Technical White Paper

FloodScope™: An Innovative Approach to National Flood Zone Mapping Using High-Resolution Digital Terrain Models

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Introduction

Floods are among the most common hazards in the United States and around the world. The geospatial community has developed various tools to help create flood zone maps to be used for flood risk assessment, flood mitigation and planning, and emergency response during and after flooding. Despite the numerous options available for flood zone modeling, currently existing tools are typically only suitable for small regions or for producing low resolution datasets, due to the high complexity of the modeling process. These existing tools would require many years and extensive computing resources to create nationwide flood zone maps.

This paper presents the latest results from Intermap Technologies® FloodScope™ flood model — the only flood model that is built on a contiguous, manually-edited digital terrain model (DTM) for the lower 48 states and Hawaii. Elevation data is a key input into any flood model, so the ability to leverage a high quality DTM at full resolution is a significant achievement. The flood zone maps created by FloodScope are validated using flood extents of historic events.

Input Datasets

One of the input datasets used in Intermap's flood modeling process is the high resolution version of the National Hydrography Dataset (NHD) (http://nhd.usgs.gov/). This includes river/stream centerlines, water body areas, and the watershed boundary dataset (WBD). Intermap's high resolution NEXTMap® USA DTM is another important input layer. The DTMs are posted at 5-meter sample spacing and are derived from Interferometric Synthetic Aperture Radar (IFSAR or InSAR) digital surface models (DSMs). This data has a 1-meter LE90% vertical accuracy in low–slope unobstructed terrain and is available for many regions throughout the world, including the contiguous USA and Hawaii.

Process

The process starts with pre-conditioning the input data layers to ensure they are complete, consistent, and properly attributed to support the modeling. This includes removing vectors that are without a defined flow direction and that are feature-coded as coastal lines. Next, the hierarchical structure of the river network is determined. At this stage, each river/stream segment is assigned a Strahler order and an accumulation area value, which are the two most important parameters in the flooding probability calculation. At the final stage of modeling, a raster grid surface is produced showing flood depth for each location. This is accomplished by associating each 5-meter posted grid cell with a river vector and calculating the flooding probability for each return (time) period (RTP) using a statistical Multiple Adaptive Regression Splines (MARS) function. Flood hazard zones for each modeled return period can then be visualized as all locations with a flood depth greater than 0 meters.

Example Outputs

Figures 1 and 2 show some example outputs from this process. The test area is in the Upper Canadian Basin in the states of New Mexico and Texas.

Figure 1(a) depicts the pre-conditioned river centerlines overlaid on National Agriculture Imagery Program (NAIP) imagery. Figure 1(b) shows the same centerlines overlaid on the NEXTMap USA DTM.

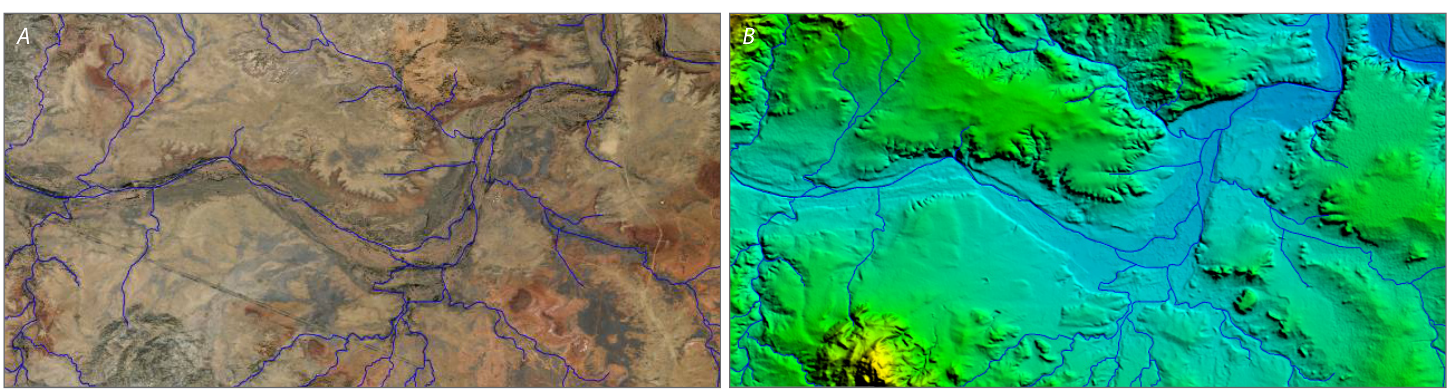

Figure 1. Example outputs: (a) Selected river centerlines on NAIP imagery; (b) NEXTMap USA DTM

The flood depth map in Figure 2(c) is the output from the flood model for a 100 year RTP, which corresponds to a 1% annual chance of flooding. In Figure 1(d), the flood zone maps from all three RTPs are shown: 20 years (red), 100 years (yellow), and 500 years (blue).

