NASA Program Overview

Dr. Eric Lindstrom

NASA HQ, Washington, DC

Presentation to the US CLIVAR Summit

August 8, 2017

8/4/17

Where does NASA Oceanography fit into the overall NASA mission?

- **Earth Science Division (ESD) <u>Strategic Goal</u>:**
  - Advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet.

- **ESD Science Questions:**
  - How is the global Earth system changing?
  - What causes these changes in the Earth system?
  - How will the Earth system change in the future?
  - How can Earth system science provide societal benefit?

- **ESD Climate Focus Area (lead: Eric Lindstrom)**
  - Physical Oceanography (lead:Lindstrom)
  - Modelng, Analysis and Prediction (lead:Considine)
  - Cryospheric Sciences (lead:Wagner)

Physical Oceanography
Program Manager: Eric Lindstrom

- **Support Physical Oceanography Missions on Orbit**
  - Jason-2 and Jason-3 (Altimetry), QuikSCAT (Winds), SMAP (Salinity), GRACE (Gravity)
- **Support Physical Oceanography Missions in Development**
  - Surface Water and Ocean Topography (SWOT), Sentinel-6 A&B(Altimetry),
- **Support Research Teams**
  - Ocean Surface Topography (OSTST), Ocean Vector Winds (OVWST), Ocean Salinity (OSST), Next Generation SST (GHRSST), Atlantic Meridional Overturning Circulation (AMOC), Sea Level Change (NSLCT)

- **Support Climate Focus Area/Ocean Observing**
  - US CLIVAR, USGCRP, GOOS, GCOS, OOPC, GODAE OceanView, NOAA COSC, IOOC, CEOS, ….

- **Process Studies Related to NASA Physical Oceanography**
  - **S**alinity **P**rocesses in the **U**pper ocean **R**egional **S**tudy: SPURS-1 (2012-2015)
  - **S**alinity **P**rocesses in the **U**pper ocean **R**egional **S**tudy: SPURS-2 (2016-2018)
  - Oceans Melting Greenland, OMG (2015-2019)

Salinity Processes in the Upper ocean Regional Study (SPURS)

http://spurs.jpl.nasa.gov
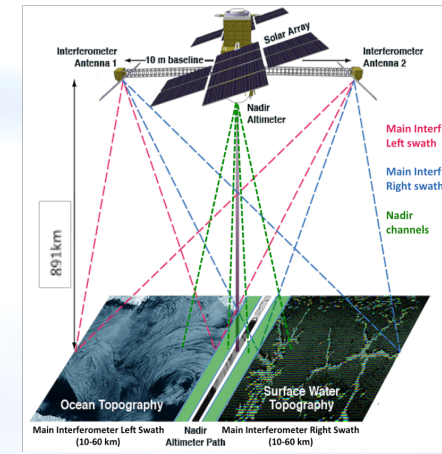
What is controlling the upper ocean salinity?

This question is addressed with interagency/international collaboration of measurements from satellites, ships, drifting surface buoys & profiling floats, gliders, AUVs and theoretical & numerical model simulations.

Motivation

Launch of the Aquarius/SAC-D satellite motivates plans for field campaigns in the salinity maximum and minimum region of the North Atlantic and Eastern Tropical Pacific.
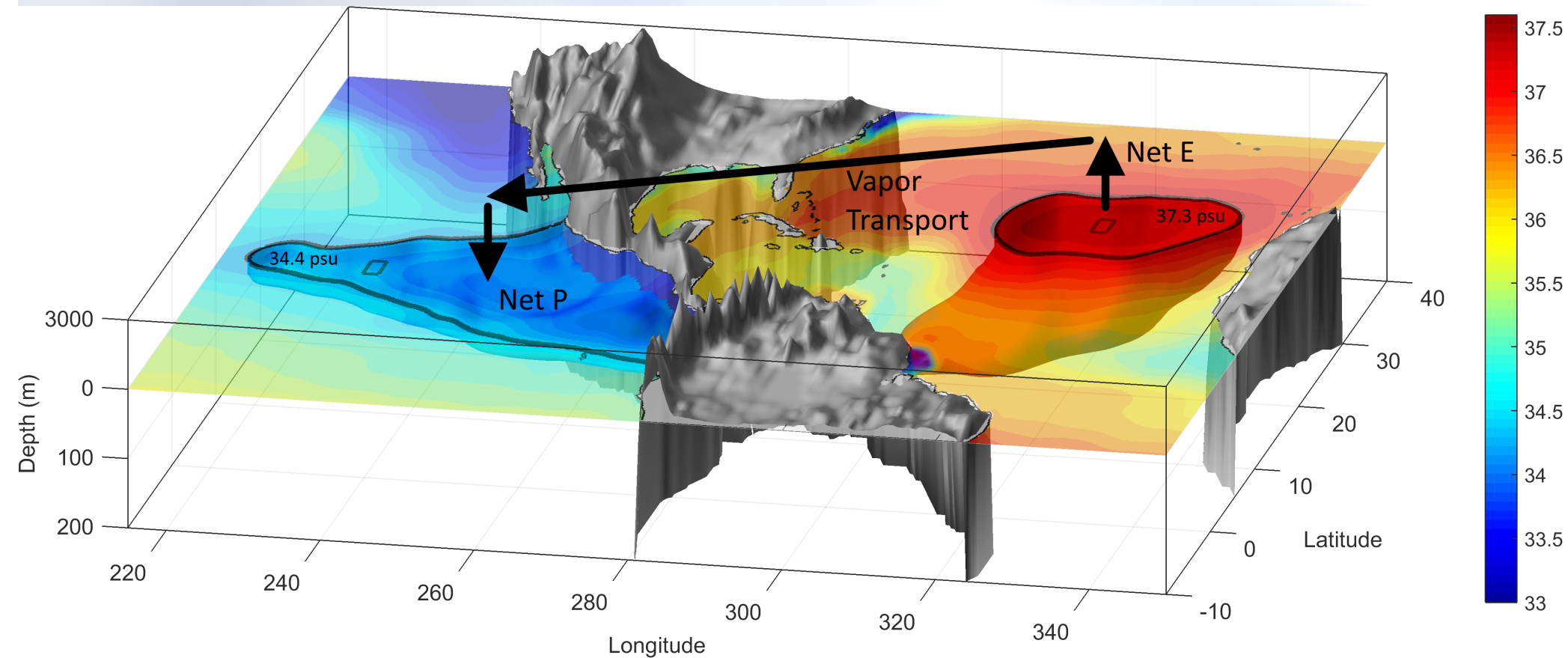
Sea Surface Salinity
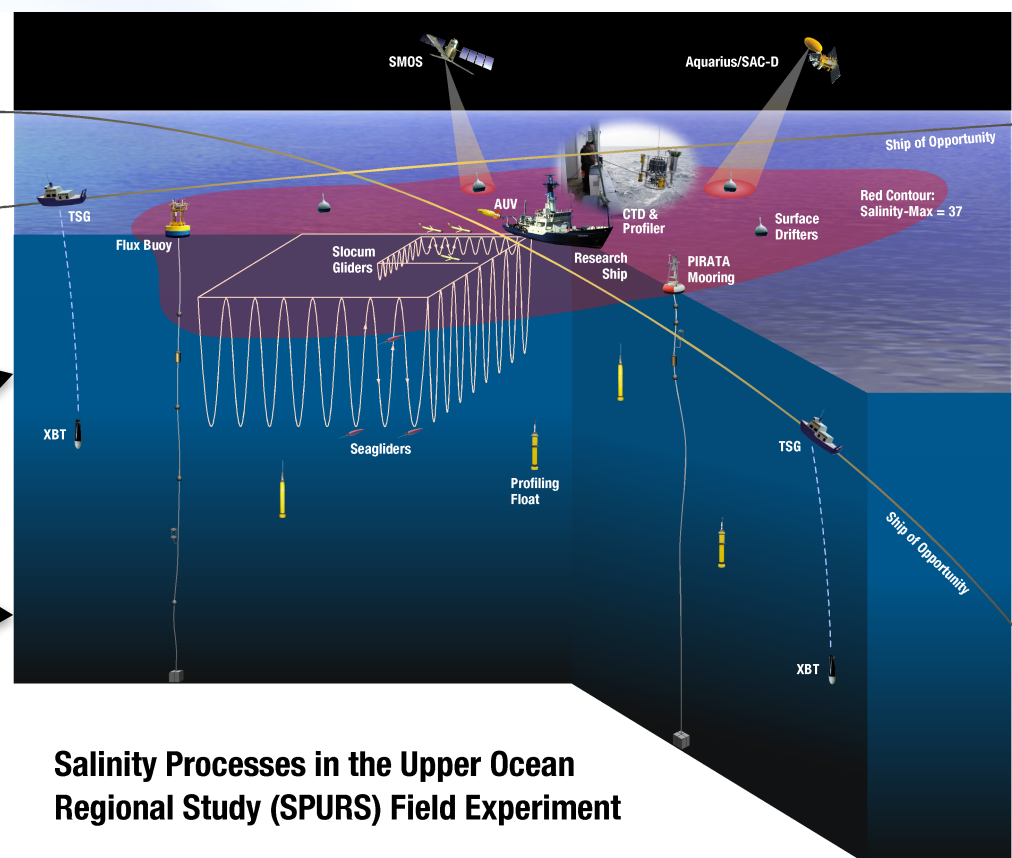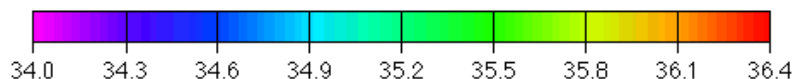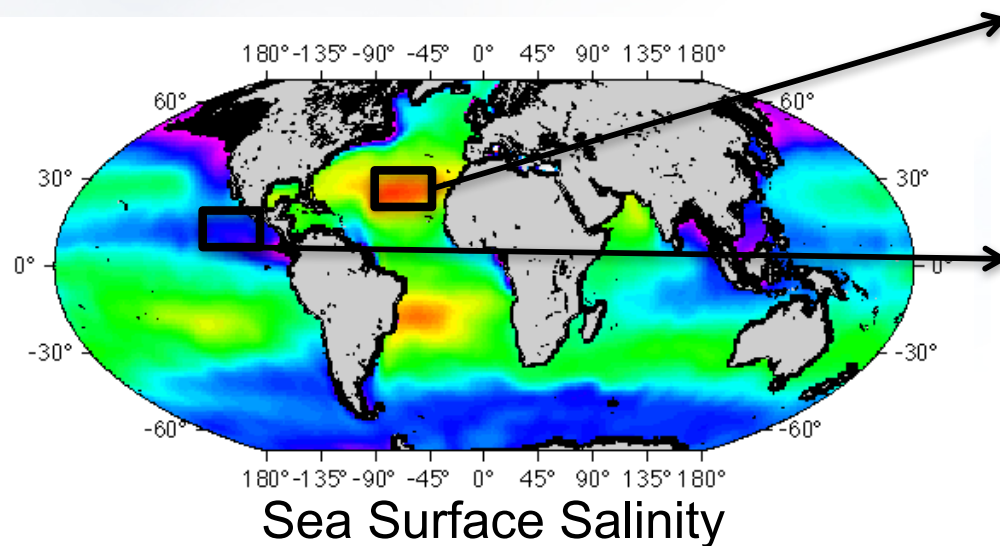
Salinity Processes in the Upper Ocean Regional Study (SPURS) Field Experiment

