Disaster Mitigation
How to live with natural hazards?
Satellite Applications

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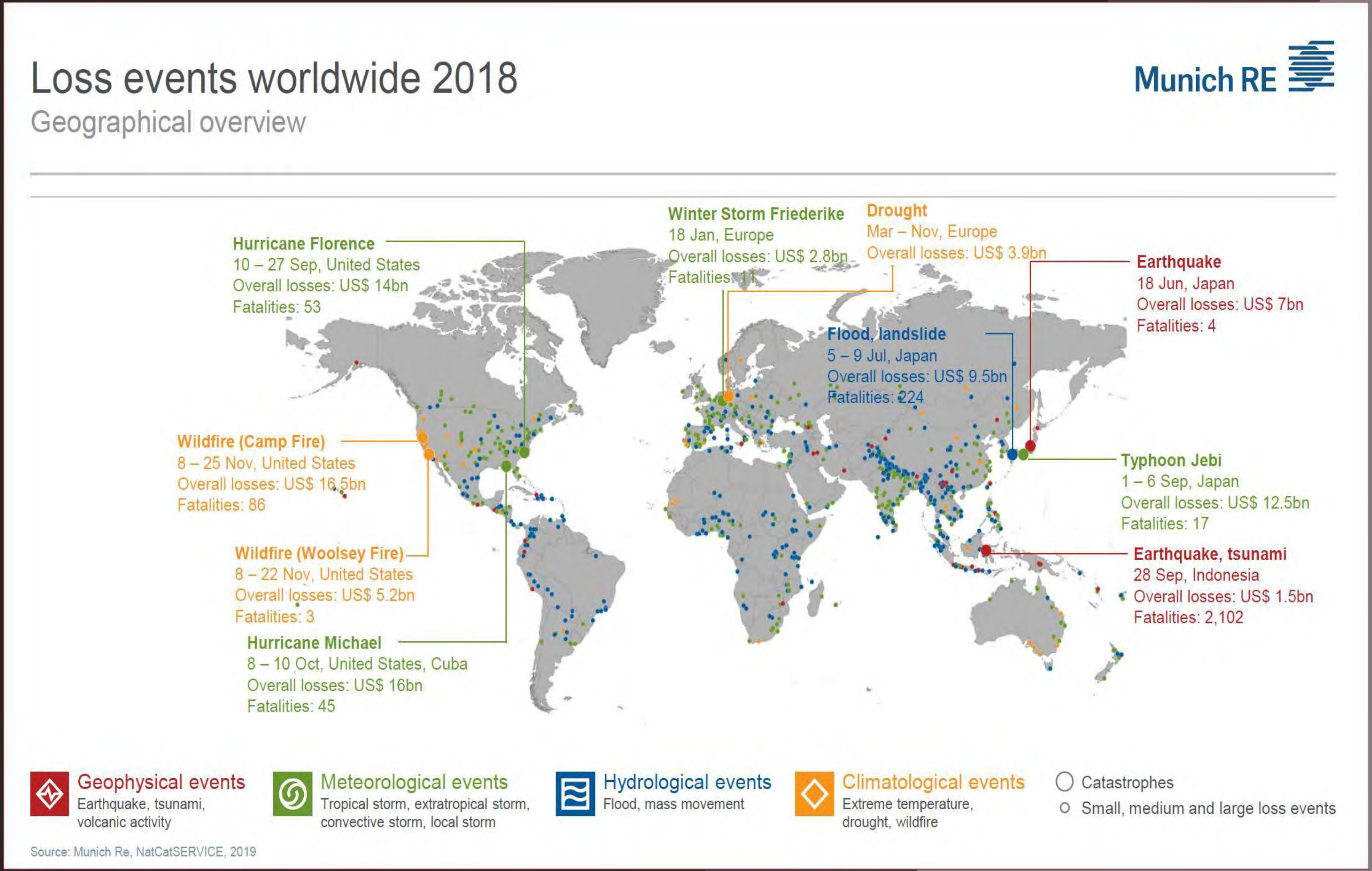
Outcomes

-*Background -Satellite Applications, Case Studies, Research Gaps.*

What will you learn: EO applications for Disaster Mitigation

Question? What sensors and techniques can be applied for different types of disasters?

Global Disasters



Space-based information for disaster-risk reduction

- (United Nations/Germany Expert Meeting on Space based Information, Bonn 2014)
- www.un-spider.org/expertmeeting2014.

- KEY MESSAGES – Can be applied today
- Satellite-derived information is essential for disaster-risk reduction and disaster management. The high temporal resolution and the increasing spatial resolution make it an indispensable source of information to replace or complement local measurements or assessments.

- With geospatial and space-based information we can detect, map, monitor and
- visualize indicators relevant to risk analysis on local and global scale.

- With geospatial and space-based information we can map the uneven distribution of risk across national borders in an objective way.

- Using space-based information, we can access time series data from the 1960s to date even in areas where no statistical data or ground-based measurements are available.

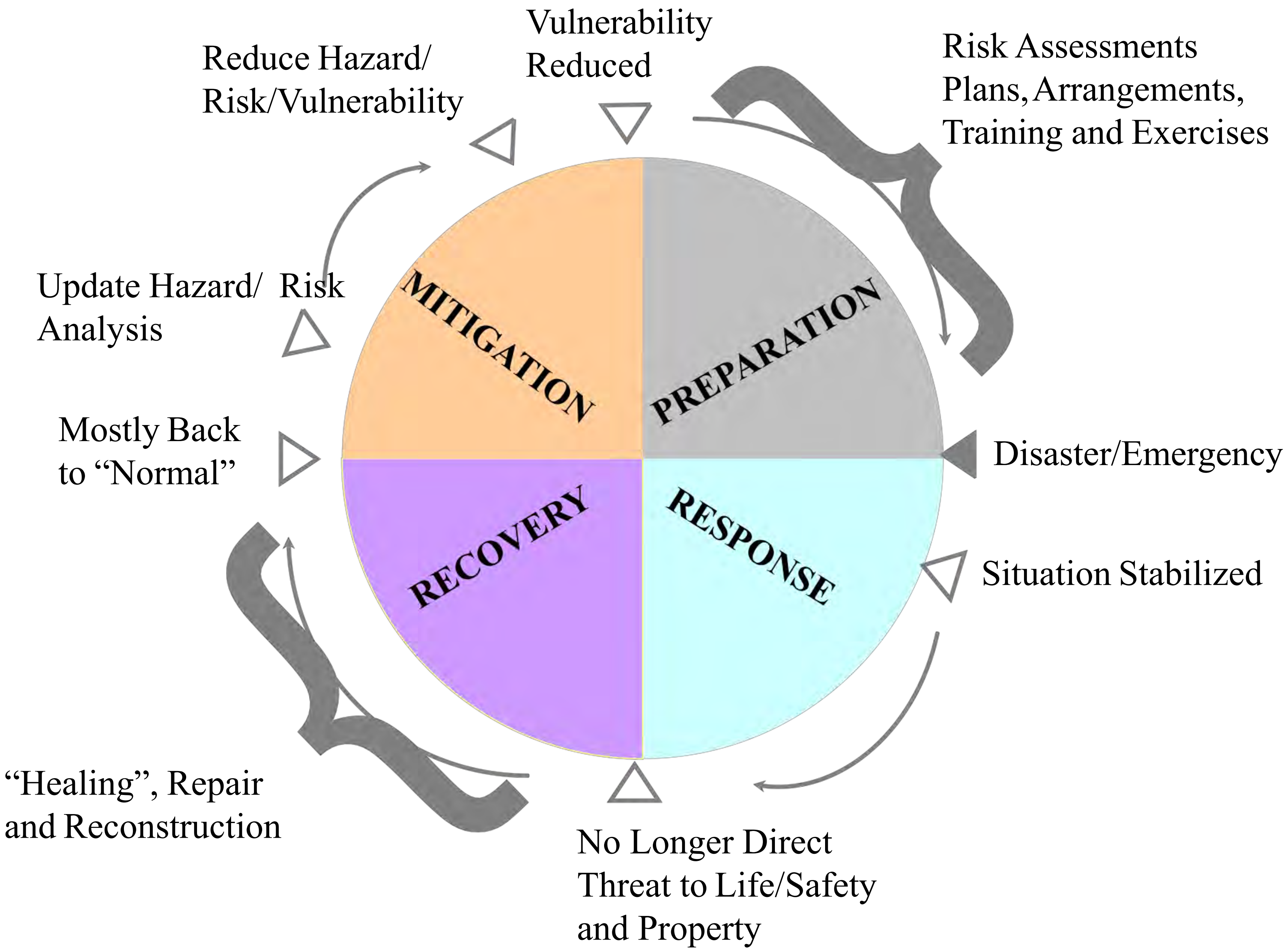
- Satellite data and related products aiming at improved decision-support have improved immensely over the last ten years. They have matured to become a key source of information for risk assessment and the sustainability of human interventions.

