Application of JPEG 2000 Wavelet Compression to Multibeam Echosounder Mid-water Acoustic Reflectivity Measurements

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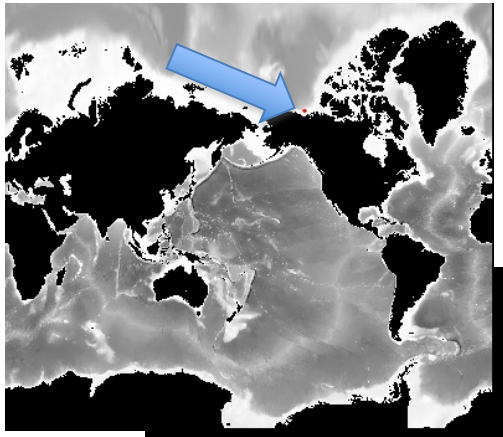

CCGS Amundsen – Mackenzie Shelf, 2009-10-01
EM302 30 kHz MBES (1.0ºx2.0º)

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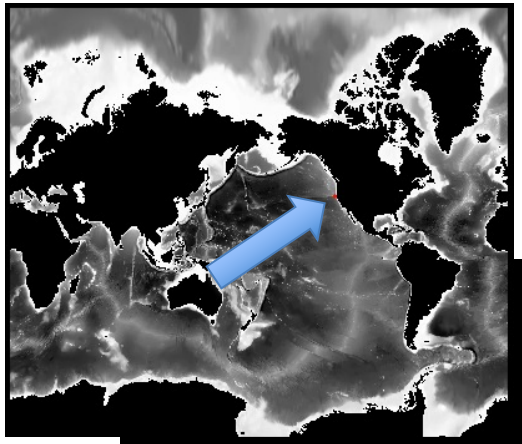

NOAAS Okeanos Explorer – Northern California Margin
EM302 30 kHz MBES (0.5ºx1.0º)

2,500 m

5,000 m

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J. V. Gardner, M. Malik, and S. Walker. Plume 1400 Meters High Discovered at the Seafloor off the Northern California Margin. Eos Trans. AGU, 90(32), 2009

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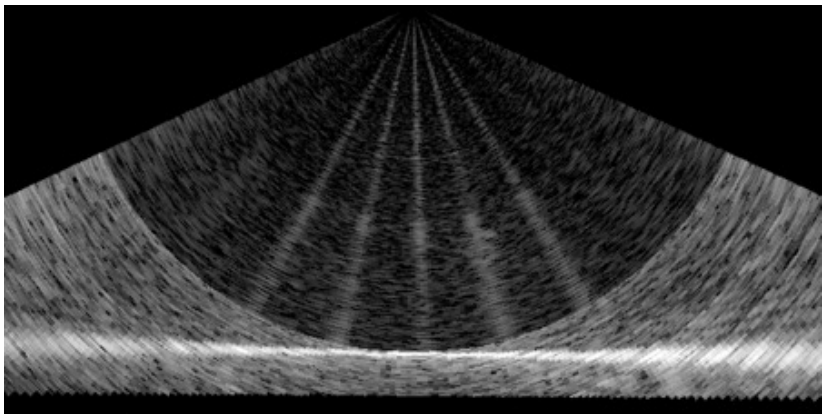
Data Storage Requirements

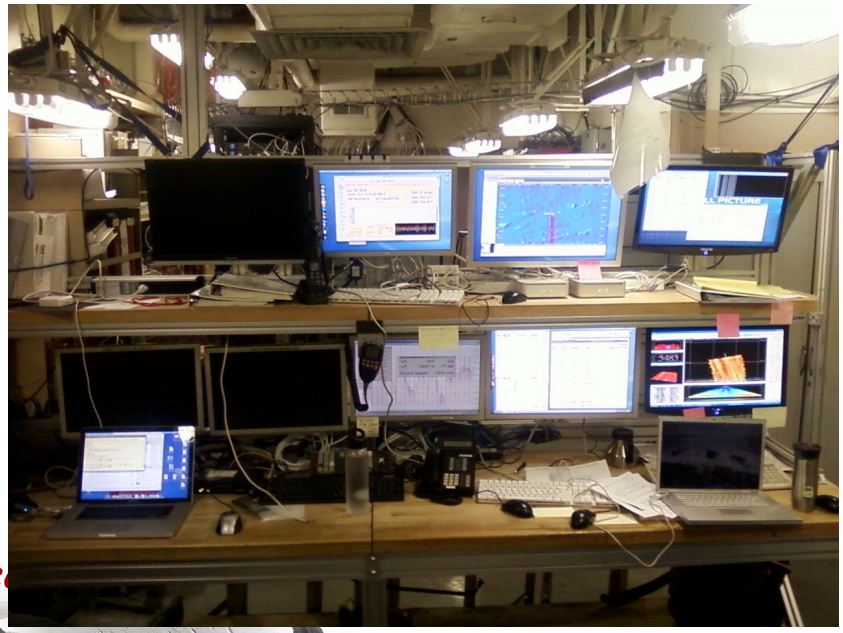
- Logging WC data increases file sizes:
  - CCGS Amundsen, 2009 field season
    - 135 days at sea, *continuous* MBES logging
    - "Regular" data: 860 GB (.all files)
    - Water column data: 783 GB (.wcd files)

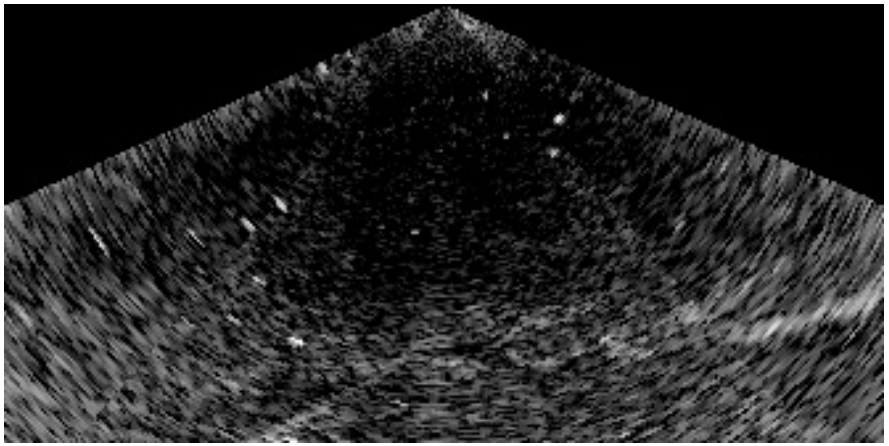
- File size grows by factor of 2-8, depending on water depth and angular sector
- Some (most?) don't bother logging WC, *especially in shallow water*



Recording “Interesting” Data only

How do you define “interesting”?





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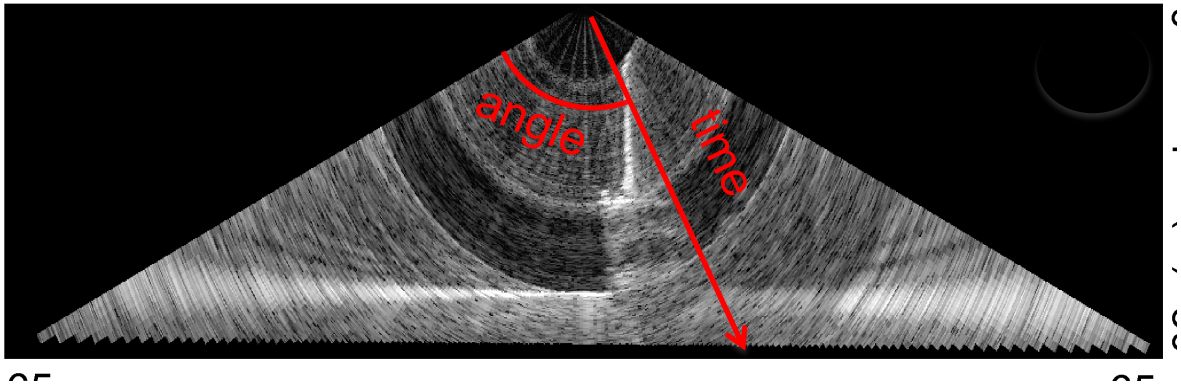
Solution?

