Transitioning Toward an Ice-Free Planet

Although Earth has been free of permanent ice for an estimated 85% of its history, humankind has not lived through a transition to a significantly different cryosphere state. This transition to a new state could take place over many thousands of years, or Earth could be free of summer sea ice within decades and free of marine-based ice sheets in centuries. As depicted in the figure, Earth has now reached the fork in the road in the stability landscape. The Earth system can take two possible paths in the future (dotted lines). Currently, Earth is on a "hothouse" path driven by human emissions of greenhouse gases. If Earth exceeds the planetary tipping point, it will follow an irreversible path to a hothouse state. The alternative path leads to a Stabilized Earth, where human stewardship of the environment will allow the Earth system to maintain a quasi-stable state. Scientific ocean drilling provides the globally distributed samples needed to determine changes in climate system parameters—such as atmospheric CO_2 levels and the amount of ice loss—that caused the cryosphere to tip to new states in the past. Records that accurately characterize Earth's past transitions to ice-free conditions provide the ground truth data needed for calibrating and testing climate models. Marine sedimentary records are essential for understanding where Earth is today on the stability path, whether we are closer to the planetary tipping point than the figure depicts, and how much time humankind still has to take steps to prevent Earth from hurtling toward a hothouse world. *Illustration by Rosalind Coggon and Geo Prose, inspired by Figure 2 in Steffen et al. (2018), https://doi.org/10.1073/pnas.1810141115*