GPS and seismic constraints on the M=7.3 2009 Swan Islands earthquake (to be submitted)

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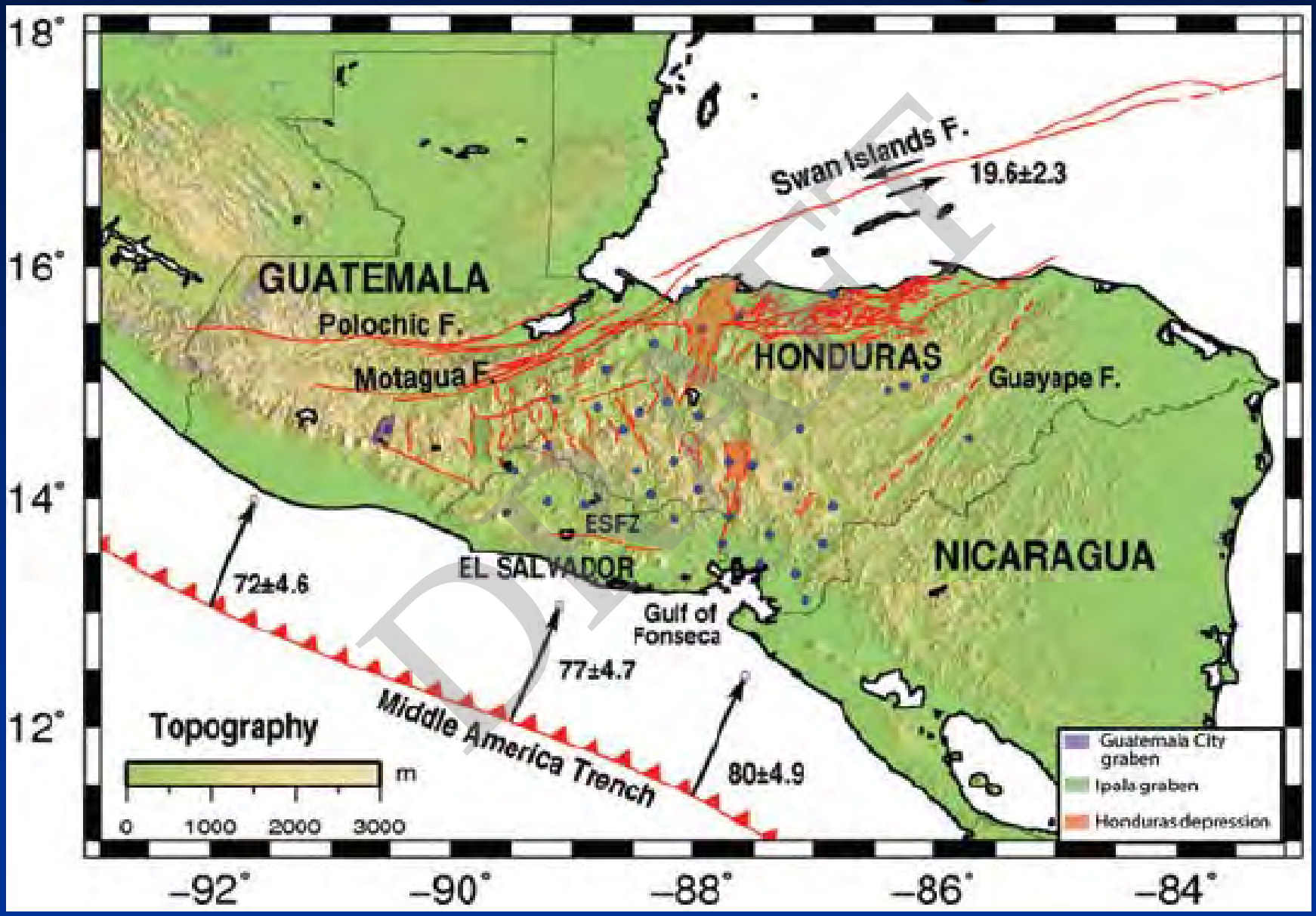
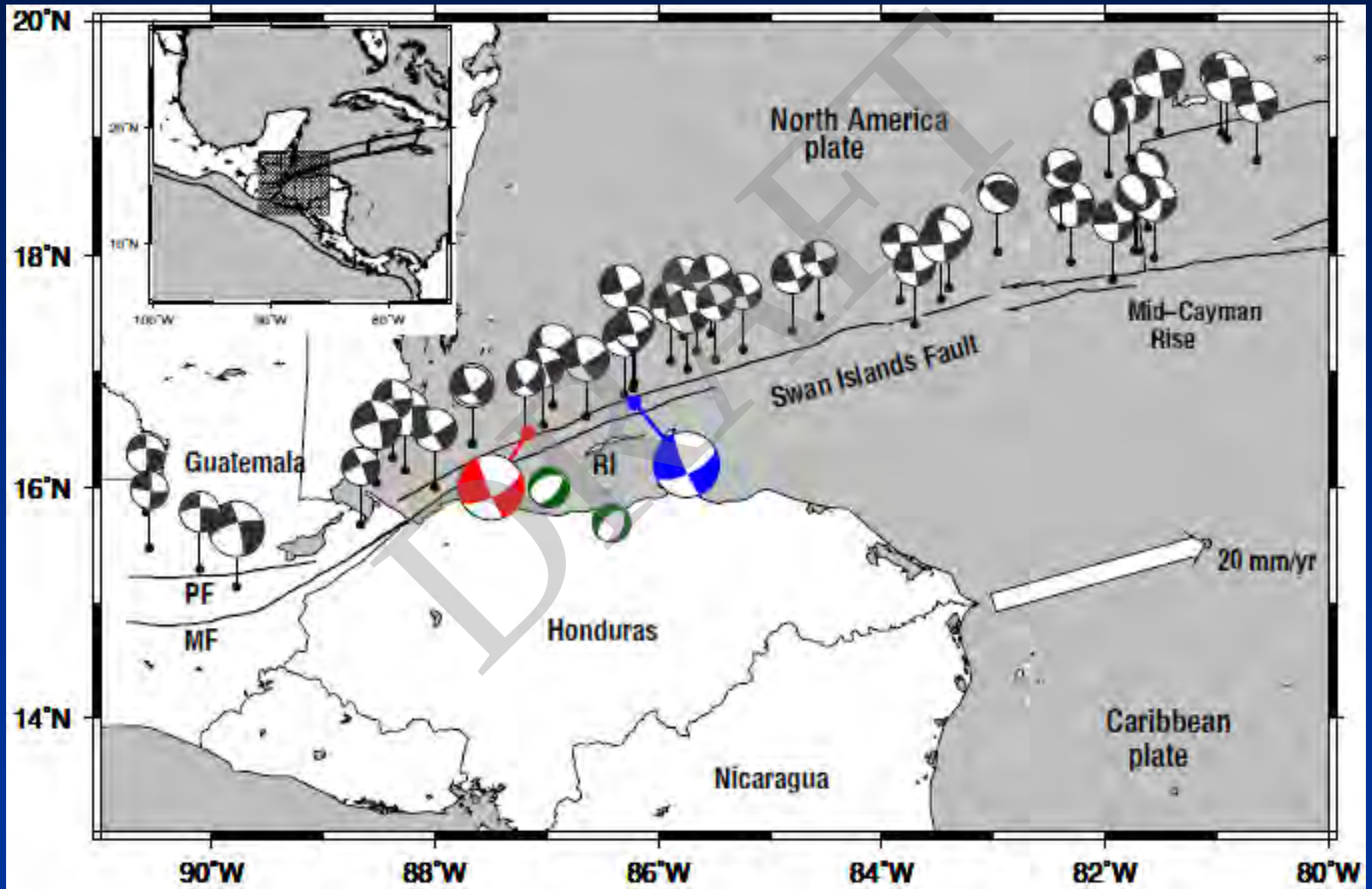
Tectonic Setting

