Coastal and Arctic Marine Gravity from CryoSat-2 and Jason-1 Geodetic Mission Altimetry

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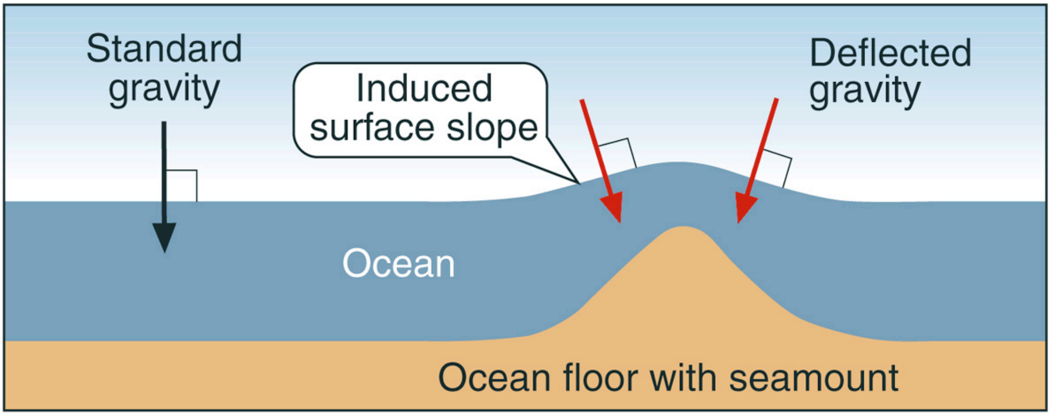
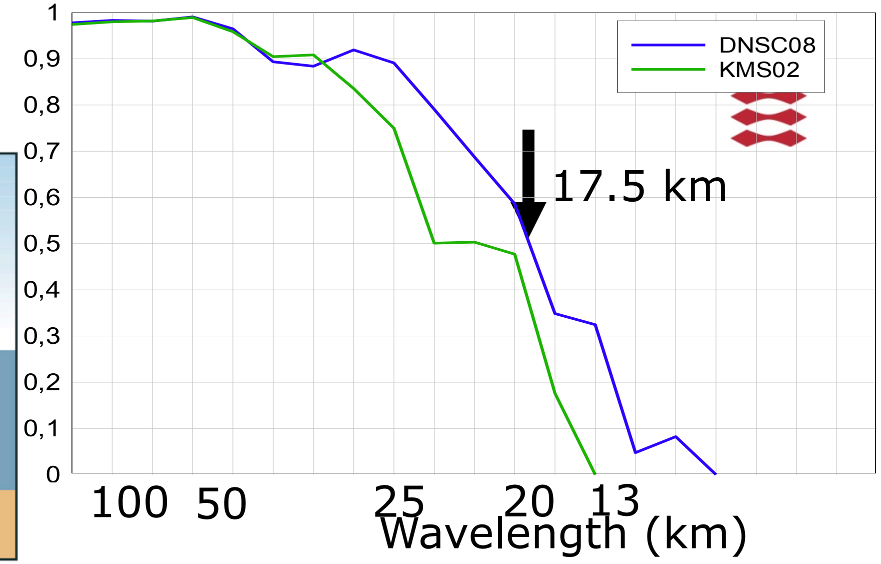
DTU Space
National Space Institute

State of the art





Two approaches: Use ssh heights (DTU) or ss slopes (Sandwell)

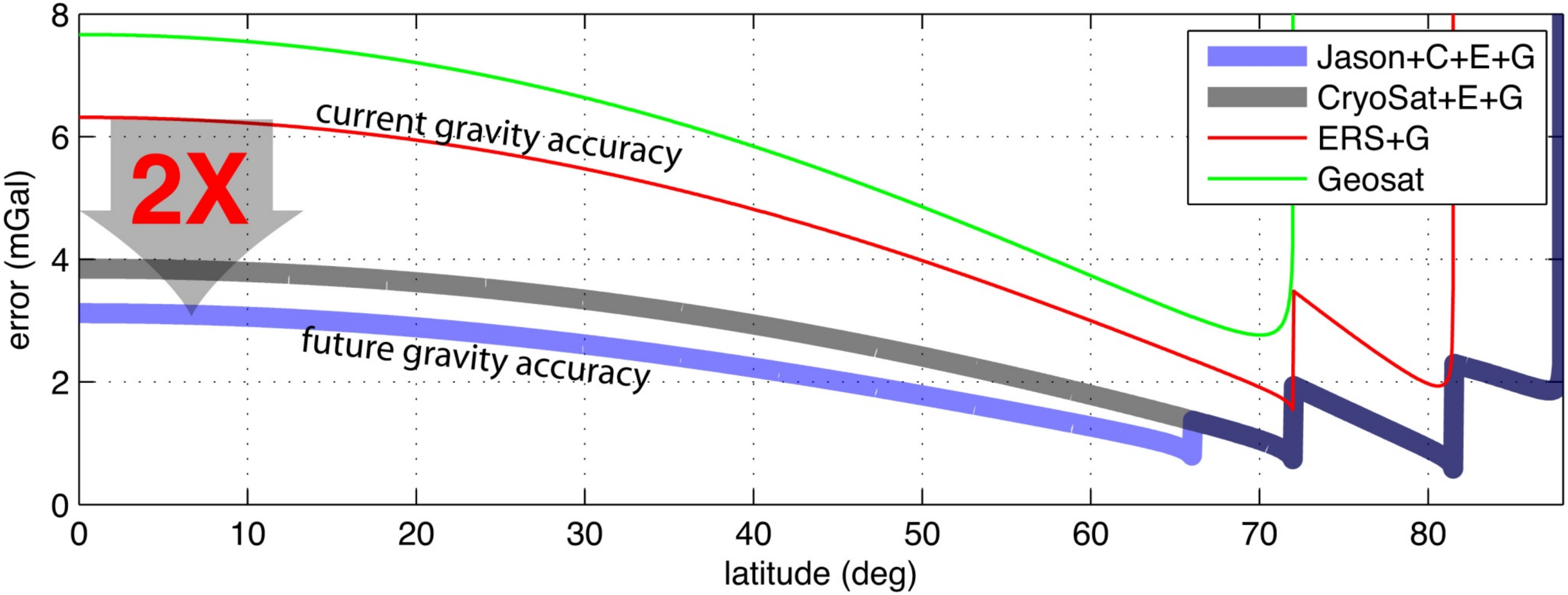
321.400 obs	Mean	**Std Dev.**	Max Dev	Note
KMS02	0.44	**5.15**	49.38	
DNSC08	**0.39**	**3.91**	**36.91**	**Double Retrack**
DTU10	**0.39**	**3.82**	**36.89**	
DTU12	**0.39**	**3.79**	**36.81**	**Cryosat-2**
SS V12.1	0.62	**5.79**	82.20	
NTU01	0.79	**6.10**	92.10	
SS V16.1	0.59	**4.88**	45.29	Retracked ERS1+GSA
SS V18.1	0.41	**3.96**	36.99	
SSV19.1	0.39	**3.92**	36.31	Cryosat-2

Many reasons for requiring More accurate GRAVITY

Many reasons for requiring More accurate BATHYMETRY

CryoSat-2 and Jason-1 predicted gravity improvement

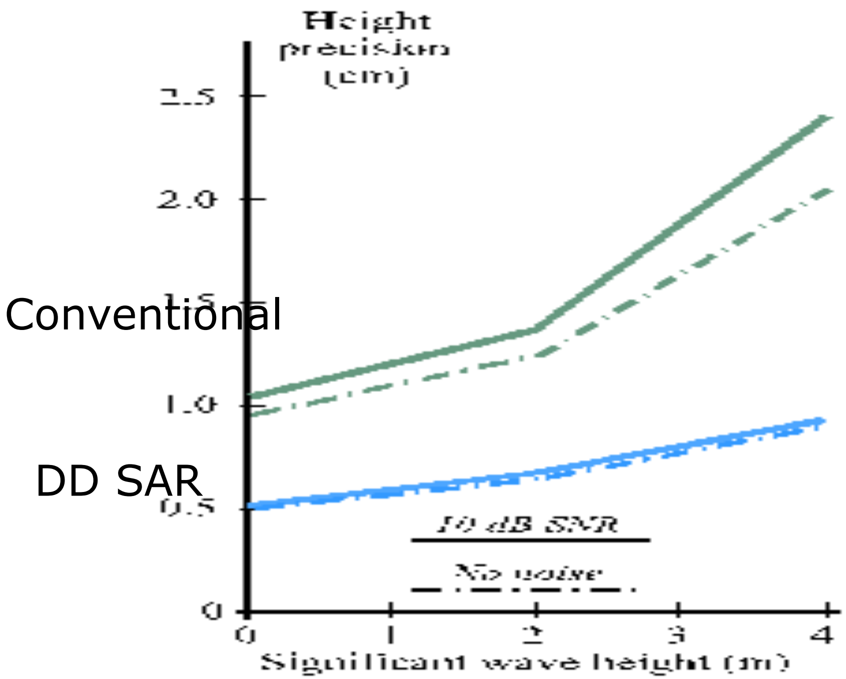
assumes 1.4 better range precision with 3 years of C-2 and 409 days of Jason-1



