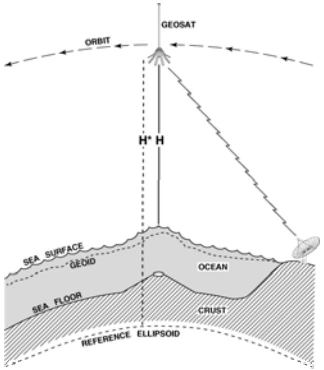
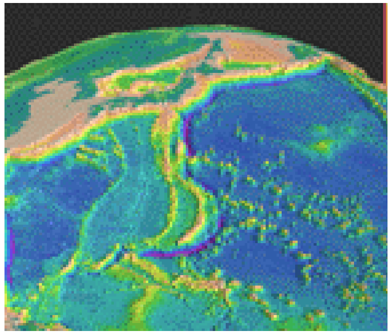


Improved Marine Gravity from CryoSat and Jason-1



David T. Sandwell, Emmanuel Garcia,
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- gravity anomalies from satellite altimetry
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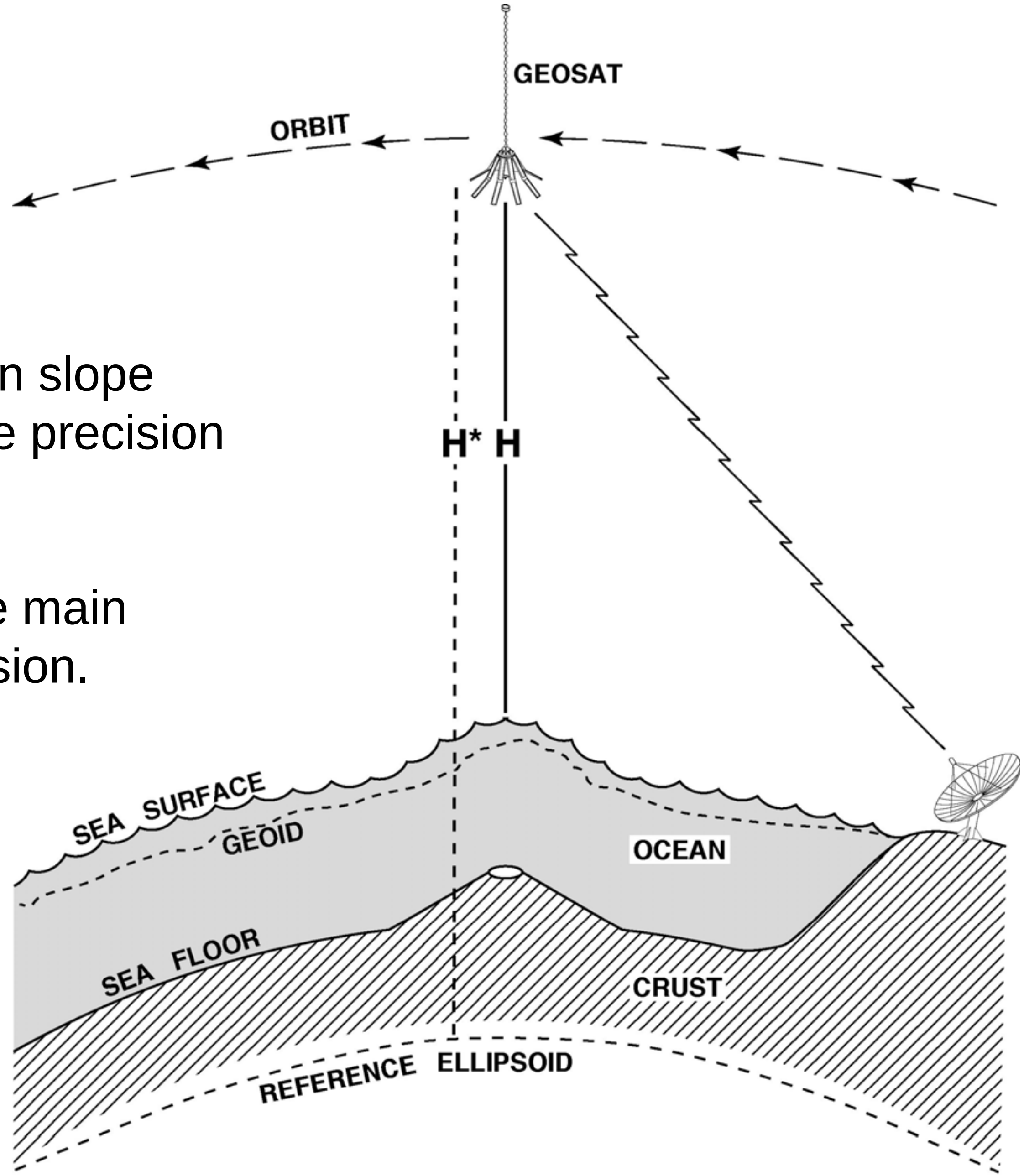
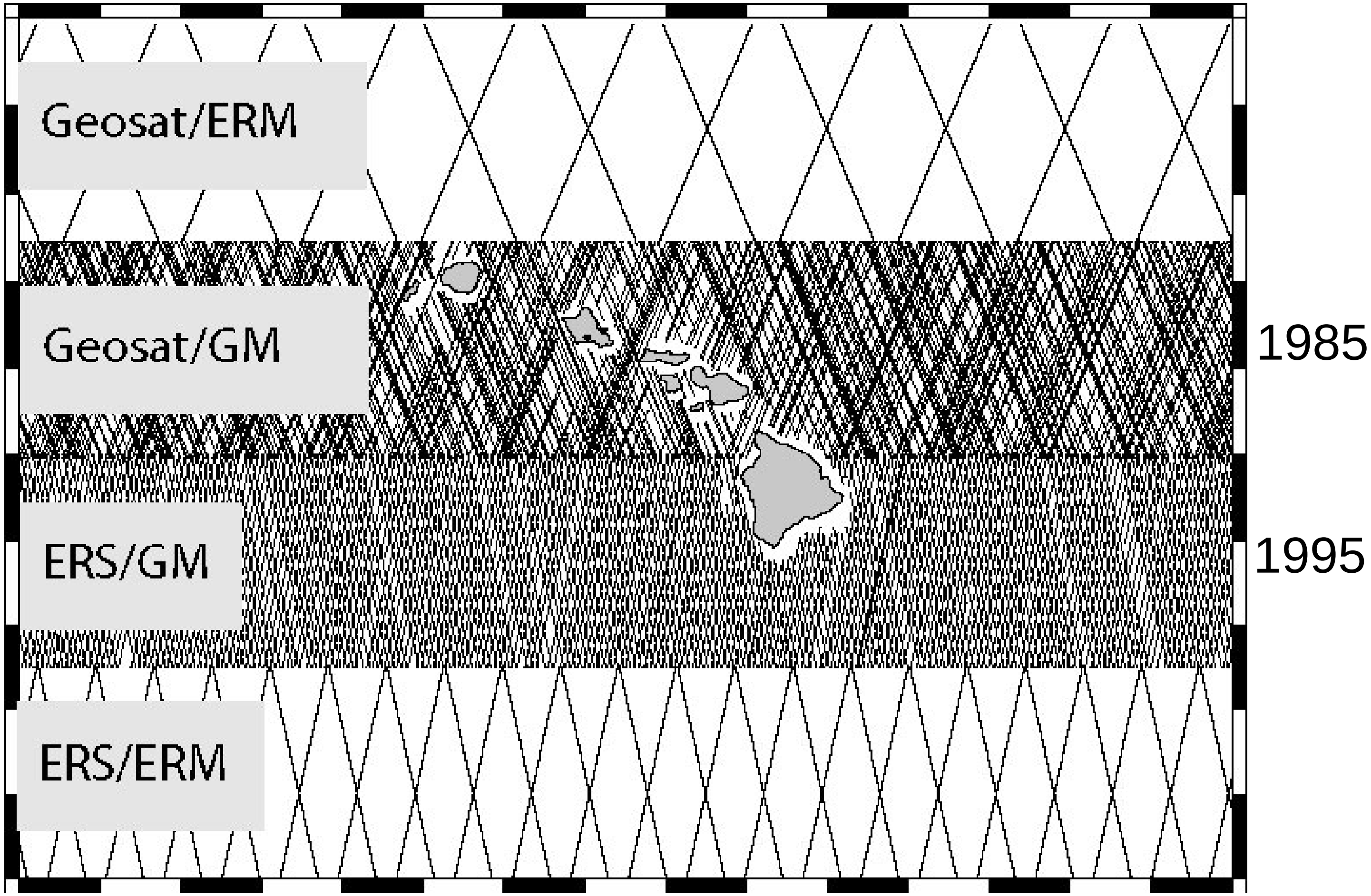
radar altimetry

