



Status report on the installation and testing of InSAR radar reflectors in Denmark

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Agency for Climate Data

Outline

1. Field test of compact active transponders (CATs)
2. Status of the establishment of a fundamental network of corner reflectors (CRs)
3. Status regarding other corner reflectors (for specific applications)

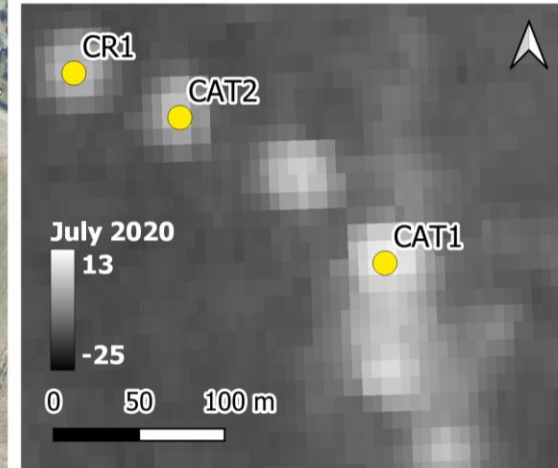
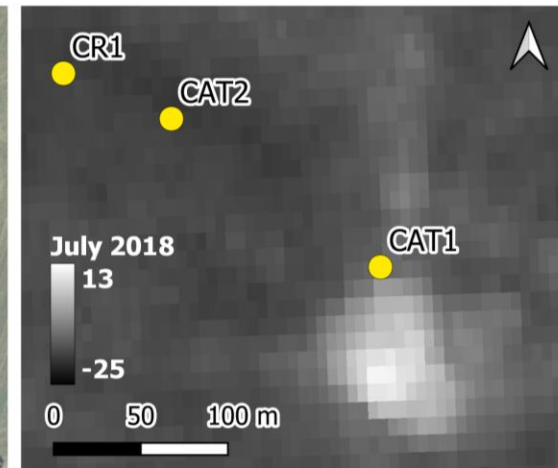
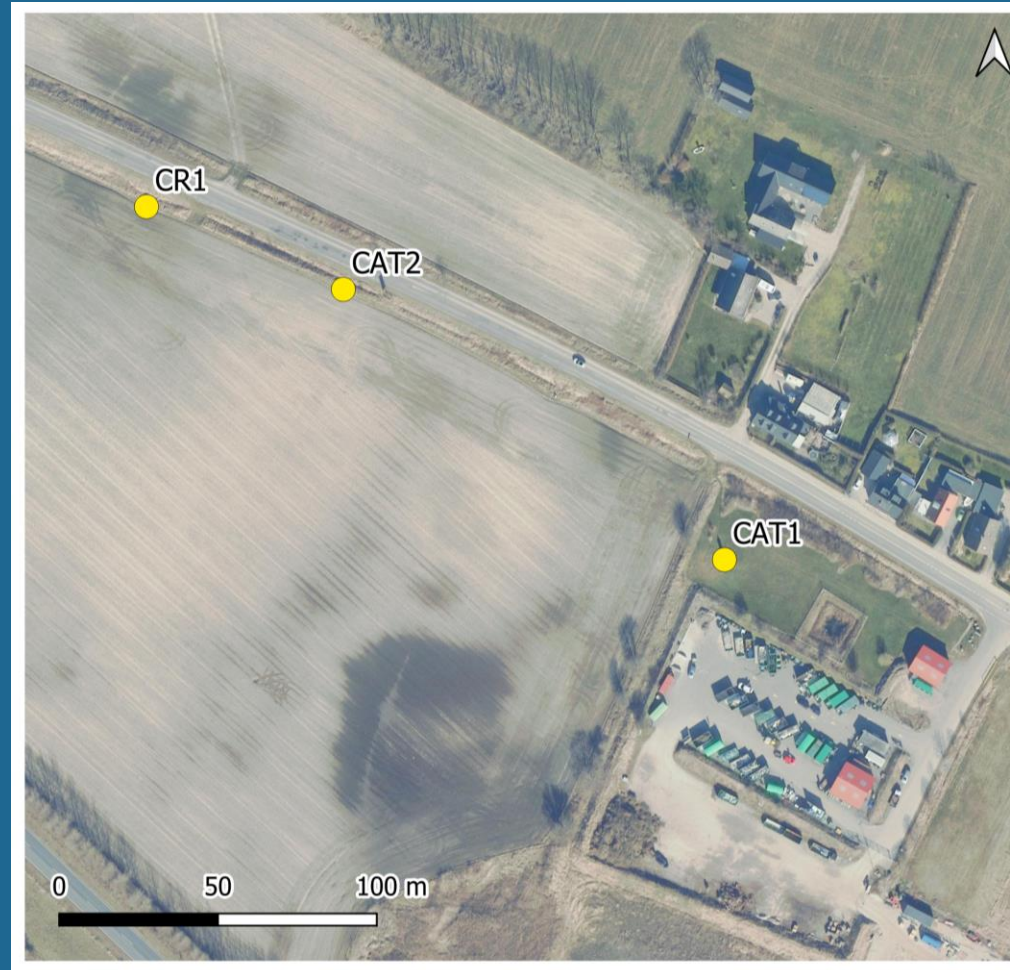
1. Field test of compact active transponders (CATs)

Purpose:

- To determine the long term (phase) stability of CATs
- To determine the accuracy by which a vertical displacement of a CAT can be resolved

Overview

- Test period: 2020-2025
- Location: At GNSS station HABY – in northwestern Zealand, Denmark
- Two CATs produced by MetaSensing tested
 - › CAT1 fixed
 - › CAT2 manually displaced six times
- Corner reflector
 - › CR1 fixed
- Ground truth established by levelling (24 times including before and after each manual displacement)
- InSAR displacement time series from Sentinel-1



