National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

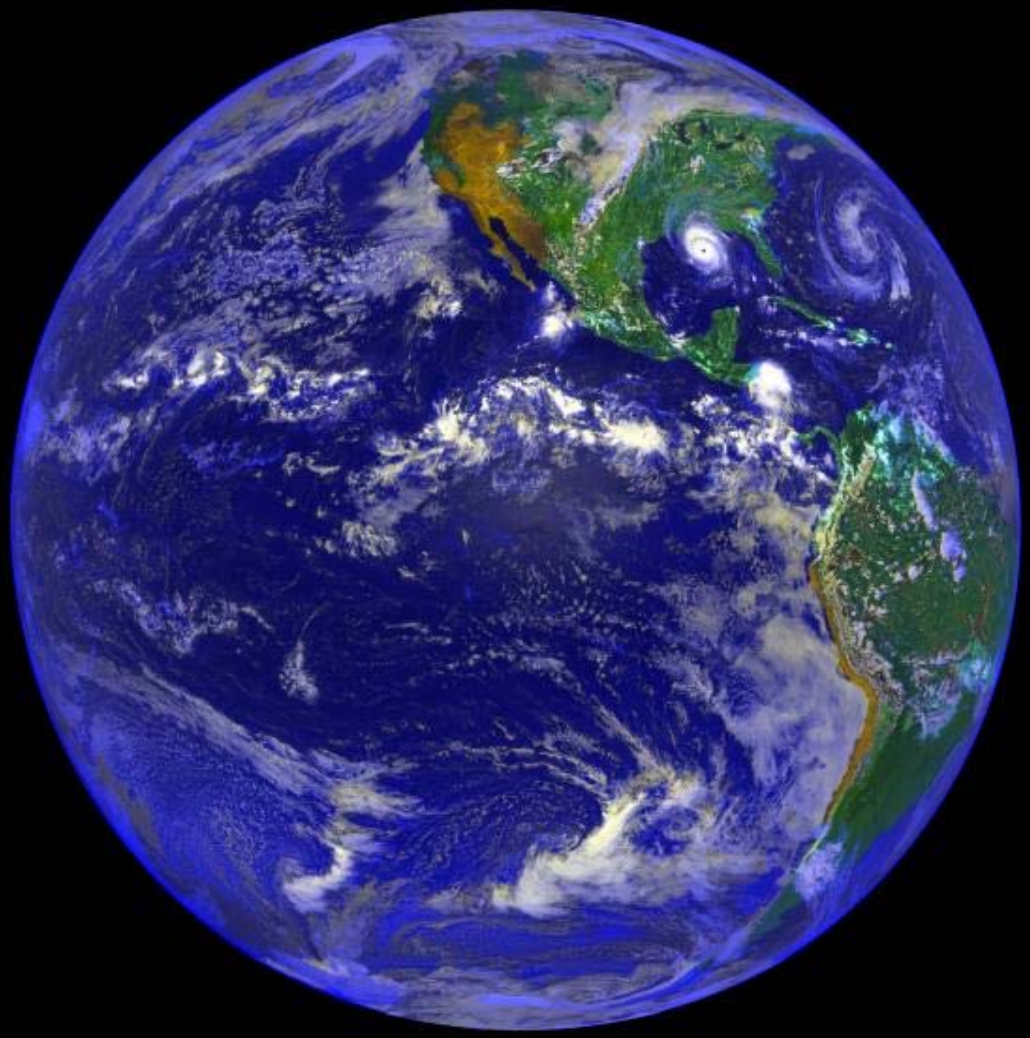
Exploring Our Home Planet: JPL's Earth Science and Technology

