

Tipping Points for Climate Change

The following excerpts are from Target Atmospheric CO₂: Where Should Humanity Aim?, published in the Open Atmosphere Science Journal by James Hansen et al in 2008.

4.1. Tipping points

Realization that today's climate is far out of equilibrium with current climate forcings raises the specter of 'tipping points', the concept that climate can reach a point where, without additional forcing, rapid changes proceed practically out of our control. Arctic sea ice and the West Antarctic Ice Sheet are examples of potential tipping points. Arctic sea ice loss is magnified by the positive feedback of increased absorption of sunlight as global warming initiates sea ice retreat. West Antarctic ice loss can be accelerated by several feedbacks, once ice loss is substantial.

We define: (1) the tipping level, the global climate forcing that, if long maintained, gives rise to a specific consequence, and (2) the point of no return, a climate state beyond which the consequence is inevitable, even if climate forcings are reduced. A point of no return can be avoided, even if the tipping level is temporarily exceeded. Ocean and ice sheet inertia permit overshoot, provided the climate forcing is returned below the tipping level before initiating irreversible dynamic change.

Points of no return are inherently difficult to define, because the dynamical problems are nonlinear. Existing models are more lethargic than the real world for phenomena now unfolding, including changes of sea ice, ice streams, ice shelves, and expansion of the subtropics.

The tipping level is easier to assess, because the paleoclimate quasi-equilibrium response to known climate forcing is relevant. The tipping level is a measure of the long-term climate forcing that humanity must aim to stay beneath to avoid large climate impacts. The tipping level does not define the magnitude or period of tolerable overshoot. However, if overshoot is in place for centuries, the thermal perturbation will so penetrate the ocean that recovery without dramatic effects, such as ice sheet disintegration, becomes unlikely.