Ocean Exploration and Research — NOAA

NIWA Taihoro Nukurangi

economie FPS Economy, S.M.E.s, Self-employed and Energy

CCOM JHC

BSIP: Backscatter Software Intercomparison Project

Preliminary Evaluation of Multibeam Backscatter Consistency through Comparison of Intermediate Processing Results

GEOLOGICAL SURVEY OF NORWAY

Project Facilitators:
Mashkoor Malik, NOAA, USA
Giuseppe Masetti, UNH CCOM/JHC, USA
Alexandre Schimel, NIWA, New Zealand
Marc Roche, ECONOMIE, Belgium
Margaret Dolan, NGU, Norway
Julian Le Deunf, SHOM, France

Project Collaborators:
SonarScope, IFREMER
FMGT, QPS
HIPS & SIPS, Teledyne CARIS
MB Process, Curtin University, CMST

SHOM

GeoHab 2019 – BSWG meeting
Saint-Petersburg, Russia

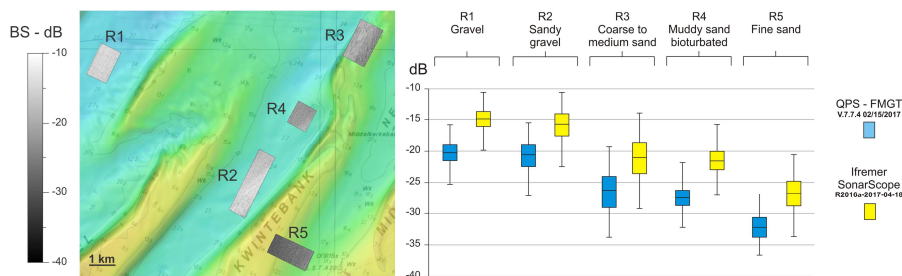**Ifremer** · **QPS** · **TELEDYNE CARIS** Everywhereyoulook · **Curtin University**

From **observation** to explanation

Significant differences in **backscatter products**

generated by **different software**

using the **same dataset**

→ **Major limitation for users**
- Quantitative analysis
- Combining multiple sources
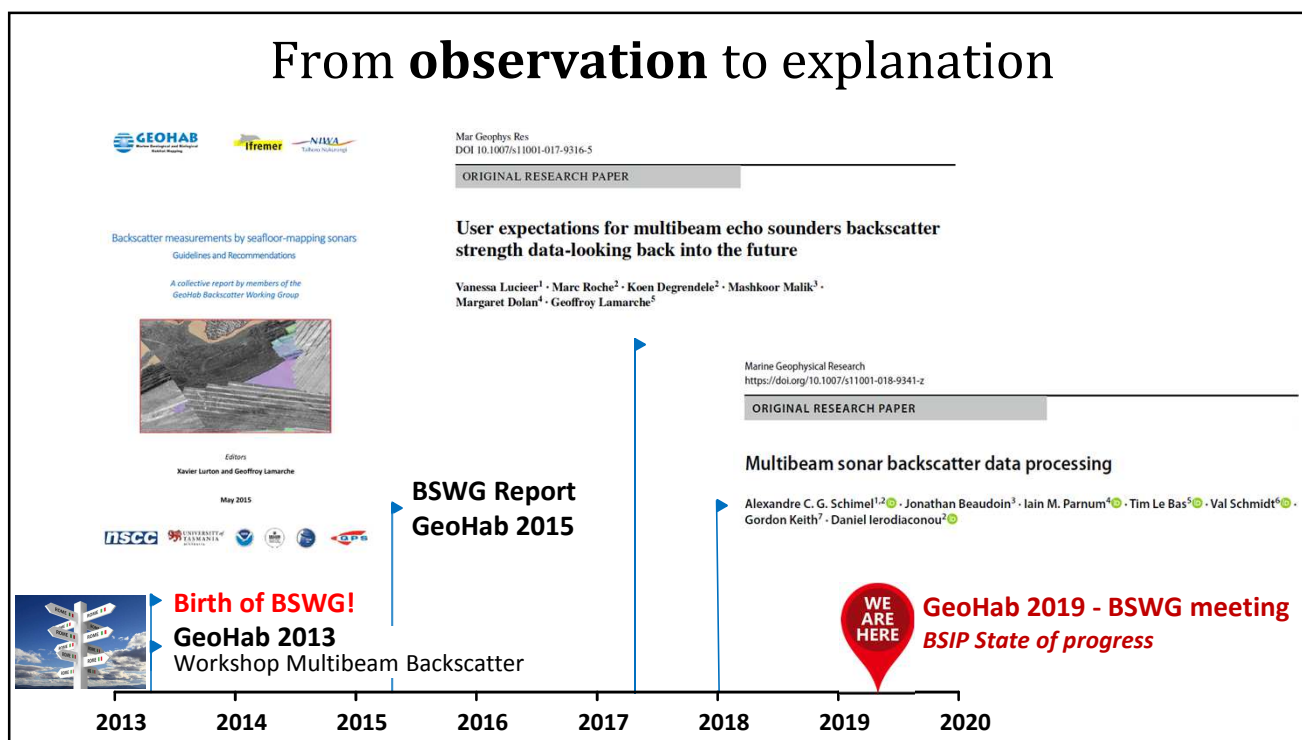- Time-monitoring of seafloor changes…

