**Response to Referee #2' Comments**

**Response to Major comments**

1) Dust concentration and dust flux were derived through inversion from multiple datasets, which inherently involve various uncertainties that may affect the reliability of the results. These include the spatiotemporal sampling limitations of CATS, potential errors in the mass extinction efficiency (MEE) values, and uncertainties related to wavelength extrapolation between CALIPSO and CATS. It is recommended that the authors add a dedicated section (either in the main text or as an appendix) to qualitatively or quantitatively discuss these error sources and their potential impacts on the key conclusions. This would significantly improve the completeness and credibility of the study.

**Response:** Thank you for the suggestion. We have added a dedicated Section 3.7 in the main text to systematically address the retrieval uncertainties of dust concentration and flux. The discussion covered uncertainties arising from the selection of the mass extinction efficiency (MEE), CATS sampling and cloud-aerosol discrimination, extinction wavelength conversion, and wind fields. Based on this analysis, we estimated that the overall uncertainty in dust mass concentration is approximately 10–20%, while that in dust flux is about 25–45%.

2)The authors used the wavelength ratio from CALIPSO at 1064/532 nm to convert the CATS 1064 nm extinction data. The accuracy of the dust extinction coefficient derived through this approach remains unclear. It is advisable to further validate the quality of the CATS dust extinction inversion over the study region, for instance, by comparing with independent measurements or other relevant datasets.

**Response:** Thanks for the suggestion. We have included a comparison between CATS and the CALIPSO L3 product at 532 nm to evaluate the practical performance of the wavelength conversion.

As illustrated in Fig. S6 (in the supplement), the springtime vertical profiles of dust extinction coefficients over three representative regions demonstrated that CATS captured the main dust distribution patterns, their typical decrease with height, and relevant regional differences. For instance, dust over the Thar Desert was strongest near the surface and declines rapidly with height, whereas a distinct elevated dust layer around ~3 km above sea level was present over the Taklamakan Desert. However, CATS exhibited a slight positive bias in the mid-troposphere (~4–6 km) relative to CALIPSO. The full-year scatter statistics (Fig. S7 in the supplement) further showed good regional-scale agreement between the two datasets, with high correlation (r = 0.88) and low errors (Mean Bias ≈ 0.01 $km^{-1}$, MAE ≈ 0.01 $km^{-1}$, RMSE ≈ 0.02 $km^{-1}$). These results demonstrated that CATS retrievals reliably captured the spatiotemporal variability and relative magnitude of dust extinction, and were suitable for analyzing dust spatial distribution, seasonal cycles, and diurnal characteristics.