8th Annual NASA/JPL Space Science Symposium For Small Business

Hamilton Crowne Plaza
Washington, DC
June 10, 2004

Randall R. Friedl,
Chief Scientist,
Earth Science and Technology

The **Changing Earth**



By the year 2050…

There may be 9 billion people…

>6 billion tonnes per year of greenhouse gases…

>60 million tonnes per year of urban pollutants…

Given these possible scenarios…

We will tax the world's resources…

Withdrawing 30% of available fresh water…

Converting 65% of frontier forests…

And due to our growing numbers…

We will live increasingly in health and hazard risk areas…

~80% people will live in major urban areas

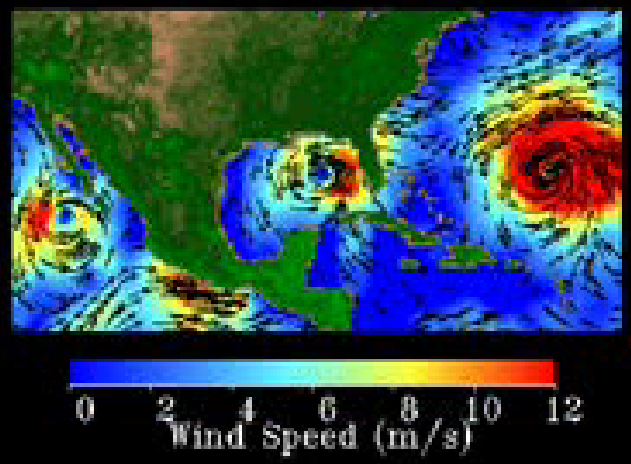
>25% people near earthquake faults…

~2% will live on coastlines within 1m of mean sea level…

Carbon Build up on earth-
3 year cycles from SeaWifs

The 1999 Hurricane Season Observed by QuikSCAT

W. Timothy Liu, Hua Hu, and Wenqing Tang



Antarctic ozone from Total Ozone Mapping Spectrometer (TOMS)- 7/15/01-10/09/01

Subsidence at Lost Hills, CA from European Space Agency Remote Sensing Satellites(ERS-1 & ERS-2)

What Lies Beyond This Decade?

Enabling Earth System Prediction

<u>Goals for 2025</u>

Weather	→ 7-10 Day forecast at 90% → 7 day rainfall forecast routine → Hurricane landfall +/-75 nautical miles at 3 days → Air quality forecast at 7-10 days
Climate	→15-20 month El Nino prediction; 12 month regional rain rate forecast →10 year climate forecasts with 90% confidence (experimental); 10-year regional sea level
Natural Hazards	→ 30-60 day eruption warnings → Monthly assessment of hazards at major faults

The future is in our hands…

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.

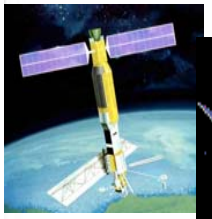
Missions to Enable Ocean Science

TOPEX/Poseidon & Jason-1
provide global views of El Niño/La Niña Pacific Decadal Oscillation, and sea level rise

SeaWinds
increases prediction time for hazardous weather events over oceans by 6-12 hours

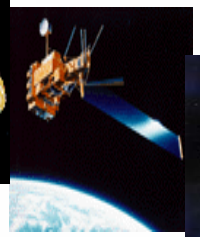
OSTM/Jason-2
will discriminate mesoscale ocean features

Aquarius
OVWM/MEOScat
will improve climate models



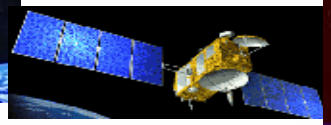
SeaSAT (1978)

TOPEX / Poseidon (1992-Present)



NSCAT (1996)

QuikSCAT (1999-Present)



Topex / Poseidon and Jason-1 Tandem (2002-Present)

SeaWinds on Midori-II (2002-2003)

Ocean Surface Topography Mission: (2007)

Aquarius (2008)

Ocean Vector Winds Mission (Proposed)

= New

= Future

1978 1992 1996 1999 2002 2003 2007 2008

Missions to Enable Atmospheric Science

ATMOS & MLS were instrumental in understanding ozone depletion

ACRIMSAT is measuring the total amount of solar energy reaching the Earth

MISR distinguishes different aerosols, and cloud forms to develop 3-D models

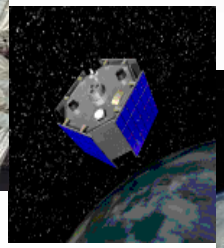
AIRS measures air temperature and humidity for input into weather forecasts

TES will make the first-ever measurements of tropospheric ozone from space

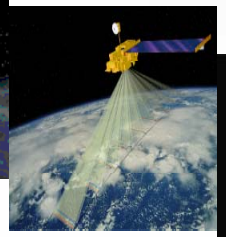
CloudSat
OCO
Blue Horizons
data will improve estimates of global warming

ATMOS (1985)

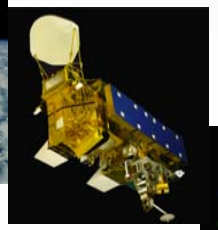
UARS MLS (1991-Present)



ACRIMSAT (1999-Present)



MISR on TERRA (1999-Present)



AIRS on AQUA (2002-Present)

