SUPPLEMENT FOR

Measurement report: Vanadium-containing ship exhaust particles detected in and above the marine boundary layer in the remote atmosphere

Maya Abou-Ghanem,[1] Daniel M. Murphy[1], Gregory P. Schill,[1] Michael J. Lawler,[1,2] and Karl D. Froyd[1,2]

[1] Chemical Sciences Laboratory, National Oceanic and Atmospheric Administration, Boulder, CO, USA
[2] Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO, USA

ORCID

Maya Abou-Ghanem	0000-0003-1417-8937
Daniel M. Murphy	0000-0002-8091-7235
Gregory P. Schill	0000-0002-4084-0317
Michael J. Lawler	0000-0003-0421-6629
Karl D. Froyd	0000-0002-0797-6028

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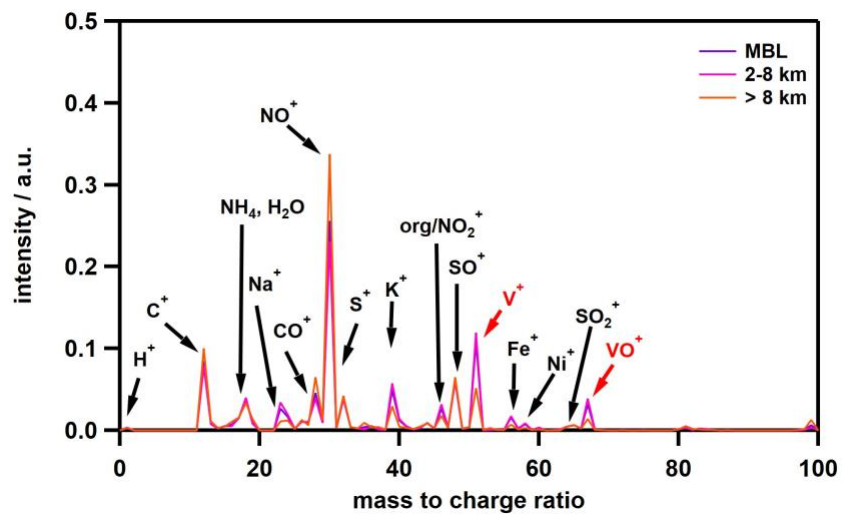
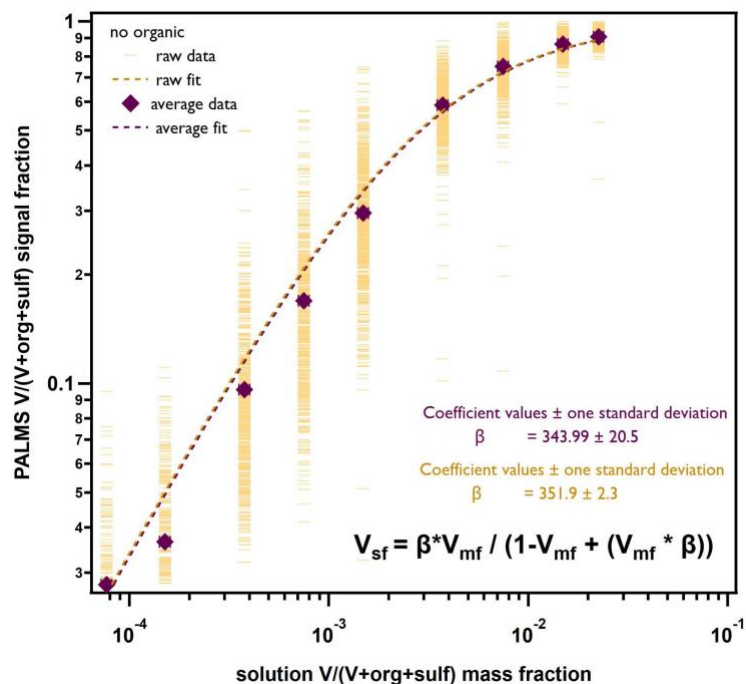


Figure S1: Mass spectra degraded to unit mass resolution for average mass spectra comparisons of vanadium-containing ship exhaust particles measured during ATom 4 at varying altitudes

a)

