

# A Global Surface Turbulence Heat Flux Dataset resolving tropical cyclones

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**Abstract.** The Global Surface Turbulence Heat Flux Dataset (GHFD) presents a dataset of surface latent heat flux and sensible heat flux, at spatial resolutions of  $0.25^\circ \times 0.25^\circ$  and available daily from 1993 to 2023. The GHFD is generated using the IBTrACS, OISST, CCMP, Copernicus Marine, and ERA5 datasets, with the wind speed field adjusted to incorporate tropical cyclone (TC) information and using the COARE 3.6 algorithm to conduct the heat flux calculations. The GHFD includes seven meteorological elements at the air-sea interface, including surface latent and sensible heat flux, 2-m specific humidity, sea surface temperature, 2-m air temperature, sea surface salinity and 10-m wind speed. A comparison between GHFD and various flux products (J-OFURO 3, OAFux, ifremerflux) in terms of the fundamental components is conducted with moored observation data, in-situ observation data, and high-resolution simulation data. Results show an improvement of GHFD compared to the other three flux products in resolving TCs. The GHFD dataset in NetCDF format is freely available for download at <https://doi.org/10.57760/sciencedb.24400> (Peng et al., 2025).

## 1 Introduction

Surface turbulence heat flux, in terms of surface latent and sensible heat flux, characterizes the air-sea heat and moisture transport between the atmosphere and ocean (Bourassa et al., 2010; Ma et al., 2015; Roberts et al., 2012). The magnitudes of surface turbulence heat flux are thus central to the energy budget of the Earth system as well as global climate changes (Chou et al., 2003). Tropical cyclones are among the most drastic weather systems that extract large amounts of latent and sensible heat from the ocean into the atmosphere, and disperse it into higher-latitude regions or the land (Mei et al., 2013; Trenberth and Fasullo, 2007). The energy input from the ocean in terms of surface latent and sensible heat flux is the primary energy source of the TC system (Mei et al., 2013; Trenberth and Fasullo, 2007). For the Earth system, the flux transport under TCs is an important component of the global energy cycle (Emanuel, 2001). Thus, accurate knowledge of air-sea flux is crucial for understanding not only TCs themselves but also for global energy transport.

Several heat flux products have been constructed in previous work. They mainly come from three sources: numerical weather prediction (NWP) models, voluntary observing ships (VOSs), and remotely sensed data (Bentamy et al., 2013; Yu et al., 2004). These methods represent a significant improvement over the previous decades through improving heat flux accuracy by optimizing inversion algorithms, assimilating various types of data, or optimizing flux calculation algorithms. Following are some representative datasets: the Japanese Ocean Fluxes data sets with the Use of Remote sensing Observations (J-OFURO

31 3) (Tomita et al., 2019), the Objectively Analysed Air-Sea Fluxes (OAFlux) (Yu and Weller, 2007), the Institut Français pour  
32 la Recherche et l'Exploitation de la Mer (ifremer) (Bentamy et al., 2017; Bentamy et al., 2017), the Hamburg Ocean  
33 Atmosphere Parameters and Fluxes from Satellite Data (HOAPS) (Andersson et al., 2010), a high-resolution satellite-derived  
34 ocean surface flux product (XseaFlux) (Liu et al., 2011), and National Centers Of Environmental Prediction (NCEP) (Kalnay  
35 et al., 1996; Kanamitsu et al., 2002). Even though these datasets have improved the information on surface heat flux, there is  
36 a commonly huge mismatch of flux magnitude under TCs between these global flux datasets and case-based field observations  
37 or high-resolution numerical simulations (Andersen et al., 2013; Song et al., 2021; Xie et al., 2024). Particularly, the flux  
38 magnitude under TC conditions has been substantially undermined by those global gridded flux datasets. This large uncertainty  
39 is because there is a scarcity of in-situ observational data beneath TCs for calculating latent and sensible heat fluxes. Direct  
40 observations using sail drones are also challenging, particularly due to the complex states of the air-sea interface under TC  
41 conditions.

42 To develop an improved surface heat flux product, not only are accurate flux-related surface meteorological variables  
43 important, but it is also critical for a good-quality flux bulk algorithm. At present, the bulk algorithm version 3.6 developed  
44 from the Coupled Ocean-Atmosphere Response Experiment (COARE) algorithm in the Tropical Ocean-Global Atmosphere  
45 (TOGA) program is a state-of-the-art formulation. The COARE has been greatly improved from version 2.5 to version 3.6.  
46 The version 2.5 (Fairall et al., 1996) was published in 1996 and the version 3.0 (Fairall et al., 2003) was published at 2003,  
47 which has been greatly improved from version 2.5 to fit the high wind speed conditions. Version 3.6 is slightly restructured  
48 and built around improvements in the representation of the effects of waves on fluxes compared to COARE 3.5 (Edson et al.,  
49 2013). COARE 3.5 was based on Edson's buoy data and was compared to an extensive database (a total of 16,000 hours of  
50 observations) combining observations from NOAA, WHOI, and U. Miami (Fairall et al., 2011). After several versions of  
51 updates and iterations, the COARE 3.6 can better minimize the errors under TC conditions. However, many flux products still  
52 use the COARE 3.0 algorithm, such as J-OFURO 3, NOAA-CD, and OAFlux.

