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15 - 19 June 2026 | Auditorium Maximum of the Jagiellonian University, Kraków, Poland

FRINGE 2026

Forecasting InSAR-Based Volcanic Deformation Using Deep Learning Trained on Complex Dynamical Models

Camila Novoa Lizama, Andy Hooper, Matthew Gaddes, Shailza Sharma, Pedro Espin, Milan Lazecky



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Volcanic and Magmatic Deformation Portal: 1480 volcanoes



A Coherence-Optimized Framework for Global Volcano Monitoring, Espin et al., 2026, Poster session II

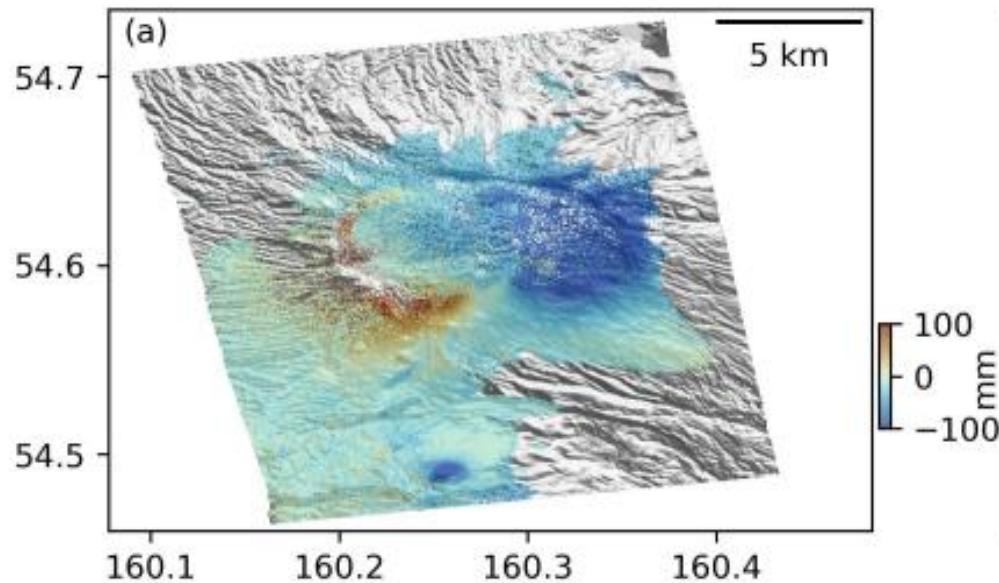


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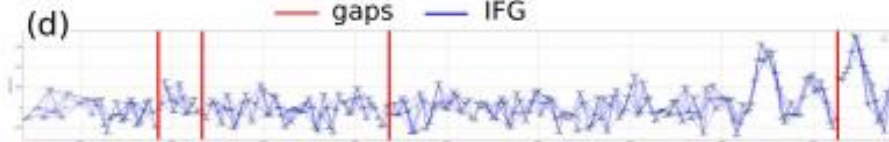
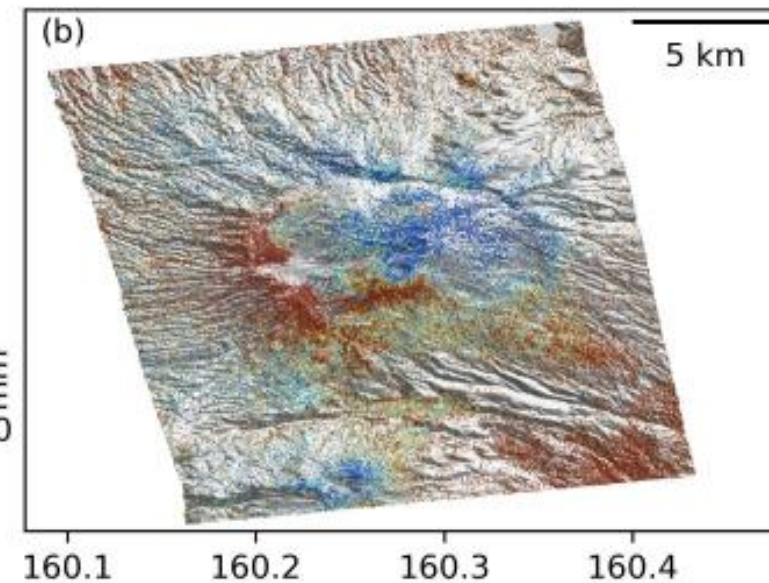


Short- and long-term interferogram connections are automatically selected based on coherence, increasing temporal density and reducing temporal gaps.

30 m resolution



100 m resolution



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Large diversity of volcanic deformation patterns makes global forecasting challenging



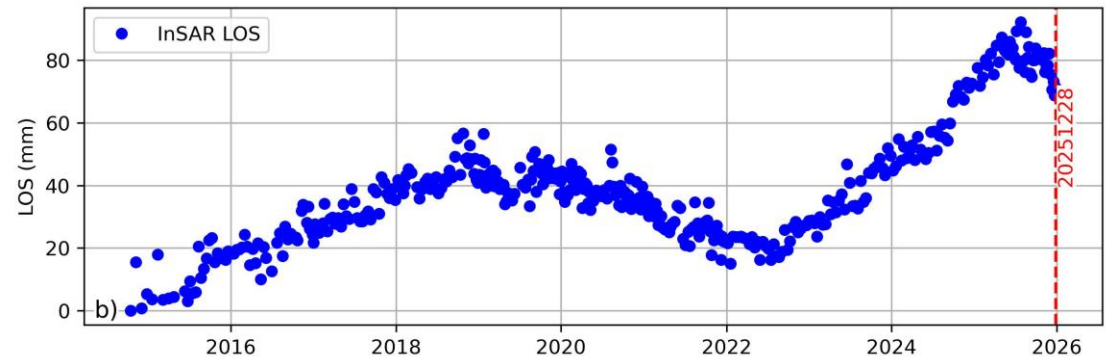
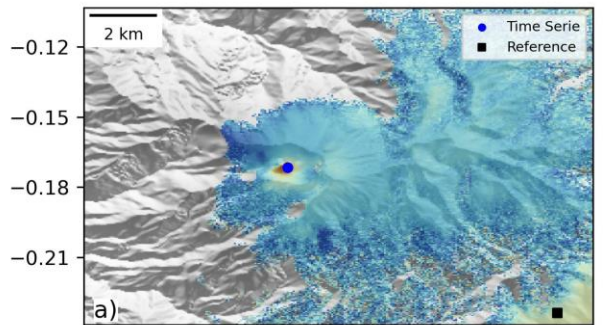
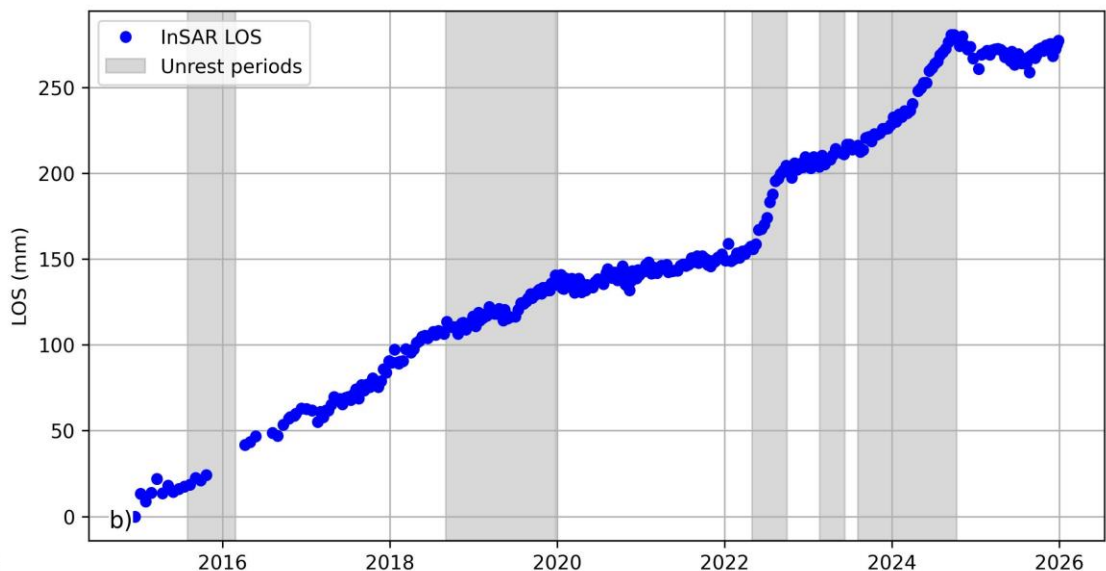
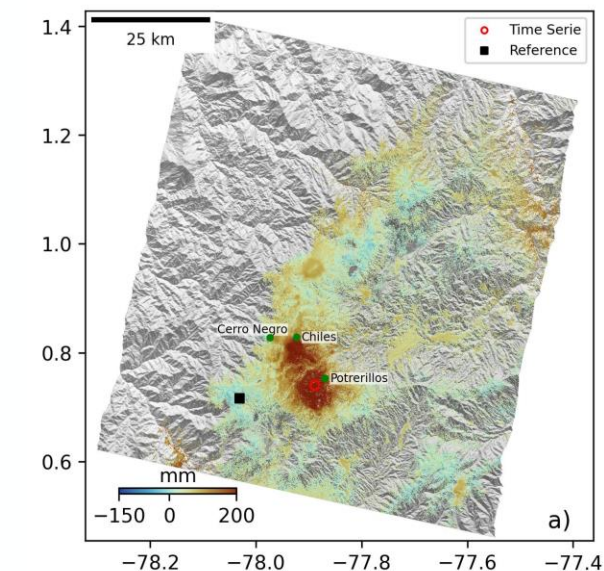
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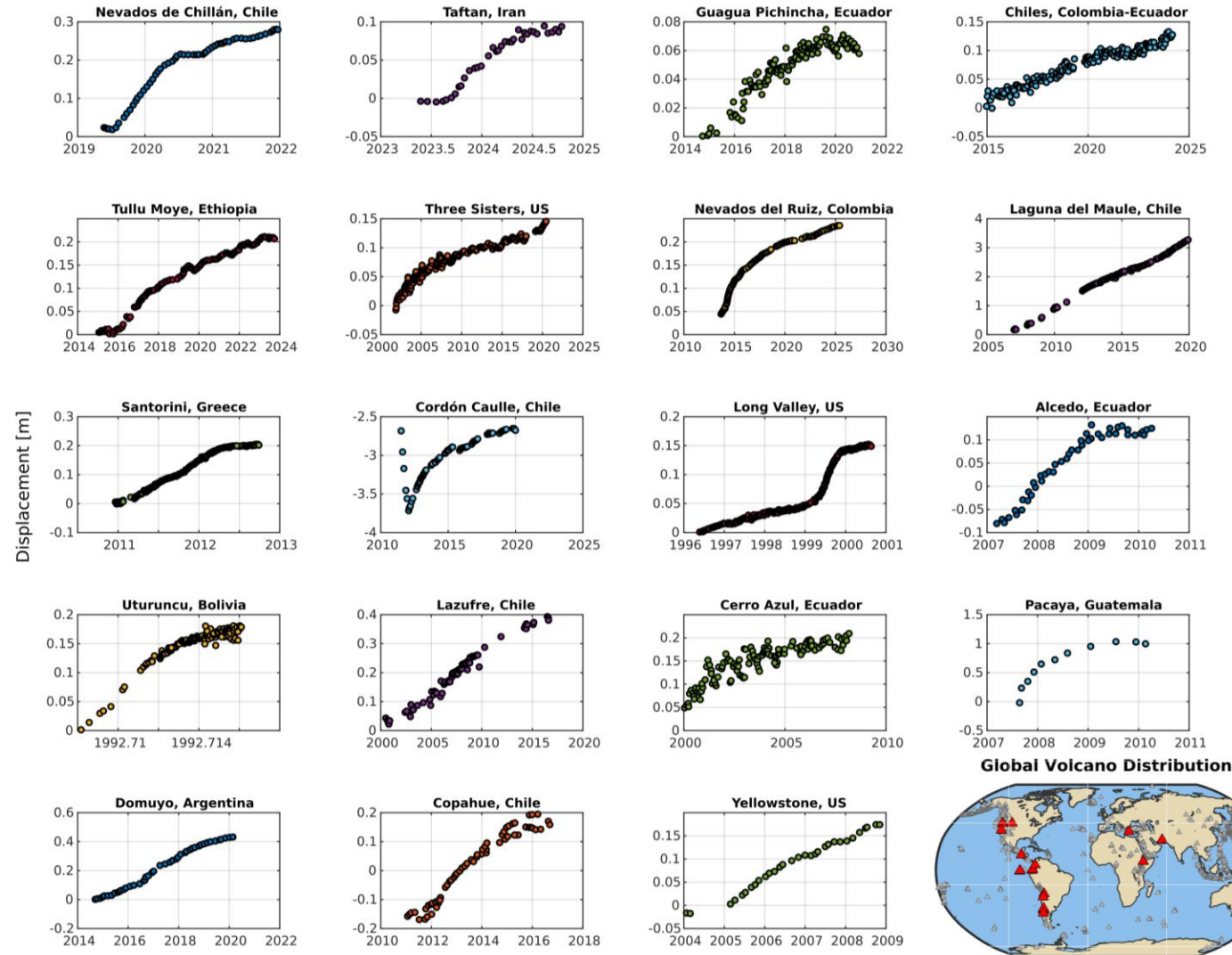
Global distribution of analysed volcanic uplift events