- Courtney (2008) applied JPEG2000 to seismic & sidescan and suggested use for MBES
- JPEG2000:
  - Discrete Wavelet Transform (DWT)
  - Lossless and Lossy methods available
- JasPer implementation of JPEG2000
  - Freely available open source library
  - Reasonably documented
  - Implemented in many open source applications

Courtney, R. (2008). Storage and dissemination of SEGY data in JPEG2000 format. In Proc. Shallow Survey 2008, Oct2008.

Implementation



time

Beam/angle

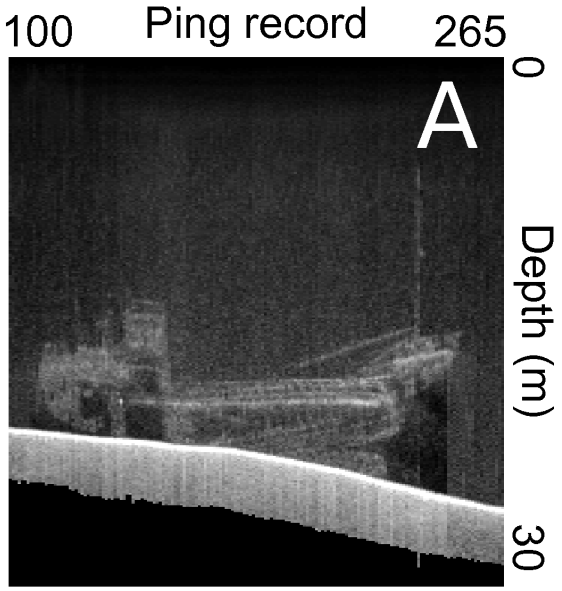
Raw

JPEG2000 image is stored along with WC datagram header along with metadata

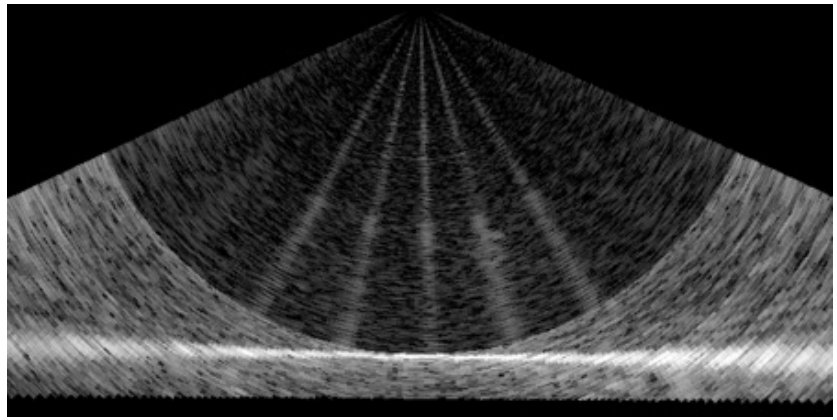
Ping-by-ping approach is ideally suited for real-time compression

JPEG2000 (20:1)

Evaluation

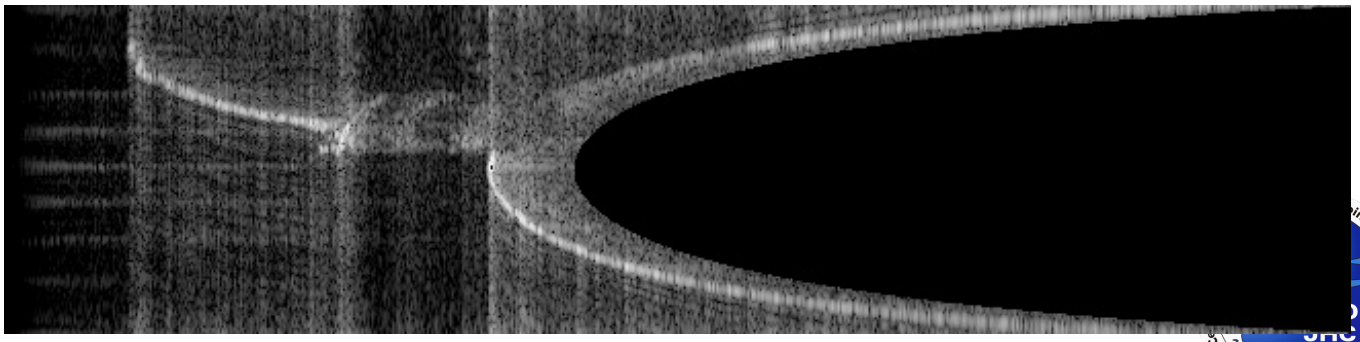


- MV G.B. Church, purposely sunk in 1991
- Mapped with EM3002 in 2006 (CCGS Otter Bay)
- 12 passes, only 1 pass fully imaged mast (1,064MB of data, 899MB of WC)
- Wreck imaged over 170 pings



Results: Lossless Compression

- Ratios 2.5:1 (raw image compared to JPEG2000)
- Effective ratio only 1.5:1 due to zero padding
- Still better than WinZip:
  - JPEG2000: packs down file size to 68%
  - Lempel-Ziv: packs down file size to 75%



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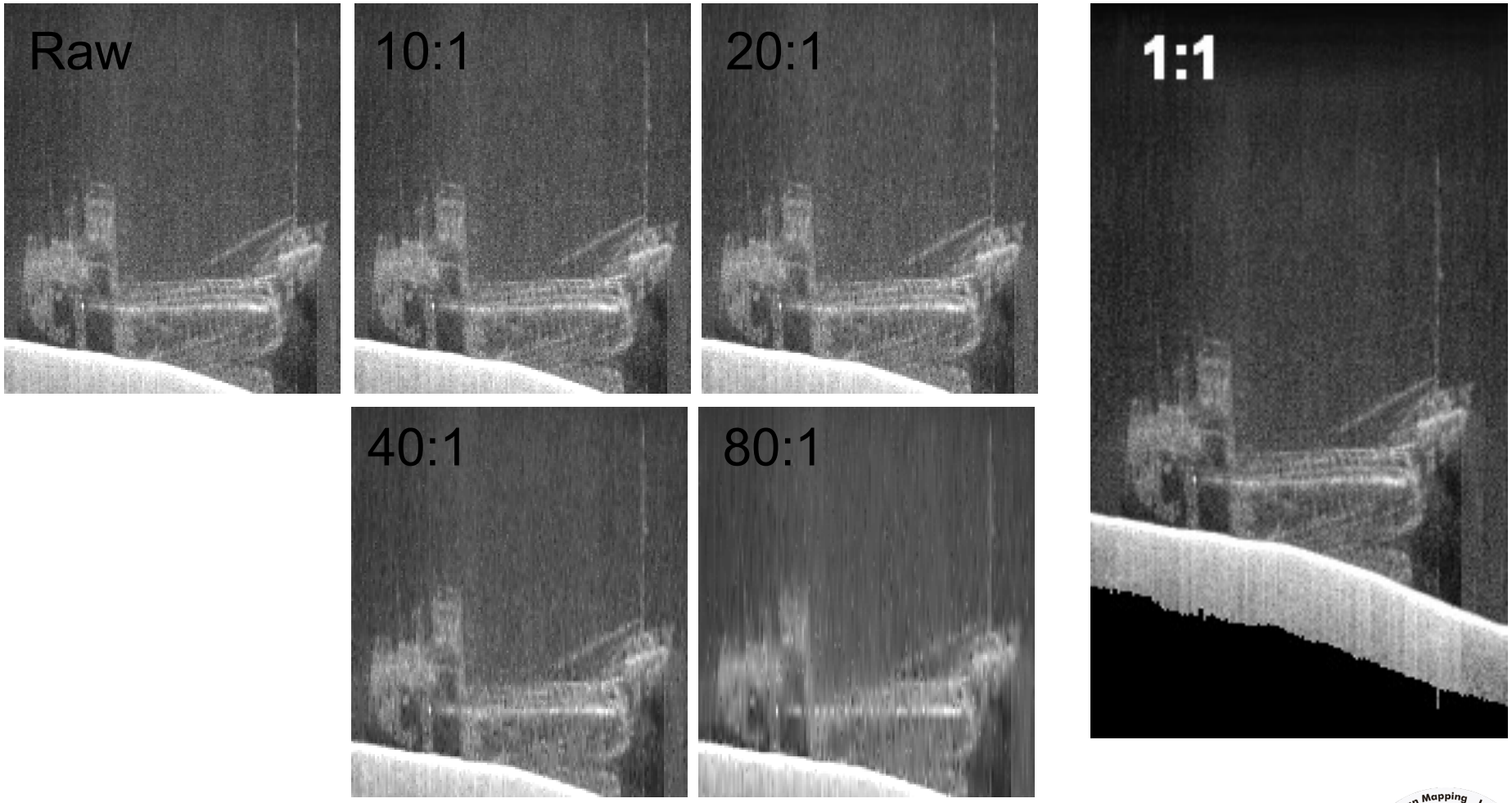
Results: Lossy Compression



