• Current bathymetry resolution worse than 10 km

• Predicting bathymetry from satellite altimetry

• Discoveries from non-repeat altimeters (Geosat and ERS-1)

• New science

• Mission requirements
1/2 of global seafloor bathymetry not resolved at 10 km resolution

[Smith and Marks, 2009]
seamounts

[Uncharted]

[Wessel, 2001]
uncharted seamounts
> 3 km tall
USS San Francisco crashed into 2-km tall uncharted seamount

• Los Angeles class nuclear submarine ran aground in route from Guam to Brisbane, Australia - 8 January, 2005
• One sailor killed, 115 injured
• Crash depth ~160 m, speed 33 kn, Sonar measured a depth of 2000 m 4 minutes before crash
• 30-hour trip back to Guam, crew managed to keep the sub from sinking
modern mapping tools

- satellite altimeter
- multibeam echo sounder
available altimeter data

2.5 years non-repeat and 65 years of repeat
bumps on the surface of the ocean
predicting bathymetry from gravity
discoveries from Geosat and ERS-1

• confirming/refining plate tectonics

• global seafloor age

• global bathymetry grids

• seamounts > 2 km tall

• seafloor roughness versus spreading rate

• microplates and propagating ridges

• lithospheric geodynamics
plate tectonics
fast vs. slow spreading
Abyssal Hills: Fast v. Slow Spreading Rate

[Smith, W.H.F.: personal communication]
ocean mixing vs. seafloor roughness

[Polzin et al., 1997]
20-km-scale bathymetry steers ocean currents

[Mitchell et al., 2005]
20-km-scale bathymetry steers ocean currents

A Kaleidoscope of Iron Limitation in the Southern Ocean
SIO: G. Mitchell, F. Azam, K. Barbeau, C. Hewes, O. Holm-Hansen, S. Gille
UH: C. Measures
UMB: M. Zhou
slope requirement

\[ \Phi \text{ disturbed potential} \]

\[ N = \frac{1}{g_o} \Phi \text{ geoid height} \]

\[ \Delta g = -\frac{\partial \Phi}{\partial z} \text{ gravity anomaly} \]

\[ \eta = -\frac{\partial N}{\partial x} \text{ slope of ocean surface} \]

Laplace’s equation, assume 2-D anomaly

\[ \nabla^2 \Phi = 0 \quad \Rightarrow \quad g_o \frac{\partial \eta}{\partial x} + \frac{\partial g}{\partial z} = 0 \]

take fourier transform w.r.t. \( x \)

\[ \Delta g(k) = i g_o \frac{k}{|k|} \eta(k) \]

1 \( \mu \)rad of slope error \( \Leftrightarrow \) 1 mGal gravity error

1 cm

10 km
fundamental limitations

- upward continuation
- ocean waves
- coastal tides
waves are $\sim 3\, m\, rms$

$1\, \mu rad = 1\, cm\, accuracy\, over\, 10\, km\, (1.4\, s)$

Topex 1 Hz noise is $\sim 4\, cm$

need 16 repeats to reduce noise to $1\, cm$

each repeat is 1.5 yr so we need 24 years of data

OR we need an altimeter with 2X better range precision
New science from < 1 μrad mission

**Oceanography** - Determining the effects of bathymetry and seafloor roughness on ocean circulation, mixing, climate, and biological communities, habitats, and mobility.

**Marine Geology and Geophysics** - Understanding the geologic processes responsible for ocean floor features unexplained by simple plate tectonics, such as abyssal hills, seamounts, microplates, and propagating rifts.

**Hazard** - Improving tsunami hazard forecast accuracy by mapping the deep ocean topography that steers tsunami wave energy.

**Navigation** - Mapping the marine gravity field to improve inertial navigation and provide homogeneous coverage of continental margins.

**Applications** - Providing bathymetric maps for numerous other practical applications, including reconnaissance for submarine cable and pipeline routes, improving tide models, and assessing potential territorial claims to the seabed under the United Nations Convention on the Law of the Sea.
Mission Requirements

- **Slope accuracy** - Better than 1 microradian over a 6 km horizontal distance.

- **Spatially uniform coverage and accuracy** - Complete spatial coverage (6 km resolution) with spatially uniform accuracy is required.

- **Moderate inclination** -- Current non-repeat-orbit altimeter data have high inclination and thus poor accuracy of the E-W slope at the equator. The new mission should have an inclination of ~60° or 120° to improve E-W slope recovery.

- **Near-shore tracking** -- For applications near coastlines, the ability to track the ocean surface close to shore is desirable.

- More information at [http://topex.ucsd.edu/concept](http://topex.ucsd.edu/concept)
satellite altimetry
Conclusions

• 1/2 of the seafloor bathymetry is not resolved at 10 km.

• Non-repeat orbit altimeters (Geosat and ERS-1) have revolutionized Marine Geology and Geophysics

• The topography of the land controls atmospheric circulation, climate and weather.

• The topography of the seafloor controls ocean circulation, tidal flow/vertical stratification, and eddies.

• We need a complete coverage altimeter mission to map the ocean basin.
ABYSS will extend short wavelength coverage by an order of magnitude beyond that of CHAMP, GRACE, and GOCE
fast spreading vs. slow spreading
Forecast models require correct global bathymetry. A single seamount as small as 20 km across can steer a major current (Kuroshio mean flow in U.S. Navy model at 1/16°). [Metsger & Hurlburt, GRL, 2001]