



Processes affecting the Evolution of Molecular Oxygen in Earth-like (N_2 - O_2) Atmospheres

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Overview

Motivation

The Great Oxidation Event

Model Description

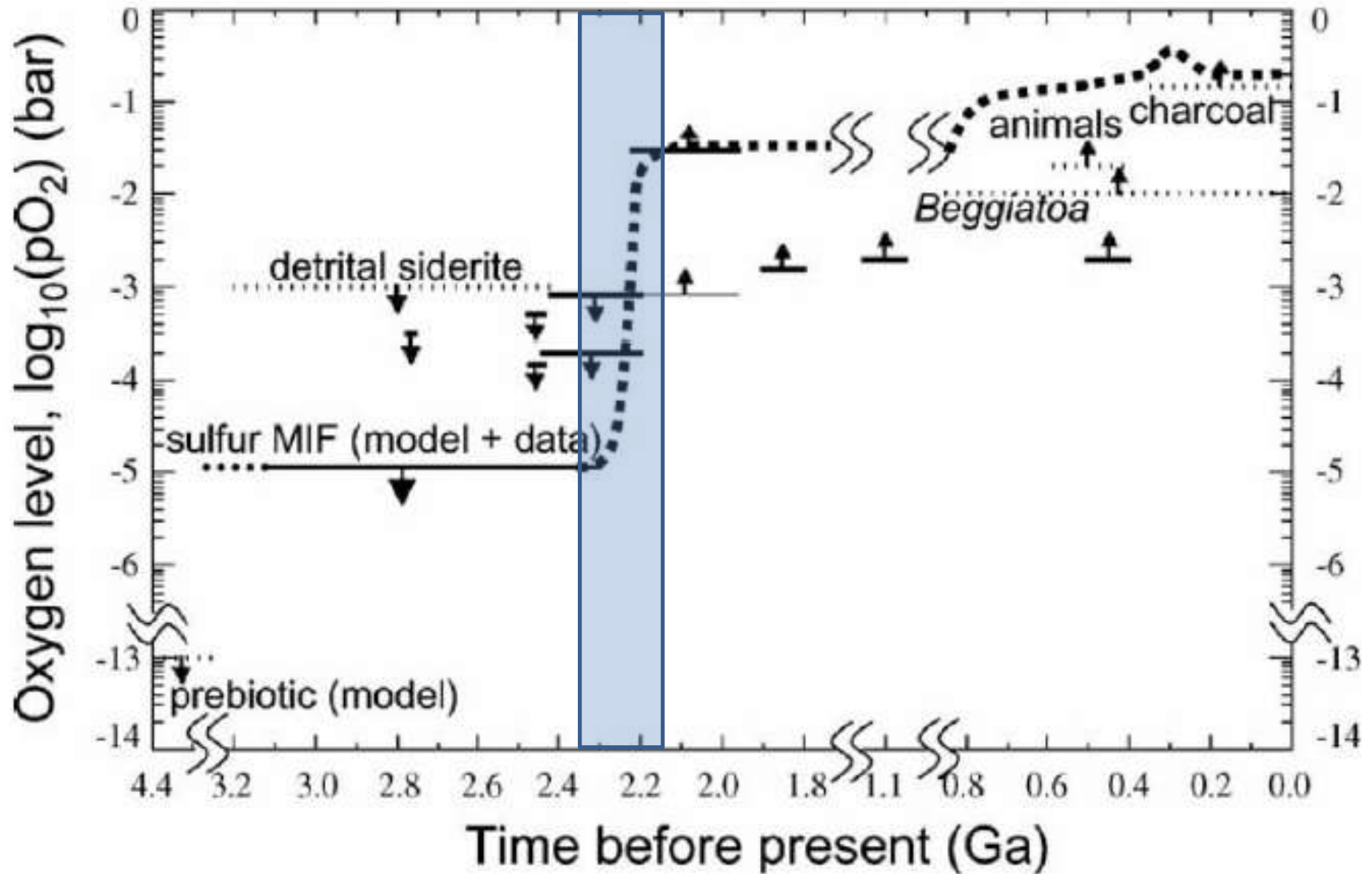
Results

Conclusions

Motivation

Improve understanding of processes affecting atmospheric chemistry and climate before, during and after the Great Oxidation Event (GOE)

Atmospheric O₂ Evolution on Earth



Adapted from Claire et al. (2006)

