

Temperature Fluctuations over the past 2000 years in western Mongolia*

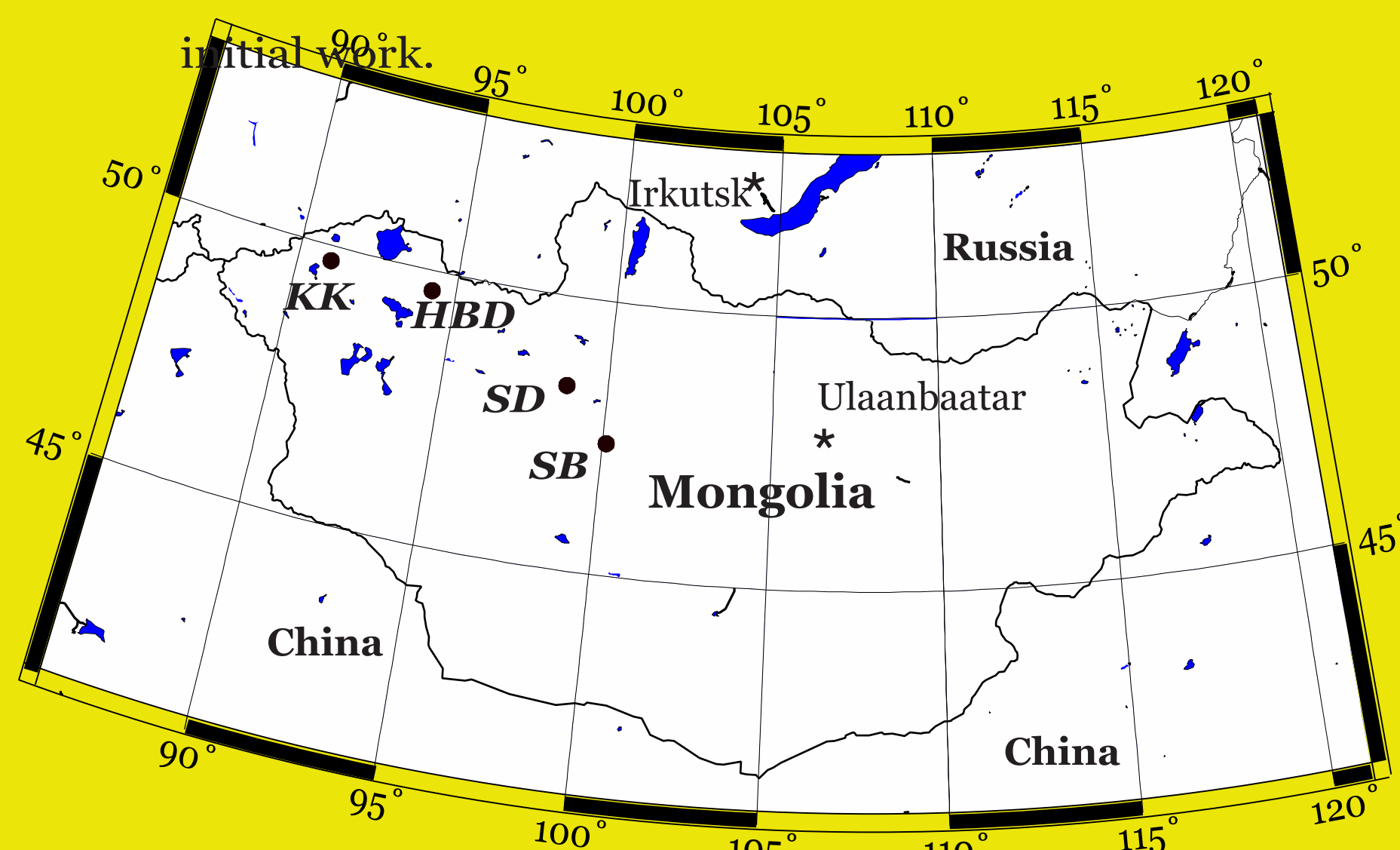
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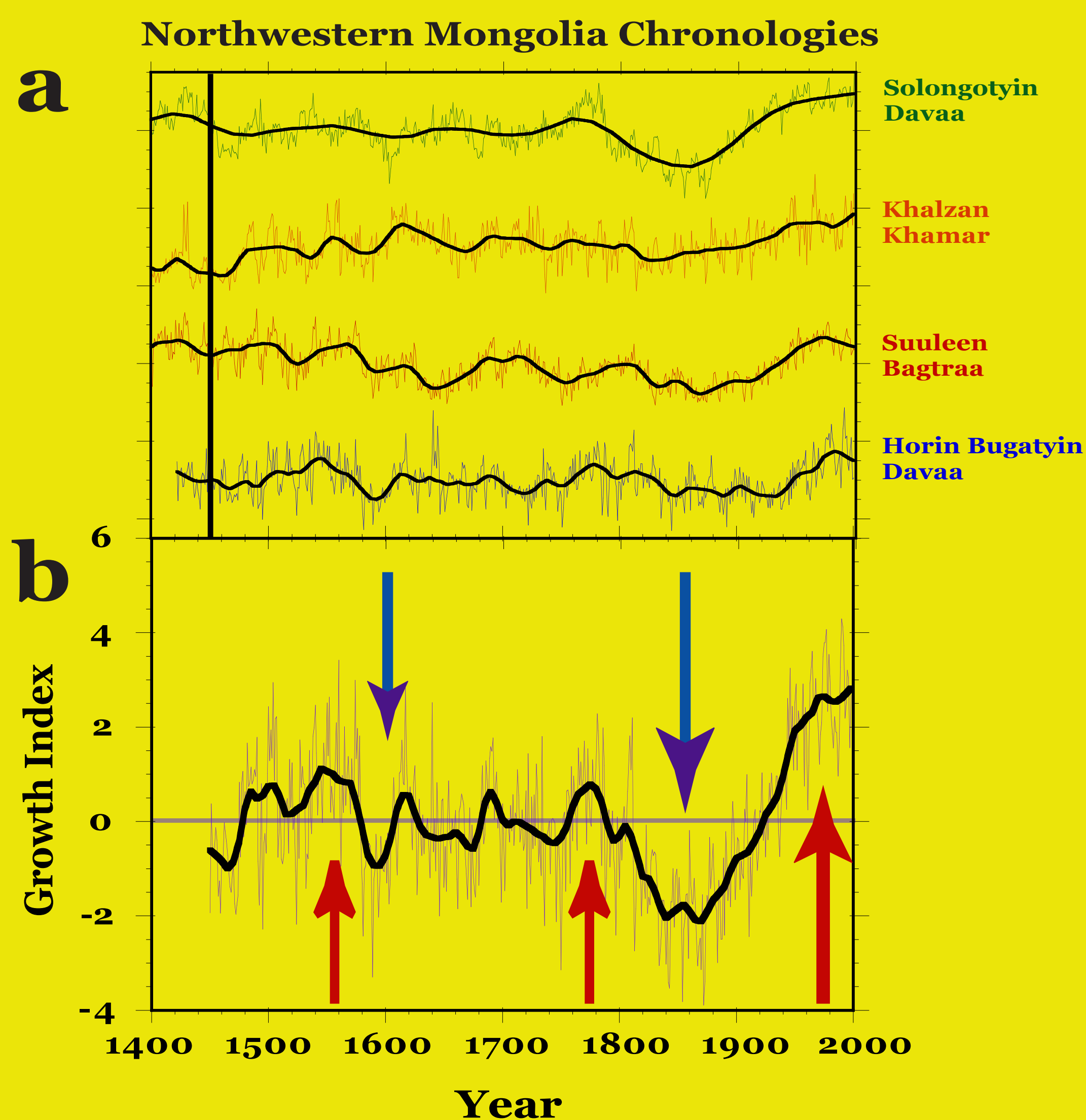
Abstract: The 1999 field season culminated a successful five year investigation of climate change by completing an east-west transect across Mongolia. An earlier tree-ring study at Tarvagatay Pass, Mongolia indicated unusual warming during the 20th century similar to other paleo-investigations of the northern hemisphere. This record had represented one of the few tree-ring records for central Asia. New data from several sites in western Mongolia confirmed the preliminary temperature study. The highest twenty-year growth period for the composite record is from 1973-1994. The western Mongolian record was significantly correlated with the Taimyr Peninsula and two northern hemisphere temperature reconstructions reflecting large-scale temperature patterns while showing some important regional differences. These difference should prove useful for climate models. We have also developed a millennial length temperature sensitive record at the Solongotyin Davaa site (formerly Tarvagatay Pass) using relict wood and living trees. Conspicuous features over the last 1000 years are a century scale temperature decline punctuated by the end of the Little Ice Age in the late-1800s and 20th century warming. The record also shows a cold period early in the 12th century and warm intervals late in the 10th, early in the 15th and at end of the 18th centuries. Despite a limited sample size before 900 AD, the new Solongotyin Davaa record is useful in indicating severe cold events and suggests some cold intervals nearly as severe as the 19th century.