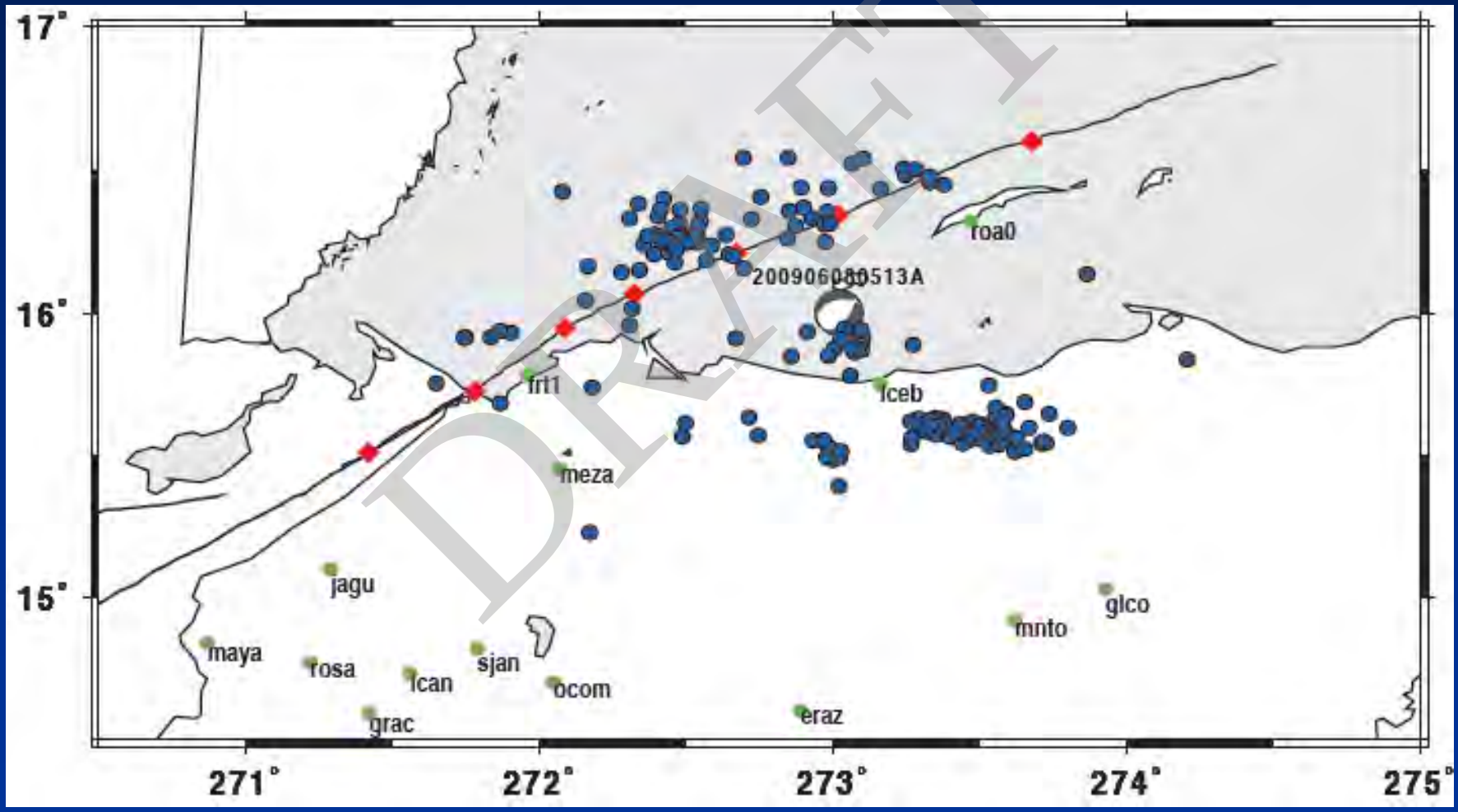


Rodriguez et al., 2009

May 28, 2009 Mw=7.3 EQ



Aftershocks recorded on a portable seismic array deployed by Wilfred Strauch 4 days after mainshock.



Damages on infrastructures caused by the Honduras, May 2009 EQ.

Goals of the study

1. Estimate the magnitude and spatial distribution of coseismic slip on the Swan Island fault using GPS and seismic data.

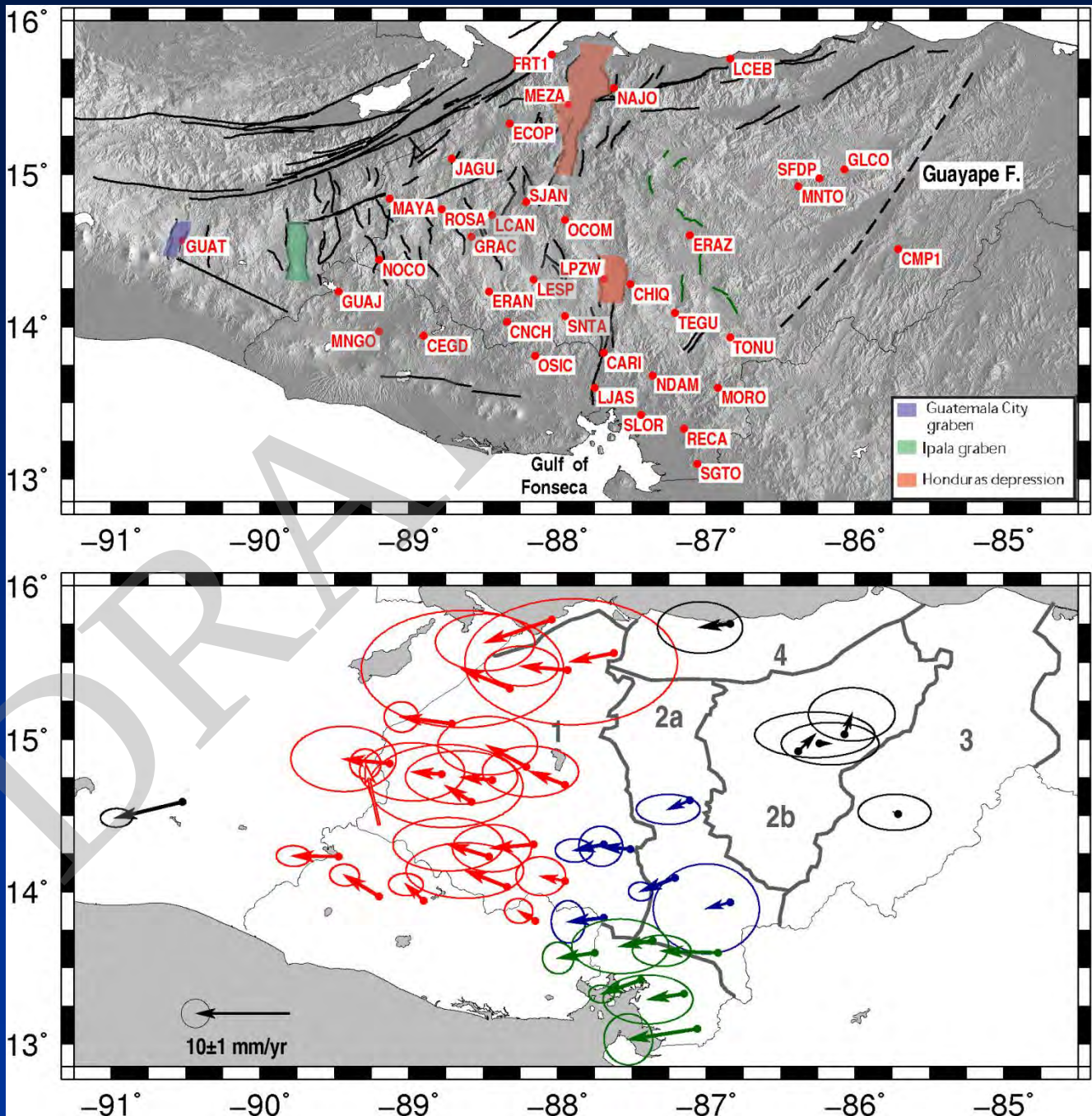
2. Distribution of Coulomb stress changes along the Motagua-Polochic FS and normal faults in northern Honduras.

