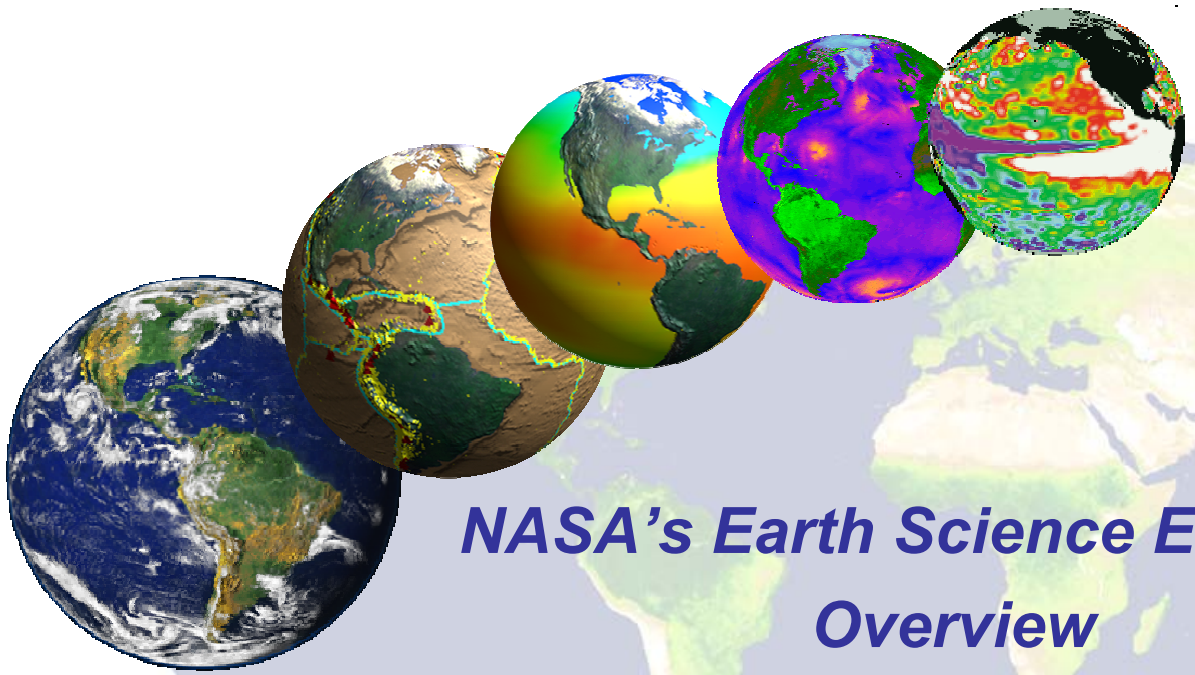
Presented to the
REASoN CAN Preproposal Conference



NASA's Earth Science Enterprise Overview

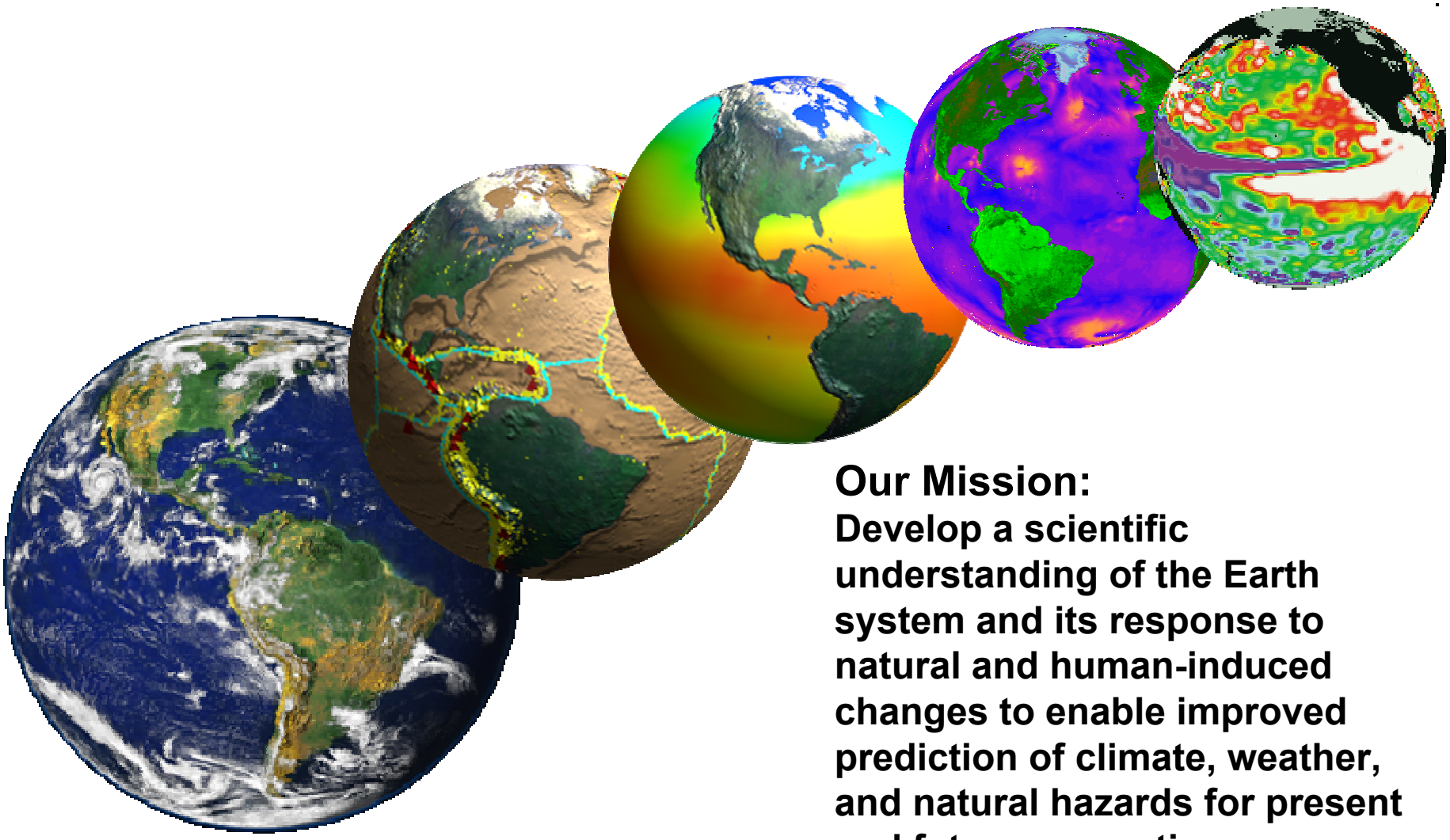
Office of Earth Science
Code Y
NASA HQ
October 10, 2002


