# Updated assessment suggests >1.5°C global warming could trigger multiple climate tipping points

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# Background

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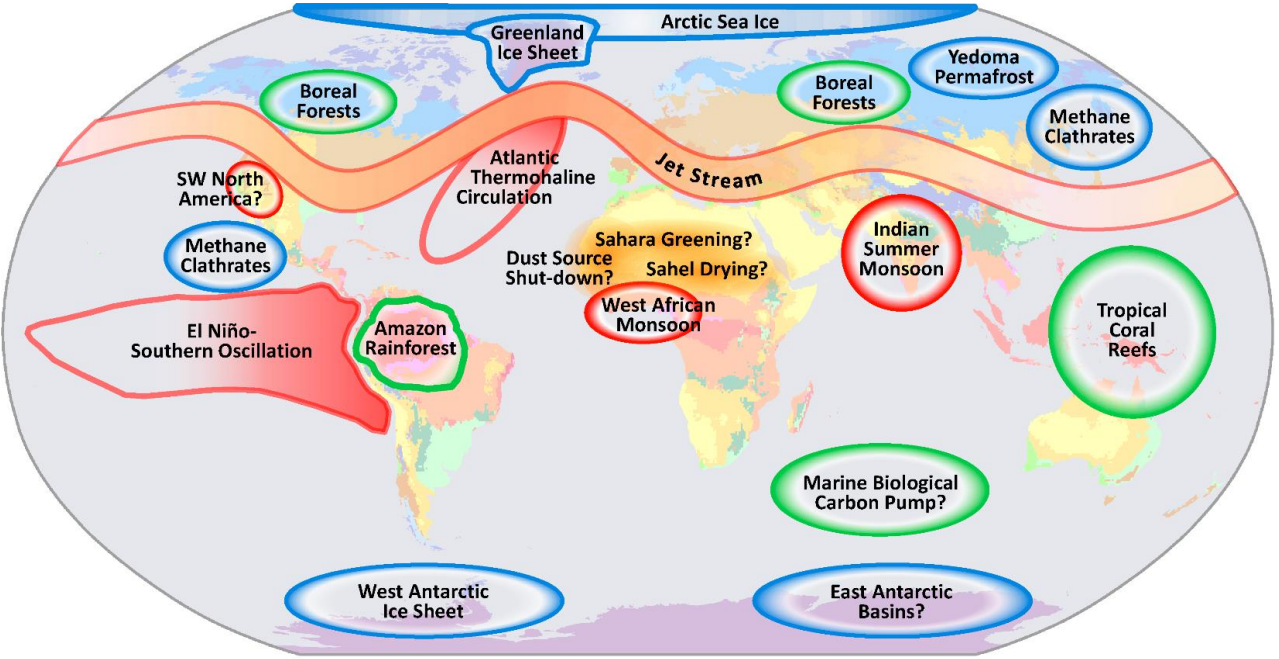
23/5/2022

- Over the past ~15 years climate tipping elements and associated **climate tipping points (CTPs) have emerged as an important research topic** and source of public concern
- **Field catalysed by** the expert elicitation & review of ***Lenton et al. [2008, PNAS]***
  - *"The term ''tipping point'' commonly refers to a critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system"*




***Credit: PIK***

Cryosphere Entities
Circulation Patterns
Biosphere Components

Köppen Climate Classification

Ar Am Aw As BS BW Cr Cs Cw Do Dc Eo Ec FT FI


## Tipping elements in the Earth's climate system

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The term ''tipping point'' commonly refers to a critical threshold at which a tiny perturbation can qual
development of a system. Here we introduce the term ''tipping element'' to describe large-scale componen
may pass a tipping point. We critically evaluate potential policy-relevant tipping elements in the climate sy
forcing, drawing on the pertinent literature and a recent international workshop to compile a short list, and w
points lie. An expert elicitation is used to help rank their sensitivity to global warming and the uncertainty ab
mechanisms. Then we explain how, in principle, early warning systems could be established to detect the proxi

