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Aurora borealis and the arctic climate change: is there any relation?

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Abstract

In our study we tested the hypothesis that one of the causes of climate change could also be the recently observed solar hyperactivity, since it differentiates the way clouds are formed. We analyzed, from specific databases, the speed (km/s) and the proton density (p/cm^3) of the solar storms in the atmosphere along with the ambient temperature and the ice extent in the arctic over the last eleven (11) years. Our study indicates indeed an explicit increase of the speed and the density of the solar wind. A not so definite analogy between the temperature's increase and the limitation of the arctic ice extent is also noticed. Yet, the period studied is short to establish a clear relation between the rise of temperature with the enhanced solar activity. A further investigation should be followed, documenting values of more solar activity and climate change parameters during longer periods of recent time to make safe conclusions.

Keywords

Solar activity; aurora borealis; climate change; arctic

Introduction

Patterns of solar irradiance and solar variation have been a main driver of climate change over the millennia to gigayears of the geologic time scale, but its role in the recent warming has been found to be insignificant *(Solar activity and climate, 2020).* At present, the gradual temperature rise of earth has been argued to be a result of the human induced greenhouse effect deteriorating in the past few decades. That being said, one of the causes of climate change could also be the recently observed hyperactivity of the sun *(SpaceWeather.com -- News and information about meteor showers, solar flares, auroras, and near-Earth asteroids, 2020)*, a fact also empirically reflected on the enhanced and more spectacular appearance of aurora borealis. Even now that we are writing these words we learn that during the past two months we have seen the strongest solar flare in years and a profusion of new sunspots *(SpaceWeather.com -- News and information about meteor showers, solar flares, auroras, and near-Earth asteroids, July 2020)*. We know that as these solar winds hit our planet, they are directed from the earth's magnetic field (which acts as a shield to the life lying in between) towards the two poles. That is the cause of the aurora borealis. Furthermore, the Aurora borealis is probably affecting the climate of our planet since it also differentiates the way clouds are formed *(Using Cloud Cover Forecast for Aurora Hunting | Aurora Forecast, 2020)*. The water vapor, the clouds accumulation is one of the factors that could cause rise of atmosphere temperature.

Scientific question and hypothesis

We studied the speculation that the enhanced, compared to previous decades, activity of the sun is partly affecting the climate of our planet. Our hypothesis is based on common sense according to which higher solar energy and by extension, increased heat load reaches our planet and of course the arctic. At the same time, aurora borealis, by affecting the formation of the clouds up in the arctic sky, could help in enclosing increased heat inside our atmosphere layers.

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Methods

We compared the activity of the sun along with the major changes in our climate in the arctic over almost the last decade, from 2009 to 2019. That way we indented to determine and compare any kind of anomaly found on the referred data to the major climate changes. To retrieve the necessary raw data, we used specific databases concerning the activity of the sun and the climate of our planet. These are mainly: the *"Space weather prediction center" (Fig. 1) and "The National Snow and Ice Data Center (NSIDC)" (Climate Change in the Arctic | National Snow and Ice Data Center, n.d.) (Fig.2).* These two databases are based on measurements recorded from satellites of National Aeronautics and Space Administration (NASA). We also visited for temperature data the *"Danish Meteorological Institute (DMI)"* database *(Fig.3).*

a)

b)

