Current, Innovative, and Standardized
Elevation Data for Flood Modeling in Australia:
The Murray-Darling Basin
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The Australian Water Act of 2007 will require an advanced and thorough Geospatial Information System to assess and implement sustainable water management for the Commonwealth and citizens of Australia. Some of the tasks that are at hand for the Water Act of 2007 are collecting water information, performing analyses, and estimating future levels of water resources. To successfully accomplish these goals an accurate spatial Digital Elevation Model (DEM) must be acquired and trustworthy flood models need to be computed.

This paper will demonstrate the uses of Interferometric Synthetic Aperture Radar (IFSAR) in combination with high-resolution flood modelling for Australia’s Murray-Darling Basin. The resulting products will enable land use managers, insurance companies, citizens, and governmental agencies to have a current, standardized, and flexible platform for flood risk assessment across the entire Basin.

Murray-Darling Basin IFSAR Data Collection

Intermap Technologies has begun mapping large regions of Australia, which are broken down into smaller “blocks” for acquisition through IFSAR technology. On March 20, 2009, IFSAR data collection started for Block 3 (97,905 km²) located in the Murray-Darling Basin. This mapping project is a part of Intermap’s NEXTMap® program that will allow governments and commercial enterprises to meet their geospatial needs.

Intermap produces four core products from the IFSAR data:
1. Digital Surface Model (DSM) - topographic model of Earth’s surface that includes buildings, vegetation, roads, and natural terrain features;
2. Digital Terrain Model (DTM) - a topographic model of the bare Earth that has had vegetation, buildings, and other cultural features digitally removed;
3. Orthorectified Radar Image (ORI) - a grayscale image of Earth’s surface; and
4. Color Orthorectified Radar Image (CORI) - a colorized version of the ORI.

The data was collected using Intermap’s STAR-4 King Air turboprop plane, flying at an altitude of 7,010 meters (23,000 feet). All of the Australian data is created with a Vertical Datum of AUS Geoid 98 (AHD) and a Horizontal Datum of GDA94. All of the data collected for this project was acquired using Intermap’s
high-resolution 270MHz mode which yields an image pixel size of 0.62m in the ORI and CORI and, therefore, a clearer picture of the ground when compared to the standard pixel size of 1.25m. The DSMs and DTMs have a vertical accuracy of 1m root mean squared error (RMSE) and are posted to 5m intervals. The accuracy and hydro-enforced editing of the DTMs is what makes the NEXTMap DEM a prime candidate for flood modelling.

The data collected in the Murray-Darling Basin are edited to Intermap’s Version 1.5 specification:
1. Streams have no interruptions of monotonicity greater than 1m for single line drainages;
2. Bridges are removed so water can flow freely;
3. Major highways and roads are left in when sensed by the radar;
4. All buildings are removed; and
5. Vegetation is removed.

Along with the editing specifications, the manner in which these blocks of data are broken down into tiles also makes the IFSAR data ideal for flood modelling. While the data is acquired in blocks of roughly 100,000 km² it is cut down into tiles for delivery to the client. At an approximate latitude of 37˚S, each tile is roughly 156 km². These tiles are generated in a way that ensures there are no seamlines or other artifacts and the flow of water is uninterrupted.

Tight quality controls, specifications, and a tremendous attention to detail ensure an accurate representation of Earth’s surface, leading to higher quality flood modelling.

Murray-Darling Basin Flood Modeling

In the hydrologic and hydraulic modeling worlds, a common problem is that the modeler does not possess elevation data that is comprehensive in geographic coverage, or consistent in methods and accuracy. Thus, the modeler is forced to meld together disparate sources of data to achieve a single unified watershed model. It can be difficult for the modeler to accurately estimate the confidence limits of the data when disparate data sources are used. Additionally, the different formats of the data can require extensive data processing that, while essential to the modeling process, is not necessarily useful for future tasks, such as transportation analyses.

The Murray-Darling IFSAR data will offer hydraulic modelers an extremely high degree of consistency in the data specifications, and broad coverage of both upland and floodplain areas. This will permit modeling on greater scales, and with greater ease, than was previously possible.
A pilot project is beginning that will demonstrate the exceptional utility of the IFSAR data for this purpose, and result in basic watershed models for wide areas. The Murray-Darling Basin offers a wide range of topographic types and some challenging scenarios for the development of hydraulic models, particularly in a more automated fashion, as is proposed for this pilot project.

