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What would a flood cost to your home?

Hazard-asset spatial overlays and induced uncertainty in natural risk assessments

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Abstract

We investigate how hazard spatial datasets and land use spatial datasets can be overlaid in natural risk assessments. Based on a case-study of a flood damage assessment on the Orb River, France, we show that the variability of spatial overlay techniques considered as a spatial model uncertainty may result in significant uncertainty in natural risk assessments.

Keywords: Uncertainty, Spatial overlay, Spatial support, Natural hazard, GIS.

1. Introduction

From typhoons to droughts, natural disasters impacted the lives of millions of people around the world in 2013. In order to prepare our societies to face such extreme events, public authorities carry out quantitative assessments of natural risks. At local scale, natural risk assessments usually require overlaying a *hazard map* and an *assets map*. We call this operation the *hazard-asset spatial overlay* (HASO). The goal of HASO is to determine, for each hazard-exposed asset in the study area, the intensity of the natural hazard in terms of quantitative physical parameters, such as water level for floods, seismic intensity for earthquakes, or wind speed for storms. HASO is usually performed using a GIS software.

Depending on the nature of the spatial datasets used, various techniques can be considered to perform the HASO spatial overlay analysis, and important variations may be observed from one technique to one another. Unfortunately, this problem is often overlooked in the natural hazard literature. Up to our knowledge, this source of uncertainty has never been carefully discussed in any natural risk assessment.

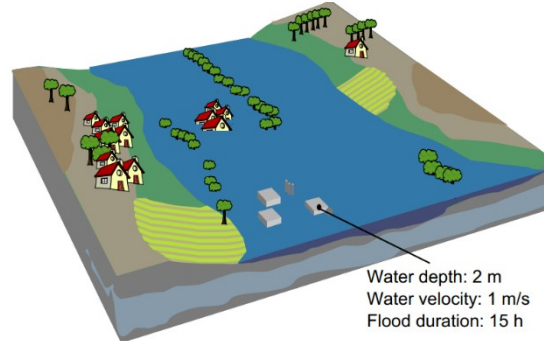
Our goal is thus to assess the impact of the HASO techniques on the uncertainty in natural risk assessments. We illustrate this issue with a case-study on flood damage estimates on the Orb Delta, France.

2. Materials and methods

2.1. Study area and data

As a case-study, we focus on a flood damage estimation for the one-hundred-year flood in the Orb Delta, south of France. The Orb Delta is a catchment of 63 sq. km, surrounding a 15 km reach of the Lower Orb River from Béziers city to the Mediterranean sea. In December 1995, a severe flooding event caused around 53 M€ in material losses (Saint-Geours, 2012).

Available data on the area include both a hazard map and an assets map (Fig. 1). The hazard map H is a grid (raster data) with 5-m pixel size that gives spatially explicit maximum water levels over the Orb Delta for the one-hundred-year flood event. It was derived from a flow simulation performed using a hydraulic flow model. The assets map A is a vector GIS layer at the 1:5000 scale that describes each flood-exposed asset



with an individual polygonal feature. Four types of assets are considered: private housing units, plots of cultivated land, campgrounds, and other economic activities.

Figure 1: Flood exposure assessment.

2.2. Data pre-processing

In order to explore the variety of possible HASO techniques, we first replicated the hazard map and the assets map to have them available with different spatial supports: either pixel-support (raster data), point support (vector data), or polygonal support (vector data). The hazard map was initially available as raster data; it was transformed to point-support and polygonal-support vector data by means of spatial interpolation. The assets map was initially a polygonal-support vector data: a point-support counterpart was created by extracting the centroid of each polygonal feature.

2.3. Hazard-asset spatial overlay (HASO)

We listed seven techniques that can be considered to perform HASO for flood exposure assessment (Fig. 2). All these techniques aim at computing hazard intensity characteristics (here, flood water level) for each hazard-exposed asset. We classify HASO techniques along two dimensions: i) the spatial support of the hazard data (pixel, point or polygonal), and ii) the spatial support of the assets (point or polygonal). For example, HASO technique n°7 relates to pixel-support hazard data and polygonal-support asset data; the water level over a polygonal asset is computed as the average of water level values of all hazard pixels that intersect the asset.

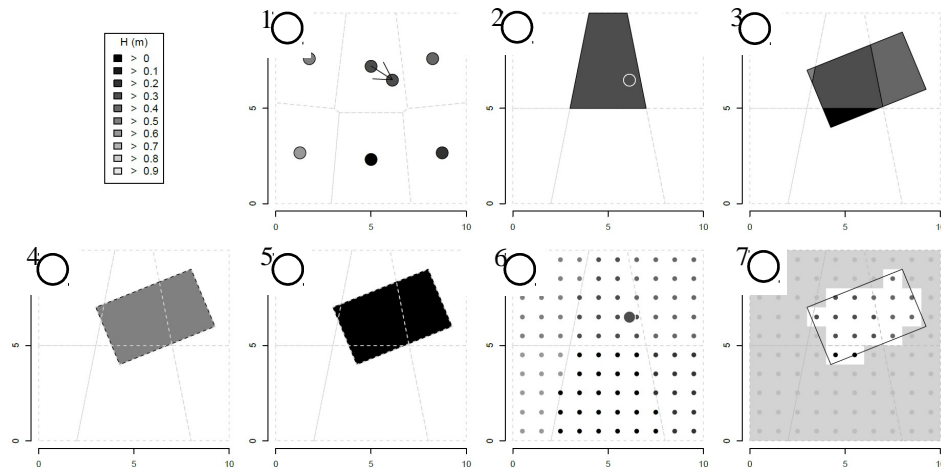


Figure 2: Seven different HASO techniques.

2.4. Flood damage estimation

Flood damage costs for the one-hundred-year flood were finally computed for each flood-exposed asset from flood exposure data, using a set of so-called *damage curves*, which model the relation between water levels, assets characteristics (type, surface area, value, ground floor elevation) and direct monetary losses (*Saint-Geours et al.*, 2013).¹

3. Results: uncertainty in flood damage estimates

Table 1 shows the total flood damages over the Orb Delta for each HASO technique, ranging from 161 M€ to 194 M€. It indicates that the uncertainty in total damage costs induced by the variety of the HASO techniques is close to 10%.

Table 1: Total flood damages for different HASO techniques.

HASO	Spatial support of hazard data	Spatial support of assets	Flood damages [M€]
1	point	point	182
2	polygon	point	186
3	polygon	polygon	173
4	polygon	polygon	161
5	polygon	polygon	194
6	pixel	point	179
7	pixel	polygon	171

3. Conclusion

We investigated the impact of the hazard-asset spatial overlay (HASO) techniques in natural risk assessments. We classified existing HASO techniques depending on the spatial support of both the hazard spatial dataset and the assets spatial datasets. From a

¹ These damage functions are either built from statistical analysis of ex-post data collected after flood events or by a synthetic approach where the elementary effects of flood on the various components of the asset are modelled (e.g., damage on furniture, walls and doors of a house)

detailed case study on flood damage estimation on the Orb Delta, France, we found that relative differences in flood damage estimates can rise up to 10%, depending on the HASO technique that was selected. A careful analysis of our results lead us to give some recommendations for spatial overlay analysis in natural risk assessments.

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