NATIONAL GEODETIC SURVEY

# HTDP and the OPUS connection.

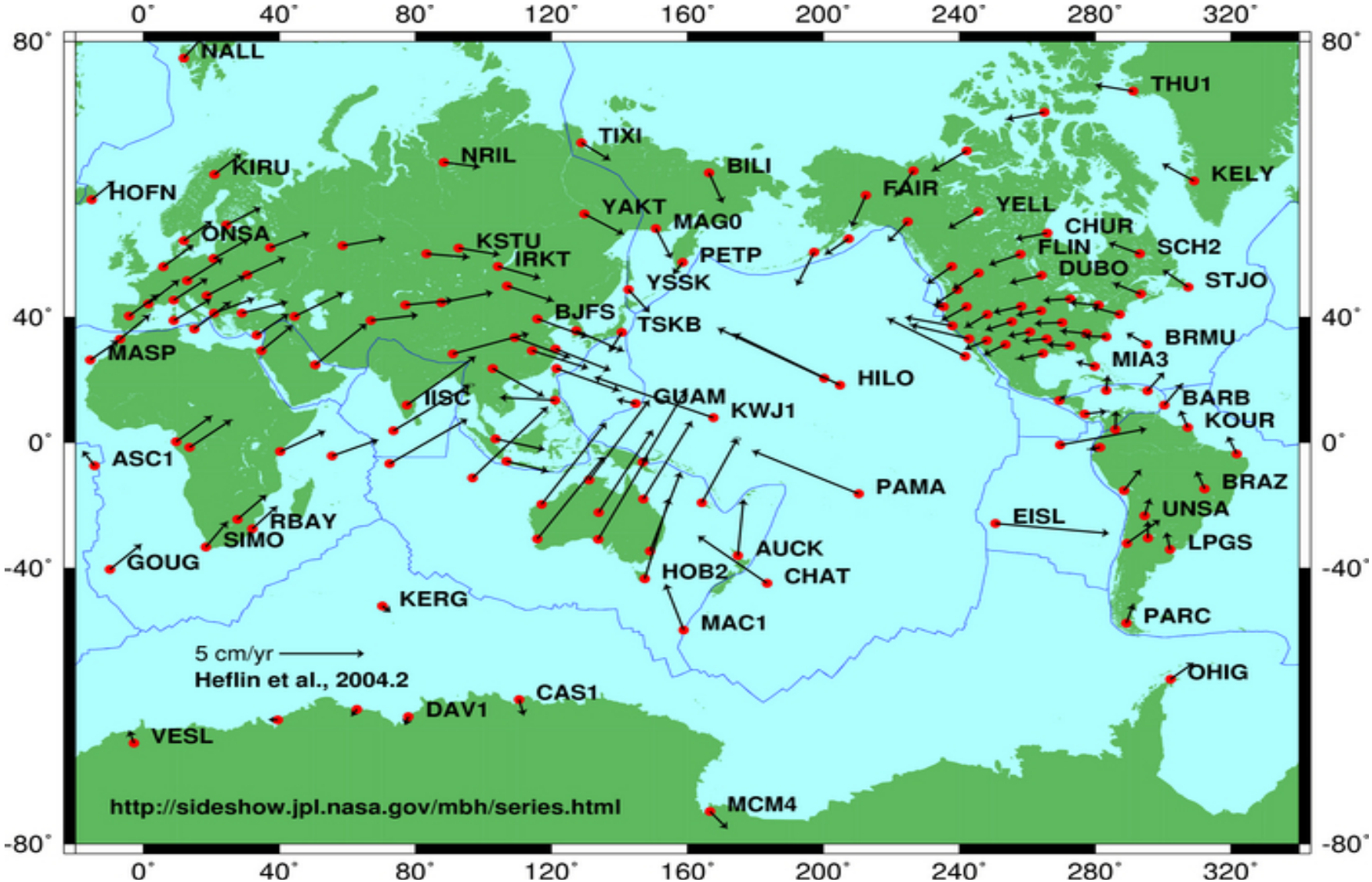
Chris Pearson
Christopher.pearson@illinois.gov

- Richard Snay
- Robert McCaffrey
- Julie Elliott and Jeff Freymuller
- Roland Bergman
- Ingrid Johansen and Jessica Murray-Moraleda
- Eric Calais and Andy Freed
- CSRC Yehuda Paul and Lynnette

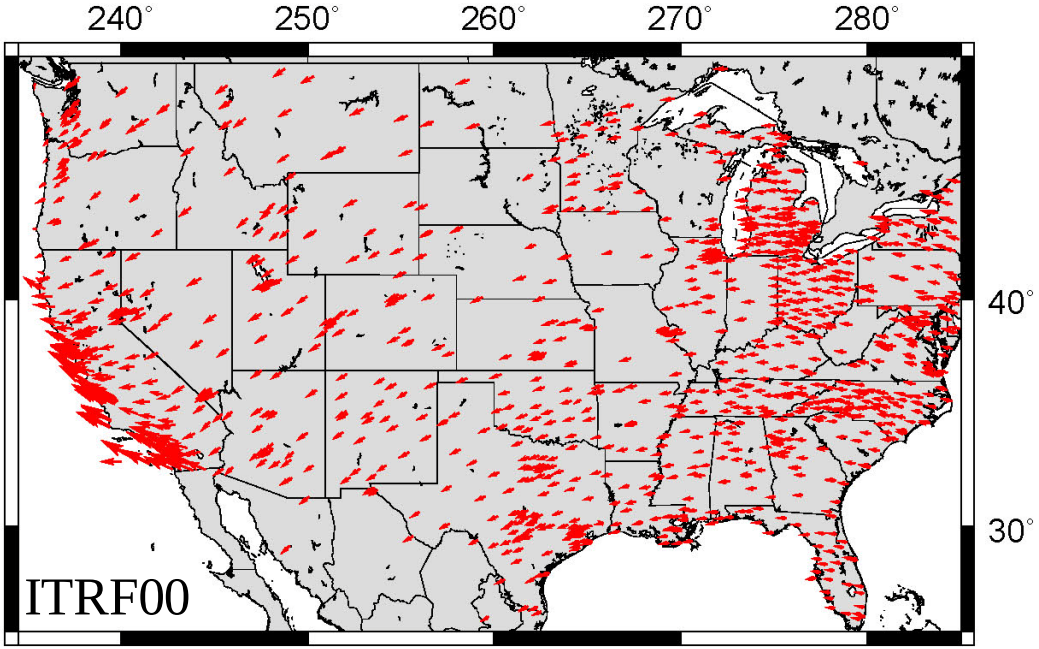
National Oceanic and Atmospheric Administration

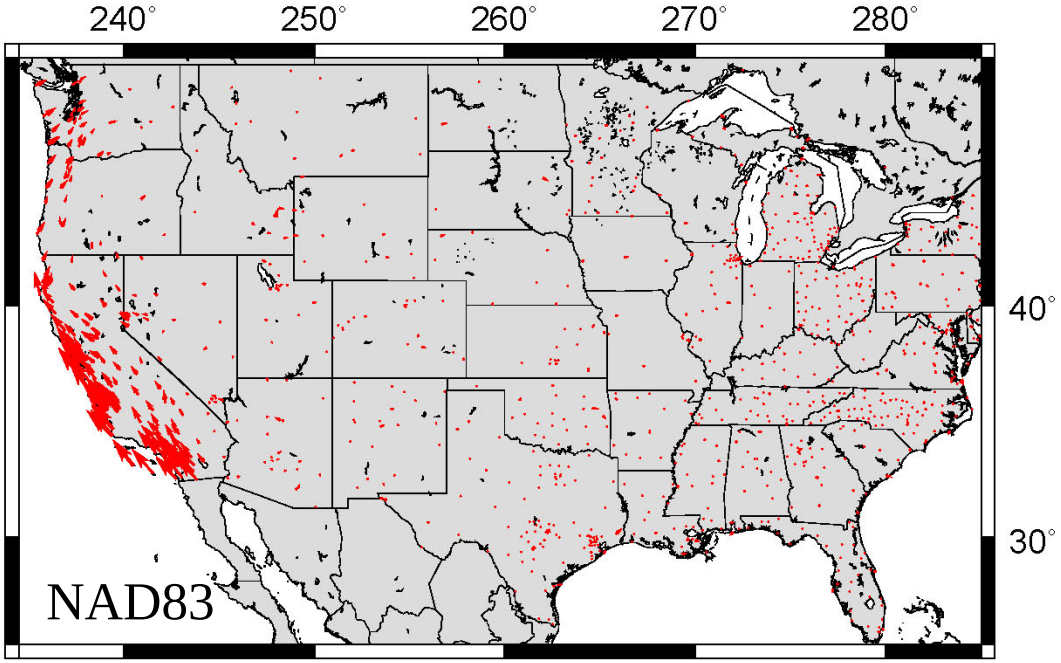
# OUTLINE

- Discuss nature of crustal motion
- Describe HTDP crustal motion model
- Demonstrate HTDP software
- Discuss software's applications
- Discuss future software enhancements

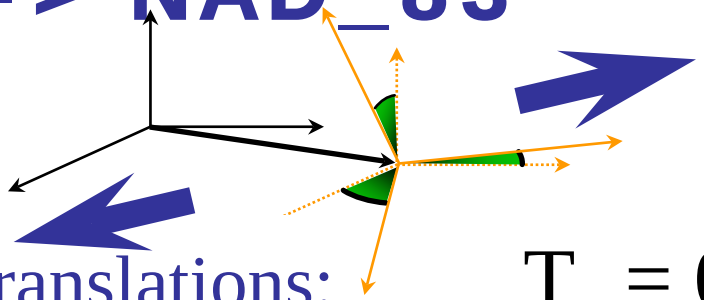

0˚
40˚
80˚
120˚
160˚
200˚
240˚
280˚
320˚
80˚
40˚
0˚
-40˚
-80˚
NALL
THU1
TIXI
NRIL
KIRU
BILI
KELY
HOFN
FAIR
YELL
YAKT
MAG0
CHUR
ONSA
KSTU
FLIN
SCH2
IRKT
PETP
DUBO
YSSK
STJO
BJFS
TSKB
BRMU
MASP
MIA3
HILO
IISC
GUAM
BARB
KWJ1
KOUR
ASC1
PAMA
BRAZ
UNSA
RBAY
EISL
SIMO
LPGS
AUCK
GOUG
HOB2
CHAT
KERG
PARC
MAC1
5 cm/yr
Heflin et al., 2004.2
OHIG
CAS1
DAV1
VESL
http://sideshow.jpl.nasa.gov/mbh/series.html
MCM4

- **ITRF** (yyyy) **I**nternational **T**errestrial **R**eference **F**rame
- All coordinates change to reflect tectonic motion
- NAD83 –in stable North American coordinates are constant
- In the far west coordinates not constant so epoch dates are important



# Transformation Parameters ITRF96 -> NAD_83



Translations: $T_x = 0.9910$ meters

$T_y = -1.9072$ meters

$T_z = -0.5129$ meters

Rotations: $R_x = [25.79 + 0.0532 \bullet (t - 1997.0)] \bullet k$

in radians $R_y = [9.65 - 0.7423 \bullet (t - 1997.0)] \bullet k$

$R_z = [11.66 - 0.0316 \bullet (t - 1997.0)] \bullet k$

Scale change: $S = 0.0$ (unitless)

where $t$ = date in years (eg., 1999.0 = 1 Jan 1999)

and $k = 4.84813681 \bullet (10^{**}-9)$

# Coordinates

NATIONAL GEODETIC SURVEY

National Geodetic Survey - CORS

```
ITRF00 POSITION (EPOCH 1997.0)

        Antenna Reference Point(ARP): PIGEON POINT 6 CORS ARP
        -----------------------------------------------------
                              PID = DI0900


 ITRF00 POSITION (EPOCH 1997.0)
 Computed in Aug. 2006 using 16 days of data.
     X =  -2725248.640 m     latitude     =  37 11 12.57747 N
     Y =  -4295998.534 m     longitude    = 122 23 23.20293 W
     Z =   3833935.240 m     ellipsoid height =    5.924   m

 ITRF00 VELOCITY
 Set equal to vel ppt1, adopted from NGS multiyear 1994-2003 in Jun. 2006.
     VX =  -0.0270 m/yr      northward =   0.0219 m/yr
     VY =   0.0339 m/yr      eastward  =  -0.0410 m/yr
     VZ =   0.0167 m/yr      upward    =  -0.0012 m/yr


 NAD_83 (CORS96) POSITION (EPOCH 2002.0)
 Transformed from ITRF00 (epoch 1997.0) position in Aug. 2006.
     X =  -2725248.117 m     latitude     =  37 11 12.56573 N
     Y =  -4295999.630 m     longitude    = 122 23 23.16119 W
     Z =   3833935.276 m     ellipsoid height =    6.459   m

 NAD_83 (CORS96) VELOCITY
 Transformed from ITRF00 velocity in Aug. 2006.
     VX =  -0.0107 m/yr      northward =   0.0364 m/yr
     VY =   0.0345 m/yr      eastward  =  -0.0275 m/yr
     VZ =   0.0279 m/yr      upward    =  -0.0018 m/yr
```

- ITRF velocities are nonzero
- NAD83 velocities zero for NC Not for CA
- Current antenna listed

