



NASA

# Applied Sciences Program

JACIE Workshop – November 8, 2004



## The NASA Vision

To improve life here,  
To extend life to there,  
To find life beyond.

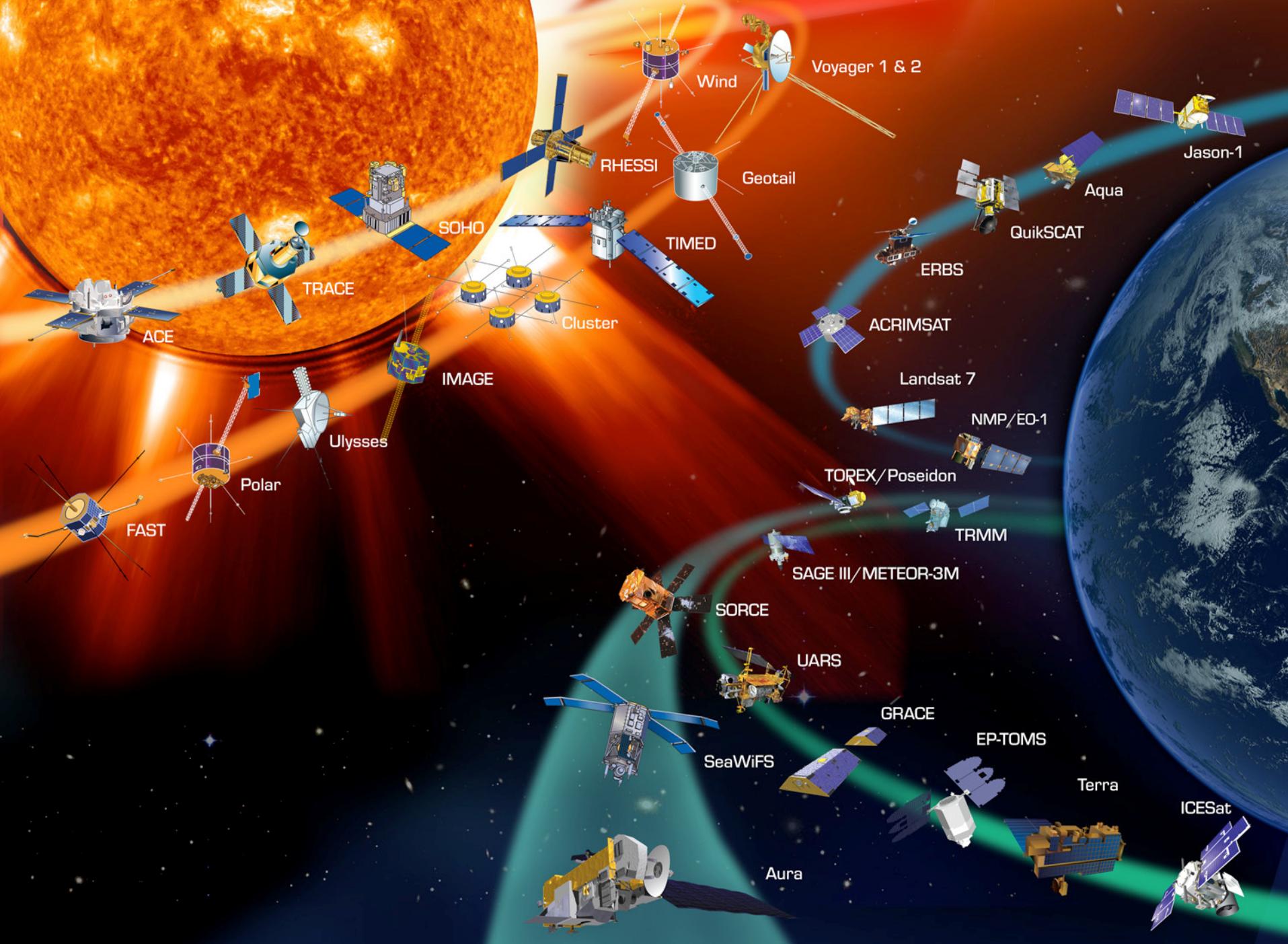
## The NASA Mission

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.



# What's New: NASA Transformation

- NASA Transformation: Merge Office of Earth Science with Office of Space Science
- Science Mission Directorate Formed
  - Three Mission Areas: Earth-Sun System, Solar System, Universe
- Sun-Earth System Division
  - Research Program
  - Missions Program
  - Applied Sciences Program
    - National Applications Program Element
      - 12 National Applications
    - Crosscutting Solutions Program Element
      - Integrated Benchmarked Systems Function
      - Solutions Networks Function
      - Human Capital Development Function
      - Geoscience Standards and Interoperability Function



