

Deep Learning with SymAE to Correct for Deepwater Statics

Brindha Kanniah

Graduate Student, EAPS

In collaboration with Prof. Laurent Demanet & Prof. Pawan Bharadwaj

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Deepwater Statics

- Statics refer to **time-shifts in reflection seismic** data due to **velocity heterogeneities** between source and receiver.
- Corrupts the **3D image** and inaccuracies propagates into **4D time-lapse analysis**.
- Deepwater settings have **spatio-temporal variations** in seawater column.
- **Tides, season, location, ocean currents** - effects water velocity.
- **Statics correction = removal of time-shifts** in individual records, so reflectors stack coherently.



Goal

Problem: **Two-Step Workflow** for correcting deepwater statics has complications and is computationally expensive.

Question: Can we **bypass this workflow** with deep learning to correct **offset and travelttime dependent time-shifts**?

Solution: **SymAE to disentangle** effects of varying water velocity and coherent subsurface geology – and correct time-shifts.



Context

SymAE Experiments

Separation of time scales

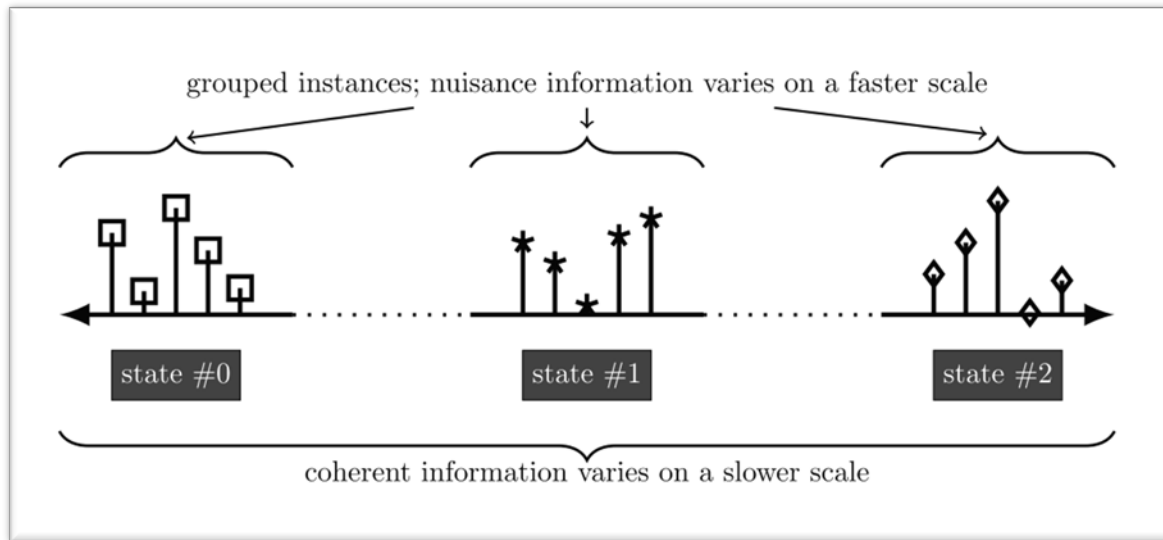
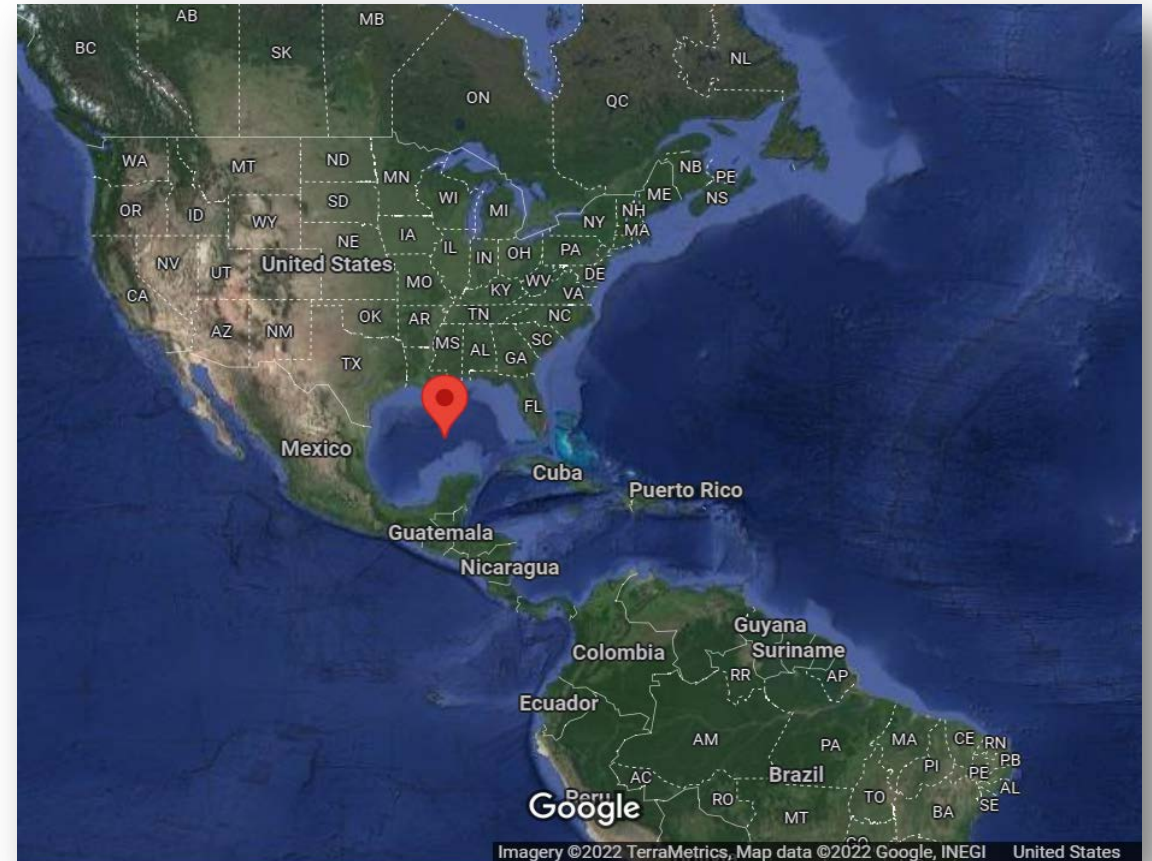


Image from Bharadwaj et al., [2022]

Nuisance (fast varying) corrupts
coherent (slow varying) measurements.

