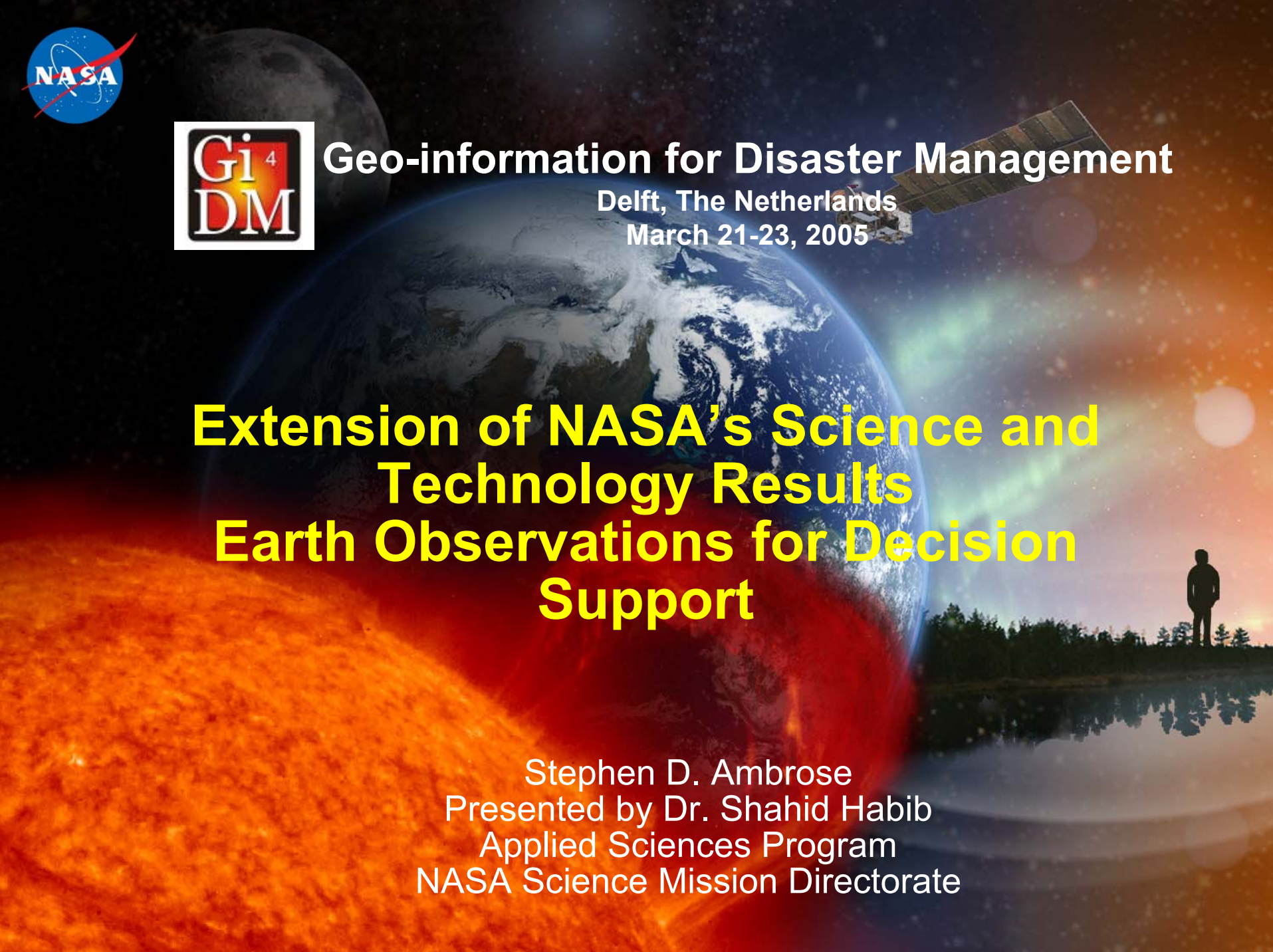


Geo-information for Disaster Management

Delft, The Netherlands

March 21-23, 2005

Extension of NASA's Science and Technology Results Earth Observations for Decision Support

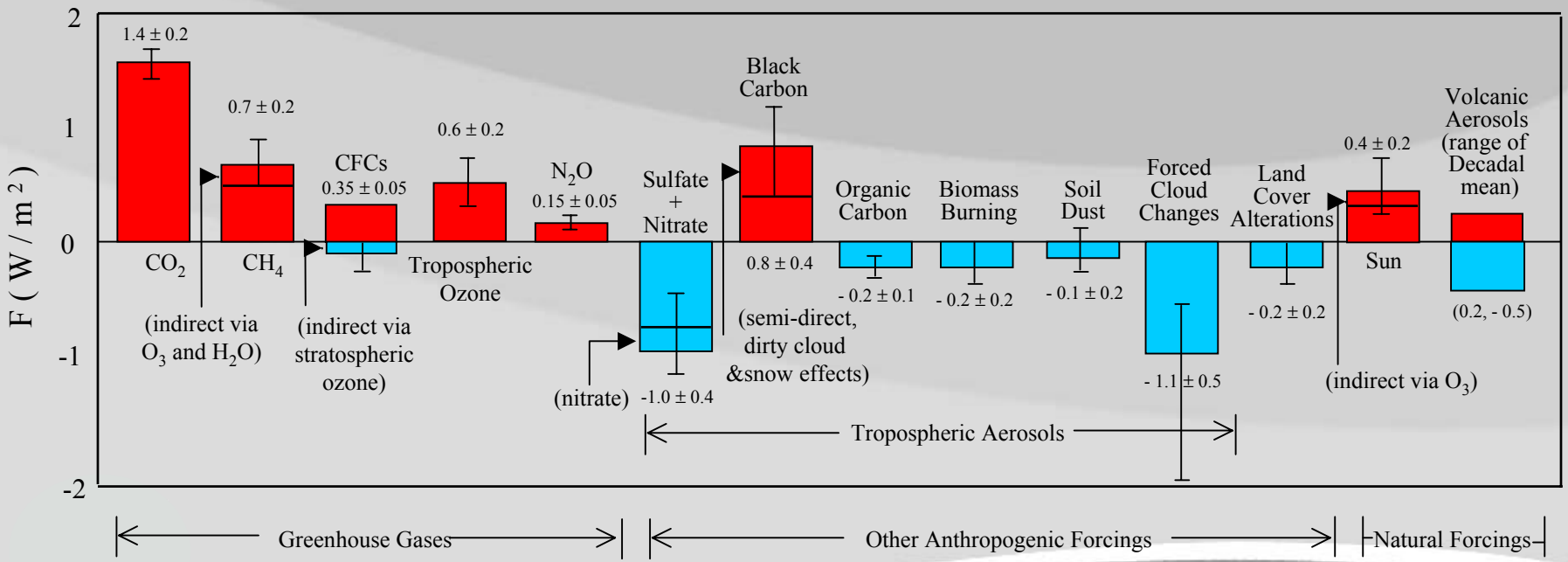
Stephen D. Ambrose
Presented by Dr. Shahid Habib
Applied Sciences Program
NASA Science Mission Directorate


