

# Planned and Ongoing High-Resolution Simulations with CESM

(0.1° ocean & sea-ice, 0.25° atmosphere & land; CESM-HR)

- Forced ocean – sea-ice hindcast simulations (G-compset)
- Fully-coupled simulations (B-compset)



## Such HR simulations are of scientific interest to the CESM community ....

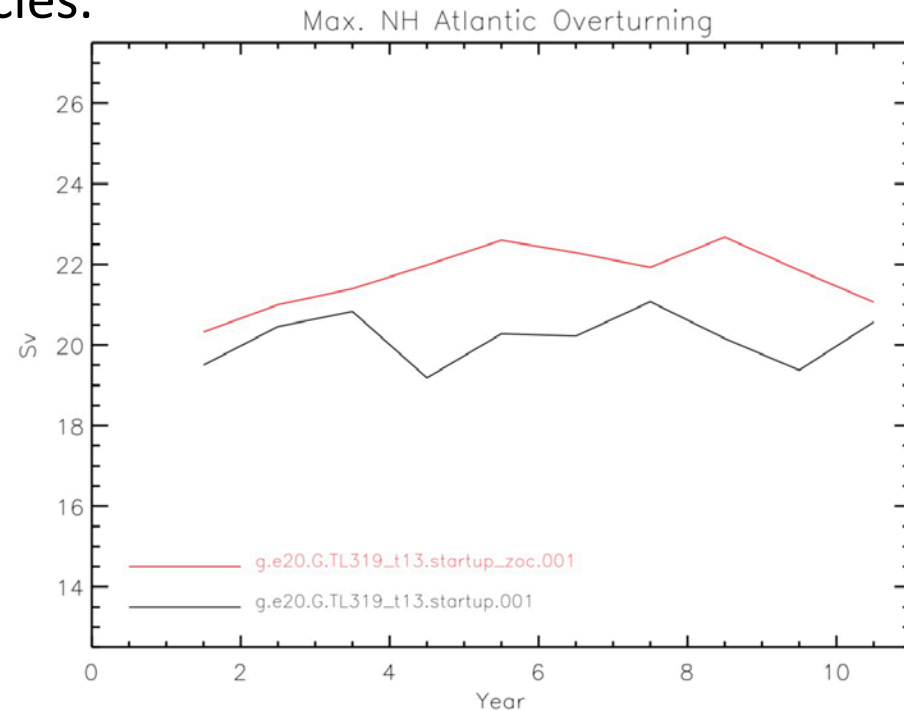
- Resolution dependence of model biases, mean state, variability, etc., e.g., eastern boundary upwelling systems (EBUS), Southern Ocean mixed layer depths, ....
- Evaluation of mesoscale eddy parameterizations; mesoscale eddy processes, impacts, and statistics.
- Air-sea interaction at frontal and mesoscale; atmospheric response to sea surface temperature fronts.
- Impacts of eddies on
  - Climate variability,
  - Prediction skill,
  - Marine biogeochemical cycles and ecosystem processes.
- ....

## Forced Ocean – Sea-Ice Hindcast Simulations (G-compset)

- Forced with the JRA55-do dataset for the 1958-2017 period
- Model version: cesm2\_0\_alpha08b; includes Estuary Box Model, Robert time filter, and ½ hour ocean coupling
- Parameterizations and parameter settings are the same as in the Accelerated Scientific Discovery (ASD) configuration
- Initial conditions
  - ocean: WOA13 (0.25°) January-mean climatology for T & S w/ state of rest
  - sea-ice: state from a 50-year GNYF HR simulation

## Forced Ocean – Sea-Ice Hindcast Simulations (G-compset)

- Two 10-year simulations with and without ocean currents in bulk formulae
- One year of simulation uses 70-75K CPU hours with 12 3D & 25 2D output fields; It is anticipated that BGC will increase the cost up to 3x.
- About one forcing cycle to be run on Cheyenne; transfer to TAMU supercomputers for additional cycles.



# International Laboratory for High Resolution Earth System Prediction (iHESP)

A Collaboration / Partnership between Qingdao National Laboratory for Marine Science and Technology (QNLMT), Texas A&M University (TAMU), and NCAR



The overarching objective of iHESP is to accelerate efforts in:

- HR ocean and earth system model development,
- HR ocean and earth system simulation and prediction, and
- Advancing scientific understanding of interactions among different earth system components across different space and time scales.

## Specific science goals of iHESP for the next 5 years are:

- Assess and quantify the role of mesoscale ocean eddies and their interactions with the atmosphere and sea-ice in climate variability, predictability, and prediction by carrying out an ensemble of present and future climate simulations at HR;

## Specific science goals of iHESP for the next 5 years are:

- Develop a new advanced modeling framework for HR regional and global earth system predictions at subseasonal-to-decadal (s2D) time scales by focusing on:
  - Improving or/and replacing the ocean component of the existing earth system model with a new ocean model that has improved upper ocean mixing processes, including surface wave and tidal effects, as well as other unresolved small-scale dynamics,
  - Developing a new online coupled data assimilation capability for high-resolution regional and global earth system models, and
  - Enhancing CESM coupling software framework by developing a set of online nesting tools for dynamical downscaling through nesting of regional CESM within global CESM.



