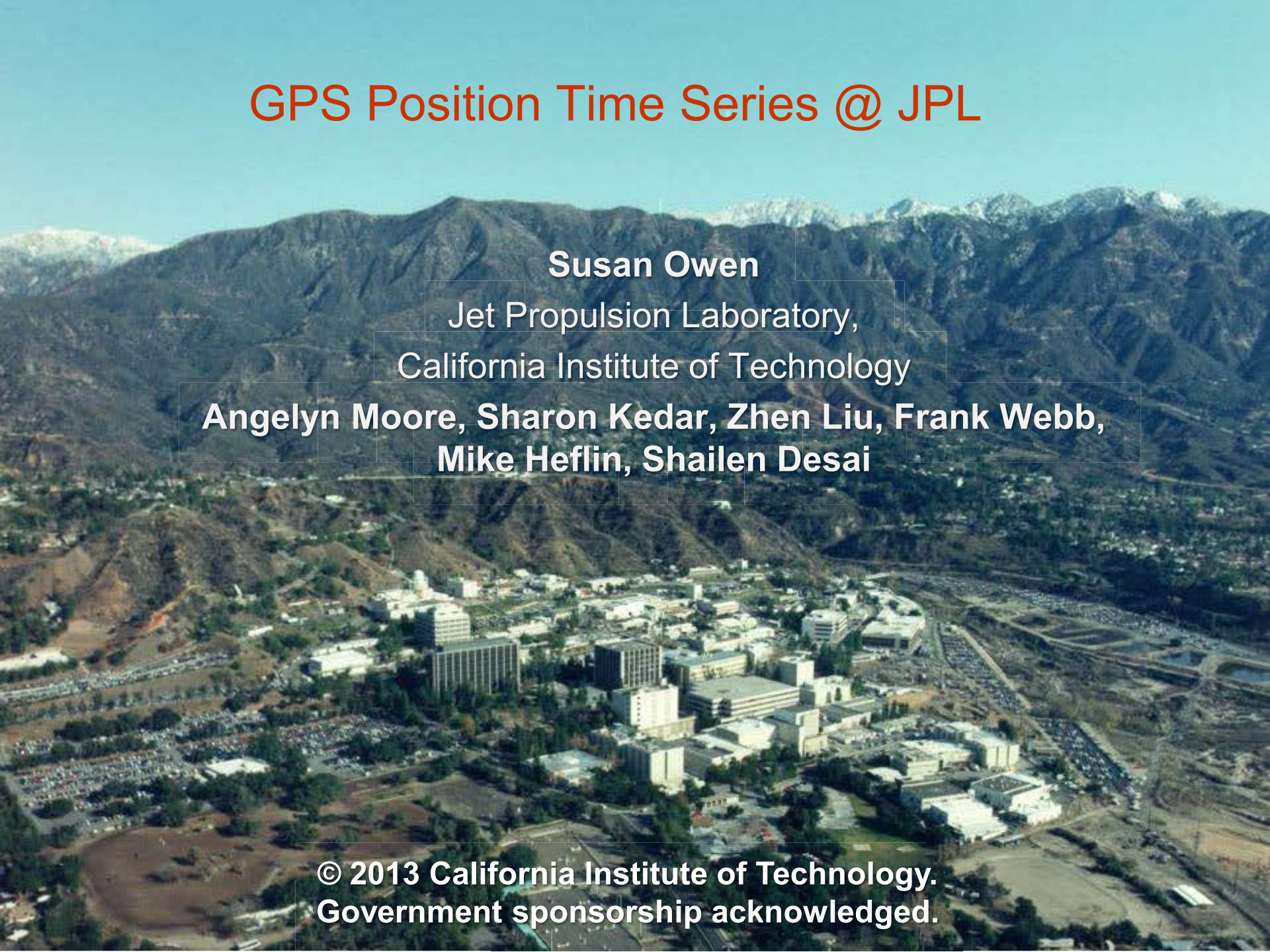
GPS Position Time Series @ JPL



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California Institute of Technology
