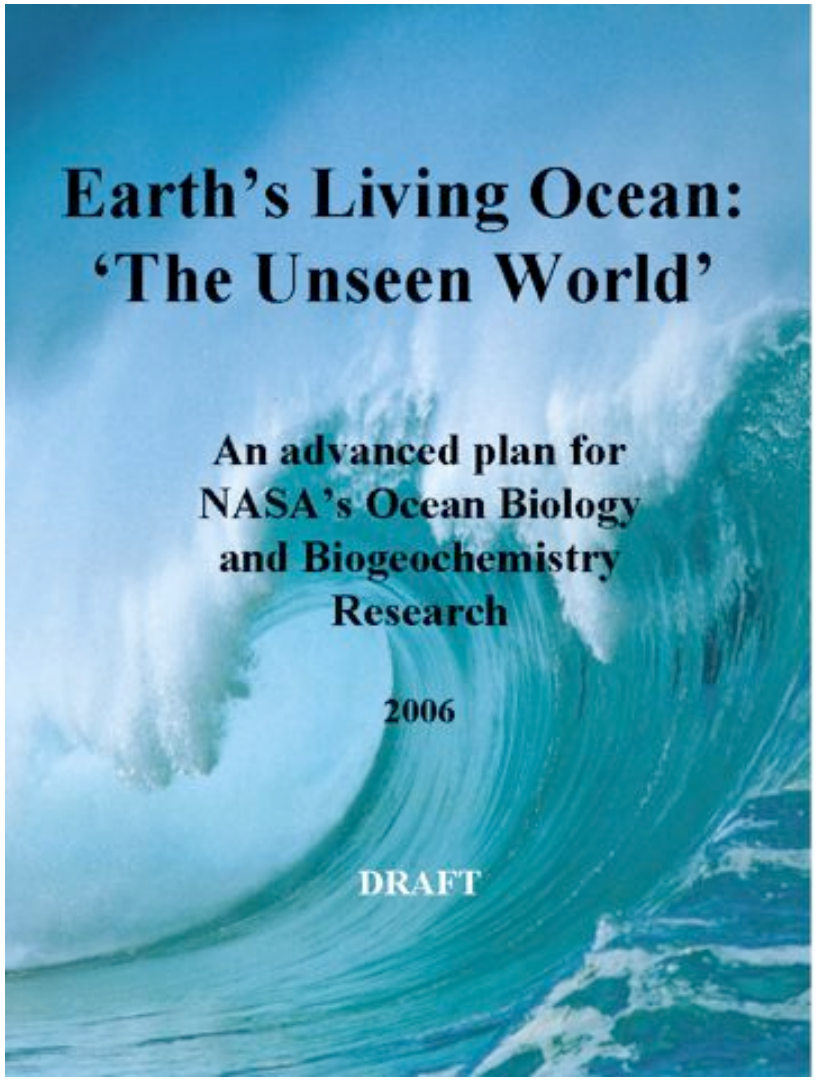
Community Plan for NASA Ocean Biology & Biogeochemistry Program



- A plan for the NASA OBB program
- Science to Requirements to Strategies to Missions
- Community plan
- Intended as a "living document"
- Will be reviewed by NRC

The Four OBB Scientific Questions

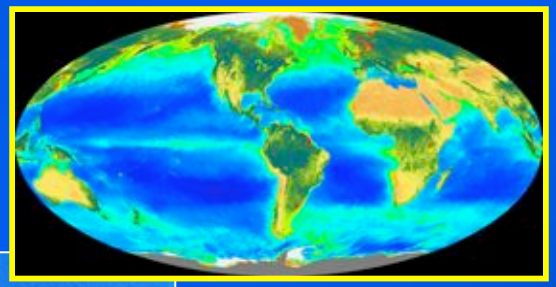
- Ecosystems & Diversity
- Carbon & Biogeochemistry
- Habitats
- Hazards

Emerging Scientific Questions in Ocean Biology and Biogeochemistry Research

- How are ocean ecosystems and the biodiversity they support influenced by climate or environmental variability and change, and how will these changes occur over time?
- How do carbon and other elements transition between ocean pools and pass through the Earth System, and how do these biogeochemical fluxes impact the ocean and Earth's climate over time?
- How (and why) is the diversity and geographical distribution of coastal marine habitats changing, and what are the implications for the well-being of human society?
- How do hazards impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?

