Unsupervised Learning of Full-Waveform Inversion: Connecting CNN and Partial Differential Equation in a Loop

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Full-Waveform Inversion (FWI)

Geophysical properties (e.g., velocity) can be obtained via seismic surveys.

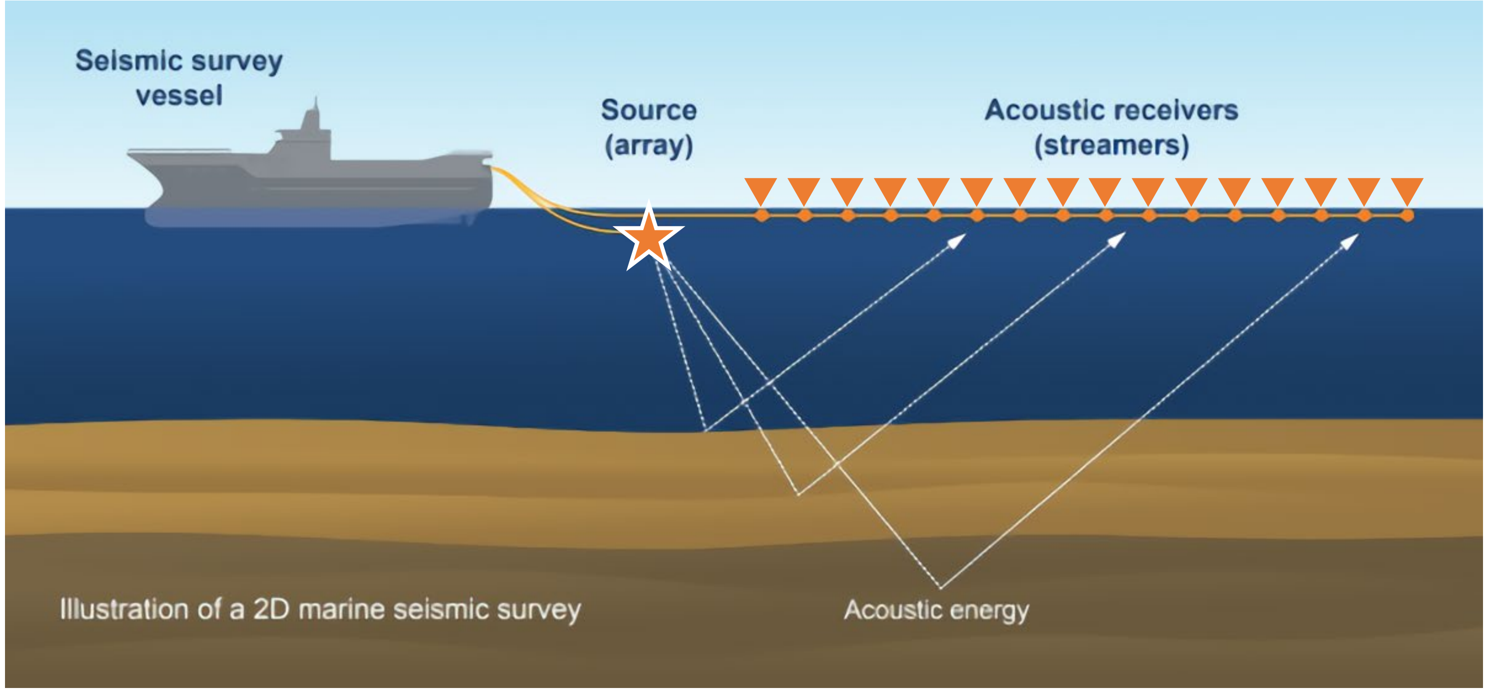

Figure from https://www.nopsema.gov.au/offshore-industry/environmental-management/marine-seismic-surveys