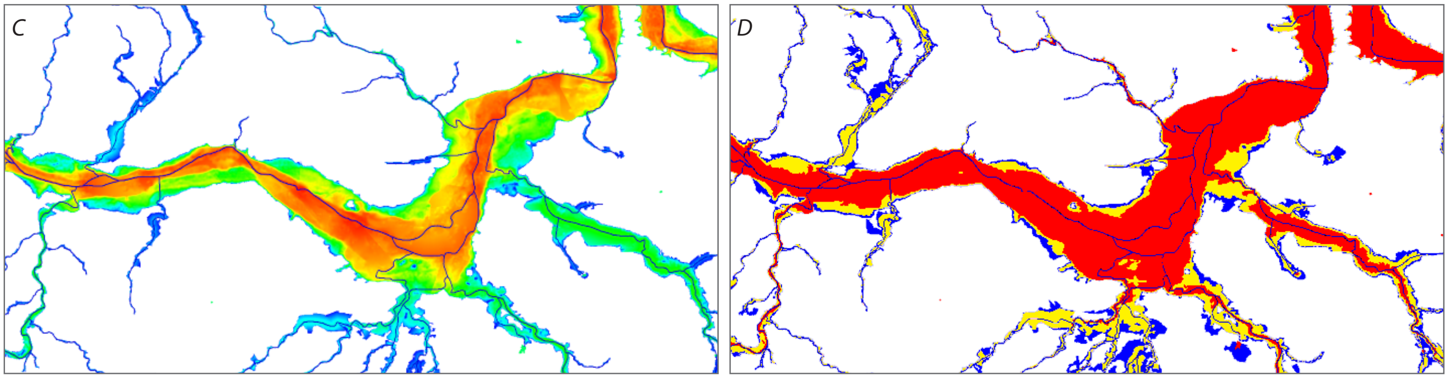

Figure 2. Example outputs: (c) Derived flood depth map for RTP 100 years; (d) Final flood zones: red – RTP 20 years, yellow – RTP 100 years, blue – RTP 500 years.

Validation

The flood zones generated from this process have been validated using the extents of historic flood events in several regions of the USA. One such area is the Lower Missouri Basin, where there was a major flood in 1993. During this flood event, the return period of discharges on segments of Mississippi as well as Missouri exceeded the 500 years recurrence (Pitlick, 1997[1]). Figure 3 provides a visual comparison between Intermap's flood zone (RTP 500 years) and the actual 1993 flood extent map produced by the Corps of Engineers[2]. It shows clearly that Intermap's estimated flood zones are in close agreement with the real flood extents.