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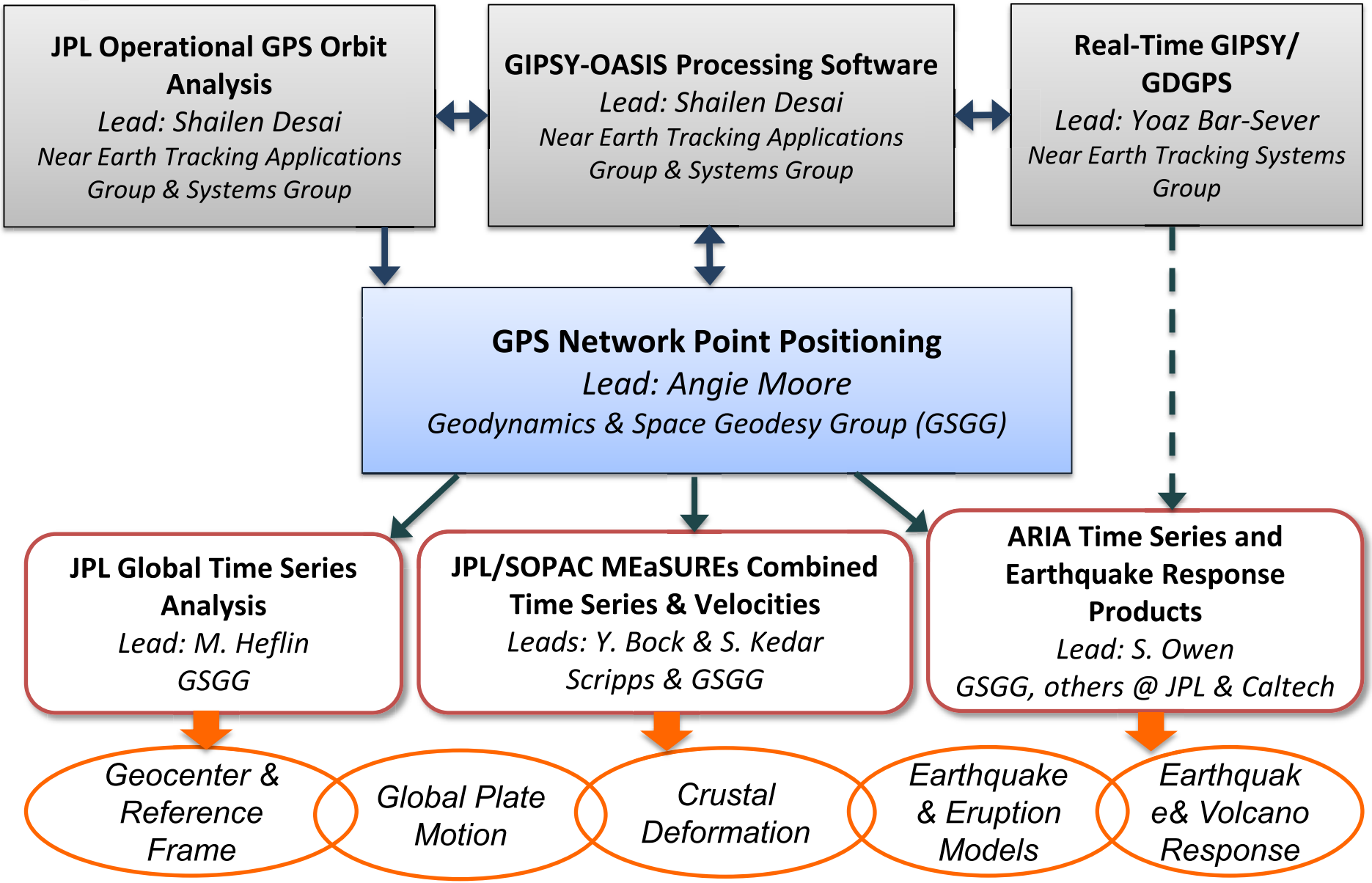
Government sponsorship acknowledged.

