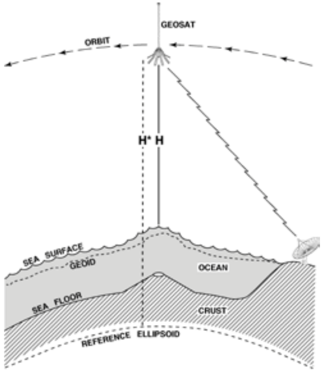

A Comparison of Altimeter Noise from Double Retracked Geosat, ERS-1, Envisat, CryoSat and Jason-1 Data

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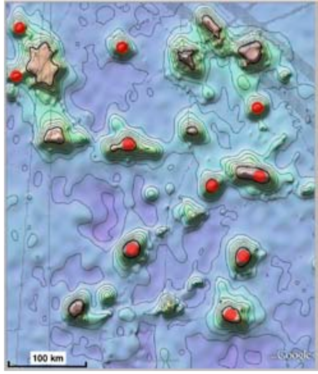

- retracking is necessary for optimal marine gravity recovery
- published studies with ERS-1 and Geosat
- applications to Envisat, CryoSat, and Jason-1
- double retracking does **not** improve SAR-mode waveforms – why??
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Published Methods for Improved Range Precision

Geophys. J. Int. (1998) **134,** 243–253

Improved ocean-geoid resolution from retracked ERS-1 satellite altimeter waveforms

Stefan Maus,[1,*] Chris M. Green[2] and J. Derek Fairhead[2]
[1] *Department of Earth Sciences, University of Leeds, Leeds* LS2 9JT, *UK*
[2] *GETECH, Department of Earth Sciences, University of Leeds, Leeds* LS2 9JT, *UK*

[Maus et al., GJI, 1998]

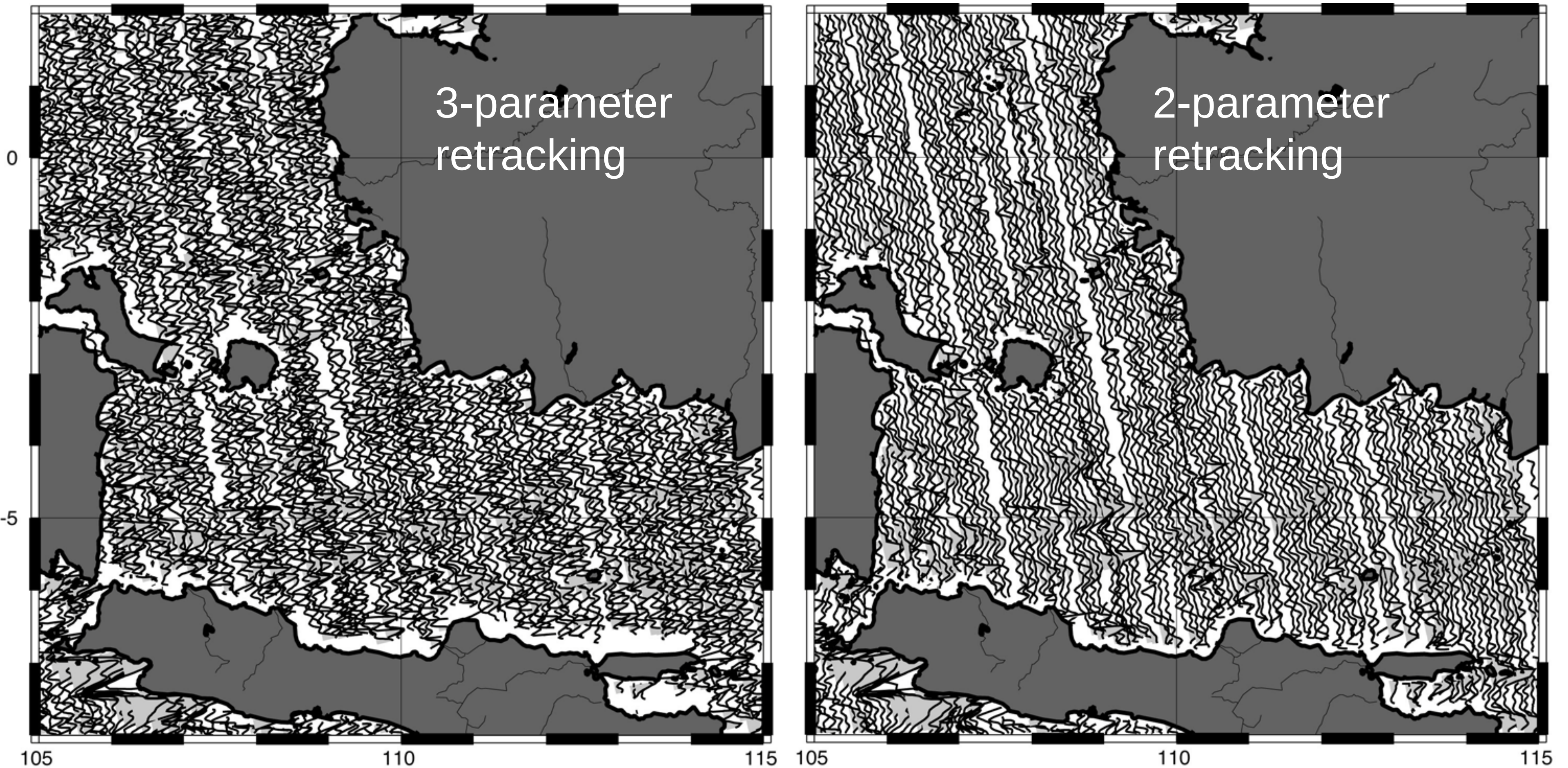
Geophys. J. Int. (2005) **163,** 79–89 doi: 10.1111/j.1365-246X.2005.02724.x

Retracking ERS-1 altimeter waveforms for optimal gravity field recovery

David T. Sandwell[1] and Walter H. F. Smith[2]
[1] *Scripps Institution of Oceanography, La Jolla, CA* 92093-0225, *USA*
[2] *National Oceanic and Atmospheric Administration, Silver Spring, MD* 20910, *USA*