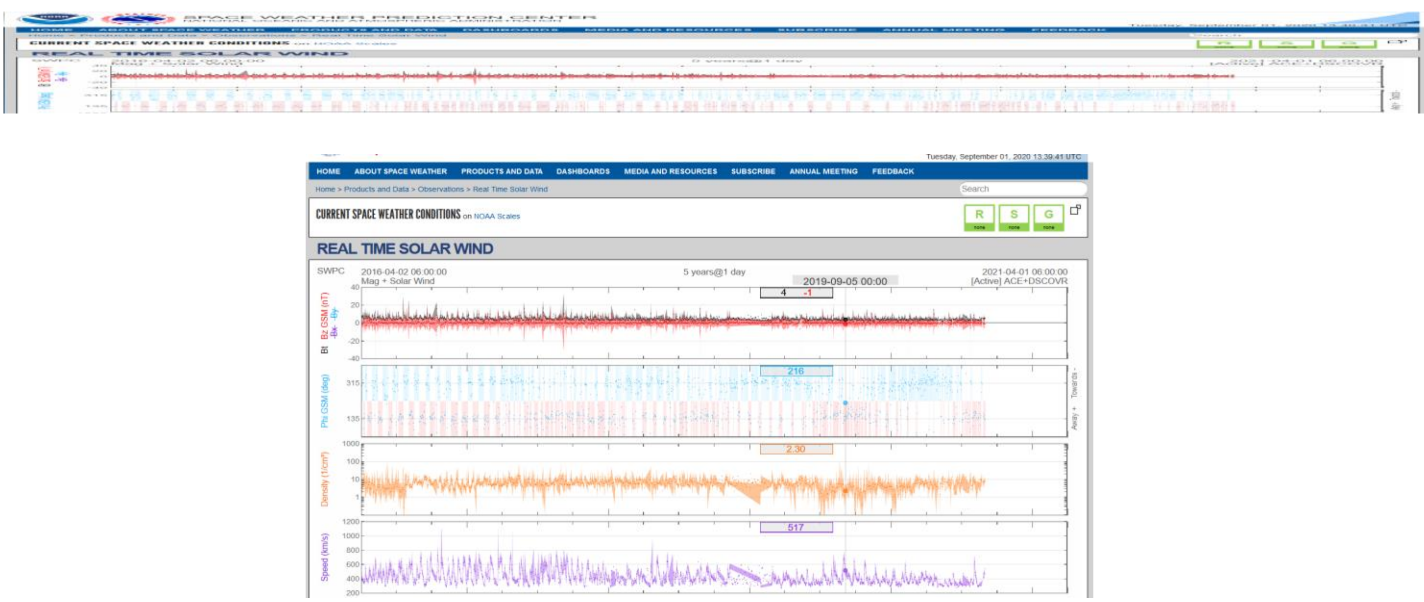
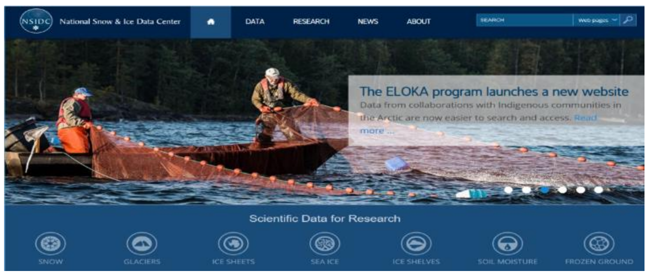


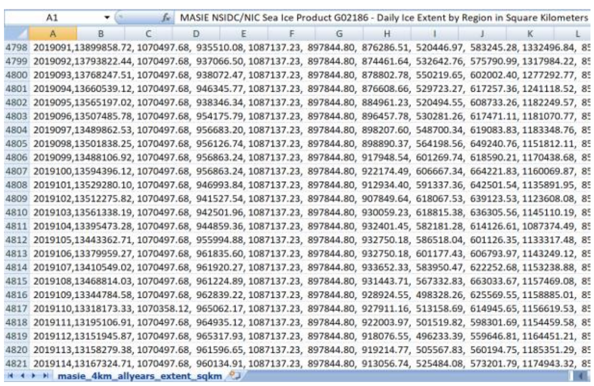
Fig.1: "Space weather": The database from which we retrieved raw data and calculated mean month values of proton density and speed of the solar winds. **a)** left side from the homepage with the link "more data" that lead us to the **b)** real time plot of several solar wind parameters. Moving the cursor across the plot we get daily values of proton density (orange graph) and speed (purple graph).

