

NORTHROP GRUMMAN

DEFINING THE FUTURE

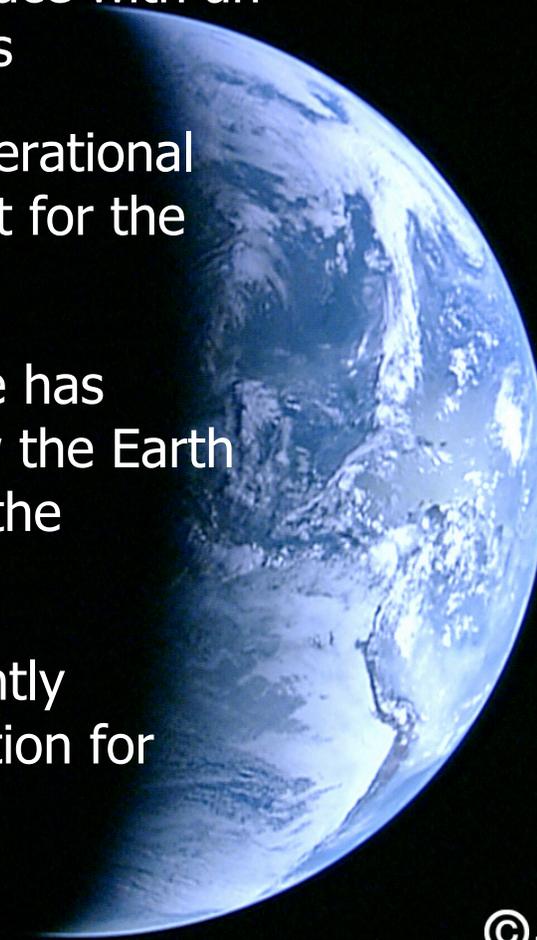
**Earth Observation Targets:
2020 and Beyond
Towards a Global Change Monitoring
System:
Observables
for
Space Missions**

Ron Birk, presented by Stewart Moses
August 17, 2008



The Earth as a Planet

- The Earth is being well studied from Space with an armada of current and planned missions
- NASA (science missions) and NOAA (operational missions) develop and manage this fleet for the nation
- Our awareness of global climate change has stimulated a new era in monitoring how the Earth is changing climactically, in addition to the ongoing weather measurements
- The Earth Science community has recently developed a decadal plan recommendation for NASA to address their needs



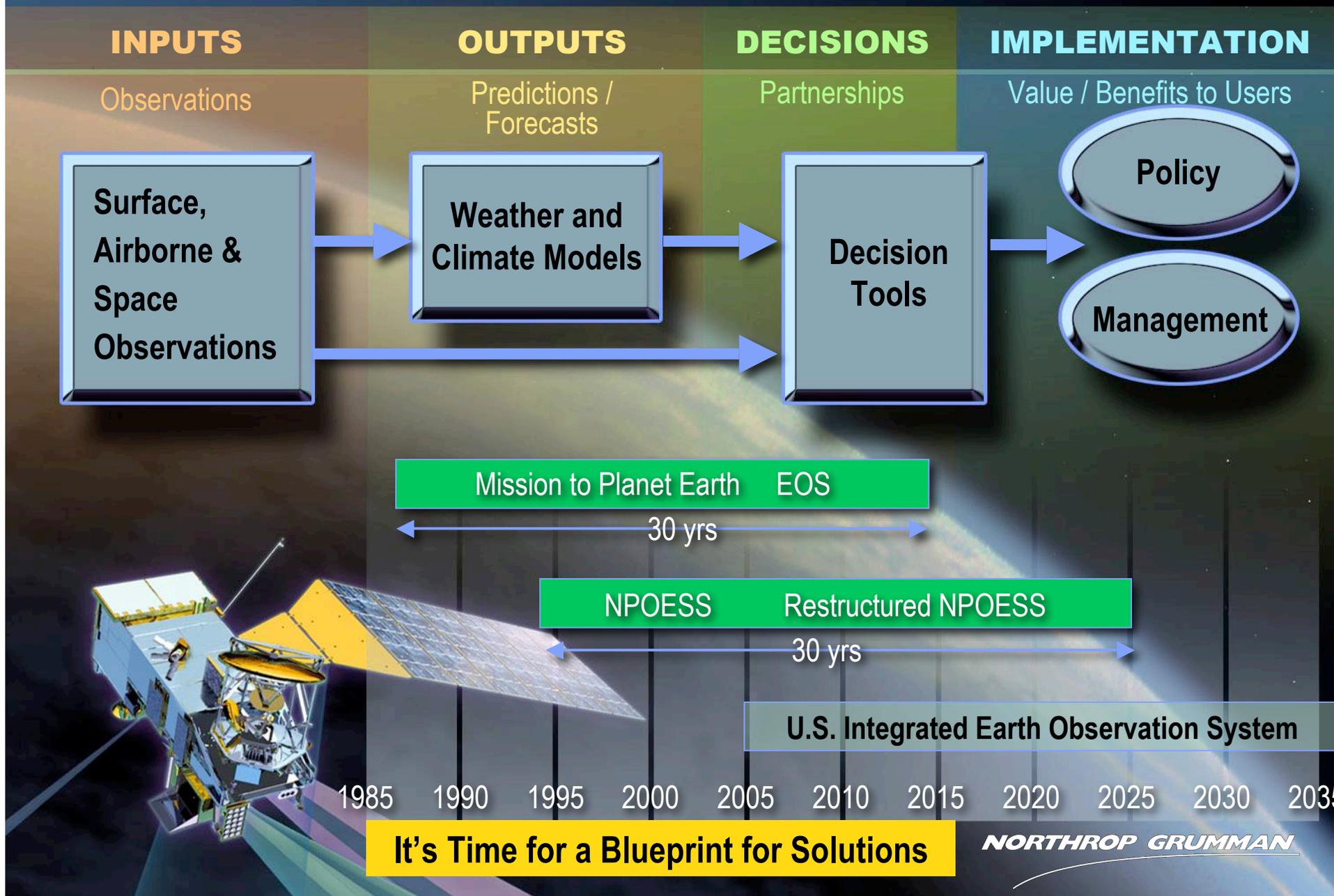
Economy, Environment, and National Security Depend Upon Global Change Information



