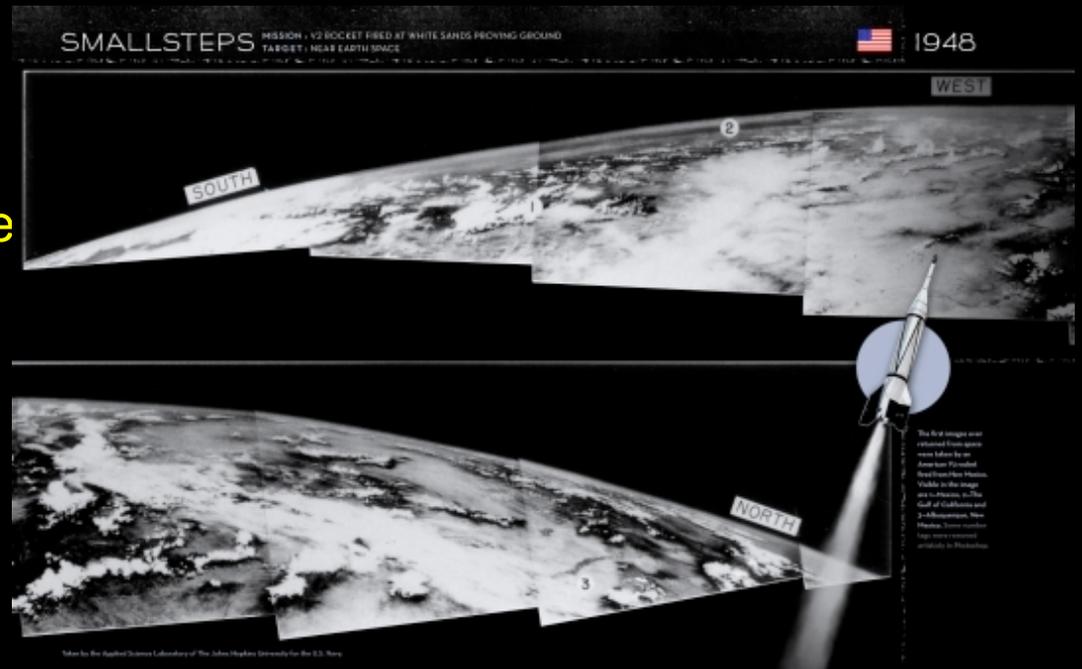


**NASA Earth System Science at 20:
Accomplishments, Plans, and Challenges**

Christopher J. Scolese
NASA Associate Administrator
June 22, 2009

The Beginning

- Space exploration was spurred by the study of the Earth
- The International Council of Scientific Unions established the period from July 1, 1957 – Dec. 31, 1958 as the International Geophysical Year (IGY).
- Space Act of 1958: NASA is to contribute materially to "the expansion of human knowledge of phenomena in the atmosphere and space."



1948 image of the Earth from V2

The Challenge



Special Message to the Congress on Urgent National Needs
President John F. Kennedy
May 25, 1961

“First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth. Fourth, an additional 75 million dollars--of which 53 million dollars is for the Weather Bureau--will help give us at the earliest possible time a satellite system for world-wide weather observation.”

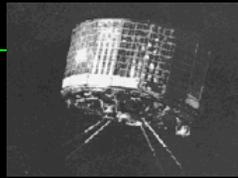
FIRST TELEVISION PICTURE FROM SPACE
TIROS I SATELLITE
APRIL 1, 1960



Earth Monitoring: the First 40 Years

1960-
1965

Tiros 1 -
Tiros 10



1964-
1978

Nimbus 1-7

1966-
1974

ATS 1-6

1972

Landsat 1

1974

SMS

1975 -

GOES 1 - GOES N

1978

Seasat 1

1981

Dynamics Explorer

1983

MOMS

1984

ERBS

1991

UARS

1992

Atlas, TOPEX/Poseidon

1997

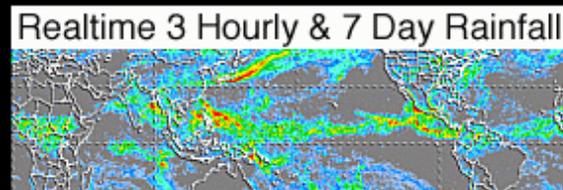
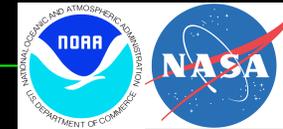
TRMM

