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A Tsunami Model for Chile for (Re) Insurance Purposes

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Catastrophe models help (re)insurers to understand the financial implications of catastrophic events such as earthquakes and tsunamis. In earthquake-prone regions such as Chile,(re)insurers need more sophisticated tools to quantify the risks facing their businesses, including models with the ability to estimate secondary losses. The 2010 (M8.8) Maule (Chile) earthquake highlighted the need for quantifying losses from secondary perils such as tsunamis, which can contribute to the overall event losses but are not often modelled.

This paper presents some key modelling aspects of a new earthquake catastrophe model for Chile developed by Impact Forecasting in collaboration with Aon Benfield Research partners, focusing on the tsunami component. The model has the capability to model tsunami as a secondary peril – losses due to earthquake (ground-shaking) and induced tsunamis along the Chilean coast are quantified in a probabilistic manner, and also for historical scenarios. The model is implemented in the IF catastrophe modelling platform, ELEMENTS.

The probabilistic modelling of earthquake-induced tsunamis uses a stochastic event set that is consistent with the seismic (ground shaking) hazard developed for Chile, representing simulations of earthquake occurrence patterns for the region. Criteria for selecting tsunamigenic events (from the stochastic event set) are proposed which take into consideration earthquake location, depth and the resulting seabed vertical displacement and tsunami inundation depths at the coast. The source modelling software RuptGen by Babeyko (2007) was used to calculate static seabed vertical displacement resulting from earthquake slip. More than 3,600 events were selected for tsunami simulations.

Deep and shallow water wave propagation is modelled using the Delft3D modelling suite, which is a state-of-the-art software developed by Deltares. The Delft3D–FLOW module is used in 2-dimensional hydrodynamic simulation settings with non-steady flow. Earthquake-induced static seabed vertical displacement is used as an input boundary condition to the model.

The model is hierarchically set up with three nested domain levels; with 250 domains in total covering the entire Chilean coast. Spatial grid-cell resolution is equal to the native SRTM resolution of approximately 90m. In addition to the stochastic events, the 1960 (M9.5) Valdivia and 2010 (M8.8) Maule earthquakes are modelled. The modelled tsunami inundation map for the 2010 Maule event is validated through comparison with real observations.

The vulnerability component consists of an extensive damage curves database, including curves for buildings, contents and business interruption for 21 occupancies, 24 structural types and two secondary modifies such as building height and period of construction. The building damage curves are developed by use of load-based method in which the building's capacity to resist tsunami loads is treated as equivalent to the design earthquake load capacity. The contents damage and business interruption curves are developed by use of deductive approach i.e. HAZUS flood vulnerability and business function restoration models are adapted for detailed occupancies and then assigned to the dominant structural types in Chile. The vulnerability component is validated through model overall back testing by use of observed aggregated earthquake and tsunami losses for client portfolios for 2010 Maule earthquake.