NASA Earth-Sun System Science Benefits for Society

Transition from Research to Operations: Plans and Challenges on the Way Forward

October 12, 2005

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Applied Sciences Program
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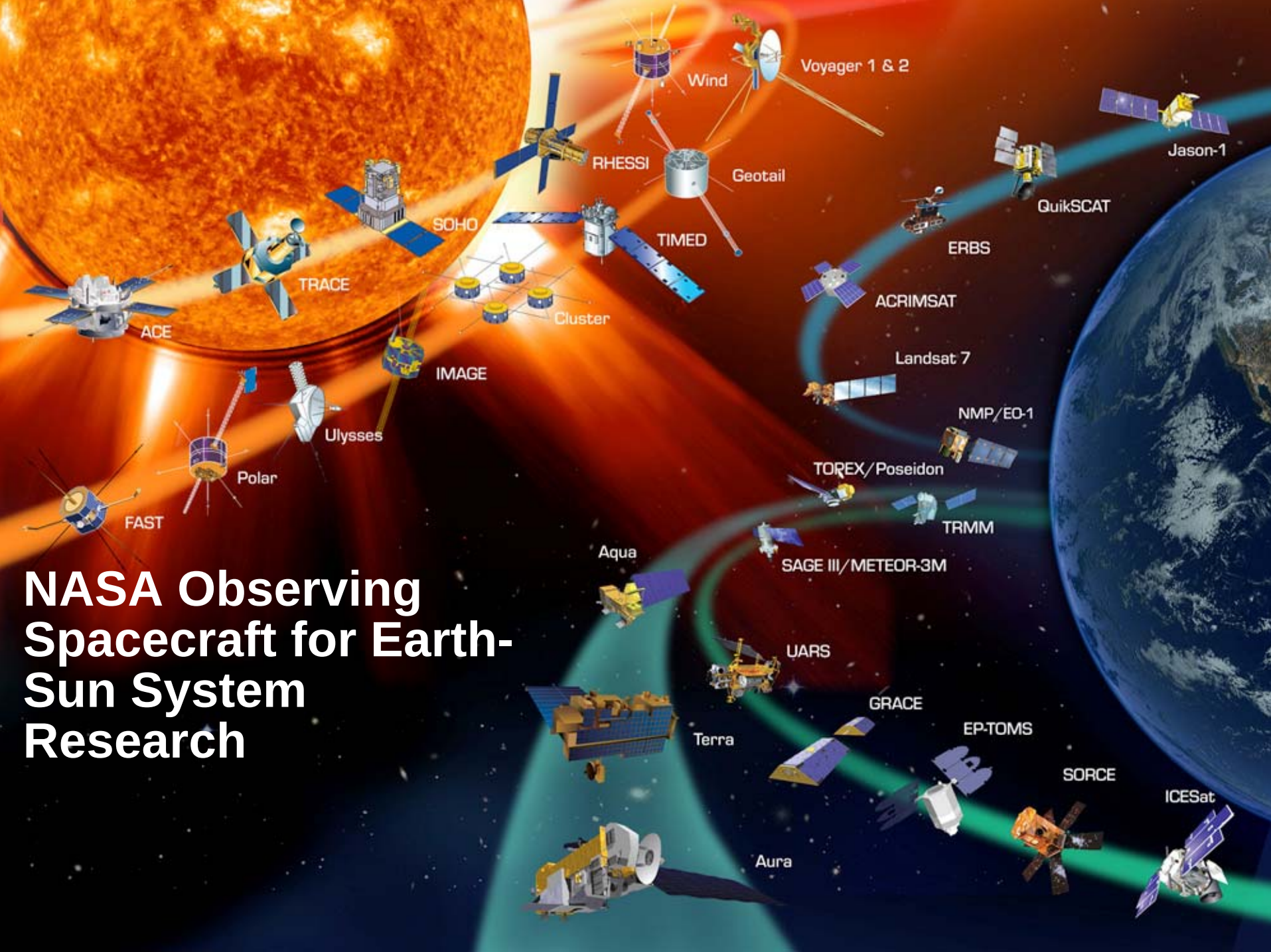
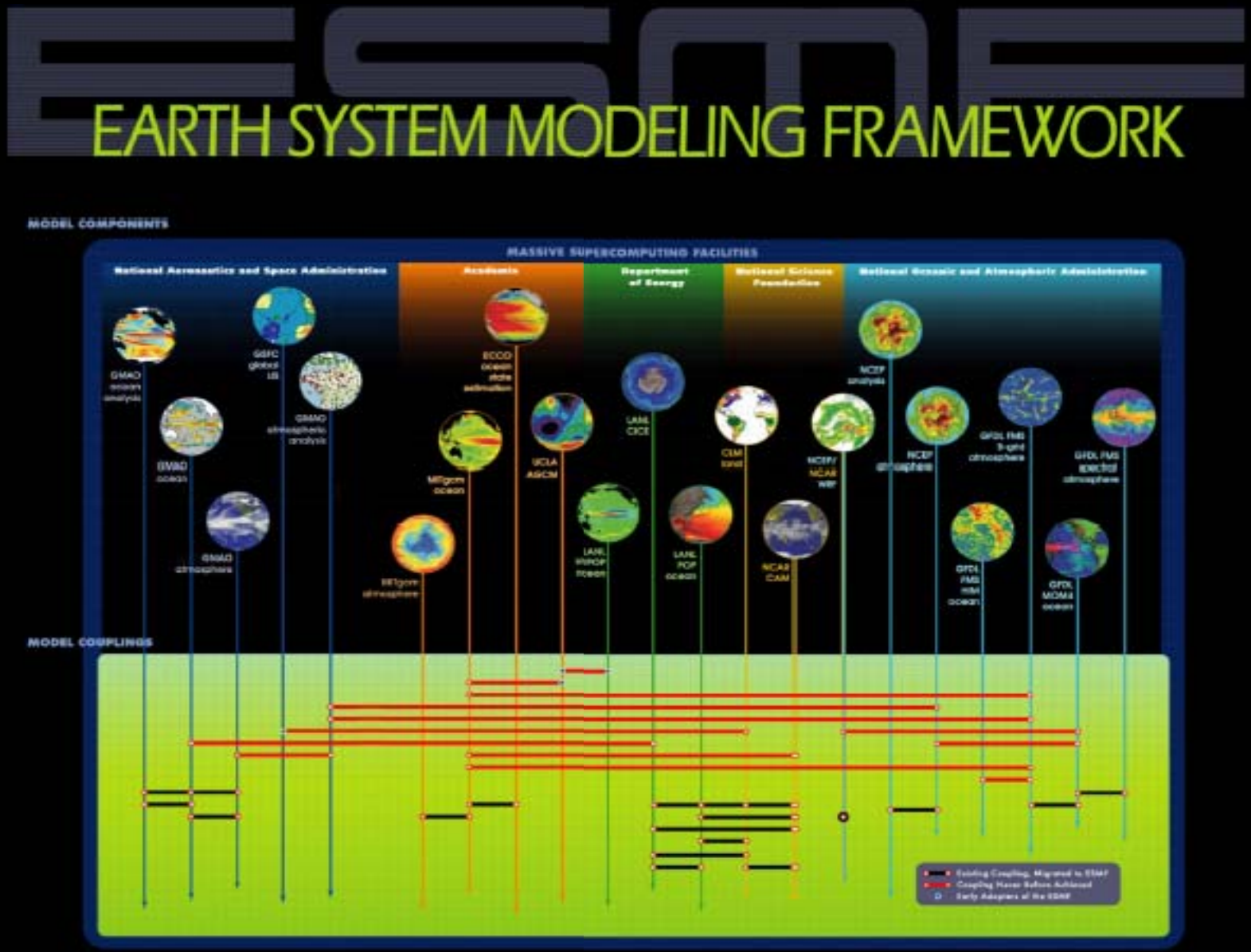
NASA Science Mission Directorate