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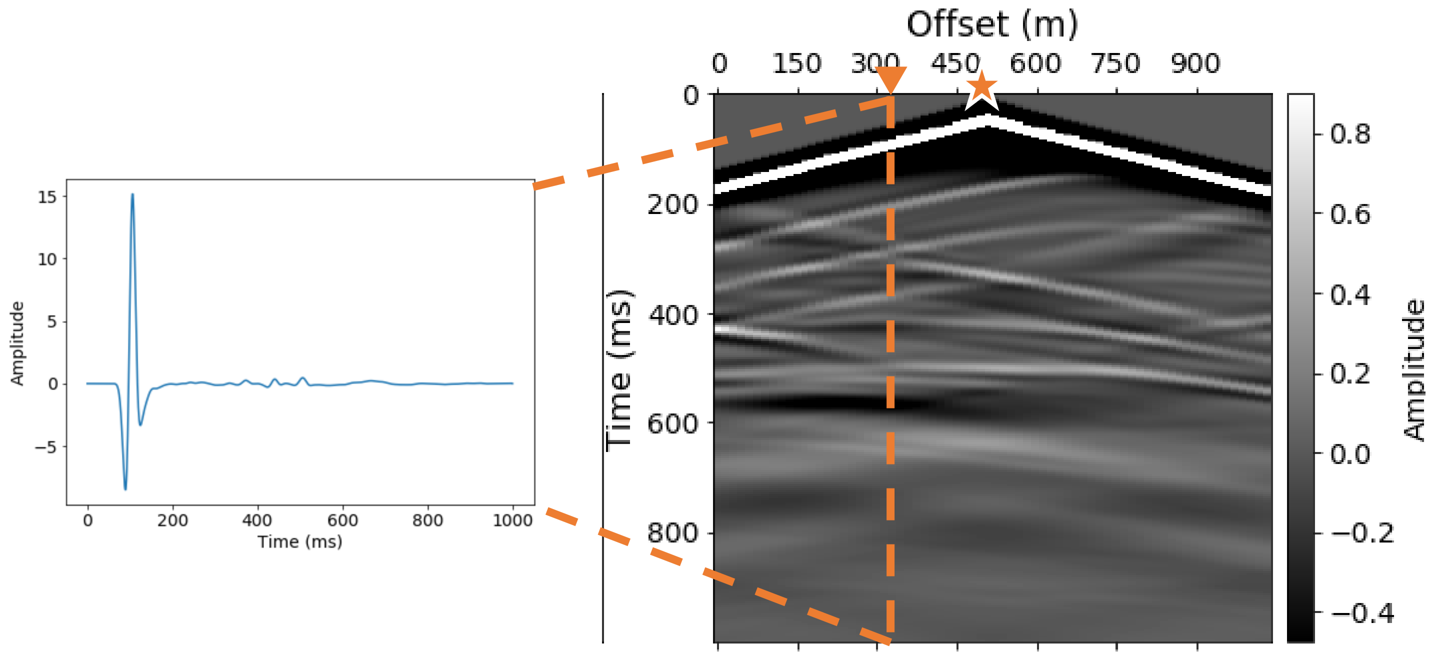
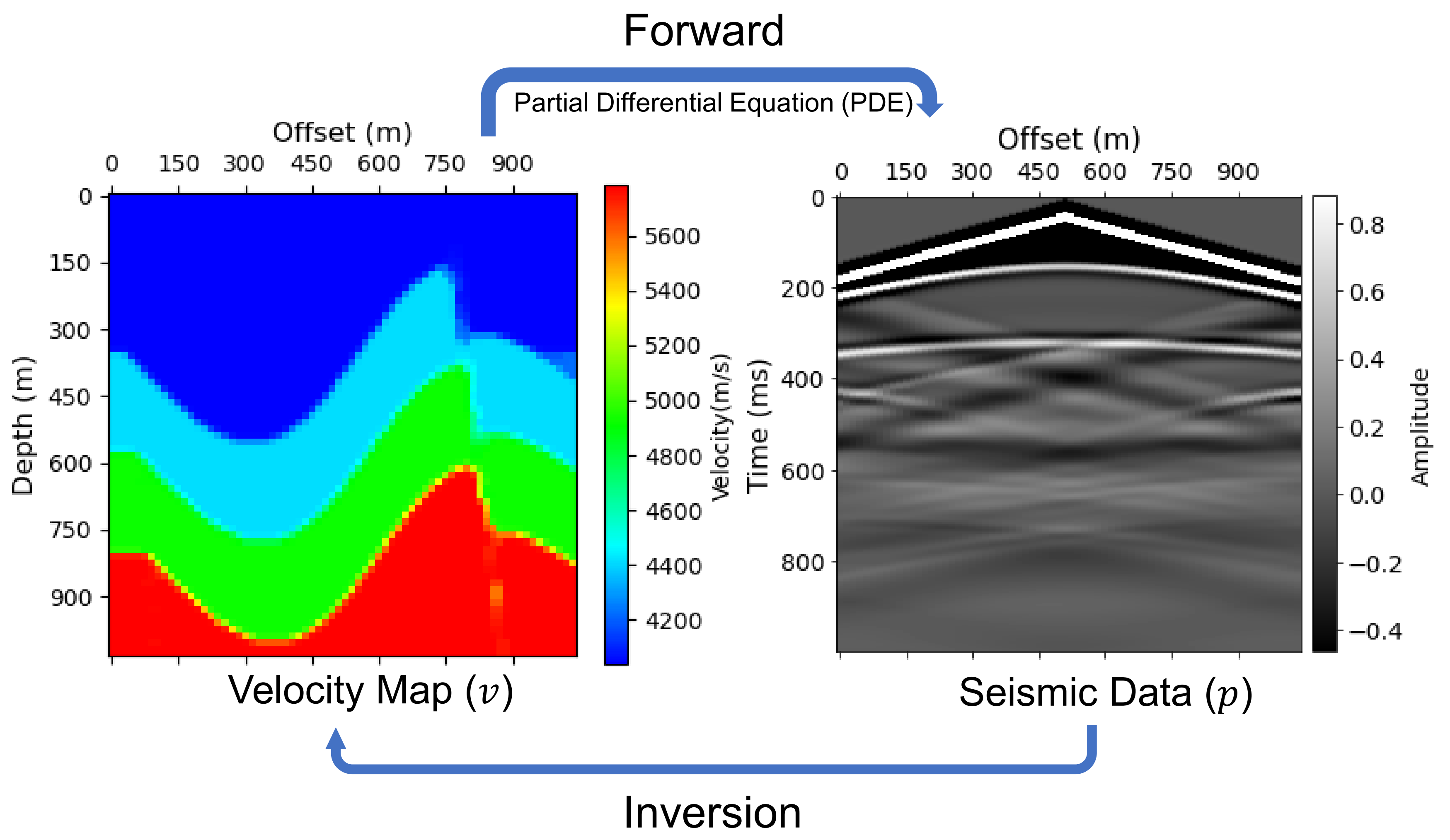


