Responses to Reviewer #2

Note: The reviewers' comments are in black, and our responses are in blue. The changes made in the revised manuscript are highlighted in green. Figures in the manuscript are labeled using Arabic numerals (e.g., Fig. 1, Figure 1), and those in our responses to the reviewers are labeled using Arabic numerals with the prefix "R" (e.g., Fig. R1, Figure R1).

Reviewer #2:

General comment:

This manuscript uses hourly LLC4320 output to compare internal-tide energetics in the Luzon Strait, a strong generation region, and the Nansha Islands, a remote energy-sink region. The source-to-sink comparison, separation of diurnal and semidiurnal bands, modal analysis, and attempt to connect the diagnosed energy ratios with both a physics-based regression and XGBoost are useful. In particular, the contrast between strong local conversion in the Luzon Strait and substantial far-field energy import around the Nansha Islands is very interesting for relevant researchers.

The manuscript is generally well organized, and the main results appear publishable. I recommend minor revision, mainly about clarifying $q>1$, distinguishing energy-budget residuals, testing robustness of modal analysis etc. These issues can largely be addressed using the existing output without redesigning the study.

Responses: We are grateful to the reviewer for the valuable suggestions on our manuscript. All comments have been carefully considered and fully addressed in the revised manuscript. We hope that these improvements will render the manuscript more refined and satisfy the reviewer.

Specific comments:

1. The conventional local dissipation efficiency q is a fraction of locally generated internal-tide energy and is therefore normally interpreted between zero and one. In the Nansha area, the reported quantity exceeds one because dissipation is normalized only by local conversion while the domain also imports energy. This is informative, but it is no longer an efficiency in the usual fractional sense. Maybe consider renaming it throughout as "local dissipation ratio"? Or for the Nansha region, you could report dissipation normalized by the total available energy supply, e.g., positive local conversion plus net incoming baroclinic flux? This would have a clearer interpretation as an efficiency.

Responses: We thank the reviewer for pointing out this issue. The term "local dissipation efficiency q" originates from the internal tidal mixing parameterization proposed by St. Laurent et al. (2002), where q is defined as the fraction of locally generated internal tidal energy that dissipates near the generation site, with the remainder radiating away as low-mode internal tides. It should be noted that this parameterization quantifies only near-field dissipation driven by high-mode internal tides, while explicitly excluding far-field dissipation associated with low-mode internal tides. By this design, q is a prescribed scalar between 0 and 1 as the reviewer commented. For example, St. Laurent et al. (2002) initially adopted a globally representative value of $q = 0.3 \pm 0.1$; subsequently, a spatially uniform value of 0.3 was taken in many ocean models (Saenko and Merryfield, 2005; Simmons et al., 2004). However, growing evidence indicates that near-field dissipation strongly depends on the modal partitioning of locally generated internal tidal energy, since high-mode energy dissipates rapidly near the generation sites whereas low-mode energy radiates over basin-scale distances (Vic et al., 2019). Consequently, q is not universal, it varies substantially among different topographies, ranging from <0.4 over large-scale steep topography to >0.8 over small-scale rough topography (Vic et al., 2019; Lefauve et al., 2015).

The physical meaning of our defined parameter q differs from the aforementioned definition: our q quantifies the ratio of local dissipation to local generation, where the energy source for local dissipation consists of two parts (both locally generated internal tidal energy and incoming internal tidal energy from the far field). As recommended by the reviewer, we have renamed it as "local dissipation ratio q^*" in the revised manuscript to improve conceptual clarity and distinguish it clearly from the aforementioned "local dissipation efficiency q". In this study, we apply the same definition of q^* to both the source region (Luzon Strait) and the sink region (Nansha Islands) to ensure a consistence. In source regions, locally generated internal tidal energy provides the principal energy supply for local dissipation; thus, q^* normally ranges from 0 to 1. In contrast, in sink regions, local generation is weak but dissipation is furnished by both local generation and incoming internal tidal energy from the far field; consequently, q^* exceeds 1.

