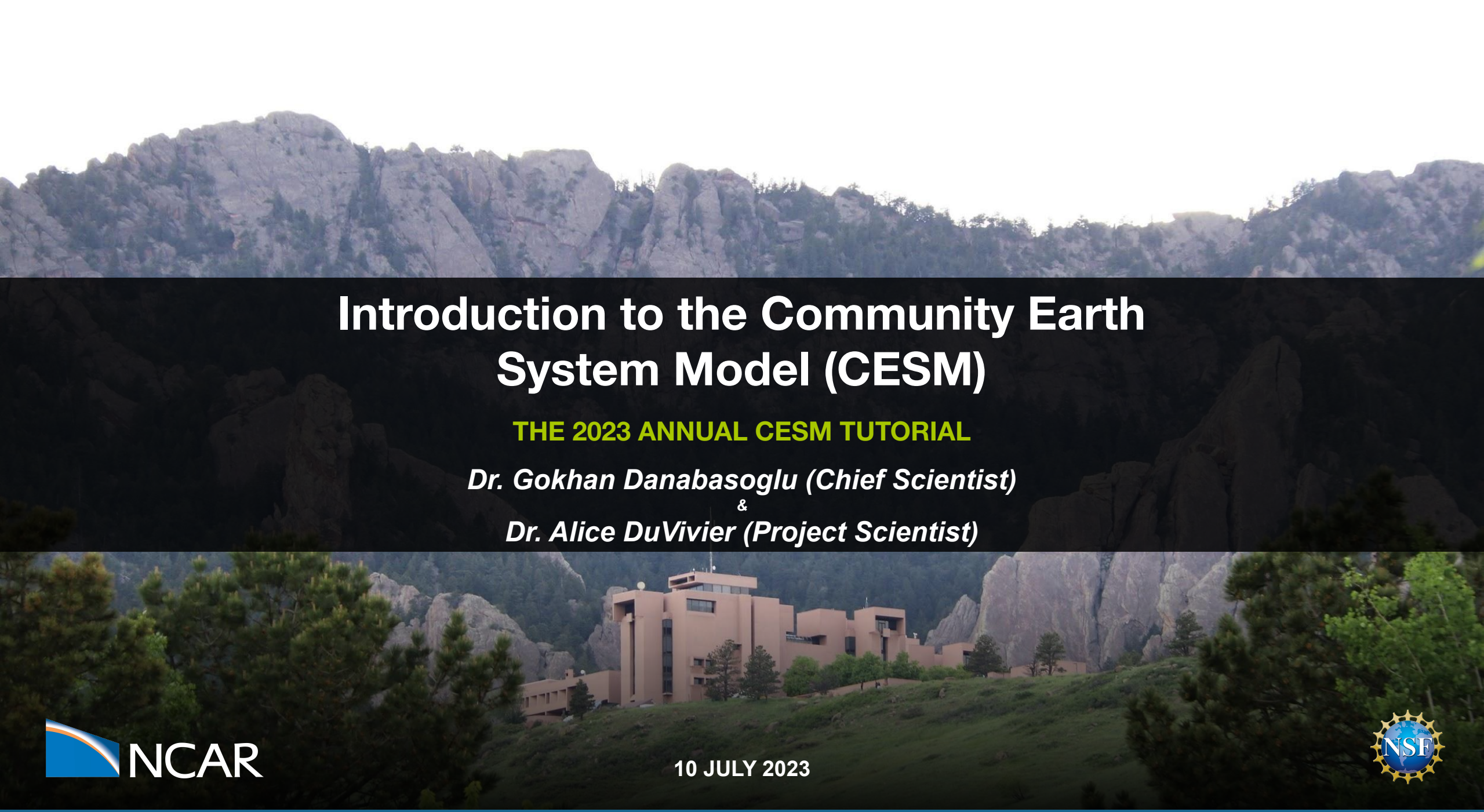

Introduction to the Community Earth System Model (CESM)

THE 2023 ANNUAL CESM TUTORIAL

Dr. Gokhan Danabasoglu (Chief Scientist)
&
Dr. Alice DuVivier (Project Scientist)