Salinity Processes in the Upper ocean Regional Study (SPURS)
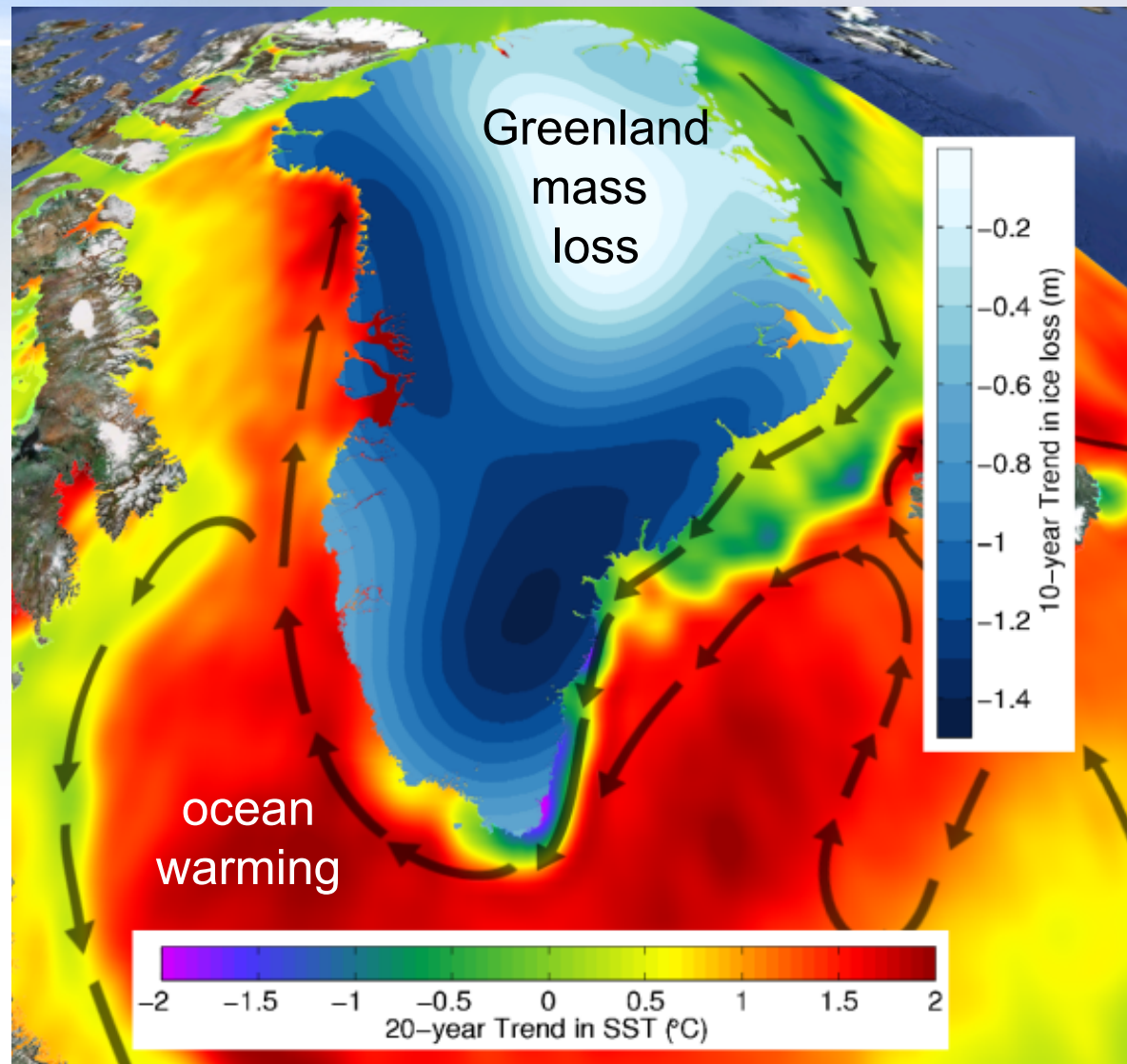
http://spurs.jpl.nasa.gov

Courtesy of Ray Schmitt @ Woods Hole Oceanographic Institution

OMG: Oceans Melting Greenland

How much are the Oceans Melting the Greenland Ice Sheet?

Greenland mass loss

Sub-surface warm water melts glaciers that reach the oceans

ocean warming

10-year Trend in ice loss (m)

−0.2 −0.4 −0.6 −0.8 −1 −1.2 −1.4

−2 −1.5 −1 −0.5 0 0.5 1 1.5 2
20-year Trend in SST (°C)

| **Ocean Obs:** Track spread of warm water | **Can we relate these?** → | **Ice Obs:** Quantify glacier loss |

OMG: Oceans Melting Greenland

Josh Willis (PI): JPL

Deputy PI: Eric Rignot
Proj. Manager: Steve Dinardo

Ocean: Ian Fenty, Jamie Morison,
 David Holland, Ichiro Fukumori,
 Andrew Thompson

Ice: Ala Khazendar, Delwyn Moller

Bathymetry: Michael Schodlock, Martin
 Jakobsson, Kristy Tinto, René Forsberg

GLISTIN
AXCTDs
Thinning
Cold, Fresh Water
Warm, Salty Water
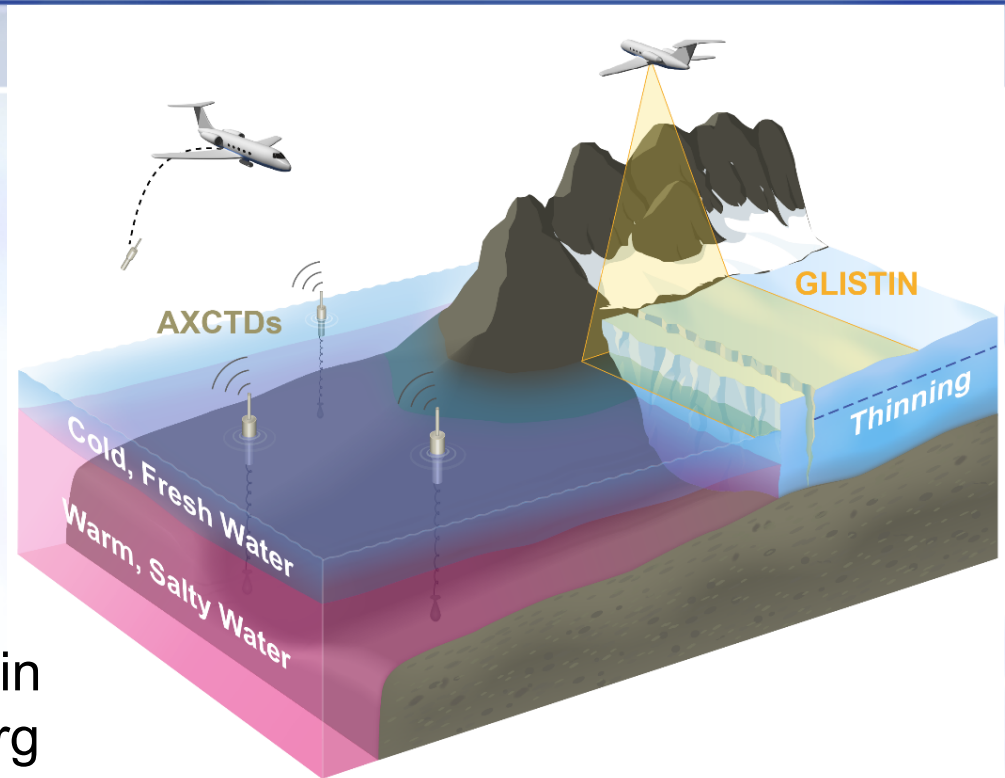
$30 M over 5 years will fund 4 observational campaigns:

