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A Numerical Simulation of Vortex Development during the 1992 East Asian Summer Monsoon Onset Using the Navy's Regional Model

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Abstract

Significant rainfall of the East Asian summer monsoon is produced by low-level disturbances moving eastward in the vicinity of the Yangtze River valley. Many of these disturbances appeared to originate from stationary vortices east of the Plateau of Tibet. Previous studies found latent heating to be the dominant energy source for the development of these vortices during mature monsoon. This work uses the navy's regional forecast model to study the development of a disturbance system during 15-17 May 1992, around the beginning of the monsoon season. The system was characterized by a preexisting stationary vortex in the Sichuan basin and the subsequent development of another vortex that propagated eastward along a Mei-yu front that moved into the Yangtze River valley.

The numerical simulation, in conjunction with an analysis of the ECMWF data using a potential vorticity inversion, indicates that during the first 24 h the stationary vortex was maintained by terrain effects. On 16 May, the forcings of an upper-level jet and a shortwave 500-hPa trough, along with latent heat release that may have been triggered by the upper forcings, intensified this vortex temporarily. Afterward, the vortex continued to develop by a low-level front-terrain interaction in which the frontal secondary circulation turned the basin-scale east-west overturning counterclockwise while the low-level vertical easterly shear was enhanced. This configuration tilted the vertical shear into a source of cyclonic vorticity. The upper-level forcings and the associated latent heat release also spun up the eastward propagating vortex, whose subsequent intensification was mainly the result of latent heat release along the front.

Sensitivity experiments indicate that the terrain effect is crucial for the vortex development within the Sichuan basin. In addition, forcing of the cold air southward by the terrain, and enhancement of the secondary frontal circulation by condensation heating were required for the low-level front to move sufficiently southward into the Yangtze River region to produce the development of the propagating disturbance. If the front stayed in a more northerly position, the disturbance would move eastward too fast to accumulate the moisture for heavy rainfall and latent heat release.

Because of the close proximity of the two vortices and the sequence of development, it may appear in the weather maps that the second vortex was originated from the first. However, the present results indicate that the propagating disturbance was a separate development rather than an eastward migration or a split of the stationary vortex in the Sichuan basin.