

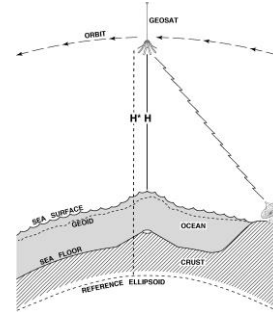
Predicting Bathymetry from Satellite Altimetry: The Good, The Bad, and The Ugly

David T. Sandwell - Scripps Institution of Oceanography

Walter H. F. Smith - Laboratory for Satellite Altimetry, NOAA

Joseph J. Becker - Naval Research Laboratory

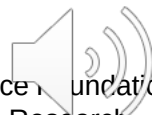
Christopher Olson - Scripps Institution of Oceanography



Objective – construct the best possible global map of the deep ocean floor for science, public outreach, and applications.

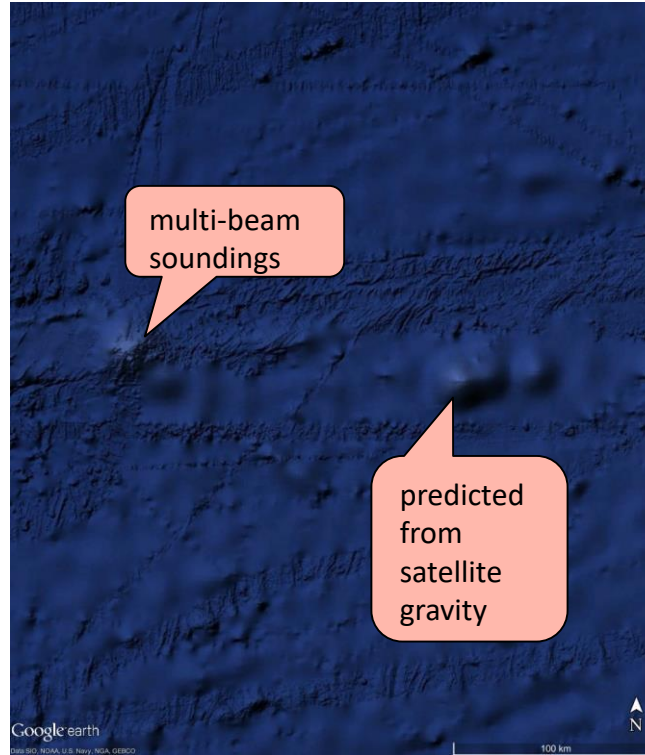
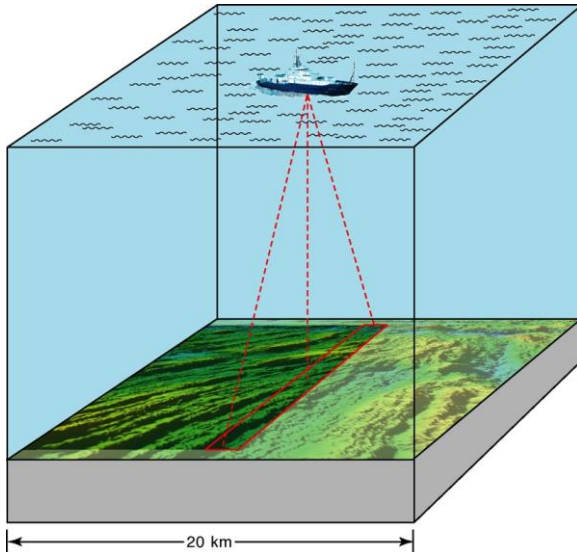
- Mapping by ships - what is missing?
- Mapping by satellites – recent developments
- Finding the important gaps

Funding:
Google Inc.
National Science Foundation
Office of Naval Research
National Geospatial Agency

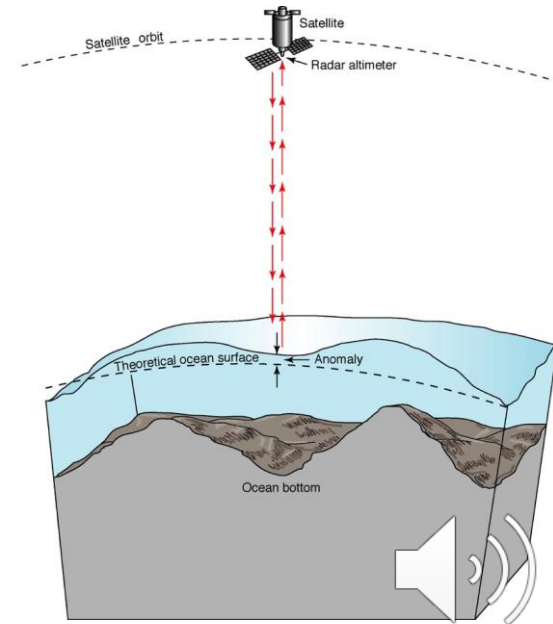


Modern seafloor mapping tools

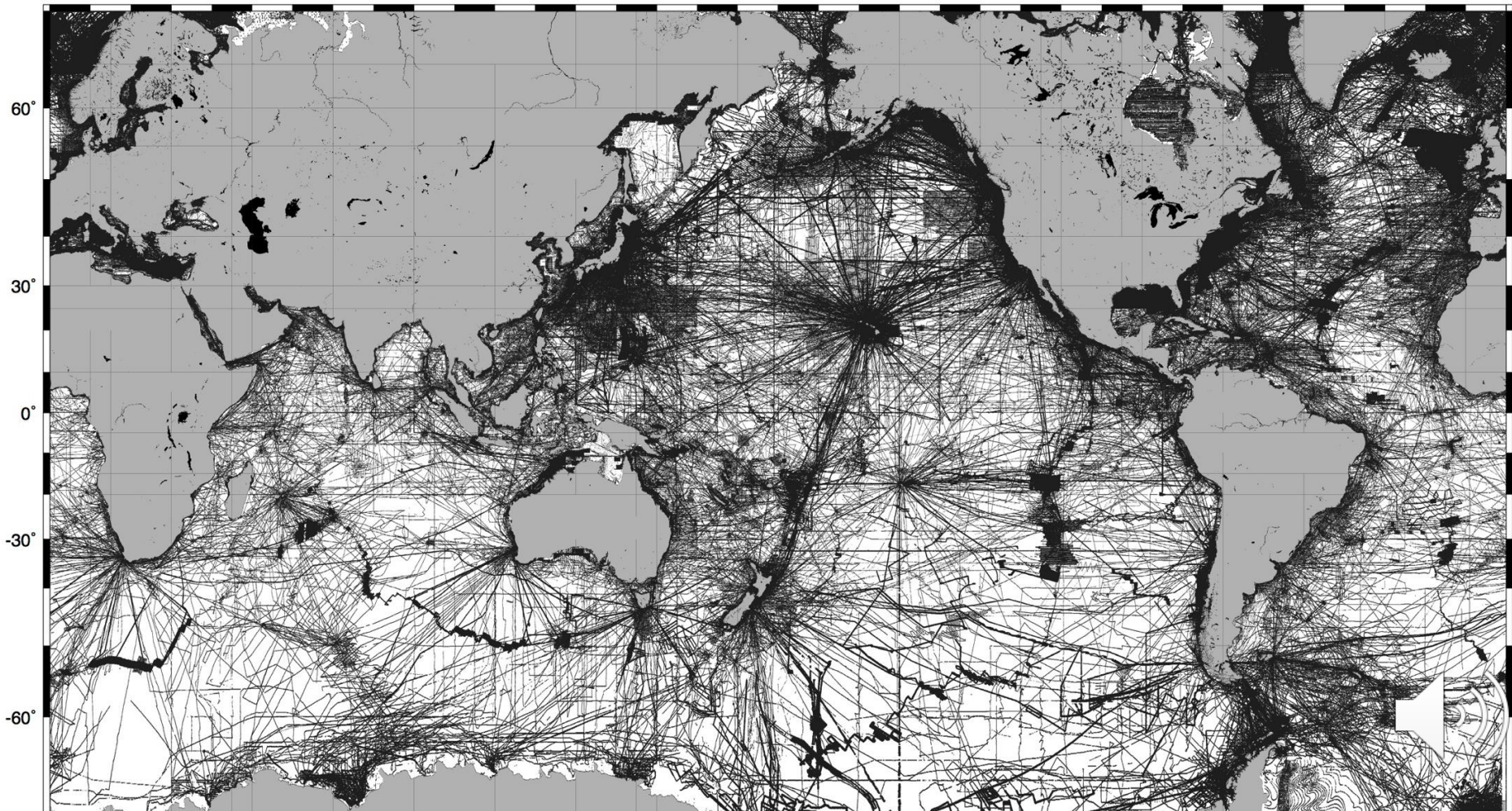
shipboard
echo sounder
(high resolution ~100 m,
poor coverage)



satellite altimeter
(global coverage,
poor resolution ~4000 m)



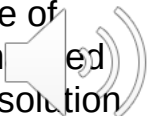
Available soundings cover 17% of seafloor at < 1 km resolution