BS - dB
-10
-20
-30
-40
1 km

R1 Gravel · R2 Sandy gravel · R3 Coarse to medium sand · R4 Muddy sand bioturbated · R5 Fine sand

dB
-10
-15
-20
-25
-30
-35
-40

QPS - FMGT
V.7.7.4 02/15/2017

Ifremer SonarScope
R2016a-2017-04-18

Birth of BSWG!
GeoHab 2013
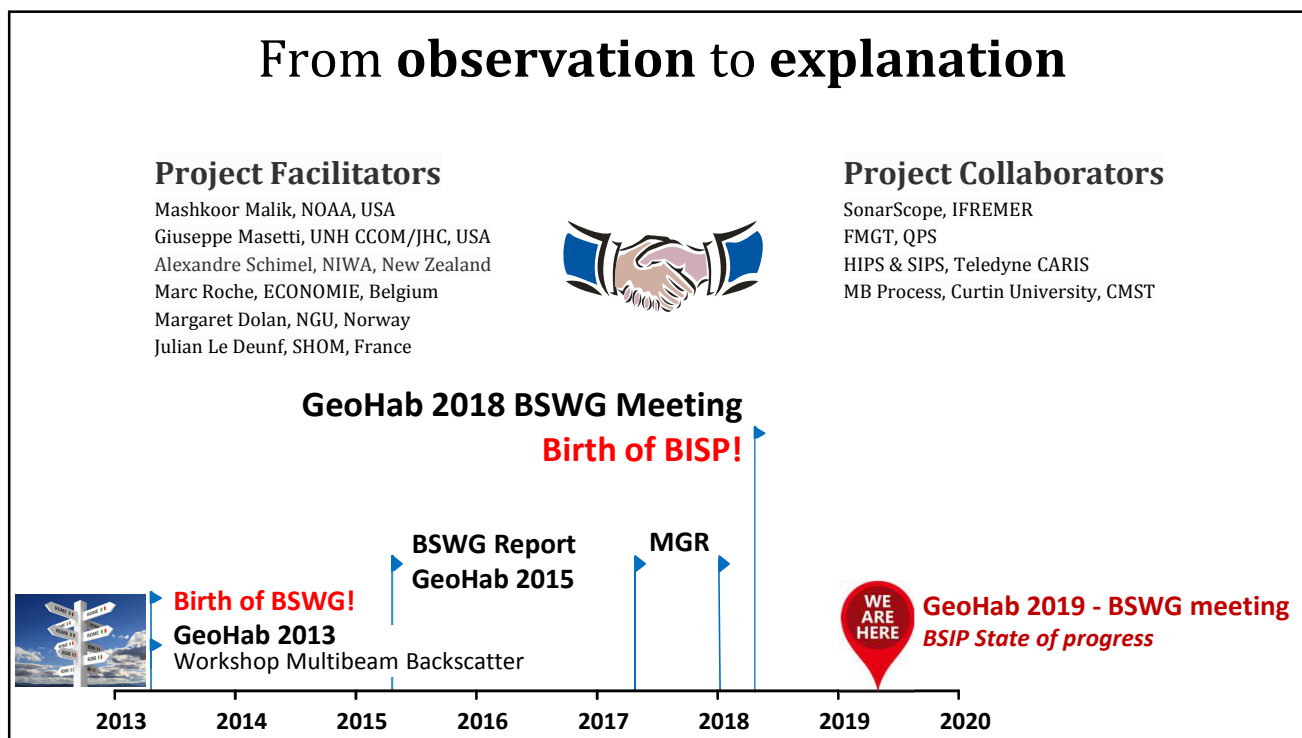Workshop Multibeam Backscatter

