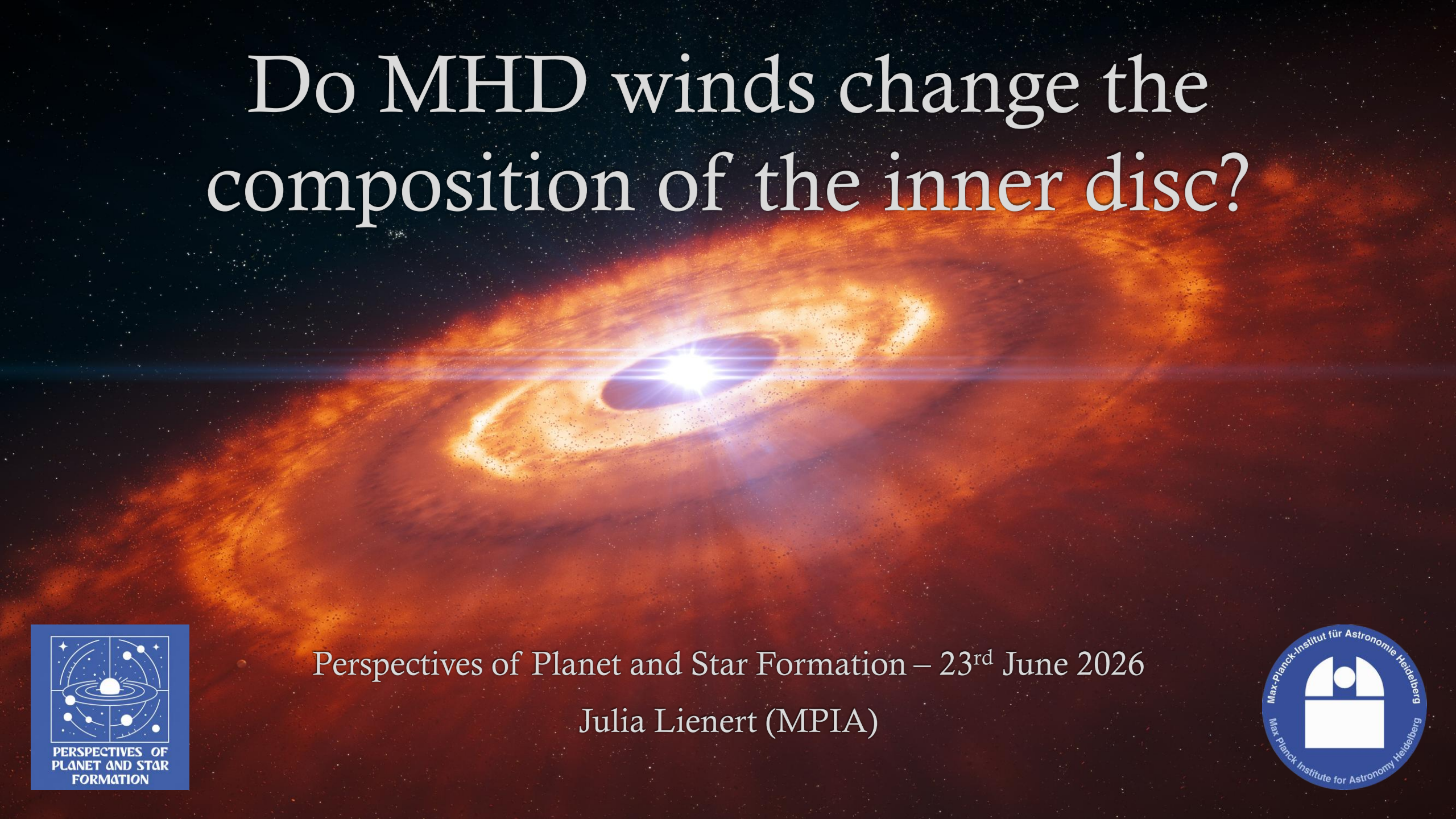
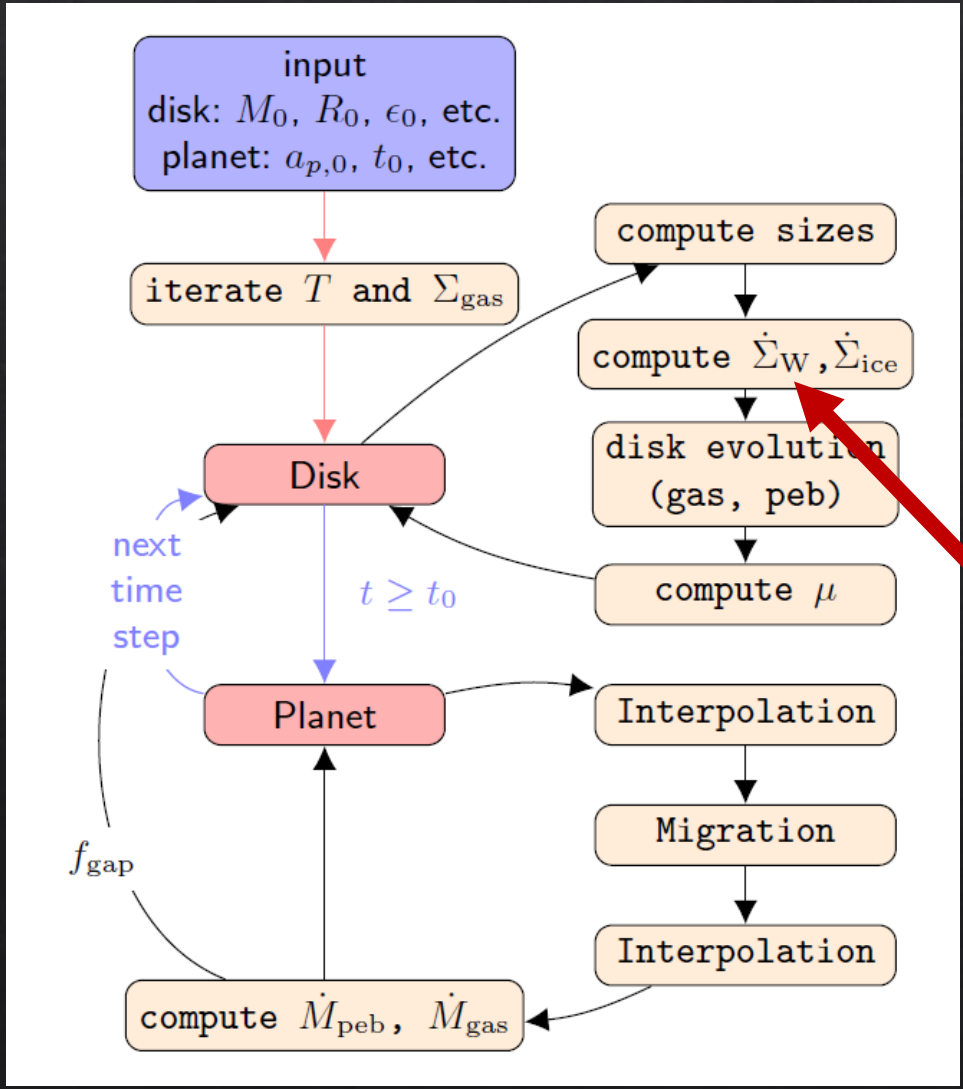
Do MHD winds change the composition of the inner disc?



