GeoClaw dtopo file

In GeoClaw, the tsunami source is typically given as a seafloor displacement in a dtopo file.

This file has columns `t, x, y, dz` giving the vertical displacement dz at time t at point (x, y).

For each t, sweeping from NW corner to SE corner in same order as a topo file.

Often only 2 times, with $dz = 0$ at $t = 0$ and final displacement dz at $t = 1$ second, for example.

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Often only 2 times, with $dz = 0$ at $t = 0$ and final displacement dz at $t = 1$ second, for example.

Instantaneous displacement is assumed at each time.

Topo is changed by dz while h is left alone, so entire water column is lifted.

Okada model for seafloor motion

Converts slip on a small planar segment of a fault beneath the earth to the vertical motion of the earth surface.

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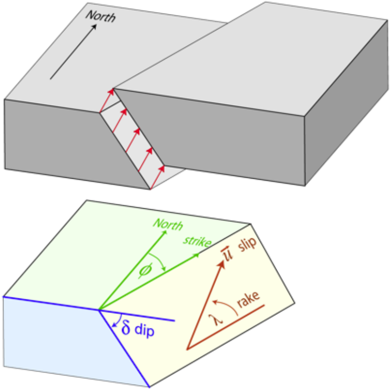
- Larger fault modeled by linear combination of these.
- Dynamic rupture can be approximated by adding in at different times.
- Does not model seismic waves generated, only final displacement.
- Assumes earth surface is flat, but resulting Δz is then applied to the real $B(x, y)$.

Fault plane geometry



The Okada fault geometry.

http://www.gps.alaska.edu/jeff/Classes/GEOS655/homework.html

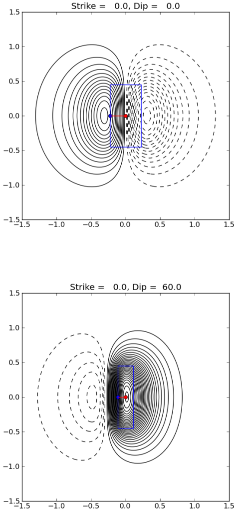
Okada model for seafloor motion

Parameters: Looking along one edge of fault (the strike direction), the plane dips down to the right.

- Strike: Angle of strike direction (clockwise from North).
- Dip: The angle downwards of dip (between $0°$ and $90°$).
- Rake: The angle of the the slip on the plane relative to the strike direction (counter-clockwise).
- Slip or Dislocation: The distance the top side of plane slips relative to the bottom, in meters.
- Longitude, Latitude: (x, y) coordinates of one point on fault plane, usually either centroid or top center.
- Depth: Depth below earth surface of the same point.
- Length, Width: Of fault plane, in meters.

1 cm contours of dz from Okada model

Depth $= 50e3$, length $= 100e3$, width $= 50e3$, rake$= 90°$, slip $= 1$ m



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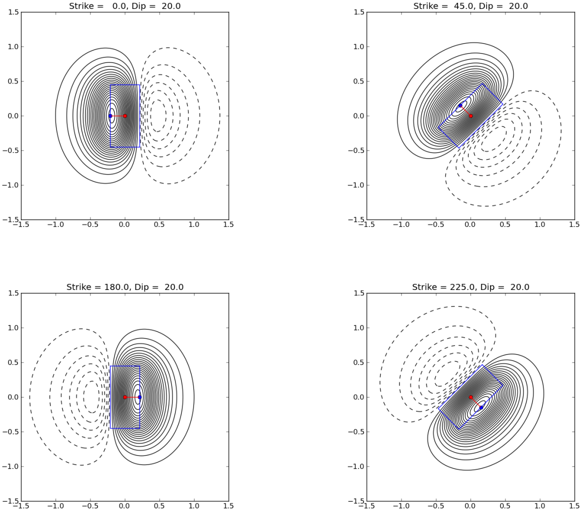

Subfaults

Often a fault is described by many distinct fault segments.

Okada model is applied to each separately and then the sum of all the resulting `dZ` displacements is used for the seafloor deformation.

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Okada model is applied to each separately and then the sum of all the resulting `dZ` displacements is used for the seafloor deformation.

