Reversal in Deformation at Aniakchak Volcano, Alaska, after rapid 2023-2024 inflation that followed the 2021 Mw 8.2 Chignik Earthquake

AGU25
New Orleans, LA | 15–19 December 2025

Funding through:
NASA-ECIP award 80NSSC24K1060;
UAF URSA Grant; NSF grants #2152252 and #1855126

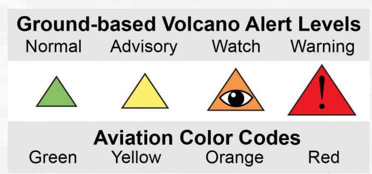
Poster number G13C-0281

Ashley Brant[1], Revathy M. Parameswaran[2], Mario Angarita[3], Ronni Grapenthin[1,2]
[1]Dept. of Geosciences, University of Alaska Fairbanks; [2]Geophysical Institute, University of Alaska Fairbanks; [3]Alaska Satellite Facility, University of Alaska Fairbanks.

Contact: rmparameswaran@alaska.edu

Introduction and Past Work

- Aniakchak Volcano on the Alaska Peninsula exhibited seismic unrest and deformation 18 months after the July 29, 2021 Mw 8.2 Chignik earthquake (Fig. 1).
- The last eruption was in 1931, a mix of explosive and effusive activity, ~0.9 km^3 volume was mostly tephra with deposits as far as 600 km north of the volcano.
- The 2022-2023 inflation was observed with Sentinel-1, ALOS-2 & SAOCOM radar satellites (Figs. 1,2).



- AVO updated its alert level to yellow during the unrest; downgraded to green after June 2023 once the deformation slowed and seismicity weaned.

