DOI:10.16262/j.cnki.1005-0841.2003.02.020

Development of Studies on Relationship between Astronomical Phenomena and Natural Disasters

Han Yanben[1] Dong Guoxuan[2] Zhao Juan[3] Ma Lihua[1]

(1 National Astronomical Observatories, CAS, Beijing 100012;
2 Division of Astronomy, Department of Mathematical and Physical Sciences, NSFC, Beijing 100085;
3 Department of Astronomy, Beijing Normal University, Beijing 100875)

1 Significance of the Research

Living and progress are the two main motifs of the human society. The security of anima and property of the human is imperiled by frequent natural disasters. Natural disaster is one of main factors restricting development and advancement of the the society. The physical process of gestation and happen of natural disasters is complex and the process is affected by many factors. At present, it is difficult to exactly predict natural disasters since the regularity and mechanism of gestation and happen of disasters have not been adequately understood yet. Studying disasters needs scholars from related subjects to co-act and develop the interdisciplinary research since the factors affecting disasters are related to many subjects. The conversion of mass and energy exists between the earth and its external, and the earth is easily affected by its astronomical environment at any time, since the earth is an open celestial system. It is important that some astronomical phenomena put the influence and modulation on the movement and change of lithosphere, atmosphere and hydrosphere of the earth. Especially, for the forthcoming disasters, some astronomical phenomena may be able to react on triggering disasters.

Preliminary studies found that the variation of the earth rotation, solar activity, variation of the lunisolar tidal force, and so on, can affect and modulate some disasters, such as earthquake, anomaly precipitation and temperature, and El Niño phenomenon, so as to induce and trigger the disasters. Some astronomical phenomena can directly lead disaster, for example, strong solar activity can affect the security of telecommunication, space navigation, and transmit electricity. Even in the large space and time scale, some catastrophes on the earth, such as variation of ice age, enormous changes of climate and sea level, large geological tectonic movement, depopulation of biology, and so on, are considered to be related to the motion of solar system in the Galaxy, secular variation of orbital parameters of the Earth. The actions of astronomical phenomena may be important in these events.

Therefore, some astronomers and geophysical scientists are interested in the interdisciplinary study of astronomy and geosciences. In order to develop the studies about the relationship between astronomical phenomena and natural disasters, a research group in the National Astronomical Observatories of the CAS is engaging in the investigation. The group attempts to lucubrate the regularity of some astronomical phenomena, the possible actions of the phenomena for affecting, modulating and triggering disasters, and to find ways providing help for study and prediction of disasters.

2 Developments of Main Studies

2.1 Variation of earth's rotation and natural disasters

The variation of the Earth's rotation is of intricacy. Besides the slow down of the secular, there are periodic and non-periodic changes in diversified time scales. The main reason of the complex variation may be from the movement of the mass in lithosphere, atmosphere and hydrosphere of the earth, and from influence of else celestial bodies put on the earth, such as solar activity and variation of the tidal force caused by change of celestial position, etc. The conservation of angular momentum in the solid earth, hydrosphere and atmosphere induces the reciprocal influence among them. Scientists understood that the mutual influence exists in each part of the earth, and noticed the influence between the earth's rotation and atmospheric movement.

Some scholars have studied the relationship between the variation of the earth's rotation and earth-

quakes since several decades ago. Stoyko, a France scholar, found that there is a close correlation between the annual energy releasing of global earthquakes, whose epicentre depth is middle and deep, and the earth's rotation variation [1]. Some scholars from other countries were also engaged in the research in succession[2]. We mainly studied that the relation between the earth's rotation variation and some big earthquakes ($M \geqslant 7.5$) during the 20th century in western China where the seismicity is very strong. Meanwhile, in order to investigate whether analysis of the variation is able to supply information for prediction of big earthquakes in the future, we analyzed the shape of earth's rotation variation in the preceding year of each big earthquake. 16 big earthquakes in the area are analyzed, the result showed that the acceleration of the earth's rotation is positive in the preceding years of 13 among these big earthquakes ($M \geqslant 7.5$). The magnitude is over 8 for six big earthquakes, and the acceleration of the earth's rotation is positive in the preceding years of occurrence of the earthquakes. The statistic result is obviously preponderant[3].

The seasonal variation exists in the earth's rotation. The accelerated motion decelerates in January and the movement state will be kept in the coming three months, and the movement will become the accelerated state from April and the acceleration is more than one in the beginning of the year. In July, the movement will become decelerating and the state will be kept up to November, then it becomes the accelerated state. According to the statistics of the above 16 earthquakes, 75% of them took place in transition periods of the variation of the earth's rotation although the sum of transition period length is only about 20% of the whole year. Especially, 6 big earthquakes occurred in about one month from the end of July to the end of August. The occurrence probability in the period, when the transition between acceleration and deceleration is obvious, is four times of the mean probability of one month. The statistical result is obviously preponderant too.

