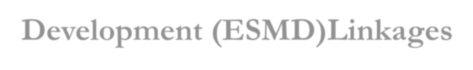
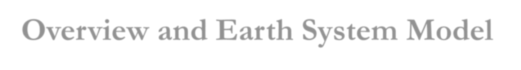
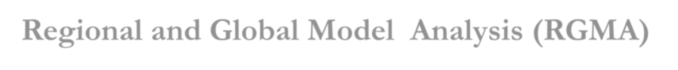
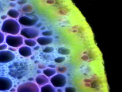
**Regional and Global Model Analysis (RGMA) Overview and Earth System Model** 

**Development (ESMD)Linkages**

**2020 ESMD PI Meeting** 

**Renu Joseph, Renu.Joseph@science.doe.gov**

**U.S. Department of Energy** 

**Office of Science**

**Office of Biological & Environmental**

**Research**

**Earth and Environmental Systems Sciences**

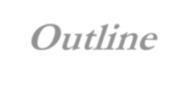
**Division**

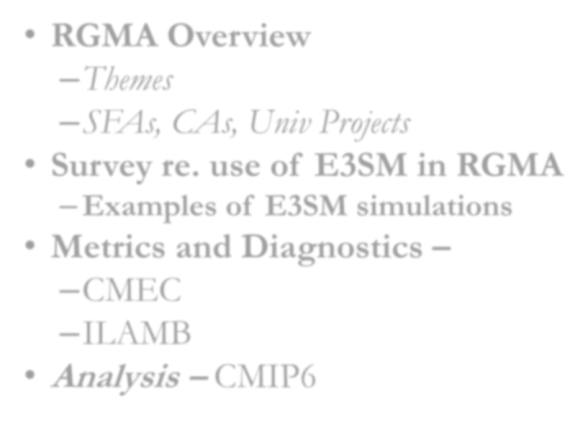
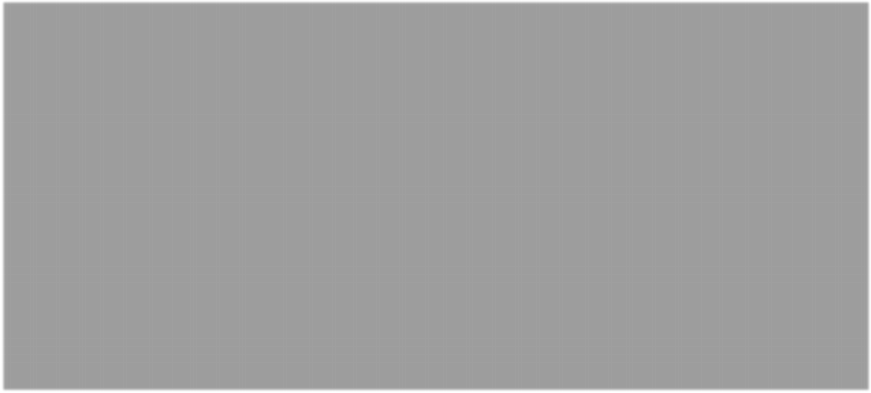
**Office** 

**of ScienceOffice of Biological  and Environmental Research**

**1 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

****Office of Science

**Outline**

• **RGMA Overview** 

–*Themes*

–*SFAs, CAs, Univ Projects*

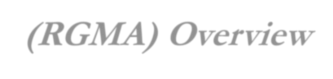
• **Survey re. use of E3SM in RGMA** – **Examples of E3SM simulations** • **Metrics and Diagnostics –** –CMEC

–ILAMB

• **Analysis –** CMIP6

**2 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

****Office of Science

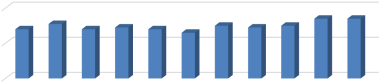
**Regional and Global Model Analysis (RGMA) Overview** 

• **Goal**: To enhance predictive and process level understanding of Variability and Change in the Earth system by advancing capabilities to design, evaluate, diagnose, and analyze global and regional earth system models informed by observations

– Primary Model we focus on is the E3SM – Energy Exascale Earth System Model – Multi-Model approaches and also a use of a hierarchy of models of varying levels of varying complexity to address the relevant science questions

