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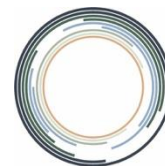
Global Systems
Institute

The skill of EO for tipping points research

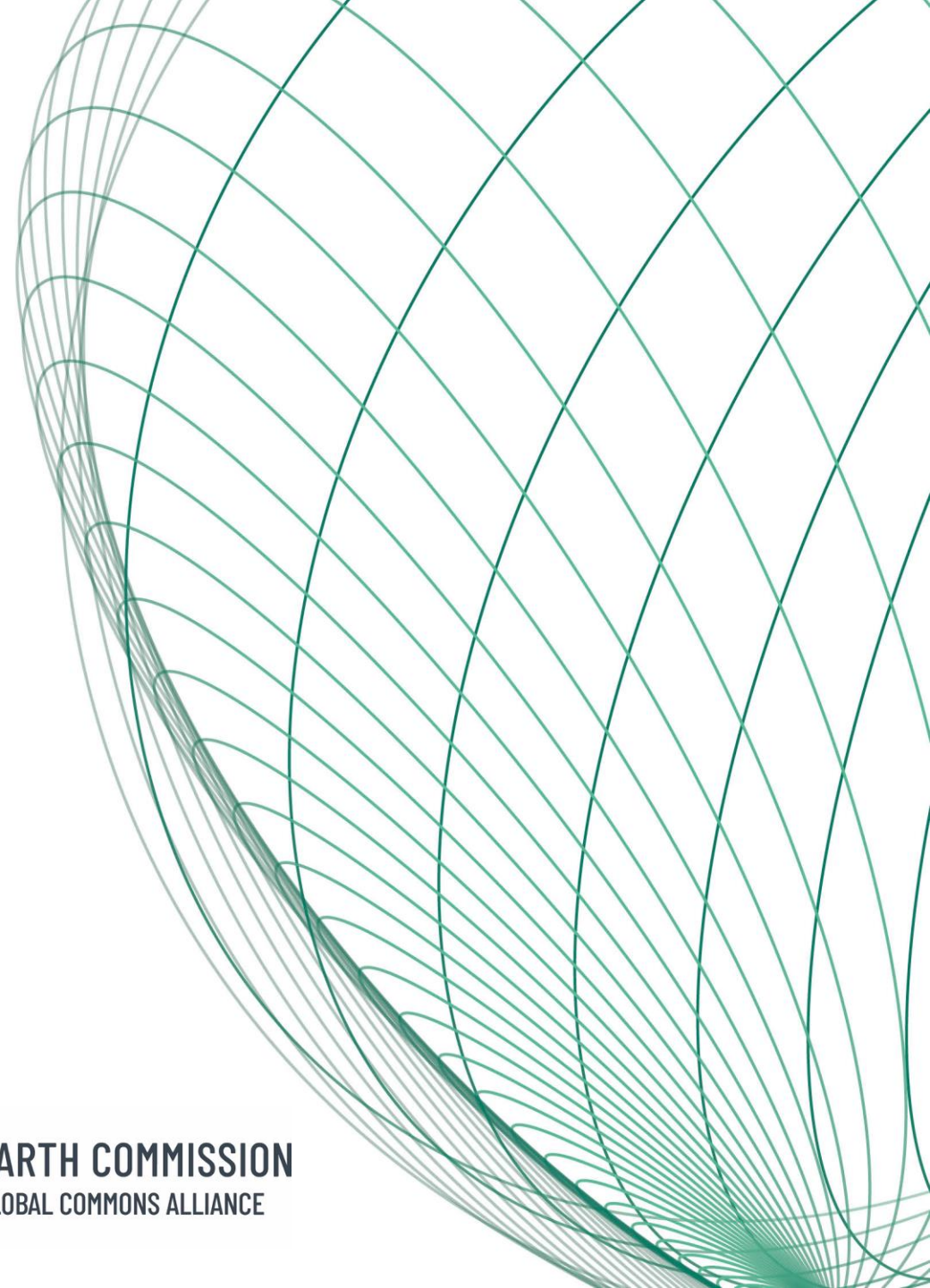
Tim Lenton

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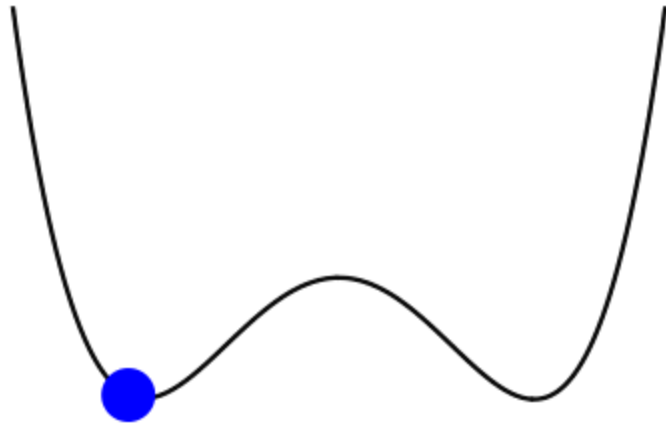
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EARTH COMMISSION
GLOBAL COMMONS ALLIANCE



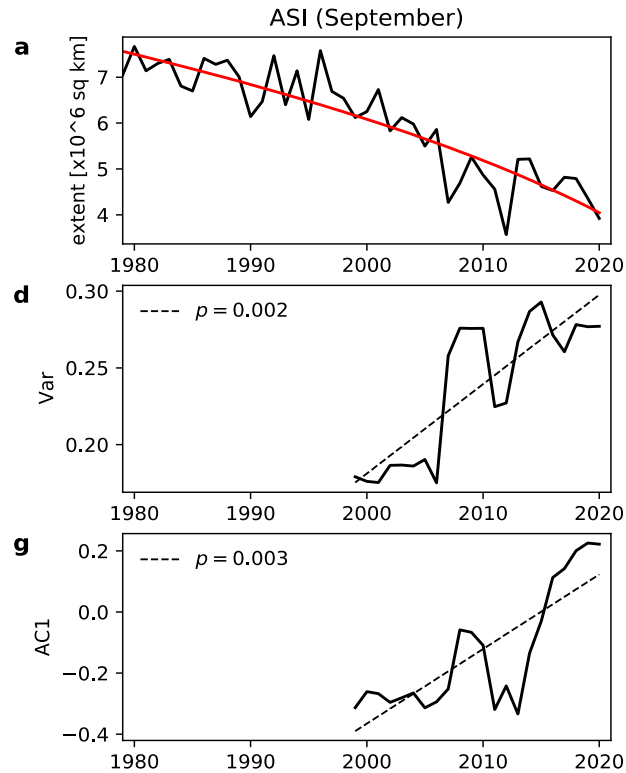
Generic example of passing a tipping point