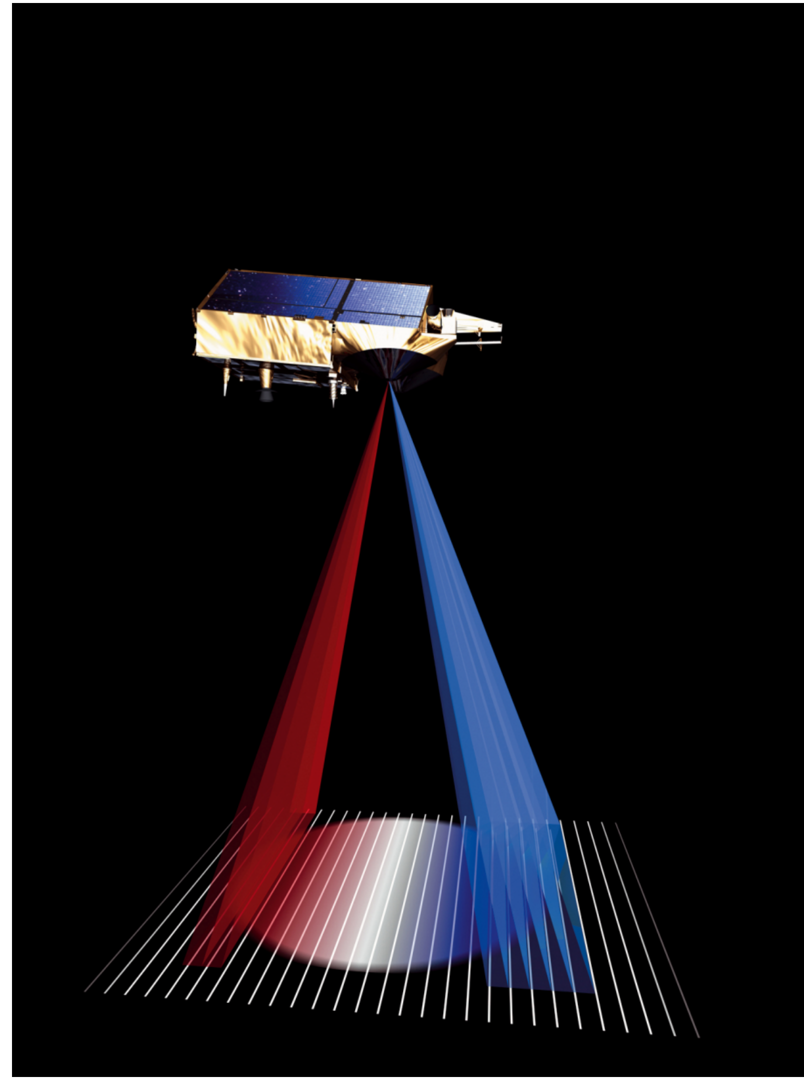
Status: 2 years of CryoSat-2 and 4 month of Jason-1

CryoSat-2

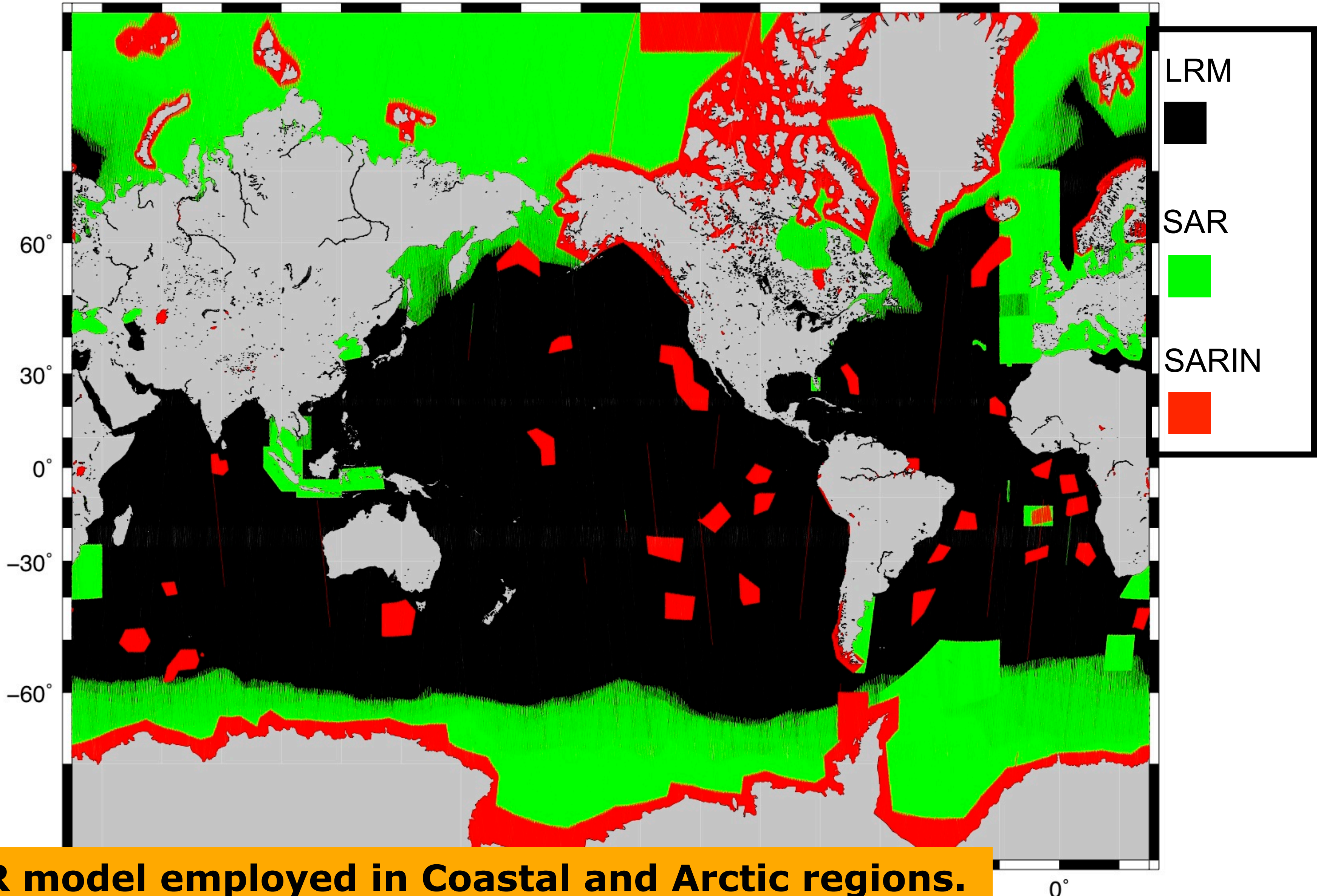
- LRM –- conventional mode
- SAR –- synthetic aperture radar provide 2-4 times better range precision.
- SARIN - uses two receiving antennas
- SAR or SARin Used in many coastal regions



source: Jensen and Raney.



