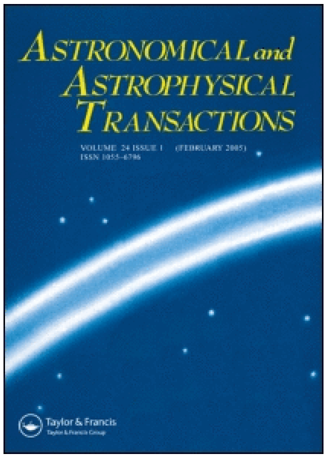

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Solar and geomagnetic activity affecting precipitation

E. P. Zaborova [a]; I. V. Dmitrieva [a]
[a] Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Troitsk, Moscow region, Russia

Online Publication Date: 01 February 2000
To cite this Article: Zaborova, E. P. and Dmitrieva, I. V. (2000) 'Solar and geomagnetic activity affecting precipitation', Astronomical & Astrophysical Transactions, 18:4, 649 - 655
To link to this article: DOI: 10.1080/10556790008208169
URL: http://dx.doi.org/10.1080/10556790008208169

Astronomical and Astrophysical Transactions, 2000,
Vol. 18, pp. 649–655
Reprints available directly from the publisher
Photocopying permitted by license only

SOLAR AND GEOMAGNETIC ACTIVITY AFFECTING PRECIPITATION

E. P. ZABOROVA and I. V. DMITRIEVA

Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Troitsk, Moscow region, Russia

(Received March 17, 1999)

In this paper, we consider variations of solar activity and their potential relevance to droughts. We have analysed data on anomalous precipitation in the European part of Russia, including the Central and Central Non-Chernozem Zones, and solar and geomagnetic activity data for the period 1851–1990. The influence of solar and geomagnetic activity is found over a long-time frames only, a decade solar cycle being manifested. Not only does the precipitation character essentially differ for different regions but it also depends on the external influence in different ways. Risky agriculture regions are more liable to this kind of dependence than moderate climate regions. Thus, we may note that the connection between solar and geomagnetic activity and precipitation is explicitly expressed, though it is mediated by complicated circulation processes.

KEY WORDS Solar activity, geomagnetic activity, climate, atmosphere circulation, precipitation

1 INTRODUCTION

Extreme weather phenomena and the possibility of their forecasting have drawn the attention of numerous investigations for a long time. Among the aforesaid phenomena which mankind has come across in historical periods are droughts. Attempts to analyse and structure the available background of information were repeatedly made. In particular, spatial dimensions of droughts and precipitation were studied for this purpose. In the present paper we consider solar and geomagnetic activity variations and their possible connection with periods of enhanced drought. Droughts are caused by a definite type of atmospheric circulation (naturally it is different for differen climate zones). Here we shall consider droughts taking place during the last century in the Eropean part of Russia.

2 DATA AND METHODS

Monthly anomalous precipitation data over Europe and the European part of Russia (EPR) during 1851–1993 (http://ingrid.ldeo.columbia.edu/sources) and as well also

