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.
NASA Transformation: Merge Office of Earth Science with Office of Space Science

Science Mission Directorate Formed

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
__Turning Observations into Knowledge Products__

**Petabytes $10^{15}$**
- Multi-platform, multiparameter, high spatial and temporal resolution, remote & in-situ sensing

**Terabytes $10^{12}$**
- Calibration, Transformation To Characterized Geophysical Parameters

**Gigabytes $10^{9}$**
- Interaction Between Modeling/Forecasting and Observation Systems

**Megabytes $10^{6}$**
- Interactive Dissemination and Predictions
## Applications, Partners and Decision Support

<table>
<thead>
<tr>
<th>National Application</th>
<th>Partner Organizations</th>
<th>Decision Support Tools - Current Priority (supporting decision processes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Efficiency</td>
<td>USDA, NOAA</td>
<td>CADRE – Crop Assessment Data Retrieval &amp; Evaluation (USDA)</td>
</tr>
</tbody>
</table>
| Air Quality               | EPA, NOAA, USDA       | CMAQ – Community Multi-scale Air Quality Modeling System  
                            | AIRNow & AOL – Air Quality Index                                        |
| Aviation                  | DOT/FAA, NOAA         | NAS_AWRP – National Air Space – Aviation Weather Research Program       |
| Carbon Management         | USDA, DOE, NOAA       | QUEST – 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,  | HAZUS-MH – Hazards U.S. – Multi Hazards                                 |
|                           | USGS, USFS            |                                                                          |
| Ecological Forecasting    | USAID, NOAA, NPS,     | SERVIR – Regional Visualization & Monitoring System  
                            | COAD, USGS                                                             |
| Energy Management         | DOE, UNEP, NOAA, NRC  | RETScreen – Energy Diversification Research Laboratory (CEDRL)          |
| Homeland Security         | DHS, USGS, NOAA, NIMA,| IOF – Integrated Operations Facility                                    |
|                           | DoD                   |                                                                          |
| 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  
                            | AWARD5 – Agricultural Water Resources & Decision Support Tool  
                            | BASINS – Better Assessment Science Integrating Point & Non-point Source |
Integrating Knowledge, Capacity and

Data

Planetary Models
- Land
- Oceans
- Atmosphere
- Solar

Sun-Earth Observatories
- Satellite
- Airborne
- In Situ

Predictions/Forecasts
- High-Performance Computing,
  Communication, and Visualization

Observations
- Standards and Interoperability

Decision-Support Tools
- Assessments
- Decision-Support Systems
- Scenario Tools

Partnership Area

Value and benefits to citizens and society
- Policy Decisions
- Management Decisions
- Exploration Decisions

INPUTS
- NASA and Research Partners

OUTPUTS
- Partners with Decision-Support Tools

OUTCOMES

IMPACTS
## National Priorities in a Global Context

<table>
<thead>
<tr>
<th>Priority</th>
<th>National Activity</th>
<th>International Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Vision for Human and Robotic Exploration</td>
<td>Understanding the Earth as the Foundation for Planetary Exploration and Search for Life</td>
<td>“Pursue opportunities for international participation to support U.S. space exploration goals”</td>
</tr>
<tr>
<td>Climate Change</td>
<td>Climate Change Science Program (CCSP, 13 Agencies)</td>
<td>Intergovernmental Panel on Climate Change (IPCC)</td>
</tr>
<tr>
<td></td>
<td>Climate Change Technology Program (CCTP, 12 Agencies)</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td>U.S. Weather Research Program (USWRP, 7 Agencies)</td>
<td>World Meteorological Organization (WMO)</td>
</tr>
<tr>
<td>Natural Hazards</td>
<td>NSTC CENR Subcommittee on Natural Disaster Reduction (SNDR, 14 Agencies)</td>
<td>International Strategy for Disaster Reduction</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Roundtable on Science and Technology for Sustainability (National Academies)</td>
<td>World Summit on Sustainable Development (WSSD)</td>
</tr>
<tr>
<td>President’s Management Agenda: E-Government</td>
<td>Geospatial One-Stop (GOS, 12 Agencies) and the Federal Geographic Data Committee (FGDC, 19 Agencies)</td>
<td>World Summit on the Information Society</td>
</tr>
</tbody>
</table>


AURA - SO2, NOx, NH3 and aerosol products & IMPROVE network. INTEX-West. NH3 emissions factors; air dispersion models (NOx, CO, PM); MM5 & assimilation of surface moisture, heat capacity, insulation. Nested model developments. RAQMS & DAS for daily 3-D ozone.

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.

TOMS 2003
Aqua/Terra 2005
AERONET 2007
ICESat 2009
Aura 2011
INTEX 2013
CloudSat 2015
CALIPSO
Glory
OCO
NPP-NPOESS
GTCM*

*Unfunded

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 NOx/SO2 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.