WE ARE HERE
GeoHab 2019 - BSWG meeting
BSIP State of progress

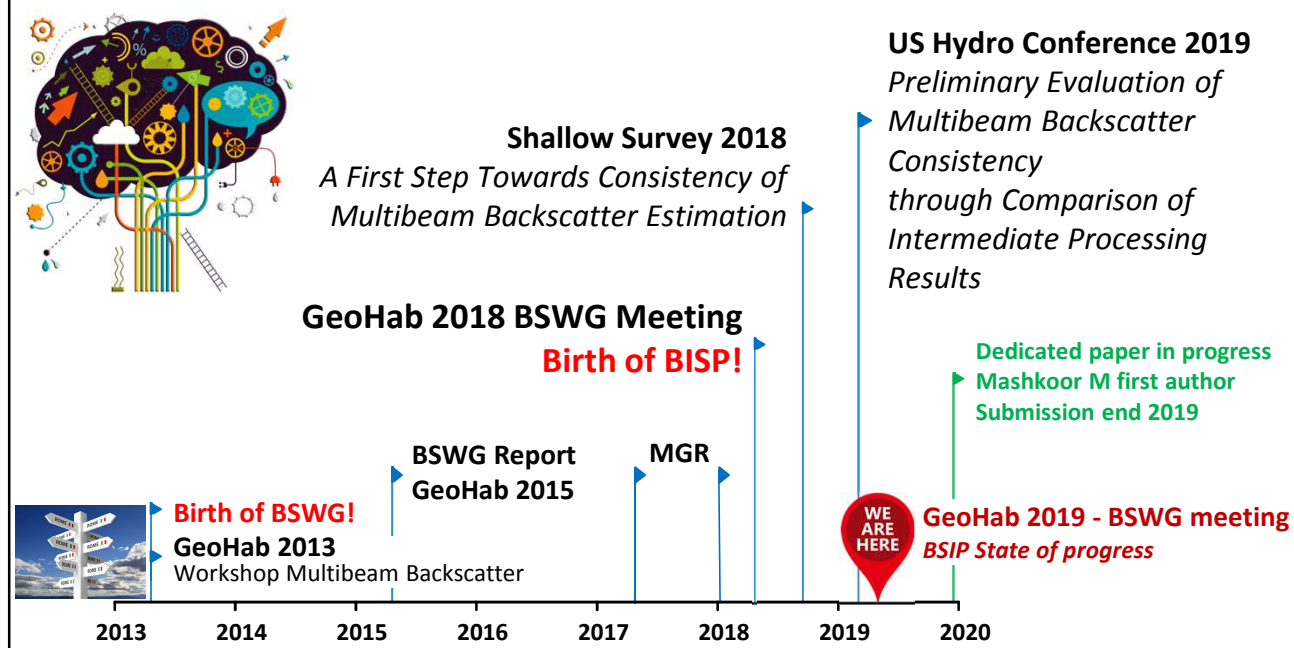2013   2014   2015   2016   2017   2018   2019   2020
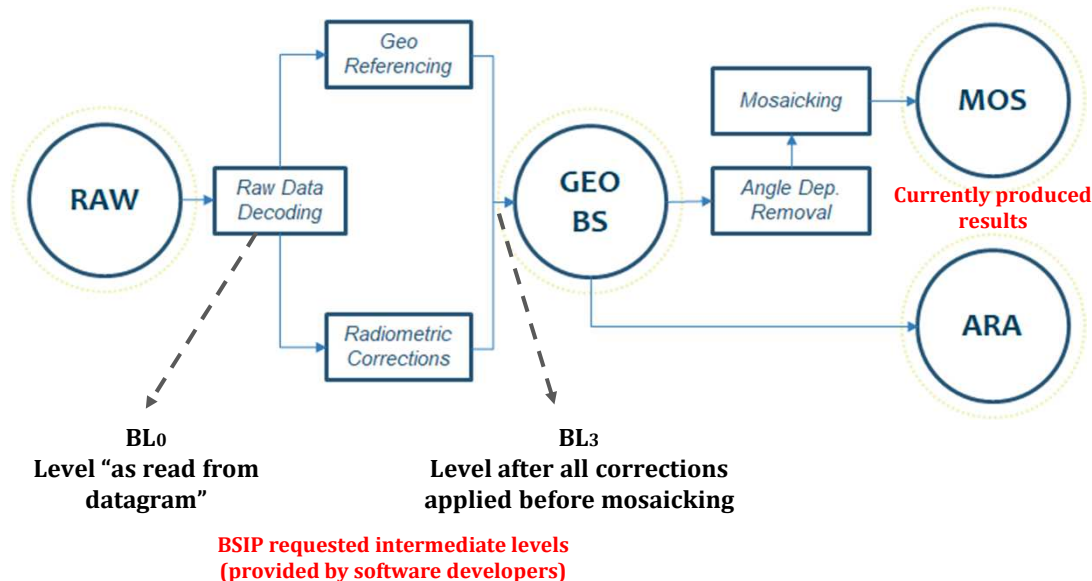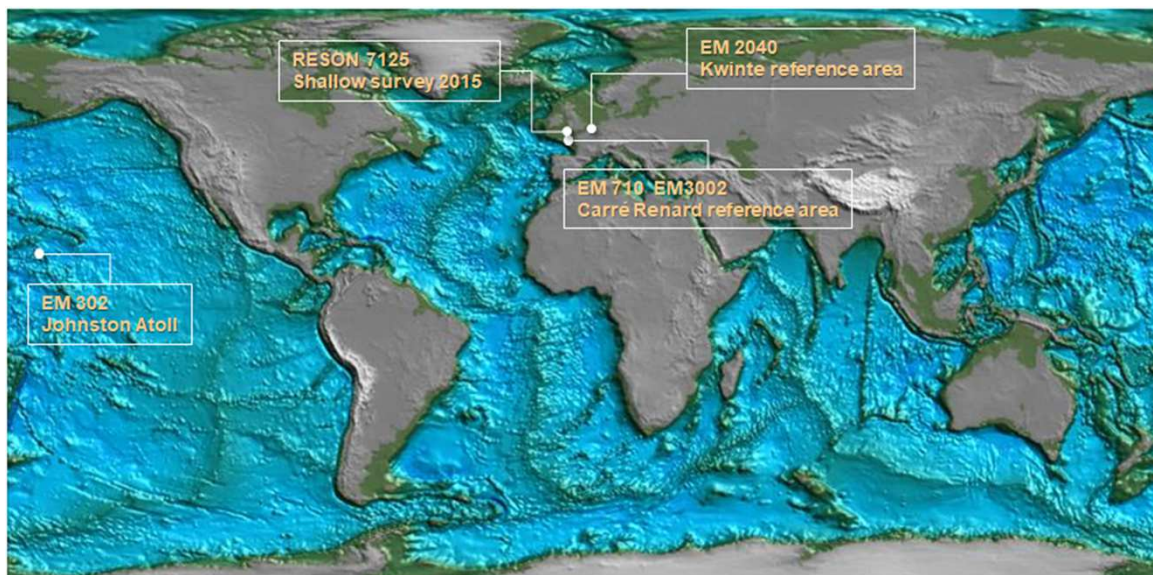
From **observation** to explanation