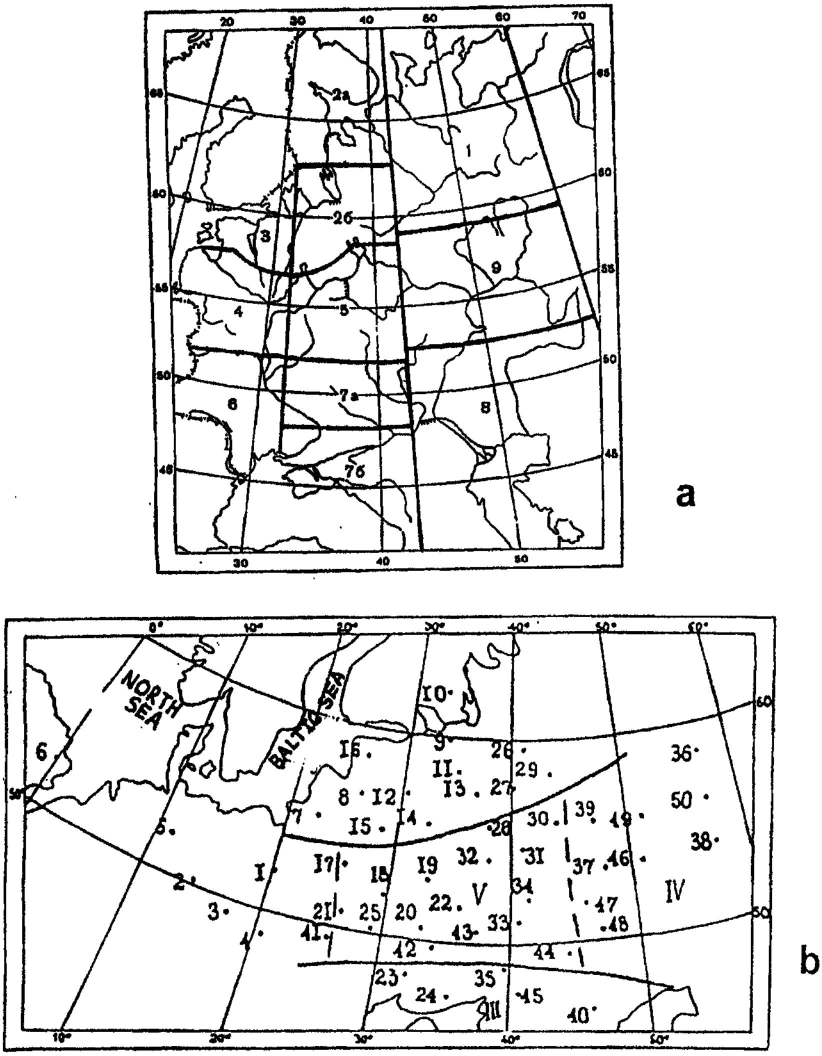

Figure 1 Climate regions in the European part of Russia defined by Vitels (*a*) and by Popova (*b*).

information about the duration of Northern hemisphere circulation seasons (Savina, 1987) during 1899–1985 and variation in the location of atmospheric active centres (Catalogue of parameters of atmospheric circulation, 1988) from 1891 to 1984 were examined. Additionally we used yearly averaged solar and geomagnetic indices according to Solar Geophysical Data, 1996. As an indicator of solar activity, sunspot number (W) data from 1851 to 1992 were used. Geomagnetic activity was characterized by the aa-index during 1868–1993.

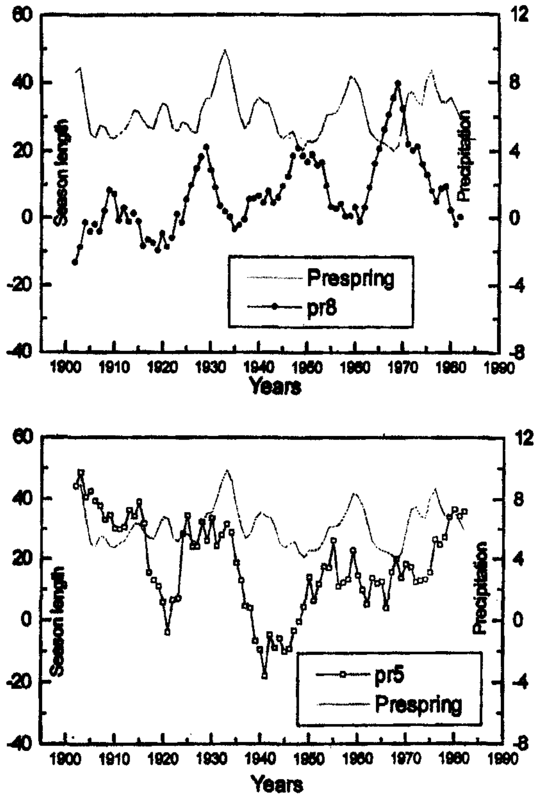

Figure 2 Annual sum of precipitation in regions 5 (-□-) and 8 (-○-) (by Vitels classification) and duration of 'prespring' circulation season (-).

