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Some lessons and thoughts from development of an old-fashioned high-resolution atmospheric general circulation model

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Some high-resolution simulations with a conventional atmospheric general circulation model (AGCM) were conducted right after the first Earth Simulator started operating in the spring of 2002. More simulations with various resolutions followed. The AGCM in this study, AFES (Agcm For the Earth Simulator), is a primitive equation spectral transform method model with a cumulus convection parameterization. In this presentation, some findings from comparisons between high and low-resolution simulations, and some future perspectives of old-fashioned AGCMs will be discussed.

One obvious advantage of increasing resolution is capability of resolving the fine structures of topography and atmospheric flow. By increasing resolution from T39 (about 320 km horizontal grid interval) to T79 (160 km), to T159 (80 km) to T319 (40 km), topographic precipitation over Japan becomes increasingly realistic. This feature is necessary for climate and weather studies involving both global and local aspects.

In order to resolve submesoscale (about 100 km horizontal scale) atmospheric circulation, about 10-km grid interval is necessary. Comparing T1279 (10 km) simulations with T319 ones, it is found that, for example, the intensity of heavy rain associated with Baiu front and the central pressure of typhoon become more realistic. These realistic submesoscale phenomena should have impact on larger-sale flow through dynamics and thermodynamics.

An interesting finding by increasing horizontal resolution of a conventional AGCM is that some cumulus convection parameterizations, such as Arakawa-Schubert type scheme, gradually stop producing precipitation, while some others, such as Emanuel type, do not. With the former, the grid condensation increases with the model resolution to compensate. Which characteristics are more desirable is arguable but it is an important feature one has to consider when developing a high-resolution conventional AGCM.

Many may think that conventional primitive equation spectral transform AGCMs, such as AFES, have no future. Developing globally homogeneous nonhydrostatic cloud resolving grid AGCMs is obviously a straightforward direction for the future. However these models will be very expensive for many users for a while, perhaps for the next some decades. On the other hand, old-fashioned AGCMs with a grid interval of 20-100 km will remain to be accurate and efficient tools for many users for many years to come. Also by coupling with a fine-resolution regional nonhydrostatic model, a conventional AGCM may overcome its limitation for use in climate and weather studies in the future.