Water velocity variations



Context

SymAE Experiments Separation of time scales

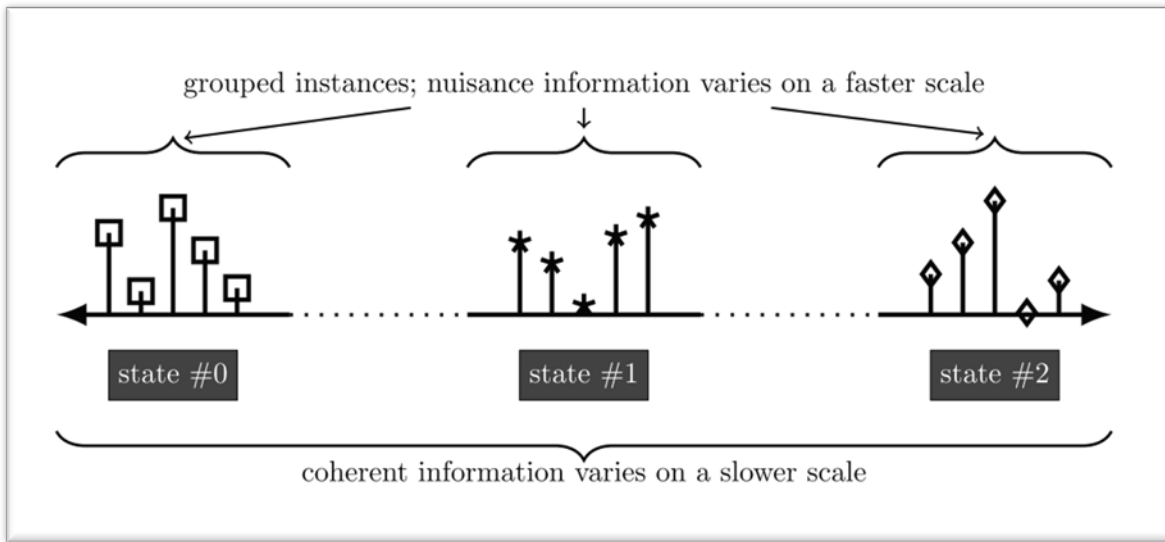
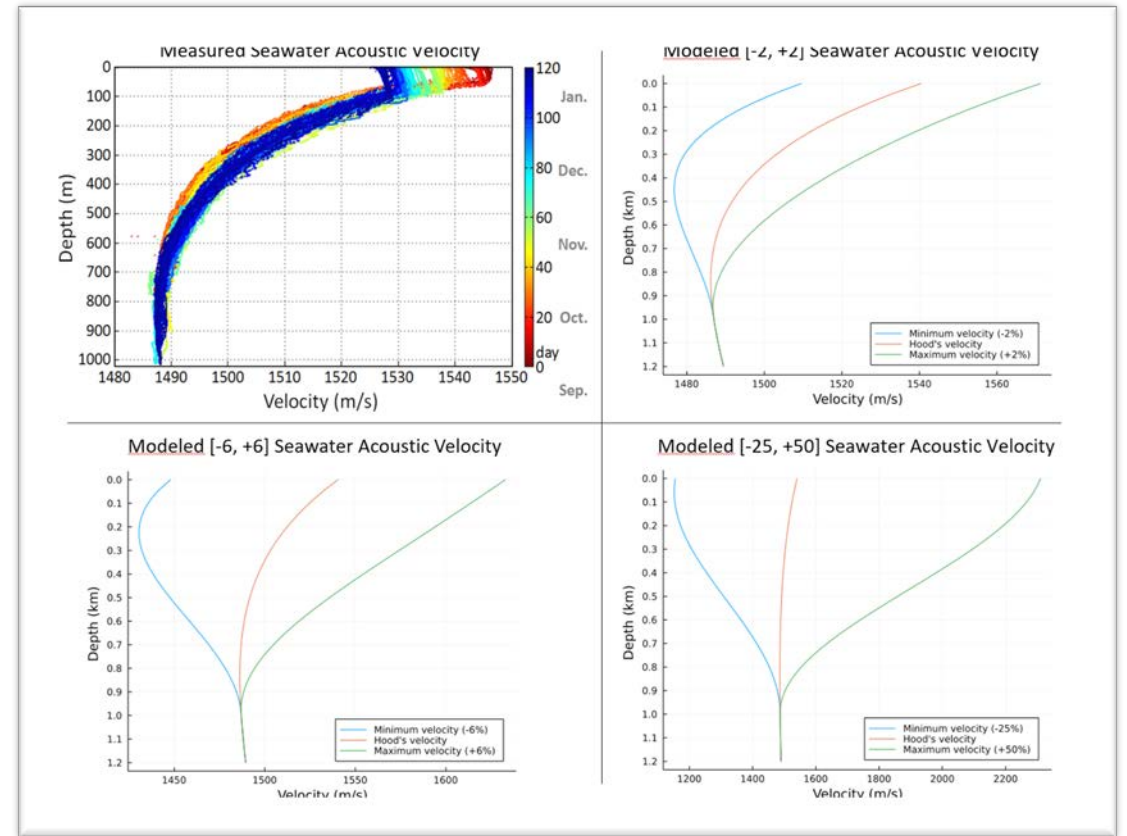


