Decision Support for Improved Hazard Analysis and Disaster Response: E-DECIDER

Margaret Glasscoe, Jay Parker, Andrea Donnellan
NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

Jun Wang, Marlon Pierce
Indiana University, Bloomington, IN

Ronald Eguchi, Charles Huyck, ZhengHui Hu
ImageCat, Inc., Long Beach, CA

John Rundle, Mark Yoder
University of California, Davis CA

ZhiQiang Chen
University of Missouri, Kansas City, MO

Anne Rosinski
California Earthquake Clearinghouse
California Geological Survey, Menlo Park, CA

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9-10 April 2016

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Margaret (Maggi) Glasscoe

- Email: Margaret.T.Glasscoe@jpl.nasa.gov

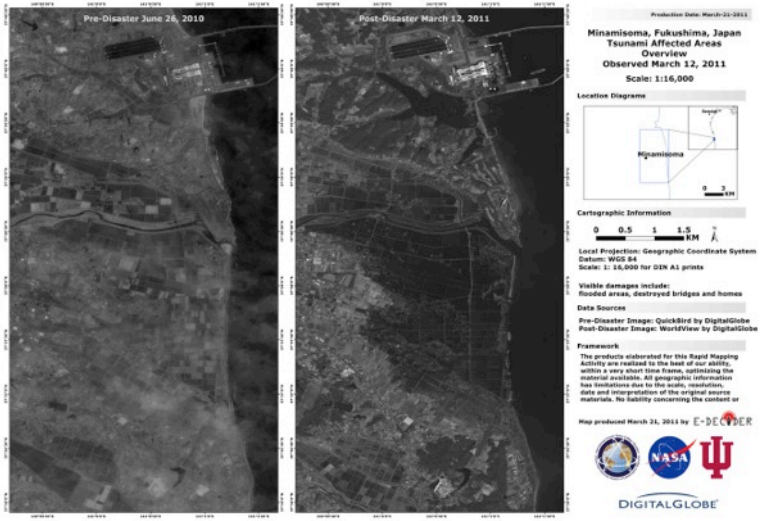
- Education:
  - Ph.D. Geology (2015) University of California, Davis; M.S. Geology (2003) University of California, Davis; B.S. Geological Sciences (1997) University of Southern California; B.A. Print Journalism (1997) University of Southern California
- Employment Background:
  - Jet Propulsion Laboratory: (2004 – present) Science Researcher (Geophysicist), Earth Surface and Interior/Solid Earth/Terrestrial Sciences Group; (2000 – 2004) Member of the Technical Staff, Data Understanding Systems Group; (1996-2000) Research Assistant, Satellite Geodesy and Geodynamic Systems Group
- Projects and Experience:
  - Principal Investigator, E-DECIDER; Co-Investigator, QuakeSim/GeoGateway; Member of NISAR Project Science Team
- Awards and Honors:
  - JPL Team Bonus Award (Nepal Response, 2015); JPL Voyager Award (Nepal Multihazard Risk Assessment, 2015); JPL Discovery Award (2013); JPL SPOT Award (2010), NASA Board Act Award (2008), SCEC Community Outreach Award (Education) (1998)
- Professional Memberships: American Geophysical Union, Seismological Society of America
- Major fields of interest/expertise: disaster response, earthquakes, numerical modeling, post-seismic deformation, geodetic observations

Talk Outline

- Introduction
- E-DECIDER services and products
- Napa earthquake response
- Nepal earthquake response
- Participation in earthquake response exercises
- Conclusions

Introduction

- E-DECIDER = **E**mergency **D**ata **E**nhanced **C**yber-**I**nfrastructure for **D**isaster **E**valuation and **R**esponse
- Provides decision support for earthquake disaster management and response utilizing remote sensing data and NASA modeling software
- **Goal: Transform and Distribute Earth Science Data in support of Disaster Response and Recovery**
- Identify standards
  - Data formats
  - Distribution methodologies
  - Compatible with the state of the art IT infrastructure
- How to produce results that have immediate utility for disaster response?

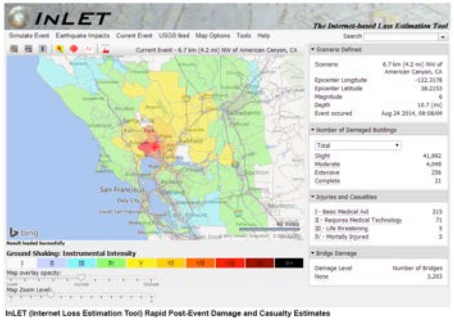


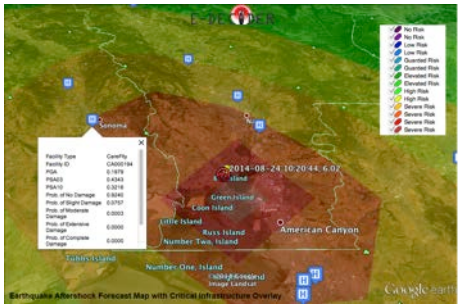
2011 Tohoku-oki Earthquake Response

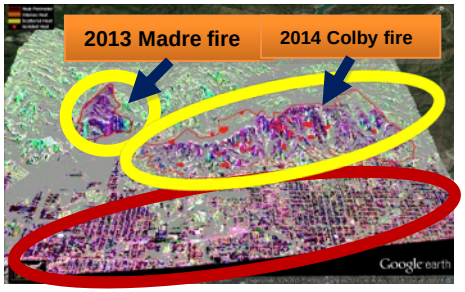
E-DECIDER Disaster Decision Support Platform

