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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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The comments of the Anonymous referee # 2 are very interesting and lead us to modify the text of our article, taking into account most of his observations. Nevertheless we would like to point out the following features:

(1) & (2) - The time series of the level of lake Tchudskoye and lake Patzcuararo appear on fig 8. The time series of the solar and geomagnetic activities as well as cosmic ray intensity are very well known and appears in many WEB pages. We have used them as a tool of control reliability: Some typical WEB pages with that information are: http://nssdc.gsfc.nasa.gov/space/model/solar/sunspot.html; http://www.gfz-potsdam.de/pb2/pb23/GeoMag/niemegk/kp_index/related.html; http://cr0.izmiran.rssi.ru/mosc/main.htm We sincerely did not consider interesting to introduce figures with the time series of these kind of data since we have already 12 figures in the work. 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. The time series of the level of both lakes and the sunspots number (Wolf number) that we will include in te paper are:.

UNFORTUNATELY WE CAN NOT INSERT FIGURES HERE, BUT WILL BE IN THE REVISED VERSION

- It is quite right that we did not furnish enough information about data of Lake Patzcuaro: the existing data began in 1950. Data from 1950 up to 1991 were taken under a same standard method. Data correspond to anomalies relative to the bench mark of (2038.38 meters over the sea level, remaining quasi-constant during the studied period). Rain in the region has noticeably decreased during the last two decades and the rate of evaporation of the mirror water is higher than precipitation - Lake Patzcuaro is a tropical lake of high mountain. It is a closed basin with no tributary rivers to feed it. The sources of feeding are rain, evaporation and infiltration proceeding from the capture area. The lake has a surface over 1000 Km2 from which about 10% corresponds to the lake mirror. Its maximum length is 20 Km from southeast to northeast and the maximum width is 14 Km The mean depth is 5 m and the maximum depth is 12.5 m. There are eight islands in the lake, including the well know Janitzio island.. There is a high ecogeographic diversity with 12 different geosystems ,(http://www.semarnat.gob.mx/regiones/patzcuaro/fisico.shtml) . - Concerning impact of human activities during the time period, the main one is a significant ecological debacle: degradation due to erosion of surrounding soils, biological erosion, severe pollution , silting, eutrophy, and consequently a trend to drying (http://www.recuperapatzcuaro.info/info.htm). - In relation to lake Tchudskoye, it is correct that there is a confusion in the way we handle the dates of data. At this respect, in the 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

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Gleissberg cycle. On the other hand, as was mentioned in Section 5, for Regression Analysis we used data of Tscudskoye since 1921 and the results shown in Figs.5-7 correspond to the period 1921-1985. Maybe the confusion that we provoked comes from the fact that we mentioned data up to 1993, while results are presented only up to 1985. The reasons are that the Patzcuaro data that 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 some 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. We shall correct all the confusing statements.

- As we are pointed out previously, the common period of the analyzed series goes from 1950 to 1991, i.e. a period of 42 years length. 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. In relation to the different climate conditions in both lakes, even if there is a regional difference betweent hem, we proceeded to concentrate the analysis on the solar activity signals that are very well known, and can not be confused with weather or climate signals at all,. In fact, a series of filters were used in order to eliminate possible variability of those frequencies that we know are typical of solar activity

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(3).- Regarding our conclusions, one of the most controvertible seems to be the estimation of a cycle with period of 80 - 90 years on the basis of data which cover only 108 years (1885 - 1993), that present the same length of one of the most conspicuous cycles of solar activity, the so called Gleissberg cycle. - According 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

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the variability of the Lake Tchudskoe level, by processing data which only cover 108, can be supported taking into account the opinión of W. J. Burroughs, regarding cycles of longer extension than data in his book “Weather Cycles. Real or Imaginary?”, 2003 (page 19), where is established that “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 in that 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. 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”. 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 included not only the amplitude spectra of each analyzed series, but also the cross spectra, amplitude, phase, and coherence. These, together with the 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.

(4) . It is not the aim of this paper to give a physical model for interpretation of our results, such a kind of efforts have been done by qualified specialists, some of which we have mentioned in the introduction of the paper (section 1), by a number of references (Chijzhevsky, Friis-Chistensen and Lassen, Zilhs et al., Dorman et al., ĔetcĔ). Nevertheless, we would like to make some comment at this regard: we do not investigate direct influence of solar activity to lake levels, obviously it happens via some another earth level processes. It is s clear that regional processes can not influence to solar activity (from this point of view, removing of dominant regional signals from data of the two lakes is insensible for this paper) so, what we really investigate are solar ac-

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tivity - hidrological processes dependencies. 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, to 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 many correlational studies. 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 the 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 correlations between cosmophysical parameters and variability of terrestrial phenomena, as has been shown in this paper and in 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

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IMF (interplanetary magnetic field) 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.

Sabatino Sofia, Eos,Vol. 85, No. 22-1, 217-224, June 2004.

Some interesting links: For solar activity indexes: ; http://nssdc.gsfc.nasa.gov/space/model/solar/solar_index.html ,http://www.ngd.noaa.gov/stp/SOLAR/SSN/ssn.html , ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/ http://www.ngdc.noaa.gov/stp/SOLAR/ftpsunspotnumber.html#american. For geo-magnetic (Kp) data ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/KP_AP/ ; For cosmic rays: ; ; 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, http://www.ngdc.noaa.gov/stp/SOLAR/sibintro.html ;http://www.ngdc.noaa.gov/stp/SOLAR/sgdintro.html ; For the Lake Patzcuaro http://www.semarnat.gob.mx/regiones/patzcuaro/geosistemas.shtml , http://www.semarnat.gob.mx/regiones/patzcuaro/fisico.shtml , http://www.semarnat.gob.mx/regiones/patzcuaro/bibliografia.shtml

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