Earth Science RAPIDs

5 RAPIDs – Onshore, offshore, and satellite observations and monitoring and subsequent modeling. Funding from OCE and EAR

-Fault mapping and search for surface rupture

-Understanding secondary effects such as landslides, lateral spreading, and tsunamis

-Examining sealevel and water table effects

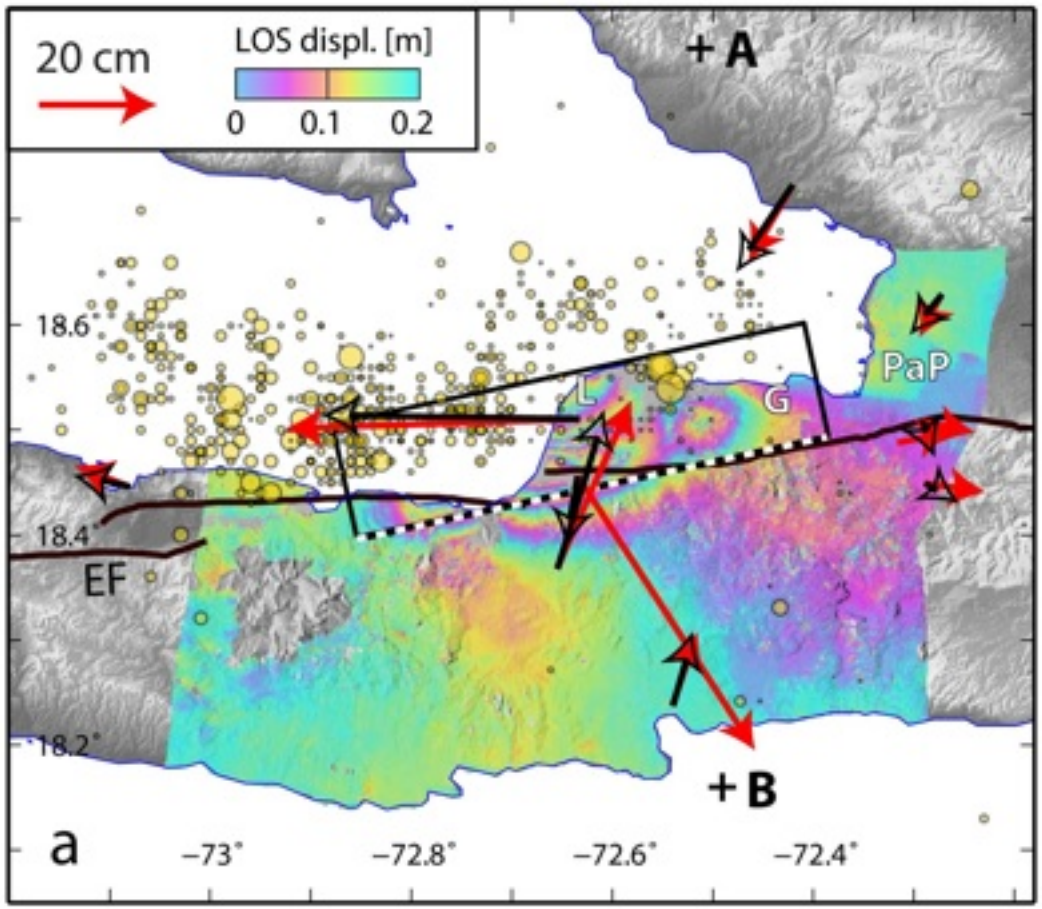
-Place January 12 earthquake into tectonic and future hazards context

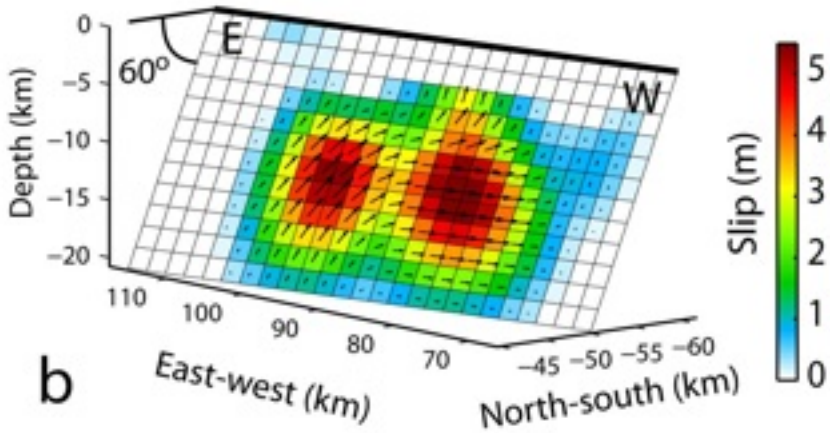
Many of the first results have been submitted for publication. Several in press in a special issue of Nature Geoscience: Hayes et al, Calais et al, Prentice et al, Hornbach et al; others being submitted to Geology: McHugh et al and de LePinay et al

