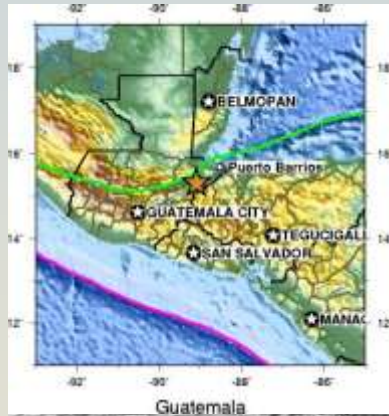


Tectonic framework and solid Earth hazards of the Caribbean region

Charles DeMets – Univ. of Wisconsin-Madison

COCONet meeting: San Juan, Puerto Rico - Feb. 2011

1976 Motagua EQ – 23,000 dead; 76,000 injured; 20% Guatemalans homeless



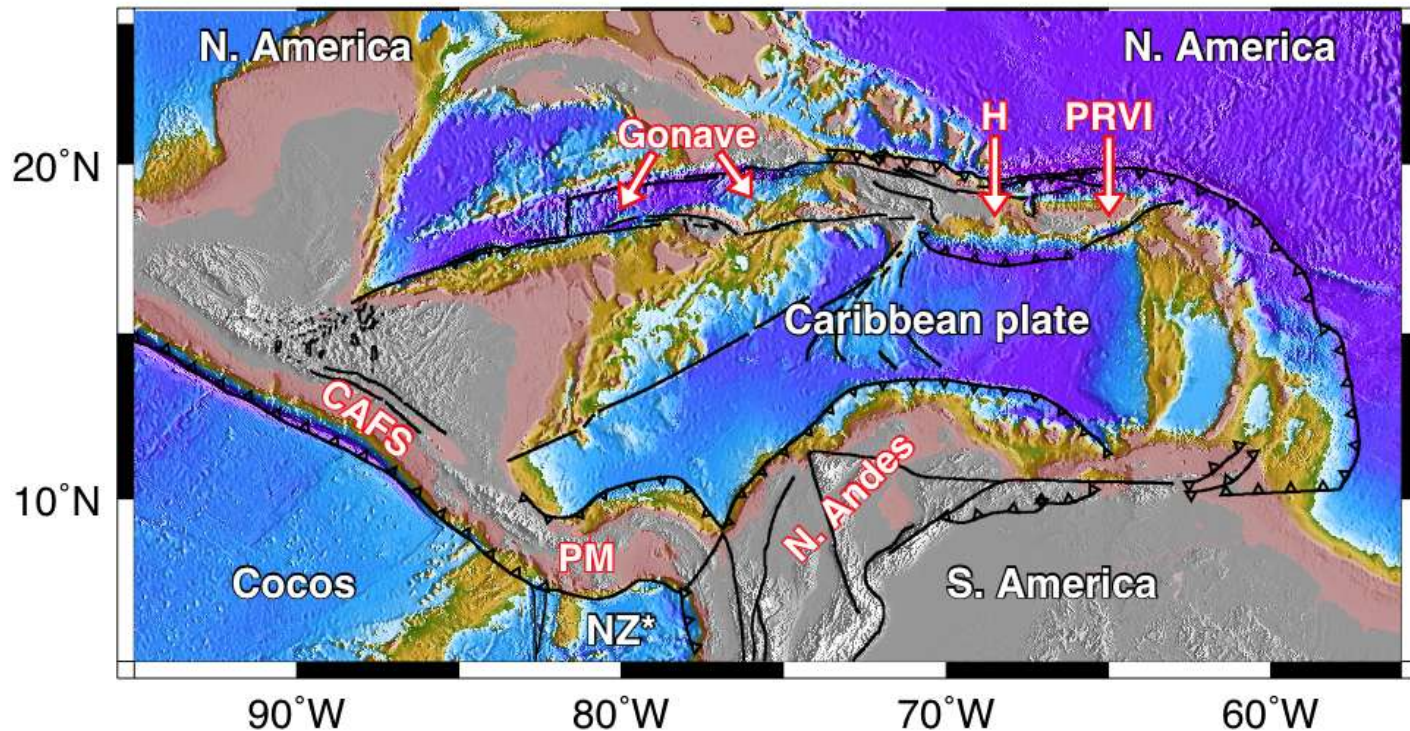
1997 Soufriere Hills eruption: capital abandoned; 2/3s of island inhabitants flee



2010 Haiti EQ: 200,000-300,000 dead, 1.5 million homeless



Caribbean plate bounded by five major plates and at least six microplates. Moves slowly eastward over mantle.



Microplate abbreviations:

CAFS – Central America forearc sliver

H – Hispaniola block

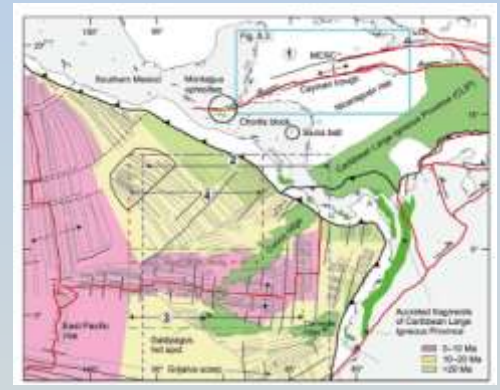
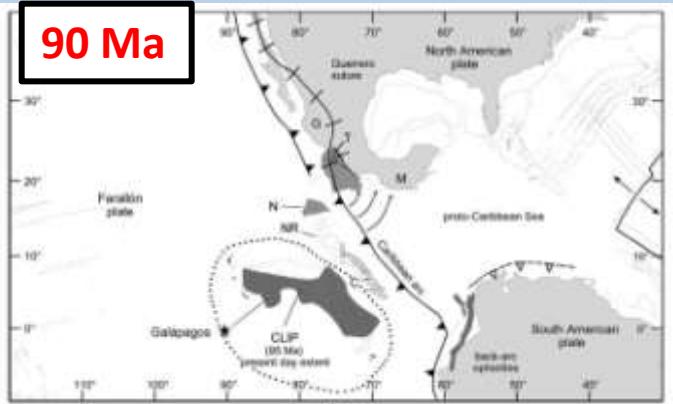
NZ* – detached from Nazca plate

PM – Panama block

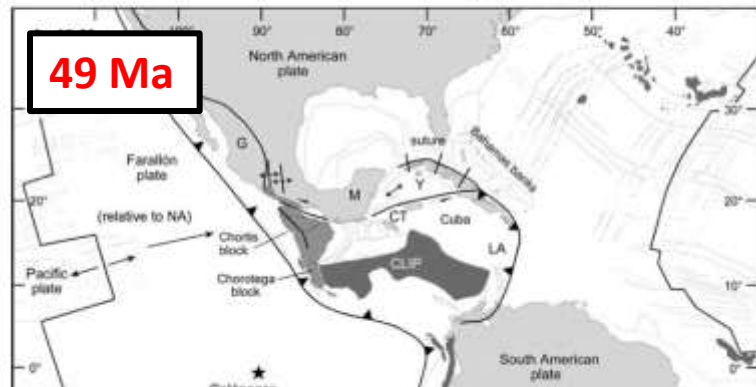
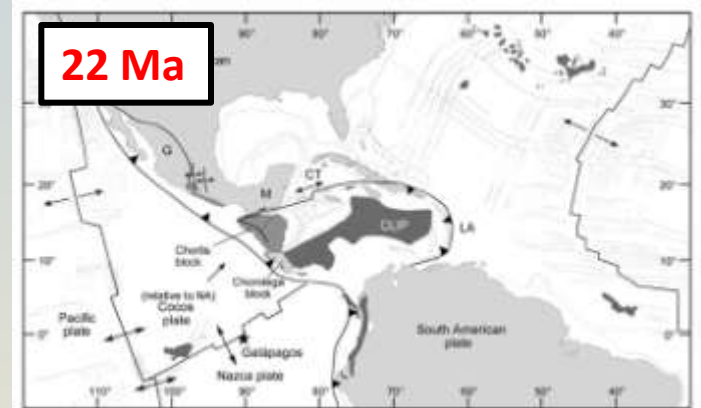
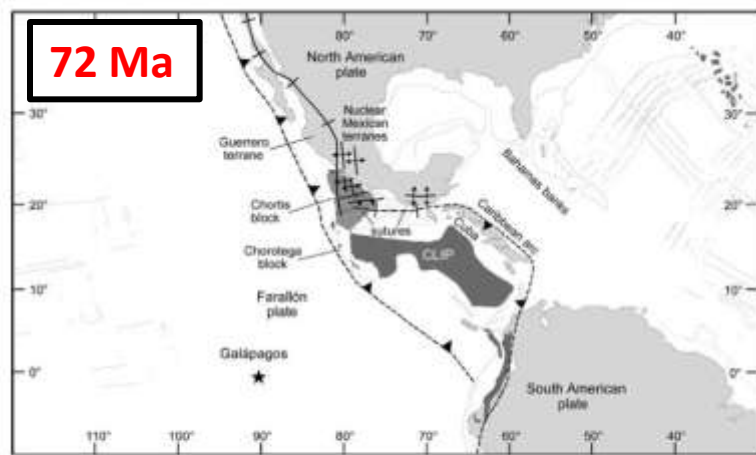
PRVI – Puerto Rico/Virgin Islands block

