EGU GENERAL ASSEMBLY, VIENNA
23-27 MAY 2022

CONTRIBUTION TO UNCERTAINTY EVALUATION ASSOCIATED WITH ON-SITE INFRASOUND MONITORING SYSTEMS

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This work is done within the JRP 19ENV03 Infra-AUV has received funding from the EMPIR programme co-financed by the Participating States and from the European Union’s Horizon 2020 research and innovation programme.

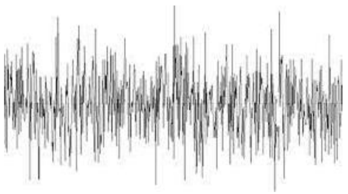
OUTLINE

1. Uncertainty propagation in propagation models
2. Methodology
3. Results
4. Further work

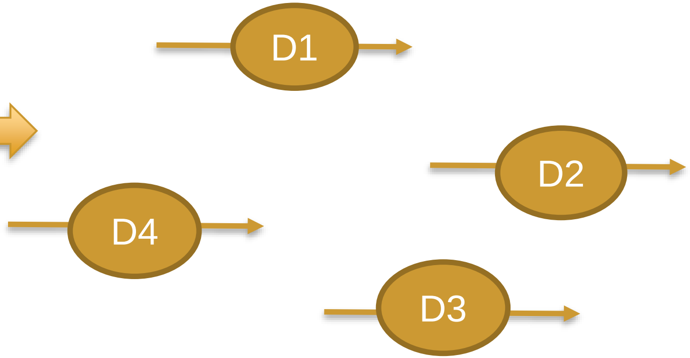
UNCERTAINTY PROPAGATION IN PROPAGATION MODELS

PROPAGATION MODEL:TDOA (TIME DIFFERENCE OF ARRIVAL)

Principle



incoming signal



known relative positions of the detectors in the array

time difference of arrival at each detector

TDOA

estimates of

- consistency
- azimuth
- speed

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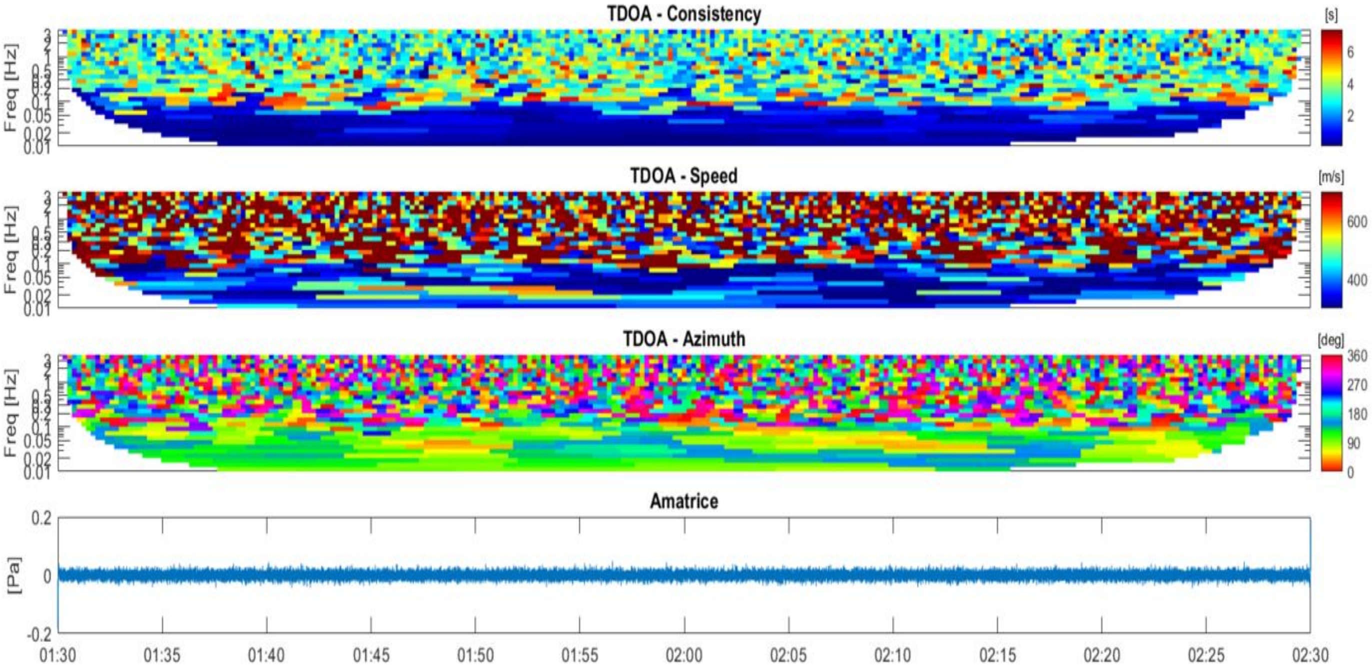
PROPAGATION MODEL:TDOA (TIME DIFFERENCE OF ARRIVAL)

