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Sensitivity of Biosignatures on Earth-like Planets orbiting in the Habitable Zone of Cool M-Dwarf Stars to varying Stellar UV Radiation and Biomass Emissions

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Grenfell et al. (2014)
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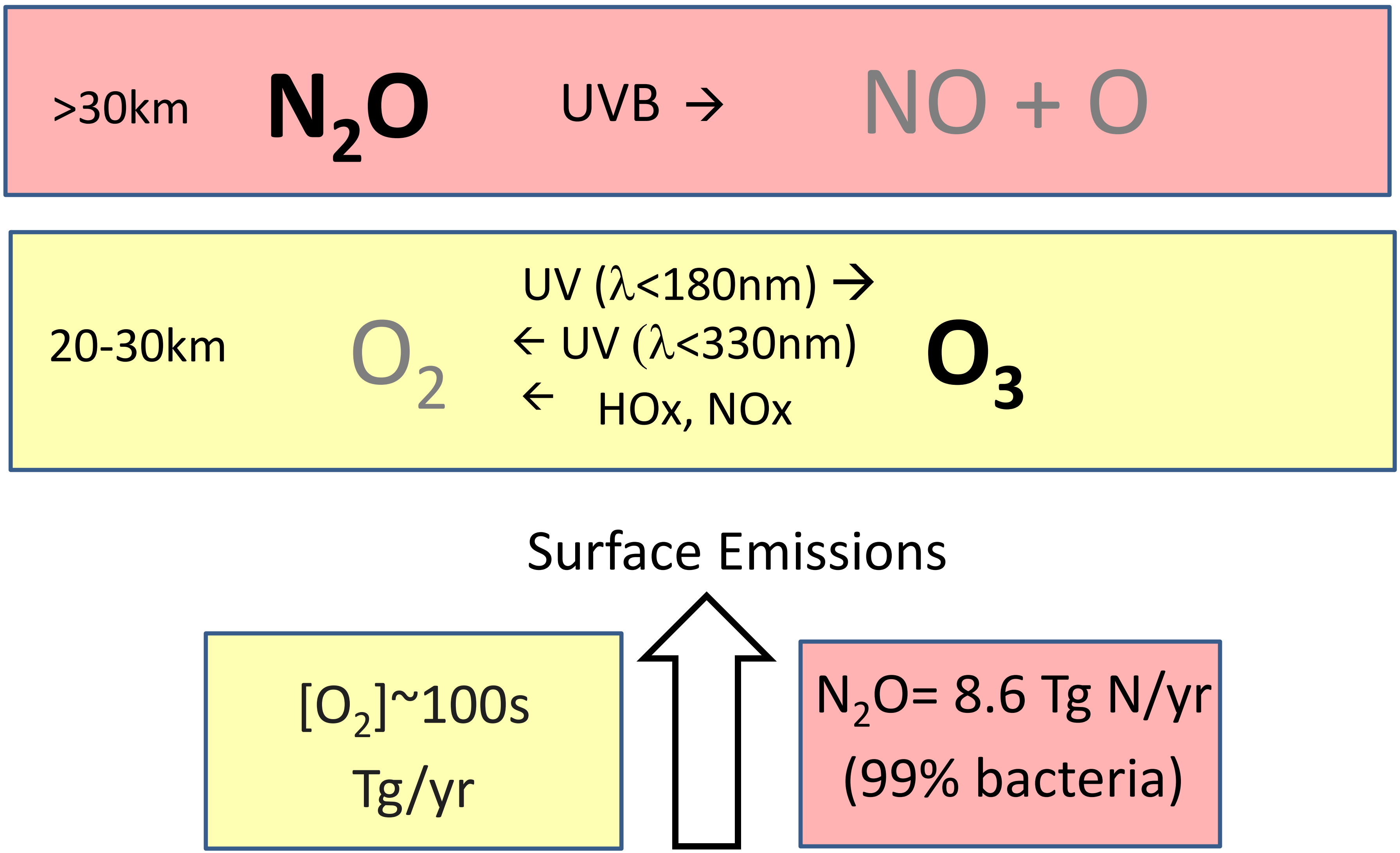
Motivation

- (Cool) M-stars are favoured targets to find Earth-like planets BUT stellar UV and possible biomass emissions are not known
- What is the effect of this uncertainty on atmospheric biosignature abundances and spectra?