CR1



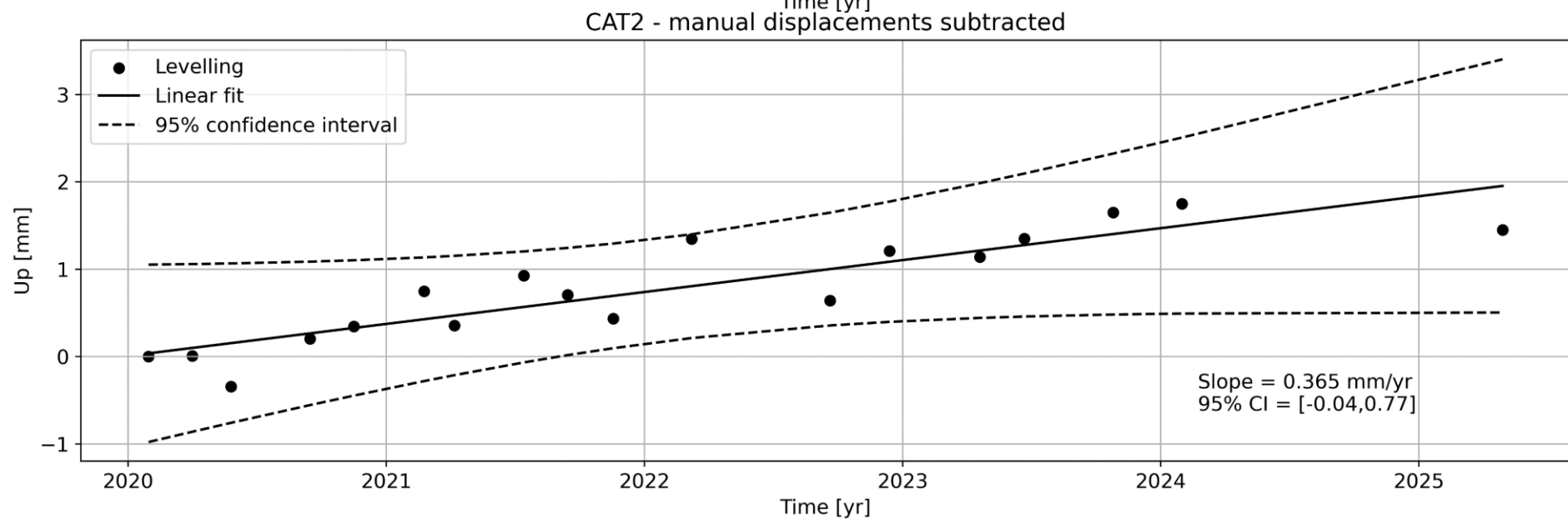
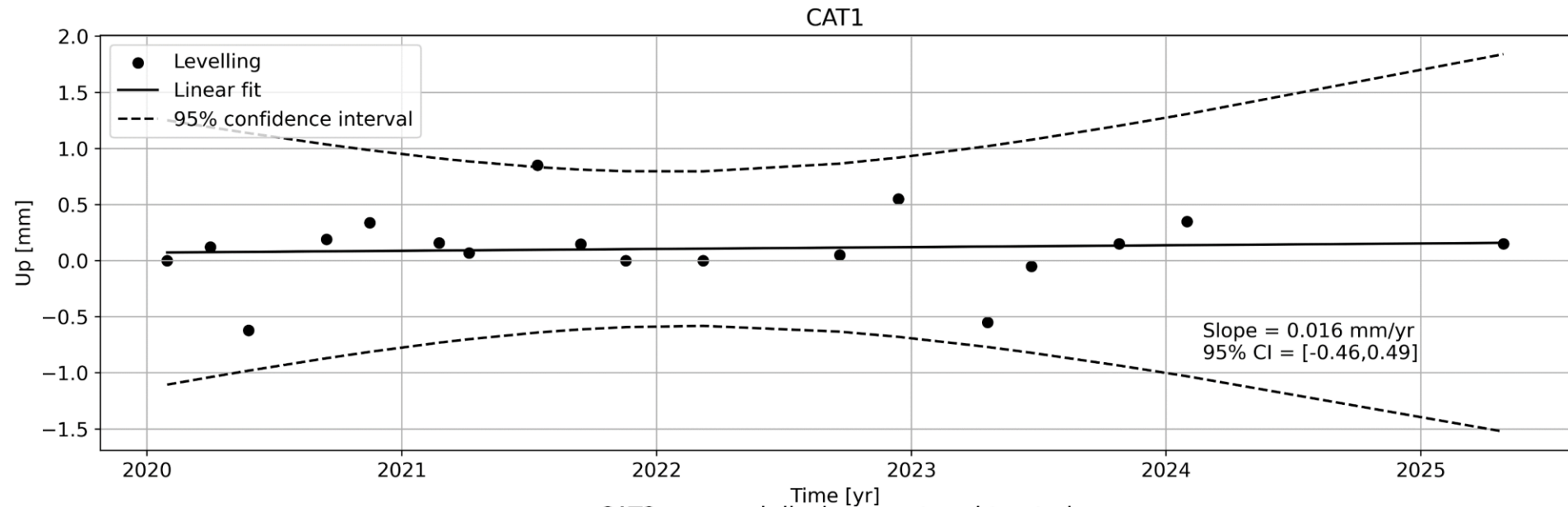
CAT1 and CAT2



Manual vertical displacements of CAT2

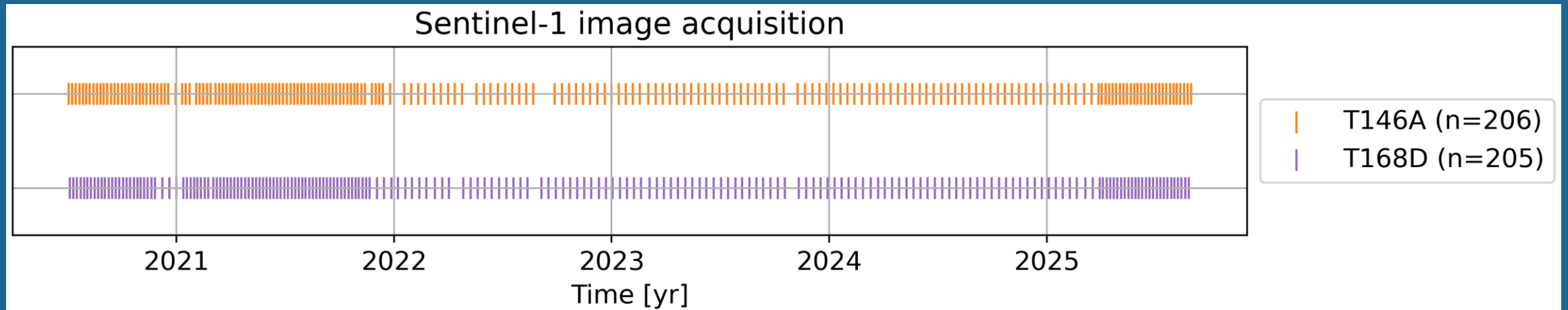
Date	Size [mm]
15 September 2020	-3.9
24 February 2021	-14.4
13 July 2021	+1.1
19 April 2023	+2.6
21 June 2023	-2.6
31 January 2024	+5.10