## Plan for the numerical experiments conducted under the partnership (NCAR effort):

### Stage I (Years 1-2)

- A 500-year, pre-industrial control;
- A subsequent, transient integration from 1850 to 1920; and
- A 5-10-member ensemble of *20<sup>th</sup> century* and future projections from 1920 to 2050. (Akin to CESM-LE)

In addition to observations, in evaluation of these HR simulations, we will utilize existing coarse resolution CESM simulations, and if necessary, new low-resolution simulations that are configured more like the proposed HR experiments will be conducted.

All the simulations are to be run on the QNLM machines.

## Plan for the numerical experiments conducted under the partnership (NCAR effort):

### Stage II (Years 2-3)

An ensemble of decadal prediction (DP) experiments, following the CMIP6-endorsed protocol for the Decadal Climate Prediction Project Model Inter-Comparison Project (DCPP-MIP). These experiments will consist of

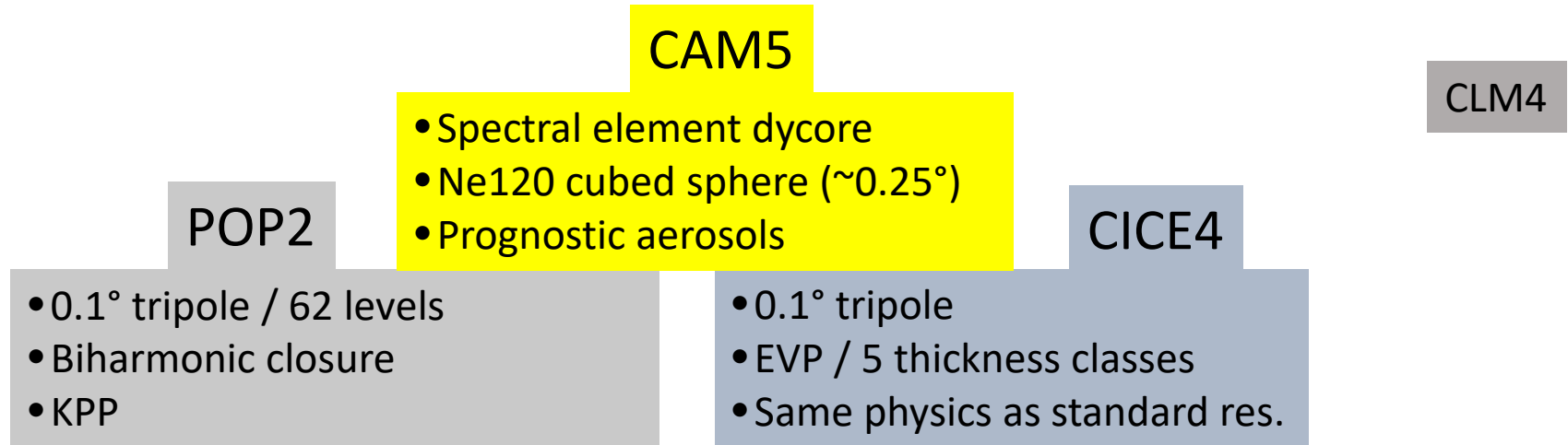
- An HR ocean – sea-ice simulation forced by atmospheric reanalysis products to provide initial conditions for the ocean and sea-ice components; and
- About fifty-five, 3-10-member ensembles of 10-year CESM-HR decadal hindcasts and forecasts, initialized once a year in November from 1960 through to about 2015 (follows DCPP-MIP protocol).

## Other major NCAR efforts:

- Leading and contributing to the analysis of model simulations
- Enhancing CESM tools, diagnostics, workflow, etc. for efficient processing and analysis of HR data sets

# CESM1+ High-Resolution Configuration (CESM-HR)

Based on Accelerated Scientific Discovery (ASD) Version



## Fully Coupled Integrations

- **Small et al (2014, JAMES)**
- O(100 year) present day control
- A few (10-50 year) sensitivity exp.

## CORE Forced Ocean-Ice Integrations

- NY: O(25 year)
- IAF: 1979-2009 (U. Maryland)
- BGC/Ecosystem: O(5 year)

Code & Documentation: [www2.cesm.ucar.edu](http://www2.cesm.ucar.edu)

Data Access: [www.earthsystemgrid.org](http://www.earthsystemgrid.org)

# CESM-HR VERSION TO BE USED

CESM-HR (cesm1.3.beta17<sup>-</sup>):

- Already sent to QNLM
- Tested and verified via duplicating a segment of the existing NCAR present-day simulation

CESM-HR<sup>+</sup> (cesm1.3.beta17\_sehires20):

- Bug corrections over CESM-HR, including for *warm worlds*,
- Additional optimizations in the atmospheric model,
- A faster barotropic solver for the ocean component,
- ½ hour ocean coupling.

“Final” tag created: cesm1.3.beta17\_sehires29

Special thanks to Nan Rosenbloom!

## Initial Conditions

Ocean: WOA13 (0.25°) January-mean climatology for T & S; state of rest; w/ ideal age starting at zero

Sea-ice: year 16 of a previous GNYF HR simulation

Atmosphere: Same as in the ASD simulation since the initial state does not really matter for our purposes.

Land: year 101 from an ne120\_g16 1850 control run with CN.

Replacing satellite phenology used in the ASD simulation

## Status

- Tag testing
- Final check of all the component namelists and input files
- Initial TOA tuning
- Port / testing of workflow and diagnostics to QNLM machines

Leveraging / partnering with other projects

Data from all the simulations available to the community