Monitoring and Interpreting Deformation along Linear Infrastructure Using Deep Clustering of MT-InSAR Analyses

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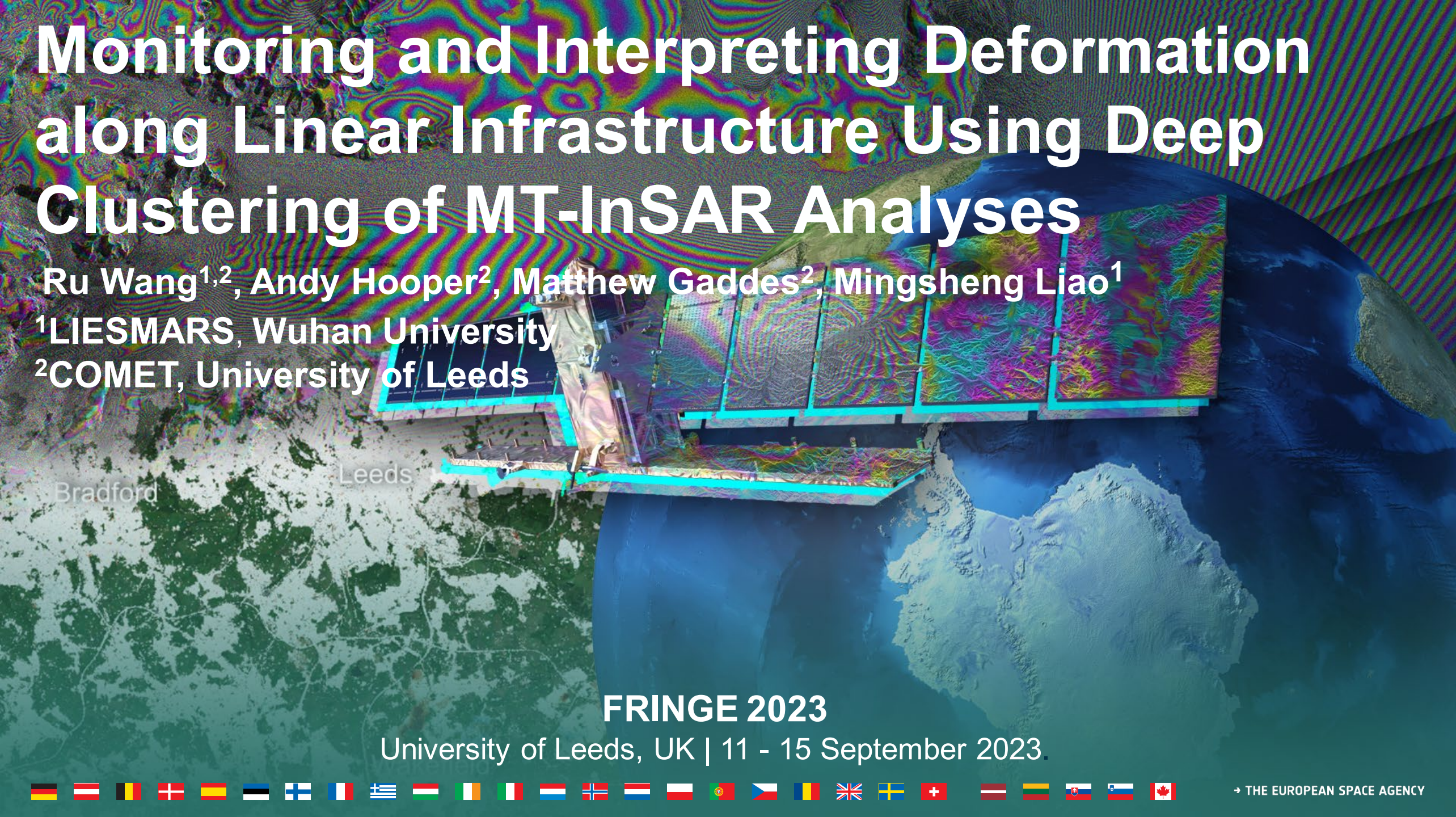
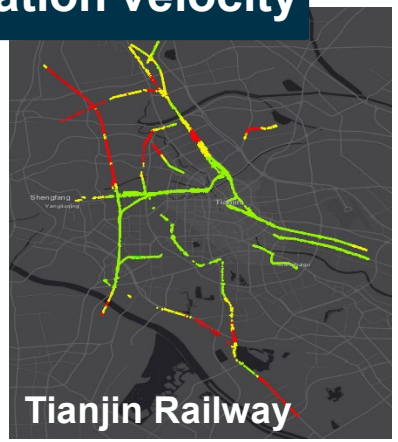


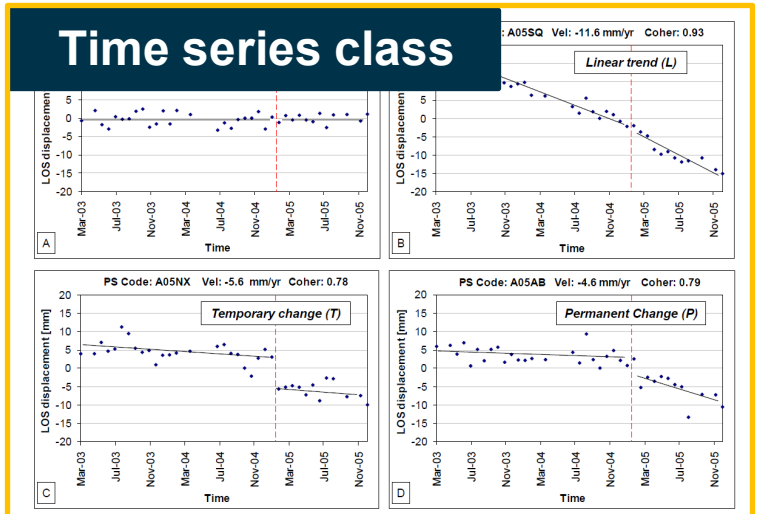
FRINGE 2023
University of Leeds, UK | 11 - 15 September 2023.