NCAR

10 JULY 2023

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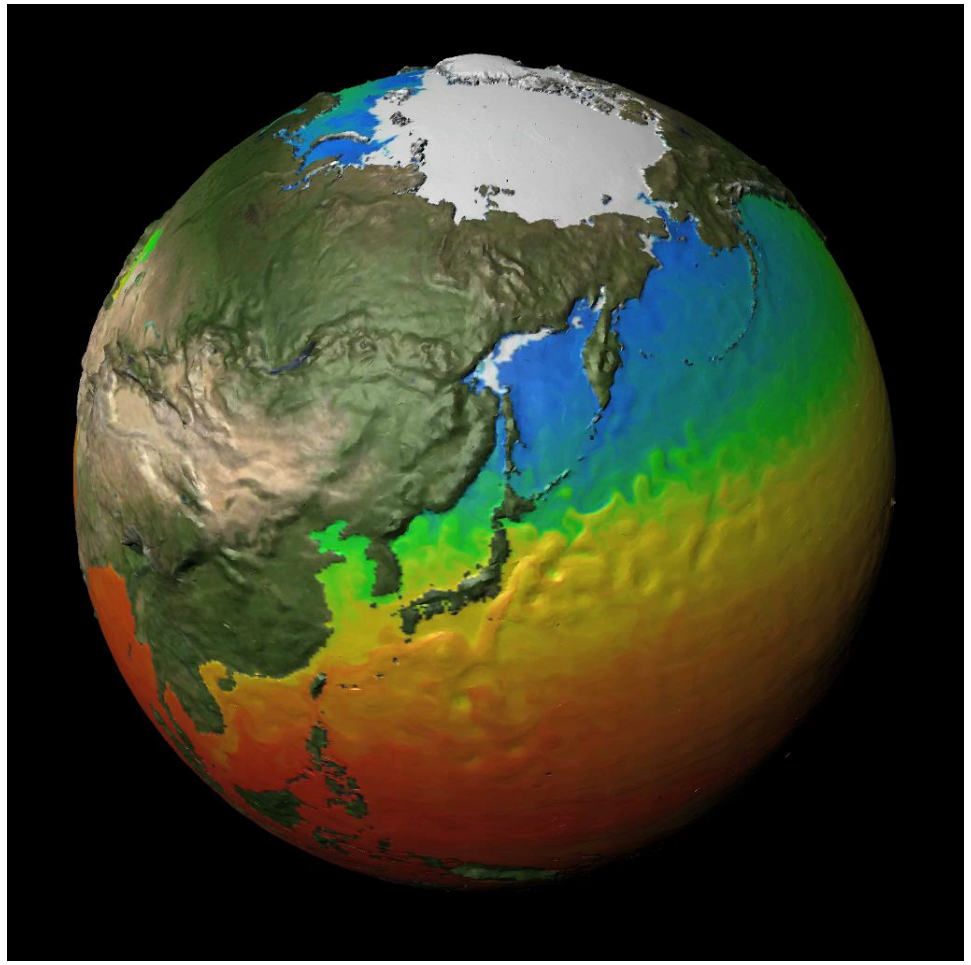
Global Earth System Models and CESM

Global Earth System Models

A virtual laboratory for experimentation ….

General purposes include:

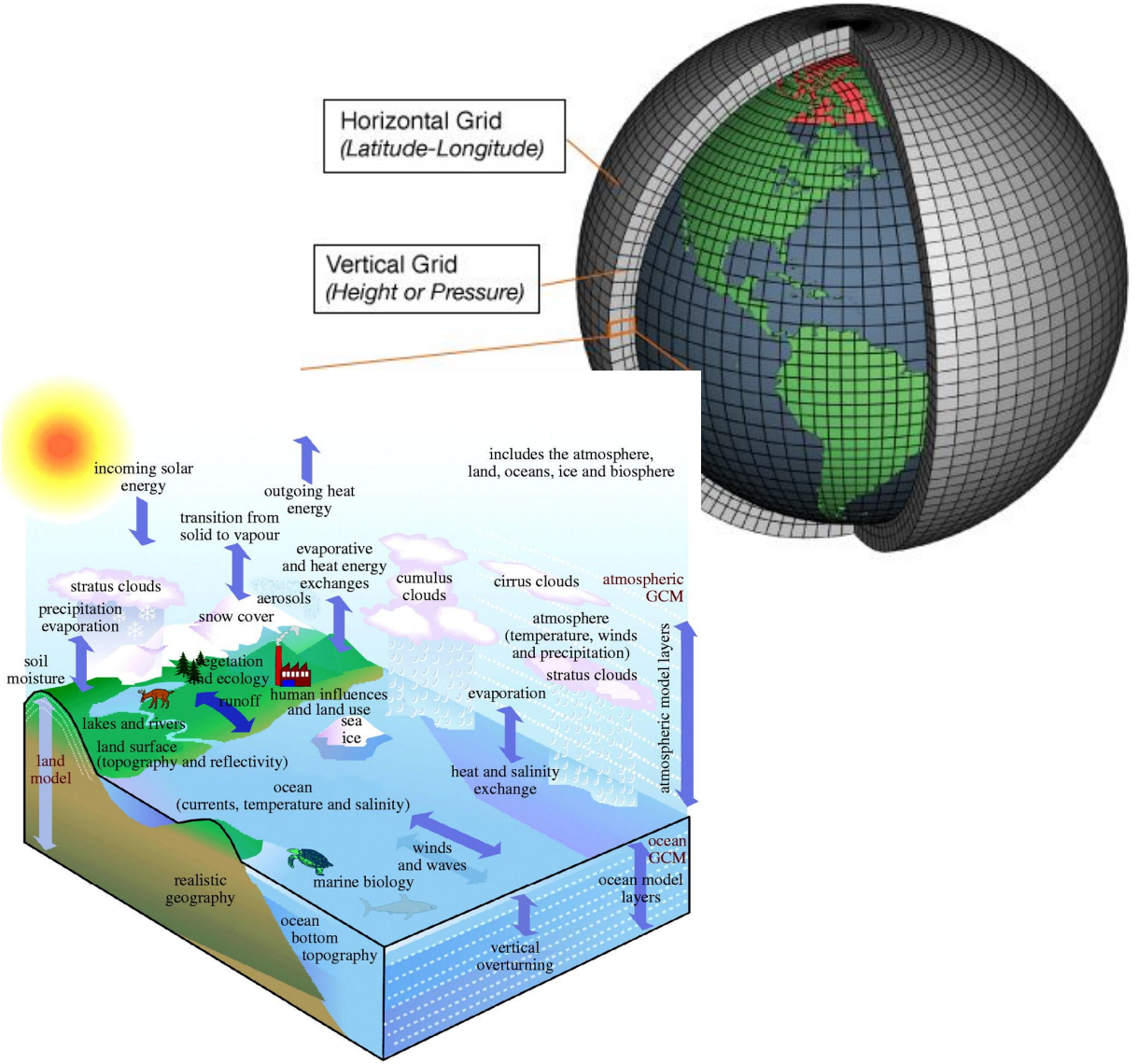
- Providing scientific and mechanistic understanding of past observed events and changes;
- Simulating recent past, present, and future (projections) climate changes and their impacts;
- Studying climate variability and making subseasonal-to-multidecadal Earth system predictions; and
- Providing actionable, societally-relevant information.



