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Research Paper

Relationship Between Global Mean Precipitation and Solar Activity

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ABSTRACT: *Solar activity has many effects on the Earth's atmospheric parameters, among which it has a significant impact on the Earth's climate. This paper compares the annual average values of the interplanetary magnetic field, Dst index, high-energy proton flux (>10 MeV) and the global mean precipitation by counting the interplanetary magnetic field, Dst index and the global mean precipitation for the period between Jan 2000 and Jan 2010. Then we finally find that: the solar activity gradually decreased during this decade, the interplanetary magnetic field and high-energy proton flux also decreased, Dst index gradually increased but its absolute value also decreased, and the global average precipitation also decreased slightly, we make the important conclusion that the weakening of solar activity may lead to a decrease in global average precipitation, which is briefly discussed.*
KEYWORDS: *Solar activity, Global mean precipitation, Interplanetary magnetic field, Dst index, High-energy proton flux*

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I. INTRODUCTION

Solar activity encompasses solar radiation, sunspots, light spots, spectral spots, flares and coronal mass ejections, among which the most direct impact of solar activity on the Earth's climate is achieved through solar radiation. The impact of solar activity on the Earth's environment has been controversial for many researchers [1-4], especially for the relationship between global temperatures and number of sunspots [5-11].

Solar radiation is mainly "light" radiation, i.e. electromagnetic radiation, which is the most dominant form of solar radiation energy, so it is often understood as solar electromagnetic radiation. In addition to electromagnetic radiation, the Sun also radiates solar winds and high-energy charged particle streams, which account for a very small proportion of the total energy radiated by the Sun, but which can significantly affect the state of the space environment of the Sun and the Earth.

Interplanetary magnetic field (IMF) is the magnetic field carried by the solar wind and scattered among the planets in the solar system, and four geomagnetic stations are selected at approximately uniform longitudinal intervals near the Earth's equator. The magnitude of these values depends mainly on the strength of solar activity. And the stronger the solar activity, the larger the IMF, the larger the absolute value of Dst index and the larger energy particle flux.

The main purpose of this paper is to outline the analysis of the possible relationship between solar activity and global mean precipitation. By analysing the interplanetary magnetic field, Dst index, and energetic ion fluxes during the decade Jan 2000-Jan 2010, the mean precipitation during this decade is compared and some potential relationships between them are found, and related summaries and discussions are provided.

II. METHOD

Weronika and Krzysztof used the autoregressive moving average model to analyse the relationship between mean monthly precipitation and sunspot numbers at US weather stationsbetween January 1749 and March 2016, and they found a significant solar activity and mean monthly precipitation They found a significant correlation between solar activity and mean monthly precipitation [12]. In addition, Takahashi used key day analysis to analyse the relationship between solar activity and precipitation and found that increases of precipitation are also found at some stations on days with strong geomagnetic disturbance or 6 days later [13].

In this paper, IMF, Dst index, >10 MeV proton flux (averaged for each year) were collected from Space Physics Data Facility [14] during Jan 2000-Jan 2010, and the annual mean precipitation for the corresponding 10-year period was collected from the Physical Sciences Laboratory [15]. (the monthly average precipitation was then averaged). The relationship between solar activity and global mean precipitation is analysed and discussed by comparing the interplanetary magnetic field, Dst index, energetic proton flux (>10 MeV) and global mean precipitation variability over the 10-year period.

III. RESULT

The results we collected are shown in Figures 1 and 2. In Figure 1, the red dash represents the annual mean change of the IMF, which can be seen to show an overall decreasing trend from 2000 to 2010, with the maximum value in 2002-2003, being 7.6 nT, and the minimum value in 2009, being -3 nT; the blue line indicates Dst index, which shows a gradual increasing trend from 2000 to 2010, its annual average value shows a gradual upward trend, with a minimum value of -22 nT in 2003 and a maximum value of 3.9 nT in 2009. The green line indicates the high-energy proton flux (>10 MeV), which shows an overall decreasing trend during this 10-year period, with a maximum value of 54.5 in 2003 and a minimum value of about 0.2 in 2007-2010.