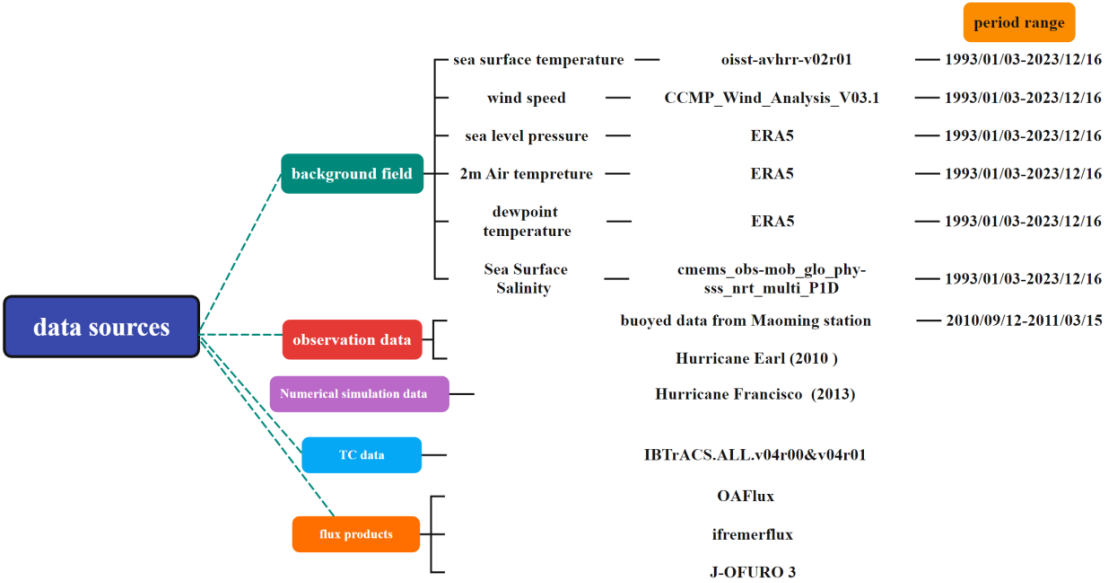
53 In this study, we construct the Global Surface turbulence Heat Flux Dataset (GHFD) on the basis of satellite and reanalysis  
54 data, in combination with the International Best Track Archive for Climate Stewardship (IBTrACS) (Gahtan et al., 2024;  
55 Knapp et al., 2010; Knapp, 2018) best track data and TC-wind data, and the COARE 3.6 algorithm is used to obtain the surface  
56 heat flux.

## 57 **2 Data and methods**

### 58 **2.1 Data**

59 The basic elements used to construct GHFD in this study come from the IBTrACS, OISST, Cross-Calibrated Multi-Platform  
60 (CCMP), and ERA5 datasets. Numerical simulation data of Typhoon Francisco (2013) (Ma, 2020) and observation data  
61 [buoyed data from Maoming station (21.46° N, 111.23° E) and Hurricane Earl (2010)] are used to compare and validate the  
62 accuracy of GHFD with three other heat flux products of J-OFURO 3, OAFlux, and ifremerflux (Figure 1). The sea surface

temperature is derived from the NOAA satellite Optimum Interpolation Sea Surface Temperature (OISST) dataset (Huang et al., 2020). The background wind speed field comes from the CCMP reanalysis data (Mears et al., 2022). The sea level pressure, 2-m air temperature, and 2-m dewpoint temperature are from the European Centre for Medium-Range Weather Forecasts atmospheric reanalysis version 5 (ERA5) dataset (ECMWF, 2024; Hersbach et al., 2020; Hersbach and Al., 2023). The sea surface salinity is from the Copernicus Marine dataset (Droghei et al., 2018). The IBTrACS (Gahtan et al., 2024; Knapp et al., 2010; Knapp, 2018) is used to locate the TC information and construct the wind field from 1993 to 2023. Specifically, we utilize the WMO-standardized 10-minute average maximum wind speed and the radius of maximum wind in IBTrACS dataset, to integrate TC wind speeds into the CCMP dataset.



**Figure 1: Datasets used to create and validate the GHFD product. In particular, five datasets of IBTrACS, OISST, CCMP, Copernicus Marine and ERA5 dataset are used to construct this product. Three variables in terms of sea level pressure, 2-m air temperature, and 2-m dewpoint temperature come from ERA5, the sea surface temperature come from the satellite OISST dataset, sea surface salinity come from Copernicus Marine dataset, and the 10-m wind speed field comes from the TC-wind merged CCMP product. The IBTrACS dataset is used to locate and reconstruct TC wind speed field. The other three flux datasets, observational data and Numerical simulation data are used for comparisons and validations.**

## 2.2 Methods

The accuracy of wind speed is key to the heat flux product, given its linearly proportional relationship. We reconstruct the wind speed field on the basis of the CCMP reanalysis dataset. The reconstruction process is divided into two parts. Firstly, the TC information in the original CCMP dataset is filtered using the approach raised by Vincent et al. (2012). Specifically, within 600 km around each TC point, an 11-day running mean is used to filter out TC signatures. A linear transition is specified between 600 km and 1200 km. Secondly; the TC wind field is reconstructed using the best-track dataset and the wind pattern

85 of Willoughby et al. (2006). By this method, the ramp functions are used to characterize wind patterns both inside and outside  
 86 the radius of maximum wind (Willoughby et al., 2006). Following is the ramp function that facilitates the transition across the  
 87 radius of maximum wind from the inner to outer profiles (Willoughby et al., 2006):

$$88 \quad V_i = V_{max} \left( \frac{r}{R_{max}} \right)^n, \quad (1)$$

$$89 \quad V_o = V_{max} \left[ (1 - A) \exp \left( -\frac{r - R_{max}}{X_1} \right) + A \exp \left( -\frac{r - R_{max}}{X_2} \right) \right], \quad (2)$$

$$90 \quad V(r) = V_i, (0 \leq r \leq R_1), \quad (3)$$

$$91 \quad V(r) = V_i(1 - w) + V_o w, (R_1 \leq r \leq R_2), \quad (4)$$

$$92 \quad V(r) = V_o, (R_2 \leq r), \quad (5)$$

93 The following are the relevant parameters:

$$94 \quad R_{max} = 46.4 \exp(-0.0155 V_{max} + 0.0169 \varphi), \quad (6)$$

$$95 \quad A = 0.0696 + 0.0049 V_{max} - 0.0064 \varphi, (A \geq 0), \quad (7)$$

$$96 \quad n = 0.4067 + 0.0144 V_{max} - 0.0038 \varphi, \quad (8)$$

$$97 \quad w \left( \frac{R_{max} - R_1}{R_2 - R_1} \right) = \frac{\frac{\partial V_i}{\partial r}}{\frac{\partial V_i}{\partial r} - \frac{\partial V_o}{\partial r}} = \frac{n[(1 - A)X_1 + AX_2]}{n[(1 - A)X_1 + AX_2] + R_{max}}, \quad (9)$$

