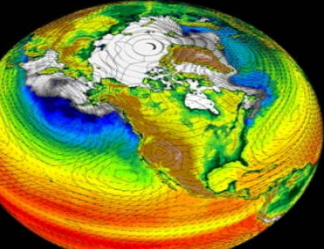
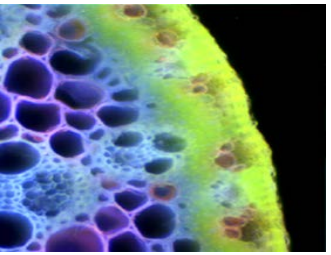
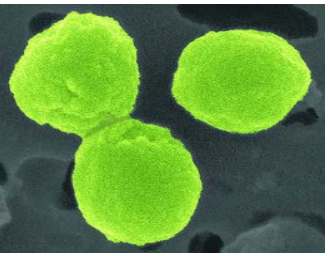


Regional and Global Model Analysis 2020 PI Meeting

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

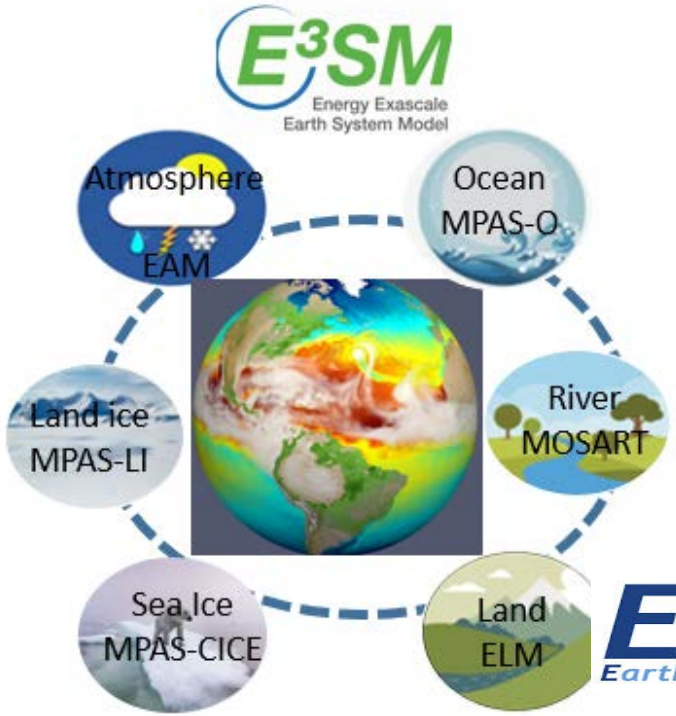
Outline

- **Thank You – over 180 abstracts!!!**
- **EESM Overview**
  - Connections within the Program
- **RGMA Overview**
  - How do your projects fit in?
  - How can they connect better
  - What can you leverage?
  - How can you synergistically work together
    - *E3SM simulations*
    - *Metrics and Diagnostics – CMEC*
    - *ML/AI tools*
    - *Analysis – CMIP6*
    - *Other?*

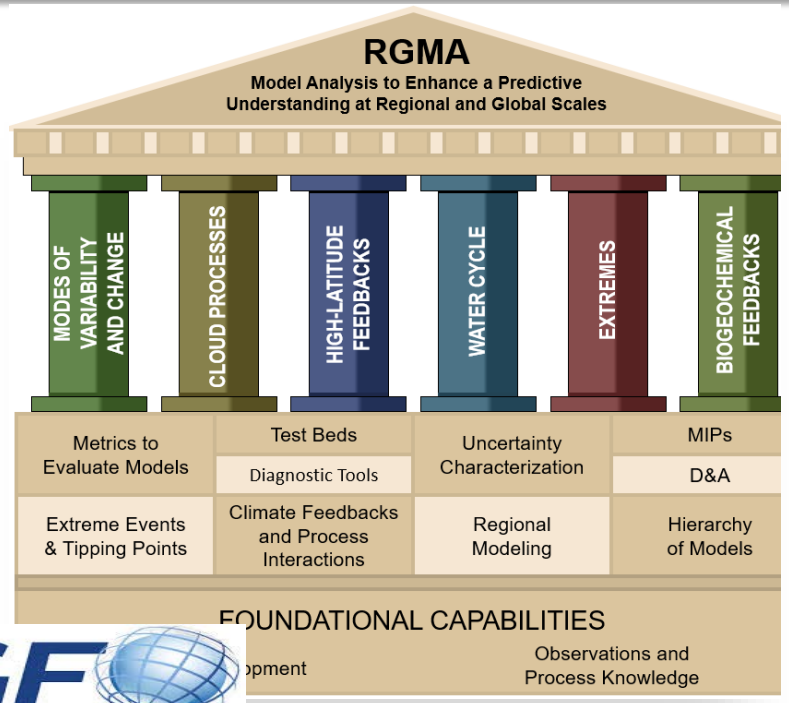
Earth and Environmental Systems Modeling - Overview

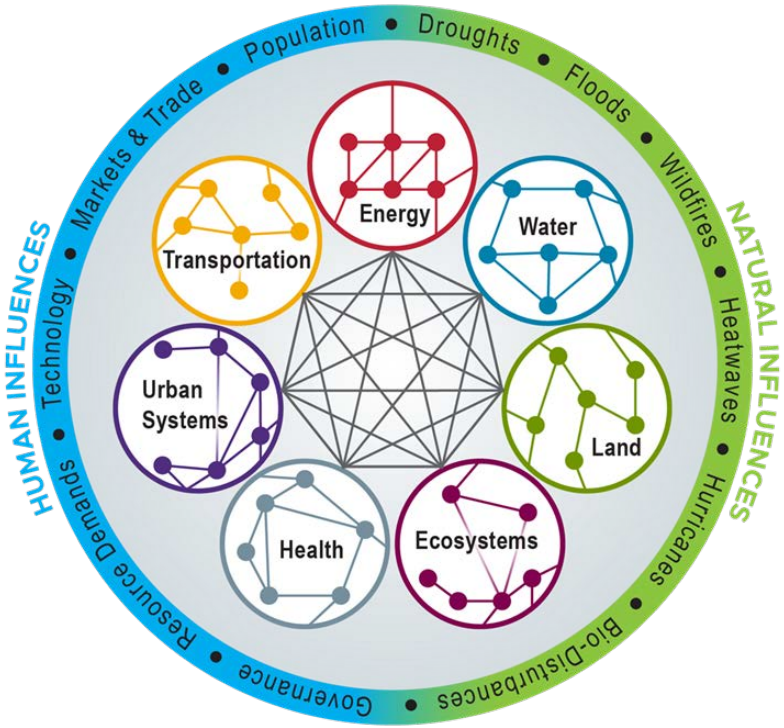
EESM Vision: EESM provides transformative insights on natural Earth systems, their interactions and co-evolution with human systems, at time scales ranging from subseasonal to centennial, delivering knowledge foundations and science-based tools for the Nation's planning of next-generation, resilient energy, environmental, and economic systems and infrastructures.

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.



Earth System Across Scales





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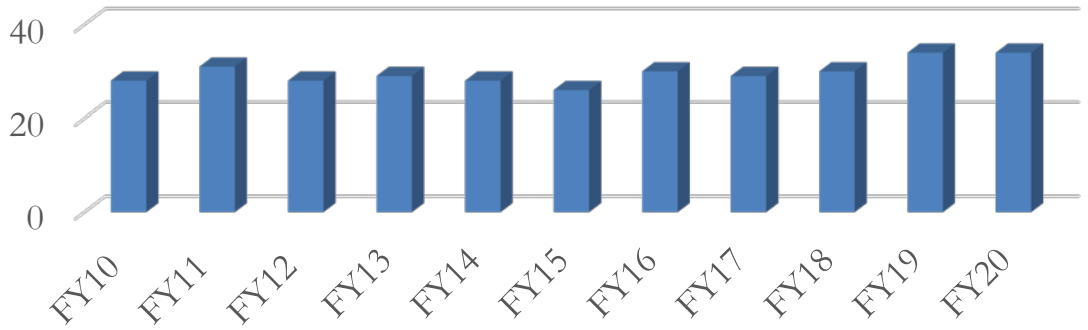
Regional and Global Model Analysis (RGMA) Overview

- **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

FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
28M	31M	28M	29M	28M	26M	30M	29M	30M	34M	34M



Roughly 120 publications/year

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RGMA

Model Analysis to Enhance a Predictive Understanding at Regional and Global Scales

MODES OF VARIABILITY AND CHANGE

CLOUD PROCESSES

HIGH-LATITUDE FEEDBACKS

WATER CYCLE

EXTREMES

BIOGEOCHEMICAL FEEDBACKS

Metrics to Evaluate Models	Test Beds	Uncertainty Characterization	MIPs
	Diagnostic Tools		D&A
Extreme Events & Tipping Points	Climate Feedbacks and Process Interactions	Regional Modeling	Hierarchy of Models

FOUNDATIONAL CAPABILITIES

Model Development

Observations and Process Knowledge

PCMDI

catalyst

Cooperative Agreement to Analyze variability, change and predictability in the earth system

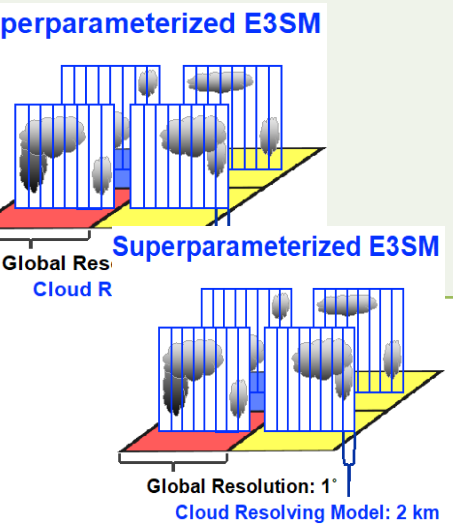
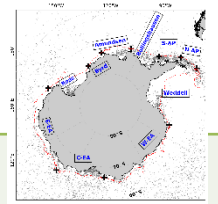
U.S. Department of Energy | Office of Science

