Characteristics of electrical conductivity in a shallow ice core at GV7, East Antarctica

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Introduction

Electrical conductivity measured from ice surface has been used as a direct measure of acidity ([H^+]) in an ice core. Fallout of volcanogenic aerosols, especially sulfuric (H_2SO_4), hydrochloric (HCl) and hydrofluoric acids (HF), increases acidity in an ice core. Peaks detected from the electrical conductivity measurement (ECM) can therefore be used as time markers of historically known volcanic eruptions and consequently provide information for depth-age relationship of the ice core and snow accumulation rates at the ice core drilling site. We applied ECM to a 78.43 m-long ice core drilled at GV7, East Antarctica to detect the conductivity peaks produced by volcanic activities and to use them as time markers. During the last ~230 years that the GV7 ice core covered, we could detect the conductivity peaks resulted from the eruptions of Pinatubo (1991 AD), Agung (1963 AD), Tarawera (1886 AD), Krakatau (1883 AD) and Tambora (1815 AD). This study stressed that ECM can be a useful tool for establishing the depth-age relationship in ice core studies.

Study area & Ice core samples

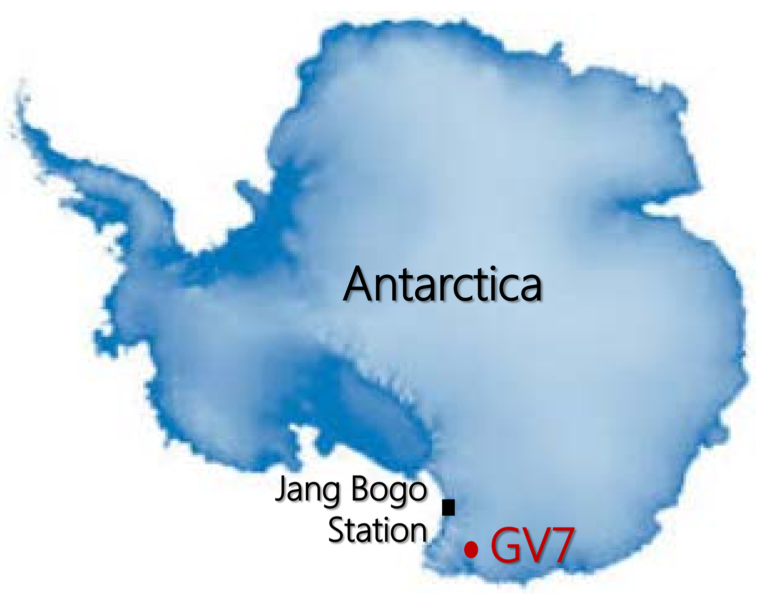


Fig. 1. The GV7 drilling site (70˚41‘S, 158˚52‘E; elevation 1950m).

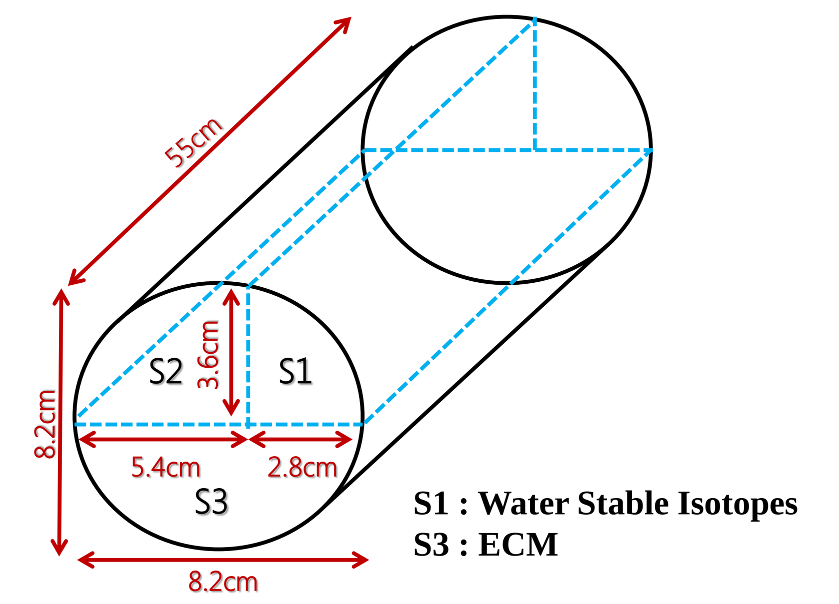


Fig. 2. Ice core sectioning strategy as defined by the GV7 Ice core (Depth: 78.43m).