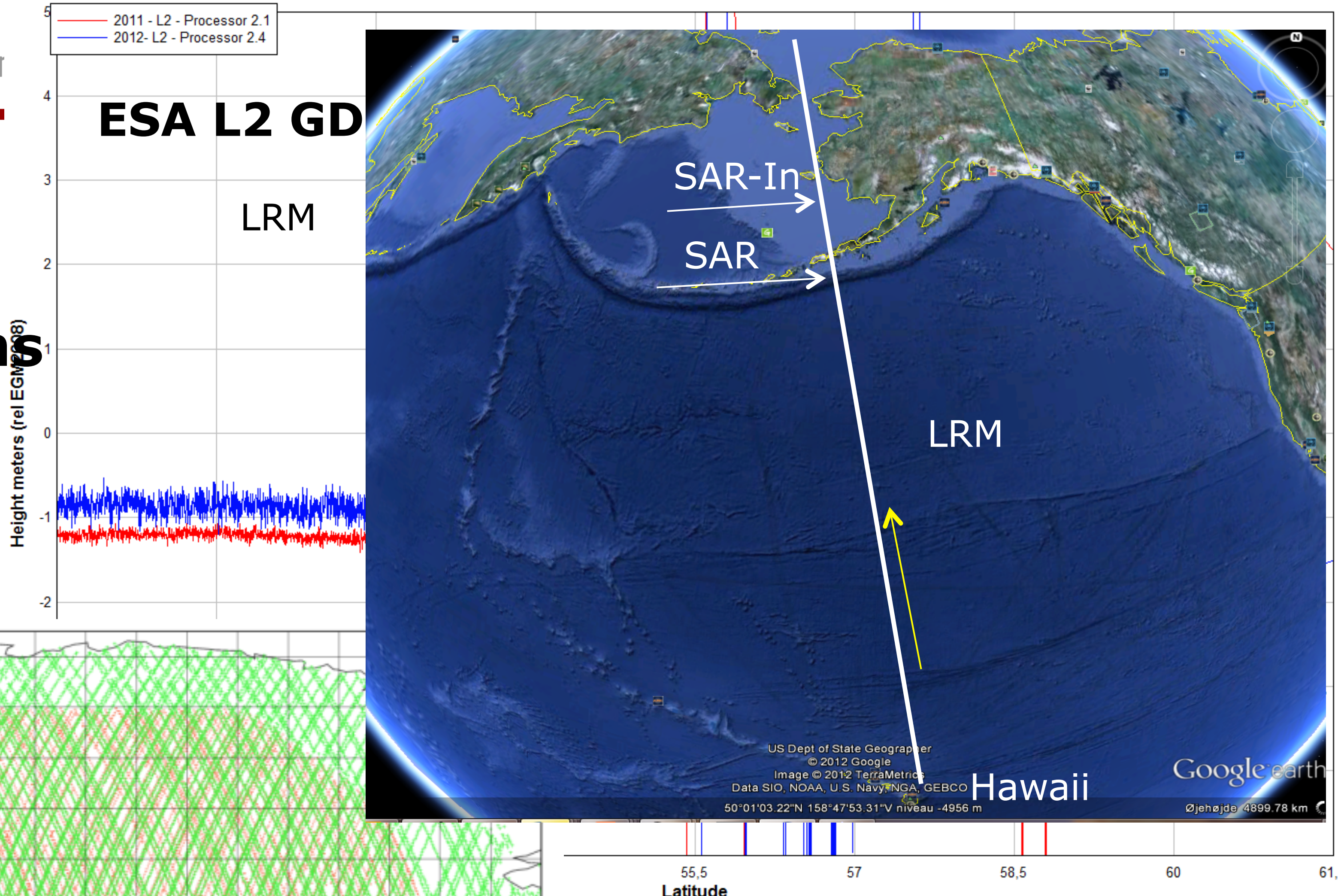
source: ESA

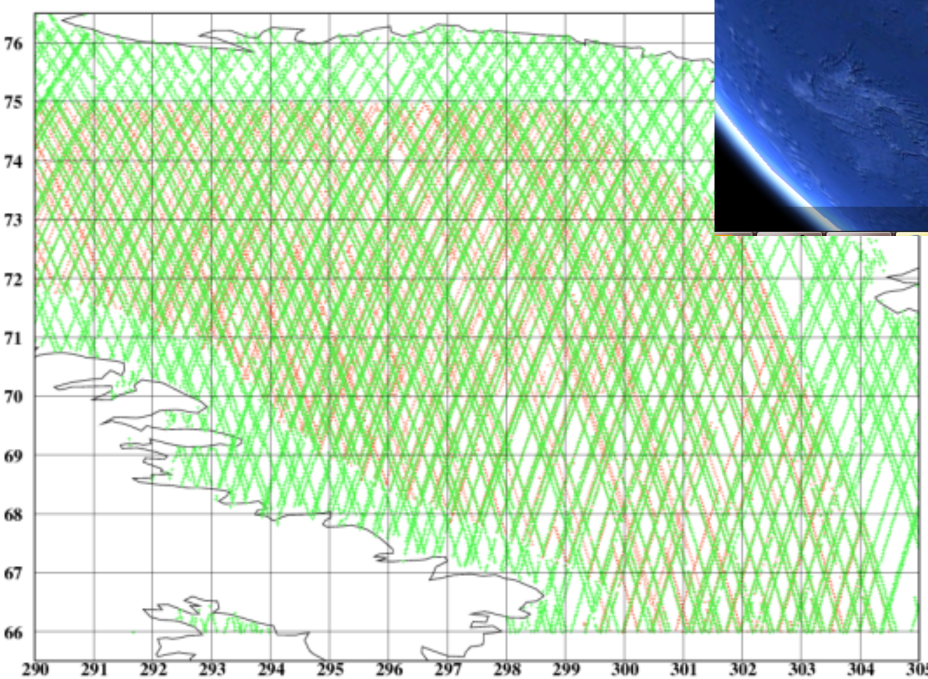


SAR model employed in Coastal and Arctic regions.

So similar to investigate – here we focus on Arctic

Cryosat problems





Mode Switching a problem for DTU

Height must be corrected.

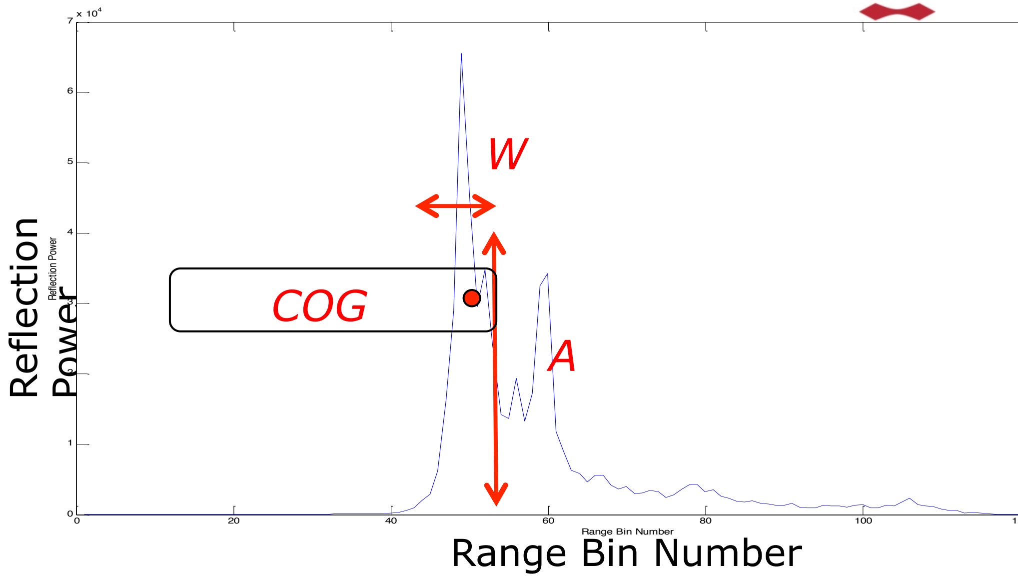
Also SAR-In very short tracks

C2 Retracking:

DTU

Focused on Leading Edge Rtrk

- Only retrack SAR and SAR-in
- LE COG and LE Treshold.
- USE ESA L2 LRM data.



Sandwell

Focused on 3 Parameters retracking

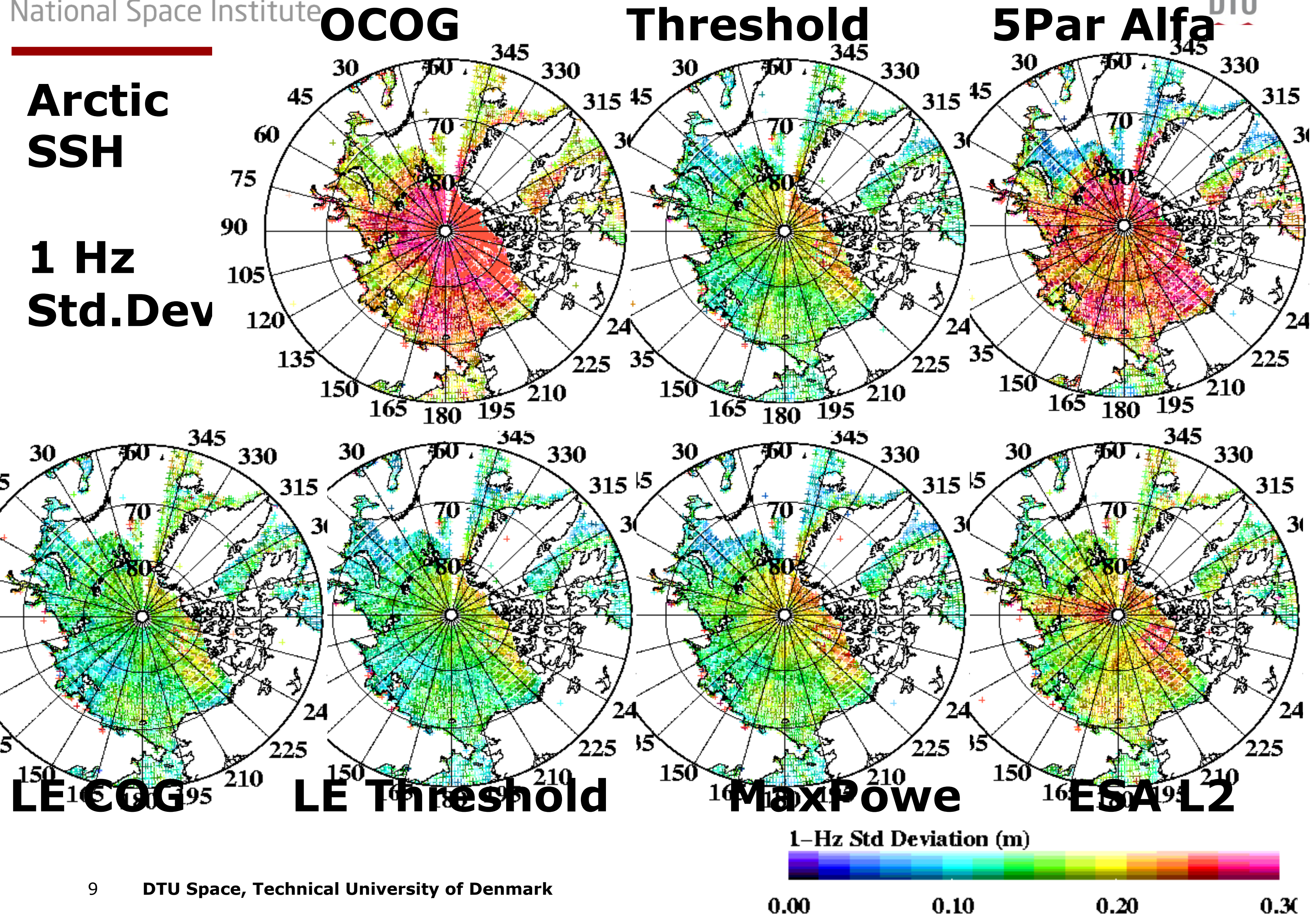
- Retrack LRM and SAR using different functions.

