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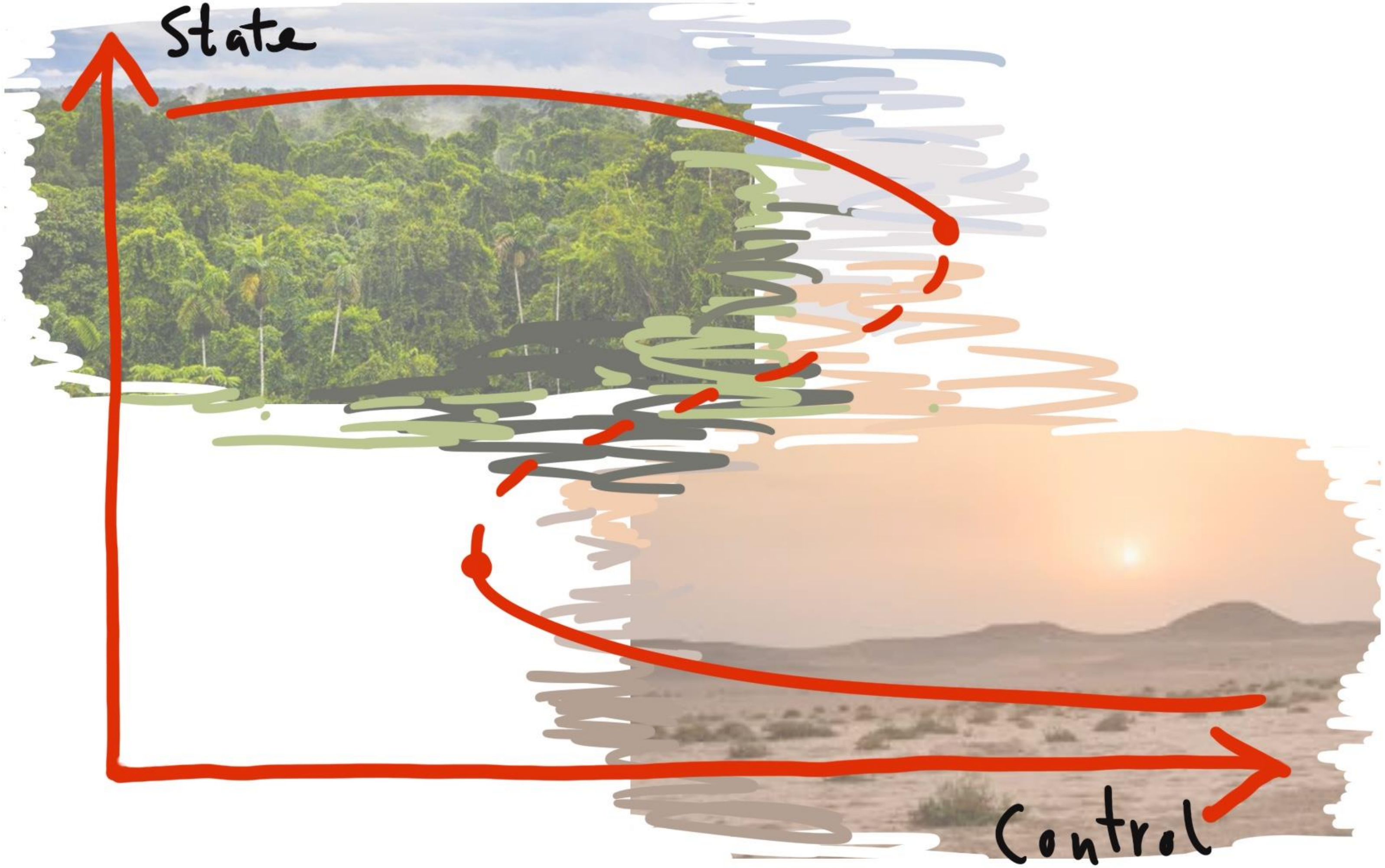

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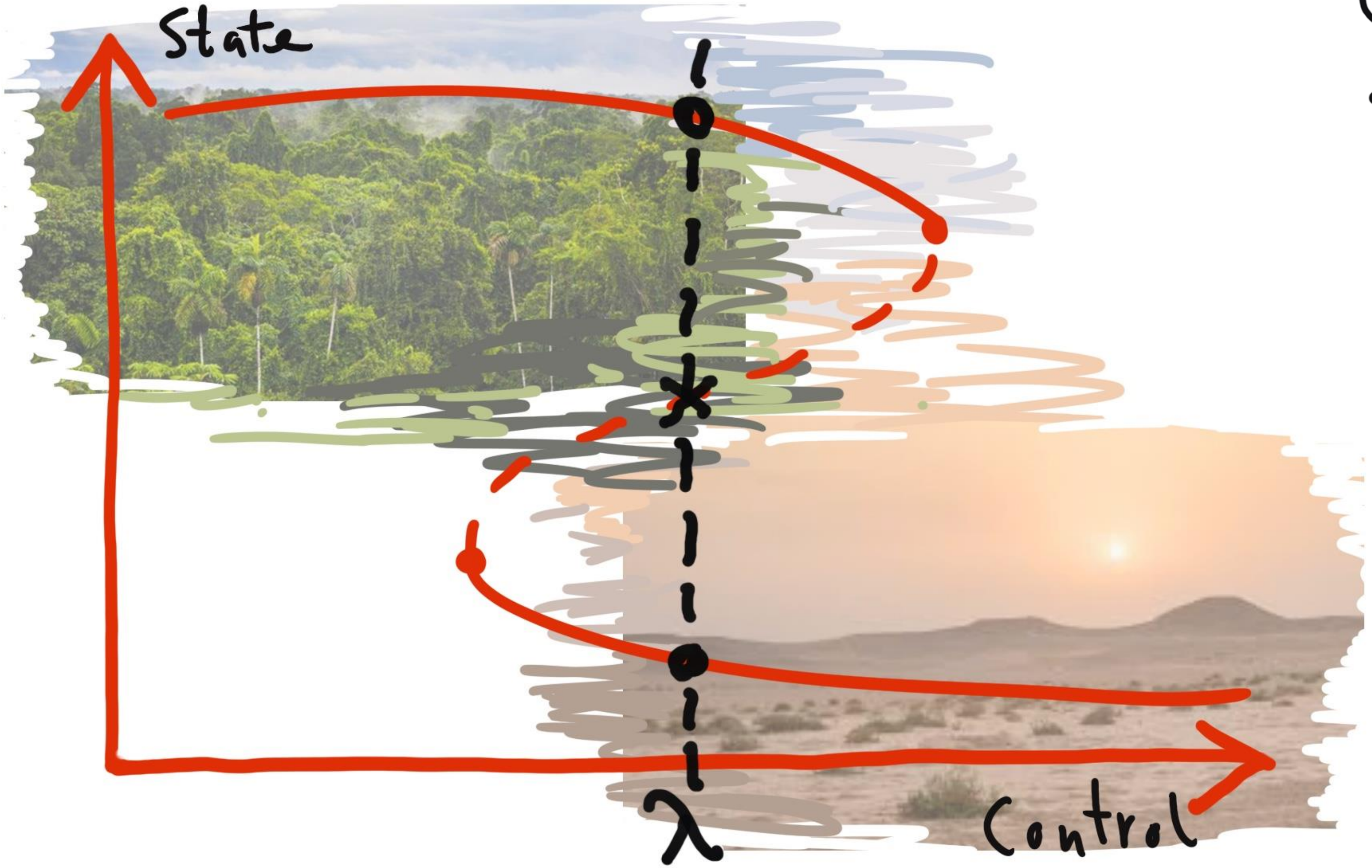

