Approches hybrides acoustique et machine learning pour l'étude du fonctionnement des écosystèmes marins

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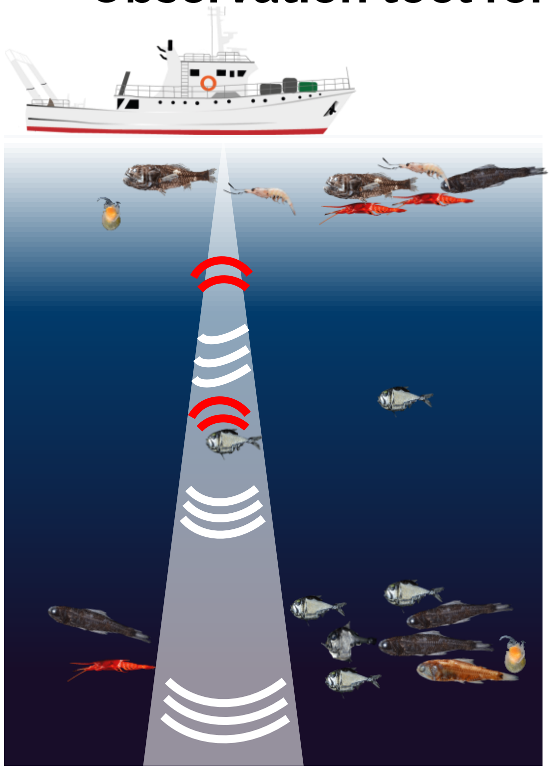
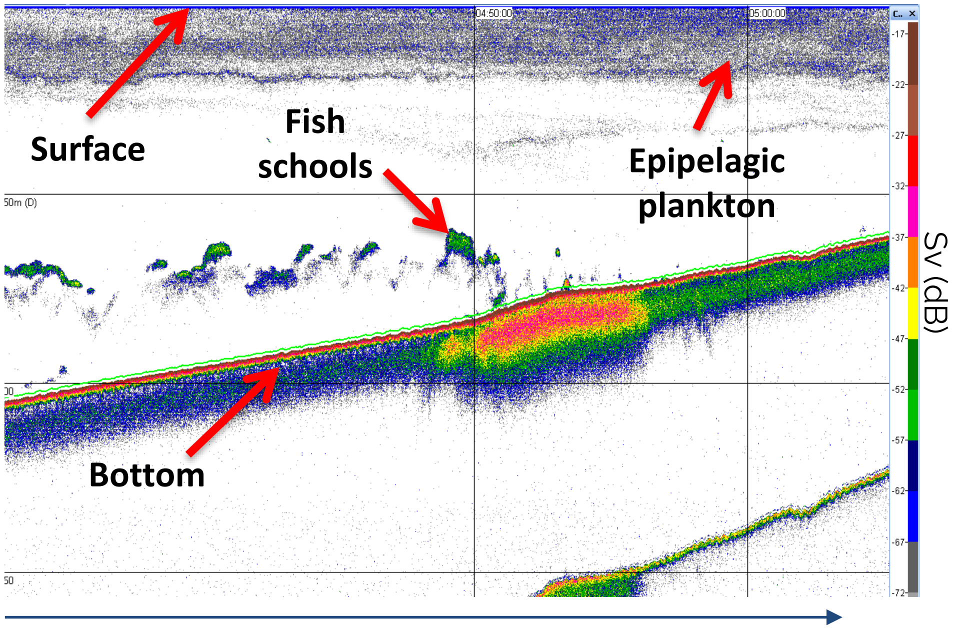
Institut de Recherche pour le Développement FRANCE