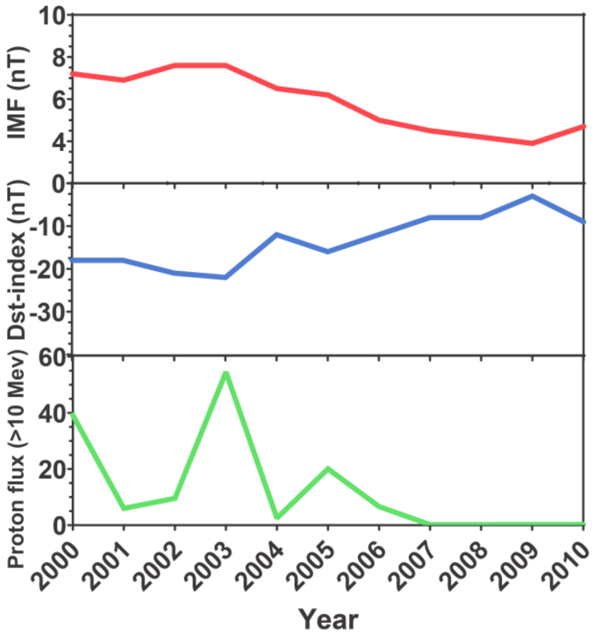

Figure1: Annual mean changes in IMF, Dst index and high energy proton flux (>10 MeV) for the period Jan 2000-Jan 2010 (red line represents IMF, the blue one indicates Dst index, and green line indicates high energy proton flux)

Comparing several physical covariates in Figure 1 shows that the overall trend of the IMF and the high-energy proton flux (>10 MeV) is essentially the same, with the IMF fluctuating somewhat more flatly. However, the trend of the Dst index is exactly opposite to them, which is consistent with common sense. From 2000 to 2010, the solar activity gradually decreases, the IMF and the energetic proton flux (>10 MeV) also decrease, and the Dst index, although increasing in value, also decreases in absolute value.

Figure 2 shows the annual mean contours of global precipitation over this 10-year period, with each year's mean contour corresponding to a subplot, with warmer shades representing greater precipitation and cooler shades representing less precipitation. In Figure 2, it is clear that precipitation is importantly concentrated near the equator, with the average precipitation decreasing the closer one gets to the geographical poles. Furthermore, Figure 2 also shows that the global average precipitation for the period 2006-2010 is slightly less than that for the period 2001-2005.

