Bette Otto-Bliesner and Gabi Hegerl
CGD, NSF NCAR and University of Edinburgh

What If Model Intercomparison Project (WhatIfMIP)





WhatIfMIP – ‘It has happened’

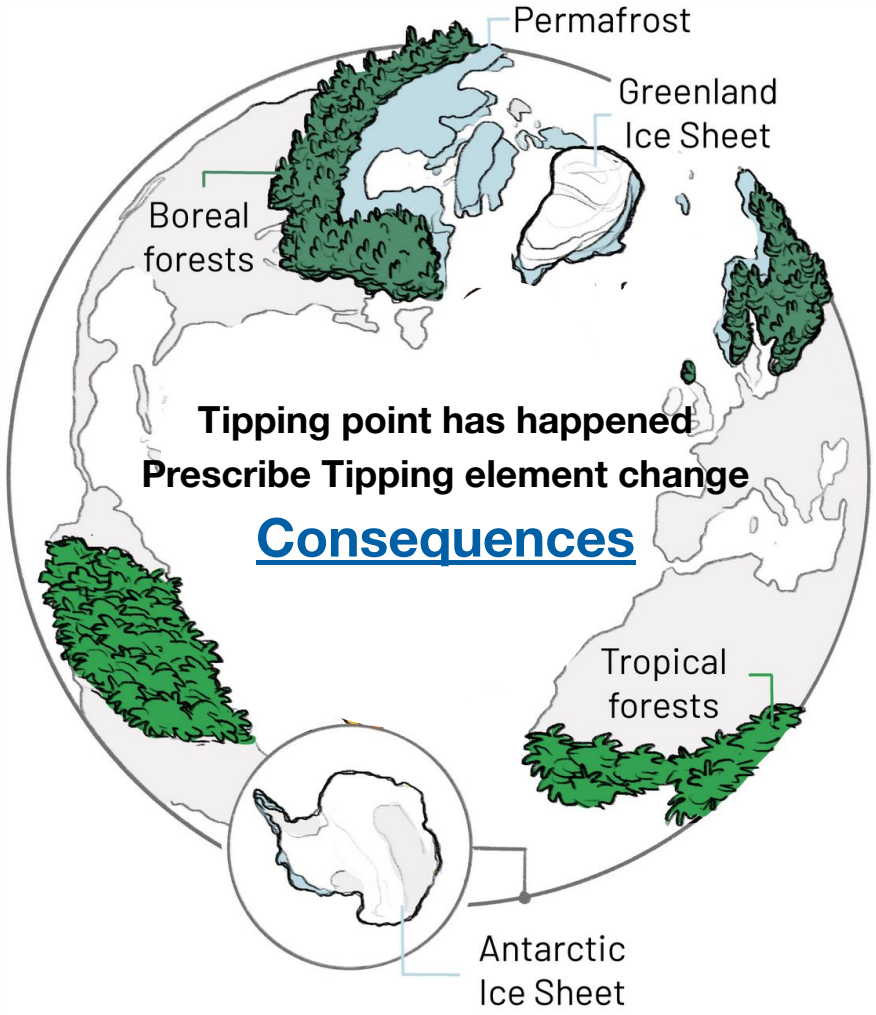
CMIP7 Community MIP

- Identify storylines of extreme outcomes in the future
- Design CMIP7 experiments assuming definitive tipping of a subset of these Earth system components -> It has happened
- Multi-model CMIP7 ensemble with AOGCM model runs

WhatIfMIP – CMIP7 Community MIP

- **Boreal Forest – Northern Expansion and Southern Dieback**
- **Sahel Greening**
- **Amazon Rainforest Browning**
- **Greenland Ice Sheet Collapse**
- **West Antarctic Ice Sheet Collapse**

- ***Boreal Permafrost Collapse***
- ***AMOC Collapse***



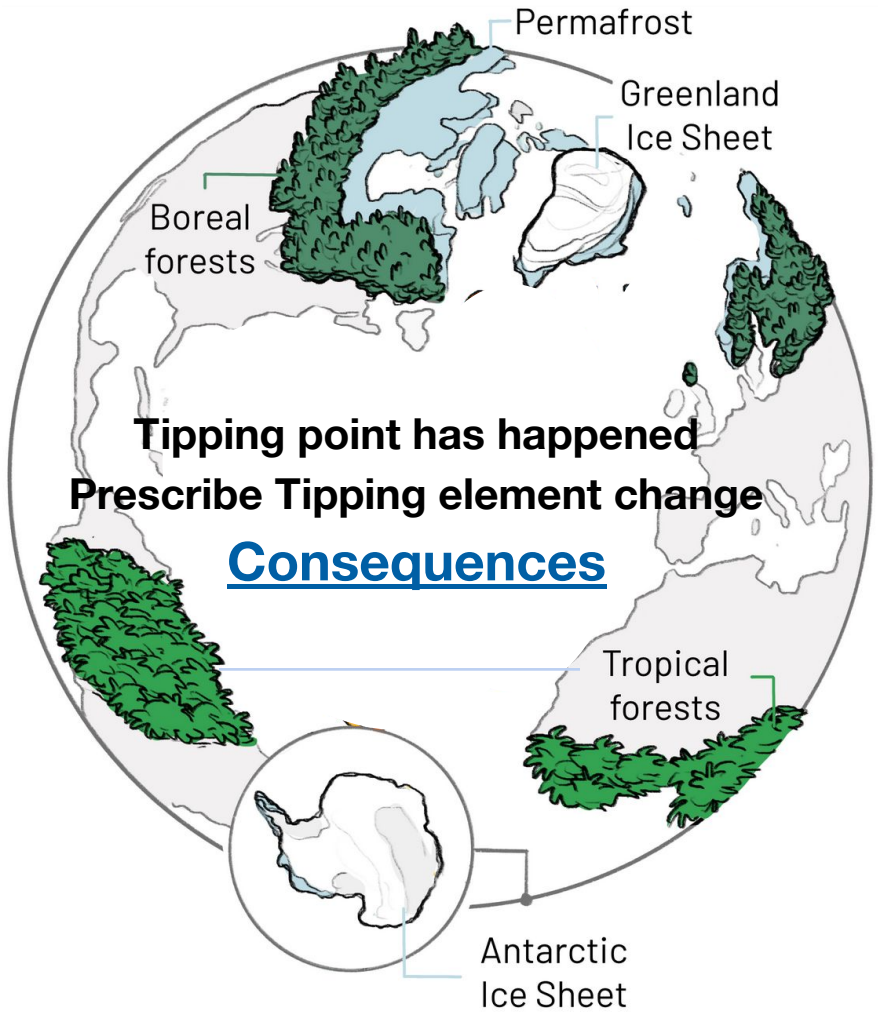
WhatIfMIP – CMIP7 Community MIP

Benefits:

- These components do not need to be interactive
- **Estimates of uncertainties in CONSEQUENCES**

Outcomes:

