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Variations in tree ring stable isotope records from northern Finland and their possible connection to solar activity

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Abstract

Within a project on climate in Europe during the past few hundred years we have collected a record on stable isotope ratios $^{13}C/^{12}C$ and $^{18}O/^{16}O$ in tree ring cellulose from pine trees in northern Finland. The records cover the time interval 1600–2002 AD and have an annual time resolution. The carbon stable isotope record from northernmost Finland correlates quite strongly with local growth period temperature. Statistical analysis of the carbon and oxygen stable isotope records reveals variations in the periods around 100, 11 and 3 years. A century scale connection between the $^{13}C/^{12}C$ record and solar activity is most evident. These results based on stable isotope records support previous evidences of a centennial solar-climatic link obtained for northern Finland using tree ring data.

Introduction

Global warming, which has a potential impact on many aspects of life, strengthens the need to quantify changes of regional and global climate in the past. For this reason reliable data on a large spatial scale extending as far back in time as possible is required. Since widespread instrumental data are only available for about the past century, we need proxy climate indicators to yield insights into past long-term climate variations (e.g. lake sediments and ice cores). Tree rings is one of the best of several existing natural archives providing annually resolved information on climate for up to thousands of years. Tree ring can be used to measure several proxy indicators e.g. ring width, density, and stable isotope composition. Biological and physical processes determine natural variations of carbon stable isotope $^{13}C/^{12}C$ ratios in organic matter during photosynthetic uptake of CO_2 from the air (Farquhar et al., 1982). The stable isotopes of oxygen $^{18}O/^{16}O$, on the other hand, are determined by isotopic composition of source water to the tree, evaporation effects in tree leaf and biochemical steps during cellulose synthesis (Roden et al., 2000; Sternberg et al., 1986). These processes in turn are influenced by local climatic and environmental conditions. Thus records of these isotope ratios in tree rings can serve as climatic proxies. Compared to ring-width stable isotope ratios in tree rings have the advantage that they need not to be age detrended due to growth related non climatic trends and thus they can contain information also in the low frequency domain (Gagen et al., 2008). Stable isotope analysis has been successfully used for investigation of different climatic parameters over various geographical areas in the past (Rafalli-Delerce et al., 2004; Barber et al., 2004; Masson-Delmotte et al., 2005; Szchepanek et al., 2006; Treydte et al., 2006; Reynolds-Henne et al., 2007; Gagen et al., 2007; Kirdyanov et al., 2008; Etien et al., 2008; Tardif et al., 2008).

Four hundred year long annual records of stable isotope ratios of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) in tree rings covering the period (AD 1600–2002) were measured from Scots pine (Pinus sylvestris L.) from sites in northern and eastern Finland (Hilasvuori et al., 2009). The present work is devoted to analysis of the obtained $\delta^{13}C$ and $\delta^{18}O$ records from northern Finland. These series are of importance because northern Fennoscandia (65–70°N) is a geographic region close to the auroral oval and remote from areas of intensive volcanic activity. Therefore, it is particularly convenient for investigation of a possible relationship between space weather anomalies and climate. Our previous research showed that a solar-climatic link could be detected from tree ring width records from northern Fennoscandia (Ogurtsov et al., 2002a).

Section snippets

Stable isotope $\delta^{13}C$ and $\delta^{18}O$ records from northern Finland

Records of stable isotope ratios of carbon and oxygen obtained using tree rings from Kessi (northern Finland, 68° 56′ N, 28° 19′ E) are shown in Fig. 1. The isotope ratios were measured from extracted tree ring cellulose and expressed using the conventional δ (delta) notation, where isotope ratios are expressed as relative deviation from the international standards VPDB for carbon and VSMOW for oxygen. A detailed description of the material, the methods used and the reliability of the data…

Spectral properties and periodicities of $\delta^{13}C$ and $\delta^{18}O$ records from northern Finland

In order to analyze the spectral content of the different records and their evolution in time, we used both Fourier and wavelet approaches. The Fourier transform can evaluate only the average power of the data sets at a given frequency, and it is impossible to trace the variation in spectral content through time. The wavelet transform differs from the Fourier one in that the analyzed signal is decomposed not into infinite sinusoidal harmonics but into a number of orthogonal waves of solyton…

Conclusions

The carbon stable isotope record from Scots pine in northern Finland reflects summer temperature quite precisely and reliably. Throughout the 20th century it correlates with instrumental July temperature better then reconstructions based on ring width data. This record also contains apparent long-term trends and thus preserves low-frequency variability, which often is suppressed in tree ring width proxies due to standardization procedure. The relation between the oxygen stable isotope record…

Acknowledgements

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References (38)

K.R. Briffa
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M. Gagen *et al.*
Do tree ring $\delta^{13}C$ series from Pinus sylvestris in northern Fennoscandia contain long-term non-climatic trends?
Chemical Geology (2008)

