Tracking Ground Movement with GNSS

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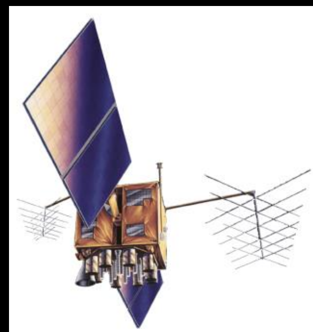
September 24, 2018

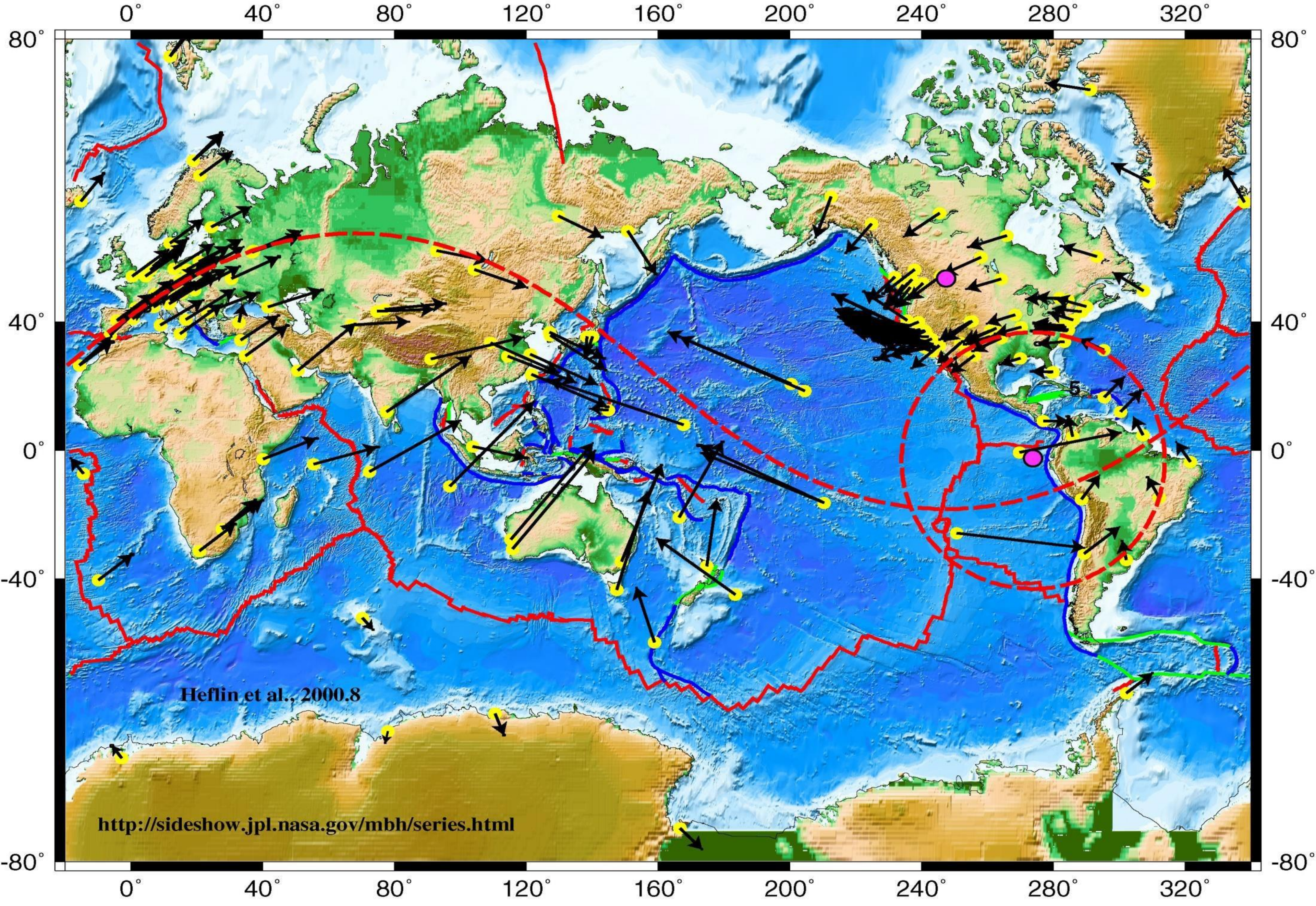
GPS/GNSS



A network of GNSS/GPS stations measures plate tectonic motions and land surface deformation, horizontal and vertical, to an accuracy of better than

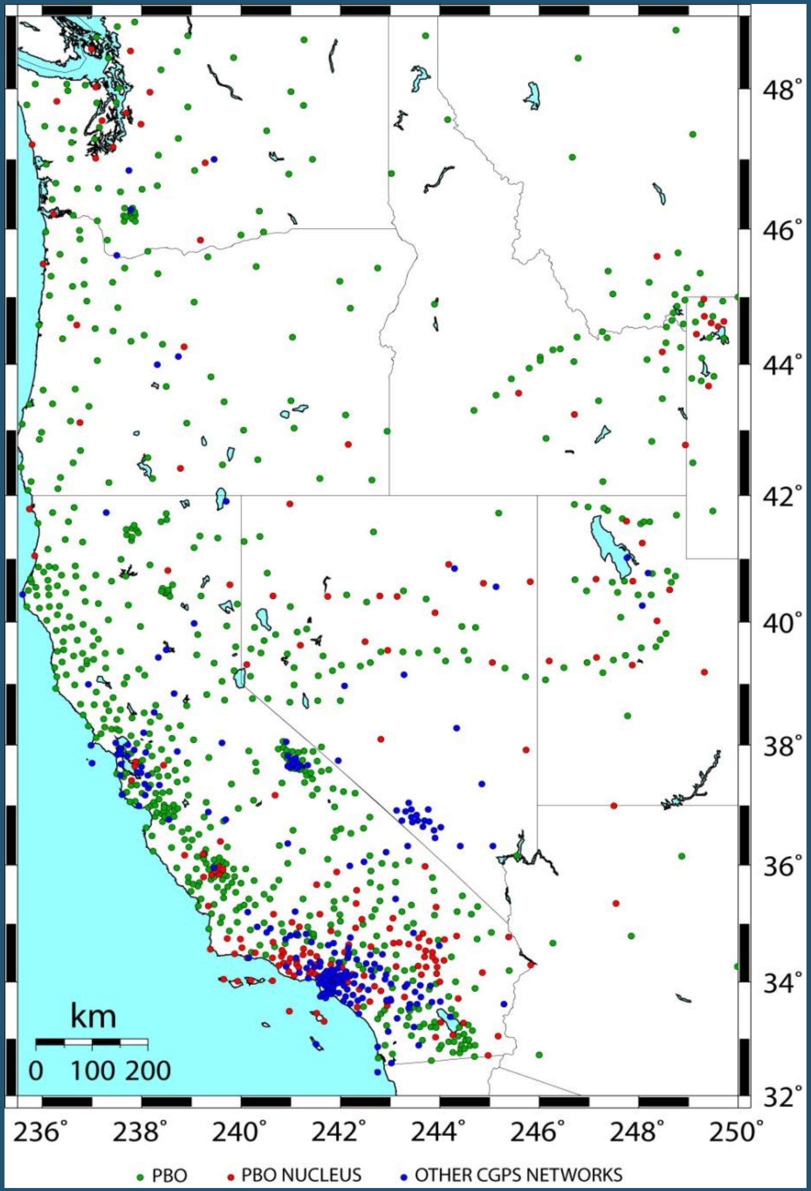
1 mm/yr

We can see whether the motion is 'slow and steady,' or perhaps more interestingly, is it sometimes accelerating or decelerating

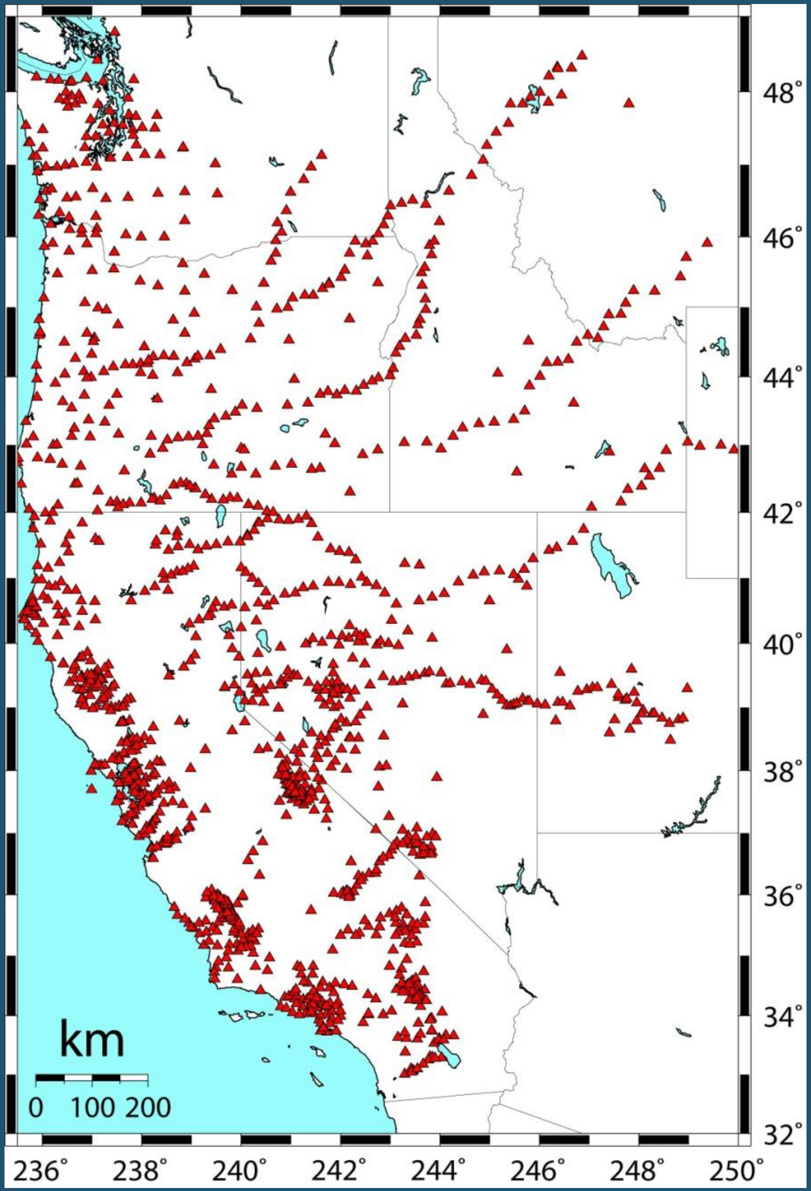

0° 40° 80° 120° 160° 200° 240° 280° 320°
80° 40° 0° -40° -80°
5
Heflin et al., 2000.8
http://sideshow.jpl.nasa.gov/mbh/series.html

