Ground Motion in Kuwait From Regional Earthquakes: Potential Effects on Tall Buildings

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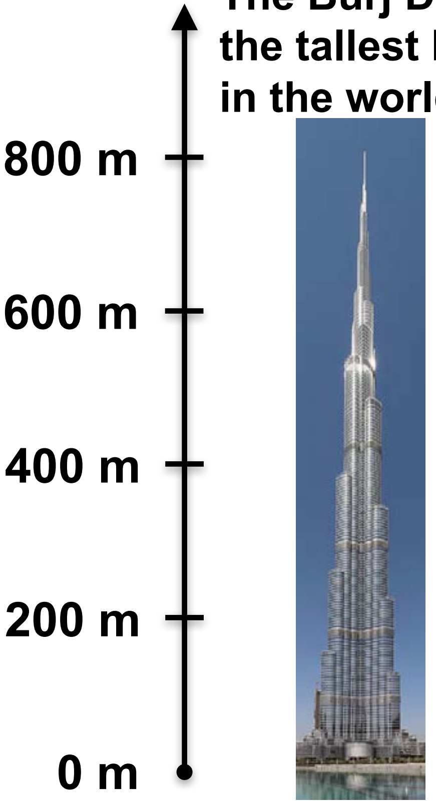
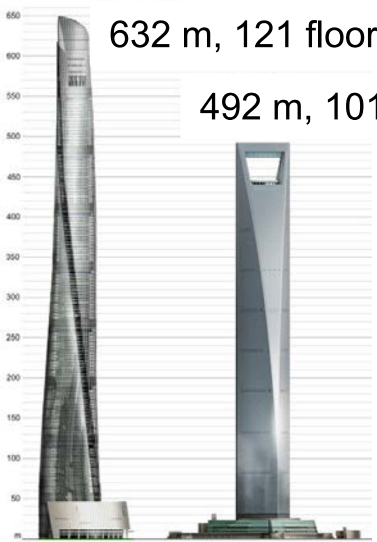
Motivation – Tall buildings all over the world

The Burj Dubai is the tallest building in the world (830 m).



The 2nd and 9th tallest buildings in Shanghai, China



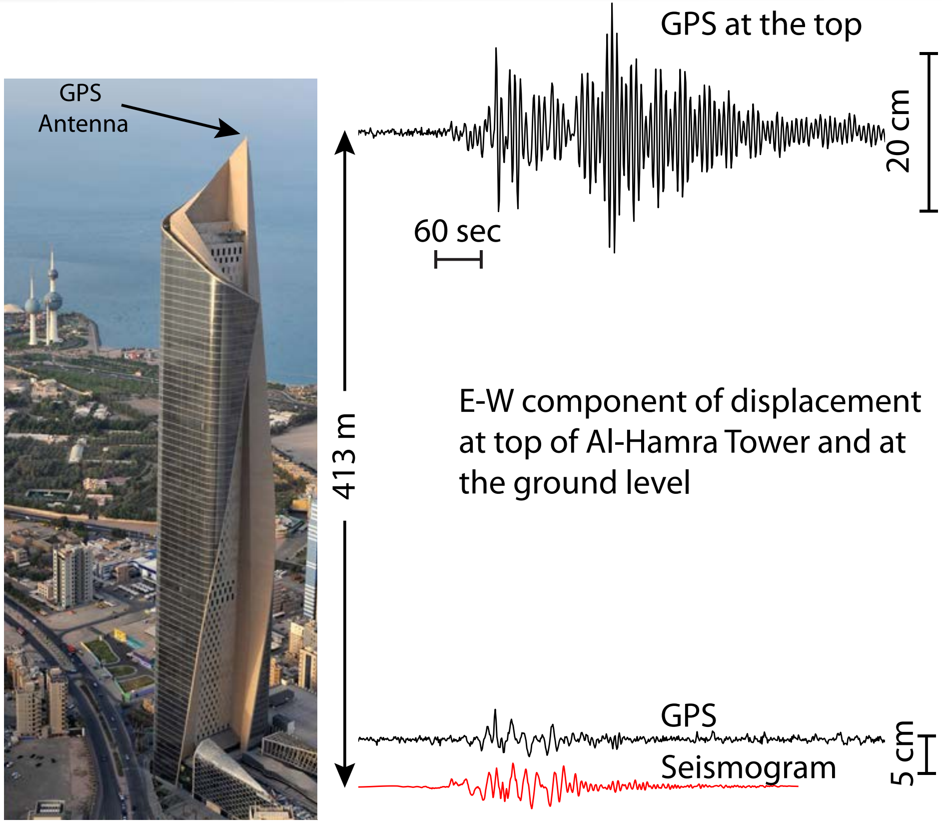
632 m, 121 floors

492 m, 101 floors

Abu Dhabi, UAE. The Capital Gate rises in 160 m and 35 stories.