We analyzed the following specific parameters: **a) proton density (p/cm^3)** (spaceweather” daily data) and **b) speed (km/s) of solar wind** (“spaceweather” daily data) as main indicators for the solar activity *(Council, Sciences and Board, 2013)* along with **c) the sea ice extent (km^2)** (NSIDC data), an index of the ice melting, and **d) atmospheric temperature** north of the 80th northern parallel, T (^{o}C) (DMI data) both indicators for the existing climate change. Temperature is presented in Kelvin (K) in DMI data so we had to reduce it to the more comprehensible for students Celsius (^{o}C) scale values by extracting 273,15 (K) (which corresponds to 0^{o}C) from Kelvin values.

a)



b)



A1 MASIE NSIDC/NIC Sea Ice Product G02186 - Daily Ice Extent by Region in Square Kilometers

	A
4798	2019091,13899858.72, 1070497.68, 935510.08, 1087137.23, 897844.80, 876286.51, 520446.97, 583245.28, 1332496.84, 85
4799	2019092,13793822.44, 1070497.68, 937066.50, 1087137.23, 897844.80, 874461.64, 532642.76, 575790.99, 1317984.22, 85
4800	2019093,13768247.51, 1070497.68, 938072.47, 1087137.23, 897844.80, 878802.78, 550219.65, 602002.40, 1277292.77, 85
4801	2019094,13660539.12, 1070497.68, 946345.77, 1087137.23, 897844.80, 876608.66, 529723.27, 617257.36, 1241118.52, 85
4802	2019095,13565197.02, 1070497.68, 938346.34, 1087137.23, 897844.80, 884961.23, 520494.55, 608733.26, 1182249.57, 85
4803	2019096,13507485.78, 1070497.68, 954175.79, 1087137.23, 897844.80, 896457.78, 530281.26, 617471.11, 1181070.77, 85
4804	2019097,13489862.53, 1070497.68, 956683.20, 1087137.23, 897844.80, 898207.60, 548700.34, 619083.83, 1183348.76, 85
4805	2019098,13501838.25, 1070497.68, 956126.74, 1087137.23, 897844.80, 898890.37, 564198.56, 649240.76, 1151812.11, 85
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4807	2019100,13594396.12, 1070497.68, 956863.24, 1087137.23, 897844.80, 922174.49, 606667.34, 664221.83, 1160069.87, 85
4808	2019101,13529280.10, 1070497.68, 946993.84, 1087137.23, 897844.80, 912934.40, 591337.36, 642501.54, 1135891.95, 85
4809	2019102,13512275.82, 1070497.68, 941527.54, 1087137.23, 897844.80, 907849.64, 618067.53, 639123.53, 1123608.08, 85
4810	2019103,13561338.19, 1070497.68, 942501.96, 1087137.23, 897844.80, 930059.23, 618815.38, 636305.56, 1145110.19, 85
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4815	2019108,13468814.03, 1070497.68, 961224.89, 1087137.23, 897844.80, 931443.71, 567332.83, 663033.67, 1157469.08, 85
4816	2019109,13344784.58, 1070497.68, 962839.22, 1087137.23, 897844.80, 928924.55, 498328.26, 625569.55, 1158885.01, 85
4817	2019110,13318173.33, 1070358.12, 965062.17, 1087137.23, 897844.80, 927911.16, 513158.69, 614945.65, 1156619.53, 85
4818	2019111,13195106.91, 1070497.68, 964935.12, 1087137.23, 897844.80, 922003.97, 501519.82, 598301.69, 1154459.58, 85
4819	2019112,13151945.87, 1070497.68, 965317.93, 1087137.23, 897844.80, 918076.55, 496233.39, 559646.81, 1164451.21, 85
4820	2019113,13158279.38, 1070497.68, 961596.65, 1087137.23, 897844.80, 919214.77, 505567.83, 560194.75, 1185351.29, 85
4821	2019114,13167324.71, 1070497.68, 960134.91, 1087137.23, 897844.80, 913056.74, 525484.08, 573201.79, 1174943.32, 85

masie_4km_allyears_extent_sqkm

Fig.2: The National Snow and Ice Data Center (NSIDC), the database from which we retrieved daily data and calculated mean month values of ice extent on the arctic. **a)** the homepage, **b)** an example of raw data: we retrieved daily measurements of the northern hemisphere. Column A shows the date and column B the daily measurements. The other columns present data from separate arctic regions.