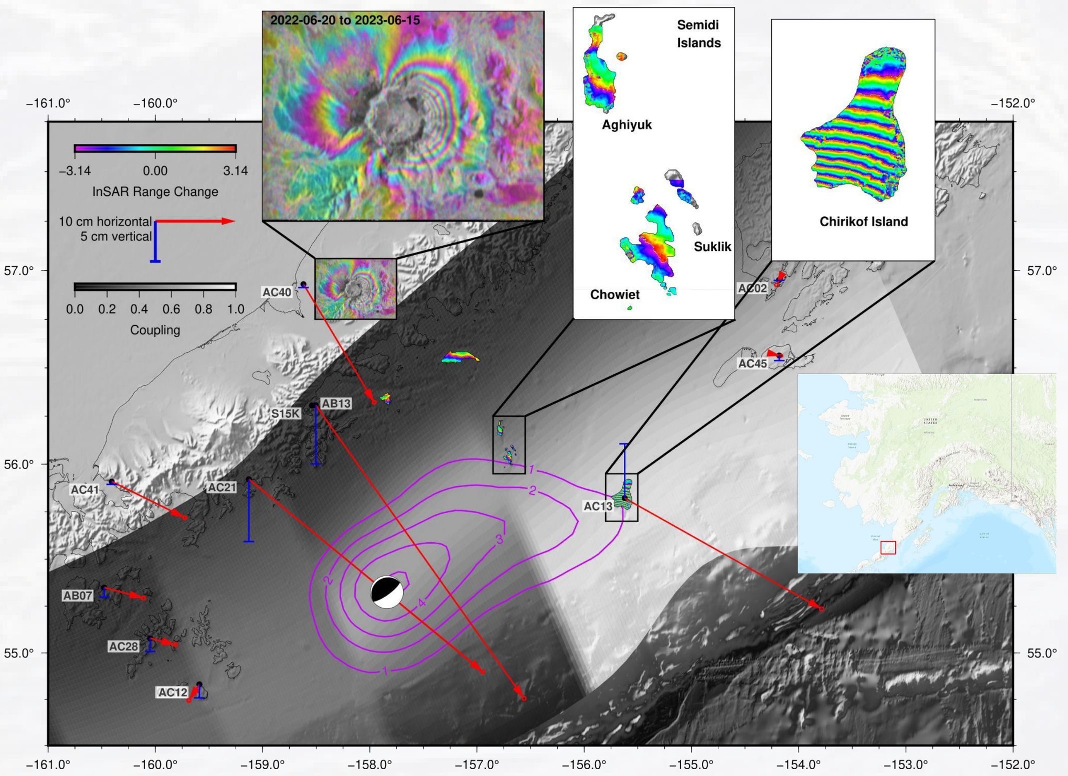


Fig. 1: Sentinel-1 interferogram for Aniakchak spanning 2022-06-20 to 2023-06-15 in the context of co-seismic GNSS displacements and wrapped Sentinel-1 