FLOOD MAPS AND SATELLITE, CASE STUDY KITTILÄ

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ABSTRACT

Severe weather have been a reality for Finland and the surrounding areas for the last two years. Risk of flooding is increasing both in inlands and costal areas. A recent reminder about this change was experienced in the city of Kittilä in the May 2005, when a snow melt flood occurred and people needed to be evacuated. An other event, series of heavy rainfalls caused major damage in the August, 2004. Storms caused nearly 10 million euros damage.

Luckily we had our FloodMAN research project going on, co-funded by the European Commission, and in this project we happened to demonstrate the developed near real time flood forecasting, warning and management system based on satellite radar images, hydrological and hydraulic models and in-situ data (http://projects.itek.norut.no/floodman). During the demonstration period we managed to acquire satellite scenes from exceptional floods that occurred in both the city of Kittilä and Ivalo in Lapland.

This paper explores experiences gained and needs of different end-users such as fire services, public, regional and federal authorities as well as compares the satellite flood mapping to the traditional flood mapping methods.

INTRODUCTION

The demonstration was done in near real time during year 2005 and for the historical earth observation data for previous years. Near-real time demonstration of the entire FloodMan system was carried out in the Kemijoki river basin, but exceptional floods were monitored in almost all watersheds in the western and northern Finland. Demonstration included:

- real time flood forecasting system with data-assimilation of earth observation data, such as soil moisture (Paloscia at al. 2006) and flood extent, in the

internet, see: www.environment.fi/waterforecast (Vehviläinen and Huttunen 2005)

- data and flood warnings were send in real time to FloodMAN system and corresponding authority
- historical flood monitoring, an advertised possibility to acquire scenes from exceptional floods
- near real time flood monitoring, based on advertised possibility to acquire image scenes nearly from the entire country
- an extranet service giving a possibility to overlay remote sensed flood extent maps with different kind of maps among the environment administration in Finland (Dubrovin at al. 2006)
- an internet site for the public was established to show flood maps for the Finns for the first time (http://wwwi9.ymparisto.fi/i9/en). Site also showed acquired earth observation data

The possibility to acquire satellite images from flood events during the demonstration was advertised for the end users from regional environment centres (REC). This option was used once to acquire historical scenes (the river Vantaanjoki) and three times to acquire in near real time scenes (the city of Kittilä, Ivalo and Rovaniemi) (Fig. 1).

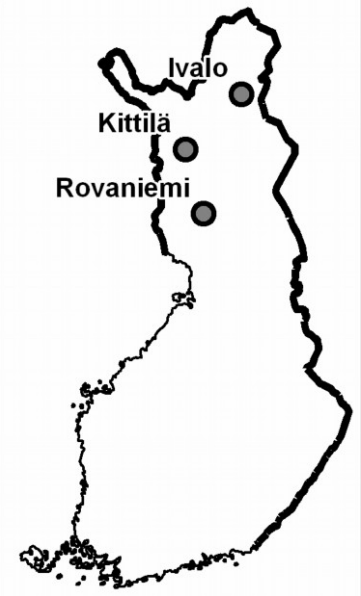

Figure 1. Near real time demonstration areas in Finland.

NEAR REAL TIME DEMONSTRATION

The REC in the city of Rovaniemi contacted us 10 days prior to expected floods in the following cities Rovaniemi, Kittilä and Ivalo (Fig. 1). Only scenes with a 10 m spatial resolution were surged because of landscape e.g. river width is typically less than 50 meters. There was an image available from each site for the same day as the flood peak was expected to occur at this time. The ordering was completed around 4-7 days prior to flood. Data was delivered with 6 hours from the city of Rovaniemi to the FloodMAN system and from the other sites within 3 hours. The scenes were improved e.g. using water mask and background map and uploaded to the internet around 12 hours after the scenes were taken. Maps were also delivered to the REC and fire rescue services. Totally two press releases were released and results were dissemination via seminars.

The city of Ivalo, May 27th, 2005

The flood was due to snow melt and heavy rains prior to flood (Fig. 2). About 25 people were evacuated. The scene was available and it was combined with the SYKE's water mask, which shows water covered area in a vector format at the average water level (Fig. 3). The water was expected to go over dikes, but luckily the height of dikes was increased prior to flooding and there was not much ice in the water to increase the water level. The responsible rescue commissioner was contacted with our new

FloodMAN product. The commissioner had no idea about this kind of a method and was glad to here that it can track floods at nights too. His comment was that the method is not very good at detecting water among bushes or forested areas.