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.

Earth Science in NASA

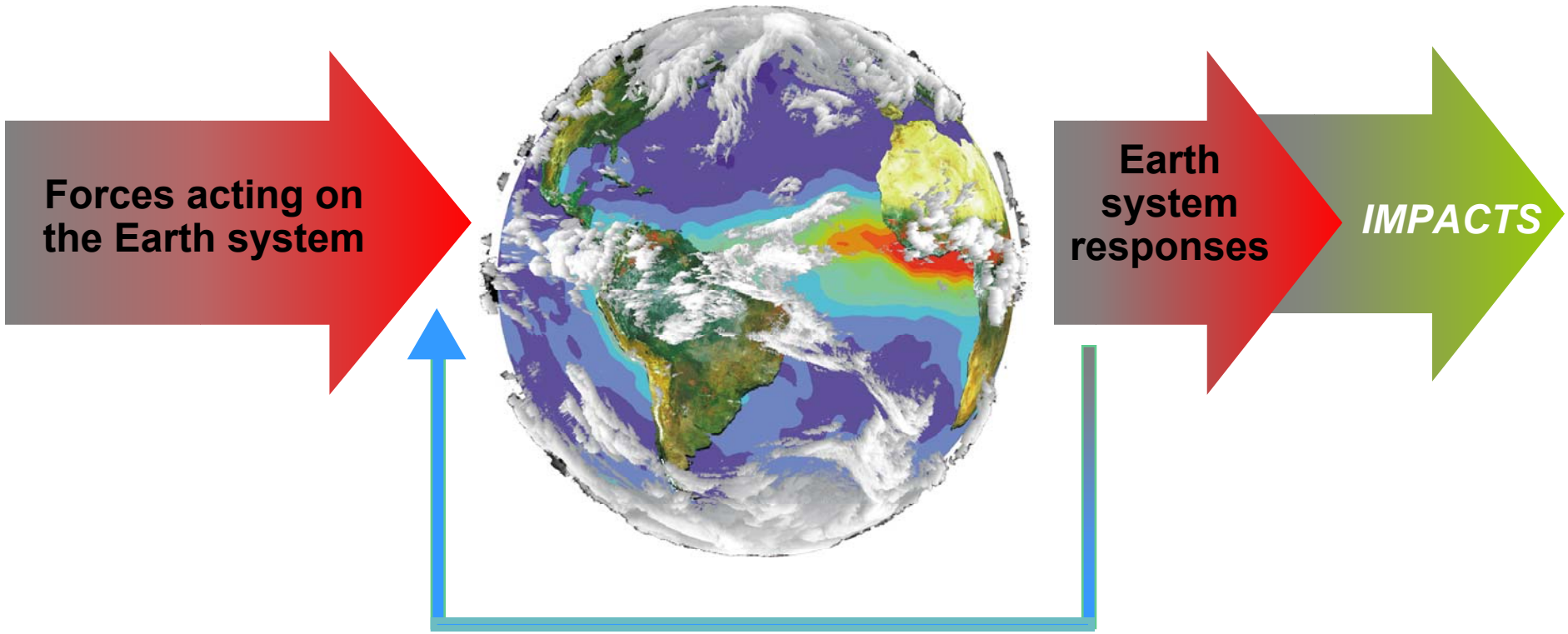
Earth Science is one of five Strategic Enterprises in NASA and is about 10% of NASA's annual budget.

