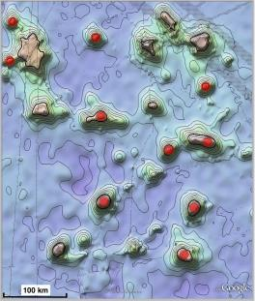
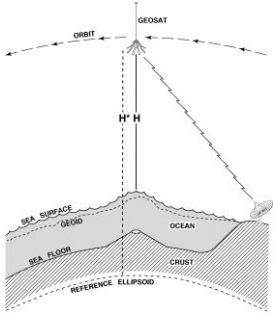


Predicting Bathymetry from Satellite Altimetry: The Good, The Bad, and The Ugly

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.

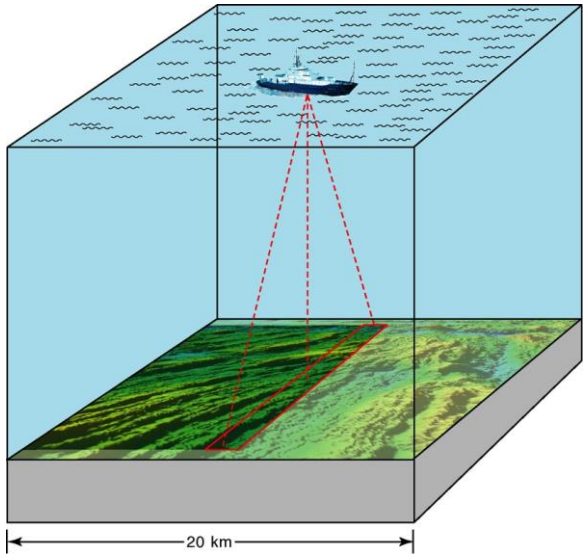
- Mapping by ships - what is missing?
- Mapping by satellites – recent developments
- Finding the important gaps

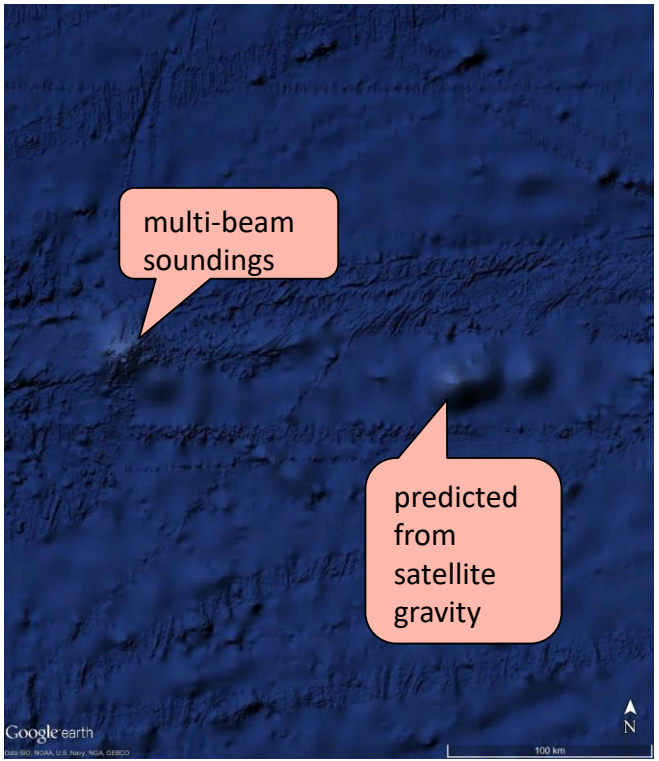
Funding:
Google Inc.
National Science Foundation
Office of Naval Research
National Geospatial Agency

Modern seafloor mapping tools

shipboard echo sounder

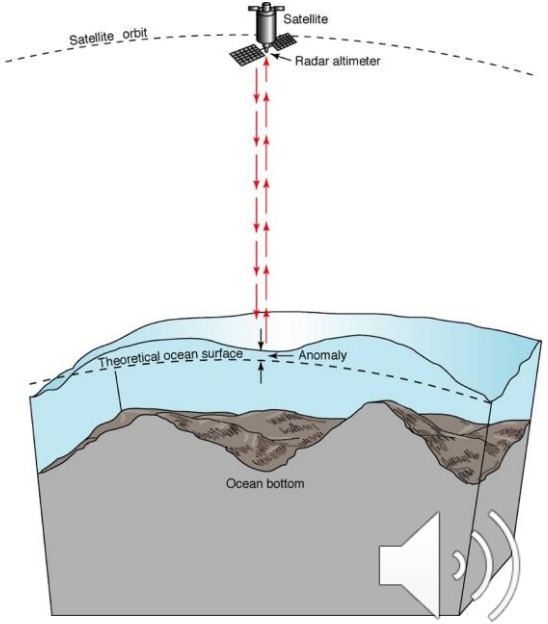
(high resolution ~100 m, poor coverage)



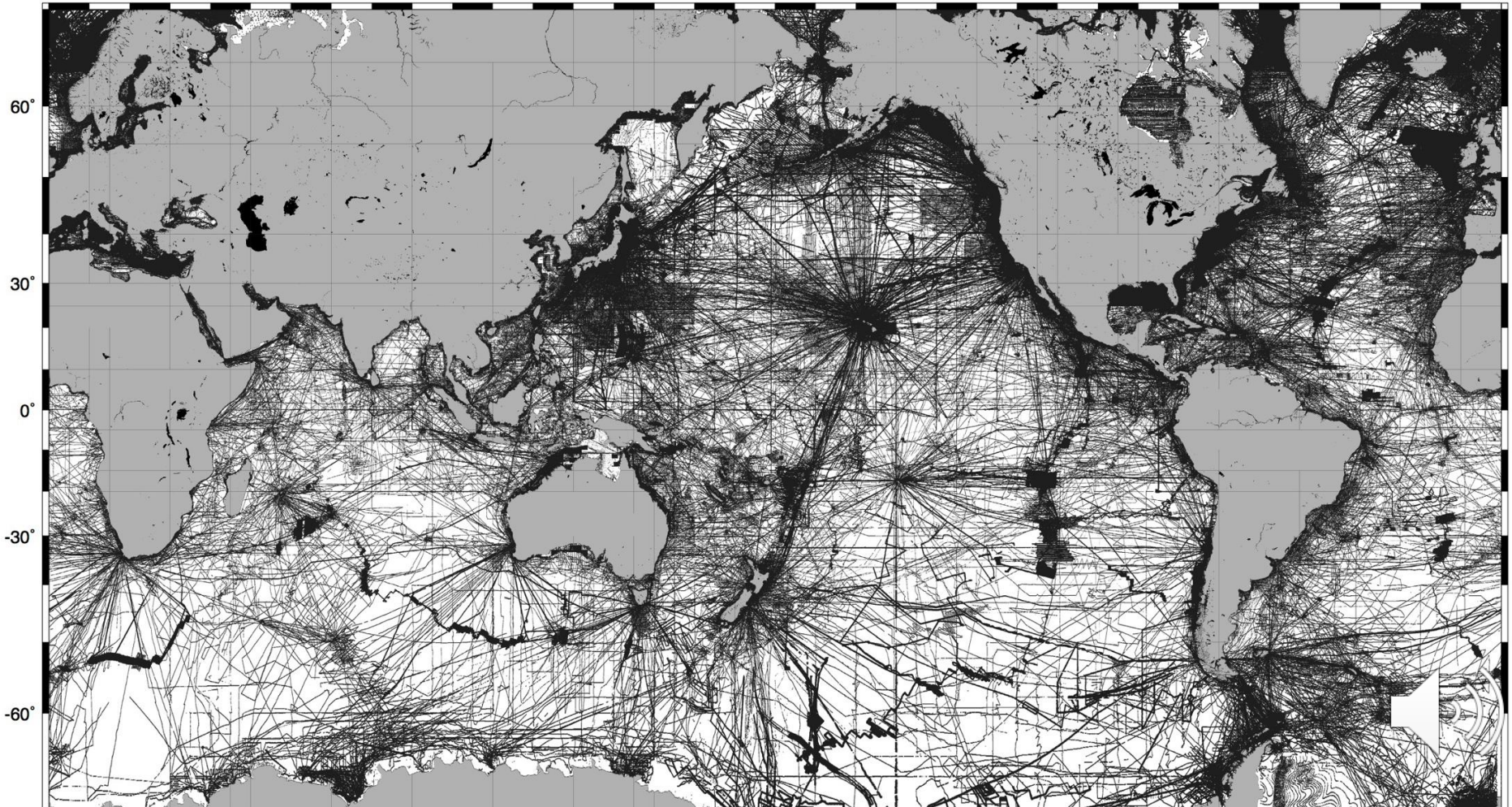


satellite altimeter

(global coverage, poor resolution ~4000 m)