Perspectives of Planet and Star Formation – 23rd June 2026

Julia Lienert (MPIA)

Internal photoevaporation



- Viscous disc equation:

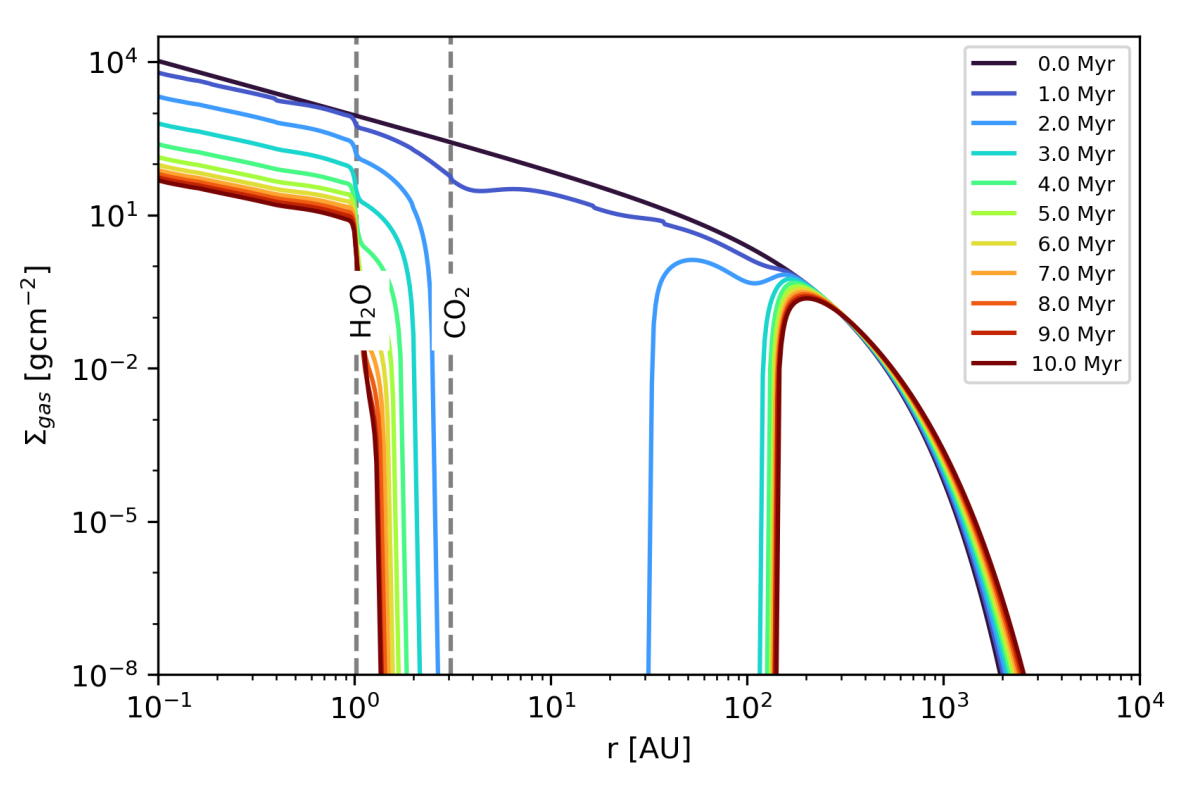
$$\frac{\partial \Sigma_{\rm gas,Y}}{\partial t} - \frac{3}{r}\frac{\partial}{\partial r}\left[\sqrt{r}\frac{\partial}{\partial r}\left(\sqrt{r}\nu\Sigma_{\rm gas,Y}\right)\right] = \dot{\Sigma}_{\rm Y} - \dot{\Sigma}_{\rm w}$$