As the reviewer suggested, normalizing local dissipation by the total available energy supply will yield q^* values between 0 and 1, even in sink regions. However, unlike local barotropic-to-baroclinic conversion, the incoming internal tidal energy is difficult to be estimated theoretically due to the complex wave-wave, wave-current, and wave-topography interactions, limiting the generalizability of q^* parameterization based on total energy supply. Therefore, local barotropic-to-baroclinic conversion is retained as our reference energy scale for defining q^*. This choice also enables an easy comparison with previous energy-budget studies in the South China Sea, in which dissipation was uniformly normalized only by local conversion (e.g., Tian et al., 2025; Wang et al., 2016).

References:

Lefauve, A., Muller, C., and Melet, A.: A three-dimensional map of tidal dissipation over abyssal hills, J. Geophys. Res. Oceans, 120, 4760–4777, https://doi.org/10.1002/2014JC010598, 2015.

Saenko, O. A. and Merryfield, W. J.: On the effect of topographically enhanced mixing on the global ocean circulation, J. Phys. Oceanogr., 35, 826–834, https://doi.org/10.1175/JPO2722.1, 2005.

Simmons, H. L., Jayne, S. R., St. Laurent, L. C., and Weaver, A. J.: Tidally driven mixing in a numerical model of the ocean general circulation, Ocean Modell., 6, 245–263, https://doi.org/10.1016/S1463-5003(03)00011-8, 2004.

St. Laurent, L. C., Simmons, H. L., and Jayne, S. R.: Estimating tidally driven mixing in the deep ocean, Geophys. Res. Lett., 29, 2106, https://doi.org/10.1029/2002GL015633, 2002.

Tian, Y., Bai, X., Wang, C., and Liu, Z.: Tidal energetics in the eddying South China Sea from a high-resolution numerical simulation, Prog. Oceanogr., 231, 103418, https://doi.org/10.1016/j.pocean.2025.103418, 2025.

Vic, C., Naveira Garabato, A. C., Green, J. A. M., Waterhouse, A. F., Zhao, Z., Melet, A., de Lavergne, C., Buijsman, M. C., and Stephenson, G. R.: Deep-ocean mixing driven by small-scale internal tides, Nat. Commun., 10, 2099, https://doi.org/10.1038/s41467-019-10149-5, 2019.

Wang, X., Peng, S., Liu, Z., Huang, R. X., Qian, Y., and Li, Y.: Tidal mixing in the South China Sea: an estimate based on the internal tide energetics, J. Phys. Oceanogr., 46, 107–124,

https://doi.org/10.1175/JPO-D-15-0082.1, 2016.

(Changes can be found in Lines 8, 75–79, 166–167, 230–231, and 352–353, the title and the headings of Sections 3.1, 3.2, and 3.3 of the revised manuscript.)

2. The present dissipation estimate is obtained as a residual of the energy budget and should therefore be interpreted as an inferred dissipation. Have you compared this estimate with directly diagnosed dissipation from the model, using the available velocity/density gradients and vertical mixing coefficients? previous studies have reported difference between the two methods, or at least relevant discussions on this point should be included.

Responses: We thank the reviewer for this insightful comment. In the revised manuscript, we clarify that the present dissipation estimate (DIS_{bc}) represents an inferred dissipation from the energy budget equation rather than a directly diagnosed dissipation from the model.

The complete form of the depth-integrated baroclinic energy equation (Niwa and Hibiya, 2004) is $TEN_{\mathrm{bc}} = -\nabla_{\mathrm{h}} \cdot \boldsymbol{F} + Conv + ADV_{\mathrm{bc}} + DIS_{\mathrm{bc}}$, where $Conv$ is the depth-integrated barotropic-to-baroclinic energy conversion, $\boldsymbol{F}$ is the depth-integrated baroclinic energy flux, and TEN_{bc}, ADV_{bc}, and DIS_{bc} denote the tendency, the advection, and the dissipation of baroclinic energy, respectively (Wang et al., 2016). After a tidal-period averaging and neglecting the time-mean tendency and advection terms, the dissipation term simplifies as $\langle DIS_{\mathrm{bc}} \rangle = \langle Conv \rangle - \langle \nabla_{\mathrm{h}} \cdot \boldsymbol{F} \rangle$, where $\langle \cdot \rangle$ denotes the tidal-period averaging, a positive $\langle DIS_{\mathrm{bc}} \rangle$ denotes the dissipation of baroclinic energy. This simplified equation has been widely applied in energy-budget studies of the South China Sea (e.g., Tian et al., 2025; Wang et al., 2016) and lays the basis for the tidal-mixing parameterization of St. Laurent et al. (2002). In this framework, $\langle Conv \rangle$ constrains the total energy available for turbulent mixing near internal tide generation sites. However, not all of the locally generated energy flux contributes to local dissipation, since a portion radiates away as low-mode waves. To account for this, St. Laurent et al. (2002) introduced a "local dissipation efficiency" (q) to quantify the fraction of locally generated internal tidal energy likely to dissipate near its source by turbulent processes.