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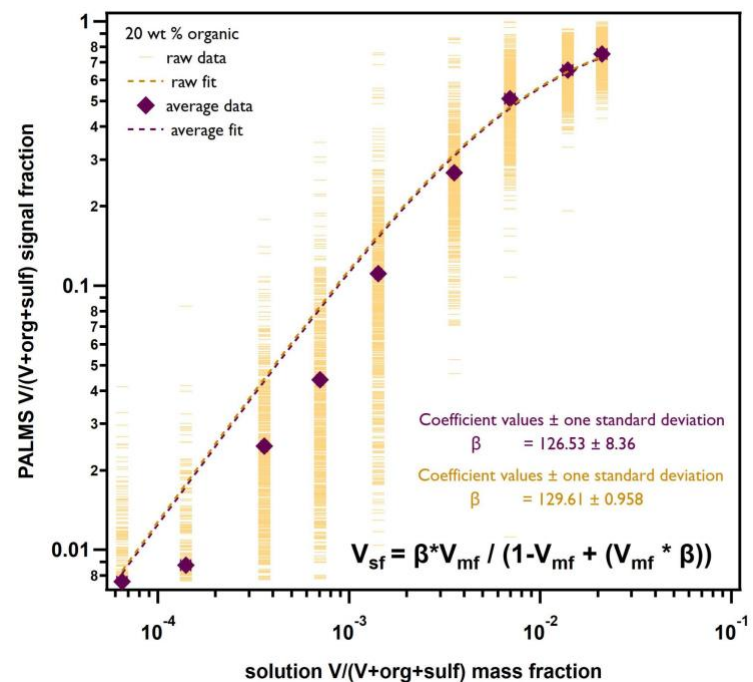
Figure S2: Vanadium ion signals normalized to the sum of vanadium, organic, and sulfate ion signals as a function vanadium single-particle mass fraction for 9 calibration standards for a) solutions without added organics and b) solutions with 20 wt % organics. The yellow lines and purple diamonds indicate raw data for individual particles and average values for a given standard, respectively. The error bars represent the uncertainty in the degree of hydration (3-5) for the vanadium(IV) oxide sulfate hydrate. In most cases, these error bars are too small to be seen. The yellow and purple dotted lines represent exponential fits for the raw and averaged data, respectively.
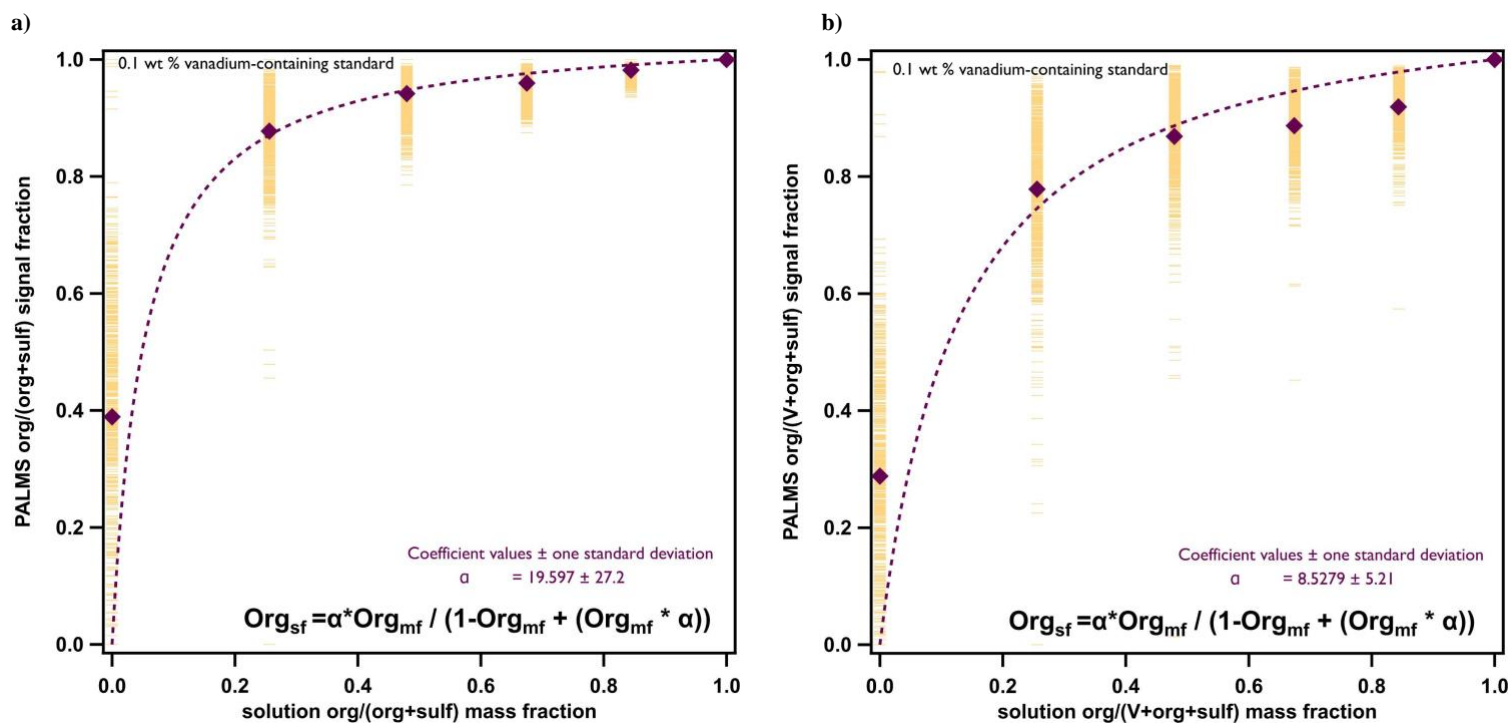
