



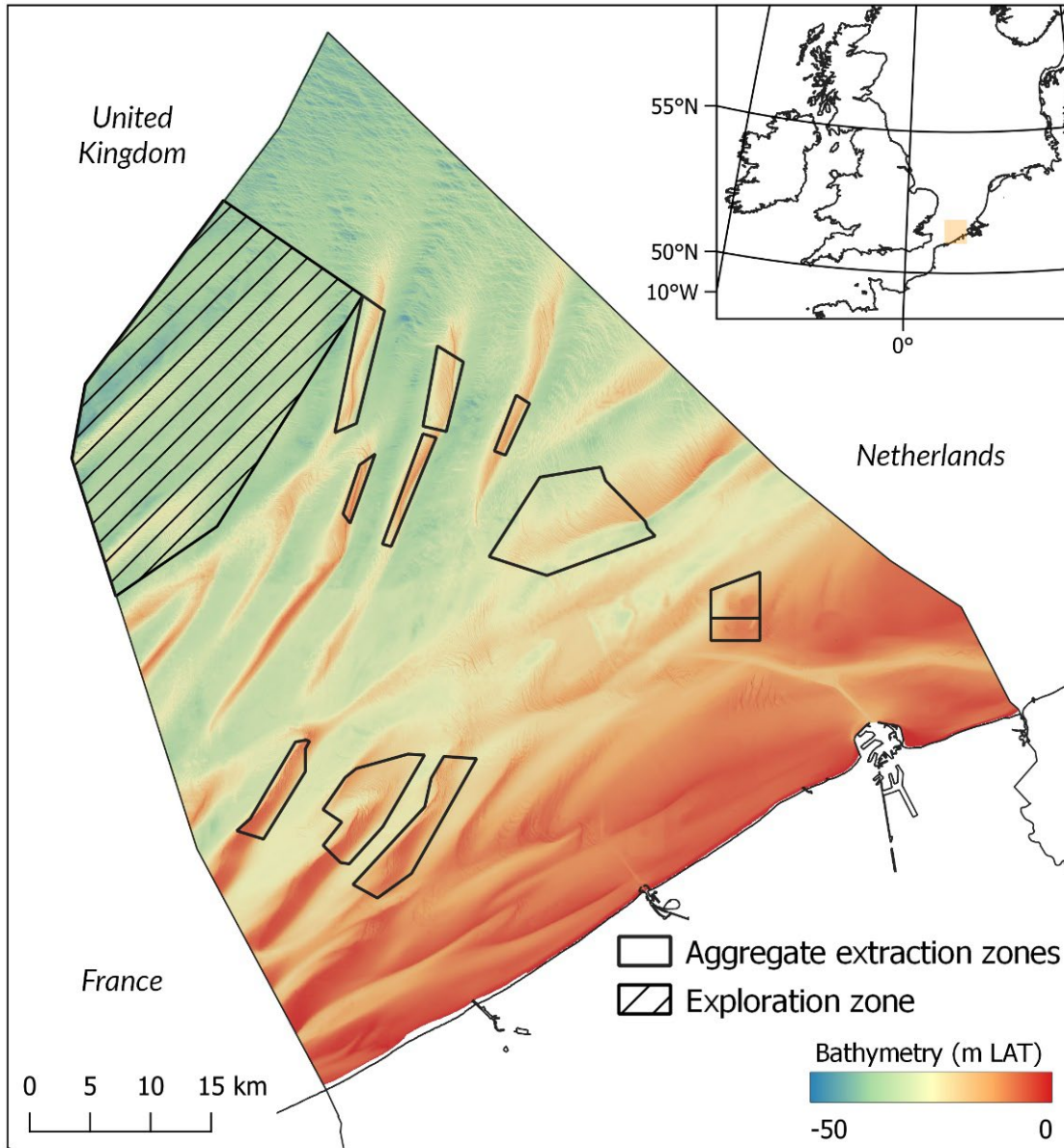
## **EM2040 backscatter cross-calibration on the Kwinte reference area (Belgian part of the North Sea): principles, results and prospects.**

**Marc Roche**, Ridha Fezzani, Samuel Deleu, Arnaud Gaillot, Kris Vanparys, Jan Vercaemst, Koen Degrendele, Florian Barette, Luciano Fonseca, Hervé Bisquay, Johan Verstraeten, Xavier Lurton, Giacomo Montereale Gavazzi & Jean-Marie Augustin



*Session 2 – Seafloor backscatter  
September 27, 2023*

# The context: what do we use MBES backscatter for?



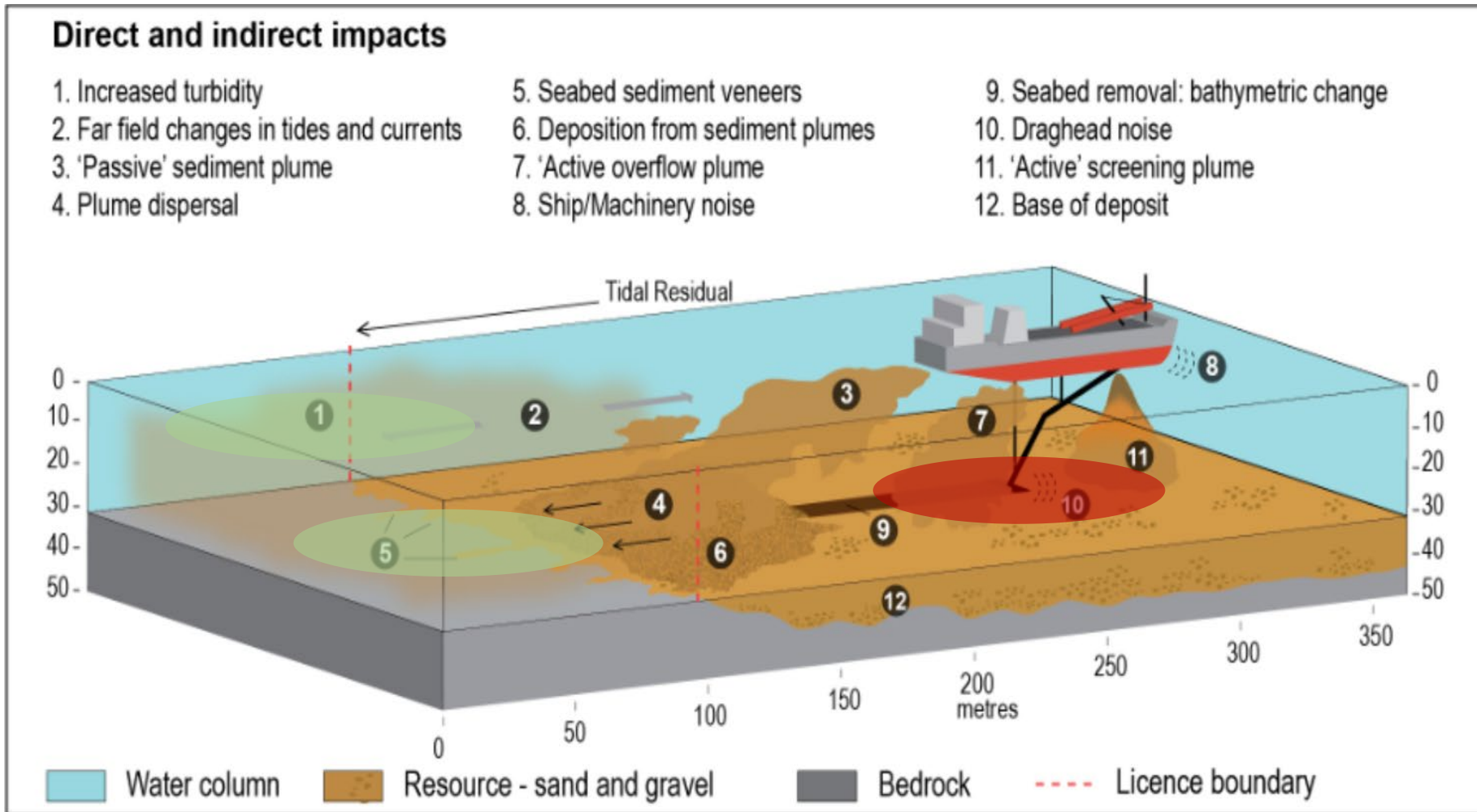
Sand extraction  
on the Belgian part of the North Sea



Industry  
3 millions m<sup>3</sup>/year

Beach maintenance  
Up to now 2 million m<sup>3</sup>/ year

# The context: what do we use MBES backscatter for?



*Tillin et al. 2011*

To monitor  
the impact of  
sand extraction

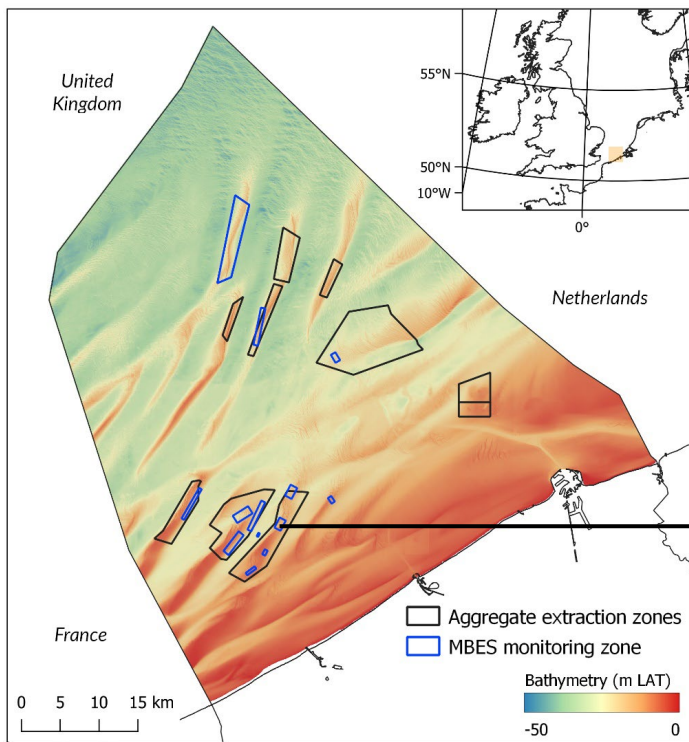
Near field impact  
Bathymetry  
Bottom BS

Far field impact  
Water Column BS

Monitoring the impact of sand extraction = National and EU legal obligation



# The context: what do we use MBES backscatter for?



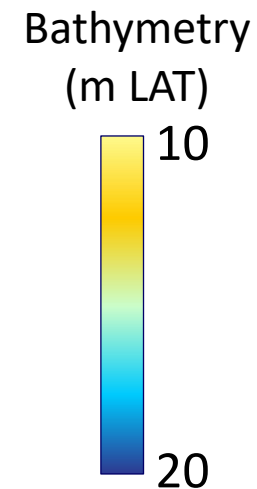
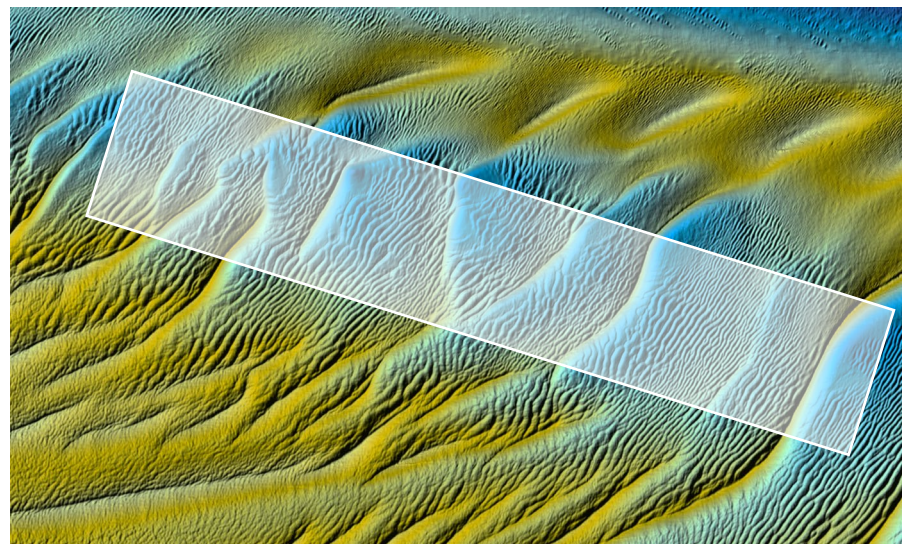
Source: Bathymetric model of the Belgian part of the North Sea (Flemish Hydrography and Continental Shelf Service)

e.g.  
KBMA area

250 m



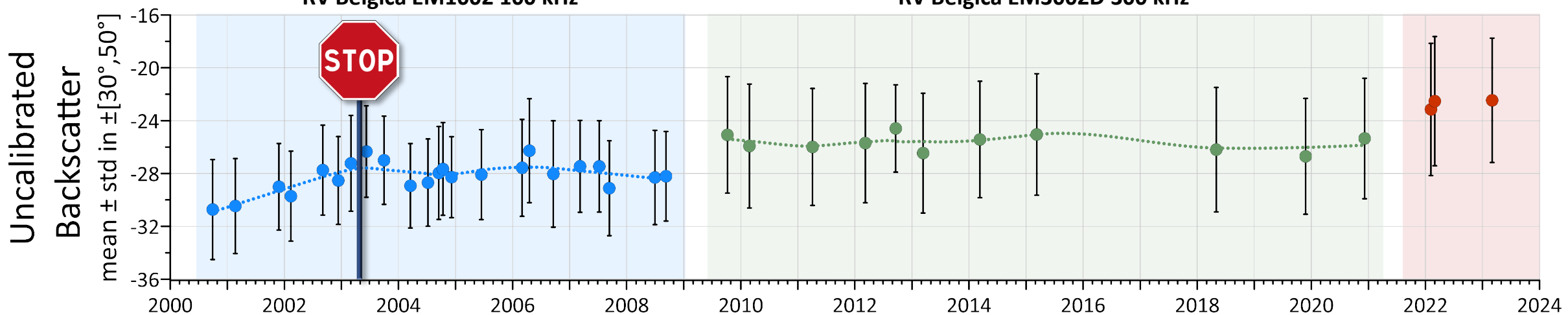
In monitoring areas :  
BS time series = proxy for seabed evolution



