

A million data centre satellites to usher in a new era of space pollution



Scene Setting

SpaceX filing February 2026 to launch 1 million satellites

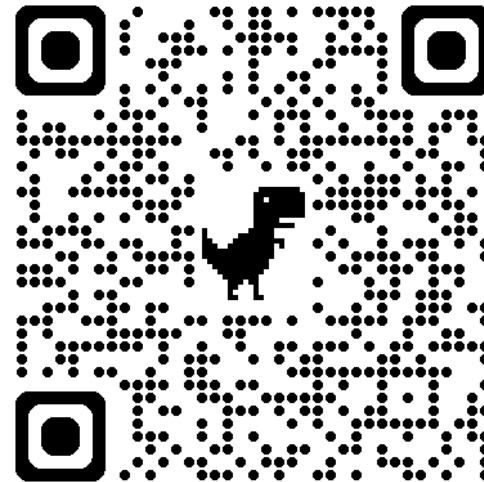
No environmental review

Filings not representative of what happens

Lots of technological challenges for orbital data centres

Many scientific gaps in understanding atmospheric harm

QR code to white paper detailing
uncertainties and a research roadmap :



Insufficient information in filings to enable environmental impact assessment



Tracking emissions from rocket launches and artificial object re-entries

Welcome to this global dataset and interactive explorer covering rocket launch and spacecraft re-entry emissions since the first orbital launch in 1957. The tracker is built on rigorous scientific research, supporting further investigation and regulation of a rapidly growing industry.

1957–2025

Years of launch & re-entry data

7

Emitted chemicals tracked

Global

Coverage of launch sites & re-entries

Click on the links below to view launch or re-entry emissions. ↓

Launch Emissions

Filter emissions by launch site, vehicle, mission type and altitude across nearly seven decades of orbital launches.

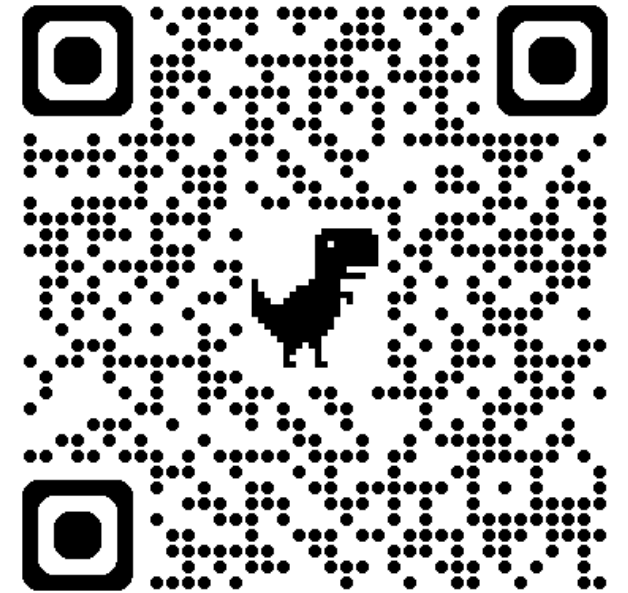
[Explore launches →](#)

Re-entry Emissions

Track the emissions from spacecraft and debris burning up on re-entry, object type and mission.

[Explore re-entries →](#)