1999

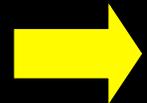
TERRA

2000

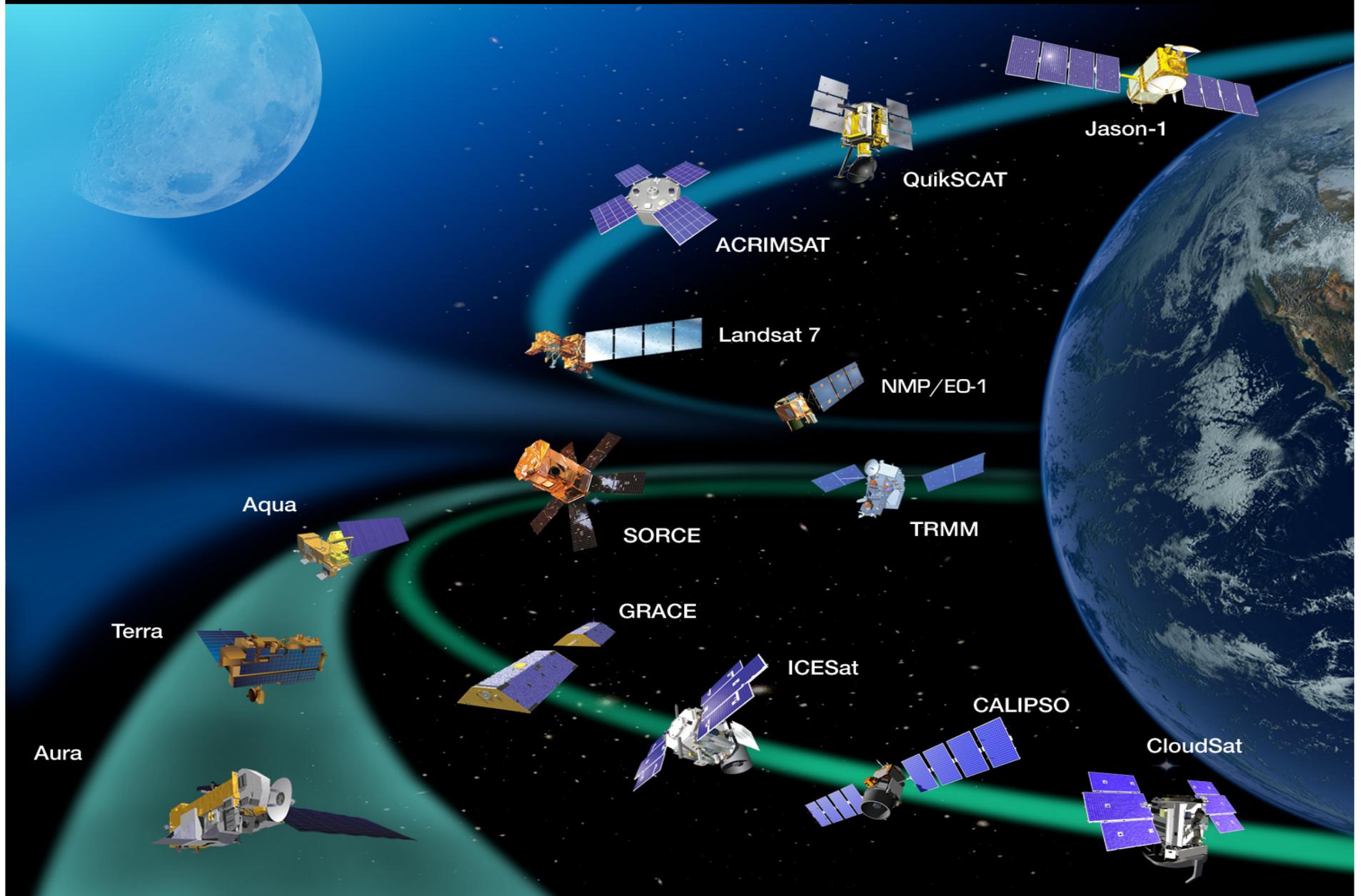
EOS-1



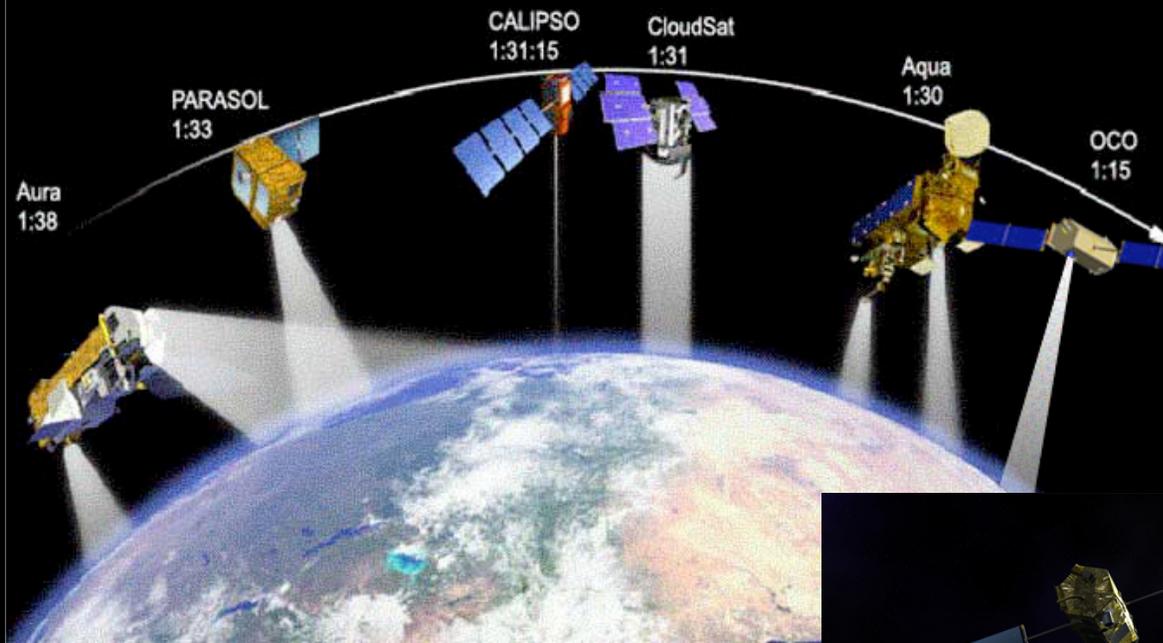
(Wait, there's more...)