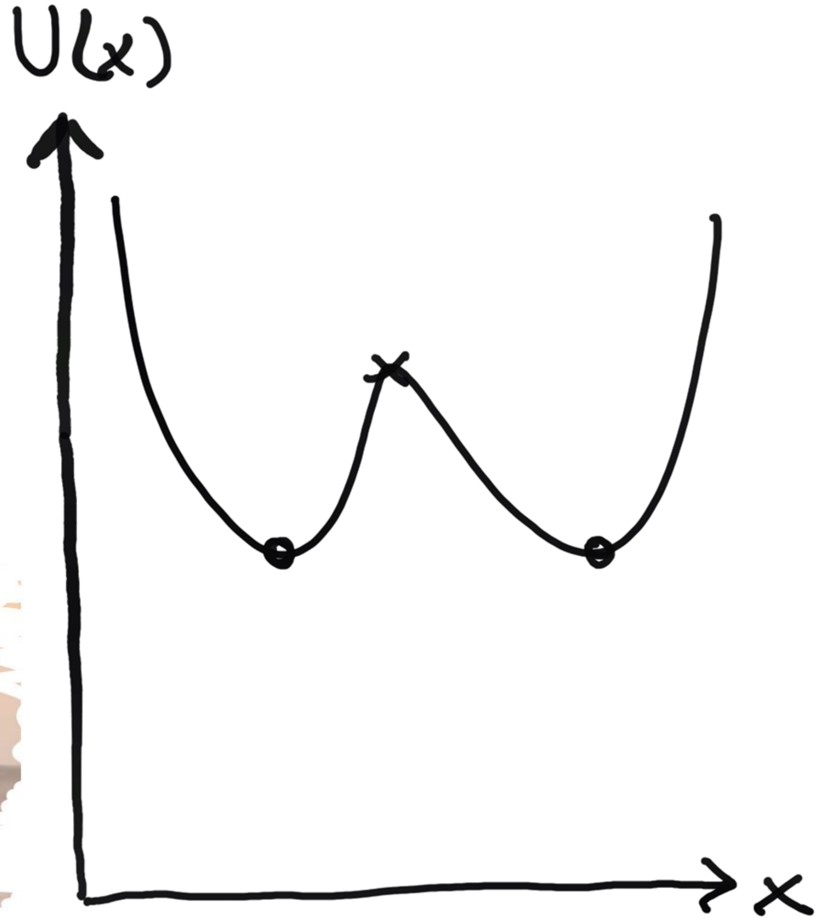

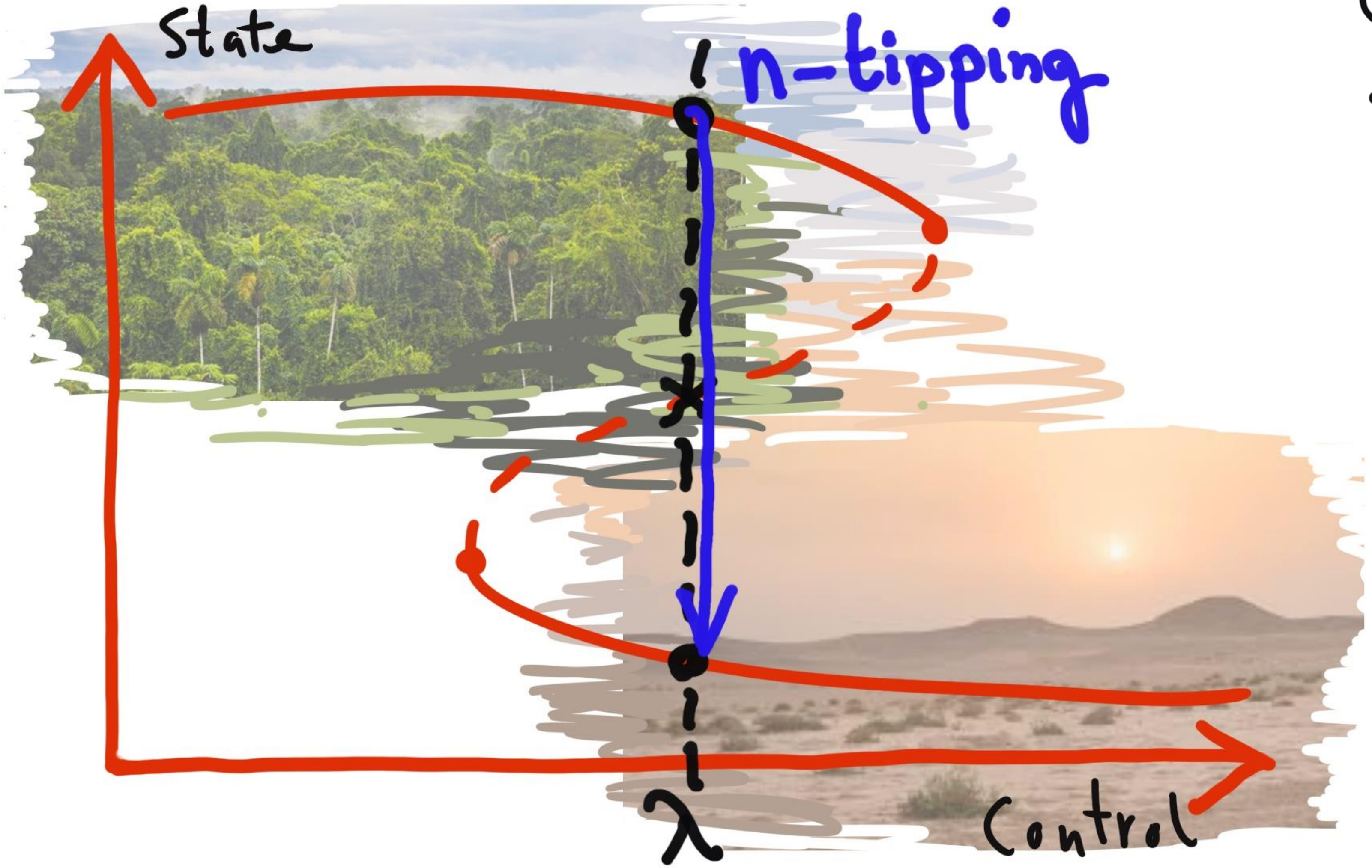
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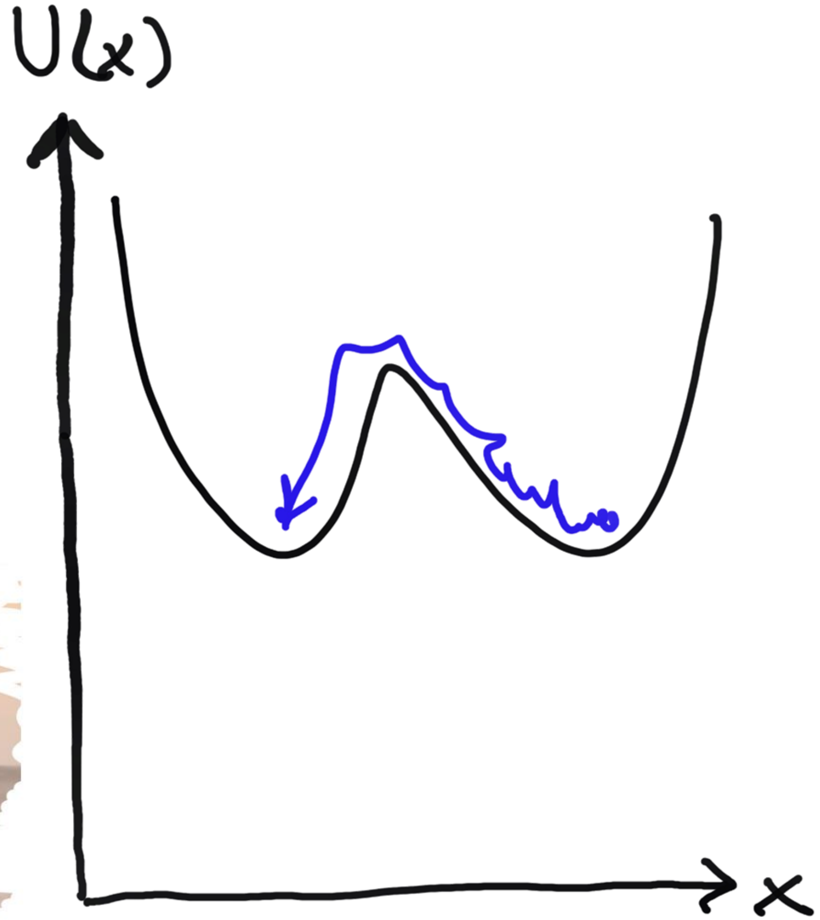
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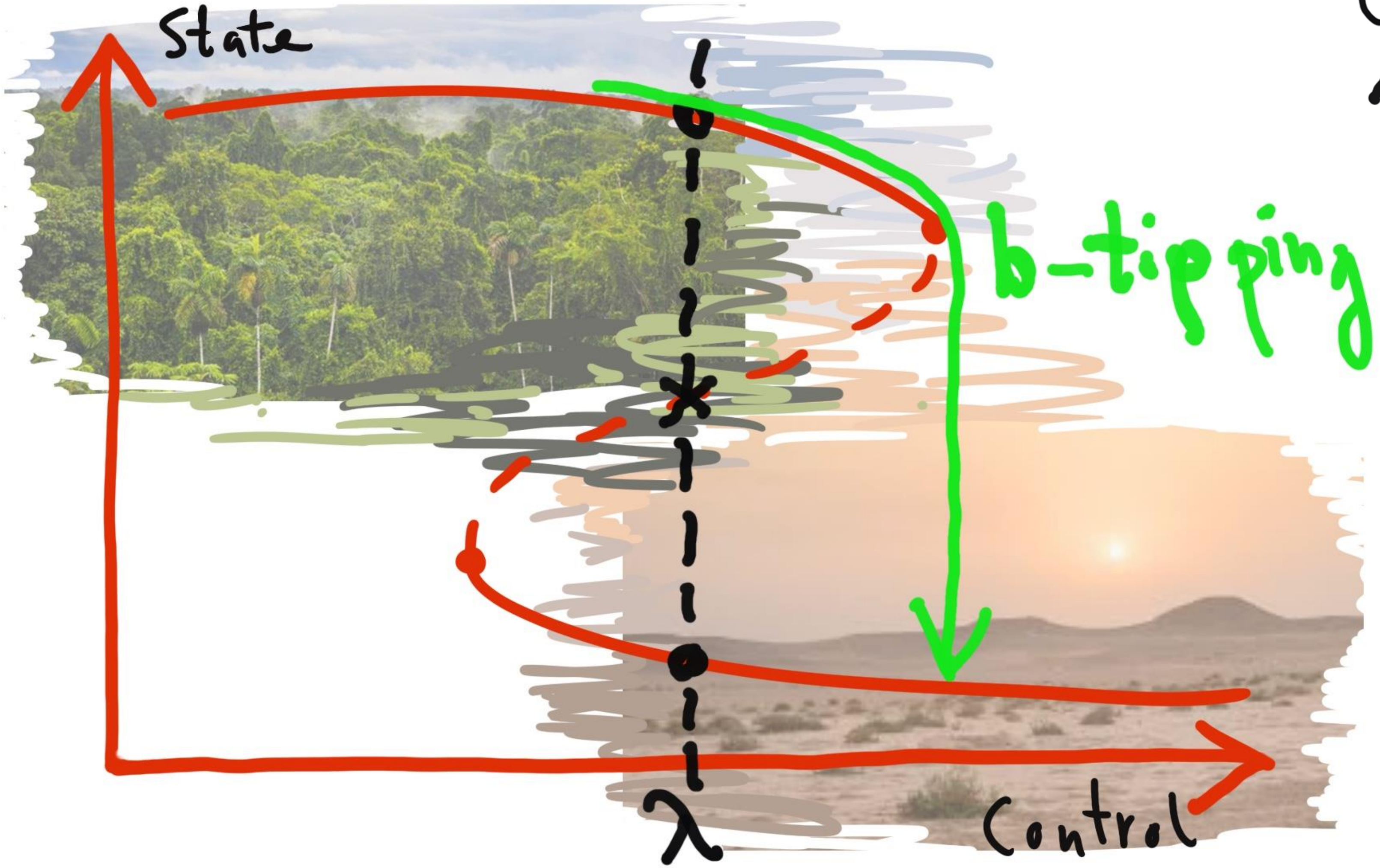

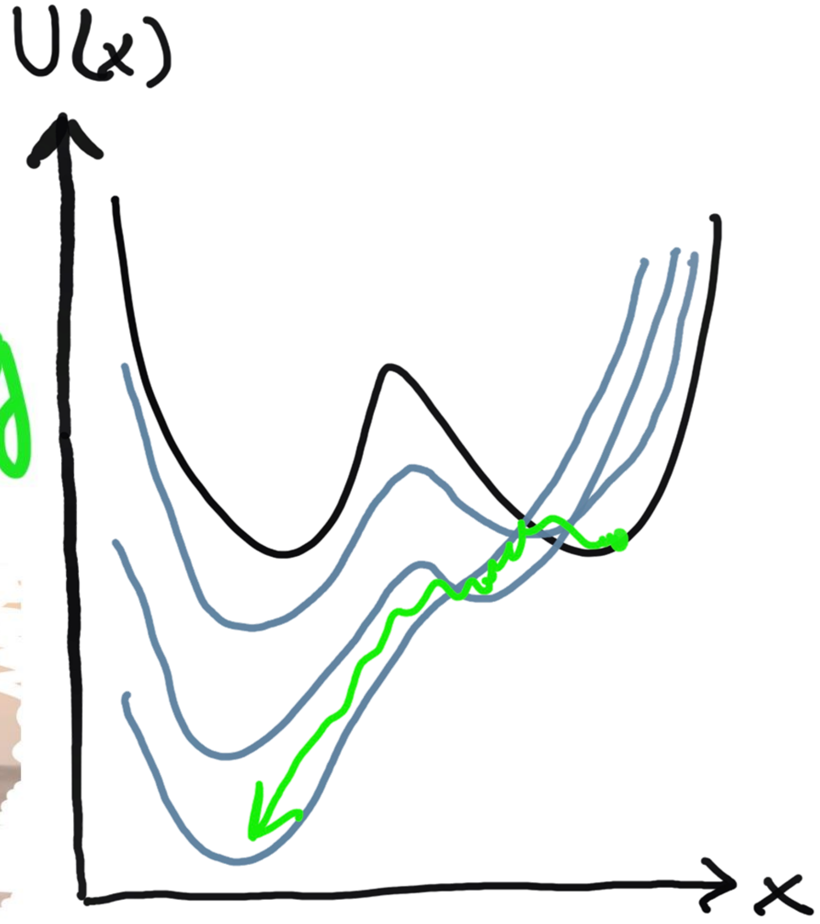

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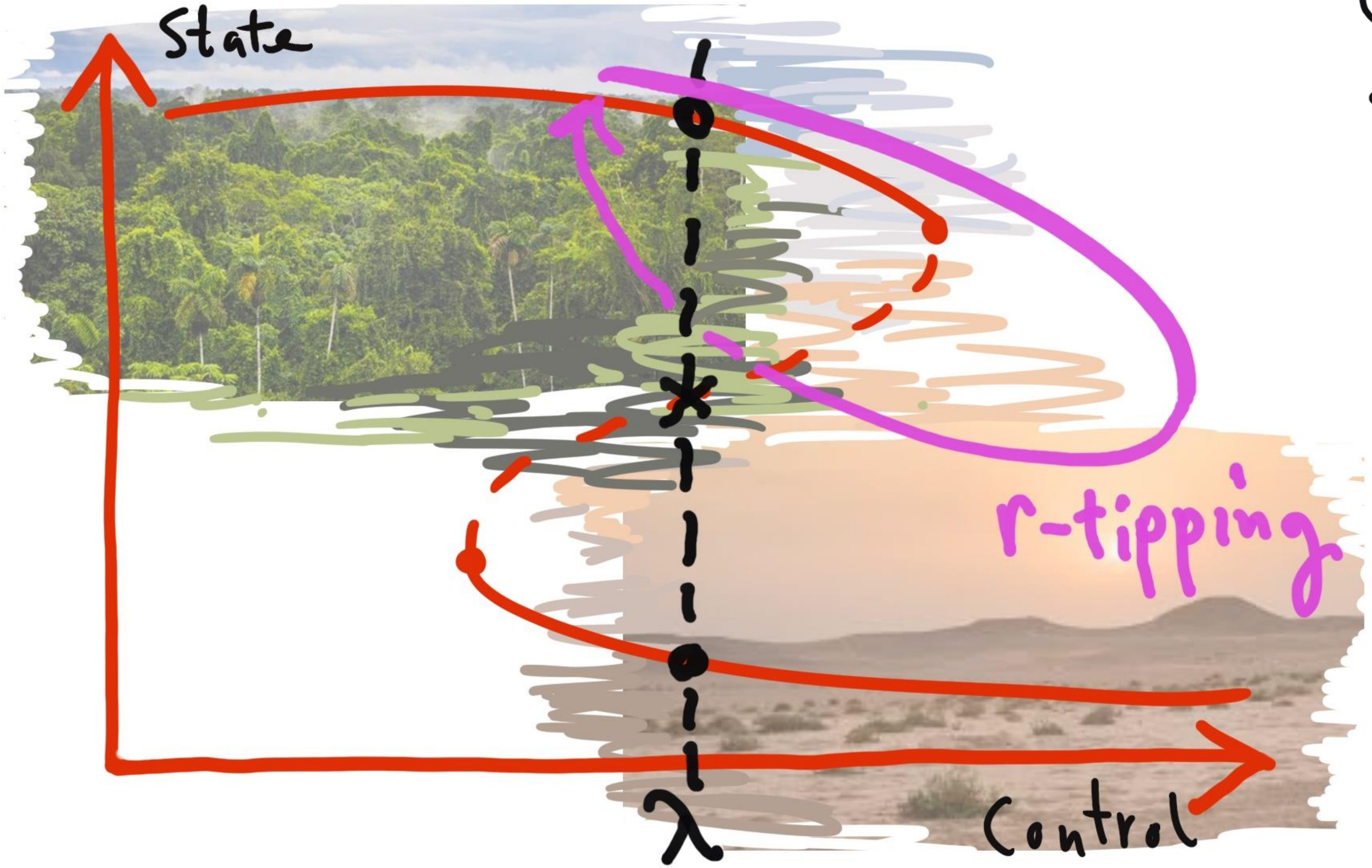