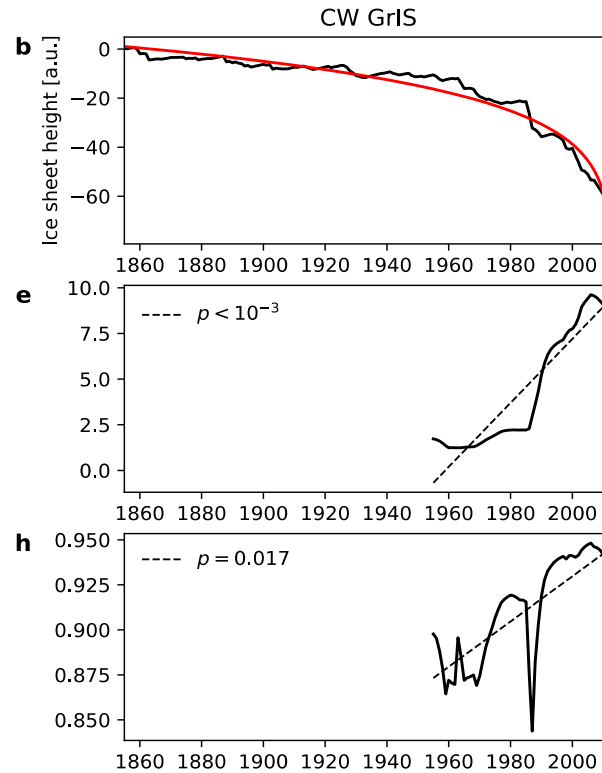
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Early warning signals in observational data

