

DOE Update U.S. CLIVAR Summit 2014

Renu R Joseph Program Manager, RGCM, DOE



PARTMENT OF C











Office of Science

Office of Biological and Environmental Research



2 CLIVAR Update 2014

Department of Energy • Office of Science • Biological and Environmental Research

Climate and Environmental Sciences Division – Process View



Climate and Earth System Modeling Strategic Plan alignment

Mission: To advance a robust **predictive understanding** of Earth's climate and environmental systems and to inform the development of sustainable solutions to the Nation's energy and environmental challenges.

Goals:



- Process knowledge and innovative computational methods advancing next-generation, integrated models of the human-Earth system.
- Process-level understanding of <u>atmospheric systems</u> and <u>terrestrial</u> <u>ecosystems</u>, extending from bedrock to the top of the vegetative canopy.
- Coupled <u>biogeochemical processes</u> in complex subsurface environments to enable systems-level environmental prediction and decision support.
- Enhance the unique capabilities and impacts of the <u>ARM and EMSL scientific</u> <u>user facilities</u> and other BER community resources to advance the frontiers of climate and environmental science.
- Address science gaps that lead to solutions for DOE's most pressing energy and environmental challenges.

CLIVAR Activities Supported over the Past 3-4 Years

- Model diagnostics and analyses through solicitations focusing on
 - modes of climate variability, extremes
 - understanding uncertainties and feedbacks
 - Tropical biases (e.g., Dynamo campaign)
 - EaSM 1 & 2 (NSF-USDA-DOE)
 - D&A with CCDD (with NOAA)



- PCMDI at LLNL and through joint support of NCAR's CGD with NSF
- CMIP5 support through support of CESM, PCMDI, ESGF [ESGF is currently supported through the Data Informatics Program]
- Model development activities [ESM program- more details in the next presentation]
- ARM infrastructure and process research support of VOCALS, DYNAMO (AMIE), SGP

RGCM Portfolio- Current and Future Priorities

5 Science Thrusts -SFAs

- 1. Single and Multimodel analysis of climate variability and change
- 2. CASCADE (CAlibrated and Systematic Characterization, Attribution, and Detection of <u>Extremes</u>)
- 3. Water cycle
- 4. High Latitude Feedbacks
- 5. Understanding feedbacks and uncertainties of biogeochemical cycles





RGCM Portfolio- Current and Future Priorities

5 Science Thrusts -SFAs

- 1. Single and Multimodel analysis of climate variability and change
- 2. CASCADE (CAlibrated and Systematic Characterization, Attribution, and Detection of Extremes)
- 3. Water cycle
- 4. High Latitude Feedbacks
- 5. Understanding feedbacks and uncertainties of biogeochemical cycles

4 CLIVAR Research Challenges:

- 1. Decadal variability and predictability
- 2. Climate extremes
- 3. Polar climate changes
- 4. Climate and marine carbon/biogeochemistry

LLNL: Multi-model perspective and understanding of climate and climate change POCS: Bader Taylor, Kleir

- PCMDI
 - Coordination of CMIP enables community-wide analysis
 - and diagnosis of climate models.
 - Climate variability and Change
 - Builds on in-house expertise in, e.g., detection and
 - attribution, MJO, ENSO and monsoon variability,
 - ocean heat content changes, and skill scores.
 - Attempts to promote more systematic and comprehensive summaries of model performance
 - Performance metrics and promotion of systematic quantitative analysis of climate models
- CAPT
 - To identify error sources in CAM's simulation of clouds and aerosols (e.g., YOTC; Correspondence of forecast errors to climate errors)
- Cloud Feedbacks component to narrow climate projection uncertainties
 - Quantifying and identify sources of inter-model spread in cloud feedbacks







LBNL : CAlibrated and Systematic Characterization, Attribution, and Detection of Extremes (CASCADE) (POC: Collins)

Extremes attribution / projection with robust UQ



- Probabilistic attribution of individual and multiple climate extremes
- Falsifiable short-range projections of extreme frequency and number
- Risks of changing scale / coincidence / duration / frequency

High-performance pipelines for UQ and metrics of extremes

- UQ system for extremes combining UQ and visualization frameworks
- Statistical analysis of PPE and perturbed IC/BC ensembles for UQ
- Analysis of CMIP5 & C20C archives for structural UQ, Type I/II errors

From model formulation to skillful attribution and projection

- Experiments to quantify roles of new scale-aware physics in extremes
- Capabilities and limitations of new refinable dycores for extremes
- Process-oriented tests to explore upper limits on model fidelity

Biogeochemistry-Climate Feedbacks Scientific Focus Area (POCs: Forrest @ ORNL; Riley @ LBNL)



Identify and quantify the feedbacks between biogeochemical cycles and the climate system, and to quantify and reduce the uncertainties in ESMs associated with those feedbacks.

iLAMB- Employing bestavailable observational data develops metrics and diagnostics for systematic assessment of Earth System Models

10 CLIVAR Update 2014

PNNL: Water Cycle and Climate Extremes Modeling (POC: Leung)

Objectives

- To improve and evaluate methodologies for high resolution modeling of water cycle and climate extremes governed by multi-scale processes
- To advance understanding of processes and feedback mechanisms associated with water cycle and climate extremes

