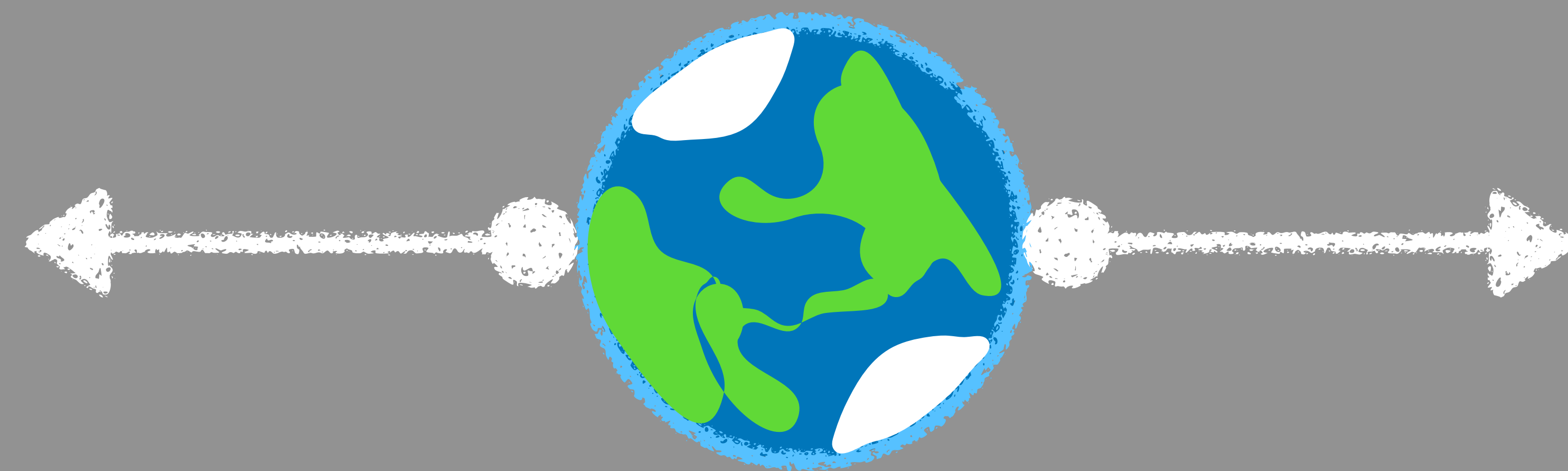




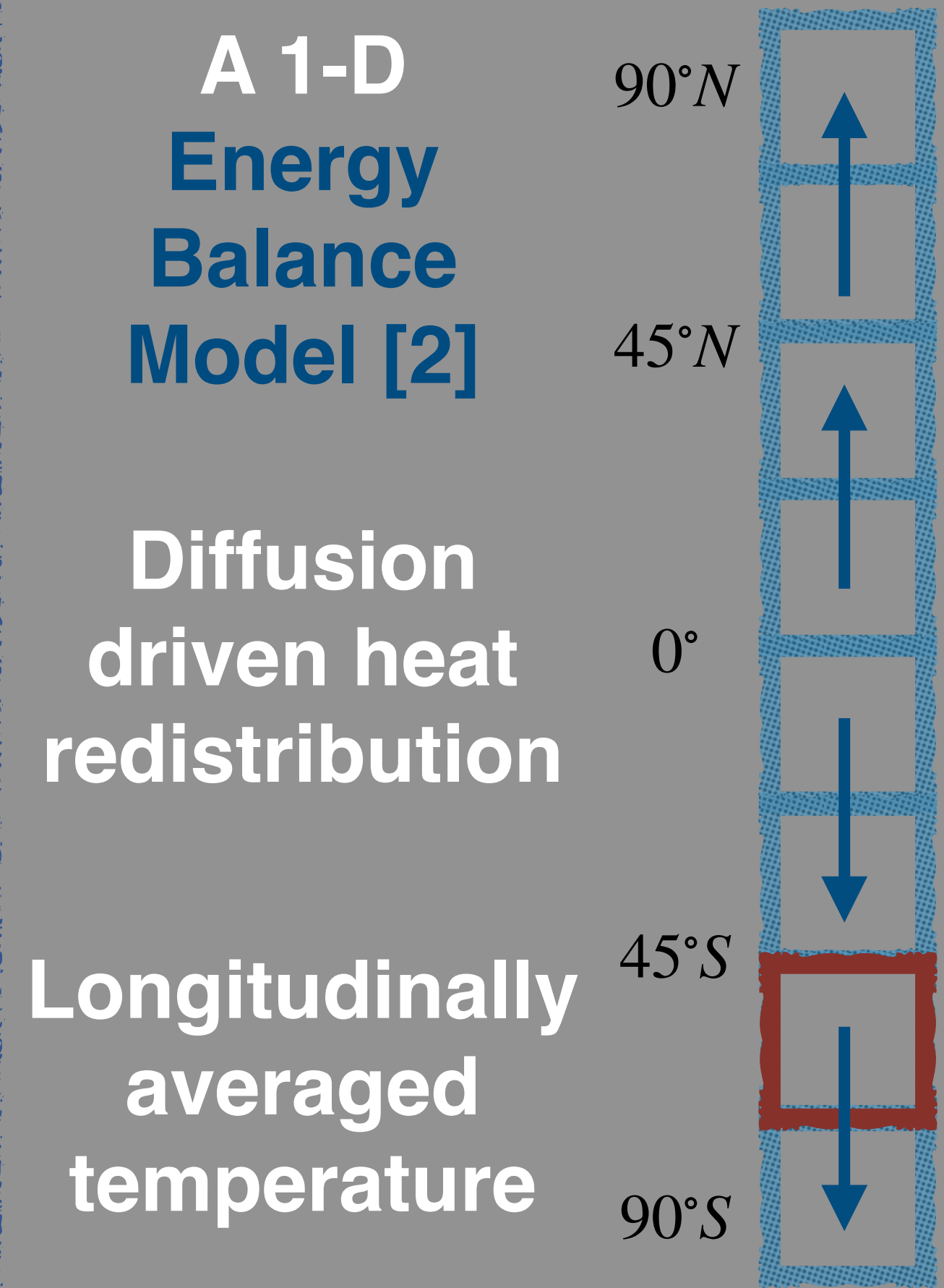
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FACULTÉ DES SCIENCES



