SEARCHING TSUNAMI AFFECTED AREA BY INTEGRATING NUMERICAL MODELING AND REMOTE SENSING

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1. INTRODUCTION

The 2004 Indian Ocean tsunami, which caused more than 237,000 fatalities, propagated entire Indian Ocean and caused extensive damage to 12 countries. Because of the devastating damage on infrastructure and local/regional/international communication network and the failure of the disaster response activities, the tsunami-affected areas and overall damage could not be addressed for months. As one of the lessons from this event, the importance of developing technologies to search tsunami-affected area has been raised. However, the extensive scale of catastrophic tsunami makes it difficult to search the impacted area in the aftermath of the event.

A project is under way to search tsunami-affected area using recent advances of remote sensing technologies combined with a numerical modeling of tsunami propagation/inundation. In the present study, the authors propose a framework in developing a method to search and detect the impact of tsunami disaster by integrating numerical modeling, remote sensing, and GIS. Part of the method is implemented to recent tsunami events including the 2009 tsunami in American Samoa to search the tsunami-affected area and detect the structural damage, using the numerical modeling and the analysis of high-resolution optical satellite images.

2. METHODS

The structure of our method consists of several damage mapping efforts. The first phase is the regional hazard mapping. Mapping the potential tsunami hazard in regional scale is based on the numerical modeling of tsunami propagation and bathymetry/topography database. The numerical model for regional scale is based on the finite difference method of shallow-water theories in spherical or cartesian co-ordinate systems[1].

In the second phase, to identify the potential tsunami impact along the coast, the authors incorporate PTE (the Potential Tsunami Exposure)[2] as the number of population exposed against the potential tsunami hazard. PTE is obtained by the GIS analysis integrating the numerical model results and the world population database, such as LandScan[3].

In the third phase, after the potential tsunami-affected areas are estimated, the analysis gets focused and moves on to the “detection” phase using remote sensing. Recent advances of remote sensing technologies expand capabilities of detecting spatial extent of tsunami affected area and structural damage. To detect the impacted area in regional and local scales, the authors use the capability of SAR (Synthetic Aperture Radar) image analysis[4] and interpretation of high-resolution optical satellite images, such as QuickBird and IKONOS.

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3. PRELIMINARY RESULTS

The method has been implemented and verified in recent tsunami events. Here, an example is shown from the most recent tsunami, which was generated by an earthquake of magnitude 8.0 on 29 September 2009 (UTC) in Samoa. The tsunami caused more than 120 fatalities in Samoa, Am. Samoa and Tonga[5]. Fig.1 is the result of our analysis searching the potential tsunami-affected area of the 2009 tsunami in American Samoa. The result indicates the possibilities that the tsunami attacked densely populated areas along the central and western coasts of Tutuila island, American Samoa. This estimation suggests that the disaster response should focus on these areas to investigate its impact using emergency satellite observation.

Fortunately in this event, Digital Globe Inc. succeeded to take the image in the central Tutuila island by QuickBird satellite. Fig. 2 is the result of visual interpretation and field inspection of pre and post-tsunami QuickBird images, which were acquired on 24 and 29 September 2009 (UTC) in Tutuila island, American Samoa. Especially, the post-tsunami image was acquired approximately four hours after the earthquake occurred. As estimated in the tsunami numerical modeling with population data, Pago Pago which locates at the central coast of the island was severely affected.

4. SUMMARY AND FUTURE PERSPECTIVE

Integrating the numerical model of tsunami propagation/inundation, GIS analysis combined with population data, and the remote sensing technologies with use of modern computing power increases possibility searching and detecting the impact of tsunami disaster. We are now developing the capability to search and detect the tsunami-affected area within 24 hours after a tsunami event occurs so that emergency response and disaster management efforts make use of it. The present research is still underway in developing automatic damage detection algorithms, real-time tsunami inundation modeling to estimate the structural damage in a quantitative manner[6], developing house and structure inventory database, and preparation of high-resolution merged bathymetry and topography data.