Typically, more automated model development techniques work best in highly incised, and minimally controlled watersheds, with clear, one-way drainage paths. The relatively poor performance of more automated methods in the past has been compounded by disparate or inaccurate topographic data sources. The more robust IFSAR topographic data will remove many of the blunders suffered by more automated techniques due to topography, and will allow the power of the techniques to be focused on placement of watershed breaks, cross-sections, and other model control features. In short, better topography will allow the model to focus on modeling, and less on compensating for unsatisfactory topography.

The main tasks for the pilot project are described below.

Using the IFSAR 5-meter Digital Elevation Model data, the watersheds for the test area will be delineated. The usual process of “burning in” stream centerlines data will be followed for areas with available data, however, past trials have shown that the IFSAR data typically results in a reasonable watershed delineation even without this step. This is due to the hydroenforcement done during the processing of the data.

Once the watersheds have been delineated to the desired drainage area threshold, the digital stream network will be built. Again, existing data will be used wherever possible in this process, but, it is feasible to perform this step from the topographic data alone. The stream network contains information on the direction of flow of the streams, accumulated drainage areas, and other geographic parameters related to the flow in the watershed. PBS&J’s proprietary tools will convert this stream network to an ArcHydro format. ArcHydro is a widely-used water resources spatial data model that allows the user to organize data in a consistent manner and share that data across multiple platforms (see http://www.crwr.utexas.edu/giswr/hydro/ArcHOSS/model/index.cfm). The water resources industry has made wide use of the ArcHydro model, and many tools have been written that allow specific hydraulic and hydrologic models to communicate with ArcHydro.

One of the key reasons for building an ArcHydro data model is that it allows the basic models being produced under the pilot study to be extended as additional data becomes available, or where existing more detailed models already exist. The ArcHydro data model also allows various data to be attached to the model that is later useful for the modeling in the pilot study, such as gage data.
Using the gage data that will be attached to the data model, a localized regression equation will be developed to model flow rates for various drainage areas and watershed characteristics. The use of such regression equations is common for initial modeling of watersheds for flood purposes, and, because of the speed and relative accuracy of the methodology, is attractive from a cost standpoint. It is, like many other features of the pilot model, easily changed out for more sophisticated methods as better data becomes available. Regression equations for the 2-, 10-, 50-, 100-, and 500-year return intervals will be developed. It is feasible to include adjustments for watershed storage in the equations.

Once the estimated flood flow rates for the watersheds have been developed, PBS&J's proprietary software will place cross-sections throughout the watershed, perform checks to verify the cross-sections are tagged to the correct flooding sources, and attribute those cross-sections with data for the creation of a flow model. This step is made far more straightforward by the availability of the IFSAR data, because of the consistent format of the information. In areas where multiple topographic data sources are required to generate a single surface model, it can become difficult to handle the formats of the various data sets, and to reconcile the overlap. Here, the consistent format makes placement and checking of the cross-sections much easier.

The cross-section data will then be ported to a common public-domain hydraulic model, HEC-RAS, to build a steady-flow analysis of the network. For this simple test case, regulated areas will be modeled only in basic form, but, again, the nature of the underlying ArcHydro network and assembly path of the model will allow modelers to add data to the simulation later, or to splice in existing more detailed data.

As the HEC-RAS runs are completed for each return period, the water surface elevation data will be used to create a three-dimensional water surface for the entire modeled area. This in turn will be intersected with the IFSAR data to form a representation of the floodplain boundaries. At this point, the proprietary software will invoke a series of quality control checks, and advise the user of the possible need to revise certain areas based on out-of-tolerance changes in model parameters.

The selection of the final area for the pilot project is occurring in short order, and work will begin to test this new, more consistent topographic data source against the needs of more highly automated floodplain modeling. Based on previous trials in other geographic areas, the pilot project is expected to produce excellent results. The final output will be a model network that contains a large amount of useful data for the Murray-Darling Basin, and also provides a skeleton on which to build or attach more detailed flood models as desired.