SABRE: Stratospheric Aerosol processes, Budget and Radiative Effects

Adam Ahern

CIRES Research Scientist funded by CIESRDS agreement

NOAA Chemical Sciences Lab (CSL)

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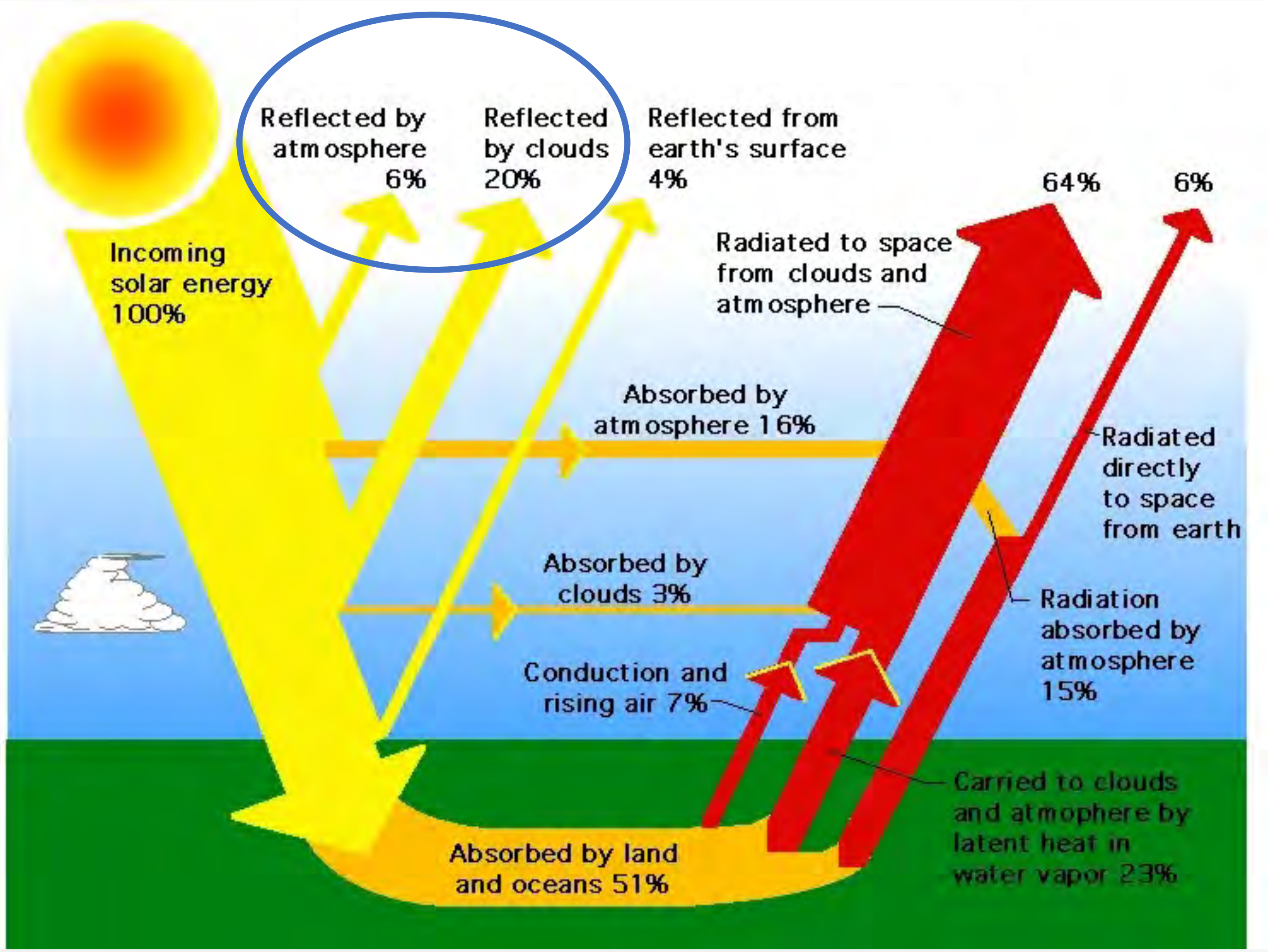
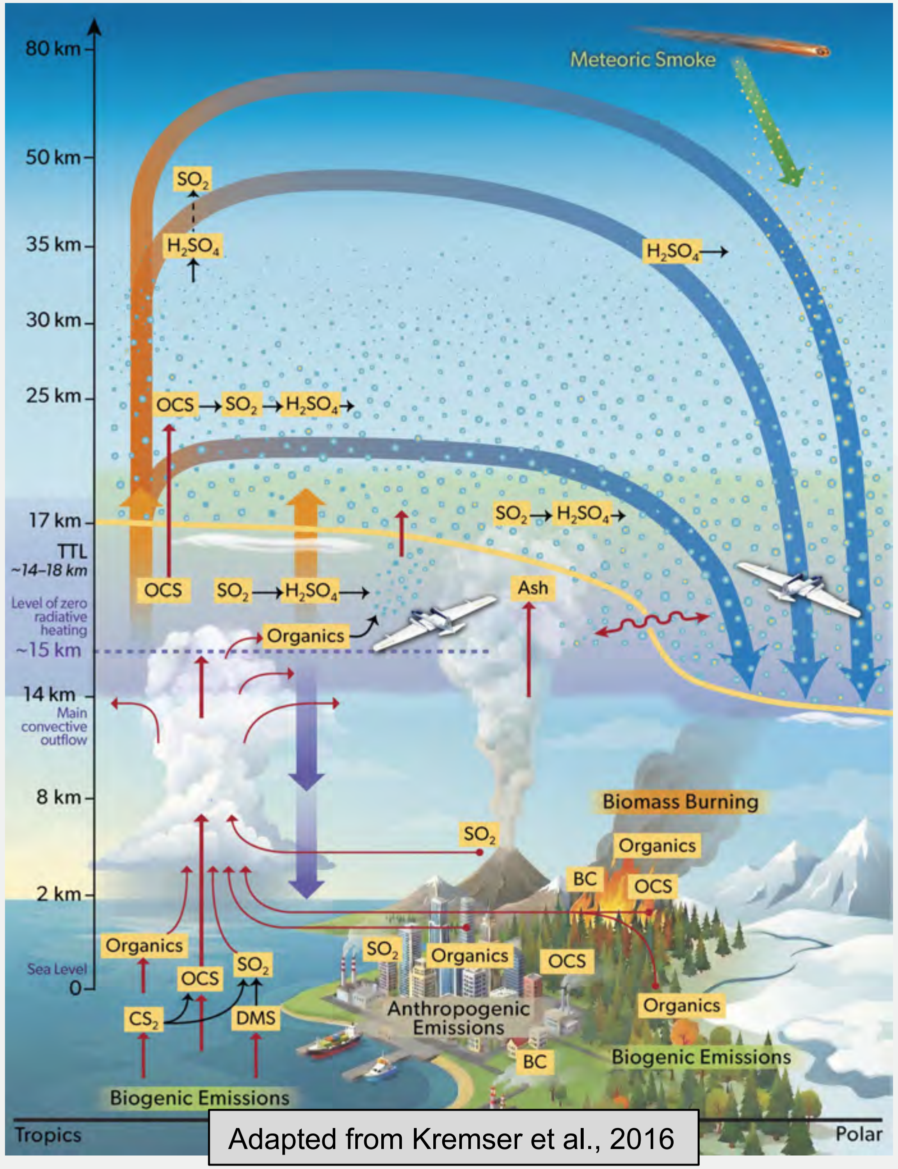
An incomplete snapshot of the SABRE team

Earth's Radiative Budget (ERB)