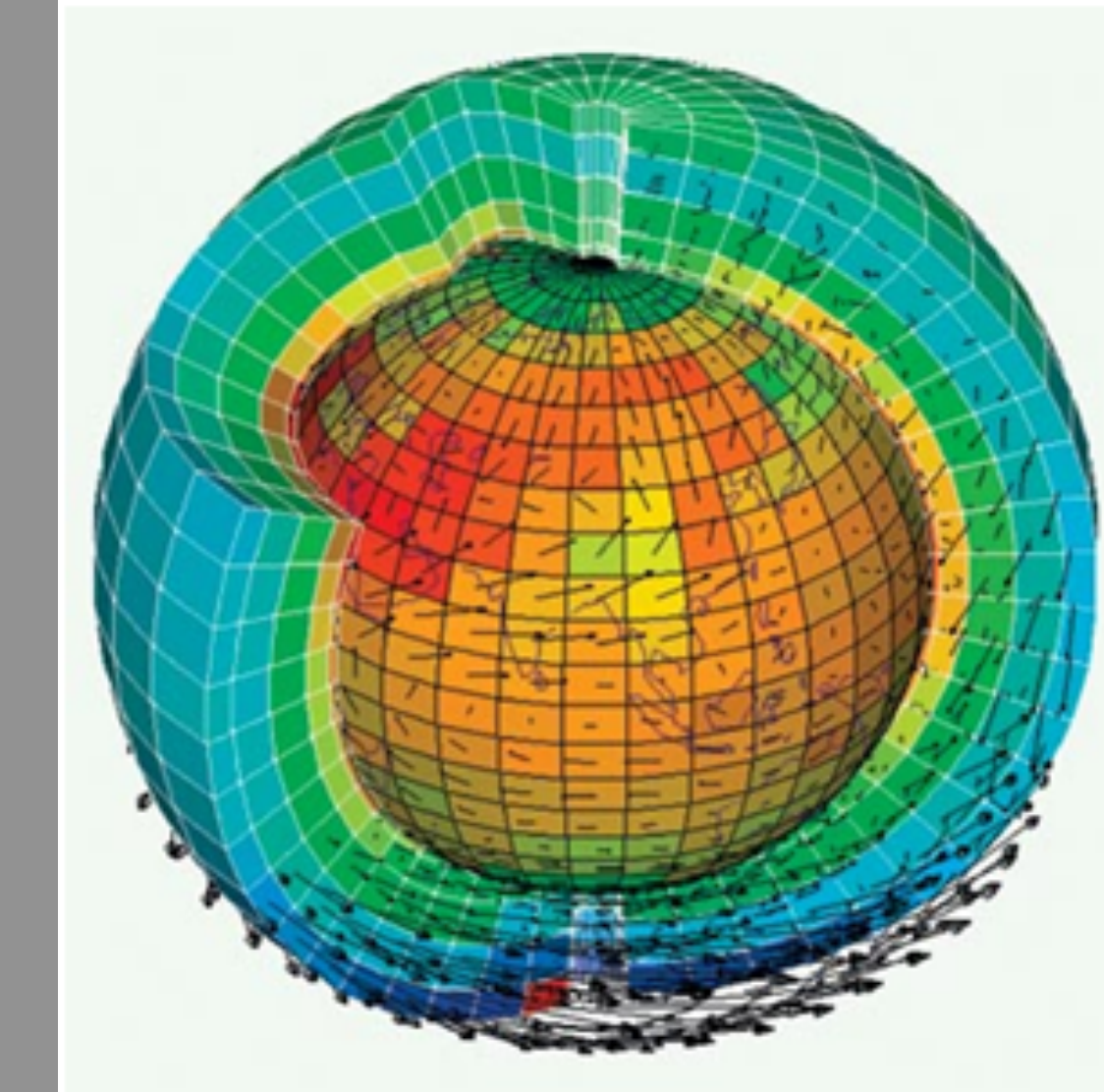
Why multistability?

- Same external forcing, *slightly different initial conditions*.
- Earth's climate features **multiple stable systems (attractors)**.
- Strongly **impacts life**.

The models



The 3-D LMDZ GCM [3]



Radiative transfer
Convection
Clouds
Chemistry
...

