# Advancing the understanding of the IAS with the Community Earth System Model

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# Potential of CESM to contribute to IAS

- The Community Earth System Model (CESM) contributes to the Intergovernmental Panel on Climate Change (IPCC).
- Coupled simulations can be integrated for hundreds of years to understand interannual-to-decadal variability.
- A better understanding of the limitations of the CESM in capturing IAS processes will be beneficial for CESM development.

# Three new sets of simulations

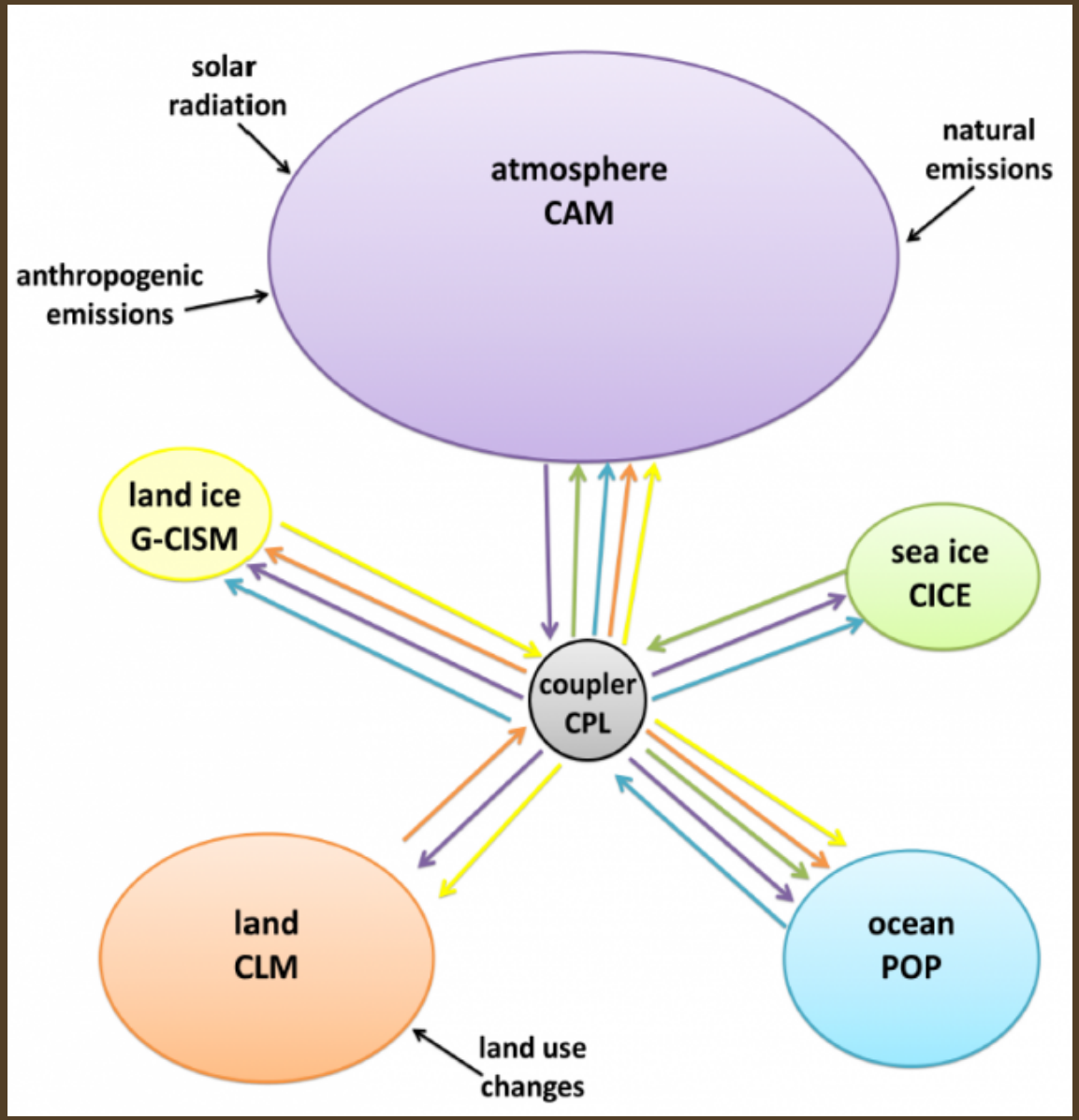
- The Carbon-Climate Feedback CESM Experiments
- The CESM synoptic global coupled simulation
- The CESM Large Ensemble Project