Overview of GPS Analysis Groups - Solid Earth

CALIFORNIA INSTITUTE OF TECHNOLOGY



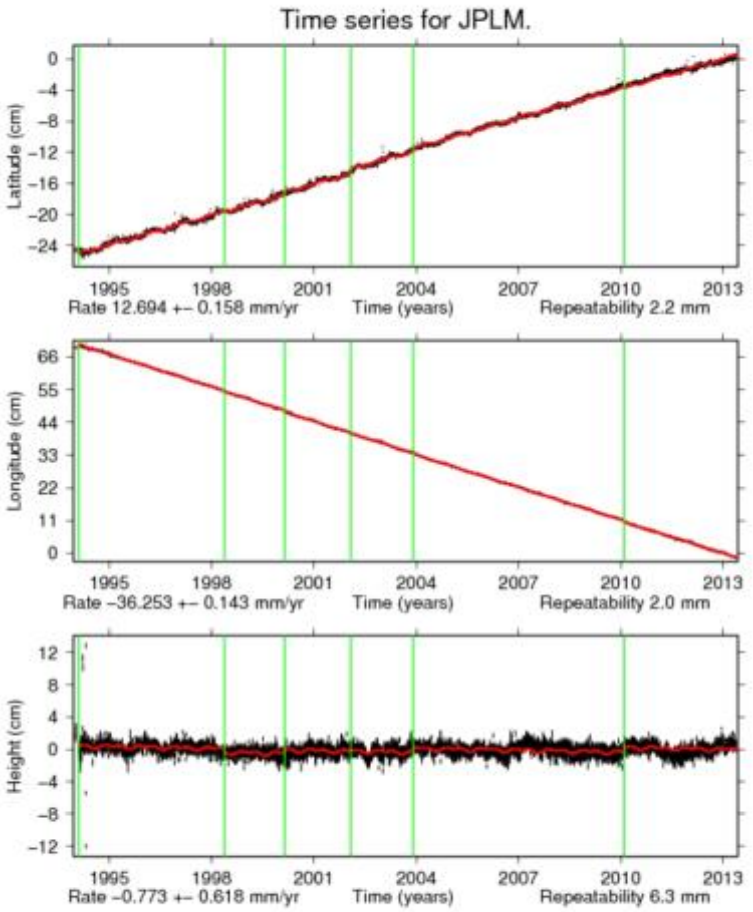
GPS Network Precise Point Positioning (PPP)

- Operational Analysis of Global GPS Stations
  - 2986 time series
  - From Aug 15, 1992 to present
  - Includes all of PBO Network
  - Positions & Tropospheric products added on weekly basis
  - Products generated using JPL Final orbits & clocks
  - IGS08 reference frame
  - Download raw time series from: **ftp://sideshow.jpl.nasa.gov/pub/JPL_GPS_Timeseries/repro2011b/raw/**
  - Go to website for more information: https://gipsy-oasis.jpl.nasa.gov , click on PPP data products

JPL Global Time Series

- Post-processing of PPP solutions includes:
  - Outlier removal
  - Offset detection
  - Time Series Fit for velocities, offsets, amplitude of annual and semi-annual periodic function
  - Parameter values available on website:

    http://sideshow.jpl.nasa.gov/post/series.html
  - Plots available as well
- 2389 sites
- 1995 to present
- Time series, residuals available at **ftp://sideshow.jpl.nasa.gov/pub/JPL_GPS_Timeseries/repro2011b/post/**



