

**Point-to-point responses to the reviewer #1's comments**  
on "A Global Surface Turbulence Heat Flux Dataset resolving tropical cyclones"

We are grateful to the anonymous reviewer #1 for the valuable time, careful reading and crucial comments on our manuscript. Following the comments, we have substantially revised our paper. This document addresses reviewers' comments point-by-point. Reviewer comments are presented in **black**, our response in **blue**, and revised manuscript text in **orange**.

**Response to Reviewer #1:**

**Comments:**

*1. Various global datasets for air-sea latent and sensible heat fluxes have been available in recent years. This database is particularly original in its approach to representing air-sea latent and sensible heat flux within tropical cyclones. However, unfortunately, at the time of review, I was unable to access the site (<https://doi.org/10.57760/sciencedb.24400>).*

**Response:** We appreciate these positive and encouraging evaluations, as well as crucial comments, following which we have carefully modified the manuscript accordingly.

Regarding the concern about accessing the data via the provided DOI (<https://doi.org/10.57760/sciencedb.24400>), we have re-checked the link from multiple network environments and confirm that it is available and directs to the publicly accessible dataset page on the Science Data Bank.

We suspect the access issue might have been caused by a temporary network instability or firewall-related factors. We will keep in active touch with the editorial office to ensure its public access.

*2. I would like to commend the efforts regarding the tropical cyclone area, particularly the strong wind distribution. On the other hand, I would like to confirm whether the average wind speed used for evaluating latent and sensible heat fluxes is a 1-minute average or a 10-minute average. In the IBtRACS dataset, the World Meteorological Organization (WMO) standard dataset uses 10-minute average wind speeds. However, 1-minute average wind speeds are commonly used when dealing with Atlantic and Eastern Pacific hurricanes. At the very least, this paper should clearly indicate to users which average time scale was used, or whether a 2-minute average was adopted following the China Meteorological Administration's definition.*

**Response:** Thanks for the positive encouragements and this insightful suggestion. The 10-min average wind speeds of the World Meteorological Organization (WMO) standard dataset have been used to construct the TC-permitted wind field together with the Cross-Calibrated Multi-Platform (CCMP) Version 3.1 dataset (Atlas et al., 2011), which is a 10-m wind field. This information has been clarified in Line 70-71, Page 3, reproduced as follows.

The IBTrACS (Gahtan et al., 2024; Knapp et al., 2010; Knapp, 2018) is used to provide 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.

**3. The results of numerical simulations should describe the specifications used in the simulation (such as the model adopted—whether it is an atmosphere-ocean coupled model—and the horizontal resolution). It is desirable to explicitly state the differences from COARE3.6. In addition to sensible and latent heat fluxes, it is desirable to make comparisons of 2-m air temperature, 2-m specific humidity, and 10-m wind speed. For simulations using an atmosphere-ocean coupled model, comparison of salinity concentrations would be also possible.**

**Response:** Following the comments, the details of the numerical simulations have been supplemented in Line 209-217, Page 12. The atmosphere-ocean coupled model has been used for the simulation, with a horizontal resolution of 3 km. The bulk formula with surface drag coefficient (Cd) leveling off at high winds (33 m/s) has been used to calculate the latent and sensible heat flux.

Figures 9 and 10 present the plan views of different flux products and high-resolution case simulation of Typhoon Francisco, based on the simulation results in Ma (2020). The simulations are conducted using the coupled Weather Research and Forecasting (WRF) model with the Stony Brook Parallel Ocean Model (sbPOM). Two domains are configured with dimensions of  $350 \times 402$  and  $217 \times 217$ , and horizontal resolutions of 9 and 3 km, respectively. The internal grid moves with the vortex center. In the WRF model, The Yonsei State University (YSU) scheme (Hong et al., 2006) is used to parameterize boundary layer processes. For the surface-layer scheme, the “isftcflx51” option is chosen, ensuring that the surface drag coefficient levels off at hurricane-force wind speeds ( $33 \text{ m s}^{-1}$ ) (Donelan et al., 2004). Microphysical processes are parameterized by the Lin scheme (Lin et al., 1983). Radiation schemes are the RRTM longwave scheme (Mlawer et al., 1997) and the Dudhia shortwave (Dudhia, 1989) scheme. The Kain-Fritsch cumulus scheme (Kain, 2004) is utilized in the outermost domain. In the sbPOM model, a total of 40 levels are distributed as default, with 20 levels in the upper 100 m.

