Forecasting and mitigating natural hazards with remote and in-situ monitoring

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Rachael Lau[A], Carolina Seguí[A], Al Handwerger[B], Nathaniel Chaney[A], and Manolis Veveakis[A]

[A]Duke University; [B]Jet Propulsion Laboratory, NASA

InSAR Motivation

Expansion of satellite data and remote sensing

- Case Study: El Forn Landslide in Canillo, Andorra
- Sentinel-1 data taken from Alaska Satellite Facility Vertex Platform + processed with Small Baseline Subset (SBAS)
- Processed using Miami InSAR Time-series software in Python (MintPy), InSAR Scientific Computing Environment (ISCE), and the HyP3 toolbox

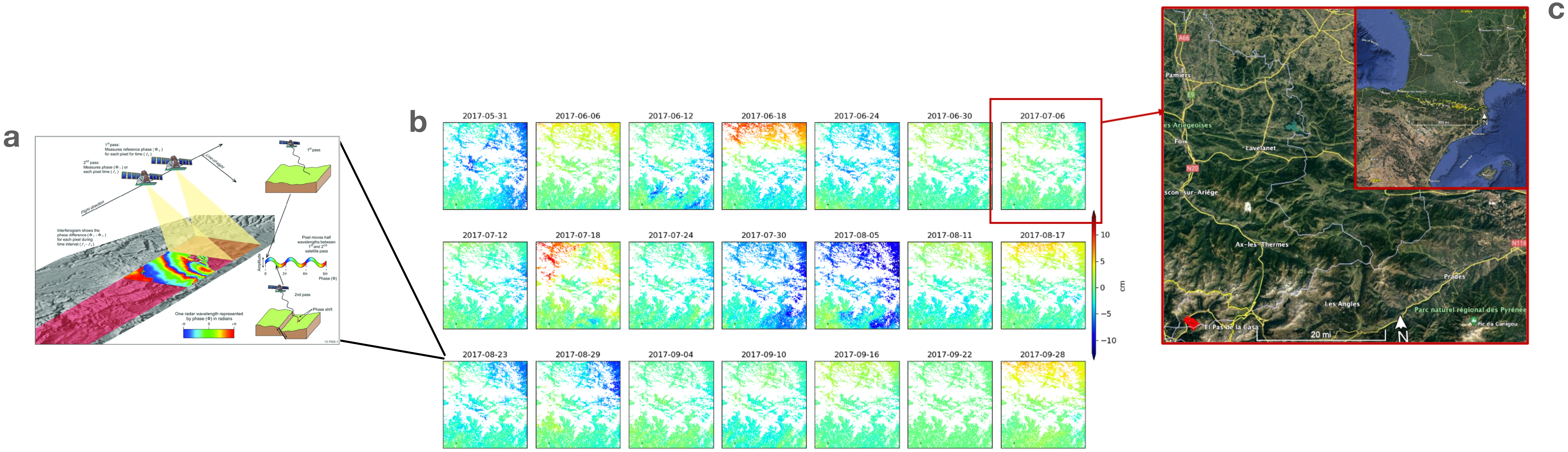


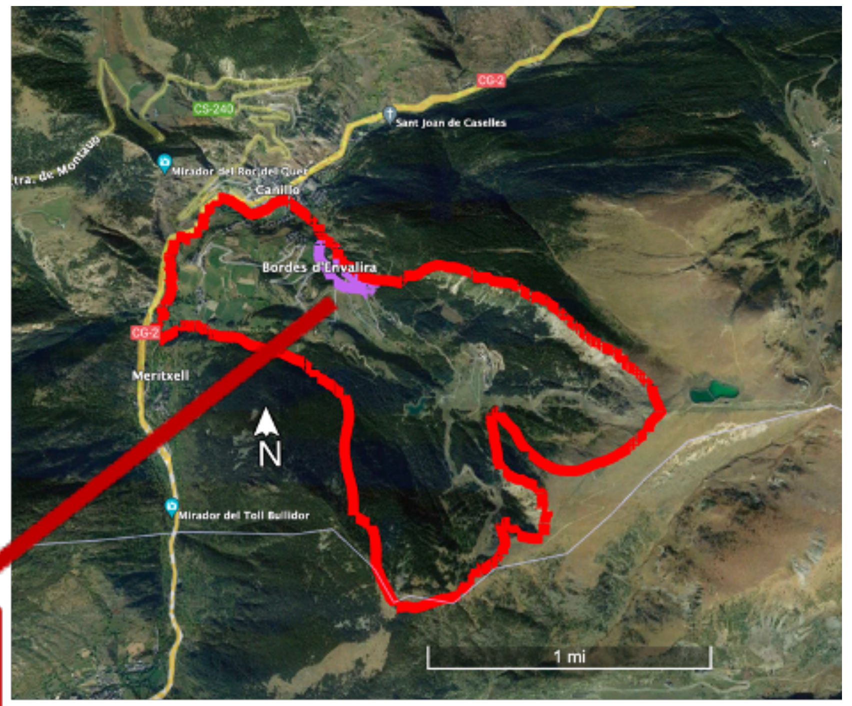
FIG1: InSAR Time Series Demo
(a) Diagram of InSAR processes[2]
(b) InSAR time series over Canillo, Andorra
(c) Satellite overview of Andorra and Canillo