TDOA outputs as functions of frequency and time

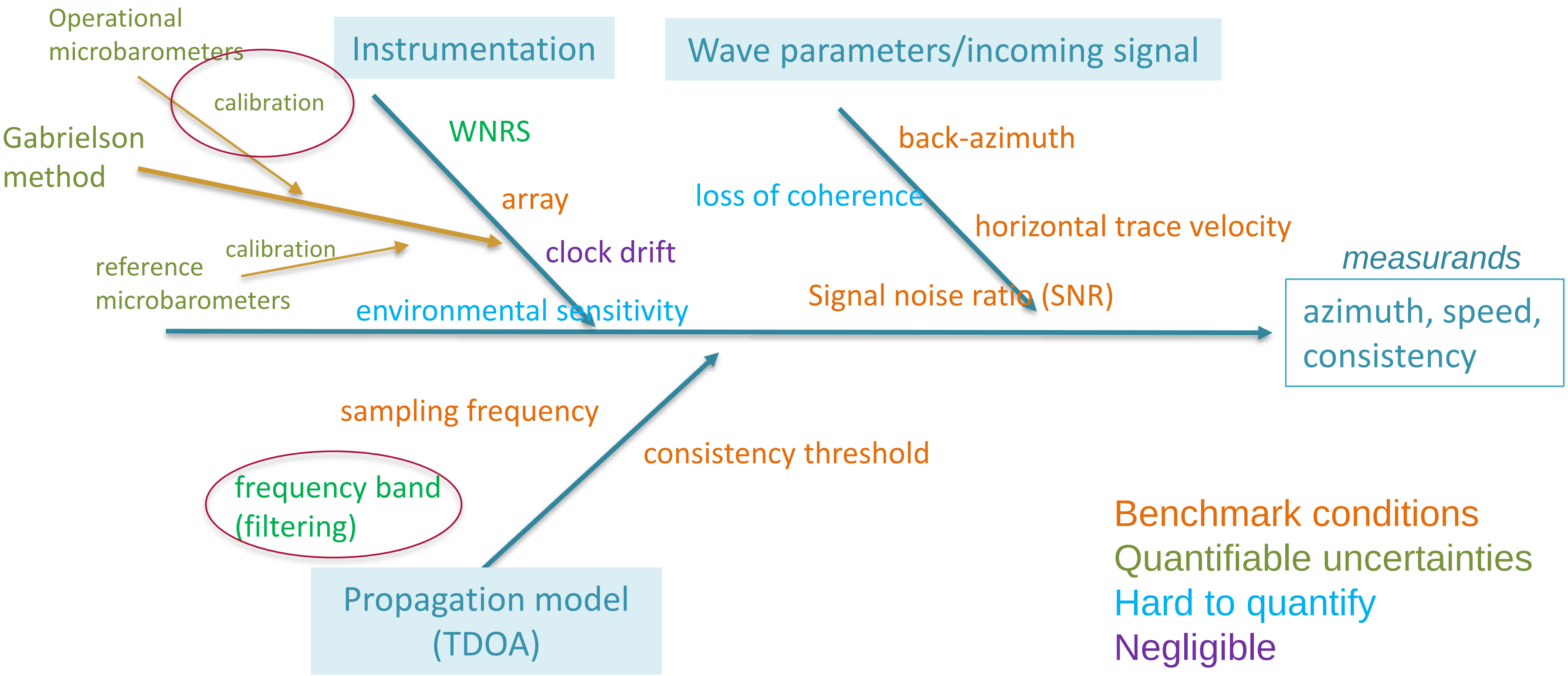


Choice of **consistency** threshold

Estimate of **speed** given the cons.th.