Over 6 billion people to serve….


Wind
Voyager 1 & 2
RHESSI
Geotail
Jason-1
QuikSCAT
SOHO
TIMED
ERBS
TRACE
ACRIMSAT
ACE
Cluster
Landsat 7
IMAGE
NMP/EO-1
Ulysses
TOREX/Poseidon
Polar
TRMM
FAST
SAGE III/METEOR-3M
Aqua
UARS
GRACE
Terra
EP-TOMS
SORCE
ICESat
Aura
NASA Observing Spacecraft for Earth-Sun System Research

Earth System Models

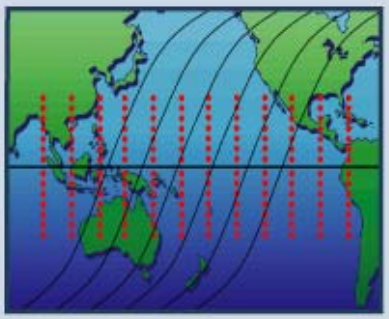


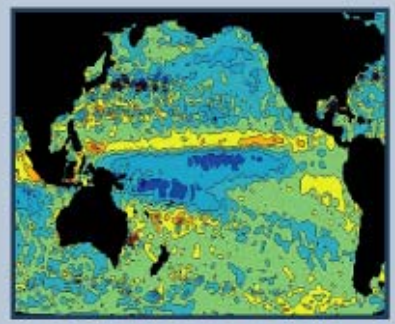
Observations to Knowledge Products

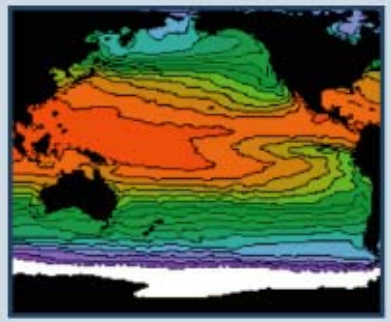
"from photons to electrons to neurons"

Downlink Speed

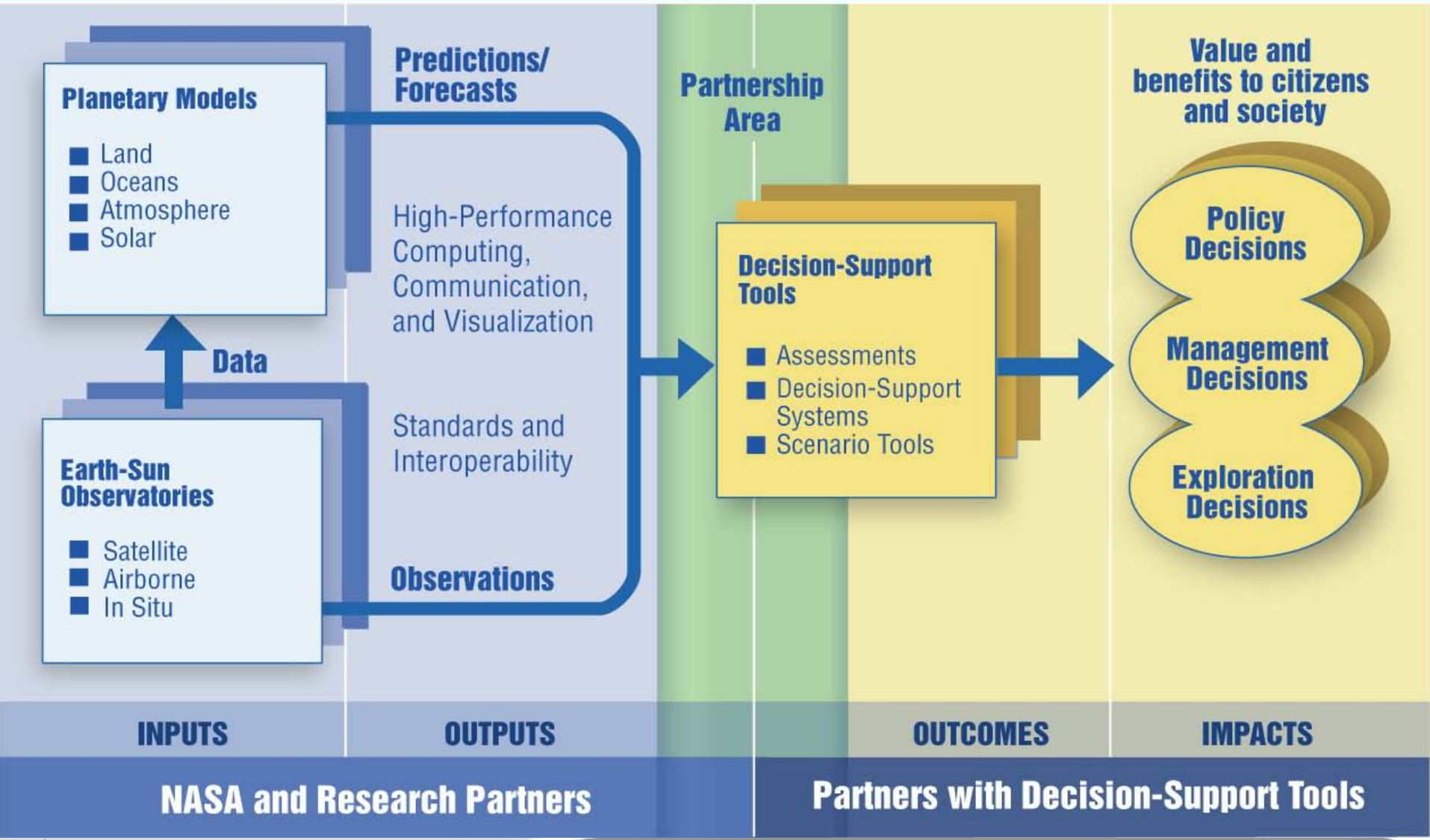
Petabytes 10^{15}	Terabytes 10^{12}	Gigabytes 10^{9}	Megabytes 10^{6}
Multi-platform, multiparameter, high spatial and temporal resolution, remote & in-situ sensing	Calibration, Transformation To Characterized Geo-physical Parameters	Interaction Between Modeling/Forecasting and Observation Systems	Interactive Dissemination and Predictions
Advanced Sensors	**Data Processing & Analysis**	**Information Synthesis**	**Access to Knowledge**