- Policy relevant for assessing **local, regional adaptation and vulnerability**
- Potential **far-field impacts** (e.g. ENSO) and **global risks** (e.g. carbon cycle, wildfire aerosols).
- Information for **Climate Services &** all 3 **IPCC WGs**

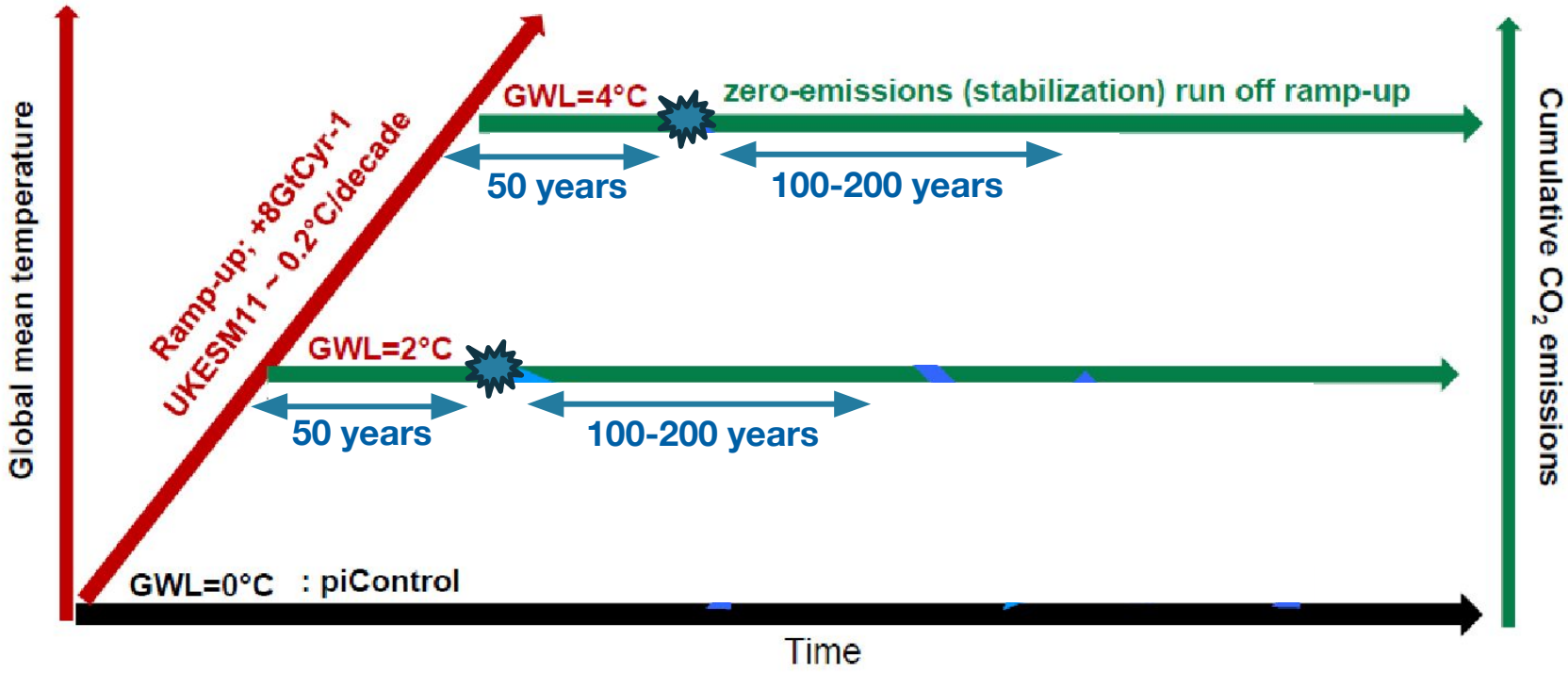


WhatIfMIP —Design proposal

CMIP7 emission-driven simulations

For each Tipping element

- **For GWLs of 2°C and 4°C**
- **Prescribe the tipping change after 50 years**
- **Run 100-200 year AOGCM simulation**



Consistent design as proposed Tier 1 ESM experiments for TIPMIP

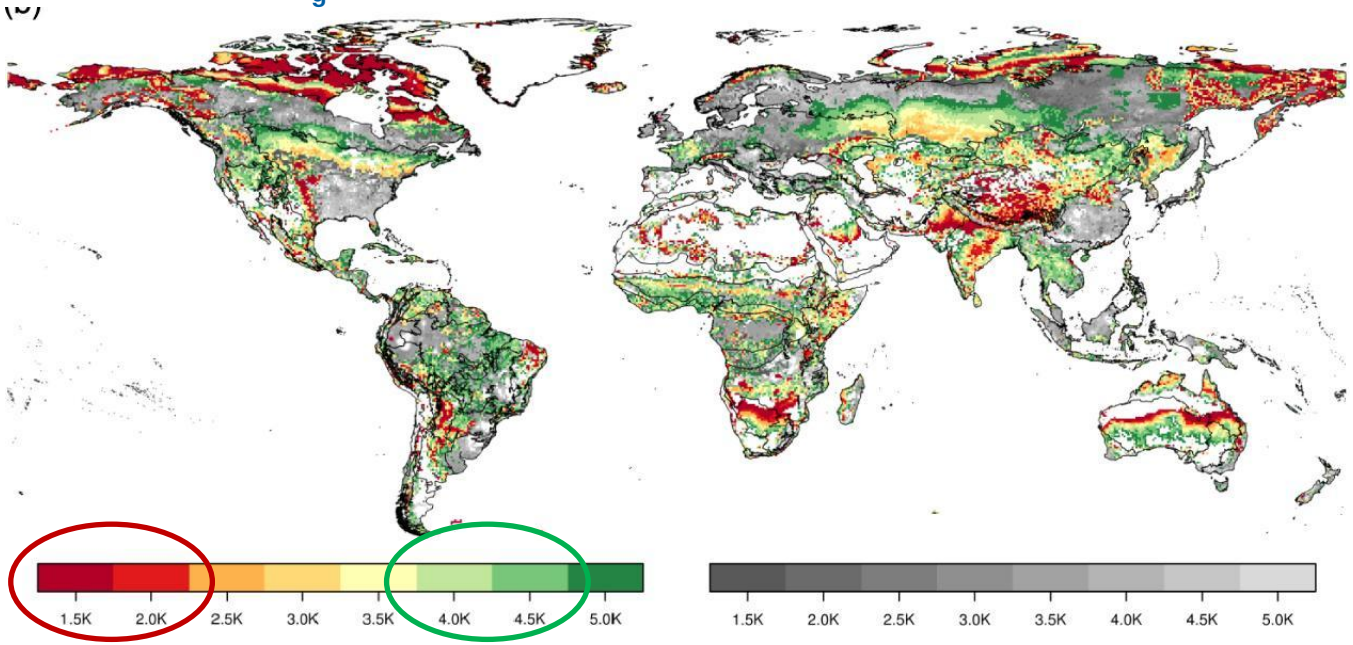
CMIP7 WhatIfMIP & Boreal Forest Experiment