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Water velocity variations

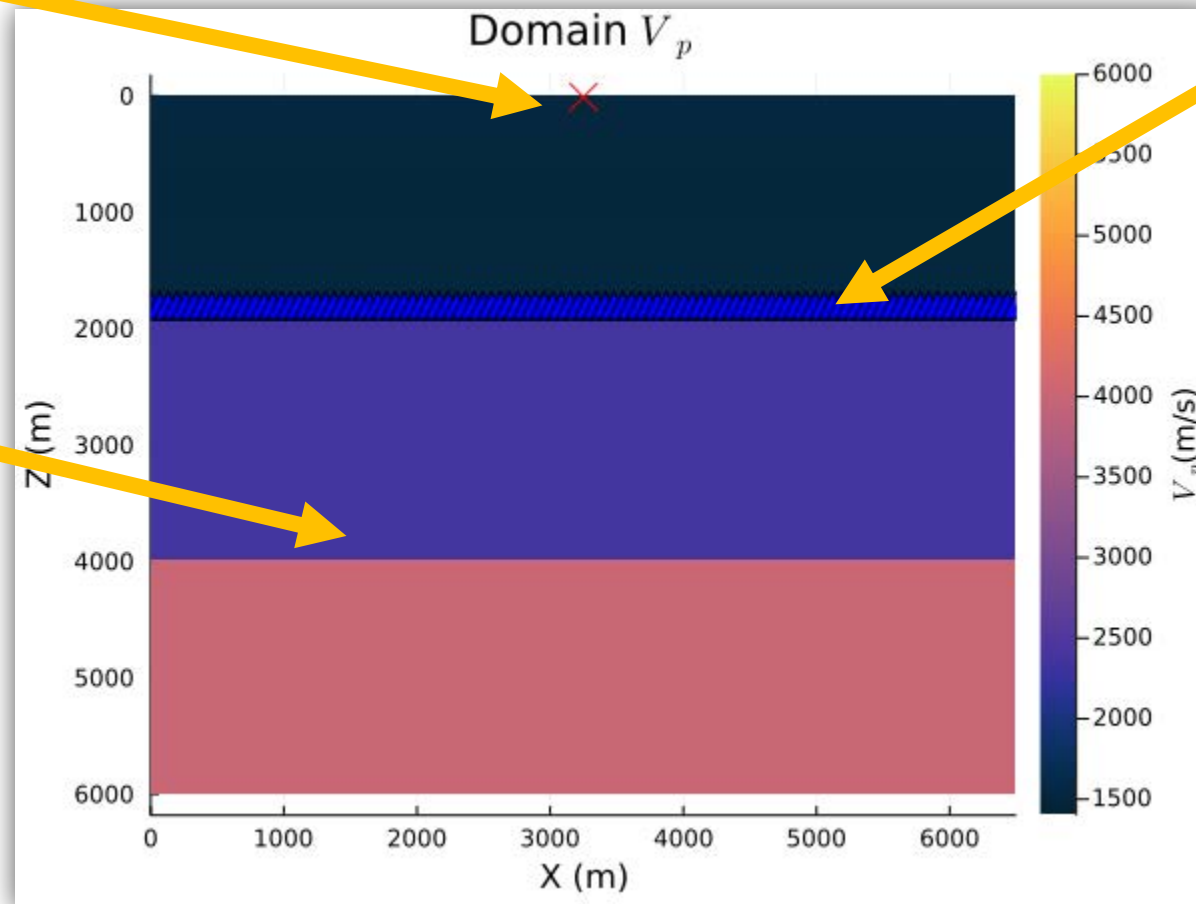


Physical Model

Single 7Hz source

100 OBN receivers

Horizontal reflector



SymAE

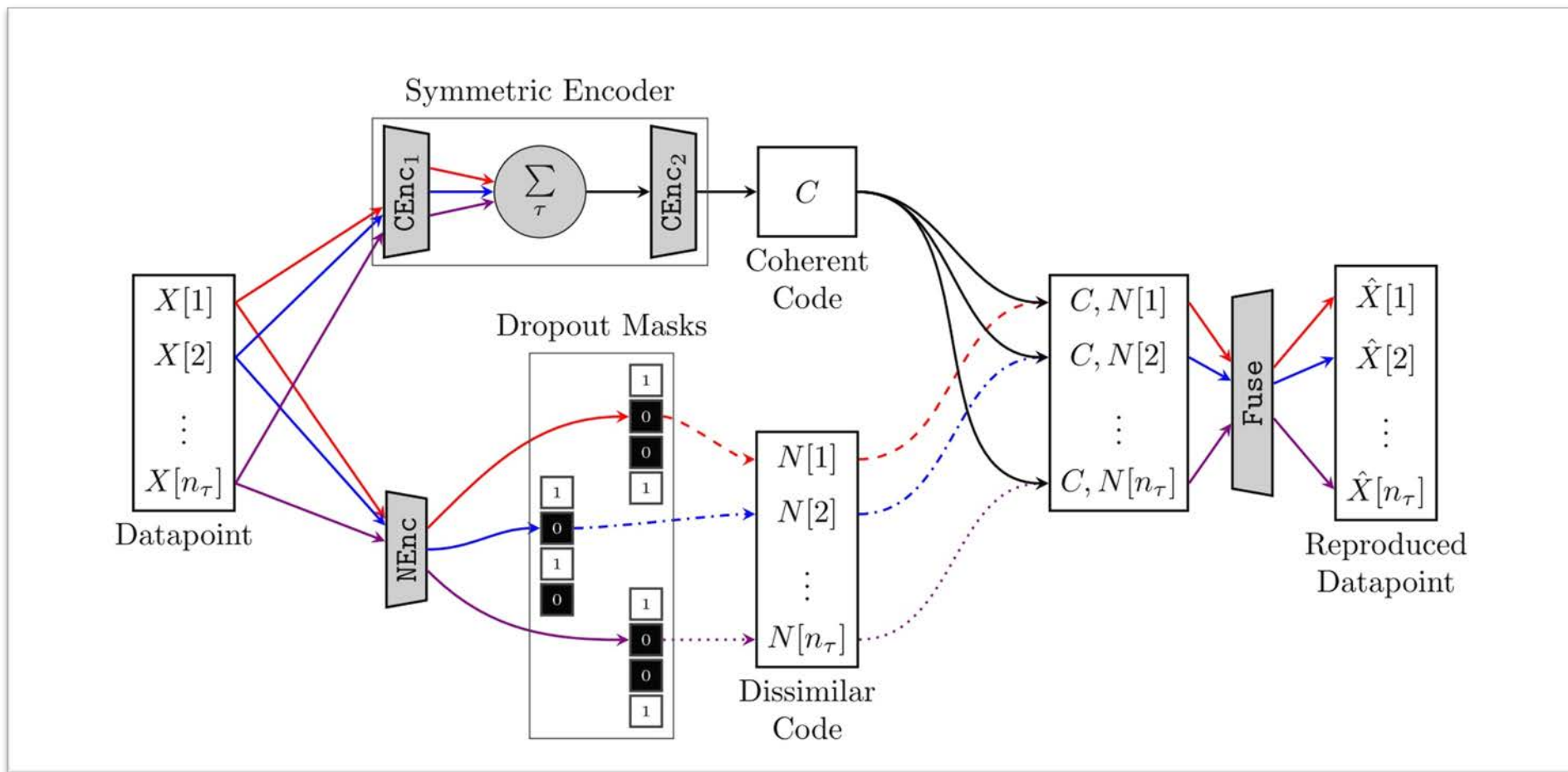


Image from Bharadwaj et al., [2022]



