Ancestral heritage saves tribes during 1 April 2007 Solomon Islands tsunami

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[1] The 1 April 2007 magnitude M_s 8.1 earthquake off the New Georgia Group in the Solomon Islands generated a tsunami that killed 52 with locally focused run-up heights of 12 m, local flow depths of 5 m as well as tectonic uplift up to 3.6 m and subsidence down to −1.5 m. A reconnaissance team deployed within one week investigated 65 coastal settlements on 13 remote Islands. The ancestral heritage "run to high ground after an earthquake" passed on to younger generations by survivors of smaller historic tsunamis triggered an immediate spontaneous self evacuation containing the death toll. **Citation:** Fritz, H. M., and N. Kalligeris (2008), Ancestral heritage saves tribes during 1 April 2007 Solomon Islands tsunami, *Geophys. Res. Lett.*, *35*, L01607, doi:10.1029/2007GL031654.

1. Introduction

[2] On April 1, 2007 at 20:39:56 UTC (local time: UTC+11), a magnitude M_s 8.1 earthquake occurred 50 km off the New Georgia Islands in the Solomon Sea generating a locally focused tsunami striking more than 300 coastal communities in the Solomon Islands. This South Pacific archipelago's worst disaster since WWII resulted in 52 confirmed death and 36'000 directly affected - roughly half of these numbers are children. A Gizo hospital visit on 11 April revealed surprising tsunami injuries such as burns from boiling water besides typical cuts and fractures, as well as collateral diseases such as cholera and the highest rate of cerebral Malaria. The burns were solely due to the early morning strike with residents boiling water in the kitchen and neither by "boiling water from the sea" nor frictional burns from being dragged over long distances by the 1998 Papua New Guinea tsunami as inferred by *Synolakis et al.* [2002]. The ground shaking pinned people to the ground and palm trees bounced back and forth with leafs touching the ground. The ancestral heritage "run to high ground after an earthquake" passed on to younger generations by survivors of smaller historic tsunamis triggered an immediate spontaneous self evacuation. Elder eyewitness reports on western and northern Ranongga Island indicate a previous smaller tsunami immediately after strong ground shaking, which the authors attributed to the M_s 7.25 earthquake on 17 August 1959 at 21:04:44 UTC and subsequent smaller tsunami [*Grover*, 1965; *Everingham*, 1977]. This 1959 event was located at 7.79°S and 156.32°E (E. A. Okal, personal communication, 2007). The 1959 and 2007 tsunami source earthquakes are only separated by 20 km. An elder of Rendova Harbor was studying on Guadalcanal in 1952 and reported in full detail witnessing a smaller tsunami in Honiara. The 1952 event observed on Guadalcanal may be associated with the 4 November 1952 Kamchatka M_s 8.2 earthquake based on the afternoon witness and expected arrival time [*Grover*, 1958; *Everingham*, 1977]. Other eyewitness accounts recorded on Rendova and New Georgia Islands may be attributed to the Kavachi volcano, 9.02°S and 157.95°E, submarine eruptions in late 1950 [*Johnson and Tuni*, 1987] or late 1951 [*Grover*, 1955]. The ancestral knowledge induced self evacuation dramatically reduced the death toll in the small evacuation window of a few minutes between the end of the ground shaking and the onslaught of the tsunami. This is further emphasized by the mismatch between the limited death toll and the massive impact resulting in more than 6000 damaged or destroyed houses including 200 schools as well as the two provincial hospitals in Gizo and Sasamunga. The survivors remained traumatized by the tsunami, afraid of the sea and living in evacuation camps on the hills. The area's history of earthquake doublets studied by *Lay and Kanamori* [1980] further feeds rumors about a second earthquake, which to date has not occurred. These psychological scars are particularly dramatic given the numerous small islands with motor canoes as the main means of transport and fishing as the primary livelihood. Few years after the Sumatra 2004 event, even in areas with low or no death toll, residents remain traumatized as observed most recently in the 2006 Javan earthquake and tsunami [*Fritz et al.*, 2007].