Figure S3: Organic ion signals as a function organic single-particle mass fraction for 5 calibration standards in a 0.1 wt % vanadium-containing standard solution for organic ion signals a) normalized to the sum of the organic and sulfate signals and b) normalized to the sum of the vanadium, organic, and sulfate signals. The yellow lines and purple diamonds indicate raw data for individual particles and average values for a given standard, respectively. The purple dotted line represents an exponential fit for the averaged data.
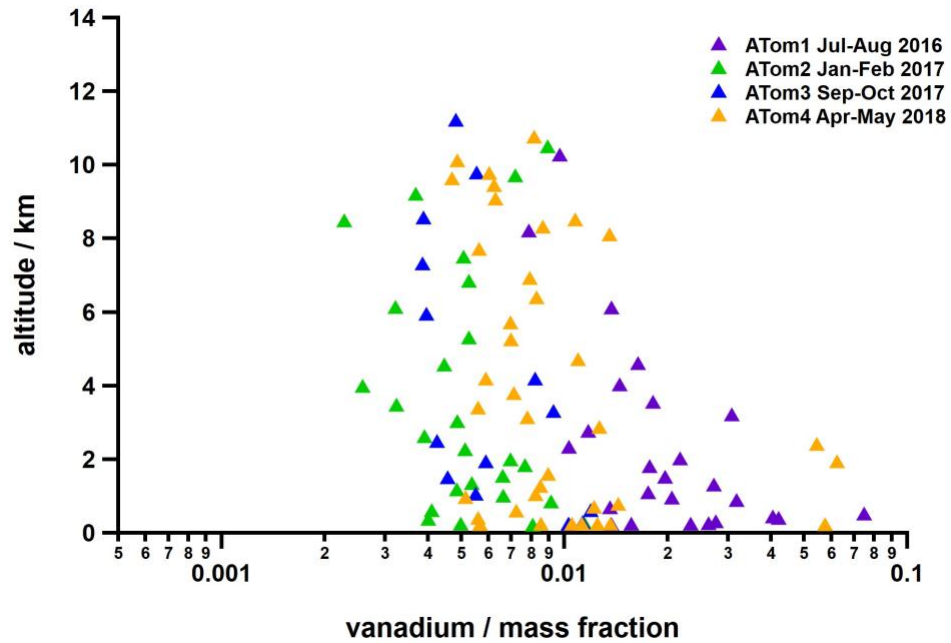
Figure S4: Sampling altitude as a function of vanadium single-particle mass fraction for vanadium-containing ship exhaust particles measured during ATom 1-4 with 20 particle averages. Each colored triangle represents a different ATom campaign.