Tipping element crossed
due to climate change and human-induced

Northern expansion at GWL 2°C
Additionally southern dieback at GWL 4°C

www.nathab.com/blog/welcoming-those-moving-north/

Threshold level of ΔT_g leading to significant local changes in terrestrial ecosystems



Regional adaptation and vulnerability
permafrost, temperature-related drought
biodiversity, people, fauna

Global influence
Arctic sea ice, Greenland ice sheet
carbon cycle, wildfire aerosols

Gerten et al., ERL, 2013

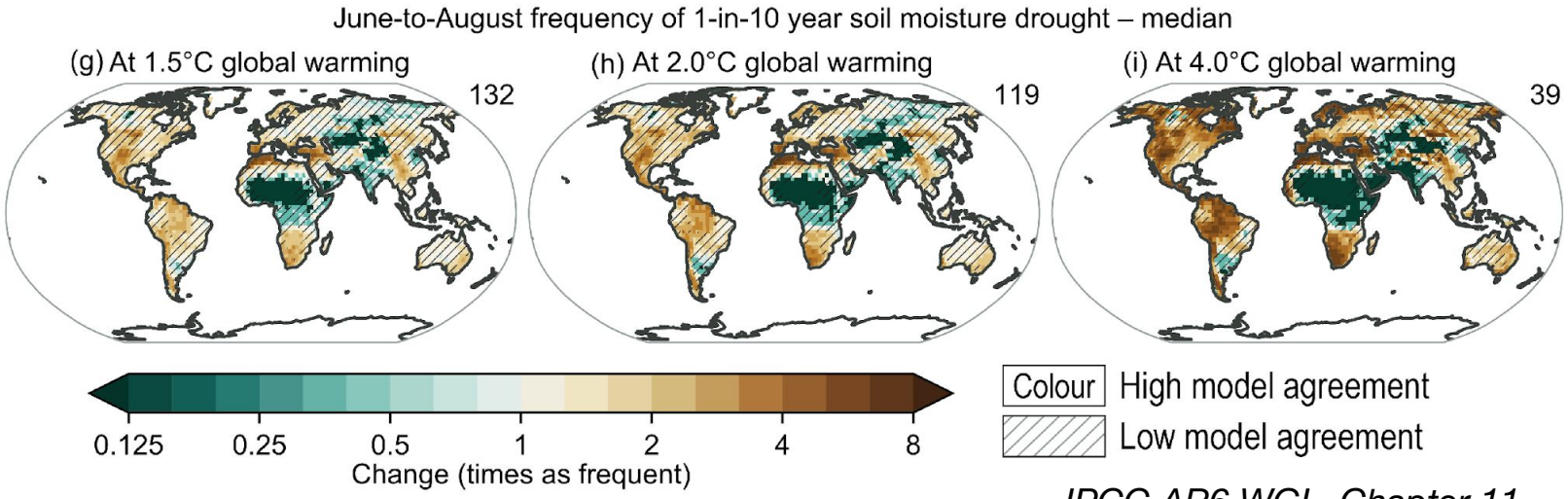
CMIP7 WhatIfMIP & Sahel Greening Experiment

Tipping element crossed
due to climate change and human-induced*

* **Africa's Great Green Wall Initiative (GGWSSI) of reforestation efforts to stop desertification**

Sahel greening* at GWL 2°C and at GWL 4°C
*** reduction in dust**

Villagers herd goats near windblown sand dunes in the Sahel region of Niger, North Africa. *Photograph by Pascal Maitre/NGS*



IPCC AR6 WGI. Chapter 11

Regional adaptation and vulnerability
monsoons, water recycling
wildfires

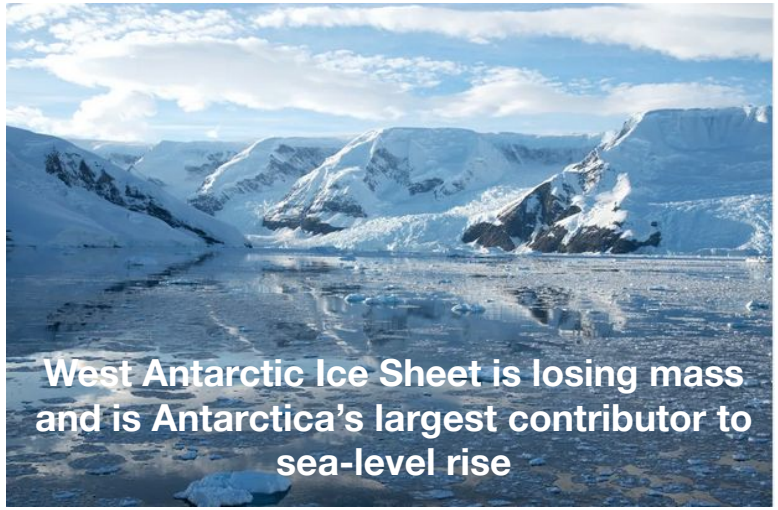
Global influence
ENSO variability, ocean productivity
N. Atlantic tropical cyclone activity

CMIP7 WhatIfMIP & West Antarctic Ice Sheet

Tipping element crossed due to climate change

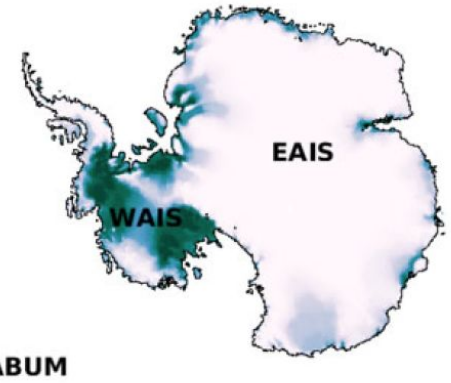
West Antarctic Ice Sheet Retreat at GWL 2° and 4°C
Moderate and extreme configurations of the AIS

Simulated meltwater associated with a negative SMB
Global coastal changes associated with fingerprints of sea level rise

