Nat. Hazards Earth Syst. Sci. Discuss.,
doi:10.5194/nhess-2016-172-AC4, 2016

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Atmospheric and ionospheric coupling phenomena related to large earthquakes" *by* M. Parrot et al.

M. Parrot et al.

mparrot@cnrs-orleans.fr

Received and published: 7 November 2016

As we have no reply from referee 1 we provide here an amended version of our previous answer. Accordingly we also download a new version of our paper where the changes from the initial text are in red (supplementary file).

The referee is right when he is asking for the statistical significance of some of the results shown in the paper but, as explained at very start of the paper (already in the abstract at line 13) the paper is devoted to "... apply already validated observations to identify atmospheric and ionospheric precursors associated with some of recent most destructive earthquakes...". So, as declared in the title, the scope of the paper was not to propose new earthquake precursors or data analysis methods (each of one obviously would require, as requested by the referee, a more extensive validation) but

Printer-friendly version

Discussion paper

just to integrate them (as their extensive validation has been already published in peer review papers) to verify if the anomalous transients foreseen by the LAIC model are confirmed or not by observations. So the text has been modified clearly indicating this circumstance and referring to the appropriate peer reviewed publications where the answers to the referee (justified) requests can be found.

More in details: ___________ Question The manuscript submitted by Parrot et al. addresses an important topic, and clearly is the result of a lot of work, analyzing a broad range of different data. It is hard for me to evaluate it since it is outside my main fields of interests, but I believe that some criticism can be made without addressing the technical details. In general, it seems to me that this study suffers from a lack of statistics-based quantification of the "significance" of the "anomalies" that are discussed. In some cases, I frankly do not see anything anomalous in graphs that the authors claim to show significant changes in some observables. This is the case, for example, of Figs. 2 and 3 and other analogous plots. In some other figures, differences can be seen visually, but there is nothing indicating that they should be considered "significant"–at least for a non-specialist as I am.

Reply: Sorry for the confusion. This is because that we try to keep the paper concise, and simply refer “for more details see Liu et al. (2011)” in the manuscript. In fact, the “anomaly” and “significance” are rigorously defined. Regarding Fig. 2 and its analogous plots, we have following criteria. To detect anomalous signals of the GPS TEC variations, a quartile-based process is performed. At each time point, we compute the median M of every preceding 15-day of the GPS TEC as well as find the deviation between the observed one on the 16th day and the computed median M. To provide the information about the deviation, we also calculate the first (or lower) and the third (or upper) quartiles, denoted by LQ and UQ, respectively. Note that assuming a normal distribution with mean m and standard deviation σ for the GPS TEC, the expected values of LQ and UQ should be m-0.67σ and m+0.67σ, respectively [Klotz and Johnson, 1983]. To have a stringent criterion, we set the lower bound, LB = M $-$ 1.5(M $-$ LQ) and upper bound, UB = M + 1.5(UQ − M). Therefore, the probability of a new GPS TEC in the interval (LB, UB) is approximately 68%. The median together with the associated LB and UB then provide references for the GPS TEC variations on the 16th day. When an observed GPS TEC on the 16th day is not in the associated (LB, UB), we declare an upper (increase) or lower (decrease) abnormal GPS TEC signal. Since the GPS TEC time resolution is 2-hour, there are 12 data points per day. If more than one third (4/12) of the upper or lower abnormal signals successively appear in one day, and the observed GPS TEC is greater or smaller than the associated UB or LB, we then consider the upper or lower anomalous (positive or negative precursor) day being detected. The probability of having a daily anomaly by observing four or more signals (negative or positive) is about 0.22, that of the successively appearing anomalies should be even less.