# Commonalities among the three sets

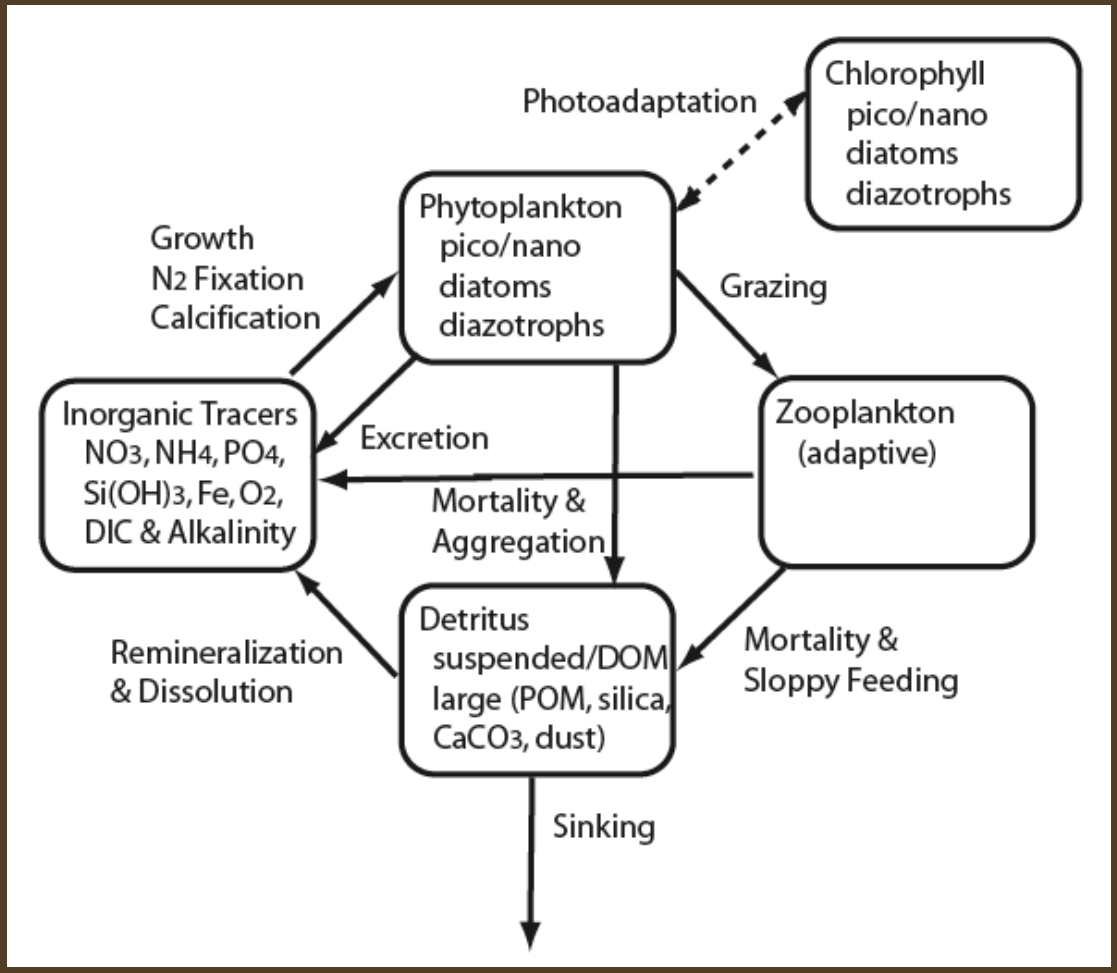
- In all three sets:
  - A version of the CESM was used
  - The simulations are “freely” coupled
  - No data assimilation was done
    - none are “reality-anchored”
  - More than a century of integration

- Biogeochemistry only in two of the sets
  - No biogeochemistry in the high resolution

