Densification and Autonomization of Geodetic GPS Stations in Southern California Capable of Producing Tropospheric Delay and Precipitable Water Vapor Measurements

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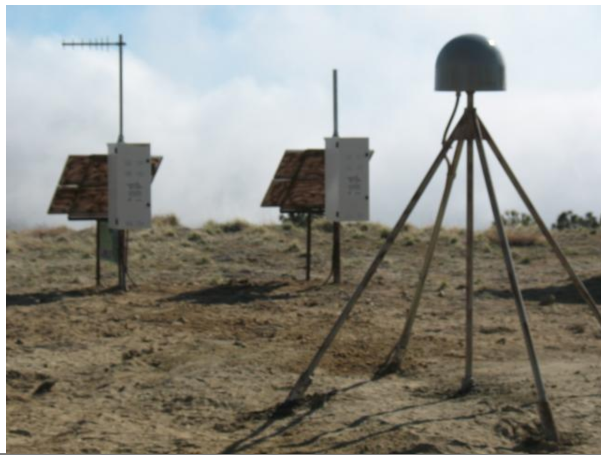
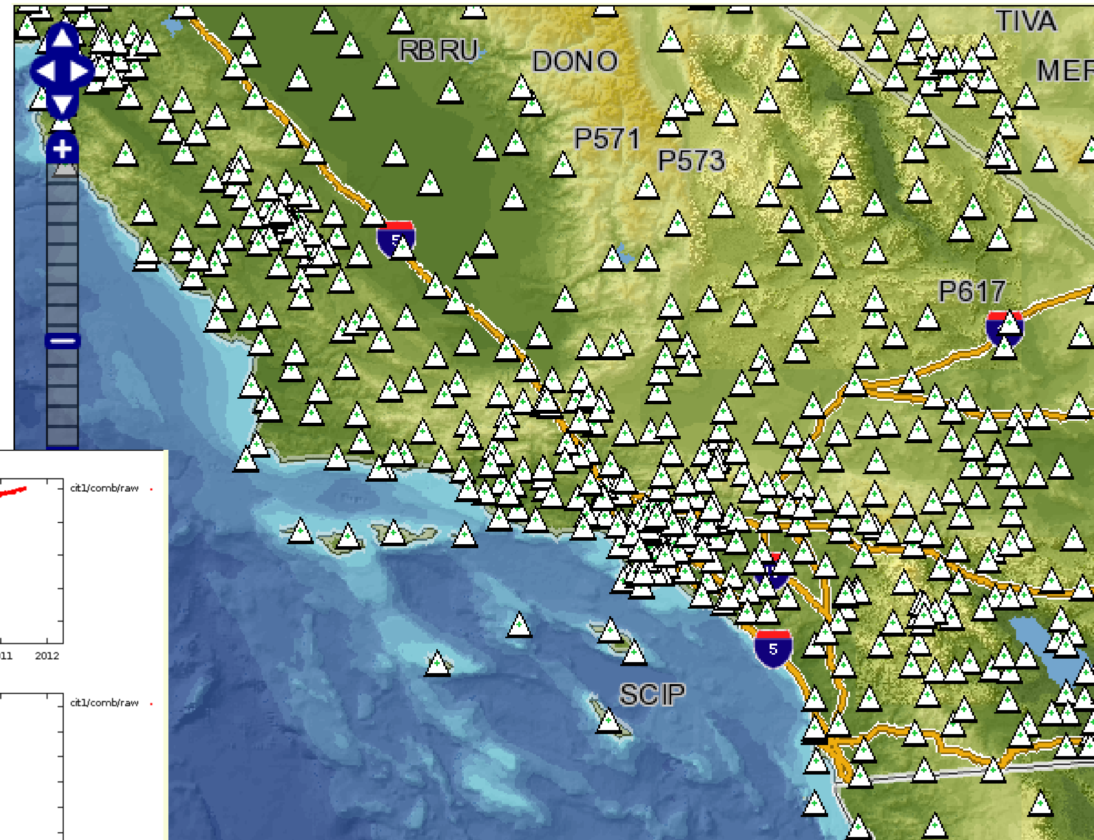