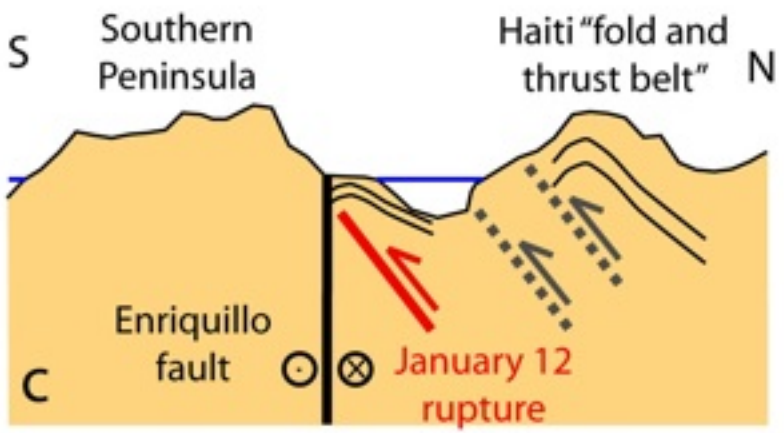
Project Description/Goals- Calais et al

- Goals:
  - Find surface evidence of the earthquake rupture.
  - Remeasure an existing network of GPS benchmarks for coseismic deformation.
  - Collect available radar data to compute coseismic interferograms.
  - Install continuous GPS instruments to measure postseismic deformation.
- Participants:
  - Purdue University (E. Calais, A. Freed)
  - Univ. Texas Austin (P. Mann)
  - Univ. Miami (F. Amelung, T. Dixon, S.H. Hong, E. Chaussard)
  - Univ. Texas Arlington (G. Matiolli, P. Jansma)
  - Bureau of Mines and Energy, Haiti (D. Anglade, C. Prépetit)
  - Université d'Etat d'Haiti (R. Momplaisir, D. Boisson)
  - Collaboration USGS
- Achievements:
  - Coseismic displacements field (30 GPS sites + ALOS interferograms).
  - Mapping of coastal features and Enriquillo fault in epicentral area.
  - Three papers under consideration for Nature Geosciences (revised version sent).

Initial Findings

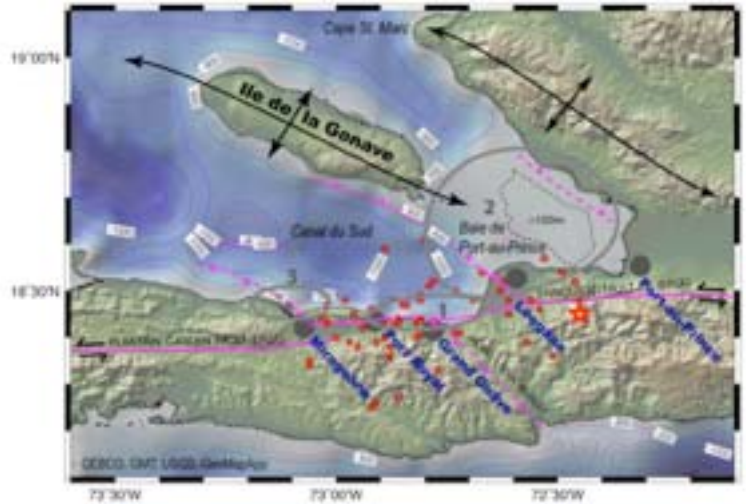




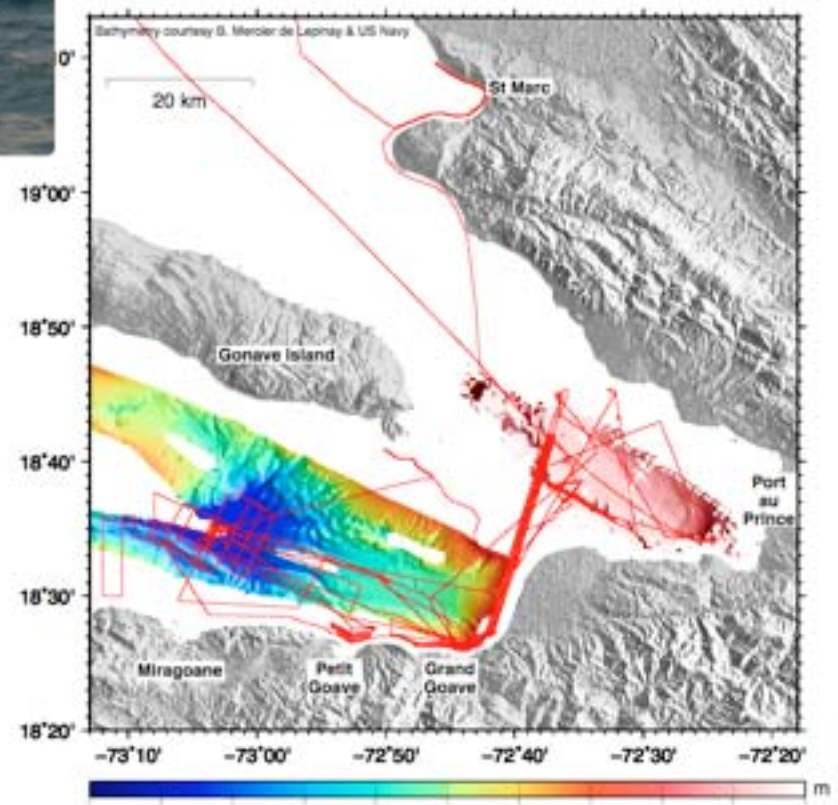


The January 12, 2010, Haiti earthquake ruptured an unmapped fault ("Leogane fault") (a) Interferogram, GPS observed (black) and model (red) coseismic displacements. Yellow circles show aftershocks. (b) Total slip distribution from a joint inversion of InSAR and GPS data,viewed from the northwest. (c) Interpretative cross-section between points A and B indicated on panel (a) *[Calais et al., Nature Geosciences, submitted]*

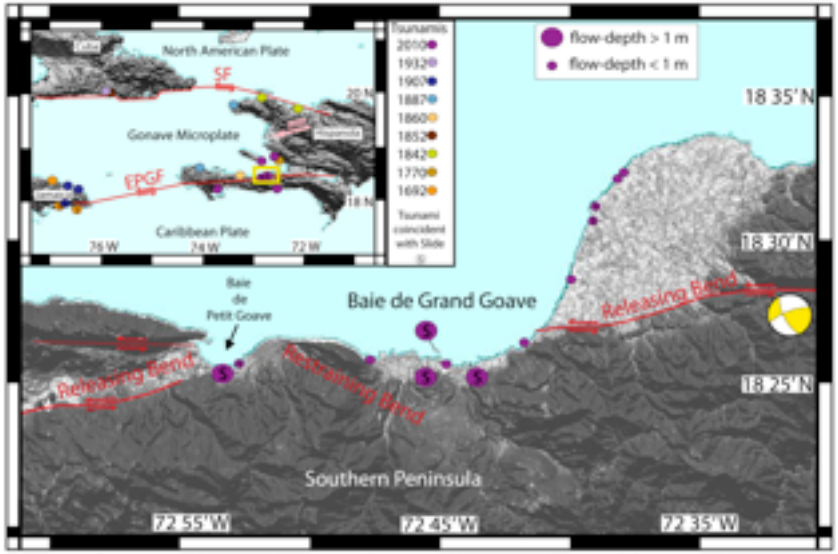
Seismic investigations of Haiti in Response to January 12, 2010 Earthquake: Understanding geohazards- 2 RAPID grants: McHugh et al and Gulick et al