Levelling time series

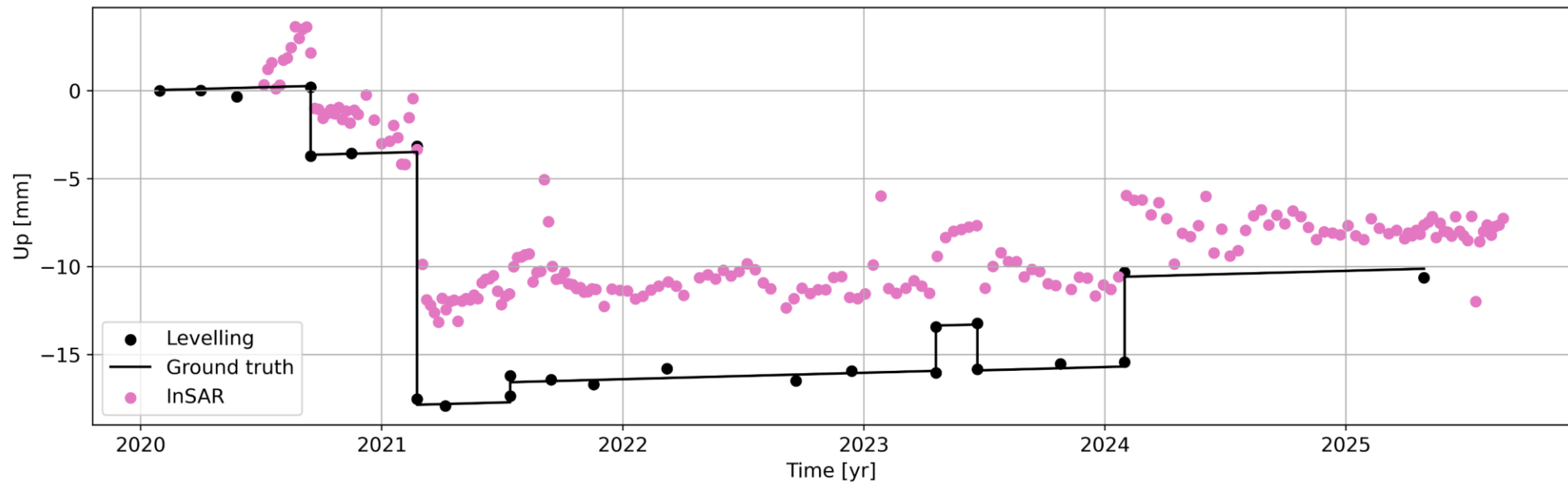
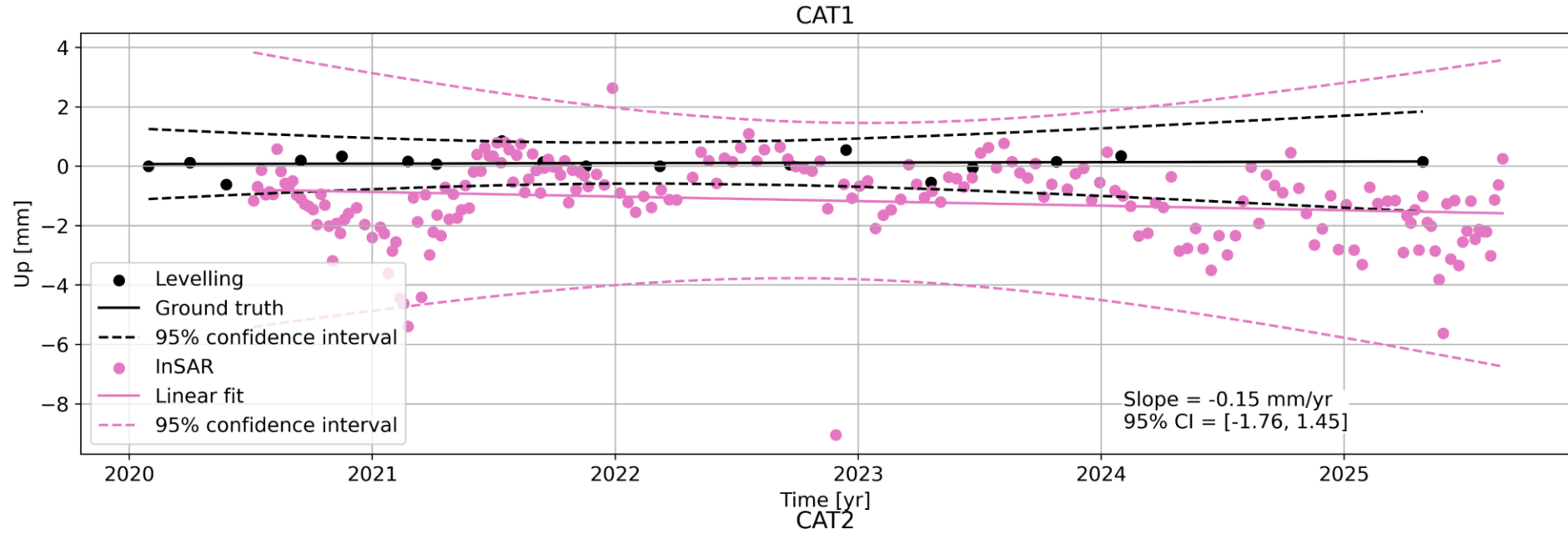