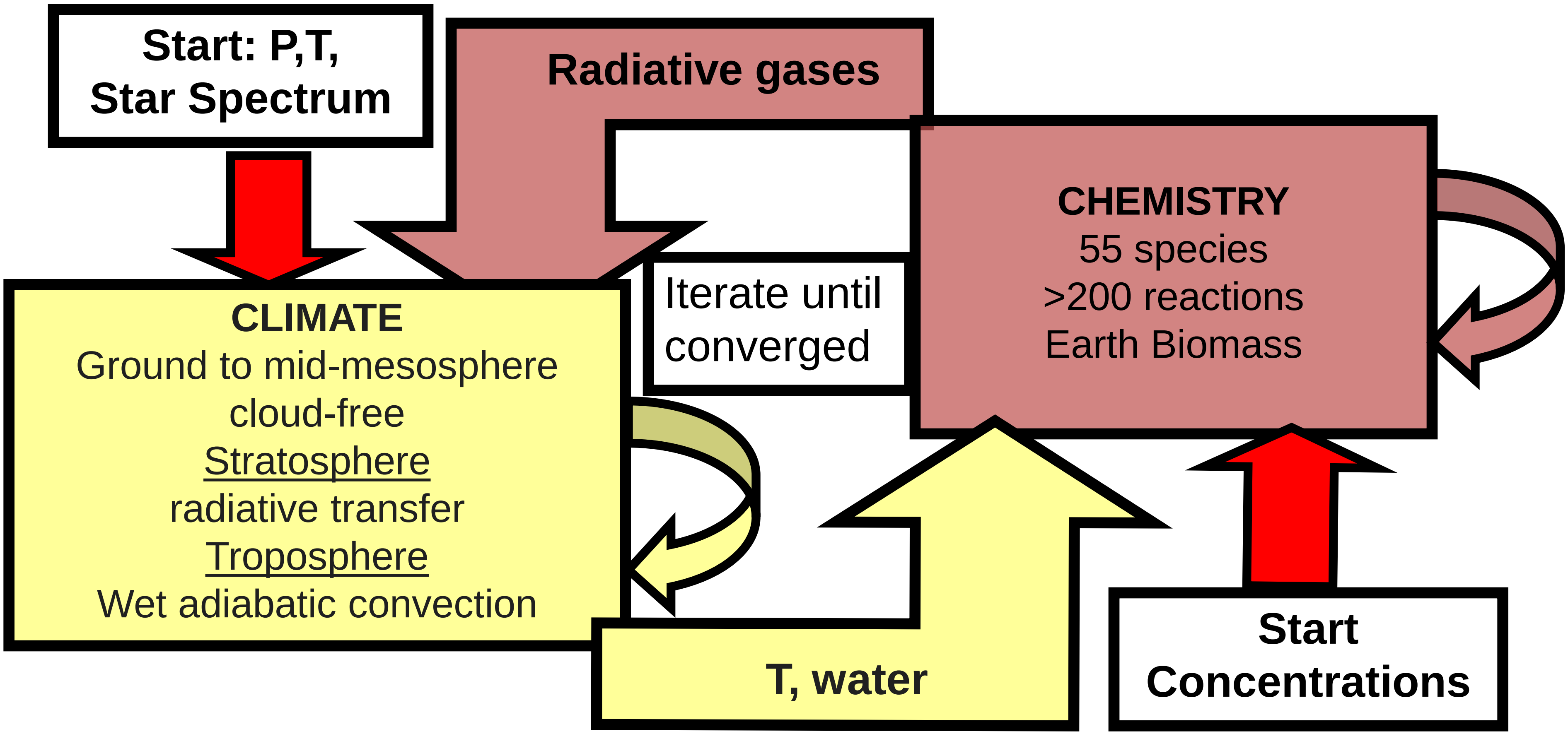
Atmospheric Sources and Sinks of Biosignatures Nitrous Oxide (N_2O) and Ozone (O_3)



Global Atmospheric Column Model

Coupled radiation, convection and chemistry

(Kasting et al. 1980; Grenfell et al. 2007; **Rauer et al. 2011**)