# A brief review of horizontal motions

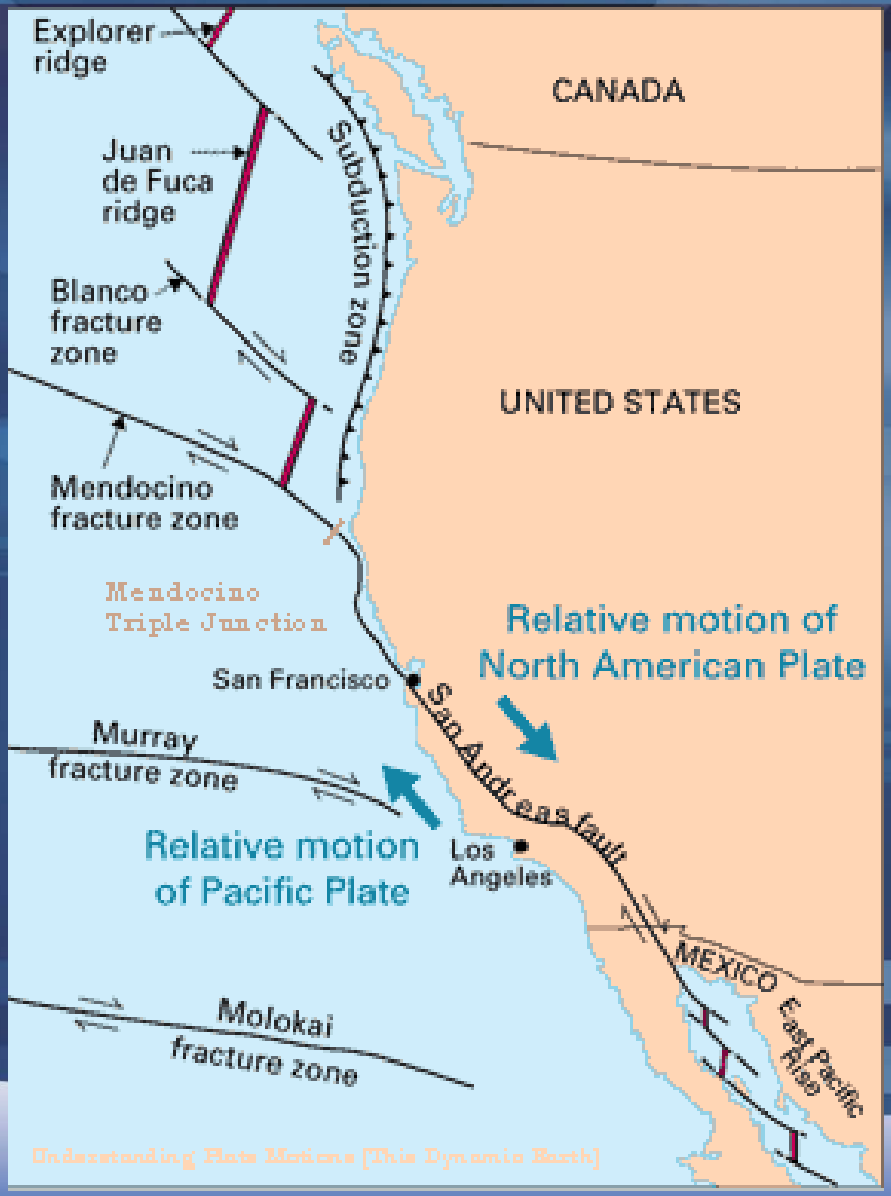


- The North American Plate contains almost all of the US
- except for a small part of western US which is on the Pacific Plate.
- The plate boundary zone follows the Pacific coast all the way to Alaska.
- In the ITRF and WGS84 reference frames, all points on both the Pacific and North American plates have non-zero velocities
- The NAD83 reference frame is defined so that all points on the North American Plate located away from this plate boundary zone will have zero horizontal velocities.
- Points located within the Pacific-North American plate boundary zone will have NAD_83 velocities magnitudes of up to 5 cm/yr.
- Accurate surveying in the western US requires a model describing crustal velocities and earthquakes to allow survey measurements to be corrected
- HTDP (Horizontal Time Dependent Positioning) software that enables its user to make these corrections

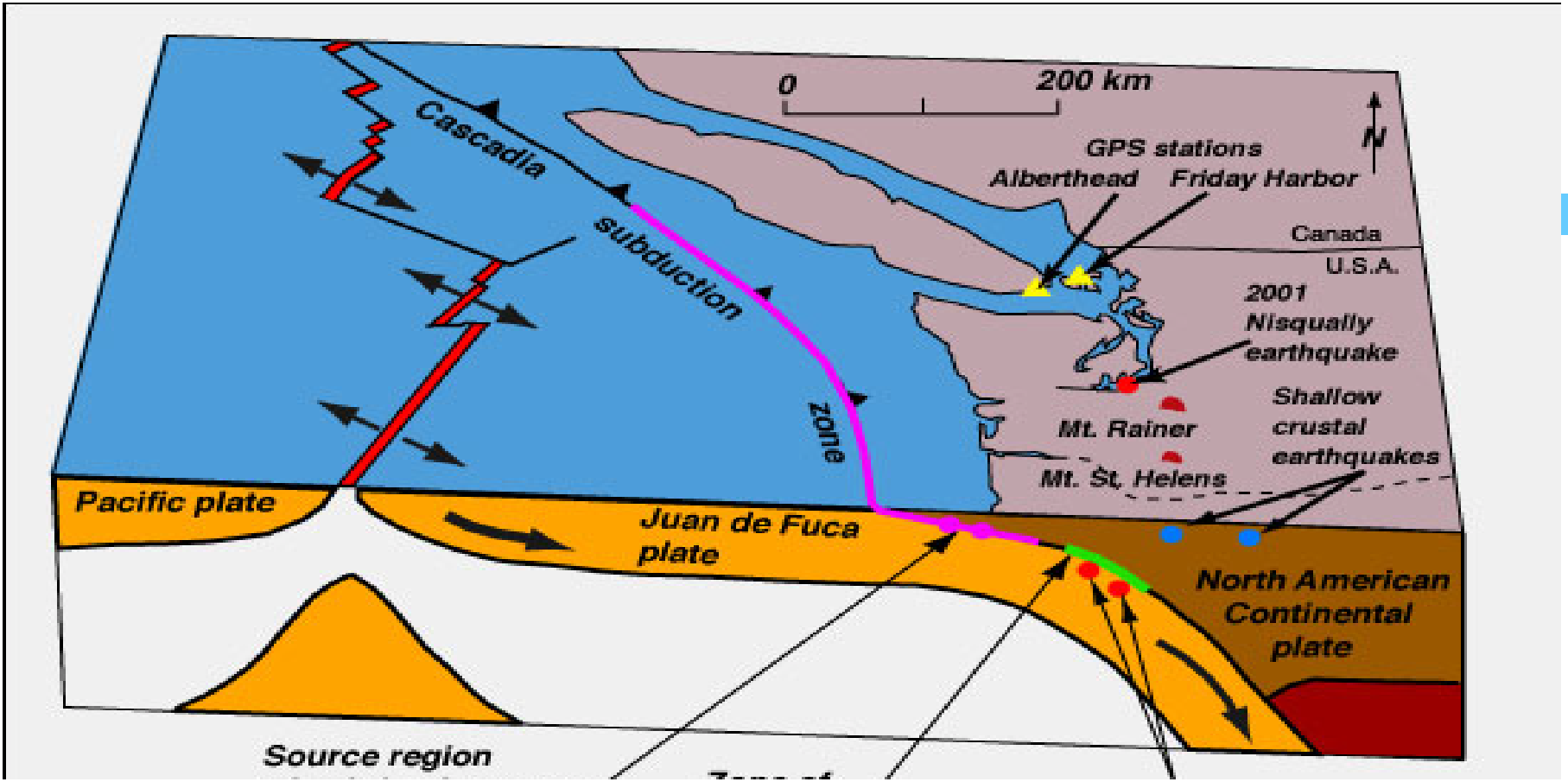
# Why a model

NATIONAL GEODETIC SURVEY

- North America lies on a plate boundary
- Most of Contiguous United States is located on the stable North America Plate
  - Its can be described by the rotation of North America about its pole of rotation
- South Western CA is located on the Pacific Plate
- The plate boundary continues off shore with the Cascadia Subduction Zone
- NGS needs a model to correct survey measurements and coordinates for the resulting deformation