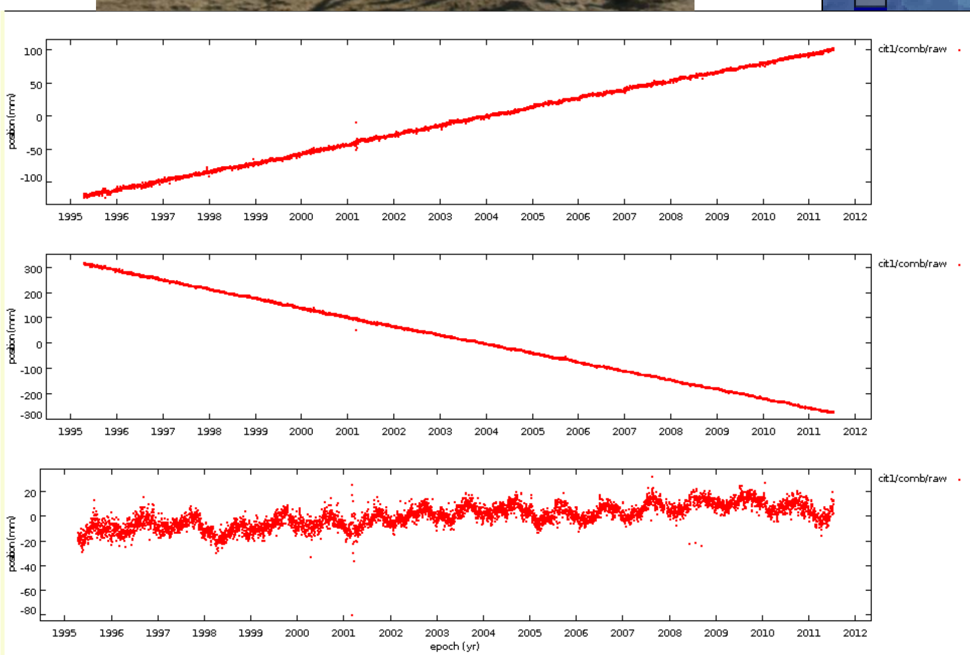
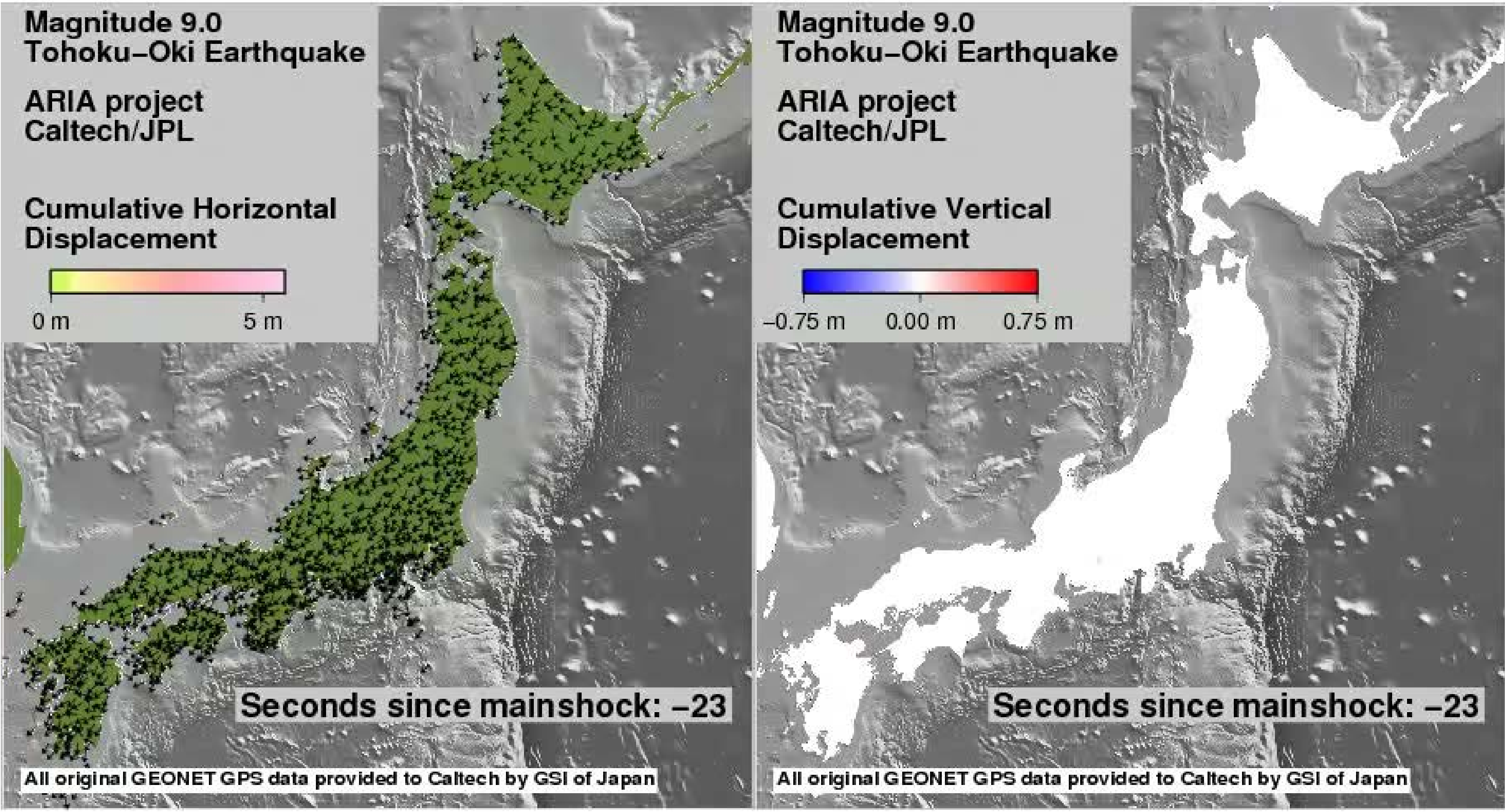
1. How we get precipitable water vapor from ground GPS (the basics)
2. A few examples of GPS integrated WV in Southern California weather
3. SIO-JPL-Caltech-NOAA project to generate NRT GPS IWV onsite

