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Spatio-temporal population estimates for risk management

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Accurate estimation of population at risk from hazards and effective emergency management of events require not just appropriate spatio-temporal modelling of hazards but also of population. While much recent effort has been focused on improving the modelling and predictions of hazards (both natural and anthropogenic), there has been little parallel advance in the measurement or modelling of population statistics.
Different hazard types occur over diverse temporal cycles, are of varying duration and differ significantly in their spatial extent. Even events of the same hazard type, such as flood events, vary markedly in their spatial and temporal characteristics. Conceptually and pragmatically then, population estimates should also be available for similarly varying spatio-temporal scales. Routine population statistics derived from traditional censuses or surveys are usually static representations in both space and time, recording people at their place of usual residence on census/survey night and presenting data for administratively defined areas. Such representations effectively fix the scale of population estimates in both space and time, which is unhelpful for meaningful risk management.
Over recent years, the Pop24/7 programme of research, based at the University of Southampton (UK), has developed a framework for spatio-temporal modelling of population, based on gridded population surfaces. Based on a data model which is fully flexible in terms of space and time, the framework allows population estimates to be produced for any time slice relevant to the data contained in the model. It is based around a set of origin and destination centroids, which have capacities, spatial extents and catchment areas, all of which can vary temporally, such as by time of day, day of week, season. A background layer, containing information on features such as transport networks and landuse, provides information on the likelihood of people being in certain places at specific times. Unusual patterns associated with special events can also be modelled and the framework is fully volume preserving. Outputs from the model are gridded population surfaces for the specified time slice, either for total population or by sub-groups (e.g. age). Software to implement the models (SurfaceBuilder247) has been developed and pre-processed layers for typical time slices for England and Wales in 2001 and 2006 are available for UK academic purposes.
The outputs and modelling framework from the Pop24/7 programme provide significant opportunities for risk management applications. For estimates of mid- to long-term cumulative population exposure to hazards, such as in flood risk mapping, populations can be produced for numerous time slices and integrated with flood models. For applications in emergency response/ management, time-specific population models can be used as seeds for agent-based models or other response/behaviour models. Estimates for sub-groups of the population also permit exploration of vulnerability through space and time.
This paper outlines the requirements for effective spatio-temporal population models for risk management. It then describes the Pop24/7 framework and illustrates its potential for risk management through presentation of examples from natural and anthropogenic hazard applications. The paper concludes by highlighting key challenges for future research in this area.