Constrain the geometry and locking across the North/South American and Caribbean plate interface based on GPS data constrain the subduction interface to a 75 kilometer downdip extent, a 10° dip angle, and near the LA trench to Aves Island and compared to calculated displacements for 88 different subduction models. Finite Caribbean Euler pole was used to place our observations in a CAR-fixed frame. Surface displacements for each site were estimated for 2.7 years. CAR-fixed velocities are projected onto a 500 kilometer transect from the LA trench to Aves Island and compared to calculated displacements for 88 different subduction models. Finite dislocations within an elastic half-space with variable parameters such as angle of the subducting slab, the downdip extent of the locked zone, and percentage of plate interface locking were investigated. Other parameters, such as trench length and slip remained constant. Using a chi-squared, best-fit statistical criterion the GPS data constrain the subduction interface to a 75 kilometer downdip extent, a 10° dip angle, and near 50% locking. This implies that the subduction zone offshore Dominica is in an intermediate state, thus accumulating strain and causing small westward and upward displacement of the Lesser Antilles relative to the stable Caribbean interior.

Objective

Constrain the geometry and locking across the North/South American and Caribbean plate interface based on the surface deformation observed in Dominica, Guadeloupe, and Aves Islands.

Assess strain accumulation from the subduction zone and its effect on the central Lesser Antilles Arc.

Methods

Collect high-precision GPS data in Dominica using geodetic grade GPS receivers and antennas. Analysis scheme and methods are the same as reported in Janous & Mattioli, 2005.

- Astakh Z, 12, µ, and Tingley N-O. FT units
- Choice ring antenna (Trimble Zephyr antenna used for some sites in 2007)

Obtain site positions with latitudinal, longitudinal, and vertical ellipsoids in ITFR05 using GIPSY-OASISII software from JPL.

Calculate horizontal and vertical motion vectors using data from 2001-2007. Data prior to 2007 acquired by S. Davidson et al., 2004. Carr et al., 2006 and updated to ITFR05.

Calculate CAR-fixed movement vectors from by estimating linear velocity and subtracting predicted horizontal velocities based on rigid plate motion. See Figure 2 and 3.

- Revised Caribbean plate Euler pole is used. Data acquired from Faúria et al., 2007; Debeljs et al., 2000; DeMets et al., 2007, Weber et al., 2001.

Create fit finite dislocation models of strain accumulation for the elastic margins of the Caribbean plate to calculate predicted horizontal and vertical displacement using DEUS software (Larsen, 1992). See Figure 4. 0.2

- Simplified subduction zone geometry - straight 400 km along strike trench
- Employed because of poor spatial resolution of existing GPS vectors

- Variable parameters:
  - Angle of subducting slab varies as 10°, 15°, 20°, 30°, and 40°
  - Downdip extent of locking interface at 45 km, 60 km, 75 km, and 100 km
  - Percentage of plate interface locking varies between 25%-100% in 25% intervals.

- Compare observed data from Dominica, Guadeloupe and Aves Islands to modeled motion by projecting observed data onto a 500 km transect. Each kilometer along the transect has a predicted motion vector.

- Statistically constrain models based on goodness of fit with observed displacement. Best-fit model reports expected strain accumulation influencing deformation.

Results

- GPS data constrain the slab geometry to a 75 kilometer locked downdip extent at a 10° dip angle with 50% locking. See Figure 5. Both horizontal and vertical displacements are best correlated to this model. See Figure 6.
- According to the best-fit model, the expected effect of elastic strain from plate interface processes in the middle of Dominica is 0.9 ± 1.34 mm/yr to the West 0.3 ± 1.34 mm/yr to the South and 0.1 ± 1.34 mm/yr up.
- Resulting model is predominantly constrained from GPS sites on Guadeloupe and Aves Islands.
- Model suggests a small effect on Dominica from coupled plates.
- Observed motion from Dominica is dispersive.
- Statistical analysis shows that downdip extent may be closer to 55 km. See Figure 7. This is in agreement to average reduced χ², not individual χ².

Discussion

- Subduction geometry and strain accumulation findings are somewhat reasonable for the Lesser Antilles region.
- Modeled section of transect roughly agrees with hypocenter depth findings (Feuillet et al., 2002)
- The dislocation model in an elastic half-space for interseismic deformation normal to a subduction zone driven by Savage (1983) is appropriate.
- Based on our data mainly from Dominica, which is as center of the volcanic arc and therefore where we expect the maximum normal convergence between the Caribbean and North-South American plates, our modeled subduction zone predicts only a small amount of elastic strain accumulation on the islands.
- Residual motion can be attributed to shallow, regional processes.
- Dominica's location is also cause for its active volcanism.
- Regional tectonics.
- If residual motions are <2 mm/yr, they can be used to constrain the secular motion of the Caribbean plate.

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References