

# Post-diking deformation at Harrat Lunayyir (Saudi Arabia) from InSAR

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## Aim and objectives

How is the displacement evolution after a dike intrusion? Here we used InSAR to analyze displacement within the dike induced graben in Harrat Lunayyir from just after it formed in 2009 until now.

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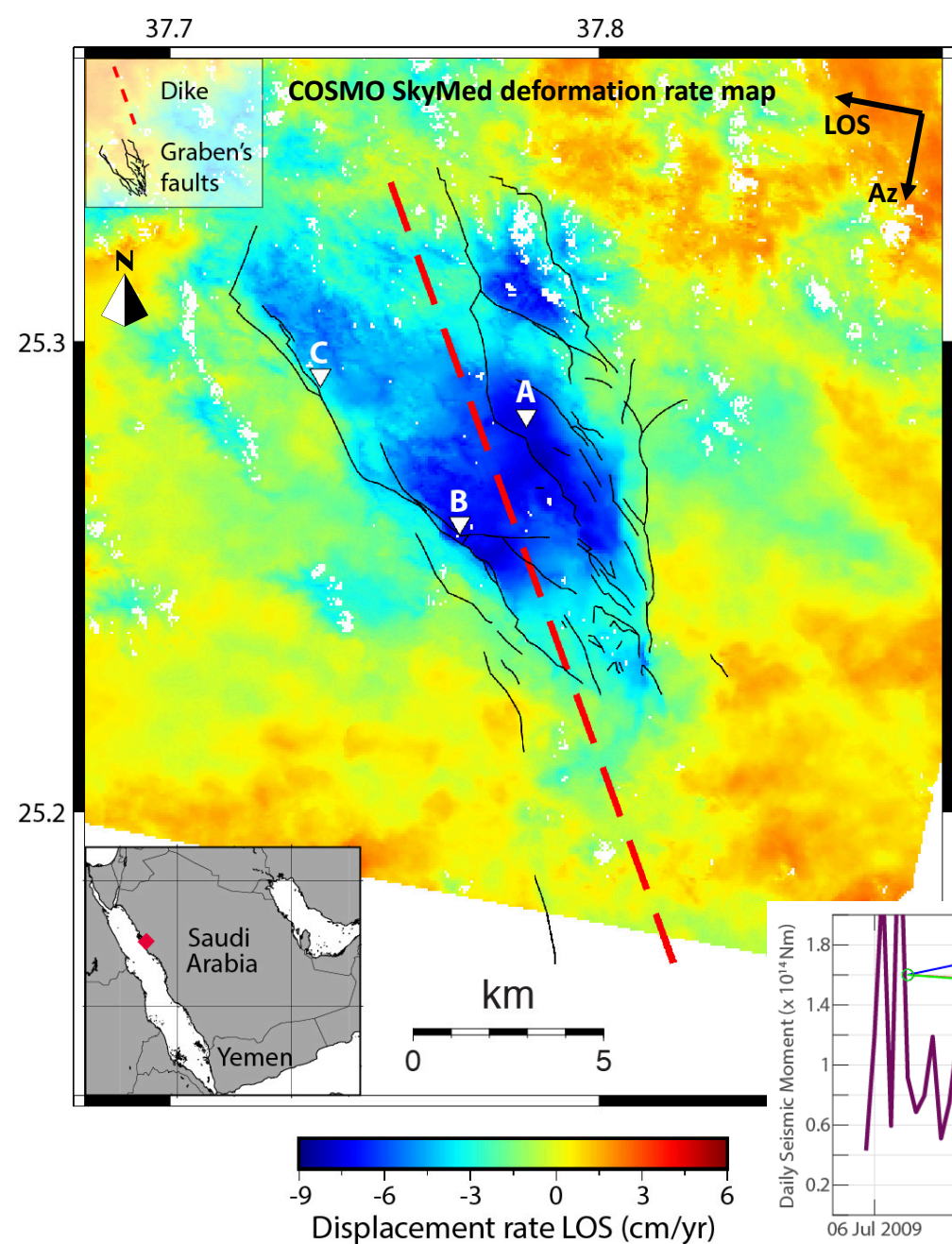
King Abdullah University of  
Science and Technology