InSAR processing

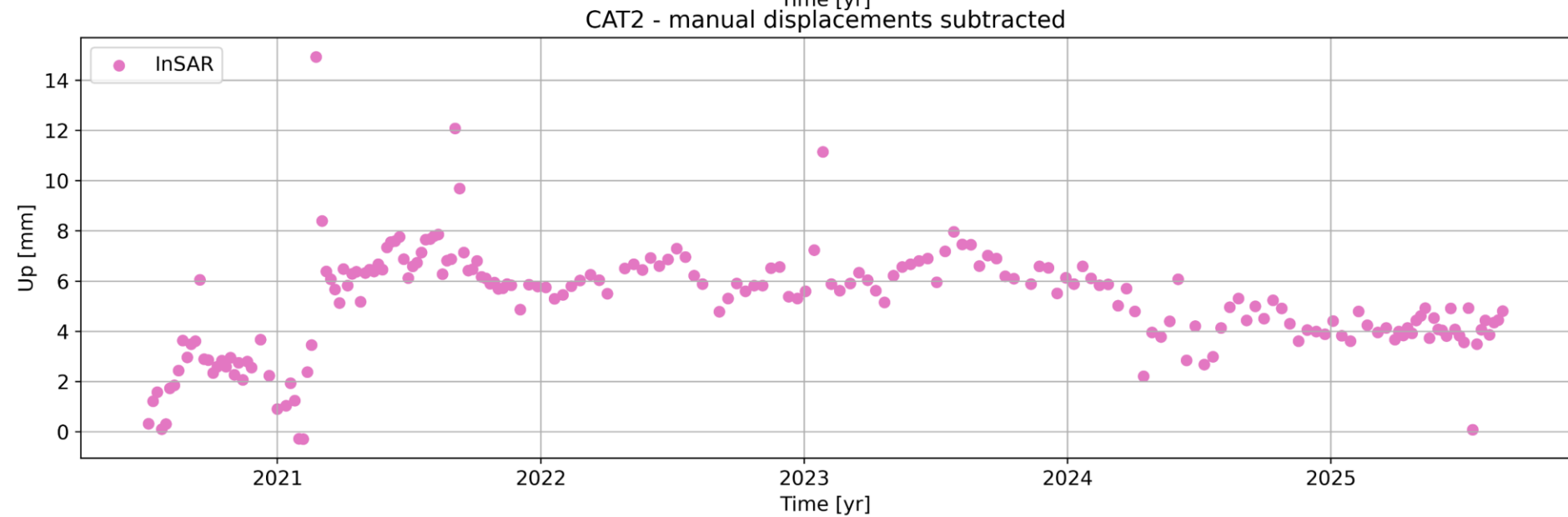
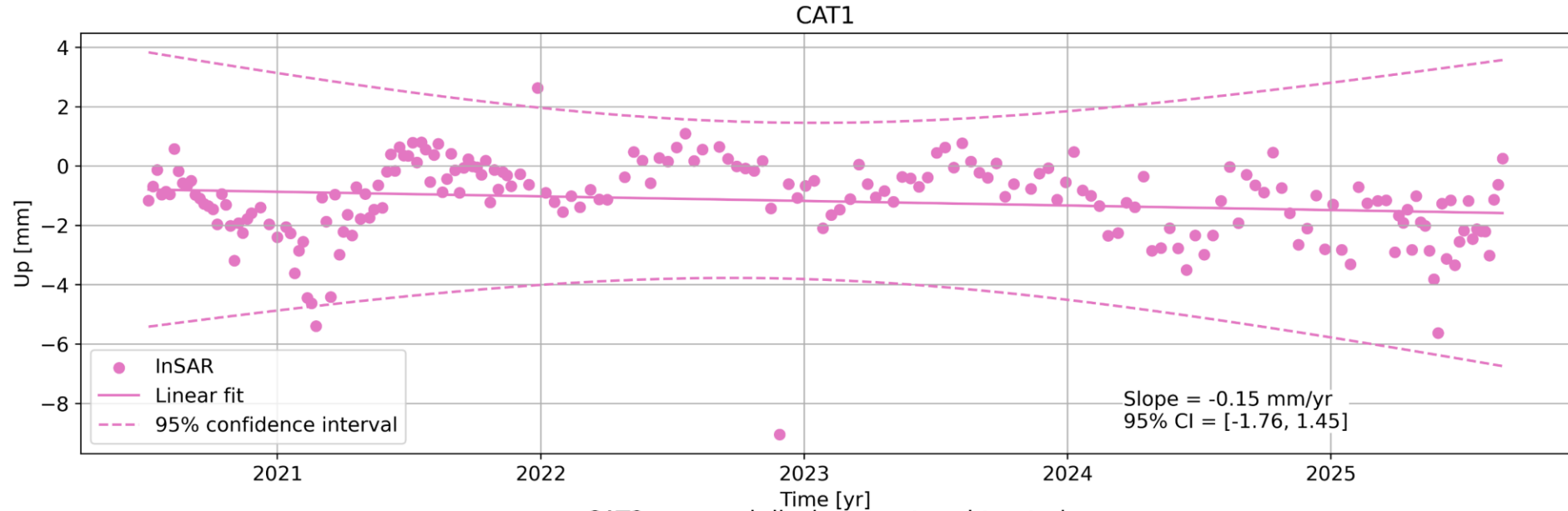
- 411 Sentinel-1 images covering the period from 3 July 2020 to 30 August 2025
- T146A and T168D
- PSInSAR method implemented in SARPROZ© software
- CR1 spatial reference
- LoS (projected to Up) and 2D (Up and East)
- Processed by John Merryman, DTU Space



