

# Anomalies of astronomical time-latitude residuals at YAO before Wenchuan Earthquake

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**Abstract.** Accurate optical astrometric observations of the local variations of the vertical contain rich geophysical information. These may be used not only in the astronomical research, but also can provide important information for the earthquake forewarning. In the paper we analyze astronomical time-latitude residuals observed in Yunnan Astronomical Observatory in 2008-2009, and find that significant anomalies appeared before the earthquake of magnitude 8.0 that occurred in Wenchuan on May 12, 2008. The results obtained make us believe that the observed anomalies of time-latitude variations may provide an important warning sign before strong earthquakes and thus deserves further research.

## A. Definition of the Astronomical time-latitude residuals and its anomalies

Earth rotation parameters (ERP), Universal time ( $UT1-UTC$ ) and polar motion ( $x, y$ ), are obtained from worldwide observations processed by IERS. Astronomical time-latitude residuals (ATLR) for a specific astrometric instrument are obtained by removing the effects of ERP from the astronomical time and latitude observations determined by the instrument. Time and latitude residuals  $RT_j, RL_j$  at  $j$ -th instrument are expressed as:

$$RT_j = (UT0 - UTC)_j + \frac{1}{15}(x \sin \lambda_j - y \cos \lambda_j) \tan \varphi_j - (UT1 - UTC)$$

$$RL_j = d\varphi_j - x \cos \lambda_j - y \sin \lambda_j,$$

where  $\varphi_j, \lambda_j$  are geographic coordinates of the instrument. If these residuals are greater or equal to two times their standard deviation ( $2\sigma$ ), we take them as warning signs before the occurrence of strong earthquakes.