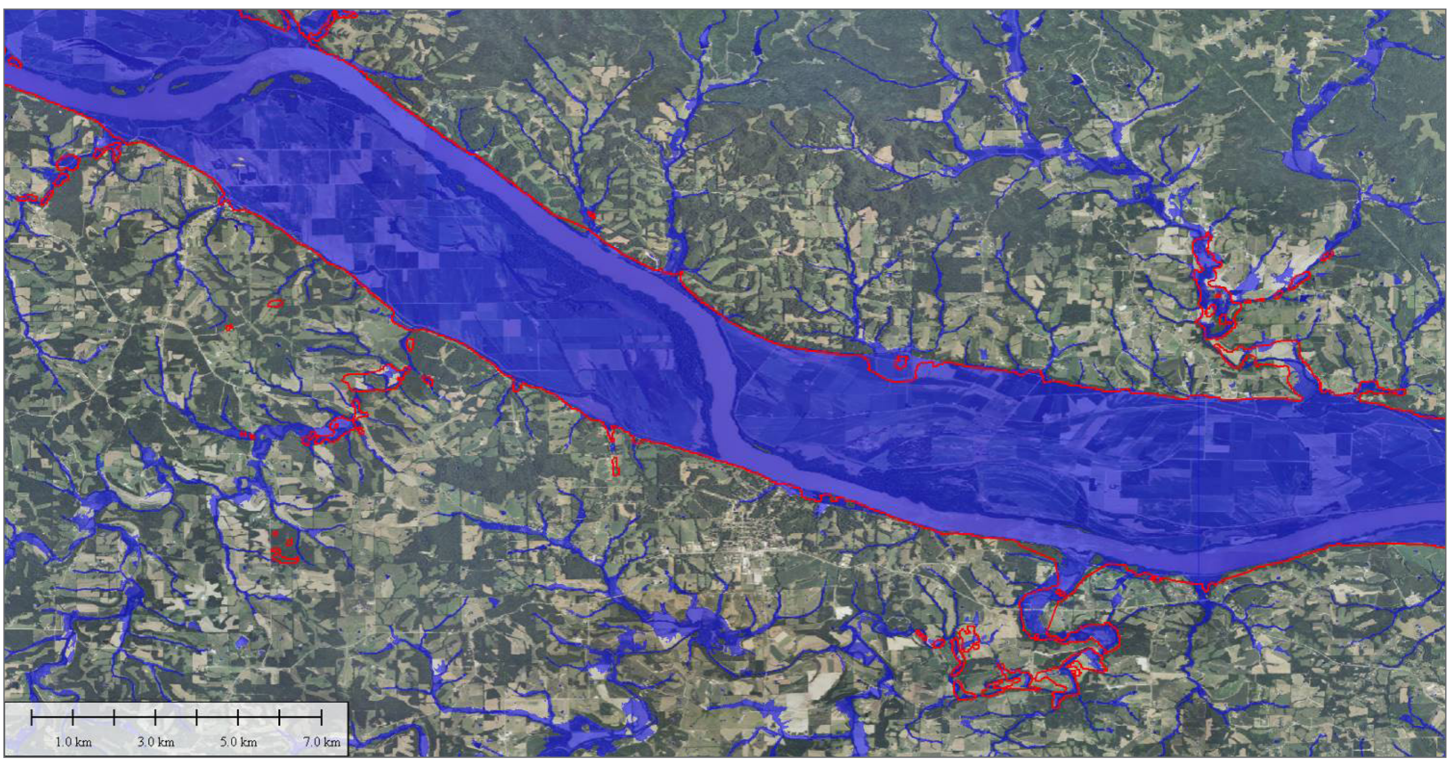

Figure 3. Flood zone map for RTP 500 years (blue shaded area) on NAIP imagery for Lower Missouri Basin: red polygons are the 1993 flood extent.

1 Pitlick, J. (1997), A Regional Perspective of the Hydrology of the 1993 Mississippi River Basin Floods. Annals of the Association of American Geographers, 87: 135–151. doi: 10.1111/0004-5608.00044
2 http://el.erdc.usace.army.mil/flood/fl93home.html

To quantify the level of agreement between Intermap's flood zone and the historic flood extents, the numbers of hits (historic flood extents located within model-estimated flood zones), misses (historic flood extents located outside of model-estimated flood zones,) and false alarms (model-estimated flood zones that do not coincide with any historic flood extents) are recorded and summarized. Table 1 shows a summary of the accuracy of Intermap's flood zone maps in the Lower Missouri Basin, using the 1993 flood extents as reference. The hit percentage in this area is around 90%, with about 12% false alarms. Validation results from other areas show a similar level of accuracy.

	Area (km^2)	Percentage
Hits	743.186	90%
Misses	81.781	10%
False Alarms	101.417	12%

Table 1. Flood zone map (500 years RTP) accuracy assessment

Conclusion

This paper has presented the results of FloodScope, a new approach to creating national-scale high resolution flood zone maps using Intermap's NEXTMap USA DTM. This innovative approach to flood modeling enables rapid generation of high quality flood zone maps based on high resolution DTMs while avoiding expensive computational costs. FloodScope is an alternative method to produce flood hazard maps with flood depth information while avoiding computationally intensive 3D modeling. It is an entirely different approach than the Federal Emergency Management Agency (FEMA) flood modeling process, ensuring an independent view of flood risk. Furthermore, FloodScope can be applied in other regions of the world with only minor modifications to the algorithms and process.