Explore the Possibilities

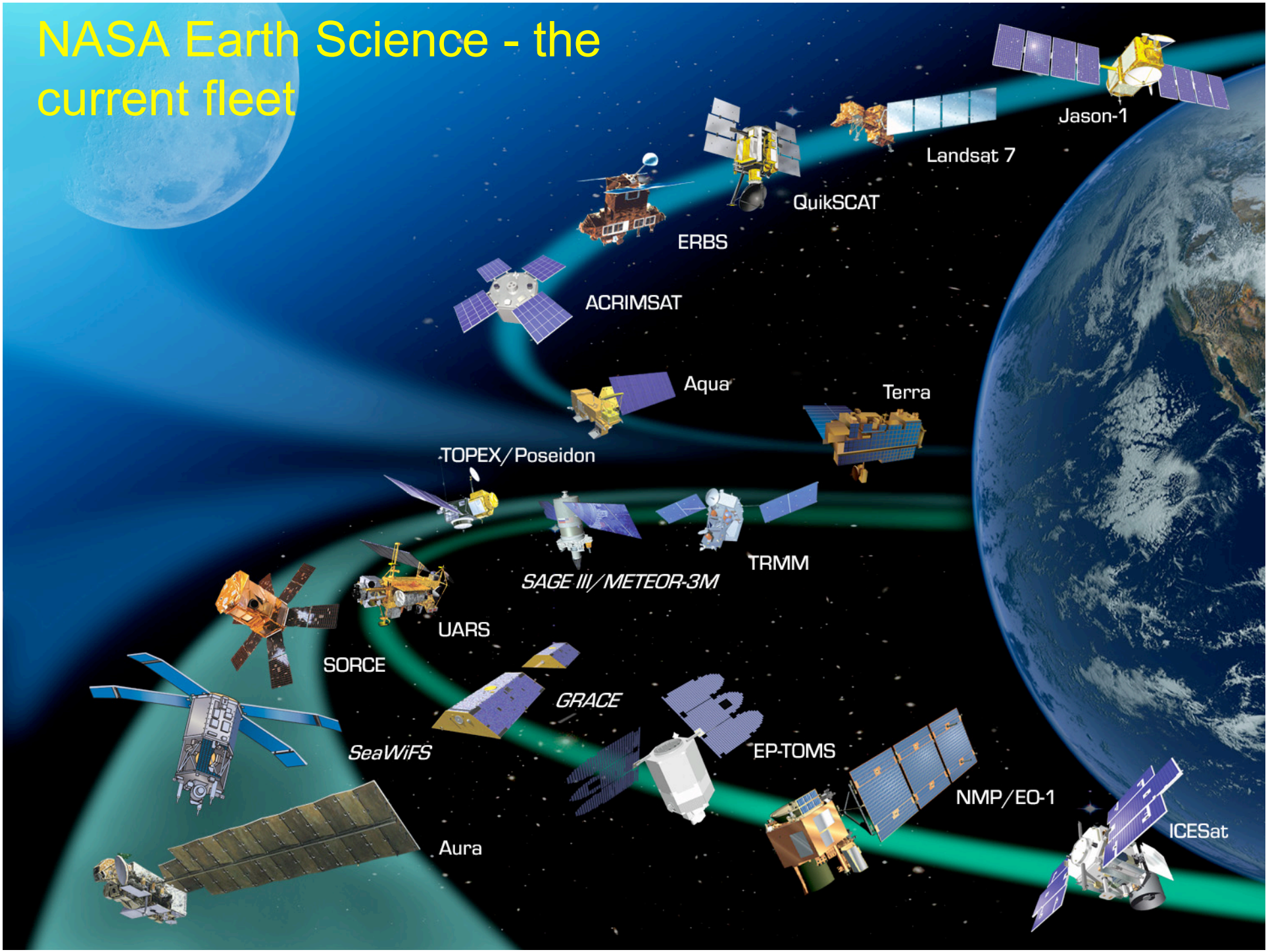
8TH BRIEFING
FOR INDUSTRY

Earth Science at JPL

Tony Freeman

Earth Science Research and Advanced Concepts Program Office Manager

April 2006


NASA Earth Science - the current fleet
Jason-1
Landsat 7
QuikSCAT
ERBS
ACRIMSAT
Aqua
Terra
TOPEX/Poseidon
TRMM
SAGE III/METEOR-3M
UARS
SORCE
GRACE
SeaWiFS
EP-TOMS
NMP/EO-1
ICESat
Aura

Explore the Possibilities

Earth Science Business Environment

- "Earth science in transition"
  - Fleet of Earth Science missions is aging; 3 terminated recently
  - Scarcity of near-term mission/instrument opportunities (2002-2008)
- Future strategy under development
  - NASA Roadmapping Group proposed robust plan
  - NRC Decadal Survey underway (complete by late 2006)

Explore the Possibilities

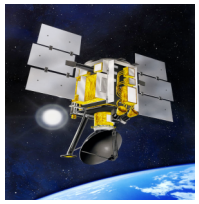
Earth Science Business Environment

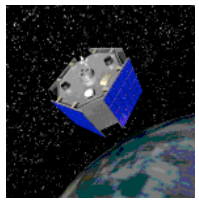
- NASA future Earth science likely includes
  - Fewer, more capable, missions
    - Partitioned between competed exploratory and assigned systematic missions
    - Balanced among 5 major Earth Science focus areas
    - Satellite validation remains critical to success (e.g. lab, ground and airborne instrument programs)
  - Emphasis on translating science understanding into societal benefit
    - Greater need to transition research missions to operational missions
    - Increasing focus on knowledge and information integration

