Deterministic Seismic Hazard Calculations for American Samoa and SW Pacific

Stephen Harmsen, March 12, 2012

The initial part of the deterministic hazard was computed by finding the median ground motion at each location (X,Y) from each contributing source zone in the model. The median is a geometric mean of medians in the case of shallow crustal events; in all other cases the median is that of the Zhao GMPE, which was used exclusively for deep intraplate and subduction source hazard calculations. For those sources, we also considered modified Zhao medians in the probabilistic hazard, but those modified medians were not used in the deterministic hazard. Table 1 shows the 11 source zones, the deterministic magnitude **M**, and the type of median associated with each of them. The maximum of the 11 medians [or however many contribute at (X,Y)] is computed and is the quantity that is multiplied by 1.8 (an approximation to one logarithmic standard deviation) to yield the deterministic ground motion.

Table 1. Source zones in the American Samoa hazard study.

Zone Name	**M**	Zone Number	Type of Median
Null		0	None; no source
Tonga-Kermadec Shallow	7.0	1	Geometric Mean of 4 GMPEs [1]
New Hebrides Subduction Shallow	7.0	2	Geometric Mean of 4 GMPEs
New Hebrides Megathrust	9	3	Zhao *et al*. (2006) subduction
Deep Seismicity 200-300 km	8.2	4	Zhao *et al*. (2006) Intraplate
New Hebrides Outer Rise	8.2	5	Geometric Mean of 4 GMPEs
Tonga-Kermadec Outer Rise	8.2	6	Geometric Mean of 4 GMPEs
General shallow seismicity	8.0	7	Geometric Mean of 4 GMPEs
Deep Seismicity 100-200 km	8.2	8	Zhao *et al*. (2006) Intraplate
Deep Seismicity 50-100 km	8.2	9	Zhao *et al*. (2006) Intraplate
Fiji Platform Shallow Seismicity	8	10	Geometric Mean of 4 GMPEs
Tonga-Kermadec Megathrust	9	11	Zhao *et al*. (2006) subduction

1 The weights that we applied are 0.5 to Zhao crustal, and 0.1667 to each of BA-NGA, CB-NGA, and CY-NGA.

The null entry is included because a few locations in the broad study area, far from islands of interest, had no deterministic contributions from any of the considered sources. For null locations, a floor deterministic value is assigned. The 11 zones above are spatially overlapping regions. Spatial overlap can exist because of spatial smoothing of historical seismic activity and because activity associated with different depth ranges can contribute, even in the absence of smoothing outside specific regions. In this study we allowed spatial smoothing of activity to lap outside the polygon that defines a given region, such as the Tonga-Kermadec subduction zone.

The computation of deterministic hazard in this study presented a challenge because none of the sources, except for the megathrust source, have a known fault trace associated with them. Instead, all of these are areal or background sources. In prior modeling, we only computed deterministic hazard (DH) relative to known (or presumed known) faults. Here, we compute DH based on distance from non-zero agrid (activity rate grid) cells. Thus, even though the rate of M8.2 outer-rise events (Zones 4 and 5 in table 1 above) at a given cell may be quite negligible by most standards, any positive value is enough to trigger a deterministic hazard calculation for sites in the neighborhood of this source cell. We view this approach as analogous to the deterministic hazard computed for known faults in prior work. In those studies, such as (ref tbd), no matter how low an activity rate is for a fault, the median motion from a characteristic-magnitude source on that fault was computed. However similar the approaches are, we should also note that the lowest activity rate for characteristic events on known faults may be several orders of magnitude greater than the rate of the maximum-magnitude areal source at a specific location (X,Y).

Results

Figures 1 and 2 below show the deterministic PGA and source-type index (with values between 0 and 11) associated with that deterministic PGA, respectively, for the majority of the study area considered in this report.