Dynamic rupture: Each subfault may rupture at a different time, with a "rise time" specifying the time period over which this segment moves.

Okada model can be applied to each piece, accumulated into dtopo file.

Some subfault examples

- **UCSB model of Tohoku 2011** Click on “Subfault format” near bottom of page.
- **USGS model of Tohoku 2011** Click on “Scientific and technical” and then “Finite fault model”.

Note that file formats are not the same!

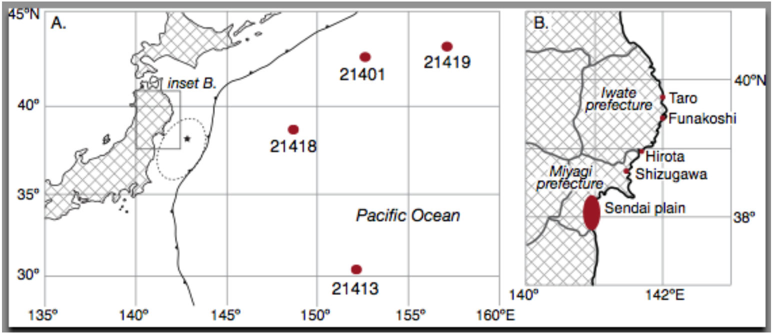
Comparison of earthquake source models for the 2011 Tohoku-oki event using tsunami simulations and near field observations,
by Breanyn T MacInnes, Aditya Riadi Gusman, RJL, Yuichiro Tanioka

http://faculty.washington.edu/rjl/pubs/tohoku1/

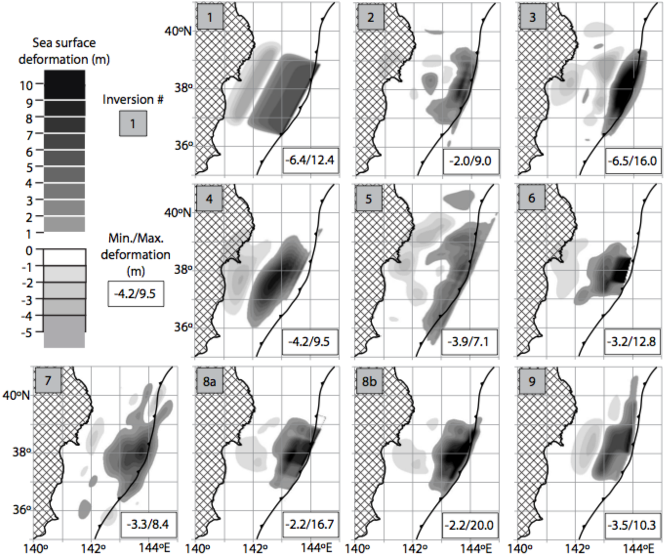
Sources compared:

- 1. GCMT
- 2. USGC (Hayes, 2011)
- 3. UCSB (Shao, et. al., 2011)
- 4. Ammon
- 5. Caltech
- 6. Fujii
- 7. Saito, et. al.
- 8a. Gusman, et. al.
- 8b. Gusman (with additional slip to north)
- 9. PMEL, NOAA (Tang et. al., Wei et. al.)

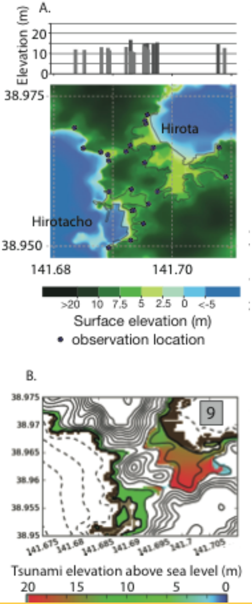
Tohoku source region and DART buoys



Seafloor deformation of various source models



Hirota, Japan



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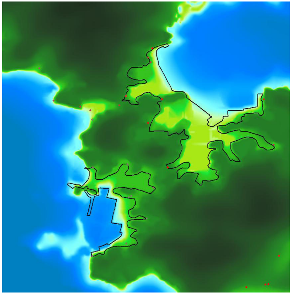
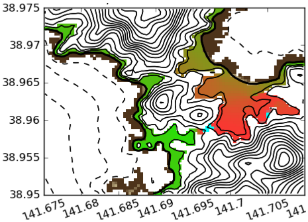
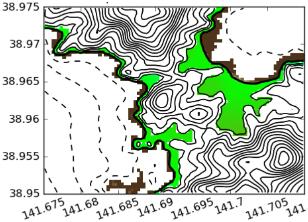


