# Director's Report

**Yehuda Bock**

**Institute of Geophysics and Planetary Physics (IGPP)**

**Scripps Institution of Oceanography (SIO)**

**University of California San Diego (UCSD)**

**May 10, 2018**

**SIO, La Jolla**

# Outline



- People
- CRTN Status
- CSRS Epoch 2017.50 (NAD83)
- Dynamic Datum
- New SOPAC/CSRC Web Interface


- *Director:* Yehuda Bock
- *Coordinator:* Maria Turingan
- *Analysis*: Peng Fang
- *System and Database Administrator*: Anne Sullivan
- *Programmers*: Allen Nance, Songnian Jiang
- *Field engineer*: Matt Norenberg
- *Radio Engineer*: D. Glen Offield
- *Postdoctoral Researchers*: Emilie Klein, Junle Jiang
- Graduate Students: Dara Goldberg, Dorian Golriz
- *Consultant*: John Canas, PLS

## CSRC Executive Committee


- *Chairperson:* Kimberley Holtz
- *Vice-Chairperson:* Mike Berber
- *Secretary:* Thomas Dougherty
- *Treasurer:* Jim McNeil
- *Member:* Art Andrew
- *Member:* Bryan Banister
- *Member:* Ken Joyce
- *Member:* John Tosto
- *Past Chairperson:* Rich Maher
- *UCSD representative*: John Orcutt
- *Director of IGPP*: Steve Constable
- *NGS Pacific Southwest Regional Advisor*: Dana Caccamise
- NGS *California Geodetic Coordinator*: Scott Martin
- *CSRC Director*: Yehuda Bock

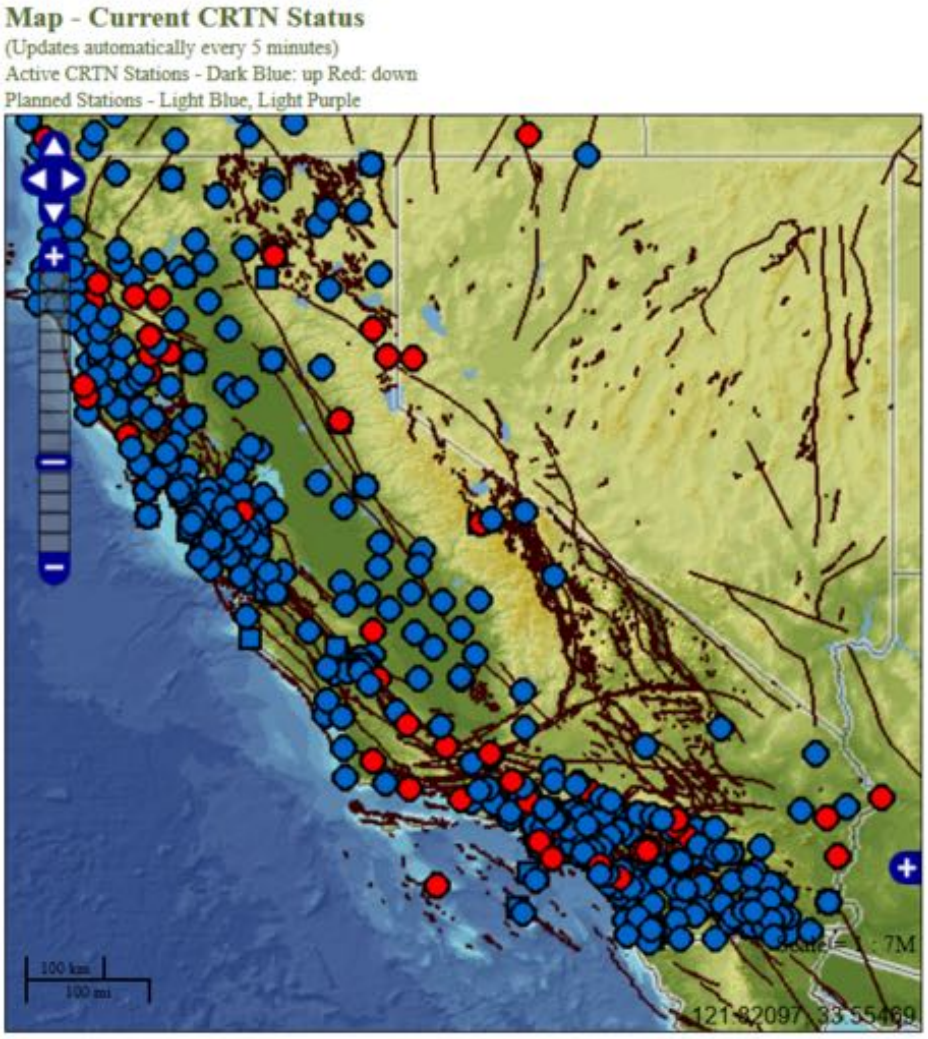
# CRTN Consortium Members

1. City of Los Angeles, Department of Public Works, Bureau of Engineering – Cesar Bregaudit, Robert Nielsen
2. Orange County Public Works – Art Andrew
3. Riverside County Flood Control and Water Conservation District – Jim McNeil
4. San Diego County, Department of Public Works – Ray Mathe
5. Riverside County Transportation Department – David McMillan, Ed Hunt, Tim Rayburn
6. Santa Clara Valley Water District – Kris Puthoff
7. City of Long Beach, Gas and Oil – Kimberley Holtz
8. California Department of Transportation – Scott Martin, Mark Turner
9. Swift Navigation – Grant Hausler
10. Scripps Institution of Oceanography, University of California, San Diego – Yehuda Bock
11. California Spatial Reference Center – Kimberley Holtz

# CRTN
# Contributing Members

1. Adkan Engineers, Tom Chrisman
2. Bock and Clark Corporation, Eric Berben
3. Burkett and Wong Engineers, Casey Lynch
4. California American Water, Stephen San Nicolas
5. Cardno Inc., Sean Fitzpatrick
6. Coast Surveying, Inc., Ken Kasbohm, Gwen del Castillo
7. Dixon Marine Services, Inc., Jeff Haran
8. East Bay Municipal Water District, Steve Martin and Tara Sweet
9. East Bay Regional Parks, Duncan Marshall
10. Helix Water District, Rebecca Vanegas
11. Honda Research Institute USA, Inc., Paul Cummings
12. Japan Aerospace Exploration Agency, Satoshi Kogure, Mike Ramirez
13. Terra-Mark Surveying, Robert Shellman
14. LocusView Solutions, Eric Gakstatter
15. MBS Land Surveys, Michael B. Stanton
16. PSOMAS, Jeremy Evans
17. Quantum Spatial, Kenny Roberts
18. Rail Surveyors and Engineers Incorporated, Cody Festa
19. RBF Consulting, Company of Michael Baker Corporation
20. RSE Inc., Cody Festa
21. Salsbury Engineering, Inc., Jon Gauthier
22. San Francisco Water Department, Edward Peterson
23. Southern California Gas Company, Gregory Irwin
24. SubCarrier Systems Corp., David Kelley
25. US Army Corps of Engineers, Ronald Spencer

# CRTN Station Status @ May 8, 2018 10:00 AM




Started in 2003, 1 Hz RTCM 3.0 data are available from 420 stations from 2 CRTN servers (SC: 206 stations; NC: 241 stations) at SOPAC with a latency of ~0.4-1.0 s. Data directly collected from SCIGN/PBO stations via UCSD's HPWREN communications (48 stations), and from UNAVCO/PBO, USGS Pasadena, UC Berkeley, Caltrans and Orange County servers.

CSRS Epoch 2017.50 (NAD83) coordinates transmitted, with station metadata in RTCM 3.0 format

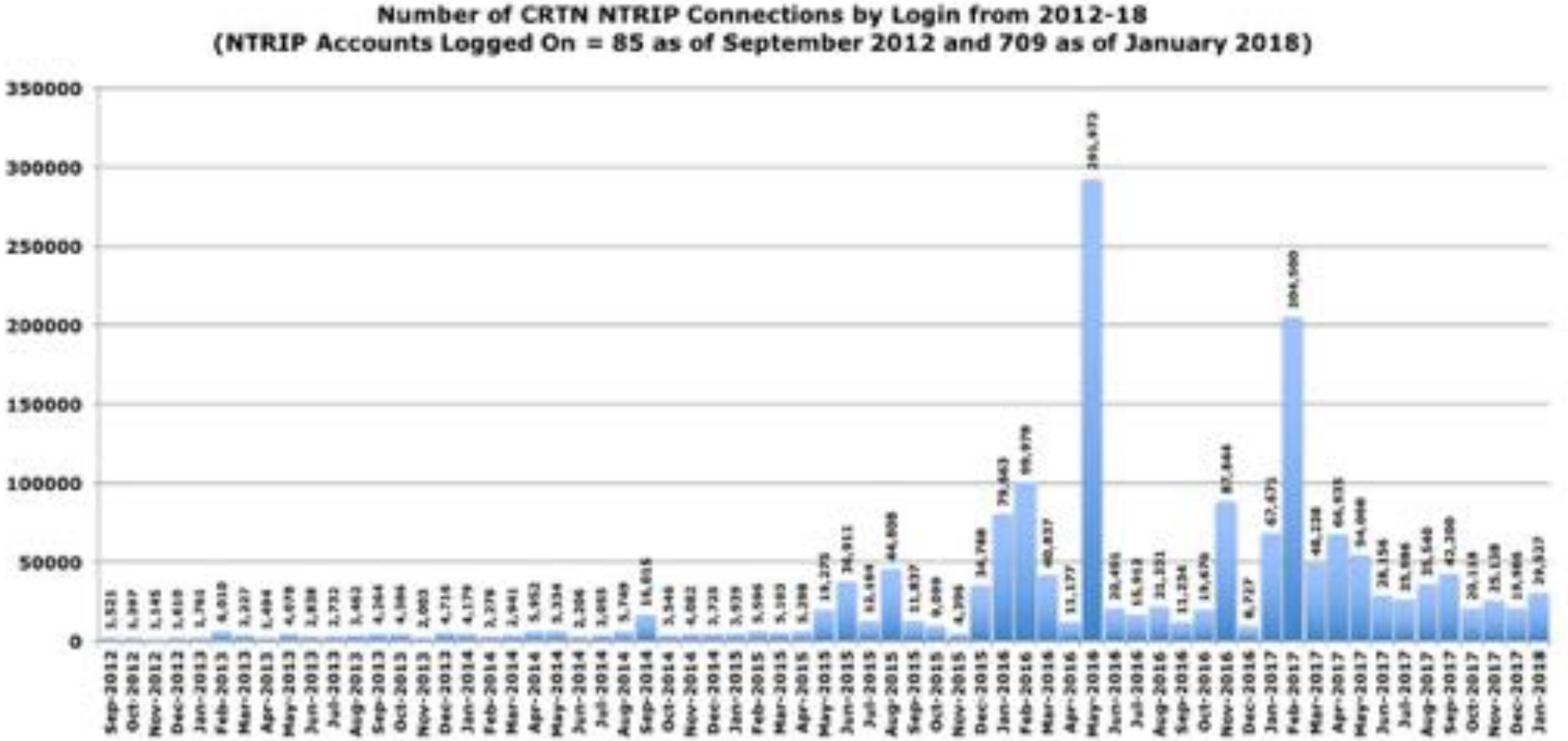
1059 registered Users

# CRTN Accounts

- An NTRIP account (username & password) is required, requested by on-line registration: (https://www.surveymonkey.com/s/CRTN_Registration)
- 1059 companies/agencies registered (up from 918 at 2017 Fall Meeting)
- > 30 multi-account users
- More visibility via Google searches

- Recent accounts
  - 964. United States Department of Defense, San Bernardino (testing and training)
  - 1016. Tangent Systems, Orange County (Telecom, Technology, Internet and Electronics, locations for potential construction)
  - 1022. US Survey Supply, San Diego (GNSS sales and training)
  - 1030. Big W Sales, Monterey County (agricultural tractor steering)
  - 1041. Lyft, San Francisco (self driving vehicles)
  - 1045. Riverside Construction (bridge repair)
  - 1058. Charles Usher Wines, Santa Clara (drones for vineyard agriculture)

# Connections to CRTN Stations through January 2018




**PROJECT REPORT**

# California Spatial Reference System

# CSRS Epoch 2017.50 (NAD83)

**Yehuda Bock, Peng Fang and Gregory R. Helmer**

Submitted: January 4, 2018

Rolled Out: March 1, 2018

Per Interagency Agreement 52A0103
Regents of the University of California &
California Department of Transportation
Scripps Institution of Oceanography (SIO)