Motivation

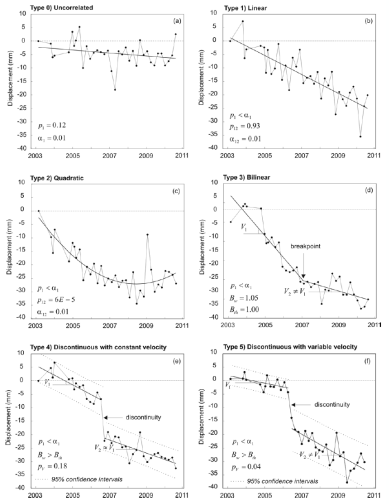
Deformation velocity



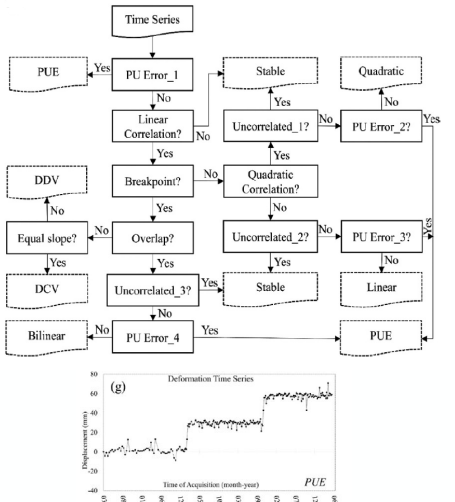
Time series class



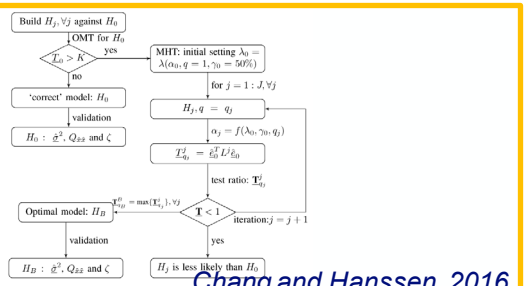
Cigna et al.,2011



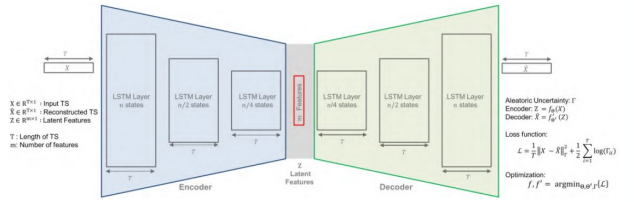
Berti et al.,2013



S. Mohammad Mirmazloumi et al., 2022



Chang and Hanssen, 2016

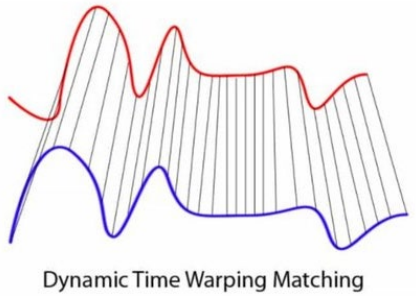


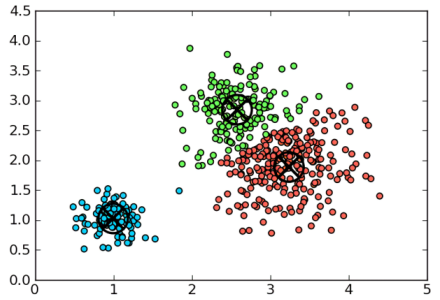
Ansari et al. 2021

Method

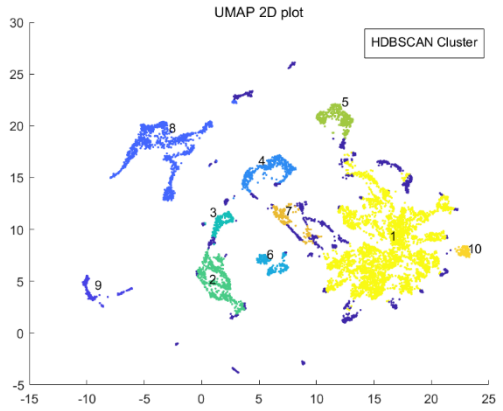
Baseline method：

1. K-mean（DTW distance）

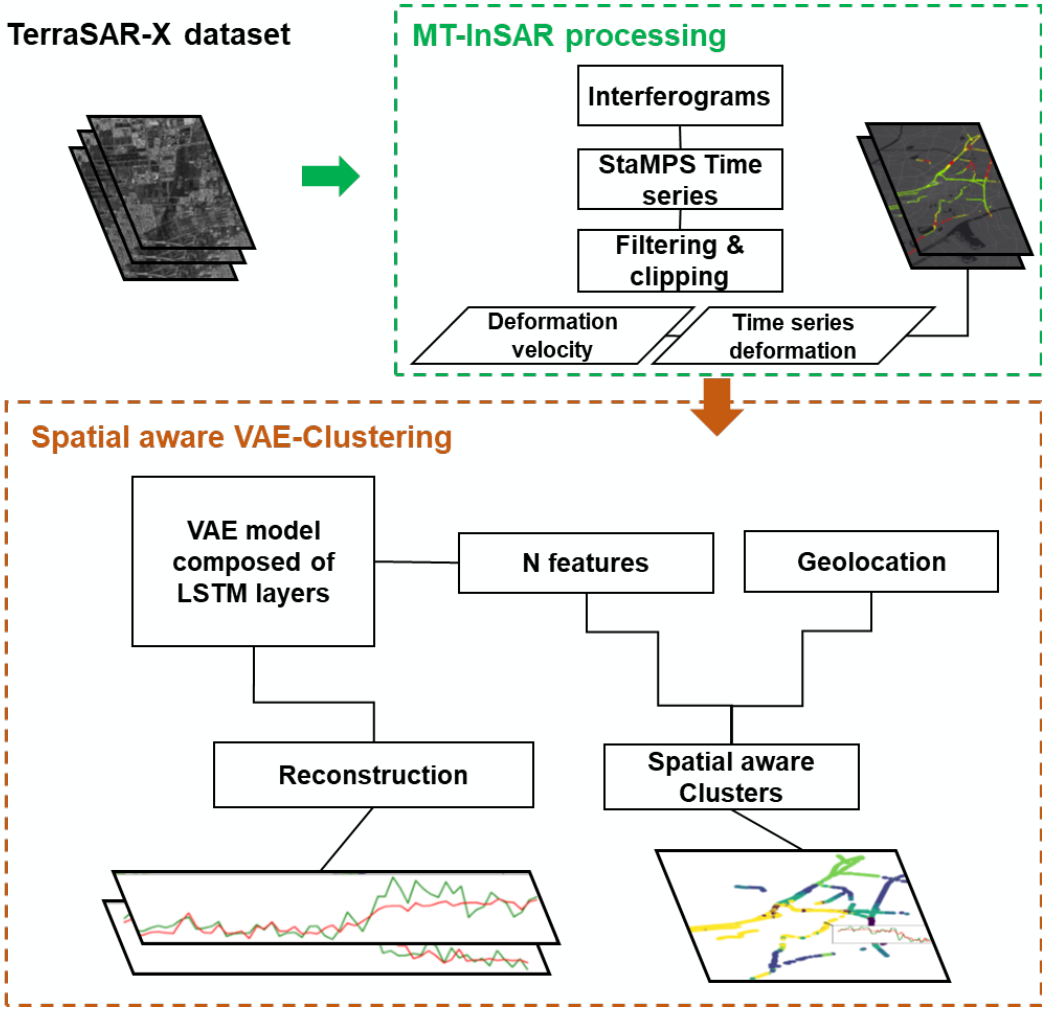




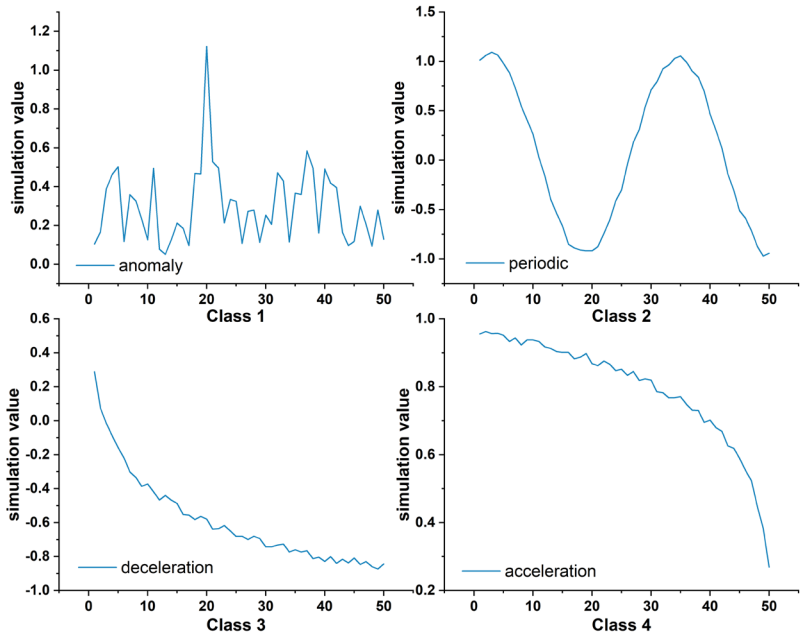
2. UMAP+HDBSCAN



Proposed method：



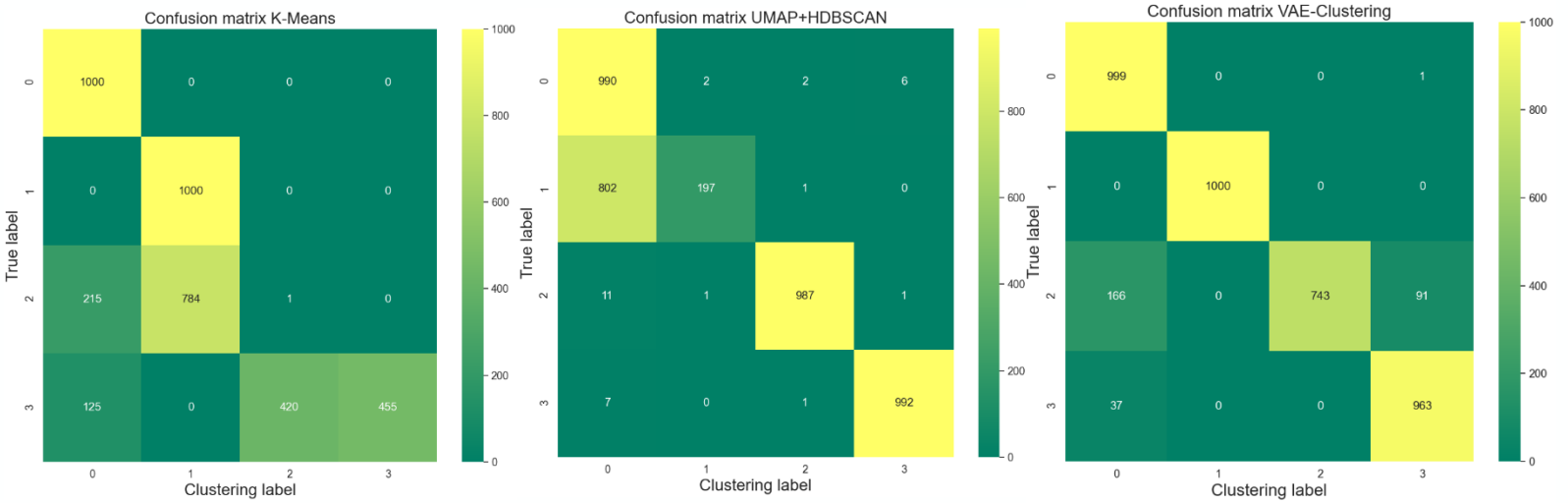
Test on Synthetic data



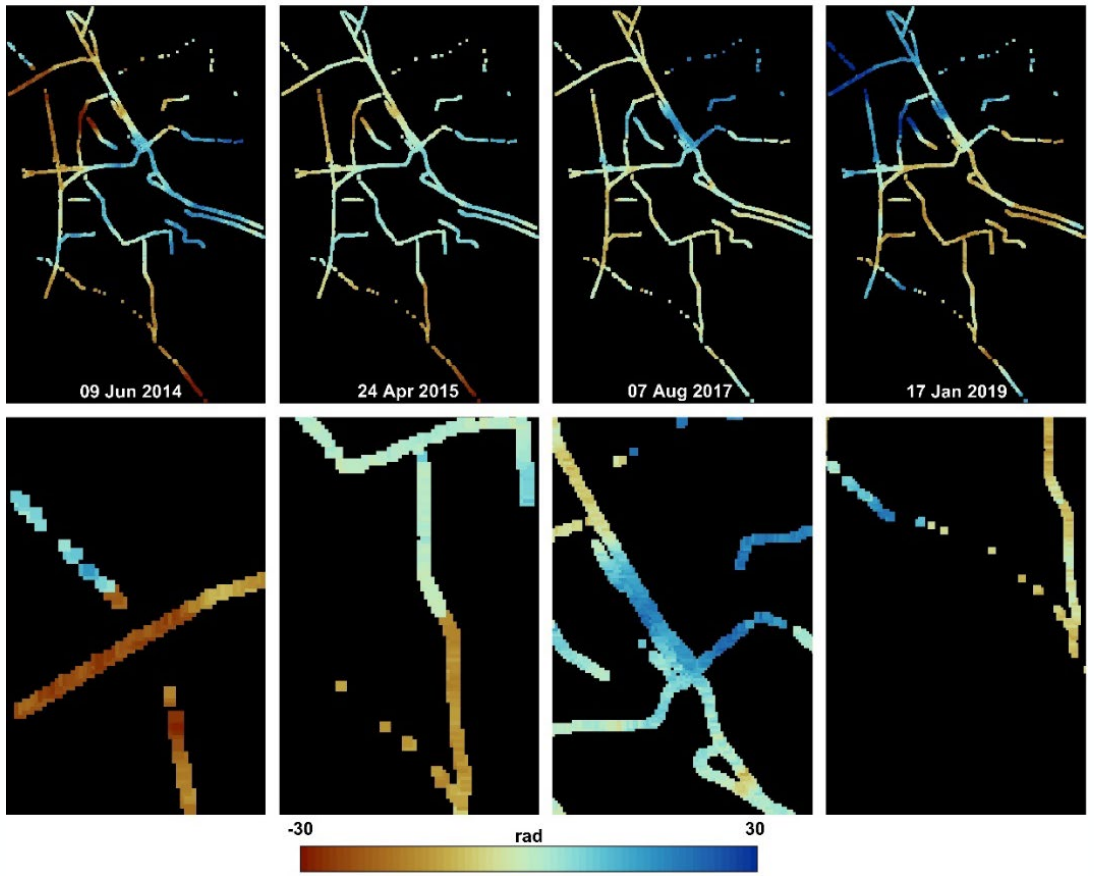
Simulating data

	Accuracy	ARI	NMI
K-means	0.614	0.514	0.642
UMAP+HDBSCAN	0.791	0.691	0.794
VAE-clustering	0.926	0.821	0.831