Ocean	Ice	Bathy	Bathy
• 5 years • ~250 AXCTDs/yr	• 4 years • GLISTIN radar: 10 km swath at terminus of 90% of all MTG	• One time • Ship survey with multibeam sonar for key, unmapped fjords	• One time • Airborne gravity survey of shelf

Some Current Contributions…

- Space-based ocean observing system
- Ocean And Climate Reanalysis (e.g. ECCO, MERRA)
- Process Studies (e.g. SPURS, OMG)
- Research Contributions (e.g. AMOC, ENSO Diversity)
- Annual PO Program Opportunity in ROSES uses US CLIVAR as a primary resource for proposers. Proposals due end June annually.

- BACK UP SLIDES

Scaling NASA's Oceanography Program

- ROM NASA Budget ~$19000M/yr
- Earth Science Division~$1900M/yr
- Oceanography Program <$190M/yr (highly variable)
- NASA 100%/ Earth 10%/Ocean <1%
- NASA (like NSF, DOI, DOE, EPA…) is not generally viewed as an "ocean agency" but makes significant contributions to ocean observing and research.

Modeling, Analysis and Prediction Program
Program Manager: David Considine

- Objectives
    - The development of consistent, coupled Earth system models is a major goal of the MAP program. Validation of a wide range of Earth observations, with particular emphasis of NASA's satellite data program, is also a priority. In order to assist investigators with the challenging task of developing, integrating, and maintaining complex numerical modeling software, the MAP program is requiring compliance with the US multiagency Earth System Modeling Framework (ESMF; http://www.esmf.ucar.edu/).

- Major Components
    - Large investigations include the Global Modeling and Assimilation Office (GMAO), the Global Modeling Initiative (GMI), the Goddard Institute for Space Studies (GISS), support for the ESMF core development team, a Cloud Modeling and Analysis Initiative (CMAI), along with many other smaller-scale research efforts in data assimilation to support global model evaluation and testing.

- https://map.nasa.gov/overview.html

Cryospheric Sciences
Program Manager: Thomas Wagner

- Program Objectives
  - To improve our understanding of the mechanisms controlling the mass balance and dynamics of the Greenland and Antarctic ice sheets, including interactions with the ocean and atmosphere.
  - To develop, validate and improve predictive models of the contributions of land-based ice to sea-level change.
  - To improve our understanding of the mechanisms controlling sea ice cover, including interactions with the ocean and atmosphere.
  - To develop, validate and improve predictive models of changes in sea ice cover, and their implications for the Earth system.
  - To improve estimates of snow accumulation on land-based and sea ice.

- Provides
  - Funding and oversight to competed, investigator-led, cryosphere-related scientific studies at universities, NASA centers and other institutions.
  - Support to cryosphere-related satellite mission Science Teams.
  - Support for the collection of cryosphere-related observations through the Airborne Sciences Program.
  - Investment in the development of satellite and airborne cryosphere-related data products, including storage and distribution capabilities.


- HTTP://ICE.NASA.GOV

Ocean Biology and Biogeochemistry
Program Manager: Paula Bontempi

- **Support Ocean Color Missions on Orbit**
  - Aqua (MODIS), Suomi NPP (VIIRS)

- **Support Ocean Color Missions in Development**
  - PACE, GEO-CAPE, ACE, HyspIRI

- **Support Research Teams**
  - Ocean Color, MODIS, Suomi NPP, PACE SDT

- **Support Carbon Focus Area/Ocean Observing**

- **Process Studies Related to NASA Ocean Color Missions**
  - **I**mpacts of **C**limate on the **E**co-**S**ystems and **C**hemistry of the **A**rctic **P**acific **E**nvironment (ICESCAPE) (2010-2011)
  - **S**hip **A**ircraft **B**io-**O**ptical **R**esearch (SABOR) campaign (summer 2014)
  - Field Campaign Scoping Study: **EX**port **P**rocesses in the **O**cean from **R**emo**T**e **S**ensing (EXPORTS) (D. Siegel, UCSB and K. Buessler, WHOI) (2017-2022)
  - Field Campaign Scoping Study: **I**nterdisciplinary **C**oordinated **E**xperiment of the **S**outhern **O**cean **C**arbon **C**ycle (ICESOCC) (G. Mitchell, Scripps/UCSD)
  - Field Campaign Scoping Study: **A**rctic **CO**astal **L**and **O**cean inte**R**actions **S**coping study (Arctic-COLORS) (A. Mannino, NASA GSFC)

EXport Processes in the Ocean from RemoTe Sensing (EXPORTS)

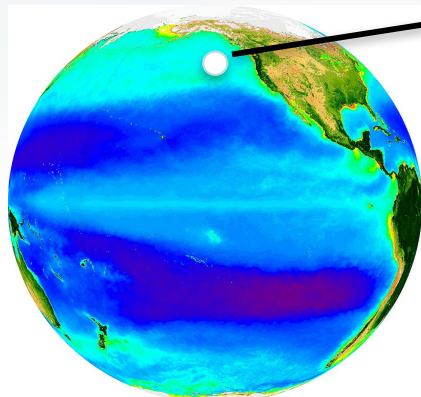http://exports.oceancolor.ucsb.edu/
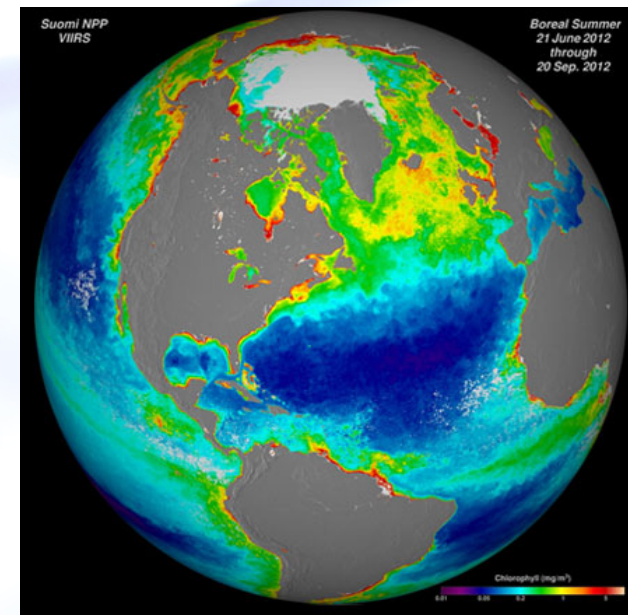
What is the role and interaction between planktonic ecosystem characteristics and the functioning of the ocean's biological pump?