JPL & SOPAC Combined Time Series

GPS observables + metadata

JPL - GIPSY

SOPAC - GAMIT

Global station positions

Tropospheric delays

Global station positions

Tropospheric delays

Combination - st_filter

Precipitable Water Vapor generator

Independent atmospheric data or Weather models

Global cal. & val. station positions

PWV

Time Series Analysis

Principal Component Analysis

Global filtered time series

Global Tectonic Velocities

SOPAC Archive / CDDIS

L0: *GPS Observables + Metadata*

L1A: Global *Long term raw Geodetic Time Series*

L1B: Troposphere delay time series

L1C: Calibrated and Validated Global Geodetic Time Series

L2A: Precipitable Water Vapor time series

L2B: Filtered *Calibrated & Validated Global Geodetic Time Series*

L3A: Global *Tectonic Velocities*

JPL SOPAC

Solid Earth Science ESDR System

GPS Explorer

Legend

Process

Product

Produced outside SESES

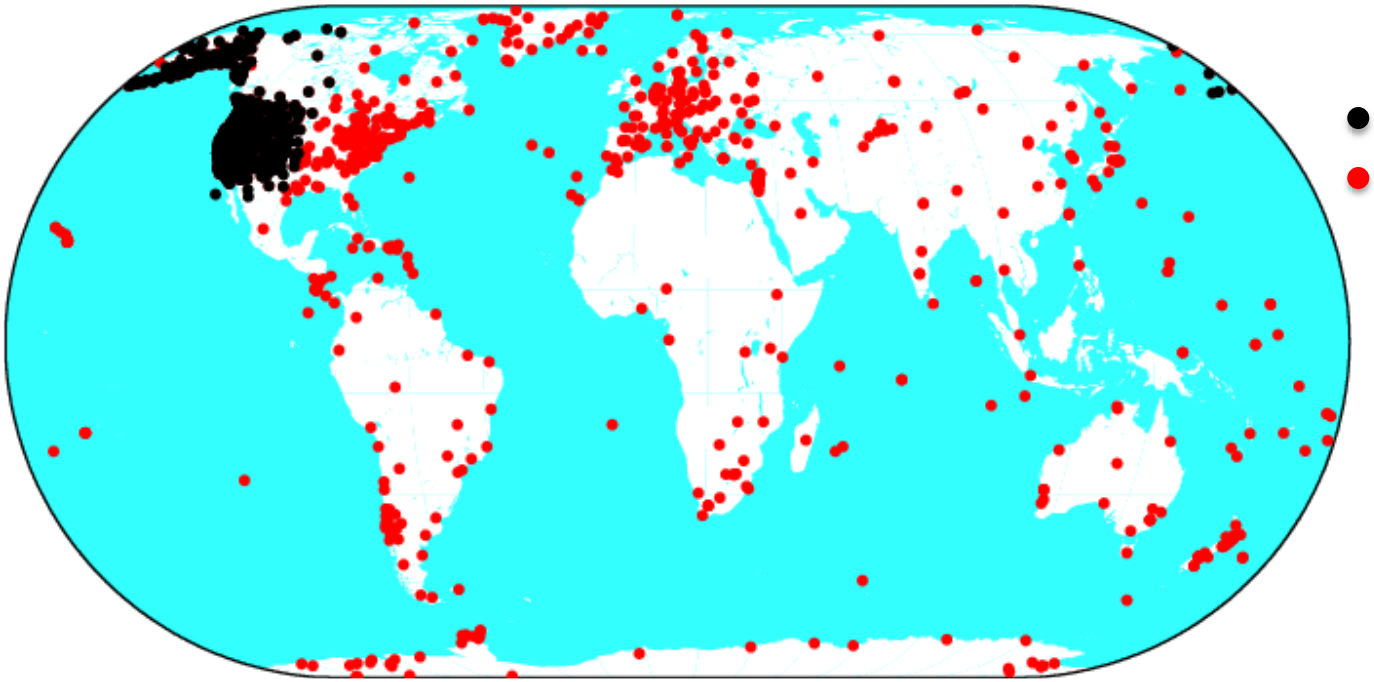