Backscatter measurements by seafloor-mapping sonars
Guidelines and Recommendations

A collective report by members of the GeoHab Backscatter Working Group

Editors
Xavier Lurton and Geoffroy Lamarche
May 2015

Mar Geophys Res
DOI 10.1007/s11001-017-9316-5

ORIGINAL RESEARCH PAPER

User expectations for multibeam echo sounders backscatter strength data-looking back into the future

Vanessa Lucieer[1] · Marc Roche[2] · Koen Degrendele[2] · Mashkoor Malik[3] · Margaret Dolan[4] · Geoffroy Lamarche[5]

Marine Geophysical Research
https://doi.org/10.1007/s11001-018-9341-z

ORIGINAL RESEARCH PAPER

Multibeam sonar backscatter data processing

Alexandre C. G. Schimel[1,2] · Jonathan Beaudoin[3] · Iain M. Parnum[4] · Tim Le Bas[5] · Val Schmidt[6] · Gordon Keith[7] · Daniel Ierodiaconou[2]

**BSWG Report
GeoHab 2015**

Birth of BSWG!
GeoHab 2013
Workshop Multibeam Backscatter

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GeoHab 2019 - BSWG meeting
BSIP State of progress

| 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |

From **observation** to **explanation**

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GeoHab 2018 BSWG Meeting
Birth of BISP!

**BSWG Report
GeoHab 2015**

MGR

Birth of BSWG!
GeoHab 2013
Workshop Multibeam Backscatter

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From observation to **explanation**

US Hydro Conference 2019
Preliminary Evaluation of Multibeam Backscatter Consistency
through Comparison of Intermediate Processing Results

Shallow Survey 2018
A First Step Towards Consistency of Multibeam Backscatter Estimation

GeoHab 2018 BSWG Meeting
Birth of BISP!

Dedicated paper in progress
Mashkoor M first author
Submission end 2019

BSWG Report GeoHab 2015

MGR

Birth of BSWG!
GeoHab 2013
Workshop Multibeam Backscatter

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GeoHab 2019 - BSWG meeting
BSIP State of progress

2013   2014   2015   2016   2017   2018   2019   2020

BSIP → Processing Steps

Geo Referencing

RAW

Raw Data Decoding

Radiometric Corrections

GEO BS

Mosaicking

Angle Dep. Removal

MOS

Currently produced results

ARA

BL0
Level "as read from datagram"

BL3
Level after all corrections applied before mosaicking

BSIP requested intermediate levels
(provided by software developers)