National Oceanic and Atmospheric Administration



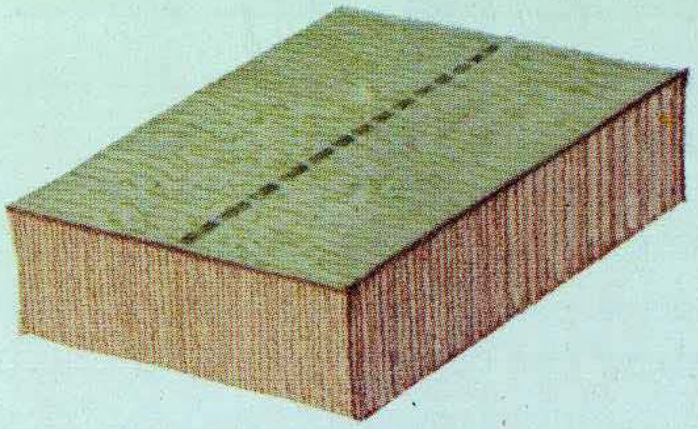

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Ocean Service

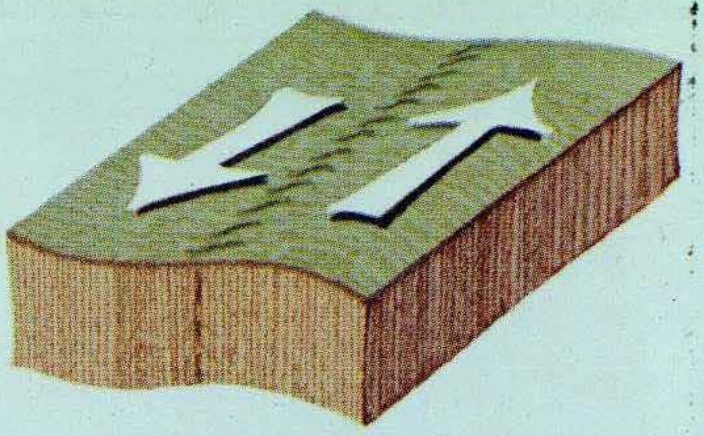
National Geodetic Survey

*Positioning America for the Future*

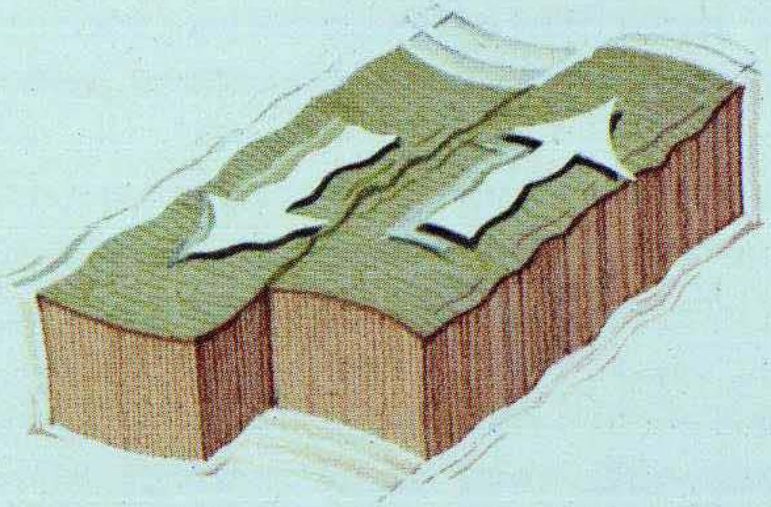
# THE TRIGGERING MECHANISM: SLIPPAGE ALONG A FAULT



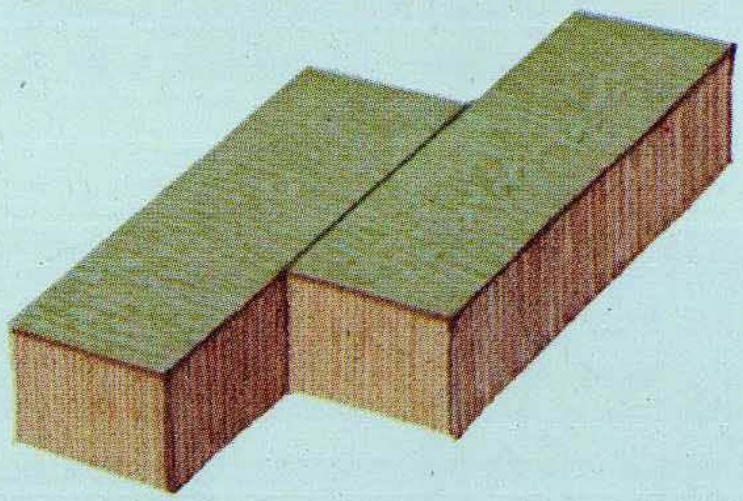
CRUSTAL BLOCKS AT REST



DEFORMATION DURING STRESS BUILD-UP



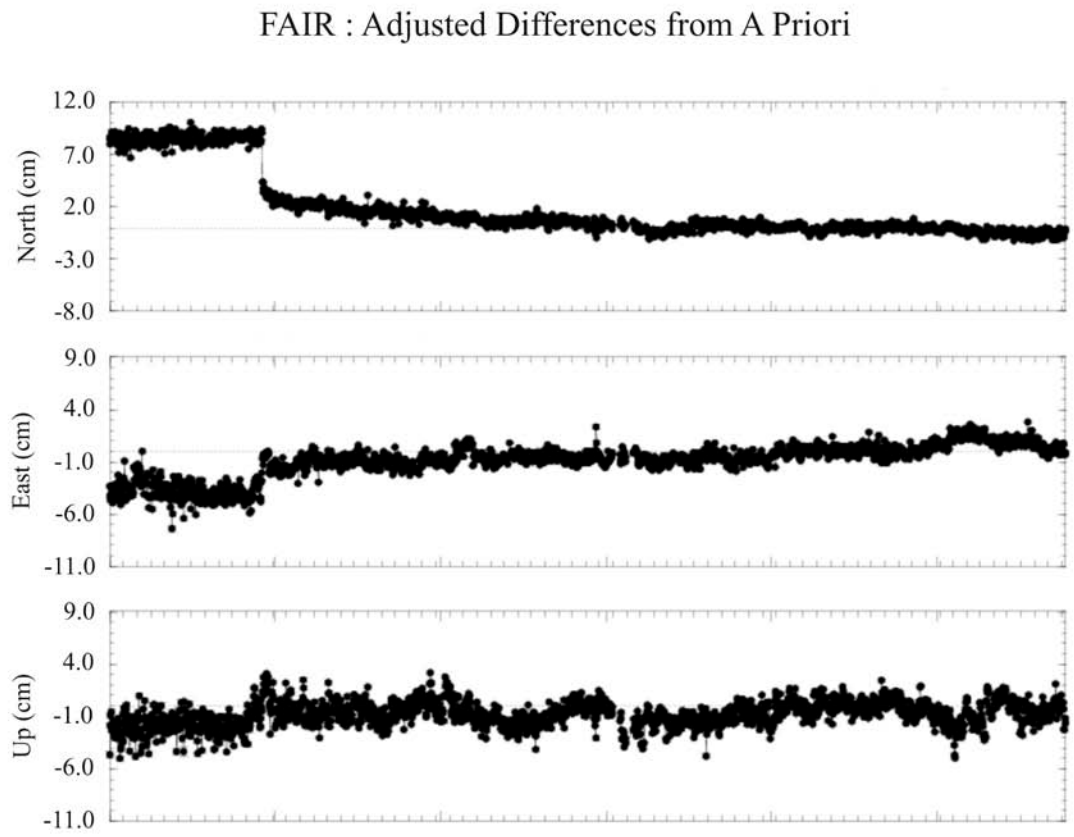
THE INSTANT OF RUPTURE



REBOUNDING TO A NEW EQUILIBRIUM

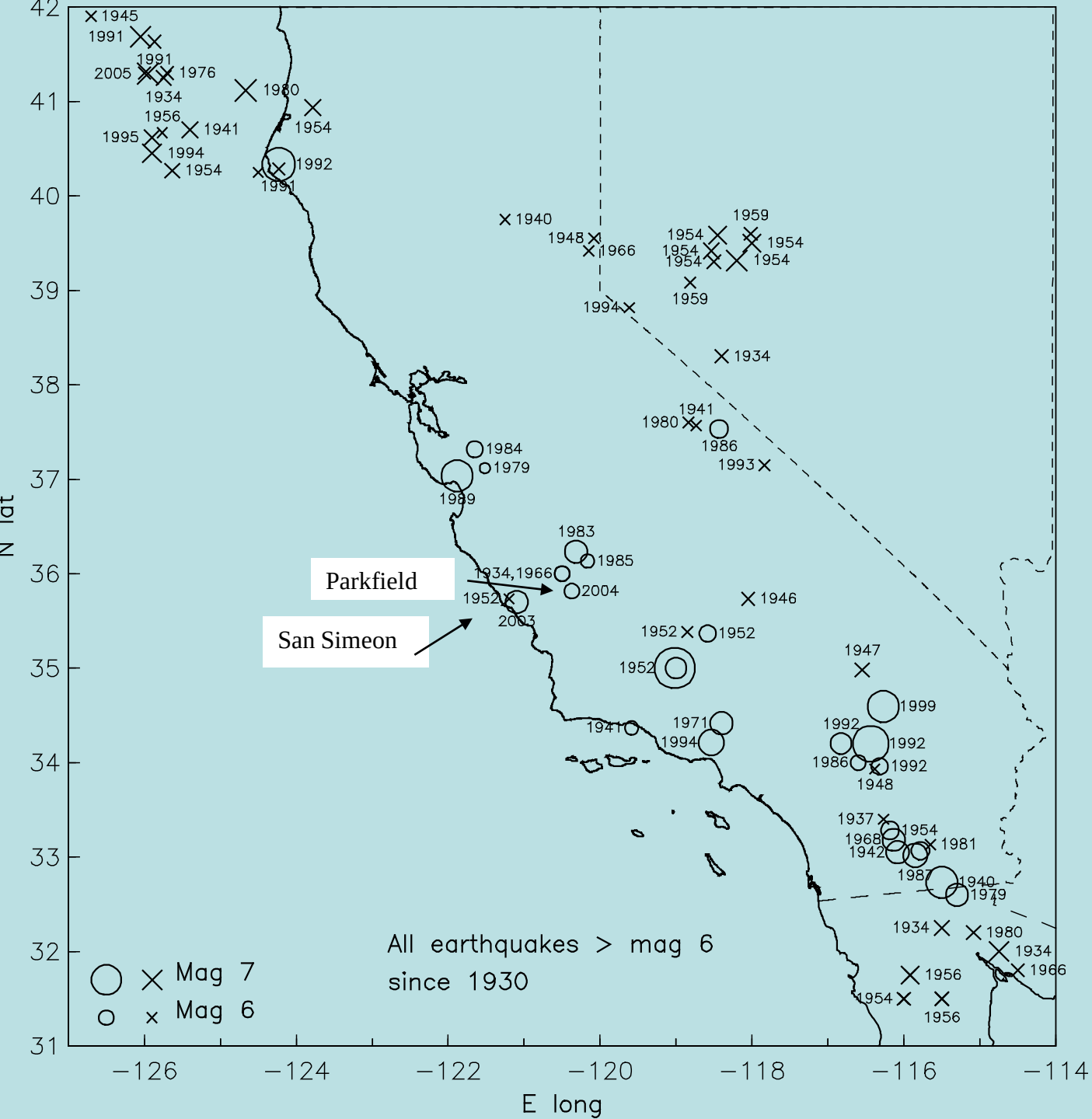
# Time series of FAIR





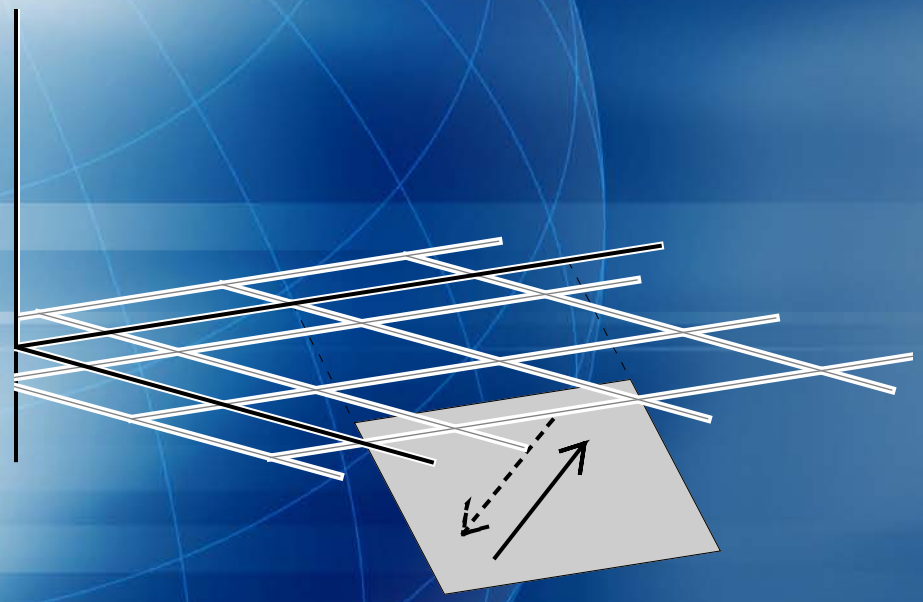

- Time series of the CORS station FAIR for the period spanning the Denali earthquake.
- Shows both a sudden co-seismic displacement and the more gradual exponential decay of the post seismic slip.

# Earthquakes in Contiguous US



# Dislocations

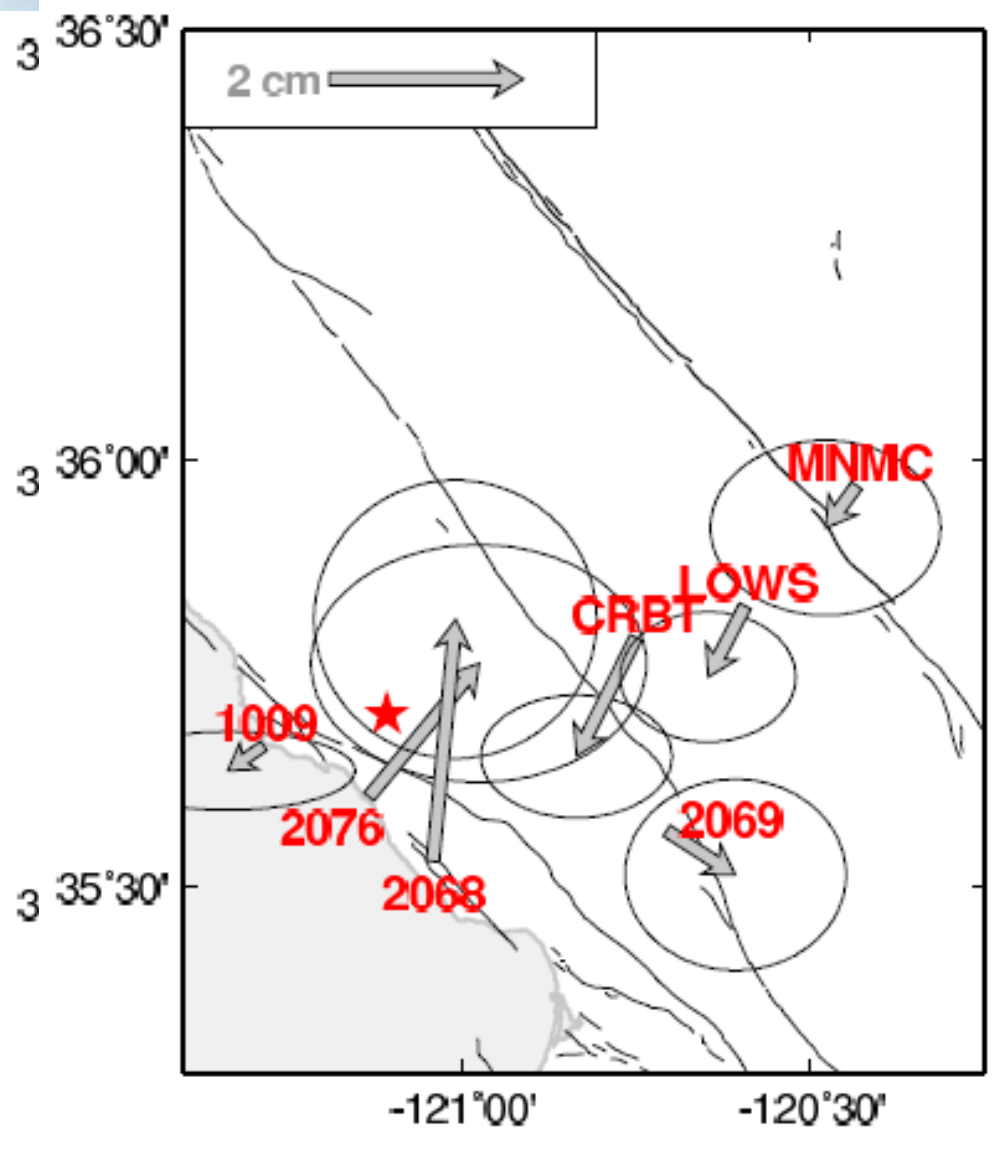




- Each dislocation represents a rectangular patch where one side slips relative to the other
- The name, dislocation, is used because the slip displacement is uniform over the rectangle
- thereby producing a discontinuity along the edges of the patch.

# San Simeon Earthquake

NATIONAL GEODETIC SURVEY

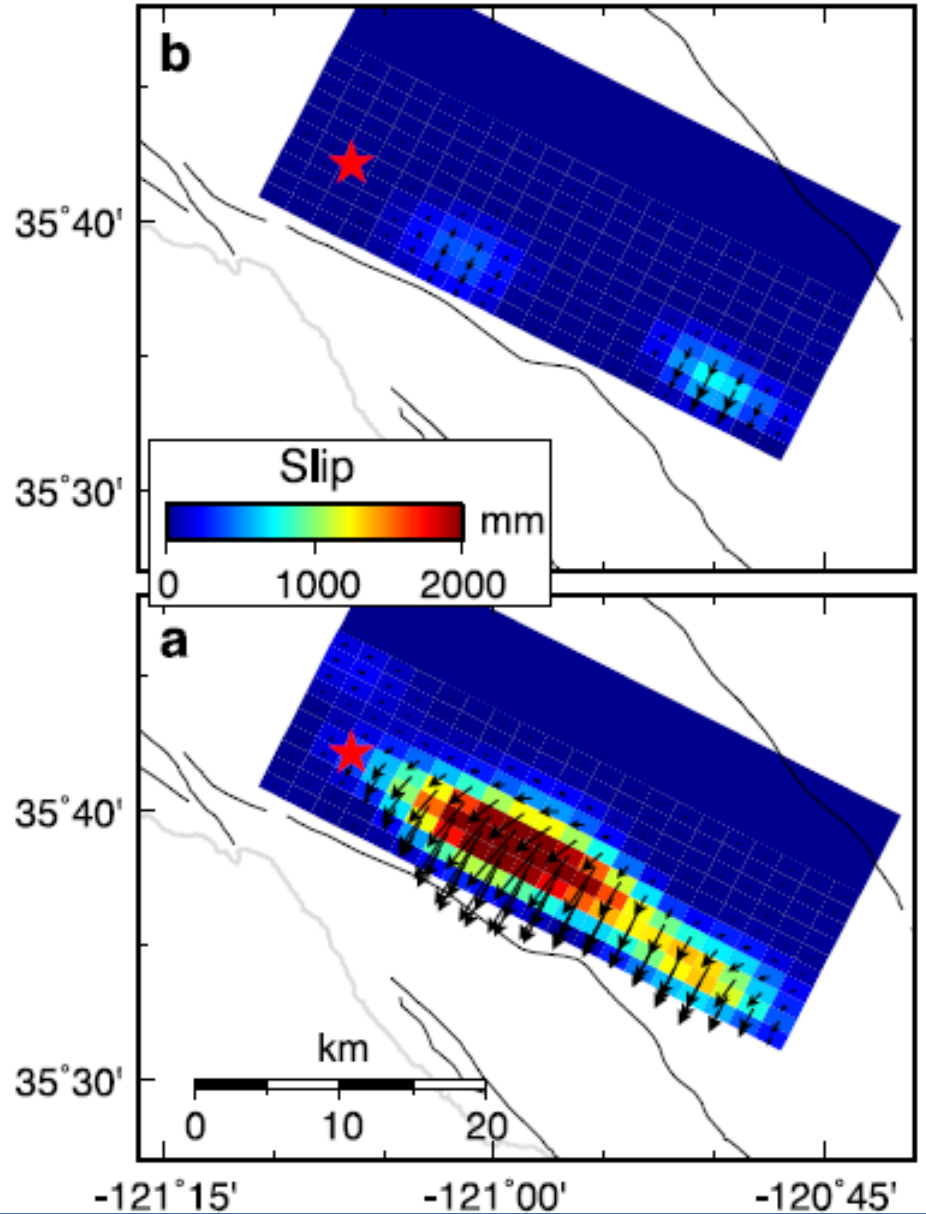



Blind thrust event

- two sides of the inclined fault plane moved toward each other
- A blind thrust, fault plane did not reach surface.
- As a result, even though the San Simeon earthquake was larger that Parkfield
- the displacement vectors are smaller but were spread over a larger area.
- Post seismic slip much smaller than Parkfield