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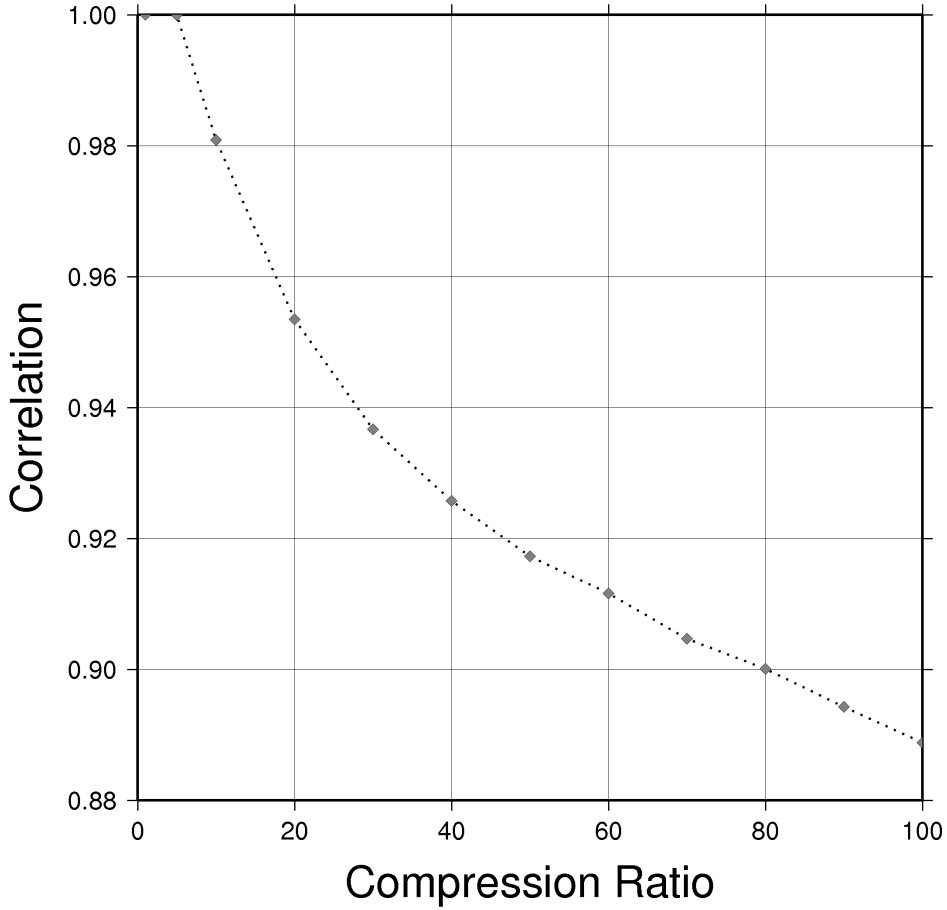
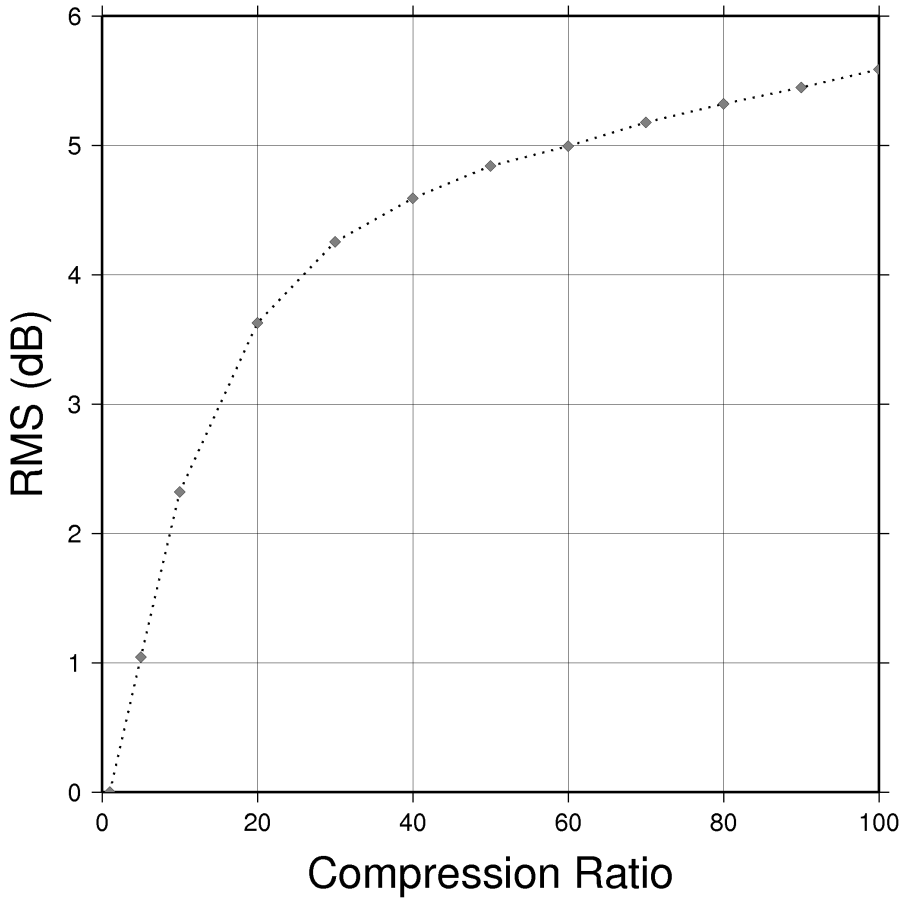
Quantifying Effects of Lossy Compression