Ecosystems & Diversity, Carbon & Biogeochemistry, Habitats, Hazards

- Relevance:
  - changing ecosystem structure, function, distribution on synoptic to climatic time scales
  - impact on higher trophic levels (e.g., fish, reptiles, birds, mammals)
- Science:
  - Assessing biogeography in a multidisciplinary manner
  - Quantifying ocean productivity
  - Identifying plankton functional groups
- Benefits to society:
  - Assessing ecosystem health, services
  - Understanding nutrient and carbon sinks/sources
  - Improving human welfare

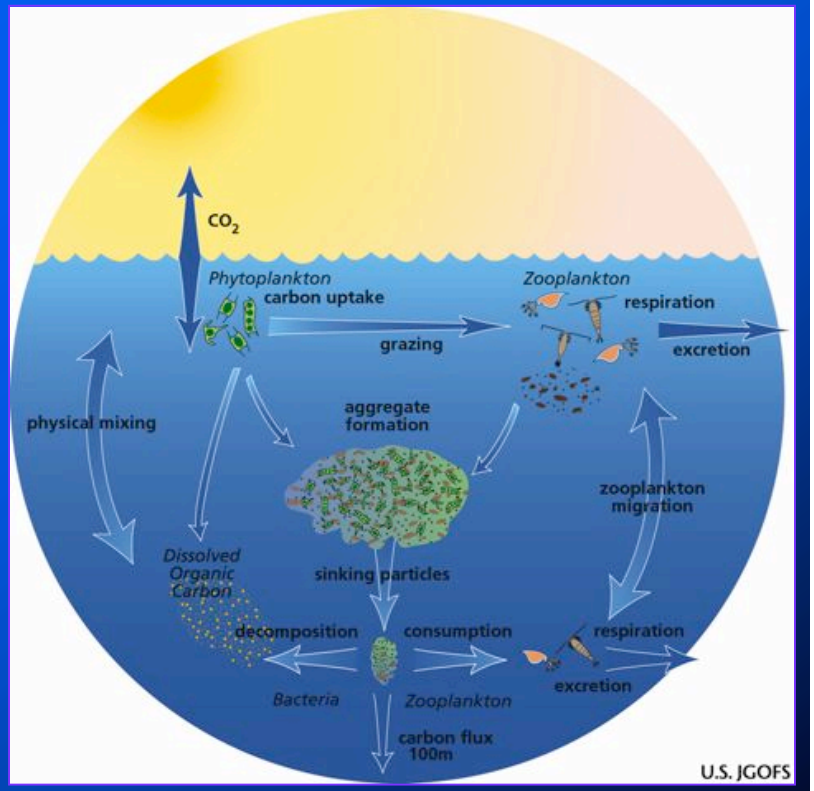






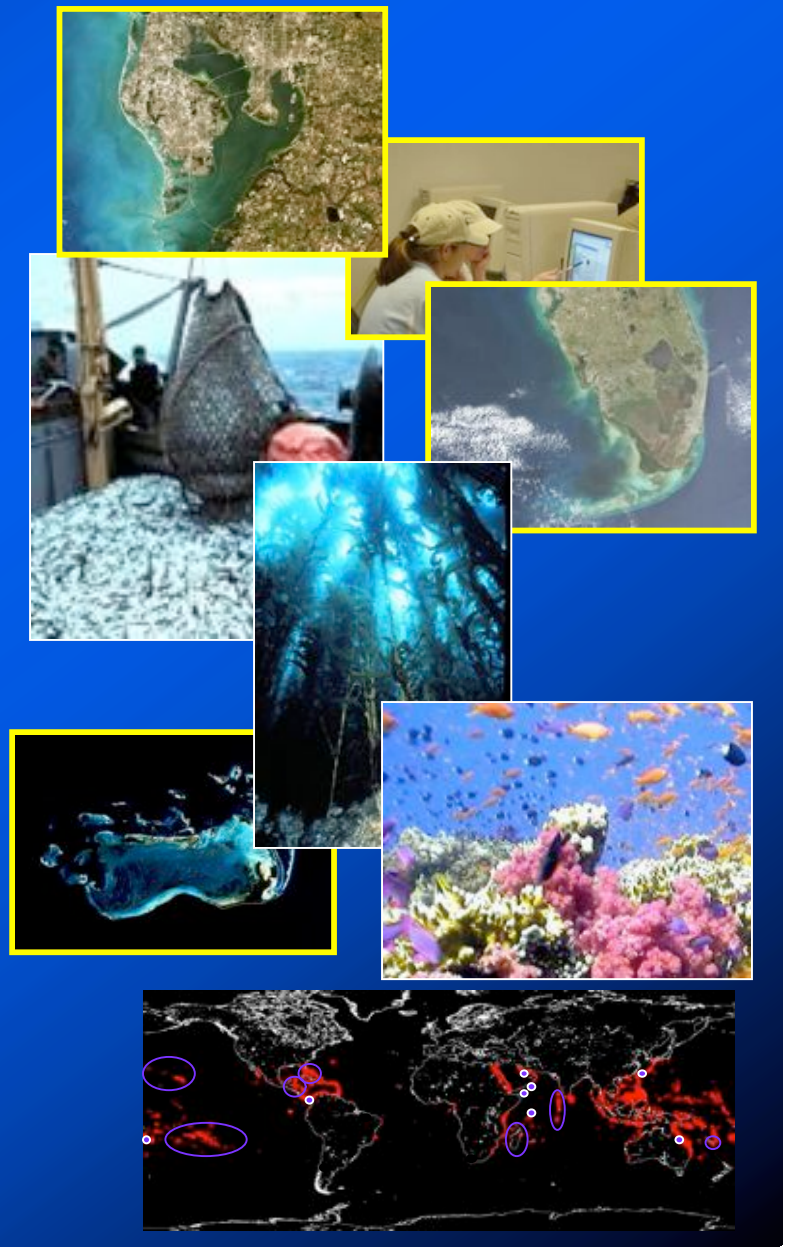
Ecosystems & Diversity, Carbon & Biogeochemistry, Habitats, Hazards

- Relevance:
  - Impacts & feedbacks of climate change on global biogeochemistry
  - Impacts of humans
- Science:
  - Assessing primary producer biomass
  - Estimating carbon fluxes
  - Understanding climate controls
- Benefits to society:
  - Assessing/verifying ocean carbon credit trading & mitigation strategies
  - Helping manage human services in a changing climate



Ecosystems & Diversity, Carbon & Biogeochemistry, **Habitats,** Hazards

- Relevance:
  - Growing human population density & dependence on ocean resources
  - Changing coastal environments
- Science:
  - Classification of regional marine habitats & coastal landscapes
  - Measuring impacts of land use
  - Understanding climate control
  - Assessing fisheries & shelf ecosystem resilience
  - Assessing red tides and coral reef health
- Benefits to society:
  - Basis for ecosystem-based management
  - Improving human health, recreation, & commerce



Ecosystems & Diversity, Carbon & Biogeochemistry, Habitats, **Hazards**

- Relevance:
  - Significant risk to human life and property
  - Protection of natural environments
- Science:
  - Acute hazards:
    - Tsunamis & Hurricanes
    - Pollution
    - Harmful Algal Blooms
  - Chronic Hazards:
    - Ocean warming and sea level rise
    - Ocean acidification
    - Eutrophication
- Benefits to society:
    - Forecasting of hazards
    - Disaster preparedness/security
    - Mitigation tools

