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An approach to secure weather and climate models against hardware faults

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Enabling Earth System models to run efficiently on future supercomputers is a serious challenge for model development. Many publications study efficient parallelisation to allow better scaling of performance on an increasing number of computing cores. However, one of the most alarming threats for weather and climate predictions on future high performance computing architectures is widely ignored: the presence of hardware faults that will frequently hit large applications as we approach exascale supercomputing. Changes in the structure of weather and climate models that would allow them to be resilient against hardware faults are hardly discussed in the model development community.

We present an approach to secure the dynamical core of weather and climate models against hardware faults using a backup system that stores coarse resolution copies of prognostic variables. Frequent checks of the model fields on the backup grid allow the detection of severe hardware faults, and prognostic variables that are changed by hardware faults on the model grid can be restored from the backup grid to continue model simulations with no significant delay.

To justify the approach, we perform simulations with a C-grid shallow water model in the presence of frequent hardware faults. As long as the backup system is used, simulations do not crash and a high level of model quality can be maintained. The overhead due to the backup system is reasonable and additional storage requirements are small. Runtime is increased by only 13% for the shallow water model.