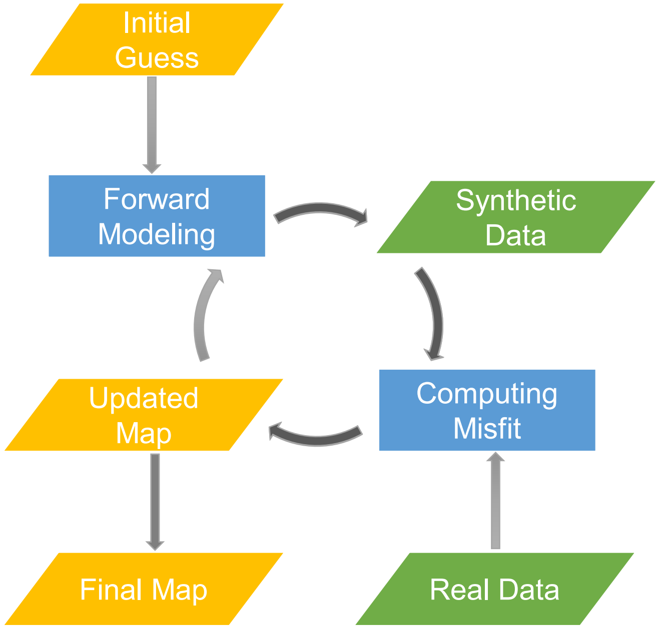
Full-Waveform Inversion (FWI)



Can we leverage the advantages of both directions?

