Ivan Stanković – ivan.stankovic@univie.ac.at
Manuel Güdel, Sudeshna Boro Saikia, Gwenaëlle Van Looveren, and Nils-Martin Robeling

Department of Astrophysics, University of Vienna

Chemical controls on the atmospheric stability of rocky exoplanets

(and why the C/O ratio is not enough)

Why chemistry?

A big variety of chemical species has been detected in exoplanet atmospheres

H_2O — Wakeford+2018, Tsiaras+2019
SO_2 — Powell+2024
CO_2 — Rustamkulov+2023
CH_4 — Bell+2023
CS_2 (?) — Holmberg+2024

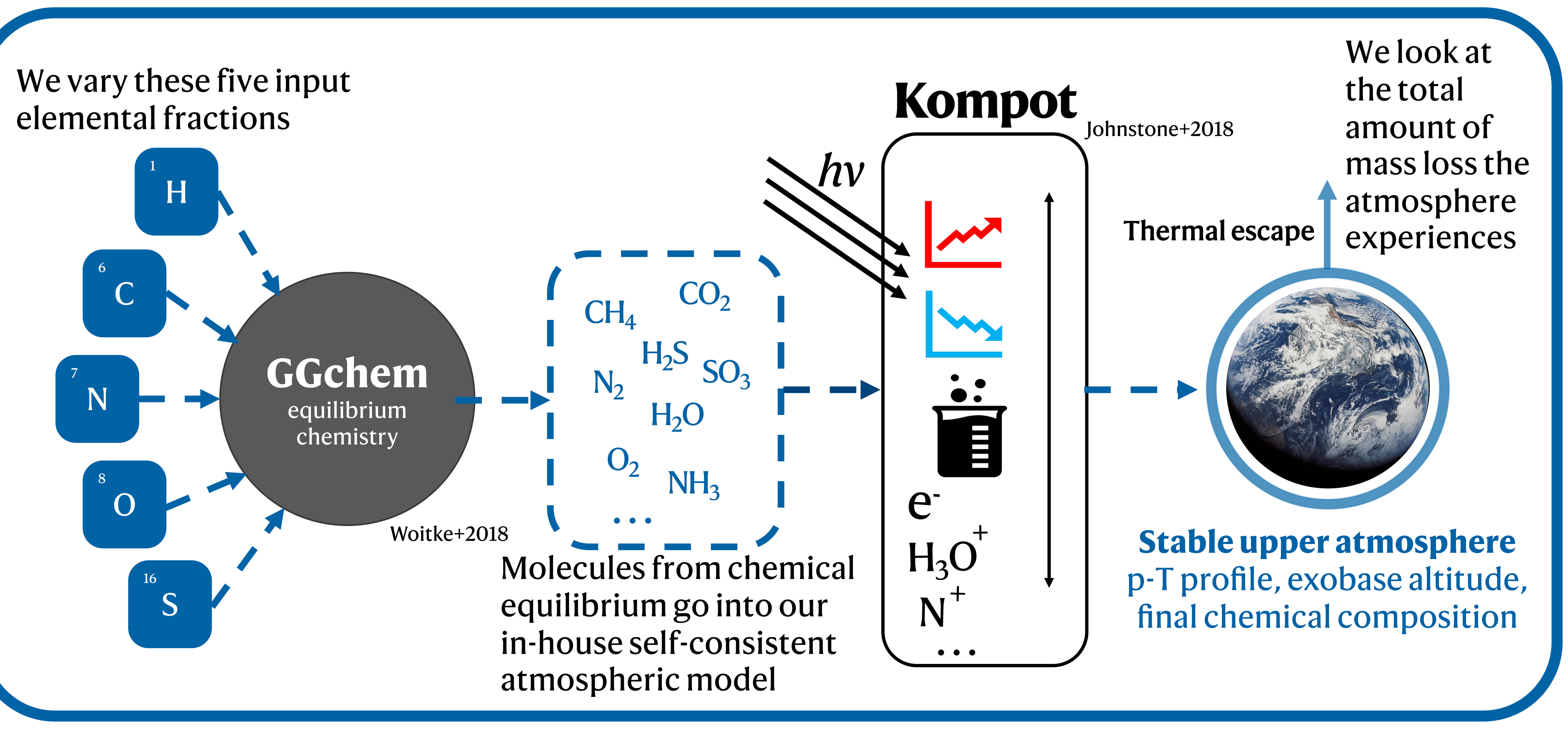
But the focus is very often on the C/O ratio or metallicity

What about us?!