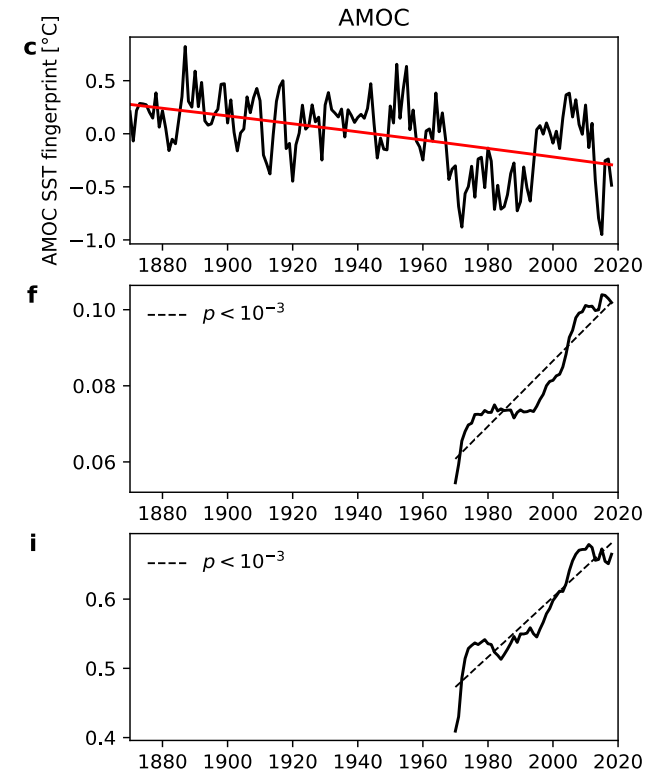
Arctic sea-ice
September extent



Central western
Greenland Ice Sheet

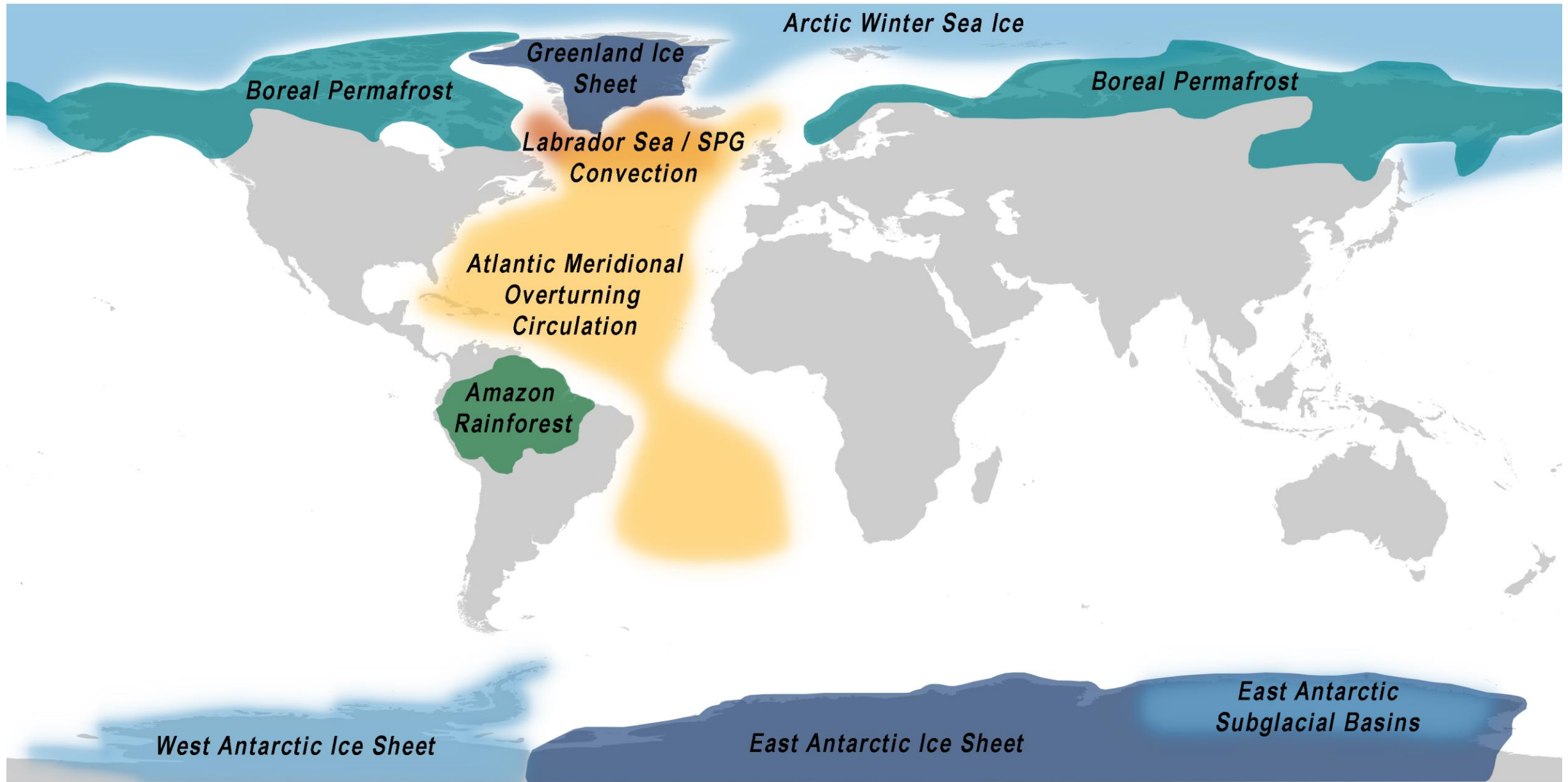


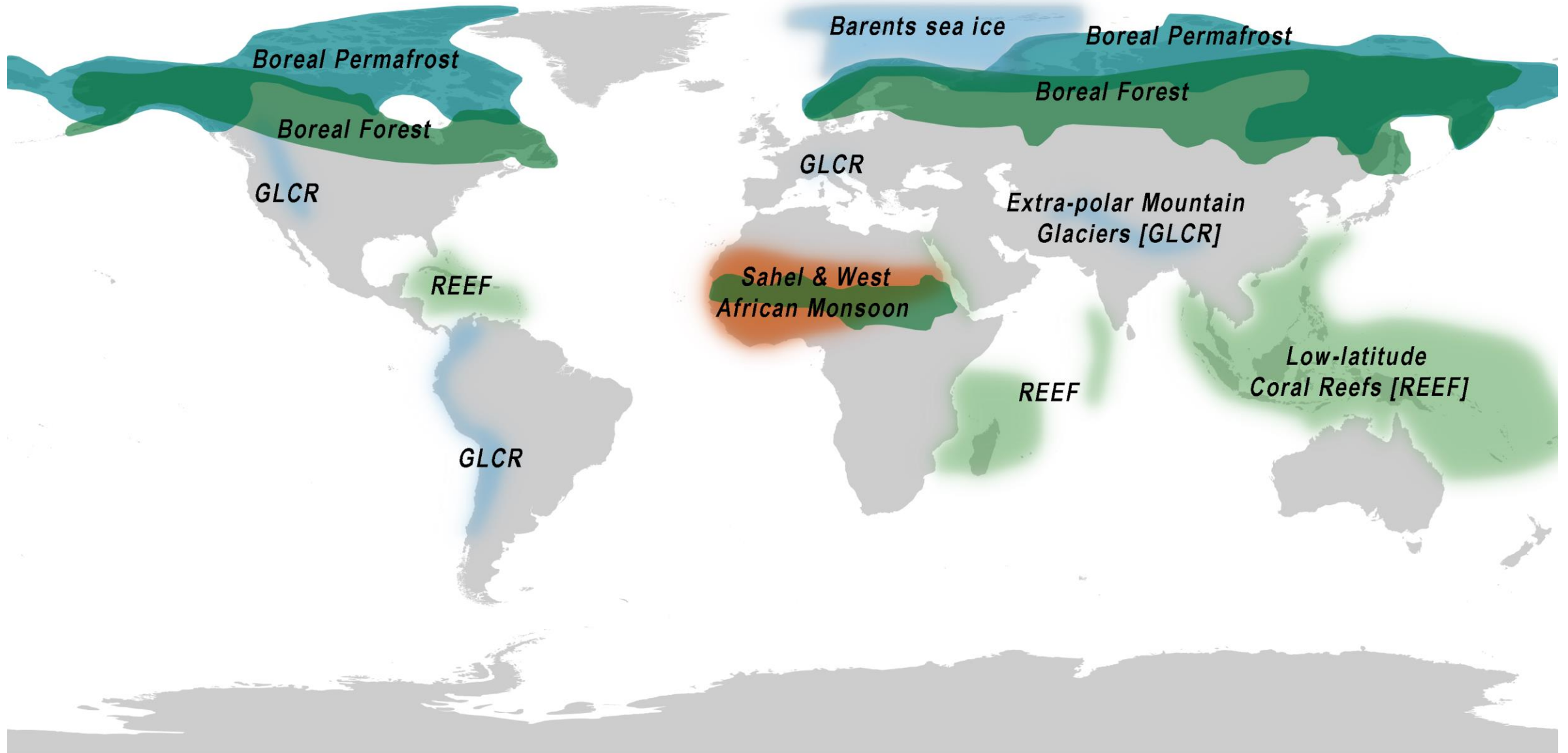
Atlantic Meridional
Overturning Circulation



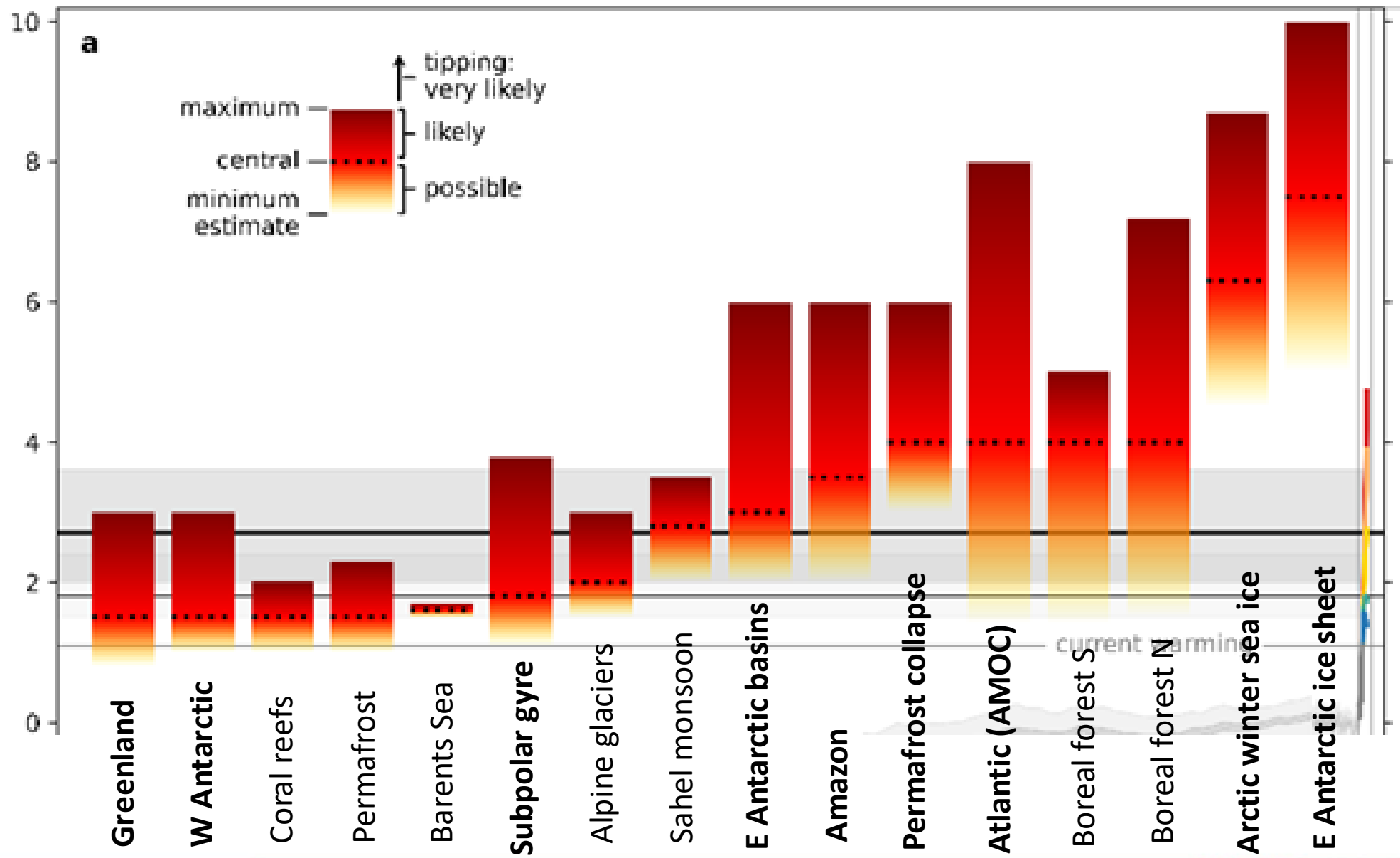
Variance

AR(1) auto-
correlation





Global warming (C)