Tectonic history:

Much of CA interior occupied by Caribbean Large Igneous Province, a thick oceanic plateau/flood basalt. May define part of plate least likely to deform



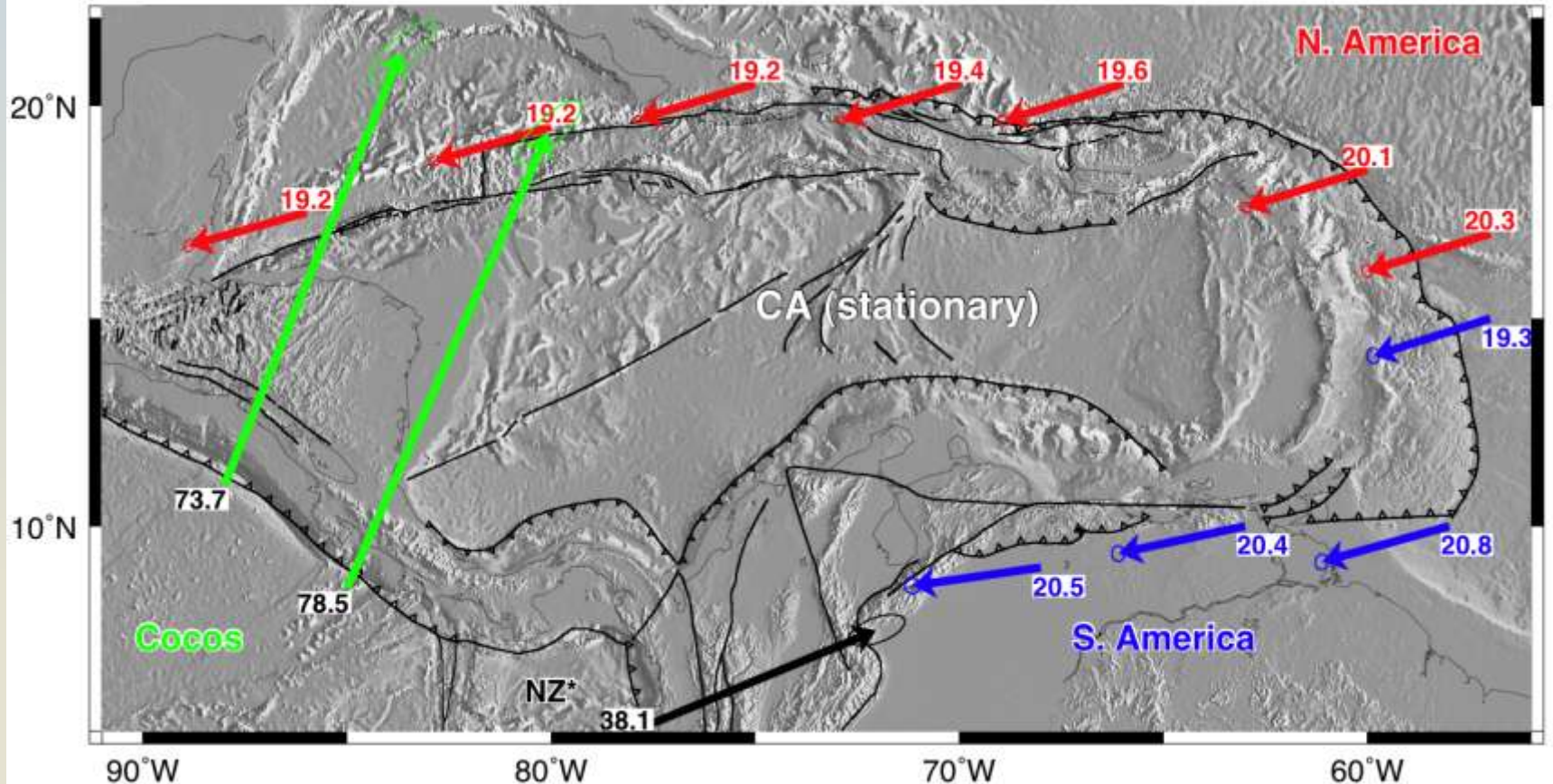
From Mann et al. (2007)



Present plate motions

from MORVEL global model – DeMets et al. (2010)

- 1) NA-SA convergence increases from only 1 mm/yr at east end of CA plate to 4-5 mm/yr near 75W
- 2) CA moves slowly (<10 mm/yr) to E or NE relative to mantle
- 3) Slivers at N and S edges of CA being “peeled” off interior via oblique convergence with NA and SA.



1963-2011 seismicity

- 1) Plate boundaries wide everywhere except strike-slip Swan Islands fault
- 2) Near absence of intraplate earthquakes with one exception (see blue rectangle)
- 3) GPS in plate interior suggests 2 mm/yr or less for intraplate deformation (DeMets et al. 2007)