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Uplift-rate deceleration across volcanic systems



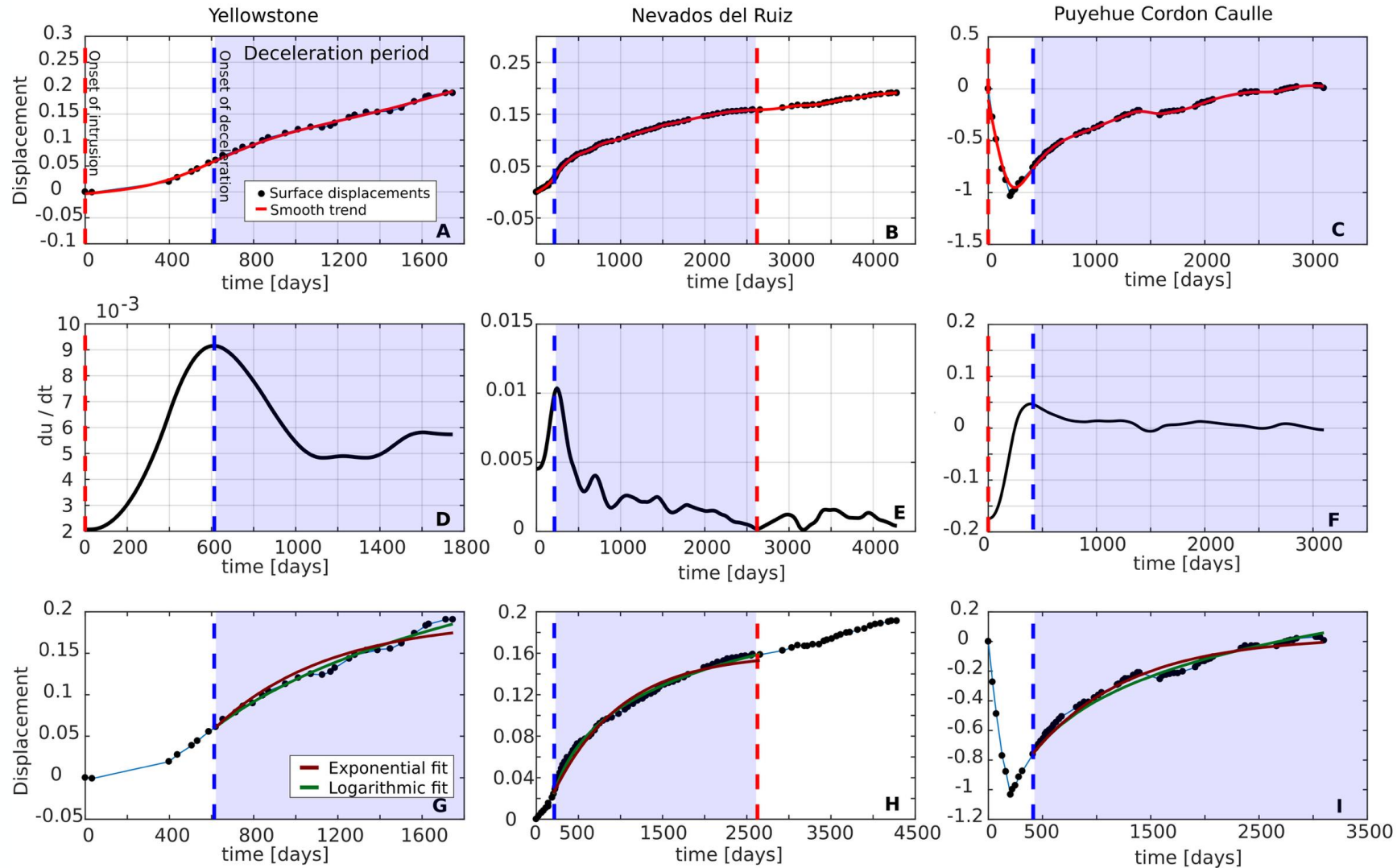
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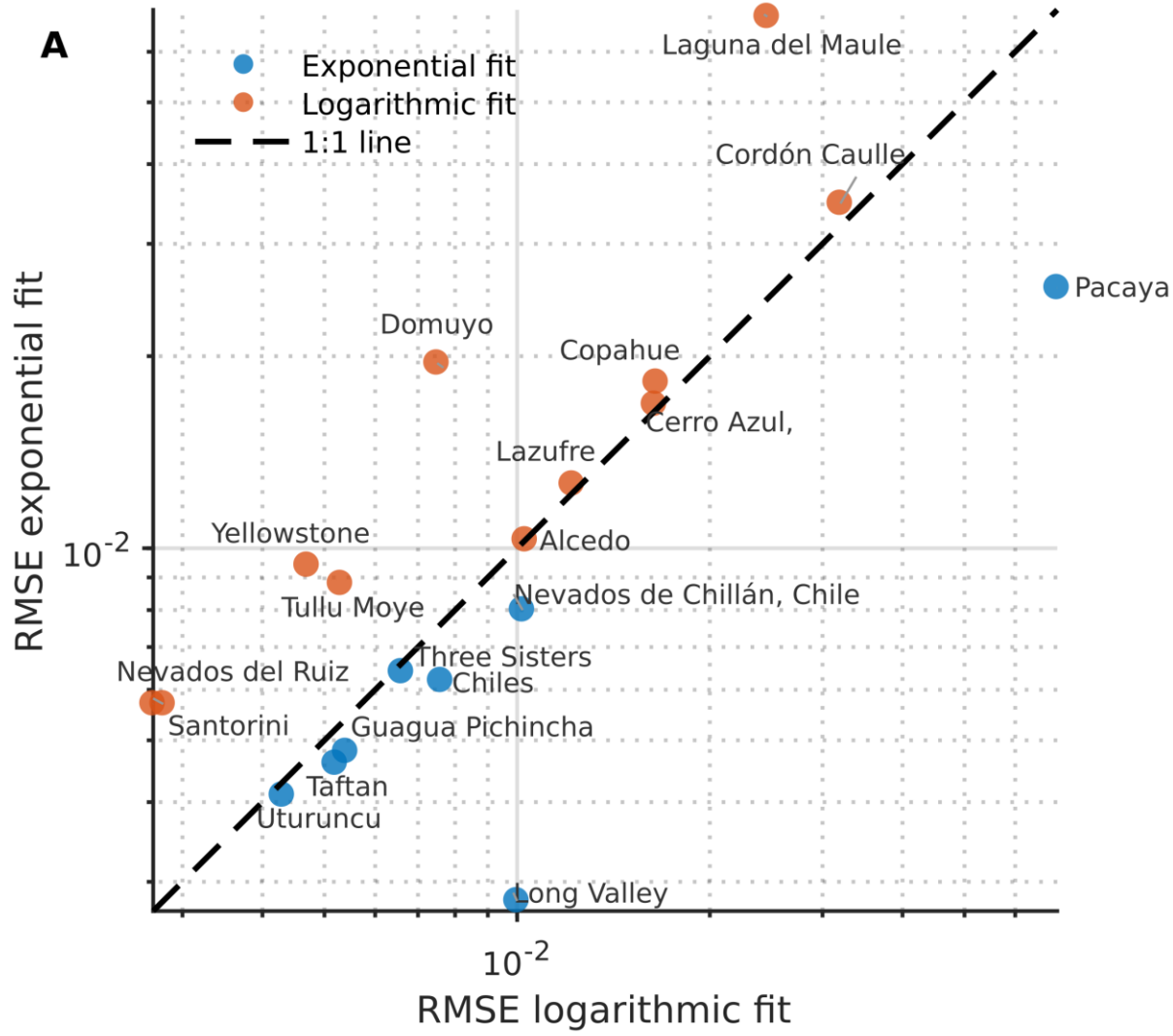
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