Tipping Elements in the Earth's climate system

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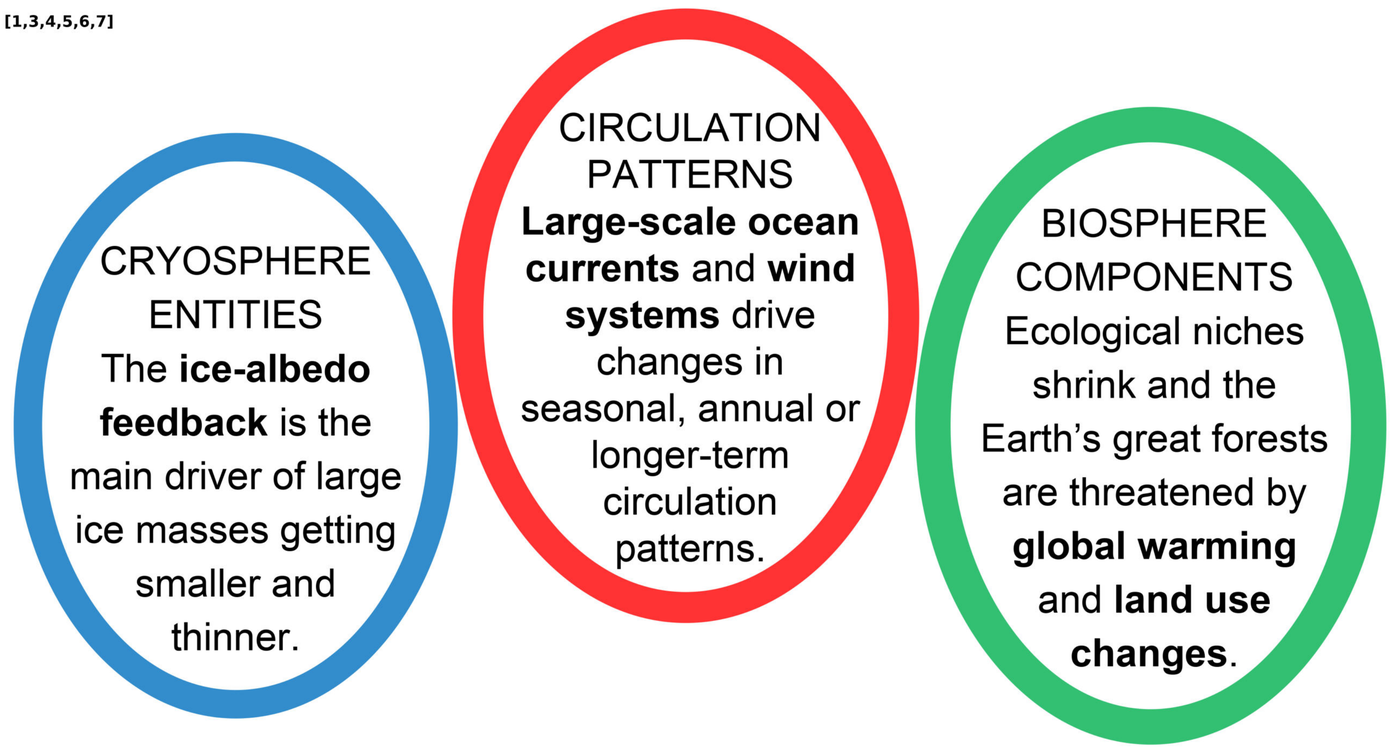
What are Tipping Elements? [1,3,4,5,6,7]

- **Tipping Points** are critical thresholds that determine a significant qualitative change in the state of a system.
- In the Earth's climate system, they occur within **Tipping Elements**: large scale components or subsystems that may pass tipping points driven by different forcings like anthropogenic climate change.
- Understanding them is essential for **policy and decision making** as a shift of those systems poses a significant risk for societies, ecosystems, and shorter-term natural hazards.



Which and where are they? [2,4,6,7]

