CGD SEMINAR

NCAR

DATE: Tuesday, 13 September 2022

TIME: 11 a.m.

LOCATION: Virtual, with Zoom link to follow

TITLE: Are GCMs obsolete?

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ABSTRACT:

Traditional general circulation models, or GCMs -- i.e. 3D dynamical models with vertical "columns" containing unresolved terms represented in equations with tunable parameters -- have been a mainstay of climate research for several decades, and some of the pioneering studies have recently been recognized by a Nobel prize in Physics. Yet, there is considerable debate around their continuing role in the future. Frequently mentioned as limitations of GCMs are: the non-local nature of certain unresolved processes in atmosphere and ocean, which do not fit readily into a GCM's "column" abstraction for unresolved scales; the "structural" uncertainty across models with different representations of unresolved scales; and the fact that the models are tuned to reproduce certain aspects of the observed Earth. It is now often contended that nothing short of resolving finer-scale motions, coupled with assimilation of present-day observations to control model biases, will in fact address these shortcomings, and that a future generation of models -- including what are sometimes referred to as "digital twins" -- will address these issues through substantially higher resolution. At the same time, models used in service of decision-making and policy, including the recently concluded IPCC AR6, rely on emulators allowing of rapid exploration of multiple future scenarios through the use of statistical techniques connecting forcings to outcomes, and for the correction of biases. Furthermore, it is noted that models pegged to present-day climate do not do a good job of representing the climate fluctuations of the past, including past warm climates that may hold lessons for the climate emergency.

In this talk, I argue that the sense that GCMs may be obsolescent comes from these conflicting demands: very high resolution for some key processes, which restrict the ability to explore and quantify uncertainties and study low-frequency variability; the need to explore many counterfactual scenarios for constructing climate policy, which cannot be guided simply by present-day observations; the long simulation times needed to understand prior episodes of abrupt climate change and global warming. We present potential approaches founded on a renewed emphasis to mathematical methods of calibration and dimensionality reduction, using the GCM's structure to connect twins to emulators to long-running models of the Earth's past and future.

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