Our objective of 1 microradian slope accuracy requires 1 cm range precision over 10 km distance.

Ocean surface waves are the main limiting factor on range precision.



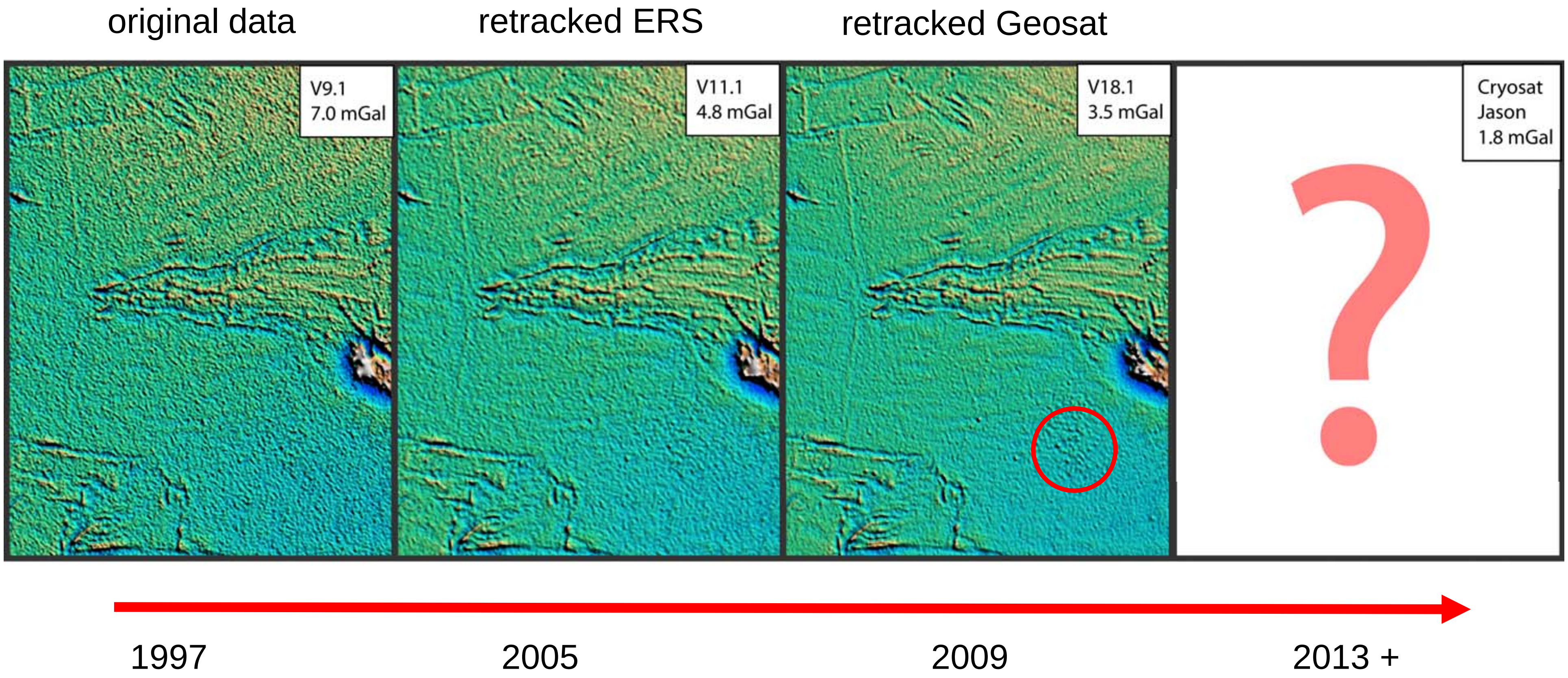
available altimeter data before CryoSat



Note - The Topex track spacing is > 200 km so it provides little new information.
GRACE and GOCE cannot resolve features smaller than 200 km.