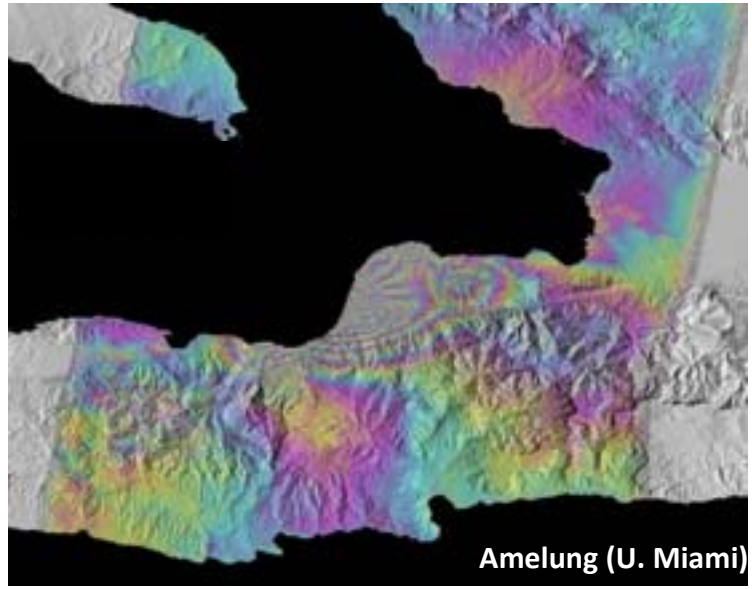


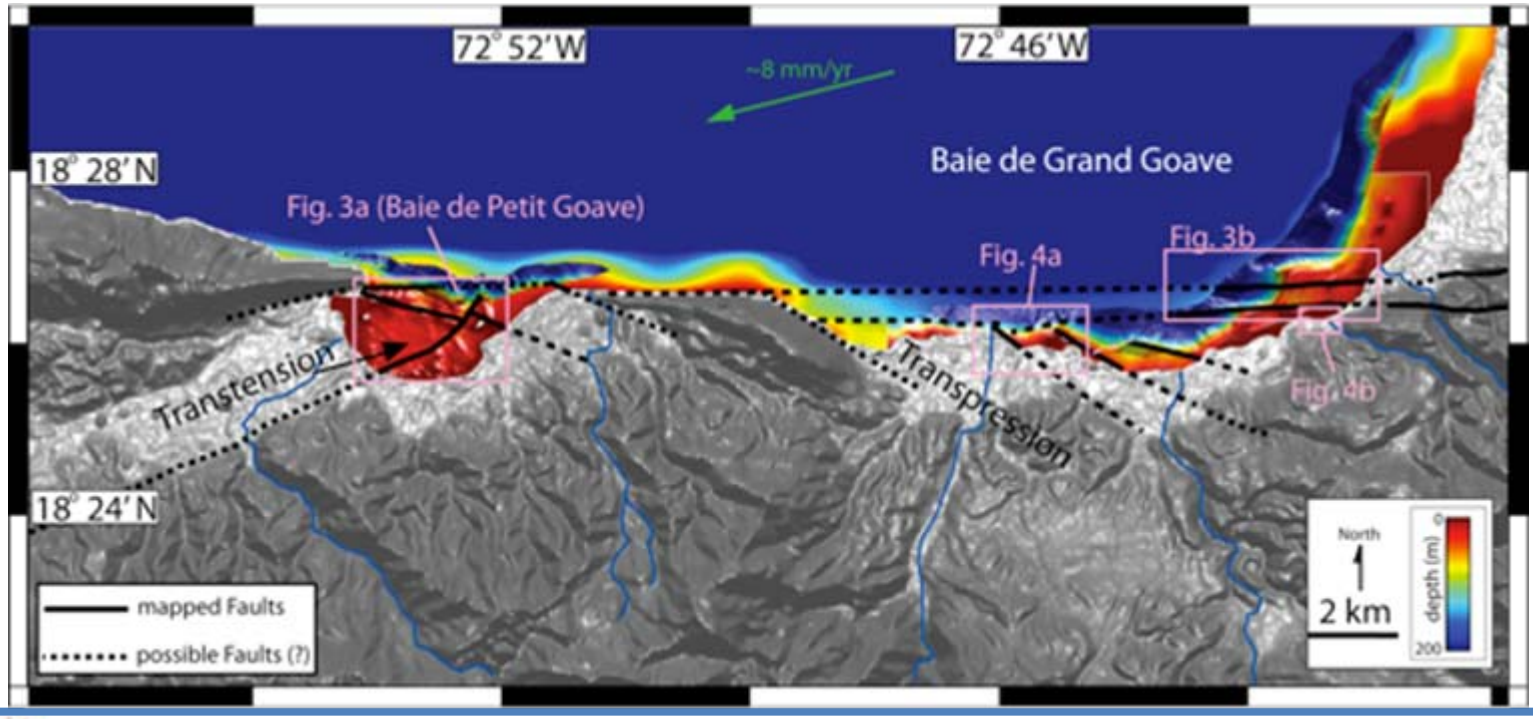
REPONS: Rapid Enriquillo-Plantain Offshore Neotectonic Study



