# Global Marine Gravity from Retracked Geosat and ERS-1 Altimetry

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## (0) Abstract

Three approaches are used to reduce the error in the satellite-derived marine gravity anomalies.

**(1)** Retracking of the raw waveforms from the ERS-1 and Geosat/GM missions resulting in improvements in range precision of 40% and 27%, respectively.

**(2)** The recently-published EGM2008 global gravity model is used as a reference field to provide a seamless gravity transition from land to ocean.

**(3)** The biharmonic spline interpolation method is used to construct residual vertical deflection grids.

Comparisons between shipboard gravity and the global gravity grid show errors ranging from 2.0 mGal in the Gulf of Mexico to 4.0 mGal in areas with rugged sea-floor topography. The largest errors of up to 20 mGal occur on the crests of narrow large seamounts.

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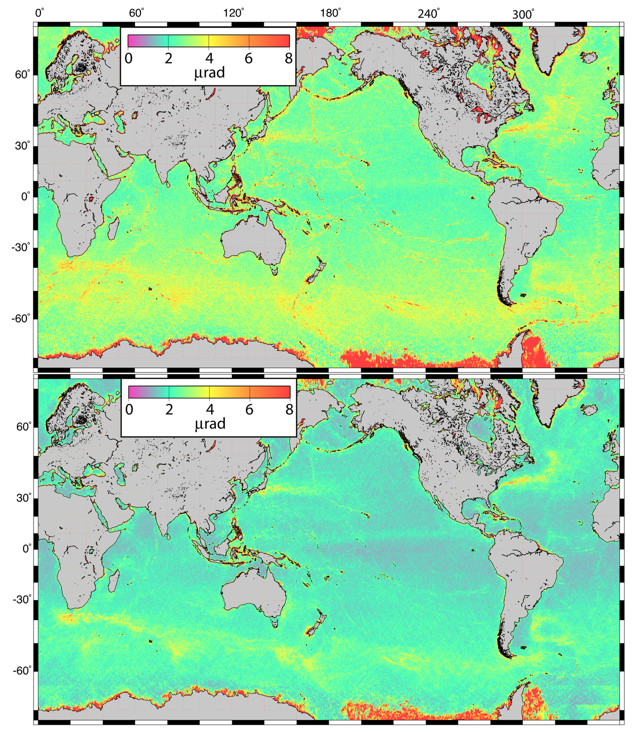
ftp://topex.ucsd.edu/pub/topex/global_grav_1min

## (1) Retracking of Geosat Altimeter Waveforms

The original Geosat altimeter data were derived from the waveform tracker onboard the satellite which is not optimized for gravity field recovery. The original rms slope differences from the V18.1 model are typically 4.4 μrad (upper). Retracking of the waveforms improves the range precision resulting in rms differences of 3.2 μrad (lower). This is a 27% improvement in precision. Retracking of the ERS-1 altimeter data resulted in a 40% improvement in precision.




## (2) Land Gravity Anomalies are from EGM2008
**See oral presentation - Tuesday 10:20h G22A-01 INVITED**

### The EGM2008 Global Gravitational Model

**Pavlis, N K** - National Geospatial-Intelligence Agency, 12310 Sunrise Valley Drive, Reston, VA 20191, United States
**Holmes, S A** SGT, Inc., 7701 Greenbelt Road, Suite 400, Greenbelt, MD 20770, United States
**Kenyon, S C** - National Geospatial-Intelligence Agency, 3838 Vogel Road, Arnold, MO 63010,
**Factor, J K** - National Geospatial-Intelligence Agency, 3838 Vogel Road, Arnold, MO 63010,

The data are available as spherical harmonic coefficients extending to degree 2190 and order 2159 as well as a 5 minute global grids of geoid height. http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/index.html

## (3) Biharmonic Spline Interpolation of Slope Data

Consider *N* estimates of slope $s(\mathbf{x_i})$ with direction $\mathbf{n_i}$ each having uncertainty $\sigma_i$. We wish to find the "smoothest" surface $w(\mathbf{x})$ that is consistent with this set of data such that $s_i = (\nabla w \bullet \mathbf{n})_i$. We develop a smooth model using a thin elastic plate that is subjected to vertical point loads. The loads are located at the locations of the data constraints (knots) and their amplitudes are adjusted to match the observed slopes [*Sandwell,* 1987]. This problem is solved by first determining the Greens function for the deflection of a thin elastic plate in tension. The differential equation is

$$\alpha^2\nabla^4\phi(\mathbf{x}) - \nabla^2\phi(\mathbf{x}) = \delta(\mathbf{x})$$

where *α* is a length scale factor that controls the importance of the tension. Through experimentation we find good-looking results when the solution is about 0.33 of the way from the biharmonic to the harmonic end-member. The Greens function for this differential operator is [*Wessel and Bercovici,* 1998]

$$\phi(\mathbf{x}) = K_o\left(\frac{|\mathbf{x}|}{\alpha}\right) + \log\left(\frac{|\mathbf{x}|}{\alpha}\right)$$

where $K_o$ is the modified Bessel function of the second kind and order zero. The smooth surface is a linear combination of these Greens functions each centered at the location of the data constraint.