As the reviewer noted, besides inferring from the energy budget equation, the dissipation can also be diagnosed directly from the simulation using the velocity gradients and the horizontal and vertical eddy viscosity coefficients:

$$\varepsilon_{\mathrm{visc}} = \rho A_{\mathrm{h}} \left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 + \left(\frac{\partial v}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2 \right] + \rho A_{\mathrm{v}} \left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2 \right],$$

where ρ is the reference density, A_{h} and A_{v} are the horizontal and vertical eddy viscosities, (u, v) is the horizontal baroclinic velocity (Nikurashin and Legg, 2011). However, in the LLC4320 simulation, A_{h} is determined internally by a parameterization scheme and is not provided as an output field; therefore, in this study it is a pity that we cannot exactly diagnose dissipation from the model output.

We acknowledge that there exist both connections and differences between the inferred dissipation and the diagnosed dissipation: the former not only includes the latter (i.e., explicit numerical dissipation), but also additionally covers other physical processes such as bottom friction dissipation. Fortunately, their quantitative discrepancy is not critical. For example, assuming a constant A_{h}, Fan et al. (2024) compared the diagnosed dissipation from the LLC4320 simulation with the inferred dissipation from the energy budget equation. They found that these two dissipation fields exhibit comparable magnitudes and broadly consistent spatial patterns across the northern South China Sea, despite localized discrepancies attributed to the constant A_h assumption.

In the revised manuscript, we add a discussion about the inferred dissipation and the diagnosed dissipation.

References:

Fan, L., Sun, H., Yang, Q., and Li, J.: Numerical investigation of interaction between anticyclonic eddy and semidiurnal internal tide in the northeastern South China Sea, Ocean Sci., 20, 241–264, https://doi.org/10.5194/os-20-241-2024, 2024.

Nikurashin, M. and Legg, S.: A mechanism for local dissipation of internal tides generated at rough topography, J. Phys. Oceanogr., 41, 378–395, https://doi.org/10.1175/2010JPO4522.1, 2011.

Niwa, Y. and Hibiya, T.: Three-dimensional numerical simulation of M_2 internal tides in the East China Sea, J. Geophys. Res., 109, C04027, https://doi.org/10.1029/2003JC001923, 2004.

(Changes can be found in Lines 152–165 of the revised manuscript.)

3. The four lower panels in Fig. 5 appear identical to the corresponding Luzon Strait panels in Fig. 3. Their magnitudes and curves also contradict lines 205–213, which state that the Nansha modal energy terms are much smaller and that mode-1 q>2, reaching approximately 5. Please recheck these panels, and verify numerical statement that depends on them.

Responses: We sincerely apologize for this error. The four lower panels in Fig. 5 were improperly duplicated from the corresponding panels of Fig. 3. These panels have now been replaced with the correct figures for the Nansha Islands, and the statements based on them have been thoroughly rechecked. The corrected figure (Fig. R1) shows that the modal energy-budget terms in the Nansha Islands are significantly smaller than those in the Luzon Strait, and the energy budget is dominated by modes 1 and 2. Mode-1 baroclinic energy flux converges into the Nansha Islands, and mode-1 q^* values are larger than those for mode 2. Diurnal mode-1 q^* ranges from 2 to 5, and semidiurnal mode-1 q^* ranges from 1 to 3. For modes 3–5, monthly q^* values occasionally become extremely large, particularly when the area-integrated modal conversion is close to zero. The q^* values outside the displayed *y*-axis ranges in panels (*l*) and (m) of Fig. R1 are omitted for visual clarity, as stated in the revised figure caption.