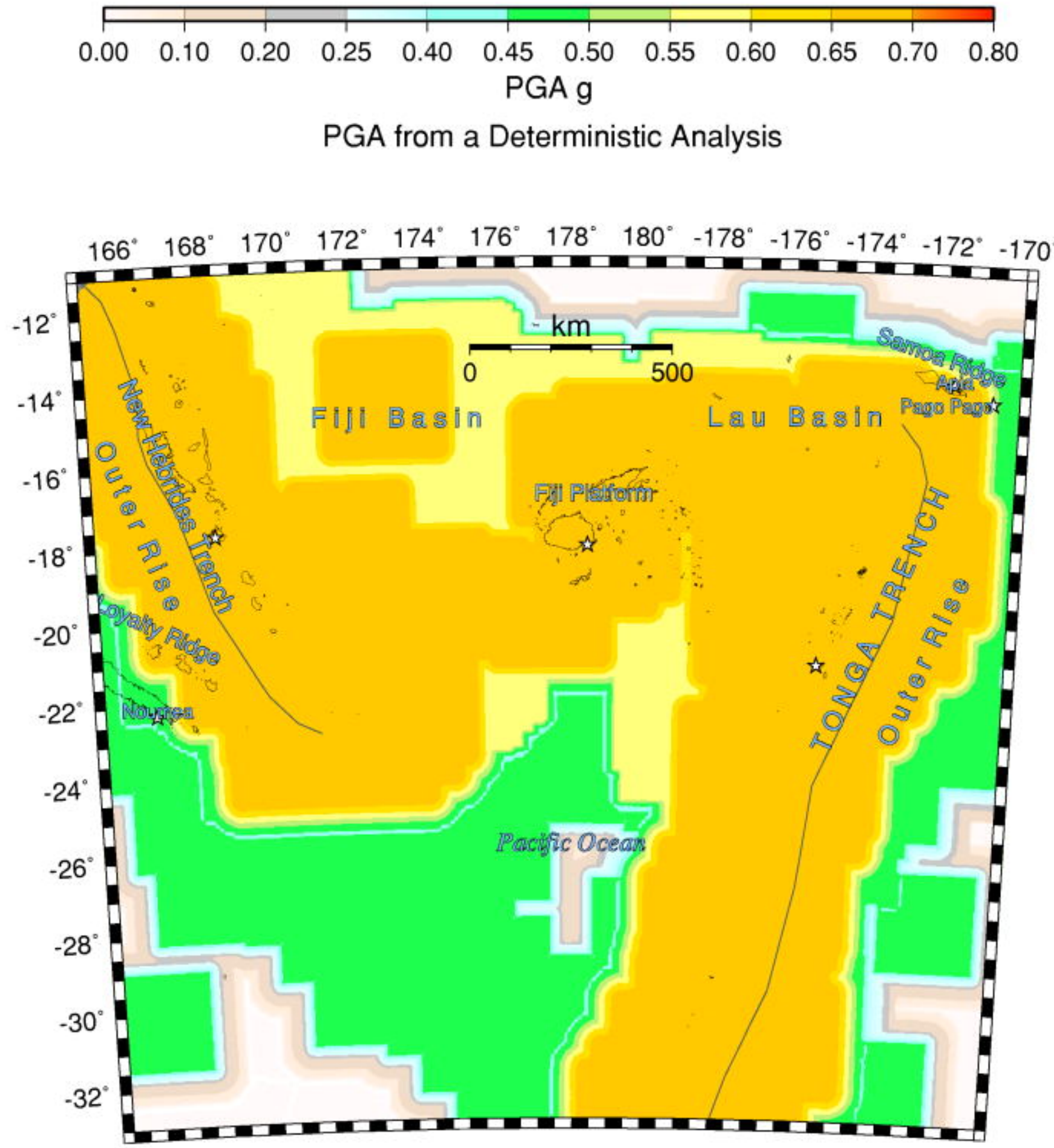

Figure 1. PGA (before multiplying by 1.8) from the Samoa study. Units are gravity or *g*.