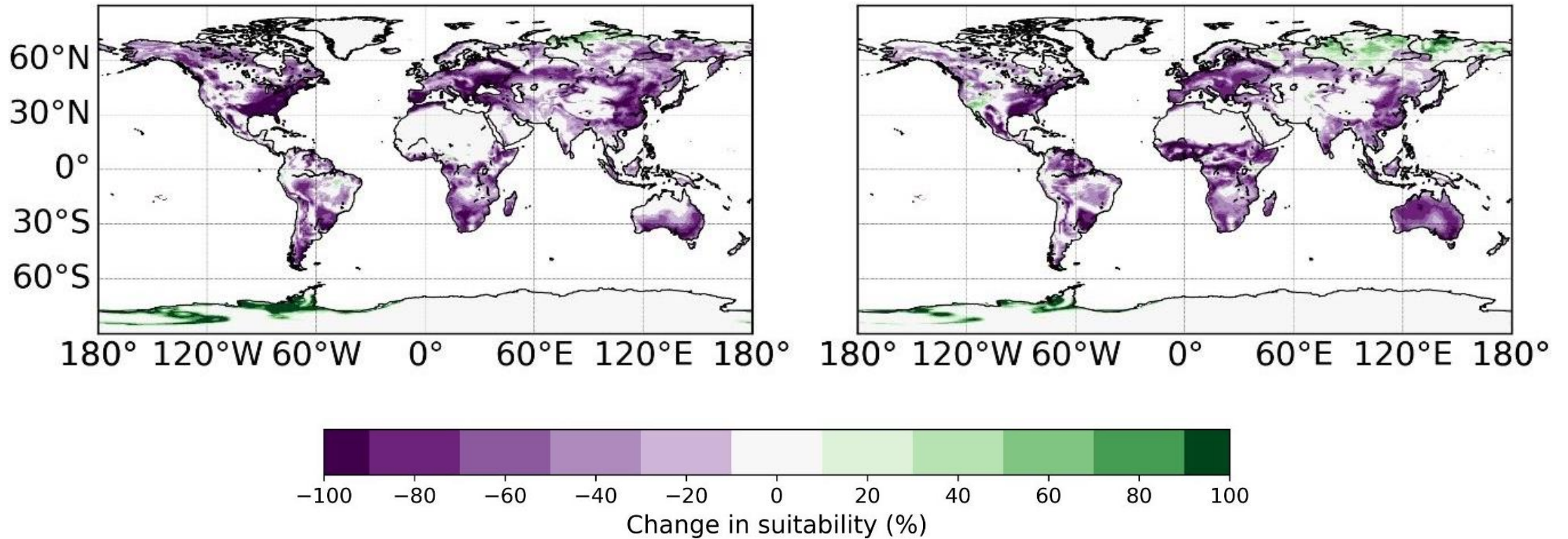


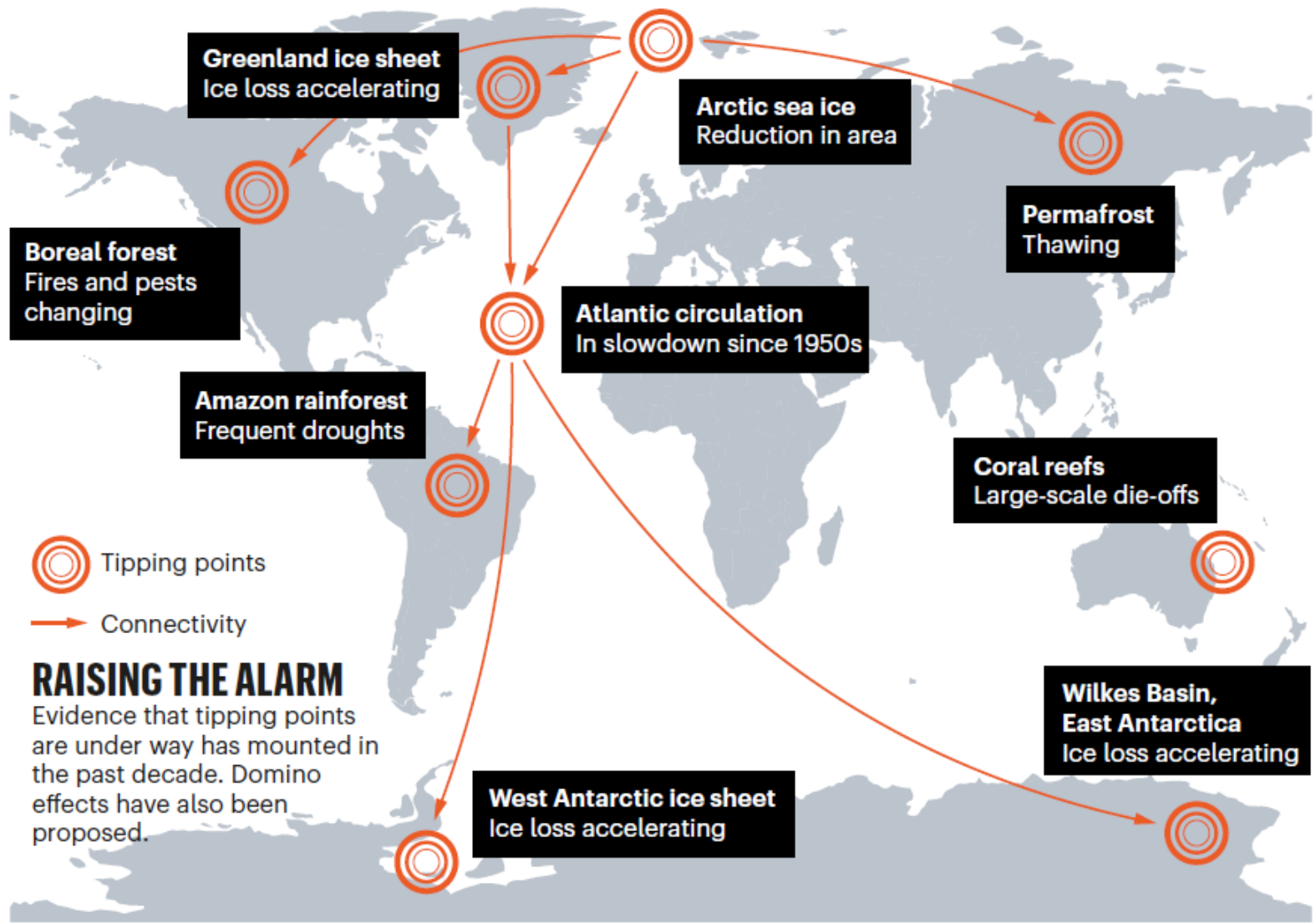
Change in suitability for growing staple crops