# The Community Earth System Model

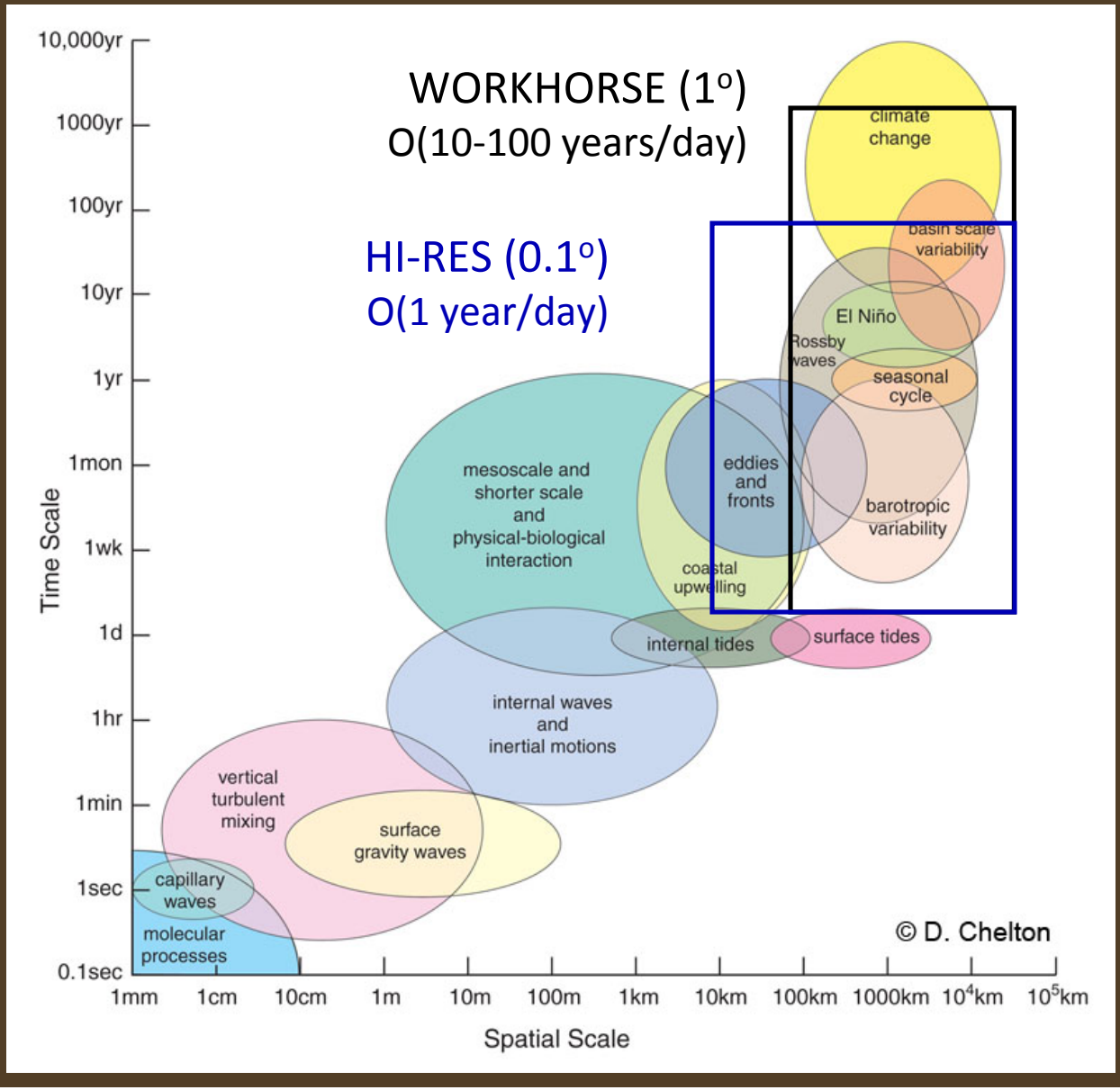


# Ocean Biogeochemical Elemental Cycling Model




- Moore, Doney, Lindsay, 2004, Global Biogeochemical Cycles.
- Doney et al 2009, J. Mar. Systems

# Resolving processes



# Climate-carbon feedback CESM experiments

- Contact person:
  - Keith Lindsay, klindsay@ucar.edu

- Reference:
  - Randerson, J. T., K. Lindsay, and Coauthors, 2015: Multicentury changes in ocean and land contributions to the climate-carbon feedback. Global Biogeochemical Cycles, doi:10.1002/2014GB005079.