Observation tool for studying the functioning of marine ecosystems



Echogram at 38kHz: density per volume unit

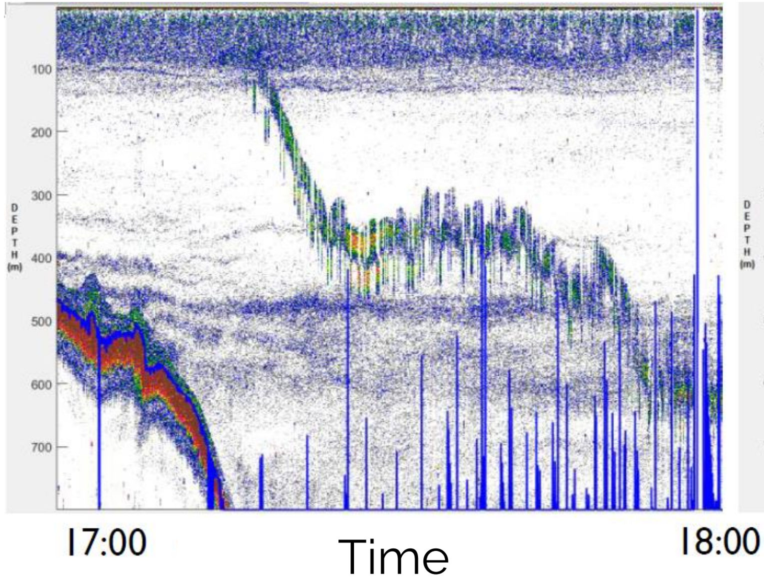


High resolution :
1 sec * 20cm vertical
Continuous
(time/space)
Down to ~1500m

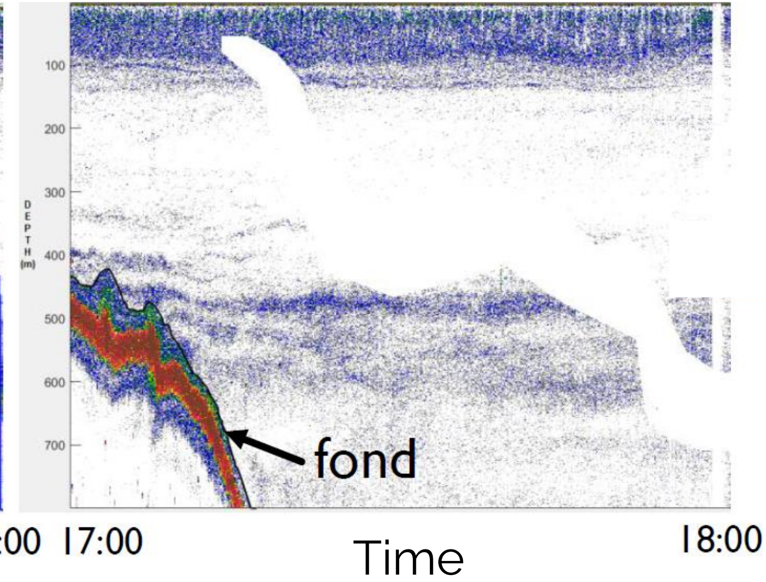
MANUAL DATA CLEANING

Accurate echogram is critical for effective data interpretation
Current algorithm faces limitations for bottom line detection