2.5C global warming + AMOC tipping point

Wheat

Maize

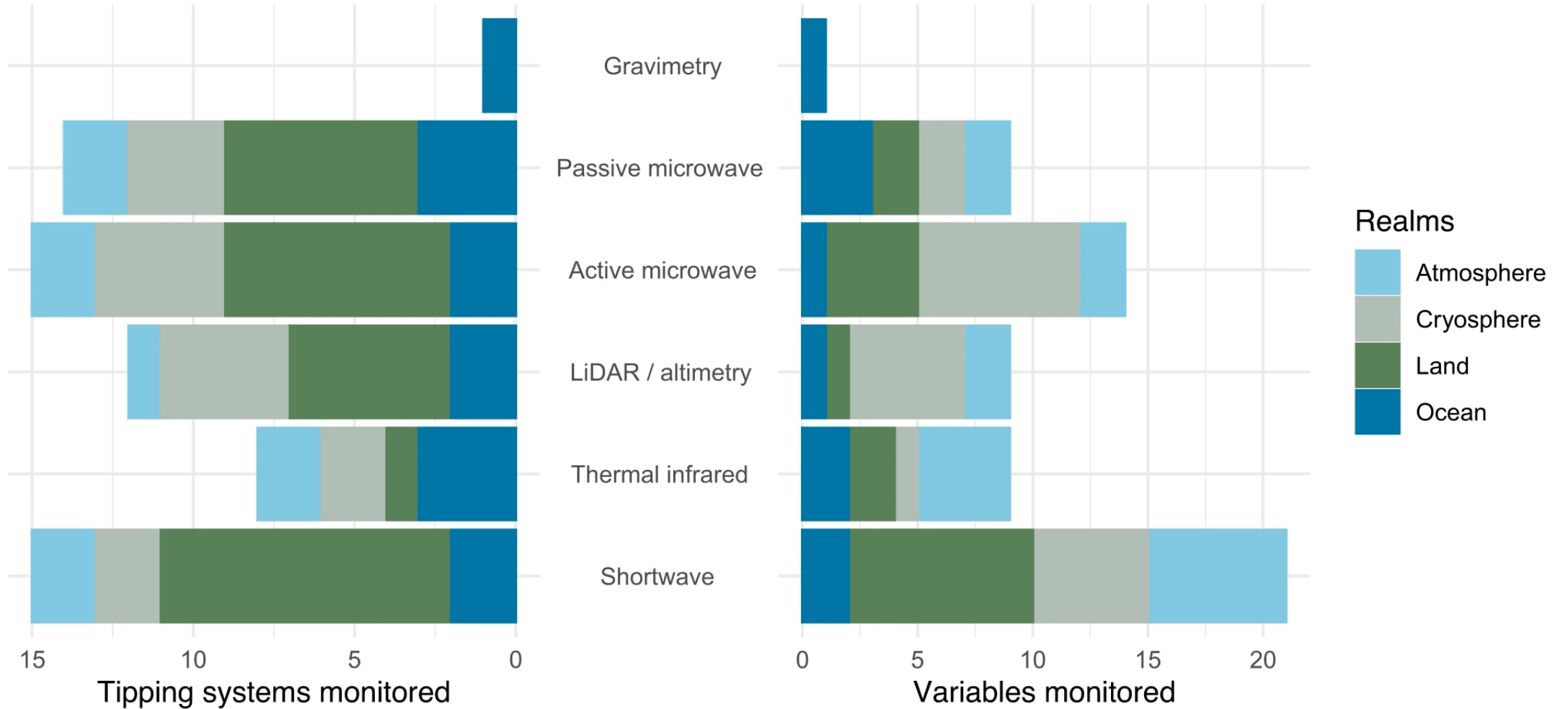




EO scientific targets for tipping points

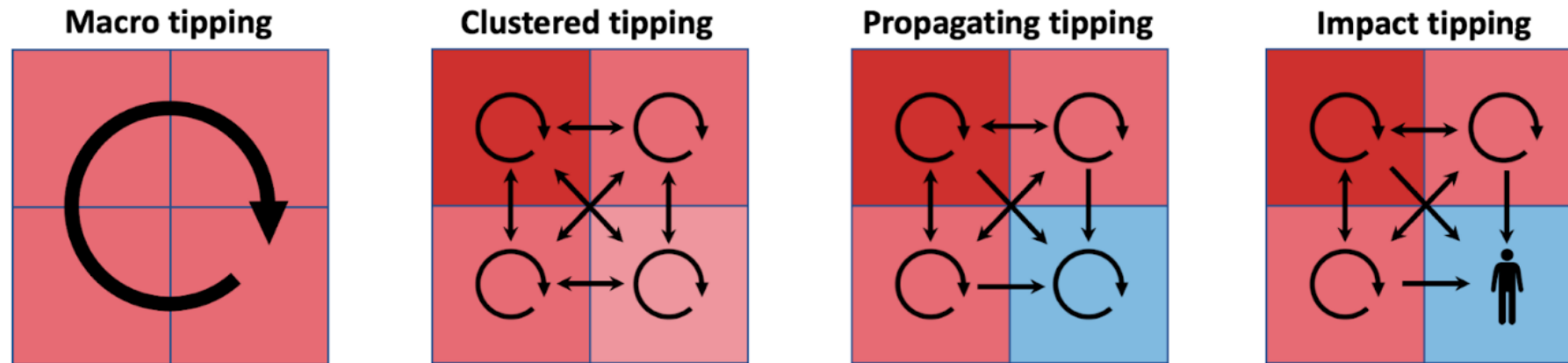
- Monitor relevant feedback processes to improve process understanding
- Detect alternative stable states and abrupt changes
- Establish links from alternative stable states and their stability to climate variables
- Observe system dynamics over time, including changes in resilience and associated early warning signals
- Calibrate, constrain and evaluate models of tipping systems to improve predictions

Capacity to monitor tipping systems



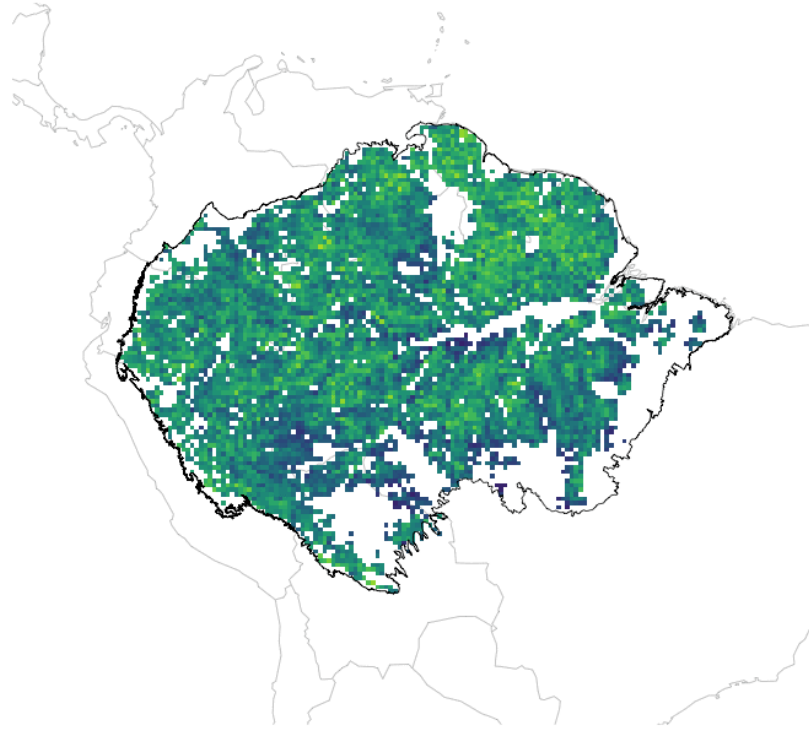
Criteria for EO datasets to be useful in tipping point applications

1. Salient variables correlated with key processes underlying tipping dynamics
2. Accurate analysis-ready data
3. Spatial coverage of the tipping systems of interest
4. Spatial resolution sufficient to resolve key feedbacks involved in tipping dynamics
5. Temporal resolution sufficient to resolve timescales of tipping or recovery
6. Temporal duration sufficient to estimate system resilience, and ideally changes thereof
7. Low data latency to support timely detection and/or early warning of tipping points