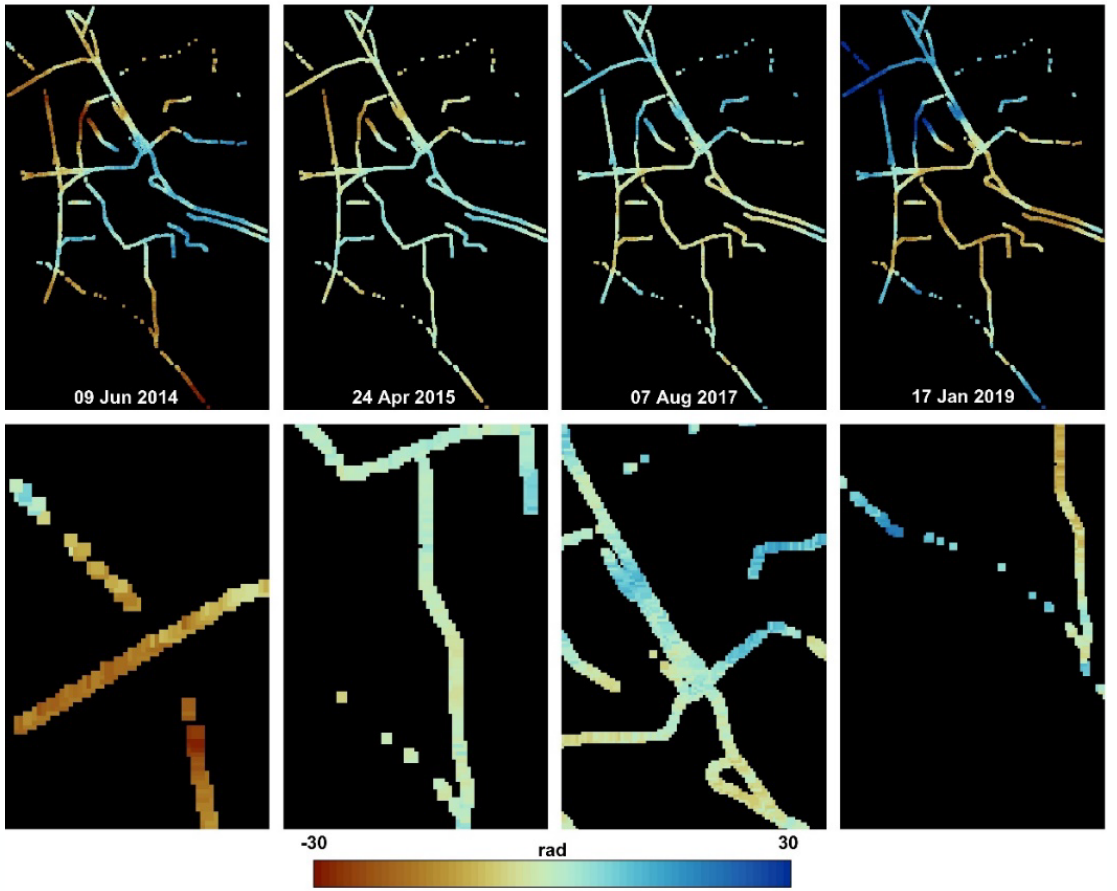
Performance of different methods



Case study #1 – Tianjin Railway

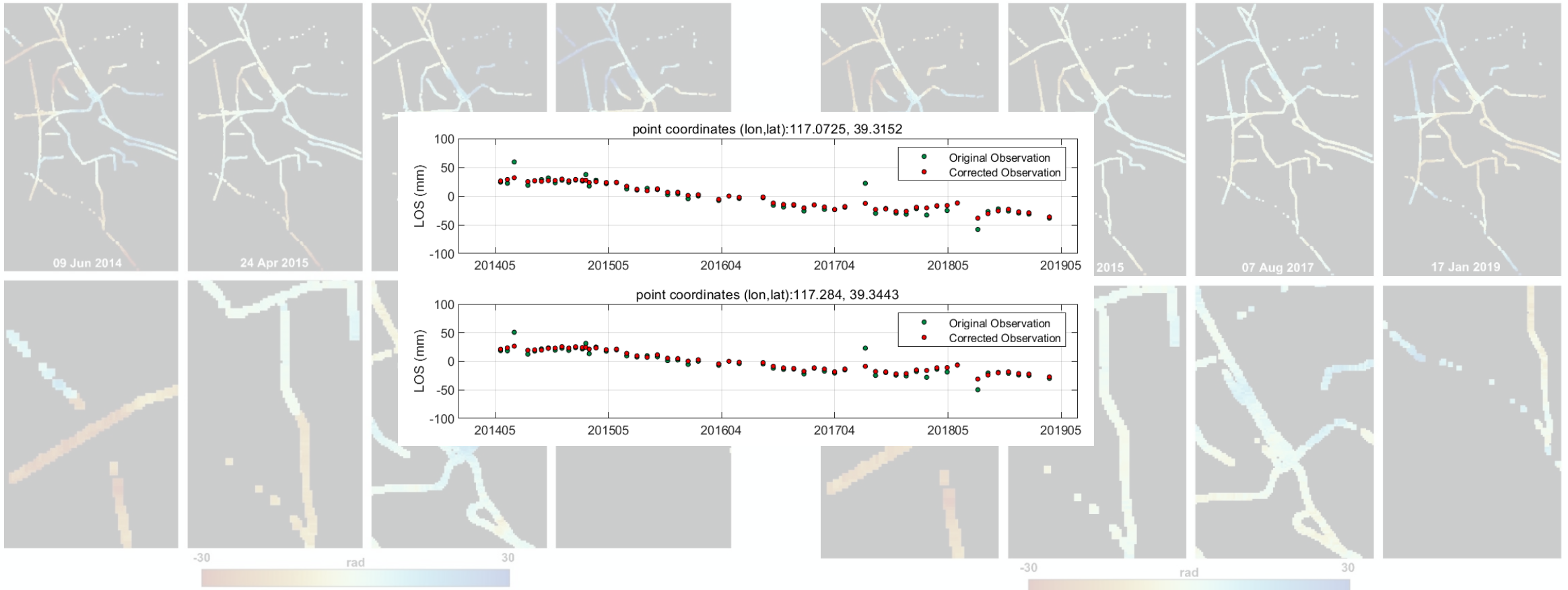


Phase unwrapping error



Corrected time series

Case study #1 – Tianjin Railway



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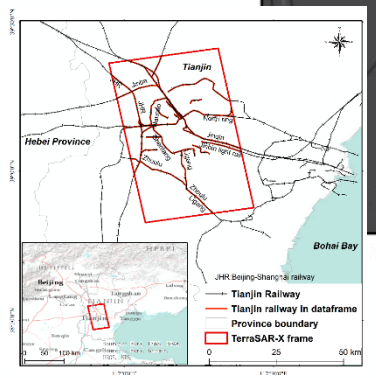
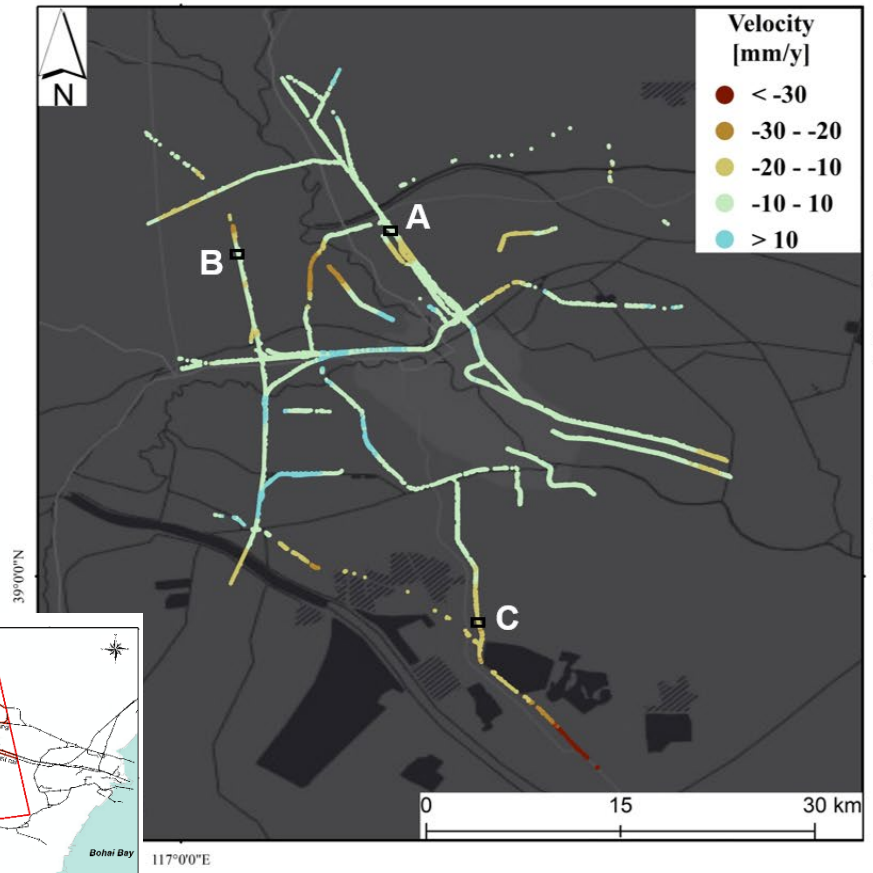
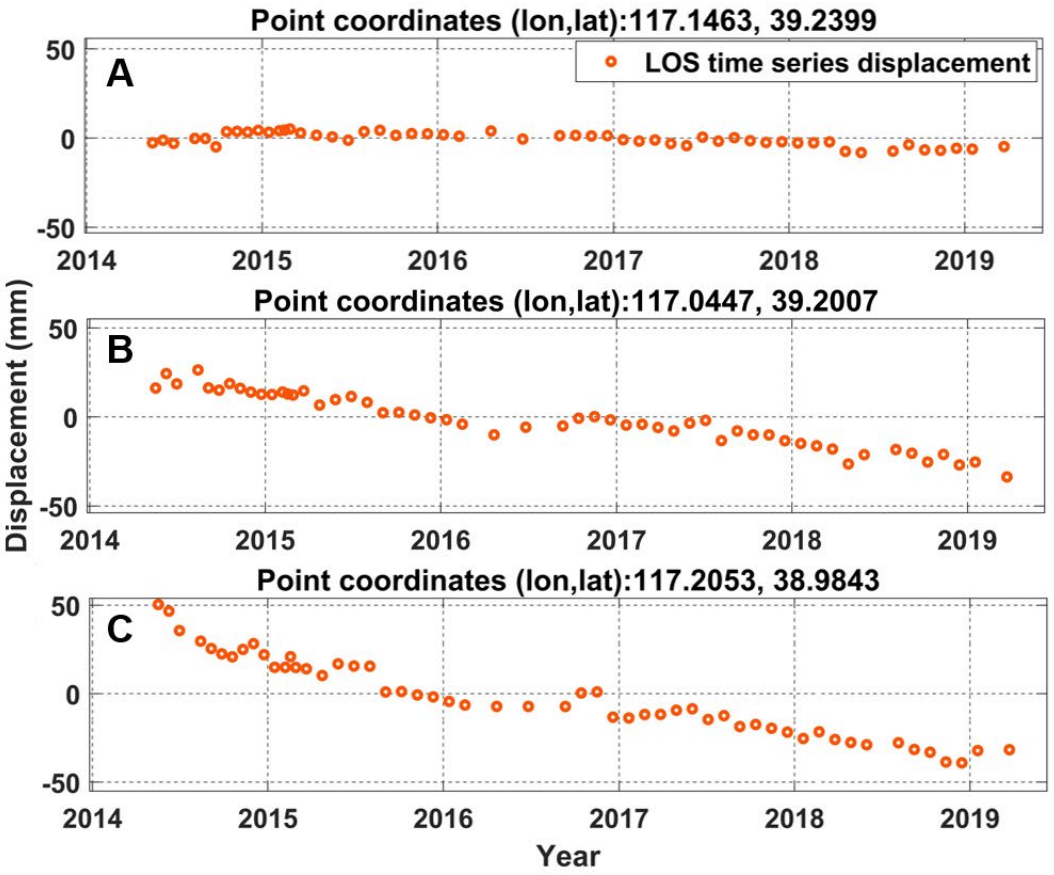




Deformation velocity map



Deformation time series

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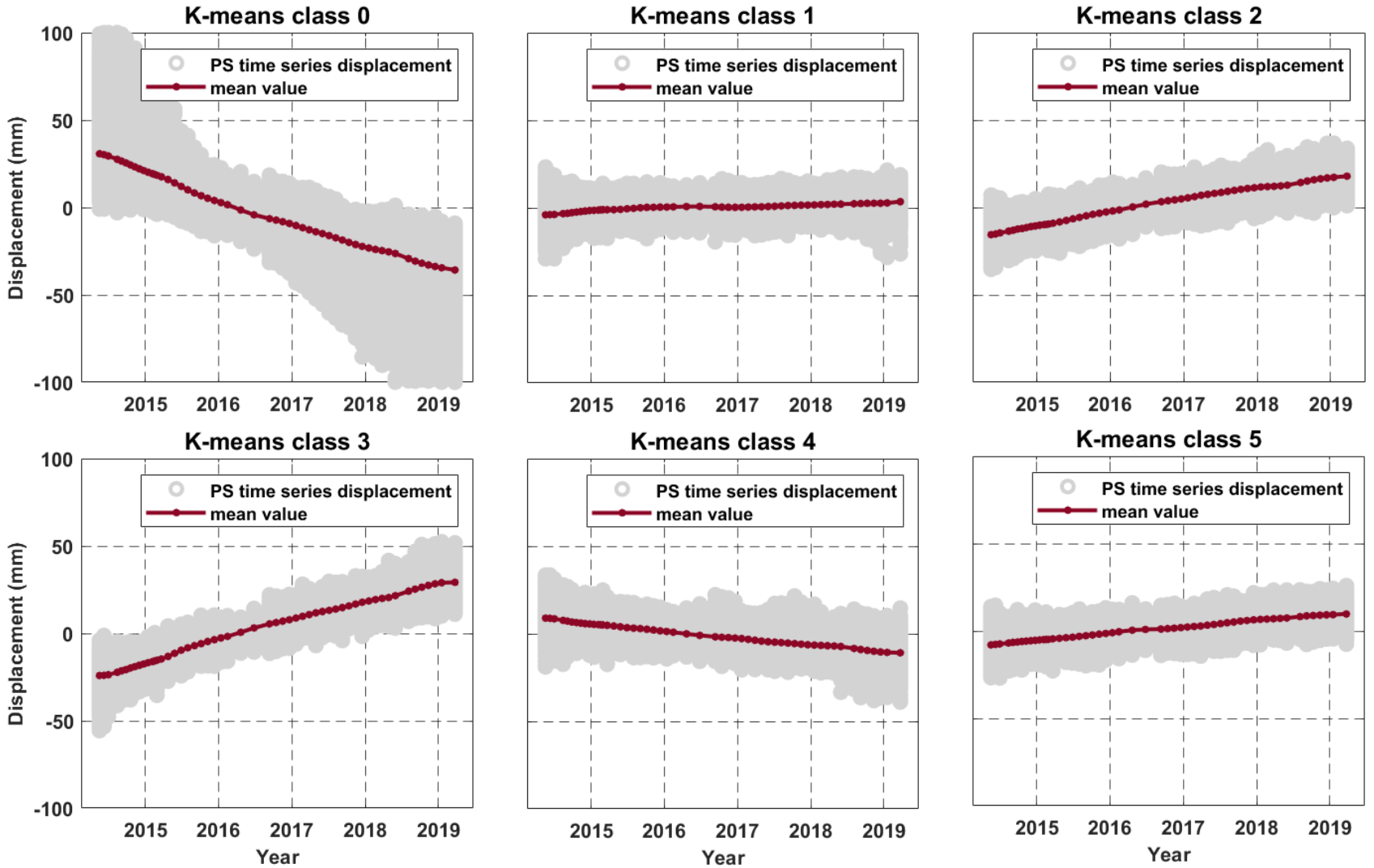

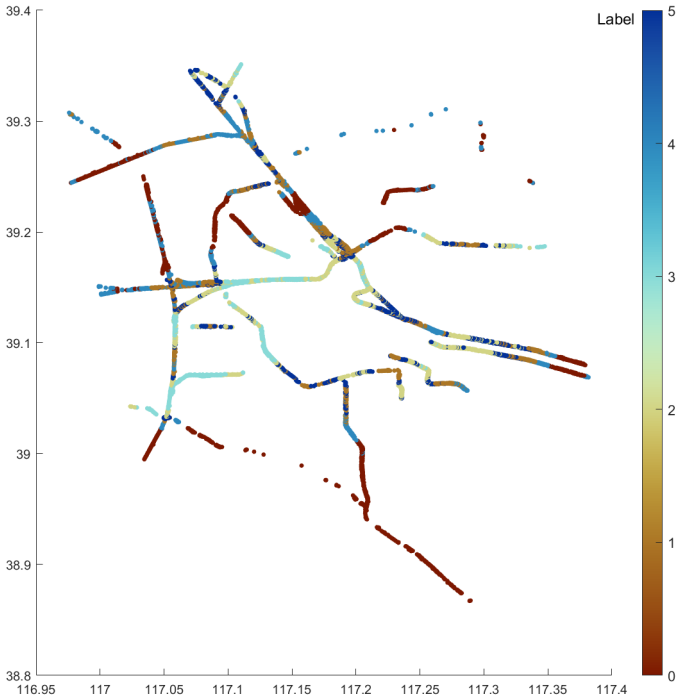

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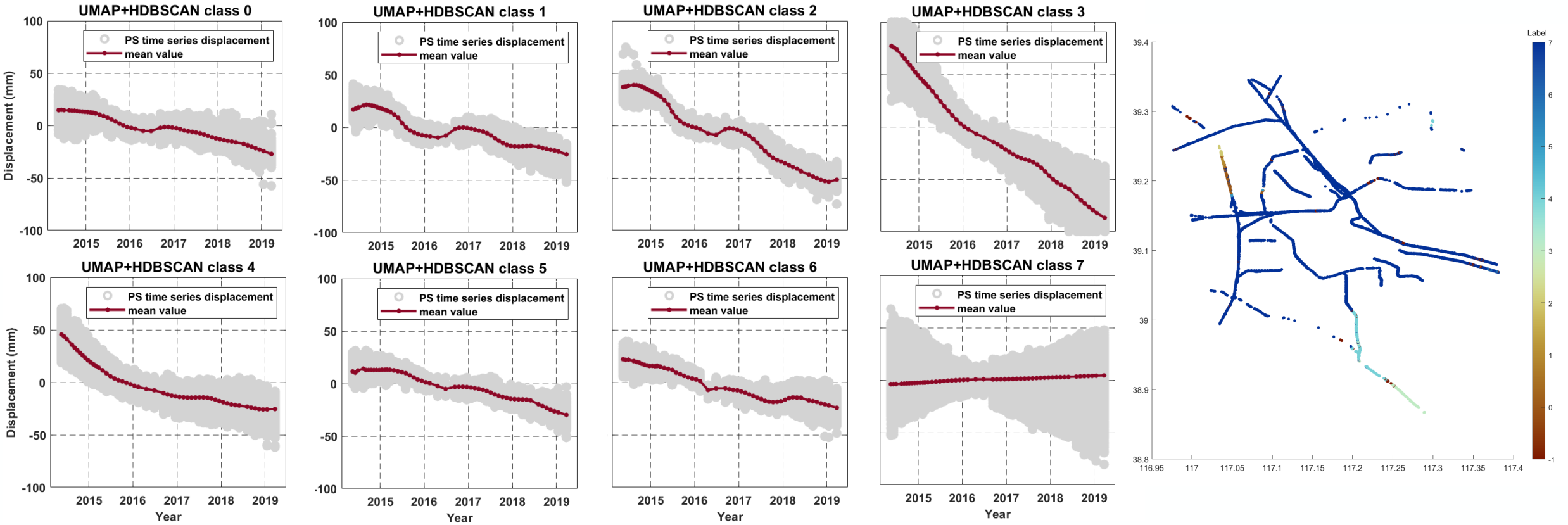