Possible mechanisms for the GOE

Stronger Oxygen Sources

Hydrogen escape

Burial

Weathering

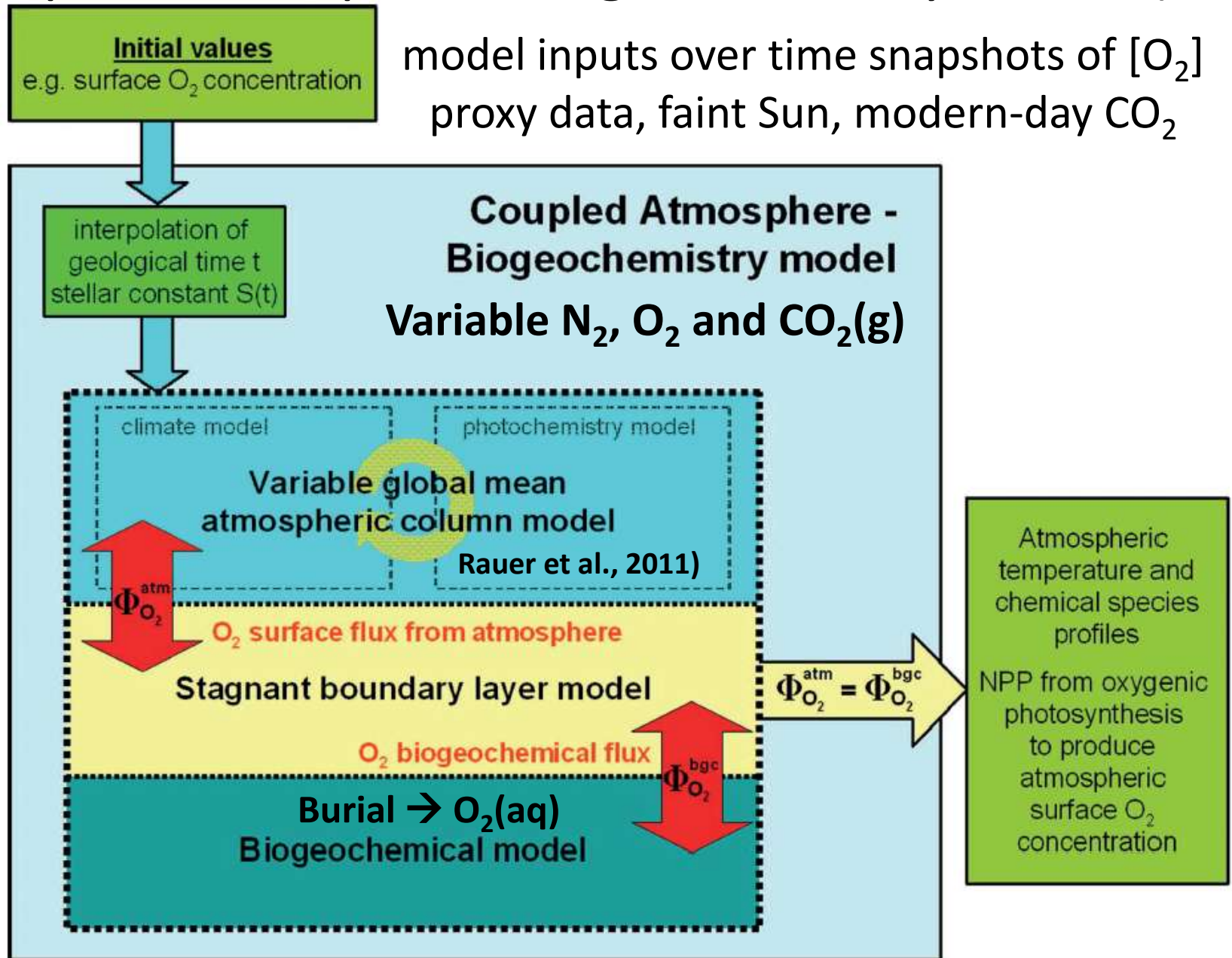
Weaker Oxygen Sinks

Outgassing less reducing

e.g. Catling and Claire (2005)

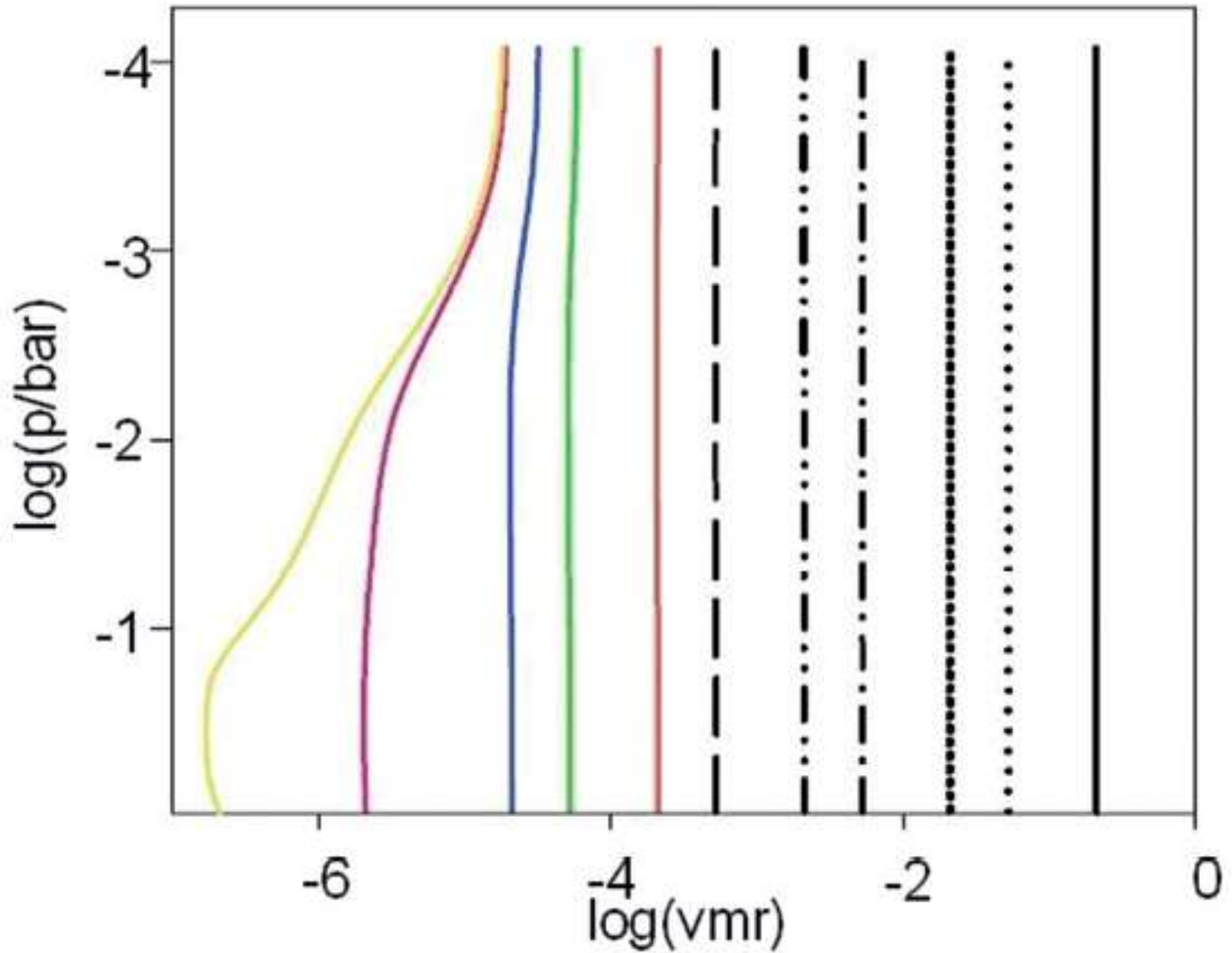
Westall et al. (2012)

Coupled Atmosphere-Biogeochemistry Model (CAB)

