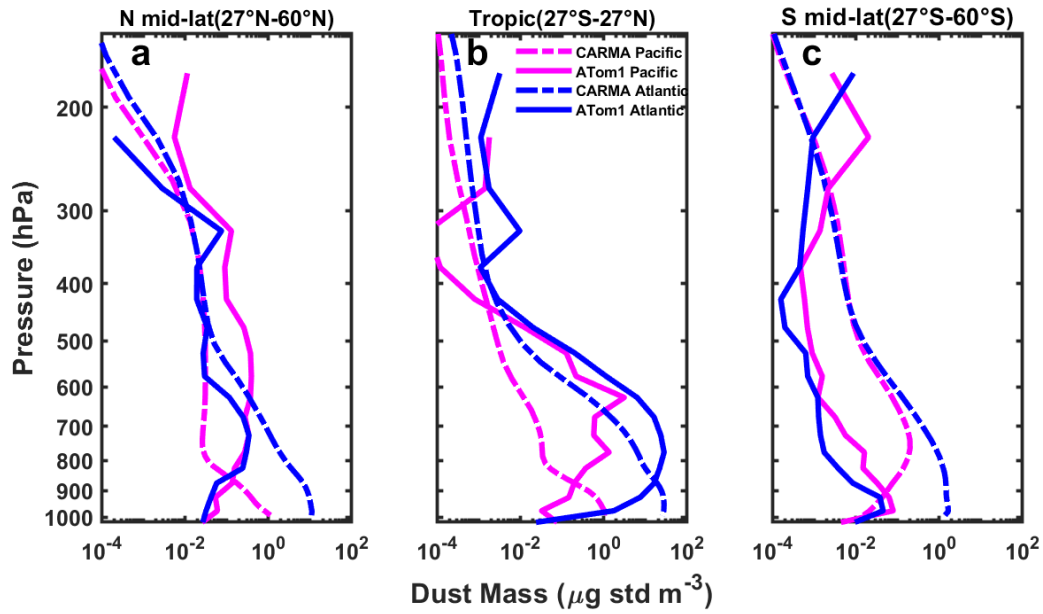


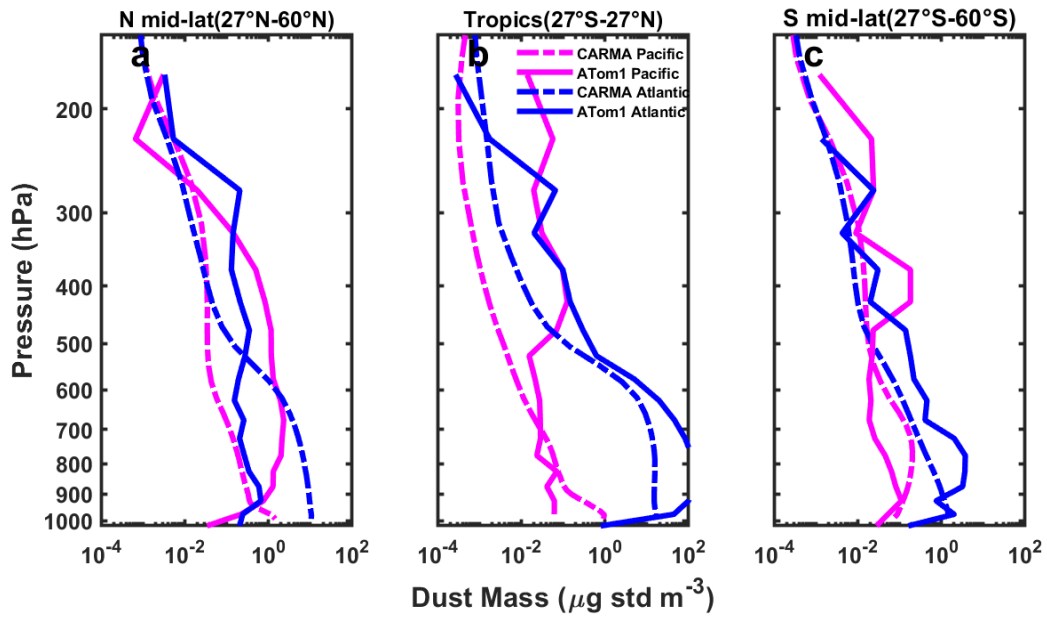
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**Figure S1.** The dust mass concentration averaged for different latitude bands (same as Figure 5) below 0.2 km and above 5 km during the ATom1 field campaign. The green and pink bar denoted coarse-mode (with diameter greater than 4.5 µm) and fine mode (with diameter less than 4.5 µm) dust mass concentration, respectively. Lines (right axis) present the coarse mode dust concentrations fraction of total dust (cyan).