JPL Earth Science Flight Projects

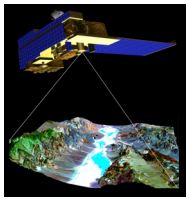
Operational

QuikSCAT (1998)

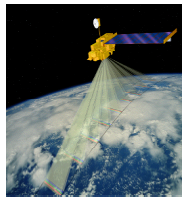




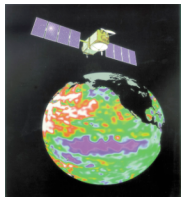
ACRIMSAT (1999)



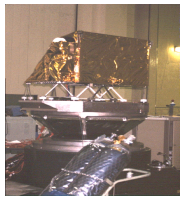
ASTER (1999)



MISR (1999)

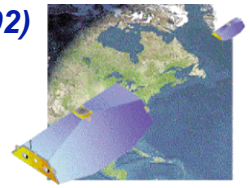


Jason-1 (2001)



AIRS (2002)

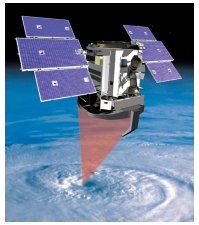
GRACE (2002)



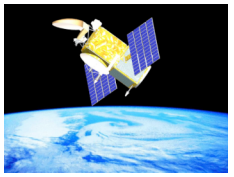
TES (2004)

MLS (2004)

Development

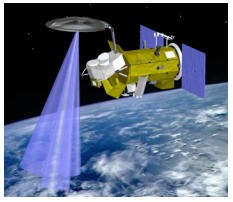


CloudSat (2006)



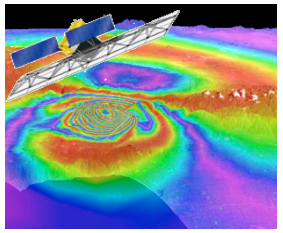
Ocean Surface Topography Mission *(2008)*

Carbon Cycle: OCO *(2008)*



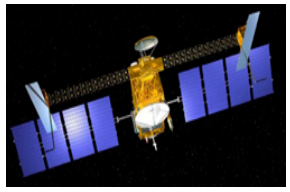
Sea Surface Salinity: Aquarius *(2009)*

Formulation/pre-formulation



L-Band InSAR (TBD)

Ocean Vector Wind Mission (TBD)



Wide Swath Ocean Altimeter (WSOA) (TBD)