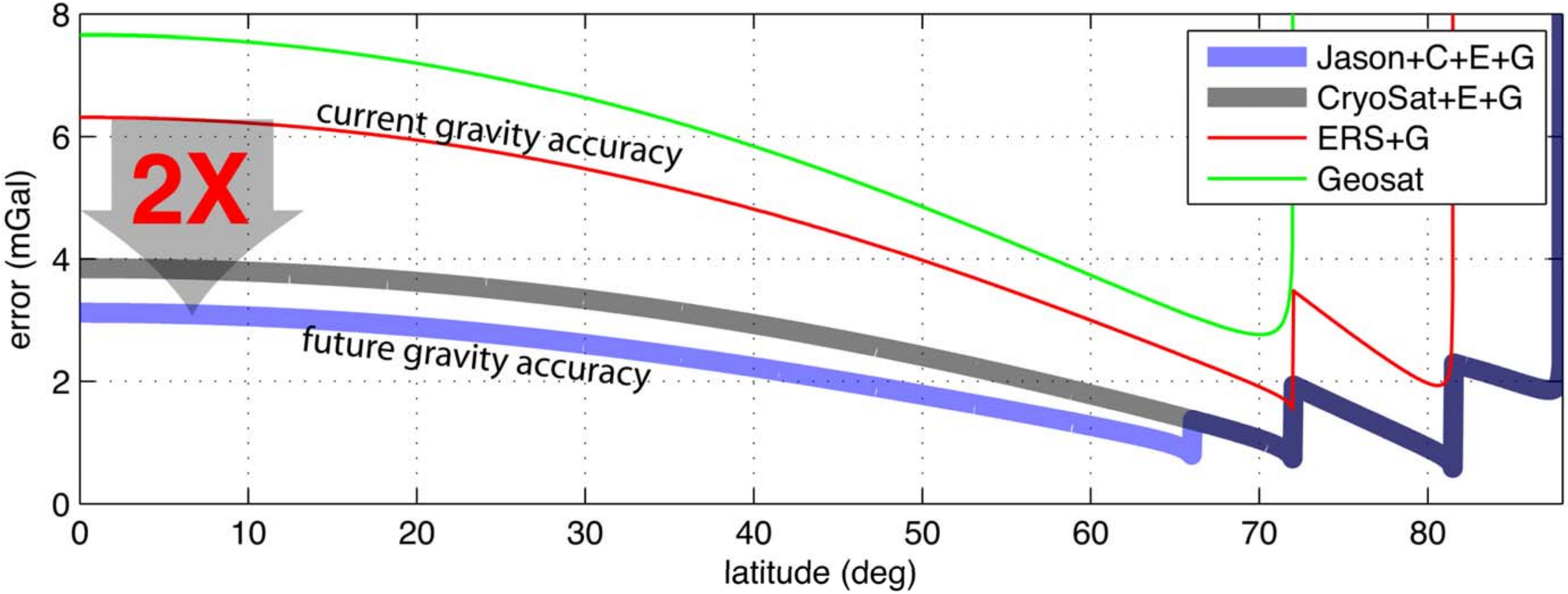
evolution of marine gravity accuracy

Evolution of marine gravity models as seen over the
Galapagos Triple Junction



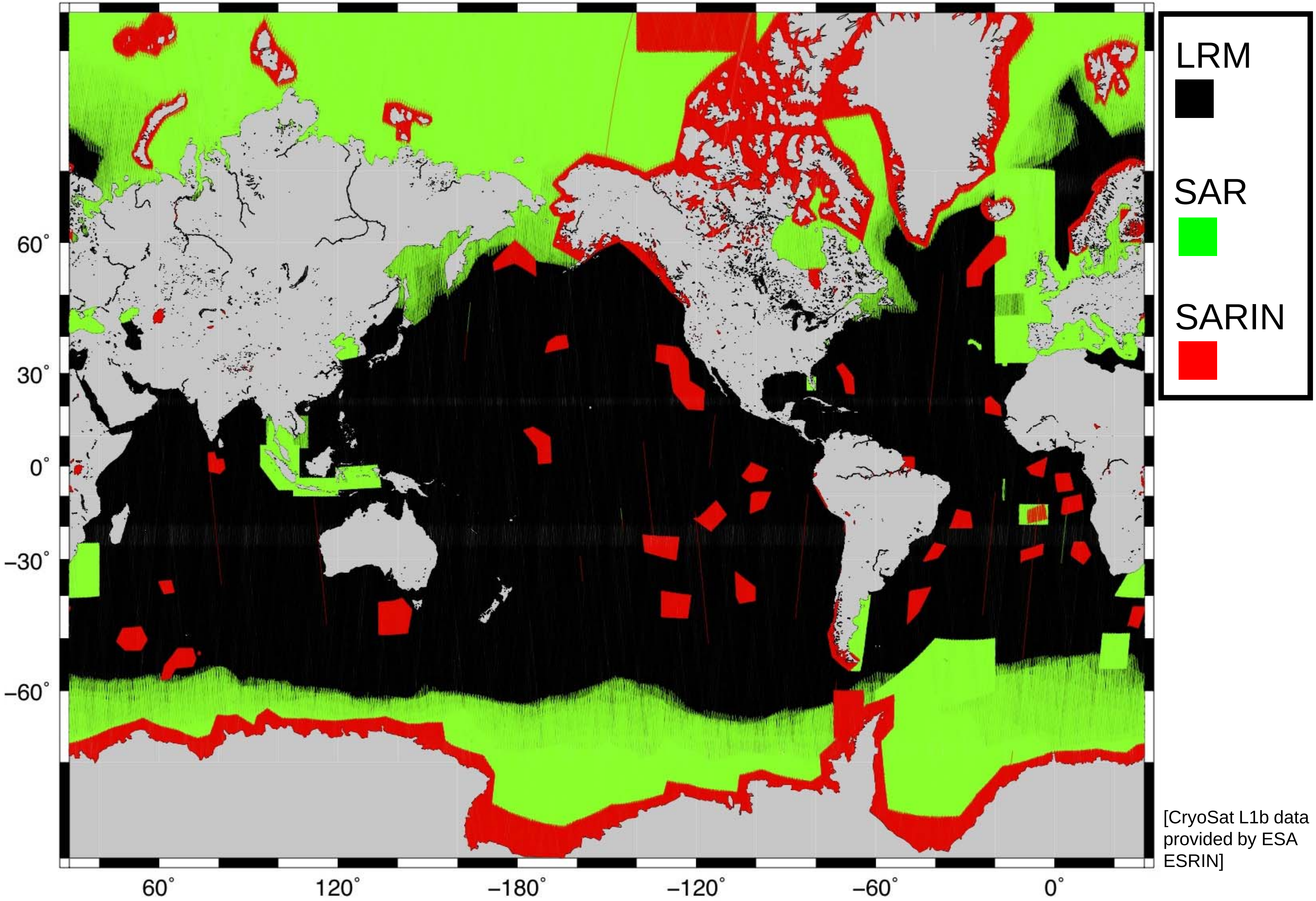
predicted gravity improvement

3 years of CryoSat and 419 days of Jason



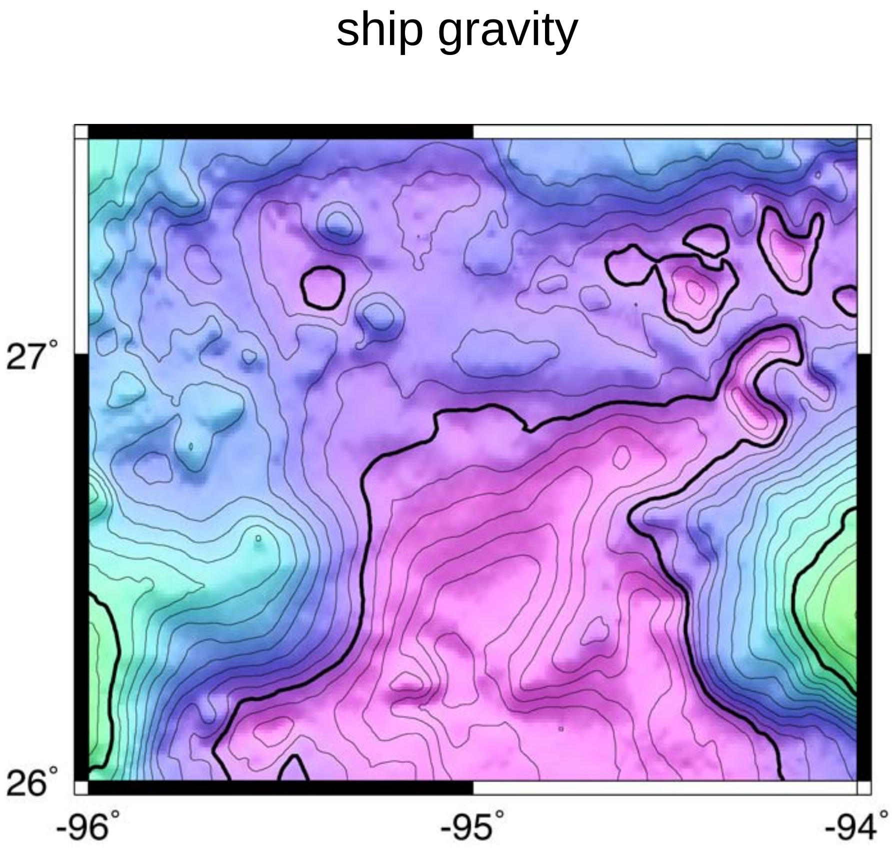
Error in north and east components was averaged.