Continuous and campaign GPS arrays

Continuously Operating GPS Stations

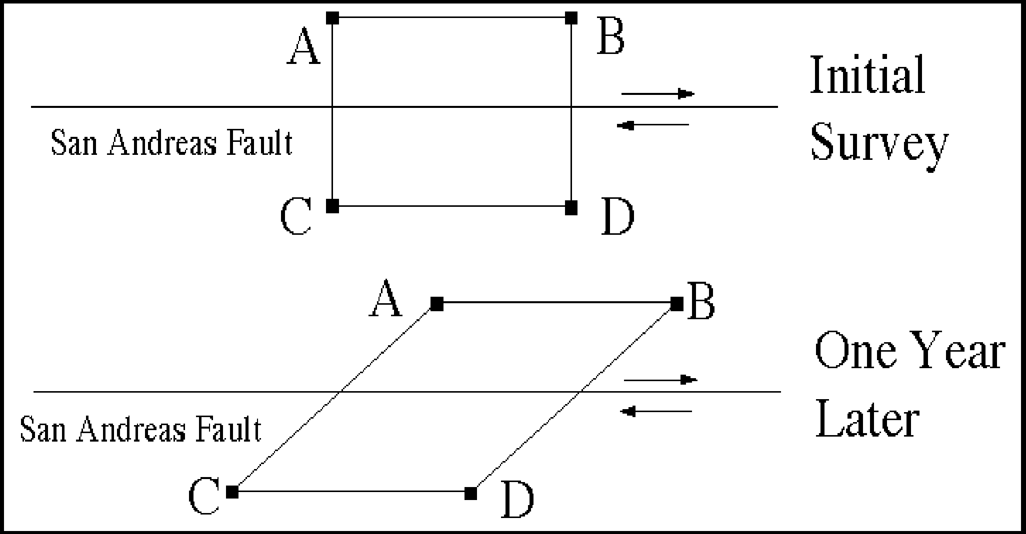


Campaign Survey GPS Points



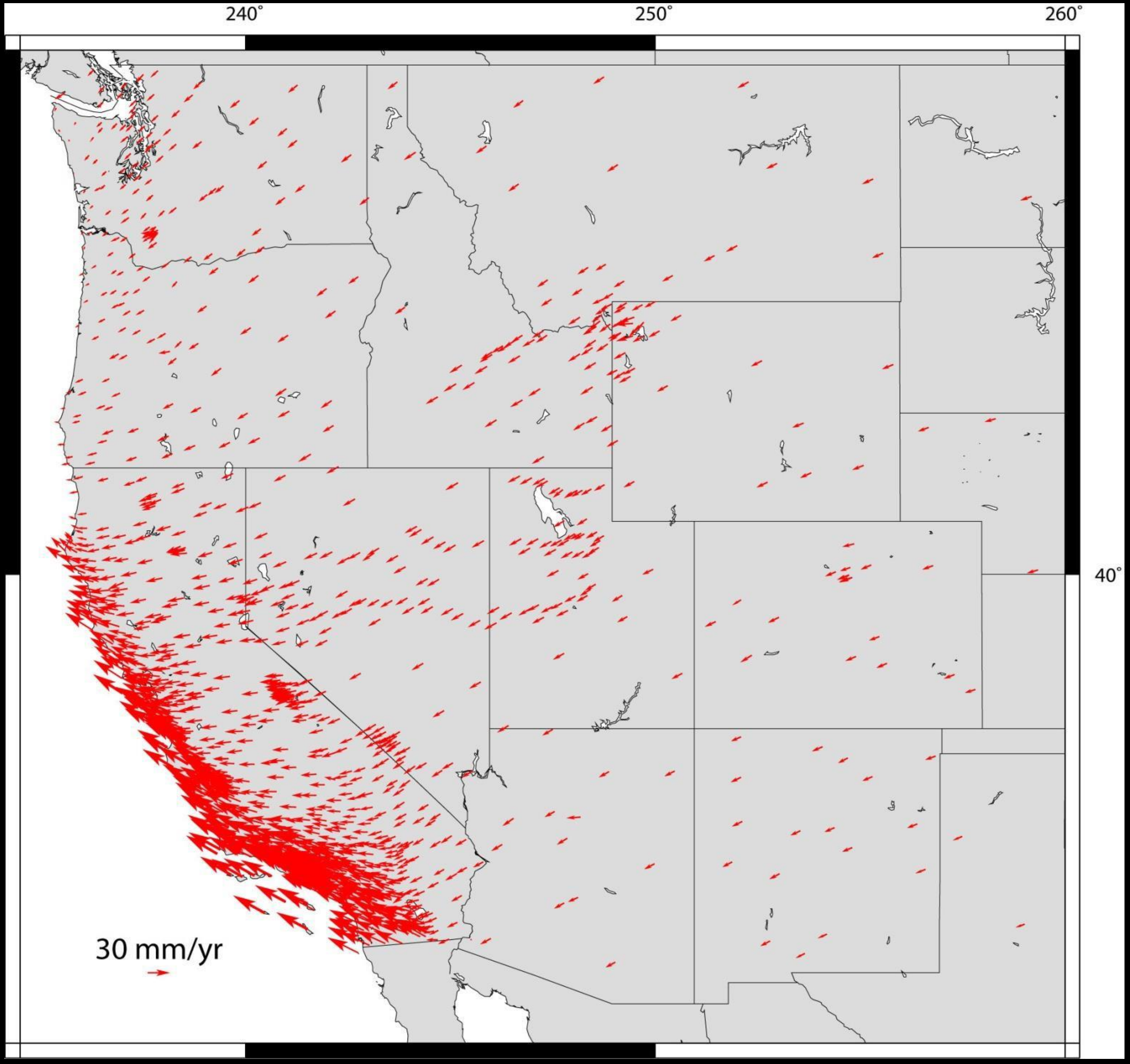
Using GNSS/GPS to measure fault motion

- Track monuments located near active faults
- Estimate motion relative to each monumented station.
- Stations are occupied simultaneously.
- Relative positions and possible motion are determined between stations to a precision near the millimeter level.



- Determine the 3D change in relative position between stations.
- Calculate accumulated strain and slip between faults.