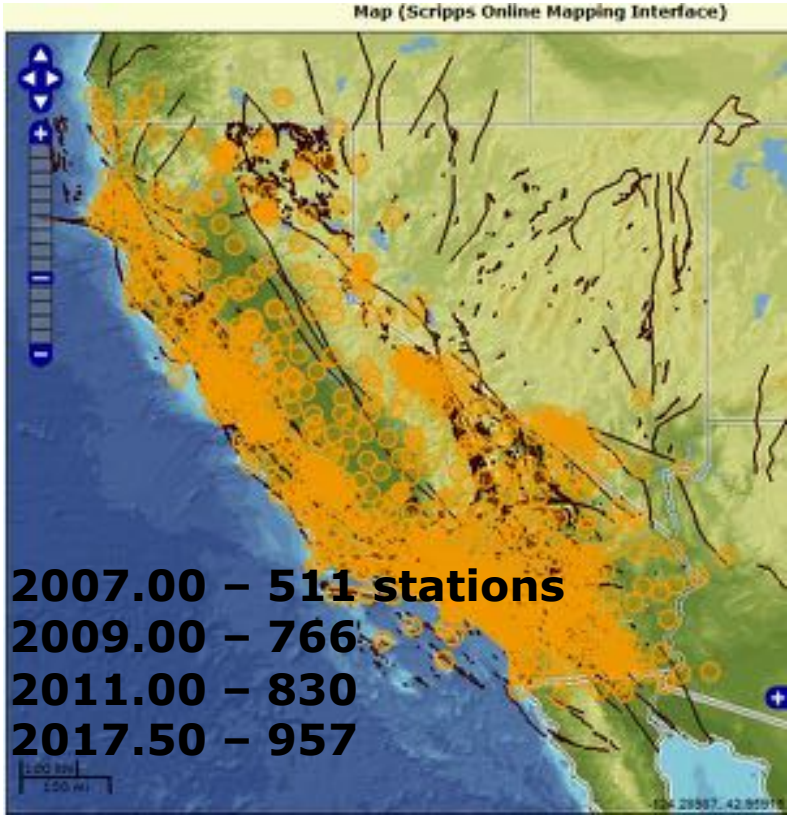
# New Geodetic Datum for California: CSRS Epoch 2017.50 (NAD83)

- 957 stations in California and borders of Arizona, Nevada and Oregon
- 849 active stations; 108 inactive stations

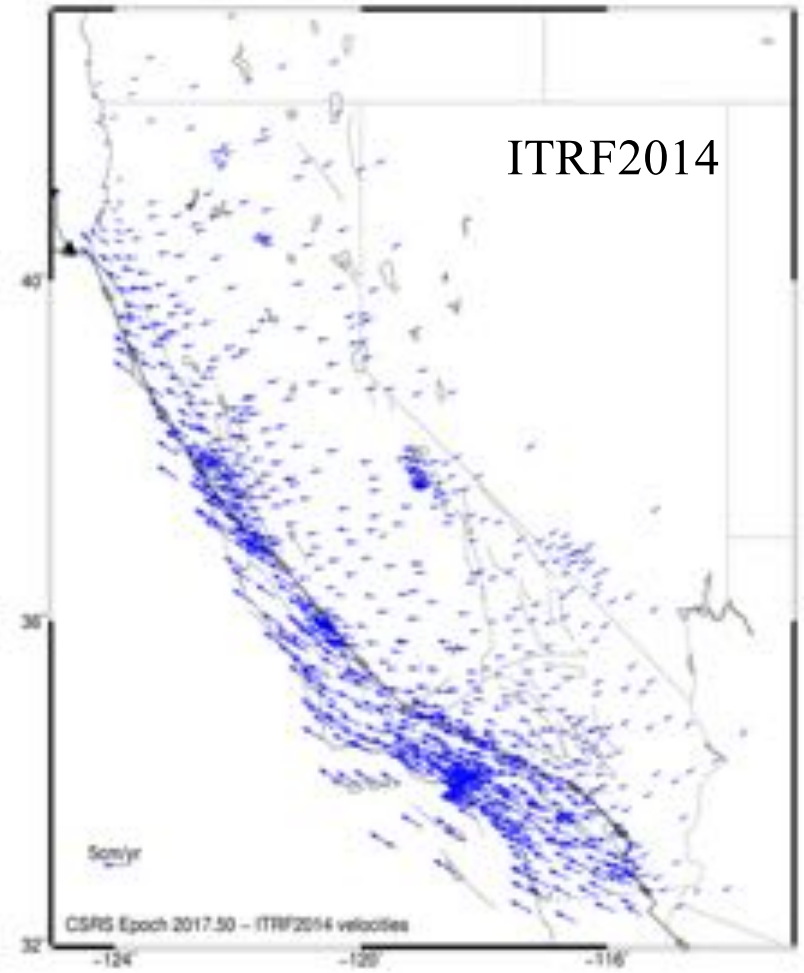
Deliverables:

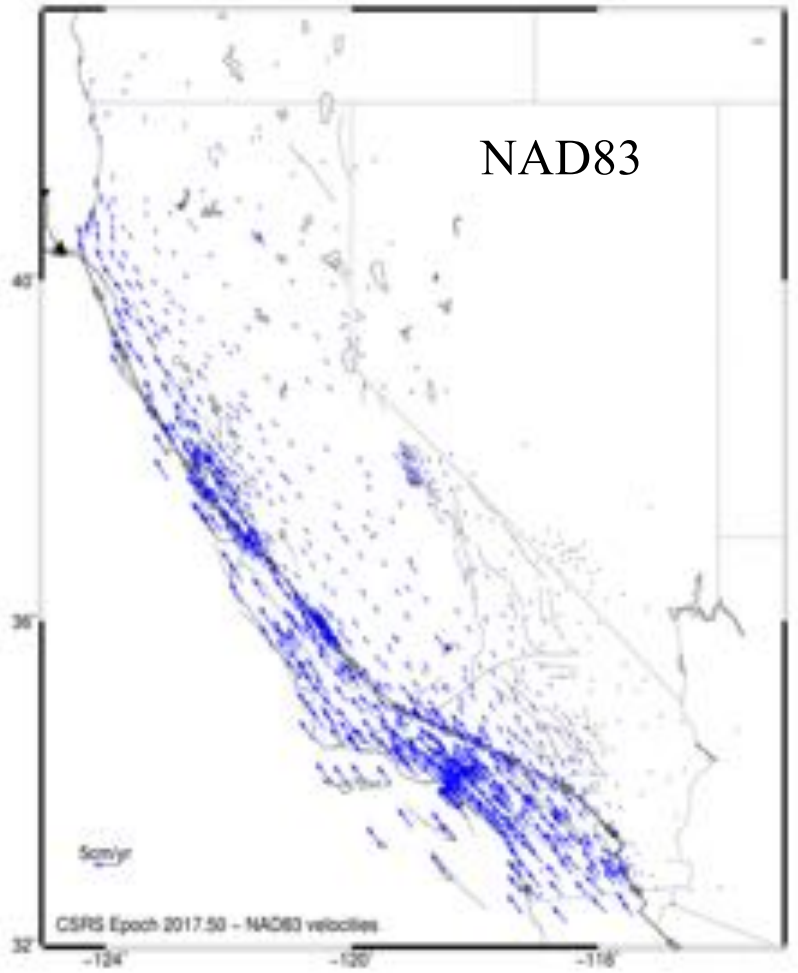
- Project report
- Table 1: Geodetic Coordinates ITRF2014 & NAD83 (2011) + uncertainties (2 sigma); orthometric heights
- Table 2: Quality control
- Table 3: Motions wrt previous Epoch dates (2007.00, 2009.00, 2011.00)

