Synthesis of volcano deformation from global SAR datasets – implications for volcano monitoring

Ebmeier SK; Andrews BJ; Araya MC; Arnold DWD; Biggs J; Cooper C; Cottrell E; Furtney M; Hickey J; Jay J; Lloyd R; Parker AL; Pritchard ME; Robertson E; Venzke E; Williamson JL (2018)

The Leverhulme Trust

European Space Agency

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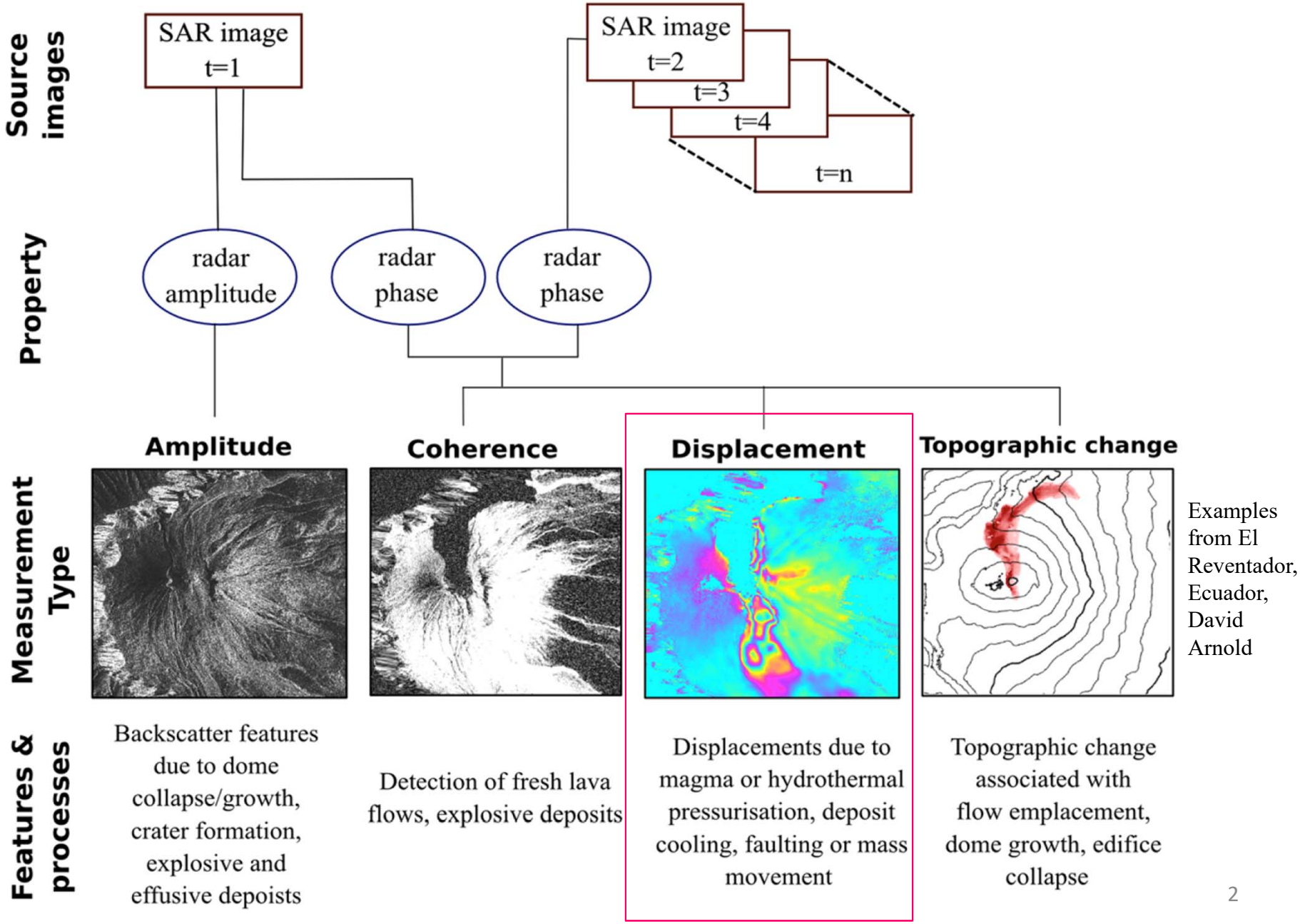
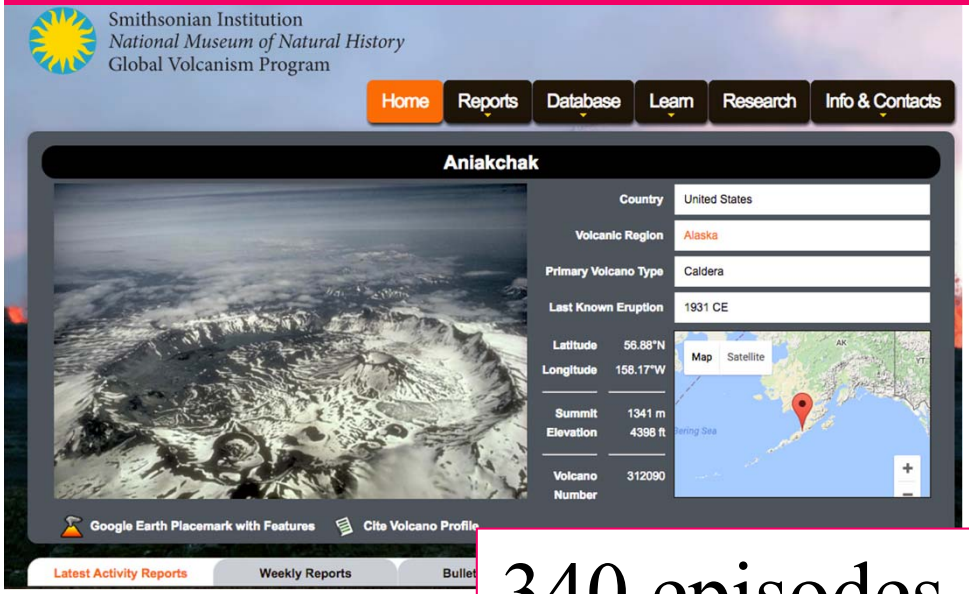
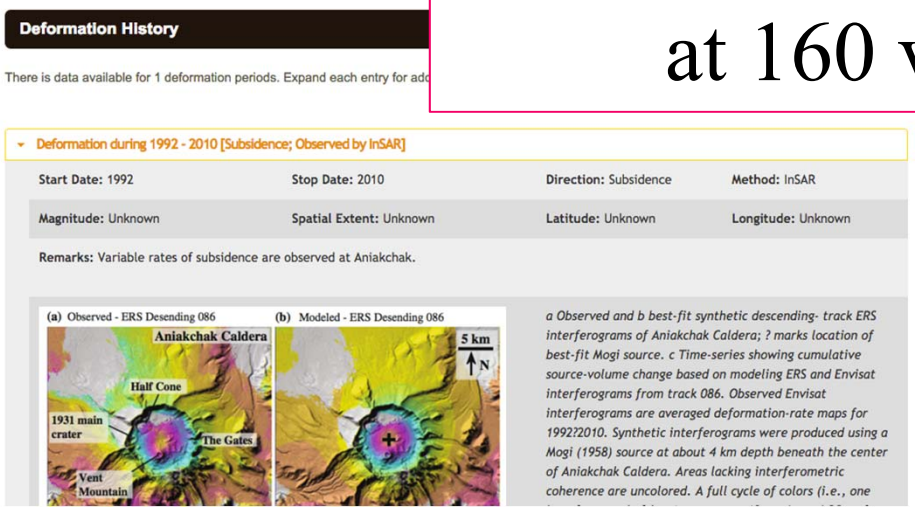
COMET