Key Issues, Challenges, Opportunities

- Global change is a critically important societal issue of our time
- U.S. is addressing the importance of developing a National Climate Change Strategy – an important dimension of global change
- Climate technologies include emissions management, alternative energy, energy efficiency, and **measurements and monitoring**
- A Global Change Monitoring System is needed to provide data needed to inform decision makers for adaptation and mitigation at the local, regional, national and global levels for **a range of environmental parameters**
- Earth is a complex system requiring a full complement of observations of key **climate (26), weather (55), and solid Earth hazards (7) parameters** in order to monitor its vital signs and its capacity to sustain 7+ billion people

Essential Decisions are enabled by Essential Data



Space-based Observables

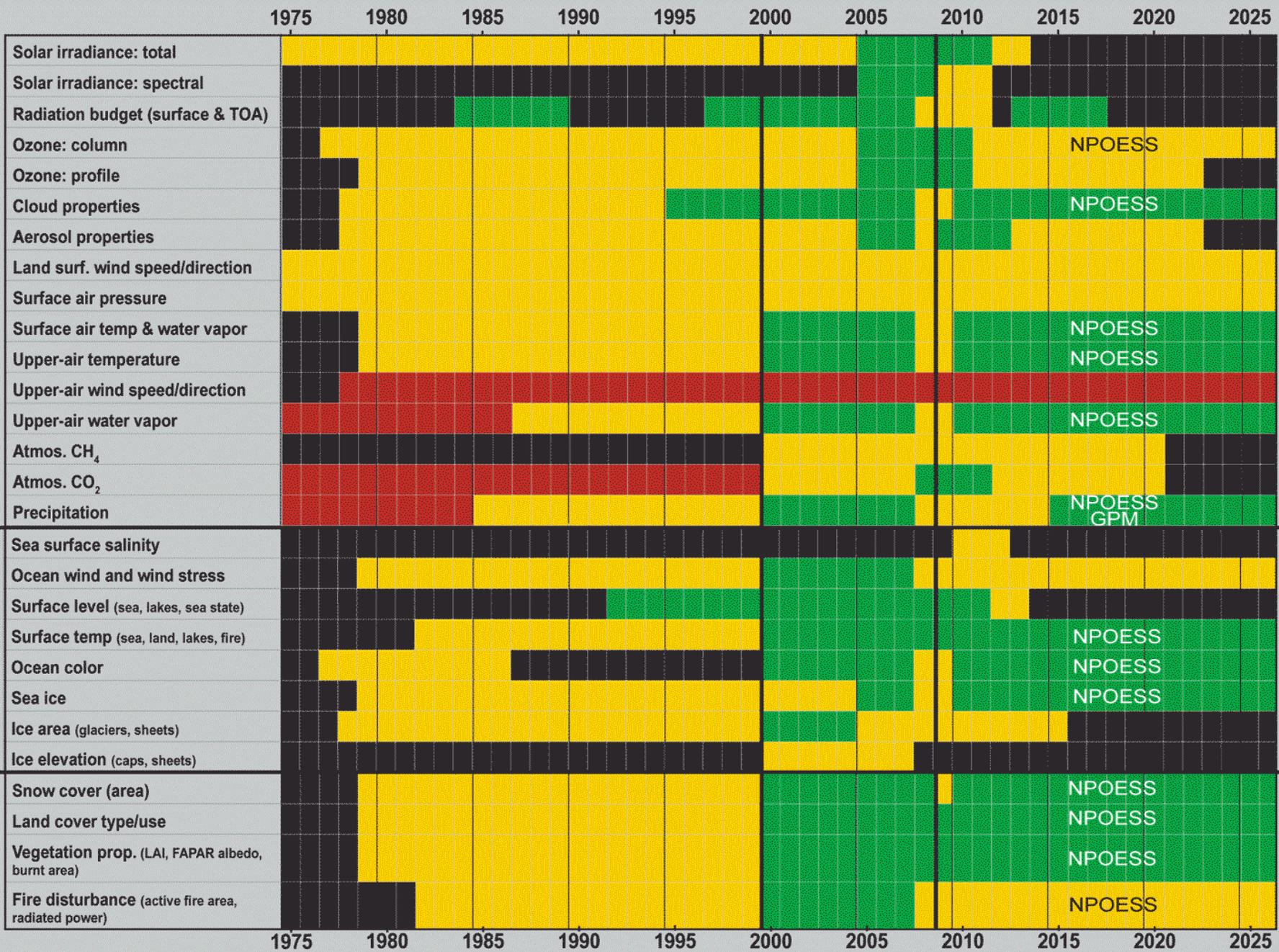
- Essential **Climate** Variables
- Environmental Data Records for **Weather**
- **Solid Earth and Natural Hazard** parameters

- Capacity and Gap Assessments
 - Assessment of representative gaps in observables
 - NRC Earth Science Decadal mission recommendations
 - NOAA 2008 (unfunded) priority observations and systems