These questions are proposed to be addressed with measurements from satellites, ships, profiling floats, gliders, and model simulations.
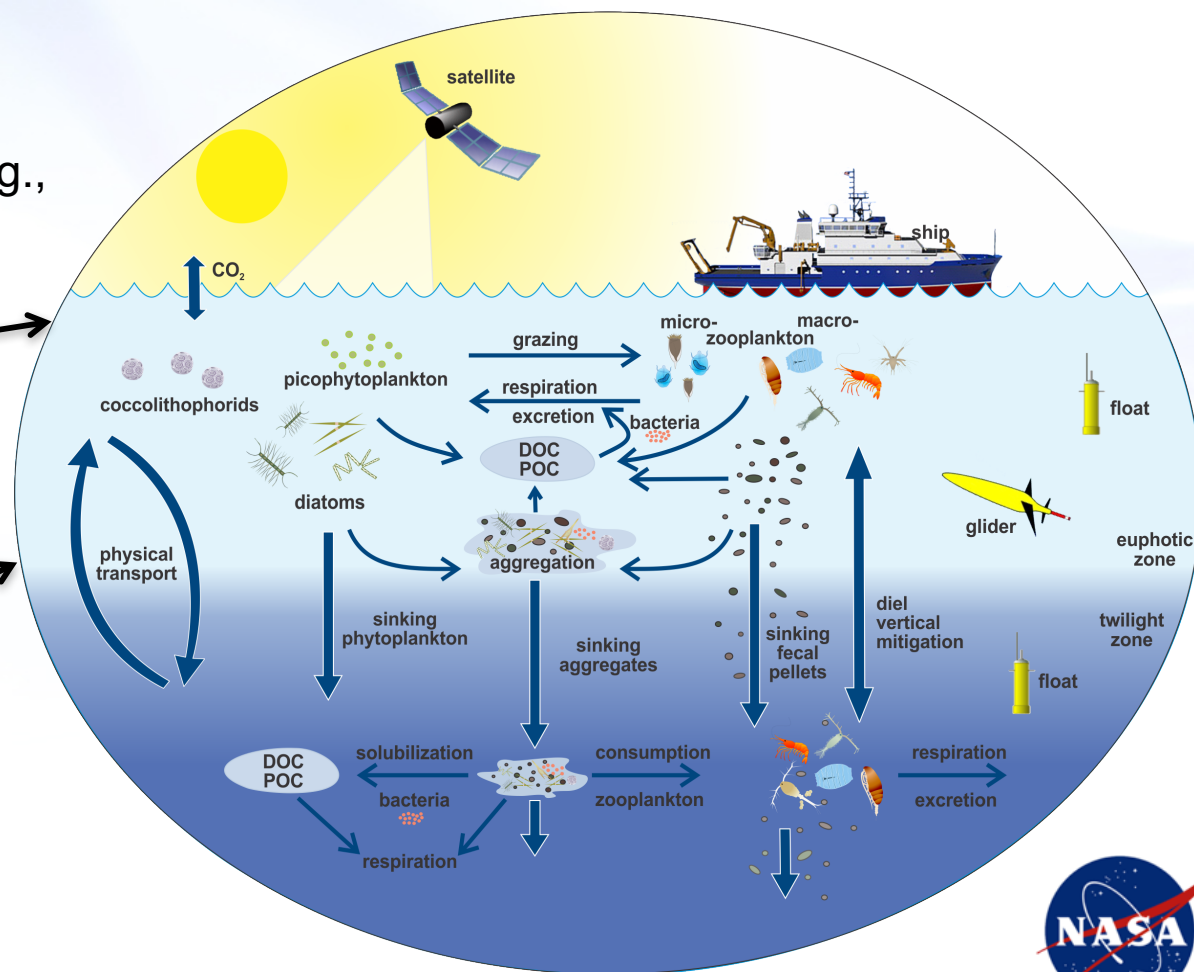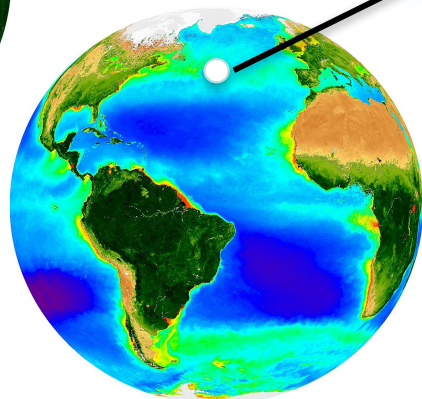
Motivation

Advances in remote sensing (e.g., PACE) and autonomous tools.

Station P

North Atlantic

satellite

ship

CO_2

grazing

micro-zooplankton

macro-zooplankton

picophytoplankton

float

coccolithophorids

respiration

excretion

bacteria

DOC POC

diatoms

glider

euphotic zone

aggregation

physical transport

sinking phytoplankton

sinking aggregates

sinking fecal pellets

diel vertical mitigation

twilight zone

float

DOC POC

solubilization

consumption

respiration

bacteria

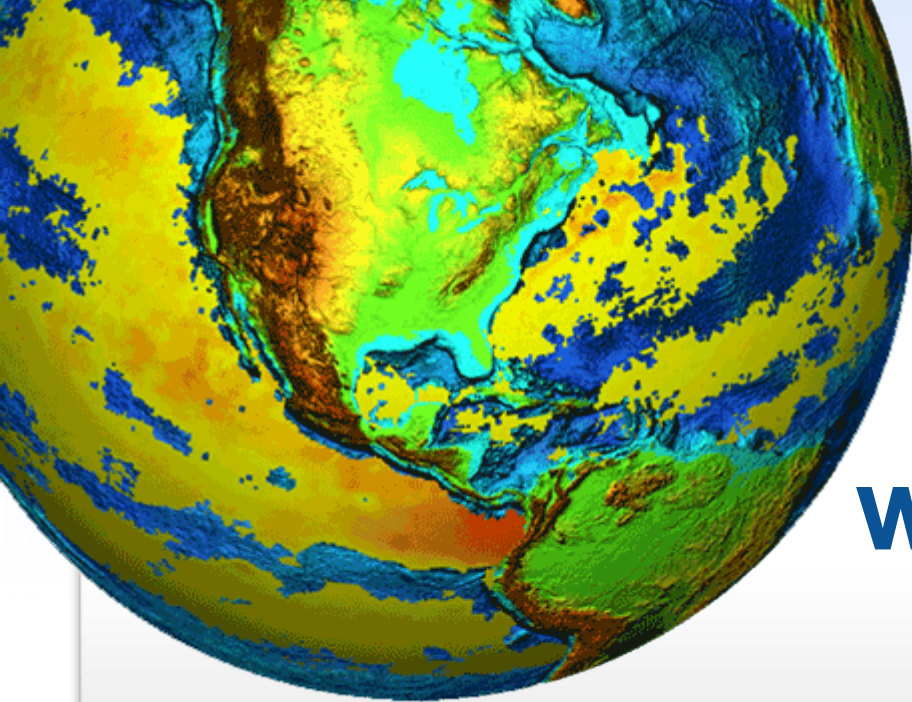zooplankton

excretion

respiration

Interagency/International Roles

- Global Ocean Observing System (GOOS) Steering Committee
- Interagency Ocean Observation Committee (IOOC)
- CEOS/CGMS Climate Working Group

8/4/17

NOAA's Engagement with U.S. CLIVAR

NOAA/OAR Climate Program Office

Sandy Lucas
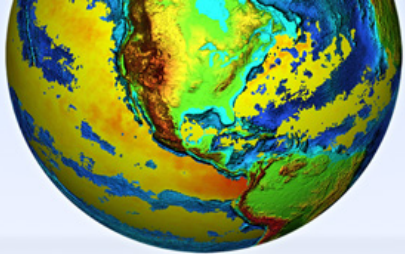Program Manager
Climate Variability and Predictability

Jin Huang
NOAA Earth System Science and Modeling

Annarita Mariotti, Dan Barrie, and Heather Archambault
NOAA Modeling, Analysis, Prediction, and Projections

David Legler and Jim Todd
NOAA Ocean Observing and Monitoring

U.S. CLIVAR Summit
Baltimore, MD
8 – 10 Aug 2017

NOAA and OAR 101

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                        NOAA

Line Offices:

 OAR        NWS      NESDIS      NOS        NMFS
(Research) (Weather) (Satellites) (Oceans)  (Fisheries)

Labs
       GFDL   ESRL   PMEL   ARL   AOML   GLERL

Programs:
       CPO   OWAQ   Sea     . . .
                    Grant
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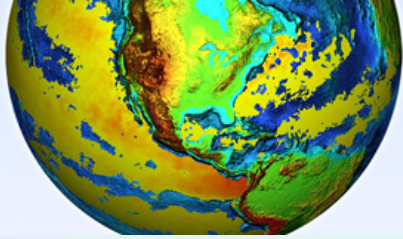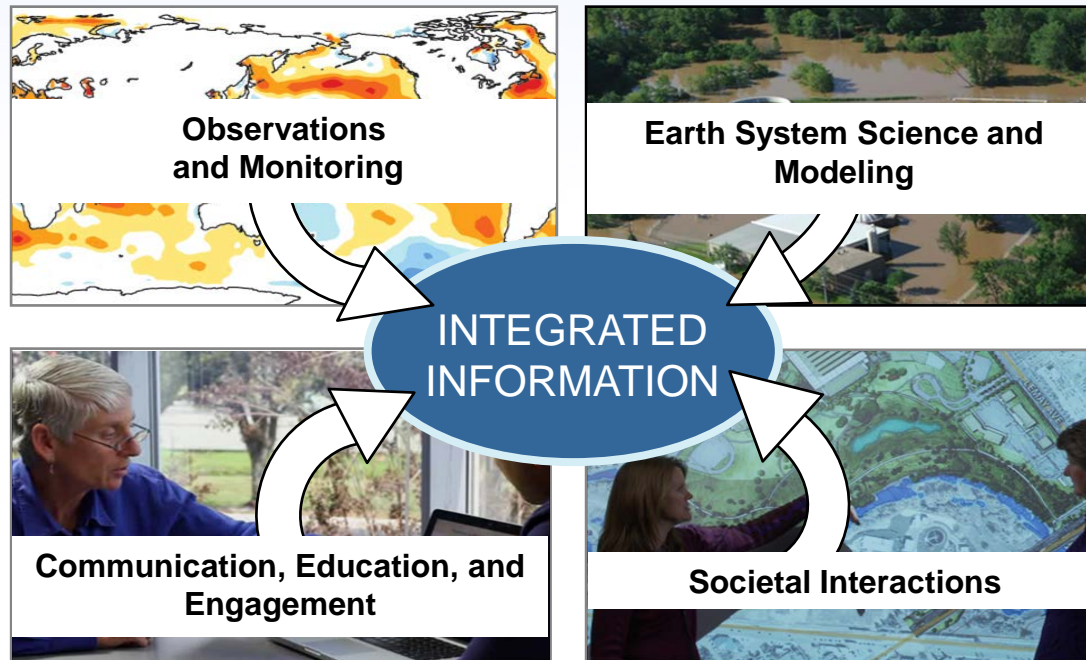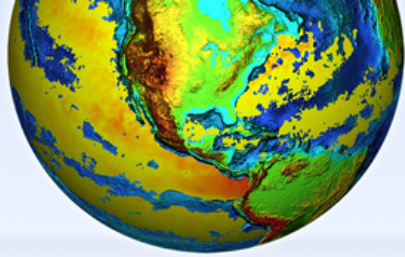
NOAA Climate Program Office
Director: Wayne Higgins

