Noise maps complexity in regards of environmental properties

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1 - Source Level (SL) estimation
(Randi 3.1 model - *Breeding et al., 1996*)
From vessel density maps using AIS (www.lloydslistintelligence.com)

2 - Transmission Losses (TL) computation
(*Parabolic Eq. & Rays methods*) based upon **local environment knowledge**

Shipping Noise modelling a complex & uncertain process

3 - RL computation by solving SONAR equation

$$RL_m = \sum_{n}^{N_s^m} SL_n - TL_{mn} + W_m$$

4 - Wind noise (W) contributions are only propagated vertically

AIS density *(Source Levels)*

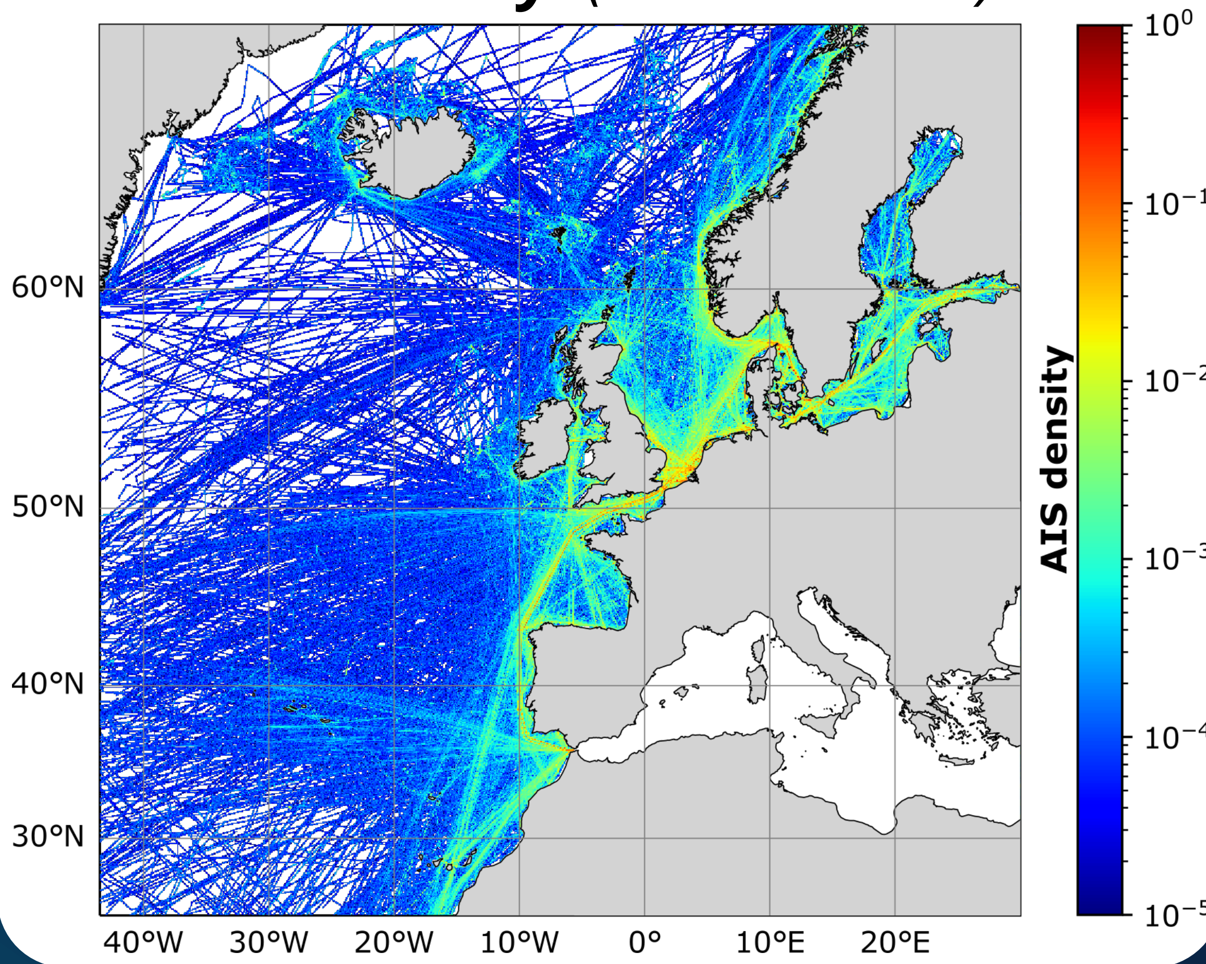
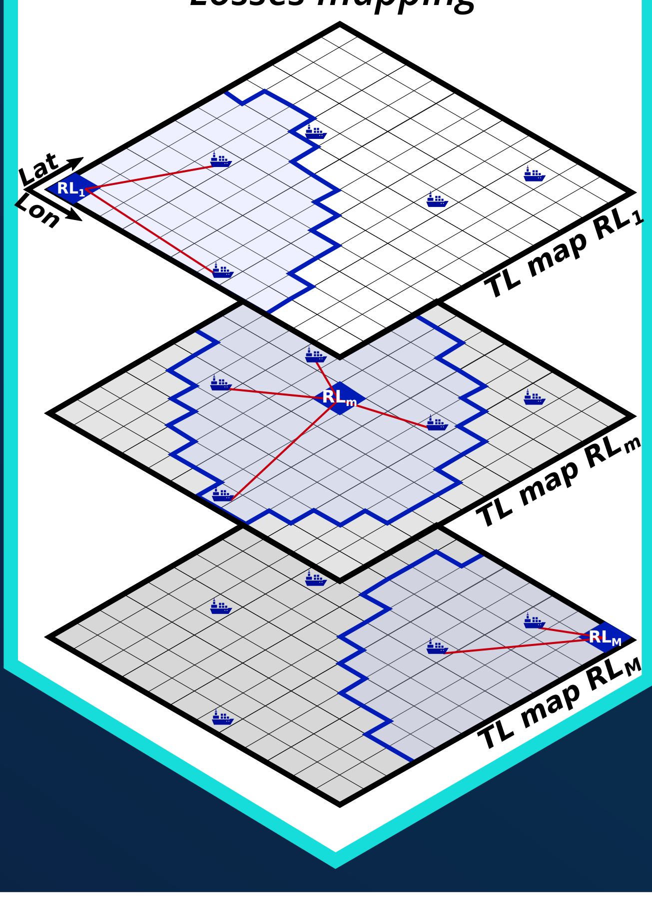
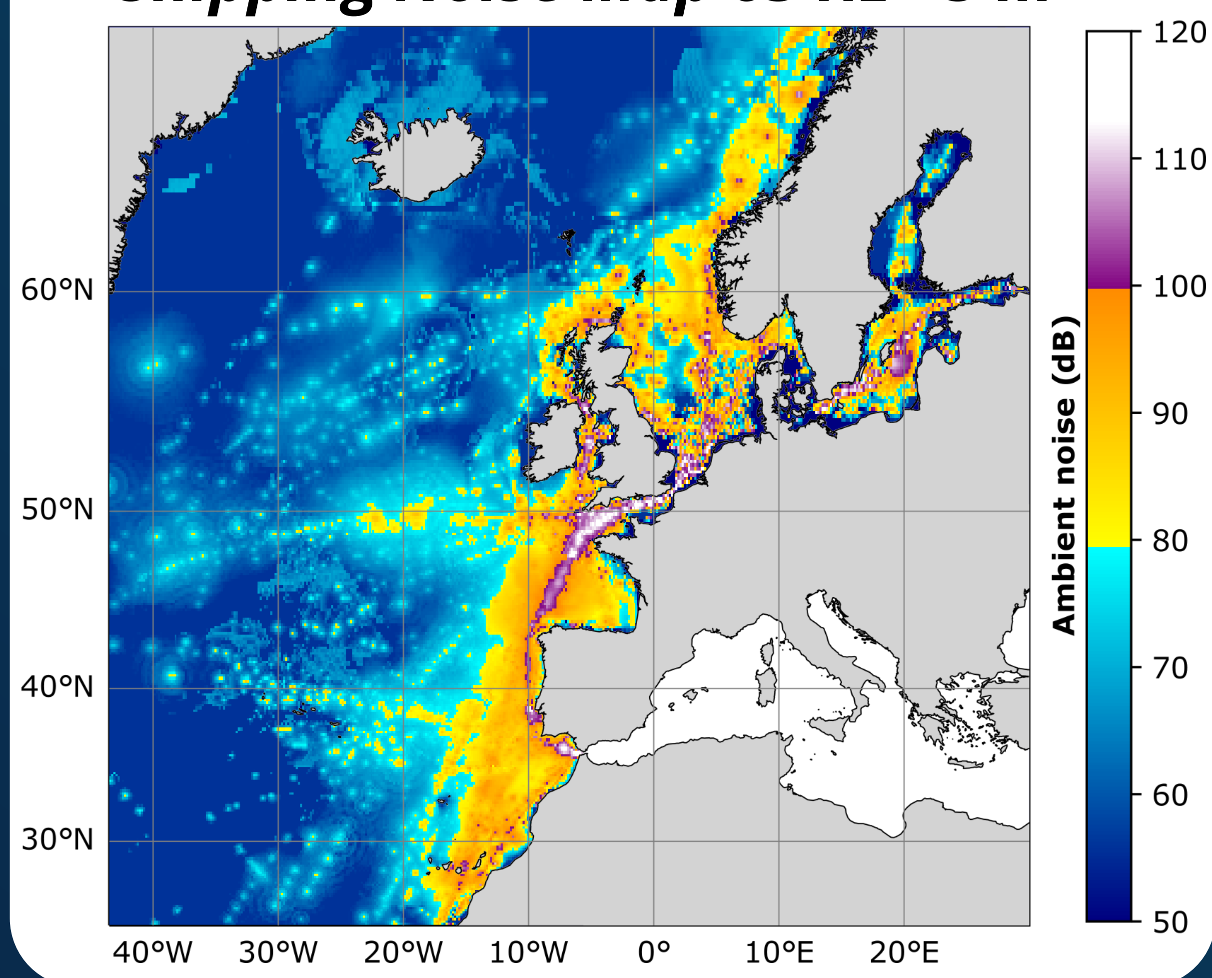