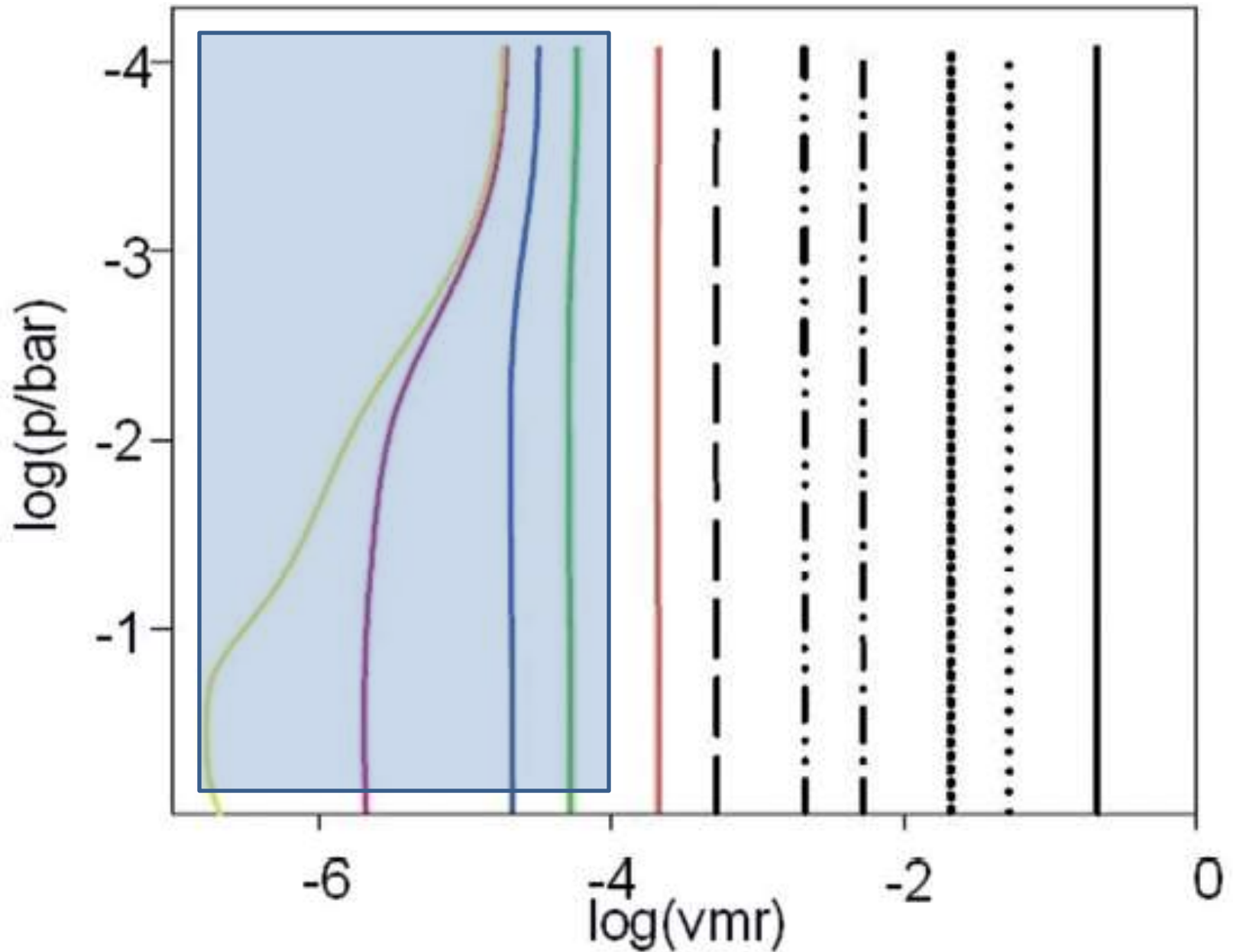


(Gebauer, Grenfell...Rauer et al., 2015; Astrobiology, under review)

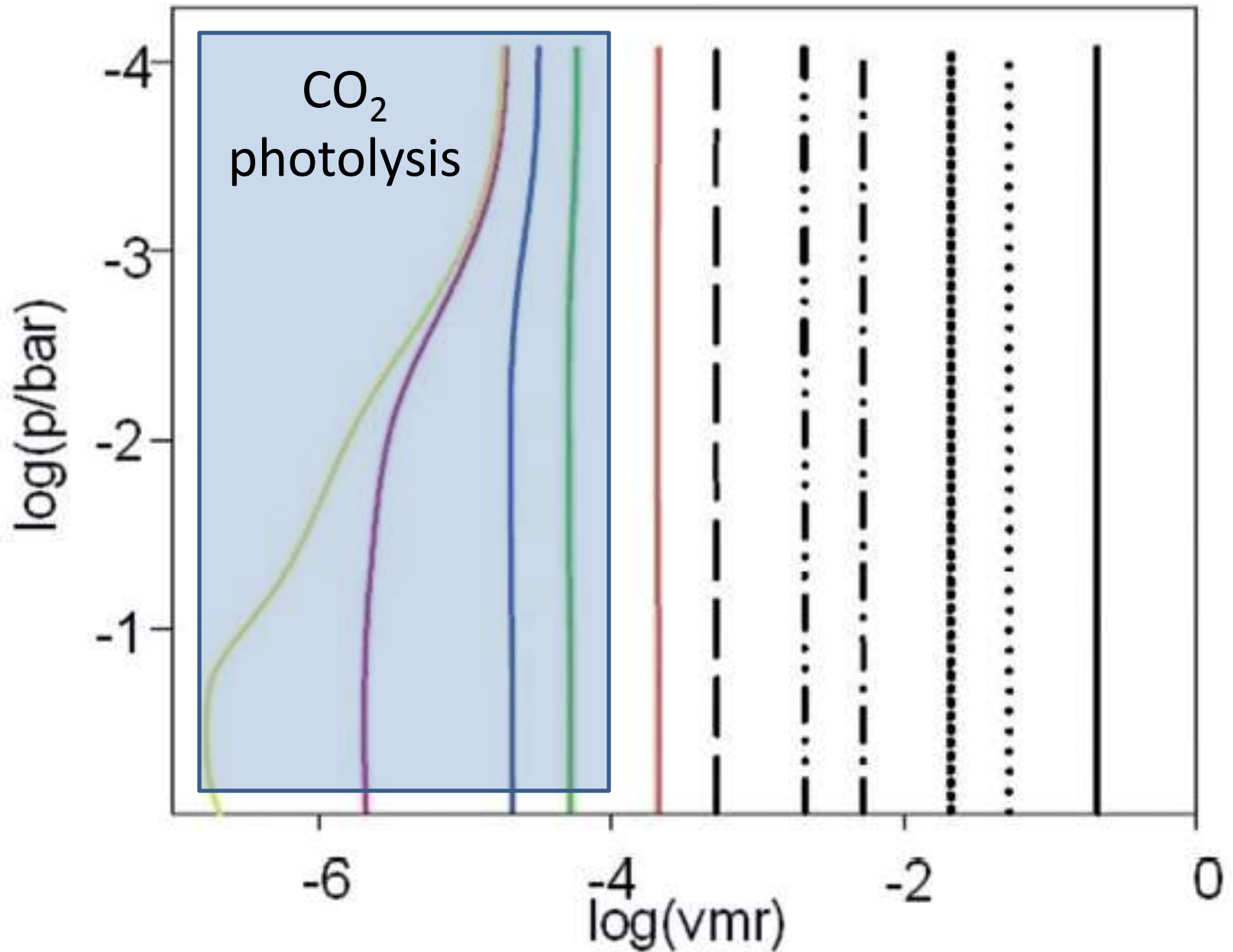
RESULTS: Molecular Oxygen (vmr)