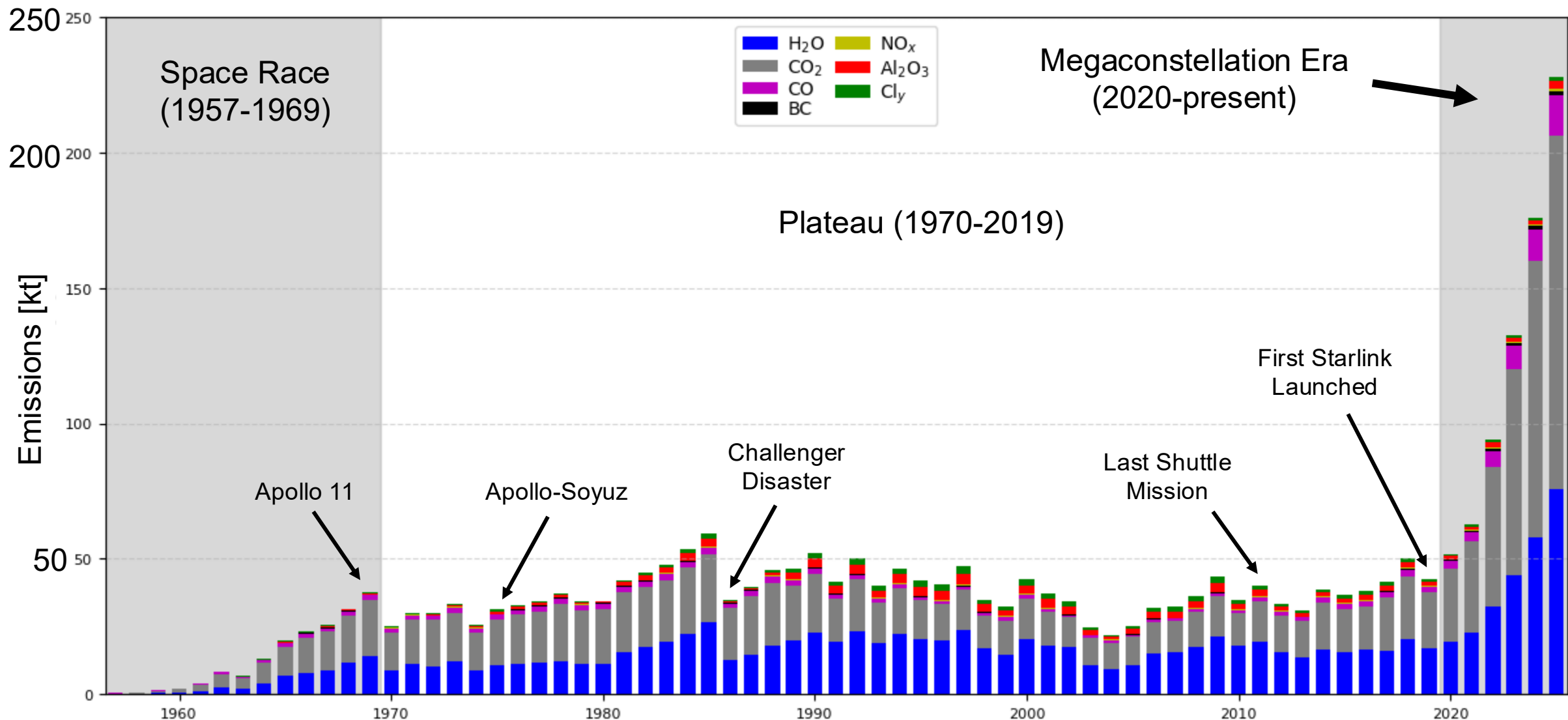
Online Emissions Tracker



Website design and development by **Connor Barker** (UCL postdoc)

In collaboration with
Jonathan McDowell

Air Pollutant and CO₂ Emissions from Rocket Launches 1957-2025



Already in a “new era” of pollution from megaconstellation launches

Similar exponential increase for re-entry pollution

Mix of Chemicals Emitted Determined by Propellant

Mix of pollutants depends on propellant type

Solid



NO_x
 $\text{HCl} + \text{Cl} + \text{Cl}_2$
 Al_2O_3
 H_2O
 BC

Hypergolic



NO_x
 H_2O
 BC

Kerosene or Methane



NO_x
 H_2O
 BC

Cryogenic



NO_x
 H_2O

BC: Black Carbon
 Al_2O_3 : Alumina

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**Climate
concern**

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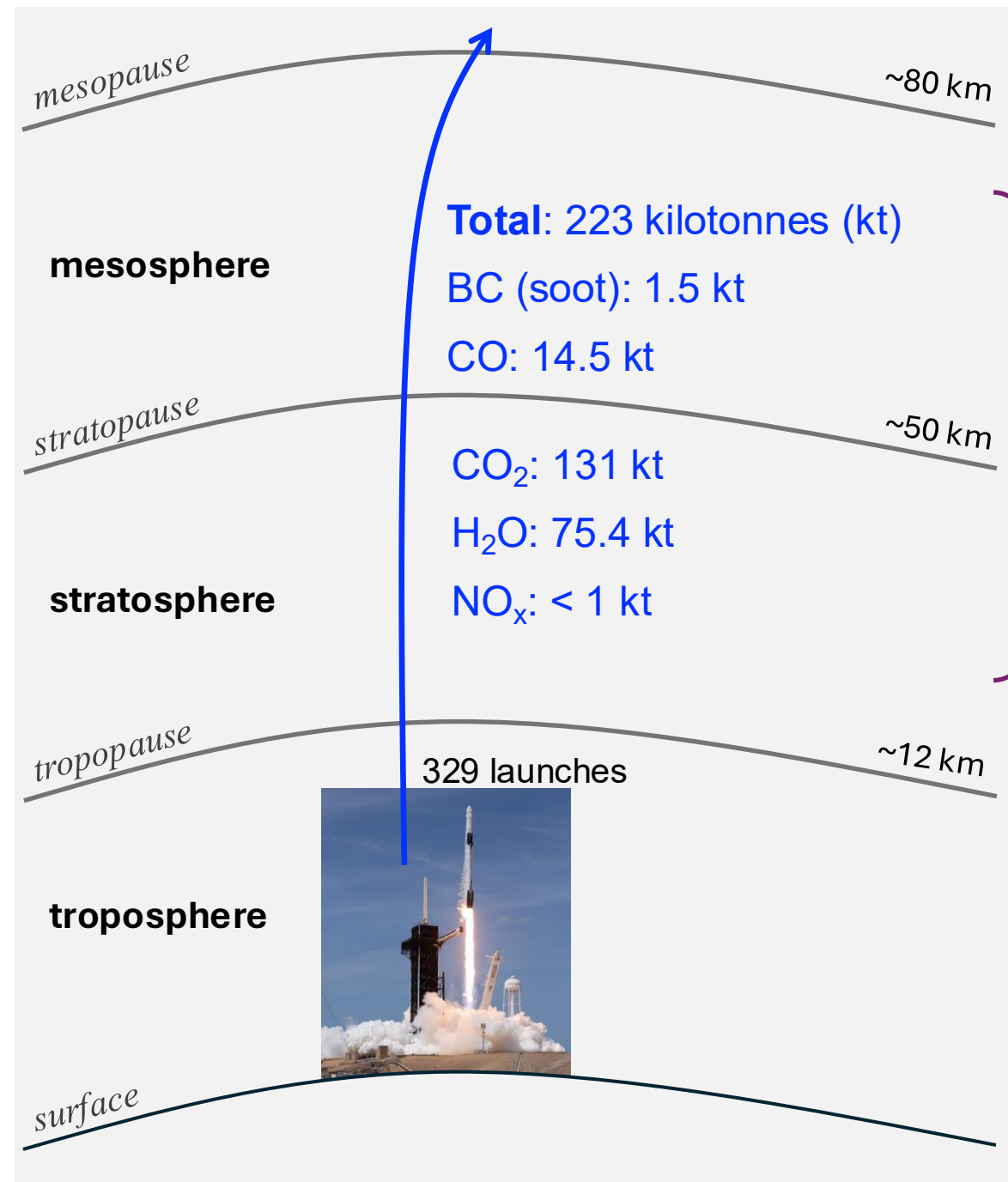
Cryogenic