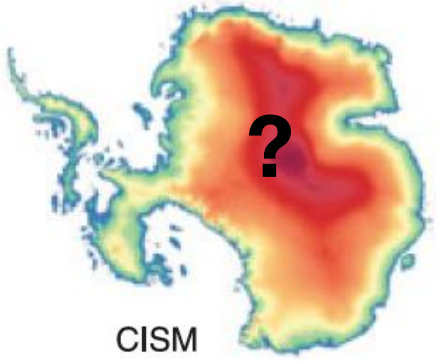


Getty Images

CONTROL

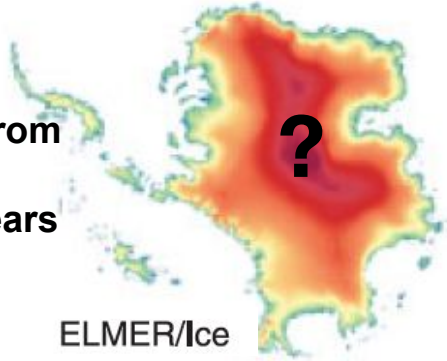


2°C stabilization



Examples from ABUM after 500 years

4°C stabilization



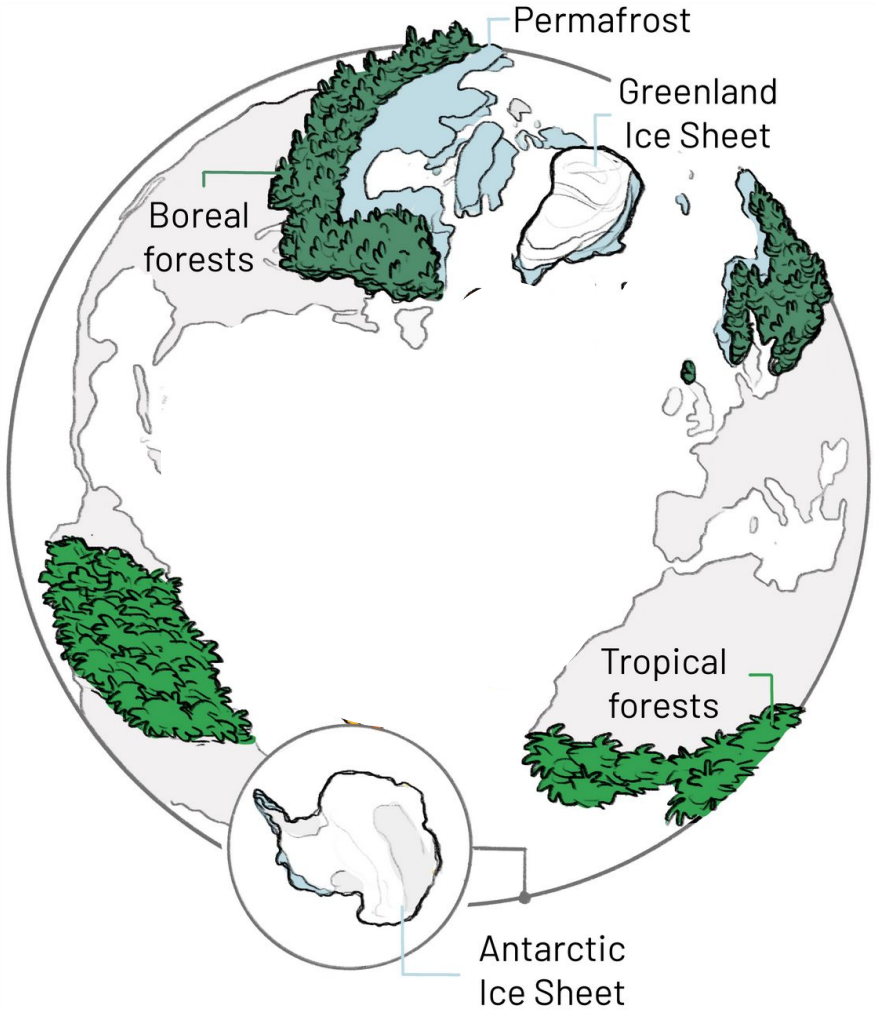
Sun et al. (J. Glaciology, 2020)

CMIP7 WhatIfMIP & Antarctic Ice Sheet

Tipping point has happened

- **Antarctic Ice Sheet Retreat**
  - **Team: Bill Lipscomb, Robin Smith**
  - **Tier 1 experiments**
    - **Control prescribed AIS at 0°C [DECK at PI]**
    - **Prescribed AIS at GWL 2°C**
    - **Prescribed AIS at GWL 4°C**
    - **Common design attributes: Meltwater from SMB calculations? Fingerprints of sea level change?**
  - **Tier 2 experiments**

Question: Do we need a design a protocol for models with an interactive Antarctic Ice Sheet?



For more information:

https://wcrp-cmip.org/mips/#registered-mips

Bette (ottobli@ucar.edu)
Gabi (gabi.hegerl@ed.ac.uk)

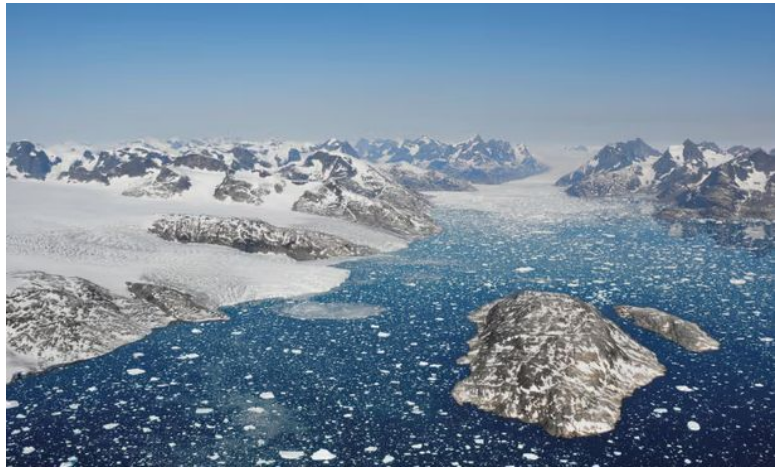
Paleo Perspectives for Future Tipping Points
CESM Paleoclimate WG – Poster

CMIP7 WhatIfMIP & Greenland Ice Sheet

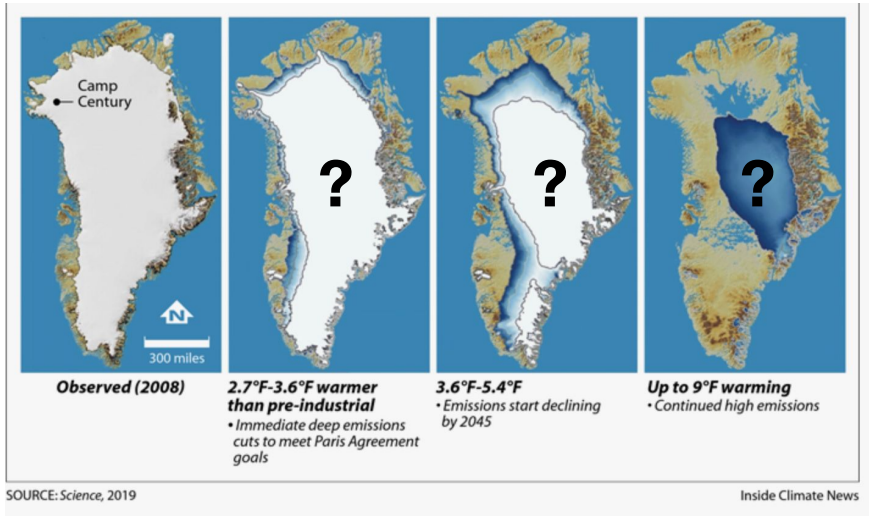
The mass of the Greenland ice sheet has rapidly declined in the last several years. Continued ice loss over the 21st century is virtually certain with total ice loss increasing with cumulative emissions.

Experiments could be designed for CMIP7 of the Greenland Ice Sheet Retreat at 2° and 4°C stabilization. Moderate and extreme configuration of the Greenland Ice Sheet.