Precipitation data were analysed in accordance with climate regions proposed by Vitels (1977) for the precipitation sum over a year (see Figure 1*a*) and by Popova (1995) for precipitation analysis of warm and cold periods (see Figure 1*b*). Taking into account the well-emphasized stochastic component we carried out 3-point smoothing for all kinds of climate data.

3 CLIMATIC SEASONS AND PRECIPITATION

In Sazonov's paper (1985) it was pointed out that droughts over EPR were characterized by the activity of the zonal circulation from February to October. So, during active zonal circulation processes in February–October at middle latitudes, a drought over EPR takes place in the spring–summer period. Therefore, first of all we have analysed the connection between circular season duration of the Northern hemisphere and the annual sum of precipitation over climate zones according

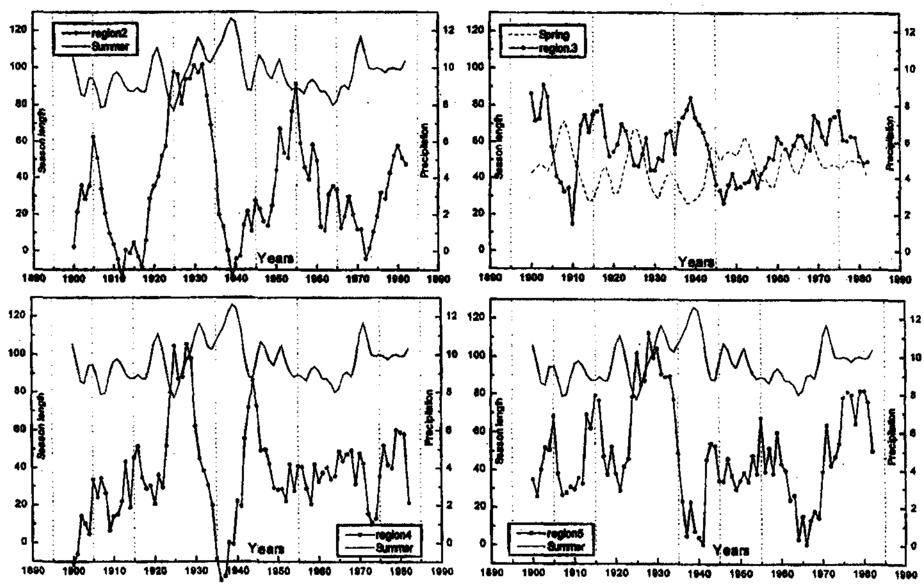

Figure 3 Precipitation sum during the warm period in regions II–V by Popova classification (–•–); duration of summer(—) and spring (- - -) circulation seasons.

to Vitels (1977) in the European part of Russia. As expected, the most important factor for precipitation is the 'prespring' circulation season with its boundaries 'floating' from February to April. In Figure 2 the annual sum of precipitation in regions 5 (central) and 8 (near Caspian sea)and the prespring season duration are presented. It is seen that precipitation and season duration are in opposite phase at almost any time. The latter is confused during periods of changing of circular epochs (Dzerdzeevsky, 1975).

Further we have separated the annual precipitation sum into two groups, namely for warm (May–October) and cold (November–April) periods, because these periods were characterized by different kinds of circulation, and have considered the regions proposed by Popova (1995). She pointed out five various types of precipitation oscillations on the EPR, spatially separated for different periods of the year. We have compared precipitation sum variations in all those regions with the circular season duration. The connection between precipitation and warm season is expressed more evidently.