HYPERFACETS

A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

University Projects through FOAs + Jointly funded Interagency Projects

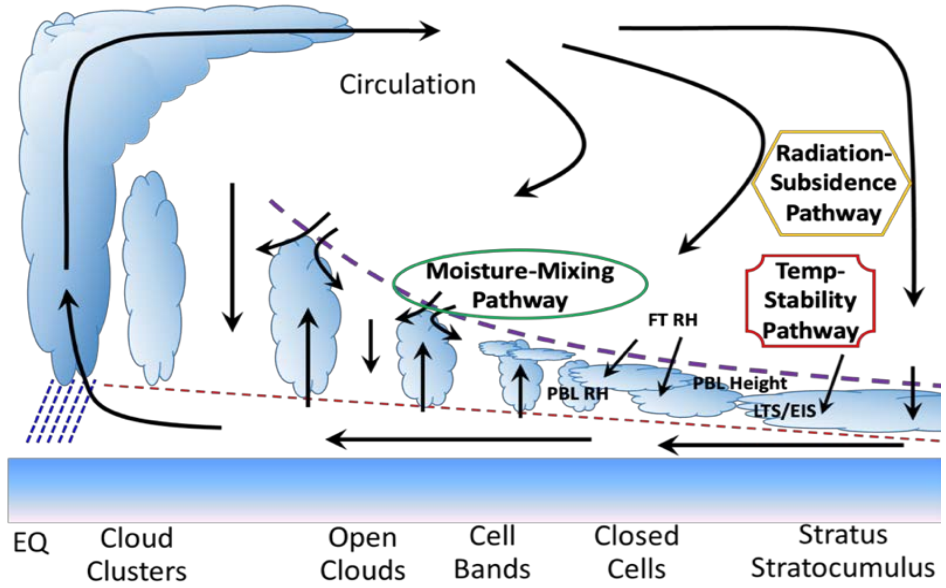
RGMA FY18 & FY19 University Projects from FOA 1862

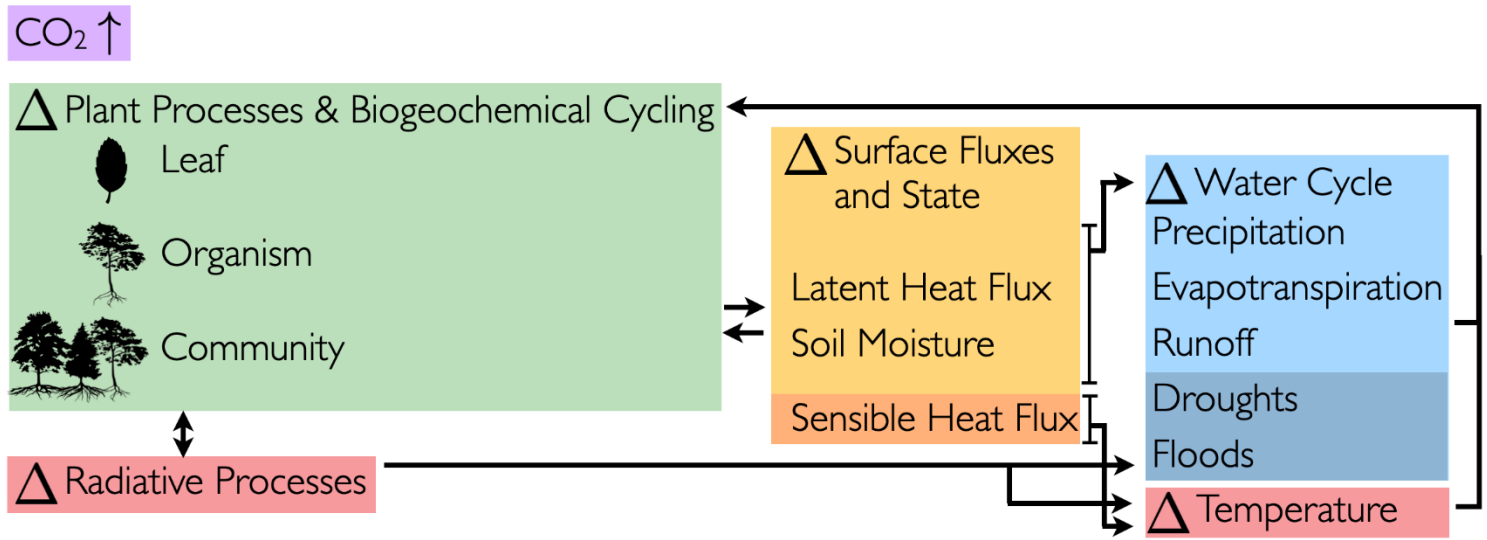
Science Themes	University Projects
• Water Cycle • Extremes 	• **Boos: Monsoon Extremes: Impacts, Metrics, and Synoptic-Scale Drivers** • **Kooperman: Simulating Extreme Precipitation in the United States in the E3SM: Investigating the Importance of Representing Convective Intensity Versus Dynamic Structure** • **Kim: Madden-Julian Oscillation, Tropical Cyclones, and Precipitation Extremes in E3SM** • **Saravanan: Assessing the influence of background state and climate variability on tropical cyclones using initialized ensembles and mesh refinement in E3SM**
Variability & Change	• **Kirtman: Decadal Prediction and Predictability of Extremes in Ocean Eddy Resolving Coupled Models** • **DiLorenzo: Mechanisms of Pacific Decadal Variability in ESMs: The Roles of Stochastic Forcing, Feedbacks and External Forcing** • **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**
 High Latitude Feedbacks	• **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**

RGMA FY20 University Projects: FOA 2230

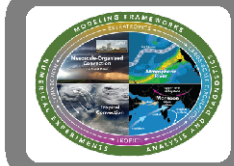
Office of Science

Science Themes	University Projects
Cloud Processes	• Soden: Investigating Cloud Feedbacks in Earth System Models • Su: The Role of Deep Convection and Large-scale Circulation in Driving Model Spread in Low Cloud Feedback and Equilibrium Climate Sensitivity
Analysis of BGC Feedbacks	• 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

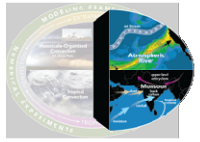




Water Cycle and Climate Extremes Modeling (WACCEM) SFA (Leung, PNNL; Skamarock, NCAR; Chen PSU)

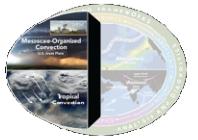


To advance robust predictive understanding of water cycle processes and hydrologic extremes and their multi-decadal changes



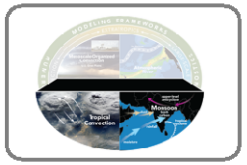
Large-scale circulation

- Predictability of atmospheric rivers and extreme precipitation
- Monsoon-ITCZ from an energetic perspective
- Baroclinic annular mode and subseasonal precipitation variability



Mesoscale convection

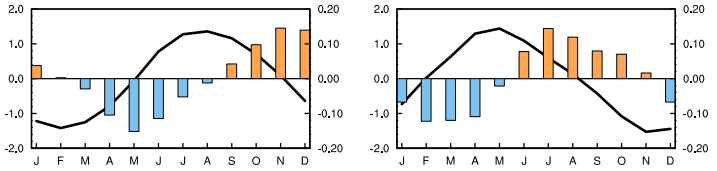
- Global characteristics of mesoscale convective systems (MCSs)
- Large-scale environments of MCSs and future changes
- MCSs and hydrologic floods in the U.S.



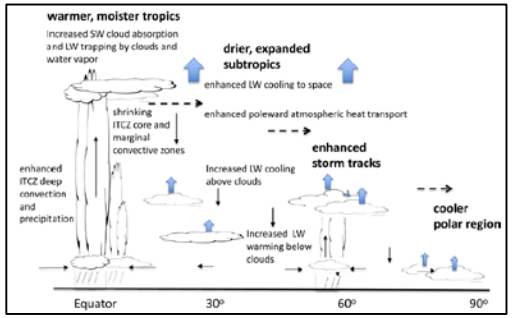
Multiscale convection-circulation interactions

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

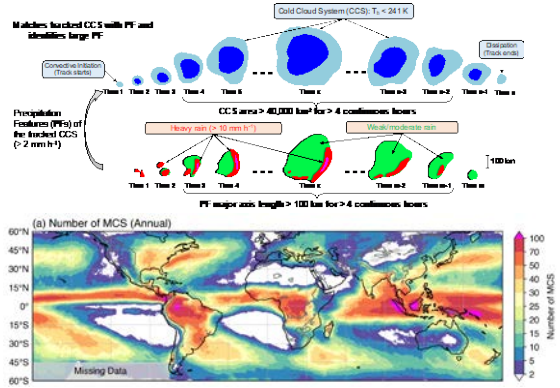
Contrasting precipitation seasonal cycle phase changes over land and ocean under warming



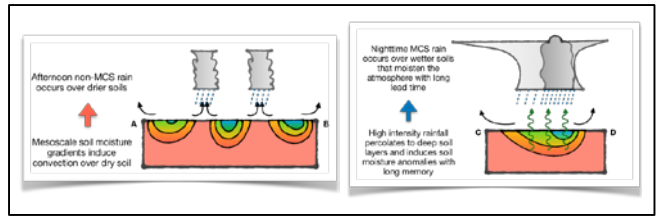
Radiation-cloud-convection-circulation induced changes in ITCZ from MMF experiments



