



# The Laki Eruption and Observed Effects on North America and Europe



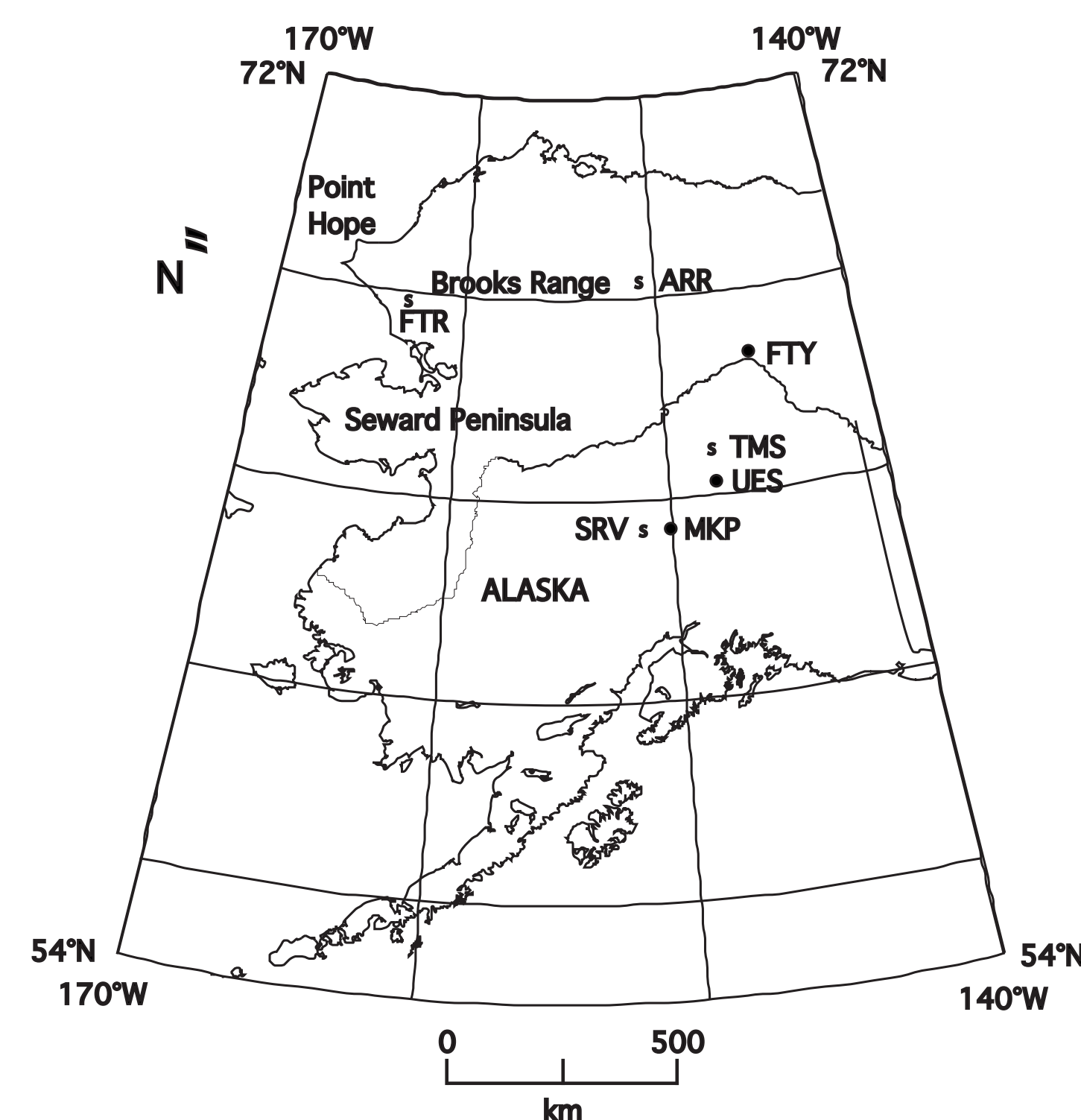
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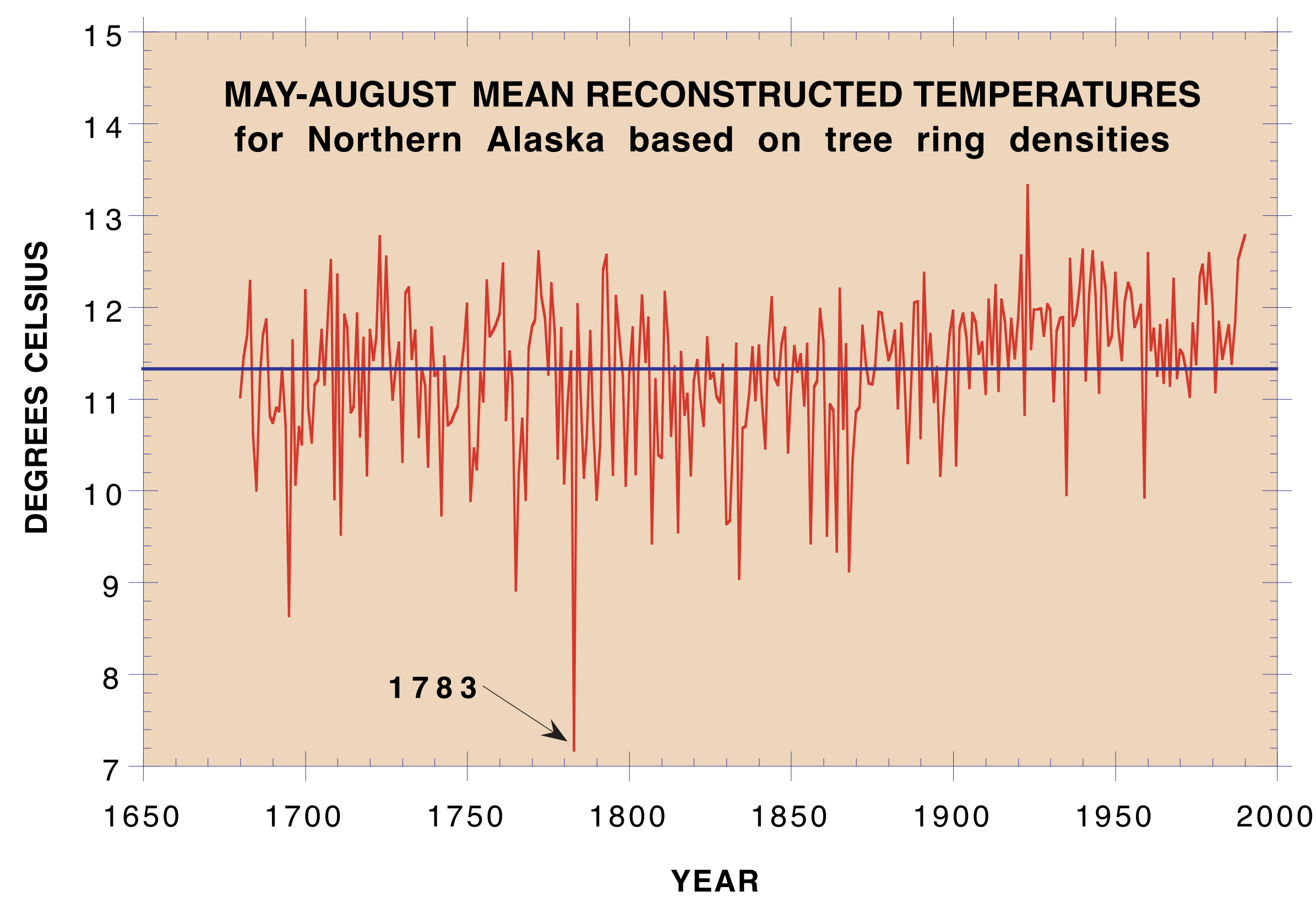
## ABSTRACT

The year of the Laki eruption, 1783, is the most visibly obvious anomaly in the northwestern Alaska tree-ring record for over 400 years. Thicker-walled, darker, latewood cells usually formed at the end of the growing season are virtually absent. Quantitatively the density is over 4 standard deviations below the mean latewood density of a sample set of trees from site 412 in northwest Alaska. This is indication of extreme cold during the summer season in this region. The tree-ring response to the event weakens toward the east, indicating that extreme cold did not extend much beyond the Mackenzie River in western Canada or south of the Alaska Range in central Alaska.