Method

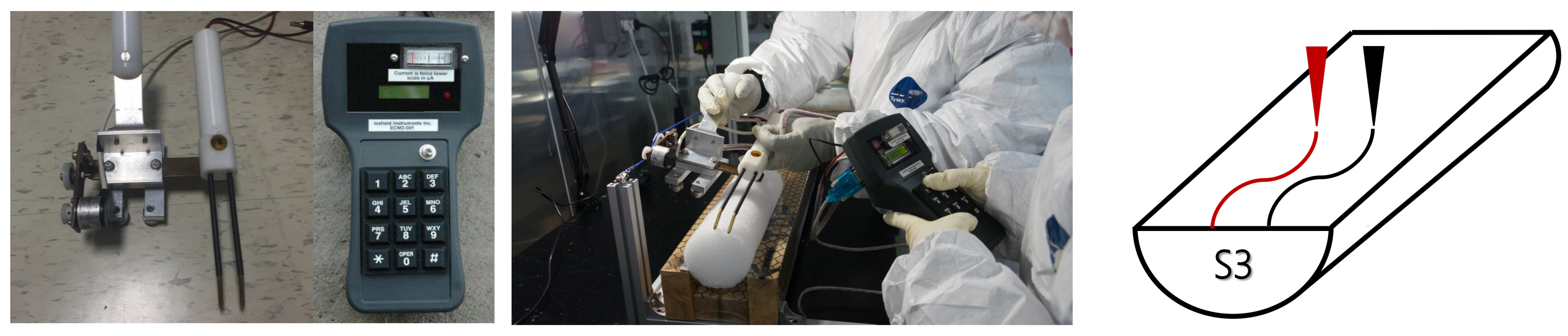


Fig. 3. The ECM instrument used (Portable ECM unit, Icefield Instruments Inc. Canada) consists of two electrodes with 20 mm spacing. Two electrodes are dragged in a zig-zag (to minimize the influence of air bubbles and other causes of poor contact) at voltage of 1000 VDC. A trimming blade used to prepare a fresh, flat surface along the length of the core (measured at -14 ℃ ± 2). It was measured 3 times to calculate the representative values. The spatial resolution of the measurement is about 5 mm.

