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Spatial and temporal aspects of exposure for insurance risk management

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Catastrophe (CAT) models estimate financial loss from damage to exposure (buildings) by large catastrophic hazards (events) of different natural perils (e.g. floods, hurricanes or earthquakes) from an event catalogue. CAT models employ vulnerability functions to compute impacts of events on exposure to estimate average annual loss. Since the relationship between hazards and exposure is inherently spatial, CAT models model space explicitly, but with a spatial granularity that is typically low. Whilst this is improving, models are often limited by input (exposure) data.

Temporal aspects of hazards are encoded in CAT model event catalogues where appropriate (e.g. the changing shape, size and intensity of a hurricane along its path) but events are treated as temporally independent of each other. Temporal aspects of hazards are the subject of other research: intense events tend to cluster in time (Vitolo et al, 2008) and this also has implications for the poorly understood phenomenon of demand surge (Olsen and Porter, 2008) – inflated prices due to increased demand.

This paper concerns temporal aspects of exposure, currently not considered by CAT models. Although often not applicable, where exposure is spatially-variant (e.g. cars or caravans) or temporally-variant (e.g. where use changes over time, such as holiday lets), the relationship of these aspects with spatially and temporally variant hazards becomes important. Our case study uses hailstorms in South Africa as the hazard and motor vehicles as the spatially- and temporally-variant exposure. This is a significant problem in South Africa and other territories (Hohl et al, 2002).

Admirat et al's (1985) summary of historical records between 1962 and 1981 (for the Transvaal Highveld region) show an average of 69 hailstorms per year, 3 of which have hailstones that exceed 3cm in diameter. Storms occur in swaths 10-19km in length and 5-9km in width, lasting 6 minutes. They found that hailstorms most frequently occur November to December (summer) at around 1700. This is consistent with Pyle's (2006) analysis of storms, which are caused by the same well-understood physical processes and which are affected by similar factors such as humidity, temperature and topography. Historical records such as these and an understanding of the physical processes involved can be used to create of event sets.

In urban areas, damage to motor vehicles can be over 50% of insured losses (Hohl et al, 2002) with the most intense storms damaging vehicle bodywork and windscreens. The amount of damage is dependent on the number and characteristics of vehicles within the hailstorm swath that are unprotected by shelters (Leigh, 1998). Since the majority of hailstorms occur in the late afternoon, it is likely that many vehicles will be on heavily congested roads during the rush hour is high. As such these vehicles will be unprotected by shelters and exposed to the risk. To take into account temporal aspects of exposure a model of the likely whereabouts of vehicles at different times of day is needed. Most transport authorities routinely collect traffic flow data using sensors under the road or at the roadside. These point locations are interpolated onto the road network to produce average traffic flows for road segments by time of day and week. For aggregate modelling, this can be used to redistribute the proportion of vehicular exposure that is likely to be in transit (unprotected by shelters) for each event. For detailed modelling, a sample of vehicles can be tracked using GPS, journeys characterised, clustered and then profiles of vehicle journeys can be made. By correlating journey profiles to other characteristics of the vehicles and of those that drive them, a better understanding of the spatiotemporal aspects of vehicular exposure can be derived.

In this paper, we demonstrate how traffic flow data can be used to characterise spatial and temporal aspects of traffic vehicle exposure and the potential implications for evaluating hailstorm risk. We use novel interactive visualisation techniques in order to elicit feedback from insurers about their attitudes towards the relationships between hazards and spatially- and temporally-variant exposure and opportunities for their visualization as they evaluate risk and develop portfolios.

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