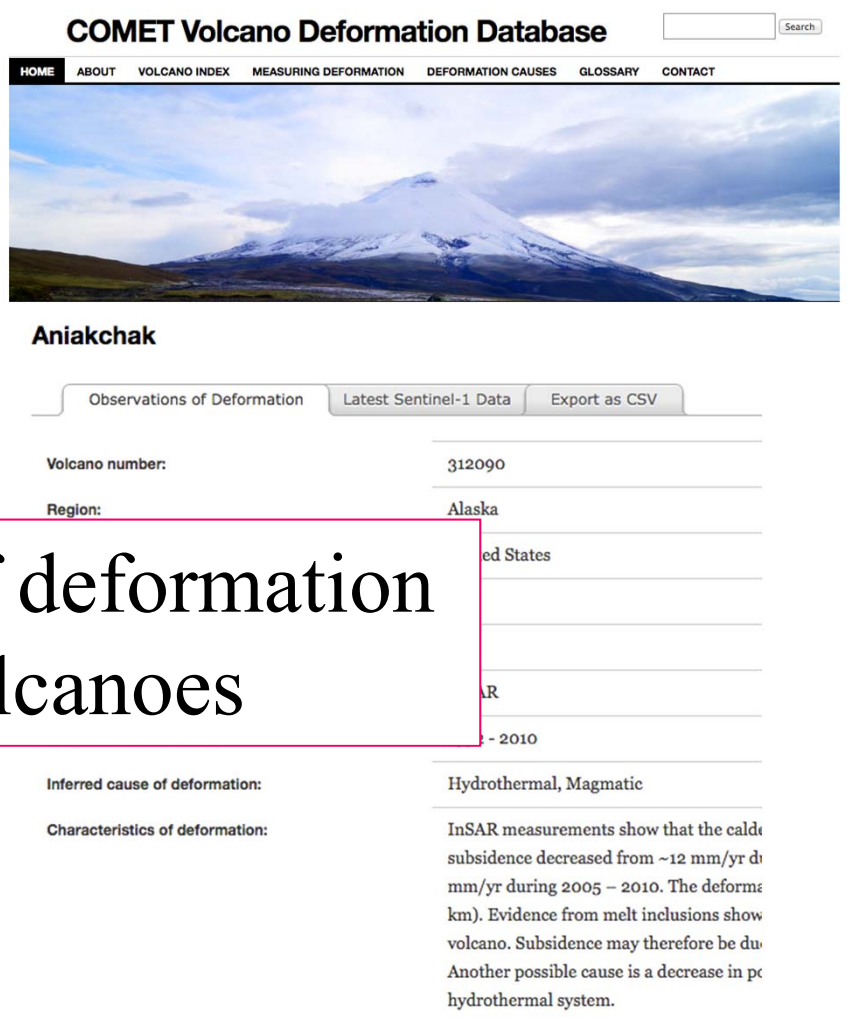


Examples from El Reventador, Ecuador, David Arnold





340 episodes of deformation at 160 volcanoes



Global Volcano Programme Database, hosted by the Smithsonian Institution. Jennifer Jay, Matt Pritchard, Maria Furtney, Ben Andrews, Ed Venzke

COMET catalogue: Susanna Ebmeier, Juliet Biggs, Amy Parker, James Hickey, David Arnold, Ryan Lloyd & Elspeth Robertson – Sentinel-1 images from Fabien Albino

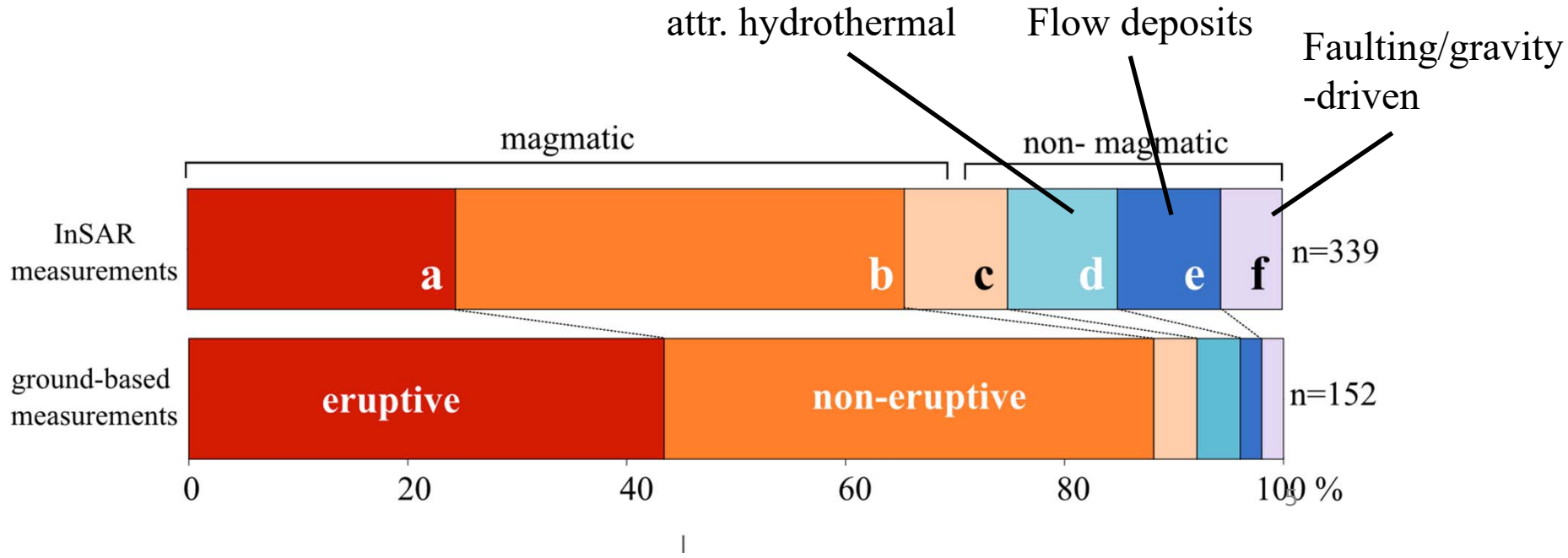
1. What type of deformation is detectable using InSAR and what are we missing?