- Uniqueness:
  - Experimental setup with and without climate change contributors, extending to year 2300

# Overview of carbon-climate feedback experiments

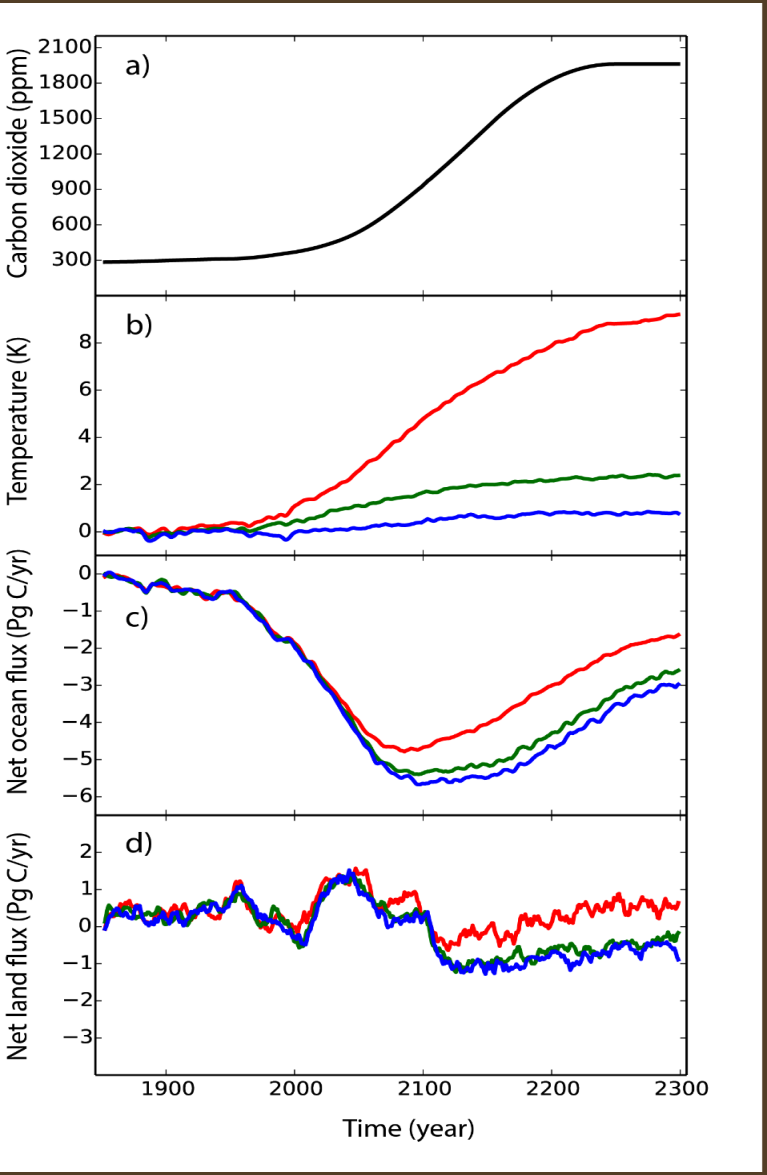
- Performed century-scale simulations with the CESM.
  - From the year 1850 to the year 2300
- Modified settings to allow certain “climate-carbon feedbacks” to be active or inactive (transient vs constant).
- List of “climate-carbon feedbacks”:
  - Radiative impact of $CO_2$
  - Anthropogenic forcings (greenhouse gases and aerosols)
  - Land use change

# Overview of carbon-climate feedback experiments

| Forcing | CASE | Rad CO2 | ATM Anth Forcings (non-CO2) |
|---|---|---|---|
| All forcings | BDRD | 20C | 20C |
| No-Anthropogenic forcing | BDRCs | 1850 | 1850 |
| No-$CO_2$ forcing | BDRC | 1850 | 20C |

- Three separate simulations
- Each with projections to year 2300

# Differences among carbon-climate feedback experiments




- Red = all forcings
- Green = no $CO_2$ forcing
- Blue = no anthropogenic forcing

