Study About Spectral Properties of the Global, Hemispheric and Latitudinal Air Surface Temperature Series from NASA/GISS Database and Sunspot Number

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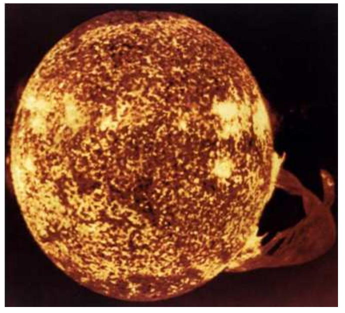
Outlook – What we are looking for?

Relationship between Sun-Earth-Climate



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B

Figure 1 (A) Sun; (B) Earth

In this work we used the global, hemispheric and latitudinal averaged air surface temperature time series, obtained from the NASA/Goddard Institute for Space Studies (GISS) database and the Sunspot Number (Rz).

In order to search for information about the possible relation between Rz (as solar proxy) and temperature.

Why temperature?

Relationship between Sun-Earth-Climate

Figure 1 (A) Sun; (B) Earth

√ The air surface temperature is a basic meteorological parameter and its variation is a primary measure of global, regional and local climate changes;

√ The largest part of this climatic warming is usually attributed to the anthropogenic effects due to the enhanced greenhouse gases concentrations...

√ There seems to be evidence that natural phenomena can contribute significantly with the temperature variability…

√ Solar irradiance variation could have some impact on Earth's climate, although this is a topic of intense debate and research…

Why Sunspot Number (RZ)?

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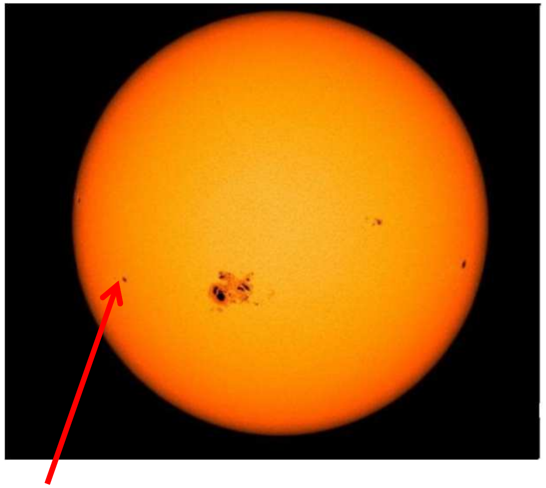
Figure 1 (A) Sun; (B) Earth



Sunspot

Rz is defined as $Rz = k(10g+f)$, taking into account the number of individual (f) and groups (g) of spots visible on the solar disk.

The longest solar activity index is the Sunspot Number (Rz), which was first compiled by Wolf in the XIX century and it is available as annual averages since 1700.

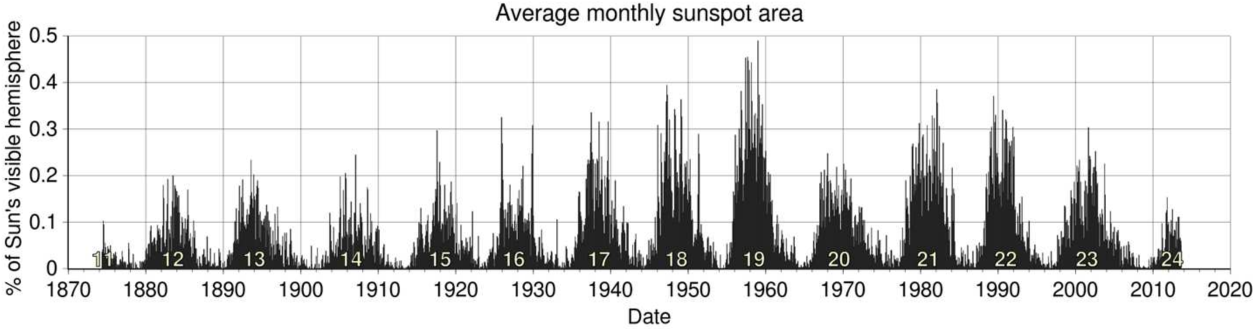


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Figure 1 (A) Sun; (B) Earth

Data sets

Sunspot Number (RZ)

The annual averages of Rz were obtained from the Sunspot Index Data Center— SIDC. The time interval for Rz used in this study is from 1880 to 2005

Air surface temperature

Air surface temperature series during 1880-2005 from NASA Goddard Institute for Space Studies (GISS), The anomaly temperatures used are the monthly deviations in relation to the 1951-1980 interval mean.

