

VALUE OF IFSAR GEOSPATIAL PRODUCTS AND SERVICES FOR EMERGENCY MANAGEMENT

X. Li*, D. Hisdal, H. W. Utter

8310 South Valley Highway, Suite 400, Englewood, CO 80112-5815, United States
xli@intermap.com; dhisdal@intermap.com; hutter@intermap.com

KEY WORDS: Emergency management, IFSAR geospatial data, risk assessment, flood modeling

ABSTRACT:

Natural disasters are an unstoppable phenomenon; however, a comprehensive understanding of potential disasters, prompt mitigation planning, and efficient emergency management can significantly reduce the effect of these natural disasters. Recent geospatial industry developments provide a well-rounded and balanced set of technology, products, and solutions for emergency management. Success factors include appropriate geospatial data availability, simulation and modeling capabilities, and system framework and platform structures. This paper will provide the conference audience with insight regarding the value of Intermap Technologies' three-dimensional (3D) geospatial data products and services as well as the significant role these products and services play in support of emergency management, with the emphasize on flood risk assessment.

1. INTRODUCTION

Geospatial technologies and resulting data products and services are playing a significant role in emergency and disaster management due to government and organizational pull around the globe and to the push from the maturing geospatial industry.

Global governments are continuously pursuing social sustainability development and striving to equip the general public with the appropriate information to enable informed decisions and life quality improvements. Natural disasters are an unstoppable phenomenon, and emergency and disaster management is one of multi-faceted issues facing every country. Nations and organizations worldwide are forming strategic alliances to develop comprehensive solutions to address these issues; collaboration is the key to fulfilling this goal.

A comprehensive understanding of potential disasters, prompt mitigation planning, as well as efficient disaster and emergency management can significantly reduce the effect of these natural disasters. The geospatial industry (including geographic information systems, remote sensing, etc.) is maturing rapidly. When coupled with the advances in space, computer, communications, and spatial information fields, the industry provides a well-rounded and balanced set of technology, products, and solutions for emergency management. These solutions enable prediction, early warning, risk assessment, and contingency scheduling as well as management and recovery in the aftermath of disasters. Major challenges in emergency management include identifying and acquiring geospatial data that is applicable at emergence of a disaster, disaster management, subsequent data processing, as well as management and delivery of the disaster response. Success factors include geospatial data availability, simulation and modeling capabilities, and system framework and platform structures.

This paper will provide the conference audience with insight regarding the value of Intermap Technologies' three-dimensional (3D) geospatial data products and services as well as the significant role these products and services play in

support of emergency management, especially flood risk assessment. Section 2 briefly discusses the demand for appropriate geospatial data for emergency management. Section 3 details Intermap's IFSAR mapping technology, NEXTMap® program, and resultant geospatial products, as well as its online data store. Section 4 describes Aquarius.NET, which is a platform used for application building and rendering. As an example of the application of geospatial data for disaster management, flood risk assessment is illustrated in Section 5. Section 6 summarizes the paper and outlines future work.

2. THE DEMAND FOR APPROPRIATE GEOSPATIAL DATA

Appropriate and affordable geospatial data is the foundation and cornerstone of an effective emergency and disaster management system. Realizing these needs, Intermap is using its proprietary airborne IFSAR technology to generate large-area precise and uniform geospatial products based on the company's NEXTMap® countrywide, global mapping programs. The timely availability of appropriate geospatial data that is fit for intended purpose forms a challenge. The following factors typically need to be considered to judge the appropriateness of geospatial datasets for emergency management:

- Coverage (local, regional, countrywide, global)
- Quality (completeness, logical consistency, positional accuracy, temporal accuracy, thematic accuracy)
- Cost effectiveness
- Ease-of-use
- Interoperability
- Associated metadata (traceability)

Demand for such geospatial data is high in all location-based applications, such as urban planning, asset management, environmental impact assessment, insurance risk management, energy development, resource management etc. Continual advances in sensor development and geo-referencing technologies, combined with exponential improvements to digital computing power, enable unparalleled functionality and

* Corresponding author. xli@intermap.com

flexibility in digital mapping. As a result, a vast amount of geospatial data exists at different scales and qualities. Among these datasets, the highly accurate and affordable 3D digital mapping data produced by Intermap's IFSAR (interferometric synthetic airborne radar) technology enables a wide range of innovative geospatial solutions worldwide.