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

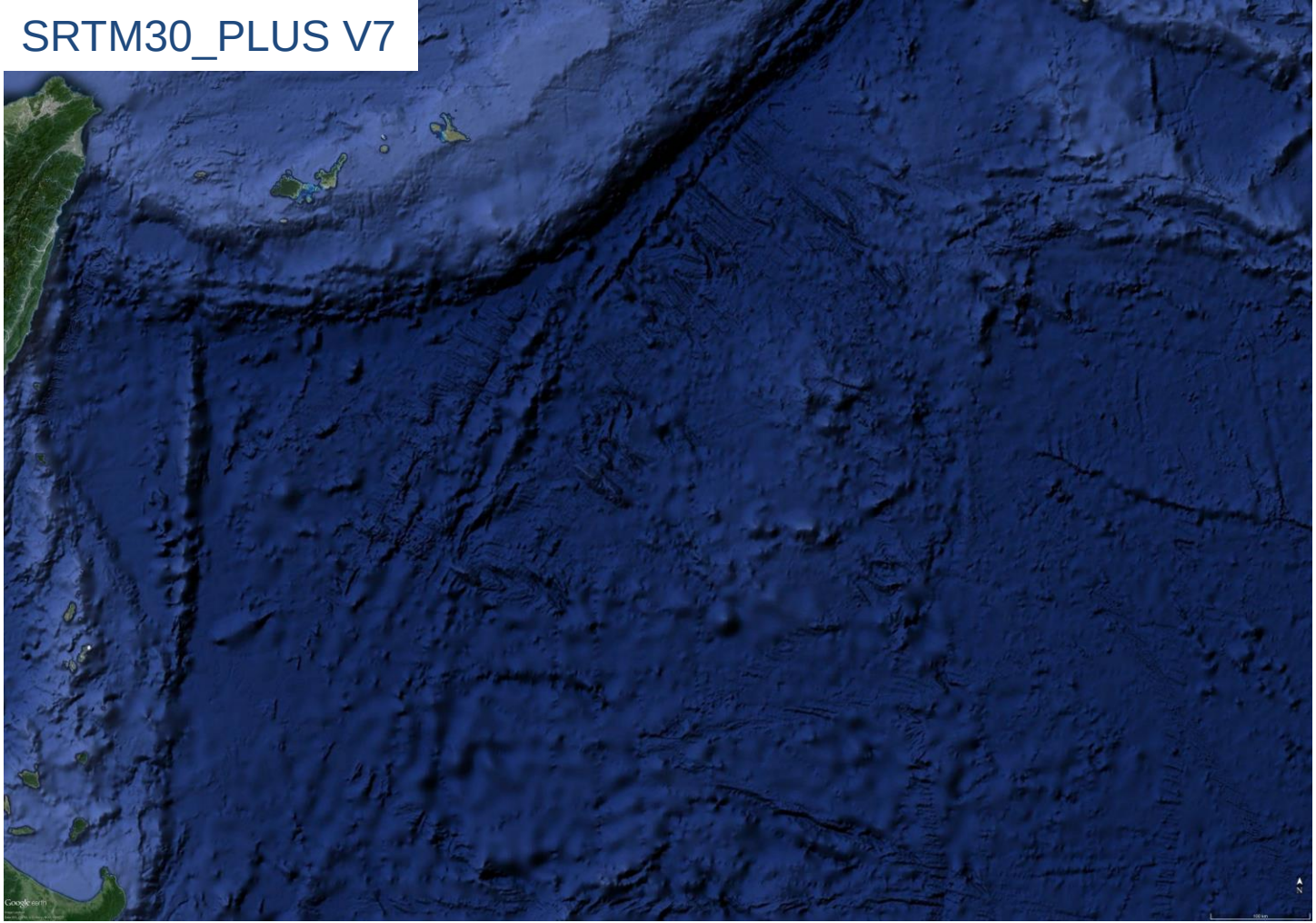


Edited soundings used in SRTM15_PLUS

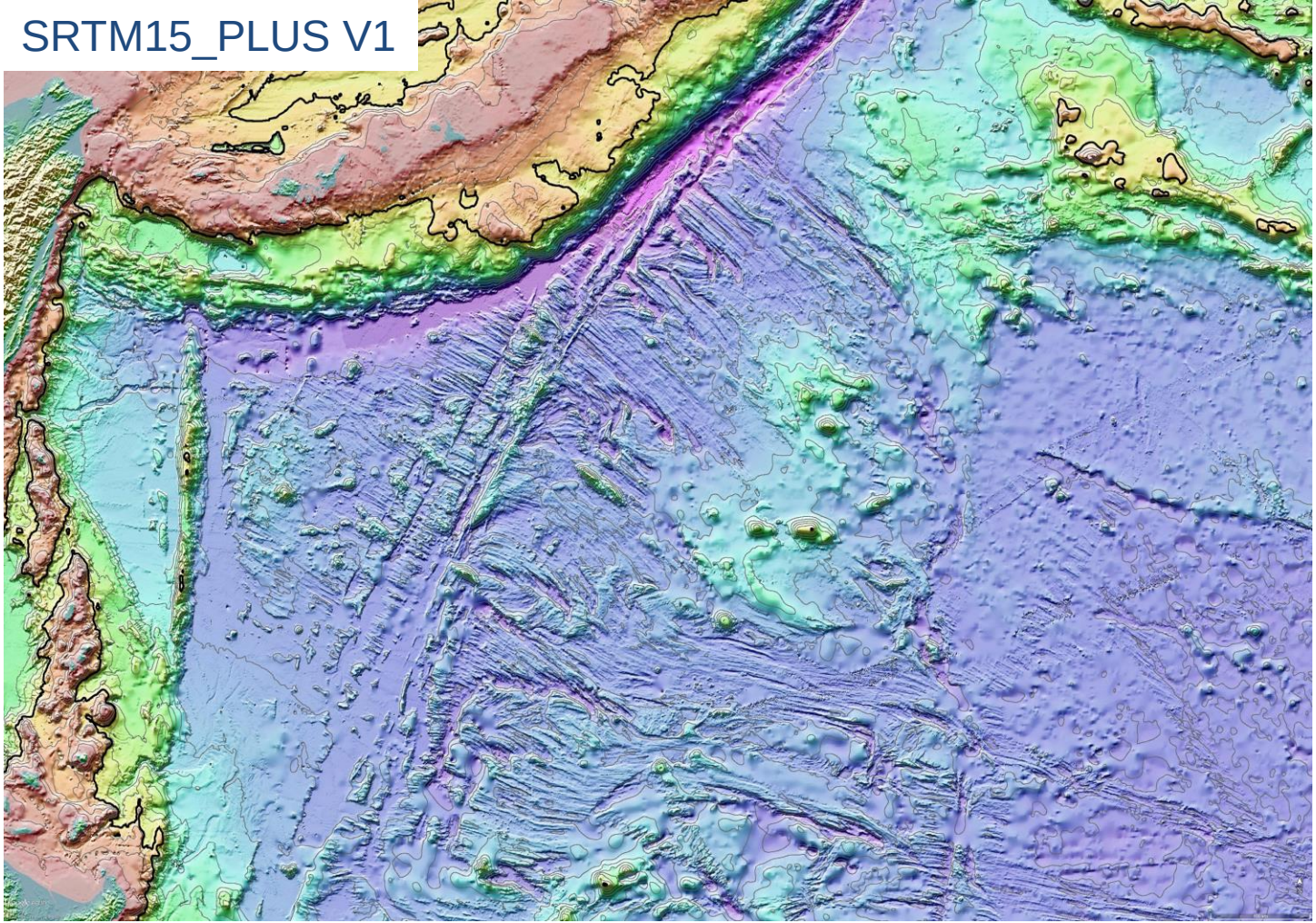
source	# points (500 m)	% flagged	% seafloor @ 1 km
NGDC_multi	127901083	4.75	5.134
NOAA_geodas	40897565	11.06	2.506
US_multi	51187020	5.32	2.219
JAMSTEC_multi	79103040	0.62	2.04
SIO_various	40754645	13.93	1.325
IBCAO_various	18302390	0.03	0.773
GEBCO_various	8950614	0.17	0.523
AGSO_grid	12875795	2.62	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 m[illegible]ed at 1 km resolution