- LRM $$M(A,t_o,\sigma) = \frac{A}{2}\{1 + erf(\eta)\}; \qquad \eta = \frac{t_o}{\sqrt{2}\sigma}$$

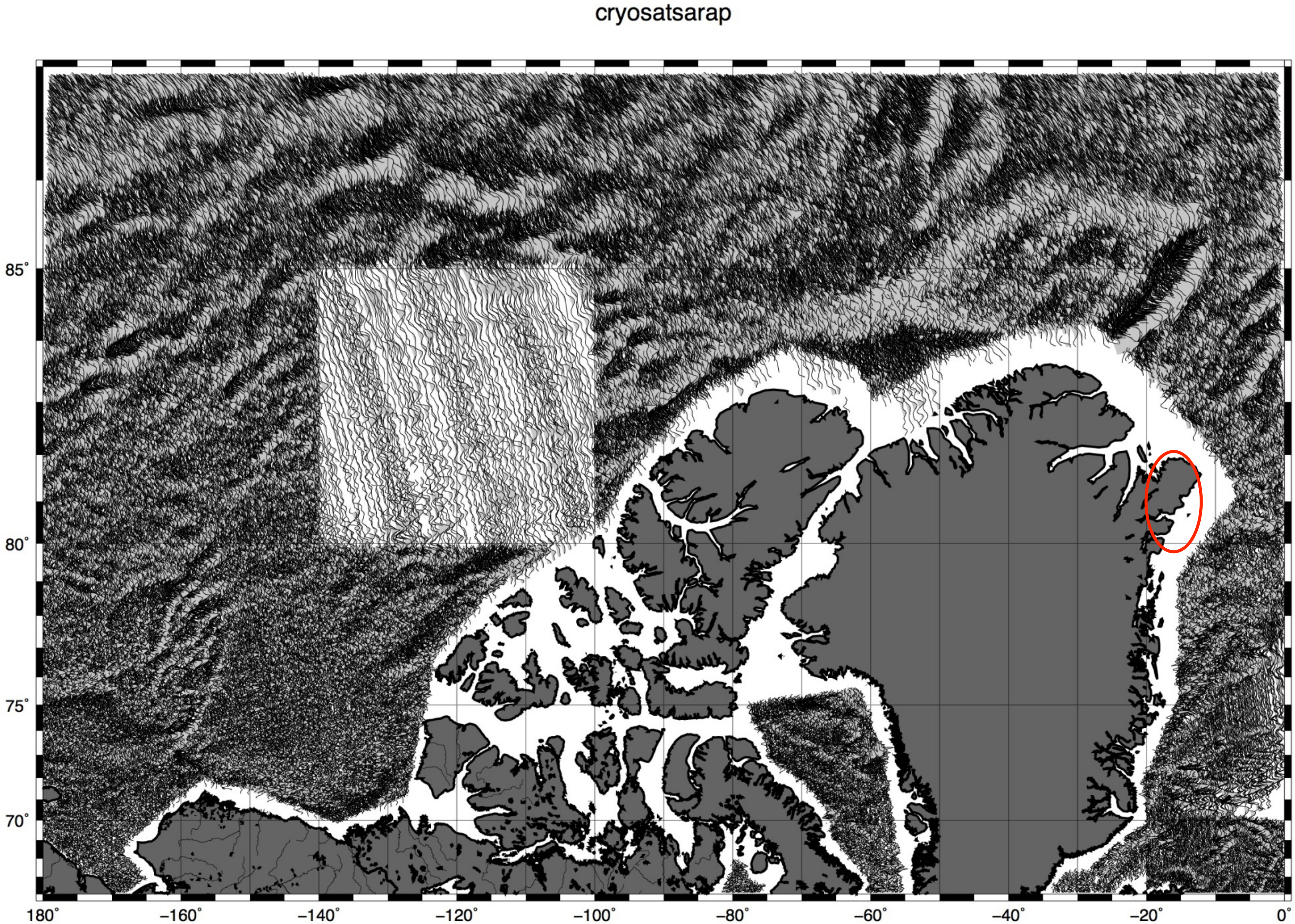
- SAR $$M(A,t_o,\sigma) = \frac{A}{2}\exp\left(-\frac{1}{4}z^2\right)D_{-1/2}(z); \qquad z = \frac{t_o}{\sigma}$$

