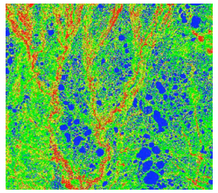
WATER AND CARBON CYCLES

Our research in water and carbon cycles is driven by the following questions:

- What are the impacts of natural processes and human activities on the distribution of water and carbon in the Earth system?
- How do the distributions of water and carbon vary over time?
- What are the links between soil moisture and snow-water content and long-term seasonal variations in climate?
- How do changes in the temporal and spatial dimensions of the terrestrial freeze–thaw process affect the duration of growing seasons?

The water and carbon cycle of Earth's climate system are closely connected through interactions with the global energy cycle. We employ microwave radiometry and imaging radar techniques to measure moisture content and freeze–thaw state of soils and characterize stages of vegetation growth. Our scientists have leading roles in the upcoming Soil Moisture Active and Passive (SMAP) mission. In addition, we are participating in the European Space Agency's Soil Moisture and Ocean Salinity (SMOS) and Japanese Earth Remote Sensing Data Analysis Center's Phased-Array L-band Synthetic Aperture Radar (PALSAR) missions.

The terrestrial biosphere and oceans have absorbed almost half of the anthropogenic CO_2 emitted during the past 40 years, but the nature, geographic distribution, and temporal variability of these CO_2 sinks are not adequately understood. We will improve our knowledge of the global distribution and variability of CO_2 reservoirs with the launch of the Orbiting Carbon Observatory (OCO) mission. Our characterizations of the growth cycle of vegetation and CO_2 reservoirs will provide valuable constraints on the models used to predict global climate change.



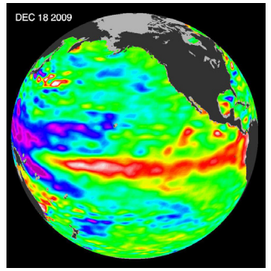
Classification of a wetlands ecosystem in Western Siberia based on data from Earth-orbiting radar, identifying important vegetation and surface moisture regimes.

OCEANOGRAPHY

Our research in oceanography is driven by the following questions:

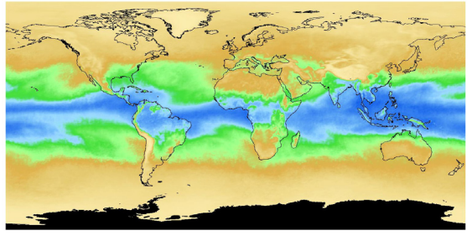
- What are the long-term relationships between climate change, global mean sea level, and ocean circulation?
- How well can we forecast seasonal-to-interannual climate events, such as El Niño and La Niña, based on changes in ocean surface topography and temperature?
- What are the rates at which heat, moisture, and particulates are transferred between the ocean and atmosphere?
- What is the impact of ocean surface wind measurements on forecasts of the behavior of hurricanes and typhoons?
- How do the areal extent of sea ice change and influx of glacial ice into the oceans vary over time?
- How does global evaporation and precipitation vary over the oceans and what are the links between the water cycle and ocean circulation?

We base our research on measurements of the temperature and topography of the ocean surface, together with the wind fields near the ocean surface, derived from data acquired by a variety of space-borne instruments. We measure surface temperature with infrared and microwave radiometers such as AIRS, the Moderate Resolution Imaging Spectrometer (MODIS), the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), and Advanced Microwave Sounding Unit (AMSU). We measure topography with the radar altimeters aboard the Jason-1 and the Ocean Surface Topography Mission (OSTM)/Jason-2 satellites. We measure wind vectors with the SeaWinds radar scatterometer aboard the Quikscat satellite. We measure the mass of the oceans with the Gravity Recovery and Climate Experiment (GRACE). With the launch of the Aquarius mission, we will generate the first global maps of sea surface salinity. In addition, we are leading the development of technologies that will enable the Surface Water and Ocean Topography (SWOT) and Extended Ocean Vector Winds Mission (XOVWM) experiments.