CryoSat Data Acquisition over 13 Months

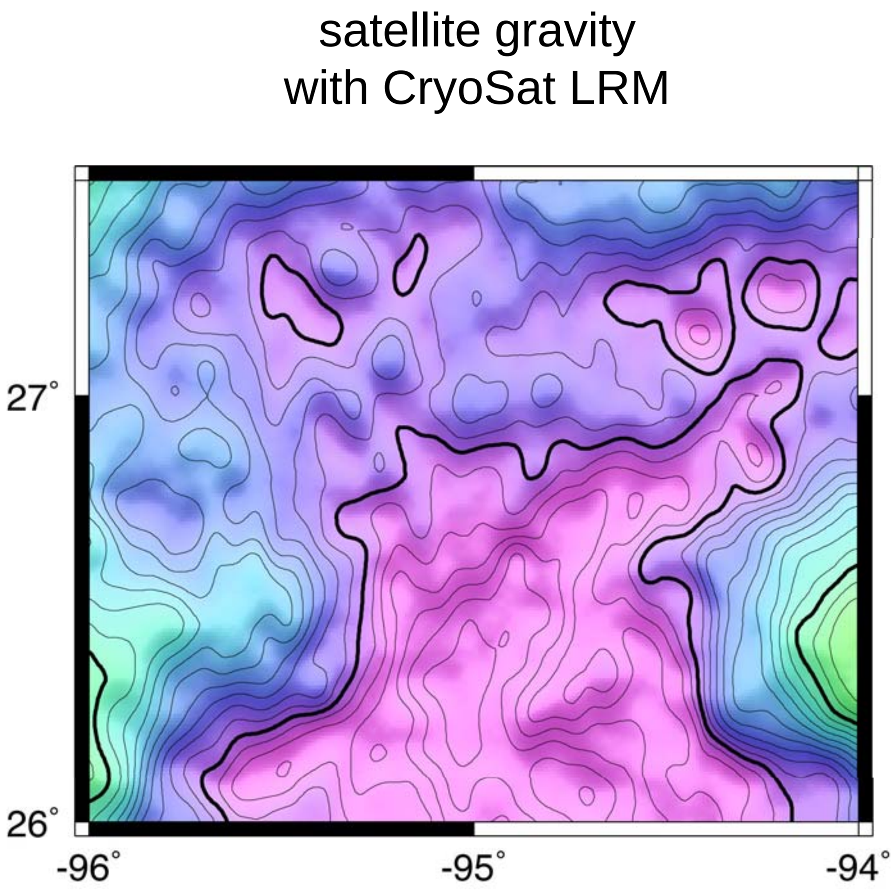


[CryoSat L1b data provided by ESA ESRIN]

Comparisons in the Gulf of Mexico



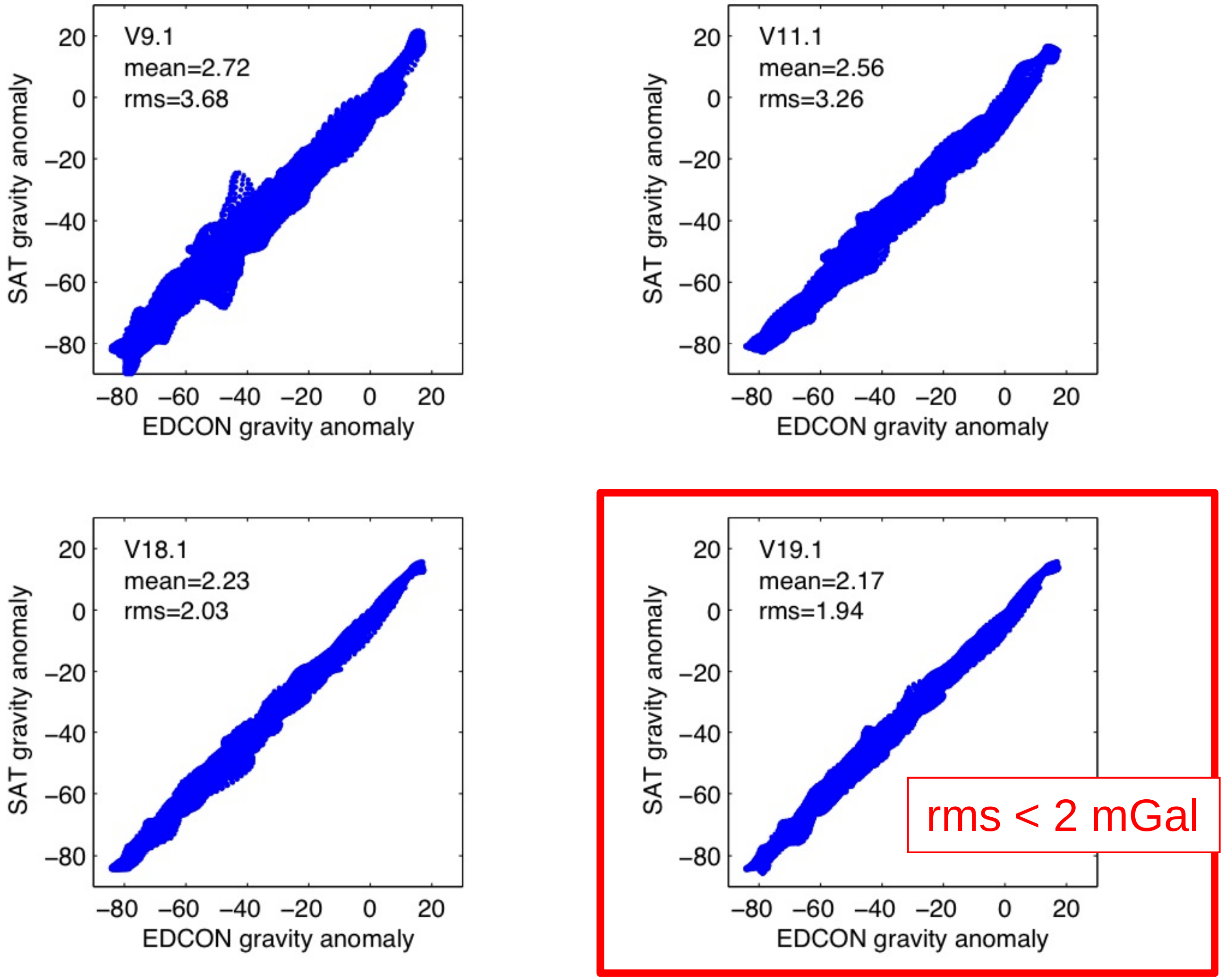
source: EDCON



5 mGal contour interval

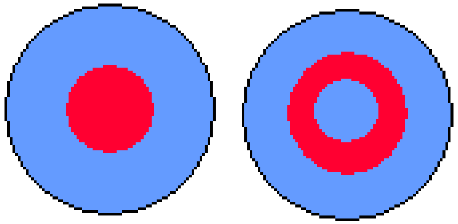
Comparisons in the Gulf of Mexico

satellite gravity with CryoSat LRM vs. ship gravity

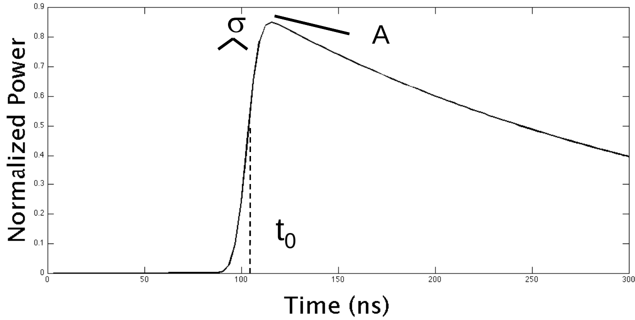


LRM Mode

Radar Footprint



Waveform Shape



Analytic Model

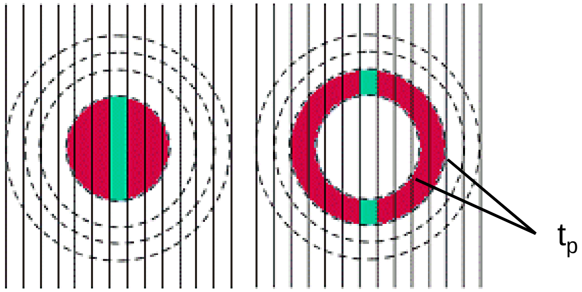
$$M(t) = \frac{A}{2}\left[1 + erf\left(\frac{t - t_0}{\sqrt{2}\sigma}\right)\right]P(t)$$

$$P(t) = \begin{cases} 1 & t < t_0 \\ e^{-\alpha(t - t_0)} & t \geq t_0 \end{cases}$$