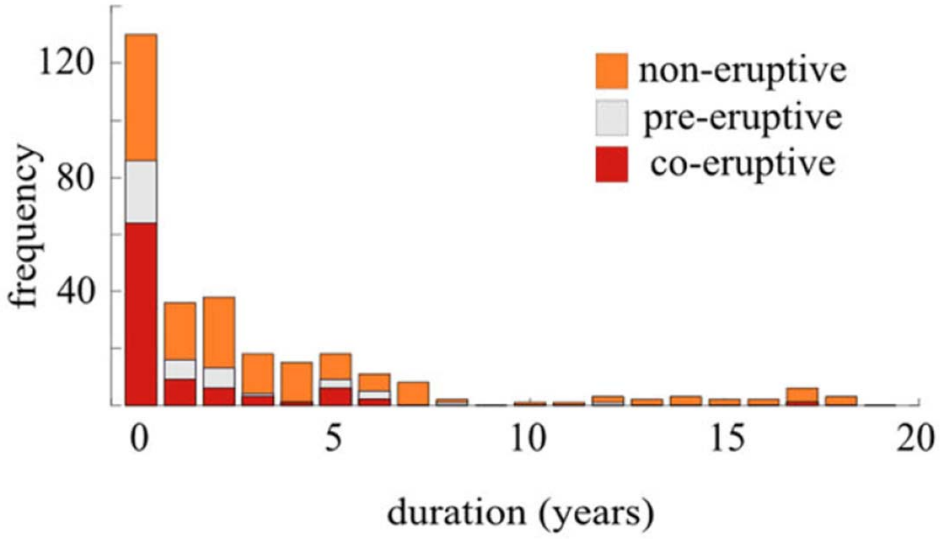
2. What are the 'baseline' characteristics of InSAR-measured volcano deformation?

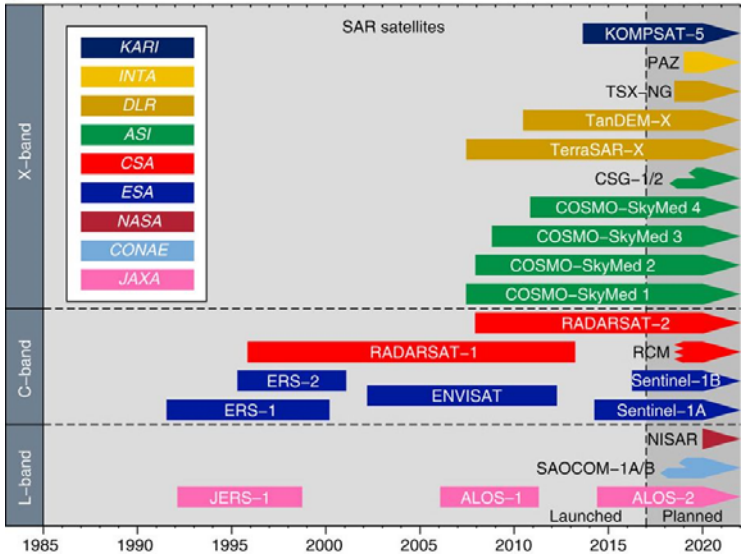
InSAR measurement record completeness

Comparison to ground-based measurements

• Higher proportion of InSAR measurements capture non-magmatic and non-eruptive processes than ground based measurements

