Global Warming Trends and the Role of Antarctic Sea Ice

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Over the last century the world has warmed and in recent years sea ice has declined at record pace. Despite this, between 1985 and 2014 Antarctic sea ice expanded. This behaviour poses interesting questions regarding our understanding of feedback processes that govern the evolution of the Earth's surface temperature. In contrast to observations, climate models indicate a decrease in Antarctic sea ice over this period. Understanding this difference is important for informing how we combine observations and climate models to improve our projections of climate change.

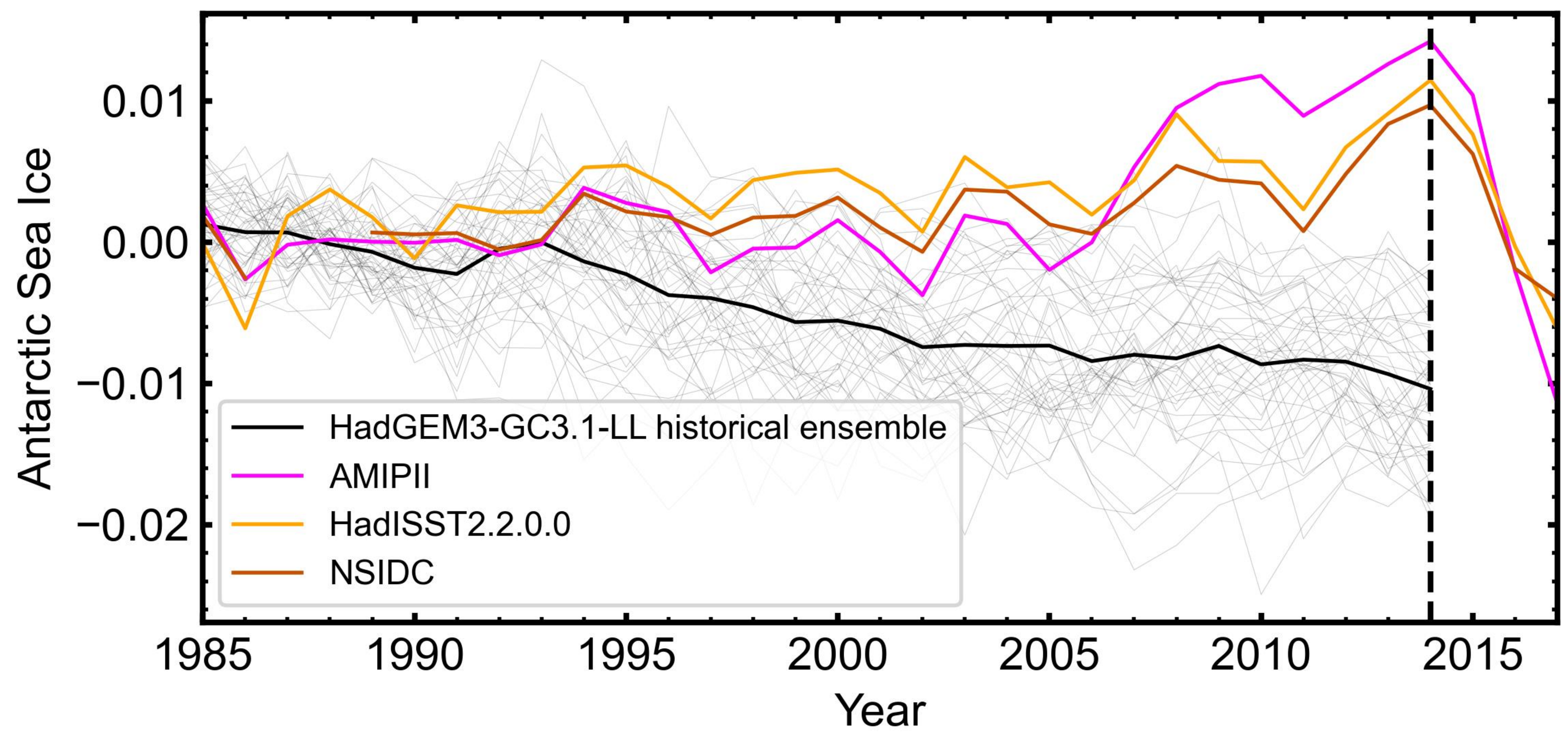

Fig 1. Timeseries of anomalous sea ice fraction between 90 - 30° S in the HadGEM3-GC3.1-LL historical ensemble and different observational datasets. Thin grey lines are individual HadGEM3-GC3.1-LL ensemble members, thick black the ensemble-mean.

Sea ice evolution over Antarctica.

- Between 1985-2014 observed Antarctic sea ice increased, despite the world warming by half a degree over this period.
- Over this same period, climate models simulate a decrease in Antarctic sea ice (Fig. 1).