- Internal photoevaporation (Picogna et al. 2021):

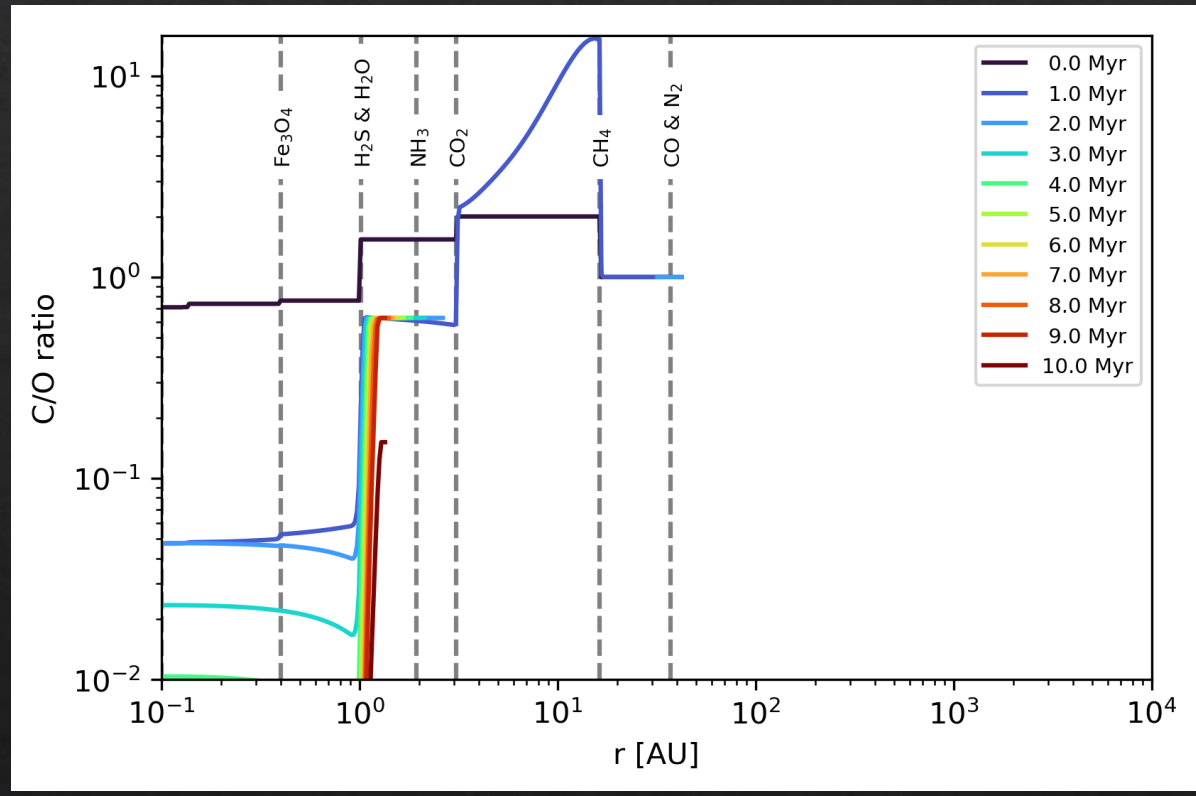
$$\dot{\Sigma}_{\rm w} = \left(\frac{6a\ln(R)^5}{R\ln(10)^6} + \frac{5b\ln(R)^4}{R\ln(10)^5} + \frac{4c\ln(R)^3}{R\ln(10)^4} + \frac{3d\ln(R)^2}{R\ln(10)^3} + \frac{2e\ln(R)}{R\ln(10)^2} + \frac{f}{R\ln(10)}\right)\frac{\ln(10)}{2\pi R}\dot{\rm M}_{\rm w}[{\rm M}_\odot\,{\rm AU}^{-2}\,{\rm yr}^{-1}]$$