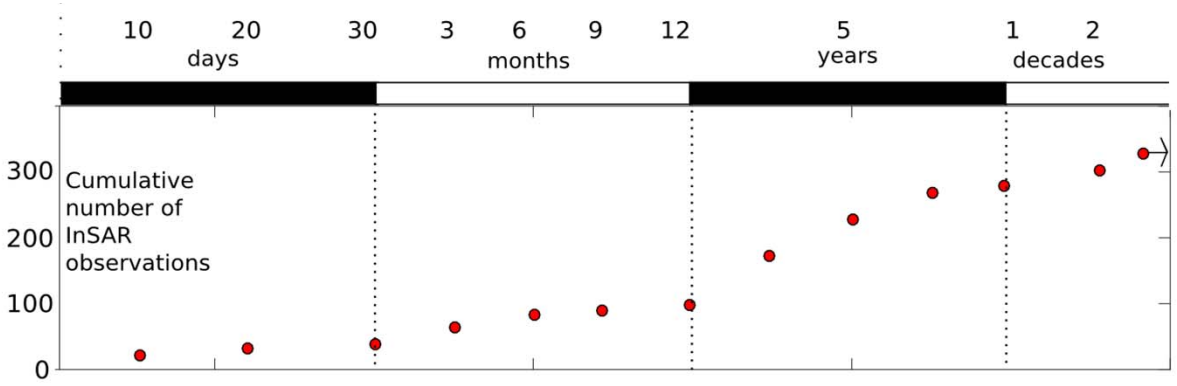




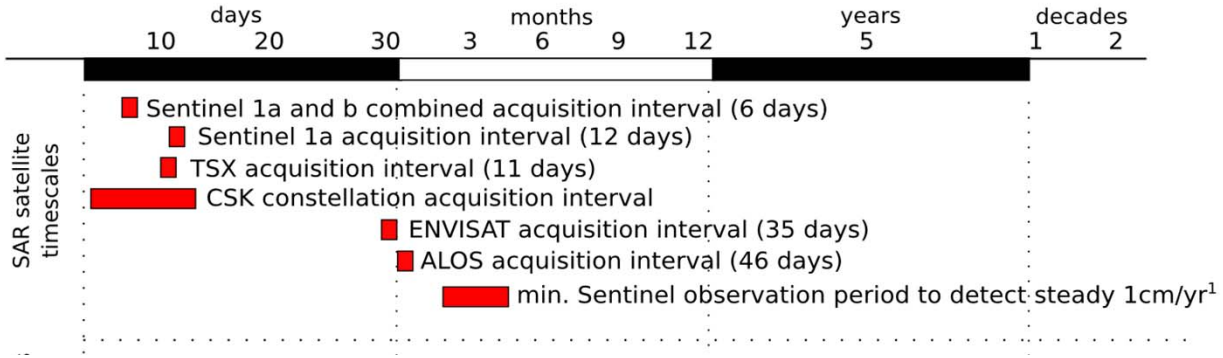


Elliott et al., 2016

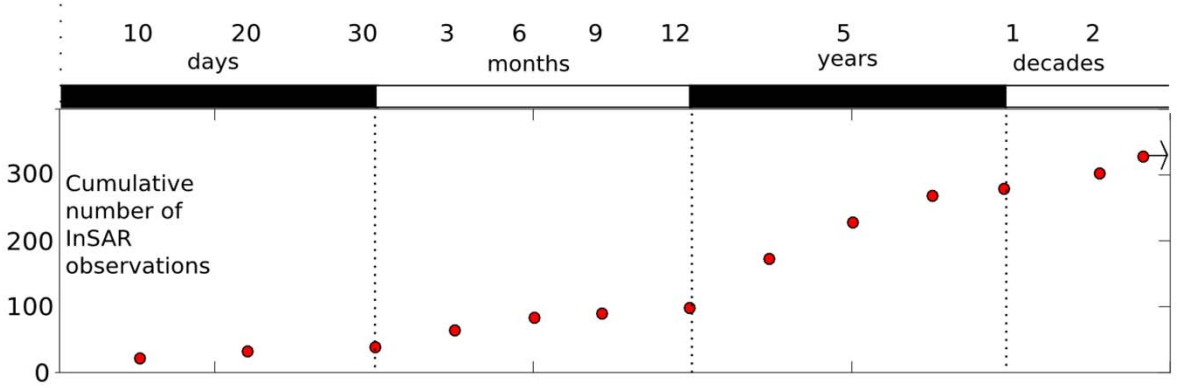
- 20% of deformation events thought to last longer than measurement window
- Long duration (> decades) and short (< month) events are under-sampled



