Environmental Risks of Re-entry Ablation

Eloise Marais, e.marais@ucl.ac.uk, https://maraisresearchgroup.co.uk/
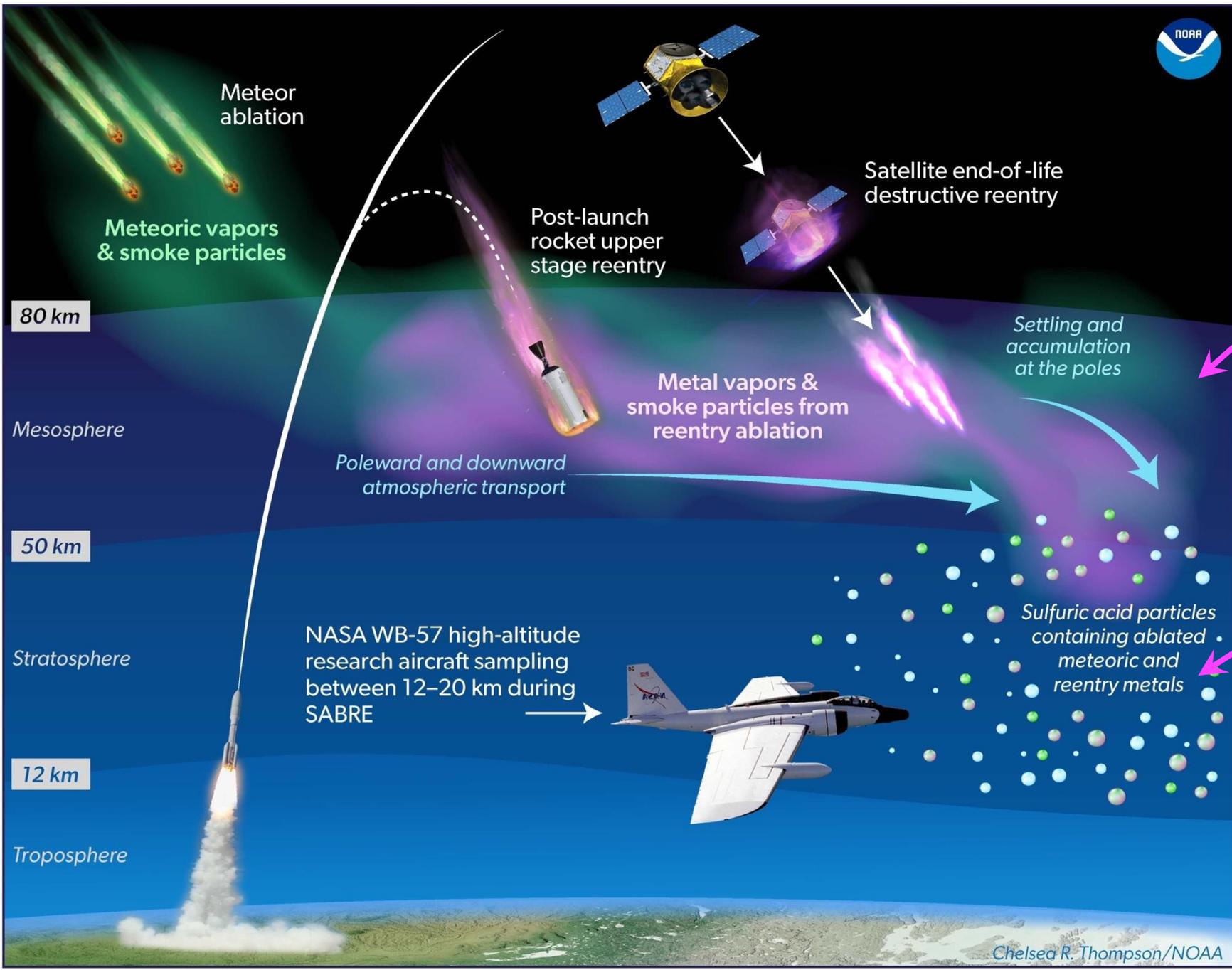
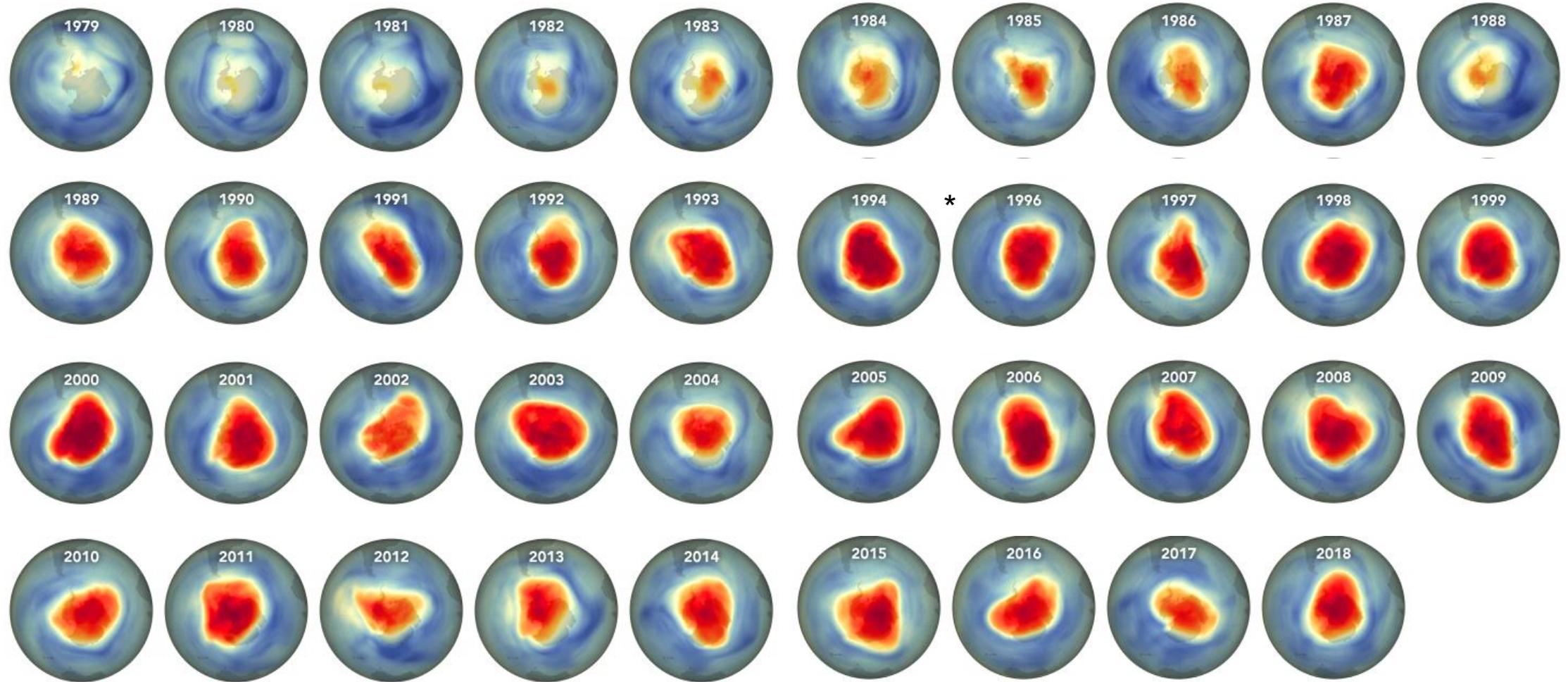**Ablation layer** (50-80 km)