Disaster Definition

- "A disaster involves 10 deaths, and/or 100 people affected, and/or an appeal for outside assistance"
- When? Rapid response
- What? Information on…
    - availability and movement of relief supplies
    - local infrastructure: hospitals, ports, airfields, roads
    - population displacement
    - mapping and other geographic information

    - More than 250 million people each year are affected by natural disasters. The annual number of natural disasters has more than doubled recently because of climate change, population increase and rapid urbanization and geophysical processes.

Emergency Management "Cycle"



Disaster Management- Background

- The International Federation of Red Cross estimates that the annual global economic costs related to disaster events average over $440 billion (U.S) per year.
- The UN report that climate change is the cause of some 250,000 deaths each year across the globe, with tropical environments and poor countries being most susceptible.
- The US alone experience losses of over $1 billion a week over the past 3 years due to natural hazards.
- Over 75% of emergency response capacity concentrated in 7 or 8 organizations (NGO)
  - – Oxfam, CARE, Médécins Sans Frontières, Red Cross, Action by Churches Together (ACT)
- EO satellites provide an important source of information for studies of the earth system

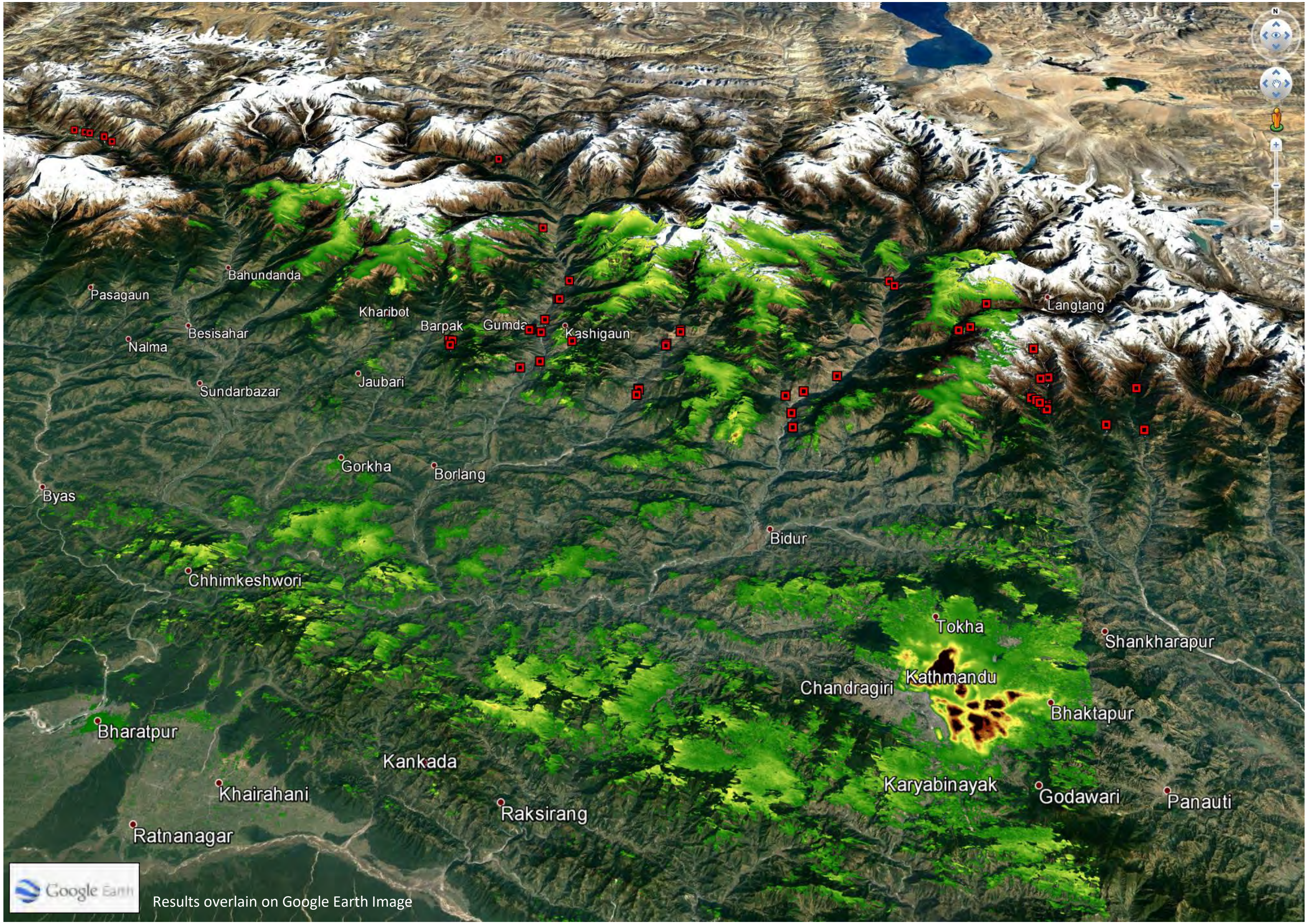
Disaster Management- Applications: Drought

- Drought is the most damaging of all the natural hazards- huge economic loss, food shortages, starvation, destruction of ecological resources
- For example, in east Africa, about 18 million people are extremely food insecure due to below-normal rains, poor crop and pasture production.
- Drought mitigation involves - prediction, monitoring, early warning, impacts, response
- NOAA/AVHRR data will continue to be the main sensor. The Normalized Difference Vegetation Index (NDVI) is used to estimate vegetation health.
- In most climates, vegetation growth is limited by water so the relative density of
- vegetation is a good indicator of agricultural drought.
- Provides measurements on : Land and sea surface temp, cloud cover, snow and ice cover, soil moisture and vegetation indices, volcanic monitoring
- NOAA Spatial res: 1.1km (.58-.68um,.72-1.1um,3.5-3.9um-SWIR, TIR- 10.3-
- 11.3um, 11.4-12.4um.
- Landsat, SPOT,IRS, RADARSAT, Sentinel ALOS, and all high-res satellites