Tall Buildings in Kuwait Skyline

Swing of Al-Hamra Tower due to a Mw 7.3 Earthquake



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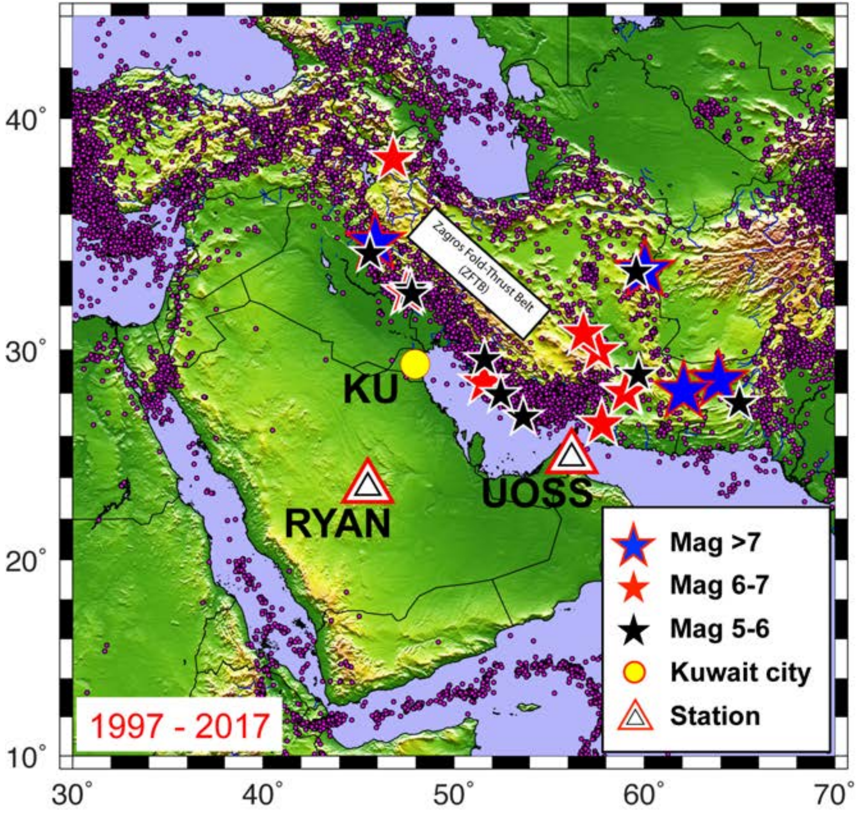
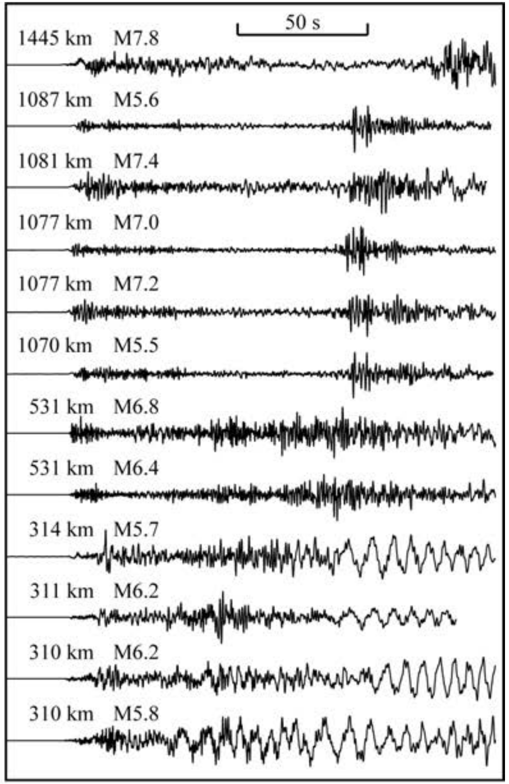
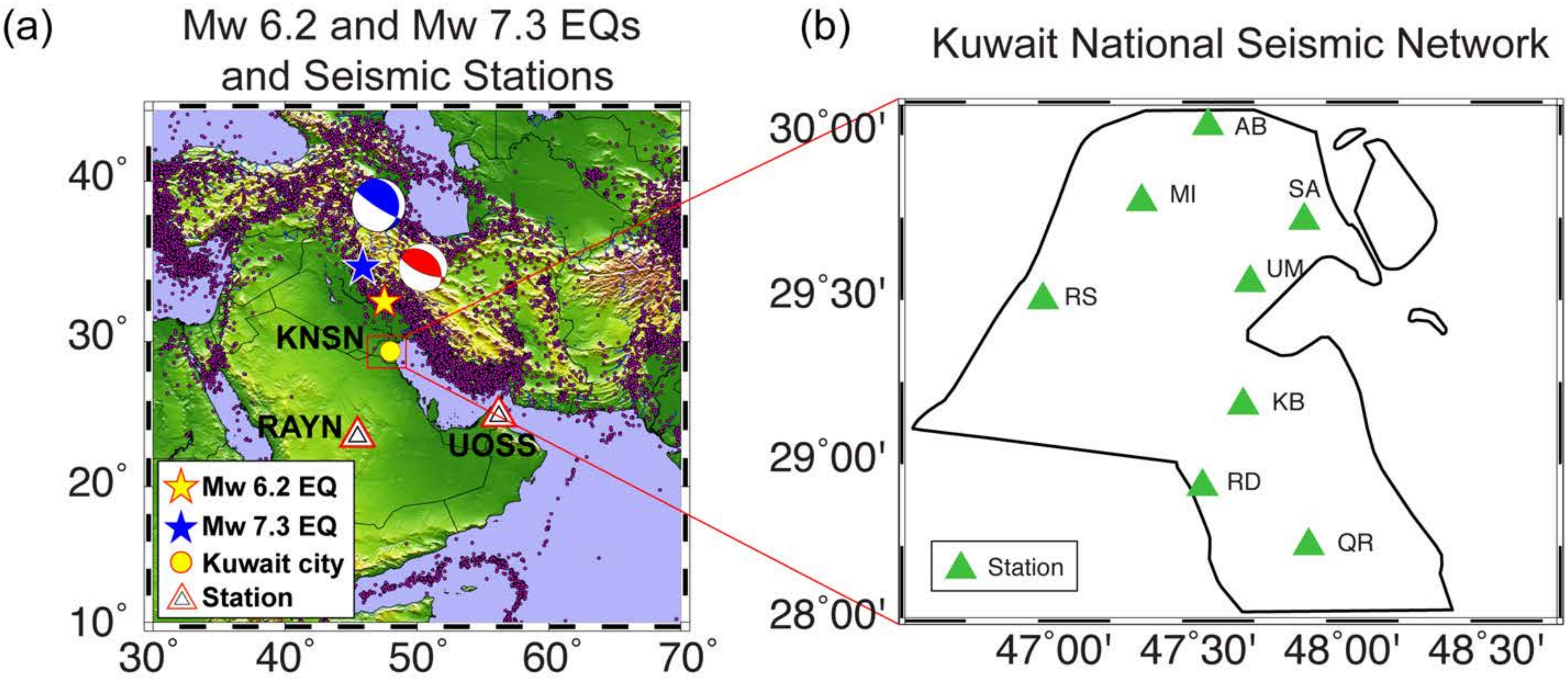
Regional Earthquakes in Kuwait