The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

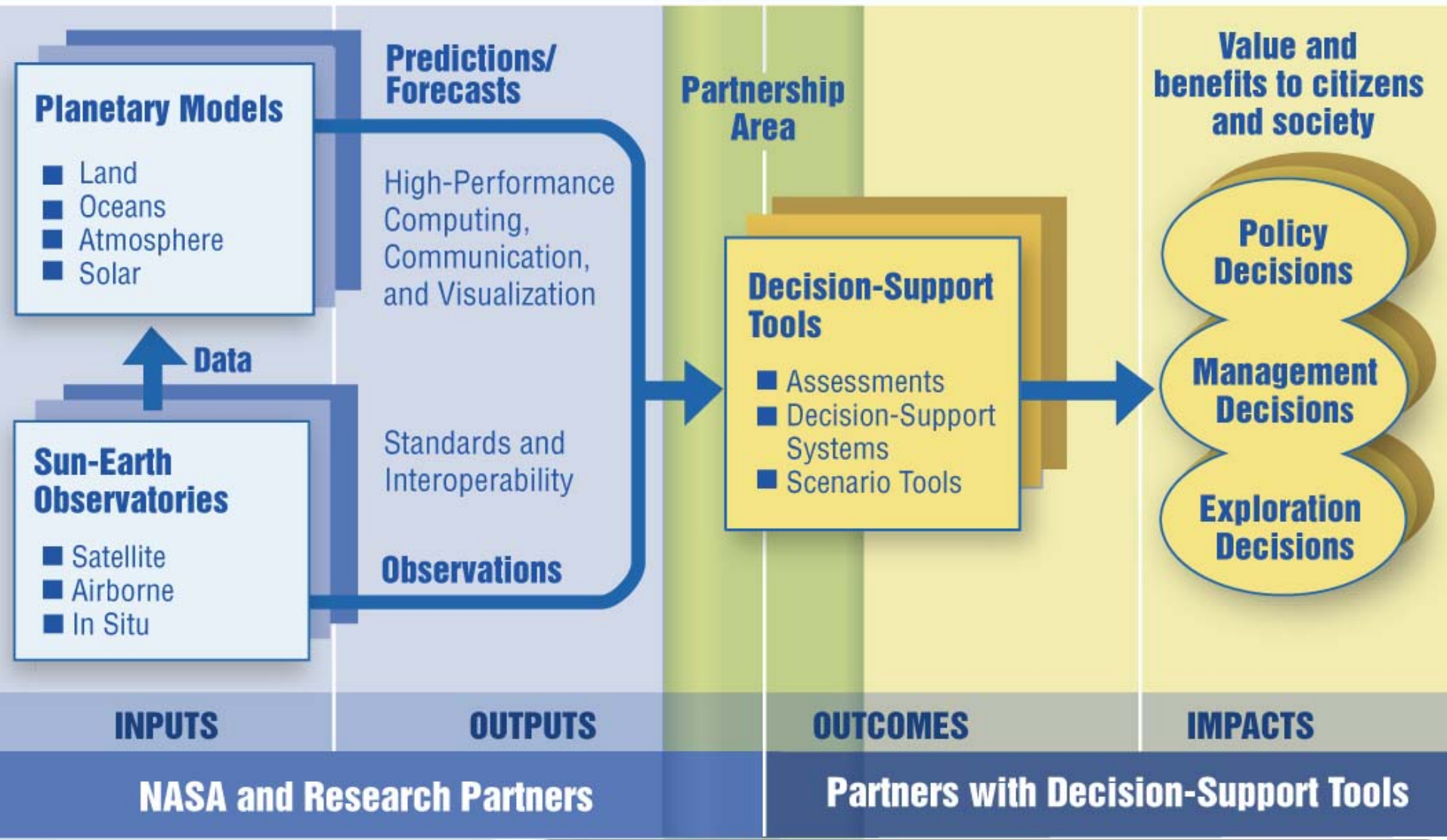
Observing Systems

Dynamic System

- How is the global Earth system *changing*?
- What are the primary forcings of the Earth system?
- How does the Earth system *respond* to natural and human-induced changes?
- What are the *consequences* of changes in the Earth system for human civilization?
- How well can we *predict* future changes in the Earth system?



Integrating Knowledge, Capacity and Systems into Solutions

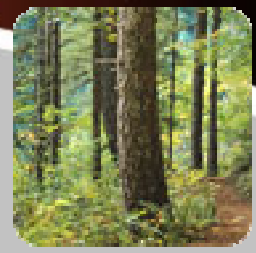


Applications of National Priority

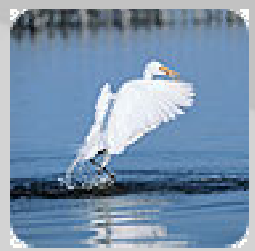
Agricultural Efficiency

Air Quality

Aviation



Carbon Management



Coastal Management

Disaster Management

Ecological Forecasting

Energy Management

Homeland Security

Invasive Species

Public Health

Water Management

National Application	Partner Organizations	Decision-Support Systems
Agricultural Efficiency	USDA,NOAA	CADRE—Crop Assessment Data Retrieval and Evaluation (USDA)
Air Quality	EPA,NOAA,USDA	CMAQ—Community Multiscale Air Quality Modeling System AIRNow AQI—Air Quality Index
Aviation	DOT/FAA,NOAA	NAS-AWRP—National Air Space-Aviation Weather Research Program
Carbon Management	USDA,DOE,NOAA	CQUEST—Support to the Energy Act of 1992,Section 1605b
Coastal Management	NOAA,EPA,NRL	HAB—Harmful Algal Bloom Bulletin/Mapping System CREWS—Coral Reef Early Warning System
Disaster Management	DHS/FEMA,NOAA,USGS,USFS	AWIPS—Advanced Weather Interactive Processing System HAZUS-MH—Hazards U.S.—Multi-Hazards
Ecological Forecasting	USAID,NOAA,NPS,CCAD,USGS	SERVIR—Regional Visualization and Monitoring System
Energy Management	DOE,UNEP,NOAA,NRC	RETScreen—Energy Diversification Research Laboratory (CEDRL) NEMS—National Energy Modeling System
Homeland Security	DHS,USGS,NOAA,NGA,DOD	IOF—Integrated Operations Facility IMAAC—Interagency Modeling and Atmospheric Assessment Center
Invasive Species	USGS,USDA,NOAA	ISFS—Invasive Species Forecasting System
Public Health	NIH,CDC,DOD,EPA	PSS—Plague Surveillance System EPHTN—Environmental Public Health Tracking Network MMS—Malaria Monitoring and Surveillance RSVP—Rapid Syndrome Validation Project
Water Management	EPA,USDA,USGS,BoR	RiverWARE—Bureau of Reclamation decision-support Tool AWARDS—Agricultural Water Resources and decision-support Tool BASINS—Better Assessment Science Integrating Point and Nonpoint Source

National Programs in a Global Context

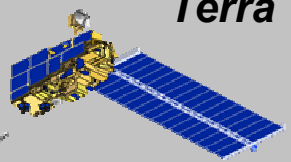
Priority	National Programs	International Programs
Vision for Exploration	Understanding the Earth as the foundation for Planetary Exploration and Search for Life	*"Pursue opportunities for international participation to support U.S. space exploration goals"*
Global Earth Observation	NSTC CENR Interagency Working Group on Earth Observations (IWGEO) Integrated Earth Observation System, 17 Agencies)	Group on Earth Observations (GEO) Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan
Climate Change	Climate Change Science Program (CCSP, 13 Agencies) Climate Change Technology Program (CCTP, 12 Agencies)	Intergovernmental Panel on Climate Change (IPCC))
Weather	U.S. Weather Research Program (USWRP, 7 Agencies)	World Meteorological Organization (WMO)
Natural Hazards	NSTC CENR Subcommittee on Natural Disaster Reduction (SNDR, 14 Agencies)	International Strategy for Disaster Reduction
Sustainability	CENR Subcommittee on Ecosystems	World Summit on Sustainable Development (WSSD)
President's Management Agenda: E-Government	Geospatial One-Stop (GOS, 12 Agencies) and the Federal Geographic Data Committee (FGDC, 19 Agencies)	World Summit on the Information Society

Disaster Management

QuikScat

SRTM

Terra



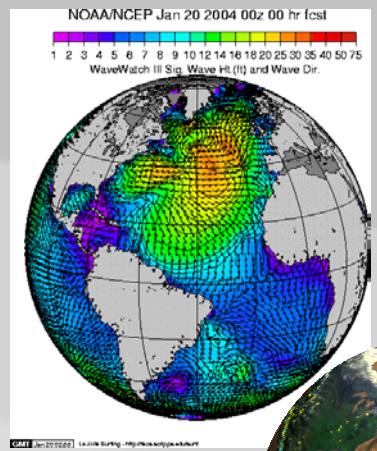
Tasking

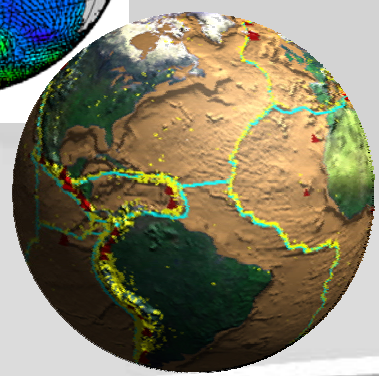
EDOS: Mission Control

Downlink

EOSDIS & DAACs

Exploitation

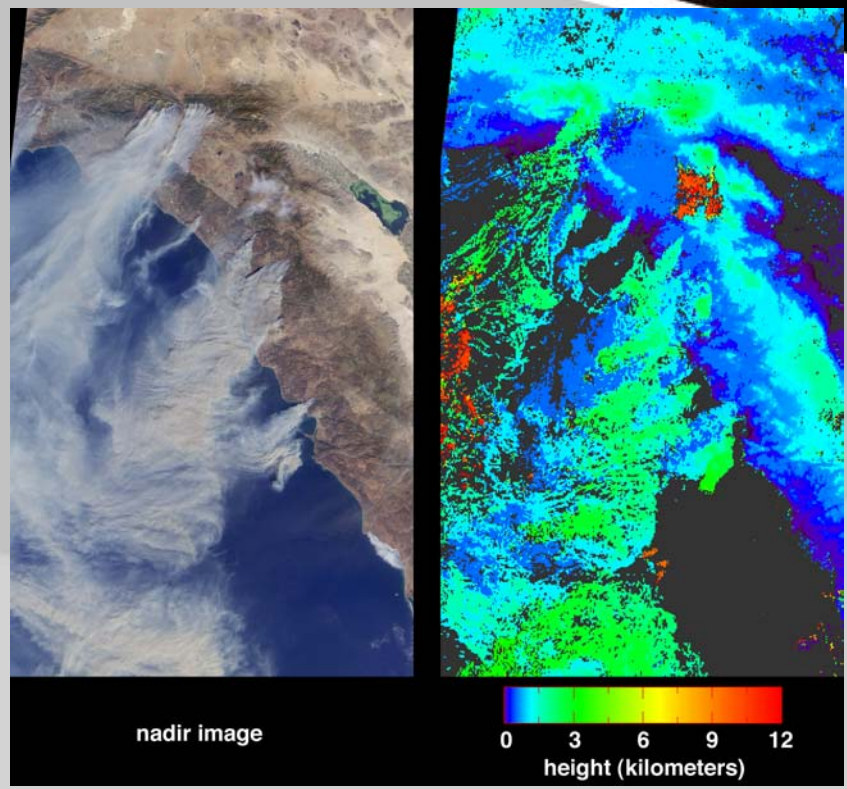




Societal Benefits

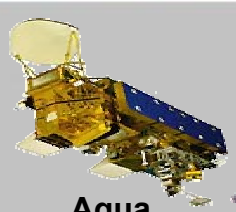
Disaster Management - Detection of Fires