Relevant research questions

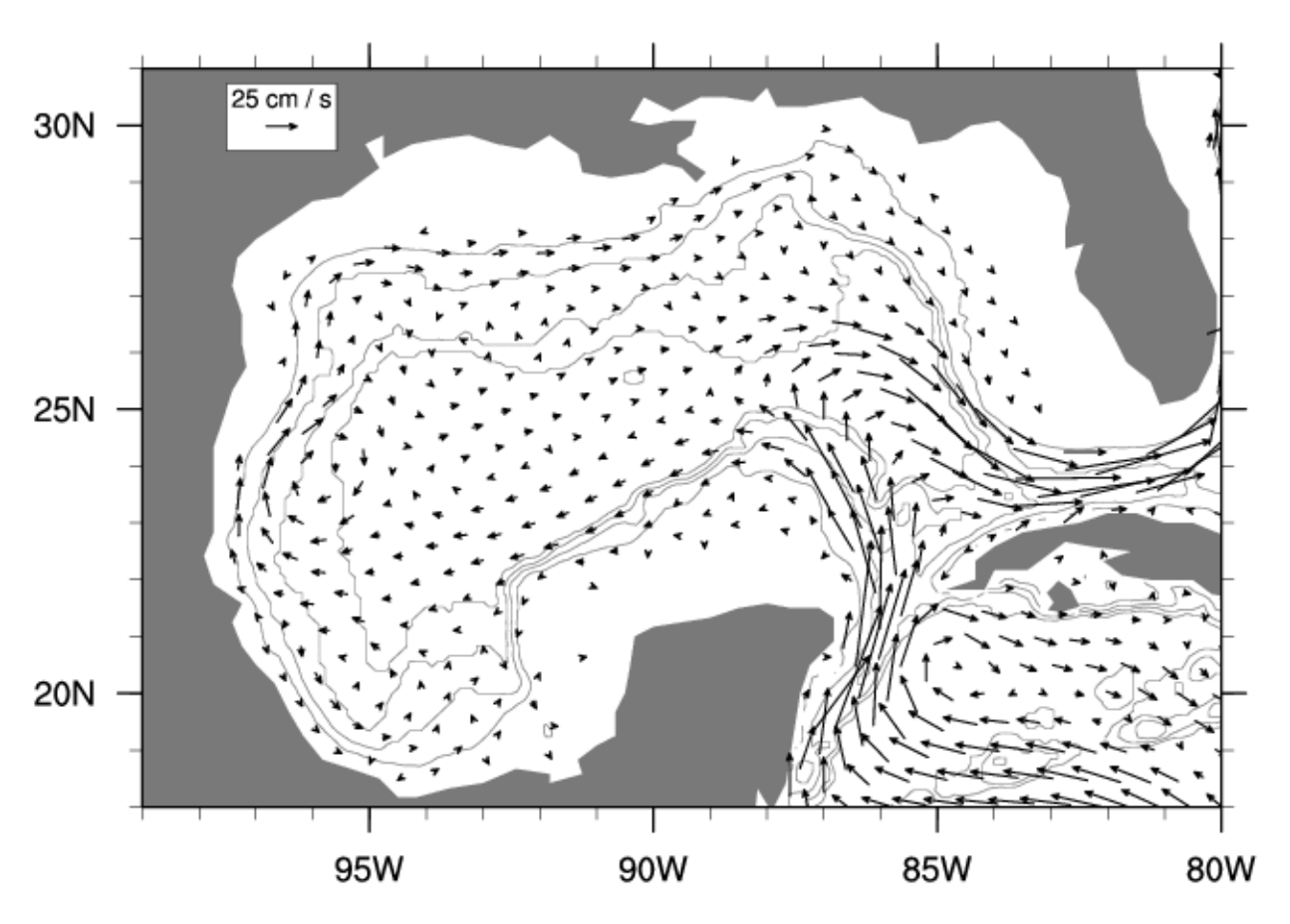
# Synoptic (high-res) global coupled simulation

- Contact person:
  - Justin Small: jsmall@ucar.edu

- Reference:
  - Small, R. J., J. Bacmeister, and Coauthors, 2014: A new synoptic scale resolving global climate simulation using the Community Earth System Model. *Journal of Advances in Modeling Earth Systems*, doi:10.1002/2014MS000363.