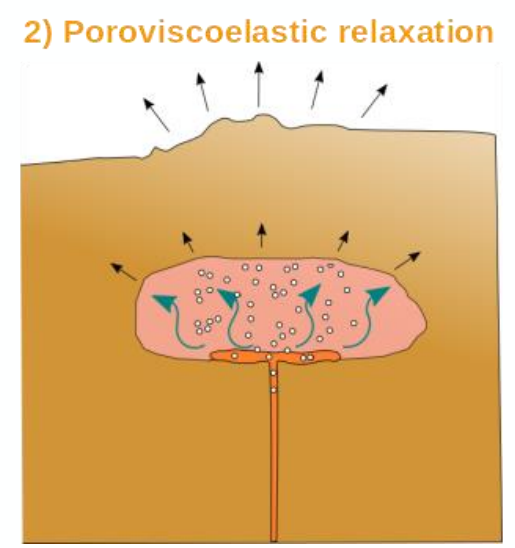
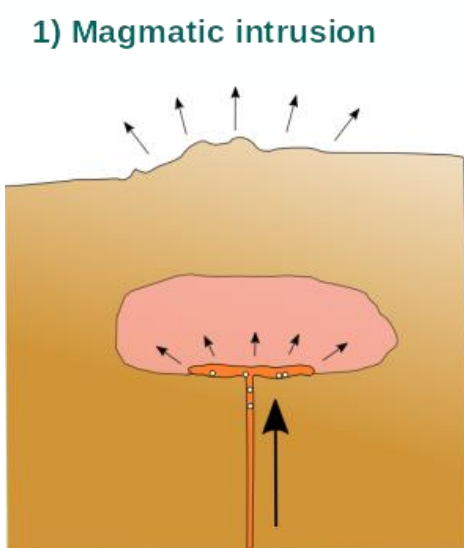
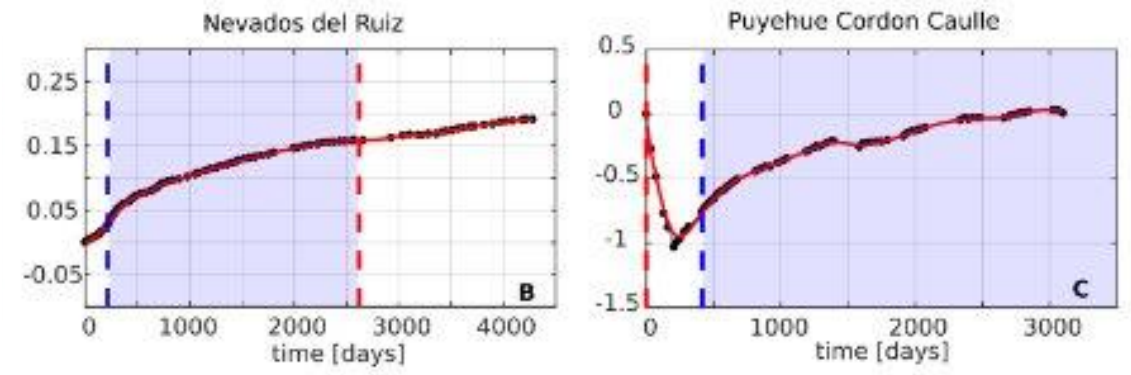
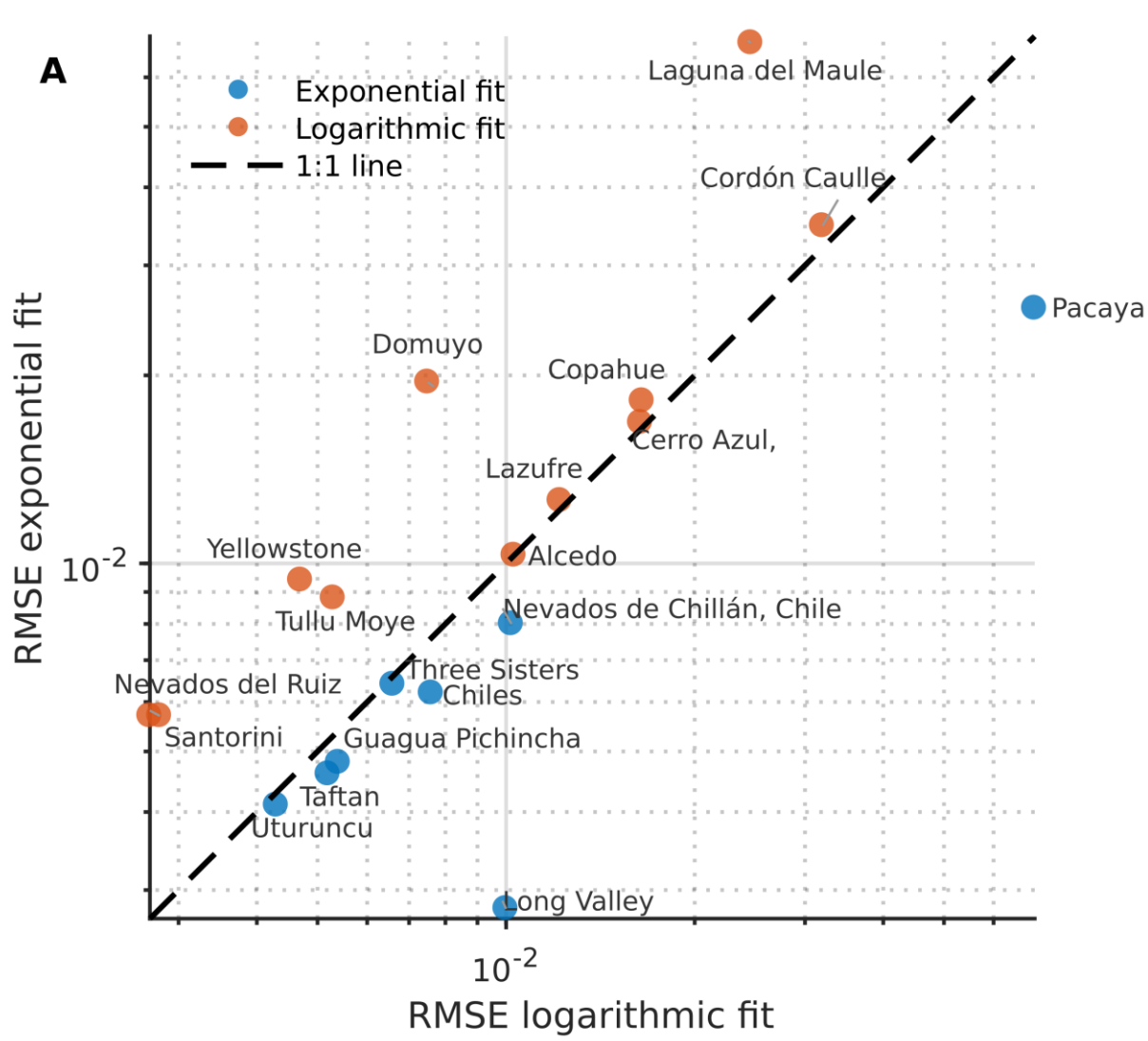
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Common uplift-rate deceleration across volcanic systems