Atmosphere

Oceans / Ice

Terrestrial



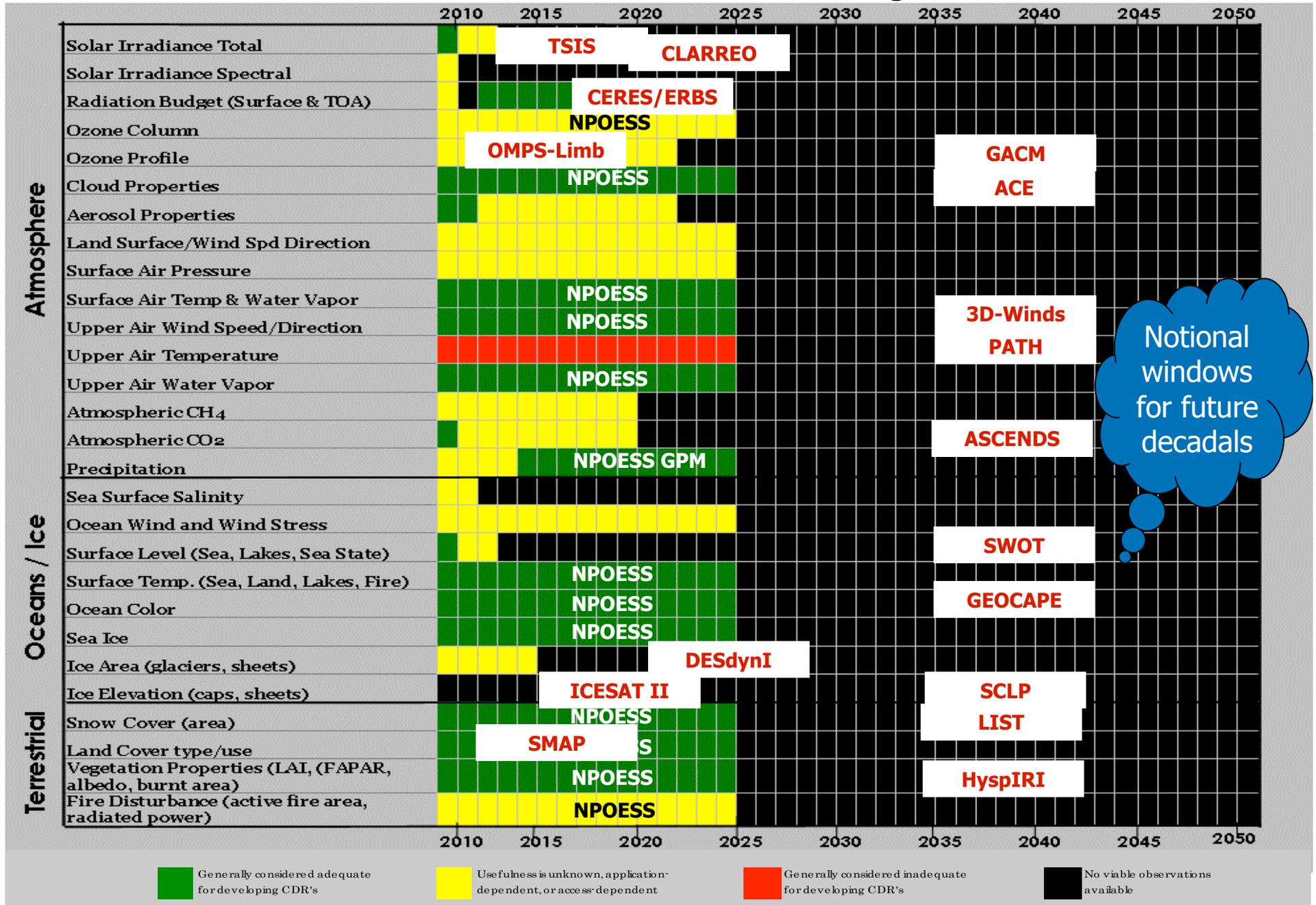
Green: Generally considered adequate for developing CDRs

Yellow: Usefulness is unknown, application-dependent, or access-dependent

Red: Generally considered inadequate for developing CDRs

Black: No viable observations available

Global Essential Climate Variables through 2050



55 Environmental Data Records (EDRs)

MISSION AREAS

 Atmosphere	 Climate
 Land	 Ocean
 Space Environment	

CMIS (16)

-  CLOUD LIQUID WATER
-  PRECIPITATION TYPE/RATE
-  PRECIPITABLE WATER
-  SEA SURFACE WINDS
-  CLOUD ICE WATER PATH
-  Surface Wind Stress
-  TOTAL WATER CONTENT

SESS (13)

-  Auroral Boundary
-  Auroral Energy Deposition
-  Auroral Imagery
-  Electric Fields
-  Electron Density Profile
-  Energetic Ions
-  Geomagnetic Field
-  In-situ Plasma Fluctuation
-  In-situ Plasma Temp
-  Ionospheric Scintillation
-  Med Energy Chgd Parts
-  Neutral Density Profile
-  Supra-Therm-Aurora Prop

-  ALBEDO (SURFACE)
-  CLOUD BASE HEIGHT
-  CLOUD COVER/LAYERS
-  CLOUD EFFECTIVE PART SIZE
-  CLOUD OPTICAL THICKNESS
-  CLOUD TOP HEIGHT
-  CLOUD TOP PRESSURE
-  CLOUD TOP TEMPERATURE
-  LAND SURFACE TEMP
-  SURFACE TYPE
-  Net Heat Flux
-  Ocean Color/Chlorophyll
-  SUSPENDED MATTER
-  VEGETATION INDEX

VIIRS (22)

-  Ice Surface Temperature
-  IMAGERY
-  Sea Ice Characterization
-  SNOW COVER/DEPTH
-  SEA SURFACE TEMPERATURE
-  SOIL MOISTURE

CrIS/ATMS (3)

-  ATM VERT MOIST PROFILE
-  ATM VERT TEMP PROFILE
-  PRESSURE (SURFACE/PROFILE)

-  Down LW Radiance (Sfc)
-  Down SW Radiance (Sfc)
-  Net Solar Radiation (TOA)
-  Outgoing LW Rad (TOA)

ERBS (4)

-  AEROSOL OPTICAL THICKNESS
-  AEROSOL PARTICLE SIZE

APS (4)

-  Aerosol Refractive Index, Single Scatter Albedo, Shape
-  Cloud Particle Size/Distrib

-  O₃ Total Column (also CrIS)

-  O₃ Profile (OMPS Only)

OMPS (1)

-  OCEAN WAVE CHARACTERISTICS
-  Sea Surface Height

ALT (2)

-  Solar Irradiance

TSIS (1)

KEY

Underlined = NPP EDRs (25)

 = NPOESS Key Performance Parameters

BOLD CAPS = LRD Environmental Data Records

02 January 2006
 DOC, NOAA, NESDIS,
 Integrated Program Office
 D. Pierce, M. Haas, S. Mango,
 J. Schaeffer, J. Whitcomb
 Northrop Grumman
 L. Wait

Looking to the future

- Assess capacity to deliver full complement of observables and current and planned systems
- Pursuant to gap analysis, look at systems that could be built and deployed to fill gaps
- Identify systems that would ideally be deployed from Ares V vehicle as component of national system
- Employ Enterprise Architecture approach to optimize interoperability and overall functionality of system of systems solution

Global Change Monitoring System 2020

Major Contributors to Shared Virtual Weather and Climate Database



Customer Needs and Requests

Needs and Requests



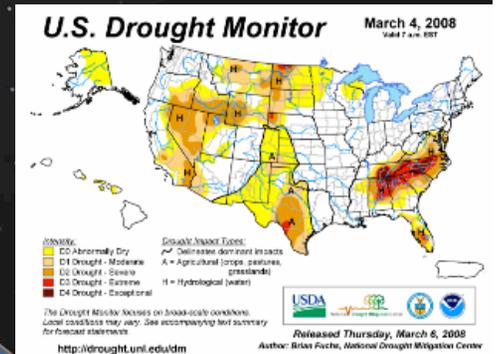
Research and Development Centers

Global Climate Modeling

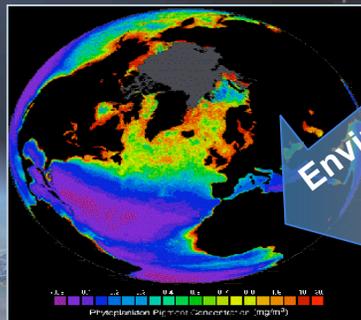
Data Integration, Fusion, and Products

Federal Enterprise Architecture

Decision Quality Information



Regional Decision Support Centers



Essential Environmental Data

Global Change Monitoring System needed to observe globally, forecast regionally, and act locally