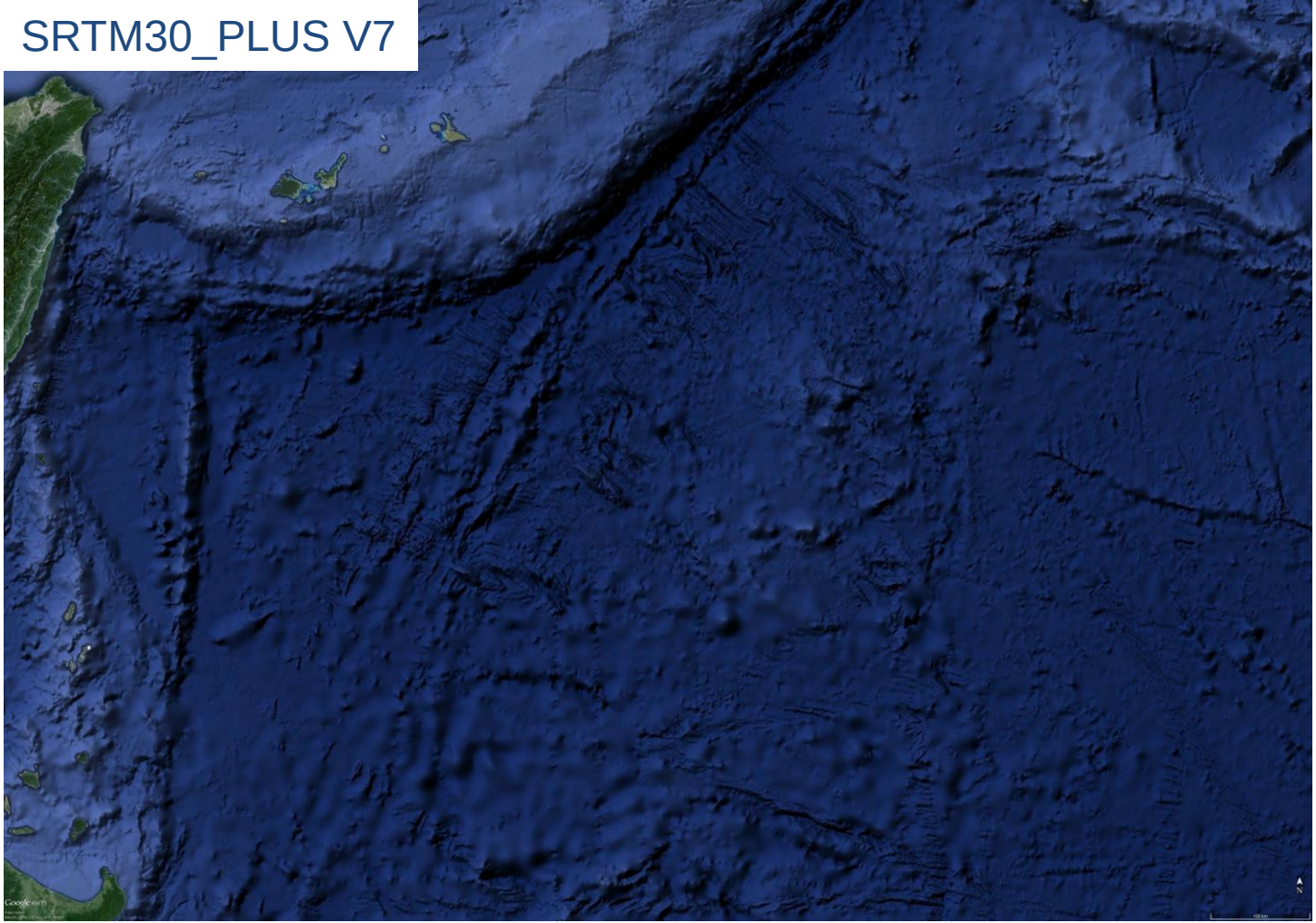
SRTM30_PLUS V7



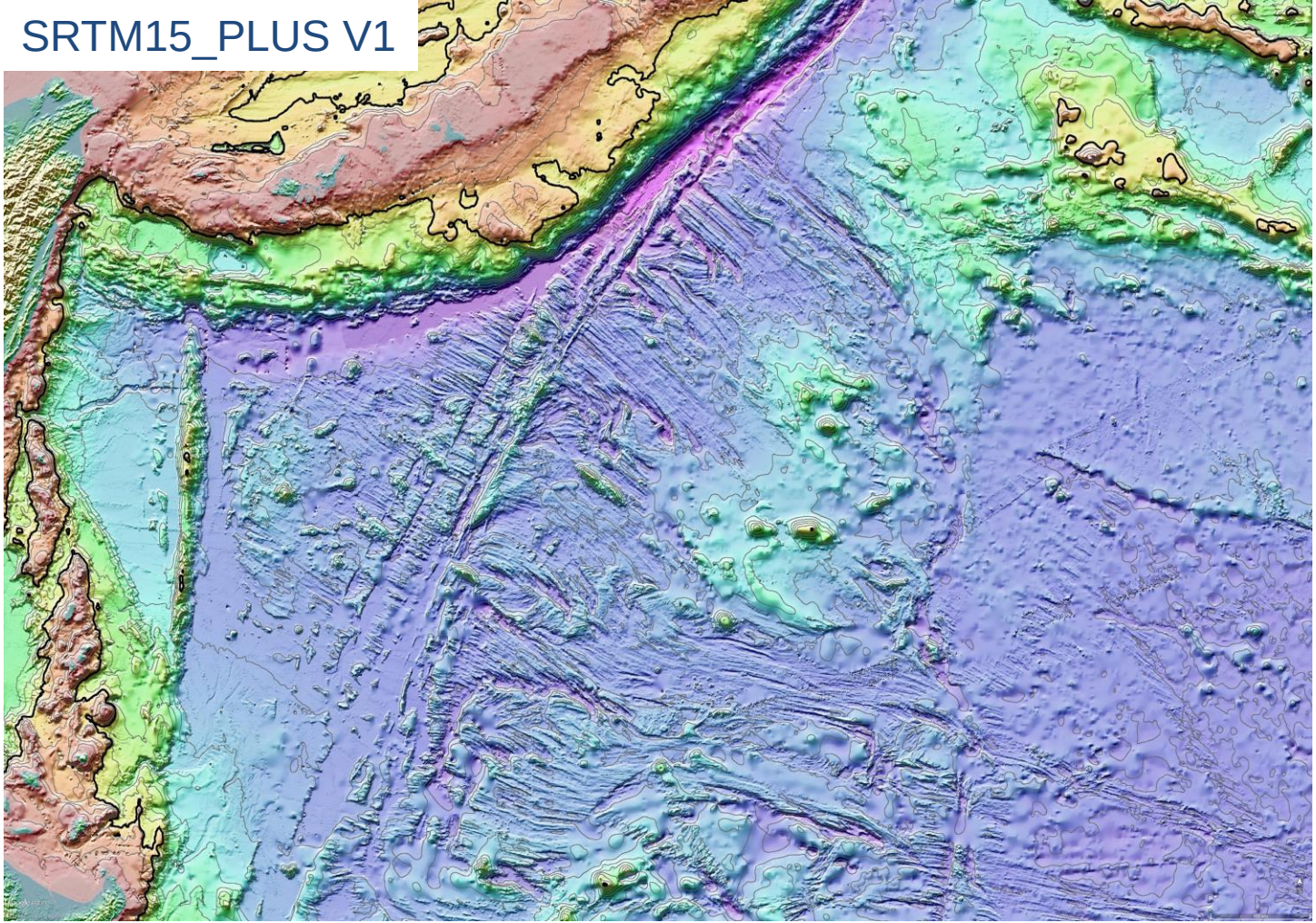
SRTM15_PLUS V1



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 ~ 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

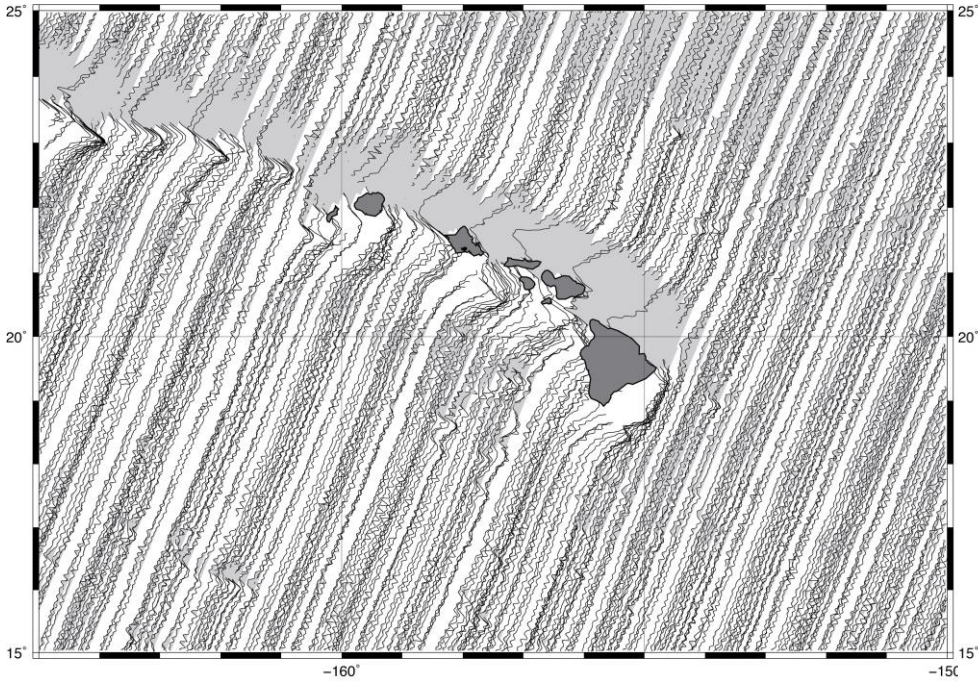
Zhang and Sandwell [2016] showed that AltiKa also benefits from 2-pass retracking.

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

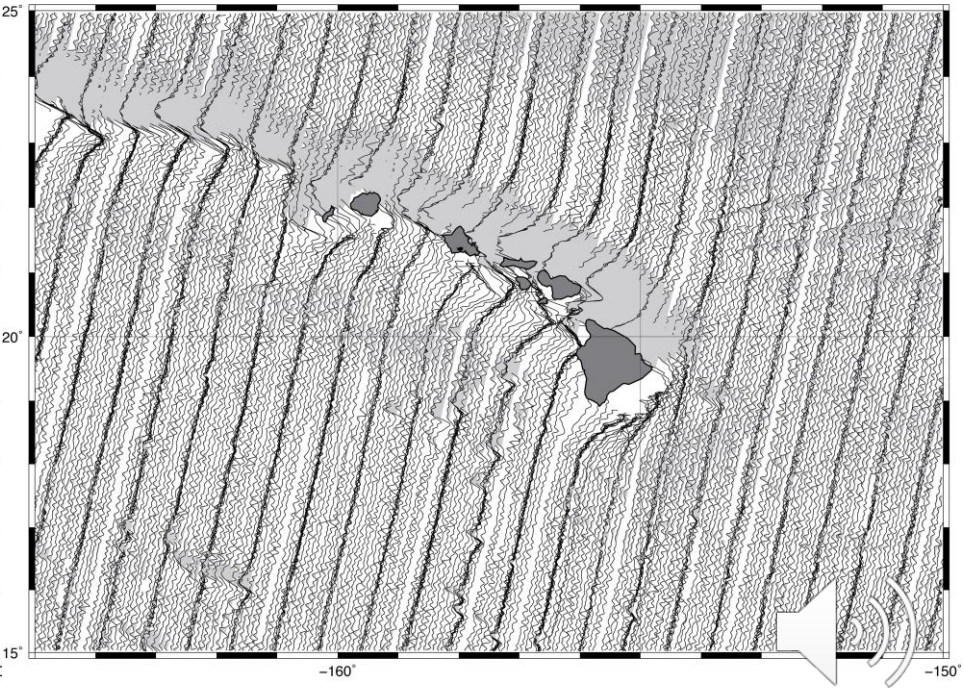
AltiKa 4.5 mm @ 1 Hz

along-track sea surface slope over Hawaii

Geosat/GM (18 mo.)