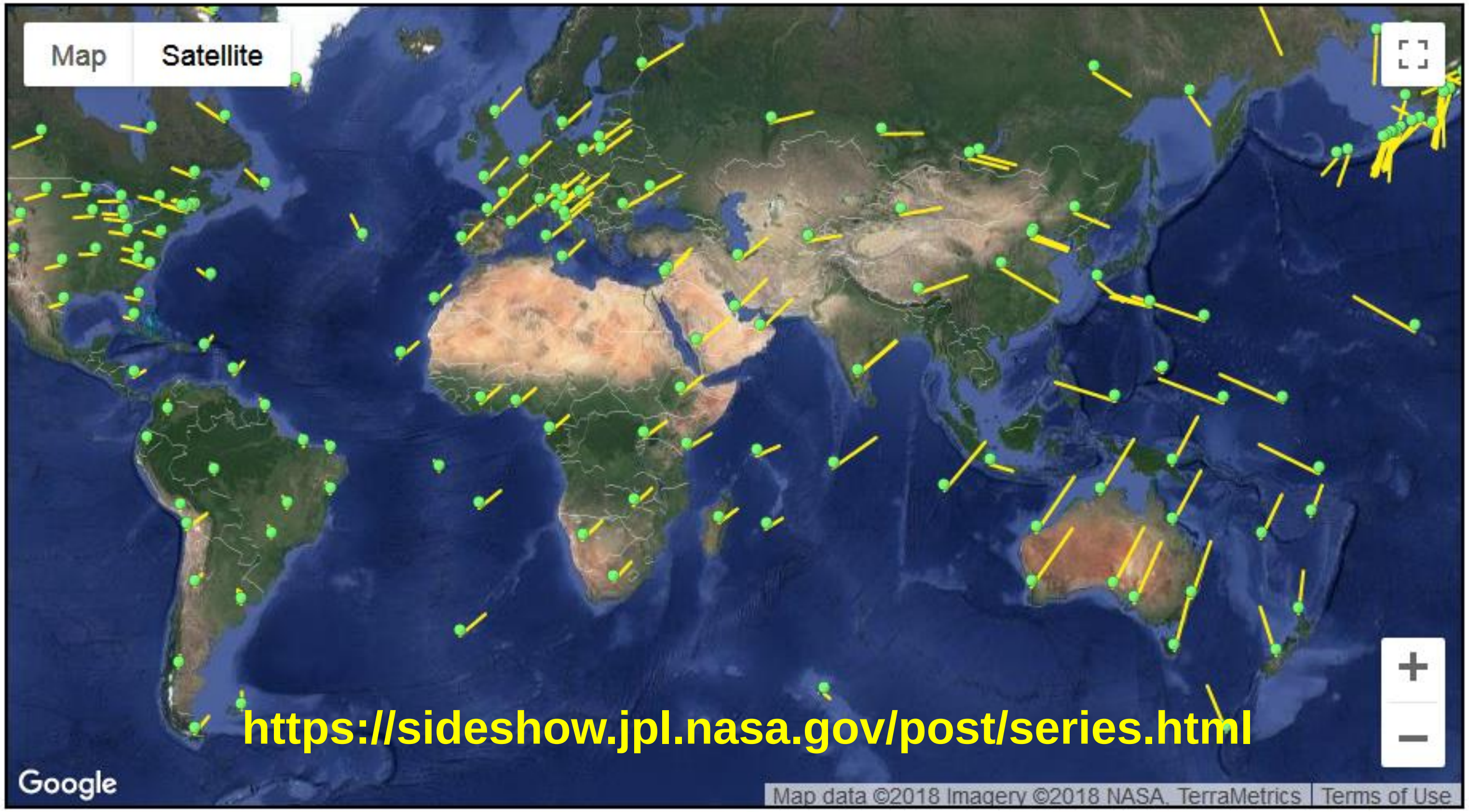
Secular velocity field for Western US



GPS Time Series

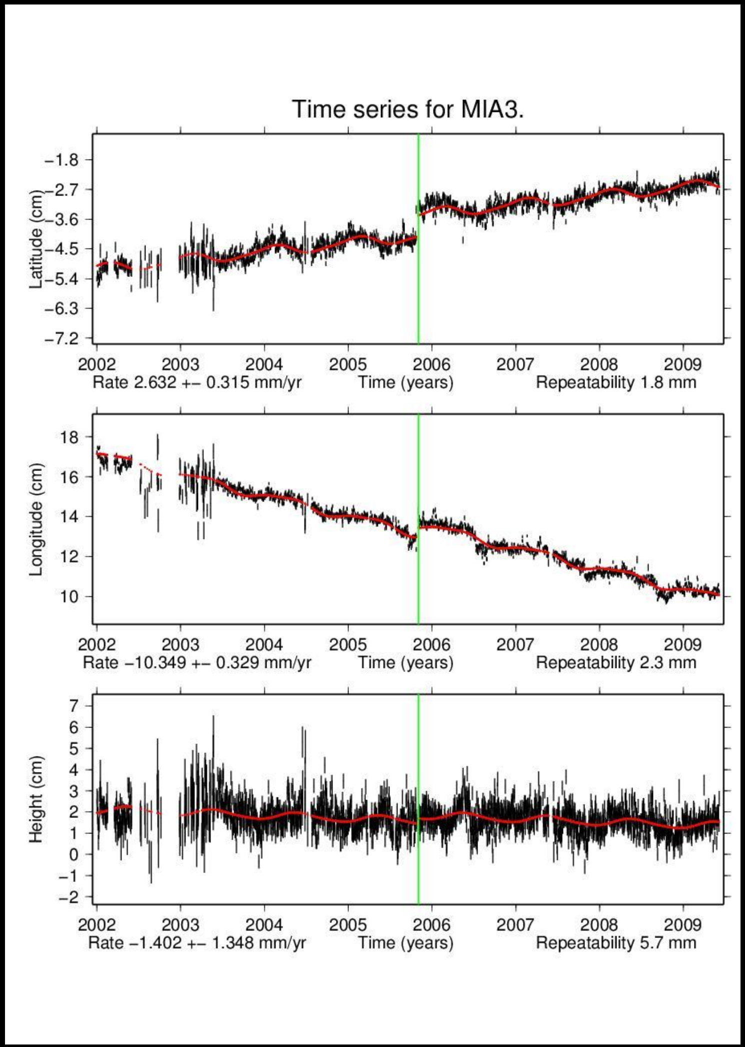
The Global Positioning System (GPS) is a constellation of 30 satellites which is used for navigation and precise geodetic position measurements. Data from over 2000 receivers have been analyzed at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration. JPL's GipsyX software is used to produce these time series and other useful data products. Horizontal velocities, mostly due to motion of the Earth's tectonic plates, are represented on the map by lines extending from each site. Click on a dot or name to see detailed time series for a particular site. Additional information may be obtained from Michael.Heflin@jpl.caltech.edu.

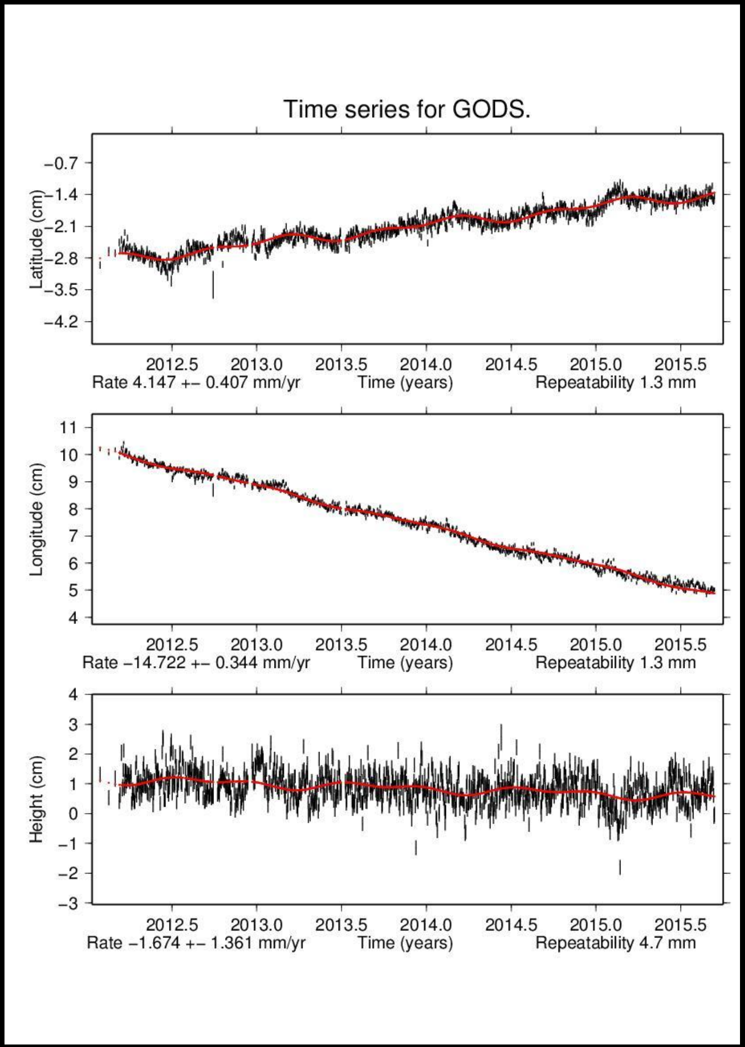
Geodetic Positions and Velocities || Cartesian Positions and Velocities
Break Estimates || Seasonal Estimates
Time Series || Residuals
Methods



https://sideshow.jpl.nasa.gov/post/series.html

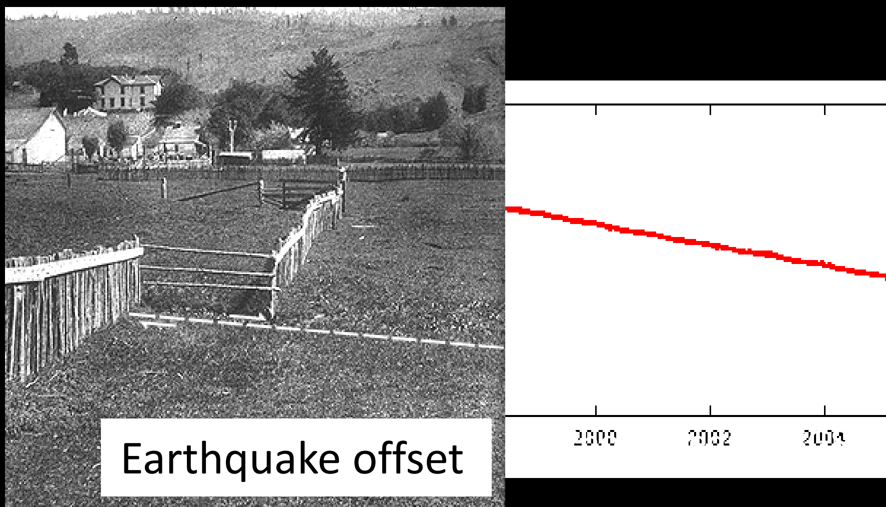
Example of GPS Time Series produced at JPL/NASA





Measurements with GNSS/GPS reveals motion between and during earthquakes

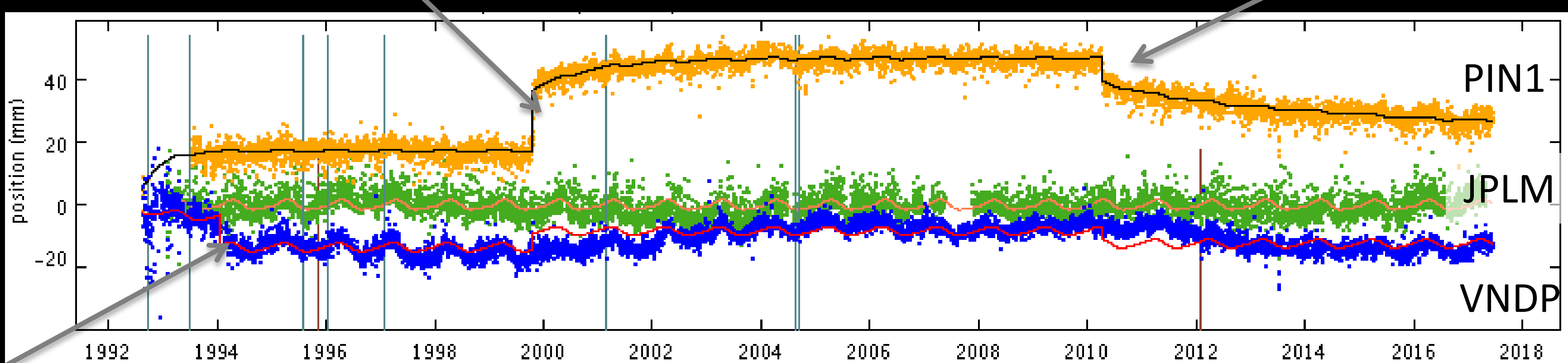
JPLM East Coordinate



1999 Hector Mine

2010 El Mayor-Cucapah

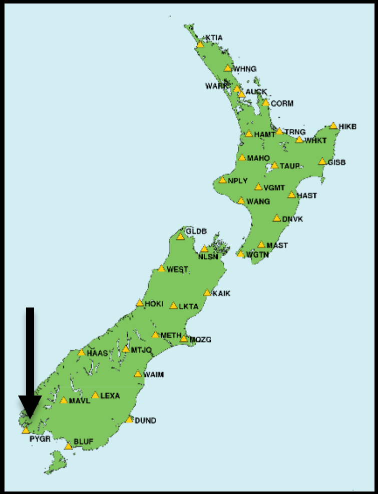
North Coordinate (detrended)