http://geoweb99.ucsd.edu/index.php/epoch2017/

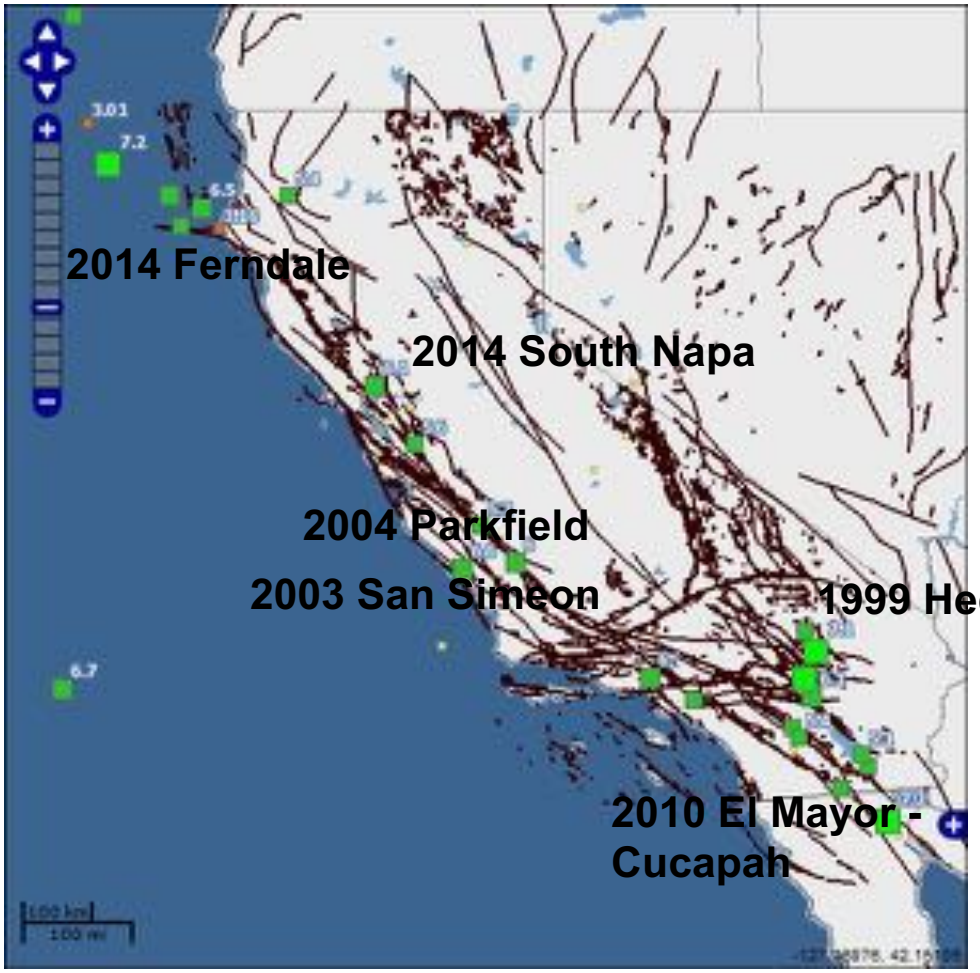


# CSRS Epoch 2017.50 (NAD83) Station Velocities

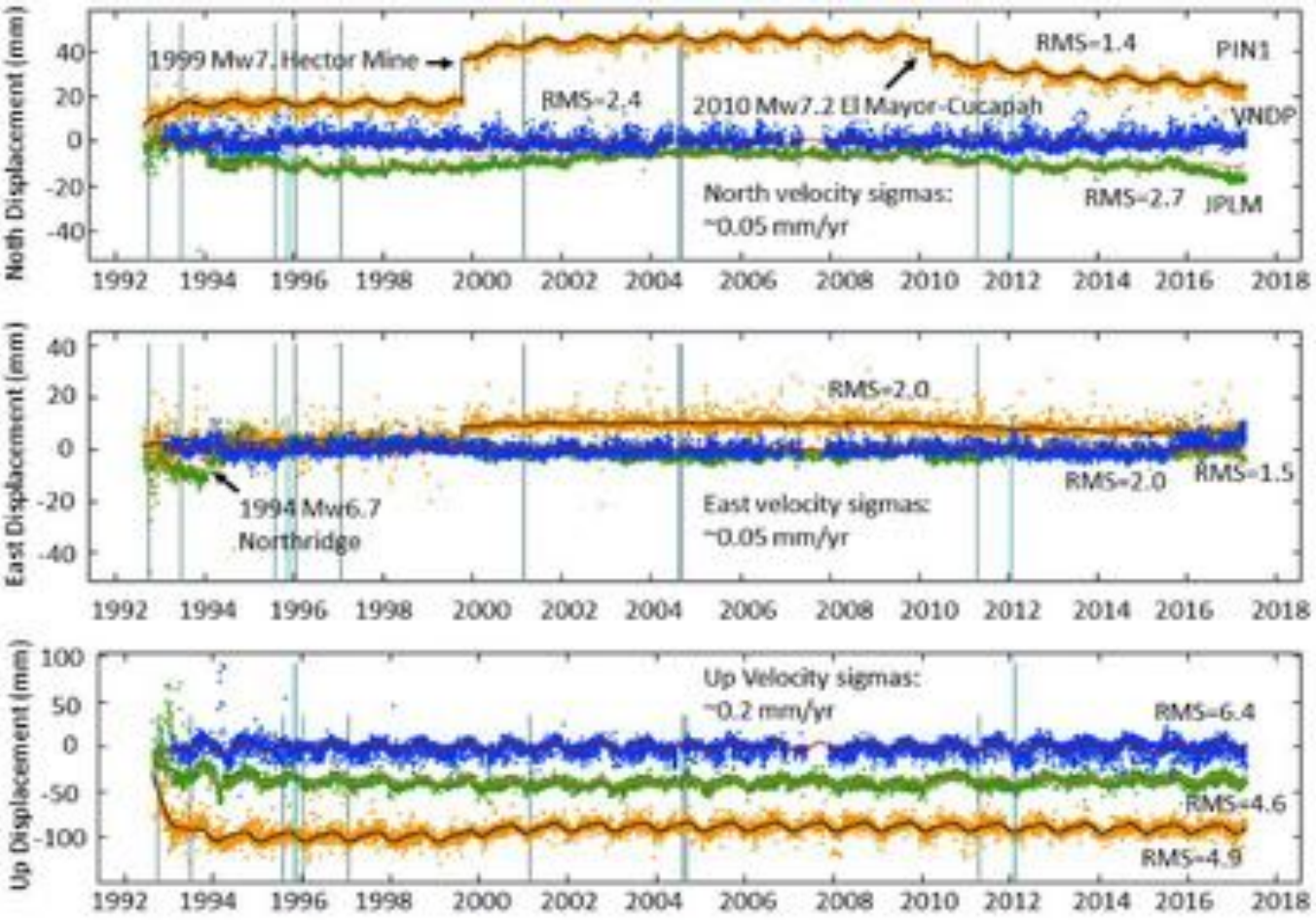


# Significant Earthquakes in California 1995-2017



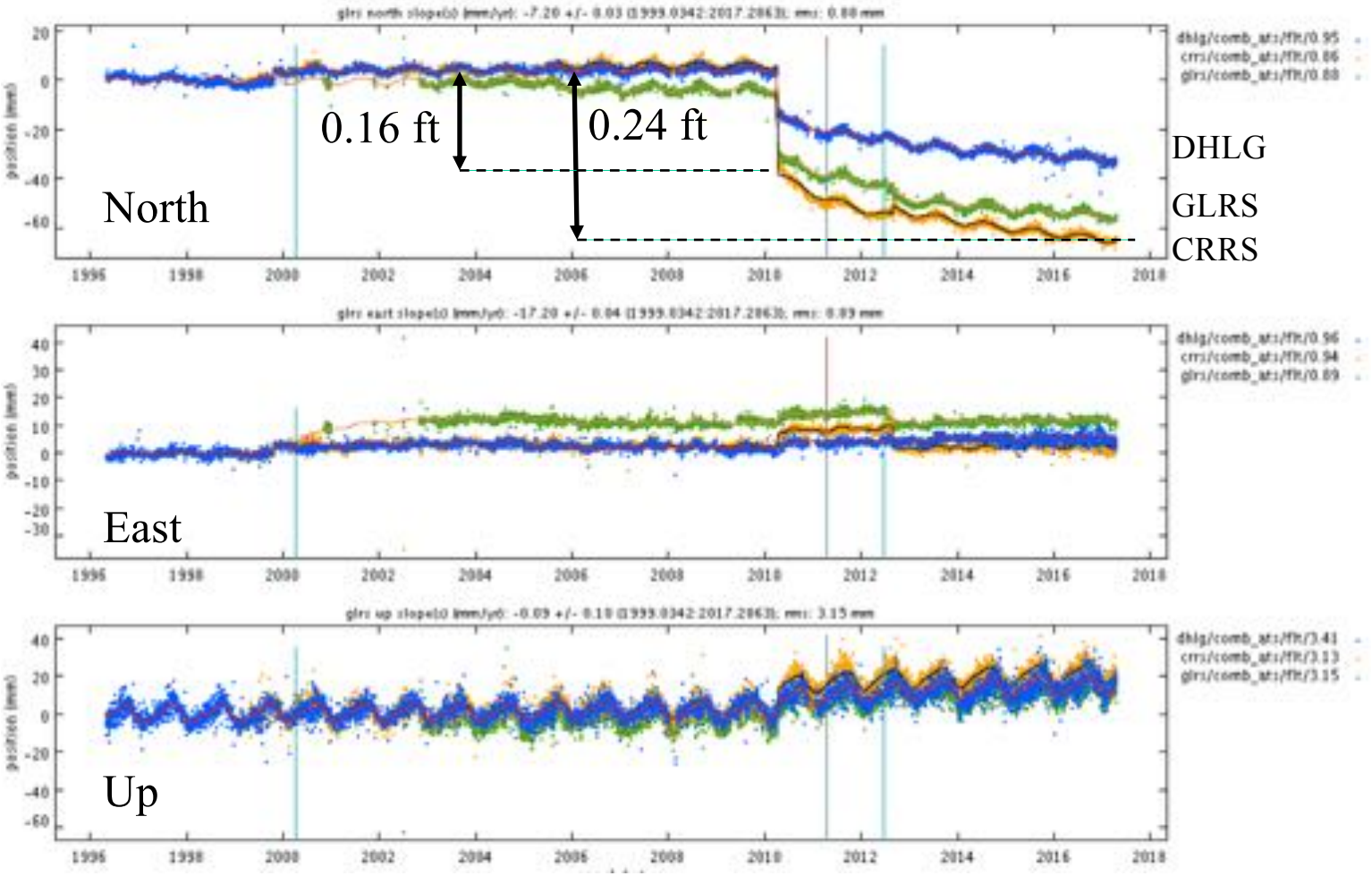
# Displacement Time Series (1992-2017)




Three stations southern California – Vandenberg Air Force Base, Pinyon Flat Observatory, Jet Propulsion Laboratory

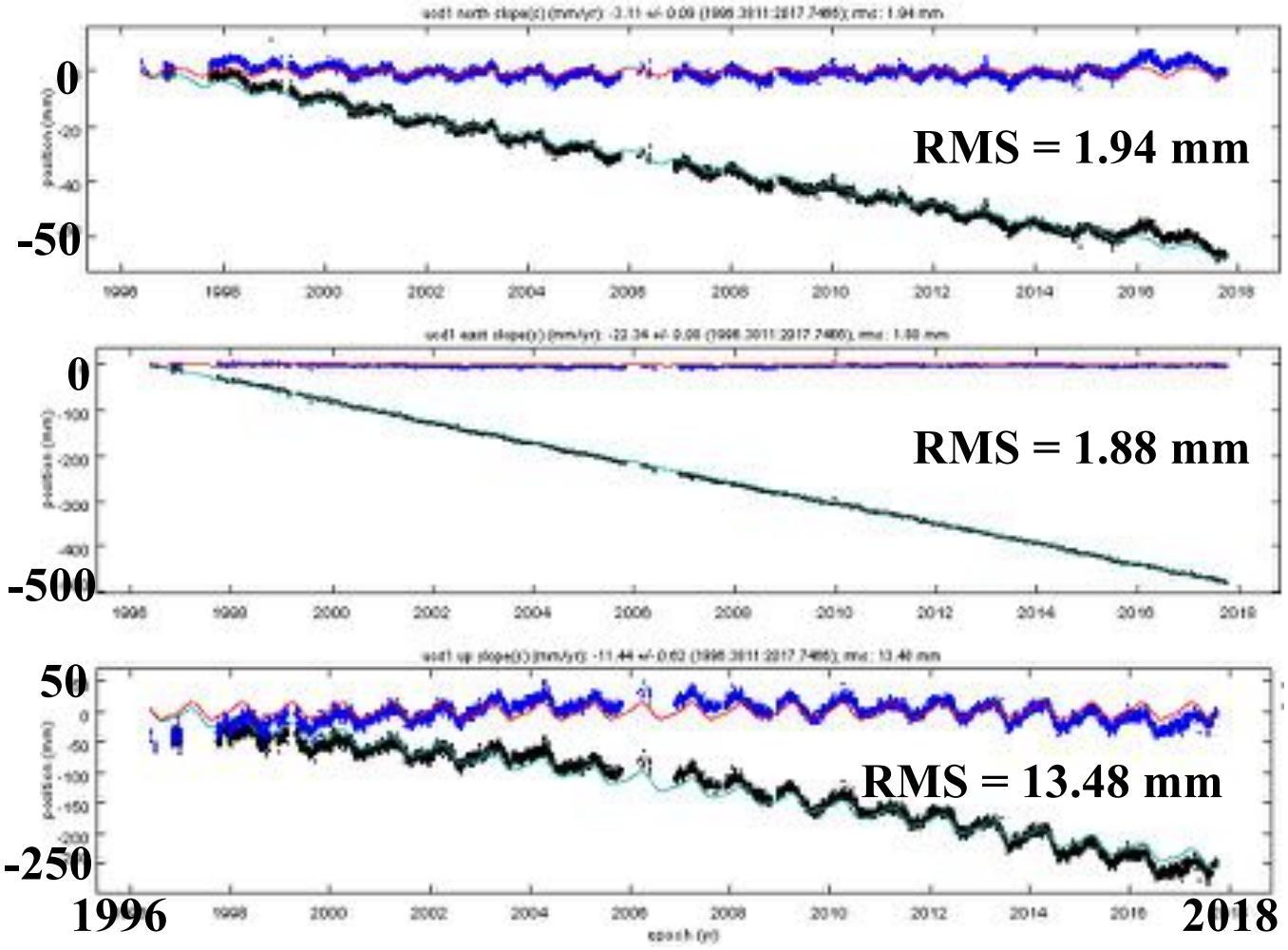
Effects of 3 three earthquakes, antenna changes, landslide