$$98 \quad X_1 = 317.1 - 2.026 V_{max} + 1.915 \varphi, \quad (10)$$

$$99 \quad X_2 = 25, \quad (11)$$

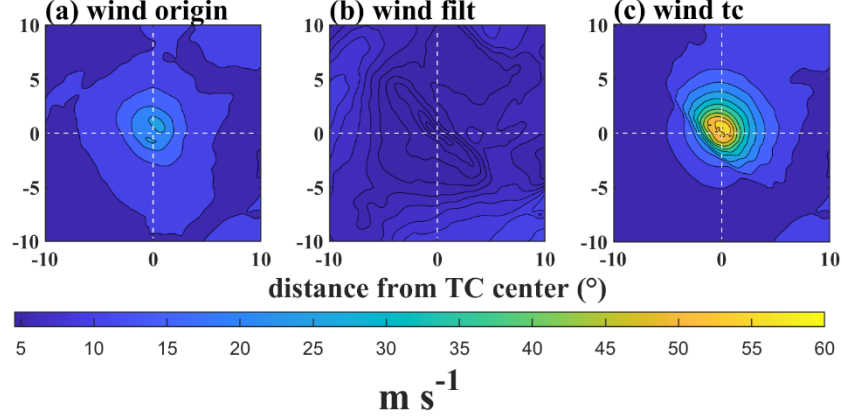
100 where  $r$  is the radial distance from the TC center;  $V$  is the wind velocity as a function of  $r$ ;  $V_i$  and  $V_o$  are the tangential wind  
 101 components in the eye and beyond the transition zone, classified by  $r = R_1$  and  $r = R_2$ ;  $V_{max}$  and  $R_{max}$  are the maximum wind  
 102 and the RMW, respectively;  $X_1$  and  $X_2$  are the exponential decay lengths in the outer vortex;  $A$  is the coefficient representing  
 103 the scale of the exponential function related to  $X_1$  and  $X_2$  [Eq. (3)];  $\varphi$  is the latitude of the TC center and  $n$  is the exponent for  
 104 the power law inside the eye. Noting that when  $r = R_{max}$ ,  $V_i(R_{max}) = V_o(R_{max}) = V_{max}$ .  $w$  is the weighting function, which  
 105 ramps up from 0 to 1 between  $R_1$  and  $R_2$ , expressed in terms of a nondimensional argument  $\xi = (r - R_1)/(R_2 - R_1)$ :

$$106 \quad w(\xi) = 126\xi^5 - 420\xi^6 + 540\xi^7 - 315\xi^8 + 70\xi^9. \quad (12)$$

107 The transition of  $R_2 - R_1$  is specified a priori to be equal to 25 km and  $X_2$  is taken as the most rapid decay length of 25 km by  
 108 Willoughby (1995).

109 Using the Typhoon Francisco (2013) case as an example, Figure 2 shows the original wind speed field from the CCMP,  
 110 the TC-removed wind speed field, and the wind speed field after TC insertion. The maximum wind speed at the center of the

111 Francisco (2013) in the original dataset is  $28.8 \text{ m s}^{-1}$ . But after the adjustment of the wind field, the maximum wind speed of  
 112 Francisco (2013) reaches  $60.2 \text{ m s}^{-1}$ . Compared to the maximal wind magnitude of  $54.0 \text{ m s}^{-1}$  in the IBTrACS best track data,  
 113 the error is reduced from the original  $25.2 \text{ m s}^{-1}$  (46.7%) to  $6.1 \text{ m s}^{-1}$  (11.2%). The notable reduction of error indicates that the  
 114 accuracy of the wind speed field has been improved, thereby improving the accuracy of heat flux at high wind speed conditions.



115  
 116 **Figure 2: Plan views of surface wind speed ( $\text{m s}^{-1}$ ) centered on Typhoon Francisco (20-OCT 2013) for (a) origin CCMP reanalysis**  
 117 **dataset, (b) TC-wind filtered CCMP dataset and (c) IBTrACS TC-wind merged CCMP dataset.**

118 The surface sensible and latent heat flux at the air-sea interface are calculated by the bulk flux algorithm:

$$119 \quad HSI = \rho c_p C_h U_a (T_s - T_a), \text{ and} \quad (13)$$

$$120 \quad HLI = \rho L_v C_q U_a (q_s - q_a), \quad (14)$$

121 where  $\rho$  is the density of the air;  $L_v$  is the latent heat of vaporization,  $c_p$  is the specific heat at constant pressure;  $U$  is the  
 122 horizontal wind speed at 10 m;  $C_h$  and  $C_q$  are surface exchange coefficients of sensible heat and latent heat, respectively;  $q$  is  
 123 the specific humidity;  $T$  is the temperature. The subscripts  $a$  and  $s$  signify the near-surface and surface, respectively.

124 The COARE 3.6 model is used to compute the surface turbulence heat flux. Version 3.6 has been improved in several  
 125 ways and notably enhances the heat flux for wind speeds exceeding  $10 \text{ m s}^{-1}$ . In the COARE 3.6 model, surface turbulence  
 126 heat flux can be obtained from the input 10-m wind speeds, sea surface temperature, sea surface salinity, 2-m air temperature,  
 127 and 2-m relative humidity. Among these elements, the relative humidity is calculated by following:

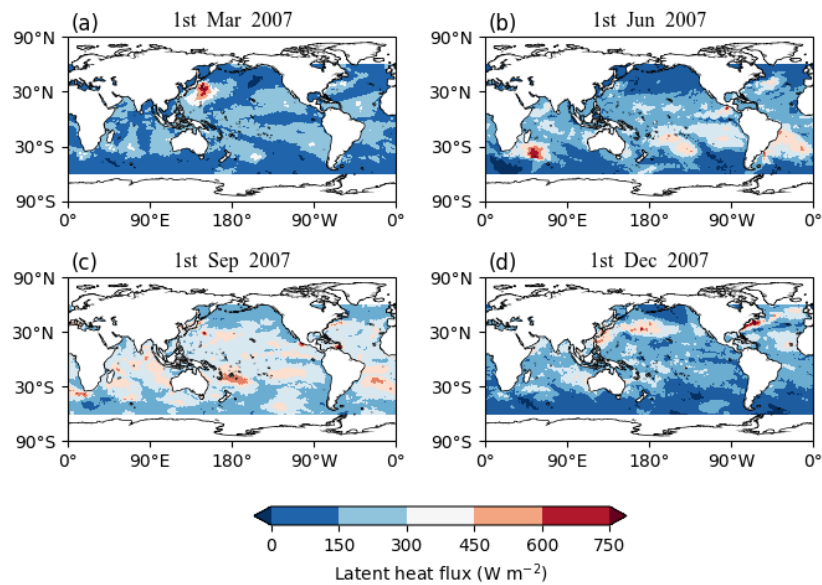
$$128 \quad RH = 100 \times \frac{\exp [(17.27 \times T_d) / (T_d + 237.3)]}{\exp [(17.27 \times T) / (T + 237.3)]}, \quad (15)$$

129 where  $T_d$  is the 2-m dewpoint temperature;  $T$  is the 2-m air temperature.

