feedbacks to exert a dominant impact on the transport of mass and heat in the ocean. These small scale processes impact the climate in two ways: vertically, heat is exchanged between the deep ocean and atmosphere via vertical mixing within the oceanic surface boundary layer; Horizontally and internally within fluid layers, heat transport occurs laterally along ocean density layers that periodically outcrop to the surface or deep ocean, providing a mechanism for deep-ocean entrainment of heat.

These vertical and horizontal processes that mix the fluid occur at subgrid resolutions for most climate simulations. The regional refinement capability of MPAS-O has allowed for the direct simulation of important small scale processes in selected regions and their impact on the climate. At such fine resolutions, post-processing diagnostics of mixing impacts is impractical. MPAS-O has in-situ analysis capabilities (e.g., via Lagrangian In-situ Global High-performance particle Tracking (LIGHT) as well as the Eliassen-Palm Flux Tensor) that allow for diagnosis and evaluation of the mixing impact of small scale eddies on the large scale flow. This diagnosis can be used to develop improved parameterizations for models that cannot directly simulate these important phenomena.

Even with this novel regional refinement capability, some processes such as vertical mixing, cannot be resolved explicitly in MPAS-O. Direct simulation of boundary layer mixing in large scale models will not be feasible for many decades, if ever. Thus, Large Eddy Simulations that resolve small scale vertical mixing processes are subsequently used to evaluate the most ubiquitous oceanic vertical mixing parameterization, the Kappa-Profile Parameterization. The influence of this parameterization on important climate phenomena (such as El Nino / Southern Oscillation) is explored. Our testing also demonstrated that improved vertical mixing schemes are needed to improve scalar transport from the surface to the deep ocean and therefore model fidelity.

Ultimately, fidelity of climate simulation depends on the mixing parameterizations used in the ocean model. Only by understanding the complexities of unresolved horizontal and vertical mixing will the correct carbon and heat uptake into the global ocean be computed. These fluxes in the coupled ocean-atmosphere system are essential to describe secular climate changes to the Earth System.

#O04 Exponential time differencing and parallel implementation

Poster Title	Exponential time differencing for large time stepping and localized approach for parallel implementation
Authors	Thi Hoang, Konstantin Pieper, K. Chad Sockwell, Max Gunzburger, Lili Ju, Zhu Wang
Group	Ocean/Ice
Experiment	
Poster Category	Future Direction
Submission Type	poster
Poster Link	

Abstract

MPAS-Ocean utilizes a multi-resolution mesh that resolves sensitive scales with a locally refined mesh. This allows for a reduction in computation time in the coarse regions. However, due to the CFL-condition, the global time-step of explicit methods is restricted by the smallest grid cell. To address this, we combine two approaches: exponential time differencing (ETD) and domain decomposition (DD) methods.

On the one hand, ETD methods allow for large time-steps, while still retaining key properties of explicit integrators. We investigate a modified ETD-Rosenbrock scheme applied to the rotating shallow water equations, discretized by the TRiSK scheme. We prove conservation of mass up to machine precision and demonstrate stability for large time-steps (orders of magnitude above the CFL-compliant one), and conservation of energy up to a time-truncation error. The main difficulty in the implementation arises in the computation of the φ-functions of the ETD-method, which are usually resolved by Krylov-subspace methods. Here, we exploit the energy conserving properties of the underlying spatial scheme and replace the Arnoldi process by a skew-Lanczos process with respect to a carefully chosen inner product, which significantly reduces computation time. Results are shown for double gyre and Gaussian pulse test cases.

On the other hand, DD methods allow to partition the domain into regions with similar mesh size and adapt the time step locally. We apply overlapping domain decomposition in combination with ETD. A semi-discrete multidomain problem with Dirichlet transmission conditions on the interfaces is derived, from which two localized ETD methods are proposed. The first method is obtained by using ETD for time integration at each time step and then applying Schwarz iteration to solve problems in the subdomains. The second method is based on the Schwarz waveform relaxation algorithm, in which time-dependent subdomain problems are solved at each iteration. Note that the subdomain problems are solved in parallel in each case. Convergence of the associated iterative solutions to the fully discrete multidomain solution and to the exact semi-discrete solution is proved for the diffusion problem. Numerical results for the one-dimensional shallow water equation are presented, which show significant speed-ups obtained by the localized approach compared to a single domain solver.