InSAR (2021-07-19, 2021-07-31) due to M8.2 Chignik earthquake (Elliott et al., 2022; Xiao et al., 2021).

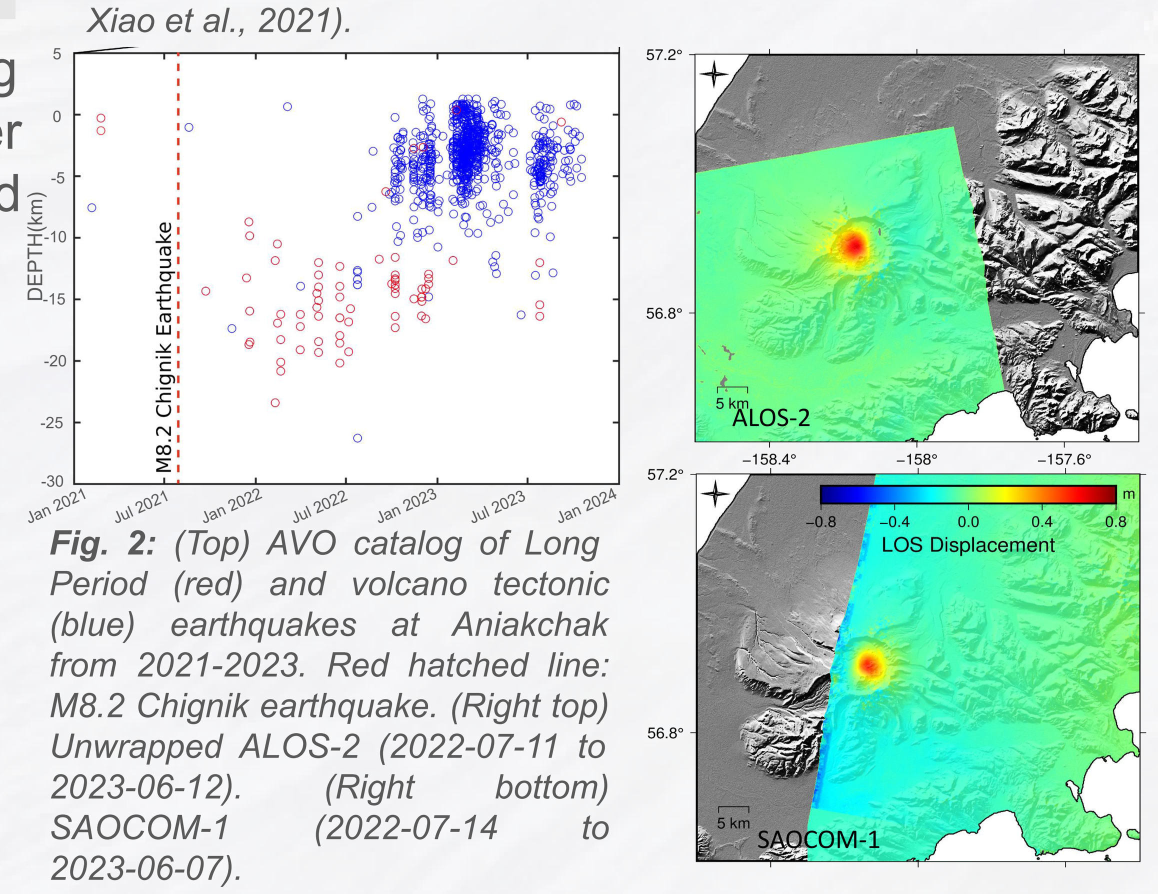
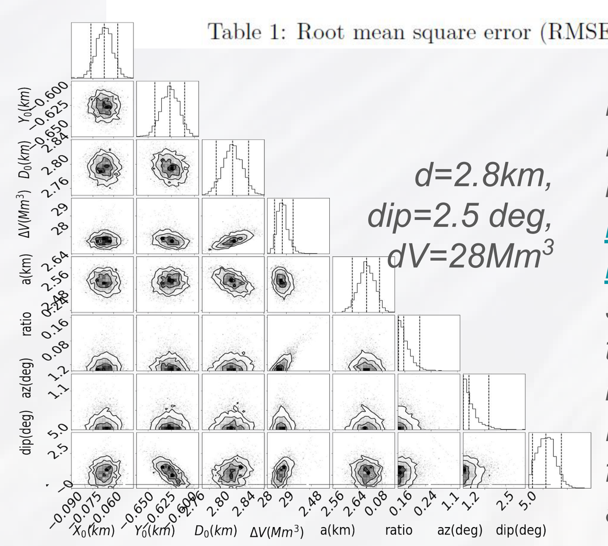