Gu et al., PAGEOPH, 2018

08/18/2014 Mw 6.2 & 11/12/2017 Mw 7.3 earthquakes



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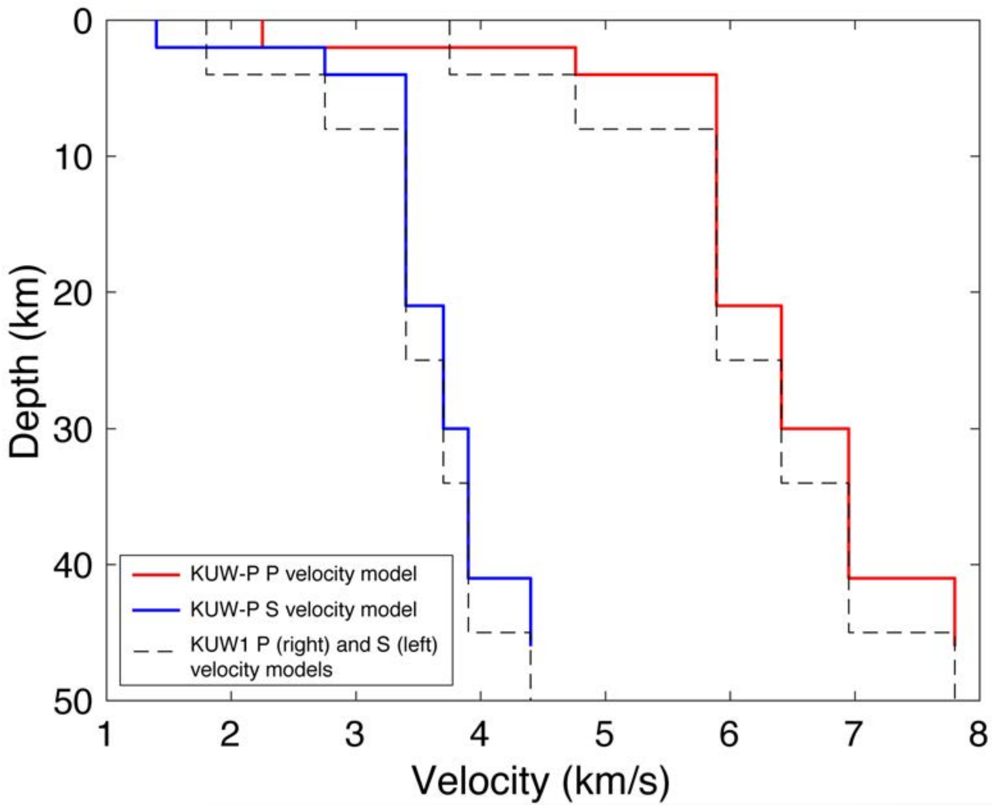
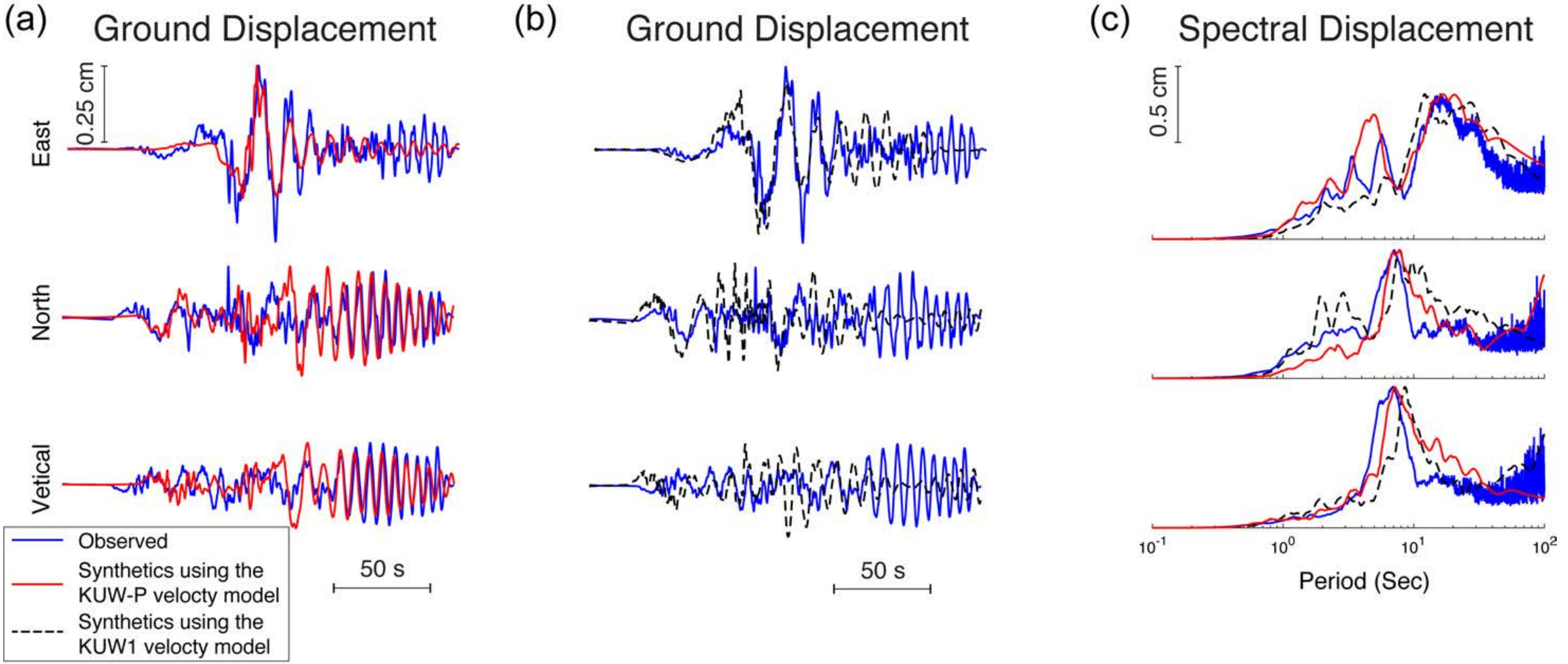
1-D Velocity Model – KUWP vs. KUW1