Roughly 120 publications/year 

RGMA Funding

40 

20

0

**3 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

****

****

Office of Science



University Projects through FOAs + Jointly funded Interagency Projects

**4 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Regional and Global Model Analysis: Core Effor**

Office of Science **Water Cycle and** 

**Climate Extremes**

**Modeling (WACCEM)**

**Calibrated and** 

**Systematic**

**Characterization,**

**Attribution, and**

**Detection of Extremes**

**(CASCADE)**

**Reducing Uncertainty in** 

**Biogeochemical Interactions**

**Through Synthesis and**

**Computation (RUBISCO)**

**High-Latitude** 

**Application and**

**Testing (HiLAT)**

****

****

**A Framework for Improving Analysis and Modeling of Earth System and** 

**Intersectoral Dynamics at Regional Scales**

**Program for Climate Model Diagnosis &** 

**Intercomparison**

**Cooperative**

**Agreement To Analyze variability, change and predictability in the earth SysTem** 

**(CATALYST)**

**Interdisciplinary**

**Research for Arctic Coastal Environments (InteRFACE)**

**Integrated Coastal**

**Modeling (ICOM)**

**5 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**RGMA FY18 & FY19 University Projects from FOA 1862**

**Science Themes University Projects**

• Water Cycle

• Extremes• **Boos: Monsoon Extremes: Impacts, Metrics, and Synoptic-Scale Drivers**

**perparameterized E3SM**

• **Kooperman: Simulating Extreme Precipitation in the United States in the E3SM: Investigating the Importance of Representing Convective Intensity Versus Dynamic Structure** • **Kim: Madden-Julian Oscillation, Tropical Cyclones, and Precipitation Extremes in E3SM** • **Saravanan: Assessing the influence of background state and climate variability on tropical Extreme Precipitation Events**

**cyclones using initialized ensembles and mesh refinement in E3SM**

**High-Resolution E3SM in the United States Global Resolution: 1˚**

**Cloud Resolving Model: 2 km**

**Superparameterized E3SM**

• **Kirtman: Decadal Prediction and Predictability of Extremes in Ocean Eddy Resolving Coupled**

**Extratropical**

**Cyclones**

**Models**

• **DiLorenzo: Mechanisms of Pacific Decadal Variability in ESMs: The Roles of Stochastic**

**Mesoscale**

**Convective**

**Global Resolution: 0.25˚**

**Atmospheric**

**Systems Tropical**

**Global Resolution: 1˚**

**Rivers**

**Forcing, Feedbacks and External Forcing**

**Cyclones**

**Cloud Resolving Model: 2 km**

ariability & Change



High Latitude

• **Kwon: The Atlantic Multi-decadal Oscillation – Key drivers and Climate Impacts** • **Cheng: Arctic freshwater pathways and their impact on North Atlantic deep water formation in a hierarchy of models**

• **Jin: Understanding Dynamics and Thermodynamics of ENSO and Its Complexity Simulated by E3SM and Other Climate Models**

• **DeMott & Klingamon: Understanding air-sea feedbacks to the MJO through process evaluation of observations and E3SM experiments**

• **Magnusdottir: Reducing Uncertainty of Polar to Mid-latitude Linkages using DOE’s E3SM in a Coordinated Model-Experiment Setting**

• **McClean: Influence of Antarctic and Greenland continental shelf circulation on high-latitude**

**6 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**RGMA FY20 University Projects: FOA 2230** Office of Science 

**Science Themes University Projects**

• **Soden: Investigating Cloud Feedbacks in Earth System Models**

Cloud Processes

Analysis of BGC Feedbacks

• **Su: The Role of Deep Convection and Large-scale Circulation in Driving Model Spread in Low Cloud Feedback and Equilibrium Climate Sensitivity**

• **Swann: Evaluating the influence of plants on hydrologic cycling: Quantifying and validating the role of plant processes and stomatal conductance** • **Ito: Ocean physical-biogeochemical interactions in the CMIP6 and E3SM Earth System Models**

**7 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**ESMD**

**ESMD - RGMA Linkages**

**Simulations for RGMA to enhance understanding** 

**New RGMA knowledge to benefit E3SM development**

**EESM Goal**: To develop and demonstrate advanced modeling and simulation capabilities, in order to enhance the predictability of the Earth system over multiple temporal and spatial scales. 