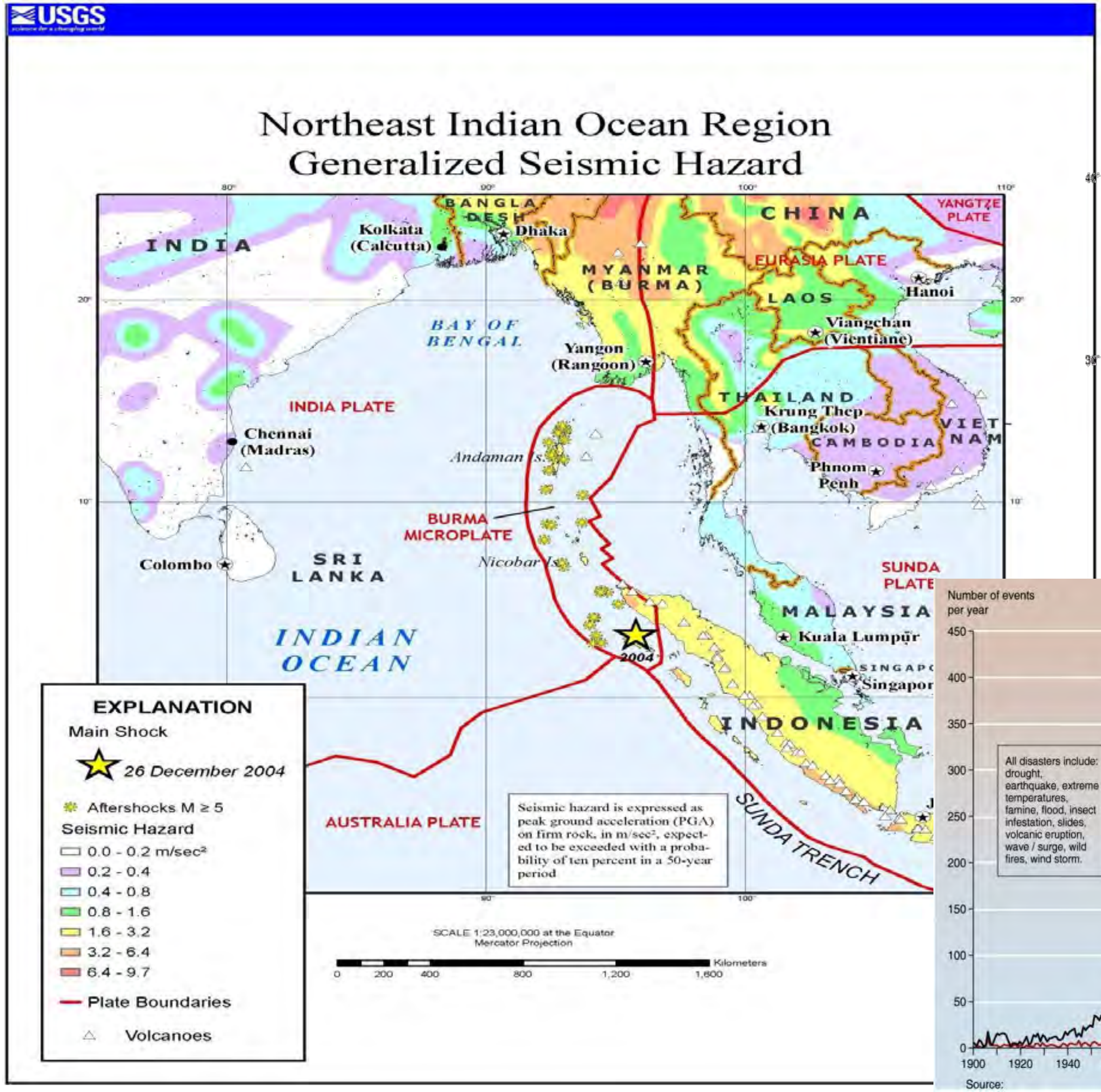
Disaster Management- Earthquakes

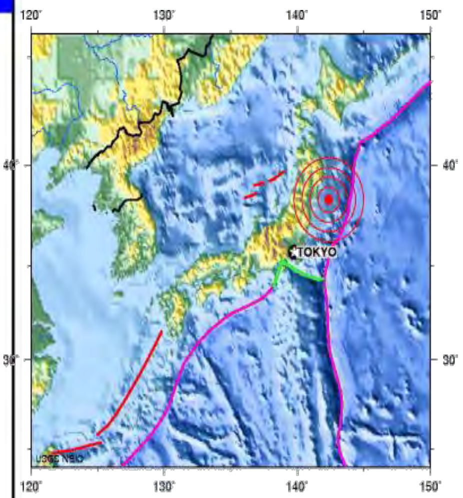
- The availability of 1 or 2 meter spatial resolution improves earthquake damage assessment- damage to buildings and infrastructure. e.g. All high-res satellites: Digital Globe Cartosat, SPOT etc.
- Damage info is required within hours of earthquake- Timeliness and accuracy
- Mitigation from satellite images-

  Structural-tectonic mapping in relation to seismicity
- SAR interferometric techniques are being used increasingly (co seismic motion).



Results overlain on Google Earth Image

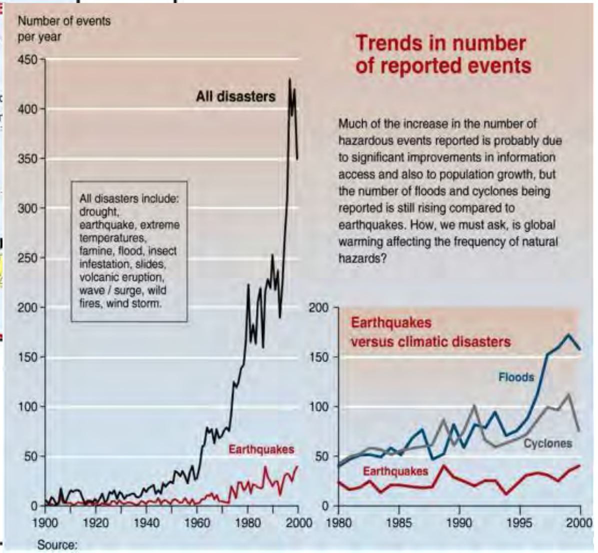




NEAR EAST COAST OF HONSHU, JAPAN

2011 03 11 05:46:23 UTC 38.32N 142.36E Depth: 24.4 km

Earthquake Location



Banda Ache June 23/04- Dec 28/04 Quickbird 1m Damage Assessment: High-Res Optical

