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TREE-RING EVIDENCES OF TEMPERATURE FLUCTUATIONS IN WESTERN HIMALAYA, INDIA

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ABSTRACT

Long-term high-resolution climate records are indispensable to understand the natural climate variability and delineate the magnitude of anthropogenic impact over it. The relevance of such long-term data increases many-fold for the climate sensitive Himalayan region, known to influence the regional and extra-regional atmospheric circulation system. The climate responsive tree-ring chronologies of several conifer species prepared from climate stressed sites in western Himalaya have been used to develop climatic reconstructions. The mean spring temperature reconstruction shows that the climate was not uniformly cool during the Little Ice Age. The cooling was interrupted by short-term warm epochs. The mean spring temperature reconstruction shows that the 20th century has warmed in the western Himalaya. The climate records spanning Medieval Warm Period are needed to develop insight into the magnitude of ongoing warming under the background influence of green house gases.

Key words: Tree-Ring, Temperature Fluctuations, Western Himalaya

INTRODUCTION

Climate of the Earth system has never been static in the geological past. However, this natural variability is much altered since the last few decades and is increasing by athropogenically-induced changes due to rapid industrialisation and deforestation to meet the insatiable human needs (Houghton *et al.*, 2001). The instrumental records, which barely extend to one or occasionally one and a half century back do not meet the requirements for the study of climate variability in time scales relevant to human society.

Temperature conditions over the Himalayan region are known to have close relationship with summer monsoon rainfall over the Indian region and El-Nino/Southern Oscillation (ENSO) (Khandekar, 1991; Prell and Kutzbach, 1992; Vernekar *et al.*, 1995; Yang, 1996; Yadav *et al.*, 1997). Such a linkage among climatic features operating over long distances shows that the longterm high-resolution climate records from the Himalayan region should provide valuable data to understand the intricacies of climate change phenomenon.

Growth rings, formed in trees growing in areas where distinct seasonality in climate exist, could be dated precisely to annual or even seasonal level of accuracy. The sequences of growth ring features like ring-width, density, isotope composition which reflect the ambient environmental conditions, are used to develop climatic reconstructions extending back to several centuries (Fritts, 1976; Cook and Kairiukstis, 1990). In the Himalayan region, many conifer species growing for the past several centuries are known to produce datable growth rings (Yadav *et al.*, 1999). The climatic reconstruc-tions from the Himalayan region using tree-ring proxy records are very limited (Hughes, 1992, 2001; Borgaonkar *et al.*, 1994, 1996; Yadav *et al.*, 1997, 1999; Yadav and Park, 2000; Yadav and Singh, 2002). The utility of most of these reconstructions for climate studies is, however, limited due to the use of few predictor chronologies in the reconstruction. The robustness of the reconstruction could be improved by use of increased number of predictors in climate reconstruction model. However, such reconstructions using multiple tree ring chronologies from the Himalayan region are very few (Hughes, 1992, 2001; Yadav and Singh, 2002). The applicability of these reconstructions in climate change studies in western Himalayan region has been discussed in the present paper.

TEMPERATURE RECONSTRUCTIONS

Hughes and Davies (1987) developed network of tree-ring (ring width and density) data of *Abies pindrow* (Royle) Spach from Srinagar, Jammu and Kashmir. The mean spring (April-May) and late summer (August–September) temperature extending back to AD 1780 were later reconstructed by Hughes (1992). Using only maximum latewood density data, the mean April-May temperature reconstruction was further extended back to AD 1690. The reconstruction lacks long-term climatic trend, which according to the author could be due to the method used in standardisation of tree-ring data. Later, using the same predictor chronologies, Hughes (2001) developed summer temperature (April through September, excluding July) since AD 1660 using tree-ring width and maximum latewood density of *Abies pindrow* (Royle) Spach from Srinagar, Jammu and Kashmir. Mid 20th century warmth and cool mid 18th century noticed in Kashmir are synchronous with conditions in western Himalayan region (Yadav and Singh, 2002) and Karakorum (Esper *et al.*, 2002). However, warm mid 19th century and cool early 19th century recorded in Kashmir valley were not recorded for the western Himalayan region and Karakorum.