Sea ice evolution effects feedback processes that act to amplify or dampen any global temperature changes.

- The sea ice surface albedo feedback is described in Fig. 2.
- Climate models typically simulate positive Southern Ocean feedbacks as well as a decrease in sea ice.
- When models are constrained to respond to observed sea surface temperatures and sea ice their Southern Ocean feedback is negative (Fig. 3).

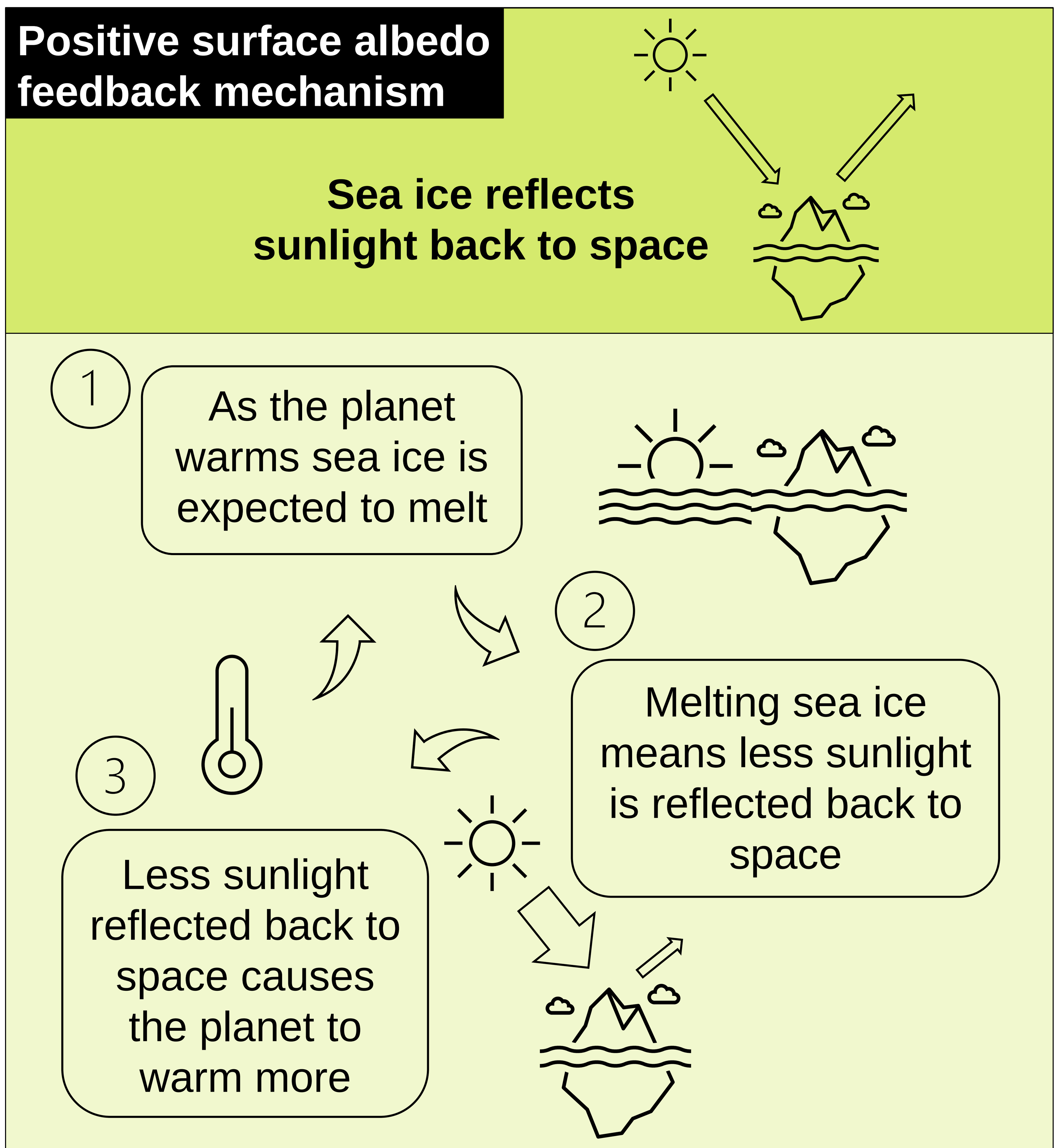

Fig 2. Description of the sea ice surface albedo feedback.

Different feedbacks lead to different global surface temperature trends.

- We use a simple equation that relates radiative forcing (e.g. from greenhouse gases) to global temperature changes. We can use this equation to understand how changes in feedbacks lead to different temperature trends.
- Had climate models been able to simulate Southern Ocean sea surface temperatures and sea ice – assuming feedbacks in all other regions remained unchanged – global temperature trends would have reduced by approximately 0.05 K decade^{-1}(Over a quarter of the observed trend in global temperatures).

