Table 1.1. Important climate feedback mechanisms

Feedback	Mechanism (as climate warming takes place)	Pos/neg
Sea ice (or lake ice)	Sea ice melts to reveal open water. The albedo decreases, more solar energy is absorbed and so there is more melting.	Positive
Snow and glacial ice	Snow and ice melt to reveal bare ground or vegetation, the albedo decreases, more solar energy is absorbed, and so there is more melting.	Positive
Water vapor	Warm air can hold more water vapor, and that leads to more warming because water vapor is a GHG, although the effect is complicated by the cloudiness factor.	Positive
Carbon dioxide solubility	The capacity of the oceans to absorb CO_2 decreases with increasing temperature, and so, as ocean water warms, more of the huge ocean reservoir of CO_2 is released into the atmosphere, producing more warming.	Positive
Methane and CO_2 in permafrost	Warming leads to melting of permafrost, releasing stored methane and CO_2 into the atmosphere, and so more warming.	Positive
Vegetation growth (CO_2)	The higher CO_2 level that led to warming enhances plant growth, which consumes more CO_2, thus moderating the CO_2 increase.	Negative
Vegetation growth (albedo)	Enhanced vegetation growth makes a surface darker, so more solar energy is absorbed, leading to more warming.	Positive
Vegetation distress	Vegetation may become distressed by warming, so less CO_2 is consumed and there is more warming. (Where cooling causes vegetation distress, the feedback may be negative, as less CO_2 is consumed.)	Positive
Wildfire	Warming and regional drought increase the potential for wildfires, which result in CO_2 and particulate emissions and reduced CO_2 consumption until the forest starts to regrow.	Positive

(and perhaps glacial ice) will accumulate in some regions, increasing the albedo and leading to more cooling. Or, with cooling, more carbon dioxide gets dissolved in the oceans, and so the greenhouse effect is reduced, and cooling is enhanced.

The alarming thing about feedbacks is that almost all of them are positive, and so there is a strong tendency for a little bit of warming to be amplified into a lot of warming, and vice versa with cooling. In fact, if that wasn't the case, it's likely that many of the dramatic climate changes that have occurred would never have happened. For example, we might not have had multiple glaciations over the past million years, or we might have had nothing but glaciation for the past million years—and, therefore, might still be in the middle of a glacial period!

It is even more alarming that there is a potential for positive feedbacks to get out of control, and, as described in chapter 10, that can lead the climate over a tipping point and into a regime that is nothing like what we are used to, and from which there is no return on a human time scale. That is a place that we do not want to go!

Geological Time

There is no disputing that the Earth is old; the bigger problem is making sense of how old it is. Four thousand five hundred and seventy million years (or 4,570,000,000 years) is such a long time, and so much longer than a human's life—or even the span of all human lives—that none of us has a hope of really understanding what it means.

The geological time scale is a mechanism for visualizing Earth's history and for placing past events into a universal framework. The version shown on figure 1.7 provides some context for important events related to life on Earth, such as the first fish, the first land animals, the beginning and end of the dinosaurs, and the first members of the genus *Homo*.

One way to wrap your mind around geological time is to put it into the perspective of a single year, since we all know how long it is from one birthday to the next. If all of the Earth's 4,570,000,000 years were to be compressed into one year, each hour of that year would be