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The Barents Sea Ice Edge During the Last Centuries[1]

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1. Introduction

To figure out what is driving the climate change it is vital to observe long climate series.
In this contribution I will report about data collection and analysis of a climate series covering the position of the Ice Edge in the Barents Sea for more than 440 years. A clear sign of planetary forcing is detected, and a model involving the solar wind is suggested. I will present a project where we use a long series of estimates of the position of the ice edge in the Barents Sea to investigate indications of planetary beat. At the conference in October 2019, only provisional results were shown, but since then we have two publications on the topic (Mörner et al. 2020 and Solheim et al. 2021). In the following I will present the data and some results from the analysis together with a simple harmonic model and suggested physical explanation.

1. The dance of the Sun conducted by planets

In the talk of Niklas Mörner (this proceedings) we learned about the Gulf Stream Beat, which changes the stream from a strong Northern Branch to a weaker and at the same time from a weak to a stronger Southern Branch, and how this may be the result of changes in Earth's rotation or length of day. He showed that this beat also exists in sea level changes in equatorial regions and in climate changes as the Little Ice Age and the warm recent era. He explained the changes in rotation as due to variations in the solar wind, which again varies with the solar activity, which is in some way related to the Sun's complicated orbit around our planetary systems center of mass as shown in Figure 1. He concluded forcefully that averages taken over the whole planet, kill the dynamicity, and destroys the information about our planet *which changes on all timescales*.

I have the deepest respect for the great observer of the orbits of the Moon and the planet Mars, Tycho Brahe (1546-1601), from his observatory on Ven between Denmark and Sweden, and the great mathematician Johannes Kepler (1571-1630) who discovered the planets elliptical orbits. The orbital periods of Jupiter are 11.9 years and Saturn 29.5 years. They meet in the sky every 19.9 years. When Jupiter has done 5 revolutions Saturn has done two and they are back in the same direction. This may be the origin of the 60-year cycle seen in many climate series.

The complicated pattern of the solar orbit (Figure 1) was first calculated by Jose (1965), who also related it with sunspot variations. He found that the pattern repeated approximately after about 179 years. This is called the Jose cycle. Charvátová and Hejeda (2014) showed that the solar orbit could be classified in regular (trefoil) periods which lasted about 50 years containing periods of high solar activity, and irregular periods which contain periods of deep minima. We

[1] The talk can be seen here: https://www.youtube.com/watch?v=oH8eYysz8lA (Recorded by Yngvar Engebretsen).

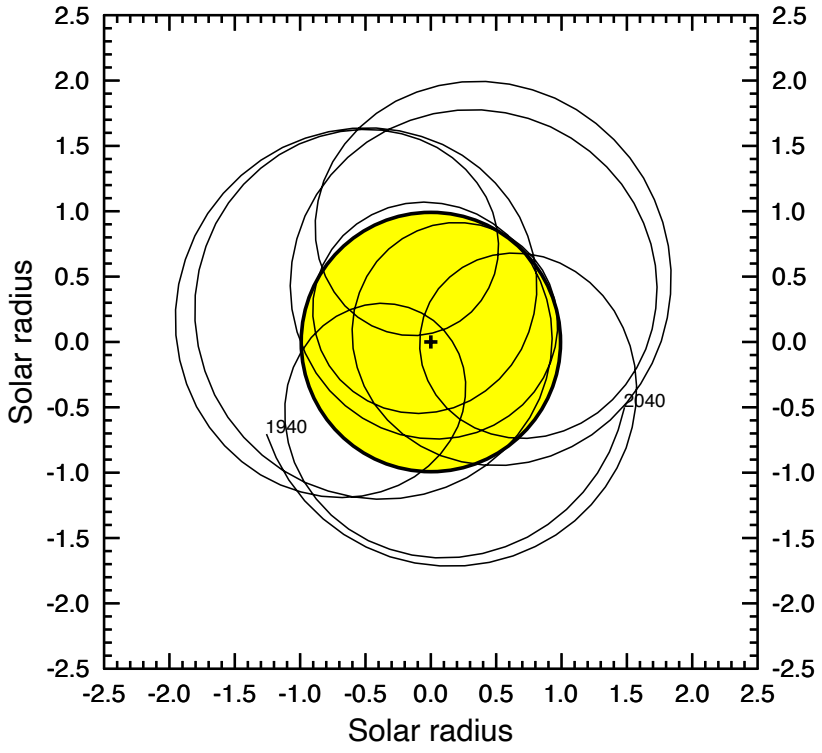

Figure 1, The orbit of the Sun relative to its orbital plane 1940-2040. The solar system barycenter is marked with a cross (+). The size of the sun is indicated by the yellow circle

are now in an irregular period which will last until 2040. Figure 4 in Mörner (2022) shows how planetary beats can lead to climate variations.

