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Properties of perturbations obtained by ensemble simulations of a relatively high-resolution atmospheric general circulation model

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Numerical experiments of the breeding of growing modes (BGM) are performed with an atmospheric general circulation model (AGCM), called AFES (AGCM for the Earth simulator; Ohfuchi et al., 2004) with a spatial resolution of T159/L48 (80-km horizontal resolution and 48 vertical levels), by changing the value of two BGM parameters, the time interval of breeding cycle and the rescaling size of growing mode at breeding cycle. The control run of the BGM experiments is a three month hindcast integration of the AGCM under the observed sea surface temperature and sea ice distributions from 1 January 2006, and the growing modes are bred around the control run for one month from 1 March. The exponential growth rate of the first growing mode, namely the first Lyapunov exponent, estimated from the BGM experiments shows a tendency to increase with shorter time interval and smaller rescaling size. The first growing mode with the largest growth rate of 0.8 (1/day) that is obtained in the case of the shortest time interval and the smallest rescaling size in the BGM experiments performed in this study has a large moist energy in the tropical lower troposphere, which is considered to be related to the convective instability. The first growing mode with smaller growth rate of 3 (1/day) that is obtained in the case of the largest rescaling size has a large kinetic and thermal energy in the extra-tropical upper troposphere, which is considered to be related to the baroclinic instability. These results imply that the rapidly growing local mode, such as convective instability, has a limitation on how much energy it stores, and that it is to be saturated in the perturbation bred with a larger energy, resulting in the dominance of larger scale instability mode that is less unstable than the local instability mode but can store more energy.
Another BGM experiment is performed, where a control run is nudged to the analysis states provided by the Japan Meteorological Agency and ninety-nine perturbations are bred along the control run through the process of globally orthogonalizing and rescaling every 12 hours. Estimated ninety-nine Lyapunov exponents are all positive and their doubling times are form 1.5 to 2.5 days. The BGM perturbations have large amplitudes in the extratropics, which seem to grow in the locally unstable areas induced by the development of mid-latitude depressions. The dominant spatial scales of the BGM perturbations have a tendency to decrease with the mode number.