Permanent GPS in Southern California

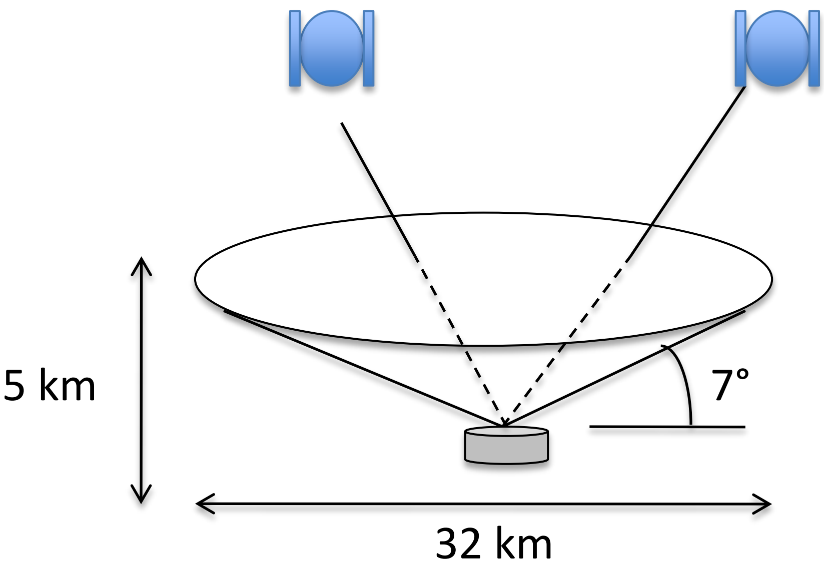







Magnitude 9.0
Tohoku–Oki Earthquake
ARIA project
Caltech/JPL
Cumulative Horizontal Displacement
0 m
5 m
Seconds since mainshock: –23
All original GEONET GPS data provided to Caltech by GSI of Japan
Magnitude 9.0
Tohoku–Oki Earthquake
ARIA project
Caltech/JPL
Cumulative Vertical Displacement
–0.75 m
0.00 m
0.75 m
Seconds since mainshock: –23
All original GEONET GPS data provided to Caltech by GSI of Japan

Precipitable Water from GPS



$\Delta t_{total} = \Delta t_{geom} + \Delta t_{iono} + \Delta t_{trop} + \ldots$

In solving for this, (Δt_{geom}) we estimate this (Δt_{trop})

Zenith hydrostatic delay = f(surface pressure)

Zenith wet delay

$TD(\theta) = ZHD \bullet mh(\theta) + ZWD \bullet mw(\theta)$

Total trop delay

Mapping functions

$PW = \kappa \times ZWD$

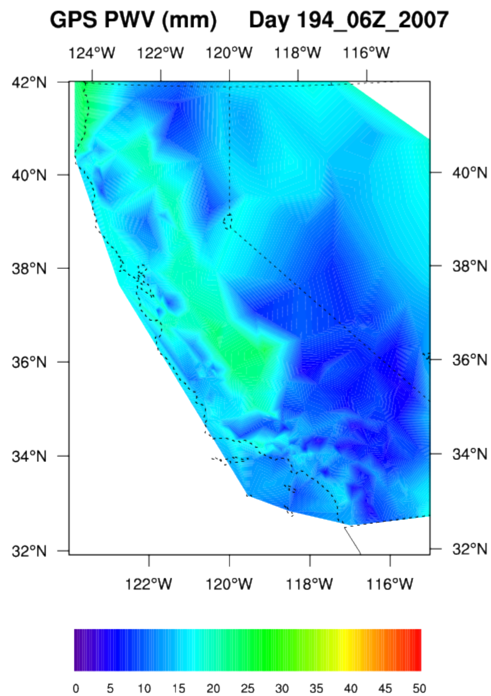
$1/\kappa = 10^{-6} \times \rho R_v[(k_3/T_m) + k_2'] \approx 6.5$

Mean atmos temp

➔With a surface pressure and a surface temperature, we get to PWV from ZTD.