#O05 Fast CVT grid generation for ocean modeling

Poster Title	Fast CVT grid generation for ocean modeling: a Lloyd-preconditioned L-BFGS method in parallel
Authors	Huanhuan Yang, Max Gunzburger, Lili Ju, Zhu Wang
Group	Ocean/Ice
Experiment	
Poster Category	Future Direction
Submission Type	poster
Poster Link	

Abstract

Centroidal Voronoi tessellation (CVT) has been a desired technique for creating high-quality Voronoi meshes and their dual Delaunay triangulations of given domains or manifolds, especially in ocean modeling applications, thanks to its ability of generating an evenly-spaced distribution of grid points. In recent years, the creation of such meshes in high-resolution, featuring variable resolution with smooth transition, is more demanding on efficiency. However, CVT algorithms in the literature have limitations either in the iterative solvers or in memory distribution during parallelization.

The Limited-memory BFGS (L-BFGS) iteration is a natural quasi-Newton method for speeding up CVT algorithms based on the classical Lloyd's iteration. To speed up further one can use a recently proposed graph Laplacian preconditioner, which can reduce the computational time to 56.9\% on average for certain non-uniform meshes. However, the graph Laplacian system is troublesome for ocean grids not only because of its limited efficiency in high resolution mesh but also its singularity on sphere. On the other hand, quasi-Newton methods as deterministic CVT algorithms call for the determination of multiple Delaunay triangulations, but available Delaunay softwares are mostly serial ones preventing efficient parallelization of CVT mesh generation.

In this work, we propose an efficient Lloyd-preconditioned L-BFGS method for CVT computation on sphere for ocean modeling, while the method is also applicable for general domain. Specifically, the Lloyd's step is iteratively updated and taken as the initial Hessian approximations. For quasi-uniform meshes, this preconditioned L-BFGS scheme performs similarly to the L-BFGS. For non-uniform meshes in our tests, however, the computation can be reduced to 6.1--34.2\% in terms of execution time and number of iterations accordingly. Different from previous works using L-BFGS in serial, we also employ a parallel framework for the Lloyd-preconditioned LBFGS using overlapping domain decomposition. The algorithm has partition deployed by an ultra-coarse CVT and it starts from parallelizing Delaunay triangulation. The parallelization algorithm features well-balanced loading of grid points and performs well in the strong scaling efficiency check, which shows almost linear efficiency when the number of grid points is in million scale.

#O06 Nearshore component of MPAS-O

Poster Title	Implementation of a tide-estuary component into MPAS-Ocean framework
Authors	Joseph Zhang
Group	Ocean/Ice
Experiment	
Poster Category	Future direction
Submission Type	poster
Poster Link	

Abstract

The project will develop a new tidal and estuary system (TES) component in DOE’s MPAS-Ocean (‘MPAS-O’ hereafter) model to improve its skills in TES and to reduce uncertainties in the coastal biogeochemistry (BGC) simulation. The new TES model will be online, one-way coupled to MPAS-O at a prescribed boundary and driven by MPAS-O.

We have done preliminary work to narrow down the design of the TES model to be largely based on a co-volume approach proposed by Chen et al. (2013), where both velocity components are specified on cell edges, and the thickness variables evolve on both the primary and the dual cell centers. This approach can handle non-orthogonal grids although accuracy is best on orthogonal grids. We will explore both split explicit and implicit time stepping, using the original (i.e. not vector-invariant) form. This is because there is enough energy dissipation in TES and so energy conservation is not as important as in large scale. The spurious modes will be filtered using an appropriate advection and viscosity scheme. The implicit approach will take advantage of the disjoint TES domains in the world and assign different numbers of compute cores to these domains for efficiency. To enhance the strong scaling, sub-cycling method (in lieu of matrix solvers using global reduction) will be explored as well. A ghost-cell Immersed Boundary Method will be used to alleviate the staircase problem near the bottom, as the bathymetry is a major driver in TES.

The proposed approach strikes a best balance between accuracy, efficiency and usability. TES is strongly dominated by forcings like boundary condition and bathymetry. The complex geometry and bathymetry pose severe challenges for grid generation for orthogonal grids. Strong forcings and inundation also set a high bar for robustness, which may be better addressed with an implicit approach.

The development of the BGC component of the new model will be presented in a separate poster (Wang et al.).