Science Requirements & Mission Themes

- Global separation of in-water constituents & advanced atmospheric correction
- High temporal & spatial resolution coastal measurements
- Active assessments of plant physiology & functional composition
- Mixed layer depth

Science Requirements Lead to Observational Strategies

- Global Hyperspectral Imaging Radiometer
- Geostationary Hyperspectral Imaging Radiometer(s)
- Multi-Spectral High Spatial Resolution Imager
- Portable Sensors from Suborbital Platforms
- Variable Fluorescence Lidar
- Mixed Layer Depth & Illumination Sensor
- Ocean Particle Profiler & Aerosol Column Distributions

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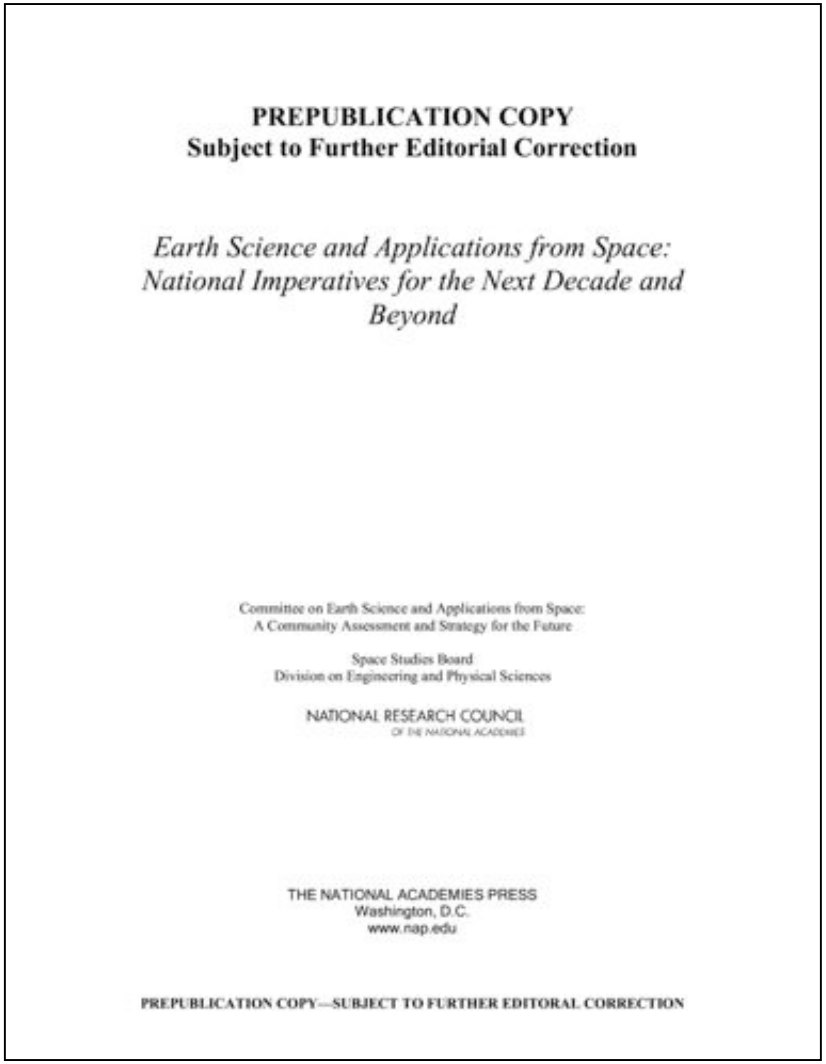
GEO partnership

Earth Science & Applications from Space Decadal Survey (2007)

NRC's response to NASA, NOAA & USGS to generate consensus recommendations regarding …

1. high-priority missions & activities to support needs for research & monitoring of the Earth during the next decade, and

2. important directions that should influence planning for the decade beyond.