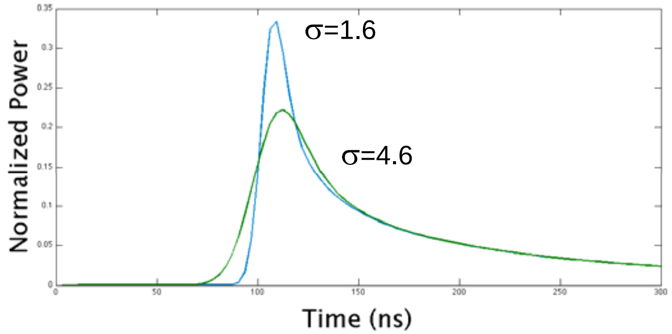
Brown (1977)

SAR Mode

analytic formulation with analytic derivatives

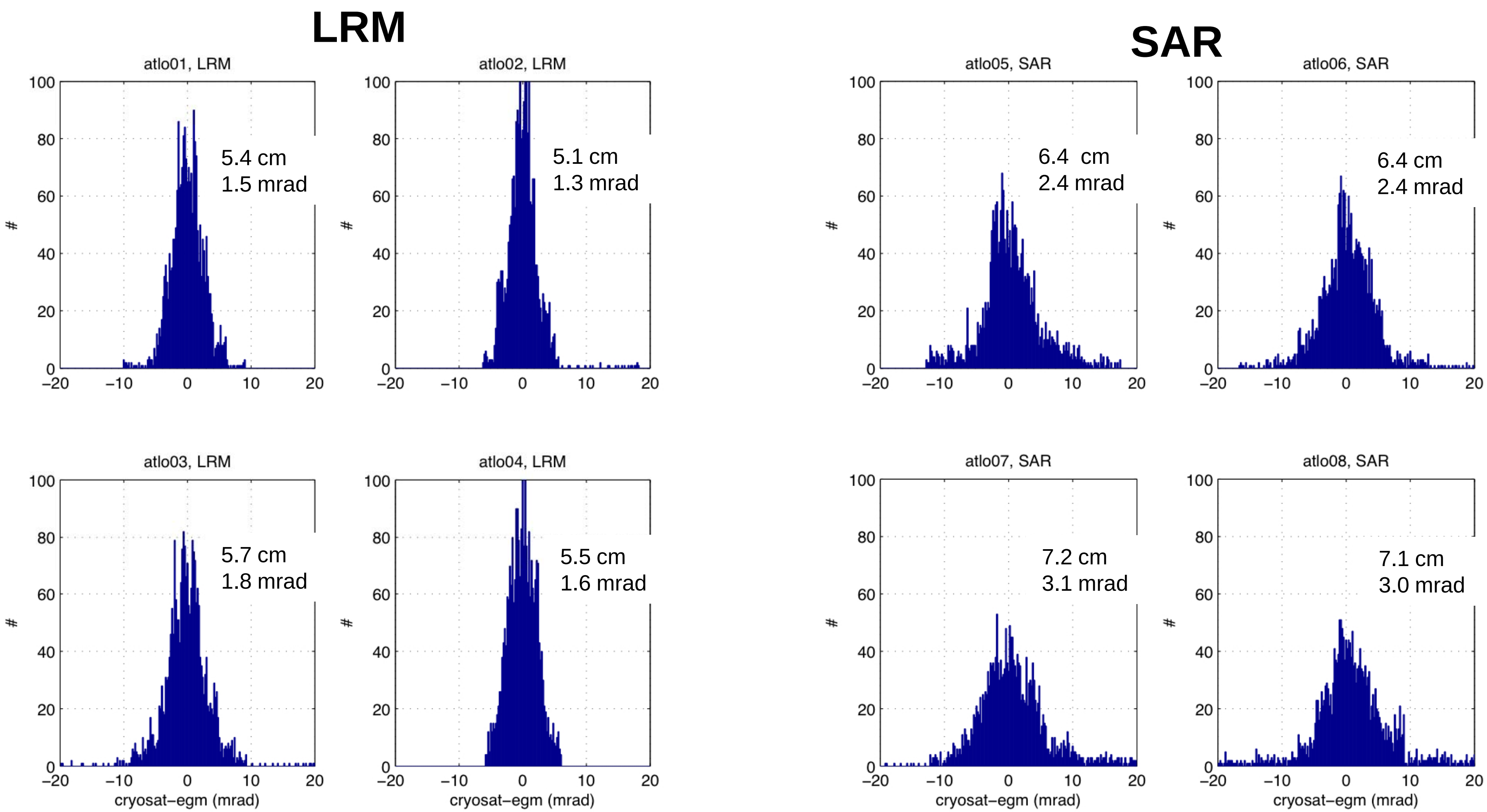


from ESA Radar Altimetry Tutorial



$$M(t) = \frac{A}{4}\sqrt{\frac{2\sigma}{t_p}}\left\{ e^{-\frac{1}{4}\left(\frac{t-t_0}{\sigma}\right)^2} D_{-\frac{3}{2}}\left(-\frac{t-t_0}{\sigma}\right) - e^{-\frac{1}{4}\left(\frac{t-t_0-t_p}{\sigma}\right)^2} D_{-\frac{3}{2}}\left(-\frac{t-t_0-t_p}{\sigma}\right) \right\} P(t)$$

$D_n(z)$ is a parabolic cylinder function of order *n*



std of 20 Hz range LRM 5.4 cm

std of 20 Hz range SAR 6.8 cm

Other groups achieve 5.5 cm and 4.9 cm std at 20 Hz for SAR mode so our fully analytic retracking model is suboptimal.