NASA On-Orbit (EOS) Missions



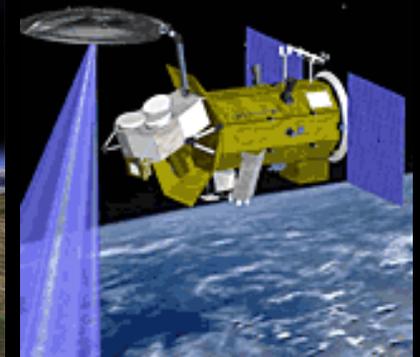
The A-Train



The On-Deck Circle



**Orbiting Carbon
Observatory
(OCO)**



**Aquarius
05/10**

**Launch Failure
Recovery Under Review**

Decadal Survey Missions - Next Generation

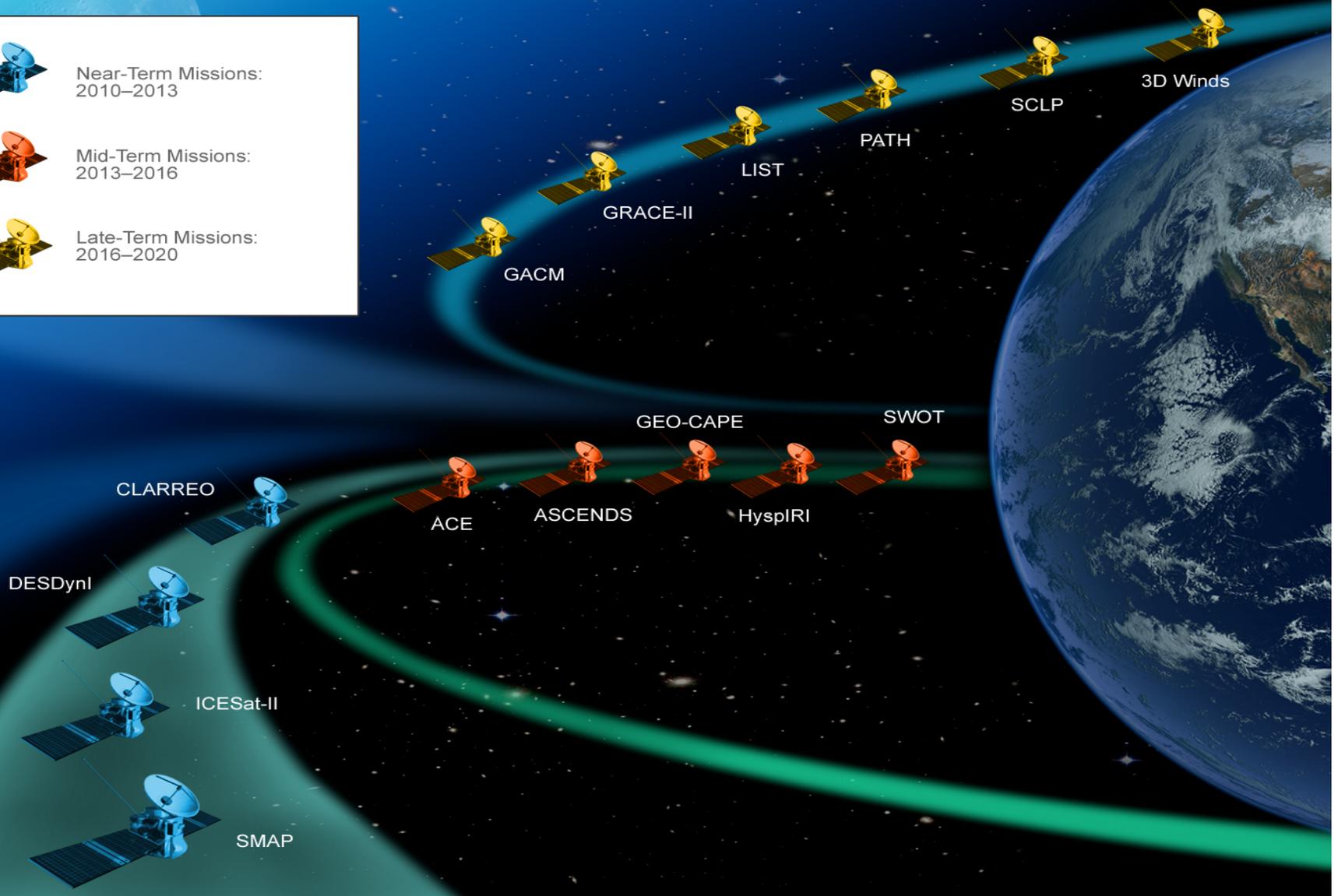


Near-Term Missions:
2010–2013

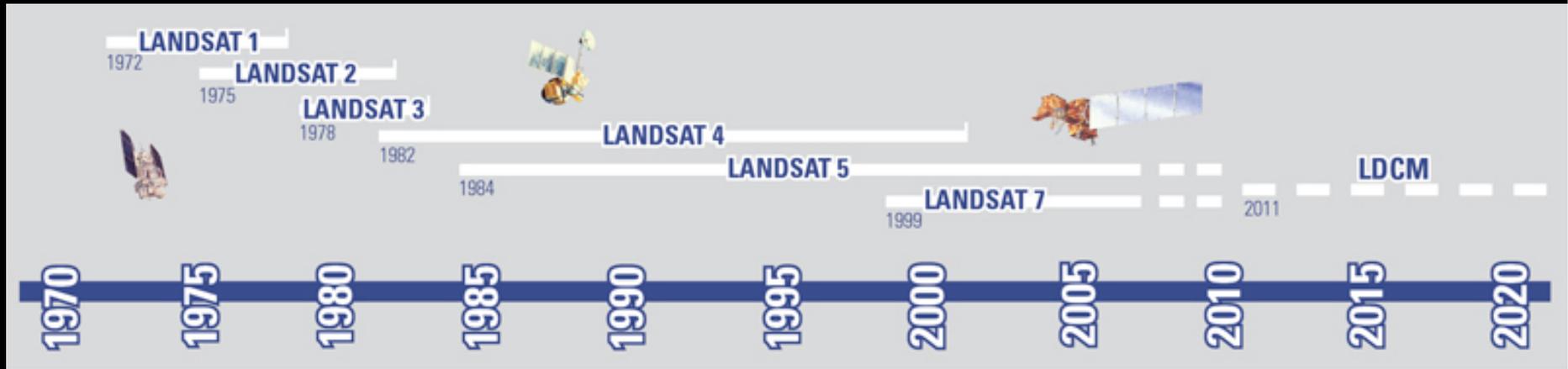
Mid-Term Missions:
2013–2016

Late-Term Missions:
2016–2020

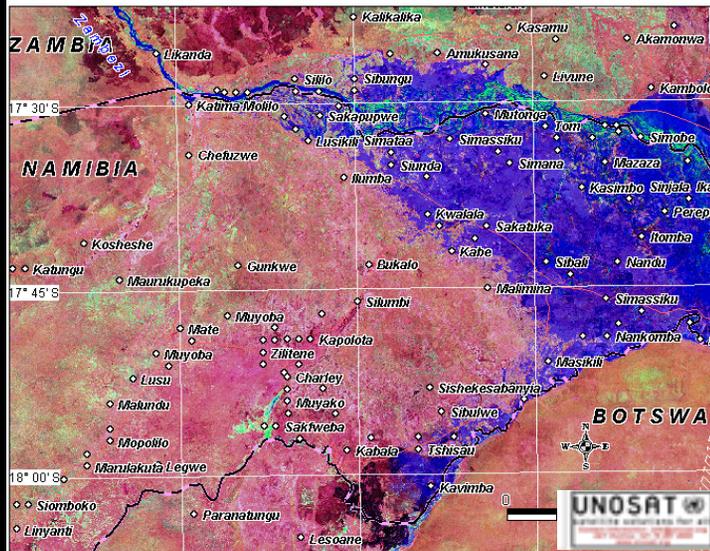
The legend uses colored satellite icons to represent the timelines: a blue satellite for Near-Term, a red satellite for Mid-Term, and a yellow satellite for Late-Term.



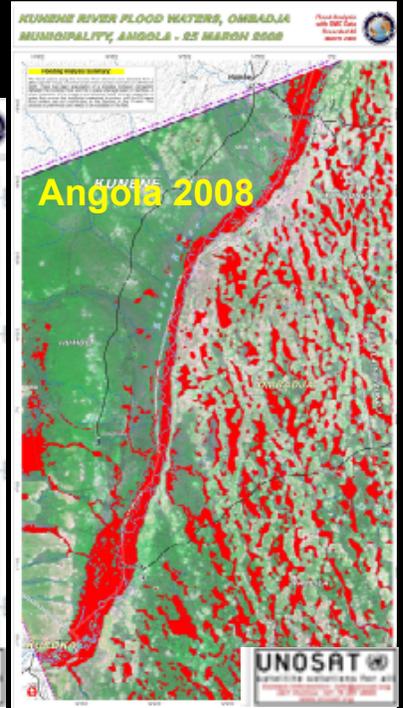
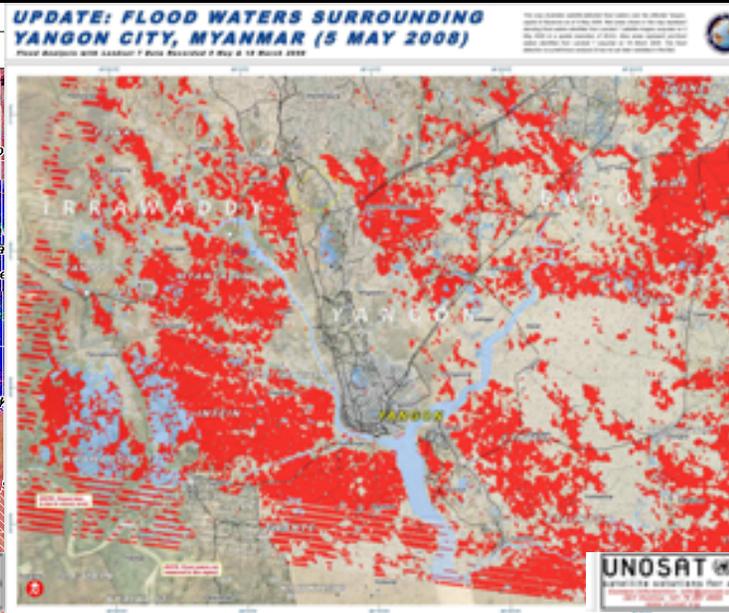
Landsat: Promoting International Cooperation



Namibia 2008



Myanmar 2008



EOS: 24 Measurements

Atmosphere

Cloud properties
Radiative energy fluxes
Precipitation
Tropospheric chemistry
Stratospheric chemistry
Atmospheric properties
Atmospheric temperatures

Solar radiation

Total solar irradiance
Solar spectral irradiance

Cryosphere

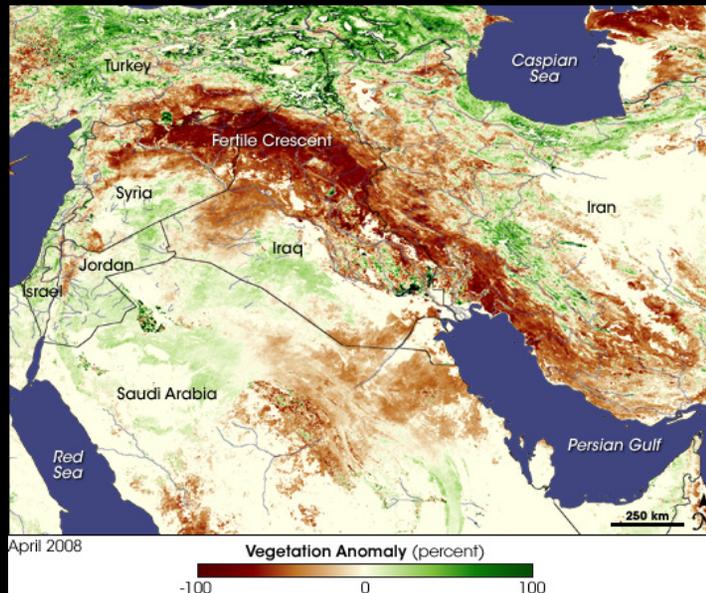
Land ice
Sea ice
Snow cover

Land

Land cover & land use change
Vegetation dynamics
Surface temperature
Fire occurrence
Volcanic effects
Surface wetness

Ocean

Surface temperature
Phytoplankton & dissolved organic matter
Surface wind fields
Ocean surface topography



Drought in Iraq, April 2008

Terra: International Collaboration in Science

- Launched December 18, 1999 to begin collecting a new 18-year global data set.
- Partnership with Canada and Japan.