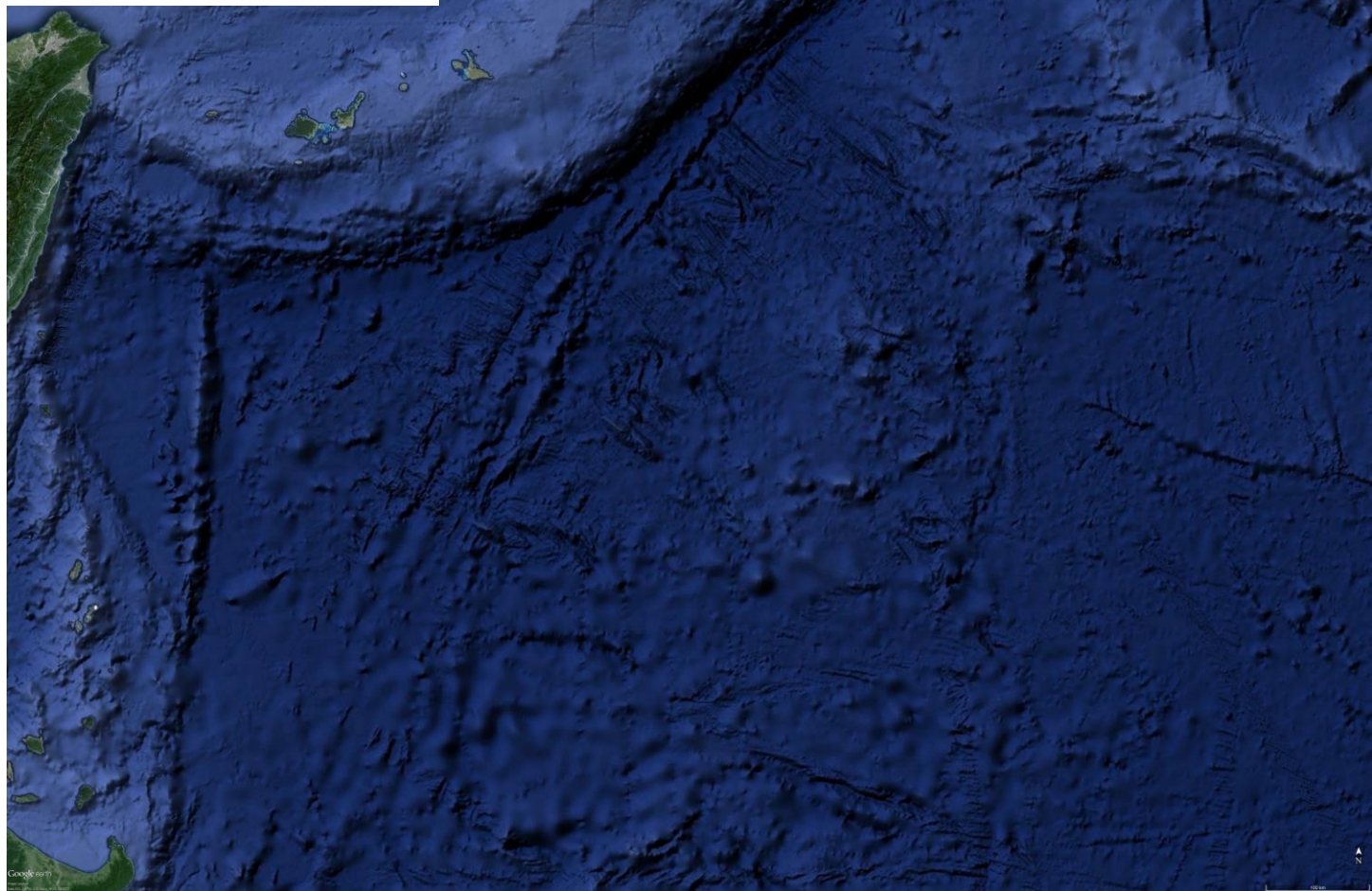
Edited soundings
used in
SRTM15_PLUS

source	# points (500 m)	% flagged	% seafloor @ 1 km
NGDC_multi	127901083	4.75	5.134
NOAA_geodas	40897565	11.06	2.506
US_multi	51187020	5.32	2.219
JAMSTEC_multi	79103040	0.62	2.04
SIO_various	40754645	13.93	1.325
IBCAO_various	18302390	0.03	0.773
GEBCO_various	8950614	0.17	0.523
AGSO_grid	12875795	2.62	0.503
DNC_points	5878651	1.23	0.49
CCOM_grid	10023471	0.08	0.195
GEOMAR_grid	18138868	0.06	0.181
NGA_single	4415125	19.44	0.179
NOAA_grids	6748376	0.49	0.162
IFREMER_single	7653537	10.62	0.151
3DGBR_various	5523560	11.36	0.112
NAVO_multi	422089	0.06	0.009
total	438,775,829		16.5 % in V11

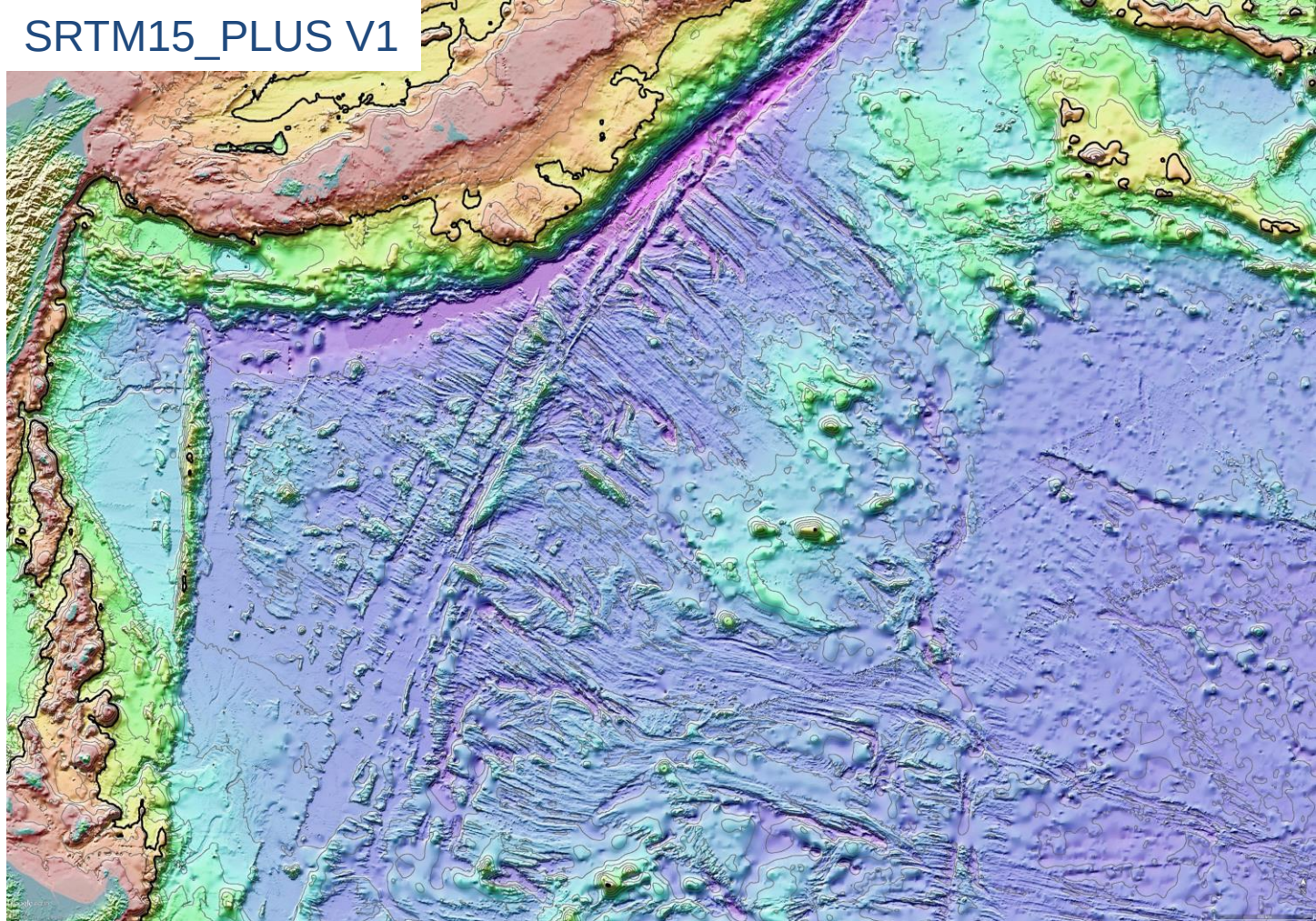
percentage of
seafloor mapped
at 1 km resolution