Small and Scheitlin

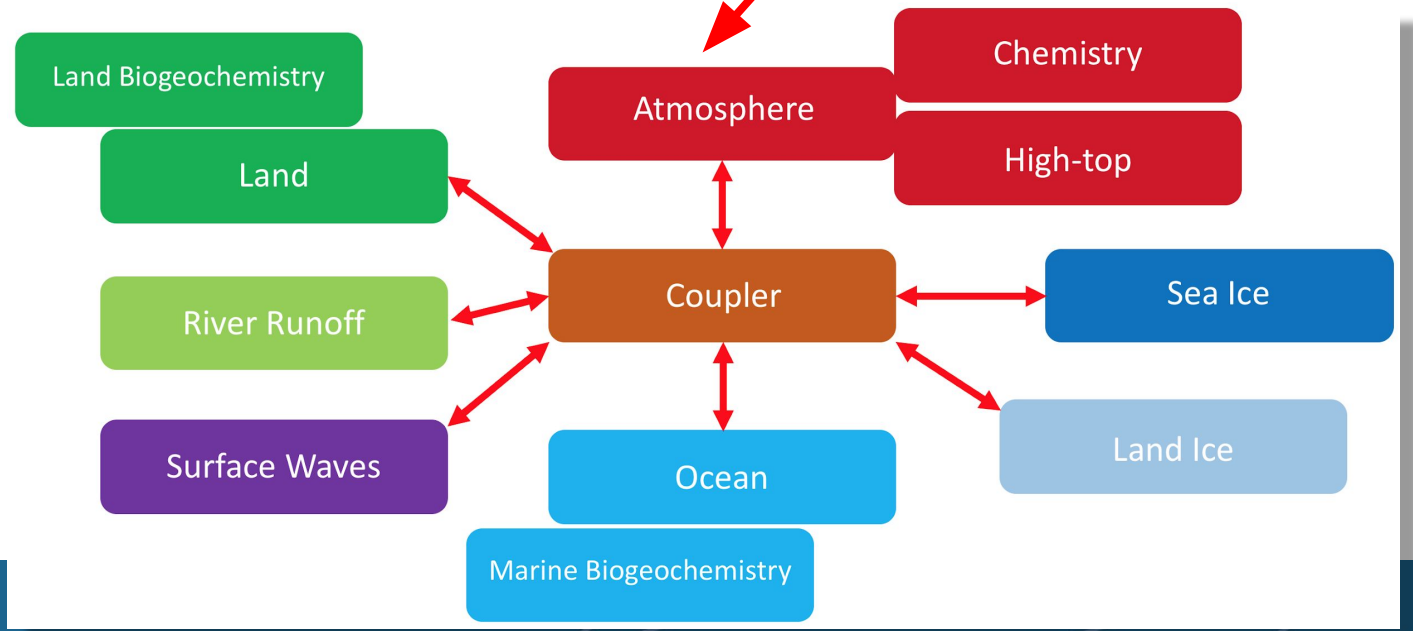
Global Earth System Models

- The models use physical equations to simulate key fields and processes in the atmosphere, ocean, land, sea-ice, land-ice, …
- Processes that remain below the grid resolution need to be parameterized.
- Build on our understanding of processes from observations and highly-detailed models (e.g., process models, large eddy simulations).