Common uplift-rate deceleration across volcanic systems



Poroviscoelastic relaxation to explain the variety of time series at volcanoes



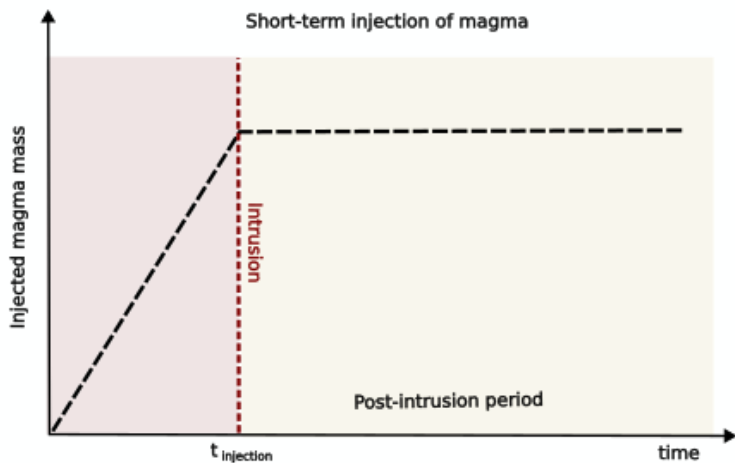
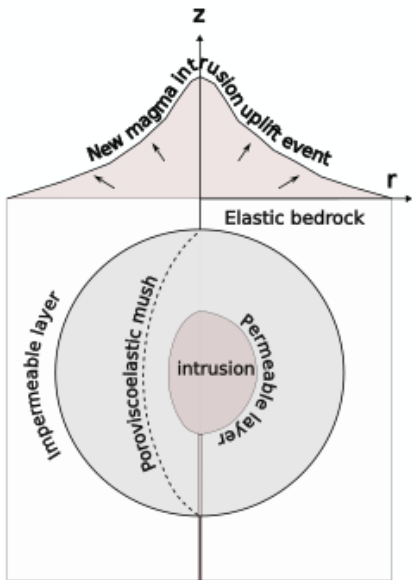
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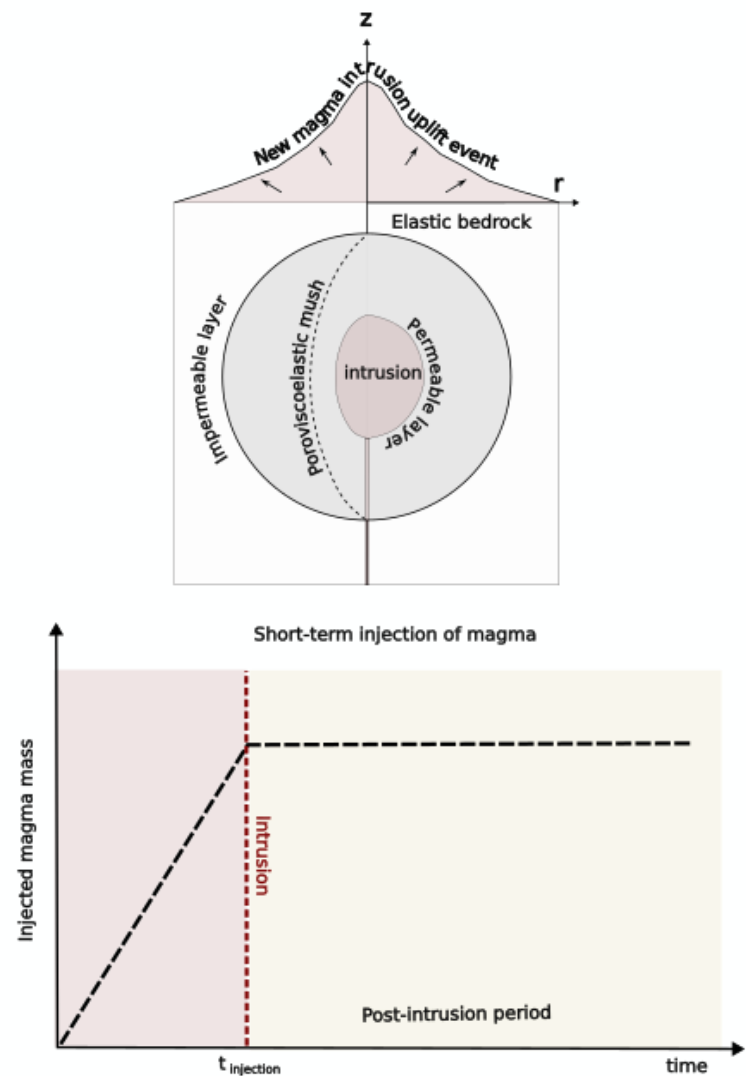


Model based on Liao et al., 2021

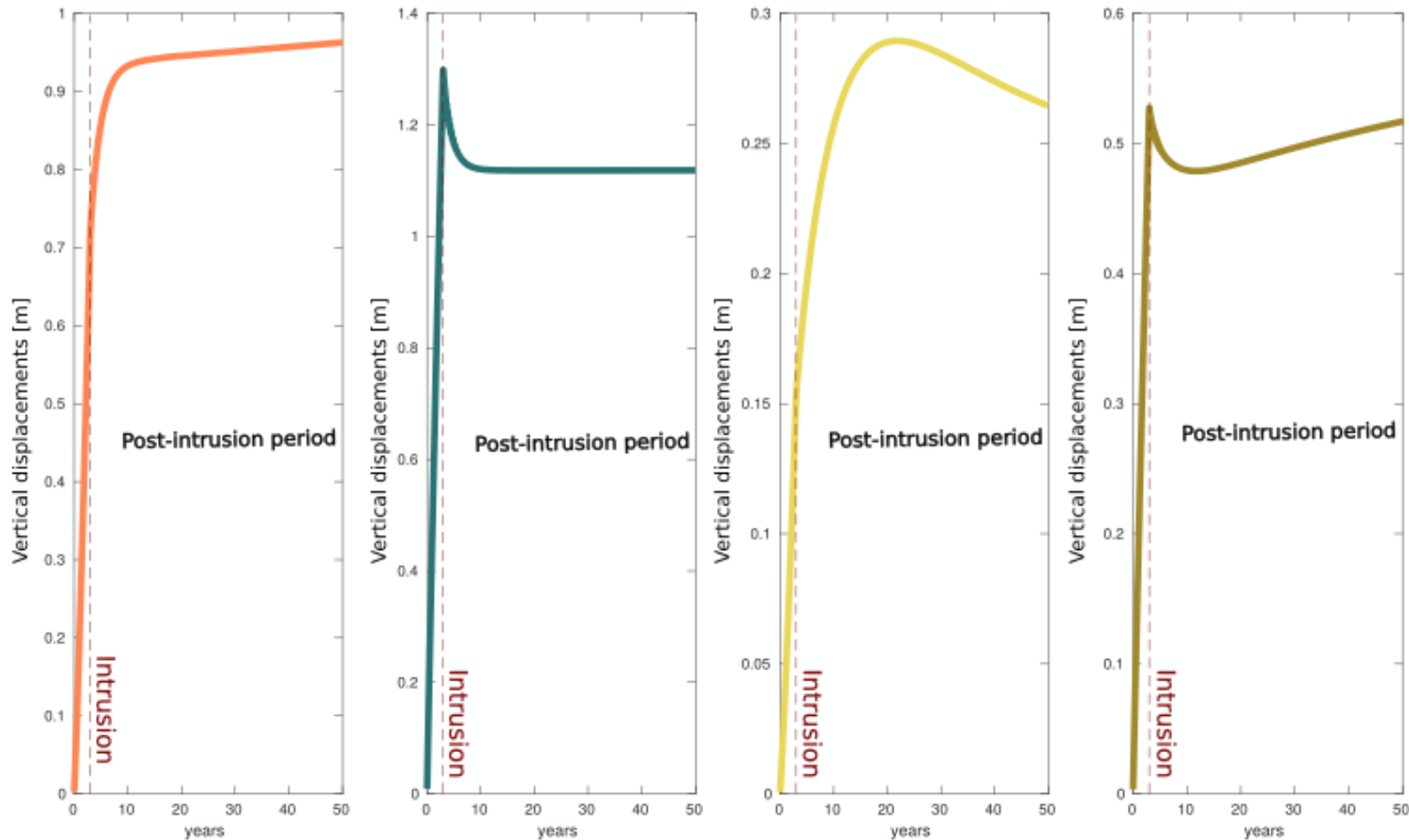
Poroviscoelastic relaxation to explain the variety of time series at volcanoes



