The Decadal Survey provides scientific priorities indirectly through a time sequencing of recommended missions. It is a first-ever comprehensive survey of all Earth sciences that could benefit from spaceborne observations. The study was requested and supported by NASA, NOAA, USGS. The final NRC Report was released 15 January 2007.

Objective of the Decadal Survey
- Supporting activities to support national needs for research and monitoring of the dynamic Earth system during the next decade.
- Identify important directions that should influence planning for the decade beyond.

Technology development in support of missions
- NASA: invest in both mission-focused and cross-cutting technology development to decrease risk in missions and promote cost reduction across multiple missions
- Leverage International Efforts
  - Restructure or defer missions if international partners select missions which meet most of the measured objectives of recommended missions then a) establish data access agreements, and b) establish science teams
  - Where appropriate, offer cost-effective additions and international missions that help extend the values of those missions

Manage Technology Risk
- Sequence missions according to technological readiness and budget risk factors...technological investments should be made across all recommended missions
- If there are insufficient funds to execute the missions in the recommended timelines, it is still important to make advances on the key technological hurdles.
- Establish technological readiness through demonstrated technology demonstrations before mission development phase.

<table>
<thead>
<tr>
<th>Decadal Survey Mission</th>
<th>Mission Description</th>
<th>Orbit</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>CLARREO (NASA portion)</td>
<td>Solar and Earth radiation processing; variability of Earth's climate system</td>
<td>LEO, Prooessing</td>
</tr>
<tr>
<td>Phase 1</td>
<td>SMAP</td>
<td>Soil moisture and freeze/thaw for weather and water cycle processes</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 1</td>
<td>ICESat-2</td>
<td>Ice sheet height changes for climate change diagnosis</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 2</td>
<td>SESYn</td>
<td>Surface area deformation for understanding ocean and climate variability</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 2</td>
<td>HySIS</td>
<td>Land surface composition for agriculture and mineral exploration</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>LIST</td>
<td>FORS (Geophysical focus areas)</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>LIST</td>
<td>Solar backscatter data for atmospheric and oceanic applications</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>ICESat II (NASA portion)</td>
<td>Ice sheet height changes for climate change diagnosis</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>CLARREO (NASA portion)</td>
<td>Climate Absolute Radiance and Refractivity Observatory</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>SMAP</td>
<td>Soil Moisture Active Passive</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>DESDynI</td>
<td>Deformation, Ecosystem Structure and Dynamics of Ice</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>SWOT</td>
<td>Surface Water Ocean Topography</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>HyspIRI</td>
<td>Hyperspectral Infrared Imager</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>ASCENDS</td>
<td>Day/night, all-latitude, all-season CO2 column integral for climate emissions</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>GEO-CAPE</td>
<td>Atmospheric gas columns for air quality forecasts; ocean color for coastal ecosystems</td>
<td>GEO-CAPE</td>
</tr>
<tr>
<td>Phase 3</td>
<td>ACE</td>
<td>Aerosol and cloud profiling for climate and weather cycle; ocean color for open ocean ecosystems</td>
<td>GEO-CAPE</td>
</tr>
<tr>
<td>Phase 3</td>
<td>PATH</td>
<td>High frequency, all-weather temperature and humidity soundings for weather forecasting and SST</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>GRACE-G</td>
<td>High temporal resolution gravity fields for tracking large-scale water movement</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>SCLP</td>
<td>Snow accumulation for fresh water availability</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>GACM</td>
<td>Ozone and related gases for understanding atmospheric ozone layer</td>
<td>LEO, SSO</td>
</tr>
<tr>
<td>Phase 3</td>
<td>S-3 Wind</td>
<td>Topographic winds for weather forecasting and pollution transport</td>
<td>LEO, SSO</td>
</tr>
</tbody>
</table>

Recommendations
- Include all recommended missions
- Phase 1: CLARREO, SMAP, ICESat-2, SESYn
- Phase 2: HySIS, ASCENDS, GEO-CAPE
- Phase 3: ACE, PATH, GRACE-G, SCLP, GACM, S-3 Wind

The SWOT Satellite Mission and its wide-swath altimetry technology is a means of completely covering the world’s oceans and freshwater bodies with repeated elevation measurements.