Emergency Event

Generate Products



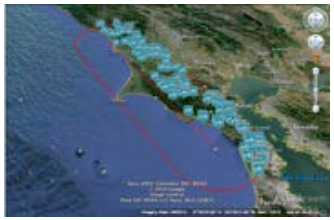


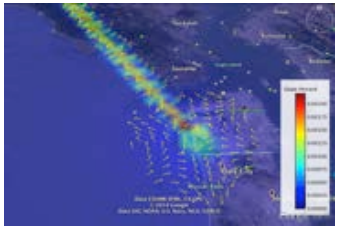


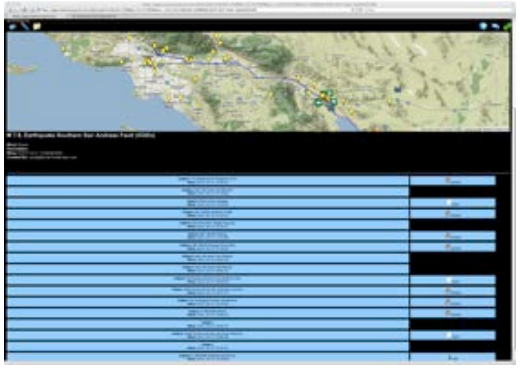
Deliver to Decision Makers

Data Exchange to End Users

Working in partnership with CA Earthquake Clearinghouse, CalOES, CA National Guard, FEMA, local governments, and other agencies



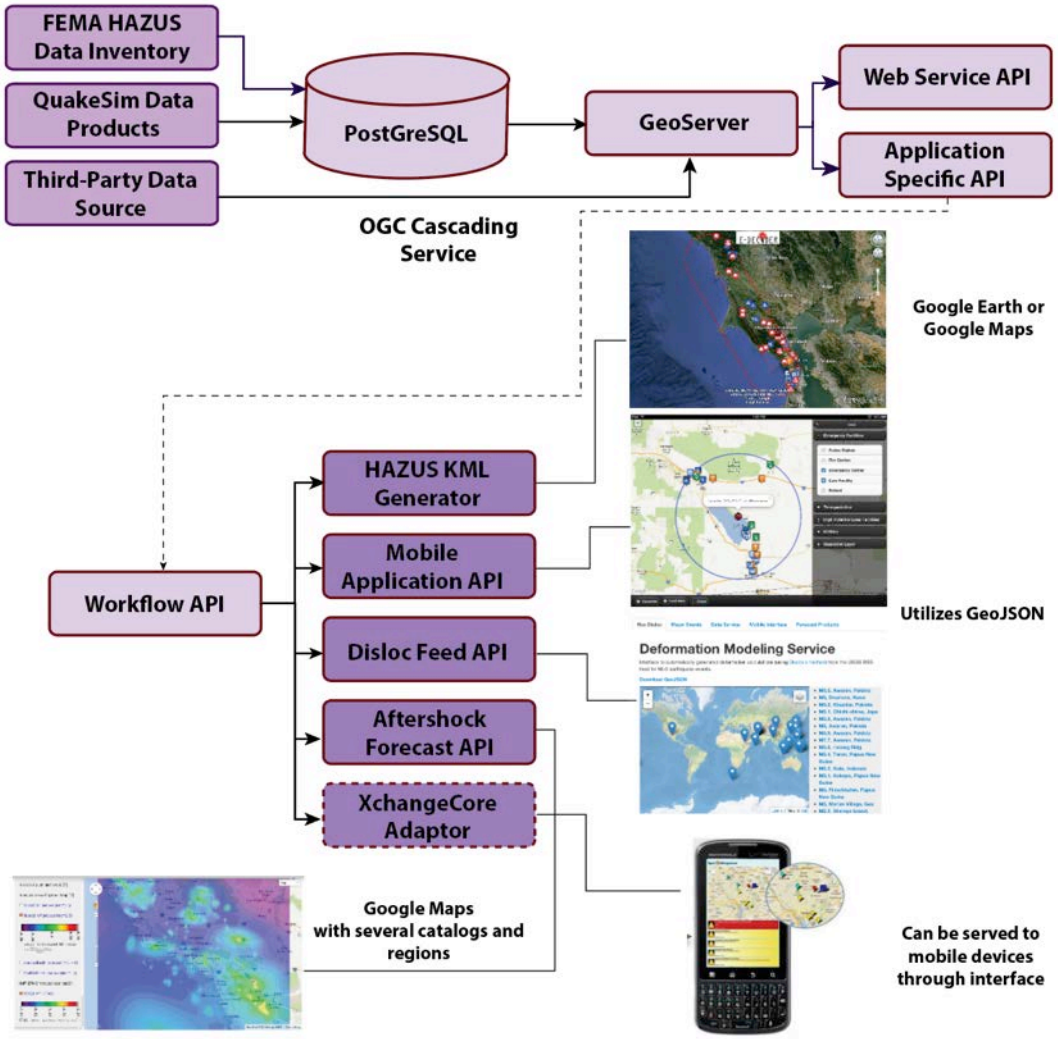




Products Generated → **Authoritative data securely shared** → **Users query products (SpotOnResponse, NICS, Google Earth, etc)** → **Pass on to Decision Makers (local, state, federal)**