3. Seismic hazard implication of the results.

Fault slip estimate from GPS

GPS stations and GPS velocity field before the 2009 EQ.

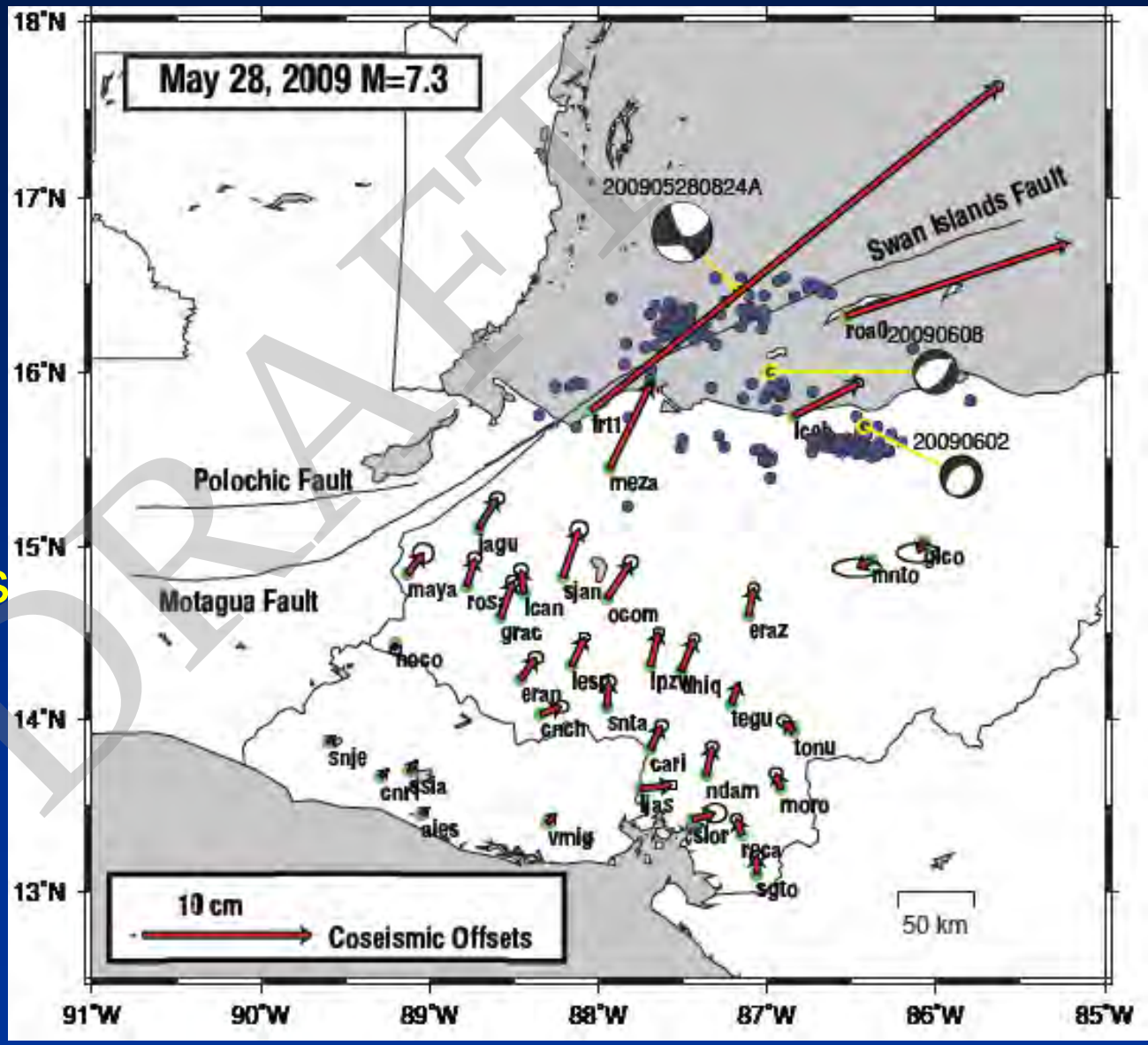
Stations near epicenter were occupied 1-3 weeks after EQ, rest 9-12 month.



Observed coseismic offset

FRT1 308+/- 3 mm
ROA0 138+/- 3 mm
MEZA 55+/- 3mm
LCEB 43 +/- 3mm

6+/-1 mm at
El Salvador stations



Inverse modeling of GPS data

- Inversion of coseismic slip along the fault using BVLS:

$$\begin{bmatrix} \mathbf{WG} \\ \alpha \mathbf{F} \end{bmatrix} \mathbf{m} = \begin{bmatrix} \mathbf{Wd} \\ 0 \end{bmatrix}$$

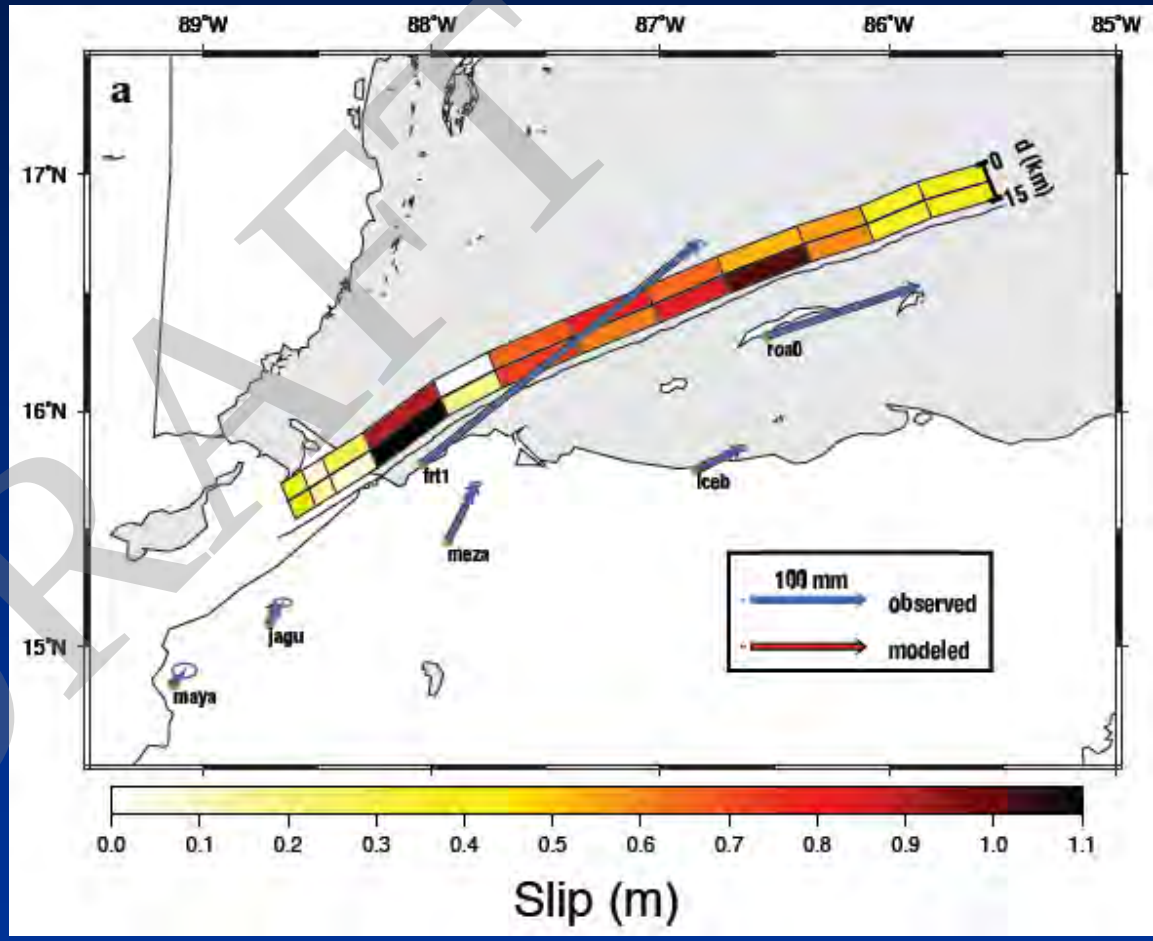
- Forward models to build G matrix generated with DISL code (Larsen, 1992).
- Fault trace from SeaMARC II survey (Rosencranz and Mann 1991; Rogers and Mann 2007). Length used for inversion was determined from aftershocks distribution.
- Only 6 sites nearest to the rupture zone were used, remaining 29 offsets to test the predictive power of solution.

