Ocean Currents are Influenced by Seafloor Topography

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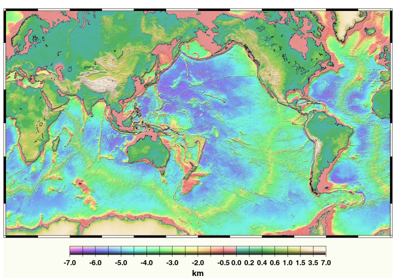
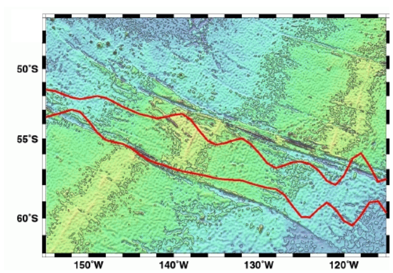
Topography influences ocean circulation in two ways.
Altimetry helps us understand both.

A. Currents are steered around seafloor ridges



A.1 Global ocean bathymetry from space. The largest influence on sea surface height comes from the Earth's geoid. The geoid does not vary in time, so each time a satellite altimeter passes over the same point, it sees the same geoid. The slope of the geoid is partially related to bathymetry. Altimeter data helps estimate seafloor bathymetry on lengthscales shorter than 160 km (Smith and Sandwell, 1997).

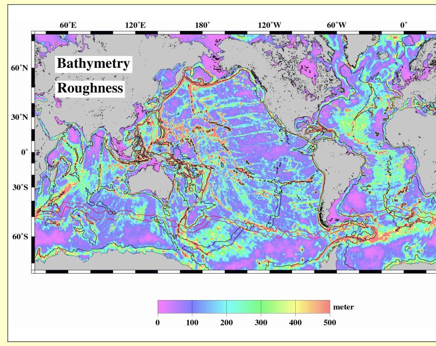
Ocean circulation is steered by bathymetry. Currents tend to pass through deep gaps in ridges and follow contours of constant depth.



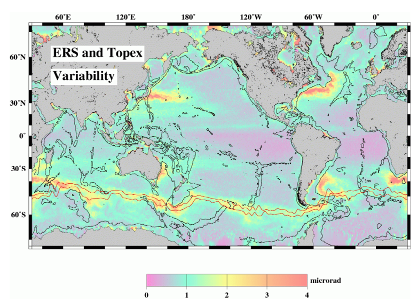
A.2 Topographic Steering through the Eltanin and Udintsev Fracture Zones. Sea surface height varies each time the altimeter returns to the same groundtrack. This time-varying signal tells us about variability in ocean currents and can be used to determine where major ocean currents are located.

For example, altimeter data has shown that in the south Pacific, the jets that make up the Antarctic Circumpolar Current pass through separate gaps in the Pacific-Antarctic Ridge. The southern jet, the Polar Front, passes through the Udintsev Fracture Zone, while the northern jet goes through the Eltanin Fracture Zone.

B. Rough topography dissipates energy

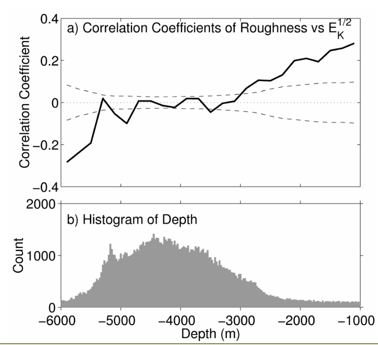


B.1 Estimates of bottom roughness from global altimetry. Available ocean bathymetry allows us to estimate roughness on lengthscales from 160 to 20 km. The results mapped here show that roughness is high along the mid-Atlantic Ridge, and that there is no comparable roughness in the Pacific Ocean.



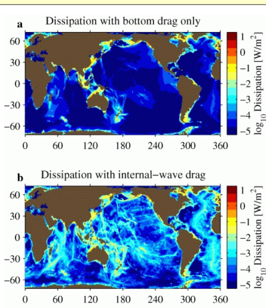
B.2 Ocean variability from altimetry. Average variability of the slope of the ocean surface (here measured in microradians) is a measure of the eddy kinetic energy of ocean currents. Strong variability is linked to major currents—the Gulf Stream in the Atlantic, the Kuroshio Extension in the Pacific, the Antarctic Circumpolar Current south of 30 S (marked with red lines).

Notice that variability is low in regions of high bottom roughness, such as the region over the mid-Atlantic Ridge in the North Atlantic Ocean.



B.3 Correlations between bottom roughness and eddy kinetic energy. Depending on the depth of the ocean, eddy kinetic energy measured from altimetry appears either correlated or anti-correlated with seafloor roughness. In the deepest parts of the ocean, high bottom roughness implies reduced eddy kinetic energy, suggesting that topography helps remove energy from the ocean.

Panel b shows a histogram of ocean depth. Most of the ocean is between 3000 and 5000 m depth where a strong correlation pattern is not detectable using available data.



B.4 Ocean tides are strongly dissipated over rough topography. Jayne and St. Laurent (2001) compare two simulations of tides. Panel a uses normal bottom friction. Panel b has high dissipation over rough topography, leading to more deep ocean tidal dissipation than panel a. This roughness induced dissipation is a better match to observations (from TOPEX/Poseidon).

C. What lies ahead?

C.1 Jason and the TOPEX/Poseidon Tandem Mission. The launch of Jason will guarantee an extended altimetric time series with ongoing information about the variability of the ocean and changes in ocean circulation. Together Jason and TOPEX/Poseidon will provide denser spatial coverage that will refine existing estimates of ocean variability.

C.2 ABYSS is a proposed altimeter to improve our estimates of sea floor bathymetry. ABYSS is designed to fly on the International Space Station. Its new, high-precision altimeter and non-repeating orbit will measure changes in sea surface slope over shorter distances than TOPEX/Poseidon or Jason. The new estimates of sea floor bathymetry and bottom roughness will benefit global ocean climate studies.

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