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Climate of the Past Discussions

Interactive comment on "Reconstruction of recent climate change in Alaska from the Aurora Peak ice core, central Alaska" *by* A. Tsushima et al.

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The Aurora Peak ice core is a very intriguing addition to the growing archive of alpine ice cores from Kamchatka, Alaska, the Yukon and British Columbia. From information presented in this manuscript, the Aurora Peak record appears well-dated for the 20th century, contributing valuable records of water stable-isotopes, major-ion chemistry, and snow accumulation to considerations of regional climate in the recent past.

Exploration here of relationships between the ice core record and instrumental climate data is not entirely clear. While a meaningful relationship appears to exist between deuterium, regional temperature data, and the Pacific Decadal Oscillation Index (an index which is not broadly discussed or even introduced in this manuscript), only basic correlations are presented and for relatively long-term averages. For instance, 6-

year average correlations between deuterium and weather station data are presented, and average values over often-discussed multi-decadal "shifts" in the PDOI. This work would benefit greatly by exploring synoptic climate data available for the past 30-50 years from reanalysis efforts (e.g. NCEP or ERA-Interim) to support assumed physical mechanisms driving recent increases in accumulation rate and regional temperatures. Considering that the PDOI is a measure of N. Pacific sea surface temperature, investigating correlations between ice core data and reanalysis SST would certainly prove valuable. Spatial correlations between sodium and geopotential heights, may also provide insight into whether or not increasing storminess is the cause of observed increases in sodium since the 1970s at Aurora Peak. This is likely associated with the Aleutian Low, the well-known center of low-pressure that strongly influences winter storms along the west coast of North America (see Rodionov et al., 2007). Similarly, relationships between deuterium and geopotential height may clarify the effects of temperature and changing moisture source regions on deuterium values seen at Aurora peak. Moisture source effects on water stable-isotopes are currently not discussed in the manuscript.

Again, this ice core record represents a very valuable contribution to climate research in the North Pacific, and will be interesting to compare with developing records such as that recently retrieved near Denali (Alaska). Careful work must be done to better understand physical mechanisms driving the relationships described in this discussion paper.

Specific comments:

Section 1. The introduction here is generally thorough and clear, but could better incorporate contributions to research in the North Pacific from additional cores drilled at Mt. Logan, Eclipse Icefield, etc. These records have been exhaustively examined, especially with respect to temperature, precipitation, water stable-isotopes and snow accumulation.

Section 2. The methods here are well described and clear.

-What is the assumed pore close-off density reported here at 55m?

-Are all samples reported here at 0.1 m resolution? The deuterium data looks like higher-resolution, but this is unclear.

Section 3. 3.1 The ice core chronology is generally clear and quite robust. Wintertime minima (maxima) in deuterium (sodium) values are clear, and supported by melt features for the section presented in Figure 2. Forest fire, bomb, and volcanic markers are convincing.

3.2 The extreme increase in snow accumulation is interesting, and possibly worth closer examination here to better demonstrate that it is not an anomaly due to any part of the density correction, ice flow calculation, or any other unforeseen cause.

-Why was a flank flow value chosen for the critical depth in the Dansgaard-Johnsen model? This would not make a very large difference, but divide flow may be more appropriate for the Aurora Peak site considering the small measured horizontal motion from Fukuda et al., 2011.

-It would be good to state or show how well the modeled depth-age relationship matches that observed from the ice core chronology, especially considering that snow accumulation rate, which relies on a good ice flow correction, is a fundamental aspect discussed in the rest of the paper.

Section 4. -Why were 6-year averages chosen for comparing deuterium and snow accumulation to regional climate observations? What do the correlations look like for 1-year? 3-years? Presumably the correlations will increase as you average over greater lengths of time. . .

-What might cause areas of southeast Alaska to show the highest correlation between temperature and deuterium (Figure 5)?

-There is a wealth of information about temperature and precipitation trends in Alaska, most recently Bienek et al. (2014) in Journal of Climate (and references therein).

http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-13-00342.1

This analysis of regional and temporal trends for Alaska does not necessarily illustrate a clear influence of the PDO on Alaskan climate, but does support some state-wide coherence in temperature trends as opposed to highly spatially- and temporally-variable precipitation. The applicability of this data to mountainous regions, however, is not clear and represents a major challenge of interpreting alpine ice core records.

-The PDOI is not well-discussed or introduced. Simply referencing literature possibly does not provide enough of a foundation for the reader's understanding. The PDOI is the first principal component of N. Pacific sea surface temperature variability (poleward of 20N). This impacts how one considers PDO impacts on temperature and precipitation.

-Figure 7 is problematic. A linear regression of three data points is not incredibly useful, and an R-squared of 1.0 in a natural system of any kind should not be expected. What would this plot look like if annual values of deuterium and the PDOI were plotted? There may still be a linear relationship. One must be careful with averaging. What would 2-year, 5-year, or 10-year averages look like? There does seem to be a meaningful relationship between deuterium and the PDOI, so don't average it away. The next challenge is exploring the physical mechanism behind correlation of the PDOI and water isotopes at Aurora peak.

References:

Bienek PA, Walsh JE, Thoman RL and Bhatt US (2014) Using climate divisions to analyze variations and trends in Alaska temperature and precipitation. Journal of Climate, Vol. 27, 2800-2818.

Rodionov SN, Bond NA and Overland JE (2007) The Aleutian Low, storm tracks, and

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