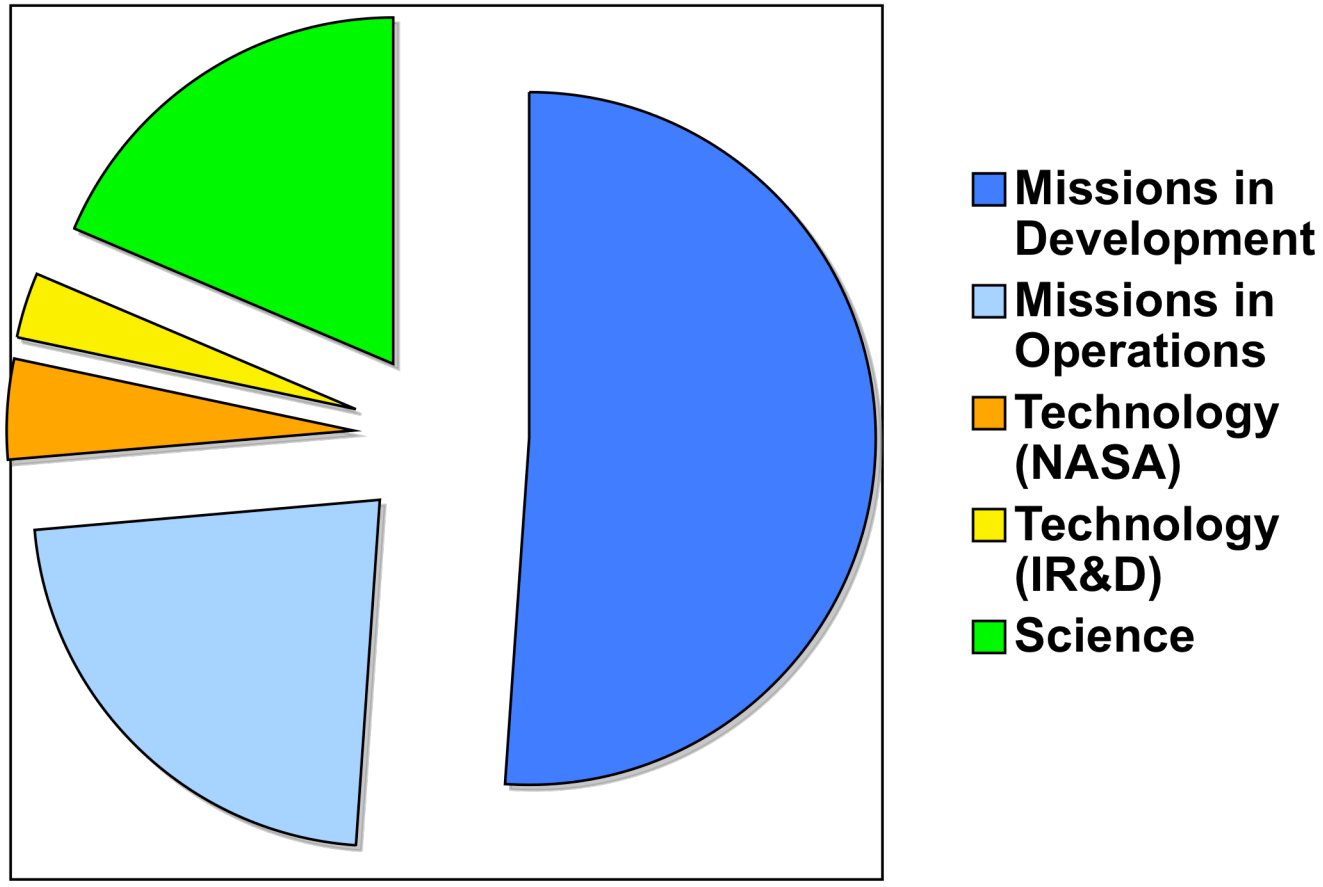
ESSPs

JPL Earth Science Metrics

- ~11% of NASA's Earth Science Budget
- 4 missions, 5 major instruments currently in operations
- ~600 active engineers/scientists

Explore the Possibilities

Earth Science
Current Funding Breakdown



Explore the Possibilities

Procurements Forecast

- Current Missions in Operations
  - NASA Senior review in 2007 (and in 2009 for TES, MLS)
  - Expect all current JPL missions to be extended through that process
  - Procurements will target elements of ground systems for these missions
- Current Missions in Development
  - All are beyond PDR stage (most major procurements already under way)

Explore the Possibilities

Earth Science Mission Opportunities (across NASA)

Opportunity	Expected Start Date	Launch Date
ESSP-8 (2013)	2009	2013
SYS/M-1 (2014)	2009	2014
ESSP-9 (2015)	2010	2015
SYS/L-1 (2016)	2011	2016
ESSP-10 (2017)	2012	2017
SYS/M-2 (2018)	2013	2018
ESSP-11 (2019)	2014	2019

Mission Class	$M
ESSP	350
SYS/M	600
SYS/L	900

NRC Decadal Survey is expected to set priorities for these opportunities in '06

- Procurements will include instruments, spacecraft, ground systems, launch vehicles

Explore the Possibilities

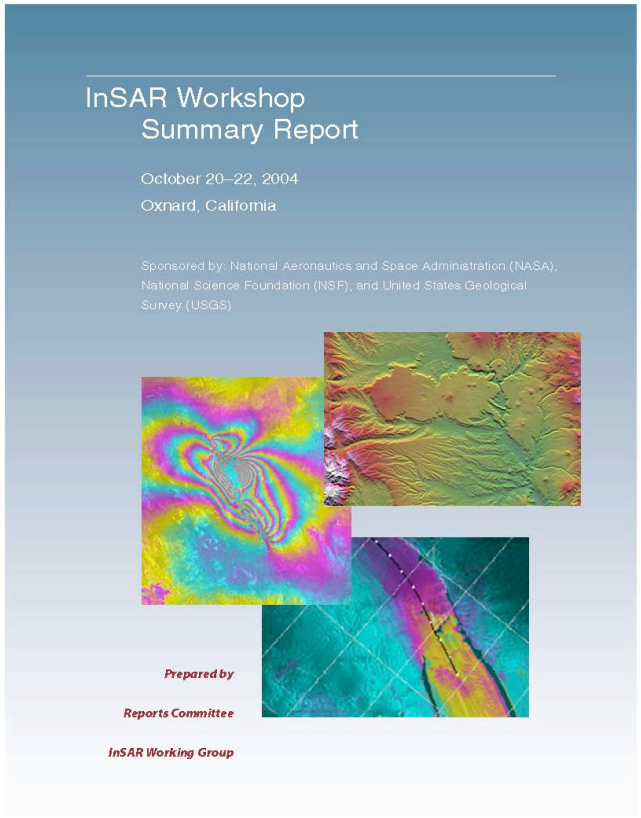
Projected Competitive Opportunities

	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
Technology								
NASA ESTO NRAs (IIP, ACT, AIST)	1-2	2-3	1-2	2-3	1-2	2-3	1-2	1-2
Missions								
ESSP AO				1	1	-	1	1
MOO				1 ?	1?	-	1?	1?
Systematic				1	-	1	-	1