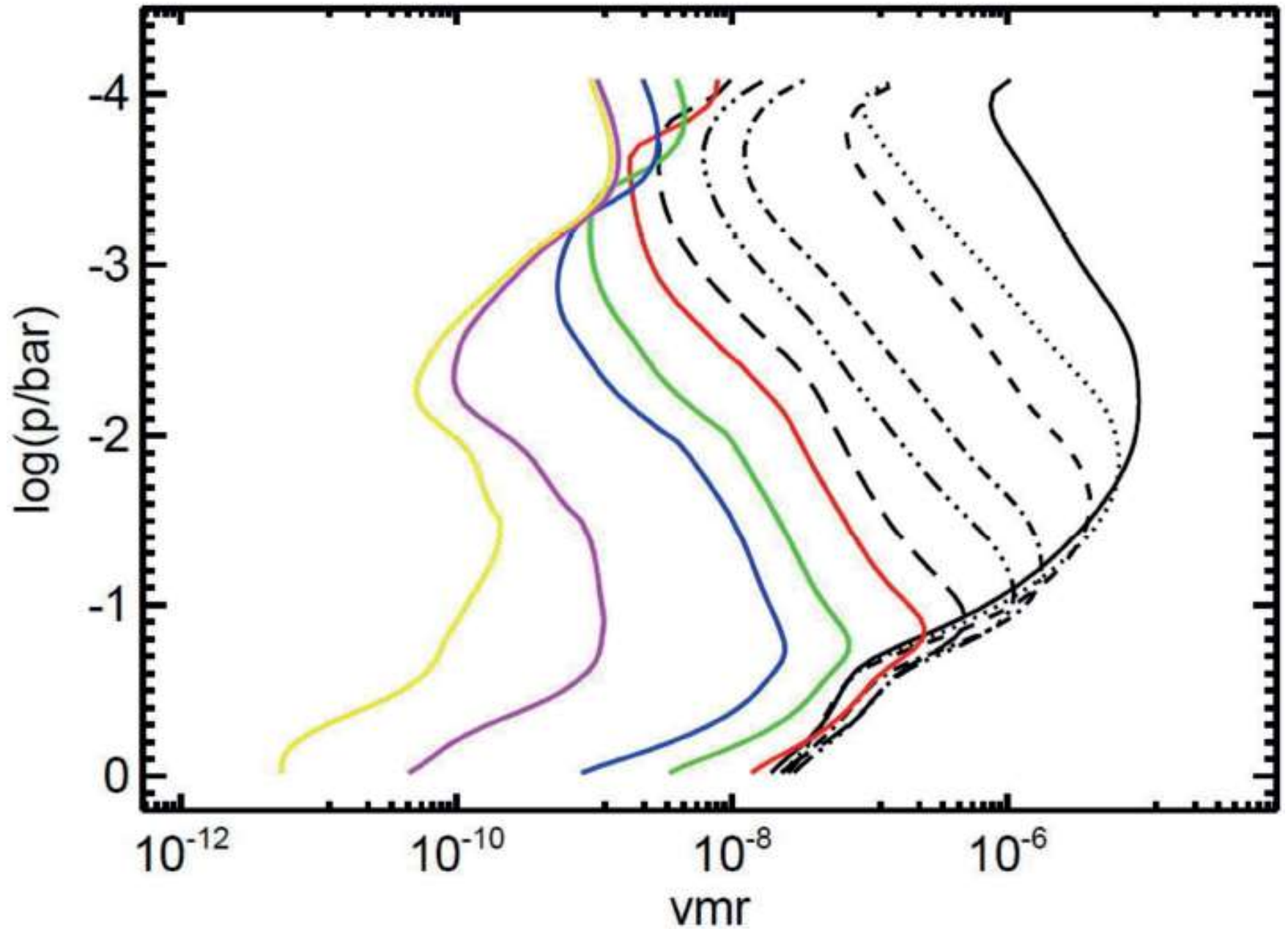
RESULTS: Molecular Oxygen (vmr)