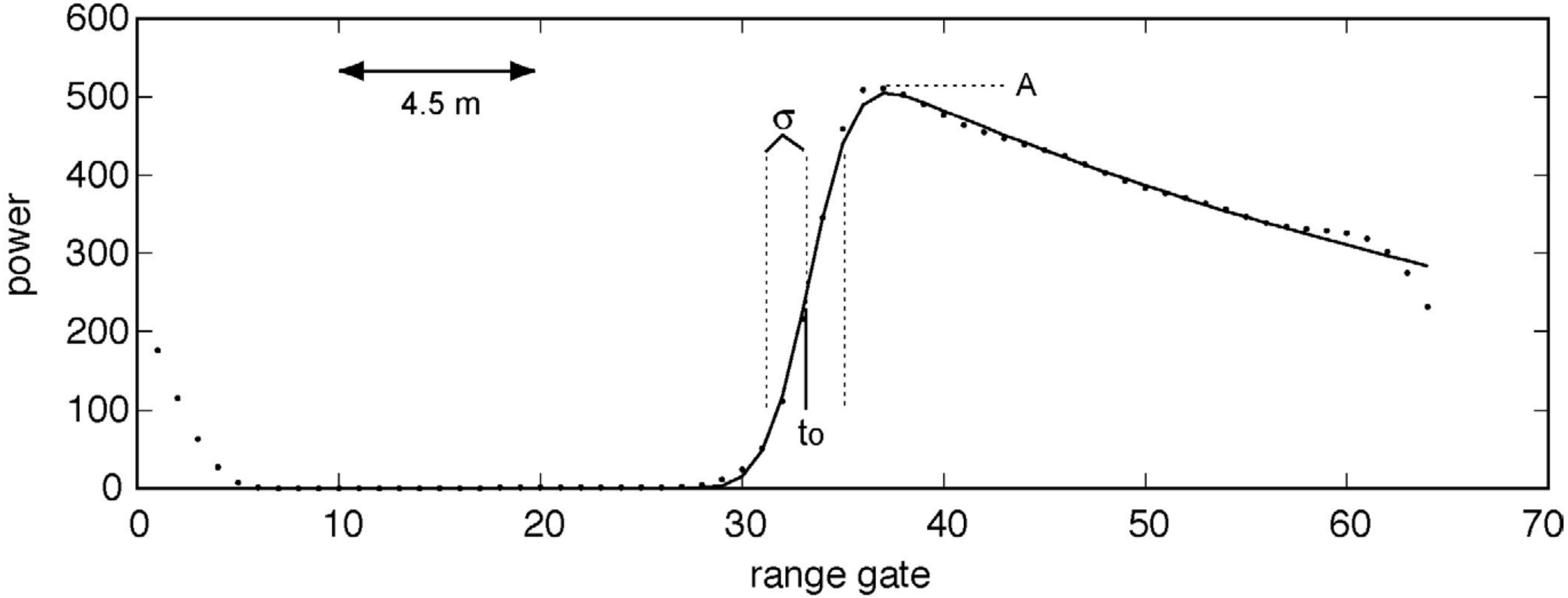
[Sandwell and Smith, GJI, 2005]

ERS slope profiles minus EGM96



[Sandwell and Smith, GJI, 2005]

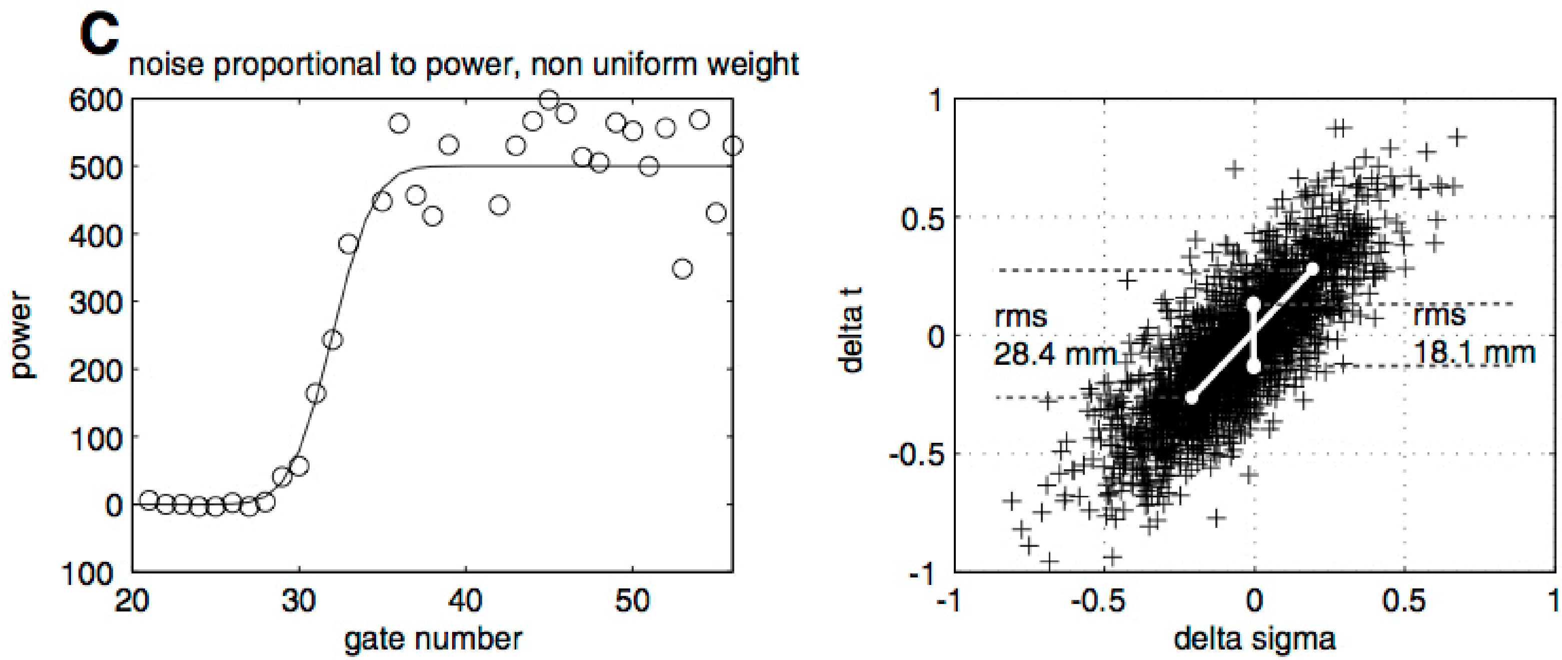
waveform retracking



Estimate 3 parameters: arrival time (t_o), wave height (σ), and power (A).