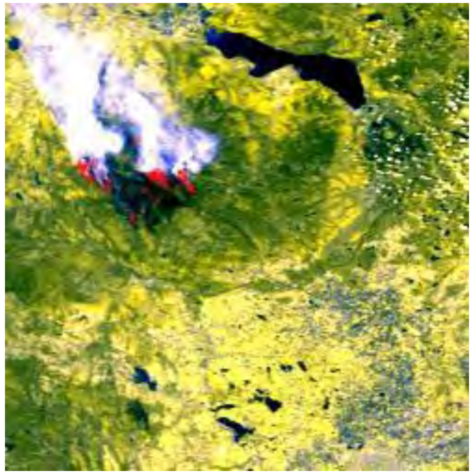
Disaster Management: Fire

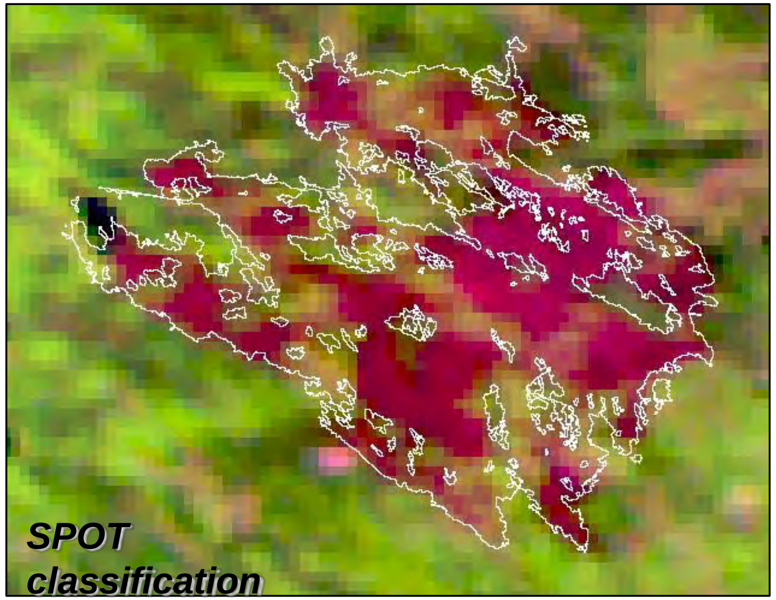
- Most fires- on natural forest, brush and grassland ecosystems- are caused by human activities and natural causes -volcanoes, lightning
- Requirement for satellite data : Assessment of fire potential, (dry biomass); location and direction; behavior/spreading; damage assessment and recovery.
- Develop technologies and method to generate global accurate updatable fire fuel maps.
- Develop mesoscale weather models for daily prediction
- Existing satellite fire detection sensors-NOAA GOES, NOAA- AVHRR and DMSP-OLS Defense Meteorological Satellite Program- visible /IR (DMSP)

Satellite Fire Monitoring: Applications

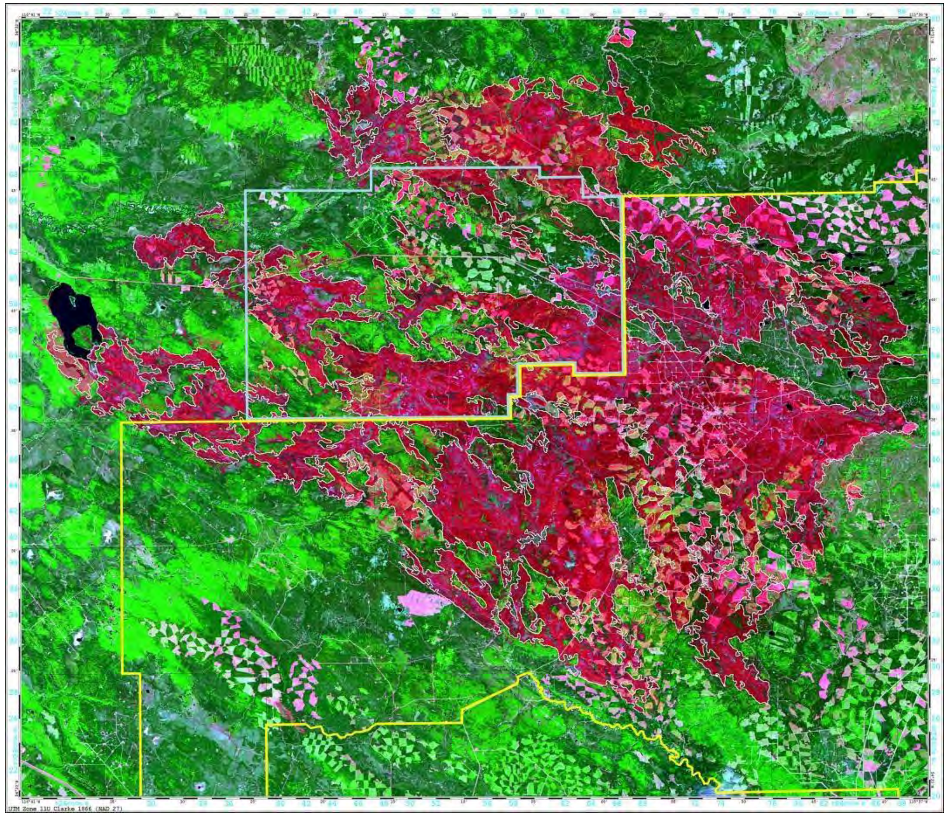
- Automated Monitoring and Mapping of Wildland Fires
- Large Scale Fire Mapping & Verification
- Fire Behavior and Modeling (GIS Integration)
- Systems Integration, Products & Services
- Monitoring of fire hot spots using AVHRR
- Investigation of high res optical and SAR for area burned mapping
- Development of fire area mapping methodology
- Validation of fire area maps
- Detection and mapping of smoke from fires

Forest Fire Monitoring and Mapping (CCRS)





SPOT classification



Landsat 5 TM classification of Virginia Hills Fire. Alberta, Canada

$1b Damage- Slave Lake Canada

Fire Damage Buildings : Fort McMurray Forest Fire, Canada (3-5-16)
Source: Pleiades-1A (May 6th 2016)
NRCan

Disaster Management- Applications: Floods

- Types- River floods, coastal floods, flash flood (Ice jams)
- Sensors used: SAR and optical- high-res IRS data are very useful
- Detail mapping -hazard assessment-flood plain maps, hydrological and land use maps.
- Regional mapping- general flood situation within the watershed or coastal zone.- mapping flooded areas at regional level.