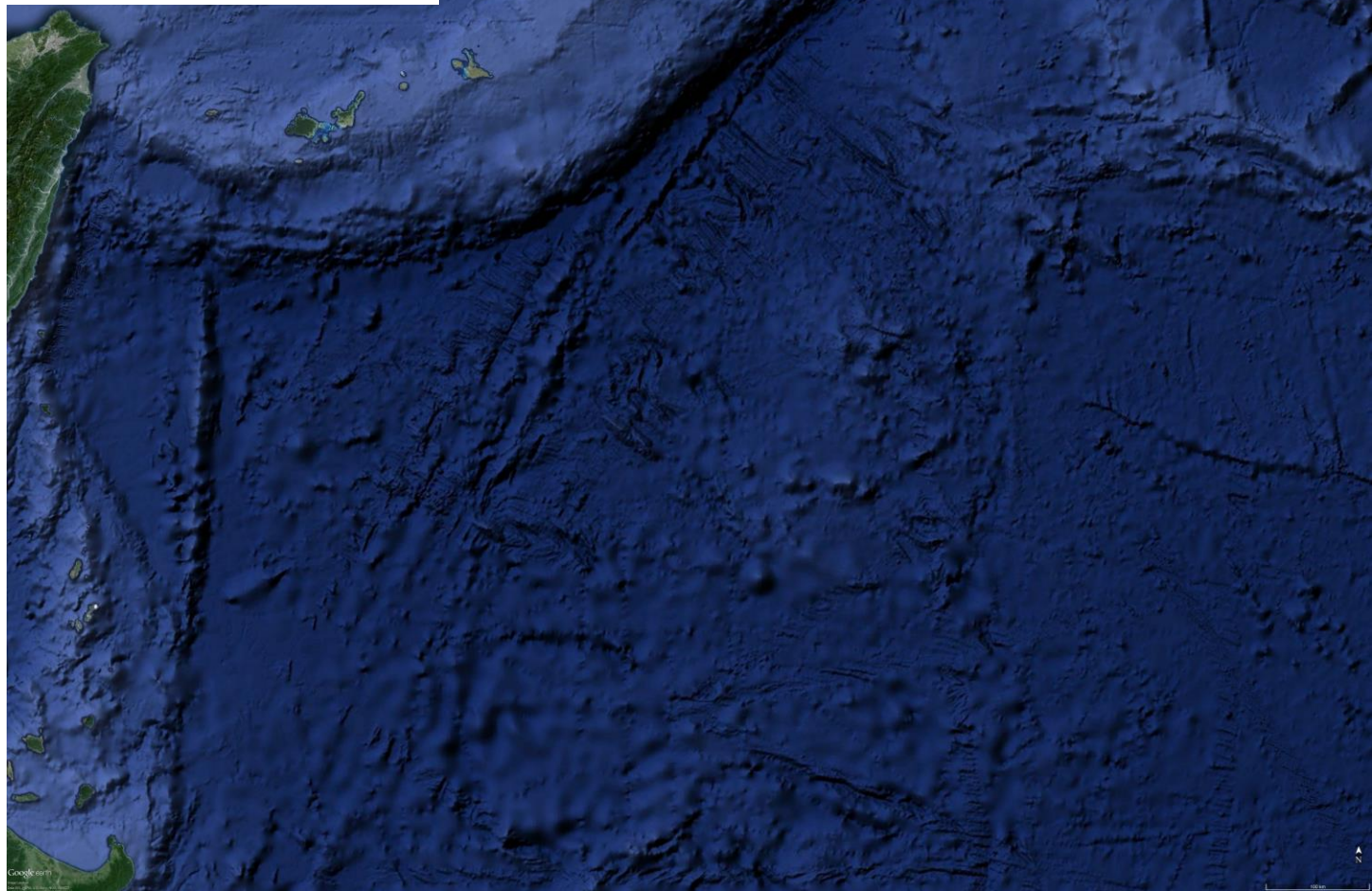
SRTM30_PLUS V7



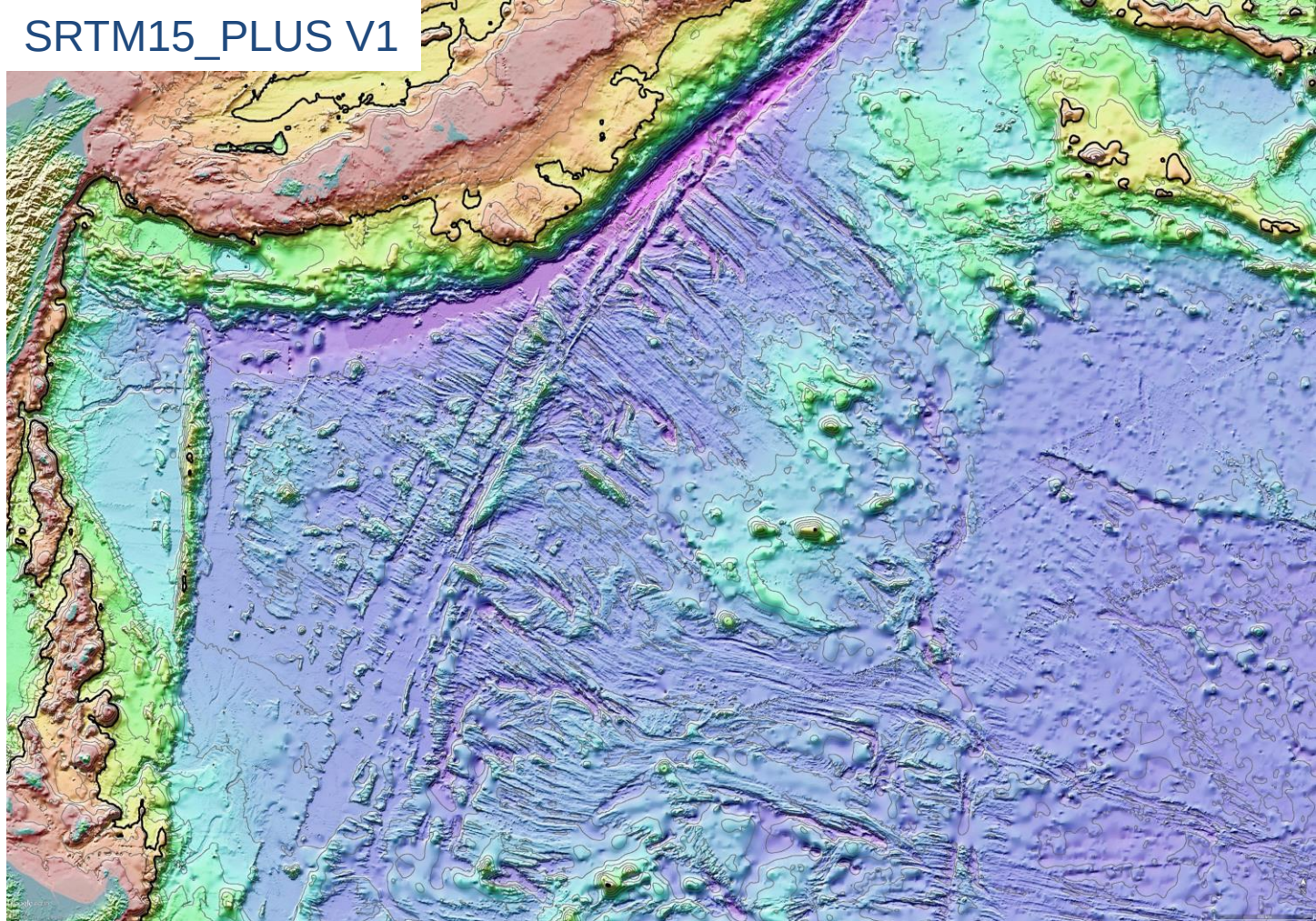
SRTM15_PLUS V1



SRTM30_PLUS V7



SRTM15_PLUS V1



Mapping by satellites - Ideal geodetic mission objectives

- high altimeter range precision

measure sea surface slopes to an accuracy of < 1 microradian
(1 μrad : 10 mm elevation change over 10 km distance)

1 μrad slope precision $\sim$ 0.98 mGal gravity accuracy

- dense ground track spacing

< 5 km separation at the equator OR swath coverage



AltiKa is 2 times more precise than all previous altimeters

Altimeter	3-PAR @ 2 m	2-PAR @ 2 m
Geosat	88.0	57.0
ERS-1	93.6	61.8
Envisat	78.9	51.8
Jason-1	75.9	46.4
CryoSat-2 LRM	64.7	42.7
CryoSat-2 SAR	49.5	49.7
AltiKa	34.3	20.5

Smith [2015] showed standard GDR of AltiKa is 2 X more precise than Envisat

Zhang and Sandwell [2016] showed that AltiKa also benefits from 2-pass retracking.

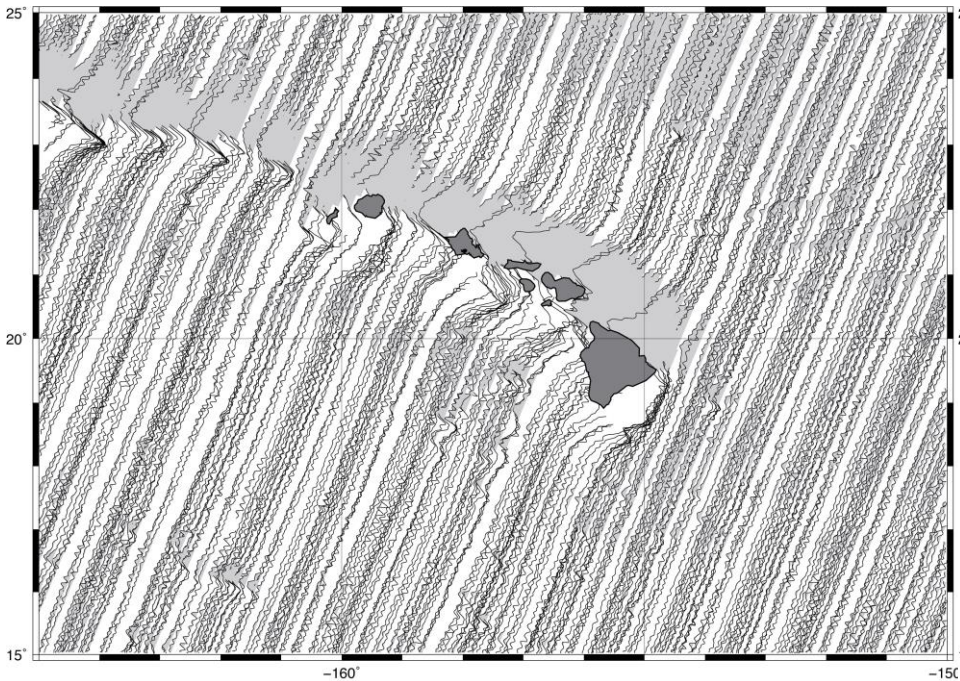
In July 2016 AltiKa began geodetic mapping. Could achieve 1 mGal global marine gravity.