UMMAN

Global Change Information from Integrated and Layered Platforms

- Real time weather
- Scientific forecasts of long term climate change
- Continuous monitoring of environmental hazards
- In-situ ground truth to calibrate space sensors
- Routine and systematic reporting
- Ocean monitoring



Possible Missions Enabled by an Ares V



- Large GEO Platforms
 - Large apertures (>10 m) Microwave Sounders to provide useful spatial resolutions (< 4 km) measurements of:
 - Temperature and moisture soundings
 - Rain measurements
 - Severe weather monitoring/prediction with microwave technology require)
 - Synthetic aperture Radars for Surface Wind Measurements
 - Full disk access
 - Superior revisit times (< 1 hr vs days from LEO)

The Ares V lift capacity and faring volume will enable these missions

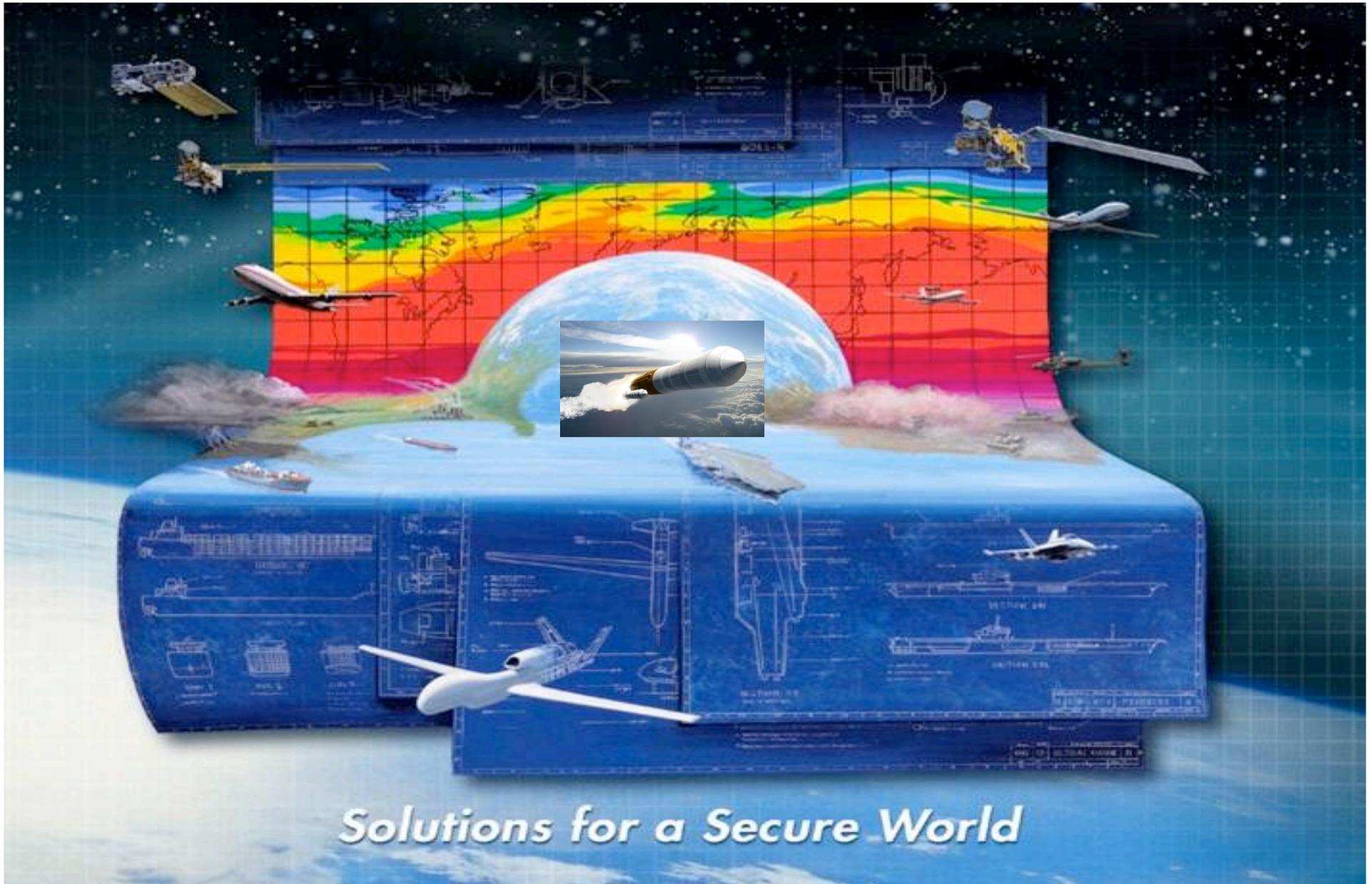
Possible Missions Enabled by an Ares V

- Distant vantage points L1/L2:
 - Why L1/L2 for Earth Science
 - Synoptic view (all times at once)
 - High time resolution (1 min or better)
 - Sunrise to sunset coverage
 - Long integration times and high stability allows extraction of small effects over many years
 - Measuring the integrated Earth will provide a basis to aid in the search for life on extra-solar planets
 - One Example of a distant vantage point Earth Science Mission
 - The L2 Earth Atmosphere Solar-Occultation Imager (EASI) suggested by Wiscombe, Herman, and Valero (IGARSS 2002) to measure greenhouse gases and map their 3D distribution using a 10 m IR telescope with an imaging spectrometer. (They have also looked at a Mars observing version)

