National Aeronautics and
Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Disaster Risk Reduction Across the Americas

Discussion Sessions:

Remote Sensing for Geohazards

Instructors:

- Erika Podest, ARSET: Erika.Podest@jpl.nasa.gov
- Tim Stough, ARSET: stough@jpl.nasa.gov

Week 3

Course Structure

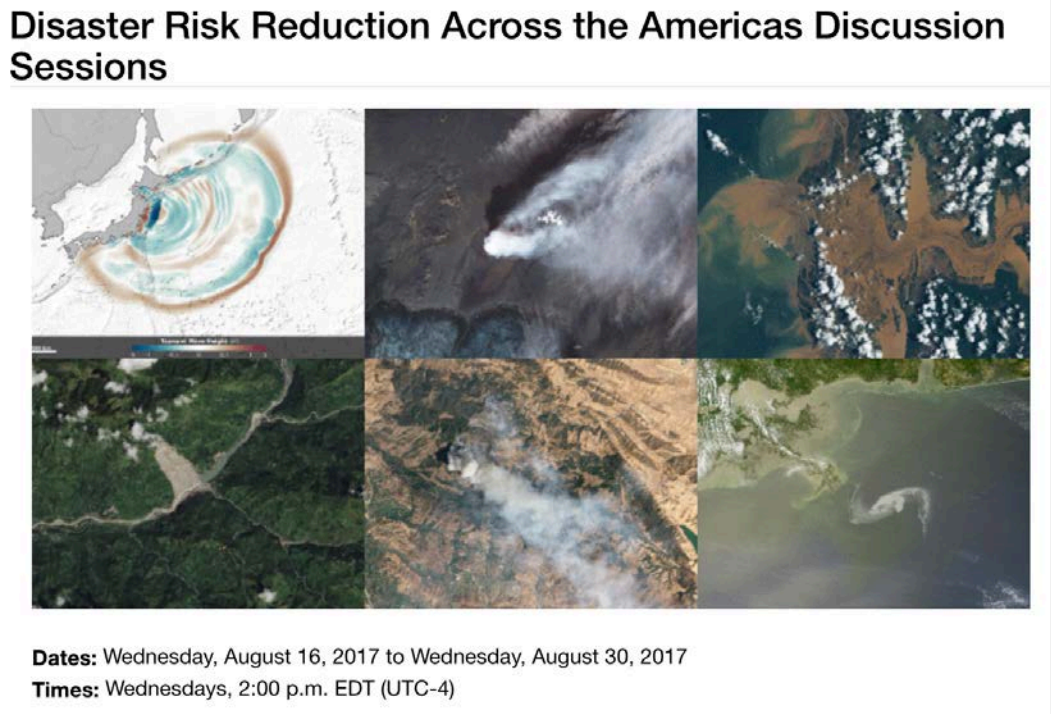
- **One session per week on August 16, 23, 30, 2017**
  – 2 p.m. – 3 p.m. EDT (UTC-4)
- **Each session will include**
  – A Short Introduction (~10 min.)
  – Online Question and Answer (~50 min.)
- **Additional Q&A by email to:**
  – Erika Podest: erika.podest@jpl.nasa.gov
  – Tim Stough: stough@jpl.nasa.gov
  – Amita Mehta: amita.v.mehta@nasa.gov

Course Material

https://arset.gsfc.nasa.gov/disasters/webinars/dpraas-17

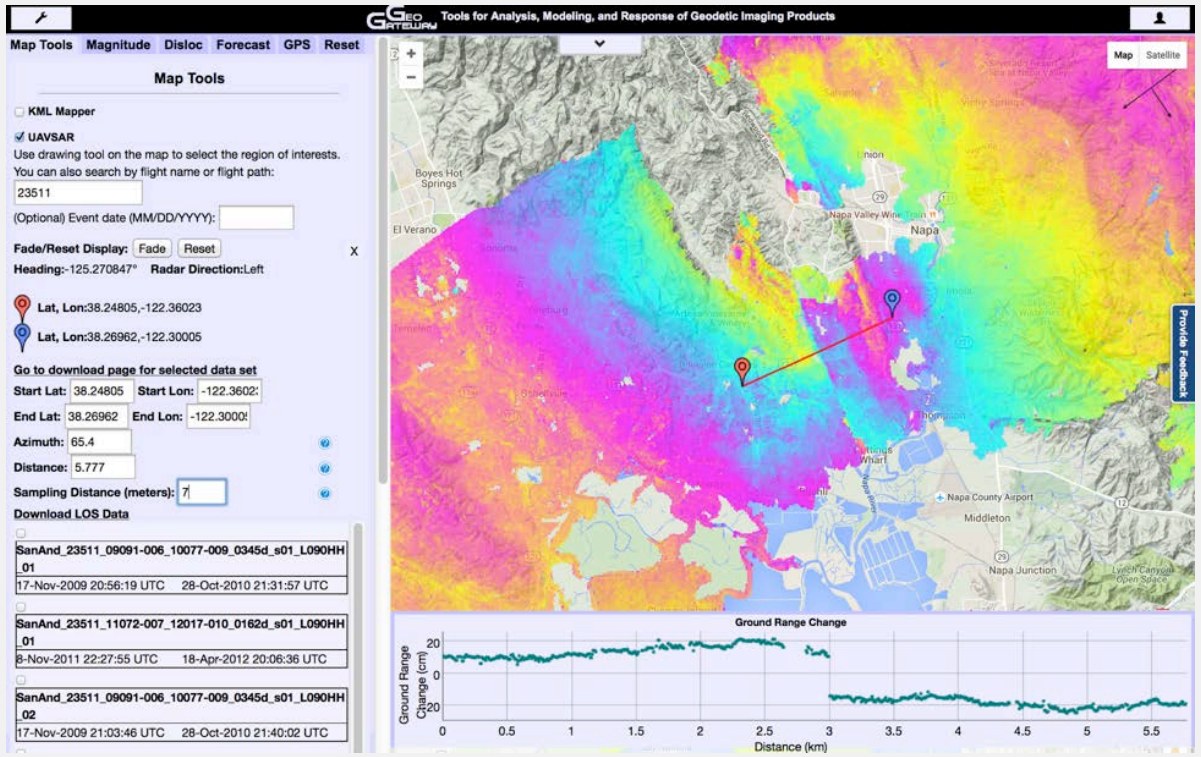
Prerequisite webinar presentations, and recordings