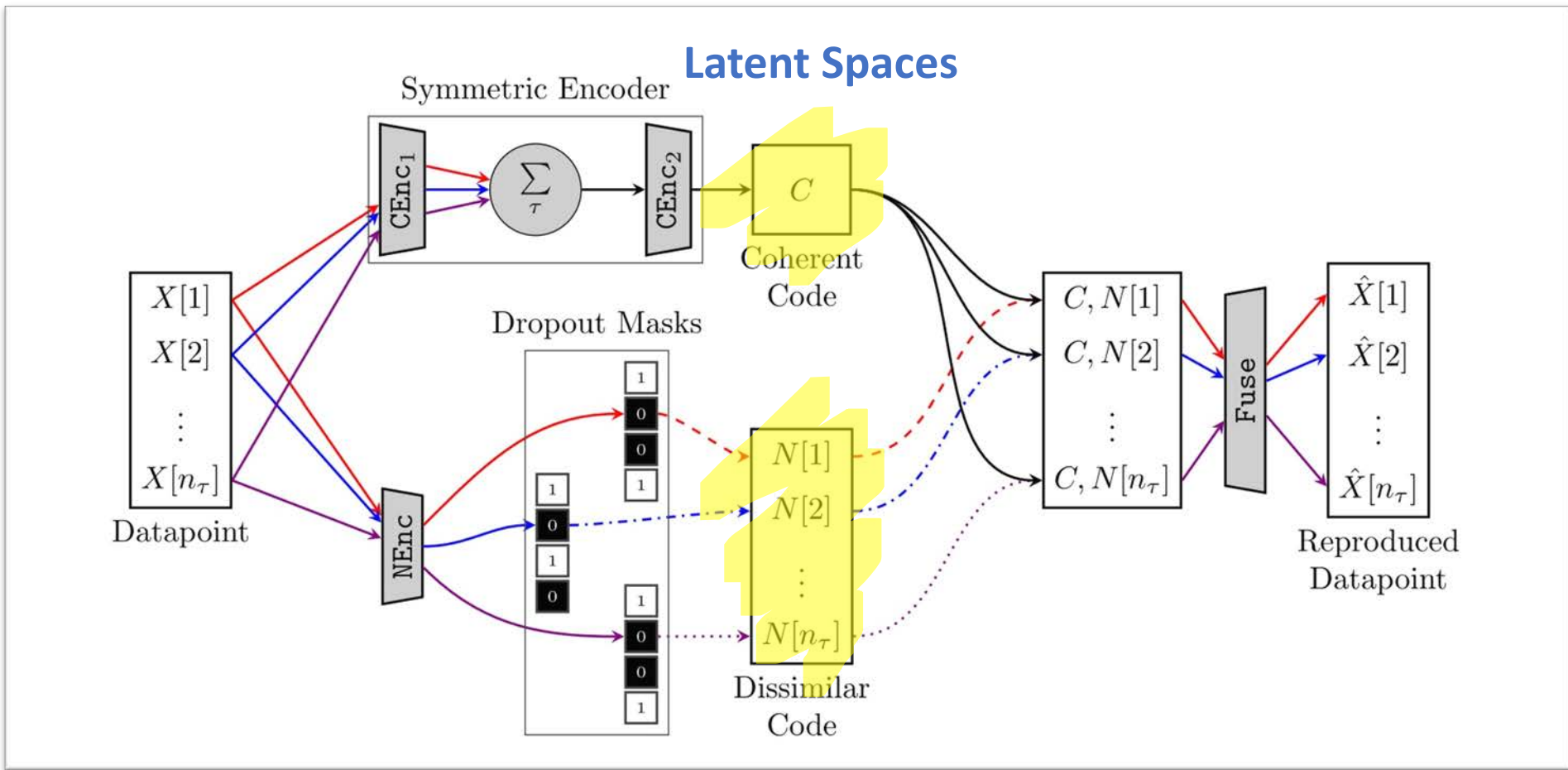


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SymAE

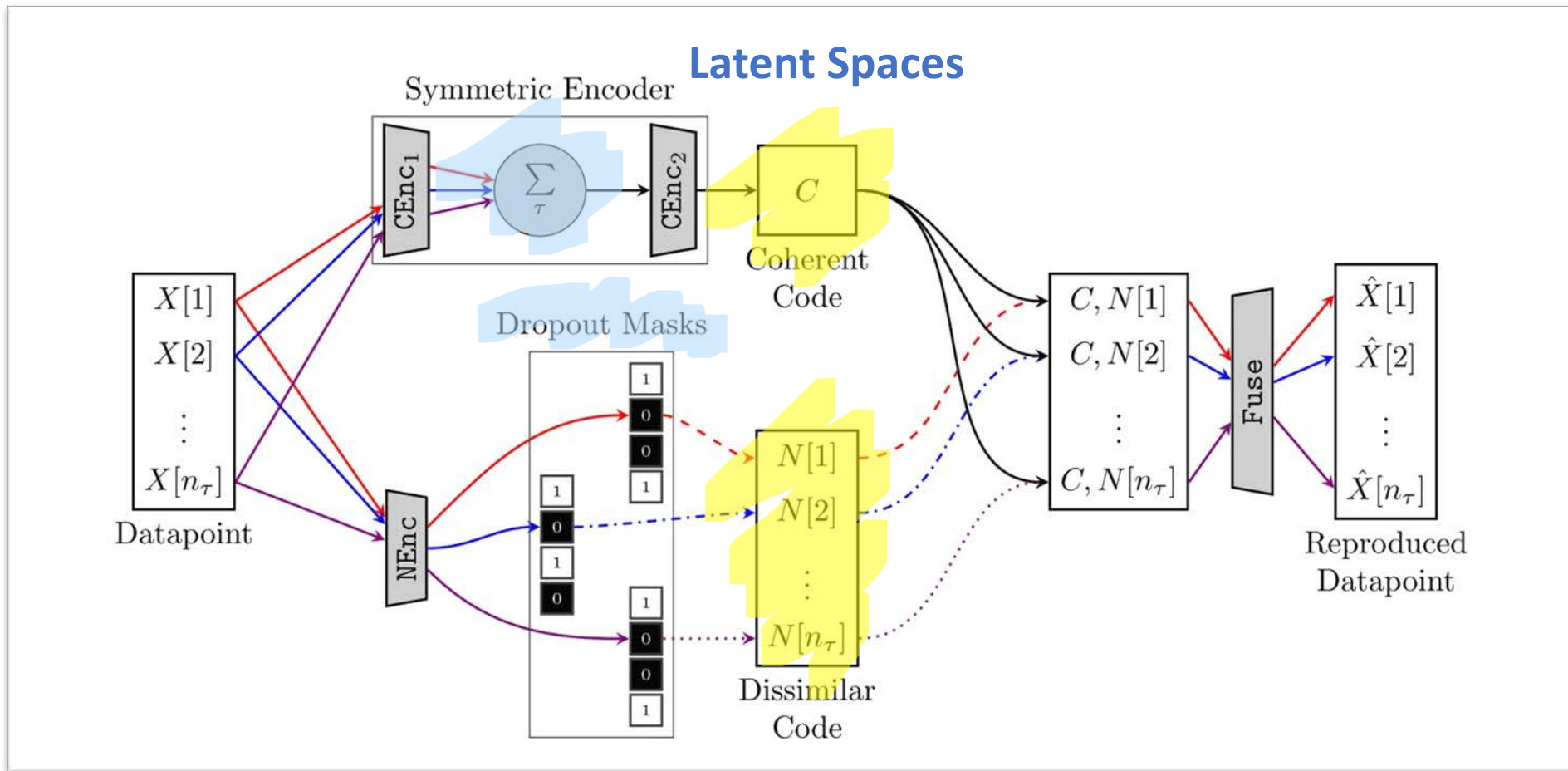
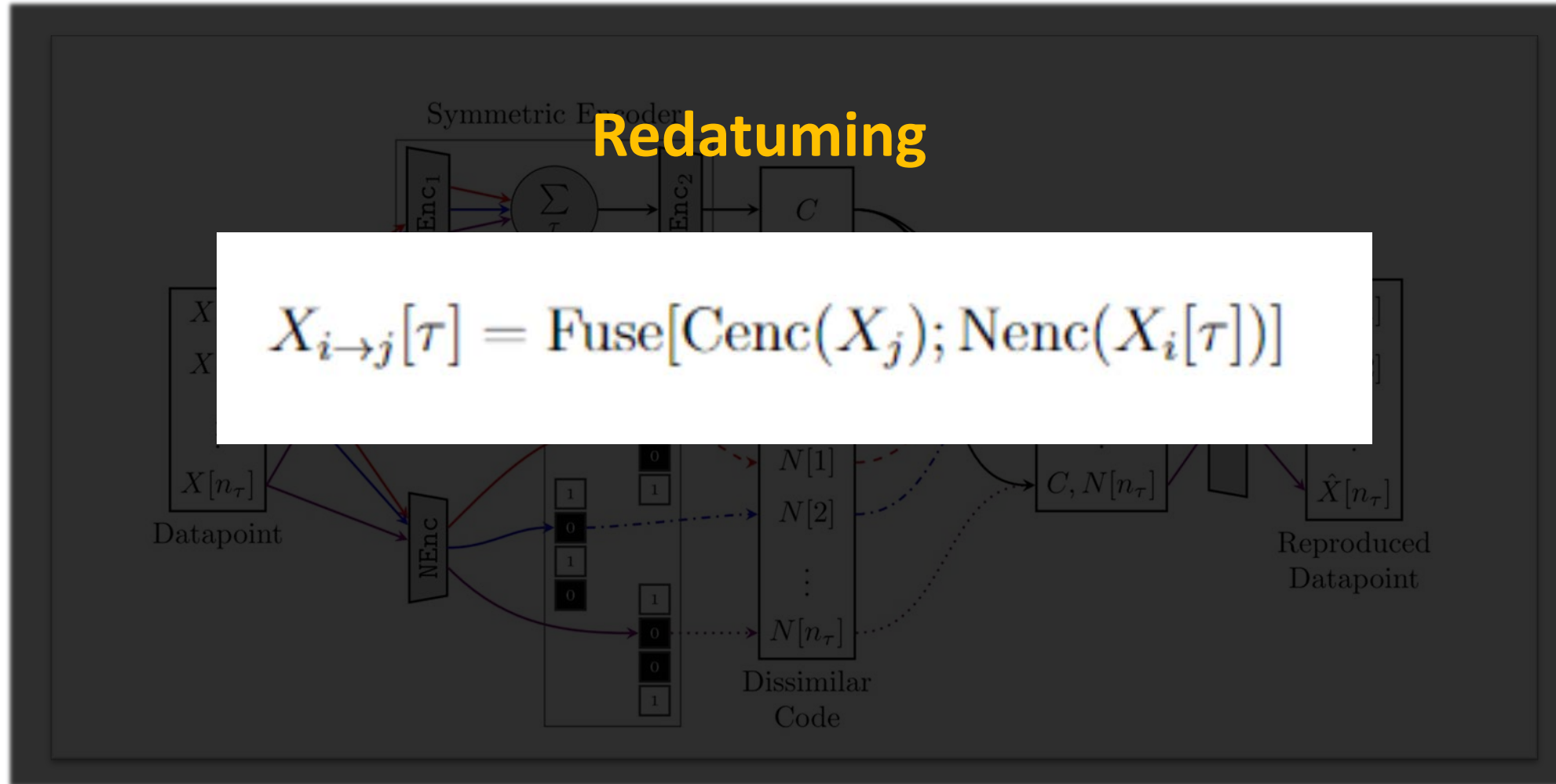