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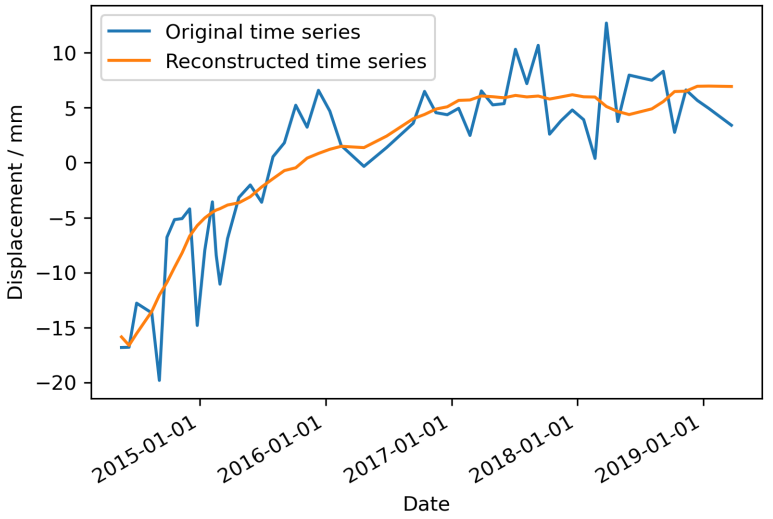

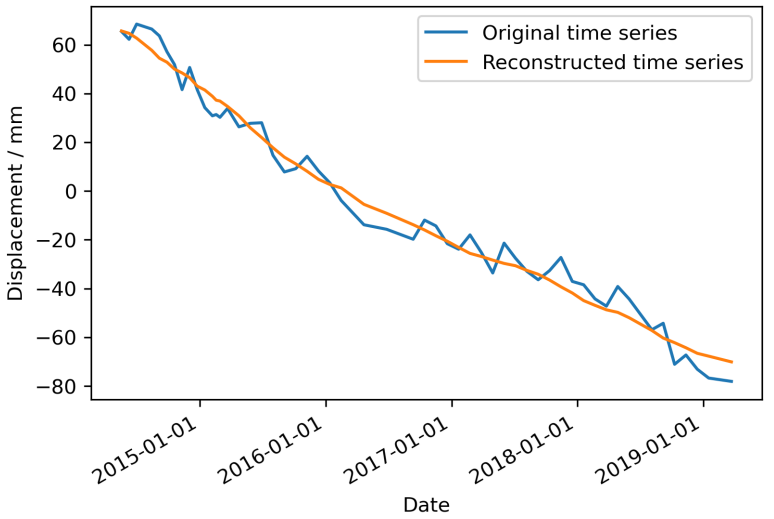

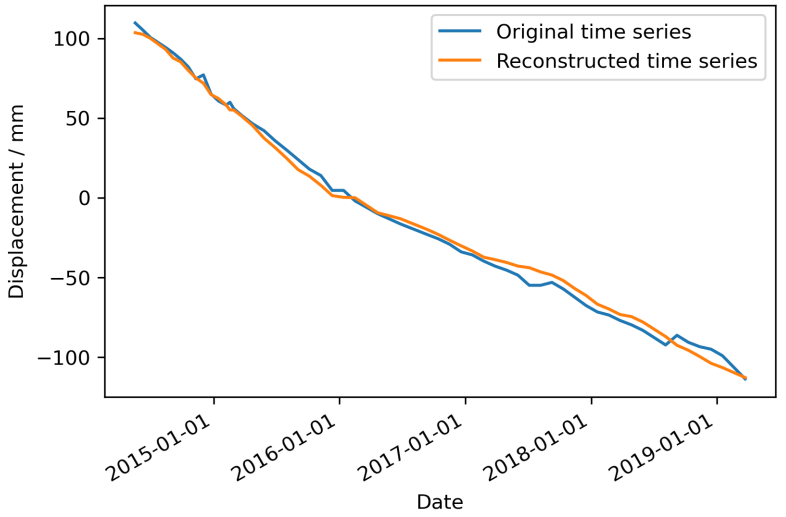

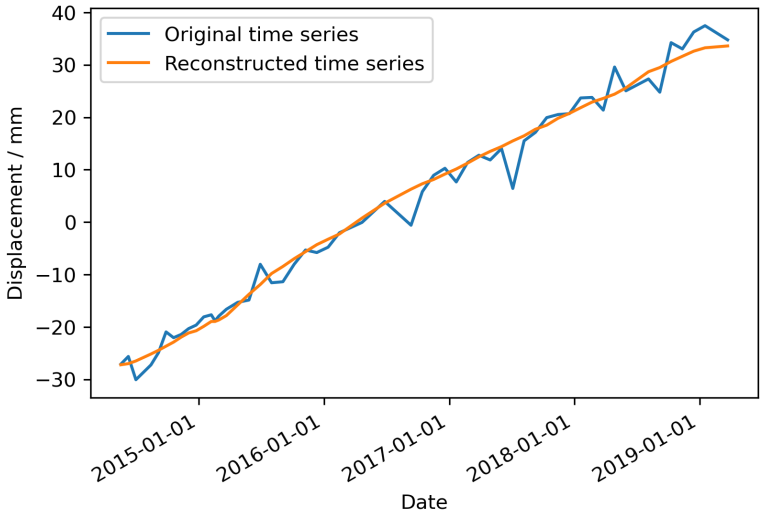

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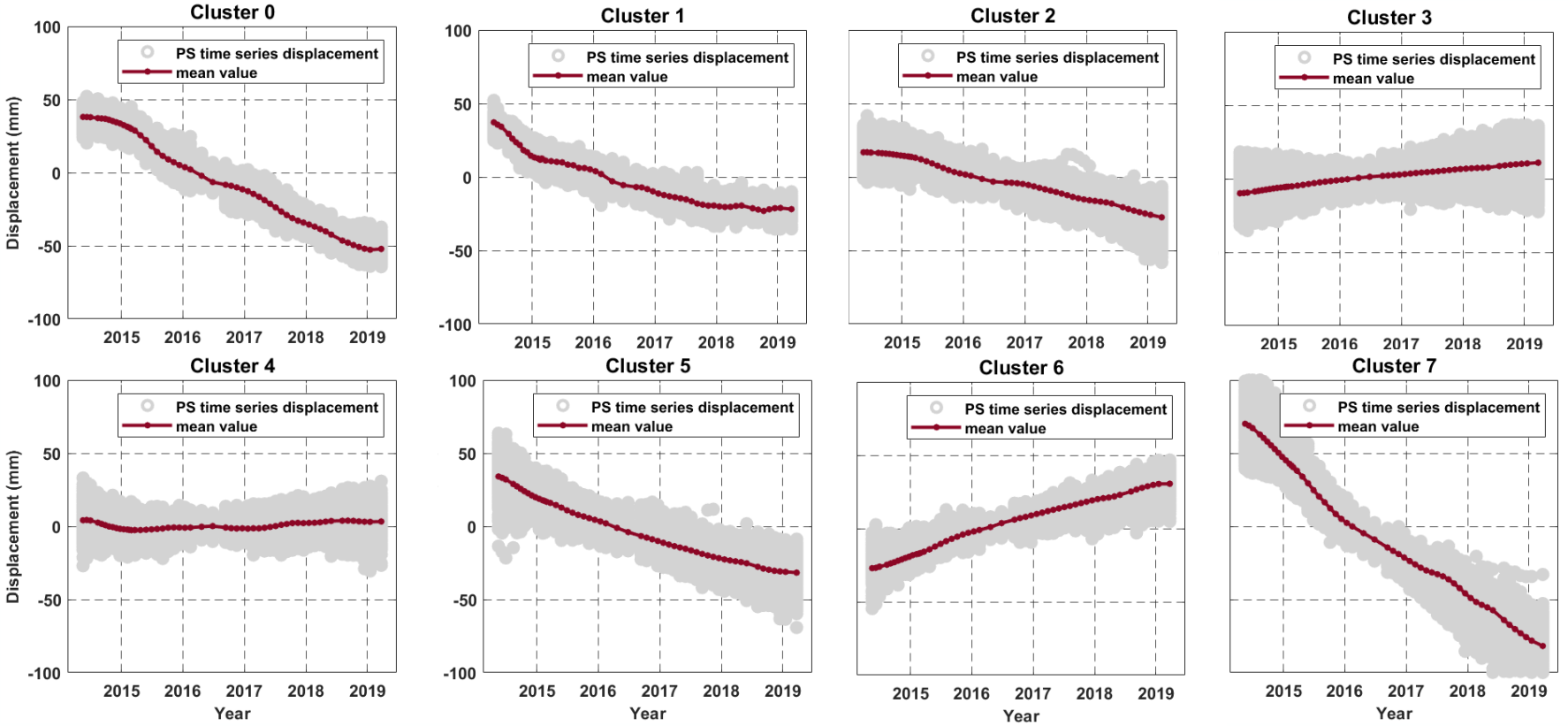
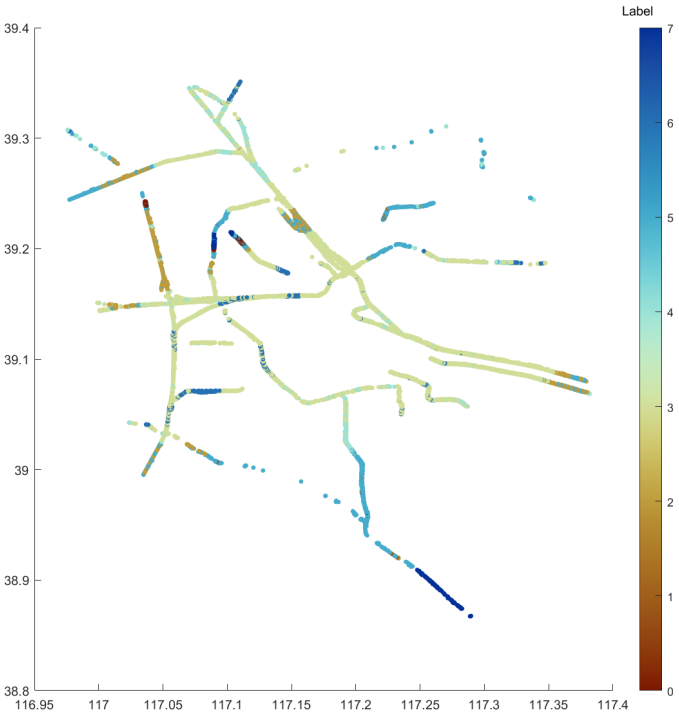
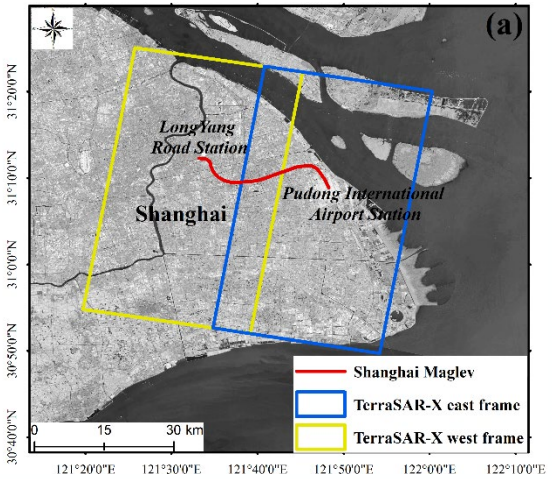
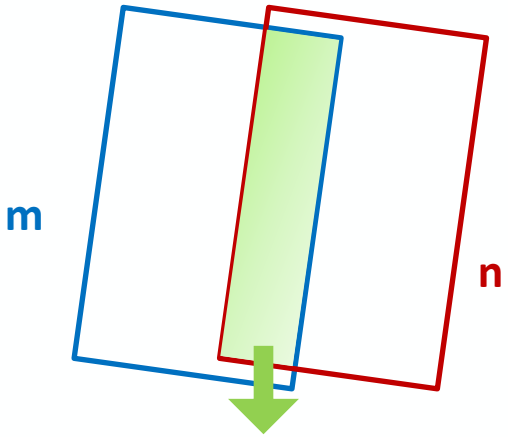




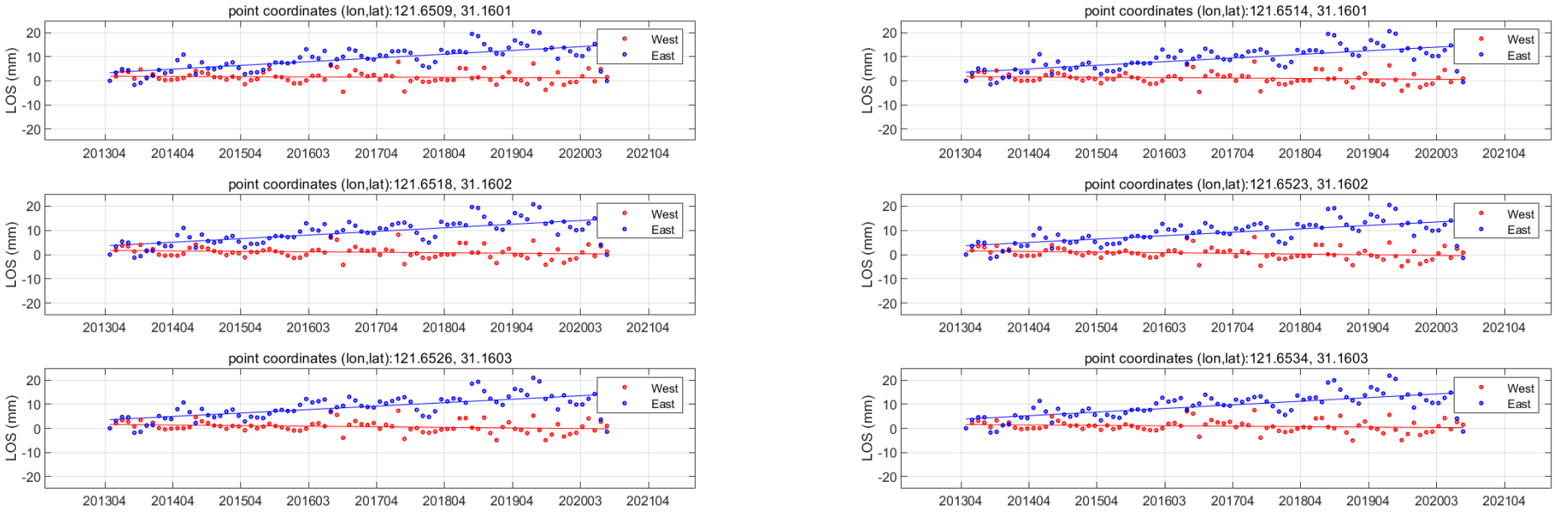
Case study #2 – Shanghai maglev



There is difference on the time series.