BSIP dataset

Backscatter results provided by different vendors

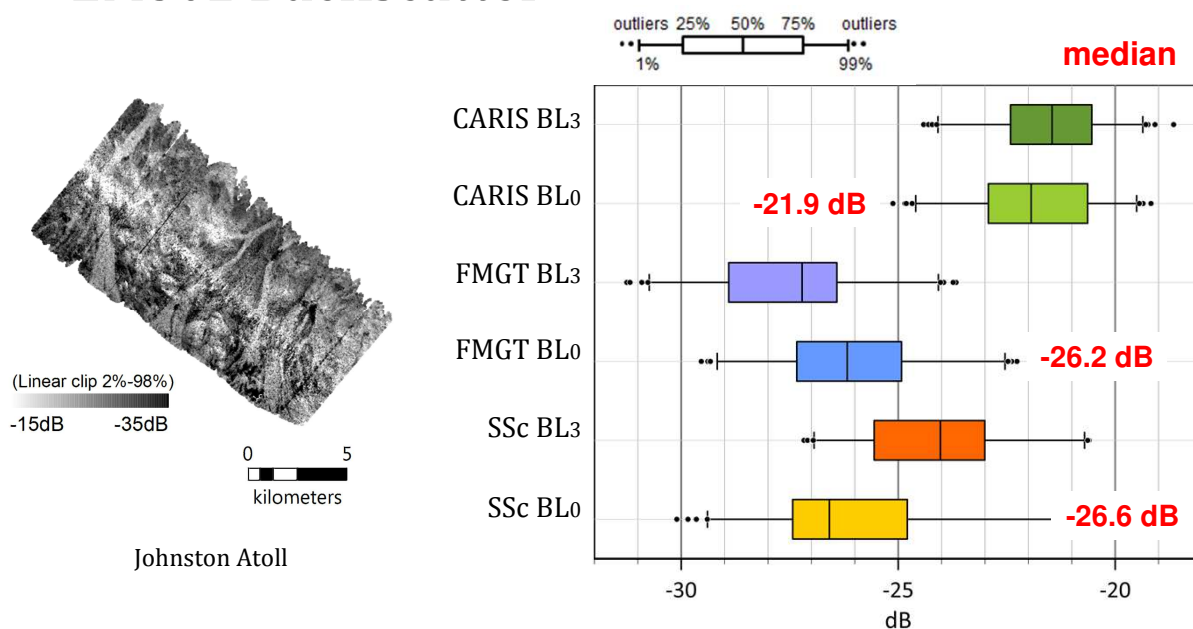| Software	SonarScope	FMGT	CARIS	Curtin
Time stamp	Time	Ping Time	Timestamp	Ping Time
Ping #	Ping first ping = 0	Ping Number First ping = 1	Ping	Ping Number
Beam #	Beam first beam = 1	Beam Number	Beam	Beam Number
Beam location (Lat / Long)	Latitude/Longitude	Latitude /Longitude	Longitude /Latitude	Longitude / Latitude
Beam location (E / N)	GeoX / GeoY	Easting / Northing	Easting / Northing	Easting / Northing
Beam depth	BathyRT	Depth	Depth	
Incidence angle	IncidenceAngles	True Angle	IncidentAngle	Incidence Angle
BL_0 BS as read from data files	ReflecKM	Backscatter Value	BL0	Backscatter value
BL_3 BS after all corrections applied before mosaicking	ReflecSSc	Corr Backscatter Value	BL3	Corr Backscatter Value

EM2040 **Backscatter**

Kwinte reference area

black dots = beams
white line = navigation
yellow = calculation area

median

outliers 25% 50% 75% outliers
1%   99%

CARIS BL3

CARIS BL0 -11.5 dB

FMGT BL3

FMGT BL0 -14.9 dB

SSc BL3

SSc BL0 -17.1 dB

dB
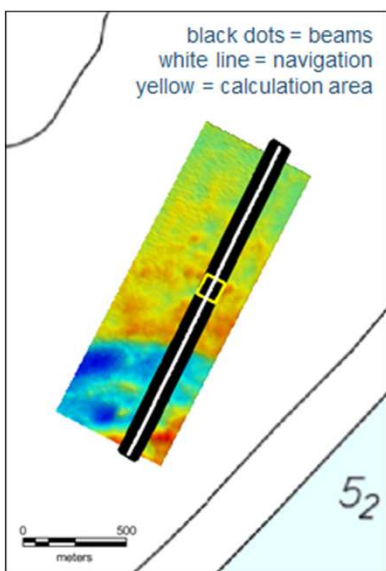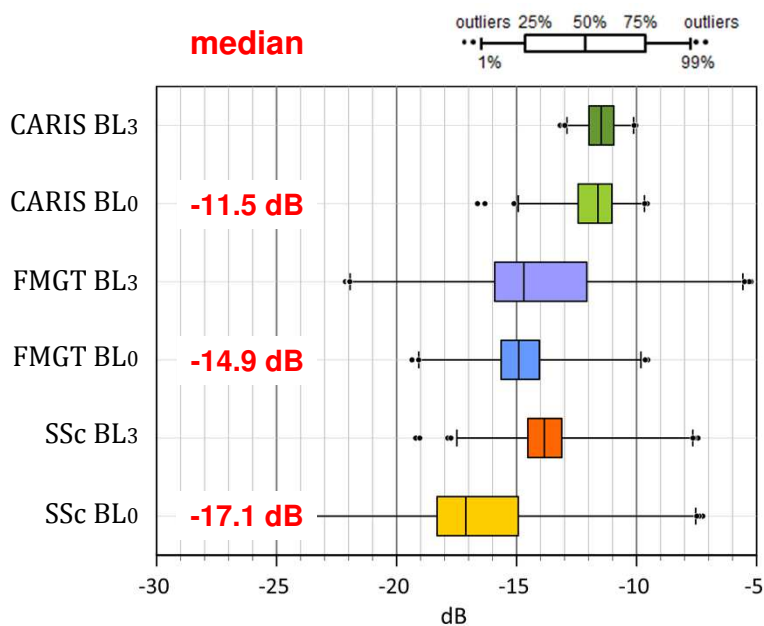
EM710 **Backscatter**

Carré Renard area

Linear clip (2%-98%)