Each range gate is 454 mm long and we would like 40 mm precision!

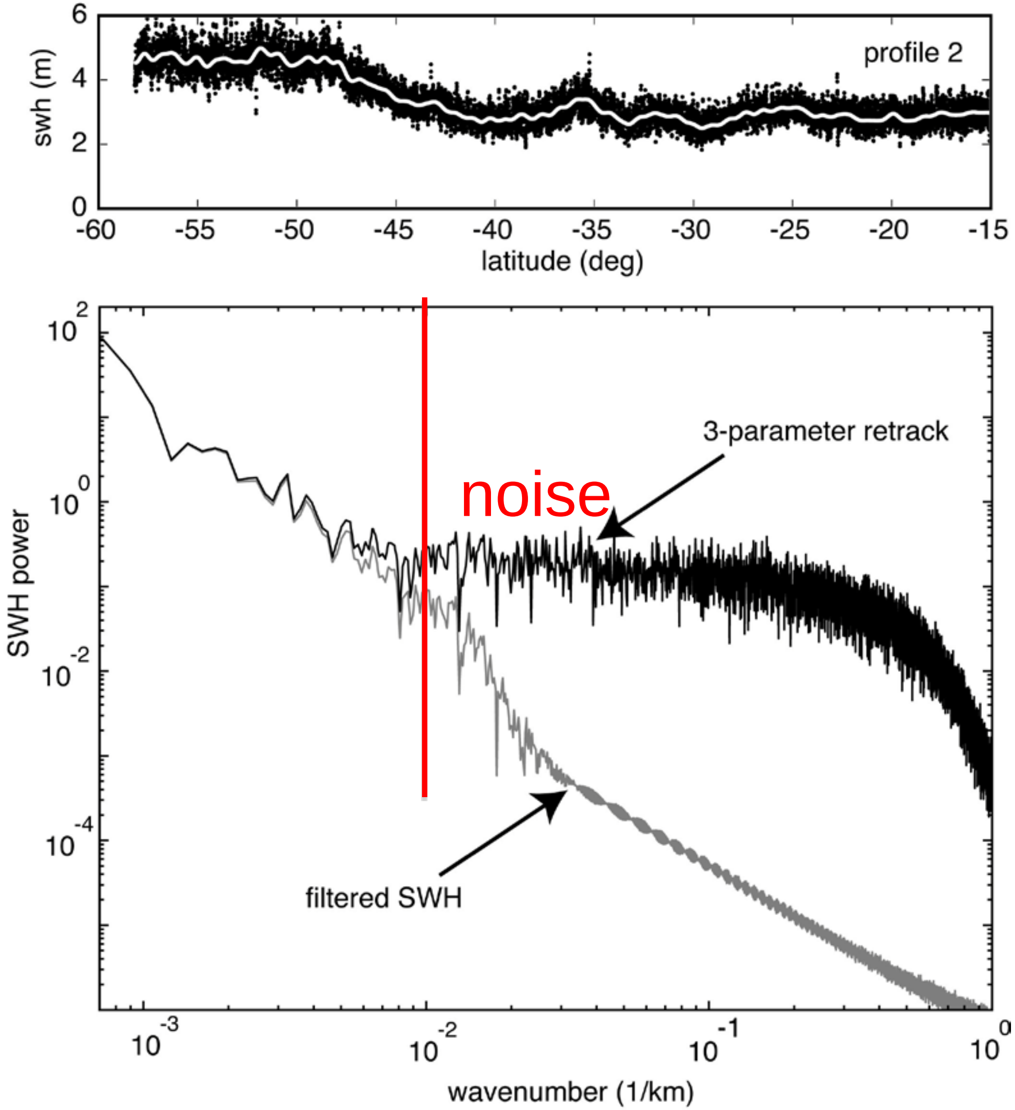
least squares correlation of arrival time and rise time



If the wave height were known then one could estimate the arrival time 1.56 times more precisely.

[Sandwell and Smith, GJI, 2005]

Power spectrum of SWH – ERS-1 shows noise floor for wavelengths < 100 km.



[Sandwell and Smith, GJI, 2005]

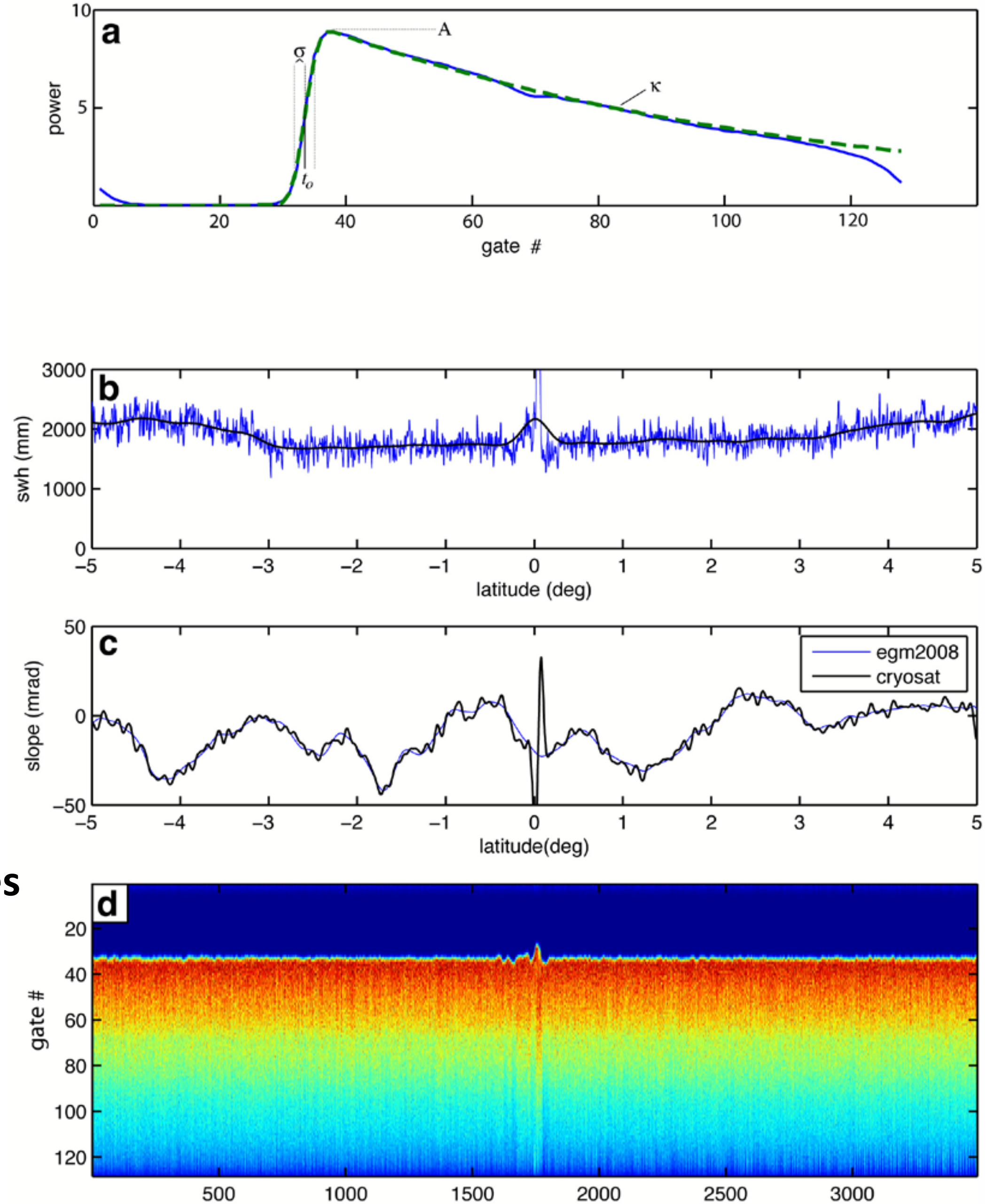
Double retracking to improve range precision