Best fitting fault-slip solution

Fault depth: 15km

Fault slip ranges from 1.1m to 0-0.2 m, averages 0.7-1.0 m close to Roatan Island near epicenter.

Western limit of slip in 2009 nearly reaches eastern limit of 1976 Motagua EQ.

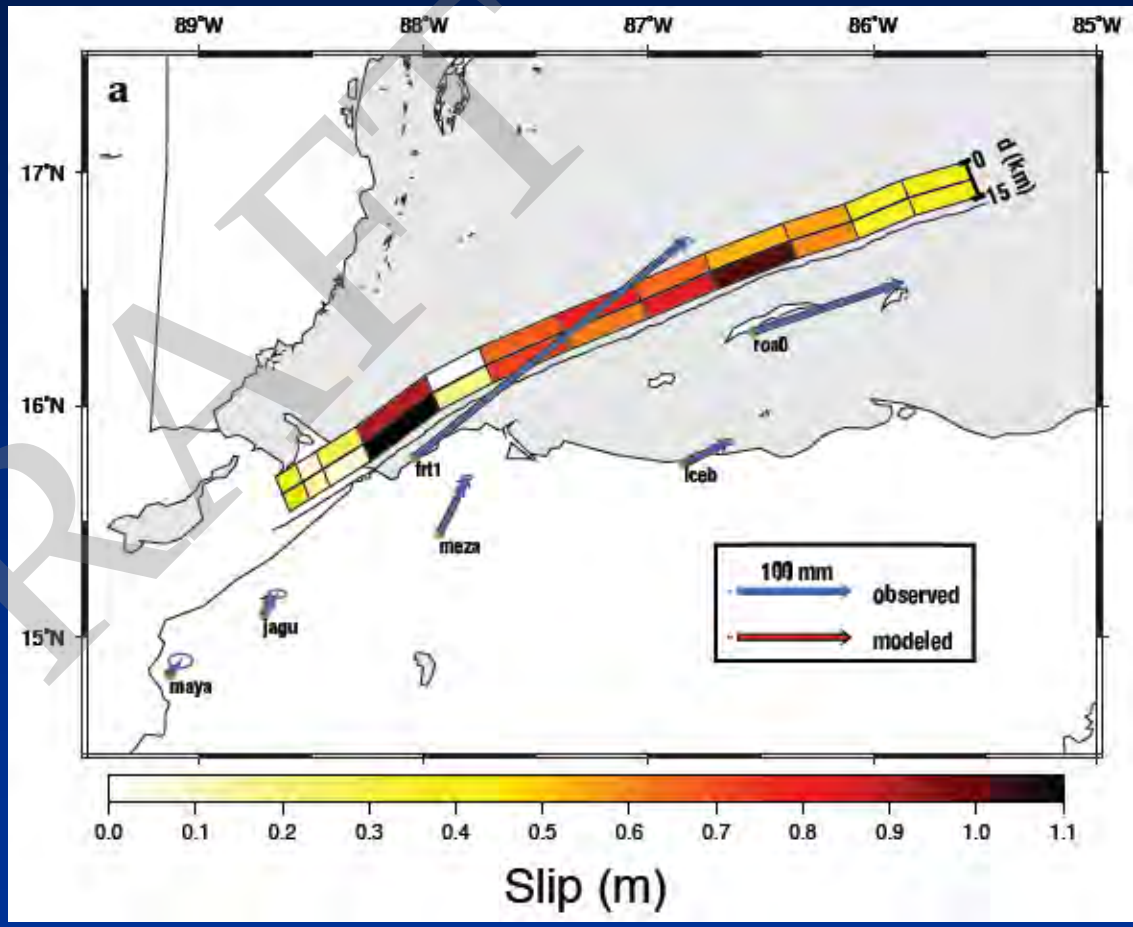


Best fitting fault-slip solution

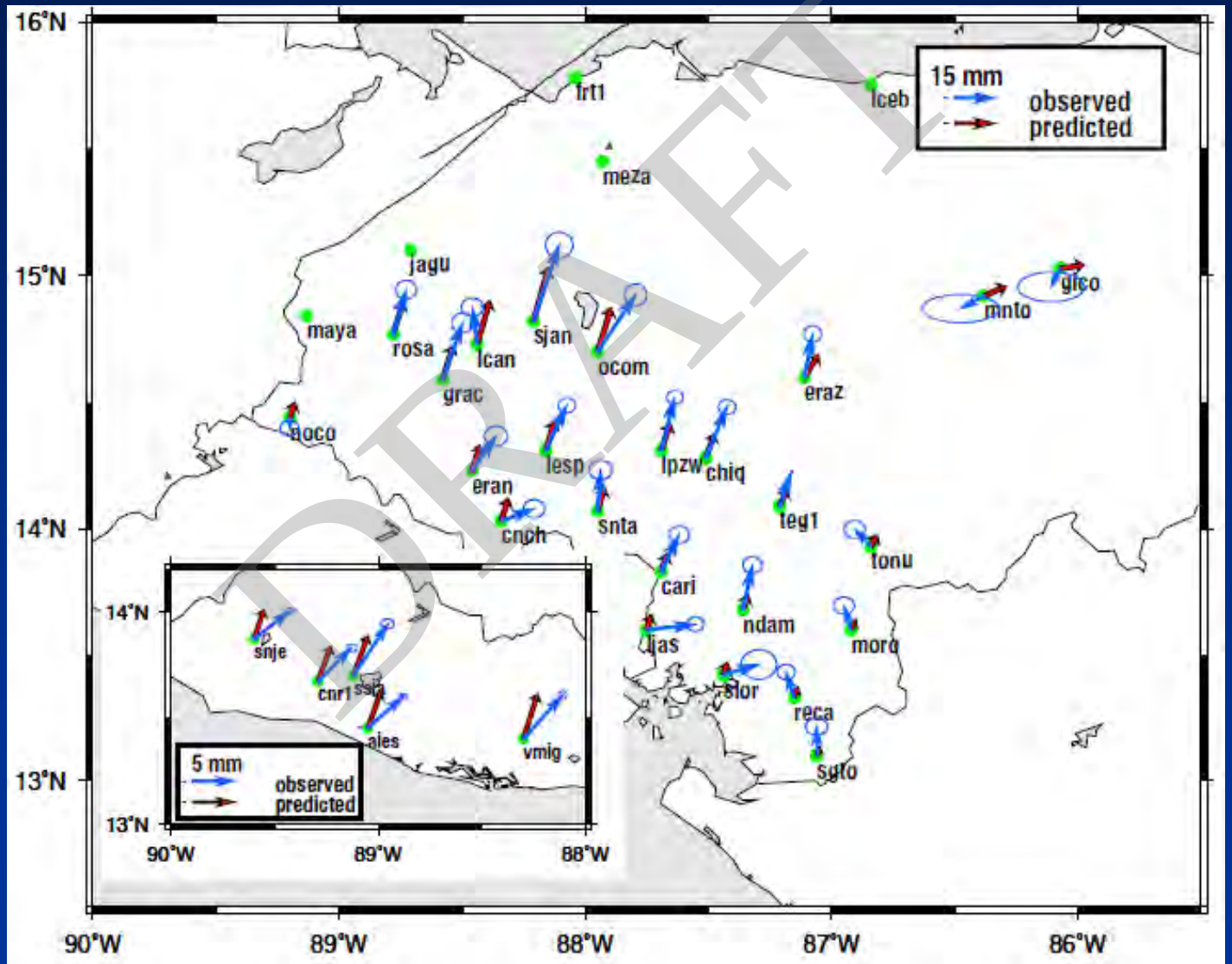
Seismic moment from best fitting solution:
12.8×10^{19} Nm