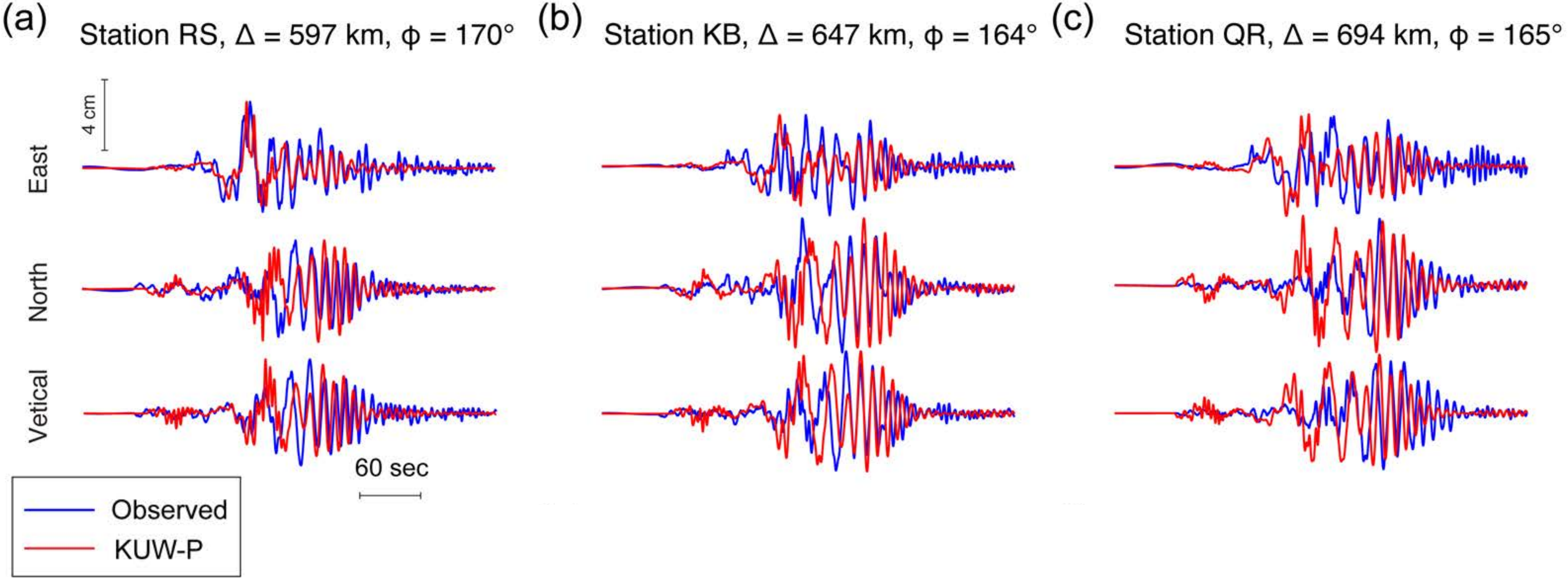


Pasyanos et al., 2007

Waveform matching – Mw 6.2 earthquake



Waveform matching – Mw 7.3 earthquake