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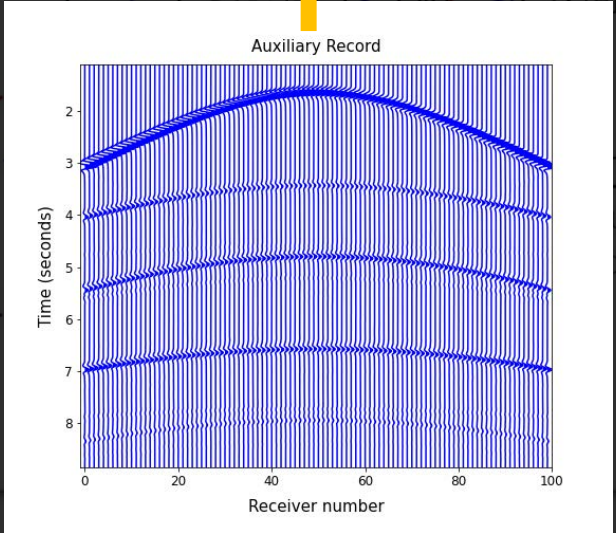
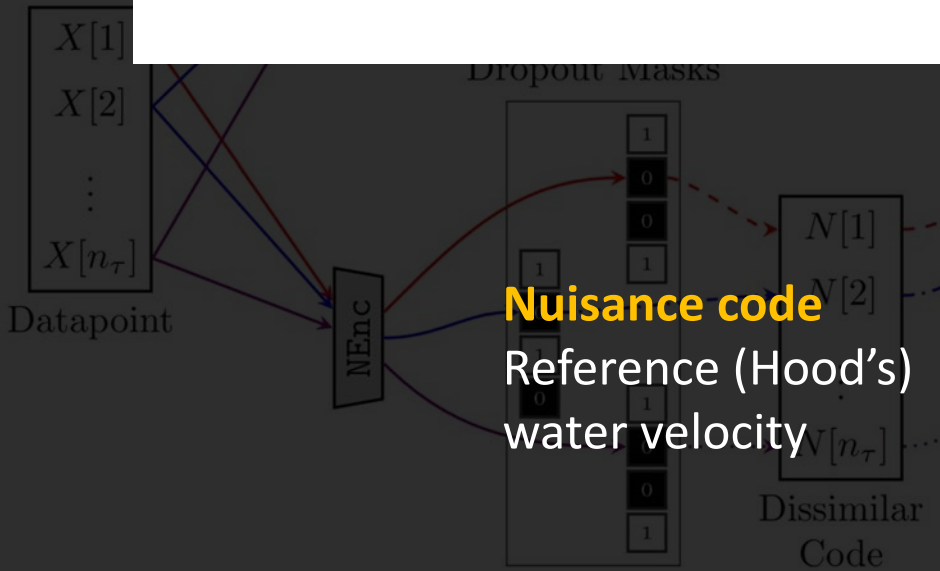
SymAE



Redatumed Datapoint

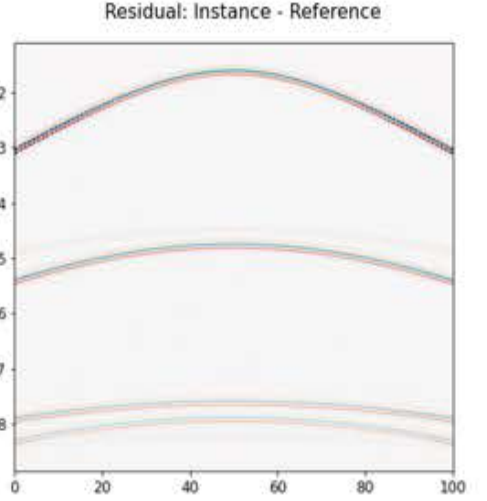
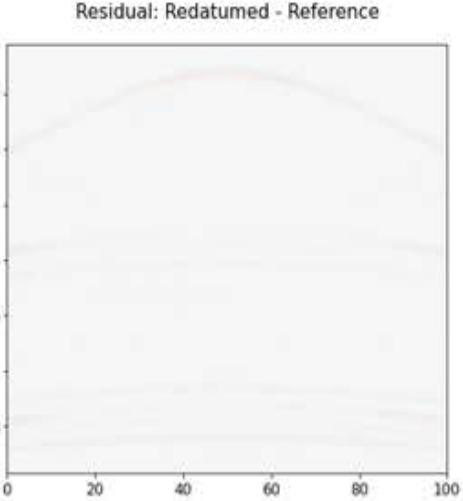
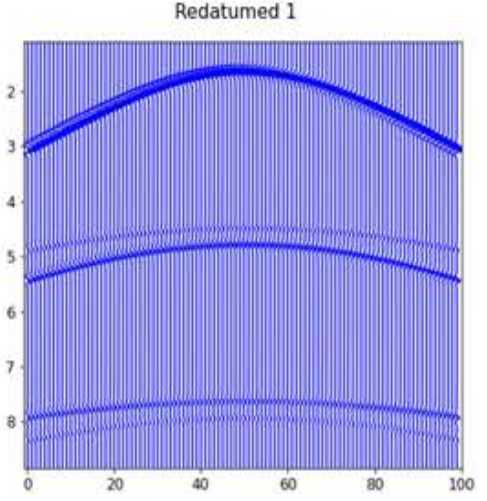
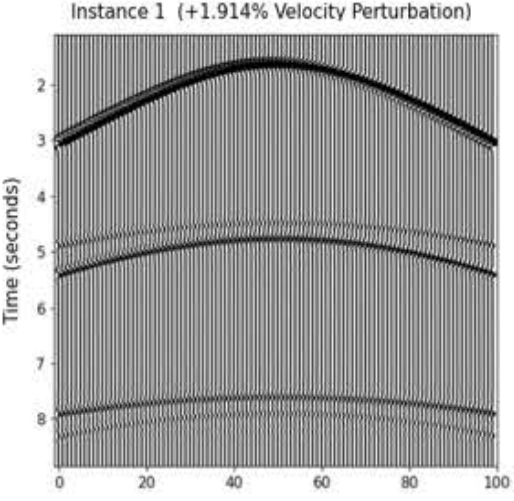
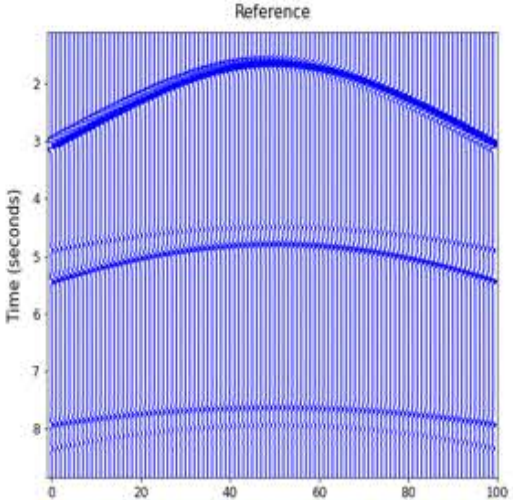
Hybrid Latent Space