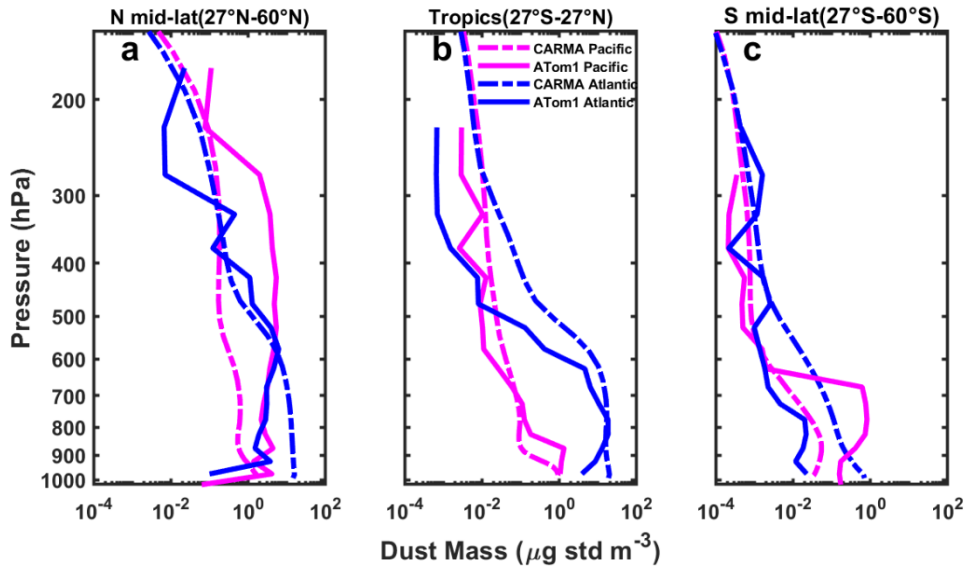
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**Figure S2.** Simulated (long dash line) and measured (solid line) vertical profiles of the dust concentrations in February 2017 during the ATom2 field campaign. Graphs are equivalent to Figure 5. The profiles are averaged over the Pacific Ocean (pink) or Atlantic Ocean (blue) in the Northern Hemisphere midlatitudes (27°N-60°N, panel a) and tropics (27°S-27°N, panel b), and in the Southern Hemisphere midlatitudes (27°S-60°S, panel c).



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**Figure S3.** Simulated (long dash line) and measured (solid line) vertical profiles of the dust concentrations in October 2017 during the ATom3 field campaign. Graphs are equivalent to Figure S2.