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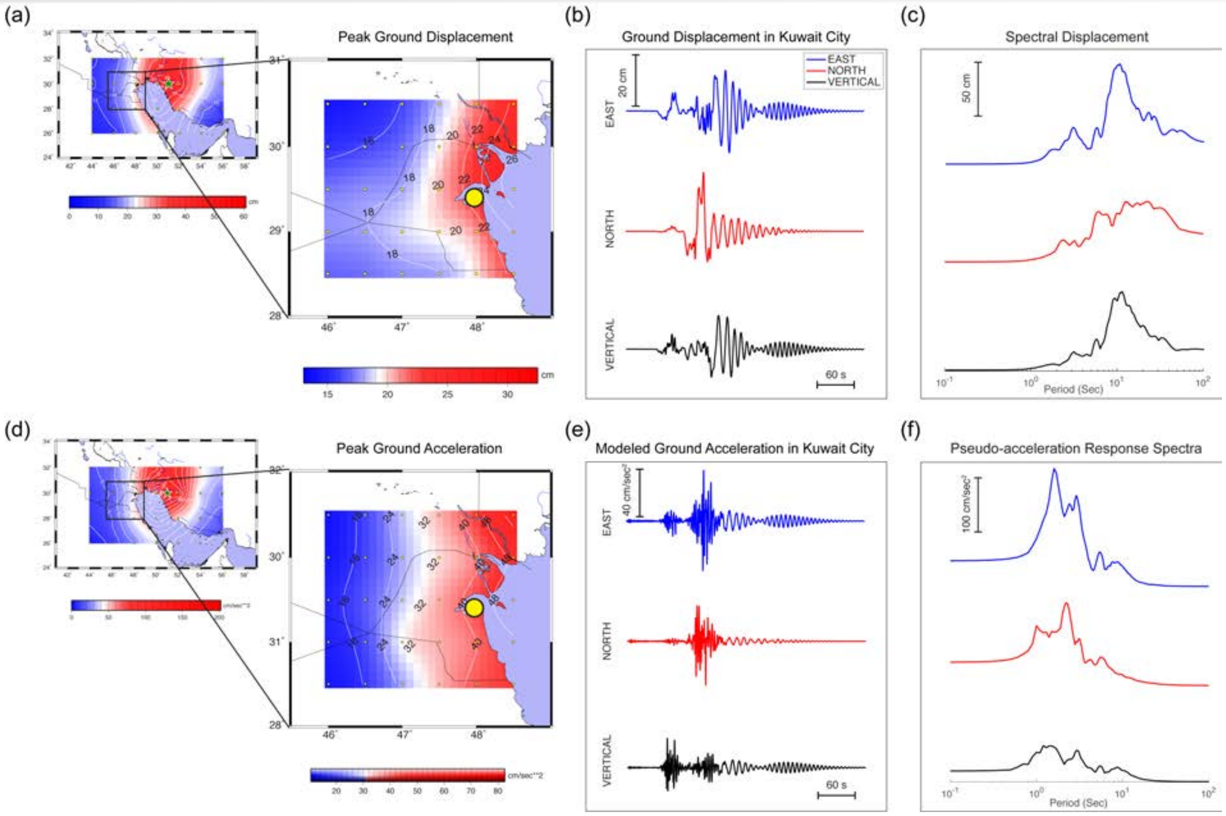
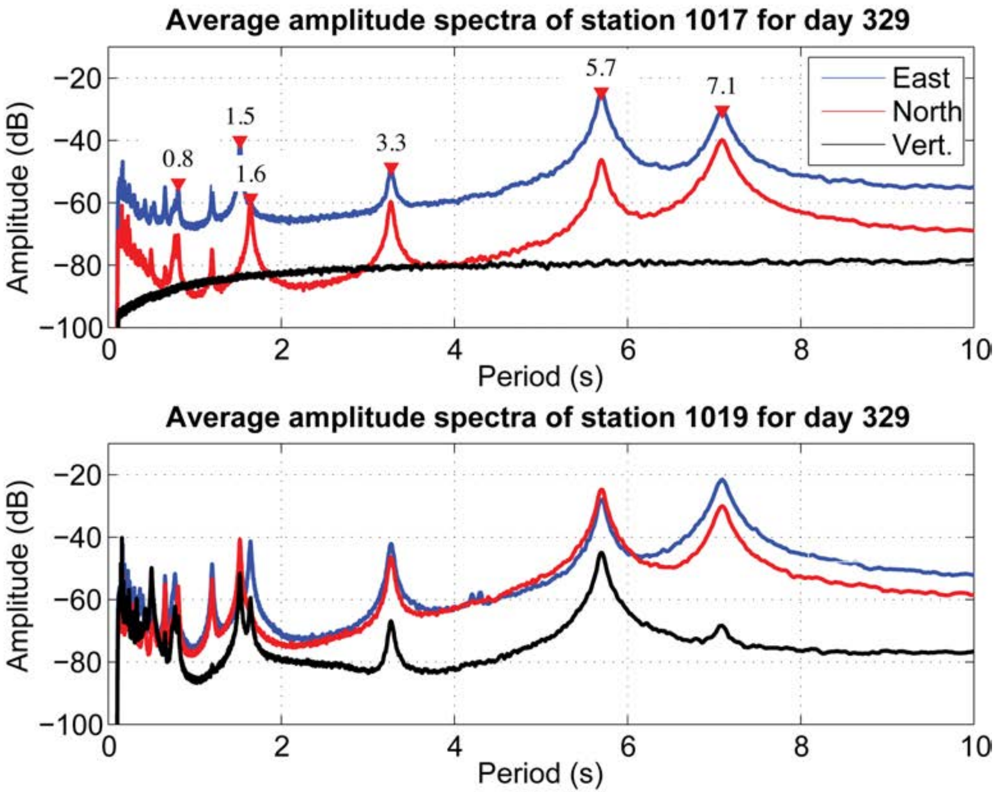
Ground motion modeling due to a Mw 7.5 earthquake