AltiKa 4.5 mm @ 1 Hz

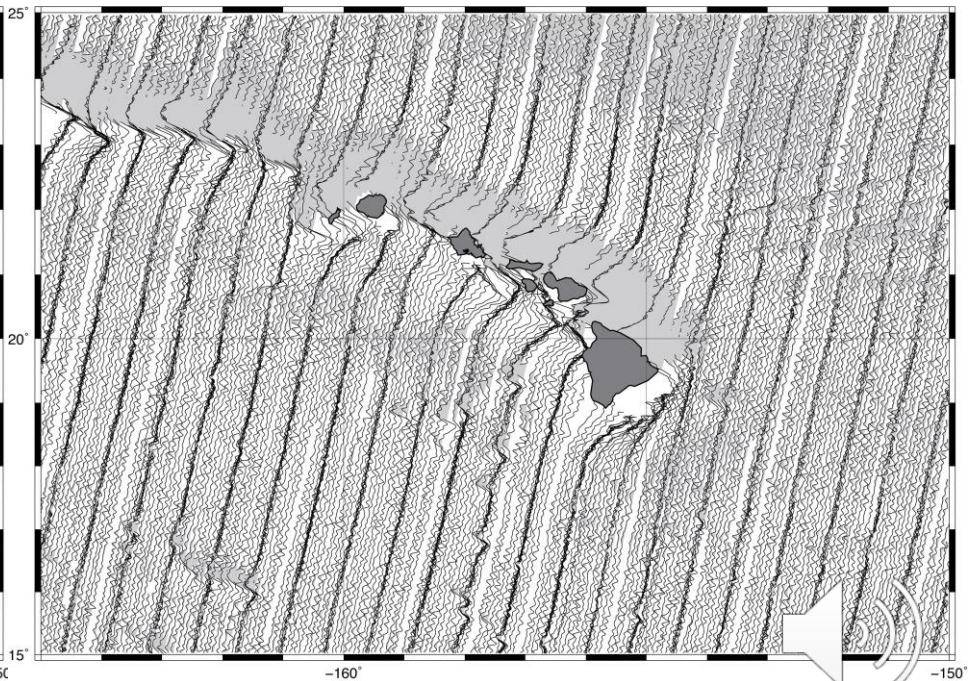


along-track sea surface slope over Hawaii

Geosat/GM (18 mo.)



ERS/GM (12 mo.)

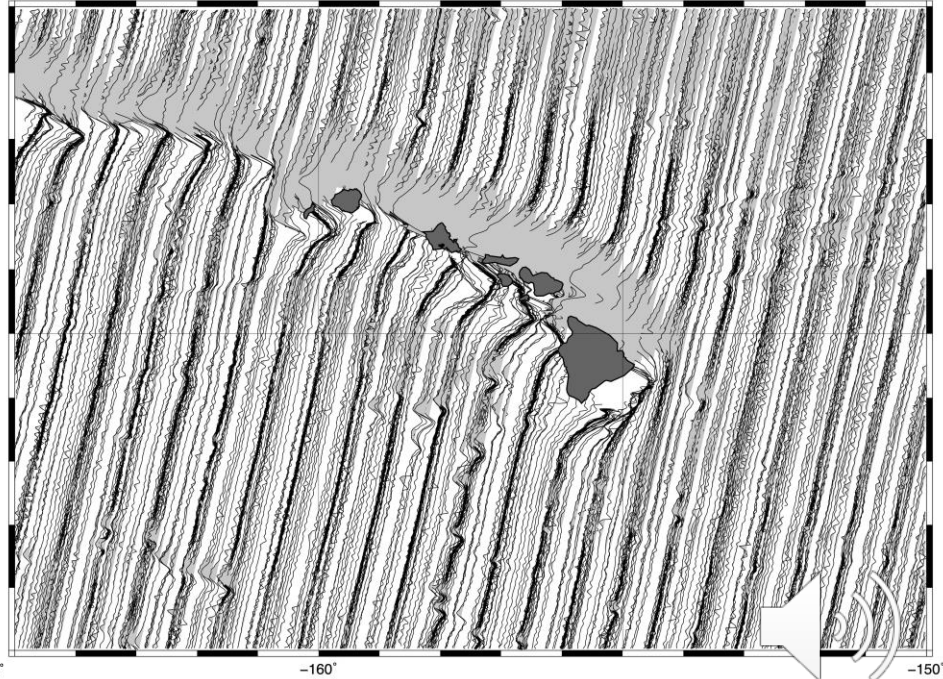


along-track sea surface slope over Hawaii

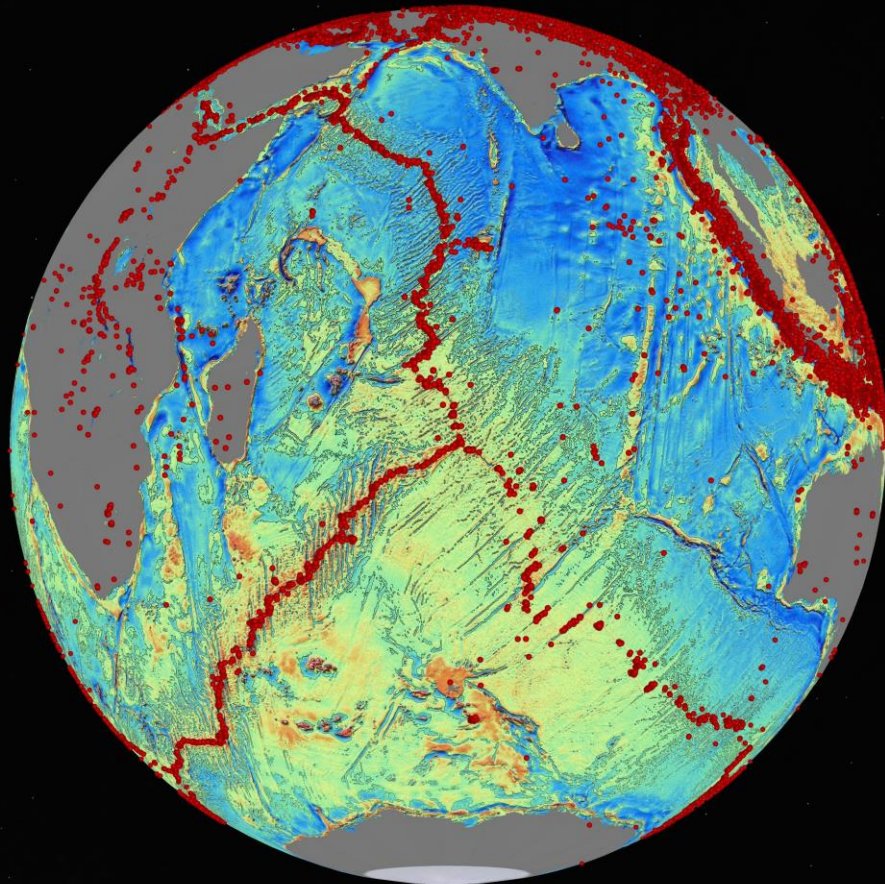
CryoSat-2 (77 mo.)



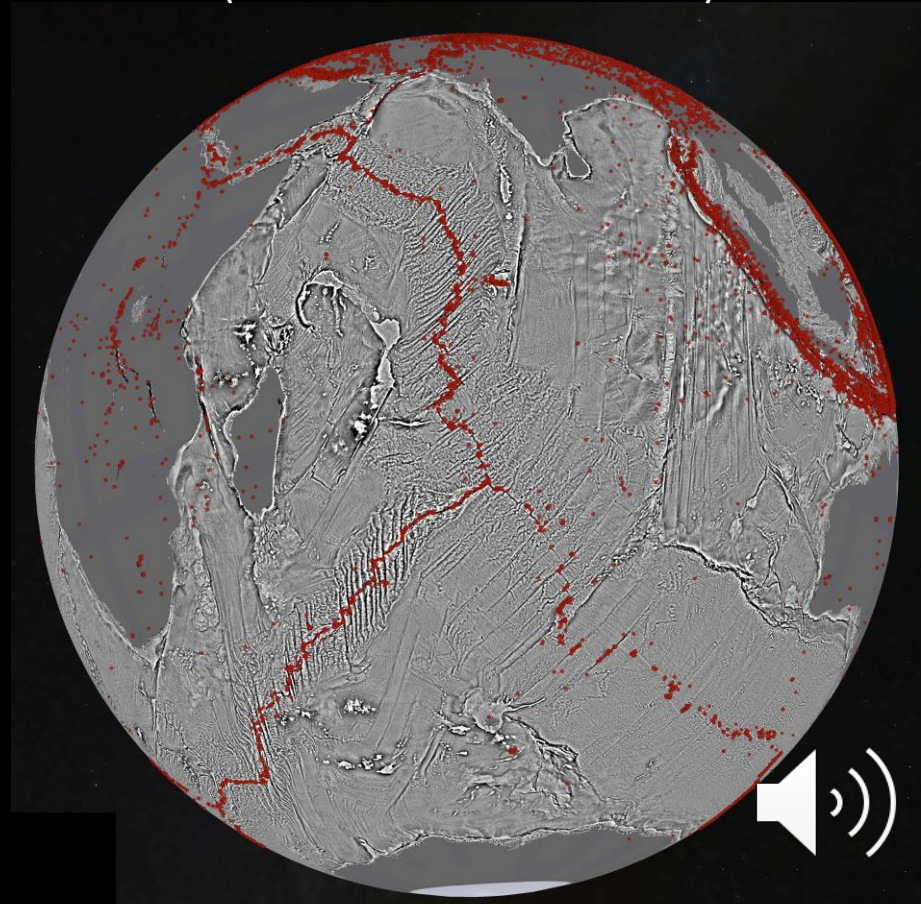
AltiKa/GM (13 mo.)