Global Earth System Models

Forcings:
- Greenhouse gases
- Anthropogenic aerosols
- Volcanic eruptions
- Solar variability



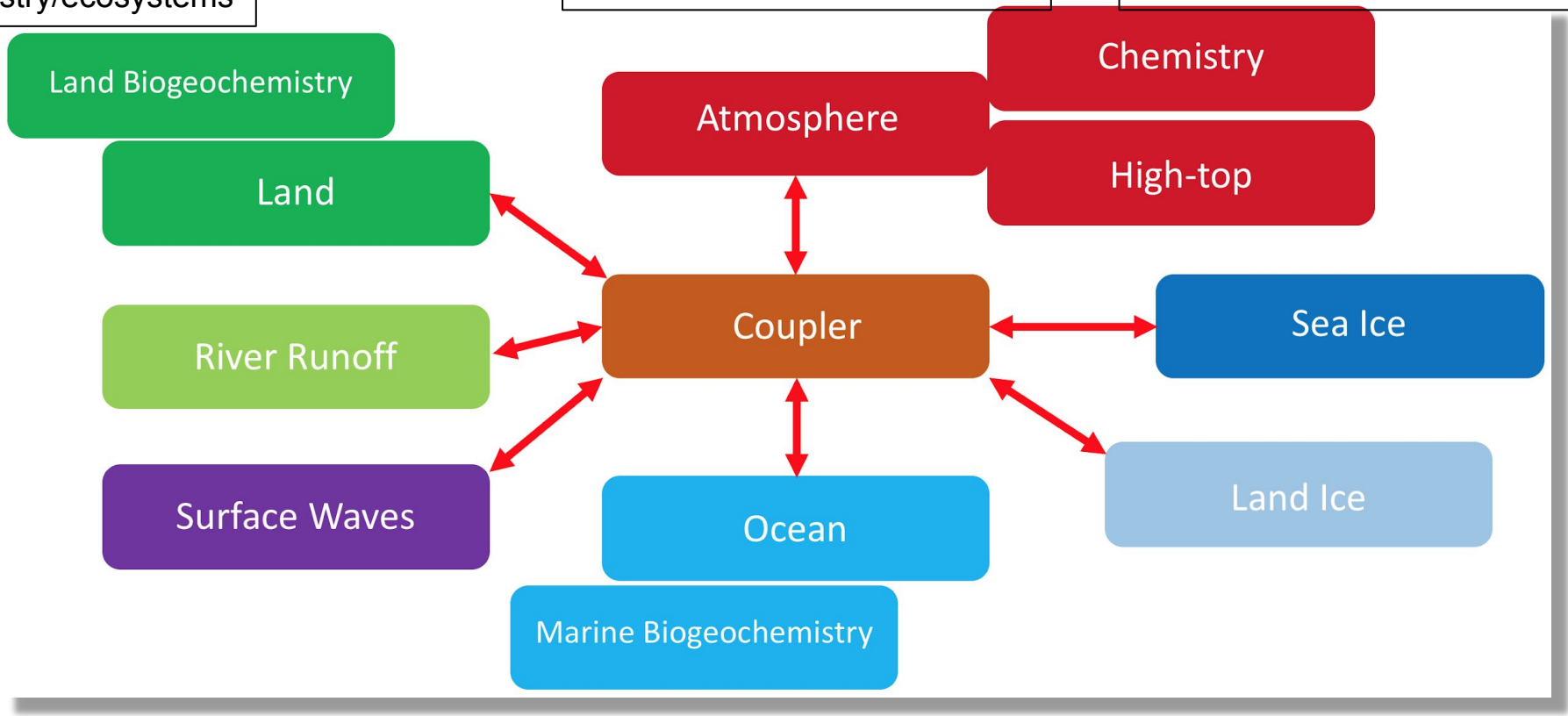
Community Earth System Model (CESM) is an open-source community model available via GitHub.