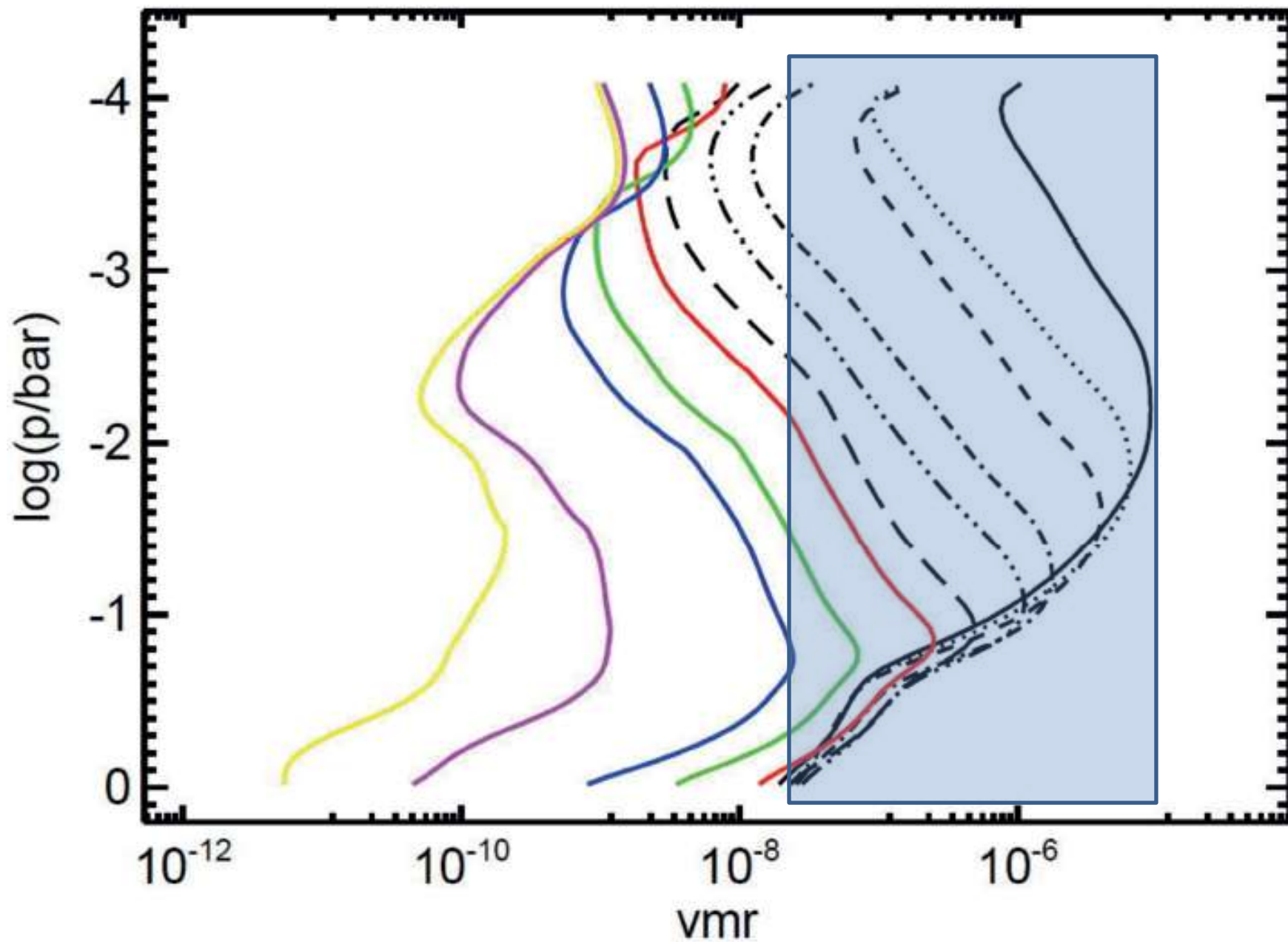
RESULTS: Molecular Oxygen (vmr)



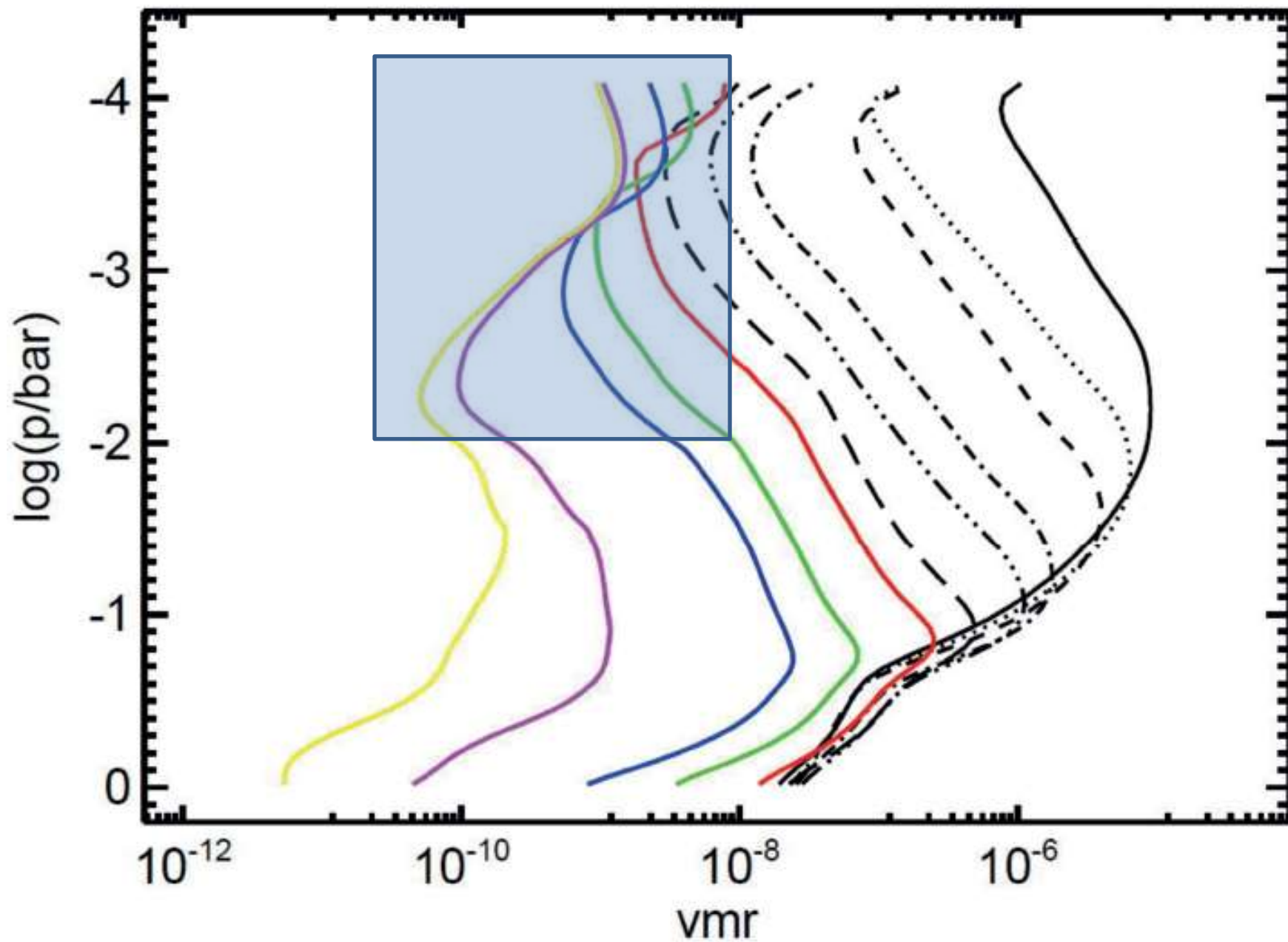
Ozone (vmr)