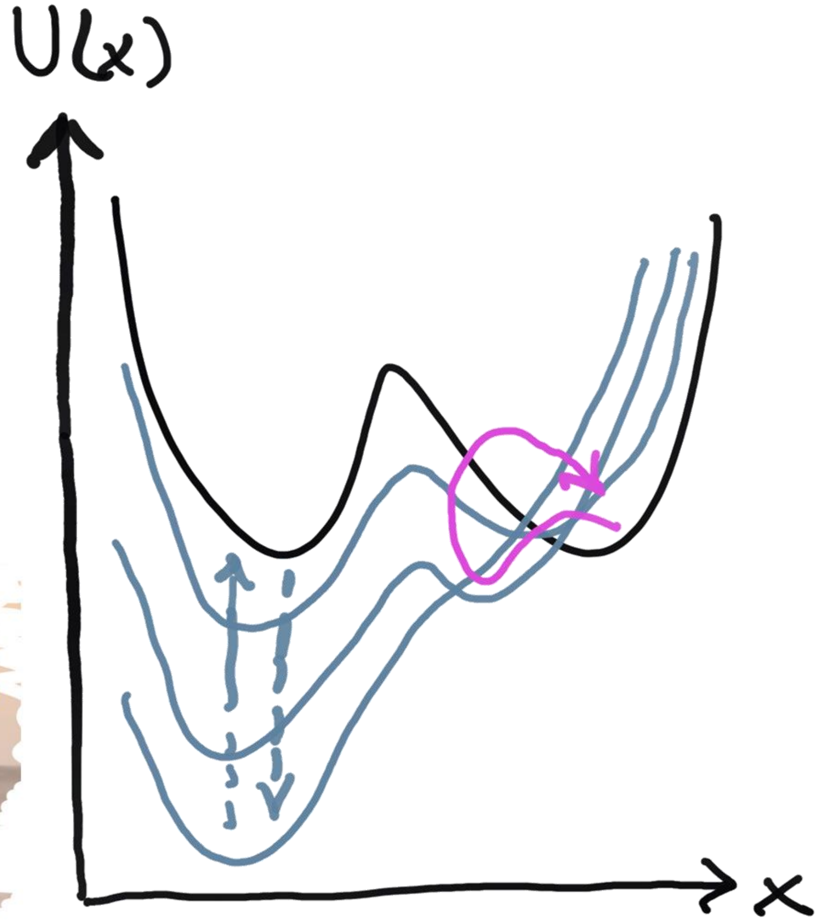

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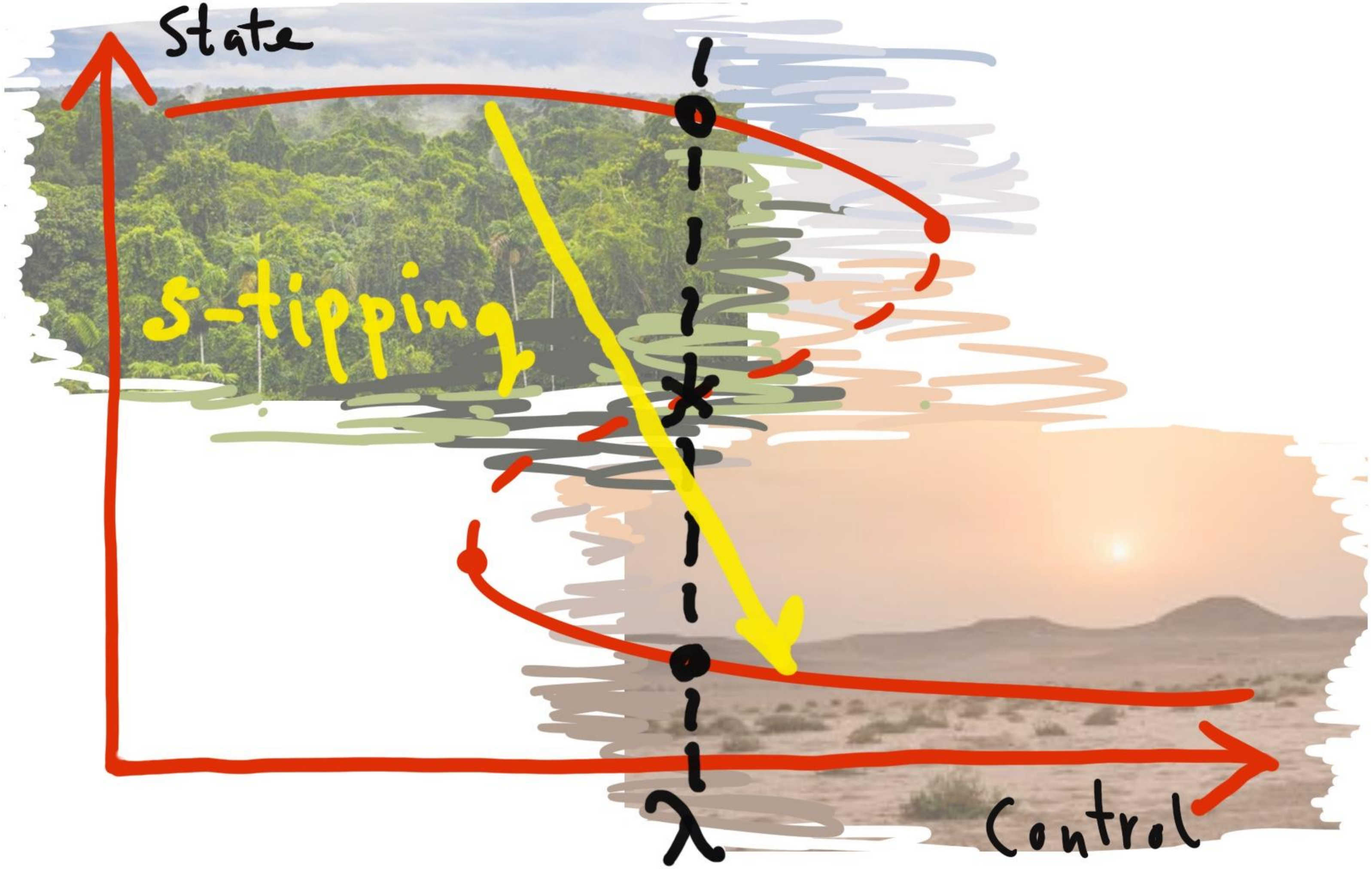

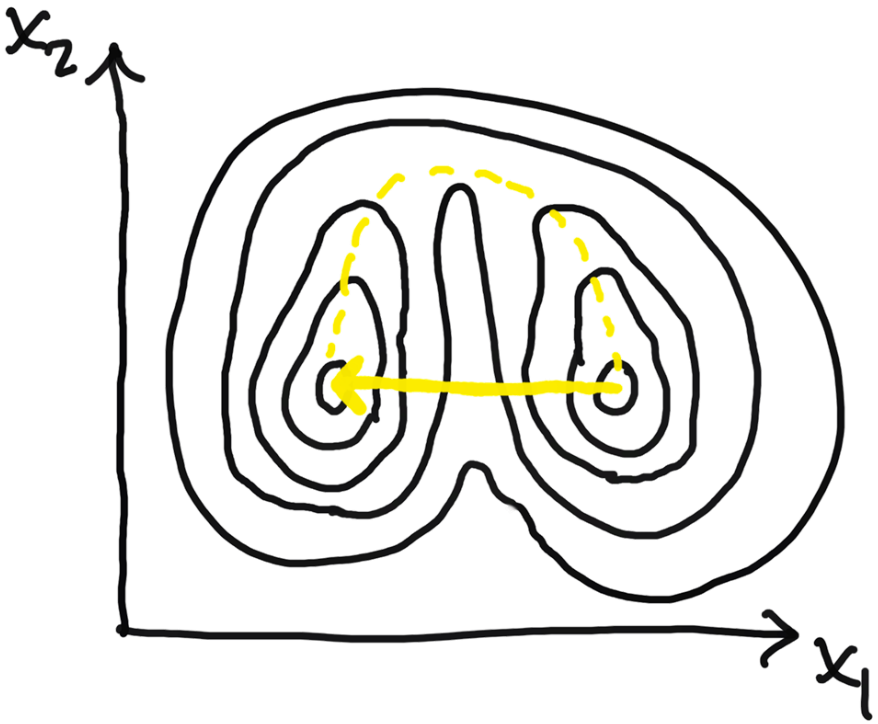

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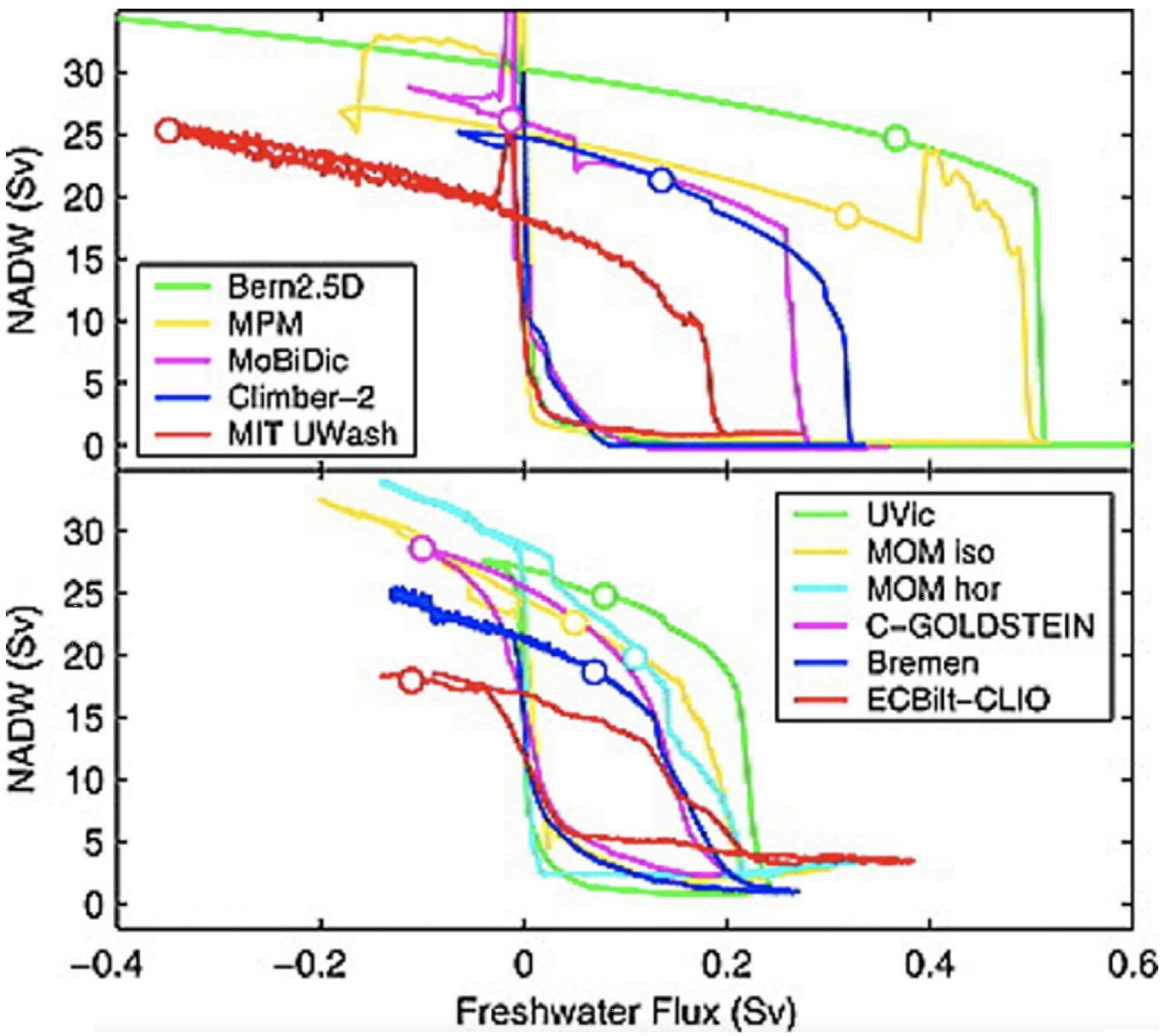