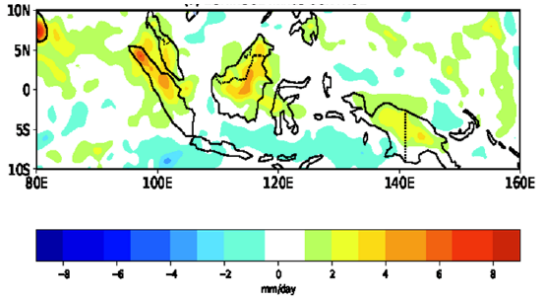
A new global MCS dataset



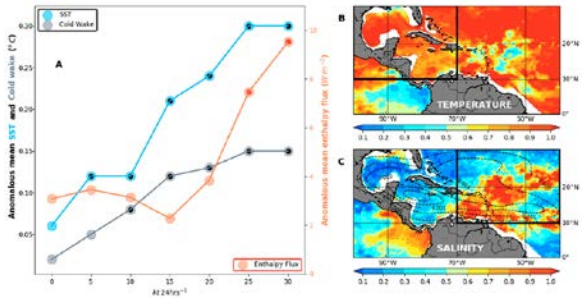
MCS plays a larger role than non-MCS in soil moisture-precipitation feedback in the central US



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



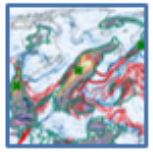
Salinity has pronounced impact on rapid intensification of tropical cyclones



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

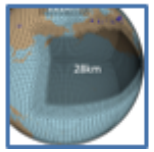


TECA3

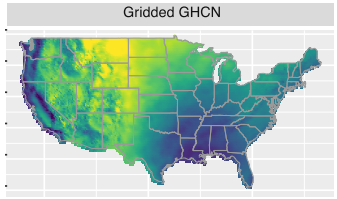
Statistical Analysis Software

Preparing for Exascale

Ad hoc Tool Development

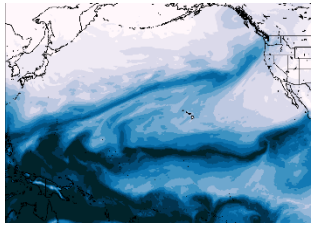


Extremes in Observations



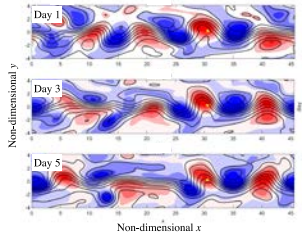
- Statistical modeling to interpret trends in the observational record
- Innovative geostatistical approaches for reducing signal-to-noise

Variability in Extremes



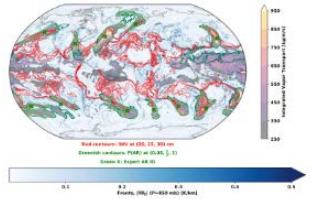
- Investigation of response of extremes to thresholds & non-linearities in the coupled system
- Emphasis on mountain hydroclimate

Extremes @ Native Scales



- High-resolution model & observational analysis of multiscale extremes
- Focus on MJO, blocking, teleconnections and model fidelity

Detection of Extremes & UQ



- Develop machine-learning approaches for detecting weather phenomena: ARs, TCs, ETCs, fronts,…
- Uses statistical and NN-based ML approaches

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

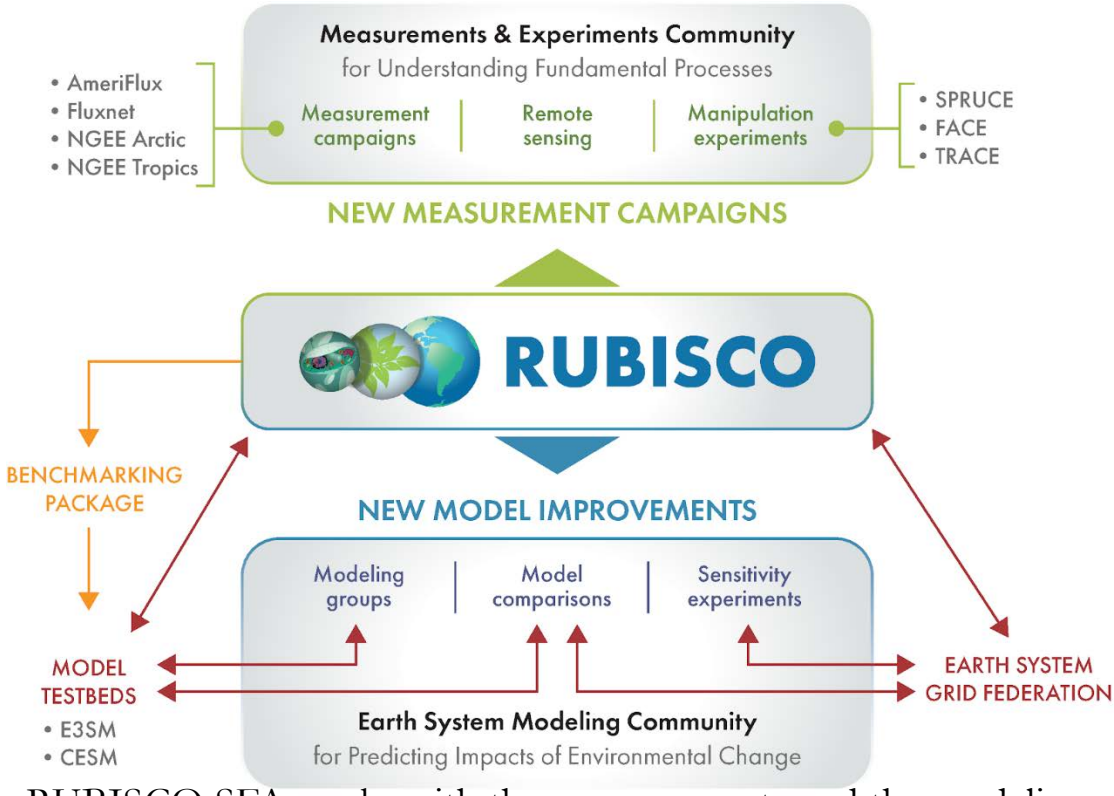
Forrest M. Hoffman (Laboratory Research Manager), William J. Riley (Senior Science Co-Lead), and James T. Randerson (Chief Scientist)

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.

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

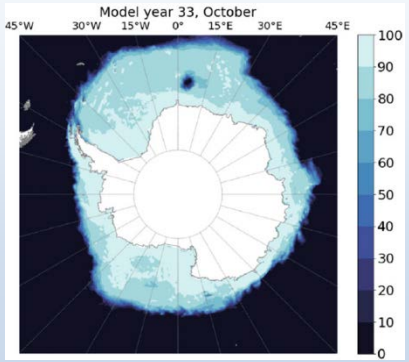
(Weijer, LANL; Wang, PNNL, Maslowski NPS)

- *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

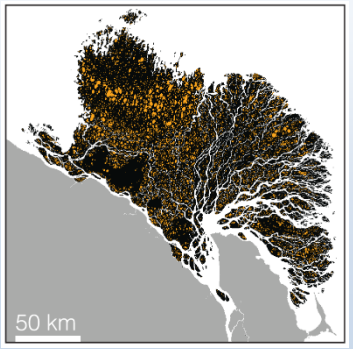


Maud Rise Polynya in E3SMv0-HR (Kurtakoti et al. 2018)

Theme 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***

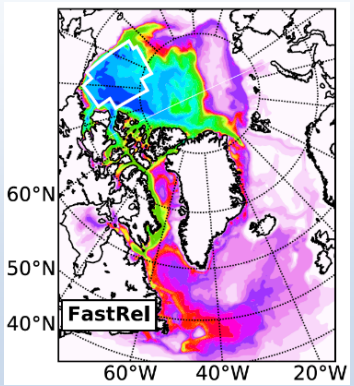


Lakes of the Lena River Delta (Pilioura & Rowland 2020)

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***

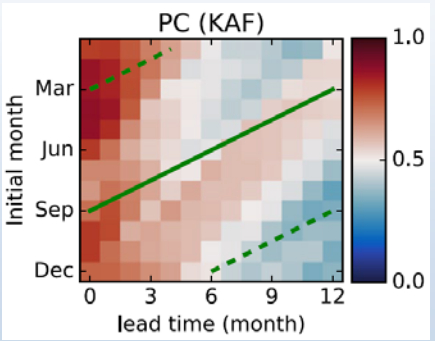


Distribution of Beaufort Gyre freshwater 13 years after release (Zhang et al. 2020)

Theme 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)

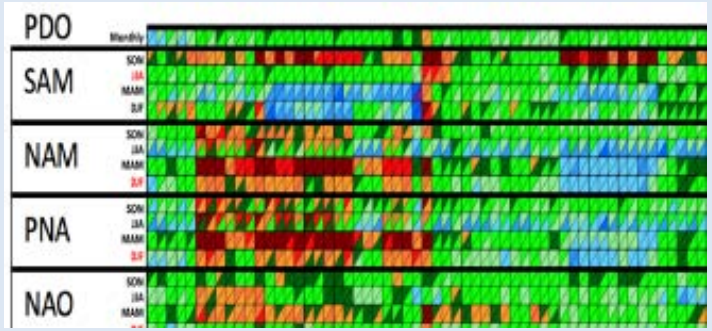
PCMDI – An Earth System Model Evaluation Project

PI: Steve Klein

PCMDI Earth System Model Evaluation Project

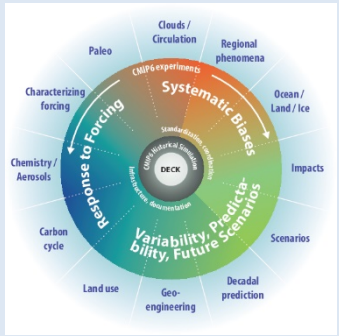
Using model ensembles of today and tomorrow to measure model performance, reduce uncertainties in their predictions, and determine the pathways for their improvement

