Flooding is a major hazard in both rural and urban areas worldwide, but it is in urban areas that the risks to people and the economic impacts are most severe.

Predictions of flood extent for an event of a given magnitude are useful for prioritising maintenance of flood defences and for insurance purposes. Such predictions are made by flood inundation models.

## 3. TerraSAR-X image of 1-in-150 year flood

![Figure 1. TerraSAR-X image of the Severn July 2007 flood, with DLR flood extent overlay](https://example.com/figure1.jpg)

A 1-in-150 year flood took place on the Severn near Tewkesbury, UK, in July 2007, which resulted in flooding of 1500 homes in Tewkesbury (rectangle). TerraSAR-X acquired a 3m resolution image of the flood (fig. 1) that shows incredible detail in urban areas (not fig. 2). The DLR flood extent estimate is mainly accurate in rural areas.

## 4. Aerial photo validation of TerraSAR-X flood extent

![Figure 2. TerraSAR-X flood extent overlay on Tewkesbury scene](https://example.com/figure2.jpg)

Aerial photos taken only a few hours before and after the TerraSAR-X scene can be used to validate the flood extent determined in urban areas from TerraSAR-X (fig. 2). The photos (fig. 3) show flooding in a number of urban areas including A, B, C.

## 5. Regions unseen due to radar shadow and layover

![Figure 4. LiDAR Digital Surface Model of Tewkesbury](https://example.com/figure4.jpg)

Due to the side-looking nature of SAR, substantial areas of urban ground surface would not be visible due to radar shadow and layover caused by buildings. The DLR SETES SAR simulator was used in conjunction with the LiDAR data (fig. 4) to estimate these regions (fig. 5). Some of the older parts of the town containing narrow streets contain significant areas where flooding would not be seen. But flooding would be more visible in the newer, less densely constructed parts.

## 6. Detection of urban flood extent

![Figure 5. Regions unseen (black) due to shadow and layover](https://example.com/figure5.jpg)

Flood extent in a SAR image can be determined automatically using a region-growing algorithm based on an image processing device called a snake (Mason et al., 2007). This finds dark regions adjacent to flood flows from channels. The snake algorithm uses the DLR DTM in conjunction with the SAR image to ensure that the snake waterline varies smoothly in height down the reach. Fig. 6 shows that the algorithm detects the flood quite well in rural areas, but not in the urban areas. This is because of high curvatures in the narrow streets, and because urban flooding may be unconnected to the rural flood due to shadow/layover.

## 7. Algorithm modification

- A modified approach has been adopted that uses the snake to delineate the flood in rural areas, but a simpler region-growing approach in urban areas.
- The two methods are linked.
- Seed regions having low backscatter are identified in urban areas using supervised classification based on training areas for water taken from rural flooded areas. Seed pixels must have brightness less than a spatially-varying threshold determined from nearby snake waterlines brightness. Seed regions are grown by adding adjacent pixels that are not quite so dark. Areas of shadow/layover are masked out.

## 8. Results and future work

- In fig. 7, 76% of the urban water pixels actually visible to TerraSAR-X were correctly classified by it, with a false positive rate of 25%. A more pertinent figure is the fraction of the urban flood extent visible in the aerial photos that was detected by TerraSAR-X, and in this case the classification rate fell to 50% with a false positive rate of 19%. This implies that, at least for this event, TerraSAR-X is good at identifying those flooded urban areas visible to the SAR, and reasonably good at identifying all flooded urban areas.
- The next step will be to estimate the degree to which the radar-detected urban flood regions enable a 2D-flood inundation model to predict the correct urban flood extent, by comparing the friction parameters in the urban areas. The Bristol LISFLOOD-FP model is being used for this.

### References