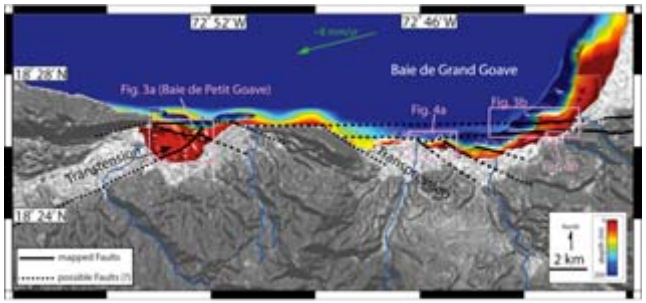
Goals: Geophysically map the EPGF offshore and search for tsunami origin

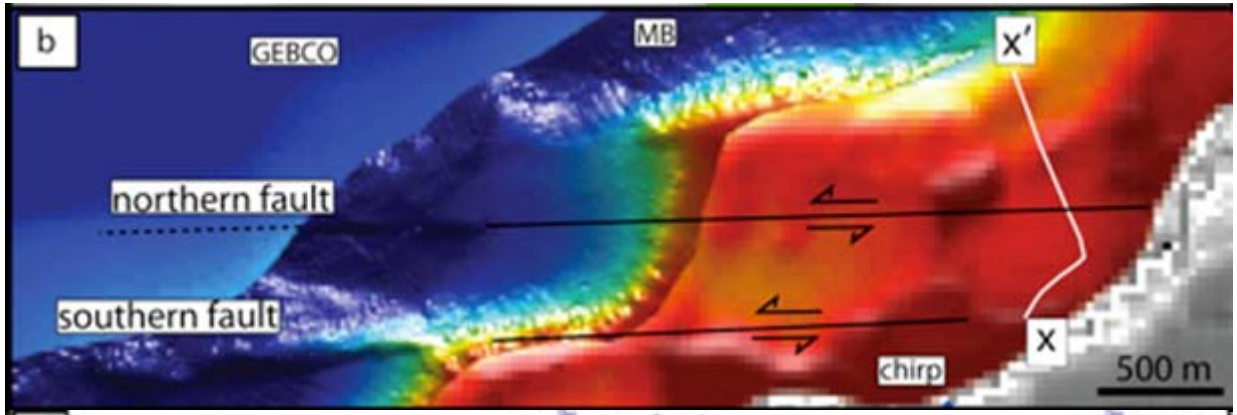


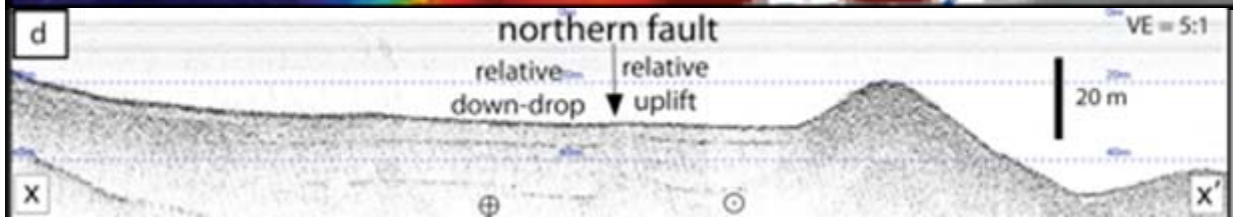


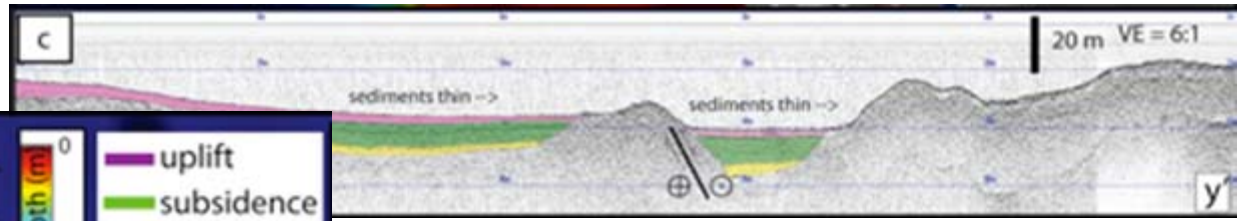


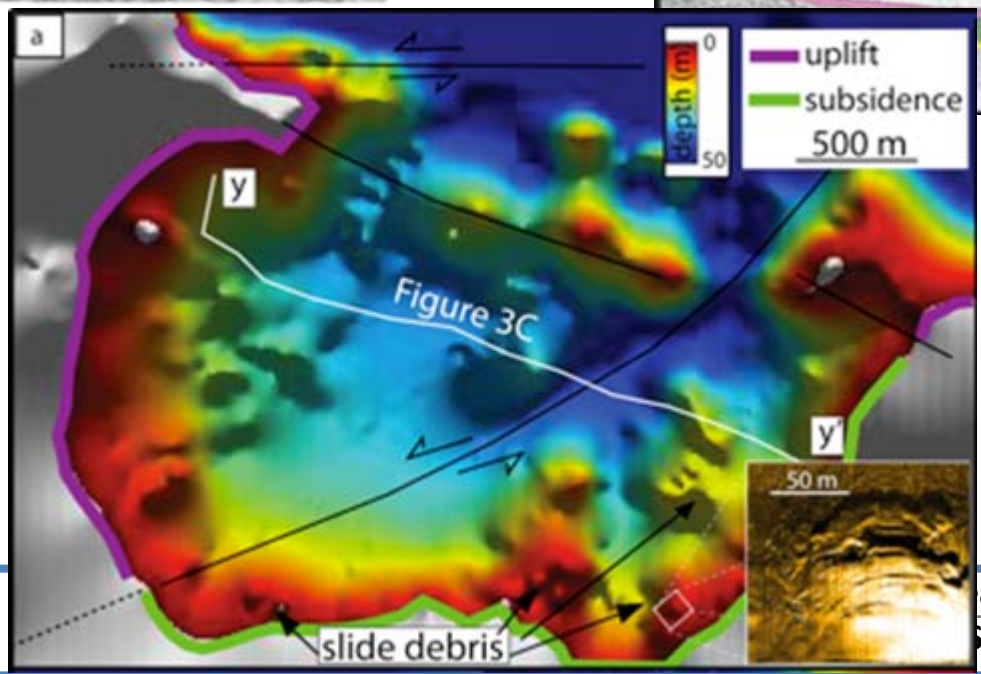
Results in Hornbach et al, in press Nature Geoscience