**8 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Science questions (from Survey) from 20 RGMA projects that use**

• **Modes of climate variability:** – Air-sea interactions and MJO

– MJO propagation across Maritime Continent

**E3SM** 

• **Extreme precipitation and weather events:** • Processes controlling extreme precipitation

– ENSO and connections to other modes of variability – AMOC and high-latitude connections

• **Arctic and Antarctic:**

– Heat transport, connections to lower latitudes, polar amplification, sea ice loss and atmospheric response

– Delivery of warm water to Antarctic and Greenland ice shelves

– Arctic region storms

– Permafrost, benthic habitats, wave attenuation in Arctic coastal regions

• **Tropical cyclones:**

– AEW and Atlantic TC

– Factors controlling landfalling TC and genesis – Effects of air-sea interactions on landfalling TC

• Impacts of model biases and resolution on

simulation of weather extremes

• Extreme weather events and future changes • **Cloud and radiation:**

• ITCZ and cloud-radiative interactions

• Role of coupling between dynamics and radiation on weather extremes and climate sensitivity

• Climate sensitivity and cloud feedback

• **Biogeochemistry:**

• Ocean carbon uptake

• Carbon cycle feedback, CO2 fertilization effect

• Impacts of plant biogeochemical responses on water cycle processes

**9 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Comparison of E3SM with other models /** 

**contribution to model** 

**intercomparison**

• CMIP6 (e.g., DECK, **C4MIP, CFMIP**, HighResMIP, **PAMIP**)

• WRF-Arctic (Walsh)

• GFDL (Soden)

• CAM (Saravanan)

• CESM (HyperFACETS-Zarzycki; DeMott)

• ATS-MOSART(InteRFACE)

• CAM-MPAS (WACCEM)

• UK Met Office Unified Model (Klingaman)

• RASM (HiLAT)

• UWIN-CM (ICoM)

**10 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Reducing Uncertainty of Polar to Mid-latitude Linkages Using DOE's E3SM in a Coordinated Model Experiment** 

**What are the causes and consequences of polar amplification ? What is the** 

**impact of Arctic/Antarctic sea ice loss on the climate of the mid-latitudes ?**

**G. Magnusdottir**1, A. Audette2, R. Fajber2, T.-Y. Hsu1, Z. Labe1, P. Kushner2,

Y. Peings1, F.Primeau1

**Contributed to E3SM in PAMIP simulations**

****

Schematic of ways to influence

Northern Hemisphere mid

latitude weather (Cohen et al.

2014)

**11 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

***Variable Resolution E3SM-Arctic*** 

******

• The HiLAT-RASM team is working on Arctic-refined

configurations of E3SM: *E3SM-Arctic* – Ocean-sea ice configuration (JRA55-forced) – Two grids: *60-to-10* and *60-to-6*

– Key metrics are well represented

• Veneziani et al. (in review)

– Currently working on a fully-coupled configuration 

*Veneziani et al. (in review)*

**High-Resolution modeling of Arctic cyclones – John Walsh,** Xiangdong Zhang, Erika Roesler and Ben Hillman



**12 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Multi-Year Predictability and Prediction in Ocean Eddy Resolving Coupled Models** 

**Ben Kirtman,** Leo Siqueira, 

**Multi-Model~~:~~ CESM & E3SM**

Lucas Laurindo

Kathy Pegion Robert Burgman

• **Predictability**

• **Extended Simulations**

• **Homogeneous (Identical Twin)**

**Experiments**

**CESM-LR**

**(Ocean Eddy Parameterized)**

****

**CESM-HR (Ocean**

**Eddy**

**Resolving)**

• **Initialized Prediction**

• **Brute Force (Operational NOAA Analysis)** • **Ocean-Only (CORE Forcing) Derived**

**E3SM-LR E3SM-HR (Ocean Eddy (Ocean Parameterized) Eddy Resolving)**

**13 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Mechanisms of Pacific Decadal Variability in ESMs**

**Emanuele Di Lorenzo, Matt Newman, Sam Stevenson,** Luke Van Roekel, Sang-Ik Shin and Antonietta Capotondi

Develop fundamental understanding and synthesis of the **mechanisms**

**that energize Pacific decadal variability (PDV)** in Earth System

Models (ESMs)

**Contributing E3SMv1 Large Ensemble: unique initialization strategy** 

***PDV Hypothesis***

**14 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Collaboration on E3SM Simulations** 

• RUBISCO and the E3SM Coupled Biogeochemistry Group collaborating in CMIP6 simulations

• RUBISCO is also applying different versions of the modeling system to address specific science questions, like deforestation/afforestation, AMIP-style ENSO simulations, etc.