RV Belgica EM1002 100 kHz

RV Belgica EM3002D 300 kHz

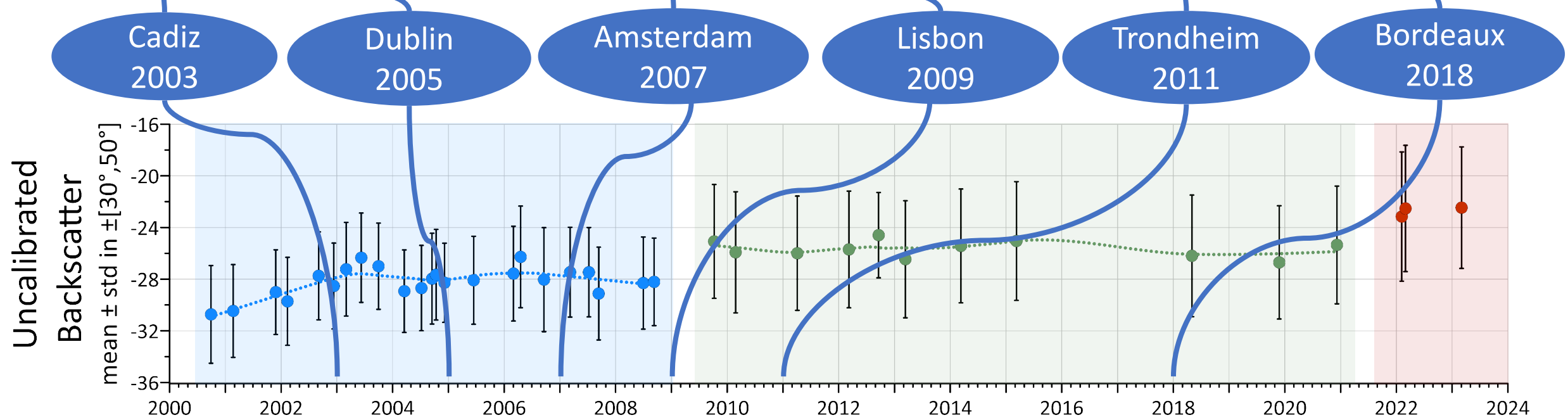
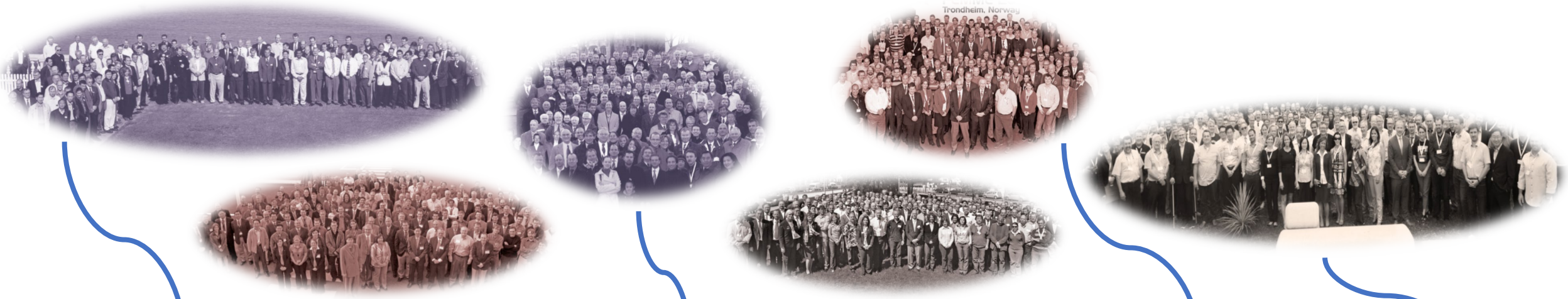
New RV Belgica  
EM2040 DUAL RX



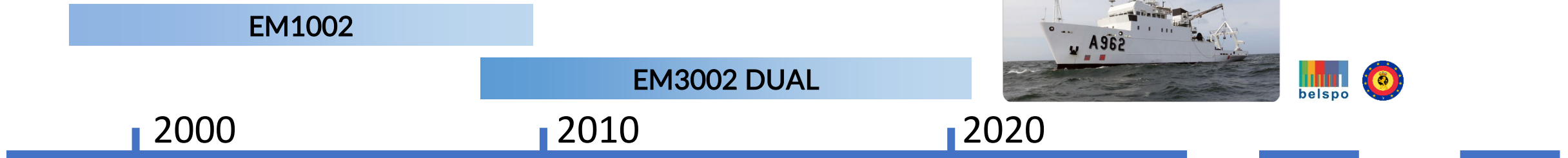


# The context: what do we use MBES backscatter for?

To present our results and our expectations in FEMME...



# MBES past and future



**Optimal sharing of BS data**  
≠ MBES  
≠ Acquisition mode  
For integration in seabed sediment mapping and monitoring  
➤ **Calibration**

**EM2040 DUAL RX**  
New RV Belgica  
See poster!  
belspo Genavir

**EM2040 DUAL RX**  
RV Simon Stevin  
VLIZ VLOOT

**EM2040 DUAL SWATH**  
HV Sirius  
AGENCY FOR MARITIME & COASTAL SERVICES  
Flanders State of the Art

# A plea for MBES BS calibration:

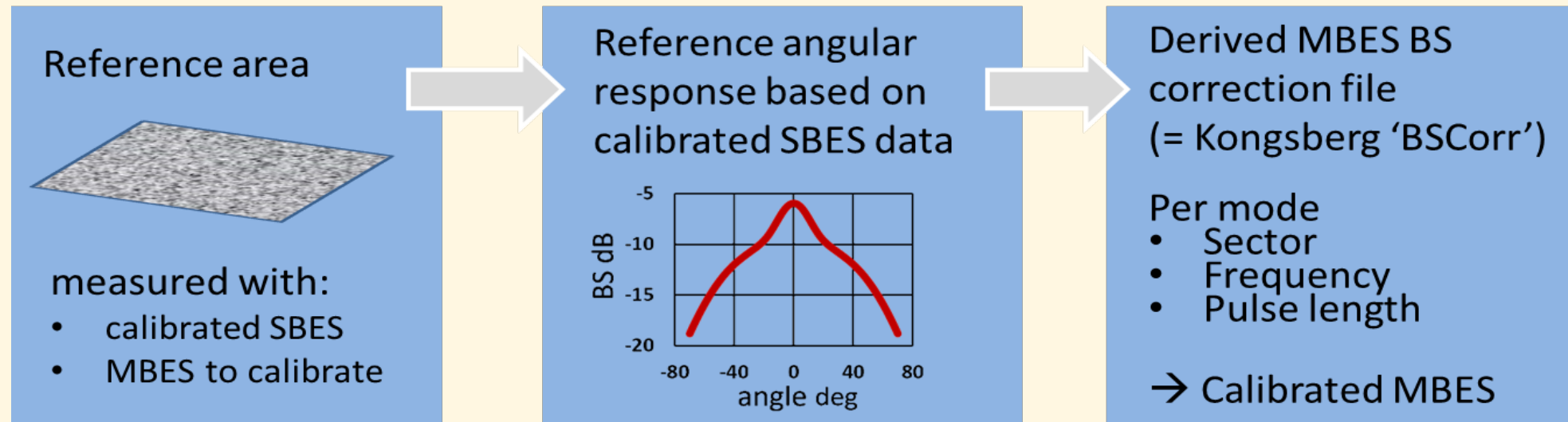
- A key point for any objective use of BS
- Only **absolute calibration** gives access to the sediment properties
- Calibration is applied uniformly and without problems for:
  - Satellite-radar BS measurements of the Earth
  - Fisheries acoustics, biomass monitoring
  - Bathymetry measurements done by the same echosounders!
- **Actually, sensor calibration does not raise question in any scientific measurement activity - why is it still a problem with sediment BS?**



# Things are moving in the right direction:

- See T. I. Birkenes Lønmo, J. H. Clarke and R. Fezzani & L. Berger FEMME 2023 contributions
- Ifremer's pioneering work over the last two decades (e.g. Eleftherakis et al., 2018)
- Recent expressions of interest from IHO, NOAA, SHOM
- Backscatter Working Group II - Calibration Branch

For users, cross-calibration on a reference area provides a pragmatic solution for BS calibration



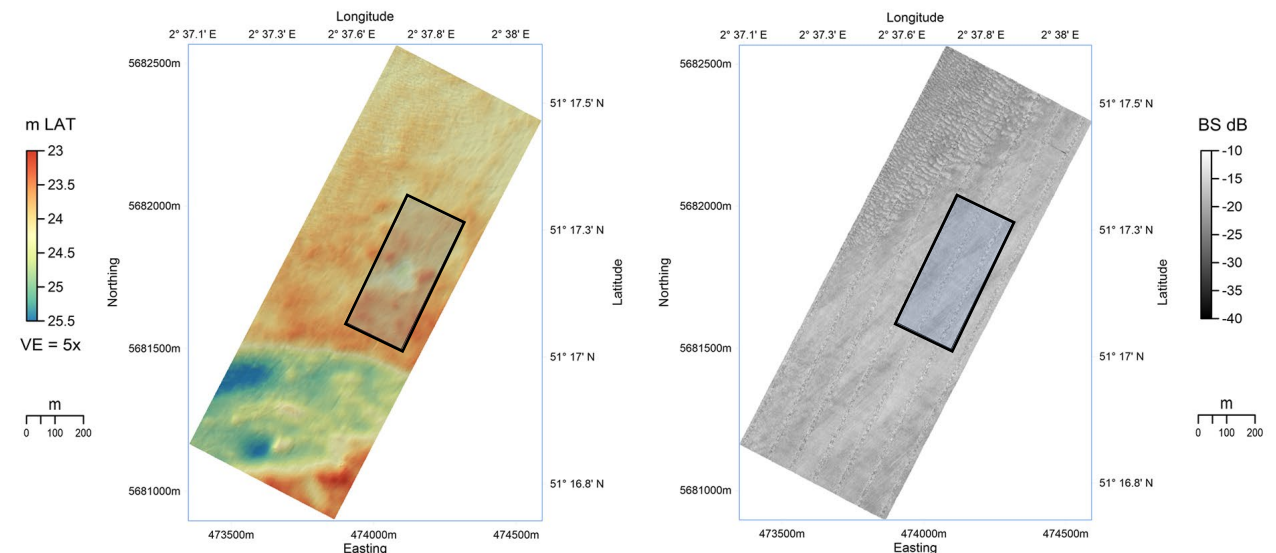
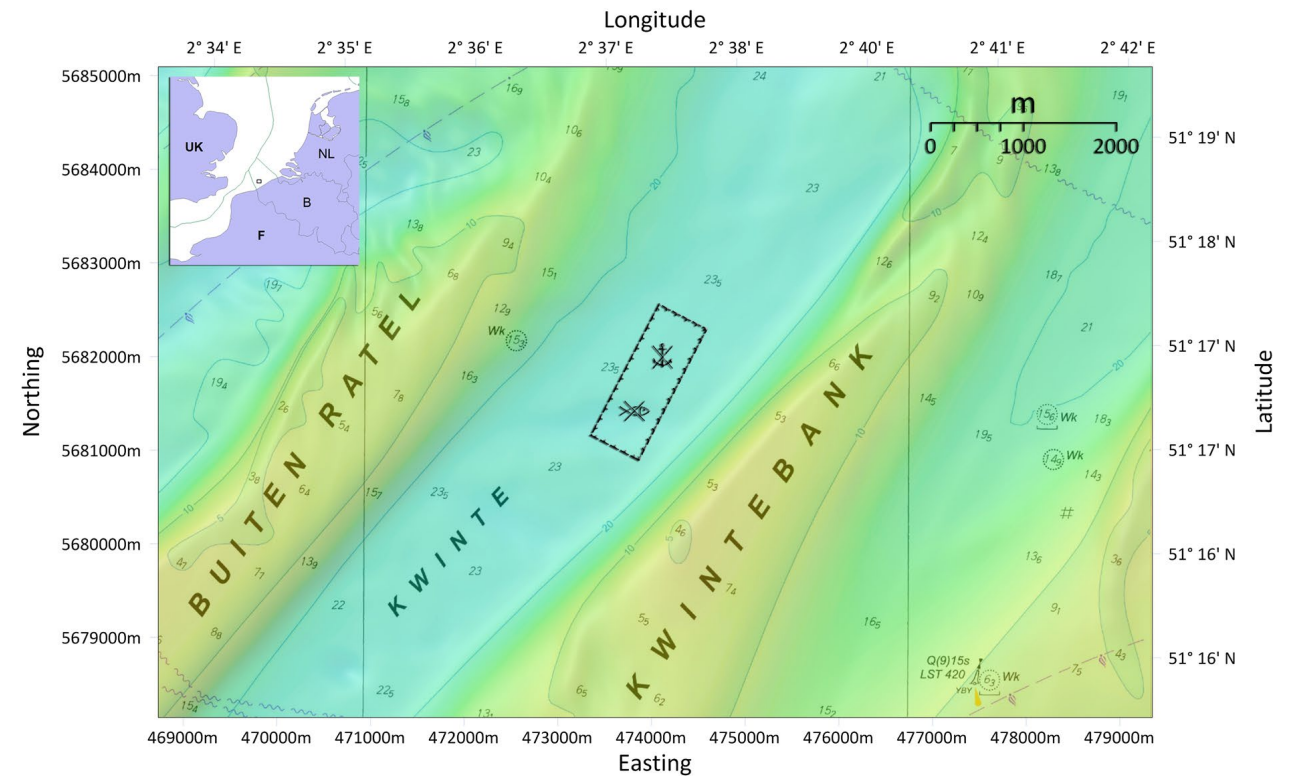
# The Kwinte reference area:

- 17 km from the coast between two sandbanks
- Length: 1 km; width: 440 m  
Depth: 23 to 26 m LAT
- Sediment : sandy gravel with shells
- Defined in the Belgian Marine Spatial Plan 2020-2026 *as a reference area for the calibration and quality evaluation of measuring devices where seabed disturbing activities are prohibited*