Yadav and Singh (2002) developed mean March-April-May temperature reconstruction for western Himalayan region using a close network of twelve ring width chronologies of *Cedrus deodara* (Roxb. ex Lambert) G. Don (Himalayan cedar) growing in Garhwal region. The reconstructed mean spring temperature

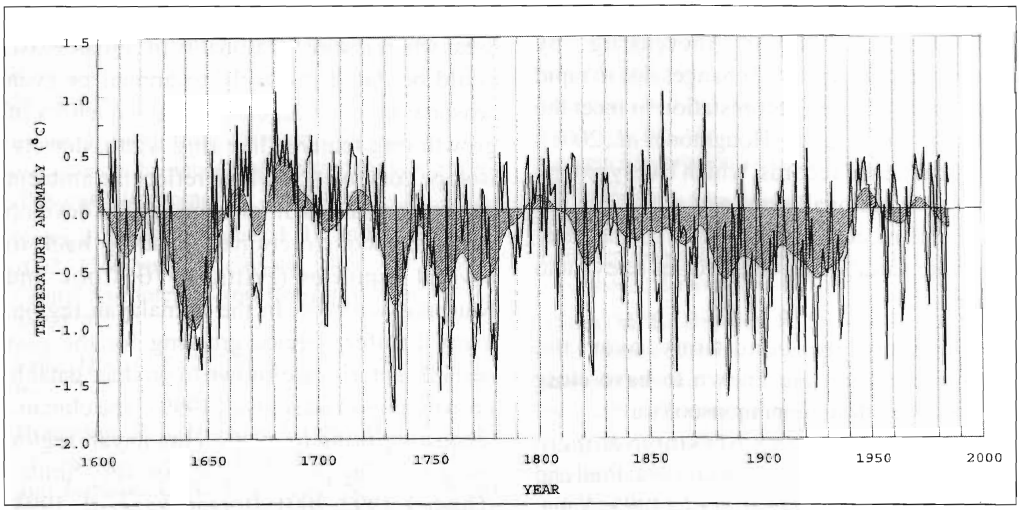

Fig. 1.Mean spring (March-May) temperature reconstruction (AD 1600-1985) overlain by its filtered version emphasizing the variations in the range of 20-year's and above (after Yadav and Singh, 2002).

anomalies (AD 1600-1985) relative to the 1951-1980 mean are characterized by interannual to decadal scale variability superimposed on century-scale trends (Fig.1). The most conspicuous feature of the reconstruction is the 20th century spring warmth, especially since the 1920s. The 20th century warmth noticed in the reconstruction is coherent with Urals (Briffa *et al.*, 1995), and Fennoscandia (Briffa *et al.*, 1992). The 1945-1974 period was the warmest 30-year mean period of the 20th century. The 20th century warming also matches with warming in the Northern Hemisphere (Mann *et al.*, 1999). Temperature decrease noticed in the reconstruction since the mid 1970s is also seen in instrumental data. The subdued warming in the last few decades of the 20th century has also been reported in central Asian mountains (Diaz and Bradley, 1997), Karakorum (Esper, 2000), and northern and southern reaches of the Kolyma drainage basin, Siberia (Earle *et al.*, 1994; Johansen, 1995).

The spring temperature reconstruction further shows that the early part of the 17th century was very cool in the past 400 years. However, this cooling was interrupted by warm epoch around 1662-1691. The early 17th century cold with very severe conditions during 1631-1650 in reconstruction is coherent with the northern Hemisphere records (Bradley and Jones, 1993; Cook, 1995; Briffa *et al.*, 1999; Jacoby *et al.*, 2000), Karakorum (Esper, 2000), northern Urals (Briffa *et al.*, 1995) and northern Fennoscandia (Briffa *et al.*, 1992). The cool 1700s recorded for the western Himalaya matches with the cool 18th century in northern Yakutia, Siberia (Hughes *et al.*, 1999), Canadian Arctic (Hughen *et al.*, 2000), and Japan (Bradley and Jones, 1993). The 18th and 19th century experienced prolonged cooling. However, the cool 18th century was punctuated by warmth during 1713-1722, and 1797-1806. The 1731-1740 and 1877-1886 represent the coolest 10-year period during the 18th and 19th century respectively. The cool 19th century recorded in western Himalaya is similar with polar Urals (Briffa *et al.*, 1999), Taymir peninsula (Jacoby *et al.*, 2000) and Mongolia (D'Arrigo *et al.*, 2000).