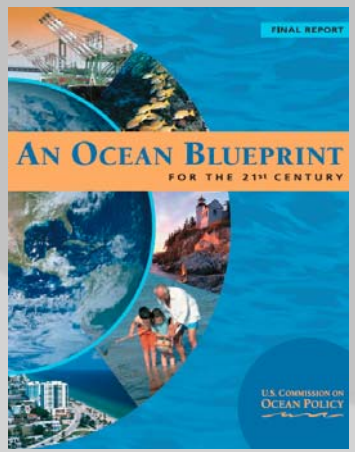




Integrating Knowledge, Capacity and Systems into Solutions

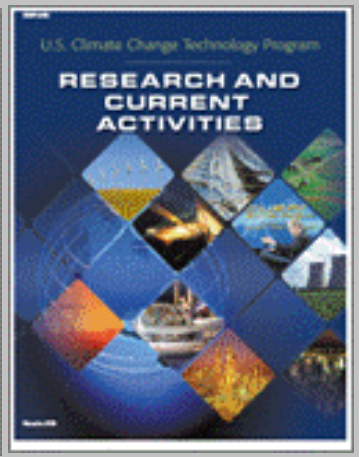


National Plans



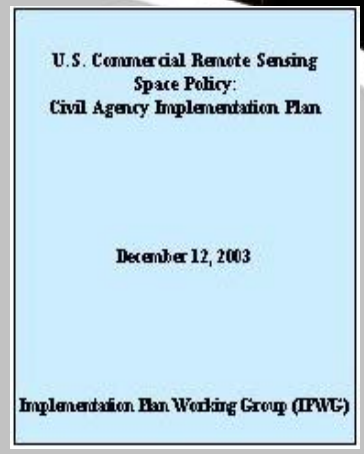
Commission on Ocean Policy

Integrated Earth Observation System



Climate Change Technology Program

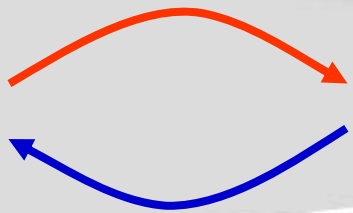
Climate Change Science Program



Commercial Remote Sensing Space Policy

Administration plans and policies form a basis for a **formal** NASA – NOAA Research & Operations Transition Plan

NASA Research Capabilities



NOAA Operational Capabilities

National and NASA Objectives

National Objective 5 – Study the Earth system from space and develop new space-based and related capabilities for this purpose.