2. Post-Tsunami Reconnaissance

[3] A fully self sufficient International Tsunami Survey Team was dispatched within a week of the event. Difficult logistics between the various islands were incurred: 1200 km by small outboard engine boat, 100 landings in the surf, 1000 km by propeller airplanes and 200 km by US-Navy Seahawk helicopter. The 10–24 April 2007 reconnaissance covered more than 65 villages on 13 Islands: Choiseul, Vella Lavella, Ranongga, Simbo, Ghizo, Nusatupe, Kasolo (Kennedy Island), Kolombangara, Vonavona, Lola, New Georgia, Rendova and Guadalcanal. The team measured local tsunami heights, maximum runup, inundation distances, recorded structural damage and interviewed eyewitnesses per established methods [*Synolakis and Okal*, 2005]. Eyewitnesses described between one and four main waves with an initial recession, which could correspond to a leading depression N-wave [*Tadepalli and Synolakis*,

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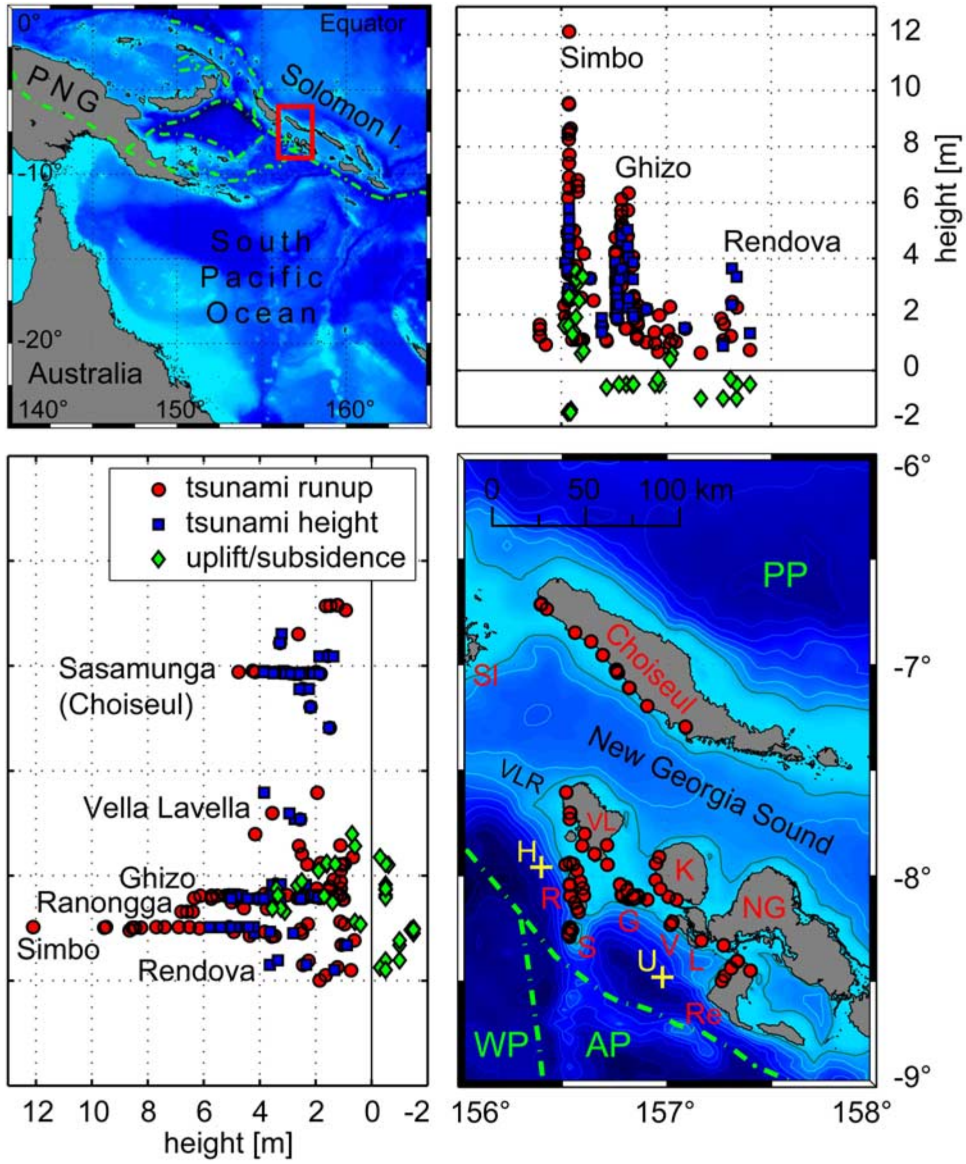

Figure 1. Measured tsunami runup (red), tsunami heights (blue) and land level changes (green) along the Choiseul and Western Provinces of the Solomon Islands. Solomon Sea bathymetry with fault lines [*Bird*, 2003], tectonic plates (PP: Pacific Plate, AP: Australian Plate, WP: Woodlark Plate), earthquake epicenter estimates (U: USGS, http://earthquake.usgs.gov/eqcenter/eqinthenews/2007/us2007aqbk/; H: Harvard solution, http://neic.usgs.gov/neis/eq_depot/2007/eq_070401_aqbk/neic_aqbk_hrv.html), islands (NG: New Georgia, Re: Rendova, L: Lola, V: Vonavona, K: Kolombangara, G: Ghizo, VL: Vella Lavella, R: Ranongga, S: Simbo, Sl: Shortlands), VLR: Vella Lavella submarine ridge.