The Ares V lift capacity and faring volume will enable these missions

Global Change Monitoring System: Blueprint for Measurement and Monitoring System

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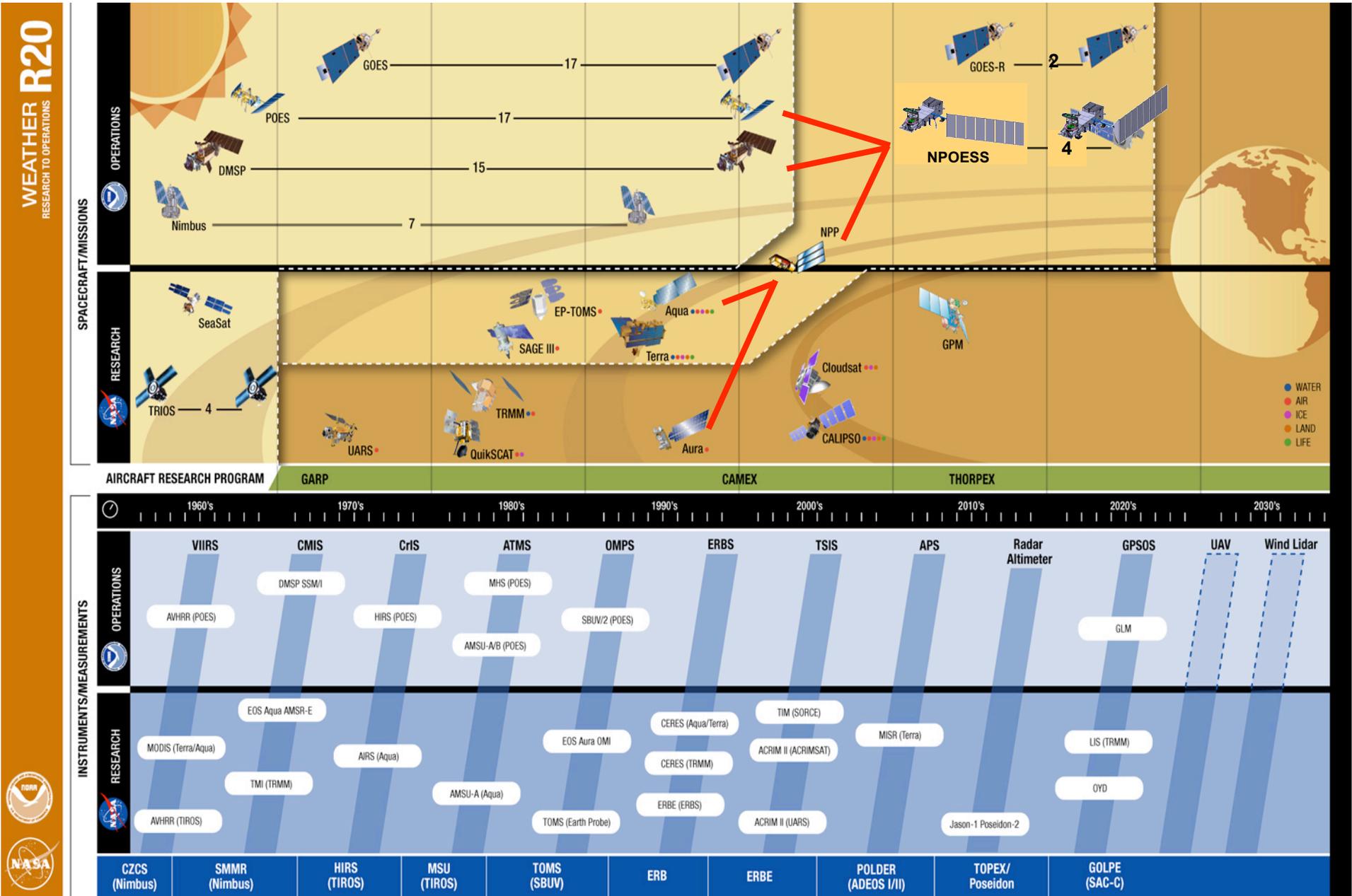