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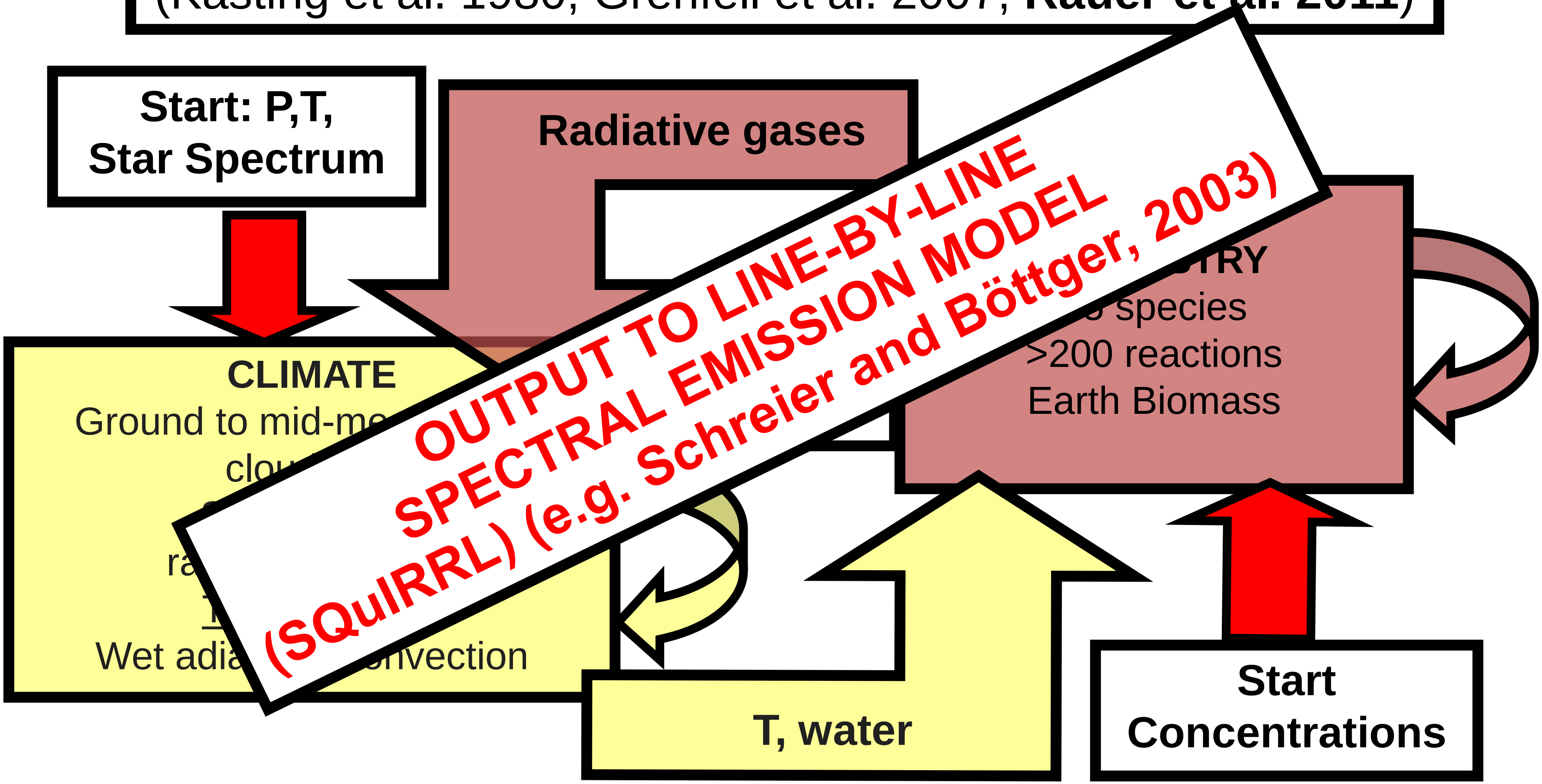
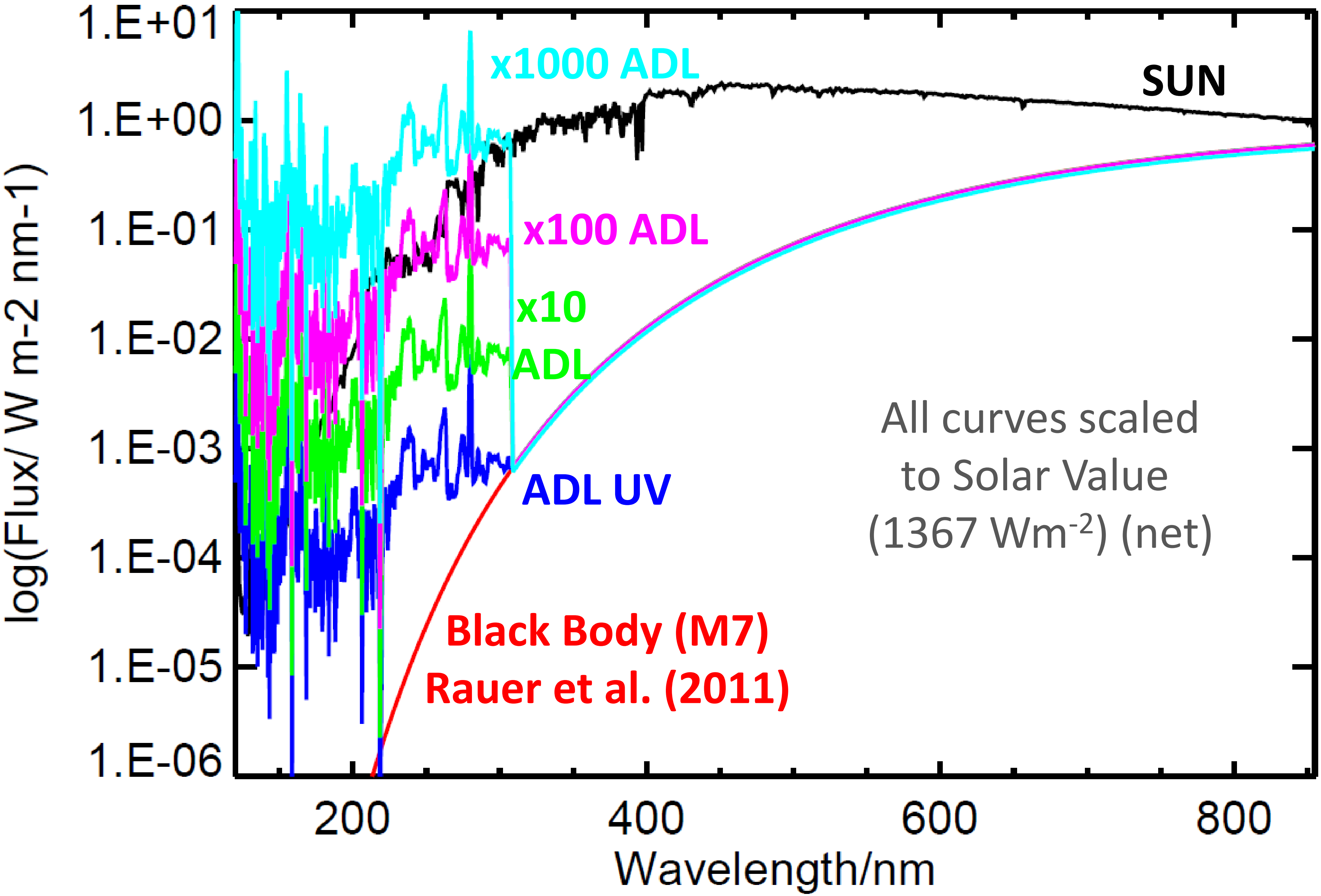