USGS: 11.0×10^{19} Nm

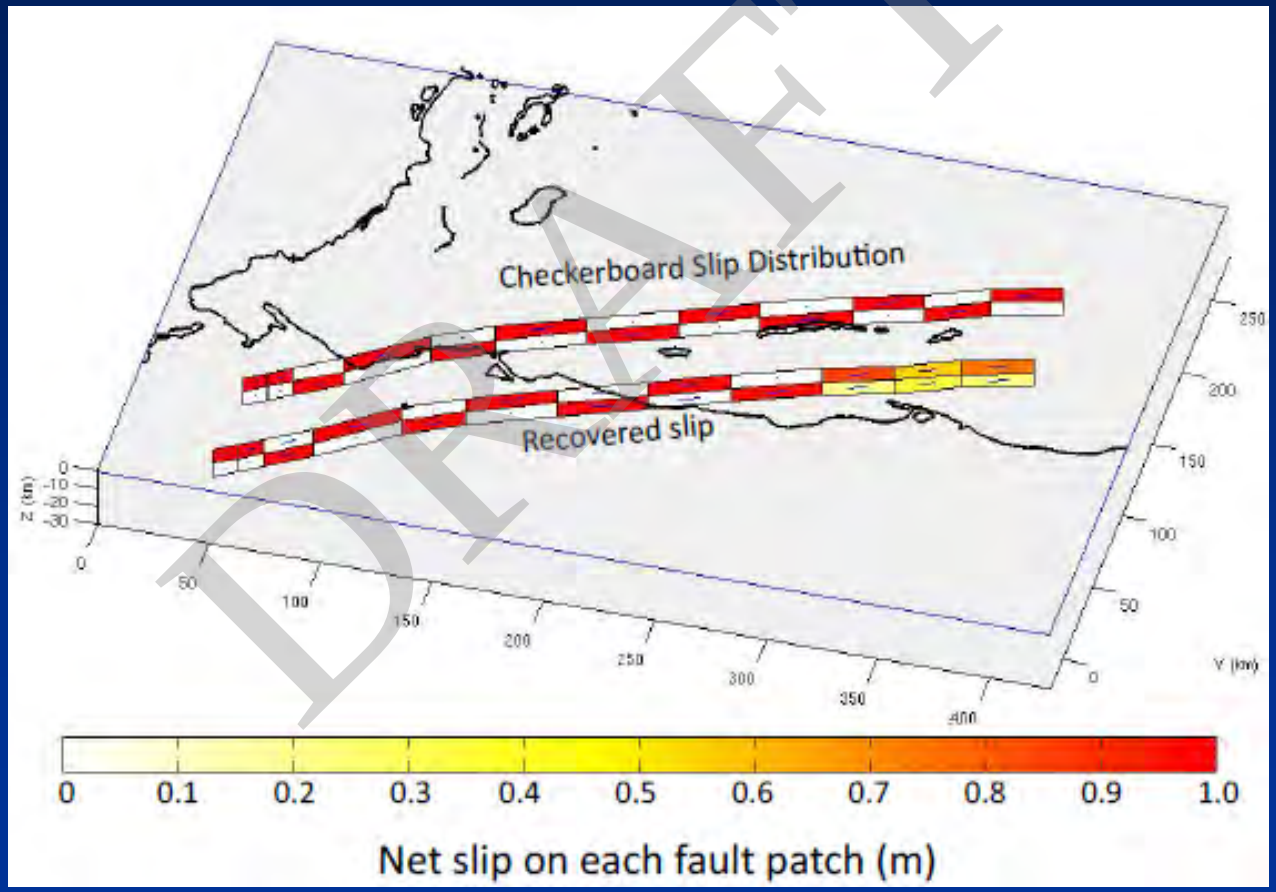
Global CMT catalog:
12.8×10^{19} Nm



Comparison of measured coseismic offsets (blue) to offsets predicted (red) by the best fitting coseismic slip distribution