Portugal fires August 4, 2003



California fires captured by MODIS October 26, 2003

MODIS Rapid Response Process



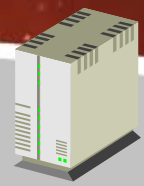
Aqua

Terra

Direct Broadcast
Receiving Station

L1B Data

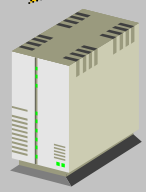
T+30min



USDA Forest Service
Remote Sensing
Application Center

Cumulative Fire Maps
http://www.fs.fed.us/eng/rsac
Updated twice daily

Backup Feed
L1B Data



Rapid Response System
NASA/GSFC

Active Fire
Locations

T+5hrs

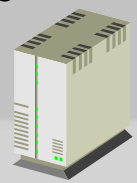
Burn Severity Maps

EDOS

MODIS
L0 Data

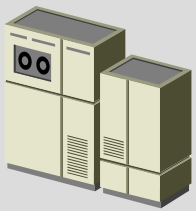
T+2-5hrs

Active Fire Locations
Selected Imagery

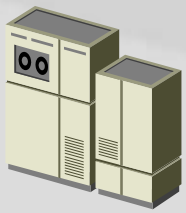


University of Maryland
Geography Dept

Active Fire
Locations



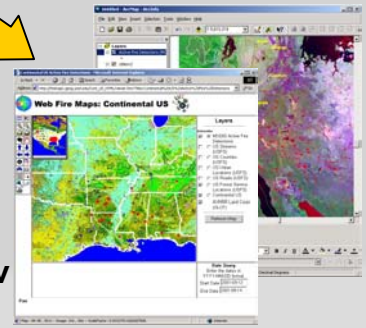
GES DAAC
NASA/GSFC



NOAA

T+5hrs

Active Fire and
Corrected Reflectance
http://rapidfire.sci.gsfc.nasa.gov



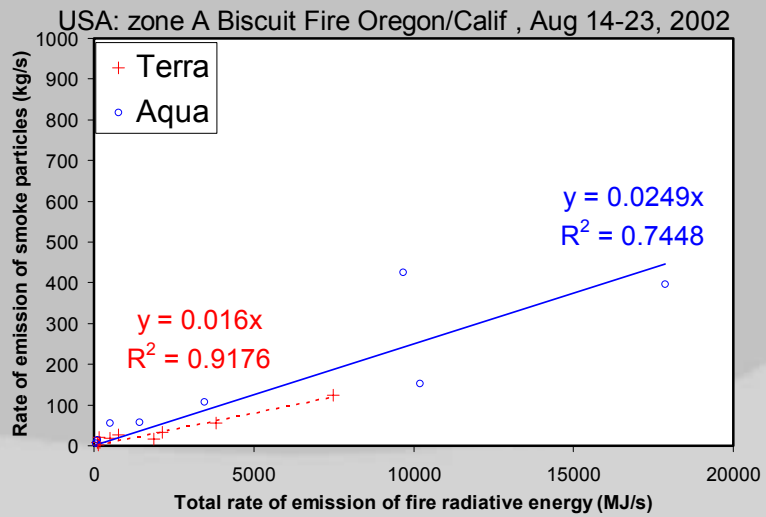
Web Fire Maps and Fire
Feature Server
http://rapidresponse.umd.edu

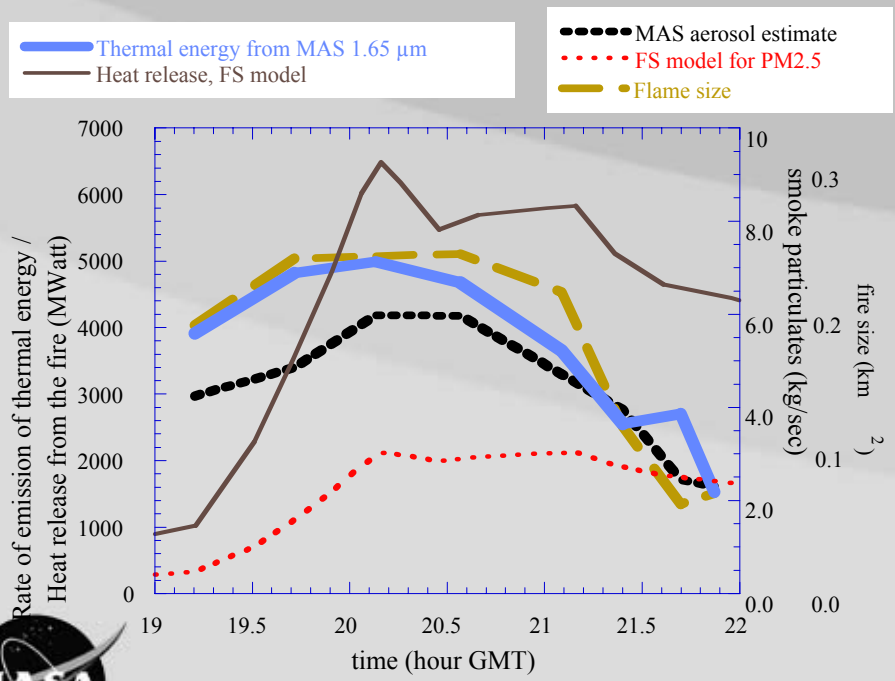
NASA Earth
Observatory
http://earthobservatory.nasa.gov

MODIS home page
http://modis.gsfc.nasa.gov

Disaster Management-Fire Burn Information

- **Forecast smoke/CO advancement and hazards – Partnership with USFS**





Landsat and MODIS Images

Tsunami Destruction of Aceh Province, Sumatra

Landsat ETM+

December 29, 2004

December 17, 2004

Terra MODIS

December 29, 2004

December 17, 2004

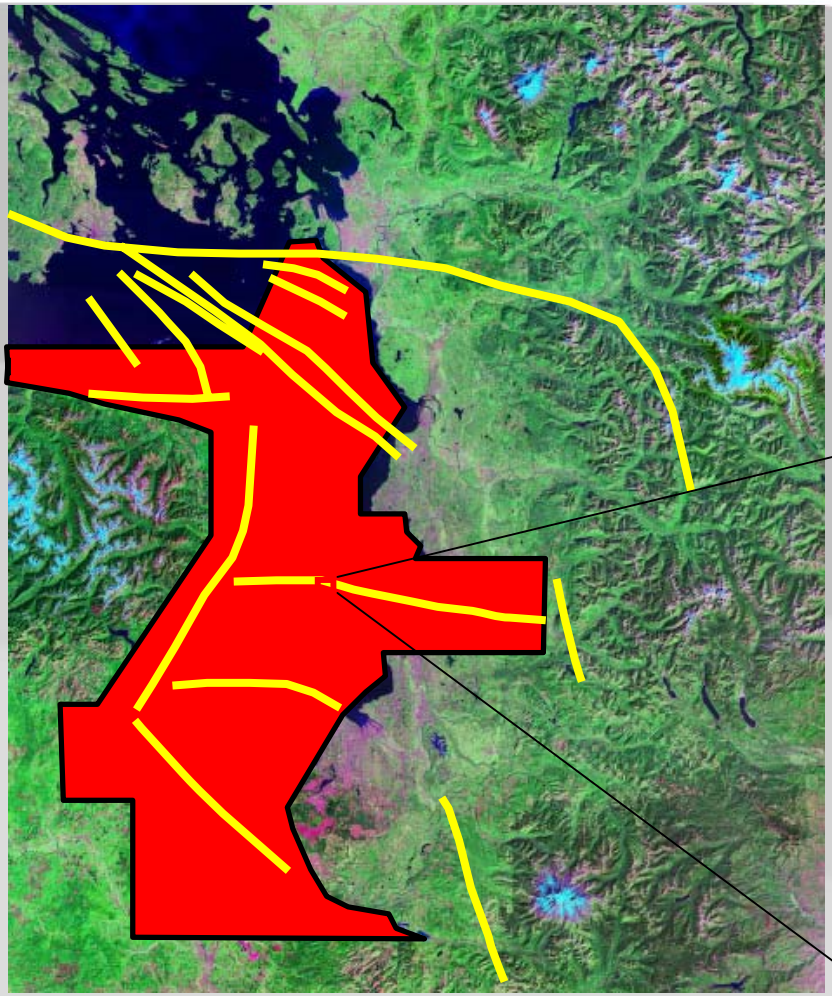
ASTER Images

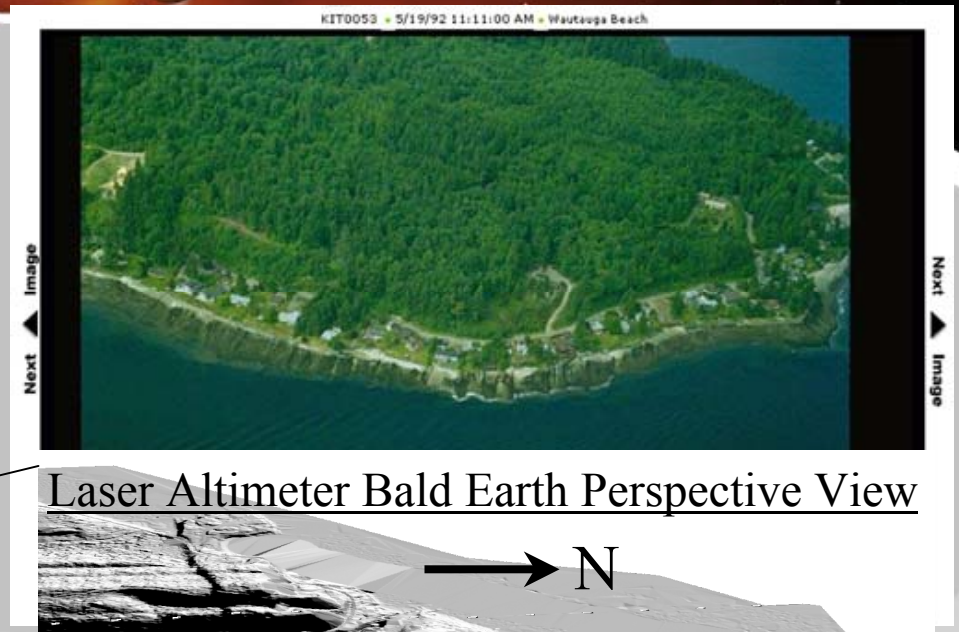
- The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is used to obtain detailed maps of land surface temperature, emissivity, reflectance and elevation.