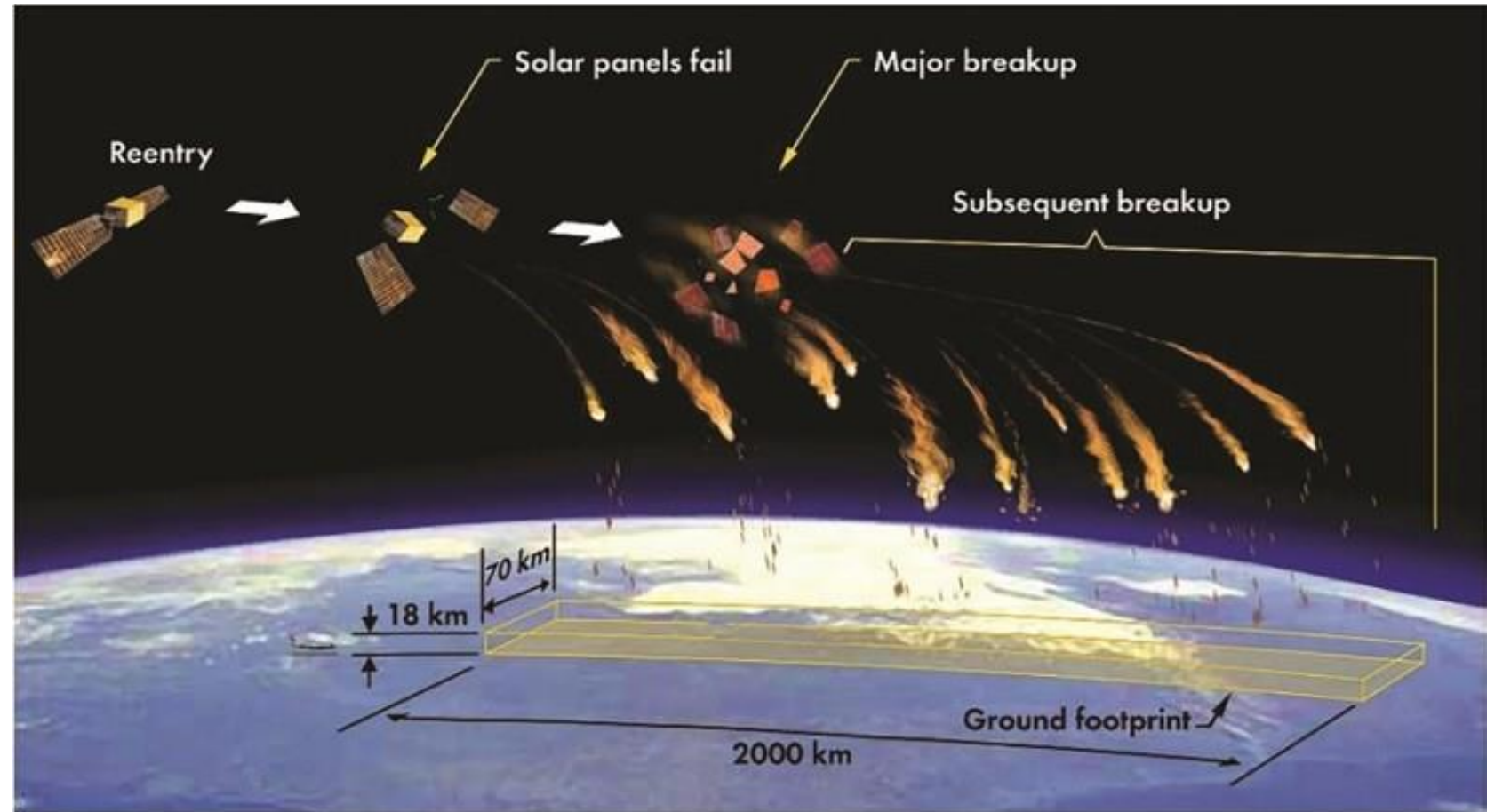
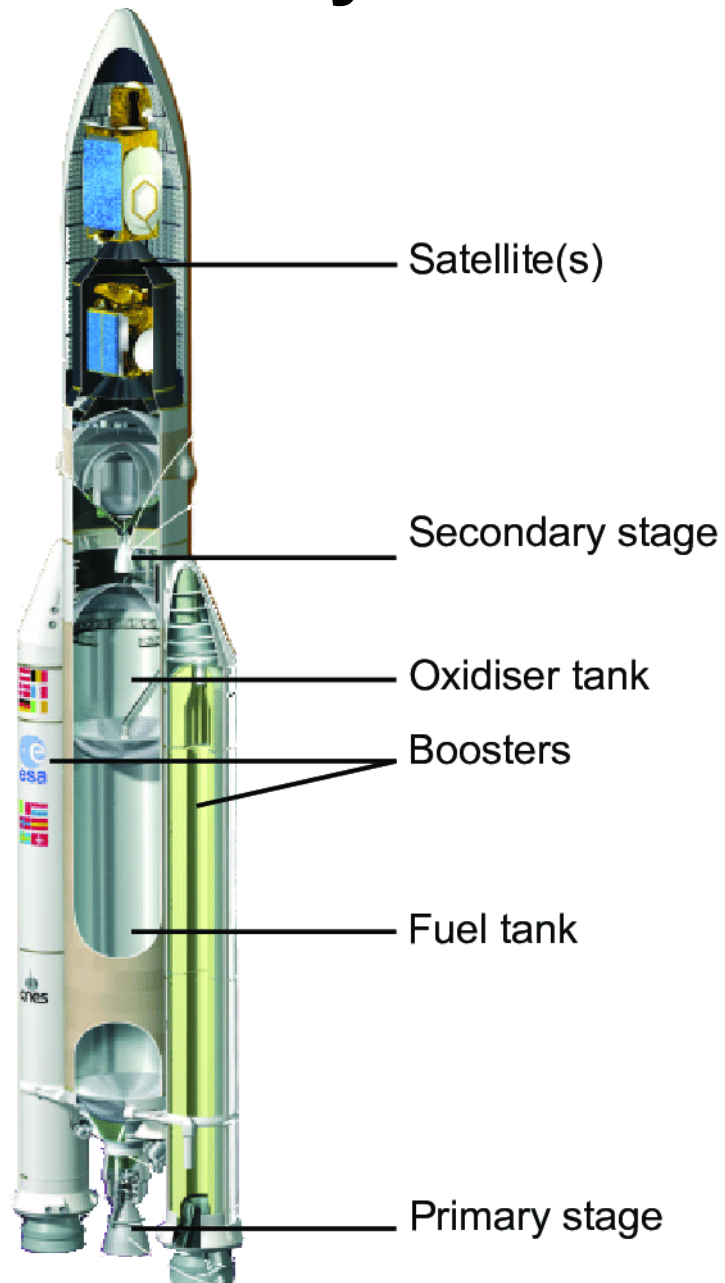
NO_x
 H_2O