Habitability, redefined

Climate multistability through the lens of EBM and GCMs

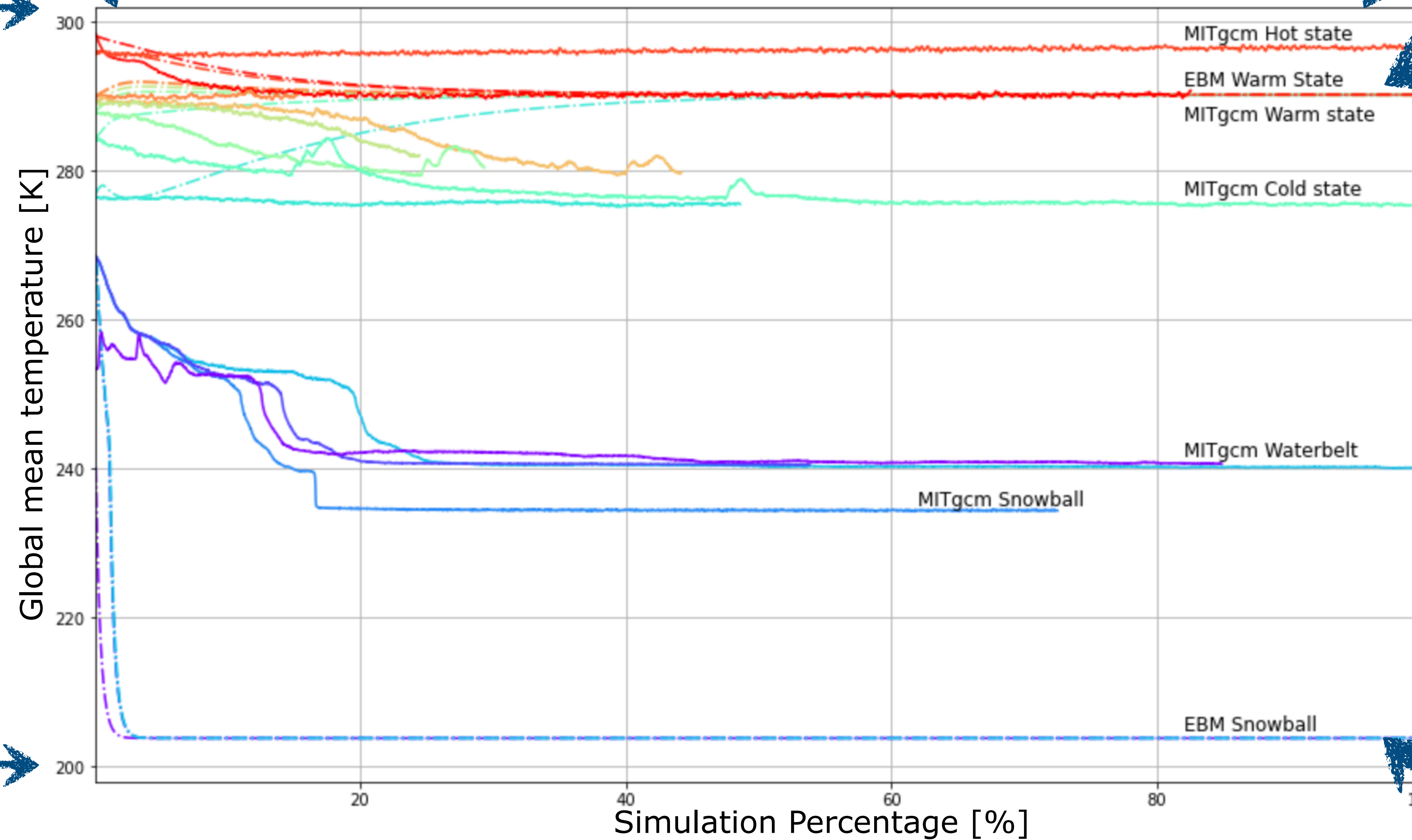