Measuring Model Performance and Facilitating Community Involvement

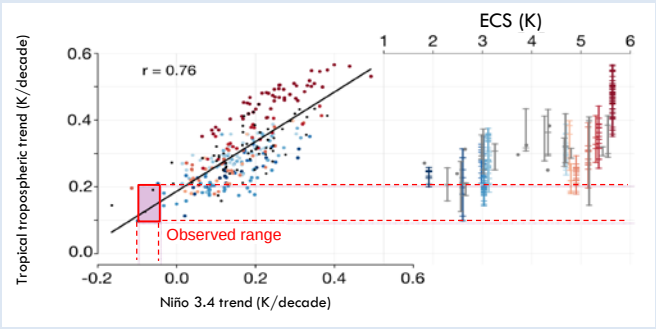


Supporting Ensembles of Earth System Models

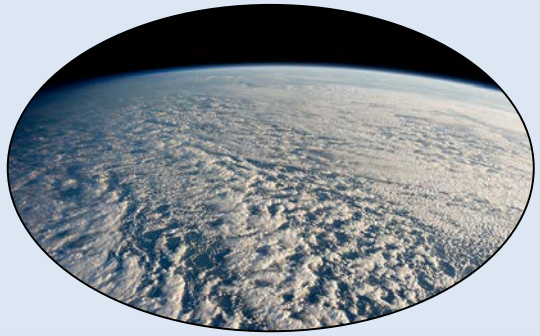
CMIP6



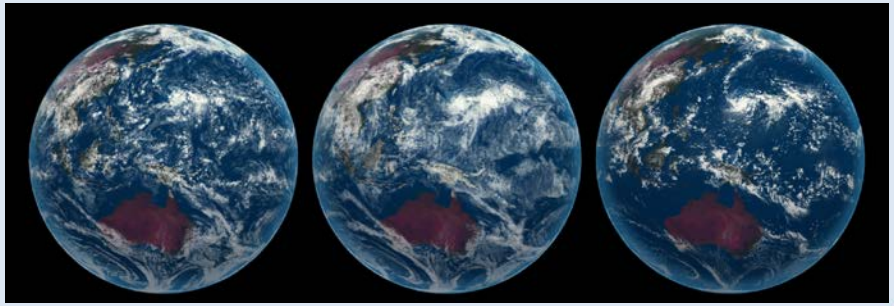
Interpreting Recent Changes in Climate to Inform Predictability



Reducing Uncertainties in Cloud Feedbacks & Climate Sensitivity



Engaging with the Convection Permitting Models of Tomorrow



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

catalyst
Cooperative Agreement To Analyze variabiLity, change and predictabilitY in the earth SysTem

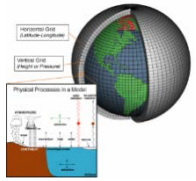
Perform foundational research toward advancing a robust understanding of modes of variability and change using models, observations and process studies

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

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

Use-Inspired Metrics

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?

Expert Guidance

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

Stakeholder Engagement

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

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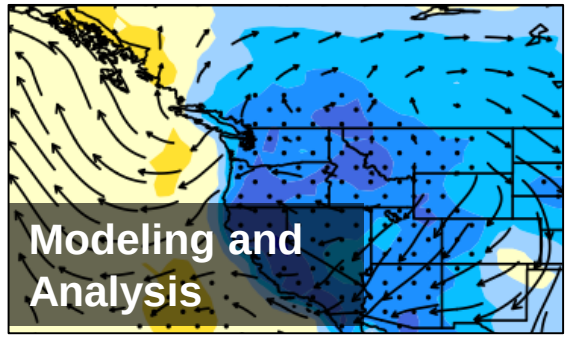
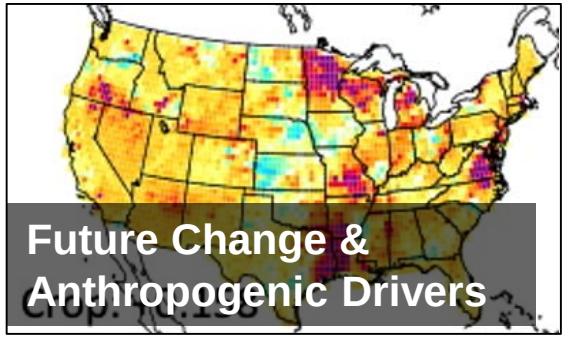
HYPERFACETS

A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales



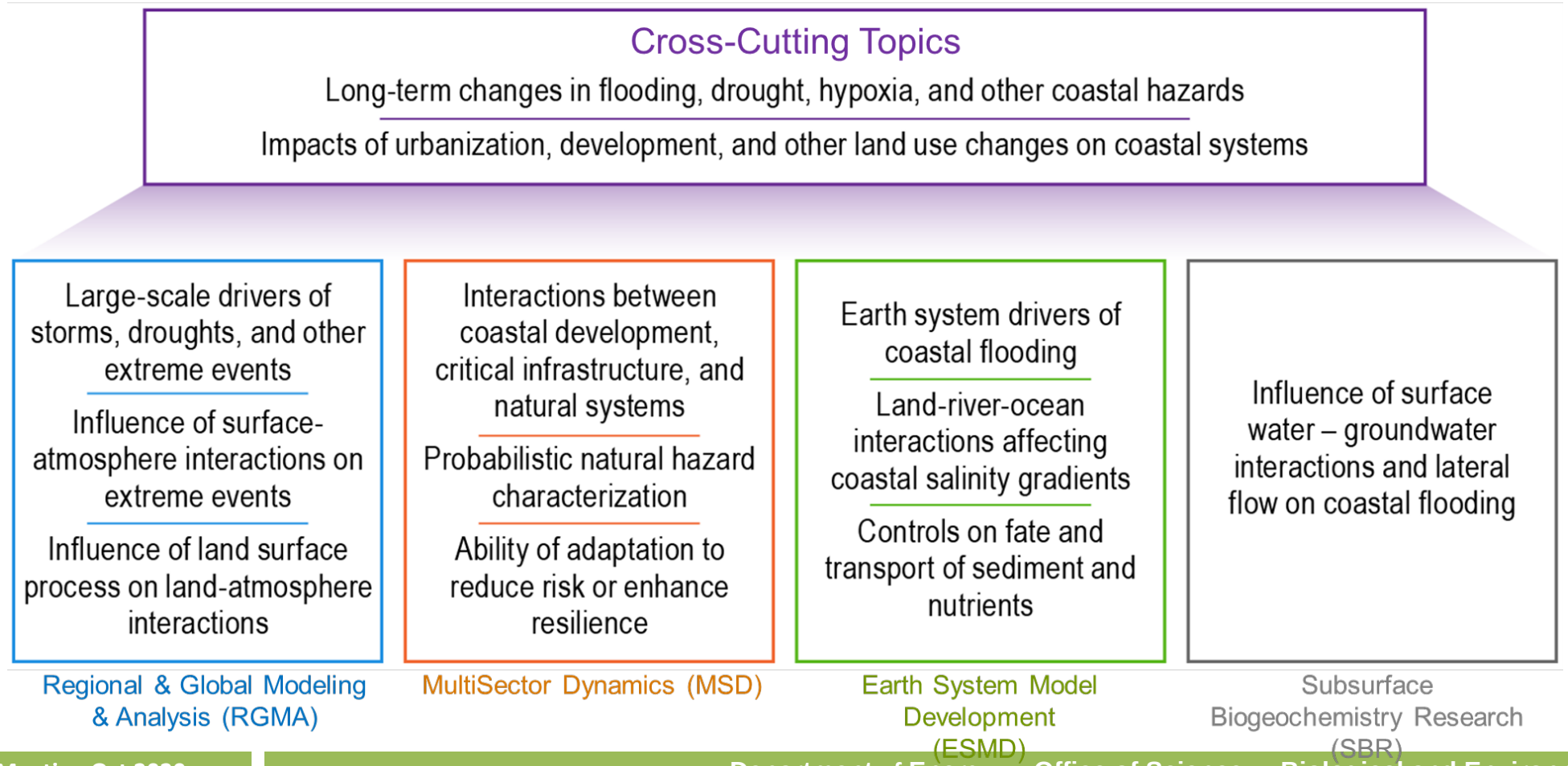


U.S. DEPARTMENT OF ENERGY

Office of Science

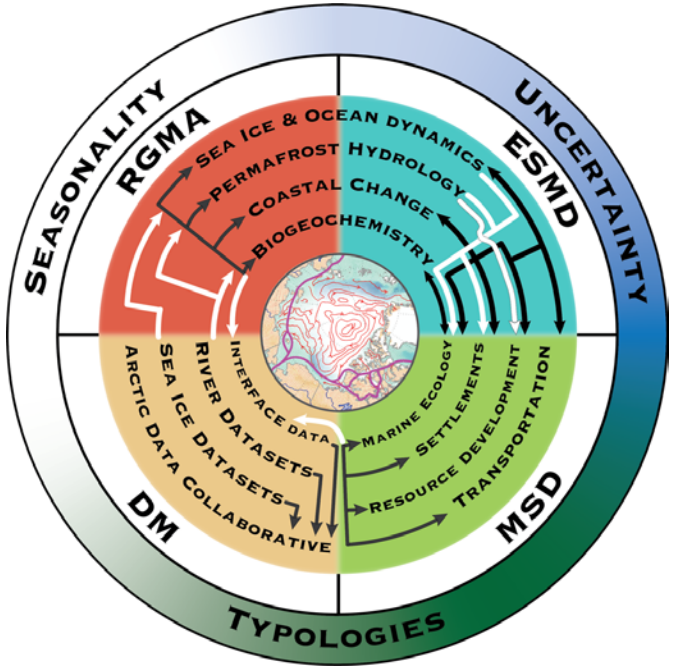
DOE's Integrated Coastal Modeling (ICoM) Project (Kraucunas, PNNL)