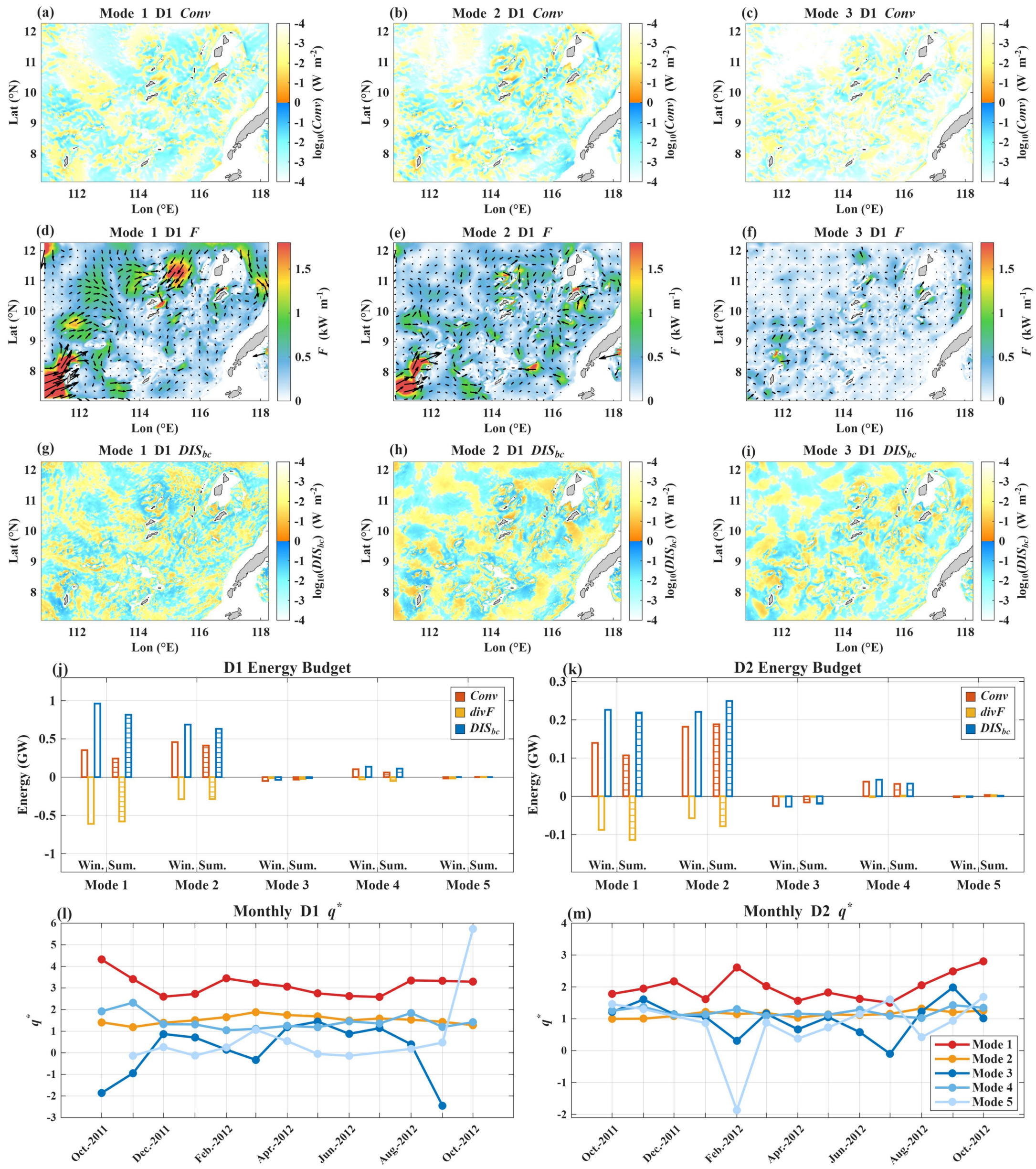

Figure R1. Same as Fig. 3, but for the Nansha Islands and (a–i) for diurnal internal tide. In (*l*–m), monthly mean values of q^* outside the displayed y-axis ranges are not shown for clarity.