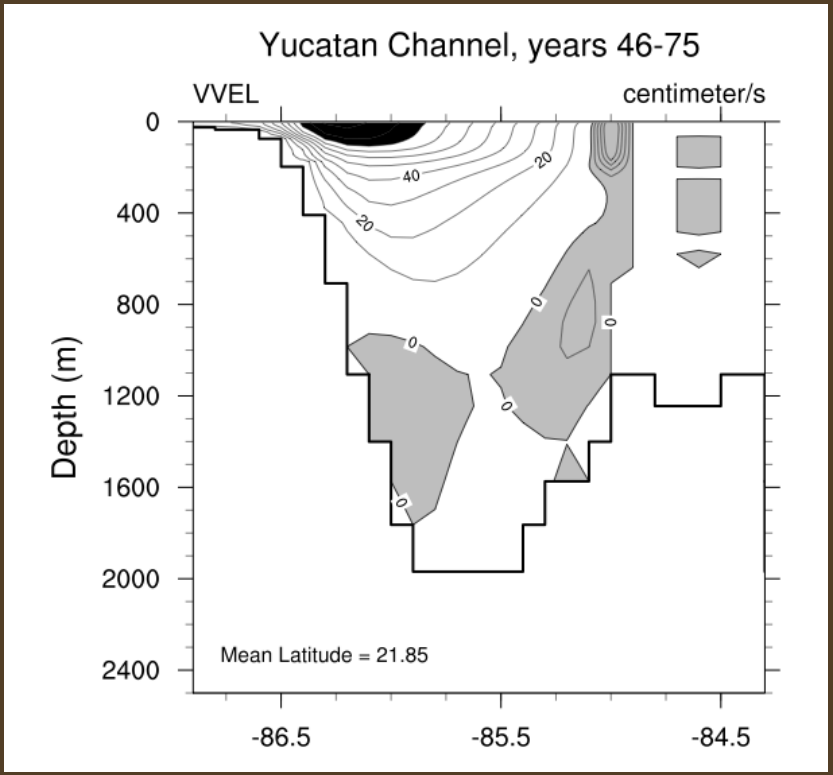
- Uniqueness:
  - Tenth-degree ($0.10^o$) global ocean coupled to quarter-degree ($0.25^o$) atmosphere for 100 years

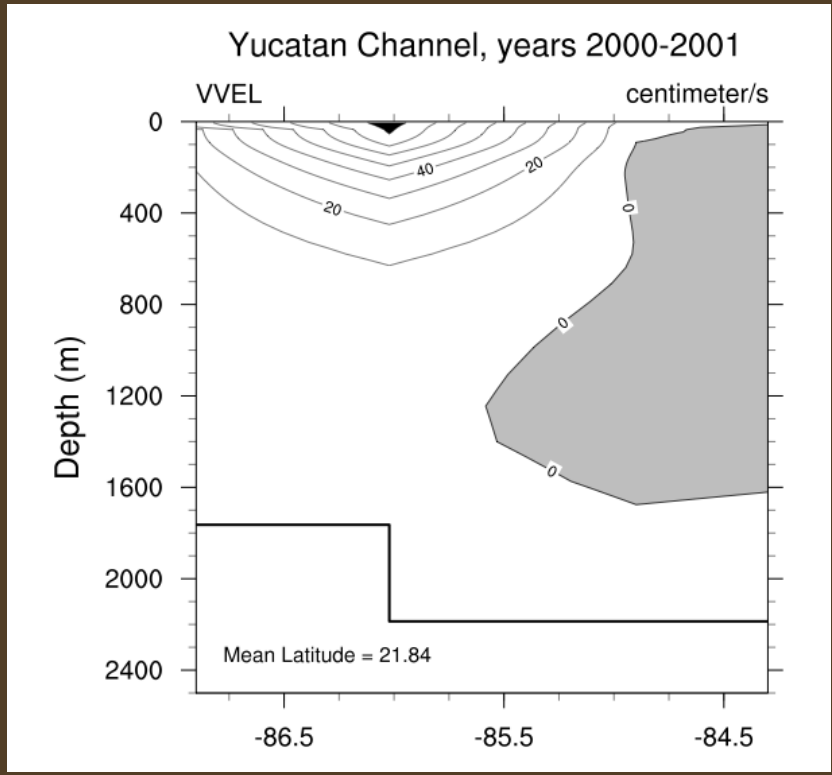
# Velocity at depth of 55 meters




- General circulation in the Gulf of Mexico is well resolved, including Loop Current