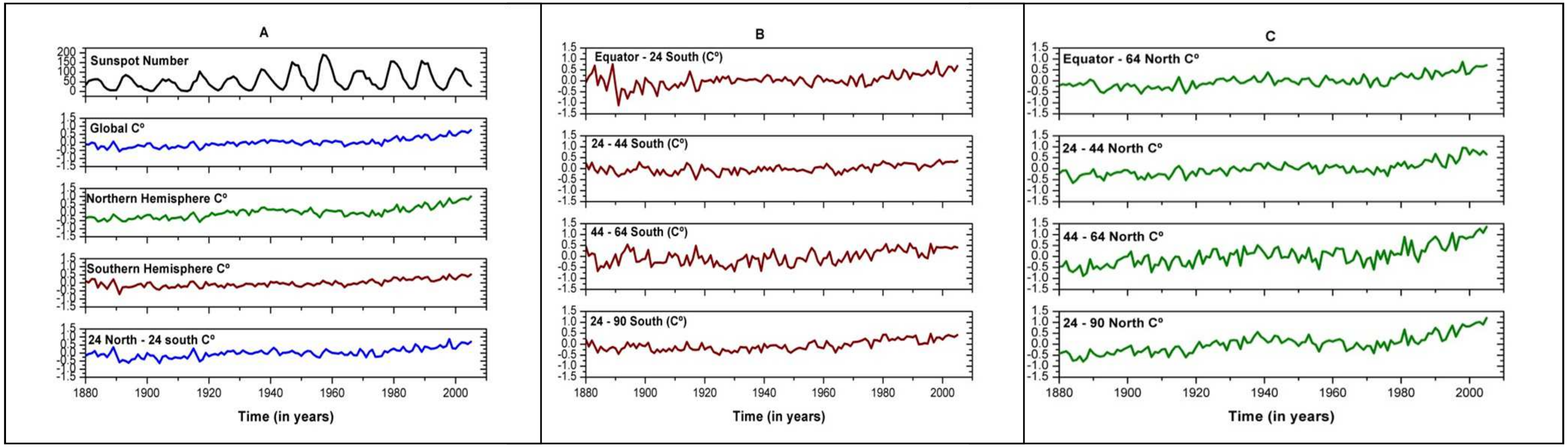

Figure 1 shows a panel A, B and C with 13 plots for the anomaly surface temperatures (AST ºC) and Sunspot Number (Rz) original data series.

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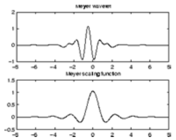
Figure 1 (A) Sun (B) Earth

Methodology

➡ **Meyer wavelet transform**



The wavelet decomposition was performed until the D5 level with approach of the A5.
The band frequencies are approximately D1 (2-4y), D2 (4-8y), D3 (8-16y), D4 (16-32y), D5 (32-64y). A5 is the scaling level, corresponding to the long term periods (> 64y).

Wavelet Results (D3)