# Earth-Sun System Research



Sun-Earth  
Connection

Climate Variability  
and Change

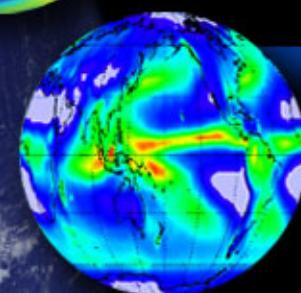
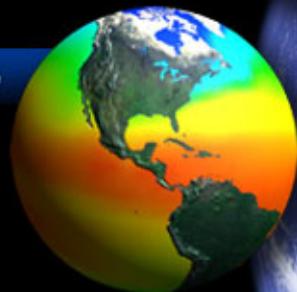
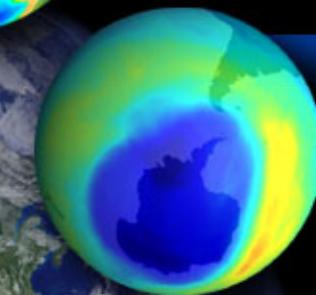
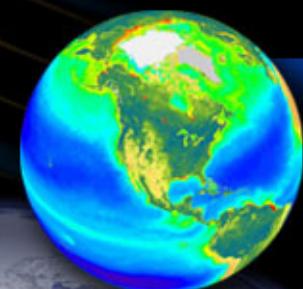
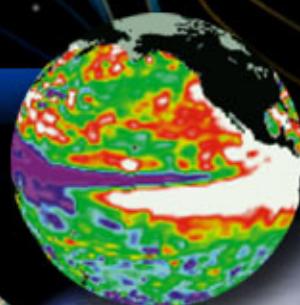
Carbon Cycle  
and Ecosystems

Earth Surface  
and Interior

Atmospheric  
Composition

Weather

Water &  
Energy  
Cycle





# Turning Observations into Knowledge Products

Downlink Speed

Petabytes  $10^{15}$

Multi-platform,  
multiparameter, high spatial  
and temporal resolution,  
remote & in-situ sensing

Advanced Sensors



Terabytes  $10^{12}$

Calibration, Transformation  
To Characterized Geo-  
physical Parameters

Data Processing & Analysis



Gigabytes  $10^9$

Interaction Between  
Modeling/Forecasting  
and Observation Systems

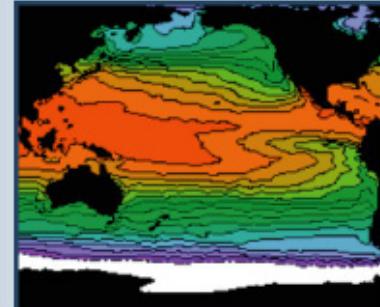
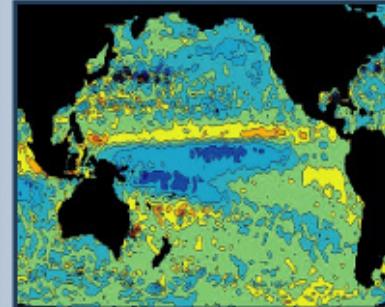
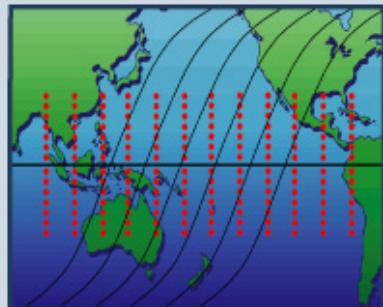
Information Synthesis



Megabytes  $10^6$

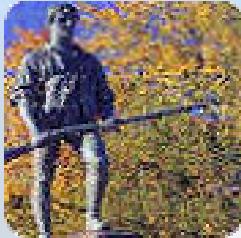
Interactive Dissemination  
and Predictions

