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BUILDING A BETTER CAT-TRAP: DEPLOYING FOOTPRINTS FROM 3D GROUND MOTION SIMULATIONS AND HARNESSING COULOMB STRESS TRANSFER IN CAT MODELS WILL PROFOUNDLY CHANGE (RE)INSURANCE DECISION MAKING

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Abstract: *Significant steps in understanding the earthquake impact on the built environment have been made in recent decades, with contributions from many disciplines ranging from seismology, geology, engineering and social sciences. Catastrophe modelling for the (re)insurance industry can perhaps still be considered in its early stages in comparison to some of these disciplines, with a number of key scientific advances that still need to be incorporated. This work aims to bridge the gap between academia and industry, presenting two studies sponsored by the Willis Research Network and implemented by Willis Re to support (re)insurance decision-making.*

The talk will first focus on the use of earthquake footprints developed using advanced ground motion simulation techniques, through collaboration with San Diego State University, for M~9 megathrust scenarios in the Cascadia Subduction Zone.

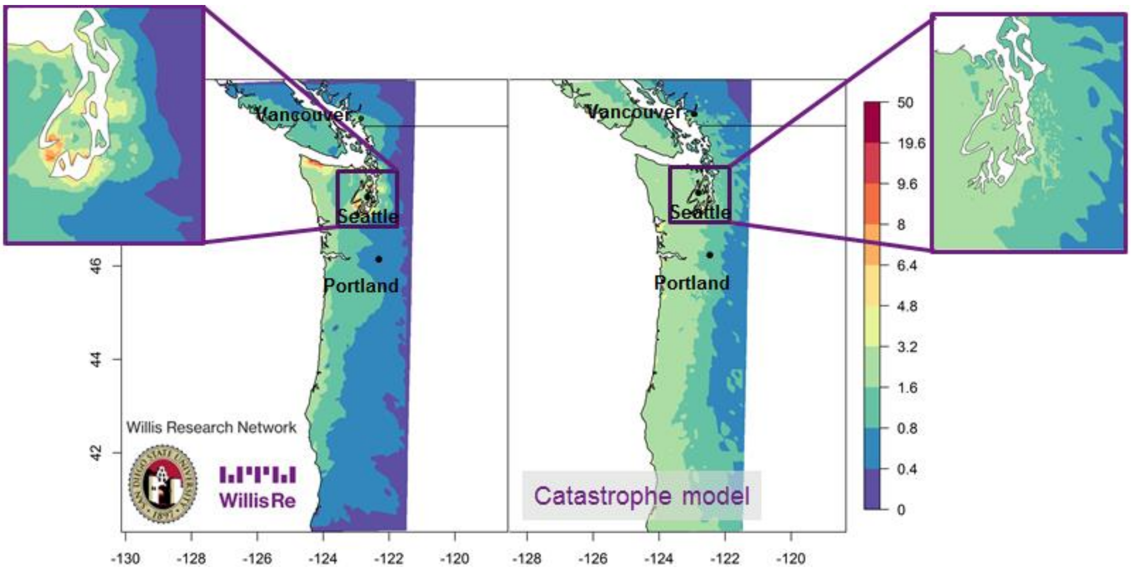

Figure 1. Spectral acceleration at 3sec (in m/s^2) from a M9 scenario predicted by 3D ground motion simulation (left) compared to an equivalent scenario from a catastrophe model (right). The differences in ground motion from the two approaches are highlighted for Seattle region.

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The ground motion footprint is a controlling factor in damage, and along with its uncertainty, needs to be determined as accurately as possible for the best estimate of insured losses. However, seismic waves and the resulting ground motions are strongly sensitive to details of the rupture propagation as well as 3D structural boundaries in the crust. In contrast, the techniques in widest usage today instead rely on a grossly simplified rupture geometry, no information on rupture front propagation, and empirical ground motion prediction equations. Here, we explore the impact of such state-of-the-art realizations of M~9 megathrust scenarios on insured loss estimation in the Cascadia Subduction Zone, in comparison with the tools currently available (Figure 1).