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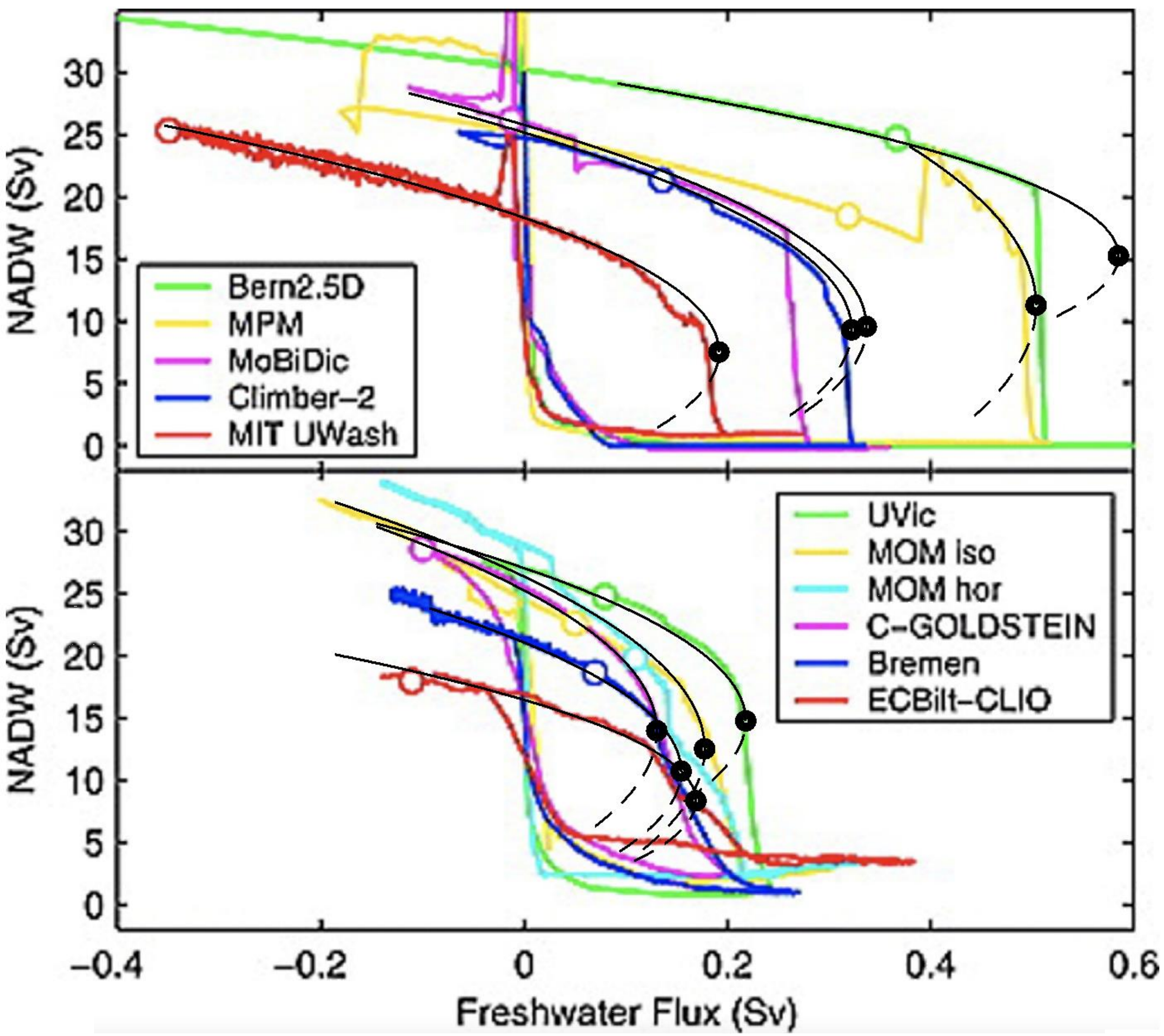

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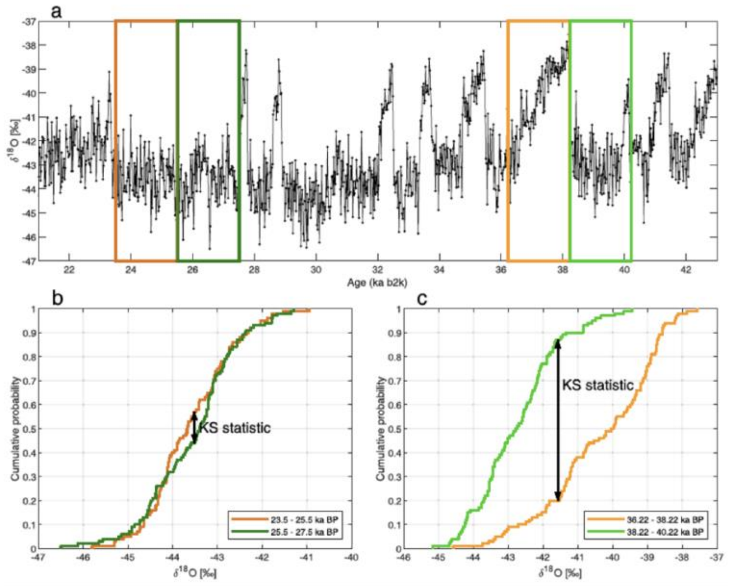

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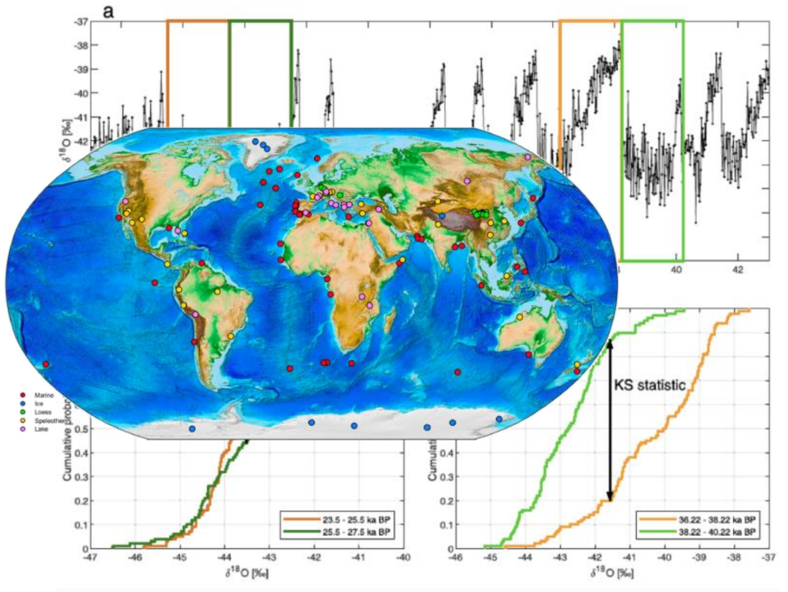

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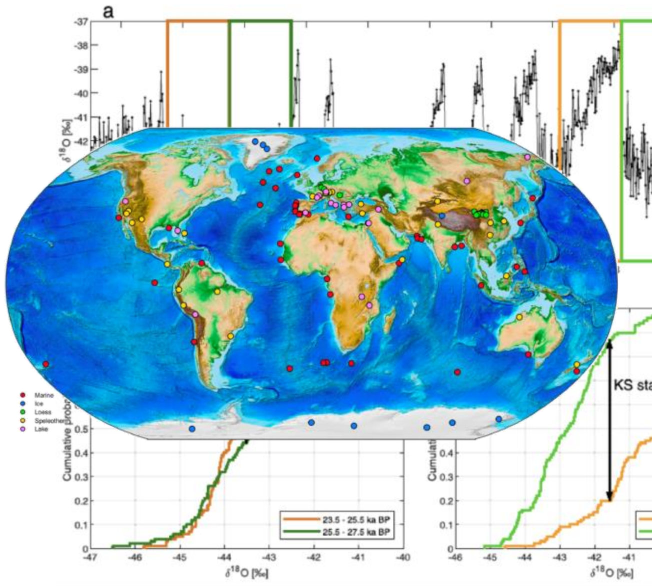

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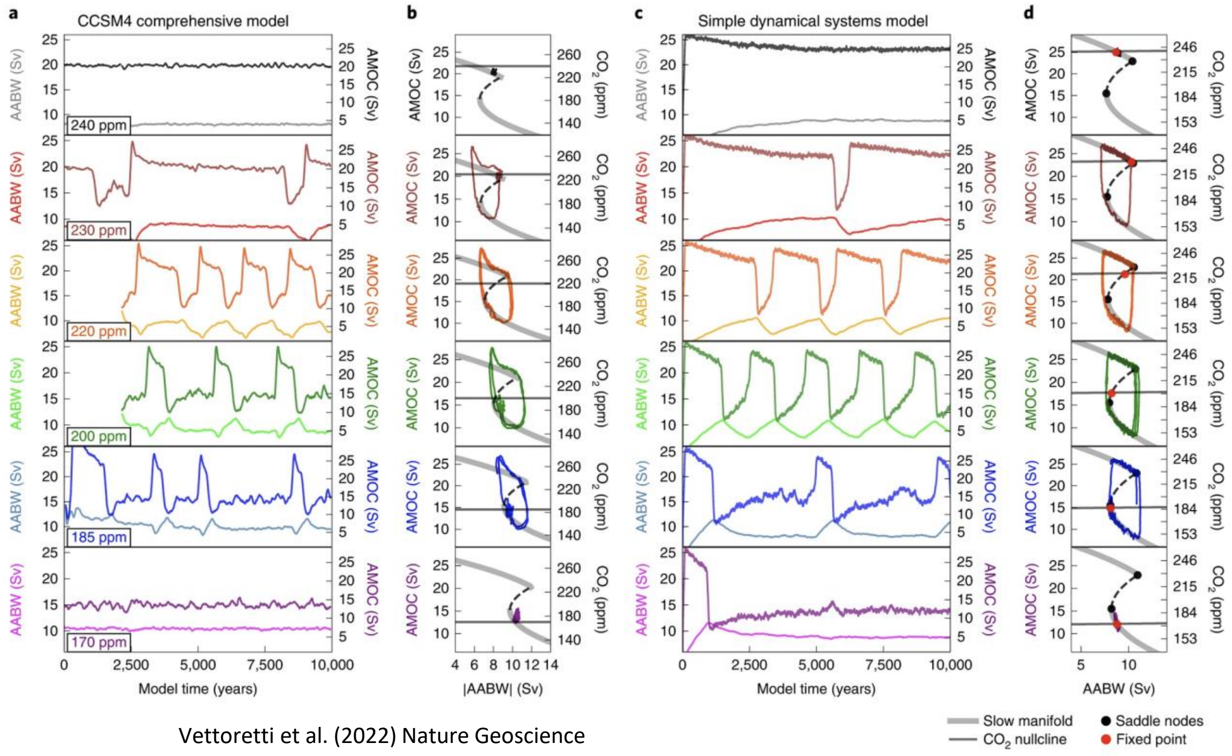

Vettoretti et al. (2022) Nature Geoscience

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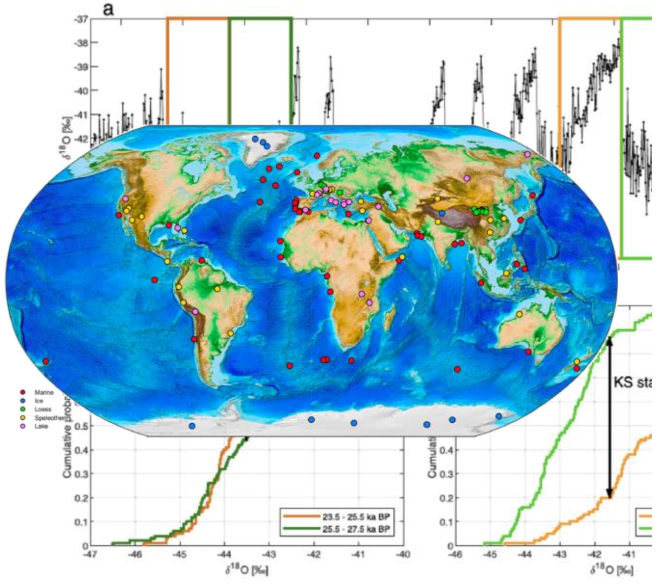

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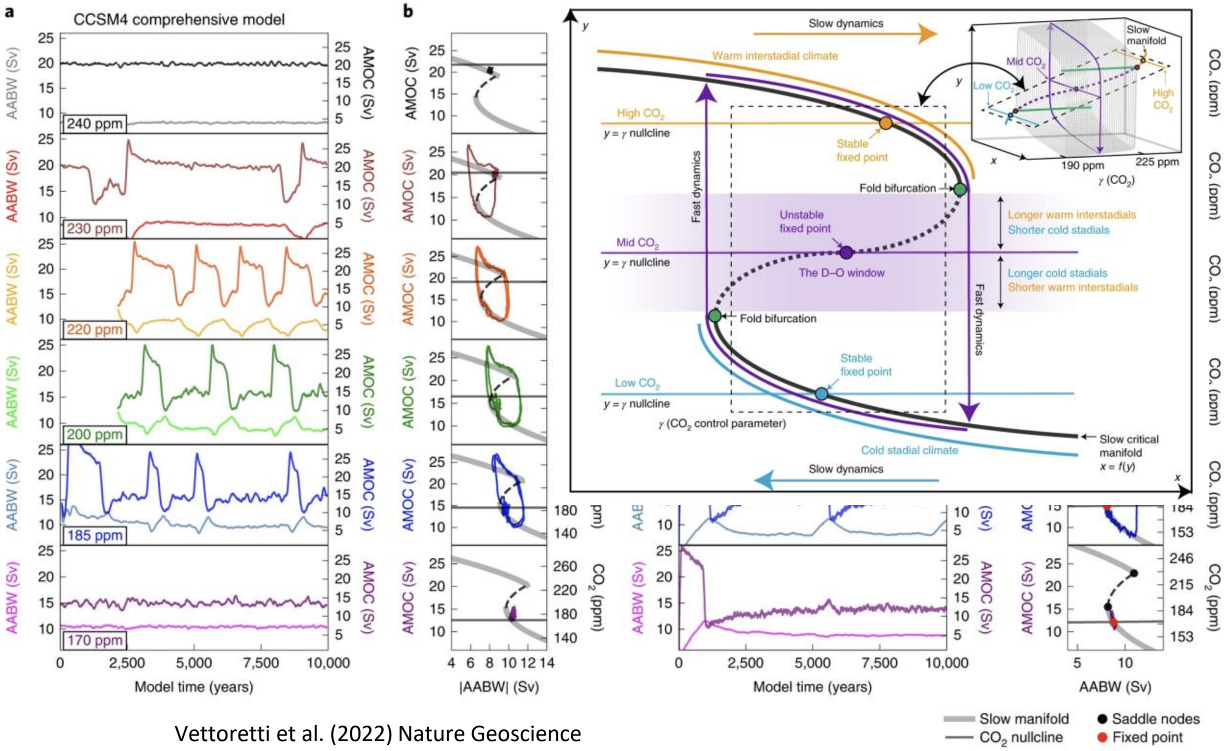