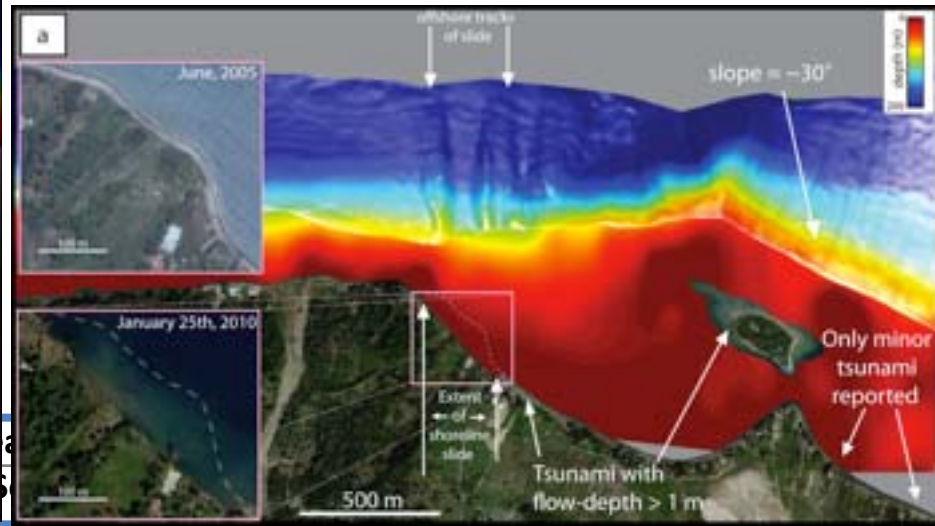

72°52'W
72°46'W
18°28'N
18°24'N
Baie de Grand Goave
Fig. 3a (Baie de Petit Goave)
Fig. 4a
Fig. 3b
Transpression
Transpression
2 km
mapped Faults
possible Faults (?)


b
GEBCO
MB
x'
northern fault
southern fault
chirp
x
500 m


d
northern fault
VE = 5:1
relative down-drop
relative uplift
20 m
x
x'

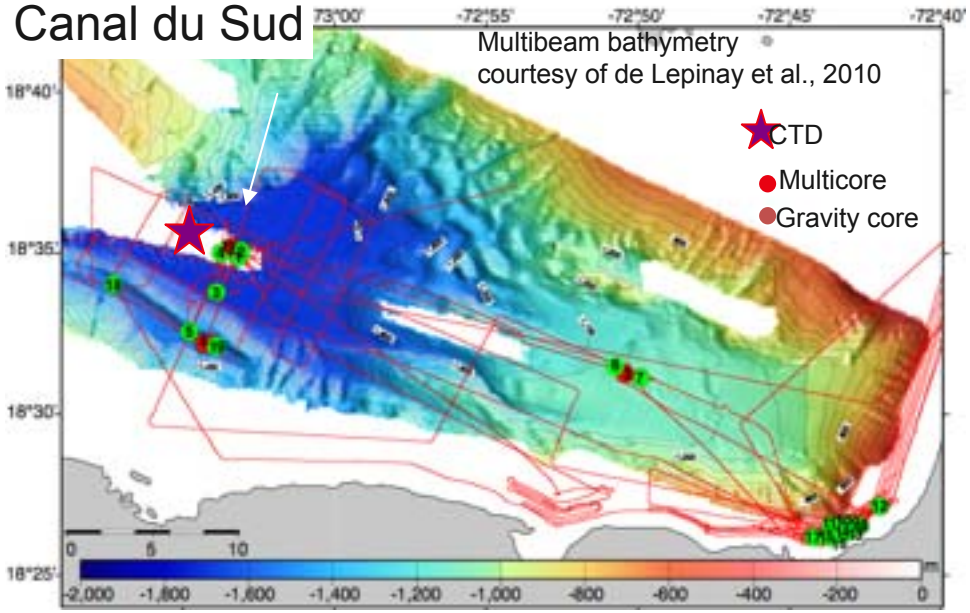

c
20 m
VE = 6:1
sediments thin -->
sediments thin -->
y'