We find that the basin sediments beneath Seattle and Vancouver significantly amplify the long-period ground motion, in a way that is poorly captured by the ground motion prediction equations employed in conventional loss estimation. Moreover, the losses resulting from 3D ground motion simulations are characterised by a much lower volatility than in catastrophe models, thus allowing a more accurate and less uncertain decision making.

Willis Towers Watson also collaborated with Temblor Inc., and Tohoku University, which have been leaders in estimating the impact of past earthquakes on the probability of occurrence of future events. Every earthquake imparts stress to its immediate surroundings. Depending on the orientation and sense of slip on the surrounding faults, the stress can promote or inhibit failure on those faults. The most ubiquitous example of this stress redistribution is aftershocks, which generally occur where stress is promoted. Successive mainshocks also occur in regions of stress increase, and so this process is not limited to aftershocks. In contrast, the rate of earthquakes drops in the 'Coulomb stress shadows,' where the stress brings faults farther from failure. The Temblor/Tohoku team forecast earthquake rate changes caused by stress transfer in recent great earthquakes: the 2017-2018 M=8.2 Mexico sequence, and the 2016 M=7.8 Kaikoura, New Zealand event. They find substantial increases in hazard in large populated urban regions during the first several years after these events. The presentation will outline the methodology and framework established for the rapid creation of conditioned event sets that provide a forward-looking view of risk and facilitate critical decision-making around reinsurance capacity adequacy, both vertical and sideways, and portfolio optimisation following a significant earthquake (Figure 2).

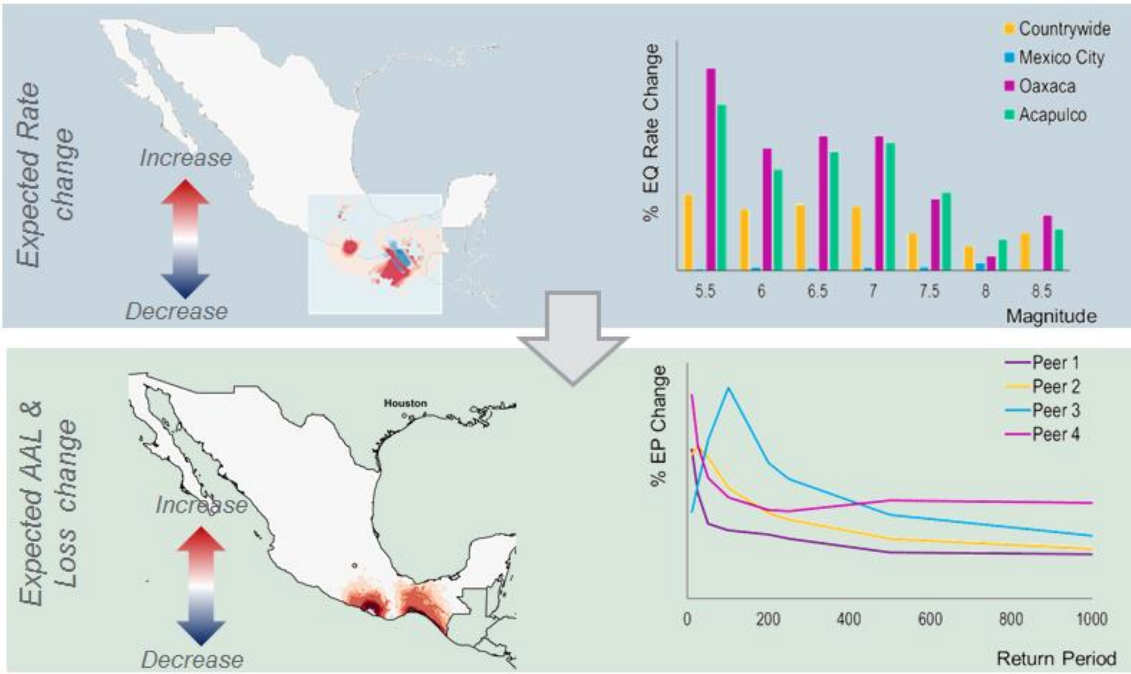

Figure 2. Implementation of the seismicity change due to the 2017-2018 M=8.2 Mexico sequence in terms of earthquake rate (top), and corresponding impact on Average Annual Loss (AAL) and Exceedance Probability (EP) curve for typical portfolios (bottom).