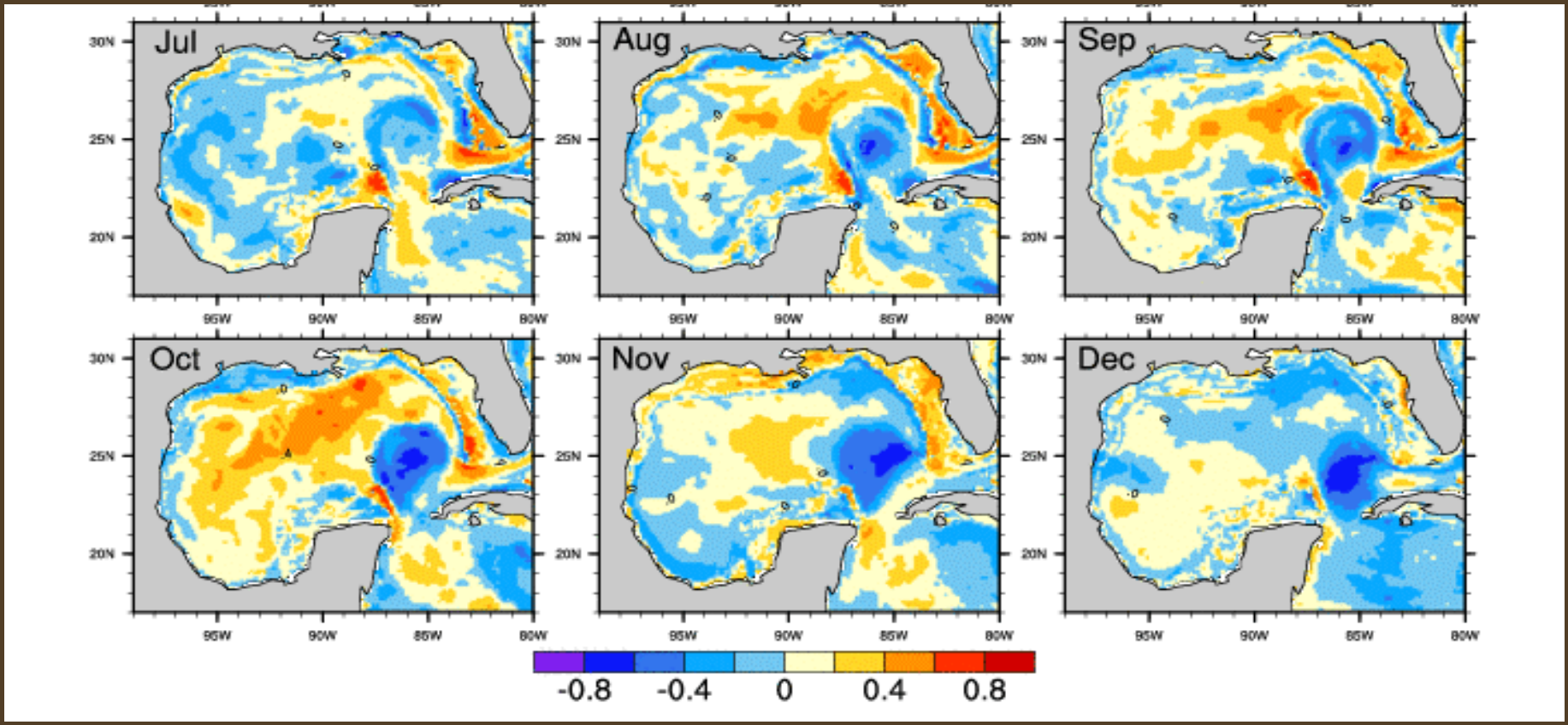
# Differences in Yucatan transport between 0.10-degree and 1.0-degree




- Tenth-degree ocean has great representation of Yucatan flow.

