CLIMATE CHANGE

# Climate Change in Nontraditional Data Sets

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Scientific examinations of nontraditional data sets collected by naturalists, hobbyists, or indigenous peoples have been instrumental in linking changes in biological communities to recent climatic changes. Many phenological records in particular show close correlations between timing of biological events and climatic conditions (*1*). The timing of these biological events is likely to be related to climate warming through intermediary processes that affect food and habitat availability, such as snowmelt or ice thaw. Here we report an unusual 84-year data set on timing of river ice breakup that shows temporal patterns consistent with previously reported trends toward earlier spring.

The Nenana Ice Classic is a betting contest held in Nenana, Alaska (64°34′N, 149°05′W), in which participants attempt to guess the exact minute in spring that a wooden tripod positioned on the frozen Tenana River will fall through the breaking ice (Fig. 1). Started as a diversion for railroad engineers in 1917 with a pot of $800, the contest has grown into a popular event in which hundreds of thousands of entrants compete for jackpots exceeding $300,000. Contest records of the exact minute of ice breakup date back to 1917 and can be considered quite accurate as the high stakes lead to constant vigilance at the time of breakup. The tripod location was moved away from a railroad bridge before the 1970s (when heavier and more frequent train traffic began) and is occasionally moved several meters away from gravel bars but remains in a straight section of the river that has not altered course substantially (*2*).

River ice breakup is known to be due to a combination of thermal effects (direct melting) and dynamic effects (mechanical forces from upstream drift ice) (*3*). Warmer climate would be expected to advance the time of breakup through both thermal effects and dynamic effects, due to thinning ice and increased snowmelt runoff into rivers (*3*). River ice breakup has direct economic consequences, as breakup marks the beginning of waterborne commerce and travel between high-latitude population centers. Ecologically, ice breakup is a time of rapid temperature increase and nutrient loading (*3*). Changes in the timing of ice breakup thus would be expected to have "bottom-up" ecosystem effects, although these have not been documented.

We examined the entire record of ice breakup (*4*) to look for long-term trends in breakup. We compared the ice breakup record from 1949–2000 with available climatic data for Nenana and Fairbanks, Alaska (90 km away). Climatic data for January to April (the months preceding ice breakup) of each year obtained from the Western Regional Climate Center (*5*) included daily precipitation (PCPN), snowfall (SNFL), and air temperature minima (TMIN) and maxima (TMAX). Years in which any month had fewer than 15 days of data were removed from analysis, leaving 32 to 35 years of data for the Nenana records and 47 to 51 years for the Fairbanks records. Heat-island effects due to urbanization and movement of the weather station may affect the Fairbanks record. By contrast, Nenana is a small town of fewer than 500 people, with a stationary weather station but with large gaps in the record.

**Fig. 1.** Townspeople of Nenana, Alaska, raise the tripod on the frozen Tenana River, 4 March 2001. [Photo by J. Coghill (9)]

We examined temporal trends in the monthly means of climatic data using regression models. Intraseries correlation was small for all variables and did not exceed the 95% confidence interval at all lags. We examined cross correlation between ice breakup and climate data using Pearson correlation.

The full record of ice breakup from Nenana shows a significant negative trend reflecting an advancement of breakup relative to the vernal equinox by 5.5 days (Fig. 2A). Within the record, periods of advancement and delay highlighted by polynomial regression (Fig. 2A) mirror long-term temperature records for northern high-latitude regions that show a warm period from 1920 to 1940, a cooling period until 1970, and resumed warming until the late 1990s (*6*). The magnitude of ice breakup advancement at Nenana is similar to what has been found in other phenological records (*7*).

Significant positive trends in maximum and minimum air temperatures were found in both Nenana (TMAX: $t = 2.28$, $P = 0.03$; TMIN: $t = 2.31$, $P = 0.03$) and Fairbanks (TMAX: $t = 3.17$, $P = 0.003$; TMIN: $t = 4.08$, $P = 0.0002$) (Fig. 2B). Trends for precipitation and snowfall were nonsignificant for both cities. Cross correlation between the ice breakup and the temperature series revealed significant negative correlations for Fairbanks only (TMAX: $R = -0.38$, $P = 0.01$; TMIN: $R = -0.28$, $P = 0.05$). Correlations between ice breakup and precipitation or snowfall were positive and statistically significant only for Fairbanks (PCPN: $R = 0.28$, $P = 0.05$; SNFL: $R = 0.31$, $P = 0.03$).

Records of ice melt have been called "more accurate long-term indices of air temperature than air-temperature records themselves" (*8*, p. 166). The Nenana contest may be especially valuable because it is based on a more consistent definition of ice breakup than many records (*7*). Although the record does not reveal the mechanisms of breakup, long-time Nenana residents observe that thermal breakups, where the ice under the tripod "rots" away, have been more common than dynamic breakups in recent years (*2*).

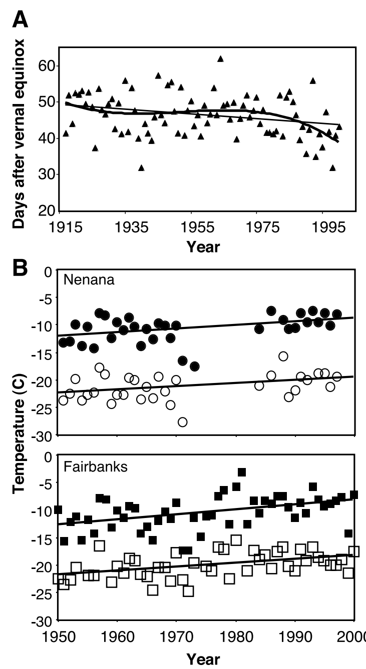


**Fig. 2.** (**A**) Ice breakup trends on the Tenana River. Breakup occurs between calendar dates 20 April and 20 May. Light line: linear regression (slope $= -0.07$, $t = -2.53$, $P = 0.01$, $R^2 = 0.07$). Heavy line: third-order polynomial regression (ice break $= -1E{-}04$ year$^3$ $+ 0.59$ year$^2$ $+ 1144$ year $+ 744660$, $F = 4.18$, $P = 0.008$, adjusted $R^2 = 0.10$). (**B**) Temperature data for Nenana and Fairbanks, Alaska. ● and ■, TMAX; ○ and □, TMIN.

**References**

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