Characteristics of AGCM20 Precipitation Output Comparing with AMeDAS Observation

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1. Introduction

In 2007, Japan’s Ministry of Education, Culture, Sports, Science, and Technology (MEXT) launched the Innovative Program of Climate Change Projection for the 21st Century (Kakushin21), and have developed a super-high-resolution atmospheric model having 20-km spatial and 1-hour temporal resolution (hereafter AGCM20). The AGCM20 provides two terms of future projection run output based on the A1B climate change scenario, which are near-future term (2015~2039) and future term (2075~2099). The controlled run using an observed sea surface temperature (SST) provides the present term (1979~2003) atmospheric data1), 2), 3). Here, the controlled simulation output was evaluated using the AMeDAS observed precipitation data to check the reproducibility of the model.

2. Evaluating the AGCM20 precipitation output

The 25 years of controlled run output of AGMC20 was evaluated using the AMeDAS observation data. For a reasonable comparison, the point-gauged AMeDAS data was converted into the 20-km grid-based spatially averaged data as the AGCM20 output format. Inverse-distance weighting factor method was adopted for the AMeDAS data conversion.

2.1 Annual mean precipitation

First, annual mean precipitation was estimated from the converted AMeDAS observation data and the AGCM20 output data. Spatial distribution pattern of the annual mean precipitation also shows considerably good match between the AGCM20 output and the AMeDAS observation. Winter precipitation such as heavy snowfall in Hokuriku mountainous area along the northern seashore of Kanto and Tohoku region is showing successful reproducibility. Summer heavy rainfall in Kyushu, Shikoku and Kansai region, which is mostly due to frontal rain-band and Typhoon, is also well presented in the model output.

However, it is noticeable that the clear spatial pattern of the observed precipitation is presented in somewhat smoothen way in the AGCM20 precipitation output. It is mainly because of topographic information in the AGCM20, which also has 20-km spatially averaged elevation values. The 20-km resolution topographic data has rather flattened shape comparing to the original topography. Even though there is several physical parameterization schemes are applied in the AGCM20 to properly consider the influence of flattened sub-grid scale topographic data1), the performance of the atmospheric model still shows some limitations.

To understand the model performance on seasonal variation, monthly mean precipitation was estimated, and correlations of each month’s spatial distribution pattern were calculated (Fig. 1). Except the late summer season, from July to October, the AGCM20 precipitation output shows very high performance level. The reason of the low spatial pattern matches in the late summer season is due to difficulty in the simulation of unstable atmospheric conditions in summer season.

2.2 Extreme events

Reproducibility of daily and hourly maximum precipitation of each grid was evaluated by checking 100 maximum precipitation of the AGCM20 controlled run output and the AMeDAS observed one within the same period. The 100 maximum values of daily and hourly precipitation were selected by
choosing 4 maximum values of each year during 25 years. As shown in Fig. 2, a regression coefficient was calculated using one pair of 100 maximum values on each grid. Desirable reproducibility on the extreme value will be showing 1.0 regression coefficient. If it is less than 1.0, it means that the AGCM20 output has generally underestimated extreme values compared to the observation and vice versa. Regression coefficient is depending on the choosing sample numbers however, this simple evaluation method provides direct and clear understanding on the overall model performance related to extreme values.

According to the regression coefficients of each grid over Japan Island, it is very clear that the AGCM20 output has underestimated daily and hourly maximum in most part of Japan. The same characteristics on the controlled run output of the AGCM20 was also found in the analysis on the Tone River Basin.4) using the precipitation output data over the Tone River basin. This underestimation on the extreme precipitation values reveals that the 20-km spatial resolution might be still insufficient to simulate sophisticated sub-grid scale orographic rainfall.

3. Characteristics of the AGCM20 output

Orographic effect and elevation dependency of precipitation is well known phenomena, especially in mountainous area of Japan. However, the AGCM20 precipitation output shows a limitation to simulate clear orographic effects mainly due to its 20-km resolution topographic data, and the AGCM20 precipitation output shows low dependency on topographic elevation, as shown in Fig. 3. The figure shows mean rainfall amount during summer season (July–September) in Kyushu, corresponding to the elevation information of 20-km grid in the AGCM20. While the AMeDAS observed rainfall amount shows clear dependency on elevation (even though it is spatially averaged within the 20-km grid), the AGCM20 output was not able to show reasonable elevation dependency.

References

Keywords: AGCM20, Precipitation, Reproducibility