Access to Knowledge





# Applications of National Priority



Homeland  
Security



Disaster  
Management



Energy  
Management



Aviation



Water  
Management



Public Health



Coastal  
Management



Carbon  
Management



Agricultural  
Efficiency



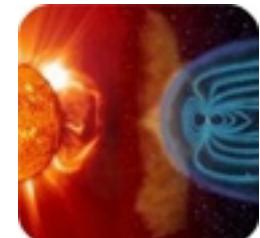
Invasive  
Species



Ecological  
Forecasting



Air Quality



Space Weather

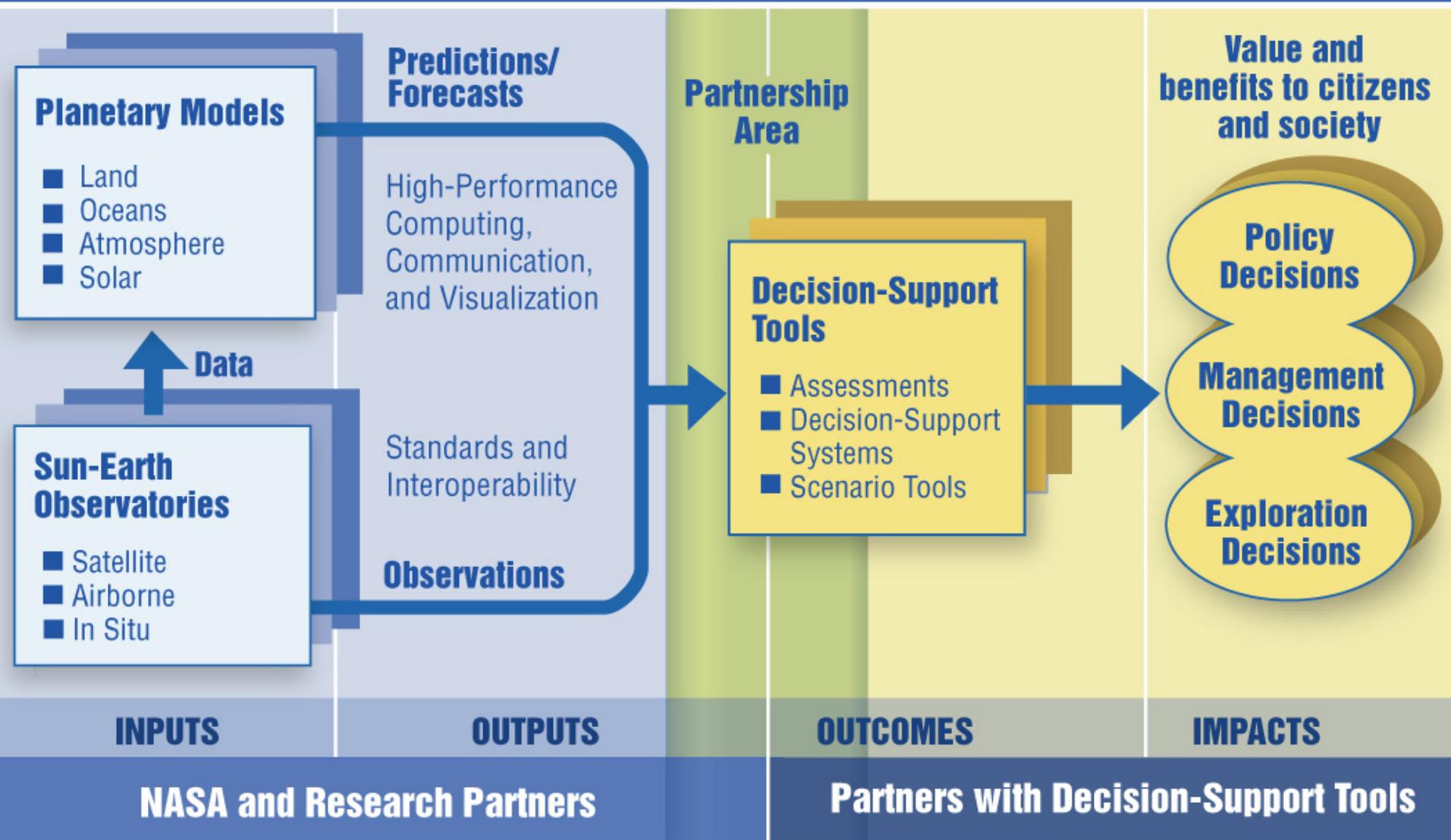


# Applications, Partners and Decision Support

National Application	Partner Organizations	Decision Support Tools - Current Priority (supporting decision processes)
Agricultural Efficiency	USDA, NOAA	CADRE – Crop Assessment Data Retrieval & Evaluation (USDA)
Air Quality	EPA, NOAA, USDA	CMAQ – Community Multi-scale 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	HAZUS-MH – Hazards U.S. – Multi Hazards
Ecological Forecasting	USAID, NOAA, NPS, CCAD, USGS	SERVIR – Regional Visualization & Monitoring System
Energy Management	DOE, UNEP, NOAA, NRC	RETScreen – Energy Diversification Research Laboratory (CEDRL)
Homeland Security	DHS, USGS, NOAA, NIMA, DoD	IOF – Integrated Operations Facility
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 & Surveillance RSVP – Rapid Syndrome Validation Project
Water Management	EPA, USDA, USGS, BoR	RiverWARE – Bureau of Reclamation Decision Support Tool AWARDS – Agricultural Water Resources & Decision Support Tool BASINS – Better Assessment Science Integrating Point & Non-point Source



# Integrating Knowledge, Capacity and Systems into Solutions



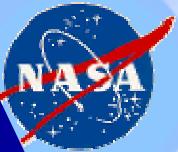


# National Priorities in a Global Context

Priority	National Activity	International Context
<b>National Vision for Human and Robotic Exploration</b>	Understanding the Earth as the Foundation for Planetary Exploration and Search for Life	<i>"Pursue opportunities for international participation to support U.S. space exploration goals"</i>
<b>Global Earth Observation</b>	<a href="#">NSTC CENR Interagency Working Group on Earth Observations</a> (IWGEO, 15 Agencies)	<a href="#">Earth Observation Summit</a> <a href="#">Group on Earth Observations</a> (GEO) Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan
<b>Climate Change</b>	<a href="#">Climate Change Science Program</a> (CCSP, 13 Agencies) <a href="#">Climate Change Technology Program</a> (CCTP, 12 Agencies)	<a href="#">Intergovernmental Panel on Climate Change</a> (IPCC))
<b>Weather</b>	<a href="#">U.S. Weather Research Program</a> (USWRP, 7 Agencies)	<a href="#">World Meteorological Organization</a> (WMO)
<b>Natural Hazards</b>	<a href="#">NSTC CENR Subcommittee on Natural Disaster Reduction</a> (SNDR, 14 Agencies)	<a href="#">International Strategy for Disaster Reduction</a>
<b>Sustainability</b>	<a href="#">Roundtable on Science and Technology for Sustainability</a> (National Academies)	<a href="#">World Summit on Sustainable Development</a> (WSSD)
<b>President's Management Agenda: E-Government</b>	<a href="#">Geospatial One-Stop</a> (GOS, 12 Agencies) and the <a href="#">Federal Geographic Data Committee</a> (FGDC, 19 Agencies)	<a href="#">World Summit on the Information Society</a>