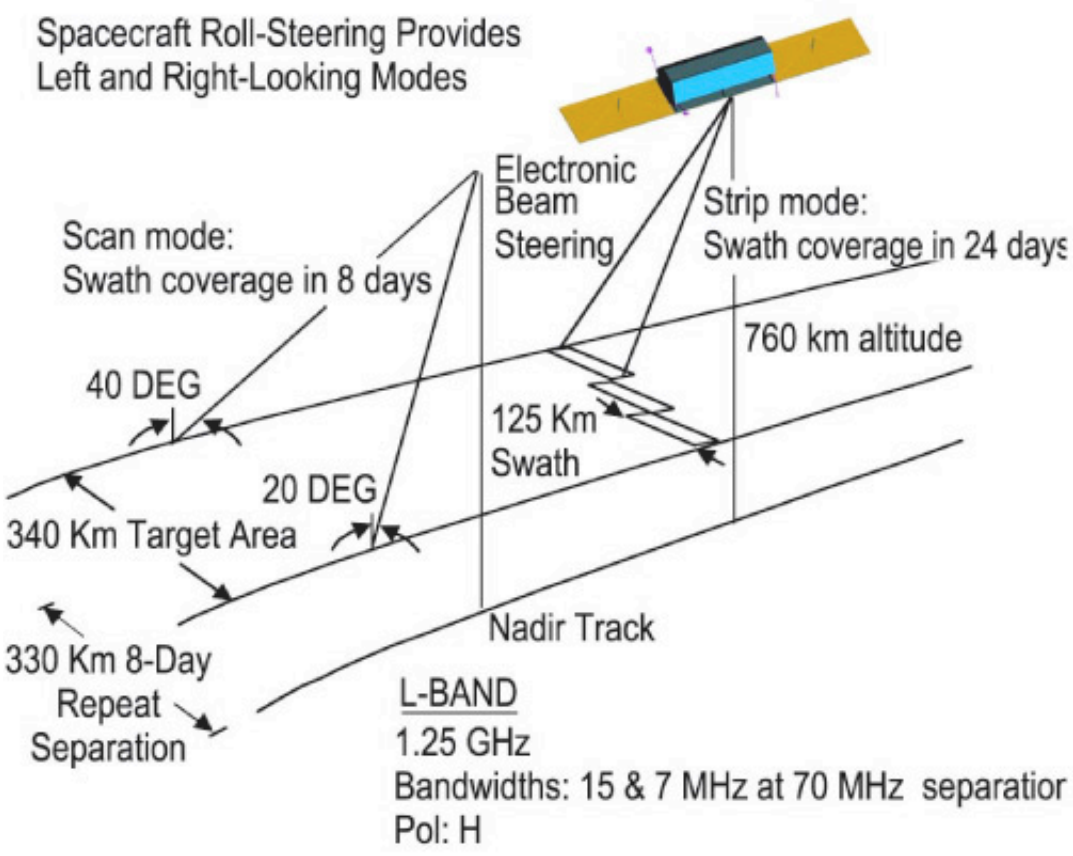
ESTO = Earth Science Technology Office
AO = Announcement of Opportunity
NRA = NASA Research Announcement
IIP = Instrument Incubator Program
ACT = Advanced Component Technology
AIST = Advanced Information Systems Technology
ESSP = Earth System Science Pathfinder
MOO = Mission of Opportunity

InSAR Mission Studies

- InSAR Workshop report (Dec 2005) - input from a broad spectrum of science areas



- Mission Studies are ongoing - joint NASA-DoD effort

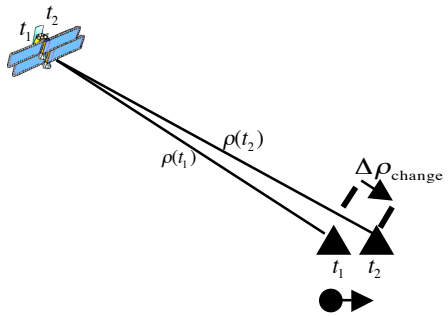


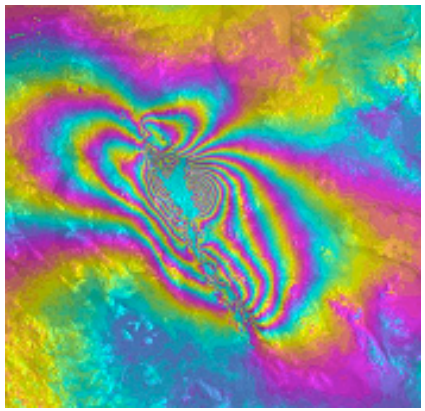
Technology Needs: Lightweight Phased Array Antenna (L-Band)

Science for Society Example: JPL InSAR Technology Enables Future Exploration of Earth's Surface

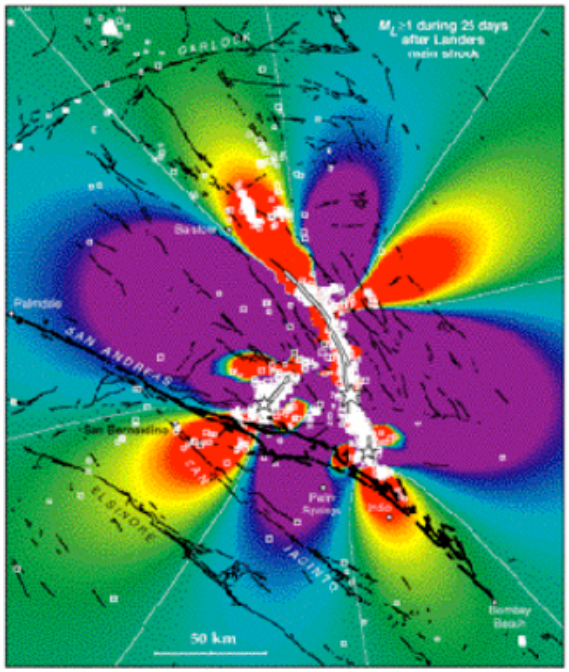
By precisely measuring small changes in Earth's surface, we can infer the subsurface behavior that leads to seismic and volcanic activity

Surface Deformation Measurement





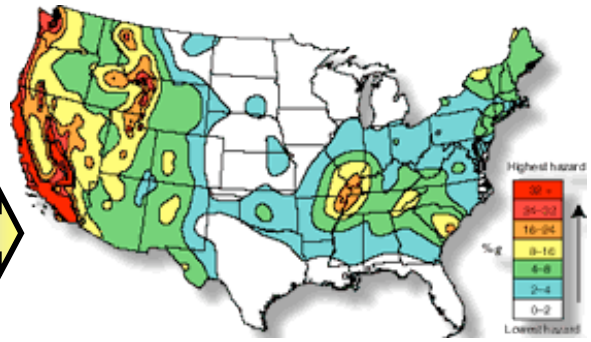
Earthquake Hazard Information (Stress Map)