TES on AURA (2004)

MLS on AURA (2004)

CloudSat (2005)

Orbiting Carbon Observatory Mission (2007)

= New

= Future

1985 1991 1999 2002 2004 2005 2007

Missions to Enable Solid Earth and Hydrology Science

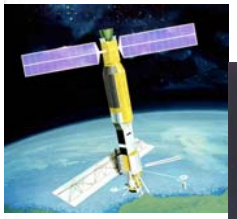
SIR
series demonstrated the most advanced radar technology ever flown

SRTM
data were used to create the most accurate and highest resolution global topographic

GRACE
has improved our estimates of Earth's gravity by a factor of 50-100X

Hydros
will improve estimates of the hydrologic cycle

InSAR
will improve our understanding of earthquakes and volcanoes

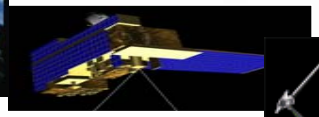


SeaSAT (1978)

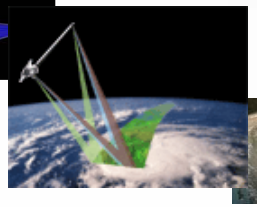
SIR-A (1981)

SIR-B (1984)

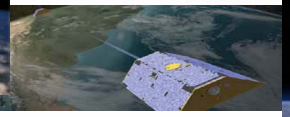
SIR-C (1994)



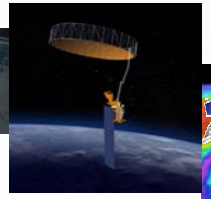
ASTER (1999-Present)



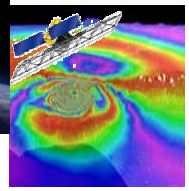
SRTM (2000)



GRACE (2002-Present)



Hydros (2010)



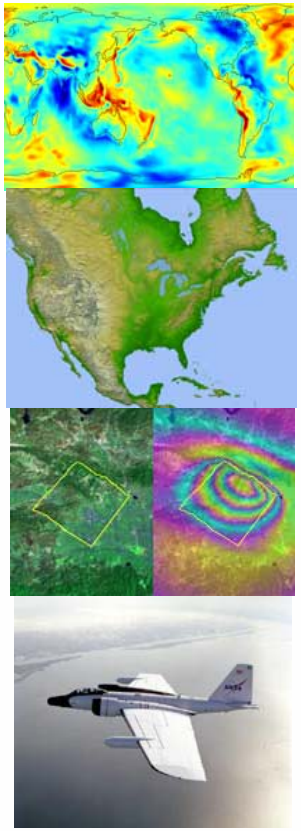
InSAR (Proposed)

= New

= Future

1978 1981 1984 1994 1999 2000 2002 2010

Research Highlights: FY04



- **NASA/JPL has published over 150 articles in 2003/4 and has lead or co-authors on 4 "Science" papers of which two were issued as press releases:**

  - SRTM data reveal that South American Ice-fields are melting at an accelerating pace and account for nearly 10% of global sea- level change. NASA's mission provided the unique vantage point for scientist to gain a larger perspective rather than looking at just a few glaciers.
  - The 1st detailed water isotope map showing H_2O transport in the lower stratosphere.

- **GRACE provided the most accurate map yet of the Earth's gravity field. The data will provide a more accurate picture of the ocean's geoid, thus allowing for a more precise assessment of the ocean's influence over global climate change.**

- **SRTM Data distribution was made available for North America, Central America, South America, Europe and Africa. The data are so popular that USGS report show that there is a file being downloaded every 1.2 second!**

- **New NASA computer models from QuakeSim may lead to quake forecast system which will be used by a variety of federal and state agencies to develop decision support tools to mitigate losses from large, future earthquakes.**

Future Research: FY05

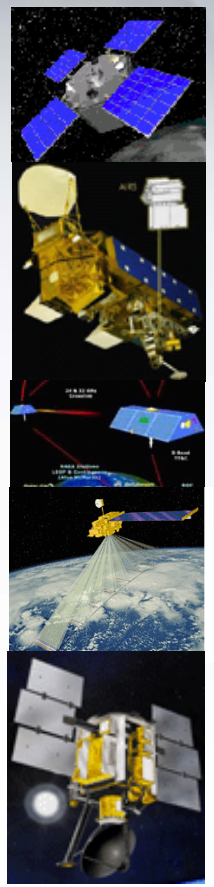
- June 19th, 2004 scheduled launch date for Aura enabling the 1st global maps of tropospheric ozone from TES and stratospheric OH from MLS for studies of air quality and ozone depletion.