Mission: *Advance scientific understanding, monitoring, and prediction of climate and its impacts to enable effective decisions*

Observations and Monitoring

Earth System Science and Modeling

INTEGRATED INFORMATION

Communication, Education, and Engagement

**Societal Interactions**

Activities:

- Support NOAA mission driven research priorities
- Engage community in NOAA mission through annual Federal Funding Opportunity
- Facilitate coordination, collaboration, and integration
- Accelerate transition activities to improve services

NOAA Climate Program Office
(www.cpo.noaa.gov/) Wayne Higgins, Director

- **Ocean Observing and Monitoring (OOMD)** - Designs, deploys, and maintains an integrated global network of ocean-based observations to produce continuous records and products for research, forecasting, and assessments. The Arctic Research Program (in OOMD) is focused on sustained observing of the Arctic in support of commerce and sustainable systems. Lead: David Legler

- **Earth System Science and Modeling (ESSM)** Lead: Jin Huang
  - **Climate Variability and Predictability (CVP)** – provides process-level understanding of the climate system through observation, modeling, analysis, and field studies to support the development of improved climate models and predictions in support of NOAA's mission. Program Manager: Sandy Lucas

  - **Modeling, Analysis, Predictions, and Projections (MAPP)** – aims to enhance the capability to predict and project variability and change in Earth's climate system; focusing on the coupling, integration, and application of Earth system models and analyses. Program Managers: Annarita Mariotti, Dan Barrie, and Heather Archambault

  - **Atmospheric Chemistry, Carbon Cycle, & Climate (AC4)** – Determine the processes governing atmospheric concentrations of greenhouse gases and aerosols in the context of the Earth System and Climate. Program Managers: Monika Kopacz and Ken Mooney

- **Climate and Societal Interaction (CSI)** – provides leadership in developing interdisciplinary science and services, including assessments, for application in climate-sensitive sectors and regions. Lead: Claudia Nierenberg

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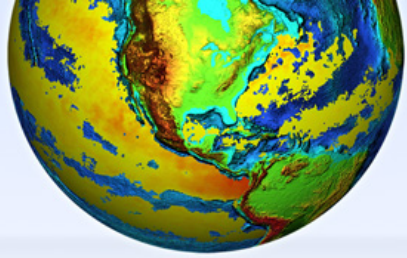
Recent U.S. CLIVAR-Relevant Activities Supported by NOAA

- Process Studies
  - Past: EPIC, NAME, VOCALS, DYNAMO; Current: AMOC, YMC, CPTs
- Modeling
  - CMEP 1 & 2, CMIP5 & 6
  - Re-analyses: 20CR, CFSR
  - S2S – DYNAMO, YMC, MAPP S2S Task Force
  - Climate Test Bed prediction projects (e.g., NMME and SubX)
  - Drought understanding, monitoring, prediction
  - Experimental seasonal prediction of sea-level and marine resources
  - Arctic Sea Ice Growth and Loss, Ice Sheet calving
- Sustained Ocean Observations
  - Argo, Tropical moored array (e.g. RAMA, PIRATA, TPOS), new technologies, etc.
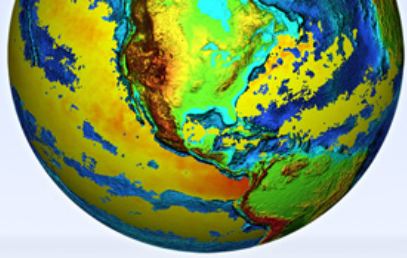
Long-range Climate Research Areas Related to U.S. CLIVAR

- Sustaining , evolving, and enhancing the ocean climate observing system (including the Arctic) - Tropical Pacific Observing System-TPOS 2020 project is underway-will be a NOAA focus.

- Observing system impact and design studies, improved obs-based products

- Predictability, prediction and projections: improving understanding of climate processes, their predictability and their representation in models and prediction systems

- Increased focus on process-oriented metrics for model development (leverage CMIP6 experiments)

- Drought understanding, predictability and prediction.

- Climate re-analyses, Explore coupled Earth system data assimilation

- Information to support decision-making on a regional scale
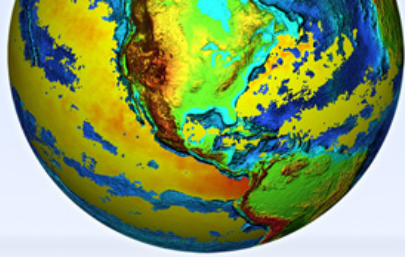
How US CLIVAR Can Engage & Provide Value

US CLIVAR:

- Organizes/Coordinates the research community to establish the needs and requirements for future scientific advancement (and current gaps) and to express where additional resources are needed.

- Helps coordinate interagency response to community research initiatives

- Helps to organize the community to deliver research results after resources are allocated.

- Helps link US research to international research initiatives

Examples (of where US CLIVAR can engage):

- NOAA will continue to need updated requirements for observation systems (e.g. OOPC, GCOS mechanisms)

- NOAA will continue to look to the research community to initiate new observing activities (e.g., Bgc-Argo) and products to exploit them

- NOAA will need support in the area of technology development (e.g., Deep Argo)

- NOAA will continue to look to the research community for development of field campaigns.
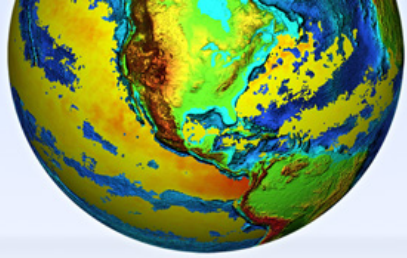
Item of Interest

NOAA CPO FY18 Federal Funding Opportunity (FFO)

- Proposals Due Aug 14, 2017 (MAPP: Sept 11, 2017)
  - **AC4:** The Role of Reactive Nitrogen in Biogenic VOC Oxidation and Aerosol Formation
  - **MAPP:** Advancing Earth System Data Assimilation
  - **MAPP:** Addressing Key Issues in CMIP6-era Earth System Models
  - **MAPP:** Climate Test Bed - Advancing NOAA's Operational Subseasonal to Seasonal Prediction Capability
  - **OOMD:** High-quality data sets for enhancing predictions and informing stakeholders
  - **CSI/SARP:** Extreme Events Preparedness, Planning and Adaptation Within the Water Sector
  - **CSI/SARP:** Coping with Drought in Support of the National Integrated Drought Information System (NIDIS)

Please see http://www.cpo.noaa.gov/ for additional information on the FFO

Thank You

Sandy.Lucas@NOAA.gov
NOAA Climate Program Office

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NSF Update

**Eric DeWeaver and Ming Cai
Climate & Large-Scale Dynamics program
GEO/AGS**

**Eric Itsweire and Xujing Davis
Physical Oceanography Program
GEO/OCE**

NEW GEO AD: William Easterling

- Dean of PSU Earth and Mineral Science College

- Election to AAAS in 2010 for contributions to climate change and food security science.

- Started 1 June 2017

Staff Change in CLD

Ming Cai, FSU
Started September
2016 (IPA)

Anjuli Bamzai
Moved to
OPP/ANS

# R. I. P.

Jay Sheldon Fein
1937-2016

How US CLIVAR can provide value to NSF

- Provide feedback on long-range scientific priorities
- Represent the broader climate research community
- Promote activities, such as fostering the availability of tools and datasets, that enhance the productivity of investigators
- Provide information and foster interactions that lead to the submission of stronger research proposals
- Serve as a venue for community input to large field campaigns
- In general, NSF core programs support basic science research and do not attempt to set priorities for the research communities.
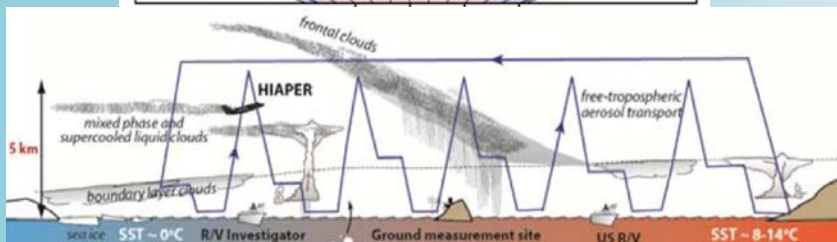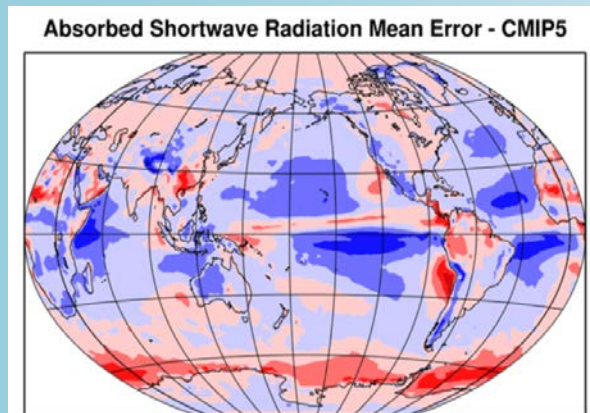
FY17 Updates