RAW echogram

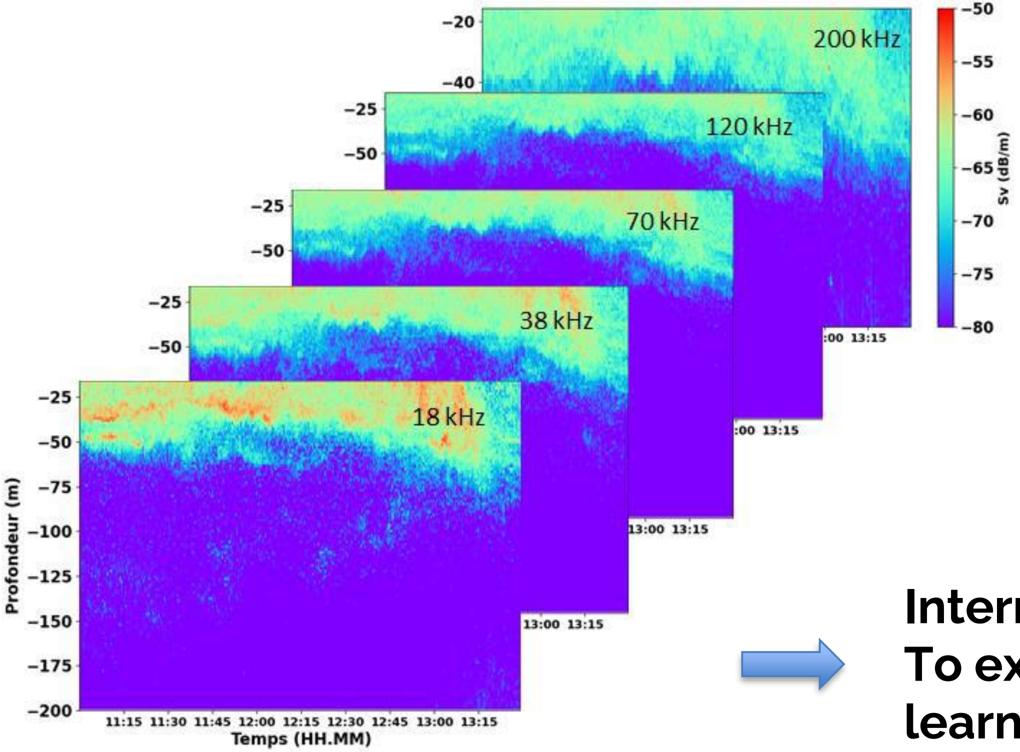


Cleaned echogram



A HUGE ANNOTATED DATABASE !

Multifrequency echograms : 3D data



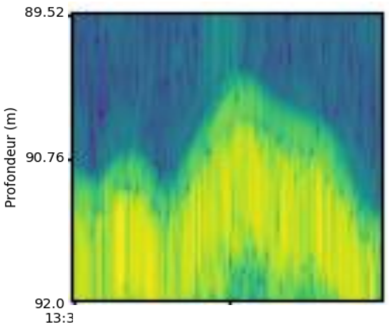
Massive volume of data
~100 000 images / survey

Time-consuming process**!!**
1 day of data =~ 1 day of processing

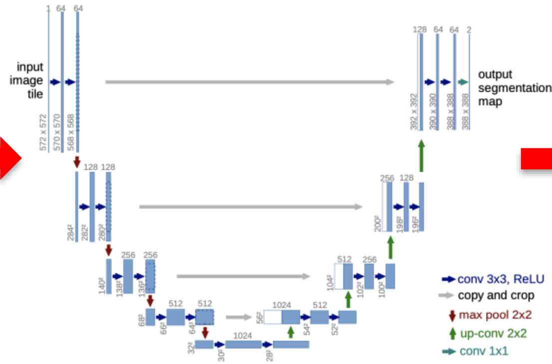
Internship :
To explore the potential of a supervised learning method for bottom detection

U-Net convolutional neural network (CNN) for image segmentation

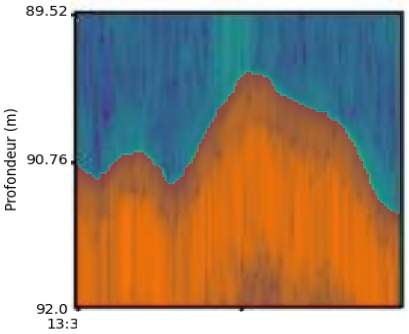
Input data



Model



Output prediction



- **Code adapted** from Ronneberger et al. 2015
- **Learning process**: gradient descent with a binary cross-entropy loss function
- **Optimization of the architecture** (ad hoc model) and hyperparameters (learning rate, batch size, number of epochs, etc.)

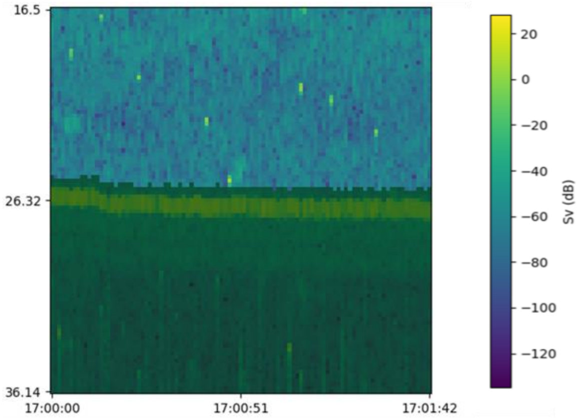
METHODS

Resources used to train the CNN:

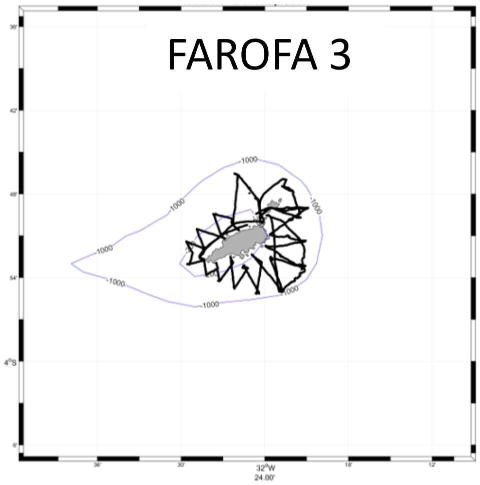
- IFREMER's **DATARMOR** supercomputer, GPUs Tesla V100-PCIE - 32GB
- ENSTA Bretagne computer with two NVIDIA TITAN V GPUs - 12GB

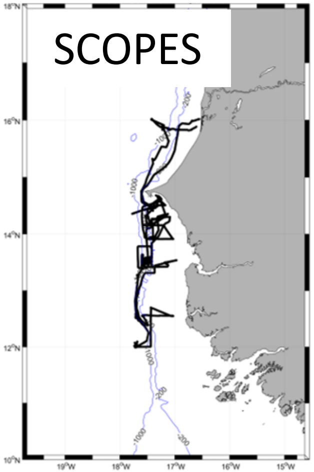
GPU memory constraint for training

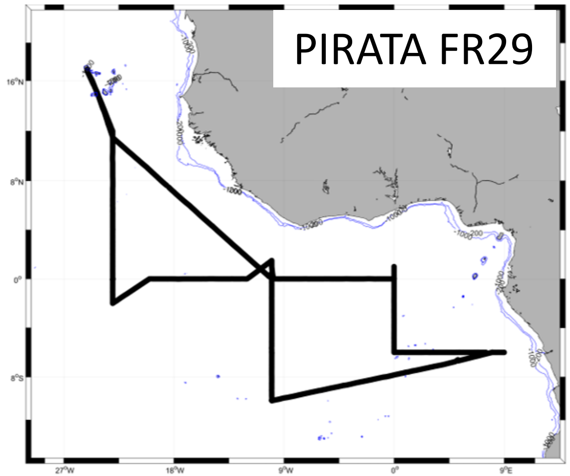
=> thumbnail extraction 100 pixels square from the global echogram centered around the annotated bottom line



Surveys with different characteristics: vertical resolution, bathymetry, etc.

