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CLIMATE RESPONSE FUNCTION ANALYSIS OF *ABIES PINDROW* (ROYLE) SPACH. PRELIMINARY RESULTS

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Abstract

Abies pindrow was used for Dendroclimatic investigation from Ayubia, moist temperate and from Astore, dry temperate area of Himalayan region of Pakistan. Trees of this species not only cross-matched in a particular site but despite belonging to two different climatic zones good cross-dating was achieved between two sites. Dated chronologics from 1500-2000AD and 1680-2000AD was presented from Astore and Ayubia respectively. Response function analysis was used to investigate climate and growth response of trees from both sites. It is shown that overall analysis was highly significant and variance due to climate was 15% to 25%. It is suggested that long term climatic variation or trend could be detected by this species, however more investigation should be carried out, increasing sample size.

Introduction

Northern part of Pakistan is highly potential and a key area for dendroclimatological studies as it is located at the boundary between tropical and continental climatic influences and has quite different climatic controls from the eastern greater Himalayan. Indian monsoon air masses, which bring significant rainfall on the southern margin, penetrate infrequently across the Himalayan Mountain divide to the Trans-Himalayan regions of the Karakoram and Hindokush Mountains. Precipitation in these northern ranges is concentrated in winter and spring months and carried on westerly disturbances, originating predominantly from Mediterranean and Caspian sea regions. Winter precipitation provides the principal source for accumulation on glaciers in the greatest area (2200 km^2) of perennial ice outside of the polar regions (Fowler & Archer, 2006).

An analysis of instrumental temperature records from 7 locations in the Karakoram and Hindokush Mountains has shown that winters have become warmer and summers are cooler. Another finding has been that the diurnal temperature rage (DTR) has consistently increased since the middle of the 20th century (Rees & Collins, 2006). This may be a result of changes in large scale circulation patterns and feedback process associated with the Indian Monsoon. The downward trend in summer temperature noted as being consistent with the observed expansion of Karakoram glaciers, which is in direct contrast to reported glacial retreats in the eastern Himalayan (Owens, 2002). It is reported that the Western Himalayan is displaying a different response to global warming to that elsewhere reported normally. Such finding highlights the importance of our expanded proposed investigation that will enable us to resolve, responding to different general predictions.

Dendrochronological investigations has been carried out by Ahmed (1987, 1988, 1989); Ahmed & Sarangzai (1991, 1992); Ahmed & Naqvi (2005) and Khan *et al*., (2008). However except Esper *et al*., (1995); Treydte *et al*., (2006) and Ahmed *et al*., (2009) no dendrochlimatological work has been published from Pakistan. The work presented in this paper is a part of research program designated to reconstruct past climatic variations using tree-ring of various pine tree species. In this paper preliminary results of growth climatic response of *Abies pindrow* are presented.

Materials and Methods

Wood samples in the form of cores were obtained from Astore and Ayubia, using increment borer. Dendrochronological technique presented in Ahmed (1984) and Norton & Ogden (1987) were followed during handling in field and preparation in the laboratory. Cores were visually cross-dated under the stereoscopic microscope than measured to nearest 0.01 mm on Volmax measuring machine attached to the computer. Program COFECHA (Holmes 1994) was used to check visual cross-dating. The output of COFECHA than subjected to a standardization program ARSTAN, established by Cook (1985) and improved by Homes (1994).

Growth climate response of *Abies pindrow* was investigated, using standardized tree-ring width series of *Abies pindrow* and ½ degree grid data average monthly temperature and precipitation by Response function analysis of Fritts (1976), modified by Palmer (1989) and Palmer & Xiang (2003). Details of this program is given by Fritts (1976) and Ahmed *et al*., (2009).

Results and Discussion

Table 1A shows the site characteristic of two sampling site. Astore fall in dry temperate area while Ayubia is located in moist temperate area. Moist temperate species *Abies pindrow* growing at 900 meter above than Ayubia in Astore on north facing steep slope. Wood samples from both sites show highly cross-matchable ring-width series under the microscope, while quality control program COFECHA gave additional support to the opinion, producing some important statistics.