Japan 6/10/08

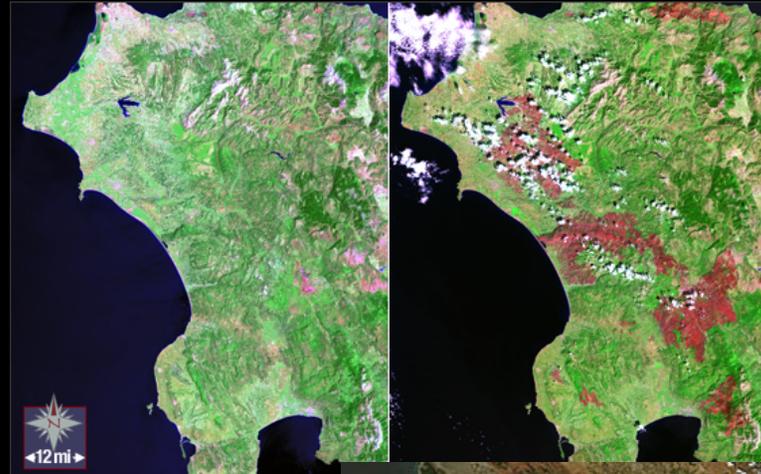


Support to Firefighters

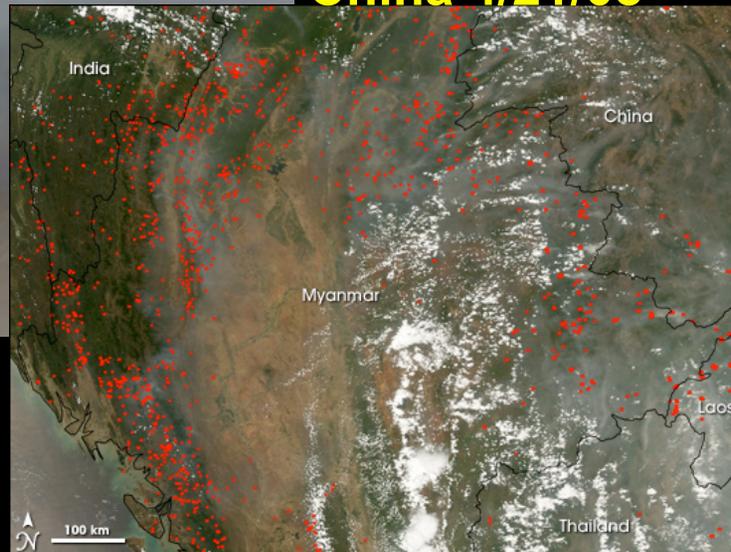
North Carolina 6/14/08



2007 Greek fire scars



India/Myanmar/
China 4/21/08



California
5/23/08



Improved Weather Forecasts

Spaceborne Scientific Sensors Add Valuable Weather Forecast Data

Aviation Week and Space Technology

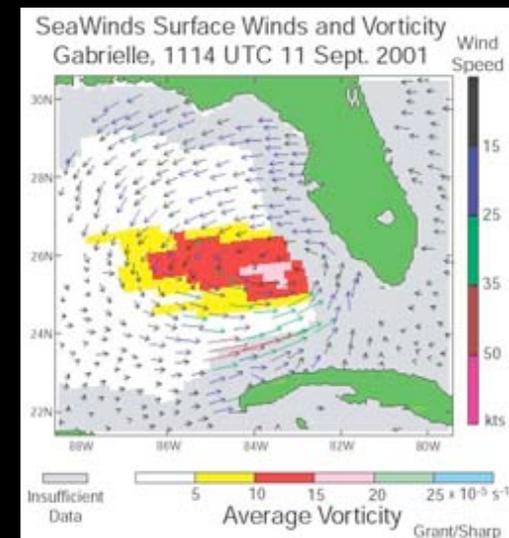
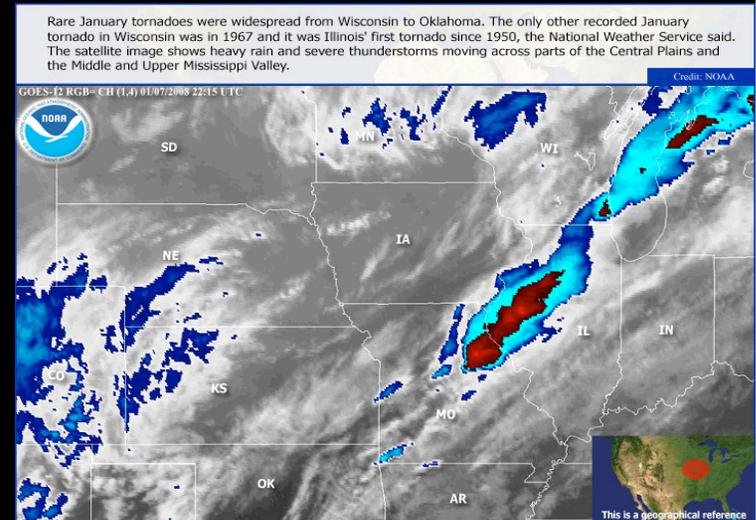
Dec 11, 2005

Frank Morring, Jr.

MODIS Polar Winds Help improve Weather Forecasts



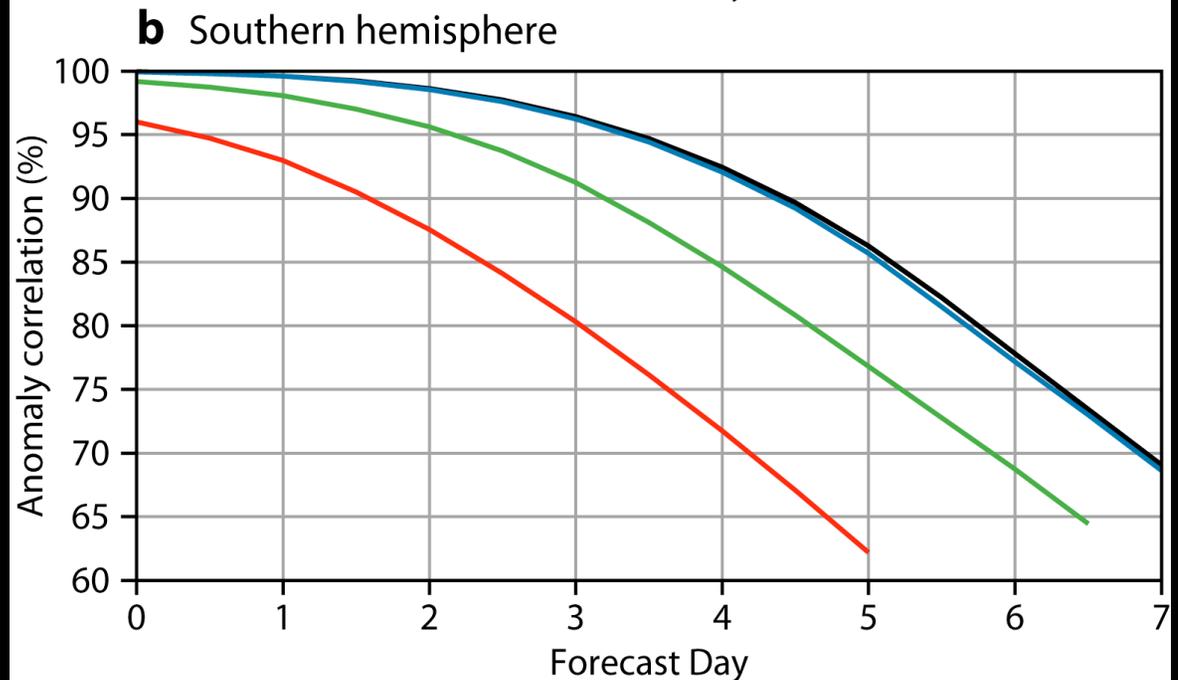
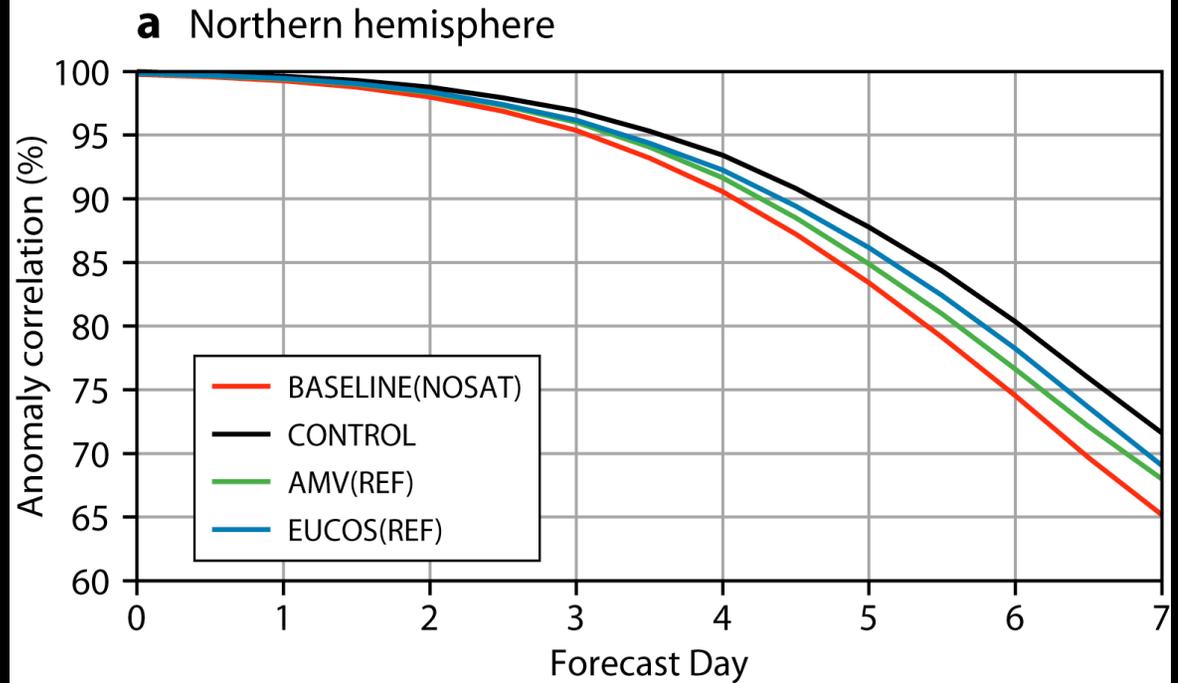
Incorporation of MODIS landcover data to improve land surface parameterization in the COAMPS numerical weather prediction model