# Dislocations

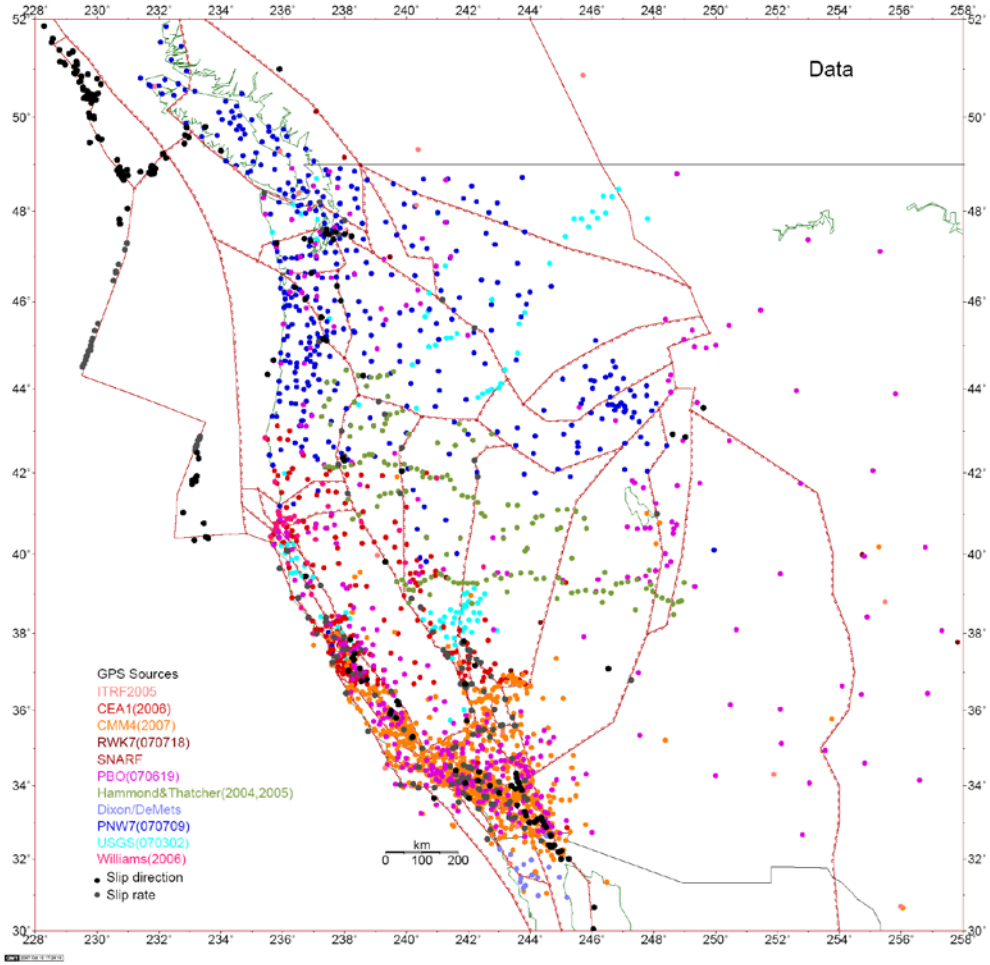


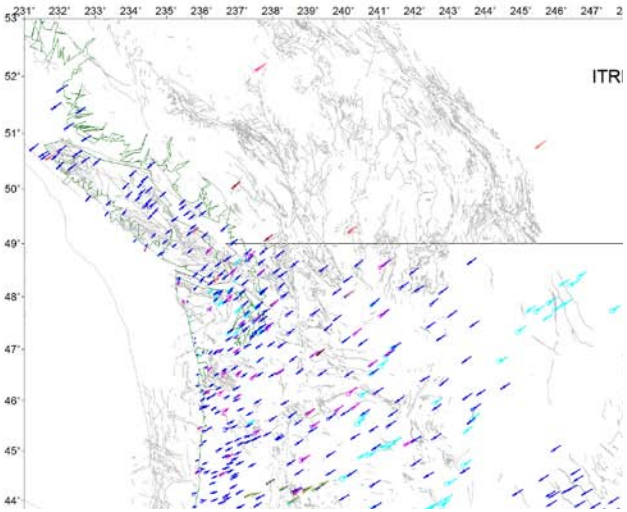



- Slip on the fault planes is far too irregular to be matched with a single rectangular dislocation
- Realistic models require an array of 200-300 rectangles, each covering 2-4 $km^2$.
- HTDP evaluates the contribution of each rectangle and sums them to produce a total displacement
- Co and post-seismic deformation require separate dislocation models

# Updated model of the secular field

- models comprised of rotating blocks subject to uniform strains
- This simple model was able to match the observations within the uncertainties.
- This block model is based on combing the two models published by McCaffrey et al (2007), McCaffrey (2005)

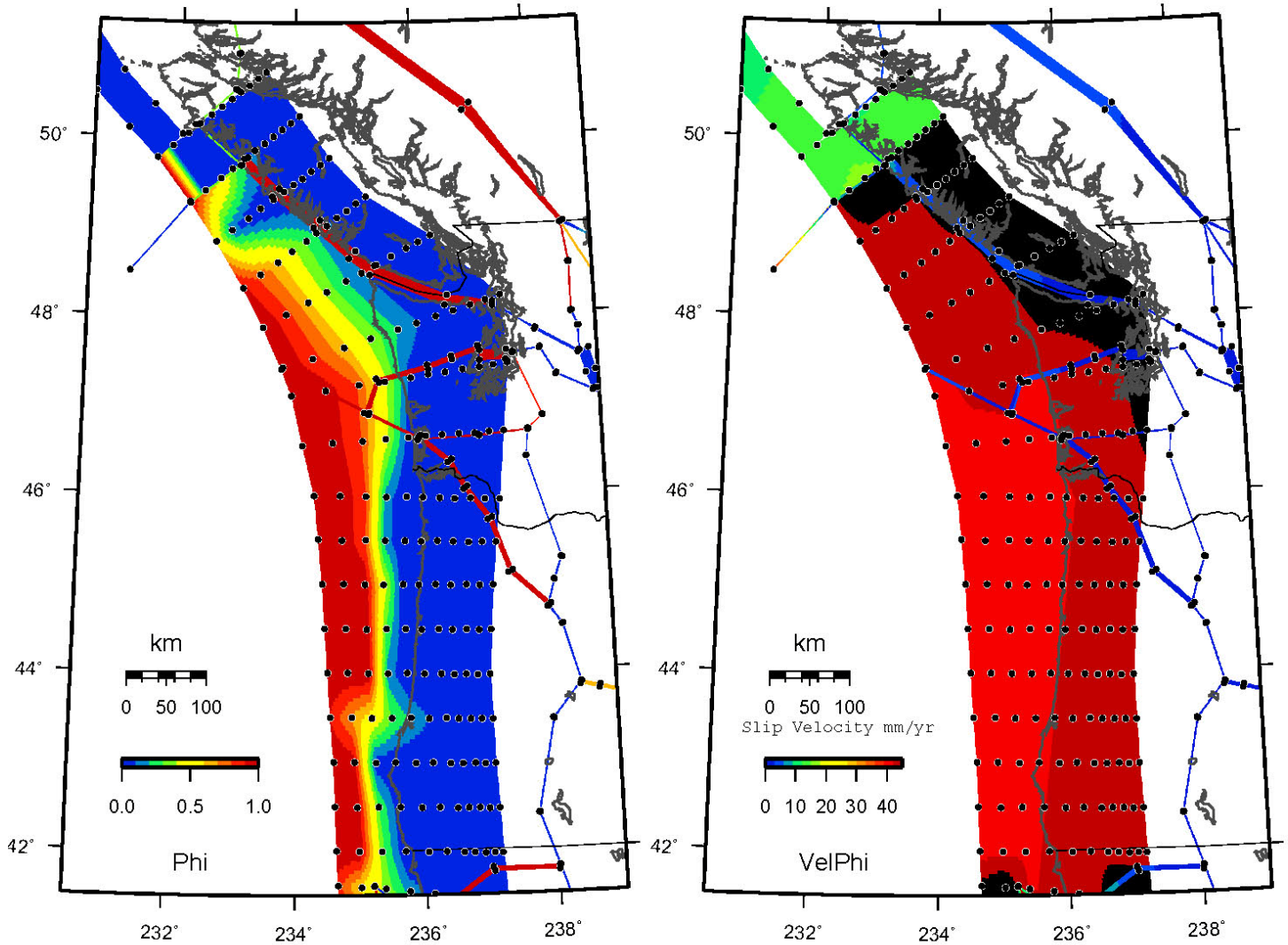





# GPS velocities

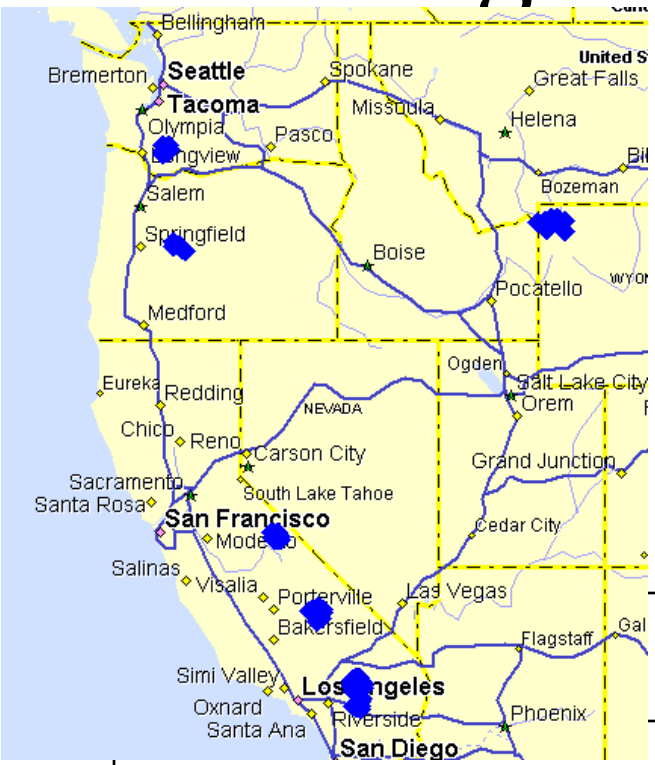
- The most important constraint for our model is GPS vectors

| Code | Num Used | Num Total | Weight Factor | Data Source |
|---|---|---|---|---|
| ITR5 | 55 | 290 | 0.44 | Altamimi et al. 2007 |
| SNRF | 18 | 22 | 1 | SNARF website |
| DXB2 | 16 | 16 | 1 | Dixon et al 2002 |
| HT04 | 67 | 67 | 1 | Hammond & Thatcher 2004 |
| HT05 | 94 | 110 | 1 | Hammond & Thatcher 2005 |
| WILL | 36 | 71 | 0.25 | Williams et al. 2006 |
| CEA1 | 1285 | 1403 | 1 | California Earthquake Authority |
| CMM4 | 1195 | 1318 | 1 | Shen et al. 2007 |
| DMEX | 12 | 14 | 0.44 | Marquez-Azua et al 2003 |
| PBO7 | 437 | 795 | 0.25 | PBO 4/2007 |
| PNW7 | 578 | 670 | 1 | McCaffrey, 2007; Payne, |




Phi refers to the degree of coupling. A value of 1.0 corresponds to full interseismic coupling, and 0 means no coupling (aseismic creep) Margin is locked over US

# Circular regions excluded from model




- 4 active volcanic areas
- Two in southern half of CA are associated with post seismic effects