Ozone
depletion

Current (2025) launch influx (baseline):



Re-entry Emissions from Reusable and Discarded Objects



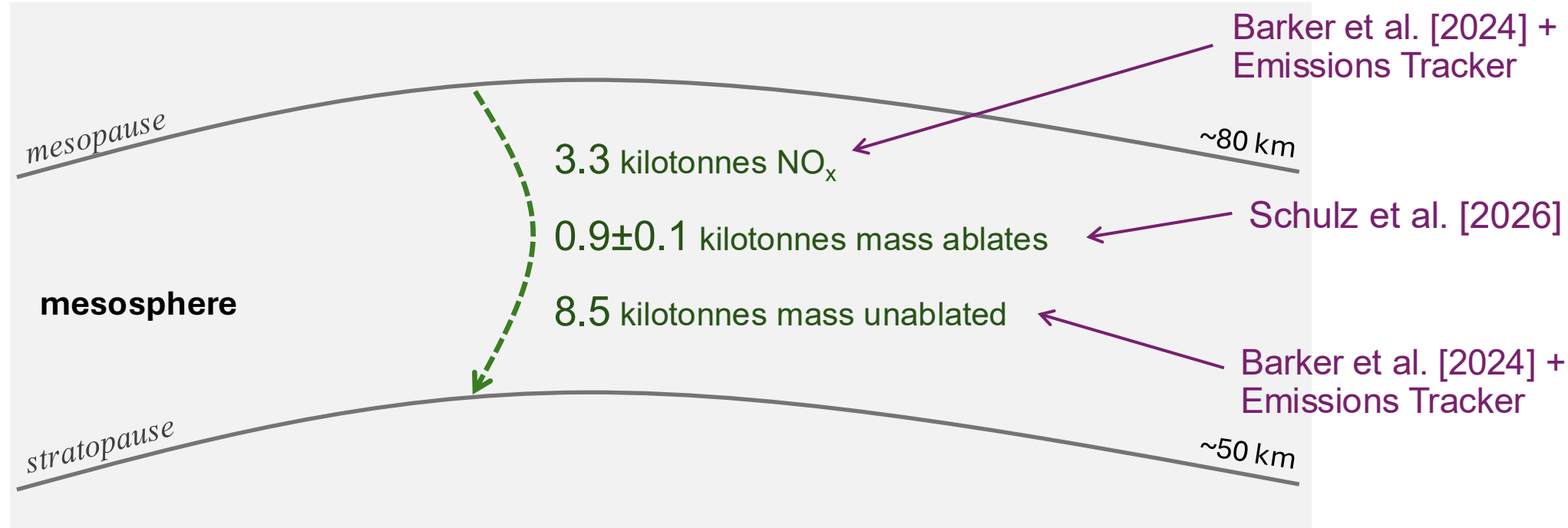
- Satellites ideally demise completely to reduce risk to life on Earth
- Heatshields likely ablate too
- Re-entry products nitrogen oxides (NO_x) from thermal energy
- Ablation emits metals oxides (mostly Al), BC, ammonia (NH_3) and more

Current (2025) re-entry mass and chemical influx

Meteors (natural):



2-40 kt
(mass and NO_x)



Anthropogenic influx less than or on lower-end of natural mass and NO_x from meteors

Constraints Provided by Filing Documents

Original 4 February filing:

- 1 million tonnes to orbit each year
- Fully reusable rocket
- Satellites designed to demise completely

Orbital configuration table (uploaded almost 3 months after filing)