-15dB   -25dB

median

outliers 25% 50% 75% outliers
1%   99%

CARIS BL3

CARIS BL0 -10.3 dB

FMGT BL3

FMGT BL0 -14.6 dB

SSc BL3

SSc BL0 -19.2 dB

dB

EM302 **Backscatter**

(Linear clip 2%-98%)
-15dB   -35dB

0   5
kilometers

Johnston Atoll

outliers 25% 50% 75% outliers
1%   99%

median

CARIS BL3
CARIS BL0   **-21.9 dB**
FMGT BL3
FMGT BL0   **-26.2 dB**
SSc BL3
SSc BL0   **-26.6 dB**

-30   -25   -20
dB
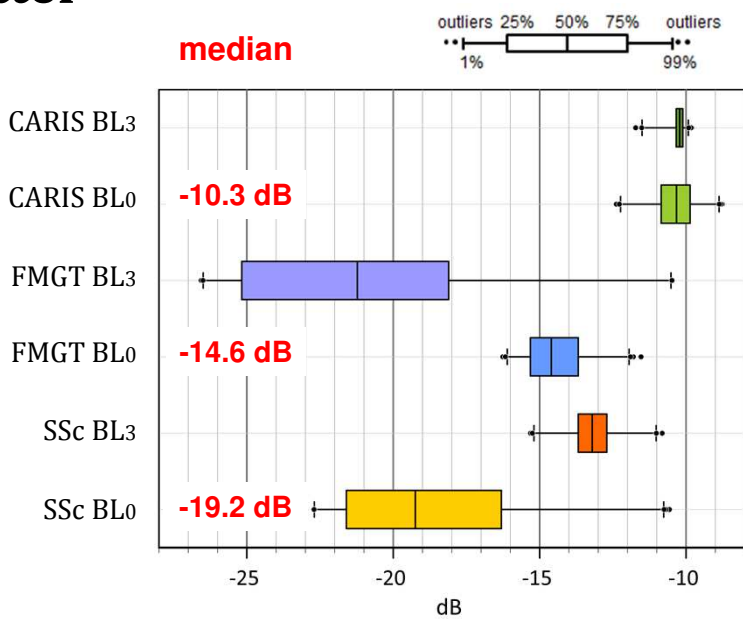
Intermediate processing stages enable further insights

BL3 - BL0 (ping – beam geometry)

CARIS   FMGT   SonarScope
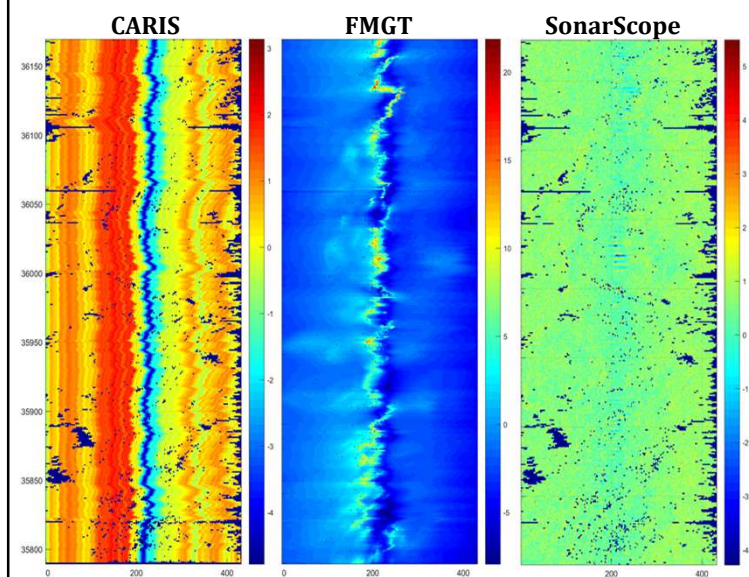
Different software :

- **Provide different results for both BL0 and BL3**

- **Apply different processing corrections between BL0 and BL3**

Intermediate processing stages enable further insights

$$\frac{(\text{CARIS BL3} - \text{CARIS BL0}) - (\text{FMGT BL3} - \text{FMGT BL0})}{(\text{CARIS BL0} - \text{FMGT BL0})}$$

(ping – beam geometry)

Which sources of differences is most significant, BL0 or BL3?
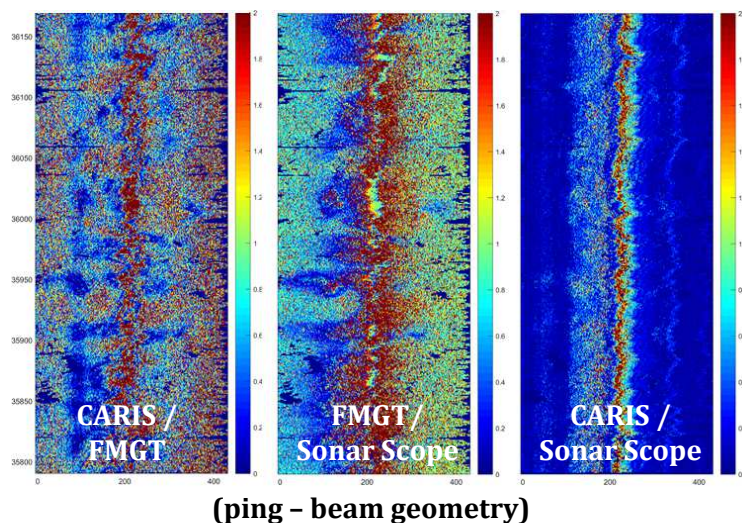
Absolute ratio
Δ BL3 – BL0 / Δ BL0
for each software pair

