A Scale Interaction Study on East Asian Cyclogenesis Using a General Circulation Model with an Interactively Nested Regional Model

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1. Introduction

Conventional one-way dynamical downscaling using a regional atmospheric model (RAM) has been developed to obtain much finer information on a particular region. One naturally expects that a part of results in the dynamical downscaling, even if it gives us a much better simulation of something than the general circulation model (GCM) integration, may have a potential to reduce GCM biases. Such a partial high-resolution model helps us examine the effect of local high resolution impact. For this we need a system of two-way nesting (TWN), where GCM and RAM simultaneously run and GCM permits the inclusion of the nested RAM results in the nested domain. We develop TWN based on MIROC and JMA/MRI non-hydrostatic model and will focus on the partial high-resolution effect, while Lorenz and Jacob (2005) was only one publication where TWN successfully reduced GCM biases.

The target of the study is to investigate the high-resolution effect around Northeast Asia and Western North Pacific in winter. Asian mountains are very complex and include a various scale of length and height. GCM (here T42 horizontal resolution) only captures planetary-scale feature, while RAM (here 40-km horizontal mesh size) can take valley, basin, peninsula, and islands in China, Korea, and Japan (not shown). TWN can investigate each of the effect of sub-synoptic topography resolution or the effect of sub-synoptic eddies that only higher-resolution model can simulate. All experiments with 10 ensembles for winter were performed. We should note that there are different GCM and RAM outputs in any experiments.

2. Results

We first gave the RAM topography as smooth as GCM resolution and only extract the effect of sub-synoptic scale eddies that only RAM may capture. In the comparison of RAM and GCM in the conventional dynamical downscaling context, we clearly found more synoptic-scale variance in the nested area. Comparing the 2-way and 1-way experiments, we found whether the effect can extend out of the nested

domain or not. The comparison reveals that the effect of sub-synoptic scale eddies in the nested area only confines the nested area and do not show any global pattern with a statistical significance. No significant pattern was found in the mean geopotential field.

We next include the effect of high-resolution topography in Northeast Asia. Comparing the 1-way RAM outputs in the different RAM topography, it was found that the fine topography forced the cyclonic circulation around the nested region. The local circulation can be propagated out to the nested region, and there is a significant global pattern in the Northern Hemisphere. Hence the sub-synoptic scale topography in Northeast Asia impacts not only local but also global circulation.

3. Discussion

TWN is thought to be posed as one of the partial high-resolution GCM strategy. The strategy may have two purposes: knowing much more information on a particular domain with finer temporal and spatial resolution and knowing much more physics working in a model grid or a model parameterization. A variable-grid GCM is fit for the former purpose, while the super-parameterization GCM is reasonable for the latter purpose. TWN is an intermediate method between the high-resolution purpose and the precise physics purpose.

See Inatu and Kimoto (2009) for more details.

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