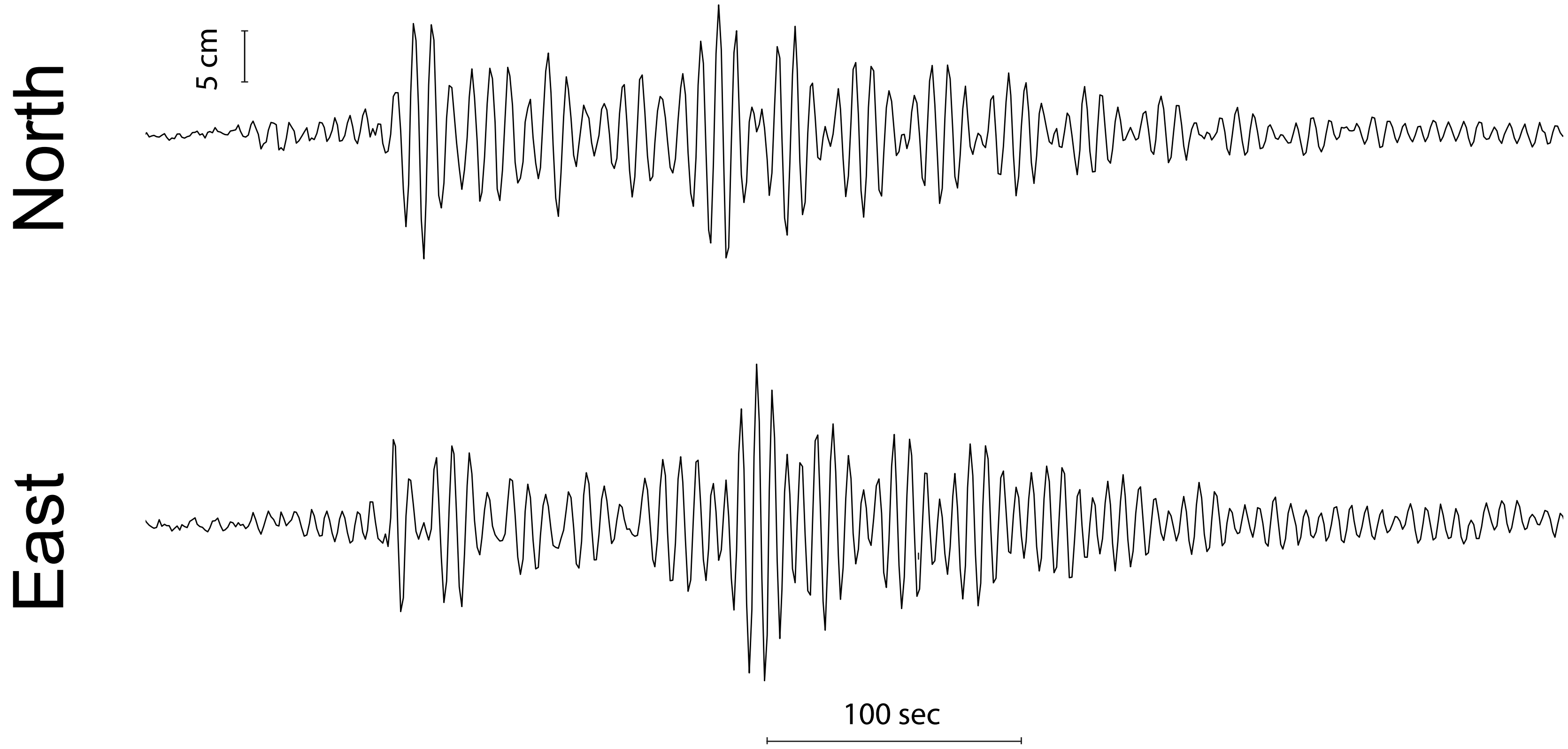
Ambient noise measurements of the Al-Hamra tower

