Roles of temperature and moisture in the recent Arctic relative humidity changes

Masakazu Yoshimori and Masatake E. Hori
Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan

Current Arctic climate change may be characterized by enhanced warming and moistening in the lower troposphere. How the warming and moistening are maintained by atmospheric processes has been studied by various approaches. One such study is Hori and Yoshimori (2023) in which the temperature advection term was decomposed and analyzed in detail. Many other studies investigated the effect of local evaporation and moisture transport from lower latitudes on the Arctic specific humidity change. However, the atmospheric control over the change in relative humidity (RH) has been rarely investigated.

The first-order, large-scale response of the RH to the global warming is often described as invariant, meaning that the RH changes little before and after the warming. This does not, however, likely hold on the regional basis. As the RH, determined by temperature and specific humidity, is strongly linked to the cloud formation, knowledge on the atmospheric control over the change in RH would provide insight into the processes affecting the Arctic climate change.

We derived the RH tendency equations by combining temperature and specific humidity tendency equations. The temperature and specific humidity tendency equations are further decomposed into the terms related to horizontal advection, vertical advection, and non-advective terms. Together, the derived formulation allows us to analyze how the individual processes contributing to temperature and specific humidity changes play roles in altering the RH. We applied this method to the recent 40-year reanalysis data.

The results suggest that RH at 900 hPa increases over the regions where sea ice has retreated in autumn and winter. The RH balance is achieved by the RH increase due to upward turbulent moisture flux and cooling due to sub-monthly eddies, and the decrease due to upward turbulent sensible heat flux and drying due to sub-monthly eddies. It is important to point out that this method has a large potential of analyzing daily-scale RH variations during extreme events such as heat and moisture intrusions.

Reference

Hori, M. E. and M. Yoshimori (2023): Assessment of the changing role of lower tropospheric temperature advection under Arctic amplification using a large ensemble climate simulation dataset. Clim. Dyn., 61, 2355-2370.