QuakeSim Data Architecture and Technology

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Session: Data System Architecture in Support of Disaster Response and Awareness

QuakeSim

Computational infrastructure for integrating remotely sensed and other data with mapping, modeling, and analysis tools

Understanding
Creeping faults
Location and size of future earthquakes, stress transfer and fault interactions

Forecasting
Mitigating losses through preparedness and targeted retrofitting

Response
Virginia Earthquake
Damage assessment
Impact to critical infrastructure

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Motivation

- NASA geodetic imaging observes the earthquake cycle of strain accumulation and release.
- Integrating these data with model and analysis tools yields new insight into earthquake processes and hence hazards.

Repeat pass displacement images

Earthquake location and size

Geologic faults

Coseismic offset

Postseismic deformation

Interseismic strain accumulation

Station position time series and velocities

UAVSAR

InSAR

Time
Approach

• Focus on science analysis, modeling, and simulation
  – Use existing data products
    – Let the experts process the data
    – GPS model has worked well
• Focus on developing tools for routine workflow
• Make products and output available for further offline analysis
Objective

Provide integrated data access and tools for online or further offline analysis

Data Products

- Faults
  - Scientific publications
  - Official data sets
  - Inferred from models
- InSAR/UAVSAR
  - JPL, ASF, UNAVCO
- GPS
  - JPL, SOPAC, UNAVCO, UNR
- Seismicity
  - USGS, SCSN, NCSN, ANSS

Application

- Data Exploration
  - Availability
  - Characteristics
  - Features
- Science
  - Crust and earthquake fault behavior
- Forecasting
  - Earthquake probabilities
- Response
  - Tilt maps
  - Aftershock likelihood

Interface

Map-based Visualization
Modeling Analysis
Datamining GIS
Compliant
Workflow

Data Products

Providers

- **Faults**
  - Scientific publications, official data sets, inferred from models

- **InSAR/UAVSAR**
  - JPL, ASF

- **GPS**
  - JPL, SOPAC, UNAVCO, UNR

- **Seismicity**
  - USGS, SCSN, NCSN, ANSS

Applications

- **Crustal Deformation**
- **Earthquake fault system simulators**
- **Time series analysis**
- **Forecast**

Outputs

- Fault geometries
- Fault slip rates
- Strain migration
- Earthquake fault behavior
- Crustal deformation anomalies
- Earthquake likelihood

Raw data → Response
Fault Models

- QuakeTables APIs and interfaces
  - View, download, or model access to fault data
- QuakeSim vector and metadata are Consolidated into geospatial database and published through GeoServer
- QuakeTables API pulls the data from GeoServer directly
- Supports spatial query on vector data through GeoServer
- JavaScript support for mobile applications
- API interfaces for both data retrieval and dynamic HTML generation

GeoJSON for Mobile Interface
KML for Google Map
WFS for Desktop GIS
Image of 2010 M 7.2 Earthquake in Baja

Each fringe represents 12 cm displacement to/from instrument
Lower plot shows total displacement to/from the instrument
Creep Occurred on Faults to the North

Superstition Hills Fault

Imperial Fault

1 cm

2.3 cm
Data Processing: UAVSAR workflow

- Registered with GeoServer
  - GeoTiff file
- Stored into PostgreSQL
  - Spatial index (bounding box of InSAR image)
  - Metadata

uavsar.jpl.nasa.gov

Product Release Notification

Release Type

New

Updated Product

Revision Controller

Generate header File

Generate GeoTiff

Extract bounding Box

Generate spatial Index

Update thumbnail mosaic

GeoServer

Index data

Version data

Geospatial DB

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InSAR Profile Tool

- Performance improvement
  - New thumbnail mosaic layers to improve loading speed

Interactive JavaScript plotting

Download values for further analysis

Stacked plots
Add options for additional plots
InSAR Profile Tool

New features under development

• New function to extract pixel values
  – Based on WCS (Web Coverage Service) and GDAL library
  – In addition to the current WMS getfeatureinfo method
  – Better sampling on native pixels to reduce aliasing
  – Better performance: 3X faster
  – More advanced spatial query support

• Profiling across overlap images

• InSAR color range web service

Linear color mapping

Nonlinear color mapping
Data Processing: GPS time series

• Looking for statistical state changes in position time series
• Implemented the processing pipeline
  – Incorporate 18 varieties of datasets from SCRIPPS
  – Enhanced the user interface correspondingly

**New data navigation panels**

**Interactive JavaScript Plot Library**
Virtual California Analysis Tool

• Interactive display of data or simulations stored or generated by a back end system
• Middleware mediates the user interaction with the data

Fault Browser

Simulated InSAR Observations
GPS Observations Suggest Second Fault

Invert for slip after fixing mechanisms for M 4.3-5.5 events

Conjugate to swarm
124 mm right-lateral, 22 mm normal slip
-32° strike; 61° dip, 11-0 km depth, $X^2=1.5$

University of Nevada Reno rapid GPS Solutions

Geodetic moment release equivalent to M5.8

Single fault inversion not accounting for events is proximal to but above swarm

Conjugate fault matches trend of small events

30 days M 2.5+

30 days all events
Earthquake Response

Tilt maps show where water and sewer lines may run backwards for an event on the Cucamonga Fault (Golden Guardian 2012)

Modeled San Andreas fault earthquake scenario (ShakeOut 2008)

Connect QuakeSim to E-DECIDER decision support
The End Goal

- Understand earthquake processes
- Save lives
- Reduce losses

What are the implications for stress accumulation on the San Andreas Fault?

http://quakesim.org