Motivation

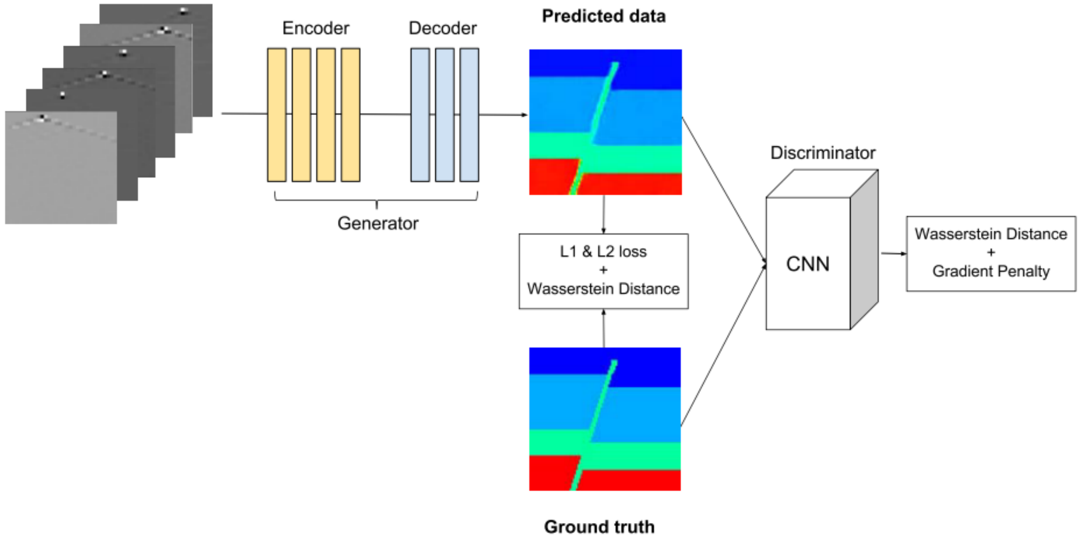
Physics-driven FWI



No ground truth needed

High computational cost
Expensive to obtain a good initial guess

Data-driven FWI



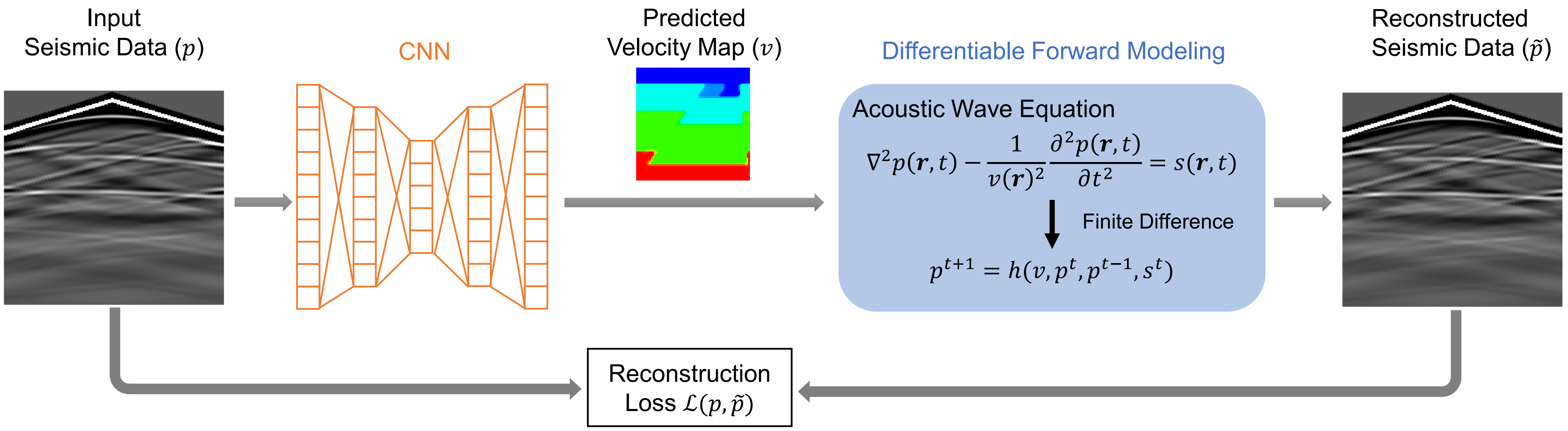
(Zhang et al., 2019)