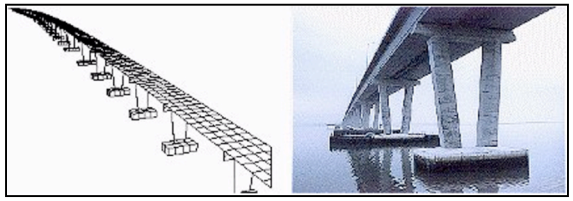


Coulomb Stress Change caused by the Landers, Big Bear, and Joshua Tree Earthquakes (bars)

-0.3 -0.2 -0.1 0.0 0.1 0.2 0.3

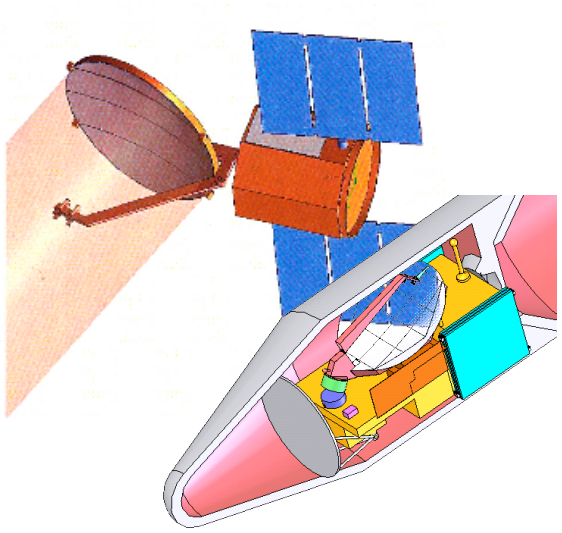
Improved Planning and Preparation

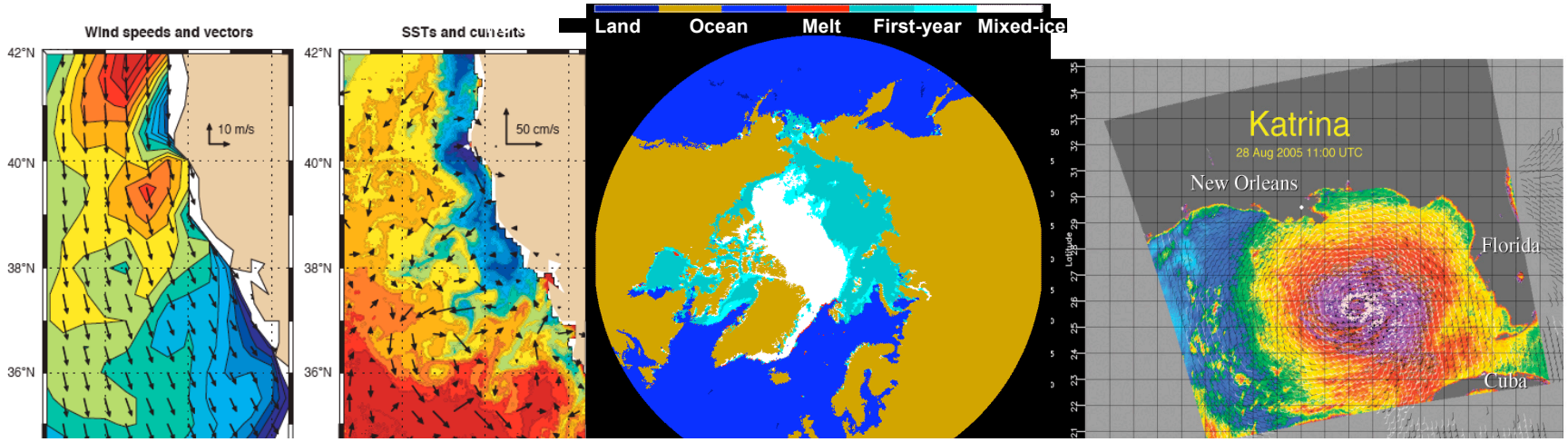




Higher Resolution Ocean Vector Winds Measurements - The Next Step

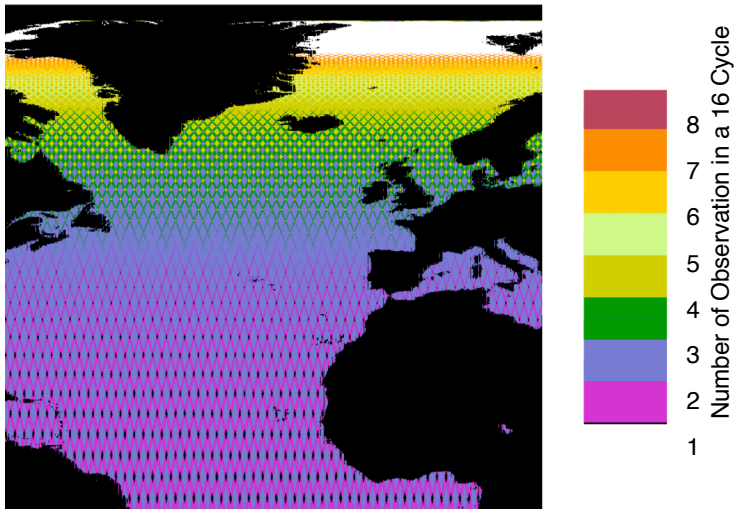
- Higher-resolution (1-5 km) ocean vector wind measurements will allow scientists to study:
  - Winds in coastal regions
  - Small (2-10 km) scale air-sea interactions
  - Scatterometer contributions to soil moisture, cryospheric and hydrologic applications
  - Improvements in hurricane forecasting