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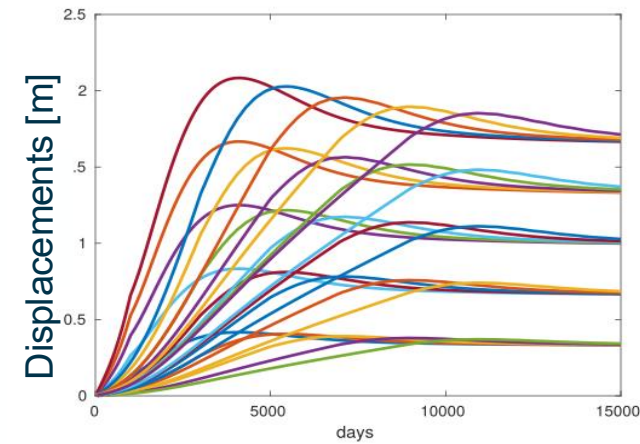
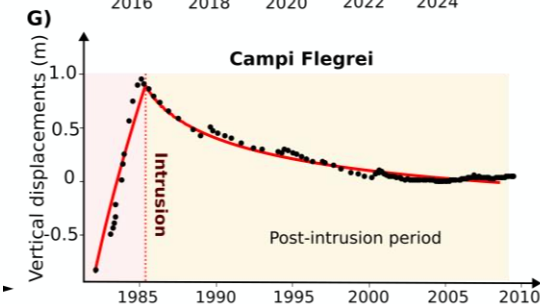


Variety of surface displacements expected on volcanoes after a new intrusion reach a mush reservoir



Model based on Liao et al., 2021

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Outcome: This framework captures both the temporal and spatial diversity of volcanic deformation observed worldwide.

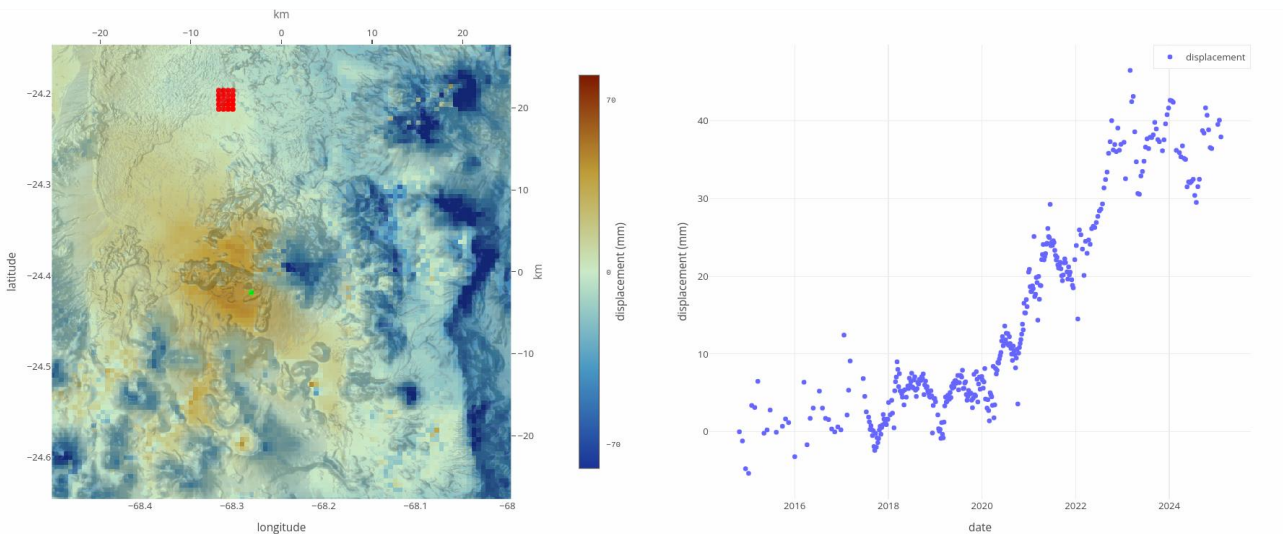
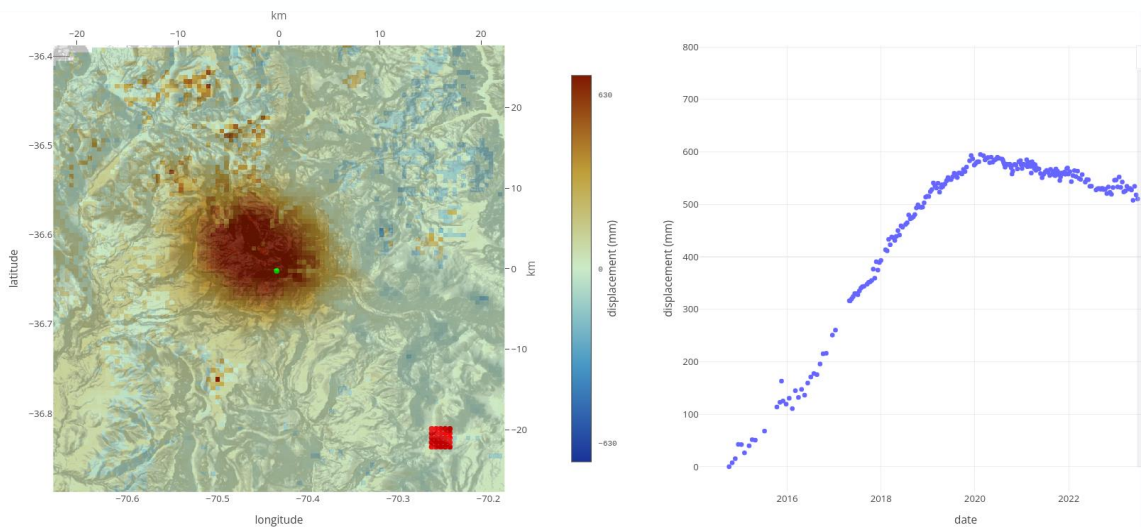
Incorporating Atmospheric Noise for Realistic Simulation of Volcanic Signals



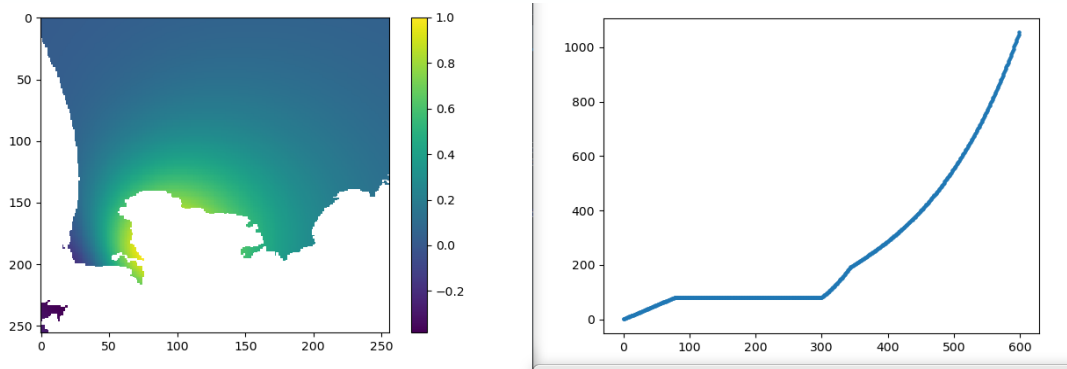
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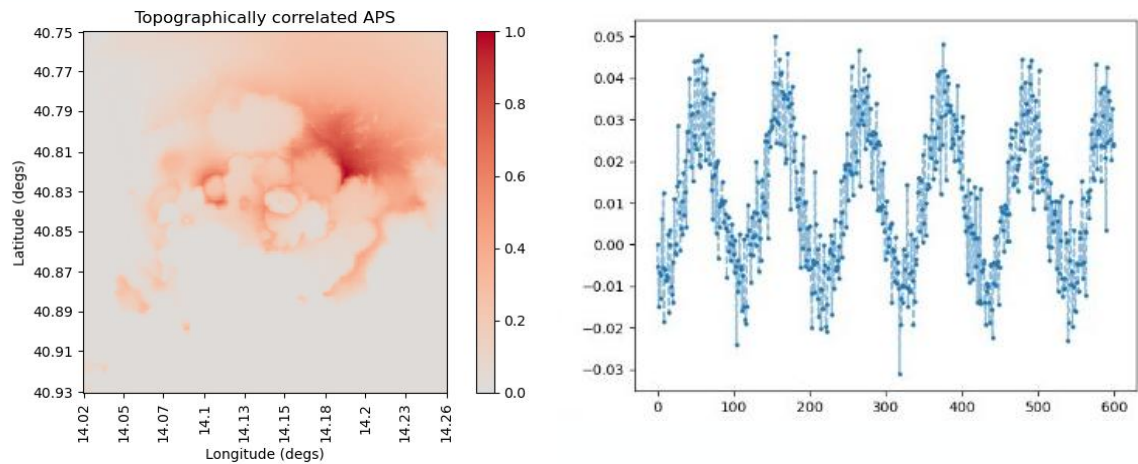
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Magmatic deformation source



Topographic correlated Atmospheric Phase Screen (APS)