(Changes can be found in Lines 259–267 of the revised manuscript.)

4. The paper attributes local dissipation to "high modes," yet only modes 1–5 are retained. Could you please compare the sum of modes 1–5 with the undecomposed modes to see the fraction for higher modes (>5).

Responses: We thank the reviewer for this insightful comment. In our analysis, only modes 1–5 are retained after modal decomposition; the baroclinic kinetic energy not captured by these five modes originates from unretained higher modes (modes>5). To quantify the residual contribution of these unretained modes, we compare the depth-integrated baroclinic kinetic energy reconstructed from the sum of modes 1–5 with the total baroclinic kinetic energy prior to modal decomposition, for each tidal band and each region individually, using data for January and August 2012. In the Luzon Strait, unretained modes (>5) account for 15% of the total baroclinic kinetic energy, and the contribution is 13% for the diurnal component and less than 2% for the semidiurnal component. In the Nansha Islands, the corresponding values are 11%, 1%, and < 2%. These results confirm that modes 1–5 capture the dominant part of the baroclinic kinetic energy across all tidal bands and regions examined, and the unretained modes (>5) make only a small contribution. In the revised manuscript, modes 3–5 are referred to by explicit mode numbers (e.g., modes 3–5) rather than using the confusing term "high modes".

(Changes can be found in Lines 13–14, 19–20, and 132–137 of the revised manuscript.)

5. L30–36 The introduction would benefit from distinguishing radiation, loss of phase coherence, scattering, and irreversible dissipation. Alford et al. (2019) provide an independent estimate of basin-scale mode-1 attenuation and emphasize that apparent flux decay can include both true energy loss and loss of stationarity. This is relevant to the manuscript's nonlocal framing.

Responses: We thank the reviewer for this constructive suggestion. As the reviewer suggested, the introduction has been revised to distinguish radiation, loss of phase coherence, scattering, and irreversible dissipation, which play different roles in the internal tide energy budget.

Radiation transports internal tidal energy out of its source region through the baroclinic energy flux. Loss of phase coherence reduces the stationary (harmonically detectable) component of the signal but not necessarily the total internal tidal energy. Topographic scattering redistributes incident internal tidal energy across different propagation directions and vertical modes, rather than dissipating it (i.e., without net energy loss). Irreversible dissipation removes energy from the internal wave field through wave breaking and small-scale turbulence. Among these four processes, only irreversible dissipation serves as a true sink of internal tidal energy.

Alford et al. (2019) estimated the spatial attenuation of the mode-1 M_2 internal tide energy flux, which consists of both a stationary component detected by multisatellite altimetry and a nonstationary component corrected using an eddy-resolving tidal model. Across the North Pacific, the total fluxes yield *e*-folding scales of approximately 750–3,000 km. This apparent decrease in the total flux includes actual loss of mode-1 energy, through irreversible dissipation or scattering to higher modes, as well as loss of phase coherence (i.e., reduced stationarity). Such an apparent decrease therefore cannot be interpreted directly as equivalent irreversible energy loss.

The apparent decay of the mode-1 M_2 energy flux emphasized by Alford et al. (2019) is directly relevant to the nonlocal framing of the present study, in which the internal tidal energy dissipated in a sink region (e.g., the Nansha Islands) is supplied by the energy radiated from the far field (such as the Luzon Strait). For example, a substantial portion of the internal tidal energy generated in the Luzon Strait radiates out through the baroclinic energy flux and propagates toward the Nansha Islands, where topographic scattering redistributes the incoming energy from low to higher modes and facilitates their subsequent breaking and local dissipation. Crucially, the observed flux decay along this propagation pathway combines true energy dissipation with loss of phase coherence rather than dissipation alone. Because the energy budgets in the present study are calculated from hourly bandpass-filtered model fields rather than from phase-locked harmonic components, the de-phased energy remains within the target frequency band as part of the diagnosed flux rather than being attributed to the residual dissipation, as long as its frequency falls within the corresponding bandpass frequency band.

