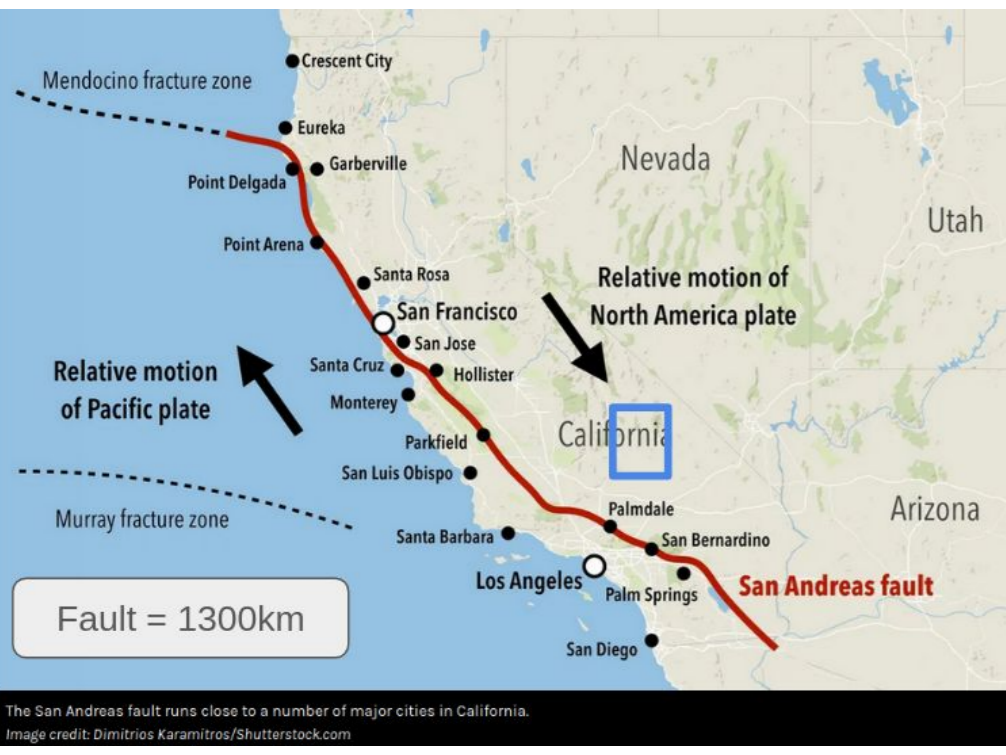


Motivation



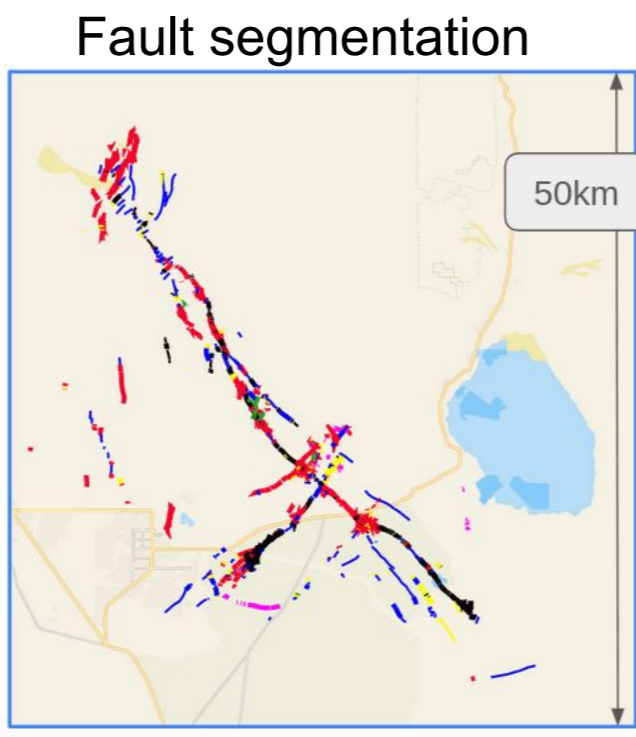
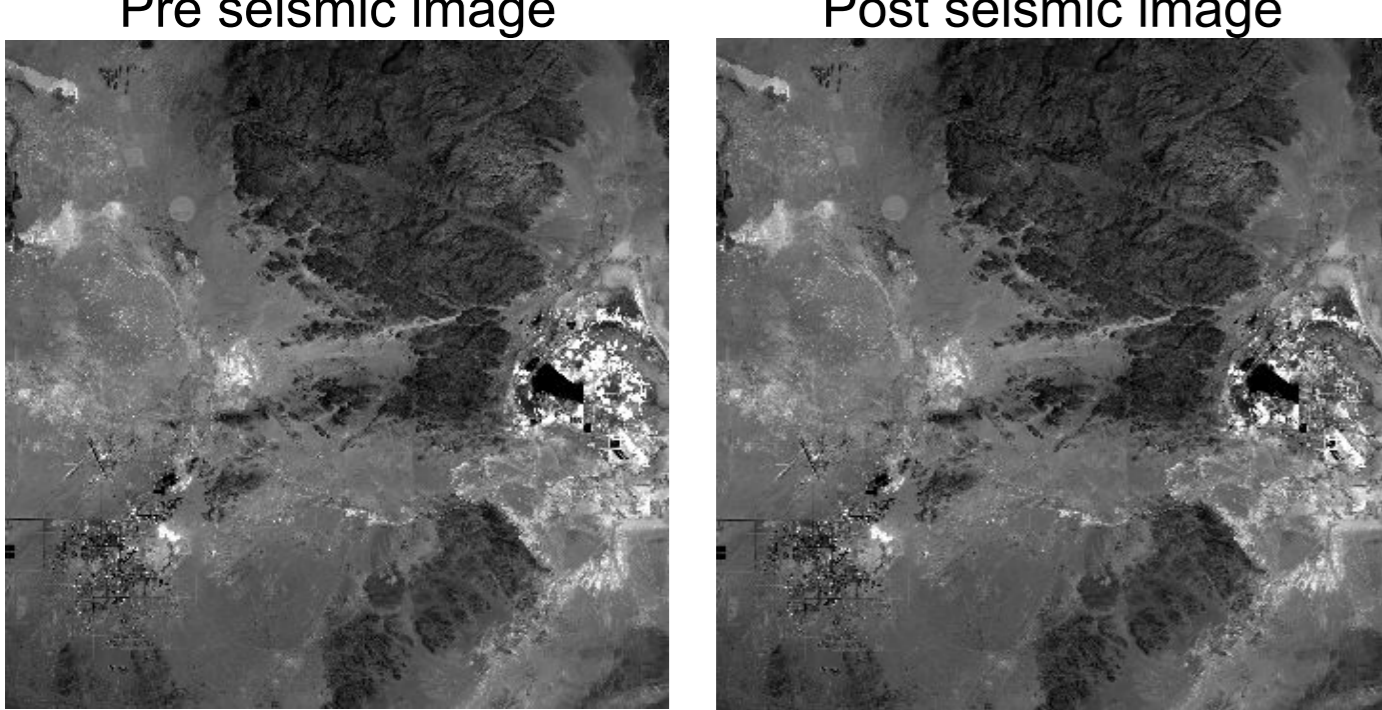
Dense ground deformation estimation in co-seismic events

A critical need for the geoscience community, to:

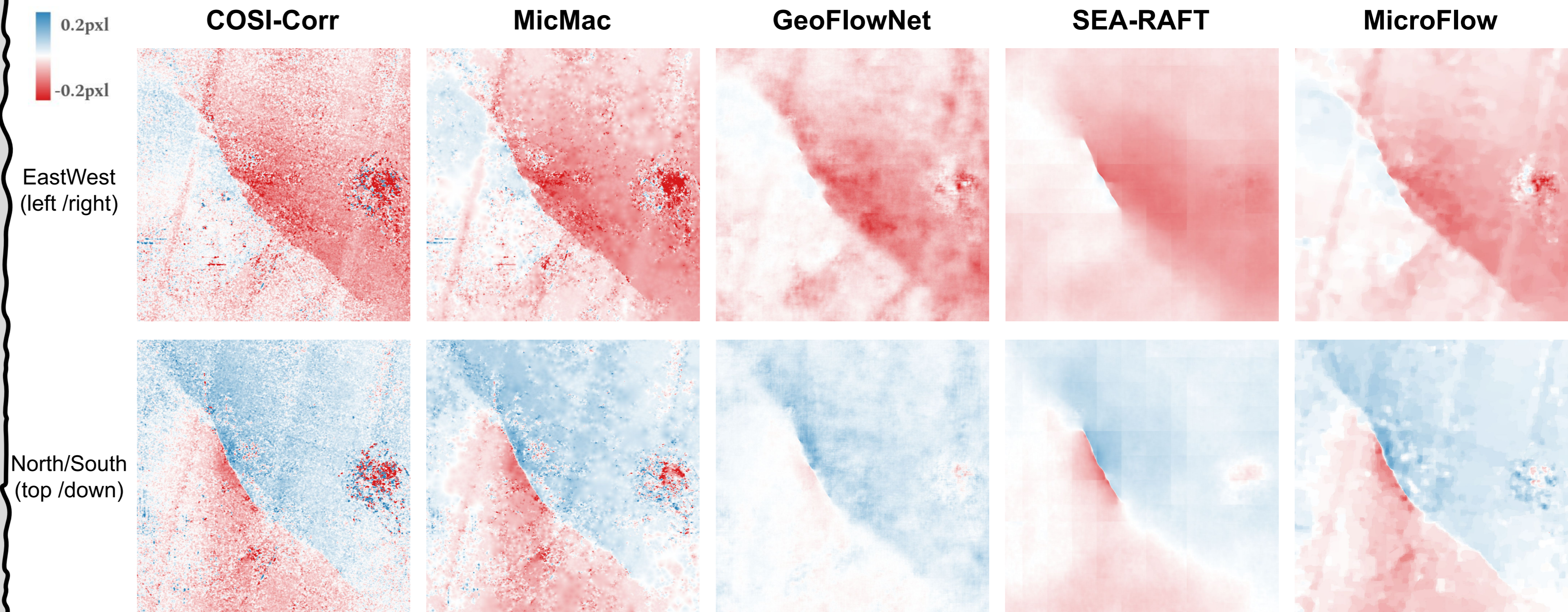
- Respond rapidly to earthquakes
- Monitor and analyse ground and fault deformation over time

Case-study with the **RidgeCrest-2019 Earthquakes** (3 main shocks)