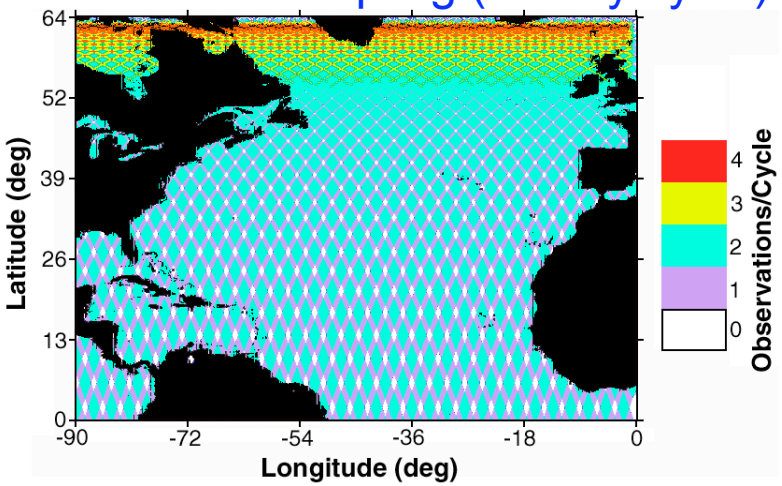
Technology Needs: 2.5 scanning Antenna (Ku/C-Band)

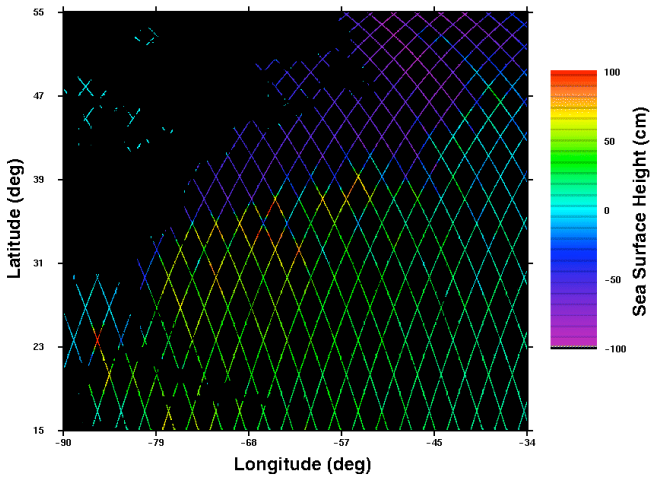
Advanced Altimeter Concept - Merge Different Altimeter Coverage Capabilities



Hydrosphere Mapper (16 day cycle)

WSOA Sampling (10 day cycle)





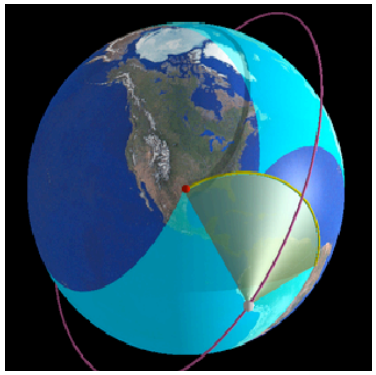
OSTM Sampling (10 day cycle)

	OSTM	WSOA	Hydrosphere Mapper/WatER
Orbit Height	1334 km	1334 km	800 km
Orbit Type	10-day repeat	10-day repeat	16-day repeat, sun-synchronous
Swath	NA	200 km	120 km
Frequency	Ku-band	Ku-band	Ka-band
Height Precision	2 cm	5 cm	~1 cm @ 1km res.
Spatial resolution	2 km	15 km	<100m imaging
Instrument Type	Nadir Altimeter	Real Aperture Interferometer	Synthetic Aperture Interferometer

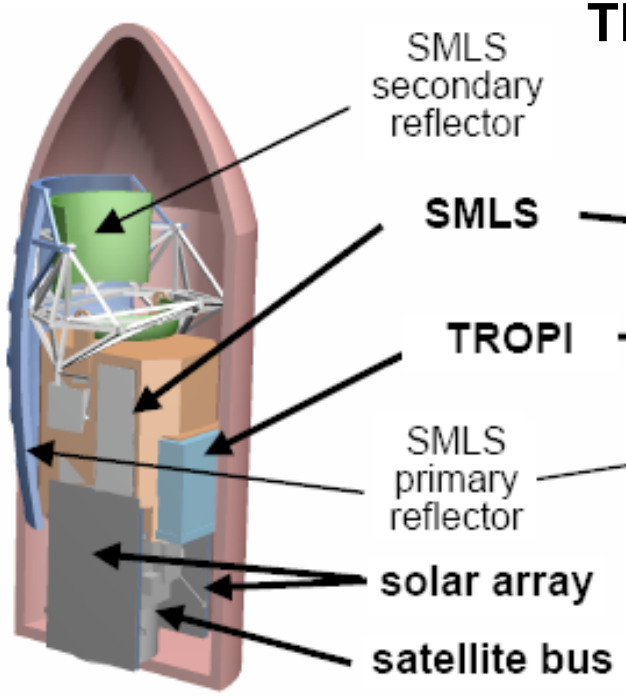
Composition of the Atmosphere from Mid-Earth Orbit (MEO)

- Global coverage, several times a day, 1-2 km vertical res.