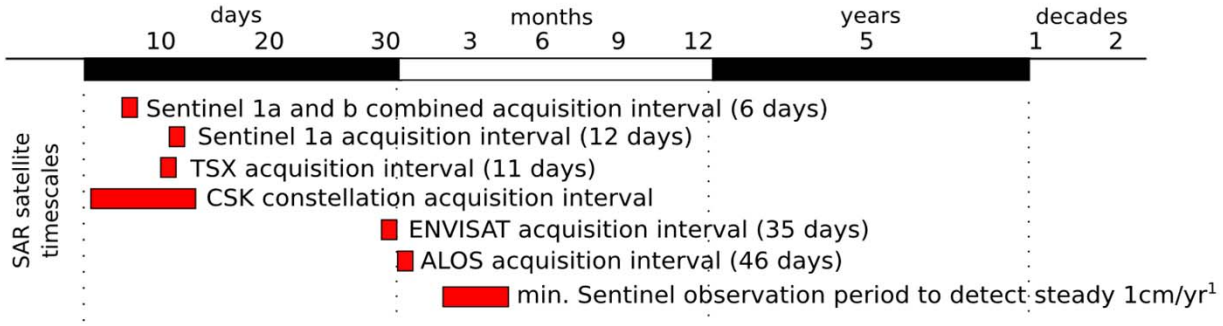
Satellite radar repeat intervals



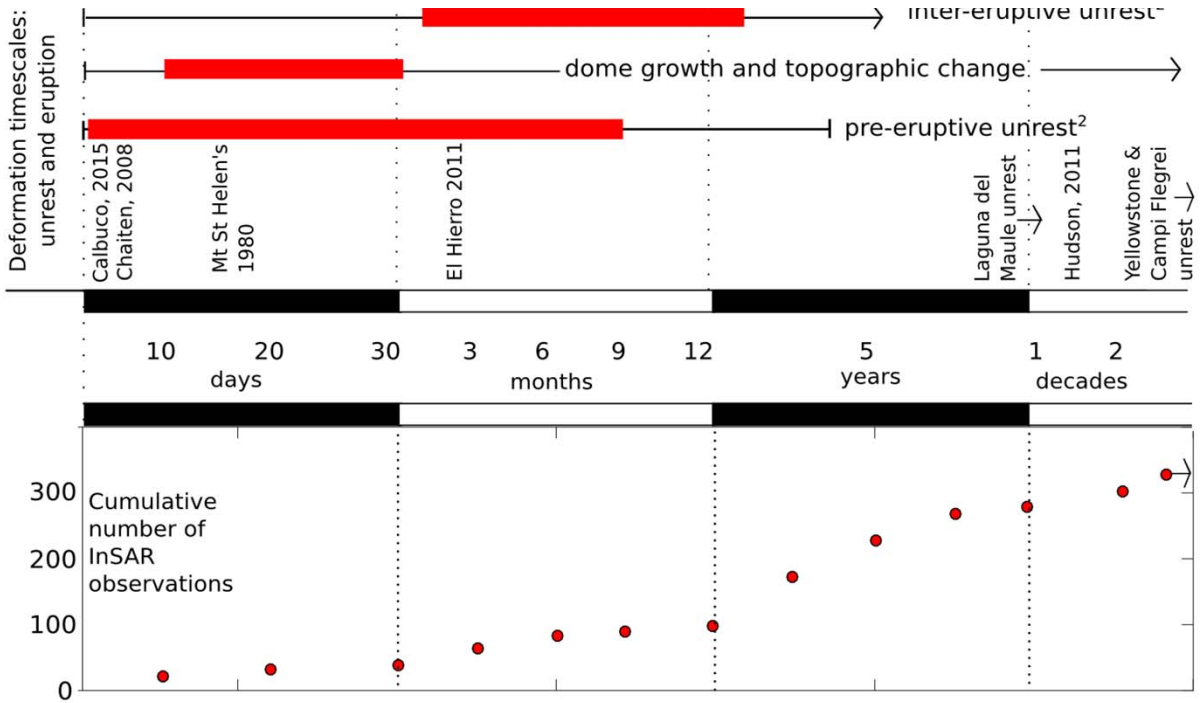
Number of InSAR measurements



Satellite radar repeat intervals



timescales for unrest and eruption



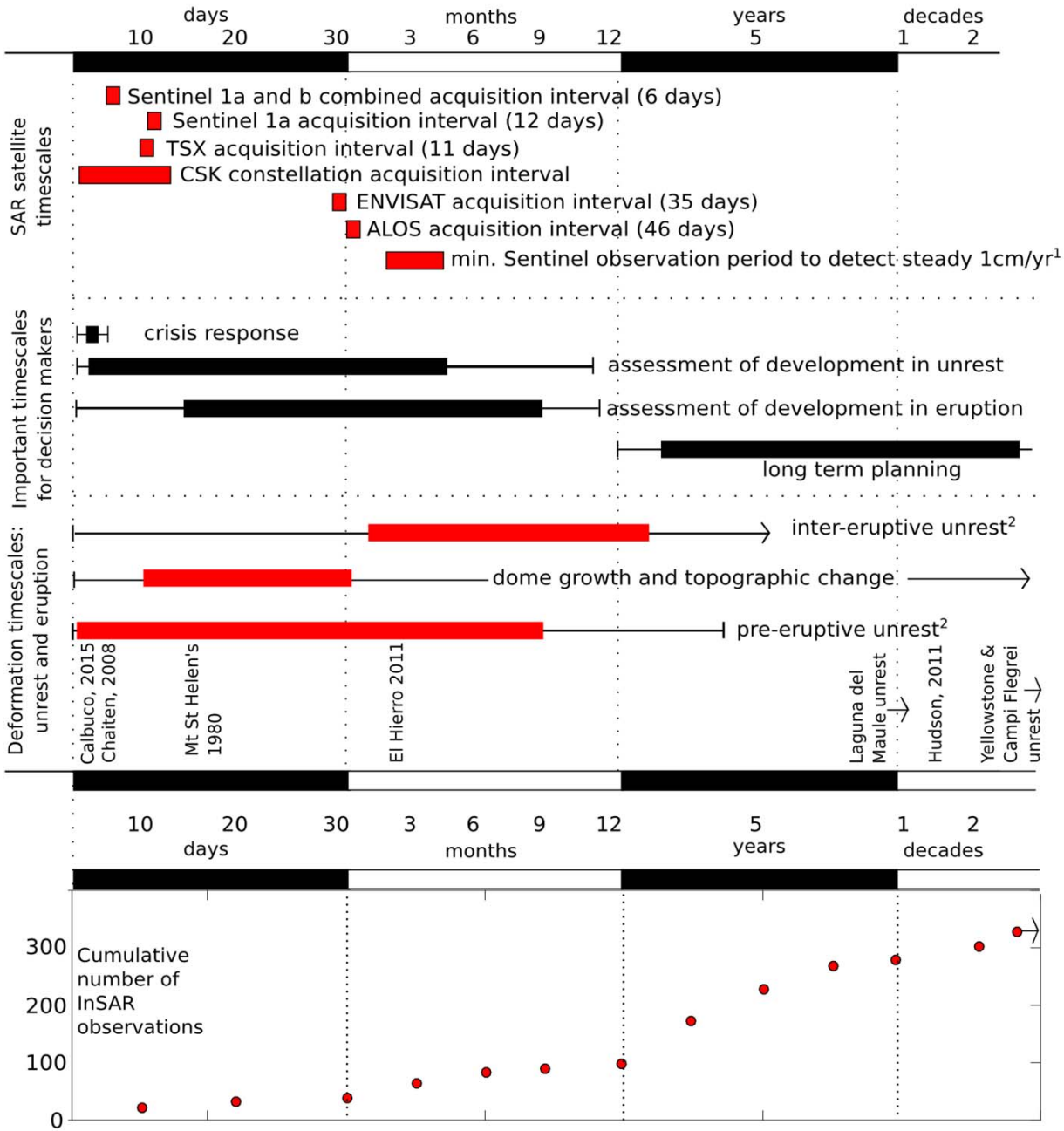
Number of InSAR measurements

Satellite radar repeat intervals

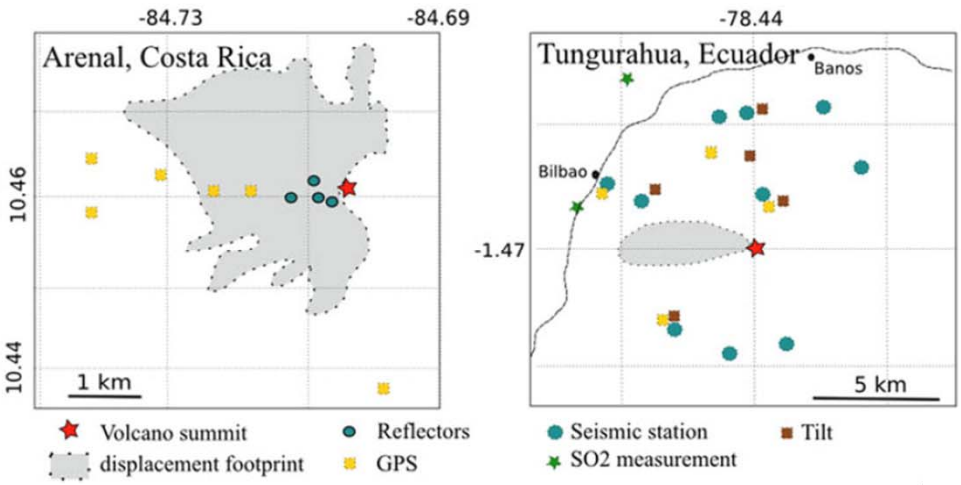
