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Hydrology and Earth System Sciences Discussions

Interactive comment on "Influence of solar activity on hydrological processes" *by* J. Pérez-Peraza et al.

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Comments of professors Holger BRAUN and Bernd KROMER are very interesting and will be cconsidered in the revised version of the paper. A) 1. We completely agree with the suggestion: we had given the time series of the lake levels in fig. 8,. For the other parameters, as it is the case of the number of sunspots we did not included them because they are very well known, appearing in many WEB pages (for instance, http://nssdc.gsfc.nasa.gov/space/model/solar/sunspot.html; http://cr0.izmiran.rssi.ru/mosc/main.htm http://www.gfz-potsdam.de/pb2/pb23/GeoMag/niemegk/kp_index/related.html;), and because the paper had already 12 figures. However, the level of lakes is not the kind of information which is worldwide openly available on the WEB, and we have shown them on Fig 8. Here we are enclosing the EMPLOYED time series in a more readable version, together with that of the sunspots number (Wolf number).

UNFORTUNATELY THE SYSTEM DOES NOT ALLOW US TO INSERT THE NEW FIGURES, BUT WILL BE IN THE REVISED VERSION

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2. Trustable data of Lake Patzcuaro exist only since 1950. Data from 1950 up to 1991 were taken under a same standard method. Rain in the region has noticeably decreased since then. Data correspond to anomalies relative to the general bench mark (2038.38 meters over the sea level). After 1991 the average bench mark has decreased. and data is furnished in another format. With respect to lake tschudskoye, in section 4 it is pointed out the use (for the spectral analysis of solar activity and level of Lake Tchudskoe) of time series from 1885 to 1987 (which is a mistake that we did in writing the paper, because the analysis was done up to 1993). From such analysis we inferred about the congruence of the a 80-90 years cycle with a kind of solar Gleissberg cycle. On the other hand, as was mentioned in Section 5, for Regression Analysis (ARMA) we used data of Tscudskoye since 1921 and the results shown in Figs.5-7 correspond to the period 1921-1985.) The reasons are that the Patzcuaro data that

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we trust go up to 1991, and on the other hand, because we had limitation of computer facilities, we decided to do the analysis by means of periods of selective nature (11-12 years) trying to give a physical meaning, that is, to cover full solar activity cycles, so, we have cut our runs in 1985. However, cross-correlation as that of Fig. 9 was done on basis to the lake Patzacuaro data (the period 1950-1991).We would like to emphasize that our work was done with the data we disposed.

3. That is right, the graphs are terrible, we are doing better and readable graphs.

B. 1. Estimation of statistic significance is not obligatory for spectral analysis, because of it is based on mathematical theorems, which are inapplicable to short time series. Estimations of significance in these cases give very approximated results, and can not be used as a tool of proof. Very well known works based on spectral analysis do not use significance in their works, (for example the series of papers of Owens, 1974). 2. The best argument for 11 year dependency is the correlation function (fig 9), probably the best result in this paper. Estimation of statistic significance could be made easily for this curve, but that does not give strong support to the obtained result. . 3. The shift between the series in the calculation of their spectral characteristics helps to identify the dephasing of the existing cycles in the variability of the corresponding processes. Mechanically, the elements of a series (A) change their position in relation with the jointly analyzed series (B) by “moving” it a given number of years (or months), forward or backward, in the time axis. Applying the spectral analysis to the so formed pair of series, it is possible identify the dephasing between the studied physical processes, i.e. between the cycles that participate in their time variability. Graphically (see figure below), the Patzcuaro series can be shifted some years in negative sense and it can be observed the increase of the correlation Tchudskoe - Patzcuaro, as approximately can be deduced from Fig. 9.

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4. Regarding our conclusions, one of the most controvertible seems to be the estimation of a cycle with period of 80 - 90 years, related with one of the most conspicuous cycles of solar activity: the Gleissberg cycle, on the basis of data which cover a period of only 108 years length (1885 - 1993). According with Sabatino Sofia (2004) the existence of still longer periods cannot be dismissed or confirmed because of the lack of early solar observations. Our inference about the existence of such a cycle in the variability of the Lake Tchudskoe level, can be supported taking into account the opinión of W.J. Burroughs expressed in his book "Weather Cycles. Real or Imaginary?" 2003, (page. 19) where it is established that "Ĕ The length of any time series has greater effects on the search for cycles. The first and most obvious is that there is no unambiguous information about periodicities longer than the length of the records. Although it is possible to draw some inferences about the longer-term components that could contribute to trend in the record (Fig. 2.4 of the book), this is limited by the accuracy with which the trend can be measured (see also sections 2.4 and 2.6 of that book). This means that in the case of a 100-year record, sampled annually, the useful information is restricted to cycles with periods from 2 to 100 years. This means that in the case of a 100-year record, sampled annually, the useful information is restricted to cycles with periods from 2 to 100 years. Where the long-term trend represents an appreciable part of the variance, it is often decided to remove the trend before performing spectral analysis Ĕ Ĕ". This is illustrated in Burroughs (2003) by means of two examples, one of them with a series which has a length shorter than the studied cycle. We call to take into account, that the spectral analysis used in our work includes not only the amplitude spectra of each analyzed series, but also the cross amplitude, phase, and coherence spectra. This, together with the applied regressive analysis by means of ARMA models of several orders give some degree of confidence to the translation of the solar cycles in the hydrological studied processes and lead to the development of a type of autoregressive model for the forecasting of the lakes level.