- These simulated natural color ASTER images of Phuket, Thailand
- The images show a 25-km stretch of coast north of the Phuket airport 2 years prior to the tsunami and 5 days after the event.

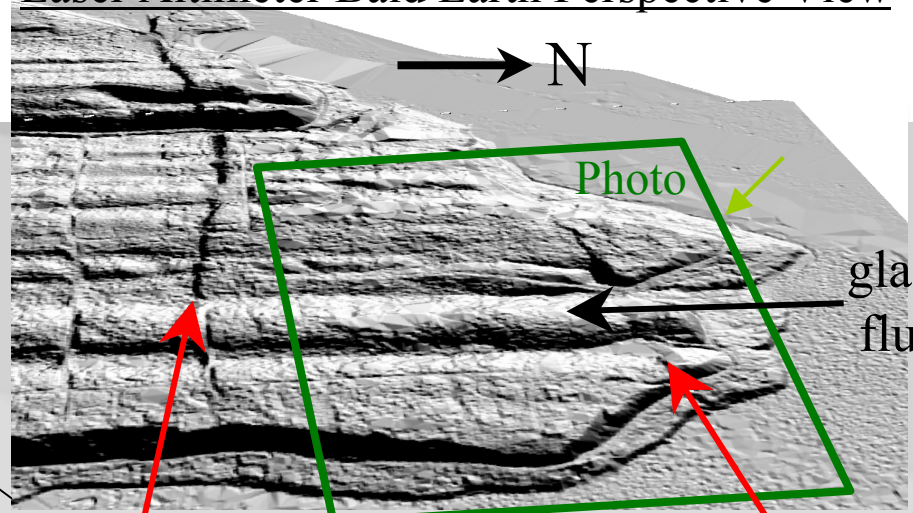
November 15, 2002 December 31, 2004

Fault Scarps Revealed Under Vegetation





Laser Altimeter Bald Earth Perspective View



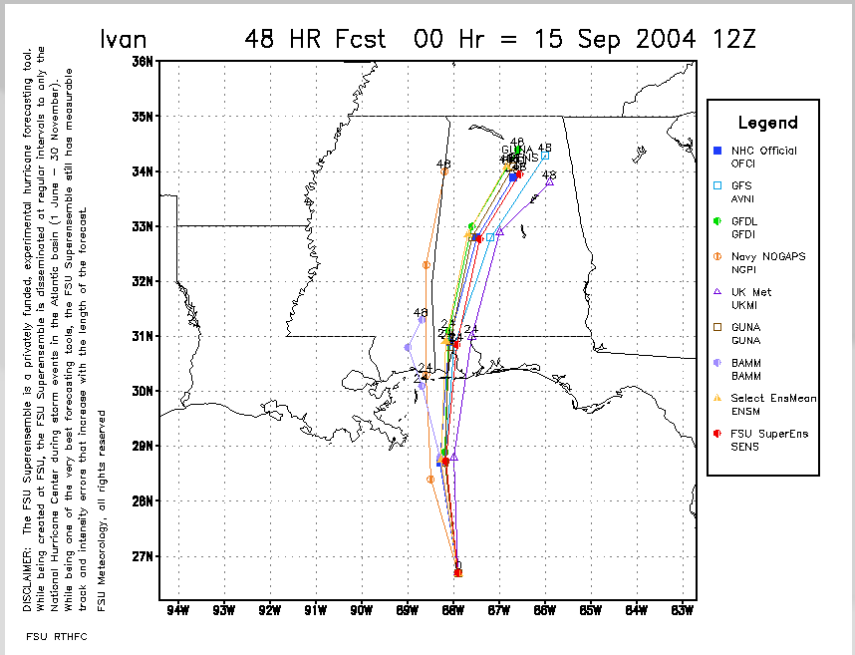
Laser Altimeter Applications in Natural Hazards and Forestry

Puget Lowland Near-Surface Faults

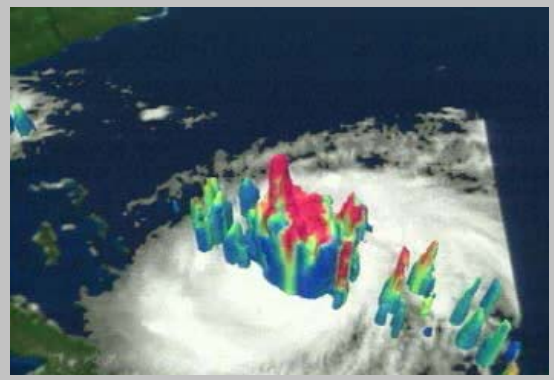
Improve Hurricanes forecasts

Assimilation of TRMM rainfall location, intensity and vertical structure into hurricane forecast models leads to improvements in forecasts of future position

Hurricane Ivan Forecast, September 2004



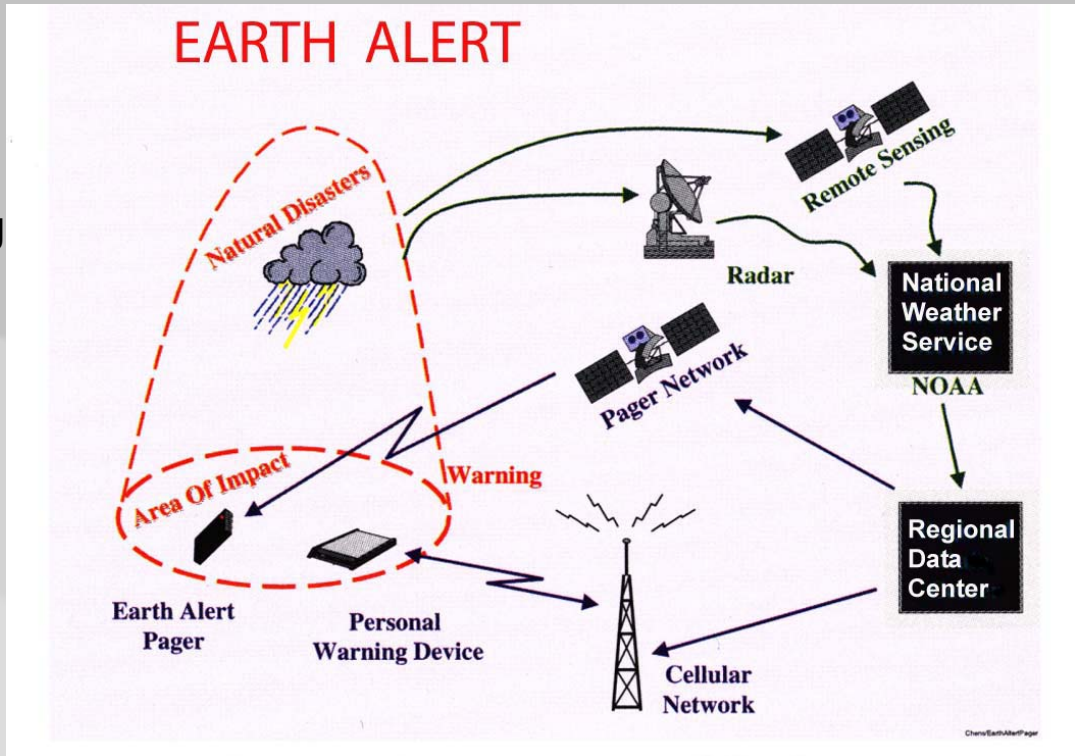
Hurricane Visualization with TRMM



Reduced track errors can save money ($600K - $1M per mile of coast evacuated) and save lives by more precise prediction of eye location at landfall

Cellular Technology for Early Warning

- NASA's Earth Alert Emergency Management System
- Economically utilizes existing satellite pager and cellular technologies
- Increases warning time for impending disasters
- Economical hardware and receivers
- GPS and Wireless 2- way communications



Disaster Management

HAZUS-MH - Risk Assessment and Loss Estimation

January 12, 2004,
S. Ambrose

State 2- Improved
Hurricane prediction
Flood prediction
Severe Storm prediction
Wildfire prevention and prediction
Earthquake prediction

Primary Partners:

Socioeconomic Impact

Transfer of advanced event-modeling capabilities using next-generation hardware, software, and communications

Outcomes: Improvement of FEMA capabilities across all hazards and phases

Impacts: Reduce losses across all disasters

Land use/Land cover, changes in earth's surface topography and Improved geodetic imaging, ocean measurements to track hurricanes

Outcomes: Improvement of FEMA planning, and response capabilities to weather and natural hazards

Impacts: Reduce losses across all weather-driven Disasters and earth movement

Improved measurements of soil moisture, global precipitation, water vapor, and wind

Outcomes: Improvement in wildfire prediction, HAZUS-MH High Winds Module Final Version

Impacts: Reduce losses related to hurricane, fire, and high wind disasters.

Understanding of Earth's gravity field And terrestrial reference frame changes in geomagnetic field and understanding of sea level change and climate

Outcomes: Improvement of the HAZUS-MH earthquake assessments And flood inundation for coastal areas

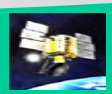
Impacts: Reduce losses related to hurricanes and earthquakes.