Fig. 2: (Top) AVO catalog of Long Period (red) and volcano tectonic (blue) earthquakes and volcano tectonic from 2021-2023. Red hatched line: M8.2 Chignik earthquake. (Right top) Unwrapped ALOS-2 (2022-07-11 to 2023-06-12). (Right bottom) SAOCOM-1 (2022-07-14 to 2023-06-07).

Model	ALOS 2	SAOCOM 1	Sentinel 1 (220620-230615)	Sentinel 1 (220912-230615)
Spherical	3.72	5.61	1.62	3.26
Spheroidal	3.38	5.12	1.62	3.39
Sill	6.06	7.17	2.17	4.13

Table 1: Root mean square error (RMSE) for the best fitting models in cm/yr.



d=2.8km,
dip=2.5 deg,
dV=28Mm^3

***Fig. 3**: Bayesian inversion tests for the intrusion episode (VMOD https://github.com/uafgeotools/vmod) using Mogi, Yang, Okada sources of 4 InSAR sets shows that the Yang source reduces misfit best. Figure shows Posterior Probability Densities for spheroidal model (diagonal) and parameter correlations (lower half matrix)*

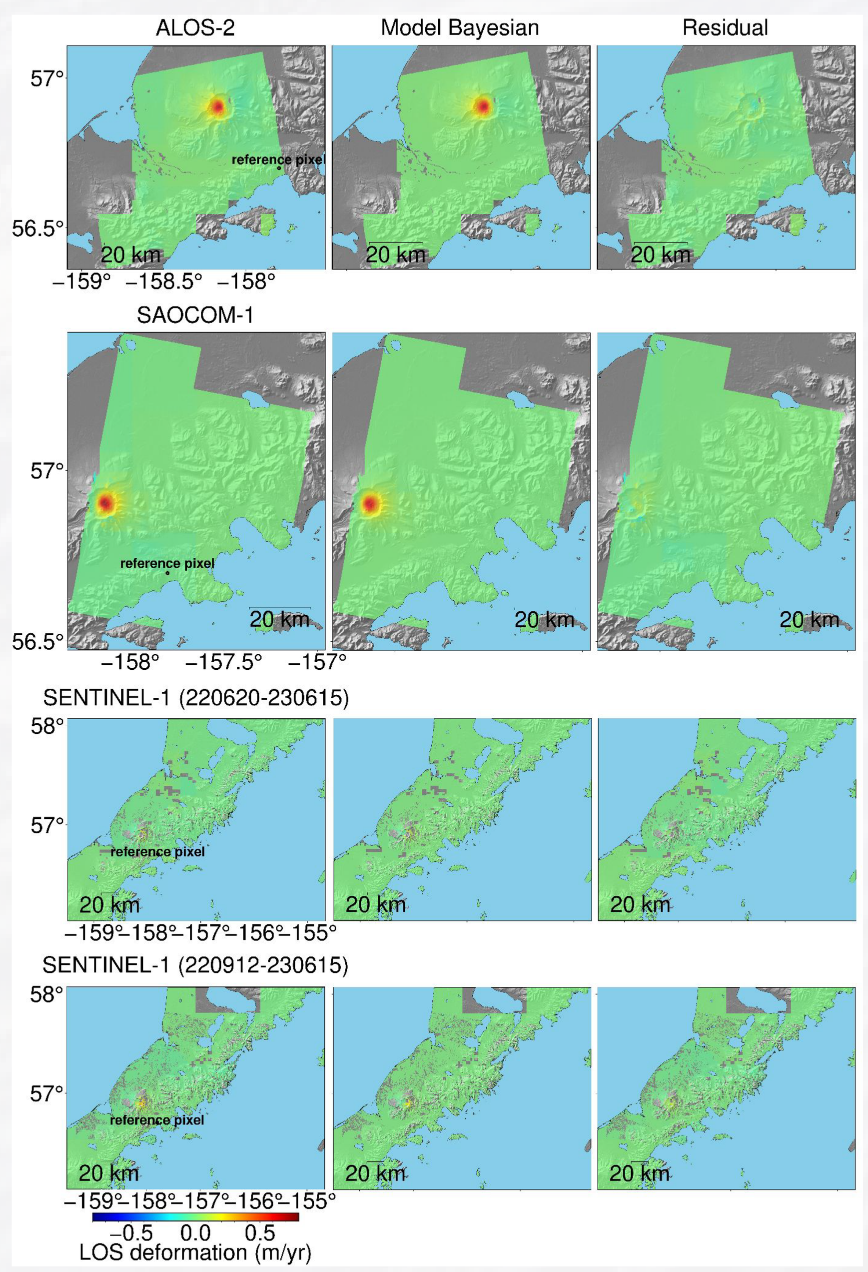


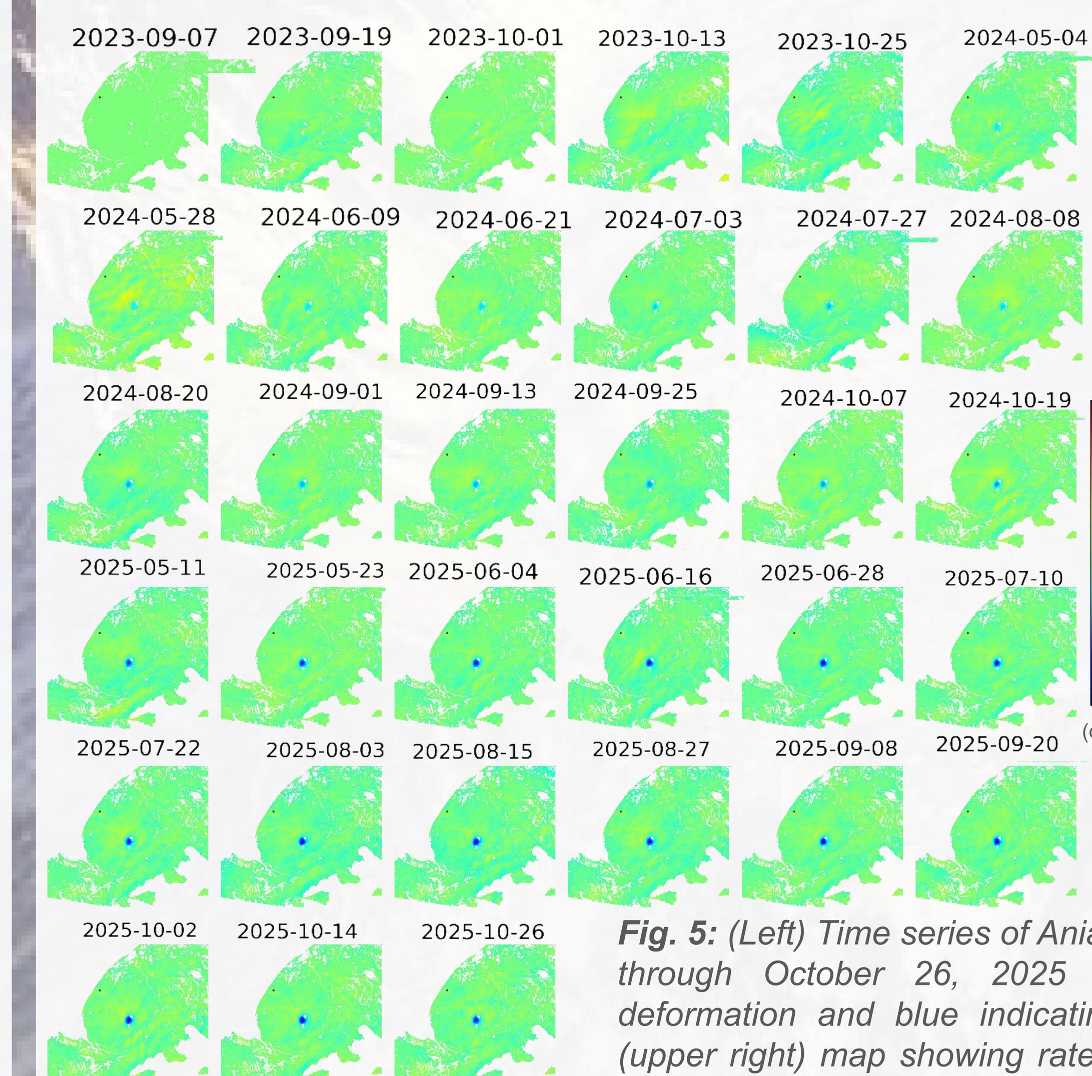
Fig. 4: (Left) Downsampled InSAR data, (Middle) Inversion predictions, (Right) Residuals.

Motivation

What has been going on at Aniakchak since the rapid inflation and what does it mean for the volcano?

InSAR Analysis

