PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC SCIENCE BRIEFS: USING ICE CORE DATA FROM THE ECLIPSE ICEFIELD AS AN INDICATOR OF HISTORIC NORTH PACIFIC CLIMATE VARIABILITY

This is the first of a regular series of brief reports on recent climate science literature relevant to stakeholders in the Pacific and Yukon Region of Canada. The PCIC Science Briefs contextualize and explain the results and implications of important scientific findings.

A recent study by Kelsey et al. demonstrates the potential to use ice cores to reconstruct the history of the influence of dominant modes of climate variability on our region's climate. The results should help researchers to better understand the natural variability in the climate system and more accurately project future changes to our region's climate.

Mt. Logan, Canada's highest peak, located in the Saint Elias Range near the Yukon-Alaska border, is home to the Eclipse Icefield. Researchers are actively working with ice core data from this icefield to improve our understanding of the climate history of the Pacific region prior to observational records. This history is called the "paleoclimate." Proxy data from ice cores provide important clues about the paleoclimate of the area. Proxy data are physical and chemical features of the ice cores that indicate certain features of past climates, such as temperature, wind speed, solar activity and atmospheric circulation.

In a recent paper published in the Journal of Climate (Kelsey et al., 2012), Kelsey and colleagues explored data from three ice cores taken from the Eclipse Icefield with the goal of improving our ability to reconstruct and hence, understand the atmospheric and oceanic climate variability patterns that have the greatest effect on regional climate in BC and Yukon. These are the Pacific Decadal Oscillation[1] (PDO) in the Pacific Ocean, and the Pacific-North American teleconnection pattern[2] (PNA) in the atmosphere of the Northern Hemisphere. This paper suggests that reconstructions of these patterns further back in time may be possible.

The location of the Eclipse Icefield in the St. Elias mountain range in Yukon, which is the source of the ice cores used for this study.

The authors compared ice core data with the observed climate record over the time period of 1942-2001. Their goal was to relate variations in ice accumulation and its chemical features to large-scale atmospheric circulation and sea surface temperature

1. To learn more about the Pacific Decadal Oscillation, see the National Oceanic and Atmospheric Administration's (NOAA) discussion, here: http://www.ncdc.noaa.gov/teleconnections/pdo/
2. To learn more about the Pacific-North American Teleconnection Pattern, see NOAA's discussion, here: http://www.cpc.ncep.noaa.gov/data/teledoc/pna.shtml

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patterns.

Relating local proxy climate data from ice cores to large-scale atmospheric phenomena is a difficult task. The quality of this data depends on a variety of factors, including the rate at which snow accumulates in the area and the annual amount of melt. Fortunately, the Eclipse Icefield has a high snow accumulation rate with little melt, so ice cores from this area can provide seasonal-resolution records with very small dating errors (±1 year).

The authors found that periods of high accumulation and certain compositions of oxygen isotopes in the frozen water that makes up the ice cores are associated with large-scale atmospheric circulation and sea surface temperature patterns. The least fractionated[3] isotopes and highest accumulation cold seasons are associated with positive PDO and PNA indices, but do not necessarily occur together. The authors attribute their not occurring together to variation in the source of the moisture for precipitation. Negative PDO and PNA values are associated with the most fractionated isotopes and low-accumulation cold seasons. However, the consistency of the atmospheric circulation patterns with warm seasons, less extreme fractionation and less extreme accumulation is lower and hence, the authors find that only about 20% of cold seasons can be reconstructed with high confidence.

Methodology

The authors first gathered isotope and accumulation data from three well-dated ice cores, taken from the Eclipse Icefield. These were averaged together into a single composite proxy, in order to maximize the signal-to-noise ratios (the noise here results from processes such as melt and wind scour). The authors also gathered temperature and precipitation data from weather stations in the region, information on air pressure patterns, and a variety of large-scale climate indicators that affect the region, including those for the PDO, the El Niño-Southern Oscillation, the PNA and the Arctic Oscillation.

The seasonal accumulation and stable isotope ice core data were broken up into eight groups by cold and warm season, extreme high and low accumulation, and extreme high and low isotope fractionation. The authors then examined the correlation between ice core accumulation and fractionation, and modes of variability in temperature and precipitation data common to all stations. Accumulation and fractionation data from the ice cores were also tested for correlation with the climate indicators. Maps of air pressure patterns were combined into composites for the eight individual cases of warm and cold seasons with extreme high and low accumulation and high and low fractionation in the ice core. These maps show the atmospheric circulation patterns that correspond to the individual cases in the ice core data.

With these methods of analysis, the researchers were able to study the ways the accumulation and isotope data from the ice cores is correlated with the patterns of climate variability considered, and thus draw the conclusions discussed above.

Kelsey, E. P., C. P. Wake, K. Yalcin and K. Kreutz, 2012: Eclipse Ice Core Accumulation and Stable Isotope Variability as an Indicator of North Pacific Climate. Journal of Climate, 25, 6426–6440.

3. Fractionation refers to the process that alters the ratio of the different stable isotopes of oxygen in the water molecules that make up the glacier as compared to the ratio of those same isotopes in the ocean. If the ratio of the isotopes in the ice core is different from the average ratio of the same isotopes in the ocean, the ice core's isotopes are said to be "fractionated." If the ratios are the same, then the ice core's isotopes are