130 **3 Results**

131 **3.1 Validation**

132 Figure 3 and 4 illustrate the global distribution of surface latent and sensible heat flux of GHFD on March 1st, June 1st,  
133 September 1st, and December 1st, 2007, ranging from 60° S to 60° N. Results show that both surface latent and sensible heat  
134 flux are generally larger in the Southern Hemisphere during the summer and fall, while they are more pronounced in the  
135 Northern Hemisphere during spring and winter. Additionally, in spring and winter, there are notable regional peaks for both  
136 types of heat flux in the western Pacific. The distribution pattern of GHFD over the globe is similar to the distribution of other  
137 products (Fig. S1-Fig. S6). Overall, there is minimal difference between GHFD and other products under normal wind  
138 conditions.



139  
140 **Figure 3: The global distribution of the surface latent heat flux ( $\text{W m}^{-2}$ ) from 60° S to 60° N on (a) March 1, 2007, (b) June 1, 2007,**  
141 **(c) September 1, 2007 and (d) December 1, 2007 for GHFD.**

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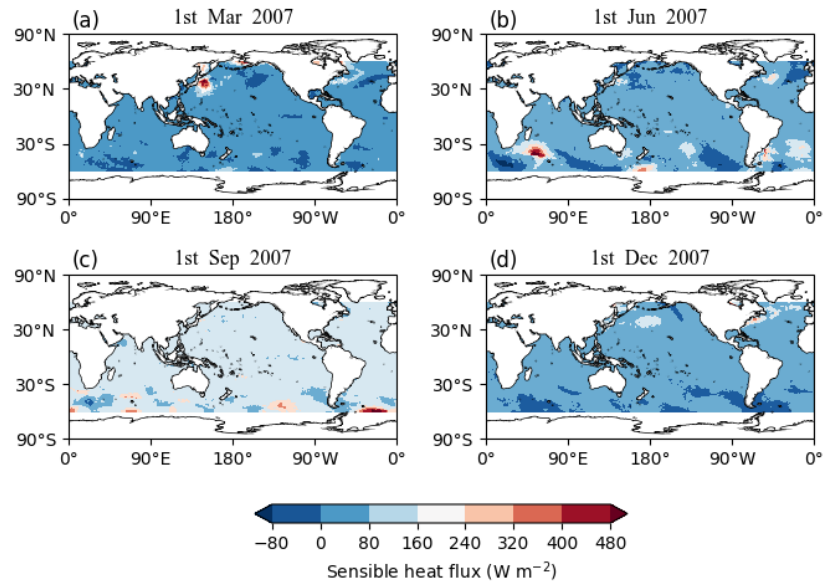


Figure 4: The global distribution of the surface sensible heat flux ( $\text{W m}^{-2}$ ) from 60° S to 60° N on (a) March 1, 2007, (b) June 1, 2007, (c) September 1, 2007 and (d) December 1, 2007 for GHFD.

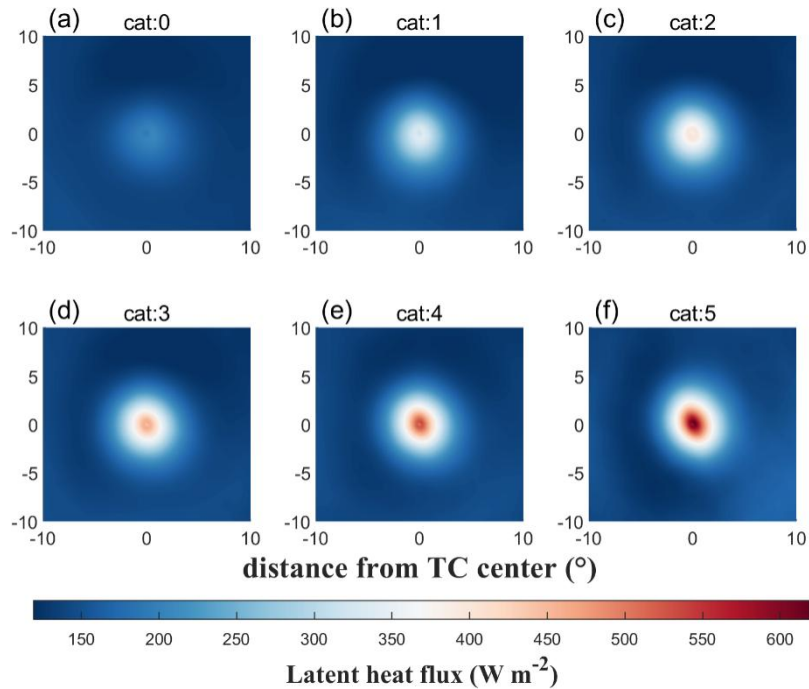
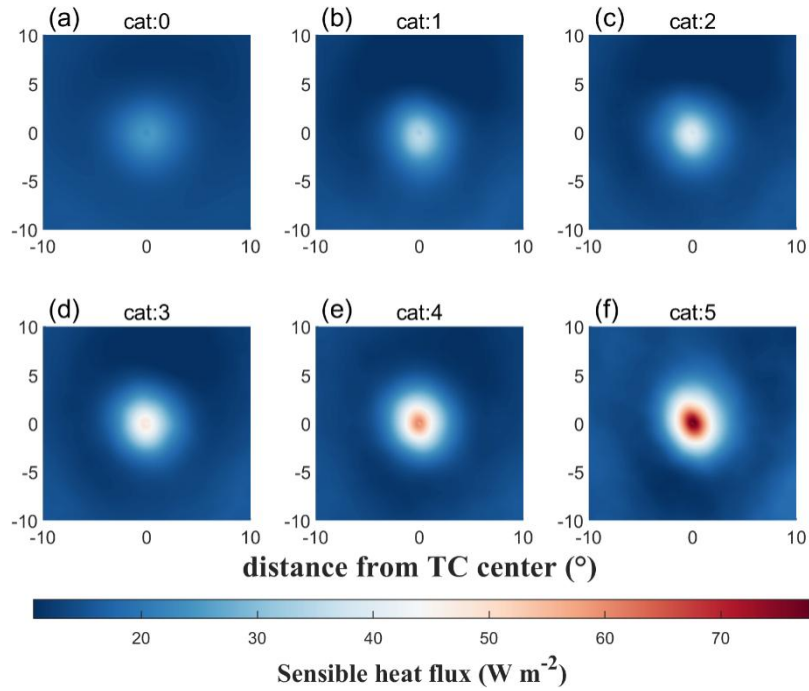


Figure 5: Plan views of composite surface latent heat flux ( $\text{W m}^{-2}$ ) centered on TC classified by TC intensity for (a) Cat 0, (b) Cat 1, (c) Cat 2, (d) Cat 3, (e) Cat 4, and (f) Cat 5.



