Physics and Chemistry of the Earth 34 (2009) 409–415

Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

journal homepage: www.elsevier.com/locate/pce

Shoreline changes and vertical displacement of the 2 April 2007 Solomon Islands earthquake Mw 8.1 revealed by ALOS PALSAR images

Ashar Muda Lubis [a,*,1], Nobuhiro Isezaki [b]

[a] Graduate School of Science and Technology, Chiba University 1-33, Yayoi-cho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan
[b] Geophysics Laboratory, Department of Earth Science, Faculty of Science, Chiba University 1-33, Yayoi-cho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan

ARTICLE INFO

Article history:
Received 29 February 2008
Received in revised form 3 September 2008
Accepted 30 September 2008
Available online 11 October 2008

Keywords:
Solomon Islands
SAR
Shoreline
Displacement

ABSTRACT

The Solomon Islands earthquake with magnitude Mw = 8.1 occurred on 2 April 2007 at 7:39 local time. We used six L-band Synthetic Aperture Radar (SAR) images acquired by the Advanced Land Observing Satellite (ALOS) Array L-band Synthetic Aperture Radar (PALSAR) data to roughly estimate the shoreline and vertical displacements associated with this earthquake. We processed the raw SAR data with the SIGMA-SAR software package, produced by Japan Aerospace Exploration Agency (JAXA). Our measurements showed good agreement with field observations performed by Japanese scientists just a few weeks after the earthquake. We estimated the dislocation related to this earthquake between Ranongga Island and Simbo Island. Moreover, we compared the radar imagery analysis data with Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data and found that the SAR images were more efficient for investigating vertical displacements than similar techniques based on data from optical sensors. Measurements of offset cross-correlation intensities in SAR images indicated about 1.4 m of uplift on southwestern New Georgia Island.

1. Introduction

At 7:39 a.m. local time on 2 April 2007, an Mw = 8.1 earthquake occurred in the Solomon Islands along the Solomon Islands subduction zone (Fig. 1). Not only was the earthquake strong enough to cause damage by itself, it also generated a tsunami with waves from 2 to 10 m high that damaged surrounding areas. The main affected areas were Gizo, Simbo, Ranongga, Vella Lavella, and Kolombangara Islands, and the western and southern coasts of New Georgia Island.

The Solomon Islands subduction zone is noted for producing an unusual pattern of earthquakes called doublets, where two earthquakes of similar magnitude occur close together in space and time. In the northwestern part of rupture of the 2007 earthquake event, the largest reported earthquake doublet is a pair of Mw = 8.0 and 8.1 earthquakes that occurred 12 days apart in 1971 (Schwartz et al., 1989). The same part of the fault that ruptured in the first earthquake of the 1971 doublet reruptured in a different manner during a Mw = 7.7 earthquake in 1995 (Schwartz, 1999). Other doublets occurred in 1919 and 1920, 1945 and 1946, and 1975 (both in the same year), all in the Mw = 7–8 range. In the southeastern part of the Solomon Islands subduction zone, doublets occurred in 1931 and 1939, and a triplet in 1977 (Lay and Kanamori, 1980). The mechanism causing earthquake doublets to occur is unclear, although stress triggering from the first earthquake of the doublet is likely a significant factor.

The mechanism of the 2 April 2007 Solomon earthquake and tsunami generation has been studied by tsunami modeling (Namegaya et al., 2007), by using seismic waves to study the rupture process (Biryol and Beck, 2007), and by fault modeling (Tanioka et al., 2007). In addition, after the earthquake, Nakamura et al. (2007), Nishimura et al. (2007), Rafiau et al. (2007), and Fritz and Kalligeris (2008) conducted field observations and Albert et al. (2007) analyzed reef damage at several sites in the Solomon Islands to detect land displacement and shoreline changes. However, not all areas deformed by the earthquake have been studied, because access to some regions is difficult, and more time is needed to investigate many points. On the other hand, remote sensing can be used to obtain an overview of crustal deformation along an entire rupture zone. Remote sensing techniques have been successfully applied to the detection of surface changes caused by catastrophic events (Matsuoka and Yamazaki, 2001; Bignami et al., 2004), and, in particular, Tobita et al. (2006) used Synthetic Aperture Radar (SAR) data to detect vertical displacement caused by the great Sumatra–Andaman earthquake in December 2004.

In this study, we first used SAR data to detect shoreline changes and vertical displacement associated with the Solomon earthquake and tsunami inundation by comparing data acquired before and

* Corresponding author. Tel.: +81 43 290 2854; fax: +81 43 290 2859.
E-mail addresses: asharml@graduate.chiba-u.jp (A.M. Lubis), nisezaki@faculty-chiba-u.ac.jp (N. Isezaki).
[1] Permanent address: Department of Physics, Faculty of Mathematic and Sciences, Bengkulu University, Indonesia.