Introduction:

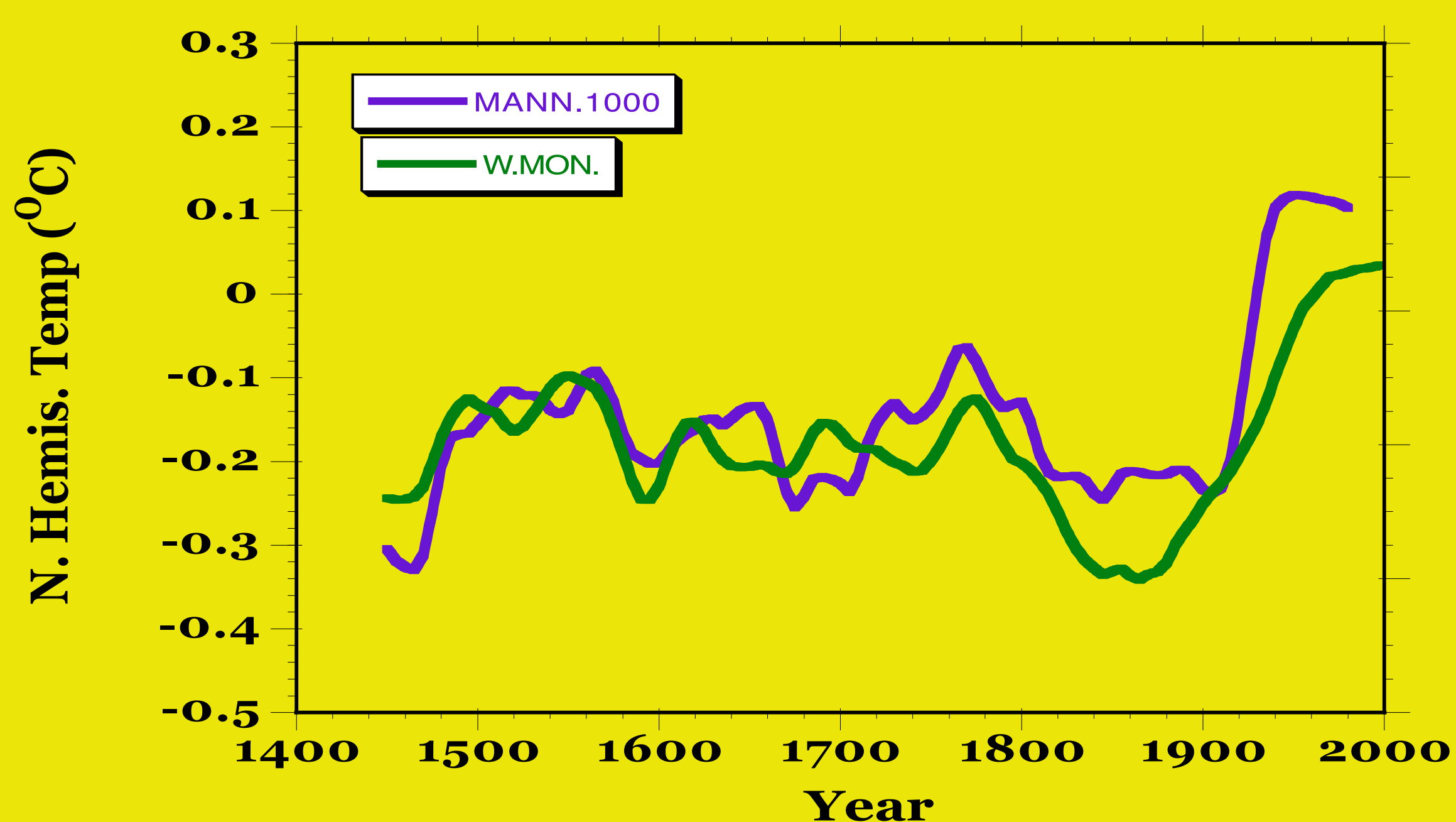
- A 1996 Science paper indicated Mongolia was experiencing unusual warming in the 20th century (Jacoby et al., 1996).
- Since 1995 we have completed an East - West transect in Mongolia that supports the findings of the