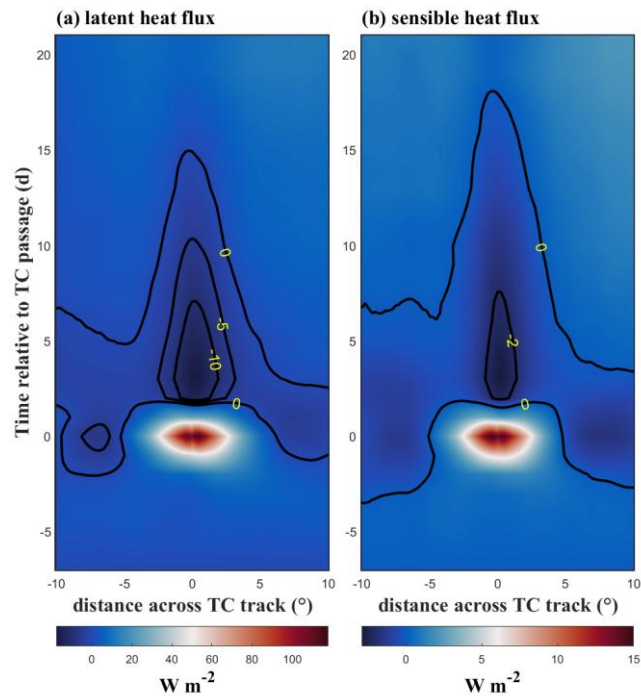
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152 **Figure 6: Plan views of composite surface sensible heat flux ( $\text{W m}^{-2}$ ) centered on TC classified by TC intensity for (a) Cat 0, (b) Cat**  
 153 **1, (c) Cat 2, (d) Cat 3, (e) Cat 4, and (f) Cat 5.**

154 Figure 5 and 6 show the plan views of surface latent and sensible heat flux centered on TCs with different intensities of  
 155 GHFD, categorized as follows: cat 0 ( $V_{max} < 64$  kt), cat 1 ( $64 \text{ kt} \leq V_{max} < 83$  kt), cat 2 ( $83 \text{ kt} \leq V_{max} < 96$  kt), cat 3 ( $96 \text{ kt} \leq$   
 156  $V_{max} < 114$  kt), cat 4 ( $114 \text{ kt} \leq V_{max} < 136$  kt), and cat 5 ( $V_{max} \geq 136$  kt). The data sample sizes in each category are 134386,  
 157 16806, 8825, 6753, 6058, and 1315, respectively. It is evident that with increasing the intensity of the TCs, both surface latent  
 158 and sensible heat flux increase significantly, with the peak values being  $206.19 \text{ W m}^{-2}$ ,  $339.96 \text{ W m}^{-2}$ ,  $401.64 \text{ W m}^{-2}$ ,  $461.36$   
 159  $\text{W m}^{-2}$ ,  $533.60 \text{ W m}^{-2}$ ,  $619.75 \text{ W m}^{-2}$  and  $25.03 \text{ W m}^{-2}$ ,  $35.26 \text{ W m}^{-2}$ ,  $40.75 \text{ W m}^{-2}$ ,  $48.21 \text{ W m}^{-2}$ ,  $60.29 \text{ W m}^{-2}$ ,  $77.77 \text{ W m}^{-2}$   
 160 from cat 0 to cat 5, respectively. The magnitudes of heat flux correspond positively to the magnitude of the wind velocity. The  
 161 peak magnitude of latent heat flux reaches over  $600 \text{ W m}^{-2}$  at cat 5 while the magnitude of sensible heat flux reaches  $70 \text{ W m}^{-2}$ ,  
 162 with the former almost one order of magnitude larger than the latter. For other heat flux products (Fig. S7-Fig. S12), the  
 163 peak magnitude of the surface latent heat flux is approximately  $200 \text{ W m}^{-2}$  while the sensible heat flux is 20 to  $30 \text{ W m}^{-2}$  at cat  
 164 5. The surface heat flux in GHFD is more in line with the theoretical analysis of Trenberth et al. (2007) than the other products  
 165 in representing TC information. The global mean ( $60^\circ \text{ S}$ - $60^\circ \text{ N}$ ) surface latent heat flux is estimated at  $113.4 \text{ W m}^{-2}$  for GHFD,  
 166  $98.7 \text{ W m}^{-2}$  for J-OFURO 3,  $92.4 \text{ W m}^{-2}$  for OAFlux and  $90.6 \text{ W m}^{-2}$  for ifremerflux, while the surface sensible heat flux is  
 167 estimated at  $16.6 \text{ W m}^{-2}$  for GHFD,  $6.8 \text{ W m}^{-2}$  for J-OFURO 3,  $10.4 \text{ W m}^{-2}$  for OAFlux and  $19.1 \text{ W m}^{-2}$  for ifremerflux.

168 Figure 7 displays the temporal evolution of averaged surface latent heat flux and sensible heat flux for TCs from 1993 to  
 169 2023, with a total of 163826 data samples. Both the surface sensible and latent heat flux increase significantly as the TC  
 170 approaches and reach a maximum on the day of TC arrival. At this time, the averaged surface latent heat flux reaches over 120

171  $\text{W m}^{-2}$  while the surface sensible heat flux is about  $15 \text{ W m}^{-2}$ . The GHFD is approximately five times larger than other surface  
 172 heat flux products (Fig. S13-Fig. S15). Following the passage of the TCs, there is a notable cold wake left behind by TCs (Ma  
 173 et al., 2020). The detection of the cold wake also reflects the accuracy of GHFD to some extent, which remains pronounced 2-  
 174 3 weeks after the TC departure.