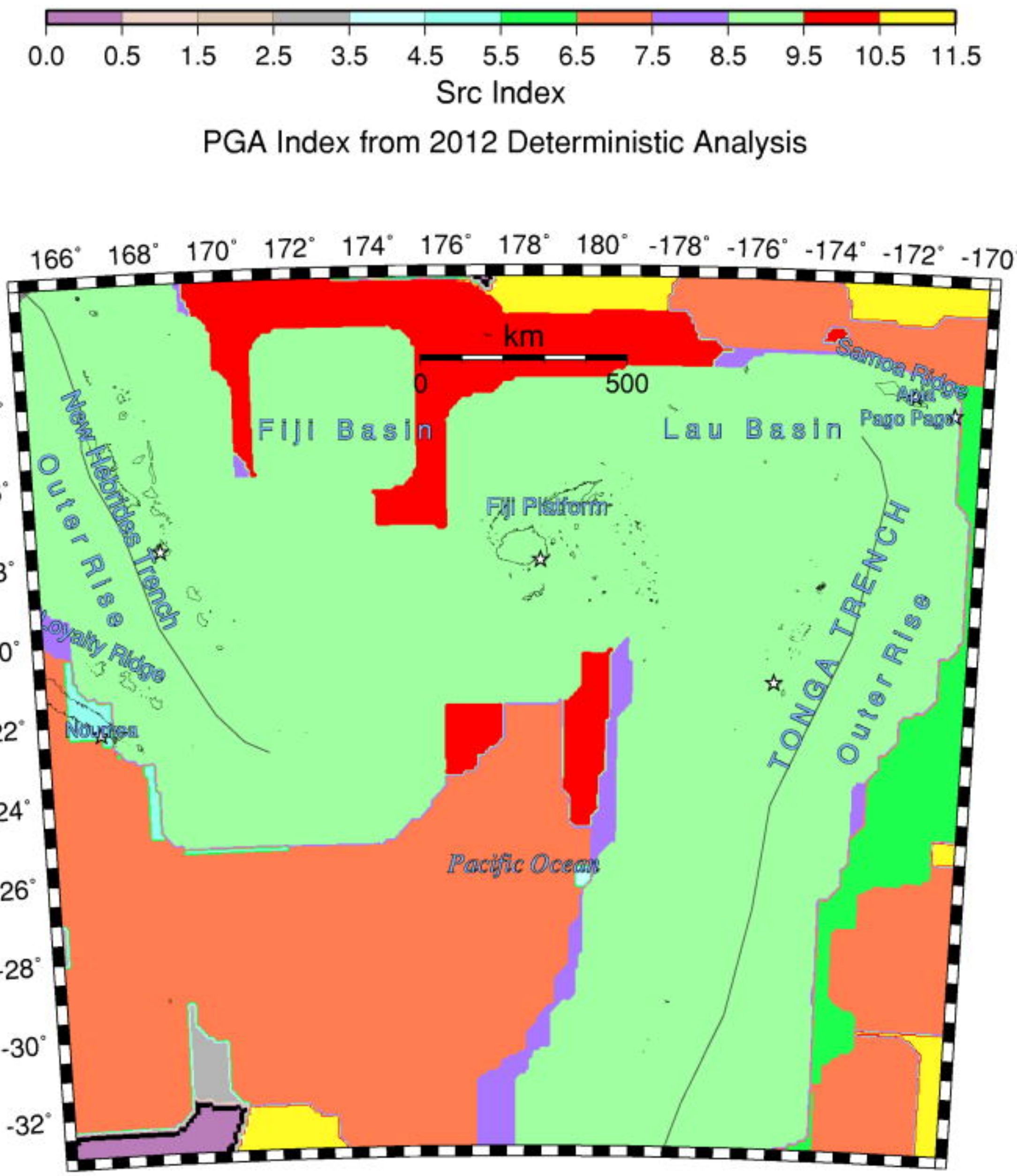

Figure 2. PGA source index (see table 1 above for source types). A few small regions, such as the southwest corner of this map, indicate 0 or no deterministic source associate with this location.

Figures 3 and 4 below show the deterministic spectral acceleration (SA) at 1-s period, and source-type index (with values between 0 and 11) associated with that deterministic SA, respectively, for the majority of the study area considered in this report.