ICoM Research Topics for FY 2020–2022



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

INTERFACE

Los Alamos NATIONAL LABORATORY

OAK RIDGE National Laboratory

Pacific Northwest NATIONAL LABORATORY

Sandia National Laboratories

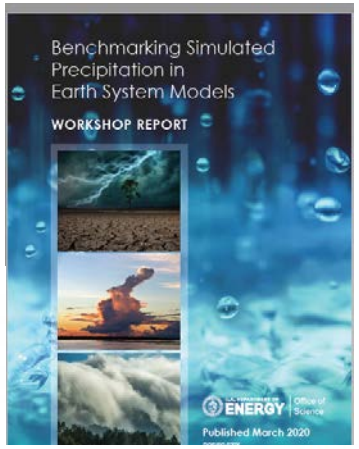
UAF UNIVERSITY OF ALASKA FAIRBANKS

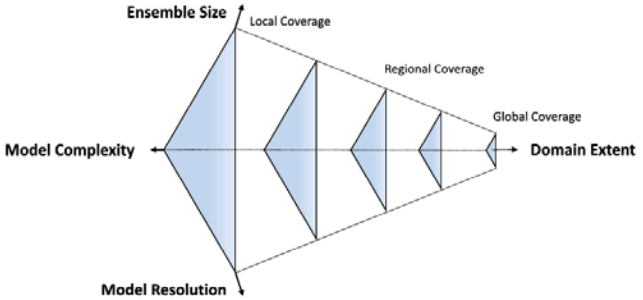
tal Research

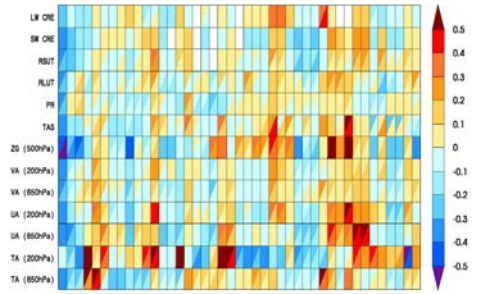
RGMA Collaborative Activities

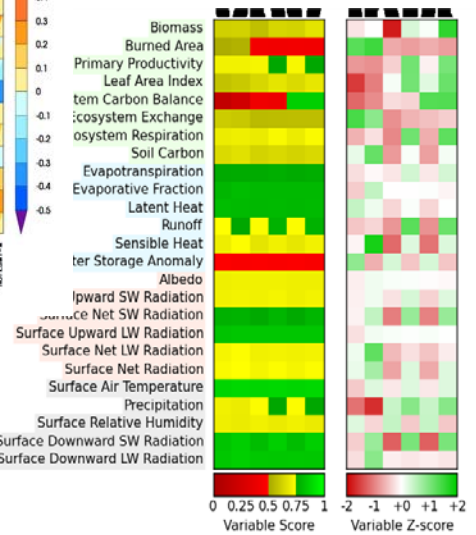
Office of Science

- 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









2019 -2020 Awards

Office of Science

2019


Inez Y. Fung, University of California-Berkeley
AMS *Carl-Gustaf Rossby Research Medal*


Fei-Fei Jin, University of Hawaii
AMS *Sverdrup Gold Medal,* & AMS Fellow


Samson M. Hagos, PNNL
AMS *Clarence LeRoy Meisinger Award-Early Career*


Benjamin P. Kirtman, University of Miami
AMS Fellow


Ruby Leung, PNNL
AGU Bert Bolin Award and Lecture


Alex Hall, UCI
2019 Future Horizons in Climate Science: Turco Lectureship Award and Lecture from AGU

**Apologies if I have missed some*

2020


Stephen Klein, LLNL
AMS Fellow


Sarah Gilles, Scripps
2021 AMS Fellow, The Sverdrup Gold Medal


Benjamin D. Santer, LLNL
AGU Bert Bolin Global Environmental Change Award

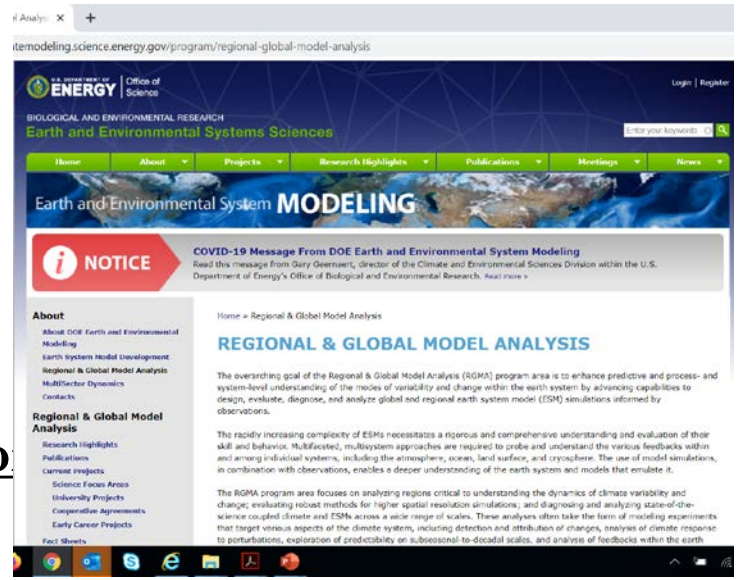

Abigail Swann, University of Washington
AMS Walter Orr Roberts Lecture 2021


Warren Washington, NCAR
National Council for Science and Environment Lifetime Achievement Award

Expectations of Funded Projects:

Office of Science

- Send **highlights** when publications are accepted
  - This helps us highlight your successes to our upper management
  - Identify synergies across the portfolio
  - 34 publications were posted on the RGMA website in the last quarter
- **Use Computing Time**
  - NERSC - Use your time and request for more
  - ALCC & INCITE – Please Apply
- **Participate in regular SFA led telecons and Collaborate as appropriate**
  - Some SFAs have regular telecons
- Large projects are requested to identify milestones
  - Publications are a success metric
  - So is leadership in the field
- Identify synergistic use of **E3SM simulations**
- Collaborate on **development of Metrics**
- Develop linkages in efficiently building an **RGMA ML/AI framewo**
- Looking forward to the **Meeting report**



https://climatemodeling.science.energy.gov/program/regional-global-model-analysis

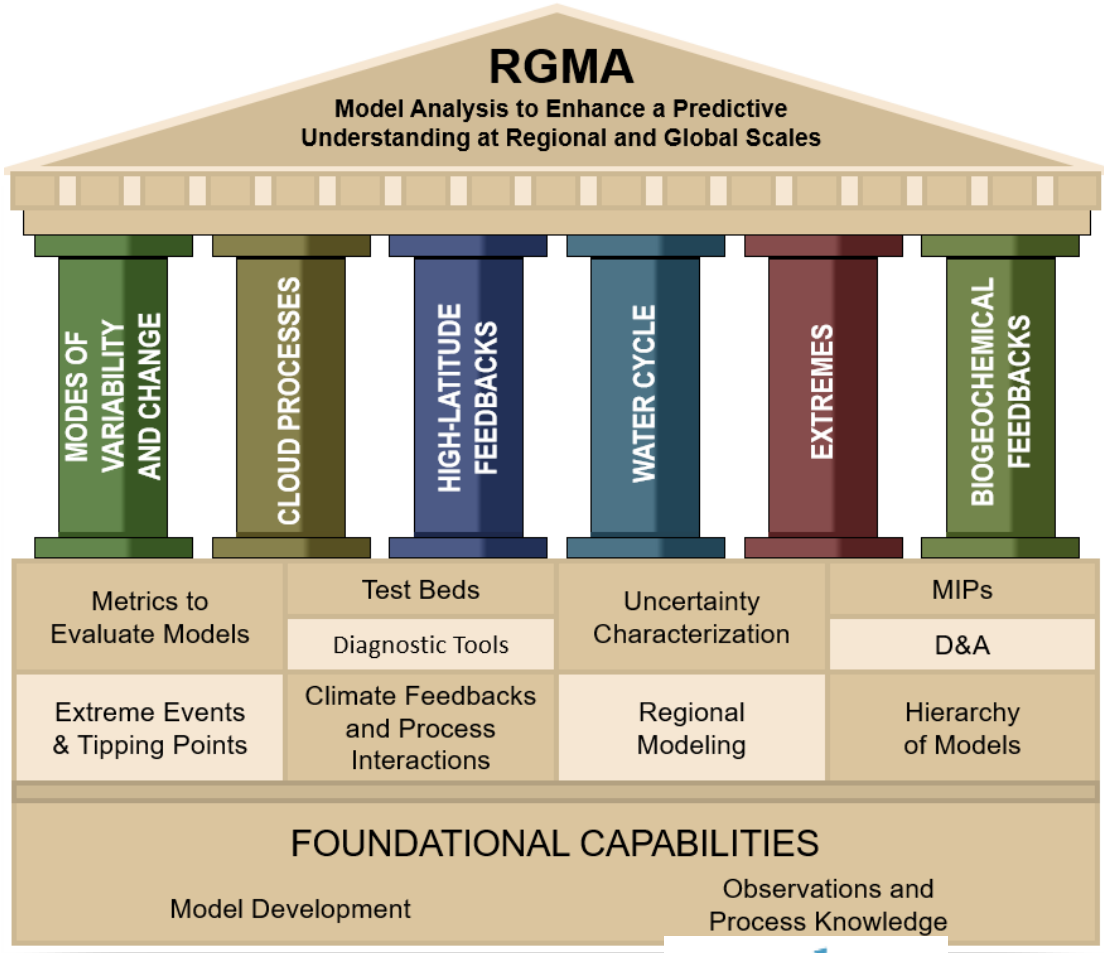
Thank You

- All of the Participants & Presenters
- **CoChairs:** Daehyun Kim, Colin Zarzycki, Yaga Richter, Kevin Reed, Jiwen Fan, Naresh Devineni, Chris Patricola, Bill Boos, Milena Veneziani, Paul Ullrich, Hailong Wang, Trevor Keenan, Hui Su, Bill Collins, Balu Nadiga, Alex Hall, Forrest Hoffman
- **Breakout Leads:** Ruby Leung, Gabe Kooperman, Forrest Hoffman, Dave Lawrence, Charlie Koven, Joel Rowland, Kartik Balaguru, Yun Qian, Bill Boos, Jian Lu, Angie Pendergrass, Kevin Reed, Jesse Norris, Steve Klein, Hui Su, Brian Medorois, Jiwen Fan, Ben Kirtman, Jerry Meehl, Chris Patricola, Wilbert Weijer, Gudrun Magnusdottir, Hailong Wang
- **Program Committee**: Forrest Hoffman, Paul Ullrich, Ruby Leung, Travis O' Brien
- **ORISE Support**: Tracey Vieser, Lee-Ann Kiser, and the ORISE Team