Pioneering Scientific Observations of the Earth



Our Mission:
Develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations

Earth as a Dynamic System

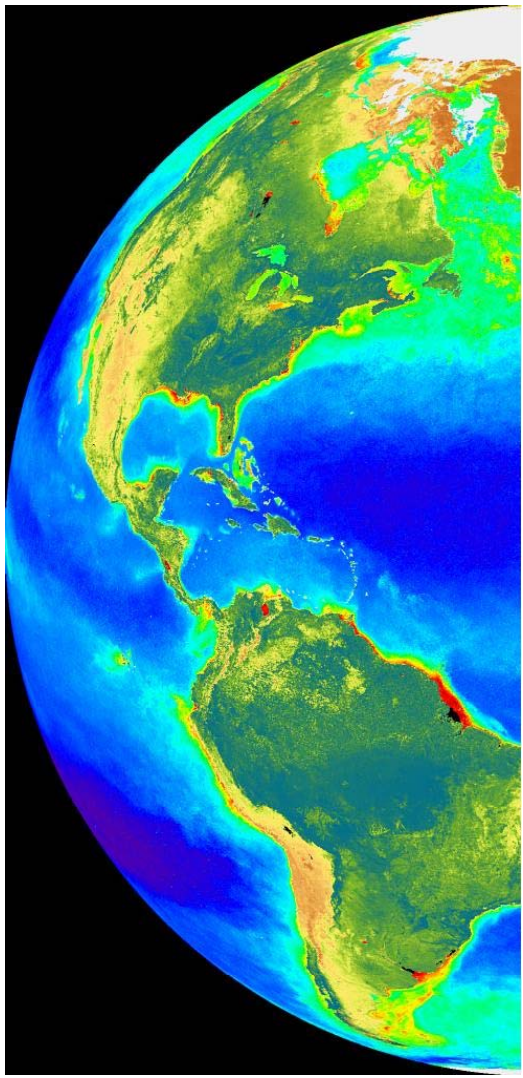


Feedbacks

Of the total forcing of the climate system, 40% is due to the direct effect of greenhouse gases and aerosols, and 60% is from feedback effects, such as increasing concentrations of water vapor as temperature rises.

Science Questions

- 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?



Science Questions from the Research Strategy

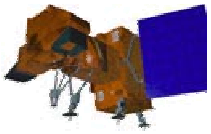
Variability	Forcing	Response	Consequence	Prediction
Precipitation, evaporation & cycling of water changing?	Atmospheric constituents & solar radiation on climate?	Clouds & surface hydrological processes on climate?	Weather variation related to climate variation?	Weather forecasting improvement?
Global ocean circulation varying?	Changes in land cover & land use?	Ecosystem responses & affects on global carbon cycle?	Consequences in land cover & land use?	Transient climate variations?
Global ecosystems changing?	Surface transformation?	Changes in global ocean circulation?	Coastal region change?	Trends in long-term climate?
Stratospheric ozone changing?		Stratospheric trace constituent responses?		Future atmospheric chemical impacts?
Ice cover mass changing?		Sea level affected by climate change?		Future concentrations of carbon dioxide and methane?
Motions of Earth & interior processes?		Pollution effects?		

Answering Science Questions: What is required?

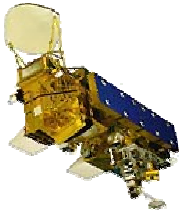
- **Research & Analysis**
  - Sponsor competitively selected research, analysis and modeling via open solicitations structured around the science question
  - Support basic Earth science R&A and related EOS and other mission science teams, the suborbital science program, and the interdisciplinary research investigations.
- **Observations**
  - Systematic measurement missions to detect trends against the background variability in the Earth system
  - Exploratory measurement missions to examine lesser understood but important Earth system processes (particularly in forcings and responses)
- **Technology**
  - Technology development and demonstration to reduce the cost and enhance the capability of future missions and data product capabilities
- **Data Management and Distribution**
  - Provide access to massive volumes of data, needed for increasingly fine resolution analyses and models and for the application of multiple data sets from many sources
  - Improve access with the advent of a network of active archives, science and applications data and information partners, and data services
- **Modeling**
  - Modeling via advanced computing to enhance the predictive power with space based observations and prepare accurate geophysically-consistent global data sets
- **Assessments and Decision Support**
  - The results of research will be used in periodic reassessment of questions and prioritization
  - Data sets and models will be incorporated into decision support systems through partnership with other federal and non-federal agencies

Multiple Satellite Observations Provide Global Perspectives

The Earth Observing System -- systematic measurement of interactions among land, oceans, atmosphere, ice & life

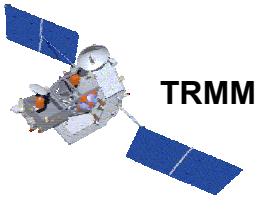


Landsat



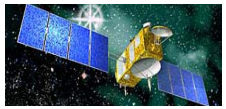
Aqua

Exploratory missions to probe key Earth system processes globally for the first time