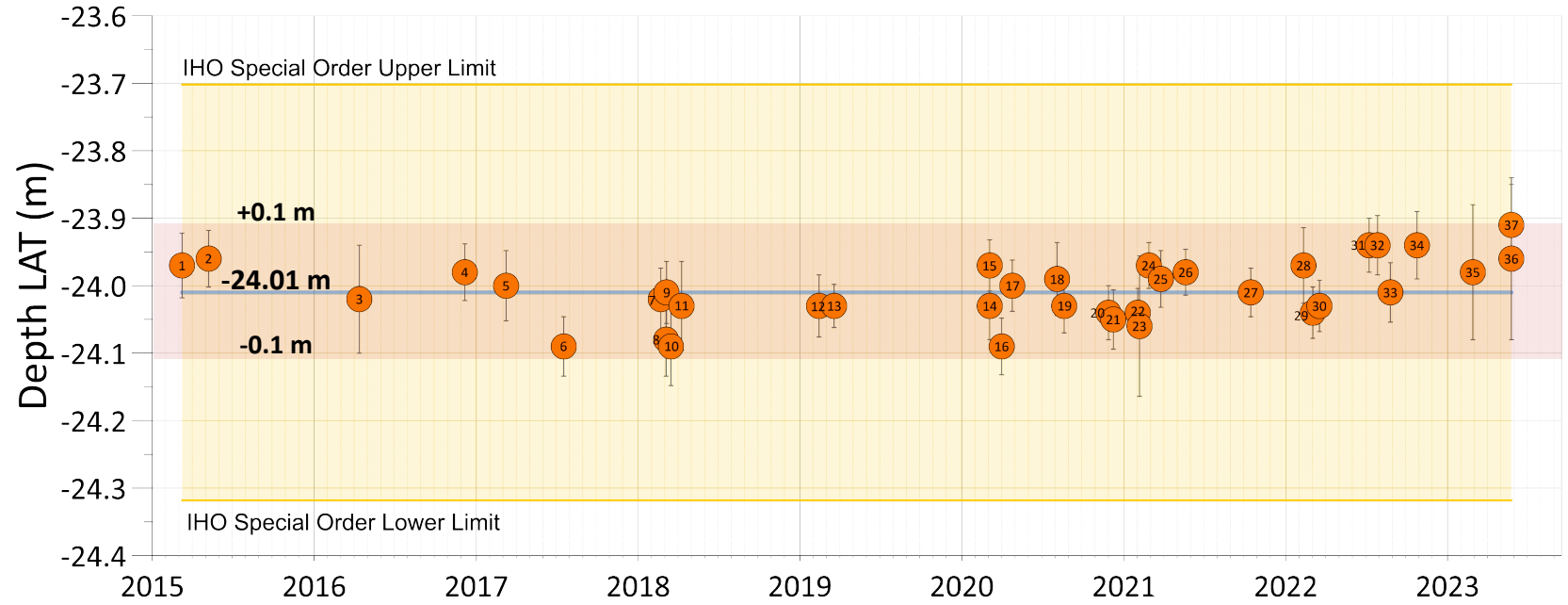
- Calculation in subarea

- Open to everyone to validate bathymetry and backscatter strength data

[www.afdelingkust.be/en/acoustic-reference-area-kwinte](http://www.afdelingkust.be/en/acoustic-reference-area-kwinte)



# Stability of the Kwinte reference area

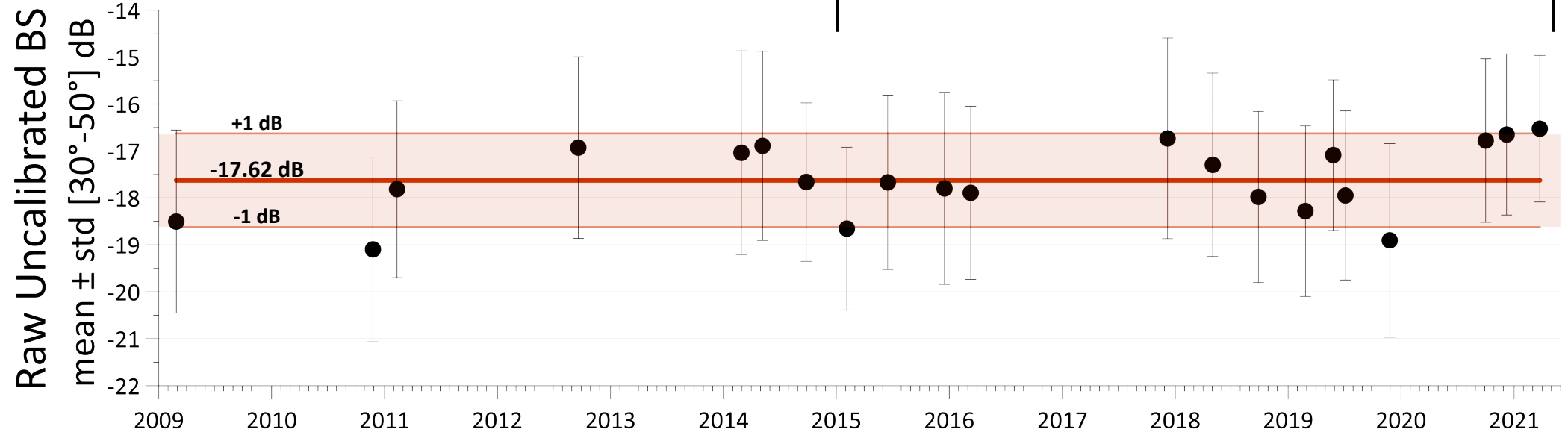


- 1 Libertas
- 2 Libertas
- 3 Simon Stevin
- 4 Simon Stevin
- 5 Simon Stevin
- 6 Ter Streep
- 7 Simon Stevin
- 8 Sirius
- 9 Simon Stevin
- 10 Ter Streep
- 11 Ter Streep
- 12 Sirius
- 13 Patriot
- 14 Geosurveyor XI
- 15 Geosurveyor VI
- 16 Patriot
- 17 Geosurveyor XVI
- 18 Simon Stevin
- 19 Geosurveyor VIII
- 20 Geocean IV
- 21 Geosurveyor VIII
- 22 Geosurveyor X
- 23 Geosurveyor XI
- 24 Geosurveyor XVI
- 25 Geosurveyor IV
- 26 Geosurveyor VI
- 27 Zr. Ms. Luymes
- 28 Anais
- 29 Belgica
- 30 Jan Breydel
- 31 Simon Stevin
- 32 Aquaway
- 33 Ter Streep
- 34 Zr. Ms. Snellius
- 35 Belgica
- 36 Sirius
- 37 Geosurveyor XVII

AGENCY FOR  
**MARITIME &  
COASTAL SERVICES**

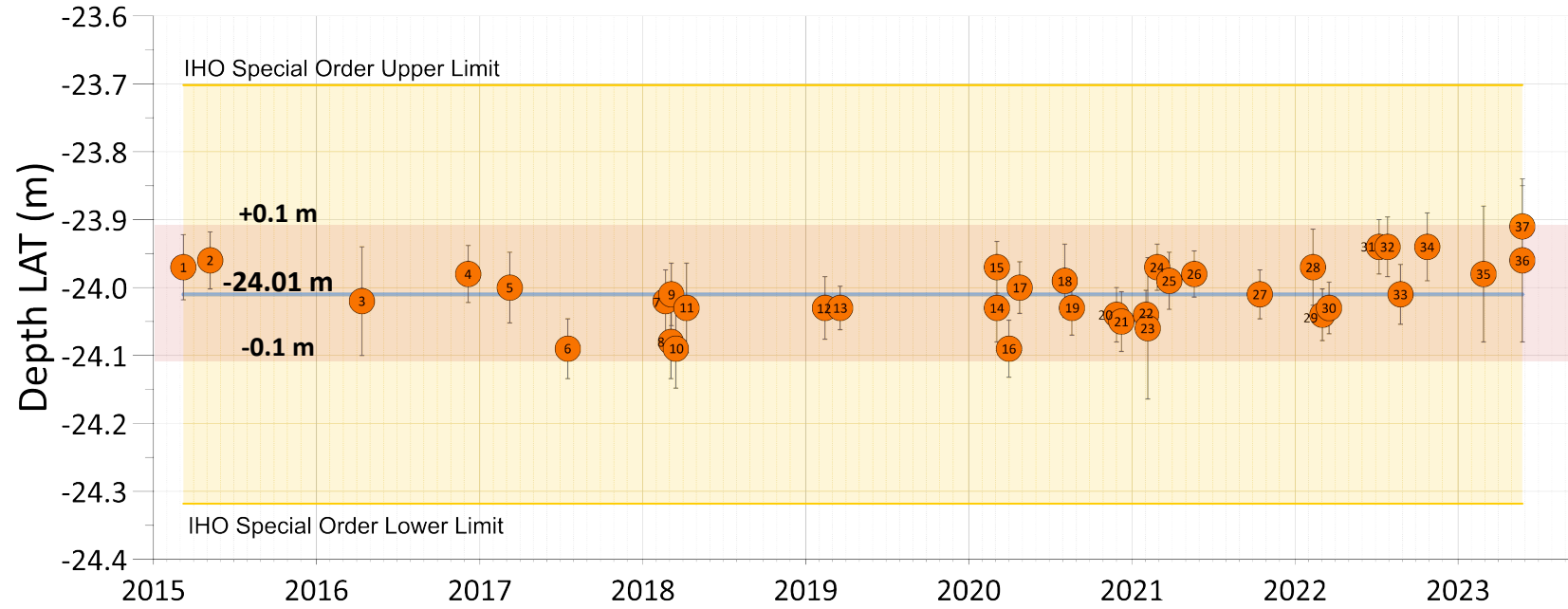


RV Belgica A962  
EM3002D 300 kHz



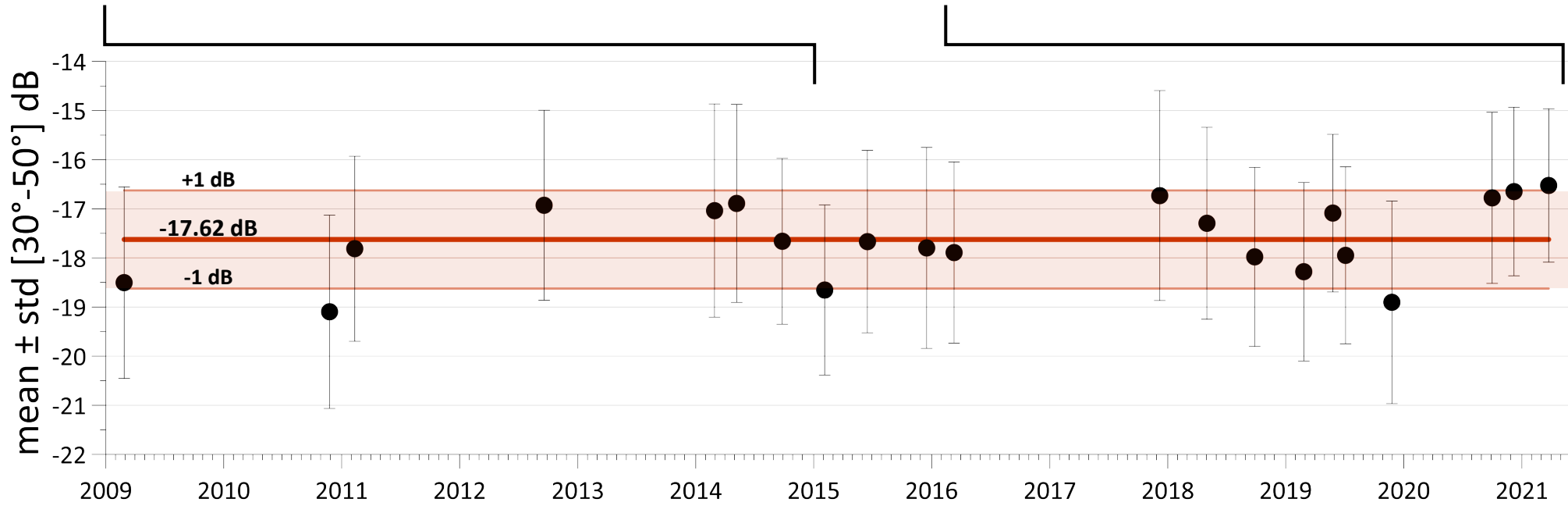


# Stability of the Kwinte reference area



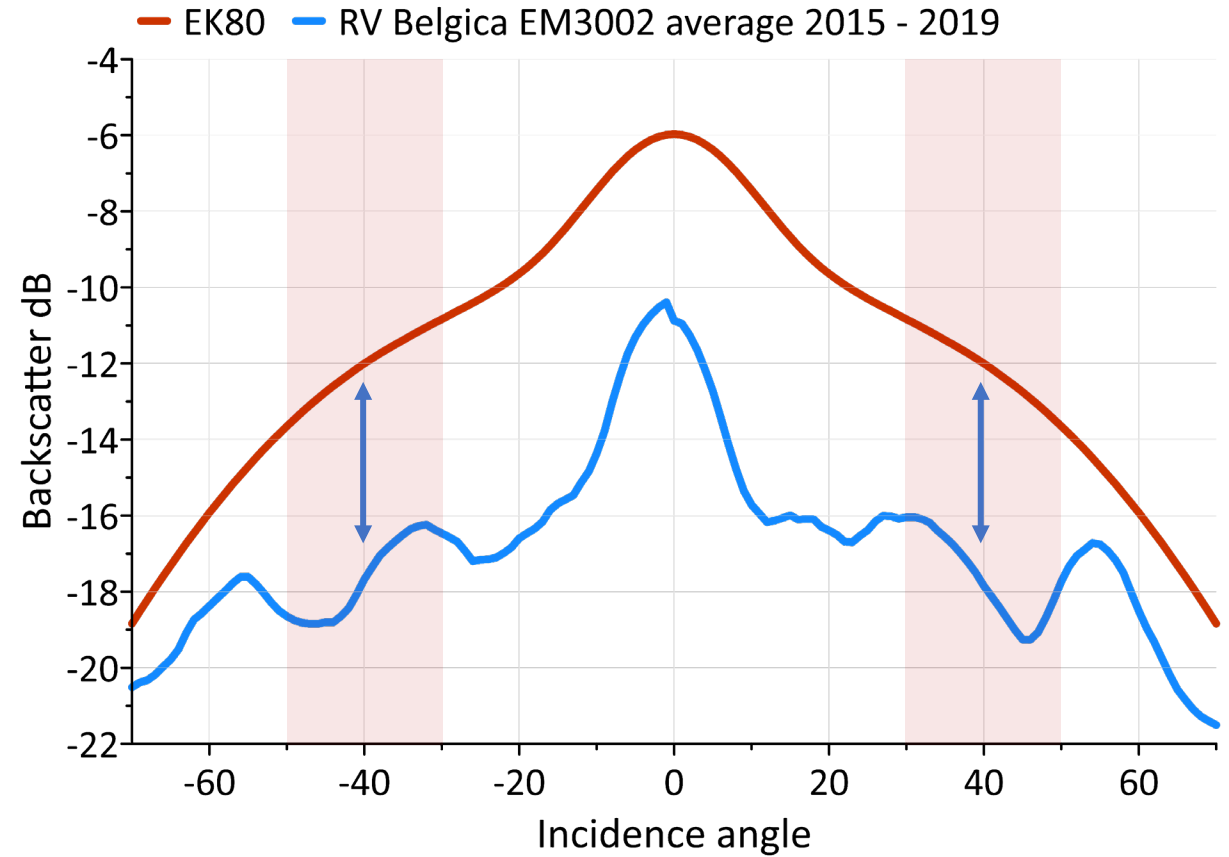
Bathymetry and BS are stable  
No significant trend is observed

Raw Uncalibrated BS



RV Belgica A962  
EM3002D 300 kHz

From Carré-Renard reference area → Kwinte @ 300 kHz  $\approx$  12 dB!