El Niño/La Niña phenomena are tracked by Jason-1. White indicates sea surface height; red indicates sea surface temperature.

Our comprehensive research programs combine satellite observations with state-of-the-art data analysis, analytical and numerical modeling, and data assimilation techniques. We provide science leadership for the Physical Oceanography Distributed Active Archive Center (PO-DAAC) and Group for High-Resolution Sea Surface Temperature (GHRSST) Project.



The total precipitable water vapor for May 2009, as seen by AIRS. The large area of maximum water vapor (blue) near the equator is the Intertropical Convergence Zone, a region of strong convection and powerful thunderstorms.

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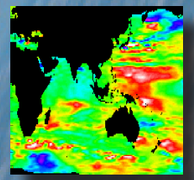
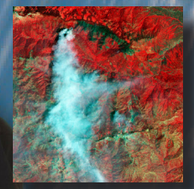
JET PROPULSION LABORATORY

Earth Science





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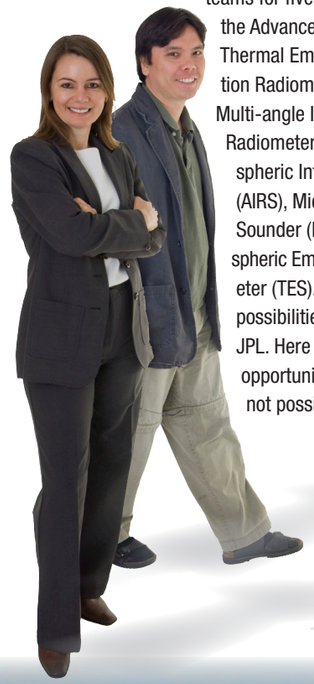
Earth scientists at JPL conduct research to characterize and understand the atmosphere, land, and oceans on our home planet to make better predictions of future changes. Our wide-ranging research topics include studies of distributions of ozone, carbon dioxide, water vapor, and aerosols in the atmosphere, roles of clouds and aerosols in Earth's radiation balance, ocean circulation and interactions between the oceans and atmosphere, roles of water vapor isotopes, cirrus cloud formation, and soil moisture in the global water cycle, earthquake fault systems, volcanic eruptions, and the composition of Earth's surface. Our research incorporates field and laboratory studies, balloon, aircraft, and satellite-based observations, theoretical modeling, and data analysis. We are key participants in NASA's Earth Observation System (EOS) missions, and JPL investigators lead the science teams for five EOS instruments: the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Multi-angle Imaging Spectro-Radiometer (MISR), Atmospheric Infrared Sounder (AIRS), Microwave Limb Sounder (MLS), and Tropospheric Emission Spectrometer (TES). A world of possibilities awaits you at JPL. Here you will find opportunities for research not possible anywhere else.

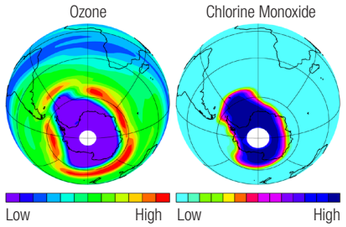


Explore the Possibilities

ATMOSPHERIC SCIENCE

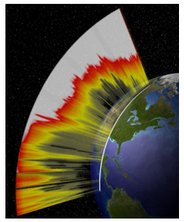
Our research in atmospheric science is driven by the following questions:

- What are the changes in atmospheric composition and the time-scales over which they occur, and what are the natural and anthropogenic forcings that drive these changes?
- Is water cycling through the atmosphere more rapidly, and how are clouds, water vapor, and precipitation affected?
- Is the frequency and intensity of hurricanes and severe weather increasing?
- What are the key factors in cloud formation processes, what are the cloud–climate feedbacks, and what are the roles of aerosols and clouds in Earth's radiation balance?
- How do "moist thermodynamic" atmospheric processes over diverse temporal and spatial scales operate, and how are they coupled to regional and global weather and climate?
- How do trace components in the atmosphere react to global environment change, and what is the impact of these reactions on climate?
- What are the effects of global atmospheric chemical and climate changes on air quality?
- What are the three-dimensional distributions of water vapor and ozone, greenhouse gases whose radiative forcing is strongest in the upper troposphere, and how do these distributions vary over time?
- What are the physical and chemical processes that lead to the depletion of stratospheric ozone, and how does the stability of the stratospheric ozone layer in both polar and midlatitude regions vary over time?
- What are the roles of aerosols and clouds in the Earth's radiation balance?