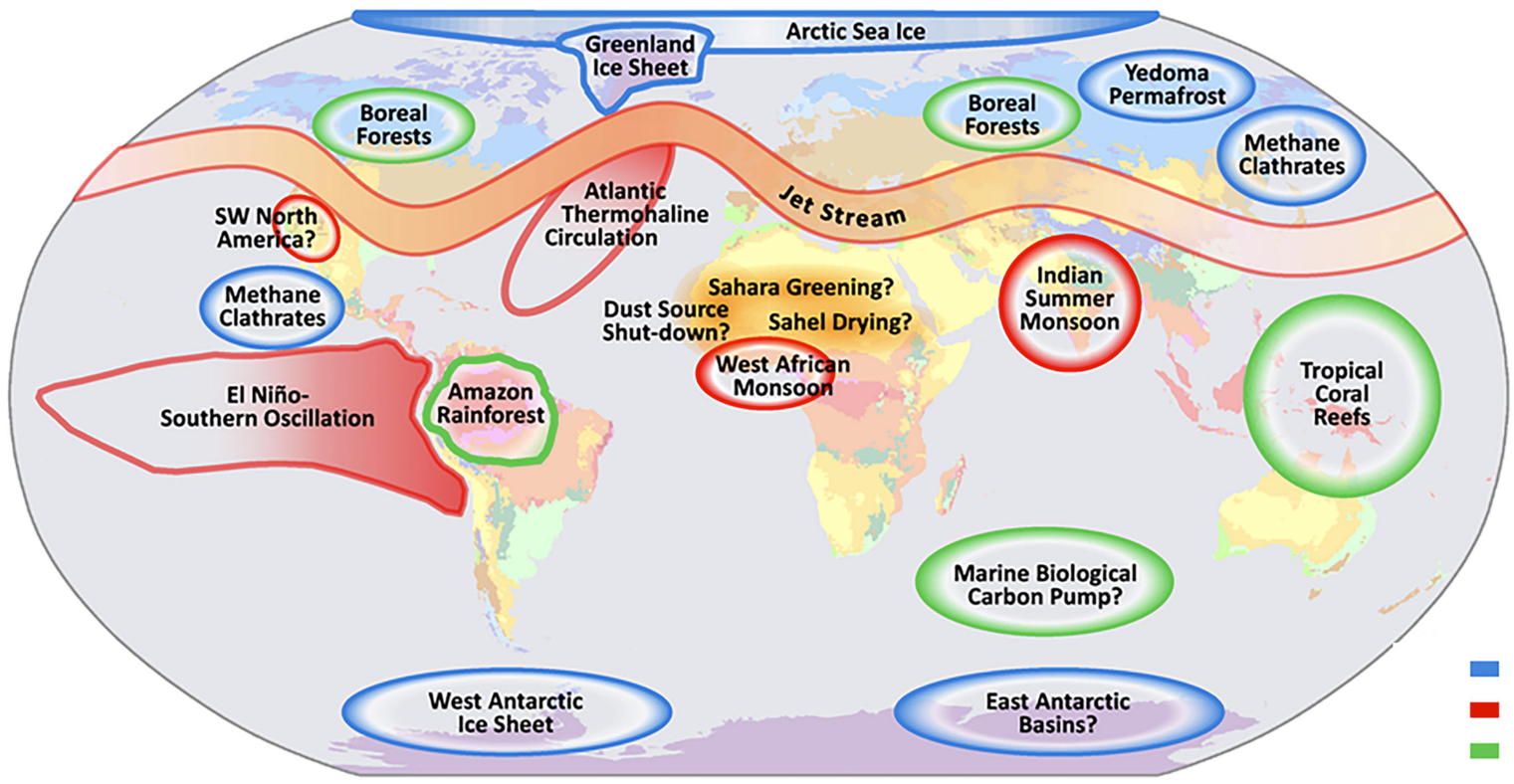


Figure 1. Important Tipping Elements in the Earth's climate system.
Source: Potsdam Institute for Climate Impact Research (PIK).

Tipping Elements are complex and interconnected [2,3,4,6,8]

Table 1. Examples of policy-relevant, potential future Tipping Elements of the Earth's climate system.
Adapted from Lenton et al. (2008).

Tipping Element	Global warming*	Transition time scale	Key impacts
Arctic summer sea-ice	+ 0.5 – 2°C	≈ 10yr (rapid)	Amplified warming, ecosystem change
Greenland ice sheet (GIS)	+ 1 – 2°C	> 300yr (slow)	Sea level + 2 – 7m
West Antarctic ice sheet (WAIS)	+ 3 – 5°C	> 300yr (slow)	Sea level + 5m
Atlantic thermohaline circulation (THC)	+ 3 – 5°C	≈ 100yr (gradual)	Regional cooling, sea level, ITCZ shift
El Niño–Southern Oscillation (ENSO)	+ 3 – 6°C	≈ 100yr (gradual)	Drought in SE Asia and elsewhere
Amazon rainforest (AMAZ)	+ 3 – 4°C	≈ 50yr (gradual)	Biodiversity loss, decreased rainfall

ITCZ: Inter-tropical Convergence Zone; SE Asia: South-East Asia
*** Global mean temperature change above present (1980-1999)**

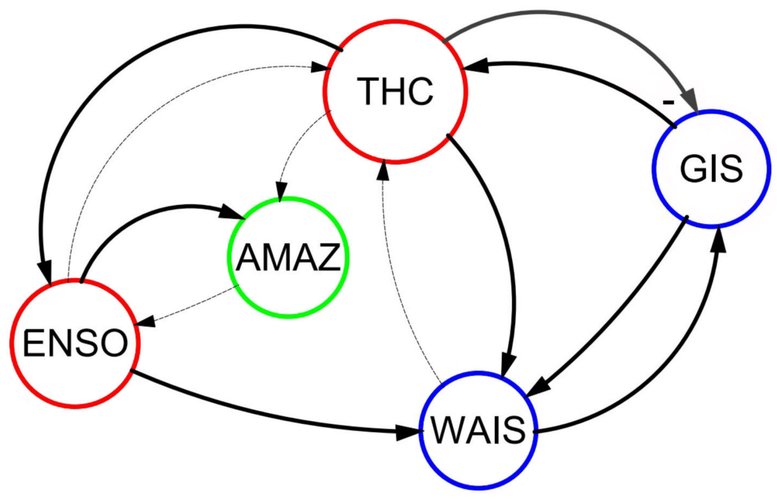


Figure 2. Interconnections between five Tipping Elements.
Lines represent positive influence, minus represent mitigating influence, and dotted lines uncertain influence. Acronyms' meanings in Table 1. Adapted from Kriegler et al. (2009); Cai et al. (2016).

To reflect: Tipping Elements should not be treated as independent systems; small changes may already trigger cascading effects. Even if the forcing conditions fall below their former threshold, the change may be irreversible.

References

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