A millennium-scale CESM2 ensemble to the year 3000

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Motivation for a future ensemble in deep future time

• Are there unanticipated tipping points that once identified, can provide motivation for stronger climate mitigation over the next several decades?
• Are emissions targets established for 1.5°C or 2.0°C truly stable, or do temperatures continue to drift upward for overshoot scenarios?
• Can we use high resolution simulation output to illustrate to the public in a novel way the long-term consequences of 21\textsuperscript{st} century decisions regarding resource use?
  – Create animations and movies for the public of the climate system evolving in response to sustained forcing
• How does the earth system function in a warmer world?

• The timespan of IPCC-class simulations is shortening with the focus remaining on 2100 from AR1 through AR5.
Deep future time science questions

• Land
  – How will permafrost degrade, and is carbon loss proportional to fossil fuel emissions?
  – How do plants live in the Arctic when it’s dark and warm?
  – Will we lose the Amazon?
• Ocean
  – How does AMOC evolve for low, medium and high emissions scenarios?
  – Does tropical anoxia undergo cycles of expansion and contraction?
  – Does nutrient trapping in the Southern Ocean ultimately starve phytoplankton and
    global fisheries?
  – Once the heat pulse has moved through the deep ocean, and density gradients
    weaken, do we see new modes of deep water formation?
• Land Ice
  – Can we use these simulations as a boundary condition for forcing of the uncoupled
    land ice model for CMIP7?
• Climate Variability and Change
  – How do different climate modes operate in a warmer world (e.g., ENSO, PDO, AMO)
  – Do we see evidence for abrupt reorganization of the climate system in some
    simulations?
  – What is the probability of an abrupt event occurring in the different ensembles?
  – Do the different ensembles diverge in terms of atm. CO₂ and climate?
Preliminary results from the BGC Working Group using CESM1 simulations to the year 2300


Precipitation reductions in neotropical forests by 2300 driven equally by radiative and physiological effects of CO₂

Hoffman Ph.D. thesis
Expansion and contraction of oxygen minimum zones from century to century

How might this work?

- Use emissions-forced simulations so that the CO$_2$ pulse can evolve naturally after 2300
  - So that we are exploring the long-term consequences of a 21$^{\text{st}}$ century carbon dioxide pulse
- Assume land use and aerosol conditions remain constant after the end of the SSP scenario
- Aim for 3 future scenarios – high, middle, and low (overshoot) greenhouse emissions
- 4 ensemble members x 3 scenarios x 1000 years = 12,000 model years
- Write a proposal to NSF to secure computer time on Cheyenne and to support simulation design, execution, and analysis
Questions and comments?