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Interactive comment on "The slope seismic response monitoring of Wenchuan aftershocks in Qingchuan" *by* Y. H. Luo et al.

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Dear Referee, thank you for giving the valuable comments to improve this artical, according to your comments, I have made some revisions and discussion with you as follows:

1 Revision and discussion: Yes, I agree the comment of using the 'Arias intensity', so the 3 page on line 25 and 11 page on the line 3 should be revised the 'arias intensity' to 'Arias intensity'. According to the comments about the core question of the paper: the origin of topographic amplification, I think that the size of the terrain,the slope and the relavite height to riverbed are the main factors of the amplification effect, even though some old references use for review, the core questions of amplification effect

contain those references literatures, I have also re-read some references and rewrote the introducing as follow: Slope seismic amplification effect has always been an interesting scientific question, which is observed in many field experiments and practical earthquakes, and it can also find some factors of the topographic amplification effect. Field experiments at the crest and base concluded that the topography plays a significant role and the ratios between mountaintop and the valley sites are generally amplified from 1.5 to 4.5 and the frequency range of topographic amplification is between 1.0∼3.0Hz. (Davis and West, 1973; Griffiths and Bollinger, 1979; Sergio et al, 2005; Hartzell et al,1998). Theoretical and simulation studies also have got amplifications factor from 1.3 to 2.0 less than observation (Bouchon, 1973; Wong and Jennings, 1975; Lee et al, 2008). Many of the observed slopes failures characteristics during earthquake are explained by its amplification effects associated with steep slope and narrow ridge (Murphy, 2006; Bouchon and Barker, 1996; Susan et al, 2010; Sepulveda et al, 2005). Geli has done a good summary of the theoretical and observational studies, which the topographic amplification effect increases with the increasing of slope ratio and occurs at the hilltop when the incident wavelength approximately equal to the slope terrain width (Geli et al, 1988). During the "5.12" Wenchuan earthquake, even though the Qingchuan county is far away from the epicenter of Yingxiu, strong seismic dynamic failure were also found around the periphery county town such as the Mountain Dong (Mt. Dong), Mountain Shizi (Mt. Shizi) and Weigan hill (Fig1). Earthquake cracks and rock falls always were distribution along the ridges, while some rock falls or landslides were always distribution at a relative height to riverbed. In this paper, we report a systematic slope seismic dynamic response monitoring on both sides of Qiaozhuang river, Qingchuan county. Five monitoring adits with each 15m depth were excavated on the different elevations of Mt. Dong and Mt. Shizi and the stations were emplaced at the middle of the adit. From 2009 to 2010 those five monitoring stations recorded dozens of Wenchuan aftershocks, this study describes dozens of group typical aftershocks that were triggering more than three stations to analyze the horizontal and vertical components of peak ground acceleration (PGA), the Arias intensity (Ia) and those synthesis values for the amplification effect along with the altitude at Mt. Dong and Mt. Shizi. In addition, the horizontal to vertical spectral ratios (HVSR) was calculation as a comparison analysis. Those results are analyzed to investigate the variations of amplification relationship with relative height to riverbed, topography and lithology of the monitoring site.

2 Revision and discussion: In the discussion section, the 11 page on line 14 to 17 has explained the reasons of Q9 NS records. Due to rusty damage of combined sensors in NS component at Q9, so only the EW and vertical components recorded the more complete events.

3 Revision and discussion: The gentle profile curvature is showing the narrow ridge of Mt. Dong, which the width is almost within 3m∼10m less than the Q4, even though the Q6 did not emplace at the ridge, the location of it is close to the ridge. Actually, the Q6 is close to the cross site of the Macro topography (Figure 2), where the nearly east-west elongation of Mt.Dong is intersection with the nearly north-south extension ridge. This topography site characteristic is not conducive to the seismic amplification response. So this may be another important reason of lower amplification at Q6. With respect to the frequency domain analysis, I agree with the comments of not only the height but also the width of a mountain influences the amplified frequency range. With respect to the interest of Fig 8, although the Q4 amplified obviously (compare to Q3), in most case not all monitoring stations could record the same event due to various reasons, thus Fig 8 is showing the amplification effect of Q4 compare to other stations of the same event.