3. IFSAR – A COST-EFFECTIVE GEOSPATIAL DATA ACQUISITION TECHNOLOGY

IFSAR coherently combines microwave signals (phase and intensity information) collected from two across-track displaced antennae to generate three-dimensional (3D) geospatial products. IFSAR has been a technology of considerable scientific interest for some time due to its high-resolution 3D information extraction capability, quick turn-around time, and near weather-independent operation. Interest in IFSAR has been growing since data became widely available from the microwave sensor on the ERS-1 satellite. Also, the Shuttle Radar Topographic Mission (SRTM), which flew successfully in February 2000, provided a further impetus for mapping applications using IFSAR technologies. Compared to other common geospatial data acquisition technologies, IFSAR possesses much strength:

- Virtually nonexistent weather restrictions
- Profound cloud penetrating capability
- Rapid turn-around time
- Significant reduction in collection costs for large areas

3.1 Single-pass Airborne IFSAR Mapping Process

The two antennae can be mounted on a single platform (single-pass) or can be a single antenna passing over an area twice (dual-pass). The platform can be either an aircraft (airborne) or a satellite (spaceborne). Single-pass airborne IFSAR implementation can enable the creation of greater quality, 3D geospatial data because of its practical advantages when compared to other implementations:

- No temporal decorrelation
- Flexible system deployment
- Higher spatial resolution
- Lesser degree of atmospheric influence

Intermap's proprietary single-pass airborne IFSAR digital mapping technology produces 3D map products by processing raw radar data collected by airborne IFSAR systems. Thematic information for a scene is derived from the synthetic aperture radar (SAR) images. Height information is obtained in a single-pass mode by using the phase difference between two coherent SAR images, simultaneously obtained by two antennae separated by an across-track baseline. Figures 1 and 2 below illustrate this high-level mapping process and radar imaging geometry. Intermap owns and operates a fleet of such systems configured as across-track X-band SAR sensors. Figure 3 below illustrates some of these mapping platforms.

3.2 Nationwide NEXTMap® Mapping Program

Intermap is a provider of geospatial data products and has a strong heritage of photogrammetric and radar mapping experience. Its commercial capacity and professional reputation in meeting demands for high-quality and low-cost geospatial data are attracting worldwide attention, especially since the launch of its NEXTMap® program in early 2000, with its “off-

the-shelf” data availability business model. Figures 4 and 5 below depict the coverage of Intermap's NEXTMap® Europe and NEXTMap® USA programs.