# Air Quality

## Clean Air Standards and Air Quality Forecasts



January 2004,  
L. Friedl

### Socioeconomic Impact

Simultaneous high-time & space resolved pollutants (O<sub>3</sub>, CO, NO<sub>x</sub>, SO<sub>2</sub>, HCHO, aerosols); local resolution in boundary layer. Nighttime chemistry & transport. Feedbacks betw. aerosols, O<sub>3</sub>, H<sub>2</sub>O, climate. Chem-radiation coupling in GCMs. Quantify LRT in regional pollution.

NPP-NPOESS - ozone trend & aerosols. Feedbacks between O<sub>3</sub>, H<sub>2</sub>O, and aerosols. Global trop. winds. Geographic evol. of trop. O<sub>3</sub> & aerosols. Lightning NO<sub>x</sub> emission inventories. Trop. mixing & BL interaction. Urban-scale heat flux. High-res. soundings.

CloudSat & CALIPSO - cloud profiles. Accurate energy & water in MM5. Vertical levels in lower troposphere. Models incorporate radiative forcings. Land-atmos. interactions. Chemistry-transport models. Stratospheric/trop. coupling. Chemistry-climate interactions.

AURA - SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub> and aerosol products & IMPROVE network. INTEX-West. NH<sub>3</sub> emissions factors; air dispersion models (NO<sub>x</sub>, CO, PM); MM5 & assimilation of surface moisture, heat capacity, insulation. Nested model developments. RAQMS & DAS for daily 3-D ozone.

AURA - AURA - AURA. Trop. residuals (O<sub>3</sub>, NO<sub>2</sub>, SO<sub>2</sub>, HCHO); NRT NO<sub>x</sub> & VOC emission inventories (top-down/bottom-up) for CMAQ & ozone precursors; O<sub>3</sub> assimilations in CMAQ; 3-D global trop. chemistry in GEOS-CHEM; aerosol pattern rendering.

INTEX continental inflow-outflow; ICESat - vertical distribution of dust & clouds; ASTER urban heat flux; Global-to-regional RAQMS - prototype BCs in CMAQ; DAS nested GCM to 0.5° grid. Pollution trajectories & BL deposition of LRT of aerosols. PM network.

MODIS AOD, MOPITT CO, TOMS ozone residuals - correlate to EPA ground measures. Large scale transport of aerosols. GOCART assimilations for B.C.s in models. NRT MODIS-TEOM data fusion.

**State 1 (c.2003)**  
**CMAQ & AIRNow-AQI**

Accurate pollution forecasts updated regularly within day. Reduced hospital visits from extreme events. Improved NAAQS planning - fewer non-attainment areas. Insight on mobile emission fluctuations. Advanced, targeted mitigation of impacts from severe episodes.

Clear Skies NO<sub>x</sub>/SO<sub>2</sub> Trading Program. Longer lead-time on source & destination of ozone and aerosols. Alerts to re-route airplanes. Alerts to hospitals to expect specific symptoms. Ozone attainment areas. Potential EPA SIP credits for heat island reduction approaches & corresponding state/city policies.

Forecasts of beginning & length of annual "pollution season." Improvements from achievable SIPs - reduced haze, improved visibility in parks, cleaner water, healthier forest ecosystems, reduced lost work/school days. Support US treaty on long-range transport of organic pollutants.

Support for goals of Clear Skies initiative. Science-based attribution of source emissions. States quantify voluntary stationary emission reductions within 18 months. Heat island effects in local weather and air quality forecasts. Longer-term AQI forecasts. UV-B notice.

Support 2004 NO<sub>x</sub> SIP call. State justify & EPA corroborates claims for foreign-born pollution waivers. Annual EPA analysis of worst 20 pollution events for trends. Extend PM/O<sub>3</sub> forecasting to rural areas - warnings to farmers. Targeted mitigation approaches. Ozone loops in EPA's AQI.

States assess emissions control options, development options & emissions strategies to build attainable SIPs. Achievable SIPs improve air quality, public health & economic development opportunities. Urban health alerts for temperature-induced pollution events. EPA guidebook on heat island reduction approaches. States claim waivers for foreign-born pollutants.

Policy-Forecasts-Health-Economics. Aerosol transport loops in EPA Air Quality Index (AQI) for regional forecasts. Improved siting for surface monitoring network locations. Support EPA-developed tools for state/locals on regional haze. Evaluate exceptional events for effects on NAAQS violations. EPA PM transport rule making.