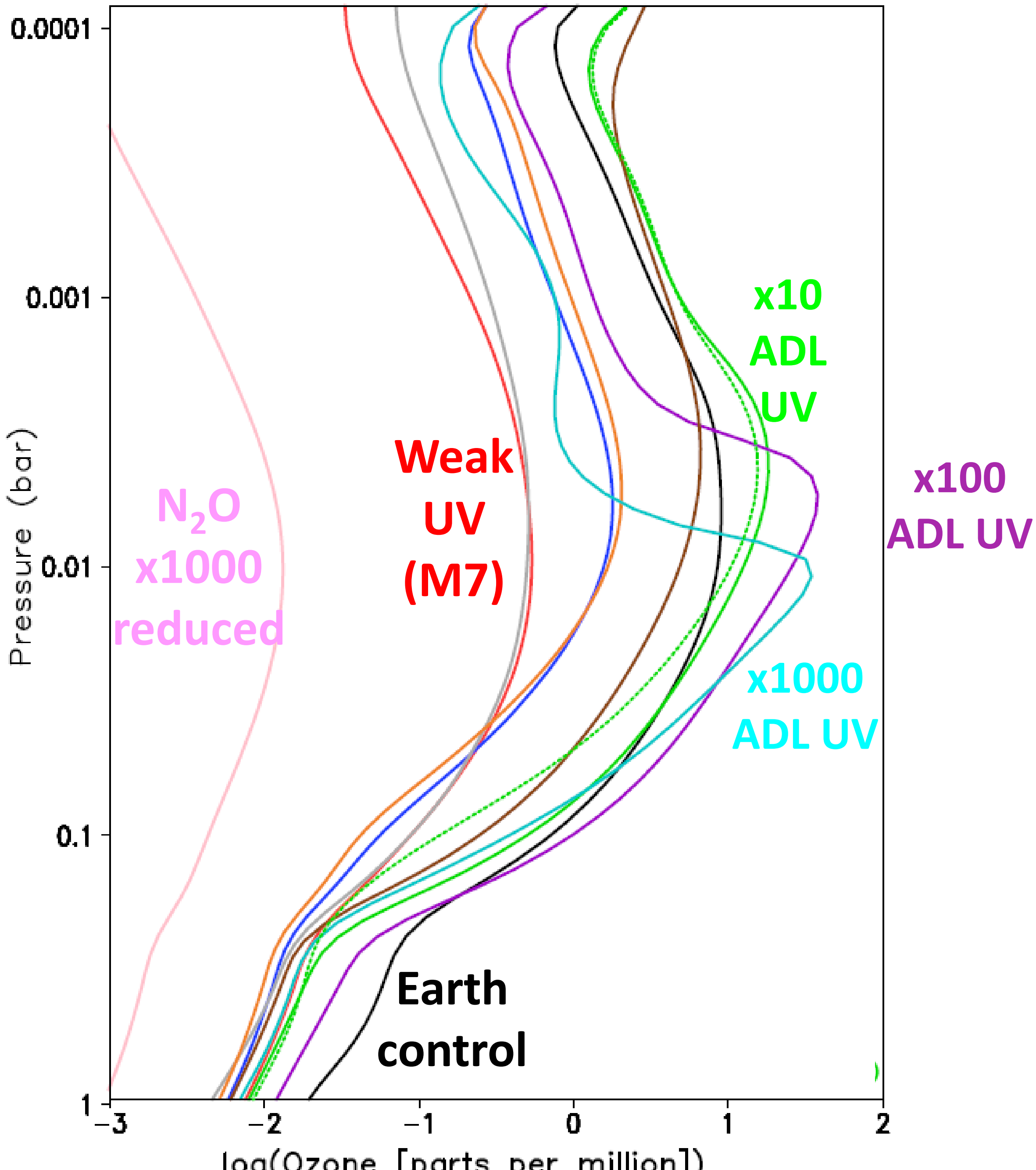
Scenarios

Run 1 – Earth (N_2-O_2 atm., biomass) around the **Sun**
Run 2 – Earth around **quiet** cool M-star (M7)
Run 3 – as Run 2 but for **active** M-star (ADL)
Run 4 – as Run 3 but with stellar UV **x10**
Run 5 – as Run 3 but with stellar UV **x100**
Run 6 - as Run 3 but with stellar UV **x1000**
Run 7 – as Run 4 but with x5 UV (300-350nm)
Run 8 –as Run 3 but x100 TOA Lyman-α
Run 9 – as Run 2 but x100 less CH_4 emissions
Run 10 – as Run 3 but x100 less CH_4 emissions
Run 11 – as Run 3 but no N_2O emissions
Run 12 – as Run 2 but x1000 less N_2O emissions
Run 13 – as Run 3 but with x2 CH_4 emissions
Run 14 – as Run 3 but with x3 CH_4 emissions