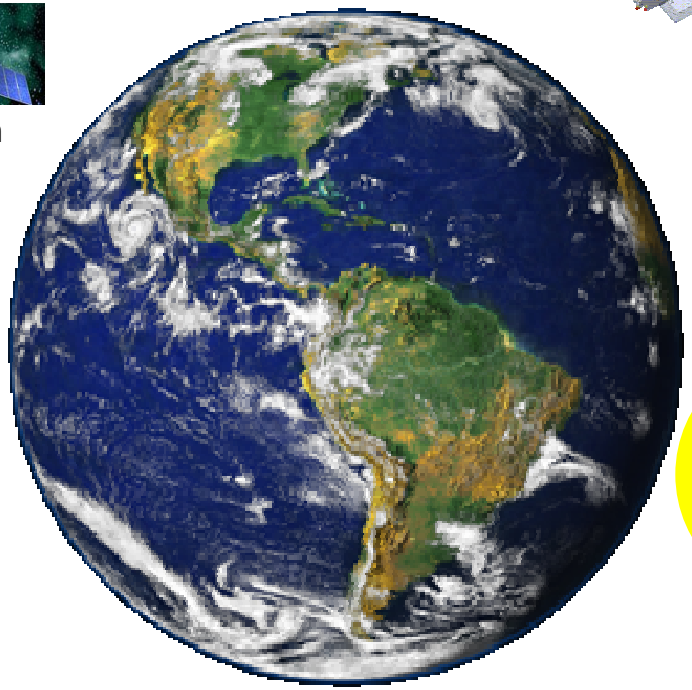
TRMM

GRACE



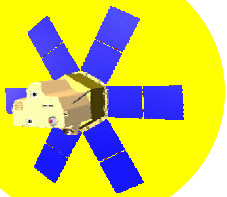
Jason

Terra



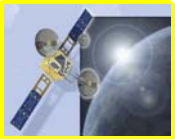
CALIPSO

Cloudsat

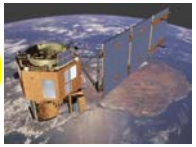


SORCE

ICESat



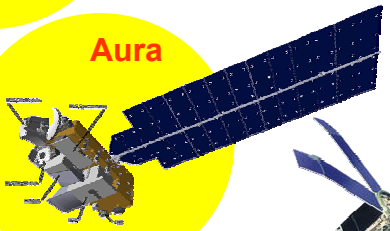
EO-3: GIFTS

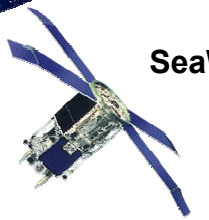


EO-1: ALI & Hyperion

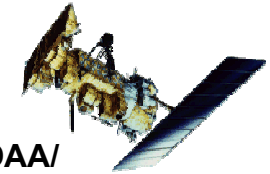
Operational precursor / Technology demos

Aura





SeaWiFS



NOAA/ POES

NOAA/ GOES

Operational weather services missions for NOAA

Development of Enabling Technologies

Planning

- Capability/Needs Assessment
- Development and Infusion Planning

Development Projects

- Instrument Incubator
- Advanced Tech Initiativ
- Advanced Info Sys Tech
- Computational Technologies
- New Millennium Program
- Suborbital and Space Validation

Products

- Instruments
  - –Critical components
  - –Measurement Techniques
- Information Systems
  - –System elements
  - –Modeling Infrastructure
- Platform Capabilities