Overlapping area



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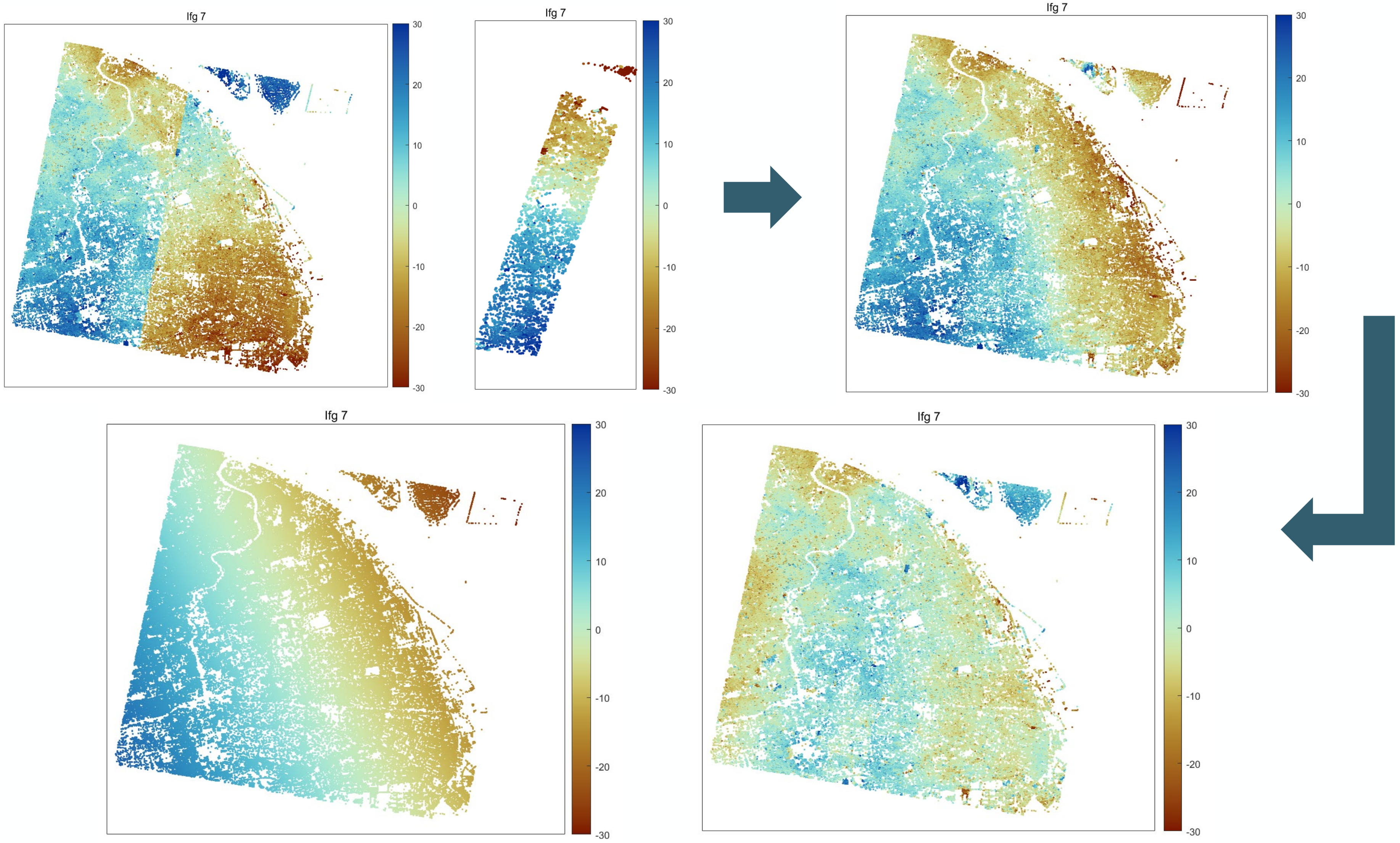

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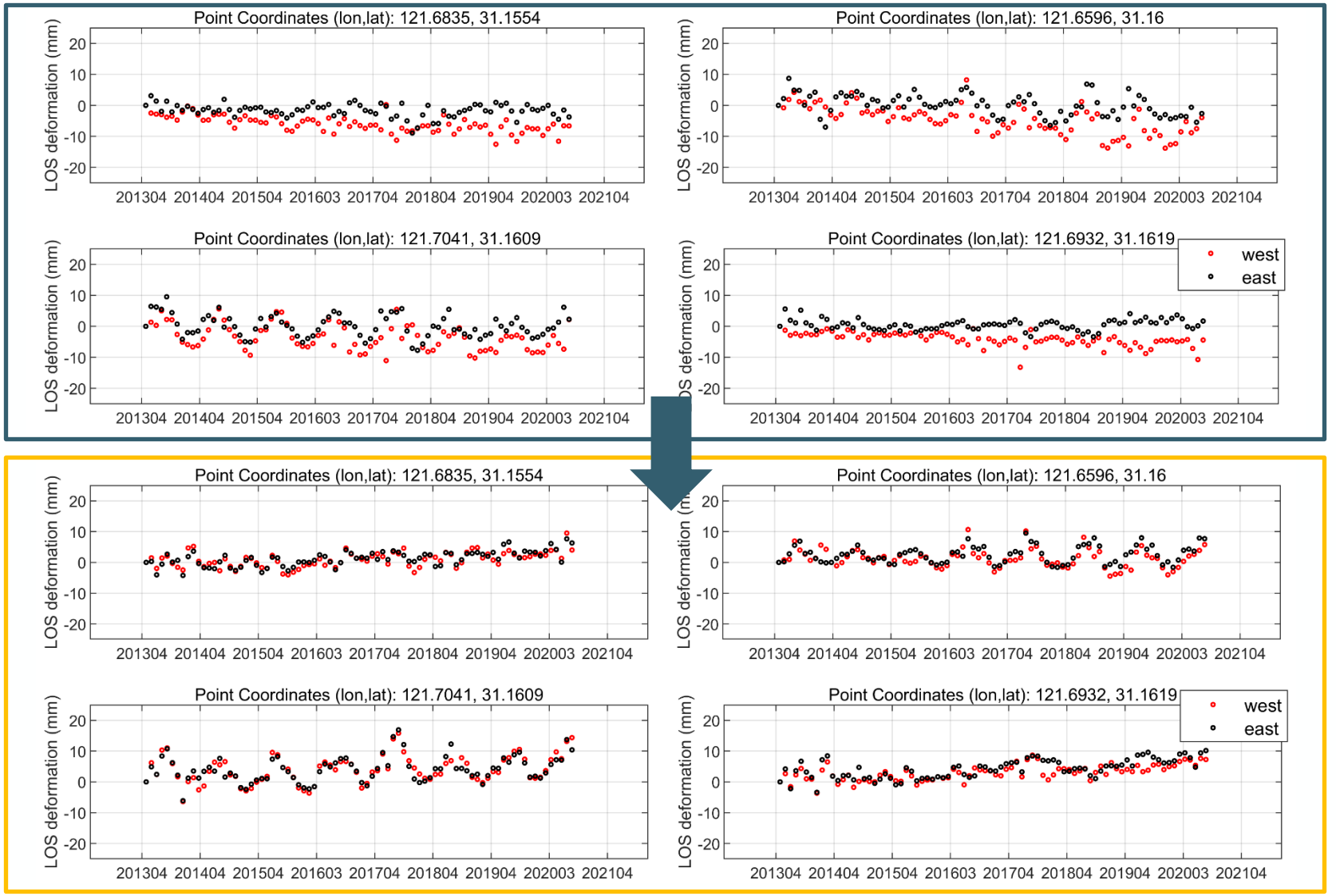
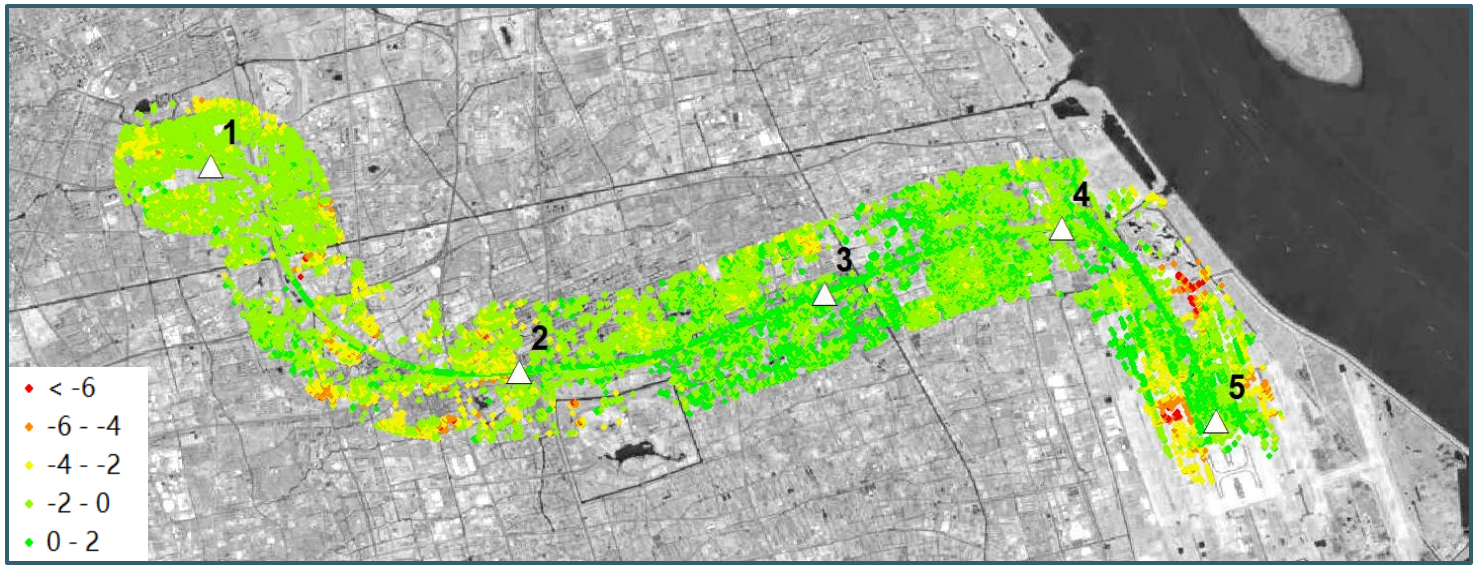
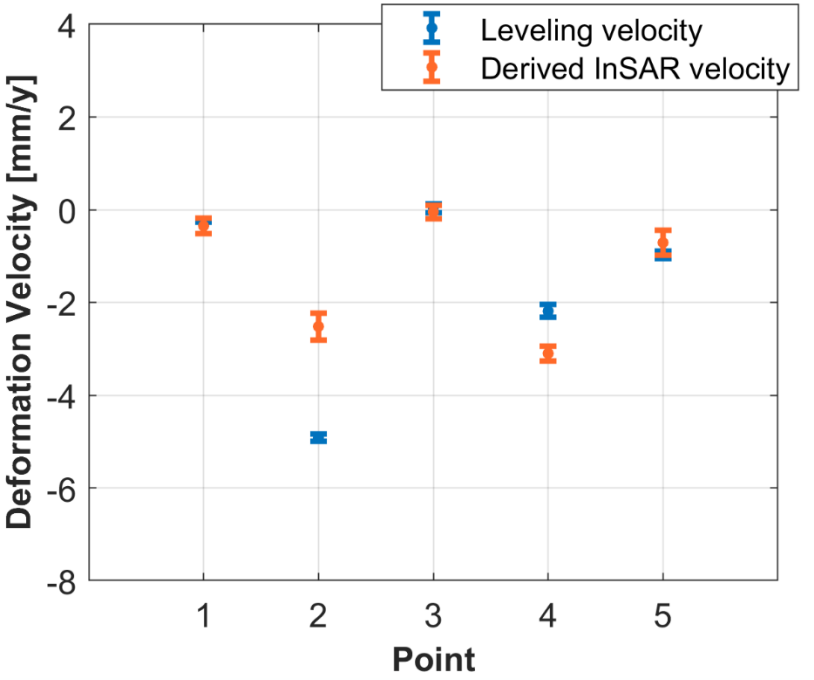


Case study #2 – Shanghai maglev

Deformation Velocity [mm/y]





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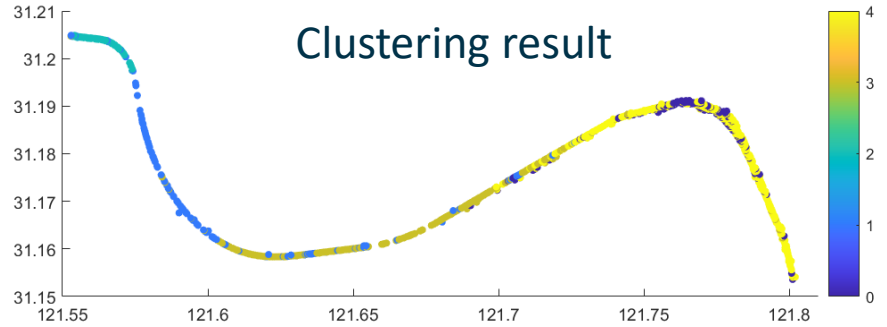