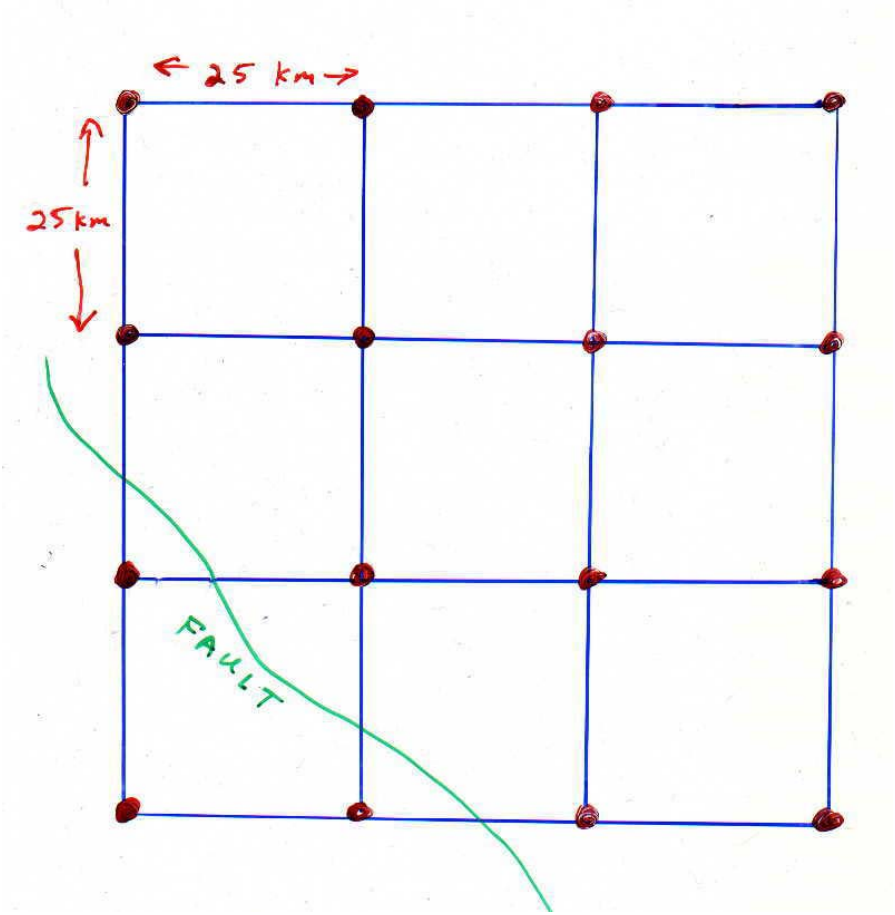
| Name | Center Latitude | | | Center longitude | | | |
|---|---|---|---|---|---|---|---|
| | deg | min | Sec | deg | min | sec | radius km |
| Long Valley V. F. | 37 | 42 | 0 | 118 | 54 | 0 | 20 |
| Coso Volcanic Field | 36 | 0 | 0 | 117 | 45 | 0 | 20 |
| Yellowstone | 44 | 25 | 48 | 110 | 40 | 12 | 50 |
| South Sister Volcano | 44 | 6 | 0 | 121 | 51 | 0 | 20 |
| Mt St Helens | 46 | 12 | 0 | 122 | 10 | 48 | 20 |
| Landers quake | 34 | 24 | -0 | 116 | 30 | 0 | 20 |
| Landers quake | 34 | 0 | 0 | 116 | 30 | 0 | 20 |

# Grids

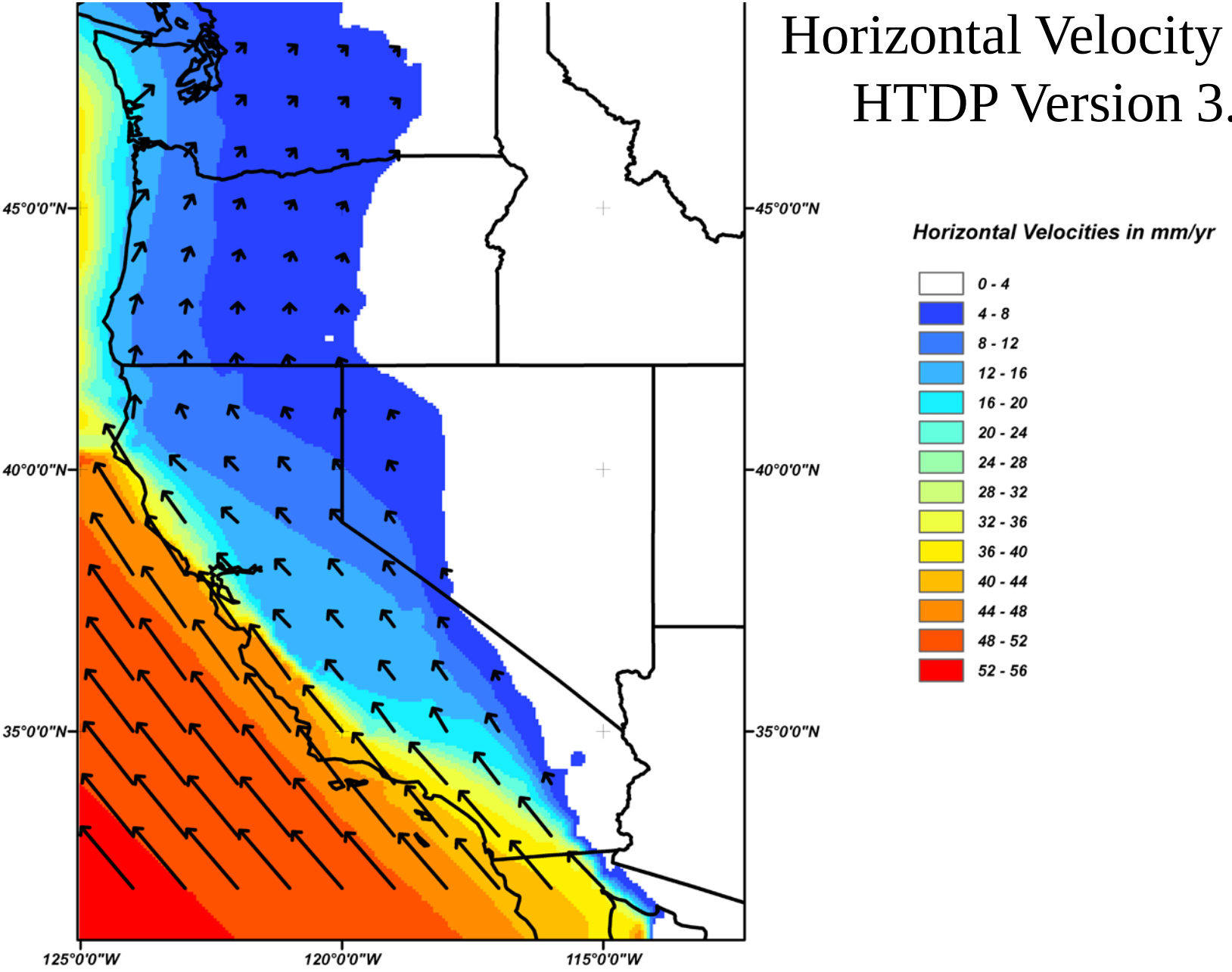
- *HTDP* uses four interpolated grid files to calculate the secular velocities.
- These grids cover different regions with different cell sizes in order to obtain higher accuracy in regions of higher velocity gradients
- HTDP will automatically choose the most accurate grid for the point in question

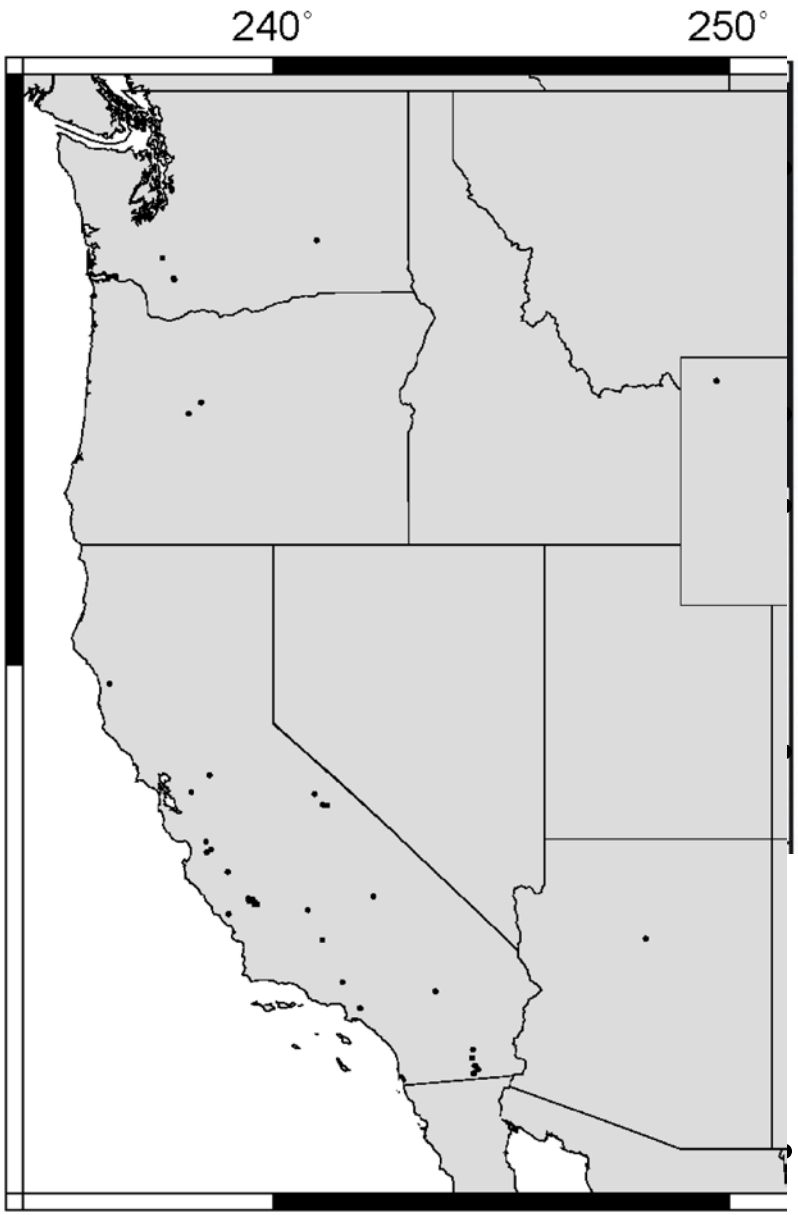
| Longitude range | Latitude range | Cell spacing (minutes) | Grid dimensions | Region |
|---|---|---|---|---|
| 125º to 100ºW | 31º-49ºN | 15 | 101 x 73 | Entire region |
| 125º to 122ºW | 40º-49ºN | 3.75 | 49 x 145 | Pacific NW |
| 125º to 119ºW | 36º-40ºN | 3.75 | 97 x 65 | Northern CA |
| 121º to 114ºW | 31º-36ºN | 3.75 | 113 x 81 | Southern CA |

# *Interpolating a Grid of Velocities*



# Horizontal Velocity Map
# HTDP Version 3.0






# Test of Con US secular velocity field

RMS residuals are 1.9 mm/yr for the north and 1.7 mm/yr for the east

Average residuals are nearly zero

Over 90% of the stations had a combined residual of less than 3 mm/yr.

HTDP 2.9 has a RMS residuals of 3.3 mm/yr for the north and 3.1 mm/yr for the east component using the same data set.

introducing the new model of the secular field produces a > 30% improvement

# *Horizontal Time-Dependent Positioning (HTDP)*

- Contains crustal motion models for CONUS
- Models address
  - Continuous motion (plate tectonics)
  - Episodic motion (earthquakes)
- Web utility, source code, and user's guide at
  - http://www.ngs.noaa.gov
  - Click on: geodetic tool kit
  - Then click on: HTDP

# *HTDP Applications*

- Predict velocities
- Predict displacements
- Update positions
- Update observations
- Transform positions between reference frames
- Transform velocities between reference frames

# Homogenizing

Obs at time $T_1$

Obs at time $T_2$

Obs at time $T_3$

Control Positions at time $T_A$

Control Positions at time $T_B$

HTDP

Obs and control positions at time $T_0$

ADJUST

Positions for all stations at time $T_0$

# EPOCH DATE

… date for which published positional coordinates are valid.

Horizontal Time Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/TOOLS/Htdp/Htdp_velocity.html What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

## PREDICTING VELOCITIES

**Select how you wish to specify positions:**

- Individual points entered interactively
- Points on a specified grid
- *80* records in a specified Blue book file. Explain
- Points on a specified line

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=2&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

**PREDICTING VELOCITIES**

**Specify the reference frame for the input values:**

NAD_83
ITRF88
ITRF89
ITRF90
ITRF91

Input the site's position either in terms of latitude, longitude, and ellipsoidal height or in terms of geocentric Cartesian coordinates -X,Y,Z- but not both. For latitude (positive north) and longitude (positive west), use the form degrees, minutes, and seconds and use either commas or spaces to separate the individual values. The field for seconds must include a decimal point. To denote negative values, use negative degrees, minutes, and seconds.
Valid examples for latitude are:
`37,34,35.67`
`37 34 35.67`
`-37 -34 -35.67` denotes a point in the southern hemisphere.
Values for ellipsoidal height or for X, Y, and Z must be specified in meters and must be entered with a decimal point.

**Select the type of coordinates to be entered:**

◉ Latitude, Longitude, Height ○ X, Y, Z

Latitude or X: `36 40 11.28`

Longitude or Y: `121 46 19.92`

Height or Z: `0.0`

Station Name (optional): `BETA`

Submit Query | Clear Form

Document: Done

# HTDP Output

```
 HTDP (version 2.6) OUTPUT

VELOCITIES IN MM/YR RELATIVE TO NAD_83


           BETA
LATITUDE    =  36 40 11.28000 N  NORTH VELOCITY =  35.90 mm/yr
LONGITUDE   = 121 46 19.92000 W  EAST VELOCITY  = -27.68 mm/yr
ELLIPS. HT. =       0.000 m      UP VELOCITY    =   0.00 mm/yr
X = -2696934.816 m               X VELOCITY     = -12.24 mm/yr
Y = -4354426.684 m               Y VELOCITY     =  32.80 mm/yr
Z =  3788064.740 m               Z VELOCITY     =  28.80 mm/yr
```

## PREDICTING DISPLACEMENTS BETWEEN TWO DATES

**Specify the reference frame for the input values:**

NAD 83
ITRF88
ITRF89
ITRF90
ITRF91

**Dates** must be expressed as a numerical month (between 1 and 12), a numerical day of the month, and a four character nur
year may be separated by spaces or by commas.
Valid examples are:
`5,4,1998` for May 4, 1998
`5 4 1998` for May 4, 1998
The htdp models are not valid for dates before 1907 (the San Francisco earthquake).

**Specify the first date:** `1 1 1985`

**Specify the second date:** `1 1 1995`

Input the site's position either in terms of latitude, longitude, and ellipsoidal height or in terms of geocentric Cartesian coordin
latitude (positive north) and longitude (positive west), use the form degrees, minutes, and seconds and use either commas or
values. The field for seconds must include a decimal point. To denote negative values, use negative degrees, minutes, and se
Valid examples for latitude are:
`37,34,35.67`
`37 34 35.67`
`-37 -34 -35.67` denotes a point in the southern hemisphere.
Values for ellipsoidal height or for X, Y, and Z must be specified in meters and must be entered with a decimal point.

**Select the type of coordinates to be entered:**

(•) Latitude, Longitude, Height ( ) X, Y, Z

Latitude or X: 36 40 11.28

Longitude or Y: 121 46 19.92

Height or Z: 0.