In order to understand the tree-ring effects due to the Laki eruption, it is helpful to also consider other similar events in 1641, 1816-17 and 1836. In each case there is evidence of extreme cold that caused very low density latewood in the rings of white spruce (*Picea glauca*) near the latitudinal treeline and associated volcanic events. The effects in the tree-ring record are spatially variable. Evidence of extreme cold extends for about 60-70 of longitude; 1641 in central Canada, 1783 in Alaska, 1816-17 in eastern Canada and 1836 in central Canada. One interpretation of this spatial and timing pattern is that in addition to general cooling, the thermal effects of volcanic events can lead to regional outbreaks of extremely cold polar air on a regional basis. This interpretation is compatible with indications of increased thermal gradient from tropical regions to polar regions and increased meridional flow. Such extreme regional cooling can result in great impact on human conditions.

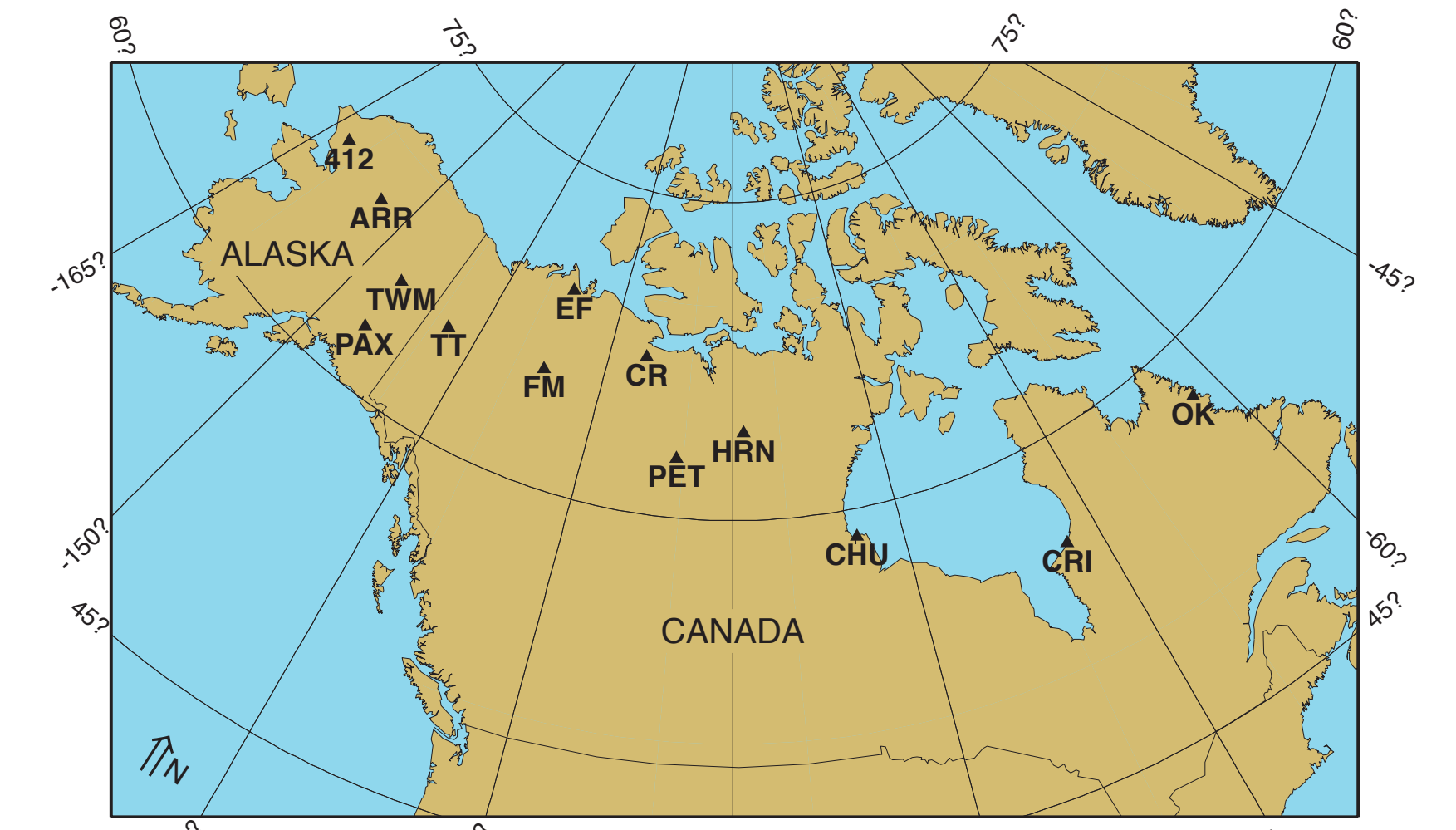


Map of Alaska showing the tree-ring sampling sites and meteorological stations used for estimating summer temperatures. The solid circles are meteorological stations: UES = University Experiment Station, MKP = McKinley Park, FTY = Fort Yukon. The solid triangles are tree-ring sampling sites: FTR = 412, ARR = Arrigetch, SRV = Savage River, TMS = Twelve Mile Summit. The western and southern coast of the Seward Peninsula are where the explorer reports came from and the events in the oral history took place.



