Earth Science and Applications

Using our unique expertise to better understand how Earth works as a system for the benefit of society
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INNOVATE • IMPLEMENT • IMPACT

Water Cycle  Sea Level  Natural Hazards  Carbon Cycle  Weather and Air Quality

Jet Propulsion Laboratory
California Institute of Technology
Four Decades of Innovation

A SPECTRUM OF TOOLS

- Sea Level Altimetry
- Ocean Wind Scatterometry
- Radar for Surface Deformation
- Atmospheric Sounding
- Multi-Angle Imagery
- Imaging Spectroscopy
- Cloud Radar
- Gravity
- Radio Occultation
Earth Remote Sensing

A SPECTRUM OF PLATFORMS

- ECOSTRESS
- Jason 3
- GRACE-FO
- OCO 2
- OCO 3
- SMAP
- SWOT
- NISAR
- RainCube
- GRACE
Successful Mission Implementation

PARTNERSHIPS AND EXPERTISE SPANNING FOUR DECADES OF EARTH OBSERVATIONS

Major contributions to NASA’s Earth observing fleet of satellites

History of successful mission implementation and extended missions

International Partners

[Logos of international partners]
Future JPL Missions

- **NISAR**
  - 12/20
- **SWOT**
  - 9/21
- **Sentinel-6 M.F. /B**
  - 11/20
- **MAIA**
  - 2022
- **PREFIRE 2022**
- **Climate Change**
- **Air Quality**
- **Sea Level**
- **Hazards, Ice Sheets & Biomass**
- **Sea Level, Lakes & Rivers**
- **Dust Sources**
- **EMIT 2021**
- **(PRE) FORMULATION**
- **IMPLEMENTATION**
Mission Impacts

ENABLING FUNDAMENTAL ADVANCES IN EARTH SCIENCE

- Peer-reviewed science publications
  - > 400 publications/year involving JPL scientists
  - > 1000 publications/year based on JPL missions
- Training next generation Earth Science leaders
  - ~50 postdoctoral scientists
- Participation in National Academy of Science and Engineering studies
Mission Impacts

APPLYING OBSERVATIONS FOR REAL WORLD BENEFITS

- FEMA and U.S. Homeland Security
- National Drought Monitor
- California Seismic Safety Commission
- World Meteorological Organization (WMO)
- National Climate Assessment
- California Department of Water Resources
Mission Impacts

SHARING KNOWLEDGE AND DATA WITH THE PUBLIC

• Award-winning NASA Global Climate Change website: climate.nasa.gov
• Eyes on the Earth/Earth Now – real-time satellite and data for digital platforms
• In-person and social media outreach campaigns
• ~100 Earth Science press releases per year
Water Cycle

DEVELOP AND ENABLE PREDICTIONS FOR REGIONAL WATER SHORTAGES

INNOVATE • IMPLEMENT • IMPACT

Challenge
Develop useful predictions of regional water shortages for lead times from weeks to years

Approach
• Design and build first-of-a-kind instruments/satellites
• Measure the components of the Earth’s water cycle
• Understand and model the flow of water through the Earth system
• Develop integrated programmatic approach between science and engineering
• Partner with international, federal, state and local agencies to improve predictions of water

Satellite Missions
GRACE-FO, SMAP, ECOSTRESS, SWOT, AIRS, CloudSat, Jason-2/3, NISAR

Other Activities
Western Water Applications Office
Water Cycle

DEVELOP USEFUL TOOLS AND INFORMATION FOR CALIFORNIA WATER MANAGEMENT

INNOVATE

Lidar + Hyperspectral Imagery = Snowpack Observatory

Repeat pass radar interferometry for Earth surface monitoring

Gravity observations to provide groundwater estimates
Water Cycle

DEVELOP USEFUL TOOLS AND INFORMATION FOR CALIFORNIA WATER MANAGEMENT

IMPLEMENT

ASO : Sierra snowpack measurements

UAVSAR & ARIA : Central Valley subsidence and Bay Delta levee integrity

GRACE & GRACE-FO : Central Valley groundwater variations
**Water Cycle**

**DEVELOP USEFUL TOOLS AND INFORMATION FOR CALIFORNIA WATER MANAGEMENT**

**IMPACT**

- Department of Water Resources
  - Summer water supply
  - Snowpack
  - Groundwater
  - Evapotranspiration
  - Atmospheric Rivers & flooding
  - Levee monitoring