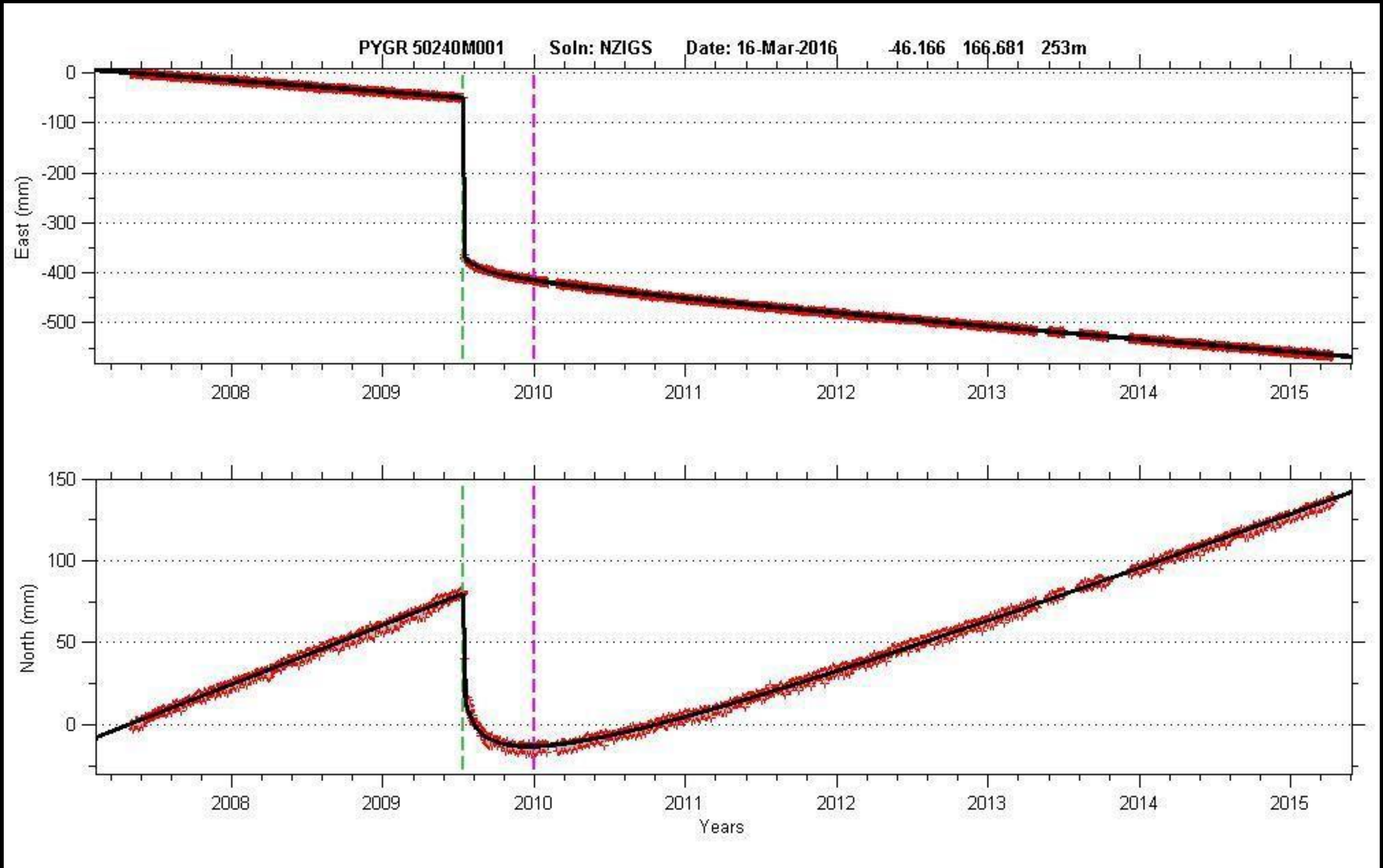


1994 Northridge earthquake

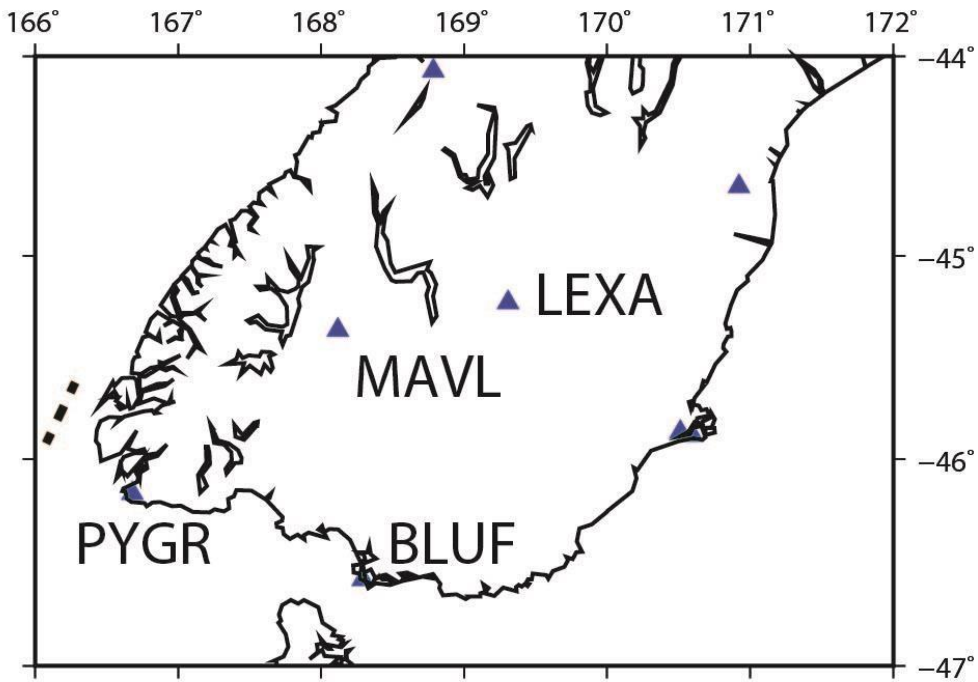
Time series for IGS station PYGR South Island, New Zealand

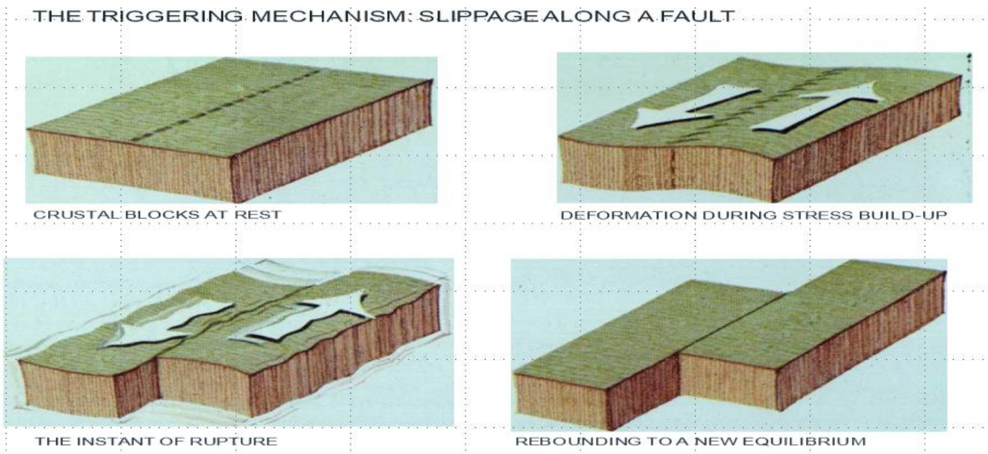
M7.8 Dusky Sound Earthquake, Wednesday, July 15, 2009