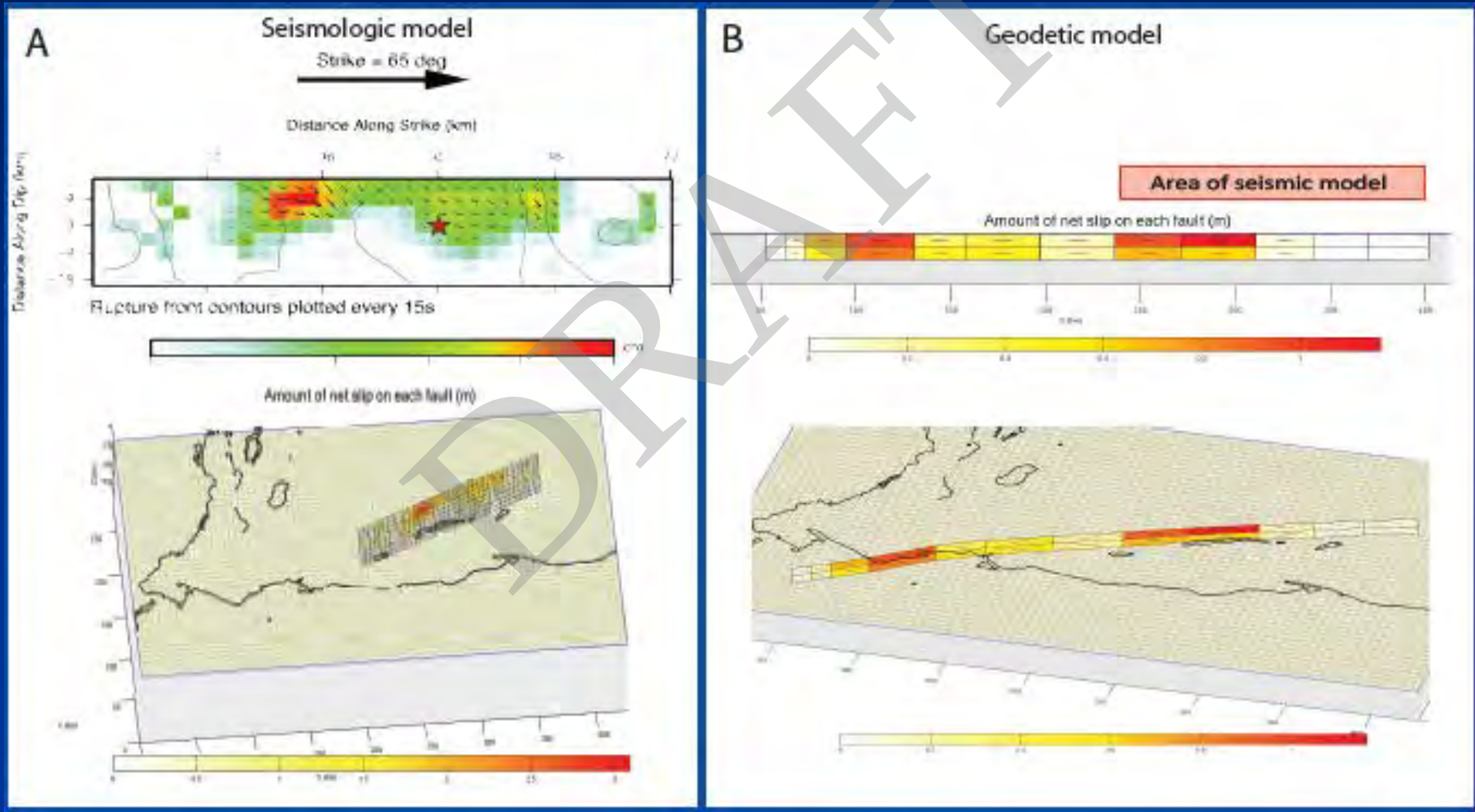


Model validation via checkerboard test

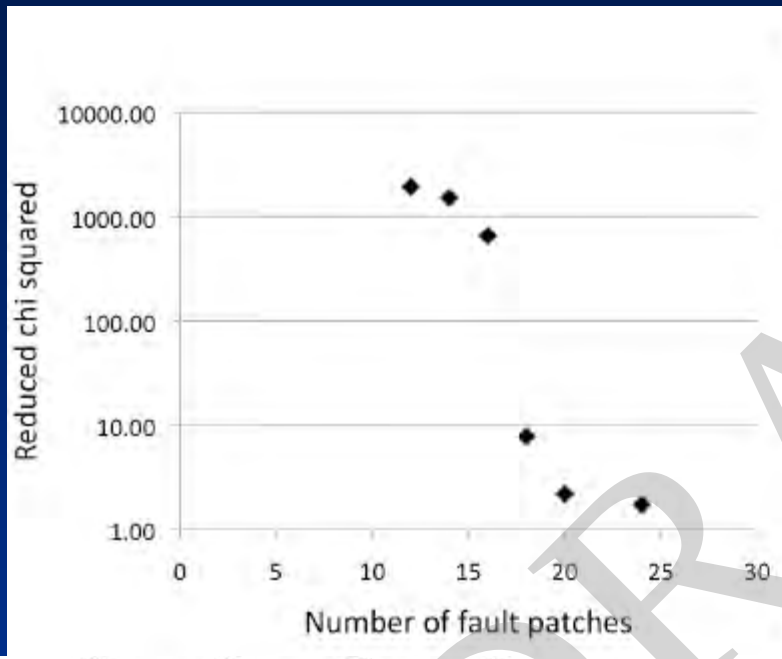


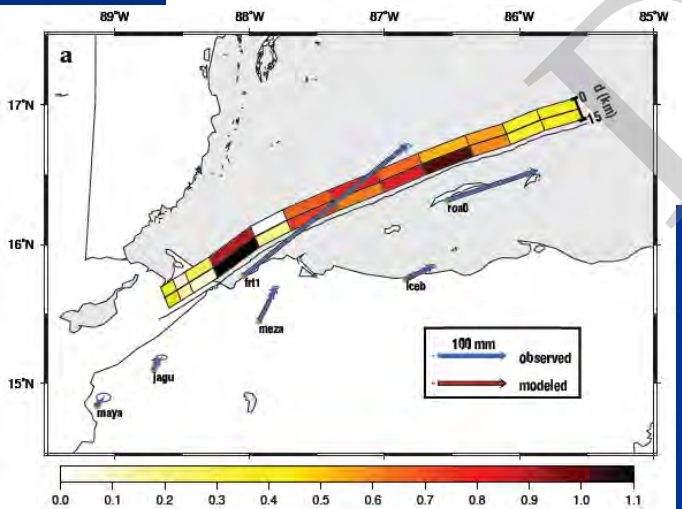
Extent of the western limit of fault

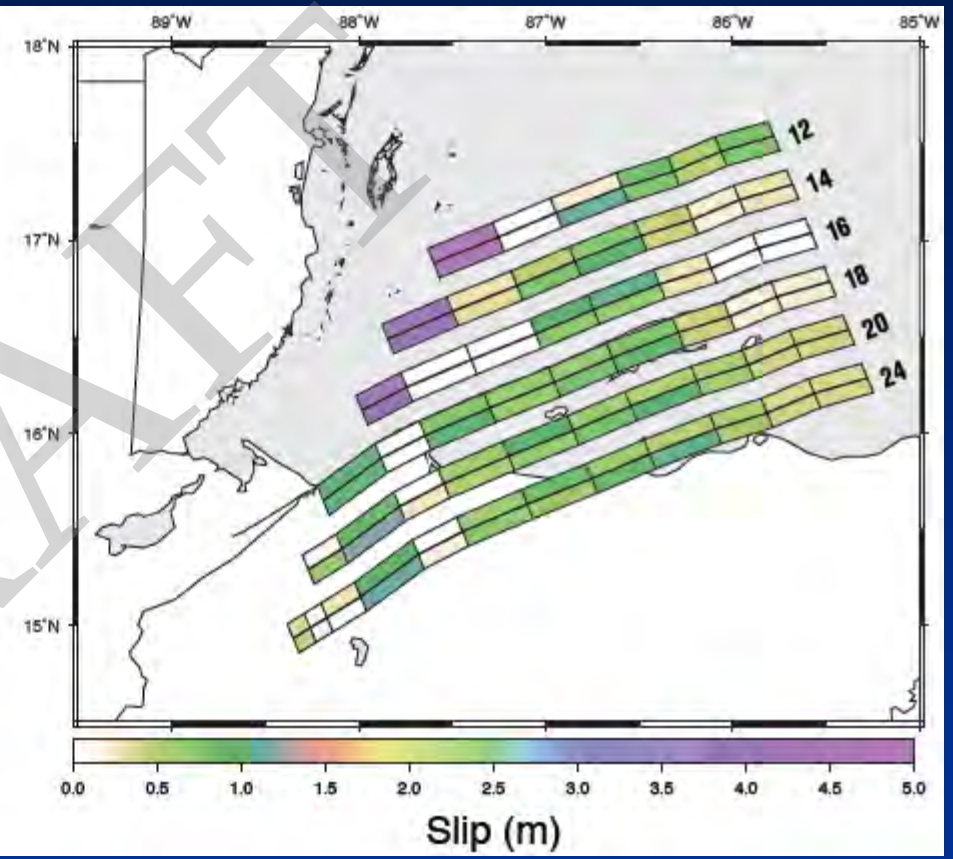
Slip distribution from: Hayes and Ji (2009)



Tradeoff between GPS model fit and assumed western limit of the 2009 earthquake rupture zone.







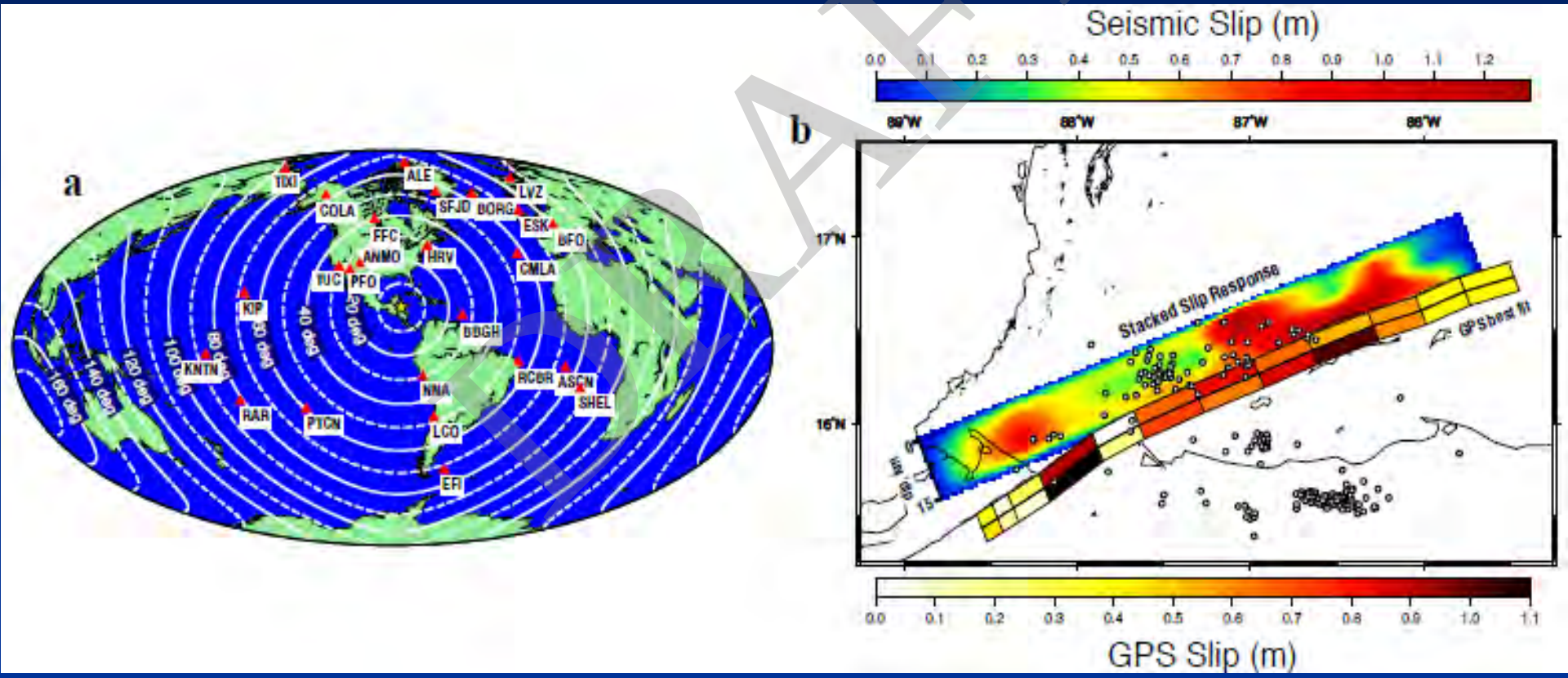
Fault slip estimate from teleseismic waves