Map of Mongolia showing sites where temperature sensitive trees were sampled in 1995, 1998, & 1999. KK = Khalzan Khamar; HBD = Horin Bugatyn Davaa; SD = Solongotyin Davaa; SB = Suuleen Bagtraa



Using principal components analysis, the four chronologies (Graph a) were combined into one series (Graph b). All chronologies were coherent back to 1450 (Graph a). The final chronology covers the period 1450-1998 (Graph b). The final series indicates 2 cool periods during the mid-16th and 19th centuries. Warm periods are seen in the mid-16th and late-18th centuries. The warming during the last half of the 20th is unprecedented in the 550 year record supporting earlier work (Jacoby et al., 1996).



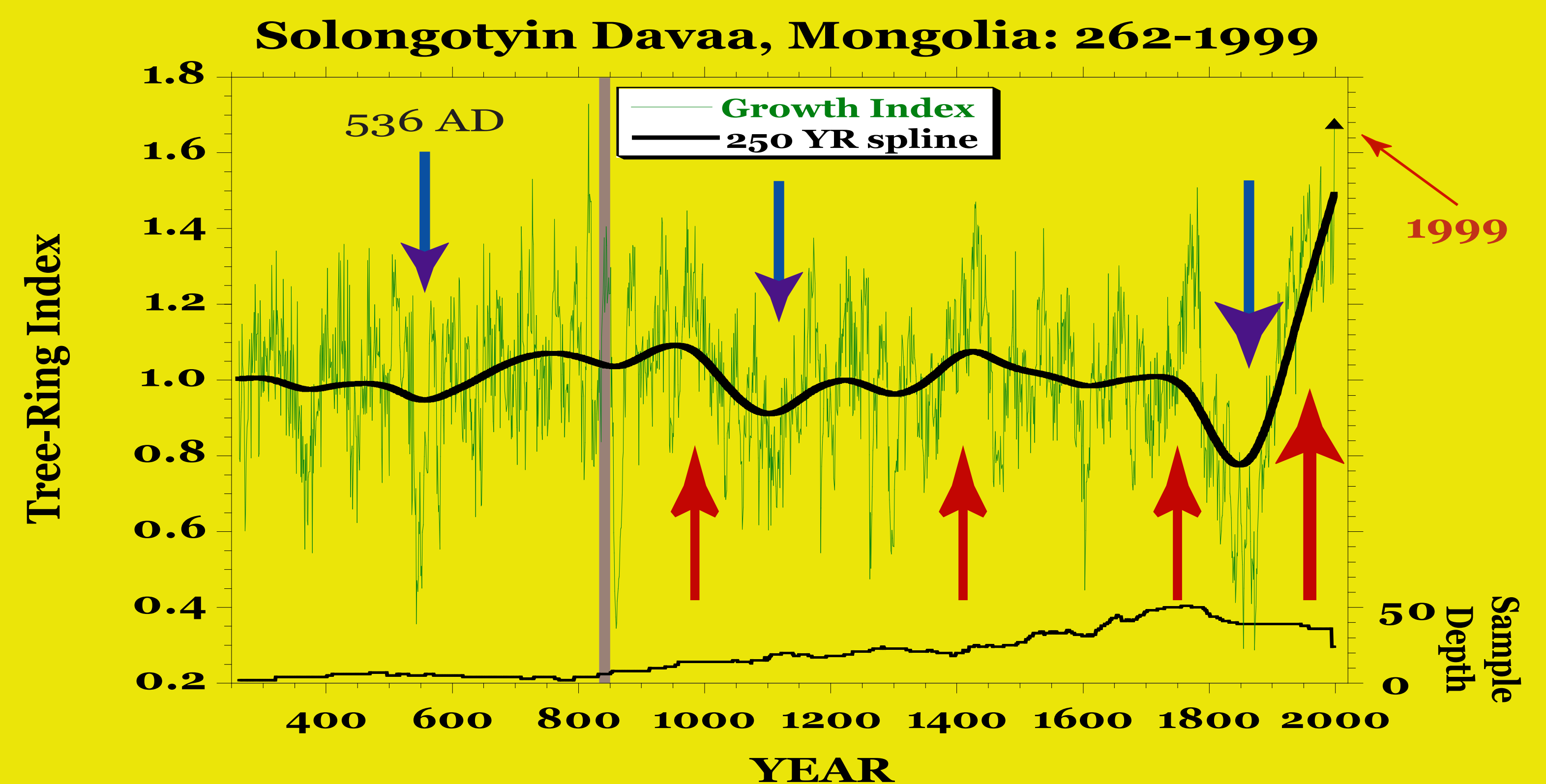
Comparison of Mann's Northern Hemisphere temperature reconstruction (MANN.1000) and the 4 site chronology from western Mongolia (W.MON.) shows a high degree of correlation. Thus, the new Mongolian series probably represents large scale temperature changes for central Asia since 1450.