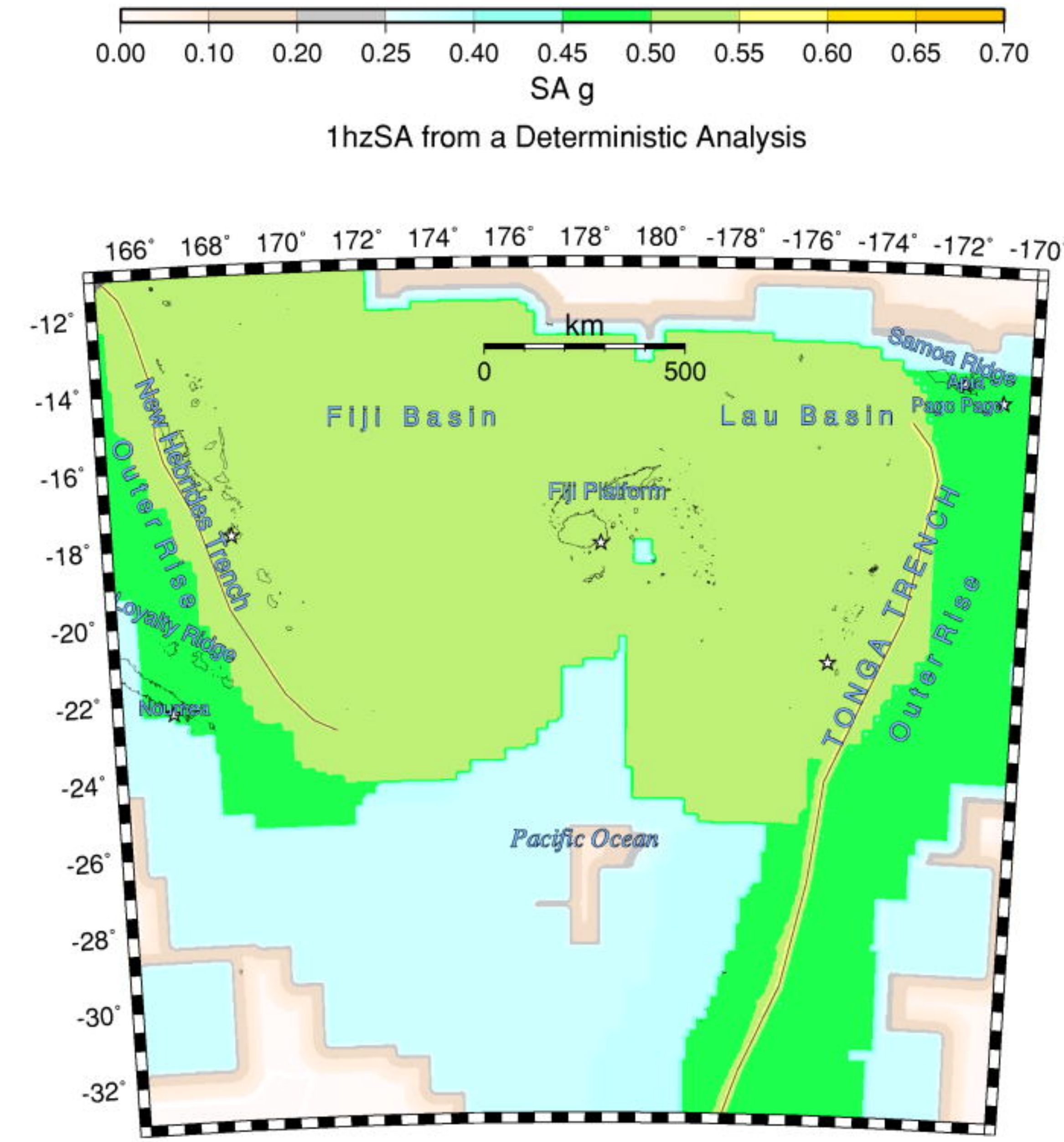

Figure 3. Deterministic median for the 1-hz (1-s) spectral acceleration.