Synthetic Data Generation Framework



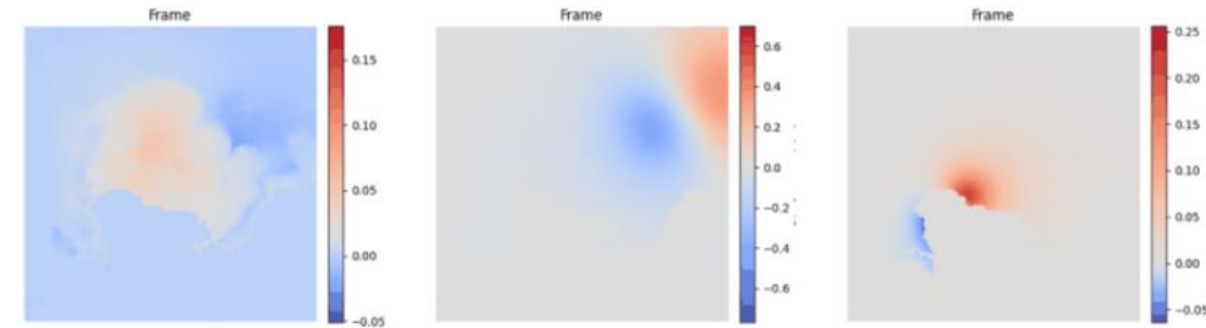
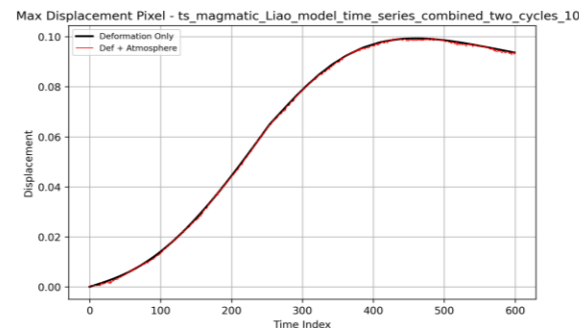
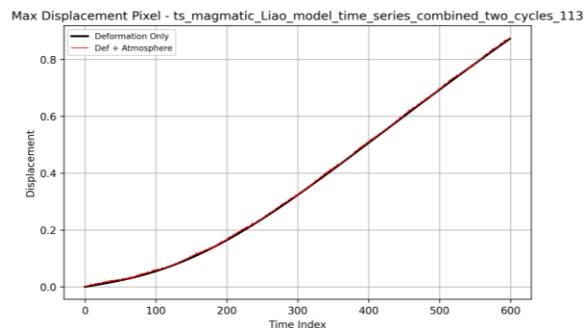
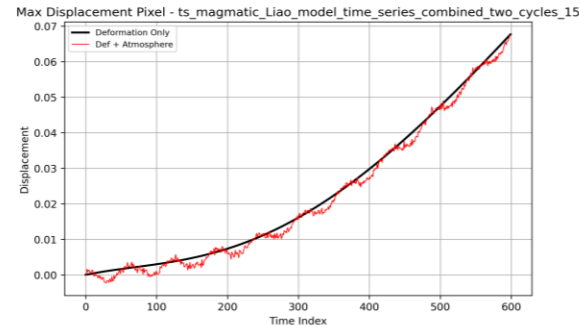
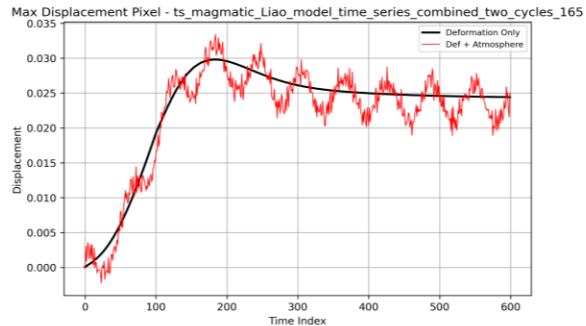
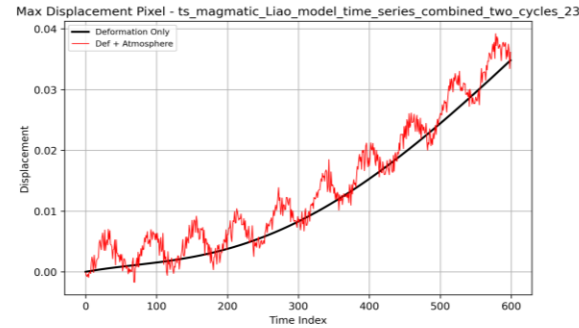
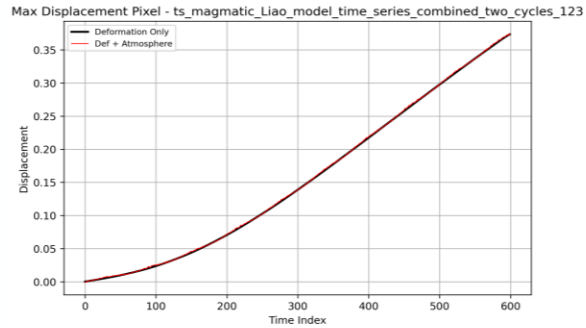
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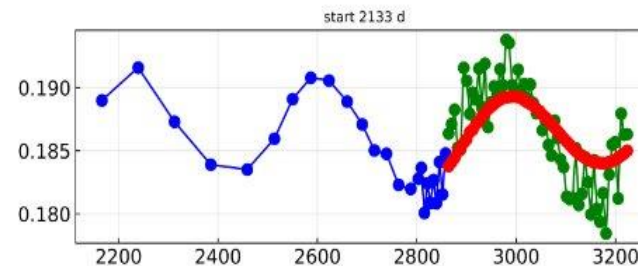
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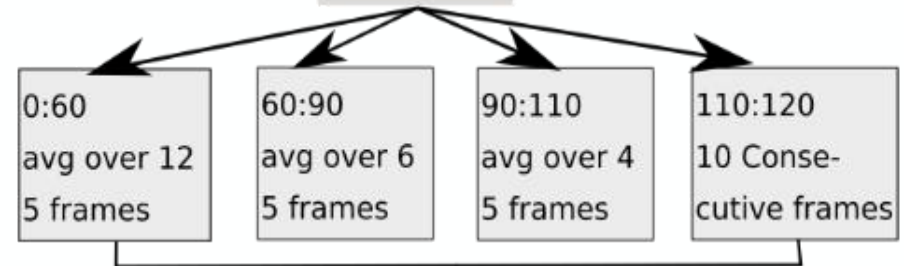


- Physics-based simulations of volcanic deformation using poroviscoelastic reservoir models.
- Diverse deformation geometries and spatial patterns.
- Realistic InSAR conditions including topographic atmospheric noise.
- 130 synthetic time series (600 images each; ~10 years, 6-day sampling).



120 Frames

2 Years



- **Input:** 2 years of deformation history (120 -> 25 frames).
- **Forecast:** 60 future frames (~1 year).
- **Recursive prediction:** each forecast is fed back to predict the next timestep.