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Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond

Committee on Earth Science and Applications from Space:
A Community Assessment and Strategy for the Future

Space Studies Board
Division on Engineering and Physical Sciences

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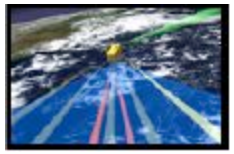
17 Recommended New Missions: "Minimal Yet Robust"

3D-Winds

ACE



ASCENDS

CLARREO

DESDynI

GACM

- **NOAA & NASA missions launched from 2010-2020:**
  - **Seven "small" ($65M to $300 million, ~50% "error bar")**
  - **Eight "medium" ($350M to $600M)**
  - **Two "large" ($700M & $800M, ~30% "error bar")**

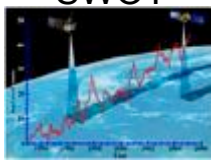
Geo-CAPE

- **NOAA: Transition 3 LEO "research" to "operational"**
  - **Extended vector winds, GPS radio-occultation, total solar irradiance**
- **NASA: Implement 14 other missions**
  - **2 GEO & 12 LEO**
  - **Four 2010-2013, Five 2013-2016 & Six 2016-2020 launches**

GPSRO

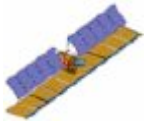
XOVRM

SWOT



SMAP

SCLP



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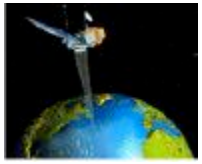