Production of assimilated data sets, reanalysis of long period observations

Outcomes: Improvement in climate data and information for risk assessments

Impacts: Reduce losses related to flood and wind disasters. Better community planning

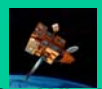
State 1- Earthquake Damage assessment

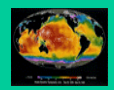

QuikSCAT


Terra


Aqua


TRMM


SeaWinds


OcnTopo


Hydros


* OSWinds


Aquarius


NPOESS

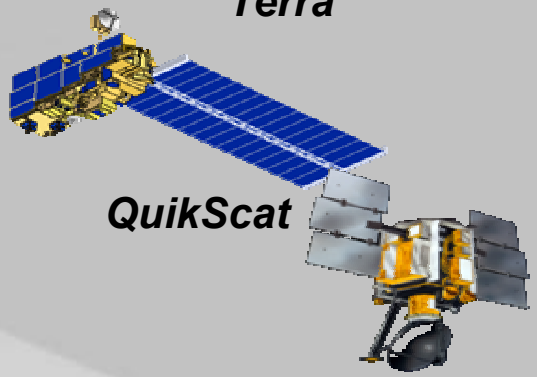
* Pre-formulation

2004 2005 2006 2008 2010 2020

An operational decision support system for quantification and verification of solutions for natural hazard predictions.

Public Health

Terra



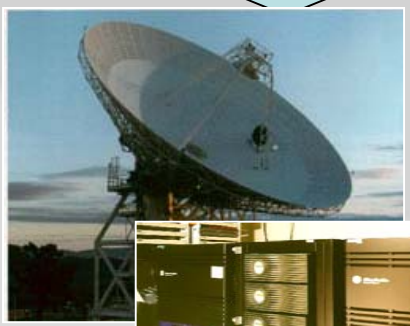
QuikScat

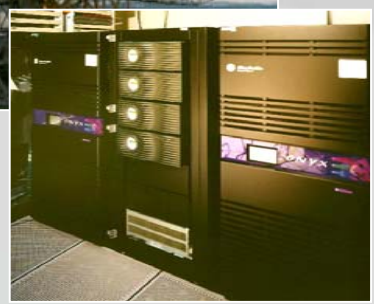
Tasking

EDOS: Mission Control

Societal Benefits

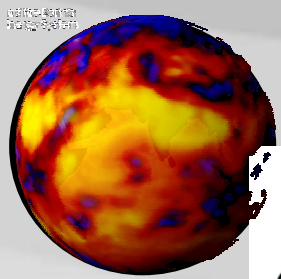
Downlink

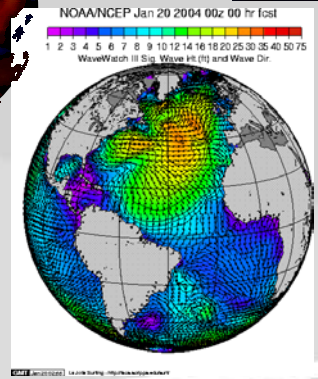




EOSDIS & DAACs

Exploitation



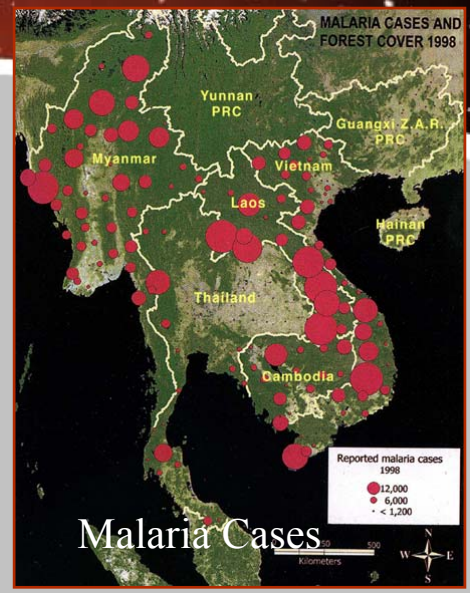


Environmental
Public Health
Tracking Network

Public Health - Mekong Malaria and Filariasis

BACKGROUND

- The Greater Mekong Sub-region is the world's epicenter of multi-drug resistant *falciparum* malaria
- Lymphatic filariasis has incapacitated more than 50 million people worldwide



PARTNERS

- Armed Forces Res. Inst. for Med. Sciences
- US Army Med. Res. Inst. for Infec. Disesease
- Uniformed Services Univ
- Naval Dis. Vec. Ecology & Control Cente)
- Mahidol University, Thailand

Satellite Data

- Ikonos
- ASTER
- Landsat
- MODIS

Models

- Surface Hydrology
- Climate Prediction
- Vector Habitat
- Transmission
- Risk Prediction

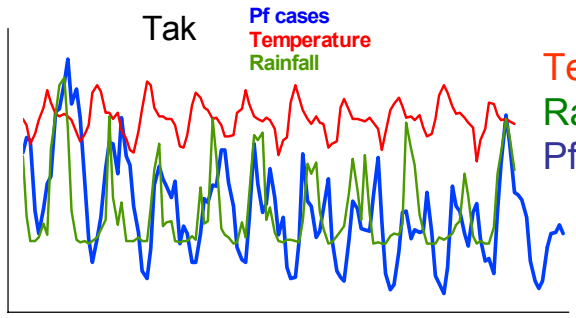
Decision Support

- ***Vector Habitat Identification:*** when/where to apply larvicide and insecticide
- ***Identification of Key Factors:*** Curtail ongoing Transmission
- ***Risk Prediction:*** Predict Transmission

Benefits

- Advance warning
- Optimized pesticide and chemoprophylaxis usage
- Reduced damage to environment
- Reduced morbidity and mortality

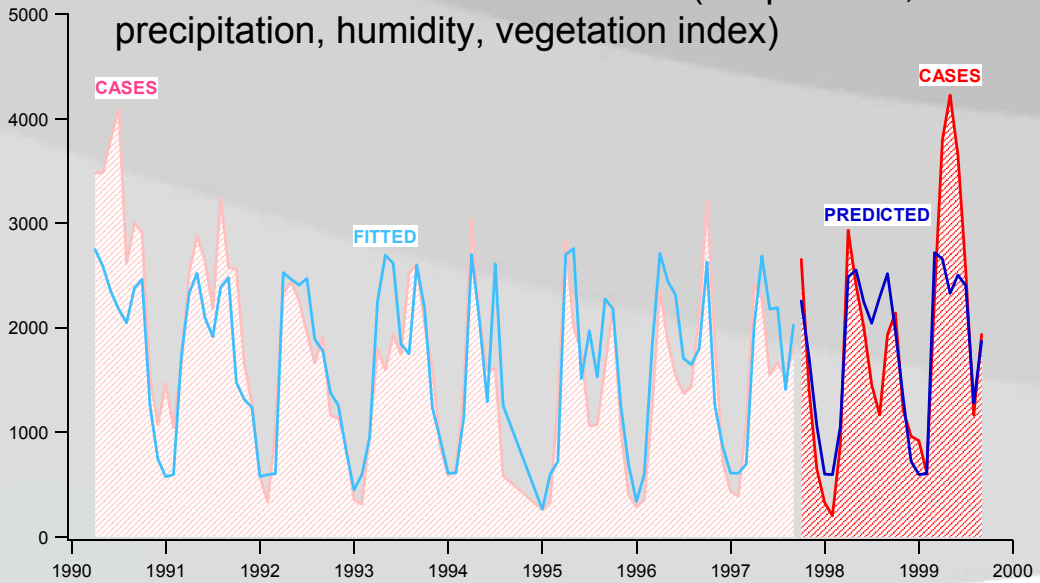
Public Health - Mekong Malaria in Tak, Thailand



Temperature--satellite
Rainfall--satellite
Pf Parasite—field observations

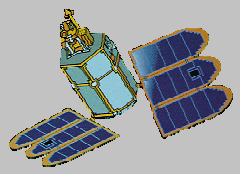
Satellite Vegetation Data used for Insecticide Planning

2-Year Prediction of Malaria Cases Based on Environmental Parameters (temperature, precipitation, humidity, vegetation index)

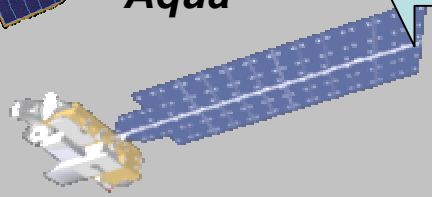


Air Quality

TOMS-EP



Aqua



Tasking

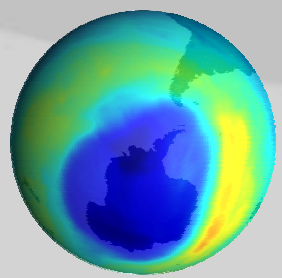
EDOS: Mission Control

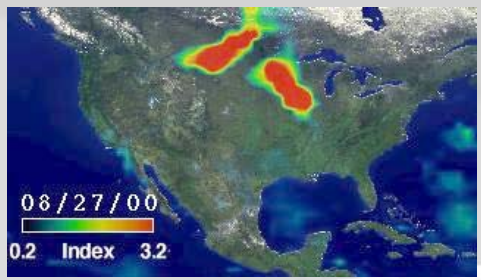
Downlink

Exploitation

Societal Benefits

EOSDIS & DAACs

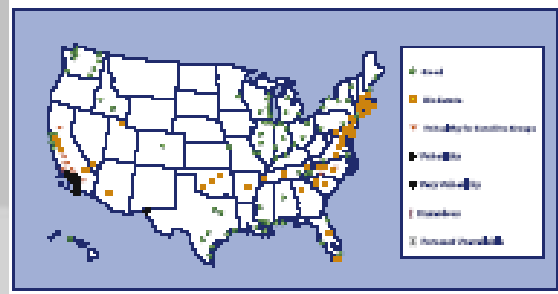




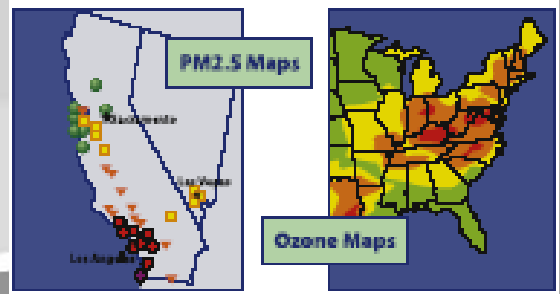
AIRNOW
www.epa.gov

The U.S. EPA has developed the AIRNow website to provide the public with easy access to national air quality information. This website offers daily Air Quality Index forecasts as well as real-time conditions for over 300 cities across the U.S.