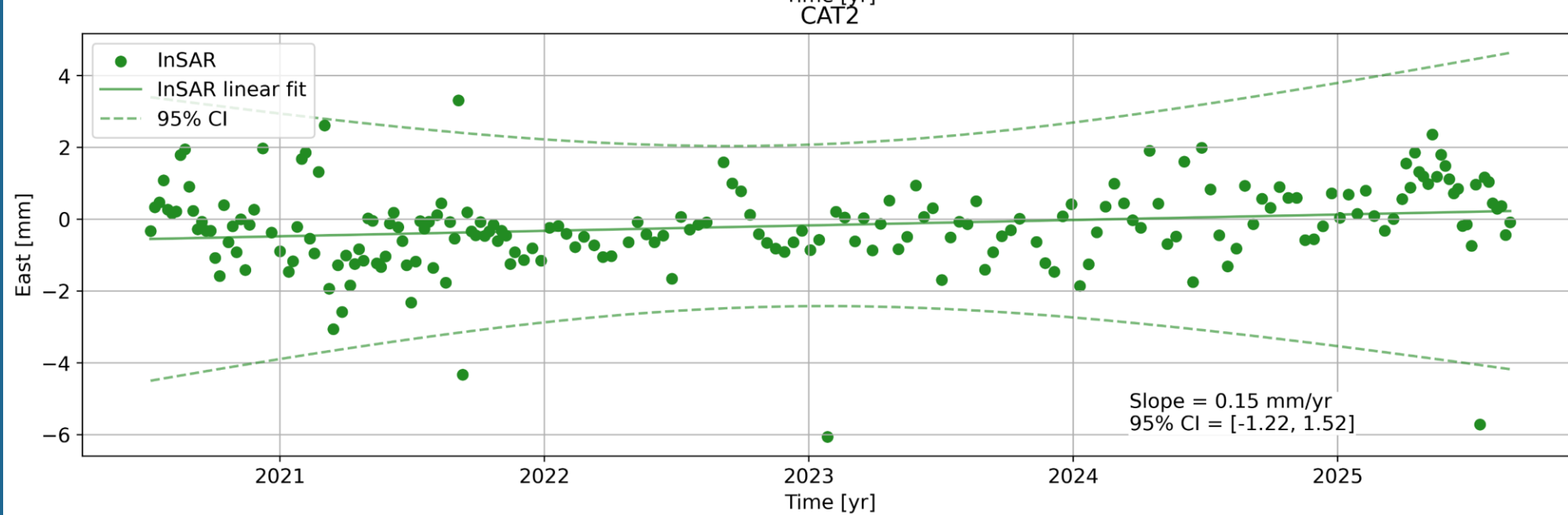
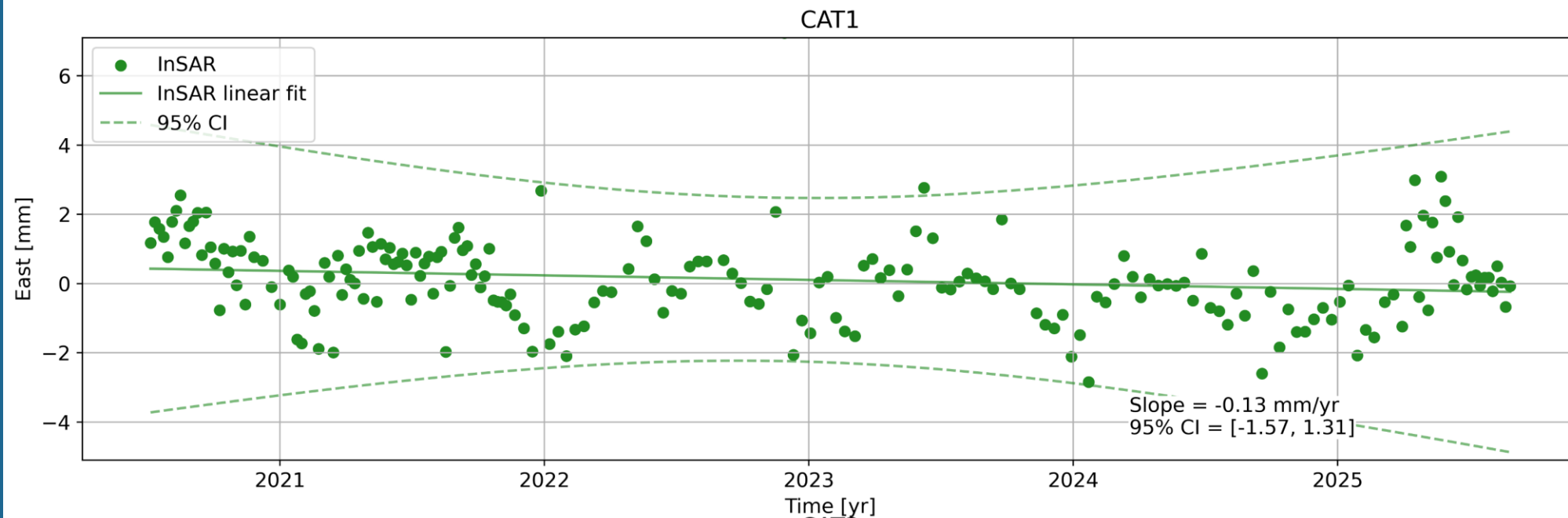
InSAR 2D Up vs. ground truth



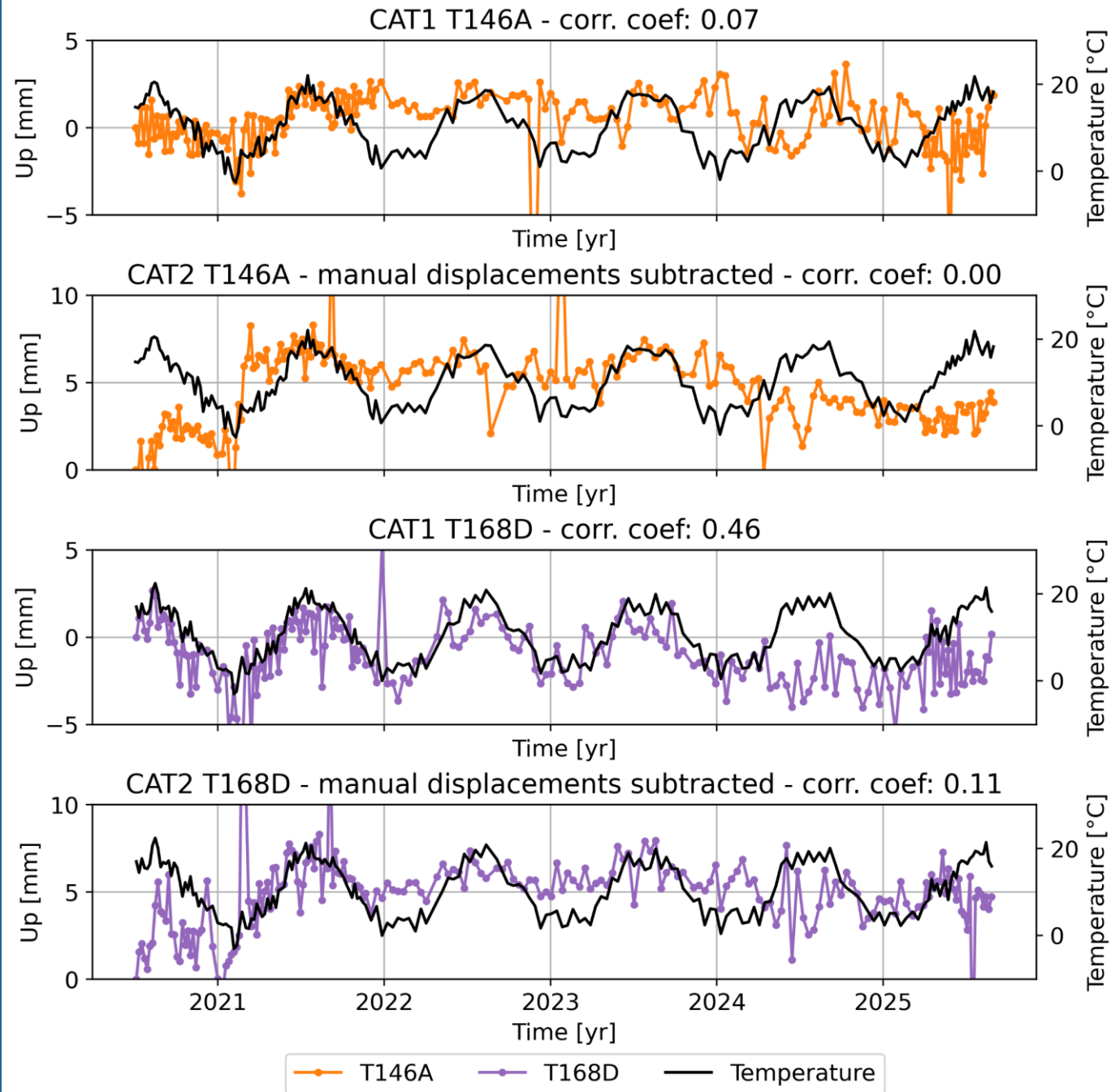
InSAR 2D Up - manual displacements subtracted