Arctic SSH

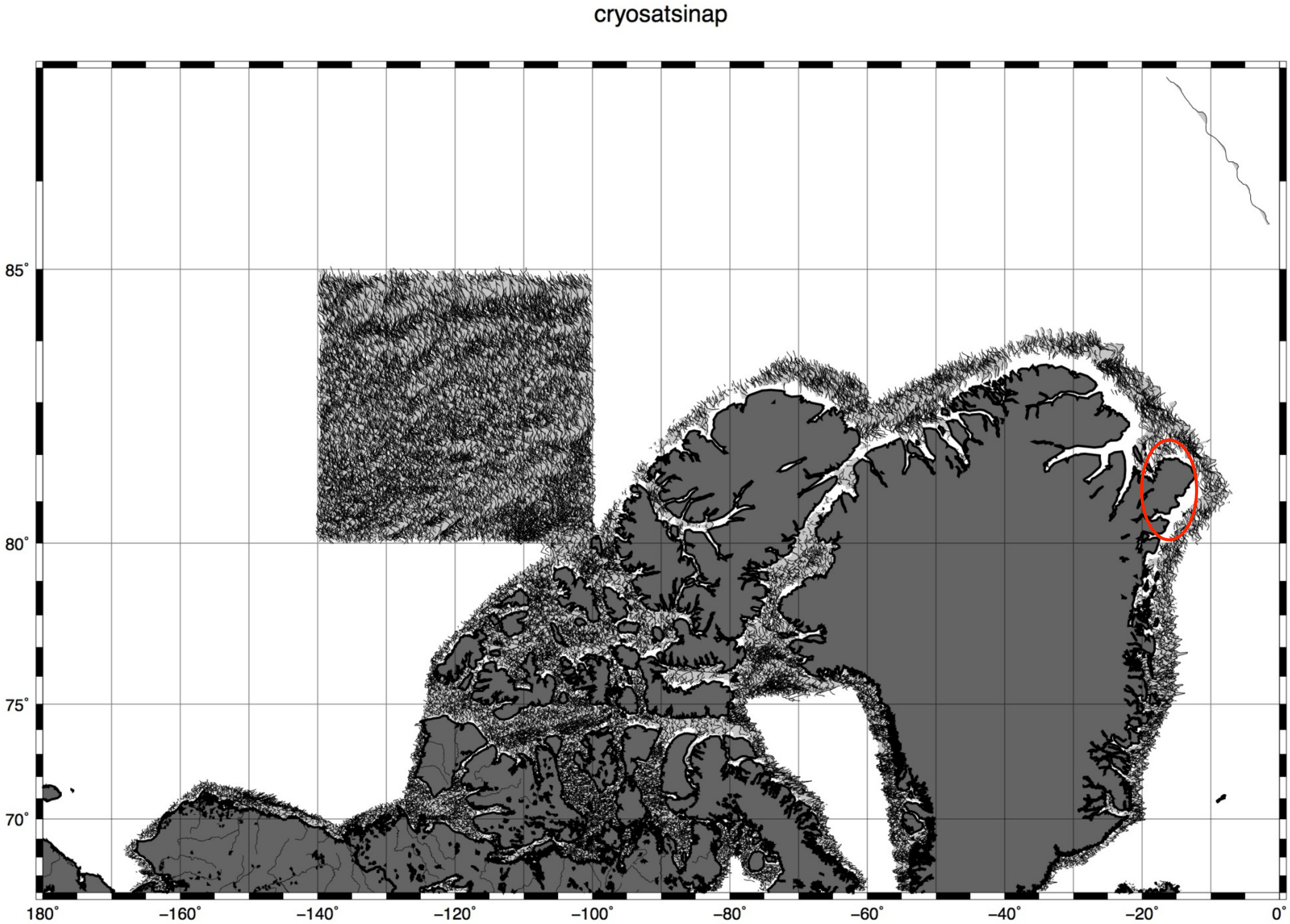
1 Hz Std.Dev



Canadian Arctic - C2 SAR

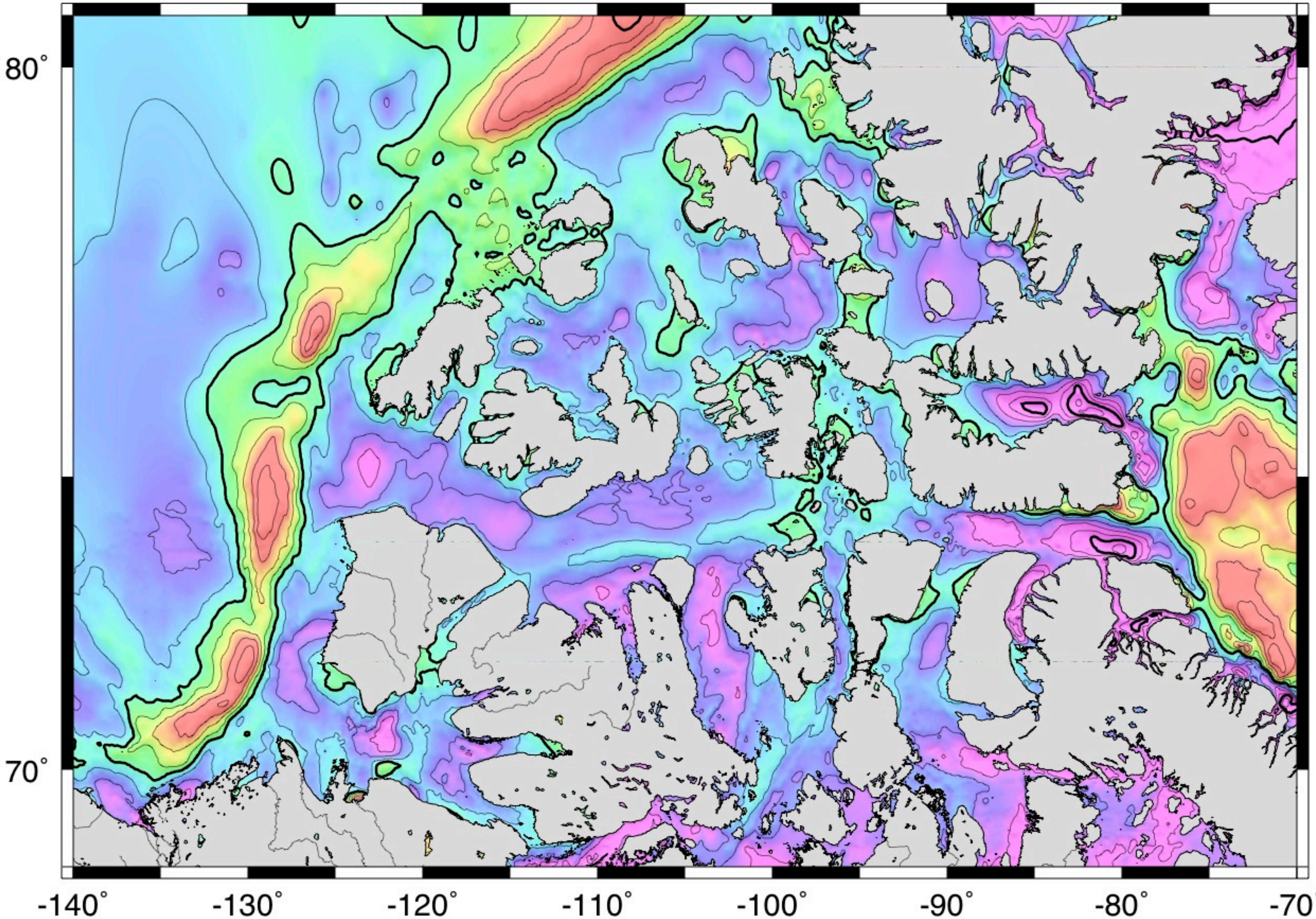


Canadian Arctic - C2 SAR



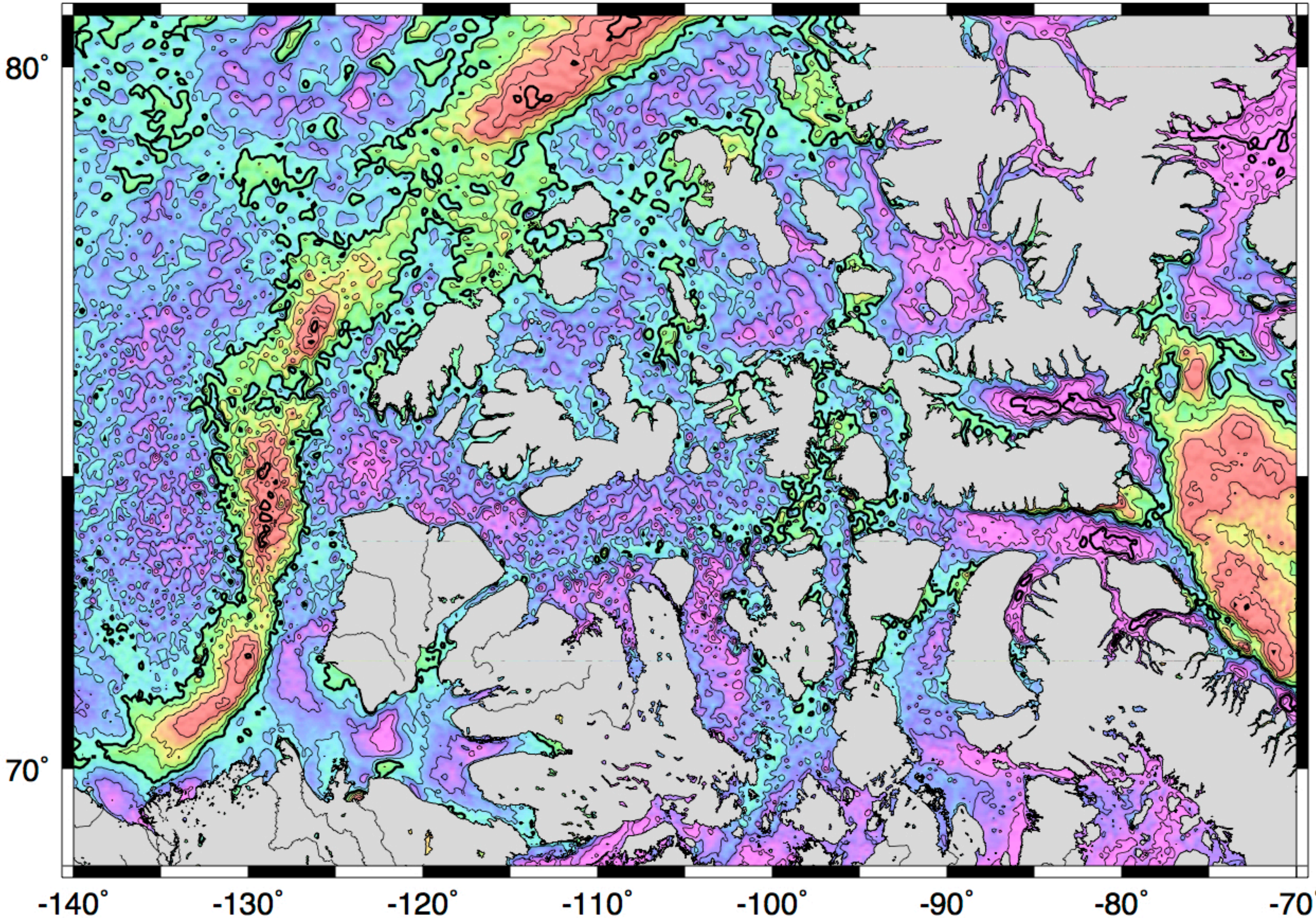
Canadian Arctic

Ship Gravity



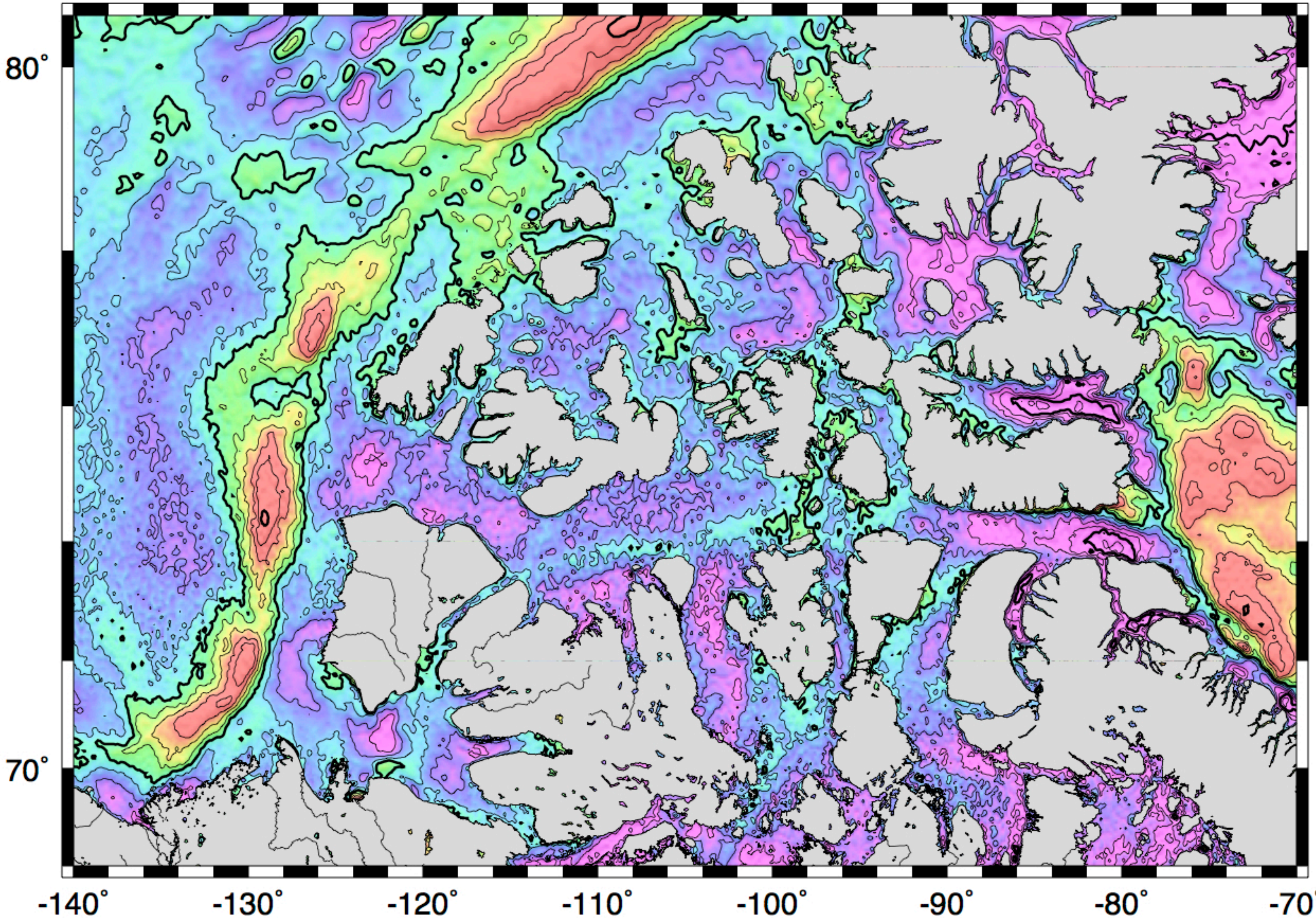
Canadian Arctic

Geosat, ERS-1 (old)



Canadian Arctic