Summary statistics of COFECHA reveals the higher correlation with master chronology and narrower rings in Astore samples (Table 1B). Standard deviation, lower autocorrelation and low mean sensitivity was recorded in this dry temperature site.

Statistical summary of standardized ARSTAN is presented in Table 1C. Ayubia showed higher values than Astore. Some other RF results are available from Pakistan. In both areas, mean sensitivity values are considerably lower than *Picea smithiana* of Chera. *Abies pindrow* from Ayubia shows higher mean sensitivity than dry temperate *Picea smithiana* of Nalter (Ahmed *et al*., 2009). Correlation with master chronologies from *Picea smithiana* sites (Chera & Nalter) is much higher than *Abies pindrow* (Astore & Ayubia). Table 1C show the summary of standardized chronology (ARSTON). *Picea smithiana* Chera sites has higher values of statistics while Ayubia with *Abies pindrow* (Nalter) has low values of statistics than Chera.

For initial analysis, sample size from Ayubia is satisfactory, however beyond 1850 AD, *Abies pindrow* samples are fairly low in number. For better cross-dating between 1850-1700AD and extend the time series beyond 1700AD, examination of more samples from the same site is recommended. Chronology from Astore span from 1500 to 2000AD but for better statistical analysis more samples are required beyond 1700AD. In addition this chronology may be extended beyond 1500AD by sampling larger trees (Fig. 1).

Table 1A. Sites characteristics of *Abies pindrow*.

Sites	[1]Lati N	[2]Long E	[3]Ele m	[4]Asp	Slope (0)
Astore	35 º 20 `	74 º 48 `	3450	N	30
Ayubia	34 º 02 `	73 º 23 `	2500	NW	25

Note: 1= Latitude, 2= Longitude, 3= Elevation (m), 4= Aspect,

Table 1B. Summary statistics of COFECHA of *Abies pindrow*.

Sites	/------------- Unfiltered -------------\\					//--- Filtered ---\\			
	[1]Corr with master	[2]Mean msmt	[3]Max msmt	[4]Std dev	[5]Auto corr	[6]Mean sens	[7]Max value	[8]Std dev	[9]Auto corr
Astore	0.593	0.99	8.25	0.384	0.771	0.184	1.37	0.227	0.003
Ayubia	0.549	1.59	11.36	0.934	0.778	0.262	2.22	0.355	0.004

Note: 1= correlation with master chronology, 2= Mean ring width,
3= Maximum ring width, 4 and 8= Standard deviation, 5 and 9= Autocorrelation, 6= Mean sensitivity, 7= Maximum value.

Table 1C. Summary of standardized chronologies ARSTAN Statistics of *Abies pindrow*.

Sites	[1]Ch.Sp	[2]Mean sens	[3]Std dev	[4]Skw	[5]Kurts	[6]Tr.Var	Order 1	Order 2	Order 3
Astore	1505-2005	0.131	0.139	-0.044	0.101	-0.0149	0.29	0.02	-0.07
Ayubia	1678-2005	0.187	0.211	0.001	-0.135	-0.002	0.42	-0.06	0.09

Note: 1= Chronology span, 2= Mean sensitivity, 3= Standard deviation,
4= Skewness, 5= Kurtosis, 6= Trend Variance, 7= Partial autocorrelation.

Raw chronology from Astore show two waves of fast growth from 1520AD to 1620, however around 1700AD a gradual increase in growth rate is evident which reached to the maximum on 1900AD. Ayubia and Astore show different trend from1980 to 2000AD. Decline growth at Ayubia may be associated with intense urbanization and development in this area. Increased growth in Astore may be due to cutting of neighbor trees which reduced the competition among trees. From 1800 to 1980AD trees from both places show similar trends in growth. Since 1800 AD pressure on forests increased for fuel, construction and trade, hence beside legal cutting illegal cutting has increased and remaining tree have more chance to grow with less competition.

