For how long can we predict the weather? – Insights into atmospheric predictability from global convection-allowing simulations

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A tremendous increase in computing power has facilitated the advent of global convection-resolving numerical weather prediction (NWP) models. Although this technological breakthrough allows for the seamless prediction of weather from local to global scales, the predictability of multiscale weather phenomena in these models is not very well known. To address this issue, we conducted a global high-resolution (4-km) predictability experiment using the Model for Prediction Across Scales (MPAS). The goals of this experiment are to investigate error growth from convective to planetary scales and to quantify the intrinsic, scale-dependent predictability limits of atmospheric motions. The globally uniform resolution of 4 km allows for the explicit treatment of organized deep moist convection, alleviating grave limitations of previous predictability studies that either used high-resolution limited-area models or global simulations with coarser grids and cumulus parameterization. Error growth is analyzed within the context of an "identical twin" experiment setup: the error is defined as the difference between a 20-day long "nature run" and a simulation that was perturbed with small-amplitude noise, but is otherwise identical. It is found that in convectively active regions, errors grow by several orders of magnitude within the first 24 h ("super-exponential growth"). The errors then spread to larger scales and begin a phase of exponential growth after 2-3 days when contaminating the baroclinic zones. After ∼16 days, the globally averaged error saturates—suggesting that the intrinsic limit of atmospheric predictability (in a general sense) is about two weeks, which is in line with earlier estimates. However, error growth rates differ between the tropics and mid-latitudes as well as between the troposphere and stratosphere, highlighting that atmospheric predictability is a complex problem. The comparatively slower error growth in the tropics and in the stratosphere indicates that certain weather phenomena could potentially have longer predictability than currently thought.