InSAR 2D East

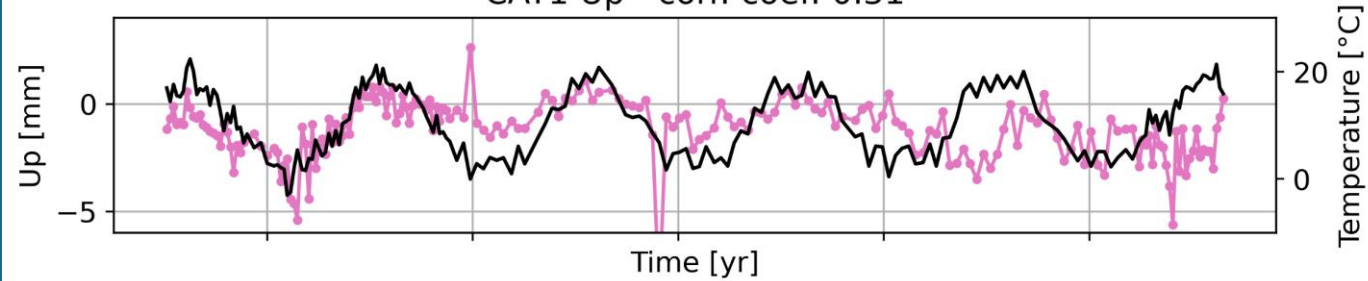


InSAR LoS vs. temperature

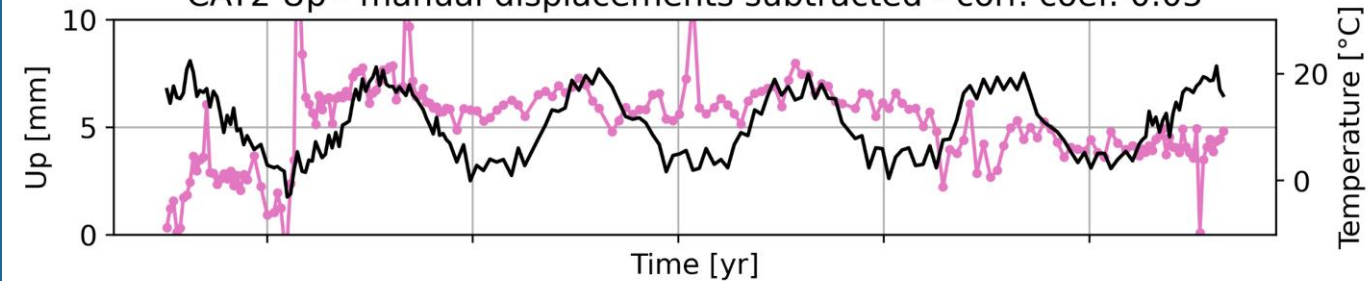


InSAR 2D vs. temperature

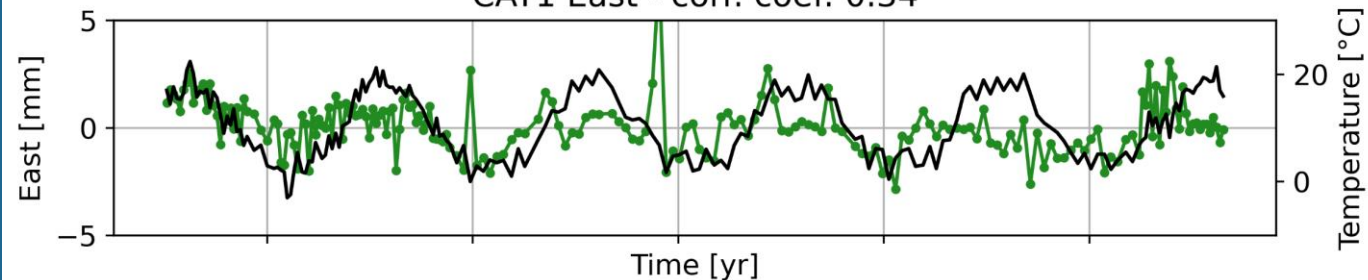
CAT1 Up - corr. coef: 0.31



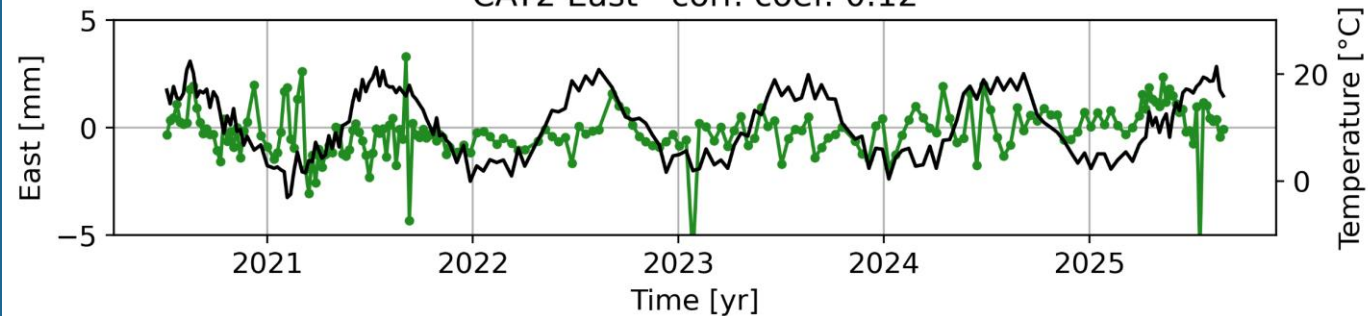
CAT2 Up - manual displacements subtracted - corr. coef: 0.05



CAT1 East - corr. coef: 0.34



CAT2 East - corr. coef: 0.12



— Up — East — Temperature

Conclusions

- Phase stability $\sim 0.1\text{-}0.2$ mm/yr vertically and horizontally (over a five year period)
 - A vertical displacement can be resolved with an accuracy of a few mm
 - Weak correlation between InSAR time series and temperature
- ➔ CATs can potentially be useful for geodetic and technical applications if practical issues regarding maintenance and durability can be solved