ARSTAN chronologics from both sites show slight variation in different period of time may be due to the comparatively small sample size of Ayubia chronology. As it is suggested it could be improved by increased sample size. However it is to be considered that *Abies pindrow* growing in (Ayubia) moist temperate area while Astore is regarded as a dry temperate area. Astore is not only on higher elevation than Ayubia but also surrounding by snow covered peaks. Therefore difference in growth response is not surprising.

Response function analysis from Ayubia, is presented in Fig. 2. Rainfall showed 10 positive and 7 negative significant responses while 11 positive and 6 negative significant responses were postulated by temperature. Since more than 4 coefficient were significant, overall analysis was considered to be significant (Grey *et al*., 1981). However variance due to climate (R^2 = 15%) was low.

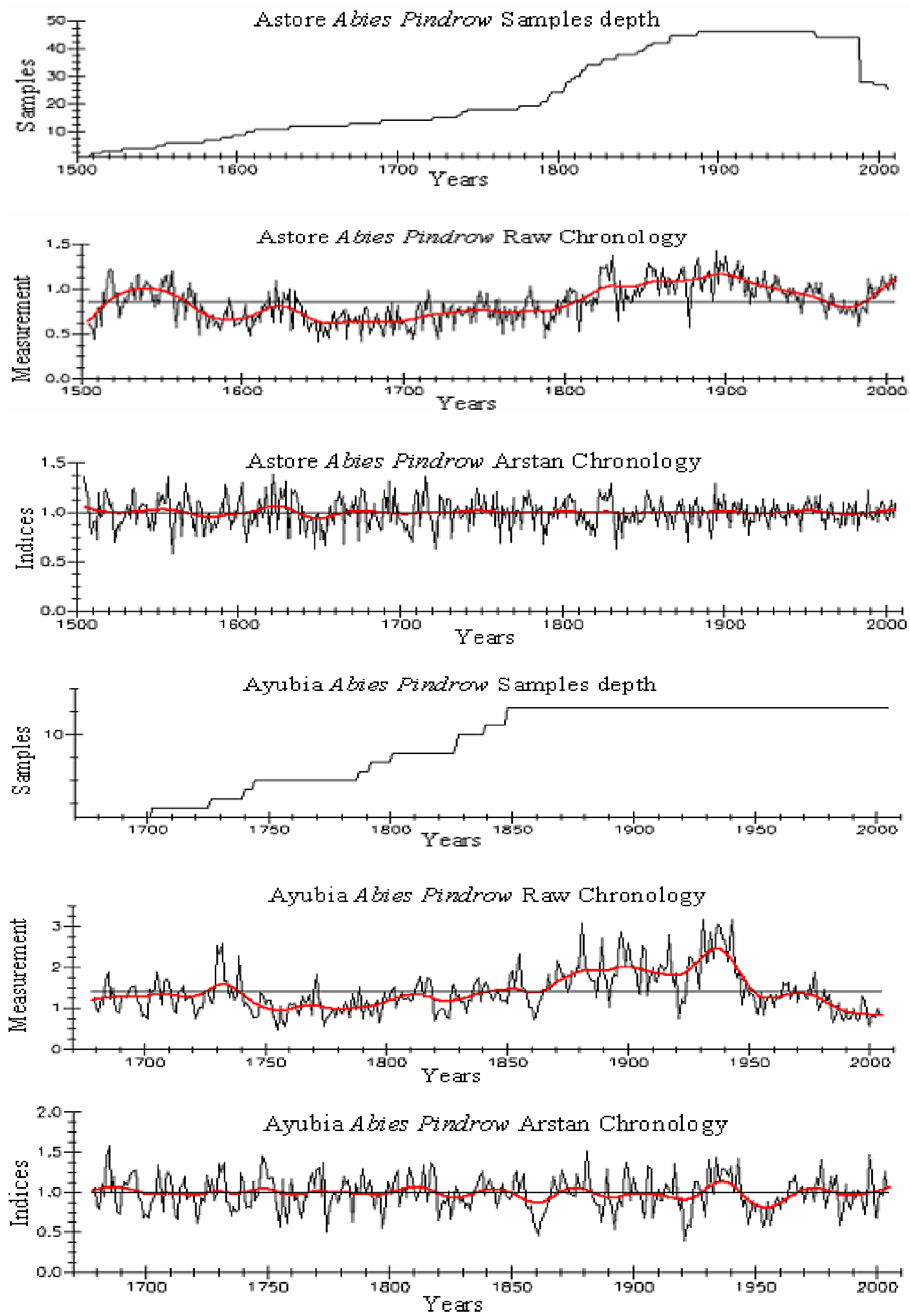

Fig. 1. Comparison of two individual chronologies of *Abies pindrow*. Outcome of standardization program ARSTAN.