- Interferograms pairs for Sentinel-1 SAR images from 2023-09-07 to 2025-10-26 generated using GAMMA through ASF Hyp3 service.
- Deformation timeseries generated with MintPy (Yunjun et al., 2019)
- Cumulative displacement shows that Aniakchak has subsided ~15 cm since September 2023, at a rate of ~6.5-7 cm/yr in LOS.



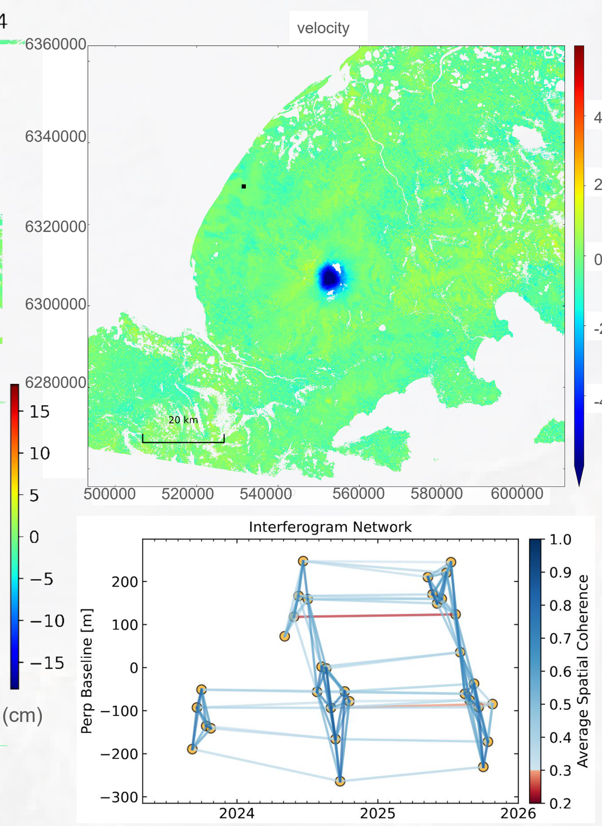


Fig. 5: (Left) Time series of Aniakchak starting at August 20, 2024 through October 26, 2025 with green showing 0 cm of deformation and blue indicating ~15 cm of total deformation, (upper right) map showing rate of deformation per year. (bottom right) Interferogram network showing average coherence.