• Completed CMIP6 simulations with E3SMv1.1 and land/ocean BGC include: – LS3MIP offline land simulations with multiple atmospheric reanalysis and factorial forcings (Contact Jiafu Mao)

– 1pctCO2 (rad, bgc, full) for CTC-CNP, ECA-CNP, and CTC-CN (Recently completed) – abrupt4xCO2 (rad, bgc, full) for CTC-CNP and CTC-CN (Recently completed)

• Planned CMIP6 simulations with E3SMv1.1 and land/ocean BGC include: – 1pctCO2Ndep (bgc, full) for CTC-CNP, ECA-CNP

– ssp5-85-ext (extension to 2300)

– SSP1.2, SSP2-4.5, SSP3-7.0, SSP5-3.4os and LUMIP simulations swapping land use

• Planned CMIP6 simulations with E3SMv2 and land/ocean BGC include: – esm-historical, esm-ssp5-85, esm-ssp5-85 extension

**15 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Investigating Cloud Feedbacks in Earth System Models** Brian Soden & Gabe Vecchi

Questions:

i) Is convective aggregation important in the presence of *realistic boundary conditions*? ii) How do cloud-circulation feedbacks influence *weather extremes*?

iii) How do cloud-circulation feedbacks influence *climate and climate sensitivity*? iv) How can observations be used to *evaluate*

Brian Soden (PI)

*the representation* of these feedbacks? Gabriel Vecchi (Co-I)

Will use E3SM and GFDL models 

– Modified Cloud Feedbacks (PCMDI) - CFMIP 

– Various ways to suppress cloud-radiation feedback (each 11 years), 

and with 4K warming and 4xCO2 forcing and 4xCO2 SST pattern

(WACCEM)

Regional and Global Model Analysis (RGMA) Principal Investigators (PI) Virtual Meeting Oct 14, **16 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**CMEC - Coordinated Model Evaluation Capabilities** Office of Science 

**Integrated Tools and Science for Event Analysis** 

*****TECA* 

*TempestExtremes*

*ILAMB* 

*PMP*

**17 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

****Office of Science

**RGMA CMIP6 Analysis and Hackathon** Wilbert Weijer 

Forrest Hoffman

Paul Ullrich 

Mike Wehner



Data is available on NERSC

More Data is being added

**18 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

***For RGMA news check out***

Office of Science https://climatemodeling.science.energy.gov/program/regio nal-global-model-analysis

**19 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research** 

***Thank You***

**20 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**RGMA Survey regarding use of E3SM**

• Questions:

– What science questions will your projects address using E3SM?

– What is your simulation plan? (e.g., model version, model configurations, major code changes, resolution, simulation period and length)

– What computational resources are needed for your simulations and how will you obtain the resources?

– Will you develop a modeling hierarchy using E3SM?

– Will you produce or need any spun-up states for initializing your simulations?

– Will you compare E3SM simulations with those from other models?

• PIs of 20 projects responded

– SFAs (HiLAT, WACCEM, PCMDI, RUBISCO, ICoM, InteRFACE)

– 14 university projects

**21 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Simulation plan** 

• Low resolution coupled:

– Modified cloud feedbacks (PCMDI)

– 100 members of 14-month runs with prescribed Arctic/Antarctica sea ice loss (Magnusdottir) – Hypothesis-testing simulations: changing insolation or parameters in ZM scheme; nudged atmosphere (Kim)

• RRM simulations coupled:

– E3SM v2: Arctic coupled (ARRM and WC14) (HiLAT; Walsh-Roesler)

– E3SM v2 WC14 mesh - HighResMIP type simulations with 10 ensemble members (1950-2015) (InteRFACE)

• Biogeochemistry simulations (LR):

– Require long spinup (e.g., 200 years)

– Long simulations (e.g., 140 years)

– Partially coupled with ELM and ELM-FATES hypothesis testing (Swann; RUBISCO)

– DECK type simulations with land and ocean BGC and different scenarios (e.g., various SSPs) (RUBISCO)

**22 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Simulation plan** 

• Atmosphere-only runs:

– 10-year AMIP runs at LR and HR (Saravanan)

– ~ 100 seasonal-to-annual simulations at HR (Patricola)

– Radiation feedback suppression at HR (Soden)

– Various ways to suppress cloud-radiation feedback (each 11 years), and with 4K warming and 4xCO2 forcing and 4xCO2 SST pattern (WACCEM)

– Cloud feedback experiments with prescribed SST (e.g., AMIP-p4K, AMIP-p4xCO2, etc) (PCMDI) – 100 members of 14-month runs with PI/future Antarctic sea ice at LR (Magnusdottir) – WC14; comparison with WRF-Arctic (Walsh-Roesler)