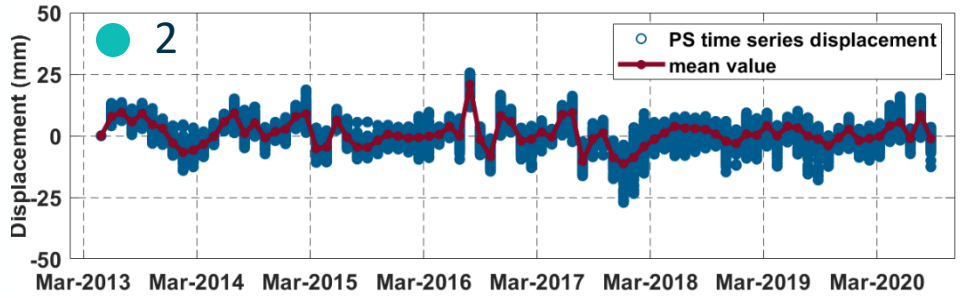

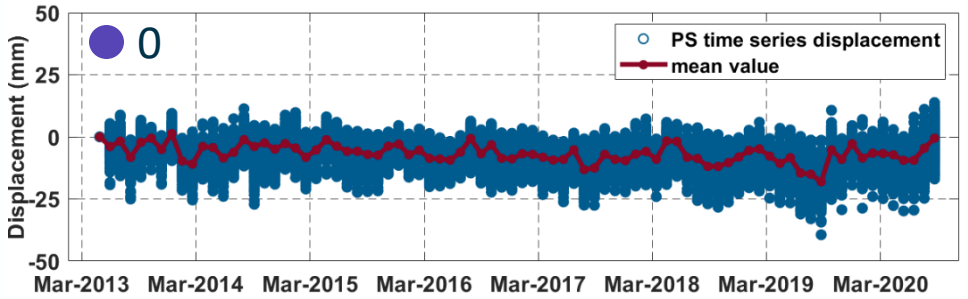

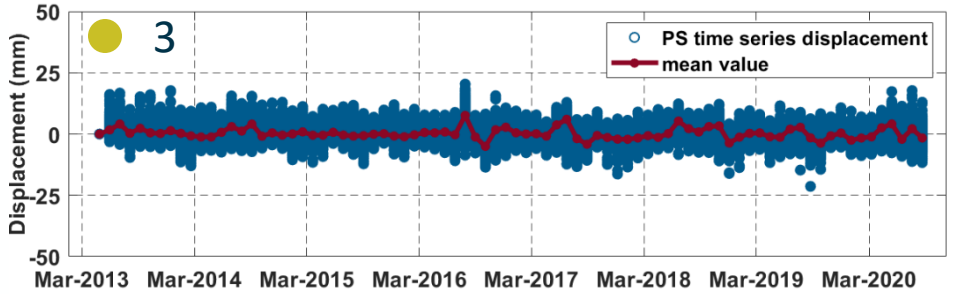

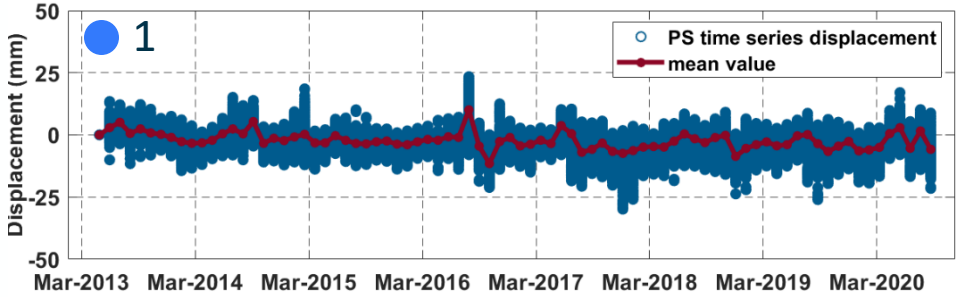

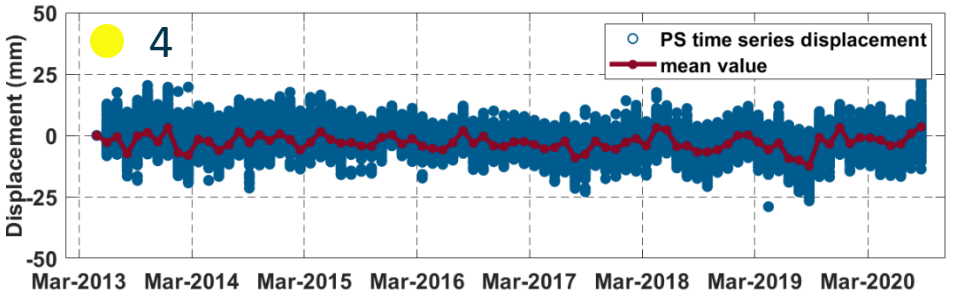

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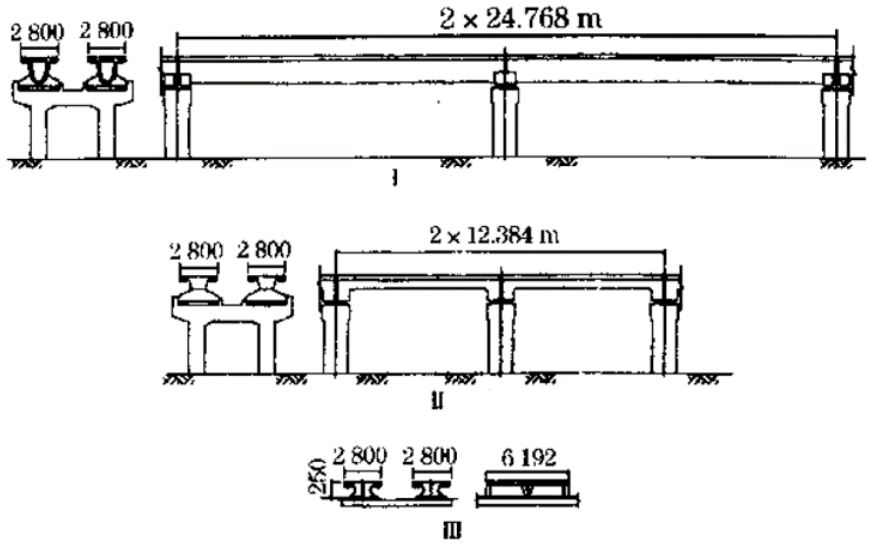
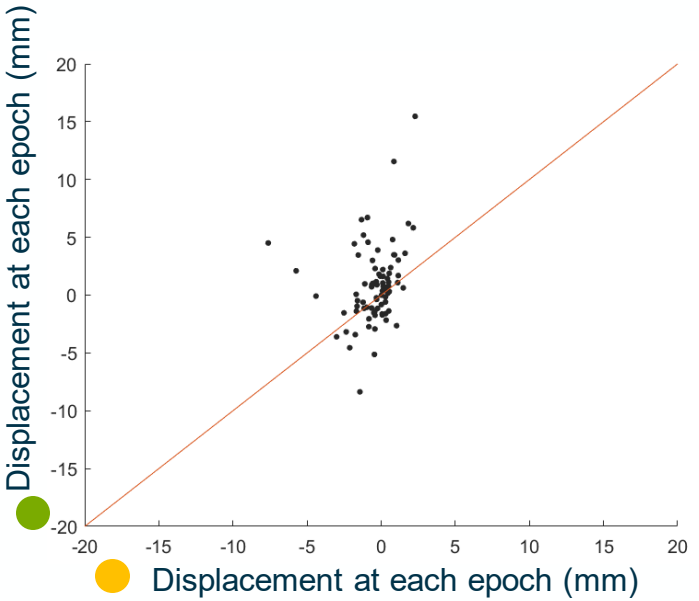


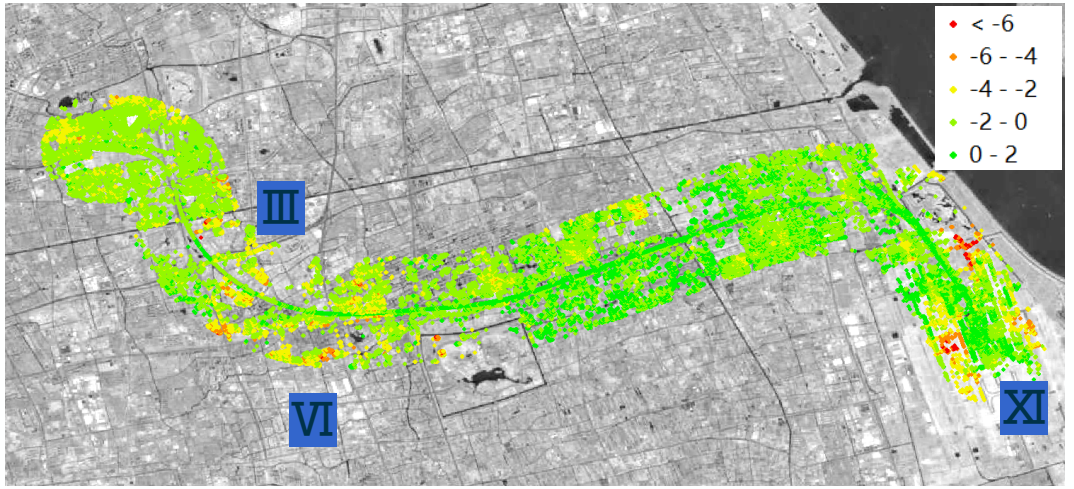


Beam end pier: Δy = L / 6000

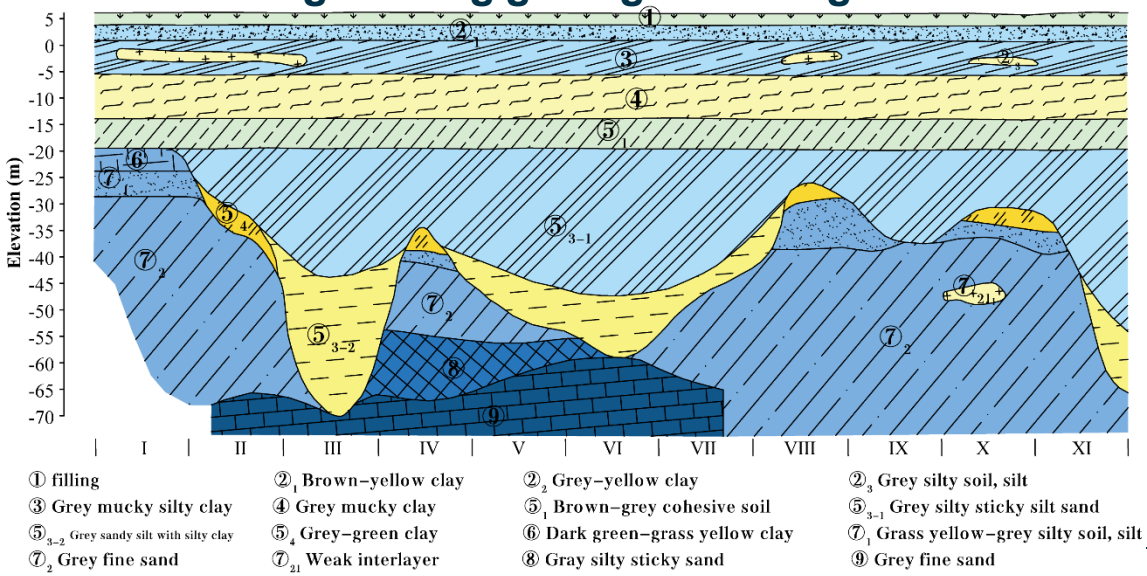
Intermediate piers of multi-span beams: Δy = L / 4500

Case study #2 – Shanghai maglev

Deformation velocity [mm/y]

