

Abyssal Marine Tectonics from SWOT Altimetry

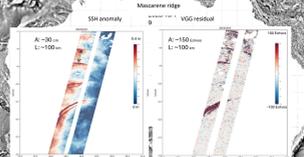
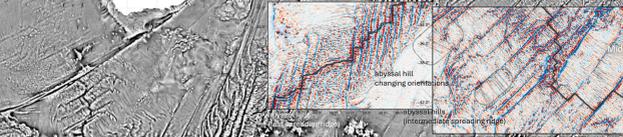
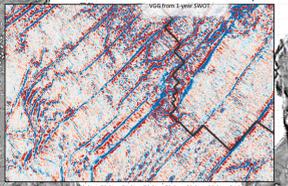
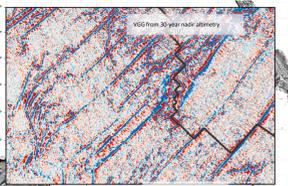
Yao Yu (yayu@ucsd.edu), David Sandwell, Gerald Dibarboure
 Scripps Institution of Oceanography, San Diego, USA; Centre National d'Etudes Spatiales, Paris, France

Vertical Gravity Gradient (VGG):

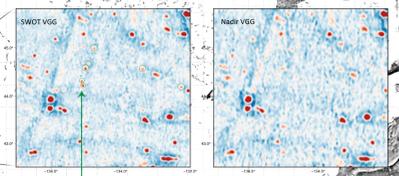
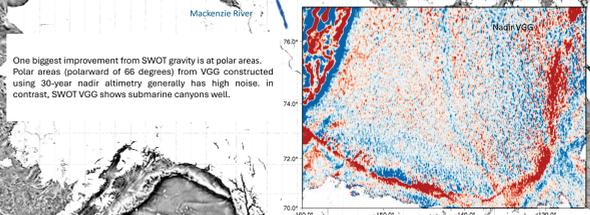
- VGG is the curvature of the sea surface.
- this map was constructed using 1-year SWOT sea surface height data.
- highlights small-scale (4-km) solid earth signals.
- reveals seafloor structures not covered by ship soundings (75% of global ocean).
- light — mass excess; dark — mass deficit.

Prior to SWOT, abyssal hills were only mapped using multibeam sonar. Now they are visible almost everywhere in the ocean basins. Abyssal are the most common landform on Earth. They form at seafloor spreading ridges and thus reveal past plate tectonics. With a mission lasting for 3-5 years, SWOT promises a clear mapping of abyssal hill global distributions.

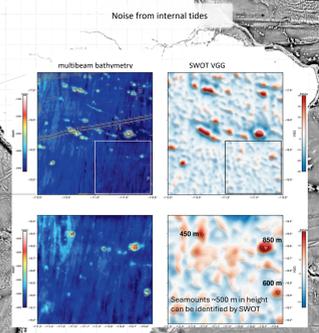
Comparison between nadir altimetry and SWOT at SEIR. No illumination nor spatial filtering applied.



One biggest improvement from SWOT gravity is at polar areas. Polar areas (polarward of 66 degrees) from VGG constructed using 30-year nadir altimetry generally has high noise. In contrast, SWOT VGG shows submarine canyons well.

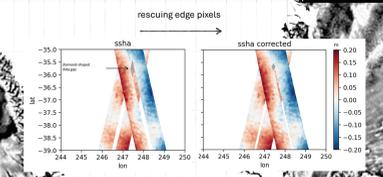


New seamounts (in green circle) identified by 1-year SWOT. SWOT VGG sharpens seafloor features and smooths abyssal orange peel effects. With more SWOT data coming, it is promising to greatly extend current seamount catalogue.



This continental margin separating from the Argentine Plateau is mostly 500 m and 1000 m contours is submarine canyon system. It is mostly 500 m and 1000 m contours is submarine canyon system. It is mostly 500 m and 1000 m contours is submarine canyon system.

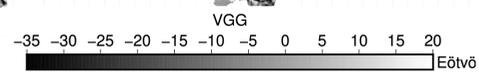
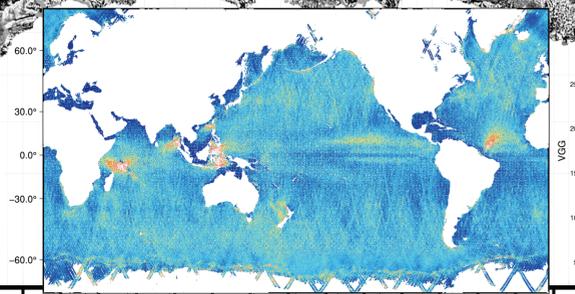
Part of the continental slope created by the 500 m and 1000 m contours is submarine canyon system. It is mostly 500 m and 1000 m contours is submarine canyon system.



Currently SWOT 2-km product covers 88% of the 250-m reaching edge pixels on using L3 250-m product. It can potentially cover 91% of open ocean. It is especially important for data recovery.

SWOT VGG RMS:

- Largest error (~25 Eotvos) at strong internal tide sites.
- M2 tide has an aliasing period of ~65.6 days in SWOT 21-day phase (non-repeat) and stacking 5-year SWOT data can effectively reduce its signature on sea surface slope/VGG.
- Continental margins with shallow depth having smallest error.



Summary

Currently, only a quarter of the seafloor has been surveyed by ship echo sounders, offering a 200 m spatial resolution. SWOT offers a novel opportunity to indirectly survey the remaining 75% of seafloor with a 4-km spatial resolution. One-year of SWOT data reveals unprecedented details at abyssal hills formed at seafloor spreading ridges, small seamounts created by off-ridge volcanism, and continental margin canyons incised by rivers.

Data

1-year of SWOT L2 LR ocean data (April 2023 to May 2024). Credit: NASA/JPL; CNES

Method

- Start with L2, 2 km ocean data products with crossover correction.
- Project north and east model sea surface slope into along-track and cross-track slope.
- Estimate cross track phase screen using model slopes and stack residual along-track and cross-track slopes from SWOT.
- Compute second derivatives and add to obtain residual VGG.
- Restore model VGG to residual VGG and low-pass at 8 km.

Conclusions and Outlook

- The accuracy and resolution of the gravity field from 1 year of SWOT is superior to the best gravity based on 30 years of nadir altimetry.
- VGG from SWOT resolves the abyssal hills for the 75% of the oceans not mapped by ships. Abyssal hills reveal past seafloor spreading directions and have steep slopes to generate high-mode internal waves.
- Seamount analysis coming soon.
- We plan to use the 250 m ocean product to recover 2-4 km of data lost on the edges of each swath.
- Global grids of gravity and bathymetry will be available in November 2024 and January 2025, respectively.