Estimate of **azimuth** given the cons.th.

REVIEW OF UNCERTAINTY SOURCES



Benchmark conditions
Quantifiable uncertainties
Hard to quantify
Negligible

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METHODOLOGY

METHODOLOGY OF THE PROOF OF CONCEPT

- Methodology derived on a **simulated** broadband « true signal » at the OHP station (4 detectors)

  → **azimuth and speed errors (bias)**

- Focus here on 2 uncertainty sources: operational microbarometer (MB) calibration and filtering in TDOA ;
- Use Monte Carlo method to propagate all **quantifiable uncertainties** (GUM-S1); in particular for MB calibration sample latent signals to propagate calibration uncertainties;

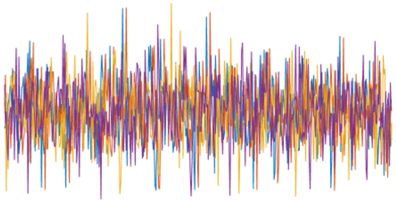
PROPAGATING CALIBRATION UNCERTAINTIES OF MICRO BAROMETERS

In-lab calibration certificate

Data
$x = (x_1, \dots, x_d)$

deconvolution

Sample latent signals corrected for phase and amplitude errors for each microbarometer
$X = (X_1, \dots, X_d)$



T. Esward, S. Eichstädt, I. Smith, T. Bruns, P. Davis, P. Harris, *Estimating dynamic mechanical quantities and their associated uncertainties*: *application guidance*, Metrologia 56 (2019). doi:https://doi.org/10.1088/1681-7575/aaeeba.

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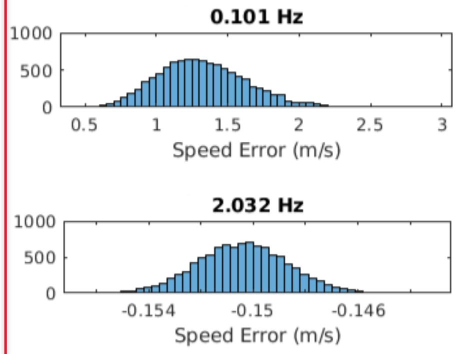
UNCERTAINTY ARISING FROM FILTERING IN TDOA

uncertainty propagation (MB cal)

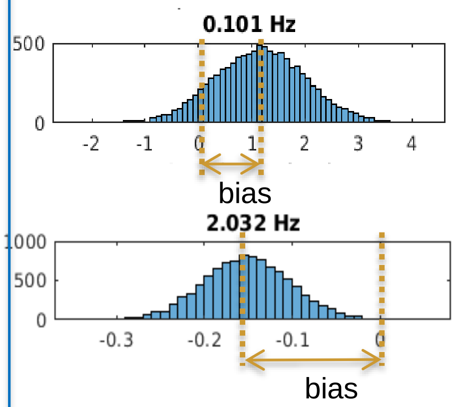
No uncertainty

‘baseline’



Estimates of bias and its uncertainty due to filtering only

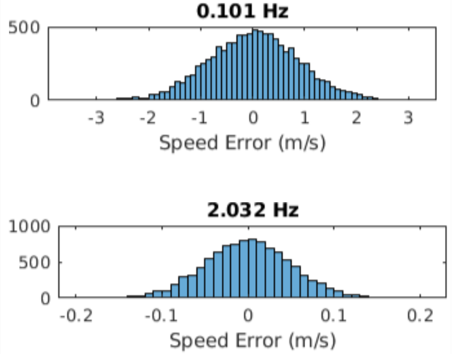
‘not corrected’



MB calibration contributes to uncertainty only

correct bias due to filtering in TDOA when propagating uncertainties in Monte Carlo sampling