ICESat-II & LIST

HyspIRI

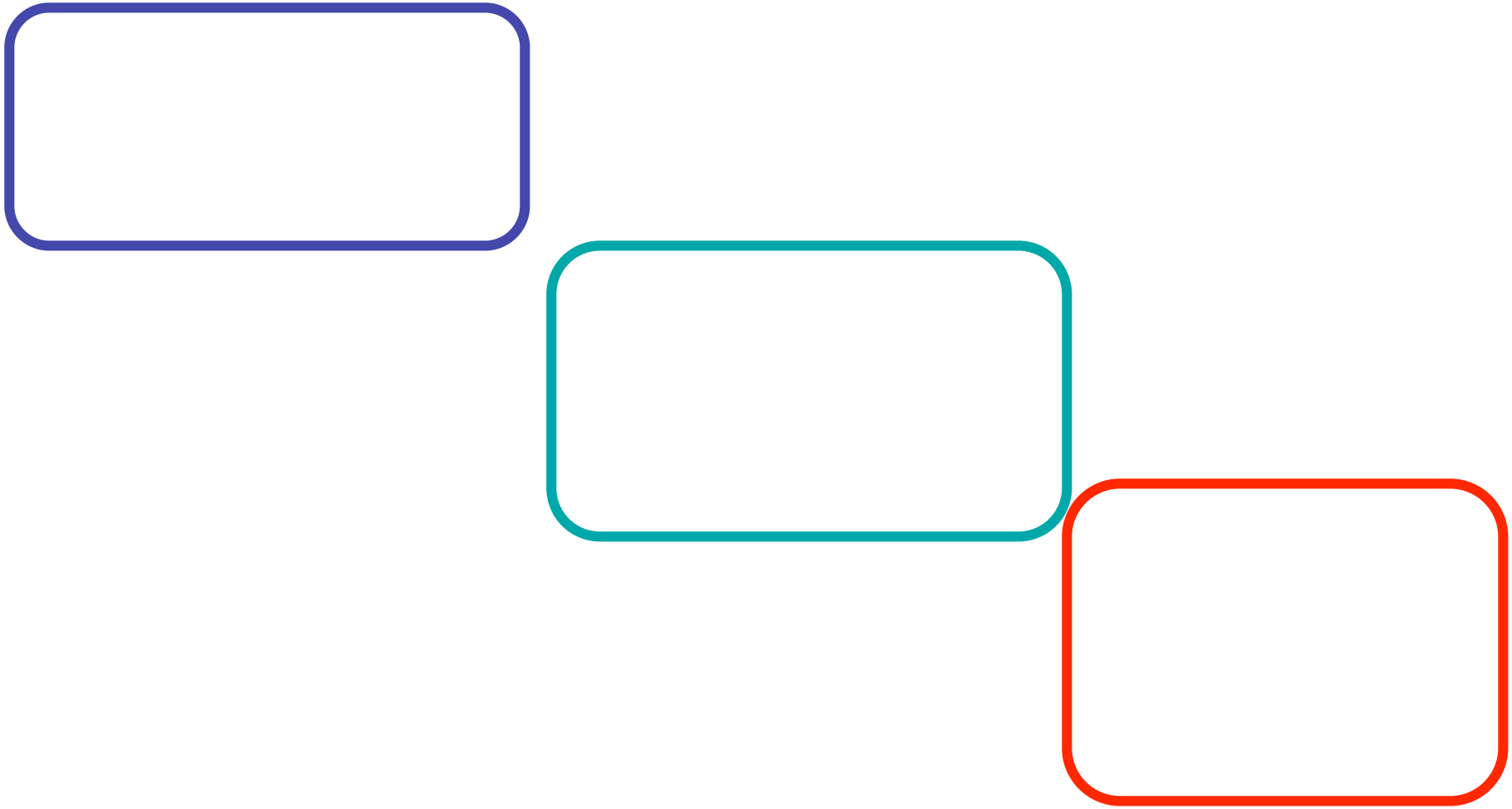
GRACE-II

OBB Plan Mission Prioritization

Global Hyperspectral Imaging Radiometer

Geostationary Hyperspectral Imaging Radiometer

Multi-Spectral High Spatial Resolution Imager



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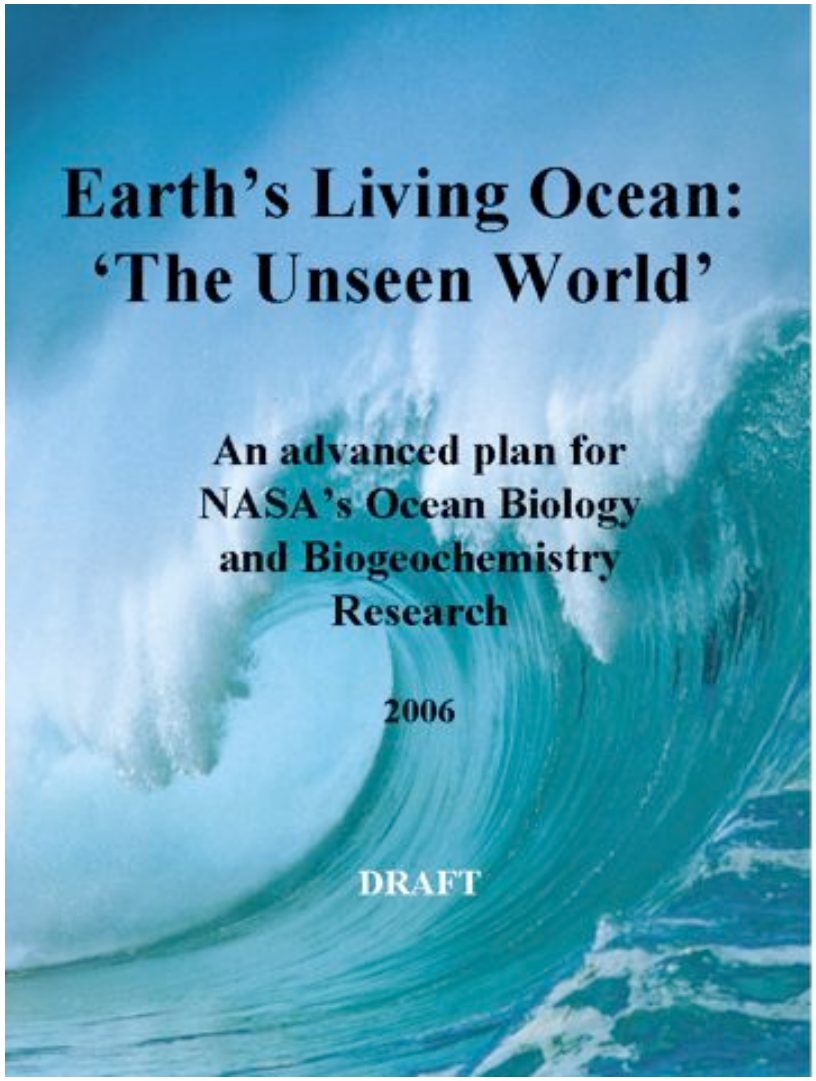