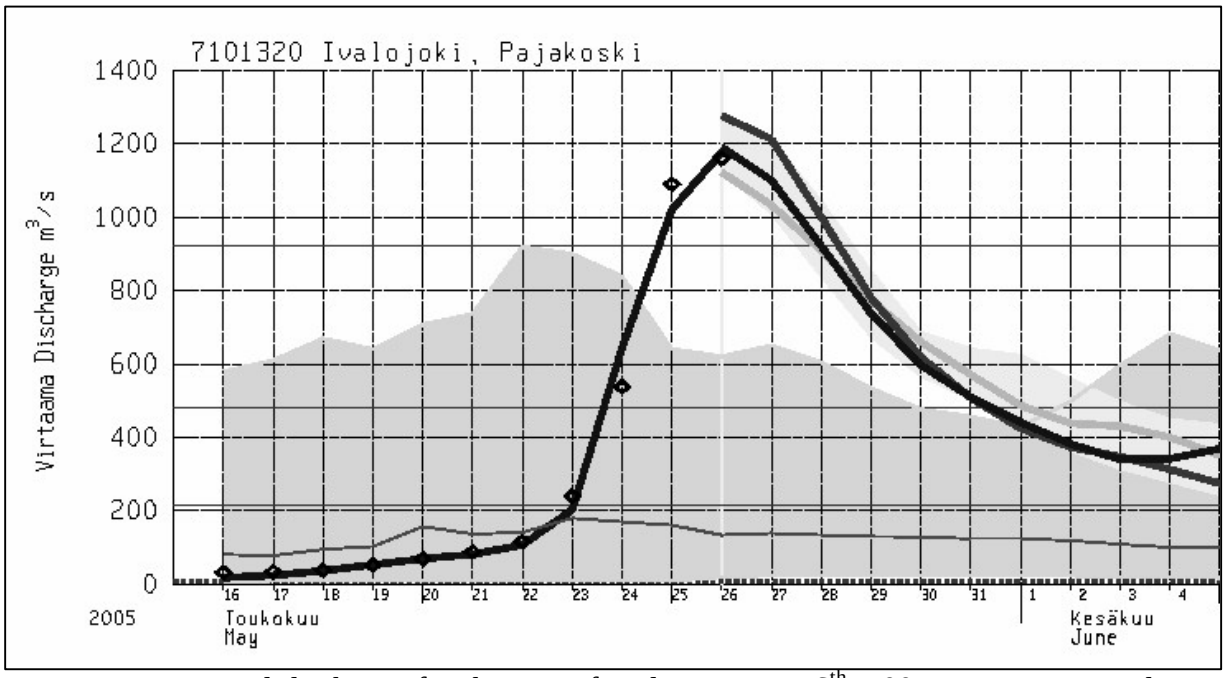

Figure 2. Forecasted discharge for the city of Ivalo on May 26th, 2005. Previous record was around 900 m^3/s (gray area, observed 1961-2003) and new around 1200 m^3/s. The middle black line is the average forecasting curve. Points area discharge observations.

