Technical White Paper

WorldFlood™

Intermapping Technologies, Inc.®
8310 South Valley Highway, Suite 400
Englewood, CO 80112

07032014 v1

Introduction

WorldFlood™ Version 1, created by Intermap Technologies®, was completed April 2014 and provides a global fluvial flood model that is used as a base layer for risk assessment in InsitePro™. Intermap's WorldFlood Version 2 is to be completed in late 2014 and provides some key updates to the foundation created in WorldFlood Version 1.

WorldFlood Version 2 improves on Version 1 in a number of areas. First, the quality of the river centerlines used for modeling input has been greatly improved by introducing new derivation techniques that focus on planimetric accuracy and river detail. Second, Intermap has built an improved custom input digital elevation model (DEM) created specifically for flood modeling leveraging its NEXTMap® 5-meter dataset. Finally, the modeling has been specifically calibrated and targeted to high priority areas to improve resolution of the output product. WorldFlood Version 2 will be combined with WorldFlood Version 1 and FloodScope™ [1] USA to maintain global coverage, which is a key aspect of the InsitePro application.

Background: WorldFlood Version 1

The primary goal of WorldFlood Version 1 was to create a global flood model for use as a base layer in InsitePro. It is a worldwide flood model covering all areas below 60 degrees N, as well as all of Scandinavia in Europe. It is effective for portfolio-level modeling where risk can be distributed across an entire portfolio.

WorldFlood Version 1 is built based on 90-meter resolution SRTM digital surface model (DSM) elevation data and utilizes HydroSHEDS river vectors as produced by the Conservation Science Program of World Wildlife Fund (WWF) for the input river centerlines.

Multiple advancements were made over the course of the development of this product that are leveraged in the development of WorldFlood Version 2.

Coverage Footprint

WorldFlood Version 2 covers 27M km^2, which represents 23% of the area covered in WorldFlood Version 1, and is split into 43 sub-basins globally. The selection of these sub-basins targets areas across the globe where Intermap has NEXTMap coverage as well as other high value areas for flood modeling. The coverage footprint of WorldFlood Version 2 is shown in Figure 1.

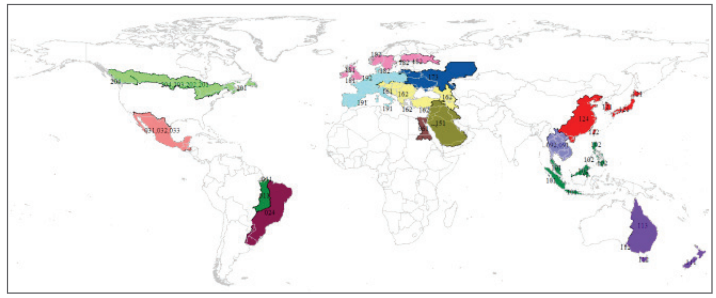

Figure 1. Coverage footprint of WorldFlood Version 2. Colored areas are included in the update.

Flood 30 Input

To help prepare for the creation of WorldFlood Version 2, a new proprietary elevation surface called Flood 30™ was created. This product is built using a combination of Intermap's World 30™ DSM, NEXTMap digital terrain model (DTM) data (where available), as well as some other key enhancements specific to flood modeling.

The base layer of Flood 30 is Intermap's World 30 DSM, which is a seamless elevation surface data set with 30-meter posting covering the entire world. It is composed of SRTM data, ASTER Global DEM v2 data, and GTOPO-30 data, which have been combined using a proprietary algorithm and controlled using ICESat data. The proprietary algorithm contains aspects of ASTER pre-conditioning, vertical correction using the ICESat data, and complex-weighted data fusion to blend the data sets together into a final DSM product. Measurements have shown the LE95 vertical accuracy to be in the order of sub-10 meters versus 14 meters for SRTM or 20 meters for ASTER on their own.