Seismic data and fault assumptions

- Coseismic slip was also estimated from an inversion of broadband seismic data using a teleseismic body-wave inversion program described by Kikuchi an Kanamori (1991, 2003).
- 25 stations retrieved from IRIS catalog.
- High signal-to-noise ratio, epicentral distances from 26^{o} to 89^{o}
- The fault plane used extends 15km down and 300km along strike, a dip of 68^{o} the same from the global CMT catalog.

Seismic stations used for the inversion and the best fault slip solution.

Estimated seismic moment 12.6 x 10^{19} Nm.



Coulomb stress changes from 2009 Swan Islands fault EQ and associated triggered earthquakes

Coulomb stress changes

- We calculated the Coulomb stress changes induced by the May 2009 earthquake, using our best-fitting geodetic slip distribution as input to Coulomb 3.2 (Toda et al. 2005; Lin and Stein, 2004).

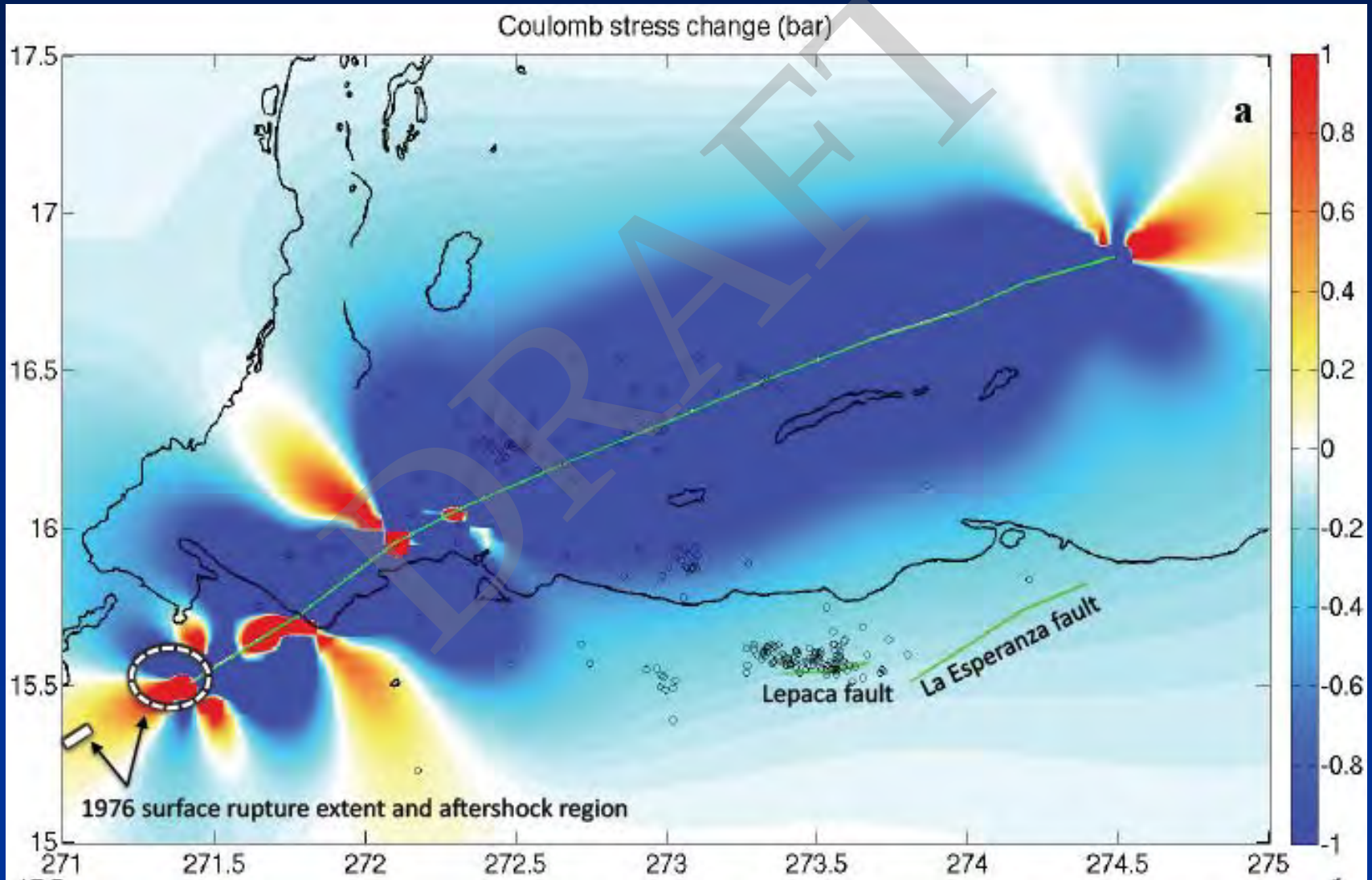
- Stress changes are calculated with the Coulomb failure criterion: $\Delta\sigma_f = \Delta\tau_s + \mu' \Delta\sigma_n$ where $\Delta\sigma_f$ is the change in failure stress on receiver faults, $\Delta\tau_s$ is the shear stress change, μ' is the fault's effective coefficient of friction, and $\Delta\sigma_n$ is the change in normal stress.