NASA Objective 14

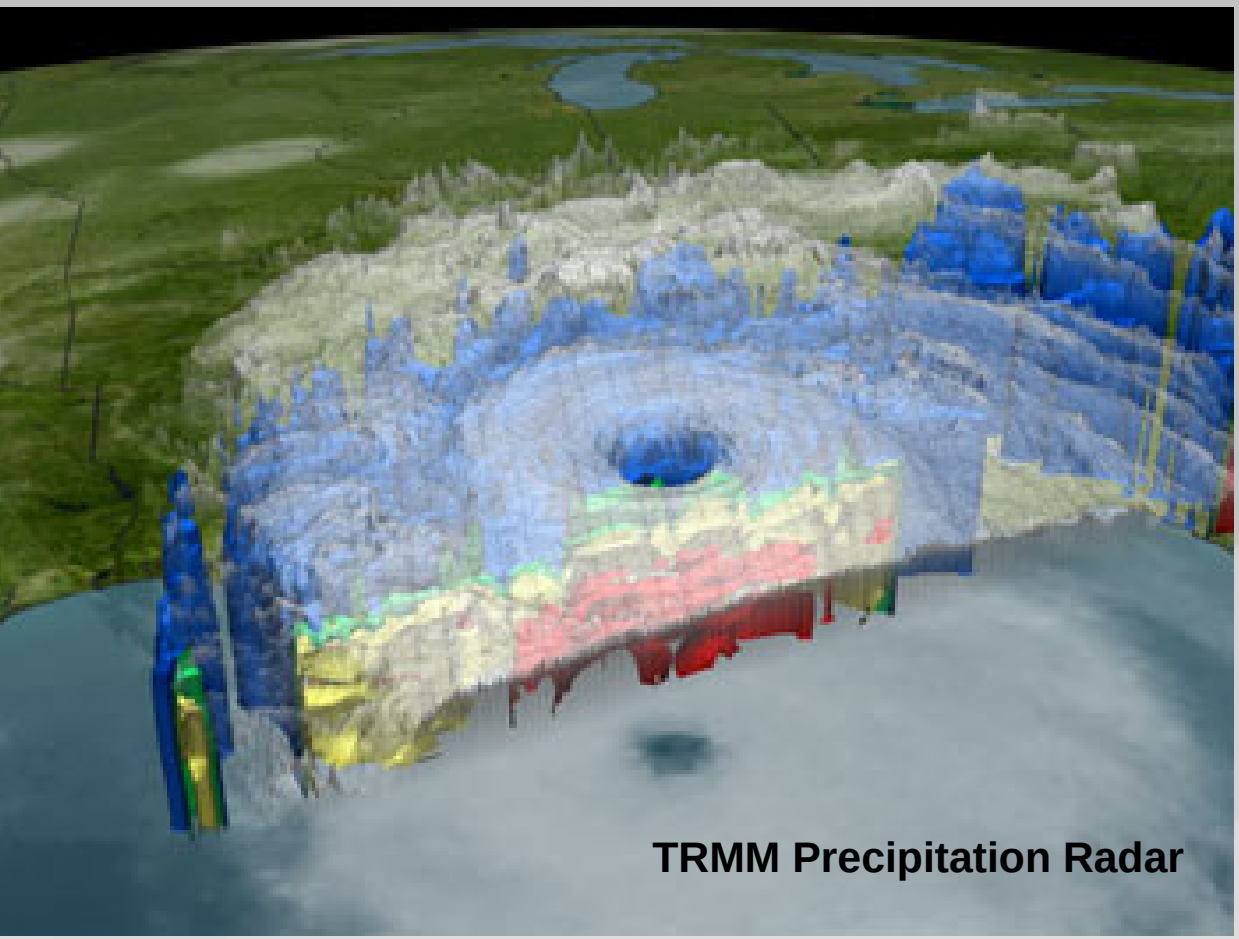
Advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities, including those with potential to improve future operational systems.

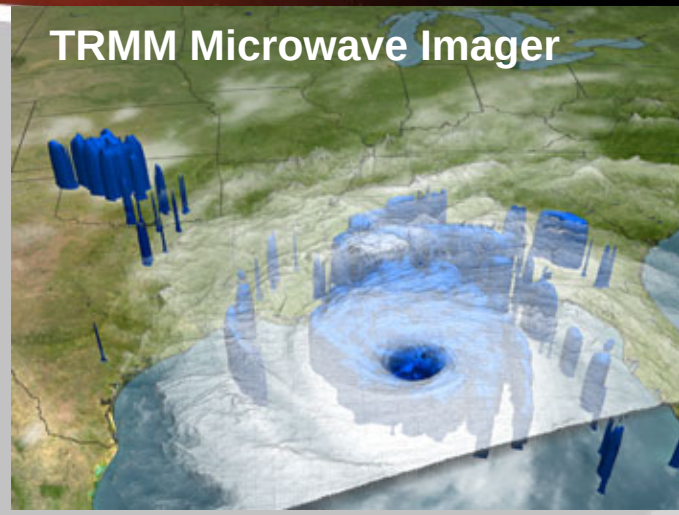
NASA Objective 15

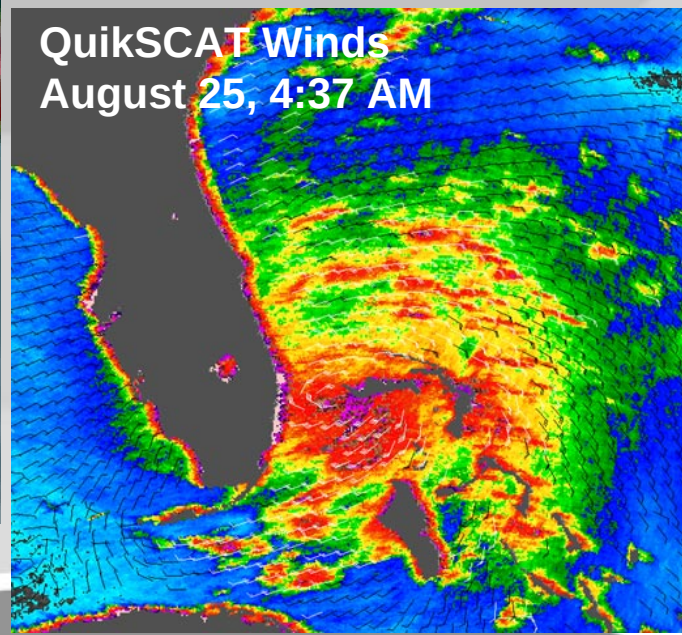
Explore the Sun-Earth system to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by human explorers, and demonstrate technologies that can improve future operational systems.

Observing Birth and Intensification of Deadly Cat-5 Hurricane Katrina

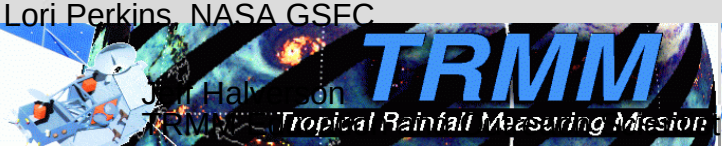
TRMM August 28, 10:25 pm

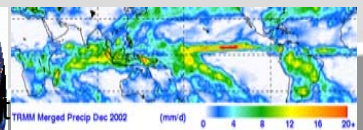






Lori Perkins, NASA GSFC





Jo[illegible] Hal[illegible]son
TRM[illegible]