Results for $M_\star = 0.5 M_\odot$

Gas surface density



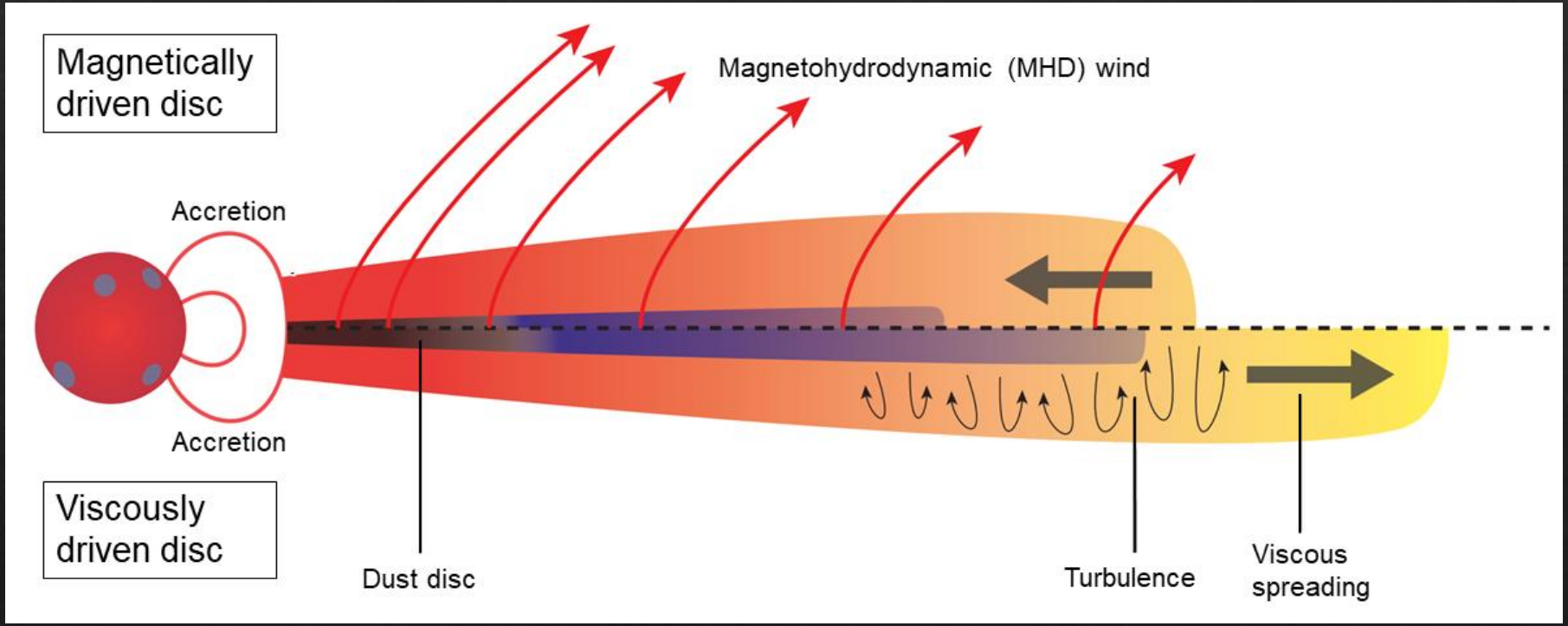
C/O ratio



Introduction & model setup

What are MHD winds?