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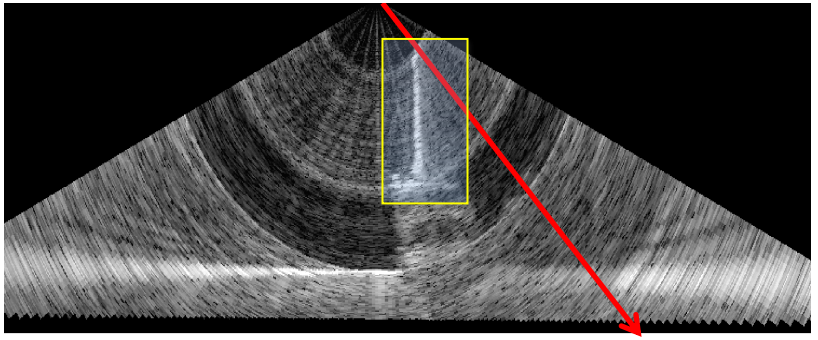
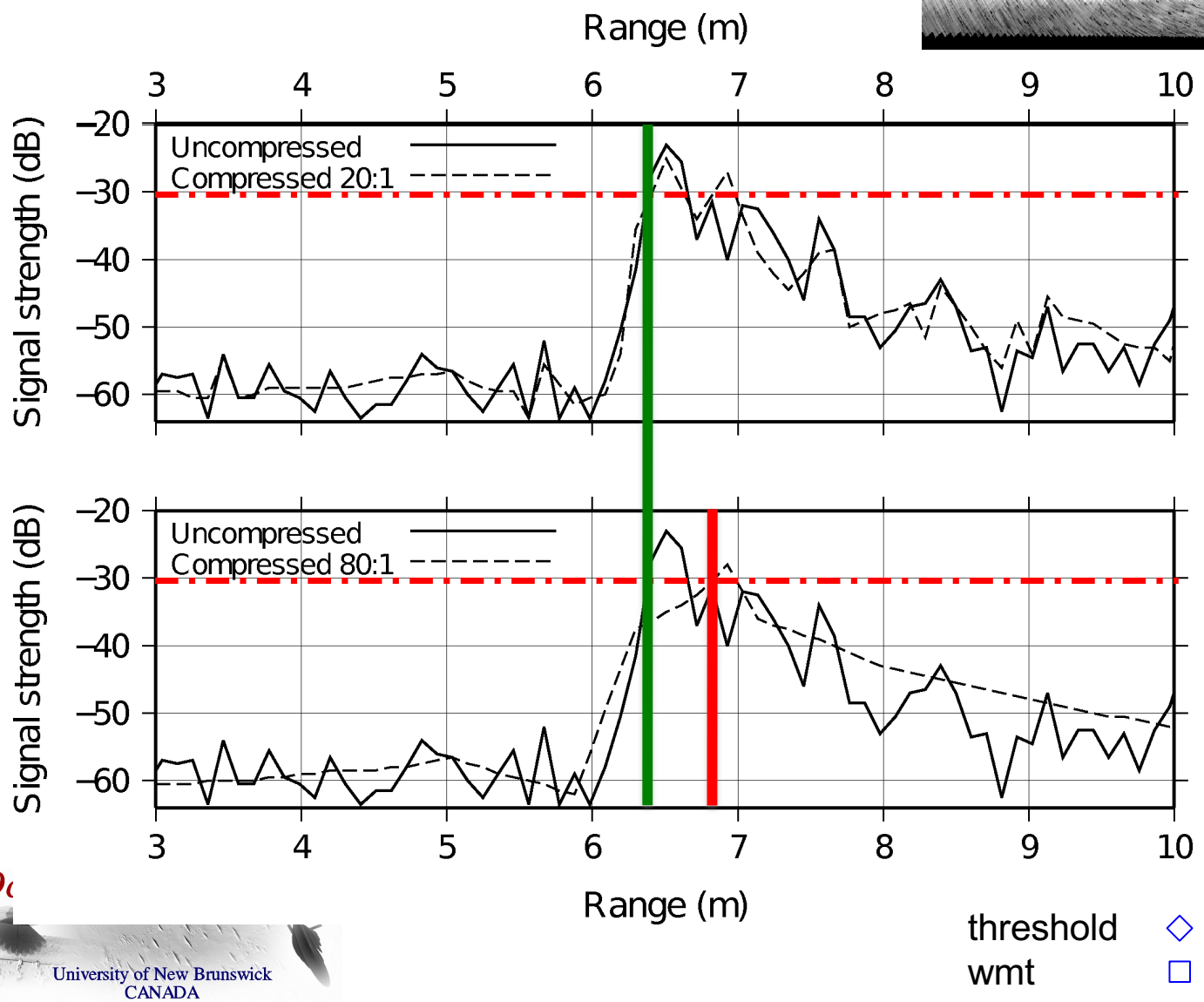
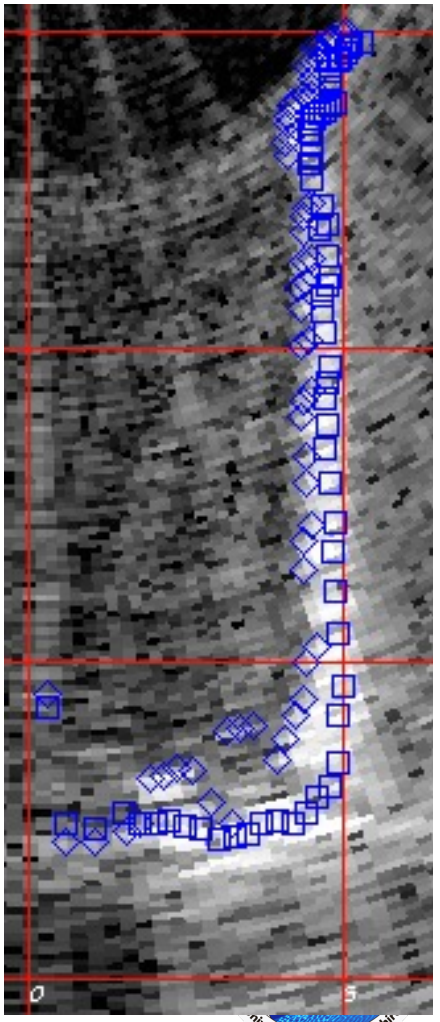
Wreck Measurement