In Figure 3 precipitation sum variations during the warm period over the EPR and variations of summer and spring circulation season duration are shown. Precipitation and season duration are in antiphase. In regions II and III (the Northern part of Russia and regions close to the Black and Caspian seas) such a connection is emphasized best of all. In region III located further toward the south the spring period but not the summer period plays a leading role. It indicates that the sum-

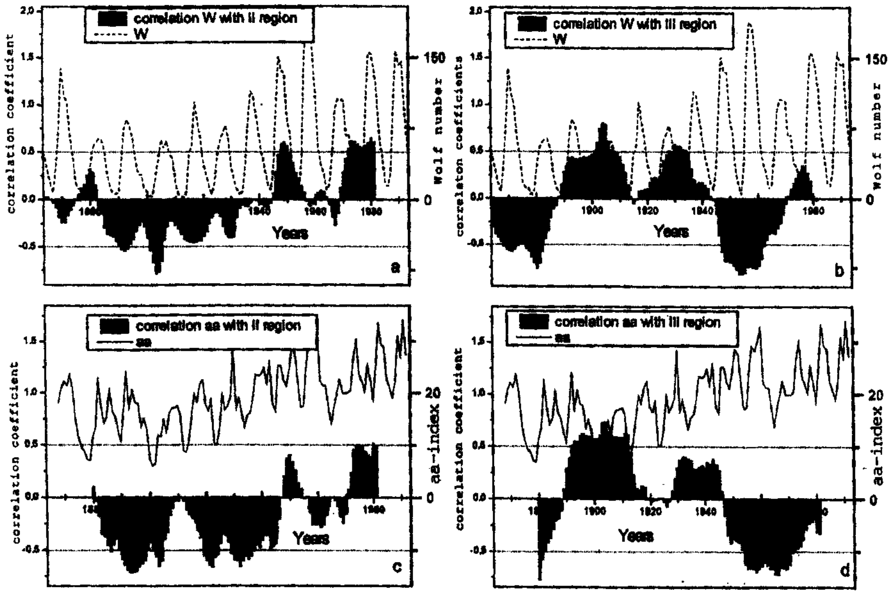

Figure 4 Variation of correlation coefficients (■) between precipitation sum during the cold period and sunspot number (a – II region, b – III region), and between precipitation sum during the cold period and aa – index (c – II region, d – III region). The solid line represents the aa-index itself; the dashed line represents the sunspot number itself.

mer type of circulation containing mainly zonal types gives a basic influence on the warm period precipitation (Dzerdzeevsky, 1975).

Precipitation fluctuation over the cold period in region II is in phase with the autumn duration, and in region III with the prespring duration. It seems that this phenomenon is caused by the autumnal redistribution of the circulation from summer type to winter type. It must be noted that the correlation coefficient between precipitation and season duration changes its sign in different circular epochs.

Thus, we have confirmed the connection between precipitation separated into semiannual and circular seasons, the connection being emphasized better for the warm half-year. The interconnection of the aforesaid malfunction is seen mainly at the some periods as for annual precipitation: 1900–1910, 1925–1935, and 1965–1970. These are the periods of circular epoch changes.

4 PRECIPITATION, SOLAR AND GEOMAGNETIC INDICES

In our previous paper (Zaborova, Dmitrieva, and Obridko, 1997) we considered the relation between circular season duration and solar and geomagnetic indices. It became clear that the connection during any separate circulation epochs is pronounced and changes its behavior to the opposite one when epochs change. Thus, indirectly, precipitation anomalies have to be related to this phenomenon too. However it is of great interest to analyse this connection directly.

To this end a 23-year sliding correlation coefficient of the precipitation time series during warm and cold half-year periods over all five regions, and solar and geomagnetic indices were calculated. The correlation coefficient, $R(n)$, referred to the year n, was calculated for every 23-year interval from $n-11$ to $n+11$. The period of 23 years was taken to remove high-frequency periodicity, including distinctions in the development of geomagnetic activity between the even- and odd-numbered solar cycles.