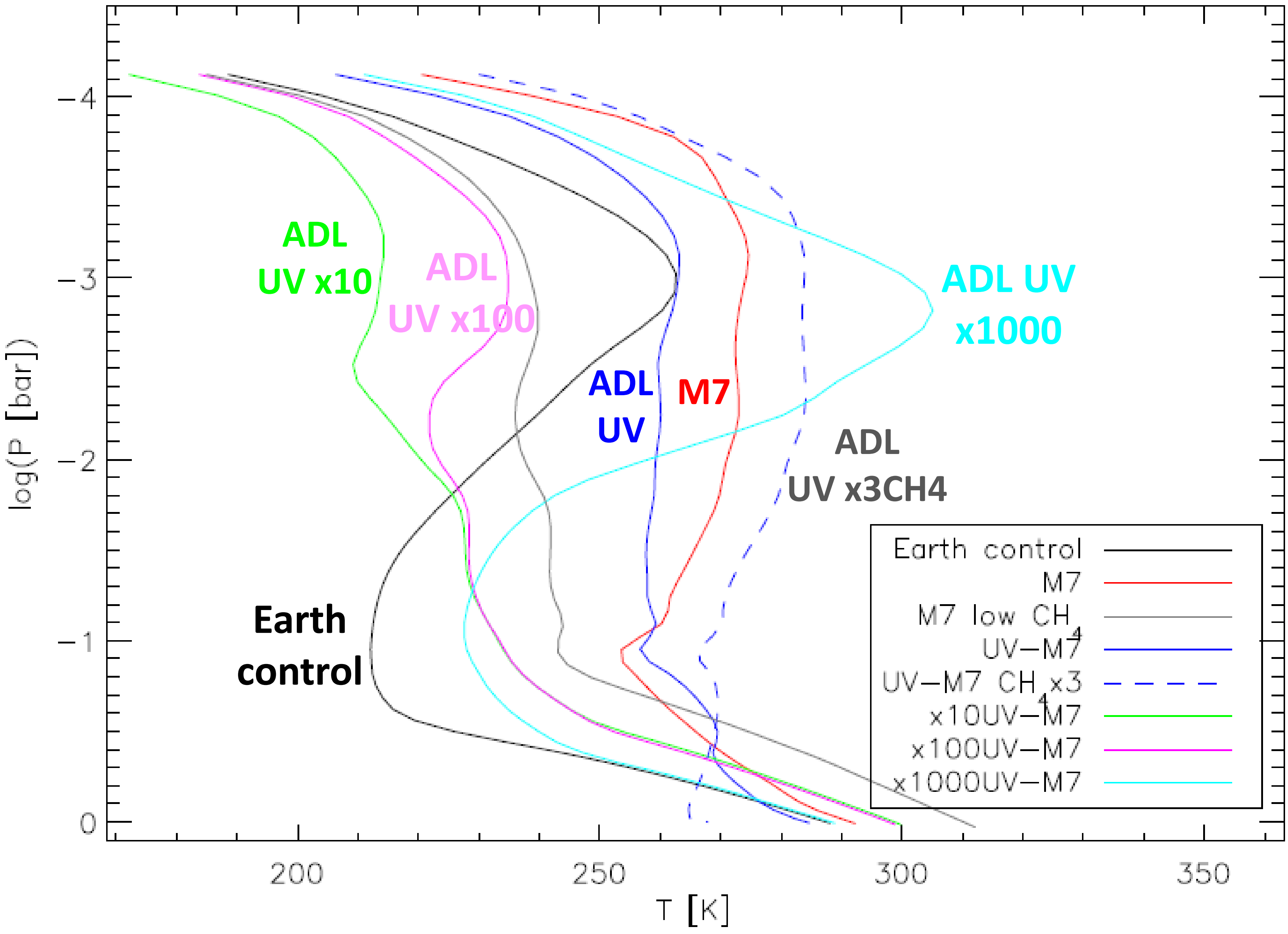
Stellar UV Top-of-Atmosphere Input Spectra