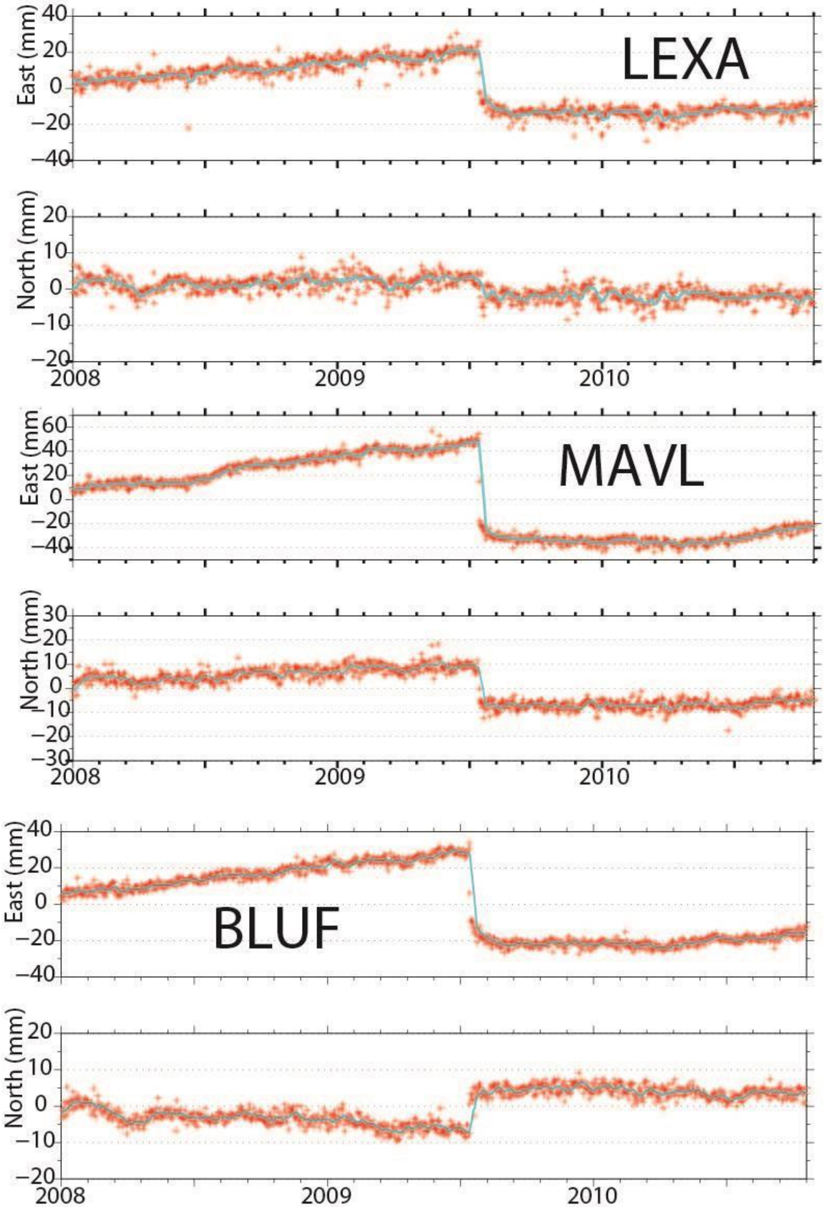




Post-seismic relaxation - 2009 Dusky Sound earthquake

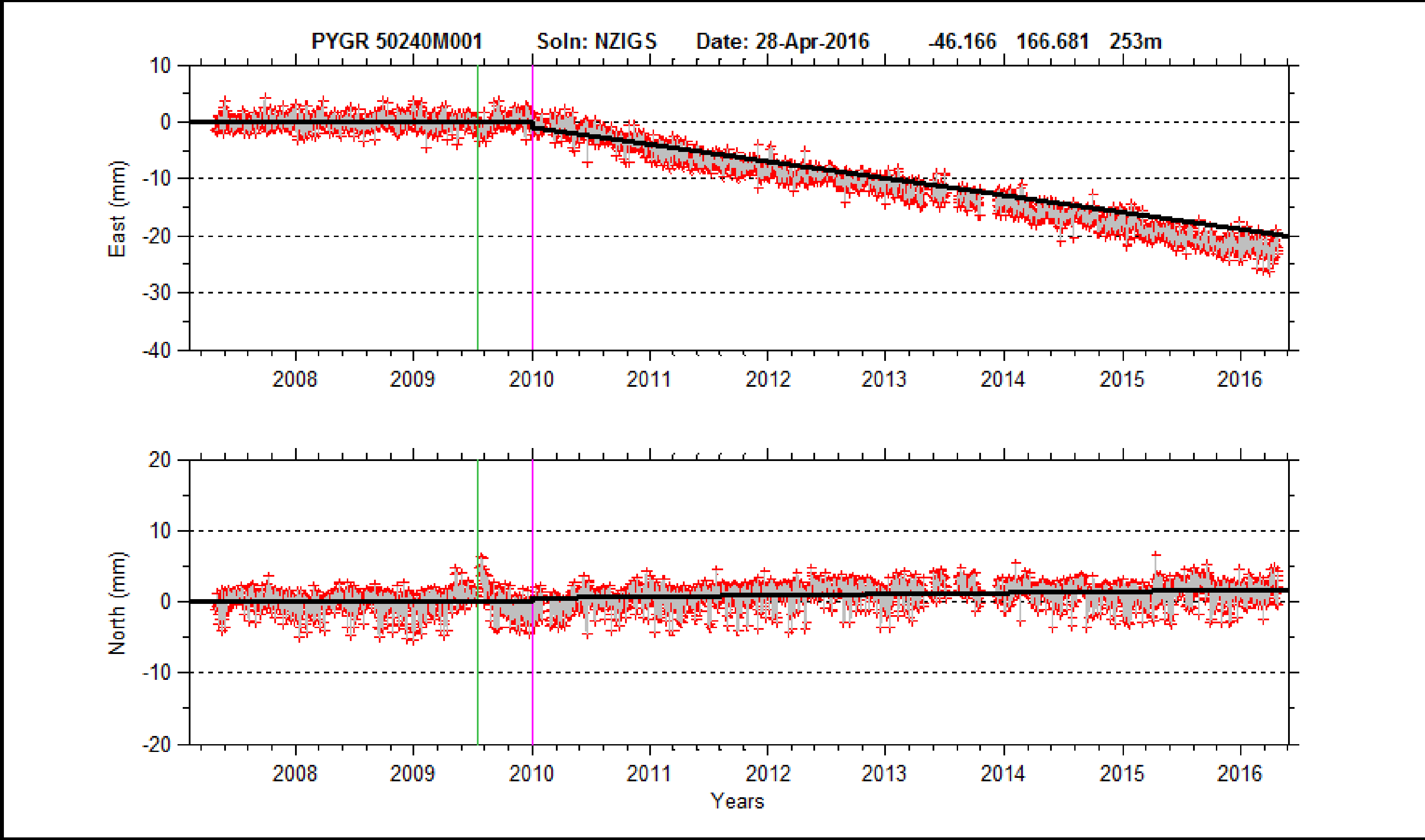


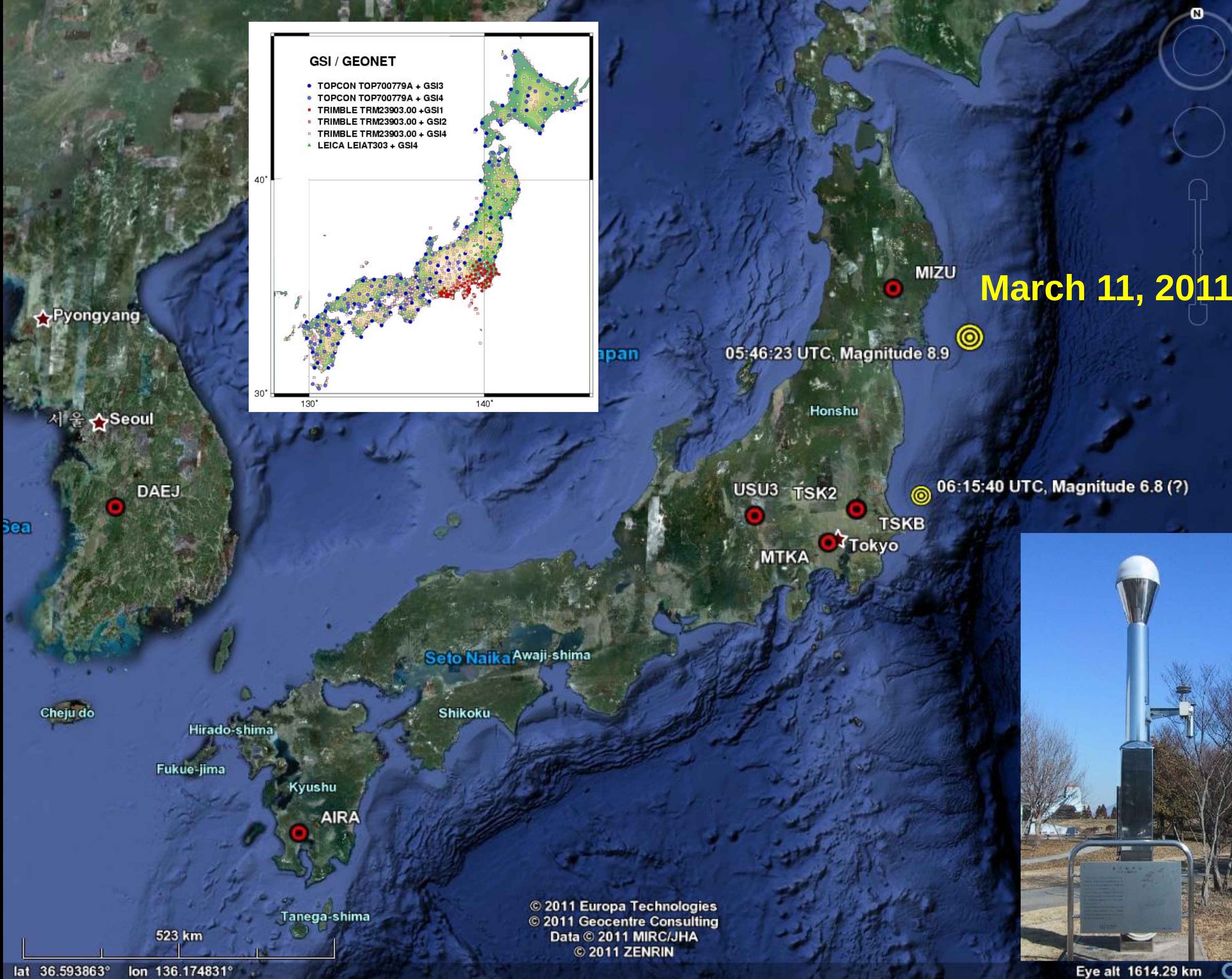


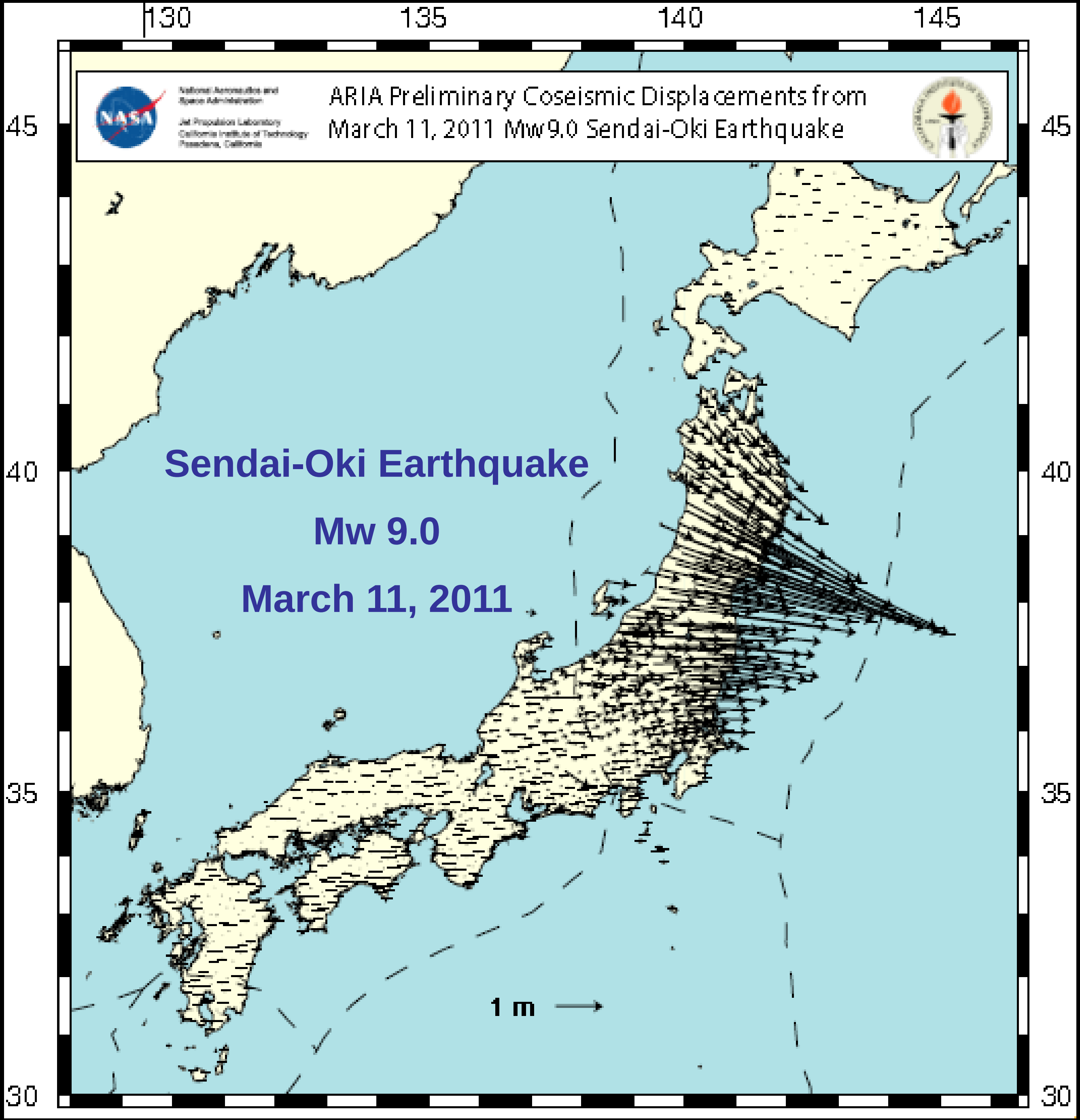


GNSS monitoring velocity change

Station PYGR, South Island, New Zealand



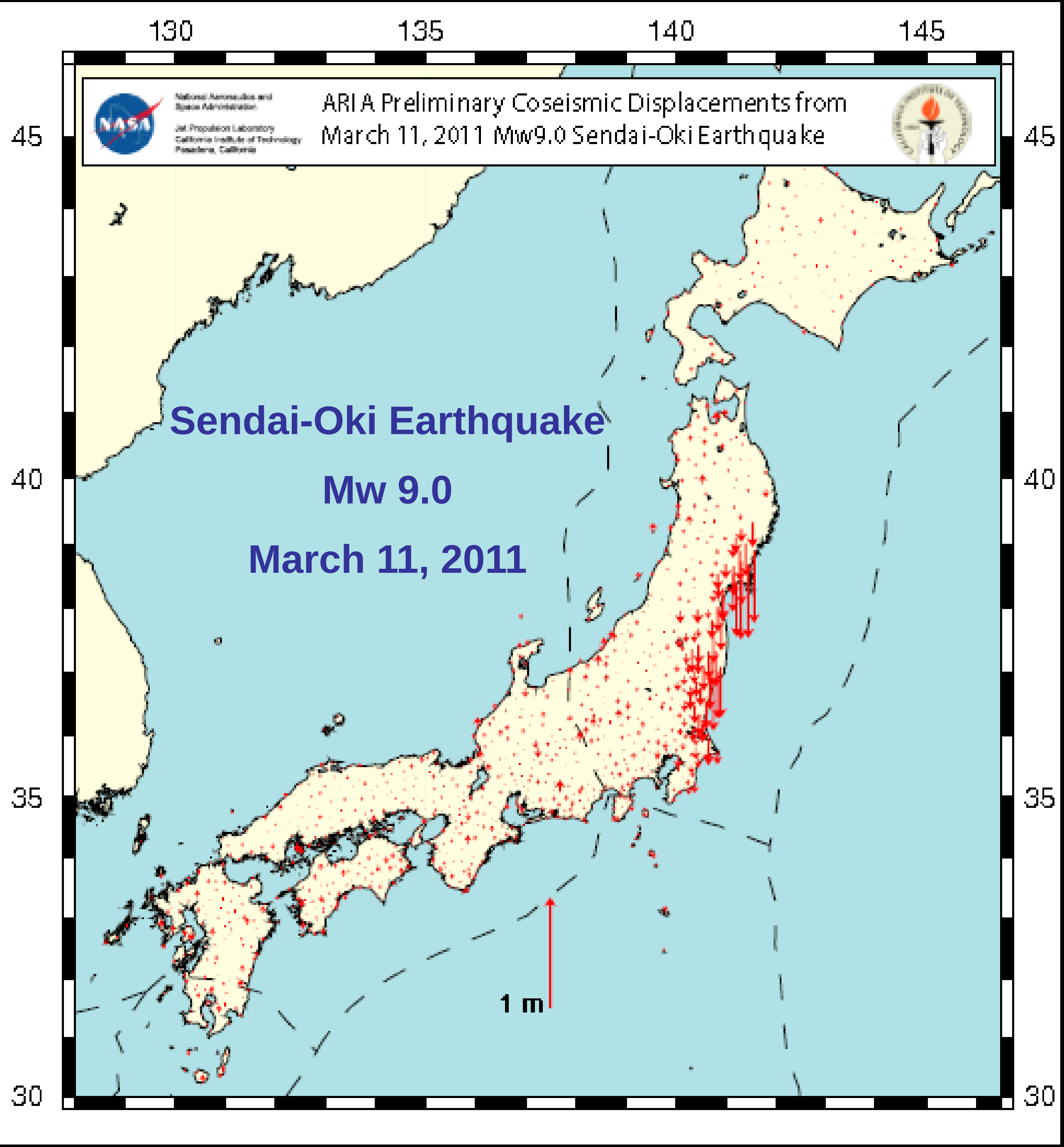

March 11, 2011
GSI / GEONET
TOPCON TOP700779A + GSI3
TOPCON TOP700779A + GSI4
TRIMBLE TRM23903.00 +GSI1
TRIMBLE TRM23903.00 + GSI2
TRIMBLE TRM23903.00 + GSI4
LEICA LEIAT303 + GSI4
40°
30°
130°
140°
MIZU
05:46:23 UTC, Magnitude 8.9
06:15:40 UTC, Magnitude 6.8 (?)
USU3
TSK2
TSKB
MTKA
Tokyo
Honshu
Pyongyang
서울
Seoul
DAEJ
Seto Naikai
Awaji-shima
Shikoku
Cheju do
Hirado-shima
Fukue-jima
Kyushu
AIRA
Tanega-shima
523 km
© 2011 Europa Technologies
© 2011 Geocentre Consulting
Data © 2011 MIRC/JHA
© 2011 ZENRIN