Back up

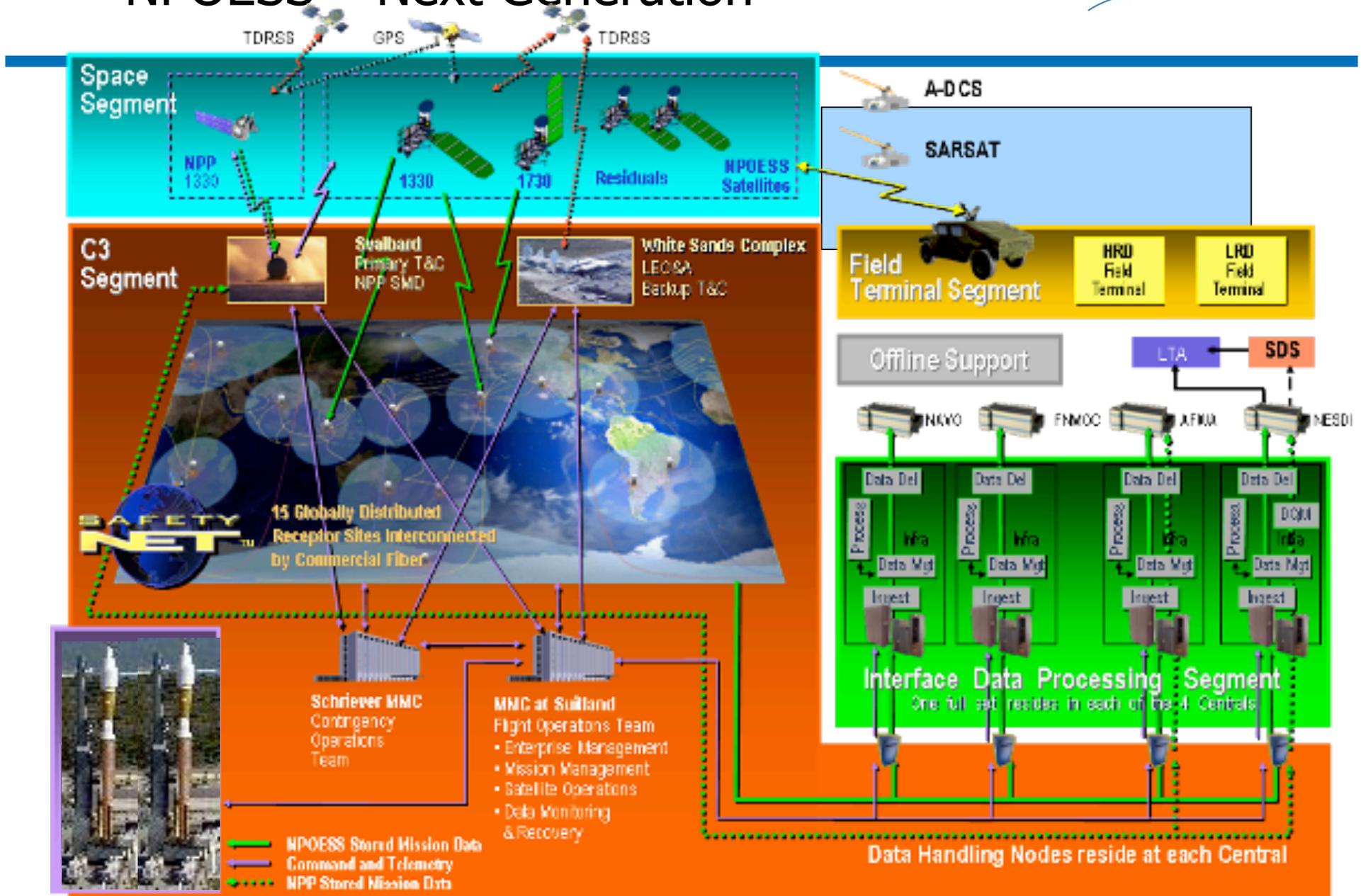
Space-based Observation Systems

- Multi-decadal roadmap of U.S. weather systems
- U.S. next generation weather/climate system - NPOESS architecture
- Current set of NASA research missions

