

Chaotic divergence in a whole-atmosphere climate model

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It has been well established that the atmosphere is chaotic by nature and thus has a finite limit of predictability. The chaotic divergence of initial conditions and the predictability are herein explored in the context of the whole atmosphere (from the ground to the thermosphere) using the NCAR Whole Atmosphere Community Climate Model (WACCM). From ensemble WACCM simulations, it is found that the growth of differences in initial conditions becomes apparent first in the upper atmosphere and progresses downward. The growth rates, measured by Lyapunov exponent, change in various atmospheric regions and with seasons, and correspond closely with the strength of planetary waves. For example, the growth rates are largest in the northern and southern mesosphere and lower thermosphere and northern stratosphere, and smallest in the southern stratosphere in December, January and February. The growth rates, on the other hand, are not sensitive to the altitudes where the small differences are introduced in the initial conditions or the physical nature of the differences. Furthermore, the growth rates are significantly reduced if the lower atmosphere is regularly reinitialized, and the reduction depends on the frequency and the altitude range of the re-initialization. The implications for the feedback interactions between the lower and upper atmosphere will be discussed.