**Comparison of
EUCOS(REF) and
AMV(REF) with
BASELINE (NOSAT)
and CONTROL**

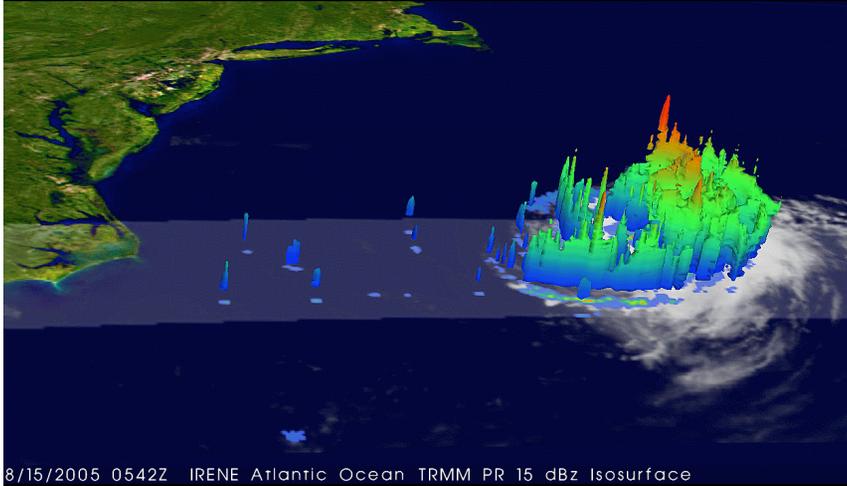
(a) northern hemisphere

(b) southern hemisphere



Severe Weather in Near-Real Time

TRMM Data for Hurricane Irene

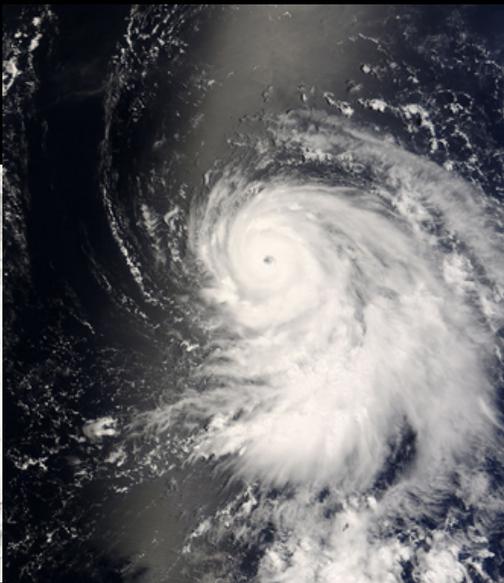
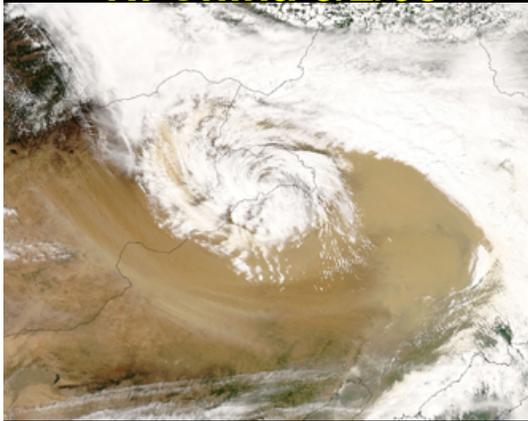


