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Tree-ring studies in the Dolpo-Himalya (western Nepal)

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Introduction

The central Himalaya in the state of Nepal comprises a broad variety of regional climates and mountain-forest types. More than 80% of the annual precipitation is brought by the Indian Summer Monsoon (ISM) between June and September. However, there is a pronounced gradient of decreasing ISM intensity from Southeast to Northwest. In western Nepal, the influence of westerly disturbances in winter is increasing. This general trend is strongly modified by the complex topography. Jumla (2.344 m a.s.l.), Southwest of the main Himalayan crest formed by the Kanjiroba (6883 m) in western Nepal, receives 935 mm of annual rainfall, whereas Mugu, North of the main crest, receives only 583 mm (Donner 1996). In humid areas, the upper treeline is formed by *Abies spectabilis* and *Betula utilis*. In dry regions of the inner Himalaya, *Pinus wallichiana* is found in higher elevations up to 3900 m a.s.l.

The present state of the dendrochronological exploration of the central Himalaya is still fragmentary. Initial collections made in the late 1970s by Rudolf Zuber and other chronologies were first published by Bhattacharyya *et al.* (1992). In a recent study, Cook *et al.* (2003) greatly improve the coverage of tree-ring sites across Nepal. In the frame of a long-term archaeological project in upper Mustang (central Nepal), several chronologies of *Pinus wallichiana* were developed which were supplemented by several hundred wood samples from historic buildings to form a regional master chronology spanning the period 1324-1997 (Schmidt et al. 1999). It could be shown that historic wood samples cross-date well with overlapping chronologies from living trees (Schmidt 1992) and that it is possible to reconstruct periods of house-construction activities and settlement patterns.

Methods

Increment cores from birch, pine and juniper trees were smoothed with razor blades and contrasted with white chalk. Cross-dating was accomplished using TSAP software (Rinn 1996). Standardisation of the chronologies was carried out with the help of the program ARSTAN. Due to the general lack of meteorological data in the region, correlation coefficients between the resulting index chronologies and climate data from Jumla (1957-1990) and the Indian Summer Monsoon Index (calculated as a regional mean over northern India; Pant & Rupa Kumar 1997) were calculated.

Results

Relationships between tree-ring chronologies and climate

Three local chronologies from different tree species from sites close to the upper treeline could be established (Table 1, Fig. 1). Apart from ring width (RW), maximum latewood density (MLD) was measured at the site of Rara at the WSL laboratory at Birmensdorf, Switzerland. The birches at Tschagö La were difficult to crossdate due to missing rings and the occurrence of micro-rings. It is the first chronology derived from this species. The chronologies shown in Figure 1 contain a remarkable common low-frequency signal, especially during the well-known northern-hemispheric cold phases during the 19th century (Briffa et al. 1998).

Table 1: Tree-ring standard chronologies from the Mugu and Dolpo regions

site name	Lat.	Long.	Elev. m. asl	species	no. of trees	length	Chronology	AC1	SNR
Rara RW Rara MLD	29°27'N	82°07'E	3500	*Abies spectabilis*	15	334	1665-1998	0.72 0.72	5.34 2.22
Tschagö La	29°40'N	82°36'E	4020	*Betula utilis*	10	344	1655-1998	0.23	1.26
Samling Gompa	29°26'N	82°54'E	3850	*Pinus wallichiana*	12	324	1675-1998	0.62	5.57

The chronologies have a sufficient replication over the last 300 years. Initial results evaluating their climatological potential are shown in Table 2, where the highest correlation coefficient between the tree-ring series and climatic variables are listed.

Table 2: Highest correlation coefficients between tree-ring series and meteorological data from Jumla and the Indian Summer Monsoon Index (ISM after Pant & Rupa Kumar 1997)

chronology	species	correlation coefficient with climatic variable (Jumla station)	correlation coefficient with ISM
Rara MLD	*Abies spectabilis*	$T_{Sep\text{-}Nov}$: 0.77**	0.34*
Rara RW	*Abies spectabilis*	$T_{Nov/py\text{-}Jan}$: 0.77**	0.41**
Tschagö La	*Betula utilis*	$T_{Jul/py+Sep/py}$: 0.88**	0.47**
Samling Gompa	*Pinus wallichiana*	$N_{Apr\text{-}Sep}$: 0.42*	-0.01