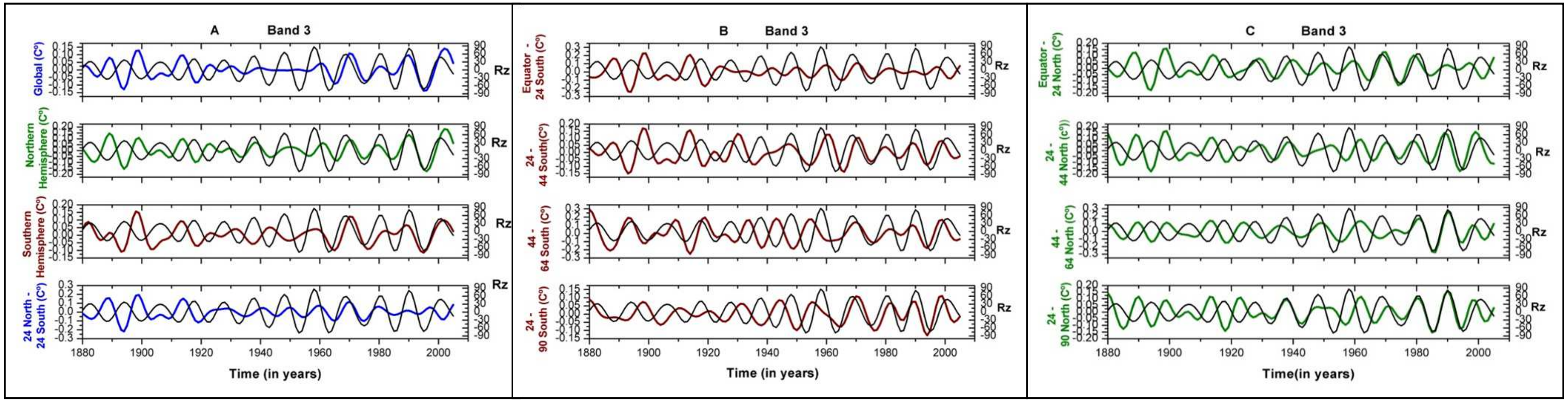


Figure 2 Temperature D3 decomposition level for 12 different regions as we can see (A), (B) and (C) on the right and Rz on the left

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Figure 1 (A) Sun; (B) Earth

Methodology

➡ **Meyer wavelet transform**

Wavelet Results (D4)

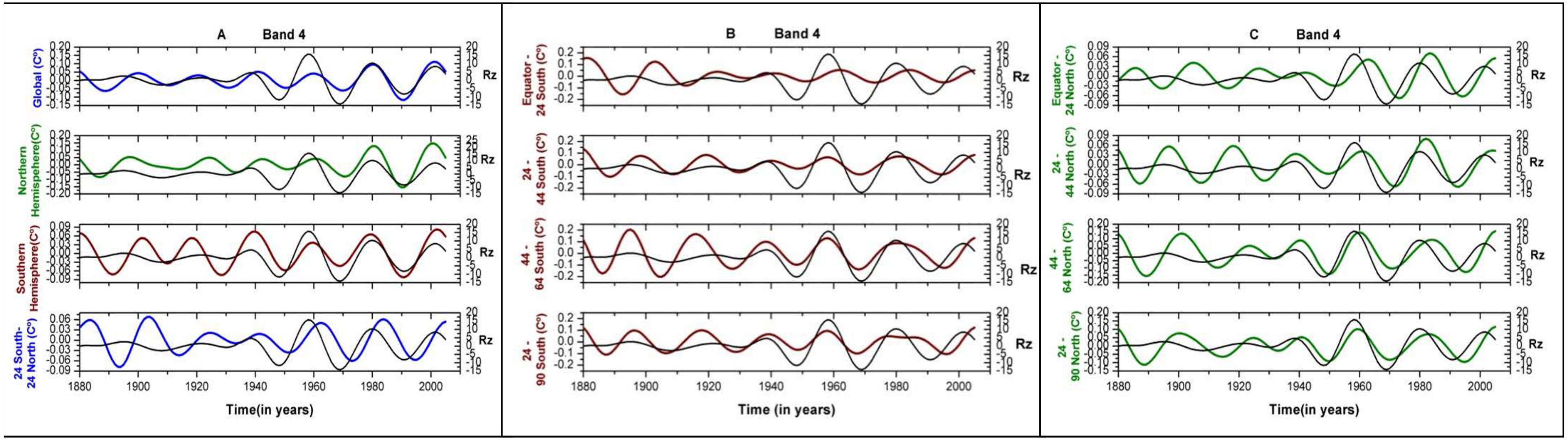

Figure 3 Temperature D4 decomposition level for 12 different regions as we can see (A), (B) and (C) on the right and Rz on the left

Methodology

ARIST (Iterative Regression Analysis)

After decomposing the original data sets, we applied the Iterative Regression Analysis.

$$(F = Y - a0_N \sin(a1_N t + a2_N))$$

Where :Y is the observed signal
a0N, a1N and a2N are the amplitude, frequency and phase; t is the time;
F parameter represents the difference between the measured value Y and the fit curve for the corresponding abscissa ;and N is the frequency

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Figure 1 (A) Sun; (B) Earth

ARIST's results

TABLE 1 Significant periods of the air surface temperature.