5. REFERENCES

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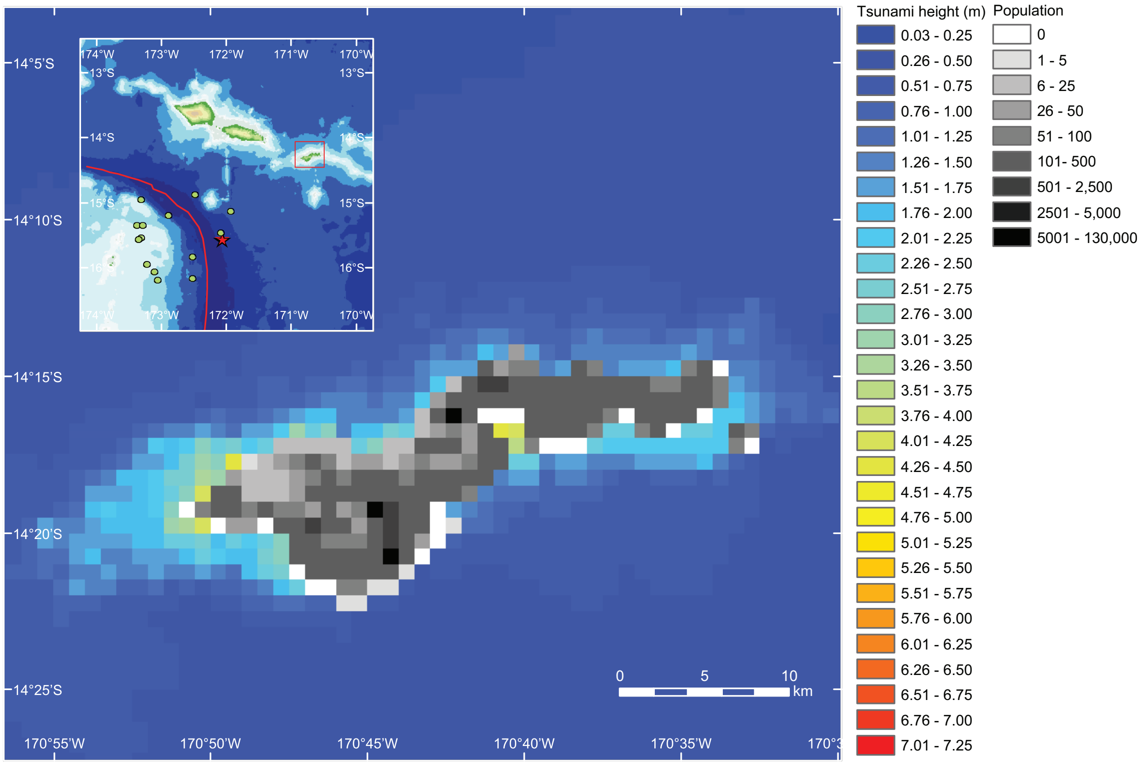

Fig. 1. The estimated tsunami height of the 2009 tsunami in American Samoa and distribution of exposed population.

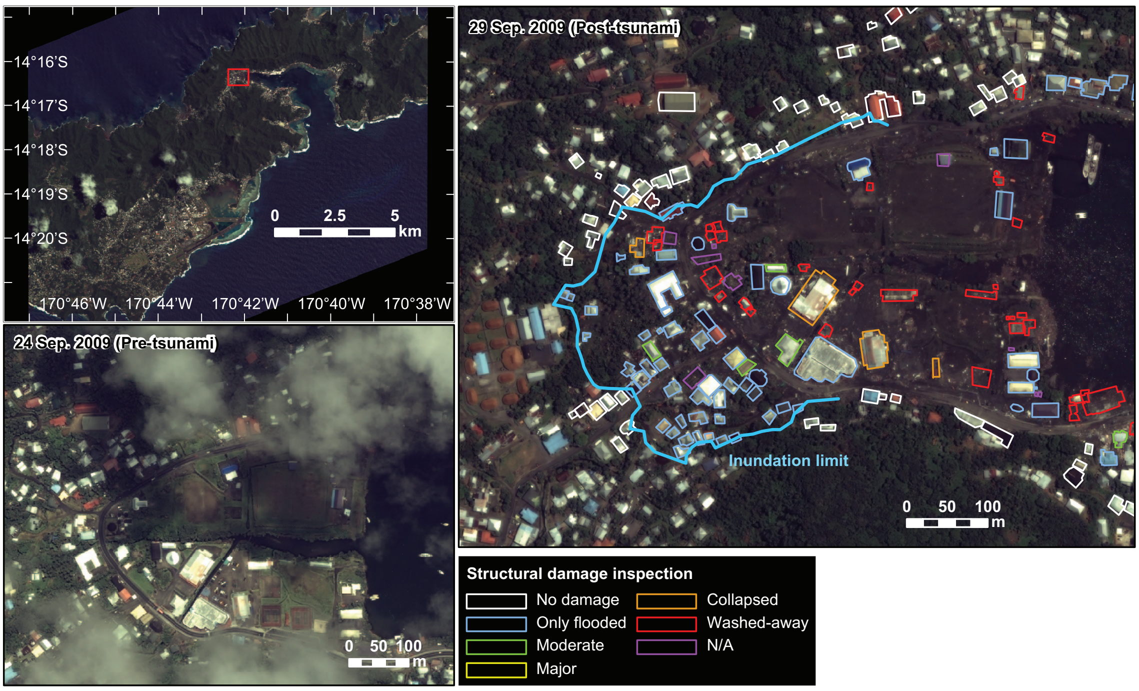

Fig. 2. Interpretation of structural damage in Pago Pago, Tutuila island, American Samoa, combined with the field inspection.