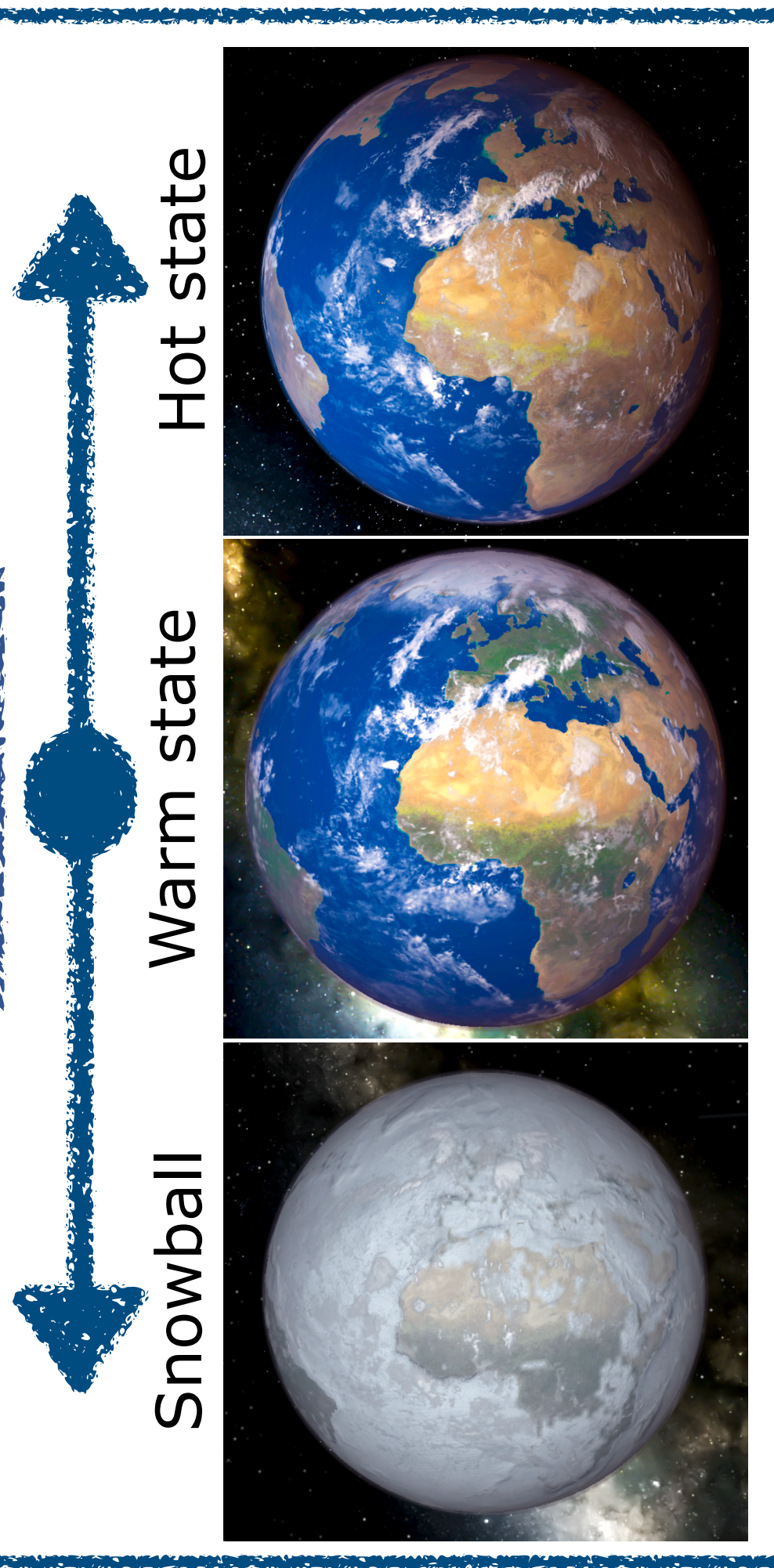
Same external solar forcing,
different initial conditions

