Dynamics and variability of the late Permian climate-carbon state in an Earth System Model

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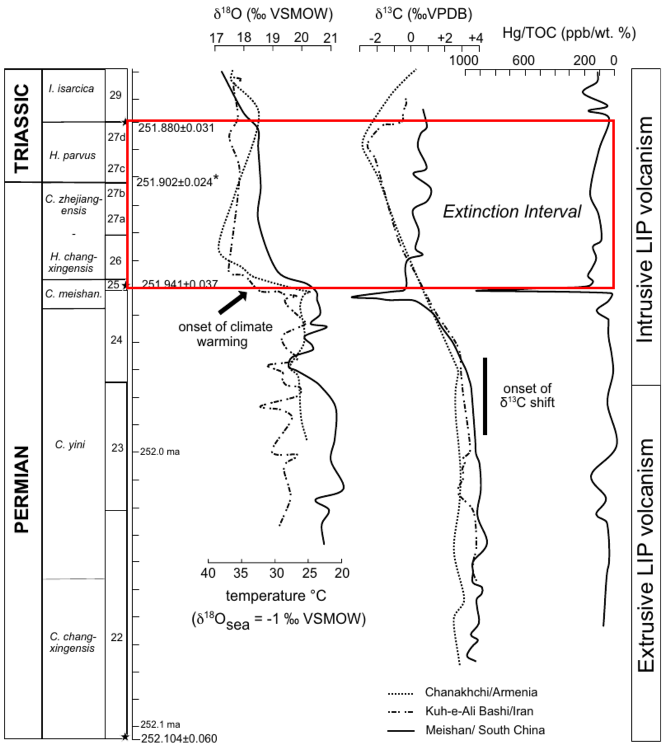
Permian-Triassic Mass Extinction (252 Ma)



Modified from Joachimski, M.M., et al. (2020) *Geological Society of America Bulletin*

- Extinction of >90% of species (Song et al. 2013)
- 6-fold increase in atmospheric CO_2 (Wu et al. 2021)
- Equatorial sea surface temperatures rose by 8-10 °C (Joachimski et al. 2020)

What are the characteristics of the late Permian climate-carbon state simulated by the Max-Planck Institute Earth System Model?

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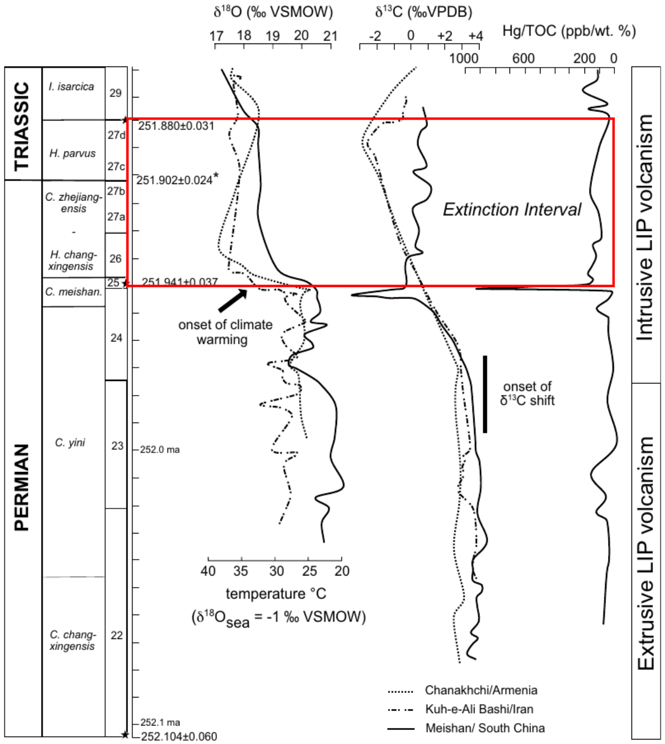