• Ocean-ice only runs:

– Arctic with marine BGC (HiLAT)

– Freshwater flux release in Greenland and Antarctica (McClean)

• E3SM coupled to a 1D mixed layer ocean: several 30-year simulations (DeMott; Klingaman; HiLAT)

**23 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Simulation plan** 

• Shorter simulations (atmosphere-only):

– Storyline simulations (multiple < 10 days): large ensemble (O(100)) atmosphere-only at multiple resolutions (110km, 28km, 14km) (Zarzycki-Reed)

– Short-term (2-4 week) forecast ensemble equivalent to 10 years at LR and HR (Saravanan)

– Multi-year, short-range (5-day long) hindcasts initialized every day at 00Z from Jan 1, 2010 to Dec 31, 2018, with EAM v1 and v2 (ne30) (PCMDI)

• Comparison of coupled simulations at LR (1.5 deg), HR (0.3 deg), and MMF (1.5 deg) 5 years each (Kooperman and Hannah)

• Repeat E3SM v1 LR / HR simulations for higher frequency / special outputs (DeMott; Ito; Jin; ICoM)

**24 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Water Cycle and Climate Extremes Modeling (WACCEM) SFA (Leung, PNNL; Skamarock, NCAR; Chen PSU)** 

To advance robust predictive understanding of water cycle processes and hydrologic extremes and their multi-decadal changes

**Large-scale circulation**

**Contrasting precipitation seasonal cycle phase changes over land and ocean under warming**

**A new global MCS dataset**

Cold Cloud System (CCS): Tb < 241 K

**Matches tracked CCS with PF and**

**identifies large PF**

Dissipation

(Track ends)

**Radiation-cloud-convection-circulation induced changes in ITCZ from MMF experiments**

****

Convective Initiation (Track starts)

**… …**

• Predictability of atmospheric rivers and extreme precipitation

Time 1 Time 2 Time 3 Time 4 Time 5 Time x Time n-3 Time n-2 Time n-1 Time n

**MCS plays a larger role than non-MCS in soil**

• Monsoon-ITCZ from an energetic perspective

Precipitation Features (**PF**s) of

the tracked CCS (> 2 mm h

-1)

**CCS area > 40,000 km2for > 4 continuous hours** -1) Weak/moderate rain

Heavy rain (> 10 mm h

**moisture-precipitation feedback in the central US**

• Baroclinic annular mode and subseasonal precipitation variability

**Mesoscale convection**

• Global characteristics of mesoscale convective systems (MCSs) • Large-scale environments of MCSs and future changes • MCSs and hydrologic floods in the U.S.

**Multiscale convection-circulation interactions**

• Role of convection in tropical overturning circulation • Subseasonal variability of convection and influence on extremes • MJO and tropical cyclones

**… …** 100 km

Time 1 Time 2 Time 3 Time 4 Time x Time m-2 Time m-1 Time m

**PF major axis length > 100 km for > 4 continuous hours**

****

**Solar insolation and soil moisture affect how the MJO interacts with the Maritime Continent**

****

****

**Salinity has pronounced impact on rapid intensification of tropical cyclones **

**25 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

***CAlibrated and Systematic Characterization, Attribution, and Detection of Extremes (CASCADE) SFA – Collins (LBNL)*** 

To advance understanding of natural and anthropogenic influences on 

multi-scale climate extremes in observations and models

**ML & Infrastructure Crosscut**

****

**Extremes in Observations**

• Statistical modeling to

interpret trends in the

observational record

• Innovative geostatistical

approaches for reducing

signal-to-noise

**Extremes @ Native Scales**

• High-resolution model &

observational analysis of

multiscale extremes

• Focus on MJO, blocking,

teleconnections and model

fidelity

**Variability in Extremes**

• Investigation of response 

of extremes to thresholds

& non-linearities in the

coupled system

• Emphasis on mountain

hydroclimate

**Detection of Extremes & UQ**

• Develop machine-learning

approaches for detecting 

weather phenomena: ARs,

TCs, ETCs, fronts,…

• Uses statistical and NN

based ML approaches

**26 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Reducing Uncertainties in Biogeochemical Interactions through Synthesis and Computation (RUBISCO)** 

***Forrest M. Hoffman (Laboratory Research Manager), William J. Riley (Senior Science Co-Lead), and James T. Randerson (Chief Scientist)* Research Goals** 