We calculated mean values, from the daily recorded measurements (raw data) of these specific parameters for March and September of each year from 2009 to 2019. We selected March because it is the month with the biggest coverage of ice extent along with very low arctic temperatures and September because it is the month with the smallest ice extent on the north pole along with still high temperatures of each year.

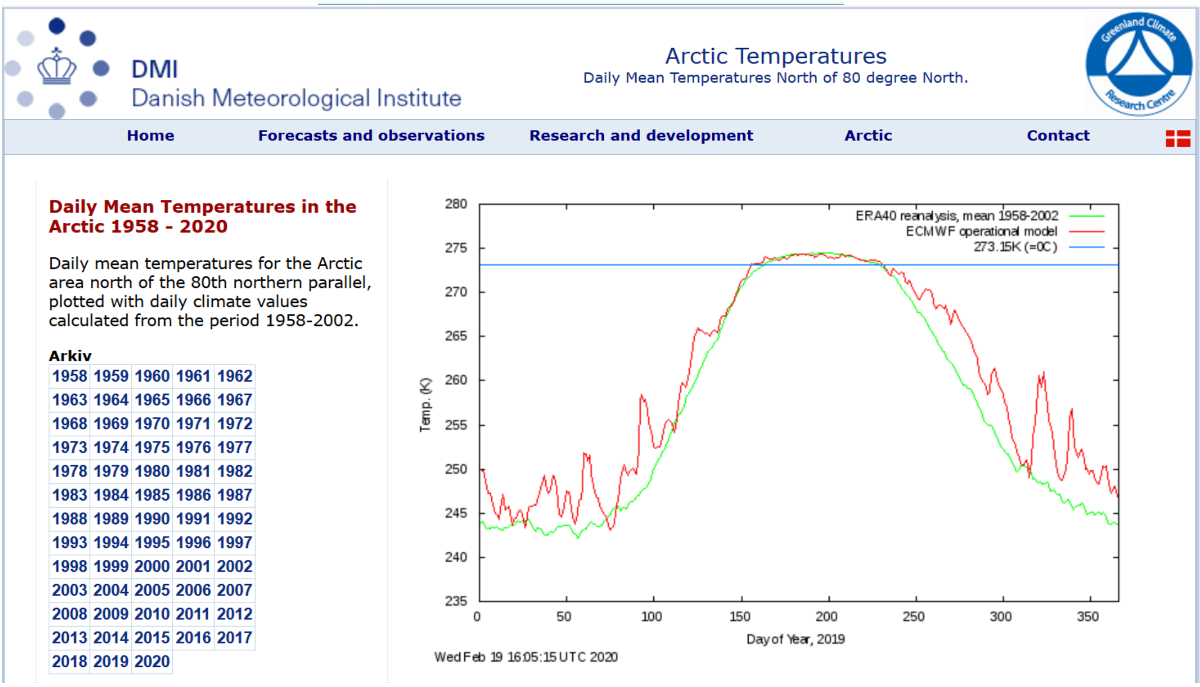

Fig. 3: The Danish Meteorological Institute (DMI) (http://ocean.dmi.dk/arctic) which presents daily data for arctic air temperature north of 80^{o} latitude. Each year is presented in a separate plot. This one shows 2019 temperatures (in Kelvin).