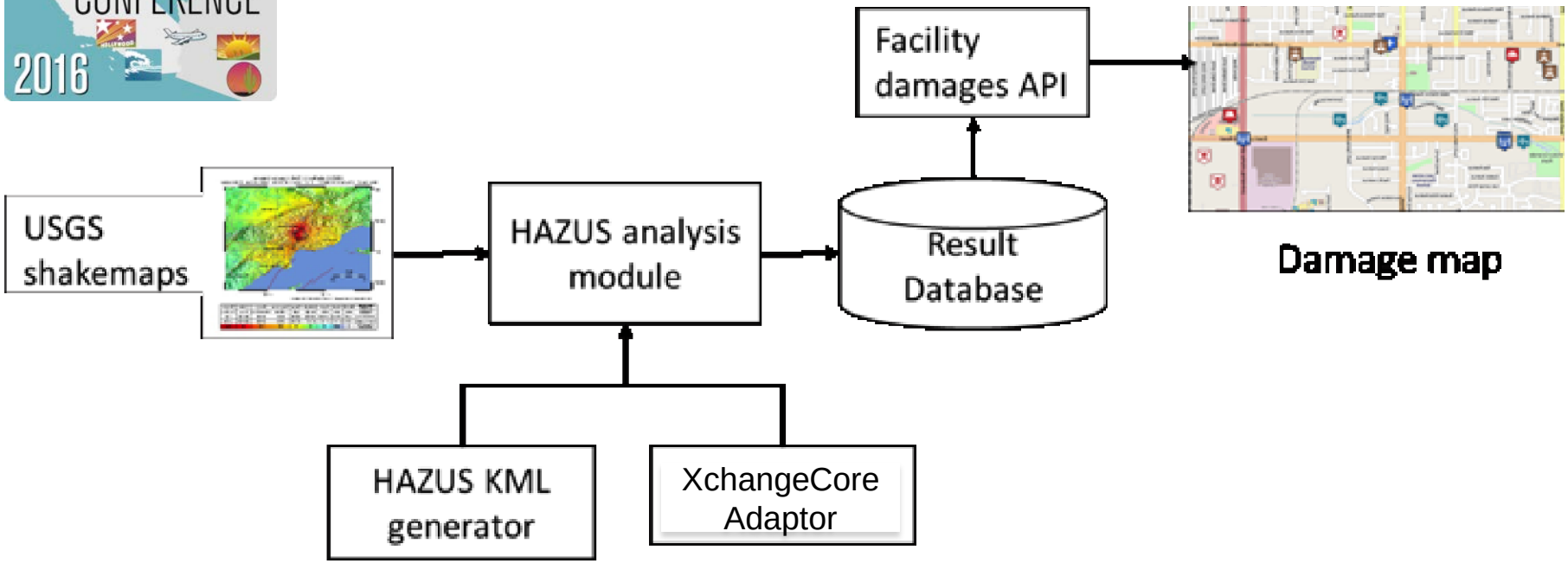
E-DECIDER Service Architecture

- Data sources are stored in a PostGreSQL database and distributed via GeoServer.
- Web service and application specific APIs generate products and services.
- Can be accessed via the web, mobile interfaces, and XchangeCore.



From Glasscoe, et al., 2015

Damage and Loss Estimation Service

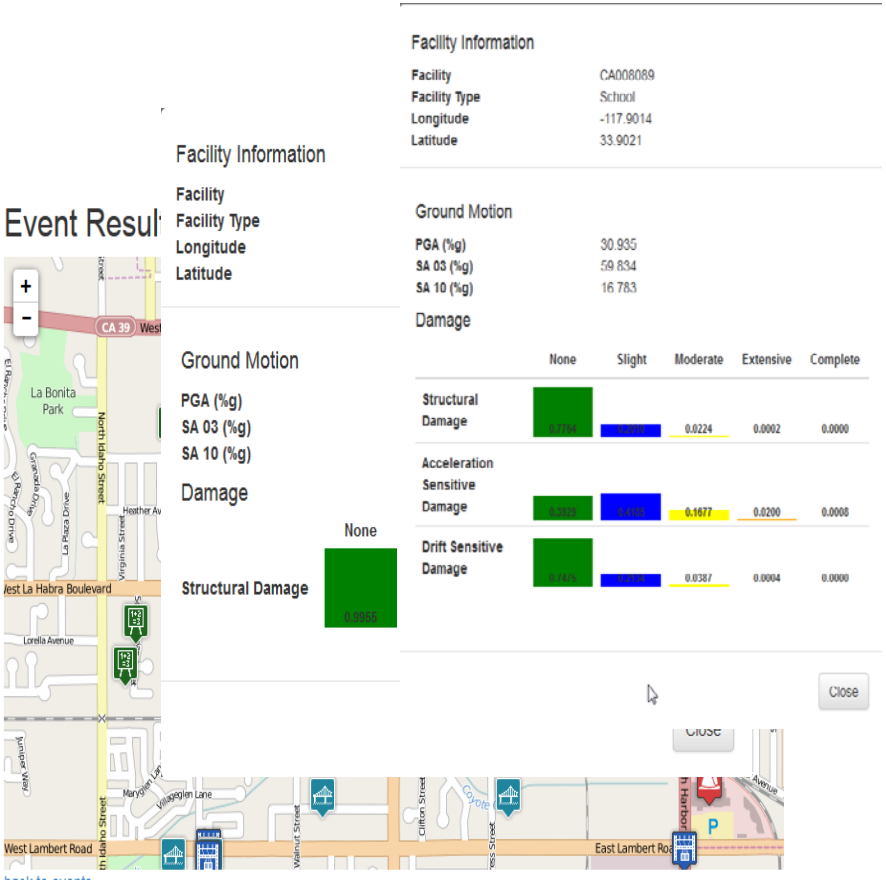


From Glasscoe, et al., 2016 (in press)

- Workflow for E-DECIDER damage estimation module in an earthquake disaster.
- Analytical module is designed for full integration with multiple existing components within E-DECIDER computing potential damage to infrastructure.
- Utilizes available online resources to perform the assessment.

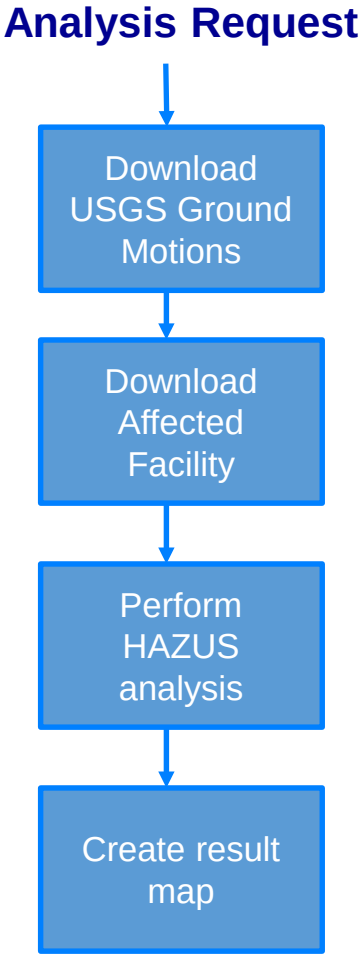
HAZUS analysis

- USGS ground motions data from Shakemaps
- Direct Physical Damage assessment using HAZUS methodology
  - Essential High Potential Loss Facilities
  - Transportation Facilities
  - Utilities
- Result map for visualization