• Identify and quantify interactions between biogeochemical

cycles and the Earth system

• Quantify and reduce uncertainties in Earth system models

(ESMs) associated with interactions

**Research Objectives**

• Perform hypothesis-driven analysis of biogeochemical &

hydrological processes and feedbacks in ESMs

• Synthesize in situ and remote sensing data and design metrics

for assessing ESM performance

• Design, develop, and release the International Land Model

Benchmarking (ILAMB) and International Ocean Model

Benchmarking (IOMB) tools for systematic evaluation of model fidelity

• Conduct and evaluate CMIP6 experiments with ESMs

The RUBISCO SFA works with the measurements and the modeling communities to use best-available data to evaluate the fidelity of ESMs. RUBISCO identifies model gaps and weaknesses, informs new model development efforts, and suggests new measurements and field campaigns.

**27 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**HiLAT-RASM: High-Latitude Application and Testing of Earth System Models - Phase II** 

**(Weijer, LANL; Wang, PNNL, Maslowski NPS)**

• **Integrative Earth System Science** to reduce uncertainties in modeling and enhance predictive understanding of high-latitude environmental change and its global consequences

**Theme 1: Role of sea ice in mediating meridional heat transports in the ocean and atmosphere**

We are studying: 

***Relationships between sea ice and***

***meridional heat transports in the ocean***

***and atmosphere***

*Maud Rise Polynya in E3SMv0-HR*

*(Kurtakoti et al. 2018)*

**Theme 3: Extra-polar impacts of Arctic change**

We are studying: 

• ***Impact of sea ice loss on extra-polar***

***climate and weather***

• ***Impact of Beaufort Gyre variability on the***

***AMOC, and global climate***

*Distribution of Beaufort Gyre freshwater*

*13 years after release (Zhang et al. 2020)*

**Theme 2: Role of fine-scale and transboundary transport processes in Arctic change**

We are studying: 

• ***Impact of small-scale processes on AA***

• ***Impact of riverine fluxes on Arctic***

***warming***

*Lakes of the Lena River Delta*

*(Piliouras & Rowland 2020)*

**Theme 4: Decadal predictability of high-latitude environmental change**

We are studying if predictability can be 

improved by:

• ***combining dynamical and statistical***

***models***

• ***explicitly resolving mesoscale***

***processes (downscaling)***

*Predictive skill of Kernel Analog Forecasting*

*for Arctic sea ice (Comeau et al. 2019)*

**28 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**PCMDI – An Earth System Model Evaluation Project PI: Steve Klein** 

*Using model ensembles of today and tomorrow to measure model performance, reduce uncertainties in their predictions, and determine the pathways for their improvement*

Measuring Model Performance and Facilitating Community Involvement 

Supporting Ensembles of Earth System Models 

Interpreting Recent Changes in Climate to Inform Predictability 

ECS (K)

)

e

d

a

c

e

d

/

K

(

d

n

e

r

t

c

i

r

e

h

p

s

o

p

o

r

t

l

a

c

i

p

o

r

T

Observed range

Niño 3.4 trend (K/decade)



Reducing Uncertainties in Cloud Feedbacks & Climate Sensitivity

Engaging with the Convection Permitting Models of Tomorrow

**29 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

****Office of Science



**Cooperative Agreement To Analyze variabiLity, change and predictabilitY in the earth SysTem (CATALYST) (Meehl, UCAR)** 

Perform foundational research toward advancing a robust 

understanding of modes of variability and change using models, observations and process studies

**External forcing, internal variability, and predictability** 

• Interplay between external forcing and internal variability

• Earth system simulation capability to study variability and predictability

• Changes of variability on multi-decadal timescales

**High impact events** 

• Processes and mechanisms that produce high impact extremes

• Possible future changes to high impact events

• Global and regional sea level rise

**Parametric and structural uncertainty** 

• Quantify uncertainties and feedbacks; machine learning

• Evaluate model improvements using a hierarchy of models

• Optimization and calibration at the development timescale

**30 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**HyperFACETS- A joint RGMA, MSD Effort PI: Paul Ullrich ( UCD)** 