# Background

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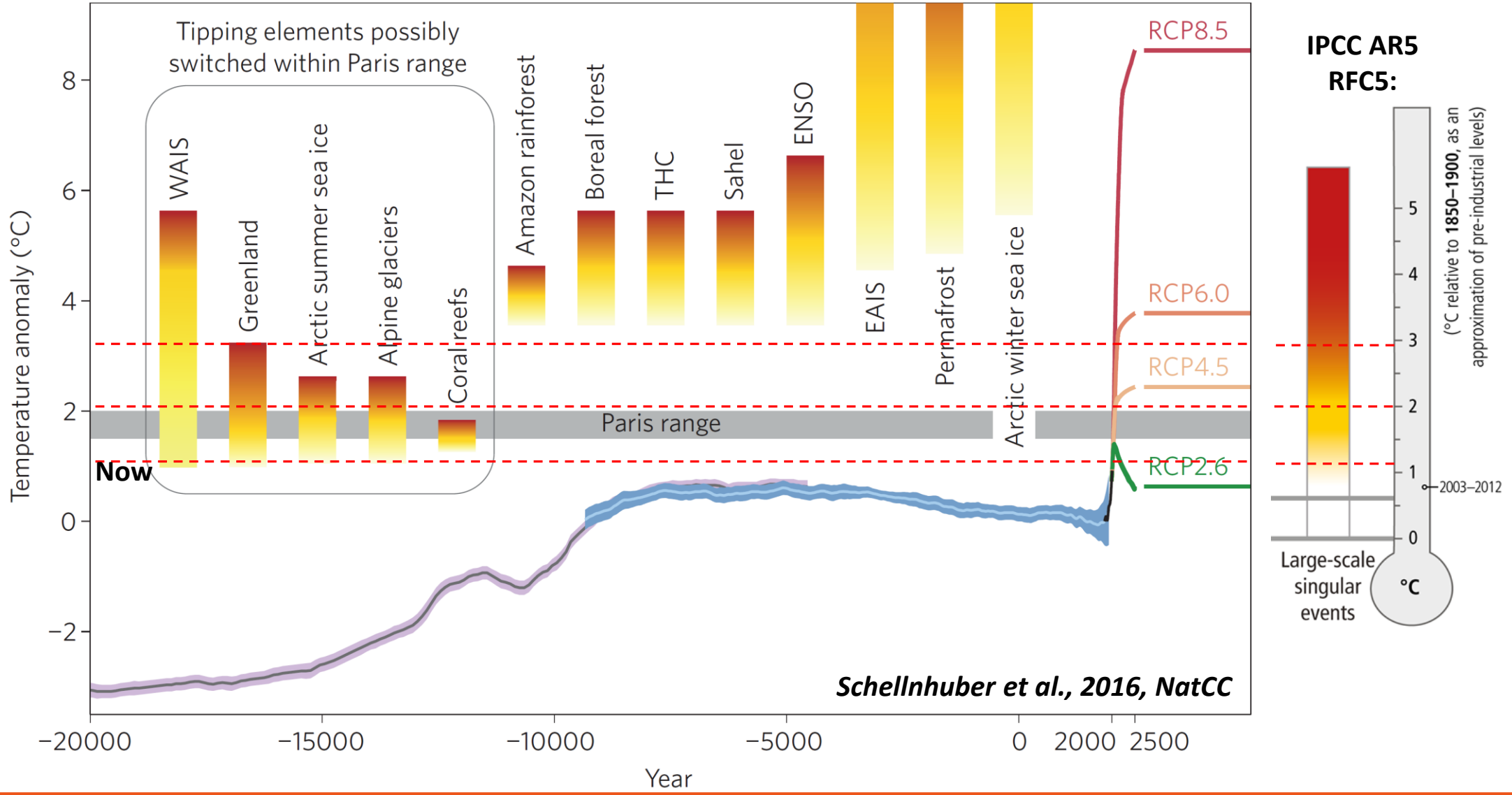
- Previous estimates indicate **likelihood of reaching CTPs grows above 1°C, becomes moderate above 2°C, and high above 3°C**