- April 2005 scheduled launch date for Cloudsat will provide the 1st ever space based global survey of cloud structure and physical properties.

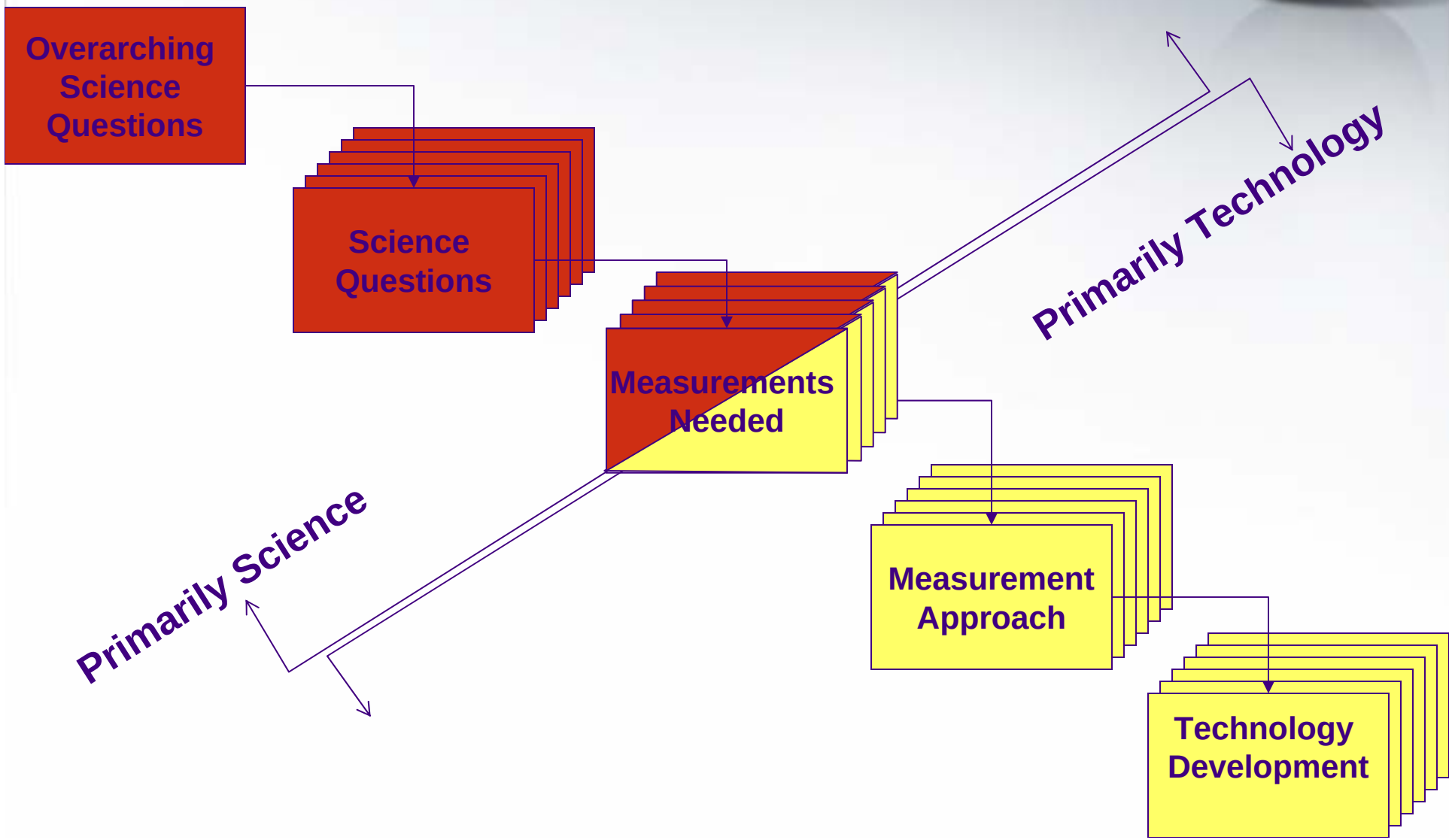
- Continued science results from Quikscat, AcrimSAT, GRACE, TOPEX/Poseidon & Jason-1, ASTER & MISR on Terra. Since 1999 to present, there is a total of 939 papers* among these projects.