N H S

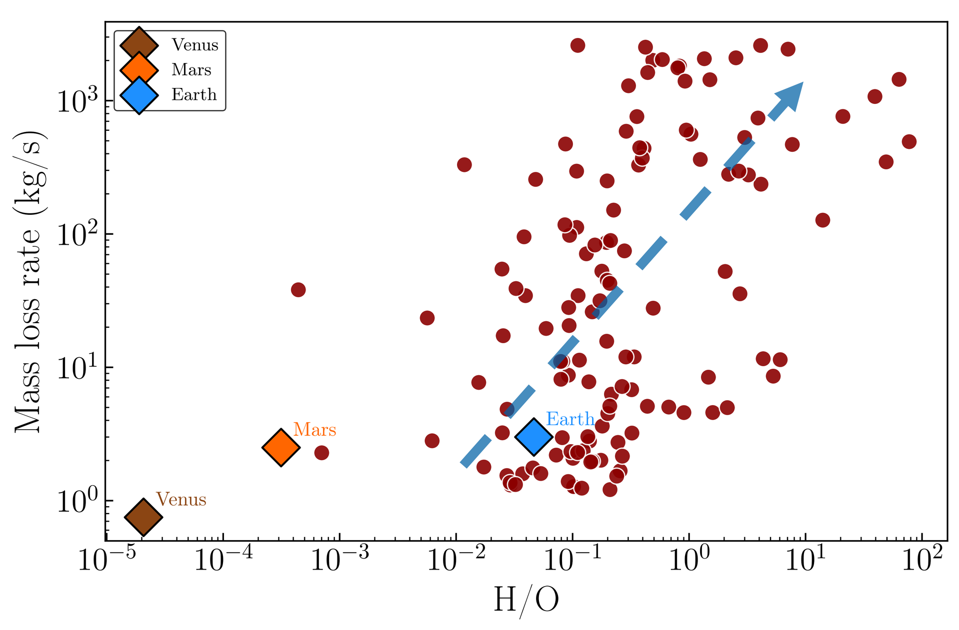
We want to see which chemical compositions are the most stable, and which are more easily lost

What did we model and how?

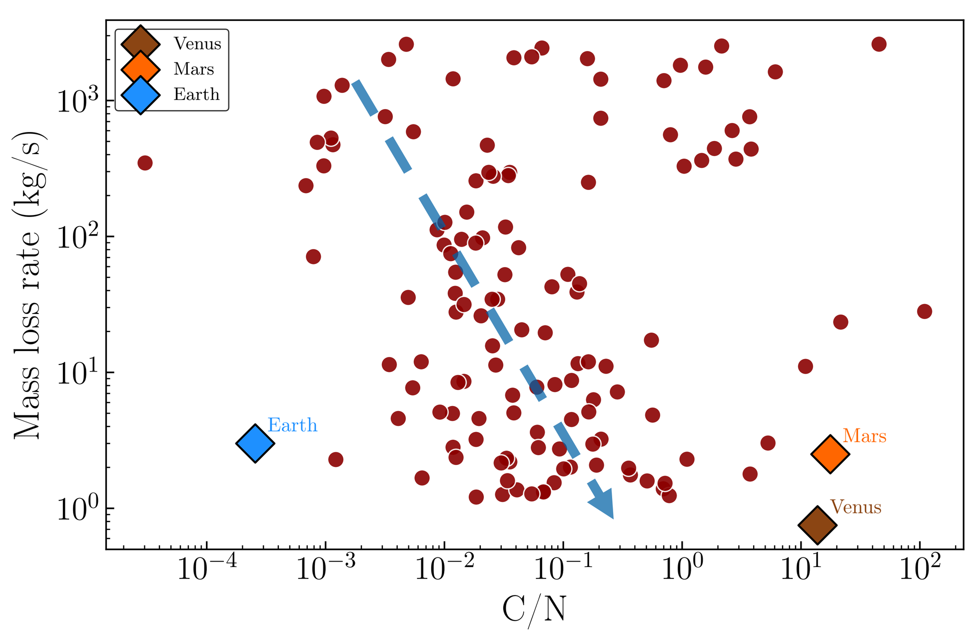


How important are all the elements?