# Background

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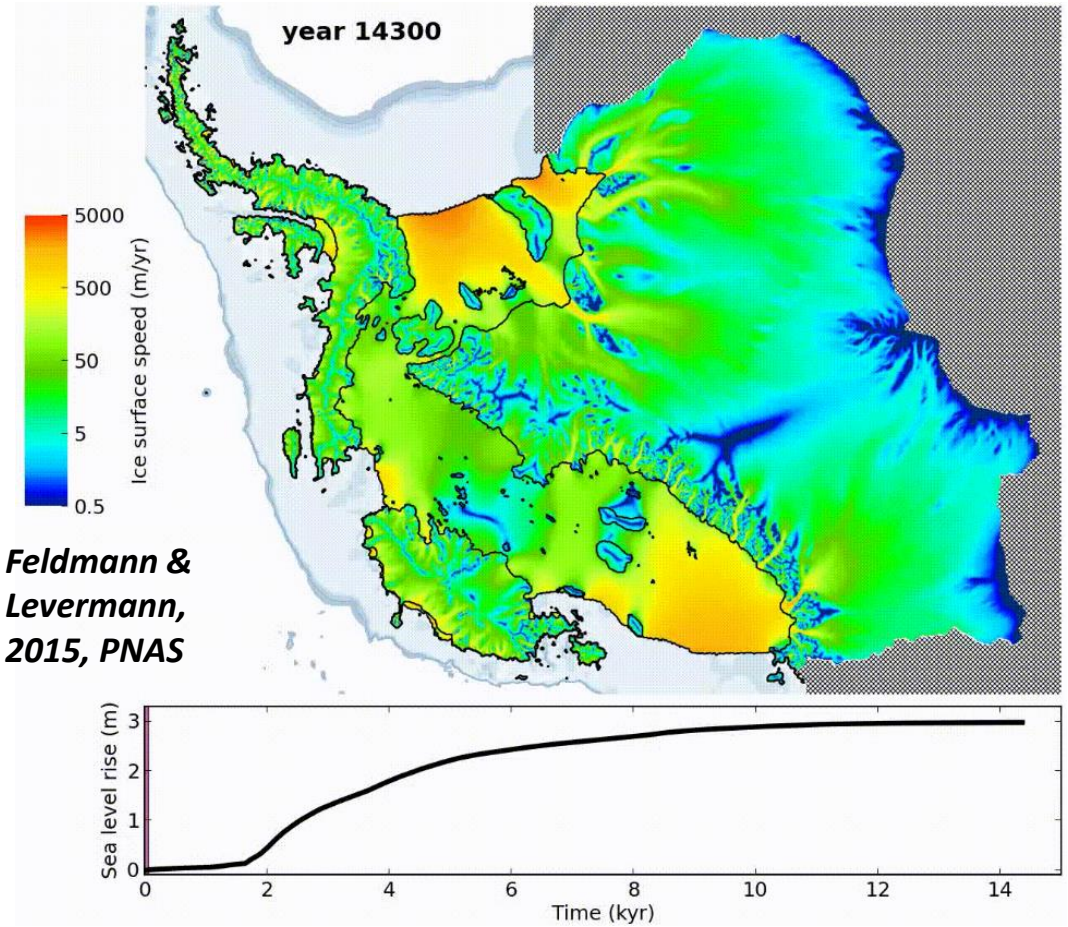
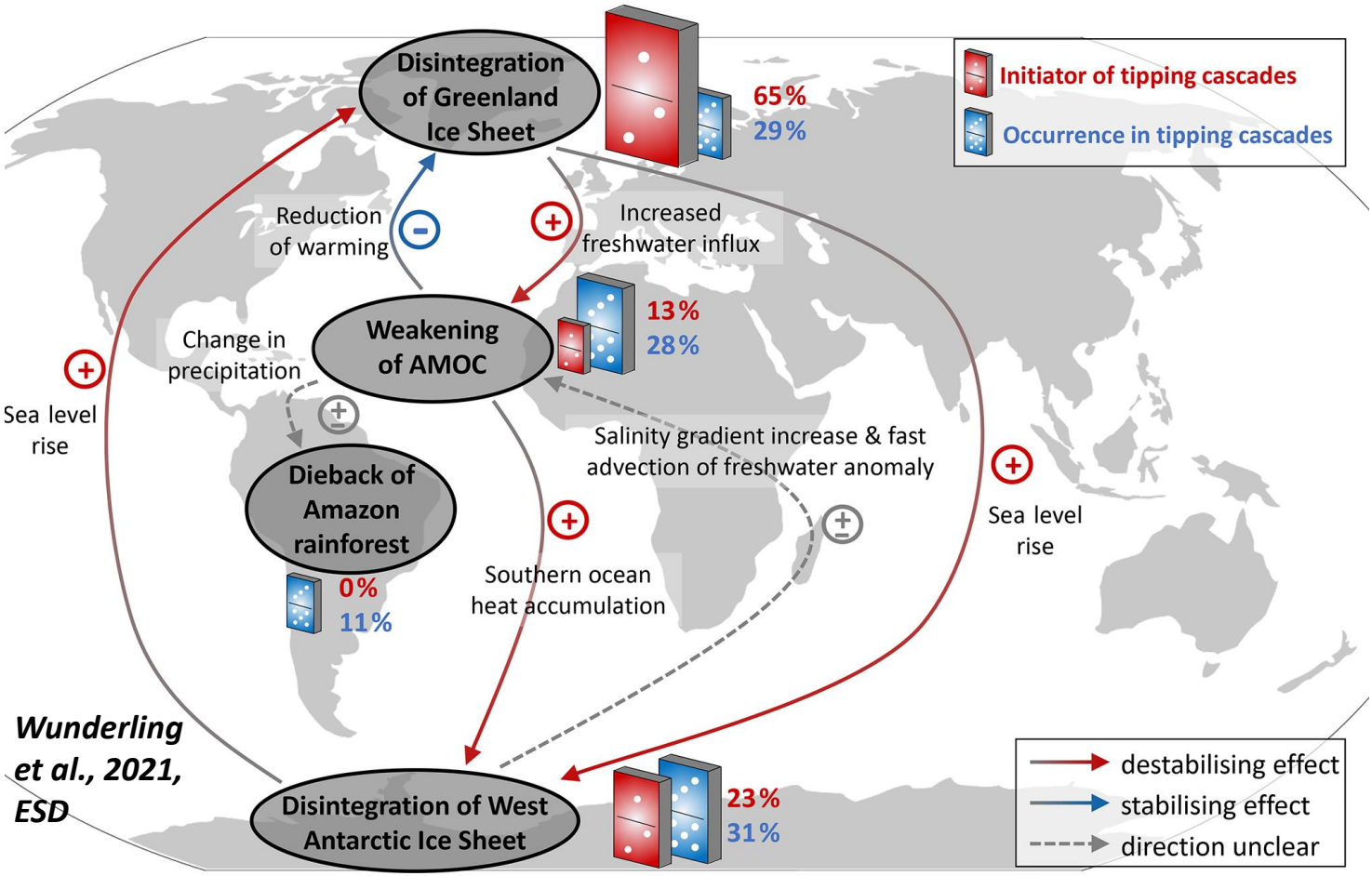
- Observations & models suggest **parts of West Antarctic Ice Sheet may be approaching or have even passed a CTP ↓**, and possible early warning signals in Greenland IS & AMOC




