

## CLIMATIC WARMING, GLACIERS AND SEA LEVEL

### (Abstract)

by

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The modern consensus outside of the glaciological community is that "greenhouse" gases, released by human activity, will cause an unprecedented temperature rise over the next 100 years and thereby cause a socially-threatening rise of sea level. With respect to ice the concept is simple: warmer means less. The relationship between glaciers and climate is much more complex than this. Warmer also means more vapour transport and there is ample evidence from both theory and ice-core data that snow accumulation rates in both Greenland and Antarctica were lower during the last glacial period. The problem is whether the increased accumulation rates will be exceeded by increased melting of ice in the ablation areas. Antarctica could play a dominant role because of its size and very low temperatures. Only a small percent of Antarctica will increase its meltwater run-off into the ocean. Furthermore, its dynamic response time is so large that the calving rate will not change over a 200-year period. Most of the increased melt will be absorbed in the firn and the question is how much the snow accumulation rate will increase over the major part of the continent.

In the northern hemisphere one has to consider the way in which the warming will manifest itself seasonally. Most of the "forecasts" indicate that most of the warming will occur in the winter rather than the summer. In this case one has to consider the balance between greatly increased winter snowfall rates and only slightly increased summer melt rates. In this respect a review of the snow accumulation and ice melt rates from different glaciers and ice caps in the Canadian Arctic Islands is pertinent. Over the past 20 to 30 years we see no sign of a trend of either side of the balance equation (accumulation, melt). Is this the effect of high noise levels or is there simply no trend?

Finally, we review the ground-ice potential in terms of sea-level change. Ground ice may not form a large part of the world's ice reserves but it covers a large area. Both increased snowfall rates in winter, and summer warming will move to increase the thickness of the active layer. This will result in run-off to the oceans.

Global circulation models might be modified to determine a "best guess" of future sea-level change. To do this they must incorporate all of the parameters considered in this paper.

## PAST TEMPERATURE RECORD FROM THE ANALYSIS OF MELT FEATURES IN THE DYE 3, GREENLAND, ICE CORE

### (Abstract)

by

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The layered sequences of melt features preserved in inland polar ice sheets provide valuable proxy data on past variations in summer temperature. A continuous detailed light-table examination was made on the 2037 m-deep Dye 3 ice core immediately after core recovery. Melt features are products of high air temperatures or solar insolation which occur only at or near the snow surface during summer months. A correlation is made between these features and the extent and intensity of summer temperatures. Care must be exercised to identify and distinguish between all mm-thick radiation crusts and wind crusts contained in the record. The absence or presence of

these discrete features serve respectively as indicators of total summer cloud cover and the extent of winter storm activity although they are difficult to differentiate from only light-table observations. In this analysis both thin radiation crusts and wind crusts are not in themselves significant indicators of long-term temperature trends, but may serve as incipient subsurface horizons or barrier crusts for the formation of thicker ice melt features caused by downward melt percolation during elevated surface temperature conditions.

More than 10 000 individual melt features, including ice layers, ice lenses and ice wedges (but excluding ice glands)

were measured down to a depth of 1278 m; below this depth transformation of air bubbles to transparent air hydrate inclusions occurs (Shoji and Langway, 1987) and the megascopic melt features become obscure. The melt-feature data extends back to 1883 B.C. or approximately 3900 years B.P., based on the accurate time scale of continuous  $\delta^{18}\text{O}$  measurements (Dansgaard and others, 1985) For the entire core profile investigated the annual melt percentage is 5.7. Individual melt features range in thickness from 1 mm to 100 mm. A mean value for melt-feature thickness was calculated for continuous 30-year time intervals to consider the general long-term summer temperature trends with corrections made for progressive annual accumulation layer thinning due to ice flow.

Since the AMP parameter includes noise from radiation and wind crusts it appears that the simple average of melt-feature thickness per longer time-units is a better indication of air temperature paleodata. The average melt-feature thickness is 1.2 cm. The complete curve obtained shows a higher thickness value of about 1.5 cm for the period

1800 B.C. to 1300 B.C. A lower, almost constant thickness value of about 1 cm is shown for the period 1000 B.C. to 1800 A.D., with a slight reduction in thickness recorded around 200 B.C., 400 A.D. and 1600 A.D. These long-term trends are coherent with those recorded in the  $\delta^{18}\text{O}$  profile for the same ice core.

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## ATMOSPHERIC CHEMISTRY CHANGES OVER THE LAST CLIMATIC CYCLE (180 000 YEARS) INFERRED FROM THE VOSTOK (ANTARCTICA) ICE-CORE STUDY (Abstract)

by

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A 2 200 m-deep ice core from Vostok Station (East Antarctica) has been used for a comprehensive study of a series of ions ( $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{H}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{NO}_3^-$  and  $\text{SO}_4^{2-}$ ) originating from impurities deposited over the whole last climatic cycle (180 000 years) as depicted from the isotopic composition of the ice.

Concentration profiles confirm that both marine and terrestrial aerosol inputs were higher (up to five and 30 times the Holocene values respectively) during cold climatic conditions. Such large variations of marine and terrestrial aerosol concentrations measured in ice mainly reflect global (source strength and atmospheric transport efficiency)

changes, and to a lesser extent local (deposition) changes.

As opposed to these primary aerosols, secondary aerosols or gases ( $\text{HNO}_3$ ,  $\text{HCl}$ ) exhibit more moderate variations. Finally, variations of other minor ions such as  $\text{NH}_4^+$  provide information on the capacity of ammonia to neutralize the natural acidity of the past background atmosphere.

Spectral analyses performed on our chemical profiles (200 samples) exhibit several specific periodicities (around 20 and 40 k year) close to the Earth's orbit tilt and precession frequencies which are discussed in terms of atmospheric response to climatic fluctuations.