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Methane Sulphonic Acid trend associated with Beryllium-10 and Solar Irradiance

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Abstract:. The solar activity has been propose as one of the main factors of the climatic variability. Also another type of processes, the biological ones, have been proposed as important factor in the climatic variation through the modification of the cloud albedo. In the present work we used the wavelet analysis to investigate the relation between the polar concentrations of Methane Sulphonic Acid (MSA), that is a product of marine seaweed and total solar irradiance (TSI) and Beryllium 10, an isotope that forms in the atmosphere and is a proxy of the cosmic rays. We found that the MSA presents in the 11 years sunspot cycle a negative correlation with the TSI and a positive correlation with Beryllium-10. Moreover, the Beryllium-10 presents a positive correlation with the MSA at 22 years.

Introduction

Solar radiation is the fundamental source of energy that drives the Earth's climate and sustains life. Due to the small change in TSI along the solar cycle, other solar-related phenomena have been explored in the context of the climate, in particular cosmic rays.

Cosmic rays are the main source of atmospheric ionization in the low marine atmosphere. Clouds have a major impact on the heat and radiation budget of the atmosphere through the albedo, however to form a cloud, water vapour requires a condensation nucleus on which to condensate.

The DMS concentration is controlled by the phytoplankton biomass and by a web of ecological and biogeochemical processes driven by the geophysical context . According to other authors the major source of CCN over the oceans is Dimethylsulphide (DMS). It has been proposed that DMS produced by planktonic algae in seawater, could change the Earth's radiation budget5, dimethylsulfoniopropionate in phytoplankton cells is released into the water column where it is transformed into DMS.

DMS diffuses through the sea surface to the atmosphere where it is oxidized to form SO_2; this compound can be oxidized to H_2SO_4 that forms sulphate particles which act as CCN.

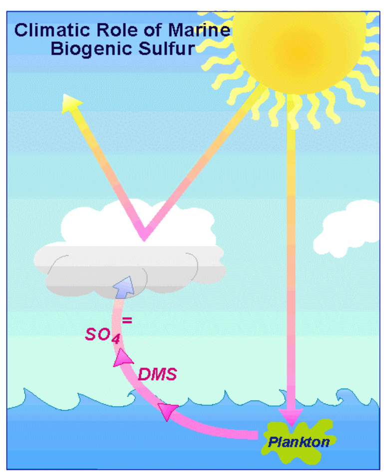

Figure 1. Hypothesized a climate feedback link where changes in cloud albedo and subsequent changes in surface temperature and/or solar radiation below clouds could affect the production of DMS by marine phytoplankton.

Data and Results

As the highest concentrations of DMS are in high latitude regions of both hemispheres, we use two annual concentration records of MSA from ice cores: the Arctic Svalbard (79°N, 16°E) set that extends from 1920 to 1995 and the Antarctic coastline Law Dome (66°S, 110°E) set from 1841 to 1995.

Additionally we work with the TSI time series from 1860 to 2000 and two SST reconstructed time series (78°-80° N, 15°-17°E) (65°-67° S, 109°-111°E) that include the area of the MSA records.

In order to analyze localized variations of power within a time series at different frequencies we apply the wavelet method, using the Morlet wavelet.

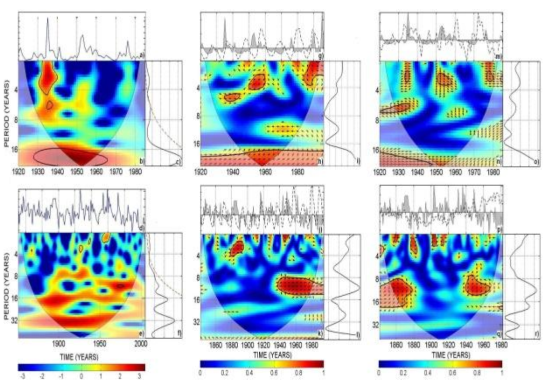

Figure 2. Wavelet and wavelet coherence analysis of the MSA time series. (a) North Pole MSA time series; (b) wavelet spectrum; (c) global wavelet spectrum; (d) South Pole MSA time series; (e) wavelet spectrum; (f) global wavelet spectrum; (g) TSI and North Pole MSA time series (shaded area); (h) wavelet coherence spectrum; (i) global wavelet coherence spectrum; (j) TSI and South Pole MSA time series (shaded area); (k) wavelet coherence spectrum; (l) global wavelet coherence spectrum; (m) North Pole MSA (shaded area) and SST time series; (n) wavelet coherence spectrum; (o) global wavelet coherence spectrum; (p) South Pole MSA (shaded area) and SST time series; (q) wavelet coherence spectrum; (r) global wavelet coherence spectrum The key for the arrows and the remarks on the wavelet spectra and the global spectra are the same.