Group	Altitude Range (km)	Inclination Range (deg)	Number of Shells	Planes Per Shell	Satellites Per Plane	Maximum Satellites per Group
1	550-568	26-32	10	30	333	99,900
2	565-585	97.7	10	2	4,999	99,980
3	686 - 718	30	25	30	333	249,750
4	707 - 744	97.2	22	2	5,565	244,860
5	946 - 978	30	25	30	333	249,750
6	967 - 1002	99.4	22	2	5,770	253,880
TOTAL						1,000,000

Ablative re-entry

Graveyard orbits

Plan for ~200,000 (~20%) of satellites to demise

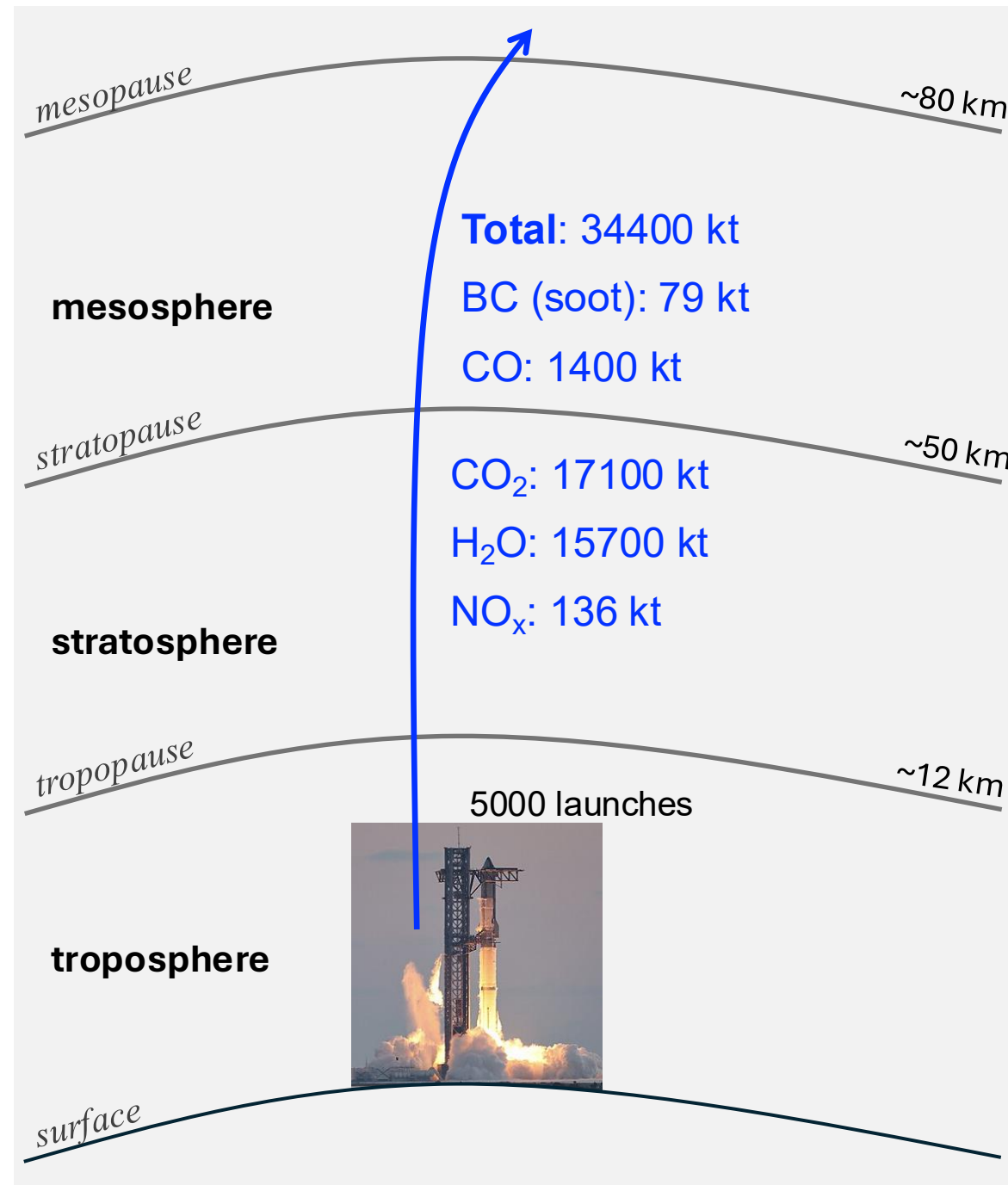
Additional information sought to constrain launch emissions

Variable	Value or Specificity	Source
Rocket	Starship Block 4	Assumed
Payload mass	200+ tonnes	GCAT
1 st stage propellant mass	4050 tonnes	GCAT, Wikipedia
2 nd stage propellant mass	2300 tonnes	GCAT

Able to rely on reputable source

Influx for a year of data centre launches:

Other concerns:
Surface air quality
Methane (CH₄) emissions



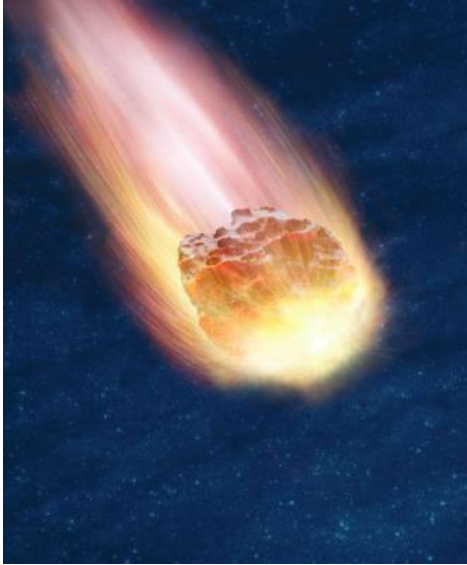
Additional information sought to constrain re-entry emissions

