NEWS RELEASE

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Using Next Generation Exascale Supercomputers to Understand the Climate Crisis

Inaugural Award Bestowed for Trailblazers in Modelling Climate Change

Denver, CO, November 16, 2023 – ACM, the Association for Computing Machinery, presented a nineteen-member team with the inaugural ACM Gordon Bell Prize for Climate Modelling for their project, "The Simple Cloud-Resolving E3SM Atmosphere Model Running on the Frontier Exascale System." The new award aims to recognize innovative parallel computing contributions toward solving the global climate crisis.

The members of the team are: Mark A. Taylor, Luca Bertagna, Conrad Clevenger, James G. Foucar, Oksana Guba, Benjamin R. Hillman, Andrew G. Salinger (all of Sandia National Laboratories); Peter M. Caldwell, Aaron S. Donahue, Noel Keen, Christopher R. Terai, Renata B. McCoy, David C. Bader (all of Lawrence Livermore National Laboratory); Jayesh Krishna, Danqing Wu (both of Argonne National Laboratory); Matthew R. Norman, Sarat Sreepathi (both of Oakridge National Laboratory); James B. White III (Hewlett Packard Enterprise); and L. Ruby Leung (Pacific Northwest National Laboratory).

A consensus has emerged among the international scientific community that, if current trends are not reversed, global warming caused by the human use of fossil fuels will pose an existential threat to life on Earth. Scientists point out that there is more carbon dioxide in our atmosphere than at any other time in human history, sea levels are rising faster than ever before, and climate-induced severe weather events such as hurricanes and droughts are leaving destruction in their wake. The urgency of the situation was underscored in a recent report by the UN's Intergovernmental Panel on Climate Change, which concludes that "there is a rapidly closing window of opportunity to secure a livable and sustainable future for all."

To develop the most effective carbon emission reduction policies, governments are working with scientists to better understand the relationship between carbon emissions, the earth's atmosphere, and climate change. Because of the mind-boggling number of variables in understanding climate phenomena

(e.g., temperature, humidity, precipitation), scientists have increasingly used powerful supercomputers to process all these variables in order to develop high resolution simulations.

As the team that won the inaugural ACM Gordon Bell Prize for Climate Modelling notes in their paper, "Climate simulations present a huge computational challenge because they need to run long enough to capture the slow evolution of climate but also need to capture scales of motion ranging from micron-level collisions between droplets to global-scale circulations."

Climate scientists are especially interested in understanding convective clouds (clouds that are formed by the process of warmer air rising above a less dense atmosphere). Deep convective clouds (which can be many kilometers thick) are particularly important to simulate correctly because they drive the tropical overturning circulation and modulate energy transfer over much of the planet.

A class of algorithmic models known as global cloud-resolving models (GCRMs) have been used to attempt to simulate deep convective clouds and have been accurate in certain instances such as providing simulations of short time periods or limited physical areas. But the Prize-winning team notes that the drawbacks of GCRM's include the fact that running these algorithms on existing supercomputers has been slow and computationally expensive (e.g., the algorithms require too many steps).

The team proves that by using just-introduced exascale supercomputers along with a new algorithmic model they have introduced, the longstanding challenge of developing efficient and accurate simulations of deep convective clouds can be accomplished. The prize-winning team introduces the new algorithmic model, "Simple Cloud Resolving E3SM Atmosphere Model (SCREAM)."

SCREAM consists of combining four key innovations:

- Portable C++ innovations, including using the Kokkos programming model, a C++ library for on-node parallelism
- Algorithmic innovations**,** including formulations which help the core of the model conserve energy with exact timestepping
- Subgrid physical parameterizations, a class of models used in climate simulations
- I/O Strategy: SCREAM uses the Software for Caching Output and Reads for Parallel I/O (SCORPIO) library and the Adaptable Input Output System I/O (ADIOS) library

Exascale Computing

Exascale computers are the newest generation of ultra-powerful supercomputers. Frontier, the world's first exascale supercomputer, came online in 2022 at the Oak Ridge National Laboratory. It can perform a quintillion (a billion billion) operations per second. When Frontier came online, it was 2.5 times faster than the world's second most powerful supercomputer.

Performance

Using 32768 graphics-processing units (GPUs) on 8192 Frontier (exascale supercomputer) nodes, the

ACM Gordon Bell Prize for Climate Modelling Prize-winning team obtained a record-setting performance of 1.26 simulated years per day for realistic cloud resolving simulations.

Conclusions

The team notes that their successful cloud simulation on the Frontier exascale supercomputer is a transformative accomplishment for climate science, and will allow trustworthy predictions of future climate impacts which have traditionally been localized in time and space.

The inaugural ACM Gordon Bell Prize for Climate Modelling was presented during the International Conference for High Performance Computing, Networking, Storage and Analysis (SC23), which was held in Denver, Colorado.

About ACM

ACM, the Association for Computing Machinery is the world's largest educational and scientific computing society, uniting computing educators, researchers, and professionals to inspire dialogue, share resources and address the field's challenges. ACM strengthens the computing profession's collective voice through strong leadership, promotion of the highest standards, and recognition of technical excellence. ACM supports the professional growth of its members by providing opportunities for life-long learning, career development, and professional networking.

About the ACM Gordon Bell Prize for Climate Modeling

The ACM Gordon Bell Prize for Climate Modelling aims to recognize innovative parallel computing contributions toward solving the global climate crisis. Climate scientists and software engineers are evaluated for the award based on the performance and innovation in their computational methods. A cash prize in the amount of $10,000 accompanies the award, which was conceived and funded by Gordon Bell, a pioneer in high performance computing and researcher emeritus at Microsoft Research. The award will be given annually for the next ten years. Recipients of the ACM Gordon Bell Prize for Climate Modelling will have their research published in The International Journal of High Performance Computing Applications (IJHPCA).

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