Dynamical UTLS control on summertime precipitation from weather to climate

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Jet stream is known to affect precipitation, but its dynamics has not been fully explored. Here, we present our studies on the role of jet and synoptic disturbances in the extratropical upper troposphere/lower stratosphere (UTLS) in summertime precipitation mainly over East Asia and the Northwestern Pacific.

In the UTLS, summertime subtropical jet axis tends to lie near the contours of potential temperature being ~350 K and potential vorticity being ~2 PVU, which roughly divides the isentropic surface into tropospheric and stratospheric portions. Using satellite precipitation and reanalysis data, it is shown that daily precipitation over East Asia and the Northwestern Pacific is significantly enhanced along (to the south of) these contours, which is quantified by composite analyses. A novel diagnosis of dynamical forcing based on quasi-geostrophic potential enstrophy and a trajectory analysis reveal that UTLS synoptic disturbances force near-surface winds in favor of moisture supply to these precipitation belts. A Q-vector analysis shows dynamical induction of upwelling to create the precipitation enhancement. The observed relation is further quantified in terms of the UTLS disturbance phases. As expected, precipitation is especially enhanced to the east of upper-level troughs, but the enhancement along the contours occurs at all phases, even to the west of the troughs. We devised idealized quasi-geostrophic potential vorticity configurations to examine the forcing of upwelling and solved them incorporating latent heating effects. It is shown that low-level flows, which is affected by the upper-level disturbances, help create the precipitation enhancement. The idealized model is also useful to explain climatological summertime subtropical precipitation zones. These studies have been published in two papers.[1,2] Also, precipitation characteristic differences across the subtropical jet are elucidated.[3]

We have conducted analyses using coupled-model outputs in the CMIP5 database. The above-mentioned relation between jet and precipitation over East Asia and the Northwestern Pacific is reproduced in the daily outputs of the models. The relation is also found in the monthly mean data, so the inter-annual variation of the precipitation area of the East Asian summer monsoon (especially, the Meiyu-Baiu rain band) tends to co-vary with monthly-mean subtropical jet axis. This correlation is also seen in the inter-model differences in changes from the present to future (near the end of the 21st century) climate. Possible effects of inter-model sea-surface temperature differences are suggested.

Key words: Subtropical jet, Precipitation, East Asian summer monsoon, Piecewise PV inversion, CMIP5

References

1: Horinouchi, 2014: *J. Meteor. Soc. Japan*, **92**, 519-541.

2: Horinouchi and Hayashi, 2017: *J. Atmos. Sci.*, **74**, 1233-1247.

3: Yokoyama,, Takayasu, Horinouchi, 2017: *J. Climate*, **30**, 8127-8147.