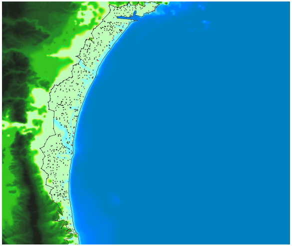
Gusman earthquake model:



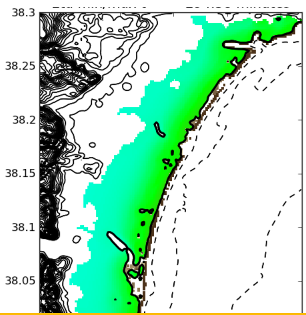
USGS earthquake model:

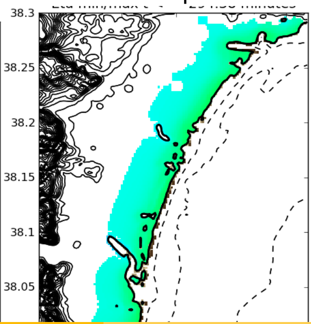


Sendai Plain



UCSB earthquake model: USGS earthquake model:





Source inversion

Given measurement data from earthquake and/or tsunami
(seismic, GPS, tide gauge, DART buoy, ...),
determine motion of seafloor that created tsunami.

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Inversion using only tsunami data may give seafloor deformation directly.

Seafloor motion may still be parameterized using earthquake fault parameters and Okada model, e.g. unit source approach of NOAA.

NOAA unit sources for subduction zone

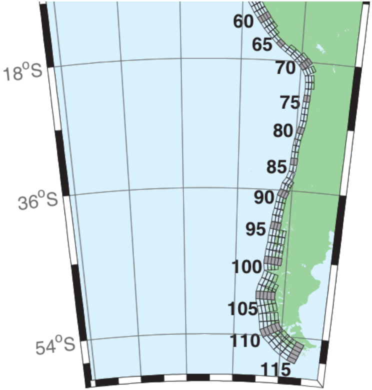

Figure B2: Central and South America Subduction Zone unit sources.

From: Tang, L., V.V. Titov, and C.D. Chamberlin (2010): A Tsunami Forecast Model for Hilo, Hawaii. NOAA OAR Special Report, PMEL Tsunami Forecast Series: Vol. 1, 94

http://nctr.pmel.noaa.gov/pubs.html

National Oceanic and Atmospheric Administration's

National Data Buoy Center

Center of Excellence in Marine Technology

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- Classic Maps
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  - MMS ADCP
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- APEX
- TAO
- DODS

Storm Special! View the latest observations near Atlantic HURRICANE IGOR as of INTERMEDIATE ADVISORY NUMBER 53A @ 800 AM AST TUE SEP 21 2010, Atlantic TROPICAL STORM LISA as of ADVISORY NUMBER 2 @ 500 AM EDT TUE SEP 21 2010 and East Pacific TROPICAL STORM GEORGETTE of SPECIAL ADVISORY NUMBER 1 @ 500 AM PDT TUE SEP 21 2010.