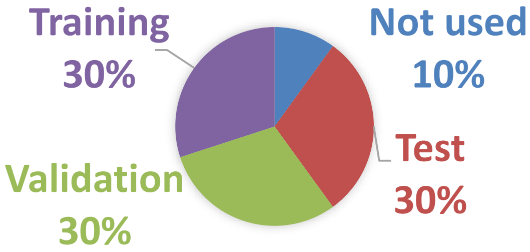




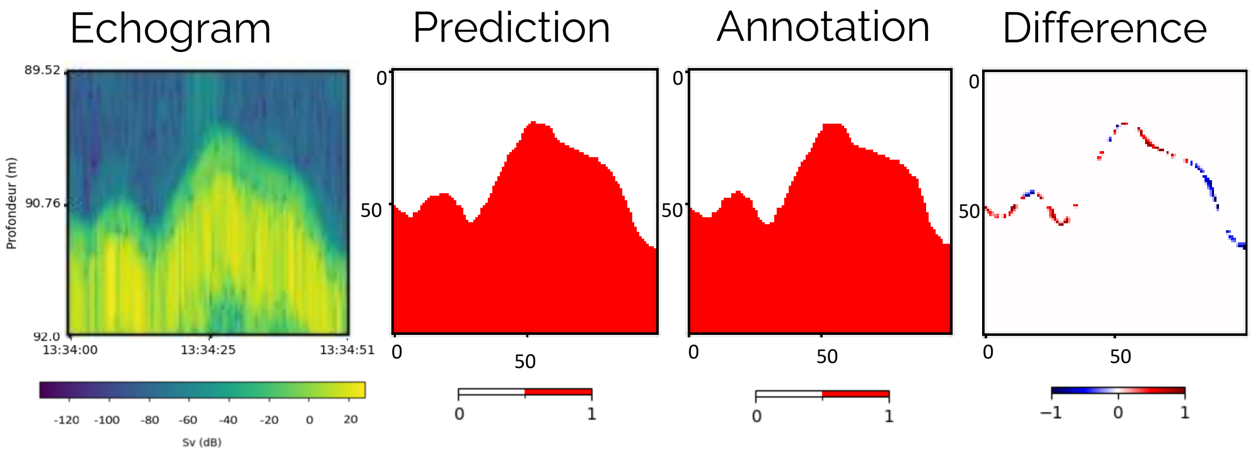


Cross-domain training

Creation of training and validation sets



RESULTS

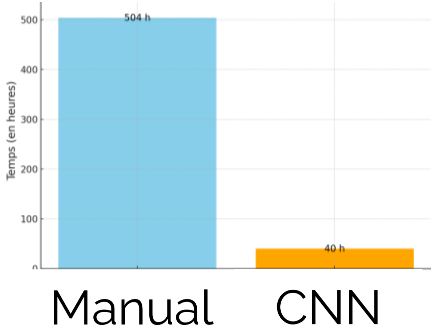


Metrics :
difference between predicted and corrected bottom lines [pixels or cm]

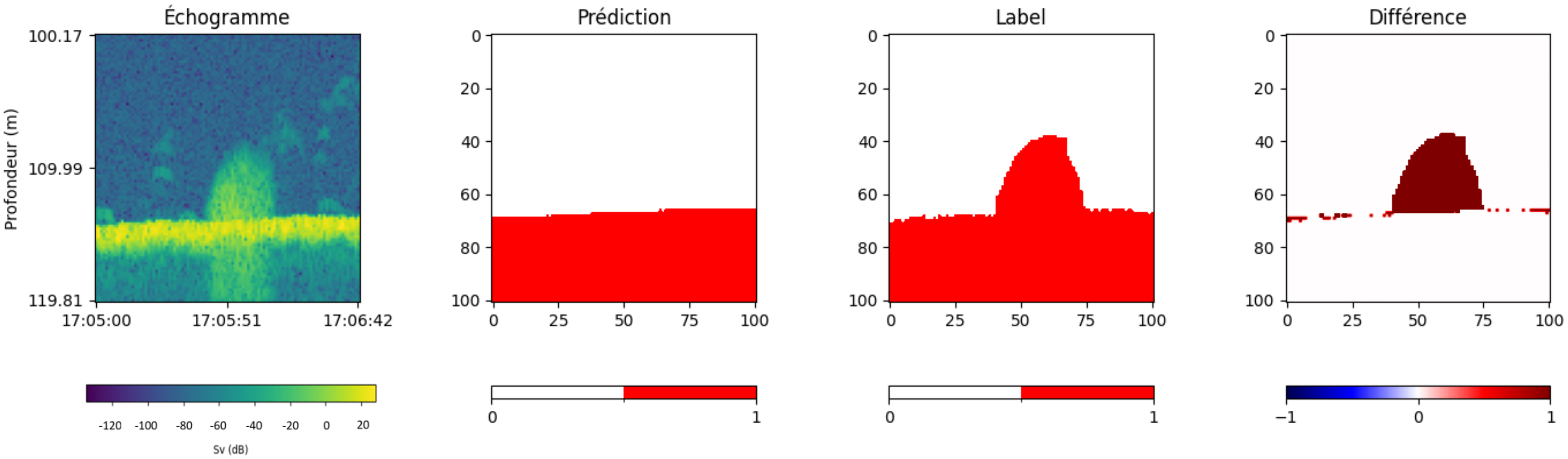
Mean difference precision

- Continental shelf : **~4cm**
- Slopes : **to improve**
- High seas : **to improve**