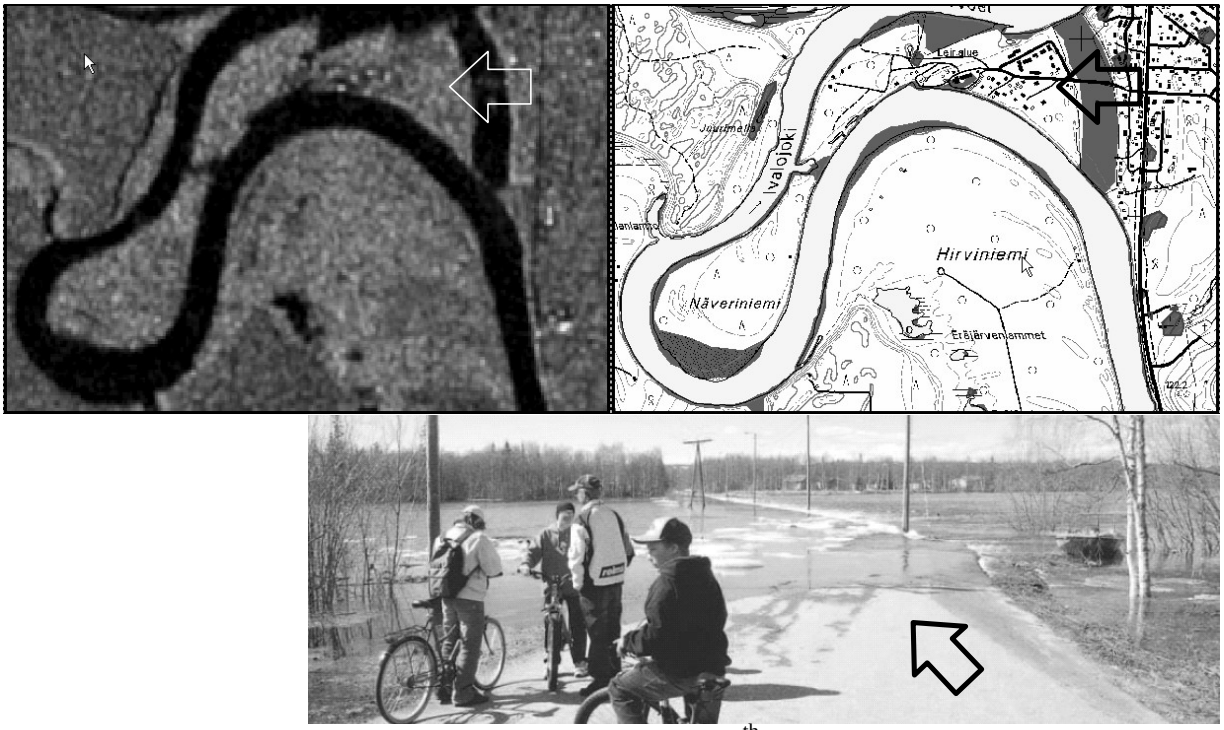

Figure 3. City of Ivalo. RADARSAT scene from May 27th, 2005 (RSAT-1, UTC 15:50, 10 m resolution), flood extent derived from the satellite image on the base map (gray) and photo from the same site. Road was flooded as can be seen from the images.

The city of Kittilä, May 30th, 2005

People were also evacuated from the city of Kittilä. Flood maps were produced using near real time satellite data (May 30th, UTC 16:03, RSAT-1, 10 m resolution) and published in the next morning in the internet in scales 1:30 000 and 1:250 000. Total damages were around 5 million euros. Afterwards flood extents derived from satellite image were compared with high resolution oblique aerial photographs (~ 130 photos) taken from the same area around the same time (Fig. 4). Flood extents were also compared with CORINE Land Cover 2000 -classification. End-user feedback was request from the REC of Lapland. They said that the temporal coverage is very important in case of an exceptional flood. This kind of flood occurs once every 70 years in the city of Ivalo and in the city of Kittilä once every 100 years. The REC of Lapland also promoted FloodMAN results in a seminar held in SYKE on the October 25th , 2005.