Station 32412 - 630 NM Southwest of Lima, Peru

Owned and maintained by National Data Buoy Center
2.6-meter discus buoy
DART II payload
17.975 S 86.392 W (17°58'30" S 86°23'30" W)

Important Notice to Mariners

Meteorological Observations from Nearby Stations and Ships

Station 32412 - 630 NM Southwest of Lima, Peru

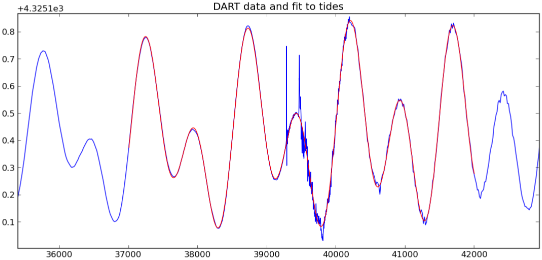
Owned and maintained by National Data Buoy Center
17.975 S 86.392 W (17°58'30" S 86°23'30" W)

Available historical data for station 32412 include:

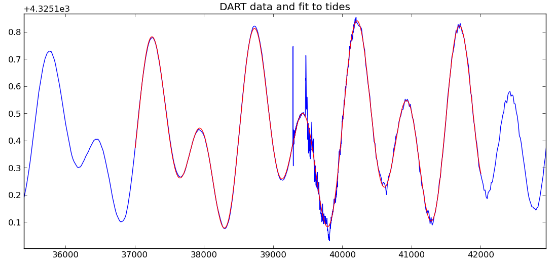
- **Quality controlled data for 2010** (*data descriptions*)
  - **Water column height (Tsunami) (DART) data:** Jan Feb Mar Apr May Jun Jul
- **Historical data** (*data descriptions*)
  - **Water column height (Tsunami) (DART) data:** 2007 2008 2009

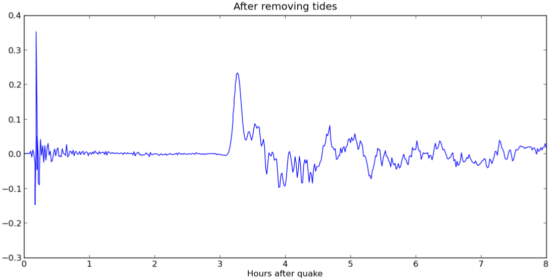
www.ndbc.noaa.gov/station_page.php?station=32412

DART buoy data

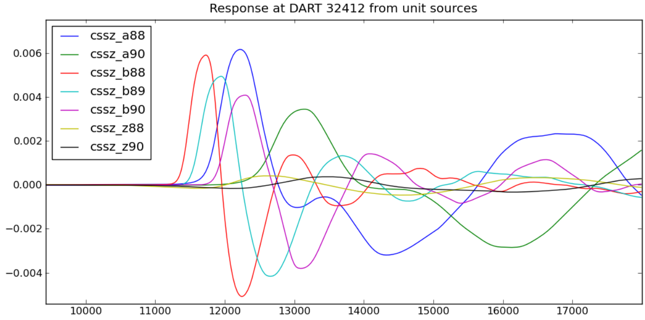


DART buoy data





Response at DART buoy from unit earthquakes



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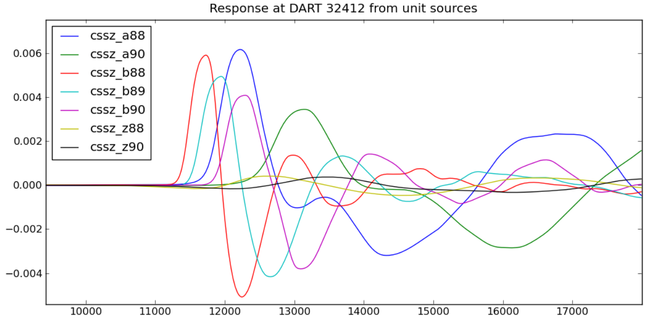
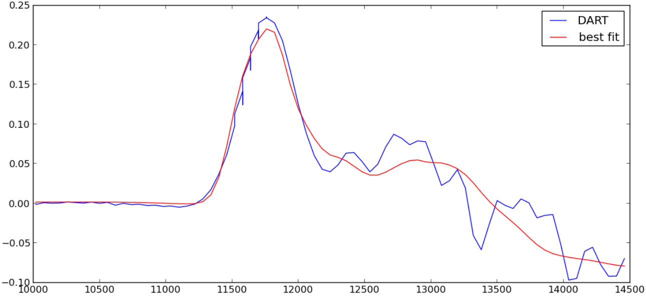


Propagation in deep water is essentially linear...