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ALOS-1 interferogram  
Oct 2008 – Aug 2009  
Co-diking deformation



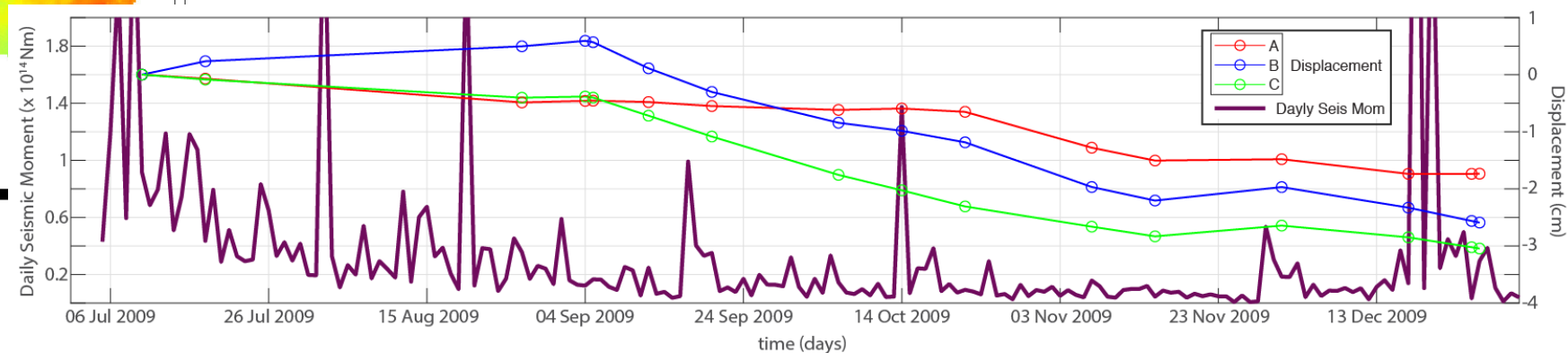




# Early post-diking deformation

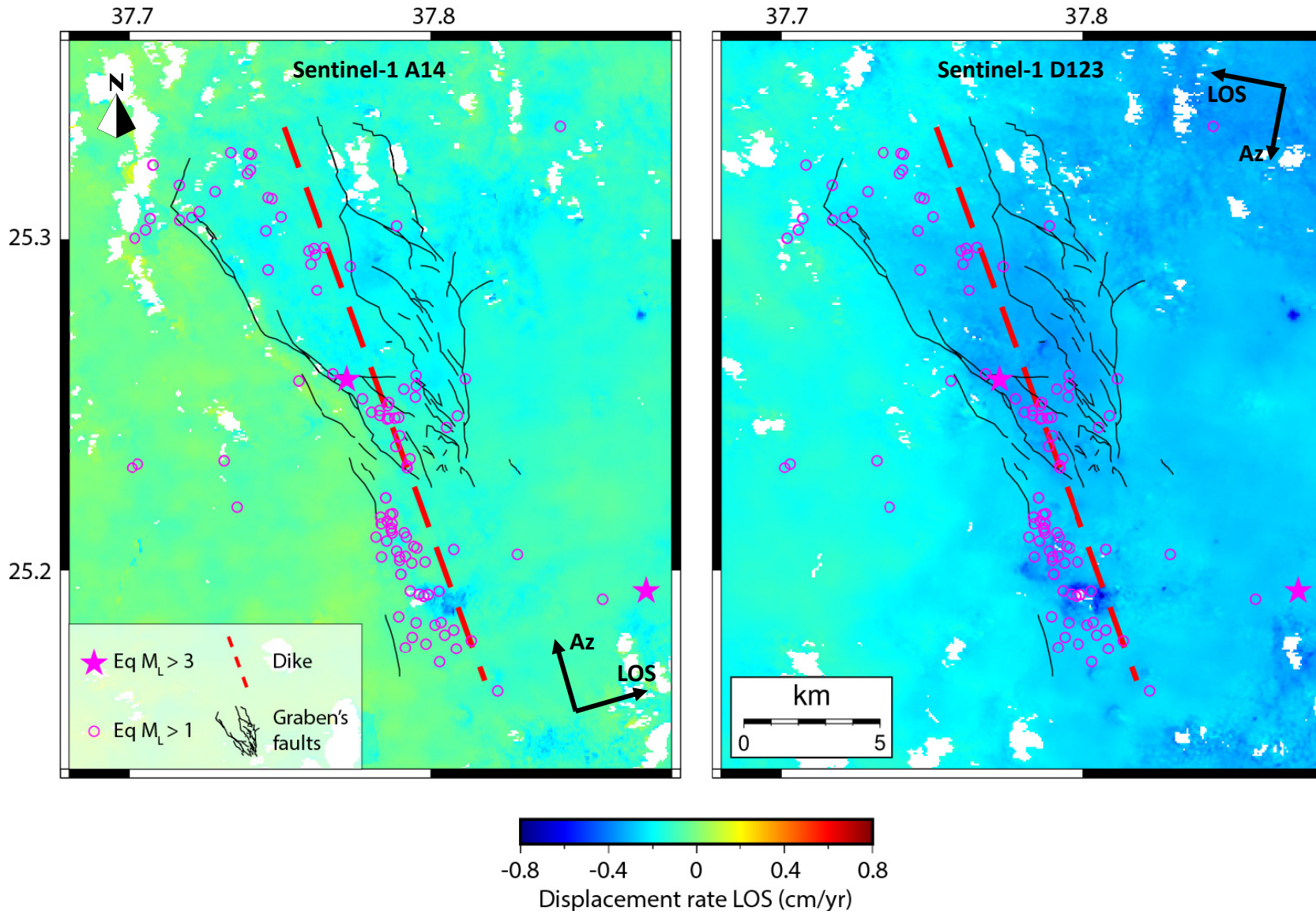
10 July – 26 December 2009

- Subsidence within the graben up to 8 cm/yr
- Seismic moment release generally decreased with from July to December 2009
- The overall seismic moment too small to explain observed deformation



# Long-term post-diking deformation

June 2015 – March 2019



- Subsidence within the graben up to 4 mm/yr (only 5% of the rate in 2009)
- Steady ground deformation
- Steady background seismicity with  $M_L < 1.5$  in general and sporadic larger events
- Total seismic moment release for 2015-2019 corresponds to a single  $M_w = 3.5$  earthquake
- The seismicity also cannot explain the observed deformation for this time period