Region	Periods in Years
Global	2–2.8; 3.7–6.6; 7.7; 8.3; 9.1; 10.4; 11.5; 20.6; 26.3; 29.6; 65
Northern Hemisphere	2.1–2.8; 3.1–6.6; 7.1; 8.3; 10.2; 11.3; 20.4; 26.4; 54.3;70.4
Southern Hemisphere	2–2.6; 3.6–5.3; 7.7; 8.3; 9.1; 10;11.9; 14.2; 17.2; 20.7; 30.8
24º North–90º North	2–2.7; 3.3–5.3; 6.2–7.7; 8.3; 9.9; 11.1; 12.4; 15.2; 20.5; 26.5; 53.1;72.2
44º North–64º North	2.1–2.8; 3.3–5.6; 6.3–7.4; 9.1–9.9; 11.2; 12.8; 15.4; 26.7; 53.1;75.6
24º North–44º North	2–2.7; 3–6.4; 7.8; 8.3; 9.1; 12.4; 14.4; 52.7; 67.1
Equator–24º North	2.4–2.8; 3–4.6; 5.1–7.1; 8.2; 9; 10; 11.6; 13.4; 19.6; 25.4; 38.4; 58.6
24º North–24 South	2.6–2.9; 3.2–6.3; 7.1; 9; 11.8; 20; 25.8; 59.9 ; 63.4
Equator–24º South	2.5–3.6; 4.1–6.3; 7.6; 9; 11.9; 20.2; 58; 61.4
24º South–44º South	2–3.7; 4.2–6.6; 7.5; 8.3; 10.1; 12.2; 32.9 ; 59.5
44º South–64º South	2.1–3.8; 4.3–6.7; 7.7–8.9; 10.7; 12.8; 15.1; 21.5; 29.4; 41.6; 98.9
24º South–90º South	2–3.6; 4.7–6.7; 11.3; 12.7; 14.5; 17.5; 21.1; 28.7; 34.4; 108.7

Relationship between Sun-Earth-Climate

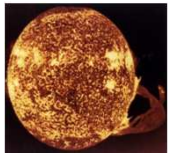

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Figure 1 (A) Sun; (B) Earth

Cross correlation results

From Cross correlation - Between temperature and Rz for D3 (8–16 years) and D4 (16–32 years).

*the cross correlation coefficients between Rz and Global, hemispheric and latitudinal temperature series in D3 band are low (values from 0.15 to 0.27).
Nevertheless, by spectral analysis we found clearly the 11 years signal in the temperature series;

* the band D4 shows higher correlation coefficients (values from 0.44 to 0.80). This seems to indicate that the 20-to-22 years solar magnetic cycle can
be more influent on temperature than the 11 years solar cycle.

Summary

Relationship between Sun-Earth-Climate

A B

Figure 1 (A) Sun; (B) Earth

- We have studied the spectral properties of the Global, hemispheric and latitudinal air surface temperature series from NASA/ GISS database and RZ From SIDC.

We applied:

- Meyer wavelet transform to perform the decomposition , it was performed until the D5 level with approach of the A5;
- ARIST to detect principal periodicities;
- Cross correlation between Temp. and Rz;

We found several periodicities in the different latitudinal ranges. In the midst of these oscillations we have band-pass filtered temperature data around the 11 year and the 22 year periodicities.

Relationship between Sun-Earth-Climate

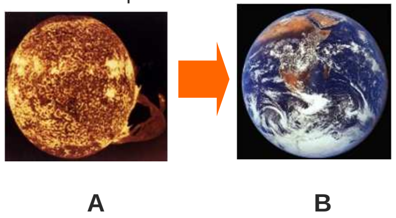

Figure 1 (A) Sun; (B) Earth

Summary

√ a very significant correlation (R 0.57 to 0.80) is found in the 22 yr solar Hale cycle band (16–32 years) with lags from zero to four years between latitudinal averages air surface temperature and Rz.

√ we can "speculate" on the fact that the 22 years signal is stronger than the 11 years in temperature time series may indicate that the mechanism could be more related to the solar magnetic field and solar wind variability, influencing Earth's atmosphere, perhaps through galactic cosmic ray modulation of cloud cover and atmospheric electric field;

√ the physical mechanism that could explain the effects of solar variability on Earth's climate cannot be determined by the present study;

√ the influence of the natural solar oscillations on the air surface temperature can be dependent on local conditions, such as ocean–land contrast, latitude and altitude effects.

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Figure 1 (A) Sun; (B) Earth

Acknowledgments

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Figure 1 (A) Sun; (B) Earth

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