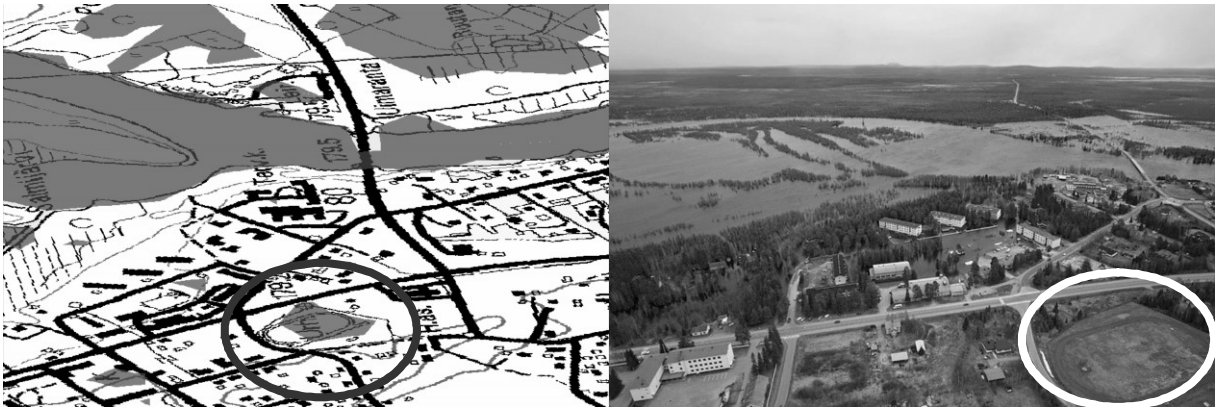

Figure 4. City of Kittilä 2005. Instead of orthorectified photographs, flood extent derived from the satellite image on a base map (gray) were navigated to the same scene as the air photo in order to make comparison easier. Incorrect flood extent due to flat area is rounded to the images. Picture © Studio Tunturi Lappi Oy, Sauli Koski.

The city of Rovaniemi, May 30th, 2005

The city of Rovaniemi was expected to be flooded in the end of the May 2005. However, the flood was avoided by a good regulation. It was delivered both 10 m resolution and 25 m resolution scenes from the area (May 30th, UTC 04:30, RSAT-1). Flood extents derived from these two satellite images were compared (Fig. 5) and the scenes were validated using 1-dimensional hydraulic model data (Fig. 6).

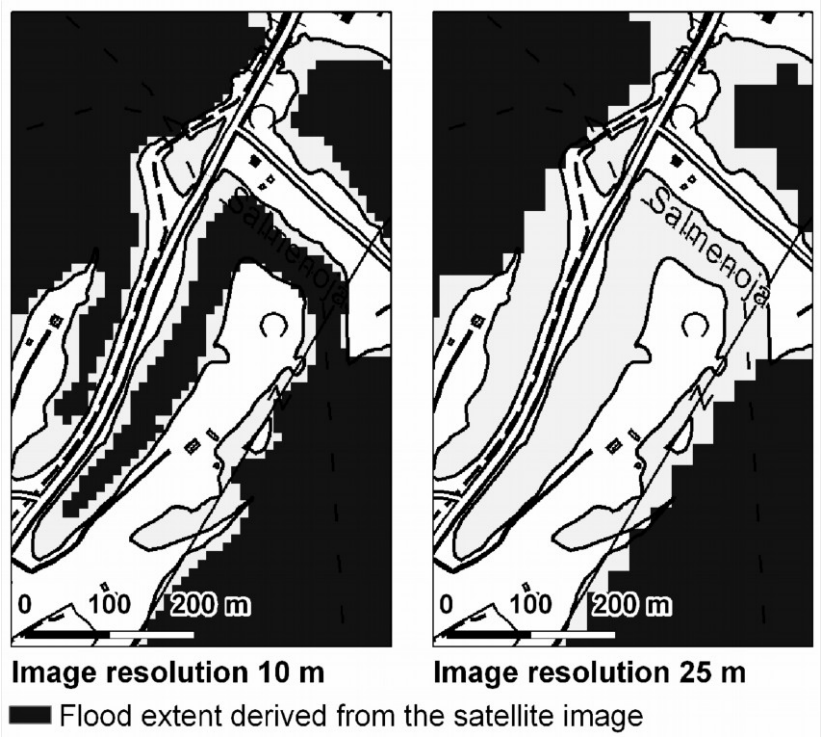

Figure 5. Comparison between 10 m and 25 m resolution flood extent in the city of Rovaniemi. Light gray is area covered naturally by water and dark gray analyzed water extent from the satellite image.