- Provide a plan for future of the NASA OBB program
- Science to Requirements to Strategies to Missions
- Community plan - intended as "living document"
- Rec's consistent with the NRC Decadal Survey


Plans are worthless, but planning is everything.
Dwight David Eisenhower

2013-2016 NASA Missions

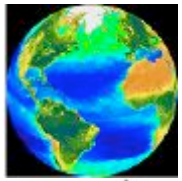
Mission	(#) Measurement Types (Panel Themes)	Orbit	Instruments	Estimate
Hyperspectral/IR Imagery (HysplRI)	(4) Land surface composition for agriculture & mineral characterization, vegetation types for ecosystem health (Ecosystem, health, solid earth)	LEO, SSO	Hyperspectral spectrometer	$300M
Active S Emissi Days, and Seasons (ASCENDS)	health (Climate, ecosystem, health)			
Surface Water/Ocean Topography (SWOT)	(4) Ocean Circulation, Heat Storage, & Climate Forcing, Algal Blooms & Water-Borne	LEO, SSO	Ka-band wide swath radar	$450M
	(Climate, health, water)			
Geostationary Coastal & Air Pollution Events (Geo-CAPE)	(9) Air Pollution, Acute Toxic Pollution Releases, Algal Blooms & Water-Borne Infectious Disease, Global Ecosystem Dynamics, Heat Stress & Drought, Inland &	GEO	High & low spatial resolution hyperspectral	$550M
	(Ecosystem, health, water, weather)			
Aerosol/Cloud/Ecosystems (ACE)	(10) Aerosol-Cloud, Acute Toxic Pollution Releases, Air Pollution, Algal Blooms & Water-Borne Infectious Disease, Clouds, Aerosols, Ice, & Carbon. Ice Dynamics, Global Ocean Productivity, Ozone Processes, Aerosol Characterization & Ozone (Climate, ecosystem, health, weather)	LEO, SSO	Backscatter lidar Multiangle polarimeter Doppler radar	$800M

OBB #3 Multispectral High Spatial Resolution Radiometer

OBB #2 Geostationary Hyperspectral Radiometer

OBB #1 Global Hyperspectral Imaging Radiometer

Decadal Survey Q's Driven by *Societal Needs**



***Air Quality**:* More reliable forecasts for effective urban pollution management

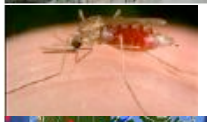
***Climate Prediction**:* Robust estimates of climate forcings for better forecasts, including local predictions of climate change effects

***Earthquake Warning**:* Identify active faults & predict likelihood of earthquakes for effective structural improvements & informed land-use decisions

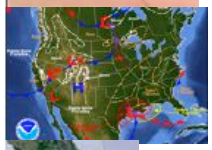
***Ecosystem Services**:* Improved agricultural land-use & ocean productivity forecasts to improve planting & harvesting schedules & fisheries management

***Extreme Event Warnings**:* Better storm track forecasts & intensification predictions, volcanic eruption & landslide warnings for effective evacuation planning

***Freshwater Availability**:* Improved precipitation & drought forecasts for better management



***Human Health**:* Better infectious & vector-borne disease forecasts for control & response



***Improved Weather Prediction**:* Longer-term, more reliable forecasts

***Sea-level Rise**:* Better ocean temperature & ice-sheet volume change forecasts & feedback for effective coastal community planning

