Astronomical Climate Pacing in a Model Framework for Late Triassic Lake Level Cycles

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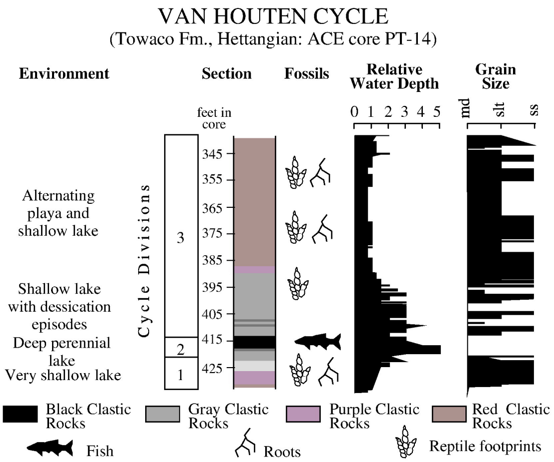
Newark Basin – Sediment Cycles

(Olsen & Kent 1996, Olsen et al. 2019, ...)

- 233–199 Ma, largely lacustrine
- **lake depth cycles**:
  - precession
  - modulation by eccentricity
  - recently: obliquity/inclination
- **orbital modulation of hydroclimate**
  ⇒ stronger/weaker rainy season

Astronomical effects on climate for the Mesozoic, Pangea and greenhouse states.

Enhanced climatic interpretation with Earth system modeling?



(Kent et al. 2017)

Paleoclimate Simulations

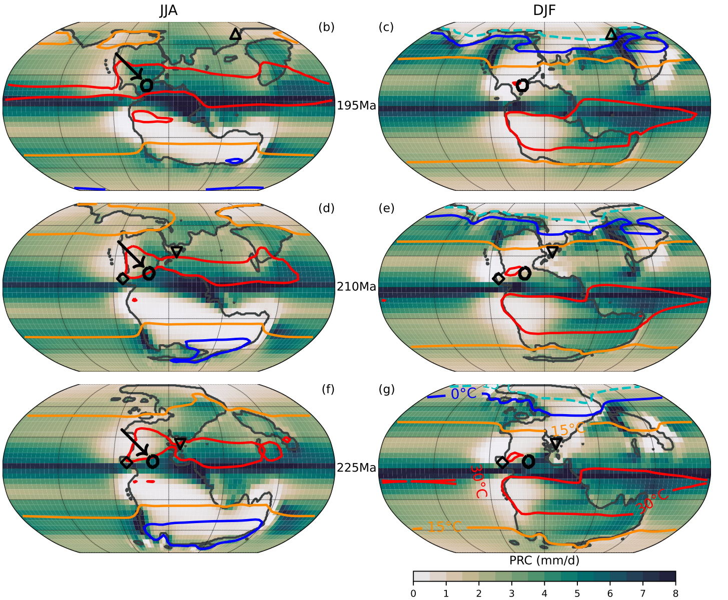
(Landwehrs et al. 2022, under review)

climate model:
CLIMBER-X EMIC
(5°×5° grid; Willeit et al. 2022)

Experiments:

- 9 time-slices (230–190 Ma)
- 2 paleogeographic reconstructions (Marcilly et al. 2021, Cao et al. 2017, 2018)
- 3 pCO_2 values (750, 1500, 3000 ppm)

Maps:
seasonal long-term mean precipitation rates (colors) and surface air temperatures (30/30/0/-15°C contours)



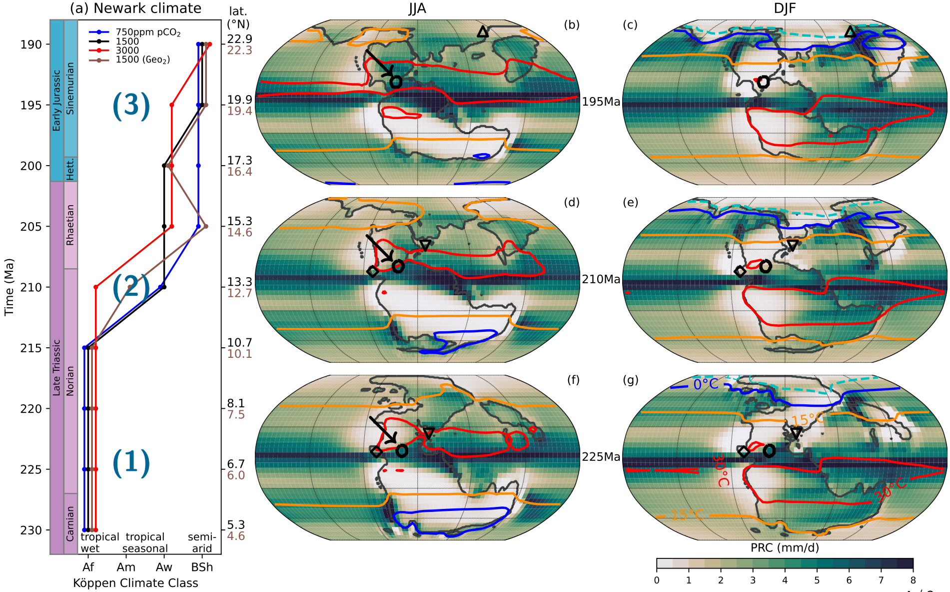
Newark Basin – Climate Setting and Trends