ERS/GM (12 mo.)



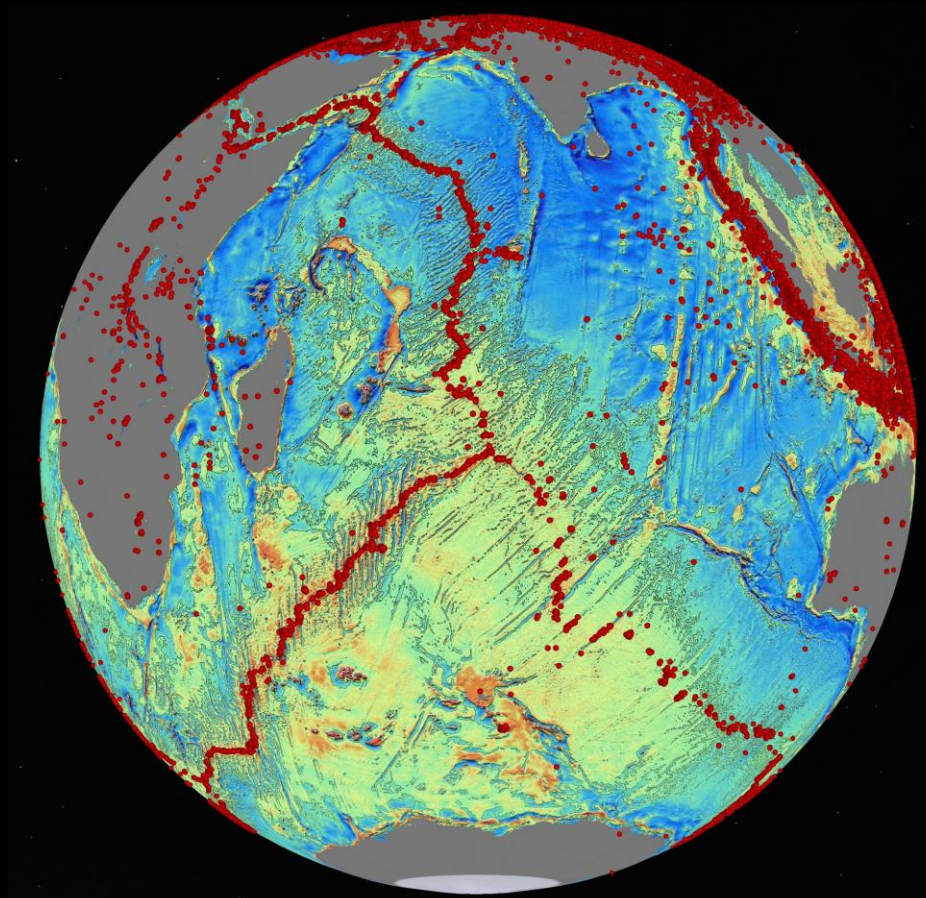
along-track sea surface slope over Hawaii

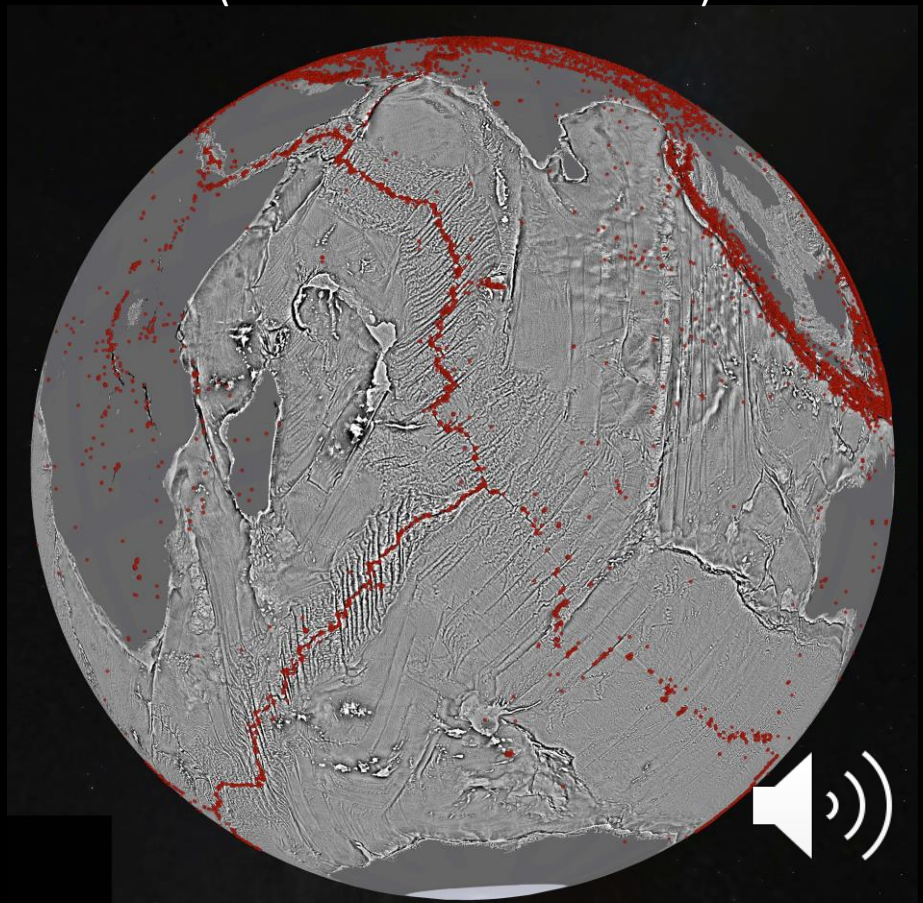
CryoSat-2 (77 mo.)

AltiKa/GM (13 mo.)

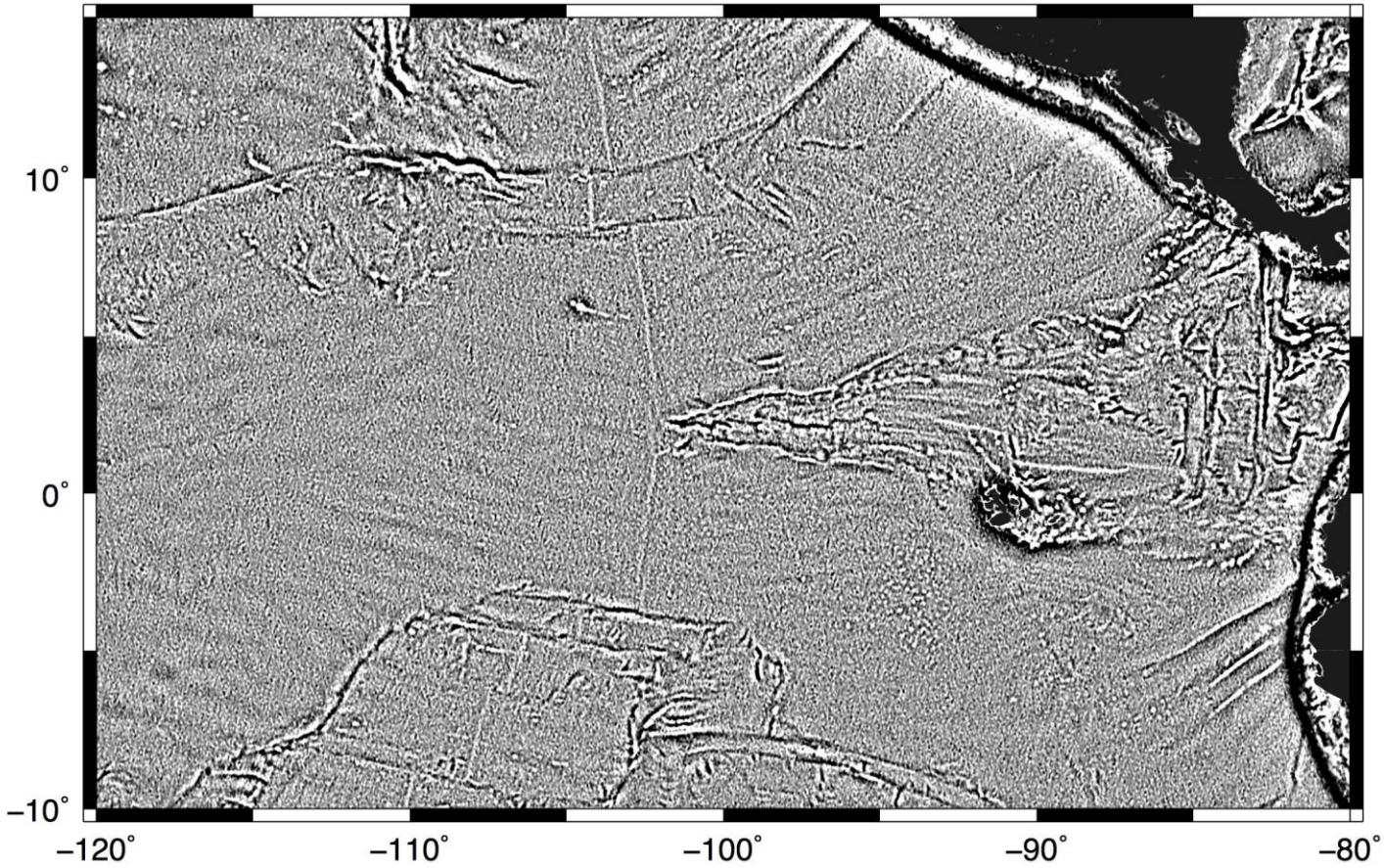
gravity anomaly

vertical gravity gradient
(curvature of sea surface)