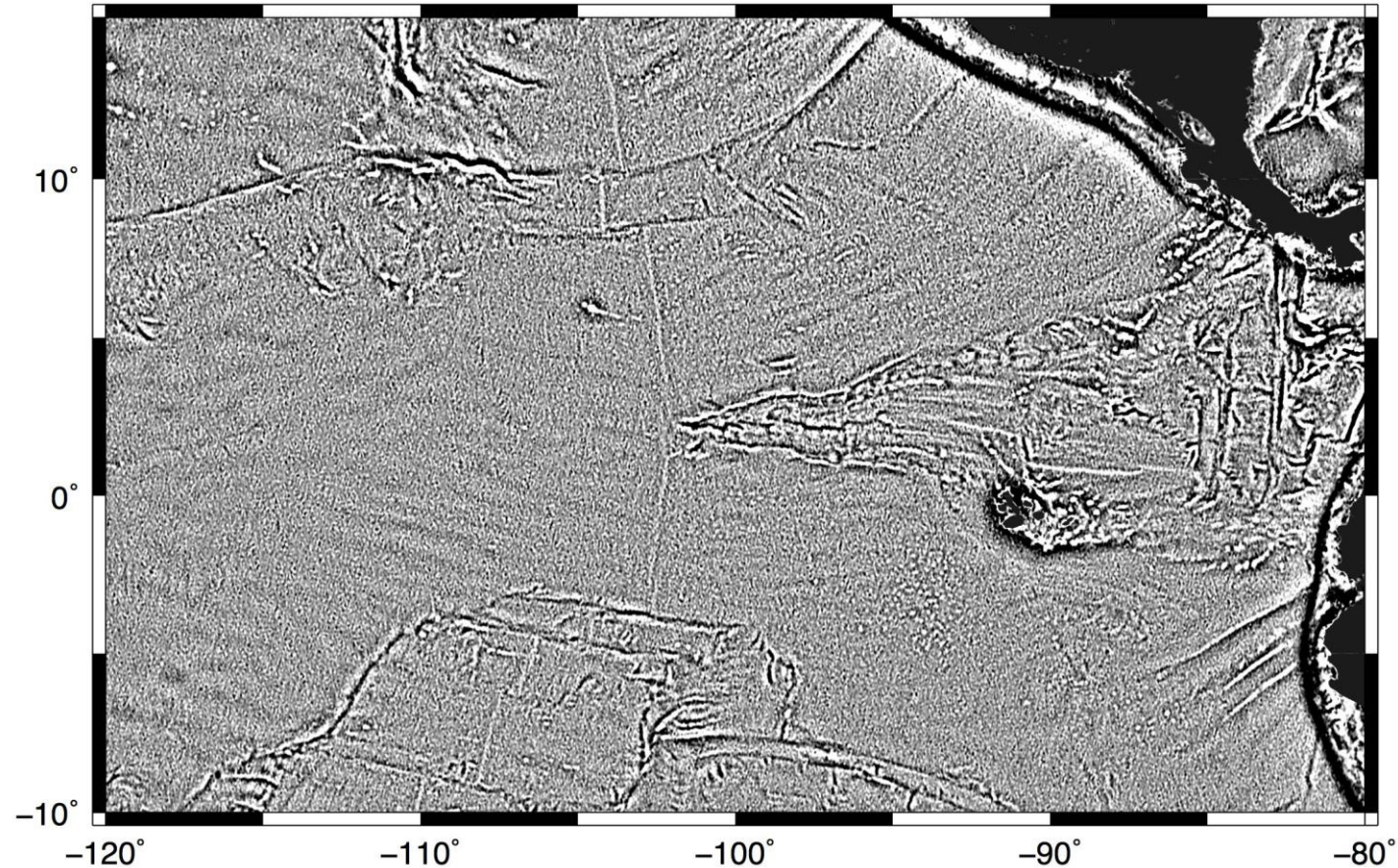
gravity anomaly



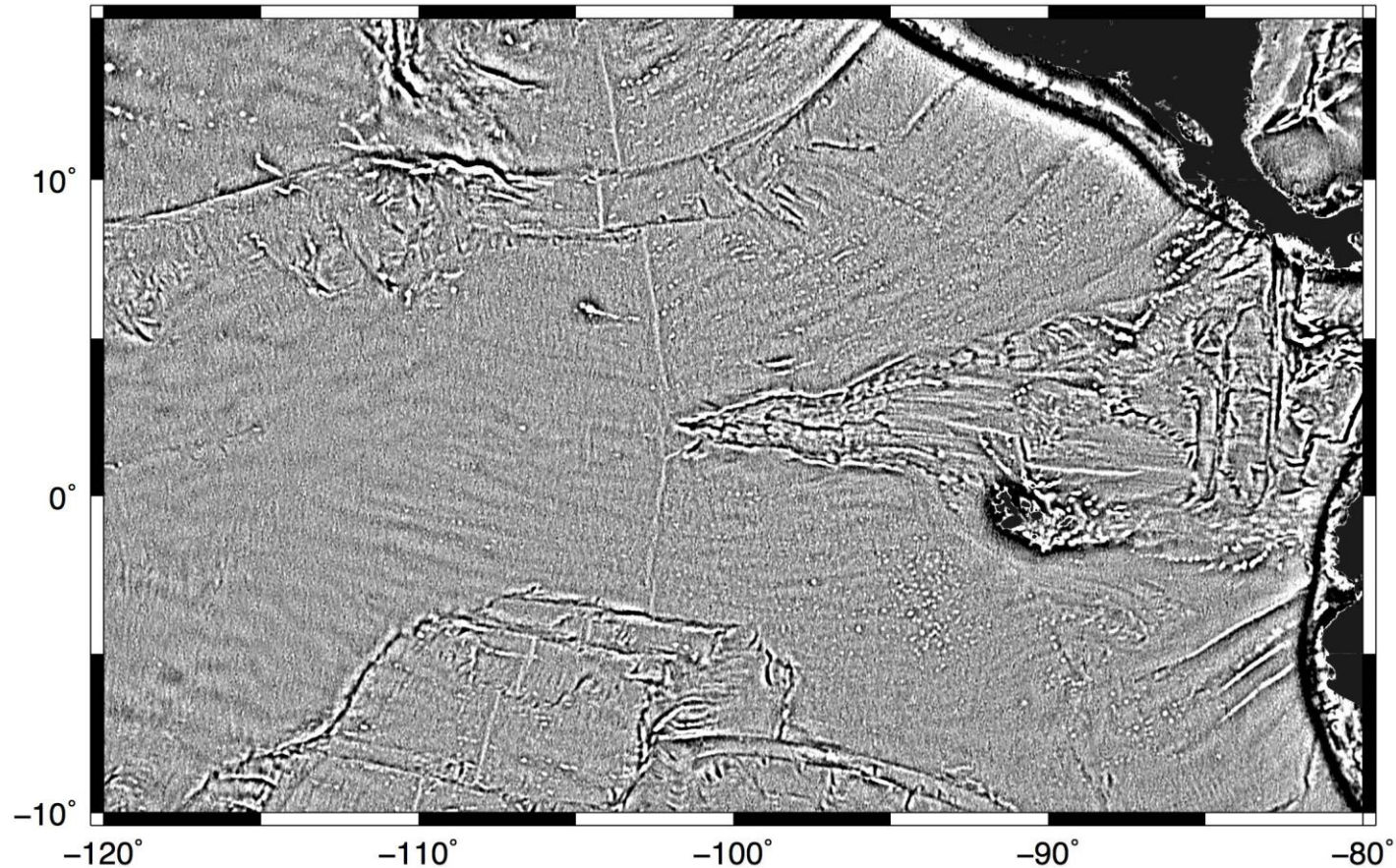
vertical gravity gradient
(curvature of sea surface)