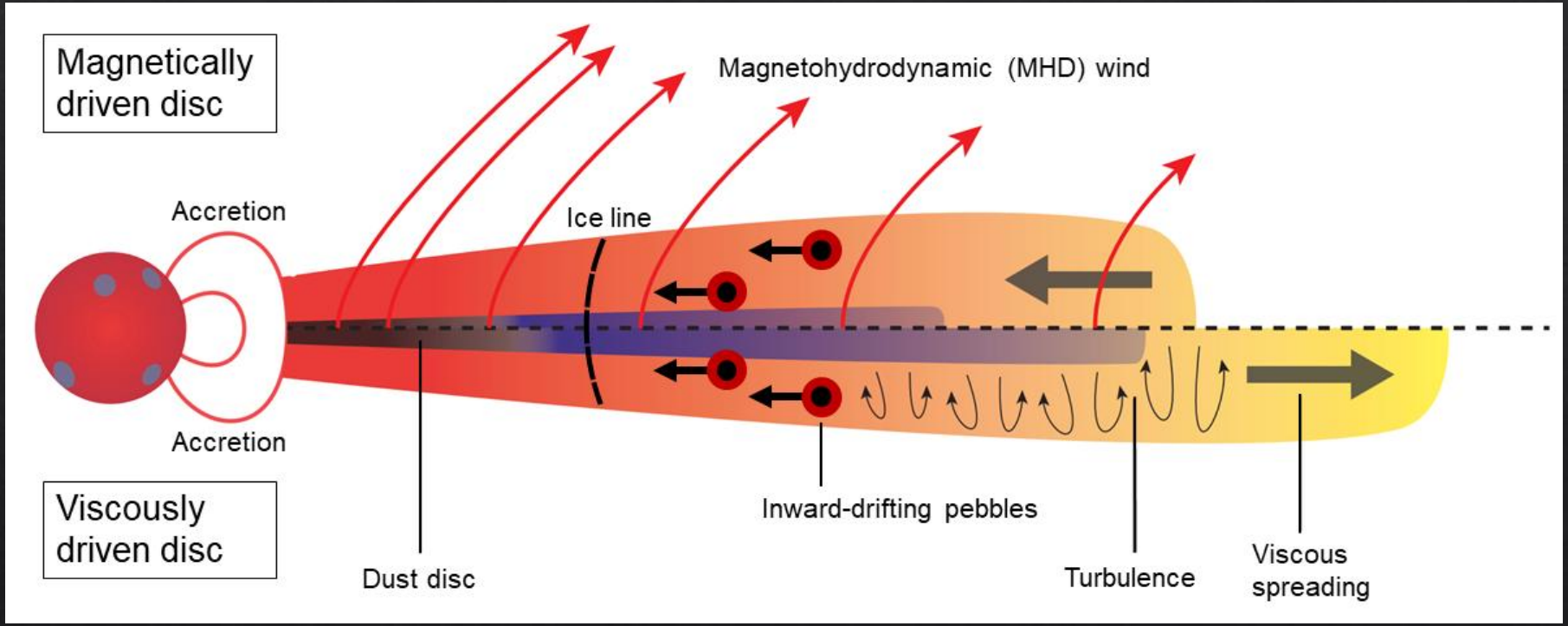
Viscous evolution vs. MHD winds



Adapted from Manara et al. (2022)

- Driver of disc accretion? Viscosity ⟷ MHD winds
- Viscous evolution:
  - Turbulence
  - Viscous spreading
- MHD winds:
  - Magnetic fields
  - No viscous spreading

Code: chemcomp



Adapted from Manara et al. (2022)

- 1D, semi-analytical model for PPDs
- Included physics:
  - Viscous evolution & heating
  - Pebble growth & drift
  - Pebble evaporation & condensation
  - Simple chemistry

MHD winds in chemcomp

- Extra term (Tabone et al. 2022):

$$\dot{M} \propto \alpha_{\mathrm{DW}}, \lambda_{\mathrm{DW}}$$

- Simulations:

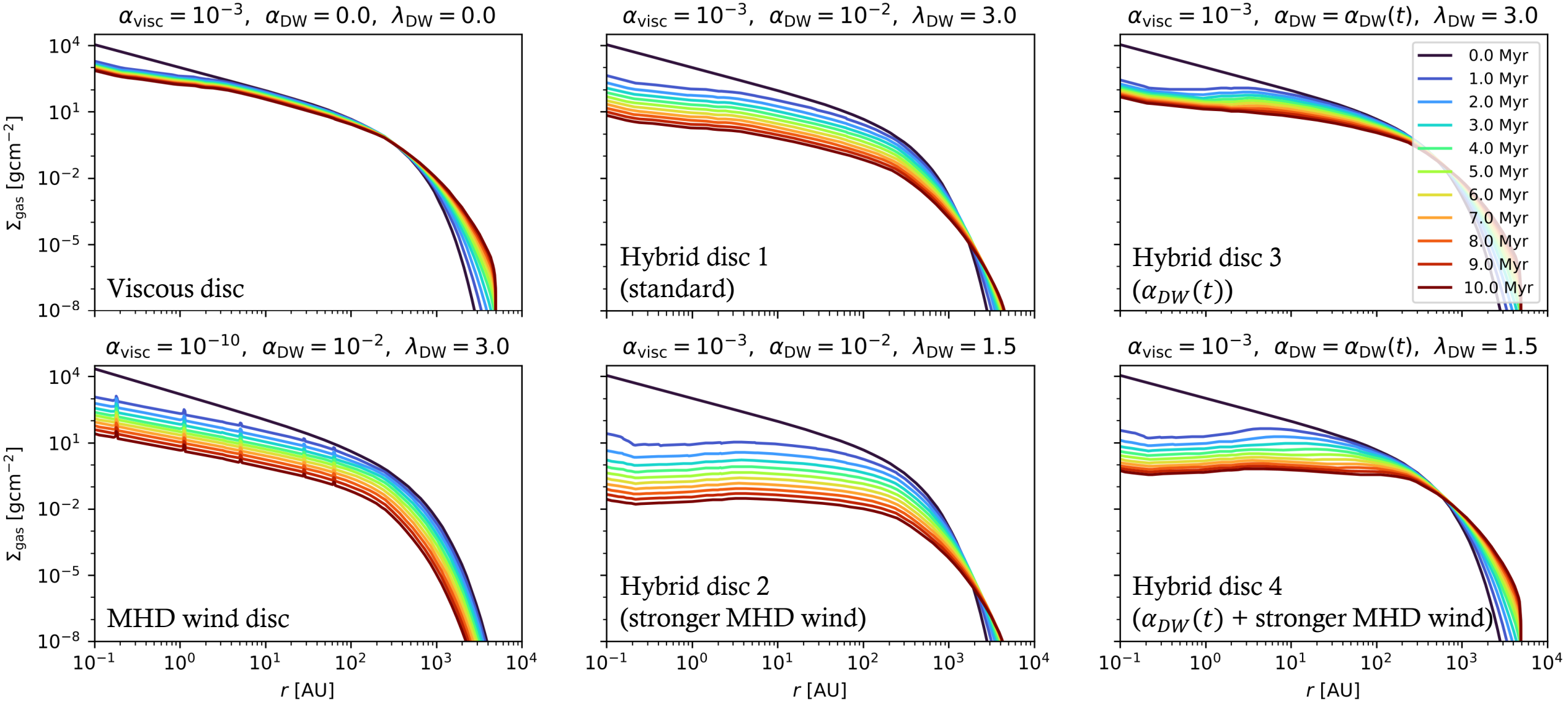
$$M_{\star} = 1\mathrm{M}_{\odot}$$
$$M_{\mathrm{disc}} = 0.1\mathrm{M}_{\odot}$$
$$R_{\mathrm{disc}} = 150\mathrm{AU}$$