Source: NASA GMP

SABRE Science



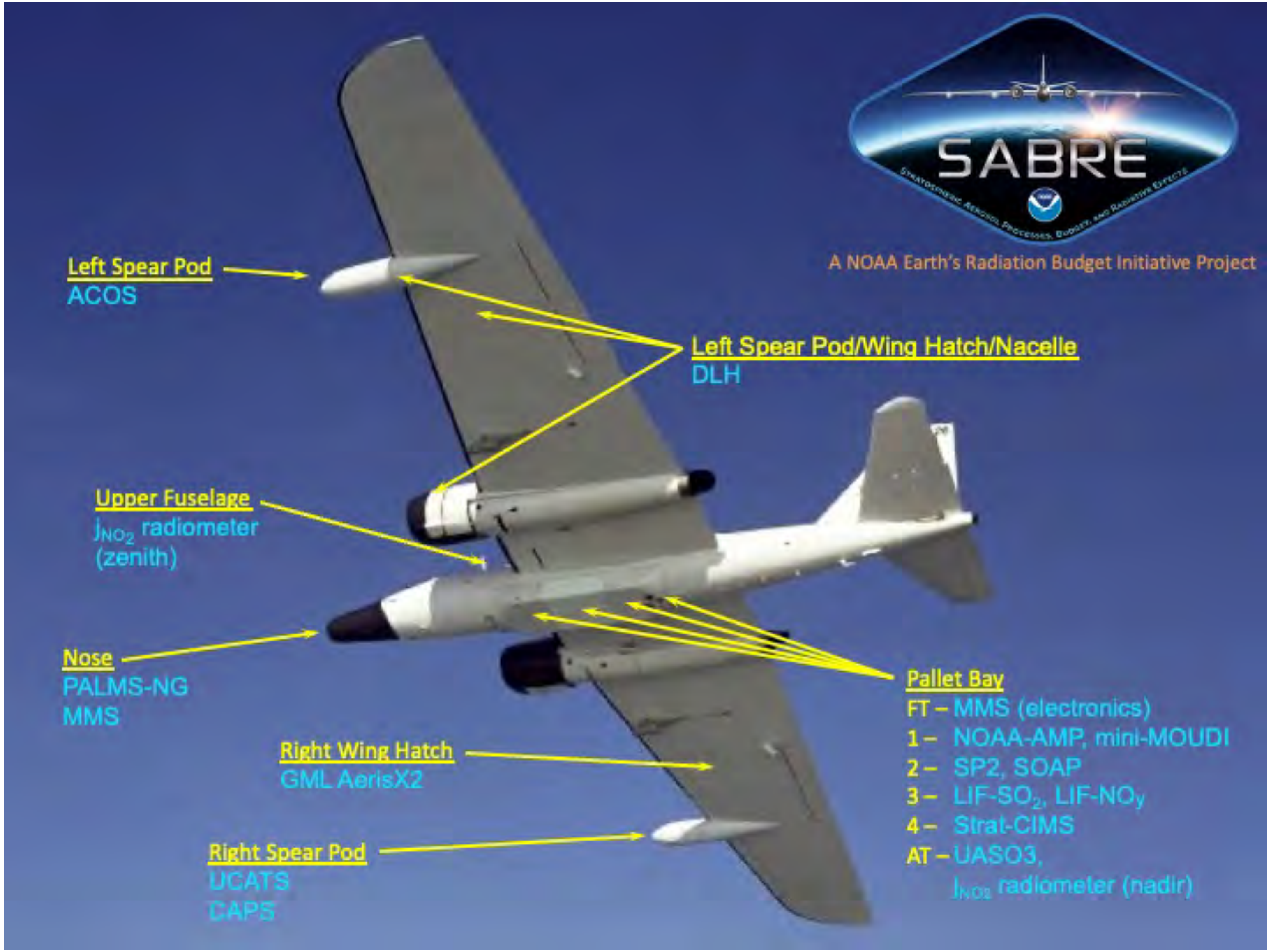
Adapted from Kremser et al., 2016

SABRE science goals include increasing understanding of:

- Stratospheric aerosol microphysics, composition, and optical properties
- Stratospheric sulfur budget and non-sulfur contributions to stratospheric aerosol loading
- Impacts of stratospheric aerosols on ozone chemistry and dynamics
- Stratospheric aerosol response to perturbations (volcanic eruptions, pyro-convective injections, rockets)

→ *Assess and improve the representation of stratospheric aerosol processes in models*

When the instrument doesn't exist, we build it.



Particle measurements:

- Aerosol size distribution from 3 nm to super-micron
- Direct aerosol optical extinction measurement
- Aerosol composition from PALMS and BC number and mass from SP2
- Aerosol impactor for off-line particle analysis

Gas-phase measurements:

- SO_2 and OCS
- Dynamical tracers N_2O, CH_4, SF_6
- NO, NO_2 and NO_y
- I^- CIMS measuring halogen species (ClO, BrO, $ClONO_2$) and N_2O_5

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Unexpected discovery during SABRE 2023

PNAS | RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES | OPEN ACCESS

Metals from spacecraft reentry in stratospheric aerosol particles

Daniel M. Murphy[a,b,1], Maya Abou-Ghanem[a], Daniel J. Cziczo[b], Karl D. Froyd[a,c], Justin Jacquot[b], Michael J. Lawler[a,c], Christopher Maloney[a,c], John M. C. Plane[d], Martin N. Ross[e], Gregory P. Schill[a], and Xiaoli Shen[b]

Edited by Mark Thiemens, University of California, San Diego, CA; received August 3, 2023; accepted September 7, 2023