Results and Discussion

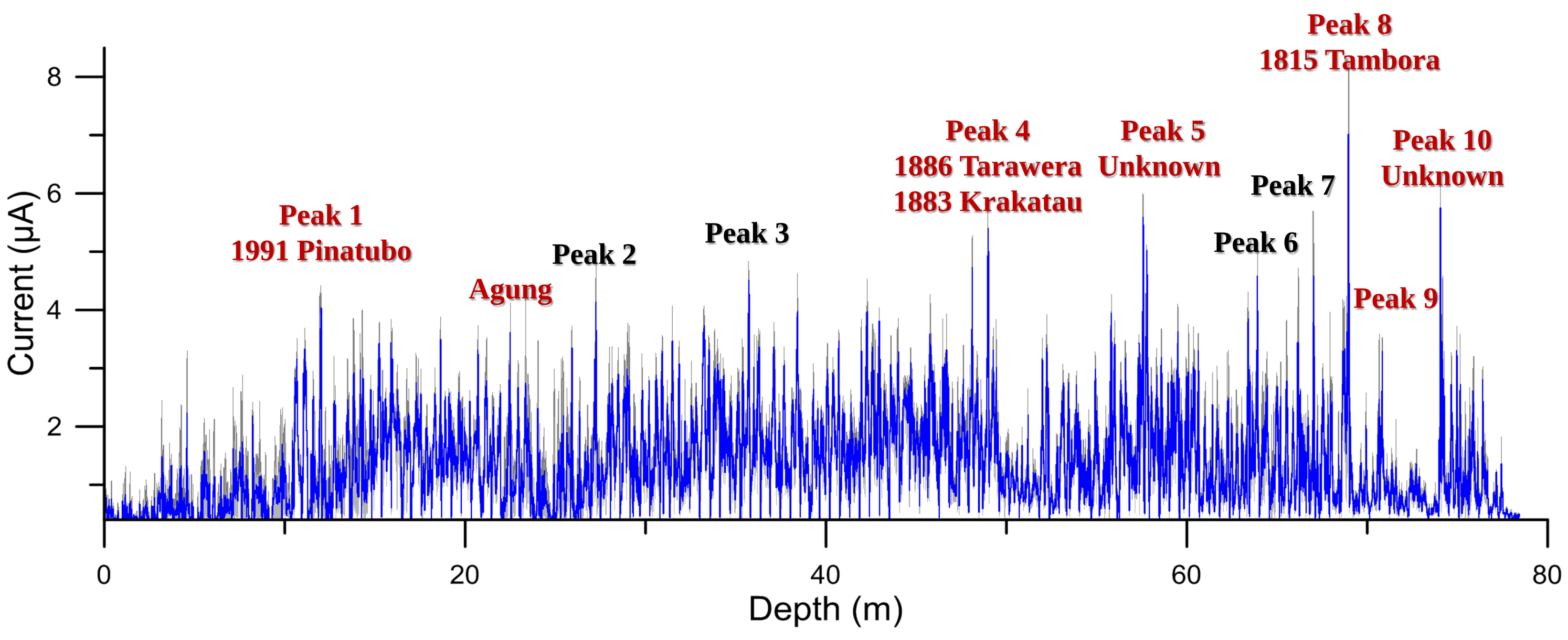


Fig. 4. Electrical conductivity versus depth for the whole core. Shaded line in gray behind the blue line provide an standard deviation of representative values. About 10 volcanic signals appeared in GV7 shallow core. Red peaks are explained below.

Peak 1 - 1991 Pinatubo

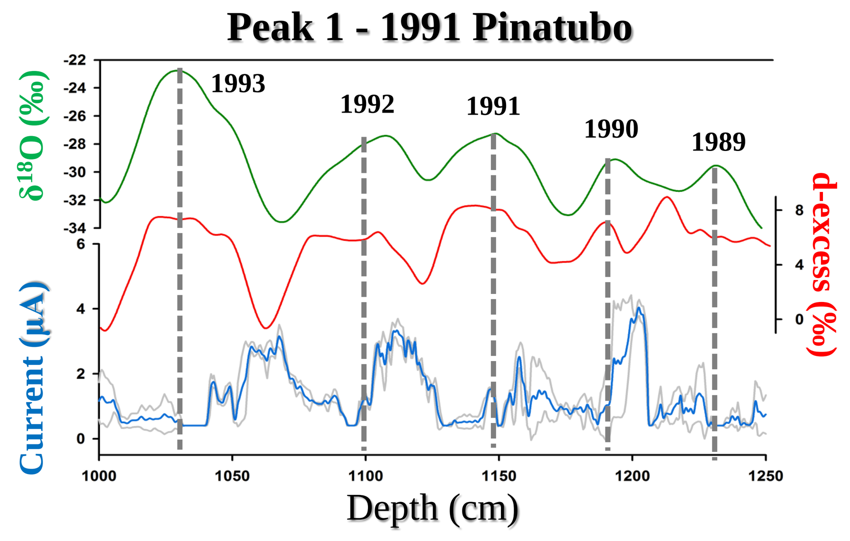


Fig. 5. The eruption of Pinatubo (Volcanic Explosivity Index, VEI 6), Philippines, 1991 AD on 15 June 1991 produced largest terrestrial eruption of the 20th century. Global temperatures dropped by about 0.5 ℃ in the years 1991-93. The peak of Pinatubo appears in 1992-1993 AD which seems to be overprinted by the eruption of the Cerro Hudson, Chile, 1991 AD (VEI 5).

Unclear - 1963 Agung

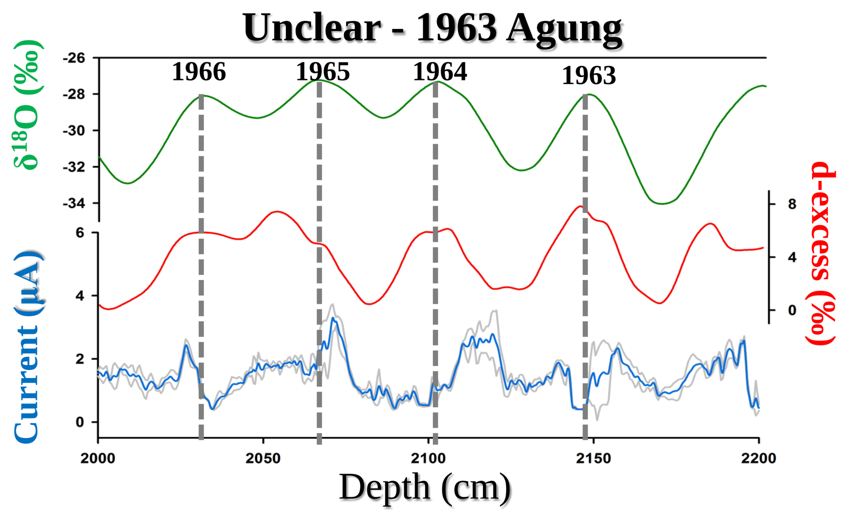


Fig. 6. The eruption of Agung in 1963 is not seen. The absence of conductivity peak was previously documented from other Antarctic ice cores by Watanabe et al., 1999 and Kohno et al., 1996.

Peak 4 – 1886 Tarawera, 1883 Krakatau

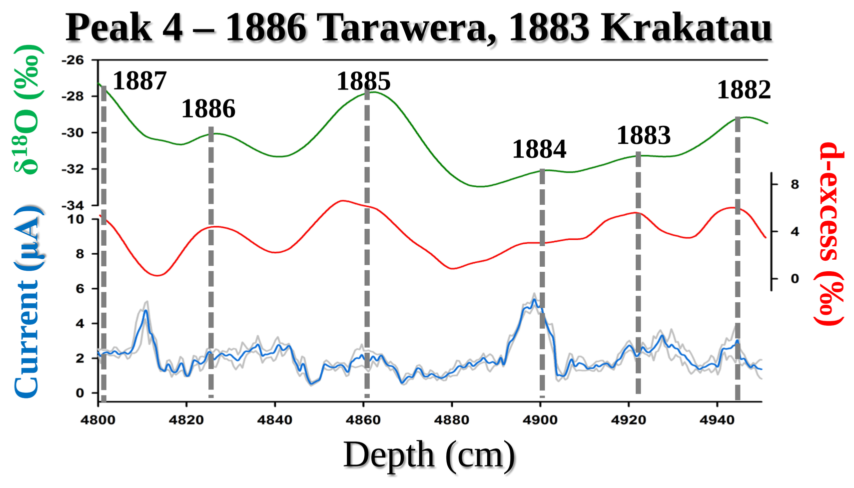


Fig. 7. Peak 4 at a depth of 48 m corresponds to the eruption of Krakatau 1883, Indonesia (VEI 6) and Tarawera, New Zealand (VEI 5). Due to the remoteness of Krakatau, the peak appeared 1 year later after the eruption. In contrast, the lag was less significant for the eruption of Tarawera due to its proximity.

Peak 5 –Unknown peak

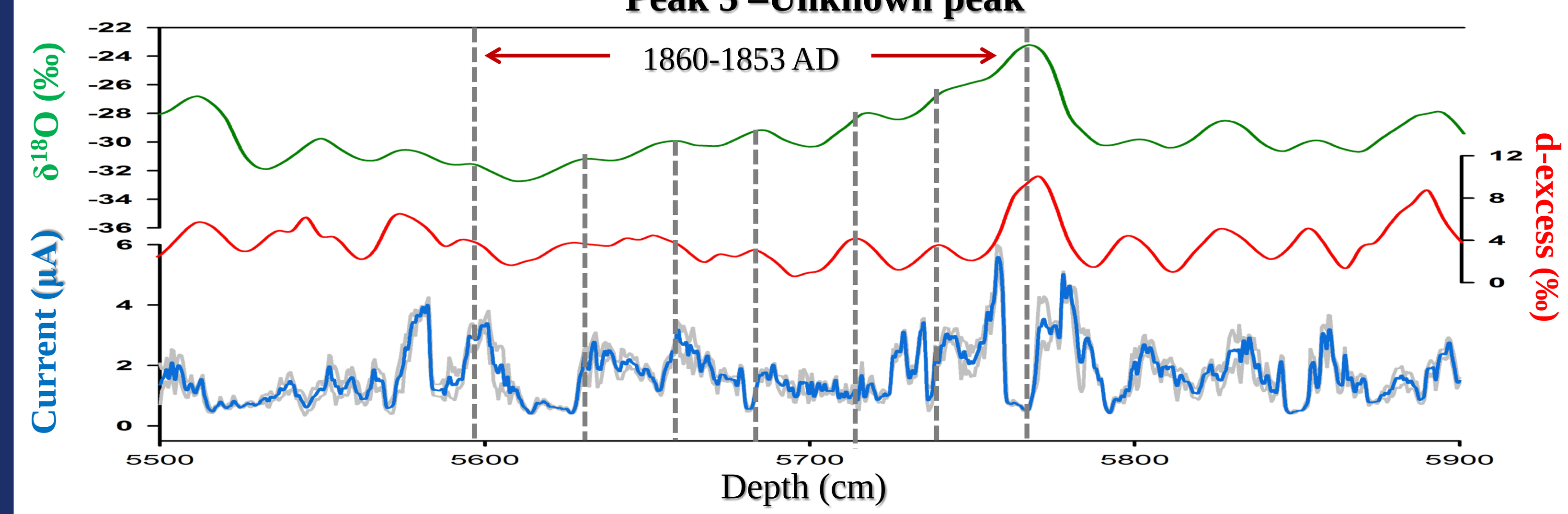


Fig. 8. Oxygen isotope composition ($\delta^{18}O$) and deuterium excess (d-excess) dropped dramatically in 1853-1860AD. The ECM peak 5 appeared in this section. The eruption of Shiveluch located in Kamchatka Krai, Russia in 1854 AD is unlikely the source of the conductivity peak due to its remoteness.

Peak 8, 9 – Tambora, 1810 peak

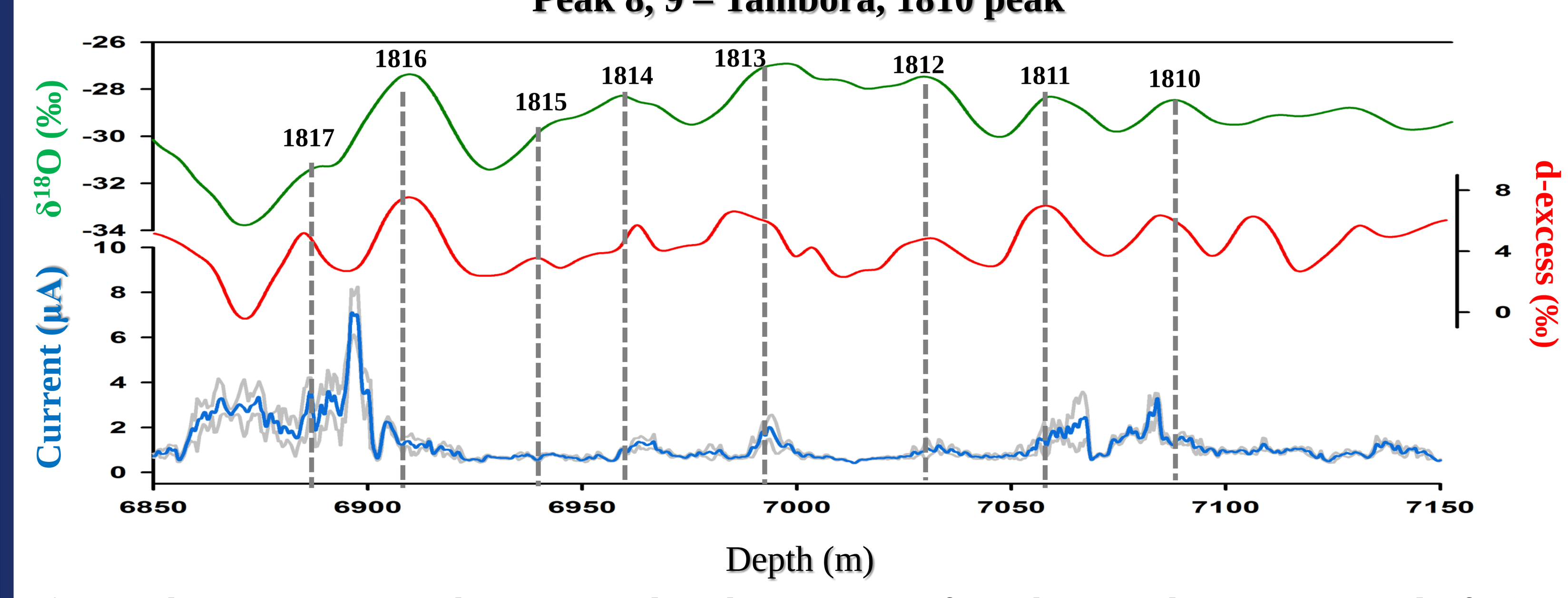


Fig. 9. The 1816-1817 peak is assigned to the eruption of Tambora, Indonesia, in April of 1815 AD with deposition in Antarctica during 1816-1817 AD (**Peak 8**). This eruption was about a VEI of 7, the only unambiguously confirmed VEI-7 eruption since the Lake Taupo eruption in about 180 AD. In addition, it is accompanied by the 1810 unknown peak (**Peak 9**).

Peak 10– Unknown peak

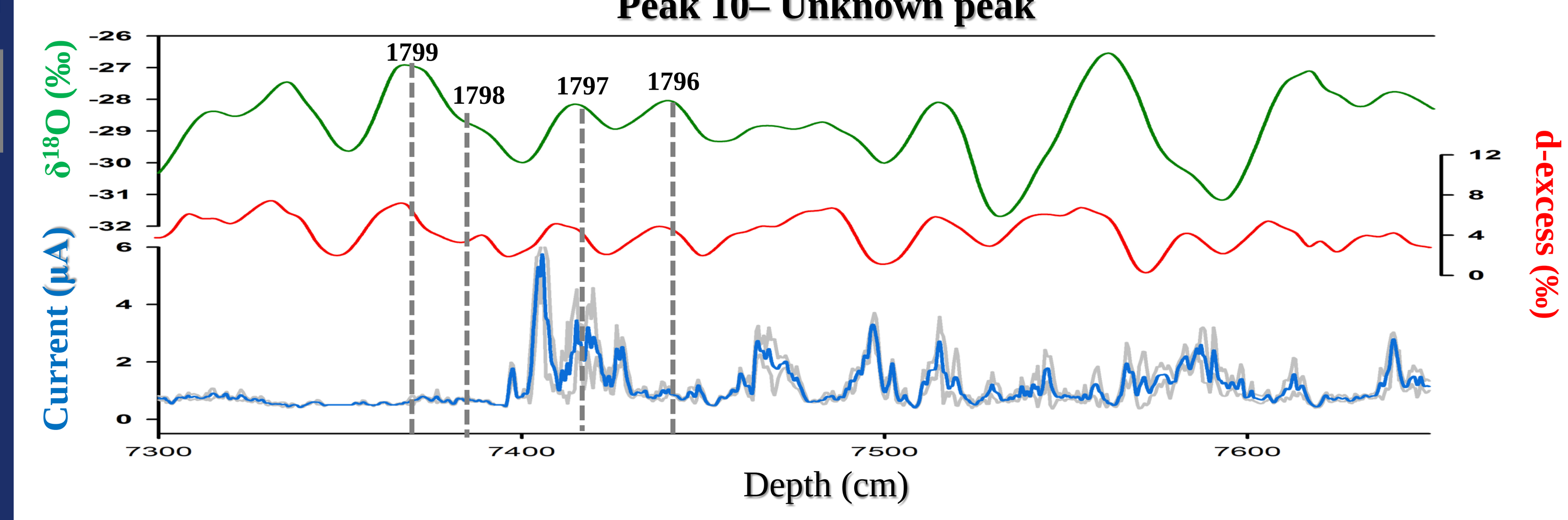


Fig. 10. The large peak in 1797-1798 AD is not listed in the historical records.

Application of ECM to annual layer counting in the ice core

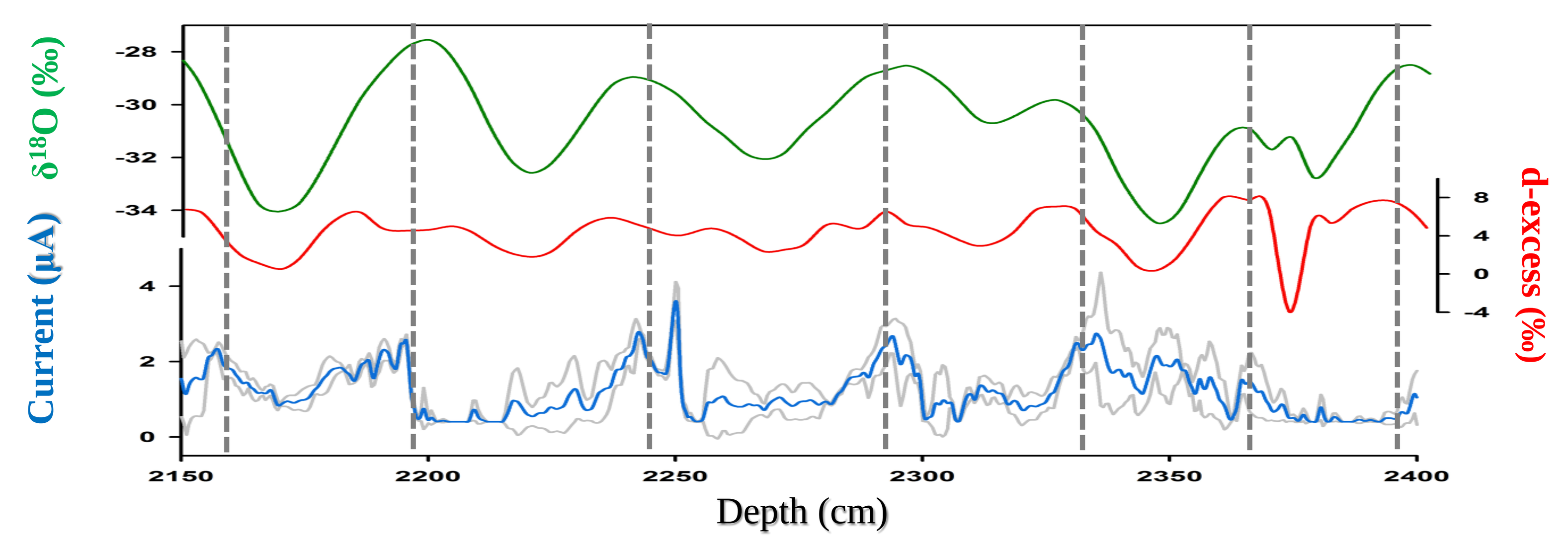
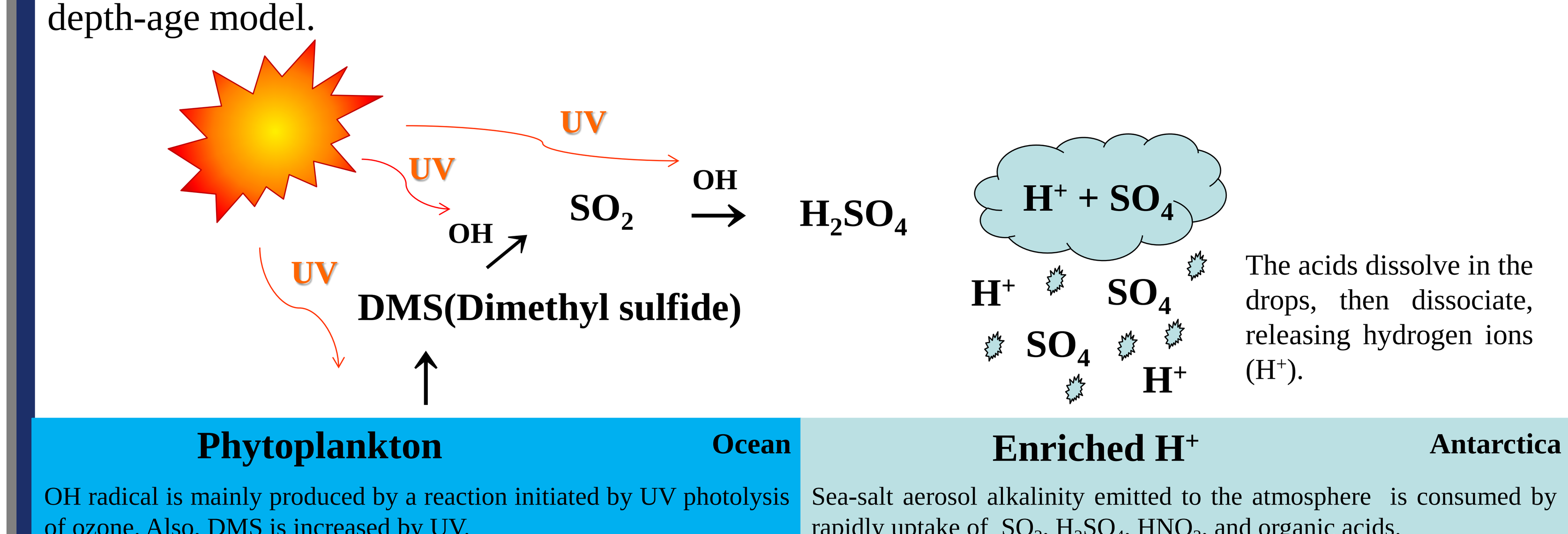


Fig. 11. Seasonal variations in conductivity were observed from some ice core sections. The higher conductivity in summer would be mainly driven by photochemistry that causes oxidations of DMS to SO4. The seasonality can contribute to the annual layer counting for constructing the depth-age model.



REFERENCES

- Kenorick Taylor, Ice-core dating and chemistry by direct-current electrical conductivity, Journal of Glaciology, v. 38, no. 130, 1992
- L.Karlöf, A 1500 year record of accumulation at Amundsenisen western Dronning Maud Land, Antarctica, derived from electrical and radioactive measurements on a 120 m ice core, Journal of geophysical research, v. 105, no. 105, p. 12,471-12,483, 2000.
- Moore, J.C.,, The chemical basis for the electrical stratigraphy of ice, J. Geophys. Res., 97, 1887-1896, 1992.
- H.B. Clausen, C.U. Hammer, A comparison of the volcanic records over the past 4000 years from the Greenland Ice Core Project and Dye 3 Greenland ice cores, Journal of geophysical research, v. 120, no. c12, p. 26,707-26,723, 1997
- Eric W. Wolff, Factors Controlling the Electrical Conductivity of Ice from the Polar Regions-A Summary, J. Phys. Chem. p.101,6090-6094, 1997