Reference area for

- bathymetry
- backscatter

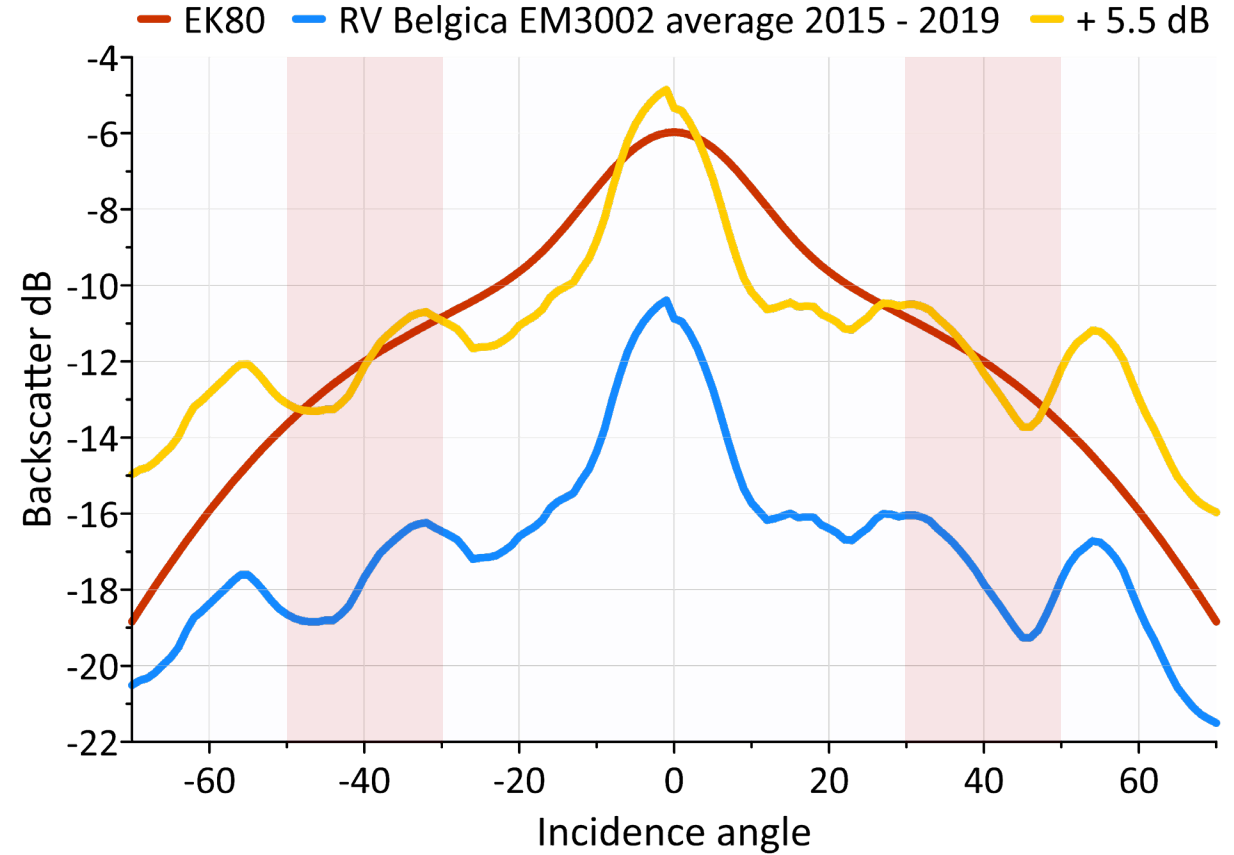


RV Belgica EM3002 dual 300 kHz

- 2010
- 2015



From Carré Renard reference area → Kwinte @ 300 kHz  $\approx$  12 dB!



Reference area for

- bathymetry
- backscatter



RV Belgica EM3002 dual 300 kHz

- 2010
- 2015

On Carré-Renard,  $\pm[30^\circ, 50^\circ]$ :

Bias RV Belgica EM3002D – EK80 = 5.5 dB

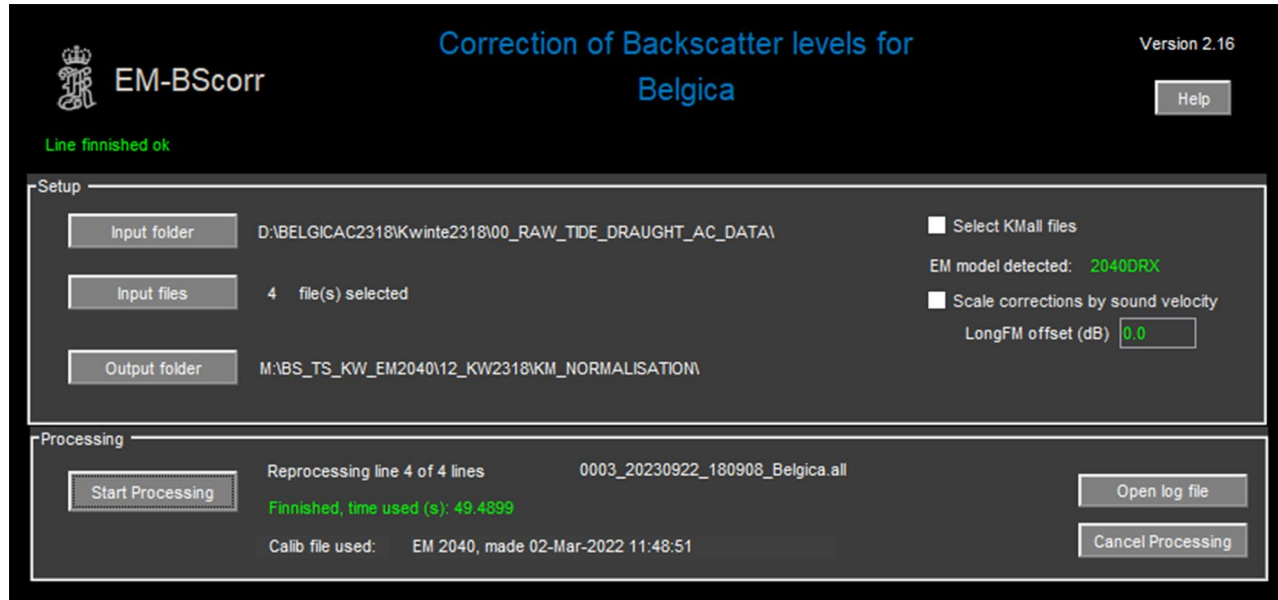
On Kwinte,  $\pm[30^\circ, 50^\circ]$ , RV Belgica EM3002D time series:

Mean BS level = -17.6 dB

**“calibrated” Kwinte area reference backscatter level in  $\pm[30^\circ, 50^\circ]$  @ 300 kHz = -12 dB**



# Based on -12 dB: KM BS corrections for RV Belgica EM2040 dual RX

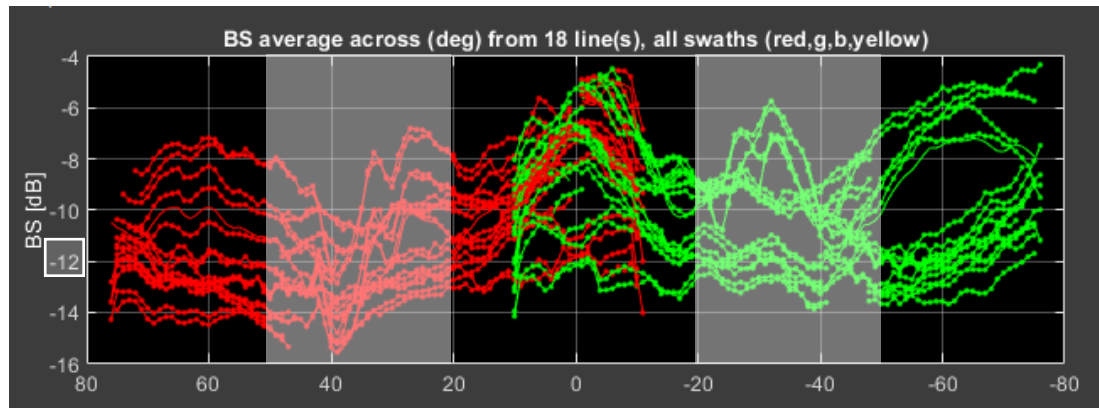


- BS corrs for 18 runtime settings (3 frequencies, 2 sector modes, 3 pulse lengths)
- Based on recordings on Kwinte area
- Assuming a BS mean level of -12 dB



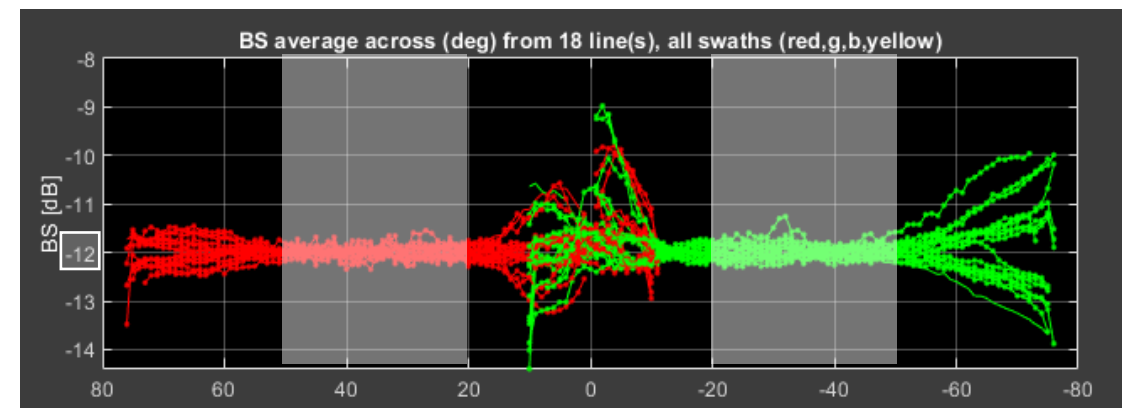
Torgrim Eldevik  
February/March 2022

Before



-12 dB  
reference  
level  
→

After



👍 ± [20°, 50°]

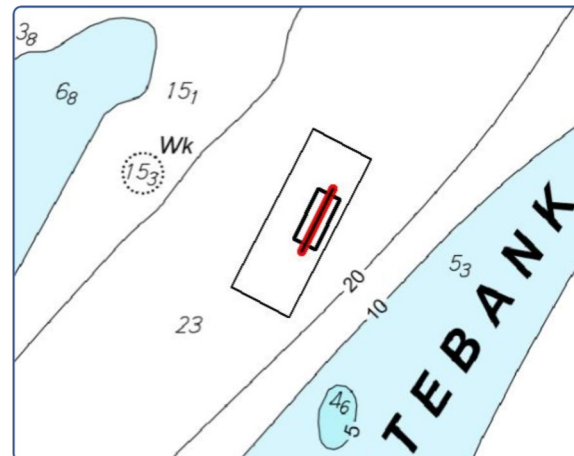
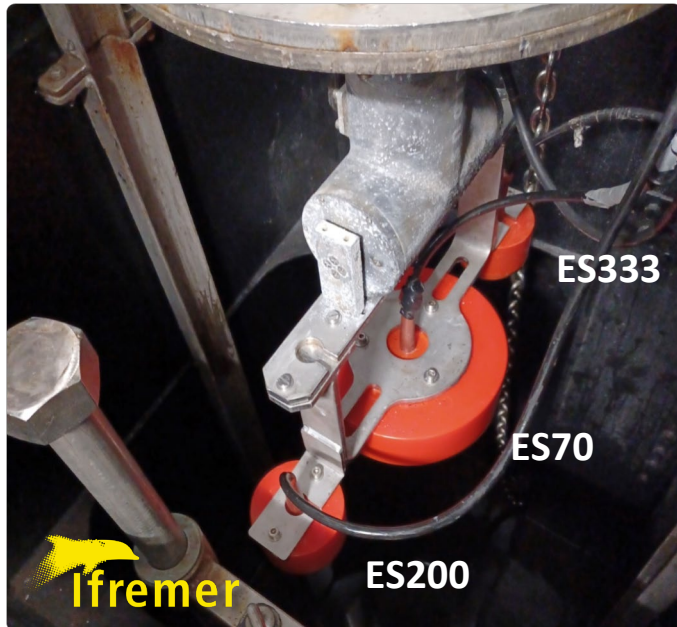
# Backscatter reference level on Kwinte area (22-25 May 2023):