**How are stakeholders using climate data? What are stakeholder needs for climate data?**

**Stakeholder**

**Engagement**

**How credible and salient are Earth system models and available datasets for stakeholder need?**

**Use-Inspired Metrics**

**Expert Guidance**

**How well do Earth-system models, integrated human-Earth system**

**models, and available datasets perform for relevant quantities?**

**Process**

**Understanding**

**What are the drivers and processes that are most important for**

**ensuring model performance?**

**What role does human activity (GHG vs. land-use) play in affecting these quantities?**

**Stakeholder Engagement** 

**Significant Events (Storylines)** 

**Modeling and Analysis** 

**Future Change & Anthropogenic Drivers**

**31 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

****Office of Science

**DOE’s Integrated Coastal Modeling (ICoM) Project (Kraucunas, PNNL)**

**32 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Interdisciplinary Research for Arctic Coastal Environments (InteRFACE): A joint EESM and DM Project- (J. Rowland, LANL)** 

The INTERFACE project focuses on how the coupled, multi-scale

feedbacks among land processes, sea ice, ocean dynamics, coastal

change biogeochemistry, atmospheric processes, and human

systems will control the trajectory and rate of change across the 

Arctic coastal interface.

**Earth System focus on:** 

• Sea ice and ocean dynamics

• Coastal Change

• Permafrost Hydrology

• Marine Biogeochemistry

**Multi-sector dynamics focus on:**

• Shipping

• Settlements

• Resource development

**33 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**MJO in E3SMv1 – Multiple projects:** 

**CATALYST CA, University Projects [Kim (UW), DeMott (ColoState)]**

• E3SMv1 realistically simulates MJO’s eastward

propagation, including the spatial pattern of 

precipitation anomalies around the Maritime

Continent (phases 4 and 5)

• MJO MSE budget shows that horizontal and

vertical advection terms are responsible for the

eastward propagation, as in observations and

consistent with the moisture mode framework

Projection domain: 60E-180E, 20S-10N

**ERA5**

**E3SMv1**

**h: moist static energy (MSE)**

12

**34 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Role of AMOC in Transient Climate Response to increasing CO2 in E3SMv1 and CESM2** 

**Objective:** We focus on the Atlantic Meridional Overturning Circulation (AMOC) and its role in determining equilibrium climate sensitivity (ECS) and transient

climate response (TCR) to increasing CO2.

**Approach:** The models used here are the Community Earth System Model version 2 (CESM2) and the Energy Exascale Earth System Model version 1 (E3SM1) and the experiments include preindustrial control, historical and 1% CO2runs.

**Results/Impacts:** While CESM2 and E3SM1 have very similar ECS, our analysis suggests that a weaker AMOC contributes in part to the higher TCR in E3SM1 by permitting a faster warming of the upper ocean and a concomitant slower warming of the subsurface ocean. Likewise the stronger AMOC in CESM2 with a slower warming of the upper ocean leads in part to a smaller TCR. Thus, while the mean strength of AMOC does not affect the ECS, it is likely to play an important role in determining the TCR on the centennial time scale. 

**Hu, A.**, L. V. Roekel, W. Weijer, O. A. Garuba, W. Cheng, B. T. Nadiga, 2020, Role of AMOC in transient climate response to greenhouse gas forcing in two coupled

models, *J. Climate*, 33, 5845-5859, doi: 10.1175/JCLI-D-19-1027-1.

Figure 1. Time evolution of the AMOC index (top 4 panels) and global mean temperature (bottom 4 panels) in the (top left) preindustrial control run, (top right) twentieth century and future SSP runs, (bottom left) 1% CO2 runs, and (bottom right) the percentage changes relative to the control run mean in 1% CO2 runs

**35 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**RGMA Collaborative Activities** Office of Science 

• DOE Precipitation Metrics Workshop 

– Develop Baseline and Exploratory Metrics

• NOAA-DOE Workshop on Precipitation Predictability – Nov 30-Dec 2

– DOE funded scientists involved

• 3rd ARTMIP Workshop

– Enabled tracking of ARs

• Two BGC Working Groups led by RUBISCO – Soil BGC & RUBISCO-Ameriflux – produced many publications

**36 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**RGMA Collaborative Activities** Office of Science 

• The Ongoing Need for High-Resolution Regional Climate Models – BAMS Publication -(An outcome of the last PI meeting) • DOE Precipitation Metrics Workshop 

– Develop Baseline and Exploratory Metrics

• NOAA-DOE Workshop on Precipitation Predictability – Nov 30-Dec 2 

– DOE funded scientists involved

• 3rd ARTMIP Workshop

– Enabled tracking of ARs

• CMIP6 Hackathon –

– Data for the DOE Community - NERSC



• Two BGC Working Groups led by RUBISCO

– Soil BGC & RUBISCO-Ameriflux – produced many publications • Community Model Evaluation Capabilities