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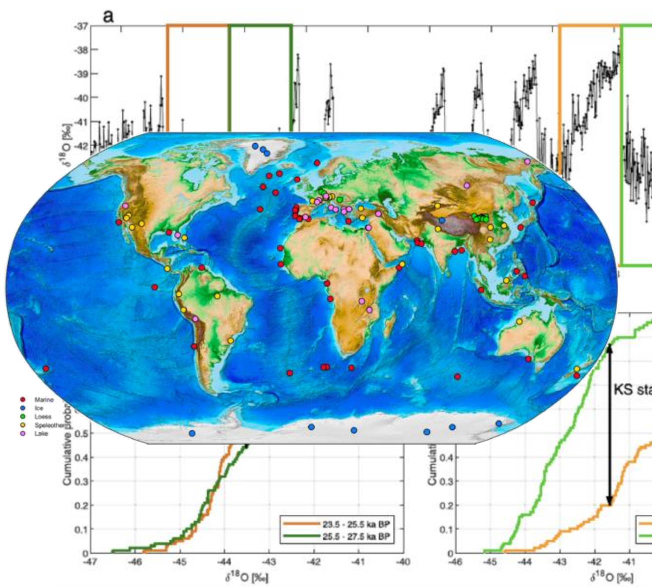

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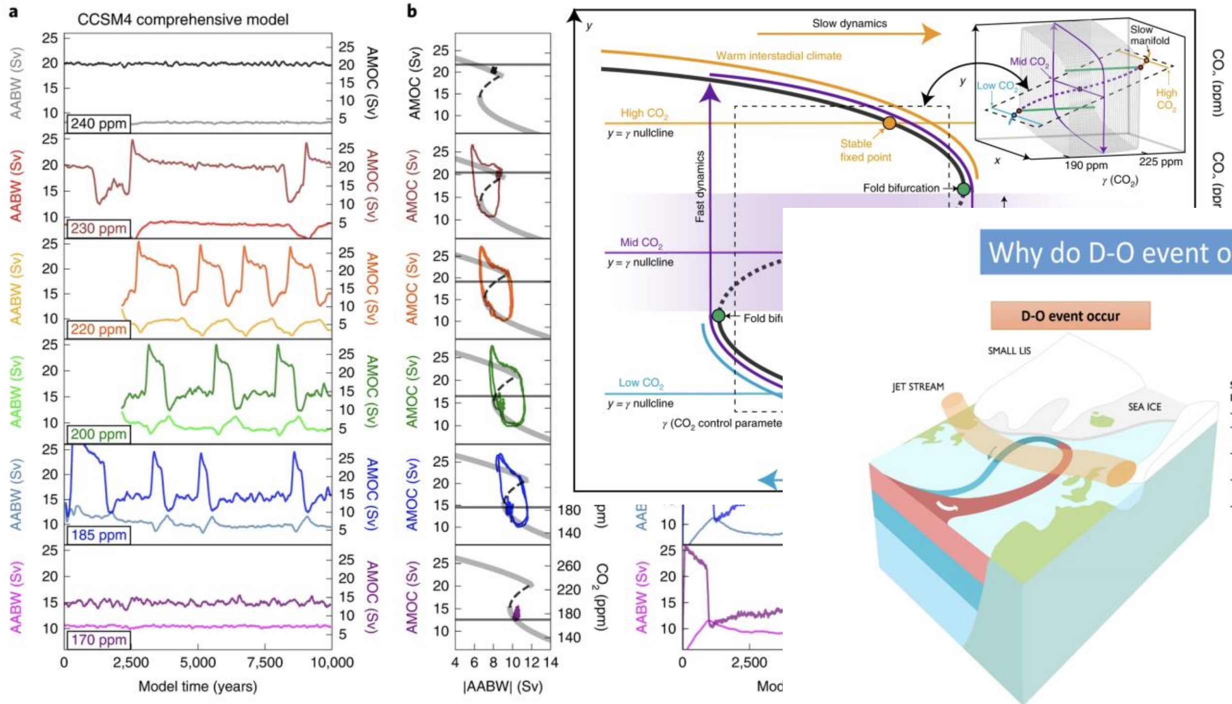

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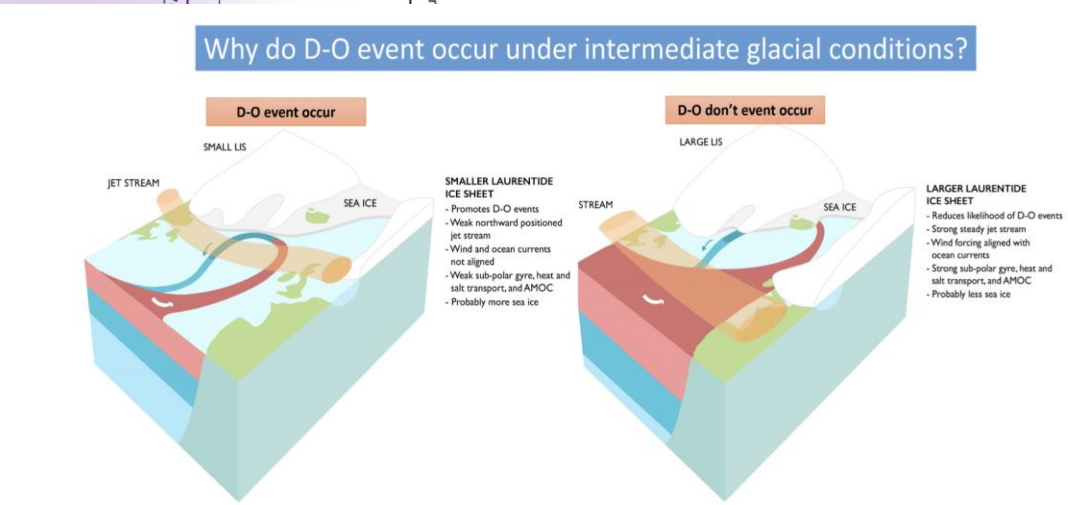

Malmierca, Sime, and the DO community (2022)
Climate of the Past Discussions

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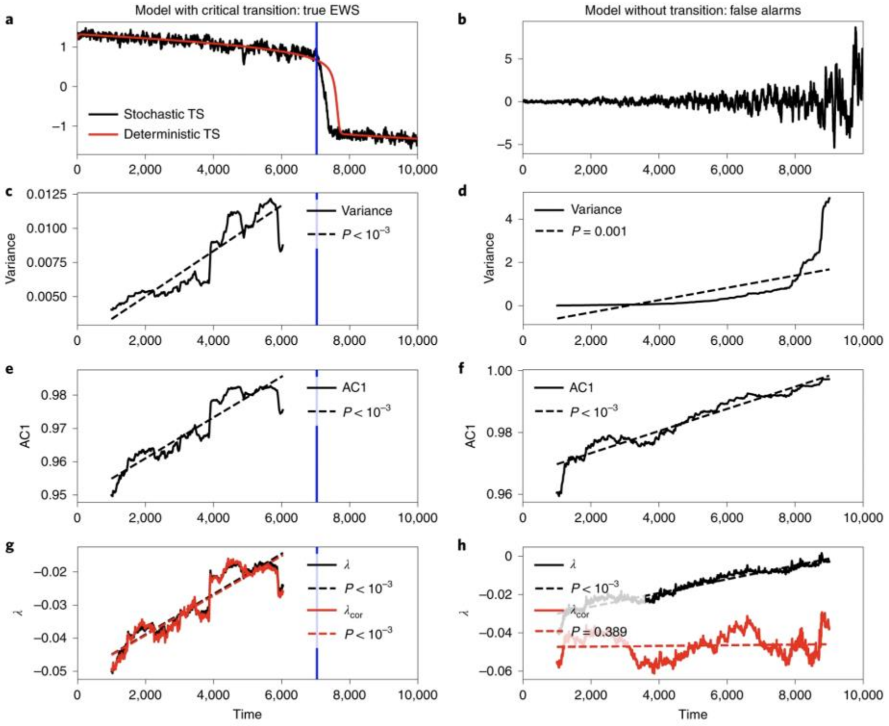

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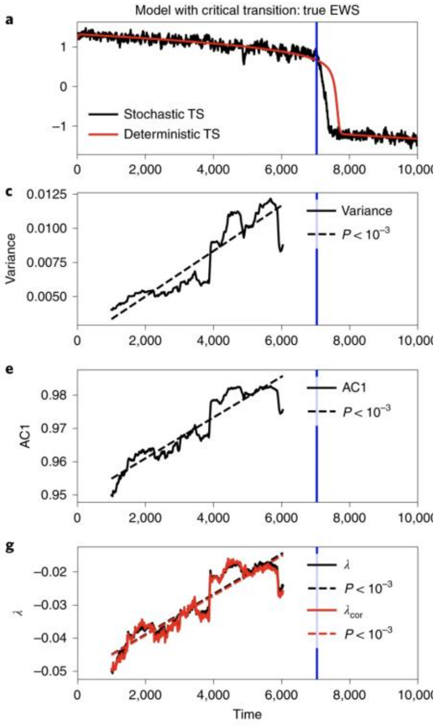

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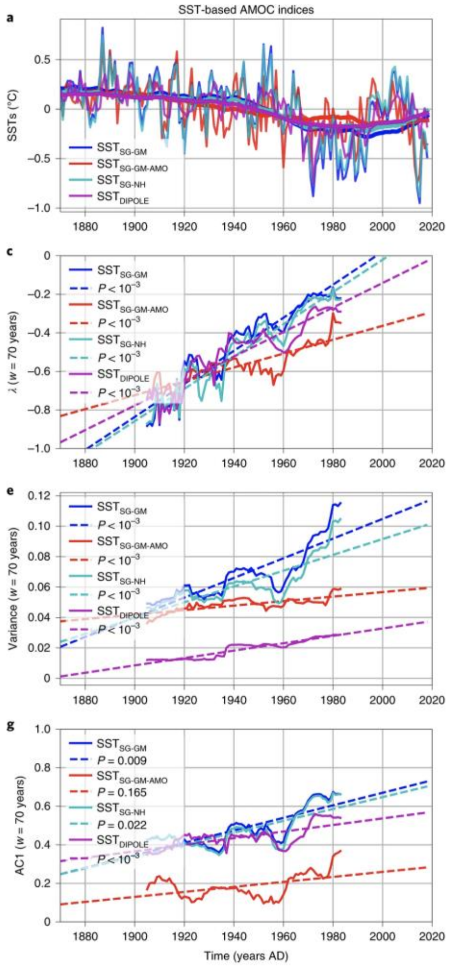

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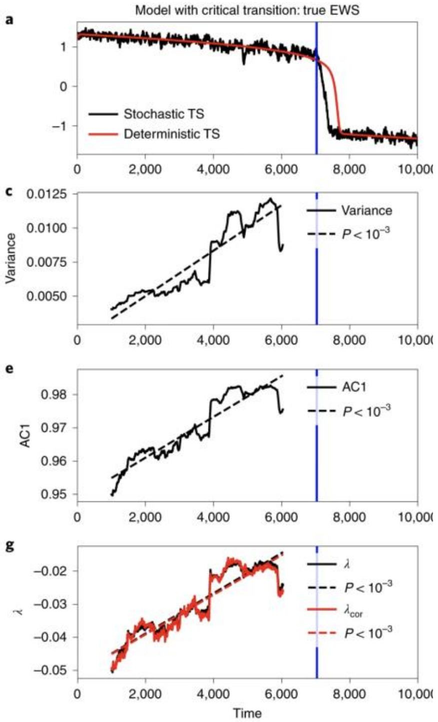