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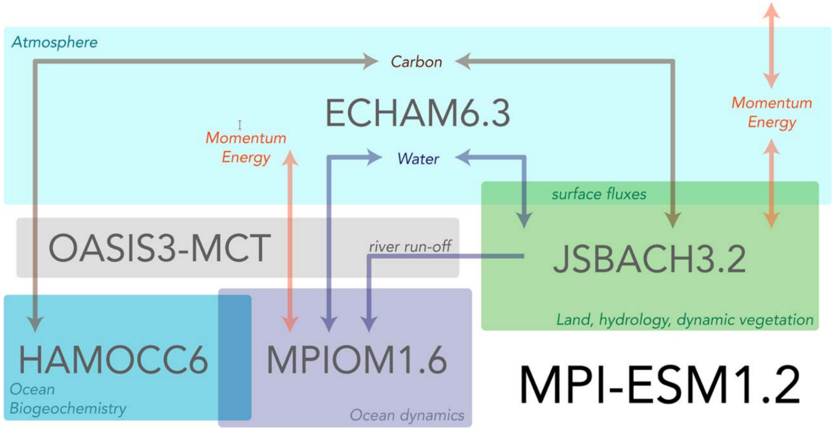
Sharing is encouraged

Model Set-up and Boundary Conditions

Adapted **M**ax-**P**lanck **I**nstitute **E**arth **S**ystem **M**odel (MPI-ESM) used for the 6th phase of the Coupled Model Intercomparison Project for late Permian simulations.



Mauritsen, T., et al. (2019) *Journal of Advances in Modeling Earth Systems*

- Reduce solar intensity to 1361.37 Wm^{-2}
- Homogeneous atmospheric forcing
- Atmospheric CO_2 = 500 ppm
- Atmospheric CH_4 = 808 ppb
- Atmospheric N_2O = 273 ppb

- Implemented 7 plant-functional types (PFTs)

- Increase initial ocean salinity to 40

- Removed shell-producing phytoplankton
- Added shell-producing zooplankton
- Included additional Nitrogen cycle processes and species

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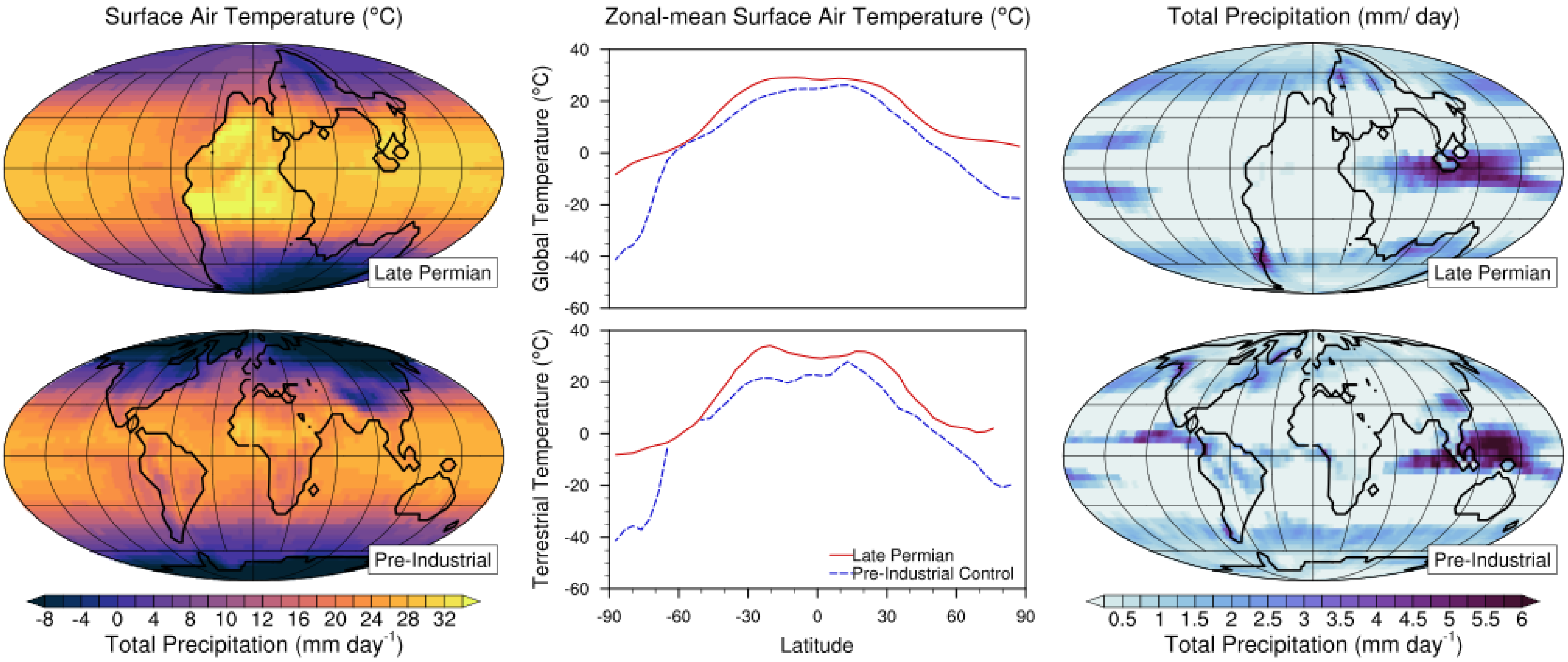
Modelled late Permian is warmer and wetter than pre-industrial simulation