Regional and Global Model Analysis Program Area

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

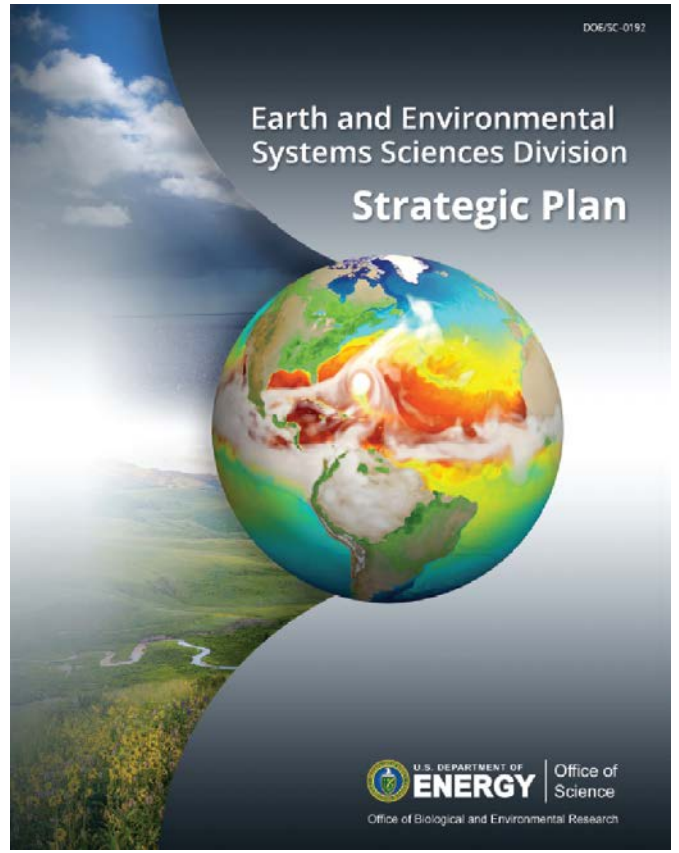


Portfolio consists of peer reviewed Core (logos below) and University Projects (that are part of FOAs)

DOE Strategic Plan

EESSD's Vision: An improved capability for earth system prediction on seasonal to multi-decadal time scales to inform the development of resilient U.S. energy strategies.

Integrated Water Cycle Scientific Grand Challenge: Advance understanding of the integrated water cycle by studying relevant processes involving the atmospheric, terrestrial, oceanic, and human system components and their interactions and feedbacks across local, regional, and global scales, thereby improving the **predictability of the water cycle** and reducing associated uncertainties in response to short- and long-term perturbations.



1. **Integrated Water Cycle**
2. **Biogeochemistry**
3. **High Latitudes**
4. **Drivers & Response in the Earth System**
5. **Data-Model Integration**

U.S. DEPARTMENT OF ENERGY

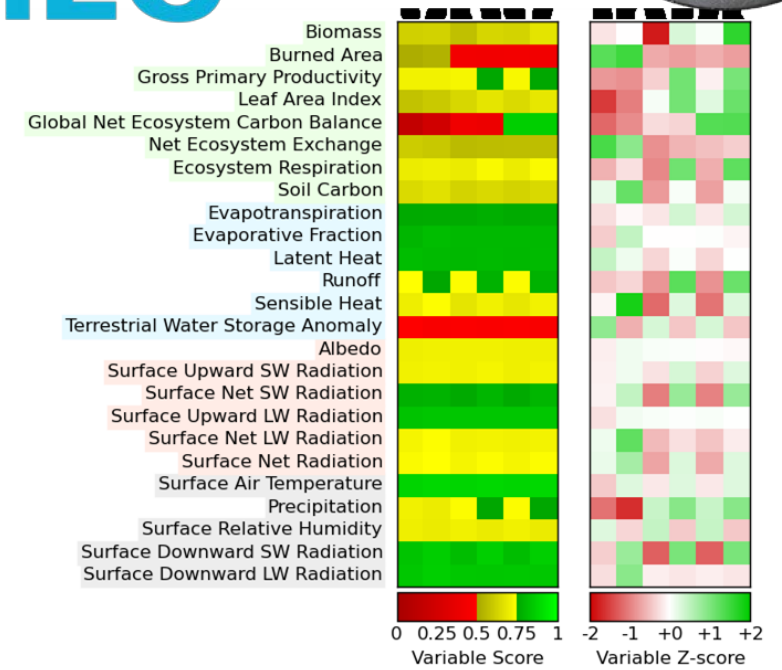
Office of Science

CMEC - Coordinated Model Evaluation Capabilities (CMEC) for Historical Simulations Joint Analysis of Variability, Extremes and BGC

Integrated Tools and Science for Event Analysis

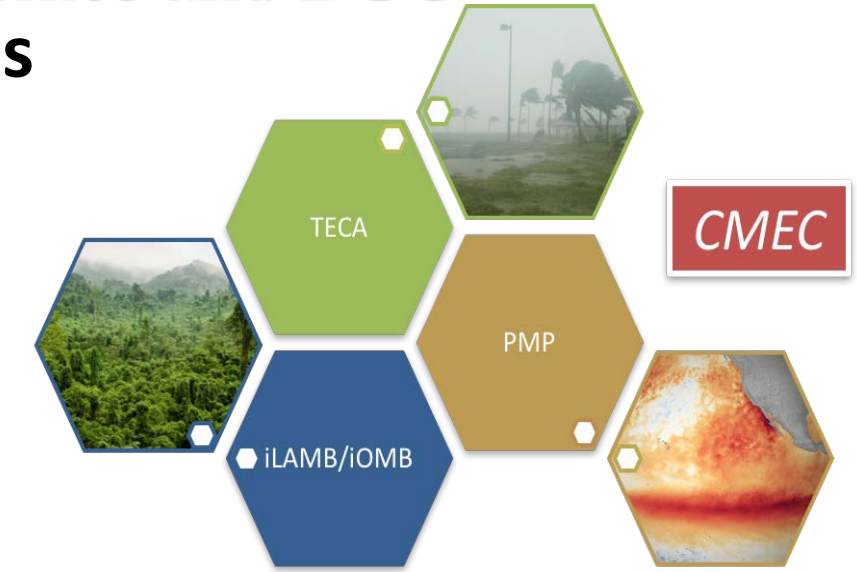
CMEC

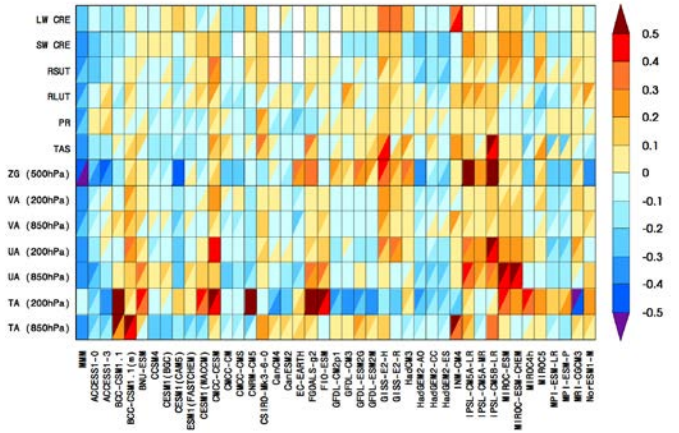
TECA



ILAMB

CMEC





PMP

The Ongoing Need for High-Resolution Regional Climate Models – (An outcome of the last PI meeting)

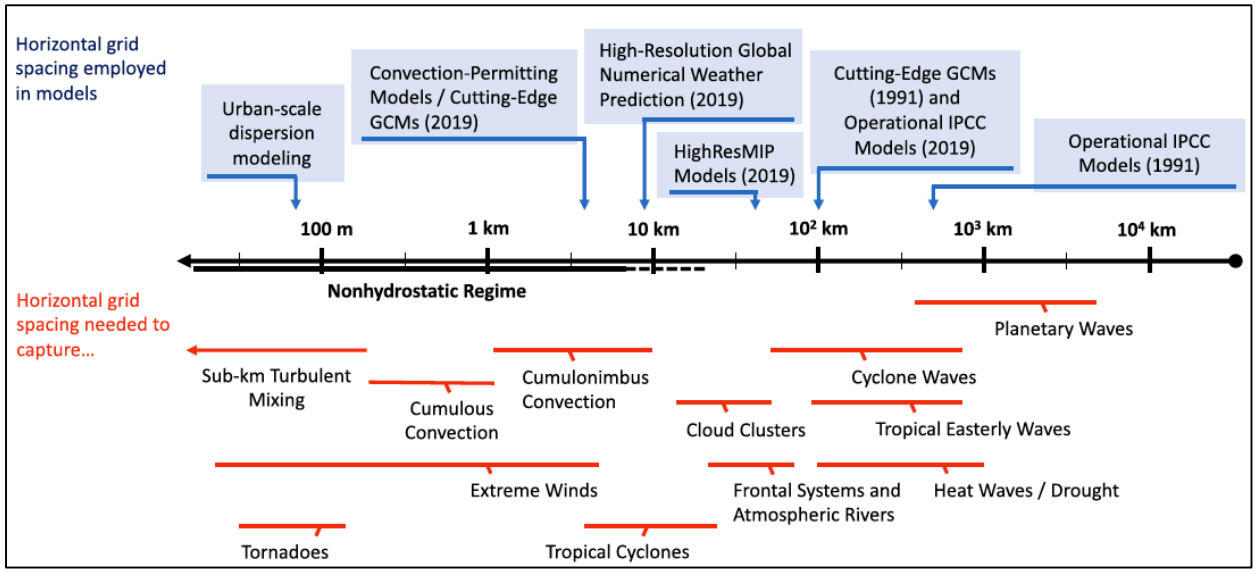
- Regional and global climate modeling have been simultaneously advancing toward higher resolution along complementary paths to provide a deeper understanding of the processes that govern climate and its regional changes
- There is a need to support development of modeling tools tailored for targeted problems (e.g., storm tracks for GCMs and local land-atmosphere coupling for RCMs)
- The configurability of RCMs allows for a wide range of studies to disentangle local climatic response to global forcing vs. regional processes