**37 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Precipitation Metrics Workshop**

****

****• Inspired by the lack of objective and systematic benchmarking of simulated precipitation

**Identify targets for improvement**

**Team of experts identifies useful measures for gauging how well models simulate precipitation**

**Develop capability to gauge model quality**

**Baseline metrics**

**incorporated into a**

**model evaluation**

**capability and used to assess current**

**models**

**Improve simulated Precipitation** 

**Modelers provided with metrics capability to serve as a target for improving newer model versions**

• Community input via DOE 2018 AGU Town Hall and international modeling working groups • Date/venue: July 1-2, 2019 in Rockville, Md



**Establishing a pathway to help guide modelers**

● Select a limited set of established benchmarks and develop a strategy for implementing them in a model evaluation capability ● Define how to use this capability for baseline evaluation ● Address the multiscale nature of precipitation, including the existence of model errors at all scales scales

● Identify key research areas where exploratory work can yield more in-depth and informative metrics to include

● Challenge the modeling community to use the expert groups’ evaluation metrics as a guide to improve their models; quantify improvement in the next generation of models

**38 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research** 38

**NOAA - DOE** 

**Precipitation Processes and Predictability Workshop**

**Nov. 30 – Dec. 2, 2020**

A **community workshop** jointly organized by NOAA and DOE in partnership with USGCRP and

USCLIVAR

**Scope and focus of the workshop**: • Contiguous U.S. in the context of global models

• Subseasonal to multi-decadal timescales

**Major Themes:**

1. Sources and limits of predictability

2. Key processes critical to precipitation biases

3. Interdisciplinary Processes 4. Regions

● Samson Hagos ● Ben Kirtman

● Hsi Yen Ma

● Angeline Pendergrass

RGMA participating scientists

**39 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research** 39

**RUBISCO-AmeriFlux Working Group **● Formed after community recommendation from 

the 2016 International Land Model Benchmarking (ILAMB) Workshop Report

● Objective is to use AmeriFlux data to improve process understanding and to develop,

parameterize, and test models

● Multiple conference calls led up to a meeting at the UC Berkeley Botanical Garden (outside LBNL) on October 15–17, 2019



Four key areas of research emerged from the Working Group Meeting: ● **Ecosystem trend spotting** - employing long ecosystem carbon and water flux records to detect trends in ecosystem metabolism and to disentangle responses of ecosystems to elevated CO2, climate change, and human disturbances

● **Ecosystem responses to extreme events** - use long-running AmeriFlux measurements, which include ecosystem responses to extreme weather conditions, to evaluate models

● **Untangling contributions to carbon exchange** - use complementary measurements of respiration fluxes and satellite derived vegetation indices to improve partitioning methods for eddy covariance estimates of GPP and *R*eco

● **Scaling up from sites to ecosystems** - combine bottom-up and top-down approaches for scaling fluxes across spatial scales

For more information, see Measuring, Monitoring, and Modeling Ecosystem Cycling in *Eos Trans. AGU* (August 5, 2020)

**40 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**

**Soil Carbon Dynamics Working Group **

Office of Science

• Formed after community recommendation from the 2016 International Land Model Benchmarking (ILAMB) Workshop Report

• Objective is to apply data and models to improve predictive understanding

**Data to**

**Knowledge**

Synthesize existing data from collaborative networks, archives, and publications

**Knowledge to Data**

Perform simulations to test hypotheses and characterize model structural uncertainties

**Predictive**

**Understanding**

Design functional relationship metrics to confront models and apply data-driven approaches to model formulation

• June and September conference calls led to meeting at ORNL in October

**Global Data Synthesis Theme**

● Combine field observations from collaborative sampling networks and databases, including International Soil Carbon Network (ISCN) and published literature

● Quantify vertical distribution of SOM and responses to controlling mechanisms

**Model–Data Integration Theme**

● Develop consistent datasets for initializing, forcing, and benchmarking microbially explicit soil carbon models

● Characterize model structural uncertainty through software frameworks to understand controlling mechanisms

*For more information, contact Forrest M. Hoffman <forrest@climatemodeling.org> or Umakant Mishra <umishra@anl.gov>*

****41 ESMD PI Meeting Oct 2020 Department of Energy • Office of Science • Biological and Environmental Research**