Reference:

Alford, M. H., Simmons, H. L., Marques, O. B., and Girton, J. B.: Internal tide attenuation in the North Pacific, Geophys. Res. Lett., 46, 8205–8213, https://doi.org/10.1029/2019GL082648, 2019.

(Changes can be found in Lines 32–45 of the revised manuscript.)

7. Lines 40–46 define higher q as stronger near-field dissipation at a generation site. This interpretation cannot be transferred directly to Nansha, where $q>1$ arises from imported energy.

Responses: We are sorry for this confusion. In the revised manuscript, we clearly distinguish two related but conceptually distinct quantities in terms of both the physical meanings and the symbols: (1) the "local dissipation efficiency" q (restricted between 0 and 1) used in prior parameterizations; (2) our newly defined "local dissipation ratio" q^* (can be larger than 1). Both quantities normalize local dissipation by local energy generation, but they differ fundamentally in how "local dissipation" is sourced: q considers only dissipation driven by locally generated internal tide energy, whereas q^* includes all dissipation fueled by both locally generated internal tide energy and incoming internal tide energy from the far field. In the revised introduction, a lower q indicates stronger far-field radiation of low-mode internal tides and a higher q indicates stronger near-field dissipation within an internal tide source region. In the *Methods* section, the inferred q^* is not necessarily restricted between 0 and 1, because the dissipation, furnished by both locally generated and imported internal tidal energy, is normalized by the local barotropic-to-baroclinic conversion alone, as in the Nansha Islands.

(Changes can be found in Lines 52–55, 78–79, and 169–171 of the revised manuscript.)

8. L69–71, here the introduction identifies background-flow shear as a possible control on q. Wang and Legg (2023, 2025) examined how baroclinic eddy shear affects internal-tide refraction, modal energy transfer, and dissipation, and therefore directly connect vertical shear to dissipation of internal tides.

Responses: We thank the reviewer for sharing these valuable references. Following the reviewer's suggestion, these references (Wang and Legg, 2023, 2025) have been added to the revised manuscript, together with a brief summary of their key findings. Specifically, these studies show that the shear current associated with strong baroclinic eddies can transfer part of the incident mode-1 internal tide energy into higher modes and trap these high modes within the eddies, thereby making the eddies hotspots for internal tide dissipation. This mechanism establishes a direct link between vertical shear and internal tide dissipation.

References:

Wang, Y. and Legg, S.: Enhanced dissipation of internal tides in a mesoscale baroclinic eddy, J. Phys. Oceanogr., 53, 2293–2316, https://doi.org/10.1175/JPO-D-23-0045.1, 2023.

Wang, Y. and Legg, S.: Agulhas rings locally enhance dissipation of internal tides, Sci. Adv., 11, eadq5963, https://doi.org/10.1126/sciadv.adq5963, 2025.

(Changes can be found in Lines 84–90 of the revised manuscript.)

9. L199–203, Kelly et al. (2013) is a relevant independent reference for the redistribution of incident mode-1 energy among reflection, transmission, and scattering to higher modes at large topographic features. It would also help the authors distinguish scattering from final irreversible dissipation.

Responses: We thank the reviewer for sharing this valuable reference. The reference (Kelly et al., 2013) has been added into our revised manuscript. In Section 3.2, topographic scattering is now explicitly distinguished from the irreversible dissipation that follows the breaking of the scattered high-mode waves.

Reference:

Kelly, S. M., Jones, N. L., Nash, J. D., and Waterhouse, A. F.: The geography of semidiurnal mode-1 internal-tide energy loss, Geophys. Res. Lett., 40, 4689–4693, https://doi.org/10.1002/grl.50872, 2013.

(Changes can be found in Lines 251–258 of the revised manuscript.)

10. Abstract: Please distinguish total-band *q*, constituent-specific *q*, and modal *q*. The abstract reports total *q* occasionally exceeding 2.5, whereas the text later reports mode-1 values approaching 5.