Station Name (optional): BETA

**Select how the required velocity (relative to the input frame) is to be entered:**

(•) Use the velocity predicted by this program (ignore the input boxes below)

( ) Specify the velocity in terms of north-east-up components (use the input boxes below)

( ) Specify the velocity in terms of global X-Y-Z components (use the input boxes below)

North or X (mm/yr):

East or Y (mm/yr):

Up or Z (mm/yr):

Submit Query | Clear Form

# HTDP Output

```
 HTDP (version 2.6) OUTPUT

 DISPLACEMENTS IN METERS RELATIVE TO NAD_83
 FROM 01-01-1985 TO 01-01-1995(month-day-year)

NAME OF SITE                LATITUDE            LONGITUDE            NORTH    EAST
BETA                        36 40 11.28000 N    121 46 19.92000 W     0.433   -0.278
```

NGS HOME PAGE

# Why the discrepancy?

Northward velocity = 35.90 mm/yr

Cumulative continuous motion over 10 years = 0.359 meters

Displacement over 10 years = 0.433 meters

0.433 - 0.359 = 0.074 meters

Loma Prieta earthquake  Mw=7.1 10/18/1989
Lat=37.08028 Lon=121.86667

# Use of HTDP and OPUS

- The ITRF coordinates for the CORS are updated to the midpoint of the time interval when the submitted data were observed using the CORS velocity which is never zero.
- The ITRF baseline components, given at the midpoint of the data time interval, are individually transformed to the NAD 83 reference frame.
- The NAD83 coordinates the three CORS stations come from the NGS IDB database. These are also updated to the midpoint of the interval, applying the NAD 83 velocities
- Baselines and CORS NAD 83 coordinates are added to determine values of the coordinates of the unknown point on NAD 83.
- Finally, these coordinates are then transformed in time to the reference epoch date of January 1, 2002 in NC by using the NAD 83 velocity for the point as predicted by the HTDP (Horizontal Time-Dependent Positioning) software.

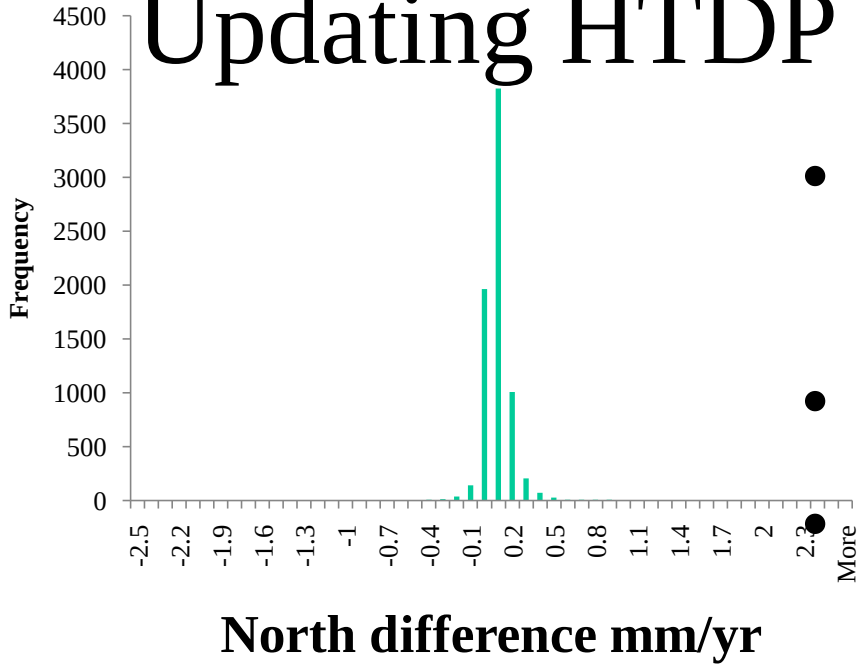
# Coordinates

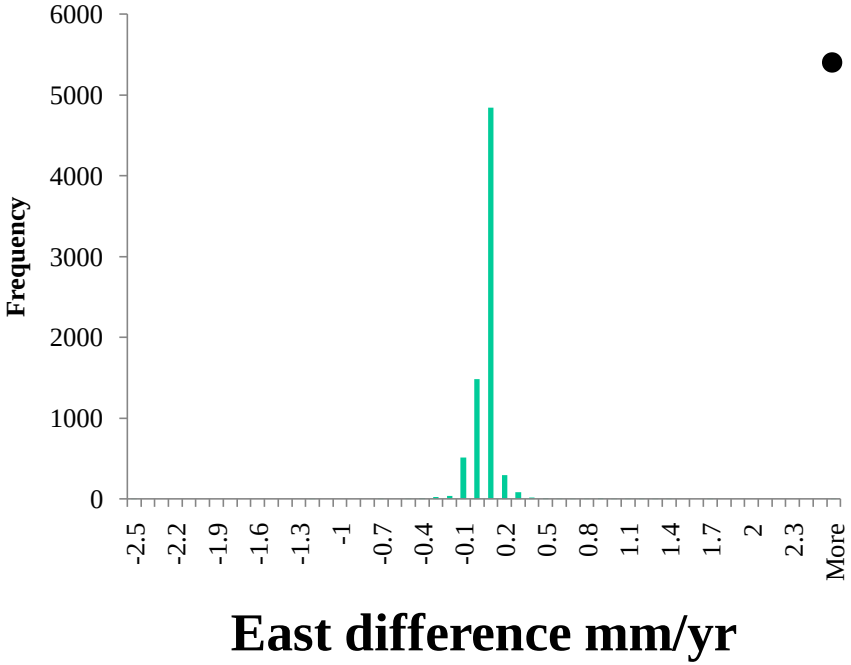
```
REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)  ITRF00 (EPOCH:2007.1746)

        X:    1094963.312(m)   0.007(m)    1094962.619(m)   0.007(m)
        Y:   -5182924.578(m)   0.022(m)   -5182923.074(m)   0.022(m)
        Z:    3540353.836(m)   0.005(m     3540353.680(m)   0.005(m)

      LAT: 33 56  2.25937      0.009(m) 33 56  2.28442      0.009(m)
    E LON:281 55 44.76919      0.010(m)281 55 44.75489      0.010(m)
    W LON: 78  4 15.23081      0.010(m) 78  4 15.24511      0.010(m)
   EL HGT:        -31.396(m)   0.019(m)        -32.822(m)   0.019(m)
ORTHO HGT:          5.587(m)   0.031(m) [Geoid03 NAVD88]
```

# Future Enhancements of HTDP

- Improve the model of Alaska
- Provide error estimates for predicted motion
- Address non-constant velocities (seasonal variations, post-earthquake acceleration, silent earthquakes)
- Address vertical motion

# Updating HTDP for new PBO solutions

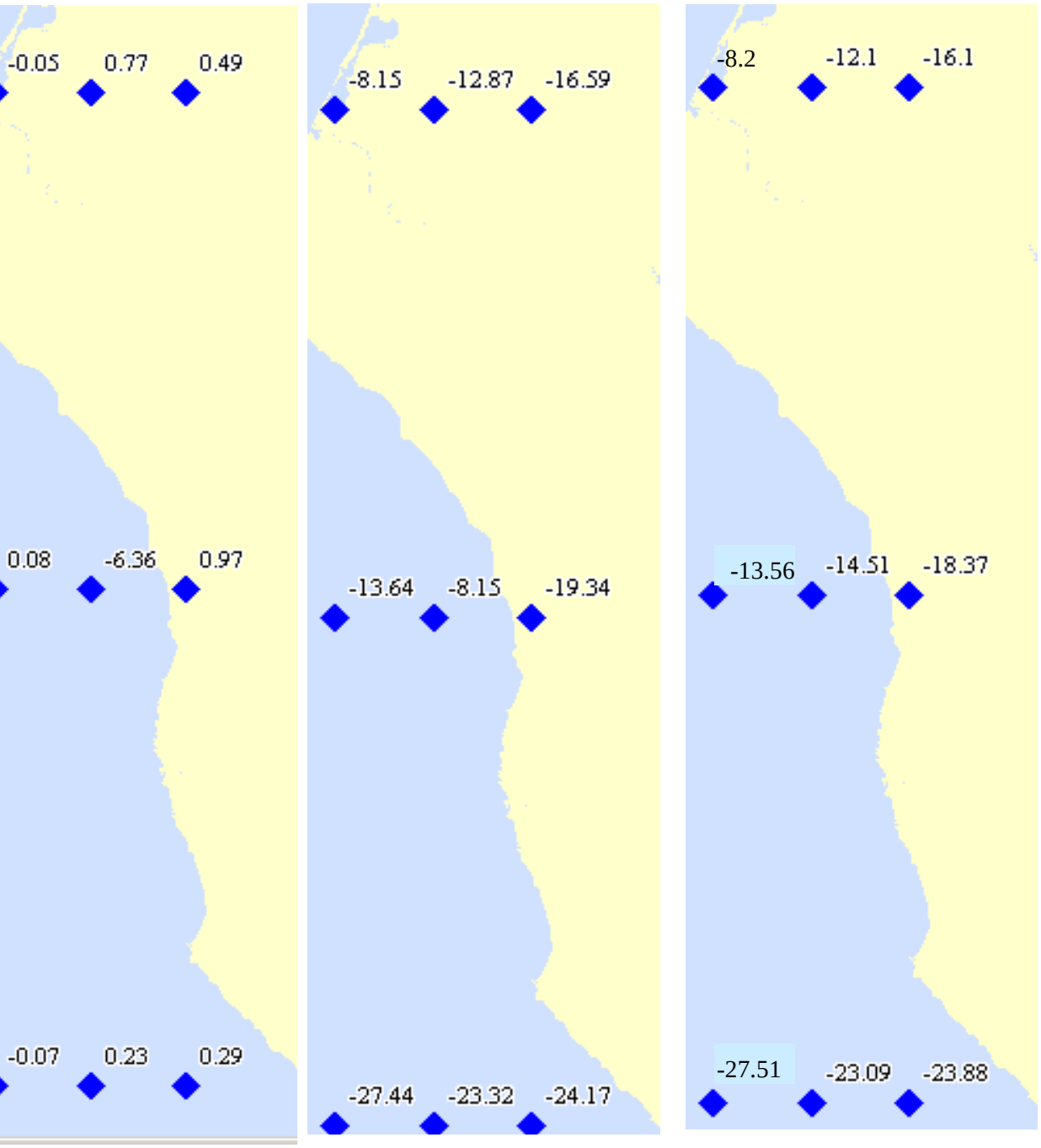



- New inversion of GPS data including PBO8 solution
- An extra 13 mo of data
- An extra 366 vectors (1161 vs. 795 for PBO7
- Used 78% of observations rather than 55% for PBO7

| | North | East |
|---|---|---|
| Max | 1.81 | 4.47 |
| Min | -6.36 | -4.78 |
| Mean | 0.06 | 0.03 |
| St Dev | 0.14 | 0.13 |

# New vs. old




- The inversion including PBO8 looks more reasonable

# Question 1

- How often is the national CORS velocity model updated
  - HTDP 3.0 does not include velocity estimates of the CORS because these had not been determined since 2002. The Positions and velocities of the CORS are being re-determined now and a new version of HTDP which included these will be released in 2010

# Question 2

- Are the UNAVCO PBO west coast CORS velocities part of the current model and included in NSRS2007
  - HTDP3.0 includes the PBO7 solution which was released in mid 2007. The NSRS2007 adjustment however was done using HTDP2.9 which used an older model of the secular field
  - As far as the more recent PBO solutions are concerned, I did another inversion using the PBO8 solution (October 2008). This was not released because the changes were too small. I am working on incorporating the PBO9 solution now and I hope that this will be released with the next version of HTDP.

# Question 3

- Are OPUS versions updated to correspond with HTDP updates
  - OPUS uses the most current of HTDP that has been adopted by NGS.

# Question 4

- What percentage of input horizontal velocity data is estimated or interpolated vs measured
  - All of the constraints to our DEFNODE model were measured velocities except for the geologically determined slip rates etc.
  - This is used to generate a series of grid files and the velocities which you get from HTDP are bi-linear interpolations from these

# Question 5

- Would it be appropriate to have a menue choice of HTDP versions when using OPUS particularly for different regions of the country
  - There are no plans for this. OPUS just uses the most current version of HTDP and this represents are best estimate of deformation in the western US.