A.V. Kirdyanov *et al.*
Climate signals in tree-ring width, density and $\delta^{13}C$ from larches in Eastern Siberia (Russia)
Chemical Geology (2008)

M. Leuenberger
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Solar activity during the last 1000 yr inferred from radionuclide records
Quaternary Science Reviews (2007)

J.S. Roden *et al.*
A mechanistic model for interpretation of hydrogen and oxygen ratios in tree-ring of cellulose
Geochimica et Cosmochimica Acta (2000)

J.C. Tardif *et al.*
Tree rings, $\delta^{13}C$ and climate in Picea Glauca growing near Churchill, subarctic Manitoba, Canada
Chemical Geology (2008)

V.A. Barber *et al.*
Reconstruction of summer temperatures in interior Alaska from tree-ring proxies: evidence for changing synoptic climate regimes
Climatic Change (2004)

J. Beer *et al.*
Solar variability traced by cosmogenic isotopes

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Cosmic rays, clouds and climate
Science (2002)

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Assessing the signals of the Hale solar cycle in temperature proxy records from Northern Fennoscandia
2020, Advances in Space Research

> *Citation Excerpt :*
> …Since physics of GCR-climate link has not been established reliably, we cannot exclude completely that the ca 22-year periodicity in NF climate has a pure natural origin and is independent of the corresponding change of solar activity. A potential link was shown between Northern Fennoscandian temperature and the Sun's activity over the Hale time scale, in addition to the previous evidence obtained at century-scale (Ogurtsov et al., 2001, 2011, 2013) and millennial-scale (Helama et al., 2010), reinforcing the views that solar activity has likely played an important role in affecting the NF climate history. The obtained results show also that the climatic imprints of the double solar cycle are not only a local/regional feature of Northern Fennoscandia but are likely manifested in climatic variability of larger, from synoptic to even hemispheric scales.…

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Decadal and multidecadal natural variability in European temperature

2020, Journal of Atmospheric and Solar-Terrestrial Physics

Citation Excerpt :

…Protracted cold periods in Scotland during Maunder and Spörer solar minima of the LIA were documented by Rydval et al. (2017) on the basis of tree rings. In Fennoscandina, solar connections to temperature were documented on centennial to millennial-scales (Haltia-Hovi et al., 2007; Karlén and Kuylenstierna, 1996; Sejrup et al., 2010), some referring specifically to summer (Ogurtsov et al., 2011, 2017; Zawiska et al., 2017) and spring (Helama and Holopainen, 2012). Similar solar forcing on temperatures was suggested for Iceland (Hanna et al., 2004; Moffa-Sanchez et al., 2014; Reynolds et al., 2016)….

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2018, Journal of Atmospheric and Solar-Terrestrial Physics

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North Atlantic sea surface temperature, solar activity and the climate of Northern Fennoscandia

2017, Advances in Space Research

Citation Excerpt :

…In addition century-scale (55–140 year) cyclicity, likely of solar origin, has been reported in reconstructed summer temperatures over Lapland (68–70°N, 20–29°E) and Northern Fennoscandia (67–70° N, 19–33°E) during the last millennium (Ogurtsov et al., 2001, 2002, 2013). These tree ring based evidence for century-scale relationship between solar activity (SA) and the climate of Fennoscandia has further been confirmed by an analysis of the 13C record obtained from Kessi area in North Finland (68.56°N, 28.19°E) (Ogurtsov et al., 2011). Kobashi et al. (2011)revealed 210 yr and 87 yr solar cycles in Greenland surface temperature over the past 4000 years….

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2015, Dendrochronologia

Citation Excerpt :

…In order to evaluate the stability of the climate/tree-ring isotopic ratio over time, a few studies followed the evolution of the correlation between climatic parameters (temperature, relative humidity or precipitation) and isotopic series (δ13C and/or δ18O) over the periods when reliable measured data are available. Attempts were made to assess the relationship between isotope ratios and climatic parameters with the centred moving average method (Aykroyd et al., 2001; Etien et al., 2008; Haupt et al., 2011; Ogurtsov et al., 2011; Reynolds-Henne et al., 2007; Seftigen et al., 2011). These studies have found losses of correlation through time, which vary depending on the isotopes used and the various climatic parameters selected….

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2015, Dendrochronologia

Citation Excerpt :

…The power spectrum analysis reveals that the major periodicities are concentrated on 5, 11, and 102–103a cycles at the 99% confidence level. The 102–103a cycle is close to the quasi-70–100a cycle (Gleissberg cycle) (Eddy, 1977) of solar activity, which has been found in extensive geological records (Gou et al., 2010; Ogurtsov et al., 2011). The quasi-200a and quasi-100a cycles are notable in research on global temperature of the last millennium….

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