Ozone layer (12-50 km)

10% of particles in stratosphere contaminated with space junk

[Murphy et al., 2023]

Greatest Concern: Slow or Reverse Ozone Recovery
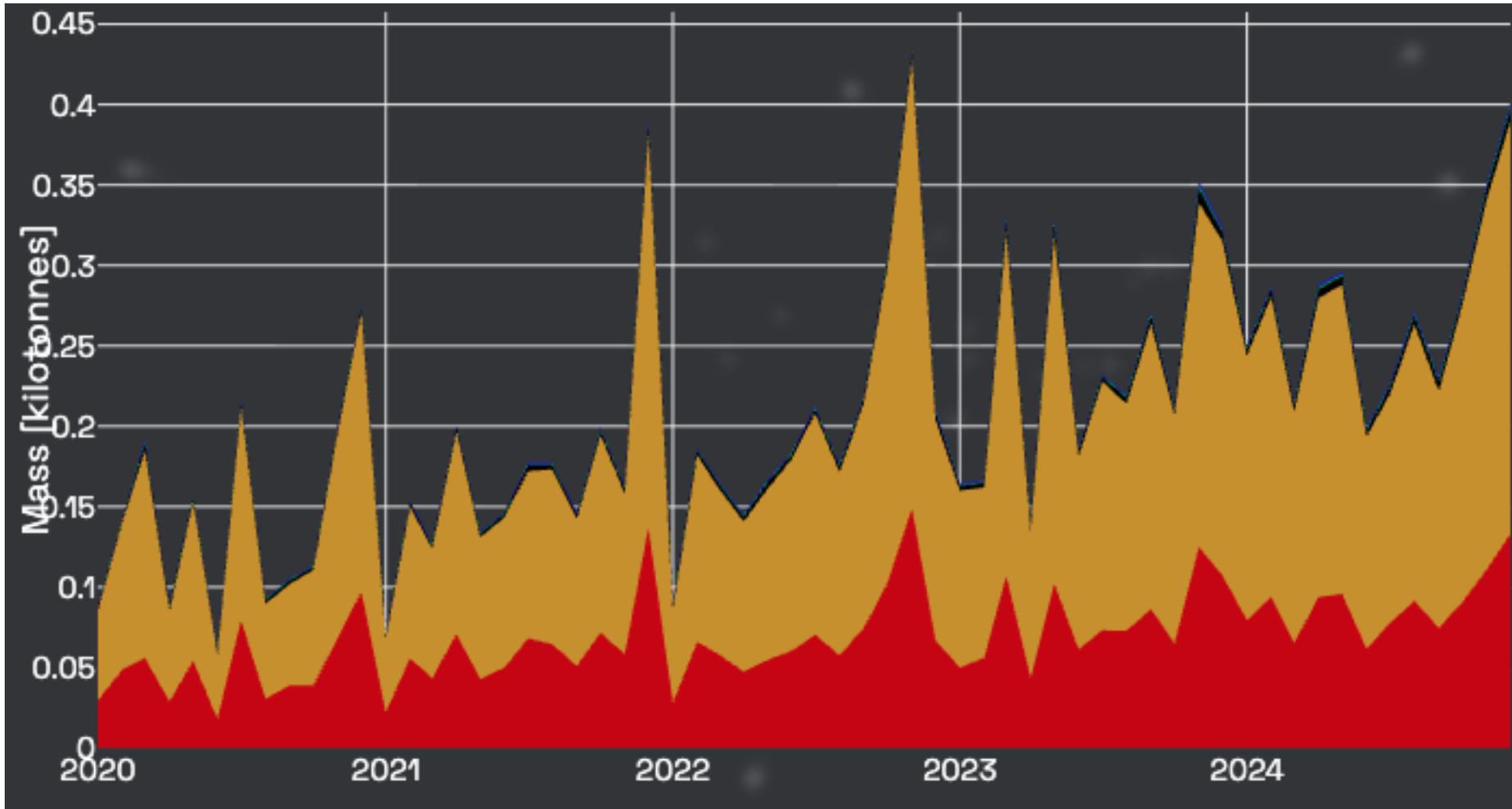
Satellite record of stratospheric ozone over the Antarctic for 1979-2018

* no data in 1995

Inventory of Re-entry Emissions to Track Trends

Global re-entry emissions of pollutants from 2020 to 2024

Recent increases of ~20% pe year due to re-entry of megaconstellation satellites

Many metals (titanium, copper, zinc, lead, lithium, etc.) not shown

UCL spacecraft emissions tracker: https://cbarker211.github.io/reentries.html

Mass of some of the metals from space junk **greater than natural** input from meteors

Combined Impacts of Re-entry Ablation and Launch Pollution

Kerosene (SpaceX)

Pollutants injected into all atmospheric layers by rockets:

Nitrogen oxides

Water vapour

Black carbon (BC)

- Potent climate forcer

- Warms the atmosphere

- Warming speeds up ozone loss reactions

- Warming alters atmospheric circulation patterns

Additional Issues and Useful Links

- Large reliance on models to gain insights into global environmental impacts

- Need observations to evidence impact, and to improve and validate models

- Observations are costly, so requires dedicated sustained funding

- Murphy et al., 2023, https://www.pnas.org/doi/10.1073/pnas.2313374120

UCL Launch Emissions Tracker:

UCL Re-entry Emissions Tracker: