Ultra-low electromagnetic resonances and monitoring of the Greenland and Antarctica Ice sheets.

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Monitoring of the total mass of the Greenland and Antarctica ice sheets as a proxy for climate change is in an important task. Different approaches have been and are currently used, but most are based on local measurements, which is their inherent drawback. One of the most successful is radio echo-sounding. The range of applied echo-sounding frequencies is, however, very broad with all exceeding 1 MHz. Recently, another approach has been proposed based on the monitoring of naturally-induced electromagnetic (EM) resonances within the ice sheets. Such resonances can exist because of the peculiar property of the dielectric constant of the ice, which is rather large (on the order of 90) for frequencies below 2 kHz. The large value of the dielectric constant leads to a trapping of incident EM waves within the ice due to total internal reflections at the ice boundaries. These resonances can be excited by the ambient EM field, which at low frequencies is trapped between the Earth and ionosphere and is typically produced by mid-latitude and tropical thunderstorms. Because the spectrum of the ambient EM noise is rather flat, the resonant frequency can be determined from the location of the peak of the intensity of the local EM field as a function of frequency at practically any point in the vicinity of the ice sheet.

Due to the very low frequencies used, only large masses of ice may possess the resonances. Estimates show that the thickness of the ice sheet should exceed roughly 560 m to observe resonant behavior. The conductivity of pure ice at these frequencies is very low. Thus, at ultra-low frequencies, large ice masses behave as natural dielectric resonators. According to our estimates, the lowest resonant frequency of the Greenland ice sheet should be on the order of 625 Hz with a distance between resonances of about 10 Hz. Assuming a rate of ice loss in the Greenland ice sheet of about 100 km^3/year, the rate of variation of the resonant frequencies is expected to be on the order of 10^{-4} Hz/week. In the absence of noise, the detection of such variations will require a record of about 1.5 hours in length. Thus, monitoring the total mass of the Greenland and Antarctica ice sheets on a weekly basis is potentially feasible.

An overview of the proposed method, including recent results and a suggested approach to performing such measurements, will be presented.