Cooperating Programs

SBIR NIAC
Pioneering Revolutionary Techs
OSS NMP

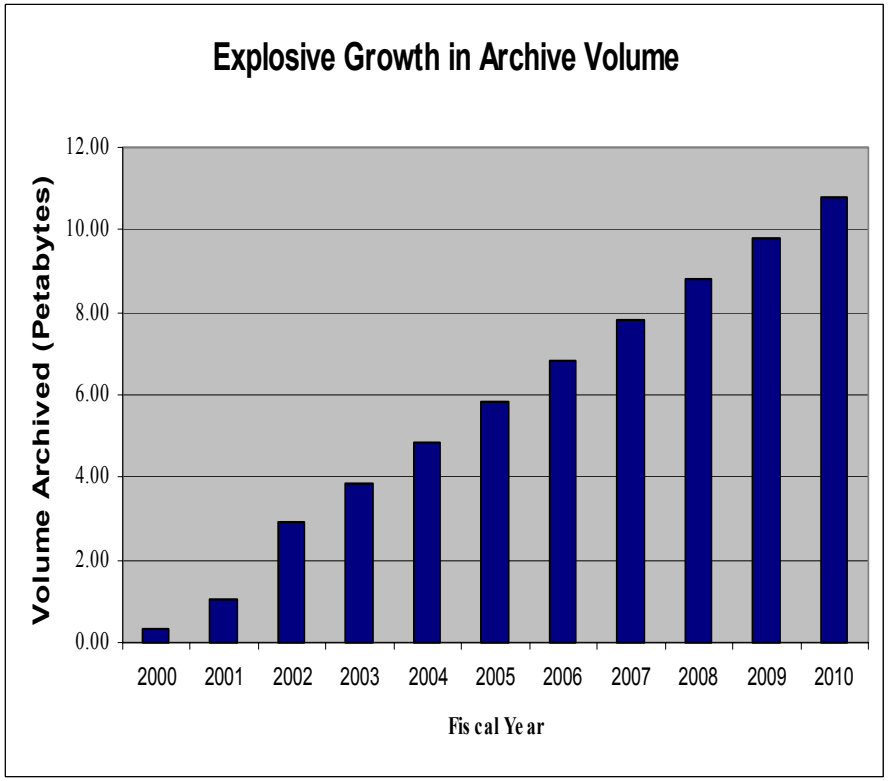
External Programs

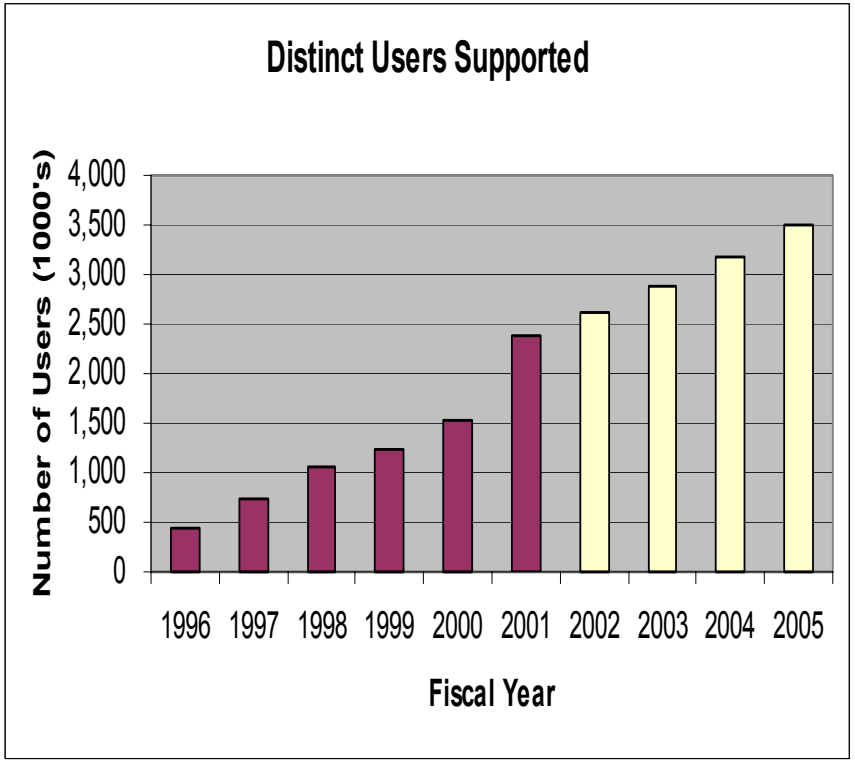
DoD DARPA
DoE NOAA

NASA is Meeting a Growing Demand for Earth Science Data and Information

Ingesting, processing, and archiving an unprecedented volume of climate and Earth science data.

NASA is benchmarking capabilities and processes for handling the capacities for future operational needs (e.g., NPOESS).





NASA provides access to Earth system science data, information, and services to millions of unique users.

Over the next decade, NASA will ensure the timely delivery of Earth Science information at an affordable cost by evolving to a more open, distributed set of data systems and service providers.