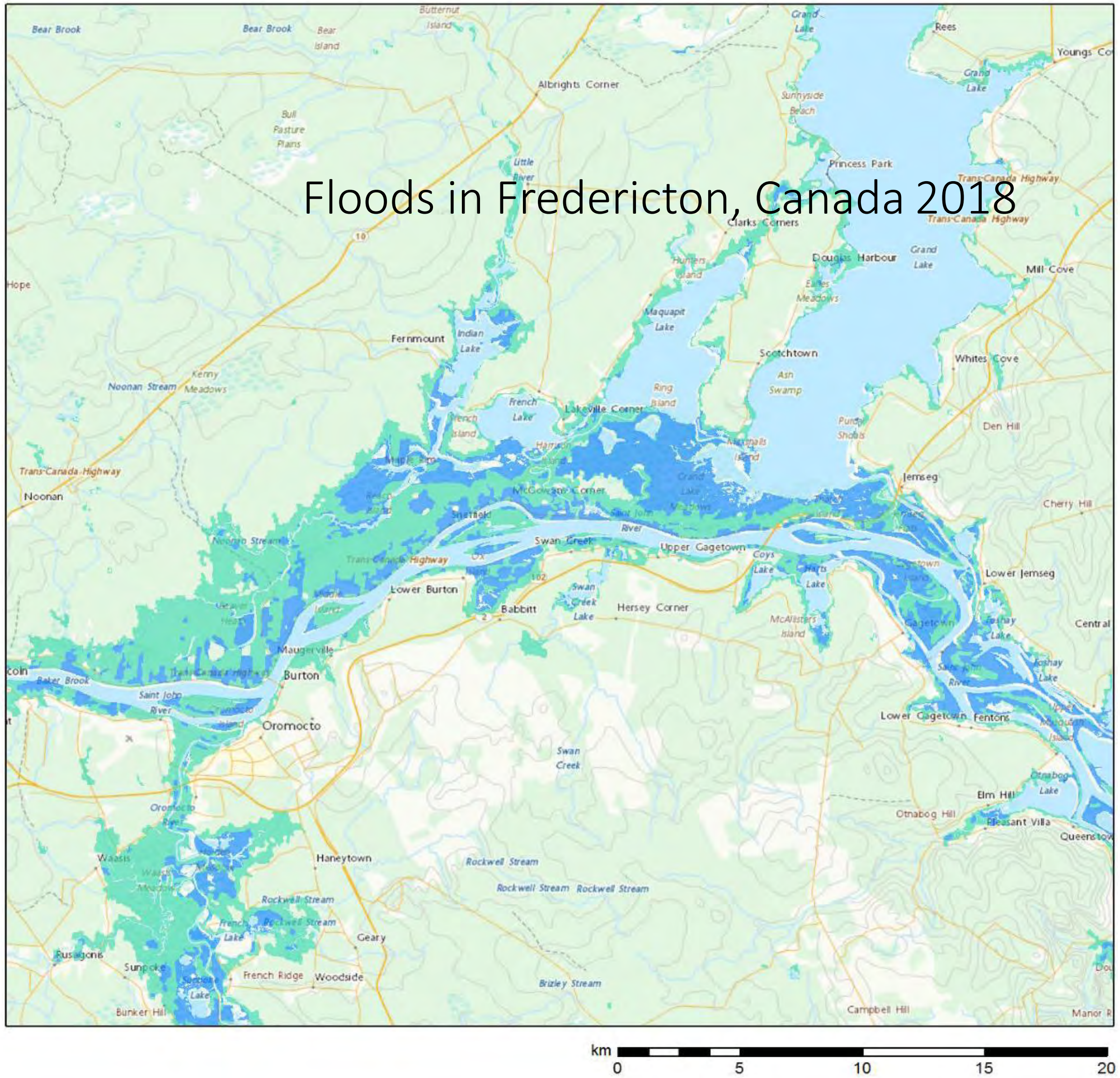
Floods

- The greatest number of floods in Europe, occurred in France 22%, Italy 17%,
- UK12% of the country
- EU focuses on ways to prevent predict mitigate and manage floods
- EU spends 58 million on flood risk mapping, flood forecasting and preventive
- landuse planning
- The commission is currently developing a European Flood Alert System EFAS
- In India, scientists warn that if global warming continues there will be significant increase in sea level by 2020 and cities like Mumbai and Kolkata will be partially submerged.

2015	
28 December	Flood in Argentina
03 December	Other in INDIA
02 December	Flood in India
06 November	Flood in Iraq
07 September	Flood in Bangladesh
26 August	Flood in Turkey
12 August	Flood in Argentina
09 August	Flood in Chile
05 August	Flood in Myanmar
30 July	Flood in Vietnam
11 June	Flood in Brazil
30 March	Flood and landslide in India
25 March	Flood in Chile
27 February	Flood in Brazil
25 February	Flood in Bolivia
20 February	Flood in Australia following Cyclone Lam
20 February	Flood in Australia following Cyclone Lam
15 January	Flood in Madagascar
08 January	Flood in Malawi

2016	
29 November	Flood in Costa Rica
21 November	Flood in Panama
20 October	Flood in Panama
05 October	Hurricane Matthew in the Dominican Republic
26 September	Flood in Australia
24 September	Flood in Indonesia
26 August	Flood in India
14 August	Flood in United States
09 August	Flood in Sudan
01 August	Flood in Bangladesh
21 June	Flood in China
31 May	Flood in the United States
17 May	Flood in Sri Lanka
15 April	Flood in Iran
12 March	Flood in the United States
04 January	Flood in the United States

Floods in Fredericton, Canada 2018



Permanent Water

Open Water Flood

Flooded Vegetation

Olthof, Tolszczuk *et al*. ©2019 CCRS

EO Requirements for Floods

Application	Disaster Cycle	Threshold	Optimum	Sensor Type
Land Use	Preparation/ Response	30 m	4-5 m	MSI
Infrastructure Status	Preparation/ Response	5 m	<= 1 m	PanVis
Vegetation	Preparation/ Response	<= 250 m	<= 30 m	MSI/HIS
Soil Moisture	Preparation	1 km	100 m	SAR/PM
Snow pack	Preparation	1 km	100 m	SAR/PM
DEM (vertical)	Preparation Mitigation	1-3 m	.10-.15 m	InSAR/ PanVis
Flood development and flood peak	During flood Post flood	<= 30 m	<= 5 m	SAR/MSI/ PanVis
Damage Assessment	Response	2-5 m	.3 m	MSI/PanVis/ SAR
Bathymetry (near shore)	Preparation	< 1 km	90 m	SAR/MSI/HIS

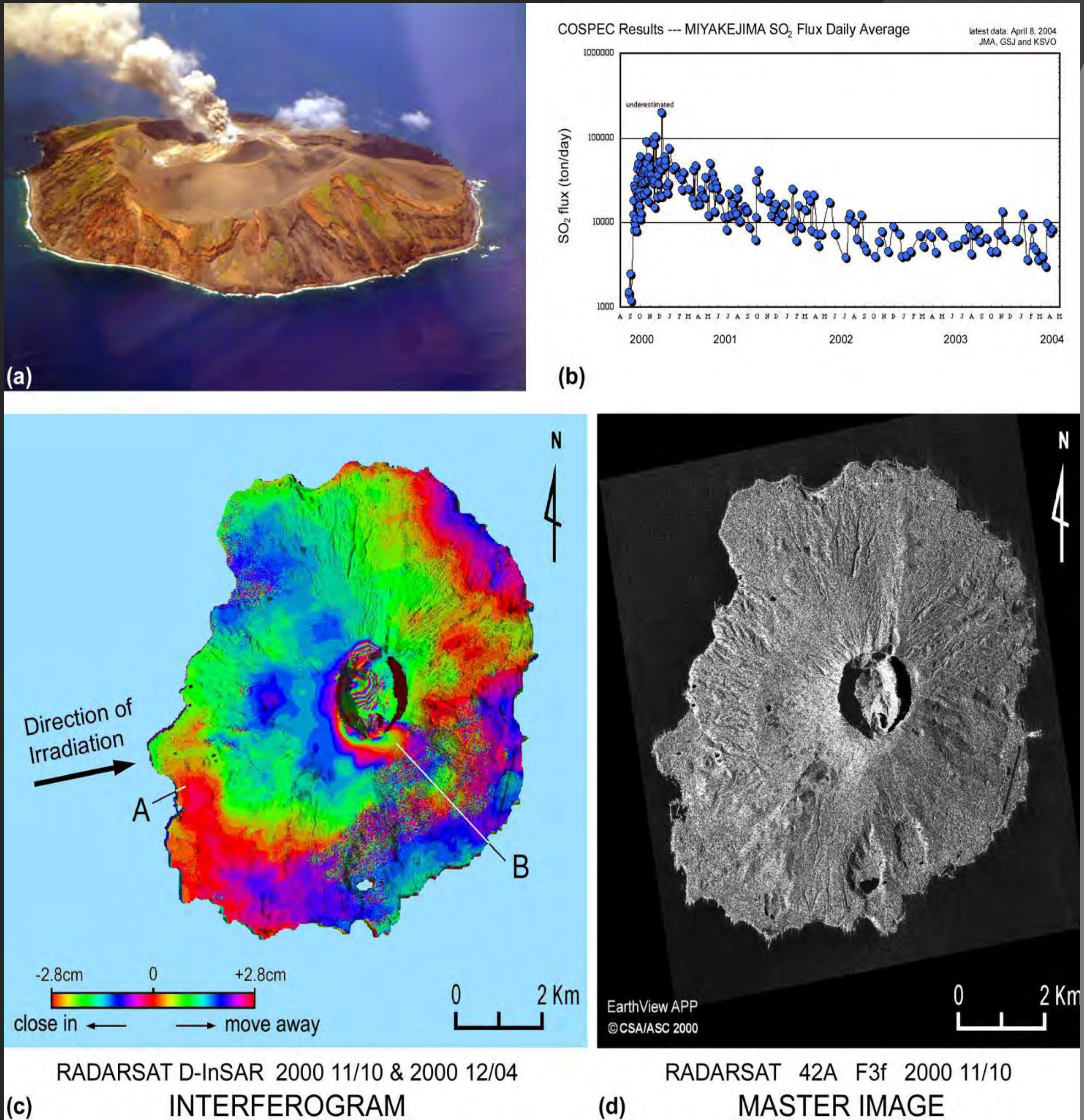
MSI = Multi-Spectral Imagery PanVis = Panchromatic Visible InSAR = Interferometric SAR
HIS = Hyper-Spectral Imagery SAR = Synthetic Aperture Radar PM = Passive Microwave