2. Status of the establishment of a fundamental network of corner reflectors (CRs)

Purpose:

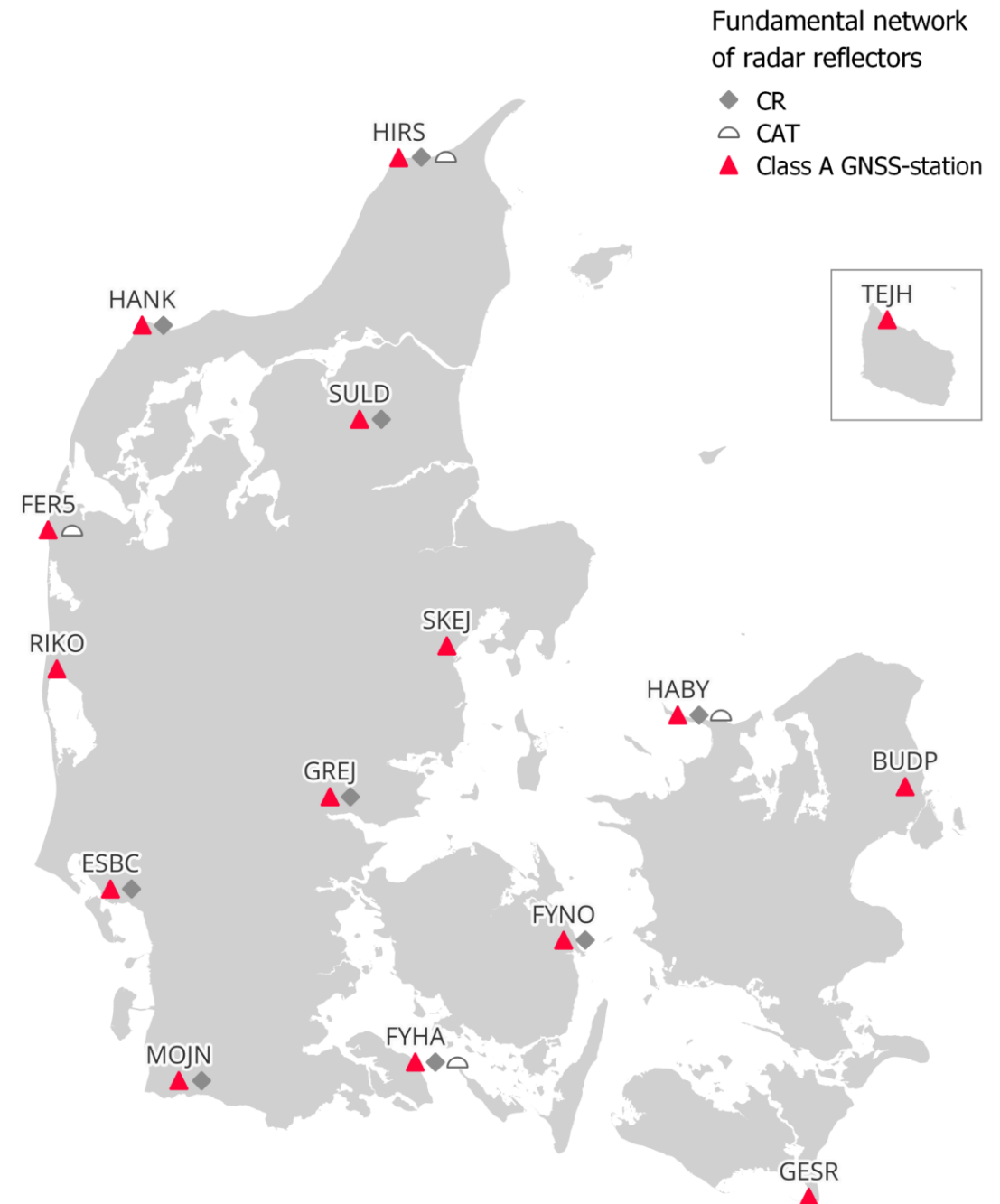
- Datum referencing of InSAR (via co-located GNSS stations)
- Correction of long-wavelength errors in InSAR
- QA of InSAR deformation products
- Stability control of co-located GNSS stations

Fundamental network of corner reflectors (CRs)

- Owned/operated by the Danish Agency for Climate Data
- 9 corner reflectors co-located with class A GNSS stations (approx. 50 m apart)
 - › Double square trihedral CRs (MUSE-design) with inner leg length of 0.65 - 0.7 m
 - › Levelling between CRs and GNSS stations every 2 years
 - › Co-located with absolute gravity points
 - › Stable relative to national ETRS89 and national height system DVR90
- 4 compact active transponders (still in operation) installed onto foundation of GNSS stations