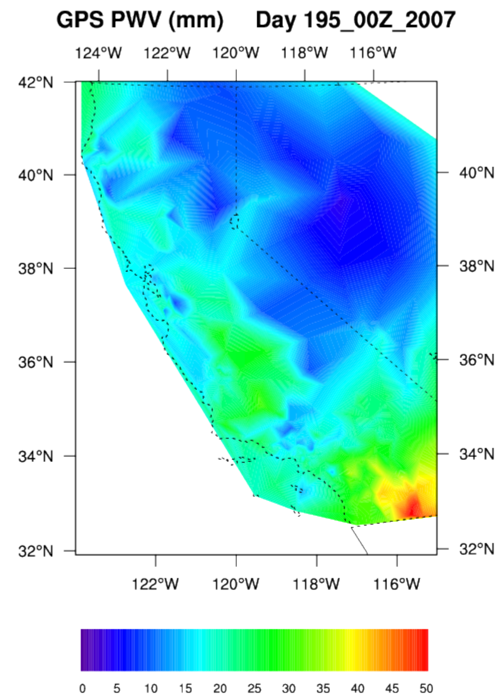
Monsoon Progression in California

Pre-monsoon



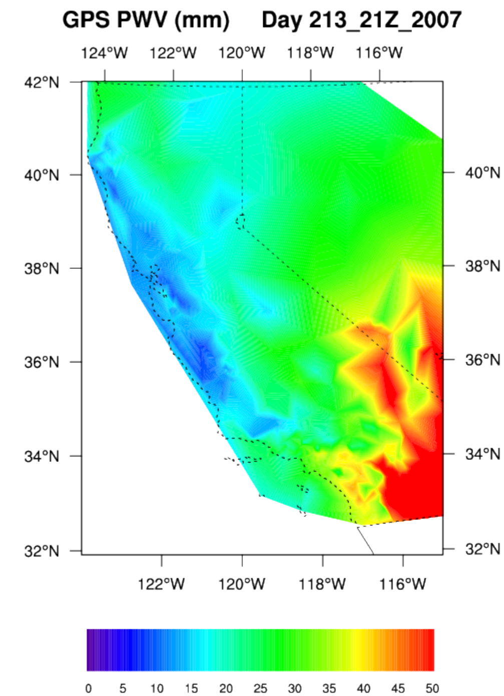
July 13, 2007
06Z

Monsoon onset



July 14, 2007