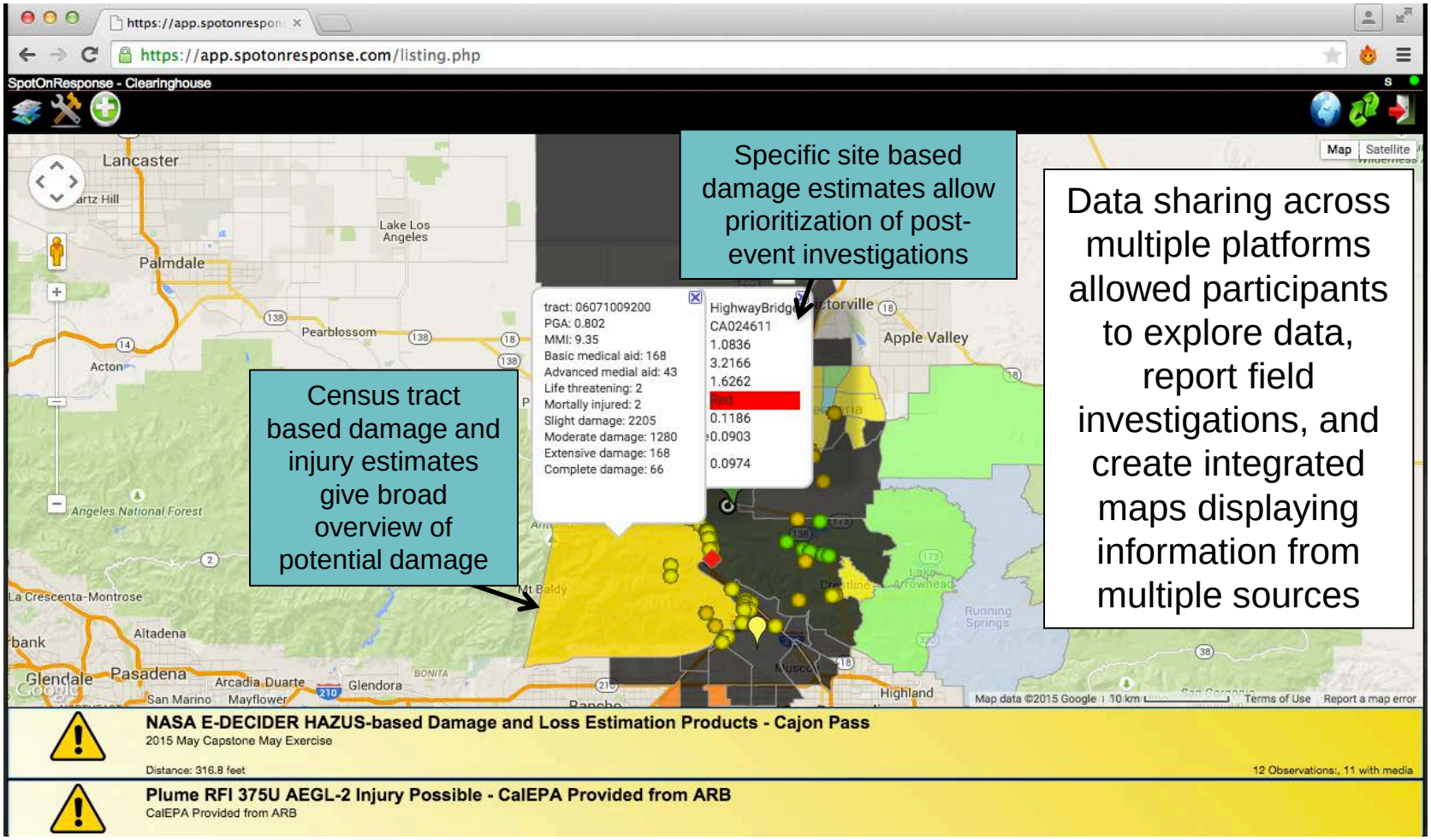


HAZUS analysis (cont.)

- Automatically downloads required data
- Modular and self-contained design
- Fully integrated with other components of project as web service



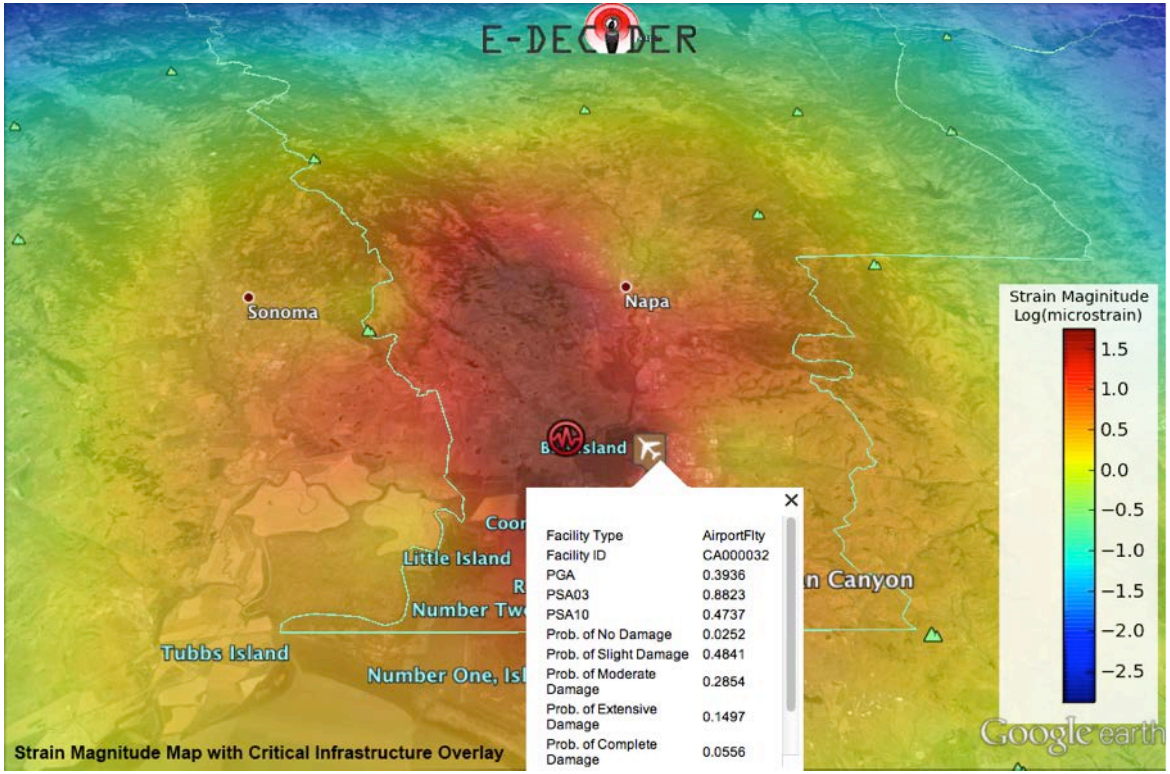
HAZUS Damage Estimation for May Capstone