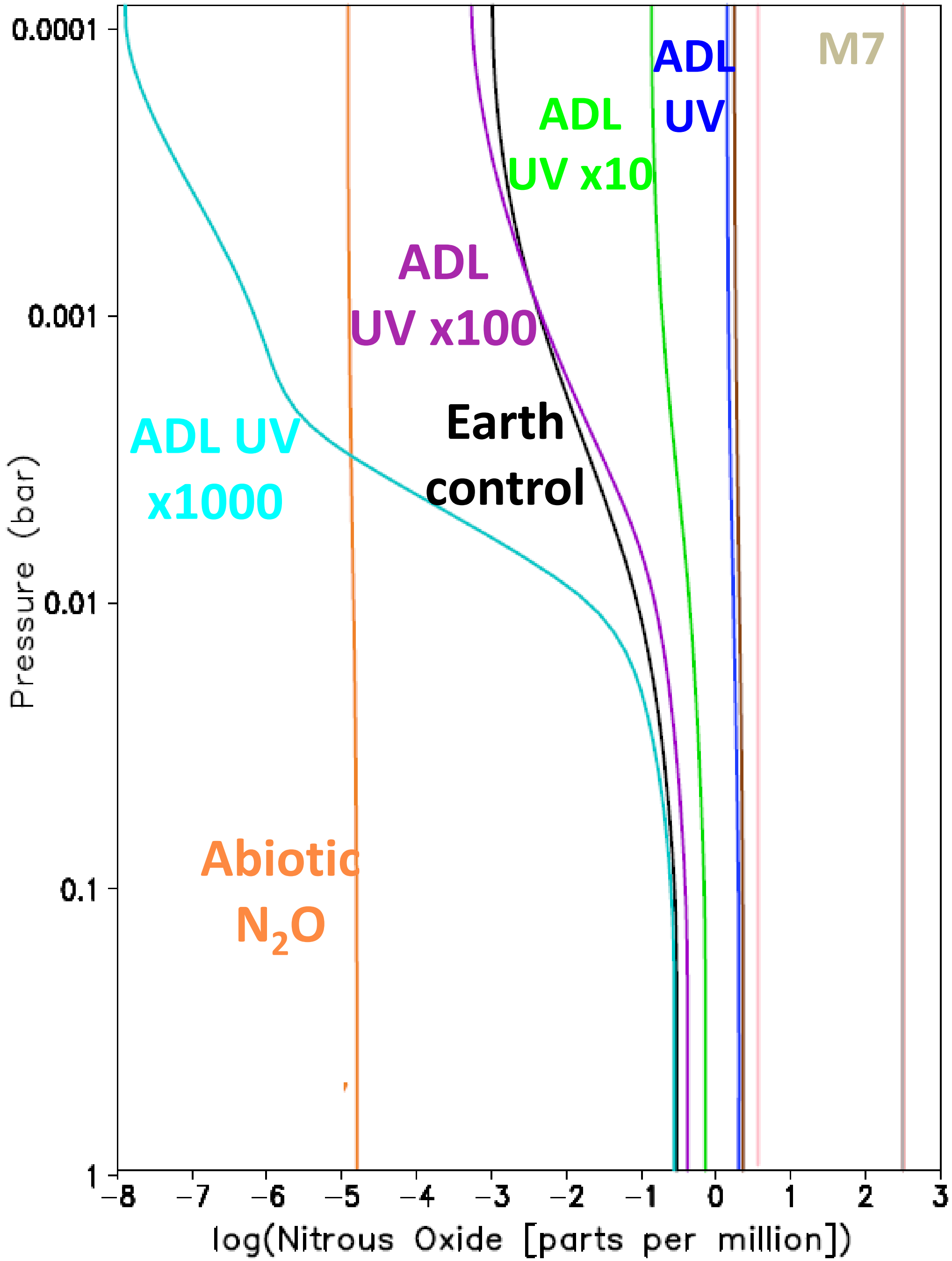
Results: Ozone



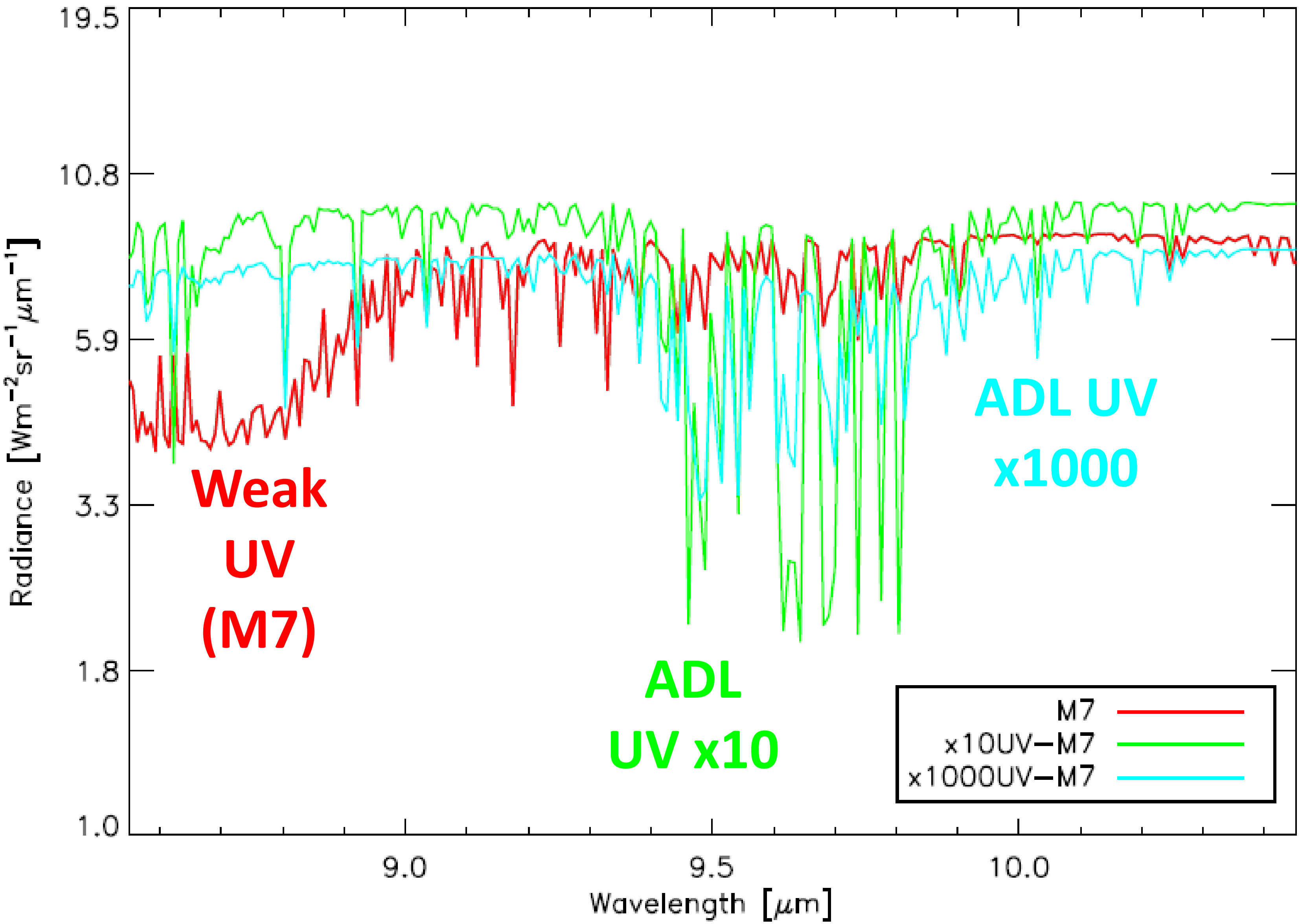
Results: Temperature



Results: Nitrous Oxide



Results: Ozone Emission Spectra



Conclusions

- Biosignatures respond sensitively to UV emissions of the central M-dwarf star
- Ozone is favoured by enhanced UV(C) which stimulates its formation whereas enhanced UV(B) levels leads to ozone loss via photolysis
- Enhanced ozone weakens vertical T gradients which leads to weaker spectral bands. Maximum ozone band at x10 UV ADL
- Nitrous oxide responds strongly to UV and non-linearly to biomass emissions