# Example of analysis with 0.10-degree ocean

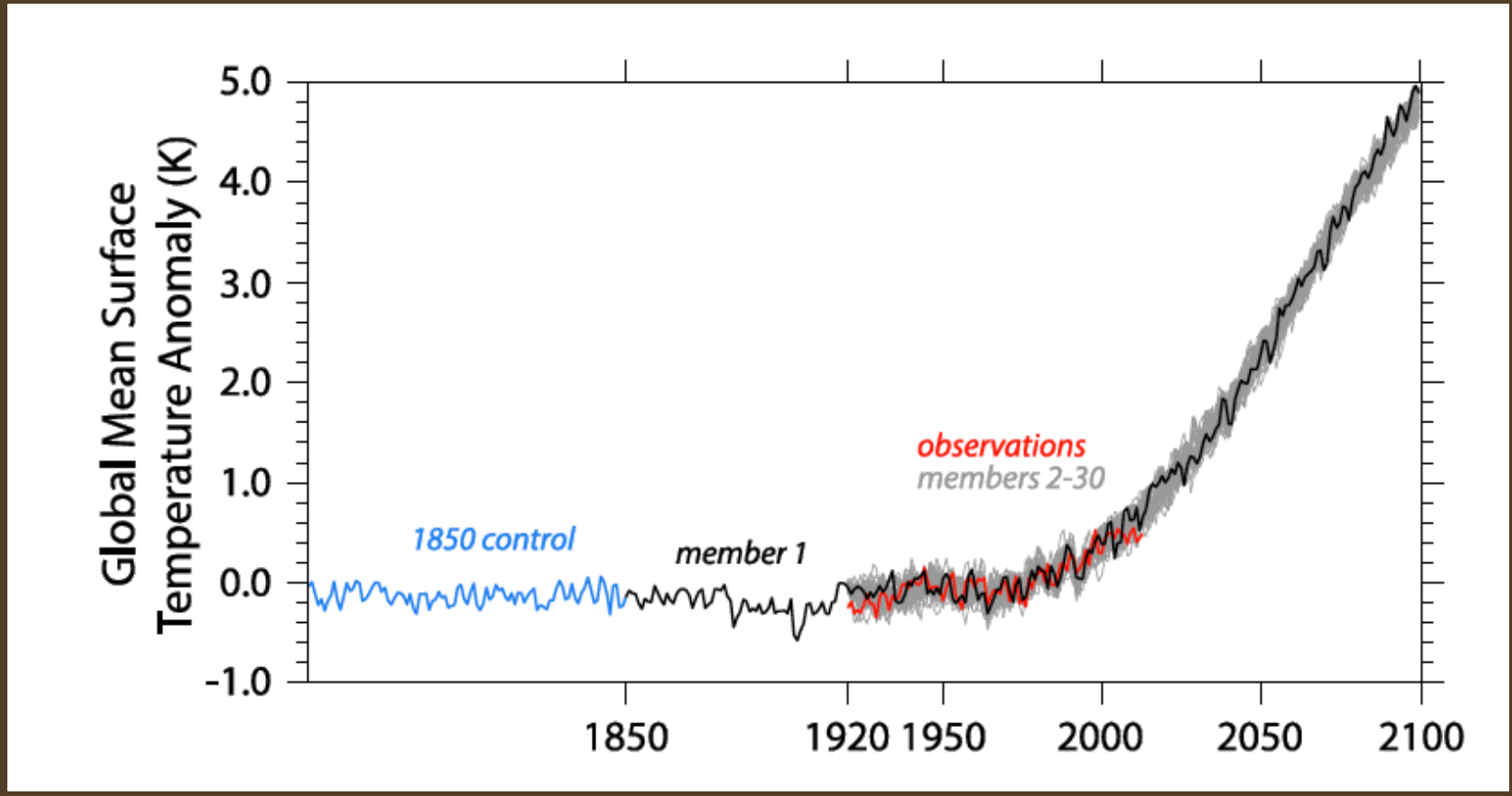



- Correlation of Yucatan transport with mixed-layer depth
- Notice the fine structure of the spatial pattern

# The CESM Large Ensemble Project

- Contact person:
  - Jen Kay, jennifer.e.kay@colorado.edu
- Reference:
  - Kay, J. E., Deser, C., Phillips, and Coauthors, 2015: The Community Earth System Model (CESM) Large Ensemble Project: A Community Resource for Studying Climate Change in the Presence of Internal Climate Variability, *Bulletin of the American Meteorological Society*, doi:10.1175/BAMS-D-13-00255.1, in press.
- Uniqueness:
  - Numerous ensemble coupled simulations, with different initial conditions in atmospheric temperature

# Overview of Large Ensemble simulations




- Different initial conditions are applied in year 1920.
- Projections extend to year 2100 under RCP 8.5 scenario.

# Summary

- The CESM is a great resource of model data for various types of studies of the Intra-Americas Sea.
- Some data sets have been documented but are still unexplored regarding capturing coupled processes in the Intra-Americas Sea.
- The IASCLiP community can contribute to the understanding of the IAS phenomena and its simulation by the CESM, thereby guiding model development foci.

# Thanks

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# Abstract

## Advancing the understanding of the IAS with the Community Earth System Model


- Simulations with the Community Earth System Model (CESM) are produced on a yearly basis at the National Center for Atmospheric Research (NCAR). Staff at NCAR's Climate and Global Dynamics Laboratory (CGD) routinely runs the CESM as part of model development efforts or to meet requirements of experiment protocols. In recent years some outstanding CESM simulations have been completed at NCAR that are great resources for the understanding of climate processes in the Americas and the Intra-Americas Sea (IAS) region. This presentation provides an introduction to those various sets of global CESM simulations. Learning about those simulations allows for the proper selection of experiments for a given research project. Aspects that can be addressed with these experiments span the quantification of ensemble statistics in the Americas, the analysis of oceanic Gulf of Mexico processes at 10-km resolution, and the impact of climate change in the IAS with and without carbon dioxide's radiative forcing. In addition, these CESM simulations have biogeochemistry fields available, thereby allowing for the analysis of the link between IAS physical processes and biogeochemical processes.