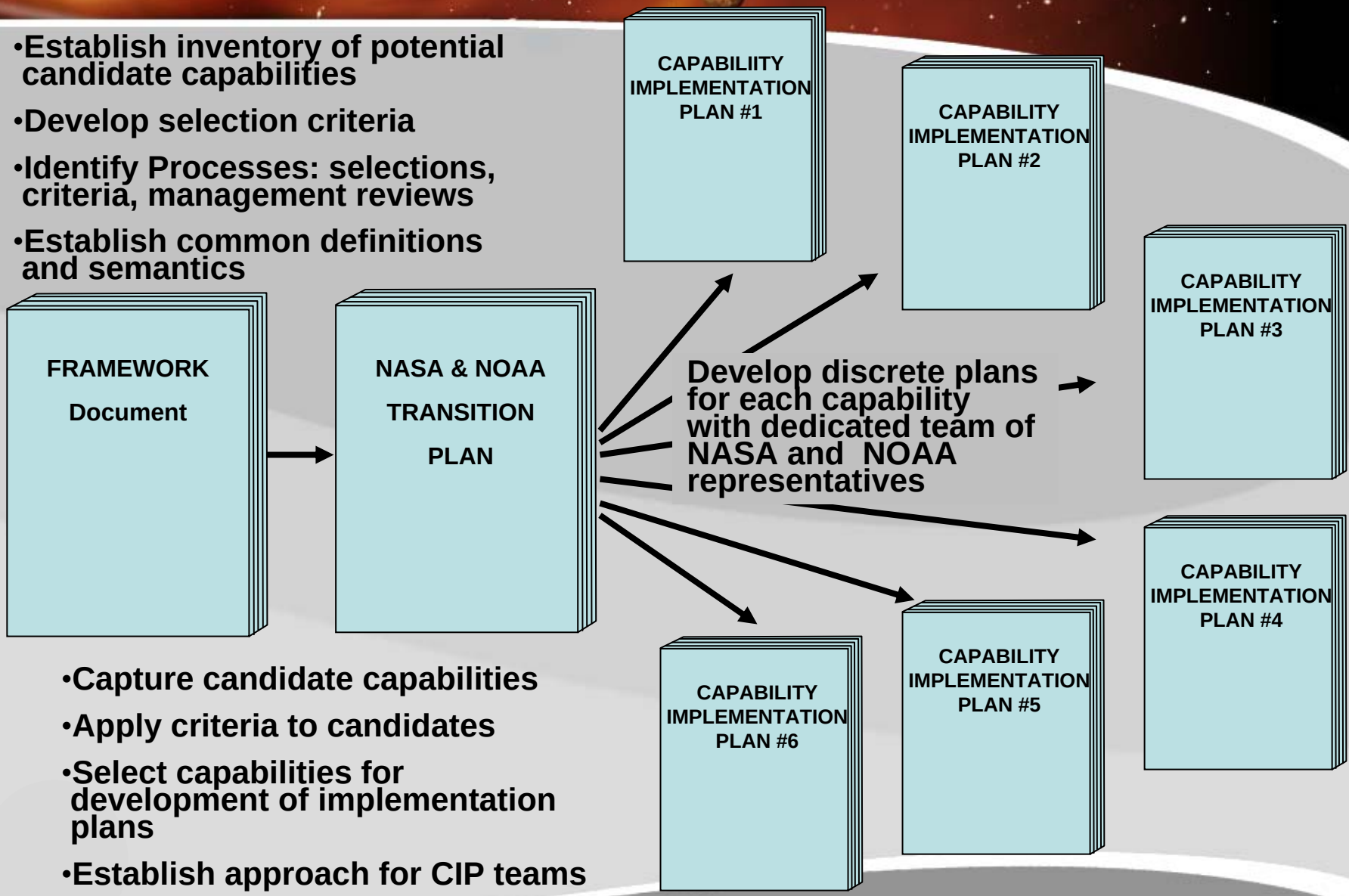
QuikSCAT Science Team, JPL

Joint Management Structure for NASA – NOAA R&O

- **Transition Management Oversight**
  - Establishes framework for collaboration, sets bilateral policy and priorities, approves Transition Plan, and oversees implementation
    - NOAA/J. Kelly
    - NASA/Mary Cleave
- **Ad hoc Joint Working Group**
  - Prepares overall Transition Plan, identifies Transition Capabilities, oversees development of individual implementation plans, and coordinates senior review of implementation plans
    - NOAA/Chet Koblinski
    - NASA/Ron Birk
- **Transition Capability Teams**
  - Prepares an implementation plan for each identified Transition Capability