The SWOT mission will provide multi-year elevation data needed to determine ice sheet mass balance as well as cloud property information, especially for stratospheric clouds common over polar areas.

SMAP will provide global measurements of soil moisture and its freeze/thaw state. These measurements will be used to enhance understanding of processes that link the water cycle with surface temperatures and extend the capabilities of weather and climate prediction models.

The ICESat-II mission will provide multi-year elevation data needed to determine ice sheet mass balance as well as cloud property information, especially for stratospheric clouds common over polar areas.

ASCENDS will provide improved ability to predict/model long-term changes in the carbon cycle and dynamic atmospheric processes which link the water cycle and carbon cycle.

HyspIRI data will be used for a wide variety of studies primarily in the Carbon Cycle and Ecosystem focus areas.

The GEO-CAPE mission will provide improved ability to predict/model long-term changes in the climate system and help improve understanding of the natural processes driving the variability of natural carbon sources and sinks, and on the transport of carbon through the atmosphere.

The solar backscatter data will provide aerosol optical depth information for assimilation into aerosol models and downscaling to surface concentrations.

The solar backscatter data will provide aerosol optical depth information for assimilation into aerosol models and downscaling to surface concentrations.

3D-Winds: 3-Dimensional Topospheric Winds from Space-based Lidar

GACM will enable scientists to better understand the relationship between atmospheric ozone distribution and the factors that alter it.

The SWOT Satellite Mission and its wide-swath altimetry technology is a means of completely covering the world’s oceans and freshwater bodies with repeated elevation measurements.

The SWOT mission will provide multi-year elevation data needed to determine ice sheet mass balance as well as cloud property information, especially for stratospheric clouds common over polar areas.

SMAP will provide global measurements of soil moisture and its freeze/thaw state. These measurements will be used to enhance understanding of processes that link the water cycle with surface temperatures and extend the capabilities of weather and climate prediction models.

The ICESat-II mission will provide multi-year elevation data needed to determine ice sheet mass balance as well as cloud property information, especially for stratospheric clouds common over polar areas.

ASCENDS will provide improved ability to predict/model long-term changes in the carbon cycle and dynamic atmospheric processes which link the water cycle and carbon cycle.

HyspIRI data will be used for a wide variety of studies primarily in the Carbon Cycle and Ecosystem focus areas.

The GEO-CAPE mission will provide improved ability to predict/model long-term changes in the climate system and help improve understanding of the natural processes driving the variability of natural carbon sources and sinks, and on the transport of carbon through the atmosphere.

The solar backscatter data will provide aerosol optical depth information for assimilation into aerosol models and downscaling to surface concentrations.

The solar backscatter data will provide aerosol optical depth information for assimilation into aerosol models and downscaling to surface concentrations.

3D-Winds: 3-Dimensional Topospheric Winds from Space-based Lidar

GACM will enable scientists to better understand the relationship between atmospheric ozone distribution and the factors that alter it.

The SWOT Satellite Mission and its wide-swath altimetry technology is a means of completely covering the world’s oceans and freshwater bodies with repeated elevation measurements.
The CLARREO mission is currently envisioned to consist of two duplicate observatories each carrying a payload of one infrared instrument suite and a Global Navigation Satellite System Radio Occultation (GNSS-RO) instrument system.
SMAP: Soil Moisture Active Passive

SMAP will provide global measurements of soil moisture and its freeze/thaw state. These measurements will be used to enhance understanding of processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models.

**Science Objectives**

SMAP will provide a capability for global mapping of soil moisture and its freeze/thaw state with unprecedented accuracy, resolution, and coverage. SMAP science data will enable acquisition of large-scale and hydrological estimates that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models.