In the context of our results, if cosmic rays also contribute to alter cloud albedo, then their effect along the 11yrs sunspot cycle will reinforce the effect of the MSA as the cosmic ray flux is anti-correlated with the TSI.

In this case, solar activity could influence climate through two mechanisms: indirectly through TSI and directly through cosmic ray flux (Beryllium-10).

Also the wavelet coherence and phase difference are obtained. The wavelet coherence is especially useful in highlighting the time and frequency intervals where two phenomena have a strong interaction.

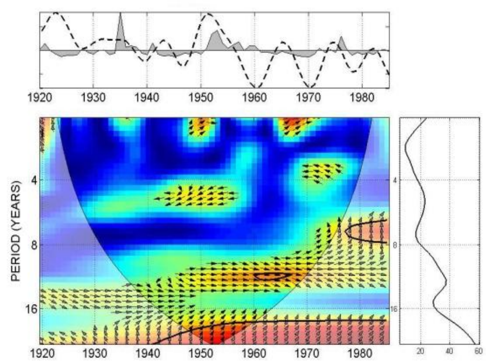

Figure 3. Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude north and Beryllium-10.

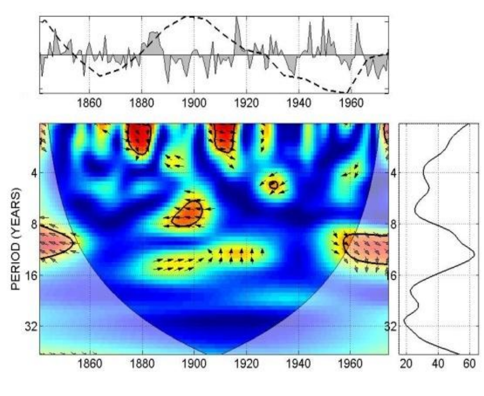

Figure 4. Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude south and Beryllium-10.

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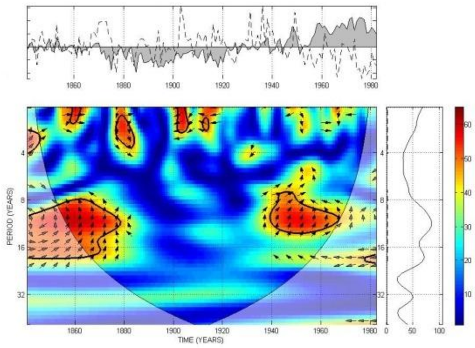

Figure 5. Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude north and Sea Surface Temperature (SST).

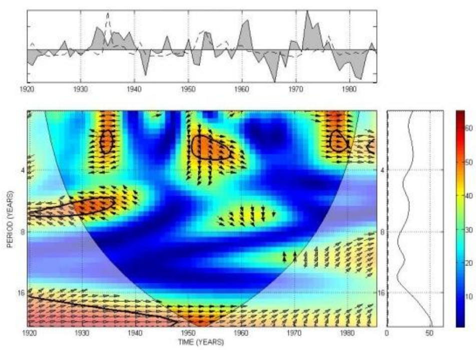

Figure 6. Wavelet and wavelet coherence analysis of Methane Sulphonic Acid (MSA) of high latitude south and Sea Surface Temperature (SST).

Conclusions

The coherence in the North Pole between the MSA and the SST is strongest at ~22yrs in phase (Figs. 2n and 2o). At the time scales of the solar cycle the coherence is roughly in phase; a correlation between North Pole MSA and SST in decadal time scales has 6 already been reported.

Coherence in the South Pole between the MSA and SST is strongest at ~12yrs but the interaction is non linear (Figs. 2q and 2r), another study implies an anticorrelation. According to these results, the North Pole MSA presents the strongest interaction at the ~22yrs, coinciding with the time scales of the most conspicuous frequency of the solar magnetic cycle, but for the South Pole MSA it is at ~12yrs, that would correspond to the time scales of the most conspicuous frequency of the sunspot cycle. At the 11yrs sunspot cycle time scales when the TSI increases the MSA decrease and vice versa, but the coherence between MSA and SST is non linear, with a slight correlation for the North Pole, indicating that other sources of SST variability must be present.

Then, in the poles the relation between the TSI and the MSA, and therefore the DMS, promote a positive feedback on climate at the time scales of the sunspot cycle. This is opposite to a recent study proposing a DMS/solar radiation negative feedback, but supports previous results that find a strong anticorrelation between TSI and low clouds: if increases of DMS and MSA favour the increase of clouds, then also a negative correlation between TSI and MSA should be found, as our results confirm.