lat 36.593863° lon 136.174831°
Eye alt 1614.29 km



Horizontal Displacements

Difference between estimated positions of GEONET stations at 05:00 and 06:30 UTC, March 11, 2011

GPS 1 Hz data in RINEX format provided by the Geospatial Information Authority (GSI) of Japan.



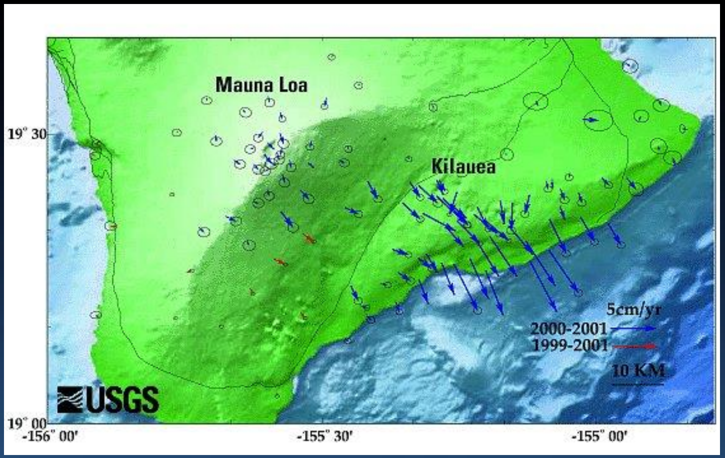
Vertical Displacements

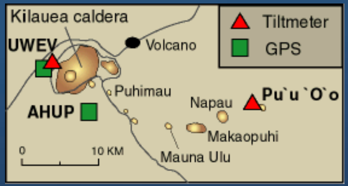
Difference between estimated positions of GEONET stations at 05:00 and 06:30 UTC on March 11, 2011

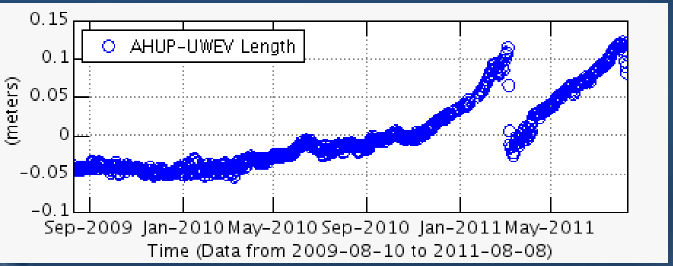
GPS 1 Hz data in RINEX format provided by the Geospatial Information Authority (GSI) of Japan.

Using multi-GNSS measurements for monitoring volvanoes
Data telemetered for near-real time measurements

Motions of volcanoes' flanks can indicate the arrival of new magma; **GPS is used to monitor changes in activity.**