Al-Hamra Tower



Herring, Gu, et al., SRL, 2018

The "scalloping" feature of the GPS recordings



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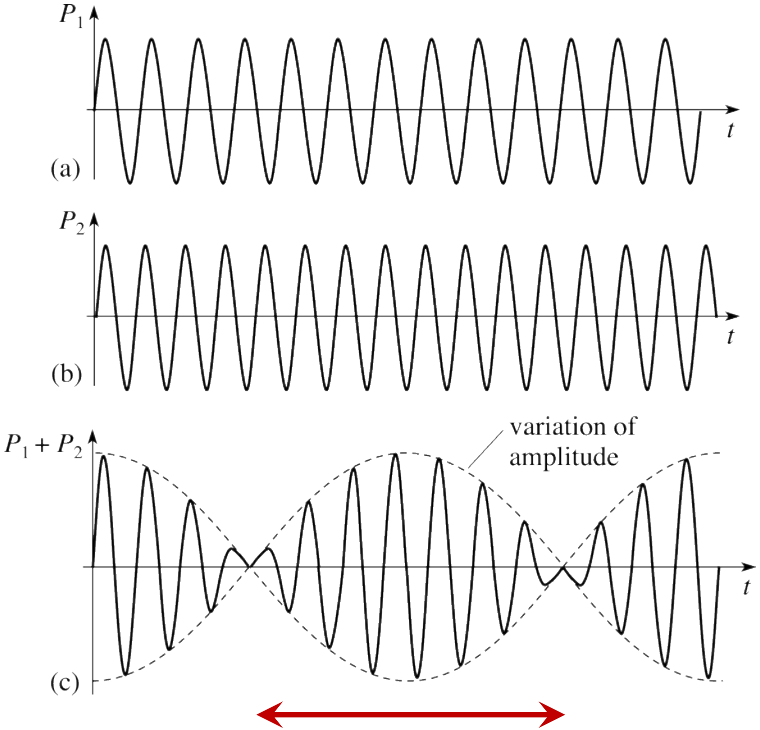
Wave Interference and Beat Frequency