1994]. The tsunami struck the New Georgia Group within minutes of the earthquake and Choiseul Island's south coast within less than 30 min. The team measured 175 tsunami and runup heights together with 37 recorded island level changes due to tectonic uplift and subsidence. The measurements shown in Data Set S1 were adjusted for astronomic tide levels at tsunami arrival based on tide predictions for Rendova Harbor, Gizo, Sasamunga and Taro at Choiseul Bay.[1] The tsunami height and run-up distributions show pronounced peaks increasing from east to west and similarly from north to south (Figure 1). The maximum tsunami runup of 12 m and local flow depth of 5 m were observed along the northwest tip of Simbo Island, where the village of Tapurai was completely washed away (Figures 2 and 3a). The bulk of the 234 inhabitants managed to escape to the hills and only 7 perished - a kill ratio of less than 3%. A similarly low fatality ratio was observed during the 26 November 1999 Vanuatu tsunami [*Caminade et al.*, 2000]. A sad example of a village, where no self evacuation was triggered by a strongly felt earthquake, was observed by the authors during the 15. August 2007 tsunami survey in central Peru. Lagunilla is located 60 km south of the 15. August 2007 M_s 8.0 earthquake epicenter. At Lagunilla 43% of the inhabitants were killed by the tsunami while none was killed directly by the earthquake. The tsunami

[1]Auxiliary materials are available at ftp://ftp.agu.org/apend/gl/2007gl031654.

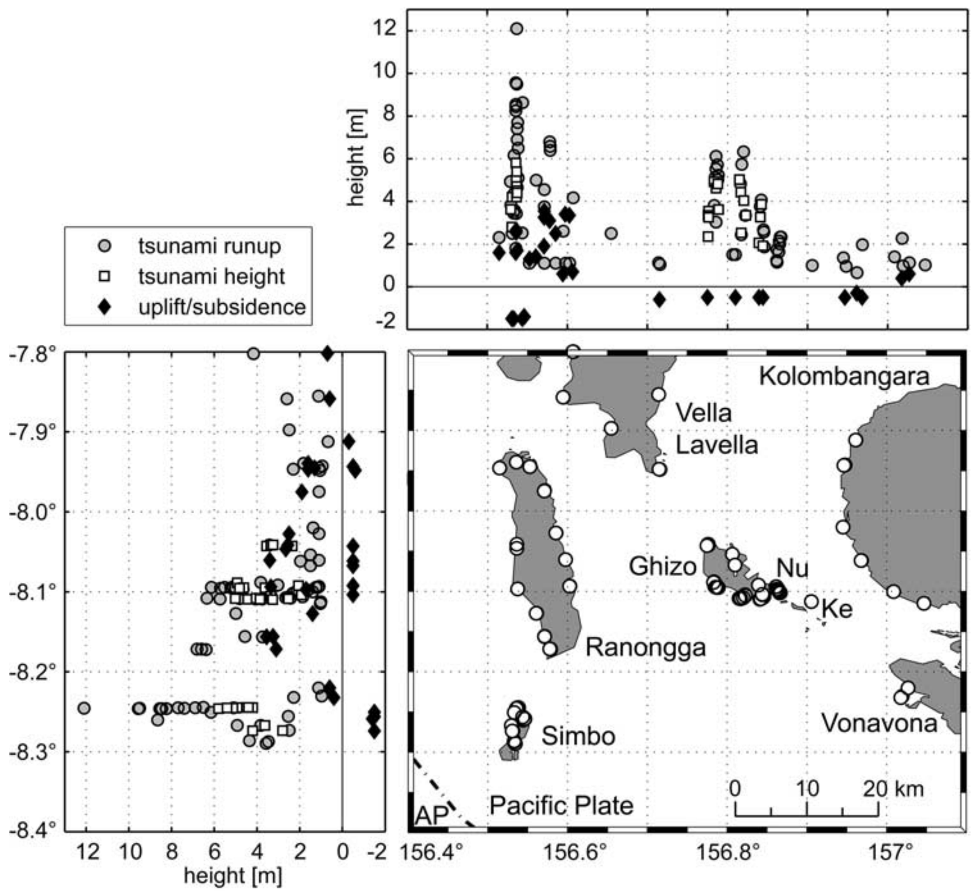

Figure 2. Survey detail of the hard hit Ghizo and surrounding islands with measured tsunami runup, tsunami heights and land level changes. Tectonic fault lines [*Bird*, 2003], AP: Australian Plate, Ke: Kasolo Island (also J.F. Kennedy), Nu: Nusatupe Island (Gizo Airport).