Responses: We are sorry for this confusion. In the revised abstract, the q^* values specifically refer to those of the total internal tide. The q^* value of the total internal tide fluctuates between 0.3 and 0.7 in the Luzon Strait and is generally larger than 1 in the Nansha Islands, occasionally exceeding 2.5. The q^* values of individual tidal constituents and vertical modes are reported in the *Results* section. In the LS, the semidiurnal q^* ranges from 0.6 to 0.8 and the mode-1 semidiurnal q^* ranges from 0.3 to 0.7. In the Nansha Islands, the diurnal q^* ranges from 1.5 to 3.0 and the mode-1 diurnal q^* ranges from 2.0 to 5.0.

(Changes can be found in Lines 13–18 of the revised manuscript.)

11. Table 1. revise caption. The caption promises "associated errors," but no coefficient errors or confidence intervals are shown.

Responses: We are sorry for this error. Table 1 presents the fitted coefficients together with two metrics R^2 and RMSE, which are indicators of the overall model performance rather than errors or uncertainties associated with individual coefficients. To improve clarity, both the table caption and the corresponding sentence in the manuscript have been revised accordingly.

(Changes can be found in Lines 293–296 and 319 of the revised manuscript.)

12. Figure 8. Only D2 results are shown, although performance claims are made for both bands.

Responses: We are sorry for this information gap. Figure 8 has been expanded to show the time-series comparisons between the predicted q^* and actual q^* for each combination of region and tidal band, namely, (a) LS-D1, (b) LS-D2, (c) Nansha-D1, and (d) Nansha-D2. The revised Fig. 8 is provided below as Fig. R2.