a
depth (m)
0
50
uplift
subsidence
500 m
y
Figure 3C
y'
50 m
slide debris

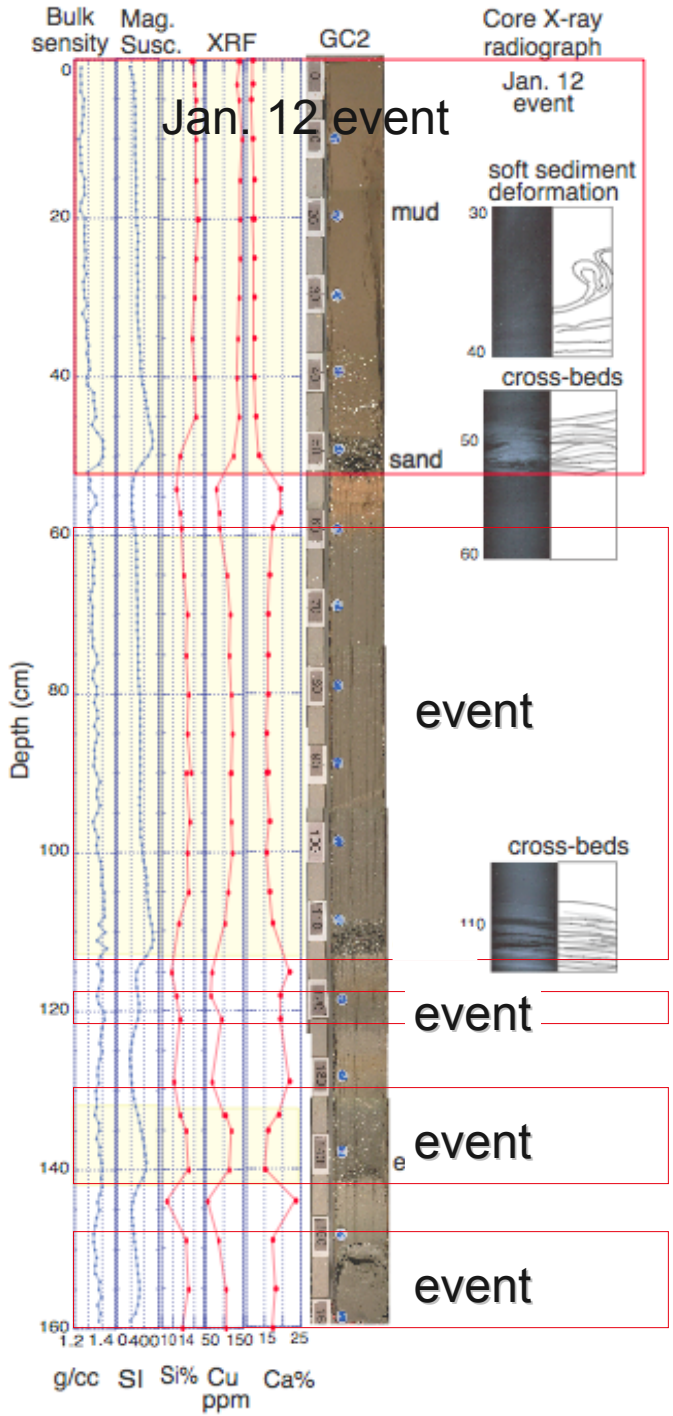

a
offshore tracks of slide
June, 2005
slope = ~30°
January 25th, 2010
Extent of shoreline slide
500 m
Only minor tsunami reported
Tsunami with flow-depth > 1 m

We sampled the Jan. 12 turbidite and older turbidites at shallow, intermediate and deep water depths

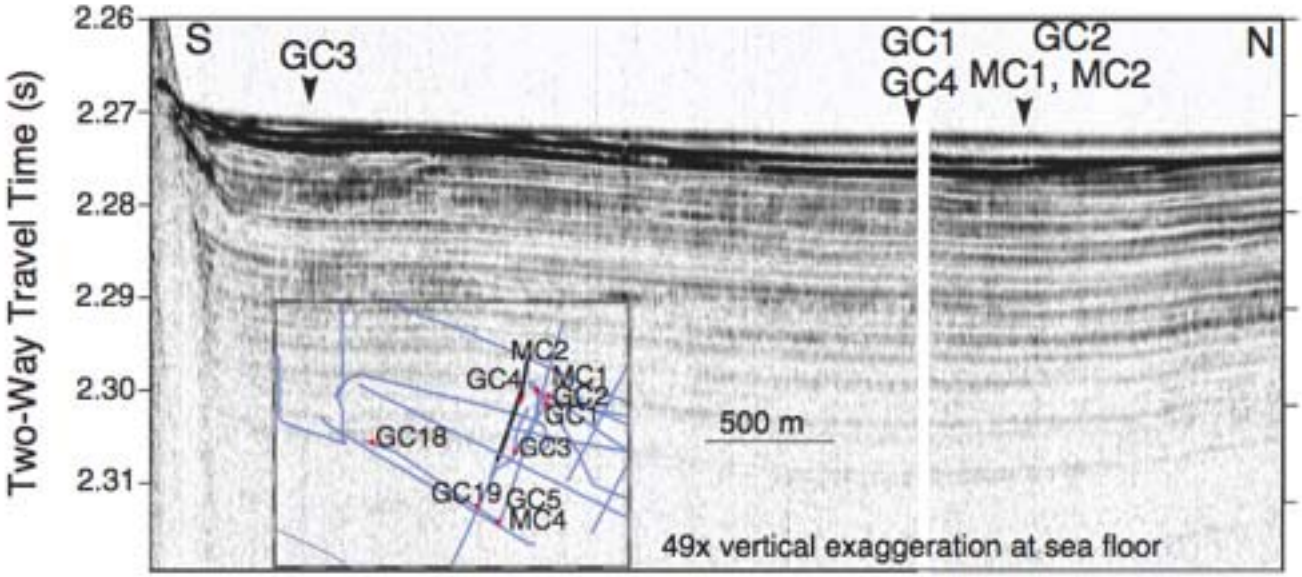
Canal du Sud

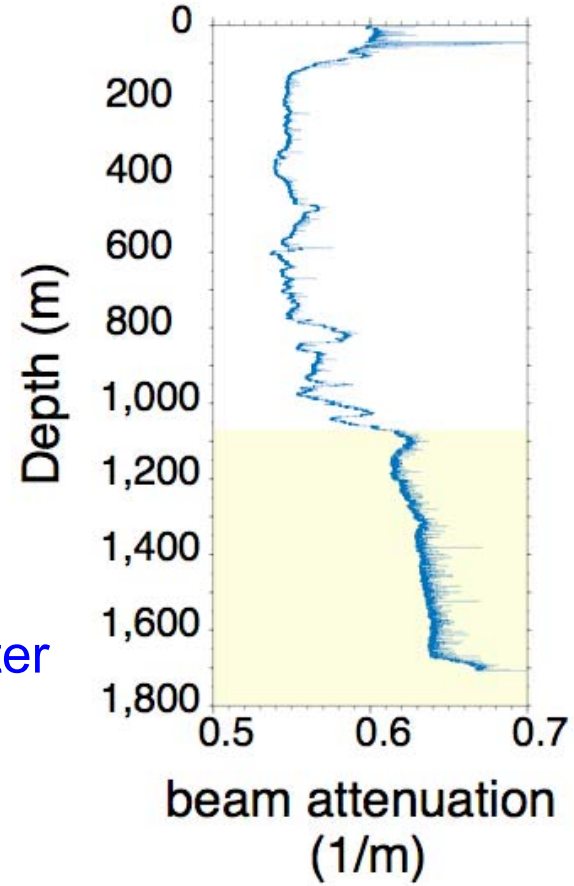


By using a multiproxy approach of short-lived radioisotopes (^{234}Th, ^{7}Be, ^{210}Pb, ^{137}Cs), xrf elemental and microprobe analysis, physical properties, and core x-ray radiographs, we identified four older events. Currently being dated by ^{14}C.