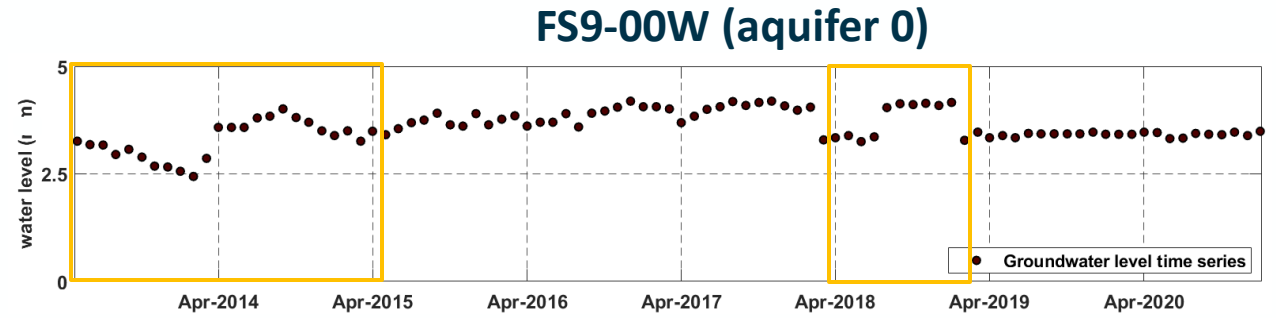


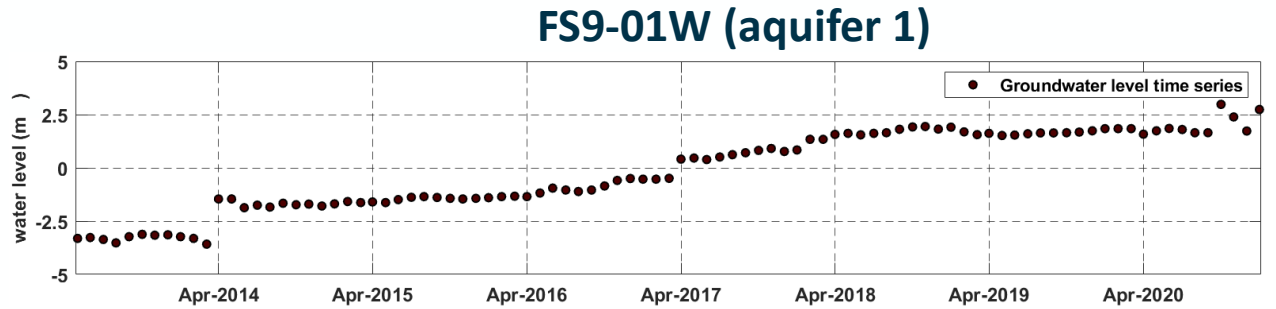
Engineering geological background

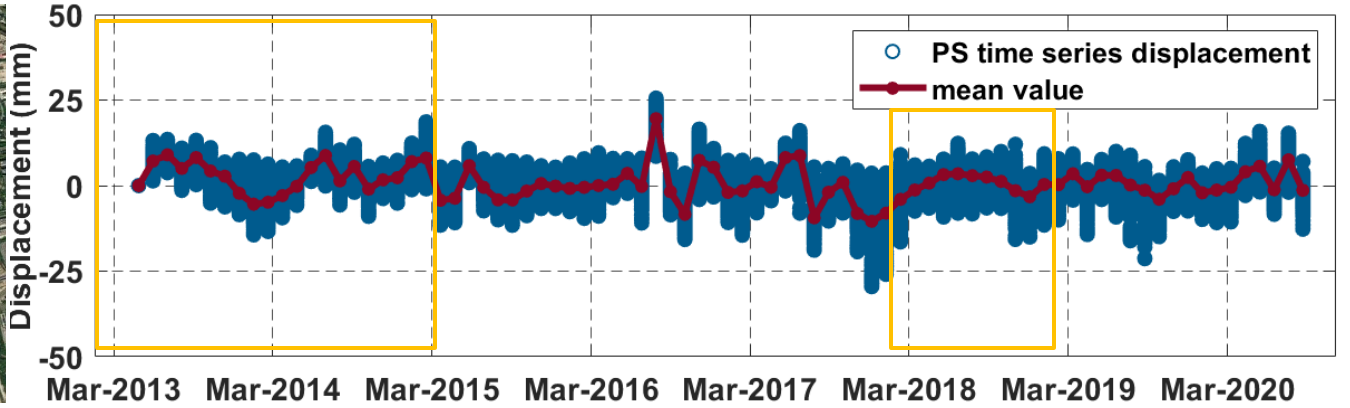


Section	Stake number
I	K0+000~K2+906
II	K2+906~K4+661
III	K4+661~K5+406
IV	K5+406~K7+247
V	K7+247~K8+544
VI	K8+544~K11+052
VII	K11+052~K13+529
VIII	K13+529~K16+997
IX	K16+997~K17+938
X	K17+938~K29+232
XI	K29+232~K29+842

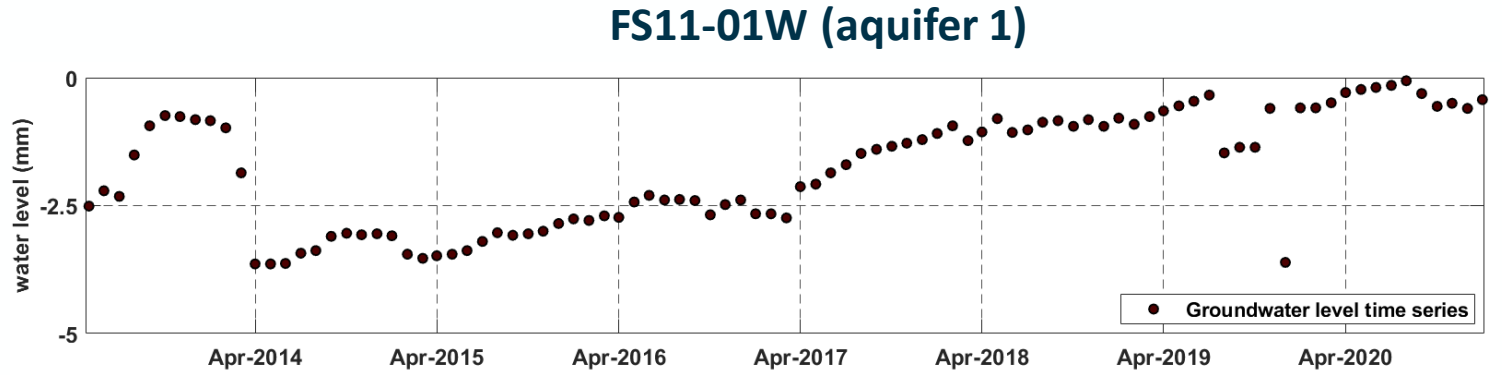
Case study #2 – Shanghai maglev

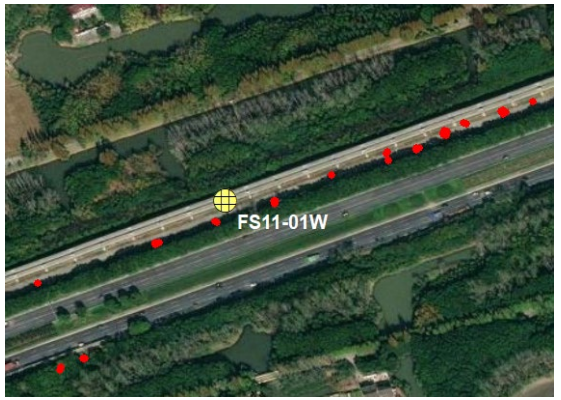


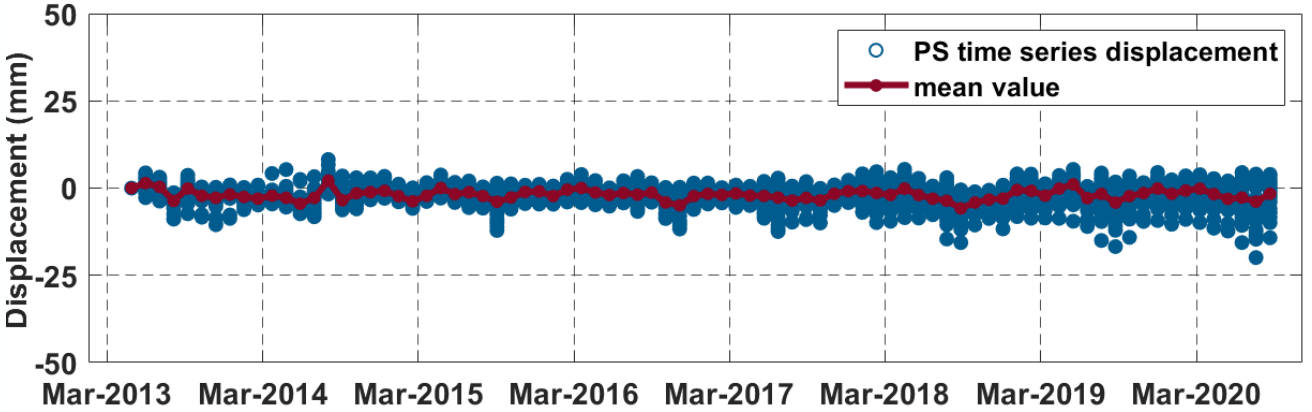




Case study #2 – Shanghai maglev

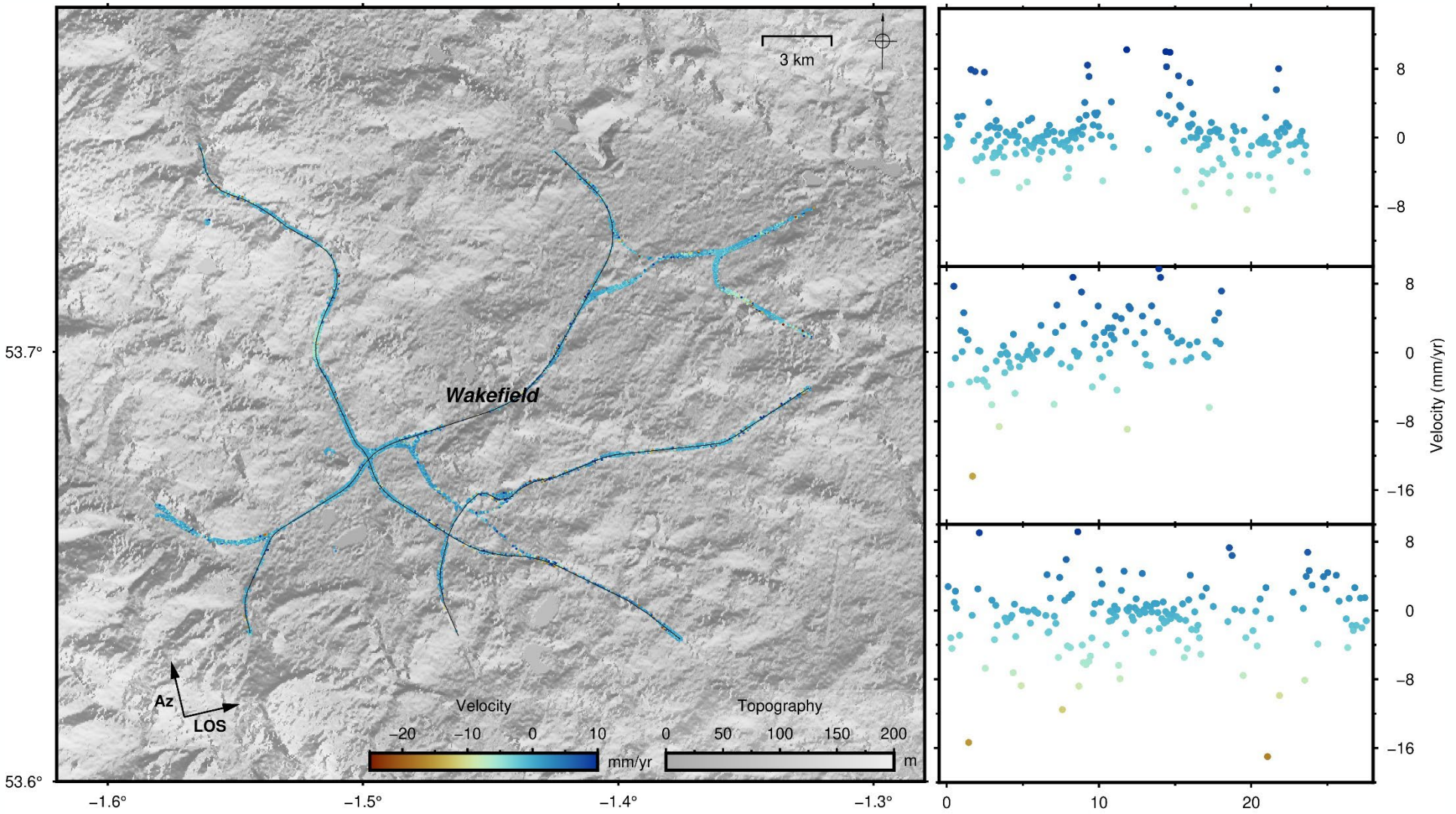






Groundwater level change of aquifer 0 has more correlations with surface displacement.