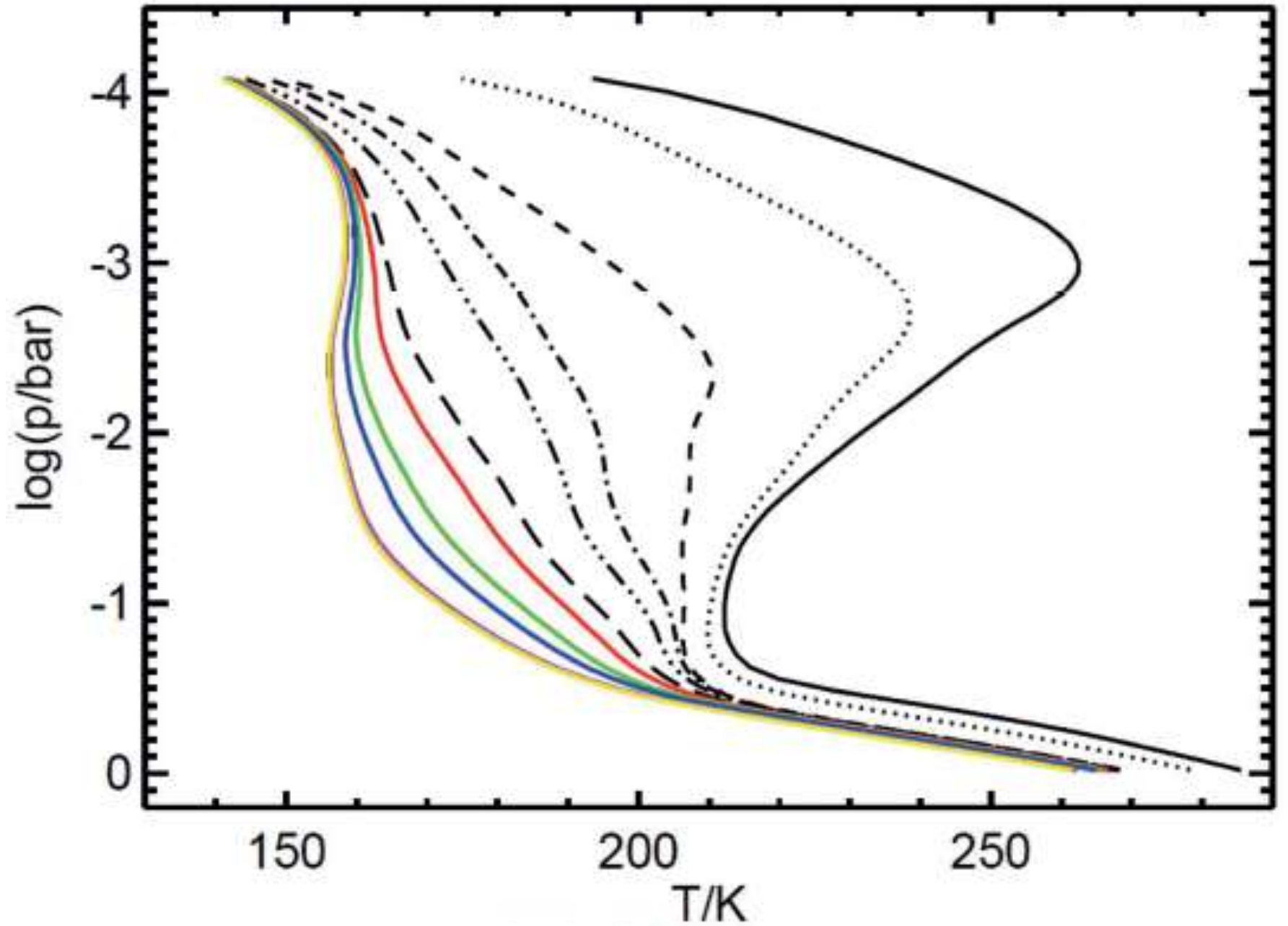
Ozone (vmr)