Scenario	Parameters
Viscous disc	$\alpha_{\mathrm{visc}} = 10^{-3}$ / $\alpha_{\mathrm{DW}} = 0$ / $\lambda_{\mathrm{DW}} = 0$
MHD wind disc	$\alpha_{\mathrm{visc}} = 10^{-10}$ / $\alpha_{\mathrm{DW}} = 10^{-2}$ / $\lambda_{\mathrm{DW}} = 3.0$
Hybrid disc 1	$\alpha_{\mathrm{visc}} = 10^{-3}$ / $\alpha_{\mathrm{DW}} = 10^{-2}$ / $\lambda_{\mathrm{DW}} = 3.0$
Hybrid disc 2	$\alpha_{\mathrm{visc}} = 10^{-3}$ / $\alpha_{\mathrm{DW}} = 10^{-2}$ / $\lambda_{\mathrm{DW}} = 1.5$
Hybrid disc 3	$\alpha_{\mathrm{visc}} = 10^{-3}$ / $\alpha_{\mathrm{DW}}(t)$ / $\lambda_{\mathrm{DW}} = 3.0$
Hybrid disc 4	$\alpha_{\mathrm{visc}} = 10^{-3}$ / $\alpha_{\mathrm{DW}}(t)$ / $\lambda_{\mathrm{DW}} = 1.5$