In the context of our results, if cosmic rays also contribute to alter cloud albedo, then their effect along the 11yrs sunspot cycle will reinforce the effect of the MSA as the cosmic ray flux is anticorrelated with the TSI. In this case, solar activity could influence climate through two mechanisms: indirectly through TSI *and* directly through cosmic ray flux.

Summarizing, we study the relationship between MSA, a sole product of DMS, the TSI and the SST. All the main frequencies of the MSA time series coincide with the solar activity periods related to the sunspots and the solar magnetic cycle. The North Pole MSA presents the strongest coherence with TSI and SST at the ~22yrs, but for the South Pole it is at ~12yrs. At the sunspot cycle time scales the DMS/TSI would favour a climate positive feedback; however the SST is clearly influenced by other sources. As the DMS production, and therefore the MSA production, depends on the quantity of the solar radiation, then TSI could influence climate indirectly through the MSA (DMS).

Aknowledgements

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References

[1] Mendoza B. Total solar irradiance and climate. *Adv. in Space Res*. **35**, 882-890 (2005).

[2] Svensmark, H. & Friis-Christensen, E. Variations of cosmic ray flux and global cloud coverage-a missing link in solar-climate relationships. *J. Atm. Solar-Terr. Phys*. **59**, 1225-1232 (1997).

[3] Marsh N. D. & Svensmark H. Low cloud properties influenced by Cosmic Rays. *Phys.Rev. Lett*. **85**-23, 5004-5007 (2000).

[4] Kristjánsson, J.E., Staple, A. & Kristiansen, J. A new look at possible connection between solar activity, clouds and climate. *Geophys. Res. Lett*. **29**, 2107, doi:10.1029/2002GL015646 (2002).

[5] Charlson, R.J. Lovelock, J.E., Andreae, M.O. & Warren, S.G. Oceanic phytoplankton, atmospheric sulfur, cloud albedo and climate: a geophysiological feedback. *Nature* **326,** 655-661 (1987).

[6] Fröhlich, C. Total solar irradiance variations since 1978. *Adv. Space Res*. **29**, 1409-1416 (2002).

[7] Harrison, R.G. & Carslaw, K.S. Ion-aerosol-cloud processes in the lower atmosphere. *Rev. Geophys*. **41**, (2)1-(2)26 (2003).

[8] Dickinson, R.E. Solar variability and the lower atmosphere. *Bull. Am. Meteorol. Soc*. **56**, 1240-1248 (1975).

[9] Pallé-Bagó, E. & Butler, C.J. The influence of cosmic rays on terrestrial clouds and global warming. *Astron. Geophys.* **41**, 418-422 (2000).

[10] Usoskin, I.G., Marsh, N., Kovaltsov, A., Mursula, K. & Gladyssheva, O.G. Latitudinal dependence of low cloud amount on cosmic ray induced ionization. *Geophys. Res. Lett*. **31**, (2004).

[11] Lockwood, M. Solar outputs, their variations and their effects on Earth. In *The Sun,Solar Analogs and the Climate,* Saas-Fee Advanced Course **34**, 109-306 (Springer, the Netherlands, 2005).

[12] Simó, R. Production of atmpospheric sulfur by oceanic plankton: Biogeochemical,ecological and evolutionary links. *Trends Ecol. Evol.* **16**, 287-294 (2001).

[13] Kettle, A. J. *et al*. A global data base of sea surface Dimethylsulfide (DMS) measurements and a procedure to predict sea surface DMS as a function of latitude, longitude and month. *Global Biogeochem. Cycles* **13**, 399-444 (1999).

[14] Simó, R. & Dachs, J. Global ocean emission of dymethylsulfide predicted from biogeophysical data. *Global Biogeochem. Cycles* **16**, doi: 10.1029/2001GB001829 (2002).

[15] Simó, R. & Vallina, S.M. Strong relationship between DMS and the solar radiation dose over the global surface ocean. *Science* **315**, 506-508 (2007).

[16] Larsen, S.H. Solar variability, dimethyl sulphide, clouds, and climate. *Global Biogeochem. Cycles* **19**, GB1014, doi:10.1029/2004GB002333 (2005).

[17] Toole, D.A. & Siegel, D.A. Light-driven cycling of Dimethylsulfide (DMS) in the Sargasso Sea: Closing the Loop. *Geophys. Res. Lett.* **31**-9, L09308, doi: 10.1029/2004GL019581 (2004).

[18] Kniventon, D.R, Todd, M.C., Sciare, J. & Mihalopoulos, N. Variability of atmospheric dimethylsulphide over the southern Indian Ocean due to changes in ultraviolet radiation. *Global Biogeochem. Cycles* **1 7**, 1096, doi: 10.1029/2003GB002033 (2003).

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