Clim. Past Discuss., 4, S101–S105, 2008
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Climate of the Past Discussions

CPD
4, S101–S105, 2008

Interactive Comment

Interactive comment on "Ice core precipitation record in central Tibetan plateau since AD 1600" *by* T. Yao et al.

T. Yao et al.

Received and published: 16 April 2008

Question 1: The map displayed in figure 1 does not have a detailed caption. I suggest to show a general map with a legend showing the location of previous and this new ice core, and a more detailed map (or picture) showing the topography near the drilling site and the location of the Tuotuohe meteolorogical station used for the calibration study. Reply: We re-draw the map in the revised manuscript and gave more information in the caption.

Question 2: I also suggest to show the raw measurements conducted on the ice core. This could be a figure showing, as a function of depth, the variations of density, of water 18O and dashed vertical lines showing the identification of annual layers based on the visual inspection of the dust horizons in the ice core. I understand that the actual accumulation reconstruction requires a correction for layer thinning, and this figure could help the reader to understand how this thinning is varying with depth. As glaciological effects could have a profound influence on the layer thickness, any information relevant for the ice flow would be useful. Have there been radar echo soundings conducted on the ice field, analyses of ice flow? What is the total estimated ice depth at the site of drilling? What are the topographic properties at the drilling site? Are there inclined layers identified in the core? while I understand how difficult it is to model the flow of such a glacier, it is important to give to the reader the most detailed available information on the ice flow. Also, the authors do not mention melt features, have such features been identified in the cores? This can be potentially important for the identification of past warm periods. Reply: In the revised manuscript a new figure is made to show the raw data of dust concentration with depth, and the dashed vertical lines showing the identification of annual layers based on the peak of the dust concentration in the ice core. The glacial accumulation of the ice core is based on the dust layer counting. The Puruogangri Icefield is a summer accumulating glacier. The densification process is, therefore, very fast. Snow transformed into ice in two or three years. As a result, the density of the whole core is ice density except the upper one meter. For the upper one meter, we reconstructed the glacial accumulation with a snow pit study. The mean summer temperature of -4℃ on the top of the glacier is estimated by temperature at Tuouohe station. It is true that sometimes temperature is above 00C which will introduce some melting. We did observe surface melting on the glacier in different melting periods during the drilling season. To see if there is mass loss caused by surface melting, we dug three snow pits at the core site to study the percolation process. From the snow pits we did observe surface melting water which penetrates 2-3 cm in each melting period. When the next snowfall comes after the melting season, the surface melting stopped. The next surface melting starts on the new snow surface which produce water penetrates another 3-4 cm. This kind of process produces a few thin ice layers with thickness of 2-3cm in a year. However, there is no mass loss caused by surface melting water percolation which means that the temperature on the top of the glacier is not warm enough to alter the interannual variability in snow accumulation. The Puruogangri ice core was drilled on a flat platform with an area of over 150 km2, so the horizontal topography has little affection on the redistribution of snow. The dirty layer is in the horizontal level. Using a radar echo soundings, the ice thickness of the Puruogangri Icefield is measured ˜260m at the deepest part, which is also the drilling site. We added the equation for the glacial accumulation reconstruction in the revised manuscript. The ice thickness thinning is considered in the model represented by p in Equation 1 in the revised manuscript.

Question 3: Regarding to the age scale, it is apparently only based on the seasonal visible dust layers. Is there a possibility to use alternative age markers to support the age scale, such as volcanic horizon? It would be extremely useful to back up the counted age scale with an independent information, and to estimate objectively the uncertainty associated with the layer counting. Reply: We measured the βradioactivity which had a peak in 1963. The profile ofβradioactivity with depth is shown in figure 3 in the revised manuscript.

Question 4: Figure 3 shows the time variations of the estimated accumulation and a statistical test used to assess if the 31 year running average is significantly different from the long tern mean. First, it would be interesting to calculate the spectral properties of this annual accumulation signal. Does the record show frequencies already identified for instance in tropical or temperate rainfall interannual to decadal variability? An analysis of spectral properties would also be very useful to decide what should be the length for calculating long term trends (here, 31 years). Reply: Our idea in the paper is to show the fact of dry or wet period recorded by a new ice core recovered in the central Tibetan Plateau. We would like to write a more comprehensive paper after we have a composite curve of precipitation from several ice cores.

Question 5: Regarding these long tern trends, I would suggest to show the long term running average and running standard deviation of the annual accumulation data. It is quite striking that not only does the mean accumulation vary significantly, but also the interannual variability as well (for instance, it seems very low in the 19th century).

Reply: We strengthened the discussion in the paper following the comment.

Question 6: When discussing the quality of the accumulation reconstruction, the authors discuss the sources of uncertainty and estimate that the error is less than 10% for annual data and less than 5% on the 10 year mean. The authors must support this statement by evidence. The only evidence given in the manuscript is in the very interesting figure 2 showing the comparison between Tuotuohe instrumental precipitation data and Puruogangri ice core data. When looking at this comparison, it seems indeed that the quality of the correlation is good, but that r=0.45 suggests more than 10% of uncertainty. It would be nice to show the annual data and the 5 year running average which is said to have a high correlation coefficient. By the way, what is the precipitation seasonality at TMS (a diagram showing the distribution of rainfall in the different months would be useful). Also, the authors should compare the annual accumulation derived from the 3 ice cores drilled on the same location in order to assess the signal to noise ratio and the spatial coherency of the local accumulation counted layer records. Reply: Unlike temperature, precipitation varies spatially with large variability. So it is logical that there are difference between the precipitation in the Tuotuohe station and the accumulation in the Puruogangri core. The precipitation seasonality is shown in the figure 2 in the revised paper. Although we drilled 3 ice cores in Puruogangri glacier, we only analyzed one core at the moment since it takes long time to complete analysis of all the ice cores.

Question 7: The interpretation of the data is given in terms of temporal long term accumulation changes, and also in terms of spatial differences between temperature and accumulation. It is frustrating for the reader to see a stack of 18O converted to temperature and each record for accumulation. I suggest to change figure 4 and to show on the left panel, the 3 accumulation records, and on the right panel, the 3 18O records. Data treatment methods such as principal component analyses could be used to highlight the common or specific features of these different records. Reply: In the revised manuscript, we have added more figures to support our discussion.

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Question 8: This would be useful to see the spatial differences and also the links between 18O and accumulation, as many processes within the atmospheric water cycle can alter 18O such as continental recycling, moisture origin, droplet re-evaporation, convective versus stratiform processes, and therefore both local temperature and precipitation amount. I have never seen a detailed analysis of the links between 18O and accumulation for different ice core sites, and many recent results even from the Antarctic coast clearly show that you can learn something from the difference between 18O and accumulation (probably linked with changes in air mass trajectories). A solid discussion of the past temperature history and of the potential and limits of 18O to estimate past temperatures is clearly needed. Reply: δ18O has been intensively studied in the northern Tibetan Plateau by a lot of scientists. Precipitation is, however, not so intensively studied. Our idea is to reconstruct ice core precipitation record from different ice cores first and then study the correlation betweenδ18O and glacial accumulation.

Interactive comment on Clim. Past Discuss., 4, 233, 2008.

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