5. At this regard we pointed out in the text (Section 5, 6th row) "Ĕ it must be kept in mind that the cross power spectra give confident estimations of the (correlations)

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among the observed processes. However, the reliability of a series of relations is just in the limit of reliability of Ĕ obtained results Ĕ". For this reason, it was decided to apply the autoregressive analysis to the lakes time series, taking into account that the calculation of spectra by means of AR models permits to obtain the auto and cross correlation functions and different properties of them. This way the residual dispersion of the series is estimated and the orders of the AR and MA models for each series is obtained. The comparison of the spectra obtained in this way with those obtained by means of the spectral analysis revealed a good coincidence of results in the high frequency region, i.e. for the well known solar activity signals with periods of 22y and 11y, and in the region of the 2 - 6y.

6. Removing of dominant regional signals from both data is insensible for this paper. We do not investigate direct influence of solar activity to lake levels, obviously it happens via some another eath level processes. It I s clear that regional processes can not t influent to solar activity, so we really investigate soalr activity - hidrological processes dependencies. In fact, we proceeded to the analysis of the solar activity signals that are very well known, and used a series of filters trying to eliminate other kind of variability.

7. The coincidence we argue between results shown in Figs. 10 and 11 refers to the presence of the same signals in both cases (the lakes and the solar activity), taking into account the 10y and 4y signals. The solar activity nature of the 4y signal is shown in Fig. 11, and the correlation between both lakes may be interpreted as a common influence through the solar activity signals in both lakes. The result presented in Fig. 9 revealed that there is a dephasing between the oscillation of the Tchudskoe and Pátzcuaro, and that a shift in the time could increase the correlation between them. It can be observed in the last figure, previously shown above, where both series are drawn, and the Patzcuaro series are shifted back in the time axis. This dephasing between both oscillations perfectly could be the result of the climate conditions that modulate the solar activity signals in both cases, in the ENSO-dominated Lake Patzcuaro

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and the NAO dominated Lake Tchudskoe. Nevertheless, we will look in the future for new data that could be useful to confirm (or deny) our results.

C It is true that the field of Solar-Climate Relationships is at present one of the more controversial fields in the literature, just because the big amount of works in this field are not yet enough convincing about the processes involved in a presumable indirect influence of solar phenomena on the earth atmospheric layers. It would be emphasized that it is not the aim of this paper to give a physical model for interpretation of our results, such a kind of efforts are given in the introduction of the paper (section 1) by quite a large number of references (Chijzhevsky, Friis-Chistensen and Lassen, Zilhs et al., Dorman et al., ĚetcĚ). On this basis, in order to avoid confusions and false expectations, perhaps we should change the title of the paper by something like “Solar activity - hydrological processes dependencies” or “Correlational analysis of hydrological processes vs solar activity”, ĚĚ. but not to give the wrong idea that we pretend to establish in the same paper the physical mechanism. Again, what we do here is really investigate solar activity - hidrological processes dependencies. Nevertheless, we would like to make a comment at this regard: Generally, hydrological disturbance are primarily associated to the meteorological conditions near water surfaces: changes in atmospheric temperature, pressure and wind velocity, the effective moisture resulting from evaporation and precipitation, presumably due to changes in the atmospheric circulation. It may be argued , that the conditions in the lower ionosphere assist also, in some extend, to hydrological disturbances, and is precisely this layer that is mostly influenced by the solar activity, geomagnetic activity and cosmic rays. Though, by the moment is still very early to express that quantitavely, however, from the phenomenological point of view this conception is supported by the values obtained in our correlations. It is true that is difficult to suppose that the CR ionization of the upper atmosphere and the geomagnetic field disturbances, having billion times smaller energy than water thermal sources, could provoke superficial changes. Similarly, it is difficult to conceptualize that a weak signal from sun due to solar activity ( 0.1% around the so-called solar constant) would be observable. But on the other hand it is obvious that, there are clear

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correlations between cosmophysical parameters and variability of terrestrial phenomena, as has been shown in this paper and a big amount of works that constitute the field of solar-weather-climate-relationships. At present this is one of the more controversial fields in the literature, just because that big amount of works are not yet enough convincing about the processes involved in a presumable indirect influence of cosmophysical phenomena on terrestrial phenomena. Several hypothesis have been given, as for instance related with the concept of atmospheric “transparence”, but what we can stress here, from the qualitatively point of view is the concept of the so called “peck effect” associated with the variability of solar outputs, mainly solar-wind disturbances, that make the geospheric system react in a highly non-linear way to the sporadic or intermittent signals produced by the interaction of plasmoids and shock waves with the earth environment. Such interaction is highly sensitive to the relative position between transient output events on the sun, the heliospheric neutral current sheet and the orientation of the interplanetary magnetic field (IMF) at the earth: a kind of “detonator” for stratospheric cyclonic activity occurs when a boundary sector of the IMF crosses the earth, which effects spread in lower altitudes, in longitude and latitude. This indicates that our earth environment is such sensitive systems that even second order effects may disturb it.

Owens, A.J., J. Geophys Res. 75-7, 907-910, 1974, and series of papers in the same journal (1974). Sabatino Sofia, Eos,Vol. 85, No. 22-1, 217-224, June 2004.

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For cosmic rays: http://cr0.izmiran.rssi.ru/mosc/main.htm; http://cosmicrays.oulu.fi/; http://neutronm.bartol.udel.edu/%7Epyle/bri_table.html; http://cr0.izmiran.rssi.ru/txby/main.htm; http://cgm.iszf.irk.ru/irkt/months.htm; http://helios.izmiran.rssi.ru/cosray/months.htm; http://cgm.iszf.irk.ru/irkt/nm.htm and http://www.igeofcu.unam.mx/geomag/rcosmicos/indexi.html. Somelinks:http://www.ngdc.noaa.gov/stp/SOLAR/sibintro.html; http://www.ngdc.noaa.gov/stp/SOLAR/sgdintro.html ; **********

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