KEM Research Question
KEM-49b InSAR *Surface Deformation on Grass*

Objective

The Ministry of Economic Affairs and Climate Policy seeks to enhance cavern stability assessment through additional monitoring methods. InSAR offers promise for detecting small elevation changes across large areas with high measurement frequency, enabling identification of unstable salt caverns prone to subsidence and sinkhole development that may require infilling. Improved understanding of cavern-surface deformation relationships would strengthen risk assessment and mitigation procedures.
Previous research by Sensar and TNO (KEM-49) demonstrated InSAR's effectiveness for monitoring unstable salt caverns in the Twente region, where increasing subsidence levels signal potential sinkhole formation. Strong subsidence observations can support data assimilation and inverse modelling to understand underlying failure mechanisms.

However, existing satellite sources struggle to accurately measure surface deformation over vegetated surfaces. Current monitoring is thus restricted to infrastructure around caverns, limiting spatial coverage of accurate subsidence estimates. Recent developments may address that. Therefore this proposal builds further upon the work of KEM 49 and looks for further improvements around subsidence detection and surface deformation in the Twente region.

This RFP explores opportunities offered by new L-band satellite constellations, particularly the recently launched NISAR mission (2025), for enhanced salt cavern monitoring.

State of the art, background

Combining multiple pixels for Distributed Scatterer (DS) processing can introduce 'closure-phase' errors, caused by moisture-induced non-linear phase shifts during triangulation. While advanced DS algorithms can correct these inconsistencies via complex regression, they require sufficient image pairs with long temporal baselines and high coherence.

Vegetated surfaces typically exhibit low coherence, particularly in summer months in temperate climates like the Netherlands. Consequently, DS-InSAR on grasslands often fails to correct closure-phase effects, leaving results susceptible to moisture variations in vegetation and soil. Although recent studies show promise for vegetated areas, these rely heavily on predictive models. Since salt cavern instability involves unexpected signals that cannot be pre-modeled, such model-driven approaches have limited applicability for this specific use case.

Opportunities with L-band

L-band sensors offer a solution, as their longer wavelengths maintain coherence over time and are less sensitive to small-scale changes. This reduces susceptibility to closure-phase inconsistencies, promising more reliable deformation estimates. Historically, L-band availability was limited by commercial constraints, but the newly launched NISAR mission (NASA/ISRO, 2025) and the upcoming ESA ROSE-L (2028) will provide open access.

NISAR operates on a 12-day global repeat cycle with a 3–5 year lifespan. Currently in commissioning (ending June 2026), it began releasing pre-calibrated data in February 2026, with fully calibrated products for the Netherlands expected by late 2026 (covering data from October 2025). This project will utilize NISAR data to assess feasibility.
Trade-offs L-band is not without drawbacks: the longer wavelength reduces measurement precision (higher phase noise per unit distance) and increases sensitivity to ionospheric disturbances, particularly over large areas.

Research Question

In order to assess the feasibility of L-band data for accurate and reliable estimations of surface deformation for the use case of monitoring salt caverns, several questions need to be answered:

- Is the wavelength offering observations precise enough to detect subsidence related to cavern instability?
- How big is the closure phase in L-band observations? And how are they related to moisture?
- Are the observations coherent over time to cancel out closure phase inconsistencies?
- To what extent are ionospheric disturbances expected to disturb surface deformation estimates?

Deliverables expected

- **Presentation to the KEM-panel**
- **Final report**

Timeline

8 months + 3 months for KEM-panel review

Expected use

The report will be made public for open usage.

Expertise and tools preferred for the team

The project team needs to be qualified and have experience with InSAR measurements related to salt cavern deformation

Quality assurance, Organisational and communication requirements

Bimonthly progress meetings with the KEM panel.
Intermediate reports

Remarks and Suggestions

References