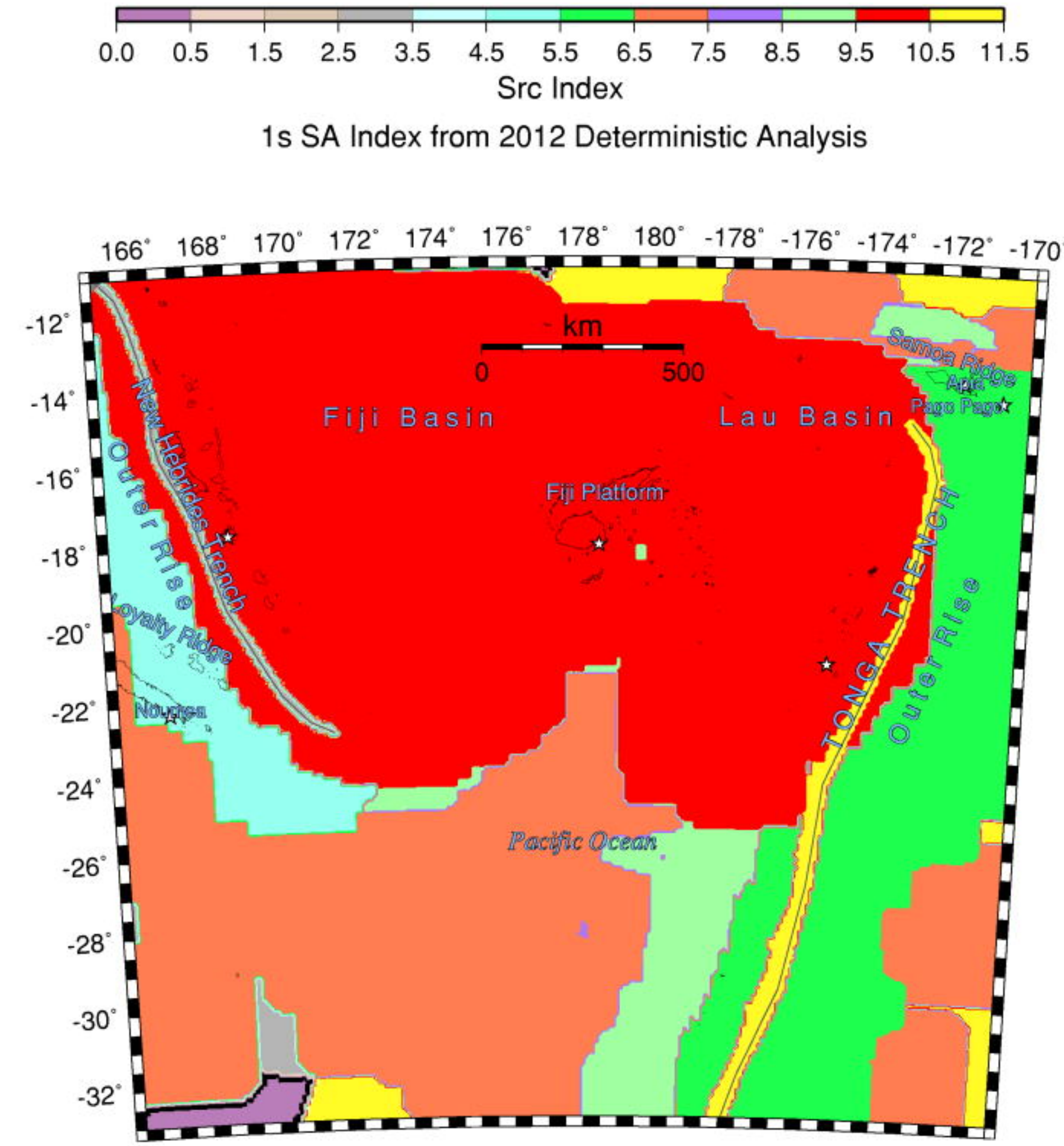

Figure 4. Source index for deterministic 1-Hz spectral acceleration.

Figures 5 and 6 below show the deterministic spectral acceleration (SA) at 0.2-s period, and source-type index (with values between 0 and 11) associated with that deterministic SA, respectively, for the majority of the study area considered in this report.