Ozone and the primary agent of its destruction, chlorine monoxide, measured by the Microwave Limb Sounder on NASA's Aura satellite on a day in late Antarctic winter.

- What are the contributions of wildfires and volcanic eruptions to the injection of aerosols into the free troposphere?
- What are the physical and chemical processes that lead to the formation of oxidants in urban and regional environments?



TES is an infrared spectrometer onboard NASA's Aura satellite that measures concentrations of ozone, carbon monoxide, water vapor and methane at various altitudes in the atmosphere.

To address these wide-ranging questions, we combine remotely sensed data acquired from spaceborne, airborne, and ground-based instruments with numerical models of the thermodynamic, radiative, and chemical properties of the atmosphere and evolution of weather and climate. We employ state-of-the-art experimental techniques to measure the kinetic, photochemical, and spectroscopic parameters related to elementary atmospheric processes.

Our remote-sensing measurements, which include data from the spaceborne AIRS, MISR, MLS, and TES instruments, span the electromagnetic spectrum from the visible to the microwave. We also participate in field campaigns to study hurricanes and other atmospheric processes with aircraft instruments developed at JPL. We pioneered remote sensing at submillimeter microwave frequencies and the use of multi-angle imaging to estimate the distributions and microphysical properties of aerosols, altitude of clouds, and wind velocity vectors from multi-angle imagery.

Our scientists have extensive knowledge of instrument design and calibration and retrievals of atmospheric state parameters from remotely sensed data, and are leading the use of such data in atmospheric research. We are leading the development of key technologies to enable the Aerosol-Cloud-Ecosystem (ACE), Geostationary Coastal and Air Pollution Events (GEO-CAPE), and Precipitation and All-weather Temperature and Humidity (PATH) missions.

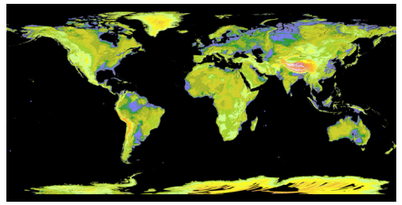
GEOLOGY AND GEOPHYSICS

Our research in geology and geophysics is driven by the following questions:

- How is Earth's surface being transformed by naturally occurring tectonic and climatic processes?
- What are the dynamics of Earth's interior and how do these forces drive change at Earth's surface?
- How is global sea level affected by natural variability and human-induced change in the Earth system?
- How can knowledge of Earth's surface change be used to predict and mitigate natural hazards?

We employ active and passive remote-sensing techniques, including radar interferometry, multispectral imaging, and satellite-based mapping of Earth's gravitational field to study deep crustal and mantle processes, earthquakes and active tectonics, volcanic gas emissions and eruption plumes, geothermal phenomena, surface composition, and dynamic mass changes in the oceans and ice sheets. In addition, we employ forward modeling, inversion techniques, and numerical simulation to analyze earthquake focal mechanism data, coseismic, postseismic, and interseismic strain measurements, and model the response of the crust to large earthquakes.

Our collaborators include the Southern California Earthquake Center (SCEC), EarthScope Consortium, United States Geological Survey (USGS), and the Gravity Recovery and Climate Experiment (GRACE) mission. We lead the science teams for the Shuttle Radar Topography Mission (SRTM) and ASTER mission, and have prominent roles in the upcoming Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI) and Hyperspectral and Infrared Imager (HyspIRI) missions.



This global digital elevation model created from ASTER images is colorized to indicate elevation (purple is lowest).