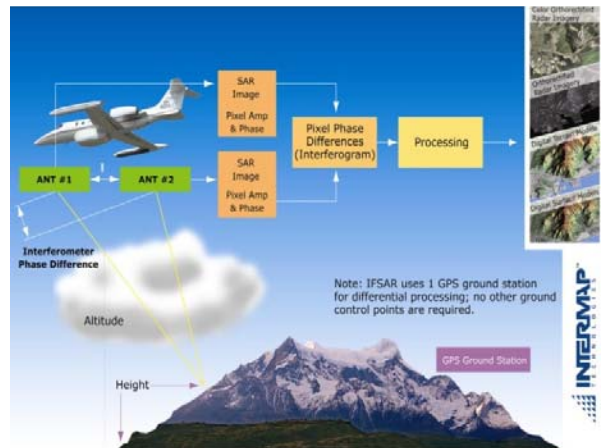


Figure 1. Concept of single-pass airborne IFSAR mapping

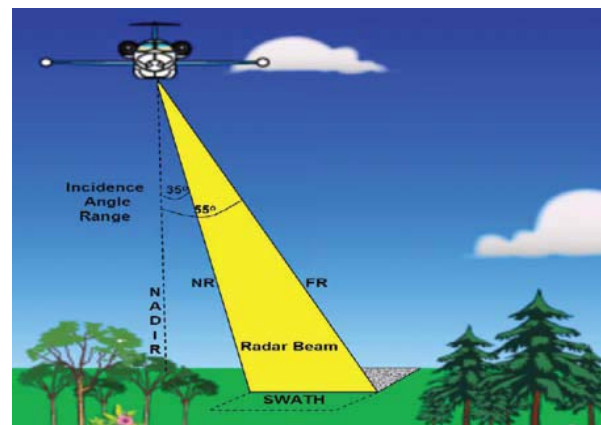


Figure 2. Radar imaging geometry



Figure 3. Intermap IFSAR mapping systems

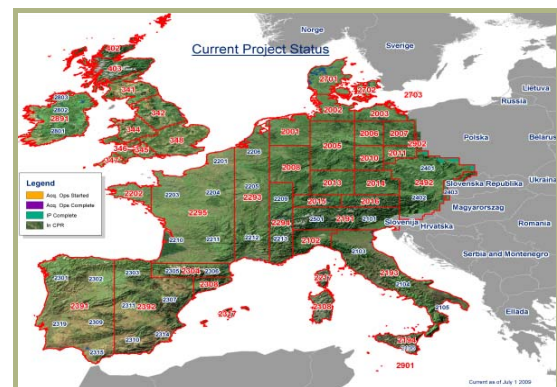


Figure 4. Intermap NEXTMap® Europe program

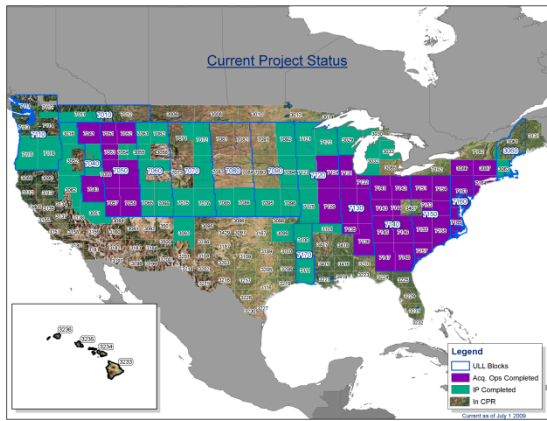


Figure 5. Intermap NEXMap® USA program

3.3 3D IFSAR Geospatial Products

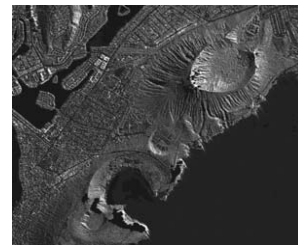
The success of risk assessments and modeling largely depends on the receipt of high quality background information, especially geospatial data. Three Intermap core products (i.e., orthorectified radar image, digital surface model, and digital terrain model), which are generated by the company's IFSAR mapping system are discussed in sections 3.3.1, 3.3.2, and 3.3.3. Figure 6 shows examples of these products. Tables 1, 2, and 3 describe the technical specifications of these products.

3.3.1 Orthorectified radar image (ORI): The ORI is a grayscale image of the earth's surface that has been corrected to remove geometrical distortions and terrain relief displacements. This product appears similar to a black-and-white aerial photograph. What differentiates an ORI from a photograph is that an ORI uses radar signals, not visible light, to produce images. The key feature of this product is that it provides a means of viewing the earth's surface in a way that accentuates features far more than is possible with aerial photography. The ORI has many applications in value-added products. For example, it can be used to extract cultural features, such as road networks and buildings, and it lends itself readily to terrain, land cover, and geological analyses.

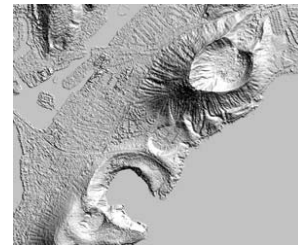
3.3.2 Digital surface model (DSM): The DSM is a topographic model of the earth's surface that can be manipulated using a computer. Surface elevation models play a critical role in applications such as, flood analysis, geologic and topographic mapping, environmental hazard assessment, oil and gas, and telecommunications. The key feature of this product is that it provides a geometrically correct reference frame over which other data layers can be draped. For example, the DSM can be used to enhance a pilot's situational awareness, create 3D fly-through, support location-based service applications, augment simulated environments, and conduct view-shed analyses. It can also be used as a comparatively inexpensive means to ensure that cartographic products, such as topographic line maps and road maps, have a much higher degree of accuracy than would otherwise be possible.