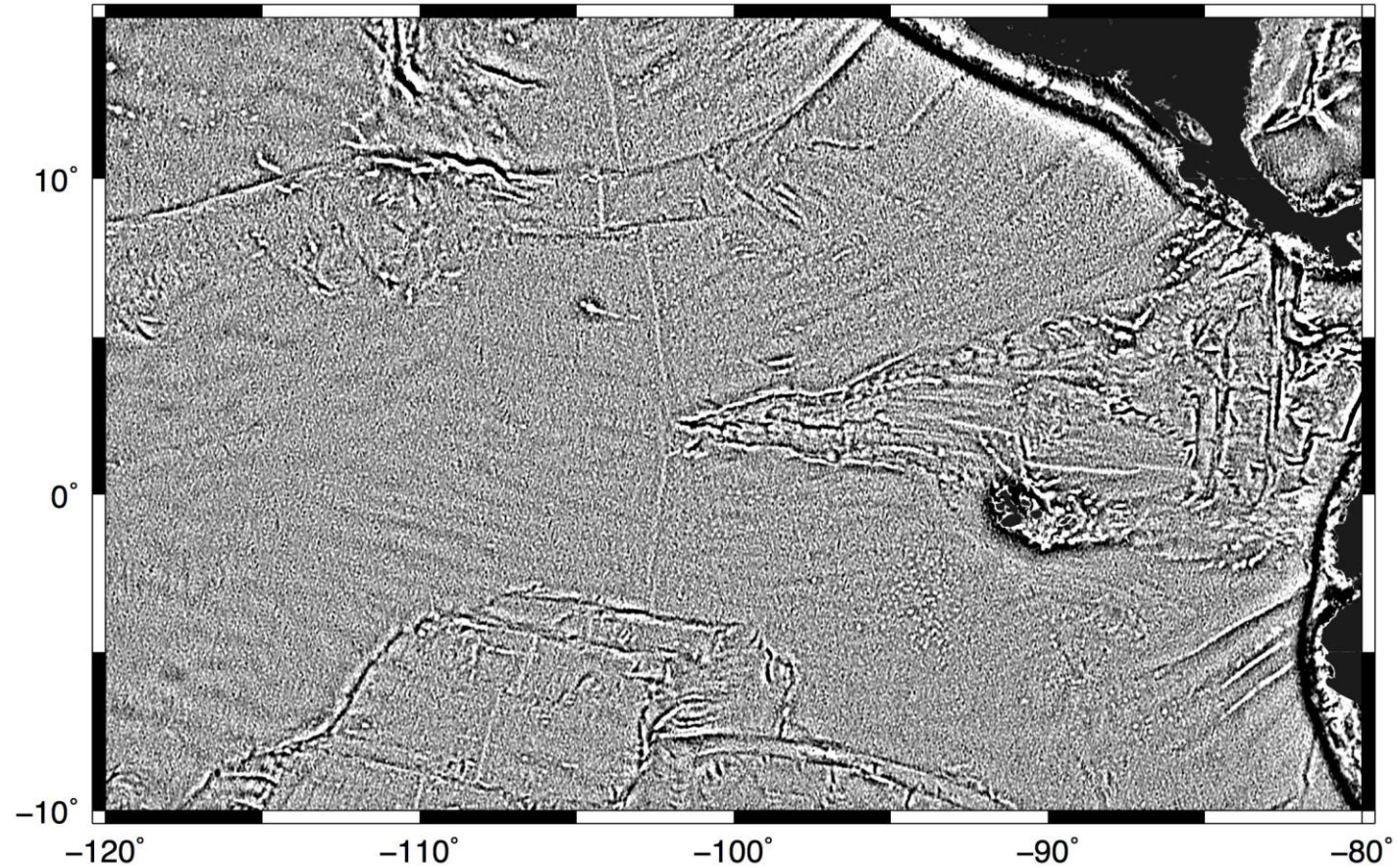
VGG (V18) Geosat + ERS



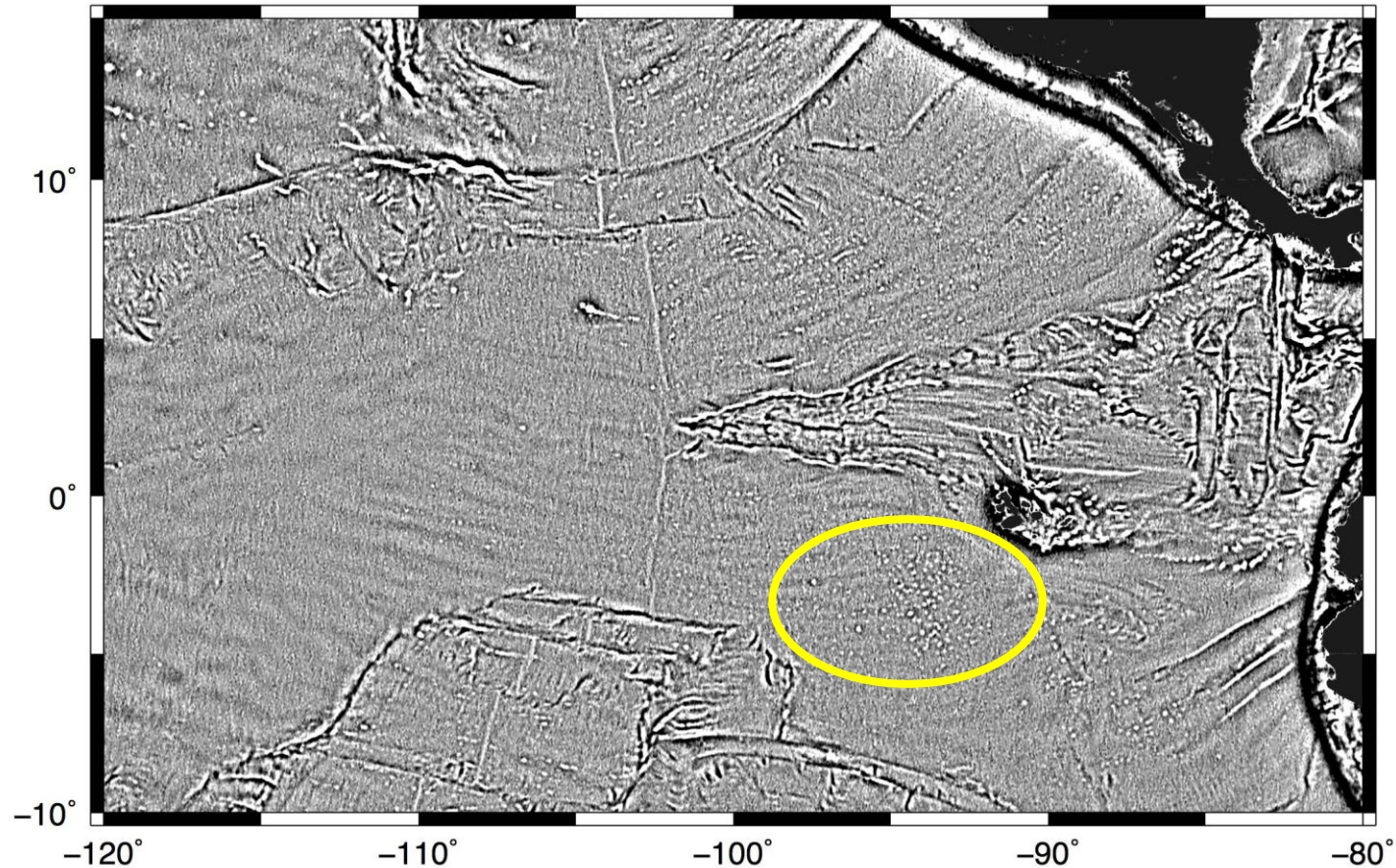
VGG (V24) + CryoSat + AltiKa + Jason-1



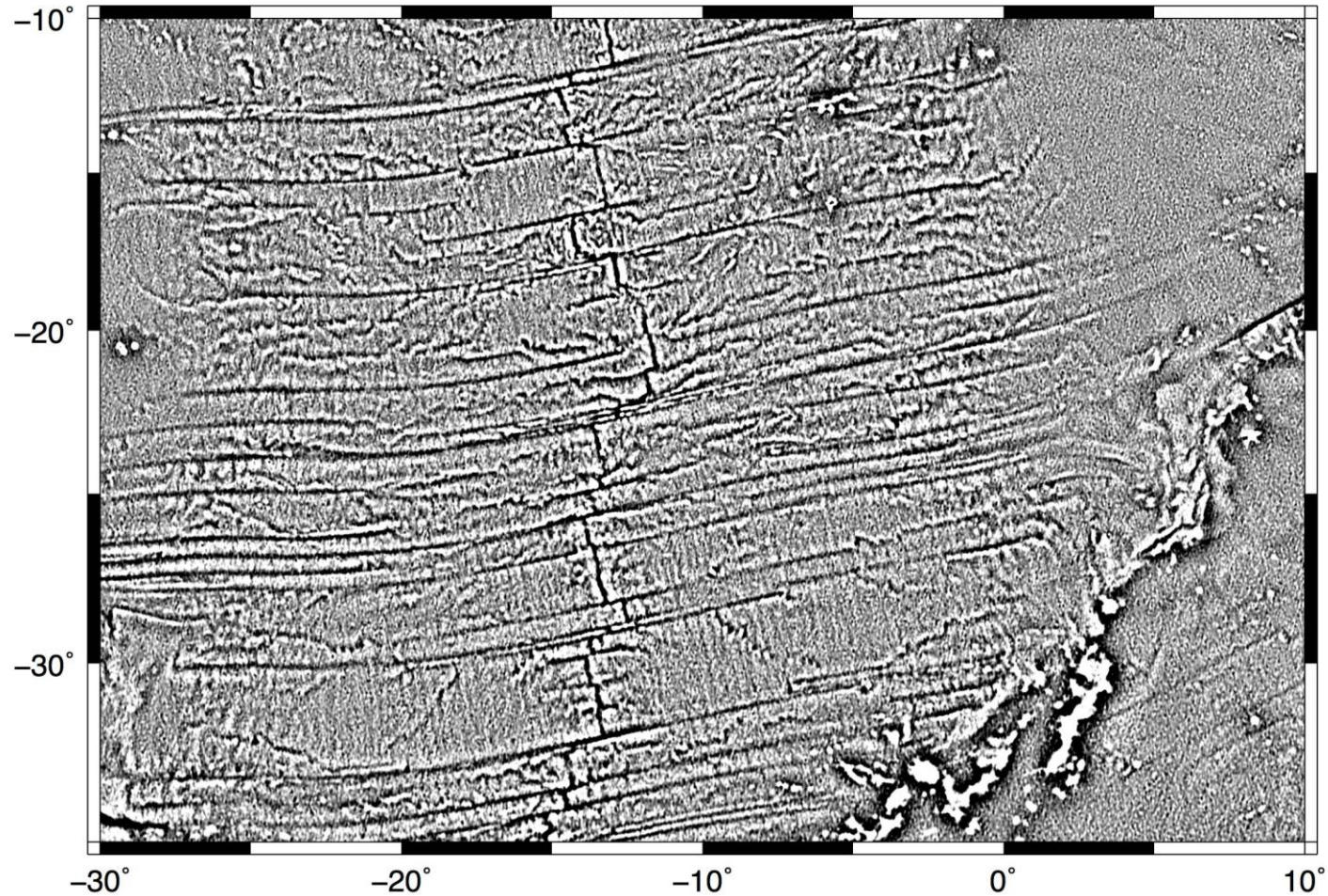
VGG (V18) Geosat + ERS



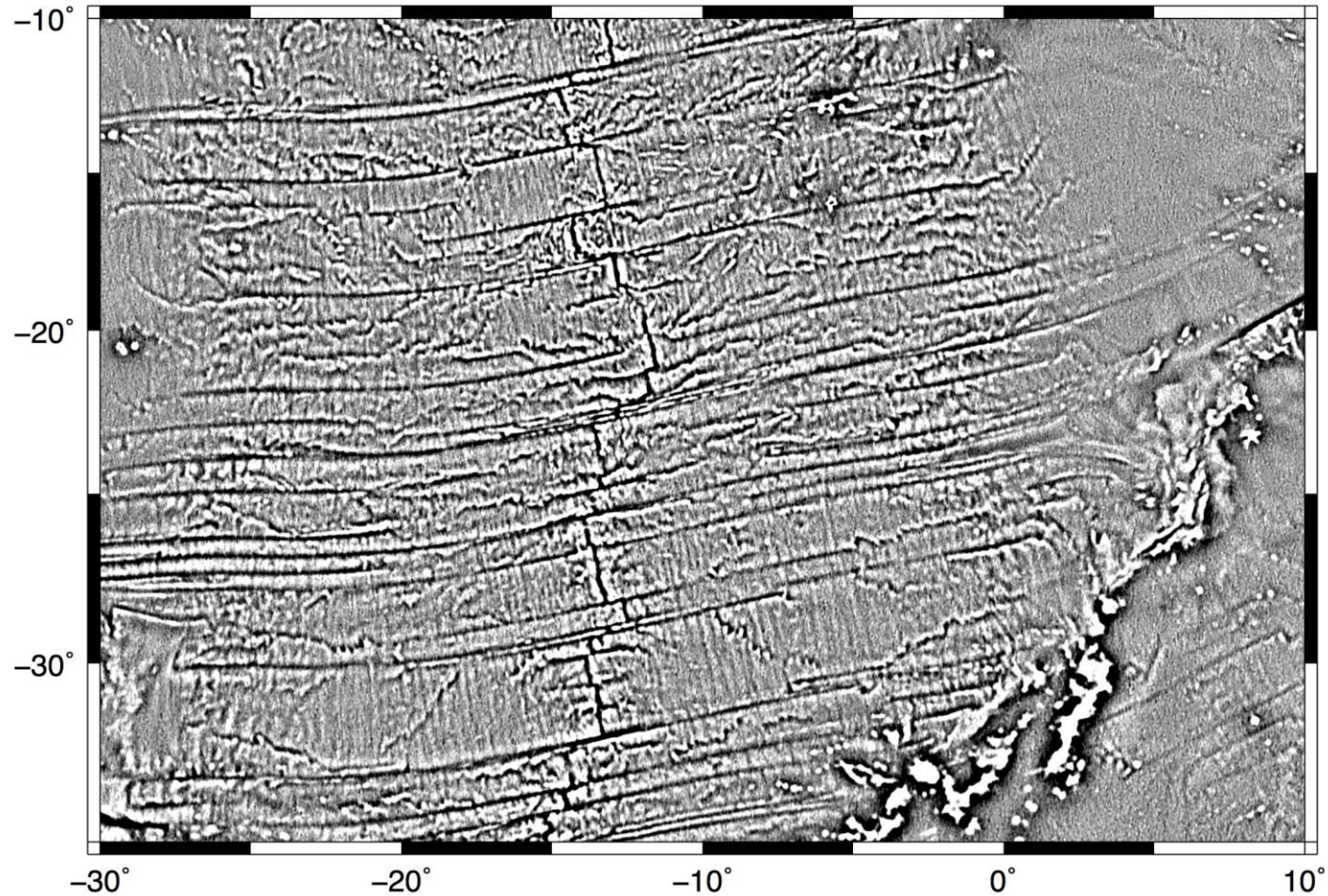
Discovery of small seamounts



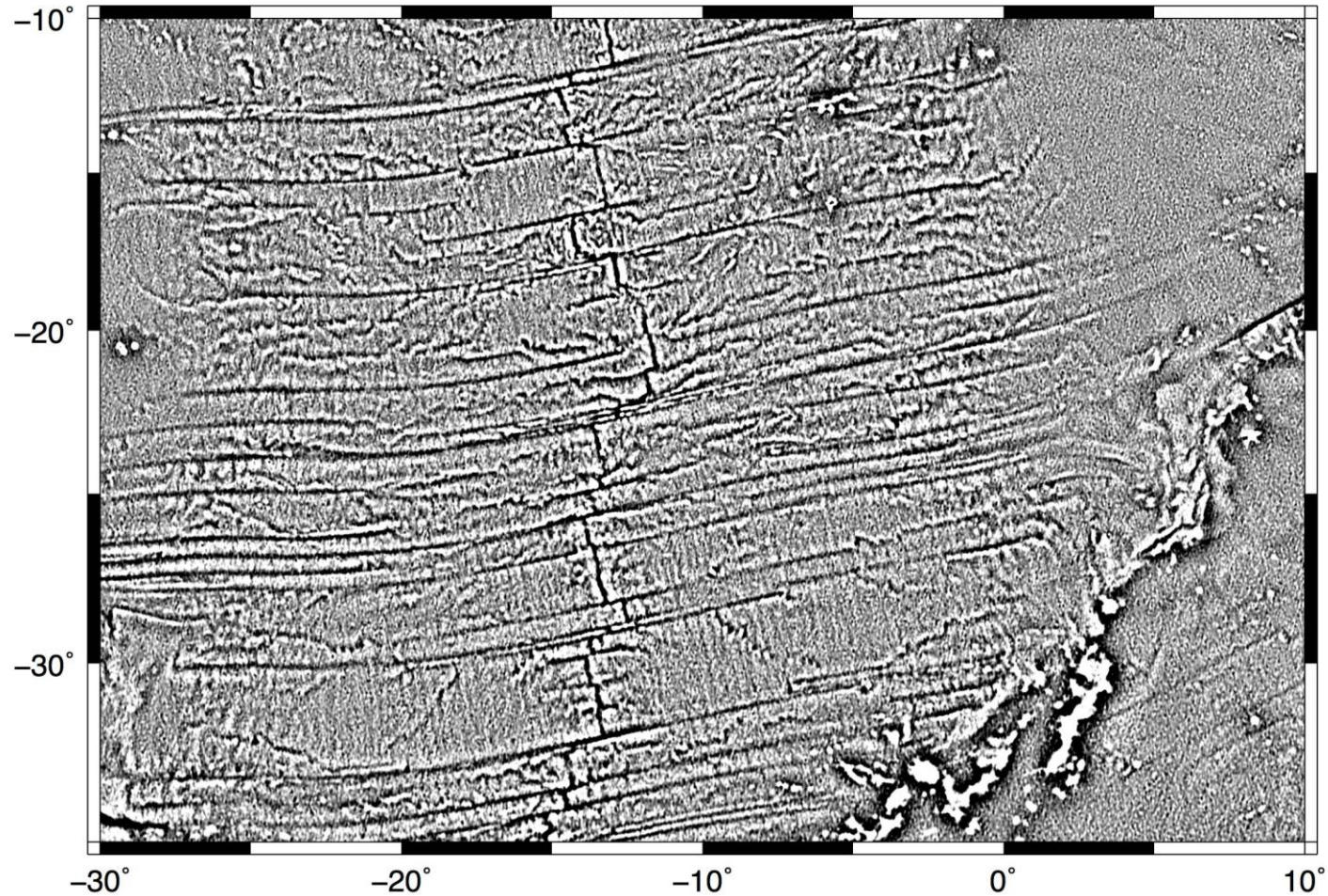
VGG (V18) Geosat + ERS



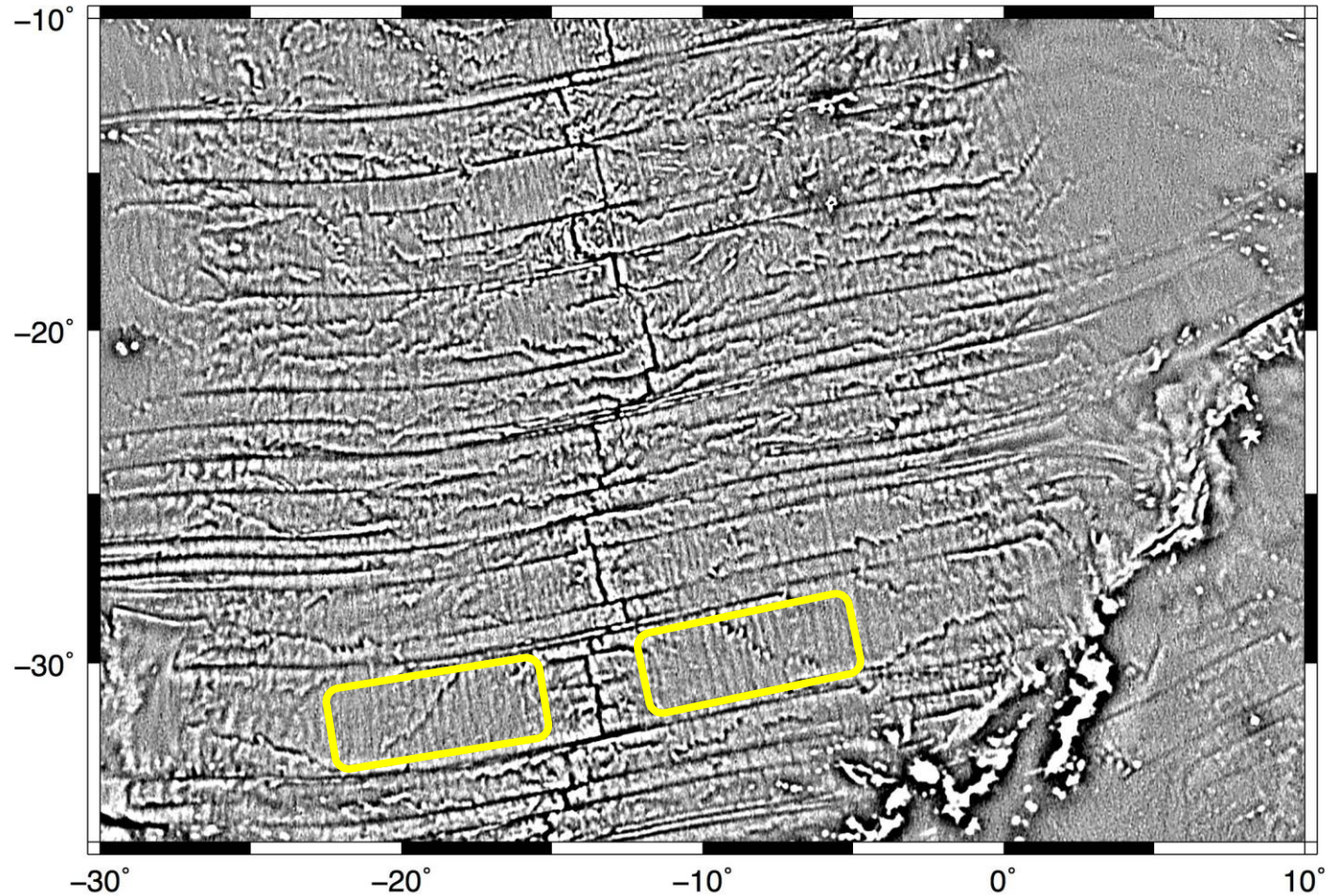
VGG (V24) + CryoSAT + AltiKa + Jason-1



VGG (V18) Geosat + ERS



Resolution of uncharted abyssal hills



Seamount Discovery Tool