TOMS



Aqua/Terra



AERONET



ICESat



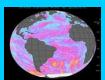
Aura



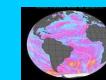
INTEX



CloudSat



CALIPSO



Glory



OCO



NPP/NPOESS



GTCM\*

2003

2005

2007

2009

2011

2013

2015

\* Unfunded

### State 2 (c. 2015): ESMF

- Robust emissions control planning
- Routine warnings of pollution events
- Multiple-day air quality forecasts



Improved capabilities to air quality managers to assess, plan & implement sound-science, emissions control strategies, policy, & air quality forecasts.



# Air Quality

## Integrated System Solution



### EARTH SYSTEM MODELS

- Aerosol Transport: GOCART
- Global-Regional Assimiliations: RAQMS
- Atmospheric Chemistry: GEOS-CHEM
- Emissions: SMOKE
- Meteorology: MM5, ETA
- Air Trajectories: NOAA-Hysplit4

Predictions

Data

### EARTH OBSERVATIONS

- Aerosols: Terra, Aqua, TOMS, Aura, Aeronet, AIRNow, INTEX, CALIPSO, Glory-APS
- Ozone & Precursors: TOMS, Aura, SAGE III, AIRNow, INTEX
- Trace Gases: Terra, Aqua, OCO
- Clouds: Terra, Aqua, CloudSAT, CALIPSO
- Land Use/Cover: Terra, Aqua, Landsat
- Atmospheric Parameters: GOES, POES, GITS, NPP, NPOES

Observations

### DECISION SUPPORT TOOLS

- Atmospheric state parameters
- Global-to-regional concentrations
- Emissions inventories
- Regional-Global transport
- Trace Gas Sources
- Aerosol properties
- Ozone profiles & columns
- Global-regional boundary conditions
- Data fusion techniques
- Ground-satellite data comparison techniques

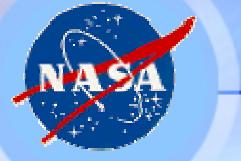
### AIRNow & AQI (Air Quality Index)

- Forecast transport of dust/pollutants
- Actions to reduce source emissions
- PM<sub>2.5</sub> forecasts

### International Treaties

### VALUE & BENEFITS

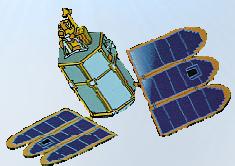
- Reduce lung-related diseases & premature death
- Reduce hospital admissions & use of medicines
- Reduce lost workdays and schooldays
- Improve visibility and reduce haze for tourism
- Improve resiliency of crops; increase yields
- Increase confidence in government
- Improve crop estimates
- Sensitive populations can change activities



# Air Quality



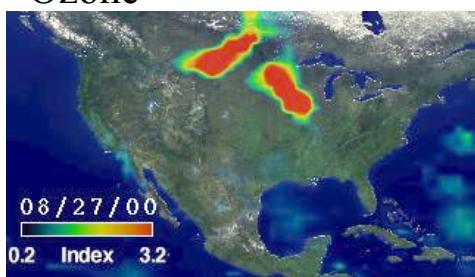
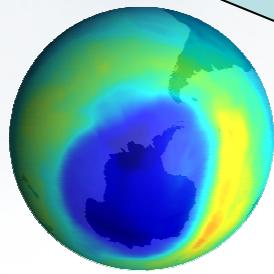
TOMS-EP



Aqua



Processing



Tasking



Data Processing & Mission Control



Exploitation



Public Access

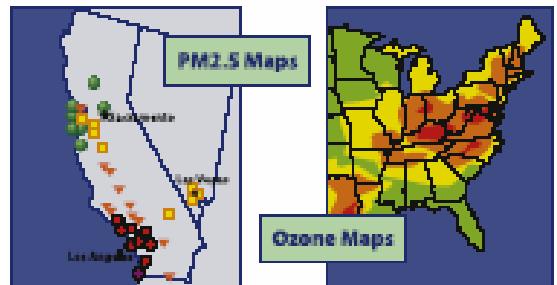


The U.S. EPA has developed the AIRNow website to provide the public with easy access to national air quality information. This website offers daily Air Quality Index forecasts as well as real-time conditions for over 300 cities across the U.S.

Ozone and PM2.5 Forecasts



Current Air Quality Conditions



EOSDIS Science Data Systems:  
DAACs



# Applied Sciences and JACIE

- NASA Research is Undertaken Utilizing Best Possible Data Sources AND Not Competing with Private Industry
- JACIE is integral to the Applied Sciences goal of incorporating commercial data sources into scientific research
  - Used by Earth System Science Research as an high resolution augmentation to NASA remote sensing assets
  - Used by Space Science to help characterize “Mars Analog” Features on Earth for Future Exploration
- Applied Sciences Annual Performance Goals Include:
  - Crosscutting Solutions: Work within the Joint Agency Committee on Imagery Evaluation and the Commercial Remote Sensing Policy Working Group through partnerships with NIMA, USGS, NOAA, and USDA to verify/validate at least two commercial remote sensing sources/products for Earth science research, specifically with respect to land use/land cover observations for carbon cycle and water cycle research.