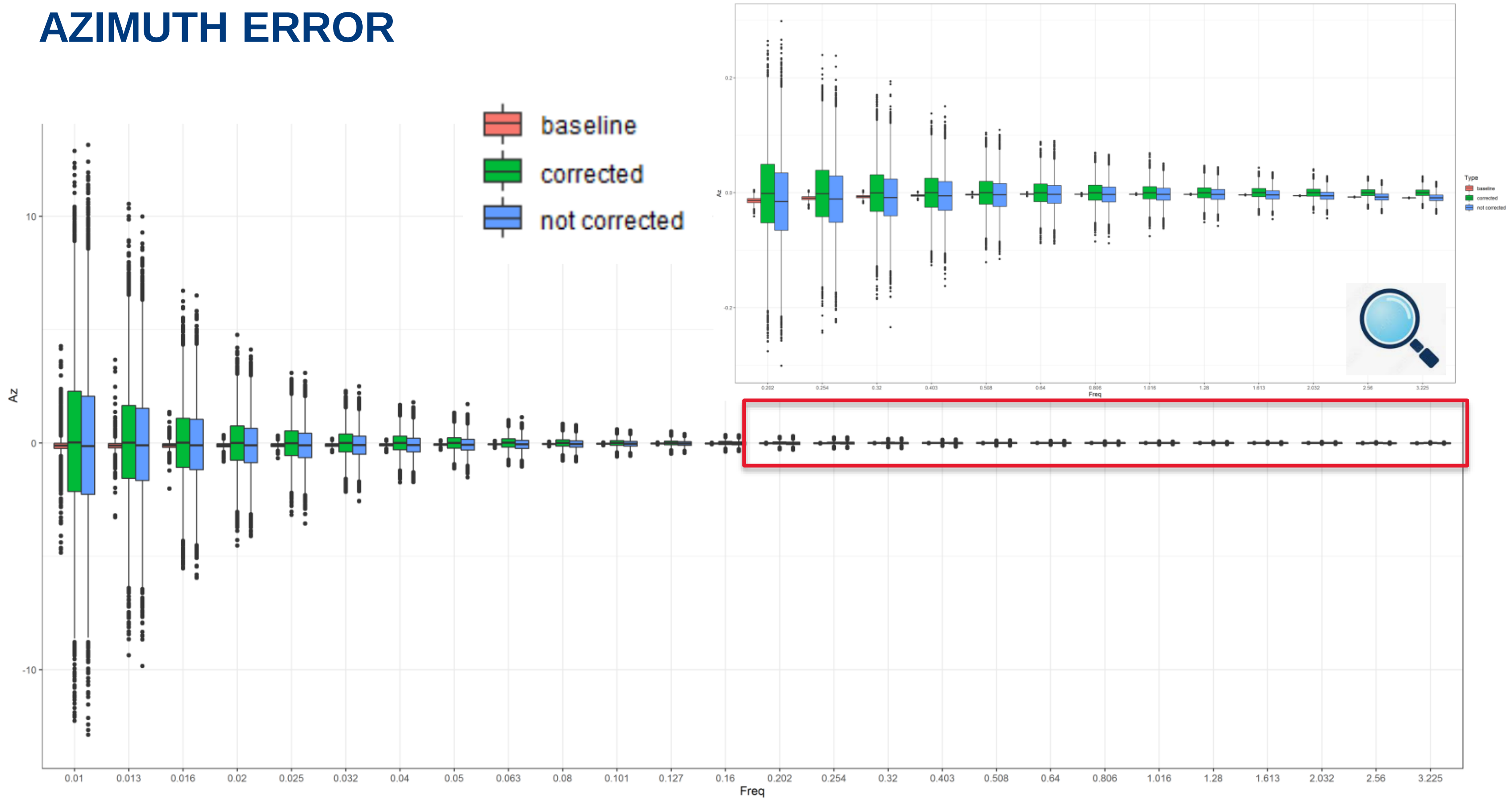
‘corrected’