Earthquake Rapid Response

- Responded to two recent events:
  - August 2014 M 6.0 South Napa earthquake
  - April 2015 M 7.8 Gorkha Nepal earthquake
- Data products are provided to stakeholders rapidly (within minutes to hours) of an earthquake or disaster
- Information can aid in prompt allocation of resources

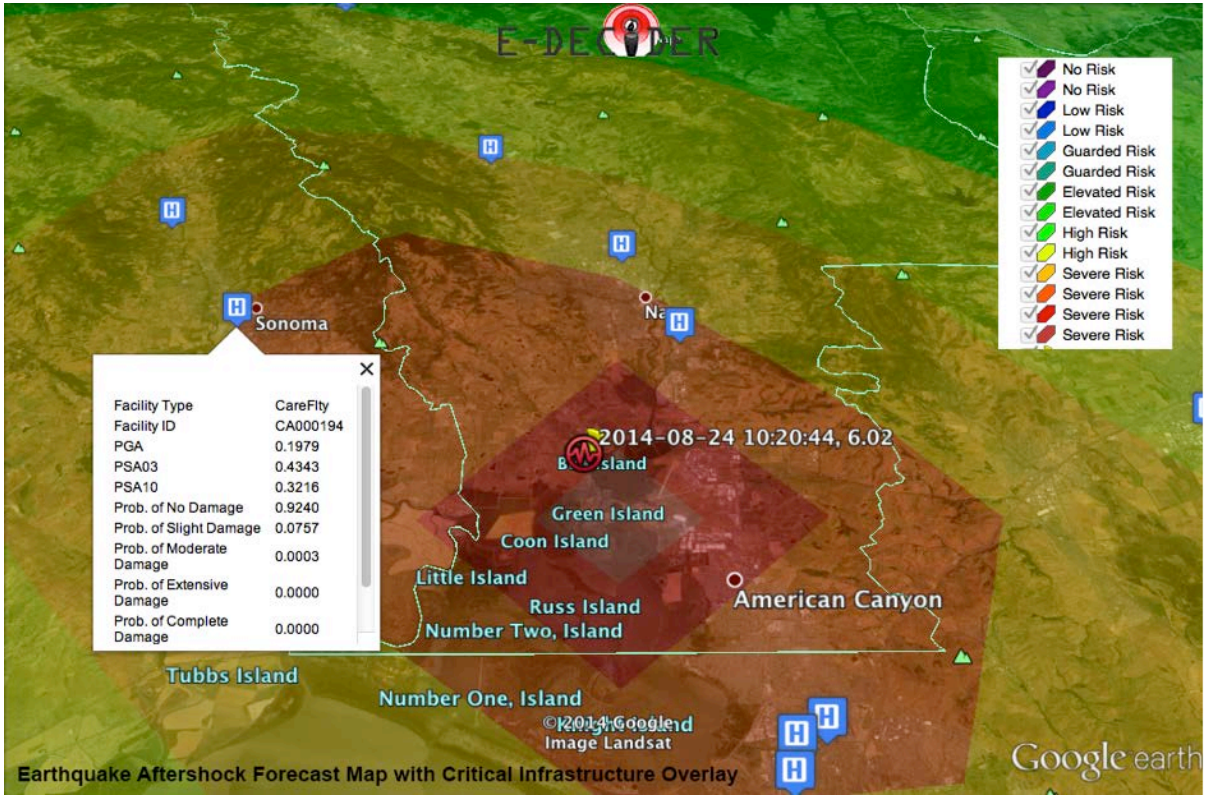
Napa Earthquake Strain Magnitude Map with Critical Infrastructure Overlay



Strain Magnitude Map with Critical Infrastructure Overlay

- Highlights areas where greatest ground deformation (motion) has occurred based on a fault model.
- Model can be refined and deformation better constrained once geodetic observations are available.
- Provide an early estimate of where deformation has occurred, and where damage may be localized.
- Critical infrastructure overlays with damage estimates allow decision makers to direct response efforts.
- Map shows an airport in the affected area that was predicted to have sustained minor damage (location and damage estimate.
- Later airborne or satellite observations and field reconnaissance can verify.