# Applied Sciences Solicitation: Decision Support through Earth Science Results

## A--NASA COOPERATIVE AGREEMENT NOTICE (CAN) APPLIED SCIENCES PROGRAM-2004

### General Information

Document Type: Presolicitation Notice  
Solicitation Number: NN-H-04-Z-YO-010-C  
Posted Date: Sep 03, 2004  
Original Response Date: Dec 17, 2004  
Current Response Date: Dec 17, 2004  
Original Archive Date: Sep 03, 2005  
Current Archive Date: Sep 03, 2005  
Classification Code: A -- Research & Development

### Description

The National Aeronautics and Space Administration (NASA) is announcing opportunities to participate in the Applied Sciences Program of the Science Mission Directorate. The Program requests innovative solutions to evaluate, verify and validate, and benchmark solutions that **integrate NASA Earth and Space science results into decision-support tools of partnering organizations**. Proposals are invited in two main areas: 1) Integrated Systems Solutions to integrate NASA Earth and Space science results into applications of national priority, demonstrate prototypes, and benchmark performance, and 2) Solutions Networks to improve the collective ability of Earth science organizations to interact and harness the results of NASA Earth and Space science research. Participation in the CAN is open to all categories of domestic and foreign organizations, including educational institutions, industry, non-profit institutions, NASA research centers, and other government agencies and laboratories. This solicitation will be available electronically on the release date via the Internet at the Science Mission Directorate ? Destination Earth Home Page: <http://www.earth.nasa.gov/> under ?Research Opportunity.? Paper copies of the announcement will be available to those who do not have Internet access by calling (202) 358-3552 and leaving a voice-mail message. The following dates apply to this announcement: CAN Release Date: September 17, 2004 Step 1 (Pre-Proposals) Due: October 22, 2004 Step 2 (Final) Proposals Due: December 17, 2004 POC: Lawrence Friedl Program Manager, Science Applications Applied Sciences Program NASA Headquarters Washington, DC 20546 Phone: (202) 358-1599 Fax: (202) 358-3098 E-mail: [Lawrence.A.Friedl@nasa.gov](mailto:Lawrence.A.Friedl@nasa.gov) "This is a broad agency announcement as specified in FAR 6.102 (d) (2). Notwithstanding the posting of this opportunity at FedBizOpps.gov, Grants.gov, or at both sites, NASA reserves the right to determine the appropriate award instrument for each proposal selected pursuant to this announcement.



# Back Up Slides

- Questions or Comments, Contact:
- Martin Frederick/Deputy Director, Applied Sciences Program
  - Email: [Martin.Frederick-1@nasa.gov](mailto:Martin.Frederick-1@nasa.gov)
  - Program Website: [www.earth.nasa.gov/eseapps/](http://www.earth.nasa.gov/eseapps/)
  - Phone: 202-358-0913



# Disaster Management

## HAZUS-MH - Risk Assessment and Loss Estimation

January 12, 2004,  
S. Ambrose

### Primary Partners:



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



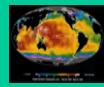
Terra



Aqua



TRMM



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.

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



# Disaster Management

## Integrated System Solution

### EARTH SYSTEM MODELS

- Earthquake: *MMI, Quakesim*
- Hurricane: *HURRSIM*
- Flood: *SLOSH, WAVEwatch, STWAVE, HURSURGE*
- Land: *GPS Network, SBEACH*
- Building Cost Models: *ATC-13*
- Building Structure Models: *EPEDAT*

Data

### EARTH OBSERVATIONS

- Land: *Landsat, SRTM, GPS, SCIGN, Terra, Aqua*
- Ocean: *QuickSCAT, IceSAT, GOES, POES, SSMI, JASON, TOPEX/POSEIDON*
- Atmosphere: *TRMM, GOES, POES, GPM, NPP, NPOESS*

\*Future Mission

Predictions

- Earthquake prediction
- Floods
- Hurricane & Typhoons

- Land Surface Topography
- Global Precipitation
- Ocean Surface Winds
- Surface Deformation
- Motions of the Earth's Interior

Observations

### DECISION SUPPORT TOOLS

- HAZUS-MH (Hazards U.S. - Multi Hazard)
  - Disaster Recovery/ Mitigation
  - Land use decision
  - Potential economic loss
  - Estimation of direct damage, induced damage, direct losses, and indirect losses
  - Accurate risk prediction to communities
  - Loss estimates of buildings, essential facilities, transportation & utility lifelines, and population
  - Social impacts



### VALUE & BENEFITS

- Identify/ Prioritize high-risk communities
- Reduction in lives lost
- Reduction in damage cost
- Anticipate the scope of disaster-related damage
- Improve disaster response
- Community Planning



# Disaster Management



QuikScat

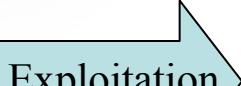
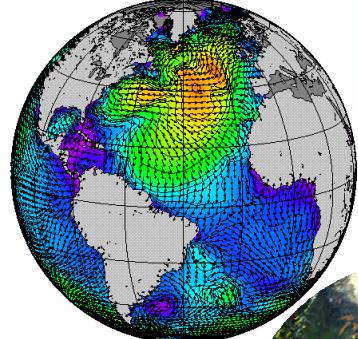


GRACE



Data Processing &  
Mission Control

Processing



EOSDIS Science Data Systems:  
DAACs

Tools for Decision Makers

**HAZUS**  
EARTHQUAKE • WIND • FLOOD



**HAZUS MH**  
can estimate losses from earthquakes,  
hurricane winds, and floods.

Use GIS technology to combine hazard layers with national databases and apply a standardized loss estimation and risk assessment methodology.