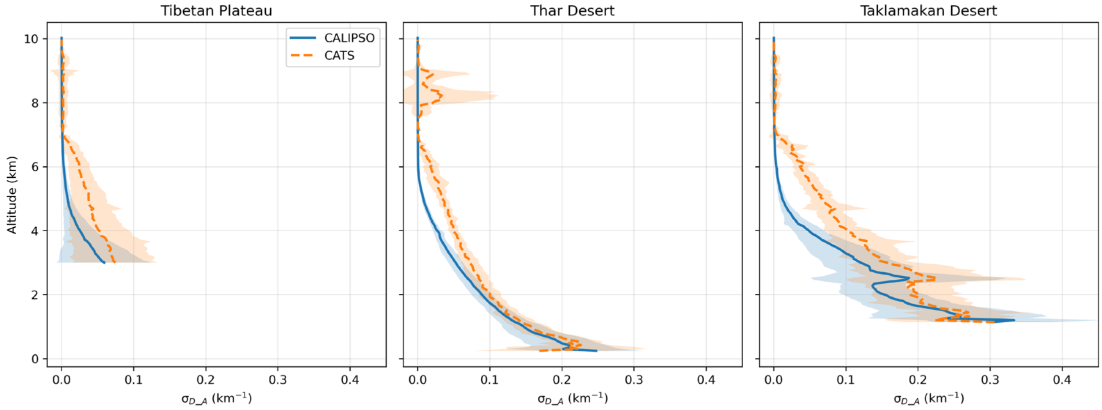


**Figure S6.** Comparison of springtime $\sigma_{D\_A}$ profiles at 532 nm between CATS and CALIPSO.

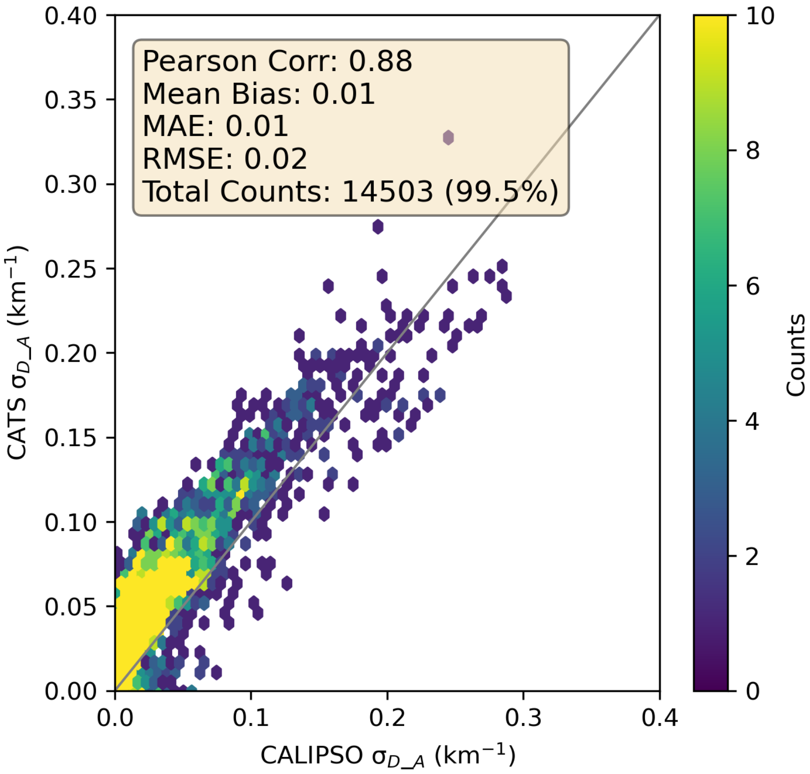


**Figure S7.** Comparison of annual-mean $\sigma_{D\_A}$ at 532 nm between CATS and CALIPSO Level 3 data. The number in parentheses following the total sample size indicated the percentage of samples retained after removing outliers using the interquartile range (IQR) method.

3)The formula used for the "Dust Exposure" metric appears relatively simplistic and lacks a solid scientific rationale. The authors should provide further justification for the theoretical basis of this indicator and clarify its applicable scope and limitations.

**Response:** Thanks for the comment. We agree that this metric was overly simplistic and lacked a solid theoretical basis. Therefore, we have removed this part from the revised manuscript.

4)While the study estimates dust input from surrounding deserts to the plateau via cross-sectional flux integration, as well as the contribution from the Qaidam Basin to downstream regions, the potential influence of locally emitted dust from within the Tibetan Plateau itself is not sufficiently addressed. Differentiating between the contributions of local soil erosion and long-range transported dust would add significant value to the analysis.

**Response:** Thanks a lot for the suggestion. We agree that it is important to distinguish between local dust emissions on the Tibetan Plateau and dust transported from distant sources. We would like to clarify that this study focused on quantifying two dust-related processes from a flux perspective. To do this, we first used boundaries S1–S4 to estimate the inflow of externally transported dust into the Tibetan Plateau. We then treated the Qaidam Basin as a major local dust source and used transects X1–X2 to estimate its net downwind export. In this way, our analysis already accounted for both external dust inflow and local dust sources within the Plateau.

Our results indicated clear annual differences in external dust inflow across the boundary transects S1–S4. The northern pathways (S1+S2) serve as the dominant route, with an inflow magnitude of about 10.2 $Tg \cdot yr^{-1}$. For local dust sources within the Plateau, the Qaidam Basin showed an annual net export of about 6063 $ton \cdot km^{-1}$, as estimated from transects X1–X2, with the largest contribution occurring in spring. Overall, these results indicated that—at the transport/export flux scale examined here—the dust budget over the Tibetan Plateau was influenced both by long-range inflow from surrounding deserts and by outflow from internal dust-source regions such as the Qaidam Basin.

We also highlight that local dust emissions from wind erosion require more precise parameterization and inventory support. Our satellite-based approach instead characterized column dust loading, advective transport, and net regional export. Therefore, within the current framework, we quantified the internal dust contribution from the Plateau in a representative manner by estimating the net export from local source regions such as the Qaidam Basin. This approach provided flux-based evidence that allowed direct comparison between local contributions and external transport, without introducing additional assumptions from emission models. We appreciate the reviewer's point and consider it an important direction for future work, which could include incorporating emission parameterizations and further resolving dust contributions from different land-surface types within the Plateau.

