Geophysical Research Abstracts
Vol. 15, EGU2013-11464, 2013
EGU General Assembly 2013

Changing Climate Drives Lagging and Accelerating Glacier Responses and Accelerating Adjustments of the Hazard Regime

Jeffrey Kargel
Department of Hydrology & Water Resources, University of Arizona, Tucson, AZ, USA (jeffreyskargel@hotmail.com)

It is virtually universally recognized among climate and cryospheric scientists that climate and greenhouse gas abundances are closely correlated. Disagreements mainly pertain to the fundamental triggers for large fluctuations in climate and greenhouse gases during the pre-industrial era, and exactly how coupling is achieved amongst the dynamic solid Earth, the Sun, orbital and rotational dynamics, greenhouse gas abundances, and climate. Also unsettled is the climate sensitivity defined as the absolute linkage between the magnitude of climate warming/cooling and greenhouse gas increase/decrease. Important questions concern lagging responses (either greenhouse gases lagging climate fluctuations, or vice versa) and the causes of the lags. In terms of glacier and ice sheet responses to climate change, there also exist several processes causing lagging responses to climate change inputs. The simplest parameterization giving a glacier's lagging response time, τ, is that given by Jóhanneson et al. (1989), modified slightly here as τ = b/h, where b is a measure of ablation rate and h is a measure of glacier thickness. The exact definitions of τ, b, and h are subject to some interpretive license, but for a back-of-the-envelope approximation, we may take b as the magnitude of the mean ablation rate over the whole ablation area, and h as the mean glacier thickness in the glacier ablation zone. τ remains a bit ambiguous but may be considered as an exponential time scale for a decreasing response of b to a climatic step change. For some climate changes, b and h can be taken as the values prior to the climate change, but for large climatic shifts, this parameterization must be iterated. The actual response of a glacier at any time is the sum of exponentially decreasing responses from past changes. (Several aspects of glacier dynamics cause various glacier responses to differ from this idealized glacier-response theory.) Some important details relating to the retreat (or advances) of glaciers due to historic and future anthropogenic and longer term climate change relate to a changing glacier hazard regime. Climate change is connected to changes in the geographic distribution and magnitudes of potentially hazardous glacier lakes, large rock and ice avalanches, ice-dammed rivers, and surges. I shall consider these changes in hazard environment in relation to response-time theory and dynamical divergences from idealized response-time theory. Case histories of certain hazard-prone regions, including developments in fast-response-type glaciers and slow-response glaciers and ice sheets will also be discussed. In short, there will be a strong tendency of the hazard regimes of glacierized regions to shift far more rapidly in the 21st century than they did in the 20th century. The magnitude of the shifts will be more dramatic than any simple linear scaling to climate warming would suggest; this is largely because, due to lagging responses, glaciers are still trying to catch up to a new equilibrium for 20th century climate, while climate change remains a moving target that will drive accelerating glacier responses (including responses in hazard environments) in most glacierized regions.