- The semi-transparent layer represents the Jan. 12 turbidite estimated at ~0.05 km^3 and deposited over 50km^2.
- Sediment from the coastline not sufficient and additional sediment was contributed from adjacent slopes. Consistent with short-lived radioisotope data.





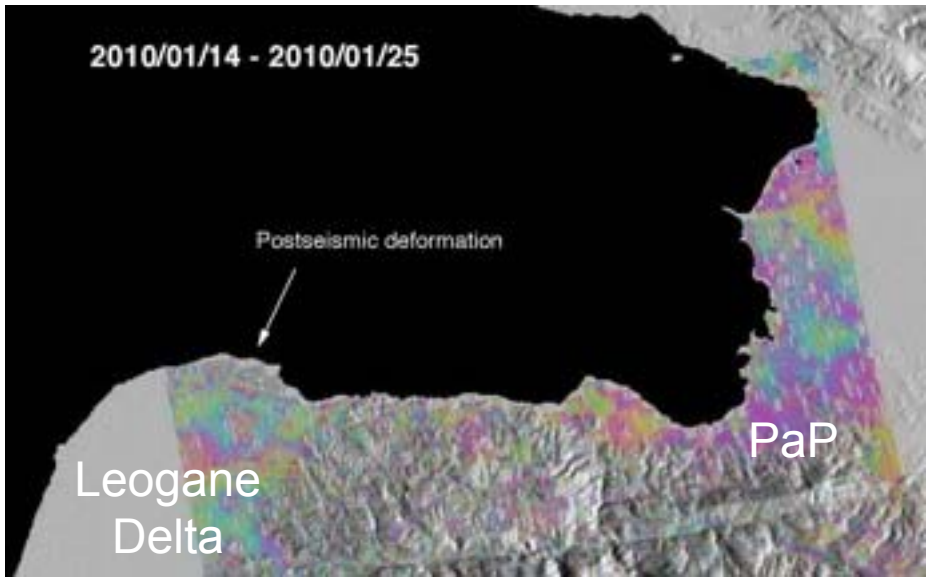
Nearly 2 months after the earthquake a sediment plume remained in suspension above the sea floor in the Canal du Sud at 1750 m. The CTD transmissometer measured beam attenuation in the water column. The 600 m anomaly from 1100 to 1750 m is interpreted as sediment stirred into suspension by the earthquake.

Monitoring postseismic crustal deformation in Haiti with TerraSAR-X observations

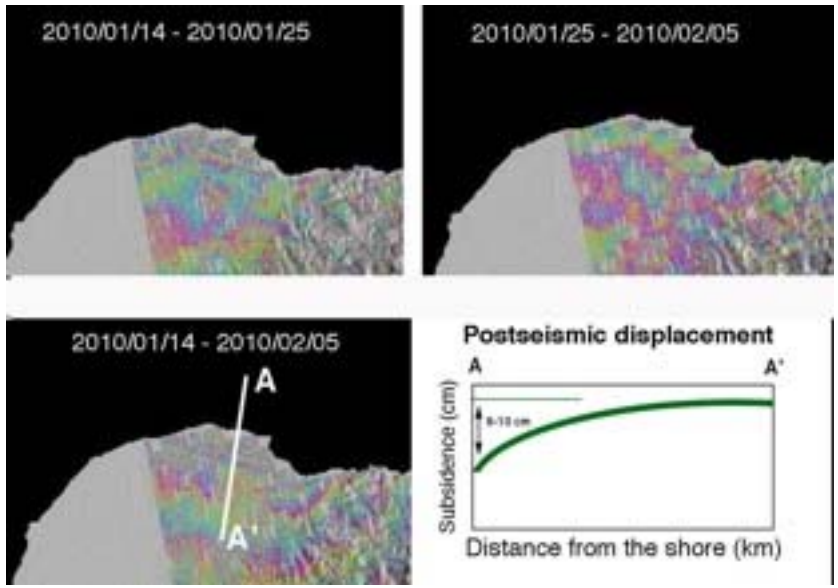
Shimon Wdowinski[1] and Sang-Hoon Hong[1,2]

1. Division of Marine Geology and Geophysics, University of Miami, Miami, FL
2. Korea Aerospace Research Institute, Republic of Korea

Postseismic deformation is a time-dependent deformation of the Earth's crust occurring in response to the main earthquake.



Using TerraSAR-X observations, we detected in 3 interferograms (phase changes) postseismic deformation (subsidence) that occurred in the northern section of the Leogane delta.

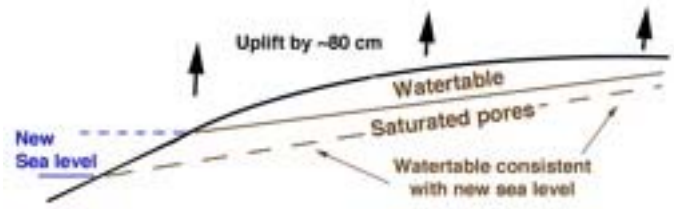


Three post-earthquake interferograms showing time-dependent deformation. Most deformation occurred between January 14th and January 25th, 2010. A profile normal to the shoreline (A-A') shows an increasing subsidence from inland areas toward the shore, with maximum subsidence of 8-10 cm.

Conceptual model explaining the cause for the observed postseismic

Before the earthquake

Water table is in equilibrium with sea level.



During the earthquake

Uplift of the delta by ~80 cm disturbed the water table equilibrium.

After the earthquake

Groundwater flew downward toward the sea in order to reach an equilibrium with the new sea level. Sediment compact in response to water loss. It is a time dependent process.