World 30 is a DSM, which means that all "first-returns" are included in the product. This is not ideal for flood modeling, as buildings and trees are included in the elevation model and impact the flooding profile, often leaving gaps in the model where these features exist. In order to improve the Flood 30 input for flood modeling, Intermap has incorporated their NEXTMap 5-meter DTM in all areas where it is available. The DTM has been edited to ensure that all non-ground features such as buildings and trees have been removed. The available DTM coverage includes the USA, Western Europe, and large parts of the Asia-Pacific region, including some of Australia. In order to incorporate the 5-meter DTM into the Flood 30, it was necessary to down-sample the data set, adjust the vertical datum for consistency, re-flatten the water, and seamlessly fuse the data set into the World 30 DSM using proprietary fusion techniques. Figure 2 shows a side-by-side comparison of the Flood 30 DEM and the SRTM data used in the WorldFlood Version 1 modeling.

1 Please see Intermap's white paper: "FloodScope: A New Approach to National Flood Zone Mapping Using High Resolution Digital Terrain Models".

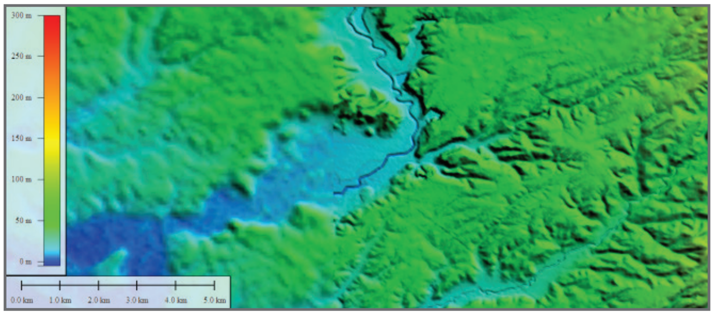

Figure 2. Side-by-side comparison between SRTM (as used for WorldFlood Version 1) and Flood 30. Left: SRTM, Right: Flood 30

Additionally, the Flood 30 DEM was also specifically tuned for flood modeling by addressing the ocean-river boundary delineation to ensure the flood model incorporates all of a river mouth or estuary in the fluvial model, but does not use the ocean. In order to make this distinction, the ocean area must be set to null as opposed to zero using either the SRTM water mask or NEXTMap edit mask, depending on the area of the world, to define the boundary. In addition, a technique was developed that automatically filled estuaries beyond the water mask out to the ocean, such that they would be included in the flood modeling.

River Centerline Improvements

The primary advancement in WorldFlood Version 2 is the addition of improved centerlines into the modeling process. There are known limitations with the HydroSHEDS data that was used in WorldFlood Version 1 specifically relating to positional accuracy. Therefore, in WorldFlood Version 1 it was necessary to use the DEM to find extra centerlines beyond the input centerlines; however, in WorldFlood Version 2 this is no longer necessary and the input centerlines are used exclusively.

The creation of improved centerlines for WorldFlood Version 2 is a multi-phase process. To meet the quality demands (notably positional accuracy), a combination of automatic extraction and manual digitization has been created to update the centerlines.

In higher slope areas of the world as well as areas where Flood 30 contains NEXTMap data, an automatic river-centerline process is used. This process utilizes the Flood 30 data and a standard eight-direction pour point algorithm (D-8) after first filling depressions in the input data. Since the input to this automated process is a 30-meter posted DEM, the detail of the rivers is superior to that of the HydroSHEDS data set that was derived from a 450-meter posted DEM. This automated process was tuned to balance centerline accuracy with overall connectivity of the river network. Additionally, the outputs of this automated process are reviewed and updated manually in order to address nuances in the output, specifically targeting populated areas and major rivers.

In the low slope areas, where the automated algorithm was found to be underperforming, Intermap has used its in-house editing team and stereo software to digitize the river vectors. Detailed edit rules were established for this digitization, such that the vectors meet the appropriate requirements for flood modeling. This process requires a high resolution color input image (i.e. satellite imagery), as well as the Flood 30 DEM to ensure that the digitized vectors follow the DEM used in the flood modeling. This is necessary to account for any temporal changes in the rivers due to differences in the currency of the image and DEM data.