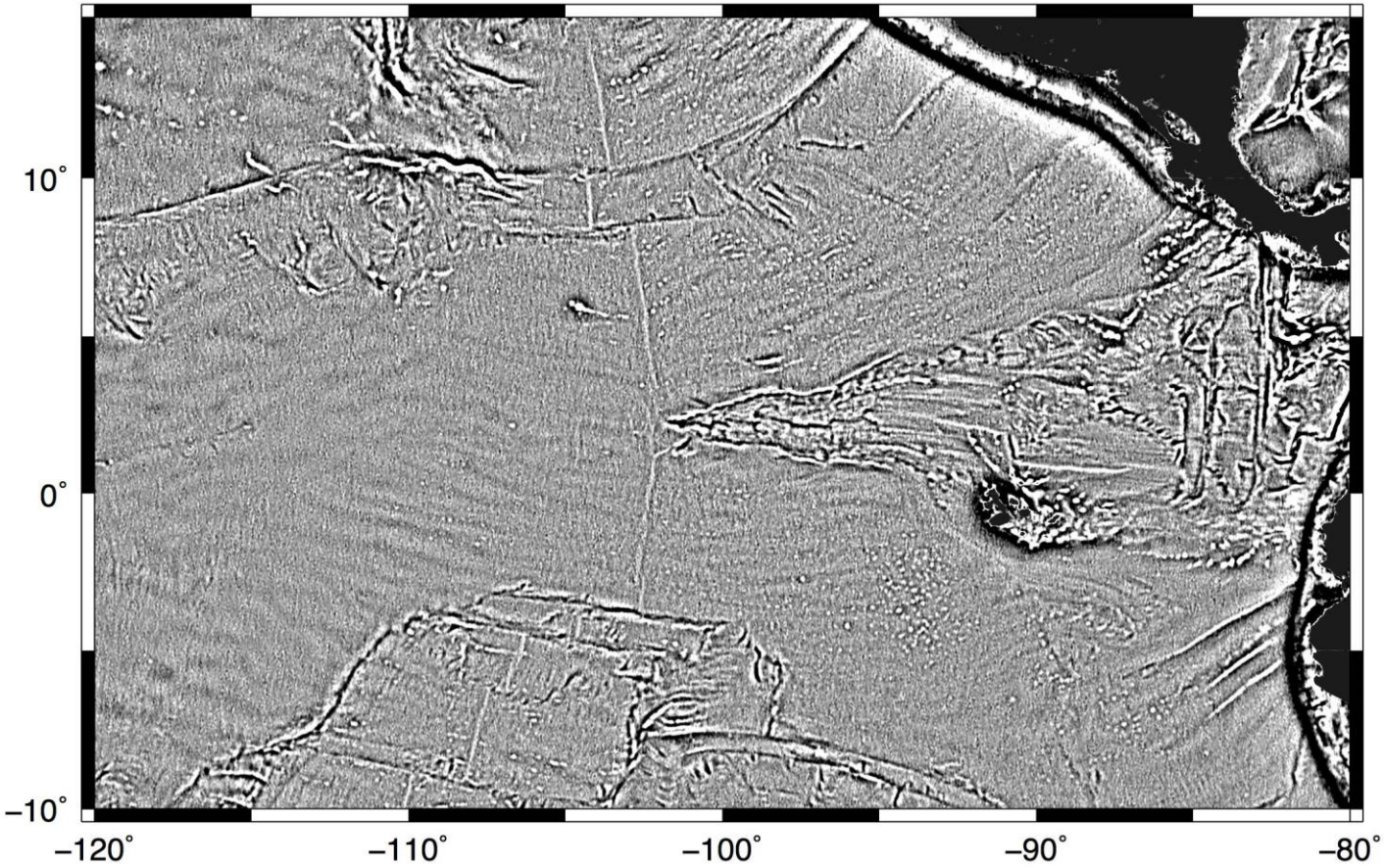




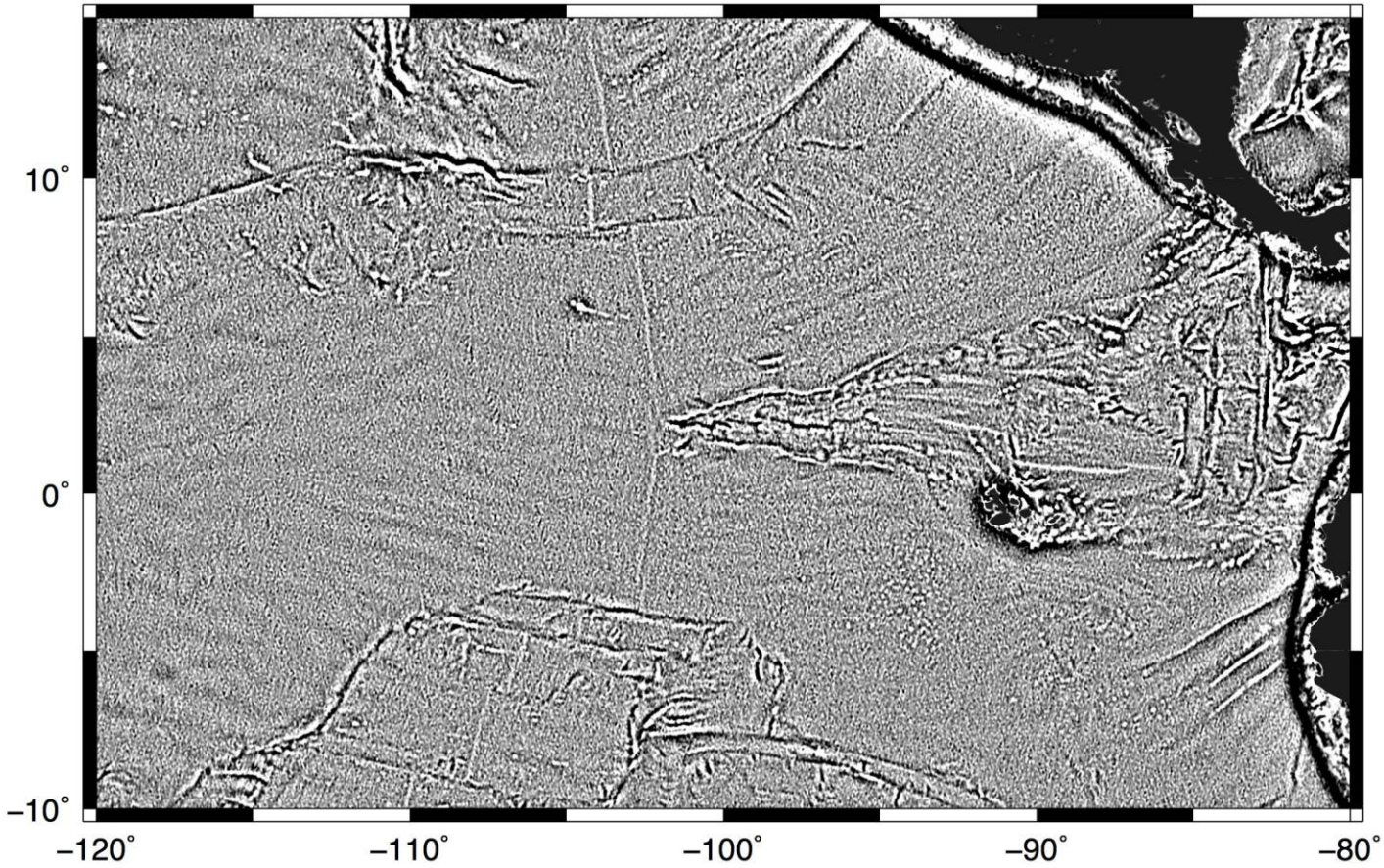
VGG (V18) Geosat + ERS



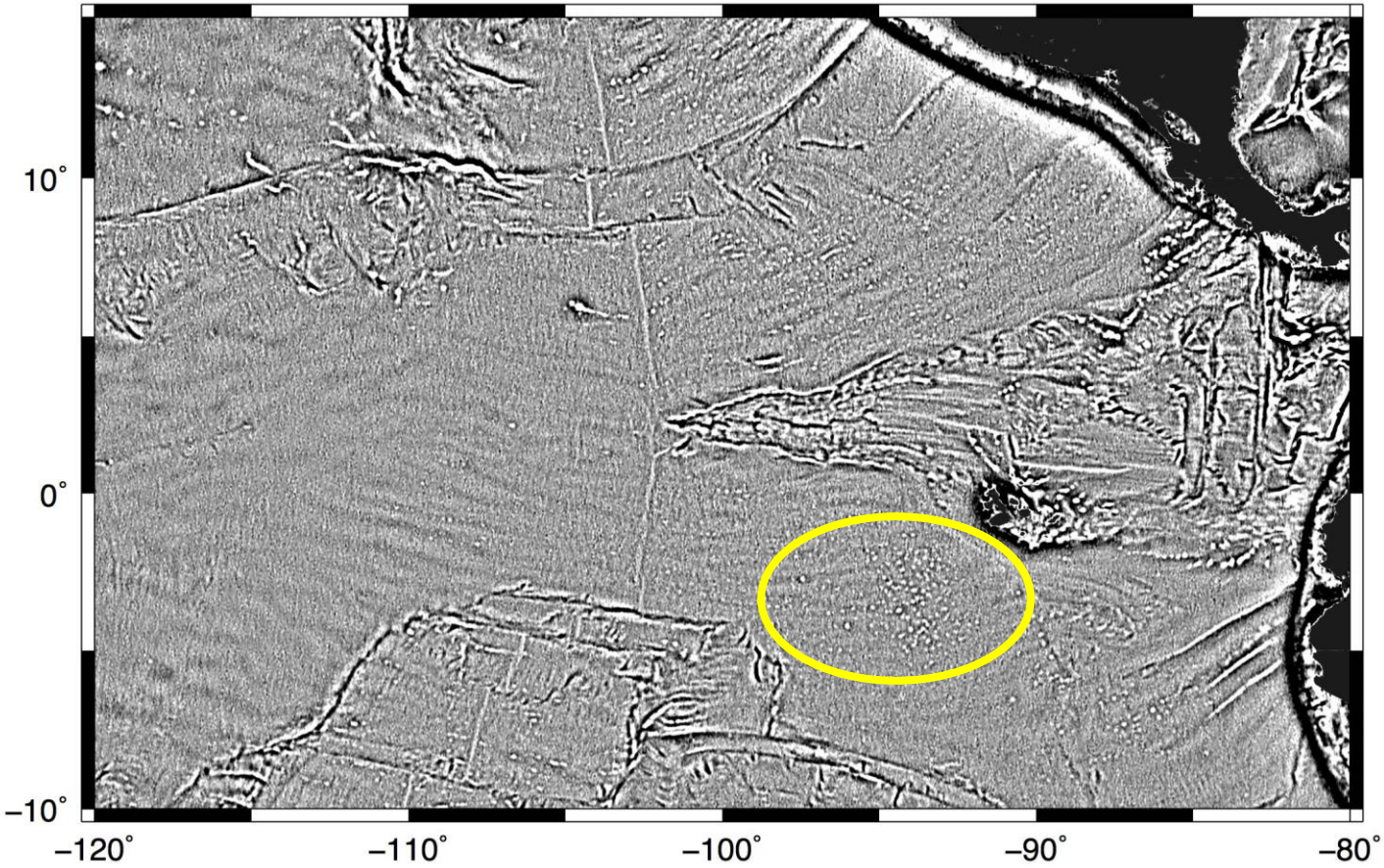
VGG (V24) + CryoSat + AltiKa + Jason-1



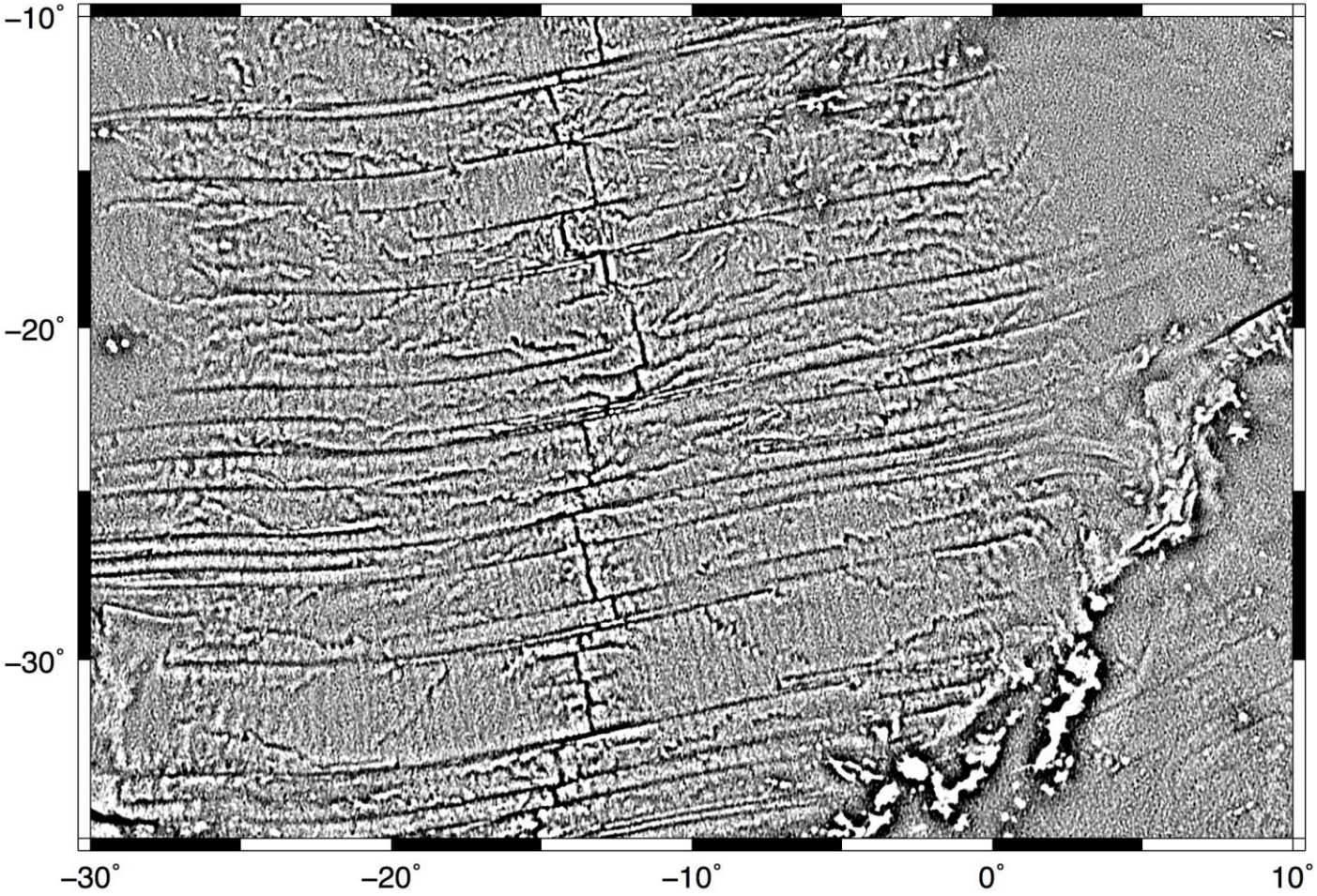
VGG (V18) Geosat + ERS



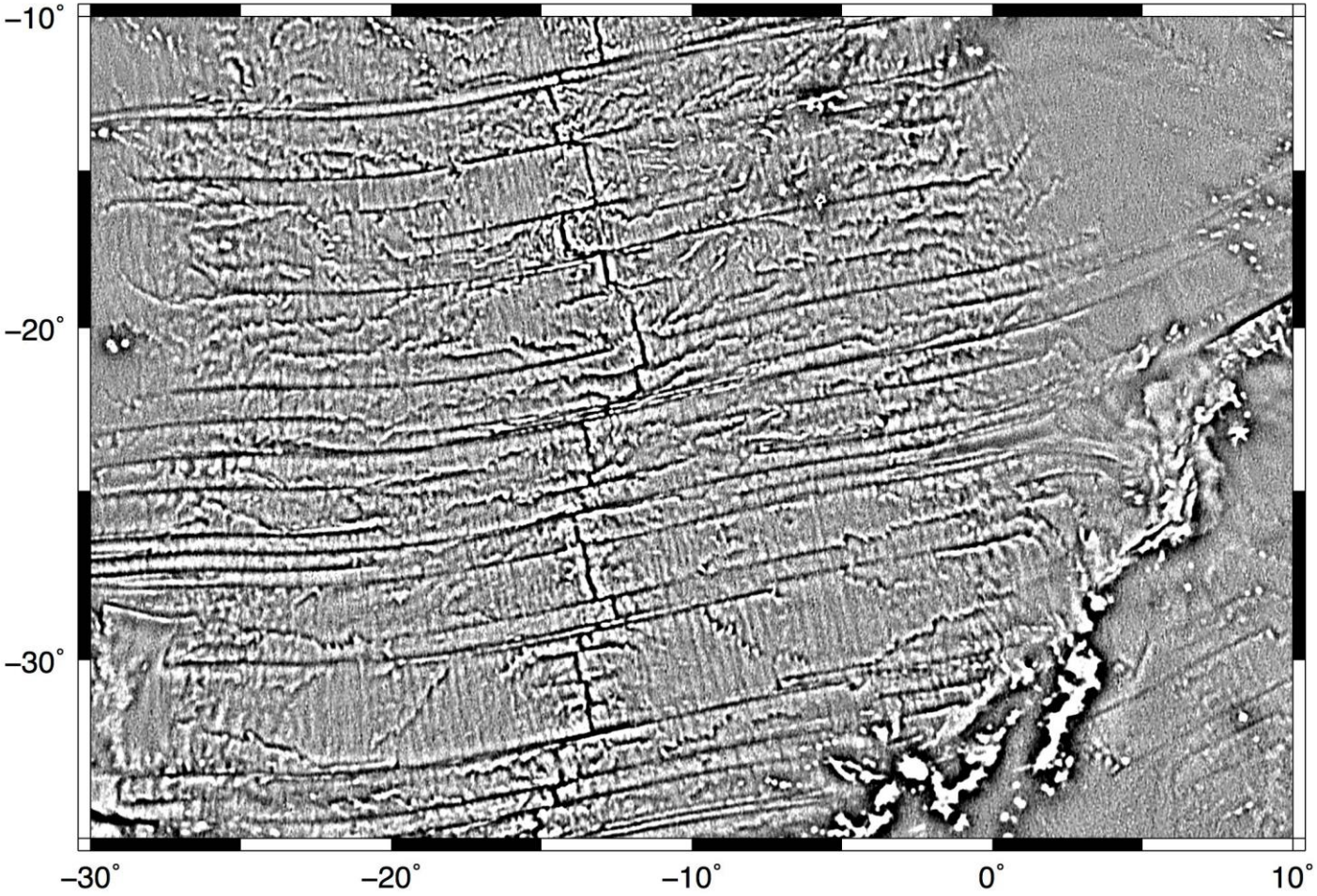
Discovery of small seamounts



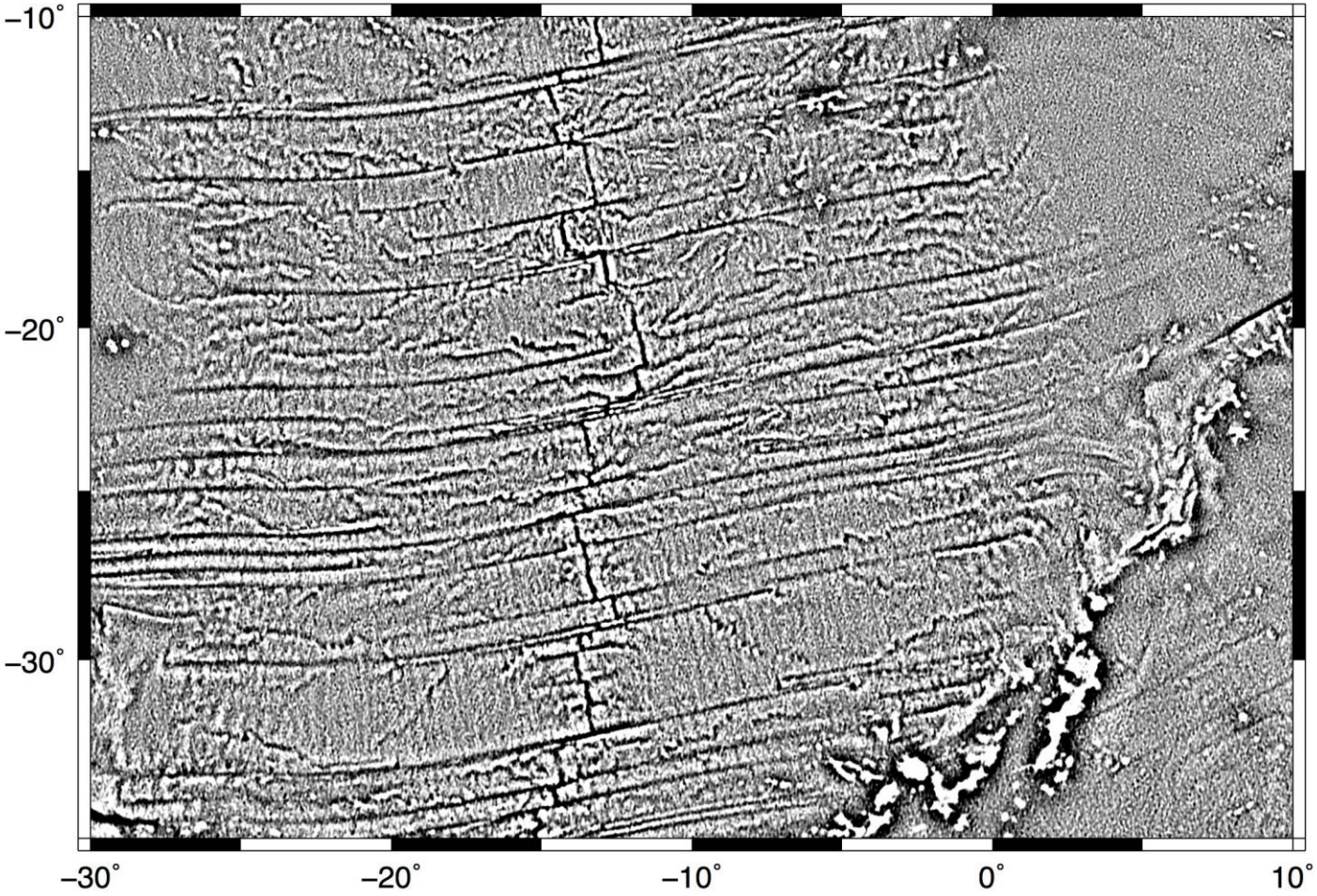
VGG (V18) Geosat + ERS