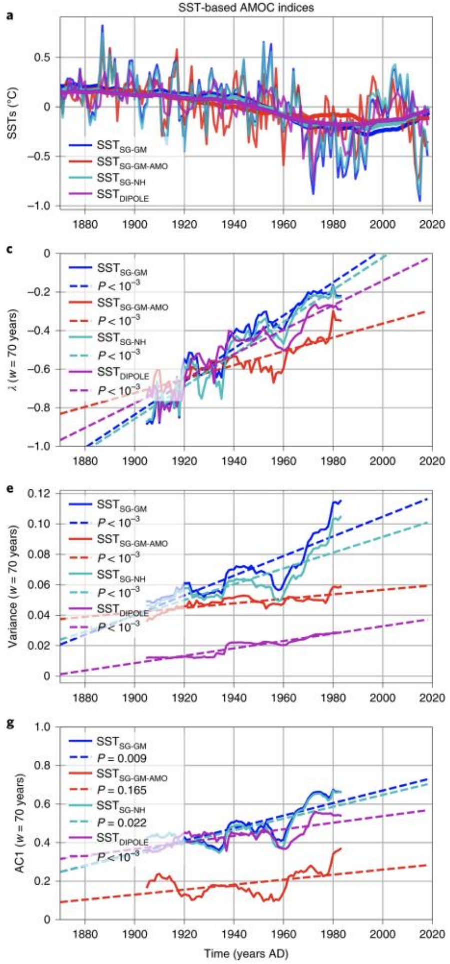

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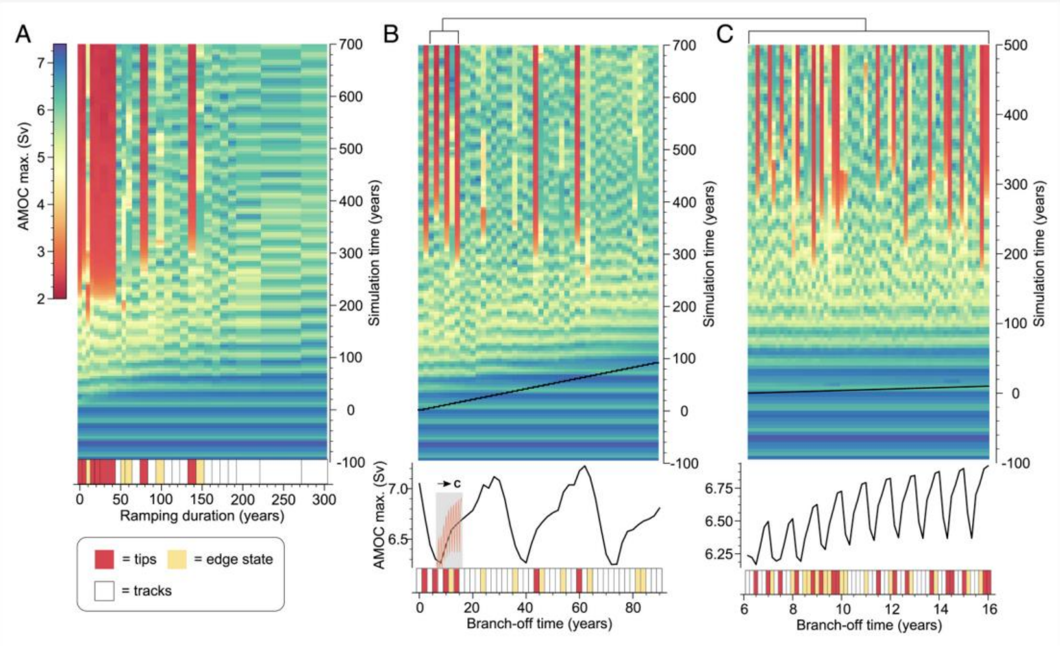

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Pronounced loss of Amazon rainforest resilience since the early 2000s

Chris A. Boulton, Timothy M. Lenton & Niklas Boers

Nature Climate Change **12**, 271–278 (2022) | Cite this article

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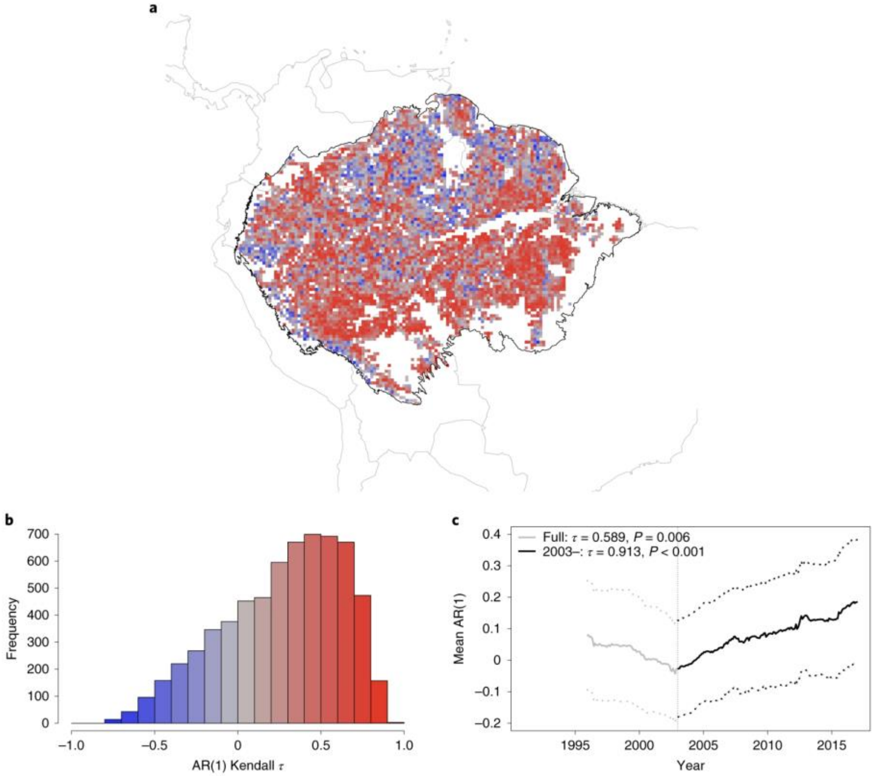
From: Pronounced loss of Amazon rainforest resilience since the early 2000s



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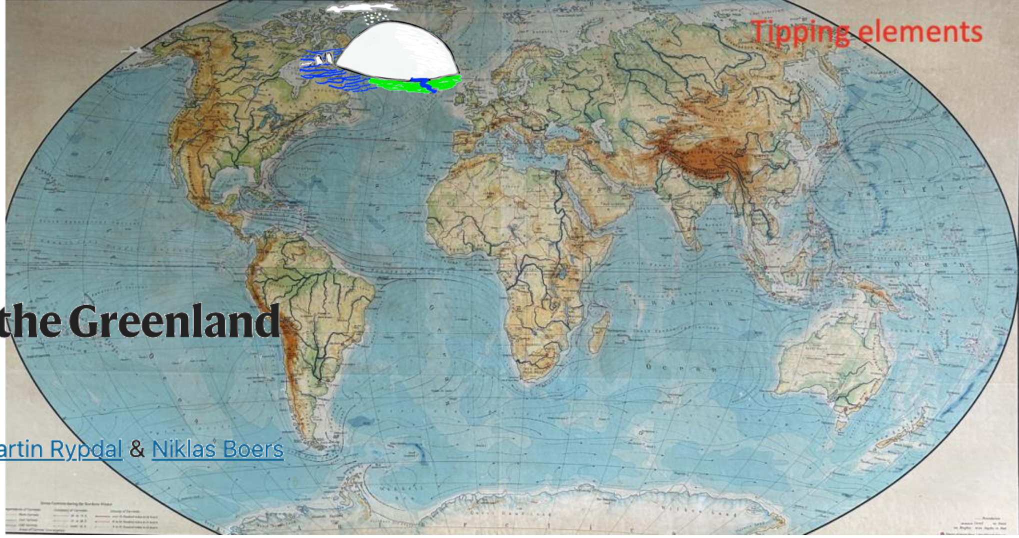

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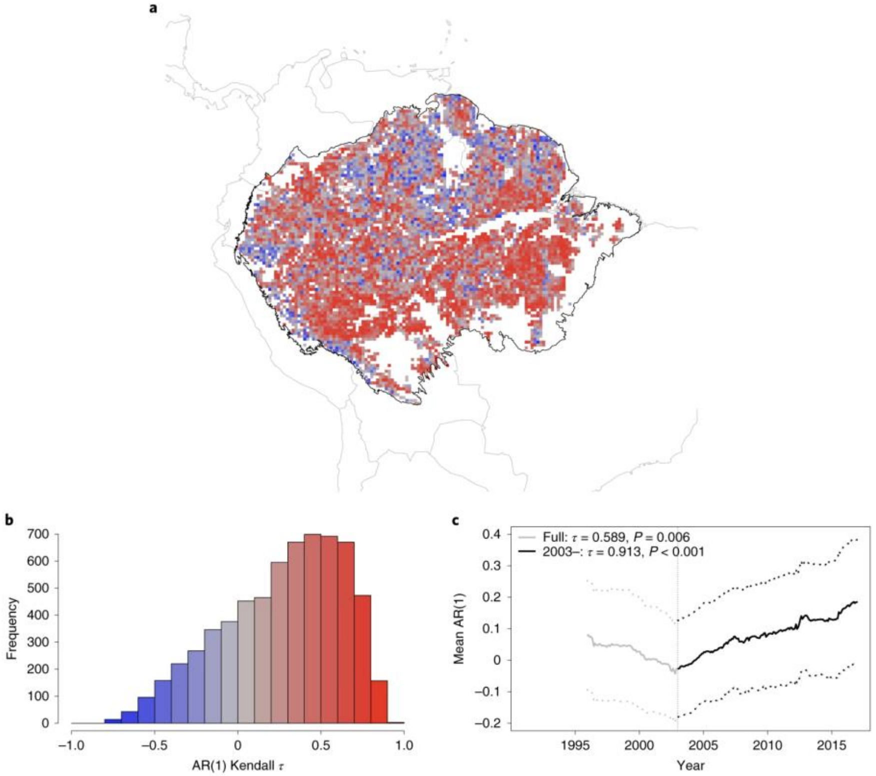

Fig. 4: Trajectories of overshoot scenarios converging to a regional summer temperature of 0 °C above present (0.5 °C GMT above preindustrial level) for various peak warmings and convergence times.

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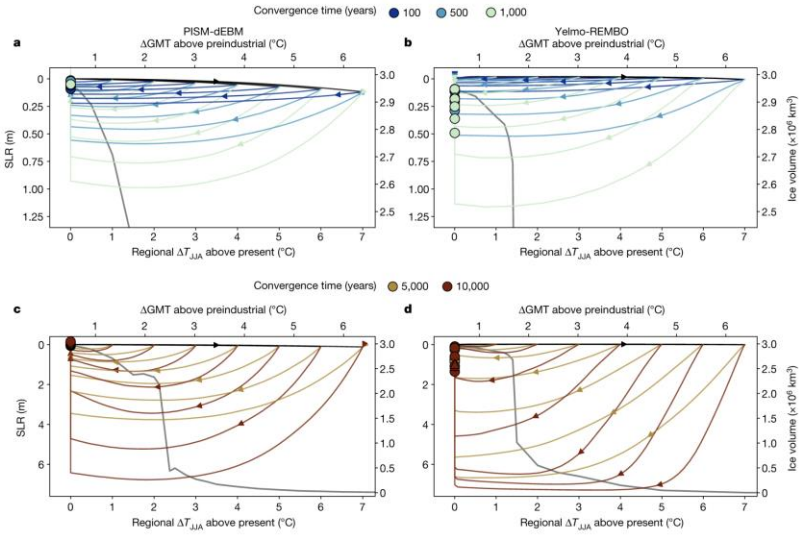

a, Trajectories of ice-sheet volume for PISM-dEBM for convergence times of 100, 500 and 1,000 years. All three scenarios show an ice loss that reaches its maximum during the cooling phase. The apparent jump of the end states (dots) at $\Delta T_{JJA} = 0$ °C corresponds to a recovery of the ice sheet after the cooling phase. The end states are defined as the mean ice volume after 90–100 kyr. The thick dark grey line corresponds to the equilibrium states for the applied temperature anomaly, showing that the actual, realistic trajectories are strongly out of equilibrium. **b**, Same as **a** but for the ice-sheet model Yelmo-REMBO. **c**,**d**, Same as **a**,**b**, respectively, but for convergence times of 5,000 and 10,000 years. For all scenarios, both models show a recovery to close to the present-day ice sheet. The maximum SLR contribution is reached during the cooling phase, highlighting the importance of considering long-term committed SLR in climate negotiations.