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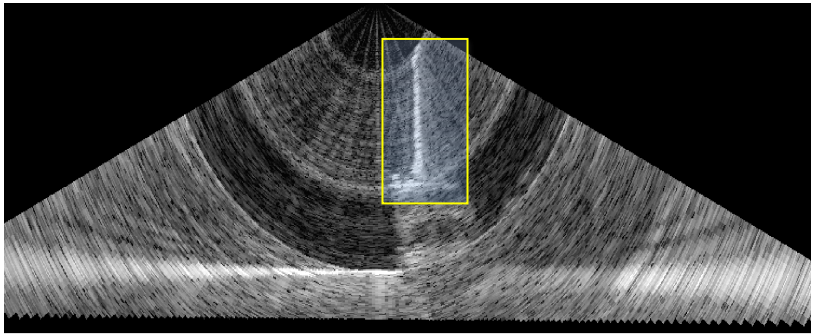
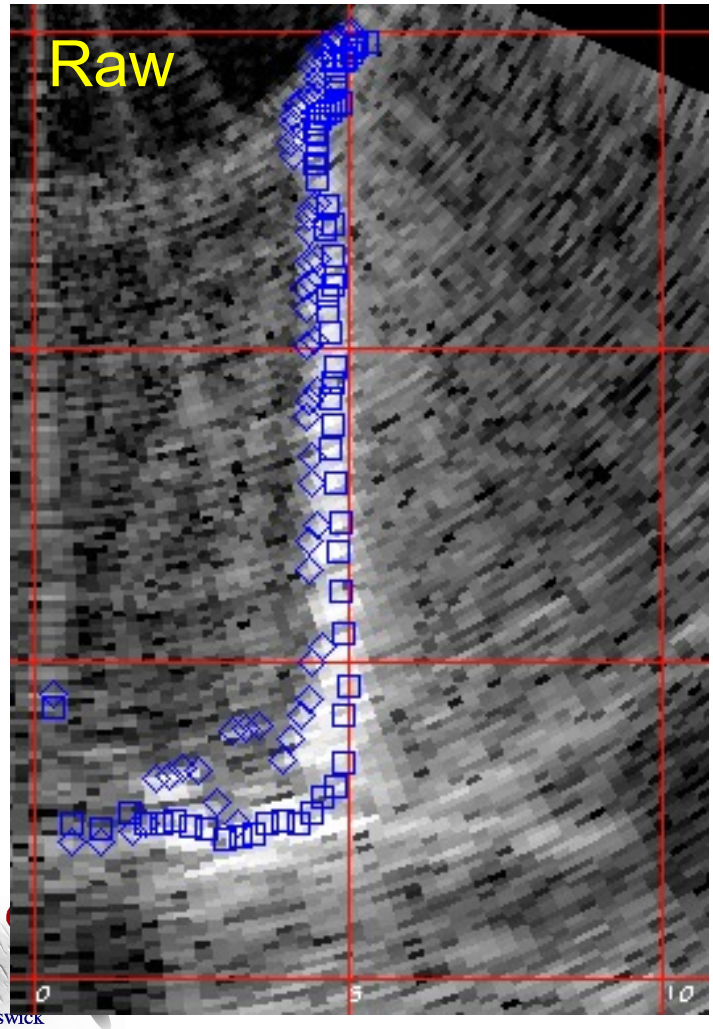
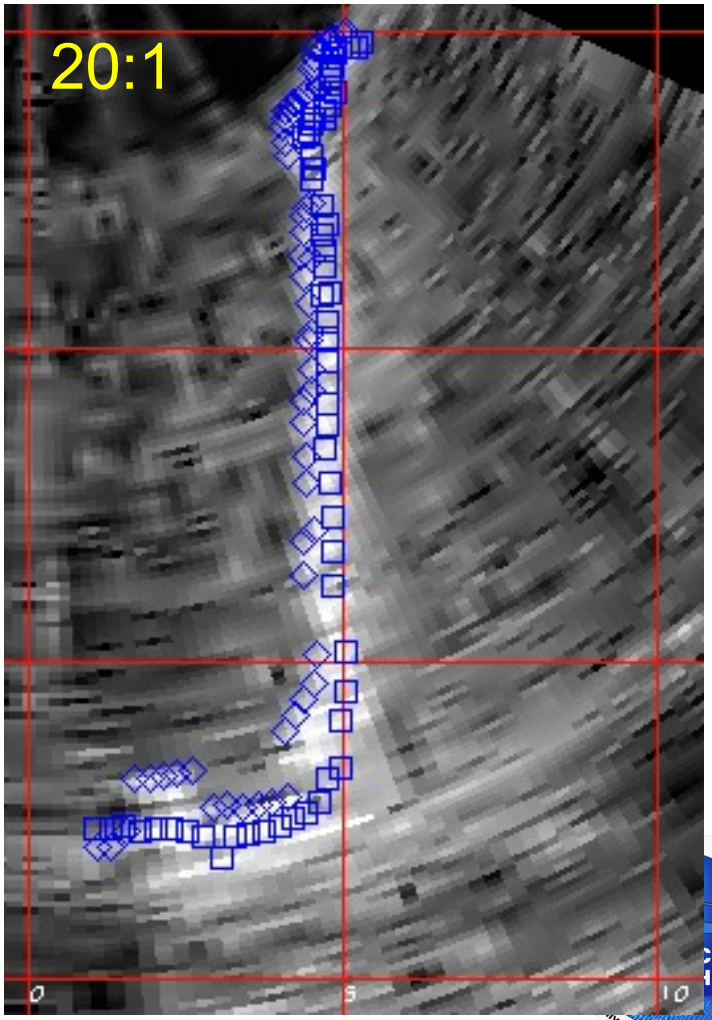


threshold ◇
wmt □





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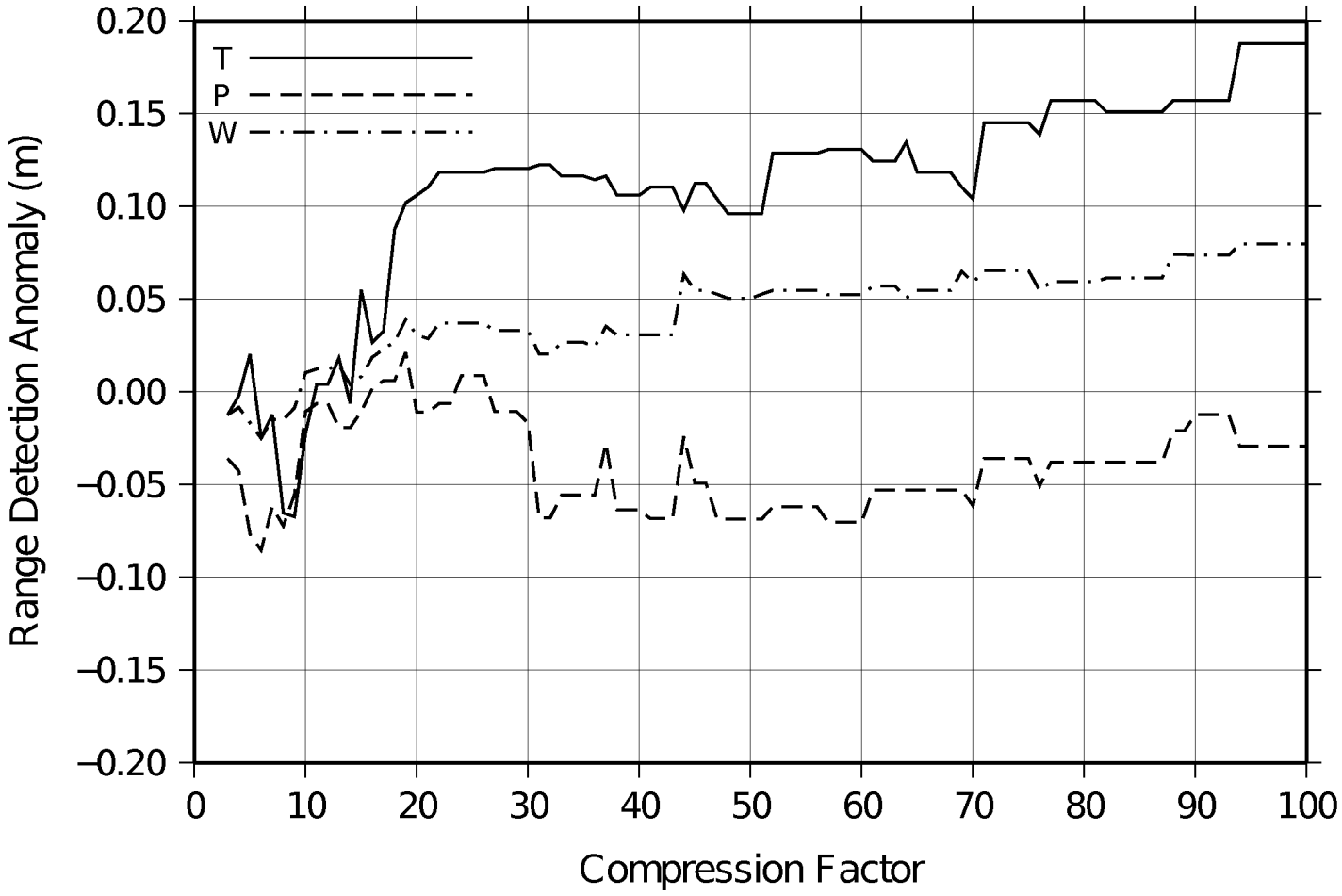
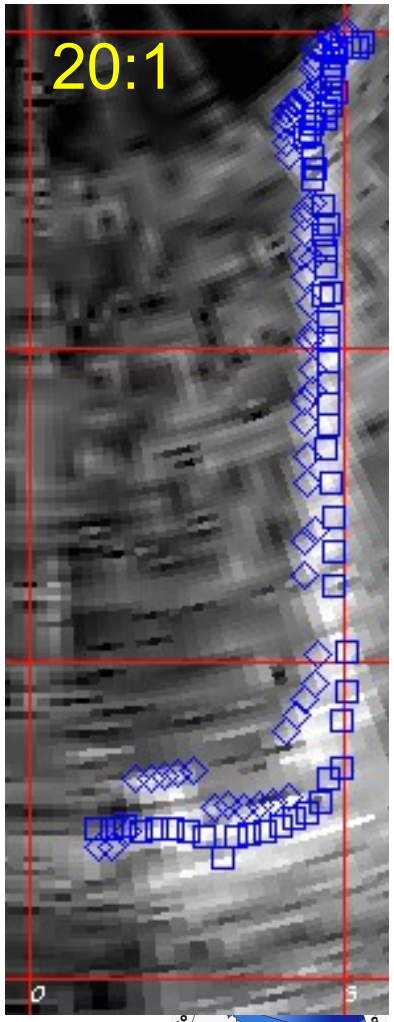
Mean Anomaly