U.S. Weather System of Systems

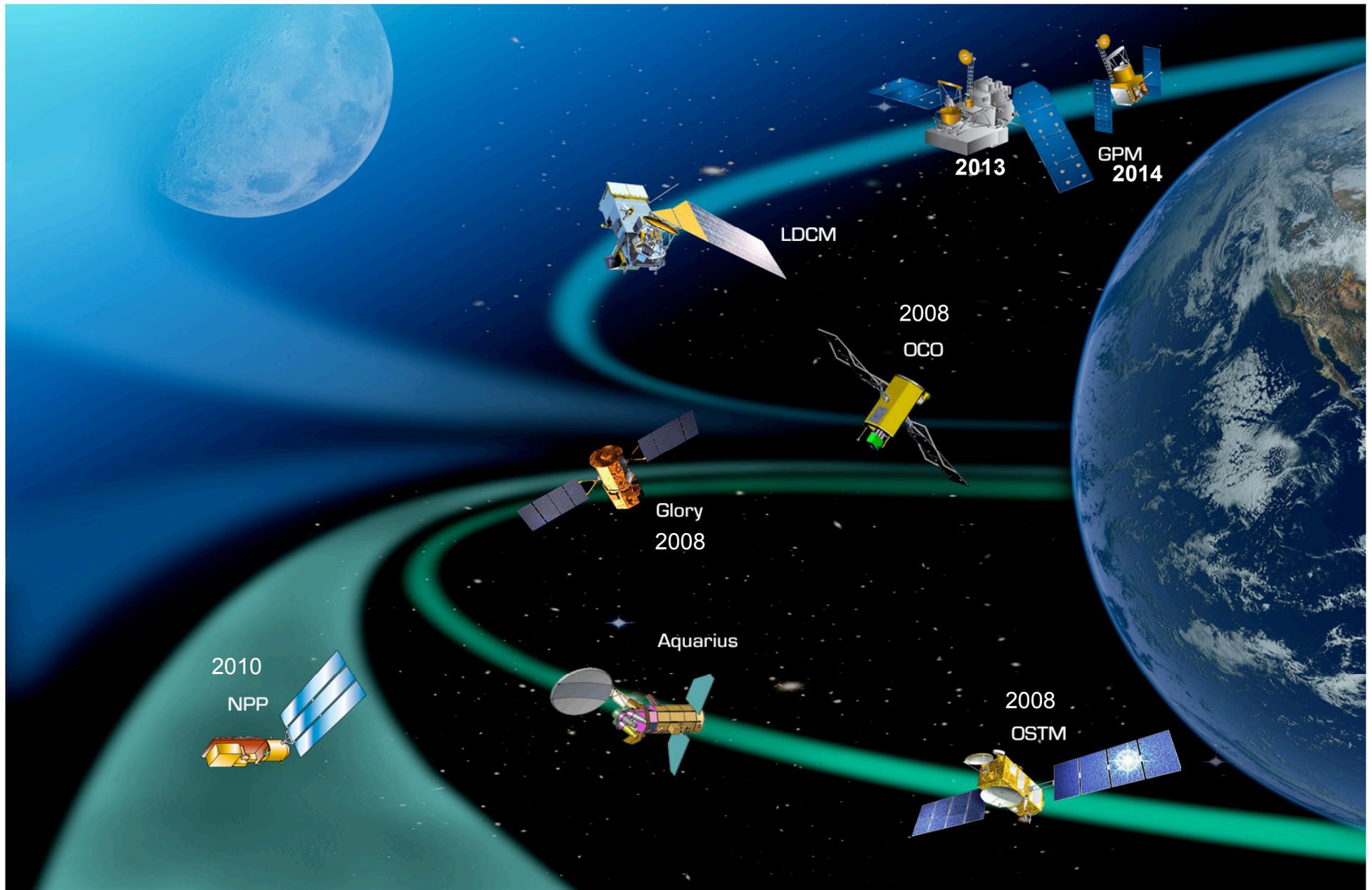


NPOESS – Next Generation



NASA Missions in Formulation 2008-2014

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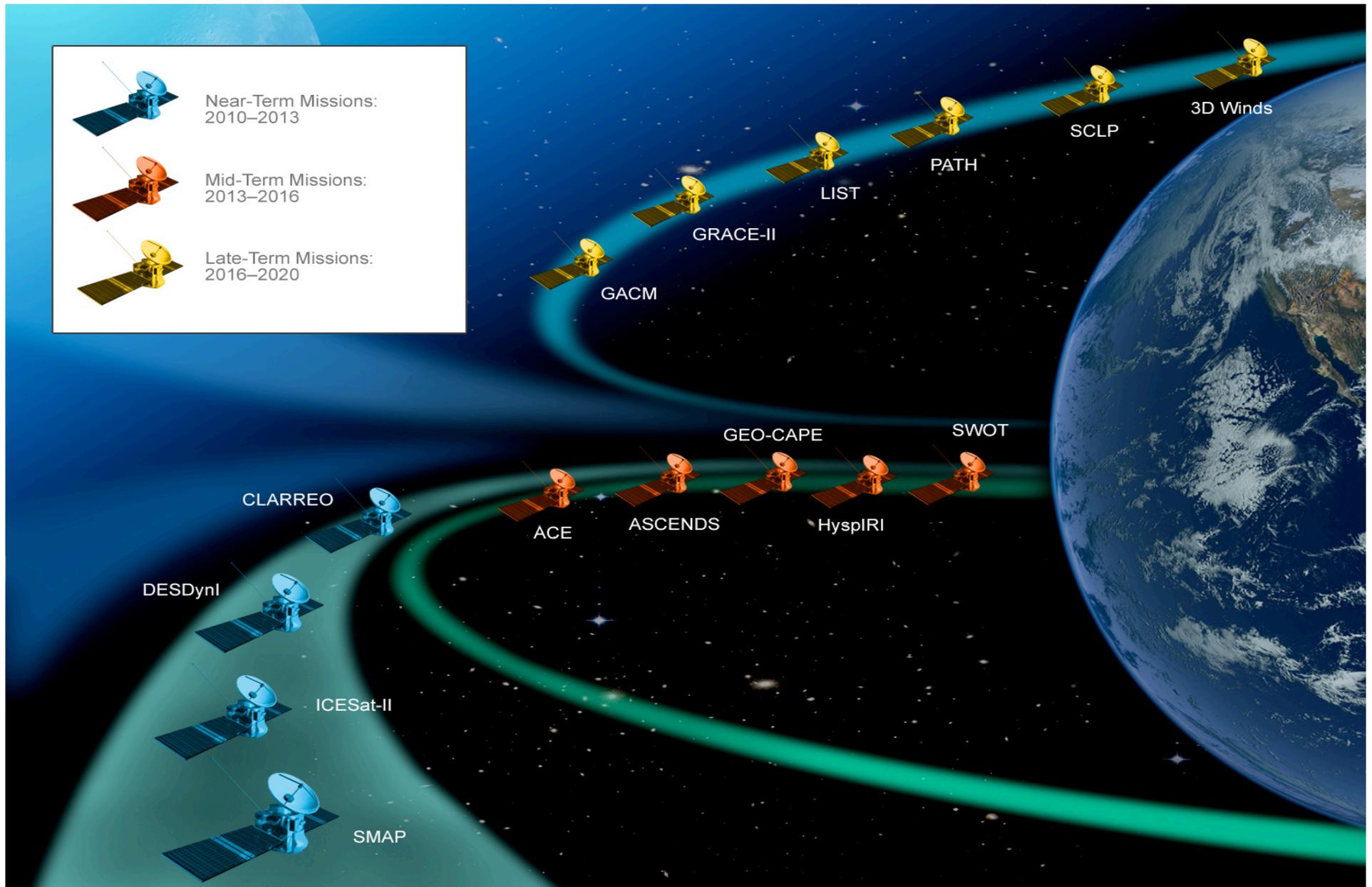
SESWG Measurement Recommendations



- Surface Deformation
- High-Resolution Topography
- Variability of Earth's Magnetic Field
- Variability of Earth's Gravity Field
- Imaging Spectroscopy of Earth's Changing Surface
- Space Geodetic Networks and International Terrestrial Reference Frame
- Promising Techniques and Observations

Decadal Survey Missions - Next Generation

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NOAA Priorities

1	OSVW Mission - Ocean Surface Vector Wind Mission
2	Solar Wind Data Buy - Currently provided by NASA ACE
3	Carbon Tracking System - Carbon Tracking Observing System (CTOS)
4	COSMIC2 (COSMIC 1 Functional Clone) - Constellation Observing System for Meteorology, Ionosphere and Climate
5	SEBN - Surface Energy Budget Network
6	Phased Array Radar - Phased Array Radar (PAR) is a multi-agency initiative
7	AK CRN - Alaska Climate Reference Network (AKCRN)
8	UAS - Unmanned Aerial System (UAS)

7 Drivers for System of Systems Approach



 Enterprise Architecture

 Interoperability

 Research and Operations (R&O)