LRM

std of 20 Hz range

our group:
5.4 cm

SAR

std of 20 Hz range

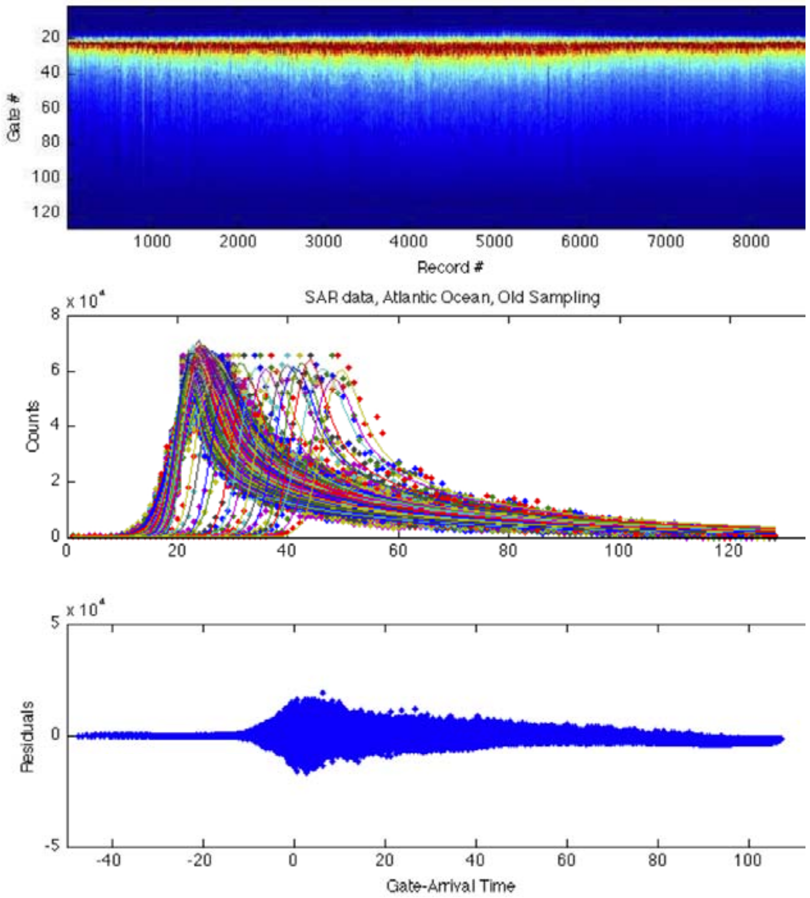
our group:
6.8 cm

other groups:
5.5 cm
4.9 cm
3.6 cm

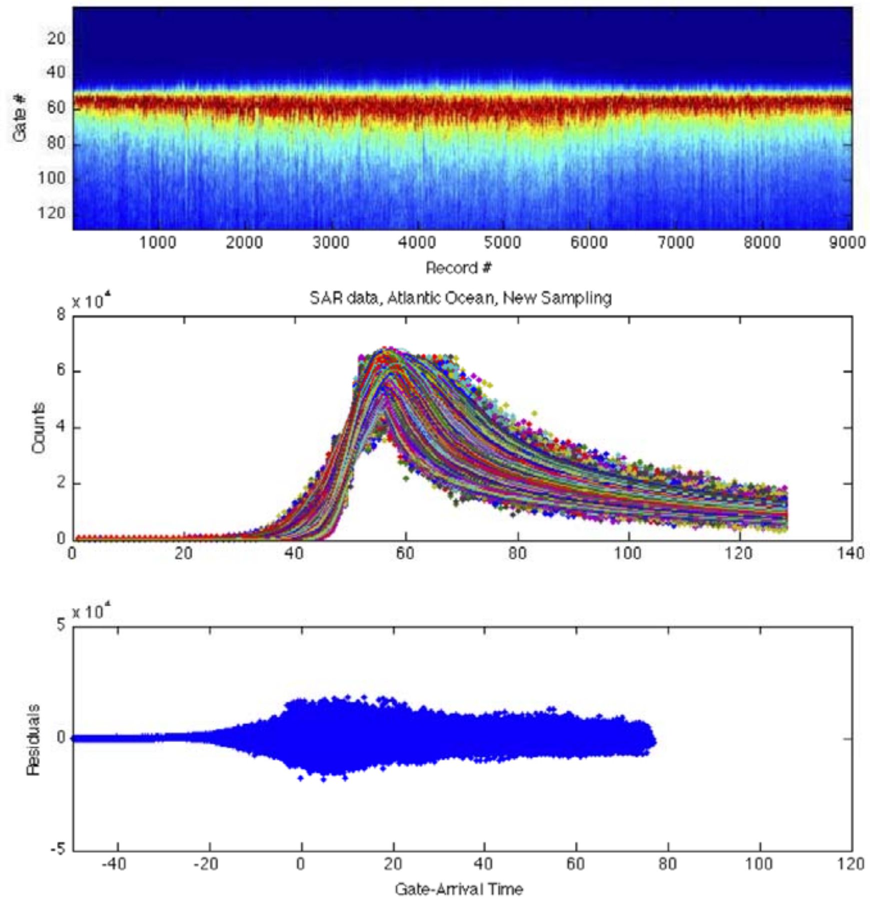
The 5.4 cm std of the 20 Hz LRM data is very close to the 4.9-5.5 cm std of the 20 Hz SAR data.

Why is the CryoSat LRM data so much better than all previous altimeters?

original gate sampling

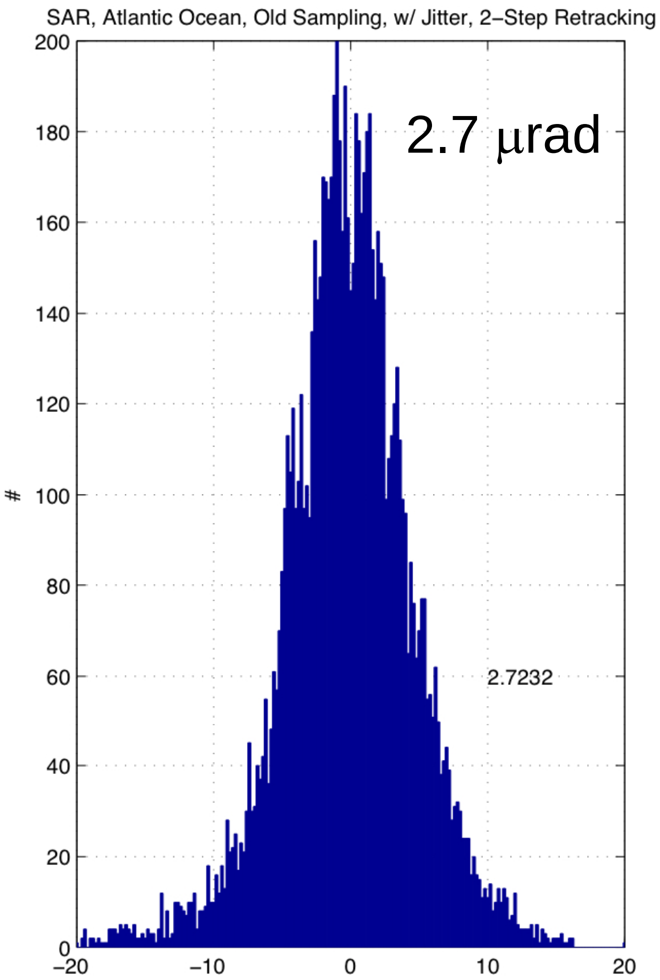


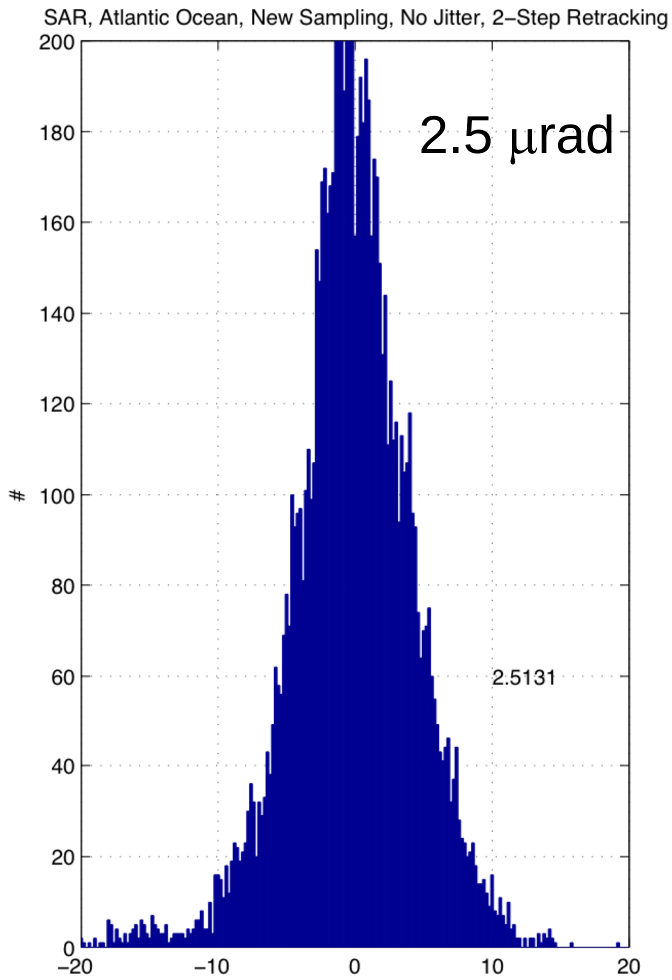
2X gate sampling and
reduced “gate jitter”
provided by Robert Cullen