1) retrack waveforms with standard 3-parameter model

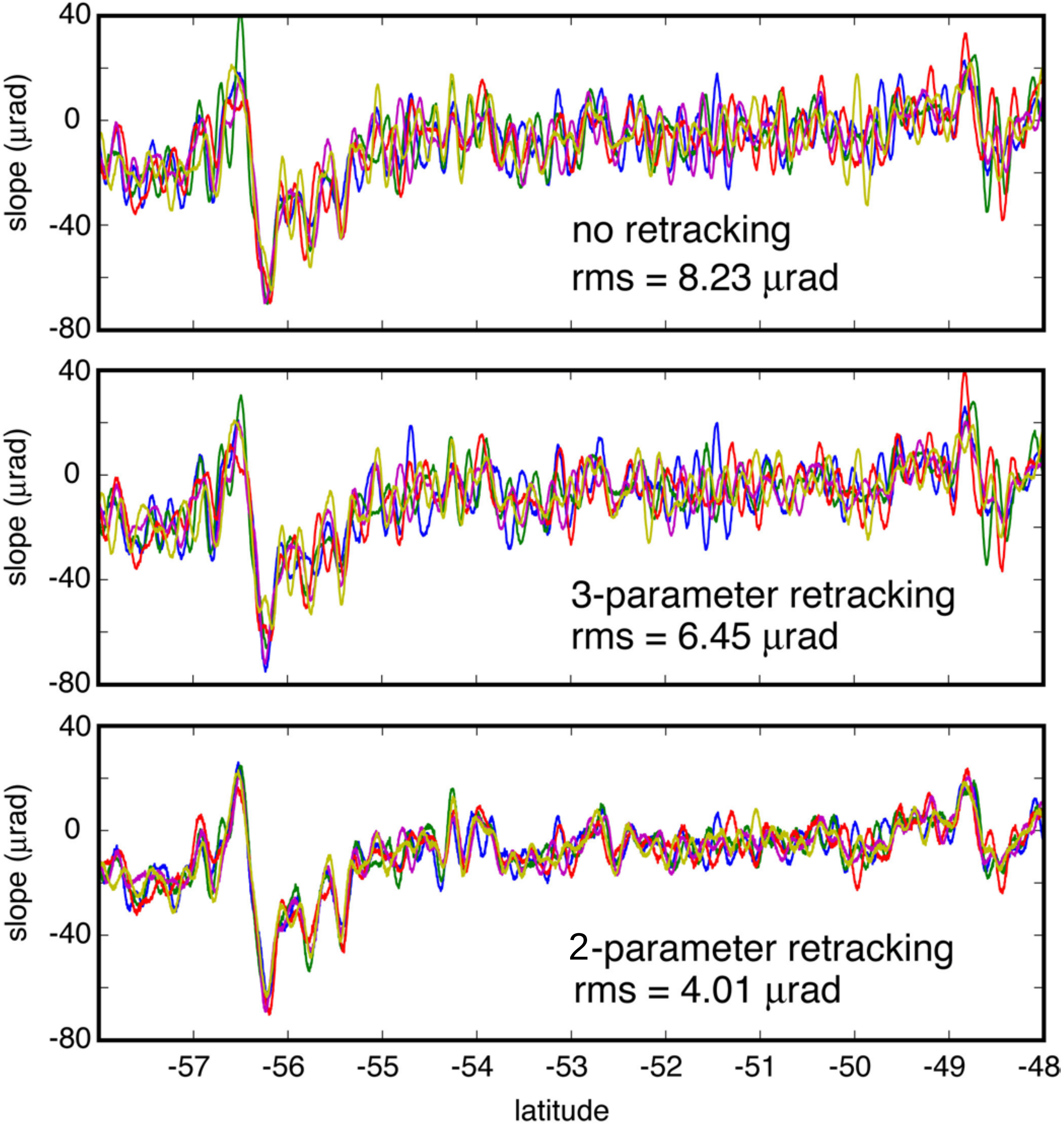
2) smooth wave height and amplitude over 40-km

3) retrack waveforms with 2-parameter model

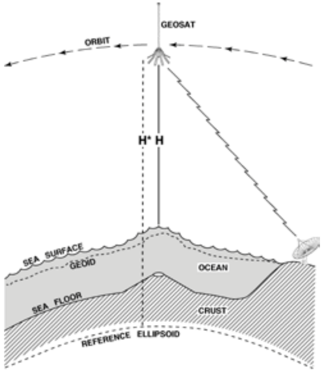
Note: this assumes wave height varies smoothly along track.