Linking with physics-based models

A Case Study of the El Forn Landslide in Canillo, Andorra

- Deep-seated landslide triggered by subterranean aquifer fed by snowmelt

FIG2A: El Forn Landslide Scarp (Google Earth Pro)



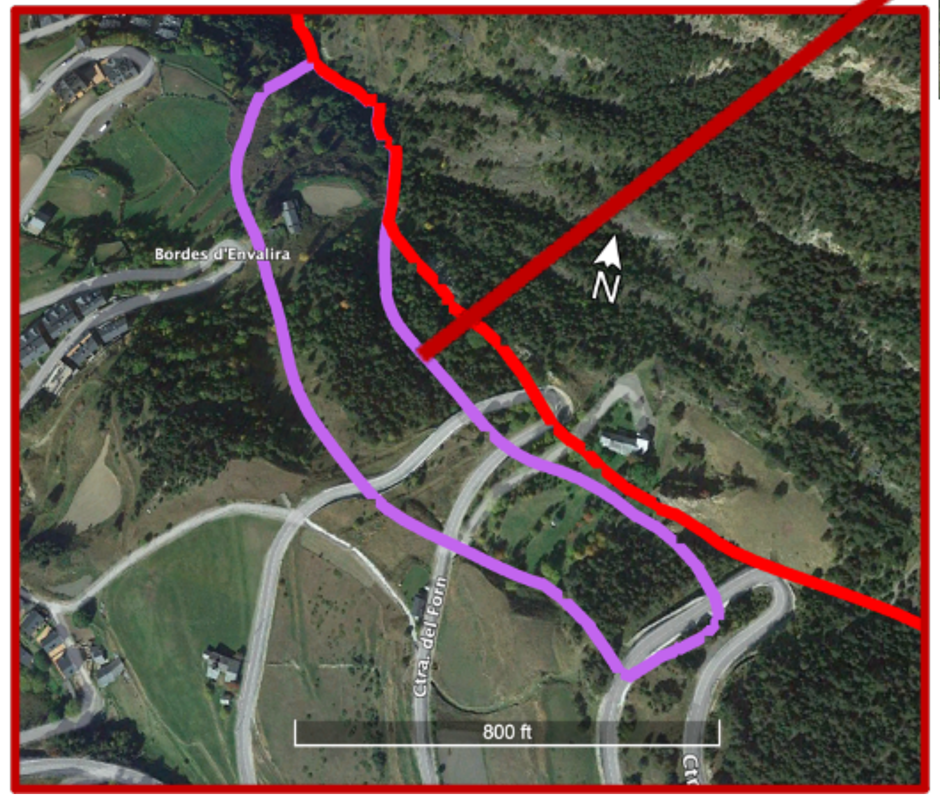


FIG2B: Fastest-moving lobe of the landslide (Google Earth Pro)

$$\frac{\partial\theta^*}{\partial t^*} = \frac{\partial^2\theta^*}{\partial z^{*2}} + Gr\, e^{\theta^*},$$

EQ1: Calculating temperature with frictional heating*

$$Gr = m\frac{\dot\gamma_{ref}}{F_\theta}\left(\frac{ds}{2}\right)^2 \tau_{ref}\left(\frac{\tau_d}{\tau_{ref}}\right)^{1-1/N}$$