$$T_{beat} = 1/f_{beat}$$

$$\cos(2\pi f_1 t)$$

$$+$$

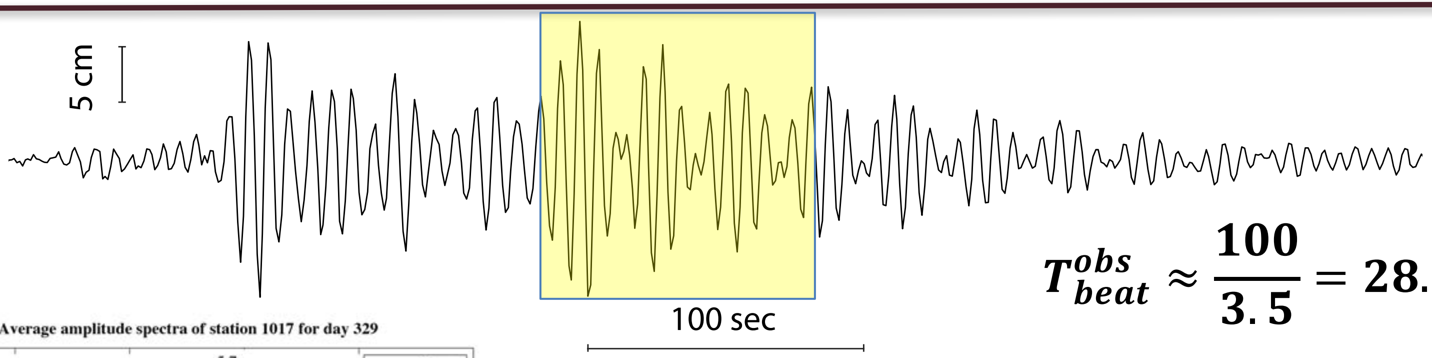
$$\cos(2\pi f_2 t)$$

$$=$$

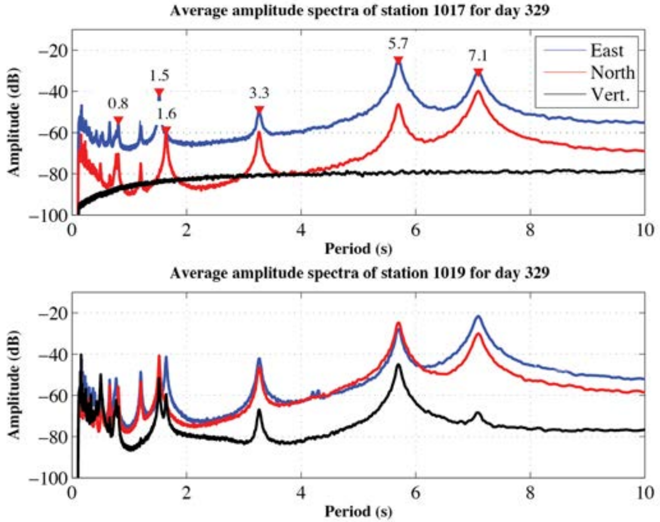
$$2\cos\left(2\pi \frac{f_1 + f_2}{2} t\right) \cos\left(2\pi \frac{f_1 - f_2}{2} t\right)$$

$$f_{beat} = f_1 - f_2$$

Beats of Building Motions



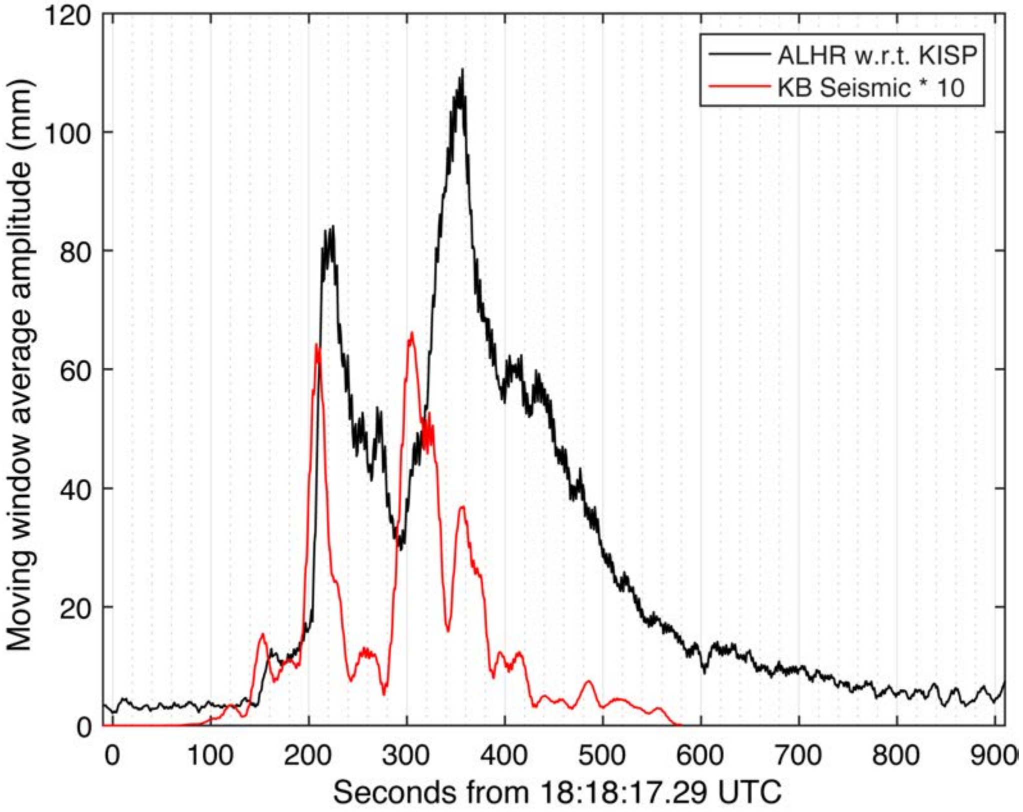
$$T_{beat}^{obs} \approx \frac{100}{3.5} = 28.6\ sec$$



Beat period for the interference of the 1st and 2nd Building Mode

$$T_{beat}^{1,2} = \frac{1}{f_2 - f_1} = \frac{1}{\frac{1}{T_2} - \frac{1}{T_1}} = 28.9\ sec$$

Amplification between 5.6 and 8.3 sec



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Conclusion

- The main seismic hazard to tall buildings in Kuwait comes from the long-duration and high-amplitude surface waves of regional tectonic earthquakes.

- We modeled the ground motions due to the recent Mw 6.2 and Mw 7.3 earthquakes. The new 1-D velocity model modeled the long-period and long-duration surface waves very well.

- The first GPS measurements on the top of Al-Hamra Tower due to a Mw 7.3 earthquake show that the long-period surface waves excited the strongest building motions.

Acknowledgement

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Thank you!