Simulations could include simulated meltwater associated with a negative SMB. Vegetation for exposed bedrock. Coastal changes associated with fingerprints of sea level rise.



Photograph: Benoit Lecavalier/PA



This will impact coastal ecosystems and populations.

As well, contributing to weakening of the AMOC, and thus impacting precipitation patterns globally.

https://insideclimatenews.org/news/15032021/ice-core-greenland-ice-sheet-climate-change/

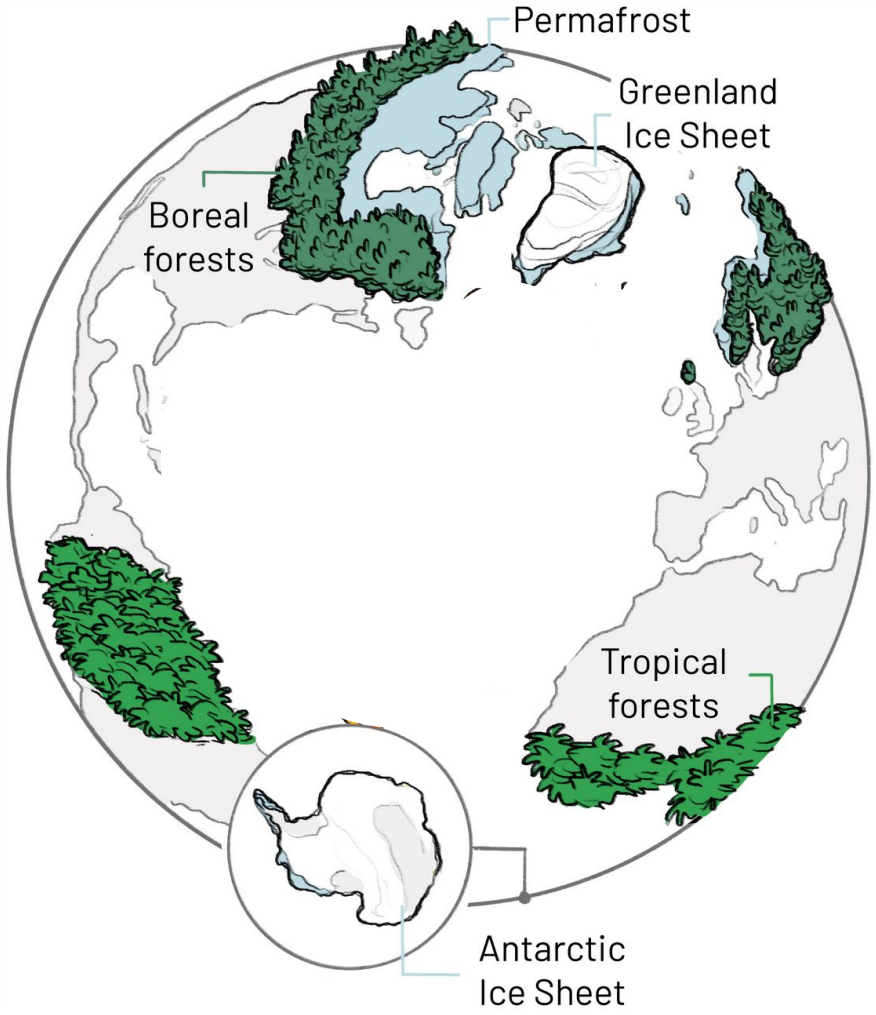
CMIP7 WhatIfMIP & Greenland Ice Sheet

Tipping point has happened

- **Greenland Ice Sheet Retreat**
  - **Team**
  - **Tier 1 experiments**
    - **Control prescribed GrIS at 0°C [DECK PI]**
    - **Prescribed GrIS at 2°C stabilization**
    - **Prescribed GrIS at 4°C stabilization**
    - **Common design attributes: Vegetation? Meltwater from SMB calculations? Fingerprints of sea level change?**
  - **Tier 2 experiments**

These experiments will branch off the 2°C and 4°C Global warming levels and be run for 100 or 200 years.

Question: Do we need a design a protocol for models with an interactive Greenland Ice Sheet?



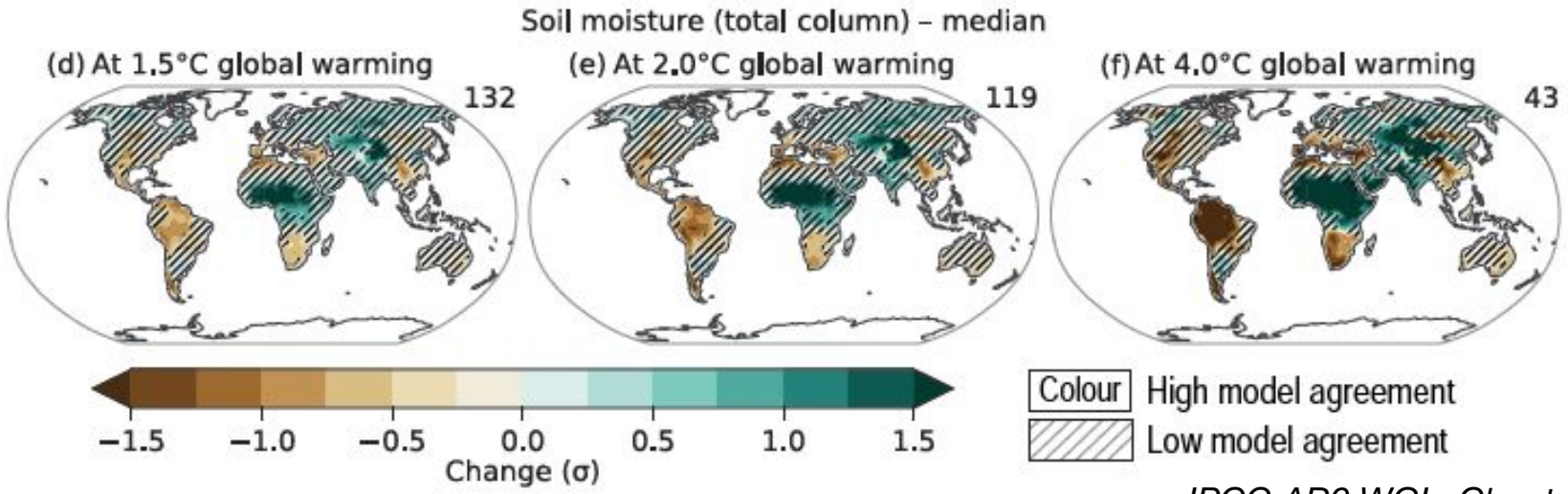
CMIP7 WhatIfMIP & Amazon Rainforest Experiment

The African Rainforest is estimated to store an estimate 150-200 billion tons of carbon. Approximately 17% of the Amazon rainforest has been lost due to deforestation.

CMIP7 simulations indicate high model agreement of significant decrease in soil moisture at 2° and 4°C global warming.

Experiments could be designed for CMIP7 of Amazon Rainforest Browning at 2° and 4°C stabilization (this tipping element crossed due to climate change and deforestation).