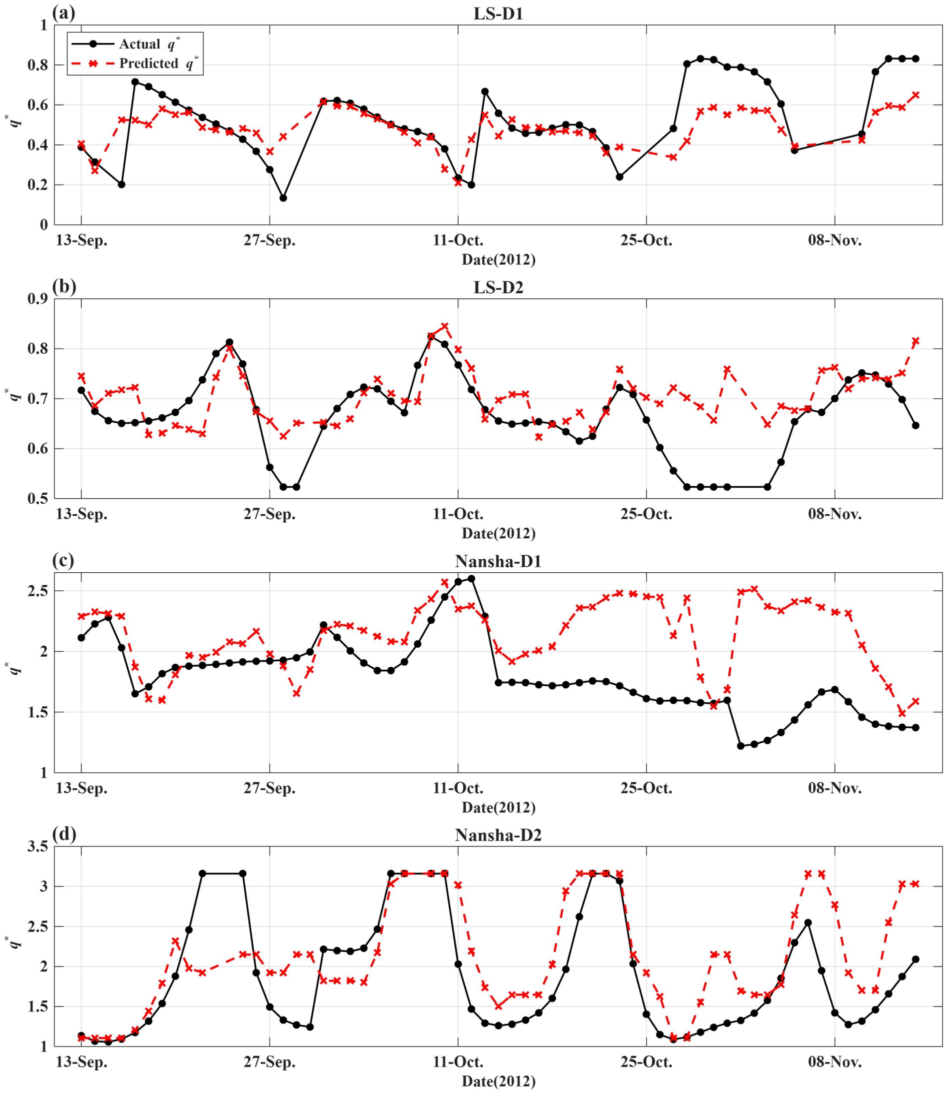

Figure R2. Time series of the predicted q^* from the XGBoost model and the actual q^* for the diurnal (D1) and semidiurnal (D2) tides in the LS and the Nansha Islands.

(Changes can be found in Lines 340–342 of the revised manuscript.)

13. Please discuss uncertainty associated with approximately 2-km horizontal resolution, unresolved wave breaking, numerical mixing, and the residual method.

Responses: We are sorry for this information gap. A new paragraph outlining the limitations of our study has been added at the end of the *Summary* section.

The horizontal grid spacing of LLC4320 output is approximately 2 km in the study region, at which the major topographic features and the low-mode internal tides are explicitly resolved. However, the small-scale topographic features, the high-mode internal tides with shorter horizontal wavelengths, the internal wave breaking and the associated turbulence remain subgrid-scale processes and hence are not resolved. Consequently, internal tide generation driven by the unresolved roughness is missing in the simulation, and the energy cascading to the subgrid-scale processes is instead dissipated via the parameterized viscosity and diffusivity, the bottom drag, and the numerical damping.

Because the present dissipation estimate (DIS_{bc}) is obtained as the residual of the simplified baroclinic energy budget equation, it conflates multiple physical and numerical processes such as the parameterized viscosity, diffusivity, and bottom drag, the numerical mixing and damping. The full energy budget cannot be closed with the archived model output, and these individual contributions cannot be quantified separately. Therefore, DIS_{bc} represents an inferred dissipation integrated over the study region rather than a diagnosed dissipation from the model at individual topographic features. Since DIS_{bc} appears in the numerator of q^*, its uncertainty propagates directly into the estimate of q^*. Crucially, the relative uncertainty of q^* is amplified where the area-integrated local conversion is weak. Such uncertainty is particularly pronounced over rough topography and for higher-mode internal tides (Vic et al., 2019). Future work with higher-resolution simulations and diagnostics of the individual dissipative terms is expected to separate and quantify these contributions.

(Changes can be found in Lines 376–390 of the revised manuscript.)

14. Equations and notation. Please define all symbols upon first use and ensure consistent notation, signs. Also clarify the sign conventions for Conv, (div F), and (DIS_bc).

Responses: We are sorry for this information gap. All equations and their accompanying descriptions have been checked and revised. Each symbol is explicitly defined at its first appearance, the notation and sign are applied consistently throughout the revised manuscript, and the sign is clearly stated in the *Methods* section. Specifically, a positive *Conv* denotes conversion from barotropic to baroclinic energy, that is, local internal tide generation; a negative *Conv* denotes the reverse (baroclinic-to-barotropic) conversion. A positive divergence of ***F*** indicates outward propagation of internal tidal energy from the local region; a negative divergence of ***F*** indicates convergence of energy flux from the far field. A positive DIS_{bc} denotes net dissipation of baroclinic energy inferred from the energy budget equation; a negative DIS_{bc} denotes a net gain of baroclinic energy. Such negative DIS_{bc} values can occur for individual vertical modes when the divergence of baroclinic energy flux for the mode exceeds its local conversion, indicating energy input from other vertical modes via inter-mode transfer.

(Changes can be found in Lines 122–123, 147–150, and 152–155 of the revised manuscript.)