Napa Earthquake Aftershock Forecast Map with Critical Infrastructure Overlay

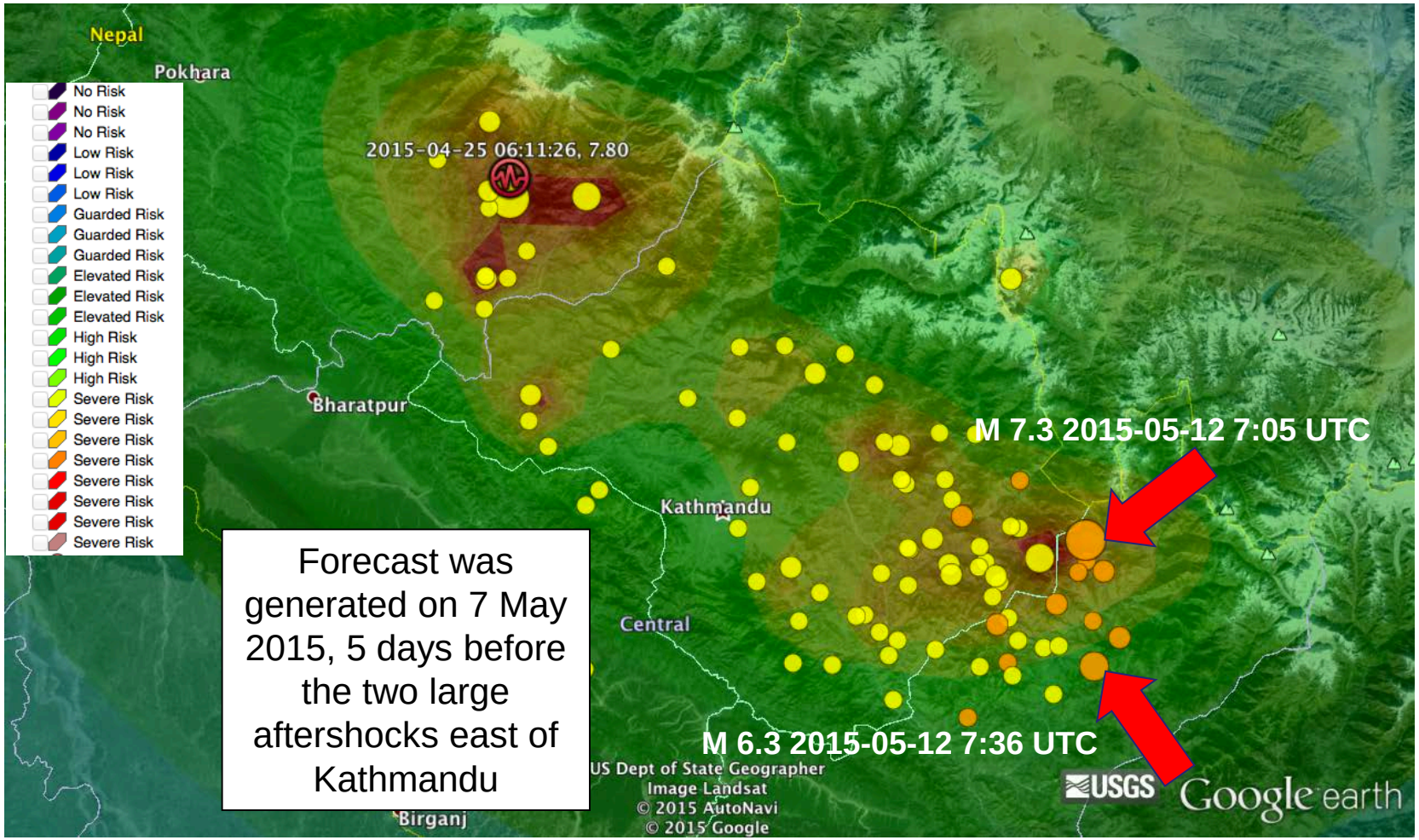


Earthquake Aftershock Forecast Map with Critical Infrastructure Overlay

- Highlights areas where aftershocks are likely to occur.
- Show estimated aftershock risk in a color scale -- warmer colors represent higher risk and cooler colors lower risk.
- Using the critical infrastructure overlays with damage estimates, decision makers can better direct response efforts.
- Map shows an emergency care facility within the affected area with predicted slight damage.
- Can be verified later in the field.

E-DECIDER Nepal 2015-05-07 aftershock forecast with overlay of aftershocks >M4 2015-04-25 to 2015-05-12