Acknowledgements
NSF – RAPID grant
German Space Agency (DLR) – TerraSAR-X data

Conclusions

•TerraSAR-X (TSX) observations detected postseismic deformation that occurred along the northern part of the Leogane delta during 24 days after the earthquake.

•The coseismic (main earthquake) deformation of the 2010 Haiti earthquake has been under-estimated (by 5-10%), because the coseismic deformation analysis is based on interferograms that include both coseismic and postseismic deformation.

•The TSX observations led to a discovery of a new postseismic deformation type that is caused by groundwater table adjustment to a new sea level.

•It is very important to task SAR satellites to monitor surface deformation right after a large earthquake. Fast response of space agencies will allow the acquisition of the time-dependent postseismic deformation. It is important to start acquiring data immediately after the earthquake, when the postseismic signal is the largest.

5 NSF RAPID Tide gauges installed March
1 mm resolution pressure transduce, 15 minute samples
Celia Schiffman, Steve Nerem, Roger Bilham

Dynamic sea level questions Haiti

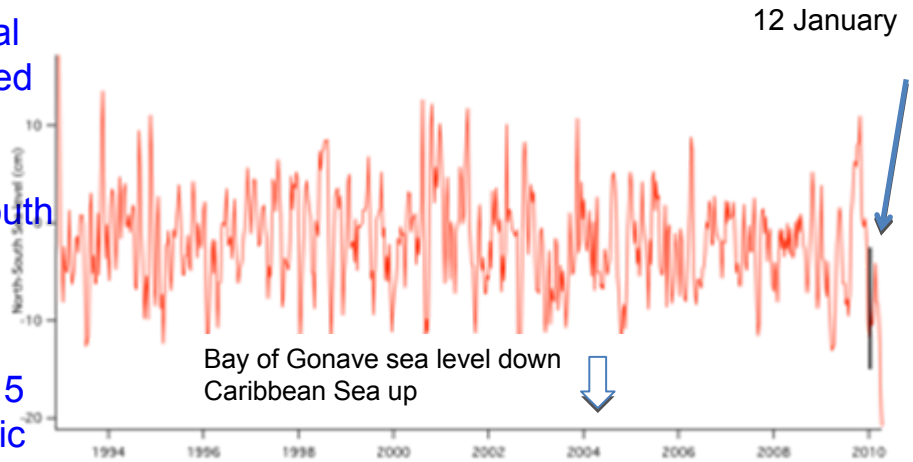
1 Was sea level anomalous at the time of the earthquake, thereby triggering the causal thrust fault?
2. What is local tidal range and can this be used to estimate pre-earthquake sea level from air photos?
3. Can sea level be used as a local datum to monitor differential post seismic adjustment?

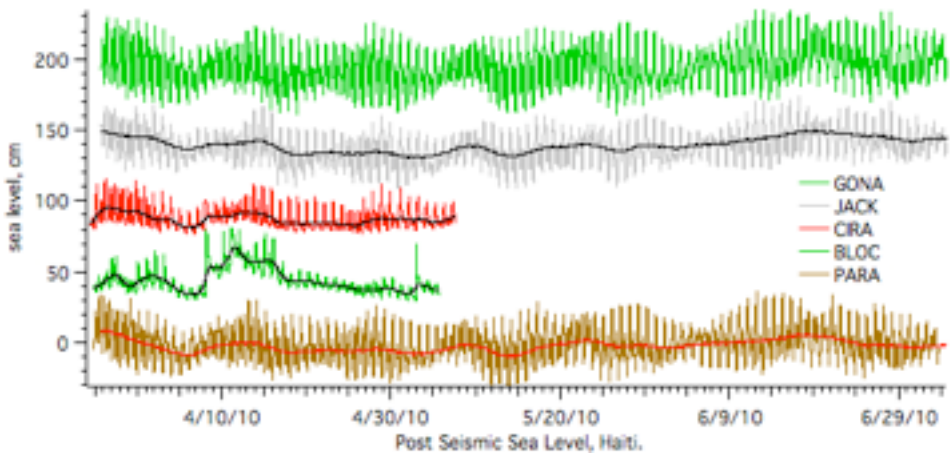
Results.

1.TOPEX-Poseidon signal in Bay of Gonave reveals coral exposed 5-7 months before earthquake. Explains observed kills – ground truth for 2.

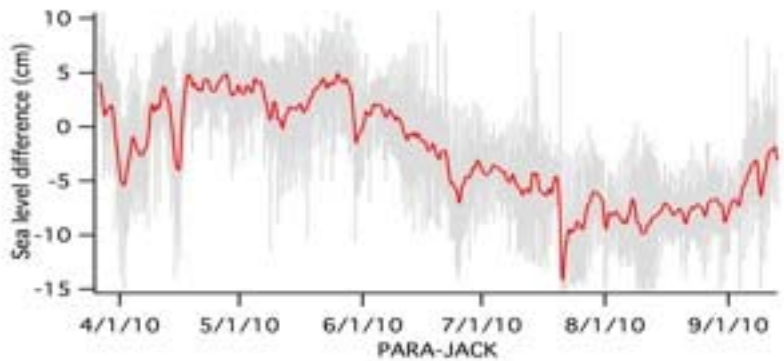
2. Earthquake occurred at maximum reversal of North-South sea level loading across peninsula observed in 16 years. Was earthquake triggered by sea level slope?

3. Five postseismic NSF Rapid gauges – three transmit 15 minute data via Iridium satelite –no significant post seismic vertical signal (No tide gauges in Haiti prior to earthquake)





Post seismic sea level data



5 months of sea level difference reveal no vertical afterslip

Summary and Future Work

Debate on exact tectonic context for Jan 12 event (transpressional EPGF or thrust fault) but consensus that Jan 12 event heralds future earthquakes for Hispaniola potentially more devastating

Interest in seeking ways to partner with experts in other fields to research the tectonics, earthquake history, geohazards, and societal effects of Hispaniola and northern Caribbean events