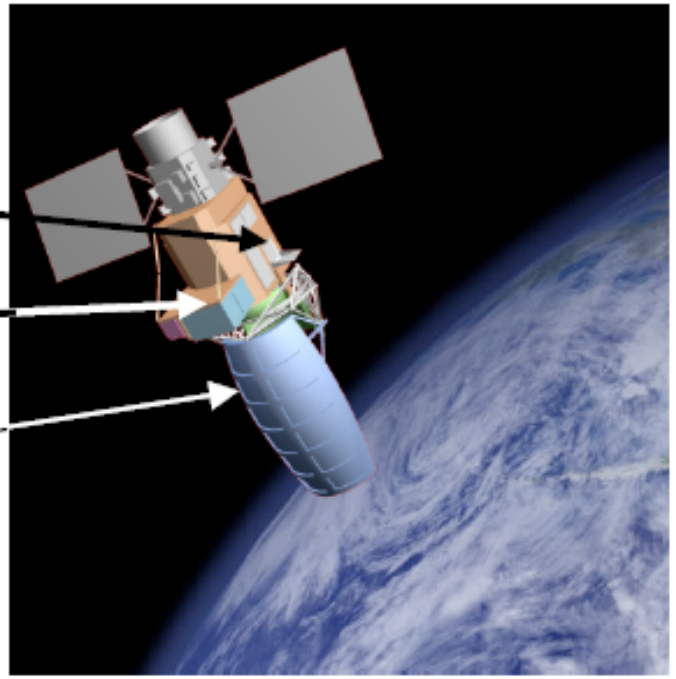
- PI: Joe Waters, JPL
- Scanning MLS follow-on
- TROPI UV/Vis instrument (NL)
- IR instrument (similar to AIRS or TES)



Presented at Air Quality Workshop, NCAR, 02/06



SMLS and TROPI stowed in the faring of a Delta-II

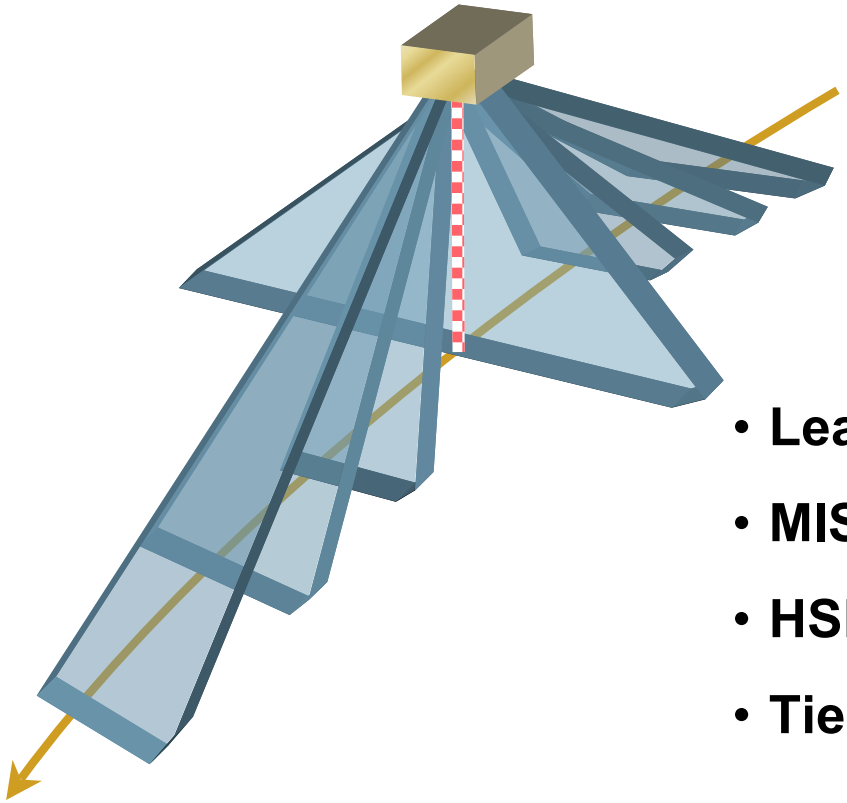


CAMEO deployed in orbit, with SMLS looking into the page

AEGIS Mission

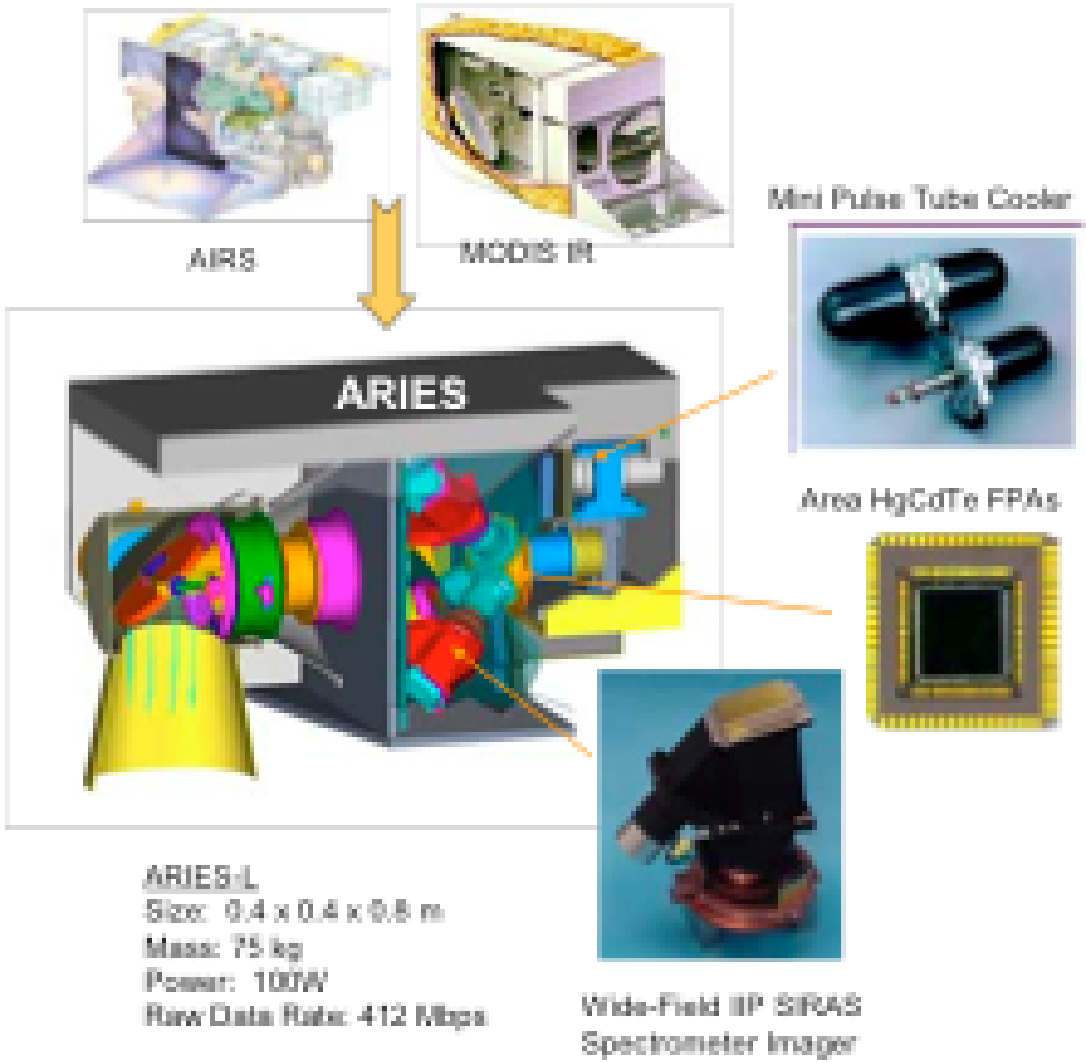
Aerosol Global Interactions Satellite (AEGIS): A Space-based Element of an Integrated Aerosol Observing System