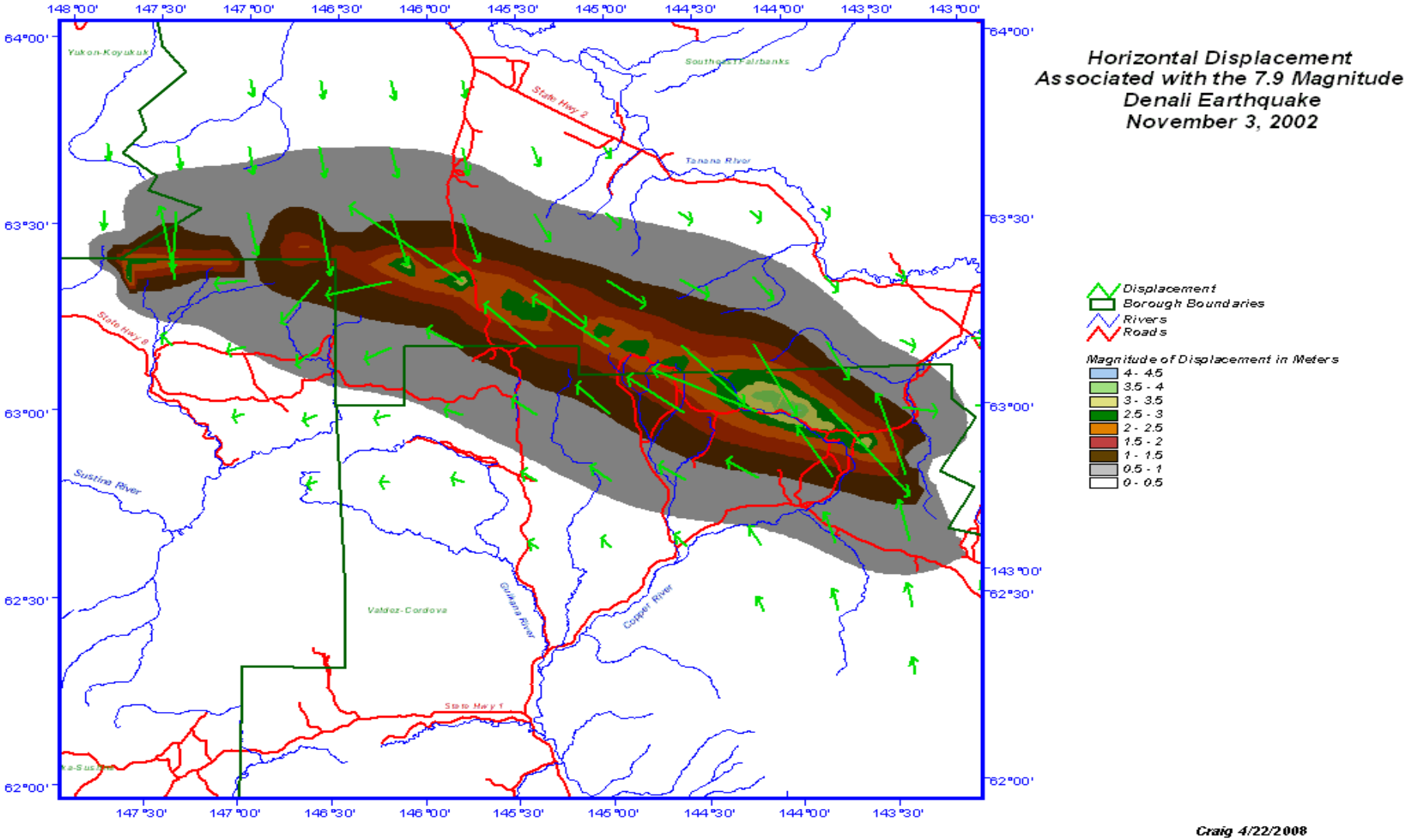
# Question 6

- Was HTDP used to update CORS coordinates prior to the NSRS2007 adjustment
  - Yes but it was HTDP 2.9 not 3.0 because that was the most current available at the time.
- Why was there such a shift in west coast CORS positions as reflected in the picture below
  - The picture shows the shift in the static points not the CORS. The CORS did not change due to the NSRS2007 adjustment, they were control. The large shift in the west in static network points reflects the fact that the western states had early HARN adjustments combined with the fact that our models of crustal deformation in the 1990's were not perfect.

# Question 7

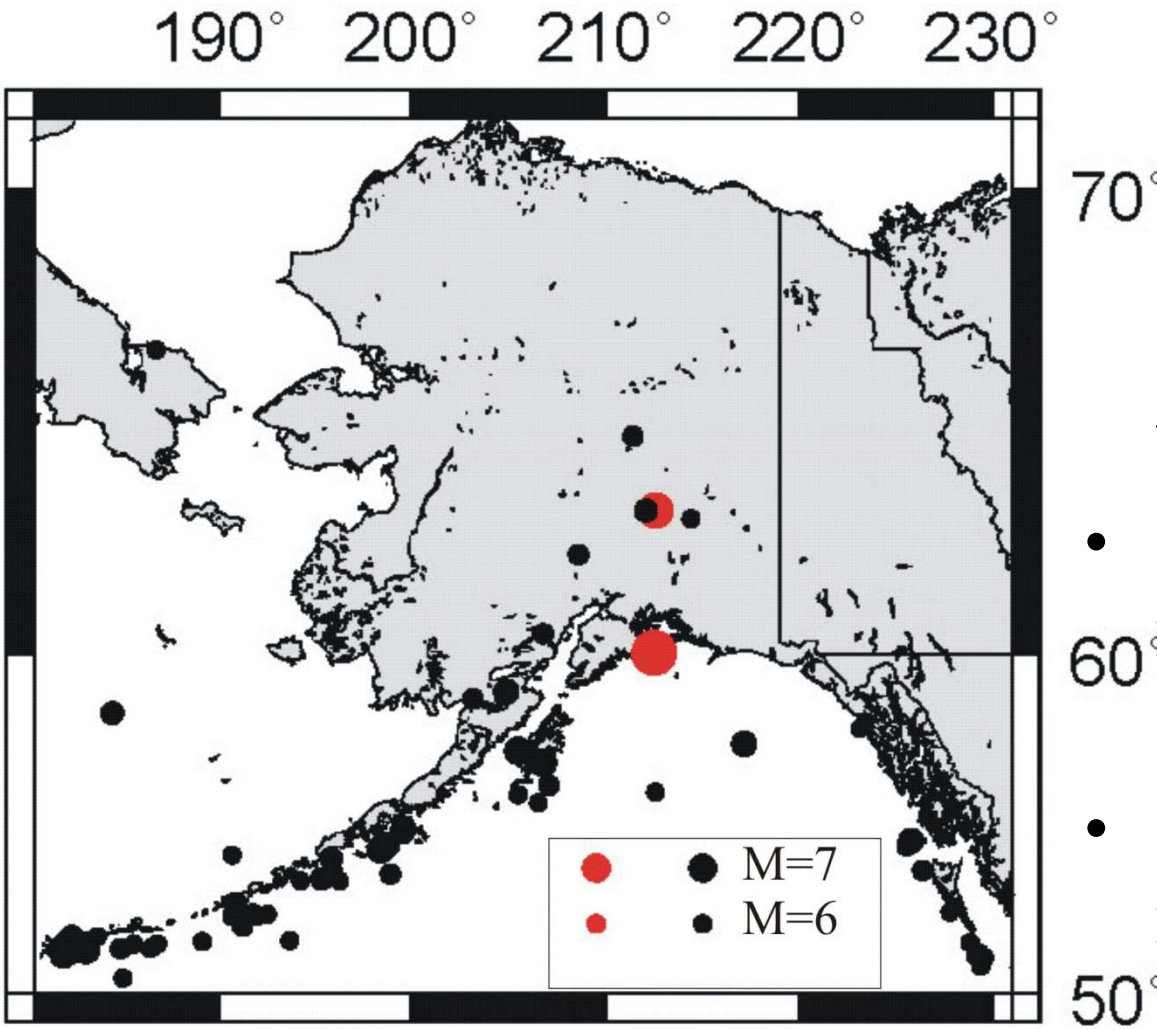
- What are plans for a vertical time dependent displacement program
  - We haven’t been able to make a vertical model because there are insufficient well determined velocities till recently. NGS plans to add this capability to HTDP, producing TDP after the completion of the multi year solution

# New Alaska data for HTDP, v 3.0 includes dislocation model for the 2002 Denali earthquake




Source: Elliott, J. L., Freymueller J. T., and Rabus B. (2007), Coseismic deformation of the 2002 Denali fault earthquake: Contributions from synthetic aperture radar range offsets, *J. Geophys. Res.*, 112, B06421, doi:10.1029/2006JB004428.

# Earthquakes in Alaska



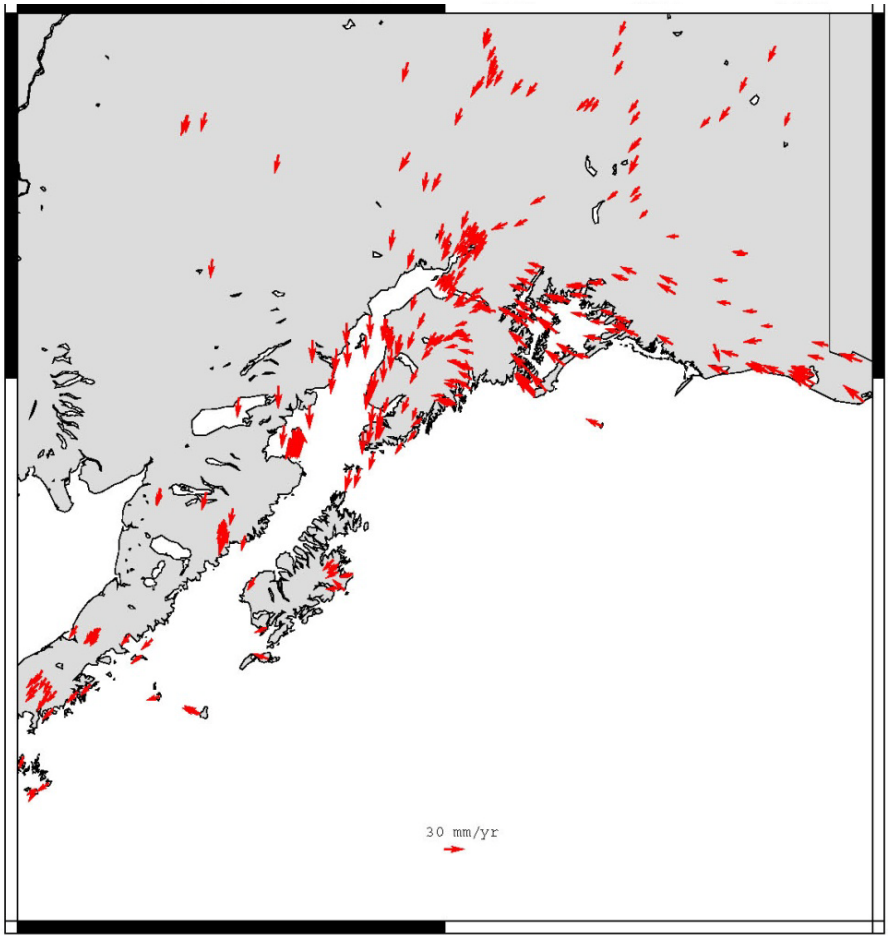

- Red symbols show earthquakes included in HTDP, Blue symbols are earthquakes occurring since 1990 that are not included.
- 69 earthquakes with magnitude greater than 6 not included in HTDP
- 5 earthquakes with magnitude greater than 7 are not included
  - 3 since 1999

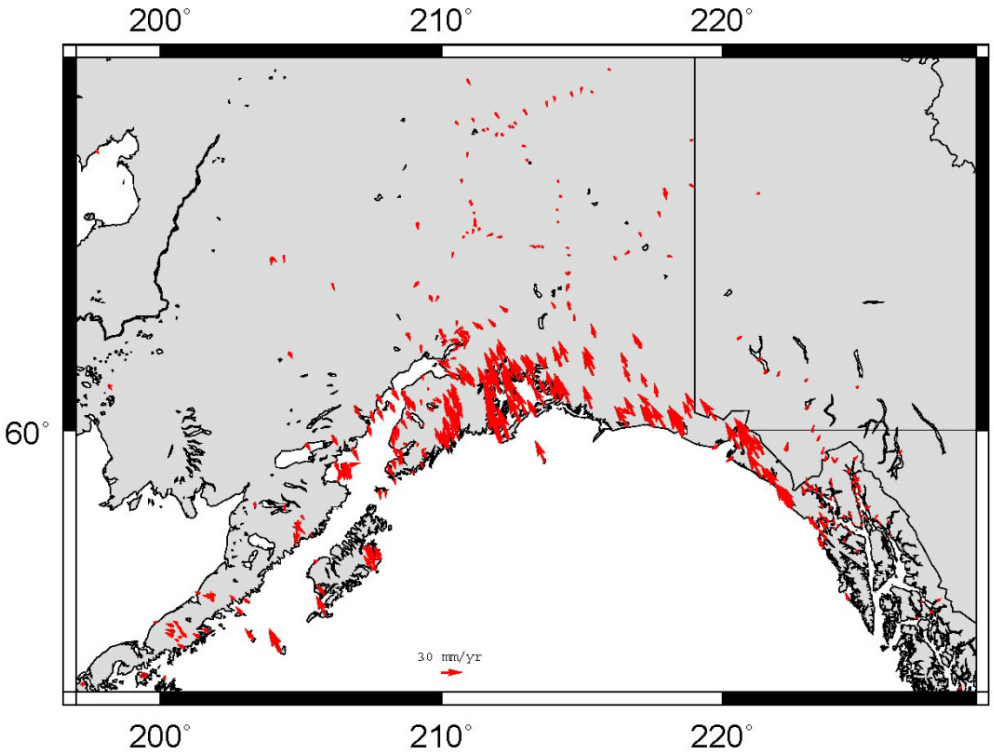
# Alaska secular field

- The Alaska secular field model has not been updated for over 10 years
- Testing vs. recent GPS derived velocity measurements (Freymueller et al 2008) reveals that significant errors exist.
- Unlike the CONUS section of our model, our model of the secular field was not upgraded with the release of HTDP3.0

- **Active Deformation Processes in Alaska, Based on 15 Years of GPS Measurements** Freymueller J. T. , Woodard H, Cohen S. C. ,Cross R, Julie Elliott J, Christopher F. Larsen C. F., Hreinsdóttir S, Zweck C.
- ftp://gps.alaska.edu/pub/users/jeff/Chapman_paper/

# Test of Alaska secular field




Residuals :Scale bar above is 50 mm/yr

Distribution of test points

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=1&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

**PREDICTING DISPLACEMENTS BETWEEN TWO DATES**

**Specify the reference frame for the input values:**

NAD_83
ITRF88
ITRF89
ITRF90
ITRF91

**Dates** must be expressed as a numerical month (between 1 and 12), a numerical day of the month, and a four character numerical year. The month, day, and year may be separated by spaces or by commas.
Valid examples are:
`5,4,1998` for May 4, 1998
`5 4 1998` for May 4, 1998
The htdp models are not valid for dates before 1907 (the San Francisco earthquake).