2. North Atlantic sea-ice

The west coast of Svalbard was "discovered" by Willem Barents in 1596 who reported rich stocks of seal and whales near the ice edge. A whaling industry started, first with land stations on Svalbard, later pelagic. When the whales went extinct around 1830, seal hunting along the ice edge became the main occupation. The English Muscovy Company operated a trade route to Archangel from 1553. From the hunting, trading, and Arctic explorers, a climatic map is constructed by Ole Humlum (2000) shown as Figure 2. This map shows the maximum sea-ice extent in various periods in addition to climatic events. Special cases aree the period 1660-1720 with ice almost to Scotland and 1769 with maximum ice limit north of Svalbard. Years of extreme weather events and crosses when species disappeared are also shown in the map.

A pioneering work was done by Torgny Vinje (1999) to create a 400-year long time series of the position of the ice edge in the Barents Sea between Svalbard and Frans Josefs Land, later updated by Norwegian Polar Institute (Falk-Petersen et al. 2015 and Solheim et al. 2021). The position is estimated for the two last weeks of August, from ship logs, expedition reports, and in recent time from airplanes and satellites. The completeness of the time series varies from 34 per cent the first 100 years (1579-1678) to 100 % after 1979 with satellite data. The Barents Sea Ice Edge (BIE) position had a southernly position (around 76 °N) in the period 1625-1680 and 1784-1830 and a nearly linear speed north 1890-2020 with 0.035°N per year.

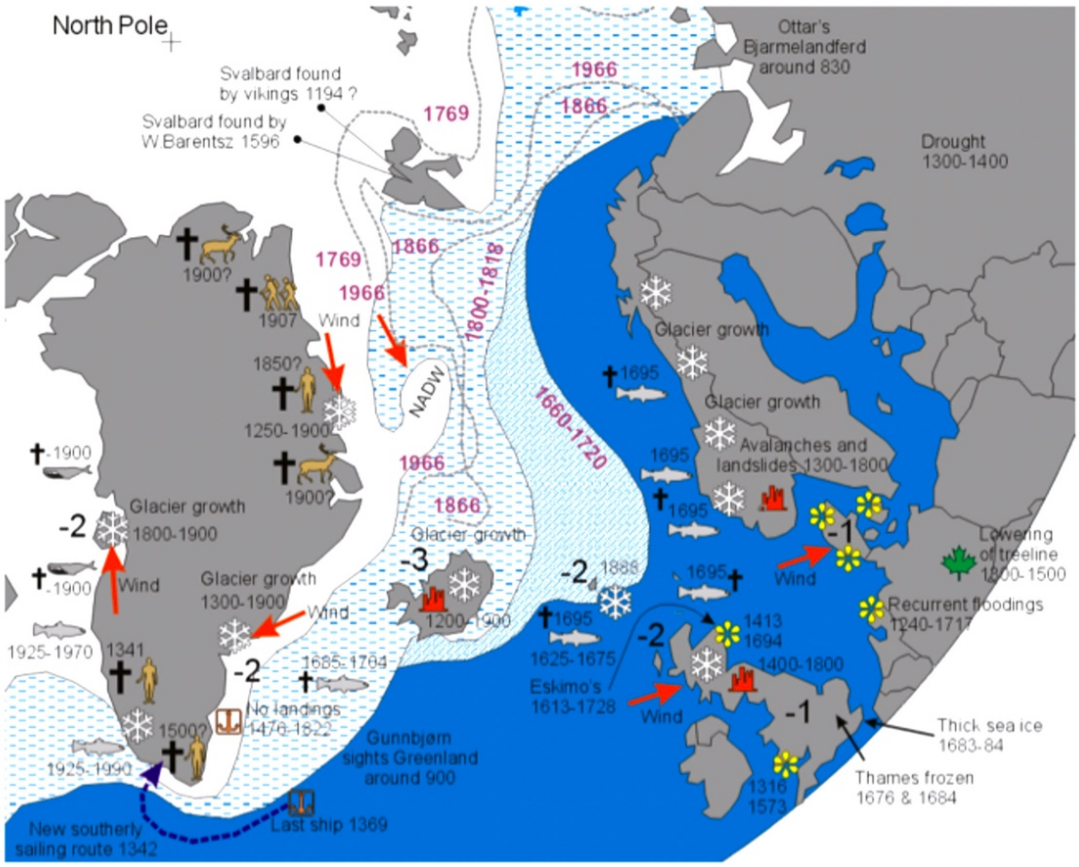

Figure 2. Climate history of Northwestern Europe – with maximum ice cover in certain periods (Humlum 2000).