# Detrended Displacement Time Series (1996-2017)
# Coseismic & Postseismic Motions

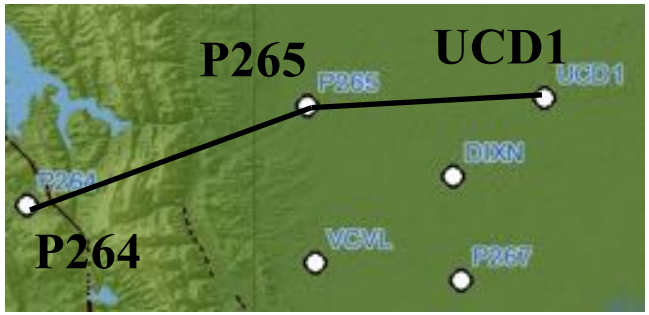


# Sacramento Valley Transect

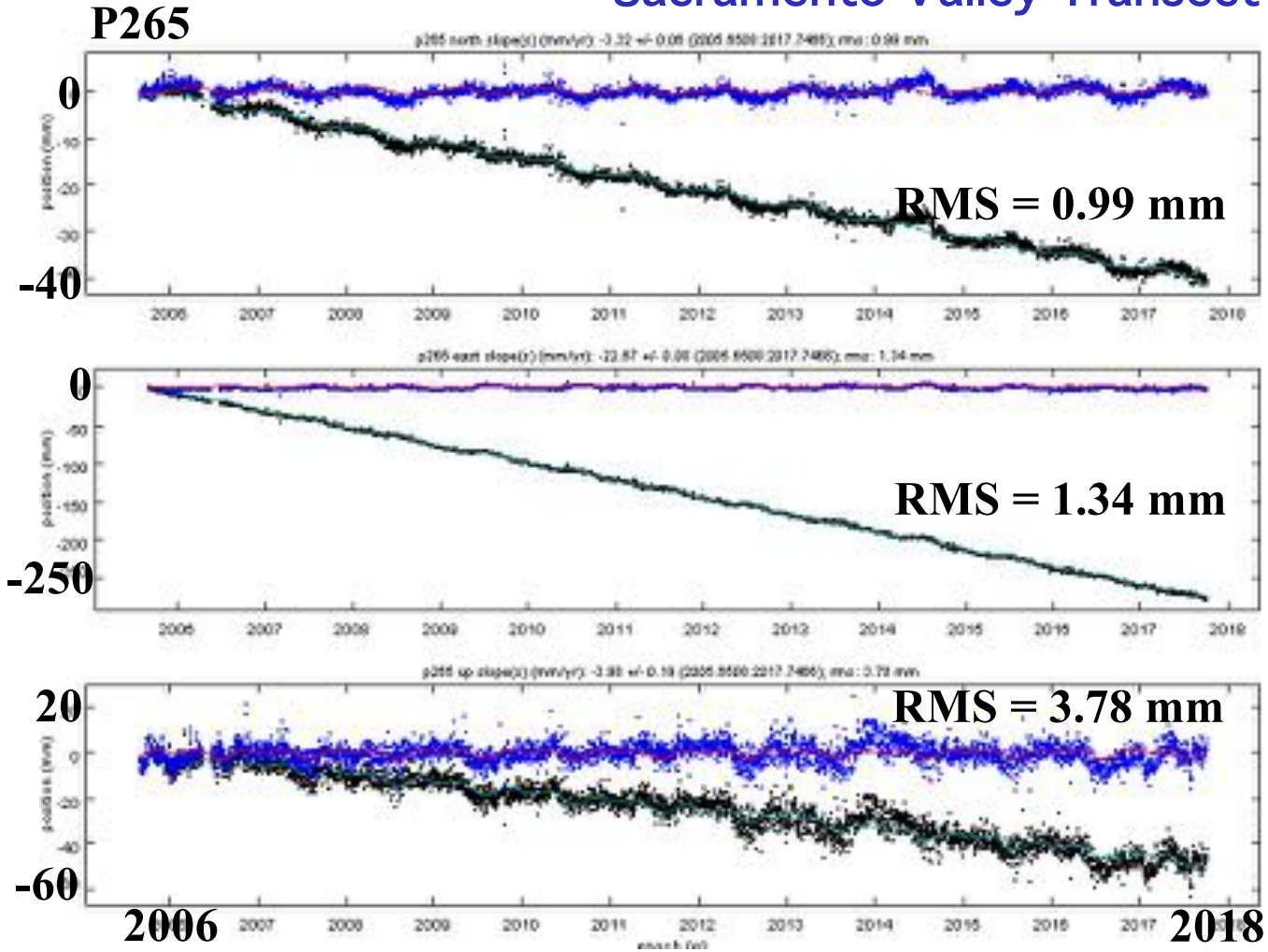
**UCD1**



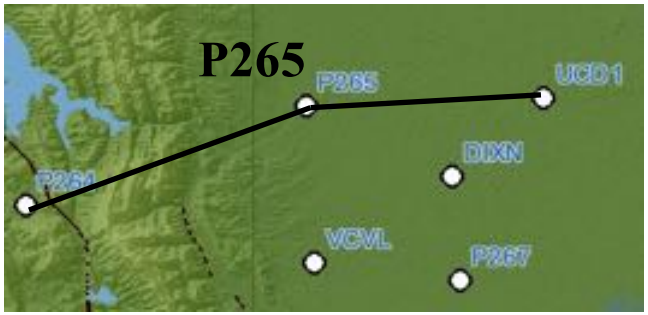

**Sacramento Valley**



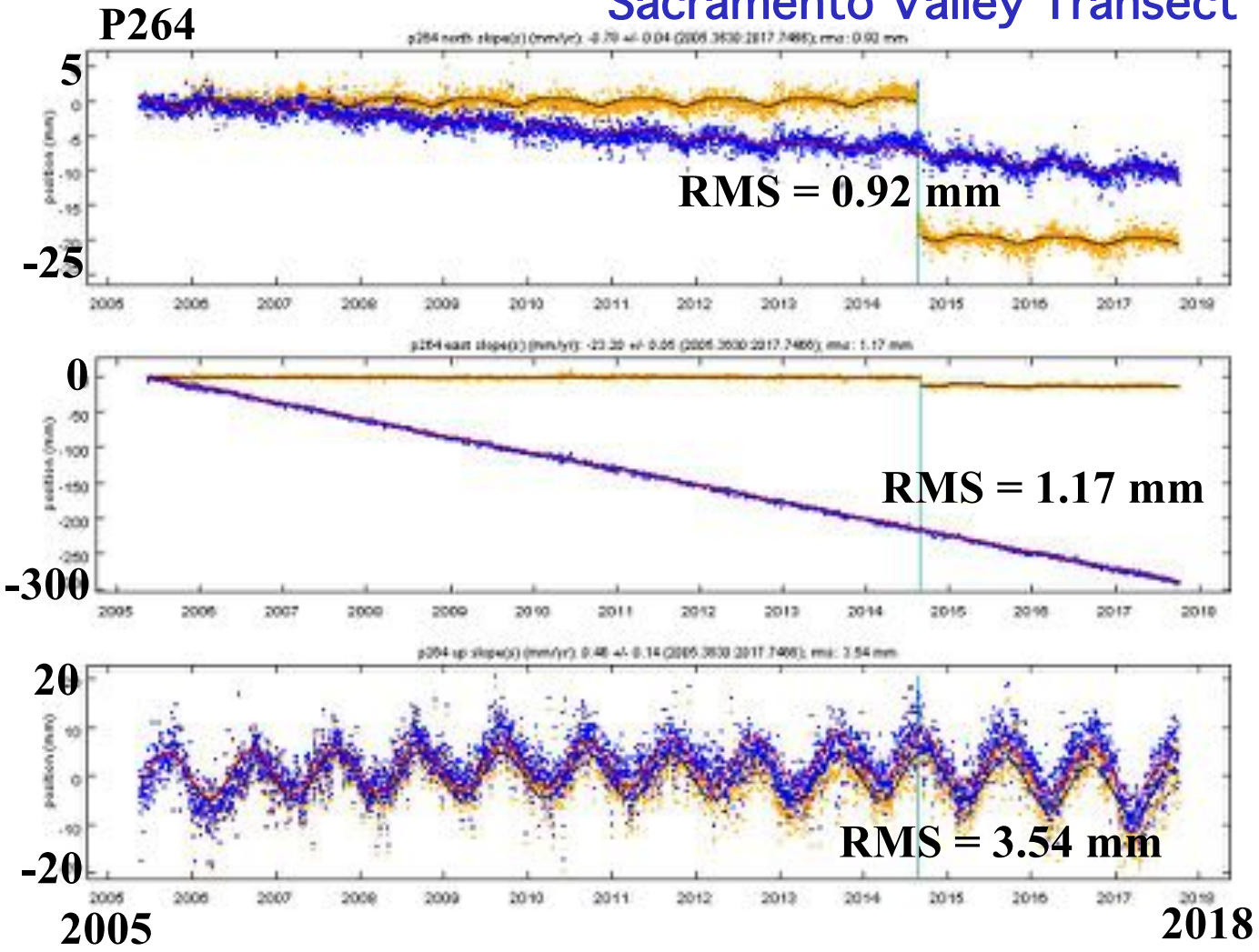
# Sacramento Valley Transect



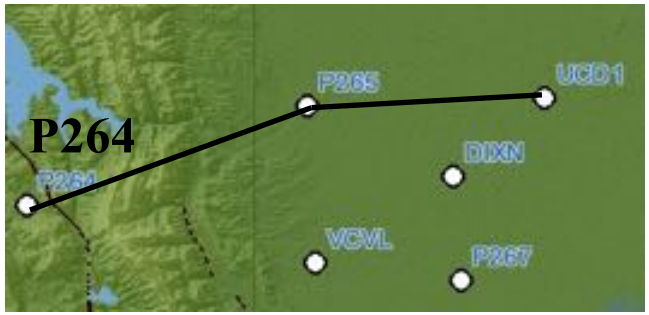

Sacramento Valley



# Sacramento Valley Transect

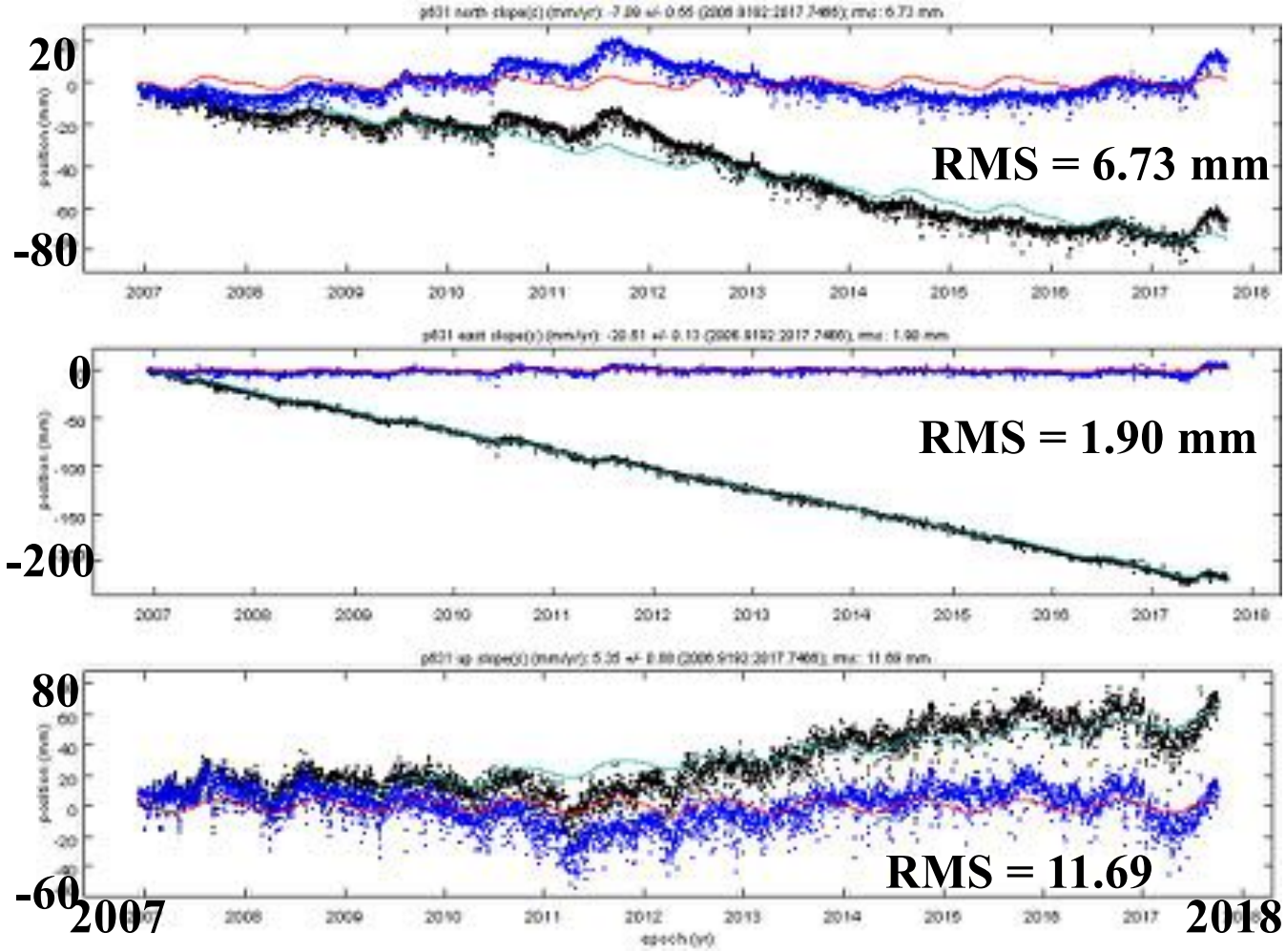



Sacramento Valley

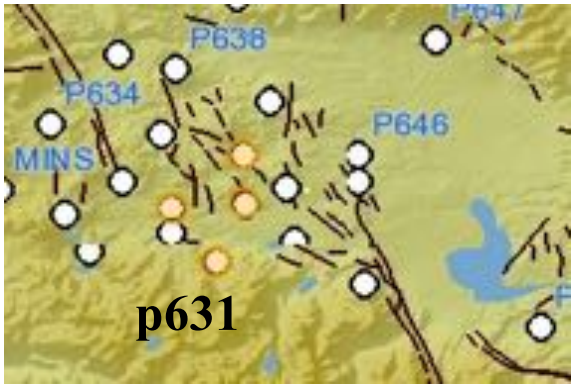


P631

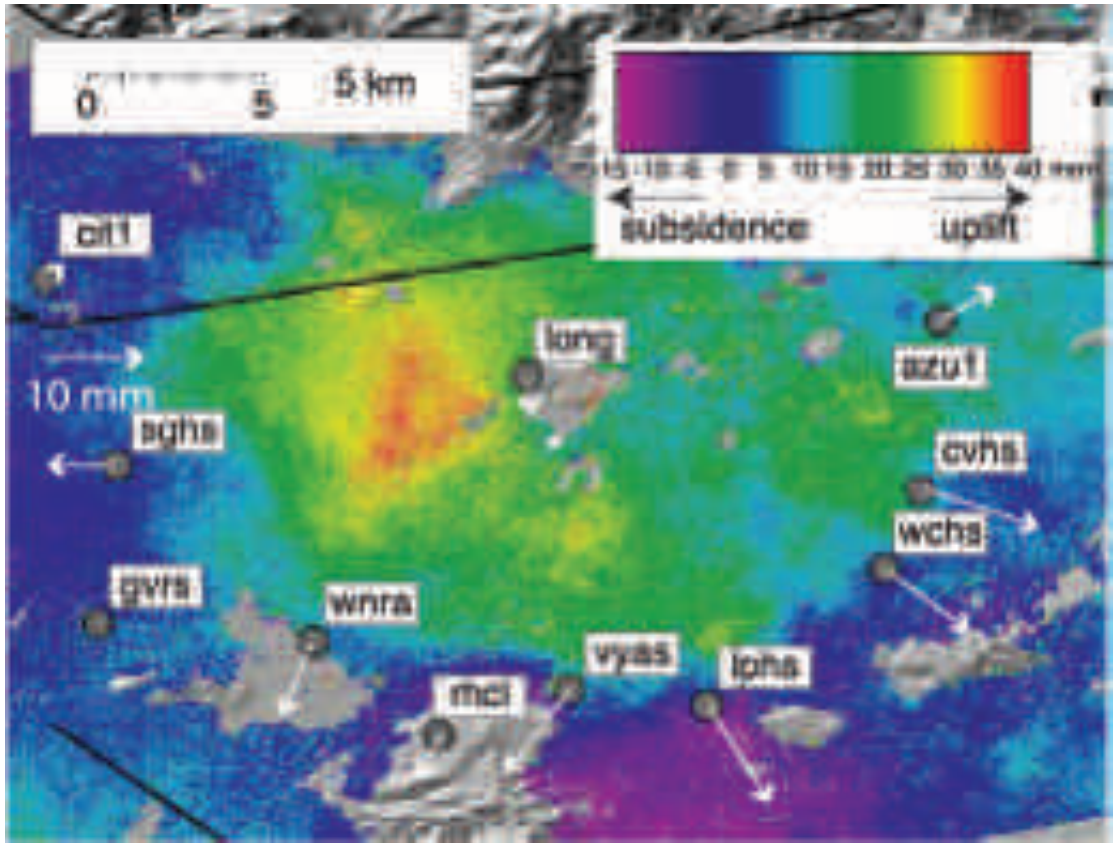
# Magmatic Effects – Uplift at Long Valley Caldera




**Mammoth Lakes Network**



# Transient Non-Tectonic Horizontal Motions from Aquifer Recharge




Continuous GPS horizontal (arrows) and vertical (color scale) displacements in the period 2005.0-2005.4 in the San Gabriel Valley, southern California caused by aquifer recharge due to heavy rains. The station LONG had an uplift of 47 mm.