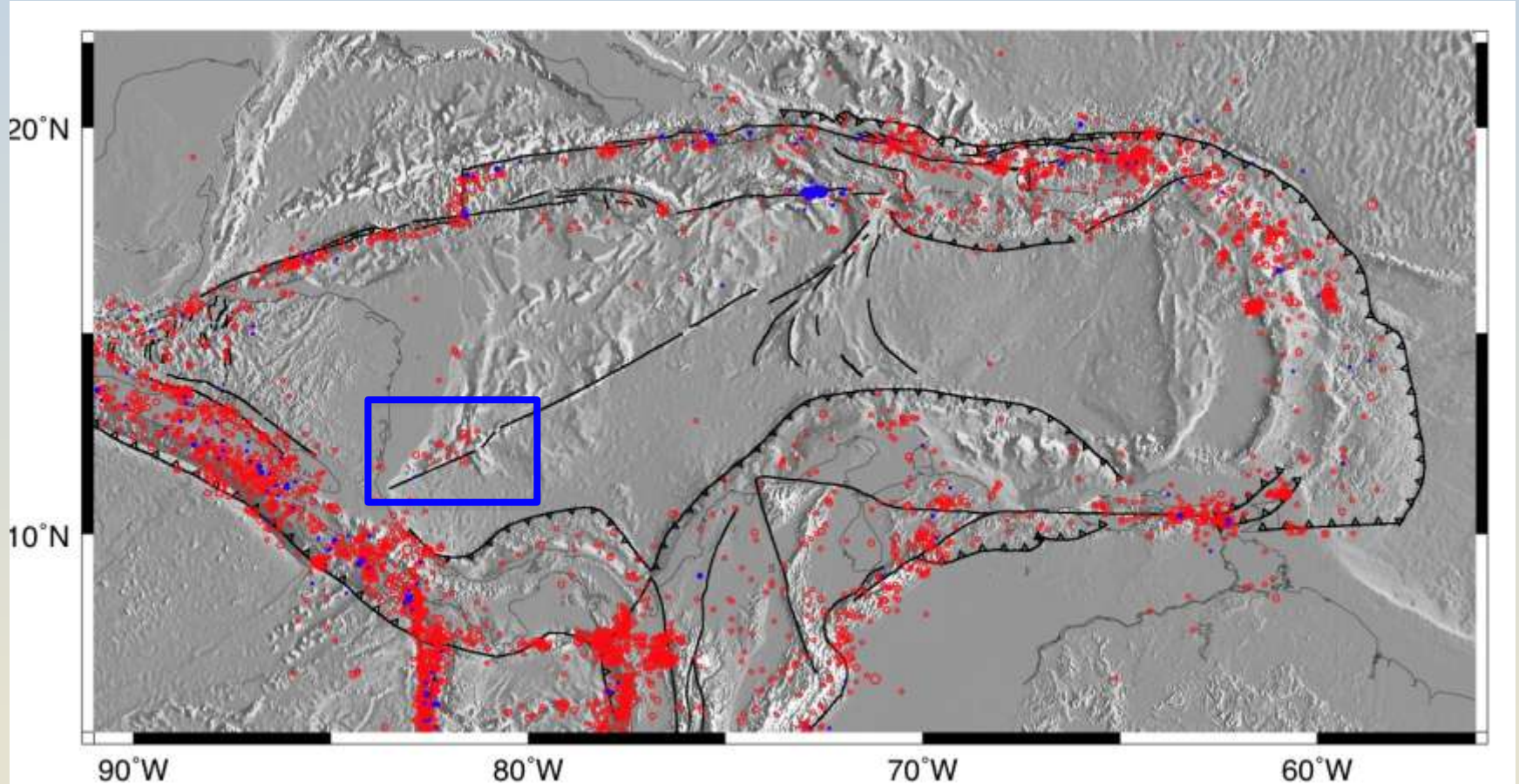
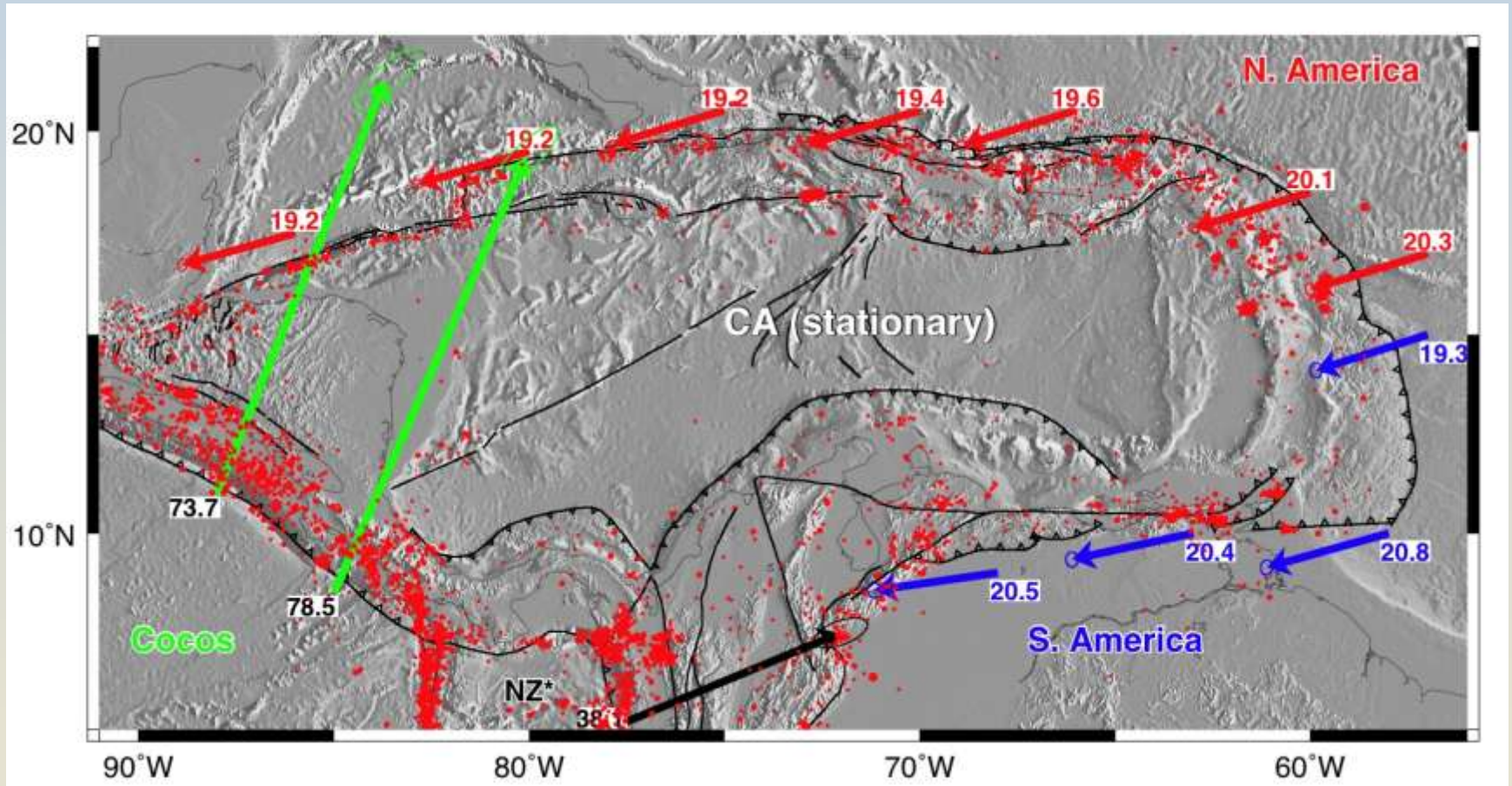


Plate motions with seismicity



Campaign and continuous GPS velocity field – CA fixed

GPS velocity sources:

Alvarado et al. (Lithosphere 2010)

Calais et al. (Nature Geosciences 2010)

DeMets, C. (unpub. 2010)

DeMets & Wiggins–Grandison (GJI, 2007)

Jansma & Mattioli (GSA Spec Paper 2005)

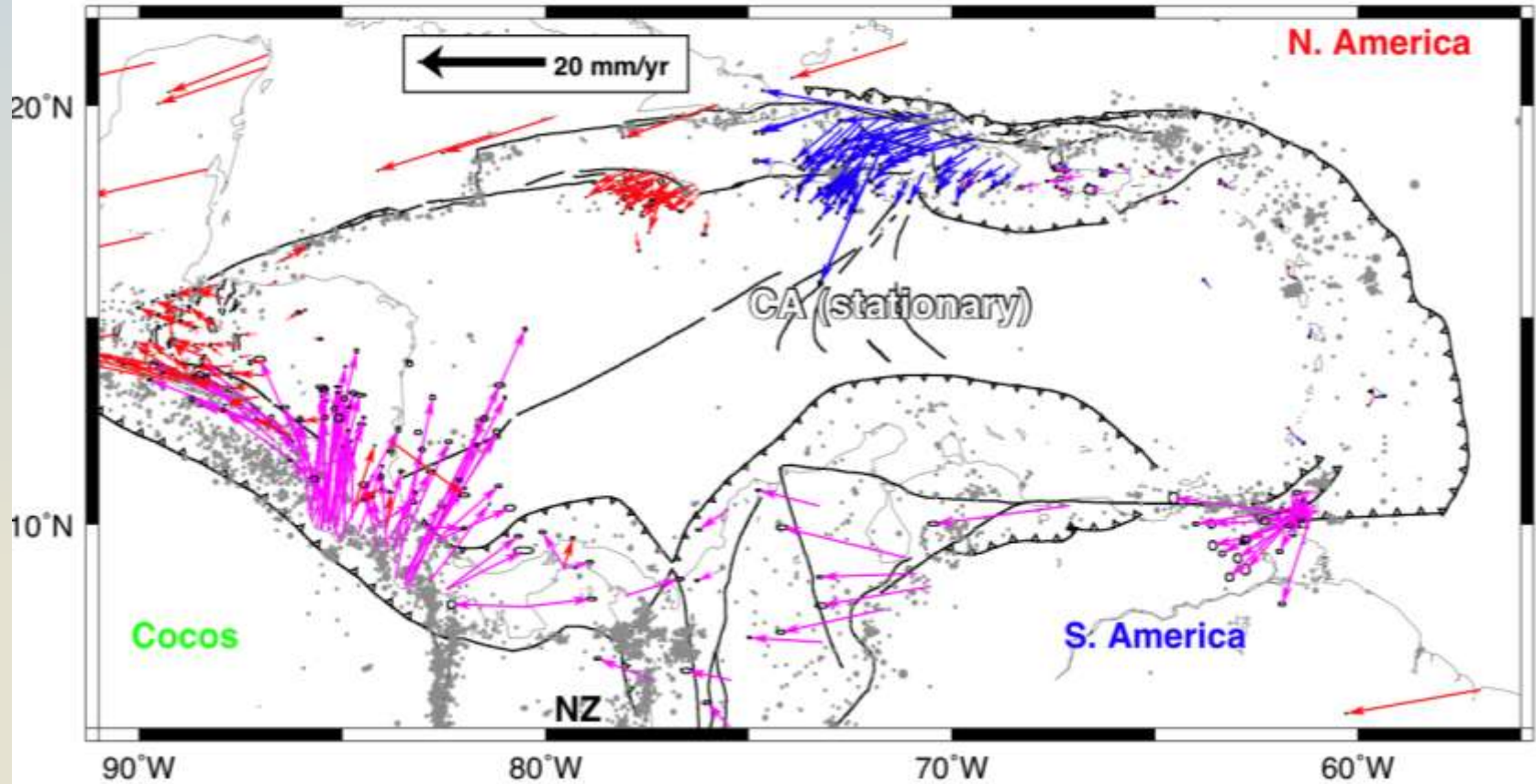
LaFemina et al. (G-Cubed 2009)