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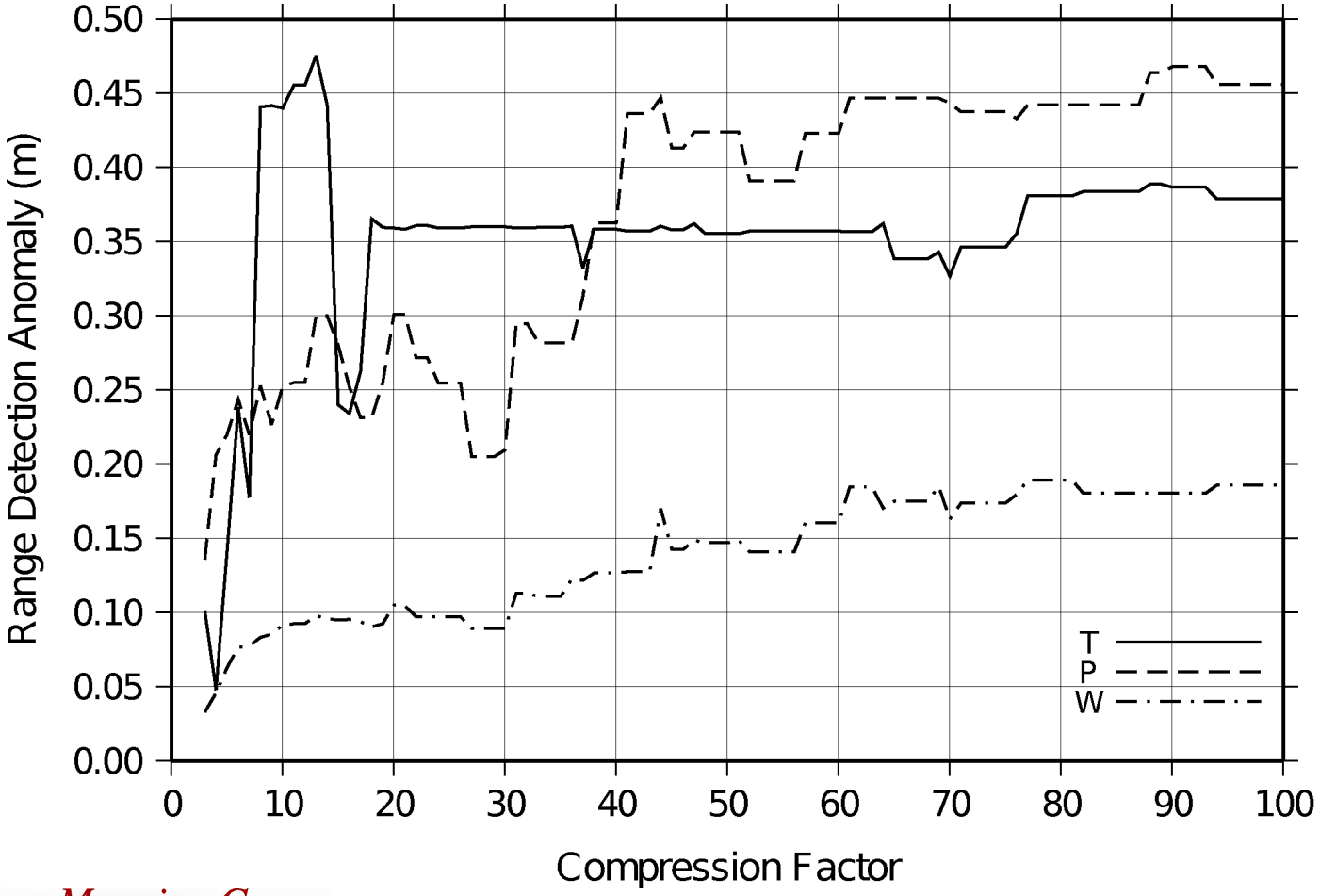
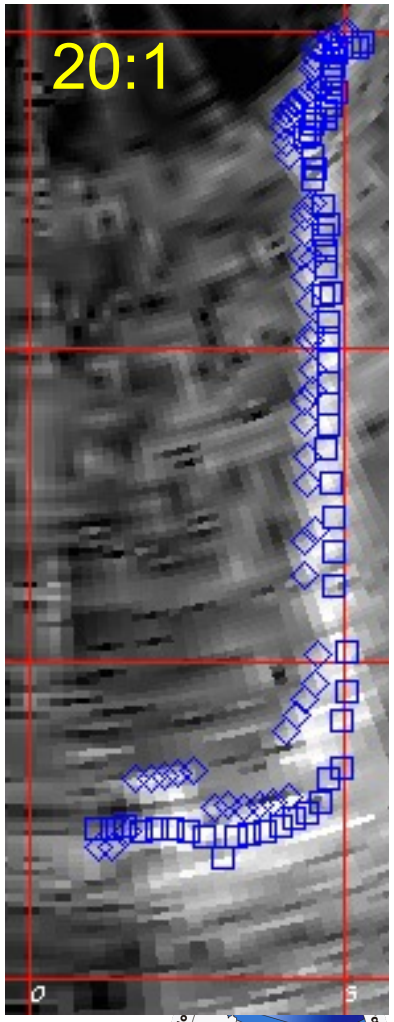
Anomaly Std. Deviation