Regarding Fig. 3 and its analogous plots, the top and lower panels are the GIM TEC and associated variation normalized by the standard deviation, respectively. The anomalies and statistical significance are defined by the associated “the standard deviation”. Note that the anomalies and the significance in Figs. 2 and 3 and their analogous plots are rigorously defined by the median and mean bases, respectively.

question

Take for example Fig. 4: we are shown three curves, each recorded on a different day. We are told that one curve represents "undisturbed conditions", and the other two, recorded on two consecutive days, are characterized by an "anomaly". But why should we call it an "anomaly"? What are the typical differences between observations of this kind that are made in the absence of large seismic events? Or does the "GPS TEC" indeed follow precisely the green curve on any day except for 4 and 5 days before the earthquake in question?

Reply One of the most spectacular features in the ionosphere is equatorial ionization anomaly (EIA). The EIA is characterized by two enhanced plasma (or electron density, TEC, etc.) crests at low latitudes straddling the magnetic equator with the electron density depleted on the magnetic equator. It is the region that yields the greatest electron density in globe. The EIA is produced by the equatorial plasma fountain, which lifts the plasma from magnetic equator to higher altitudes and then it diffuses down along magnetic field lines to higher latitudes creating two ionization crests on both sides of the magnetic equator (Namba and Maeda, 1939; Appleton, 1946; Duncan, 1960; Hanson and Moffett, 1966; Anderson, 1973; Balan and Bailey, 1995; Rishbeth, 2000; Lin et al., 2007). Thus, the EIA is a daily normal feature (for example, red and pink curves in Figs 4 and 8), which reveals that two GPS TEC enhancements (peaks) at low latitudes straddling the magnetic equator with the depletion on the magnetic equator. By contract, green curves in Figs. 4 and 8 show no peaks at low latitudes, which means the EIA disappearing. The EIA is essentially afternoon phenomenon because the east directed electric field appears at geomagnetic equator in afternoon hours of local time. As it was told above, this is afternoon phenomenon and in natural conditions the EIA cannot form in the local morning hours. On Fig 4 was shown arising in the morning hours, therefore was considering as an anomaly, and manifests the appearance of anomalous electric field generated by the earthquake preparation process.

Namba, S., and K.-I. Maeda (1939), Radio Wave Propagation, 86 pp., Corona, Tokyo. Appleton, E. V. (1946), Two anomalies in the ionosphere, Nature, 157, 691. Duncan, R. A. (1960), The equatorial F region of the ionosphere, J. Atmos. Terr. Phys., 18, 89 – 100. Hanson, W. B., and R. J. Moffett (1966), Ionization transport effects in the equatorial F region, J. Geophys. Res., 71(23), 5559 – 5572. Anderson, D. N. (1973), A theoretical study of the ionospheric F-region equatorial anomaly. I: Theory, Planet. Space Sci., 21, 409 – 419. Balan, N., and G. J. Bailey (1995), Equatorial plasma fountain and its effects: Possibility of an additional layer, J. Geophys. Res., 100(A11), 21,421 – 21,432. Rishbeth, H. (2000), The equatorial F-layer: Progress and puzzles, Ann. Geophys., 18, 730 – 739. Lin, C. H., J. Y. Liu, T. W. Fang, P. Y. Chang, H. F. Tsai, C. H. Chen, and C. C. Hsiao, Motions of the equatorial ionization anomaly crests imaged by FORMOSAT-3/COSMIC, Geophys. Res. Lett., 34 , L19101,

10.1029/2007GL030741, 2007.

question Another example is, to me, Fig. 16, where we are shown the behaviour of electron density during a month and a half, around the time of a seismic event. The curve shows a peak about a month before the event, but how does it look like over the rest of the year? and how do similar data look like in other areas, in the absence of seismic events? I am not saying that there is no relationship between this observable and the seismic event, but, rather, that this curve and the authors' discussion of it are not a convincing indication of such a relationship. Somewhat more convincing, or at least more suggestive, are Figs. 17 and 25. In both cases, "outgoing longwave radiation" is shown over one entire year, and the largest peak in its "anomalies" happens shortly before the large earthquake under consideration. I, however, did not understand what the authors mean by "average", "daily values" and "anomalies", i.e. what the difference between the three curves shown in these figures is. As a result, I do not really know what to make of these figures. Also, the red curves show many other peaks: is there a statistically significant correlation between these and seismicity?