# Discussions

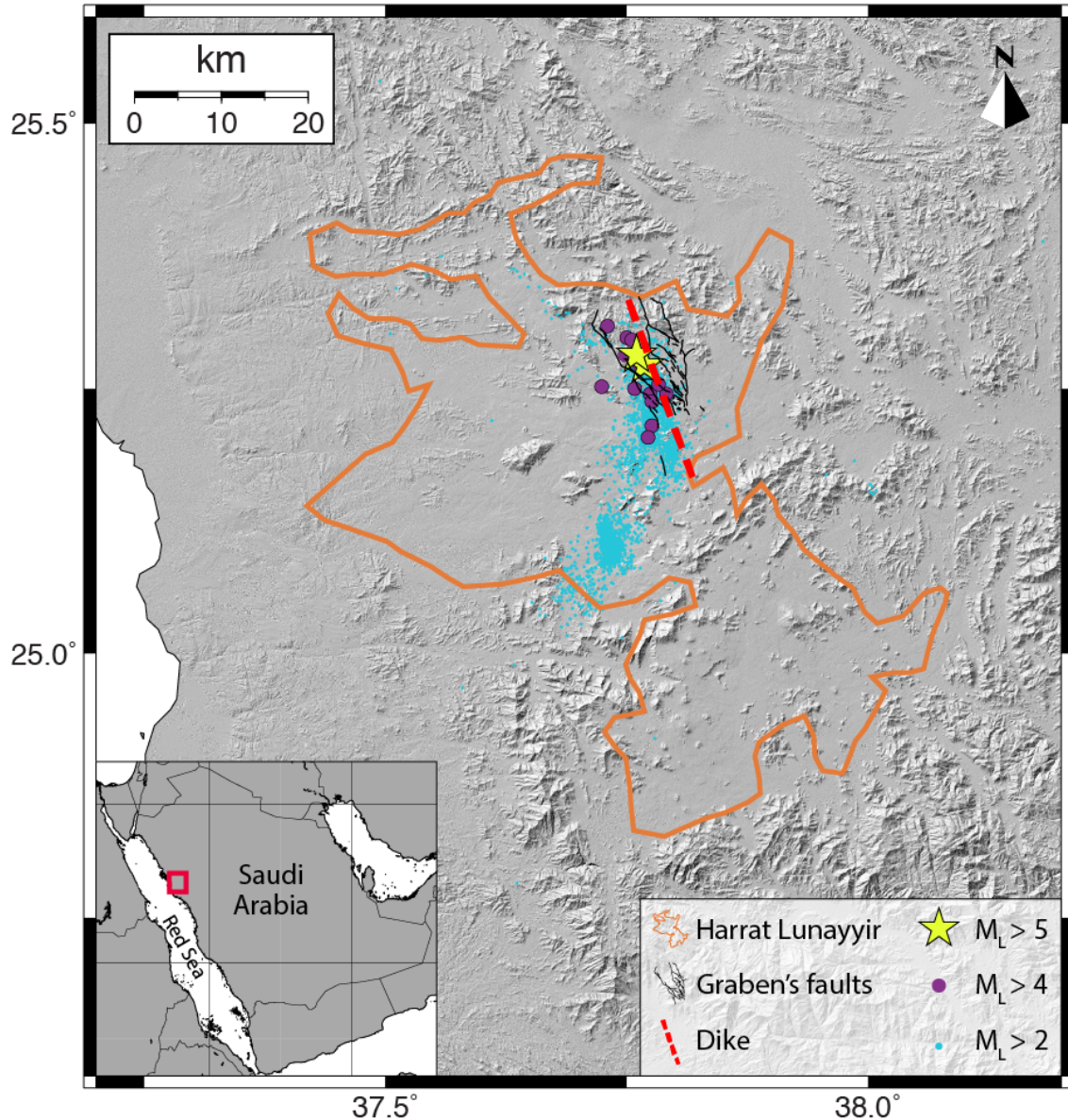
- **InSAR data** from different satellites (Envisat, ALOS-1, COSMO SkyMed, TerraSAR-X and Sentinel-1) show that **ground deformation in Harrat Lunayyir started in early May 2009 and continued up to present day**
- **Early post-diking deformation** - higher rate of subsidence and seismic energy
- **Long-term post-diking deformation** - smaller and steady rate of subsidence and seismic energy
- The observed **displacements are mainly aseismic**

# Future works

- Fill the temporal gap (2011-2014) in our InSAR dataset adding further TerraSAR-X, TanDEM-X and Sentinel-1 images
- Model the deformation source



# Appendix – Background



- Harrat Lunayyir is a monogenetic volcanic field
- It is located in west Saudi Arabia on the Red Sea coast
- In April – July 2009 > 30000 eqs occurred in the area (in the figure)
- Activity peak around May 19 with a  $M_w = 5.7$  and other  $M_L > 4$  events
- A ~10 km long and 5 km wide graben formed during the peak activity
- More than 50 cm of subsidence were observed within the graben (Jónsson, 2012 - <https://doi.org/10.1029/2012GL053309>)
- Two uplifted areas on the sides
- The ground deformation started after the beginning of the seismic activity (Xu et al., 2016 - <https://doi.org/10.1002/2015JB012505>)
- The majority of the deformation occurred during the seismic peak
- The source of the deformation is a dike that didn't reach the surface, estimated to be ~7 km in length, with an opening of up to 4 m
- Envisat data suggest that the intrusion stops at the end of June
- CSK and TSX data suggest that the intrusion continued at least in July
- Available ALOS-1 and Envisat data show subsidence within the graben until early 2011
- TerraSAR-X and TanDEM-X data will allow us to fill the gap between last Envisat / ALOS acquisitions and S1

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