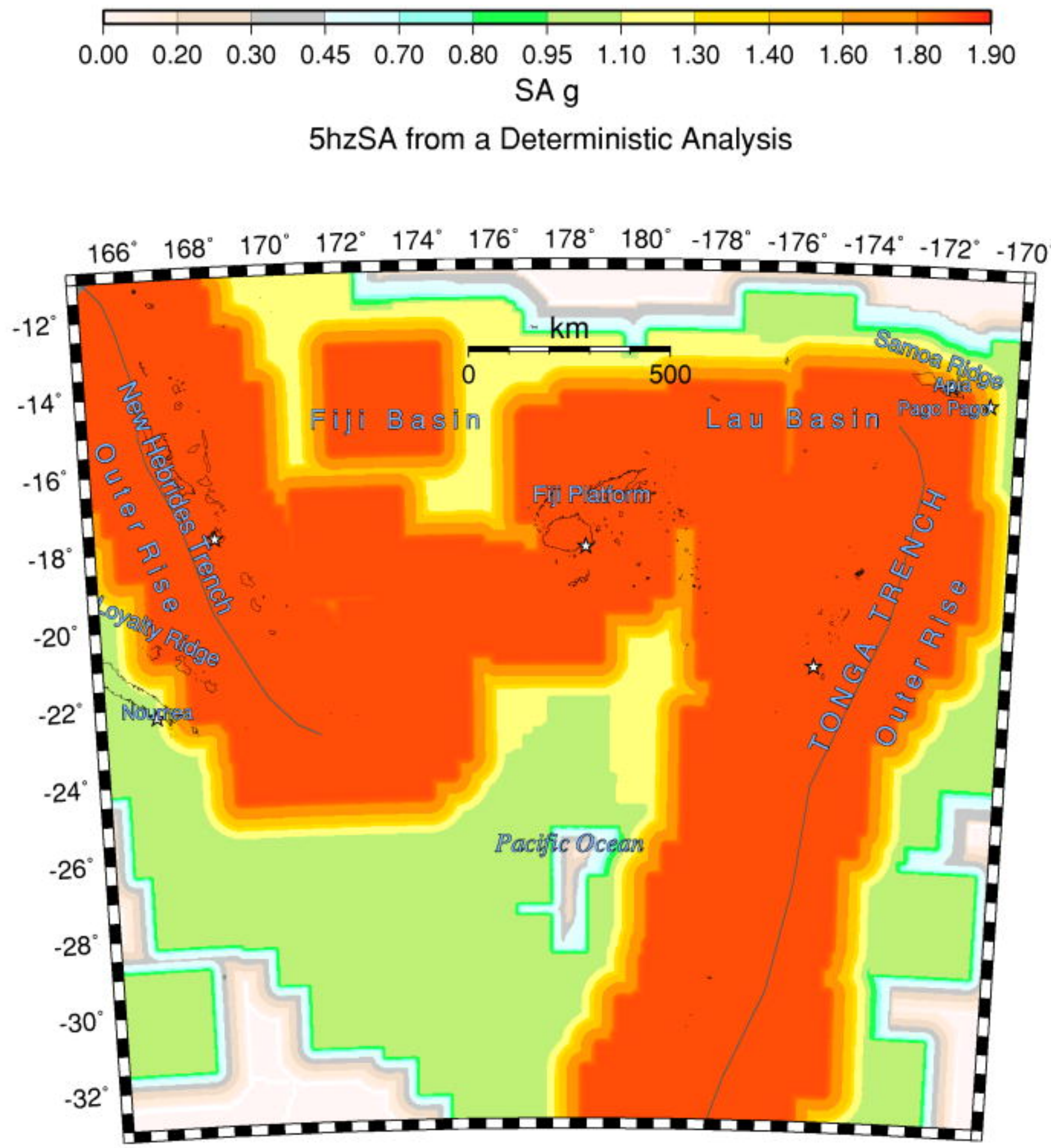

Figure 5. 5-Hz (0.2-s period) spectral acceleration (SA) from a deterministic analysis. Units *g* or gravity.