Fig. 1: Transmission Losses mapping



Shipping Noise Map 63 Hz - 5 m



Transmission Losses distribution

The *TL* probability distribution for the whole map was used to compute the entropy. It seems to fit in an *Alpha-Stable* distribution *Fig.2*.

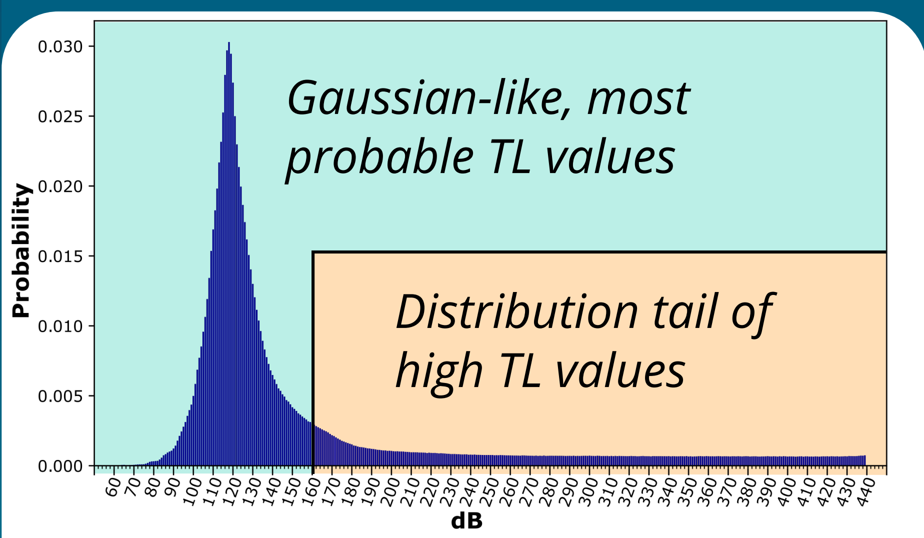
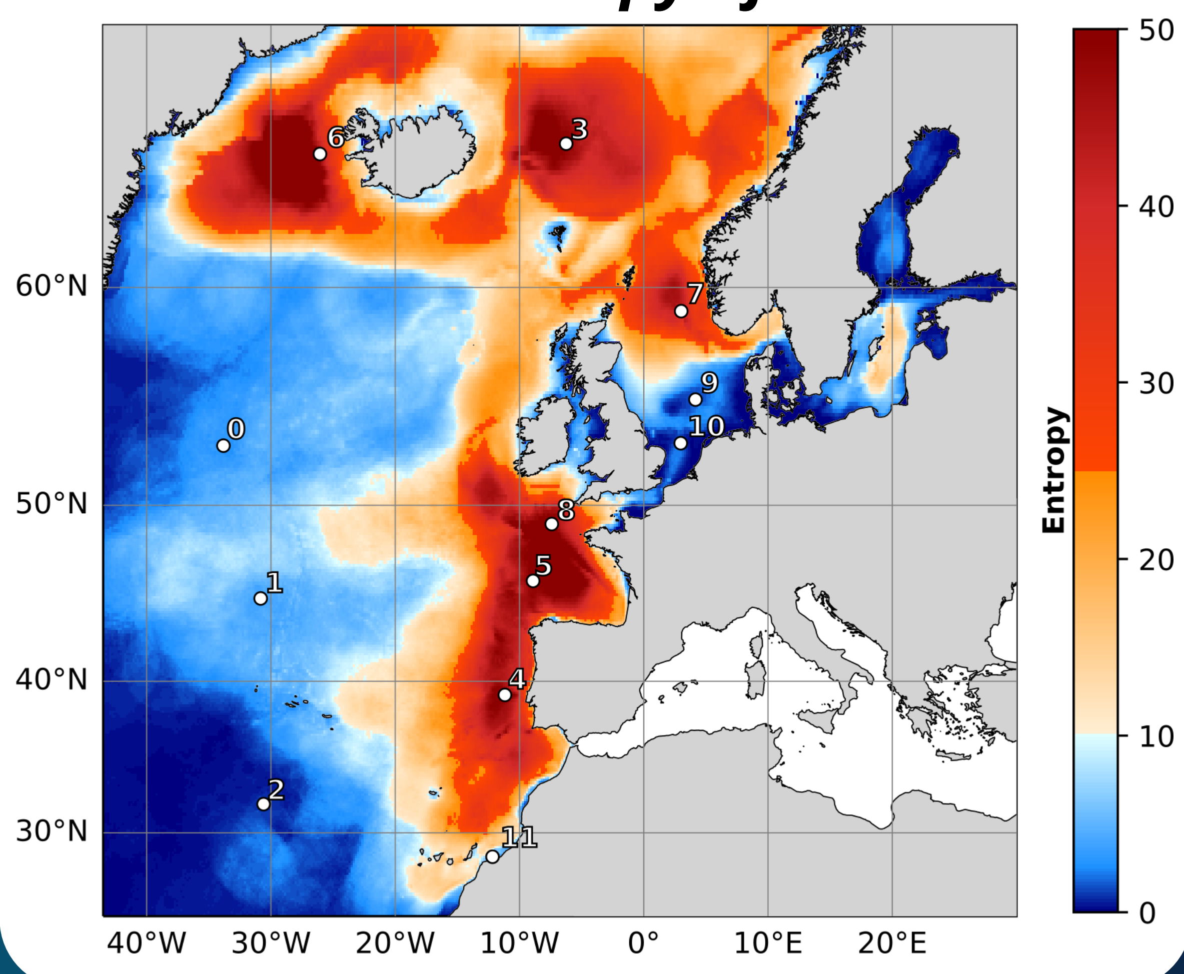


Fig. 2: Empirical distribution of the TL

Shannon Entropy of the TL



How to map Entropy ?

The goal is to investigate information quantity in noise maps using Shannon Entropy equation (*Shannon, 1948*):