Links will be available on the ARSET course page



Course Objectives

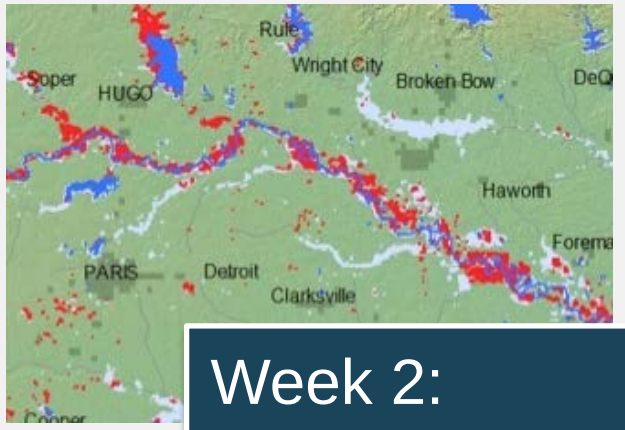
- Participants will become aware of available NASA resources for disaster management via the prerequisites
- Participants will be able to address questions to NASA ARSET and disaster program personnel
- Keep in mind that you are **expected to review the prerequisite webinars**. If you have not, you may not have sufficient background to follow the discussion



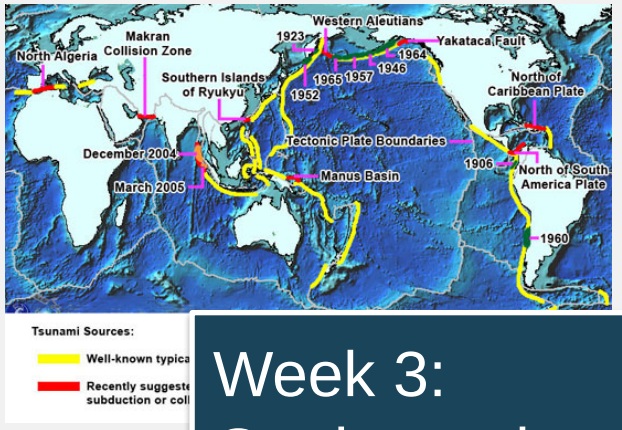
GeoGateway interface showing Napa earthquake interferogram with Line of Sight profile across the main rupture.

Course Outline

Week 1: General Disaster Management Discussion



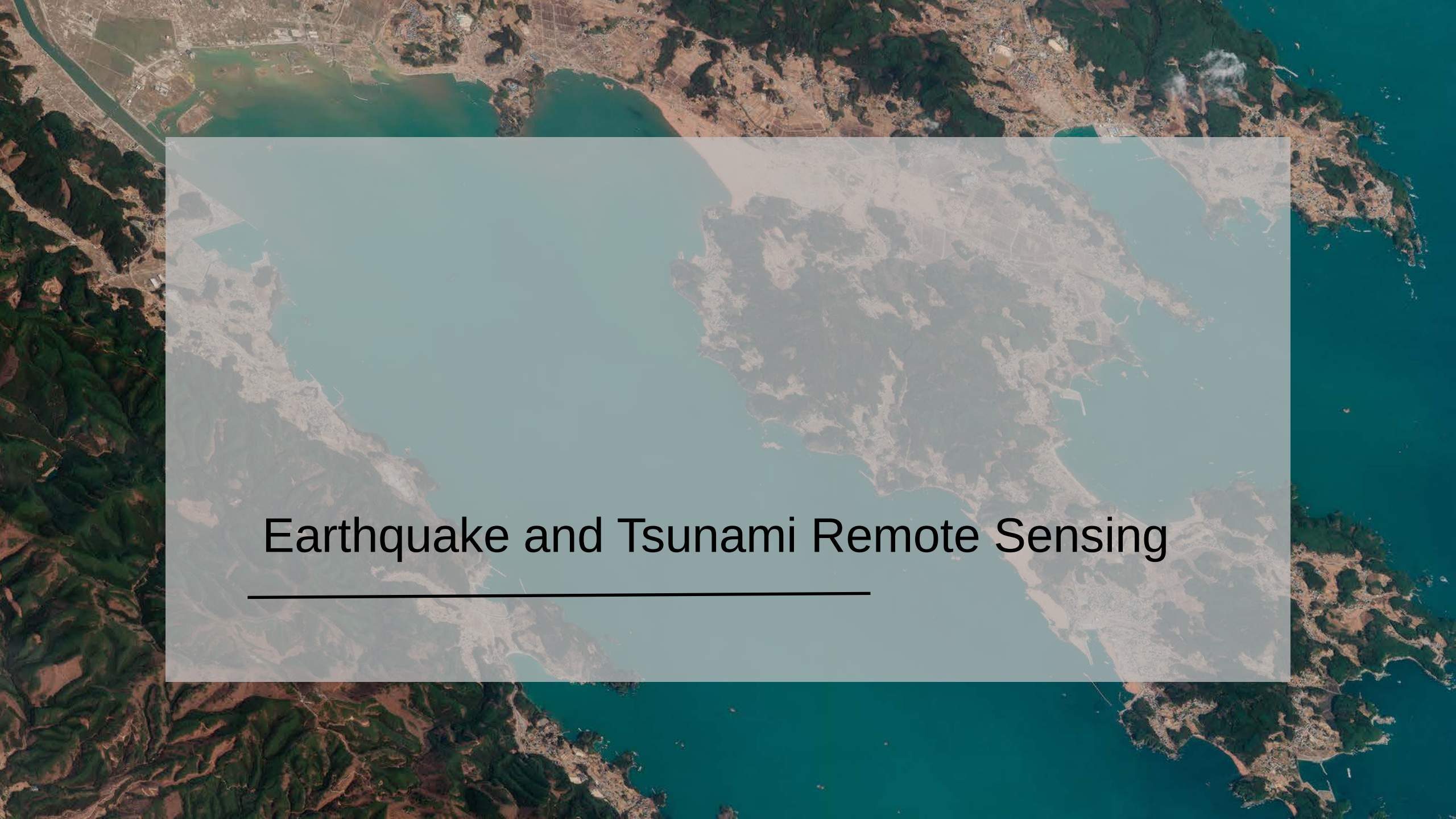
Week 2: Hydrometeoro-logical Disasters (Flooding, Tropical Storms) Discussion