## HV Sirius

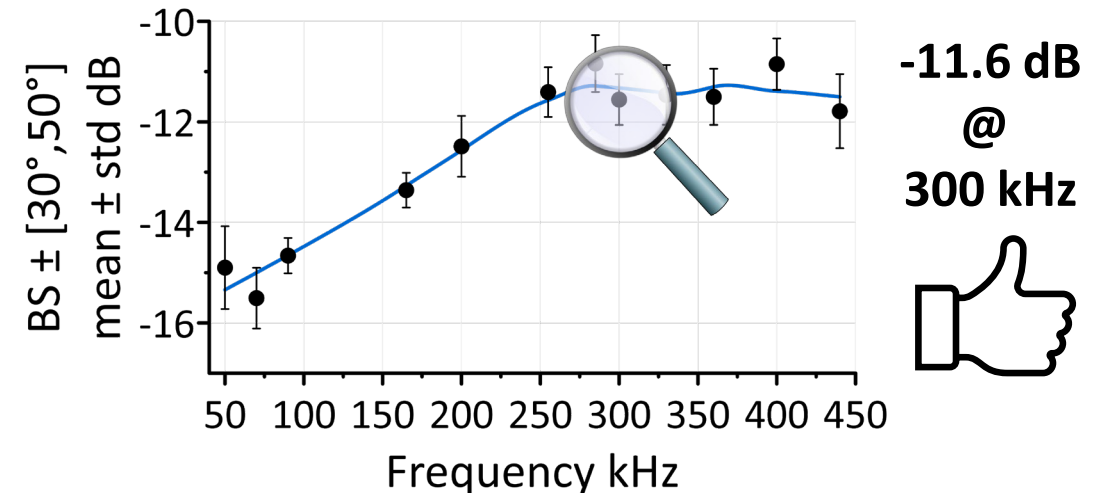
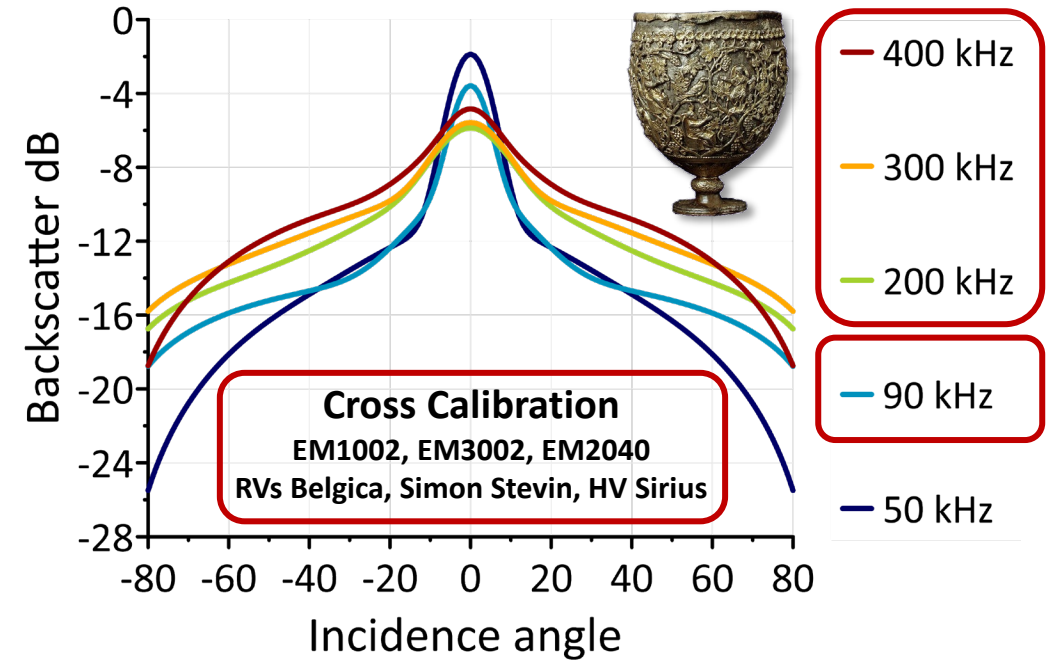


1. Installation on the moon-pool of the HV Sirius
2. EK80 calibration using a 25mm sphere
3. EK80 data acquisition on Kwinte area on a reference track:
  - 50 to 440 kHz
  - $-10^\circ$  to  $75^\circ$  step  $5^\circ$
  - 18 round-trip lines / F

## EK80 with Pan&Tilt device



## Reference angular response

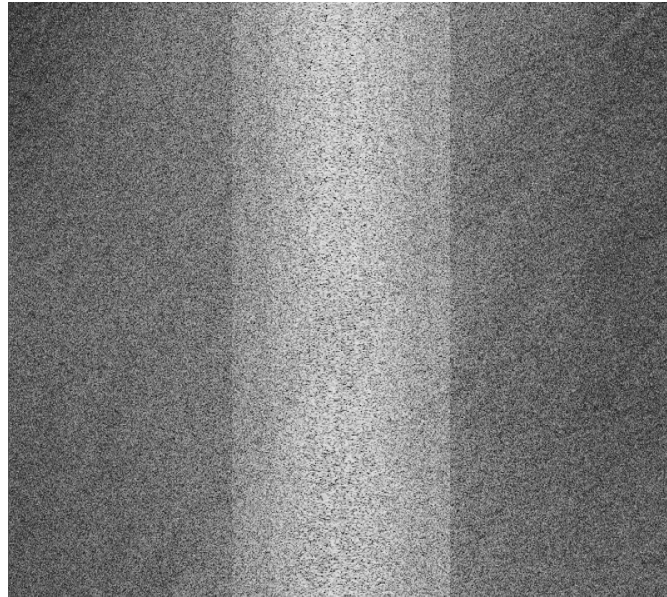




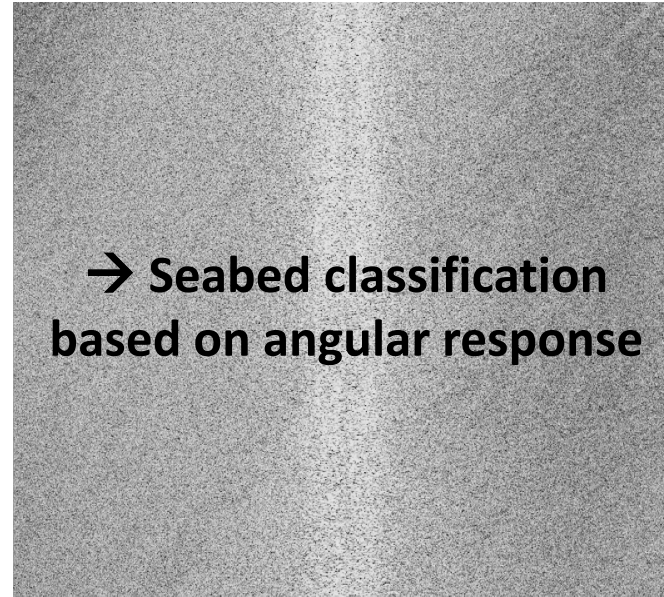
# RV Belgica EM2040 cross calibration:

**Raw BS**

0004\_20220204\_052559\_Belgica.all  
300 kHz – normal mode – medium pulse length



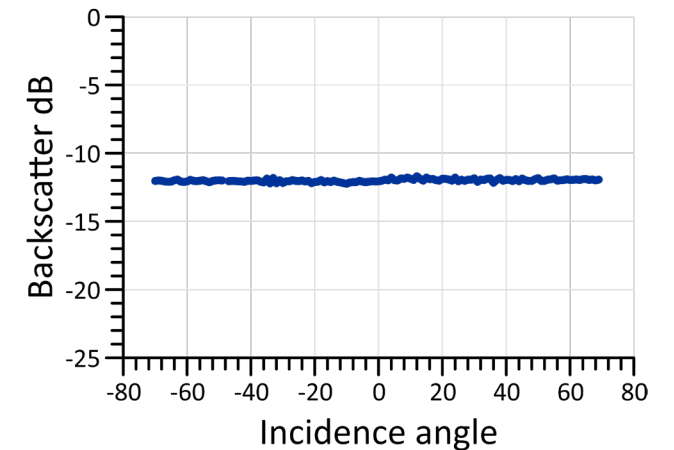
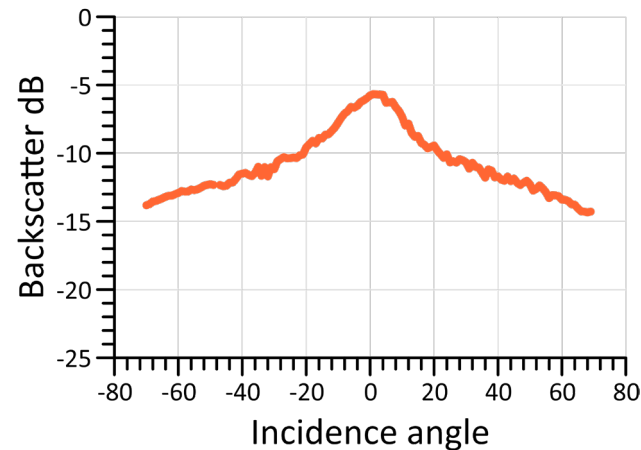
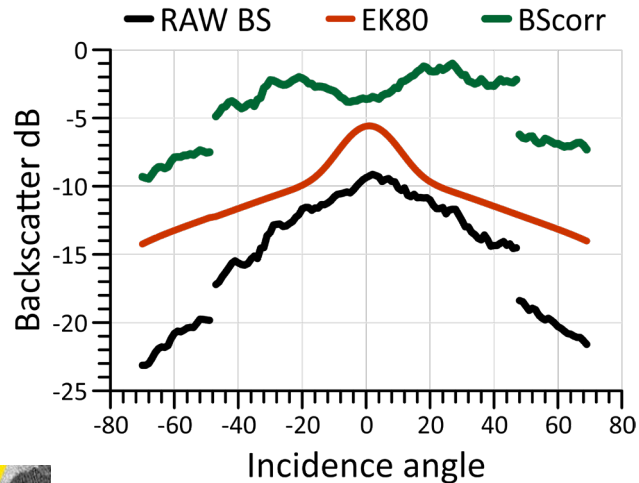
**Calibrated BS  
+ beam pattern correction**



**Calibrated BS  
+ beam pattern correction  
+ flattening – angular compensation**



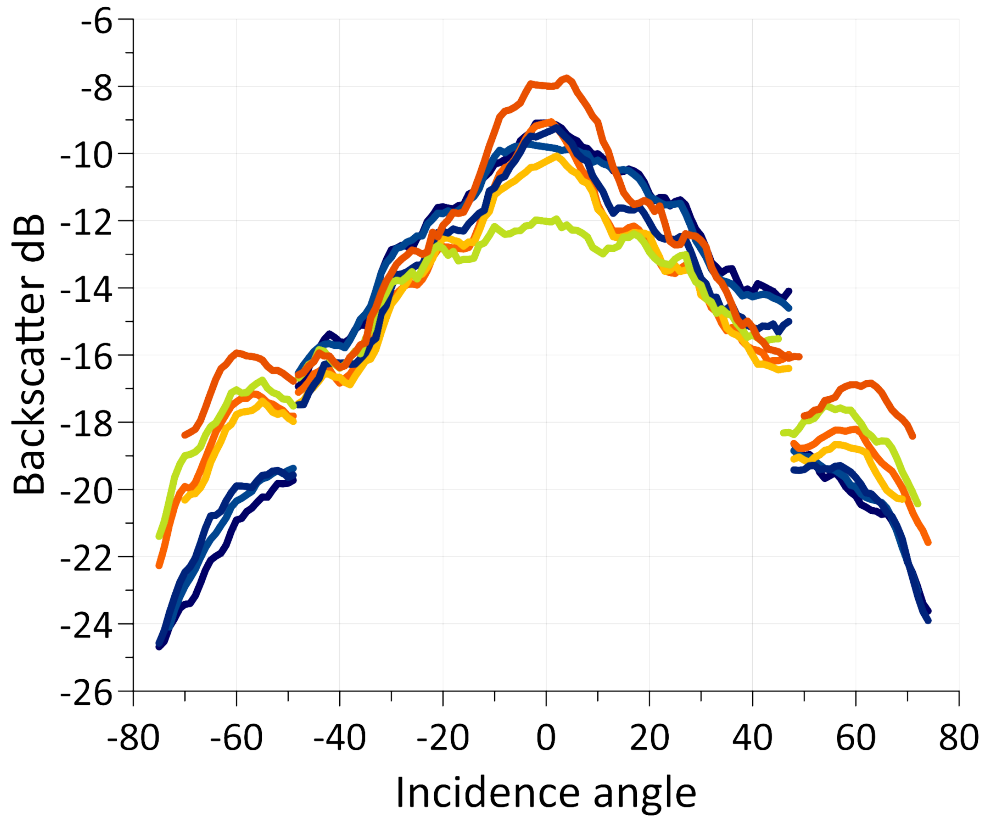
dB  
0  
-10  
-20  
-30  
-40  
-50  
ping  
↑  
beam  
→



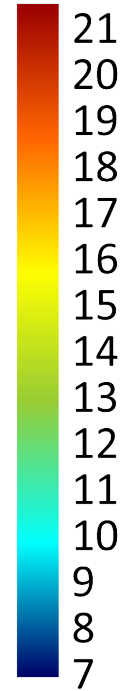


# EM2040 BS – Sea water temperature relationship

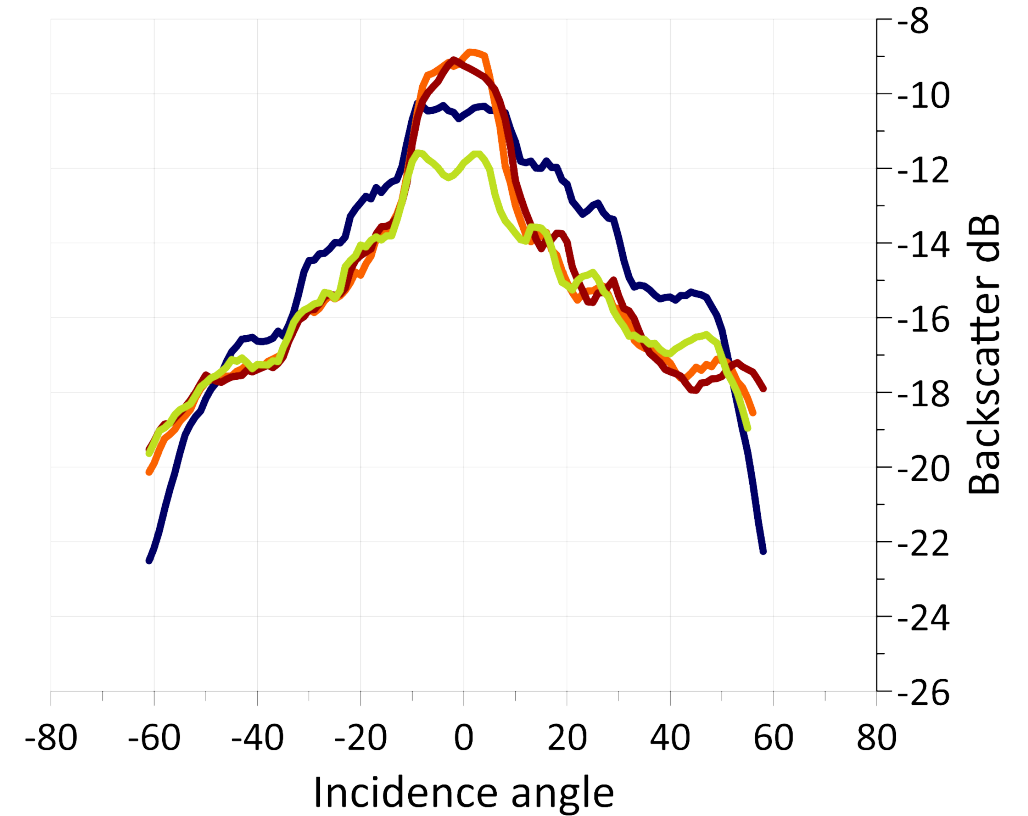
RV Belgica - Kwinte area - 2022-2023  
300 kHz, normal mode, medium pulse length