EQ2: Calculation of the Gruntfest parameter*

$$\dot\gamma = \frac{\partial V}{\partial z} = \dot\gamma_{ref}\left(\frac{\tau_d}{\tau_{ref}}\right)^{1/N} e^{m(\theta - \theta_c)}, \quad \text{where } \tau_{ref} = \mu_{ref}\,\sigma'_n,\ m = \frac{M}{N}$$

EQ3: Calculating the velocity gradient*

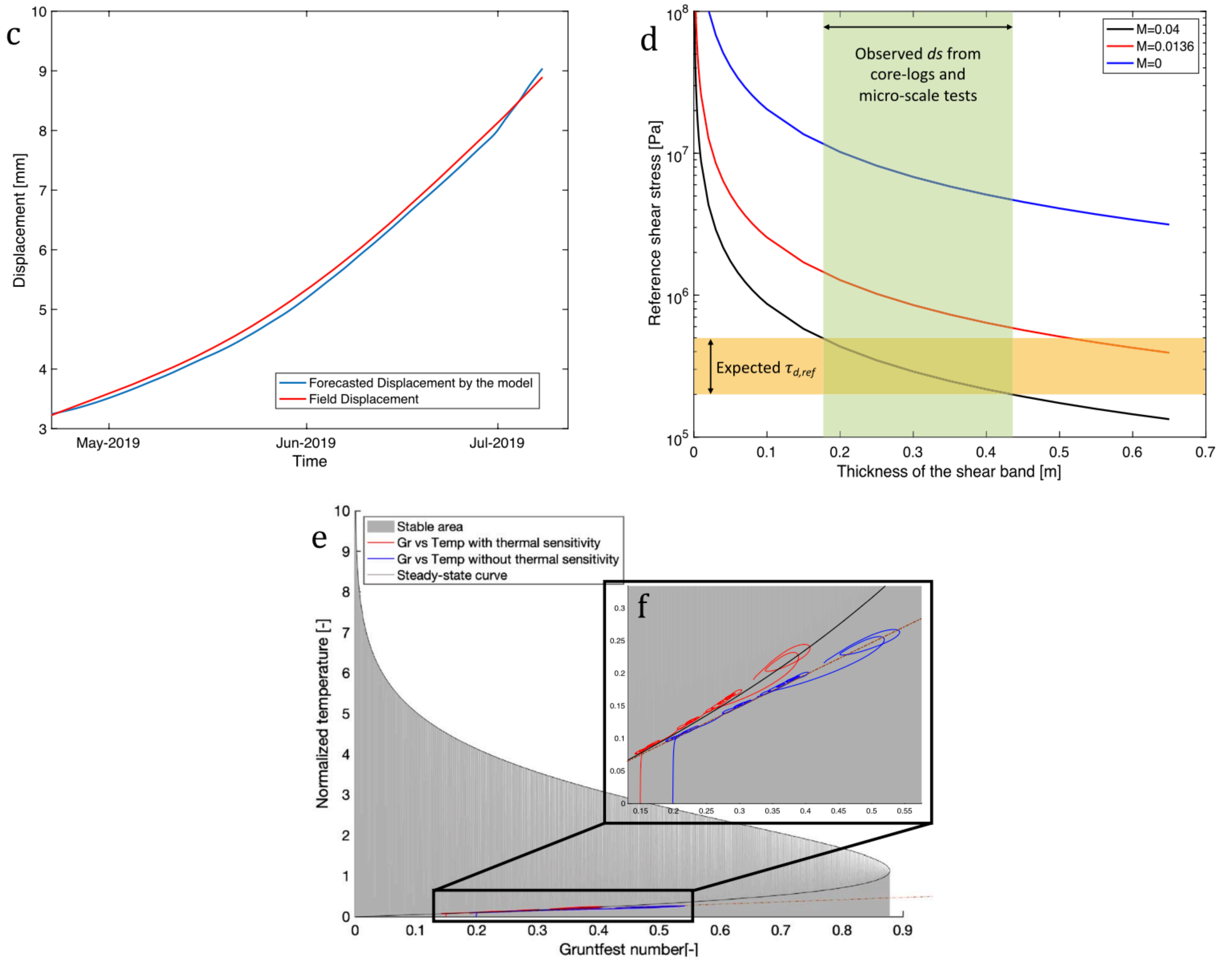


FIG3: Results of the physics-based model[1]
(c) graph of displacement [*mm*] over time [*days*].
(d) inversion of the reference shear stress, $\tau_{d,ref}$, with the thickness of the shear band, d_s.
(e) Stability of the Cal Ponet–Cal Borronet landslide, showing the evolution of the Gruntfest number with the temperature