Week 3: Geohazards (Earthquakes, Landslides, Tsunamis) Discussion

Outline

- A Few Highlights from the Prerequisites
  - Earthquakes and Tsunamis
  - Volcano
  - Landslides
- Question and Answer Format
- Your Questions

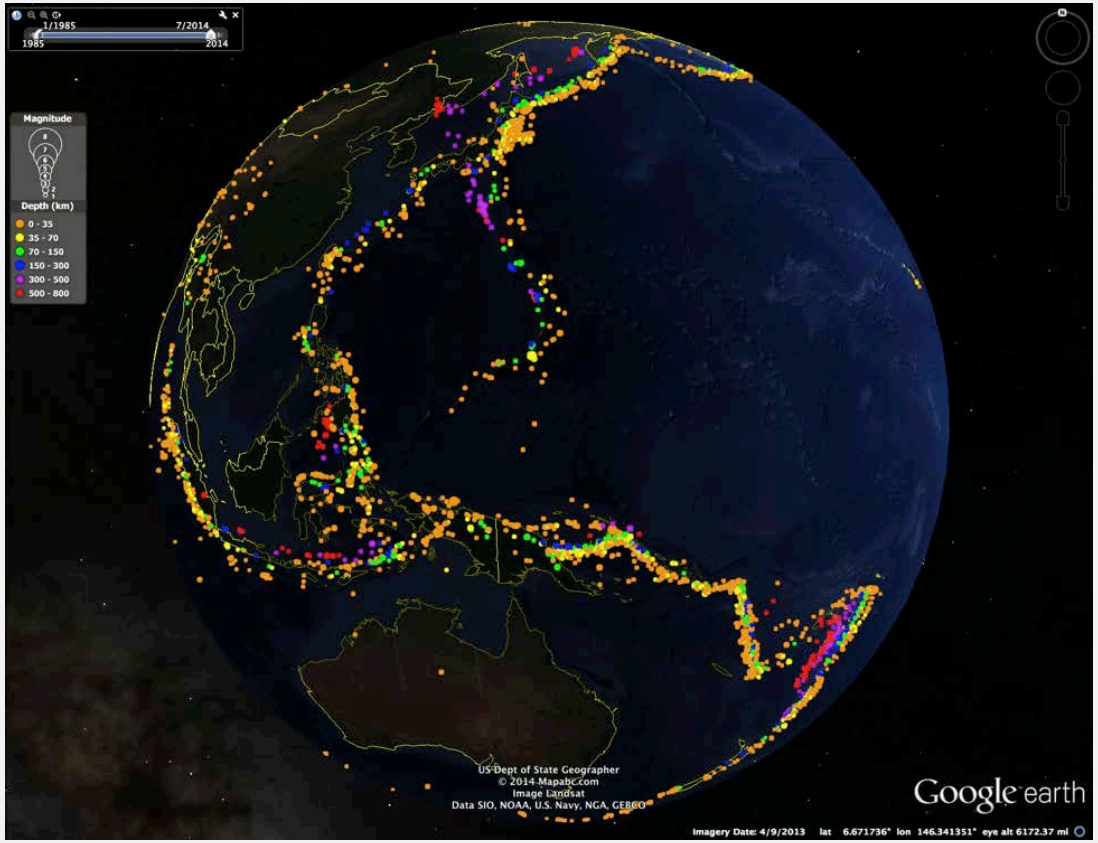


Earthquake and Tsunami Remote Sensing

Introduction

Earthquake Risk

- Annualized losses from earthquakes in the United States are $5.3B (FEMA, 2008)
- From 2000 – 2009, earthquakes killed more people globally than other natural disasters (OFDA/CRED 2009)
- From 1980 – 2009 6 of the 7 natural disasters with the largest economic impact were earthquakes (OFDA/CRED, 2009)
- In the 21st century earthquakes are expected to kill 1.9 – 3.2 million people globally (Holzer and Savage, 2013)



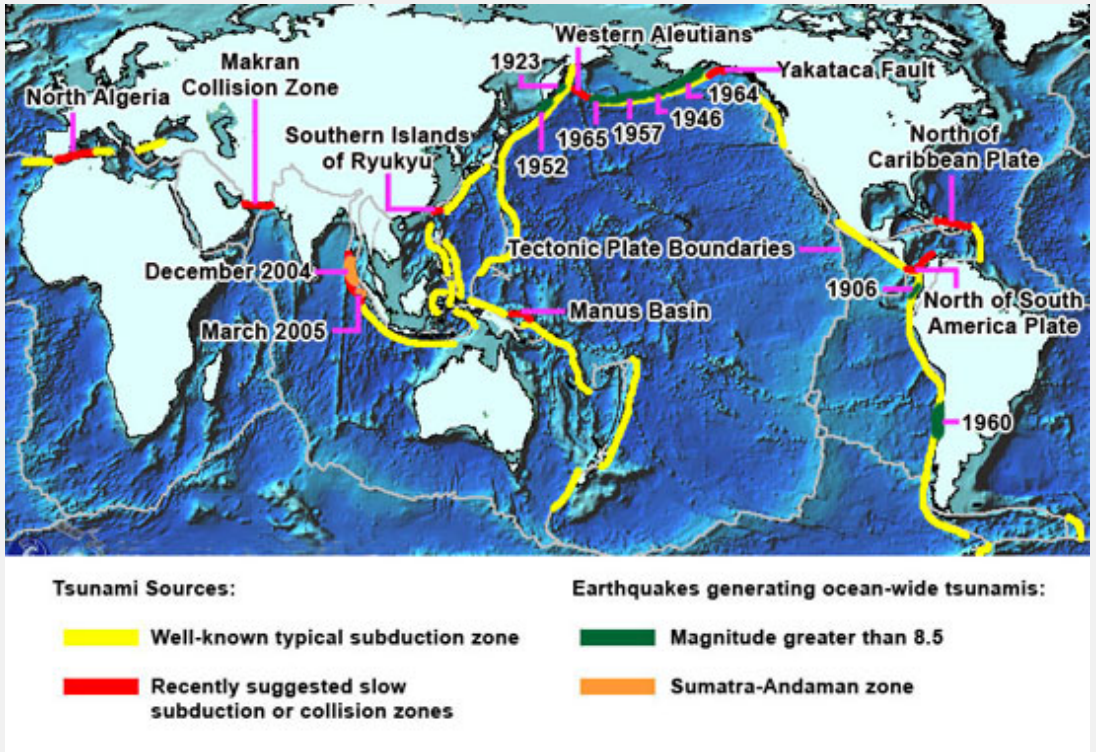
Damaging earthquakes are concentrated near coastal areas. Here two decades of potentially damaging earthquakes are displayed over East Asia and the Pacific, colored by depth. (Data are from the Advanced National Seismic System, Glasscoe, et al. 2016, Decadal Survey White Paper #2).