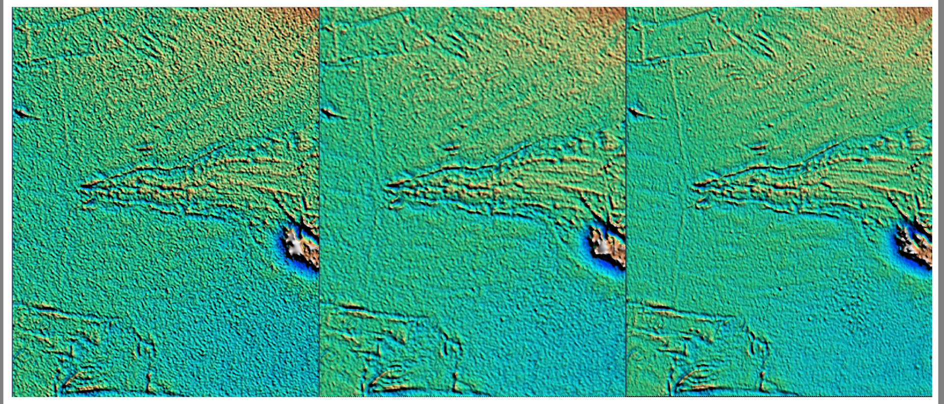
$$w(\mathbf{x}) = \sum_{j=1}^{N} c_j \phi(\mathbf{x} - \mathbf{x_j})$$

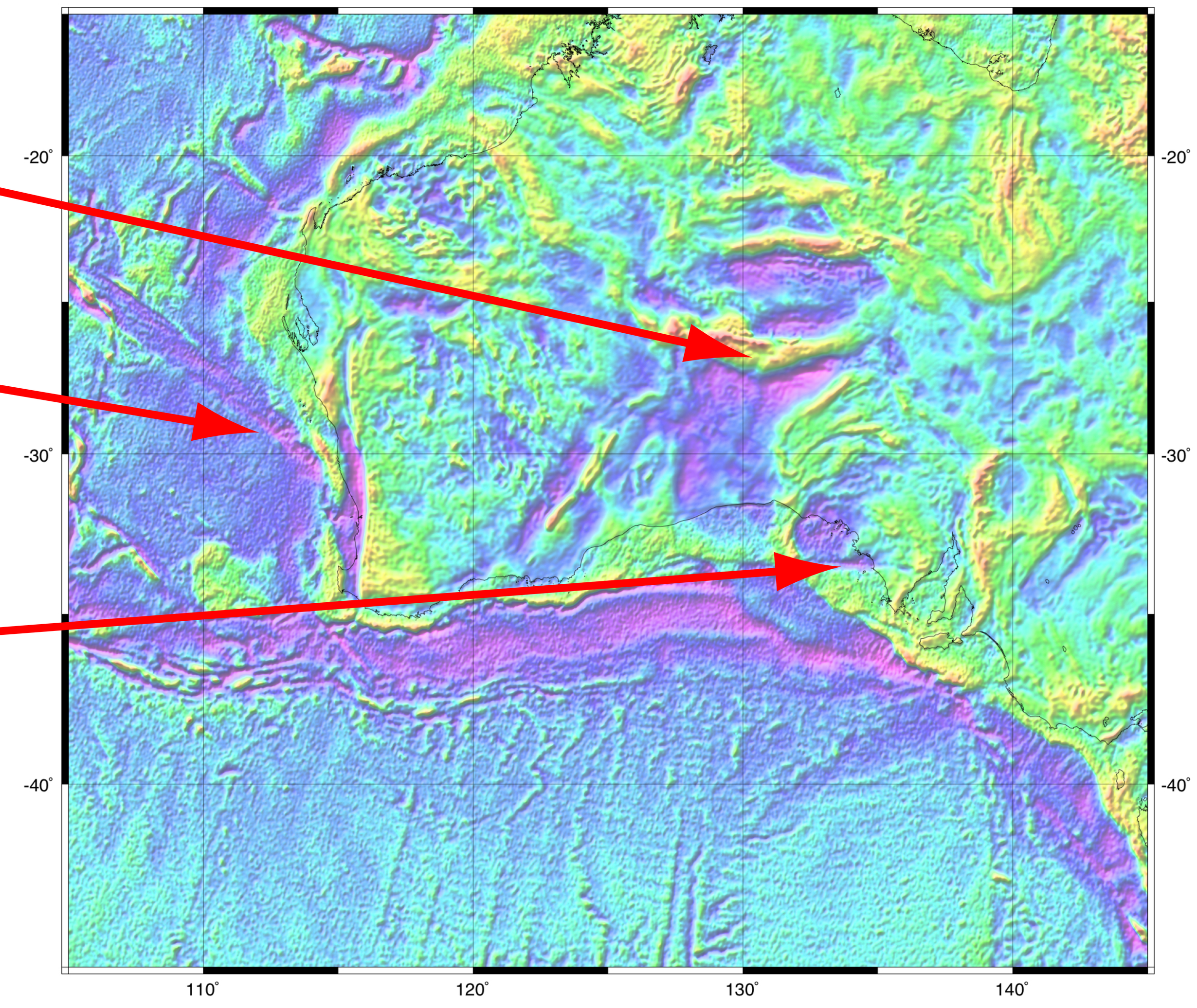
The coefficients $c_j$ represent the strength of each point load applied to the thin elastic plate. They are found by solving the following linear system of equations.