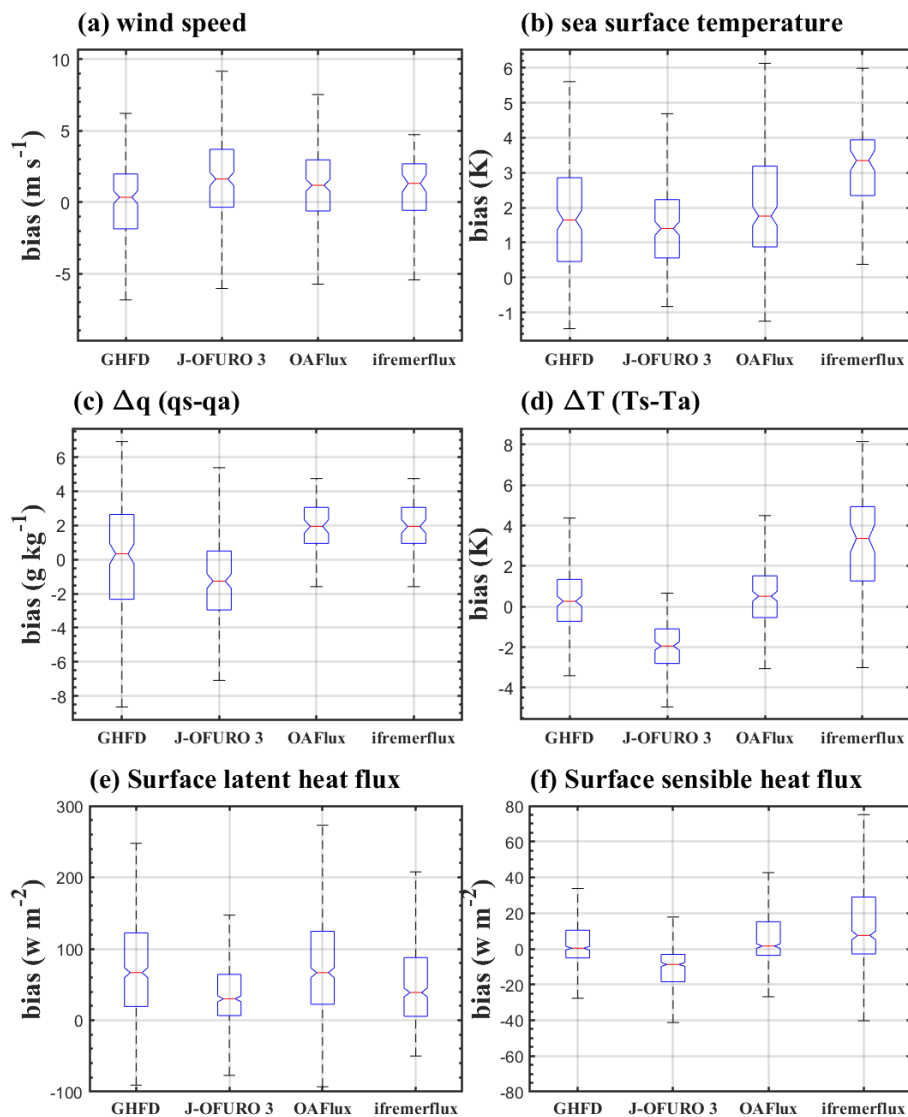


175  
 176 **Figure 7: Temporal evolution of the along-track-averaged ( $\pm 0.25^\circ$ ) composite (a) surface latent heat flux anomaly ( $\text{W m}^{-2}$ ) and (b)**  
 177 **surface sensible heat flux anomaly ( $\text{W m}^{-2}$ ) across the TC track.**

178 **3.2 Component comparisons**

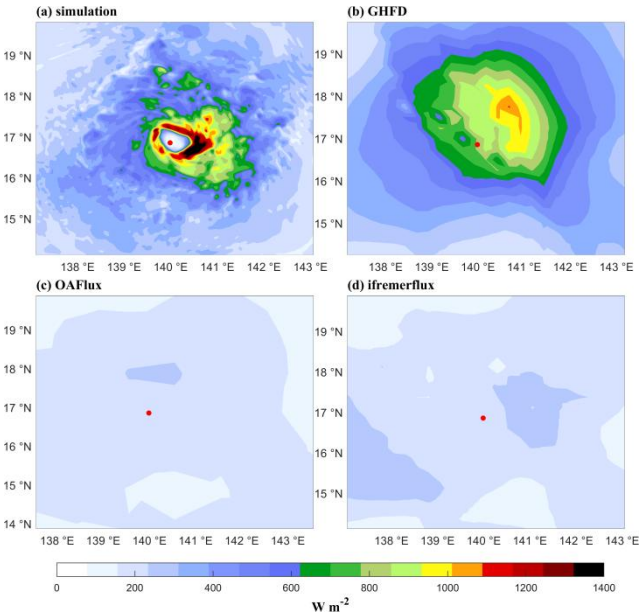
179 The moored data from Maoming station ( $21.46^\circ \text{ N}$ ,  $111.23^\circ \text{ E}$ ) is used to validate the flux components at normal wind  
 180 conditions, along with other three flux products, in terms of wind speed, sea surface temperature,  $\Delta q$  ( $q_s - q_a$ ),  $\Delta T$  ( $T_s - T_a$ ).  
 181 Except for the sea surface temperature, all the other moored data of Maoming station are at a height of 20 m. For a fair  
 182 comparison, the COARE 3.6 algorithm can be employed to compare observations at different heights through the reference  
 183 height for profile. In this study, we standardize the data to the same height with 10 m of wind speed, 2 m of air temperature  
 184 and specific humidity for comparison.  
 185 Figure 8 displays the box plots of flux component biases against the buoy data at the Maoming Station ( $21.46^\circ \text{ N}$ ,  $111.23^\circ \text{ E}$ ).  
 186 For the surface wind speed,  $\Delta q$  ( $q_s - q_a$ ),  $\Delta T$  ( $T_s - T_a$ ), the bias of GHFD is the smallest among all the surface heat flux datasets.  
 187 All of these are the crucial components to compute the heat flux, which can reveal the accuracy of GHFD in basic elements.  
 188 Among the four datasets, GHFD yields the smallest bias in surface sensible heat flux. GHFD yields the smallest bias in surface