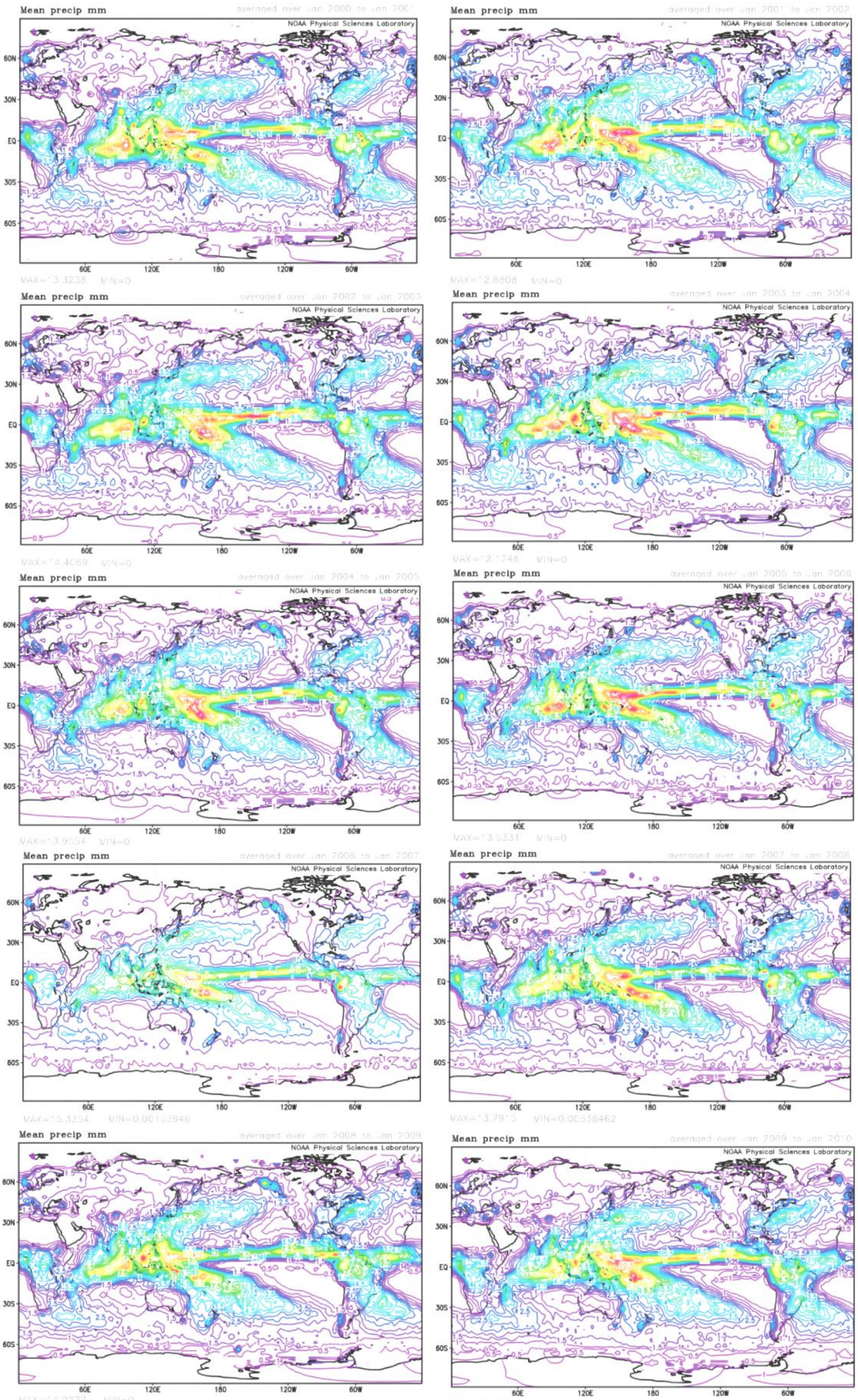

Figure 2: Annual mean contour changes in global precipitation for the period Jan 2000-Jan 2010

Combining Figures 1 and 2, the slow weakening of the IMF from 2000 to 2010, the weakening of the high-energy proton flux (>10 MeV), the increase in the Dst index and the downward trend in global mean precipitation suggest a possible link between solar activity and global mean precipitation.

IV. CONCLUSION AND DISCUSSION

In summary, after analysing the data during Jan 2000-Jan 2010, we conclude that the weakening of solar activity may lead to a decrease in global average precipitation. Why? We think the most likely explanation is that charged particle fluxes play an important role in the production of liquid and water droplets, and that the gradual weakening of solar activity has led to less ionisation in the atmosphere, fewer charged particles and therefore less precipitation. This finding has important implications for the study of climate change on Earth.

REFERENCES

[1]. B. Pittock, Possible sunweather correlation, Nature 280 (1979) 254 – 255.
[2]. B. Pittock, Solar variability, weather and climate: an update, Quart. J. R. Meteorol. Soc. 109 (1983) 23 – 55.
[3]. H. vanLoon, K. Labitzke, The influence of the 11-year solar cycle on the stratosphere below 30 km: A review, Space Sci. Rev. 94 (2000) 259 – 278.
[4]. L.J. Gray, et al., Solar influences on climate, Rev. Geophys. 48 (2010) RG4001.
[5]. N. Scafetta, Empirical analysis of the solar contribution to global mean air surface temperature change, J. Atmos. Sol.-Terr. Phys. 71 (2009) 1916 – 1923.
[6]. M. Rypdal, K. Rypdal, Testing hypotheses about sun-climate complexity linking, Phys. Rev. Lett. 104 (2010) 128501.
[7]. N. Scafetta, B.J. West, Comment on testing hypotheses about sun-climate complexity linking, Phys. Rev. Lett. 105 (2010) 219801.
[8]. L.A. Gil-Alana, O.S. Yaya, O.I. Shittu, Global temperatures and sunspot numbers. are they related? Physica A 396 (2014) 42 – 50.
[9]. N. Scafetta, Global temperatures and sunspot numbers. Are they related? Yes, but non linearly. A reply to Gil-Alana et al., Physica A 413 (2014) 329 – 342.
[10]. H. Hassani, X. Huang, R. Gupta, M. Ghodsi, Does sunspot numbers cause global temperatures? a reconsideration using non-parametric causality tests, Physica A 460 (2016) 54 – 65.
[11]. L. Kristoufek, Has global warming modified the relationship between sunspot numbers and global temperatures? Physica A 468 (2017) 351 – 358.
[12]. Nitka W , Burnecki K . Impact of solar activity on precipitation in the United States[J]. Physica A: Statistical Mechanics and its Applications, 2019, 527:121387.
[13]. Takahashi, K. Key Day Analysis on the Relationship between Solar Activity and Precipitation[J]. Journal of the Meteorological Society of Japan, 2008, 44(5):246-254.
[14]. https://spdf.gsfc.nasa.gov.
[15]. https://psl.noaa.gov

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