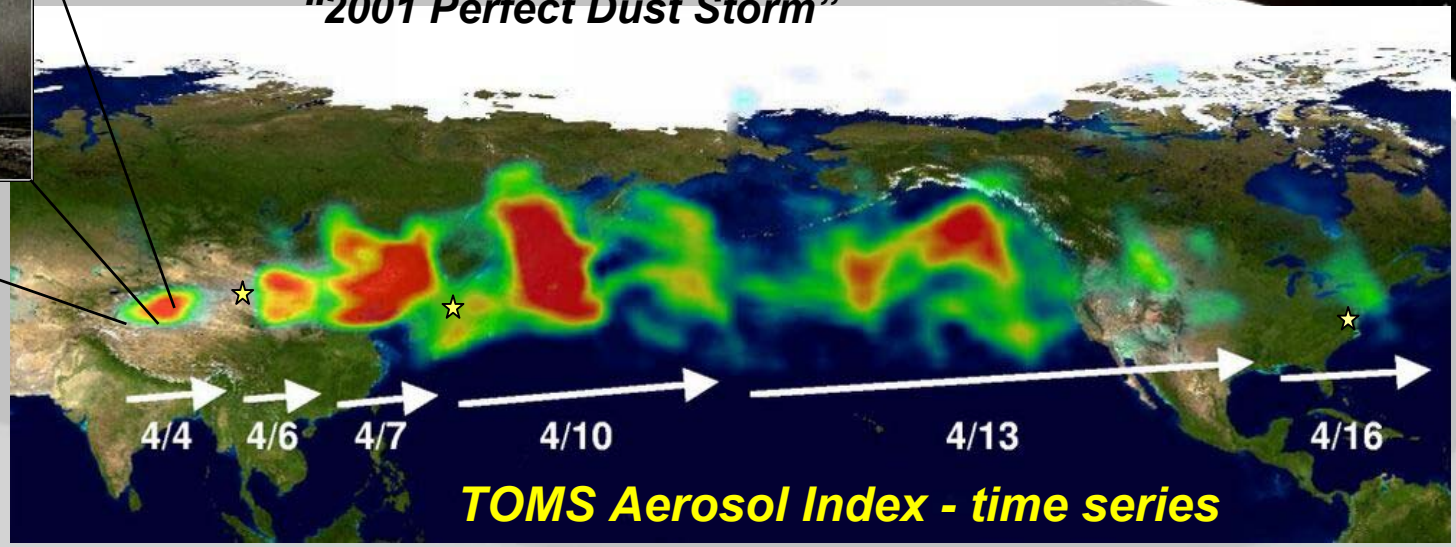
Ozone and PM2.5 Forecasts

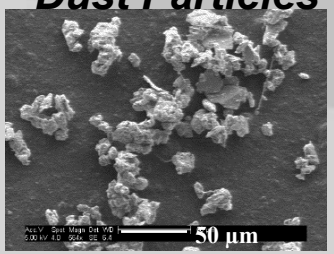


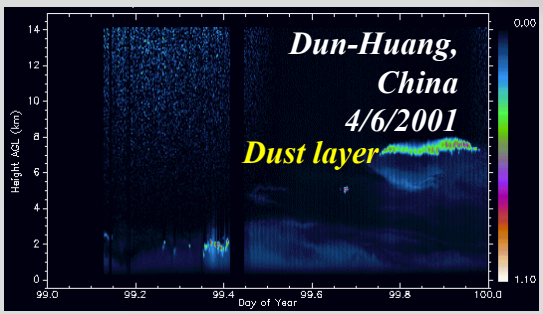
Current Air Quality Conditions

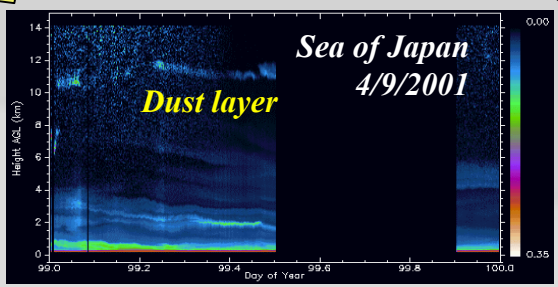


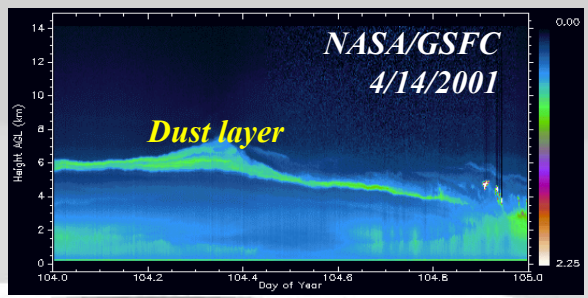
Asian Dust & microbes? Long Range Transport





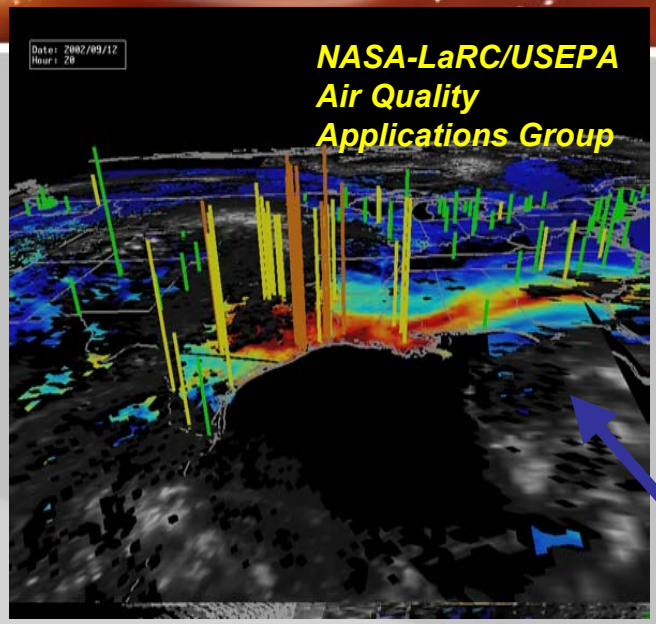






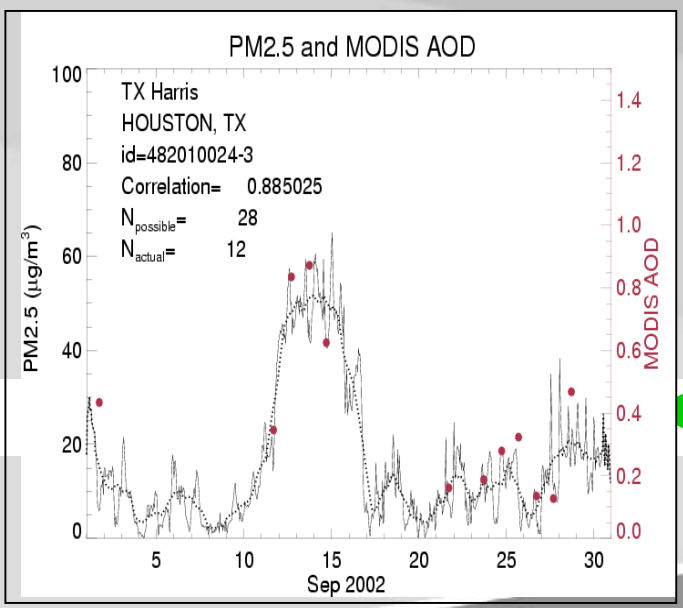
Lidar Profiling

Air Quality (*Regional*) – Adapting MODIS Aerosol Data for EPA



- Evaluating EPA network for regional areas
- Finding correlation between MODIS aerosol optical thickness and EPA ground based measurements
- Developing finer resolution MODIS products for variable urban regions

Evaluate current EPA observational network (posts) as to its ability to show regional aerosol events as resolved by MODIS (colored background).



