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Modeling Systems in the post-Dennard era

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Conventional computational hardware has reached some physical limits: the phenomenon known as 'Dennard scaling' gave rise to Moore's Law, and many cycles of exponential growth in computing capacity. The consequence is that we now anticipate a computing future of increased concurrency and slower arithmetic. Earth system models, which are weak-scaling and memory-bandwidth-bound, face a particular challenge given their complexity in physical-chemical-biological space, to which mapping single algorithms or approaches is not possible. A particular aspect of such 'multi-scale multi-physics' models that is under-appreciated is that they are built using a combination of local process-level and global system-level observational constraints, for which the calibration process itself remains a substantial computational challenge. In this talk, we examine approaches to Earth system modeling in the post-Dennard era. The possibilities include following the industry trend toward machine learning and build models that learn; stochastic methods and emulators for fast exploration of uncertainty; using fewer bits of precision, among others. The talk will present ideas and challenges and the future of Earth system models as we prepare for a post-Dennard future.