00Z

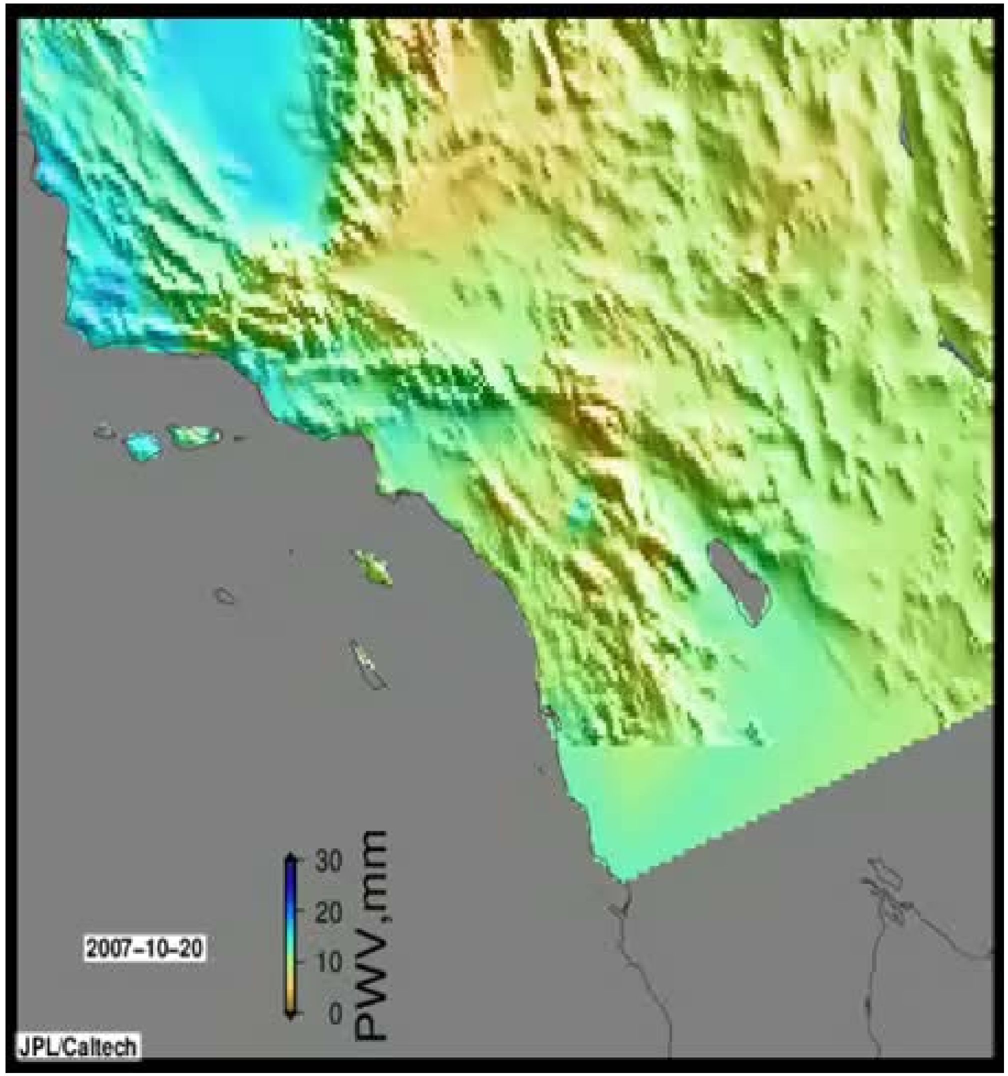
Peak monsoon



August 1, 2007
21Z

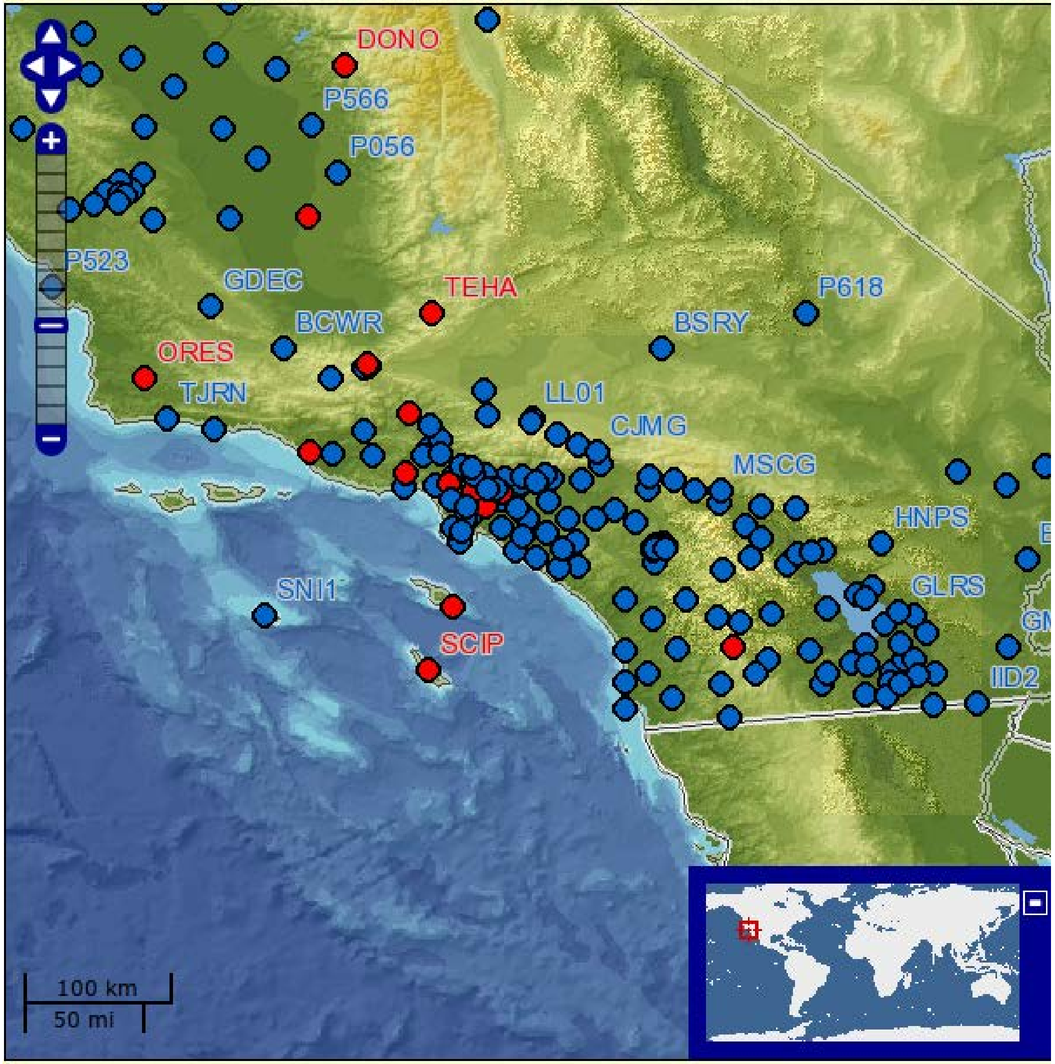
Slide credit: Jim Means/UCSD

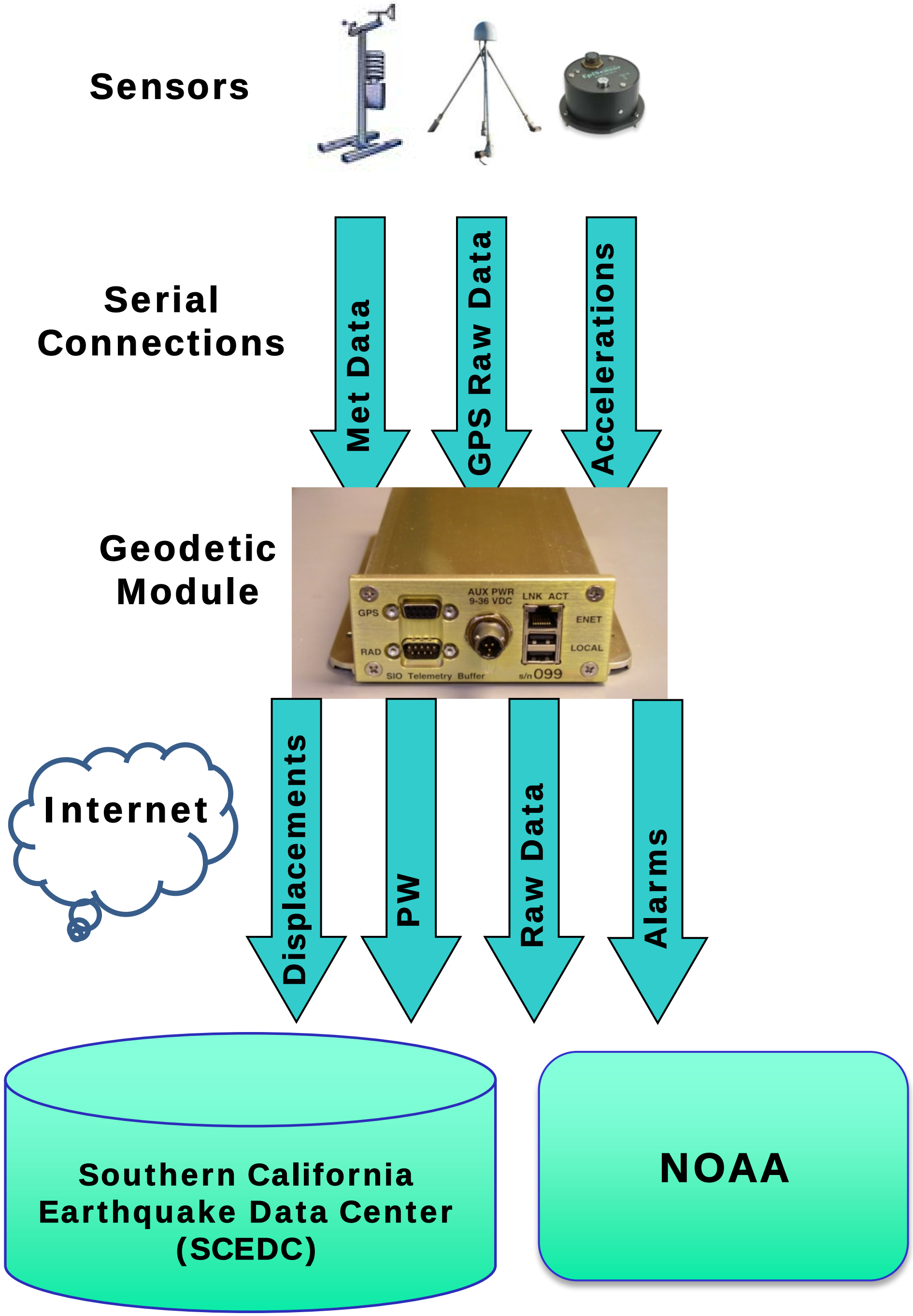
GPS WV documents Oct 2007 Santa Ana



Real-time GPS in southern CA

- Dense enough to envision using NRT WV for monitoring monsoon/Santa Ana/AR conditions