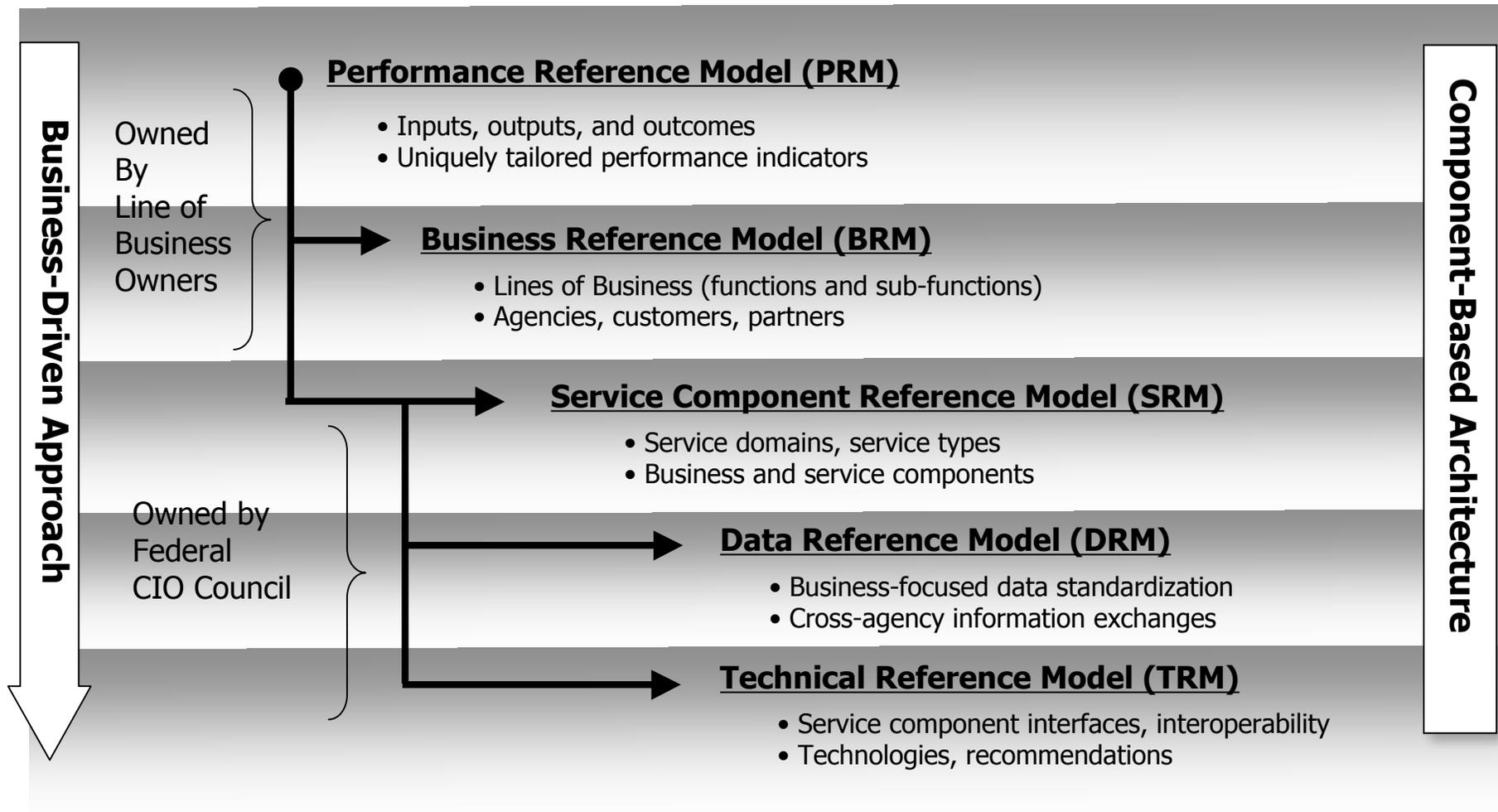
 Sustained Capabilities

 Net-Centric Approach

 Future Targets

 Delivering the Goods

IEOS & Federal Enterprise Architecture



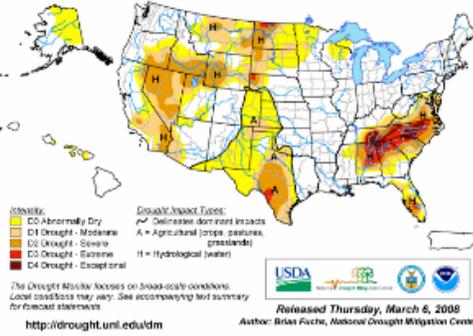
Candidate National Level Actions

Sustained capabilities are required to evolve a system of systems to monitor global change and inform decision makers

- Establish a blueprint for implementation of full complement of measurement and monitoring as part of National Climate Change Strategy and National Climate Observing System
- Augment operational systems including NPOESS & GOES R
 - Additional climate sensors can be added to expand monitoring capability
- Continue key R&D investments on path to next generation operational capabilities through Earth Science Decadal science missions and innovative missions of opportunity
 - NASA research missions enable future operational capabilities
- Approve initial funding for full complement of observing sensors and system infrastructure to deliver full benefits to society
 - Optimize benefits to constituents through tailored delivery of key information for decision support for multiple priority applications
 - Energy, water, agriculture, insurance, transportation, public health and safety

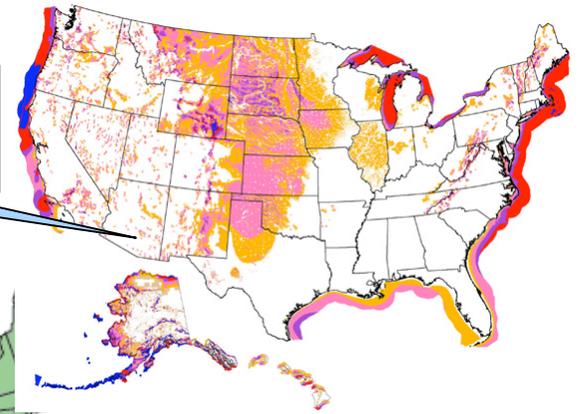
Decision Support Centers for Local Actionable Information

U.S. Drought Monitor March 4, 2008
1400 7 AM EDT



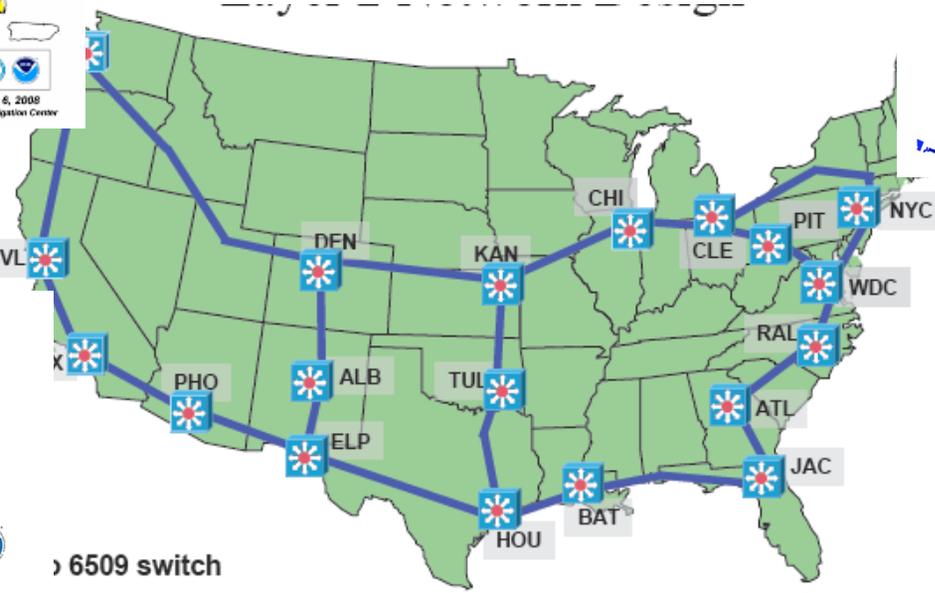
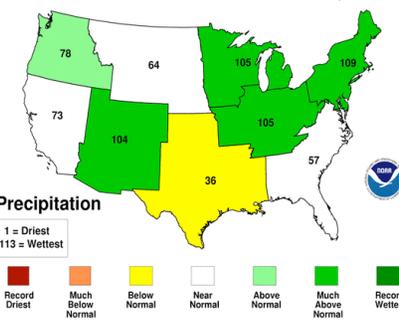
Drought for agriculture

Wind for energy availability

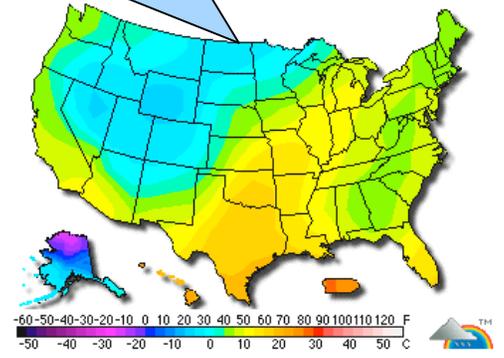


Precipitation for water availability

Dec 2007-Feb 2008 Regional Ranks
National Climatic Data Center/NESDIS/NOAA



Temperature for public health



Decision quality information integrated at regional centers enables adaptation to local conditions