* significant (p<0.05), ** significant (p<0.01)

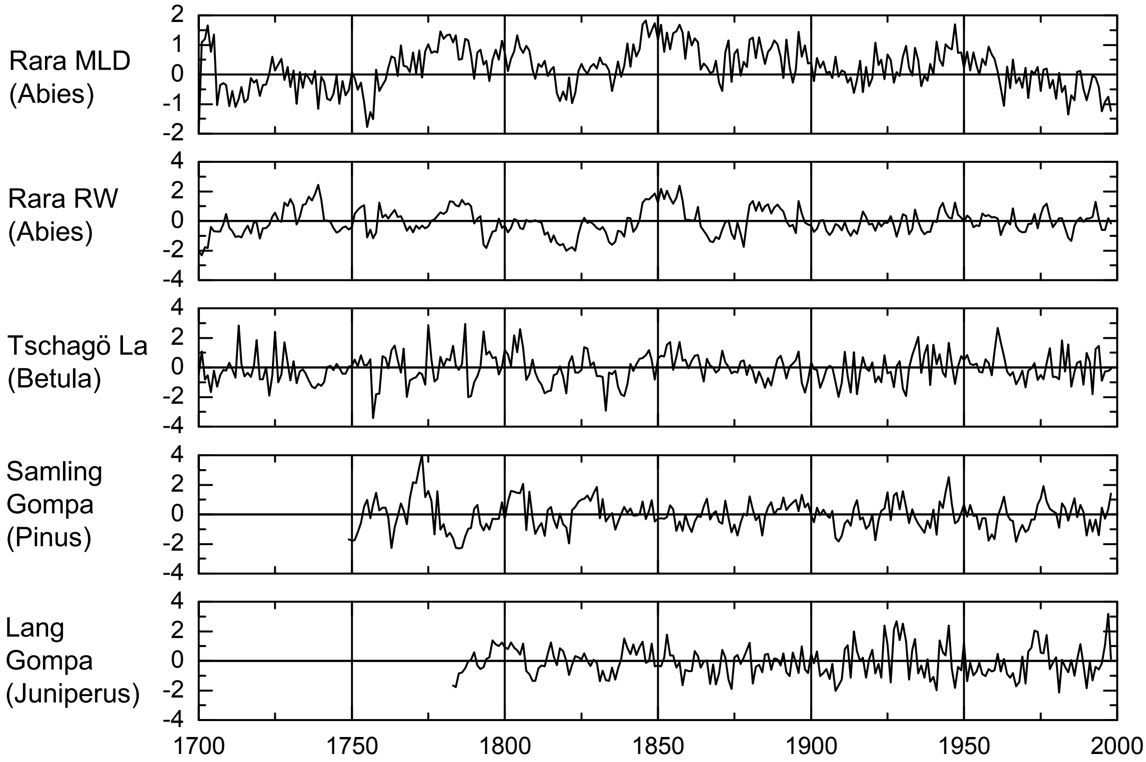

Figure 1: Tree-ring chronologies from high-elevation sites in western Nepal.

However, it must be noted that the temperature data from Jumla only span the period 1977-1986, whereas rainfall data are available from 1957-1990. The Indian Summer Monsoon index represents a regional mean of summer rainfall over northern India.

Ring width of birch is highly correlated with summer temperature of the summer prior to growth (Table 1), whereas ring width of fir is strongly correlated with temperature during the winter before the growing season. This behaviour of the frost-sensitive genus *Abies* has also been found at subalpine sites in southern and eastern Tibet (Bräuning 1999). The interpretation of the statistically highly significant correlation between the Rara MLD chronology and autumn temperature has to be verified physiologically and should be interpreted with some caution. Normally, summer temperature has a significant impact on MLD of fir (Bräuning 1994), but it seems possible that cell-wall thickening can still occur after the monsoon season, when cambial cell division has already ceased. In contrast, the chronology of *Pinus wallichiana* from the dry site in Upper Dolpo is significantly correlated to the local summer rainfall at Jumla, but not to the regional ISM. Nevertheless, as indicated in Table 1, monsoon rainfall has a significant influence on tree growth in the region.