$$X_{i \rightarrow j}[\tau] = \text{Fuse}[\text{Cenc}(X_j); \text{Nenc}(X_i[\tau])]$$



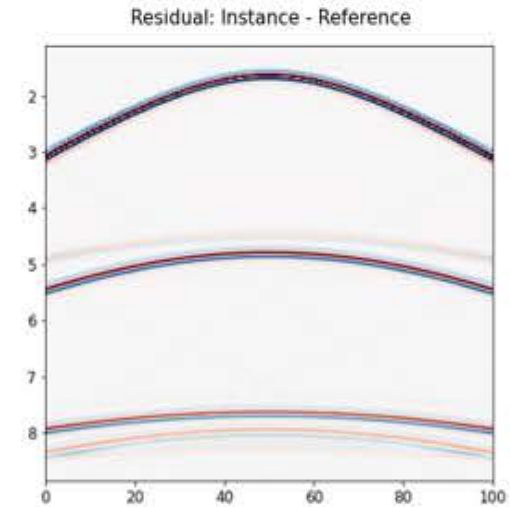
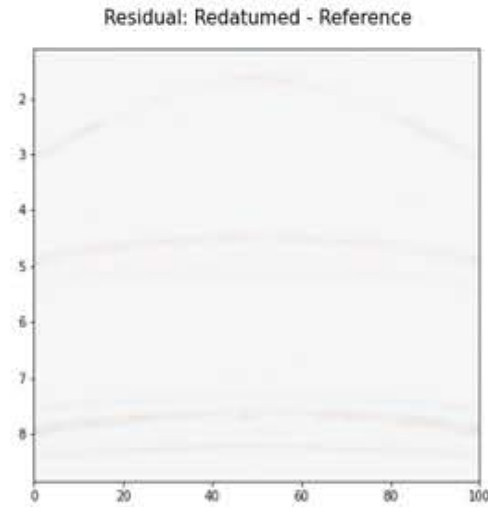
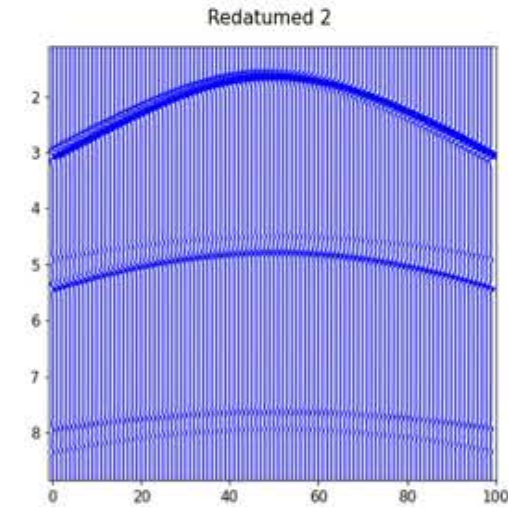
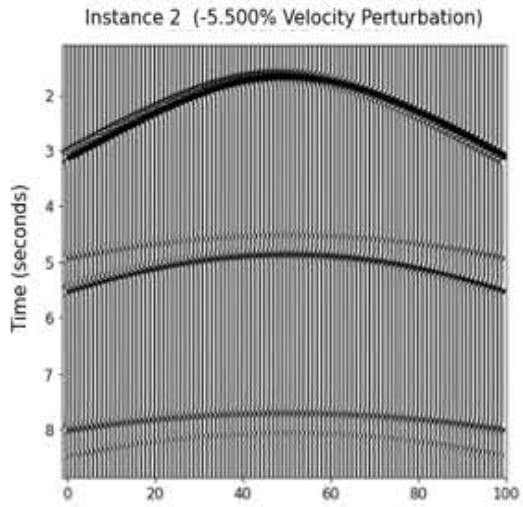
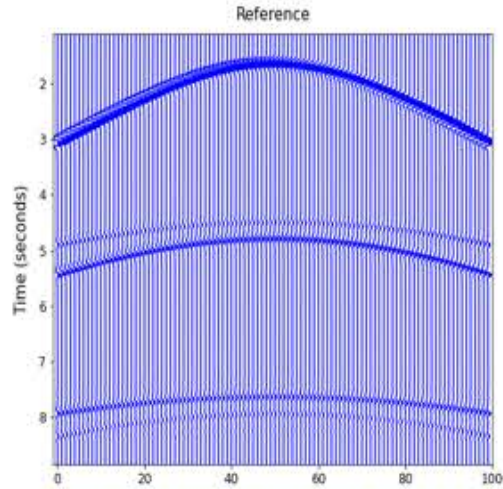
Results