L1 Processes and products

L2 Processes and products

L3 Processes and products

New products

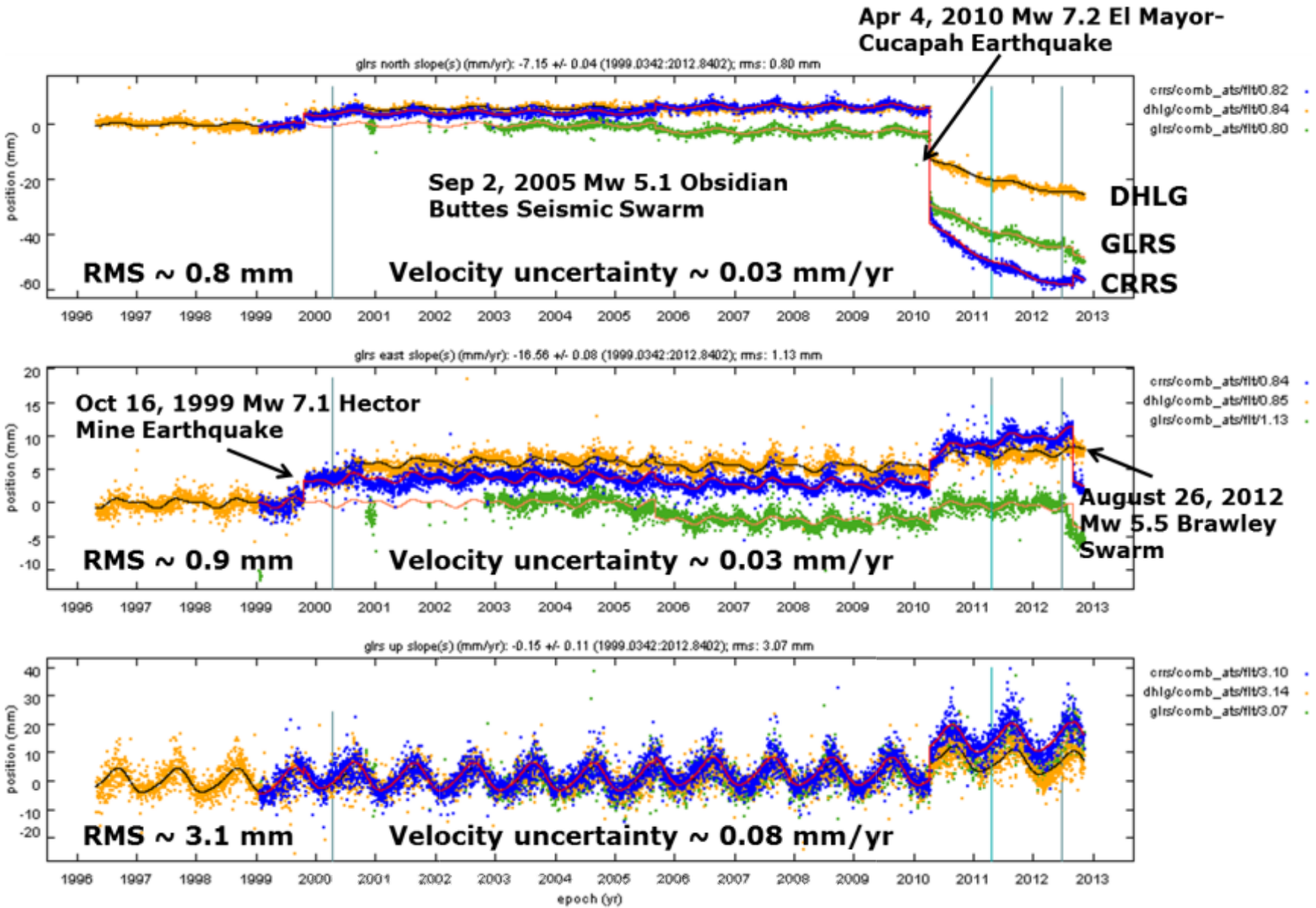
JPL/SOPAC Coverage, Time Series



Time Series Analysis:

- 1992 - present
  - 1-2 week latency in updates to time series
- 1845 sites - will expand under MEaSUREs 2012
- Outlier removal
- Velocities, offsets, seasonal amplitudes and phase, postseismic transients
  Common Mode Error removed from filtered time series
  - PCA analysis
  - Only time series residuals from well-behaved sites used in PCA

JPL/SOPAC Combined Time Series



Advanced Rapid Imaging and Analysis

JPL

Integrating
Space Geodesy
Seismology
Modeling

Seismological Laboratory
California Institute of Technology

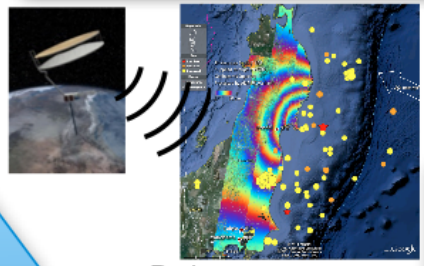
Radar Spacecraft

GPS Networks

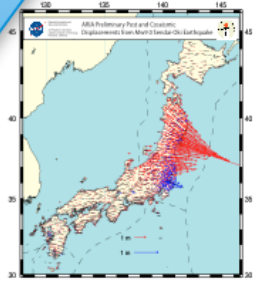
Seismic Networks

Optical Sensors

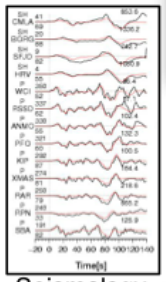
Automated Data Collection and Processing



