Over the past quarter of a century the Arctic has warmed more than any other region on Earth, causing a profound impact on the Greenland ice sheet (GrIS) and its contribution to the rise in global sea level. The loss of ice can be partitioned into processes related to surface mass balance and to ice discharge, which are forced by internal or external (atmospheric/oceanic/basal) fluctuations. Regardless of the measurement method, observations over the last two decades show an increase in ice loss rate, associated with speeding up of glaciers and enhanced melting. However, both ice discharge and melt-induced mass losses exhibit rapid short-term fluctuations that, when extrapolated into the future, could yield erroneous long-term trends. In this paper we review the GrIS mass loss over more than a century by combining satellite altimetry, airborne altimetry, interferometry, aerial photographs and gravimetry data sets together with modelling studies. We revisit the mass loss of different sectors and show that they manifest quite different sensitivities to atmospheric and oceanic forcing. In addition, we discuss recent progress in constructing coupled ice-ocean-atmosphere models required to project realistic future sea-level changes.