[Sandwell and Smith, GJI, 2005]



[Sandwell and Smith, GJI, 2005]



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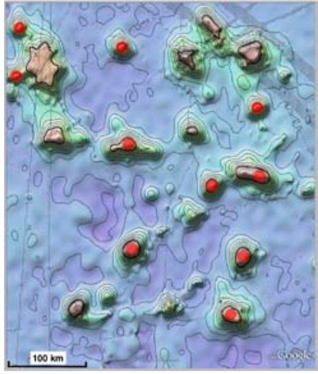

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- published studies with ERS-1 and Geosat
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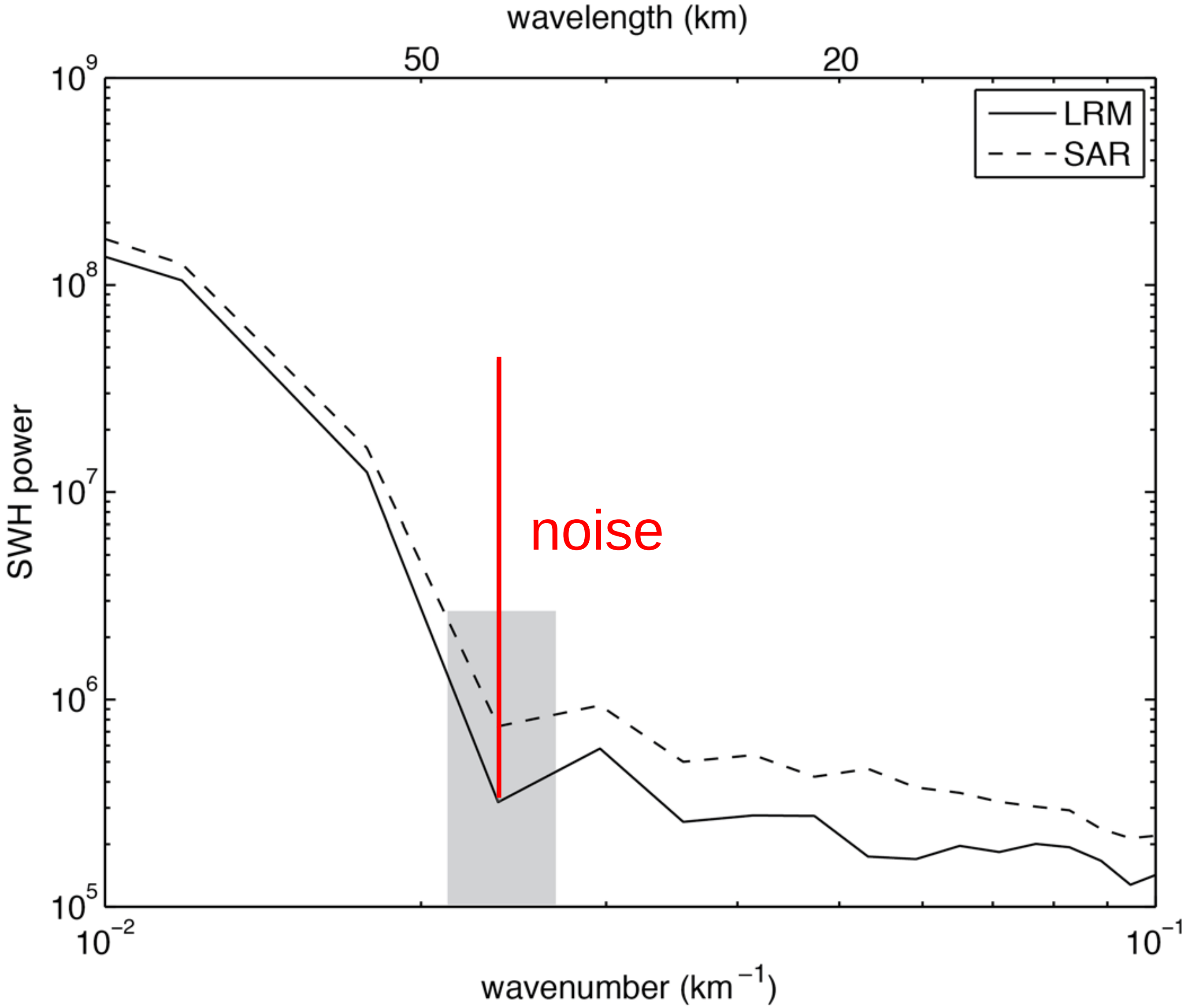
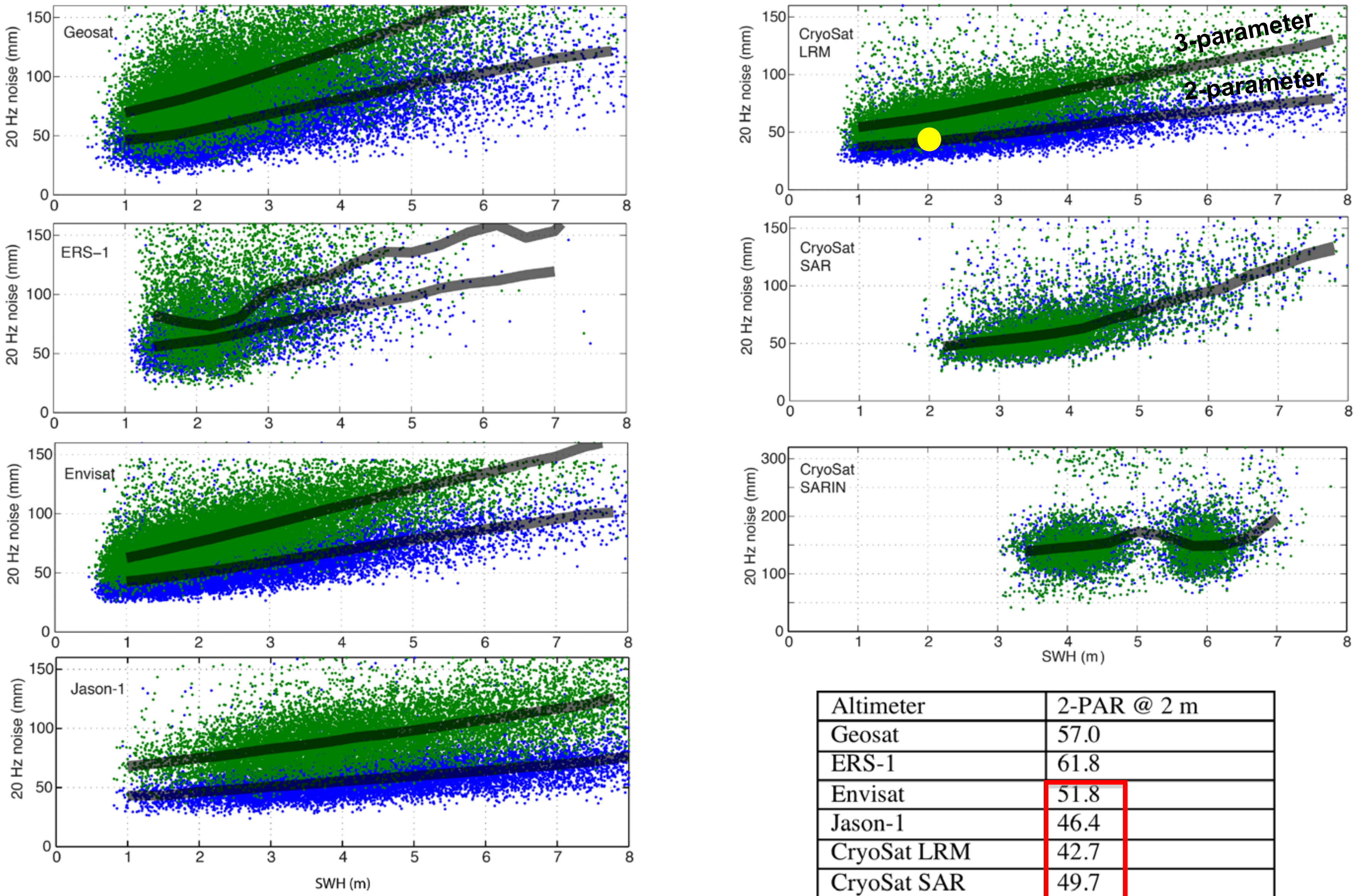
Power spectrum of SWH - CryoSat
shows noise floor for wavelengths < 46 km.