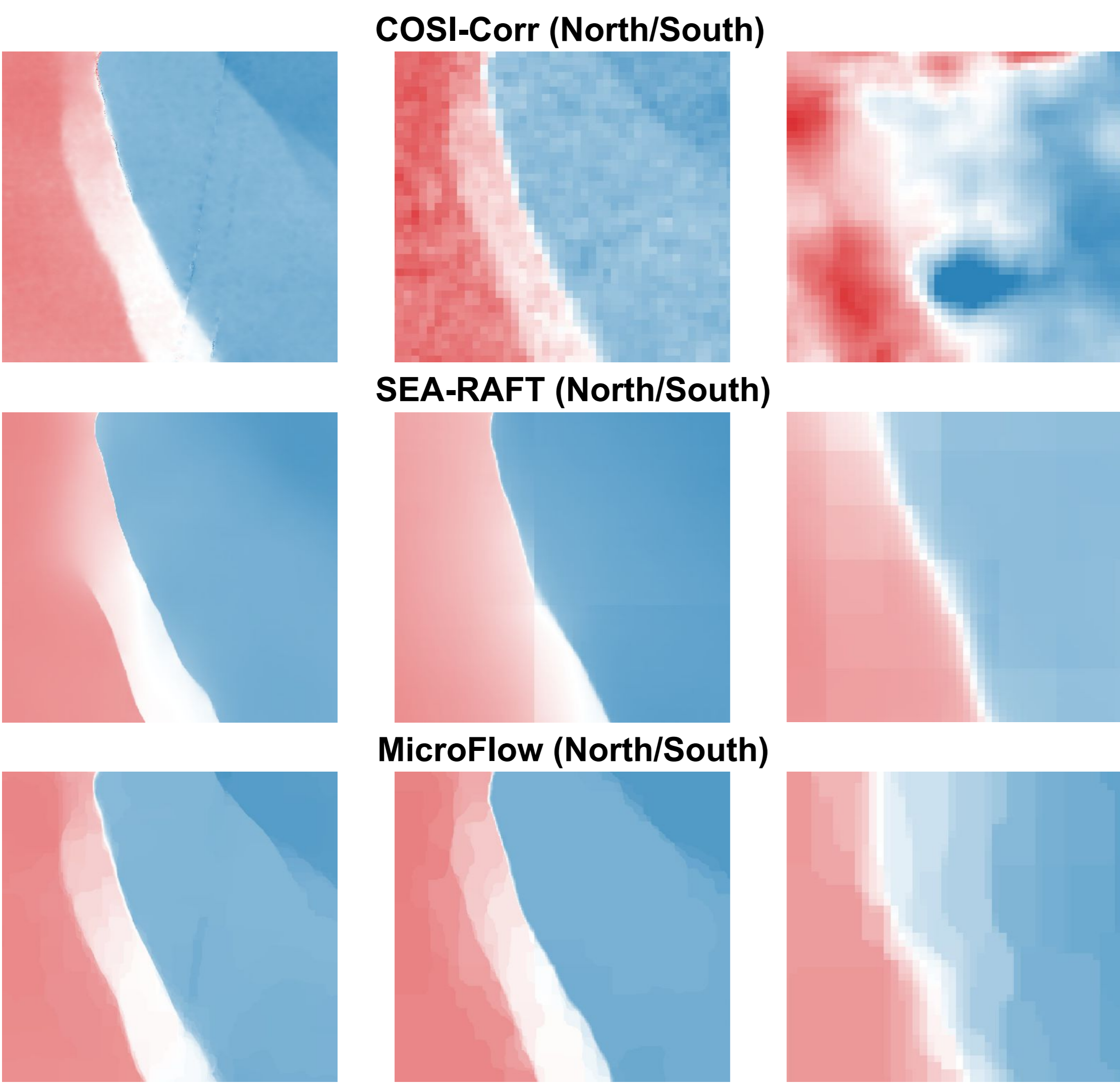
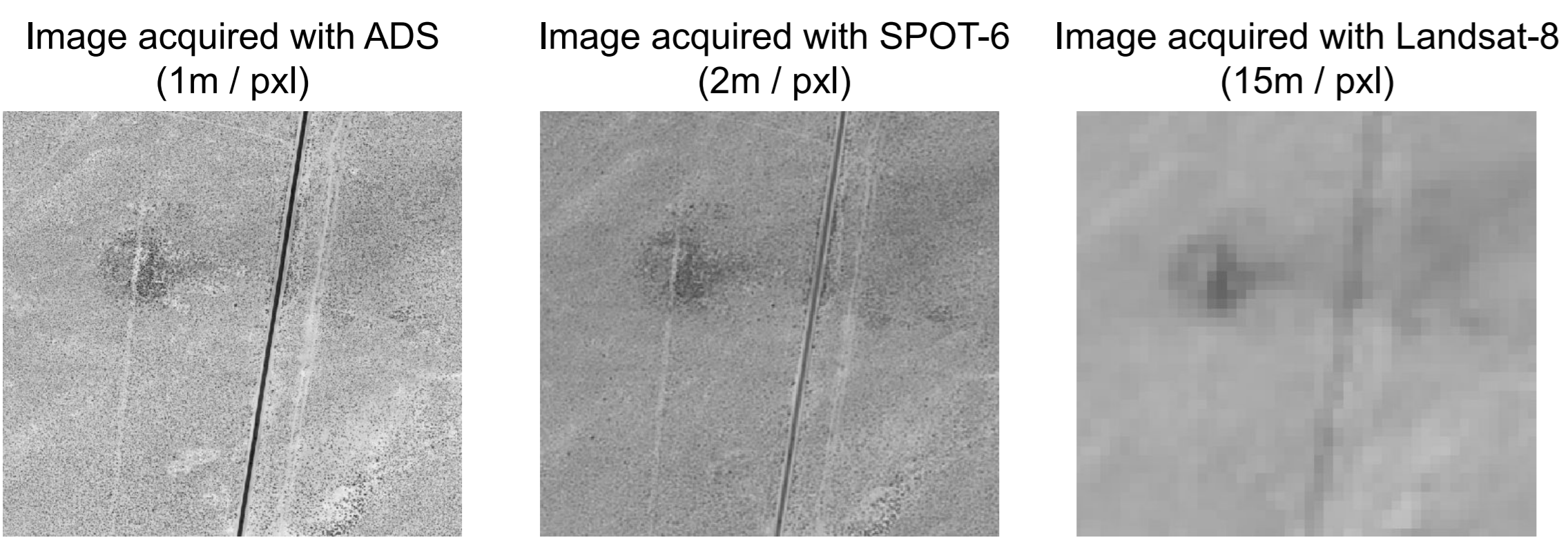
Acquisitions with Landsat-8 (15m/pxl)