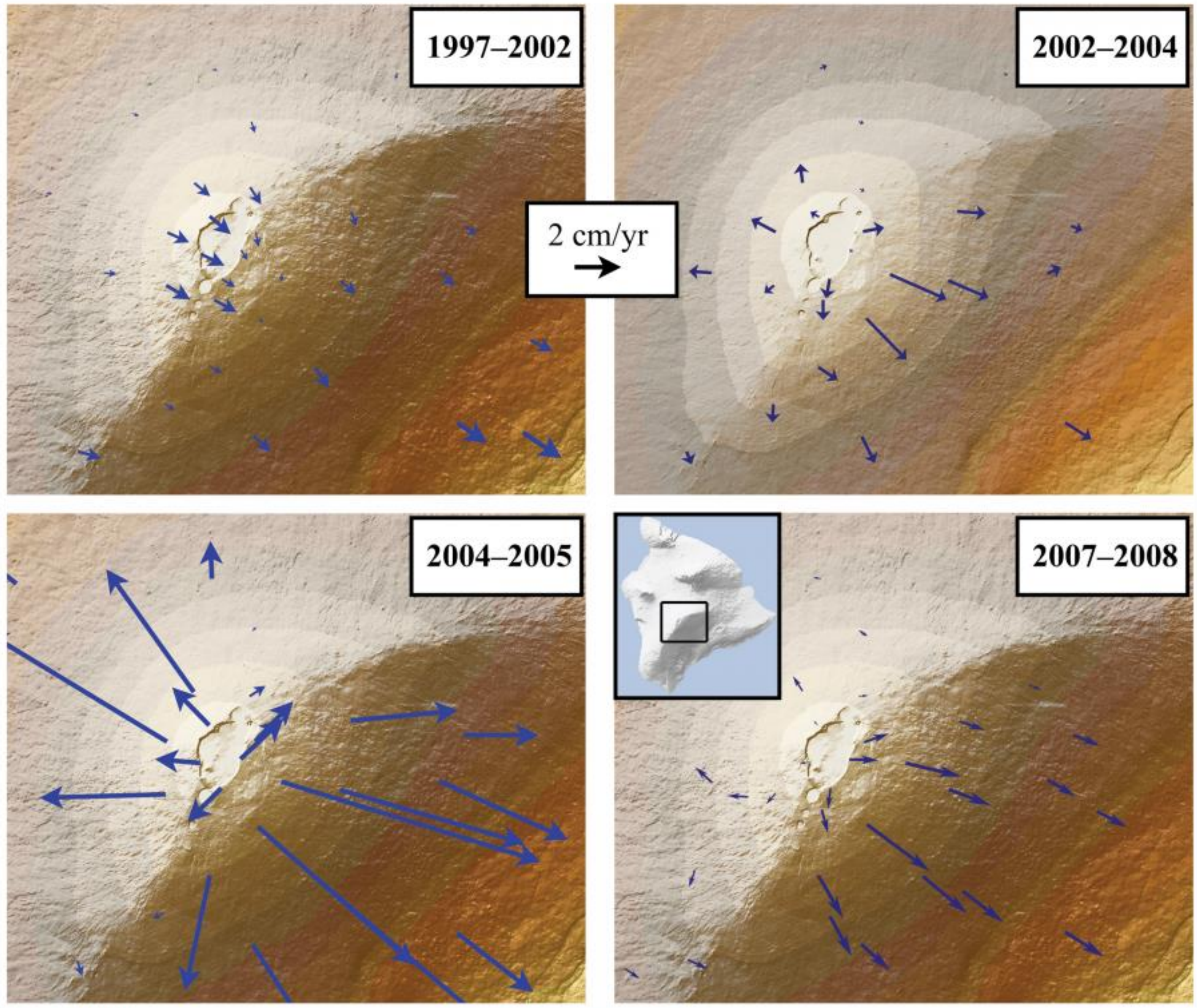




GNSS measurements provide models of the direction and rate (length of arrow) of deformation at the summit of Mauna Loa.

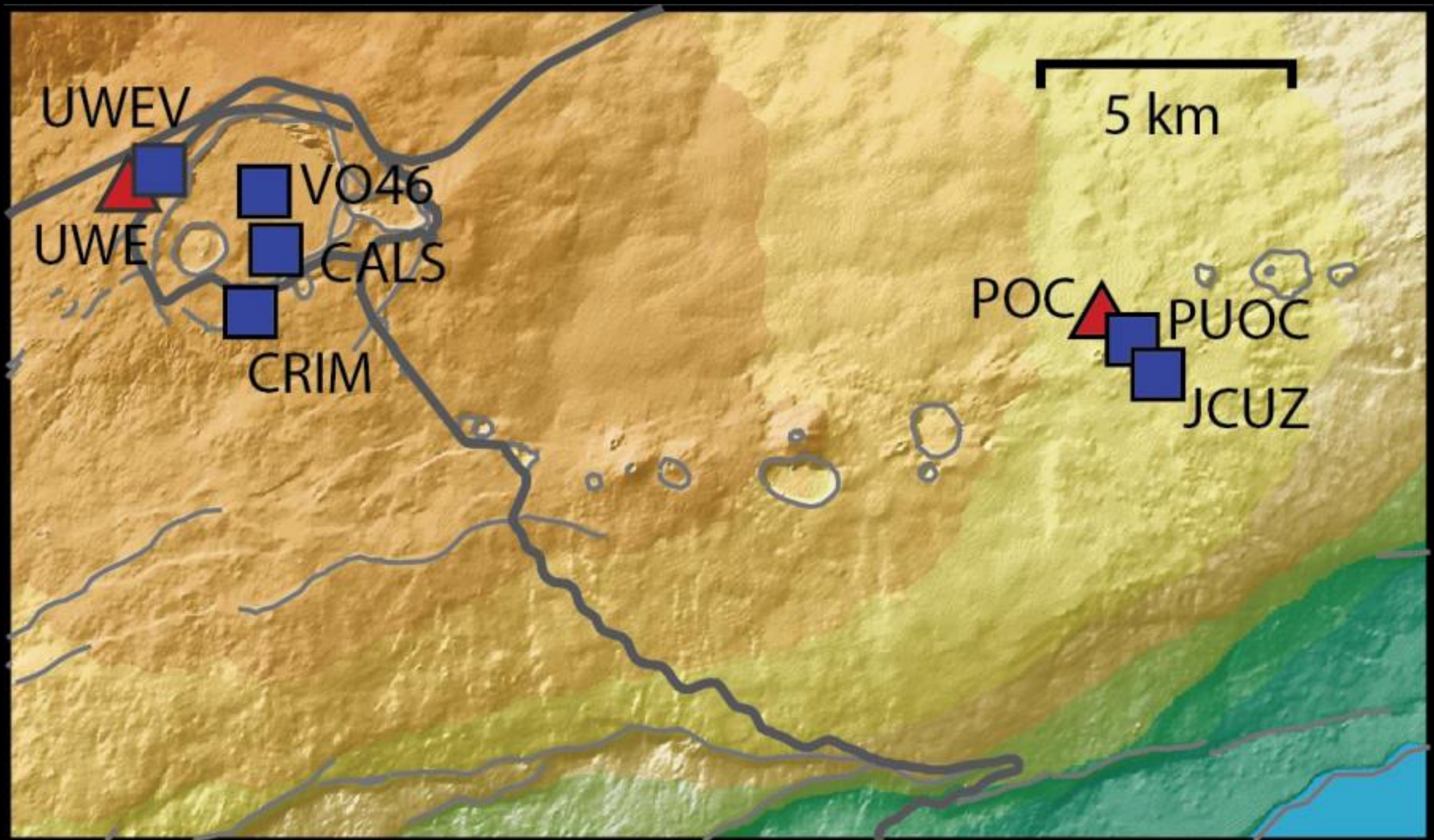
Arrows pointing in multiple directions away from the summit indicate inflation.

GPS measurements provide models of the direction and rate (length of arrow) of deformation at the summit of Mauna Loa. Arrows pointing in multiple directions away from the summit indicate inflation. x



Poland, Michael 2010

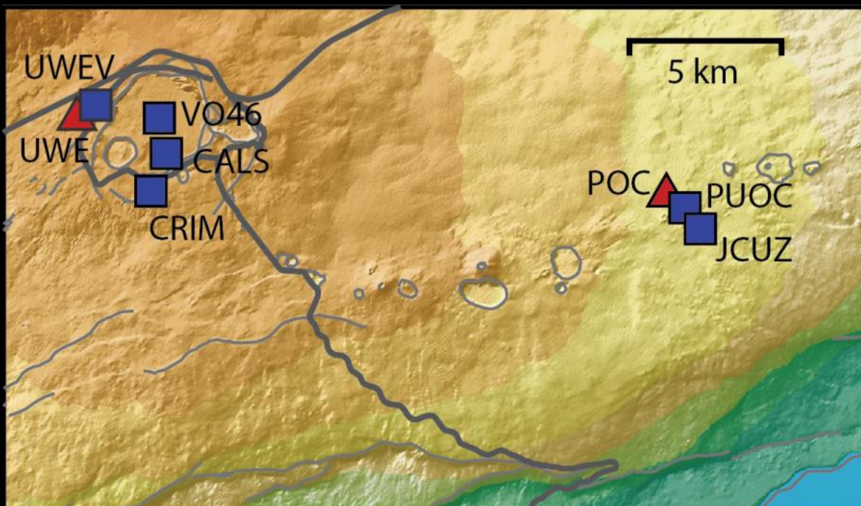
Real-time Global Positioning System at Kīlauea's summit



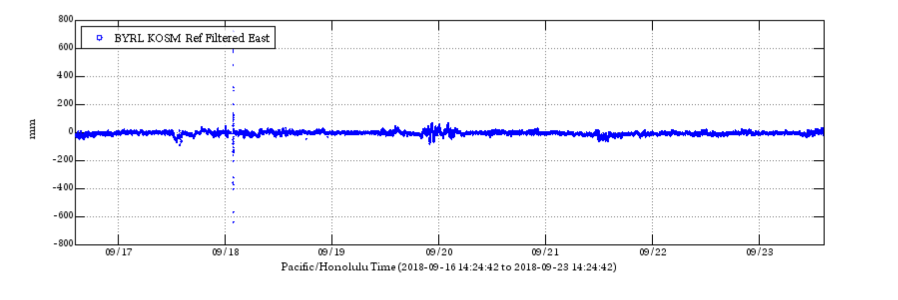
https://volcanoes.usgs.gov/volcanoes/kilauea/monitoring_deformation.html