Introduction

Tsunami Risk

- 2004 Indian Ocean Tsunami
  - Reached heights of 65-100 ft in Sumatra
  - Caused 200,000+ deaths across 11 countries
  - Registered on tide gauges globally
- 1964 Alaska Tsunami
  - Resulted in 110 deaths
- 1918 Earthquake & Tsunami
  - Killed 118 people in Puerto Rico alone
- 1700 Pacific Tsunami
  - Overran Native American fishing camps
  - Caused damage in Japan

(USGS fact sheet, 2006-3023)

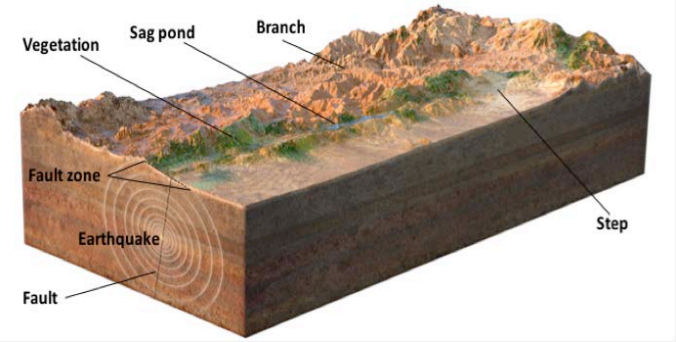


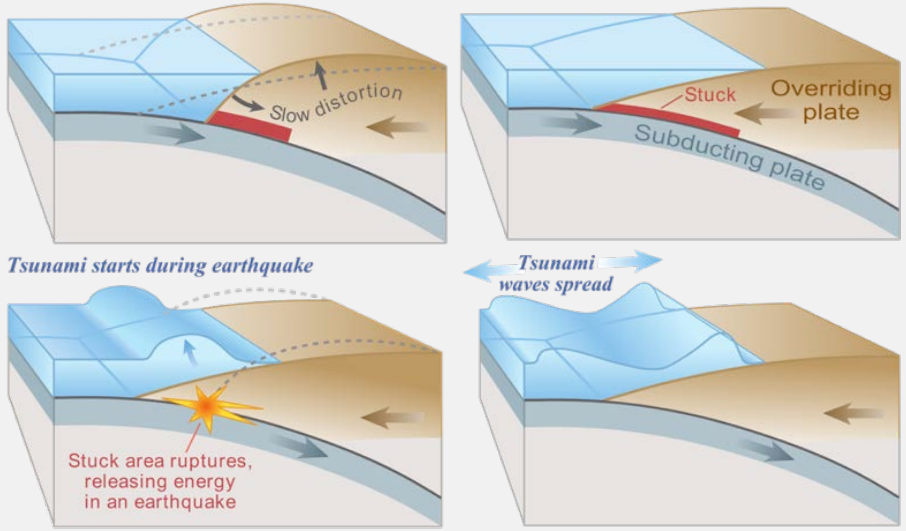
Global tsunami source zones highlighted by color.
Source: ITIC, http://itic.ioc-unesco.org/index.php?option=com_content&view=category&id=1166&Itemid=1166

Introduction

Earthquake and Tsunami Mechanism

- Faults are made up of a central core surrounded by a damage zone
- Earthquakes occur when stress builds on the fault lines and then it falls
- Ground shaking and displacement
  - lead to injury & loss of life
  - cause damage to infrastructure, homes, and injury
- Tsunamis occur when the seafloor is displaced by an underwater earthquake or landslide
  - generates waves that grow when they reach shore



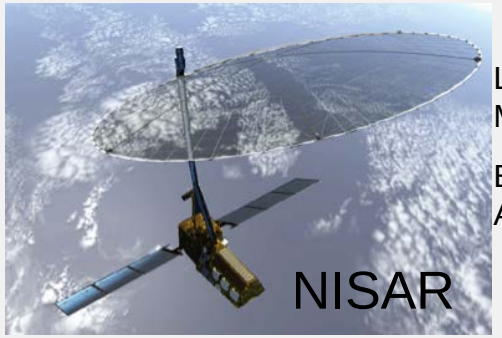


(Top): Artwork Chuck Carter, JPL; Donnellan, et al., Decadal Survey White Paper #2. (Bottom) Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan, USGS