Approach

- Use a hierarchical evaluation framework to assess how dynamical framework and physics parameterizations interact at multiple time/space scales
- Apply models to test hypotheses on process feedbacks that influence climate extremes associated with the atmospheric rivers, South American monsoon, and Asian monsoon



11 CLIVAR Update 2014

LANL: COSIM-RGCM Project – Applications and Analysis (POC: Jones)

- Focus on high latitude climate change and its impacts (MPAS)
 - <u>Ice sheets and sea level rise</u>, especially longer term implications
 - Long-term sea ice thinning, sea ice predictability and new sea ice intercomparisons
 - Ocean circulation and stability with a focus on meridional overturning and role of eddies in ocean circulation
- Development of new metrics and diagnostics
 - Eddy diagnostics
 - Long-term tracers and proxies for mode water and AMOC studies
 - Ocean, ice metrics for intercomparison and prediction
 - UQ/assimilation approaches for data comparison
- Single (or few)-component sims for science questions, process studies, and model evaluation







Long-range (~5-10 years) Climate Research Areas of Interest that Intersect with CLIVAR- RGCM and Data Informatics

- Establish advanced model metrics to guide model development and to guide selection of experimental sites [RGCM Program]
 - Development of Metrics
 - Uncertainty Characterization
 - Diagnostics for Model Evaluation [DIAG4MEP?]
 - Involvement in Metrics Panel
 - OBS4MIP (jointly with NASA)



- Continue funding the 5 SFAs encouraging interaction with the University partners [RGCM]
- Develop more sophisticated frameworks and software for model and measurement analysis, comparison, and visualization for the community through mechanisms such as the Earth System Grid Federation, UV-CDAT (<u>http://uv-cdat.llnl.gov/</u>) – [Data Informatics]

Long-range (~5-10 years) Climate Research Areas of Interest that Intersect with CLIVAR – ARM and ASR

- Support integrated studies of key processes driving aerosol-cloudprecipitation-radiation interactions and land-atmosphere interactions
 - CAUSES (jointly funded by ASR and RGCM), SGP supersite with Routine LES modeling
- Advance ARM capabilities and aggressively exploit the unique DOE facilities to understand cloud, aerosol, and radiative properties over land, sea, and ice
 - Continue investigations into dominant atmospheric processes in tropical, marine, arctic and Antarctic environments
 - Azores, AWARE, MAGIC, Oliktok
- Exploit existing and new ARM facilities and recently procured ARRA 2009 instrumentation to provide high-resolution, 3-dimensional documentation of evolving cloud, aerosol and precipitation characteristics in climatically sensitive regions.
 - An extended duration deployment of a new mobile facility at Oliktok, AK
 - MAGIC and Calwater 2 (ACAPEX) marine campaigns
 - Biogenic aerosols and clouds in boreal forest
 - GOAmazon [Instrumentation funded by ARM; analysis and synthesis from ASR, RGCM, TES]





Budget History and Outlook

	FY10	FY11	FY12	FY13	FY14
ASR	26M	28M	26M	26M	26M
RGCM	29M	32M	28M	29M	29M
ESM	31M	36M	35M	35M	36M
ARM	42M	46M	52M	65M	66M

FY15 - ?? CR & House Mark

However,

- SciDAC and Climate Variability and Change FOA: RGCM &ESM- anticipate funding proposals in FY15 also
- ASR emphasizes the analysis of results of the ARM campaigns anticipate FOA end of July
- ARM has an open solicitation for small campaigns <100K
- The main ARM solicitation AMF and G1 aircraft-preapps FOA in November

16 CLIVAR Update 2014

How to Engage and Provide Value

- Applications in response to Solicitations
- Participation in Workshops
 - Metrics
- Coordination/ Collaboration for
 - ocean model development through interagency expertise in ocean process understanding
 - land and sea-ice model development
 - for data dissemination of models and observations through ESGF
- Development of the next generation of visualization tools
- Examining processes in a comprehensive and integrated earth system

Department of Energy • Office of Science

• Collaboration for all BER programs like GoAmazon





Thank You



UCAR Cooperative Agreement: Single Model perspective for Climate Variability and Change (POCS: Washington, Meehl)

Research is divided into four integrated tasks, each taking advantage of the unique aspects and capabilities of the CA as well as capabilities provided by DOE.

Two of the tasks involve running CESM for standard and unique sensitivity experiments to advance knowledge of climate variability and change; two focus on model improvements that advance climate model capabilities and produce more credible climate change simulations:



Timeline of Climate Model Analysis

		CLIMATE CHANGE 1995 The Science of Climate Change Contribution of Working Group to the Scond Assessment Report of the Intergovernmental Penel on Climate Change	<section-header></section-header>		
Pre-MIPs	IPCC AR1	IPCC AR2	IPCC AR3	IPCC AR4	IPCC AR5
<1989	1990	1995	2001	2007	2013
(mostly) qualitative analysis	FANGIO "MIP", AMIP1	CMIP 1	CMIP2	CMIP3	CMIP5
performed by	30 models	21 models	18 models	23 models	~50 models
centers	10 countries	9 countries	8 countries	12 countries	13 countries
Difficult to share data.	10 analysis projects	15 analysis projects	22 analysis projects	>1000 papers	>700 papers
No standard benchmark experiments	Data: GB	Data: ~MB	Data: ~GB	Data: 30 TB	Data: 2 PB
PCMDI was founded					