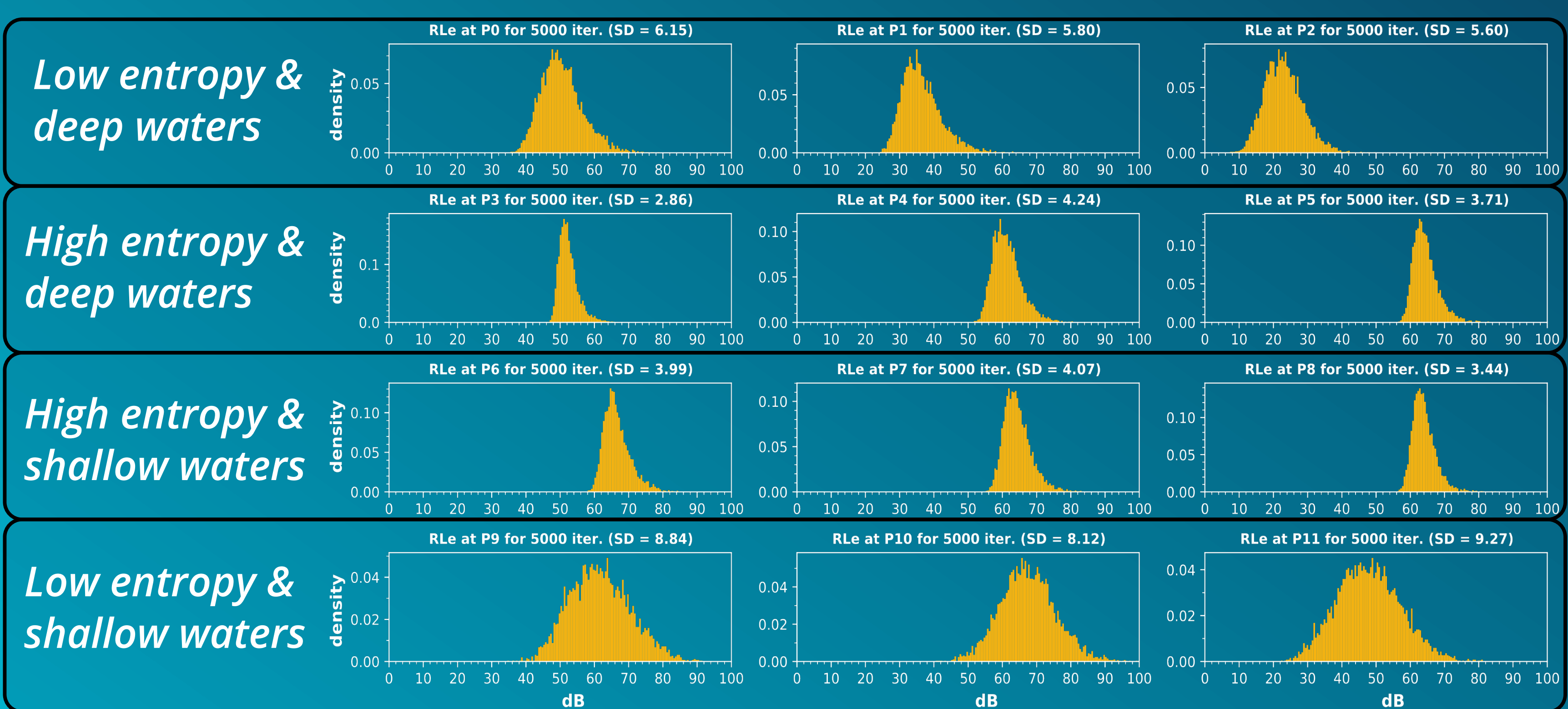
$$H_m = -k \sum_{n=1}^{N_s^m} P_{TL_{mn}} \cdot \log_2(P_{TL_{mn}})$$

Following Fig. 1, for a single position (*blue cells*) every *TL* values (*red lines*) are extracted and the local entropy is computed over the P_{TL} values (Fig. 2). Outside a radius of 300 Km from the receiver (*bold blue line*) the large (*>450 dB*) to infinite *TL* values are ignored. Inside this radius, only the values of *TL* that are associated with a ship position are considered.

RL uncertainty

For each **point** of the **entropy map**, a **Monte-Carlo** type analysis is performed. A ***RL*** is computed by considering all the ***TL* values** of the **point and** a SL of 130 dB. A randomly generated error is **added** to account for independent ***SL* errors**.

- In **low entropy contexts** ➔ higher **RL** variation.
- In **high entropy contexts** ➔ lesser ***RL*** variation and lesser uncertainties



Interpreting Entropy maps

Results are presented for a given configuration of depths and frequencies.

	Shallow waters (D<50 m)	Deep waters (D<50 m)
Low vessel density	Very low entropy values	Low entropy values
High vessel density	Low entropy values	High entropy values

Different contexts based on the **Entropy** and the **acoustic environment**:

- **High entropy & high complexity areas:** lesser RL uncertainty but less sensible to mitigation
- **Low entropy & high complexity areas:** Higher RL uncertainty but more sensible to mitigation

References

Shannon *CE. A mathematical theory of communication. The Bell system technical484journal. 1948;27(3):379–423.*

Breeding *JE Jr, Pflug L. A, Bradley M., and H Walrod M. Research ambient noise directionality (randi) 3.1 physics description. Technical report, Naval Research LabStennis Space Center MS, 1996*

EuroGOOS European Global Ocean Observing System

Poster for the 9th Eurogoos conference Session 2