Disaster Management: Volcanoes and Landslides

- Mapping the distribution of volcanic lithologies (lava flows) in remote areas- SAR, Optical.
- Mapping geological structures in relation to volcanic vents
- Identifying potential active volcanoes
- Identifying large volcanic debris
- Tracking the dispersal of volcanic plumes (GOES)
- Monitoring the thermal characteristics of lava flows and volcanic domes
- InSAR monitoring motion of Landslides triggered by earthquakes and heavy rainfall etc.

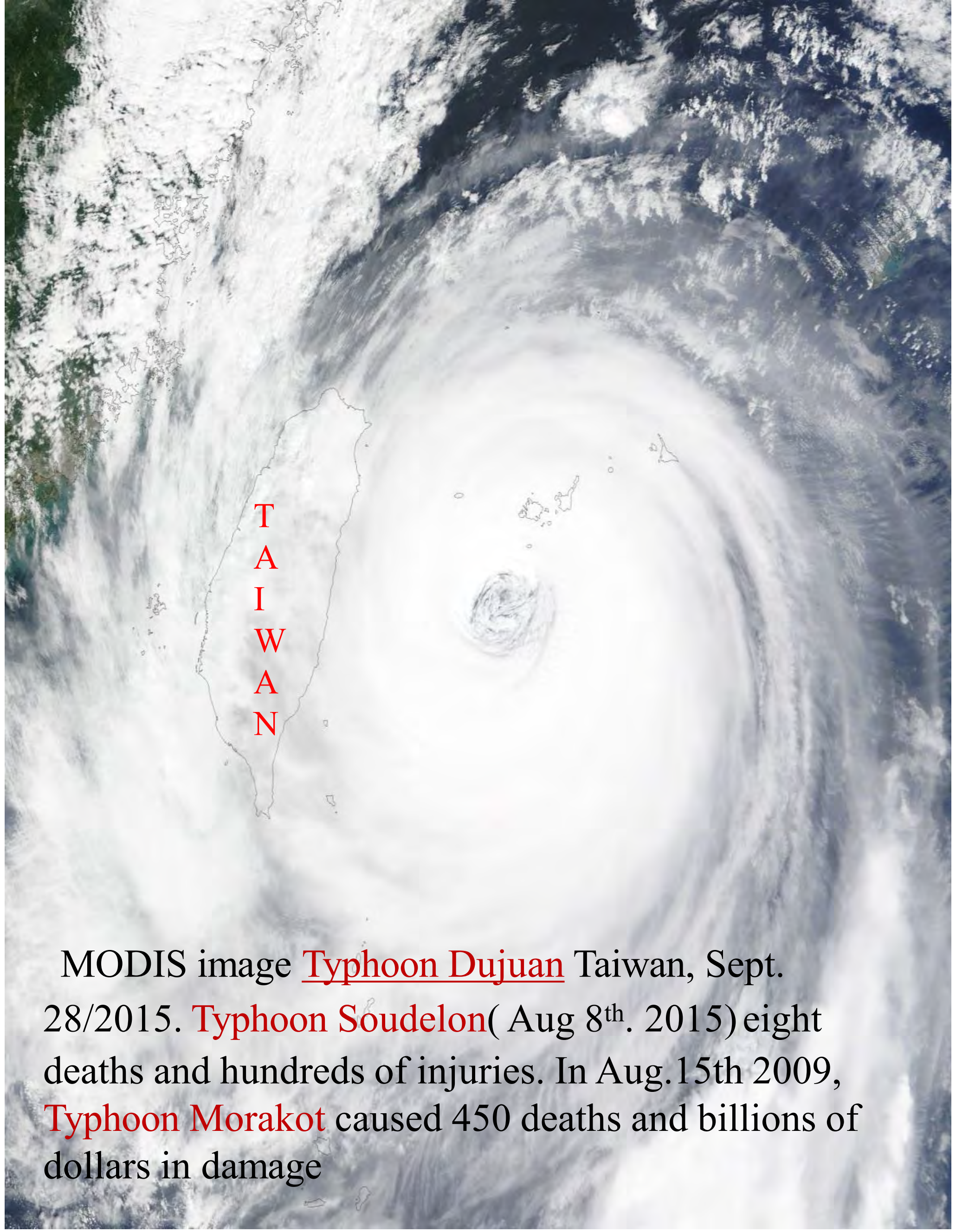
Volcano Monitoring in Japan using InSAR

Singhroy et al.