Real-time GPS measurement results at Kilauea's summit

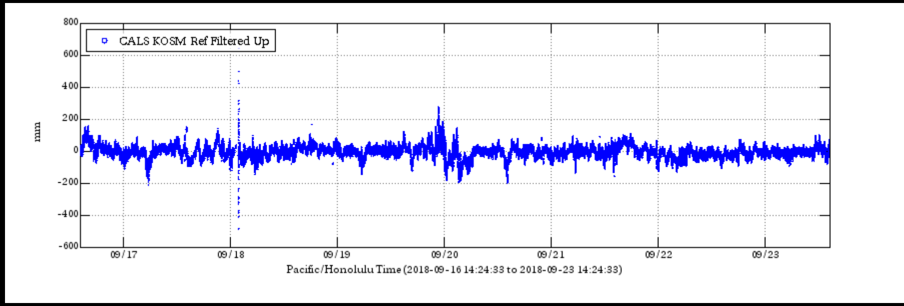
Period: September 17 through 22, 2018



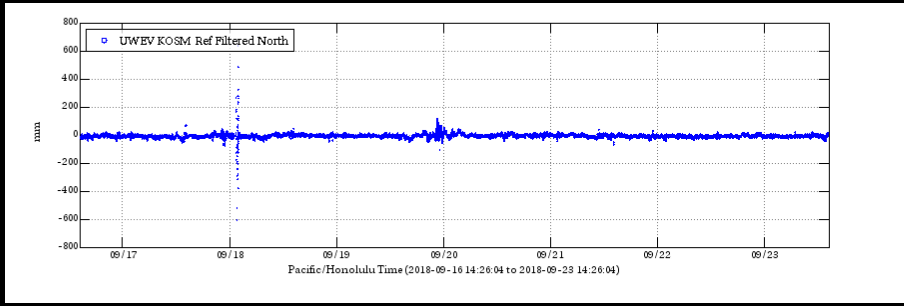
BYRL vertical component



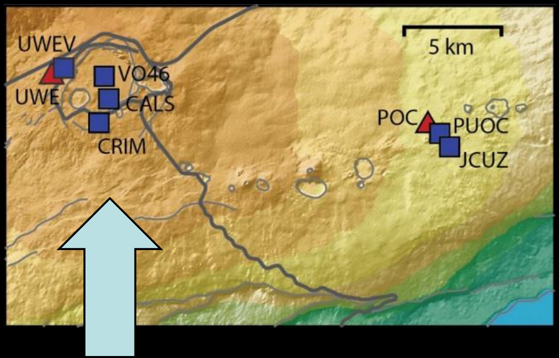
South Caldera (CALS) vertical component

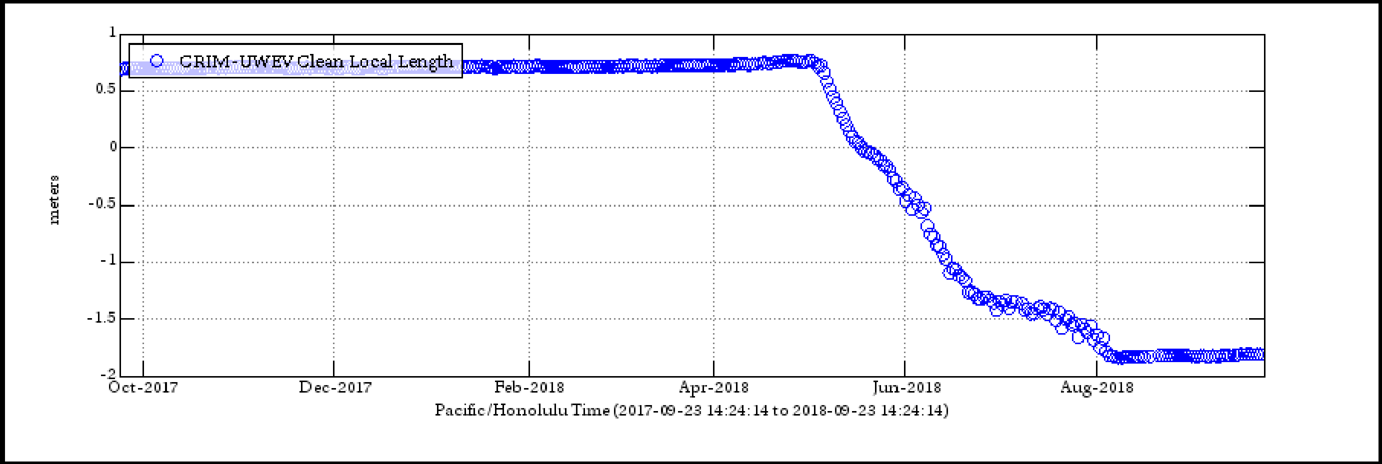


Uwekahuna (UWEV) north component

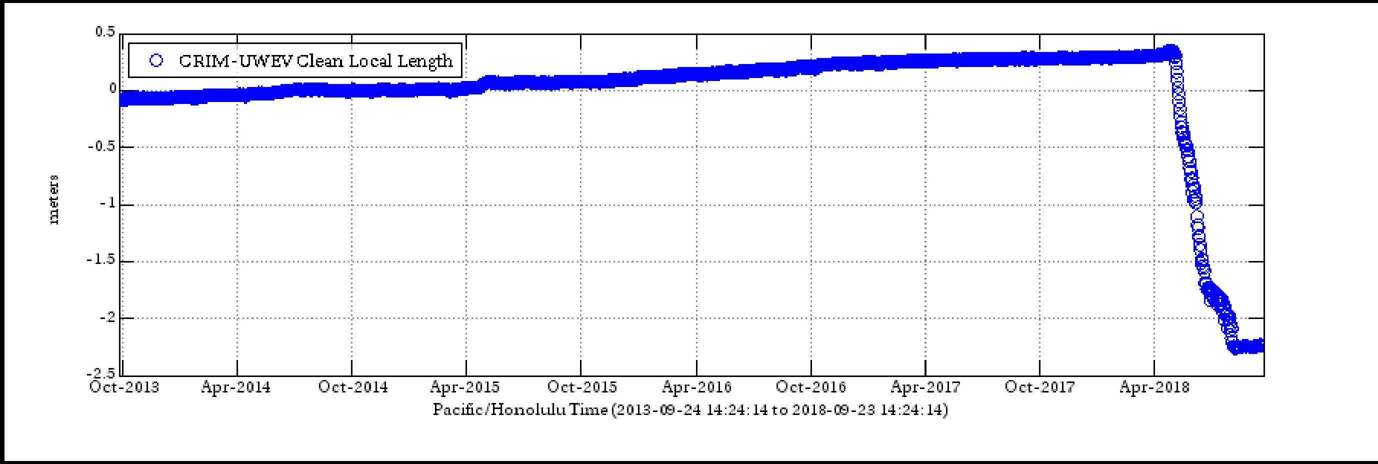


GPS positioning results – Kilauea Summit



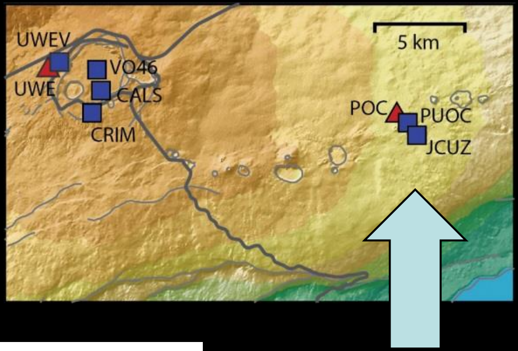


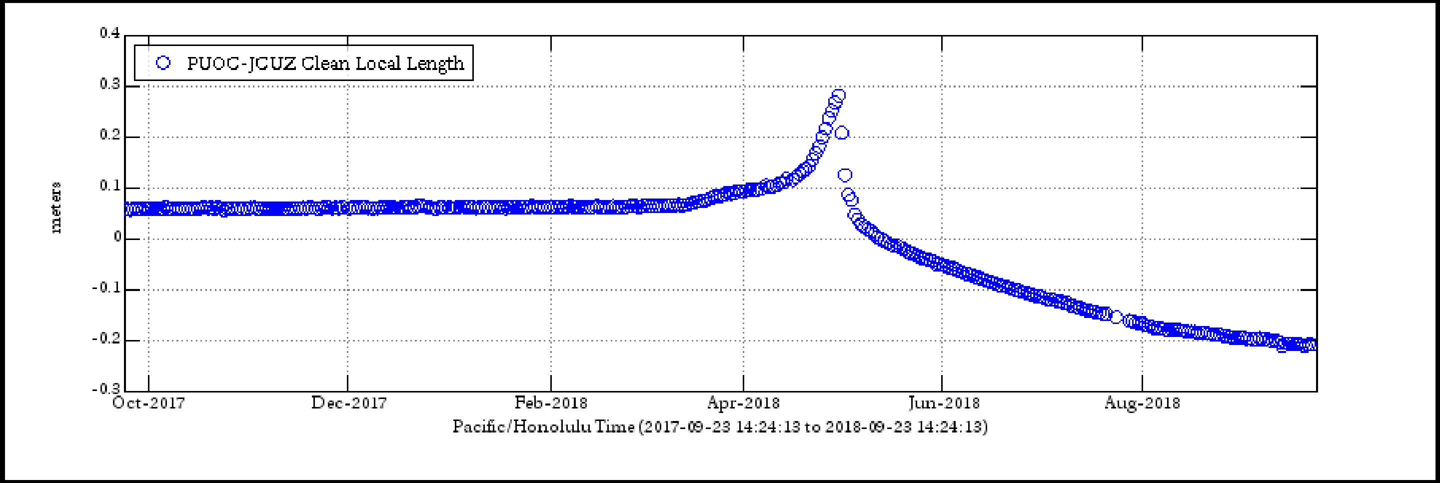
Past Year (October 2017 to August 2018)



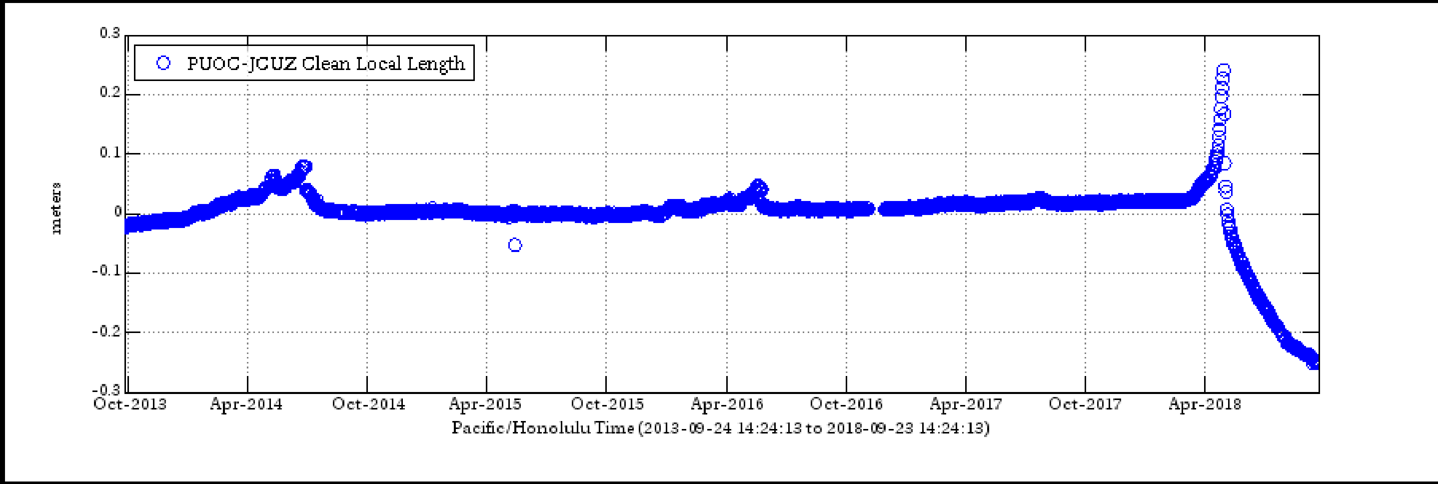
Past Five Years (October 2013 to April 2018)

GPS positioning results – Pu’u ‘Ō‘ō Cone





Past Year (October 2017 to August 2018)



Past Five Years (October 2013 to April 2018)

GPS/GNSS tracking for hazards management

- **GPS/GNSS is an essential enabling technology for the mapping and precise monitoring needed to accomplish science missions in support of hazard warnings.**
- **In the aftermath of a significant disaster event, GPS/GNSS is critical in support of updating maps and geopositioning incident features - essential in support of immediate response (e.g., support Urban Search & Rescue) as well as for long-term recovery (e.g., organizing debris removal).**


Thank you