To address ERA5 limitations, we propose an integrated parametric method for reconstructing TC wind fields, explicitly tailored for global application. The method distinguishes between TC dynamics in open ocean, landfalling, and nearshore regions to capture realistic storm structures effectively.

For TCs in the open ocean with ideal dynamic structure, the reconstructed ERA5 wind field is derived using ERA5 wind data and an idealized wind model specific to oceanic conditions. The idealized model for TC wind radial profile utilizes Willoughby adjustment method (Willoughby and Rahn, 2004), which is approximated using a gradient wind balance based on the Holland model. The gradient wind at radius is given by

, (1)

, (2)

where is the gradient wind at radius , and repesents the latitude of the TC center.

To combine the ERA5 data with the idealized model for TC wind radial profile, a weight coefficient is applied to generate the new wind field. The assimilation equation is expressed as:

, (3)

where is the weight coefficient, and is the TC moving speed, calculated from the IBTrACS dataset ( is set to zero when TC’s MWS is less than 33 m/s). The weight coefficient is defined as

, (4)

, (5)

where is the radial distance, and represents RMW.

Due to the influence of terrain, the idealized model for TC wind radial profile may not accurately represent the dynamic structure of TCs over land, limiting the applicability of the Willoughby adjustment method. To address this, the proportional correction method proposed by Li et al. (2018), which has been validated and shown to minimize the estimate error, is employed to adjust the intensity of the typhoon wind. The correction can be expressed as follows:

. (6)

The corrected wind field is then calculated as

, (7)

where is the MWS calculated from ERA5.

To integrate the methods described above and ensure smooth data transitions without abrupt discontinuities, a weight-based fusion approach is applied to combine the two correction methods. The final wind field is generated through this fusion, with the fusion equation given as follows:

, (8)

where is weight parameter, defined as follows:

, (9)

where is set to 100 km (the global average of ), representing the distance at which the TC’s dynamic structure begins to be influenced by topography.