Case study #3 – Wakefield Railway



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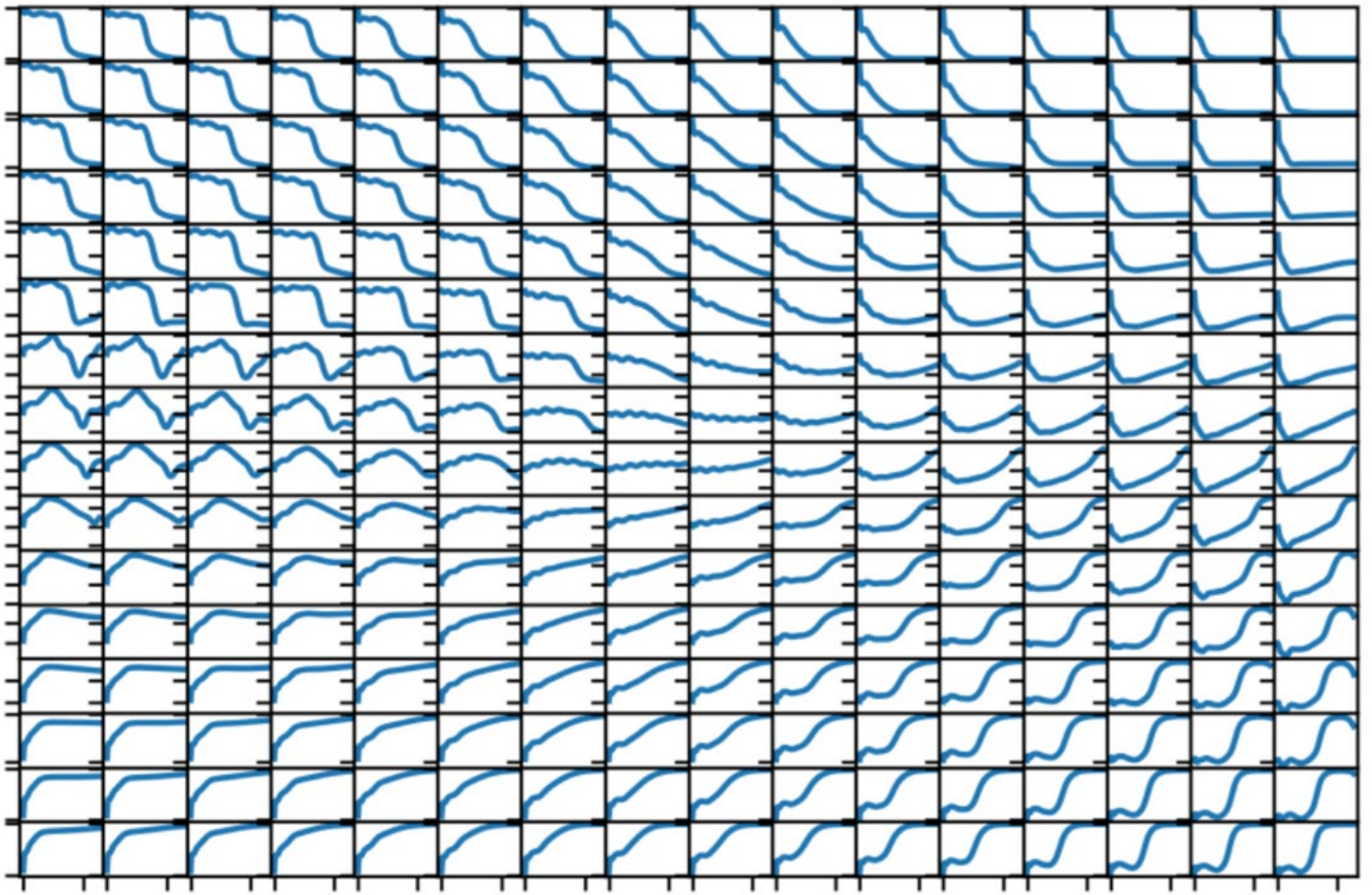
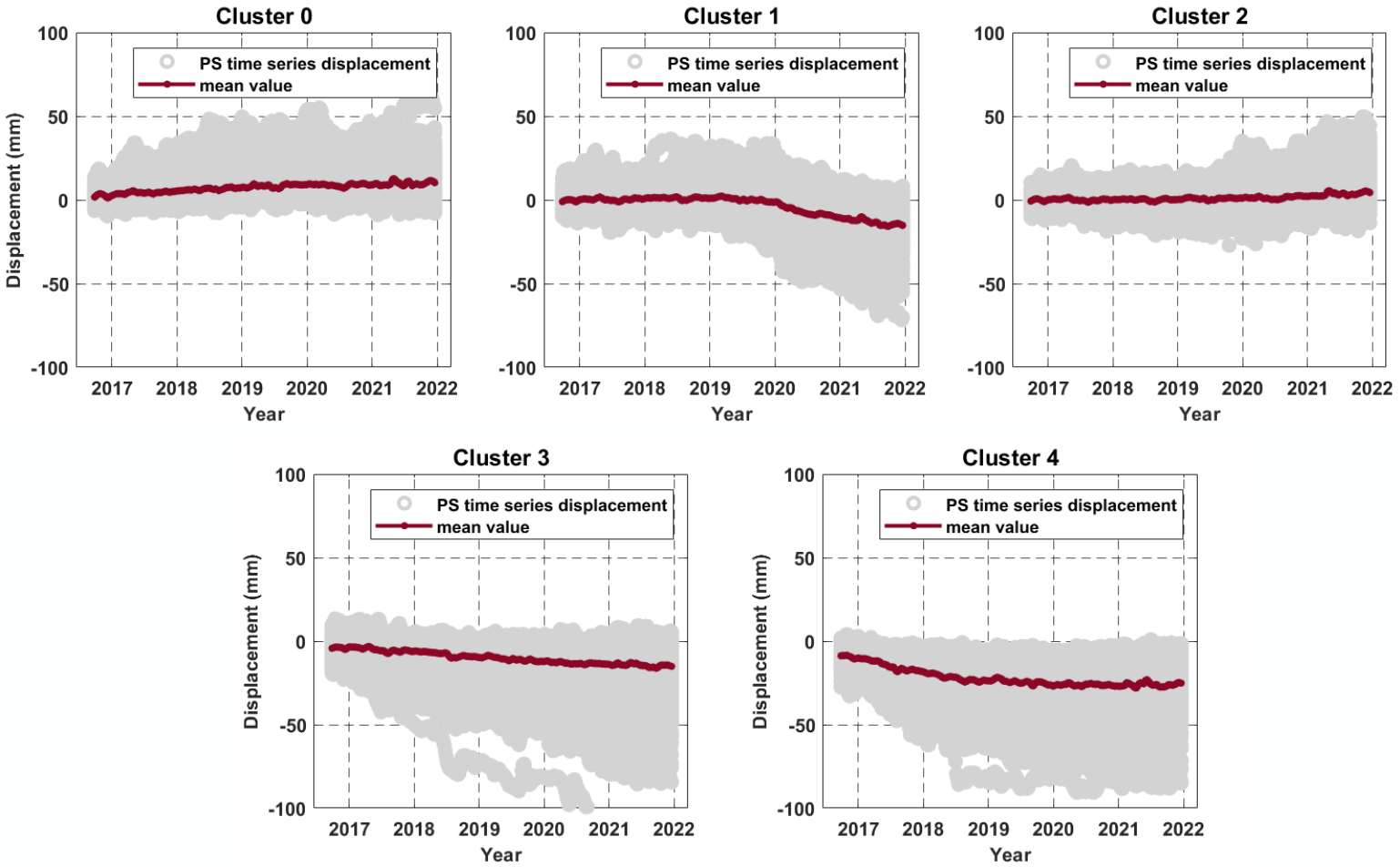
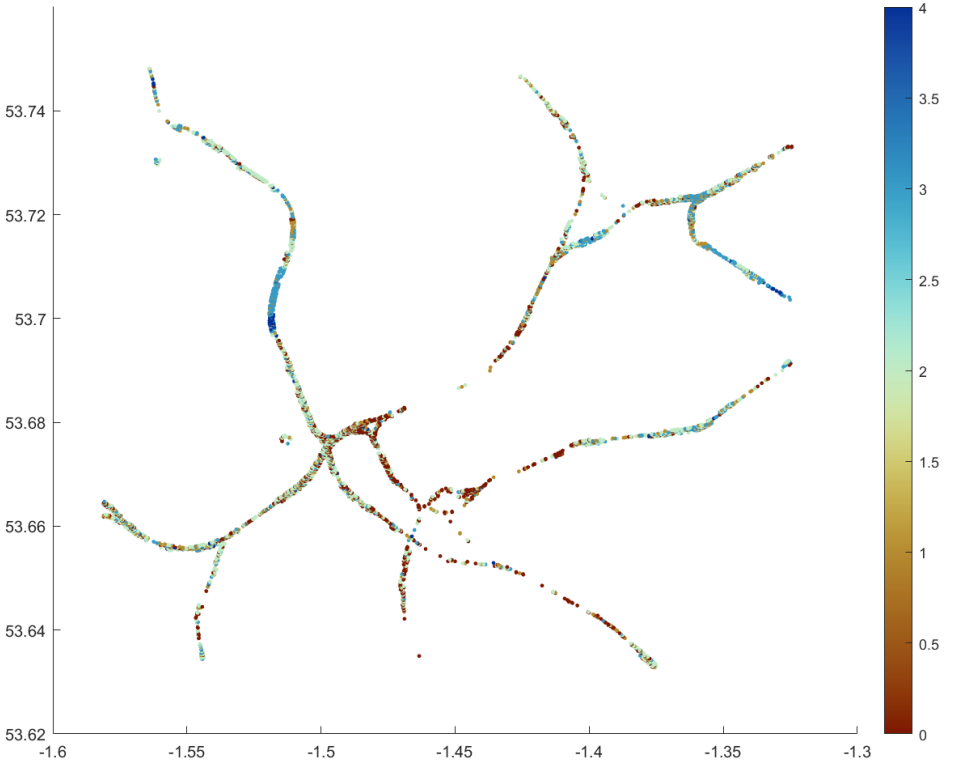


Time series in Latent space

Case study #3 – Wakefield Railway





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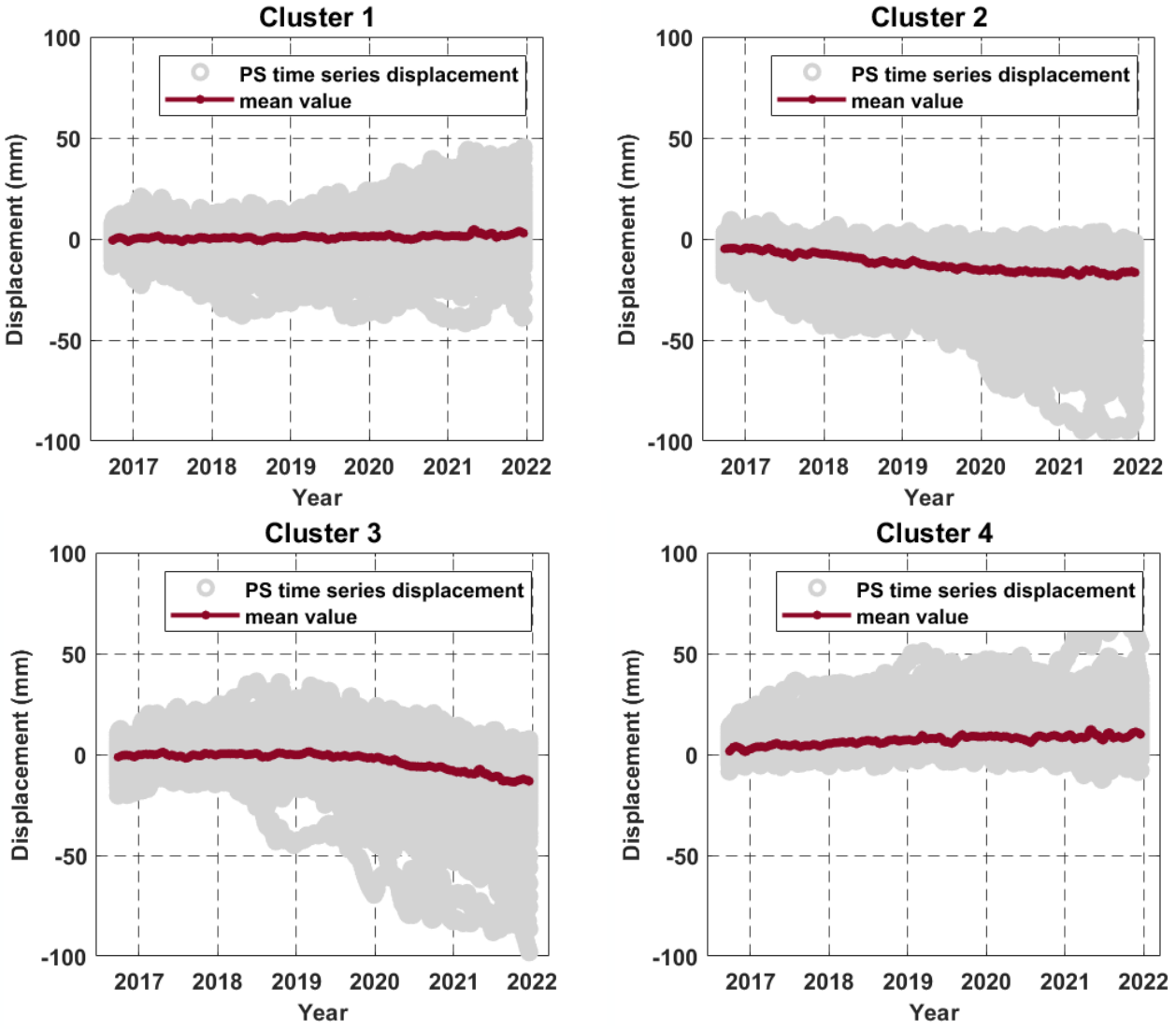
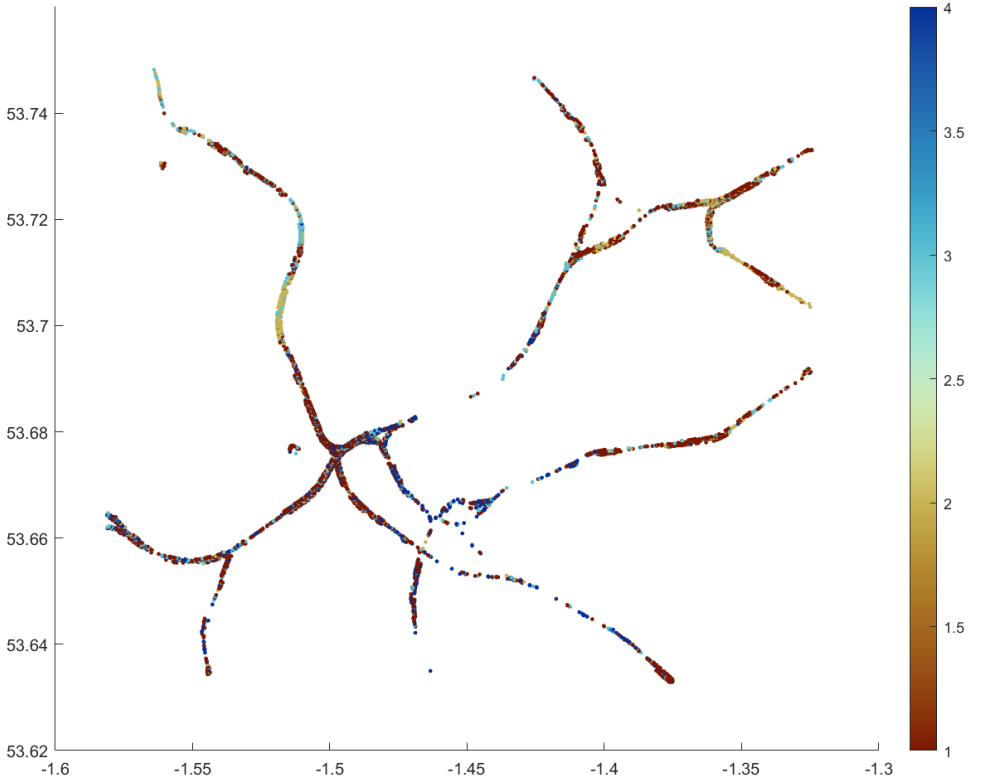
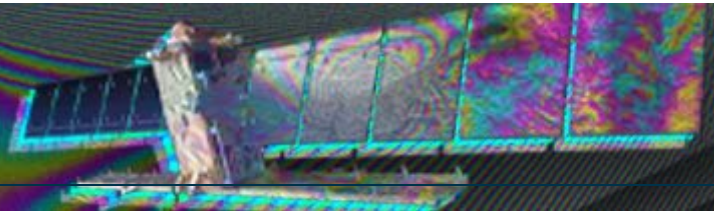




Take-home messages



1. Ensure MT-InSAR processing to get accurate time series dataset is pre-requisite.

2. Spatial-aware deep clustering on temporal evolutions helps to interpret and analyze time series data.

3. Further analysis is needed to examine the various factors contributing to the deformation.

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