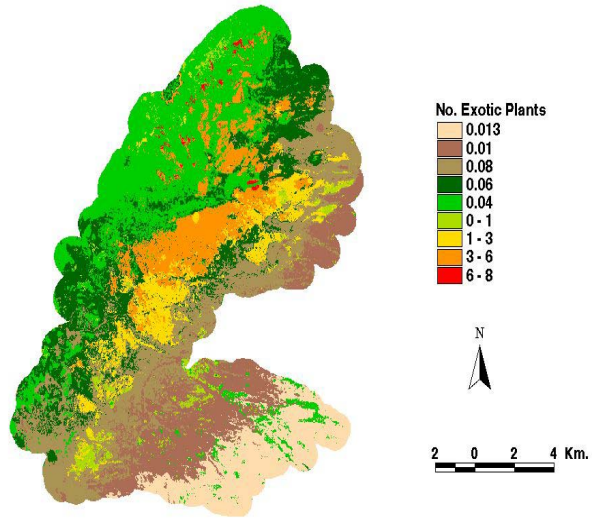
Relate MODIS AOD observations (red dots) to EPA ground station PM measurements (black time series)

Invasive Species Management

- **NASA and USGS developing a National Invasive Species Forecasting System. This uses MODIS data, aerial imagery, and ground data of various resolutions to map biological resources.**
- **Strong partnership with DoI, USDA and USGS**

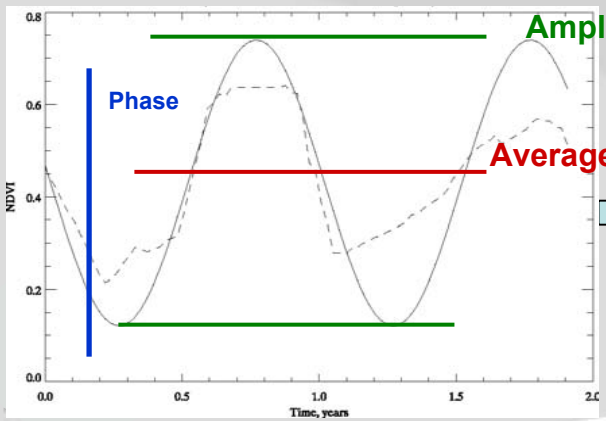
Cheat Grass (Bromis tectorum)
- ***Reduces soil moisture***
- ***Increase fire loading***
- ***Re-establishes early in burnt areas***

Predicted Spatial Map for Number of Exotic Species Richness with Mapping Unit of 30 Meters at Cerro Grande Wildfire Site, New Mexico.



Model Significant Variables:
UTM-X, UTMY, Native Plants, TM-Band (4), Vegetation Indexe (Bands 5/4, 4/3, NDVI), and TM-Tasseled Cap (Band 5); with R^2 = 58.2 %

Data fromMODIS, LandSat, EO-1



Trending & modeling

- Hot spots of native biodiversity
- Distribution of non-native species
- Potential spread of invasive species

Decision Support

- Economic and environmental risk assessment
- Priorities for control and Containment

Earth Sun Gateway Concept

Standard Browser, Web Mapping

3D GeoBrowser

Workstation Applications, Thick Clients

OpenGIS Interfaces

Earth Sun Gateway

- Portrayal Services
- Processing Services
- Catalog Services
- Authentication Services

WMS, WFS, WCS, Catalog

Application Integration Framework

Extensible, open portal architecture

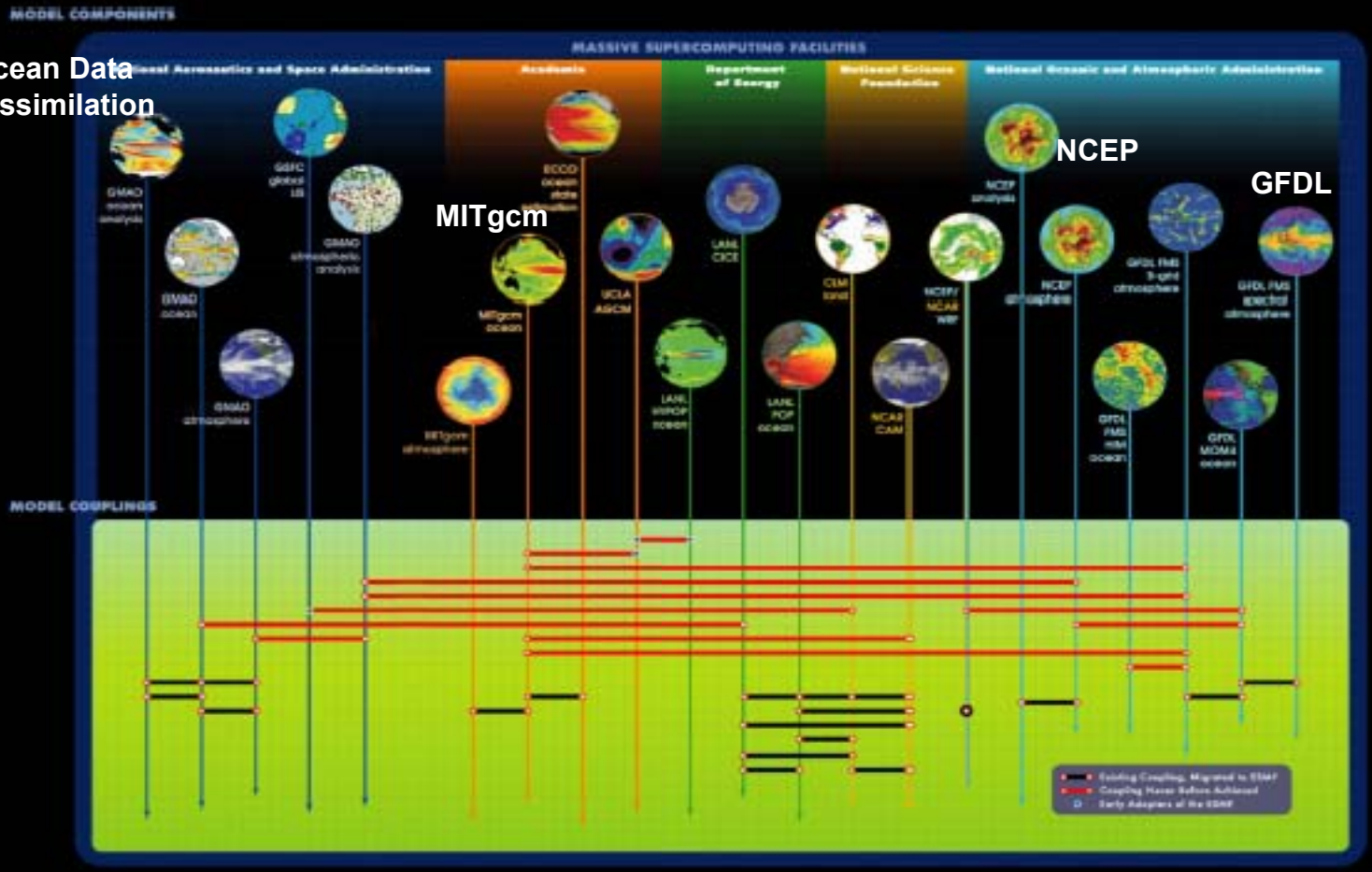
ESE Components

- Knowledge Base
- Digital Libraries
- Models
- ESMF
- Grid Resources
- Mission Data Products
- EOS Catalogs

http://webserv.gsfc.nasa.gov/images/aiwg.html

Earth System Models

EARTH SYSTEM MODELING FRAMEWORK



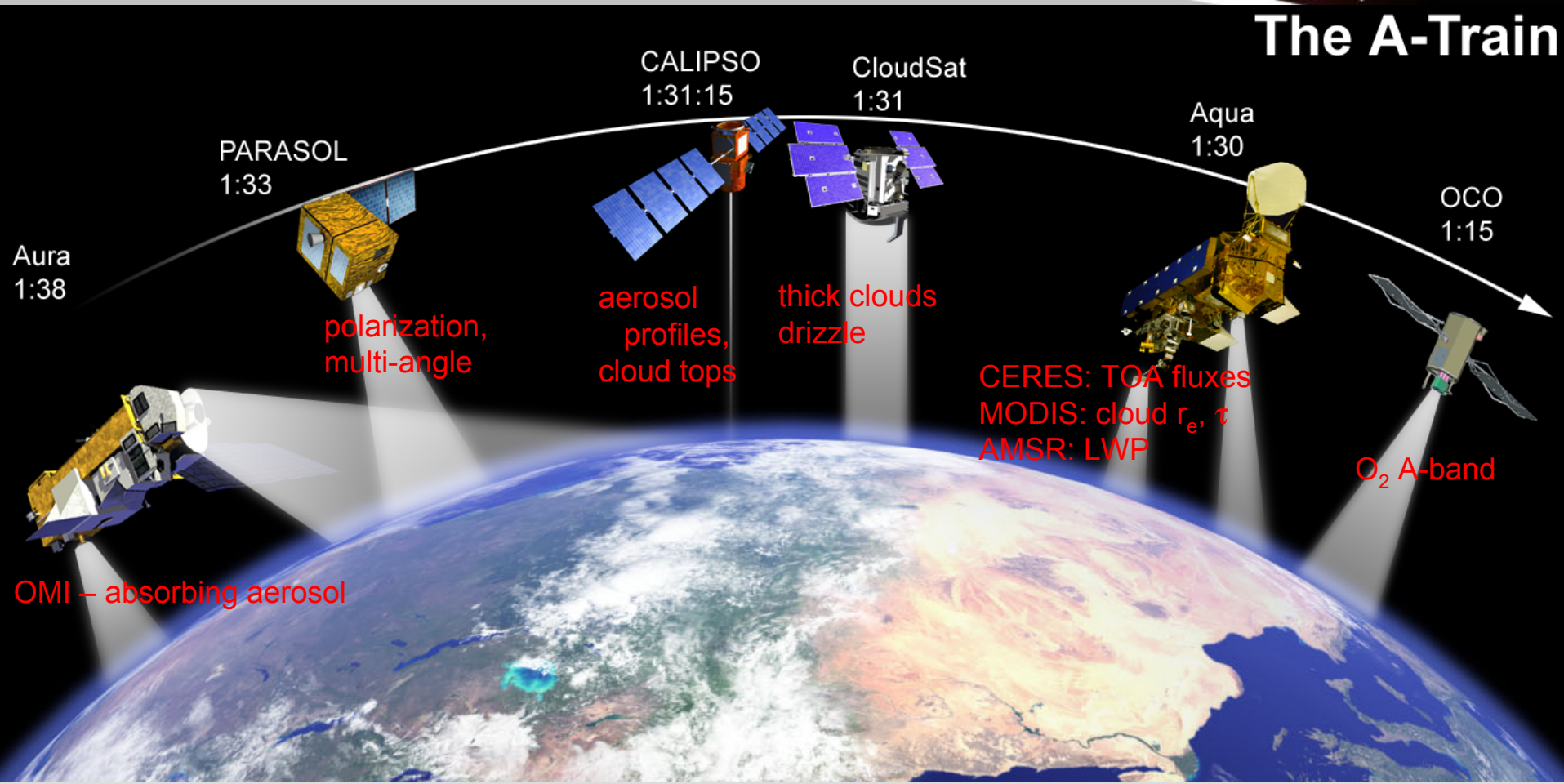
Ocean Data Assimilation

MITgcm

NCEP

GFDL

Earth Observation System A-Train: Aerosol/Clouds/Radiation



Global System for Earth Observation

Vantage Points

Far-Space

Near-Space

Airborne

Terrestrial

Permanent

Deployable

Capabilities

L1/L2/HEO/GEO
Sentinel satellites for continuous monitoring

LEO/MEO
Active & passive sensors for trends & process studies

Suborbital
In situ measurement in research campaigns & validation of new remote sensors