NASA AIST-11 project

(1) Autonomous, power-efficient, low-cost, plug-in geodetic module for existing GPS stations for data fusion of *in situ* sensors including GPS (GNSS), strong-motion accelerometers, and meteorological instruments (pressure and temperature)

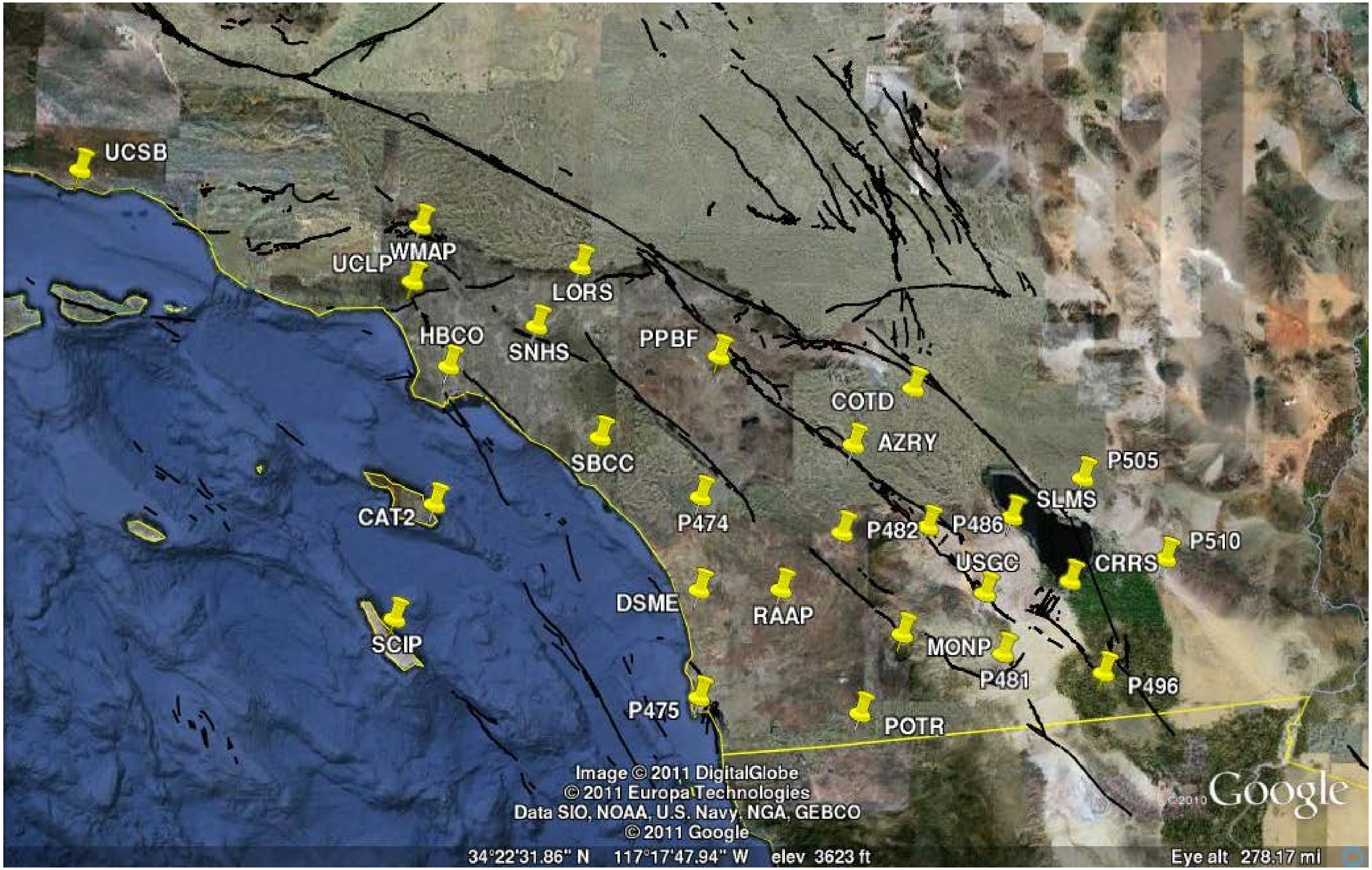
(2) Generation of on-the-fly higher-order data products including millimeter-level displacements and precipitable water within the geodetic module

(3) Enabling autonomous sensors to communicate with central nodes through the geodetic module to allow for control functions, data, data product, model exchanges, and alarming