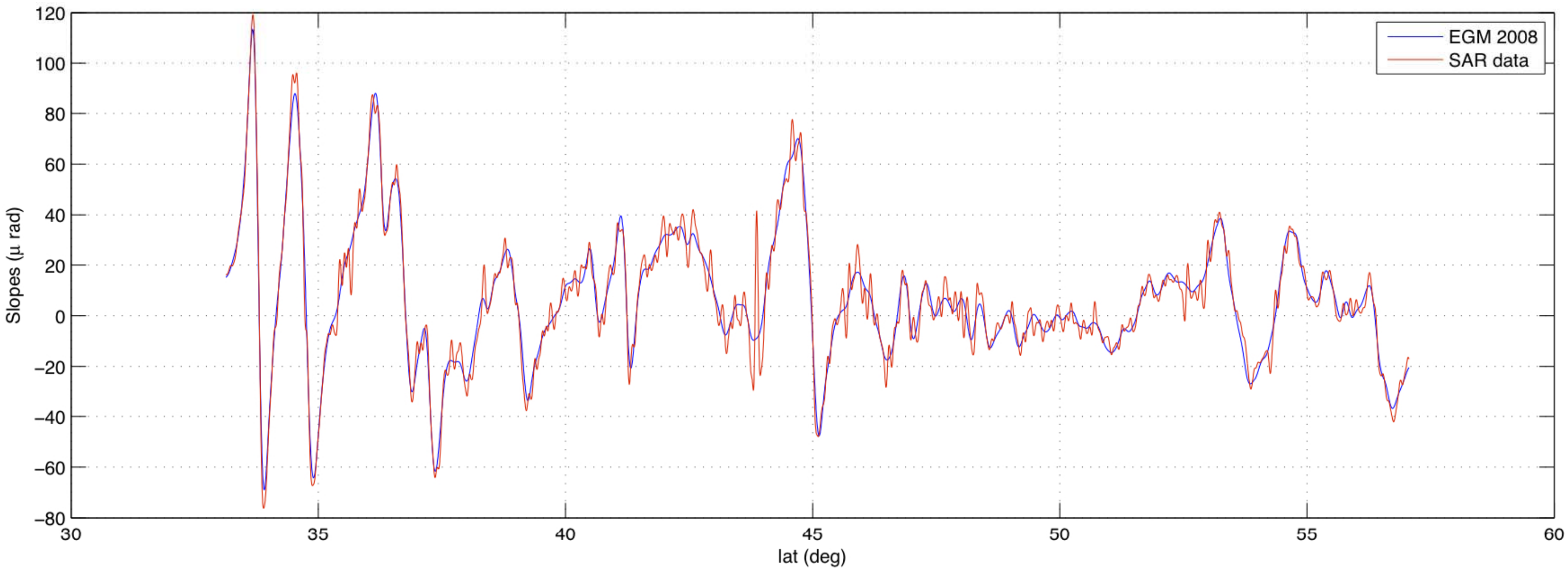
original gate sampling

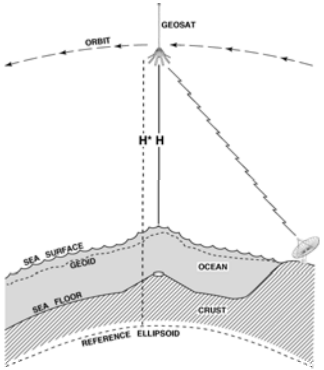
2X gate sampling and reduced “gate jitter” provided by Robert Cullen



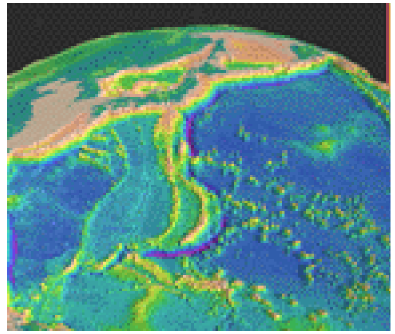


Are the short wavelength differences noise or real signal?





Improved Marine Gravity from CryoSat and Jason-1



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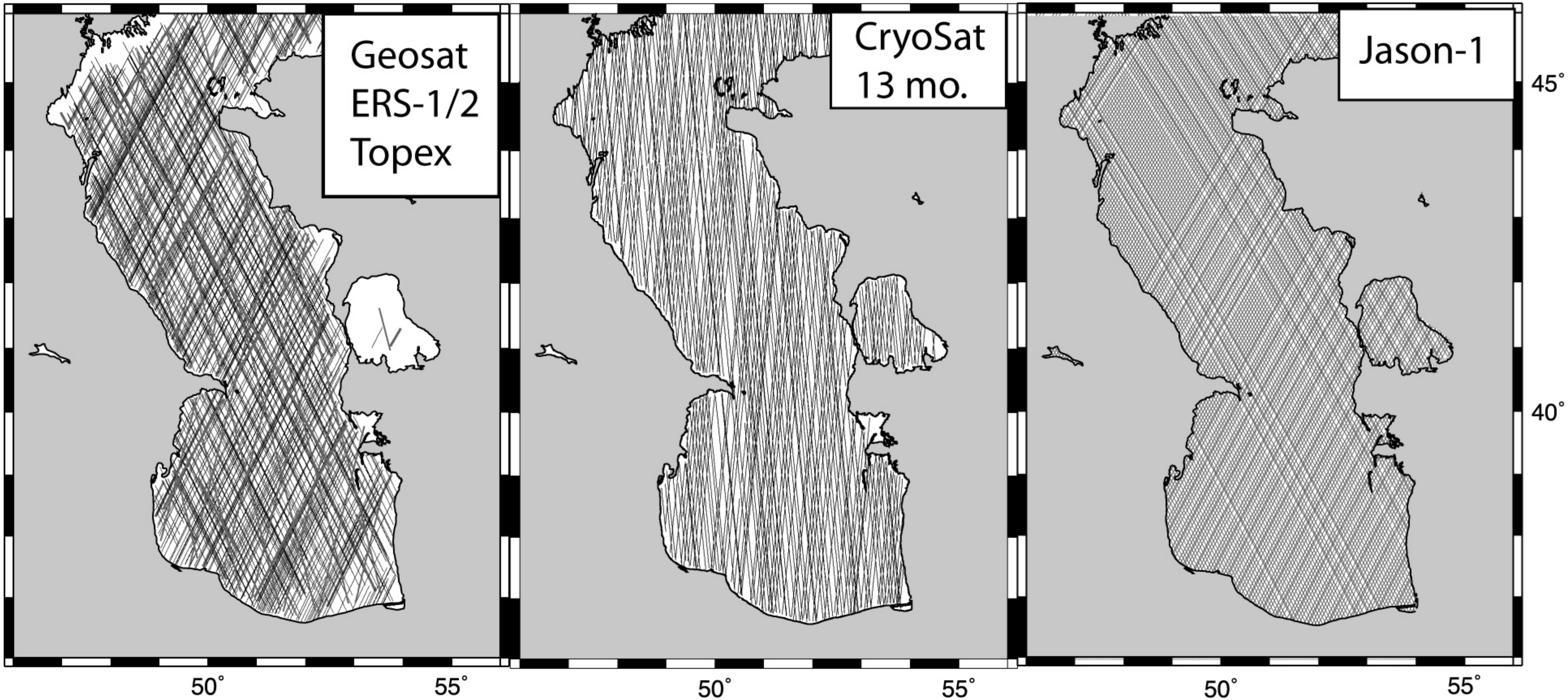
- new science from improved gravity
- Improved range precision and smaller track spacing are the critical parameters for improved gravity.
- 2X better gravity with CryoSat
- **better E-W resolution with Jason-1**