Rodriguez et al. (Geophys. J. Int. 2009)

Trenkamp et al. (J. S. Am. Earth Sci. 2002)

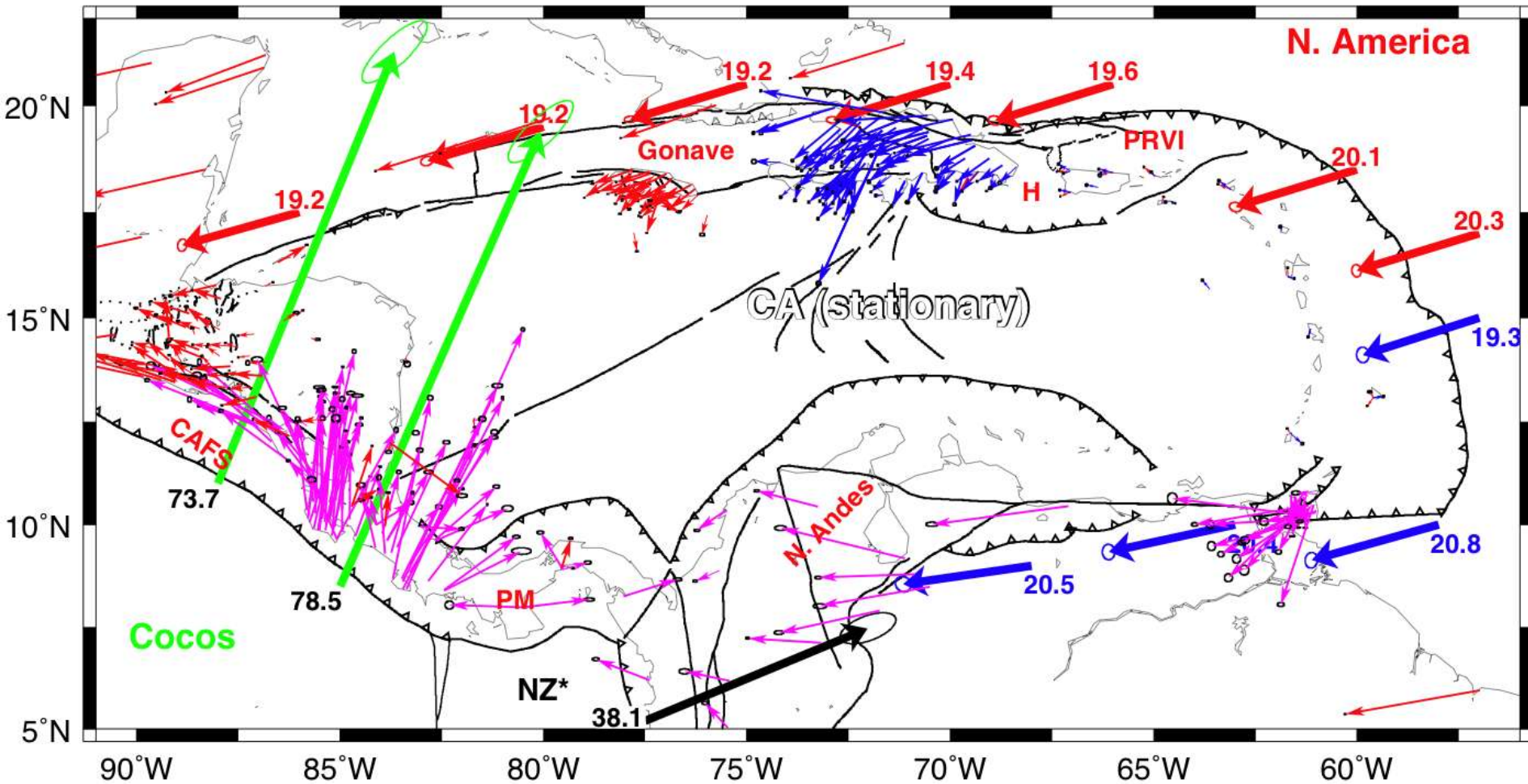
Turner et al. (GRL 2007)

Weber et al. (Geology 2001)



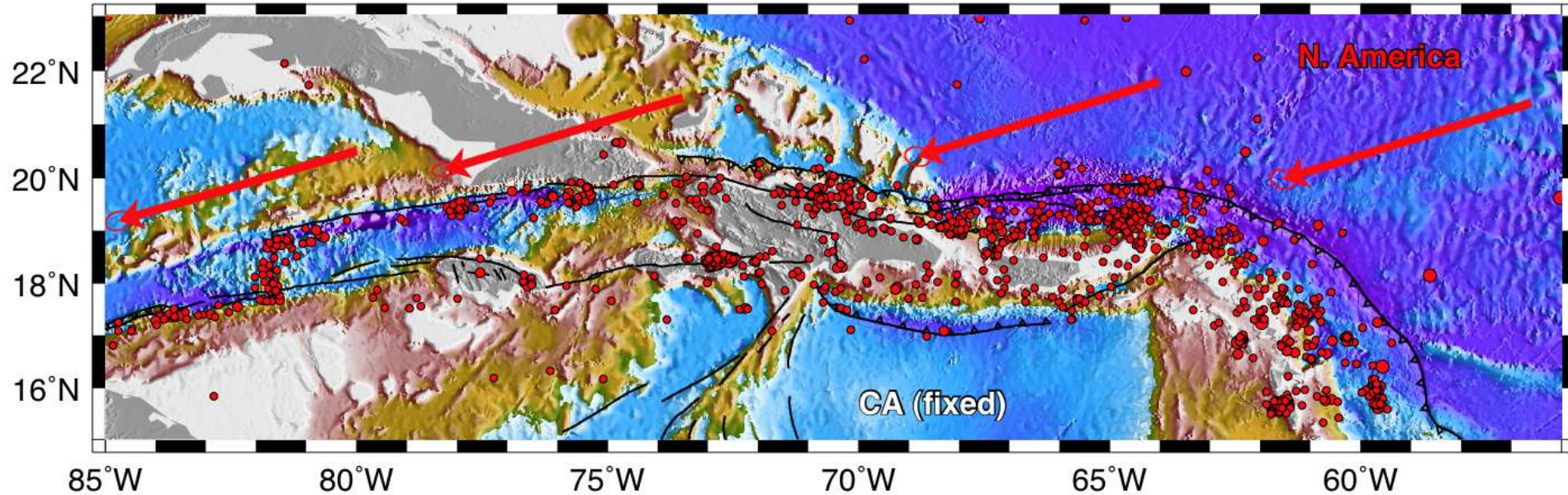
GPS with plate motions

- 1) MORVEL CA plate angular velocities based on GPS due to lack of other reliable data
- 2) Tectonics and EQ cycle processes (fault locking, postseismic) from GPS comparison to plate motions