Surface-Based Networks
Ocean buoys, air samplers, strain detectors, ground validation sites

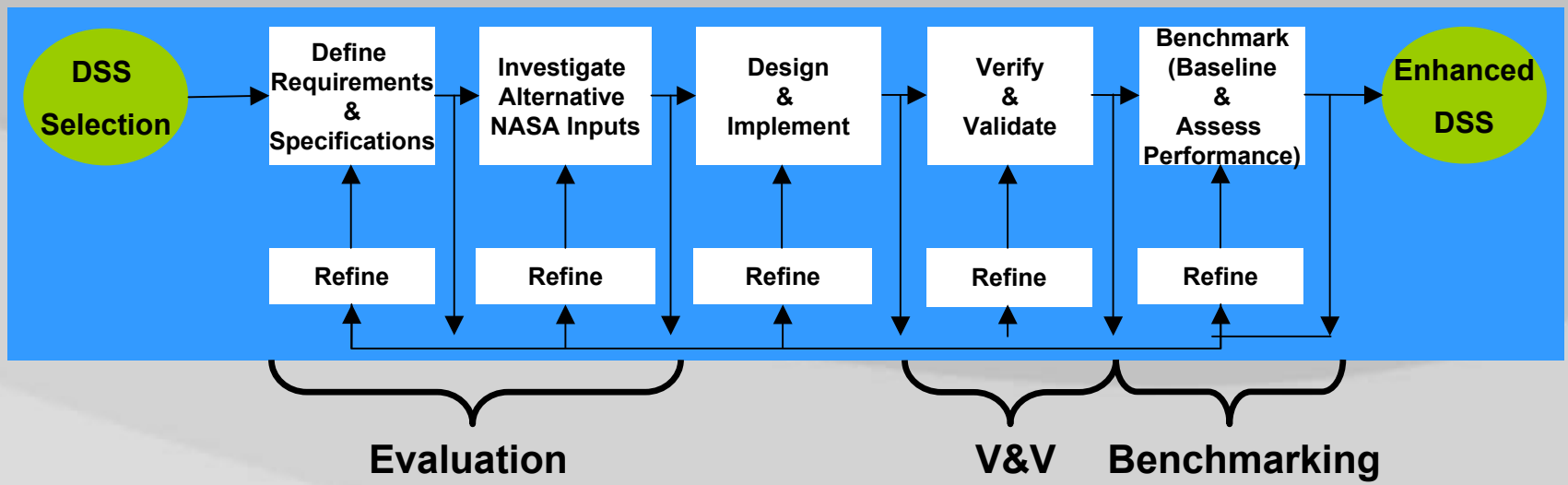
Information Systems
Data management, data assimilation, modeling & synthesis

Challenges Ahead

- Characterizing, understanding & predicting the interactions among the Sun, the Earth, and life
- Evolution of a comprehensive, coordinated and sustained Earth observation system
- Forging the partnerships required to sustain the system and its uses for scientific exploration and practical applications
- Applying the knowledge, capacity and systems from Earth-Sun System Science to Exploration
- Training the next generation of scientists, engineers, and decision-makers

Backup

Using Systems Engineering



DSS – Decision Support System

Data Acquisition to Data Access

Data Acquisition

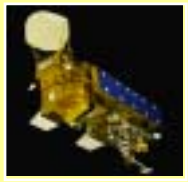
Flight Operations, Data Capture, Initial Processing & Backup Archive

Data Transport to DAACs

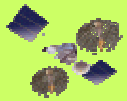
Science Data Processing, Data Mgmt., Data Archive & Distribution

Distribution, Access, Interoperability & Reuse

Spacecraft



Tracking & Data Relay Satellite (TDRS)



Ground Stations

Polar Ground Stations

Data Processing & Mission Control

NASA Integrated Services Network (NISN) Mission Services

EOSDIS Science Data Systems (DAACs)

REASoNs

WWW IP Internet

Science Teams

Measurement Teams

Research

Education

Value-Added Providers

Interagency Data Centers

International Partners

Use in Earth System Models

Benchmarking DSS

TECHNOLOGY

NASA/GIO - Agencywide Representation

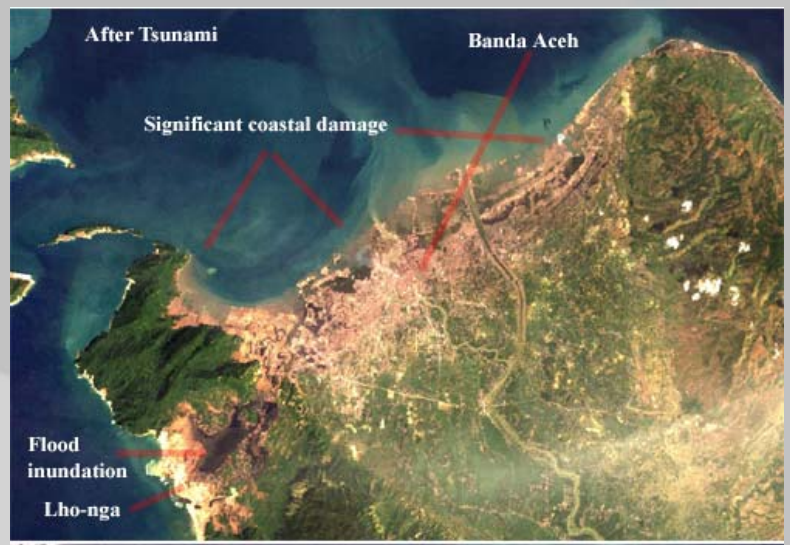
- Open Geospatial Consortium
  - www.opengeospatial.org
  - Not for profit consortium
- ISO TC211- Geographic Information
  - www.isotc211.org
  - Technical Committee of ISO
  - US Delegation; INCITS - L1
- Federal Geographic Data Committee
  - US Federal government directive
  - www.fgdc.gov
  - GAI WG
  - Homeland Security Working Group

OpenGIS® MEMBER

ISO International Organization for Standardization

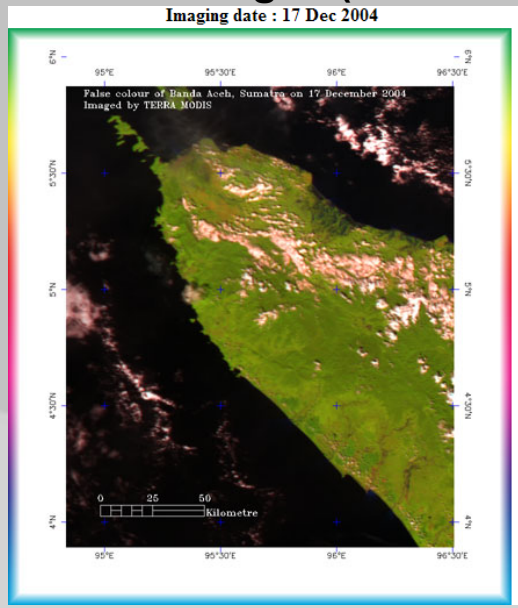
Federal Geographic Data Committee

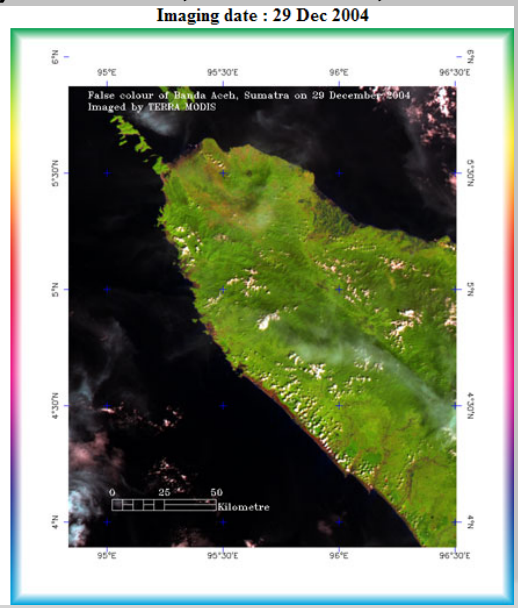
Landsat Images Pre- and Post- Sumatra Earthquake/Tsunami



NASA Satellite Views of Earthquake and Tsunami

Terra MODIS images (250m res.) of Aceh, Sumatra, Indonesia





Source: <http://www.crisp.nus.edu.sg/tsunami/>

Source: NASA Earth Observatory <http://earthobservatory.nasa.gov/>

Equivalent devastation extends 225 km southeast along the Sumatran Coast, in a band up to 3 km (1.9 miles) deep. Imagery from the MODIS (above) shows the affected area as a thin strip of brown color along the coast.