Coulomb stress changes

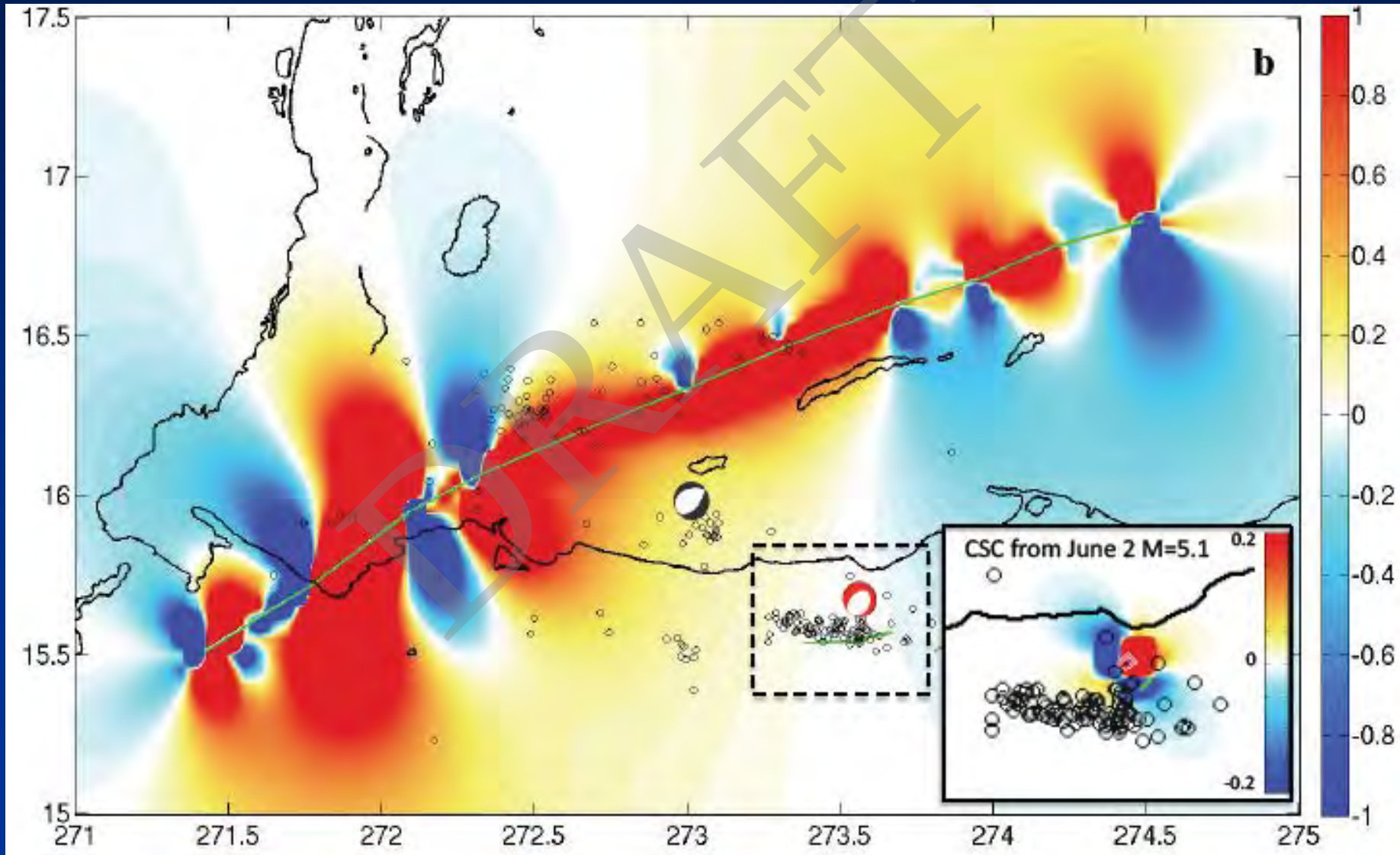
- Material properties assumed for the calculations: shear modulus G (40 GPa) Poisson's ratio n (0.28), and Young's modulus E (102.4 GPa, E = 2G(1 + n)). A typical value of 0.4 is selected for the effective coefficient of fault friction.

- Positive changes in $\Delta\sigma_f$ are thought to promote failure (King et al. 1994)

CSC for strike-slip faults parallel to Swan Islands fault



CSC for normal faults in northern Honduras and offshore

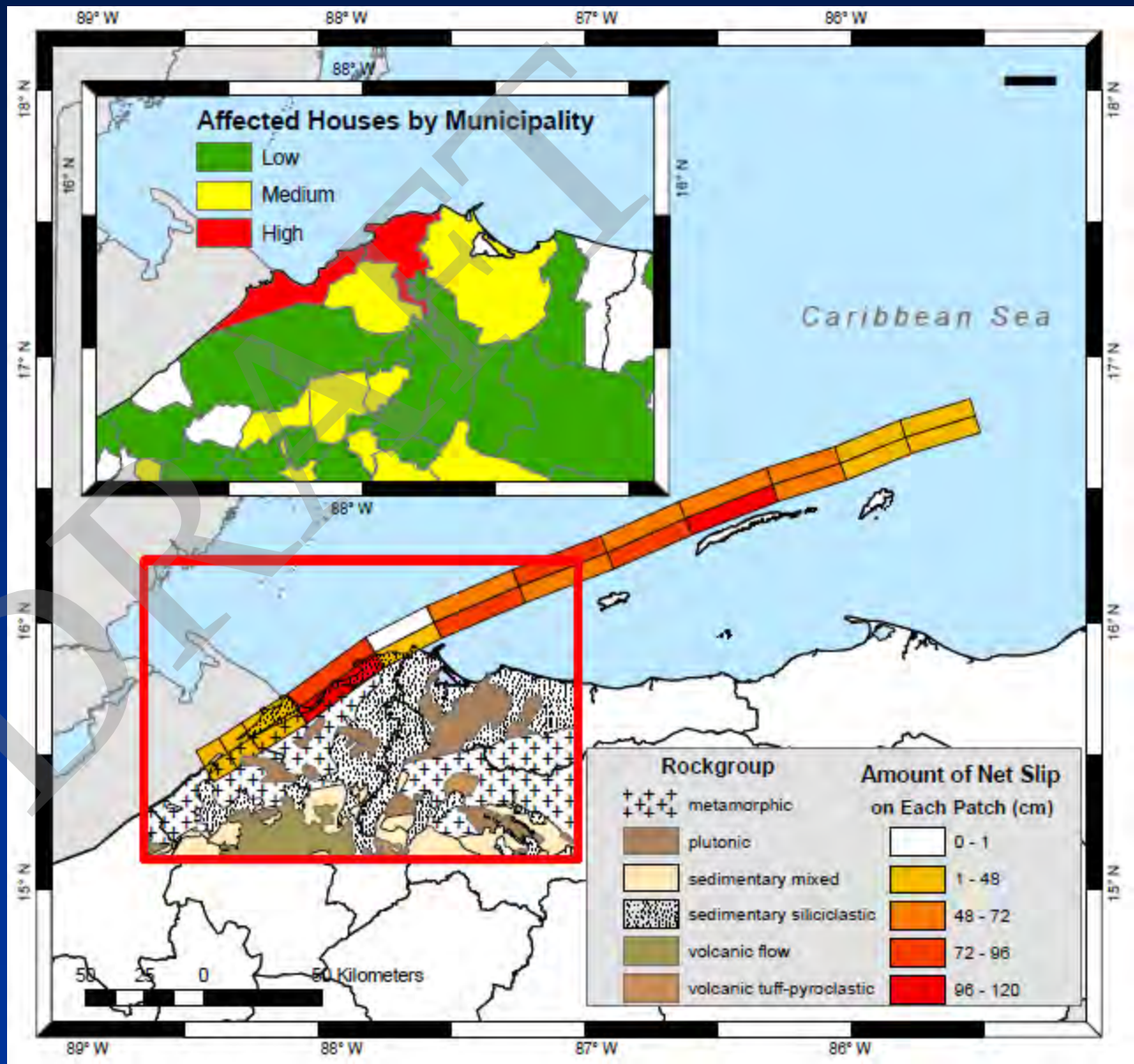


Seismic Hazard implications of results

Role of fault slip in damage in northern Honduras

Communities at more than 150 km from epicenter were damaged.

Local geology and slip distribution caused the damage.



Earthquake triggering

- The changes in Coulomb stress estimated indicate that a major earthquake along the Swan Islands Fault promotes failure along normal faults in northern Honduras.

- The apparent triggering of numerous microseisms along a ~50-km-long length of the strike-slip Lepaca fault by the M=5.1 June 2, 2009 normal-faulting earthquake indicates that triggered normal-faulting earthquakes may promote failure along the E-W-striking strike-slip faults in this province.

Conclusions

- Inversions of GPS coseismic offsets and of teleseismic waves at 25 stations indicate that coseismic fault slip averaged ~0.6m over 300 km long length of Swam Islands fault.
- Two M>5 normal faulting earthquakes 11 days after the main shock indicates that there is a triggering relationship between large earthquakes at the Swan Islands fault and normal faulting in and offshore from northern Honduras.

Thank you!

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