Maybe the Siple Dome Ice Core Records Surging Ice Streams?

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The Siple Dome ice core records two large climate changes that are not recorded in the Byrd or Taylor Dome ice cores. The changes observed at Siple Dome are difficult to interpret as a rapid regional climate change. A possible alternative interpretation is that during two time periods large and rapid decreases in the surface elevation of the ice streams surrounding Siple Dome altered the air flow around Siple Dome resulting in large but local climate changes at Siple Dome.

The Siple Dome ice core site is surrounded by ice streams. The elongate topographic depressions formed by the ice streams influence air flow around the dome. Satellite observations suggest this may cause a negative lapse rate (Shuman). Changes in the flow of the ice streams influence the surface elevation of the ice streams and alter the local meteorology, making the local climate of the summit of Siple Dome more influenced by ice dynamics then other deep ice core sites.

On the summit of Siple Dome at 15 kyr there was no firn gas diffusive column (gas isotopes [Severinghaus]), there is irregular stratigraphy (gas isotopes [Severinghaus], optical logger [Price], angular unconformities (multitrack [Taylor) and crystal size [Alley]). The lack of an increase in sea salt and crustal species is inconsistent low precipitation rates (chemistry [Mayewski]). Melt layers are present [Alley]. The air temperature changed ~ 6^{o} C (stable isotopes [White]). It is difficult to say how quickly these changes occurred because there may be a hiatus in the record.

On the summit of Siple Dome at 22 kyr there is no evidence of disturbed stratigraphy (gas age-ice age difference [Severinghaus], physical properties [Alley]). The air temperature changed ~ 6^{o} C, maybe as fast < 50 years (ice [White] and gas isotopes [Severinghaus]).

The deuterium excess (an indicator of conditions in the mid latitude Pacific moisture source area) and chemistry (an indicator atmosphere transport to Siple Dome and conditions over ice free southern latitude land areas) do not change significantly at these times, and there are no corresponding changes in the Byrd ice core that is located only 200 km away.

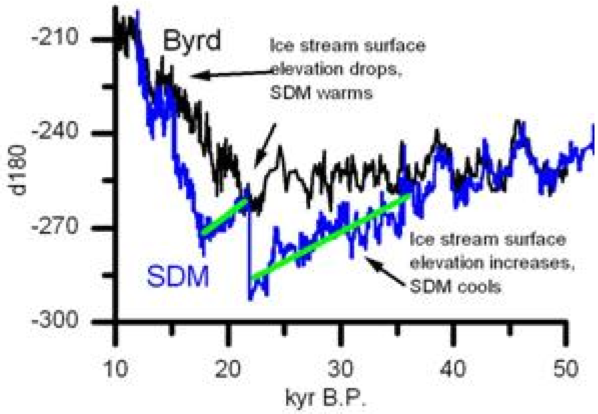
The ^{18}O record from the Mount Moulton ice core, also shows a large short duration excursion around 22.k kyr [White/Popp]. A large dating uncertainty and proximity to a large tephra layer complicates direct comparison to the Siple Dome record. The Taylor Dome record, has a poorly understood low accumulation period around 15 kyr [Steig]. Taken together the ice core record suggests there were at least two significant climate excursions during the deglacial that were expressed most strongly along the Siple coast, with a weaker expression at other coastal sites, and muted response in the interior of Antarctica.

Because the data is difficult to explain as a regional climate change, we consider the following speculative concept to encourage discussion among different disciplines that might lead to a useful interpretation. Between 40 and 22 kya sea level was decreasing and the size of the ice sheets increased. Ice flow in the WAIS adapted to the decreasing sea level by increasing the surface gradient of the ice near the coast. This slowed the Siple Coast ice streams and increased the surface elevation of the ice streams around Siple Dome. If the ice stream was moving at 80% of the steady state rate, the surface elevation would rise at 20% of the ice accumulation rate of ~10 cm/yr. So over a 15,000 year period of consistent sea level change, the ice stream surface could rise by ~ 300m. As the topographic depressions formed by the ice streams were filled in by slow moving ice, the topographic prominence of Siple Dome decreased, altering the local air flow in the Siple Dome region. During this time (40 to 22 kya) the climate at the summit Siple Dome gradually deviated from climate at Byrd in response to the local change in airflow that were forced by the greater thickness of the ice streams.

Beginning at 22 kya orbital forcing started to move the climate from a glacial to interglacial condition. The net flux of water from the ocean to the ice sheet was halted, stabilizing sea level. The ice sheet adjusted to the new boundary condition of a stable sea level by decreasing the surface gradient near the coast. During this adjustment phase the ice streams around Siple Dome accelerated and the thinned. Current ice streams have been observed thin at rates of 3 m/yr, so maybe the ~ 300 m of ice that filled in the ice streams during the period of declining sea levels was removed in a period of ~ 100 years. This would have restored the topographic depressions associated with the ice streams around Siple Dome and lead to the rapid local climate changes recorded in the Siple Dome core. The changes were not observed in the Byrd core because these were a local climate change associated with changes in the ice stream elevations.

The discharge of ice through the ice streams around Siple Dome must have only been a small part of similar events. The large seaward flux of ice might have been sufficient to affect ocean circulation, which may be recorded in marine sediment cores. This is a general concept that will require interaction between the ice dynamics, ice core, marine sediment, and climate modeling community to pursue further.

Between 50 ka and 35 ka the SDM and Byrd core respond the same way. Between 35 ka and 22 ka SDM has a cooling trend caused by thickening ice streams that is not recorded at Bryd. At 22 kya there is a rapid decline in ice stream elevation that restores the air flow patterns around SDM to what they were before 40 kya.



The abrupt changes recorded in the SDM core, shown by the vertical lines along with the dating uncertainty, occur near the start of periods of increasing sea level.