Earthquake near Chengdu, China 6/10/08 and 6/08/08



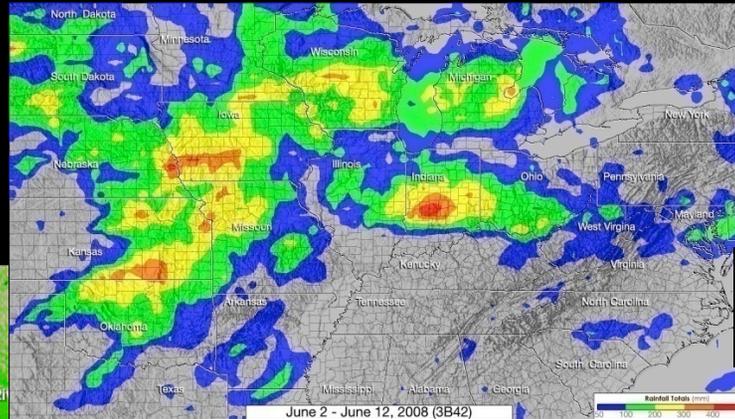
Typhoon Nakri 5/29/08

Dust storm in N. China 6/2/08



Midwestern Floods - June 2008

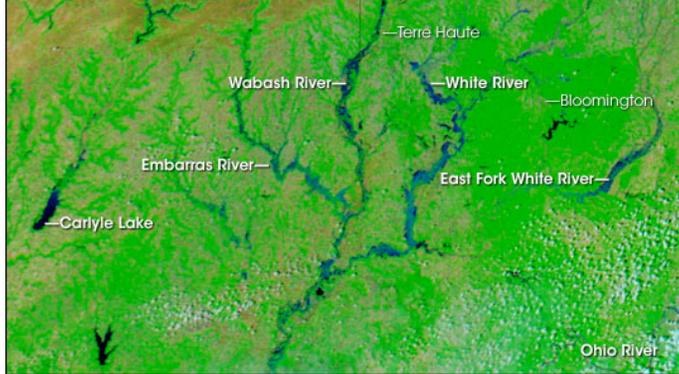
Total precipitation 6/02-6/12



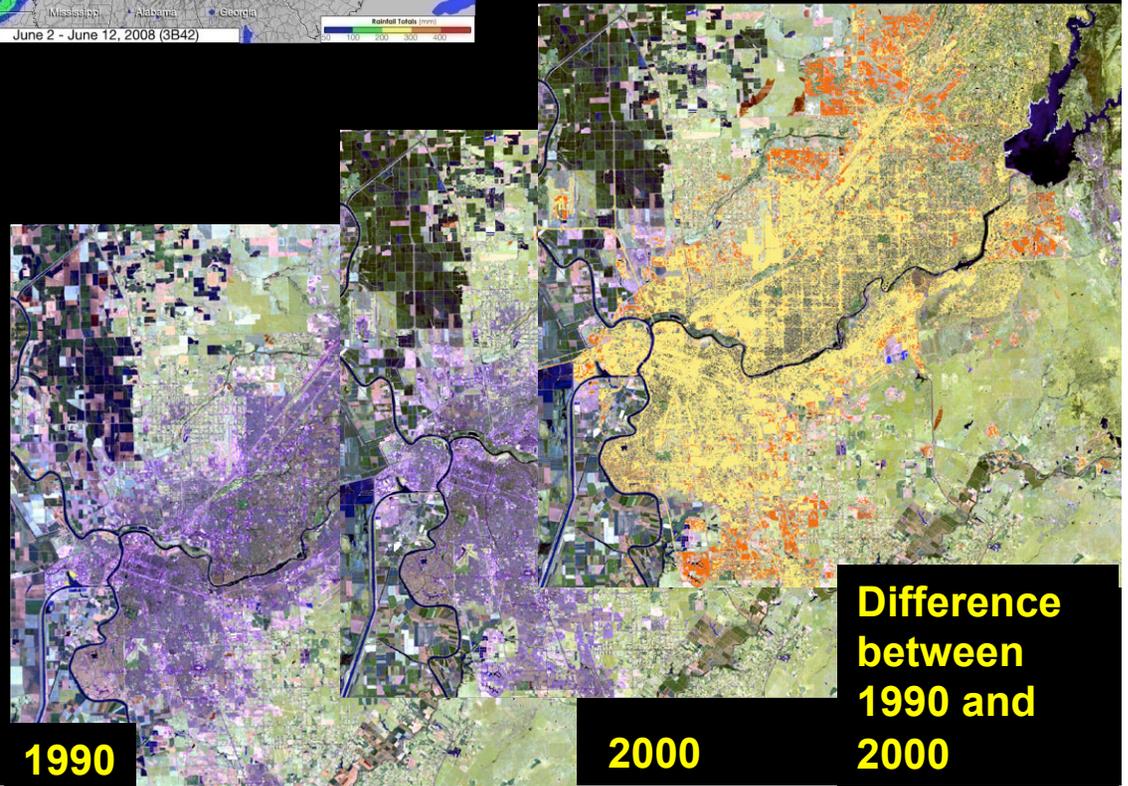
5/28/08



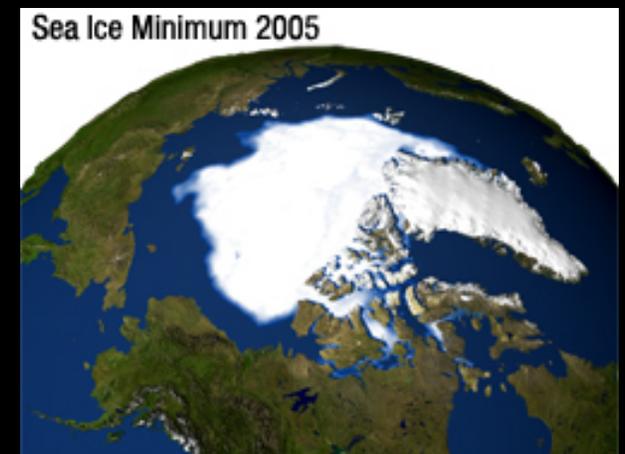
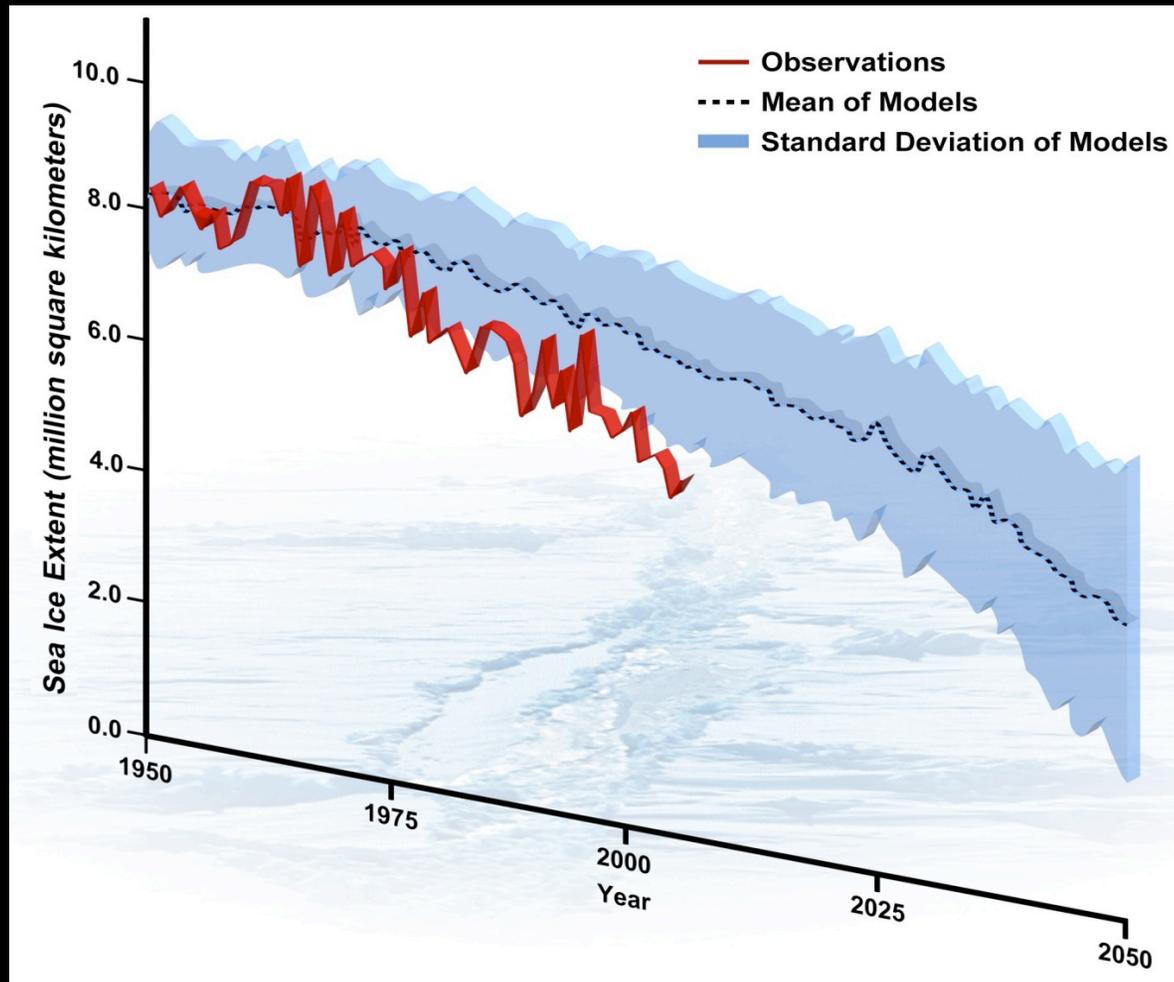
6/10/08



Sacramento, CA Urban Change Landsat Images



Disappearing Sea Ice



Building on Successive Generations of Imagery

1960



Gemini 12



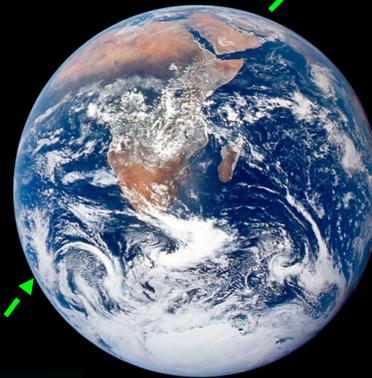
Mercury-Atlas 9



Tiros 1



Apollo 8

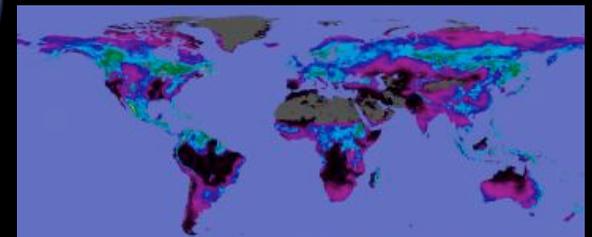


Apollo 17



Terra-MODIS

present



Net Primary Productivity



Landsat - Mt. St Helens 1972-1999

Synergy Between Research and Operations Missions

R
E
S
E
A
R
C
H

HUMAN

Gemini



Skylab



Shuttle/STM



SPACE
SCIENCE

SMM



XTE



SOHO



MRO



MER



EARTH
SCIENCE

Nimbus



UARS



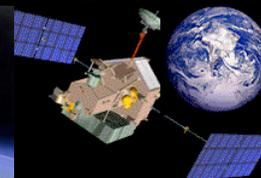
Terra/ Aqua



AURA

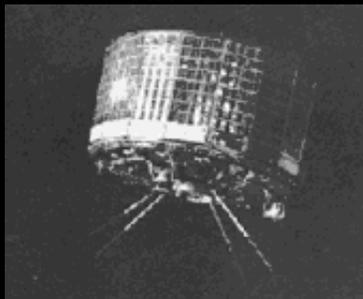


TRMM



O
P
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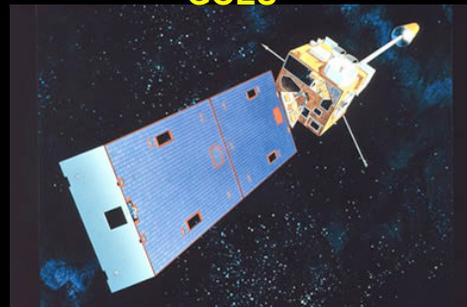
TIROS