Variable	Value or Specificity	Source
Methalox propellant	22:78 LCH ₄ :LOX mass ratio	FAA Environmental Assessment
Rocket body heat shields	On both stages	Wikipedia
Re-entry approach	60° angle “bellyflop” approach	Wikipedia
Re-entry propellant use	No entry burn	Space Expl. Stack Exchange
Unused LCH ₄ fuel	5 tonnes	FAA Environmental Assessment
Reserve propellant for return	~1% of total	Inferred from Falcon 9
1 st stage re-entry velocity	1.1 km s ⁻¹	Fandom wiki site
2 nd stage re-entry velocity	7.5 km s ⁻¹	Fandom wiki site

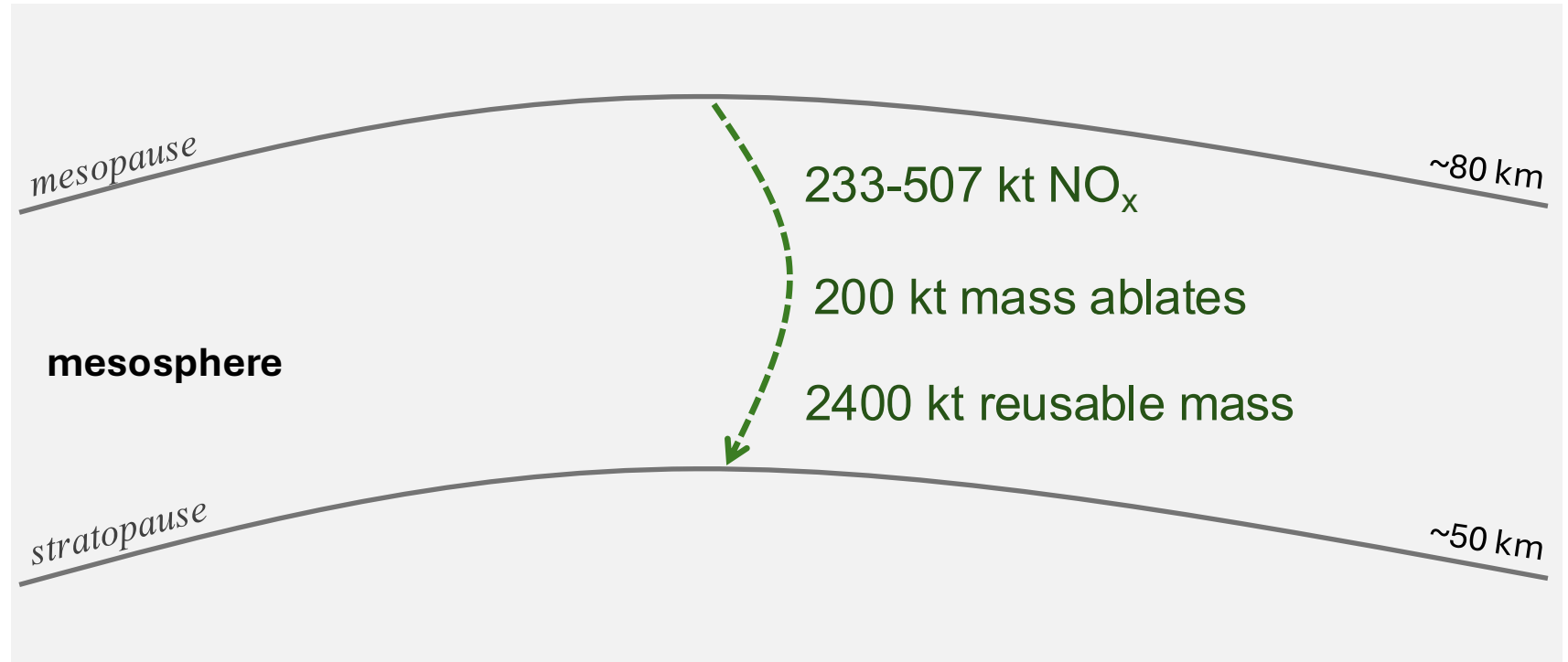
Reliant mostly on unvetted/unconfirmed sources and need to invoke many assumptions

Re-entry influx from a year of data centre launches

Meteors (natural):