**WWAO**
- Connects stakeholders with NASA scientists, technology, tools, and data
- Assists application transition into operations
- Develops custom solutions through applications projects
Weather and Air Quality

Convection & Storm Dynamics
Cloud & Precipitation Processes
Planetary Boundary Layer Structure & Evolution
Hydrometeorology, Floods & Drought
Air Quality Attribution and Impacts
Aerosol and Trace Gas Redistribution & Attribution
Stratospheric Ozone Chemistry and Transport

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ENABLE IMPROVEMENTS IN WEATHER FORECASTS AND AIR QUALITY ATTRIBUTION & FORECASTS

INNOVATE • IMPLEMENT • IMPACT

Challenge
Increase the lead-time and accuracy for weather (Wx) for safeguarding life and property, and provide accurate air quality (AQ) attribution to improve health and environmental conditions.

Approach
- Develop new remote sensing capabilities to characterize atmospheric physical and chemical processes.
- Develop and improve data assimilation methods to better exploit Wx and AQ relevant satellite observations.
- Use these capabilities to enable more skillful Wx and AQ forecasts and improve AQ attribution to inform adaptation and mitigation efforts.

Other Activities
Cubesats (RainCube, Tempest-D), FIREX-AQ, atmospheric composition state and flux estimates, A-CCP Designated Observable Study, PBL Incubation Study, HAQAST, Subseasonal Atmospheric River Forecast Development.

Satellite Missions
AIRS, GNSS-RO, MISR, Quikscat, MLS, RapidScat, SMAP, CloudSat, TES, MAIA
Sea Level

Snow Pack

Discharge

Storm Surge

Melting Glaciers & Ice Sheets

Thermal Expansion

Glacial Rebound

Innovate • Implement • Impact
Sea Level

IMPROVE PREDICTIONS OF SEA LEVEL NEAR URBAN POPULATIONS

INNOVATE • IMPLEMENT • IMPACT

Challenge
Improve long-term projections of regional sea level rise to help mitigate the consequences to urban populations

Approach
• Measure global sea level variations, maintaining a record for continuity
• Develop measurement capabilities for regional sea level variations and rise
• Identify contributing processes to global and regional sea level variations
• Partner to improve predictions of sea regional level variations and global sea level rise

Satellite Missions
Jason-2/Jason-3, GRACE-FO, NISAR, SWOT

Other Activities
NASA Sea Level Portal, Oceans Melting Greenland, Delta-X
Natural Hazards

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Increase Decision Support Information for Natural Hazard Response

Innovate • Implement • Impact

Challenge
Develop forecast potential for natural hazard events and improve our capabilities for hazard response and preparedness.

Approach
• Measure changes over the Earth surface to identify and characterize earthquakes, volcanoes, landslides, wild fire, etc.
• Improve our physical understanding of the Earth surface process to better model and predict natural hazards when/where possible.
• Develop and provide decision support products for natural hazards preparation and response.

Satellite Missions
GRACE-FO, ECOSTRESS, SWOT, NISAR, MISR, TES, EMIT

Other Activities
Advanced Rapid Image Analysis (ARIA)
Carbon and Ecosystems

Provide estimates and projections of the carbon cycle at decision-relevant scales

Innovate • Implement • Impact

Challenge
Provide actionable estimates and projections of the global carbon system, considering natural ecosystems and anthropogenic emissions

Approach
• Measure the components of the Earth’s carbon cycle
• Understand and model the flow of carbon through the Earth system
• Partner to develop predictions of land, ocean and atmospheric carbon for decision-relevant scales (e.g. seasonal to decadal)

Satellite Missions
OCO-2, OCO-3, ECOSTRESS, TES, SMAP, NISAR

Other Activities
Carbon Management System, California Methane Survey, CORAL, Delta-X