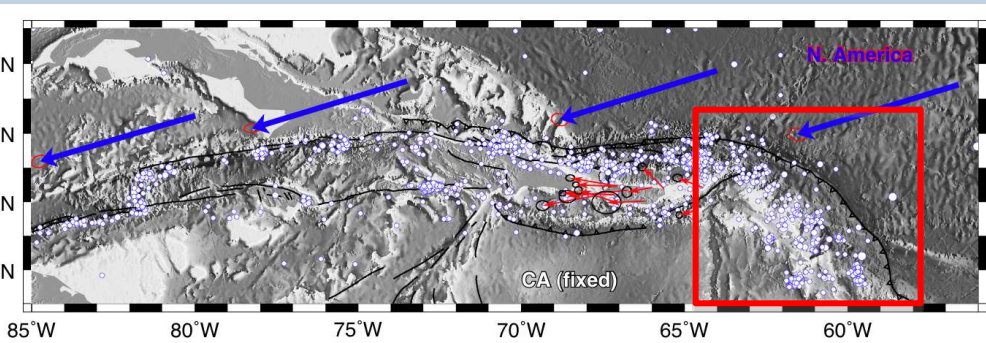
CA-NA boundary:

Effects of oblique collision of Bahama Banks on Hispaniola **AND** effects of oblique collision of Nicaragua Rise with Jamaica are key to understanding seismotectonics along eastern half of Ca-NA plate boundary

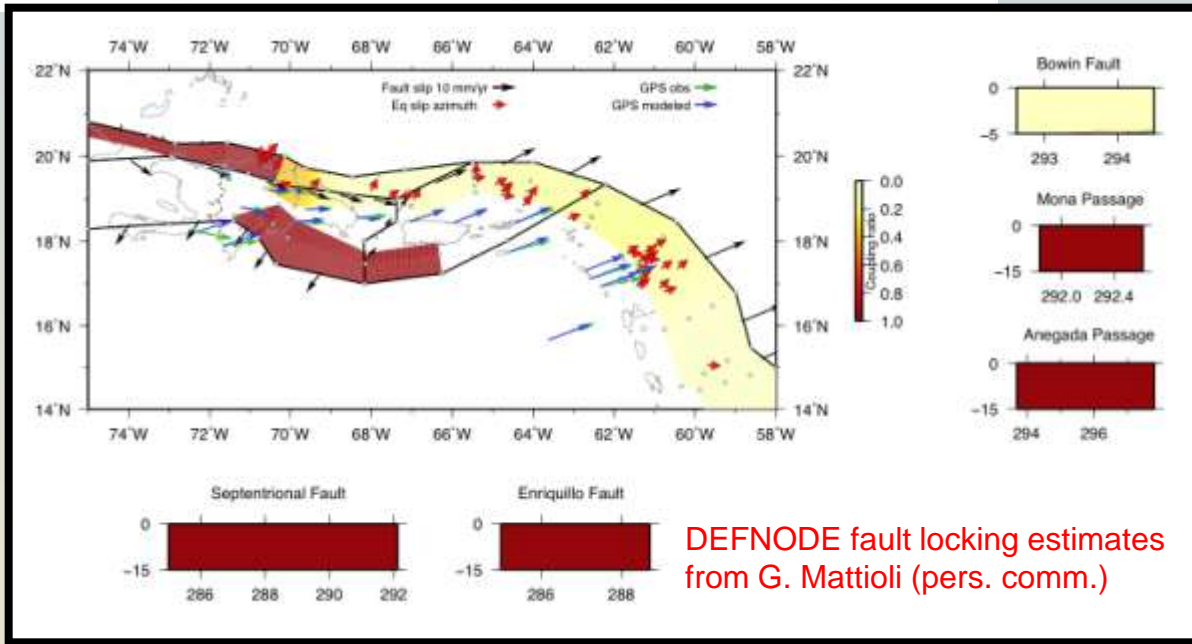


East to west: #1 – The northern Lesser Antilles

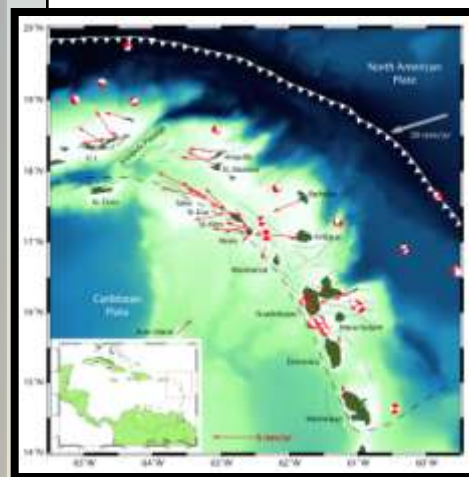
- 1) Is part of Lesser Antilles forearc detached from Caribbean plate (Lopez et al. 2006) ?
- 2) What are interseismic strain accumulation rates (Manaker et al. 2008; Glenn et al. (below)) ?



**N. America fixed
2011 GPS**



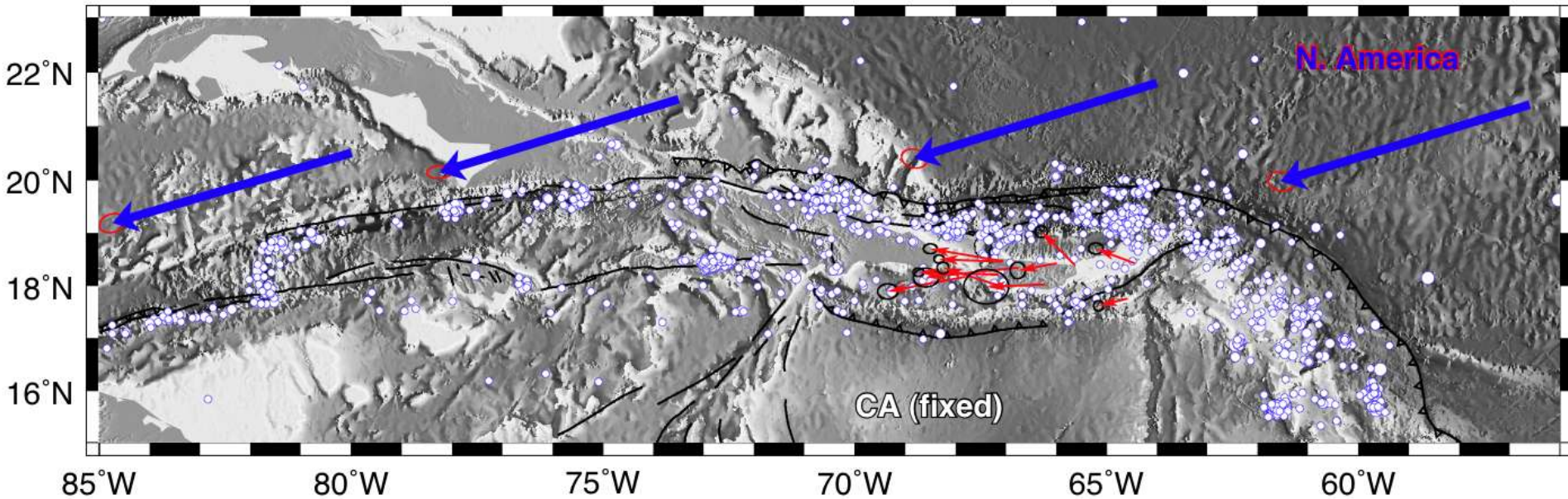
DEFNODE fault locking estimates from G. Mattioli (pers. comm.)