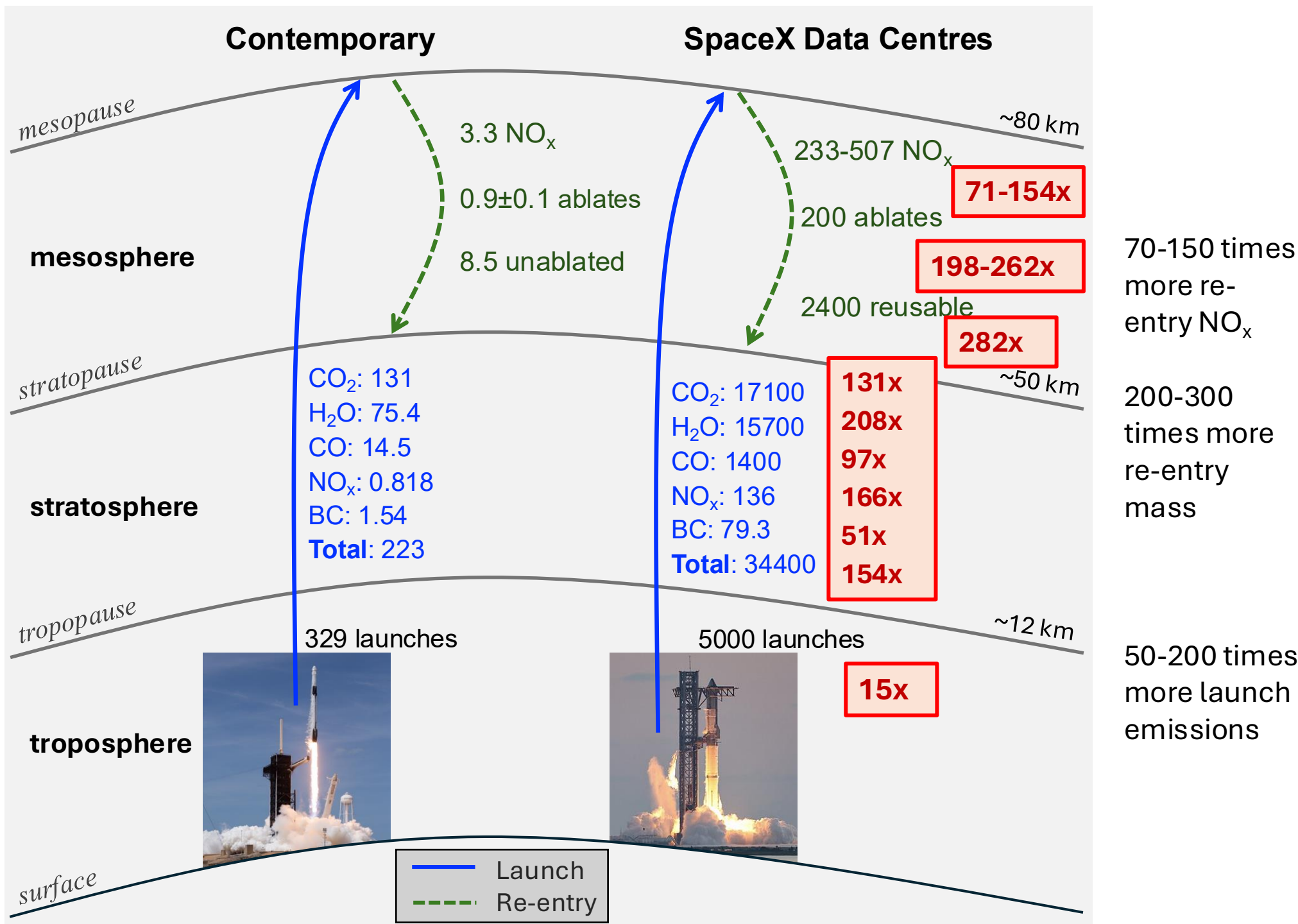
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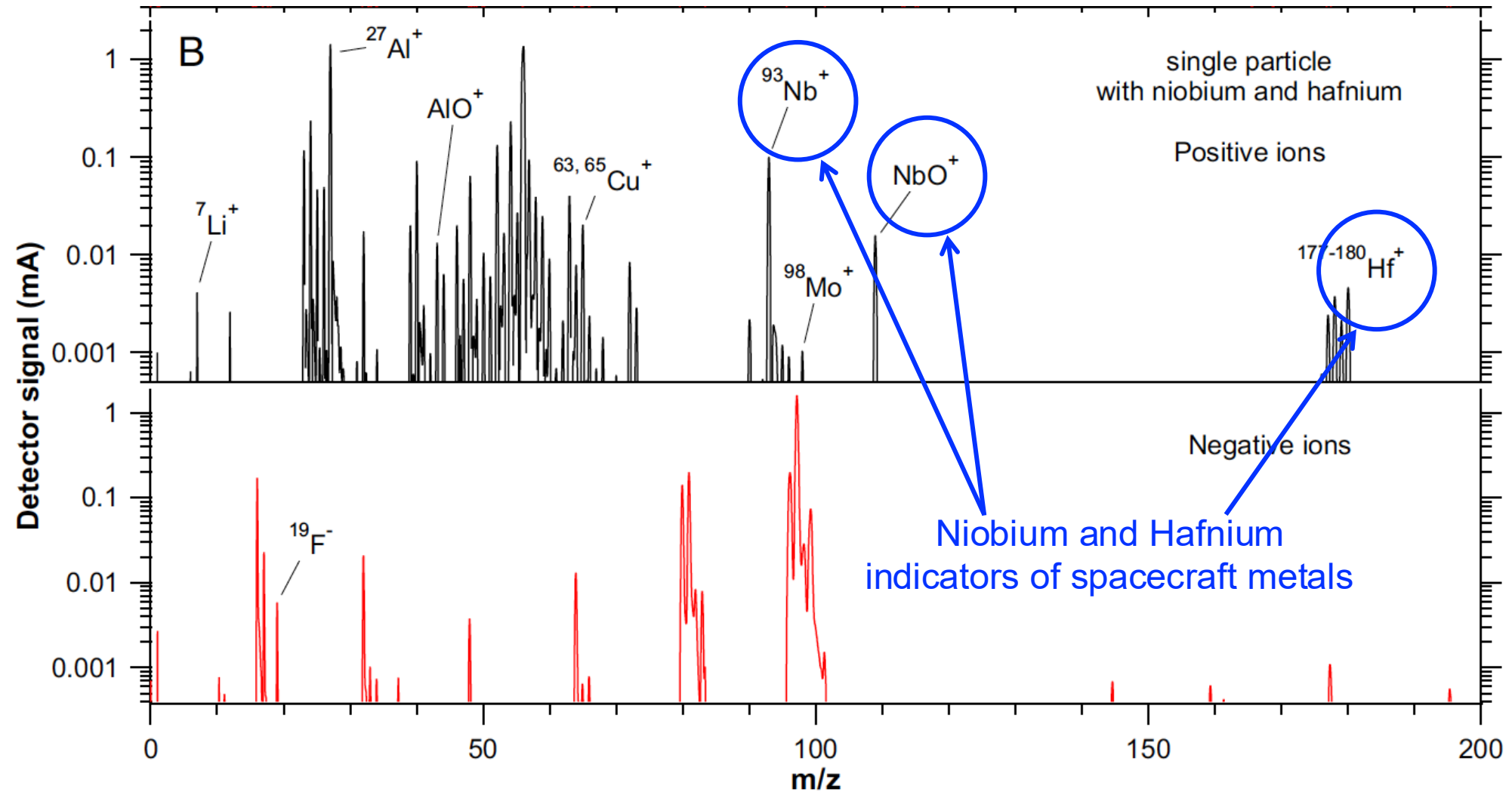
Anthropogenic influx far surpasses natural influx