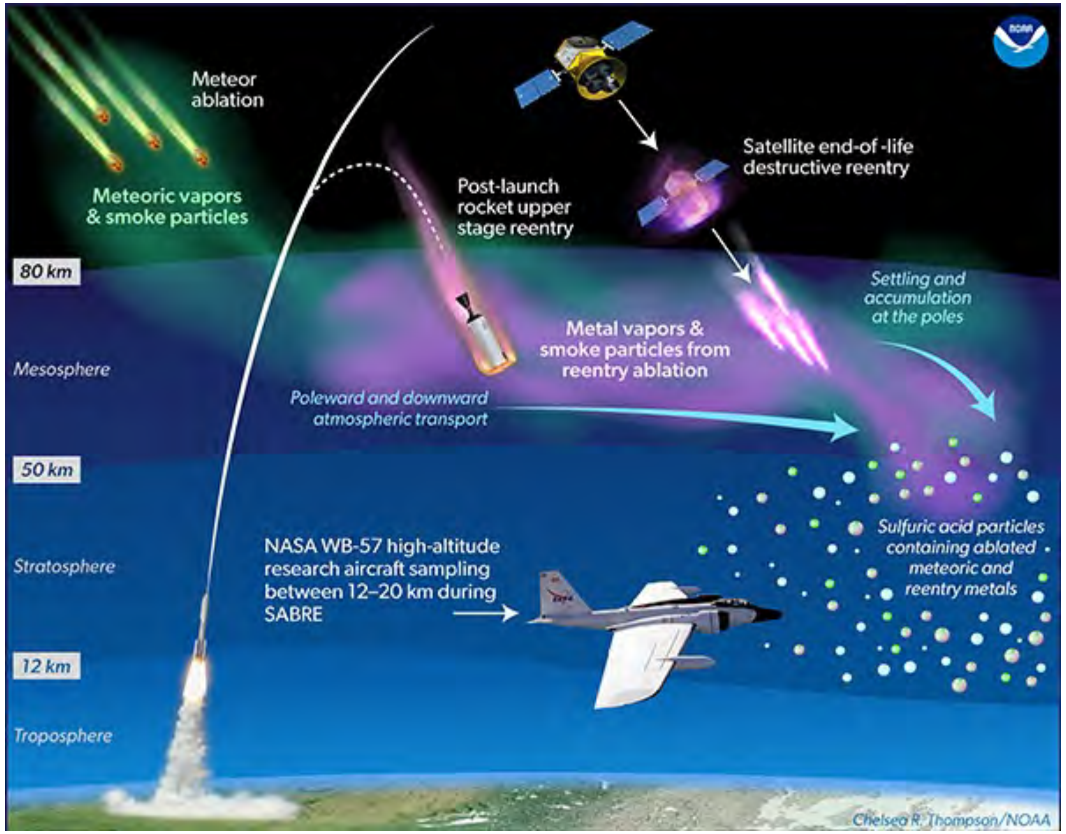
Large increases in the number of low earth orbit satellites are projected in the coming decades [L. Schulz, K.-H. Glassmeier, *Adv. Space Res.* 67, 1002–1025 (2021)] with perhaps 50,000 additional satellites in orbit by 2030 [GAO, Large constellations of satellites: Mitigating environmental and other effects (2022)]. When spent rocket bodies and defunct satellites reenter the atmosphere, they produce metal vapors that condense into aerosol particles that descend into the stratosphere. So far, models of spacecraft reentry have focused on understanding the hazard presented by objects that survive to the surface rather than on the fate of the metals that vaporize. Here, we show that metals that vaporized during spacecraft reentries can be clearly measured in stratospheric sulfuric acid particles. Over 20 elements from reentry were detected and were present in ratios consistent with alloys used in spacecraft. The mass of lithium, aluminum, copper, and lead from the reentry of spacecraft was found to exceed the cosmic dust influx of those metals. About 10% of stratospheric sulfuric acid particles larger than 120 nm in diameter contain aluminum and other elements from spacecraft reentry. Planned increases in the number of low earth orbit satellites within the next few decades could cause up to half of stratospheric sulfuric acid particles to contain metals from reentry. The influence of this level of metallic content on the properties of stratospheric aerosol is unknown.

stratosphere | aerosol | spacecraft | reentry | meteors

Significance

Measurements show that about 10% of the aerosol particles in the stratosphere contain aluminum and other metals that originated from the "burn-up" of satellites and rocket stages during reentry. Although direct health or environmental impacts at ground level are unlikely, these measurements have broad implications for the stratosphere and higher altitudes. With many more launches planned in the coming decades, metals from spacecraft reentry could induce changes in the stratospheric aerosol layer.

Aerosol particles that are formed in the stratosphere are composed primarily of sulfuric