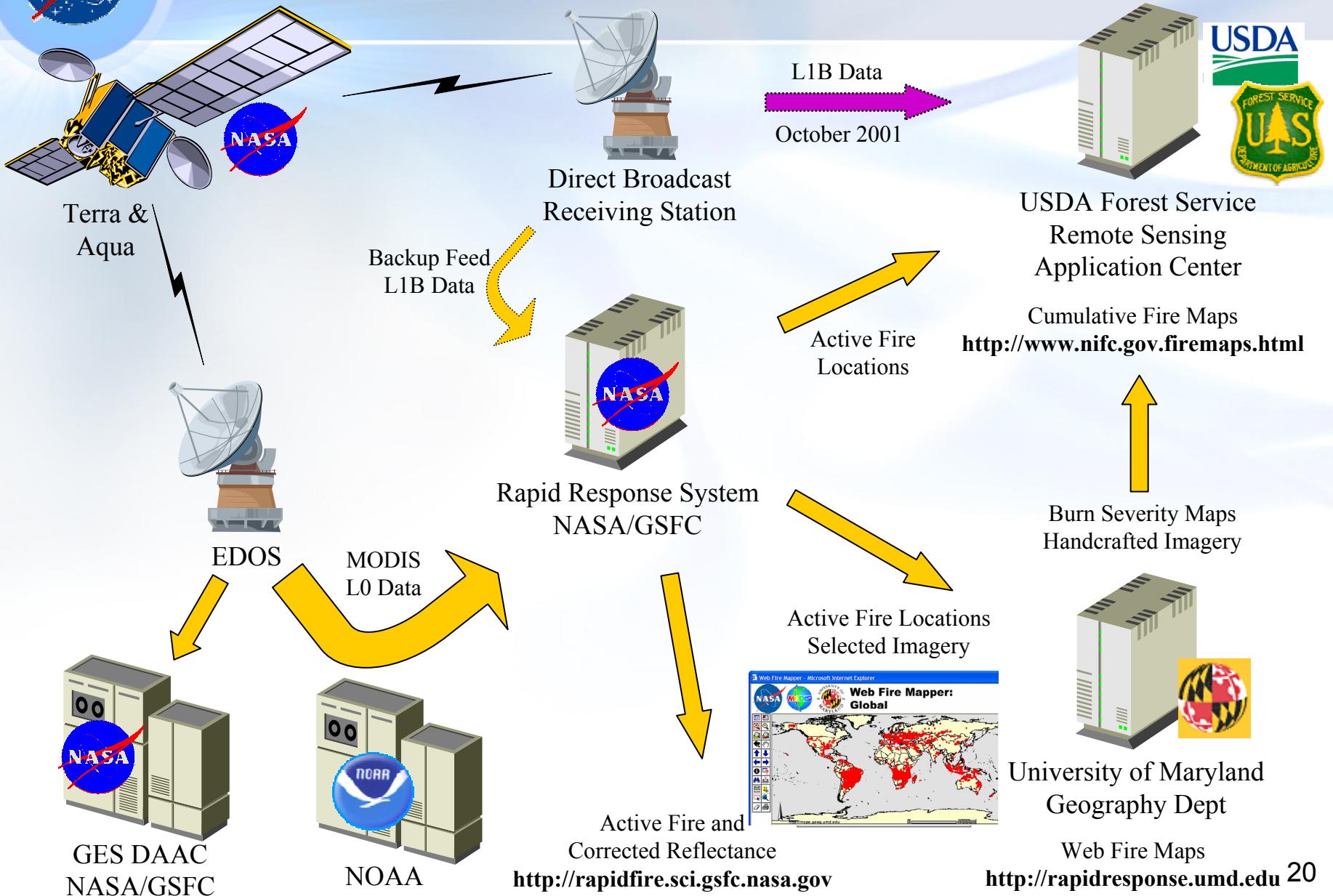
Nationwide database includes datasets on demographics, building stock, essential facilities, transportation, utilities, and high-potential-loss facilities.



Visit [www.fema.gov/hazus](http://www.fema.gov/hazus) for more information.