- AIRS on Aqua data demonstrating improvements to weather forecasts; in addition, there will be opportunities showcasing other science results such as 3 potential releases on H_2O vapor, CO, and CO_2

- Increase emphasis on highlighting upcoming science papers relating to the six science focus areas.

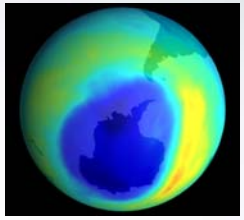
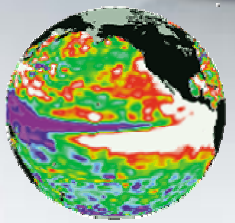
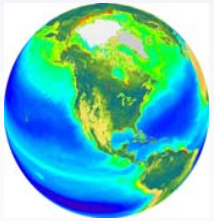
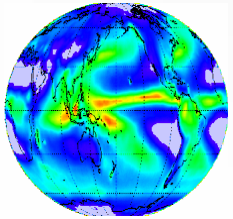
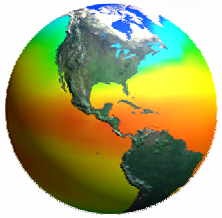
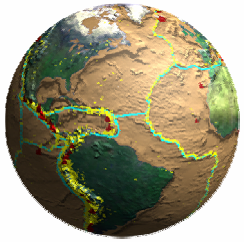


Technology Needs Defined by Requirement Flow down



Research Focus Areas

- **Climate Variability & Change**
- **Atmospheric Composition**
- **Carbon Cycle & Ecosystems**
- **Water Cycle**
- **Weather**
- **Solid Earth / Natural Hazards**

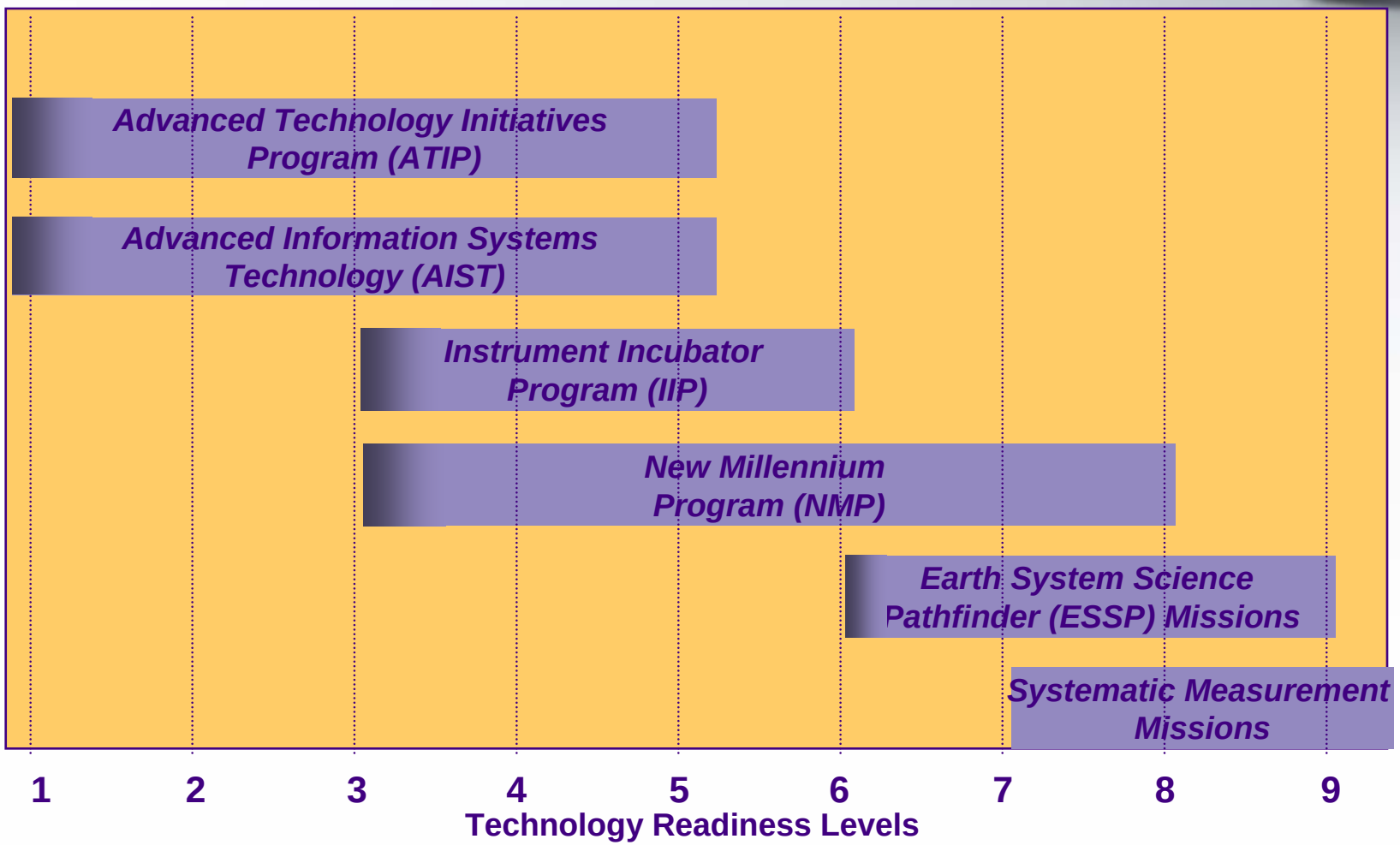
Summary of Technology Priorities for ESTD