3.3.3 Digital terrain model (DTM): The DTM is a topographic model of the bare earth derived from the DSM. The DTM has had vegetation, buildings, and other cultural features digitally removed, leaving just the underlying terrain. This is achieved using the company's proprietary software, which derives terrain elevations based on measurements of bare

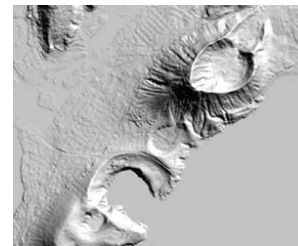
ground contained in the original radar data as well as manually reviewing and editing every tile. The key feature of the DTM is that it infers the terrain characteristics that may be hidden in the DSM.



a. Orthorectified radar image (ORI)



b. Digital surface model (DSM)



c. Digital terrain model (DTM)

Figure 6. IFSAR geospatial product examples

Pixel Size	RMSE ¹	CE95 ²
1.25 m	2.0 m	4.0 m

Table 1. Accuracy and resolution of ORI

DSM	Measures of Accuracy Specifications		Pixel Size / Post Spacing
	RMSE ¹	LE95 ²	
I	0.5 m	1.0 m	5 m
II	1.0 m	2.0 m	5 m
III	3.0 m	6.0 m	5 m

Table 2. Accuracy and resolution of DSM

DTM	Measures of Accuracy Specifications		Pixel Size / Post Spacing
	RMSE ¹	LE95 ²	
I	0.7 m	1.5 m	5 m
II	1.0 m	2.0 m	5 m

Table 3. Accuracy and resolution of DTM

For more information regarding Intermap's IFSAR technology and associated geospatial products, please refer to the *Product Handbook* which can be freely downloaded from either the company's Web site (www.intermap.com) or online data store (<http://www.terrainondemand.com>).

3.4 NEXMap® Data Store – TerrainOnDemand

In 2008, Intermap launched its NEXMap® *TerrainOnDemand*, a new and improved online data store (Figure 7) to support customer access to their growing NEXMap® digital mapping database. This enhanced data store provides immediate access to the company’s NEXMap® USA and NEXMap® Europe data. Data exploring and purchasing is made easy by empowering customers to buy what they want, when they want, anywhere in the world. It also allows access to the company’s unique national datasets, which have been created with unprecedented accuracy and detail and include precise 3D digital elevation models, orthorectified radar images, etc. As the company continues its aggressive program to generate off-the-shelf data availability for more than ten million square kilometres across Western Europe and the U.S., geospatial data will continually be added to the online library, providing up-to-date access to NEXMap® data to customers around the world.

Easy access to great data at a great price is why NEXMap® *TerrainOnDemand* was designed. Basic functionalities include:

- Product information via webinars and a Product Handbook
- Data identification and downloading
- Associated metadata for characterizing and production process information
- Drawing or uploading user-specified Shape files
- Common projection support: coordinate systems and file formats that can be imported into various off-the-shelf geospatial packages (e.g., ESRI, ERDAS, MapInfo, ER Mapper, ENVI, PCI, Autodesk etc.)

Data can typically be downloaded from the data store immediately after payment confirmation, unless customization by data store technicians is required.

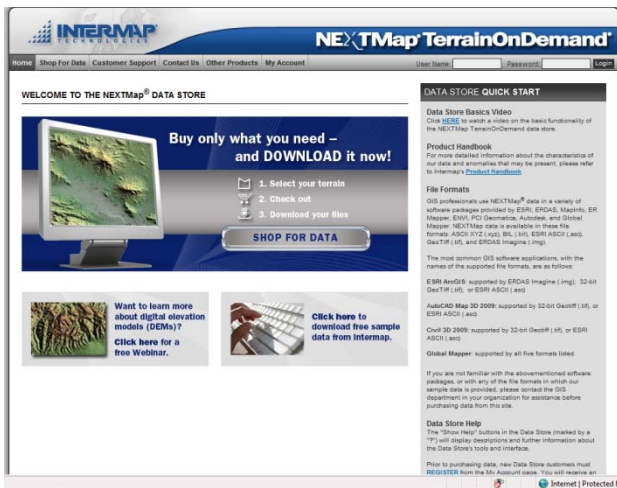


Figure 7. *TerrainOnDemand* gateway

4 APPLICATION BUILDING AND RENDERING PLATFORM – AQUARIUS.NET

Geospatial data needs to be converted into information and knowledge to support decision making in emergency and disaster management. Once the appropriate data is acquired, data management, processing, modeling, analysis, and presentation will follow. Intermap Technologies recently decided to transform its business from a pure data provider to a

more market- and product-focused organization to develop a series of solutions and services that meet various emerging market and application needs such as environmental impact assessments, insurance risk management, energy development, resource management, etc. To make this transformation feasible, the company has also committed to developing the underpinning platform and database management facility.

