Planned and Ongoing High-Resolution Simulations with CESM

(0.1^{o} ocean & sea-ice, 0.25^{o} atmosphere & land; CESM-HR)

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

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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)

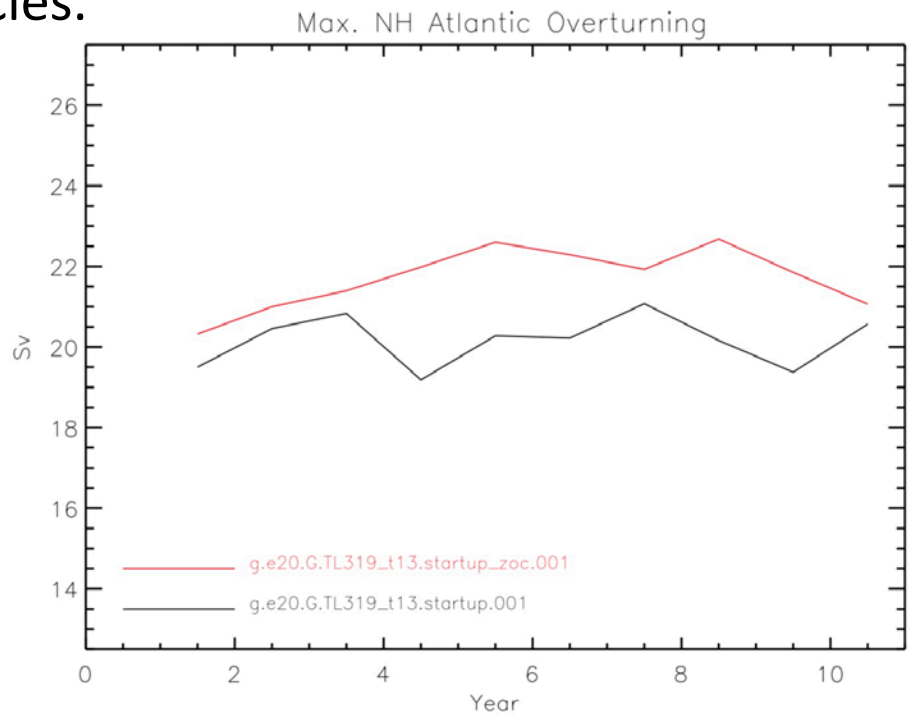
- Forced with the JRA55-do dataset for the 1958-2017 period
- Model version: cesm2_0_alpha08b; includes Estuary Box Model, Robert time filter, and ½ hour ocean coupling
- Parameterizations and parameter settings are the same as in the Accelerated Scientific Discovery (ASD) configuration
- Initial conditions

  ocean: WOA13 (0.25^{o}) 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 (QNLM), 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 *20th 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

CAM5

- Spectral element dycore
- Ne120 cubed sphere (~0.25°)
- Prognostic aerosols

CLM4

POP2

- 0.1° tripole / 62 levels
- Biharmonic closure
- KPP

CICE4

- 0.1° tripole
- EVP / 5 thickness classes
- Same physics as standard res.

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
Data Access: www.earthsystemgrid.org

CESM-HR VERSION TO BE USED

CESM-HR (cesm1.3.beta17^{-}):

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

CESM-HR^{+} (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^{o}) 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