Line color =  
Seawater °C



RV Belgica - Kwinte area - 2022-2023  
300 kHz, single sector mode, long pulse length



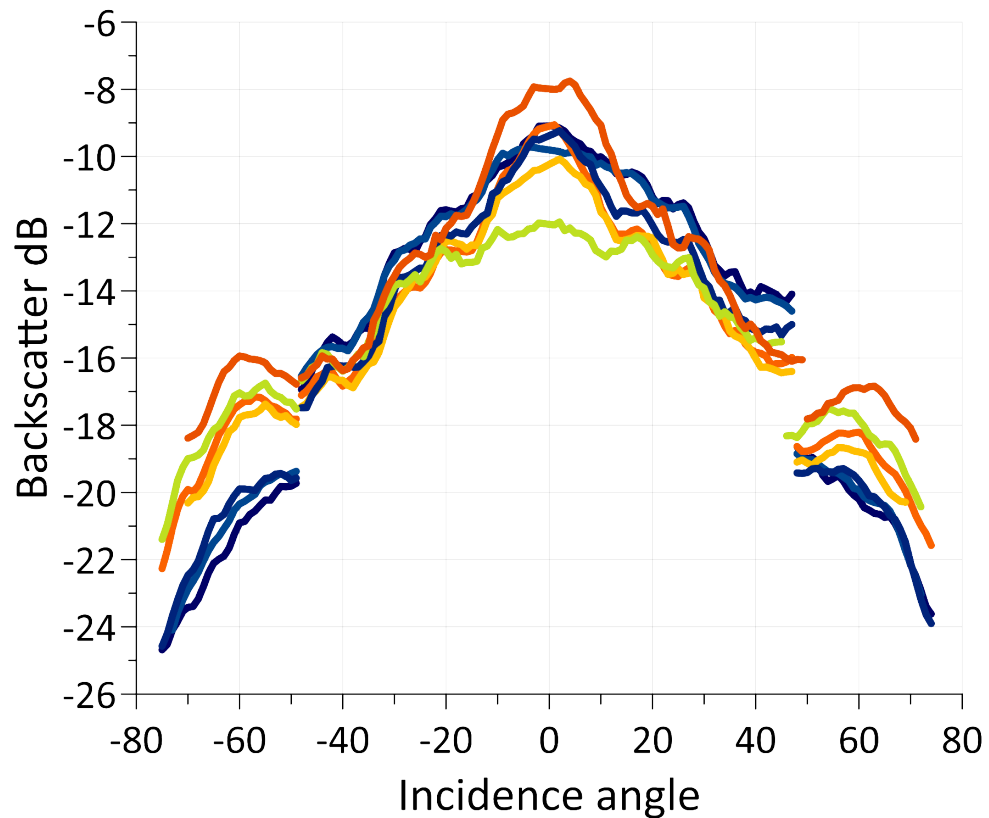
- BS variation correlated with sea water temperature
- As high as 4.5 dB on the port sector between “cold” and “warm” water
- Reversed trend between outer and central sectors in normal mode
- Similar reverse trend in single-sector mode



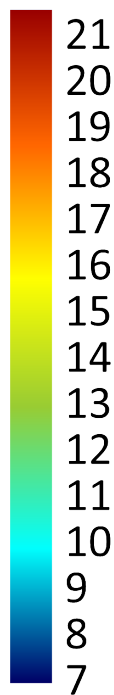
# EM2040 BS – Sea water temperature relationship

RV Belgica - Kwinte area - 2022-2023

300 kHz, normal mode, medium pulse length

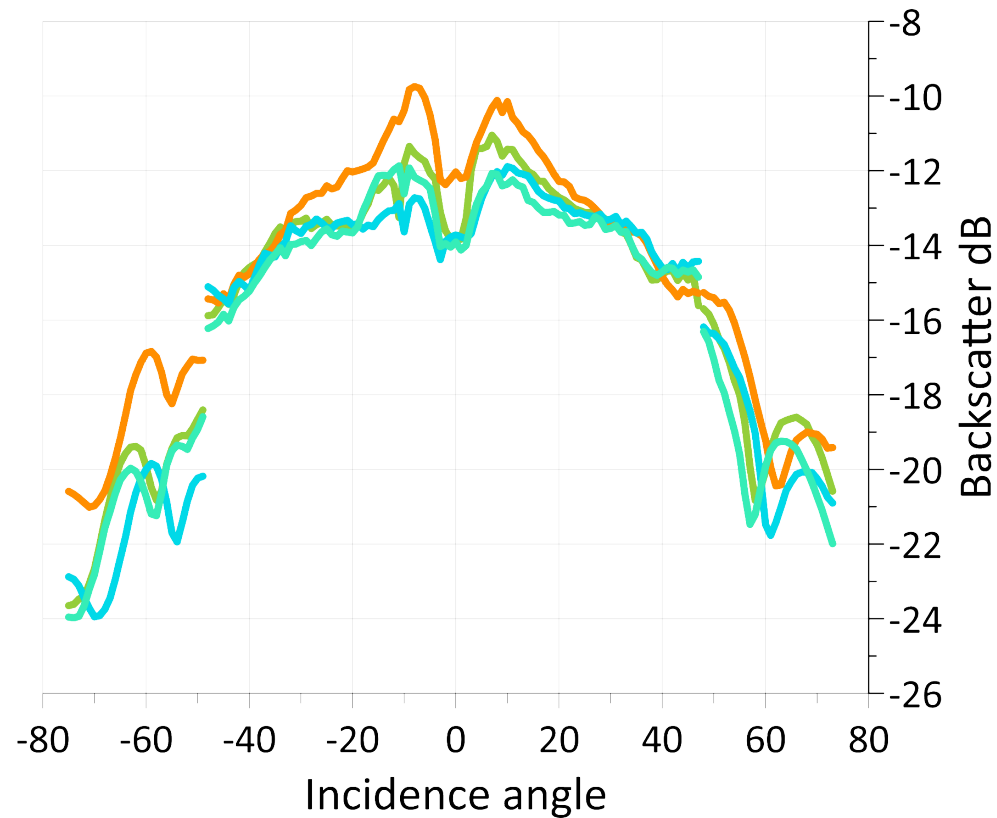


Line color =  
Seawater °C



RV Thalia - Carré-Renard area - 2019-2022

300 kHz, normal sector mode, short pulse length

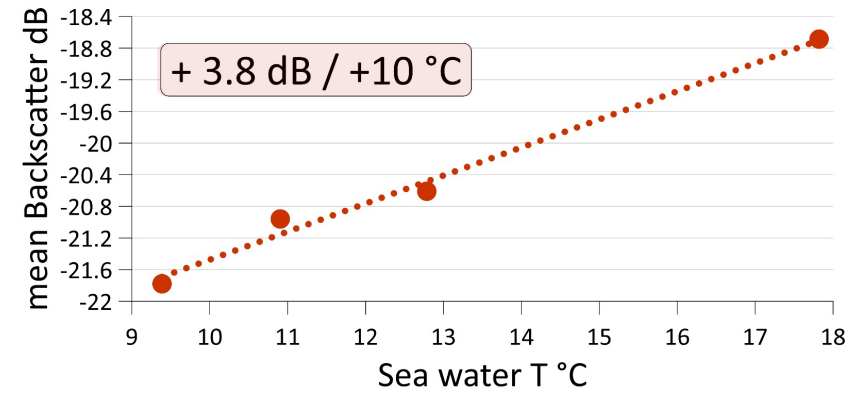
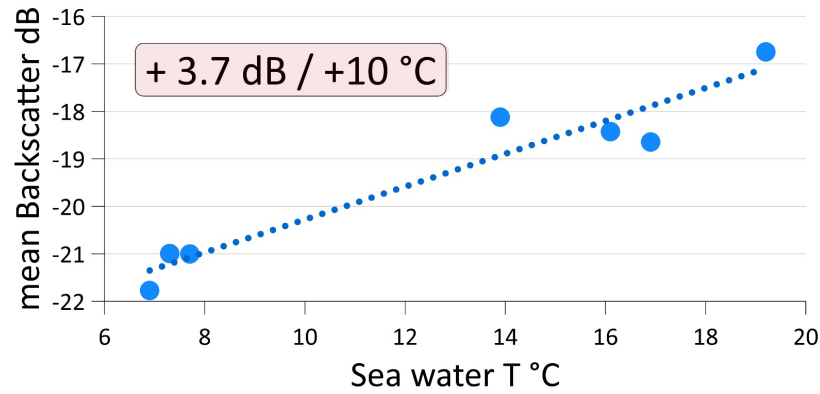


# EM2040 BS – Sea water temperature relationship

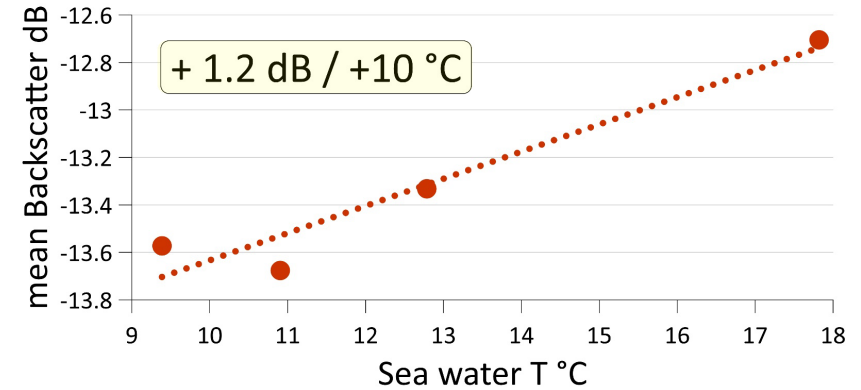
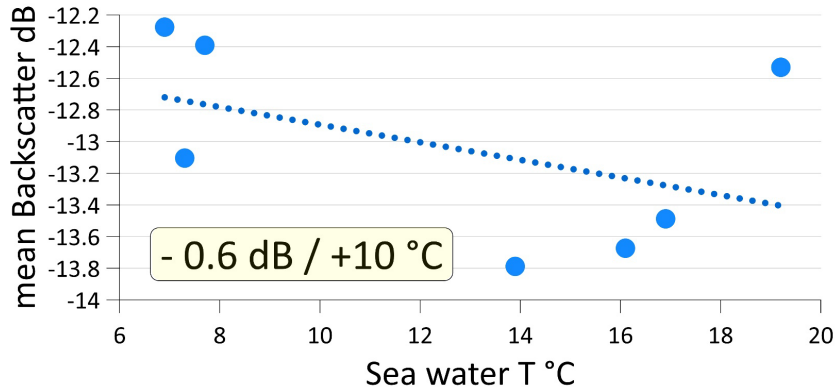
## RV Belgica

## RV Thalia

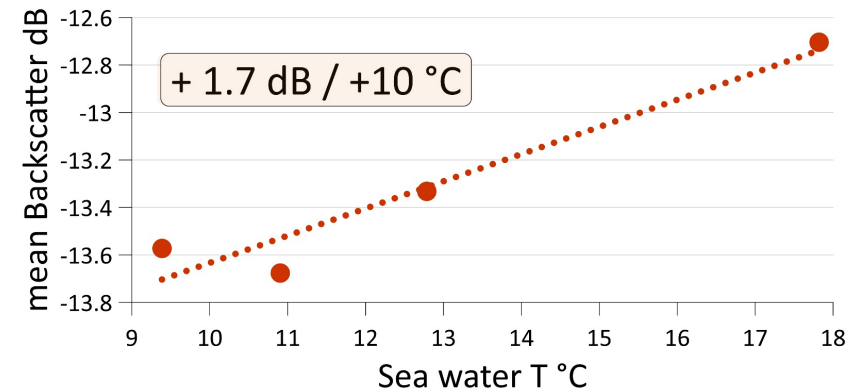
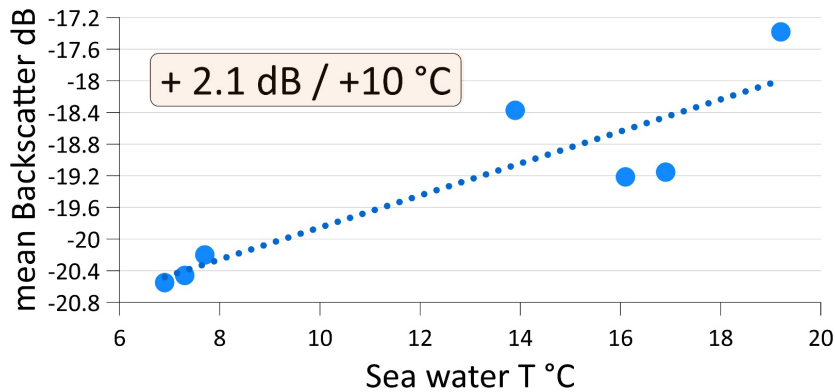
port  
sector



central  
sector



starboard  
sector

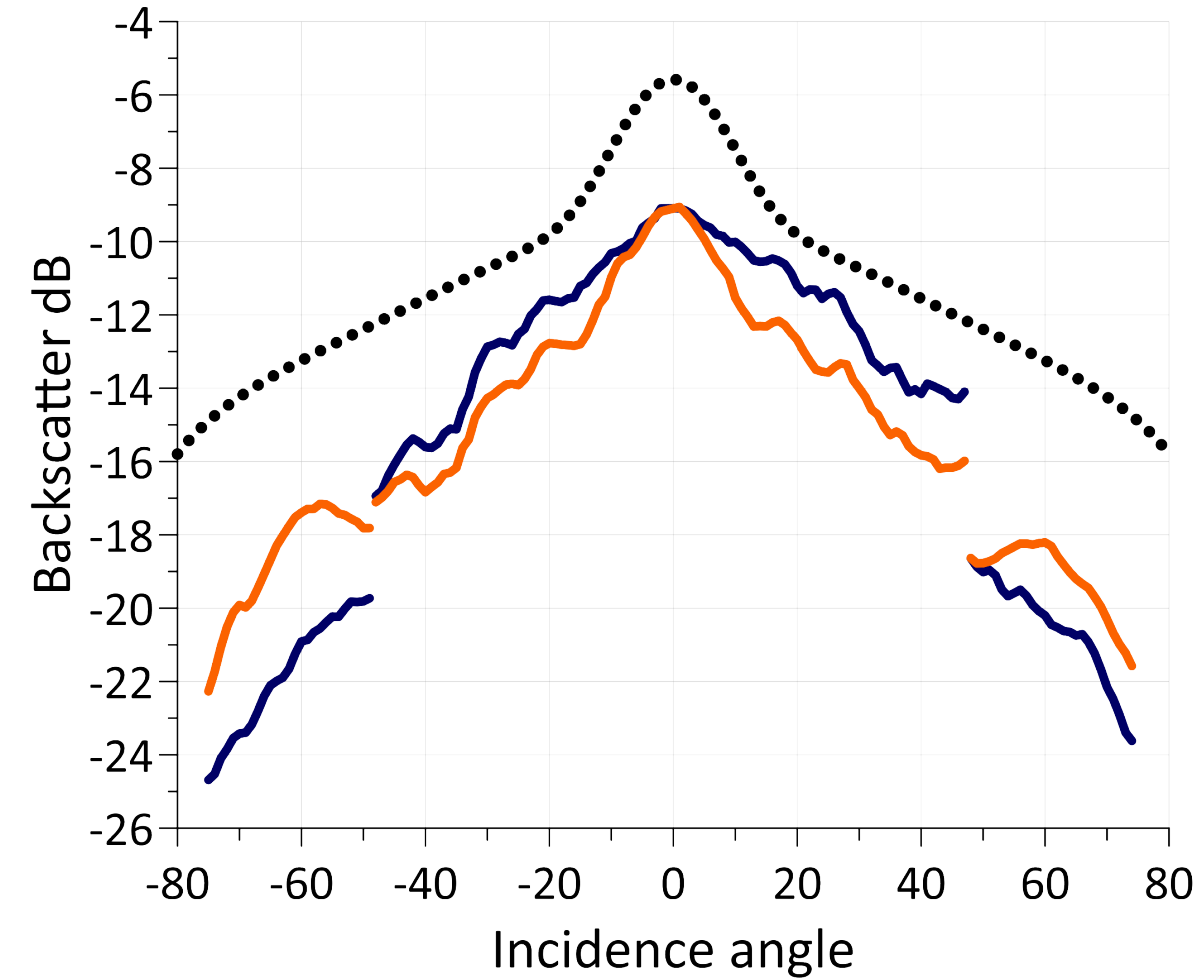




BS – T° → using the same BS corr is not possible!