Global Earth System Models

Tuesday Land Lectures:
- Biogeophysics
- Biogeochemistry/ecosystems

Monday Atmospheric Lectures:
- Dynamics
- Parameterizations

Wednesday Atmospheric Lectures:
- Whole atmosphere
- Chemistry



Wednesday
Sea Ice
Lecture

Friday
Land Ice
Lecture

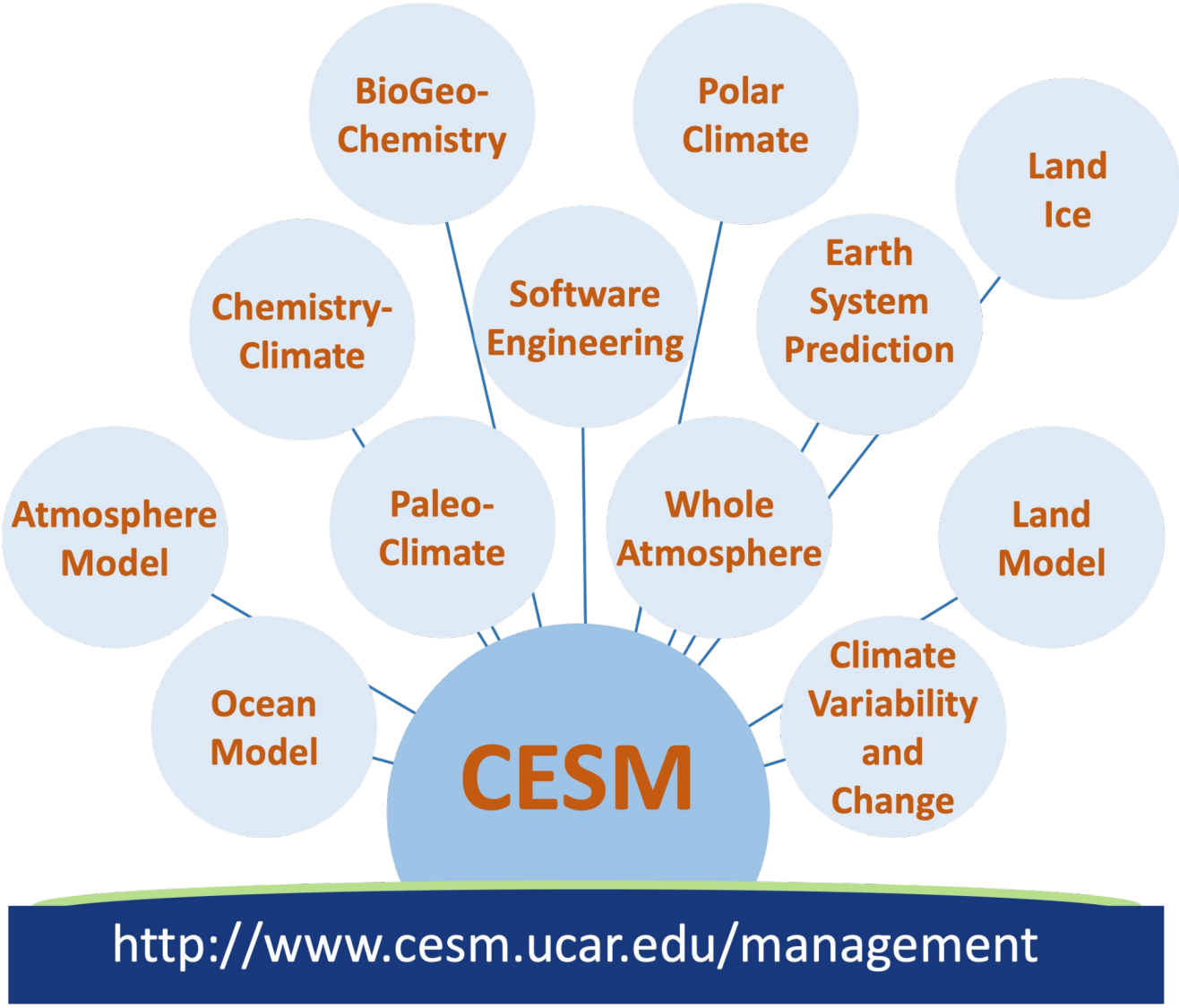
Thursday Ocean Lectures:
- Basics/overview
- Parameterizations