Results

Mean values, out of daily – raw measurements, of March and September of each year from 2009 to 2019 are presented in Table 1, but also in Graphs 1 and 2. These plots reflect the mean values of March and September per year shown in the Table. We present them in order to make our results more comprehensible. There is an explicit increase of the speed and the density of the solar wind, especially after 2013, with few exceptions: speed in March 2014, in March 2019, in September 2016, 2017 and proton density in the last 3 years during September. We can see a rather clear analogy between the increment of the ambient arctic temperature and the reduction of the ice extent in the northernmost region of Earth: both the maximal (mainly) and minimum temperatures have been rising while at the same time, the maximal ice extent (March) has been diminishing, with an exception in the last 3-4 years.

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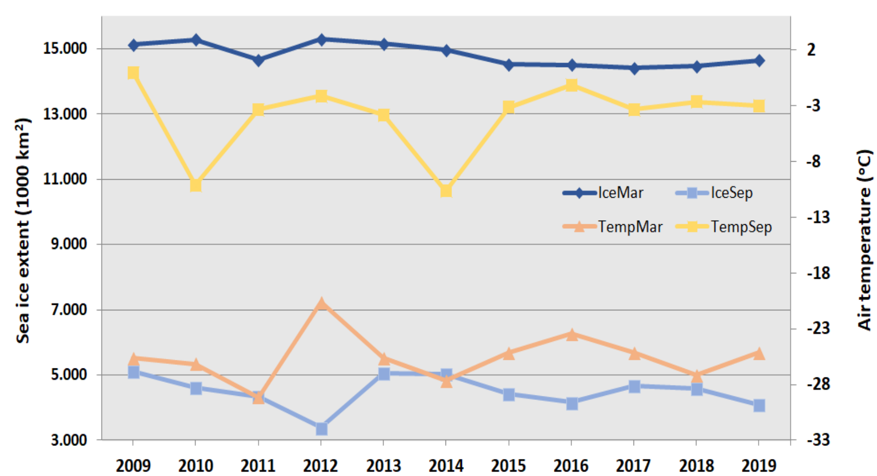
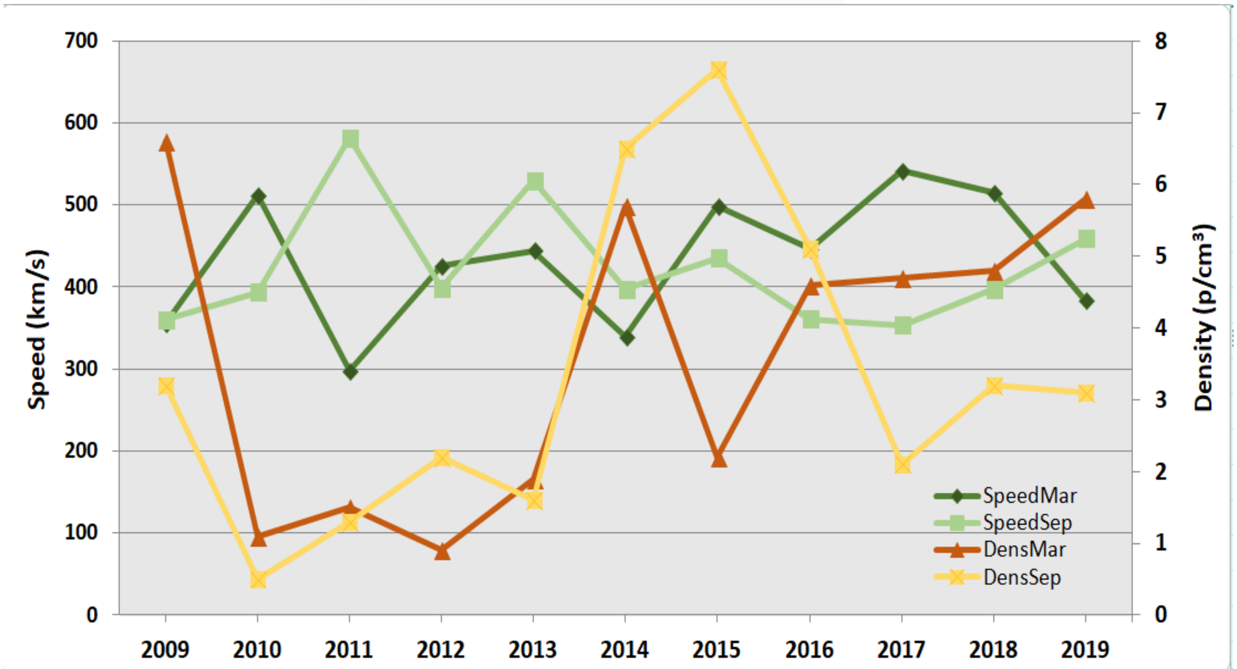
	Climate				Solar activity			
	Ice extent (1000 km^2)		Temperature (^oC)		Speed (km/s)		Density (p/cm^3)	
Year	**Mar**	**Sep**	**Mar**	**Sep**	**Mar**	**Sep**	**Mar**	**Sep**
2009	15.136	5.119	-25,7	-0,1	355,8	360,2	6,6	3,2
2010	15.283	4.615	-26,2	-10,2	511,9	393,6	1,1	0,5
2011	14.667	4.344	-29,2	-3,4	297,4	581,4	1,5	1,3
2012	15.294	3.387	-20,7	-2,2	426,3	398,6	0,9	2,2
2013	15.167	5.054	-25,7	-3,9	444,5	529,7	1,9	1,6
2014	14.964	5.029	-27,7	-10,7	339,2	397,1	5,7	6,5
2015	14.517	4.433	-25,2	-3,2	498,2	435,3	2,2	7,6
2016	14.507	4.165	-23,5	-1,2	447,1	361	4,6	5,1
2017	14.406	4.665	-25,2	-3,4	541,8	353,6	4,7	2,1
2018	14.475	4.594	-27,2	-2,7	515,7	397,2	4,8	3,2
2019	14.652	4.102	-25,2	-3,0	383,5	459	5,8	3,1