Aquarius.NET (Figure 8) is Intermap's platform for building various geospatial applications on Windows clients, servers, and mobile or embedded devices. As an integrated collection of geospatial software components, services, and user interface building blocks, Aquarius.NET allows for the rapid development of a complete geospatial solution. It also represents the most comprehensive, configurable, and flexible suite of spatially enabled software components on the market today for a Microsoft .NET environment. This suite is optimized for the easy and simple use of Intermap’s core products and services:

- Building and deploying geospatial applications
- Connecting data from files, databases, or Web services
- Analyzing integrated content to solve user queries
- Delivering results to desktop, Web, or mobile device

Application developers can use Aquarius.NET to build 3D enabled applications: Web applications, server applications, smart client applications, console applications, database applications, and more. To support this multitude of potential applications, the Aquarius.NET framework includes a broad set of supporting class libraries:

- Windows presentation components to visually enhance user experiences for Windows clients
- Web presentation components for high-performance and interactive Web-based applications
- Communication services to enable fast and flexible communications among Aquarius.NET applications across an enterprise
- Libraries for geometry, image data, digital elevation models, 3D models, and more.

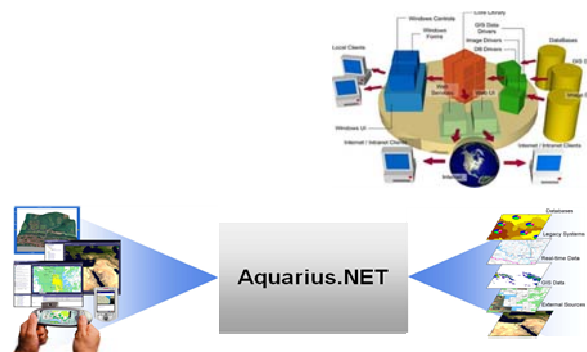


Figure 8. Aquarius.NET – the platform for application building

5 FLOOD RISK ASSESSMENT APPLICATIONS USING INTERMAP DIGITAL ELEVATION MODELS (DEMs)

Flooding is a devastating and costly natural disaster that is usually caused by intense and/or prolonged rainfall, increased windstorms, storm surges, rising sea levels, changing storm

tracks, poor flood defences, and sewage and drainage problems. Flooding is a global challenge facing areas close to oceans, rivers, and other large bodies of water (Figures 9 and 10).



Figure 9. A devastating flood in Europe



Figure 10. Damage caused by the 2004 tsunami

Accurate disaster planning and forecasting, hazard engineering, and prompt mitigation, as well as rapid after-event recovery and reconstruction all require associated flood modeling and risk assessments; geospatial data plays a significant role in these activities. Terrain information in the format of DEMs is an indispensable component in flood modeling. DEMs with appropriate resolution and accuracy are fundamental to understanding environmental processes, particularly flood risk modeling and mapping. Many existing DEMs are not fit for flood modeling or mapping purposes because of their low resolution, low accuracy, low quality, and data currency. The severity of this circumstance increases when modeling and mapping efforts encompass large geographies, such as countries and regions. The above-described NEXTMap® DEMs are proving to have many operational advantages when compared to other elevation datasets for such applications.

The value Intermap's DEMs add to flood risk assessments has long been recognized. The company's NEXTMap® program began in the United Kingdom (U.K.) where 2.2 million square kilometers were collected for Norwich Union, a leading U.K. insurance company, which utilized the NEXTMap® DEMs (both DSMs and DTMs) to derive up-to-date and more accurate flood models (Duncan et al, 2004; Sanders et al, 2005). Intermap is now in a position to let the best "flood modellers in the world" apply collective, flood application expertise, while using Intermap's NEXTMap® data to achieve world class flood risk assessment and modeling. So far, NEXTMap® data has been utilized and evaluated for whole nations by international flood modelers such as JBA Consulting and Ambiental (entire U.K.); PBS&J in the U.S. and the Czech Republic (partial USA

coverage); JBA Consulting (in the process of completing nationwide flood models in France); and Swiss Re (updated flood models for all of Switzerland). Combining unique data sources and analytical and reporting methods typically results in increased competitiveness and reduced losses for insurance industry.