Mauro Pimentel/Getty Images



IPCC AR6 WGI. Chapter 11

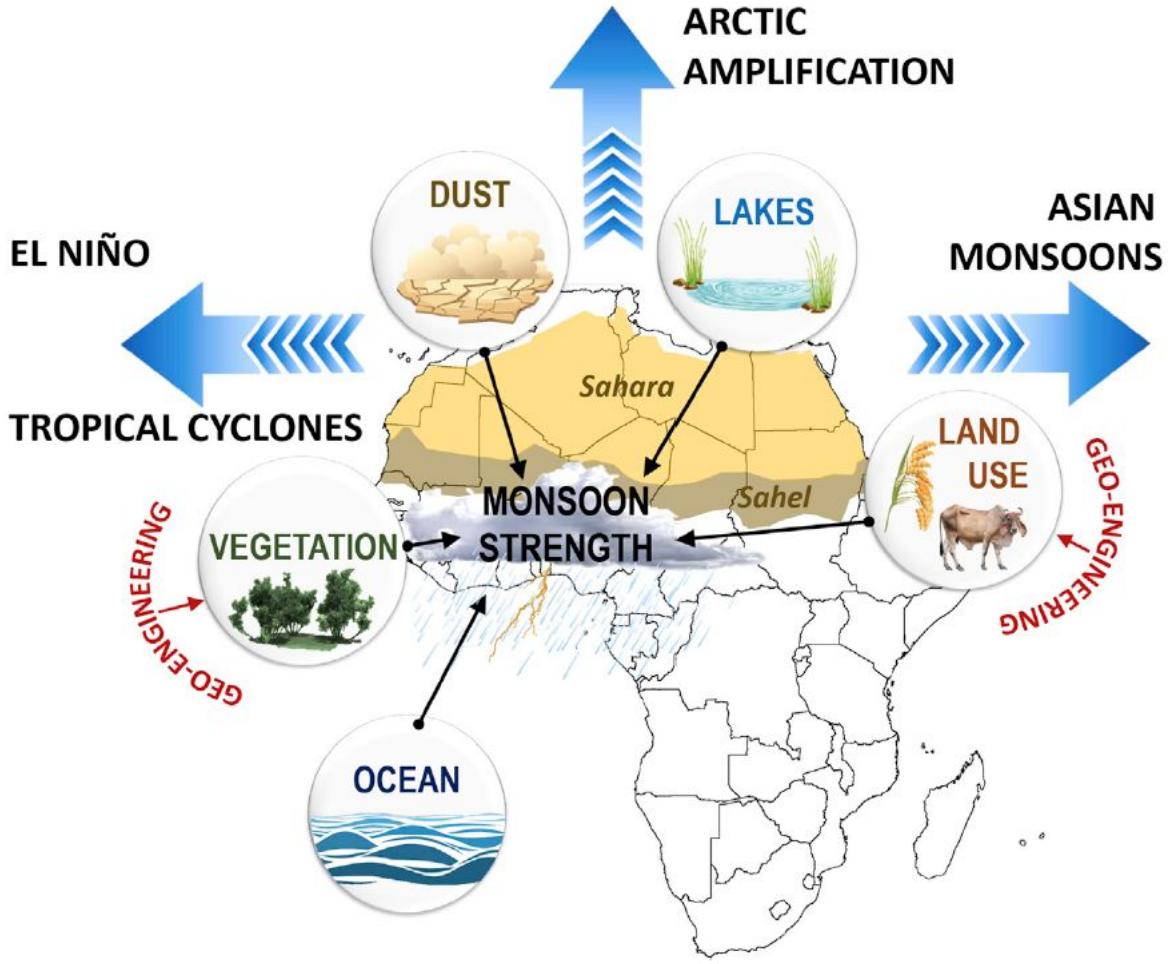
Policy relevant for assessing regional adaptation and vulnerability associated with its impacts on water availability as well biodiversity, people and fauna who live there.

Potential global risks with the influence on carbon budget and aerosols associated with wildfires.

CMIP7 WhatIfMIP & Sahel Greening Experiment

Policy relevant for assessing Sahelian-Saharan vulnerability and adaptation associated with the regional impacts on water recycling, monsoons, or wildfires.

Potential far-field impacts include ENSO variability, tropical cyclone activity, and ocean productivity.



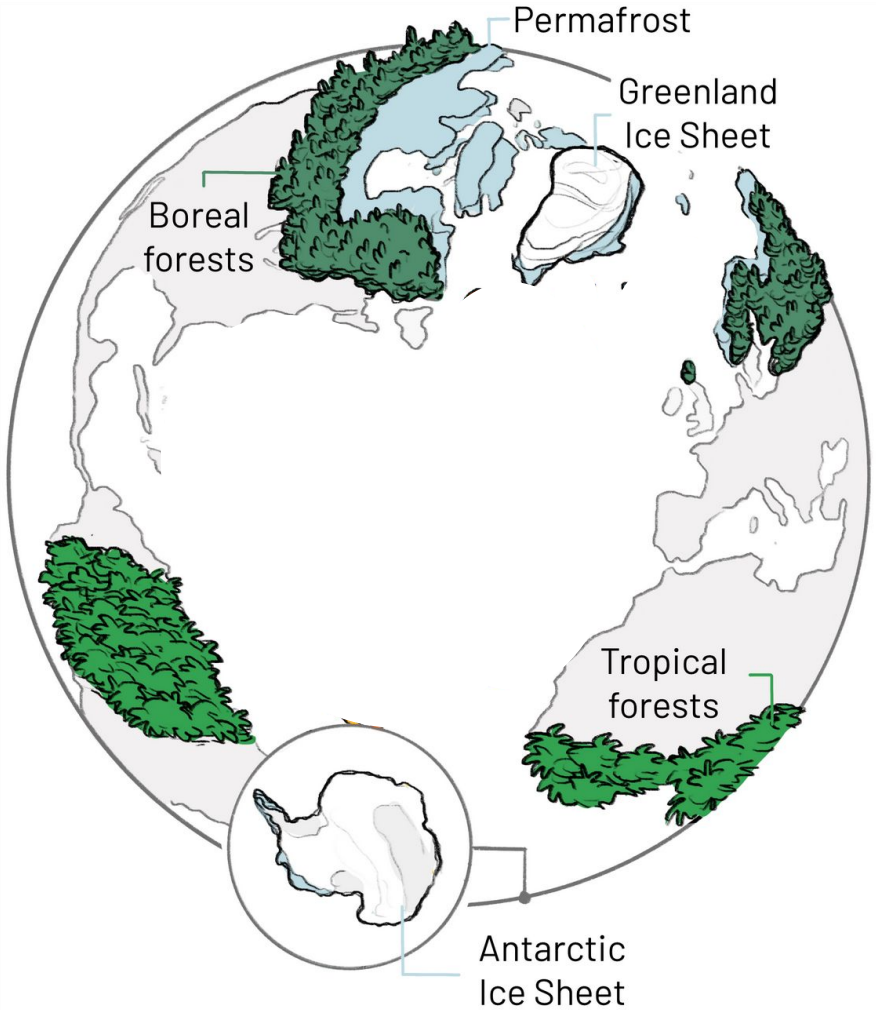
Pausata et al. (One Earth 2, 2020)

CMIP7 WhatIfMIP & Boreal/Tropical Vegetation

Tipping point has happened

- **Boreal Forest – Northern Expansion and Southern Dieback**
- **Sahel Greening**
- **Amazon Rainforest Browning**
  - **Team**
  - **Tier 1 experiments**
    - **Control Prescribed/Dynamic Vegetation for 0°C [DECK PI]**
    - **Prescribed/Dynamic Vegetation for 2°C stabilization**
    - **Prescribed/Dynamic Vegetation for 4°C stabilization**
    - **TBD design attributes: Carbon, Fire, Pests, Dust, Logging**
  - **Tier 2 experiments**
    - **Partner with HighResMIP for one?**

These experiments will branch off the 2°C and 4°C Global warming levels and be run for 100 or 200 years.