After the high and low slope rivers are created, the editing team merges the two data sets together. Editing is then done at the boundaries of the data sets as required to ensure full continuity of the river network. Finally, the rivers go through an attribution process that utilizes tools developed for FloodScope that assign accumulation areas and Strahler orders to the river vectors as a final preparatory step for flood modeling.

Overall, the new centerline creation procedures utilized in WorldFlood Version 2 have greatly improved the positional accuracy and detail of the river centerlines that are input to flood modeling. Figure 3 below shows an example as compared to HydroSHEDS in a high slope area (automatic collection) and Figure 4 shows the comparison in a low slope area (manual digitization).

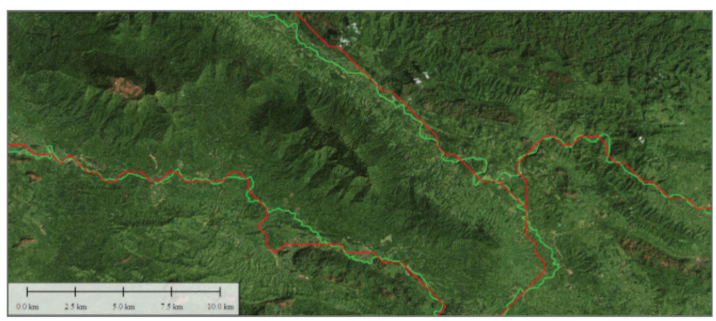

Figure 3. River centerline comparison between automatically generated centerlines (green) as used for WorldFlood Version 2 and HydroSHEDS (red) as used for WorldFlood Version 1.

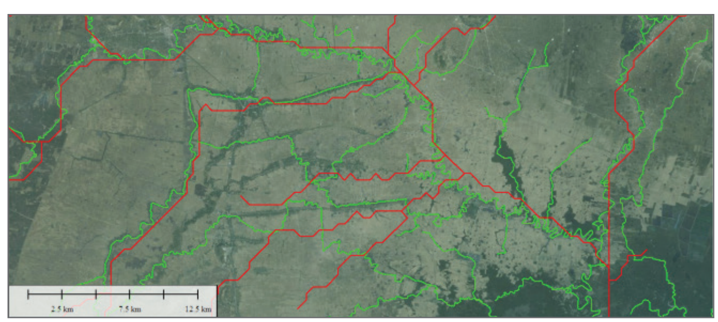

Figure 4. River centerline comparison between manually digitized (green) as used for WorldFlood Version 2 and HydroSHEDS (red) as used for WorldFlood Version 1.

Modeling Details

WorldFlood Version 2 is created using a combined modeling approach of three different modeling techniques: the WorldFlood model, Intermap's Standard model, and FloodScope. Each of these methods is calibrated at the basin level, such that optimal parameters for flooding thresholds are used. These parameters are used in all flood modeling approaches to further refine the flood zones and produce the best quality product possible.

The WorldFlood model is the same model as was used in the creation of WorldFlood Version 1. It is used in two situations in WorldFlood Version 2. In the NEXTMap areas of Flood 30, where DTM data is available, 30-meter data is used in the modeling to maintain the full benefits of using this high resolution DTM data for the modeling. For the remaining areas, Flood 30 data down-sampled to 90-meter is used as the input to the modeling to maintain schedule requirements.

Intermap's Standard model is used for the modeling of the major rivers in each sub-basin. The Standard model approach provides a more detailed flood zone map than the WorldFlood Model as it uses a 2-dimensional distance calculation in the modeling as opposed to a 1-dimensional one. This is more computationally expensive and therefore is only used on the main rivers where flood damage potential is greatest and risk assessment needs to be more precise.