I, however, did not understand what the authors mean by "average", "daily values" and "anomalies", i.e. what the difference between the three curves shown in these figures is.

reply

The “daily values”, “average” and “OLR anomalies” were established in Ouzounov et al ,2007 and Xiong et al 2010. Here is a brief summary- “Daily values” are daily raw values of OLR for the same pixel and same local time observed by the polar orbit satellite. The “average” was estimated by a multiyear average (2004-2008, or 2014-2016) for each pixel. The OLR “anomalies” were defined as a maximum change in the daily average of the OLR in comparison to the “average “(normal) field. The OLR anomaly has been calculated as a deviation from the normal state (with threshold of minimum one sigma value) and normalized by the multiyear standard deviation for the same pixel. Ouzounov D., D. Liu, C. Kang, G. Cervone, M. Kafatos, P. Taylor, (2007) Outgoing Long Wave Radiation Variability from IR Satellite Data Prior to Major Earthquakes, Tectonophysics, Volume 431, Issues 1-4, 20 February, pp. 211-220 Xiong P, X. H. Shen, Y. X. Bi, C. L. Kang, L. Z. Chen, F. Jing, and Y. Chen (2010) Study of outgoing longwave radiation anomalies associated with Haiti earthquake, Nat. Hazards Earth Syst. Sci., 10, 2169–2178, 2010

question

“As a result, I do not really know what to make of these figures. Also, the red curves show many other peaks: is there a statistically significant correlation between these and seismicity”

reply

(1) The daily OLR variations (OLR values are around 2) are caused by the daily environmental variations in the vertical atmospheric circulations in middle atmosphere. The significant deviation from the normal state in the OLR started in the beginning of Feb 2008 (Fig.17) with a systematic increase reaching the Maximum level (OLR values are around 7) with 4 sigma significance in the OLR acceleration on May 6th 2008 and going back the normal state by end of October 2008. This is also the period of ending the major aftershock activities in Wenchuan area. The black curve represents the seasonal dependence of OLR average for 2004-2008), usually getting maximum value during the summer time. The May 6-th OLR anomaly is not overlapping with the maximum seasonal variations in OLR (Fig 17, Black curve) in June-August, which is an indication for the non-weather related origin of OLR anomalous values. Similar could be said and for Fig.25 (2)A statistical check of OLR anomalies and their connection with large events (M>5.9) was studied for Japan and Taiwan. The top 10% earthquakes during the period of 2004-2009. The mean value of lag time is 5-10 days before, no activities during and after the main shocks. Alarm ratio for false positives is less then 25%. Analogous observations were observed within a few days anterior to the most

recent major earthquakes China (M7.9, 2008), Italy (M6.3, 2009), Samoa (M7, 2009), Haiti (M7, 2010), Chile (2010, 2014, 2015) , Japan (M9, 2011), M7.8 Nepal (2015). Ouzounov, D., S. Pulinets, K. Hattori, L. Lee, T. Liu, and M. Kafatos 2015, Prospective Validation of Pre-earthquake Atmospheric Signals and Their Potential for Short-term Earthquake Forecasting, EGU General Assembly Conference Abstracts 17, 7840 http://meetingorganizer.copernicus.org/EGU2015/EGU2015-7840-1.pdf Ouzounov D, S.Pulinets, D.Davidenko, M. Hernández-Pajares, A. García-Rigo, N. Hatzopoulos, M. Kafatos (2015) Transient Effects in Atmosphere and Ionosphere preceding the two 2015 M7.8 and M7.3 Earthquakes in Nepal, AGU Fall Meeting, 14-18 December 2015 in San Francisco, USA https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/62246

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2016-172/nhess-2016-172-AC4-supplement.pdf

---

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-172, 2016.