C211

# Vertical structure of the dependence of water vapor on temperature over Japan

○Sridhara NAYAK, Tetsuya TAKEMI

**Introduction:**

The intensities of heavy rainfall events are expected to increase as climate warms, because the atmosphere can hold more water vapor at a rate of ~7% per 1 °C rise in temperature according to the Clausius-Clapeyron (CC) equation (Trenberth et al. 2003). Water vapor in the atmosphere plays major role for such events and most of the studies have focused on the scaling of water vapor with respect to temperature either at surface or at column average (Nayak et al., 2018; Nayak and Takemi, 2019). However, the vertical characteristics of water vapor with respect to temperature is not well explored. In this study, the scaling of water vapor in terms of specific humidity and saturation vapor pressure with respect to the temperature at different atmospheric levels to understand their variation over different region of Japan (Fig. 1) and efficacy at each atmospheric level in causing heavy rainfall.

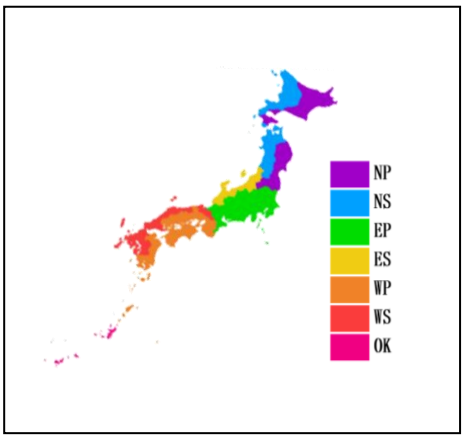


Fig 1: Seven regions of Japan.

**Data and Methods:**

For this, we analyzed d4PDF dataset (database for Policy Decision making for Future climate change) at 20 km grid resolution in two climate periods (1951-2010 and 2051-2110 with 4K warming) over different regions of Japan. We stratified the heavy rainfall events from each individual ensemble member in different temperature bins of 1°C interval and computed 99th percentile of precipitation in each temperature bin.

**Preliminary Results:**

**Vertical variation of the water vapor with respect to Temperature:**

Fig. 2 presents the relationship between specific humidity and temperature at different atmospheric pressure levels over different region of Japan.

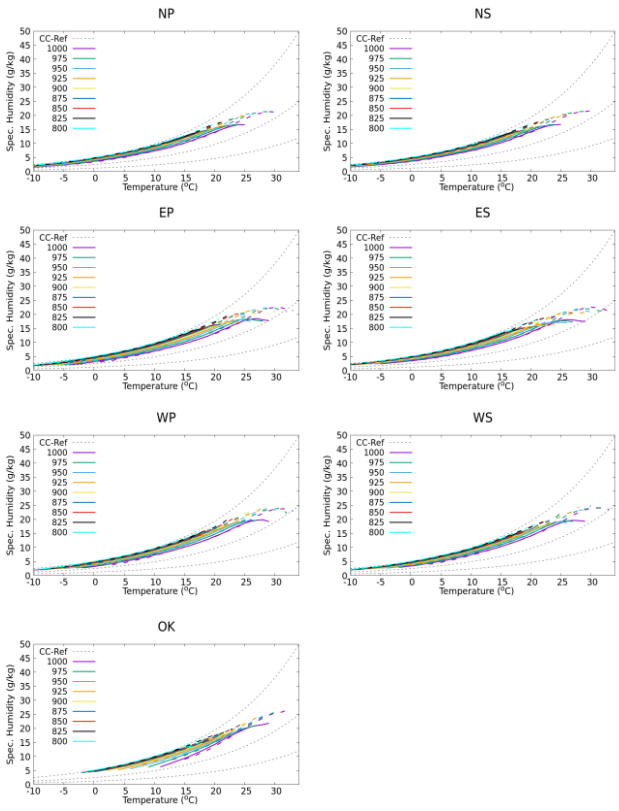


Fig 2: Specific humidity as a function of temperature at different atmospheric pressure levels.

We analyzed the relationship from 17 different pressure levels, but for clarity we have focused on 9 different pressure levels. We find that the specific humidity follows the CC relationship up to certain temperature at all atmospheric levels. At lower levels (below 850 hPa), the rate of change of specific humidity varies within the range of 6.9-7.5%/°C in present climate, while at 500 hPa the rate over southern Japan corresponds to 5.2%/°C and that over other regions shows within 6.9-8.9%/°C (Fig. 3).

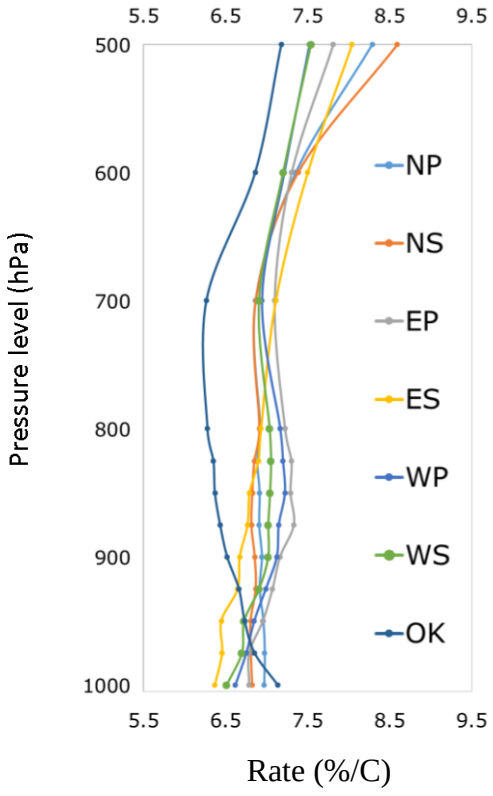


Fig 3: Rate of change of specific humidity with respect to temperature in present climate.

These rates in future climate show slightly weaker (Figures are not shown here), but the magnitude of the specific humidity with respect to temperature show increased values at all the levels and prolonged to another 4°C which may fuel the rainfall events more and ultimately would bring much intensified heavy rainfall events in future warming climate.

**Summary:**

We explored the scaling of water vapor in terms of specific humidity with respect to the temperature at different atmospheric levels to understand their variation and efficacy at each atmospheric level in causing heavy rainfall. We find that the specific humidity follows the CC relationship up to certain temperature at all atmospheric levels. At lower levels (below 850 hPa), the rate of change of specific humidity varies within the range of 6.9-7.5%/°C in present climate, while at 500 hPa the rate over southern Japan corresponds to 5.2%/°C and that over other regions shows within 6.9-8.9%/°C. We would like to extend the discuss on this issue particularly for future climate and see the impact of global warming on this relationship.

Acknowledgments:

This study is supported by the TOUGOU Program, funded by the Ministry of Education, Culture, Sports, Science, and Technology, Government of Japan.

References:

Nayak S. and Tetsuya T. (2019). Dependence of extreme precipitable water events on temperature. Atmósfera, 32(2), 159-165, doi: 10.20937/ATM.2019.32.02.06

Nayak S, Dairaku K, Takayabu I, Suzuku-Parker A and Ishizaki NN. (2017). Extreme precipitation linked to temperature over Japan: Current evaluation and projected changes with multi-model ensemble downscaling. Climate Dynamics, 51, 4385-4401 (2018), doi: 10.1007/s00382-017-3866-8

Trenberth K, Dai A, Rasmussen R, Parsons D (2003) The changing character of precipitation. Bull Am Meteorol Soc 84(9):1205–1217