- First PREEVENTS and second INFEWS competitions completed: awards will be announced soon

- Next deadline for PREEVENTS: July 2018, INFEWS: TBD

- EaSM sunset, last installment of funds to NCAR for CESM development in FY17 (Ocean and Ice models)

- DYNAMO Legacy Data website coming soon

SOCRATES

Strateole-2

Absorbed Shortwave Radiation Mean Error - CMIP5
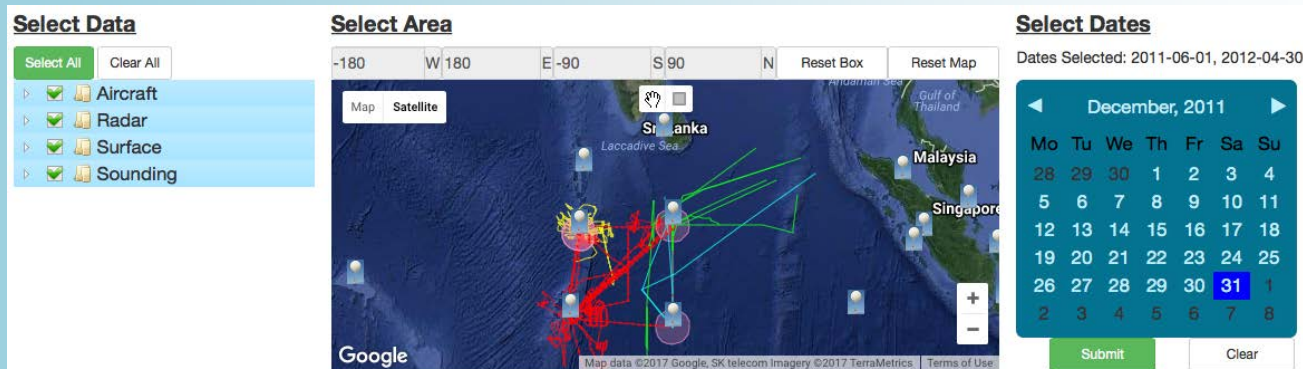
Campaign on SO clouds

January deployment, flights from Hobart

Long-duration balloons in/over the TTL

CNES project with 3 US projects

QBO, gravity waves, cirrus, water vapor

2018-2023

7

FY17 Updates - PO

- Continued investments in AMOC observations: RAPID/MOCHA, OSNAP, VOS lines

- Process studies looking at Greenland glacier melting

- Technology development: Deepglider deployment at 26.5 N and Waveglider in the Southern Ocean near the Drake Passage

President's 2018 Request: $6.65B (-11.2%)
FY 2016 Budget: $7.49B ($841M down)

DIRECTORATE FOR GEOSCIENCES (GEO)

$783,310,000
-$93,200,000 / -10.6%

GEO Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Percent
Atmospheric and Geospace Sciences (AGS)	$253.54	-	$227.68	-$25.86	-10.2%
Earth Sciences (EAR)	179.67	-	161.01	-18.66	-10.4%
Integrative and Collaborative Education & Research (ICER)	83.47	-	71.60	-11.87	-14.2%
Ocean Sciences (OCE)	359.83	-	323.02	-36.81	-10.2%
Total	**$876.51**	**-**	**$783.31**	**-$93.20**	**-10.6%**

But: House and Senate Appropriate subcommittee markups are close to level funding for NSF research
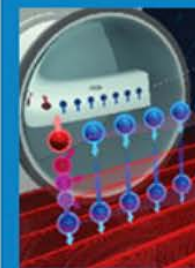
NSF's 10 Big Ideas

RESEARCH IDEAS

HARNESSING THE DATA REVOLUTION

Harnessing Data for 21st Century Science and Engineering

Work at the Human-Technology Frontier: Shaping the Future

Navigating the New Arctic

Windows on the Universe: The Era of Multi-messenger Astrophysics

The Quantum Leap: Leading the Next Quantum Revolution

Understanding the Rules of Life: Predicting Phenotype

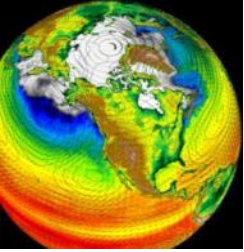## PROCESS IDEAS

Mid-scale Research Infrastructure

NSF 2050

Growing Convergent Research at NSF

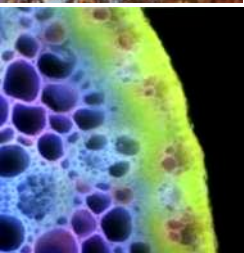NSF INCLUDES: Enhancing STEM through Diversity and Inclusion

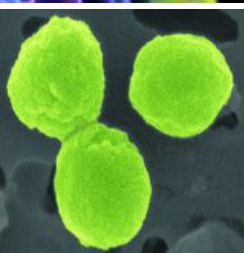# DOE Update of Relevant Modeling Activities

Earth System Modeling (ESM), Climate Model Development and Validation (CMDV) and Regional and Global Climate Modeling (RGCM)

Dorothy Koch
Earth System Modeling

Renu Joseph
Regional and Global Climate Modeling

August 8th, 2017   US CLIVAR Summit Meeting

Climate and Environmental Sciences Division
(Earth and Environmental Systems Sciences)
Gary Geernaert

Data Informatics

Atmospheric Science

- Atmospheric System Research
- Atmospheric Radiation Measurement Facility

Climate and Earth System Modeling (Earth and Environmental Systems Modeling)

- Earth System Modeling
- Regional & Global Climate Modeling
- Integrated Assessment
- Climate Model Development and Validation

Environmental System Science

- Terrestrial Ecosystem Sciences
- Subsurface Biogeochemical Research
- Environmental Molecular Sciences Laboratory Facility

Earth System Modeling (ESM)

ESM: focused primarily on Earth system model development

Budget: President's budget would reduce ESM funds by 65% (from 35M to 12M). Nevertheless budget language is positive regarding ACME (aka "**E3SM" or Energy's Exascale Earth System Mode**l), and "**high-resolution, coupled, computationally advanced model for extremes, informing energy strategies"** etc.)

Congressional mark-ups indicate approximately flat budget for BER

Personnel: Todd Ringler (LANL) - working at HQ-ESM as ¼ time Detailee

ESM Priorities:

➤ Development of coupled model designed to solve energy-relevant science questions involving
   a) water cycle and water availability
   b) sea-level rise, ice sheets and coastal science
   c) carbon cycle
➤ High resolution modeling
   o Workflow for high-resolution (model setup, debugging, data movement, etc)
   o Initialization of high-resolution coupled model (limited time/allocation for model equilibration)
➤ Effective use of DOE-HPC (current and next-generation) – increasingly challenging!

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

ACME - Now "E3SM" or Energy Exascale Earth System Model

- Model release of v1 at end of 2017 – will include MPAS ocean, sea-ice and land-ice; land developments including C-N-P, new hydrology and crops; atmosphere with 72 levels, CLUBB, MAM4.
- So far focus is coupled low-resolution version for water cycle science (100km)
- Next steps:
  - Low-resolution BGC experiments (1 degree)
  - High-resolution simulations (1/4 degree)
  - Ice-sheet-ocean coupling
  - Variable-resolution for all components, e.g. "Arctic" configuration

SciDAC – partnership between ESM and DOE-computing office (ASCR) to develop computationally advanced climate capabilities. New award announcements are imminent (order 10 project)

ESM: Code updates and releases

- **iESM:** Integrated Earth System Model (Couples GCAM and CESM) – code: https://github.com/ACME-Climate/iESM
  Just released! (Calvin, PNNL)

- **CEDS**: Community Emissions Data System (Steve Smith, PNNL) – 1750-2014 emissions particularly for short-lived species, needed by CMIP6 and ACCMIP, important for understanding uncertainties in emissions estimates. System will be released soon

- **CIME**: Open-source, infrastructure for model setup, scripts, testing – joint activity between ACME software engineers and CSEG (NCAR)

  – Version 5.4.0-alpha.27 is latest

  – CESM2 will use version 5.3.0

  – ACME v1 will use version 5.3.x

- **FATES** (Functionally Assembled Terrestrial Ecosystem Simulator) development under DOE-NGEE-Tropics – interfaces with CLM and ALM. Code: https://github.com/NGEET/fates-release

- **Sea Ice Consortium**: Sea ice collaboration with multiple centers (Hunke, LANL)