20 Hz noise of all altimeters



Altimeter	2-PAR @ 2 m
Geosat	57.0
ERS-1	61.8
Envisat	51.8
Jason-1	46.4
CryoSat LRM	42.7
CryoSat SAR	49.7
CryoSat SARIN	138.7

20 Hz noise of all altimeters

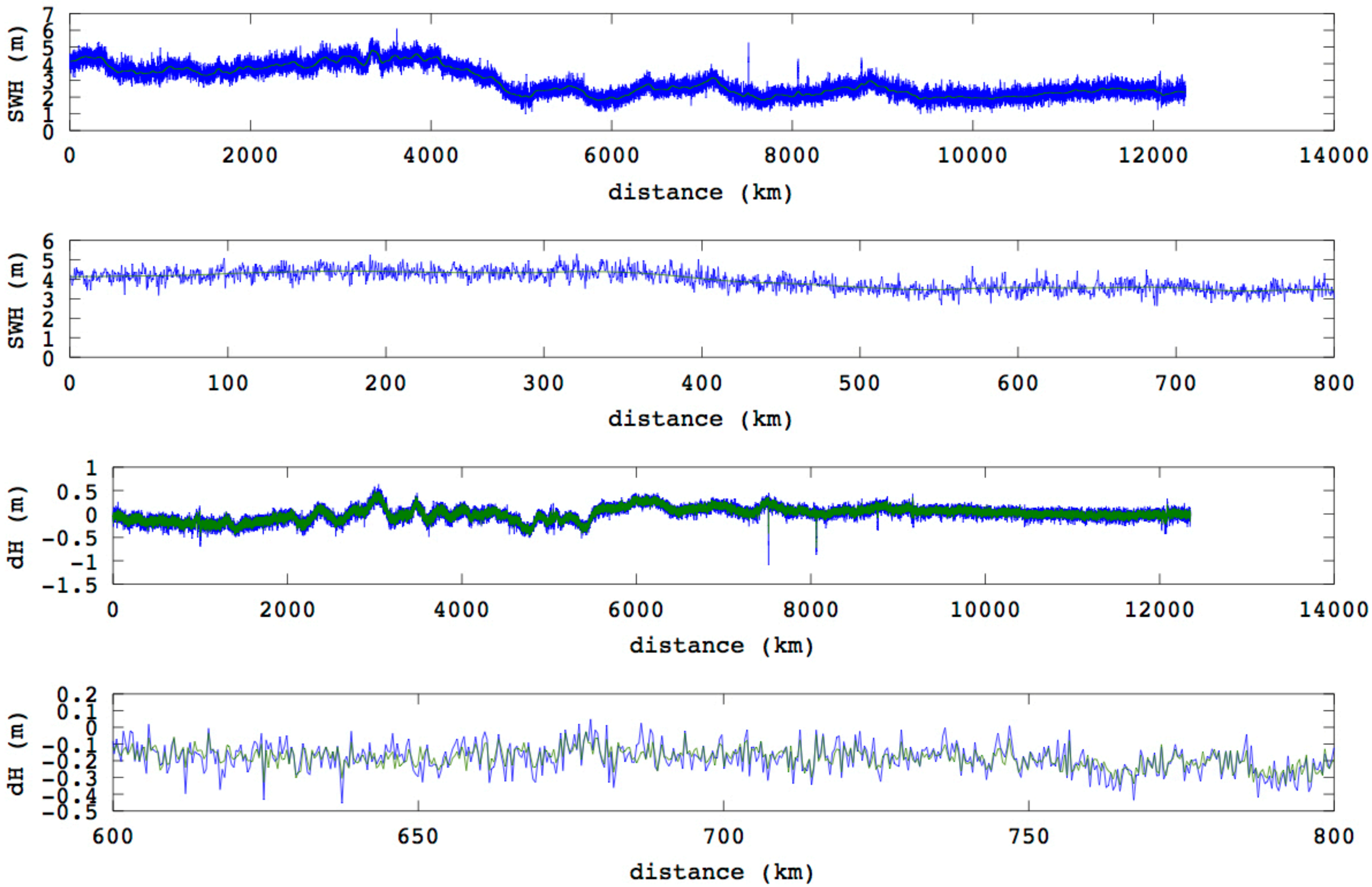
improvement factor

Table 1. 20 Hz Altimeter Noise (mm)

Altimeter	3-PAR @ 2 m	**1.56**	2-PAR @ 2 m	2 PAR @ 6 m
Geosat	88.0	1.54	57.0	105.4
ERS-1	93.6	1.54	61.8	111.8
Envisat	78.9	1.52	51.8	88.6
Jason-1	75.9	1.63	46.4	64.2
CryoSat LRM	64.7	1.52	42.7	71.7
CryoSat SAR	49.5	0.996	49.7	110.9
CryoSat SARIN	138.5	0.998	138.7	148.6

Standard deviation of retracked 20 Hz height estimates with respect to EGM2008 (mean removed). The data are from a region of the North Atlantic with relatively high sea state. The values represent the median of thousands of estimates over a 0.4 m range of SWH. The 10Hz Geosat estimates were scaled by 1.41 to approximate the errors in at a higher sampling rate.