Radar



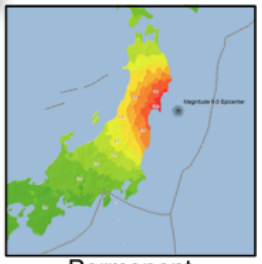
GPS



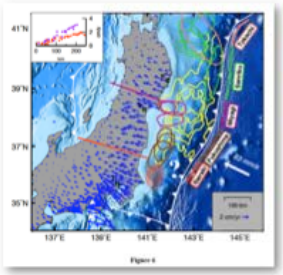
Seismology

Monitoring and Near Real-time Assessment

Damage Proxy Inundation



Permanent Ground Deformation



High Resolution Hazard Assessment from Fault Models

Potential Partners

Examples from the 2011 M9.0 Tohoku-Oki (Japan) earthquake

NASA

USGS science for a changing world

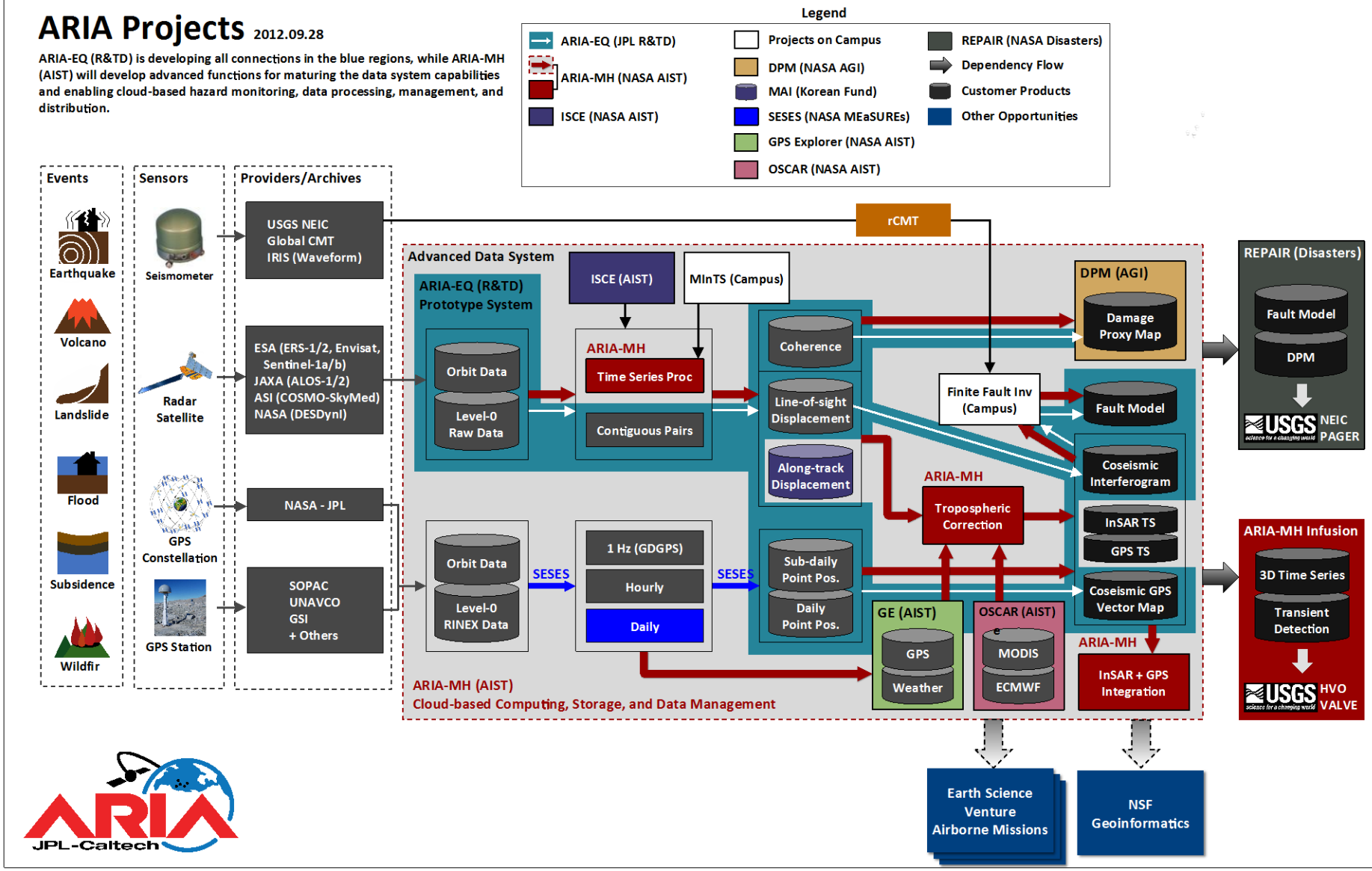
U.S. Department of Homeland Security

NSF

Cal EMA
CALIFORNIA EMERGENCY MANAGEMENT AGENCY

ARIA Projects 2012.09.28

ARIA-EQ (R&TD) is developing all connections in the blue regions, while ARIA-MH (AIST) will develop advanced functions for maturing the data system capabilities and enabling cloud-based hazard monitoring, data processing, management, and distribution.