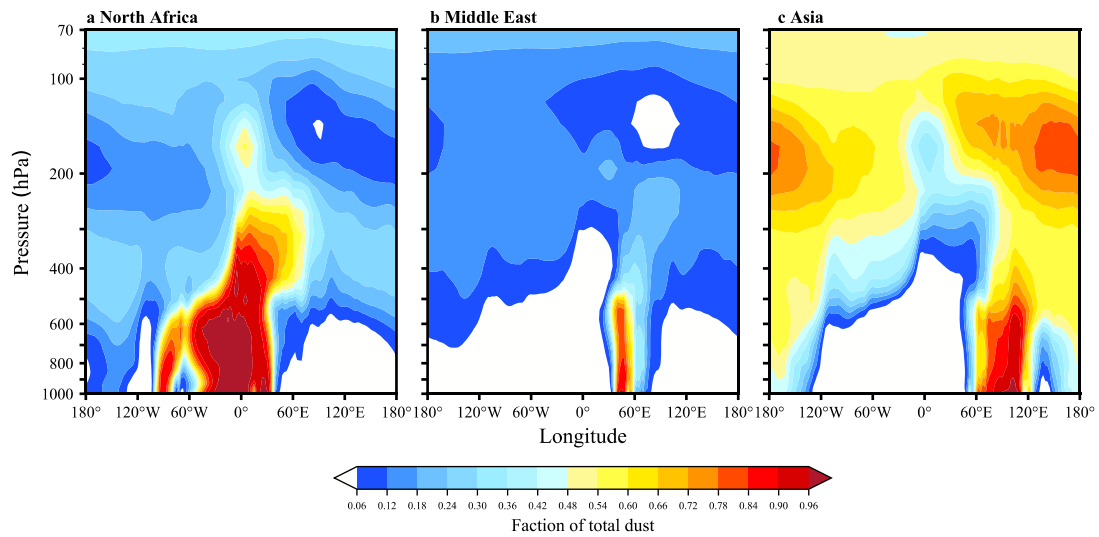


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24 **Figure S4.** Simulated (long dash line) and measured (solid line) vertical profiles of the dust

25 concentrations in May 2018 during the ATom4 field campaign. Graphs are equivalent to Figure S2.



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27 **Figure S5.** Simulation of each dust source's fractional contribution to total dust as a function of altitude  
 28 (left axis) and longitude (bottom axis). Shading indicates dust concentration.

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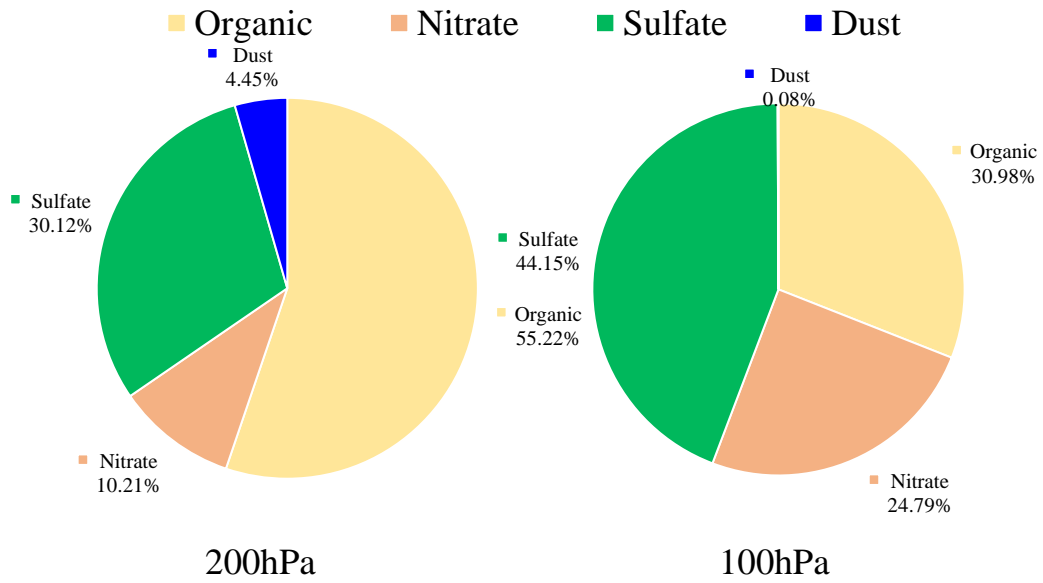
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42 **Figure S6.** (a) Simulated mass fractions of dust, organics, nitrate and sulfate at 200 mb in the Asian

43 summer monsoon (ASM); (b) same as (A) but for mass fractions at 100 mb.

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