Under this kind of direct comparison absolute values of the correlation coefficients reach 0.8 (in regions II and III, see Figure 4) both for solar and geomagnetic indices. However, it is even more interesting that in this case correlation changes its sign, too, and the absolute values of the correlation coefficients are so high both in positive and negative areas. The sign change periods 1880–1890 and 1940–1945 coincide with periods of interconnection malfunctions between the solar and geomagnetic indices themselves, which were found by Kishcha and Dmitrieva (1997). They may be a consequence of long-term variations of solar activity as well.

It is interesting to note that increased correlation coefficient values are distinctive for regions II and III too. These regions are characterized by extreme natural conditions; at the same time regions I, IV and V confirm that the same common tendencies react on external actions more slightly, the stochastic component being better expressed. It falls into line with the common rule of a slight external force acting on a liable condition system.

5 CONCLUSIONS

As mentioned above, the appearance of droughs is connected not only with a lack of precipitation but also with temperature anomalies. In this paper we have analysed the solar–geomagnetic–circular season precipitation chain and have found the following.

- The precipitation character not only differs sufficiently in different regions but also depends on external activities in a different ways. Risky agricultural regions are subject to this dependence to a greater degree than moderate climate regions.

- Warm period precipitation is closely connected to the summer circular season duration. The latter depends on geomagnetic activity, as shown by Zaborova, Dmitrieva, and Obridko, (1997). Cold period precipitation is connected with 'prespring' and 'prewinter' seasons, but such a connection is not so pronounced. Vice versa, the connection with space parameters is much more evident for the cold period. The influence of spatial agents on circular season duration is also more evident for the cold period and perhaps it causes the precipitation to respond to it.

- The influence of solar and geomagnetic activity is seen only when long-time intervals are considered, a decade solar cycle being demonstrated. The manifestations for the extreme north (II) and extreme south (III) regions are in the opposite phase.

Thus were can note that the connection of solar and geomagnetic activity with precipitation are evidently expressed; nevertheless its influence is indirect because of complicated circular processes.

Acknowledgements

The authors are grateful to the Russian Academy of Sciences Young Scientists' Grant No. 41, Russian Foundation for Basic Research (Grant No 96-02-16579, 96-02-17054, 98-02-16189) and the federal Program 'Astronomy' (Grant No. 1.5.3.6) for financial support.

References

Catalogue of Parameters of Atmospheric Circulation (1988) World Data Center, Obninsk.

Dzerdzeevsky, B. L. (1975) *Selected Papers 'General Atmospheric Circulation and Climate'*, Moscow, Nauka.

http://ingrid.ldeo.columbia.edu//sources (IRI/LDEO Climate Data Library (and NCDC)).

Kishcha, P. V. and Dmitrieva, I. V. (1997) *'Secular Variation of Solar-geomagnetic Coupling and Meteorological Parameters': Modern problems of solar cycling*, Proceeding of the Conference, 26–30 May 1997, St. Petersburg, p. 116.

Popova, V. V. (1995) *Long-term Variabiffty in the Precipitation Fluctuations all over the Russian Plain and Their Relationship with Global Climatic Changes*, Proceedings of the International Conference on Past, Present and Future Climate, Helsinki, Finland.

Sazonov, B. I. and Scheremetova, L. M. (1985) *Trudy GGO (Proceedings of the Main Geophysical Observatory)* **486**, 96.

Savina, S. S. (1987) *Materials of Meteorology Studies* **13**, 3.

Solar-Geophysical Data (1996) Prompt Reports, May 1996, No. 621, part 1.

Vitels, L. A. (1977) *Synoptic Meteorology and Geophvsics*, Gidrometeoizdat, Leningrad.

Zaborova, E. P., Dmitrieva, I. V., and Obridko, V. N. (1997) *Solar Activity-Climate Coupling and Global Circulation Epochs*, Proceedings of 8th Scientific Assembly of IAGA, Uppsala, Sweden.