#O07 Ocean/Ice BGC in ACME

Poster Title	Ocean and Sea Ice Biogeochemistry in ACME
Authors	Mathew Maltrud, Shanlin Wang, Nicole Jeffery (Nicole Jeffery), Scott Elliott
Group	Ocean/Ice
Experiment	BGC
Poster Category	Early Result
Submission Type	poster
Poster Link	

Abstract

In preparation for the ACME BGC series of coupled simulations, we have implemented models of biogeochemical and ecosystem dynamics with the MPAS framework within ACME. The ocean module is a port of the CESM package developed by Moore, etal (2004), with the addition of LANL-developed dynamic dimethyl sulfide (DMS) and explicit decomposition of dissolved organic carbon into specific macromolecular classes. The sea ice BGC is a new vertically resolved collection of reactions designed by Jeffery, Elliott, and Wang to be complimentary to the ocean formulation. As a result, we are able to pass constituents between models for studying truly coupled interactions. Since the ocean BGC is based on the CESM formulation, comparisons of ACME/MPAS results with CESM/POP and with data products can provide a baseline validation.

#O08 SeaIceBGC

Poster Title	Sea-ice biogeochemistry in ACME
Authors	Nicole Jeffery, Scott Elliott, Elizabeth Hunke, Mathew Maltrud, Shanlin Wang, Jon Wolfe, Adrian Turner, Bill Lipscomb
Group	Ocean/Ice
Experiment	BGC
Poster Category	Early Results
Submission Type	Poster
Poster Link	

Abstract

A new capability to simulate global sea-ice biogeochemistry (BGC) has been added to the ACME model. Although ice diatoms form the basis of the early spring polar ecosystem and they visibly color the sea ice, their inclusion in earth system models is in infancy. This is, in part, because most ice BGC models are based on region specific assumptions, such as restricting algal biomass to the ice bottom, and are not applicable to global scales. In our model, BGC tracers are resolved in three spatial dimensions, and we allow micro- and macro-scale physical processes to influence molecular transport and reactive processes. As a result our model is consistent with distinct differences observed in the locations and abundance of Arctic and Southern Ocean ice chlorophyll. Preliminary results are from the ACME biogeochemistry G-CASE simulation.

#O09 Variable stoichiometry ocean bgc

Poster Title	Pico-phytoplankton controls on global ocean carbon export and C:N:P stoichiometry patterns
Authors	Robert Letscher, J. Keith Moore
Group	Ocean/Ice
Experiment	BGC
Poster Category	Early Result
Submission Type	poster
Poster Link	

Abstract

Both laboratory and field populations of pico-sized (< 2 µm) marine phytoplankton exhibit plasticity in their cellular phosphorus, nitrogen, and carbon content in response to changing environmental conditions such as light and nutrient supply. Phylogenetic affiliation is an additional control on pico-phytoplankton cellular C:N:P stoichiometry. Variable carbon to nutrient stoichiometry for marine primary production has important implications for the carbon-climate feedback of the ocean's biological pump that remain largely unrepresented and unquantified in Earth System Models. We have implemented three new explicit pico-phytoplankton groups (*Prochlorococcus*, *Synechococcus*, and pico-eukaryotes) for a total of six phytoplankton functional types with variable C:P stoichiometry within the CESM-BEC ocean biogeochemistry model. Pico-phytoplankton dominate the low-nutrient subtropical ocean gyres with their greater cellular C:P plasticity giving them a competitive advantage over larger plankton (nano-plankton, diatoms) with lower C:P stoichiometry. The pattern of high C:P plankton within the subtropics and lower C:P plankton in the equatorial and polar latitudes reduces the meridional gradient in carbon export predicted by most ocean models that assume a constant Redfield C:N:P stoichiometry. Pico-phytoplankton contribute 10, 4, and 8% to global carbon export for *Prochlorococcus*, *Synechococcus*, and pico-eukaryotes, respectively. Future work will add two additional diazotrophic phytoplankton types with implementation of the nine phytoplankton types with variable C:P stoichiometry within the ACME ocean model.

#P01 Task Legions and the Coupled System

Poster Title	Task Legions and the Coupled System
Authors	Philip Jones
Group	Performance
Experiment	N/A
Poster Category	Future Direction
Submission Type	Presentation for Joint SE/Perf CMDV breakout
Poster Link	

Abstract

New programming models utilizing dynamic task parallelism have several advantages for multi-physics model coupling and for utilizing advanced architectures. Advantages include fault tolerance, dynamic load balancing, optimal mappings to hardware elements, minimization of data motion and support for hierarchical coupling and alternative time integration. We present some ideas for this approach as well as early exploration of these ideas within component models.