Synthetic Aperture Radar

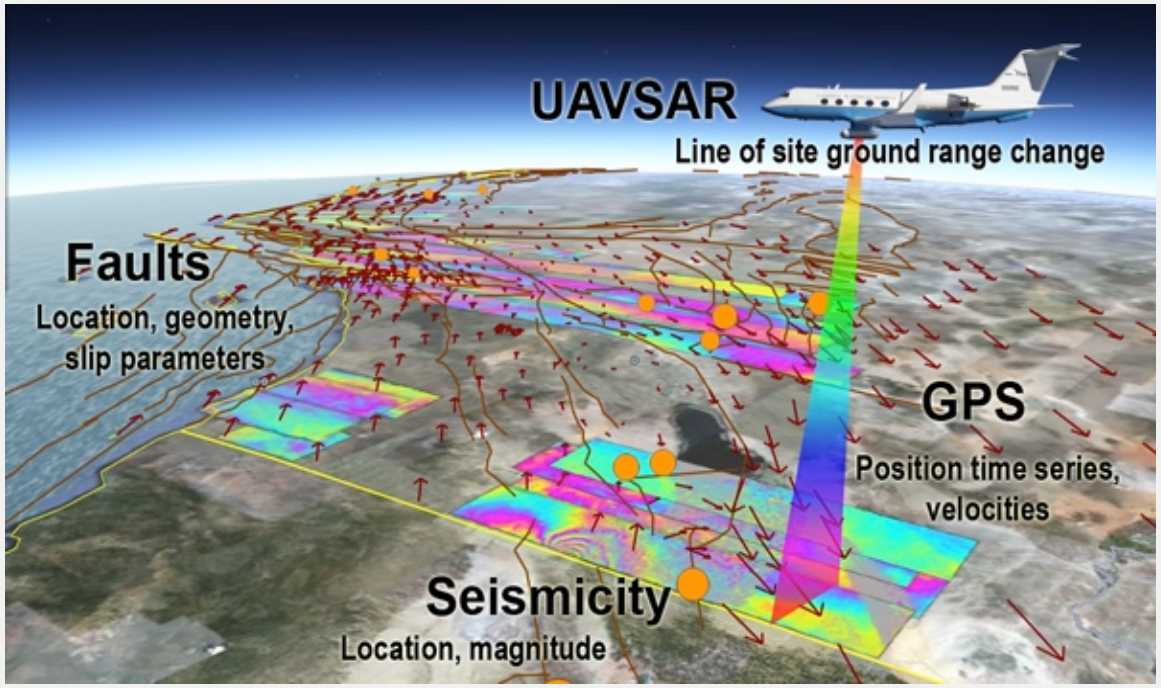
http://uavsar.jpl.nasa.gov; http://nisar.jpl.nasa.gov

- Radar is very useful for studying Earth processes
- Repeat visit allows creation of a landscape change image
- High definition:
  - 7 m pixel size (UAVSAR)
  - 10 m pixel size (Satellite)
- Sensitive: sees 1 cm surface fault slip
- NASA instruments:
  - UAVSAR airborne
  - Planned NISAR satellite



Left: satellite for the NASA-ISRO SAR Mission (NISAR)

Below: Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)



GPS Modeling of Tsunami Wave Heights

http://www.gdgps.net/; http://cddis.gsfc.nasa.gov/Techniques/GNSS/GNSS_Overview.html

- GPS – using Global Navigation System Satellites (GNSS) – can estimate tsunami potential
- Can be used to:
  - detect severity and direction after an earthquake
  - estimate tsunami wave heights within minutes
- Figure on right uses 3 historic earthquakes to predict resulting tsunamis
- Pink arrows are GPS displacement measurements