CONCLUSIONS

Tree-ring studies carried out from the Himalayan region show that old trees growing in climate stressed sites are potential surrogate of climate. The available data show that the climate during the Little Ice Age was not continuously cool in the western Himalayan region. The cooling was interrupted by short warm periods (1662-1691, 1713-1722 and 1797-1806). The 17th century experienced coolest 1631-1650 and warmest 1662-1691 in the past 400 years. The 20th century warmth has been noticed since 1920s. The 1945-1974 was the warmest period in 20th century. Coherent climatic regimes noted in the Asian mountain region show the relevance of long-term climate data from the Himalayan region for climate variability studies. The long-term climate records covering the Medieval Warm Epoch would be very useful to understand the magnitude of anthropogenic impact on ongoing warming.

REFERENCES

Borgaonkar, H. P., Pant, G. B. and Kumar, K. R. 1994. Dendroclimatic reconstruction 3 of summer precipitation at Srinagar, Kashmir, India since the late eighteenth century. *Holocene*, **4**: 229-306.

Borgaonkar, H. P., Pant, G. B. and Kumar, K. R. 1996. Ring-width variations in *Cedrus deodara* and its climatic response over the western Himalaya. *Int. J. Climatol.* **16**: 1409-1422.

Bradley, R. S. and Jones, P. D. 1993. Little Ice Age summer temperature variations 4 : their nature and relevance to recent global warming trends. *Holocene*, **3**: 367-376.

Briffa, K. R., Jones, P. D., Bartholin, T. S., Eckstein, D., Schweingruber, F. H., Karlen, W., Zetterberg, P. and Eronen, M. 1992. Fennoscandian summers from AD 500: temperature changes on short and long time scales. *Clim. Dyn.* **7**: 111-119.

Briffa, K. R., Jones, P. D., Schweingruber, F. H., Shiyatov, S. G. and Cook E. R. 1995. Unusual twentieth century summer warmth in a 1,000-year temperature record from Siberia. *Nature*, **376**: 156-159.

Briffa, K. R., Jones, P. D., Vogel, R. B., Schweingruber, F. H., Baillie, M. G. L., Shiyatov, S. G. and Vaganov, E. A. 1999. European tree-rings and climate in the 16th century. *Climate Change*, **43**: 151-168.

Cook, E. R. 1995. Temperature histories from tree rings and corals. *Clim. Dyn.* **11**: 211-222.

Cook, E. R. and Kairiukstis, L. A. (Eds.). 1990. *Methods of Dendrochronology: Applications in Environmental Sciences.* Kluwer Academic, Dordrecht.

D'Arrigo, R. D., Jacoby, G., Pederson, N., Frank, D., Buckley, B., Nachin, B., Mijiddorj, R. and Dugarjav, C. 2000. Mongolian tree-rings, temperature sensitivity and reconstructions of Northern Hemisphere temperature. *Holocene*, **10**: 669-672.

Diaz, H. F. and Bradley, R. S. 1997. Temperature variations during the last century at high elevation sites. *Climate Change*, **36**: 253-279.

Earle, C. J., Brubaker, L. B., Lozhkin, A. V. and Anderson, P. M. 1994. Summer temperatures since 1600 for the Upper Kolyma River, northeastern Russia, reconstructed from tree-rings. *Arct. Alp. Res.* **26**: 60-65.

Esper, J. 2000. Long-term tree-ring variations in *Juniperus* at the upper timberline in the Karakorum (Pakistan). *Holocene*, **10**: 253-260.