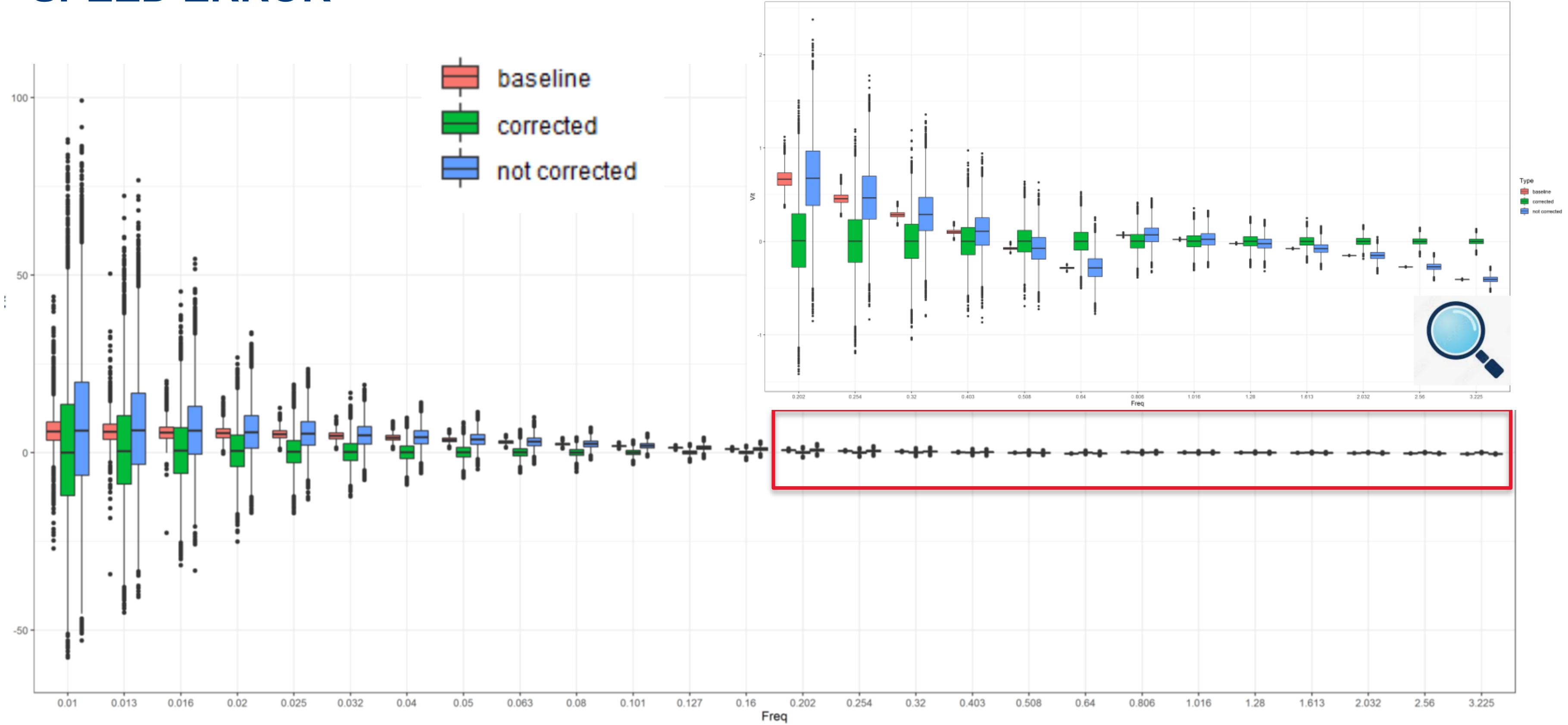
Unbiased !

RESULTS

AZIMUTH ERROR



SPEED ERROR



baseline
corrected
not corrected
100
50
0
-50
0.01
0.013
0.016
0.02
0.025
0.032
0.04
0.05
0.063
0.08
0.101
0.127
0.16
0.202
0.254
0.32
0.403
0.508
0.64
0.806
1.016
1.28
1.613
2.032
2.56
3.225
Freq

CONCLUSION AND FURTHER WORK

- The methodology for propagating uncertainty in propagation models was developed on simulated signals and can be extended to real signals.
- The methodology provides unbiased estimates of azimuth and speed.
- On the example, uncertainties decrease as the frequency increases.

Further work:

- Work on the detector uncertainty : combined uncertainty from WNRS and the microbarometers
- Adapt the methodology to tackle on-site calibration (Gabrielson method)
- Extend to real signal

Thank you for your attention