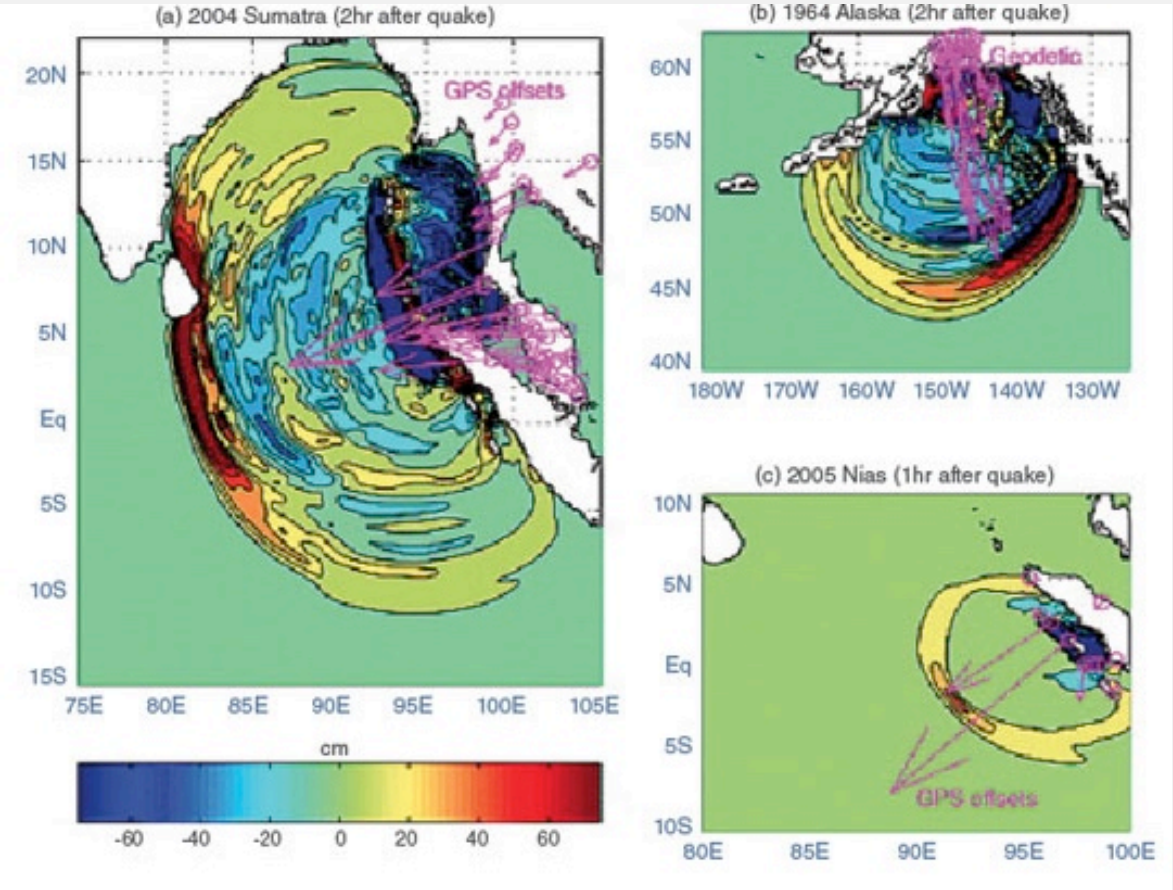


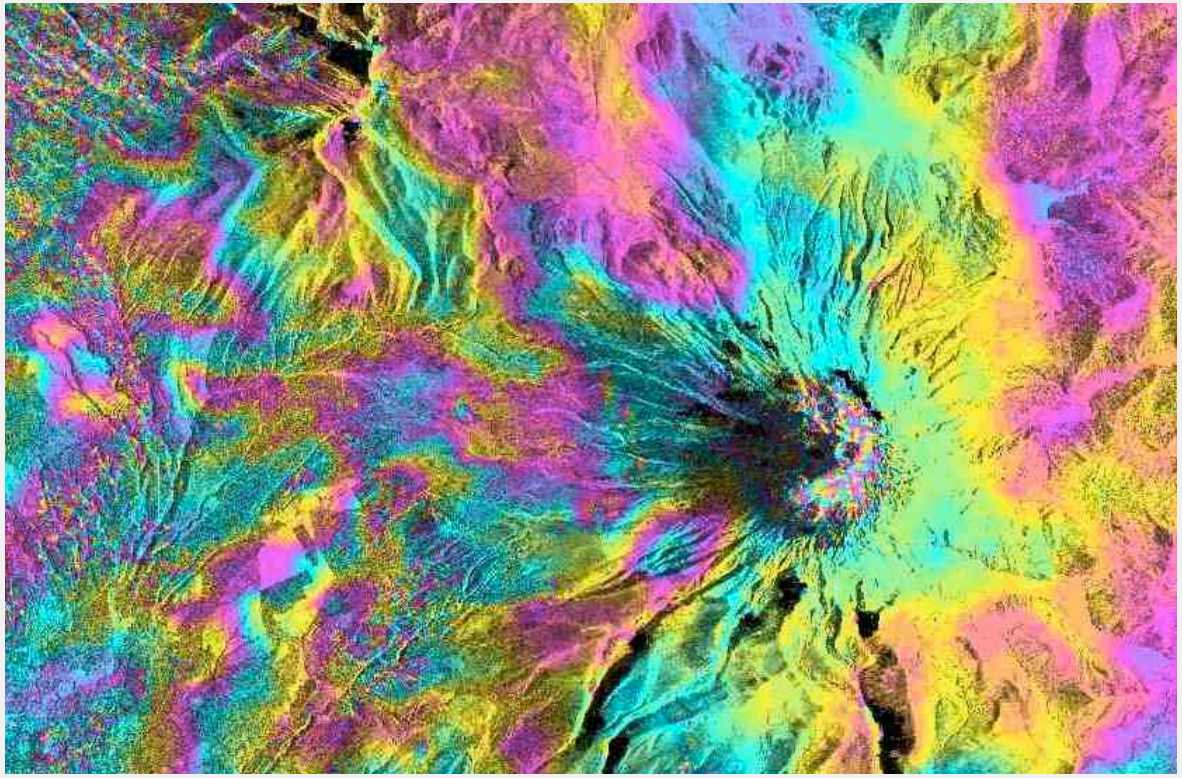
Image courtesy of T. Song, 2007, *Geophysical Research Letters*

Remote Sensing for Monitoring Volcanoes

Pre-Eruption Modeling

- Deformation
  - Interferometric Synthetic Aperture Radar (InSAR)
  - Global Navigation Satellite System stations (GNSS, GPS, GLONASS)
  - Tilt meters
- Seismic Activity

Cotopaxi Volcano 2015

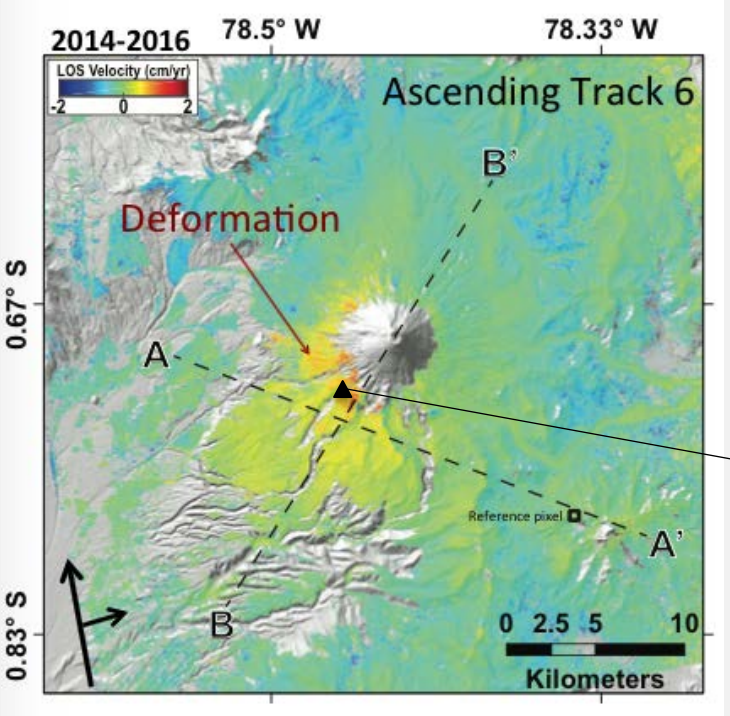


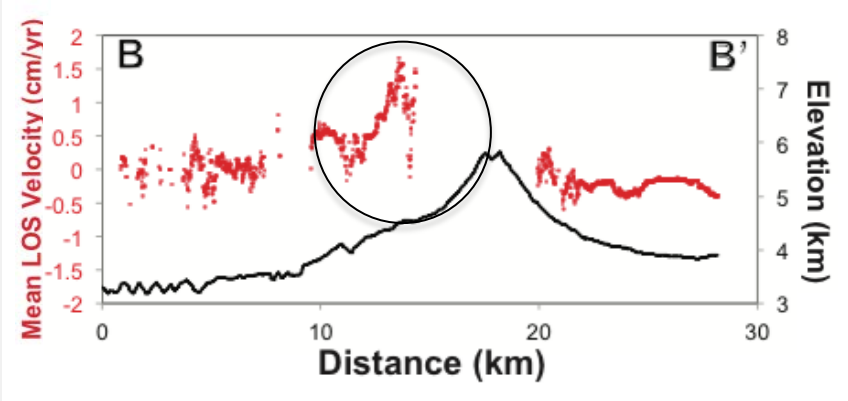
Cosmo-SkyMed InSAR – processed by Dr. Falk Amelung, University of Miami

