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Which altimeter is best for gravity field recovery?

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(1) Objective

Satellite radar altimetry collected during a number of geodetic missions has provided a new understanding of the topography and tectonics of the deep oceans. As altimeter performance and coverage improves, smaller structures are revealed. Here we investigate the contribution of six altimeter missions that have been placed into geodetic mapping phases for more than one year. The major limitation for recovering small scale gravity features is the sea surface roughness from ocean waves. There have been steady improvements in instrumentation and processing methods that will continue into the future with higher frequency radars and interferometric swath altimeters planned for future missions (e.g., SWOT). Here we assess the contribution of each geodetic mission to the recovery of the marine gravity field. Gravity field recovery depends on three factors:

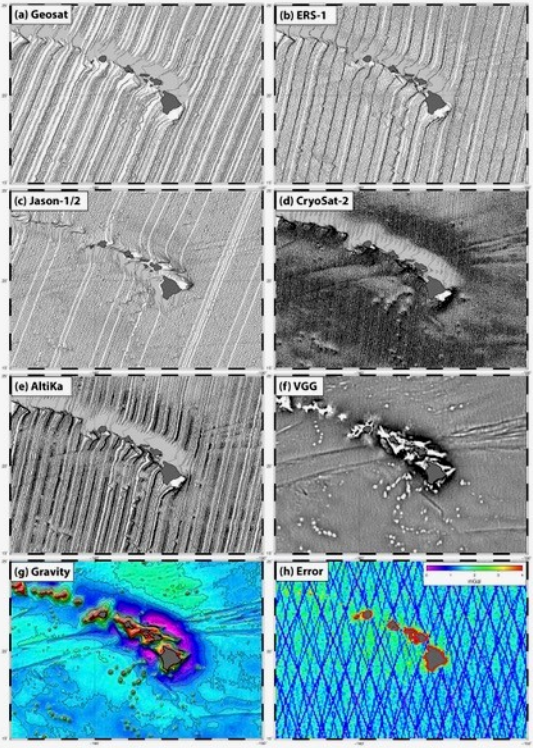
(1) altimeter **range precision** which is related to the characteristics of the radar [Raney and Phalippou, 2011];
(2) **spatial coverage** which is related to mission duration; and
(3) **diversity of track orientation** which is related to orbital inclination and latitude.

(2) Geodetic Mission Data

Table 1 – Summary of geodetic altimeter data used in the latest gravity grid (V28)

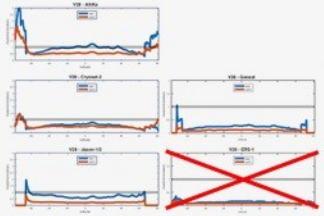
altimeter	start of GM phase	duration (mo.)	latitude coverage	noise@20Hz and 2m SWH (mm)	reference
Geosat	APR 1985*	18	+/-72°	57.0	Sandwell and Smith, 2009
ERS-1	APR 1994	12	+/-81°	61.8	Sandwell and Smith, 2009
Jason-1/2	APR 2012/ AUG 2017	14/12+	+/-66°	46.4/44.0	Garcia et al., 2014/this paper, Appendix A
CryoSat-2 LRM/SAR	JUN 2010	96+	+/-88°	42.7/49.7	Garcia et al., 2014
SARAL/AltiKa	JUN 2016	32+	+/-81°	28.9+	Zhang et al., 2017

* Geosat/GM data were declassified in June 1995 after ERS-1 completed its GM.
+ AltiKa noise at 40 Hz
In addition to the GM coverage provided in the table, we used 2520 days of 35-day repeat Envisat data, 3700 days of 10-day repeat Jason-1 data, 150 days of 10-day repeat Jason-2 data and 1225 days of 35-day repeat AltiKa data.



(a-e) Along-track sea surface slope profiles for all altimeters having a geodetic mission mapping phase. (f-h) Gravity products derived from sea surface slopes include: (f) Vertical gravity gradient (VGG) which is equal to the curvature of the ocean surface; (g) Gravity anomaly; and (h) Error or uncertainty in the gravity anomaly. Tracks having lower error are repeat profiles from Jason-1/2, Envisat, and AltiKa. Products are available at: ftp://topex.ucsd.edu.

(3) Contributions from each altimeter



Median absolute difference in microradian between the V28 gravity model and models generated with one data set omitted. A larger difference is a greater improvement. All models are filtered with a 0.5 gain at 16 km full wavelength. We treat Jason-1 and 2 as a single contribution since they have similar noise characteristics. **AltiKa provides the largest contribution especially in the east component at low latitudes.** CryoSat-2 and Jason-1/2 provide significant contributions. Geosat and ERS-1 provide minor contributions.

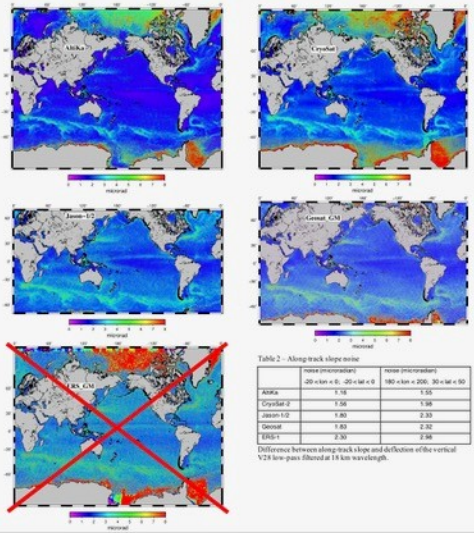
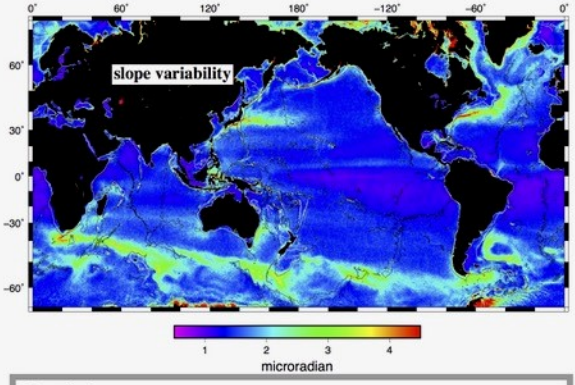


Table 2 – Along-track slope noise

	noise (microradian) -20 <lon < 0; -20 < lat < 0	noise (microradian) 160 <lon < 200; 30 < lat < 50
AltiKa	1.18	1.55
CryoSat-2	1.56	1.98
Jason-1/2	1.80	2.33
Geosat	1.83	2.32
ERS-1	2.30	2.98

Difference between along-track slope and deflection of the vertical V28 low-pass filtered at 18 km wavelength.



Conclusions

The accuracy and resolution of the marine gravity field depends on three factors: altimeter range precision, dense track coverage, and a diversity of track orientation.

The older altimeters Geosat and ERS-1 provided the first generation of gravity field models but are less important today. ERS-1 does not contribute to the gravity recovery so it will no longer be used.

The new altimeters are providing a dramatic improvement in accuracy. Here is their ranking:

(1) AltiKa is has the best range precision and 3 years of non-repeat coverage.

(2) CryoSat-2 has 9 years of non repeat coverage and has excellent range precision.

(3) Jason-1/2 provide critical information in the EW component of the gravity field.