Time processing comparison



Model revealed bad manual annotations in our database, a valuable side effect



CONCLUSION

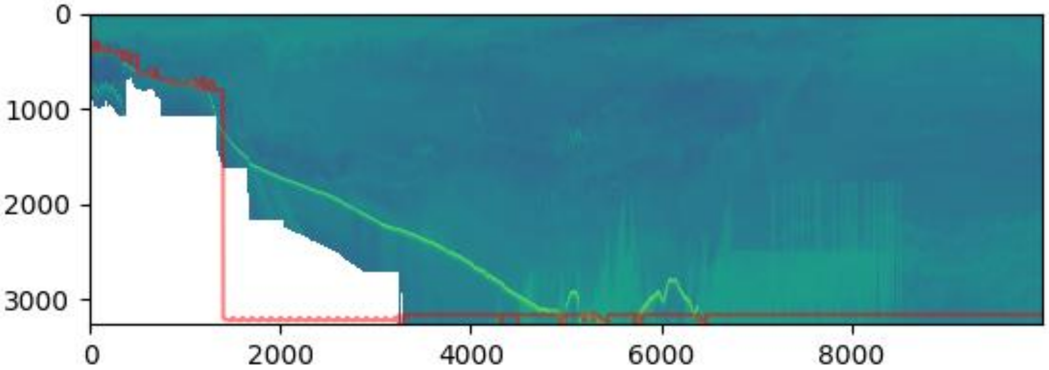
Strengths	Limitations
CNN adapted for EK80 data processing	Reduced performances on slopes
Faster and automated processing	

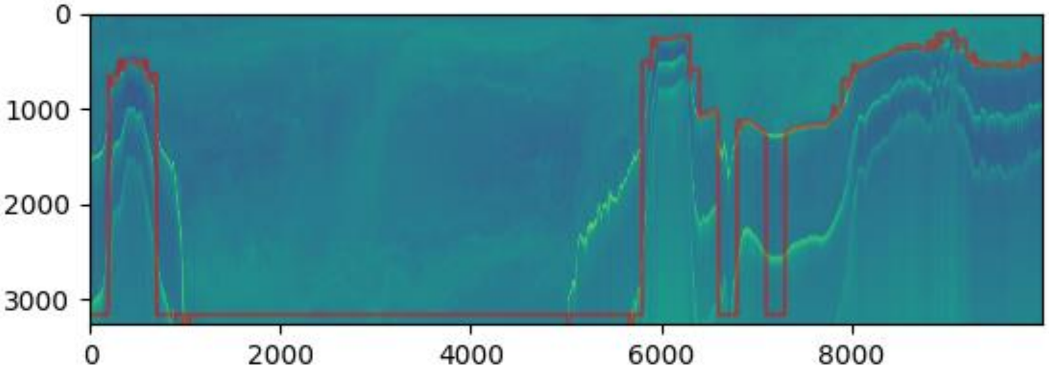
Perspectives

- Make the algorithm operational for integration into our processing tool: **another internship to finalize the work ?**
- Explore CNN applications to detect artifacts in the water column (multiple echoes, CTD rosette, surface saturation).

Python code available : https://github.com/Mauguen/Detection_fond_Unet

ANNEXE


0
1000
2000
3000
0
2000
4000
6000
8000


0
1000
2000
3000
0
2000
4000
6000
8000

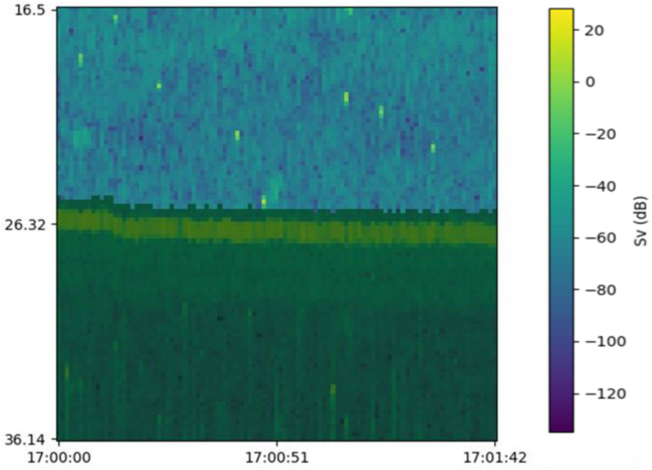
Extraction des imagettes

<u>Causes de l'extraction :</u> contrainte mémoire du GPU utilisé pour l'entraînement

<u>Procédure :</u>

- Calcul de la médiane de la ligne de fond prédite par l'algorithme de Movies3D
- Calcul des limites supérieure et inférieure des imagettes
- Extraction de l'imagette dans l'échogramme global

<u>Exemple :</u>



Imagette – campagne SCOPES