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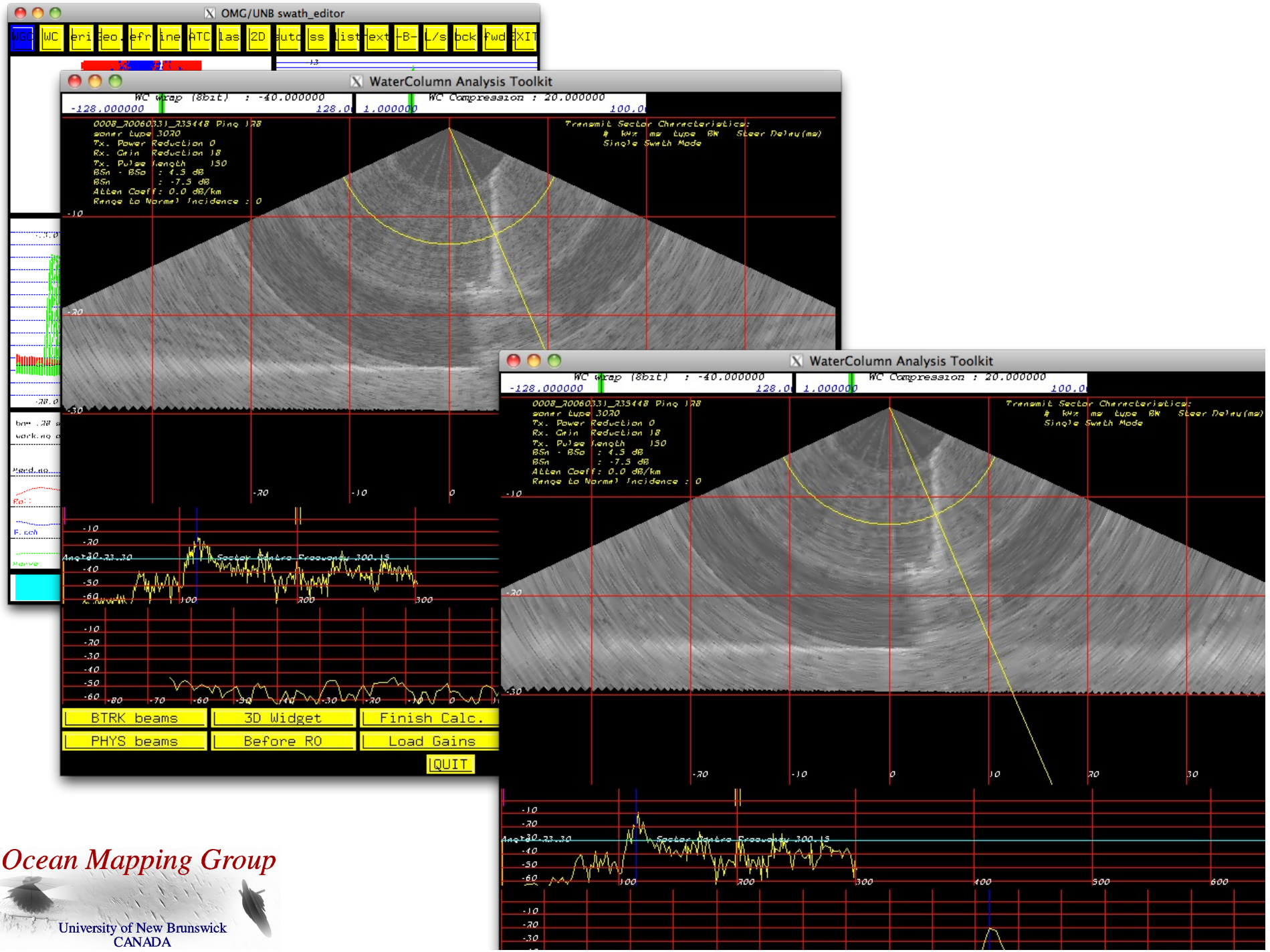

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    - "Regular" data: 860 GB (.all files)
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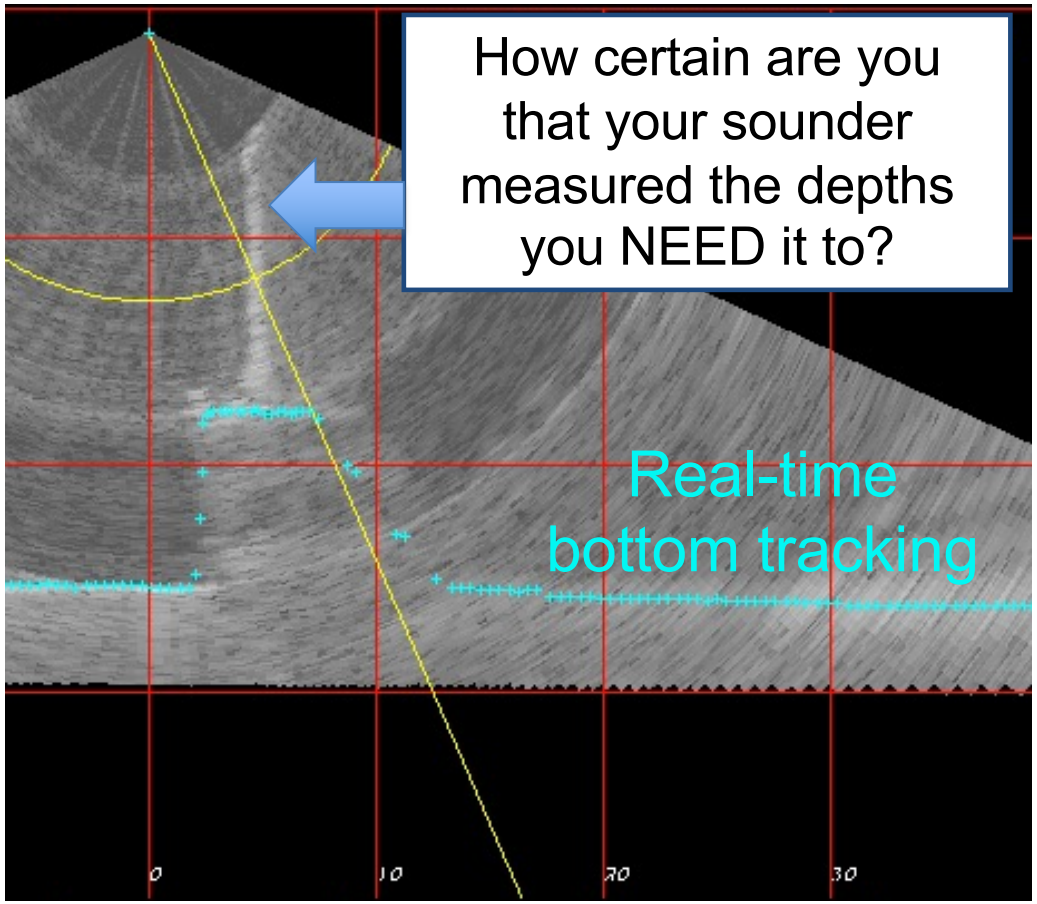
- File size grows by factor of 2-8, depending on water depth and angular sector
- Some (most?) don't bother logging WC, *especially in shallow water*

IHO Standards for Hydrographic Surveys (S44, 5th Ed.)

- **3.5 Feature detection**
- (2nd para.) … Features may exist that are smaller than the size mandated for a given order but which are a hazard to navigation. It may therefore be deemed necessary by the hydrographic office / organization to detect smaller features in order to minimise the risk of undetected hazards to surface navigation.
- (3rd para.) It should be noted that even when surveying with a suitable system 100% detection of features can never be guaranteed. If there is concern that features may exist within an area that may not be detected by the Survey System being used, consideration should be given to the use of an alternative system (e.g. a mechanical sweep) to increase the confidence in the minimum safe clearance depth across the area.