#S01 Climate-reproducibility testing with EVE

Poster Title	Automated climate-reproducibility (non-bit-for-bit) testing with EVE
Authors	Joseph H. Kennedy, Salil Mahajan, Kate Evans, Peter Caldwell
Group	SE/cpld, workflow
Experiment	
Poster Category	Future Direction
Submission Type	Either
Poster Link	

Abstract

EVE, a toolkit for Extended Verification and Validation of Earth Systems, is being developed to provide automated climate reproducibility testing in ACME. This toolkit will allow developers to analyze non-bit-for-bit code modification and determine if the model still produces statistically equivalent climates or not. EVE will help prevent long, costly V&V analyses of non-bit-for-bit code modifications, give developers more flexibility in adding new features and scientific advances, and build confidence in the model as it develops.

#W01 ACME Ensemble Results Explanation and Reproducibility with ProvEn

Poster Title	ACME Ensemble Results Explanation and Reproducibility with ProvEn
Authors	Bibi Raju , Eric Stephan , Todd Elsethagen
Group	Workflow
Experiment	
Poster Category	Problem/Solution
Submission Type	poster
Poster Link	

Abstract

ACME scientists use simulation ensembles to study how input parameter adjustments effect simulation results. Provenance can aid in explaining the factors that contribute to actual results and if captured in sufficient detail, provenance can be used as a knowledge source to reproduce all or parts of an ensemble. The Provenance Environment (ProvEn) platform helps capture provenance from ACME ensemble runs and visualize it through ProvEn Dashboard. The HArvest Provenance Interface (HAPI) is developed to crawl through the ACME case directories and disclose the data as provenance messages to ProvEn. The collected provenance can be visualized through ProvEn dashboard which helps with results explanation.

#W02 Automated Post Processing

Poster Title	Automated Post Processing
Authors	Sterling Baldwin
Group	Workflow
Experiment	
Poster Category	Problem/Solution
Submission Type	Poster
Poster Link	

Abstract

Performing post processing on model output can be tedioue, time consuming, and the tools can be brittle and difficult to port. The workflow group has worked with the coupled group to produce an automated workflow to perform many of the required post processing jobs automatically, and concurrently with the model run. Post processing jobs include, data transmission, climotology generation, regridding climotologies, timeseries generation, AMWG diagnostics, and coupled diagnostics. The user is given the choice of which jobs to run, and at what frequency. The driving force behind this tool has been a desire to remove the pain points from the post processing workflow, allowing scientists to stop worrying about performing tedious computation tasks, and freeing up valuable time. The automated workflow can be run in parallel with the model to produce diagnostic plots as soon as the data is generated, giving modelers the ability to examine the output while the model is running.

#W03 Continuous Integration via Github

Poster Title	Continuous Integration on Compute Centers via Github
Authors	Charles Doutriaux
Group	Workflow
Experiment	
Poster Category	Solution
Submission Type	poster
Poster Link	

Abstract

While Github provides various continuous integration tools to test your code, most of these system are inadequate for systems requiring huge amount of resources or taking a long time to run. We propose a solution to allow continuous integration via Github on a/many super-computer(s)

#W04 Parallel Tools to Generate, Regrid, and Split Climate Data

Poster Title	Parallel Tools to Generate, Regrid, and Split Climate Data
Authors	Charlie Zender
Group	Workflow
Experiment	
Poster Category	Problem/Solution
Submission Type	Poster or presentation
Poster Link	

Abstract

ACME component models simulate climate on a variety of grids, with older and newer formats from CESM and MPAS, respectively. These data must be compared and evaluated against other models (e.g., CMIP) and observations. We have extended the netCDF Operator (NCO) toolkit over the past year to generate, regrid, and split model and observational datasets at the scale of ACME v1 production runs. New features address researchers' requests including renormalization of sub-gridscale fields after regridding (for MPAS), conservation of sub-grid intensive properties during regridding (for ALM/ILAMB), automated timeseries extraction into CMIP5/6 format timeseries (for CAM-SE), yearly and high-frequency climatologies (for Coupled group), and improved compliance with Climate-Forecast (CF) conventions. The Automated Workbench and Coupled Diagnostics leverage some of these features, while others can be accessed through customized options. This poster or presentation highlights these new capabilities, and provides an opportunity for researchers to offer feedback for future features.