Figures from Turner, Mattioli, et al. (2009) and Glenn, Mattioli, et al. (2011, in prep)

East to west: #2 – the PRVI block

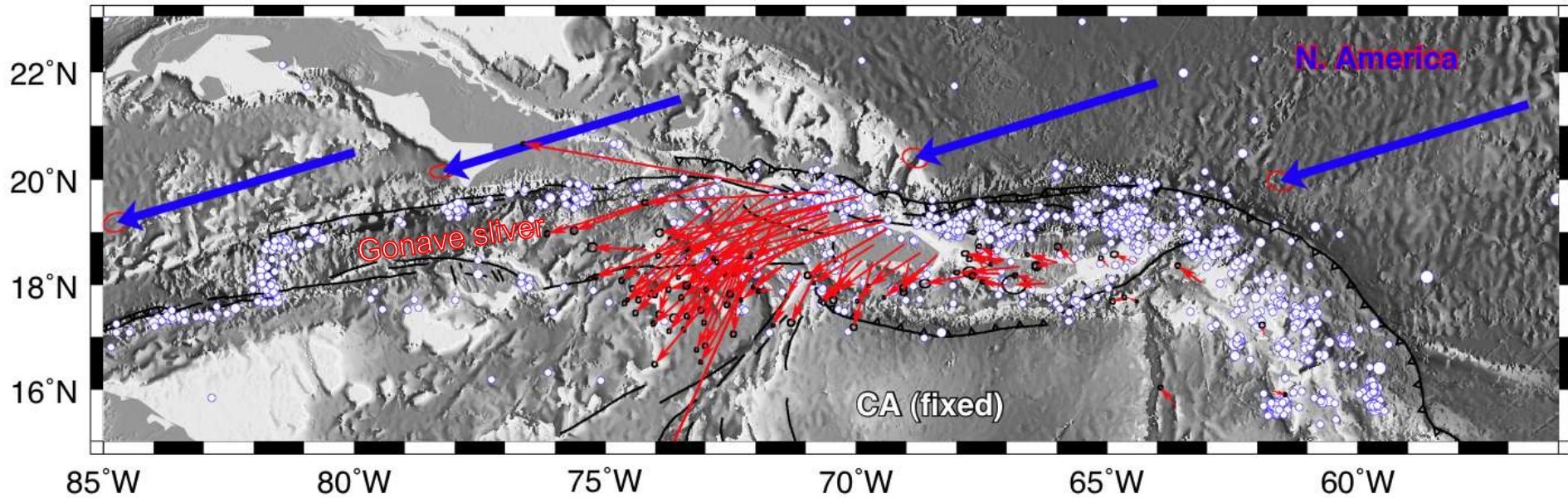
Slow westward movement of PRVI block (3 ± 2 mm/yr) a likely response to oblique NA plate subduction along PR trench (Jansma & Mattioli 2005) and possibly a small westward “push” by the Lesser Antilles forearc sliver (Lopez et al. 2006)



GPS velocities (red arrows) from Jansma & Mattioli (2005)

East to west: #3 – Hispaniola

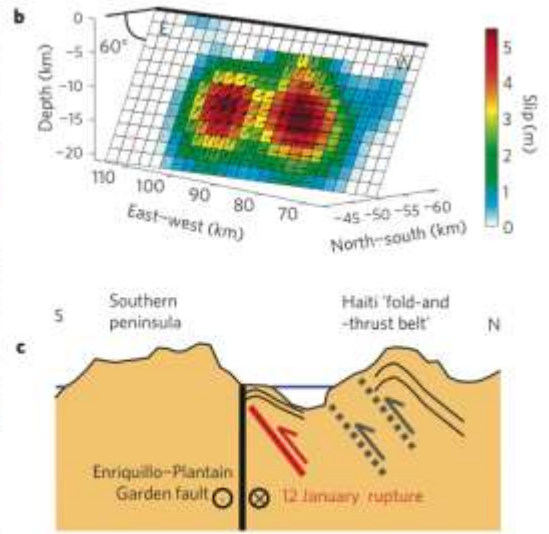
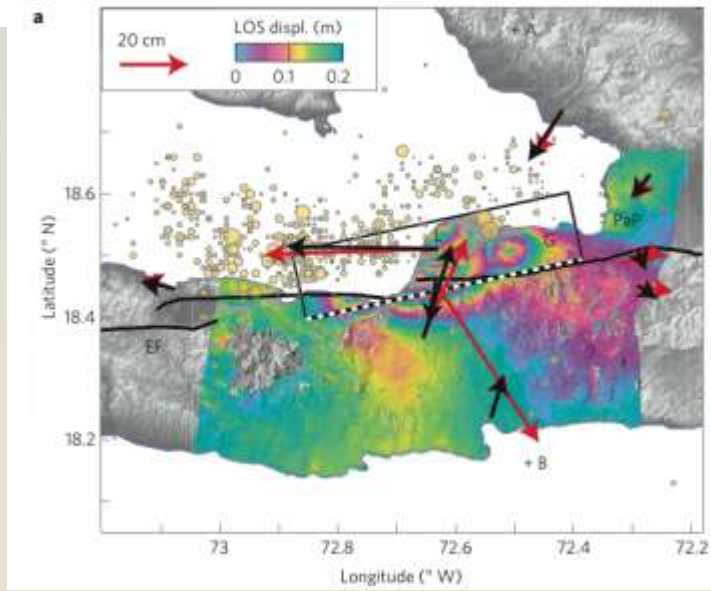
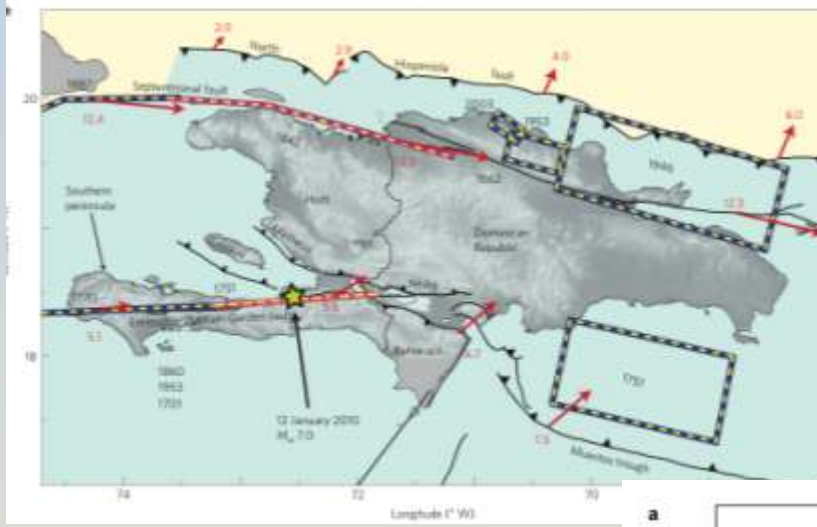
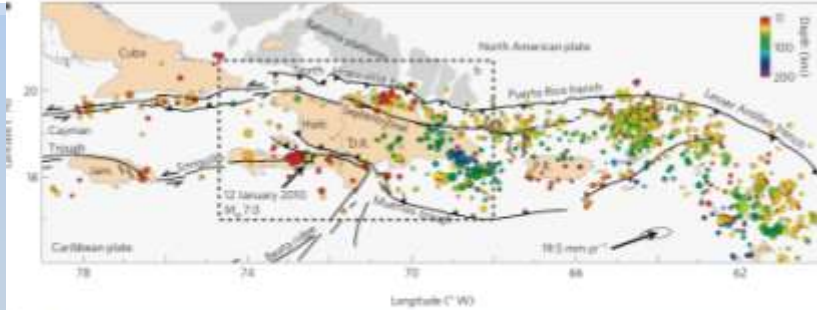
Motion of Hispaniola CCW from and faster than PRVI block motion: Likely effect of collision with Bahama Banks. Gonave sliver plate moves at ~40% of CA-NA motion.



Hispaniola GPS velocities from Calais et al. (2010)

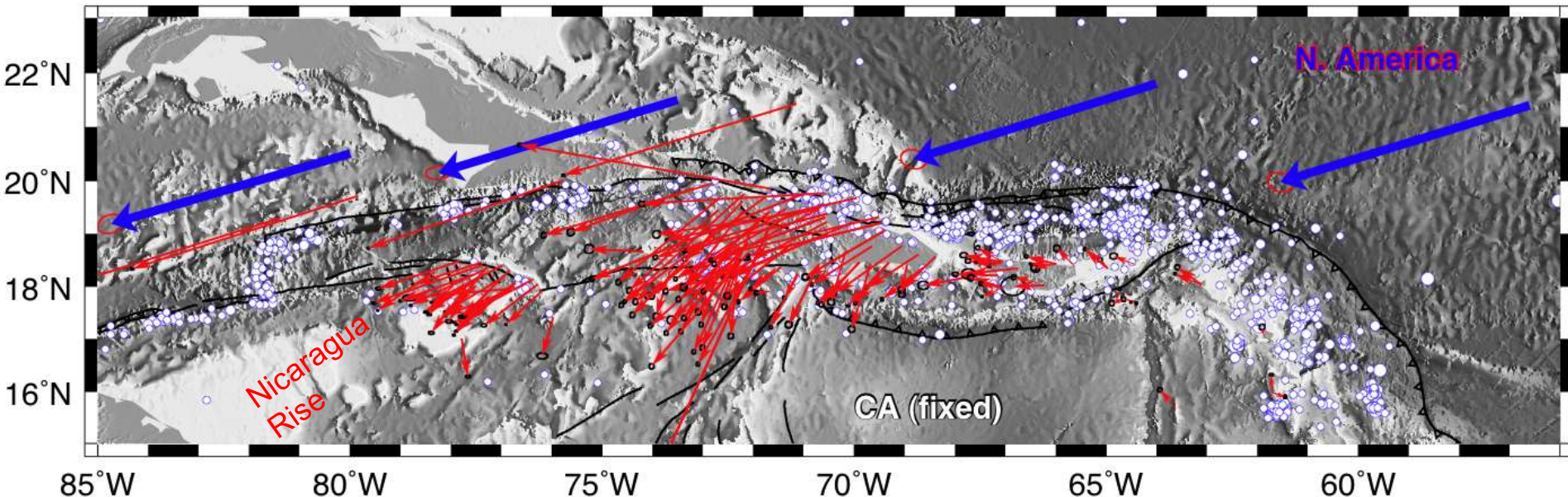
Plate motion partitioned in Hispaniola – major seismic hazard – 2010 Haiti EQ.