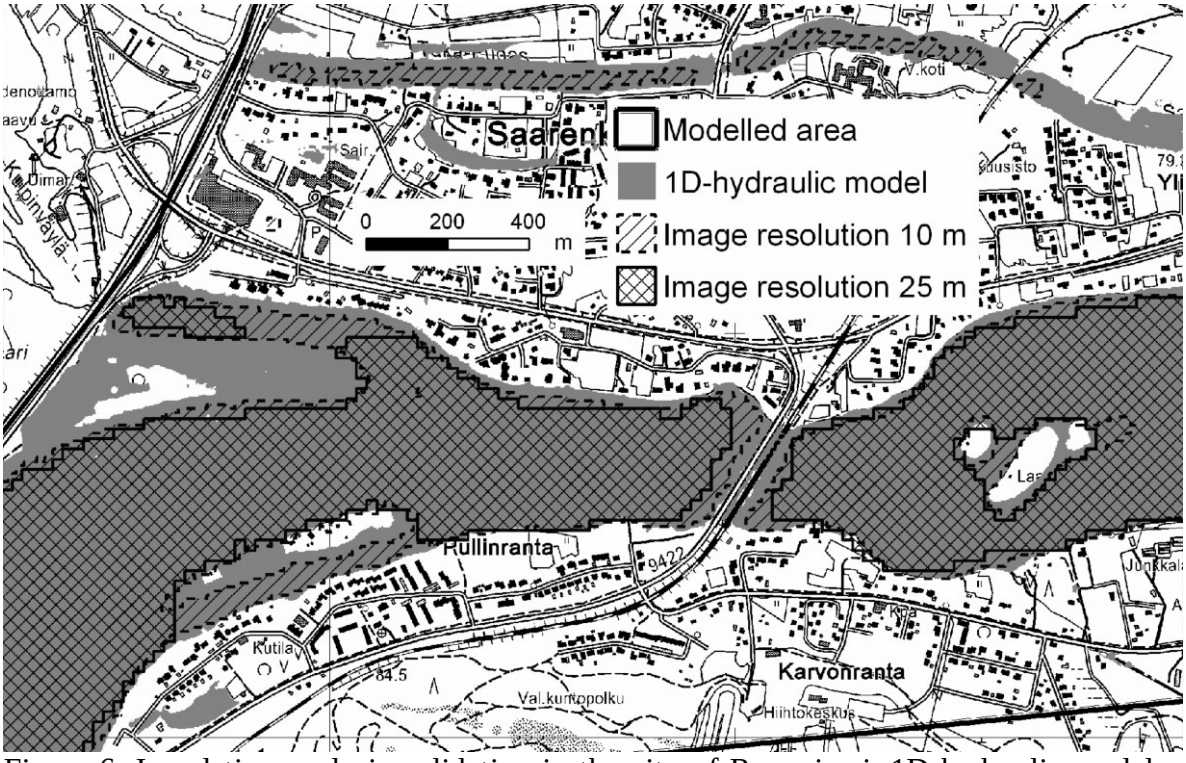

Figure 6. Inundation analysis validation in the city of Rovaniemi. 1D-hydraulic model and SAR-images (resolutions 10 m and 25 m) are compared. The narrower a reach, an island or a bridge is, the more likely it is unnoticed. An interesting feature is the northern bank which is not verified by the algorithm. The reason could perhaps be the angle of the satellite or river embankments.

DISCUSSION AND CONCLUSION

In many open areas results from the flood extent algorithm were good. Mowed fields and other flat and impermeable areas, like airfields, sports fields and large flat roofs, were seen problematic. These areas were interpreted mostly faulty as flooded areas. There were same problems with open hillsides, which were frozen, snowy or rocky, particularly if they were perpendicular to the incidence angle of the satellite. On the other hand water couldn't be interpreted from some flooded areas. Water detection was shallow but satisfactory from the fields before harvesting and poor in bushes and forested areas.

Around 80 % of the flooded area was detected with a 10 meter resolution. As a rule of thumb satellite scene resolution should be at least 1/3 of the river width. In case of an exceptional flood a satellite scenes can easily substitute modelled flood extent maps. This is especially the case, when the water level cannot be predicted prior to flooding (ice jamming, sea level impact, old flood hazard map, and land uplift).

The usage of flood extent maps were mainly seen valuable in post crisis phase when analyzing flooded areas or making land use plans. However, a near real-time (automatic processing) and more accurate method (better resolution, a method for fixing the analyzing errors), would enhance the usability of the images among rescue services and operative flood prevention forces. End users such as regional environment centers saw, that the method would rather complete air photos than substitute them.

FloodMAN system overall performed well and provided near real time data all the time. For end users it's very important that ordering system is very simple because it is rarely used. End-users were satisfied with the provided products but the temporal coverage of the satellite images was not sufficient. Price of scenes was seen rather high at the moment but the spatial coverage excellent. In any case, this kind of a new method needs to be introduced well, prior to launching.

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