Fit linear combination of these responses to DART data.

Best fit from unit earthquakes

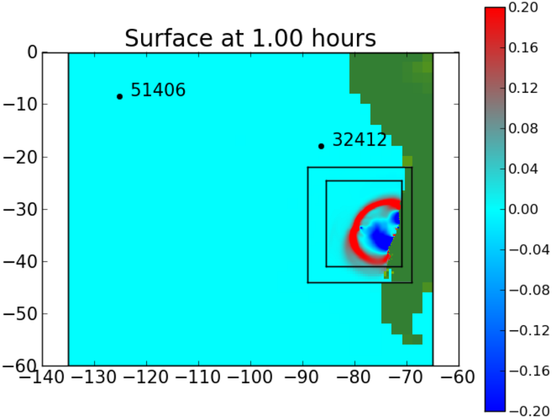


Best fit with constraint that all coefficients (dislocations) positive.

DART buoy data

Deep-ocean Assessment and Reporting of Tsunamis

NOAA's Network of pressure gauges on the ocean floor



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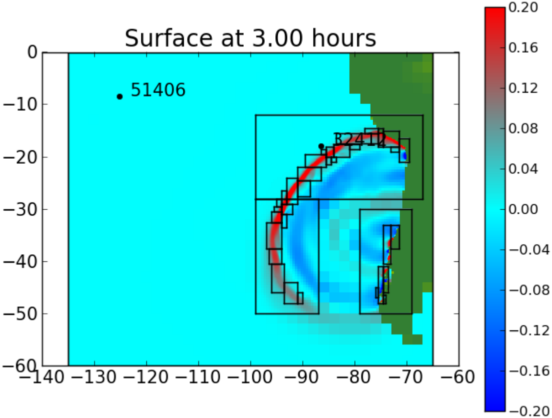

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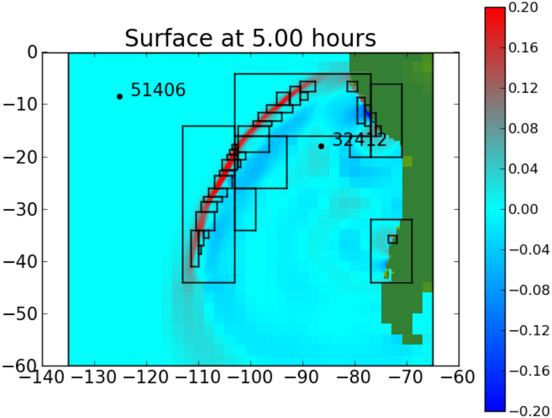

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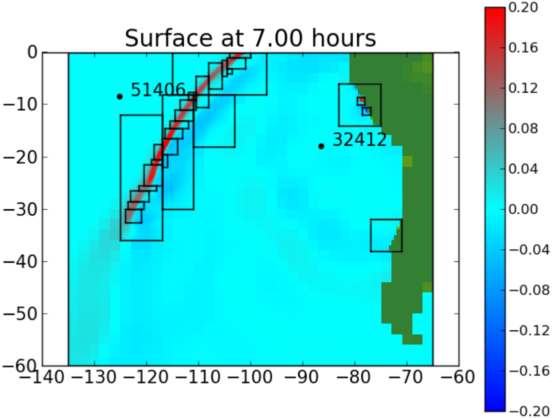

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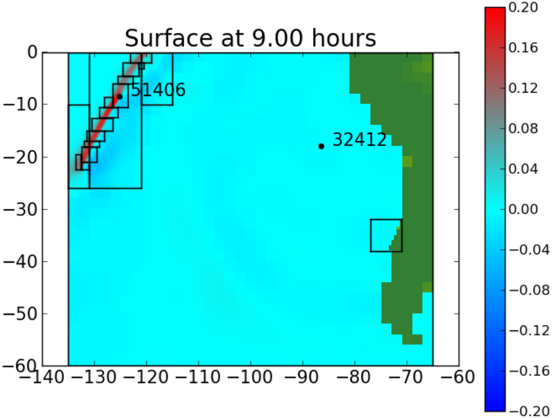

Response at DART 51406