Next Decade Mission Prioritization

Selection Process

- Panels reviewed >100 candidates, 35 recommended to Executive committee
- Range & synergy of measurements critical, not individual missions
- Robustness of mission synergies ensures measurements

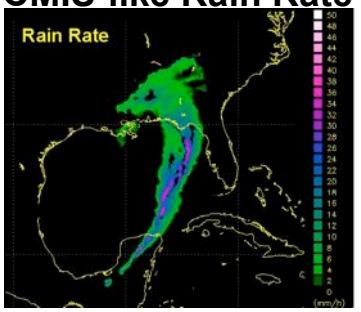
Prioritization Criteria (Not in order of importance)

- Ability to complement other systems, US & international plans
- Contribution to:
  - Applications & policy (societal needs)
  - Long-term observational record
  - Multiple applications or science disciplines
  - Top scientific questions
- Cost (mission total or per year)
- Readiness (technical, resources, people)
- Risk & strategic redundancy (backup other critical systems)

Setting NOAA's Foundation:
Recommended Current Decade

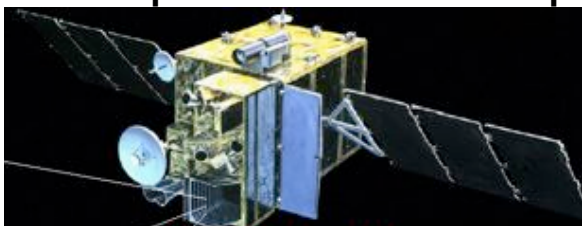
- Restore NPOESS canceled capabilities:
  - Total solar irradiation (TSI) & Earth radiation budget (ERB) to avoid 2008-2012 gap
  - Passive ocean vector winds & all-weather sea surface temperature Conical Microwave Imager/Sounder (CMIS)
  - Limb sounding by Ozone Monitoring & Profiling Suite (OMPS)
- Restore GOES-R canceled capabilities:
  - GEO temperature & water vapor vertical sounding via canceled Hyperspectral Environmental Suite (HES)
  - Recognizing technology challenges & potential HES cost growth:
    - Complete & launch Geostationary Imaging Fourier Transform Spectrometer (GIFTS), & evaluate as HES prototype; and/or
    - Restore HES study contracts to focus on cost-effective, essential GOES-R sounding
  - Will strengthen GEO sounding technology & provide experience for efficient operational implementation

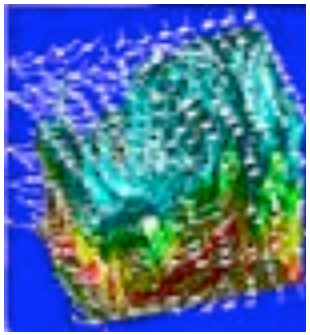
CMIS-like Rain Rate



CMIS Model

GIFTS Spacecraft Artist Concept



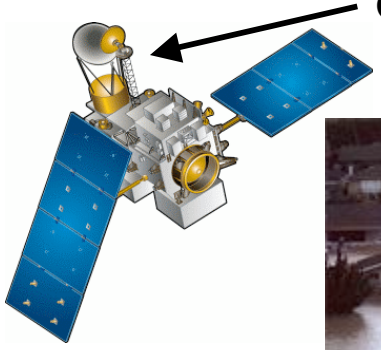


GIFTS/HES "4d" profile simulation (Univ. of Wisconsin)

Setting NASA's Foundation: Recommended Current Decade

- Near-term NASA concerns:
  - Understand changing precipitation patterns due to climate change
  - Understand land-use effects of growing population, changing economies, & agriculture intensification
- *Therefore:* Maintain Global Precipitation Measurement (GPM) mission & continue to document biosphere changes provided by Landsat
  1. Launch GPM by 2012
  2. Replace Landsat 7 data before 2012

GPM Spacecraft



Landsat 7

Landsat: Mt. St. Helens

Sustained measurements of key climate & weather variables are part of committee's strategy to achieve vision for Earth information in next decade

Relevance to Science Questions

GEO partnership