Distinction between precipitation related to a front and that to an interplay of an atmospheric river and a cut-off low

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A rainfall event occurred in Hiroshima, Japan on 19 August 2014, which recorded over 200 mm accumulated rainfall during three hours and caused a disastrous flood. Hirota et al. (2016, MWR) showed that the main factor of this flood event is an interplay of two independent phenomena in the upper troposphere; an atmospheric river (AR) which moisturizes free troposphere and an upper tropospheric cut off low (COL) which induces dynamical ascent and destabilizes the atmosphere. Moreover, Tsuji and Takayabu (AGU 2017 fall meeting) showed from a statistical analysis that such an interplay generally enhance precipitation at the same positional relationship among AR, COL, and enhanced precipitation area as the Hiroshima case. However, since ARs often emerge with a cold front or a stationary front, it is necessary to distinguish precipitation by the interplay from that by the fronts. In this study, we investigate the sensitivity of distance between AR and COL to the location of enhanced precipitation area.

Precipitation data are obtained from hourly Global Satellite Mapping of Precipitation (GSMaP) data (0.1 degree grid). Atmospheric rivers and COLs are detected using six-hourly JRA55 (1.25 degree grid) precipitable water and potential vorticity on 350 K isentropic surface, respectively. Then, to evaluate the effect of coexistence of AR and COL upon precipitation enhancement, COLs are classified into two categories named as “AR category” and “non-AR category” by the distance between AR and COL. To investigate the sensitivity of the distance, we set criteria of the distance to 4˚, 5˚, 6˚, and 7˚. The analyses are conducted over the western North Pacific region (100E-160W, 0-60N), for the period from March 2000 to February 2013.

Comparing precipitation in the AR category with that in the non-AR category, we can find regions where precipitation in the AR category is significantly enhanced at the northwest and to the north of COL. The positional relationship among AR, COL, and the enhanced precipitation region at the northwest of COL, which is very similar to that of the Hiroshima case, is confirmed even if the criterion of the distance between AR and COL is changed. In contrast, as the distance between AR and COL becomes large, the enhanced precipitation regions to the north of COL move away northward. Such difference indicates that there are two separate mechanisms to produce precipitation at the northwest of COL and that to the north of COL. Namely, the enhanced precipitation region at the northwest of COL is associated with the interplay of an AR and a COL, while that to the north of COL is associated only with an AR.

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