**PROJECT REPORT**

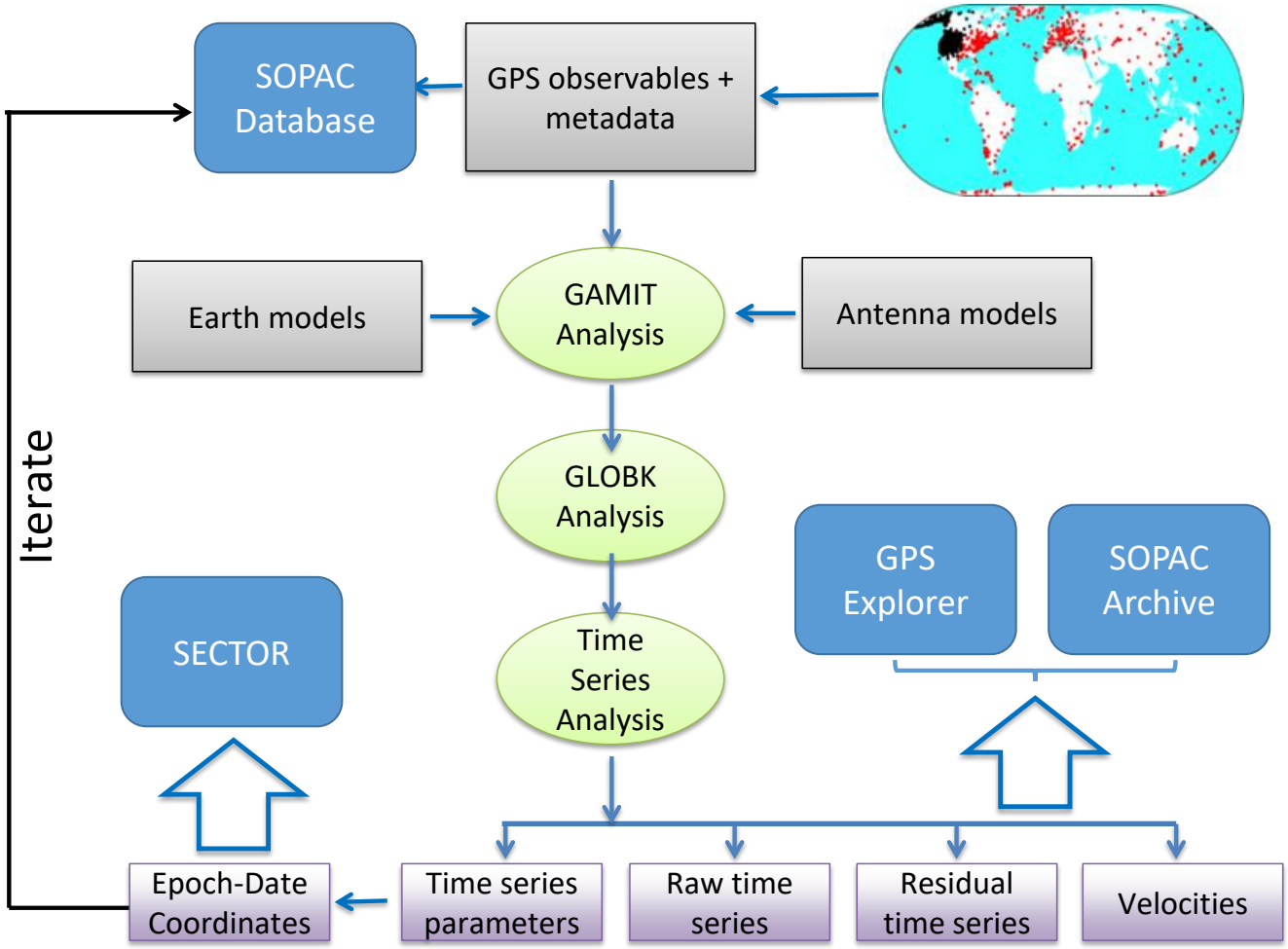
# Investigations into a Dynamic Datum for California

**Yehuda Bock and Emilie Klein**

**Draft, May 10, 2018**

Per Interagency Agreement 52A0103
Regents of the University of California &
California Department of Transportation
Scripps Institution of Oceanography (SIO)

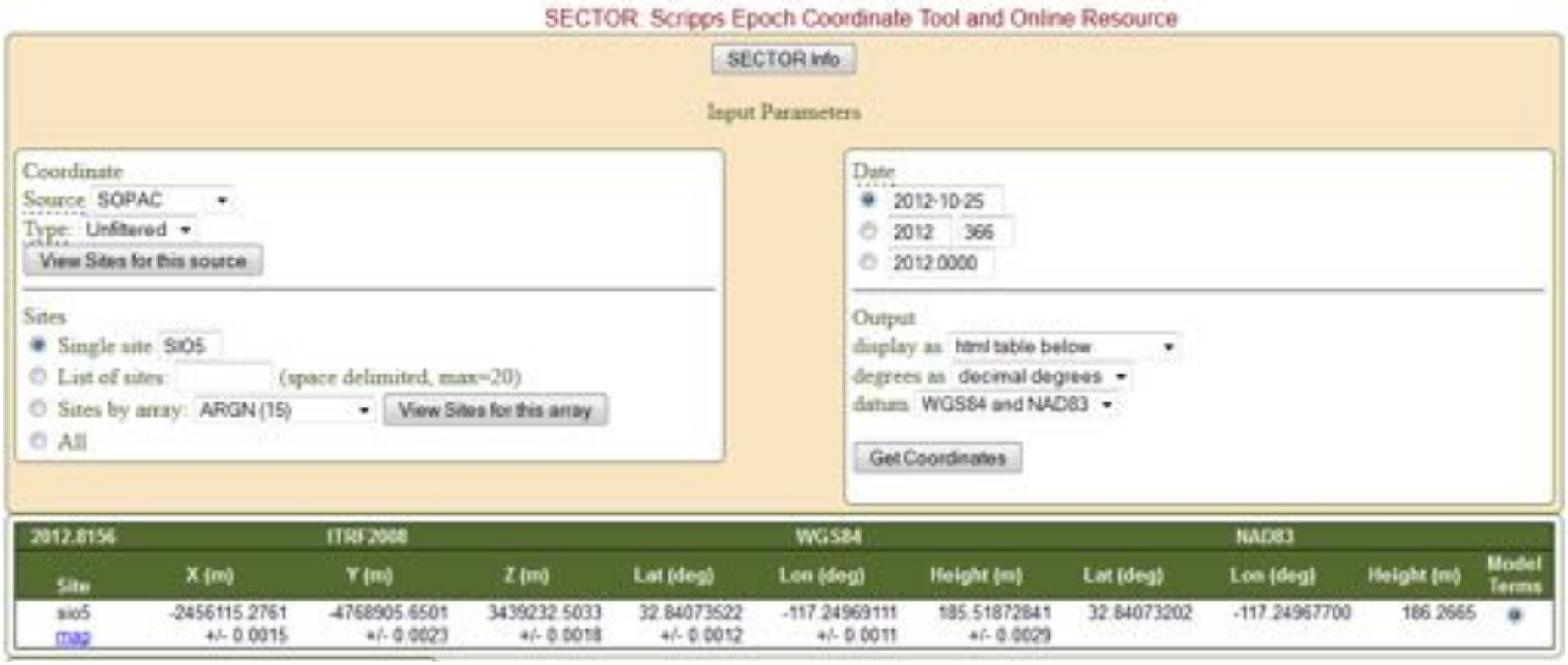
# Production of Displacement Time Series



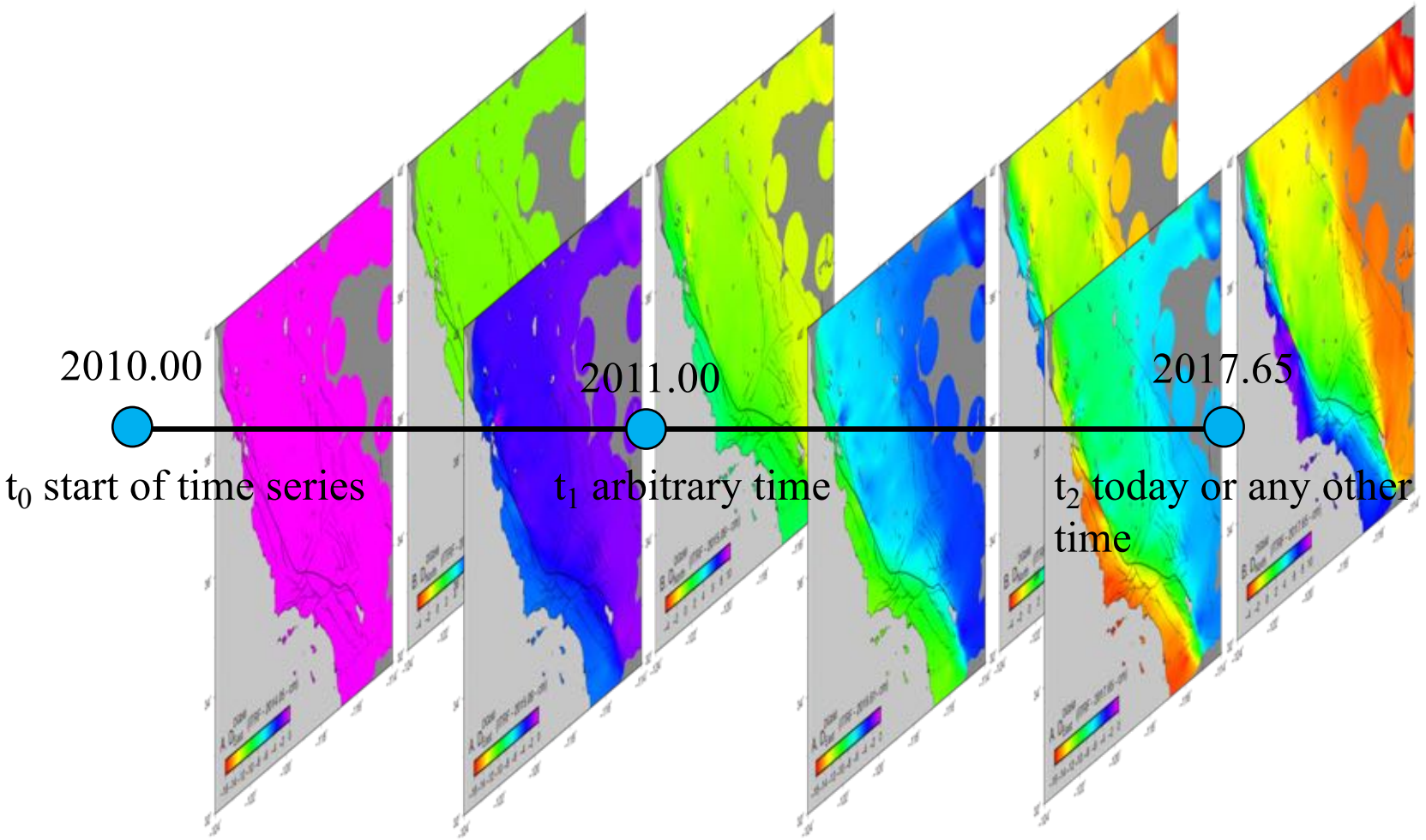

The displacement time series are modeled from their start, re-evaluated after every new week of daily GPS solutions is available.

Every week, a new dynamic datum grid is calculated and archived. Each grid represents the changes in displacements since the start of the time series. The transformation between any two Epoch dates is obtained by subtracting the two corresponding grids.