Finally, FloodScope is used in the remaining areas to ensure maximum efficiency of the modeling. FloodScope differs from the WorldFlood model in that it uses cross-profiles away from the river centerline to determine the flood model, whereas the WorldFlood and Standard models use each pixel in the full bounding box of a river segment. This is more efficient since it reduces the number of raster pixels that need to be considered.

Overall Improvements

Overall, WorldFlood Version 2 offers significant improvement in flood depths and location for all areas within the coverage footprint of the update. This is due to the significant improvement in the river centerlines and the use of Intermap's proprietary Flood 30 DEM, which also incorporates DTM everywhere that it is available. Modeling techniques that are specifically calibrated and targeted for the specific area type also contribute to the overall improvement in WorldFlood Version 2. Figure 5 shows a comparison between WorldFlood Version 1 and WorldFlood Version 2 to highlight the improvements.

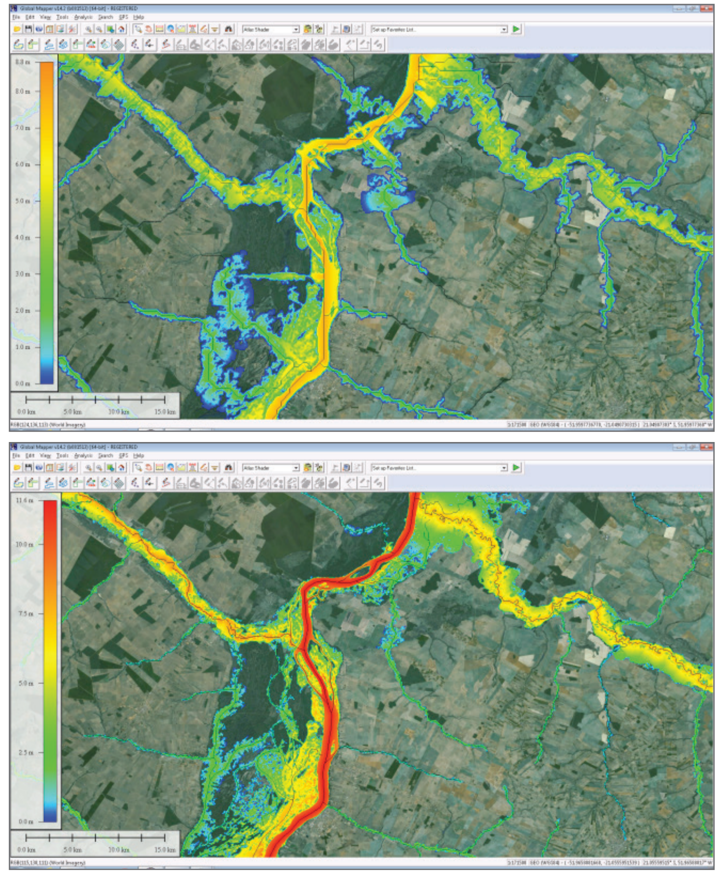

Figure 5. Improvements in WorldFlood Version 2. WorldFlood Version 1 (top); WorldFlood Version 2 (bottom).

Conclusions

WorldFlood Version 1 provides a global portfolio-level flood risk assessment solution. WorldFlood Version 2 leverages some of the key elements of WorldFlood Version 1, while improving the flood risk prediction in key geographic areas using updated input data and refined flood modeling techniques. The primary driver of the improvement is the improved river centerlines, which ensure that the derived flood models are positioned correctly. Additionally, the use of the Flood 30 DEM, especially in areas where NEXTMap DTM coverage exists, ensures that the derived flood models are following the real terrain and are not impacted by first-surface returns such as buildings or trees.

WorldFlood Version 2 remains well suited for global portfolio-level flood risk assessment and analysis, as well as visualization within InsitePro. The Version 2 improvements result in a global flood model that can be used for other applications, such as underwriting, risk accumulation, flood mitigation planning and disaster relief in regions where other flood risk information is rare or non-existent.