timescales for decision making

timescales for unrest and eruption

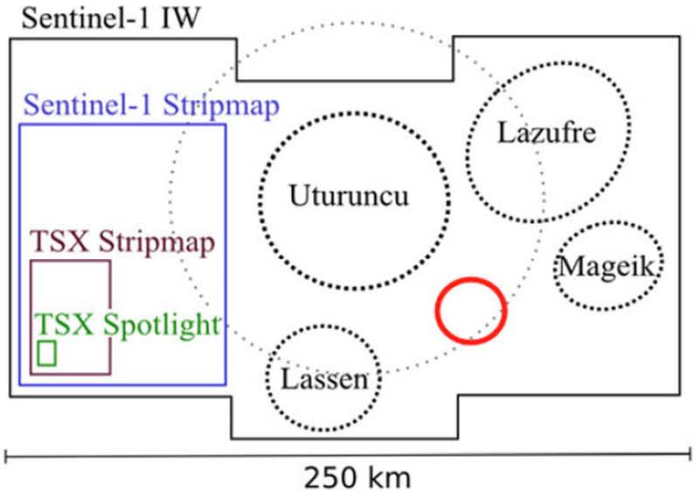
Number of InSAR measurements

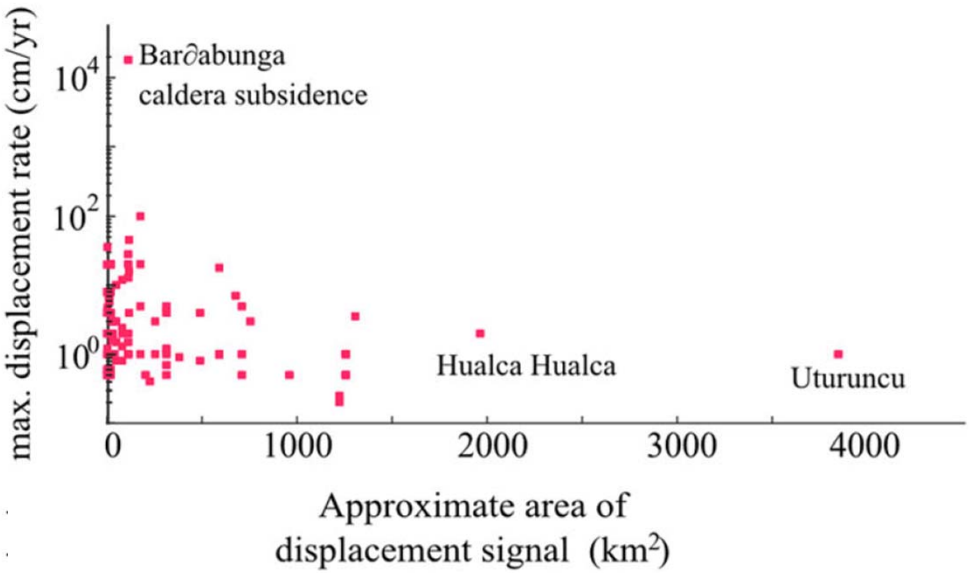


Deformation footprint within monitoring network

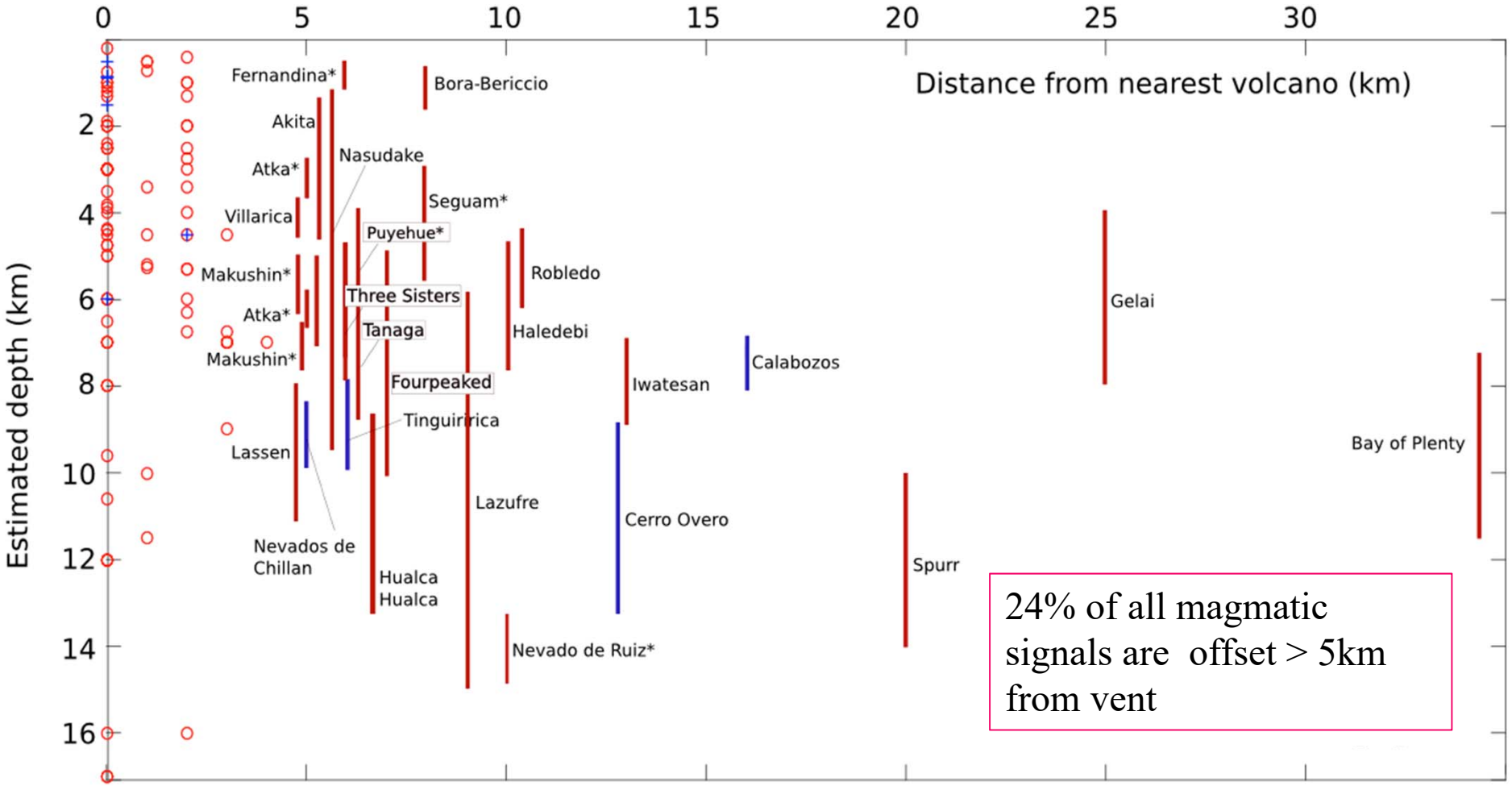


Deformation area > satellite swath

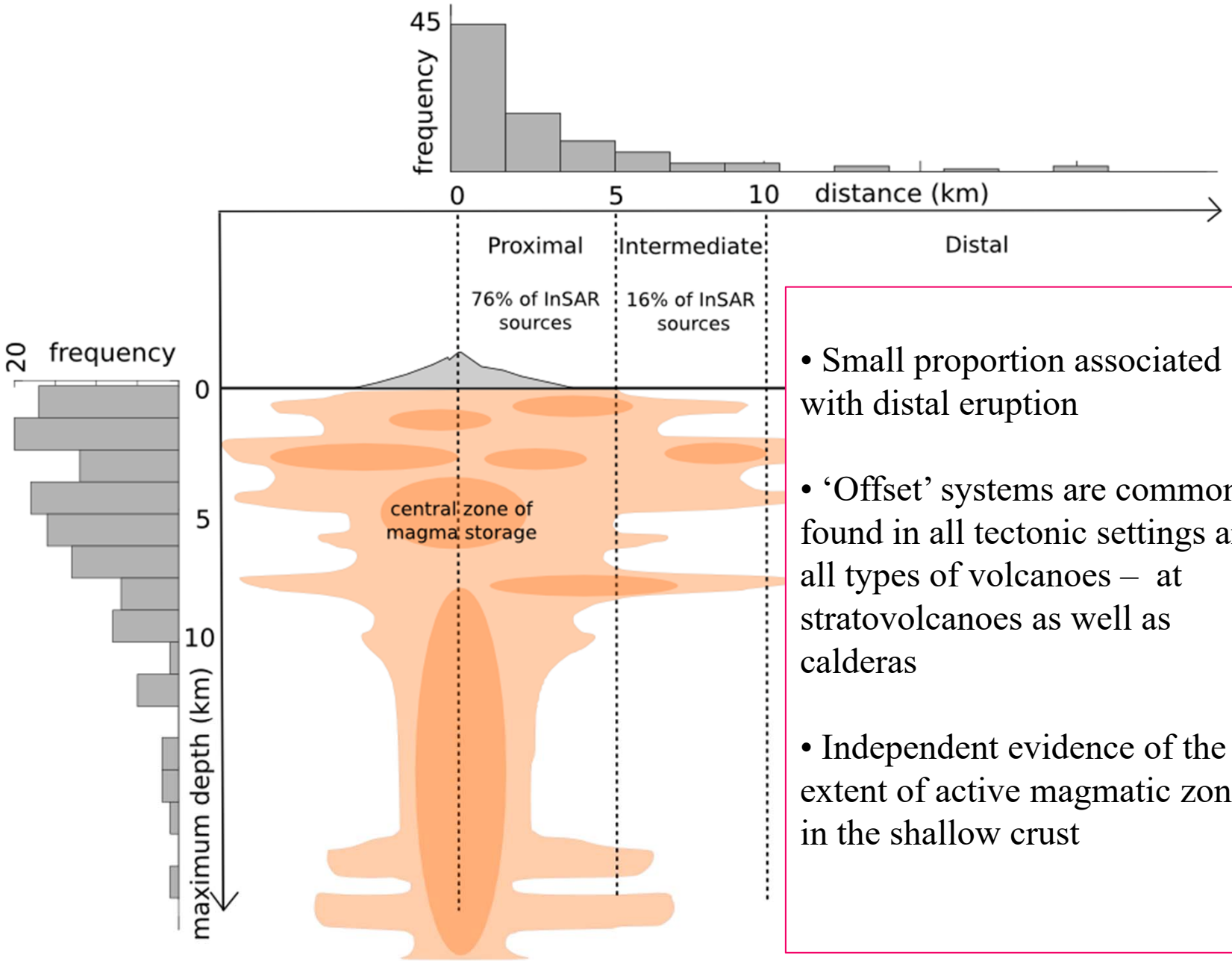




Laterally 'offset' deformation



24% of all magmatic signals are offset > 5km from vent



- Small proportion associated with distal eruption
- 'Offset' systems are common, found in all tectonic settings and all types of volcanoes – at stratovolcanoes as well as calderas
- Independent evidence of the extent of active magmatic zones in the shallow crust