Dating of historic timber

With the help of the Samling Gompa (gompa = monastery, Tibetan) pine chronology, it was possible to date wood samples from historic buildings. One example is shown from the abandoned village “ancient Pö”, located about 15 km Northwest of Samling Gompa. The sample originates from a former farm house or stable that is probably still used periodically as a shelter. Pith and waney edge were preserved and revealed the dates 1775-1946. The position compared to the chronology and the t-values and Gleichläufigkeit (the latter being the coefficient of parallel variation between series) are shown in Fig. 2

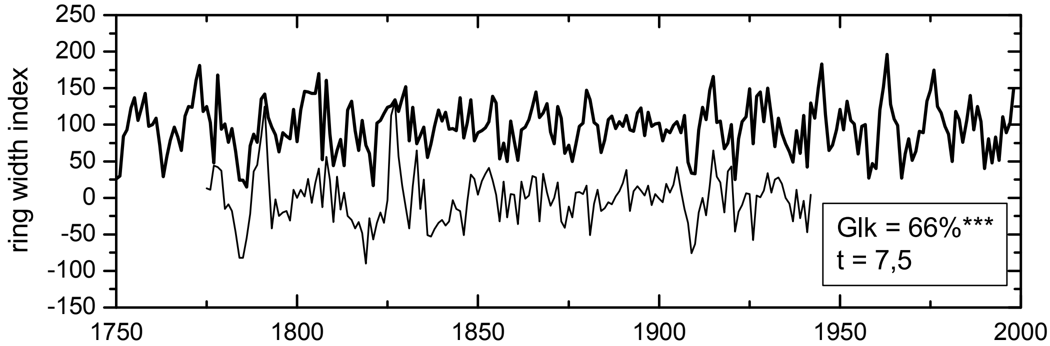

Figure 2: Synchronous position of sample "ancient Pö" and the Samling Gompa pine chronology.

In addition, 15 historic wood samples collected in monasteries within a distance of 20 km could be dated. The chronology for *Pinus wallichiana* for the Upper Dolpo region presently spans the period 1556-1998 (443 years) and could contribute significantly not only to the reconstruction of regional precipitation variations but also to the reconstruction of the regional settlement history, which is unknown to a large extent.

Conclusions

Tree-ring chronologies of different species from high-elevation sites in western Nepal have a great potential for the reconstruction of past climate conditions. Especially drought-sensitive relict stands of the widespread species *Pinus wallichiana* offer the possibility to analyse summer rainfall at the western border region of the Indian Summer Monsoon. The pine chronologies from living trees can be significantly extended by the use of historic timber, since the species has been used for construction purposes in ancient monasteries and civil houses.

References

Bhattacharyya, A., LaMarche, V.C.Jr. & M.K. Hughes (1992): Tree-ring chronologies from Nepal. Tree-Ring Bulletin 52: 59-66

Briffa, K.R., Jones, P.D., Schweingruber, F.H. & T.J. Osborn (1998): Influence of volcanic eruptions on northern hemisphere summer temperature over the last 600 years. Nature 393: 450-455

Bräuning, A. (1994): Dendrochronology for the last 1400 years in eastern Tibet. GeoJournal 34 (1): 75-95

Cook, E.R., Krusic, P.J. & P.D. Jones (2003): Dendroclimatic signals in long tree-ring chronologies from the Himalayas of Nepal. International Journal of Climatology 23 (in print)

Donner, W. (1996): Lebensraum Nepal. Eine Entwicklungsgeographie. Mitteilungen des Instituts für Asienkunde Hamburg 226: 728 p.

Gutschow, N. (1994): Kagbeni: structural analysis of dendrochronological data. Ancient Nepal 136: 23-50

Pant, G.B. & K. Rupa Kumar (1997): Climates of South East Asia. John Wiley & Sons, Chichester, England, 302 p.

Rinn, F. (1996): TSAP 3.0 Reference Manual. Heidelberg, 262 p.

Schmidt, B. (1992-1993): Dendrochronological research in south Mustang. Ancient Nepal 130-133, Kathmandu

Schmidt, B., Wazny, T., Kuber Malla, Höfs, E. & M. Khalessi (1999): Chronologies for historical dating in Haigh Asia/Nepal. In: Wimmer, R. & R. E. Vetter (Eds.): Tree-Ring Analysis. Biological, Methodological and Environmental Aspects. CABI Publishing: 205-211