BAMS Article

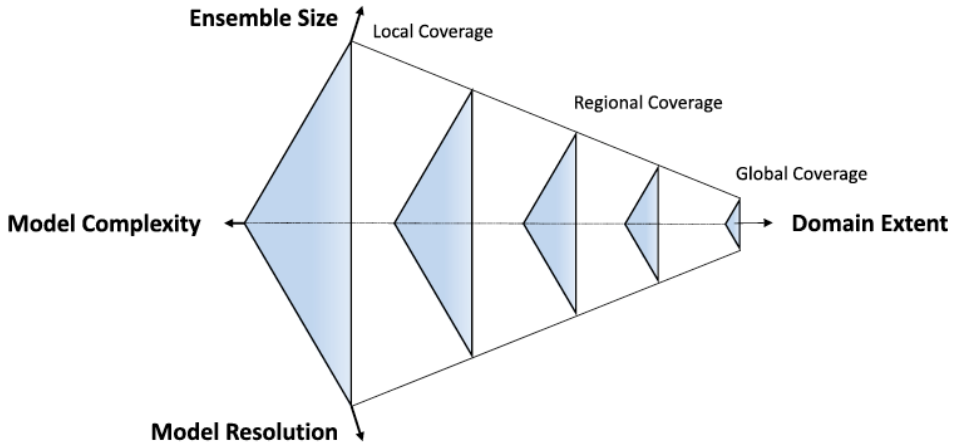
The Ongoing Need for High-Resolution Regional Climate Models

Process Understanding and Stakeholder Information

W. J. Gutowski Jr., P. A. Ullrich, A. Hall, L. R. Leung, T. A. O'Brien, C. M. Patricola, R. W. Arritt, M. S. Bukovsky, K. V. Calvin, Z. Feng, A. D. Jones, G. J. Kooperman, E. Monier, M. S. Pritchard, S. C. Pryor, Y. Qian, A. M. Rhoades, A. F. Roberts, K. Sakaguchi, N. Urban, and C. Zarzycki

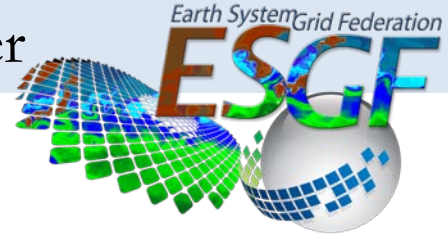


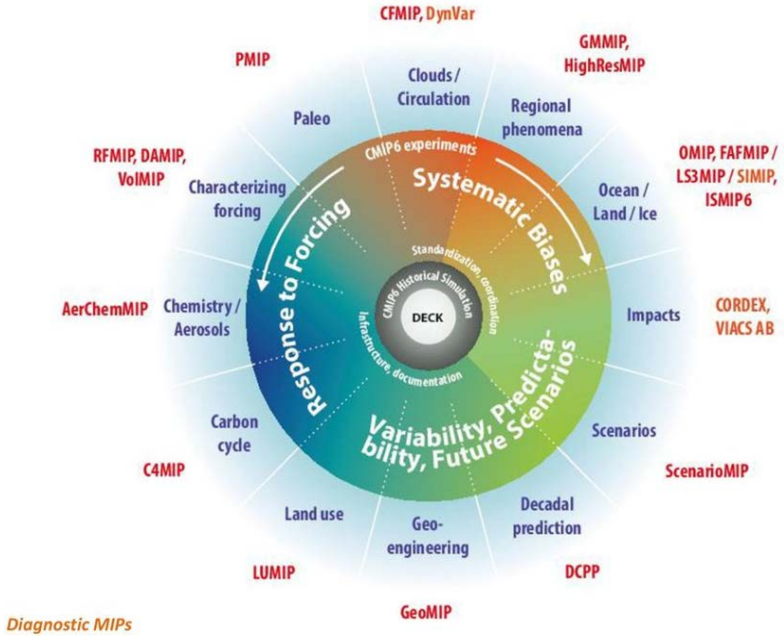
Allowed state space for RCM increases the level of configurability of modeling experiments



RGMA CMIP6 Analysis and Hackathon

Wilbert Weijer
Forrest Hoffman
Paul Ullrich
Mike Wehner





Data is available on NERSC
More Data is being added

Precipitation Metrics Workshop

PCMDI Pacific Northwest NATIONAL LABORATORY NCAR

- Inspired by the lack of objective and systematic benchmarking of simulated precipitation
- Community input via DOE 2018 AGU Town Hall and international modeling working groups
- Date/venue: July 1-2, 2019 in Rockville, Md

Identify targets for improvement

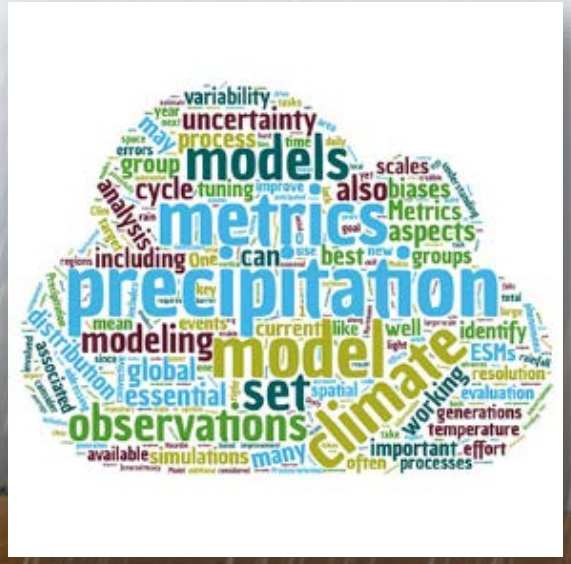
Team of experts identifies useful measures for gauging how well models simulate precipitation

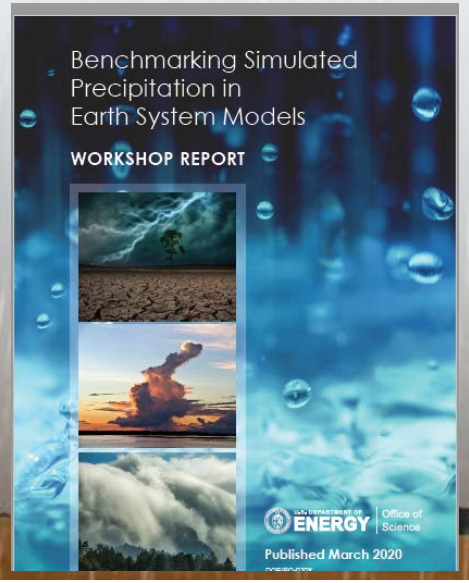
Develop capability to gauge model quality

Baseline metrics incorporated into a model evaluation capability and used to assess current

Improve simulated Precipitation

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





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

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 CO_2, 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)

Soil Carbon Dynamics Working Group

U.S. DEPARTMENT OF ENERGY

RUBISCO

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

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

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

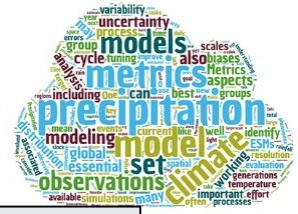
Model–Data Integration Theme

- 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>

Argonne NATIONAL LABORATORY · BROOKHAVEN NATIONAL LABORATORY · BERKELEY LAB · Los Alamos NATIONAL LABORATORY · NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH · OAK RIDGE National Laboratory · UCI · MICHIGAN

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

RGMA participating scientists

- Samson Hagos
- Ben Kirtman
- Hsi Yen Ma
- Angeline Pendergrass

U.S. DEPARTMENT OF ENERGY

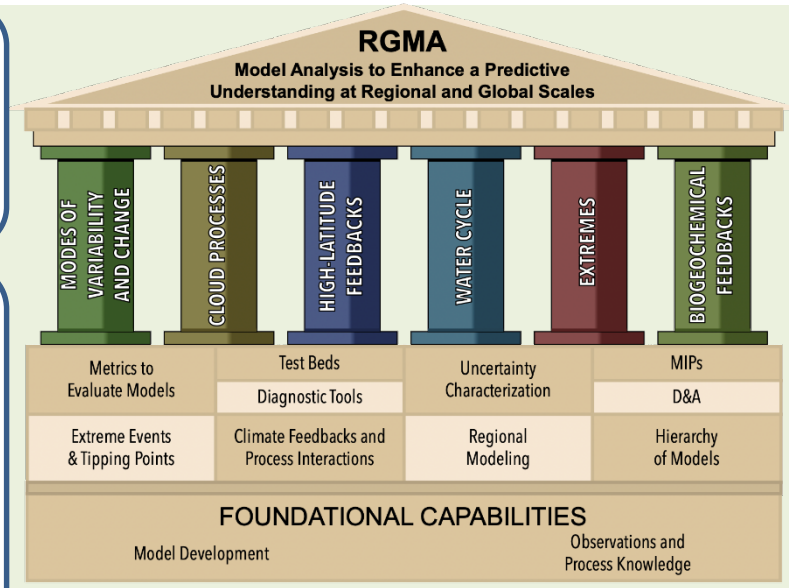
Regional and Global Model Analysis: Core Effor