#W05 The New ACME ACME Diagnostics Package

Poster Title	The New ACME ACME Diagnostics Package
Authors	Chengzhu Zhang, Zeshawn Shaheen, Chris Golaz, Jerry Potter, Dean N. Williams
Group	Workflow
Experiment	
Poster Category	Early Results
Submission Type	Presentation
Poster Link	

Abstract

A new ACME diagnostics package initiated in early 2017 has been developed by the ACME Workflow team. The goal of this work is to build a comprehensive diagnostics software as an essential ACME tool to facilitate the diagnosis of the next generation earth system models. This software is designed in a flexible, modular and object-oriented fashion, enabling users to manipulate different processes in a diagnostics workflow. Numerous configuration options for metrics computation (i.e., regridding options) and visualization (i.e., graphical backend, color map, contour levels) are customizable. Built-in functions to generate derived variables and to select diagnostics regions are supported and can be easily expanded. The architecture of this package follows the Community Diagnostics Package framework, which is also applied by two other DOE funded diagnostics efforts (PCMDI metrics package and ARM diagnostics package), to facilitate effective interactions between different projects.

#W06 Workflow Integrations of the International Land Model Benchmarking (ILAMB) with ACME Land Model (ALM)

Poster Title	Workflow Integrations of the International Land Model Benchmarking (ILAMB) with ACME Land Model (ALM)
Authors	Junqi Yin, Forrest Hoffman, Nathaniel Collier, Min Xu, Daniel Ricciuto, Valentine Anantharaj
Group	Workflow, Land
Experiment	
Poster Category	Problem/Solution
Submission Type	poster
Poster Link	

Abstract

We have implemented a cross-facility workflow for the rapid evaluation of the ACME Land Model (ALM) simulations using the ILAMB package at the Oak Ridge Leadership Computing Facility (OLCF) and the ORNL CADES. It automates the processing of the ALM output to publication of the ILAMB results via a webpage that is publicly available. An end-to-end workflow can be automated in conjunction with the Common Infrastructure for Modeling the Earth (CIME). This functionality helps with the rapid evaluation and benchmarking of ALM simulations and the collaborative ALM development process.

#X01 C++/Kokkos Refactor of HOMME

Poster Title	C++/Kokkos Refactor of HOMME
Authors	Luca Bertagna, Michael Deakin, Oksana Guba, Andy Salinger, Dan Sunderland, Irina Tezaur
Group	CMDV-SM
Experiment	Will ACME accept C++ code?
Poster Category	Future Directions
Submission Type	Poster (and presentation in SE/Perf Discussions Breakout #4)
Poster Link	

Abstract

Under the CMDV Software Modernization project, we are working to refactor the HOMME spectral element atmosphere dycore. We are rewriting HOMME in C++ and making use of the Kokkos programming model with the goal of achieving high performing code on CPU, Intel Phi, and GPU architectures with a single code base. Our plan is to reproduce the algorithms in HOMME exactly to avoid introducing new verification/validation issues. Our initial effort involved extracting the main HOMME kernels for dynamics into a mini-app and comparing single-node performance of Fortran, C++, and C++-with-Kokkos implementations on different architectures. Significant effort has gone into improving the performance of the code on GPUs, and some work on OpenMP performance as well, that fed back to improvements in Kokkos itself. As a second step, we are now porting those kernels back into a fork of the ACME repository for HOMME runs. This project raises many issues for discussion: achieving performance, programming language/compiler issues, the difficulties of writing performant code on numerous architectures, the ability to staff climate projects for performance work, processes to expedite code development, and exploiting synergies with other DOE code development efforts.

#X02 Implementation of a Quasi-3D MMF to ACME

Poster Title	Implementation of a Quasi-3D Multiscale Modeling Framework to ACME
Authors	Celal Konor, JoonHee Jung and David Randall
Group	
Experiment	
Poster Category	Future directions
Submission Type	presentation
Poster Link	

Abstract

It is well recognized that the difficulty of properly simulating the effects of clouds and associated processes is one of the most significant limiting factors for global climate models. A large part of the problem is that the current climate models can not directly resolve or even permit clouds because of their low resolution. On the other hand, extensive climate simulations with global cloud-resolving models (GCRMs) will not be practical in the next decade.