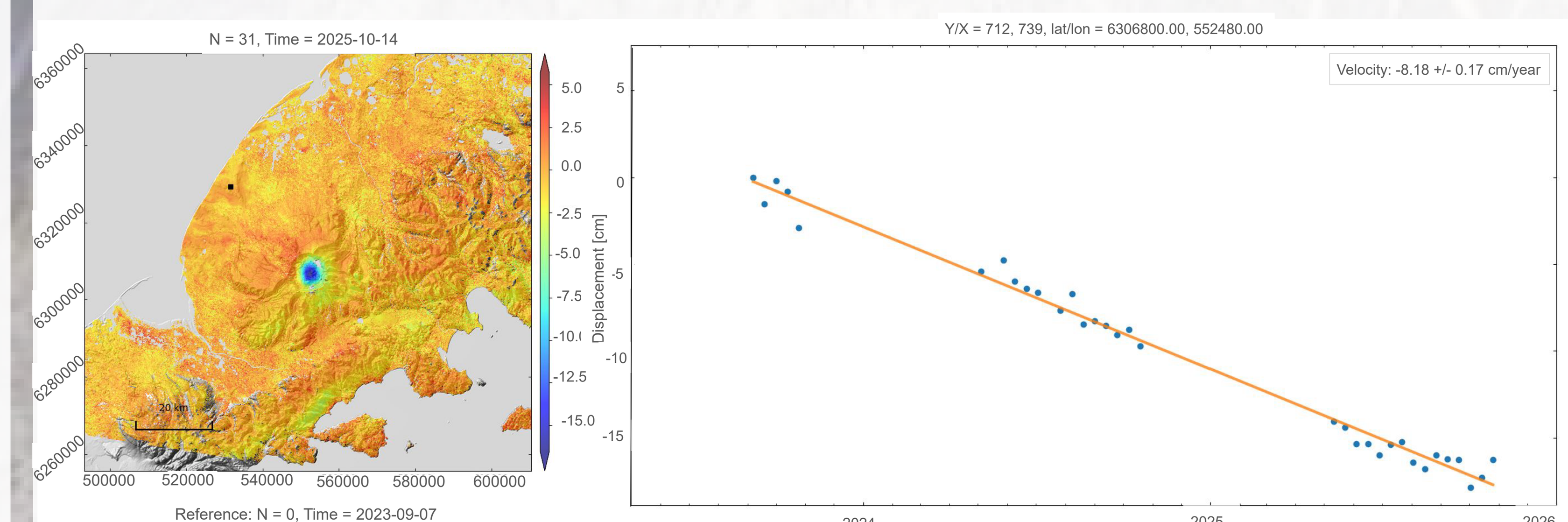
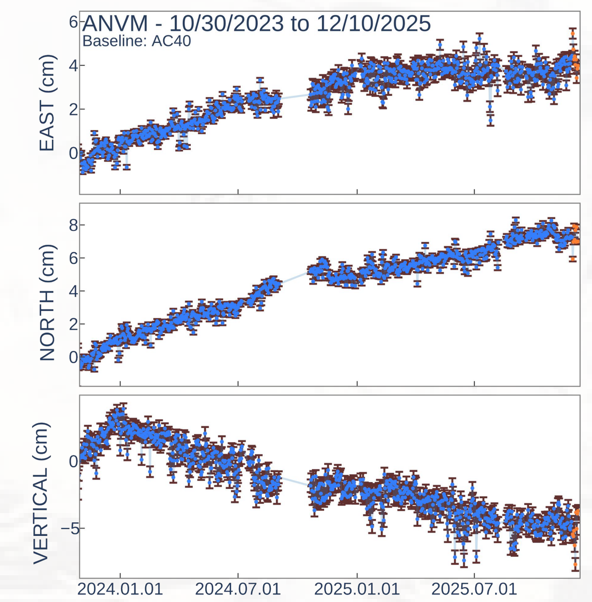
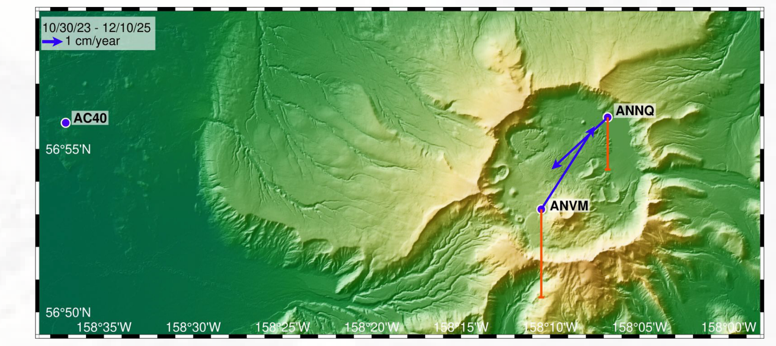