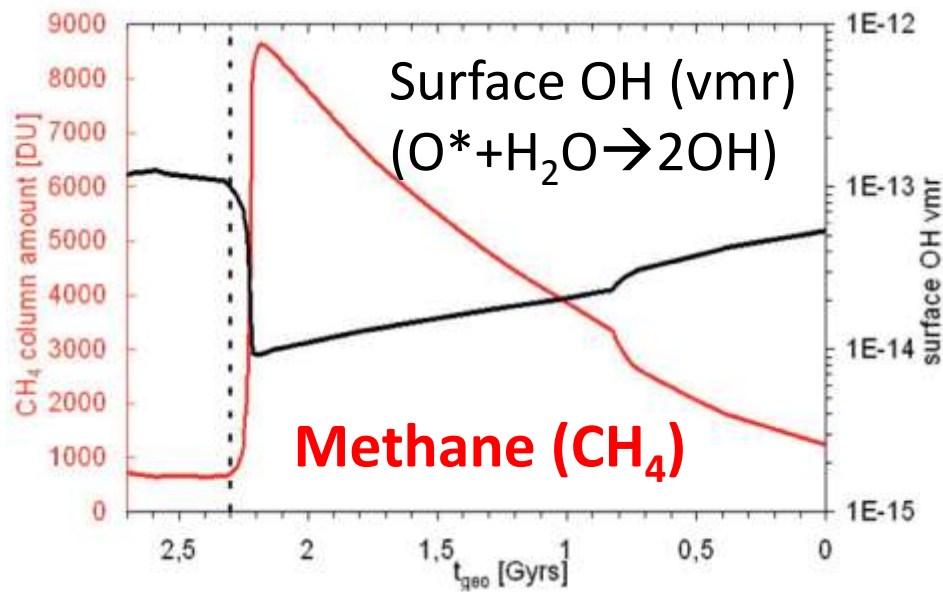
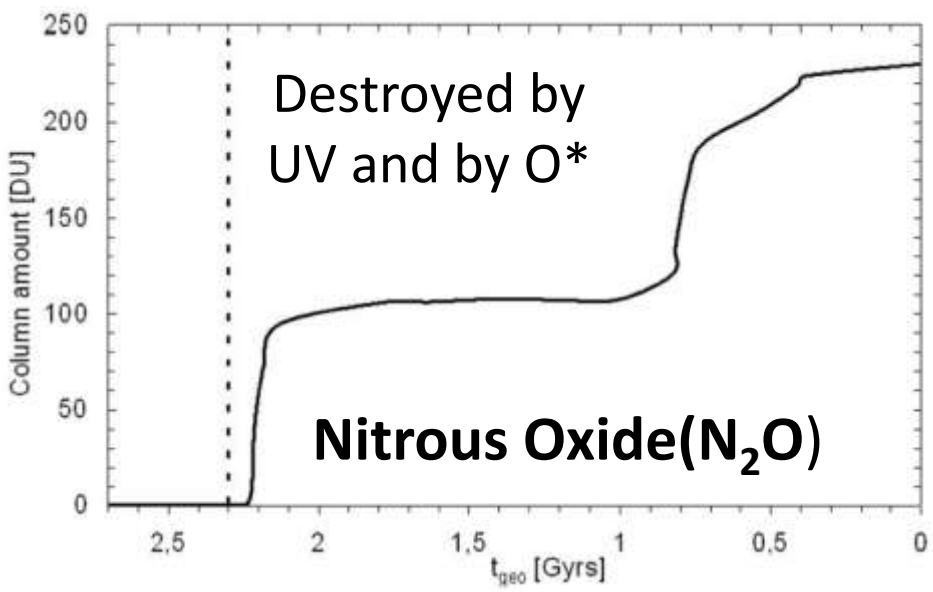
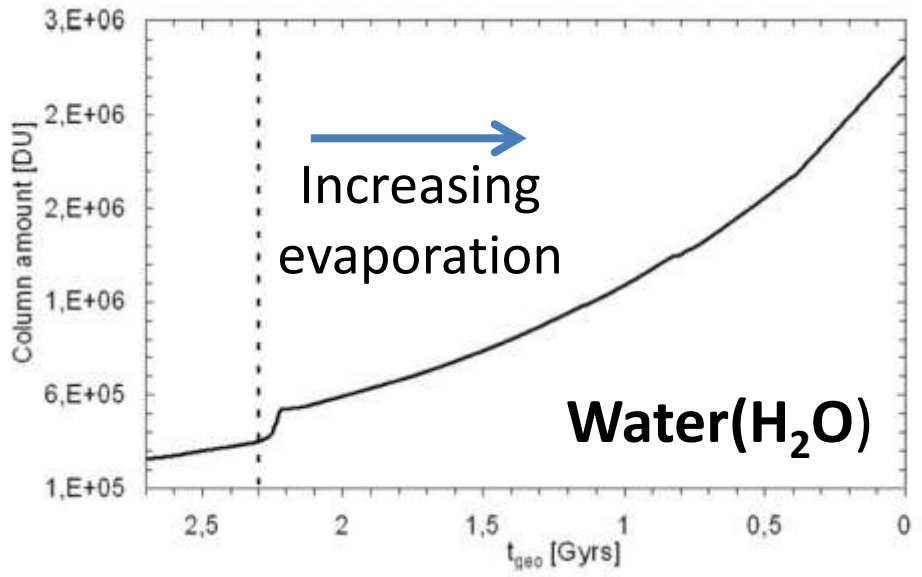
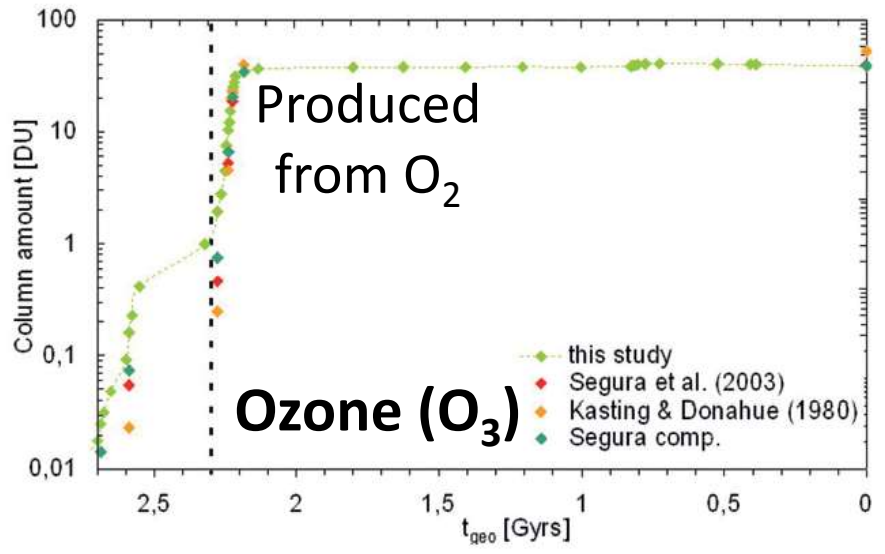
Ozone (vmr)



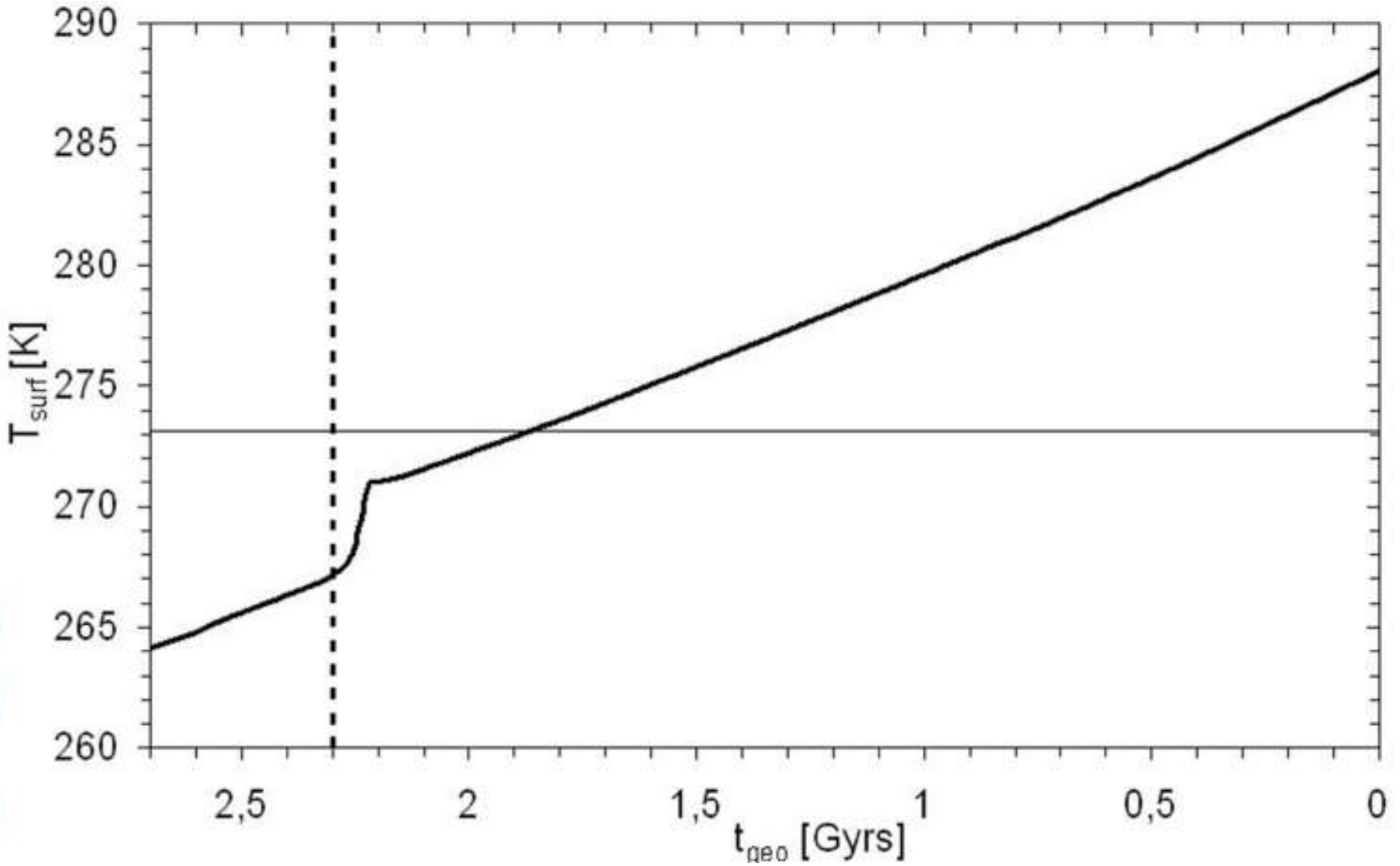
Temperature (K)