Shallow Water Hydrographic Application



Lossy compression applied in **real-time** would allow for continuous WC recording in shallow water

Would help fulfill hydrographic "detection" requirements

Also, would provide invaluable contextual information for data cleaning in complex scattering situations such as wrecks

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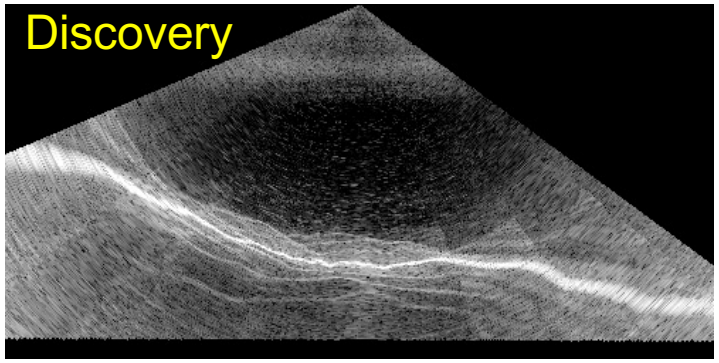
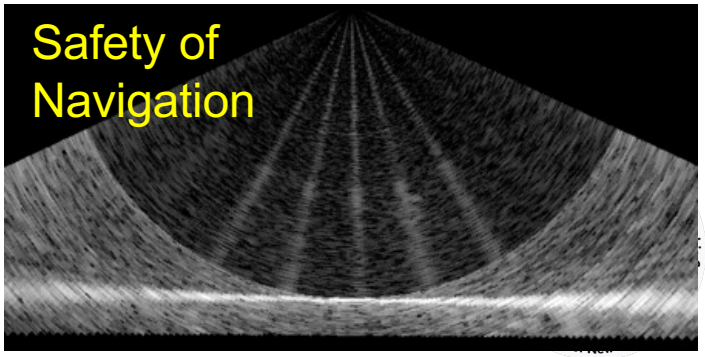
Summary

- JPEG 2000 compression easily applicable to MBES water column data
- Lossless:
  - ratios of 1.5:1 achievable
- Lossy:
  - 20:1 seems a good compromise for hydrographic purposes
  - Application specific metrics should be devised
- Real-time compression enables continuous logging
  - Facilitates discovery
  - Increases confidence in hydrographic measurements: safety of navigation





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Acknowledgements

- NOAA grants:
  - NA05NOS4001153
  - NA10NOS4000073
- ArcticNet NCE
- Sponsors of the OMG
- Officers and Crew of CCGS Otter Bay
- Robert Courtney, GSC (Atlantic)

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Questions?


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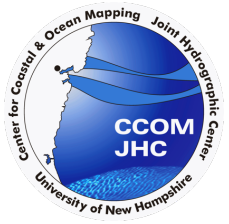
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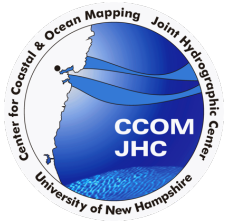
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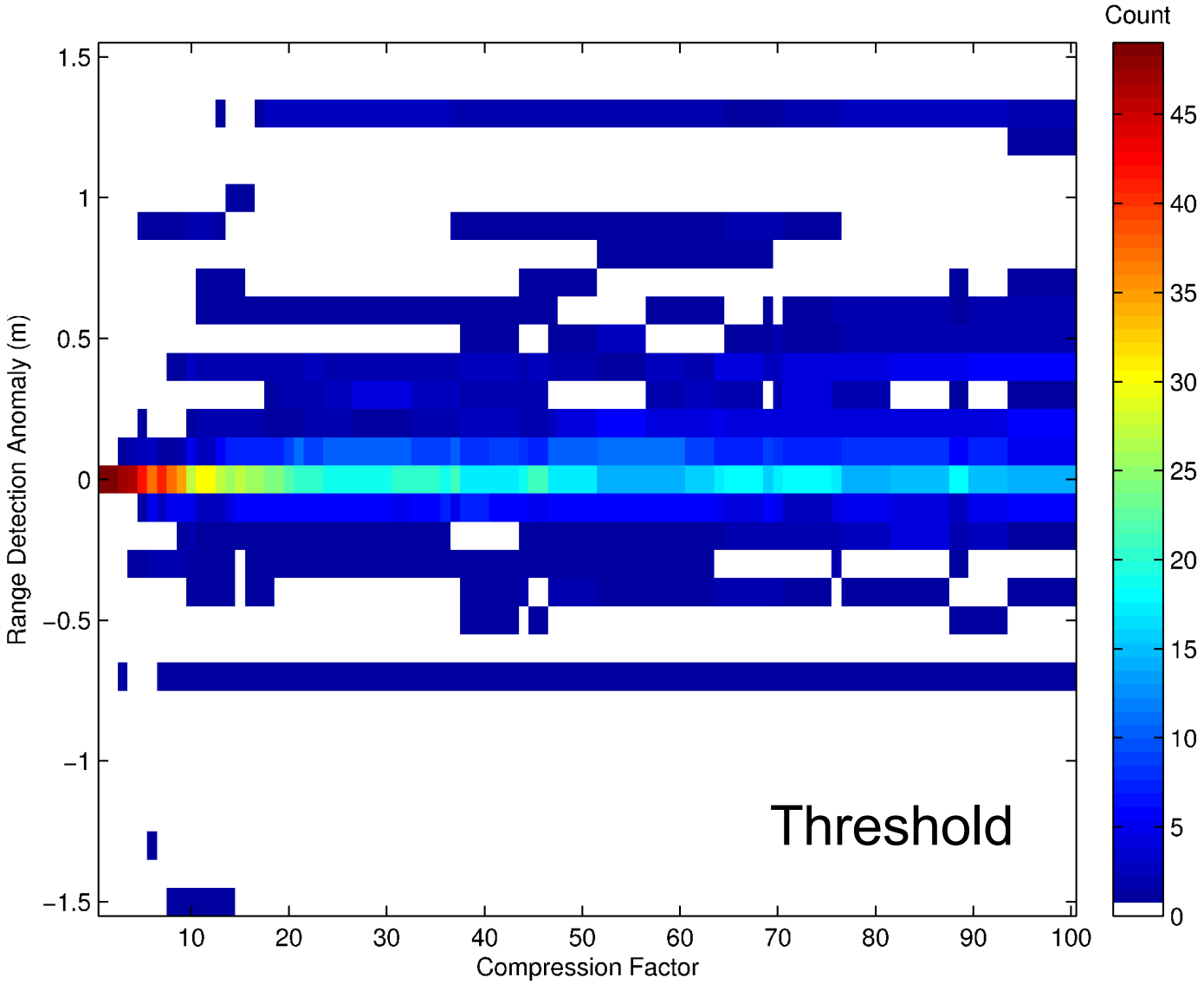
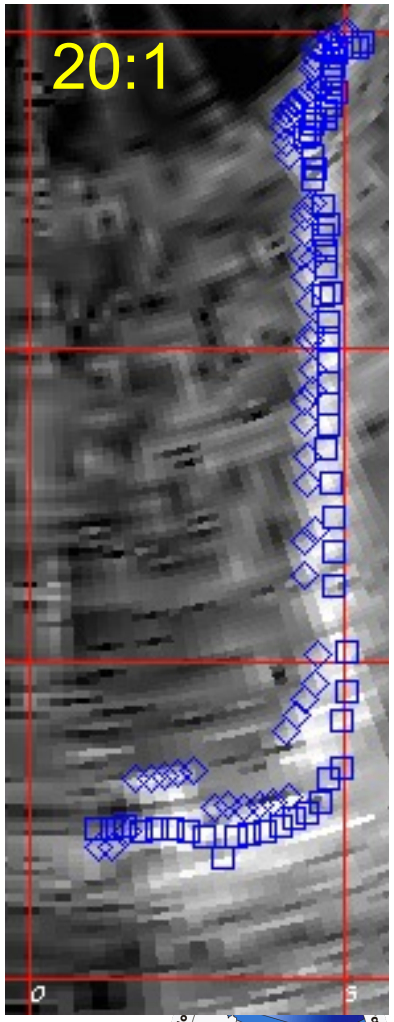
Wreck Measurement Performance





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Wreck Measurement Performance