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doi:10.1016/j.pce.2008.09.008

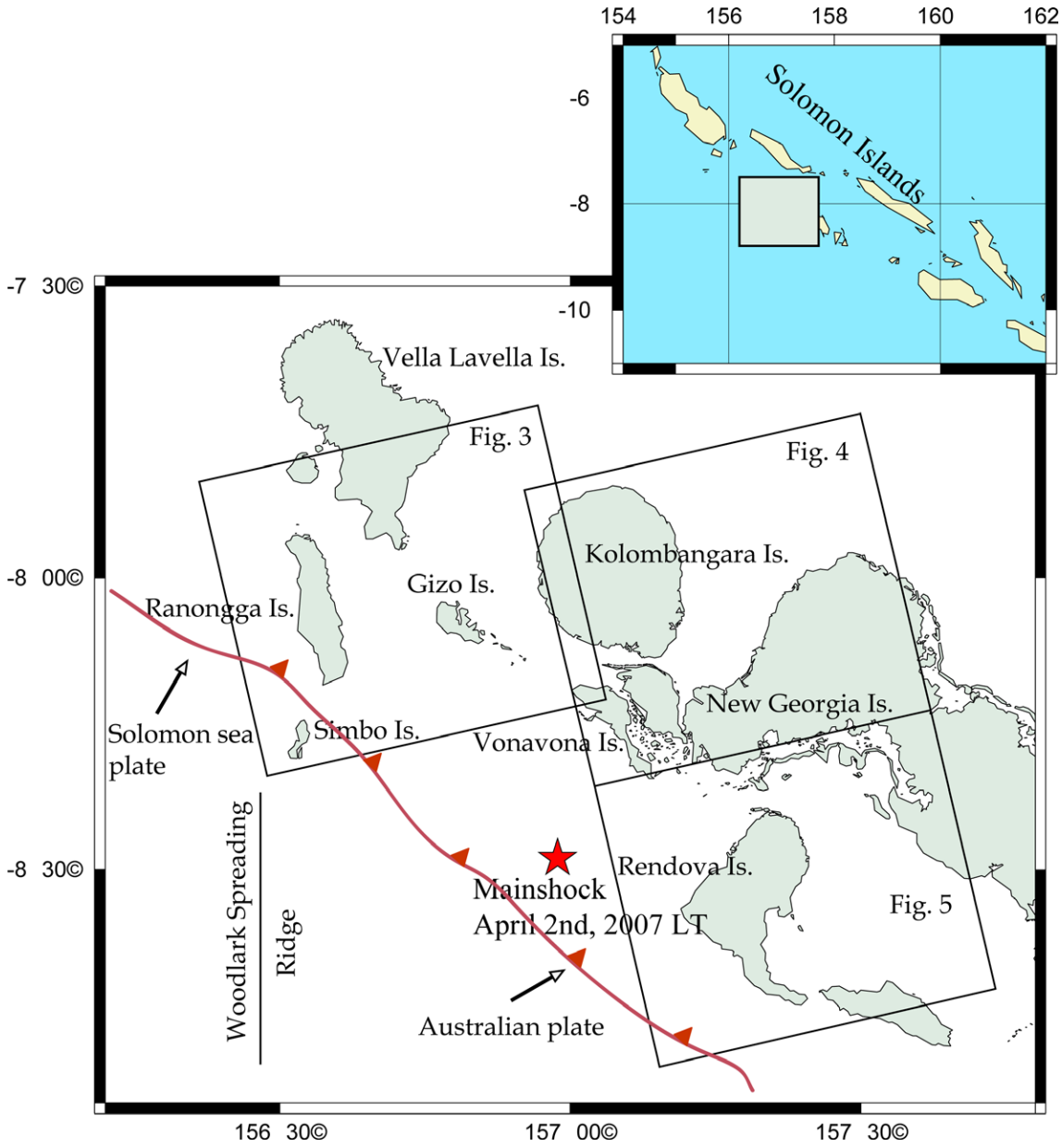

Fig. 1. Map of the Solomon Islands (inset) and our study area showing the epicenter of the earthquake on 2 April 2007. Rectangular boxes show locations of the ALOS PALSAR images used.

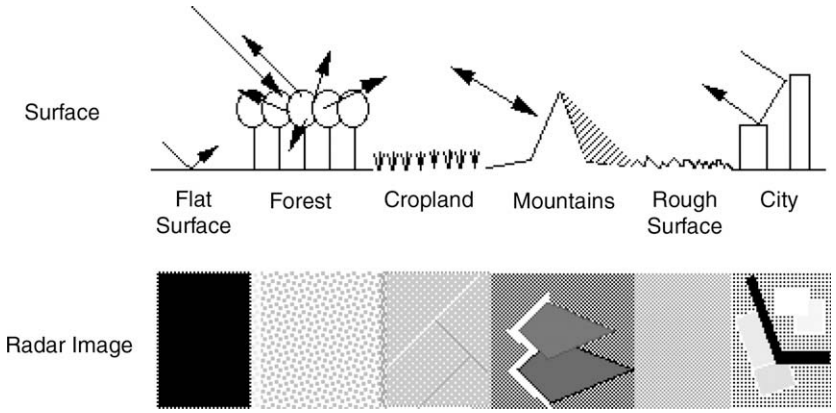

Fig. 2. Imaging of different types of surface with radar. (http://southport.jpl.nasa.gov/desc/imagingradarv3.html). Reproduced with permission.