*for details on method, please refer to *Seguí (2021)*

Starting with Geostatistics

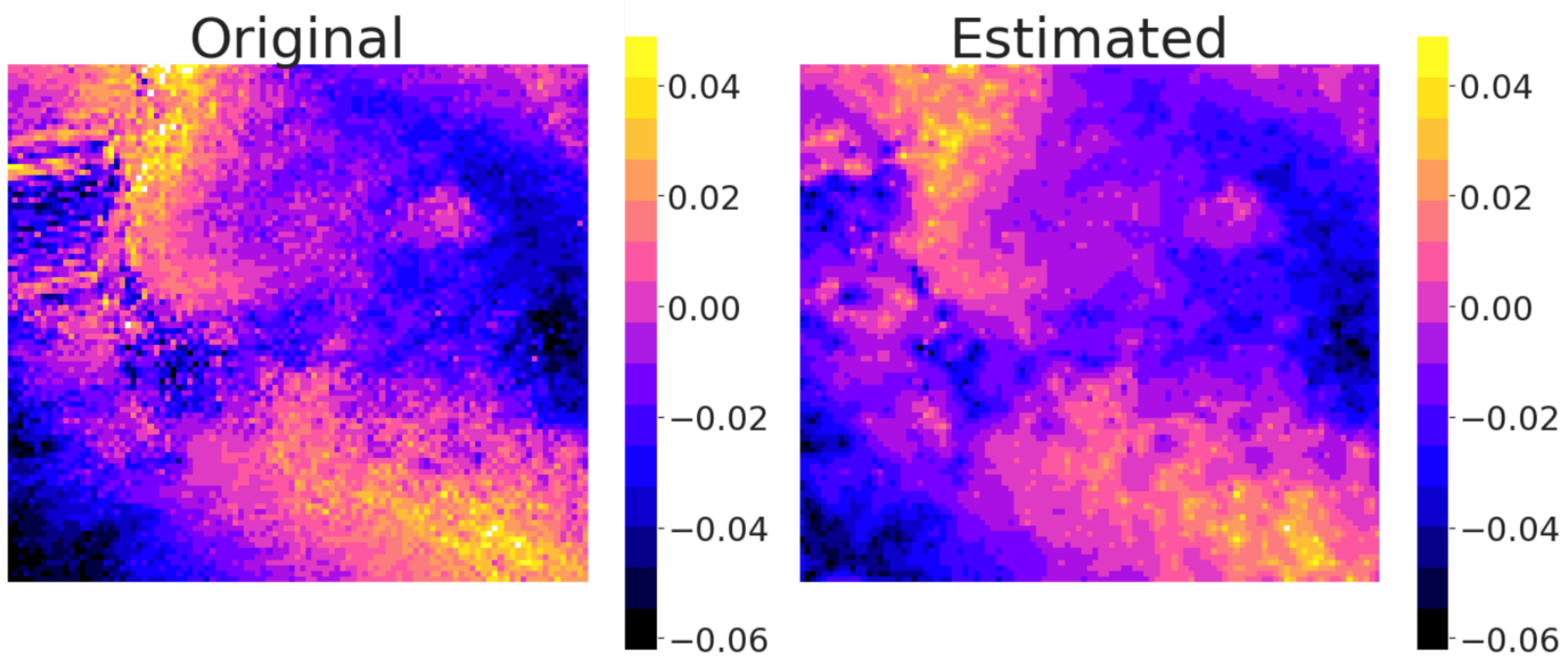
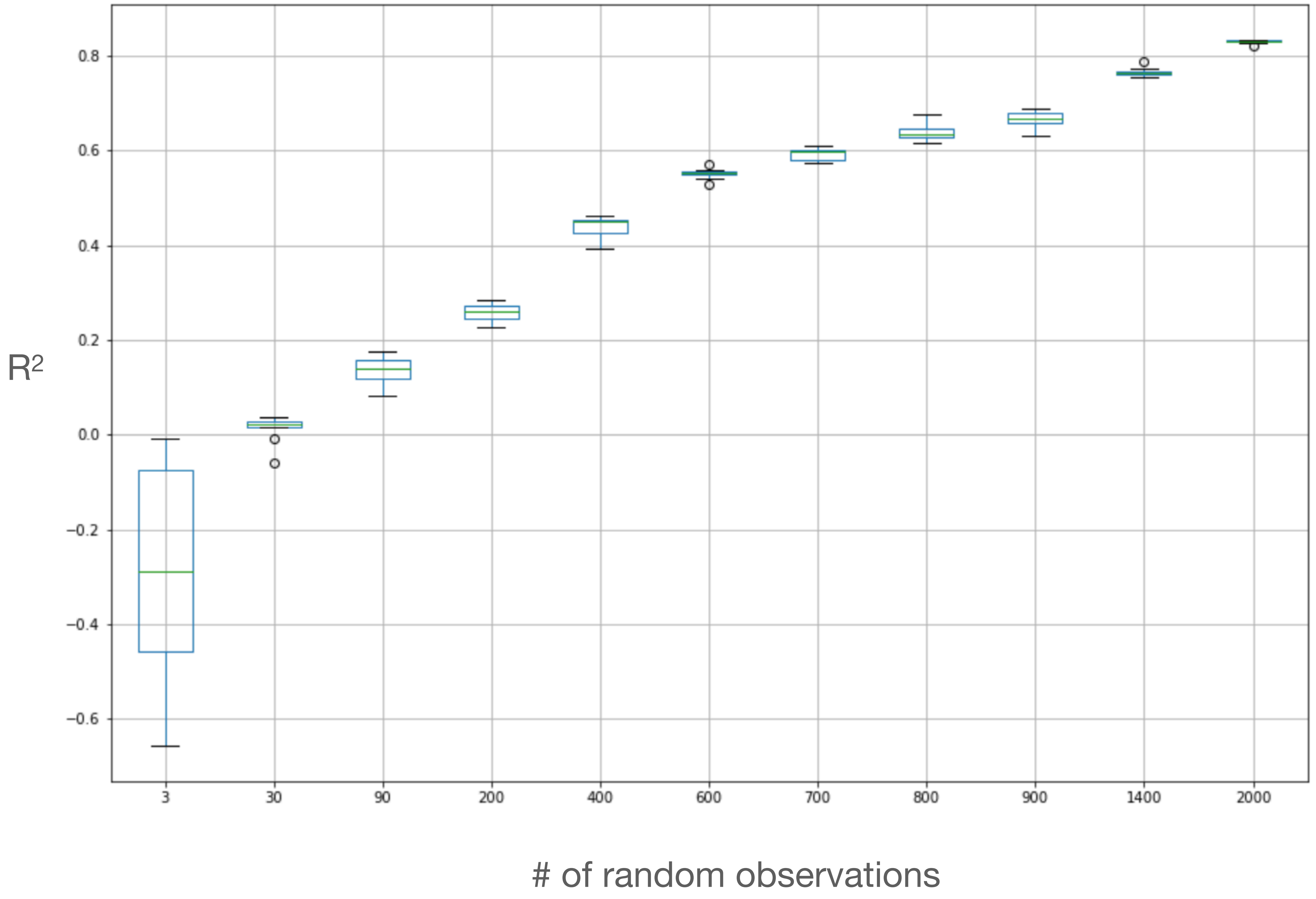


FIG4: 2-D kriging of average velocity over the landslide area using 2000 randomly selected points from InSAR during the snow-free period of 2018.

FIG5: Box plot of kriged R^2 value 10 iterative random samples of various sizes



Broader Impact + Next Steps

Next Steps

- Autocorrelation with physics-based model
- Expand kriging to 3-D to model + project entire landslide mechanism with remote sensing

Broader Impact

- More accessible understanding of natural geohazards
- Joins two methods that compliment each other

References

1. Carolina Seguí and Manolis Veveakis. “Continuous assessment of land-slides by measuring their basal temperature”. In:Landslides18 (12 Dec.2021), pp. 3953–3961.issn: 16125118.doi:10.1007/S10346-021-01762-X/FIGURES/3.url:https://link.springer.com/article/10.1007/s10346-021-01762-x
2. Geoscience Australia. (n.d.). Interferometric Synthetic Aperture Radar. In Geoscience Australia. Retrieved from https://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/geodetic- techniques/interferometric-synthetic-aperture-radar

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