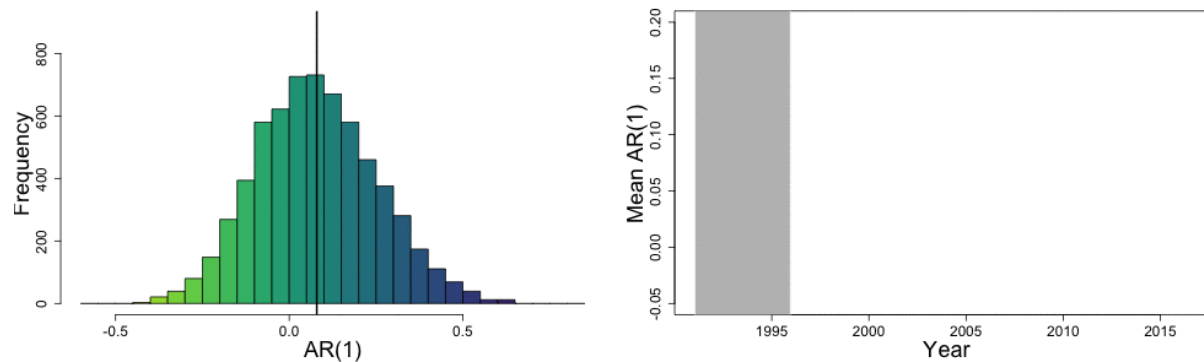
- **Macro tipping**
 - Where key reinforcing feedback mechanisms operate across large spatial scales
 - E.g. monsoons; ocean circulation; ice sheets
- **Clustered tipping**
 - Where localised tipping occurs in clusters near-synchronously across a large area due to spatially coherent forcing reaching a common threshold
 - E.g. coral bleaching (Great Barrier Reef); thermokarst and lake formation
- **Propagating tipping**
 - Where tipping starts at small spatial scales but cascades causally to larger scales
 - E.g. Pine Island Glacier => Amundsen Basin => WAIS
- **Societal impact tipping**
 - Where localised tipping has unusually large societal impacts
 - E.g. loss of Himalayan glaciers

Remotely sensing Amazon rainforest resilience



Key:
Paler = more resilient
Darker = less resilient

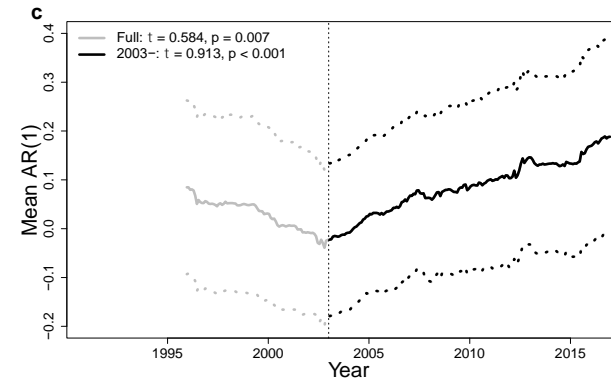
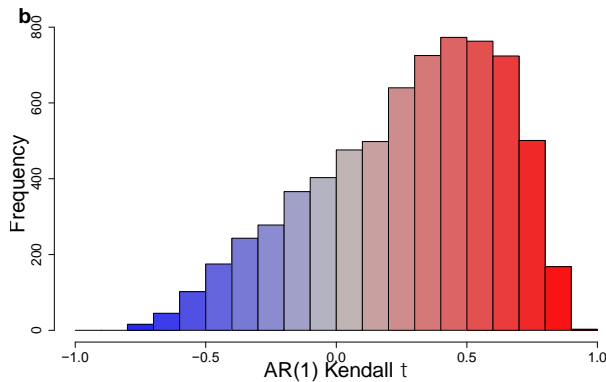
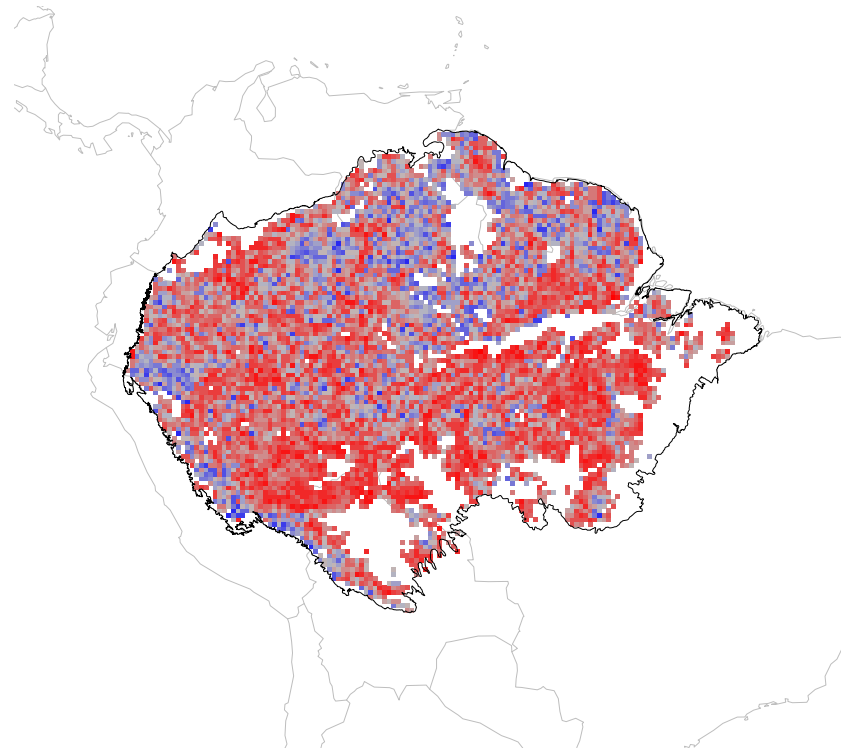
AR(1) of VOD