Esper, J., Schweingruber, F. H. and Winiger, M. 2002. 1300 years of climate history for Western Central Asia inferred from tree-rings. *Holocene*, **12**: 267-277.

Fritts, H. C. 1976. *Tree Rings and Climate.* Academic Press, London.

Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., van der Linden, P. J., Dai, X., Maskell, K. and Johnson, C. A. (Eds.). 2001. *Climate Change 2001: The scientific basis.* Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Hughen, K. A., Overpeck, J. T. and Anderson, R. F. 2000. Recent warming in a 500-year palaeotemperature record from varved sediments, Upper Soper Lake, Baffin Island, Canada. *Holocene*, **10**: 9-19.

Hughes, M. K. 1992. Dendroclimatic evidence from the western Himalaya, p. N415-N431. In : *Climate Since AD 1500* (Eds., Bradley, R. S. and Jones, P. D.), Routledge, London.

Hughes, M. K. 2001. An improved reconstruction of summer temperature at Srinagar, Kashmir since 1660 A.D., based on tree-ring width and maximum latewood density of *Abies pindrow* (Royle) Spach. *Palaeobotanist*, **50**: 13-19.

Hughes, M. K. and Davies, A. C. 1987. Dendrochronology in Kashmir using tree-ring widths and densities in subalpine conifers, p. 163-176. In : *Methods of dendrochronology.* 1: *East/west Approaches,* (Eds., Kairiukstis, L.A., Bendnarz, Z, and Feliksik, E.), International Institute for Applied Systems Analysis, Luxemburg, Austria, Polish Academy of Sciences, Warsaw.

Hughes, M. K., Vaganov, E. A., Shiyatov, S., Touchan, R. and Funkhouser, G. 1999. Twentieth century summer warmth in northern Yakutia in a 600-year context. *Holocene*, **9**: 629-634.

Jacoby, G. C., Lovelius, V., Shumilov, O. I., Raspopov, O. M., Karbainov, J. M. and Frank, D. C. 2000. Long-term temperature trends and tree growth in the Taymir region of northern Siberia. *Quat. Res.* **53**: 312-318.

Johansen, S. 1995. Dendroclimatological study of *Larix gmelnii* at the forest border in the Lower Kolyma River region, northeastern Siberia. *Guneria*, **69**: 1-20.

Khandekar, M. L. 1991. Eurasian snow cover, Indian monsoon and El-Nino/Southern Oscillation-a synthesis. *Atmosphere-Ocean*, **29**: 636-647.

Mann, M. E., Bradley, R. S. and Hughes, M. K. 1999. Northern Hemisphere temperatures during the past millennium: inferences, uncertainities, and limitations. *Geophys. Res. Lett.* **26**: 759-762.

Prell, W. L. and Kutzbach, J. E. 1992. Sensitivity of the Indian monsoon to forcing parameters and implications for its evolution. *Nature*, **360**: 647-652.

Vernekar, A. D., Zhou, J. and Shukla, J. 1995. The effect of Eurasian snow cover on the Indian monsoon. *J. Clim.* **8**: 248-266

Yadav, R. R., Park, W. -K. and Bhattacharya, A. 1997. Dendroclimatic reconstruction of April-May temperature fluctuations in the western Himalaya of India since A.D. 1698. *Quat. Res.* **48**: 187-191.

Yadav, R. R., Park, W. -K. and Bhattacharya, A. 1999. Spring temperature variations in western Himalaya, India, as reconstructed from tree-rings: A.D. 1390-1987. *Holocene*, **9**: 85-90.

Yadav, R. R. and Park, W. K. 2000. Precipitation reconstruction using ring-width chronology of Himalayan cedar from western Himalaya : Preliminary results. *Proc. Ind. Acad. Sci.* (*Earth Planet. Sci.*) **109**: 339-345.

Yadav, R. R. and Singh, J. 2002. Tree-ring-based spring temperature patterns over the past four centuries in western Himalaya. *Quat. Res.* **57**: 299-305.

Yang, S. 1996. ENSO-snow-monsoon associ-ations and seasonal-interannual predictions. *Int. J. Climatol.* **16**: 125-134.