Using Satellite Gravity to Map and Model Forearc Basins and Thickness of Trench Sediment Worldwide: Lessons from Central America

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There is growing evidence that historic great earthquakes (M >8) favor segments of subduction zones that exhibit key geologic factors, including the presence of trench-slope forearc basins (Wells et al., 2003; Song and Simons, 2003), high sediment influx into the trench (e.g., Ruff, 1989), the presence of accretionary prisms (von Huene and Scholl, 1991), and the lithology of the upper plate. The level of knowledge of subduction zones world-wide is highly uneven, but free-air gravity anomalies observed at satellite altitudes (Smith and Sandwell, 1997) provide a consistent measure of several of these geologic factors. For example, Wells and others (2003) used satellite gravity to demonstrate that regions of greatest slip during past megathrust earthquakes around the circum-Pacific spatially correlate with forearc basins and their associated deep-sea terrace gravity low. The basins may evolve because interseismic subsidence does not fully recover after earthquakes, and the subsidence itself may be linked to basal erosion of the forearc by the subducting plate. By inference, these offshore, basin-centered gravity lows in the forearc should be predictors of the location of large moment release in future great earthquakes.

Additional studies using satellite gravity anomalies may lead to new avenues in understanding the geologic processes that accompany great megathrust earthquakes, but first we must confirm the ability of satellite gravity data to serve as a suitable proxy for high-quality marine gravity data. A new compilation of shipboard gravity data from west of Central America (Barckhausen et al., 1998; 2003) affords an excellent opportunity to make this determination. A statistical comparison of satellite and shipboard datasets offshore Nicaragua, Costa Rica, and Panama found average agreement to within 1 mGal and absolute agreement to within 5 mGal everywhere, except very near the coast where errors can be significantly larger. The Sandino forearc basin offshore Nicaragua, for example, is well imaged by satellite gravity anomalies. A preliminary model based strictly on satellite gravity anomalies indicates that the Sandino basin is 7 to 9 km deep, consistent with multichannel seismic-reflection studies (Ranero et al., 2000). Most important to future studies of megathrust earthquakes, our comparison shows that conclusions regarding forearc basins would be virtually the same whether drawn from satellite gravity or high-quality shipboard gravity.