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# Noise maps classification in regards of acoustic propagation properties


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**1 - Source Level (SL) estimation**
*(Randi 3.1 model - Breeding et al., 1996)*
*Vessel density maps (AIS - **www.lloydslistintelligence.com**)*
**2 - Transmission Losses (TL) computation**
*(Parabolic Eq. & Rays methods) based upon local environment knowledge*
**3 - RL computation** $RL_m = \sum_{n}^{N_s^m} SL_n - TL_{mn} + W_m$
**4 - Wind noise (W)** *contributions are only propagated vertically*

## ... Shipping Noise mapping process

## A complex & uncertain process

- How to estimate **modelling errors**?
- How **modelling errors** can affect **decision making**?
- How to optimize **computation time** and **resolution**?
- What are the links with the **measurements**?

➔ ***A spatial approach of the information contained in noise maps***

## TL simulation - Environmental data

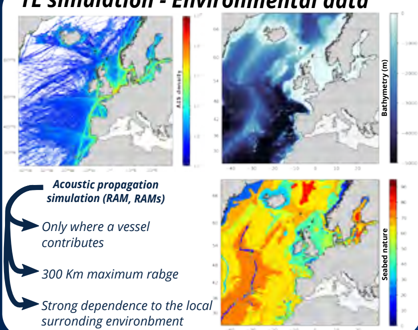
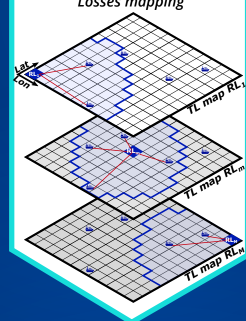
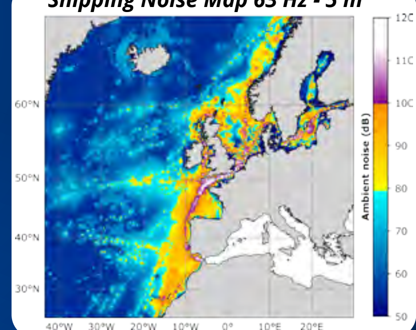



Fig. 1: Transmission Losses mapping




## Shipping Noise Map 63 Hz - 5 m



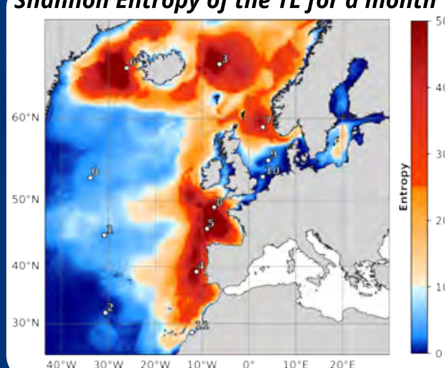

## How to map Entropy ?

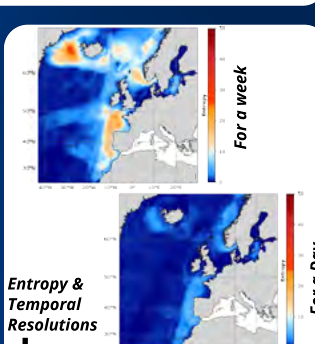
The goal is to investigate information quantity in noise maps using Shannon Entropy equation (Shannon, 1948):

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

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.

## Shannon Entropy of the TL for a month



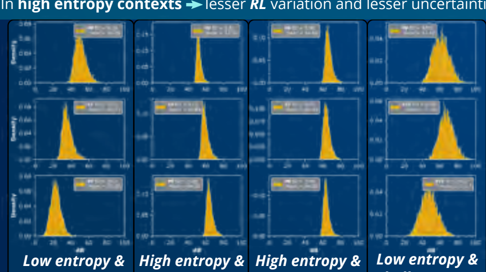

***Entropy & Temporal Resolutions***

- Entropy is proportionnal to the observation period
- High temporal resolution may not bring additionnal information everywhere

## 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*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