Coastal land change due to tectonic processes and implications for relative sea-level rise in the Samoan Islands

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Abstract

Of the major coastal land change mechanisms responsible for relative sea-level change, tectonic subsidence is generally quoted as ranging from $< \text{mm/yr}$ to 1 cm/yr. However, we documented coseismic and ongoing post-earthquake surface displacements from continuous GPS and tide gauge/altimetry data that indicated rapid subsidence on two of the major Samoan Islands of 12 - 20 cm during and following the 8.1 2009 Tonga-Samoa earthquake. Earlier results and our modeling of GRACE-derived gravimetric data provided a preliminary forecast of future relative sea-level rise through rapid land subsidence [Han et al., 2019].

Of course these numerical forecasts of time-dependent deformation are only as good as our input observations and our assumed rheological models. As part of our current NASA Earth Surface and Interior study, we are obtaining a wider range of data to constrain and test alternate models of ongoing postseismic deformation across American Samoa and Upolu, Samoa: (1) times series of altimetry plus tide gauge data processed to complement the cGPS data available to provide high-temporal resolution, point measurements of uplift/subsidence, (2) InSAR derived observations of surface deformation across the highly vegetated Samoan Islands, (3) evaluating and using NASA satellite lidar data (ICESat-I & ICESat-II, GEDI) for fusion with multi-source topographic data sets and for estimating topographic change on the decadal time scale. We are evaluating and using these new observations to better understand and separate out local, island-wide, and multi-island subsidence patterns and to evaluate the high impact of rising sea-level in a tectonically active region.
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22 Feb. 2019, Upolu Island, Samoa: Flooding
How much is the sea-level rising versus the land subsiding?

Land Motion at Tide Gauge Site

GPS
Tide Gauge
Pago Pago
ASPA
Tutuila Island (American Samoa)

401 Apia-B -13.8°-171.8°

56 PAGO -14.3°-170.7°

Sea Level (cm)

RED = tide gauge; BLUE = altimetry

Diff (cm)

~12 cm

~18 m

R. Ray, 2021
Constraining the **temporal** and **spatial** variability of land motion component of RSL

Continuous GPS

Reference Surface (DEM)

Laser Altimetry

Sentinel-1 and PALSAR-2

Interferometric SAR (InSAR)
Accounting for land motion has practical consequences:

Observed high water levels at Pago Pago harbor relative to mean sea level (1983-2001).

Questions?

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Minor flooding level surpassed

Observed high water levels at Pago Pago harbor relative to mean sea level (1983-2001).

Sea Engineering, Inc.; FHWA, US ACE

Highway shore protection, Tutuilla, AS