Gaia, modelling concepts and global greening

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The Gaia hypothesis revisited: What does it state?

- Three (at least) propositions of the Gaia hypothesis(Kirchner 2002)
  1. **Biologically** mediated **feedbacks** contribute to environmental homeostasis
  2. These make the environment **more suitable** for life
  3. Feedbacks should arise by **Darwinian natural selection**

Which of these is most relevant?

- The most popular interpretations of Gaia use 1 and 2.
- The idea that life evolves to influence the feedbacks is more difficult
- The concept that life (the biota) mediates physical processes (e.g. climate) is uncontroversial.
- However: Do biotic mediated feedbacks lead to homeostatasis?

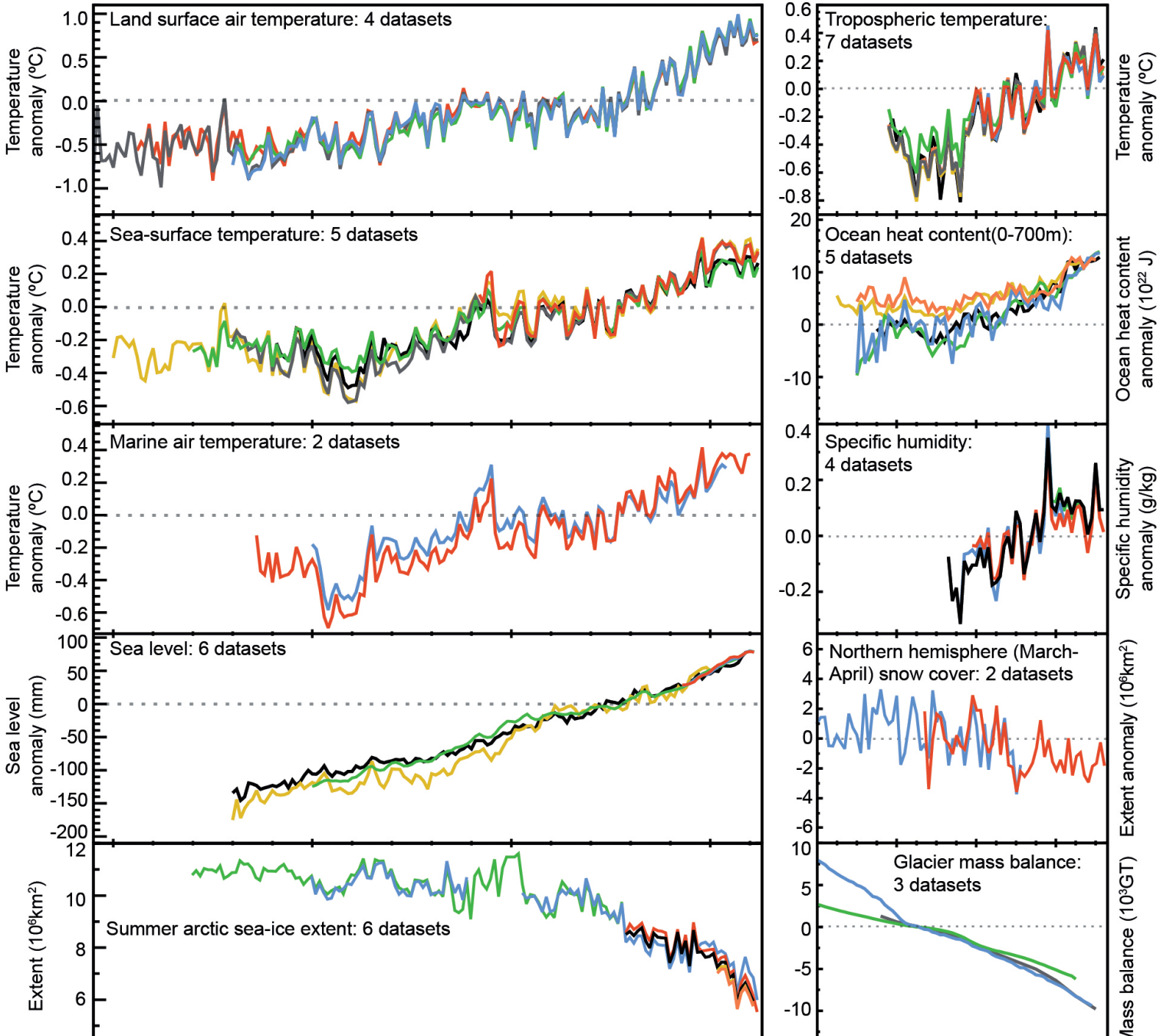
Can we ever understand Gaia through modelling?

- The Earth can be thought of as an ecosystem.
- Ecosystems and complexity.
- A **complicated** system can be described in full (e.g an internal combustion engine is a **complicated** system)
- A **complex** system can never be fully understood and predicted.
  - Complicated systems have a design. Each part has a function.
  - Complex system are not designed. Each part may have numerous roles and functions
  - Some interactions within a complex system can be understood. However the whole system is inherently unpredictable.
  - Complex systems show emergent properties that occur as the result of diverse interactions

Is the earth a homeostatic system?

- Homeostasis returns a systen to its initial state when perturbated.
- A simplistic interpretation implies one single negative feedback loop
- A more refined interpretation implies more negative feedbacks than positive feedbacks
- Attempts to predict measure the strength of each process that leads to feedbacks

Anthropogenic climate change



Positive feedbacks in terrestrial ecosystems

- Warmer temperatures increase soil respiration rates, releasing organic carbon stored in soils
- Warmer temperatures increase fire frequency, leading to net replacement of older, larger trees with younger, smaller ones, resulting in net release of carbon from forest biomass
- Higher atmospheric CO2 concentrations may increase drought tolerance in plants, potentially leading to expansion of shrublands into deserts,thus reducing planetary albedo and atmospheric dust concentrations
- Warming leads to replacement of tundra by boreal forest, decreasing planetary albedo
- Warming of soils accelerates methane production more than methane consumption
- Warming of soils accelerates N_20 production rates

-Increased atmospheric CO2concentrations stimulate increased photosynthe-sis, leading to carbon sequestration in biomass (negative feedback).

References

Kirchner, James W. 2002. "The Gaia hypothesis: Fact, theory, and wishful thinking." *Climatic Change* 52 (4): 391–408. https://doi.org/10.1023/A:1014237331082.