# ANOMALIES OF ASTRONOMICAL TIME-LATITUDE RESIDUALS AT YAO BEFORE WENCHUAN EARTHQUAKE

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ABSTRACT. Accurate optical astrometric observations of variations of the local 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 (Li et al. 1978, Zhang 1981, Han et al. 1987, Hu et al. 1989, Hu et al. 2003, Han et al. 2007) . In the paper we analyze astronomical time-latitude residuals observed at 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.

## 1. DEFINITION OF THE ASTRONOMICAL TIME-LATITUDE RESIDUALS

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 astronomically observed time ($UT0 - UTC$) and latitude ($d\varphi$) variations, determined by the instrument. Time and latitude residuals $RTj$, $RLj$ at $j$-th instrument are then expressed as:

$$
\begin{aligned}
RT_j &= (UT0 - UTC)_j + \frac{1}{15}(x \sin \lambda_j - y \cos \lambda_j) \tan \varphi - (UT1 - UTC) \\
RL_j &= d\varphi_j - x \cos \lambda_j - y \sin \lambda_j,
\end{aligned}
\tag{1}
$$

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.

## 2. 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 that occurred in 2003. 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 8-th 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 to the earthquake of $M_s = 4.3$ that occurred at Kunming. Its
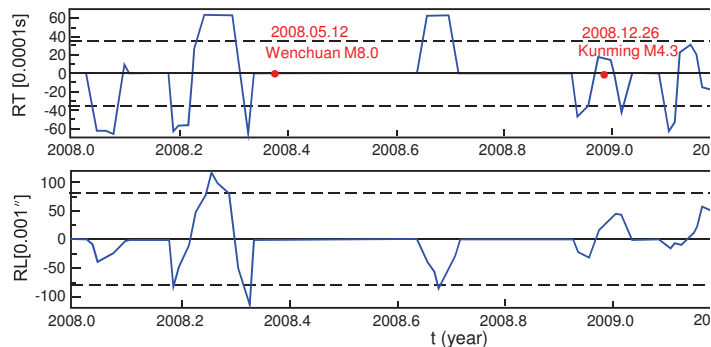
Figure 1: Astronomical time-latitude residuals observed at YAO

epicenter was only 24 km away from YAO.

## 3. POSSIBLE MECHANISM



Figure 2: Disturbed gravity vector

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 directly 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, using the expression $G_- = \theta'' G_0 / 206265$.
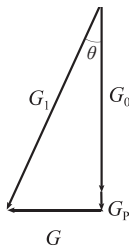
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