### RV Belgica - Kwinte area

300 kHz, normal mode, medium pulse length

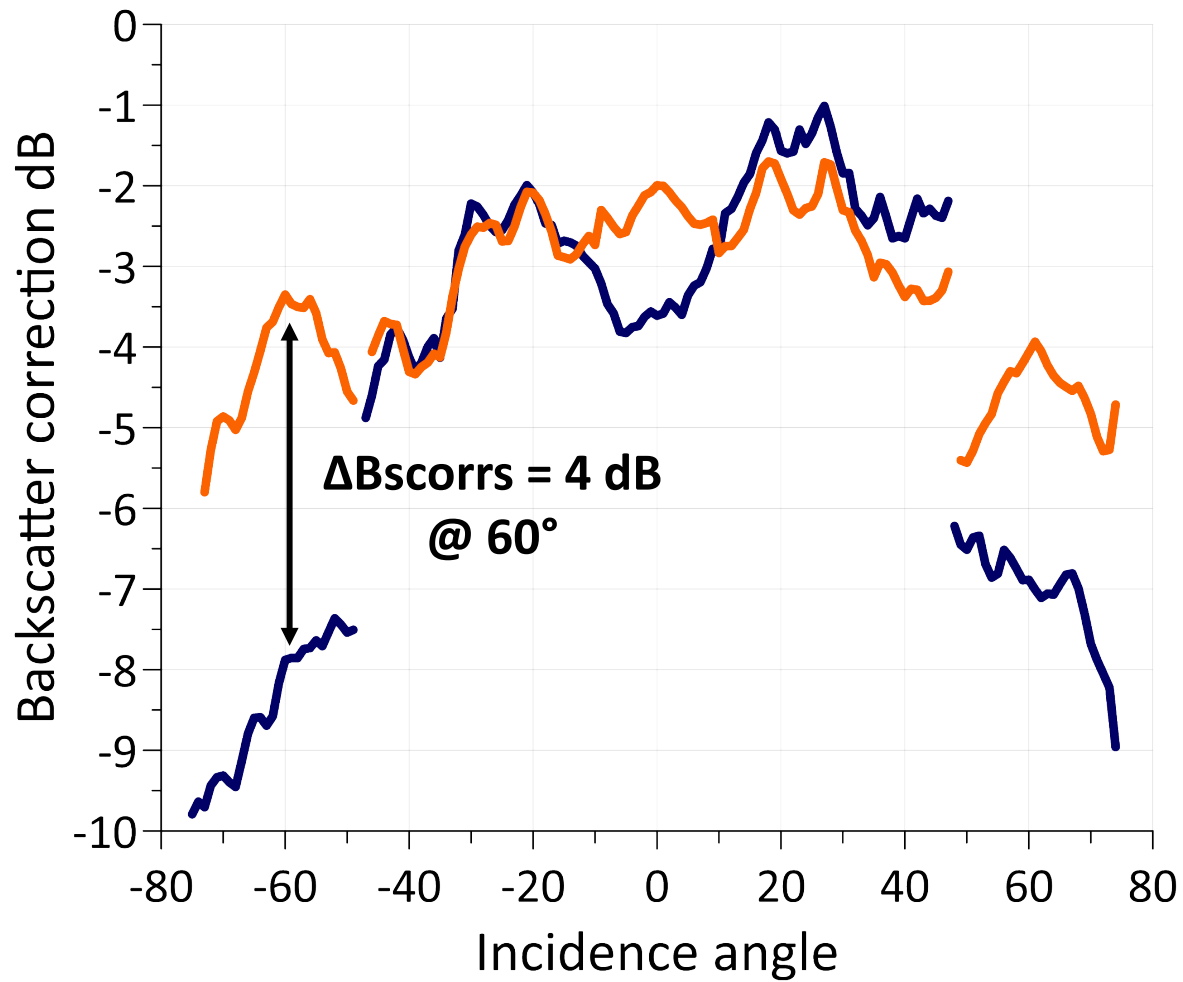
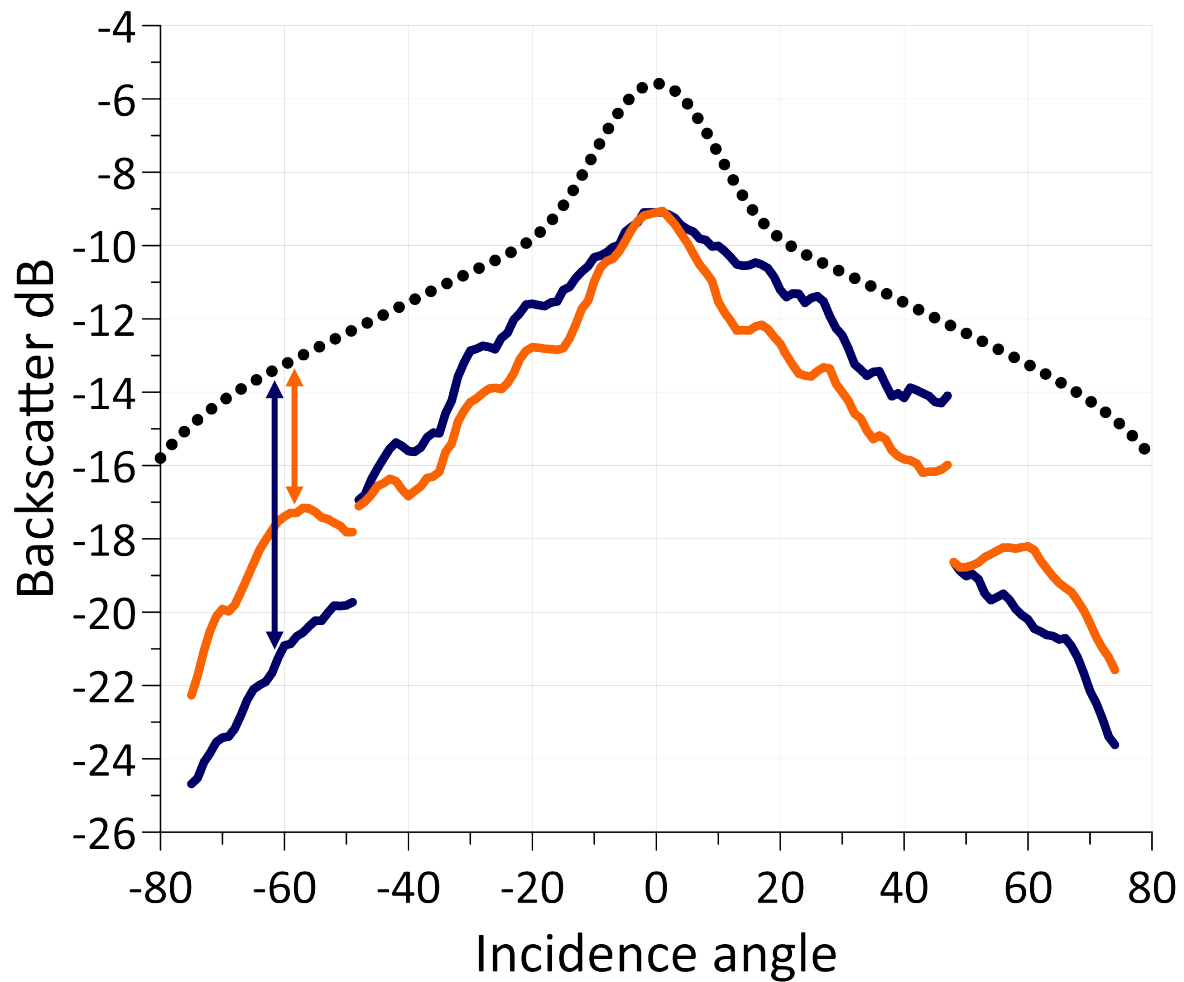


- 2022 - 04/02/2022
- 2022 - 10/04/2022
- EK80 reference - 22-25/05/2023

BS – T° → using the same BS corr is not possible!

### RV Belgica - Kwinte area

300 kHz, normal mode, medium pulse length



*All these sources of BS variation...*

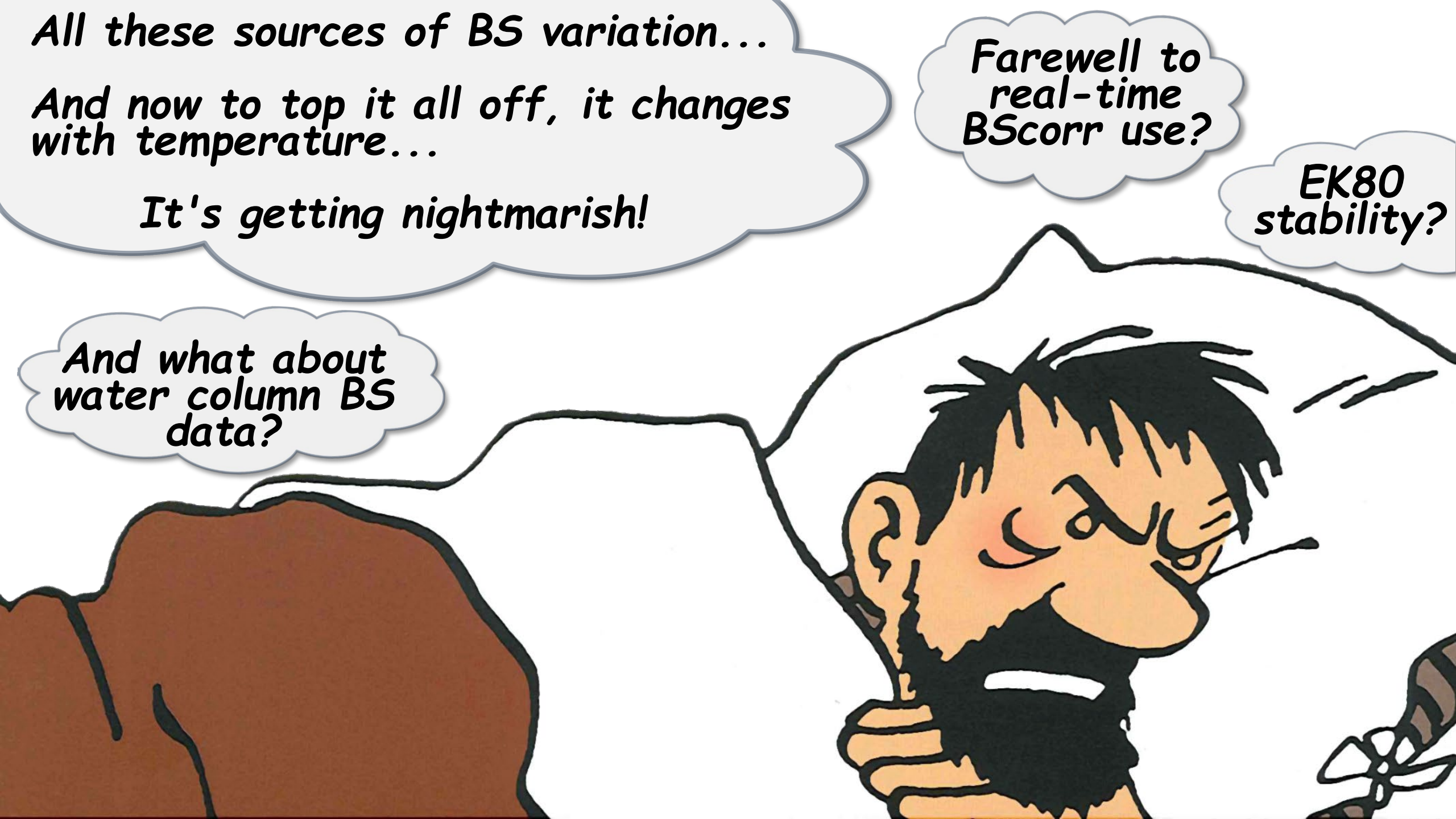
*And now to top it all off, it changes with temperature...*