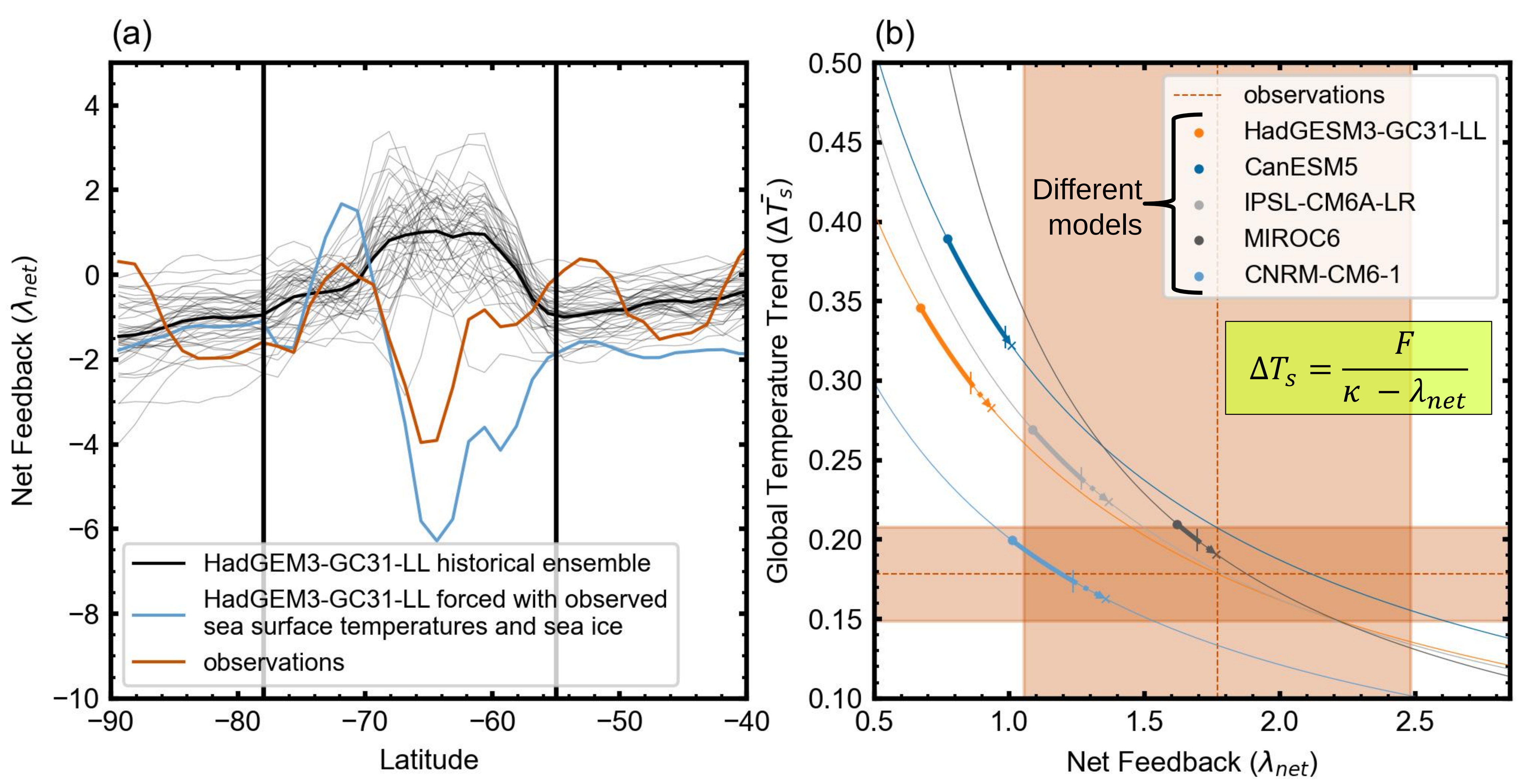

Fig 3. (a) Net feedback (λ_{net}) in HadGEM3-GC31-LL historical ensemble (black), HadGEM3-GC31-LL forced with observed sea surface temperatures and sea ice (blue), and observations (brown). (b) Net feedback against global surface temperature trends ($\Delta\bar{T}_s$) in the historical ensemble mean (dots), the historical ensemble mean with the Southern Ocean surface albedo feedback substituted from the observationally forced simulations (vertical lines) and Southern Ocean net feedback substituted in (crosses), and the relationship between net feedback against global surface temperature trends for each model (lines).

Discussion:

Since 2014 Antarctic sea ice has decreased substantially. Here we have demonstrated the impact of Southern Ocean sea ice on global temperature trends. Understanding the mechanisms behind changes in Southern Ocean sea ice and improving the representation of these processes in climate models is of high importance.

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