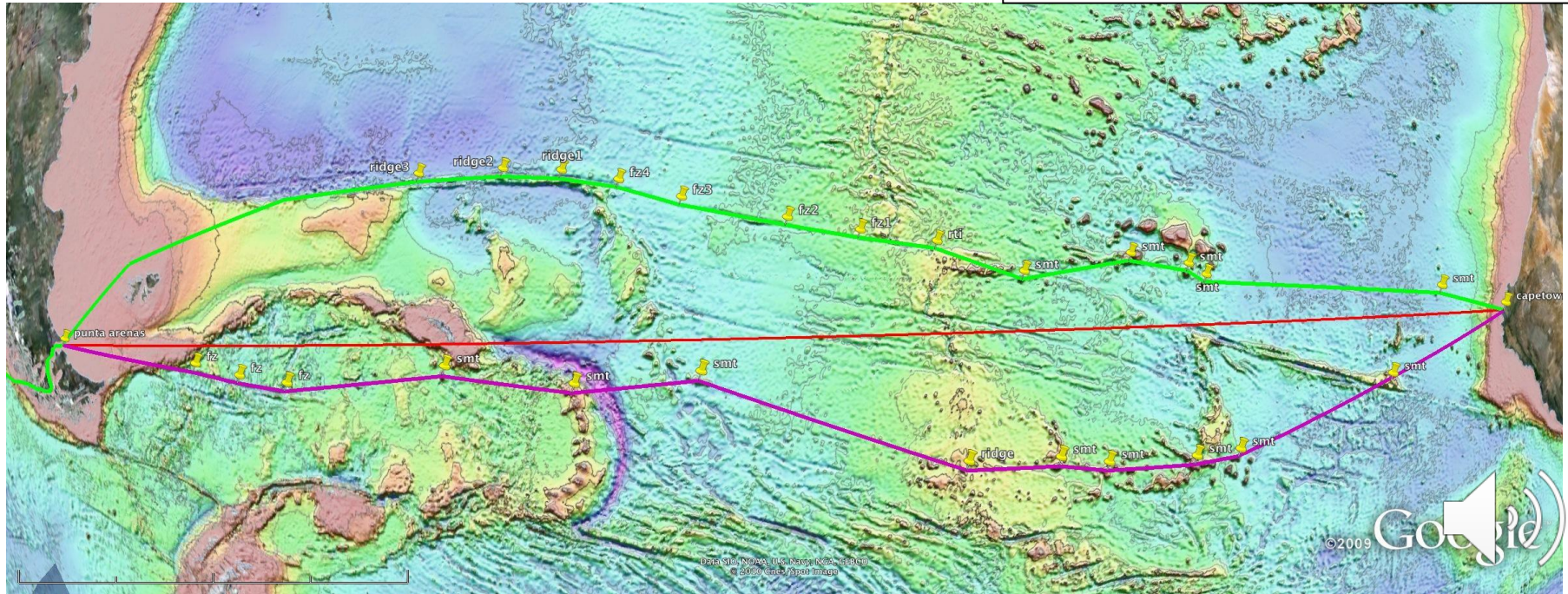
Cape Town to Punta Arenas - Melville - Feb, 2011

red - great circle = 6896 km

green - 10 new seamounts = 7130 km (1.034)

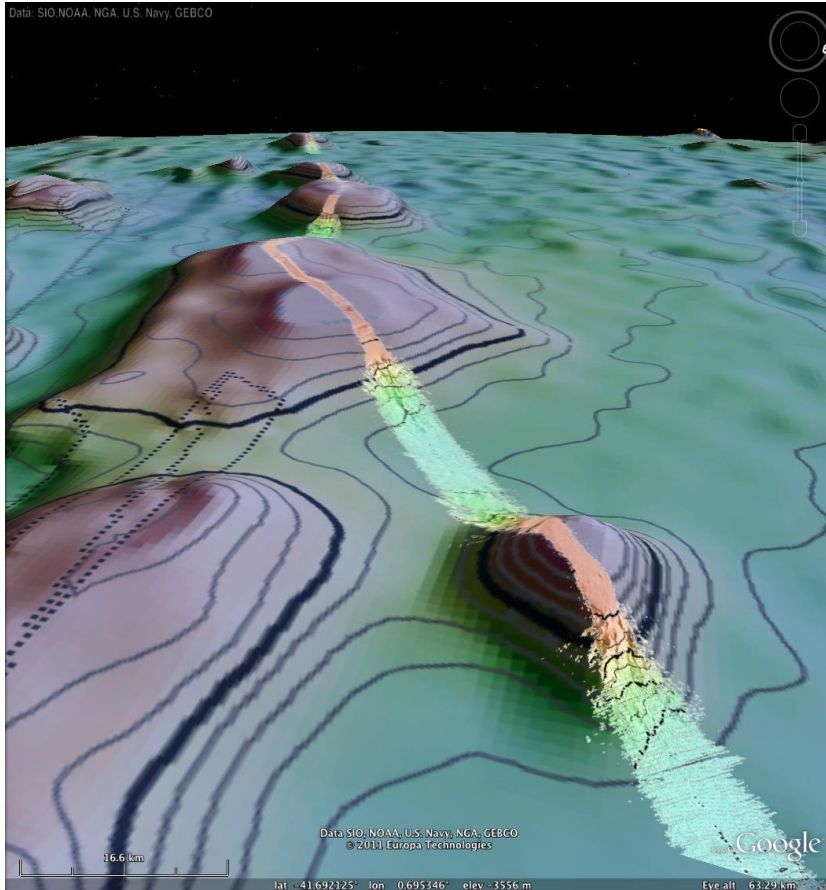
violet - 11 new seamounts = 7069 km (1.025)

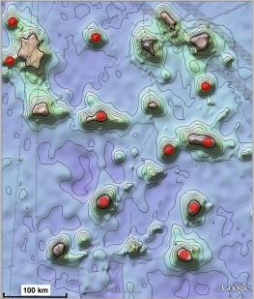
[Sandwell, D. T., and P. Wessel, Seamount discovery tool aids navigation to uncharted seafloor features, [Oceanography, 23:1, p. 24-26, 2010.](#)]



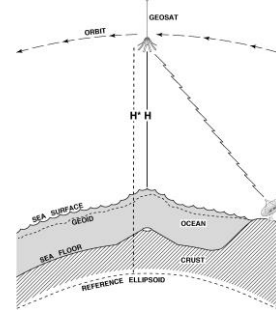
Seamount Discovery Tool

Cape Town to Punta Arenas – RV Melville - Feb, 2011





Conclusions



- **GOOD**

Global marine gravity from satellite altimetry will reach 1-mGal accuracy with CryoSat-2, AltiKa, Jason-1/2, and SWOT.

It may be possible to locate all seamounts > 1 km tall and resolve abyssal hill fabric.

- **BAD**

Only 17% of the seafloor has been mapped by sonar at < 1 km resolution.

Depths predicted from gravity have ~4 km resolution and an accuracy of only 250 – 400 m.

- **UGLY**

Bathymetric prediction fails on continental margins because sediment masks original topography.



Questions?