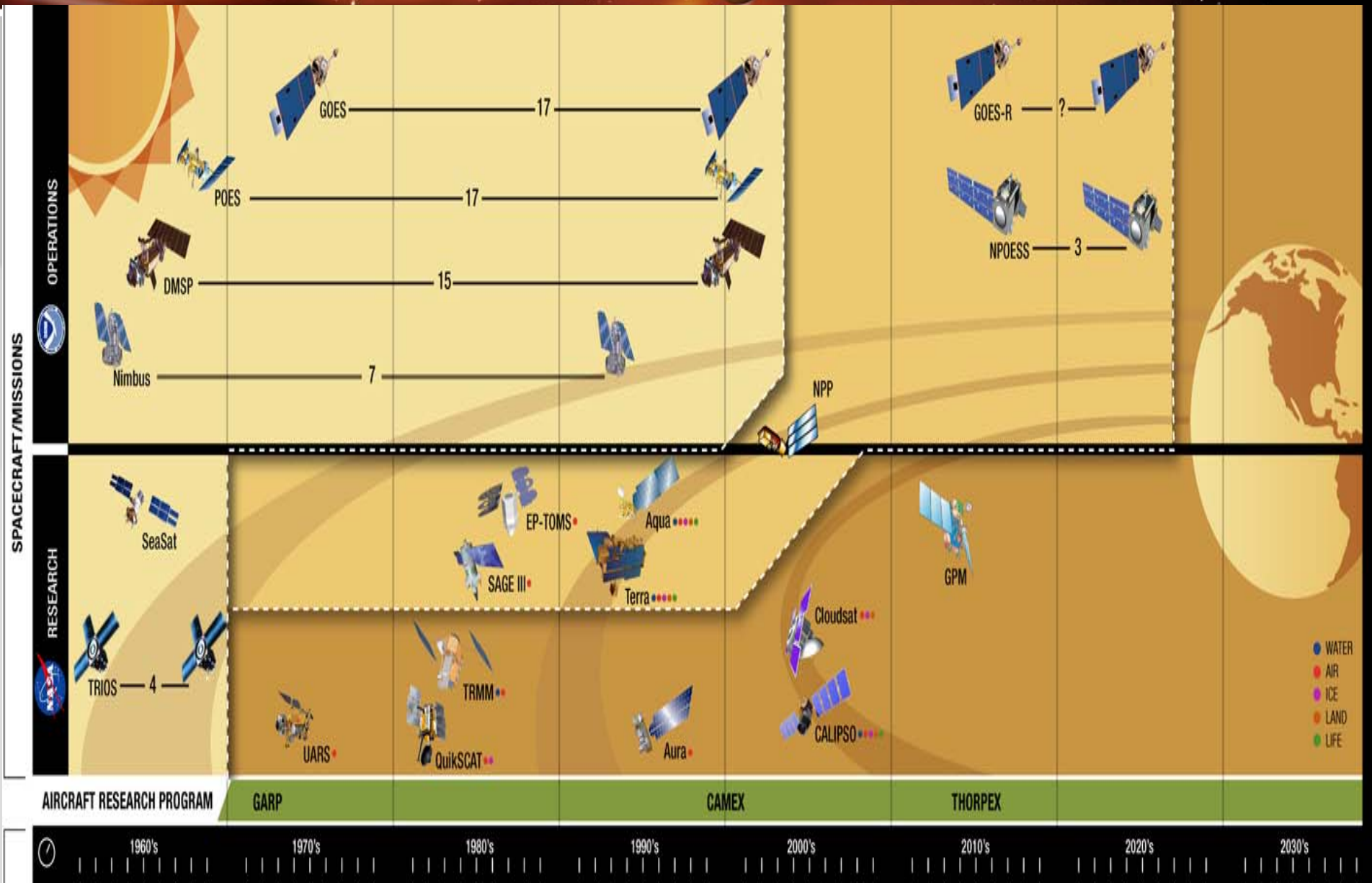
R&O JWG Documentation

- Establish inventory of potential candidate capabilities
- Develop selection criteria
- Identify Processes: selections, criteria, management reviews
- Establish common definitions and semantics



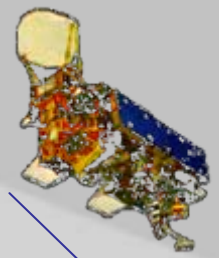
- Capture candidate capabilities
- Apply criteria to candidates
- Select capabilities for development of implementation plans
- Establish approach for CIP teams

Heritage of Spacecraft Missions transition from Research to Operations



The legacy in weather systems continues…

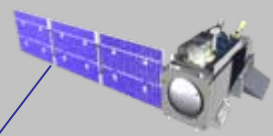
Aqua (2002)
AIRS, AMSU & MODIS



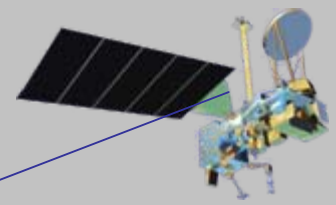
Coriolis (2003)
WindSat

METOP (2005)
IASI/AMSU/MHS & AVHRR

NPP (2008)
CrIS/ATMS
VIIRS
OMPS



NPOESS (2010)
CrIS/ATMS, VIIRS, CMIS,
OMPS & ERBS



Use of Advanced Sounder Data for Improved Weather Forecasting & Numerical Weather Prediction