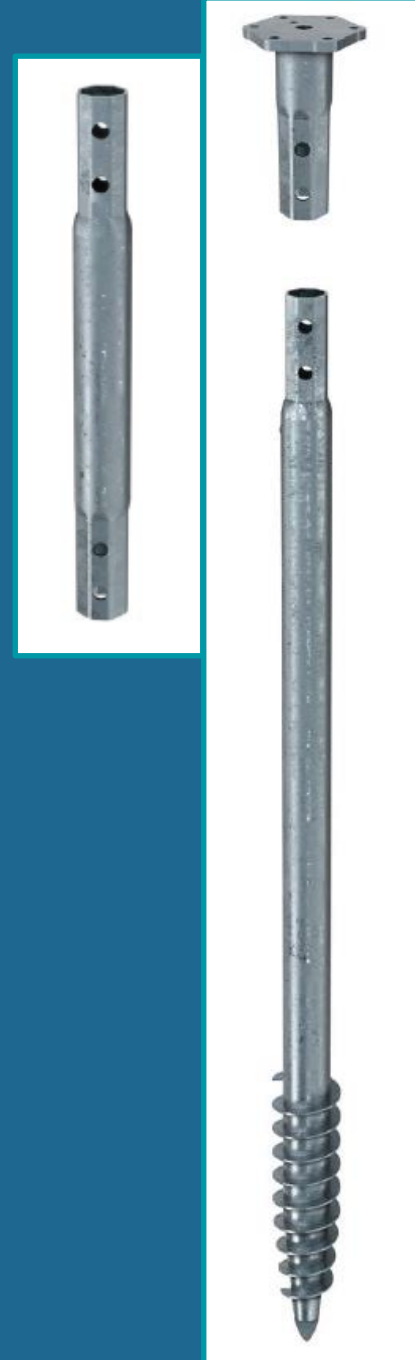
Long term plan:

- To install corner reflectors at all class A GNSS stations

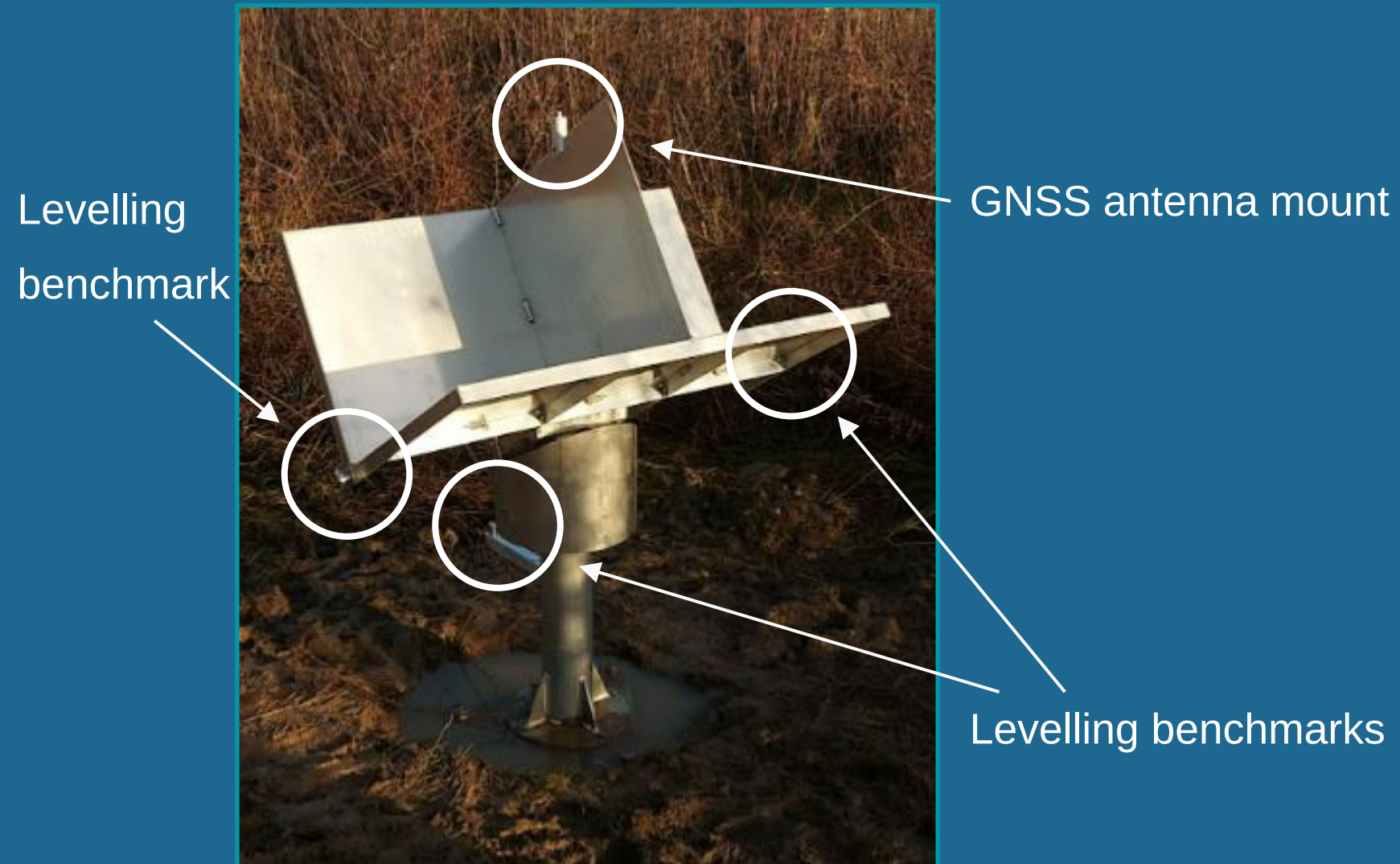


The foundation of corner reflectors

- All corner reflectors are founded in soil (no bedrock near surface)
- Each corner reflector mounted on a platform supported by three galvanized ground screws manufactured by German company Krinner
- Diameter of ground screws: 89 mm
- Length of ground screws: approx. 5-10 m (depending on local geological conditions)



Corner reflector and platform



3. Status regarding other corner reflectors

- An additional ~140 corner reflectors have been installed throughout the country for various specific applications
- Owned/financed by municipalities, utility companies, harbors etc.
- Examples of applications: monitoring/mapping of land subsidence, harbors, underground gas storages, sewerage systems, tide gauges, large rail/road bridge under construction as well as control points for airborne mapping etc.



Photos by Defakto Inspection

Thank you for your attention!