Jason-1 Example, “The Spectral Hump”



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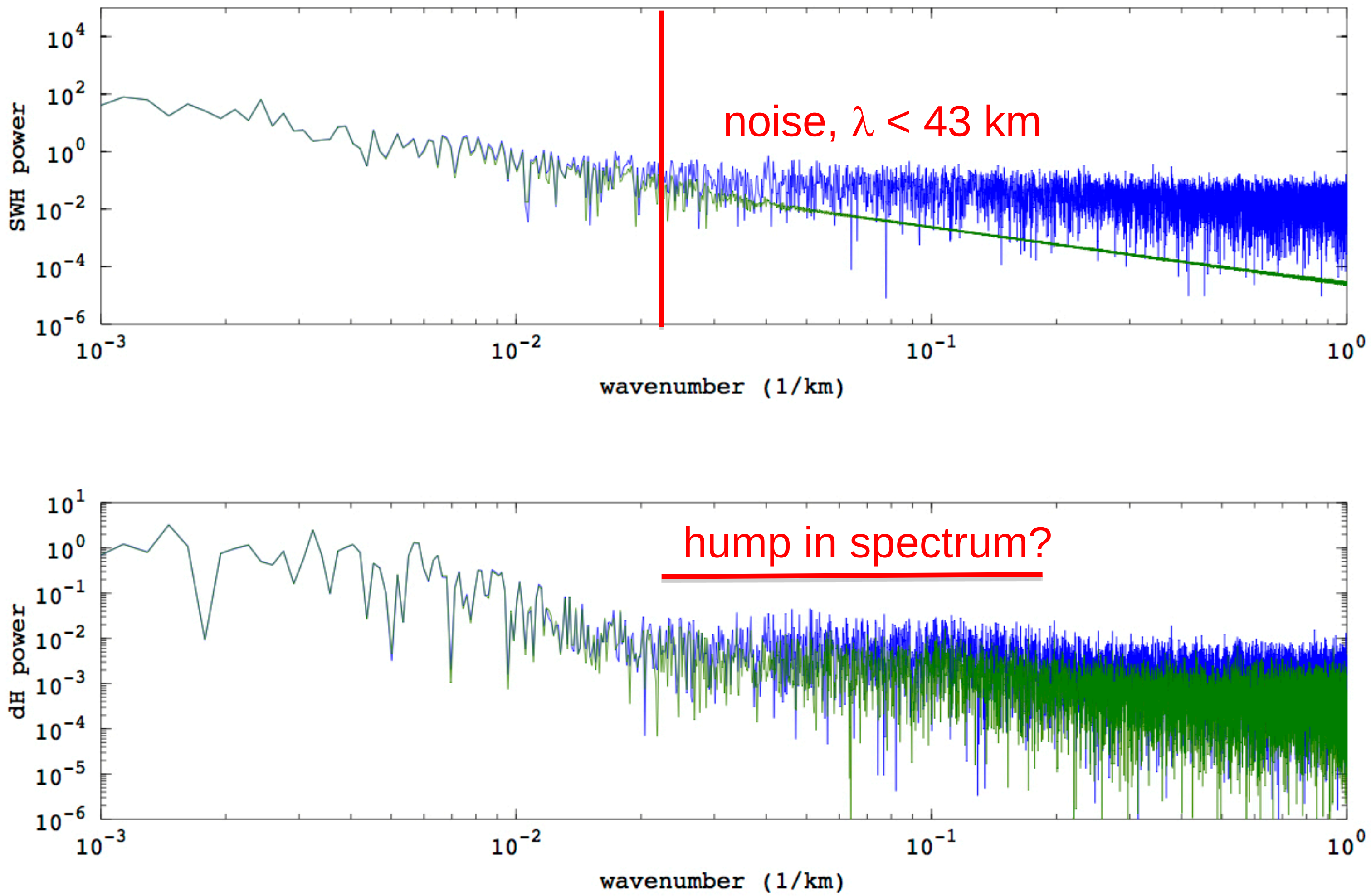
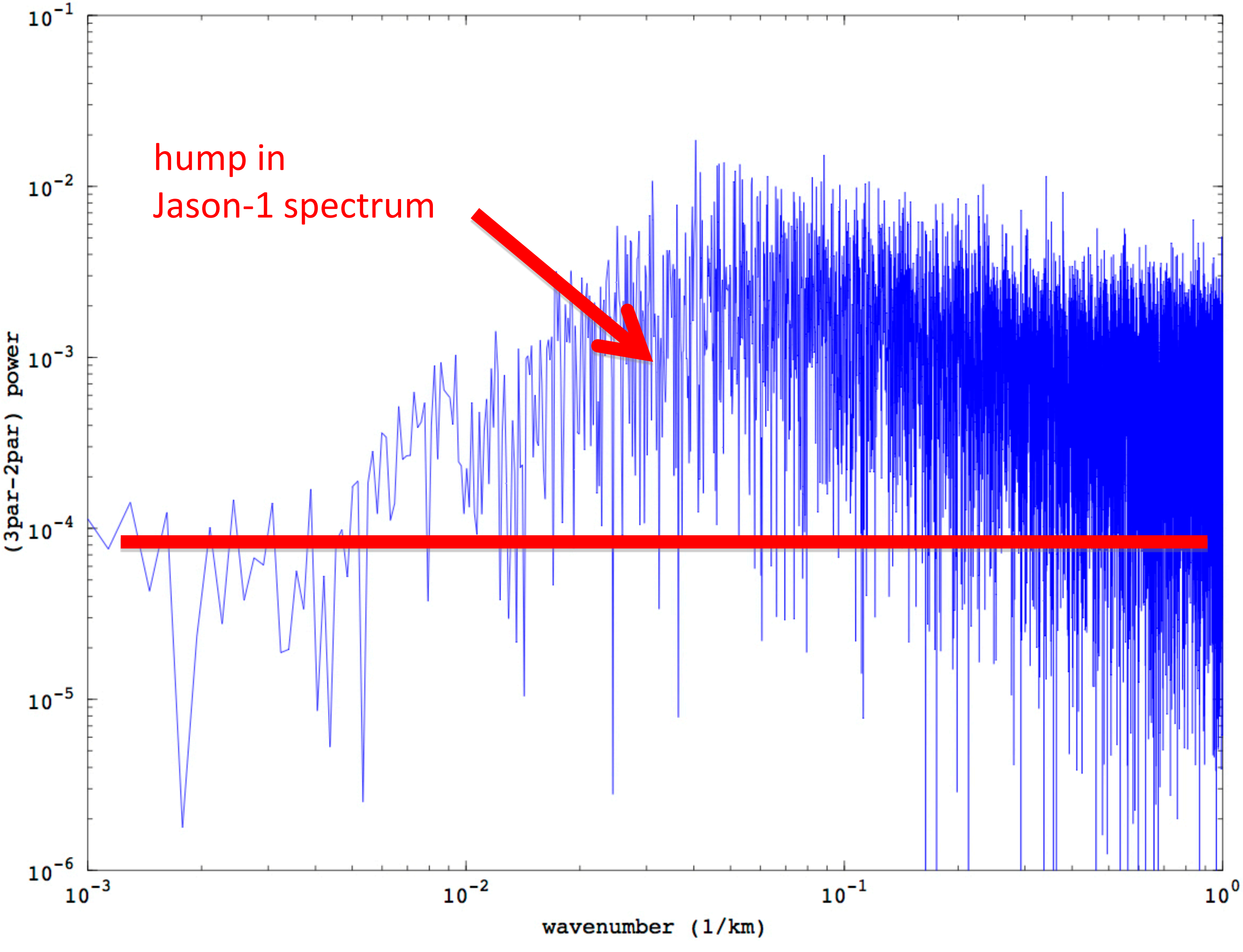
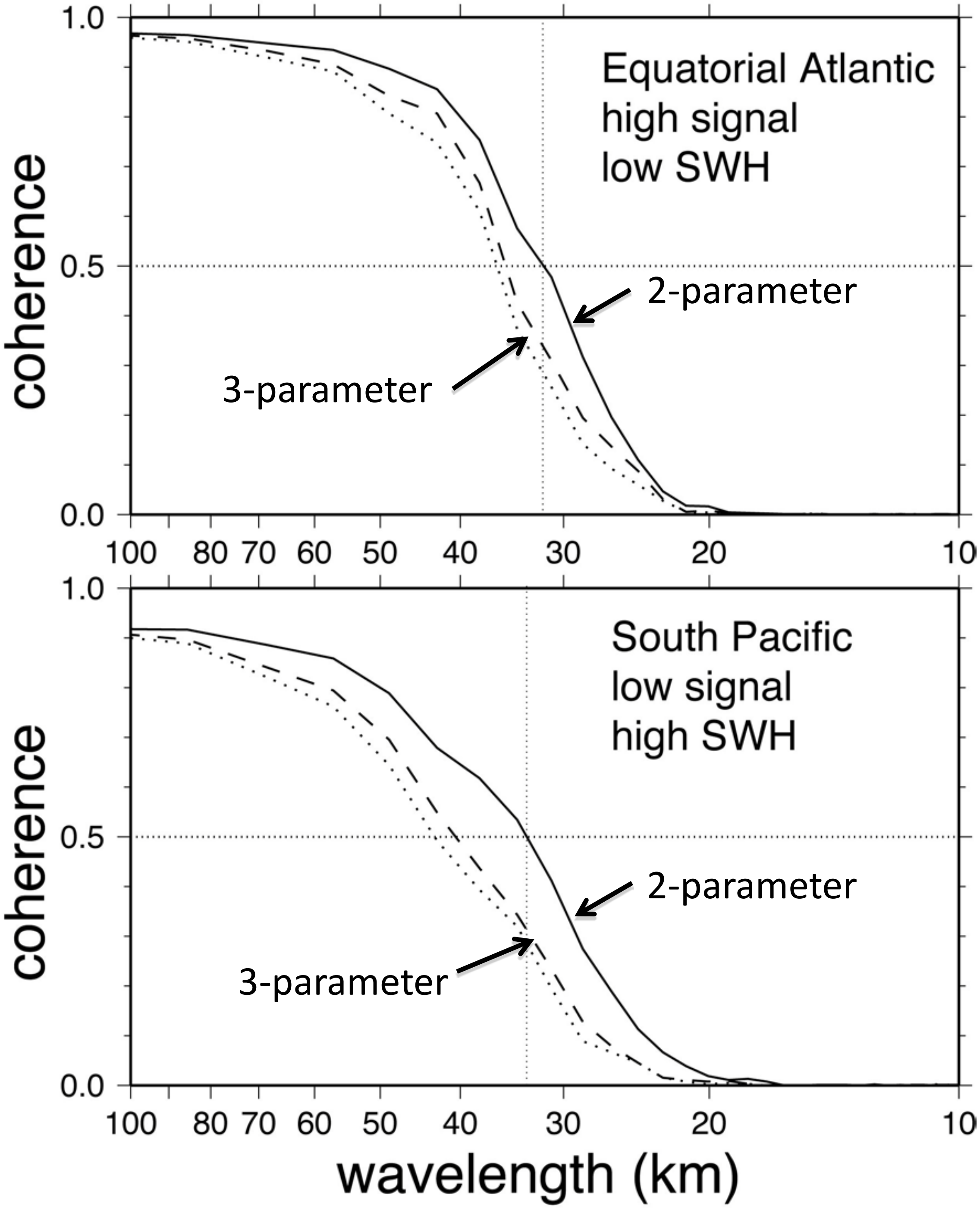


power of 3-parameter minus 2-parameter



Conclusions

- Least squares simulation suggests that double retracking improves range precision by 1.56 times.
- All LRM data show ~1.56 times improvement in range precision.
- SWH smoothing of 45 km needed for Geosat and ERS-1; 23 km needed for Envisat, CryoSat, and Jason.
- Hump in Jason-1 spectrum **disappears after double retracking**.
- Why doesn't double retracking improve range precision of SAR data?
- Does SWH smoothing reduce the accuracy of the SWH in coastal areas?
- Is sea state bias caused by the least-squares correlation of 3-parameter retrackers?



[Sandwell and Smith, GJI, 2005]