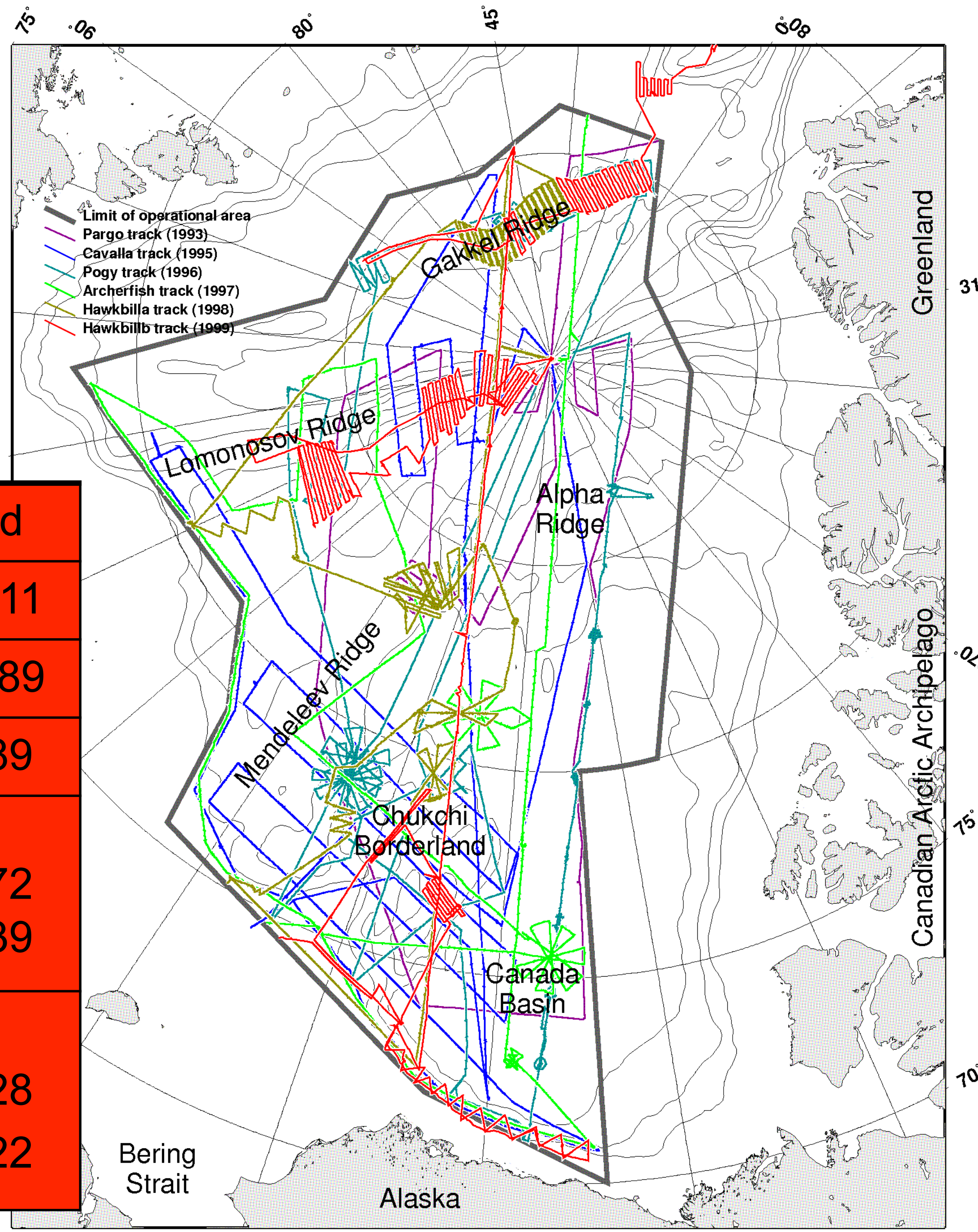
Geosat, ERS-1 (old) + **CryoSat, Envisat (new)**



Canadian Arctic SCICEX data

- Not very accurate marine data
- 4-6 mGal error
- Only data up to 86N used .

41459 obs	Max	Std
EGM2008	77	12,11
DTU10	67	10,89
ESA L2 SAR	64	8,89
Entire WF retrack OCOG Treshold	 56 52	 7.72 7.39
Lead Edge retrack OCOG Treshold	 51 51	 7.28 7.22

