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A new ensemble-based statistical methodology to verify changes in weather and climate models

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Since their first operational application in the 1950s, atmospheric numerical models have become essential tools in weather and climate prediction. As such, they are a constant subject to changes, thanks to advances in computer systems, numerical methods, and the ever increasing knowledge about the atmosphere of Earth. Many of the changes in today's models relate to seemingly unsuspicious modifications, associated with minor code rearrangements, changes in hardware infrastructure, or software upgrades. Such changes are meant to preserve the model formulation, yet the verification of such changes is challenged by the chaotic nature of our atmosphere - any small change, even rounding errors, can have a big impact on individual simulations. Overall this represents a serious challenge to a consistent model development and maintenance framework.

Here we propose a new methodology for quantifying and verifying the impacts of minor atmospheric model changes, or its underlying hardware/software system, by using ensemble simulations in combination with a statistical hypothesis test. The methodology can assess effects of model changes on almost any output variable over time, and can also be used with different hypothesis tests.

We present first applications of the methodology with the regional weather and climate model COSMO. The changes considered include a major system upgrade of the supercomputer used, the change from double to single precision floating-point representation, changes in the update frequency of the lateral boundary conditions, and tiny changes to selected model parameters. While providing very robust results, the methodology also shows a large sensitivity to more significant model changes, making it a good candidate for an automated tool to guarantee model consistency in the development cycle.