4-5 no comments;

6 Revision and discussion: According the comment I have rewrote the discussion as follows: The results of this five monitoring stations clearly demonstrate that the horizontal amplification effect of Q4 is the strongest than other four stations. In addition to the previously analyzed the important reason of the relative height to the riverbed, the

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transverse width of the slope at Q4 is about 70m that it is prone to horizontal motion, on the other hand the steep slope and homogeneous rock site are also contributed to the ground motion amplification. Comprehensive the main factors, it indicates that not only the height but also the width of Q4 influences the amplified effect. Compared with Q4, the Q6 station is nearly close to the top of Mt. Dong, even though the width of the ridge is narrow just a few meters to 20m, the horizontal amplification effect is not significant. Two main topography characteristics of Q6 may be control the seismic response, firstly the monitoring station is located in the intersection of east-west and north-south elongation ridges (Fig.2), where is not conducive to the topographic amplification. Secondly the monitoring adit excavated in the lower part of the mountain ridge, where the topographic amplification is not stronger than the ridge. With respect to Mt. Shizi monitoring stations, the continuous attenuation of Q8 which implies that the topography and other conditions are not prone to ground motion, while it has the lowest seismic response compared to other stations. Hundreds meters width of the slope horizontal transverse with the concave profile is the controlling factor of the weak dynamic response, otherwise the relative height influences the frequency range that it is not in the amplification frequency domain. Different from the horizontal component dynamic response regular, the vertical component had the similar attenuation characteristics at the Q4 and Q8, while had the similar amplification effect at the Q6 and Q9. Those monitoring phenomenon fully demonstrated the seismic wave propagation characteristics affected by different factors. Generally, when the seismic wave propagate the large angle of incidence in the Mountain, the P wave cause the up and down vibration and the S wave cause horizontal vibration, where in the middle of the mountain slopes are not prone to up and down vibration, but on the mountain top is contrary. Thus this monitoring result hints us should consider different amplification effect when we evaluate the mountain slopes and the mountain tops. The amplification effect of Arias intensive (Ia) basically reflects the same dynamic response regular as the PGA on both sides slopes. On the other hand, the HVSR calculation results show that there are multiple peak values at different frequencies of Q4, which the amplification factor is also more than other stations (Fig.11). While the peak values of Q6 and Q3 which the resonance frequencies are almost less than 5Hz and focus in a fixed frequency around 10Hz respectively. Comprehensive analysis indicates that the amplification effect of Q4 not only influences by its height and topography but also amplifies at different frequencies domain.

7 Revision and discussion: According the comment I have re-summary the discussion as follows: From the preceding results and discussion, we can make the following conclusions: 1. The slope middle elevation and the mountain top have different seismic response that the former generally amplify the horizontal component but the latter amplify not only the horizontal component but also the vertical component. Furthermore, the amplification effect at the similar elevation of different slopes which the terrain of lateral width and relative height are always the main factors can make the PGA amplification factors reach 2.5. 2. The amplification effect of PHA is always stronger than the PVA and the synthesis calculation results are close to the PHA amplification regular. Otherwise, the amplification characteristics of Arias intensive are similar with the PGA that the factor is always bigger than the PGA reach 3.47. 3. The ground-motion amplification effect shows correlation with the relative height to riverbed and the lateral topography. Note that the relative height calculation is based on the peak amplification of motion at the crest of a slope occurs at a normalized frequency $H/\lambda=0.2$ by Ashford et al. (1997). This indicates that the frequency of the seismic wave is an important factor of slope height amplification. In addition, not only the height but also the width influences the amplified frequency domain.

8 Revision and discussion: According to the comment, I have retrieved the references of depth of the analysis, but there are few reports about this.

Corrections the abstract:

Abstract. This work reports some new progress of rock slope seismic response monitoring results in the area of Mountain Dong and Mountain Shizi (Qingchuan county), located more than 250 km NE of Yingxiu epicenter (2008 Wenchuan earthquake), Sichuan province. Five adits with the maximum depth of 15 m had been excavated in different elevation on both sides slope. Stations were emplaced at middle of the adits, from September 2009 to May 2010 more than 60 Wenchuan aftershocks had been monitored, 22 typical aftershocks had been statistical calculation, whose magnitude varied between 2.3 $\sim$ 5.2 and epicentral distance was from a few to 45 km. A comparison analysis of recordings provided evidence of the amplification effect at the Q4 station of Mt. Dong, which the peak horizontal acceleration amplification factor is between 1.0 $\sim$ 2.5. But this amplification effect had no stronger at other stations. Comprehensive studies show that the relative height to riverbed and the transverse width are the main influence factors of Q4 seismic amplification effect. Meanwhile the transverse width of Q4 terrain is conducive to horizontal amplification, not the vertical amplification. The horizontal and three components synthesis calculation has the similar amplification or attenuation with the single horizontal statistics. Moreover the calculation of Arias intensity (Ia) has the same amplification effect as the PGA, only the amplification factor is between 1.0 $\sim$ 3.47 much bigger than the latter. On the other hand, the calculation of horizontal to vertical spectral ratio (HVSR) at Q4 shows that the curves have multiple peaks corresponding with different dominant frequencies, which the amplification factor is always bigger than other stations at Mt. Dong. Comprehensive research indicates that the slope's macro topography and height influences the amplified frequencies domain which plays an important role of amplification effect.

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