$$C \frac{\partial T[x, t]}{\partial t} - \frac{\partial}{\partial x} \left(D(1 - x^2) \frac{\partial T[x, t]}{\partial x} \right) + I[T] = S(1 - A[T])$$

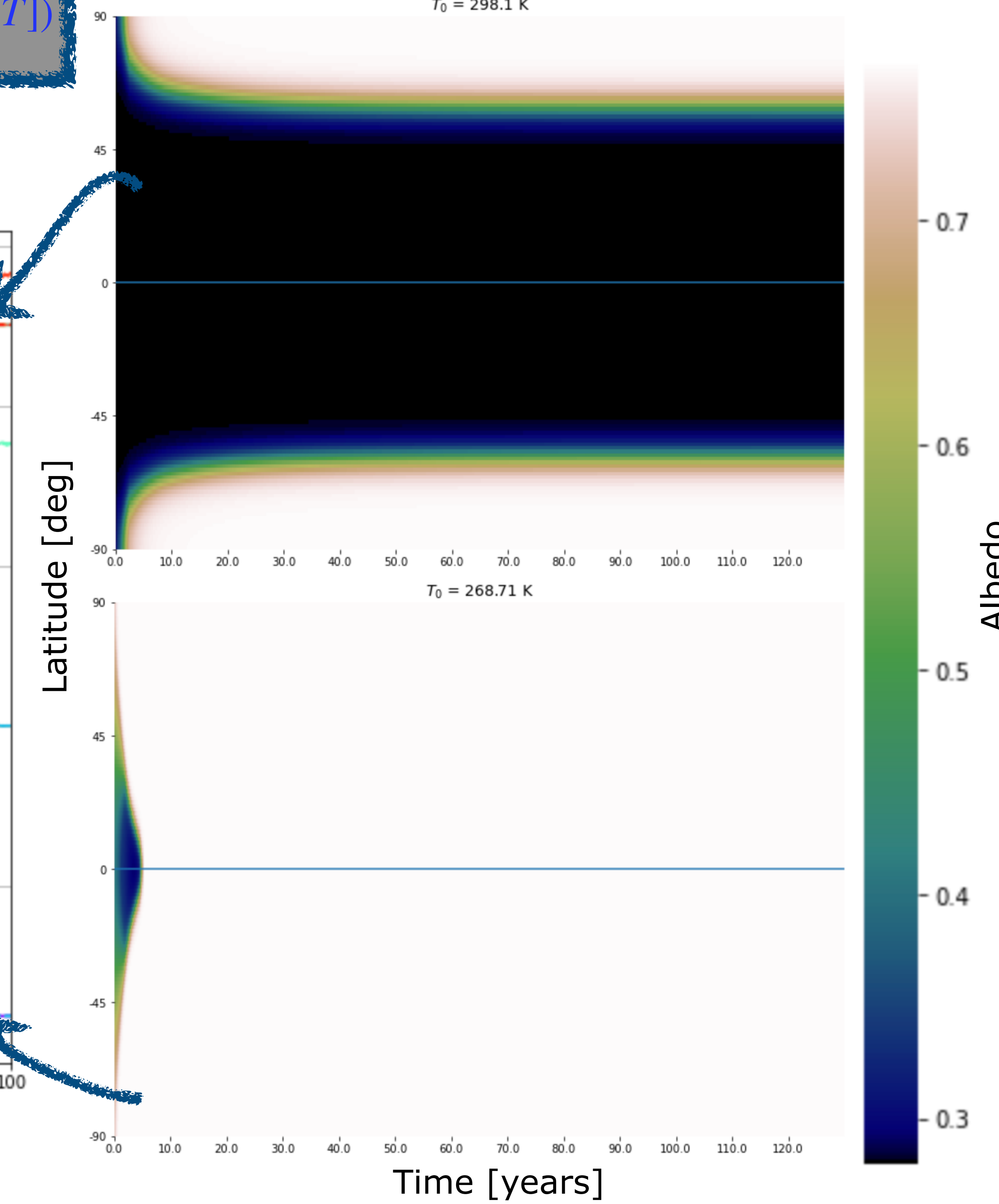
Evolution of global mean temperature and attractors
(GCM tracks adapted from [1] which uses the MITgcm)

Diversity of habitable conditions

Extended temperature range



EBM Albedo space-time diagram



Concluding remarks

- Climate multistability allows for a **diversity of habitable conditions**.
- EBM is **practical (faster!)**, but may miss **stable states**.

Future work

- Extensive simulations with the LMD-Generic.
- Diff. **external forcings, bifurcation diagrams**.
- Extended temperature range - **Extended habitable zone - Observations!**

[1] Brunetti, M., Kasparian, J., & V  rard, C. (2019). Co-existing climate attractors in a coupled aquaplanet. *Climate Dynamics*, 53(9), 6293-6308.

[2] Dressing, C. D. et al. (2010). Habitable climates: the influence of eccentricity. *The Astrophysical Journal*, 721(2), 1295.

[3] Hourdin, F. et al. (2006). The LMDZ4 general circulation model: climate performance and sensitivity to parametrized physics with emphasis on tropical convection. *Climate Dynamics*, 27(7), 787-813.