Can we match the performance of traditional methods with Deep Learning?



Robustness to multi-resolution sensors

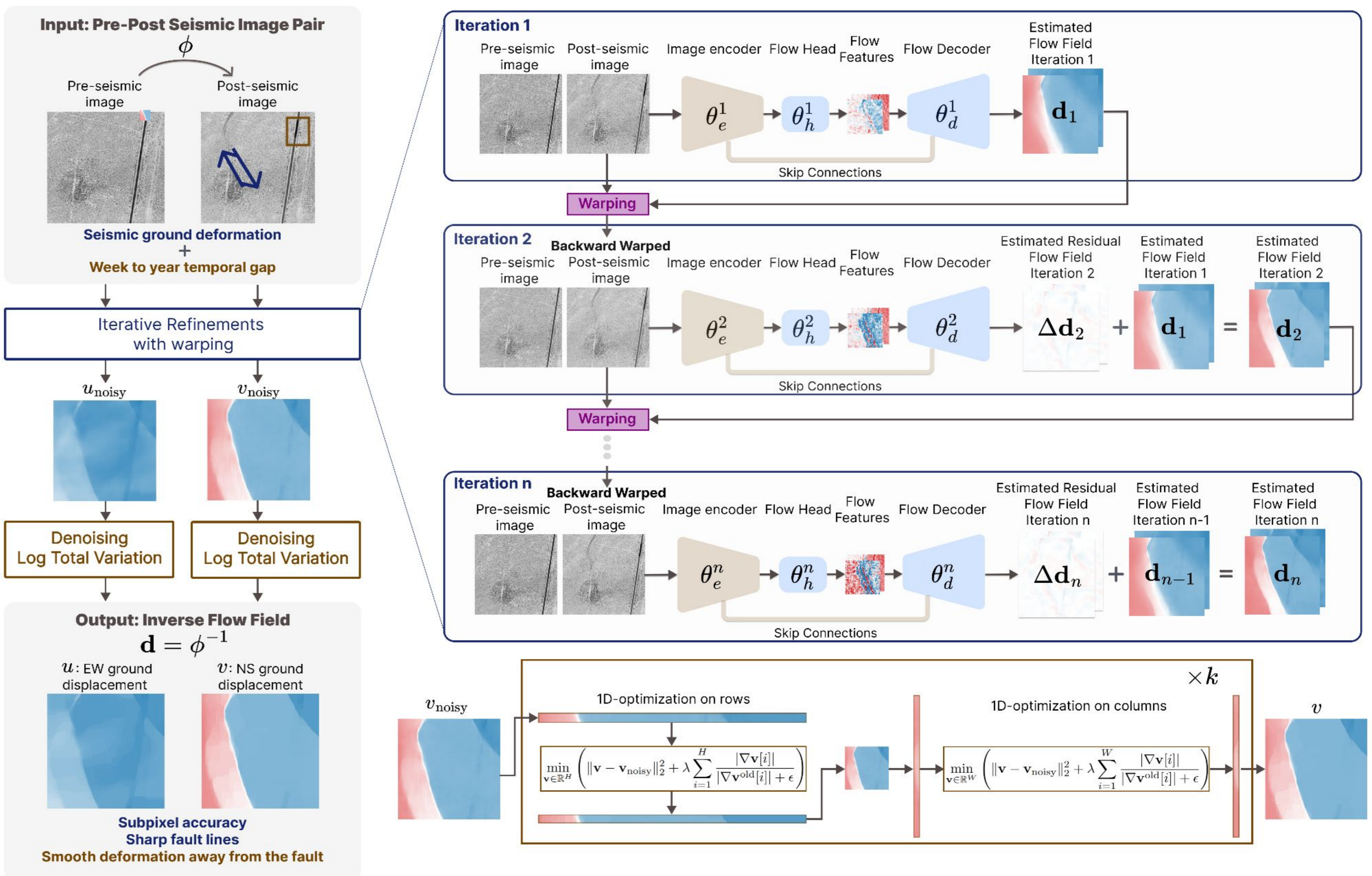


Need for subpixel accuracy both in the very small displacement and medium displacement regimes

Method

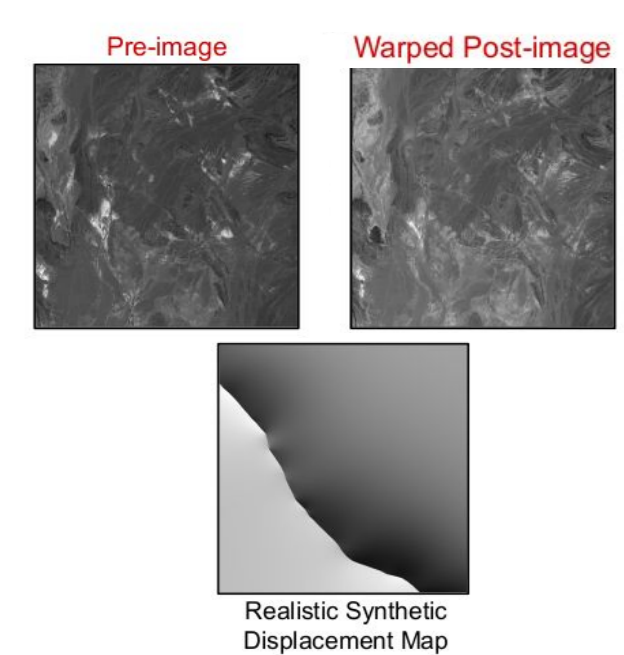
Two steps that makes the model abide with geophysical constraints:

- Iterative Refinements with explicit warping achieves sub-pixel accuracy
 - Robustness to very small displacements
 - Recovers secondary faults
- A-posteriori regularization achieves smooth regions away from the fault while keeping sharp faults



How to manage limited ground truth data?