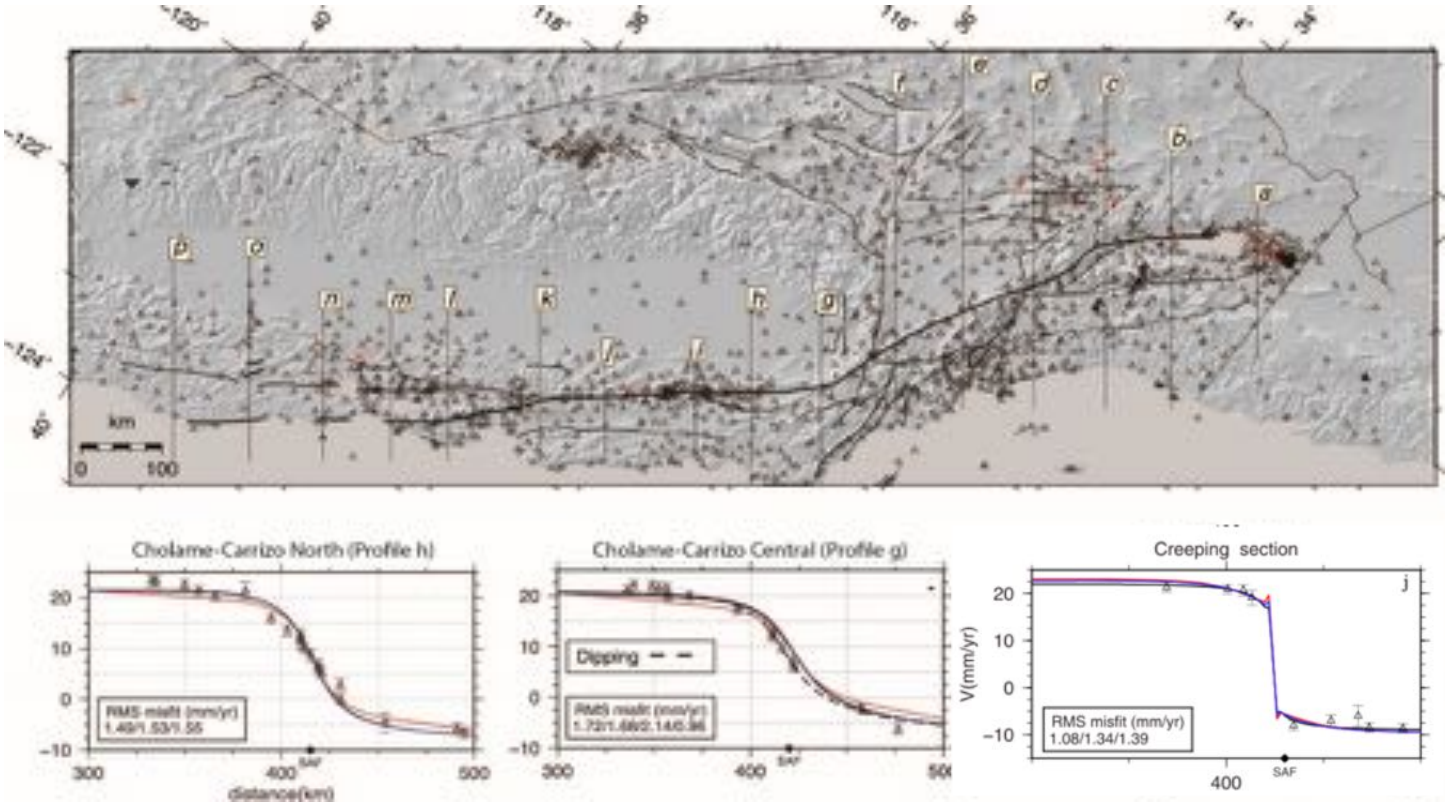
# SECTOR Utility: Epoch-Date Coordinates
# Allows Transformation of Coordinates between Epochs
# But Only for CSRN Reference Stations
# Not for Arbitrary Stations



# Dynamic Datum:
# Transform Coordinates between Epochs at an Arbitrary Location



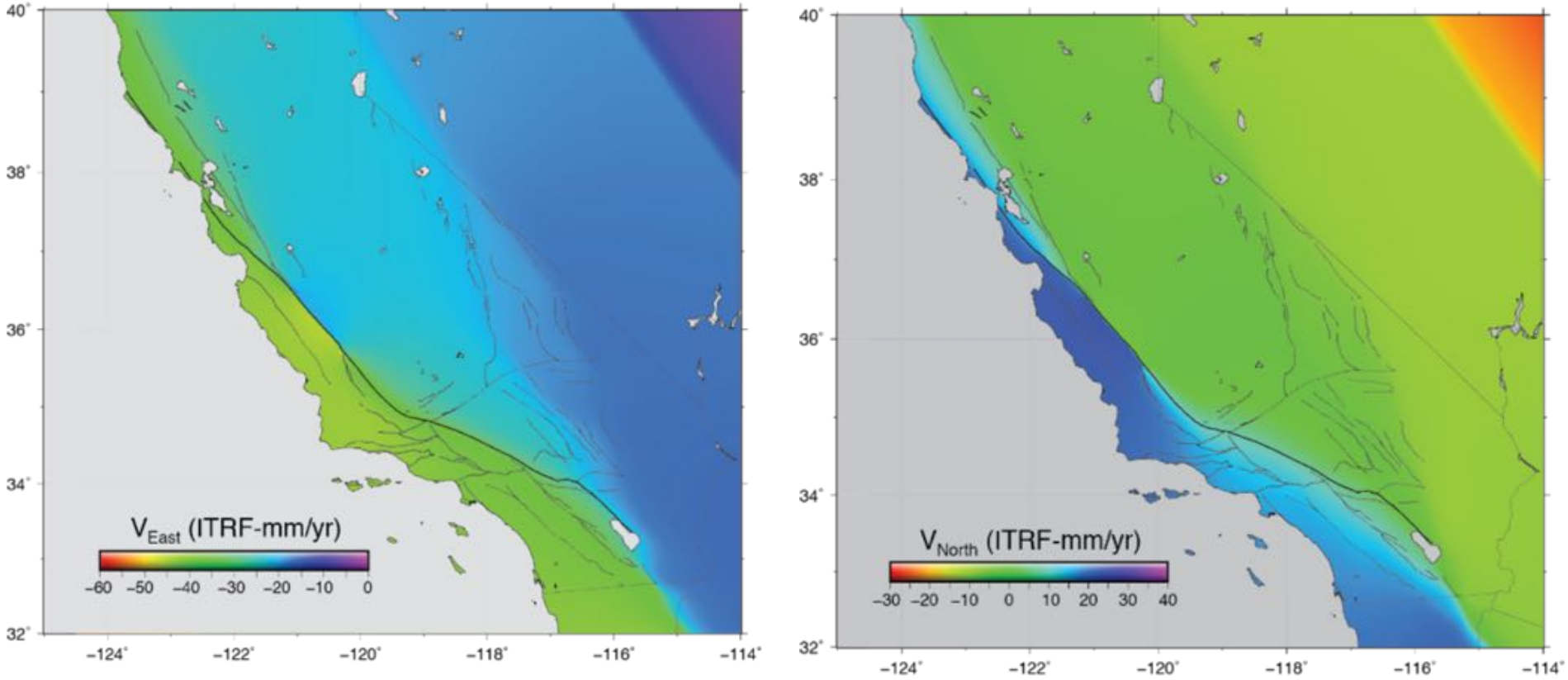
# San Andreas Fault System




A region ~200 km wide centered on the fault is deforming approximately as an inverse tangent function due to elastic deformation of the crust and other tectonic processes. Characteristics of tangent function are depending of the creep rate on the fault, highly variable. *These motions are taken into account when adopting an underlying geophysical model, rather than just interpolate surface displacements.*

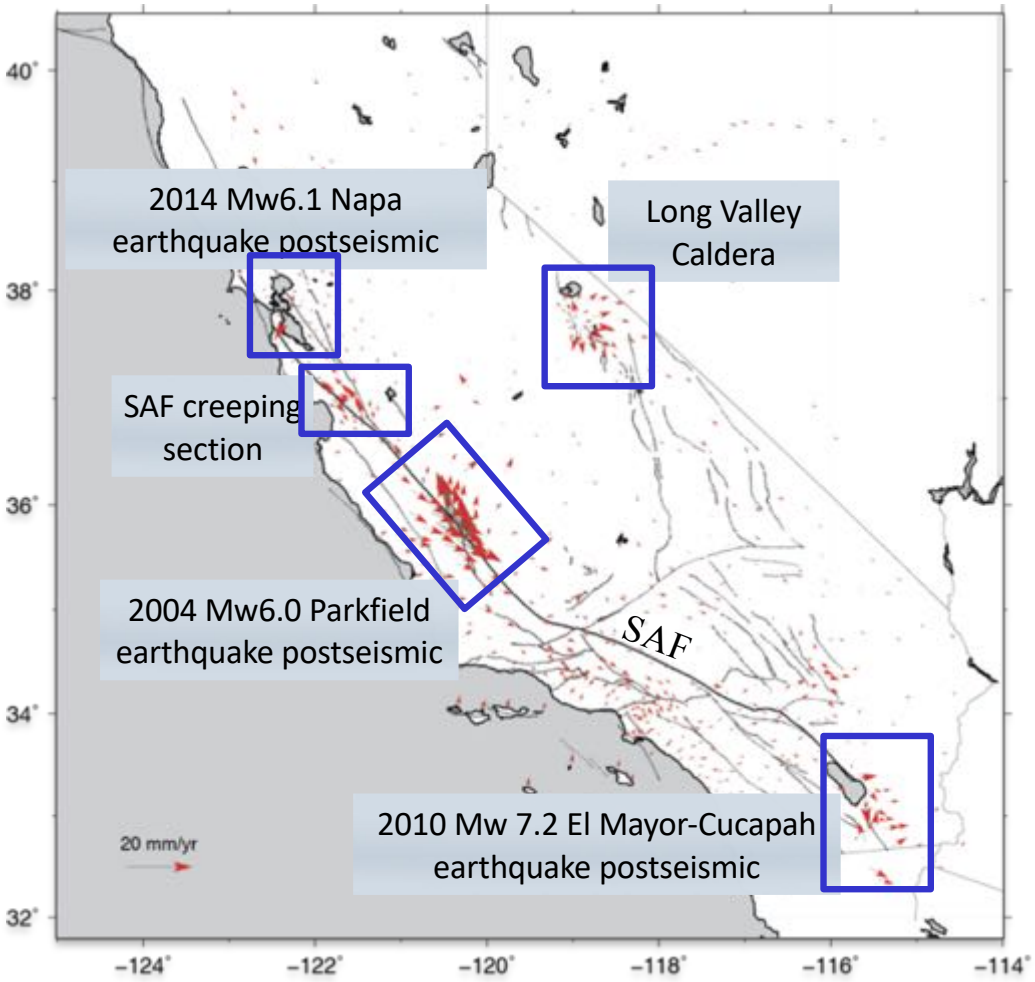
Tong et al. (2014) Geophysical model of the San Andreas fault system (horizontal)

# Predicted Surface Velocity Surface from Geophysical Model




Velocity surface in mm/yr predicted by the fault model of Tong et al. (2014), based on the1996-2014 GPS- and InSAR-based velocities, eastward (left) and northward (right) components.

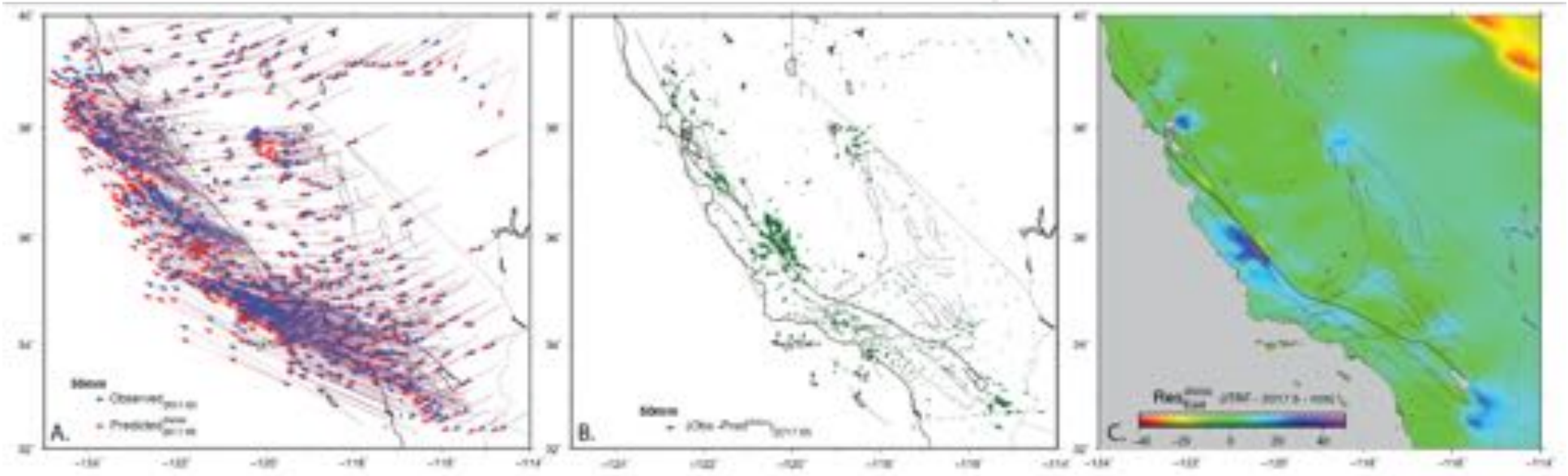
# Deviations from Geophysical Model




Velocity residuals between the Tong et al. (2014) time-independent fault model and the SOPAC time-dependent displacement time series indicating areas of significant differences due to postseismic deformation for 3 earthquakes, magmatic inflation at Long Valley caldera, and creep along the San Andreas fault.