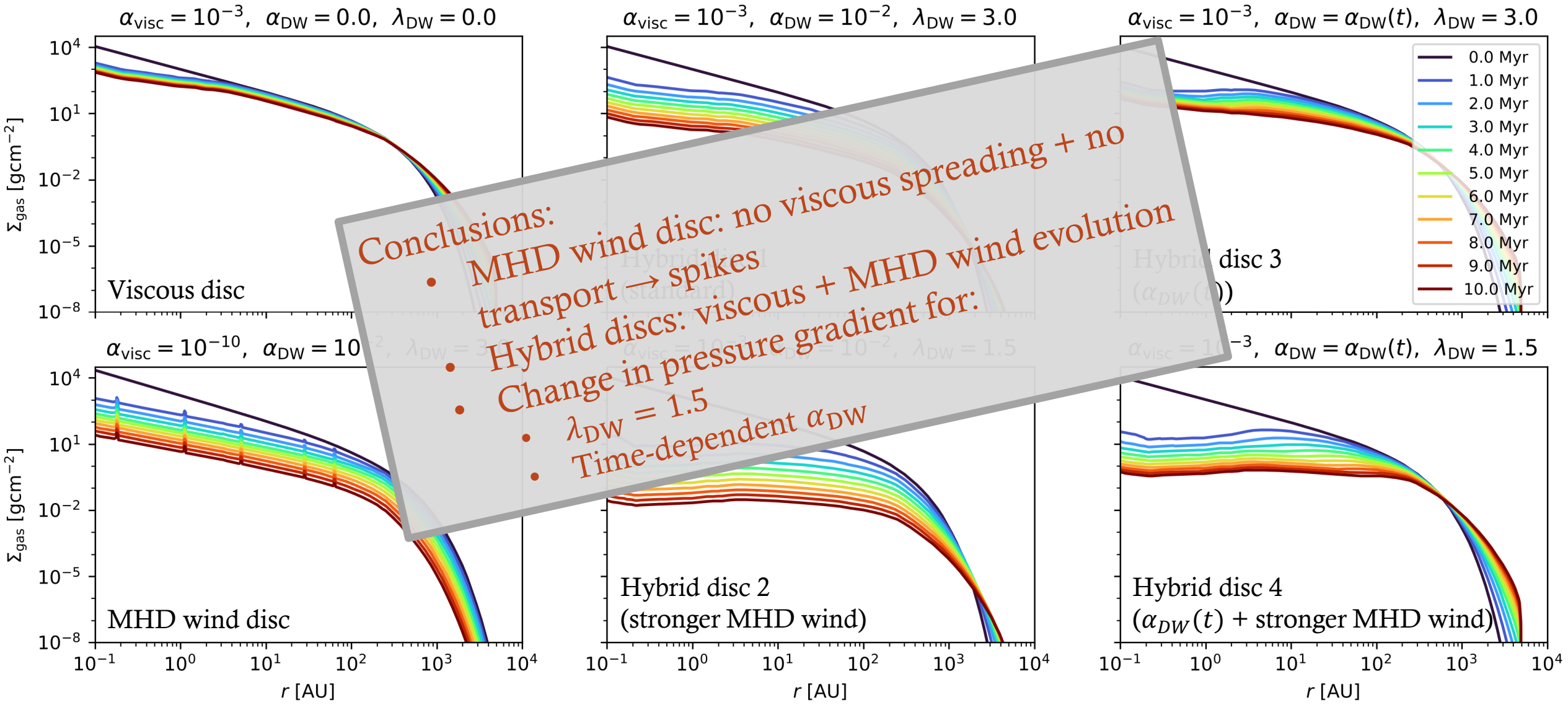
Results

How do MHD winds influence the disc's composition?

Gas surface density for $M_\star = 1.0 M_\odot$



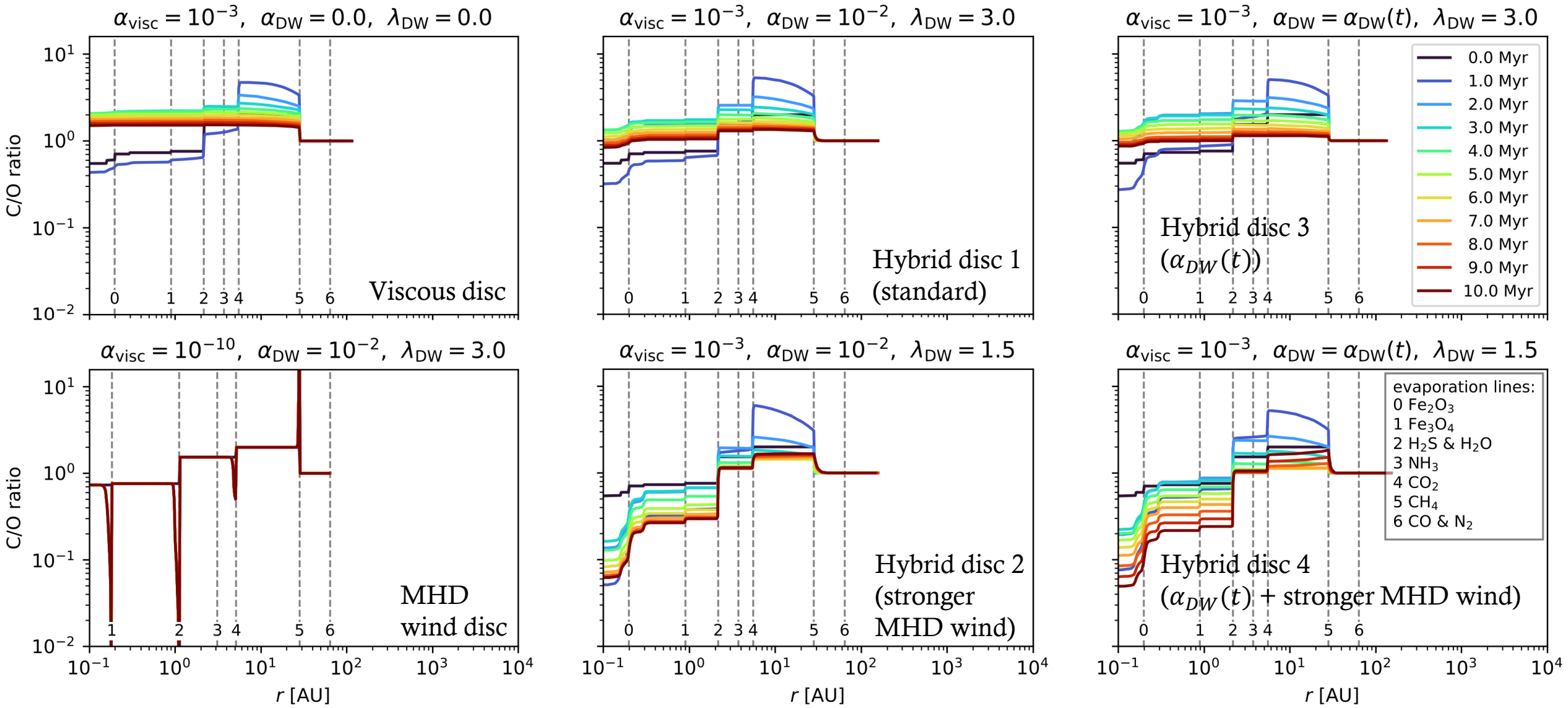
Gas surface density for $M_\star = 1.0 M_\odot$