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Warning of a forthcoming collapse of the Atlantic meridional overturning circulation

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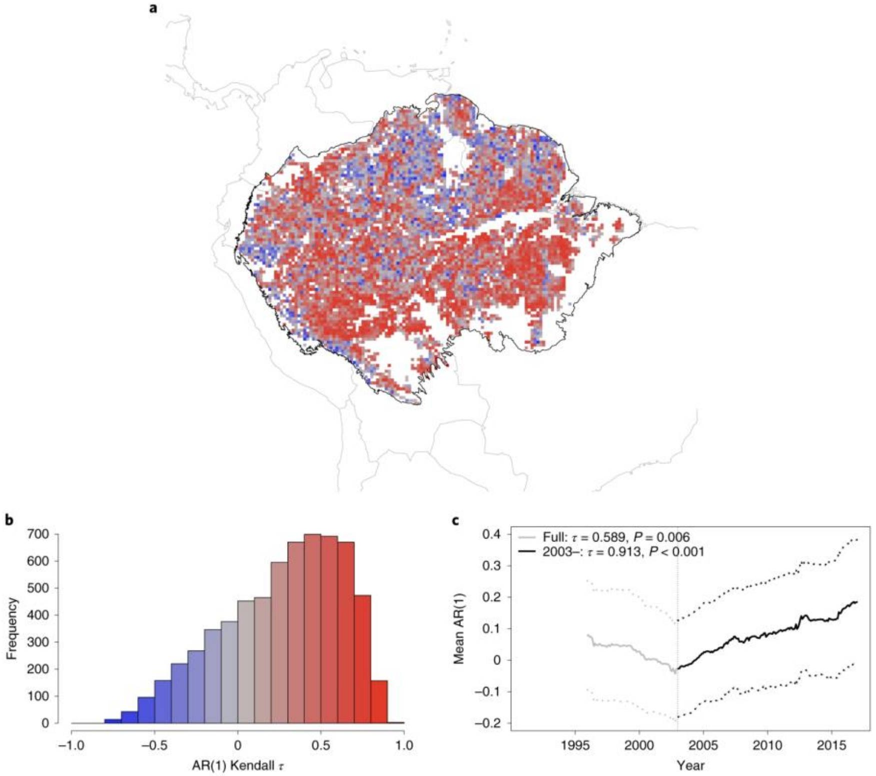

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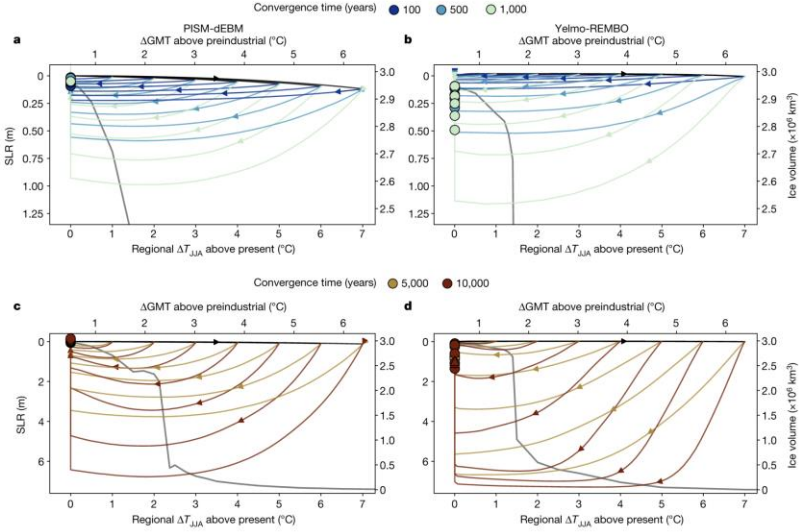

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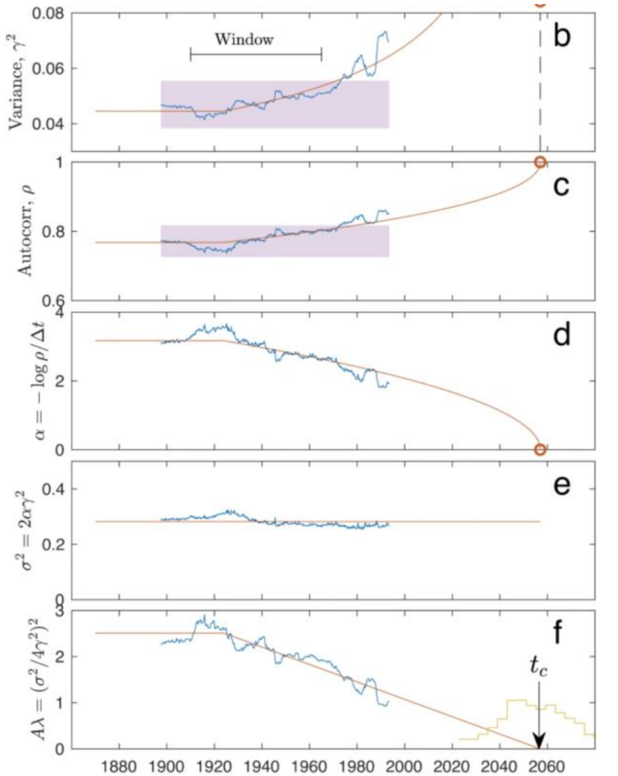

- **Objective 3 (O3). Characterise climate response in the presence of tipping points (TPs)**
- *Specific Objective 3.1*. Develop a theory of climate response (CR) that goes beyond linear and equilibrium concepts, i.e. beyond equilibrium climate sensitivity (ECS). This theory should deal with responses on distinct temporal and spatial scales, and relate the responses of different observables to external forcing through appropriate response operators.
- *Specific Objective 3.2*. Apply and evaluate this CR theory by deriving thresholds associated with both natural and anthropogenic abrupt and irreversible transitions in both warmer and colder climates, using information from appropriate paleoclimate data and climate models.

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REVIEWS OF MODERN PHYSICS, VOLUME 92, JULY–SEPTEMBER 2020

The physics of climate variability and climate change

Michael Ghil

Geosciences Department and Laboratoire de Météorologie Dynamique (CNRS and IPSL), Ecole Normale Supérieure and PSL University, F-75231 Paris Cedex 05, France and Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, California 90095-1565, USA

Valerio Lucarini

Department of Mathematics and Statistics, University of Reading, Reading RG66AX, United Kingdom, Centre for the Mathematics of Planet Earth, University of Reading, Reading RG66AX, United Kingdom, and CEN—Institute of Meteorology, University of Hamburg, Hamburg 20144, Germany

(published 31 July 2020)

The climate is a forced, dissipative, nonlinear, complex, and heterogeneous system that is out of thermodynamic equilibrium. The system exhibits natural variability on many scales of motion, in time as well as space, and it is subject to various external forcings, natural as well as anthropogenic. This review covers the observational evidence on climate phenomena and the governing equations of planetary-scale flow and presents the key concept of a hierarchy of models for use in the climate sciences. Recent advances in the application of dynamical systems theory, on the one hand, and nonequilibrium statistical physics, on the other hand, are brought together for the first time and shown to complement each other in helping understand and predict the system's behavior. These complementary points of view permit a self-consistent handling of subgrid-scale phenomena as stochastic processes, as well as a unified handling of natural climate variability and forced climate change, along with a treatment of the crucial issues of climate sensitivity, response, and predictability.

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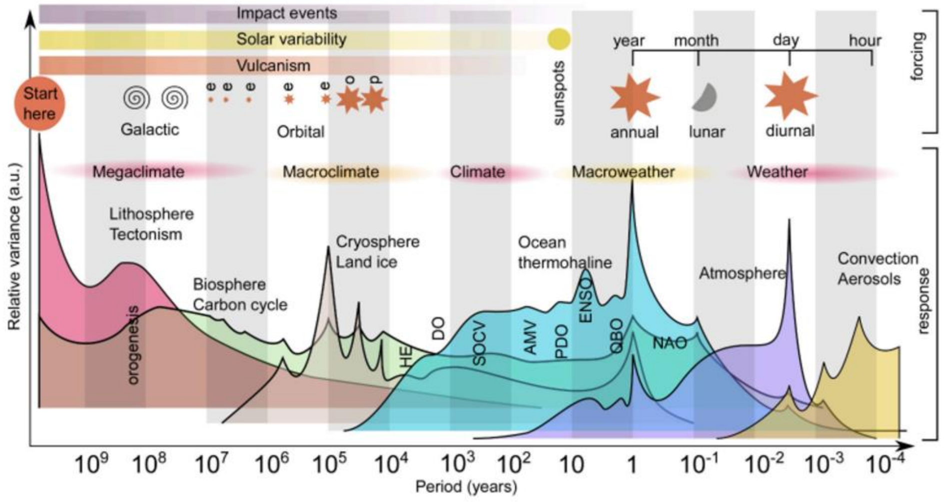
(published 31 July 2020)

The climate is a forced, dissipative, nonlinear, complex, and heterogeneous system that is out of thermodynamic equilibrium. The system exhibits natural variability on many scales of motion, in time as well as space, and it is subject to various external forcings, natural as well as anthropogenic. This review covers the observational evidence on climate phenomena and the governing equations of planetary-scale flow and presents the key concept of a hierarchy of models for use in the climate sciences. Recent advances in the application of dynamical systems theory, on the one hand, and nonequilibrium statistical physics, on the other hand, are brought together for the first time and shown to complement each other in helping understand and predict the system's behavior. These complementary points of view permit a self-consistent handling of subgrid-scale phenomena as stochastic processes, as well as a unified handling of natural climate variability and forced climate change, along with a treatment of the crucial issues of climate sensitivity, response, and predictability.



V d Heydt et al. (2021) Global and Plantary Change

TIPPING POINTS IN THE EARTH SYSTEM

Co-financed by the Connecting Europe Facility of the European Union

- **Objective 3 (O3). Characterise climate response in the presence of tipping points (TPs)**
- *Specific Objective 3.1.* Develop a theory of climate response (CR) that goes beyond linear and equilibrium concepts, i.e. beyond equilibrium climate sensitivity (ECS). This theory should deal with responses on distinct temporal and spatial scales, and relate the responses of different observables to external forcing through appropriate response operators.
- *Specific Objective 3.2.* Apply and evaluate this CR theory by deriving thresholds associated with both natural and anthropogenic abrupt and irreversible transitions in both warmer and colder climates, using information from appropriate paleoclimate data and climate models.

REVIEWS OF MODERN PHYSICS, VOLUME 92, JULY–SEPTEMBER 2020

The physics of climate variability and climate change

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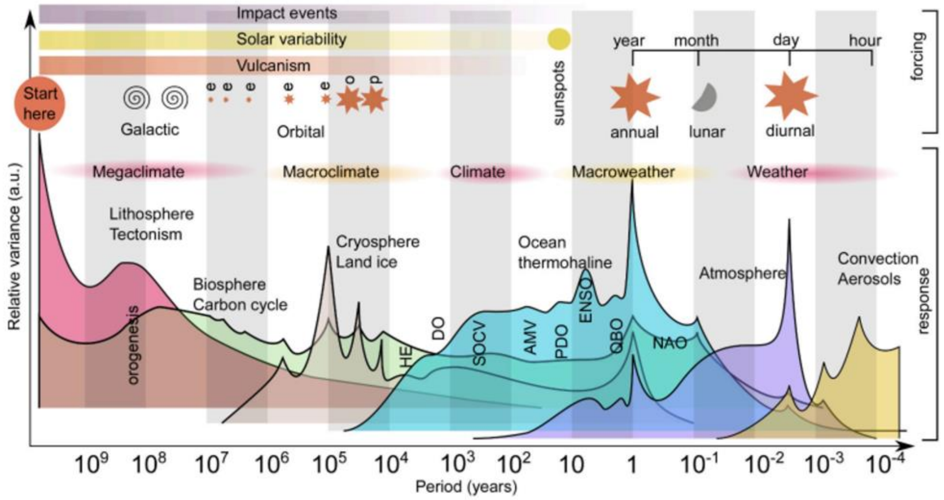

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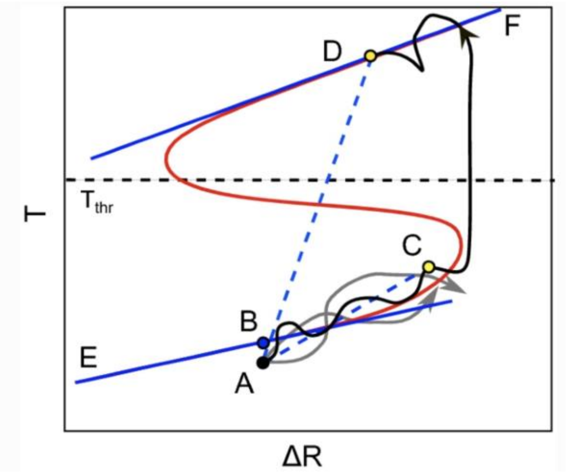

Ashwin and V d Heydt et al. (2020) J Stat Phys

- **Objective 4 (O4). Define and identify safe operating spaces**
- *Specific Objective 4.1*. Estimate the safety of operating spaces in terms that are quantitatively related to well-defined notions of bifurcations and attractors, as well as to global notions of stability for non-autonomous systems subject to time-dependent forcing.
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- *Specific Objective 4.2*. Develop quantitative estimates for the boundaries of safe operating spaces and the associated uncertainties in terms of critical levels and rates of change of distinct anthropogenic forcings. Assess the likelihood of abrupt transitions in the vicinity of these boundaries, while taking into account concepts such as noise- and rate-induced tipping.