View of Suuleen Bagtraa. The decreasing density of trees at the top of the slope indicates that temperature limits tree establishment.



At Solongotyin Davaa, relict and living trees were sampled to create a new series 1738 years in length.

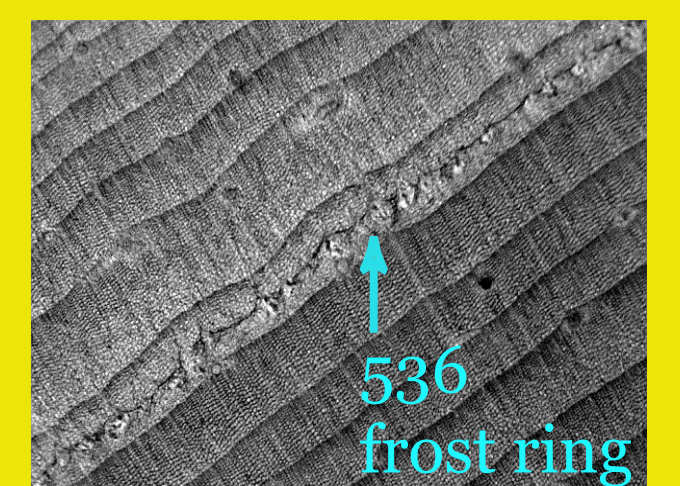


The Solongotyin series is most reliable after 850 (gray bar indicates 850 AD). Important features from 850-1999 includes: cold intervals in the 12th and 19th centuries and warm intervals during the late 10th, early 14th, late 18th and the last half of the 20th century. At the time of sampling (Aug. 21, 1999), the 1999 ring was not fully formed. Despite this, it is the largest ring of the last 1150 years and the 2nd largest of the entire record. This indicates trees at Solongotyin Davaa are reflecting the unusual warming observed (some of the greatest warming observed on the Earth) in central Asia instrumental records.

Sampling cross-sections of dead trees allows the opportunity to study frost ring formation in Siberian pine. Frost rings at this site are seen following hypothesized large volcanic eruptions like 535, 938, 1258.

The 535 event shows up in at Solongotyin Davaa as a frost ring in 536

The 535 AD event may have had societal and political implications for the Mongolian region.



Avar Invasion of Eastern Europe - mid-6th Century

- The Avars dominated Mongolia during the early 6th century.
- The Avar culture revolved around the horse and the steppe.
- Turks live in the region & lived more in forest & used cattle.
- It is hypothesized that the climate deterioration starting in 536 and continuing through the 540s favored the Turk culture leading to a Turk defeat of the Avars.
- What is known is that the Avars moved west and reached eastern Europe in 550s.



- The Avars found Europe weakened due to disease and a shortage of food.
- Avar war technology (horse, arrows, stirrups) gave them an advantage as they moved west.
- The Avar Empire stretched from Germany to the Volga River and from the Roman Empire to the Baltic (Keys, 2000).

Climatic impact on human societies have been found in Alaska (Jacoby et al., 1999) and the Virginian colonies (Stahle et al., 1998) and supports the hypothesis of Lamb (1977). The potential connection between climate change in Mongolia and Avar invasion of eastern Europe fits the Lamb hypothesis.



A young (likely <70 years old) krumholz Siberian pine. New trees are establishing above the older treeline also indicating a change in the growth environment at Solongotyin Davaa.



A stripbark Siberian pine at Solongotyin Davaa. This tree may have looked like the young tree in the picture to the left roughly 400 years ago.

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For additional information see: www.ldeo.columbia.edu/trl/Mongolia/

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