# MODIS Rapid Response Project

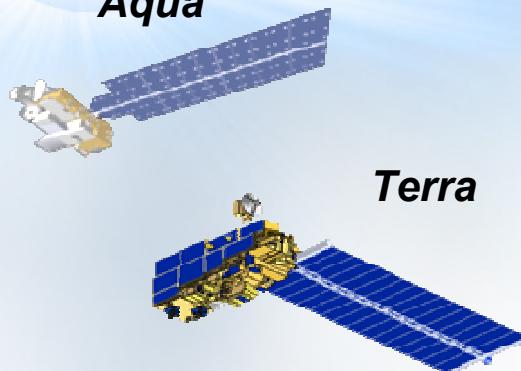




# Invasive Species

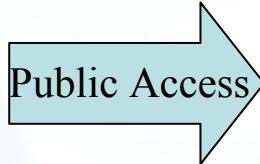


Aqua



Data Processing &  
Mission Control

Processing

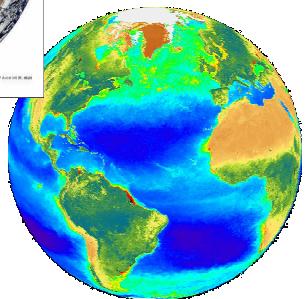
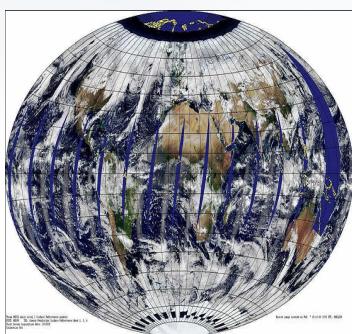


The public access interface includes:

- Microsoft Access (Relationships) showing tables like PlotCode, ParkCode, and PlotList.
- Microsoft Access (frontend2fb13 : Database) showing objects like Tables, Queries, Forms, Reports, and Pages. A table named PlotSiteDescription is shown with data:

ID	Plot Name	Date	start	elapsed time	UTM E
dry01a	7/17/98	7/17/98 7:55:00 AM	2:05	494	
wash01b	7/17/98	7/17/98 11:03:00 AM	2:27	494	
Cyan01					

- iParkInformation showing the State of the Parks Database with fields like ParkCode, Park Name, Designation, NPS Region, Superintendent First Name, Superintendent Last Name, and Superintendent Phone.
- ArcView GIS 3.2 showing a map with a white line drawn across it and a handheld device displaying the same map.



Exploitation



EOSDIS Science Data  
Systems: DAACs

Invasive Species  
Forecasting System<sup>21</sup>



# Agriculture Efficiency



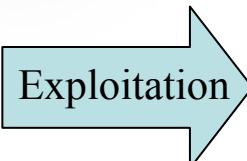
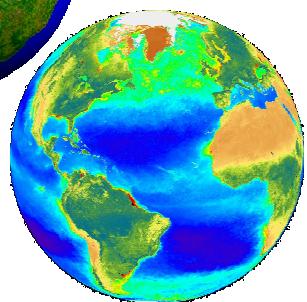
Jason



Terra



Data Processing &  
Mission Control



EOSDIS Science Data  
Systems: DAACs



CADRE



# SIAM-SERVIR

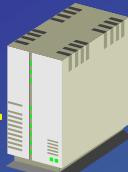
## Earth Observories



**Electronic Transfer:**

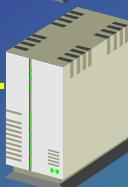
### SERVIR Node @ NSSTC

(NASA/MSFC and U. Alabama in Huntsville)



**Product Generation System**

- Ingest Data
- Subset Data Over C. Amer.
- Mine Data for Events
- Generate Products



**Web Server**  
[servir.nsstc.nasa.gov](http://servir.nsstc.nasa.gov)

- Distribute Products
- Archive Products



**Visualization System**

Source Data Archive

Product Archive

**Data & Algorithms**

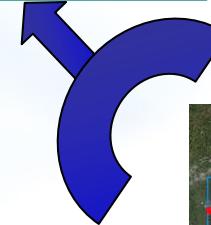
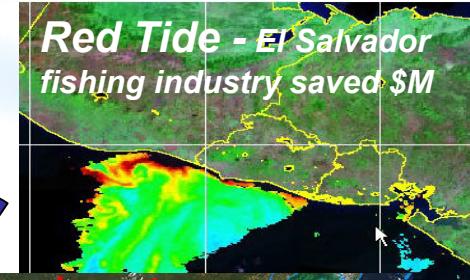
**SIAM-SERVIR Partners**

**Central American Commission for Environment and Development**



- Emergency Responders
- Environmental Managers
- Political Leaders
- Researchers, Educators

**Environmental Monitoring & Decision Support Products**



Rapid Response  
ftp, e-mail, etc.

**SERVIR Node in Panama**  
University of Arkansas  
(World Bank Funding)

- Geographic Info Systems
- Decision Support Systems
- Environmental Data from Central American countries

### Goals

- Rapid Response
- Corridor Preservation
- Species Preservation
- Sustained Development
- Better Living Conditions
- Policy Changes



# NASA Science Supporting Citizens

- NASA performs human and robotic exploration in space
  - *About 40% of NASA's budget is dedicated to the study of the Earth and the Universe using the unique vantage point of space*
  - *Our fields of research include Climate Variability and Change, Astronomy, Weather, Heliophysics, Atmospheric Composition, Astrobiology, and more*
- One of the purposes of our scientific research is to increase knowledge of the Earth-Sun System to enable improved predictions of climate, weather, and natural hazards
- The *NASA Applied Sciences Program* goal is to extend the results of our scientific research and knowledge beyond the science community to contribute to our partners' applications of national priority.
- The Program primarily optimizes benefits for citizens by contributing to partnering on applications that are used by state, local, and tribal governments.