Mass loss increases with the H/O ratio…



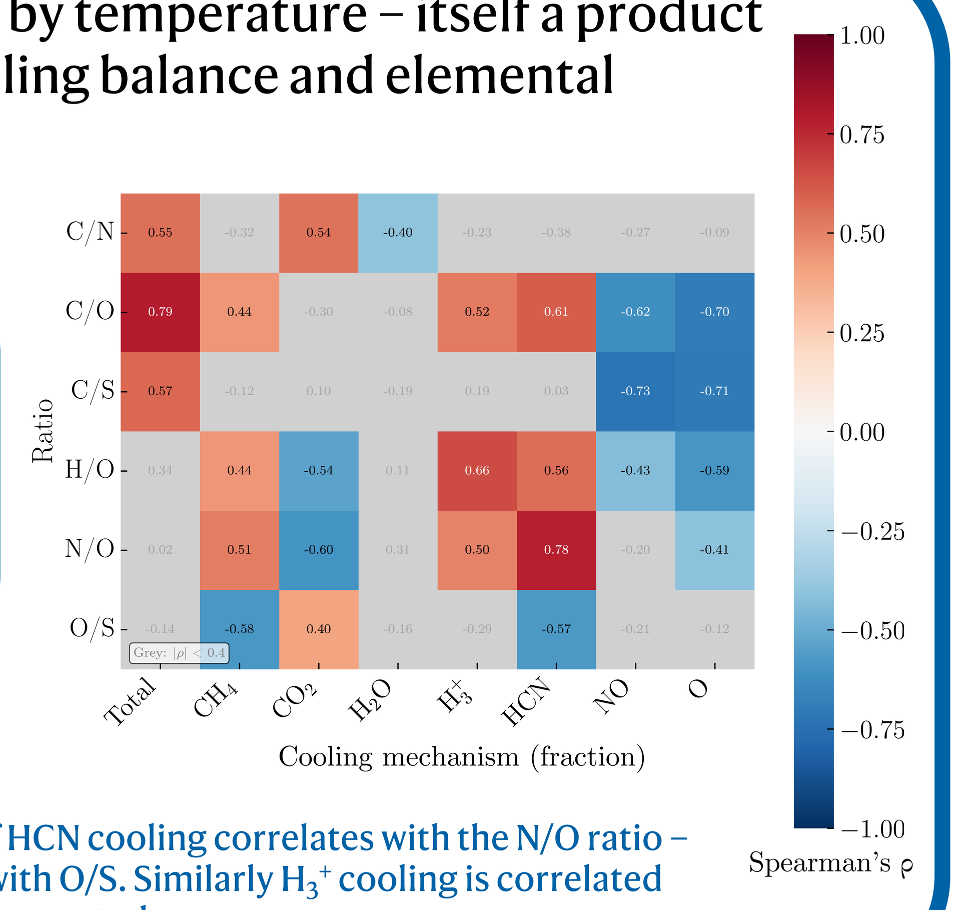
… and decreases with an increase in the C/N ratio



*The high scatter in these figures comes from the inherent chemical interdependence of the species in the model