NOAA Real-Time Data Delivery Timeline Ground Station Scenario

C3S → IDPS → NOAA Real-time User

Joint Center for Satellite Data Assimilation

NWS/NCEP
GSFC/DAO
ECMWF
UKMO
FNMOC
Meteo-France
BMRC-Australia
Met Serv Canada

→ **NWP Forecasts**

Spacecraft succession plans…

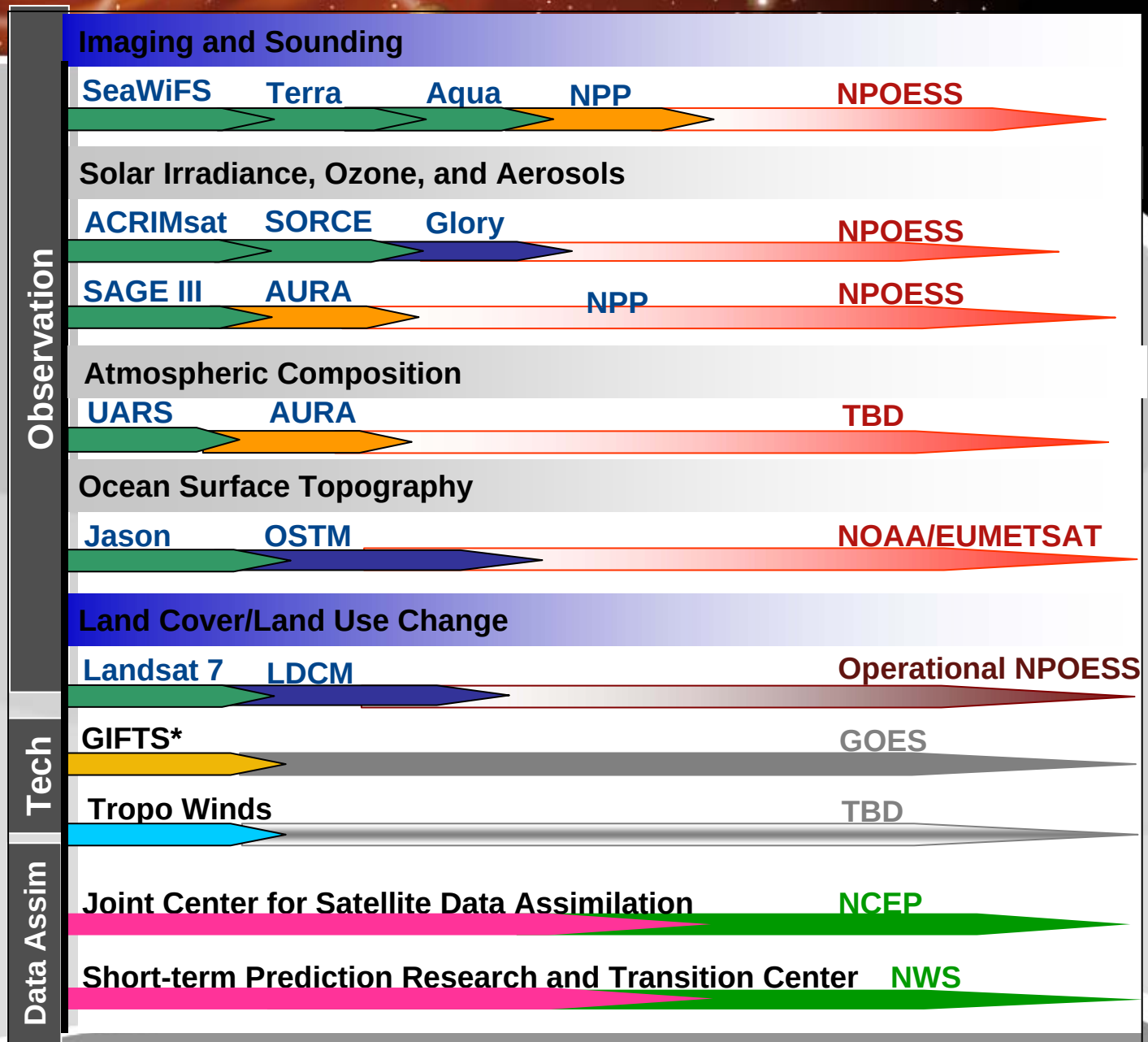
In operation

Under Development

In Formulation

Technology Development

* Canceled flight mission; gleaning technology for GOES-R

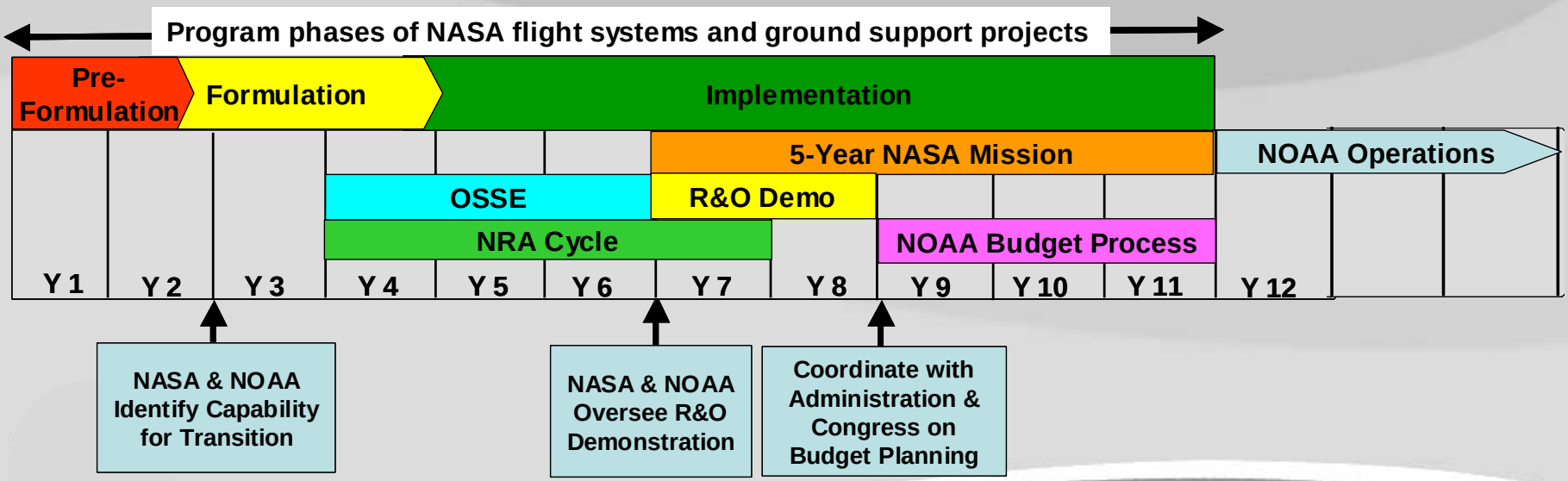


R&O Transition Timeline

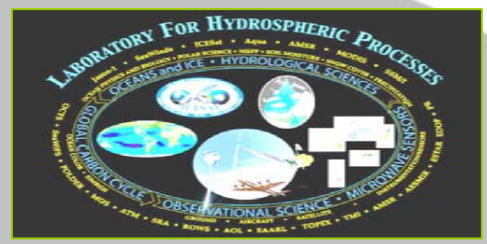
The IBPD Earth-Sun System, Objective 14, states:

14.1 Transfer 30 percent of NASA developed research results and observations to operational Agencies.

Pressing issues include timing and targets of opportunity:



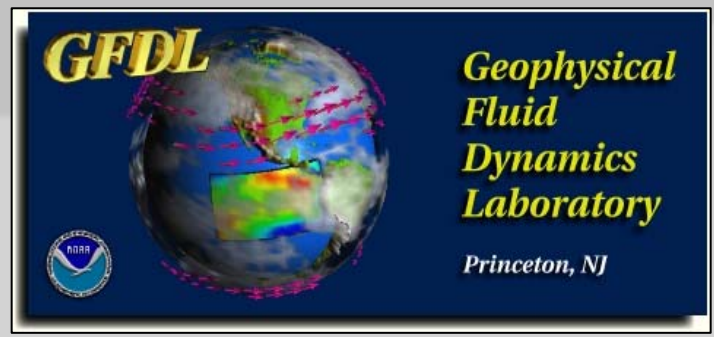
Transitioning Capabilities of Earth-Sun System Models