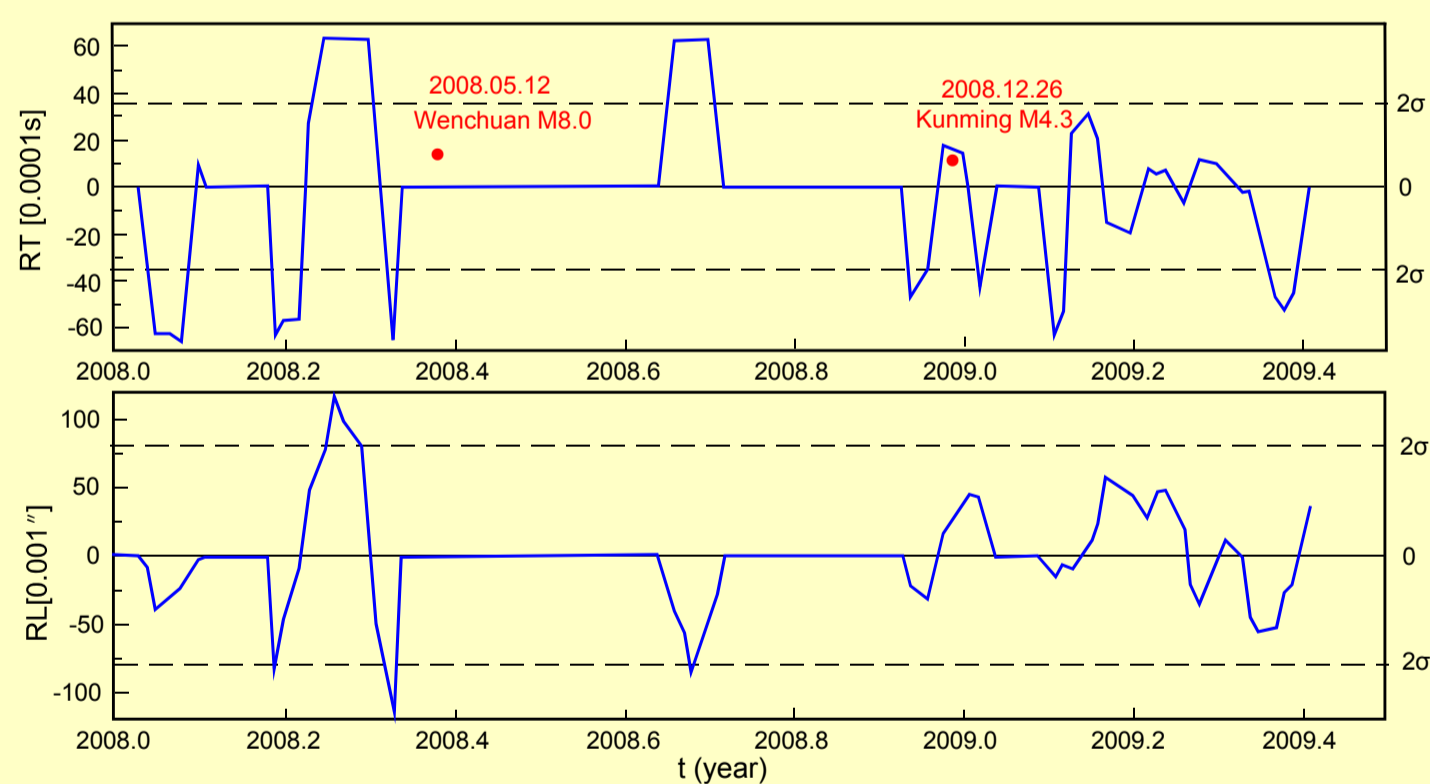


Figure 1. Astronomical time-latitude residuals observed at YAO

## B. Anomalies of ATLR at Yunnan before Wenchuan Earthquake

An earthquake  $M_s=8.0$  occurred in Wenchuan County (Sichuan province), China on May 12, 2008. It caused greatest heavy life and property losses in China's recent history. In March 2008 ATLR anomalies greater than  $2\sigma$  appeared, both in  $RT$  and  $RL$ , at Yunnan Astronomical Observatory (YAO). These are the first anomalies greater than  $2\sigma$  that appeared after the earthquake of  $M_s=6.2$  in Dayao county of Yunnan province. No earthquake  $M_s \geq 6.0$  occurred around YAO during the period from July, 2003 to 2008.0. The epicenter of Wenchuan earthquake was about 670 km away from YAO. Although the distance is rather long, Wenchuan and YAO are both located on the same Xikang-Yunnan rhombic fault block. Based on this fact, Long et al. (2006) rather precisely predicted that an earthquake of 8th magnitude would occur in the Wenchuan region in 2008; they used the commensurable principle using historical earthquakes of Xikang-Yunnan rhombic fault block. Therefore the ATLR anomalies in March 2008 (see Fig. 1) may be a warning sign of Wenchuan earthquake. The anomalies observed in September 2008, also depicted in the figure, may be related with the earthquake of  $M_s=4.3$  that occurred at Kunming. Its epicenter was only 24 km away from YAO.

## C. Possible mechanism

The ATLR anomalies possibly originate from the motion of the underground masses before earthquakes. The change of the local plumb line direction reflects the changes in the horizontal component of the gravity, while its vertical component is measured with a gravimeter. Fig. 2 shows the gravitational acceleration of a local vertical  $G_0$ . Now, due to a disturbance of underground mass, the gravitational acceleration becomes  $G_1$ . Its disturbed part can be separated into  $G_p$  and  $G_-$ . Evidently  $G_p$  is measured by a gravimeter, and the horizontal component  $G_-$  can be derived from the angle  $\theta$ , measured by the optical astrometric instrument:

$$G_- = \frac{\theta' G_0}{206265}$$

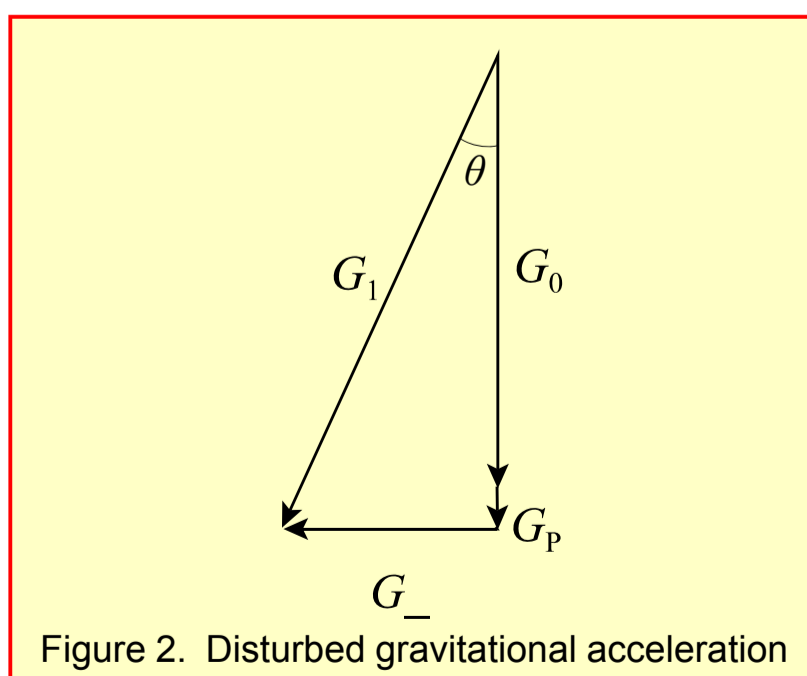


Figure 2. Disturbed gravitational acceleration

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