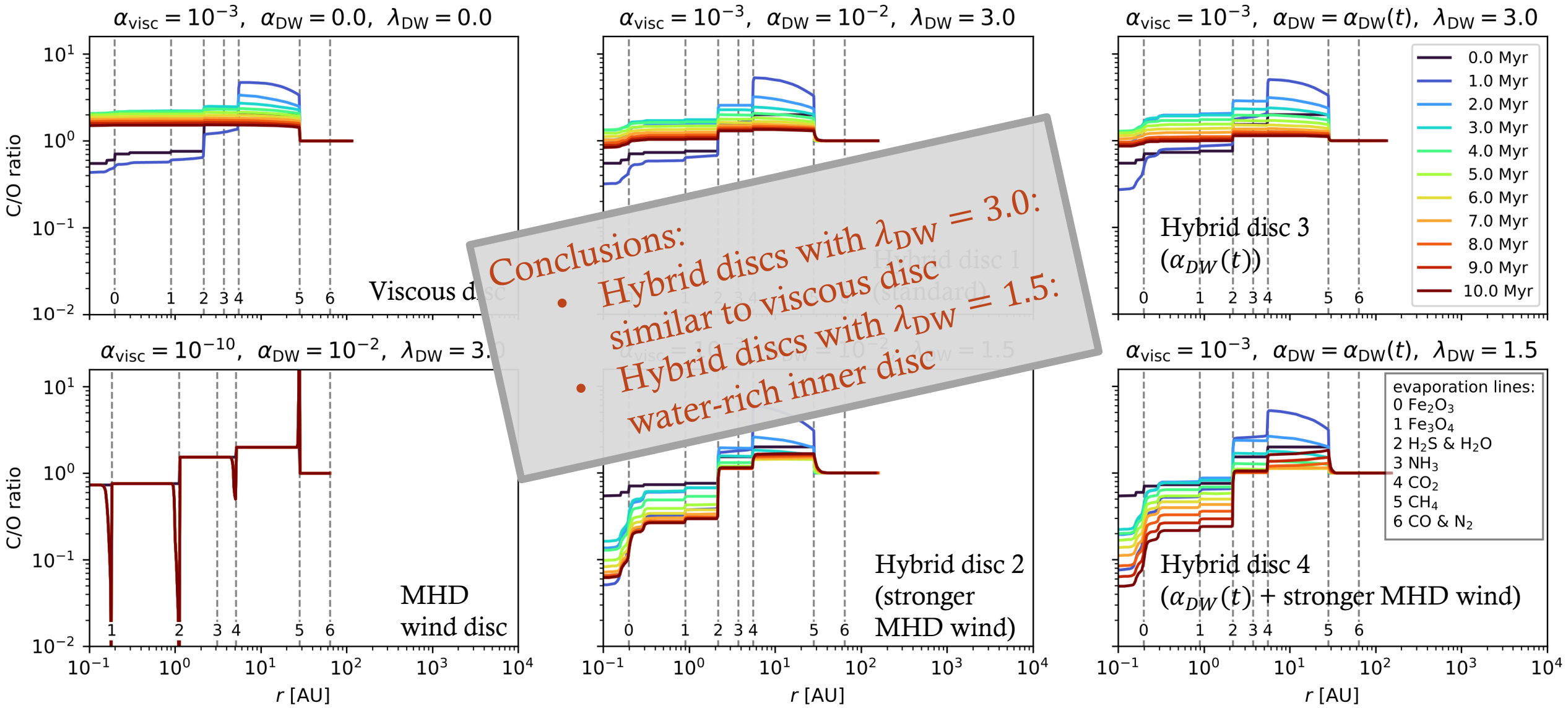
Conclusions:

- MHD wind disc: no viscous spreading + no transport → spikes
- Hybrid discs: viscous + MHD wind evolution
- Change in pressure gradient for:
  - $\lambda_{DW} = 1.5$
  - Time-dependent α_{DW}

C/O ratio for $M_\star = 1.0 M_\odot$



C/O ratio for $M_\star = 1.0 M_\odot$



Conclusions:

- Hybrid discs with $\lambda_{DW} = 3.0$: similar to viscous disc
- Hybrid discs with $\lambda_{DW} = 1.5$: water-rich inner disc

Summary

Summary

Read more:
Lienert et al. 2026
(in preparation)

Protoplanetary discs subject to MHD winds…

… experience more mass loss + less viscous spreading (compared to pure viscous disc)

… have changes in pressure gradient (for $\alpha_{\mathrm{DW}}(t)$ / λ_{DW} small)

… seem to have water-rich inner discs (if MHD wind strong)

References

- Lienert, J. L., Bitsch, B., Henning, Th., 2026, in preparation
- Tabone, B., Rosotti, G. P., Cridland, A. J., Armitage, P. J., Lodato, G., 2022, MNRAS, Volume 512, Issue 2
- Schneider, A., Bitsch, B., 2021a, Astronomy & Astrophysics, Volume 654, A71
- Schneider, A., Bitsch, B., 2021b, Astronomy & Astrophysics, Volume 654, A72

Image sources

- Image first slide: https://www.eso.org/public/images/eso1436f/
- Comic on slides 3+4: adapted from Manara, C. F., Ansdell, M., Rosotti, G. P., Hughes, A. M., Armitage, P. J., Lodato, G., Williams, J. P., 2022, Protostars and Planets VII