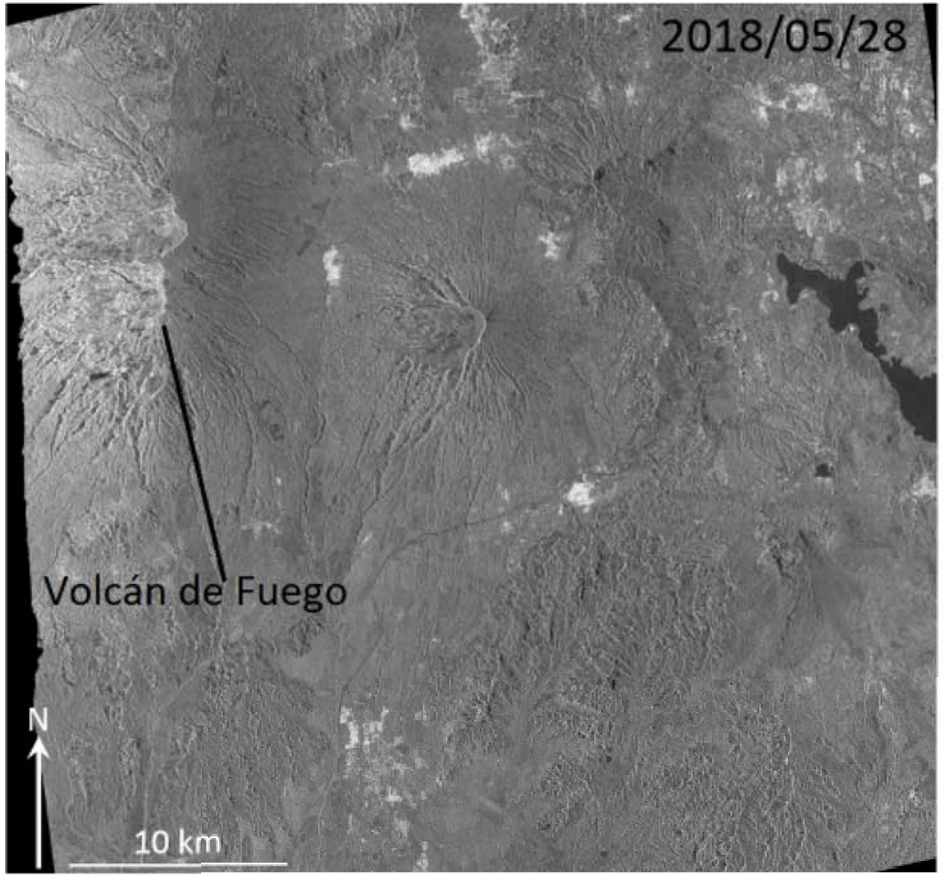
Implications for volcano monitoring

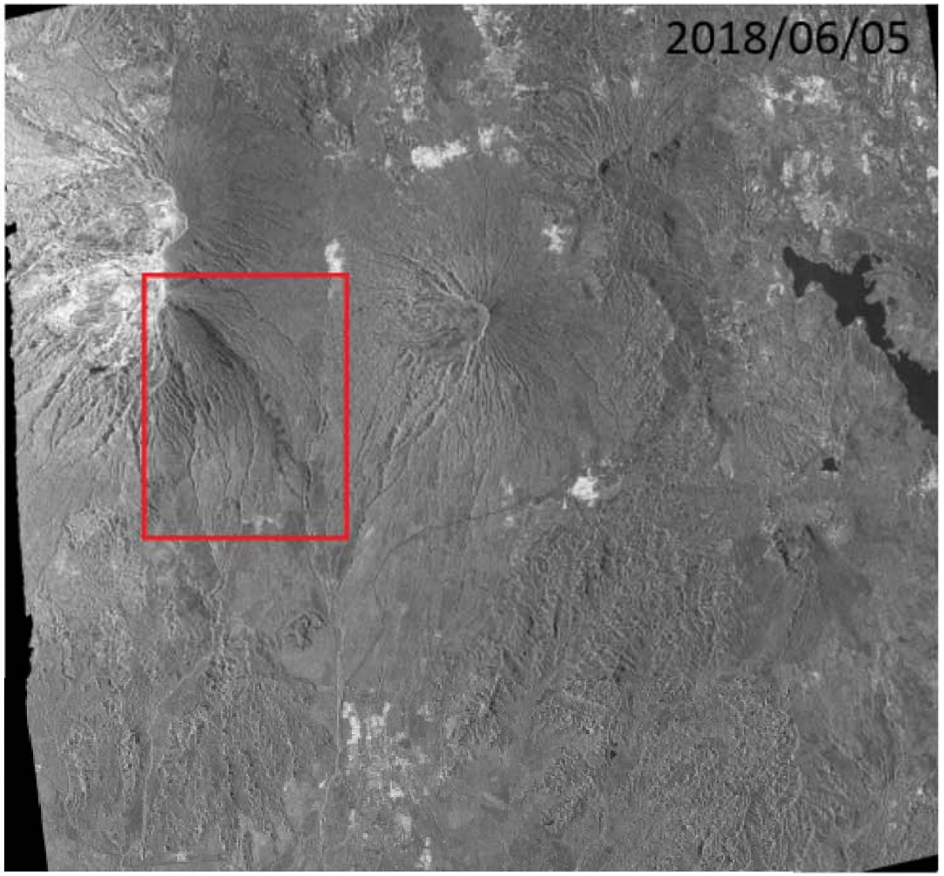
'Modal' historical volcanic InSAR signal has been:

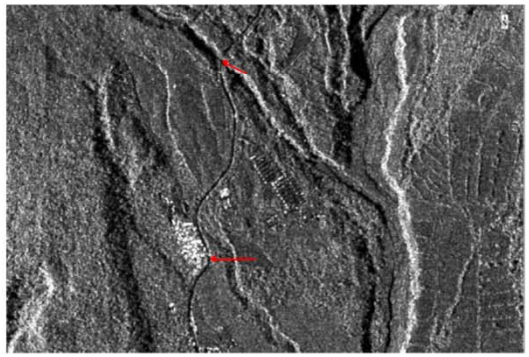
(1) located in the shallow crust, < 5 km
(2) area < 100 km^2, rate cm/yr
(3) attributed to magmatic/hydrothermal fluids
(4) not linked to eruption

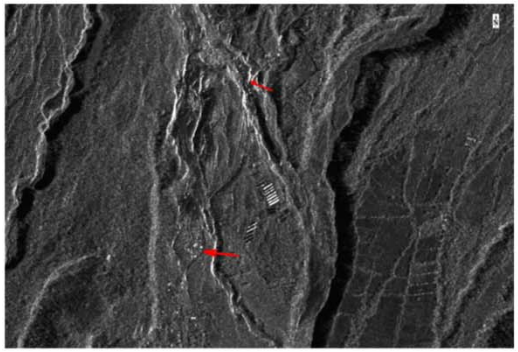
Observation	Recommendation
24% magmatic/hydrothermal deformation offset by > 5km	'Survey-mode' measurements or Search radii > 20 km would have discovered 90% of database observations
Rapid near-vent deformation is under-represented in InSAR record	Data from constellations or multiple satellite needed for monitoring

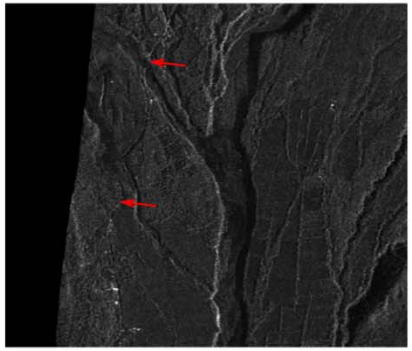
CSK imagery spanning Fuego eruptions











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Reference:

• Ebmeier SK; Andrews BJ; Araya MC; Arnold DWD; Biggs J; Cooper C; Cottrell E; Furtney M; Hickey J; Jay J; Lloyd R; Parker AL; Pritchard ME; Robertson E; Venzke E; Williamson JL (2018) Synthesis of global satellite observations of magmatic and volcanic deformation: implications for volcano monitoring & the lateral extent of magmatic domains, Journal of Applied Volcanology, 7.