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

Climate Model Development & Validation (CMDV)

- President's budget terminates the program after 2 years (the projects are now in year 2)

- **CMDV-SM** (Software Modernization):
  - Focus on ACME coupler improvements (in CIME), MG2, MAM, CLUBB
  - Testing: Unit testing, verification, testing for whether non-BFB are "climate-changing"
  - SCM: Single column model assembled with automated ARM dataset tests will be released with ACME v1 (Bogenschutz, Caldwell)

- **CMDV-Atmospheric projects**:
  - ARM to Atmospheric System Research (ASR) to Earth System Modeling (ESM) - each project includes global, LES, and ARM-dataset developments:
  1. CMDV-MCS: Ghan et al, developing CLUBB (deep), cloud microphysics (starting from P3)
  2. CMDV-RRM: Golaz et al, CAM-SE-RR with refinement over SGP, ENA, TWP-Darwin
  3. CMDV- CM4: Romps et al, shallow clouds, SPM, 3-D radar retrievals
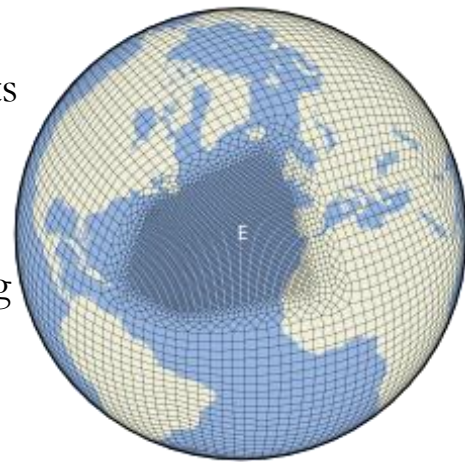
RGCM program - Overview

Goal is to enhance a **predictive and process- and system-level understanding** of the **modes of variability and change** within the Earth system by advancing **capabilities to design, evaluate, diagnose, and analyze global and regional Earth system models** informed by observations.

Analysis to enhance understanding of predictability at regional and global scales

SFAs, CAs, and University Projects contribute to these

Modes of Variability & Change	Cloud Processes	High Latitude Feedbacks	Water Cycle	Extremes	Analysis of BGC feedbacks

Cross-cutting Foundational and Enabling Capabilities

Foundational Capabilities

RGCM program - Overview

Goal is to enhance a ***predictive and process- and system-level understanding*** of the ***modes of variability and change*** within the Earth system by advancing ***capabilities to design, evaluate, diagnose, and analyze global and regional Earth system models*** informed by observations.
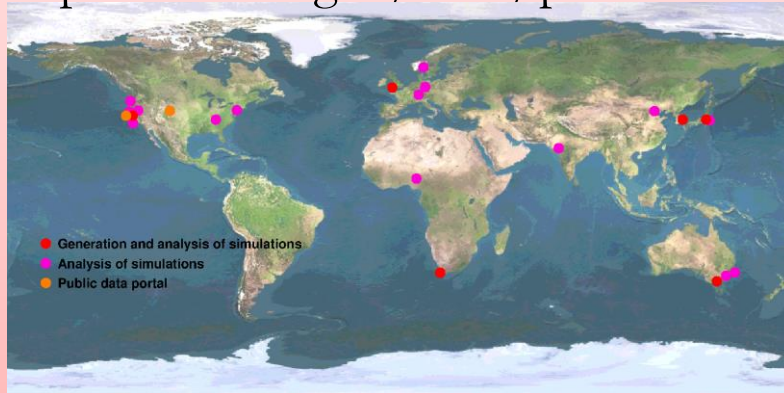
- The President's request
  - Name change to **Regional and Global Model Analysis**
  - Core research in **model intercomparison and diagnostics** will continue. Research will continue to explore **how modes of variability affect spatial and temporal patterns of weather and extreme events**, including the roles of atmospheric rivers and droughts. The incorporation of **uncertainty and performance benchmarks** will increasingly become part of research efforts.
  - Within (BER) Office, Congressional mark-ups indicate approximately flat

FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18
28M	31M	28M	29M	28M	26M	30M	30M	12M

RGCM: Community data products with CESM & TECA

CLIVAR C20C+
portal.nersc.gov/c20c/pub.html

- Generation and analysis of simulations
- Analysis of simulations
- Public data portal
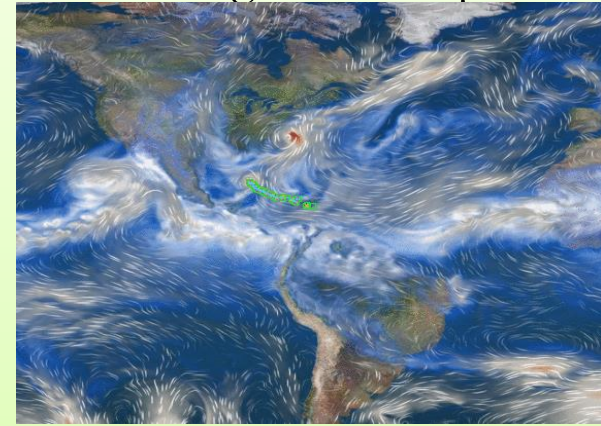
- Over 1PB data collected and served
- International collaborators
- Two workshops hosted: 2015, 2016
- 15 pubs enabled since 2013

Contact Bill Collins (PI) or Travis O'Brien (co-PI) for more details: taobrien@lbl.gov, wdcollins@lbl.gov

US CLIVAR Hurricane Working Group
portal.nersc.gov/c20c/pub.html

- 220, 110, 25 km simulations
- 100+ TB data served
- TECA
- 5 pubs enabled since 2015

ILIAD Hindcasts
portal.nersc.gov/project/m1949/iliad/

- Multi-resolution hindcasts
- 100+ TB data served
- Several active collaborations

CLIVAR Connections and Community Impacts

|	
CVC and Cloud Processes	**CMIP Planning, Metrics, Obs4MIP, CAPT testing for CAM** CMIP, ACME, CESM
High Latitude Feedbacks	**CMIP participation, AMOC science team, SIPN & Development of Metrics** POP-CICE/ACME/CESM and soon MPAS Ocean/CICE
Water Cycle	**CMIP Participation, Atmospheric Rivers,** CAM/Aqua planet simulations, MPAS-CAM, ACME
Extremes	**Tools for extreme event analysis, enabling science through CESM output,** CAM, ACME, CESM
Analysis of BGC feedback	**ILAMB** CESM, CLM, CMIP, ACME, CMIP participation

Strategic Planning Update for Climate and Environmental Science Division: Preview

- **Vision:** Improve a systems level understanding and predictability of the earth system in support of DOE's mission, through integrative testing, modelling and experiment, over a variety of spatial and temporal scales

- **Scope:** Integration of atmospheric, oceanic, terrestrial, ecological, hydrological, and human components, and inclusion of system level uncertainty quantification

- **High level Grand Challenges**

  - **System forcers** – drivers of the coupled Earth-energy-human system

  - **High latitude** – process feedbacks and interdependencies with the global system

  - **Biogeochemistry** – biogeochemical processes and cycles across multiple scales

  - **Integrated water cycle** – scale aware and response to short and long-term perturbations

  - **Data-model integration**s: interconnected capabilities and facilities that support the integration and management of models, experiments, and data across hierarchy of scales and complexity
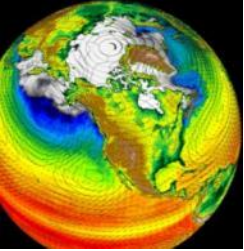
Dorothy.Koch@science.doe.gov
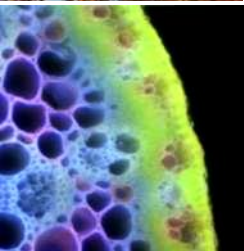
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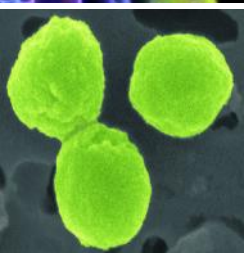

Earth System Modeling:
http://science.energy.gov/ber/research/cesd/earth-system-modeling-program/