1.914 %
perturbation



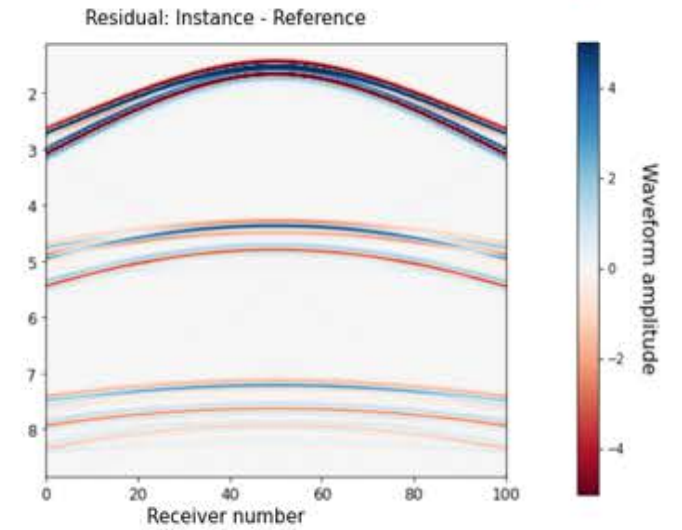
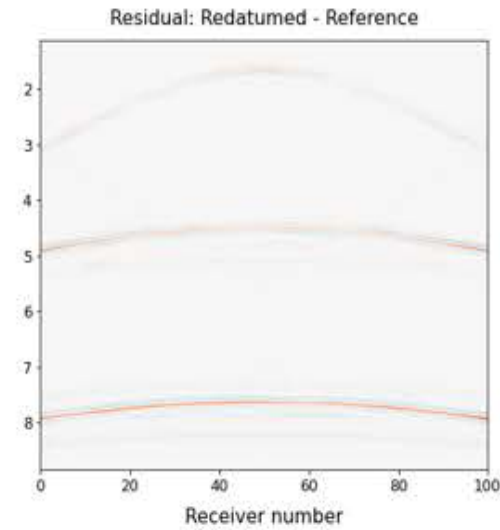
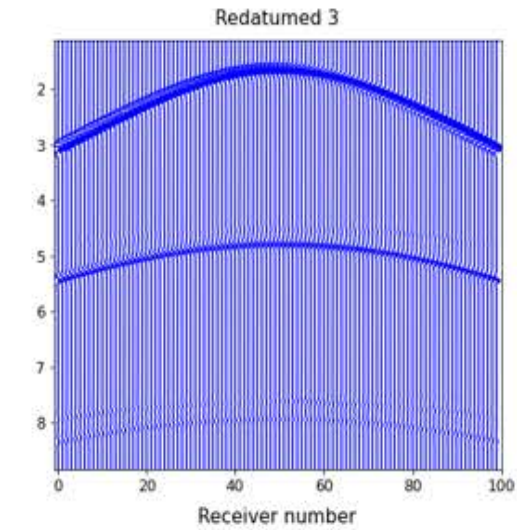
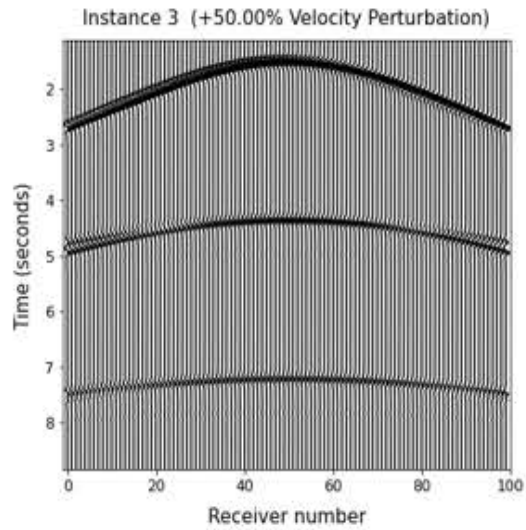
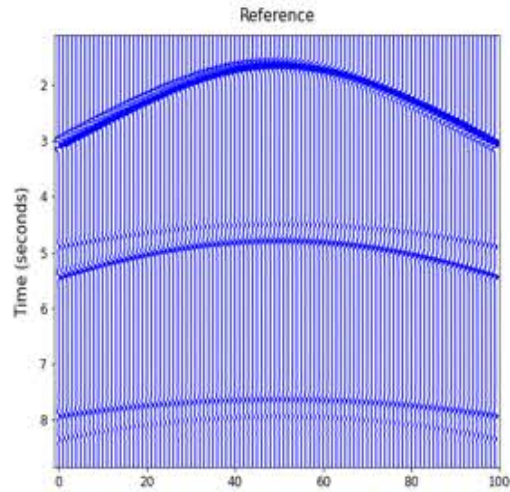
Results

-5.50 %
perturbation



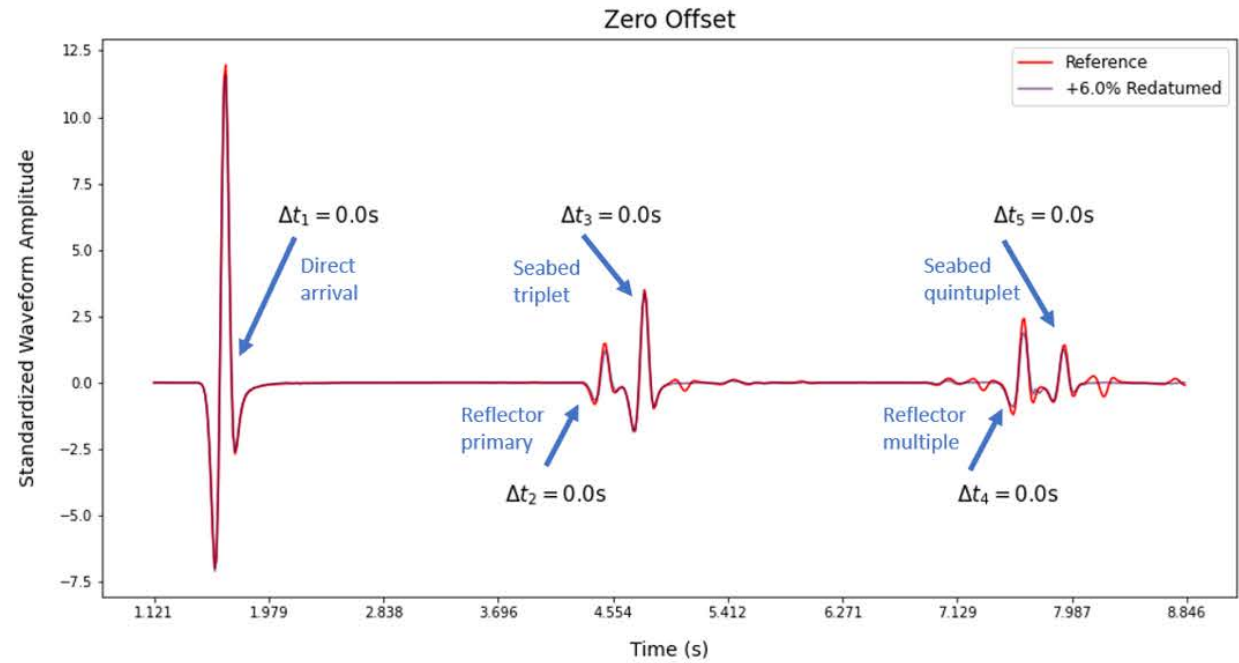
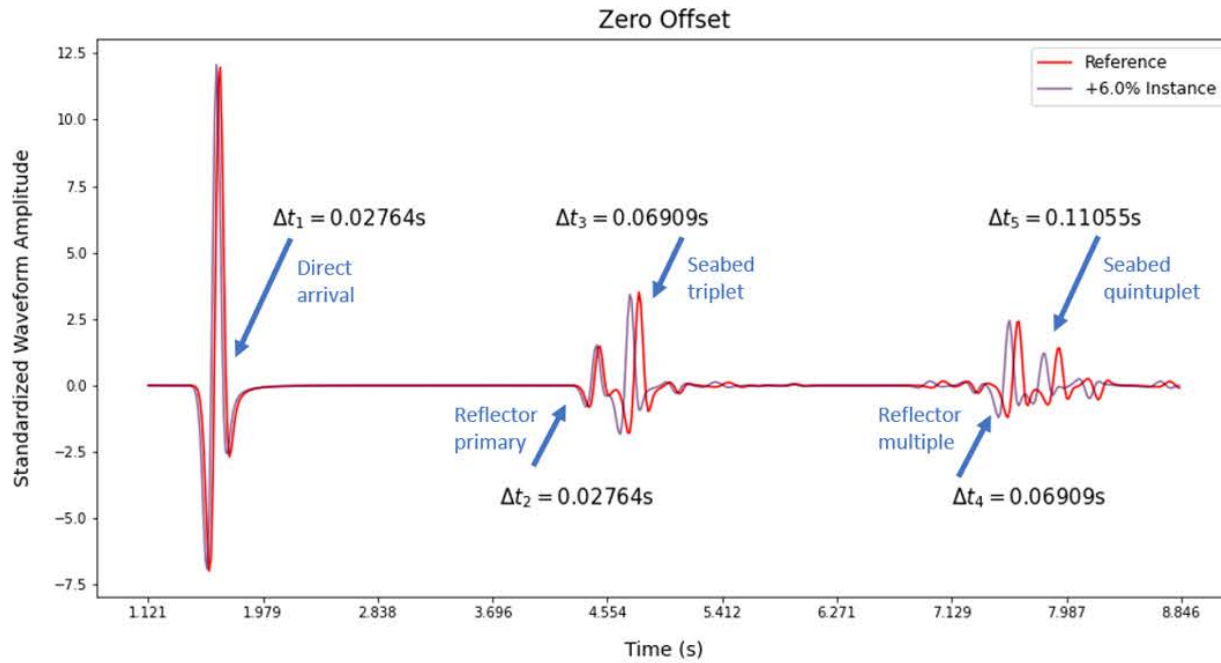
Results