**Response to Minor comments**

1)The points of innovation are currently scattered throughout the manuscript. They should be clearly and concisely summarized in both the introduction and conclusion.

**Response:** Thank you for the constructive comments. We agree that the innovation of the original manuscript was scattered across the abstract, methods, and results sections, which weakened the clarity of the scientific storyline. To address this, we have consolidated the key innovations in the introduction and conclusion of the revised manuscript and presented them in a coherent, echoing manner.

2)In several figures (e.g., Figures 5 and 7), the axis labels, legend text, and color bar scales are too small, making them difficult to read even when zoomed in. It is recommended to increase the font sizes appropriately to improve readability.

**Response:** Thank you for the reminder. We have improved the previously unclear figures, including Fig. 5 (now Fig. 4) and Fig. 7 (now Fig. 6).

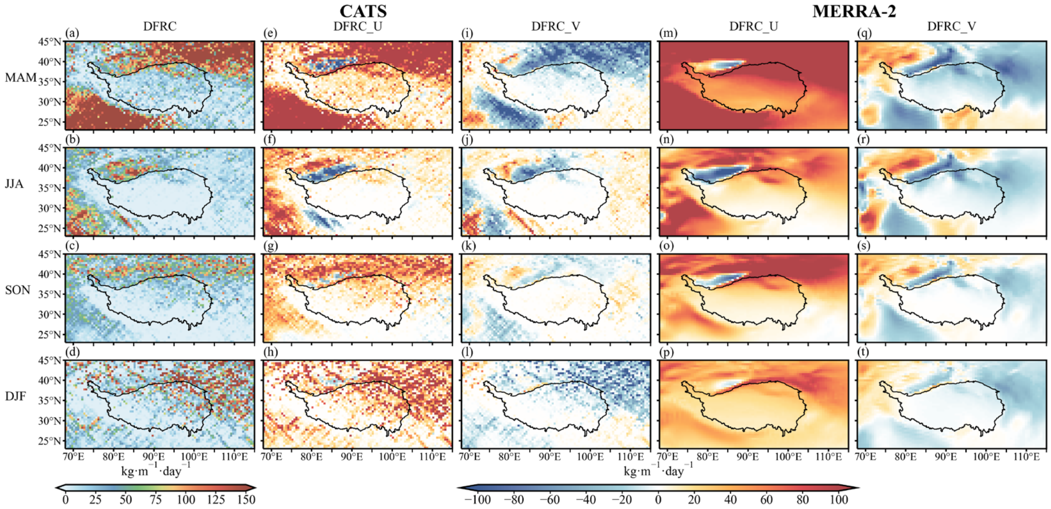


**Figure 5.** Seasonal distribution of CATS DFRC ($kg \cdot m^{-1} \cdot day^{-1}$, a-d), and DFRC_U and DFRC_V from CATS ($kg \cdot m^{-1} \cdot day^{-1}$, e-l) and MERRA-2 (m-t) datasets during the period from March 2015 to October 2017, respectively. (Positive values of DFRC_U and DFRC_V corresponded to eastward and northward transport, respectively.)