Leveraging a semi-synthetic dataset for training or fine-tuning models

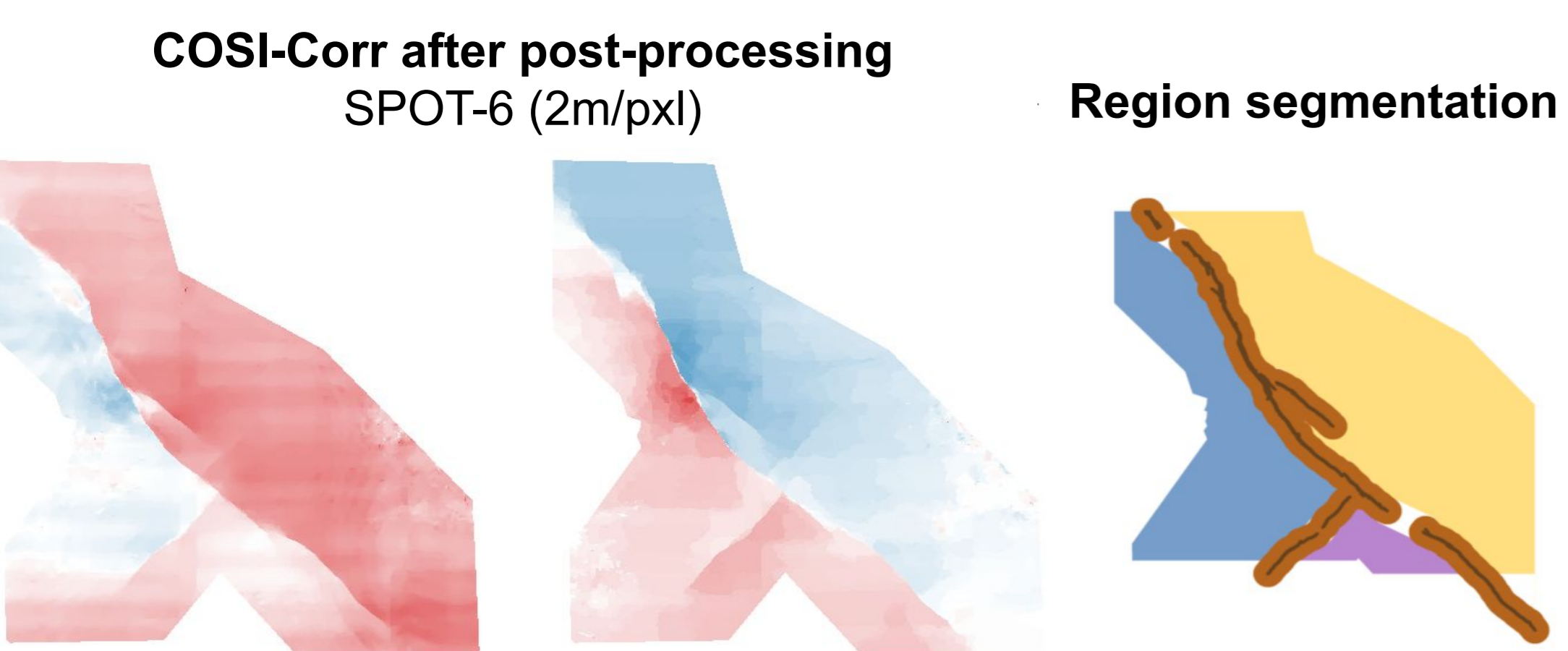


Fault Deform has been designed by domain experts:

- using a 3D fault simulator to generate realistic, sharp strike slip discontinuities
- smooth regions away from the fault

GeoFlowNet (Montagnon *et al.*, 2024)

Using pseudo pseudo-ground truth to evaluate on real-world data



Results

Semi-synthetic benchmark

Method	EPE (fault) ↓			EPE (non-fault (15km)) ↓			Smoothness (non-fault (15km)) ↓		
	very small	small	medium	very small	small	medium	very small	small	medium
COSI-Corr	0.293	1.108	3.756	0.264	0.284	0.363	0.138	0.173	0.299
MicMac	0.355	1.287	-	0.267	0.301	-	0.166	0.203	-
GeoFlowNet	0.228	0.894	3.188	<u>0.144</u>	0.244	0.351	0.039	0.082	0.189
SEA-RAFT (pretrained)	0.236	0.846	2.460	0.132	0.183	0.221	0.010	0.035	0.107
Iterative Refinements	0.234	<u>0.809</u>	2.895	0.156	0.207	<u>0.245</u>	0.058	0.084	0.171
MicroFlow	<u>0.234</u>	0.806	2.891	0.155	0.206	<u>0.245</u>	<u>0.023</u>	0.047	<u>0.136</u>

Pseudo-ground truth benchmark

Method	EPE ↓				Smoothness		
	(fault)	(100m)	(1km)	(non-fault)	(100m ↓)	(1km ↓)	(non-fault ↓)
COSI-Corr	0.075	0.061	0.050	0.045	0.222	0.072	0.053
MicMac	0.064	0.052	0.043	0.036	0.184	0.042	0.021
GeoFlowNet	0.056	0.056	0.048	0.043	0.088	0.023	0.015
SEA-RAFT (pretrained)	0.055	0.050	0.046	<u>0.034</u>	0.141	0.015	<u>0.004</u>
Iterative Only	<u>0.050</u>	<u>0.044</u>	<u>0.035</u>	0.035	0.139	0.032	0.022
MicroFlow	0.047	0.040	0.032	0.030	0.130	<u>0.016</u>	0.003