(Landwehrs et al. 2022, under review)

tectonic drift
ca. 5°N → 22°N

climatic transition

(1) tropical humid
(2) more seasonal
(3) semi-arid



Maps:
Newark Basin location indicated by black circles/arrows

Orbital Forcing & Local Response

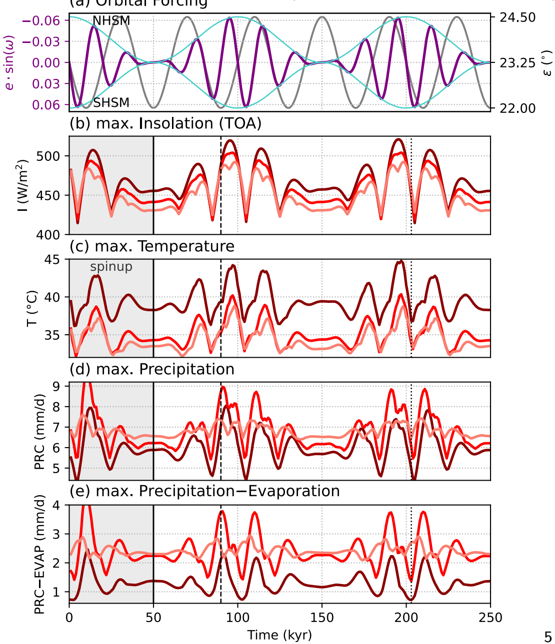
(Landwehrs et al. 2022, under review)

idealized orbital forcing (→ Fig. a):

- **eccentricity-modulated precession** (20 and 100 kyr periods)
- **obliquity** (40 kyr)
- 250 kyr transient climate simulations

Monthly max. T, PRC and PRC–EVAP in the Newark Basin region → Fig. c, d, e

- strong response to precession and eccentricity
- most humid conditions around 210 Ma near max. spring insolation (Fig. e)



225Ma (6.7°N, 3000ppm)
210Ma (13.3°N, 3000ppm)
195Ma (19.9°N, 3000ppm)

Proxies ↔ Model

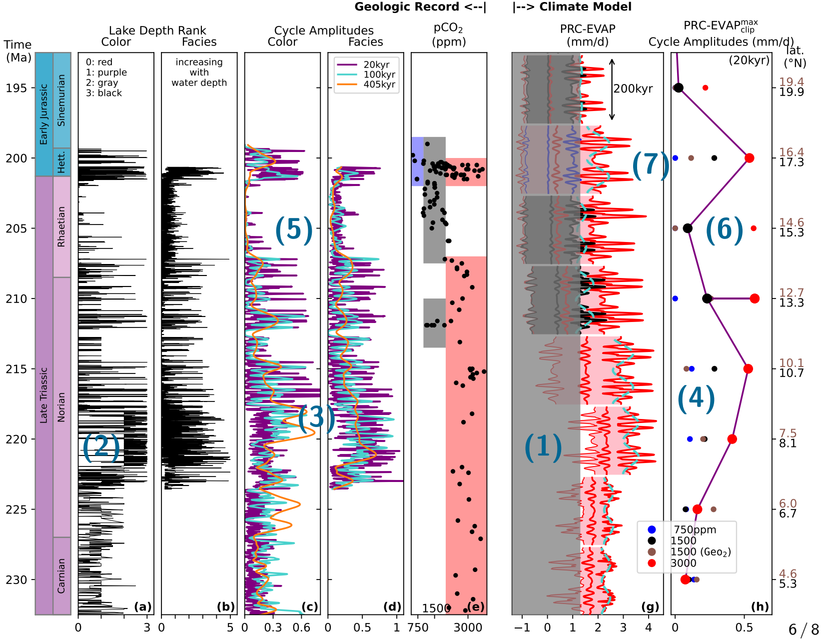
∼220 Ma: wettest simulated climate **(1)**, most frequent deep lakes **(2)**

∼220–215 Ma: strong orbital signals **(3,4)**, associated with northward drift?

∼215–205 Ma: weakening signal **(5,6)**, due to drying amplified by lower pCO_2 (Fig. e), and a humidity threshold (grey in Fig. g)?

∼200 Ma (T–J boundary): temporarily amplified humidity and orb. signal **(7)** due to elevated pCO_2? (CAMP volcanism)

Fig. a–e proxy data from Olsen et al. (2019), Schaller et al. (2011, 2012)



Conclusions & Outlook

- novel modeling approach for studying tectonic and orbital scale climate dynamics, applicable to other geologic periods
- modes of Newark Basin lake-level cyclicity linked to orbital climate forcing, continental drift and $p\mathrm{CO}_2$ variations
- extension to other records (Germanic B., Junggar B., Colorado P. ...)
  $\Rightarrow$ correlation and spatial patterns of orbital climate effects
- including carbon cycle and ice sheet dynamics?
- links to more recent orbital lake-level records, e.g. Pleistocene African lakes?

Thank you for your attention!

Collaboration on orbital paleoclimate cycles?
(looking for PostDoc funding)

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