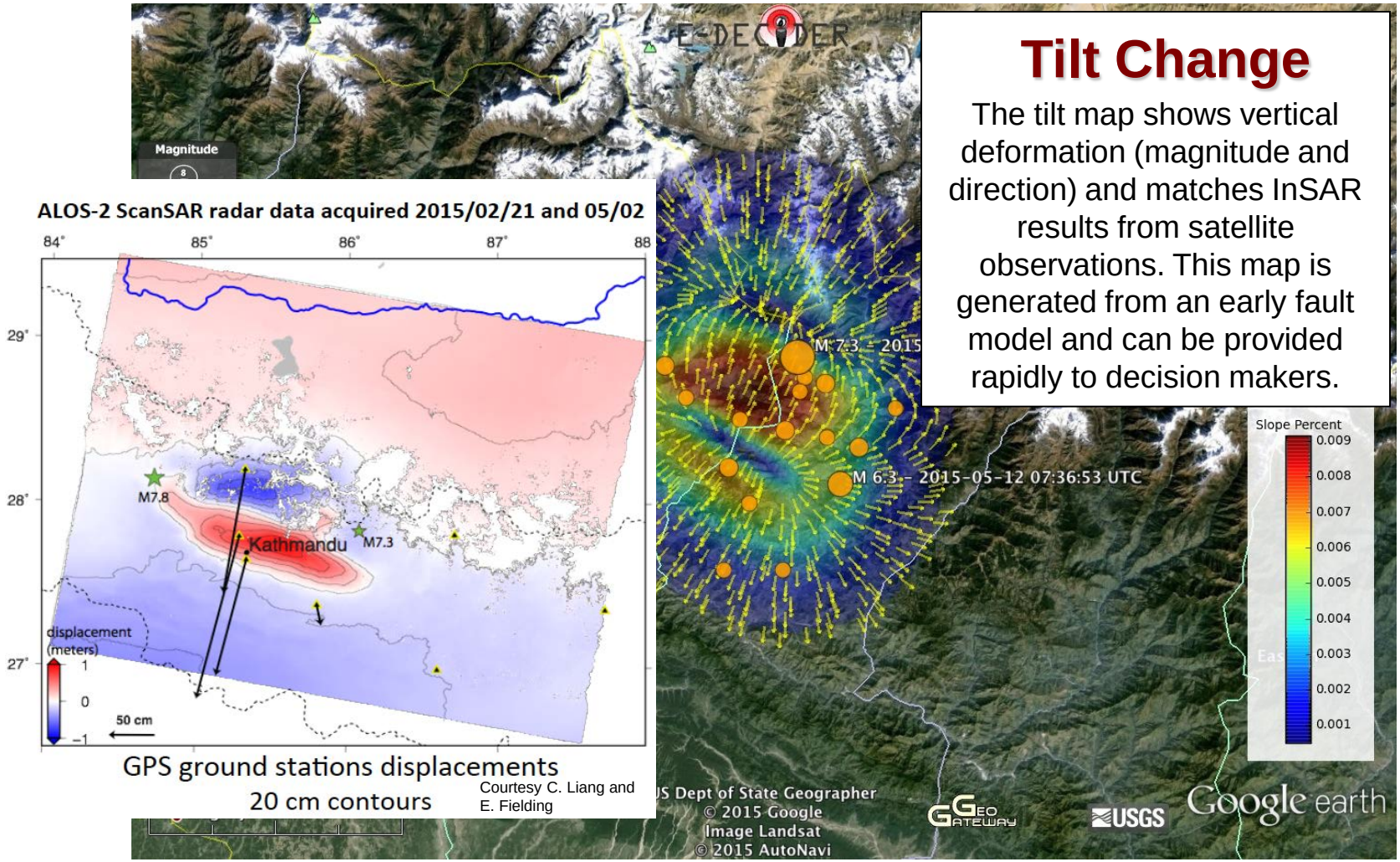
Provided by Mark Yoder, UC Davis



Forecast was generated on 7 May 2015, 5 days before the two large aftershocks east of Kathmandu

Based on Yoder, et al., 2015

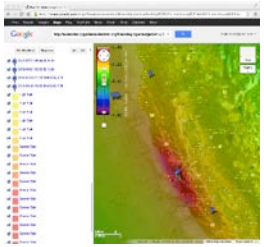
12 May 2015 M 7.2 and M 6.3 Aftershocks Northeast of Kathmandu

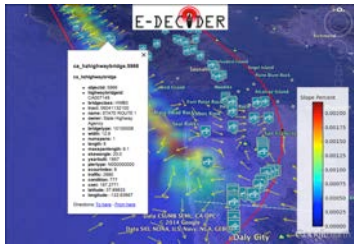


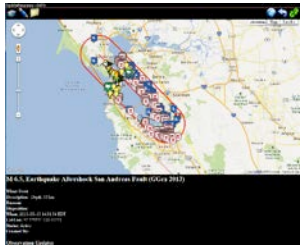
Tilt Change

The tilt map shows vertical deformation (magnitude and direction) and matches InSAR results from satellite observations. This map is generated from an early fault model and can be provided rapidly to decision makers.

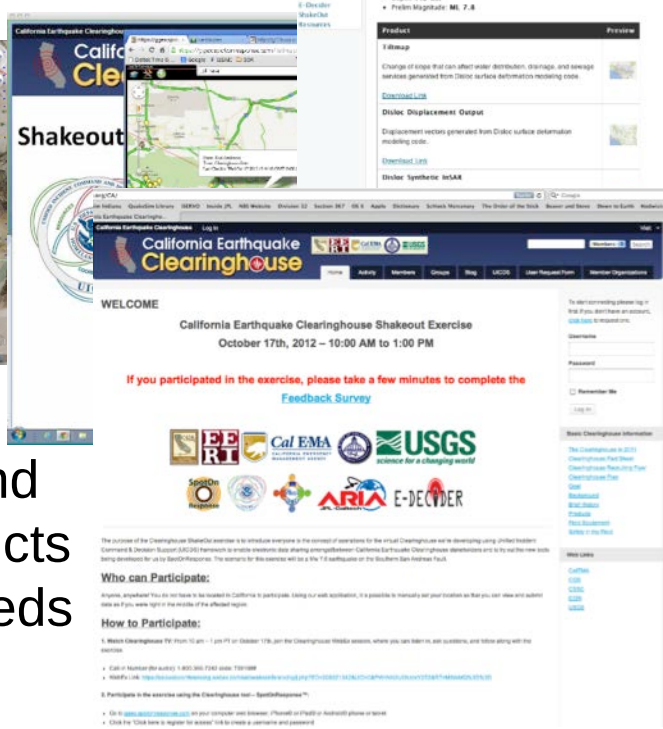
Participation in CA Earthquake Clearinghouse Exercises







- E-DECIDER has been working with the CA Earthquake Clearinghouse since 2011 and has participated in six response exercises, with plans to participate in two more in 2016:
  - Golden Guardian 2012
  - ShakeOut 2012
  - Golden Guardian 2013
  - ShakeOut 2013
  - Cascadia Exercise 2014
  - Capstone Exercise 2015
- Working in partnership with the Clearinghouse has allowed E-DECIDER to demonstrate capabilities and ensure end-user feedback in development of products and technology so that they serve their ultimate needs



Clearinghouse Objectives

- Facilitate field investigations by earth scientists, engineers and social scientists, who converge on the disaster site

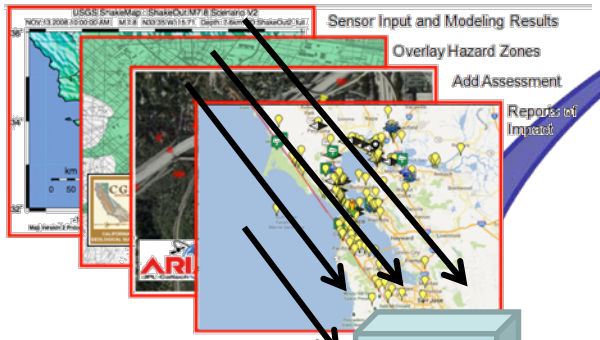
- Assist researchers in accessing perishable data through coordination with emergency management organizations and law enforcement