→ Time **dependent** processes

# Deviations from Geophysical Model

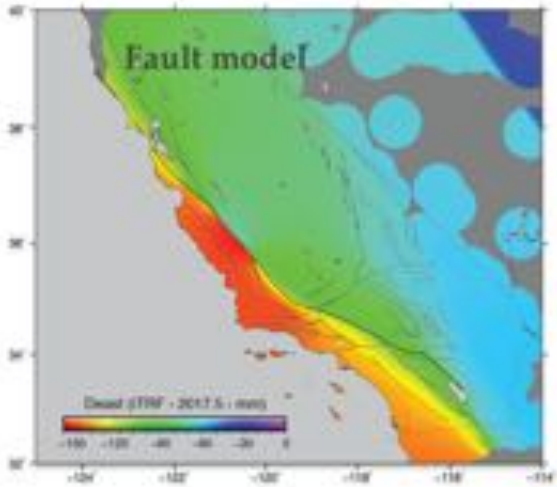


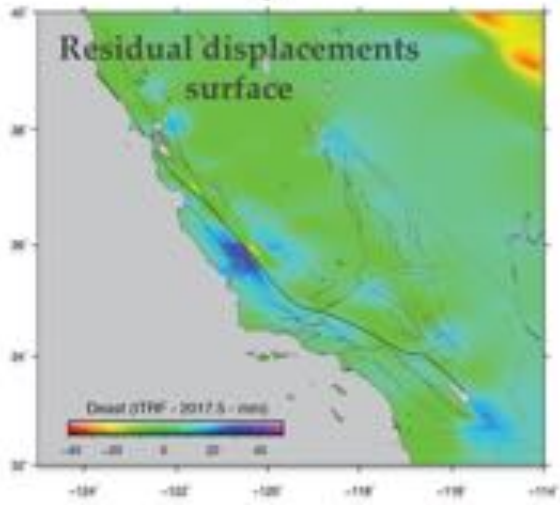

Modeling methodology to transform from survey epoch t = 2017.65 to 2014.00:

A) observed (blue) vs model predicted (red) displacement field;
B) residuals = observed-modeled;
C) surface interpolation of residuals for the eastward component.

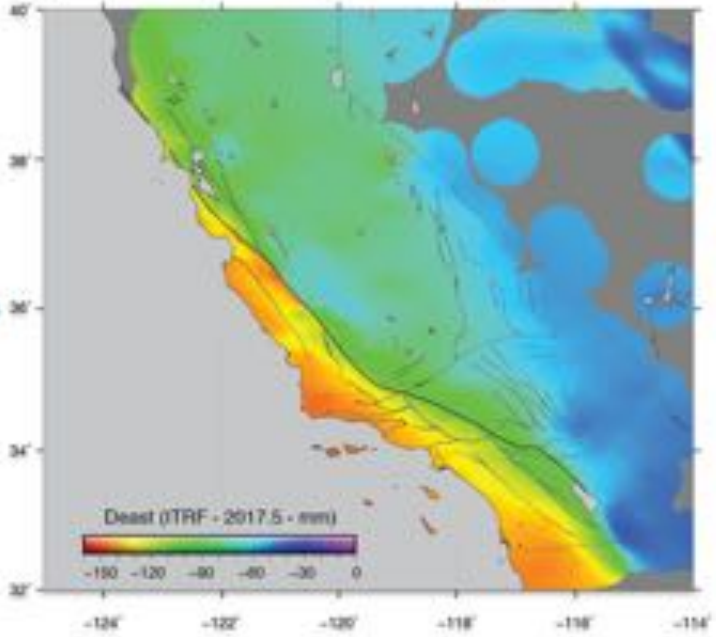
# Methodology for Creating Horizontal Surface Displacement Grids

D. Sum of the geophysical model prediction and the surface interpolation of residuals displacement for the eastward component