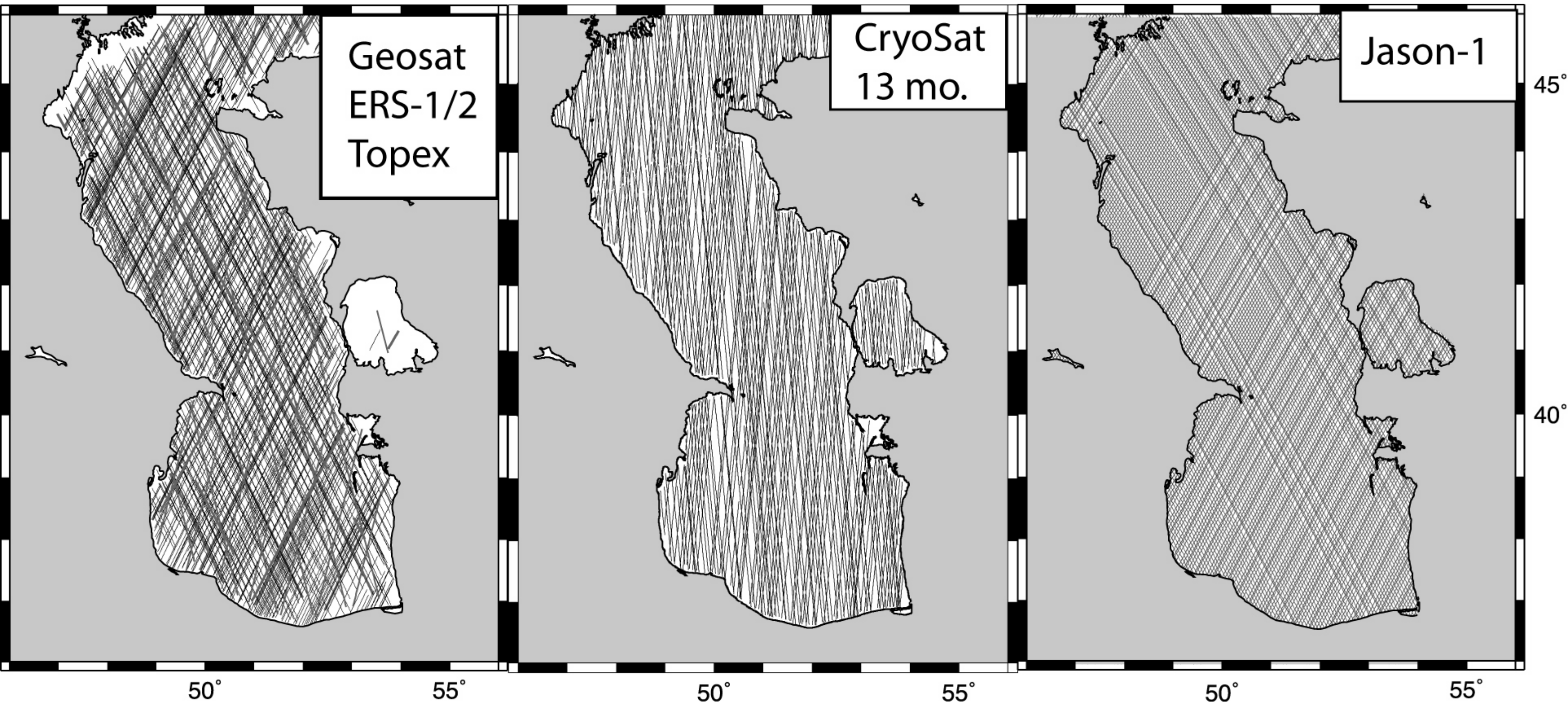


Adding in Jason-1 EOL GM mission

Caspian Sea

409-day coverage
began May 4, 2012

old tracks **new tracks** **planned tracks**



First evaluation of J1 geodetic mission data.

Standard deviation of Retrieved height in Each 1 hz data bin.

ESA L2 CryoSat

120 days of Jason-1

ERS-1

GM

”Rtrk”

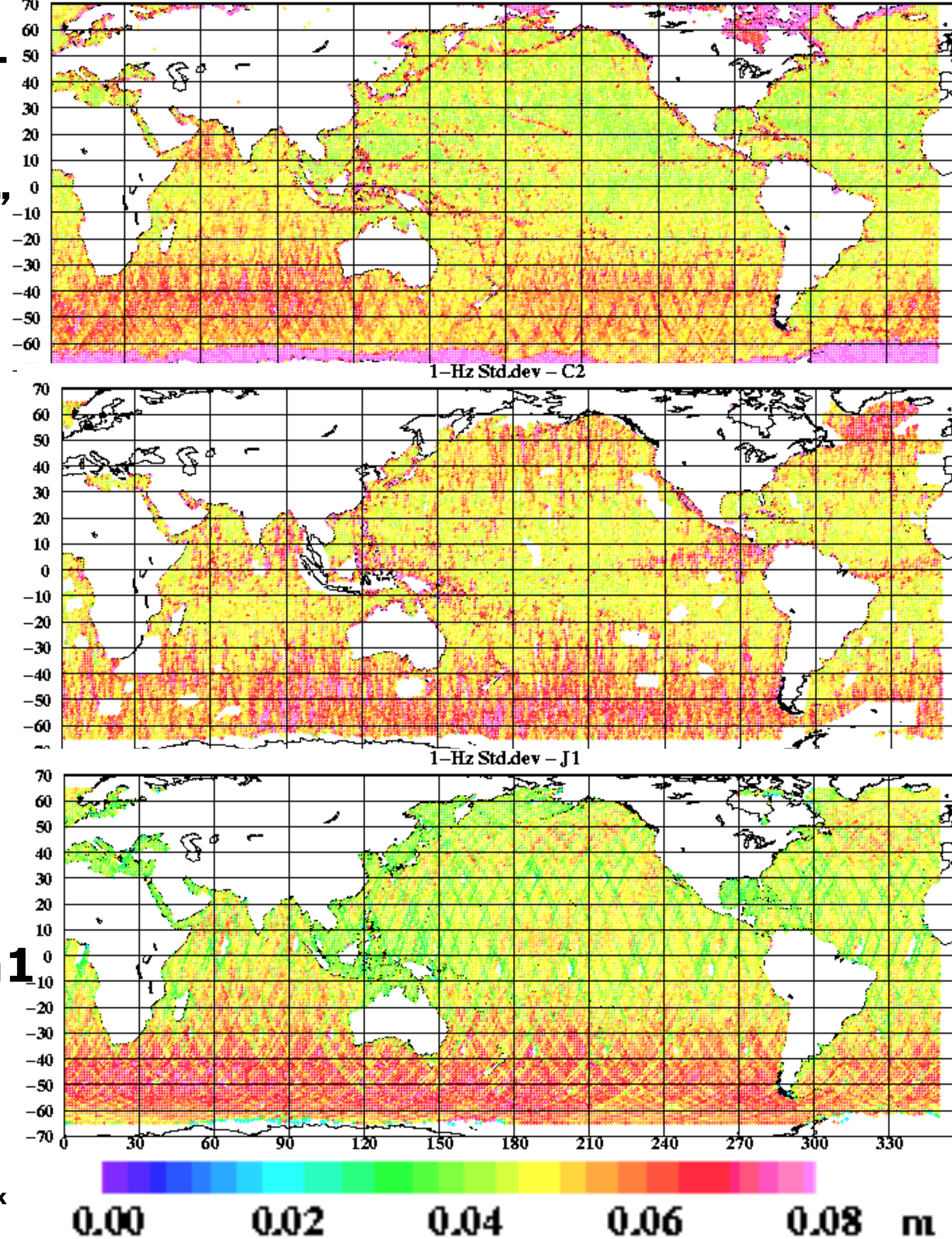
C-2

”GM”

Jason1

EOL

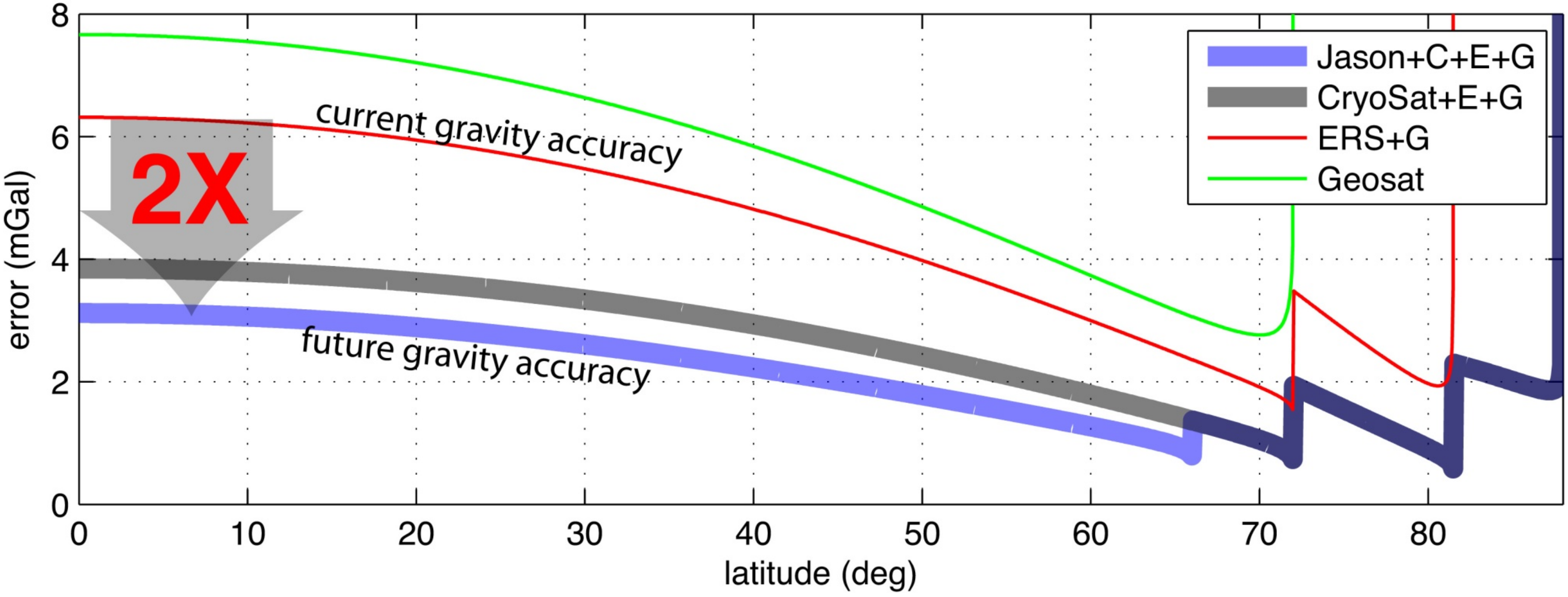
GM



New Satellites

predicted gravity improvement

assumes 1.4 better range precision with 3 years of CryoSat and 409 days of Jason



Conclusions / Outlook

- CryoSat has provided the first dense “geodetic data” since 1996.
- Mode and “processing” switch is a HUGE problem->All C2 must be retracked and each mode calibrated individually. Slopes are simpler
- Two-pass retracking of LRM waveforms provides 1.4 times better slope accuracy than Geosat and ERS-1 because of the 2X higher PRF.
- C-2 “640” Hz sampling increase noise by factor 1.8 (rel to 2000 Hz)
- Leading Edge retracking of SAR and SARIN waveforms provides higher accuracy in Coastal and Polar areas than ESA L2 data.
- We have not (yet) achieved the LRM range precision by retracking SAR and SARIN waveforms.
- More investigation on C-2 SAR high resolution Coastal gravity is next.
- If CryoSat-2 survives for more than 4 years the marine gravity accuracy will improve by more than 2 times.
- Jason-1 will provide particular high resolution at low latitudes.
- Improved gravity will have major payoffs in marine geophysics, petroleum exploration, physical oceanography/climate etc etc…….