On December 26th, 2004 a devastating tsunami hit the south western coastline of Indonesia, Malaysia and Thailand with brutal force killing in excess of 260,000 people, and creating catastrophic damage in areas as far away as the Maldives and the coast of Africa as it ripped across the Indian Ocean. In response to the critical need to support of tsunami relief efforts AusAid (Australian Aid program) worked with Intermap and Apogee Imaging International to create a 1-meter DEM over the critically affected areas. The effort created models that covered devastated coastal areas in Aceh Province and Nias Island. The IFSAR data was used to assess tsunami damage, evaluate coastal change and to create inundation risk models to help prevent future loss of life due to these catastrophic events. This effort was later expanded in 2006 under a contract with BAKOSURTANAL, the national mapping agency of Indonesia to include the entire southern coastline of Sumatera for the creation of a detailed coastal inundation model.

Intermap's DEMs and flood modeling enable the production of extremely accurate flood maps that can help benefit communities and property owners worldwide. The company's flood risk assessment solution provides key benefits by standardizing, institutionalizing, and automating emergency management functions within and across response organizations. In January 2009, Intermap Technologies launched a Web service – the Public Flood Risk Portal – for the Czech Republic Insurance Association (ČAP), which provides user-friendly, address-specific flood risk assessment and reporting data to consumers via the Internet (Beiningen, 2009). Until then, the Czech Republic had never had this type of information readily available to the public. This innovative service provides the consumer with a better understanding of their own personal property flood risk and can increase the public's understanding of flood and other natural hazard risks.

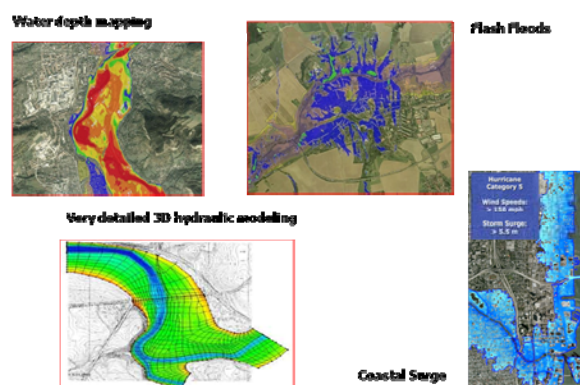


Figure 11. Flood risk and coastal inundation assessment scenarios

6 SUMMARY AND PROSPECT

Geospatial technologies and data products play a significant role in finding solutions for many current and global problems, such as disaster and emergency management. Large-area, continuous,

up-to-date, and consistent high-quality geospatial datasets are a necessity for all national economic development activities. Nationwide database creation and updating is expensive and time consuming for local and national government organizations that are using traditional methodologies; therefore, national geospatial databases either do not exist or are out-of-date. New and innovative mapping technologies are needed to generate highly accurate, wide-area datasets in an efficient and cost effective manner.

Intermap's NEXMap® programs were established to answer this need. The resulting 3D geospatial data products, especially DEMs, form a base layer for many traditional and non-traditional applications. Using the latest validated high-precision and high-accuracy flood risk assessment technologies and topographic data to select the highest risks is just one of many successful applications. The enhanced NEXMap® *TerrainOnDemand* online data store provides immediate access to the company's NEXMap® data and makes data exploring and purchasing easy by empowering customers to buy what they want, when they want, anywhere in the world. Aquarius.NET forms the backbone for all modeling and simulation for the company's geospatial product and service rendering.

There is a strong, future need for the convergence of global standards, practices, and processes when acquiring, sharing, and using geospatial data. Initiatives are underway to further exploit the value of the geospatial industry and its ability to make our earth a safer place.

REFERENCES

Beiningen, K., 2009. Flood risk reports for the public: example of the Czech Republic: public flood risk portal. In: *Association of State Floodplain Managers Conference*, Czech Republic, June 2009.

Duncan, A., B. Kerridge, J. Michael, A. Strachan, 2004. The national flood mapping program: using IFSAR for flood modeling in England and Wales. In: *Association of State Floodplain Managers Annual Conference*, Biloxi Mississippi, USA, May 16-21, 2004.

Sanders, R., F. Shaw, H. MacKay, H. Galy and M. Foote, 2005. National flood modeling for insurance purposes: using IFSAR for flood risk estimation in Europe. *Hydrology and Earth System Sciences*, 9(4), pp. 449-456.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Tara White and Lorraine Tighe for their help on this paper.