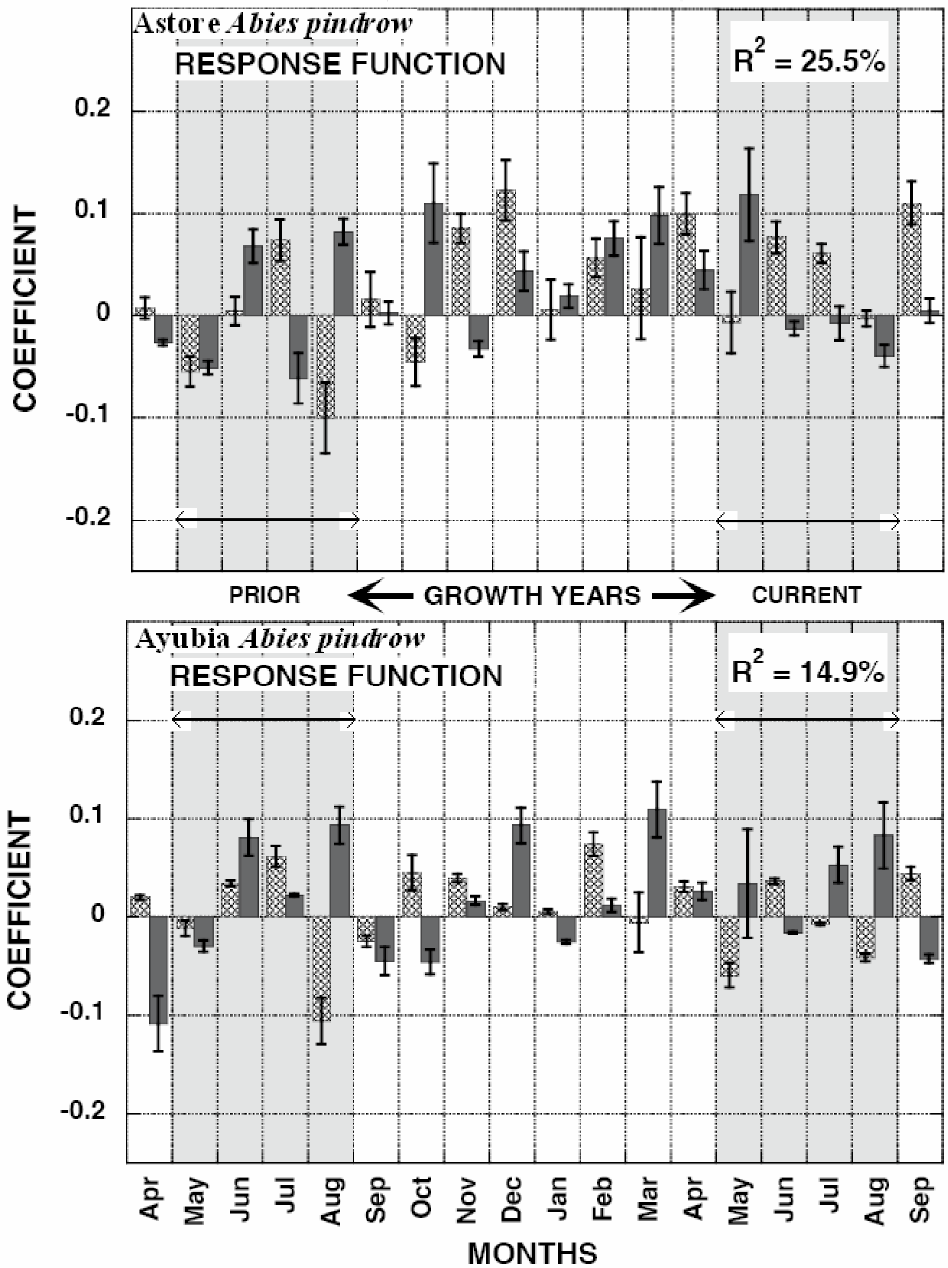

Fig. 2. Out comes of response function analysis of *Abies pindrow* from Astore and Ayubia. Significant coefficients are those where 95% confidence lines are above or under the zero line. R^2= variance due to climate.

Similarly, overall Astore response function analysis was also highly significant. Variance due to climate is low (R^2 = 25%) but higher than Ayubia. Out of 18, eight temperature coefficients were positively and only three were negatively significant, while

9 coefficients were positively and six were negatively significant. Since these climate and growth response were from two different climatic zones with considerable difference in elevation (900m), differences in response is not surprising. However, despite these differences both response function analysis showed many similar significant coefficients in different months. Trees from both areas show same significant positive response with rainfall in June/August (prior) and December, February, March, April and May, while significant negative response with some parameter was associated with April, May (prior) and June (current). It is also evident from the same figrure that Astore and Ayubia show similar significant positive response with temperate in the months of July (prior) and November, December, February, April, June, September, while significant negative response appeared in May and August only. On the basis of these similarities it is suggested that better growth climate response could be detected from *Abies pindrow* if more response function analysis are performed.

A significant negative rainfall in April indicates that more than average rainfall near the end of winter season may have dropped the temperature, and due to decrease in photosynthesis and harmonic activity plant growth was also effected. Both areas show negative significant response with temperate and rainfall in prior May. At higher elevation melting snow water may be available until May, and more rain added more water to the soil, creating a situation not suitable for roots respiration hence reduced the growth.