Managing the End-to-End Information Flow

Petabytes 10^{15}

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

Calibration, Transformation To Characterized Geophysical Parameters

Terabytes 10^{12}

Interaction Between Modeling/Forecasting and Observation Systems

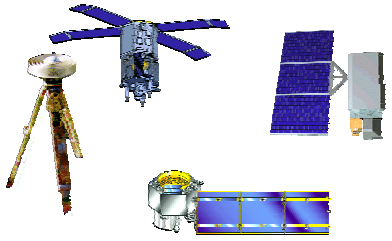
Gigabytes 10^{9}

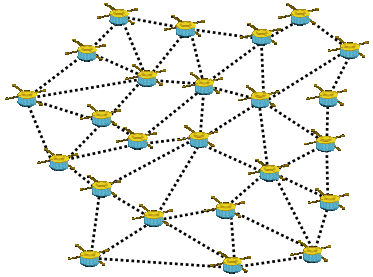
Interactive Dissemination

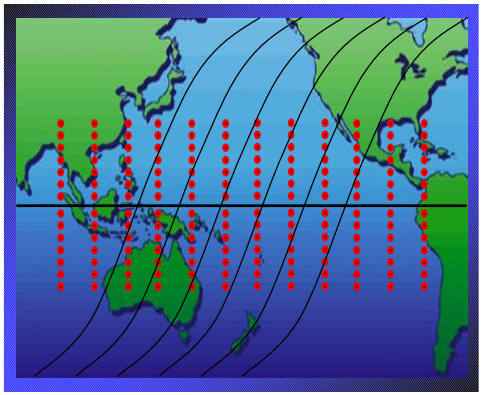
Predictions

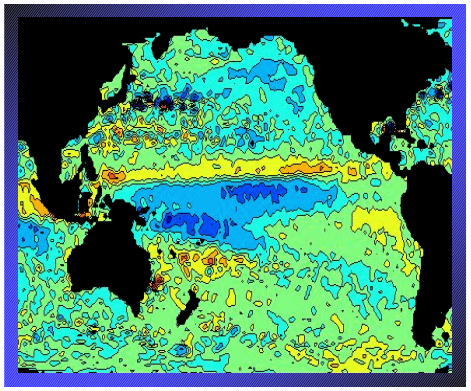
Megabytes 10^{6}

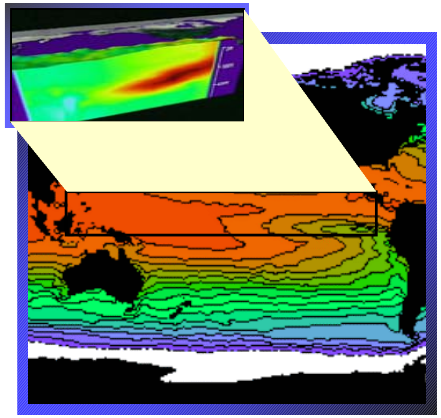
Advanced Sensors	Data Processing & Analysis	Information Synthesis	Access to Knowledge