- Understand processes that link the terrestrial water, energy and carbon cycles
- Estimate global water and energy fluxes at the land surface
- Quantify net carbon flux in terrestrial ecosystems
- Enhance weather and climate forecast and drought monitoring capabilities

**SMAP Data Products**
The SMAP baseline science data products are shown in the table below. These data products will be made available through a NASA-designated data center. The products will conform to the HDF-5 standard.

| Data Product | NetCDF Dimension | Spatial Resolution | Frequency | Lat/Lon
|--------------|-----------------|-------------------|-----------|---------|
| Level 2 Product | NetCDF Dimension | Spatial Resolution | Frequency | Lat/Lon
| L-band Interferometric Synthetic Aperture Radar (InSAR) | 0.3 km | 30 km | Daily | 0.3 km | 30 km |
| L-band Radiometer | 0.3 km | 30 km | Daily | 0.3 km | 30 km |
| Dual-polarization | 0.3 km | 30 km | Daily | 0.3 km | 30 km |
| Soil Moisture | 0.3 km | 30 km | Daily | 0.3 km | 30 km |
| Freeze/thaw | 0.3 km | 30 km | Daily | 0.3 km | 30 km |

DESDynI: Deformation, Ecosystem Structure and Dynamics of Ice

Earth’s surface and vegetation cover are constantly changing on a wide range of time scales. Measuring these changes globally from satellites would enable breakthrough science with important applications to society.

**Mission Concept**

This mission combines two sensors that, taken together, provide observations important for solid-Earth (surface deformation), ecosystems (terrestrial biomass structure) and climate (ice dynamics). The sensors are:

1. L-band Interferometric Synthetic Aperture Radar (InSAR) system with multiple polarization,
2. Multiple beam lidar operating in the infrared (~ 1064 nm) with ~ 25 m spatial resolution and 1 m vertical accuracy.

**Mission Objectives:**

- Determine the likelihood of earthquakes, volcanic eruptions, and landslides
- Predict the response of ice sheets to climate change and impact on the sea level
- Characterize the effects of changing climate and land use on species habitats
- Monitor the migration of fluids associated with hydrocarbon production and groundwater resources

**Orbit:**
- LEO, SSO

**Instruments:**
- L-band InSAR, Laser altimeter

DESDynI Data Products

The DESDynI mission combines two sensors that provide observations important for solid-Earth (surface deformation), ecosystems (terrestrial biomass structure) and climate (ice dynamics). The mission should have a 5 year life time to capture time-variable processes and achieve measurement accuracy.

**HyspIRI: Hyperspectral Infrared Imager**

HyspIRI data will be used for a wide variety of studies primarily in the Carbon Cycle and Ecosystem and Earth Surface and Interior focus areas. The HyspIRI Project will implement a spaceborne Earth observation mission designed to collect and provide global imaging measurements for surface reflectance, water leaving radiance, thermal emissivity, and surface radiance and temperature that will enable science and applications users to advance the current understanding of the Earth’s climate, biogeochemistry, biodiversity, coastal and inland waters, geology, natural hazards, hydrology, climate, and studies of the carbon cycle.

**Mission Objectives:**

- Processes indicating volcanic eruption
- Nutrients and water status of vegetation; soil type and health
- Spectra to identify locations of natural resources
- Changes in vegetation types and deforestation; drought early warning
- Improved exploration for natural resources
- Forecast of likelihood of volcanic eruptions and landslides

**Orbit:**
- LEO, SSO

**Instruments:**
- Hyperspectral spectrometer

**HyspIRI data will be used for a wide variety of studies primarily in the Carbon Cycle and Ecosystem and Earth Surface and Interior focus areas. The HyspIRI Project will implement a spaceborne Earth observation mission designed to collect and provide global imaging measurements for surface reflectance, water leaving radiance, thermal emissivity, and surface radiance and temperature that will enable science and applications users to advance the current understanding of the Earth’s climate, biogeochemistry, biodiversity, coastal and inland waters, geology, natural hazards, hydrology, climate, and studies of the carbon cycle.**