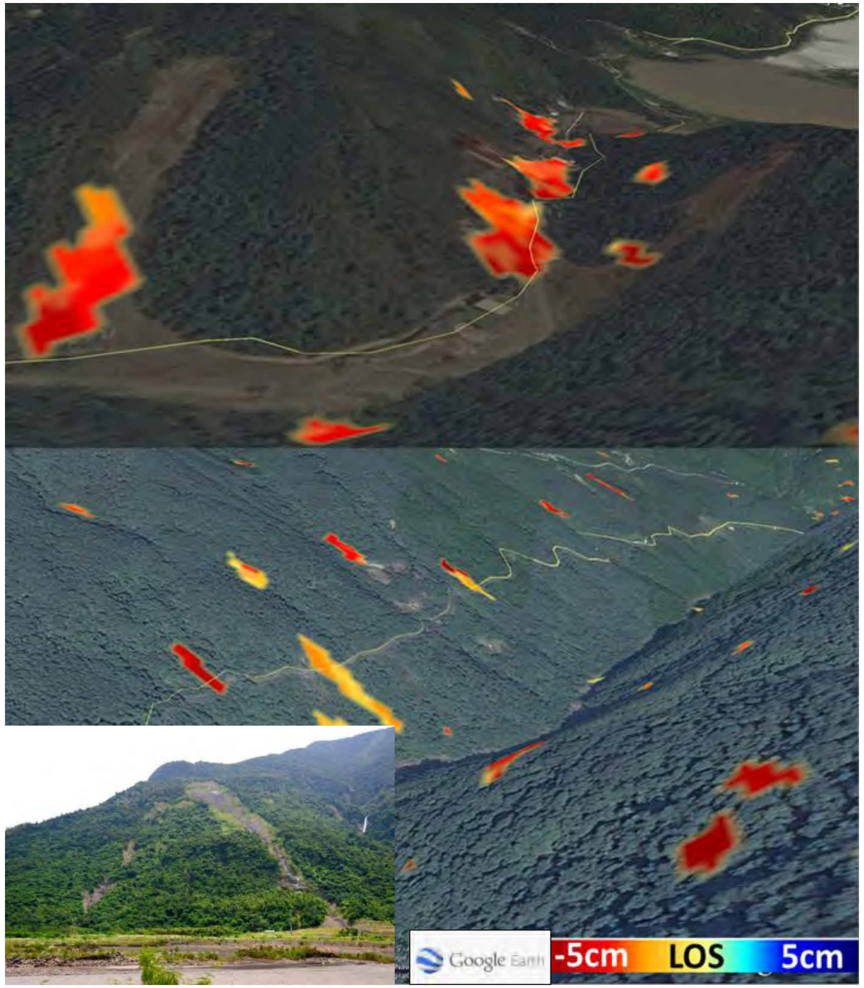
Typhoon triggered Landslides

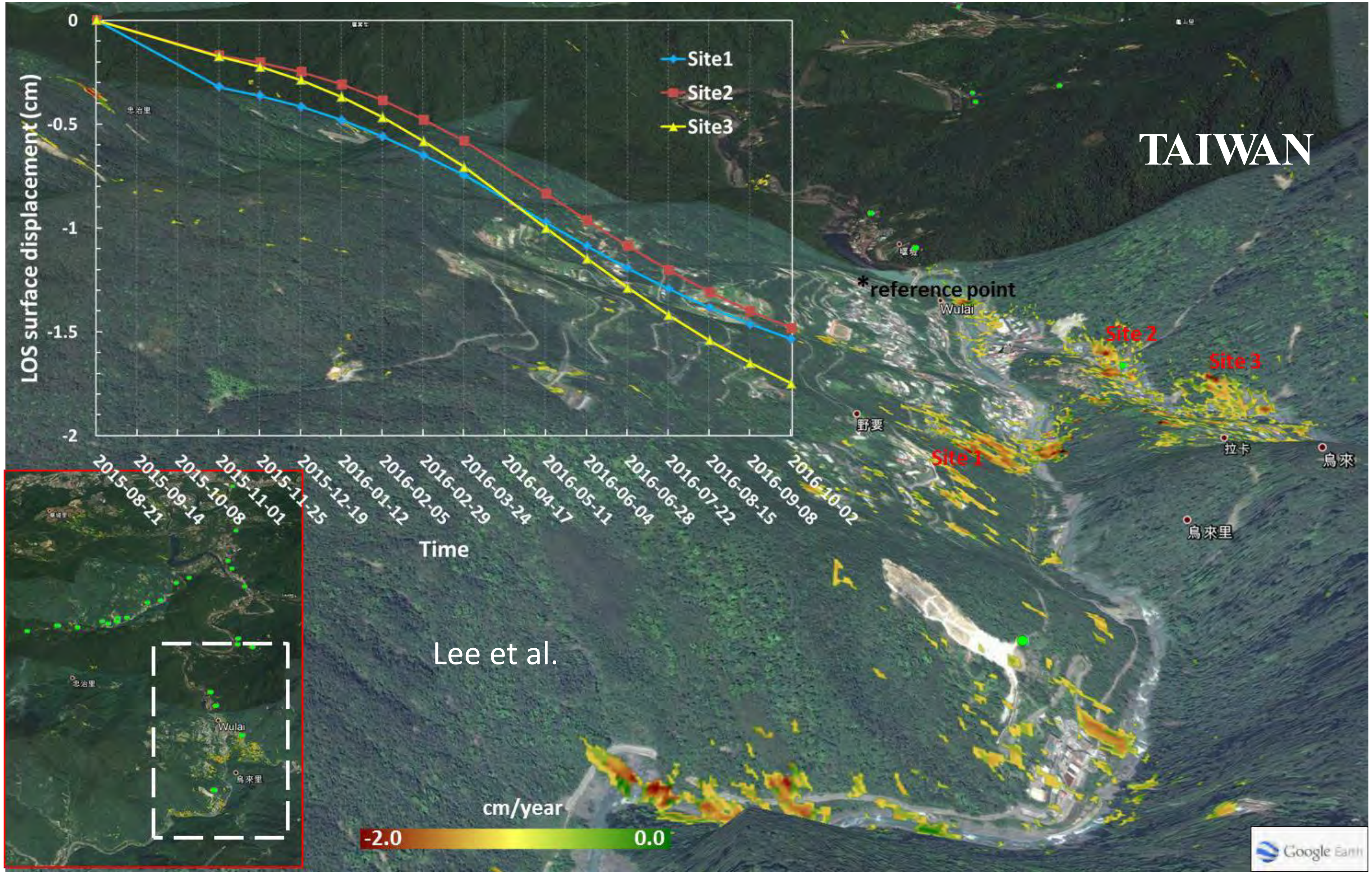
Singhroy et al



MODIS image Typhoon Dujuan Taiwan, Sept. 28/2015. Typhoon Soudelon(Aug 8th. 2015) eight deaths and hundreds of injuries. In Aug.15th 2009, Typhoon Morakot caused 450 deaths and billions of dollars in damage