3. The ice edge position – sign of planetary periods

We have correlated the BIE position series with other climate series for the North Atlantic and northern hemisphere, solar variations, both local and global, and effects integrated in the Earth's rotation. We find that most of the series are correlated. In the longer BIE-series we find planetary orbit fingerprints.

This is shown in Figure 3, where the dots are BIE positions and the red curve is a 4-period harmonic simulation with periods 3, 3/2, 4/5 times the Jose period, plus a 84 year period related to the planet Uranus. Since the periods of the planets are constant over millennia, it means that even small forcings with these periods will repeat for a long time and can create forced oscillations. In addition, some weaker, non-significant shorter periods are shown in black. They are the 60-year and 19.7-year Jupiter-Saturn periods and a 14-year period of unknown origin.

This simple harmonic model explains the almost linear trend since 1890, and a maximum in the 4 periods around 2010. In the following decades this model shows BIE moving south to about 79°N, signaling a colder climate around the North Atlantic. In Figure 3 we have also shown periods when the Gulf Stream beats (GSB) from a strong northern to a strong southern branch (see Mörner's contribution Figure 2). That happens during or after extreme low positions of BIE, which will not take place this century.

4. A suggested relation between solar activity and the BIE position

In Mörner et al. (2020) we suggested that the solar wind can change the Earth's rotation, which again acts on ocean currents which brings heat to the Arctic regions. The solar wind can work directly by pressure slowing the Earth's rotation, or by changing the Earth's shielding capacity

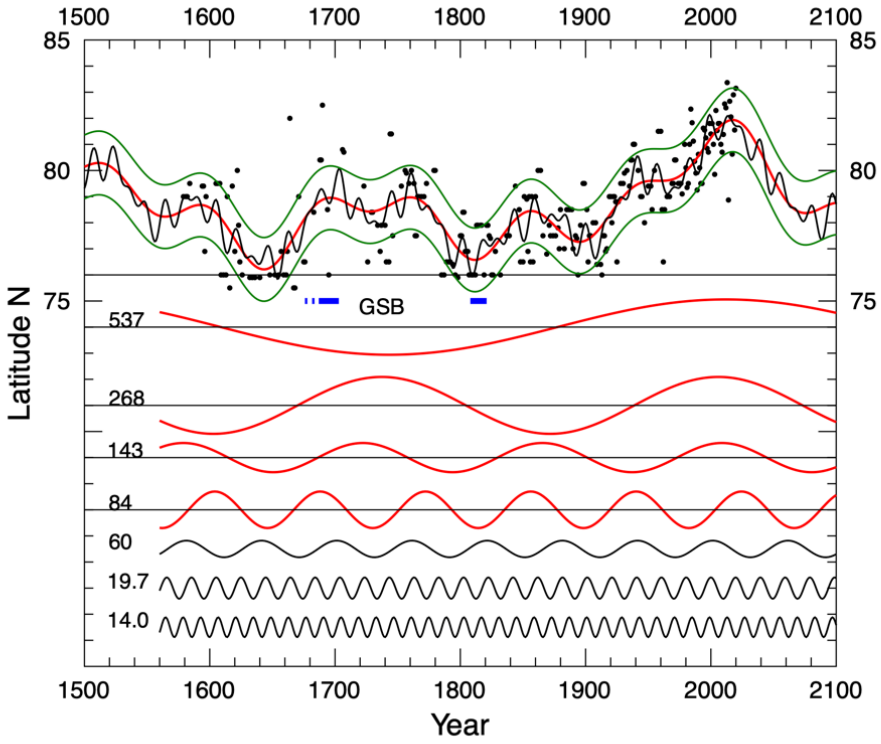

Figure 3.BIE positions with a 4-parameters harmonic model based on planetary periods (red) with uncertainty interval (green). In addition, three weaker periods are shown in black. The various components are shown separately in the lower panel

which protects the Earth against cosmic rays which can increase cloud formation. We also found that electric charges carried with the solar wind can magnetize our planet's iron core and slow the Earth's rotation. This is also modulated with the Jose period (Duhau and de Jager 2012), but with a delay of 94 years.

5. Conclusions

We have analyzed a long series of estimated the ice edge positions in the Barents Sea and found it's variations can be explained by stationary cycles which originate in the planetary system. This may explain the apparent warmer climate the last century and indicates that a change to a colder climate will take place this century.

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