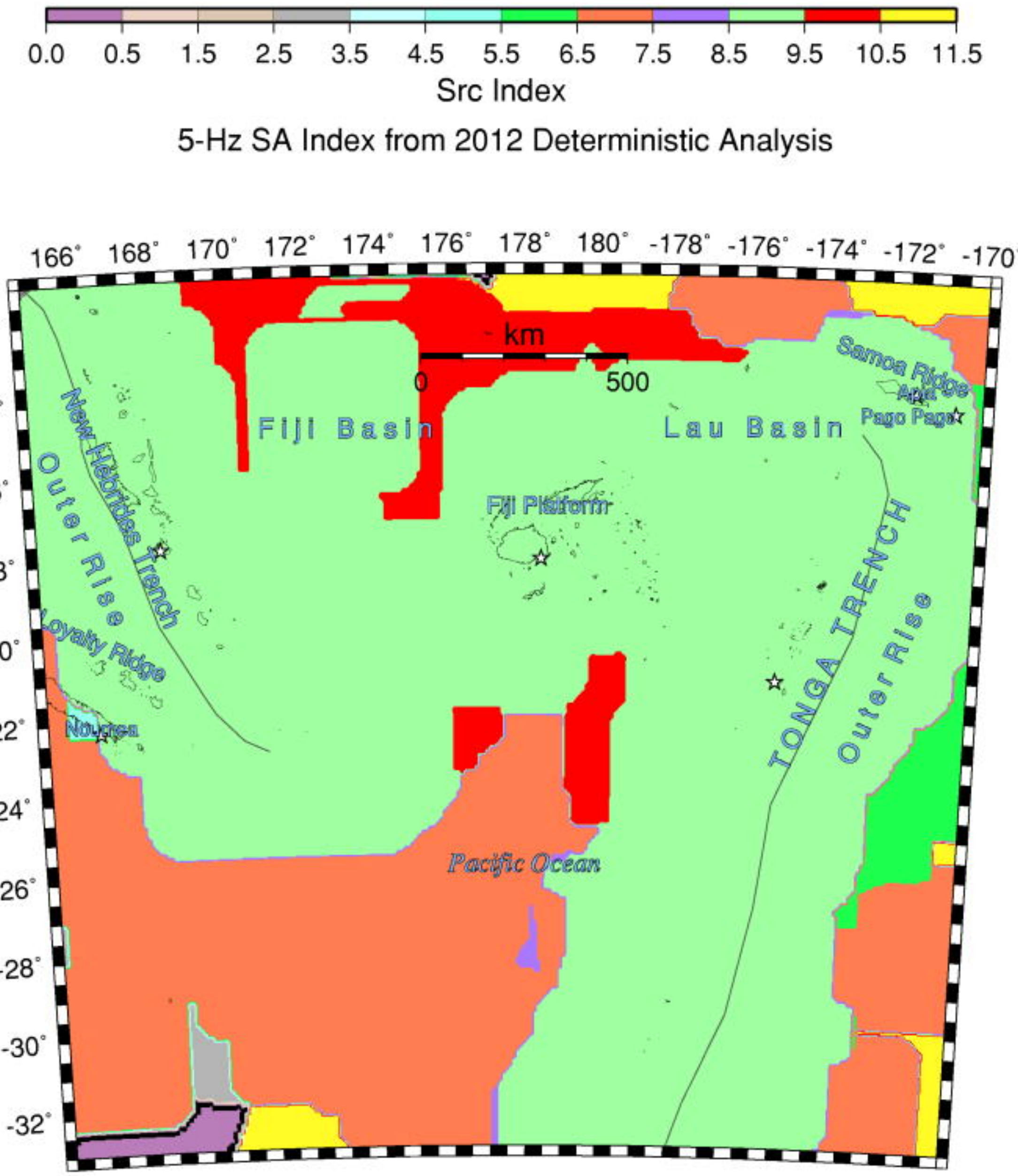

Figure 6. Index map for 5-hz SA deterministic hazard sources.

Discussion

The index maps (figs. 2,4, and 6 above) are distinctly different. The 1-s index map (fig. 4) indicates that the megathrust source (types 3 and 11) tends to dominate only at sites directly over the top of the subducting slab. For short spectral periods and PGA, this source does not dominate even there. Instead, the Fiji source tends to dominate intermediate-period hazard over large regions (bright red color in fig. 4). For PGA and 5-hz SA, however, the 50-to-100 km deep background source tends to dominate over broad regions (light green color in figs. 2 and 6). At Pago Pago, American Samoa, the 50-to-100 km deep hazard dominates short periods, but the outer rise M8.2 source dominates the intermediate periods (around 1 s). Neither deep seismicity nor outer rise activity are known to occur at Pago Pago, but hazard from these sources is picked up there due to spatial smoothing of the agrid and other factors.