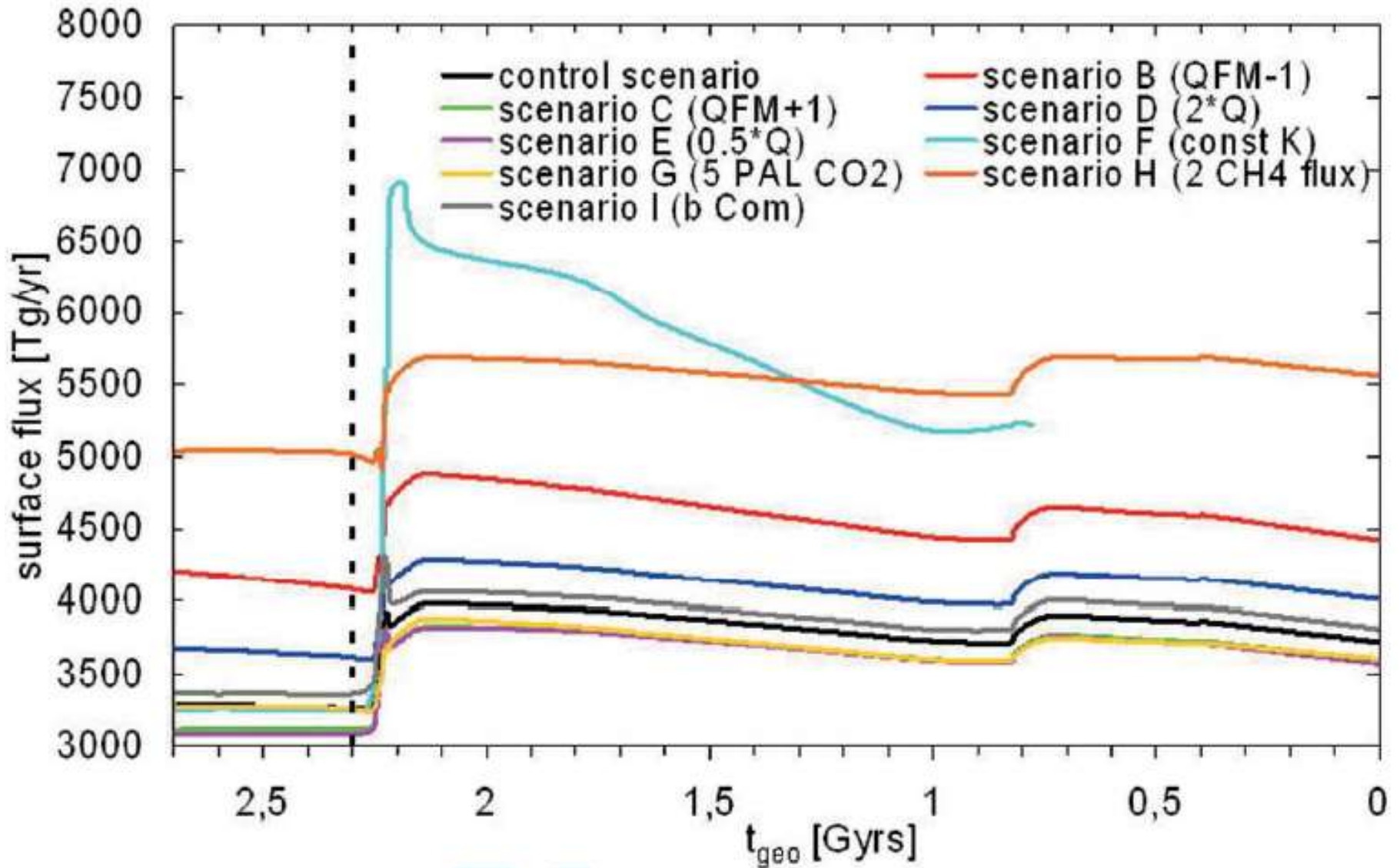
Atmospheric Column (DU) Evolution of Key Species



Surface Temperature (K) Evolution



O₂ (g) fluxes (Tg/yr) for different scenarios



Quantifying O₂ Chemical Pathways

Pathway Analysis Program (PAP)

Inputs rates and concentrations from CAB model

Builds pathways by connecting sources with sinks

Deletes pathways below a minimum flux

Distributes Δ concentration over pathways built

→ Automatically identifies and quantifies pathways for e.g. O₂

Why do we need PAP? – atmospheric sources and sinks can be complex catalytic cycles with many reactions

For PAP results see Gebauer et al. (2016) (under review)

Lehmann (2004)

Summary and Conclusions

- **New:** Coupled Atmosphere Biogeochemical model (CAB)
- Investigated key processes affecting climate and chemistry on early Earth

- **New:** Chemical Pathway Analysis of O₂ on Early Earth
- O₂ in-situ sources: CO₂ photolysis catalysed by HOx
- O₂ in-situ sinks: CO and CH₄ oxidation catalysed by HOX