Friday Ocean Lectures:
- Biogeochemistry

CESM Governance

CESM Advisory Board

CESM Scientific Steering Committee

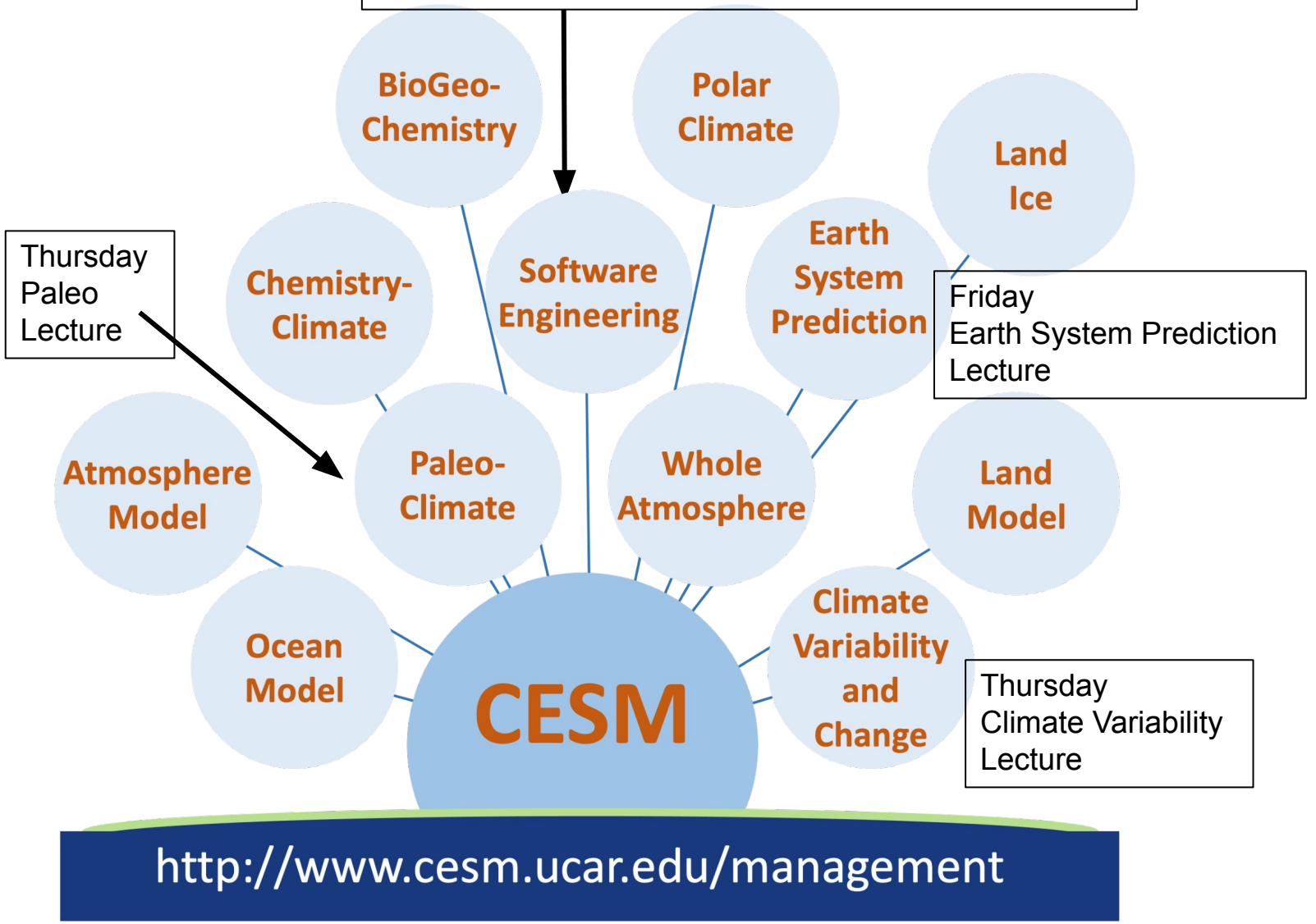


Community-based governance

~30 years of model development and applications

CESM Working Groups

SE lectures
- Monday: NCAR High Performance Computing (HPC)
- Thursday: Model Tuning, Porting/new features



Thursday
Paleo
Lecture

Friday
Earth System Prediction
Lecture

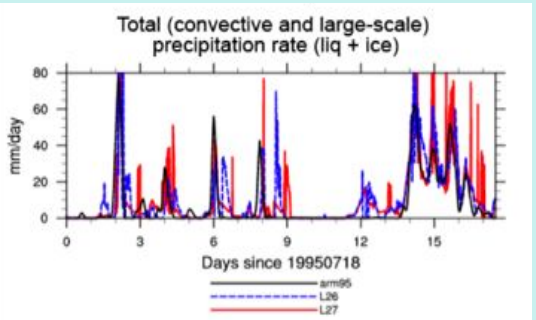
Thursday
Climate Variability
Lecture

CESM supports a range of climate science goals through a single model code base

Containerized (cloud) configurations are also available.

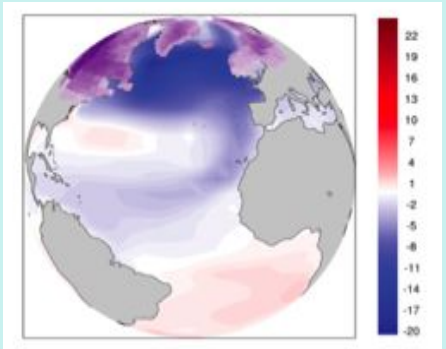
Desktop

Single column/
Coarse resolution:
Physics development



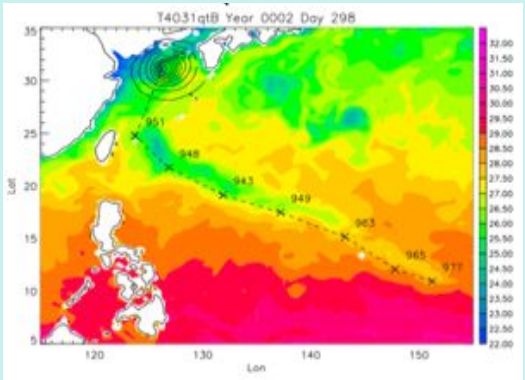
Small cluster

Low resolution:
Paleo applications,
University research



HPC

Medium & High Resolution:
CMIP, Large Ensembles,
New Frontiers



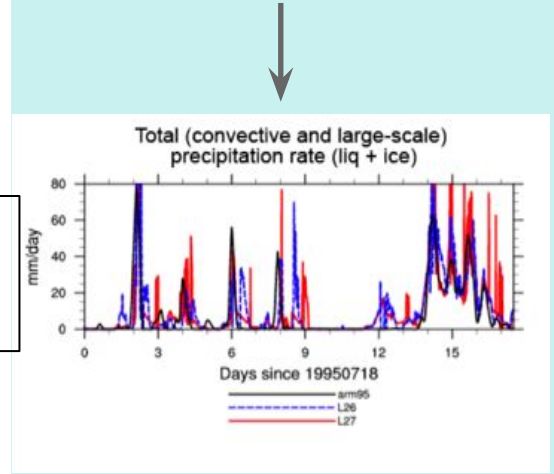
CESM supports a range of climate science goals through a single model code base

Containerized (cloud) configurations are also available.