runup at Lagunilla did not exceed 6 m compared to the 12 m at Tapurai. In addition, the distance to safe ground was shorter and the available evacuation time span between the earthquake and tsunami longer at Lagunilla compared to Tapurai. Similar runup heights and flow depths during the 2004 Indian Ocean tsunami resulted in much higher death tolls in Sri Lanka [*Liu et al.*, 2005]. Both Simbo and Ranonnga Islanders reported the wave attacking from both the east and west of the 8 km gap between the islands and amplifying the local tsunami impact. The tsunami propagating along the hard hit west side of Ranongga impacted the northwest tip of Vella Lavella and likely refracted by the Vella Lavella submarine ridge to focus its energy into Sasamunga on Choiseul Island. Inundation distances and damage more than 200 m inland were only recorded in Titiana on Ghizo Island (Figure 3b) and Sasamunga on Choiseul Island (Figure 3c). Similar flow depths and runup heights in Pangandaran during the 2006 Java tsunami resulted in significantly larger inundation distances due to the mostly flatter coastal topography [*Fritz et al.*, 2007]. The tsunami energy leaking through the shallow straits separating the islands of the New Georgia group did not cause any significant damage along the New Georgia Sound. Rendova Harbor to the east represents an unfortunate example of a village perfectly protected from ordinary storm waves by reefs a few kilometers offshore but extremely vulnerable to tsunamis due to funneling effects [*Synolakis and Okal*, 2005]. Further damage due to order 2 m tsunami runup was reported by aid workers 200 km northwest of the epicenter on the Shortland and Mono Islands as well as 450 km west-southwest on the Woodlark Islands (Papua New Guinea).

3. Observed Land Level Changes

[4] This Solomon Island earthquake represents a unique opportunity to characterize the tsunamigenic seafloor displacements as numerous islands were within proximity on both sides of the rupture. Uplift was measured on uplifted corals based on high tide water lines, while subsidence was determined based on boat docks, disappeared navigation obstacles and engulfed trees. The southern part of Ranongga Island was uplifted by up to 3.6 m decreasing towards the north with only 1.5 m uplift (Figure 3d). Less than 1 m uplift was determined on the northwest tip of Vella Lavella and Vonavona Islands. The islands were uplifted during the earthquake prior to tsunami arrival significantly reducing the tsunami impact. In the course of a few minutes, Ranongga Island acquired significant new land, mostly uplifted corals. Similarly during the 26 December 2004 earthquake, that generated the massive Indian Ocean tsunami, Pulau Salaut north of Simeulue Island (Indonesia) was uplifted by up to 2.4 m [*Jaffe et al.*, 2006]. Subsidence of up

Figure 3. (a) Total destruction of Tapurai (N Simbo Island) with maximum tsunami runup of 12 m; (b) tsunami scour induced building collapse in Titiana (S Ghizo Island); (c) giant tree uprooted due to massive erosion in Sasamunga (Choiseul Island); (d) corals uplifted by more than 3 m in Lale (SW Ranongga Island) complicating boat navigation and aid deliveries; (e) land loss due to subsidence in Gizo fishing village (NE Ghizo Island) as seen from a reconnaissance and aid flight (US Navy Seahawk); (f) almost continues Coastal Landslides (scars typically 150 m above sea level) along a 10 km stretch on northwestern Ranongga Island.

to 1.5 m along the north end of Simbo Island suggests the location of the fault line between Simbo and Ranongga rather than south of Simbo [*Bird*, 2003]. Subsidence of 1 m or less was determined on southeast Vella Lavella, Kolombangara, Lola, New Georgia, Rendova and Ghizo Islands (Figure 3e). Subsidence increased the vulnerability of coastal settlements requiring reconstruction further inland on higher ground. Similarly coastal landslides along a 10 km stretch on northwestern Ranongga require resettlements of some villages (Figure 3f). Unfortunately two fatalities at Mondo on western Ranongga were reported surviving the earthquake and escaping the tsunami by running to high ground only to be killed by a coastal landslide. Community-based education and awareness programs are particularly essential to help save lives in locales at risk from near-source tsunamis [*Sieh*, 2006; *Synolakis and Bernard*, 2006].

4. Conclusions

[5] The rapid deployment of the survey team to the Solomon Islands after the 1 April 2007 event led to the recovery of important data on the characteristics of tsunami impact in the near field. The measured land level changes due to tectonic uplift and subsidence characterize the tsunami source and indicate the plate boundary locations. Beaches protected from storm waves by reefs a few kilo-

meters offshore are vulnerable to tsunamis. This tsunami was difficult to escape as the tsunami struck within minutes of the massive ground shaking. The spontaneous self-evacuation triggered by the ancestral tsunami heritage contained the fatalities and illustrates the importance of community-based education and awareness programs.

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