Caspian Sea

altimeter tracks

Jason-1

planed 1 yr.
419-days



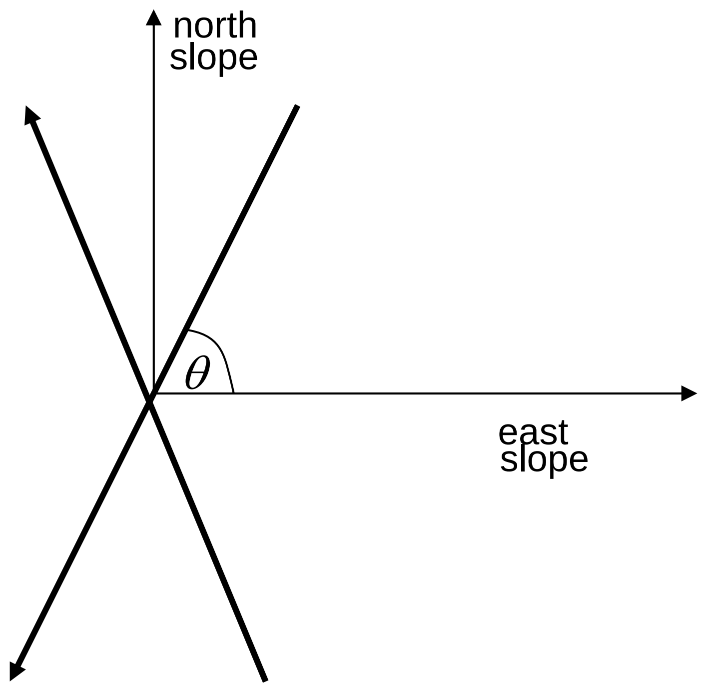
orbit inclination controls error anisotropy

- **Error propagation**
  - **θ - local inclination of track**
  - **σ - error in along-track slope**
  - **σ_x - error in east slope**
  - **σ_y - error in north slope**

$$\sigma_x = \frac{\sigma}{\sqrt{2}\cos\theta}$$

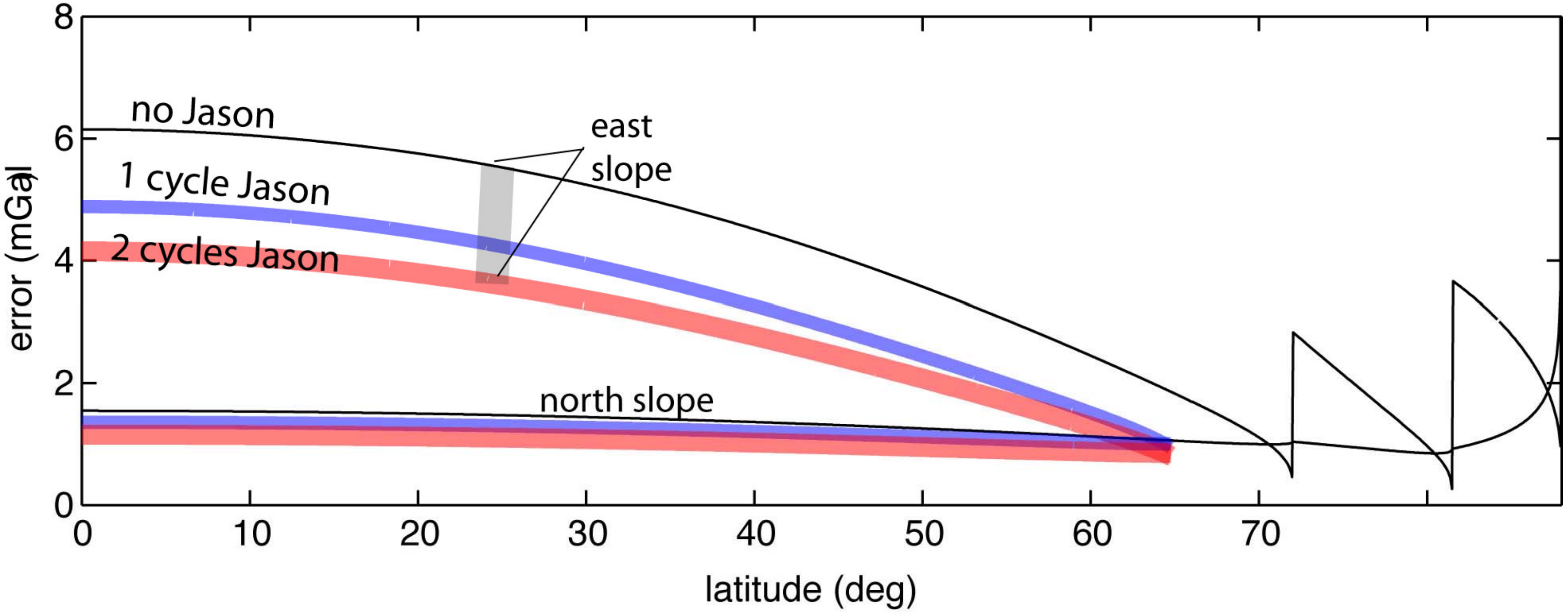
$$\sigma_y = \frac{\sigma}{\sqrt{2}\sin\theta}$$

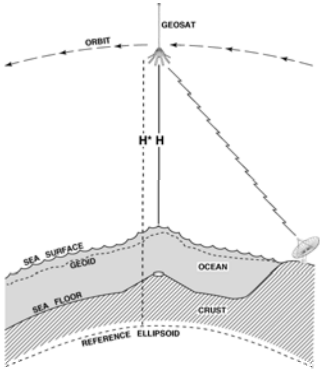
- **Orthogonal tracks are optimal**



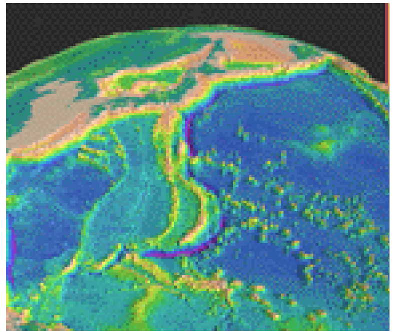
contributions from Jason-1

Without Jason, the error in the east slope component is large so N-S features such as the East Pacific Rise will be poorly resolved. One 419-day cycle provides about 25% improvement in east slope and two cycles provides about a 33% improvement. Most of the area of the earth is at latitude less than 60 degrees where Jason will make the largest improvement.





Conclusions



- CryoSat LRM data have significantly lower noise than all previous altimeters. Why?
- Our fully analytic SAR retracker is probably suboptimal.
- Smaller gate sampling will improve SAR range precision.
- We expect at least 2X better gravity with Cryosat.
- Jason-1 will provide better E-W resolution at low latitudes.