Presented at Air Quality Workshop, NCAR, 02/06



- **Lead: Dave Diner, JPL**
- **MISR follow-on**
- **HSRL (LaRC)**
- **Ties to insitu Instruments**

Atmospheric Remote-sensing and Imaging Emission Spectrometer (ARIES)



- **PI: Mous Chahine, JPL**
- **AIRS follow-on**
- **1-2 km resolution H2O**

Explore the Possibilities

Critical Technology Needs: By Science Area

Atmospheric Composition	Climate	Solid Earth	Water Cycle	Carbon Cycle &
Earth Science Modeling Framework (ESMF),	Miniaturization of components (Ka/Ku/L),			
Observation System Simulation Experiments (OSSEs),	On-board computing,	Data compression		Large Aperture (Visible)
PEM,	HEC			Miniaturization of Lidar (2um),
SIS mixer,	Large Aperture (RF), GNSS receiver,			Sensor webs,
Signal Path Chain Optimization,	Large Antenna Design			2 um 5W laser
APS or CMOS	Large Antenna metrology and control	Atom interferometer		
Uv-TIR FPA	Data Management			
	Data Mining			

Explore the Possibilities

Critical Instrument Needs: By Science Area

Atmospheric Composition	Climate	Solid Earth	Water Cycle	Carbon Cycle
Microwave Limb Sounder, Multi-Spectral Polarimetric Imager, FTIR Sub-mm/IR Radiometer	Next-generation GPS, Ku band Scatter-ometer, Ka band Radar Ku/ UHF band interfer-ometer	L band Radar, Laser Ranging, Quantum Gravity Gradio-meter	Ku band Radar Ka band Radar Laser Ranging	Hyper-spectral Imager, P/L band RADAR CO_2 Laser, Back Scatter Lidar

Explore the Possibilities

JPL Success In Competitive NASA Earth Science Opportunities

- JPL record in NASA Earth Science competitions unparalleled
  - Technology: JPL win rate is ~37% of all ESTO selections
  - Missions: At least 1 mission selected for each ESSP AO
    GRACE and alternate mission (CCOSM) in ESSP AO-1
    CloudSat in ESSP AO-2
    OCO and Aquarius in ESSP AO-3
- JPL strengths that contribute to our success
  - Strong linkage between science & technology communities, and understanding of the science focus area priorities
  - Proven track record in successful implementation of Earth and Space Science missions
  - Industry partnerships are crucial to our success
    Providing unique enhancements to fit within cost caps
    Successfully implementing what we win

Explore the Possibilities

Earth Science: JPL Contacts

- Science:
  - Dr. Randy Friedl, Chief Scientist, ESTD, randy.friedl@jpl.nasa.gov
- Technology:
  - Dr. Tom Cwik, JPL ESTO Lead, and Manager, Instrument Technology, tom.cwik@jpl.nasa.gov
  - Dr. Robert Sherwood, Manager, Earth Science Information Systems, robert.sherwood@jpl.nasa.gov
  - Dr. Jason Hyon, Chief Technologist (Acting), jason.hyon@jpl.nasa.gov
- Missions and instruments:
  - Dr. Tom Cwik, tom.cwik@jpl.nasa.gov
  - Dr. Anthony Freeman, Manager, Earth Science Management Office, anthony.freeman@jpl.nasa.gov
- Other:
  - Dr. Diane Evans, Director For, ESTD, diane.evans@jpl.nasa.gov
  - Charles Yamarone, Deputy Director, ESTD, c.a.yamarone-Jr@jpl.nasa.gov
  - Dr. Steven Bard, Manager, JPL Earth Explorer Missions Office; Earth Science Research & Advanced Concepts Office (Acting), steven.bard@jpl.nasa.gov