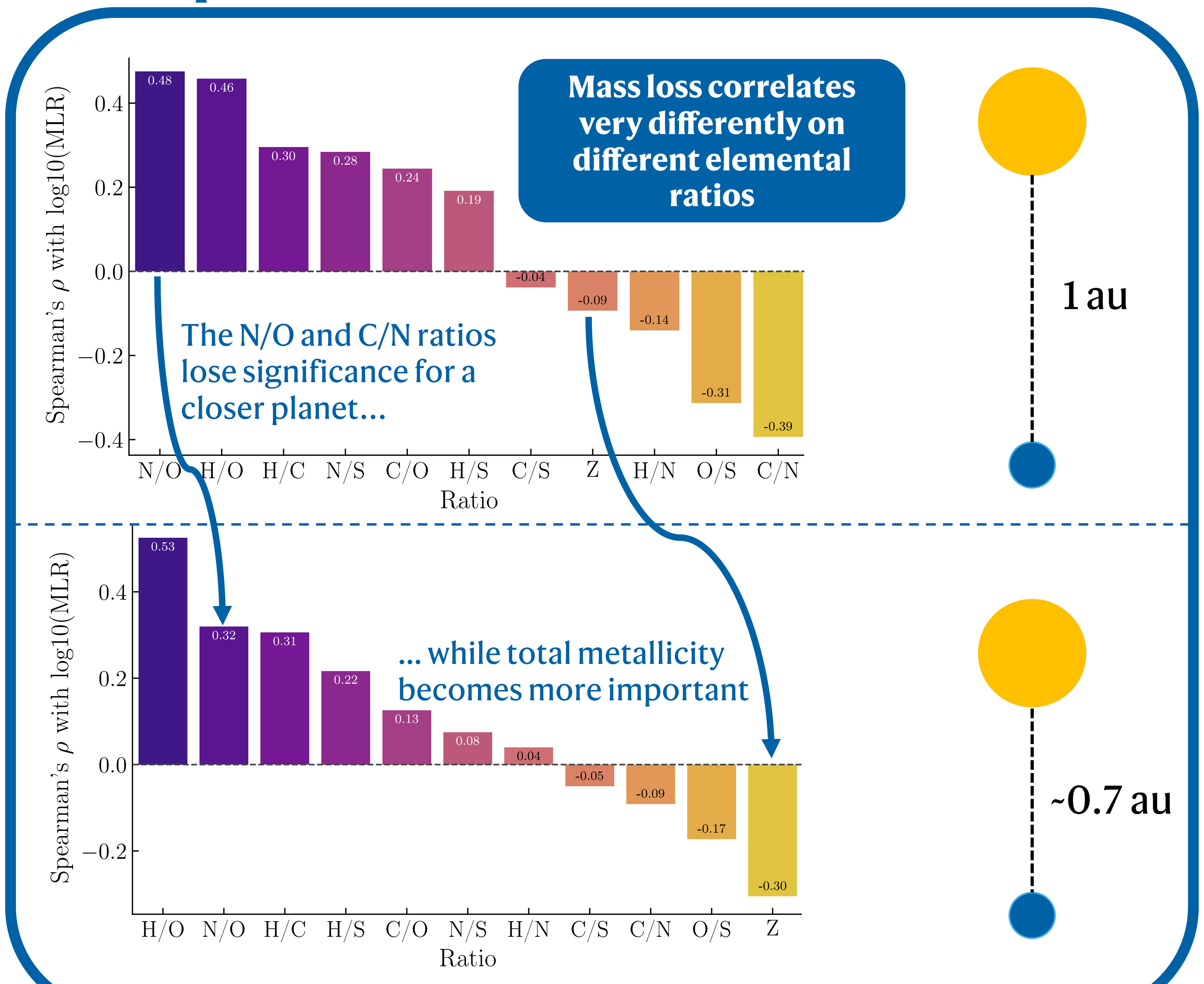
Mass loss is driven by temperature – itself a product of the heating/cooling balance and elemental composition.

Chemical coupling produces surprising correlations. See if you can spot them.*



*for example, the fraction of HCN cooling correlates with the N/O ratio – but it is also anticorrelated with O/S. Similarly H_3^+ cooling is correlated with C/O, which might be unexpected

The planet-star distance matters too



Takeaways

C/O and metallicity do not give the full picture – we need to consider all other major elemental ratios too.

This will give us:

- better constraints on the thermal structure and potential mass loss
- help us predict which atmospheres we might expect to detect in rocky exoplanets.

References

Bell et al. 2023, Nature, 623, 709,
Johnstone et al. 2018, A&A, 617, A107,
Rustamkulov et al. 2023, Nature, 614, 659,
Wakeford et al. 2018, AJ, 155, 29,
Holmberg & Madhusudhan 2024, A&A, 683, L2,
Powell et al. 2024, Nature, 626, 979
Tsiaras et al. 2019, Nature Astronomy, 3, 1086,
Woitke et al. 2018, A&A, 614, A1

Get in touch!