Figures from Calais et al. (2010).



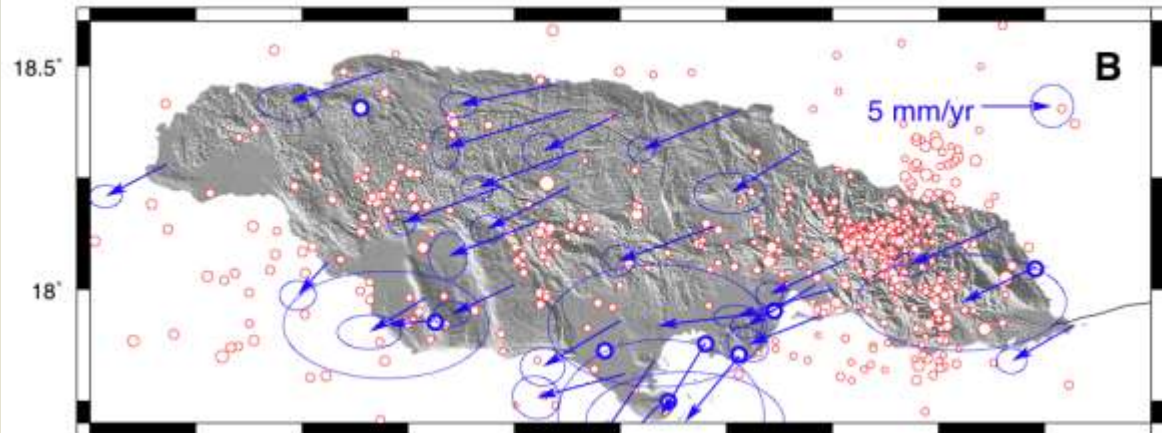
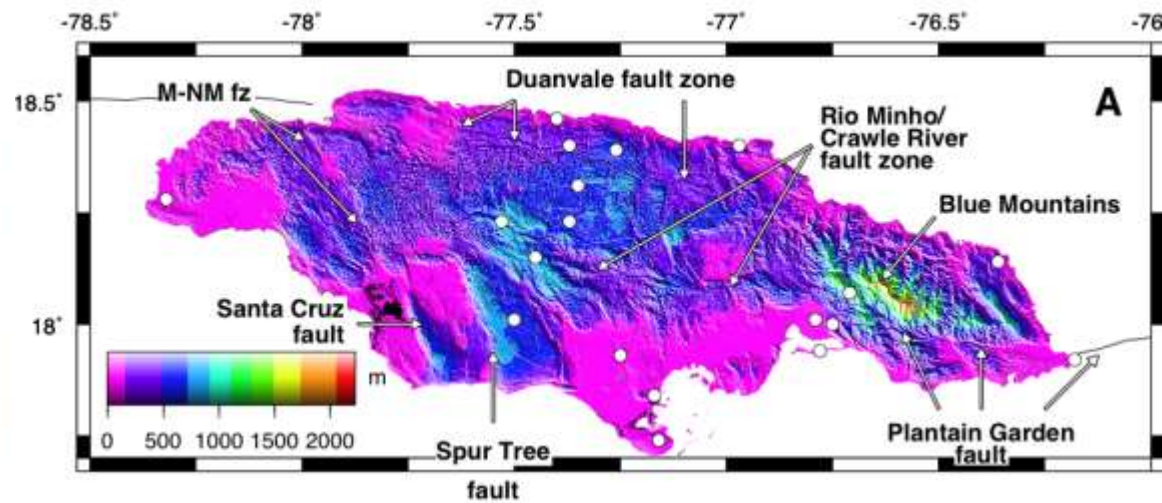
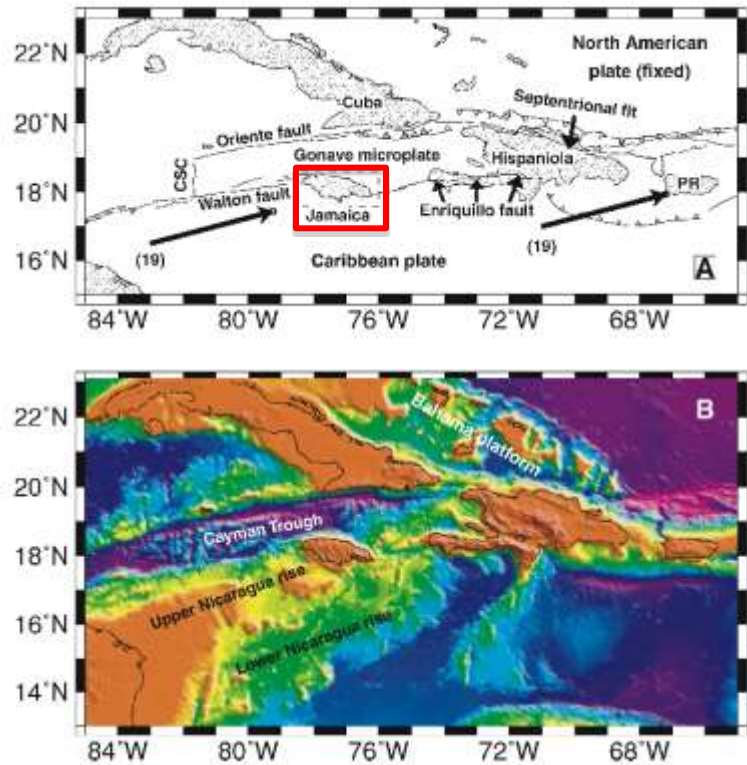
East to west: #4 – Jamaica

Oblique collision of Nicaragua rise (Cretaceous island arc) with Cayman Trough gives rise to Jamaica restraining bend along Gonave-Caribbean plate boundary.



Jamaica GPS velocities updated from DeMets & Wiggins-Grandison (2007)