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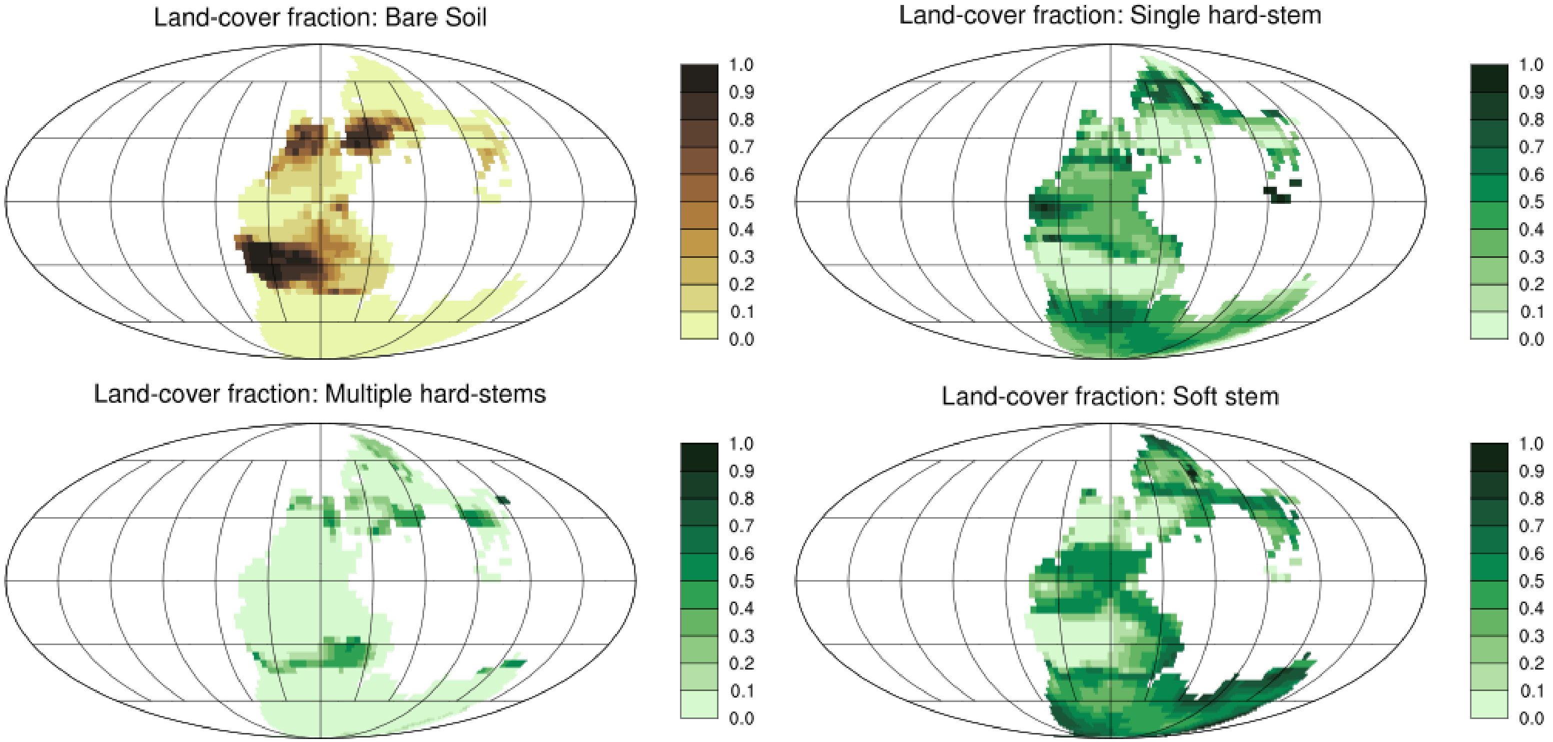
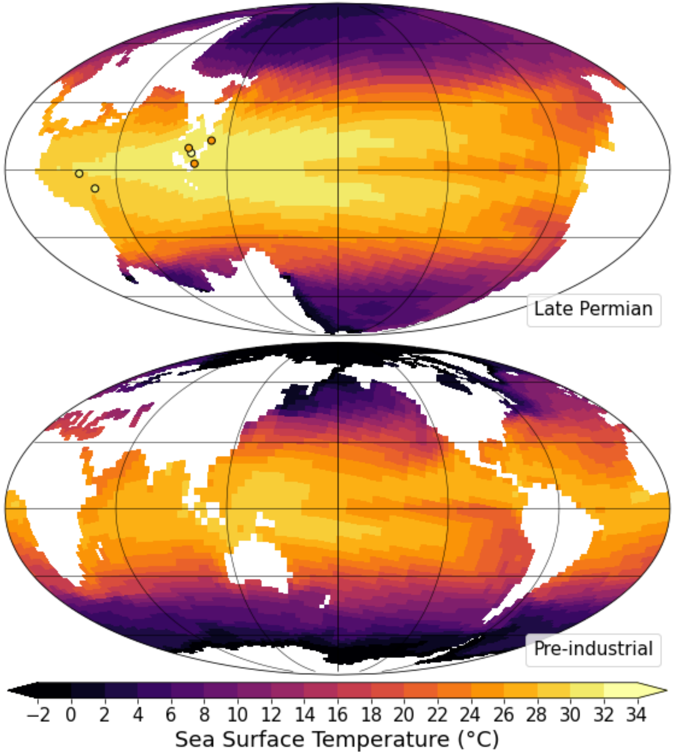
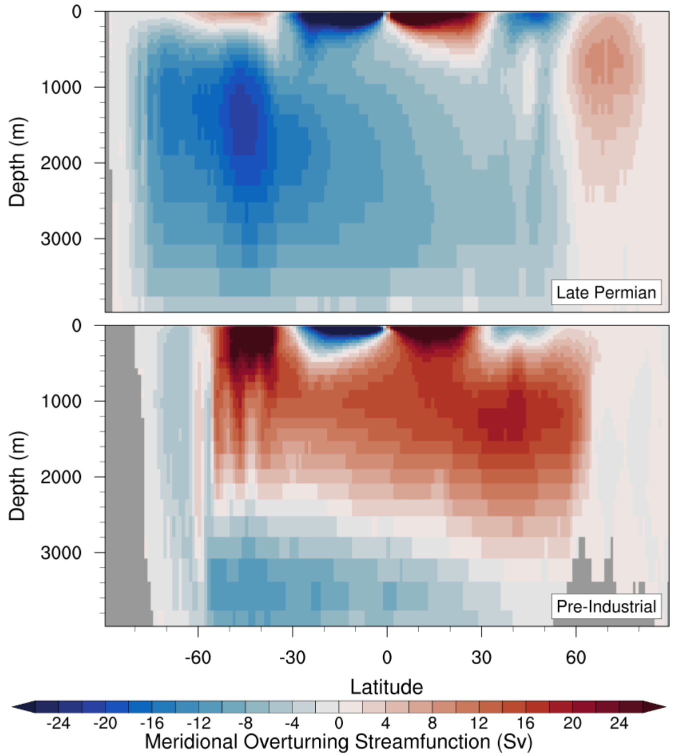
Single hard-stemmed and soft stemmed PFTs dominant in the simulated late Permian



Late Permian ocean warmer with dominant northward MOC compared to pre-industrial





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Conclusions and Outlook

- Higher global mean surface air temperatures
- More precipitation globally with more arid landmass
- Terrestrial vegetation dominated by tall hard-stemmed and soft stemmed plant functional types
- Warmer sea surface temperatures
- Southern-dominant deep water formation leading to distinct meridional overturning circulation

Ongoing analyses of ocean biogeochemistry and the overall influence of monsoon variability

Bibliography I

Joachimski, M.M., et al. 2020. “Siberian Trap volcanism, global warming and the Permian-Triassic mass extinction: New insights from the Armenian Permian-Triassic sections”. *Geological Society of America Bulletin* 132 (1-2): 427–443. doi:10.1130/B35108.1.

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