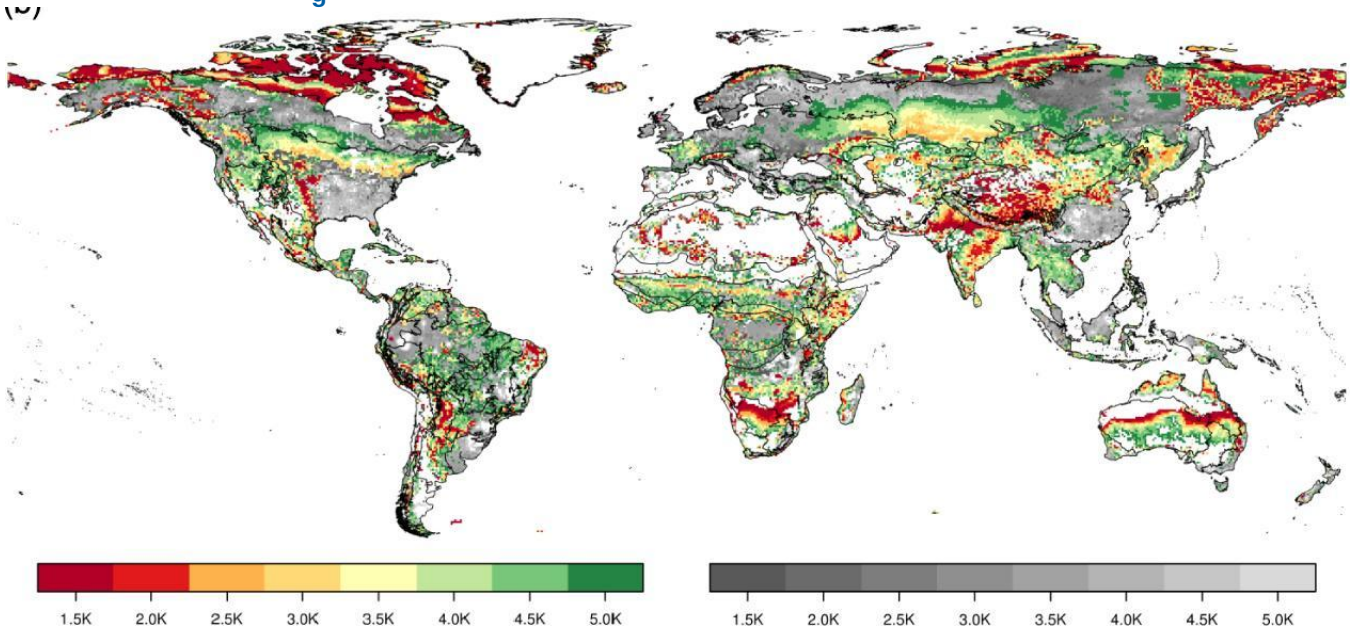
CMIP7 WhatIfMIP & Boreal Forest Experiment

Boreal shrubs and trees are expanding farther north into Arctic, while becoming stressed along their southern margins.

Experiments could be designed for CMIP7 of northern expansion at 2° C stabilization and additionally southern dieback at 4°C stabilization (this tipping element crossed due to climate change and possibly human-induced?).

www.nathab.com/blog/welcoming-those-moving-north/

Threshold level of ΔT_g leading to significant local changes in terrestrial ecosystems



Policy relevant for assessing regional adaptation and vulnerability associated with its impacts on permafrost and temperature-related drought as well biodiversity, people and fauna who live there.

Potential global risks with the influence on Arctic sea ice, the carbon cycle, and wildfire aerosols.

Gerten et al., ERL, 2013

CMIP7 WhatIfMIP & West Antarctic Ice Sheet

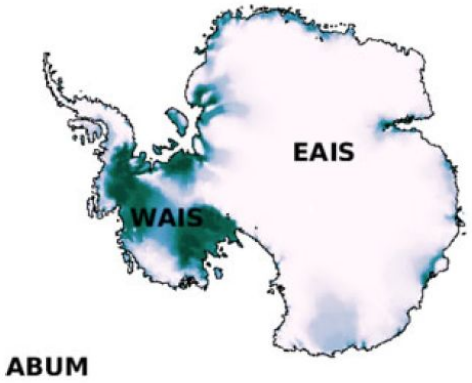
The West Antarctic Ice Sheet (WAIS) is losing mass and is Antarctica's largest contributor to sea-level rise.

An experiment could be designed for CMIP7 of the West Antarctic Ice Sheet Retreat at 2° and 4°C stabilization. Moderate and extreme configurations of the Antarctic Ice Sheet.

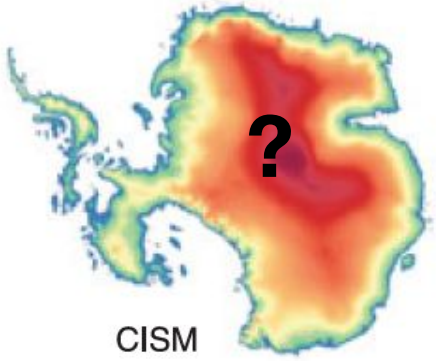
Simulations may include simulated meltwater associated with a negative SMB. Coastal changes associated with fingerprints of sea level rise.