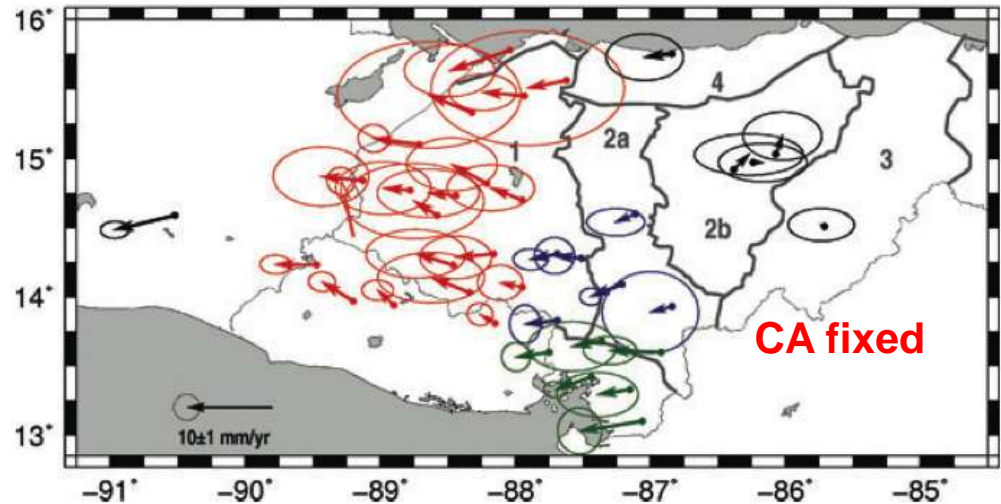
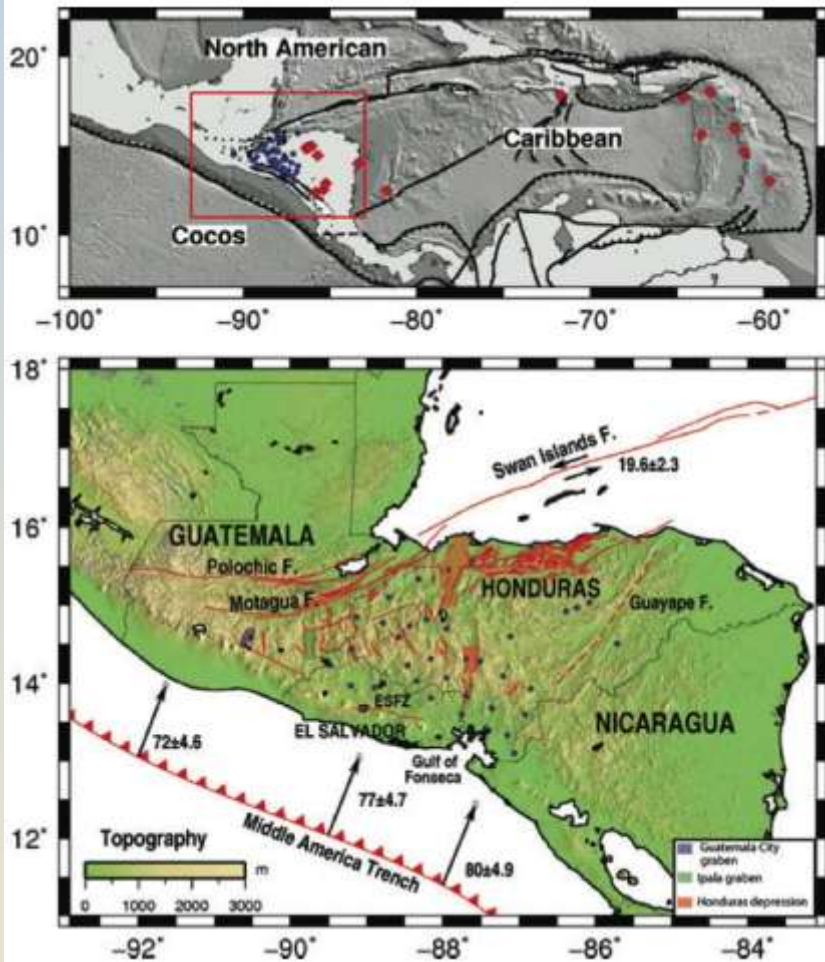
Jamaica: Major seismic hazard, $M > 7$ Eqs in 1692 & 1907. Faults nearly everywhere on island.



Figures from DeMets & Wiggins-Grandison (2007) and Benford et al. (2011, in prep.)

East-to-west: #5 – Central America CA-NA plate boundary

- 1) 1976 Motagua fault EQ devastated Guatemala – GPS shows rapid strain accumulation (Lyon-Caen et al. 2006)
- 2) W trailing end of CA plate forming new Basin-and-Range across Honduras/Guatemala. GPS measured extension of 8 mm/yr (Rodriguez et al. 2009). Normal faulting EQ hazard.



Figures from Rodriguez, DeMets, et al. (2009)

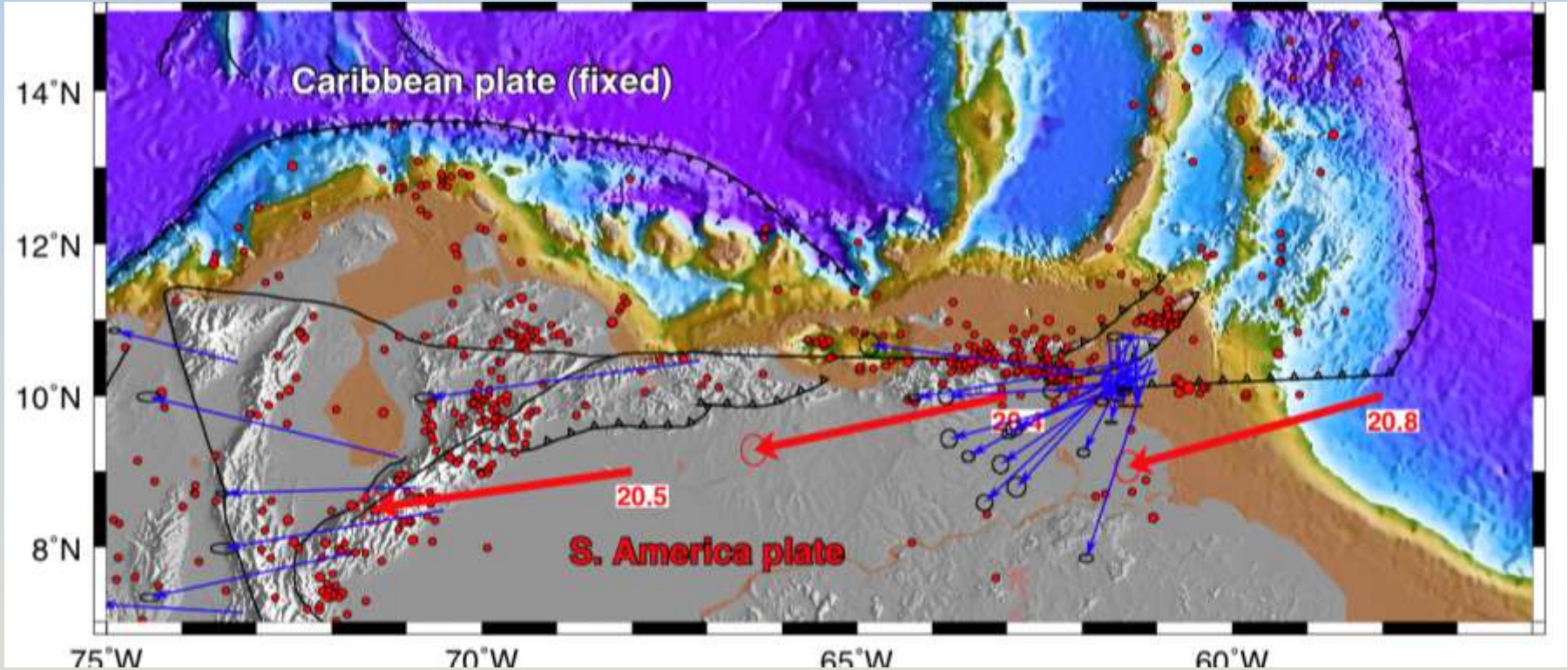
Lyon-Caen et al. 2006 – 1st GPS study of Motagua fault

Kinematics of the North American–Caribbean–Cocos plates in Central America from new GPS measurements across the Polochic–Motagua fault system

H. Lyon-Caen,¹ E. Barrier,² C. Lasserre,¹ A. Franco,¹ I. Arzu,³ L. Chiquin,⁴ M. Chiquin,⁴ T. Duquesnoy,⁵ O. Flores,⁶ O. Galicia,⁷ J. Luna,⁶ E. Molina,⁸ O. Porras,⁸ J. Requena,⁴ V. Robles,⁹ J. Romero,¹⁰ and R. Wolf⁷

Received 28 July 2006; accepted 5 September 2006; published 11 October 2006.

CA-SA Trinidad/Tobago/Venezuela



Triangulation-to-GPS and GPS-to-GPS geodesy in Trinidad, West Indies: Neotectonics, seismic risk, and geologic implications

J.C. Weber^{a,*}, J. Saleh^{b,1}, S. Balkaransingh^{b,2}, T. Dixon^c, W. Ambeh^{d,3}, T. Leong^e, A. Rodriguez^a, K. Miller^{b,4}

2010

Velocity field across the southern Caribbean plate boundary and estimates of Caribbean/South-American plate motion using GPS geodesy 1994-2000

GRL 2001

Omar J. Pérez,¹ Roger Bilham,² Rebecca Bendick,² José R. Velandia,¹ Napoleón Hernández,³ Carlos Moncayo,¹ Melvin Hoyer,⁴ and Mike Kozuch⁵