Both algorithms of heat flux of WRF model and COARE 3.6 are based on the applications of Monin – Obukhov similarity theory (MOST), where the turbulent fluxes of sensible heat and latent heat are expressed with state variable magnitudes associated with surface friction- $t_*$ ,  $q_*$  and  $u_*$  for air temperature, specific humidity, and horizontal wind velocity, respectively. Differences among the algorithms are primarily how they estimate  $\Psi_{M,\theta,q}(\zeta)$ ,  $z_o$ ,  $z_{ot}$  and  $z_{oq}$ . In the coupled model, the stability functions used in the surface layer scheme follow Paulson (1970) for unstable conditions and Cheng et al. (2005) for stable conditions. The COARE 3.6 employs stability functions based on Beljaars et al. (1991) under stable stratification, while under unstable conditions it adopts a combination of the forms of Businger et al. (1971) with additional convective adjustment (Fairall et al., 2003). Regarding surface

roughness lengths, our model calculates the momentum roughness length  $z_0$  using the parameterization of Davis et al. (2008), whereas the scalar roughness lengths for heat and moisture ( $z_{ot}$  and  $z_{oq}$ ) are computed following the COARE 3.0 (Fairall et al., 2003). In COARE 3.6, the momentum roughness length is based on a modified Charnock parameter that has been retuned against a comprehensive set of field observations (Edson et al., 2013). Moreover, the scalar roughness lengths  $z_{ot}$  and  $z_{oq}$  in COARE 3.6 have also been refined using a broader observational database.

The 2-m air temperature, 2-m specific humidity, and 10-m wind speed between simulations and the GHFD have been compared, shown as Figure S16. Relevant discussion is in Lines 225-227, Page 12, reproduced below. We understand that the salinity affects surface flux by modulating sea surface temperature response, so that this analysis has not been added to the manuscript yet. We appreciate these crucial suggestions.

In addition to heat flux, we also compare the 2 m air temperature, 2 m specific humidity, and 10 m wind speed of the simulation with the corresponding variables in GHFD. As illustrated in Figure S16, the mean bias is nearly 0.5 K for 2 m air temperature, about 1.6 g kg<sup>-1</sup> for 2 m specific humidity, and roughly 5.0 m s<sup>-1</sup> for 10 m wind speed.

**4. Carefully include captions for both the main text and supplementary material to ensure that readers can easily understand. For supplementary material, do not simply list figures and tables; explain which part of the main text they supplement.**

**Response:** Thanks for this comment. The captions in the main text have been re-checked and revised carefully to ensure they are in a standard format. A supplementary text has been added to clarify which part of the main text is explained by these supplementary figures and tables.

**5. There is a scarcity of in-situ observational data beneath tropical depressions for calculating latent and sensible heat fluxes, leaving questions about the reliability of satellite-based estimates. Even with current technology, direct observations using sail drones remain challenging, particularly due to the effects of sea spray and platform sway. In this sense, explaining the significance of releasing this dataset in the introduction serves as a consideration for the general reader to prevent misunderstandings.**

**Response:** Thanks for the insightful comment. We have followed the suggestion to add statements explaining the significance of releasing this dataset for the general reader to prevent misunderstandings in Line 40-42, Page 2, as follows.

This large uncertainty is because that there is a scarcity of in-situ observational data beneath TCs for calculating latent and sensible heat fluxes. Direct observations using sail drones are also challenging, particularly due to the complex states of the air-sea interface under TC conditions.

