The Future of Climate Modeling with CESM: Balancing High Resolution and Accessibility

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Ultra High Resolution (KM scale) Modeling

Positives:

- Improved spatial resolution enables researchers to investigate localized phenomena.
- Enhanced physical processes, fewer parameterizations.
- May lead to improved understanding of climate feedbacks.

Costs:

- Extremely computationally expensive
- Limited to a few scientists and institutions on very large HPC systems
- Significant investment in resources required to port codes to emerging and potentially short lived technologies
- Perhaps there is a tendency to have the technology determine the science.

DOE and E3SM

DOE has invested some $150M over 5 years in the E3SM model.

DOE has around 15 FTE software engineers engaged on E3SM development.

The DOE has 6 systems available to run E3SM in the June 2023 HPC top 500 list.

- Aurora 2,000? Pflop/s
- #1 Frontier 1,194 Pflop/s
- #5 Summit 200 Pflop/s
- #8 Perlmutter 70 Pflop/s
- #19 Polaris 25 Pflop/s
- #34 Frontier TDS 19 Pflop/s

NCAR Derecho lands beyond #50 with 10 Pflop/s

CESM Strengths

- A large and diverse user community.
- Portability across a variety of platforms of all different sizes
- Ability to create a wide variety of experiments useful to many disciplines
- A leading model of the CMIP experiments since 1996
- Has spawned a number of climate modeling efforts around the world.
- Bottom up science driven development model

CESM should complement and extend the capabilities of E3SM not compete with them.

Improve CESM infrastructure

Improved and easier to use infrastructure will lead to a larger user base.

- Graphical User Interface
- Improved IO subsystem including asynchronous write and data compression capability.
- Postprocessing and data analysis subsystem.
- Improved workflow tools.
- Improved ensemble tools.
- Improved interface to data assimilation component.
- Improved fault tolerance.
- On demand tutorials and improved user support forums.
- Improved portability and use of containers.
- Earth System Modeling Framework (ESMF)

Nearly all of these improvements will help with high-resolution modeling too!

Improve CESM Accessibility

- Develop user-friendly interfaces and tools that simplify the process of setting up and running CESM simulations.
- Create comprehensive and easily understandable documentation.
- Organize training programs, workshops, and educational resources.
- Foster a supportive and collaborative community around CESM.
- Actively engage with potential user communities beyond the traditional climate research domain.
- Open source, open science, open data, transparency and knowledge sharing.
- Listen to community feedback.

Community is the strength of CESM

By emphasizing the growth of the user community and improving the accessibility of CESM, the model can have a broader and more significant impact.

Enabling kilometer-scale modeling may be valuable, but it should be pursued in a manner that aligns with the goal of expanding the user base, fostering collaboration, and making CESM a widely accessible and valuable tool for climate research and applications.

Thank you for your attention