Reconstruction of mean summer (May-August) temperatures for northern Alaska. The temperature data are the average of University Experiment Station in Fairbanks, Fort Yukon and McKinley Park stations extending from 1906 to 1990. Four density series were used based on tree sampling sites at 412, Arrigetch, Savage River and Twelve Mile Summit. A principal component regression was performed using all four tree-ring density series. The regression explains 41% of the variance in the summer temperatures after adjusting for loss of degrees of freedom due to the regression. The 7.2°C estimated summer temperature for 1783 is over five standard deviations below the mean of 11.3°C. Given that May and June are not described as being unusual in the oral history; July and August could have been mostly below freezing as described by the history. Although the reconstruction extends only to 1680, some tree-ring samples are older. The density series from site 412 extends to 1580 and no earlier values are as low as 1783.

To address the spatial signature of conditions following volcanic eruptions a network of 13 maximum density chronologies from the northern treeline of North America was used. Maps showing the z-scores in the years 1641, 1783, 1816 and 1836, indicate the spatial signature of the unusually cold conditions following significant eruptions at these times. The regional nature of these cold episodes suggests volcanically induced disturbances to the polar front which resulted in unusual outbreaks of cold polar air.



Sites used in this study are: 412 = Four-Twelve, ARR = Arrigetch, TWM= Twelve-Mile Summit, PAX = Paxson Lake, TT = TTHH, EF = Eagle, FM = Franklin Mountains, CR = Coppermine River, PET = PET, HRN = Hornby Cabin, CHU = Churchill, CRI = Cri Lake, OK = Okak.

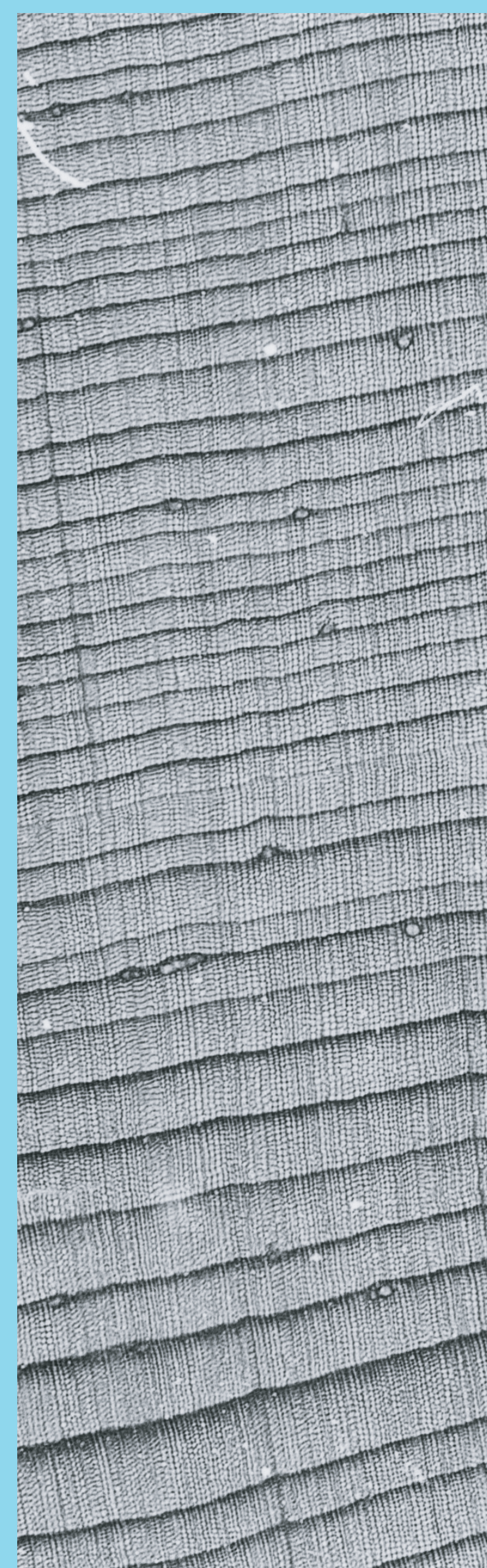
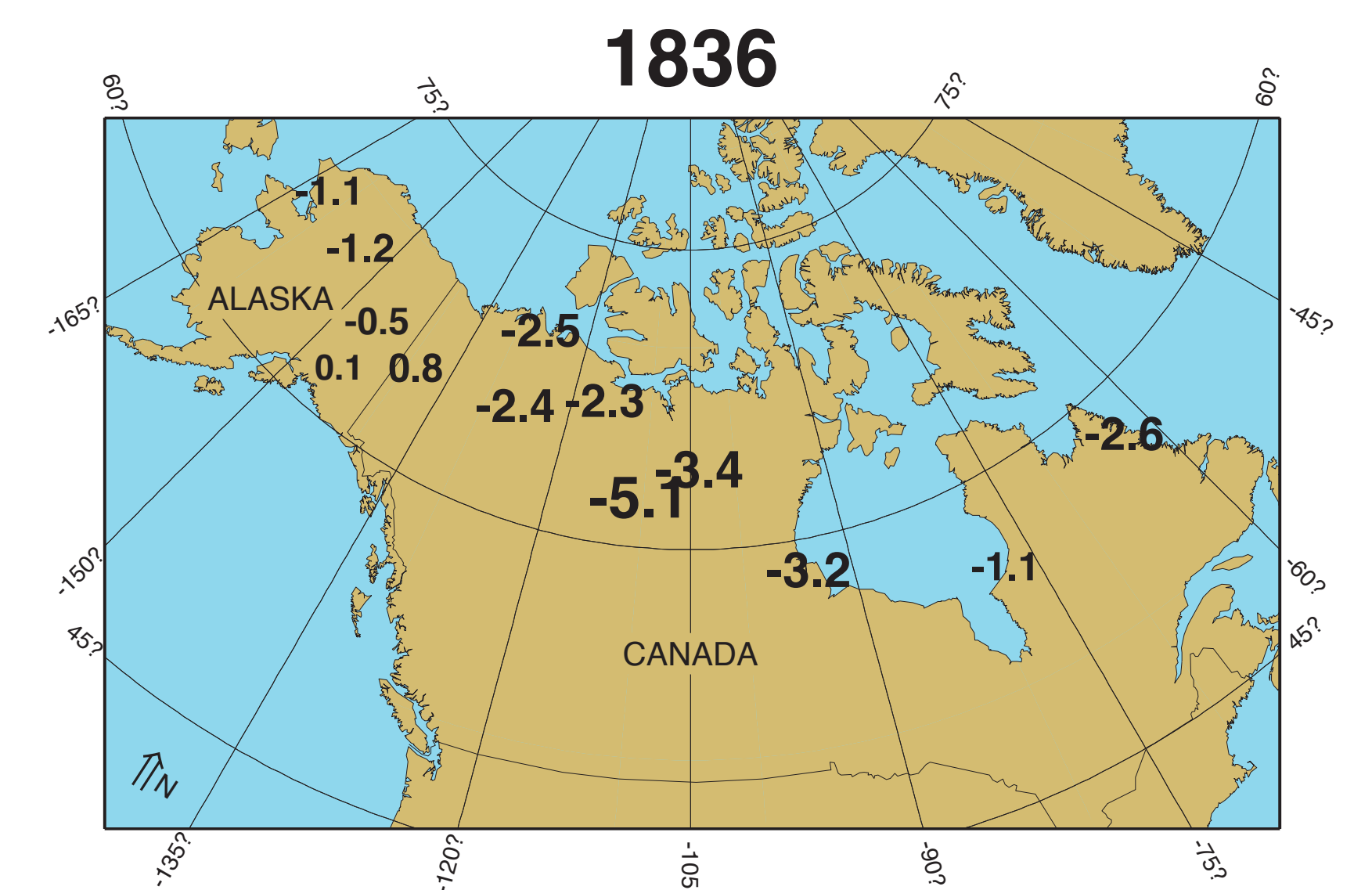
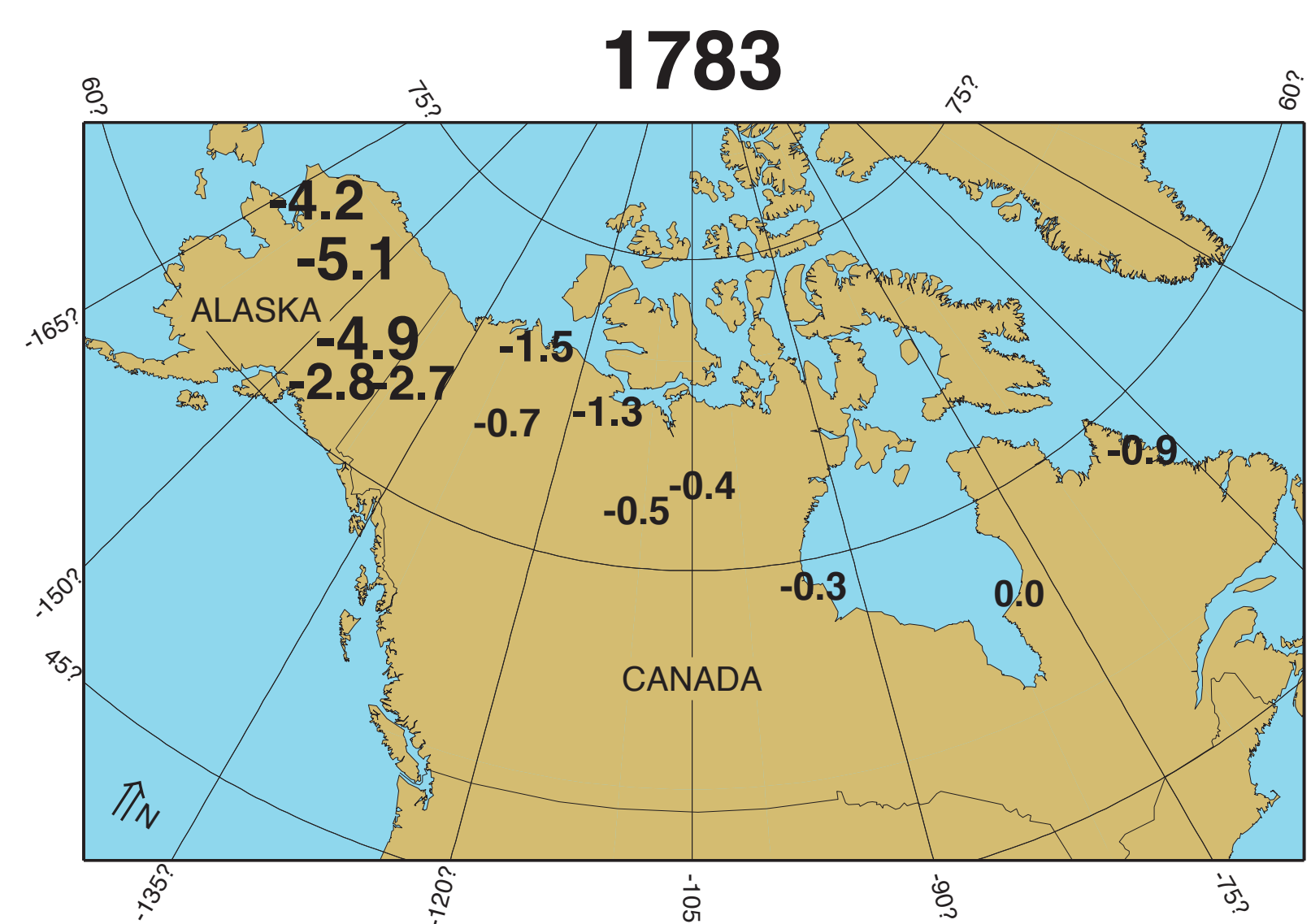
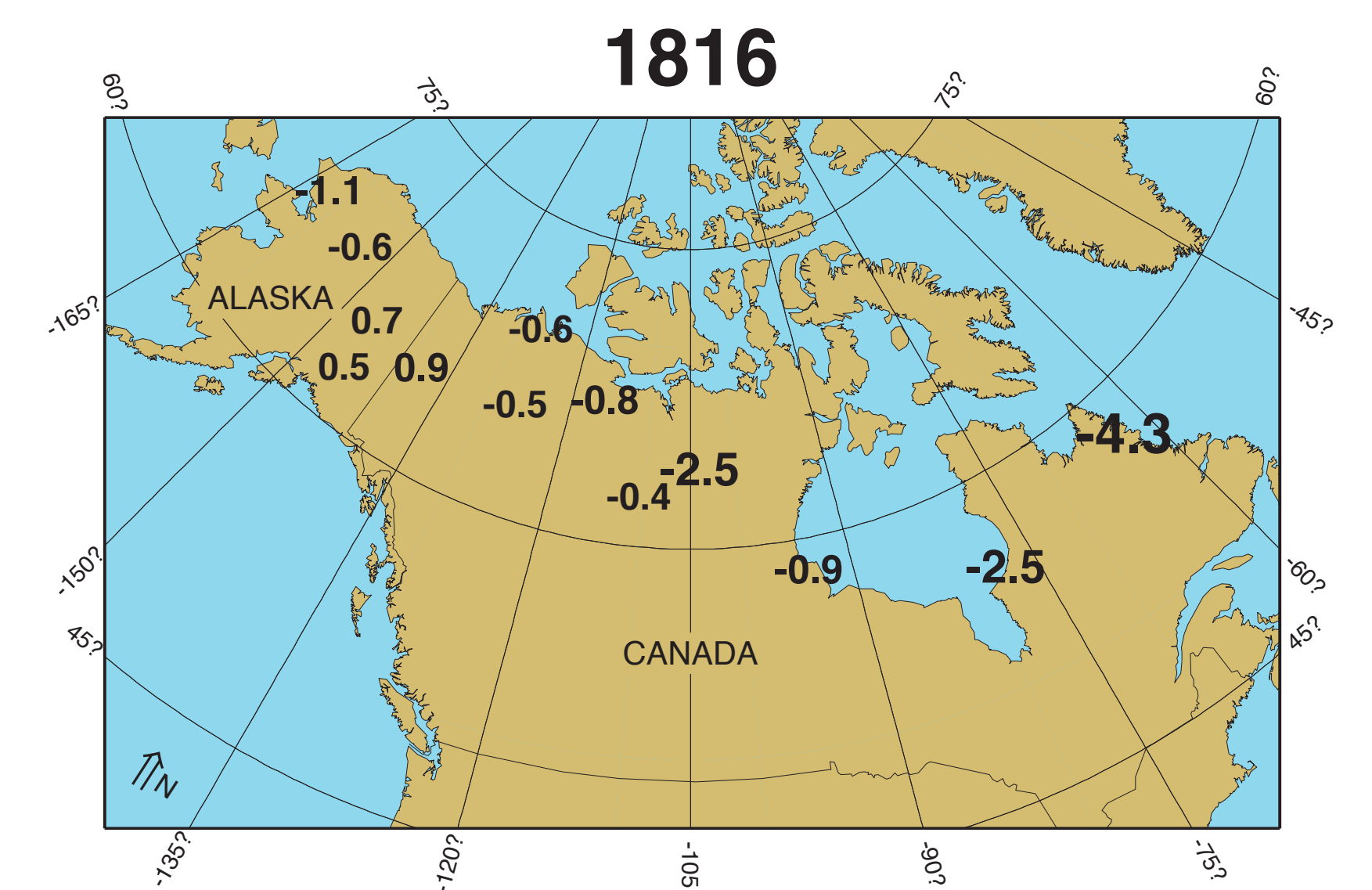
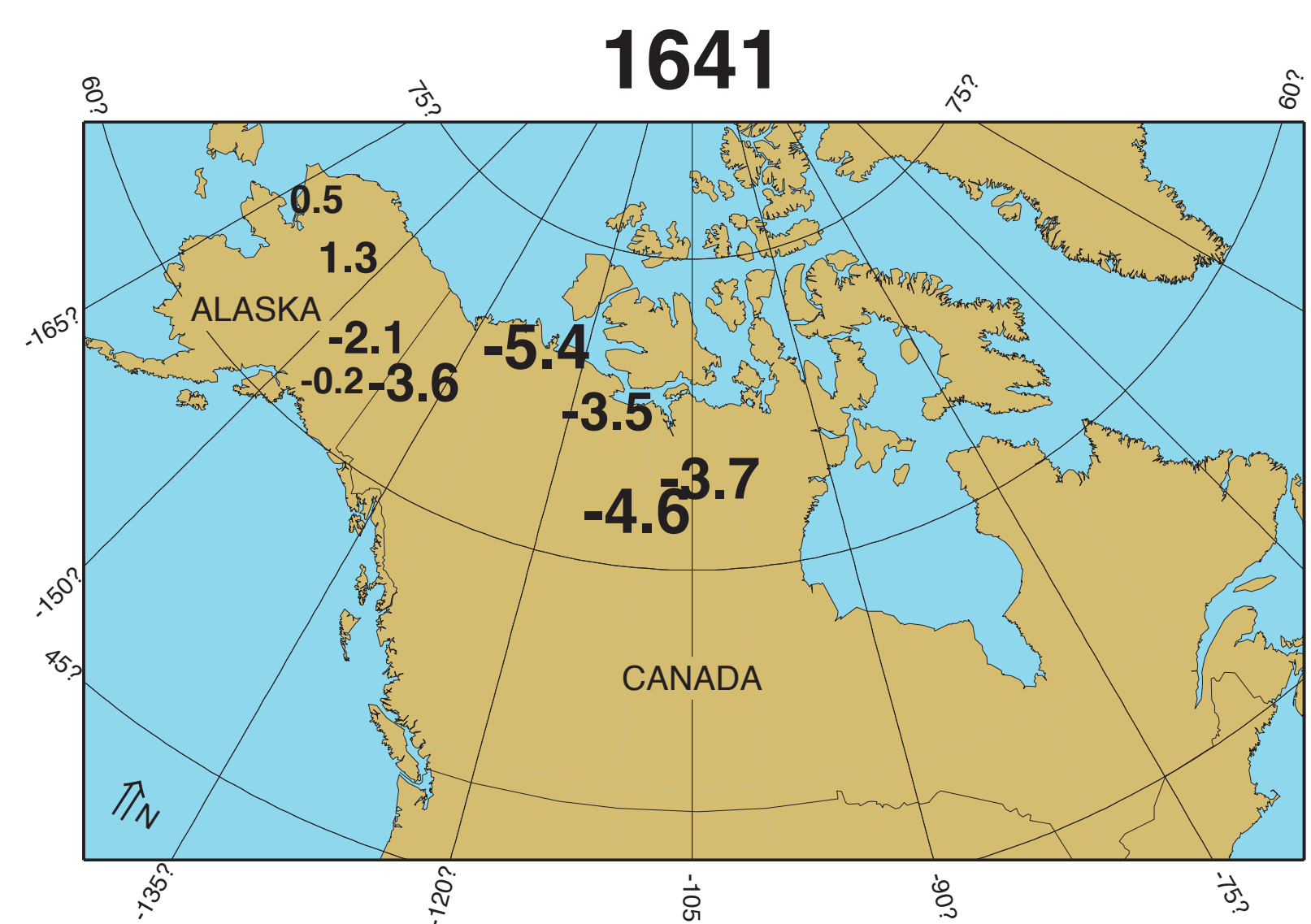


Image of a white spruce core showing the extremely low density latewood for the year 1783. Latewood density has been demonstrated to be good proxy of summer temperatures and was used for the temperature reconstruction here and for the comparison of the sites from across northern North America.

## SUMMARY

The analyses of these four events show the structure of the climatic response to several major volcanic events. This gives better insight to the effects than continental averages and reveals the potential for extreme, possibly disastrous, cold from such events even if they are not the greatest global extremes. The progression of the aerosols can be tracked by historical observations across Eurasia. Observations also show the aerosols reaching Labrador on the east coast of North America and the timing of this report suggests that there was some westward transport from Iceland in addition to the eastward flow across Eurasia. When the tree-ring density data for North America and Eurasia are averaged (Briffa et al. 1998) 1783 is greatly reduced in apparent climatic effects. Thus on a hemispheric scale it is not one of the greatest events. However, 1783 had a devastating effect of extreme cold in Northwest Alaska. These results show the substantial spatial variation in volcanic induced climatic effects and suggest the dynamics of temperature distributions.

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