	Information Technology*	Imaging Spectroscopy	High Data Rate Communications	Active Microwave Systems	Quantum devices	Lidar/ laser	Submm / mm sensors	Passive Microwave Systems	GPS	Sensor Webs	Formation Flying	Large Deployable Structures	Modeling Tools	Advanced Cryo Coolers
Oceans	X		X	X	X		X	X	X	X		X	X	
Solid Earth	X	X	X	X	X	X		X	X	X	X	X	X	X
Atmospheric Science	X	X	X	X		X	X	X	X	X	X	X		X
Advanced Instruments	X	X	X	X	X		X		X	X				

***Autonomy and on-board processing**

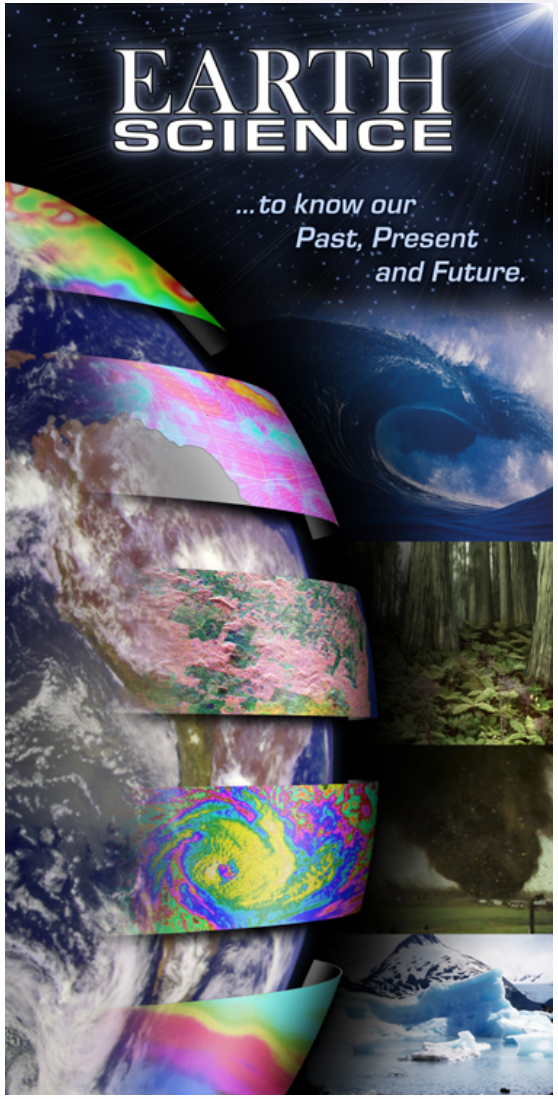
JPL Lead responsibility

ESTD Activities, by Technology Readiness Level (TRL)



Basic Technology Research → Research to prove Feasibility → Technology Development → Technology Demonstration → System/Subsystem Development → System Test launch Operations

JPL's Earth Science Strategy



Our strategy is to:

-Work with Science Communities to determine and prioritize measurement requirements

-Work with broad community to develop new measurement concepts and modeling environments leading to improved prediction of changes in the Earth System

-Work with universities, other NASA centers, non-NASA agencies, and industry to develop missions to gather measurements

-Work with operational agencies to ensure smooth transition of mature observations

-Communicate the improvements in our understanding of Earth's weather, climate and natural hazards