*It's getting nightmarish!*

*Farewell to real-time BScorr use?*

*EK80 stability?*

*And what about water column BS data?*

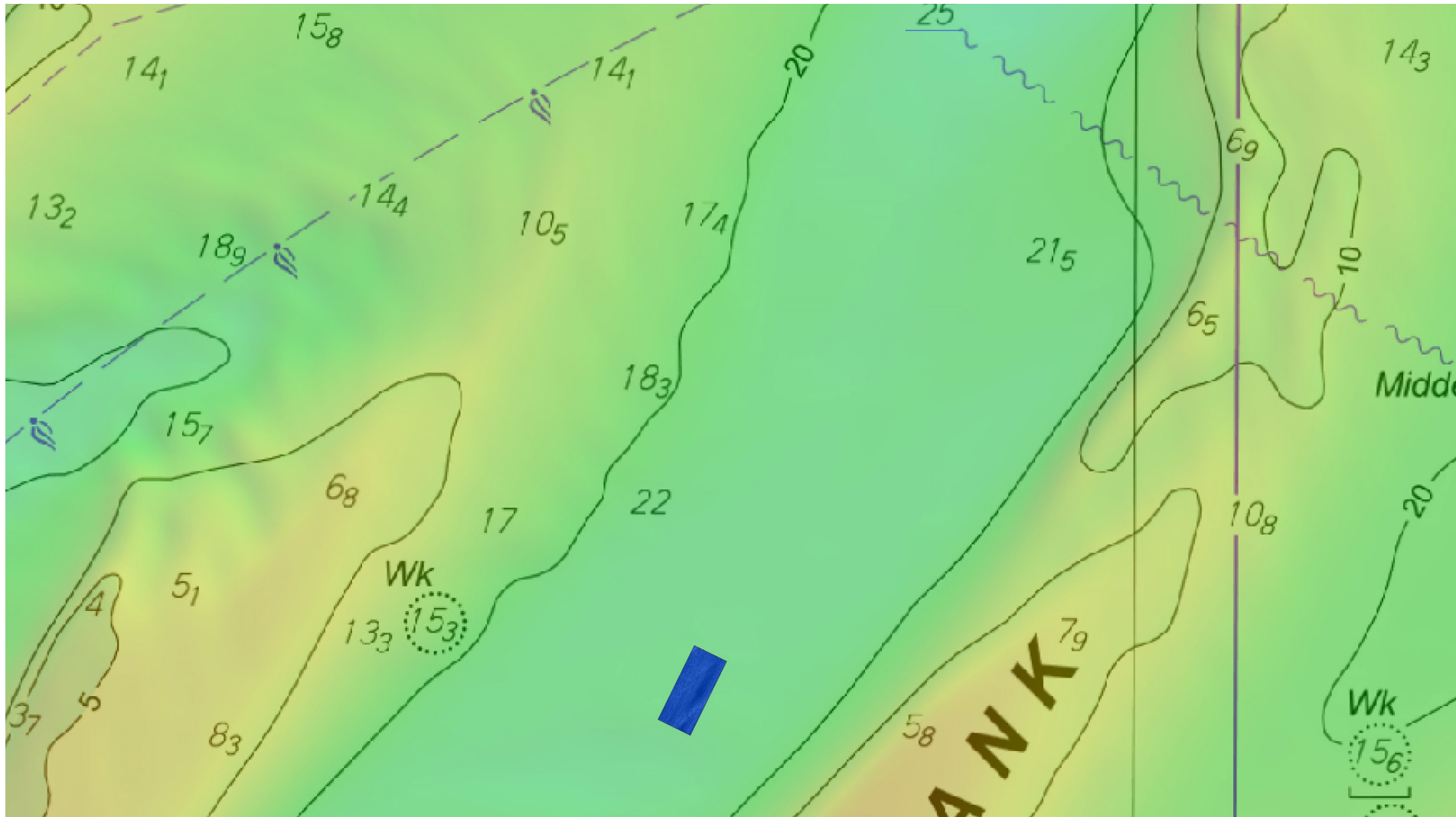




The solution:

Mandatory survey of the Kwinte calculation area during each campaign

→ Using the usual monitoring mode (300 kHz, normal mode, medium pulse length)

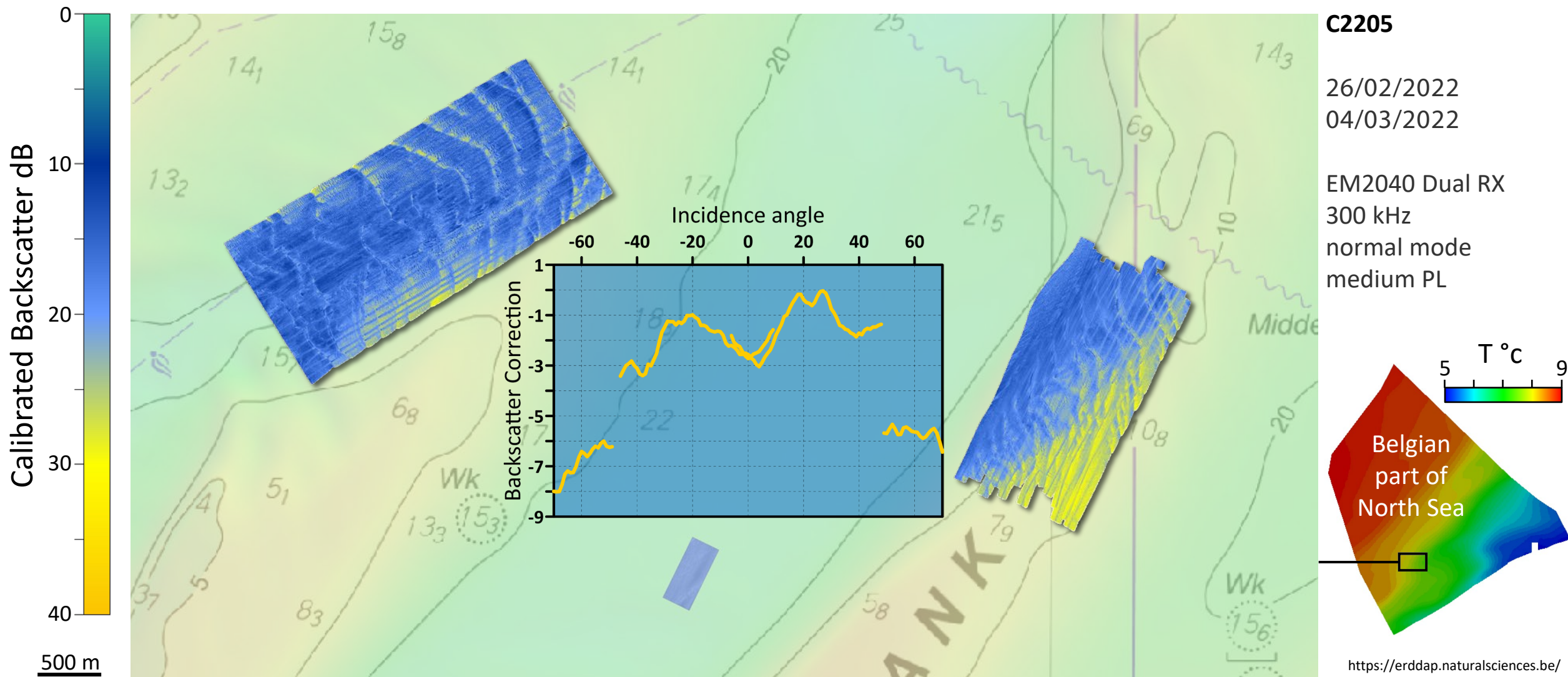


500 m

# The solution:

Mandatory survey of the Kwinte calculation area during each campaign

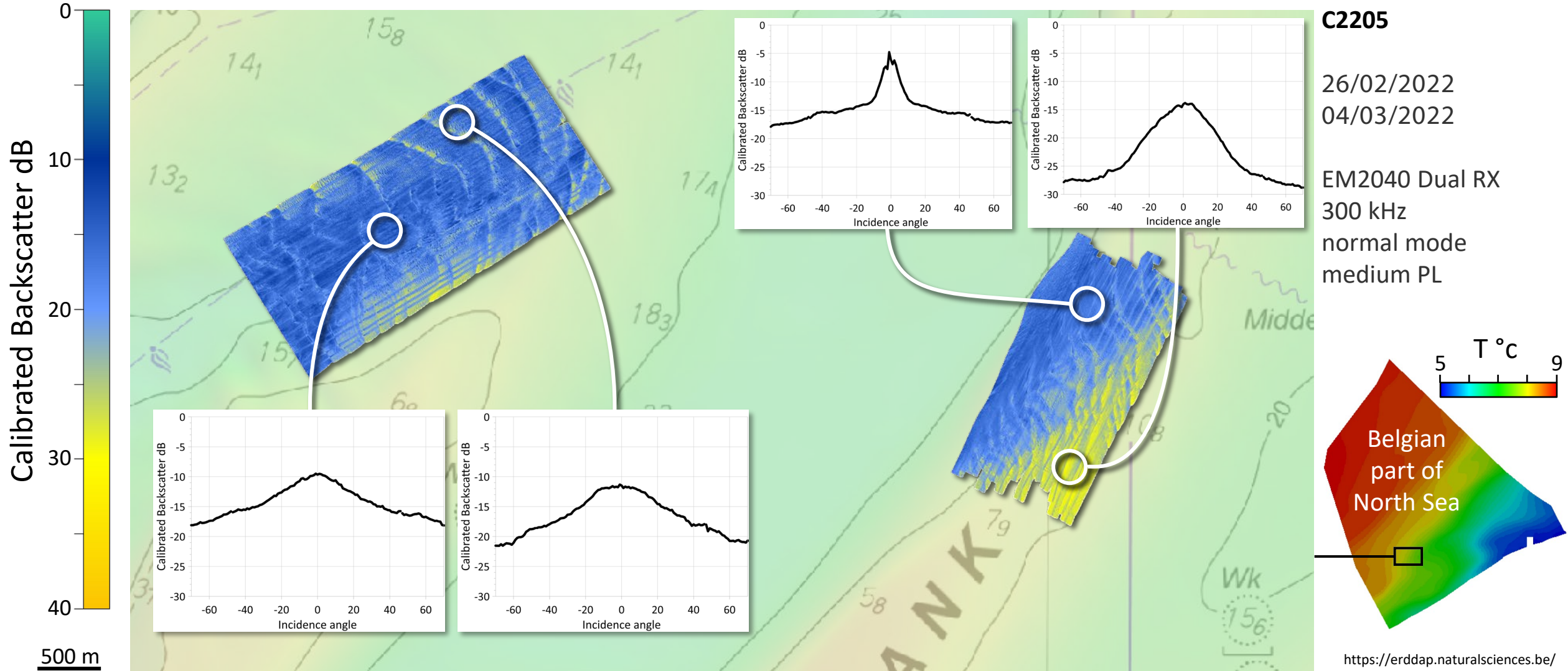
→ BScorr per campaign based on EK80 measurements from May 2023



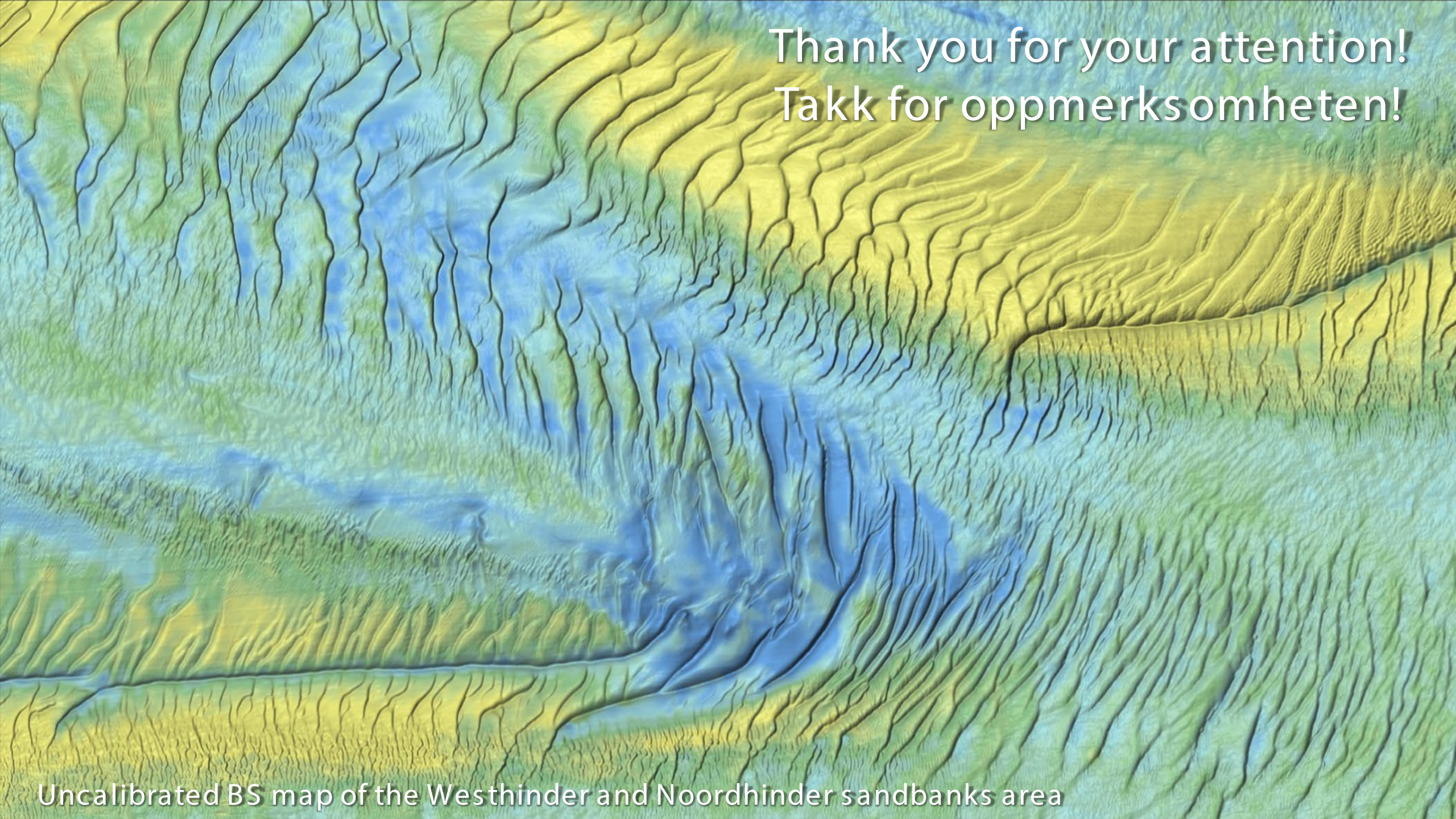
# The solution :

Mandatory survey of the Kwinte calculation area during each campaign

→ BScorr per campaign based on EK80 measurements from May 2023





A topographic map of the Westhinder and Noordhinder sandbanks area. The map uses a color gradient to represent elevation, with blue and green indicating lower elevations and yellow and orange indicating higher elevations. The terrain is characterized by numerous ridges and valleys, with a prominent river system flowing through the center. The map is oriented with North at the top.

Thank you for your attention!  
Takk for oppmerksomheten!

Uncalibrated BS map of the Westhinder and Noordhinder sandbanks area