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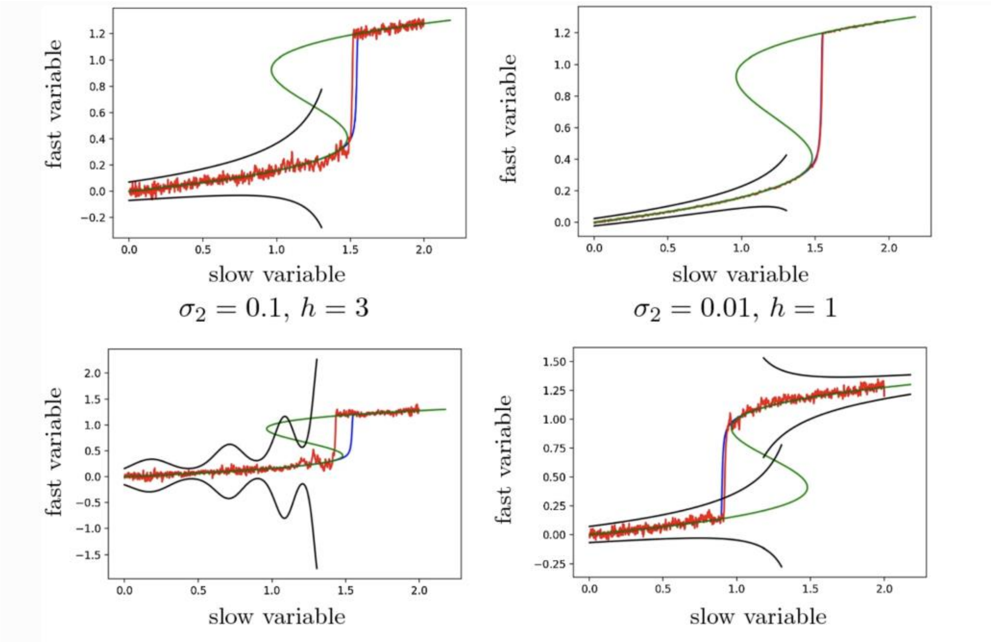

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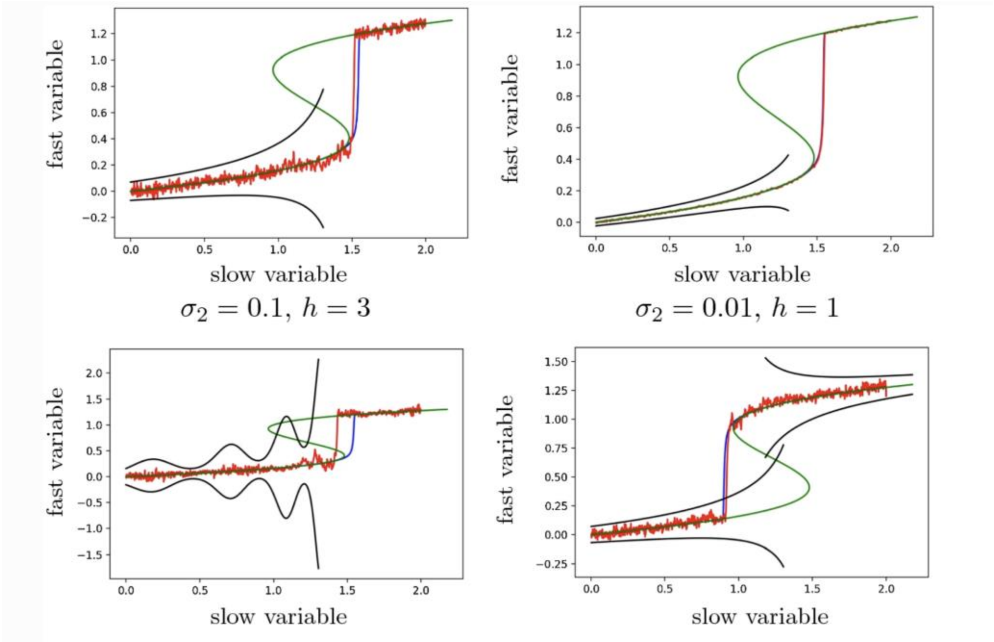
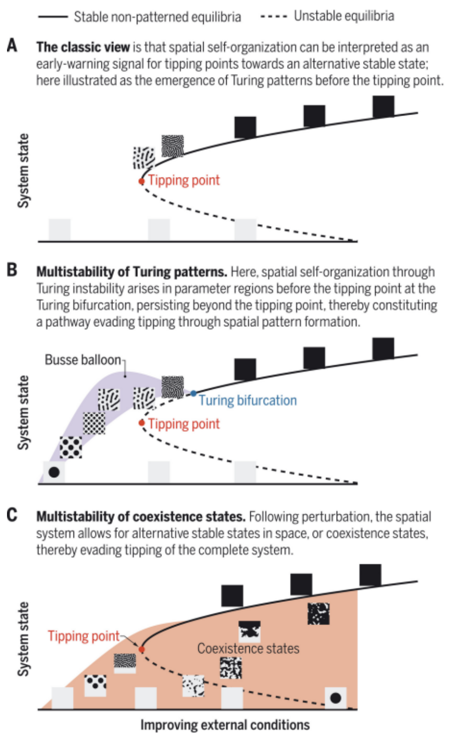


Eichinger et al. (2020) J. Stat. Phys.



Rietkerk et al. (2021) Science

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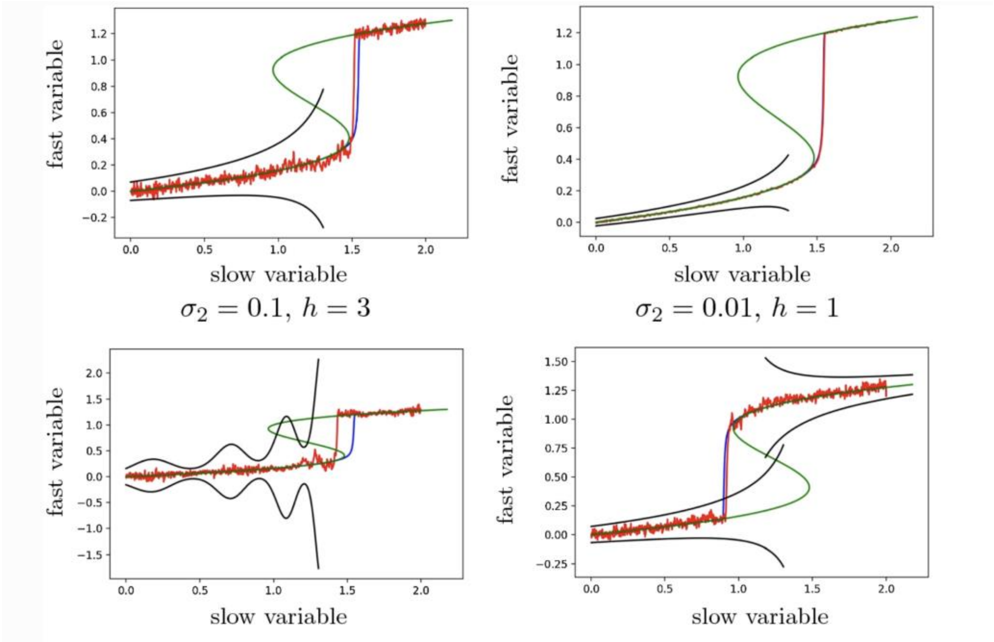

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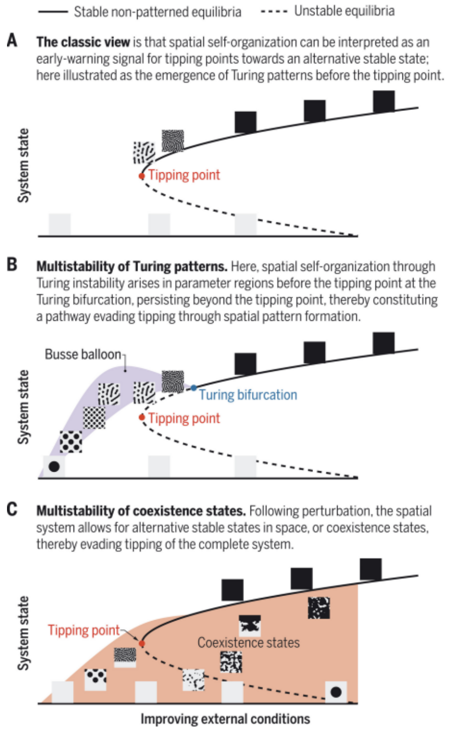

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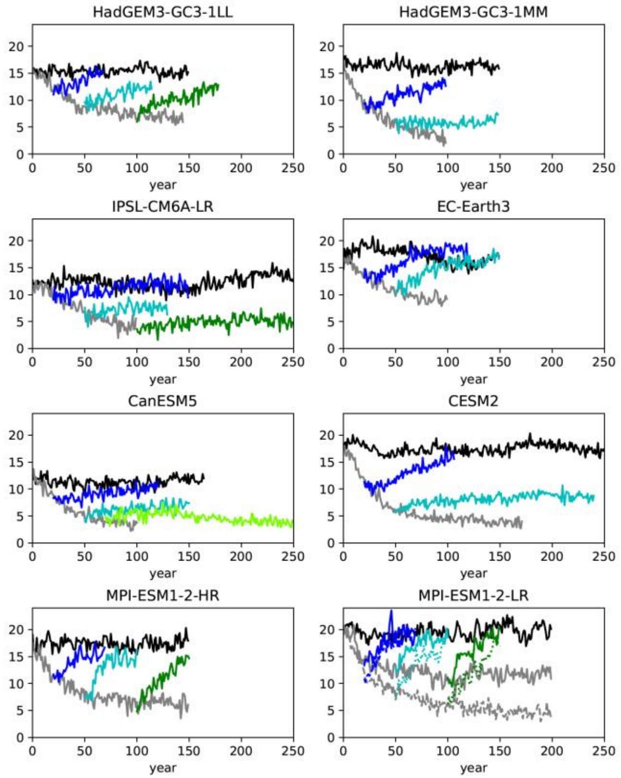

Jackson et al. (2022) submitted

Co-financed by the Connecting Europe Facility of the European Union

- **Objective 5 (O5). Bridge the gap between climate science and policy advice**
- *Specific Objective 5.1.* Develop a clear formal language (domain-specific language) to communicate concepts and connections between TP researchers and decision makers. This includes the notions of uncertainty about the consequences of crossing specific TPs, the reliability of EWSs, and the size and shape of safe operating spaces. The objective of the domain-specific language is to stand as a reference and to minimize ambiguity in the communication of research outputs.
- *Specific Objective 5.2.* Understand the impact of uncertainties on TPs for the mathematical problem of finding optimal policy mechanisms, and frame the dialog with the decision maker for defining and communicating decision problems which determine accountable policies.

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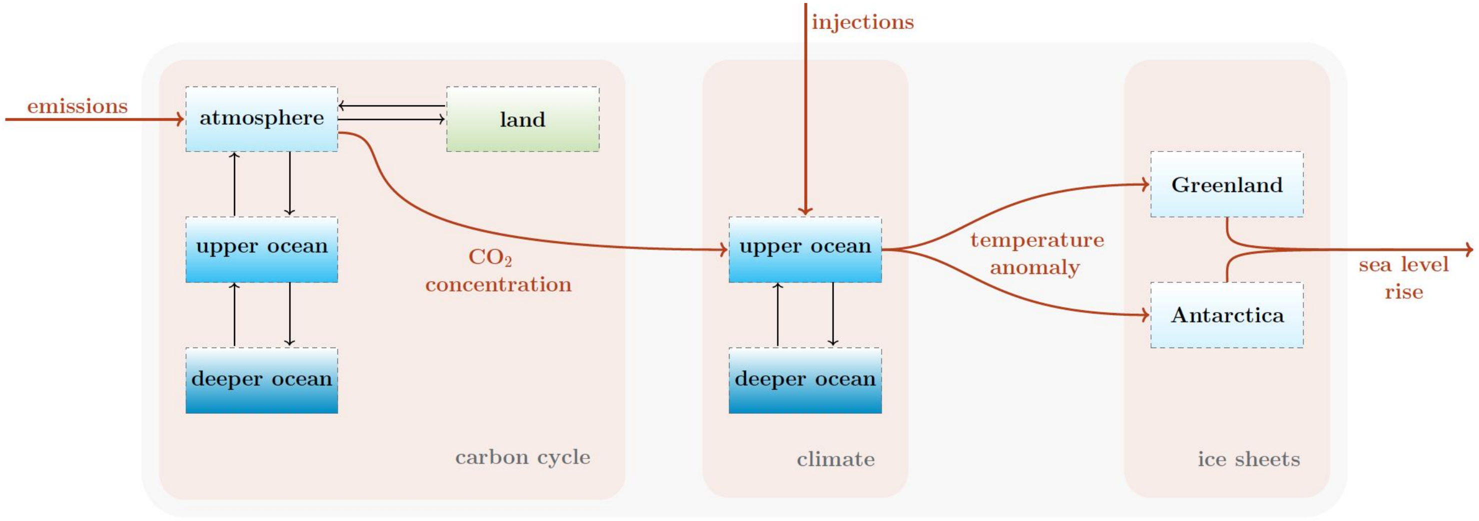

Figure 1. Conceptual diagram of SURFER. The state variables are indicated by the boxes, interactions and sources are depicted by black and dark orange arrows respectively.

Montero et al. (2022) submitted