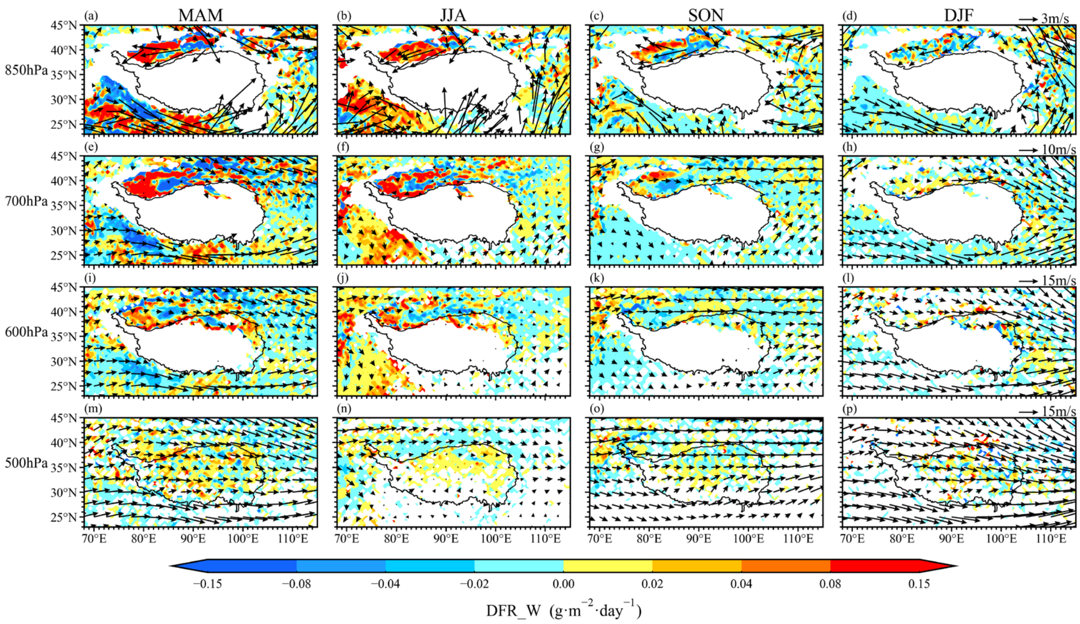


**Figure 7.** Seasonal distribution of DFR_W (dust flux rates at vertical direction, $g \cdot m^{-2} \cdot day^{-1}$) at four pressure levels from CATS during the period from March 2015 to October 2017. (The arrows represent the horizontal wind field. The positive values of DFR_W corresponded to upward transport.)

3)The latitude and longitude ranges of the cross-sectional lines (S1–S4, X1–X2) in Figure 1 should be clearly labeled to enhance interpretability.

**Response:** Thank you for the suggestion. We have added the latitude–longitude ranges for each transect in the caption of Fig. 1.

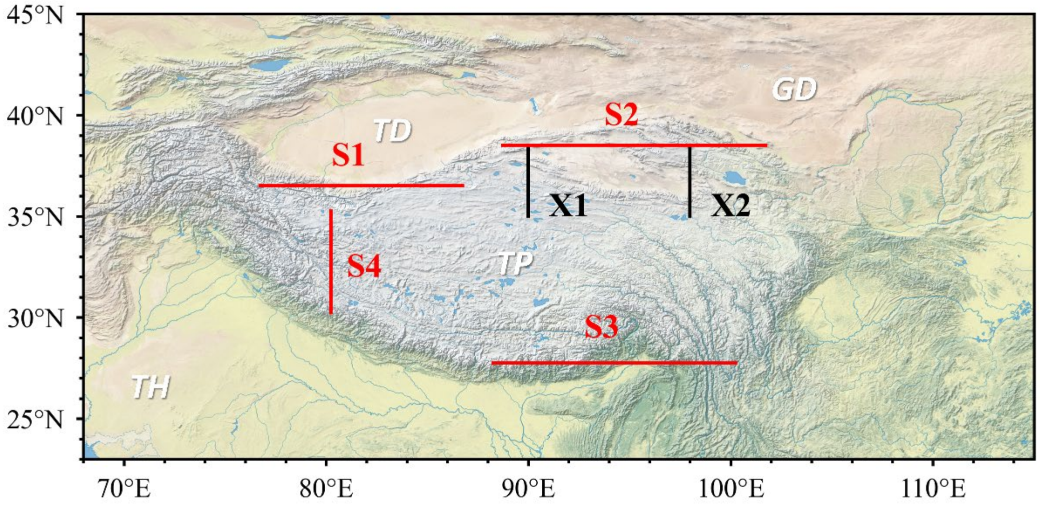


**Figure 1.** The topography of the study aera (23-45°N, 68-115°E). S1 to S4 (S1: 36.5°N, 76.75–86.75°E; S2: 38.5°N, 88.75–101.75°E; S3: 27.75°N, 88.25–100.25°E; S4: 30.25–35.25°N, 80.25°E) were the selected boundaries for the TP-ward dust flux calculation and X1 to X2 (X1: 35–38.5°N, 90°E; X2: 35–38.5°N, 98°E) were used to quantify the dust contribution of the Qaidam Basin to downstream regions.TD, TP, TH, GD are Taklimakan Desert, Tibetan Plateau, Thar Desert and Gobi Desert. Base map data sourced from the Natural Earth dataset.