- Provide a forum for sharing information via meetings at a physical location (field office) and through our new virtual Clearinghouse

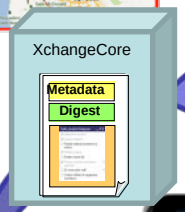
- Track fieldwork progress and minimize duplication of effort; organize data and imagery collected via various technologies and applications and synthesize information for response agencies

- ***Clearinghouse does not direct or control activities of participants***

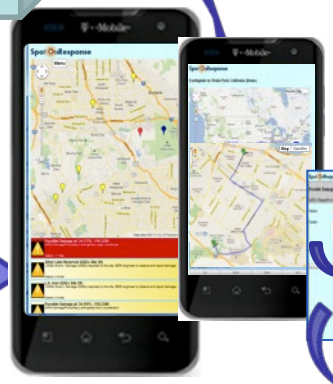
Until Skilled People Observe What Geospatial Information Depicts, There Is No Ground Truth … Or Ability To Inform



1. Geospatial Data Is Accumulated Through XchangeCore from Many Sources



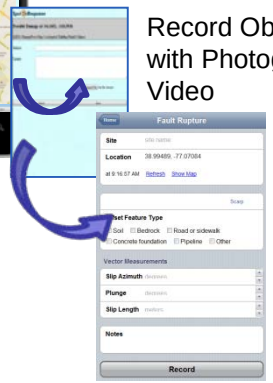
2. XchangeCore Provides All the Data to Responders and Field Observers



App Provides Directions for Scientist, Engineer, and Responders

Red Alert to Possible, Nearby Damage Locations from XchangeCore

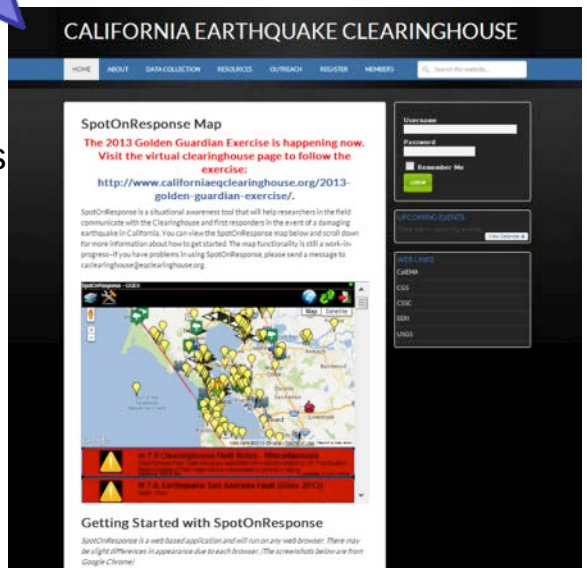
3. Field Observations Enrich the XchangeCore Common Operational Data that is Shared to Operations Managers and Executives



Record Observations with Photographs, Video

Integrate Clearinghouse Field Notes for scientific, engineering, and damage assessment forms of emergency response and recovery

4. Selected Information Becomes Available to any Organization, even the Public, on Geospatial Viewers



The Clearinghouse website is source of continuing updates and fully integrated SpotOnResponse for details of unfolding incidents and important investigation sites

Conclusions

- Disaster response operates on a number of timelines
  - Immediate (crucial first minutes to hours following the event) – rapid results to focus initial response efforts
  - Intermediate (hours to days following the event) – continued response, refining initial results and assessments
  - Longer term (weeks to months) – identify areas where repair of infrastructure needs to be addressed

From Glasscoe, et al., 2015

- Must identify where deformation is greatest and likely damage has or is likely to occur
  - Allows decision makers and responders to focus response efforts
- Format and distribution
  - Standards compliant, georeferenced data products
  - Standards compliant distribution services
- How data is currently represented may not be easily understandable or interpreted by users
  - Must move beyond science products to decision support/response products

References

1. Glasscoe, M.T.**,** Wang, J., Pierce, M.E., Yoder, M.R., Parker, J.W., Burl, M.C., Stough, T.M., Granat. R.A., Donnellan, A., Rundle, J.B., Ma, Y., Bawden, G.W. and Yuen, K., 2015, E-DECIDER: Using Earth Science Data and Modeling Tools to Develop Decision Support for Earthquake Disaster Response, *Pure and Appl. Geophys.*, v. 172, pp. 2305–2324, doi: 10.1007/s00024-014-0824-9.
2. E-DECIDER Napa Event Page. http://e-decider.org/content/napa-earthquake-august-2014
3. NASA's E-DECIDER Rapid Disaster Decision Support Products. http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA18797
4. NASA’s E-DECIDER Platform plays a crucial role in responding to the devastating M7.8 Nepal Earthquake. http://e-decider.org/sites/e-decider.org/files/E-DECIDER_Nepal_Summary.pdf
5. California Earthquake Clearinghouse Ardent Sentry 15(DOD)/ California Capstone 15 (Cal OES)/SoCal Ex 15 (FEMA) After Action Report (2015). http://www.californiaeqclearinghouse.org/wp-content/uploads/2015/07/AAR-IP_Clearinghouse-Capstone-2015.pdf
6. Yoder, M.R., Rundle, J.B. and Glasscoe, M.T., 2015, Near-Field ETAS Constraints and Applications to Seismic Hazard Assessment, *Pure and Appl. Geophys.*, v. 172, pp. 2277-2293, doi: 10.1007/s00024-014-0785-z.

Questions?

Thank you for your kind attention!

Maggi Glasscoe

Margaret.T.Glasscoe@jpl.nasa.gov

http://e-decider.org

http://www.californiaeqclearinghouse.org