189 sensible heat flux. As for surface latent heat flux, GHFD performs better than OAFlux, with comparable but marginally larger  
 190 bias than J-OFURO 3. The results indicate that the accuracy of GHFD product is comparable to that of other products in normal  
 191 wind conditions.  
 192



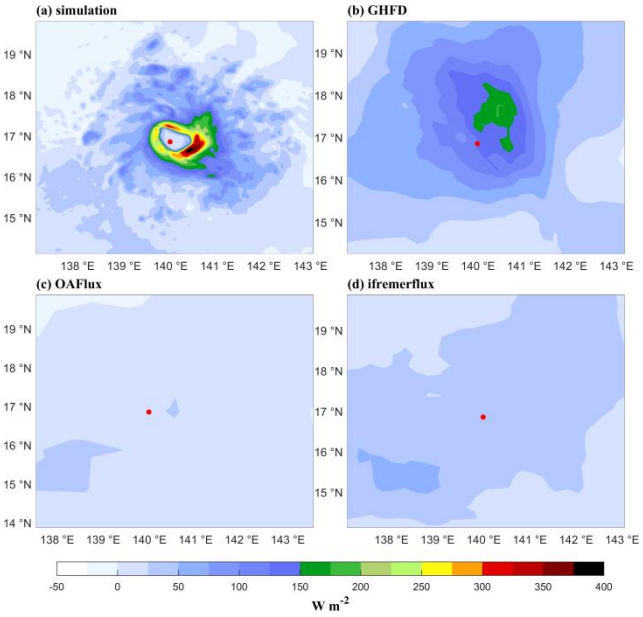
193  
 194 **Figure 8: Box plots of flux component biases of (a) surface wind speed ( $\text{m s}^{-1}$ ), (b) sea surface temperature (K), (c)  $q_s - q_a$  (2-m;  $\text{g kg}^{-1}$ ), (d)  $T_s - T_a$  (2-m; K), (e) surface latent heat flux ( $\text{W m}^{-2}$ ), and (f) surface sensible heat flux ( $\text{W m}^{-2}$ ) for different flux products**  
 195 **against the buoy data at the Maoming Station ( $21.46^\circ \text{N}$ ,  $111.23^\circ \text{E}$ ) over the period of 2010-2011 at daily resolution.**  
 196

197  
 198



200

201 **Figure 9: Plan views of composite surface latent heat flux ( $\text{W m}^{-2}$ ) centered on Typhoon Francisco (2013) for (a) simulation, (b)**  
202 **GHFD, (c) OAFlux, and (d) ifremerflux. The red point represents the Hurricane's center.**



203

204 **Figure 10: Plan views of composite surface sensible heat flux ( $\text{W m}^{-2}$ ) centered on Typhoon Francisco (2013) for (a) simulation, (b)**  
205 **GHFD, (c) OAFlux, and (d) ifremerflux. The red point represents the Hurricane's center.**

206 **3.3 TC verification**

207 Figure 9 and 10 present the plan views of different flux products and high-resolution case simulation of Typhoon Francisco,  
208 based on the simulation results in Ma (2020). The simulations are conducted using the coupled Weather Research and  
209 Forecasting (WRF) model with the Stony Brook Parallel Ocean Model (sbPOM). Two domains are configured with dimensions  
210 of  $350 \times 402$  and  $217 \times 217$ , and horizontal resolutions of 9 and 3 km, respectively. The internal grid moves with the vortex  
211 center. In the WRF model, The Yonsei State University (YSU) scheme (Hong et al., 2006) is used to parameterize boundary  
212 layer processes. For the surface-layer scheme, the “isftcflx51” option is chosen, ensuring that the surface drag coefficient levels  
213 off at hurricane-force wind speeds ( $33 \text{ m s}^{-1}$ ) (Donelan et al., 2004). Microphysical processes are parameterized by the Lin  
214 scheme (Lin et al., 1983). Radiation schemes are the RRTM longwave scheme (Mlawer et al., 1997) and the Dudhia shortwave  
215 (Dudhia, 1989) scheme. The Kain-Fritsch cumulus scheme (Kain, 2004) is utilized in the outermost domain. In the sbPOM  
216 model, a total of 40 levels are distributed as default, with 20 levels in the upper 100 m. Note that the J-OFURO 3 is not shown  
217 in this region due to its missing data.

218 Compared to the other two products, GHFD shows a more distinct TC structure, though there is still a gap relative to the  
219 high-resolution TC simulation. Meanwhile, the magnitude of surface latent heat flux is much larger than that of surface sensible  
220 heat flux. Within the TC region, the magnitude of surface latent heat flux in Figure 9c and 9d is below  $400 \text{ W m}^{-2}$ , while the  
221 GHFD is comparable to simulation data with peak values exceeding  $1000 \text{ W m}^{-2}$ . The behaviors of surface sensible heat flux  
222 from differing data are consistent with those of surface latent heat flux (Figure 10c, d), and both OAFflux and ifremerflux  
223 productions reflect smaller values of less than  $100 \text{ W m}^{-2}$  compared to that of more than  $150 \text{ W m}^{-2}$  in simulation data and  
224 GHFD. In addition to heat flux, we also compare the 2-m air temperature, 2-m specific humidity, and 10-m wind speed of the  
225 simulation against the corresponding variables in GHFD. As illustrated in Figure S16, the mean bias is nearly 0.5 K for 2-m  
226 air temperature, about  $1.6 \text{ g kg}^{-1}$  for 2-m specific humidity, and roughly  $5.0 \text{ m s}^{-1}$  for 10-m wind speed.

227 Figure 11 and 12 present the plan view of Hurricane Earl on 31 August from four surface heat flux products. Jaimes et  
228 al., (2015) calculates the surface turbulence heat flux during Earl based on related observation studies (Black et al., 2007;  
229 Powell et al., 2003; Zhang et al., 2008) in hurricanes. For Earl, the maximum surface latent heat flux is about  $900 \text{ W m}^{-2}$ , and  
230 the maximum surface sensible heat flux is approximately  $250 \text{ W m}^{-2}$  [Fig. 8 of Jaimes et al., 2015)]. Relative to the other  
231 datasets, GHFD exhibits values that are most consistent with those of Earl. The comparison of various flux datasets with the  
232 observational field of Earl further reveals that the GHFD has a significant improvement in resolving the surface heat flux under  
233 TC conditions. This improvement provides a valuable foundation for understanding air-sea interactions during TC events and  
234 an optional dataset for understanding global energy cycle and climate change.