The action of the additive stress from the variation of the earth's rotation on the crust may be the main reason that the close correlation exists between the rotation variation and the big earthquakes in the area. The statistic result is possibly helpful for understanding the influence of the earth's rotation variation on the occurrence of big earthquake and providing information for earthquake prediction although it is difficult to calculate the affecting degree at present [3]. Howsoever, it is worthwhile to proceed with the study of the phenomenon.

As mentioned above, the interaction exists among the variation of solid Earth's rotation and motions of the hydrosphere and atmosphere. At present, it is generally considered that El Niño phenomenon is possibly from the coupling between ocean and atmosphere. Therefore, it is worthwhile to study the relationship between Earth rotation and El Niño, and some scholars have paid attention to this problem[4-6], while our group focuses on inter-annual variation of the Earth rotation and El Niño phenomenon. The inter-annual variation here means that the components with period less than 1.5a and greater 8a are removed by the band-pass filter because the interval between two El Niño events is about 2~7a generally. Since the 1970's, Earth rotation series has higher precision. Utilizing the datasets to analyze the relationship among the inter-annual variation of the Earth rotation, sea surface temperature (SST) of equatorial east pacific and El Niño phenomenon, we note that there is a high correlation between the inter-annual variation of the Earth rotation and SST variation. Especially, the inter-annual component of the earth rotation will present a special state before El Niño occurrence by about half year or more. In 2001, according to the analyses of the Earth rotation variation, we made a trial prediction in advance about half year for the weak El Niño phenomenon occurred in 2002. The anomaly variation of the earth rotation is possibly from the interaction between ocean, atmosphere and the Earth rotation in the gestation process of El Niño phenomenon. The precision of observations of the Earth rotation is very high at present, and the analyses of the data could provide useful information for prediction of El Niño phenomenon occurrence.

2.2 Lunar-solar tidal force and earthquake

Tides, the movement of the coastal water, solid crust of the earth and atmosphere, raised by the gravitational forces of celestial bodies upon the Earth provide an alternating rise and fall in different areas of the Earth. Because the tidal force of planets, which is very small, is ignored entirely, we consider mainly the lunisolar tidal force, which is from the motion of the Sun and Moon, in the research. The variation of the tidal force at any area could be computed precisely. The relationship between earthquakes and tidal force has been studied by a lot of researchers. Some people thought that there exists a cor-

related character, but some got the reverse results. Therefore, we analyzed the relationship between tidal force and earthquakes in different areas and belts, such as southwest, north, northwest and Taiwan of China. We note that there is a high correlation between tidal force and earthquakes occurred in the similar belts. With comparison and analysis for the tidal force and earthquakes in different areas and belts, we found that the details of the correlation are various for seismic belts with different geologic structure[8].

However, it is a question that additional stress came from the lunisolar tidal force could influence the triggering of an earthquake, since the tidal stress is less than tectonic stress. Researches have confirmed that the variance ratio of the tidal stress is larger than the tectonic stress by about 2 orders of magnitude. From high correlated character between earthquakes in Taiwan and variance ratio of lunisolar tidal force, it would help us to understand the possibility of the trigger action of the tidal force on earthquakes. These results are useful for the improvement of earthquake prediction, especially for the short-term and impending earthquake prediction. On the basis of an earthquake prediction lasting several months or several days made by other methods, by computing the tidal force and its variance ratio on different time scales in the period, we could determine that the most dangerous period may be about one week in each month or about 5~7 hours in one day[8].

2.3 Solar activity and natural disasters

The solar activity can affect some geophysical phenomena in the earth. Many scientists from different countries have investigated the relationship between solar activity and earthquakes, and some valuable results have been obtained[9-11]. However, different conclusions exist in some results. Of course, this is not far from expectation since the relationship between earthquake and solar activity is very complex. We investigated big earthquakes ($M \geqslant 8$) occurred in China and western Mongolia after A.D.1556. Among the 22 big earthquakes, 7 big earthquakes occurred in west-east or near west-east faults. The occurrence times of 6 among the 7 earthquakes happen to be close to solar maximum years and after the maximum years. On the other hand, occurrence times of 15 big earthquakes in faults with other directions are almost not close to solar maximum year, and the departure is more than 3 or 4 years. Having investigated the activity of magnetic storms in the maximum period of solar activity, we believe that the phenomenon is related to strong perturbation in geomagnetic field caused by big magnetic storms in the maximum period of solar activity. We obtained a preliminary model for appearance of the phenomenon: (1) In the seismic active region, the fault pre-displacement take place in the later gestation period of a big earthquake — the conductivity of the rock is improved since friction heats rocks; (2) The solar activity becomes active in maximum period — strong magnetic storms frequently appear—anomalous variation exists in north-south horizontal component of geomagnetic field — conducting layer is formed in faults with west-east strike — strong eddy current is generated; (3) The fault is heated further — the shear resistant intensity and/or the static friction limit of the rock is decreased — a big earthquake in the later gestation period is easily triggered. The problem needs further study since the solar activity and the relationship between the activity and some geophysical phenomena are very complex[12].