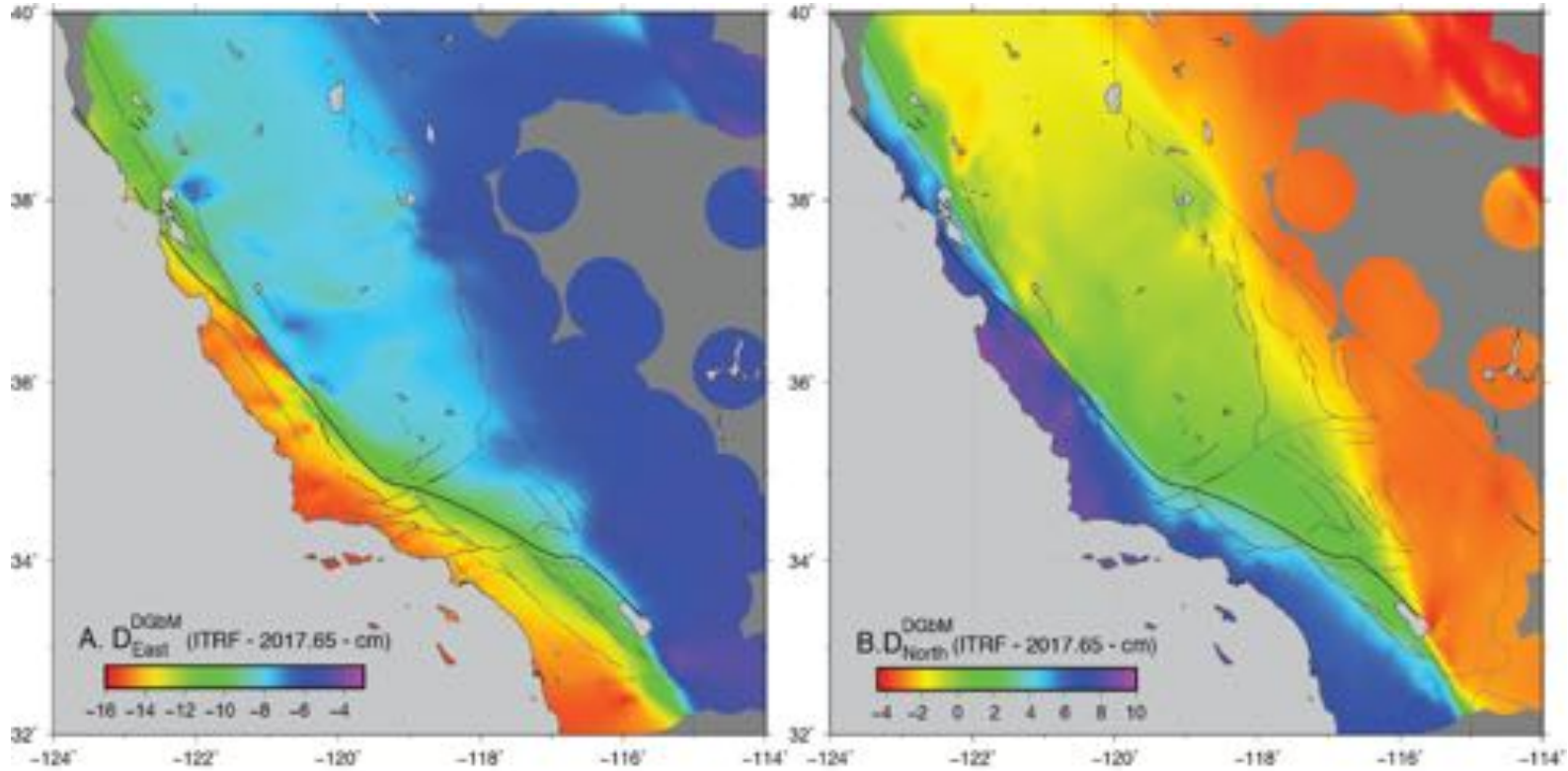




Upgraded surface displacement grid at a time *t*



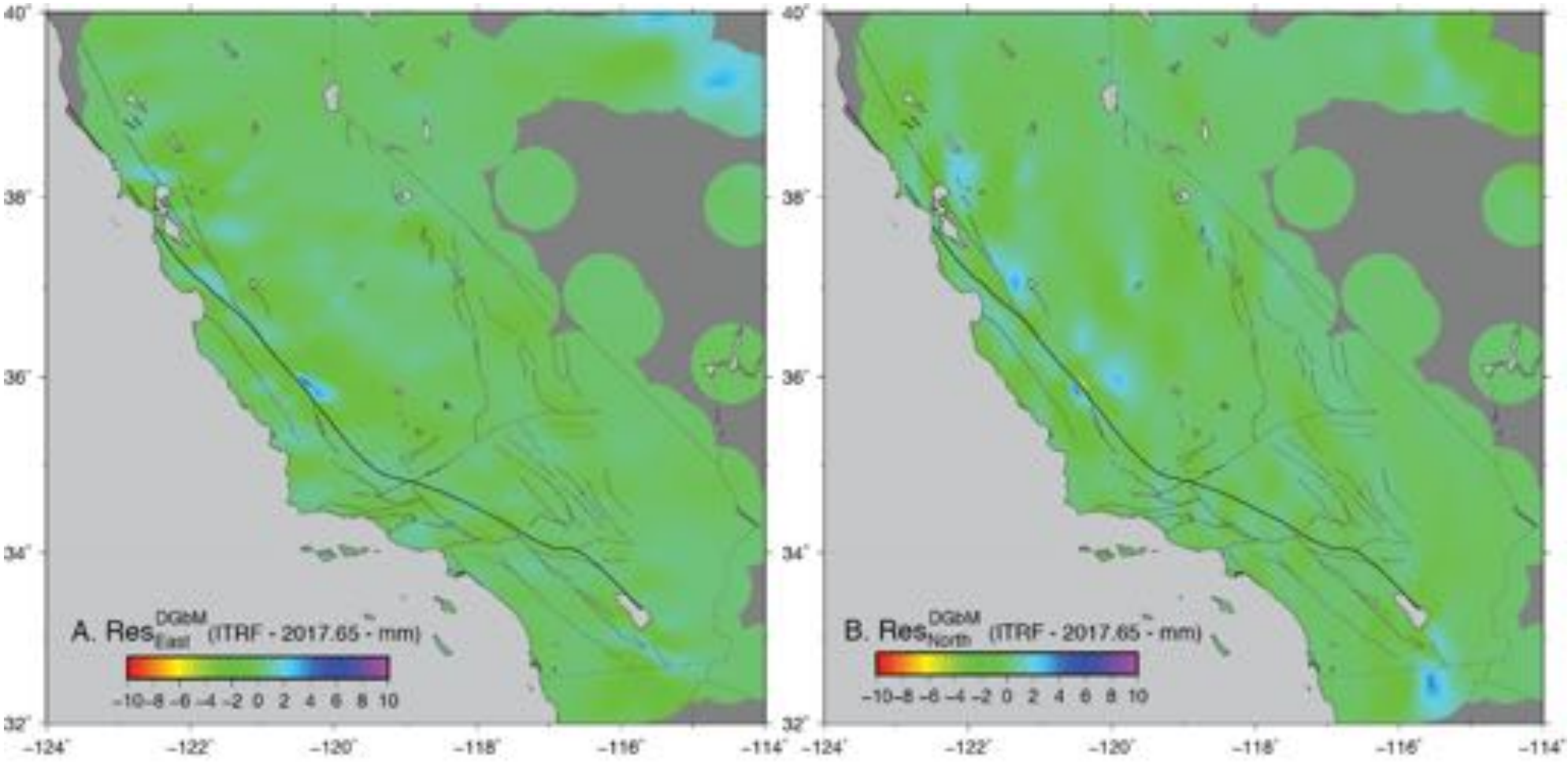

Mask distance > 50 km from a GPS station

# Dynamic Geophysical-based Model at a particular epoch t ($DGbM_t$)



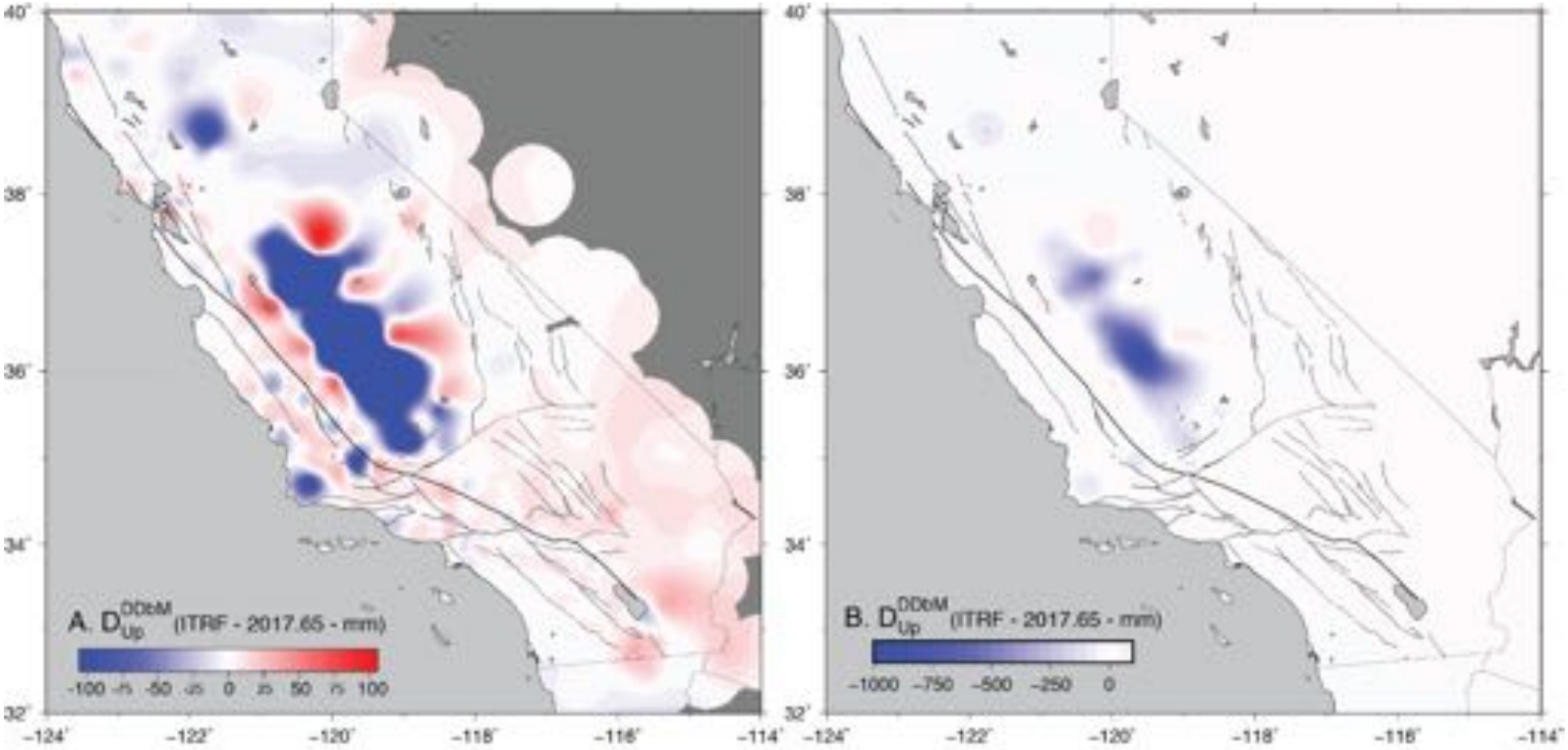

**$DGbM_{2017.65}$**: Horizontal surface displacement field (cm) of the upgraded model at the epoch 2017.65 as a sum of the time-independent model prediction from Tong et al. (2014) and the surface interpolation of the observed-model residuals from 2014.00 to 2017.65 in A) eastward and B) northward components.

# Horizontal Residual Surface for $DGbM_{2017.65}$




Final residual horizontal displacement grids (mm) from $DGbM_{2017.65}$; A) eastward, B) northward.

# Vertical Surface Displacement Grid for $DDbM_{2017.65}$



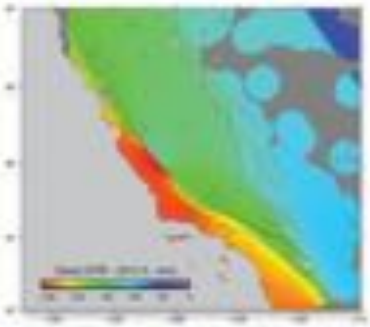

DDbM2017.65 Vertical surface displacement grid (mm) represented with 2 color scales

Velocity model **Tong 2014**
Grid in ITRF

*Geophysical underlying model - Account for the fault discontinuity*

SOPAC time series
Analyze_tserie (JPL)

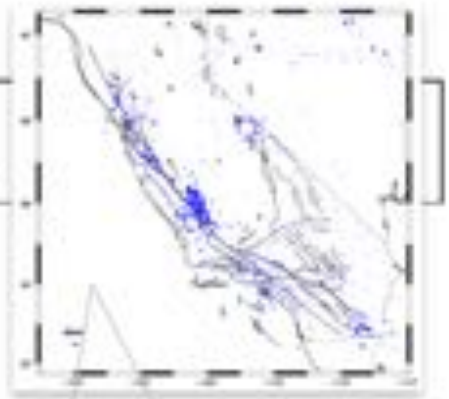
Pred of weekly displ grid
$\mathbf{gridD^{Pred\text{-}W}_{TONG}}$



Pred of weekly displacement field at all GPS sites
$\mathbf{disp^{Pred\text{-}W}_{TONG}}$

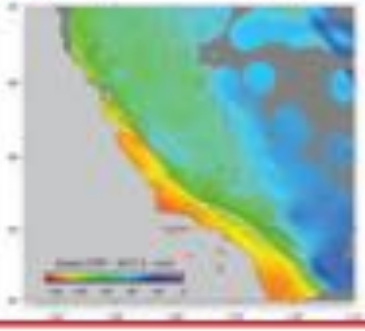
Estim weekly displacement
$\mathbf{disp^{W}_{SOPAC}}$

Estim weekly residuals :
$\mathbf{DispRes^{W}} = disp^{Pred\text{-}W}_{TONG} - disp^{W}_{SOPAC}$

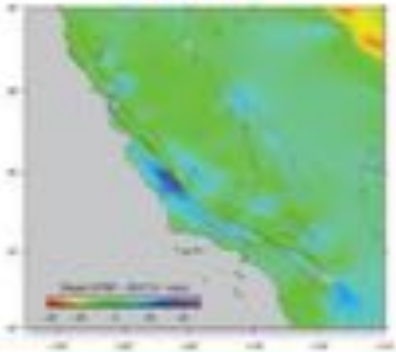


*Account for post- seismic, volcano... ie Fast processes*

Upgraded weekly displacement model:
$\mathbf{gridD^{W}_{upd}} = gridD^{Pred\text{-}W}_{TONG} + gridRes^{W}$



Surface grid (GMT5) of **DispRes$^{W}$**
$\mathbf{gridRes^{W}}$

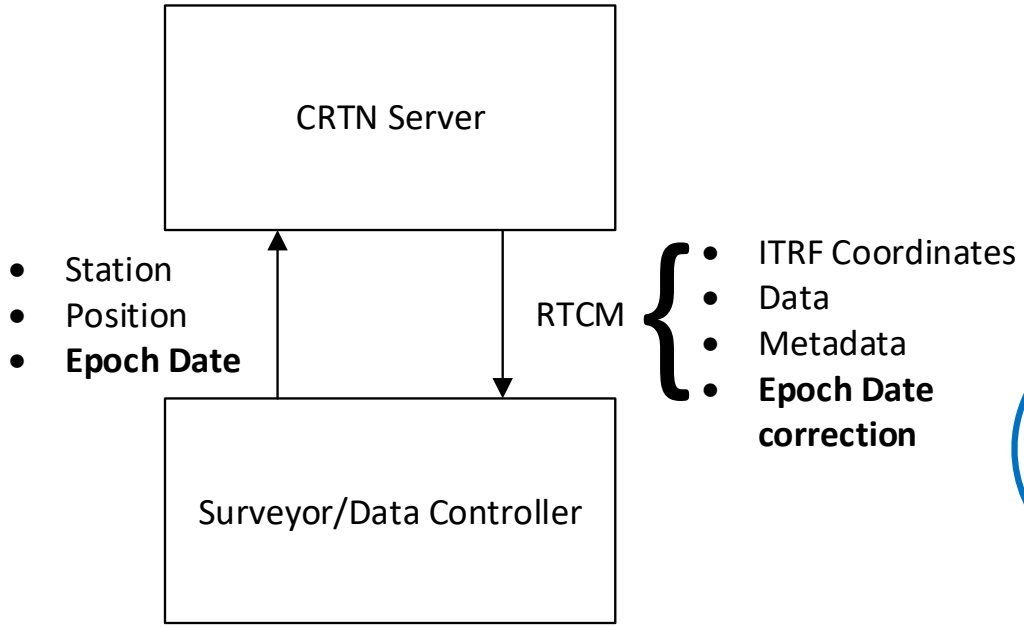


**Click toward movies:**

EastEvolution NorthEvolution

To be update with more recent GPS solution, new modules GMT6 (3D surface gridding)...

# Implementation of Dynamic Datum

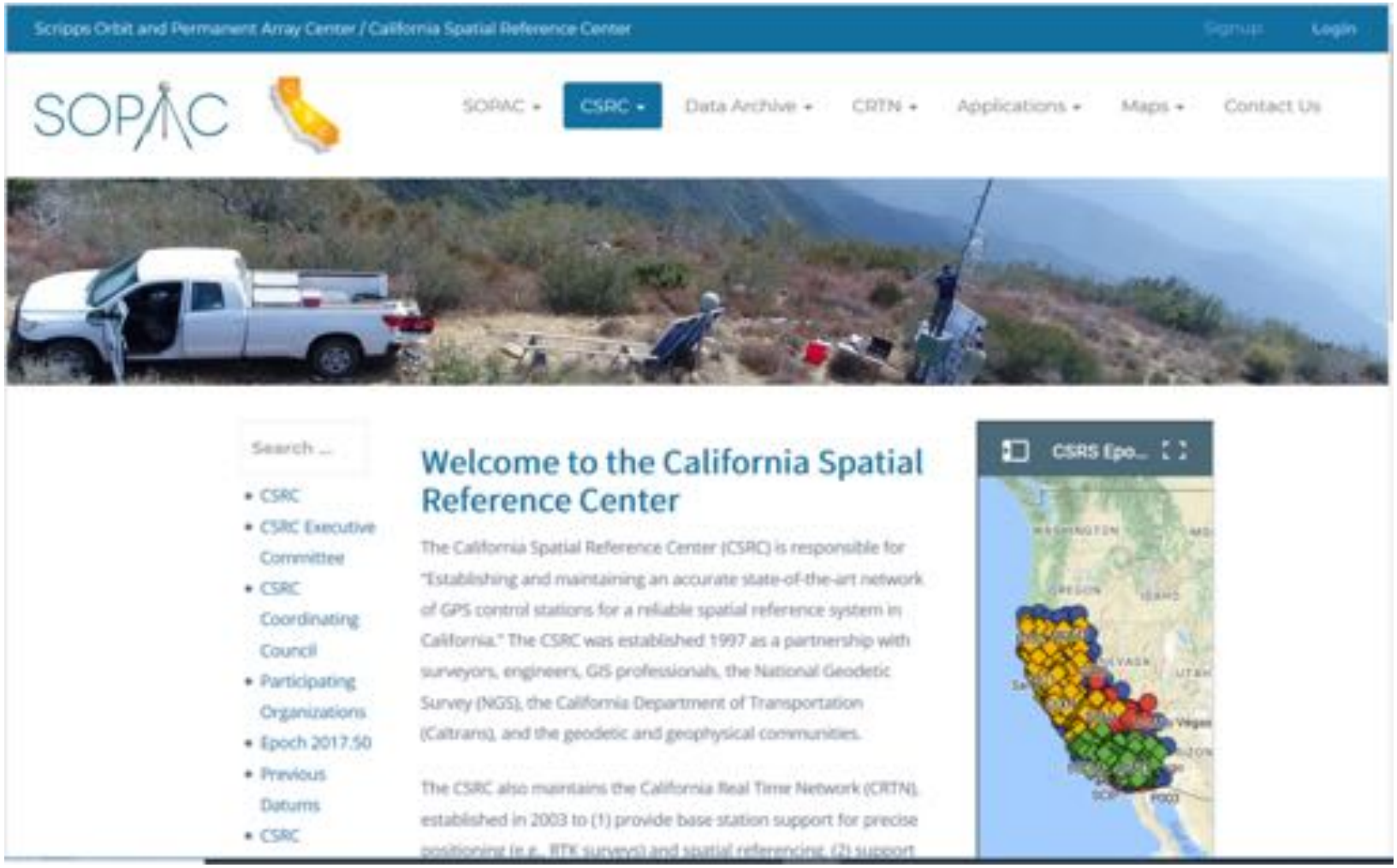



RTCM Network Auxiliary Station Data Message 1014

| DATA FIELD |
|---|
| Message Number |
| Network ID |
| Subnetwork ID |
| Number of Auxiliary Stations Transmitted |
| Master Reference Station ID |
| Auxiliary Reference Station ID |
| Aux-Master Delta Latitude |
| Aux-Master Delta Longitude |
| Aux-Master Delta Height |

How do we inform users on problematic areas?

# New SOPAC and CSRC Web Pages




SOPAC


# Questions?