No initial guess needed
Have certain level of generalization

Require ground truth velocity maps for training

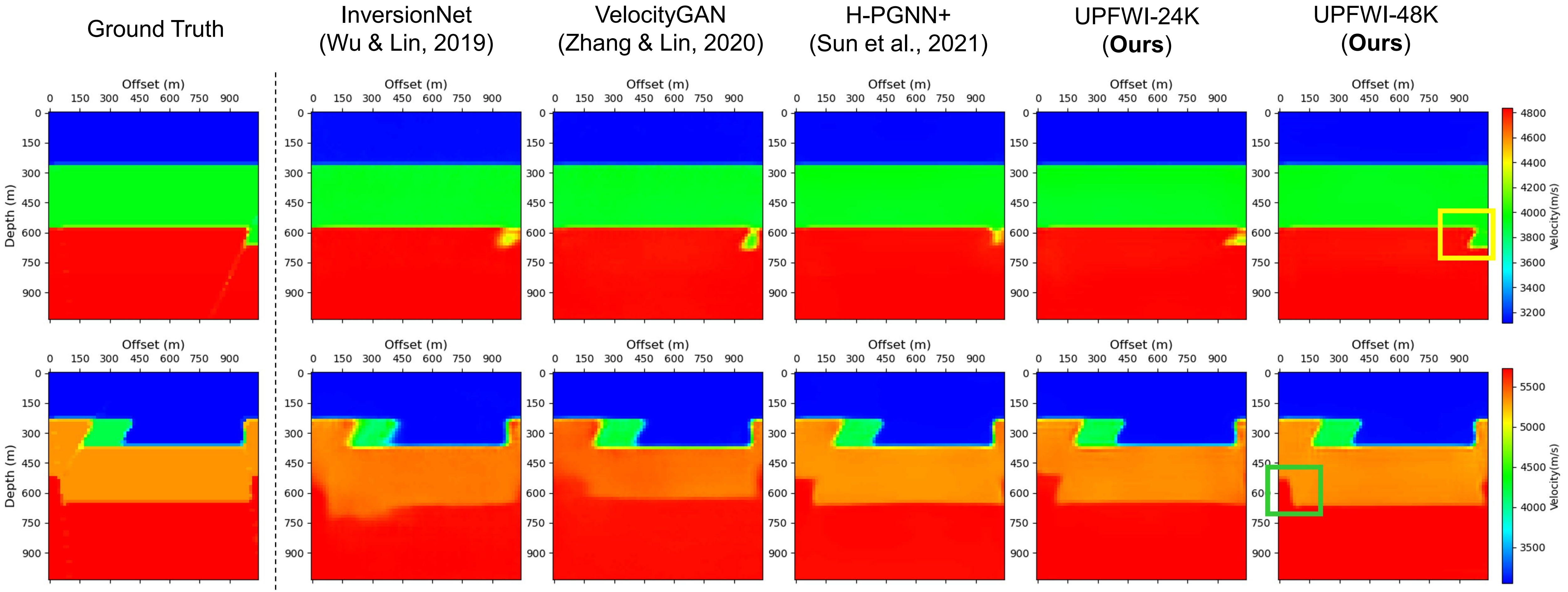
Method

Main idea: connecting forward modeling (PDE) and CNN in a loop.



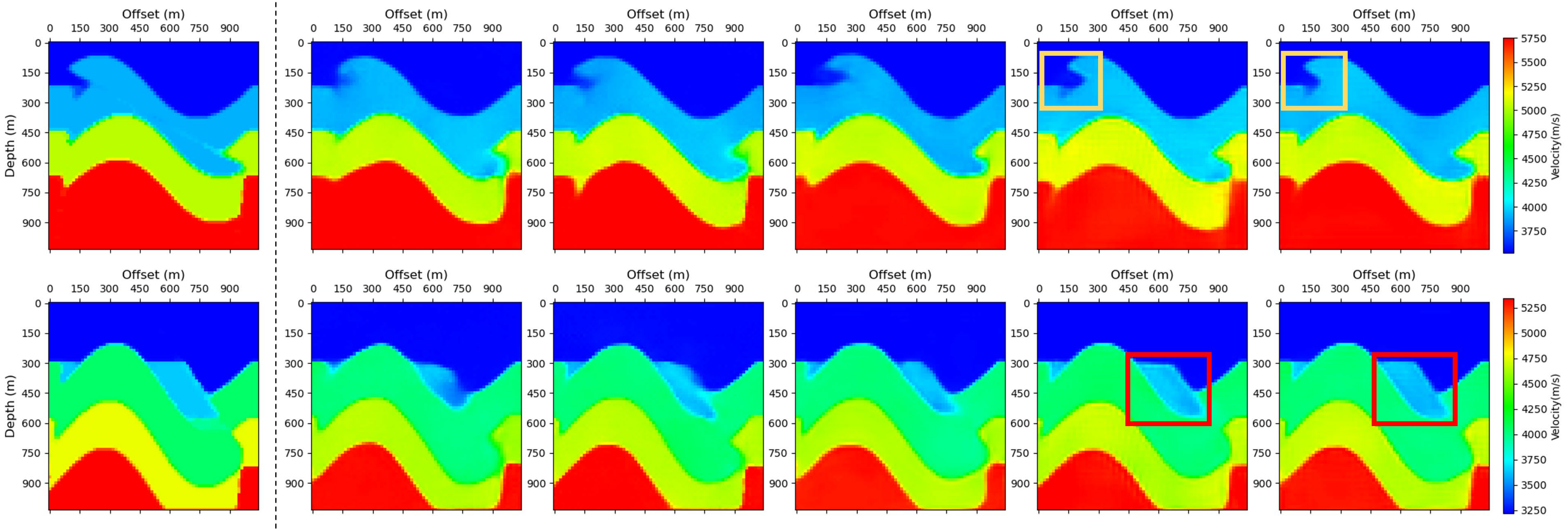
$$\mathcal{L}(\boldsymbol{p},\widetilde{\boldsymbol{p}}) = \mathcal{L}_{pixel}(\boldsymbol{p},\widetilde{\boldsymbol{p}}) + \mathcal{L}_{perceptual}(\boldsymbol{p},\widetilde{\boldsymbol{p}})$$