As an intermediate solution, the Multi-scale Modeling Framework (MMF) was introduced to global modeling. In an MMF, the cloud-scale processes are explicitly simulated by embedding a 2D CRM as a “super-parameterization (SP)” in each GCM grid column. This approach has shown its good ability to simulate various atmospheric phenomena that are closely linked to the cloud-scale processes, such as the diurnal cycle of precipitation, the Asian monsoon, and the Madden-Julian Oscillation. In spite of its encouraging performance in simulating these phenomena, however, the current MMF has inherent deficiencies. To mitigate the deficiencies of the current SP, the Q3D MMF has been introduced by Jung and Arakawa. The Q3D MMF is a major advance over the current SP: 1) The CRMs are not confined into the dynamical-core grid boxes. 2) The CRMs sense the three-dimensional large- and cloud-scale environment. 3) Two perpendicular sets of CRMs are used. 4) The Q3D MMF can simulate the vertical momentum transport due to both convection and gravity waves. 5) The CRMs also resolve the steep surface topography along the channel direction. Due to these features, the Q3D MMF is scale-aware, which means that it converges to a global CRM as the resolution of the GCM is increased.

The Q3D MMF version of ACME can bridge the gap between the much more expensive global cloud-resolving models and conventional models. Extensive climate simulations with GCRMs will not be practical in the next decade or more. During that time, the Q3D MMF can be used as the best affordable alternative to a GCRM. The Q3D version of ACME will be a cutting-edge tool for simulations of current and future climates, including especially the hydrologic cycle on local and global scales, and extreme precipitation events in mountainous regions.

#X03 Improving coupling workflow in ACME through a common infrastructure

Poster Title	**Improving coupling workflow in ACME through a common infrastructure**
Authors	Vijay Mahadevan , Iulian Grindeanu , Jason Sarich , Robert Jacob
Group	CMDV-Software
Experiment	
Poster Category	Future Direction
Submission Type	poster
Poster Link	

Abstract

As part of the ongoing CMDV effort, we are starting to rewrite and rethink many parts of the coupler to better meet ACME's near-term science and technical goals. The changes are multifold and are primarily motivated to simplify and improve the efficiency in the coupler workflow that is currently used in ACME.

We are working on integrating MOAB [1] in to the ACME suite in order to provide scalable communication infrastructure and to serve as a uniform representation for each of the model's (MPAS, HOMME) mesh and its specific decomposition. This would also allow for a unified checkpointing capability with parallel HDF5/NetCDF based I/O, for restarting runs.

The current offline model to compute the intersection of two grids on a sphere, followed by interpolation weights generation imposes a serious bottleneck in the computational workflow. In order to overcome this, and to allow dynamic decomposition in the physics models, we utilize the scalable intersection algorithms implemented in MOAB in combination with the high-order conservative remapping schemes exposed in TempestRemap [2] library. Leveraging this combination of libraries then provides a robust and accurate infrastructure for spatial remapping in the ACME coupler.

Additionally, modifications that expose runtime load-balancing in the current driver and algorithms to improve performance of the coupler by using a master-slave concept for partitioning are also being investigated on large-scale machines.

[1] MOAB, http://sigma.mcs.anl.gov
[2] Paul Ulrich, https://github.com/ClimateGlobalChange/tempestremap

#X04 Exploring an Ensemble-Based Approach to Atmospheric Climate Modeling and Testing at Scale

Poster Title	Exploring an Ensemble-Based Approach to Atmospheric Climate Modeling and Testing at Scale
Authors	Salil Mahajan, Kate Evans, Matthew Norman
Group	CMDV-SM
Experiment	
Poster Category	Early Result
Submission Type	Poster
Poster Link	

Abstract

A strict throughput requirement has placed a cap on the degree to which we can depend on the execution of single, long, fine spatial grid simulations to explore global atmospheric climate behavior. Alternatively, running an ensemble of short simulations is computationally more efficient. We test the null hypothesis that the climate statistics of a full-complexity atmospheric model derived from an ensemble of independent short simulation is equivalent to that from an equilibrated long simulation. The climate of short simulation ensembles is statistically distinguishable from that of a long simulation in terms of the distribution of global annual means, largely due to the presence of low-frequency atmospheric intrinsic variability in the long simulation. We also find that model climate statistics of the simulation ensemble are sensitive to the choice of compiler optimizations. While some answer-changing optimization choices do not effect the climate state in terms of mean, variability and extremes, aggressive optimizations can result in significantly different climate states.