50.00 %
perturbation



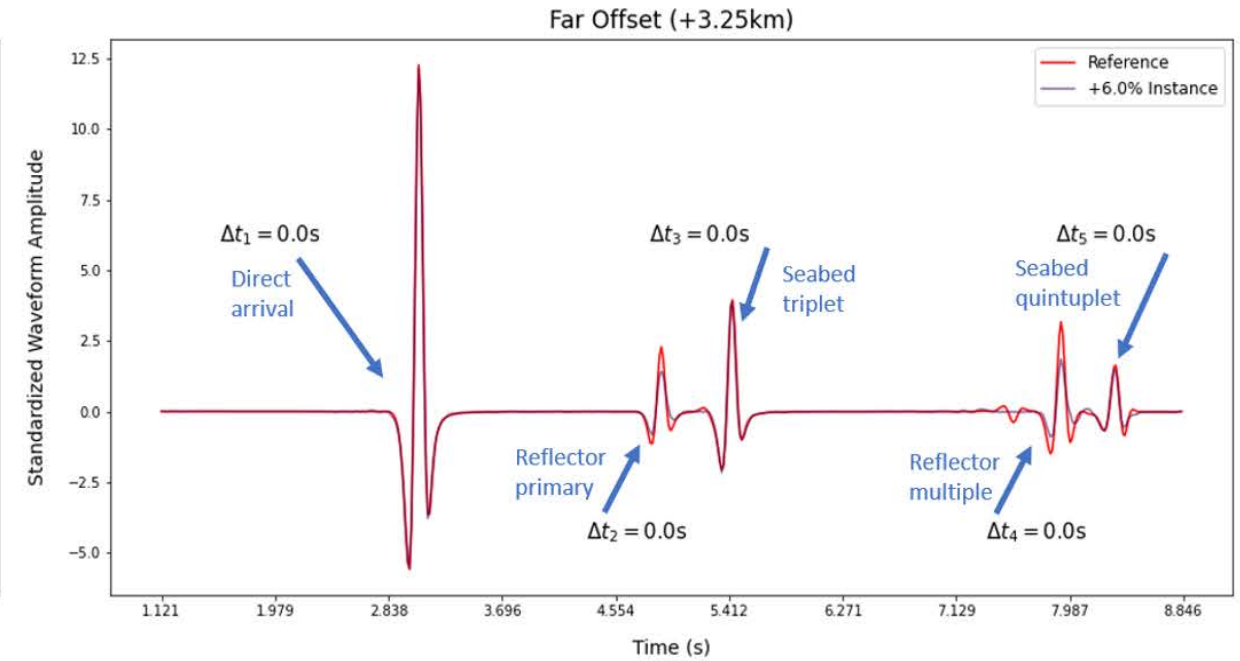
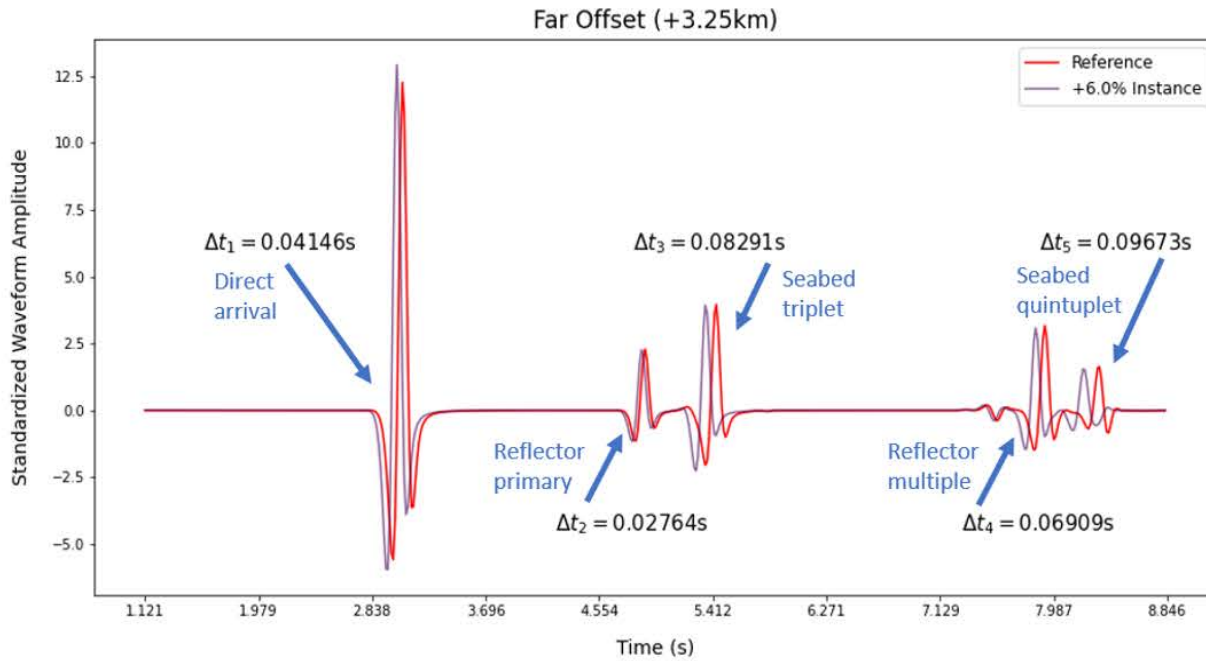
Results

Time-Shifts Reach Zero



Results

Time-Shifts Reach Zero



Results

Normalized Residual Norm across Different Ranges of Data			
Test Data	[-2,2] SymAE	[-6,6] SymAE	[-25,50] SymAE
[-2,2]	0.084	0.104	0.201
[-6,6]	0.190	0.098	0.202
[-25,50]	0.721	0.322	0.200

$$\frac{\|reference-redatumed\|_2}{\|reference\|_2}$$



Conclusion

Question: Can we bypass conventional workflow with deep learning to correct offset and traveltime dependent time-shifts?

- SymAE is a learning algorithm **capable of performing offset and traveltime dependent time-shifts** in seismic measurements.
- Caveat: Training dataset is simplified compared to real subsurface possibilities.
- Real deepwater challenges: lateral velocity variations and subsidence/uplift of seafloor.