BACKUP

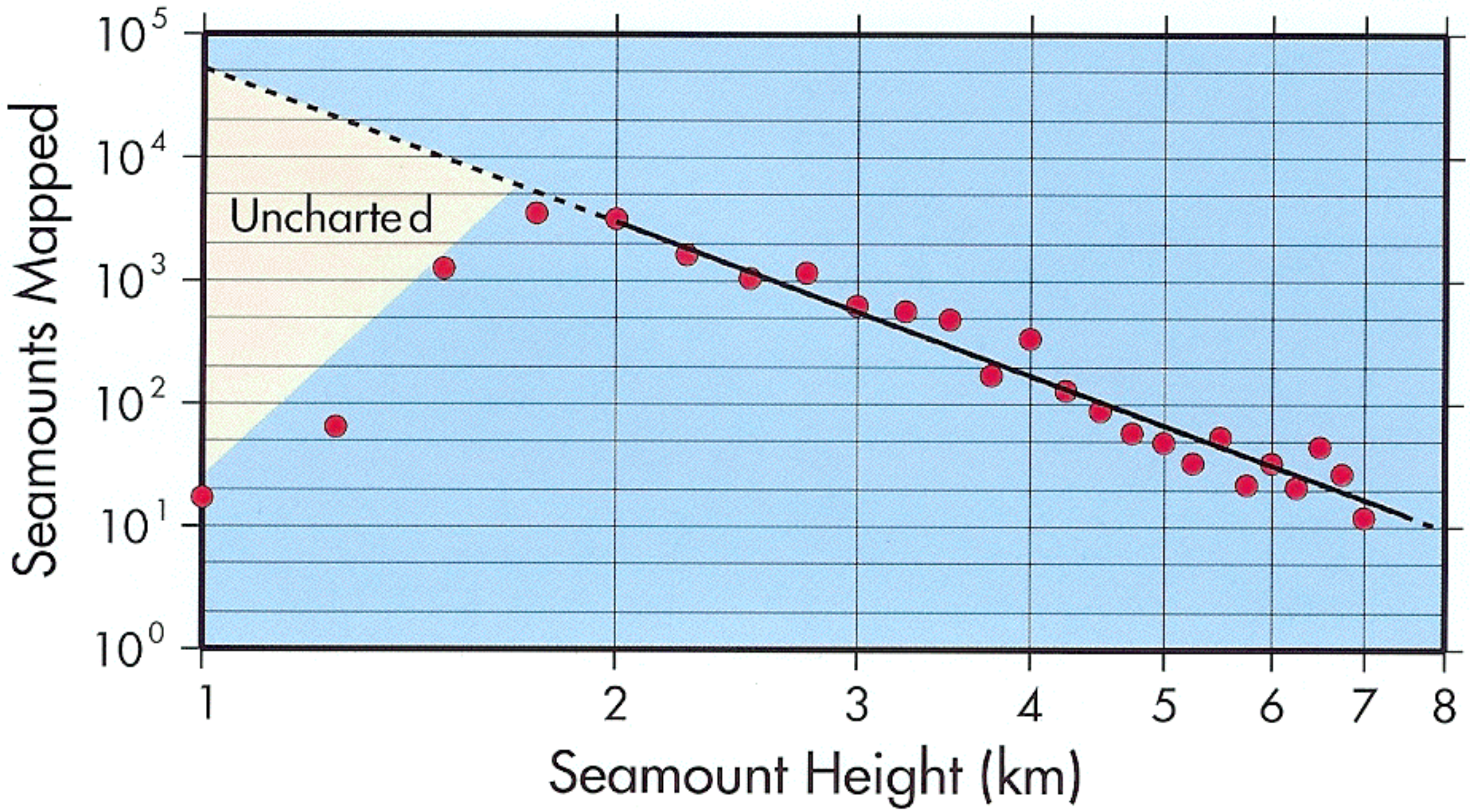
Outlook / Summary

Conventional altimetry at cross-road
Need new GM/NERM missions and/or DD instrument

DEPTH ISSUE
Bathymetry versus sea surface height (limited bandwith signal)
(Upward continuation is a problems – will never get all sea mounts)

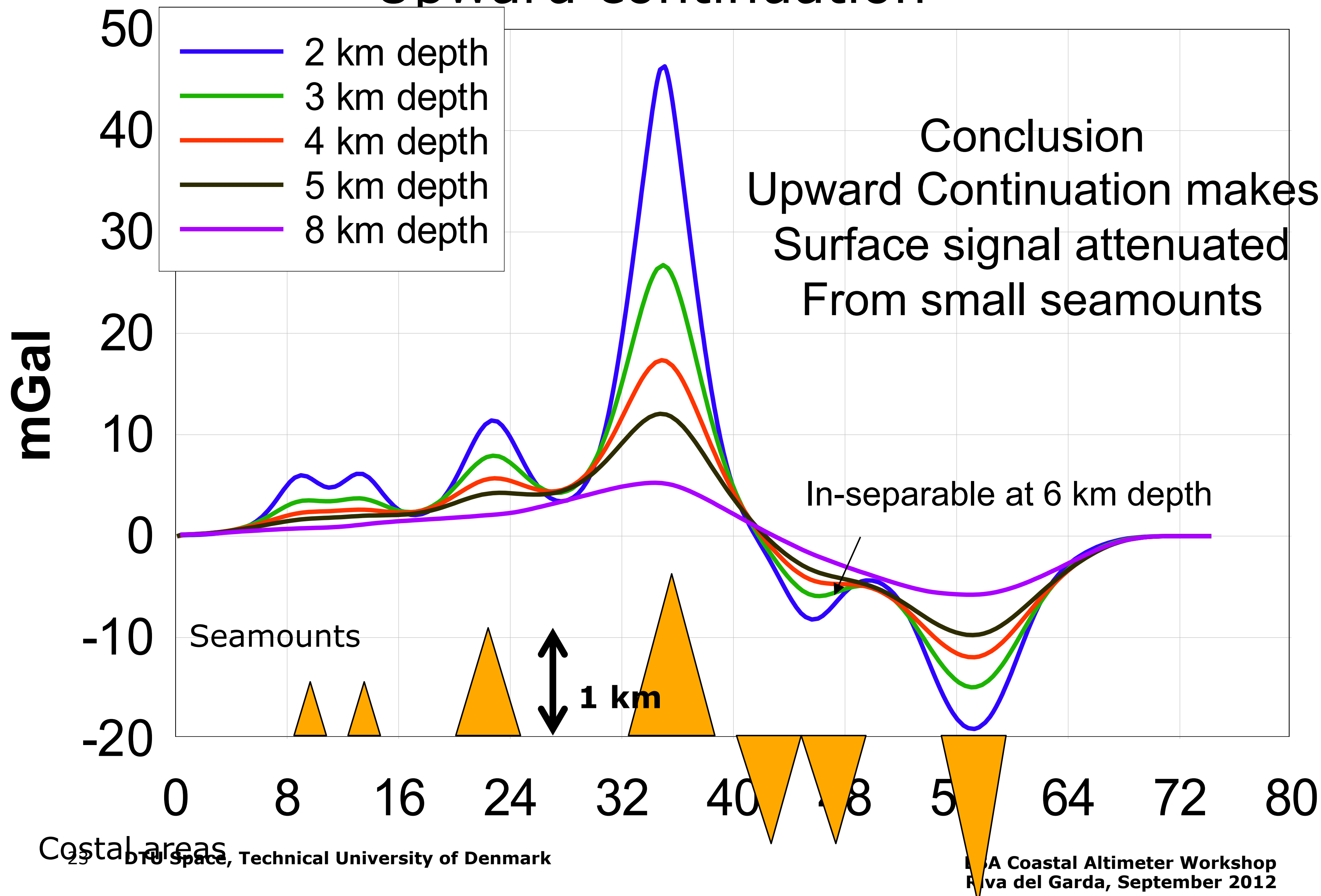
Simulations yielded optimum recovery of geophysical features at 5 Hz and 2 mGal resolution

Will be able to recover 5-10 fold of the number of sea mounts (1-2 km range) known today using CRYOSAT-II altimetry.



Defining a seamount as a undersea mountain larger than 1 km means that there is 15 TIMES as many unknown/uncharted sea mounts as charted seamounts today.

Upward continuation



Costal areas