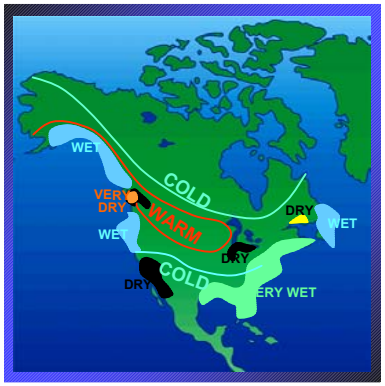










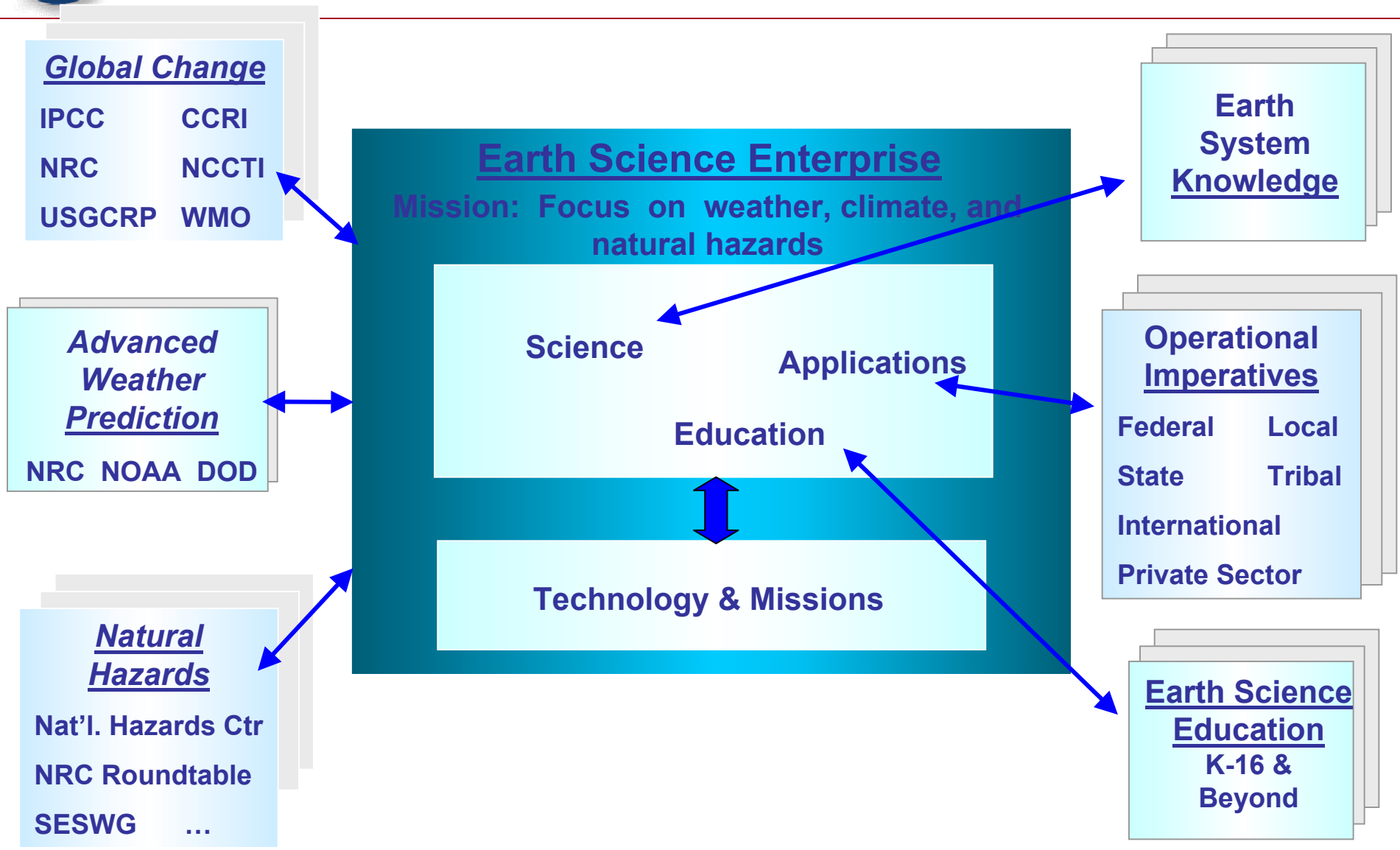


Computing & Modeling at ESE: From Observations to Predictions

- Full power of satellite data is achieved when they are integrated with computational modeling capabilities:
  - Model initialization - for weather and climate forecasts
  - Model evaluation - for all classes of models
  - Data assimilation - preparation of accurate, global, geophysically consistent data sets for research and applications uses
- The challenge facing ESE is to integrate massive amounts of data with computationally demanding scientific models and to be able to produce products for research and decision support
- NASA efforts emphasize this integration, and take advantage of the availability of large-scale computing facilities within NASA, and agency capabilities in computer architecture and software engineering

High-end computing and modeling are the key to transforming data into useful information for decision makers.

Beyond Scientific Exploration…serving Society



Learning through Telepresence

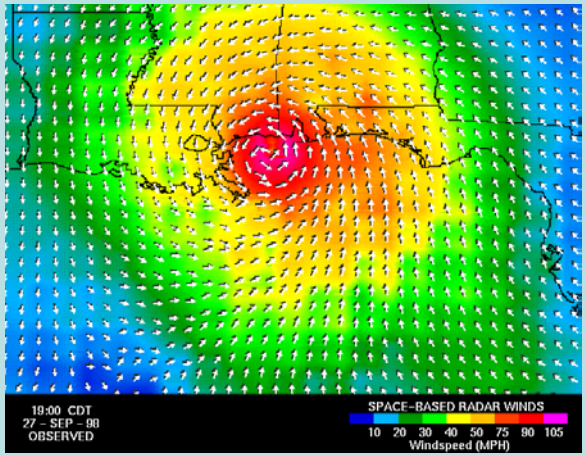
4-D Internet Visualization

Access to continuously updated databases of Earth science data with capability to view time series

Context-Sensitive Education Modules

Access to continuously updated education modules on Earth science, remote sensing technologies, missions, models, and decision support tools

Context-Sensitive Models & Decision Support Tools



Access to continuously updated models and decision support tools for learning how to run scenarios

Earth Science National Applications

Carbon Management

Public Health

Energy Forecasting

Aviation Safety

Water Management

Homeland Security

Coastal Management

Disaster Preparedness

Agricultural Competitiveness

Invasive Species

Community Growth

Air Quality

Socioeconomic Benefits

National Applications	Estimated Economic Benefits	Citation
Energy Forecasting	$9.58 B / yr **Estimated annual benefit from implementation of the POWER Project (Biomass Energy Industry and Energy Resource Planning Phases only; average for 2002-2017)**	**LARC Report: *An Estimate of NASA/ESE/POWER Program Benefits to the U.S. From 2002 through 2017*, June 3, 2002.**
Carbon Management	$150B / yr **Cost savings by soil sequestration for meeting the WRE Carbon 550 Emissions Constraint as determined by the MiniCAM model**	***Carbon Sequestration in Soils: Science, Monitoring and Beyond*; St. Michaels Workshop, Dec 1998**
Agricultural Competitiveness	$300M / yr **Projected annual benefit from improved crop prediction based upon better climate forecasting**	***NOAA Strategic Plan*: *A Vision for 2005*; September 1998**

Socioeconomic Benefits

Air Quality Management	350,000 fewer cases of aggravated asthma & 5,000 premature deaths 1 million fewer cases of reduced lung function in children $500 million estimated from ozone reductions…EPA estimate of annual benefit from adopting new NAAQS standards	**EPA Fact Sheet, June 25, 1997** **EPA Fact Sheet, July 17, 1997** **US EPA, National Air Quality and Emissions Trends Report, March 2001**
Disaster Management	$240M / yr **Reduction in losses/yr to the Property and Claims industry through adoption of geospatial technologies $100M per typical hurricane** **If 24 hour evacuation predictions could be improved to 300 miles of coastline**	**Insurance Services Office (ISO), 2002.** ***Weather Impacts, Forecasts and Policy,* March 2002 BAMS**
Public Health	$200M / yr **Amount that could be reduced to fight asthma.**	**Johns Hopkins School of Public Health, May 2000**