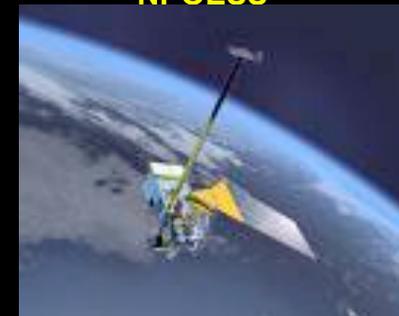
Landsat 1



GOES



NPOESS

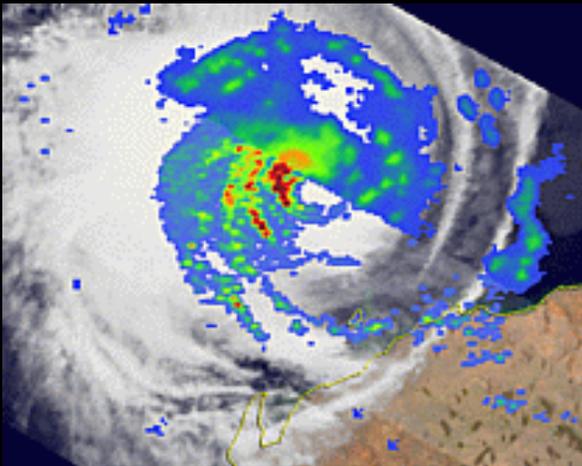


Collaborations are Critical

TRMM Tropical Rainfall Measuring Mission



December 26, 2004



Cyclones in South Indian Ocean, 2/08



29 MODIS stations in China



Tsunami 2004

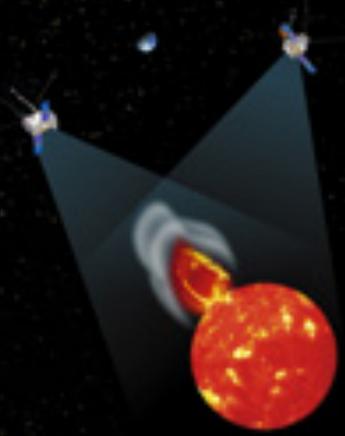
January 1, 2004

Earth as part of a System

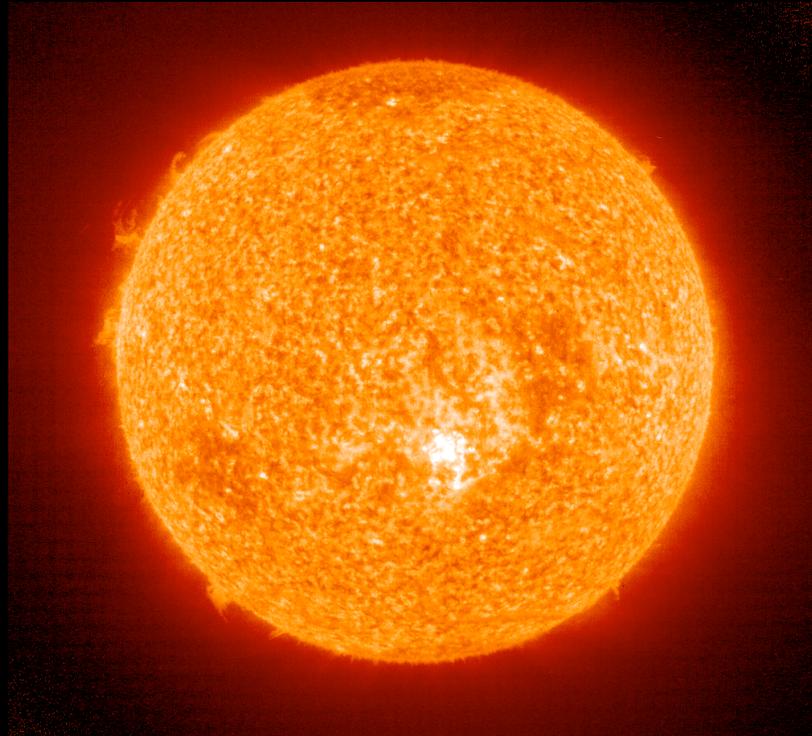
New Views – New Tools



Solar Monitoring



STEREO



GOES



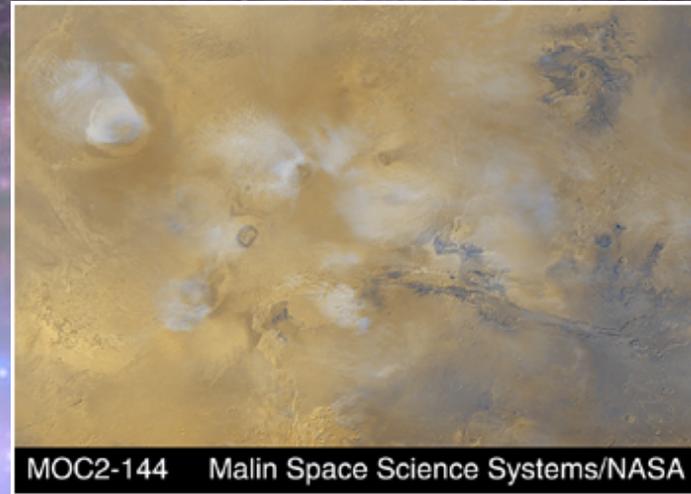
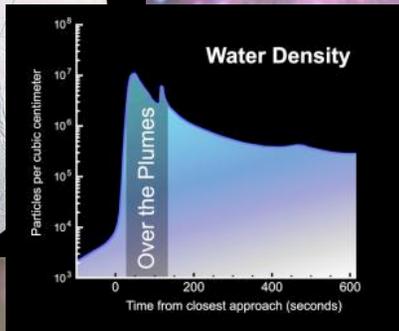
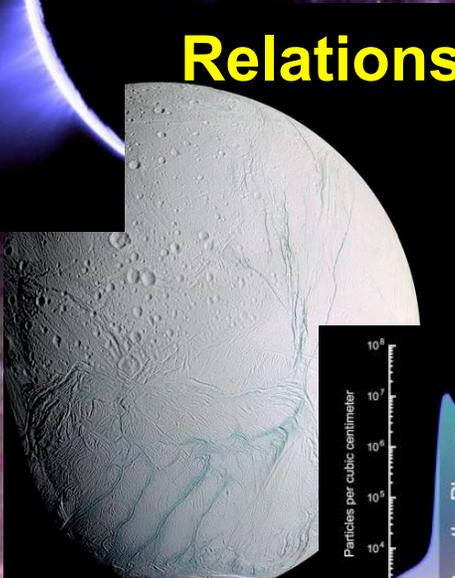
SOHO



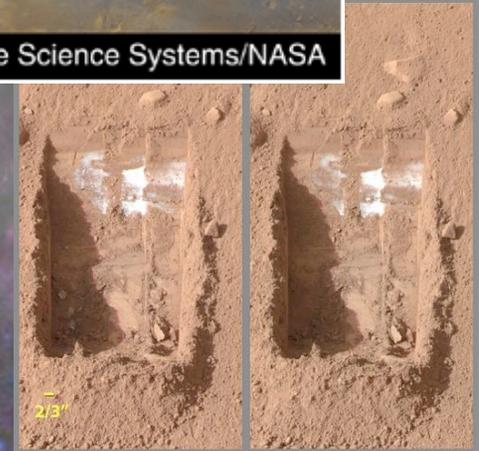
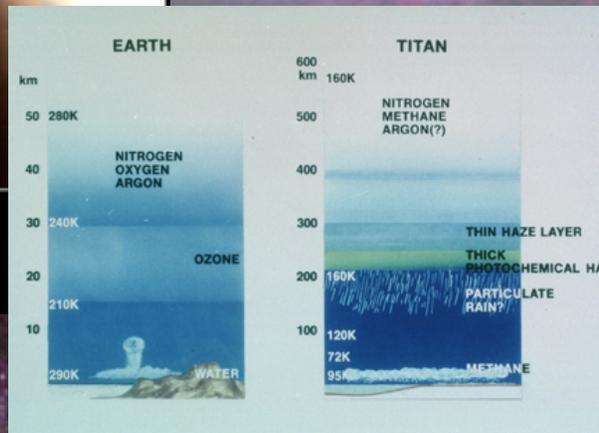
SDO

EXPLORATION

Relationship among planets and moons

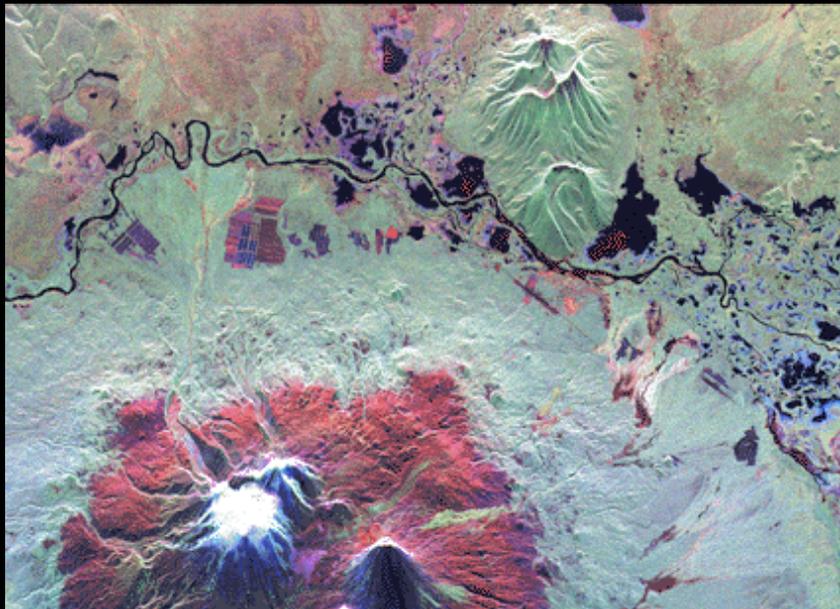


124



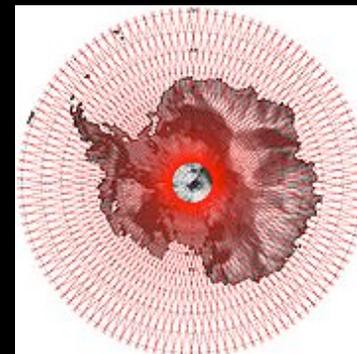
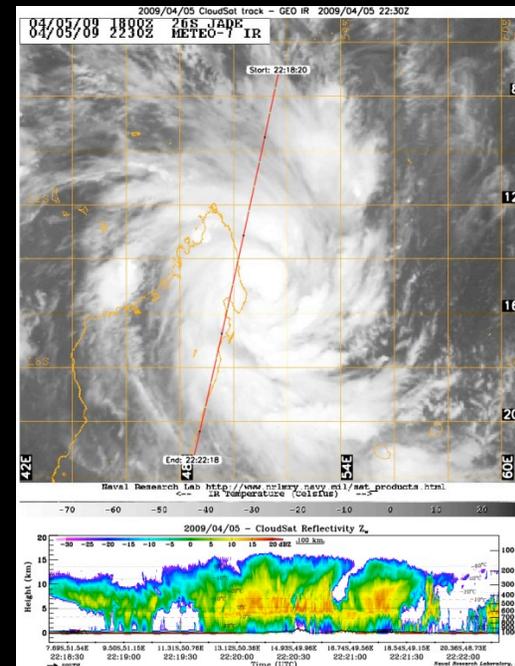
Over 300 planets discovered outside of our solar system