Table 1: Monthly mean values of climate change and solar activity parameters during September and March of each year from 2009 to 2019: ice extent coverage (blue columns), air temperature in the arctic (orange), speed (green) and density (orange-yellow) of solar wind



Graph 1: Maximum-minimum ice extent coverage (blue curves, left Y axis) of the north hemisphere and air temperature in the arctic (yellow-orange curves, right Y axis) during the time period 2009 - 2019



Graph 2: The speed (green curves, scale on the left Y axis) and the proton density (red and yellow plots, right Y axis) of the solar winds hitting the earth during the time period 2009 - 2019

Discussion

Our study could be characterized as a pilot one. We demonstrated the well known by the scientific community decreased ice extent especially on September values. Analysing the measurements, we were astonished by the enormous speed of the protons running inside the solar wind to space: higher than 300km/s. Of course, that still is 1000 times lower than the speed of light which is the maximum one in our universe.

We show that there could be a relation between solar hyperactivity and our planet's climate change since proton density and speed show a parallel boost starting in 2012. This does not mean that there is a cause and effect interaction since we found exceptions in this solar activity boost. Even more importantly, human activities and consumerism are considered, by the scientific community, to be the major factors of temperature's increment. At the same time, the period studied is quite short to establish clear interaction between the rise of temperature with the enhanced solar activity.

A further investigation should be followed including previous decades measurements plus documenting few more parameters in order to make out safe conclusions: velocity of coronal mass ejections (Km/s), atmosphere's radiation of solar storms (KHz), strength of the magnetic field in the north-south direction of the earth (Bz), frequency (nights/year) of the northern lights in parallel with ground surface temperature in the arctic (^oC), rise of the arctic sea level (mm), permafrost area (km^2). Furthermore, it is a debate if mean values or extreme ones (or even both) of the selected parameters should be considered in a future research.

We know that the Cosmics Leaving Outdoor Droplets (CLOUD) in CERN is an experiment indented to study the possible link between galactic cosmic rays and cloud formation *(CLOUD | CERN, 2020)*. Its results could also contribute much to our fundamental understanding of solar activity and climate interaction.

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