Tuesday
Simple Models
Lecture

Desktop

Single column/
Coarse resolution:
Physics development



Small cluster

Low resolution:
Paleo applications,
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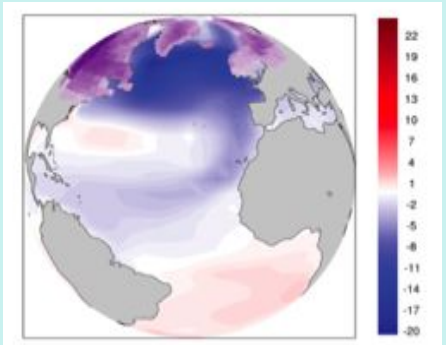

HPC

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CMIP, Large Ensembles,
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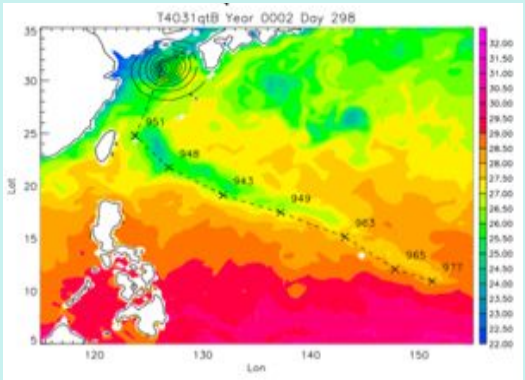
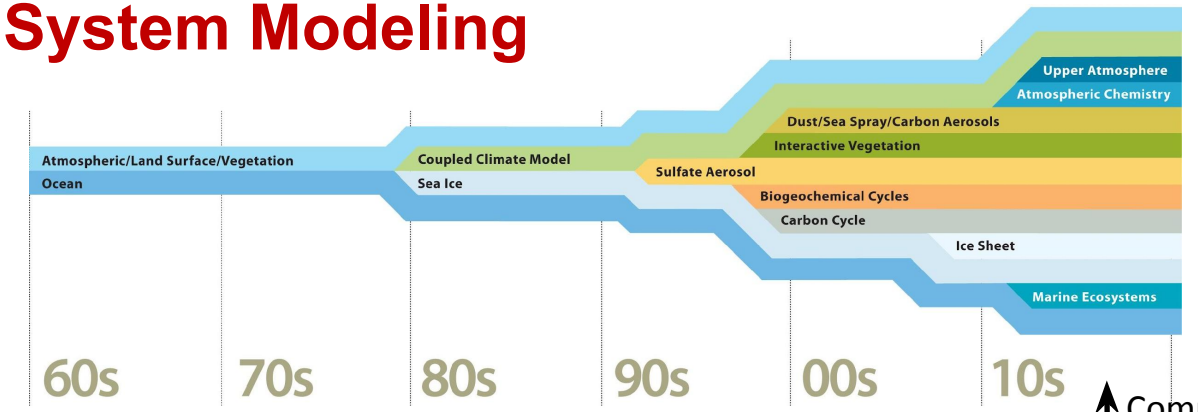
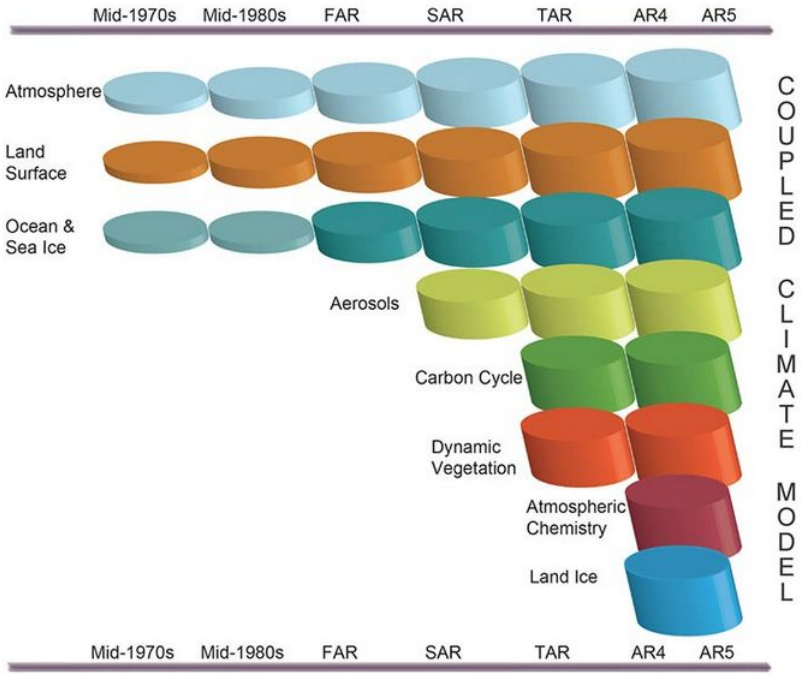


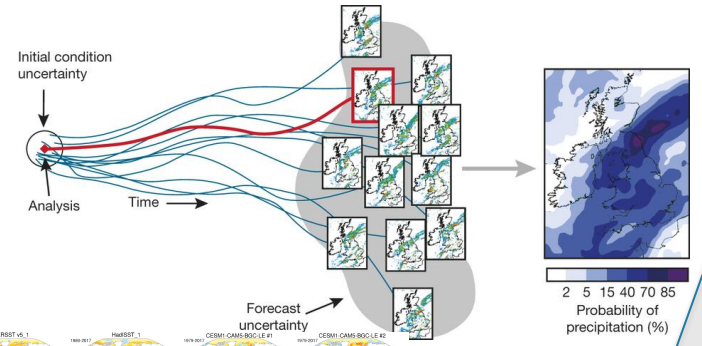
CESM supports a range of climate science goals through a single model code base