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Socompa Volcano



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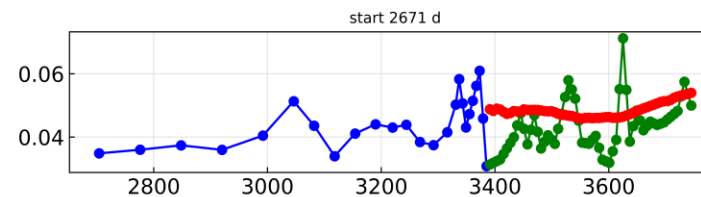
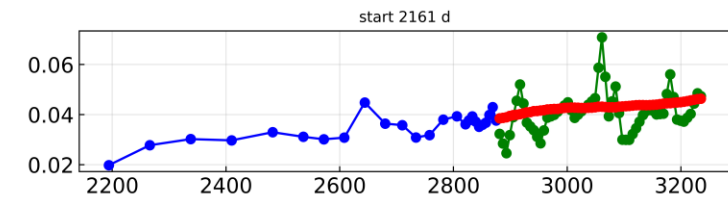
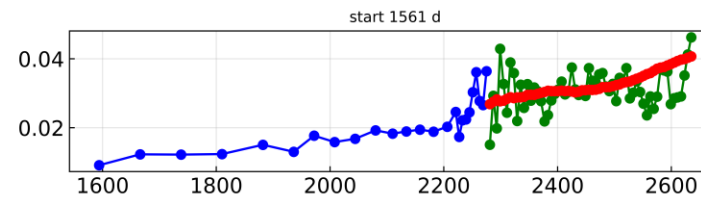
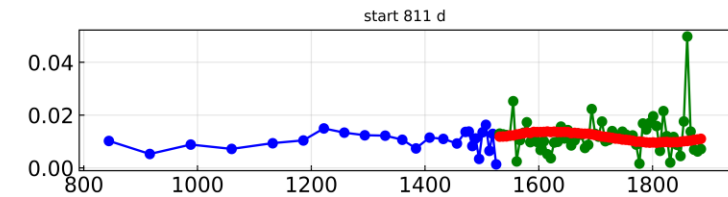
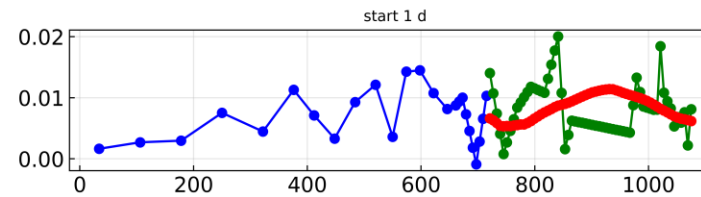
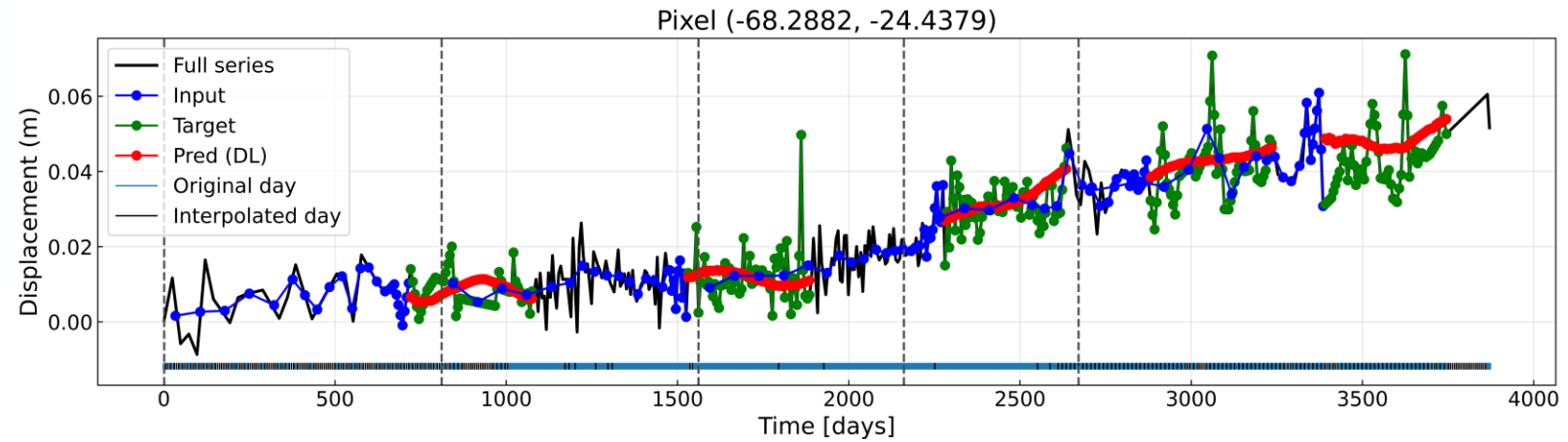
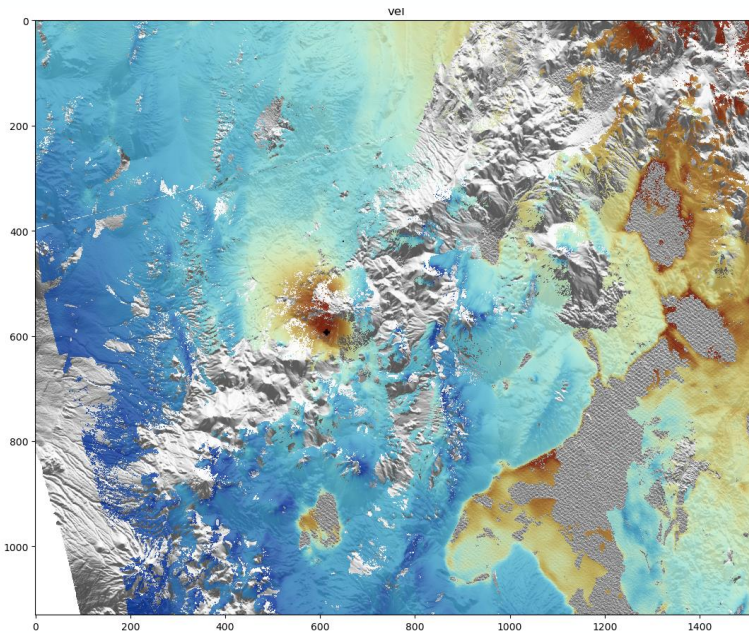


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- Detected uplift (2019–2021)
- No eruption, but deformation indicates ongoing volcanic activity



Domuyo Volcano

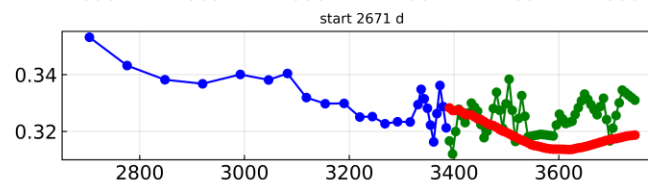
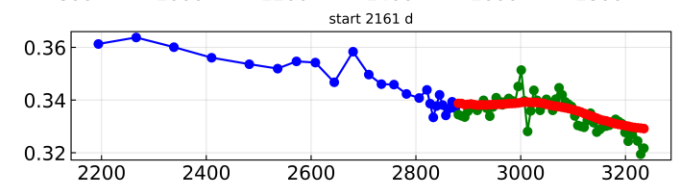
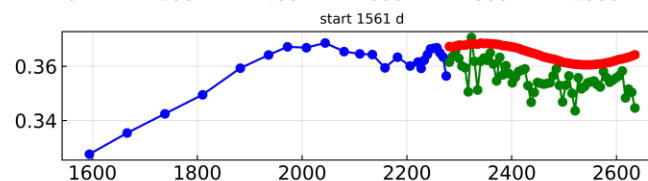
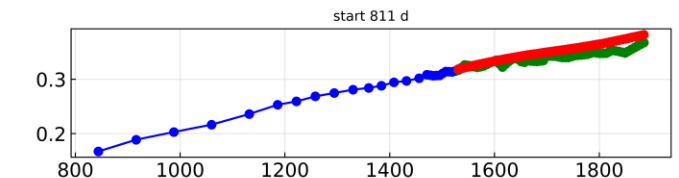
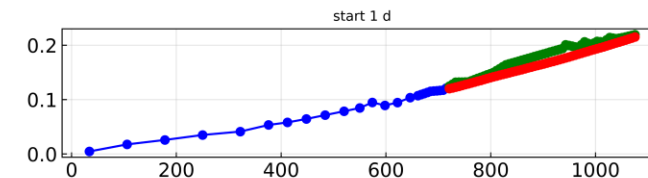
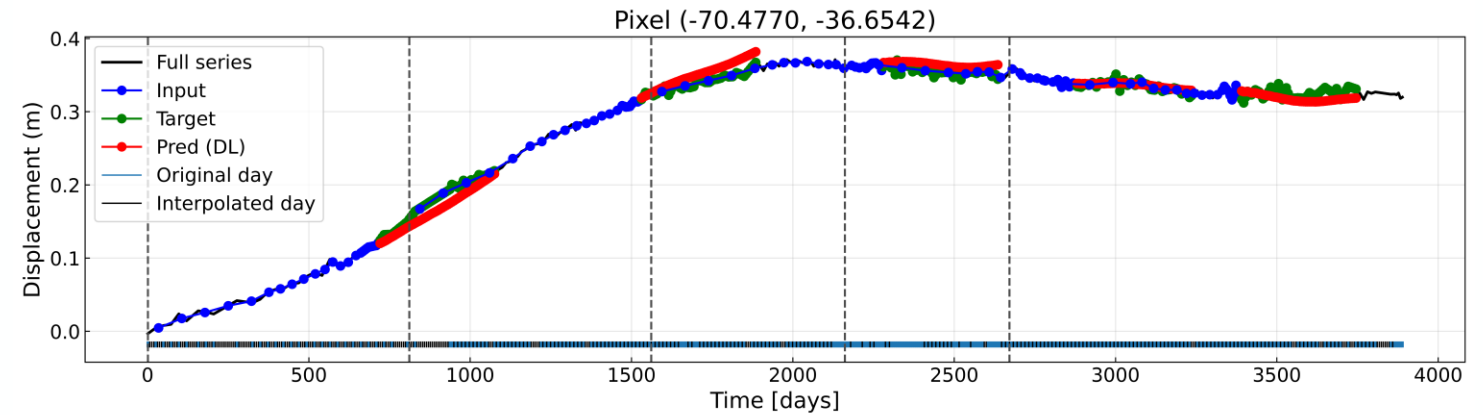
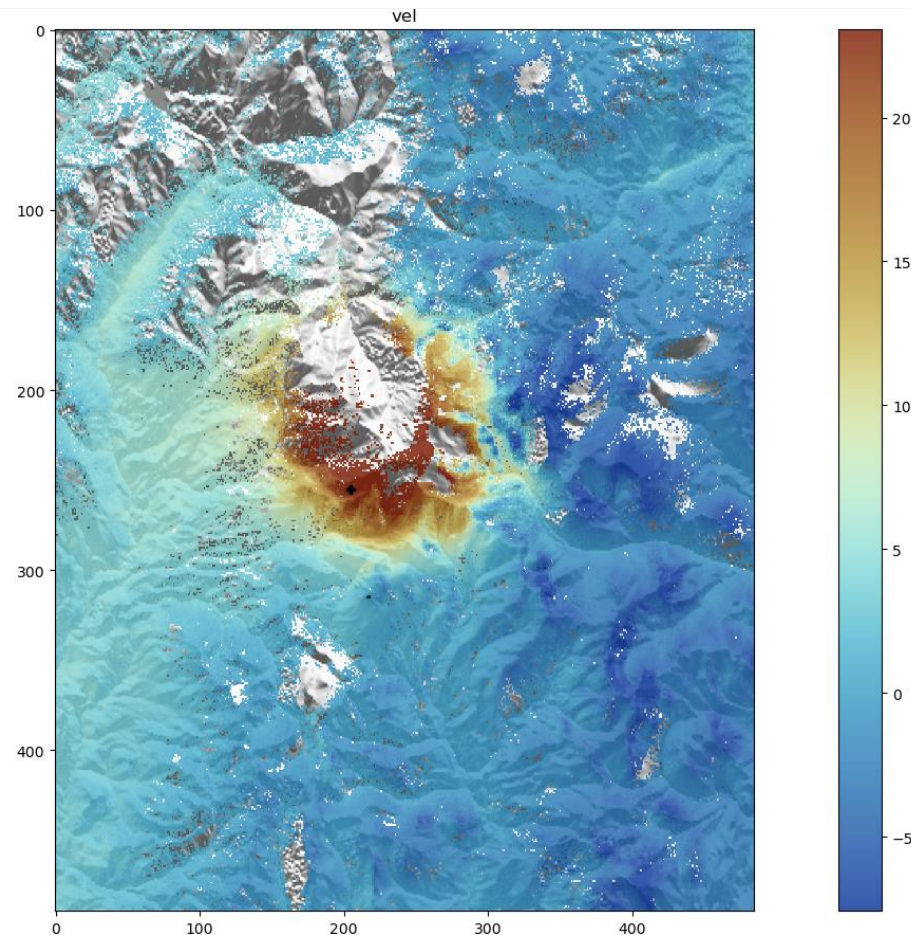