## References

- Atlas, R., Hoffman, R. N., Ardizzone, J., Leidner, S. M., Jusem, J. C., Smith, D. K., and Gombos, D.: Supplement: A cross-calibrated, multiplatform ocean surface wind velocity product for meteorological and oceanographic applications, *Bull. Amer. Meteorol. Soc.*, 92, S4-S8, <https://doi.org/10.1175/2010BAMS2946.2>, 2011.
- Beljaars, A. C. M. and Holtslag, A. A. M.: Flux Parameterization over Land Surfaces for Atmospheric Models, in, edited, American Meteorological Society, Boston MA, USA, 327-341, <https://doi.org/>, 1991.
- Businger, J. A., Wyngaard, J. C., Izumi, Y., and Bradley, E. F.: Flux-Profile relationships in the atmospheric surface layer, in, edited, American Meteorological Society, Boston MA, USA, 181-189, <https://doi.org/>, 1971.
- Chenge, Y. and Brutsaert, W.: Flux-profile relationships for wind speed and temperature in the stable atmospheric boundary layer, *Bound.-Layer Meteor.*, 519-538, 2005.
- Davis, C. C. U. E., Wang, W., Chen, S. S., Chen, Y., Corbosiero, K., Demaria, M., Dudhia, J., Holland, G., Klemp, J., Michalakes, J., Reeves, H., Rotunno, R., Snyder, C., and Xiao, Q.: Prediction of landfalling hurricanes with the advanced hurricane WRF model., *Mon. Weather Rev.*, 1990-2005, 2008.
- Donelan, M. A., Haus, B. K., Reul, N., Plant, W. J., Stiassnie, M., Graber, H. C., Brown, O. B., and Saltzman, E. S.: On the limiting aerodynamic roughness of the ocean in very strong winds, *Geophys. Res. Lett.*, 0, 2004.
- Dudhia, J.: Numerical study of convection observed during the winter monsoon experiment using a mesoscale two-dimensional model., *J. Atmos. Sci.*, 3077-3107, 1989.
- Edson, J., Jampana, V., Weller, R., Bigorre, S., Plueddemann, A., Fairall, C., Miller, S., Mahrt, L., Vickers, D., and Hersbach, H.: On the Exchange of Momentum over the Open Ocean, *J. Phys. Oceanogr.*, 43, 1589-1610, <https://doi.org/10.1175/JPO-D-12-0173.1>, 2013.
- Fairall, C. W., Bradley, E. F., Hare, J. E., Grachev, A. A., and Edson, J. B.: Bulk parameterization of air - sea fluxes: Updates and verification for the COARE algorithm, *J. Clim.*, 571-591, 2003.
- Gahtan, J., Knapp, K. R., Schreck, C. J., Diamond, H. J., Kossin, J. P., and Kruk, M. C.: International best track archive for climate stewardship (IBTrACS) project, version 4r01, <https://doi.org/https://doi.org/10.25921/82ty-9e16>, 2024.
- Hong, S., Noh, Y., and Dudhia, J.: A new vertical diffusion package with an explicit treatment of entrainment processes, *Mon. Weather Rev.*, 2318-2341, 2006.
- Kain, J. S.: The KainFritsch convective parameterization: An update., *Journal of Applied Meteorology*, 170-181, 2004.
- Knapp, K. R. E. A.: International best track archive for climate stewardship (IBTrACS) project, version 4 [v04r00, subset all]. NOAA National Centers for Environmental Information, <https://doi.org/doi.org/10.25921/82ty-9e16>, 2018.
- Knapp, K. R., Kruk, M. C., Levinson, D. H., Diamond, H. J., and Neumann, C. J.: the international best track archive for climate stewardship (IBTrACS): Unifying tropical cyclone data, *Bulletin of the American Meteorological Society*, 91, 363-376, <https://doi.org/https://doi.org/10.1175/2009BAMS2755.1>, 2010.
- Lin, Y., Farley, R. D., and Orville, H. D.: Bulk parameterization of the snow field in a cloud model, J.

- Appl. Meteorol. Climatol., 1065-1092, 1983.
- Ma, Z.: A Study of the Interaction between Typhoon Francisco (2013) and a Cold-Core Eddy. Part I: Rapid Weakening, *J. Atmos. Sci.*, 77, 355-377, <https://doi.org/10.1175/JAS-D-18-0378.1>, 2020.
- Mlawer, E. J., Taubman, S. J., Brown, P. D., Iacono, M. J., and Clough, S. A.: Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave, *Journal of Geophysical Research: Atmospheres*, Vol.102, 16663-16682, 1997.
- Paulson, C. A.: The mathematical representation of wind speed and temperature profiles in the unstable atmospheric surface layer, *Journal of Applied Meteorology* (1962-1982), 857-861, 1970.