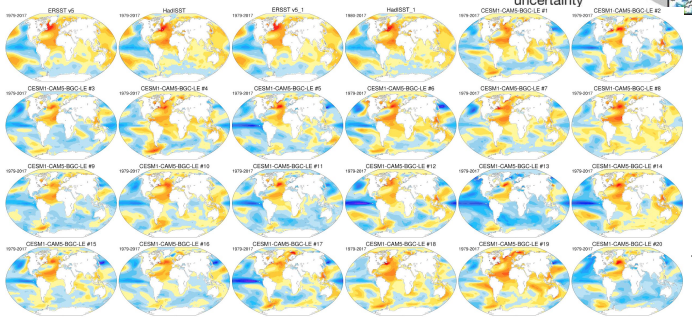
- All component models can be active.
- All component models can be replaced with “data models”:
    - Allowing, for example, ocean-only, ocean – sea-ice coupled, land-only, atmosphere-only configurations.
- Many idealized model options exist: single column atmosphere model (SCAM); dry dynamical core; dry dynamical core with idealized moisture; gray radiation aquaplanet; radiative convective equilibrium world; full physics aquaplanet; slab ocean; etc.
- Numerous choices are available within components regarding their parameterizations.
- Increasing number of supported component sets and configurations are provided.

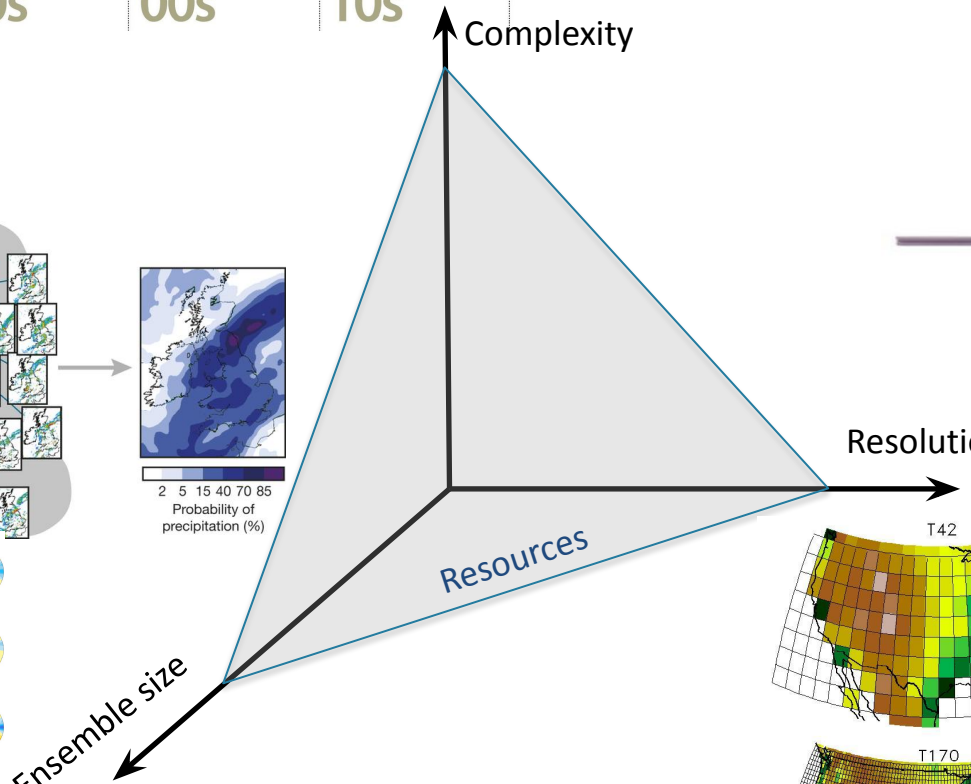
Growth of Climate / Earth System Modeling

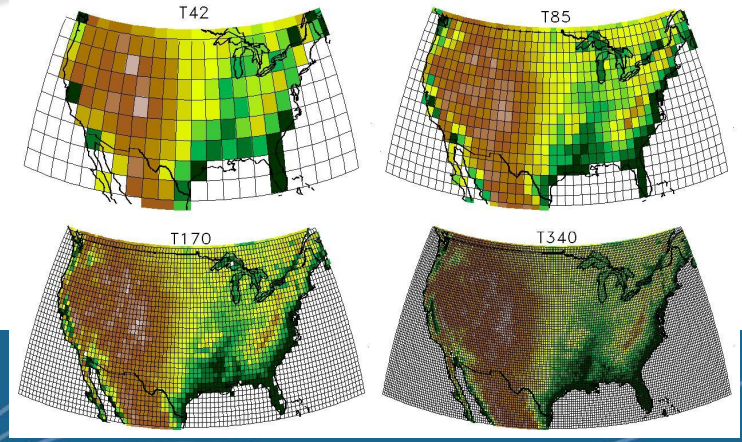












More information Friday

- Getting involved in the CESM community
- Updates and highlights of CESM2 Capabilities
- Community Experiments
- Towards CESM3

Dr. Gokhan Danabasoglu
CESM Chief Scientist

Thank You!