Results (FlatFault)

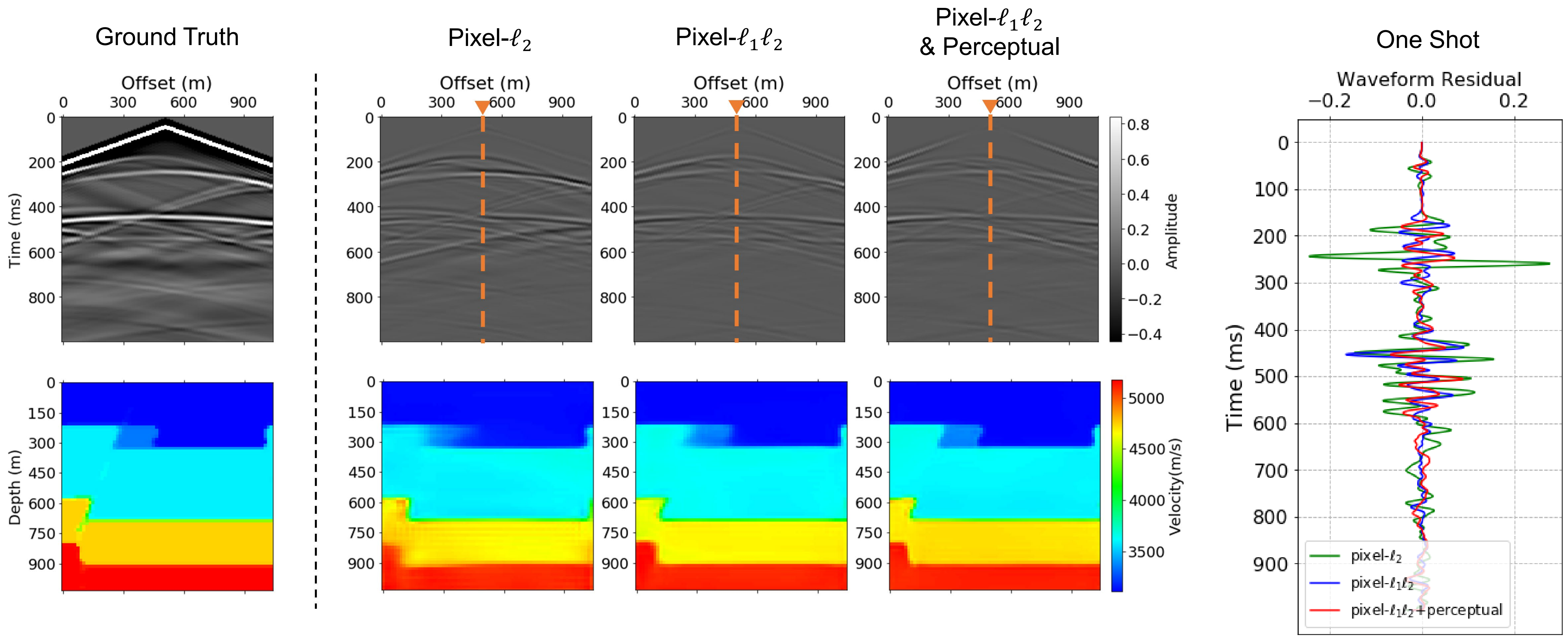


Results (CurvedFault)

Ground Truth	InversionNet (Wu & Lin, 2019)	VelocityGAN (Zhang & Lin, 2020)	H-PGNN+ (Sun et al., 2021)	UPFWI-24K (**Ours**)	UPFWI-48K (**Ours**)



Ablations (Loss Terms)



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Thank you for listening!

Our dataset is integrated in a follow-up benchmark dataset available at: https://openfwi-lanl.github.io/