Unveiling Planet Ocean

NASA's GRACE mission will reveal some of what lies hidden beneath the surface of Earth's oceans by measuring tiny changes in gravity.

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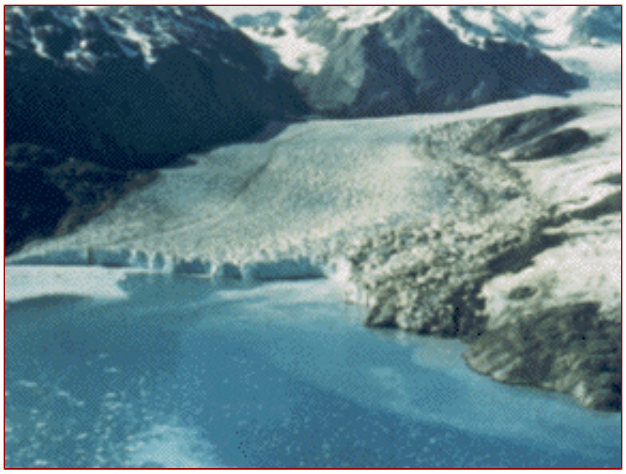


March 14, 2002: As the science fiction writer Arthur C. Clarke once pointed out, "How inappropriate to call this planet Earth, when clearly it is Ocean."

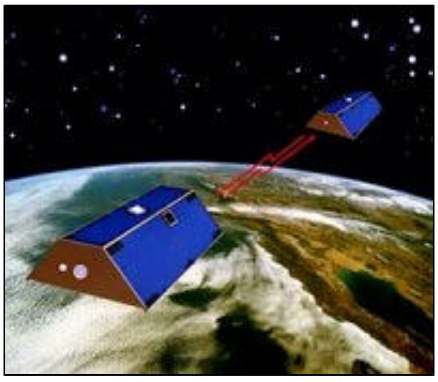
Earth's oceans are unique in the solar system. Liquid water covers 70% of our planet's surface, yet no other world (as far as we know) has even a single drop of liquid water above ground.

Without oceans our planet would be uninhabitable. Oceans temper seasonal extremes; they evaporate and provide fresh water for life on land; and marine life is a key link in the global food chain. Furthermore, oceans play an incompletely understood role in climate change.

Above: Because of water's large capacity for storing and transporting heat, Earth's climate is strongly influenced by oceans, glaciers and ice sheets.

Understanding the oceans is clearly important, yet what lies beneath the waves remains largely unexplored and invisible from above. Now, though, a pair of satellites called GRACE (short for **G**ravity **R**ecovery **A**nd **C**limate **E**xperiment) will open a new window on that hidden realm. GRACE, slated for launch on March 16, will peer beneath the oceans by measuring tiny changes in gravity -- changes caused by moving water and ice.

"We'll be able to monitor things like water moving around in ocean basins and changes in deep-sea currents," says Michael Watkins, project scientist for GRACE at NASA's Jet Propulsion Laboratory (JPL). "We'll even be able to weigh ice sheets from orbit."



Left: GRACE will measure the variations in Earth's gravity by precisely sensing the distance between a pair of satellites flying in formation. [more]

GRACE works like this: Two identical satellites will fly in the same orbit -- one 220 km (137 miles) ahead of the other. As the pair circle Earth, regions of slightly stronger gravity will affect the lead satellite first, pulling it slightly away from the trailing satellite. By monitoring the distance between the two with extraordinary precision -- the satellites can sense a change in separation about 1/50th the width of a human hair -- GRACE will be able to detect minute fluctuations in the gravitational field of Earth below.

One source of such fluctuations are ice sheets and glaciers. GRACE will measure the masses of ice deposits around the world, and perhaps more importantly, the rate of change in their masses. This information will reveal how much fresh water is entering the oceans from melting glaciers, and it will give climate scientists a better idea of the severity of global climate change.

Gravity measurements can also aid ocean researchers in less direct ways. For

example, precise gravity data will improve estimates of Pacific sea-surface temperatures.

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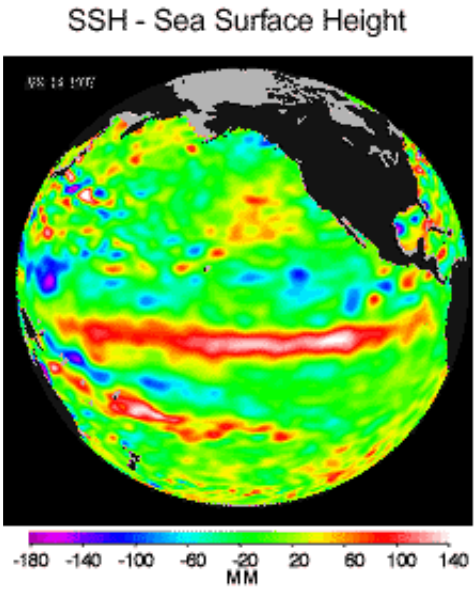
"When a patch of ocean is heated up," explains JPL ocean scientist Victor Zlotnicki, "the water column expands vertically. This raises sea level. A radar altimeter like the one aboard the NASA/CNES TOPEX/Poseidon or JASON satellites can measure this height to within centimeters. When the altimeter 'sees' a local height increase we're tempted to think that the water column is heating up -- and usually that is the right answer."

But, he continued, other things can cause the sea level to rise, too. For example, "the wind can spin large patches of ocean and deform its surface by pushing water aside -- much as a clothes washer during the spin cycle pulls water down in the middle and pushes it up at the edges." So, when an altimeter registers a bump in the ocean surface, is it due to heat expanding the water or to wind piling more water on top? GRACE will sort that out. Adding heat to a column of water raises its height but does not change its mass. Adding water changes both. By measuring the mass, GRACE can distinguish between the two possibilities.

Who cares about accurate sea surface temperatures? Anyone with an interest in weather and climate.

For instance, Pacific ocean temperatures are a telltale sign of future El Niño conditions. GRACE will improve El Niño predictions, in an indirect way, by improving our understanding of Pacific waters.



Right: El Niños happen when a band of warm surface water stretches west from the coast of South America. GRACE will help improve satellite measurements of ocean surface temperature. Image courtesy NASA/CNES TOPEX/Poseidon.

"Another surprising ability of GRACE," notes Zlotnicki, "is that it can measure currents at the bottom of the ocean. This is possible because currents flow when pressure is higher in one spot than in another. Pressure at the bottom of the ocean is proportional to the mass of the atmosphere plus ocean above that spot. By sensing that overlying mass, GRACE will be the first satellite system that can 'see through' the ocean all the way to the bottom and detect currents there."

Research involving land will of course benefit from GRACE, too -- see the Science@NASA story "Amazing GRACE" -- but the oceans have so much more to hide. GRACE will give us a new view of Ocean, the alien world on our own planet.

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Web Links
Essential GRACE Links: GRACE Homepage (U. Texas); Amazing Grace (Science@NASA); Getting the Lowdown on Gravity (JPL) **Ocean science at JPL** -- information on how satellite data is being used to better understand Earth's oceans. Includes an image of sea-surface height generated using TOPEX/Poseidon data. **NASA Oceanography** -- an overview of the many ways NASA participates in and contributes to ocean science. **TOPEX/Poseidon** -- homepage for the NASA/CNES ocean surface mapping mission, from JPL

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