Strong dominance of values below 1 is observed

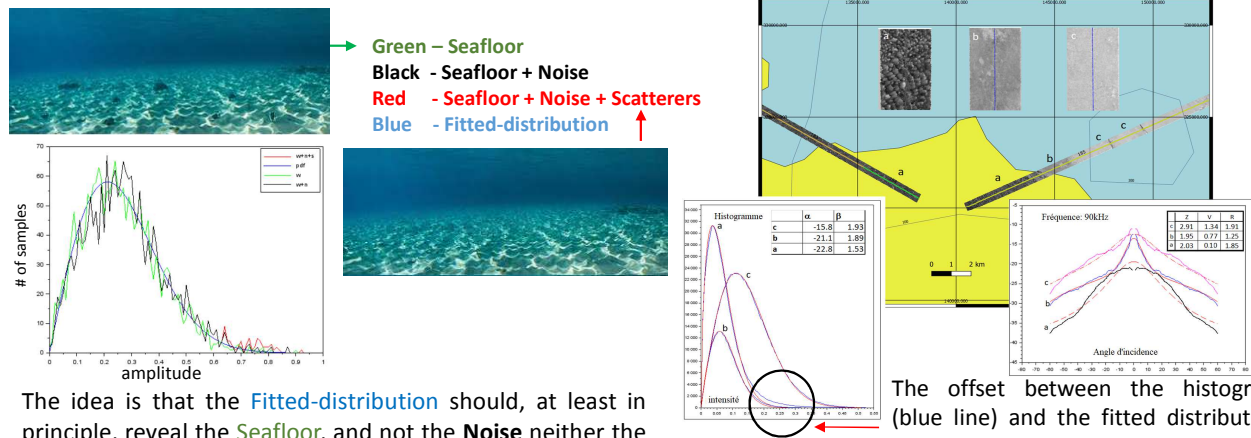**→ High significant part of differences between software is related to BL0**

Conclusions

- Intermediate processing stages provides insights into differences between software outputs
  - Differences in level "as read in the datagrams" BL_0 a surprise
- A variety of processing approaches available
  - Improved tools needed to understand impact of one choice vs. another
- Next steps
  - Round 2 processing in progress to provide other intermediate stages (corrections)
- We need your help !!
  - Users: To demand that results processed by different software should agree with each other
  - Software developers: To work together to implement agreed best practices for backscatter processing
  - BSWG: To provide a platform to facilitate these discussions

BL0 extraction from snippets to beam average = the most critical BS processing step

- Importance of a critical scientific approach!
- See: "Some Practical recommendations for averaging acoustic backscatter strength"

GeoHab 2019 contribution
L. Fonseca, X. Lurton, R. Fezzani,
J.-M. Augustin &L. Berger

Green – Seafloor
Black - Seafloor + Noise
Red - Seafloor + Noise + Scatterers
Blue - Fitted-distribution

The idea is that the Fitted-distribution should, at least in principle, reveal the Seafloor, and not the **Noise** neither the Scatterers

The offset between the histogram (blue line) and the fitted distribution (red line) reflects the density of scatterers.

About the backscatter:

- *Like spaghetti carbonara: everyone knows what it is but everyone cooks it in its own way.*

- *Small cause, great effect. A few more shells and the world changes.*

Questions ?

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Margaret Dolan (Margaret.Dolan@ngu.no)
Julian Le Deunf (julian.le.deunf@shom.fr)

Thanks to software developers

References

Fonseca L, Lurton X, Fezzani R, Augustin JM, Berger L 2019. Some Practical recommendations for averaging acoustic backscatter strength. GeoHab 2019.

Kruss A, Madricardo F, Lorenzetti G, Amos C, Kassem H, Ferrarin C, De Pascalis F, Maicu F, Petrizzo A, Umgiesser G, Zaggia L. 2016. Multibeam echosounder backscatter variability due to sediment resuspension and environmental dynamics in shallow waters. GeoHab 2016.

Lamarche G, Lurton X. 2017. Recommendations for improved and coherent acquisition and processing of backscatter data from seafloor-mapping sonars. Mar. Geophys. Res. 39:5-22.

Lucieer V, Roche M, Degrendele K, Malik M, Dolan M, Lamarche G. 2017. User expectations for multibeam echo sounders backscatter strength data-looking back into the future. Mar. Geophys. Res. 39:23-40.

Lurton X, Lamarche G. 2015. Backscatter measurements by seafloor-mapping sonars. Guidelines and recommendations. Retrieved 27th April 2018 from http://geohab.org/wp-content/uploads/2013/02/BWSG-REPORT-MAY2015.pdf.

Roche M, Degrendele K, De Mol L. 2013. Constrains and limitations of multibeam echosounders Backscatter Strength measurements for monitoring the seabed. Surveyor and geologist point of view. GeoHab 2013.