*Feldmann & Levermann, 2015, PNAS*




*Wunderling et al., 2021, ESD*

- Passing a CTP increasing likelihood of other CTPs **could lead to 'tipping cascades' ↑**; *Steffen et al. [2018]* hypothesised cascades & feedbacks at >2°C could lock in a "Hothouse Earth" future

# Background

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## Issues:

- **Tipping point definitions often inconsistent** (includes e.g. abruptly-forced events, threshold-free feedbacks, arbitrary thresholds, or general impacts → )
- **Insufficient data** to fully assess significance of current trends, early warning signals, & element interactions
- **Mixed coverage of tipping-relevant processes in Earth system models** (e.g. tipping interactions like GRIS runoff to AMOC, underestimated tropical tree mortality)
- Much still based on *Lenton et al. [2008]*, but considerable advances since then from observations, palaeo, upgraded ESMs/offline models – **an updated assessment overdue**

- **Reassessment now in revision at *Science*** (preprint available at ESSOAr: bit.ly/3CSAJjm)



# Methodology

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- **Reassess proposed climate tipping elements** based on the substantial literature published since *Lenton et al. [2008]* including observations, palaeo-records, and models (~200 papers)
- **Categorisation requires a clear & robust definition for CTPs** (not always irreversible/abrupt):

**"Tipping points occur when change in a part of the climate system (the '*tipping element*') becomes *self-perpetuating* beyond a forcing *threshold*, leading to difficult-to-reverse *nonlinear impacts.*"**

- **Summarise evidence** and confidence levels using expert judgement for self-perpetuation, hysteresis, thresholds, timescales, and impacts w.r.t. global warming for each element
- **Shortlist global 'core'** (sub-continental scale, significant to overall Earth system state) **and regional 'impact'** (synchronous localised tipping, significant to human welfare or great value)