Enter Active Sensors and New Opportunities

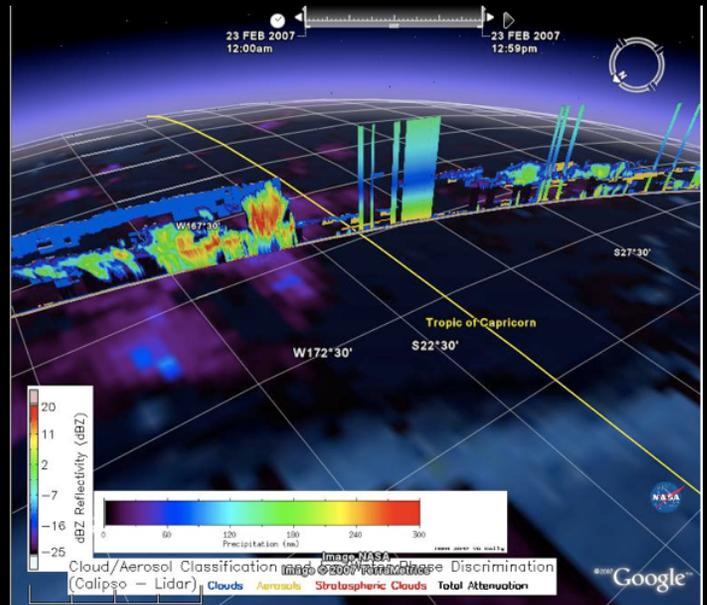
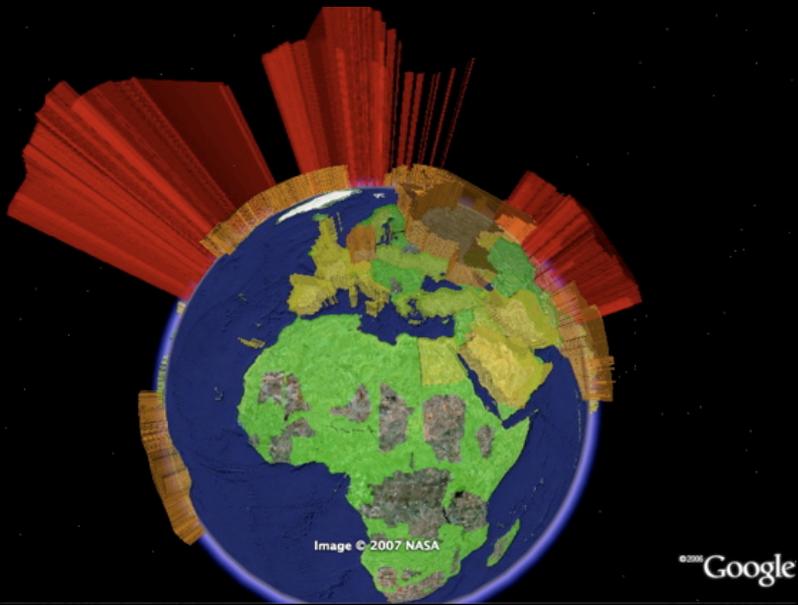


**SAR Image of
Kliuchevskoi Volcano, Russia**

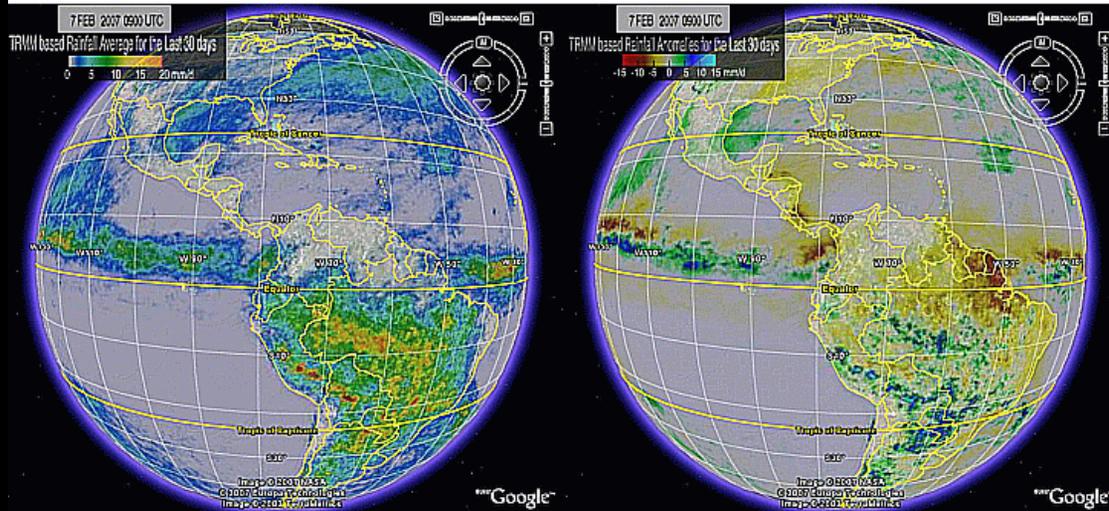
LIDAR



NASA Meets Google Earth



REALTIME 30 Day Average Rainfall and 30 Day Anomalous Rainfall



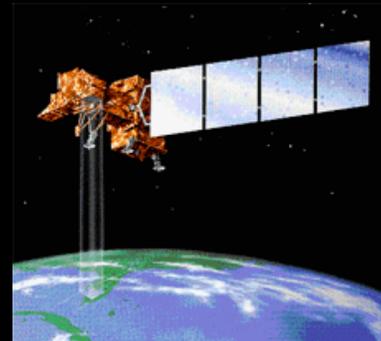
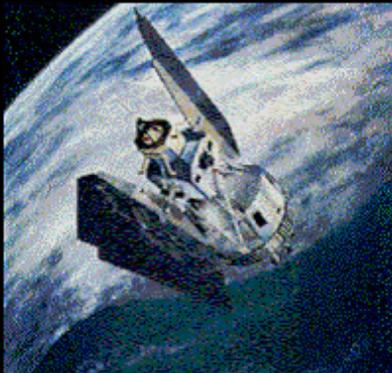
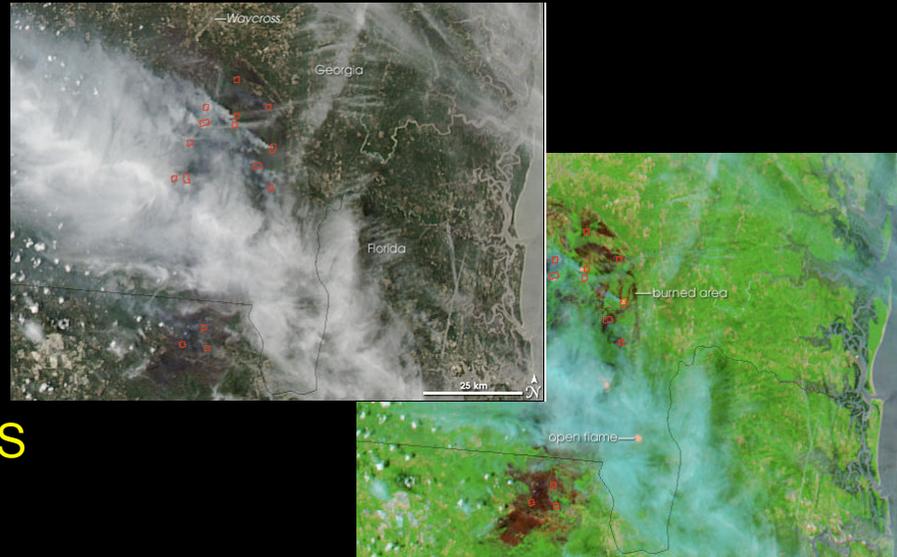
Research to Operations

Landsat 1 to LDCM

EOSDIS to NPOESS Centrals

Terra to Aqua to NPP to NPOESS

Scatterometry, Altimetry, Precipitation all moving towards operations



Challenges and Promise

- New capabilities and vantage points provide new opportunities
 - Cloud computing, active sensors, Orion and Ares, ISS
 - Exploration of the planets and the universe benefit our technologies and our understanding of the Earth
- Space missions remain very synergistic
 - Research to Operations critical to long term observations
 - Robotic and Human missions complement each other
- Space and Earth observation involve international collaboration
 - More countries involved = more opportunities to leverage benefits
- We have lost some of our skills and need to reinvigorate our instrument, detector, and modeling capabilities

“We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time.”

T. S. Eliot