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)



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)

U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales

Earth System Model Development Program Area

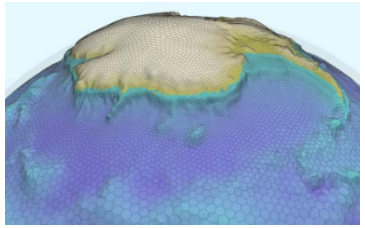
Vision: *Develop Earth system models, i.e, Energy Exascale Earth System Model (E3SM) and its subcomponents, to address the grand challenge of actionable predictions of the changing Earth system, with an emphasis on the most critical scientific questions facing the nation and DOE*

Goals:

- ✓ Improved predictability of the Earth system
- ✓ Simulations, predictions, and projections to support DOE's energy mission
- ✓ Prepare for and overcome the disruptive transition to next era of computing

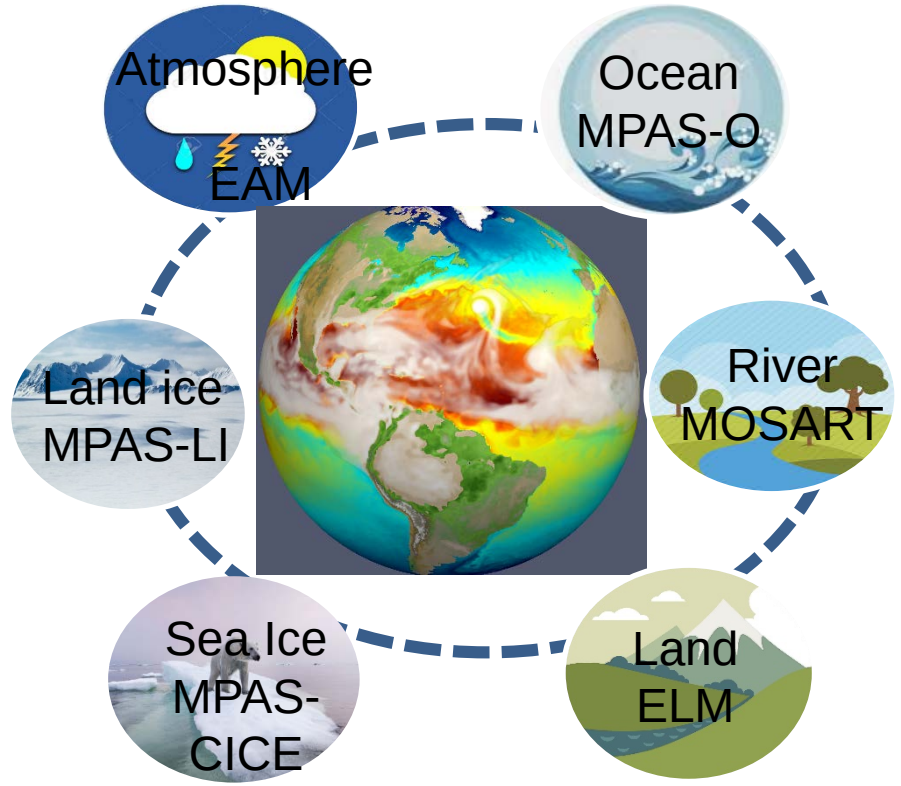
Strategies:

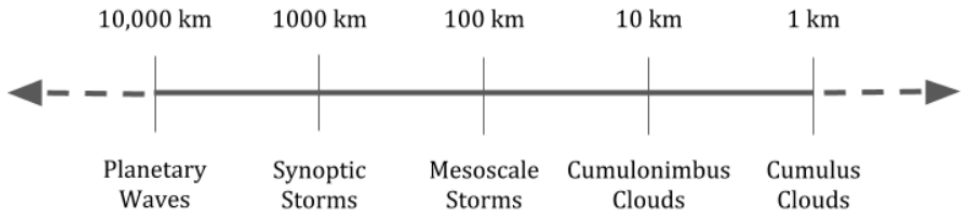
- ➢ High-resolution frontier
- ➢ Earth system across scales
- ➢ Science driver for model development
- ➢ Innovative computational methods



SciDAC
Scientific Discovery through Advanced Computing

Earth System Across Scales





MultiSector Dynamics Program Area

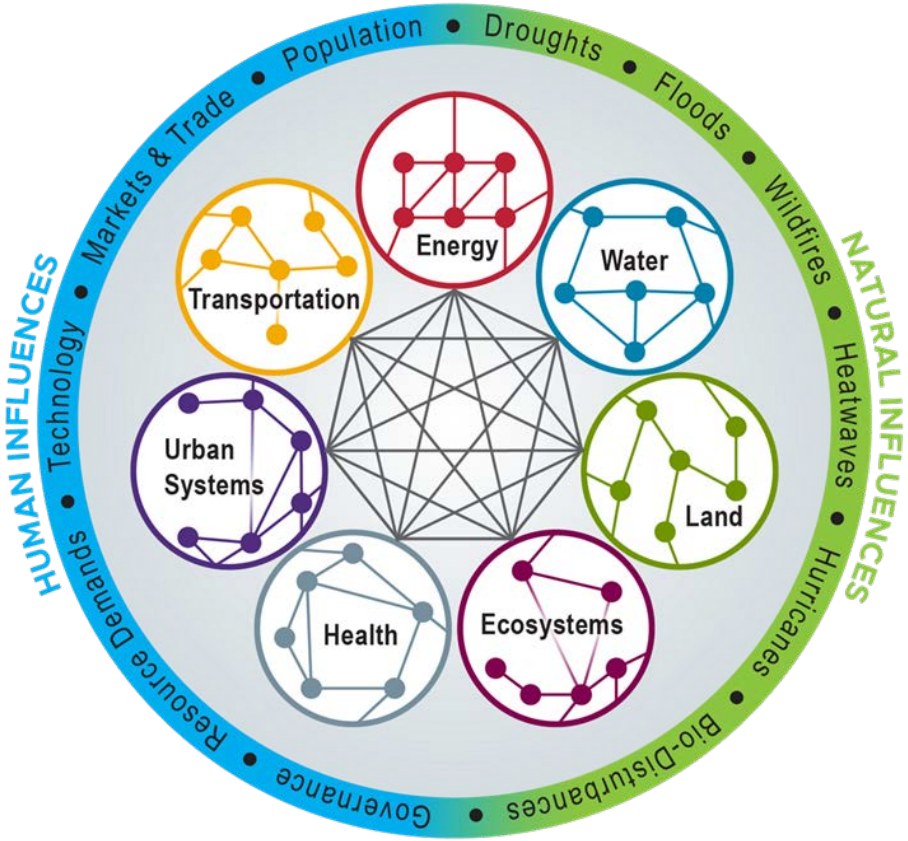
Explore the complex interactions and potential co-evolutionary pathways within the integrated human-Earth system, including natural, engineered, and socioeconomic systems and sectors.

Focus:

1. **Forces and Patterns -** patterns of development in multi-sector, multi-scale landscape evolution, including interactions and interdependencies among natural and built environments and human processes and systems.

2. **Stabilities and Instabilities -** stabilities and instabilities across systems, sectors, and scales with new insights into the role of strong interdependencies, feedbacks, and compounding influences and stressors.

3. **Foresight** - development patterns, stabilities, instabilities, and systems resilience as a result of <u>future</u> forces, stressors, and disturbances… both gradual and abrupt transitions.

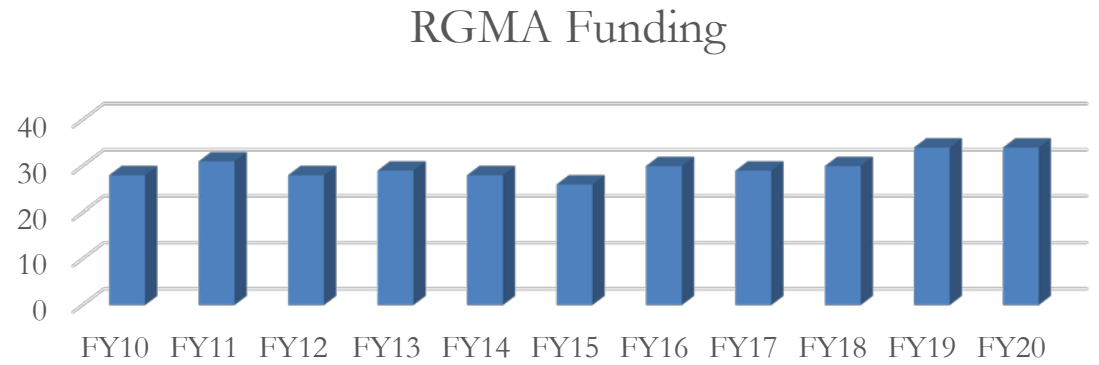


- Global to local
- Complex landscape evolution
- Multi-influence, multi-stressor
- Sectors, infrastructures, regional economies, natural resources…
- Feedbacks and dynamics

History

Office of Science

- Formed in 2010 due to an increase in funding in the Climate Change and Prediction Program
- Had a mixture of development and analysis projects
- In 2010 there were three SFAs + UCAR CA
- 2010-2012 Transitioned from over 90% "renewal" applications to <2%
- 2014/2015 Core activities were aligned into 6 science themes
- 2016 Cross-cutting projects established with MSD



FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
28M	31M	28M	29M	28M	26M	30M	29M	30M	34M	34M