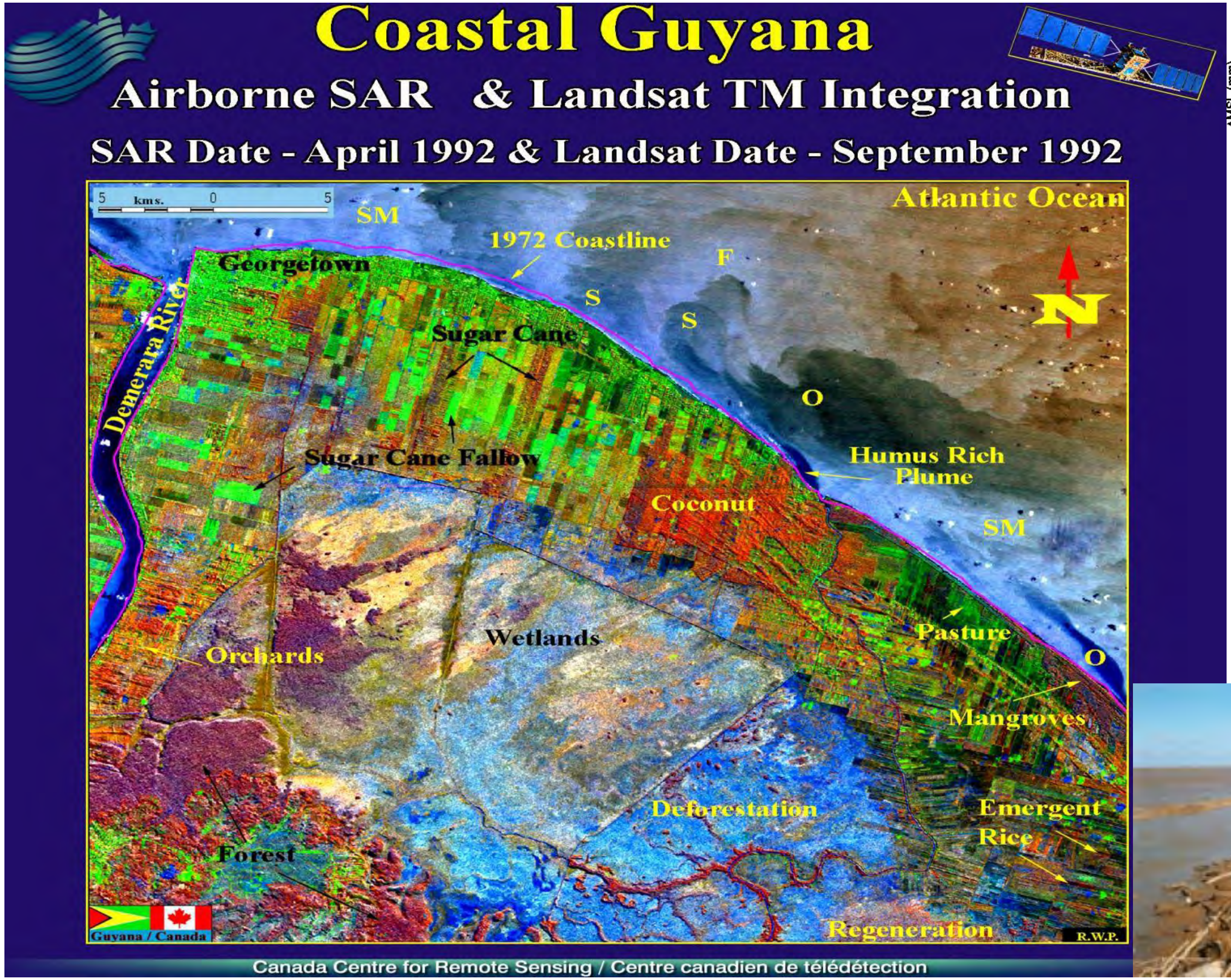
Radarsat-2 DInSAR monitoring between 2014-08-09 and 2015-08-04

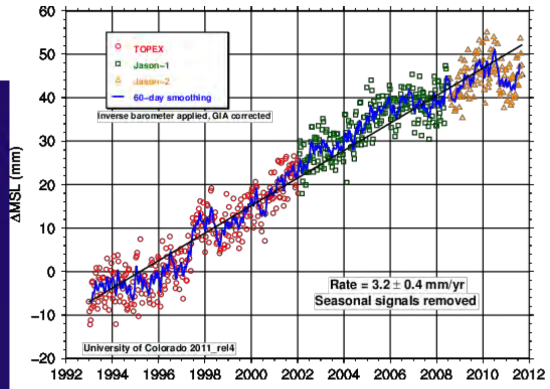




RADARSAT 2-(Extra-Fine Descending) 3m resolution for **Wulai, TAIWAN**

Sea Level Rise: coastal erosion and flooding





Projections of sea-level rise for Coastal Guyana(1990-2020) 2-9 mm/y
Relative Sea Level Projected at Specific study areas- 200-400mm/y
Omatoyo Kofi Dalrymple : Department of Civil & Environmental Engineering, University of South Florida.
10 moving mud shoals along the Guyana coast which influence local sea level rise

Singhroy et al.

Disaster Management-Applications Gaps

- Timeliness, cost, accessibility, ease of use, reliability, repeatability, and demonstrated operational capability are the most important criteria affecting the implementation of satellite information.
- For disaster warning and response, the rapid response of satellite information support of a disaster situation is the most important feature for the use of the technology.
- There is a need to integrate non-space information with space imagery to be
- able to quickly move the data in a seamless fashion
- Disaster Management (DM) and Response Agencies (RA) are too busy dealing with disasters and have not had the understanding, resources and time to assimilate space technologies into their operations
- There is a general reluctance among DM & RA to quickly assimilate new
- technologies
- Space technology, in general, has not been fully demonstrated to be useful to the DM community
- Compelling demonstrations can create wider acceptance

The UN Charter

During the United Nations' global conference on space matters, UNISPACE-III, held in Vienna from July1999, the space agencies of France (CNES) and Europe (ESA) proposed creation of a Charter of co-operation. Canada (CSA) expressed its desire to support this proposal as well. All the Space agencies are now on board

The Charter allows the various space data providers

- *to co-ordinate the use of their respective space facilities to track disastrous events and contribute towards mitigating their effects.*
- no one satellite is able to guarantee coverage of a rapidly unfolding disaster in a manner as urgent as it may be required.
- the coverage target may be some days away from the next pass of a satellite, there may be acquisition planning limitations
- the information product may require multi-satellite data integration,
- critical issue of co-ordinating operations to create the best opportunity for data acquisition and delivery,
- it must also be recognized that the end user in most cases will not be aware of these data
- acquisition opportunities
- *Consequently, the aspects of a co-ordinated data request submission, handling and delivery should be taken into account*

ISU Team Projects on Disaster Management

The following TP titles are drawn from recent SSP and Masters Programs; the final reports are all online at

- http://www.isunet,edu/ (click on 'Student reports')

- 1999 (SSP) South East Asia Disaster Management System(SEADS).
- 2000 (SSP) El Niño Southern Oscillation (ENSO): Global Challenges andSolutions.
- 2002 (SSP) Health Improvement via Space Technology and Resources(HI-TECH).
- 2002 (Masters) Charting Response Options for Threatening Near-Earth Objects.
- 2003 (SSP) Earth Climate Observation System Promoting Human Ecological Research and Education (ECOSPHERE)
- 2002 (SSP) a) Water Cycle Studies Using Space Technology(STREAM).
- b) Communications to Remote Regions (CONNECT).
- 2006 (SSP) a) Wildfire Mitigation Strategies using Space Technology (FLAMA).
- b) Threats from NEOs (CASSANDRA).
- 2007 (SSP)Technology Resources for Earthquake Monitoring & Response (TREMOR).
- 2008 (SSP) Volcanic Activity: Processing of Observation and RS Data (VAPOR)
- 2009 (SSP) Disaster Risk Evaluation And Management(DREAM)
- 2010 MSS) FOCUS : Respect Earth: future opportunity in carbon understanding andsustainability
- 2011 (SSP) H2OPE : Tigris Euphrates and the global watercrisis
- 2012 (MSS) IDEAS for Africa : identifying and developing effective applications of space for Africa
- 2012 (SSP) Space Debris
- 2013 (SSP) Koastal : Kenyan coast Observation through Affordable Space Technology Applications
- 2014 MSS Migration and population - opportunities for space

- 2010 Engineering & Construction Disaster Resource Partnership / A New Private-Public Partnership Model for Disaster Response : World Economic Forum Report