Can't determine metal and non-metal influx, as no material composition data

Scale of growth:



Evidence of contamination of stratospheric aerosols



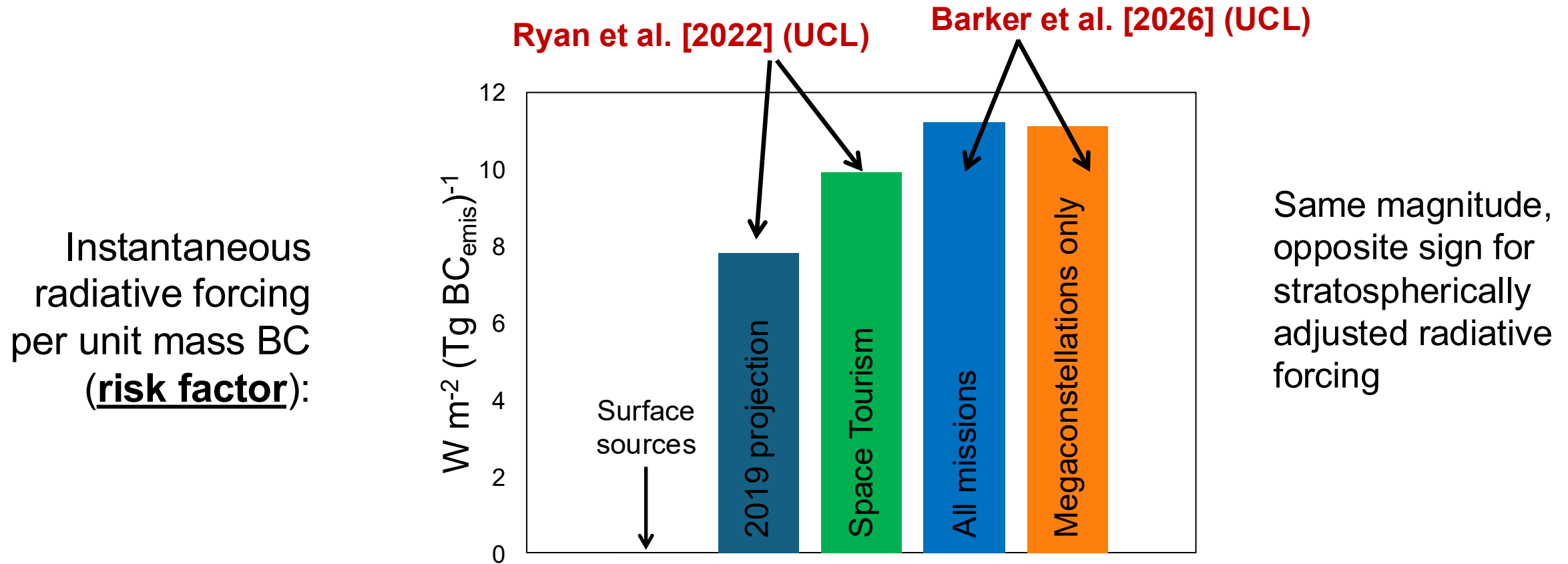
10% of stratospheric aerosols contaminated with metals from spacecraft re-entry pollution in 2023

Suggests ubiquitous and large contamination likely for SpaceX filing

[Murphy et al., 2023]

Impact Factors as Sense of Scale of Potential Harm

Climate impact of black carbon (soot) particles from Earth-bound sources vs rockets



Climate impact of black carbon from rockets **~540 times greater** than all Earth-bound sources

Assuming linear, launch BC could induce an **IRF of 0.87 W m^{-2}** and **SARF is -0.87 W m^{-2}**
(same order as CH_4 of 0.54 W m^{-2} and CO_2 of 2.16 W m^{-2})

Closing Remarks

Highlights:

- 2 orders of magnitude increases in mass and chemicals
- Transition upper atmosphere to anthropogenic state (offset chemical balance, alter nitrogen cycle in mesosphere, change stratospheric aerosol composition and characteristics etc.)
- Our calculations provide necessary information to enable environmental review
- A million data centre satellites emission estimates [Marais, Barker, 2026] is in review

General Comments:

- No preventive or reactive regulation to mitigate harm to upper atmosphere
- Actions like including our 1957-present emissions in the annual ESA Space Environment Report may help garner regulatory support
- Large science gaps in understanding impacts on upper atmosphere that need intensive research funding and capacity