**Specify the first date:** `10 16 1989`

**Specify the second date:** `10 18 1989`

Input the site's position either in terms of latitude, longitude, and ellipsoidal height or in terms of geocentric Cartesian coordinates -X,Y,Z- but not both. For latitude (positive north) and longitude (positive west), use the form degrees, minutes, and seconds and use either commas or spaces to separate the individual values. The field for seconds must include a decimal point. To denote negative values, use negative degrees, minutes, and seconds.
Valid examples for latitude are:
`37,34,35.67`
`37 34 35.67`

Document: Done

Horizontal Time-Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp_p1.prl What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# HTDP Output

```
 HTDP (version 2.6) OUTPUT

 DISPLACEMENTS IN METERS RELATIVE TO NAD_83
 FROM 10-16-1989 TO 10-18-1989(month-day-year)

NAME OF SITE              LATITUDE          LONGITUDE          NORTH    EAST
BETA                      36 40 11.28000 N  121 46 19.92000 W    0.074  -0.001
```

NGS HOME PAGE

Document: Done

Horizontal Time Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/TOOLS/Htdp/Htdp_update.html What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

## UPDATING POSITIONS AND/OR OBSERVATIONS TO A SPECIFIED DATE

**Select option:**

- **Update positions for individual points entered interactively.**
- **Update positions for blue book stations.**. Explain
- **Update values for blue book observations.**. Explain
- **Update both the positions for blue book stations and the values for blue book observations.** . Explain

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=3&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

UPDATING POSITIONS AND/OR OBSERVATIONS TO A SPECIFIED DATE

**Specify the reference frame for the input values:**

NAD 83
ITRF88
ITRF89
ITRF90
ITRF91

**Dates** must be expressed as a numerical month (between 1 and 12), a numerical day of the month, and a four character numerical year. The month, day, and year may be separated by spaces or by commas.
Valid examples are:
`5,4,1998` for May 4, 1998
`5 4 1998` for May 4, 1998
The htdp models are not valid for dates before 1907 (the San Francisco earthquake).

**Specify the epoch date of the input position:** 10 16 2002

**Specify the epoch date of the output position:** 7 1 1998

Input the site's position either in terms of latitude, longitude, and ellipsoidal height or in terms of geocentric Cartesian coordinates -X,Y,Z- but not both. For latitude (positive north) and longitude (positive west), use the form degrees, minutes, and seconds and use either commas or spaces to separate the individual values. The field for seconds must include a decimal point. To denote negative values, use negative degrees, minutes, and seconds.

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=3&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

**Select the type of coordinates to be entered:**

◉ Latitude, Longitude, Height ○ X, Y, Z

Latitude or X: 33 34 41.65651

Longitude or Y: 117 03 52.50676

Height or Z: 470.798

Station Name (optional): LAKE SKINNER CORS

**Select how the required velocity (relative to the input frame) is to be entered:**

○ Use the velocity predicted by this program (ignore the input boxes below)

◉ Specify the velocity in terms of north-east-up components (use the input boxes below)

○ Specify the velocity in terms of global X-Y-Z components (use the input boxes below)

North or X (mm/yr): 24.8

East or Y (mm/yr): -21.0

Up or Z (mm/yr): -0.6

Document: Done

Horizontal Time-Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp_p1.prl What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# HTDP Output

```
HTDP (version 2.6) OUTPUT

UPDATED POSITIONS IN NAD_83
FROM 10-16-2002 TO  7-01-1998 (month-day-year)

                    OLD COORDINATE     NEW COORDINATE     DISPLACEMENT

LAKE SKINNER CORS
    LATITUDE      33 34 41.65651 N   33 34 41.65266 N -0.119 m north
    LONGITUDE    117 03 52.50676 W  117 03 52.50344 W  0.086 m east
    ELLIP. HT.              470.798            470.797 -0.001 m up
    X                -2420419.782       -2420419.735  0.047 m
    Y                -4737132.958       -4737133.054 -0.096 m
    Z                 3507827.603        3507827.503 -0.099 m
```

Document: Done

Horizontal Time Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/TOOLS/Htdp/Htdp_transform.html What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

## TRANSFORMING POSITIONS BETWEEN REFERENCE FRAMES

**Select how you wish to specify positions:**

- Individual points entered interactively
- *80* records in a specified Blue book file. Explain

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=4&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

TRANSFORMING POSITIONS BETWEEN REFERENCE FRAMES

**Specify the reference frame for the input values:**

- ITRF94 (ITRF 96 wil be used)
- ITRF96
- ITRF97
- ITRF00
- WGS_72

**Specify the reference frame for the output values:**

- NAD_83
- ITRF88
- ITRF89
- ITRF90
- ITRF91

**Dates** must be expressed as a numerical month (between 1 and 12), a numerical day of the month, and a four character numerical year. The month, day, and year may be separated by spaces or by commas.

Valid examples are:

`5,4,1998` for May 4, 1998

`5 4 1998` for May 4, 1998

The htdp models are not valid for dates before 1907 (the San Francisco earthquake).

**Specify the epoch date of the input position:** 10 16 2002

**Specify the epoch date of the output position:** 7 1 1998

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=4&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

**Select the type of coordinates to be entered:**

○ Latitude, Longitude, Height ◉ X, Y, Z

Latitude or X: -2420420.289

Longitude or Y: -4737131.741

Height or Z: 3507827.536

Station Name (optional): LAKE SKINNER CORS

**Select how the required velocity (relative to the input frame) is to be entered:**

◉ Use the velocity predicted by this program (ignore the input boxes below)

○ Specify the velocity in terms of north-east-up components (use the input boxes below)

○ Specify the velocity in terms of global X-Y-Z components (use the input boxes below)

North or X (mm/yr):

East or Y (mm/yr):

Up or Z (mm/yr):

Submit Query | Clear Form

Document: Done

Horizontal Time-Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop

Bookmarks Location: ww.ngs.noaa.gov/cgi-bin/HTDP/htdp_p1.prl What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# HTDP Output

```
*****************************************
HTDP (version 2.6) OUTPUT

TRANSFORMING POSITIONS FROM ITRF00 (EPOCH = 10-16-2002)
                         TO NAD_83 (EPOCH = 07-01-1998)

                INPUT COORDINATES   OUTPUT COORDINATES

LAKE SKINNER CORS
    LATITUDE      33 34 41.67001 N     33 34 41.65082 N
    LONGITUDE    117 03 52.54572 W    117 03 52.49630 W
    ELLIP. HT.             470.050            470.794 m
    X                -2420420.289       -2420419.584 m
    Y                -4737131.741       -4737133.164 m
    Z                 3507827.536        3507827.454 m
```

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=5&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

# Horizontal Time Dependent Positioning

---

## TRANSFORMING VELOCITIES BETWEEN REFERENCE FRAMES

**Specify the reference frame for the input values:**

- ITRF96
- ITRF97
- ITRF00
- WGS_72
- WGS_84(original) (NAD_83 will be used)

**Specify the reference frame for the output values:**

- NAD_83
- ITRF88
- ITRF89
- ITRF90
- ITRF91

Input the site's position either in terms of latitude, longitude, and ellipsoidal height or in terms of geocentric Cartesian coordinates -X,Y,Z- but not both. For latitude (positive north) and longitude (positive west), use the form degrees, minutes, and seconds and use either commas or spaces to separate the individual values. The field for seconds must include

Document: Done

HTDP computations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-bin/HTDP/htdp.prl?f1=5&f2=1 What's Related

Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlayer

**Select the type of coordinates to be entered:**

(•) Latitude, Longitude, Height ( ) X, Y, Z

Latitude or X: 33 34 41.67001

Longitude or Y: 117 03 52.54571

Height or Z: 470.050

Station Name (optional): LAKE SKINNER CORS

**Select how the required velocity is to be entered:**

(•) Specify the ve locity in terms of north-east-up components (use the input boxes below)

( ) Specify the velocity in terms of global X-Y-Z components (use the input boxes below)

North or X (mm/yr): 12.1

East or Y (mm/yr): -34.2

Up or Z (mm/yr): 0.0

Submit Query | Clear Form

Document: Done

Horizontal Time-Dependent Positioning - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop

Bookmarks Location: w.ngs.noaa.gov/cgi-bin/HTDP/htdp_p1.prl What's Related

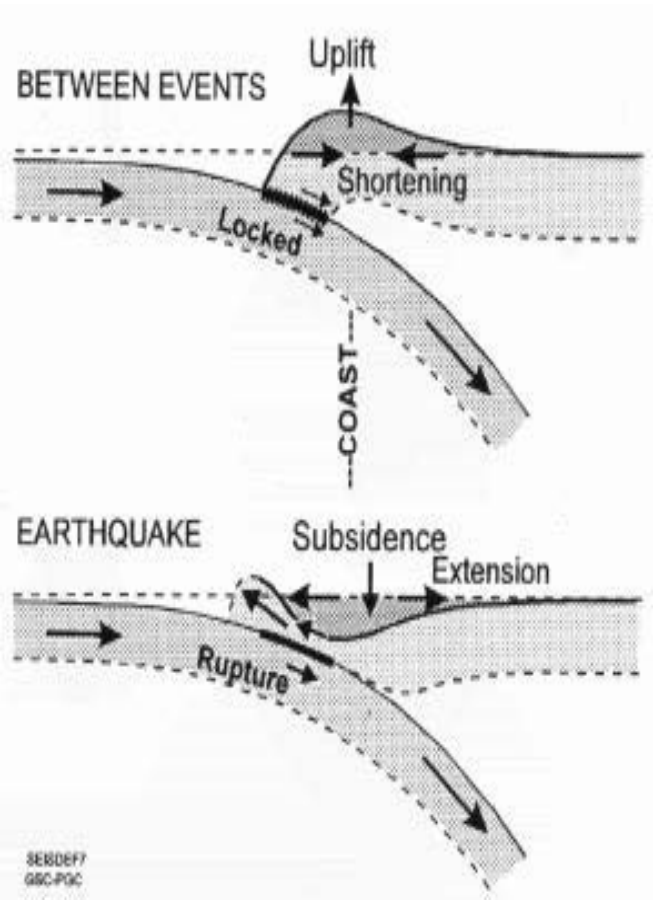
Free AOL & Unl Instant Message Internet Lookup New&Cool RealPlaye

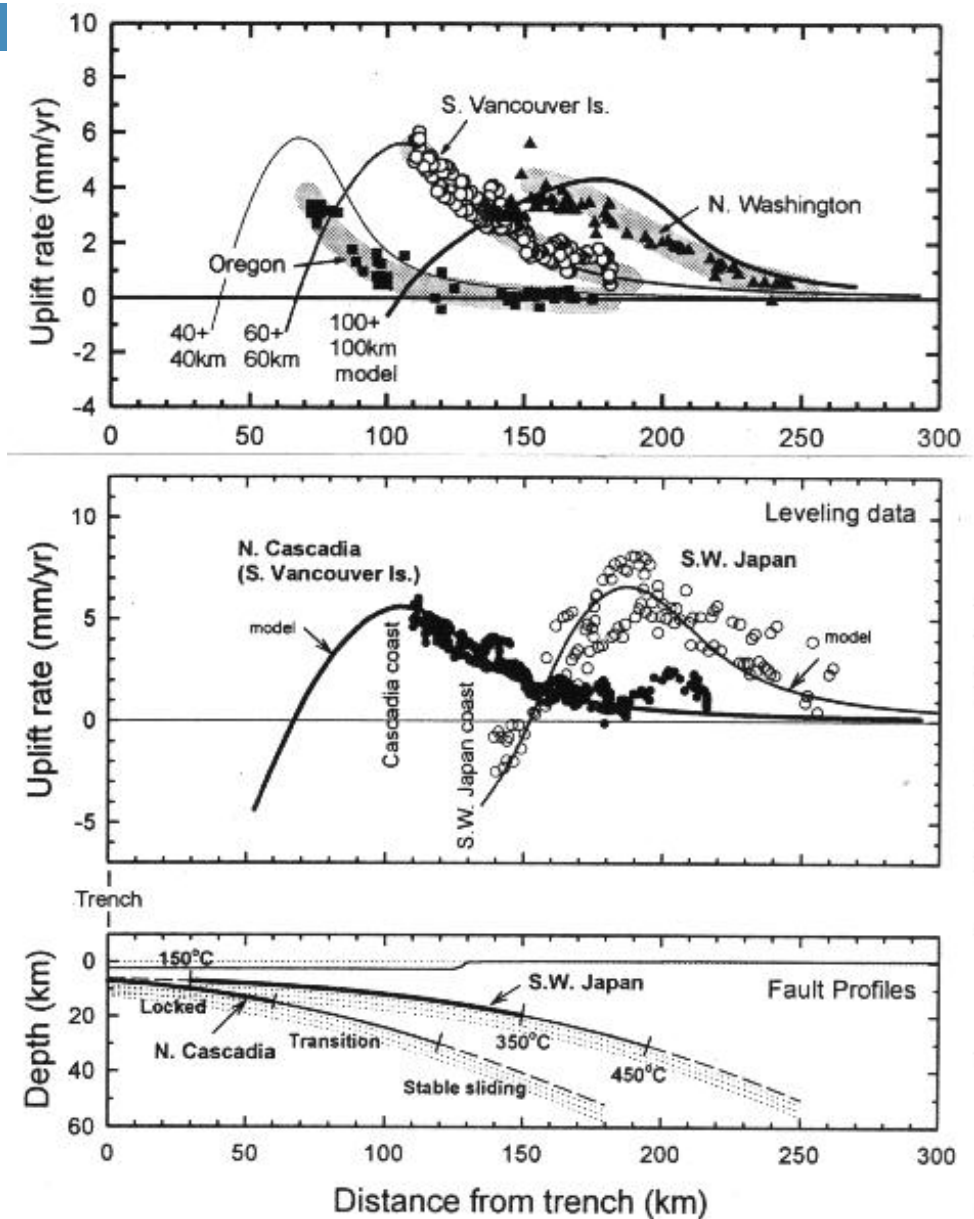
# HTDP Output

```
HTDP (version 2.6) OUTPUT

TRANSFORMING VELOCITIES FROM ITRF00 TO NAD_83

                    INPUT VELOCITIES        OUTPUT VELOCITIES

LAKE SKINNER CORS
    northward velocity     12.10            24.80 mm/yr
    eastward velocity     -34.20           -20.99 mm/yr
    upward velocity         0.00            -0.61 mm/yr
    x velocity            -27.41           -12.22 mm/yr
    y velocity             21.52            22.21 mm/yr
    z velocity             10.08            20.32 mm/yr
```

Document: Done

# Significance of the vertical




Hyndman and Wang, 1994