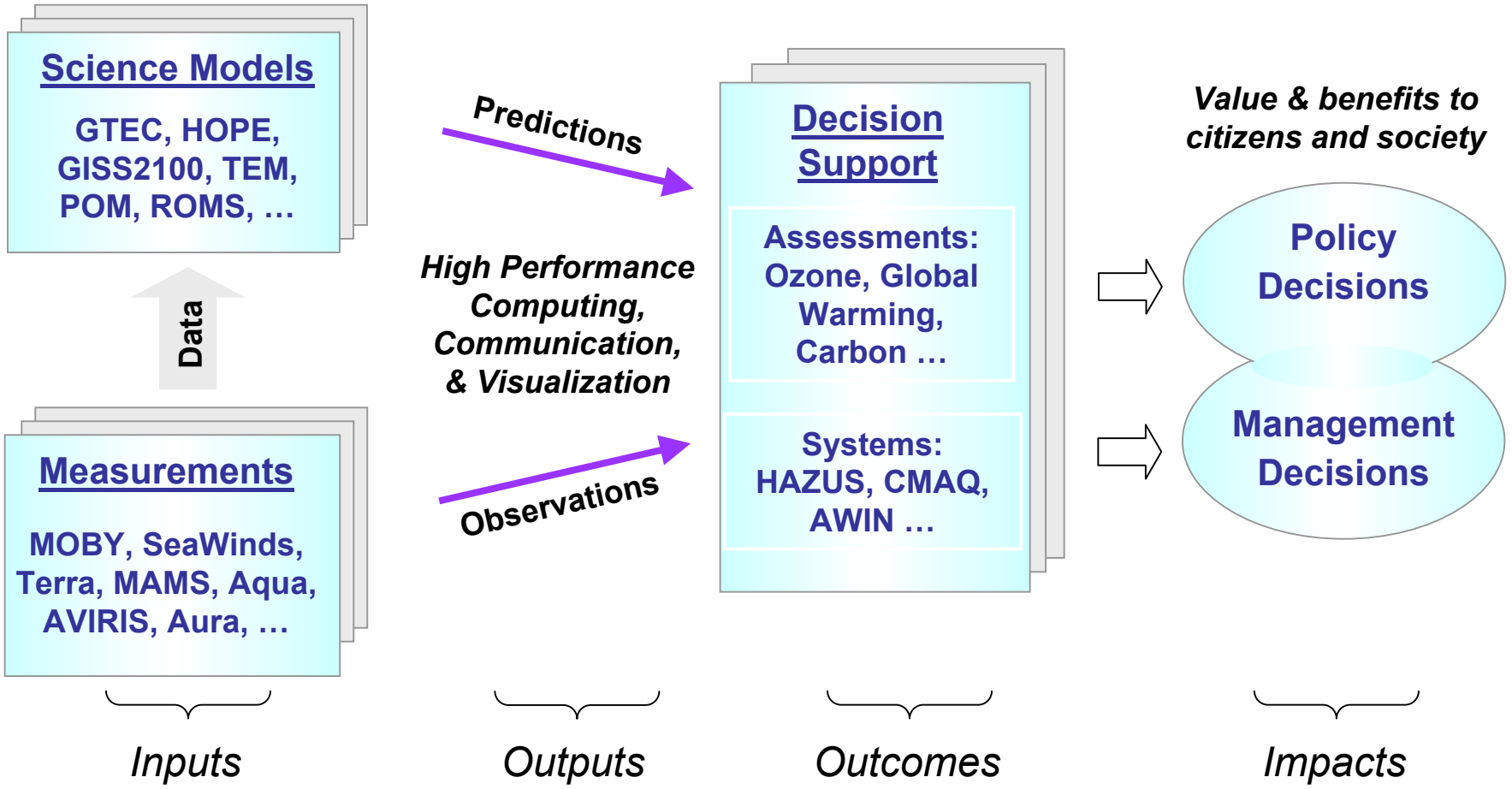
Socioeconomic Benefits

Coastal Management	**Reduce economic impacts from harmful algal blooms (HABs) affecting 1) public health 2) commercial fishery 3) recreation and tourism 4) monitoring and management costs**	**WHOA Technical Report 1999**
Invasive Species	$140 to $408M / yr **Estimated aggregated benefit of reduced environmental damage, reduced crop yield losses and decreased use of herbicides**	**Office of Technology Assessment (OTA). Report OTA-F-565, 1993.**
Water Conservation and Management	$11B / yr **Approximation of partial benefits of current water quality levels as compared to what they would have been w/o water pollution control programs**	**Application Profile (U.S. EPA)**

Socioeconomic Benefits

Aviation Safety	$1.66 B / yr **Average annual savings combined from using SVS to improve airport capacity and delay efficiencies at 10 U.S. airports**	**NASA Langley Research Center, July 2000**
Community Growth	>$1M / yr for one city **More efficient decision making for planning offices saved one city planning office (Scottsdale, AZ) millions of dollars/yr**	**GIS World November 1997**

Systems Approach: Serving our World



Conclusions

- NASA's vantage point of space makes Earth System Science possible
- NASA has a well-articulated, end-to-end strategy to answer Earth science questions of substantial societal importance
- Our challenge and opportunity is to transform remote sensing observations into earth science products that serve society's needs
- Our partners are essential to our success