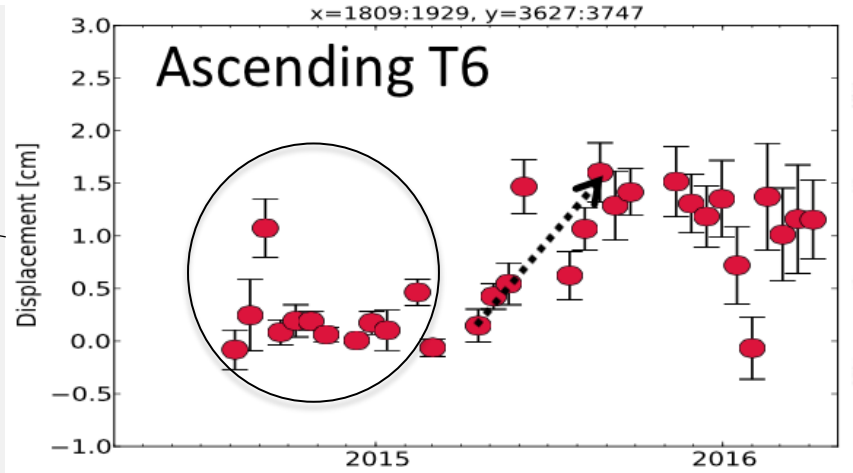
Cotopaxi Unrest and Steam Eruption, August, 2015

Analysis by Dr. Falk Amelung, University of Miami

InSAR based analysis allows inflation to be monitored without ground based sensors