Getty Images

CONTROL

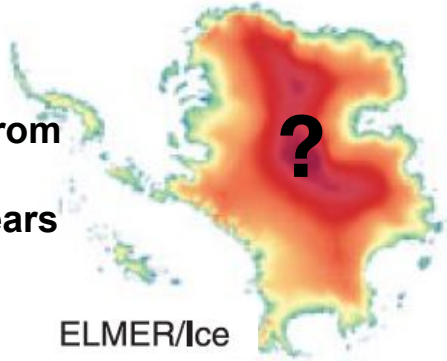


2°C stabilization



Examples from ABUM after 500 years

4°C stabilization



Sun et al. (J. Glaciology, 2020)

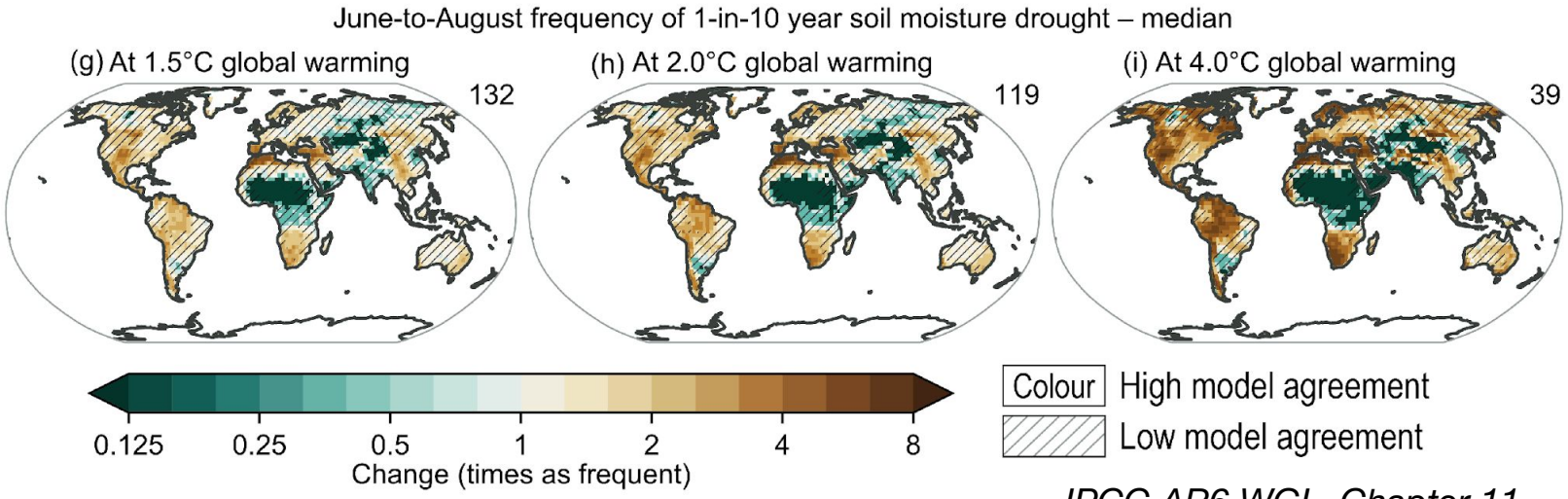
CMIP7 WhatIfMIP & Sahel Greening Experiment

The Sahel has experienced a significant wetting and re-greening in recent decades. Many models indicate this will continue in the future.

Additionally, there is Africa's Great Green Wall Initiative (GGWSSI) of reforestation efforts to stop desertification.

Experiments could be designed for CMIP7 of Sahel greening at 2° and 4°C stabilization (this tipping element crossed due to climate change and afforestation projects).

Sahel has experienced a significant wetting and re-greening in recent decades

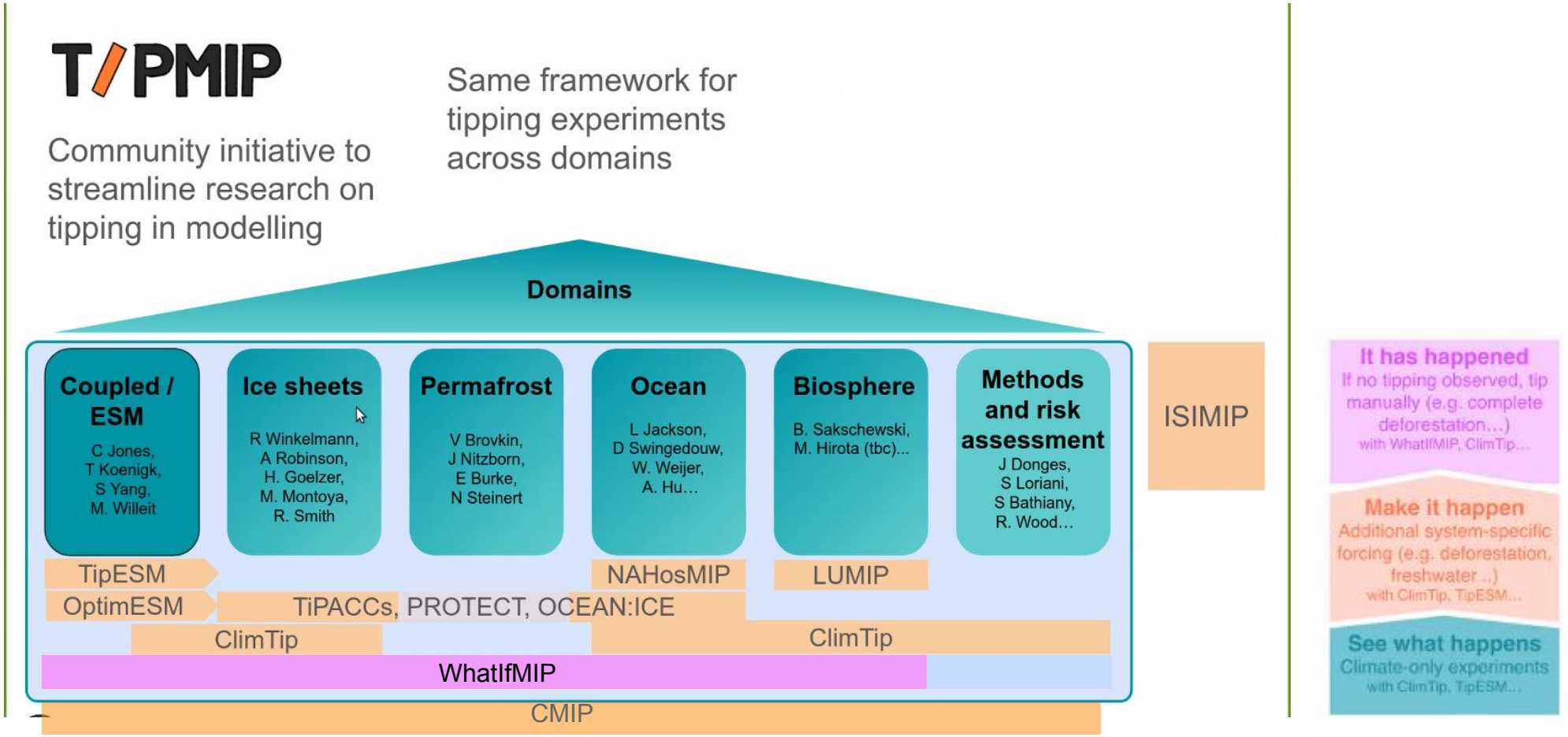


IPCC AR6 WGI. Chapter 11

Policy relevant for assessing Sahelian-Saharan vulnerability and adaptation associated with the regional impacts on water recycling, monsoons, and wildfires.

Potential far-field impacts include decreased ENSO variability, increased tropical cyclone activity, and ocean productivity.

Tipping in Modeling



CMIP7 and IPCC AR7