Does a RCM add value to its driving parent GCM simulated extreme precipitations linked to temperature over Japan?

*Sridhara Nayak[1], KOJI DAIRAKU[1], Noriko N. Ishizaki[1]

1. National Research Institute for Earth Science and Disaster Resilience

The frequency of extreme precipitation events are now of serious concern which are expected to increase in a warmer climate (IPCC 2012), because atmosphere can hold more water vapor in warmer air temperature according to the principle of Clausius-Clapeyron (CC) relationship (~7% per degree rise in temperature). As a consequence, more extreme precipitation events may occur under warmer climate and may impact on agriculture, the economy, the human health and also animal habitats. Simulations by Regional Climate Models (RCMs) are often used for impact assessments because they are presumed to simulate the regional climate, especially extreme events, better than their driving General Circulation Models (GCMs). Thus there is a growing debate on the added value by RCMs to their driving GCMs over various regions. Our study explores whether a RCM reproduces the extreme precipitation linked to temperature over Japan better than its driving parent GCM by analyzing 330 ensemble experiments [140 experiments with NHRCM at 20km (50 experiments for current climate: 1951-2010 & 90 experiments for future climate with 4˚C warming: 2051-2110) and 190 experiments with the MRI-AGCM at 60km (100 experiments for current climate & 90 experiments for future climate)]. We find that the extreme precipitations linked to temperature basically follow the CC relationship over Japan for a certain temperature (for instance ~24˚C) and a further increase of temperature decreases the precipitation intensity. These results are consistent with AMEDAS station observations and the past research conducted over various regions. All the individual ensemble experiment results of RCM and GCM show a similar qualitative behavior. Further we find that RCM ensemble experiments overestimated the extreme precipitation intensities for the temperatures above 24˚C, while GCM underestimated the same particularly at the peaks (18-26˚C). However, for the temperatures between 20-24˚C RCM added ~35% to the extreme precipitations linked to temperature over Japan compared to GCM ensemble experiments. The overestimation of precipitation intensity at higher temperatures simulated by RCM is associated with strong vertical velocity (i.e. upward motion of air) and much availability of water vapor, while the underestimation of the same by the GCM is associated with weak vertical velocity and less availability of water vapor compared to the RCM. This may lead to contribute the added value by RCM over GCM. Additions to this, the zonal and meridional winds in RCM are noticed stronger compared to that in GCM at higher temperatures. This may bring more moisture from the ocean towards Japan land and cause more precipitation in RCM. Furthermore, all ensemble experiment results in RCM and GCM show a significant increase of precipitation intensities (~30mm/d in RCM and ~15mm/d in GCM) for the temperatures roughly above 24-26˚C under future climate scenario over Japan and RCM added ~15mm/d amount of precipitation intensity to this future change. This increase of extreme precipitation intensities at higher temperature may be due to the increase in temperature under future climate (4˚C warming). The added value of RCM will be further discussed through the column-averaged total kinetic energy and column integrated moisture flux convergence by spectral analysis.

Keywords: Extreme precipitations, Clausius-Clapeyron relationship, Ensemble experiments, Added value, Spectral analysis