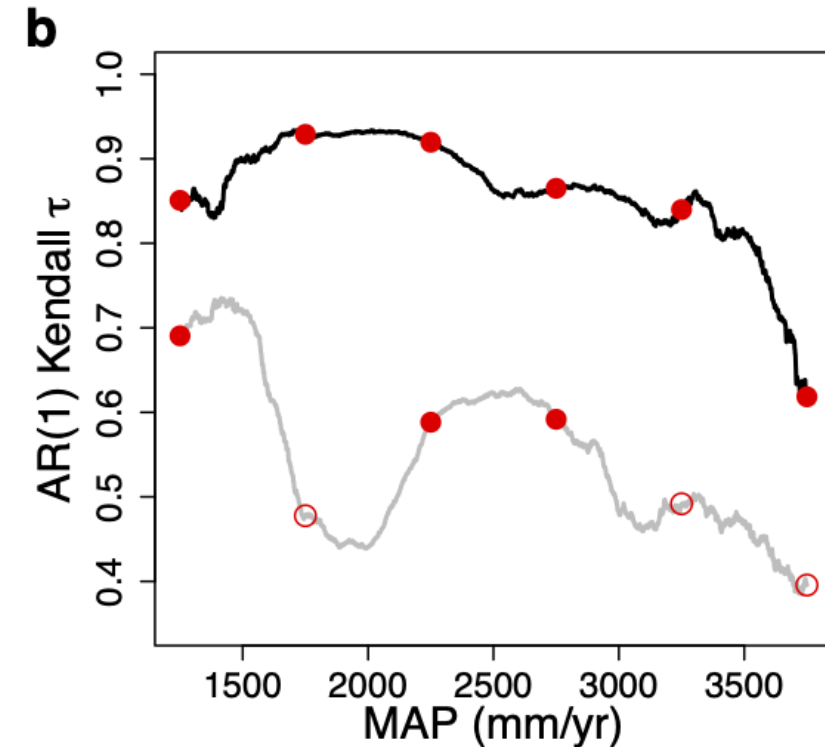
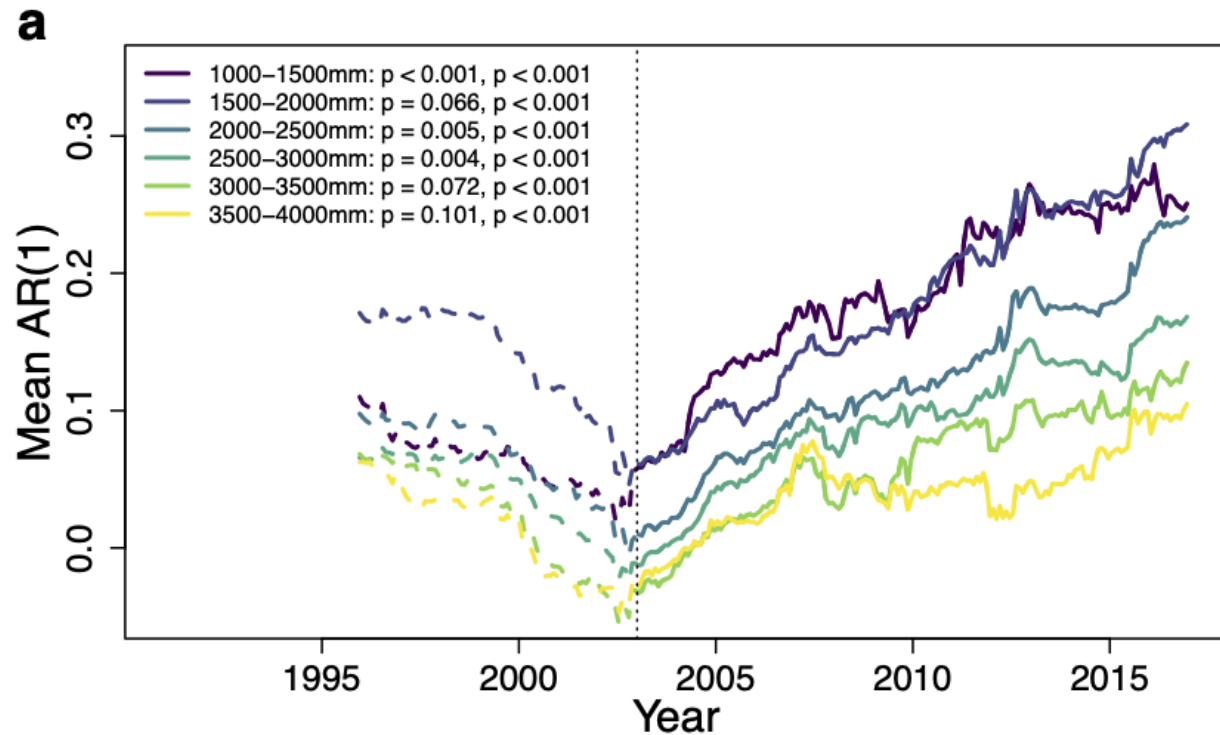
Loss of resilience of the Amazon rainforest

Trend in AR(1) of VOD since the early 2000s

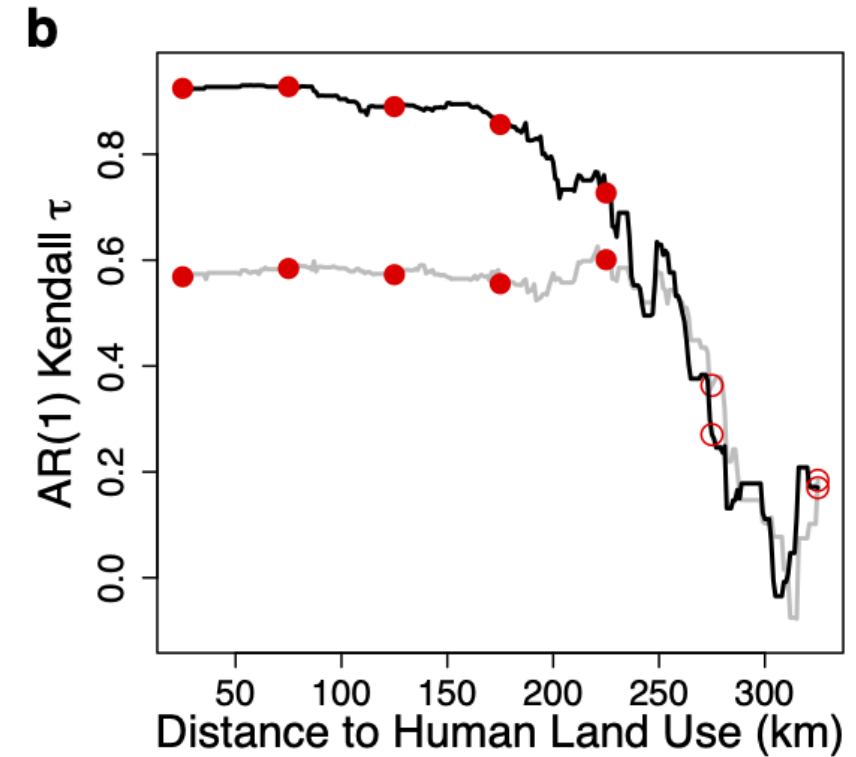
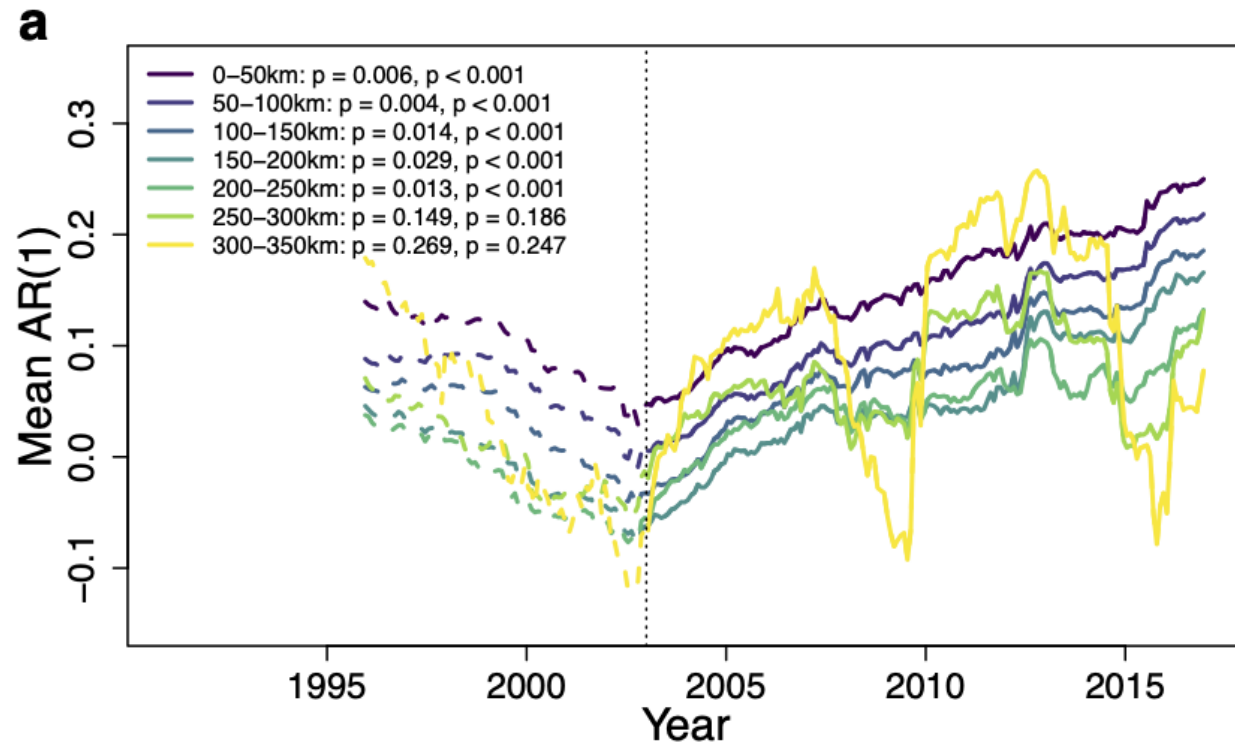
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Dependence on mean annual precipitation