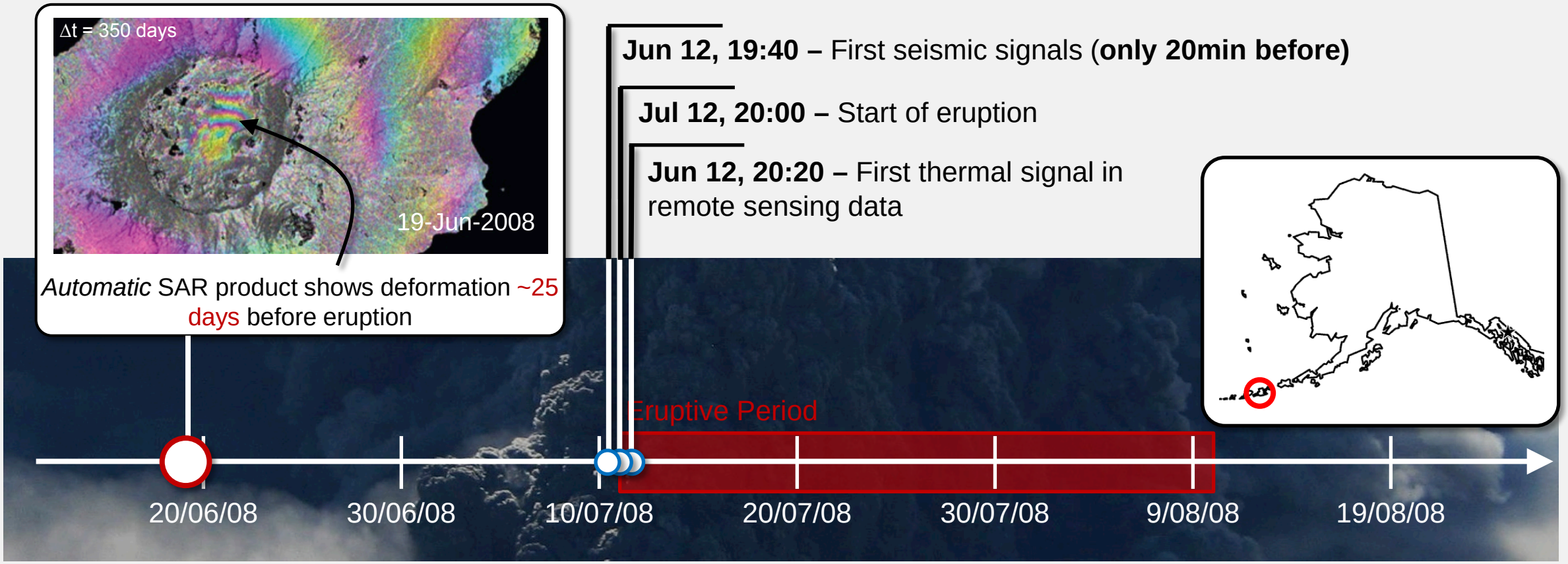




SAR-VIEWS: SAR Volcano Integrated Early Warning System

University of Alaska Fairbanks, Dr. Franz Meyer

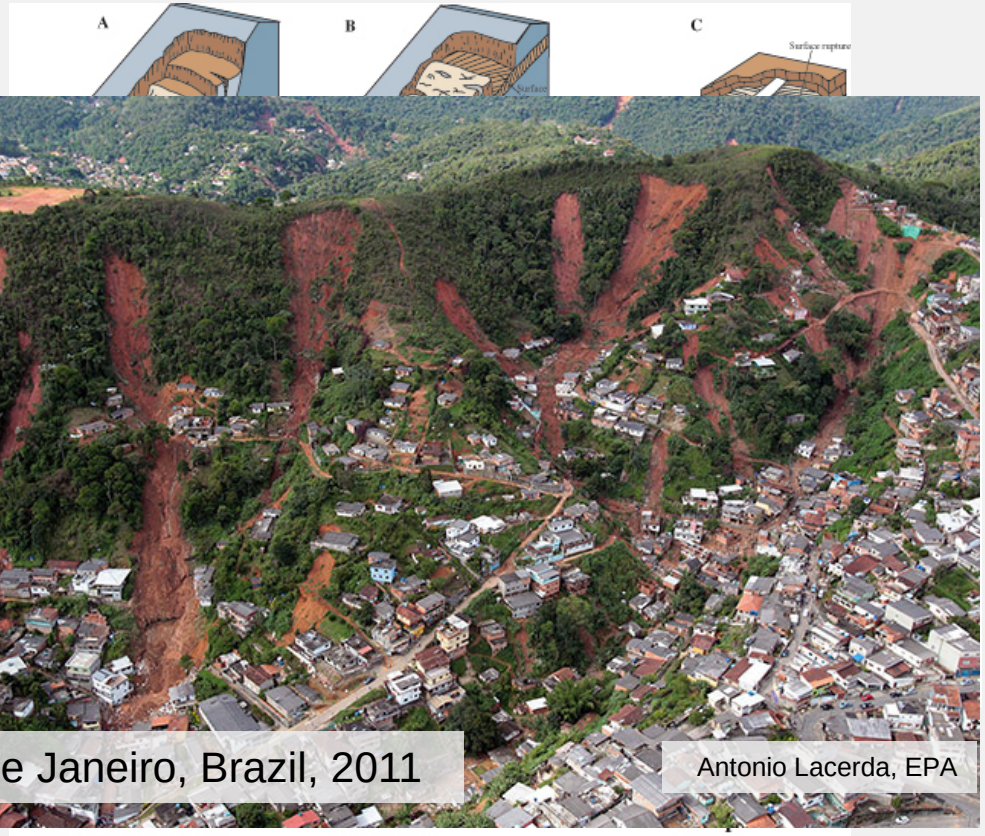
Okmok Eruption, July 2008



Remote Sensing for Landslide Monitoring

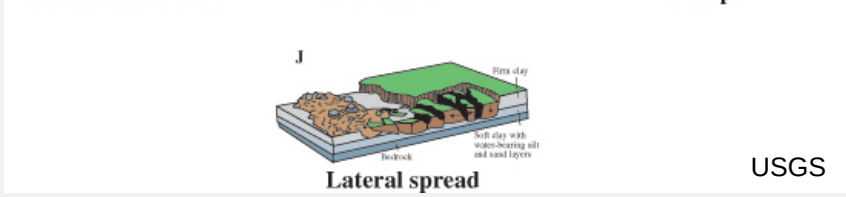
Why monitor landslides?

1. They are important geomorphologically
   - Movement of a mass of rock, debris, earth, or soil down a hill
2. They are pervasive
   - Triggered in nearly every country in the world and state in the U.S.
3. They impact people
   - Landslides have killed over 26,000 people worldwide since 2007 (~3,700/year) and impacted millions



Rio de Janeiro, Brazil, 2011

Antonio Lacerda, EPA



USGS

Landsat 8 Images of Earthquake-Induced Ground Failure

http://landsat.gsfc.nasa.gov/

- First obtained April 30
- Acquired first (mostly) cloud-free image of Langtang Valley
- Scientists analyzed imagery and compared with pre-earthquake imagery
- Part of Langtang village was completely buried
  - Eastern part appears to have been destroyed by pressure wave from related avalanche
- Large landslides or avalanches affected other villages
- Extent of damage will require further investigation using higher-res imagery

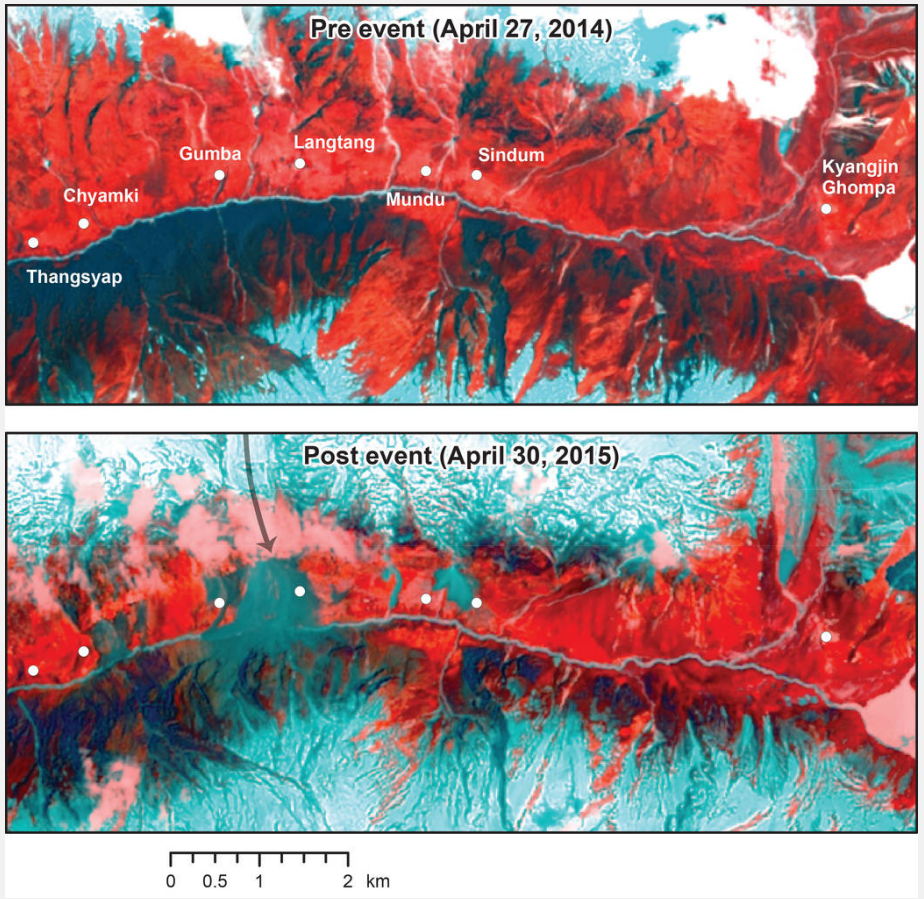


Image Credit: USGS/NASA

Question & Answer Format

Question and Answer Flow and Format

- Enter your question into the webinar interface
- NASA disaster applications professionals will select questions and type them on the whiteboard
- A short verbal answer will be given for the selected question
- Follow-up questions may be taken
- If a question is answered by an English speaker, we will try to provide a written translation into Spanish
- Please be patient, we will address as many questions as possible during the sessions

Your Questions, Please!