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.

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

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

State 2 (c. 2015): ESMF
- Robust emissions control planning
- Routine warnings of pollution events
- Multiple-day air quality forecasts
Air Quality
Integrated System Solution

**EARTH SYSTEM MODELS**
- Aerosol Transport: GOCART
- Global-Regional Assimilations: RAQMS
- Atmospheric Chemistry: GEOS-CHEM
- Emissions: SMOKE
- Meteorology: MM5, ETA
- Air Trajectories: NOAA-Hysplit4

**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, GIFTS, NPP, NPOES

**DECISION SUPPORT TOOLS**
- CMAQ (Community Multiscale Air Quality modeling system)
- Assess emissions control strategies
- Develop achievable SIPs (State Implementation Plan)
- Assess compliance
- Waivers to air standards
- Quantify voluntary stationary emission reductions

**AIRNow & AQI (Air Quality Index)**
- Forecast transport of dust/pollutants
- Actions to reduce source emissions
- PM$_{2.5}$ forecasts

**INTERNATIONAL TREATIES**
- 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

Tasking

Data Processing & Mission Control

Processing

Exploitation

Ozone

EOSDIS Science Data Systems: DAACs

Ozone Science Data Systems: DAACs

Current Air Quality Conditions

Ozone Maps

PM2.5 Maps

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 100 cities across the U.S.
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.
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 "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."
Questions or Comments, Contact:
- Martin Frederick/Deputy Director, Applied Sciences Program
  - Email: Martin.Frederick-1@nasa.gov
  - Program Website: 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

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

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

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

Production of assimilated data sets, reanalysis of long period observations

Outcomes:

Improvement of FEMA capabilities across all hazards and phases

Outcomes:

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

Outcomes:

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

Outcomes:

Improvement of the HAZUS-MH earthquake assessments and flood inundation for coastal areas

Outcomes:

Improvement in climate data and information for risk assessments

Impacts:

Reduce losses across all disasters

Impacts:

Reduce losses across all weather-driven Disasters and earth movement

Impacts:

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

Impacts:

Reduce losses related to hurricanes and earthquakes.

Impacts:

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

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

Socioeconomic Impact

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

State 1 - Earthquake
Damage assessment

QuickSCAT Terra Aqua TRMM OcnTopo Hydros OSWinds Aquarius NPOESS

2004 2005 2006 2008 2010 2020

* Pre-formulation
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*

**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*

**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
MODIS Rapid Response Project

Direct Broadcast Receiving Station

USDA Forest Service Remote Sensing Application Center
Cumulative Fire Maps http://www.nifc.gov/firemaps.html

Burn Severity Maps Handcrafted Imagery

University of Maryland Geography Dept
Web Fire Maps http://rapidresponse.umd.edu

NASA/GSFC
MODIS Rapid Response System
MODIS L0 Data

EDOS
Backup Feed L1B Data

Terra & Aqua

GES DAAC NASA/GSFC

NOAA

Active Fire Locations Selected Imagery

Corrected Reflectance
http://rapidfire.sci.gsfc.nasa.gov

Active Fire Locations

October 2001

Active Fire Locations

Web Fire Maps
http://rapidresponse.umd.edu

Handcrafted Imagery

http://www.nifc.gov/firemaps.html

Cumulative Fire Maps
Agriculture Efficiency

Jason

Terra

Tasking

Data Processing & Mission Control

Processing

Exploitation

Public Access

EOSDIS Science Data Systems: DAACs

CADRE
An Environmental Monitoring and Decision Support System for Central America

Central American Commission for Environment and Development
- Emergency Responders
- Environmental Managers
- Political Leaders
- Researchers, Educators

Environmental Monitoring & Decision Support Products
- Red Tide - El Salvador fishing industry saved $M
- Fires
- Land Cover/Use/Change
  - Rapid Response, ftp, e-mail, etc.

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

SERVIR Node in Panama
University of Arkansas (World Bank Funding)
- Geographic Info Systems
- Decision Support Systems
- Environmental Data from Central American countries

SERVIR Node @ NSSTC
(NASA/MSFC and U. Alabama in Huntsville)
- Ingest Data
- Subset Data Over C. Amer.
- Mine Data for Events
- Generate Products
- Distribute Products
- Archive Products

Web Server
servir.nsstc.nasa.gov

Electronic Transfer

Source Data Archive

Product Generation System

Terra Aqua
TOMS SSM/I GOES

Earth Observatories

SIAM-SERVIR Partners

Data & Algorithms

SIAM-SERVIR Partners

Red Tide - El Salvador fishing industry saved $M

Fires

Land Cover/Use/Change

Rapid Response, ftp, e-mail, etc.
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.