Prior August, significant positive rainfall and negative temperate response is evident from both site. During summer more than average temperate (significant negative) may reduce the growth due to increased evopotranpiration and water deficit in the soil therefore in these situation more than average rainfall (significant positive) promote tree growth. This response is also evident from *Picea smithiana* from Astore and Nalter (Ahmed *et al*., 2009) indicating a strong growth climate response on wider area, despite the different climatic zones. Therefore it may be assumed that using these chronologies, climate from wider area could be reconstructed, however more analysis are to be performed.

October show just opposite response with rainfall and temperate (Fig. 2). It should again be considered that two areas are climatically different, however significant positive rainfall and negative temperature of Astore are similar to another dry temperate area of Chera and Nalter, with *Picea smithiana* (Ahmed *et al* 2009). Therefore significant positive temperate and negative rainfall of Ayubia (moist temperate area) may be due to regionally controlled climatic factor.

Both areas show similar significant positive temperate and rainfall response in the month of December, February and April. Similar response is also evident from Chera (December) and Nalter (February) with *Picea smithiana*. April response is also similar to Chera and Nalter with *Picea smithiana*. Current May of Ayubia is similar to Nalter while current August coincide with Chera response.

On the basis of these preliminary results and discussion, it may be concluded that despite climatic and topographic differences, *Abies pindrow* is highly potential for climatic reconstruction, however detailed analysis is required.

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