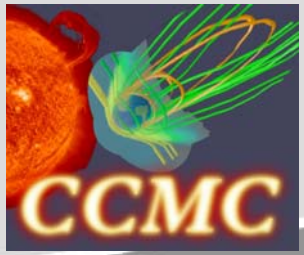
SPORT

NASA Goddard Space Flight Center
LABORATORY FOR ATMOSPHERES

National Centers for Environmental Prediction



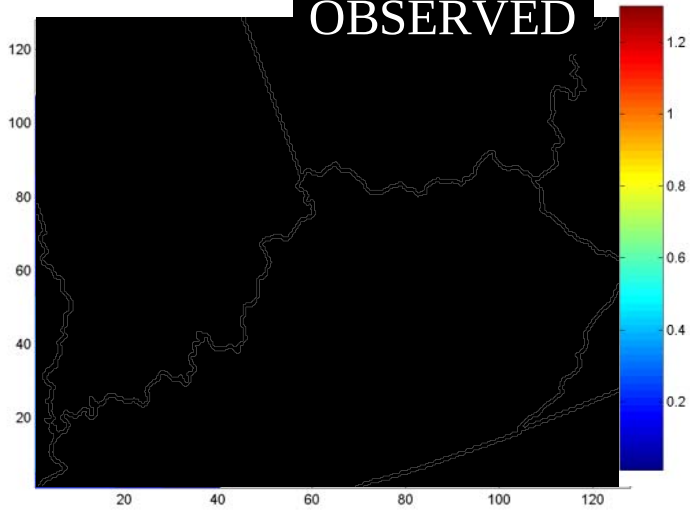
Office of Research and Applications

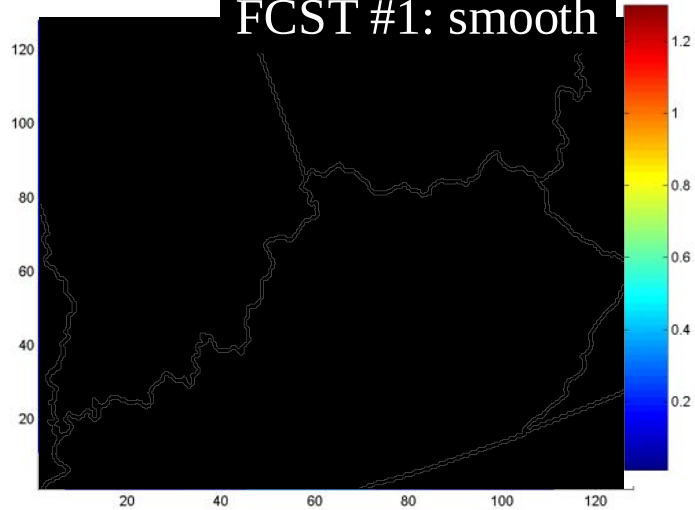


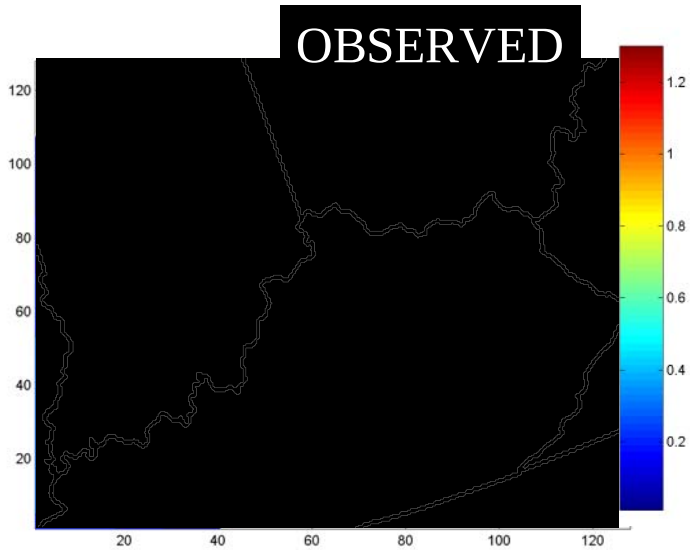
Challenges on the Way Ahead

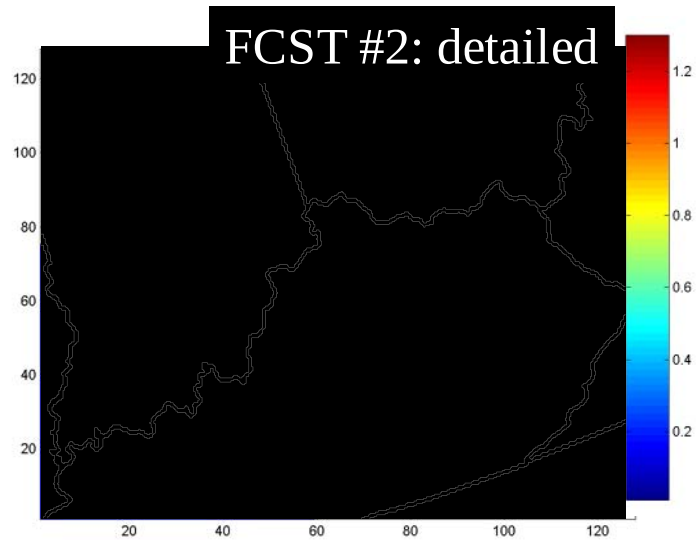
- Systematically transitioning appropriate NASA capabilities to evolve operational systems to better serve society
- Characterize uncertainty in model forecasts for weather, climate, and natural hazards
- Benefiting from increased data handling capacity to handle volume and range of data from Earth-Sun observatories
- Evolving an Earth-Sun System Gateway portal to provide interoperability and access between research results and integrators

Setting the Stage
Verification & Validation









"Measures-oriented" (Brooks and Doswell, 1996) approach to verifying these forecasts

Verification Measure	Forecast #1 (smooth)	Forecast #2 (detailed)
Mean absolute error $MAE = \frac{1}{n}\sum_{k=1}^{n}\lvert f_k - x_k\rvert$	*0.157*	0.159
RMS error $RMSE = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(f_k - x_k)^2}$	*0.254*	0.309
Bias $BIAS = \overline{f}/\overline{x}$	0.98	0.98
Threat score (>0.45) $TS = H/(F+O-H)$	*0.214*	0.161
Equitable threat score (>0.45) $ETS = \frac{H - Ch}{(F+O-H-Ch)}$	*0.170*	0.102