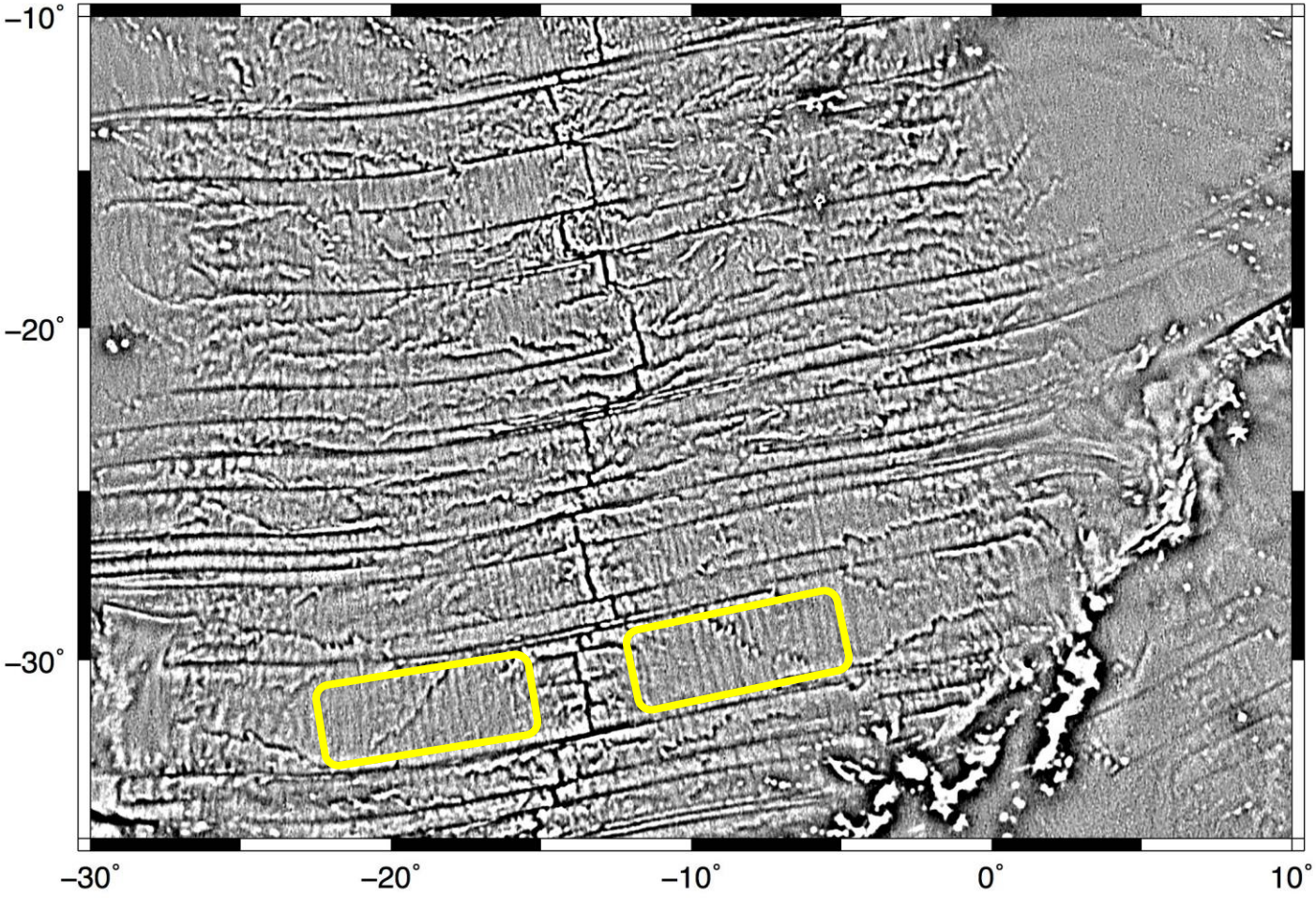
VGG (V24) + CryoSAT + AltiKa + Jason-1



VGG (V18) Geosat + ERS



Resolution of uncharted abyssal hills

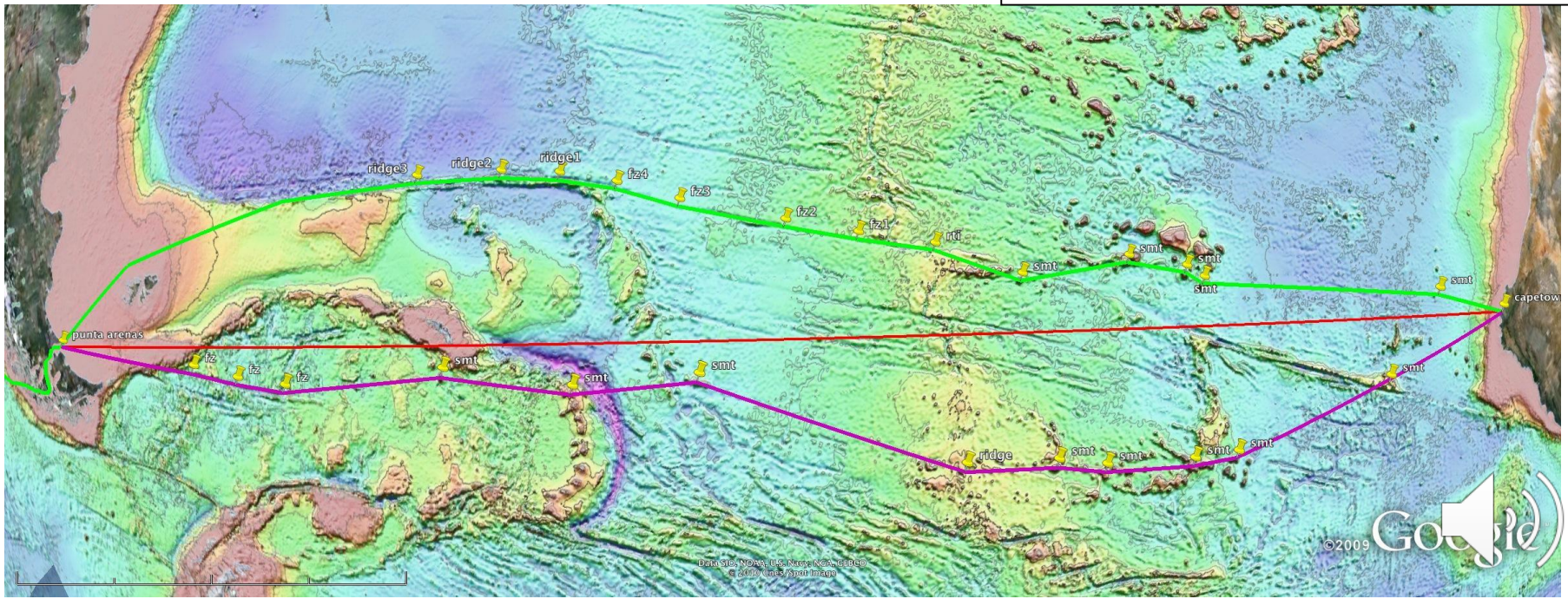


Seamount Discovery Tool

Cape Town to Punta Arenas - Melville - Feb, 2011

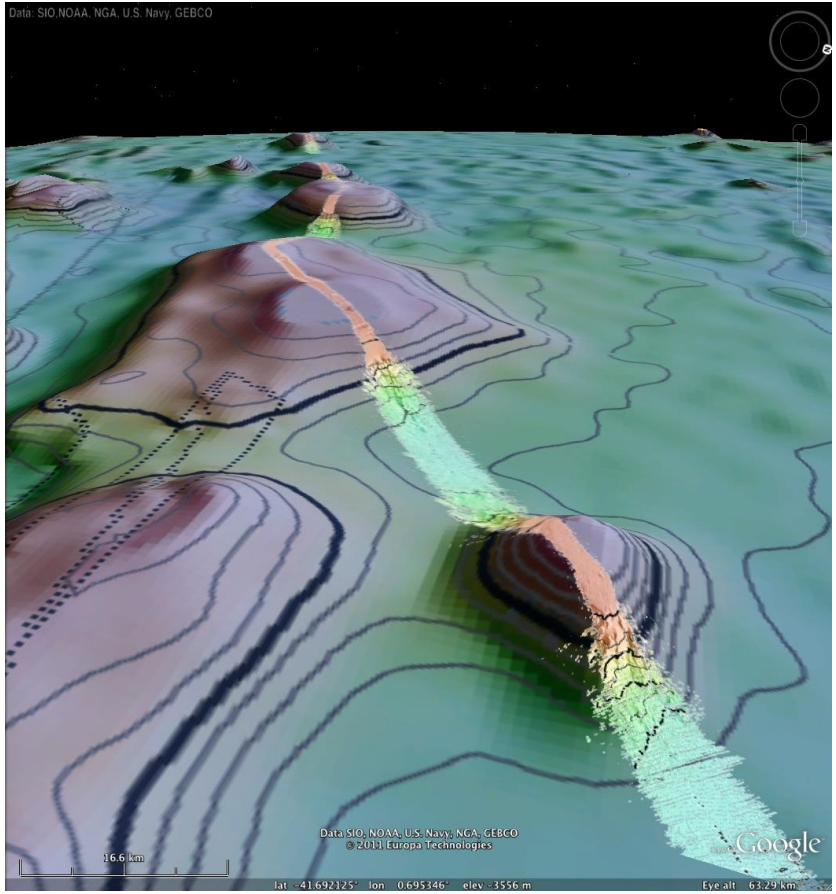
red - great circle = 6896 km
green - 10 new seamounts = 7130 km (1.034)
violet - 11 new seamounts = 7069 km (1.025)