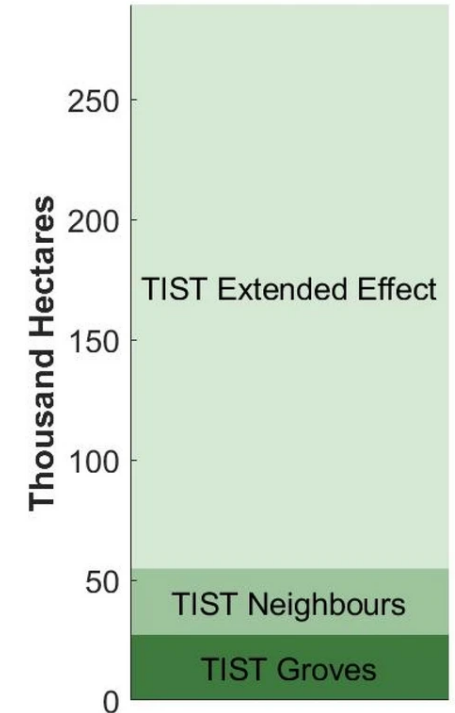
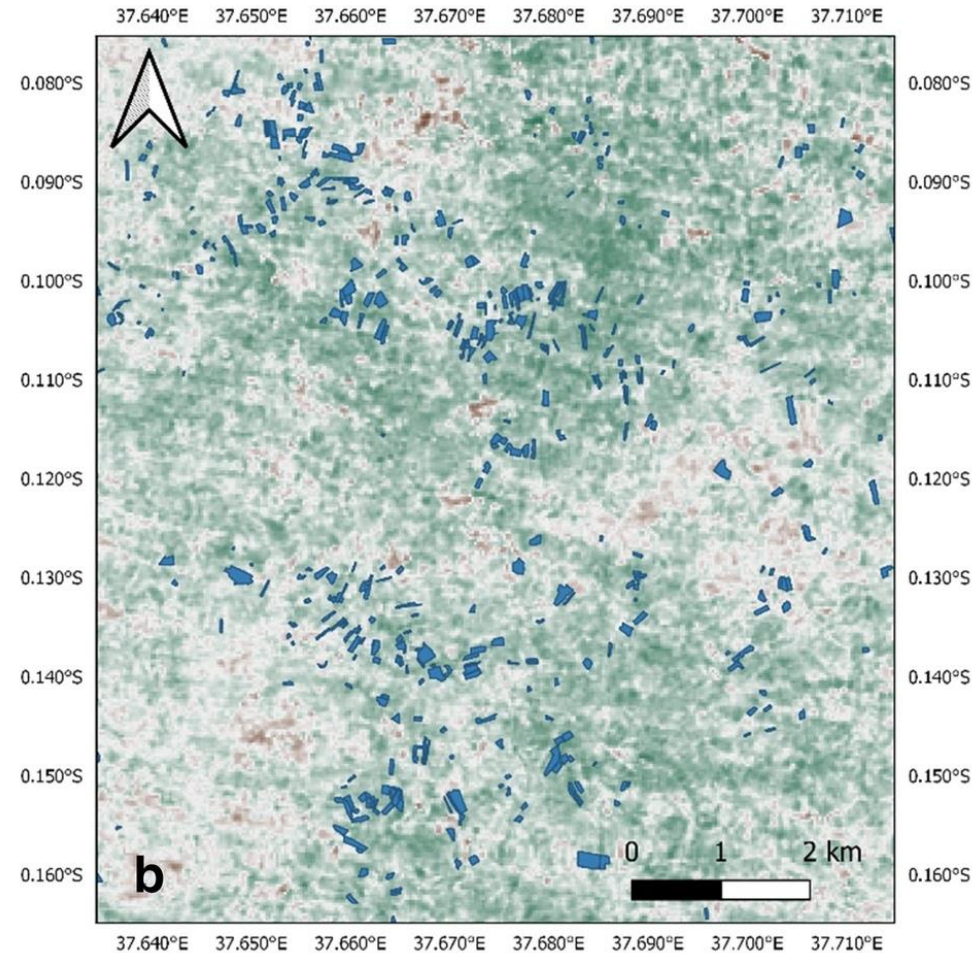
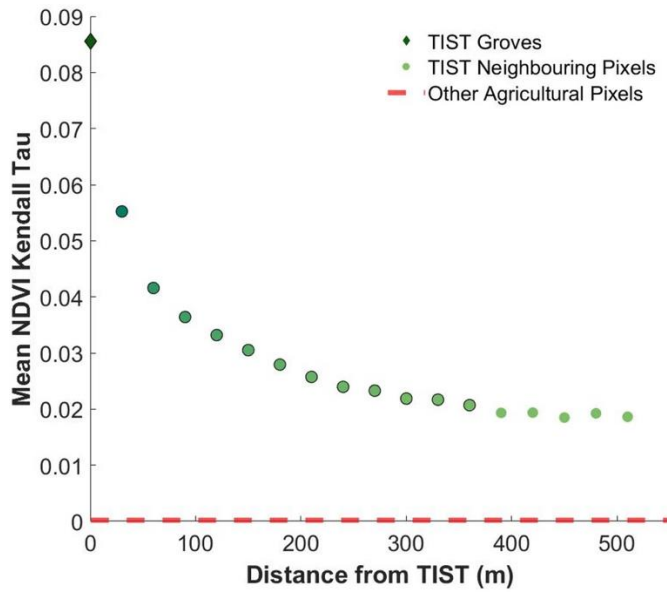
Dependence on distance to human activities



The International Small-group Tree planting initiative (TIST)



TIST greens the surrounding landscape



Summary

- EO can advance the understanding, detection and anticipation of tipping points, and their interactions, across scales
- A tipping point sensing system could be established bringing together the Earth system and Earth observation communities
- This can provide vital information to support policy-making and risk management at regional, national, and international scales