(4) Technology infusion

Slide credit: Y. Bock/UCSD

Proposed 27-station prototype network



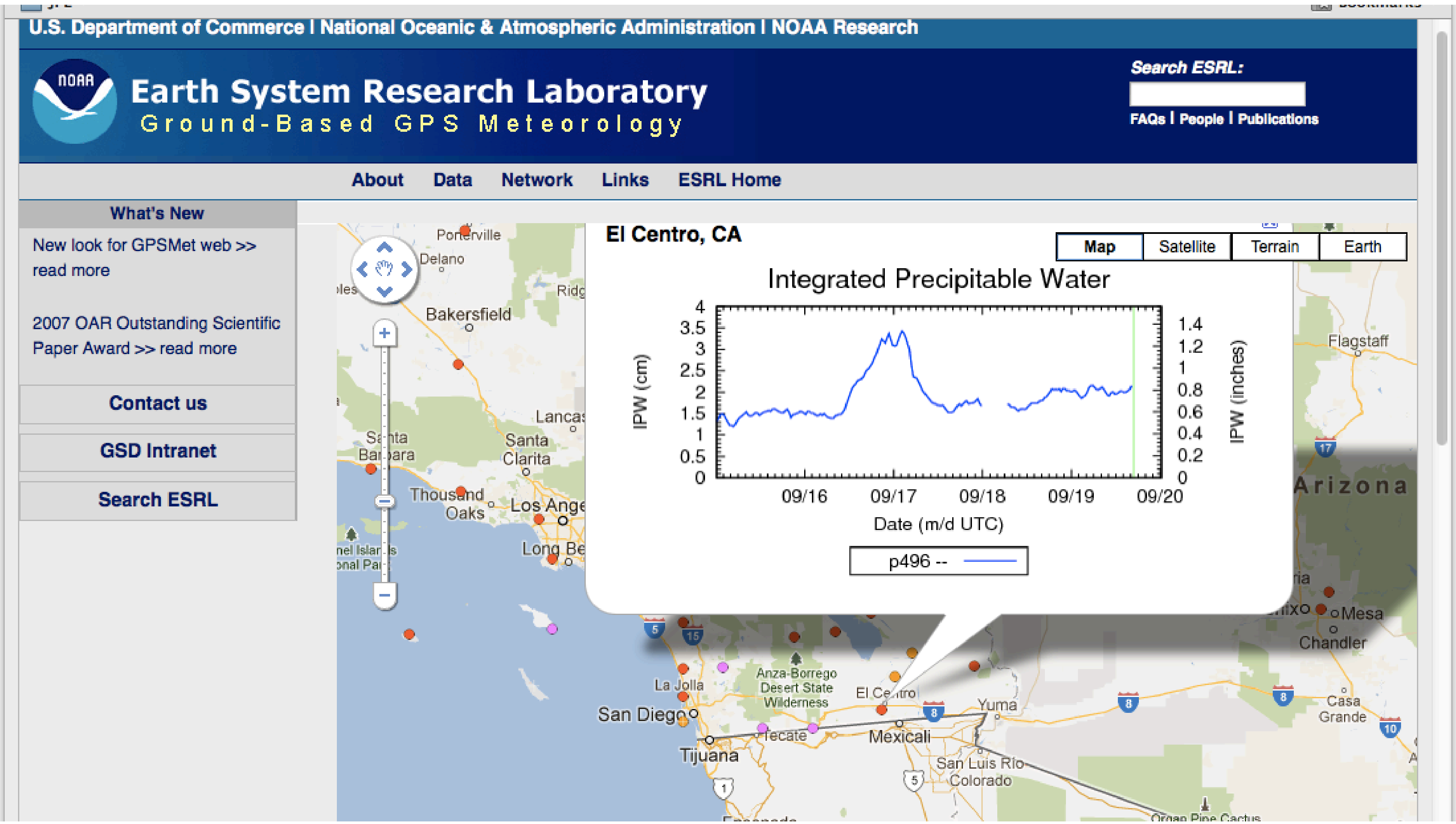
Project collaboration

- PI: Yehuda Bock, UCSD Scripps Institution of Oceanography
- JPL & Caltech
- NOAA ESRL – Technology infusion partner
- NOAA NWS WFOs Los Angeles/Oxnard and San Diego – Technology infusion partners

First steps

- increased the number of stations contributing to the NOAA ESRL GPS-Met observing network in southern California by about 27, decreasing the 12Z ZTD by roughly half (WV uncertainty now about 2.5mm)
- LOX forecasters began utilizing WV via ESRL's web page during the 2012 North American monsoon season, finding it to be an effective tool for evaluating model performance

ESRL GPSMet web interface used by forecasters



Next steps

- Prototype accelerometer package is coming soon; prototype met package is next
- Installation of Geodetic Module + onsite sensors at 27 station network
- Work toward onsite calculation and transmission of IWV
- Further development of forecaster use of GPS IWV