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Copahue Volcano



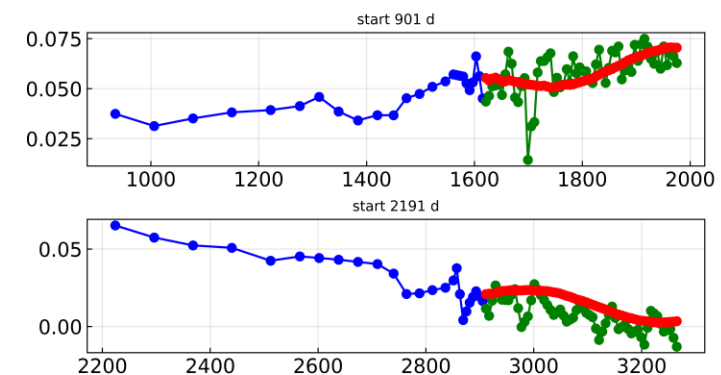
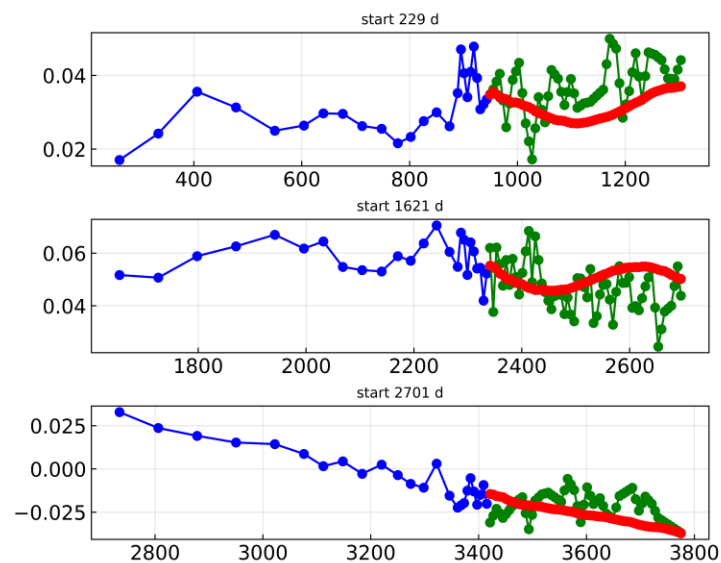
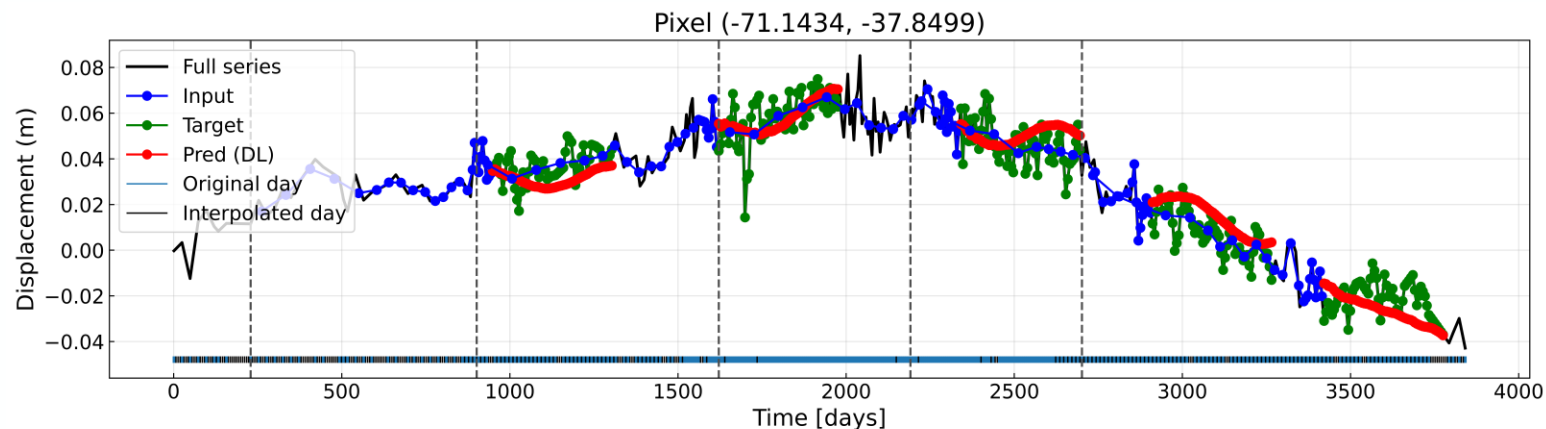
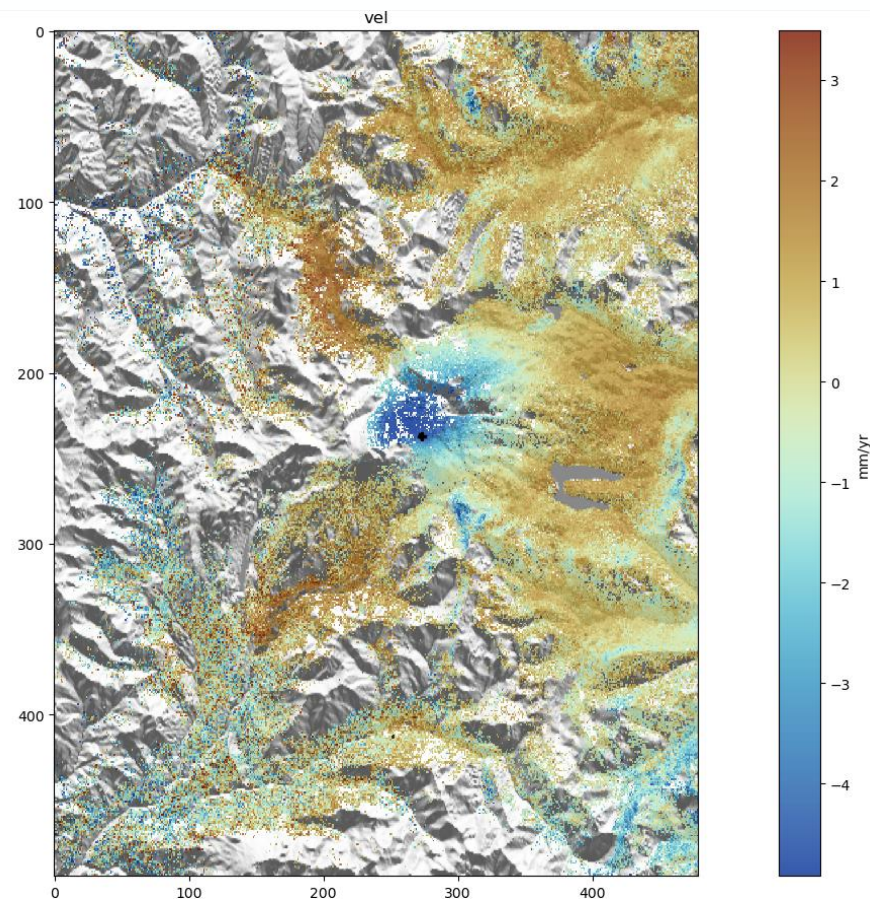
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Take home messages



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- Global volcanic deformation forecasting requires a global training strategy.
- Physics-based synthetic data reproduce the diversity of volcanic behaviours observed worldwide.
- A deep learning model trained only on synthetic data successfully forecasts real volcanic deformation.