ACME:
http://climatemodeling.science.energy.gov/projects/accelerated-climate-modeling-energy
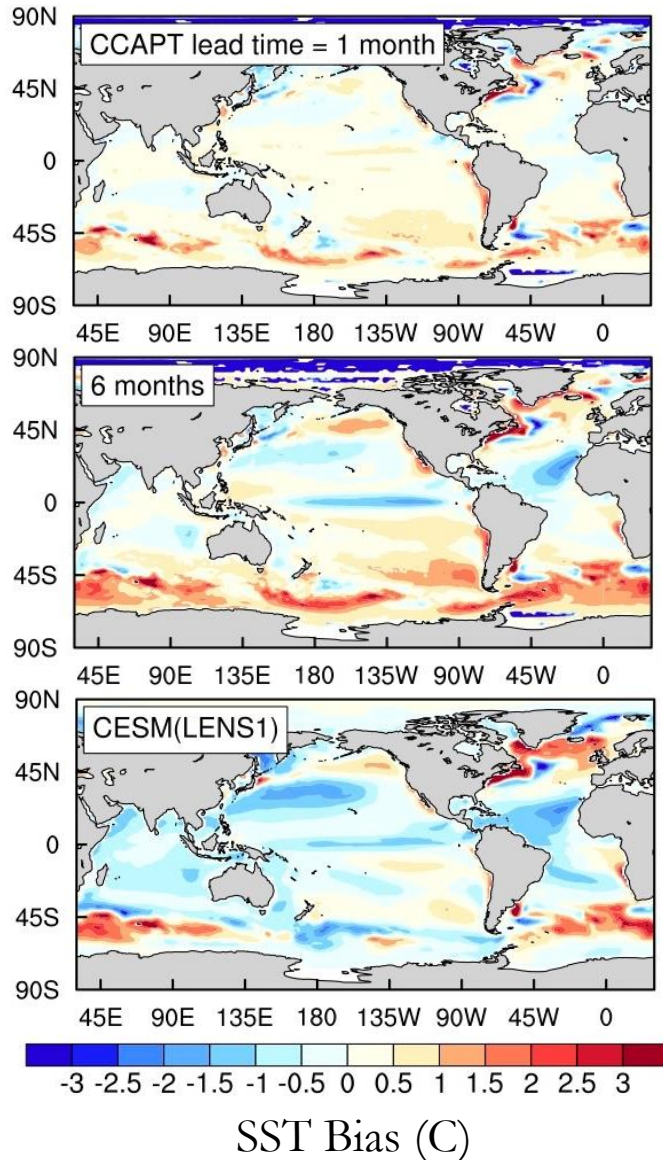
Regional and Global Climate Modeling:
https://science.energy.gov/ber/research/cesd/regional-and-global-modeling/

For Highlights:

https://science.energy.gov/ber/research/cesd/regional-and-global-modeling/

Diagnosing Tropical Ocean Surface Biases with "Coupled CAPT" – A CAPT New Initiative

SST Bias (C)

Accomplishments:

- Performed 6-month long ensemble hindcasts (24) starting every first day of each month from 2000/08 to 2005/12

- Identified SST bias correspondence between coupled hindcasts and long-term climate runs over most tropical and subtropical oceans

Current and Future Work:

- Perform ocean mixed-layer budget analysis

- Conduct model sensitivity experiments to identify the role of errors in wind stress and surface heat fluxes through atmospheric only, ocean only, or fully coupled experiments

RGCM: Update on the PCMDI Metrics Package (PMP)

Objective: Develop a diverse suite of robust summary statistics across space and time scales for providing performance summaries for all generations of CMIP and AMIP, including provenance to establish reproducibility

Capabilities: Mean state and variability metrics. New additions include metrics for sea-ice, monsoons, modes of variability, and the diurnal cycle. Additions in the coming year will include ocean T & S, cloud processes, and tropical waves

Research (e.g., Modes of Variability): The fidelity of different models is relatively insensitive to choice of reference observations or internal variability (consistent results across realizations)

Impact: This work provides a framework for objectively gauging how well models simulate the mean state and variability. It can be applied to any new simulations via the PCMDI Metrics Package (PMP)

RMSE relative errors
CMIP5 Historical Simulations
20CR and ERA20C, 1900-2005
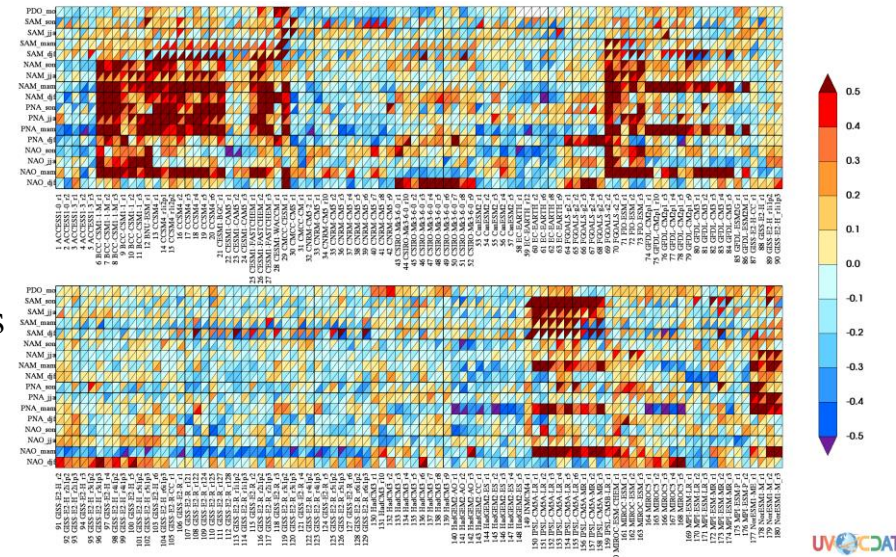
CESM1-CAM5 demonstrates dramatic improvement compared to previous CAM4-related models. Errors in amplitude dominate over pattern error

J.-W. Lee, K. R. Sperber, P. J. Gleckler, C. W. Bonfils, K. E Taylor: Quantifying the Agreement Between Observed and Simulated Extratropical Modes of Interannual Variability. Submitted to Climate Dynamics

- Roles of regional processes and feedbacks on the high-latitude Earth System (variability and trends)
  - interactions btw cryosphere, ocean, land and atmosphere
  - Terrestrial and Marine Ecosystems
  - Component responses to environmental change

- Coupling between Low and High Latitudes
  - High latitude changes impact mid-latitude weather
  - MOC impacts on the Earth system (e.g. shifts in ITCZ)
  - Mid / Low latitude transports influencing High Latitudes

- How do interactions between Land-Ice, Ocean, and Atmosphere affect SLR?

- How does high latitude environment change affect the Carbon Cycle?

The ILAMB Benchmarking System (v2) Release
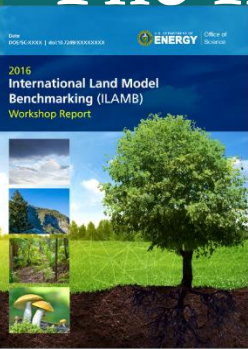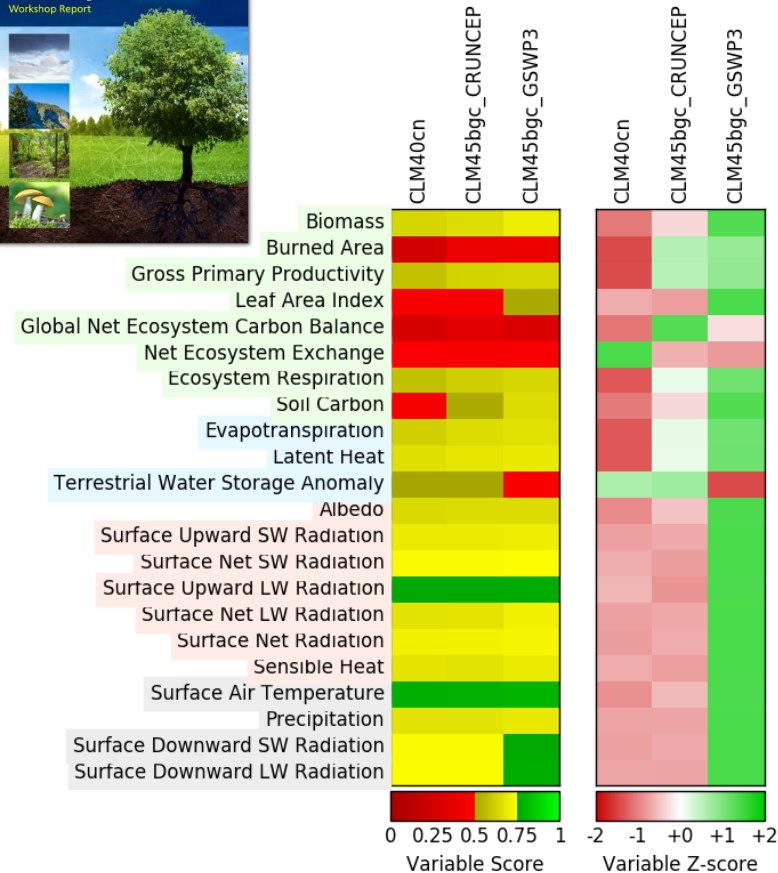
Summary graphic generated by the ILAMBv2 package depicting model performance across a wide variety of variables, emphasizing absolute performance (left) as well as relative performance (right).

Collier, N. et al. (2016), The ILAMB Benchmarking System, doi:10.18139/ILAMB.v002.00/1251621.

Objective:

Research and disseminate benchmarking procedures and datasets which improve land model fidelity.

Approach:

- Software framework written in python that compares model outputs to benchmark observational datasets in parallel on leadership-class supercomputers.
- Provides the community a means to comprehensively and routinely assess land model fidelity through comparison of 24 variables with 60 observational datasets.

Results/Impacts:

- Framework provides an abstraction that allows groups to develop plugins to extend its functionality.
- New datasets and comparisons are easily added, encouraging routine use by modeling centers across the globe.
- Package is currently used by ACME and CESM to evaluate new model developments.

BGC Feedbacks