Analyses exhibit that solar activity can influence precipitation changes, and Beijing area has a long data series of annual precipitation. We analyzed the relationship between annual precipitation in the area and solar activity, noting that Beijing area always is arid before sunspot minimum year about 1-2 years and maximum year, but after the minimum year and before the maximum year about one year, the precipitation in the area is always more. In El Niño years, the area is arid generally. On the base of spectrum analysis, a mathematical model, which is for the prediction of annual precipitation in the area, is obtained through analysis of the relationship between variation of precipitation and solar activity and El Niño phenomenon. In five trial predictions in the last years, four of them are closed to the actual precipitation. For the prediction in 2003, now we can confirm that the prediction error will be also small according to the actual precipitation in the area in the last 10 months. The variation of precipitation, influenced by many factors, is very complex, and it deserves our constant study.

3 Conclusions and Discussions

The findings on disasters are preliminary, but we can believe that disasters are related to some astronomical phenomena. The study on natural disasters is a representative problem with complexity. Many natural disasters occurred in the lithosphere, atmosphere and hydro-

sphere of the earth, some factors from interior and exterior of the earth can affect the process of gestation and happen of disasters. For some disasters, such as earthquake, the human recognizing ability seems to be feebleness. It is difficult to exactly predict earthquake at present, so it is understandable that some scholars disbelieve the possibility of predicting earthquake. When the possibility was discussed in Nature in 1998, we enjoy a scholar, Scholz's such standpoint: what should we do about earthquake prediction? Should we declare it impossible and banish it from our minds? I think not: there is much yet to be learned about earthquake physics, and rapid progress is being made[13].

For severe natural disasters, human beings should study their occurrence regularity and mechanism in order to understand them, exactly predict their occurrence and effectively cut back on influence of disasters in the future, although it is a difficult problem now. We think the profound understanding of disasters should be from the unceasing lucubrate. At least, the unremitting endeavor will help human to approach the success gradually.

Acknowledgement: This work is supported by the National Natural Science Foundation of China.

References

[1] Stoyko A. Rotationdelaterre phenomenes geophysiques et activite du soleil. Bulletin Academic Royale Belique. 1969, 5 (55): 279.

[2] Zharov V. E. Connection of the Earth's rotation with the atmospheric angular momentum and the strongest earthquakes. Astron. Astrophys. Trans. 1996, 9: 317.

[3] Han Yanben, Guo Zengjian, Zhao Juan et al., Variation of the earth's rotation and large earthquakes in the west of China, Recent Developments in World Seismology, 2003, 6:1.

[4] Eubanks T. M. The 1982—1983 El Niño, the southern oscillation and changes in the length of day, Trop. Ocean and Atmos. Newsletter, 1985, 29: 21.

[5] Chao, B. F., Length-of-day variations caused by El Niño—Southern oscillation and quasi-biennial oscillation, Science, 1989, 243: 923.

[6] Zheng D. W., Song G. X., Luo S. F., El Niño prediction, Nature, 1990, 348: 119.

[7] Han Yanben, Zhao Juan, Li Zhian. Inter-annual variation of the earth rotationand El Niño, Chinese Science Bull., 2002, 47 (2): 104.

[8] Zhao Juan, Han Yanben, Li Zhian. Variation of Lunar-solar Tidal Force and Earthquakes in Taiwan Island of China, Earth, Moon and Planets, 2002, 88: 123.

[9] Simpson J. F. Solar activity as a triggering mechanism for earthquake earth and plan, Scien. Letter, 1968, 3: 417.

[10] Sytinskij A. D. Connection of the Earth seismicity with solar activity and atmospheric processes, Gidrometeoizdat, Leningrad, 1987 (in Russian).

[11] Mazzarella, A., Palumbo A., Solar, geomagnetic and seismic activity, Nuovo Cimento C, Serie 1(11c), 1988: 353.

[12] Han Yanben, Han Yonggang, Wavelet analysis of sunspot relative numbers, Chinese Science Bull. 2002, 47 (7): 609.

[13] Scholz C. H. Earthquakes and friction laws. Nature, 1998, 391: 37.