Causes and Effects of the Advancing Date of Spring Snowmelt in the Alaskan Arctic

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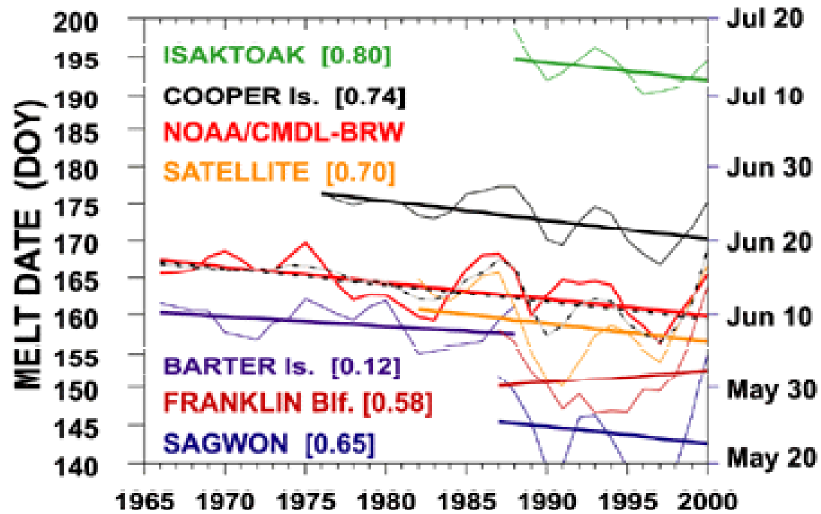
Independent records from several northern Alaskan sites indicate a regional trend towards an earlier spring snowmelt, most significant since the mid-1960s.

As shown in the figure, the time series are correlated despite showing considerable interannual variability; the numbers in brackets give the coefficient of correlation with the CMDL Barrow (BRW) record shown in red. The black, dashed line represents an ensemble analysis that indicates an advance of 8 days in 35 years.



It is important to understand the causes and effects of this phenomenon because climate models predict enhanced warming of the Arctic due to a "temperature-albedo feedback" if snow cover decreases. Key factors that control the annual snow cycle are identified and an estimate of the radiative impact of the observed trend is given. The date of snowmelt is shown to be an excellent indicator of climate change, and BRW is a representative site for assessing climate variability in this region.

The underlying *cause* of the earlier spring melt is related to shifts in the synoptic-scale circulation that have diminished winter snowfall and increased spring temperatures. Increased cloudiness has contributed because clouds enhance atmospheric thermal emissions that tend to accelerate the ablation of snow. Back-trajectory analyses are used to show how the regional circulation has changed.

The *effects* of an earlier snowmelt, include a deepening of the active layer of permafrost; perturbations of the sources and sinks of CO_2 and CH_4; and disruptions of plant, animal, and bird habitats that ultimately affect indigenous populations. Underlying all these responses is the increase in the seasonal net surface radiation budget (NSRB). Bare tundra absorbs significantly more solar energy than snow. As a result of an earlier spring melt, the *annual* NSRB of northern Alaska has increased ≈2Wm^{-2} since 1965. However, the effects are most pronounced during June, immediately following snowmelt, when the NSRB shows an increase of ≈20%. Associated with the increase in NSRB is a temperatures rise of ≈1°C, suggesting a positive radiative feedback attributable to a reduction in snow cover. While this result is predicted by theory, rarely has it been quantified using observational data.