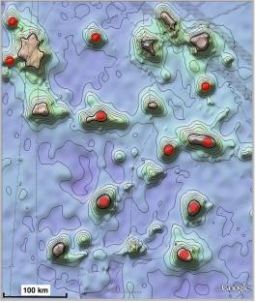
[Sandwell, D. T., and P. Wessel, Seamount discovery tool aids navigation to uncharted seafloor features, Oceanography, 23:1 , p. 24-26, 2010.]



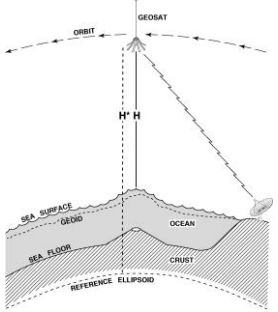
Seamount Discovery Tool

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.

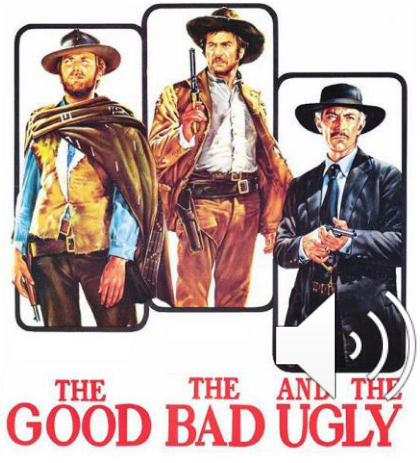
- **BAD**

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