Roche M, Degrendele K, Vrignaud C, Loyer S, Le Bas T, Augustin J-M, Lurton X. 2018. Control of the repeatability of high frequency multibeam echosounder backscatter by using natural reference areas. Mar. Geophys. Res. 39: 89-104.

Schimel ACG, Beaudoin J, Parnum IM, Le Bas T, Schmidt V, Gordon K, Ierodiaconou D. 2018. Multibeam sonar backscatter data processing. Mar. Geophys. Res. 39:121-137.

BSWG recommended processing stages
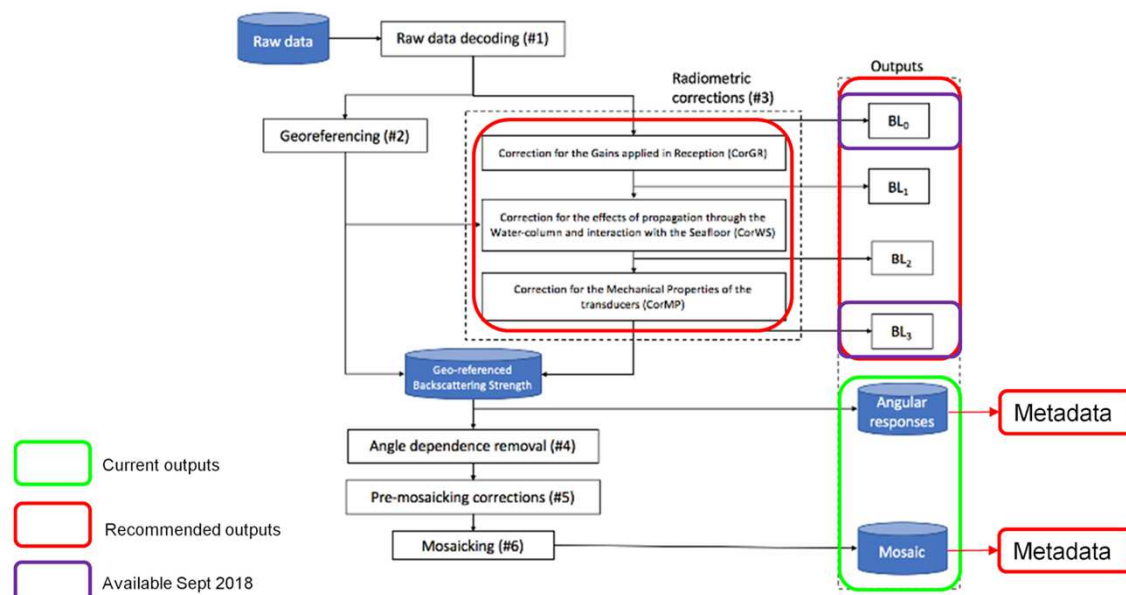
BSIP → Workflow

Evaluation of Multibeam Backscatter Consistency

through Comparison of Intermediate

Processing Results

⬇

BSWG: Majority of users use

SonarScope, FMGT, CARIS SIPS and MB System

⬇

Software developers requested to provide processed data

Ref: Malik et al. (2018) Lucieer et al. (2018)

BSIP → Rationale

Standard processing sequences

A same simple post-processing sequence applied to the same backscatter data using different software suites can, in some cases, provide significantly different results (Lucieer et al. 2017). This situation is of course far from optimal for quantitative science. The BSWG has recommended the definition of standardized post-processing sequences, at least for the initial stages, namely data reading and decoding, gain compensations, and normalization (Schimel et al. 2015). To check the consistency of the processing results provided by various software suites, initiatives promoting comparative tests on common data sets should be encouraged, in a similar fashion as for instance the "Shallow Survey" initiative developed for MBES bathymetry datasets (Shallow Survey 2015).

Ref.: Lurton, X. and Lamarche, G., *Backscatter measurements by seafloor-mapping sonars. Guidelines and Recommendations*, GeoHAB BSWG, 2015.

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the increasing use of backscatter data. The limitation regarding software was mentioned in relation to both acquisition software packages and processing software packages and that sometimes the data formats between the different platforms were not compatible in the recent past. The majority of users in the survey used the following software: Sonarscope®, QPS Fledermaus®, ArcGIS®, CARIS® and MB Systems. From this list only Sonarscope®, QPS Fledermaus®, CARIS® and MB Systems are able to provide some level of backscatter data processing while ArcGIS provides image analysis only once backscatter image has been produced by the earlier listed software tools. Amongst the four backscatter processing tools, users can apply backscatter corrections and produce mosaics (image processing) with various levels of signal processing available. One

BSIP → Original Goals

1. Identify processing stages and **intermediate results**

2. Identify **discrepancies** in the processing stages

3. Develop consensus about **standard processing chain**, nomenclature and metadata

Diversity in processing approaches

Welcomed as long as end users are clear on what was done and why?

With Proprietary software - This transparency is not available

Effect of each adopted processing method is beyond scope of majority of BS users

Hence need of a an easy to validate test bench