Stationary and transient asymmetric features in tropical cyclone eye, wavenumber-one instability, and eye-shape maintenance: Case study for Typhoon Haishen (2020) with rapid-scan high-resolution atmospheric motion vectors

Takeshi Horinouchi,[a] Satoki Tsujino,[b] Masahiro Hayashi,[b] Udai Shimada,[b] Wataru Yanase,[b] Akiyoshi Wada,[b] Hironori Fudeyasu,[c] and Hiroyuki Yamada [d]

[a] *Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Hokkaido, Japan*

[b] *Meteorological Research Institute, Tsukuba, Ibaraki, Japan*

[c] *Yokohama National University, Yokohama, Kanagawa, Japan*

[d] *University of Ryukuus, Naha, Okinawa, Japan*

ABSTRACT

Dynamics of low-level flows in the eye of Typhoon Haishen (2020) in its late phase of intensification are investigated with a special observation of the Himawari-8 satellite conducted every 30 seconds. This is accomplished by deriving atmospheric motion vectors at an unprecedentedly high spatiotemporal resolution by tracking boundary-layer clouds across five consecutive visible-light reflectivity. The overall low-level circulation center was situated several kilometers away from the storm center defined in terms of the inner edge of the lower part of eyewall clouds. This shift is to the rearward of the typhoon translation, as has been proposed with a numerical model of tropical cyclone (TC) boundary layer. Over the analysis period of 10 hours, azimuthal-mean tangential wind around this center was increased at each radius within the eye, and the rotational angular velocity was nearly homogenized. The instantaneous low-level circulation center is found to orbit around the overall circulation center at distances around 5 km. Its orbital angular speed was close to the maximum angular speed of azimuthal-mean tangential winds. This transient disturbance is found to transport angular momentum inward, which explains the tangential wind increase and the angular velocity homogenization in the eye. These features are consistent with an algebraically growing wavenumber-one barotropic instability, whose impact on TC structures has not been explored. It is proposed that this instability might play a major role to maintain nearly circular eyes in developing intense TCs against the development of barotropic instability to make the eyes polygonal.

Keywords: Typhoon; Satellite; Atmospheric dynamics