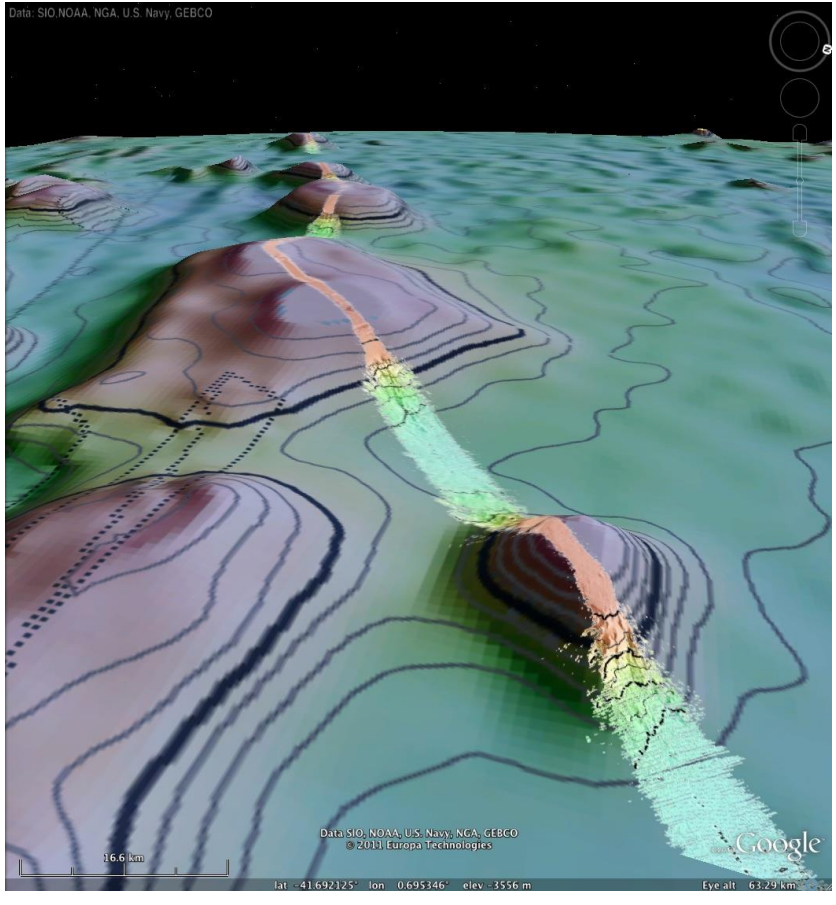
  Depths predicted from gravity have ~4 km resolution and an accuracy of only 250 – 400 m.

- **UGLY**

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



Questions?


Data: SIO,NOAA, NGA, U.S. Navy, GEBCO
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2011 Europa Technologies
Google
16.6 km
lat -41.692125° lon 0.695346° elev -3556 m
Eye alt 63.29 km