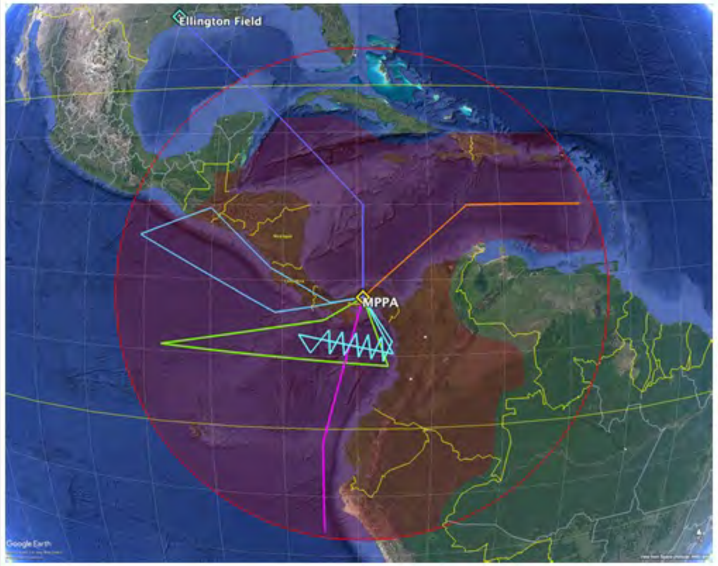


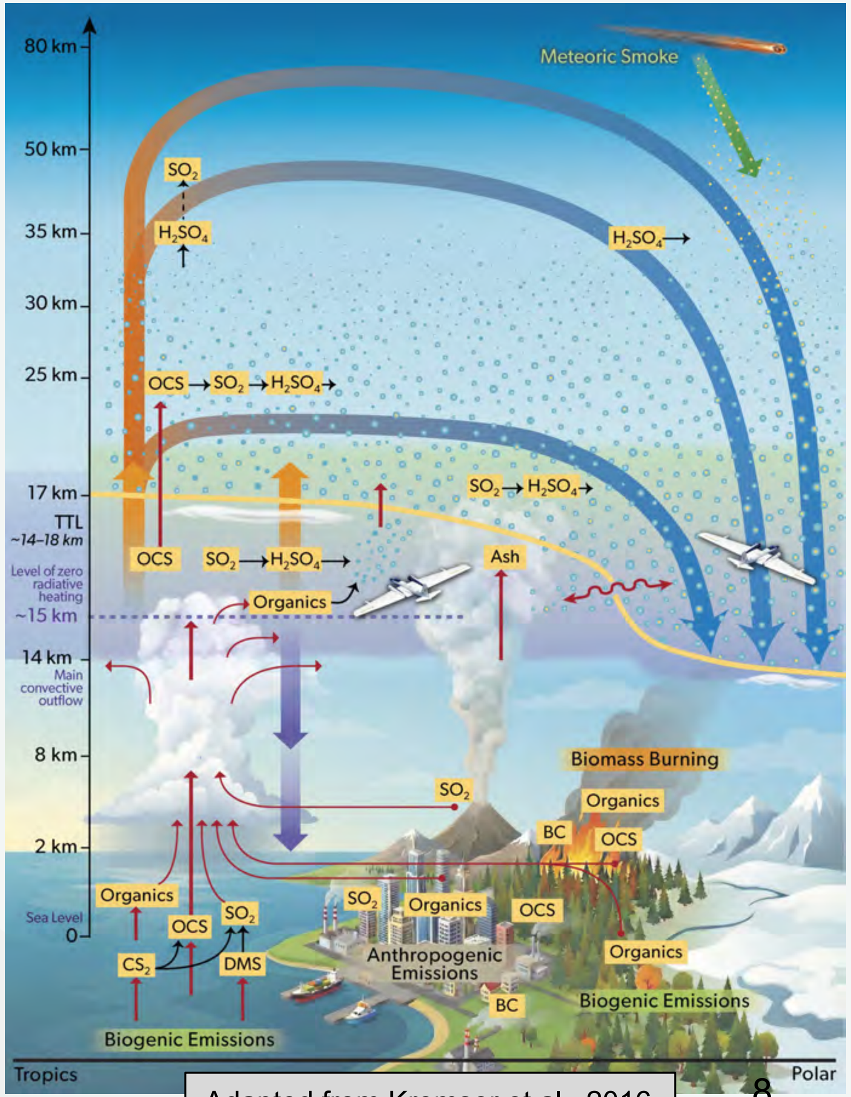
Dan Murphy (NOAA), Gregg Schill (NOAA), Mike Lawler (CIESRDS), Maya Abou-Ghanem (NRC)

July-September 2026 SABRE - Tropics

- Test flights completed in 2025 to evaluate and test new instrumentation and inlets
- Planned deployment in Panama, July-Sept 2026
  - 21 flights
  - 9 weeks
- Equatorial deployment allows access to Tropical Tropopause Layer which is the dominant pathway for material into the stratosphere

Panama Pacifico Airport, Panama





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Thank you!

Questions?

Adam.Ahern@Colorado.edu

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