# Results – threshold estimates

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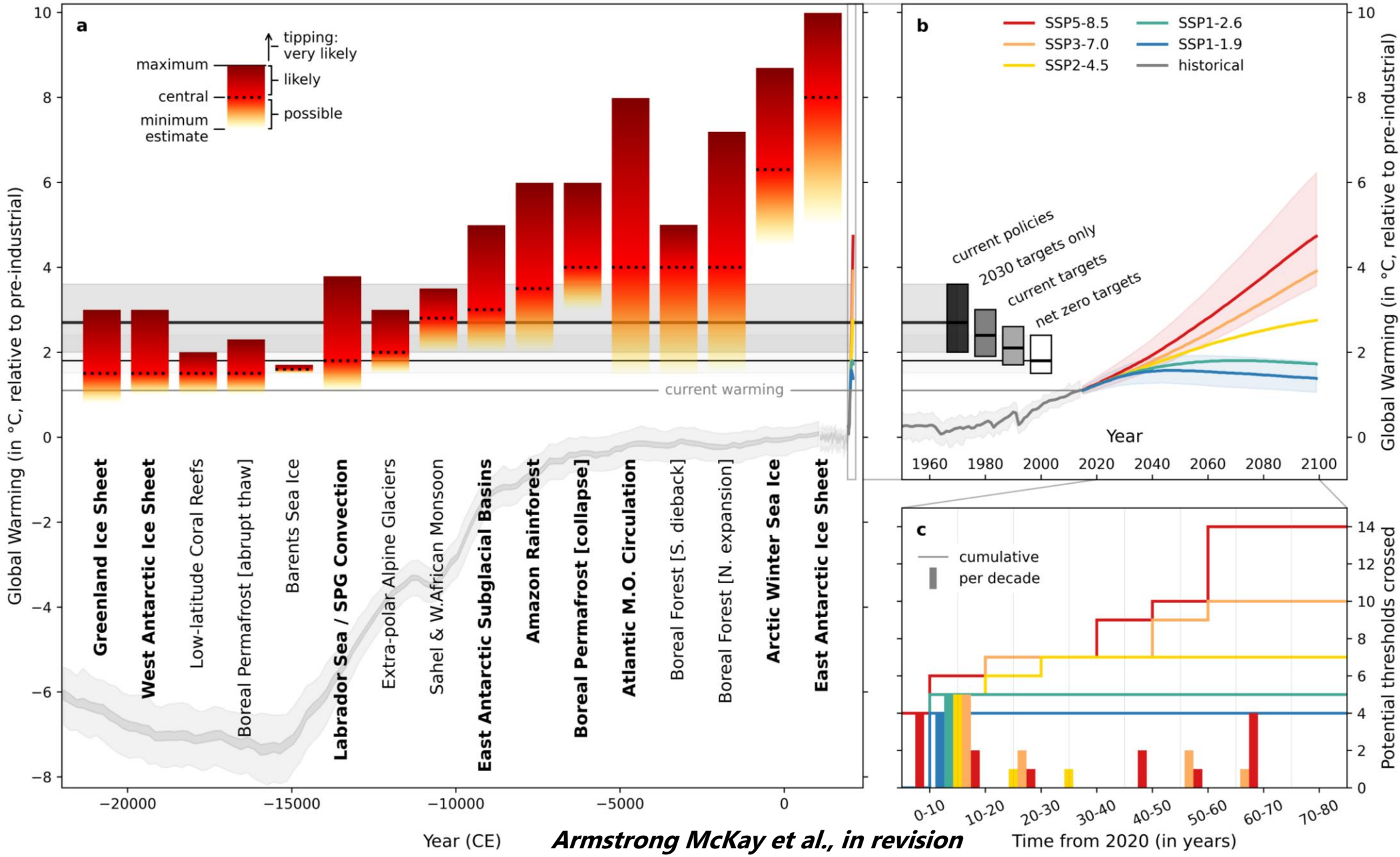
- **~1.1ºC:**
  5 CTPs possible
- **1.5ºC:**
  4 CTPs likely,
  3 possible
- **>2ºC:**
  7 likely,
  6 possible
- **Most but not all CTPs avoidable on lowest trajectories**




*Armstrong McKay et al., in revision*

# Summary

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- Climate tipping points occur when **change becomes self-sustaining beyond a threshold** in part of the climate system, locking in nonlinear impacts
- **Earth may have left a 'safe' climate state beyond 1ºC**; ≥1.5ºC Paris target has growing likelihood of passing multiple climate tipping points, e.g. in ice sheets
- **Current policies leading to ~2-3ºC warming are 'unsafe'** because they would likely trigger multiple climate tipping points and make many more possible
- **Key knowledge gaps**: high estimate uncertainty; overshoot times in slower elements; elements yet to be discovered; spatial effects; interactions
- **Future research priorities**: horizon-scanning exercise; systematic scan of CMIP6 output; further ESM improvements; machine learning for CTP early warnings

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