Fig. 6: (Left) map showing cumulative displacement from Sept 7, 2023 to Oct. 14, 2025. Black rectangle is reference pixel. (Right) Timeseries of deformation at center of caldera; orange line is best fitting velocity at this location.

GNSS





- Clear subsidence and inward motion since October 2023 in two AVO cGNSS stations record deflation

Model

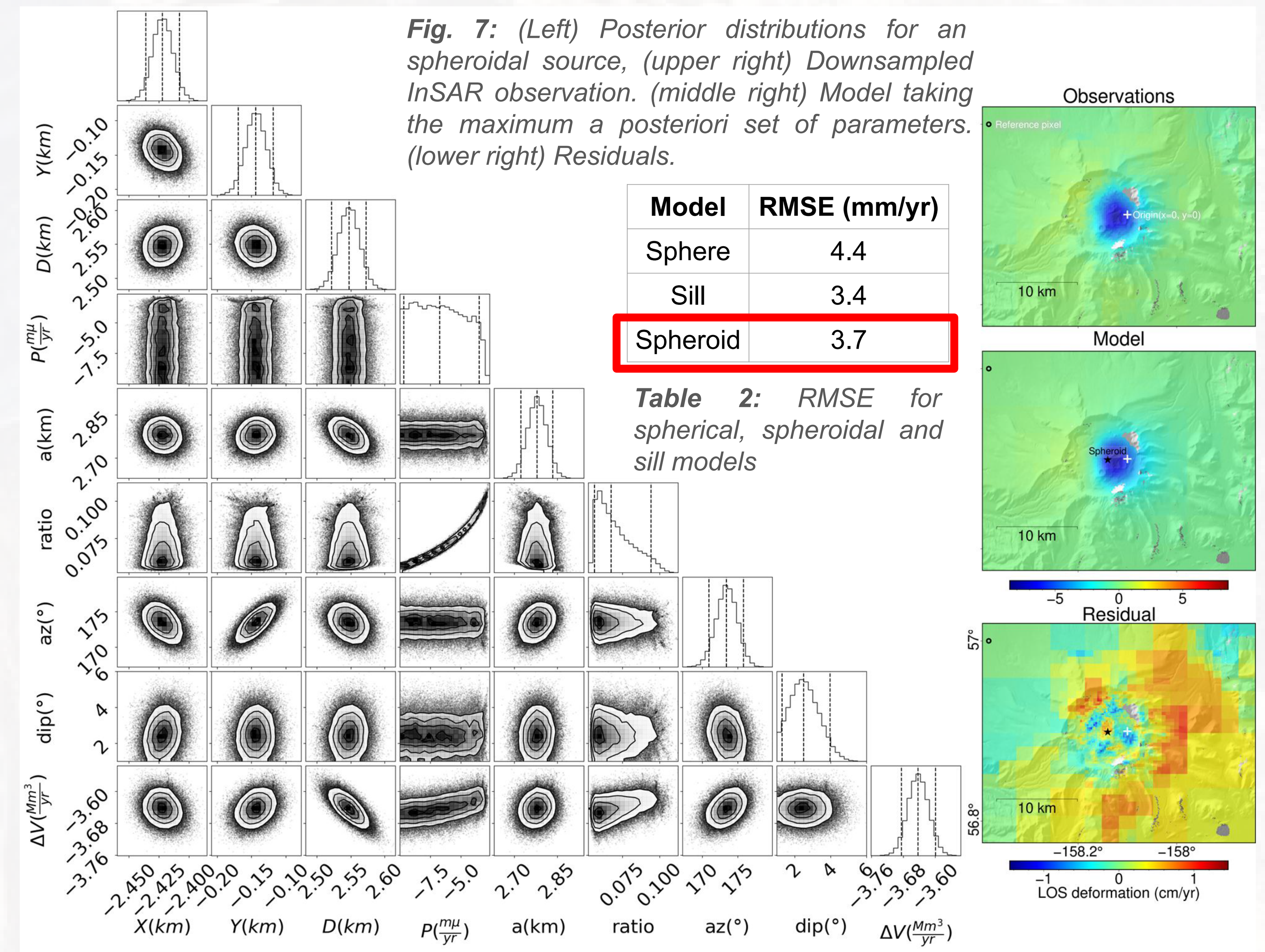


Fig. 7: (Left) Posterior distributions for an spheroidal source, (upper right) Downsampled InSAR observation. (middle right) Model taking the maximum a posteriori set of parameters. (lower right) Residuals.

Model	RMSE (mm/yr)
Sphere	4.4
Sill	3.4
Spheroid	3.7

Table 2: RMSE for spherical, spheroidal and sill models

Conclusions

- Rapid deflation, recorded by InSAR and GNSS, began immediately after inflation
- Source of deflation is the same as for the 2023-2024 inflation
- Deflation likely due to a mix of cooling, crystallization and volatile loss (although no clear degassing signals)

Future work

- Integrate continuous GNSS observations into inversion

Resources:

Grapenthin, R (2023)., Magmatic intrusion at Aniakchak Caldera, Alaska, related to the 2021 M8.2 Chignik earthquake?, vol. 2023, no. 483, Art. no. G43A-0483 || Alaska Volcano Observatory, 2005-2025, Alaska Volcano Observatory website: http://www.avo.alaska.edu | Elliott, J. (2022), Cascading rupture of a megathrust, Sci. Adv. 8, DOI: 10.1126/sciadv.abm4131 | Zhuohui Xiao, Z. (2021), The deep Shumagin gap filled: Kinematic rupture model and slip budget analysis of the 2020 Mw 7.8 Simeonof earthquake constrained by GNSS, global seismic waveforms, and floating InSAR, Earth and Planetary Science Letters, vol 576, https://doi.org/10.1016/j.epsl.2021.117241. | Mogi (1958), Relations between the eruptions of various volcanoes and the deformations of the ground surface around them, Bull. Earthquake Res. Inst. Univ. Tokyo, 36, 99– 134 | Okada, Y. (1985). Surface deformation due to shear and tensile faults in a half-space. BSSA, 75(4), pp.1135-1154 | Yang et al. (1988). Deformation from inflation of a dipping finite prolate spheroid in an elastic half-space as a model for volcanic stressing.JGR, 93(B5), pp.4249-4257. | McTigue, D.F. and Mei, C.C. (1987), Gravity-induced stresses near axisymmetric topography of small slope. Int. J. Numer. Anal. Meth. Geomech., 11: 257-268. https://doi.org/10.1002/nag.1610110304