ARIA Data Systems Overview

- ARIA-EQ prototype data system
  - Current automated capabilities
    - InSAR
      - Raw frames (ALOS, ENVI, CSK)
      - Geocoded interferograms
      - On-demand Damage Proxy Map
    - GPS
      - Kinematic Position Time Series (sub-daily positions)
      - Daily Position Time Series
      - Quality control
  - Runs on Beowulf compute cluster
  - Year 3 developing automated EQ Product and fault modeling capability
- ARIA-MH data system
  - Migrate capabilities onto *hybrid* cloud computing infrastructure.
  - Integrate Monitoring Data Products (e.g., InSAR Time Series Analysis)
- REPAIR - Integrate ARIA Products with USGS NEIC
- ARIA Co-Laboratory - Build Analysis & Modeling Workbench

ARIA EQ: Events with Demo Response Data Products

2010 M7.0 Haiti
- Coseismic Interferogram

2010 M7.2 M El Mayor-Cucapah
- GPS offsets
- Coseismic Interferograms
- SAR Pixel offset image

2011 M9.0 Tohoku
- GPS displacement waveforms
- GPS coseismic offsets (mainshock, major aftershock)
- Coseismic interferograms (mainshock, aftershock)
- Damage Proxy Map (for tsunami damage in select regions)

2011 M6.3 Christchurch
- Coseismic interferogram
- Damage Proxy Map

2011 M7.1 Van
- Coseismic Interferogram
- SAR Pixel offset image
- GPS coseismic offsets

2012 Brawley Seismic Swarm (M5's)
- GPS displacement waveform
- GPS coseismic offsets (for cumulative events)

2012 M7.6 Costa Rica
- GPS displacement waveform
- GPS coseismic offsets

2013 M5.8 Sumoto, Japan
- GPS coseismic offsets

ARIA Monitoring Data Products

Product	Needs/Applications
GPS time series and displacements	Forms the basis for higher level products. Provides high temporal resolution for monitoring surface deformation, transient detection.
InSAR displacements	Forms the basis for higher level products. Provides high spatial resolution maps of surface deformation for assessing hazards.
Coherence Change maps and time series	Detects damage from lava flow, ash fall, earthquakes, landslides, levee failure, floods, etc. Very useful with all-weather day/night capability and comprehensive coverage. *U.S. patent for algorithm (Yun et al., 2011b).*
InSAR Time Series	Provides history of surface deformation with high spatial resolution, input for data fusion and transient detection.
Reflectivity Change maps	Detects damage from flood and tsunami. Can provide volcano monitoring capability. Very useful with all-weather day/night capability and comprehensive coverage.
Troposphere-corrected interferograms	Higher fidelity surface deformation measurements.
Combined GPS and InSAR 3D surface motion maps	High spatial and temporal resolution products for monitoring. Provides basis for transient detection.
Advisory Alerts of anomalous ground motion	Identifies regions that need further investigation. Useful for regions where data set is too large to evaluate manually

Summary/Comments

- Different flavors of GPS time series analysis at JPL
  - Use same GPS Precise Point Positioning Analysis raw time series
  - Variations in time series analysis/post-processing driven by different users.
    - JPL Global Time Series/Velocities - researchers studying reference frame, combining with VLBI/SLR/DORIS
    - JPL/SOPAC Combined Time Series/Velocities - crustal deformation for tectonic, volcanic, ground water studies
    - ARIA Time Series/Coseismic Data Products - Hazard monitoring and response focused
- ARIA data system designed to integrate GPS and InSAR
  - GPS tropospheric delay used for correcting InSAR
  - Caltech's GIANT time series analysis uses GPS to correct orbital errors in InSAR
  - Zhen Liu's talking tomorrow on InSAR Time Series analysis…