$$s_i = (\nabla w \bullet \mathbf{n})_i = \sum_{j=1}^{N} c_j \nabla\phi(\mathbf{x}_i - \mathbf{x}_j) \bullet \mathbf{n_i} \qquad i = 1, N$$

## (4) Gravity field improvements due to retracking

V9.1 no retracking | V11.1 retracking of ERS-1/GM | V18.1 retracking of ERS-1/GM and Geosat/GM

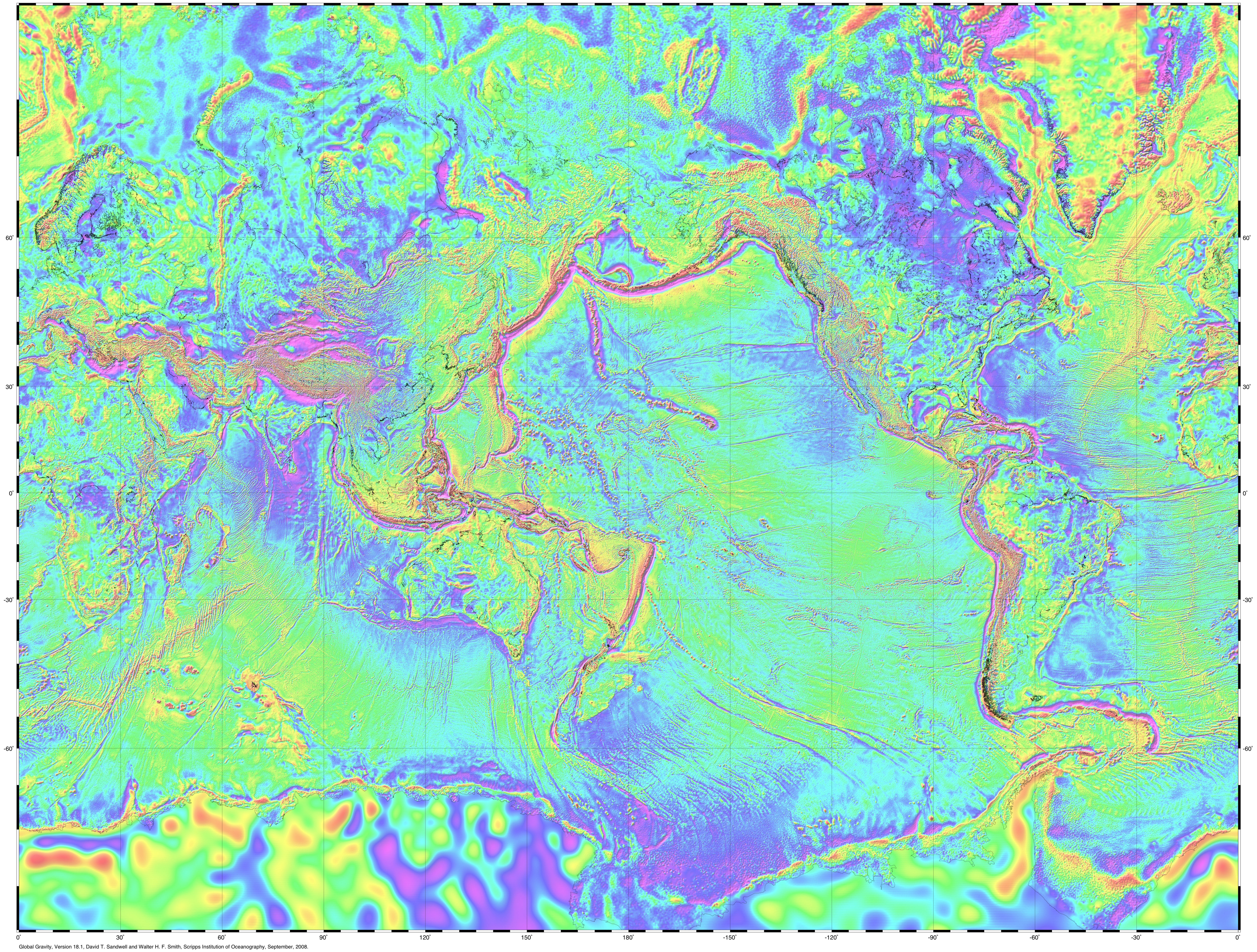




Land from EGM2008

Ocean from Geosat and ERS-1 altimetry

Note gravity is continuous from land to ocean.



Global Gravity, Version 18.1, David T. Sandwell and Walter H. F. Smith, Scripps Institution of Oceanography, September, 2008.