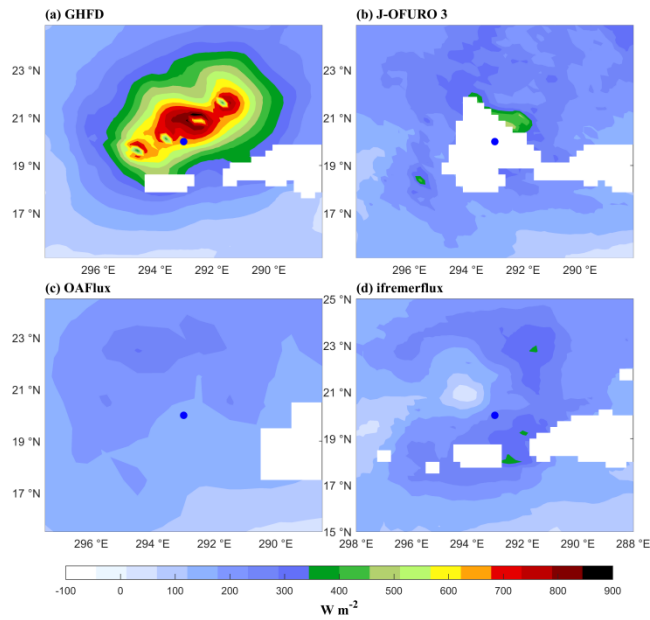


Figure 11: Plan views of composite surface latent heat flux ( $\text{W m}^{-2}$ ) centered on Hurricane Earl for (a) new product, (b) J-OFURO 3, (c) OAFlux, and (d) ifremerflux. The white part is land or values that do not exist in the dataset. The blue point represents the Hurricane's center.

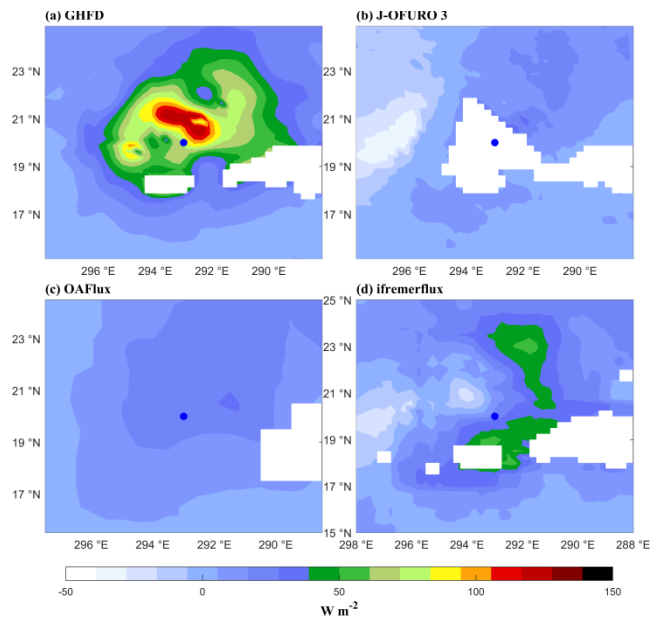


Figure 12: Plan views of composite surface sensible heat flux ( $\text{W m}^{-2}$ ) centered on Hurricane Earl for (a) new product, (b) J-OFURO 3, (c) OAFlux, and (d) ifremerflux. The white part is land or values that do not exist in the dataset. The blue point represents the Hurricane's center.

243 **4 Data availability**

244 The GHFD dataset in NetCDF format is freely available for download at <https://doi.org/10.57760/sciencedb.24400> (Peng et  
245 al., 2025). The size of the GHFD is approximately 5.99 GB per year and 185.8 GB for 31 years. They are stored in zip-  
246 compressed files, each file per year, named YYYY.zip, where “YYYY” denotes the year. Each daily file is stored in NetCDF  
247 format, named “fluxdataset-YYYYMMDD.nc”, where MM denotes the month, DD denotes the date. The GHFD contains 9  
248 values: surface latent heat flux (HLI), surface sensible heat flux (HSI), latitude (lat), longitude (lon), 2-m specific humidity  
249 (qa), sea surface temperature (sst), sea surface salinity (sss), 2-m air temperature (ta) and wind speed (wnd).

250 **5 Conclusion**

251 This study addresses the prominent bias of existing heat flux products under high wind speed conditions, which cannot meet  
252 the current needs for quantitative analysis of energy transfer. Therefore, by using the existing reanalysis data products (CCMP)  
253 and IBTrACS, adopting the wind speed profile within the TC region proposed by Willoughby et al. (2006), the TC wind speed  
254 in CCMP was reconstructed. By comparison, it was found that the reconstructed TC-merged wind speed field is more in line  
255 with the observed wind speed of TCs, and thus more accurate. Then, the pre-prepared datasets (sea surface temperature, sea  
256 surface salinity, 10-m wind speed, 2-m relative humidity and 2-m temperature) were interpolated to the same spatial and  
257 temporal resolution and input into the COARE 3.6 algorithm. We construct a new heat flux dataset GHFD with a spatial  
258 resolution of  $0.25^{\circ} \times 0.25^{\circ}$  and a temporal resolution of one day to meet the need under high wind speed conditions.

259 Comparing the basic parameters and heat flux of GHFD with other three heat flux products, observational data, the  
260 simulated TC (Francisco) and observational data of Earl is conducted. Compared with other products, GHFD shows better  
261 performance under TC conditions. A comparison of each parameter indicates that the bias of GHFD is significantly smaller  
262 than that of other products. These results indicate that the accuracy of the GHFD product is comparable to that of other flux  
263 products in low wind conditions; under TC conditions, the heat flux accuracy is significantly improved in GHFD.

264 **Author contributions**

265 W.P. conducted all the analysis and drew the figures. Z.M. conceived and designed the work. W.P. and Z.M. wrote the initial  
266 draft. D.Z. and H.Y. conducted the wind field construction. All authors discussed and improved the manuscript.

267 **Competing interests**

268 The authors declare no competing interests.

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