Validation of Compact Active Transponders used for ground deformation monitoring

Joanna Balasis-Levinsen[1] (jofle@sdfi.dk), Aslak Meister[1], May Ritt Veybøll Pedersen[1], Kristian Keller[1], John Peter Merryman Boncori[2], Mathias Jensen[1]

1) Agency for Data Supply and Infrastructure, Ministry of Climate, Energy and Utilities, Rentemestervej 8, Copenhagen , Denmark

2) DTU Space, Technical University of Denmark, Elektrovej, Building 327, Kongens Lyngby, Denmark

Agency for Data Supply and Infrastructure

Motivation

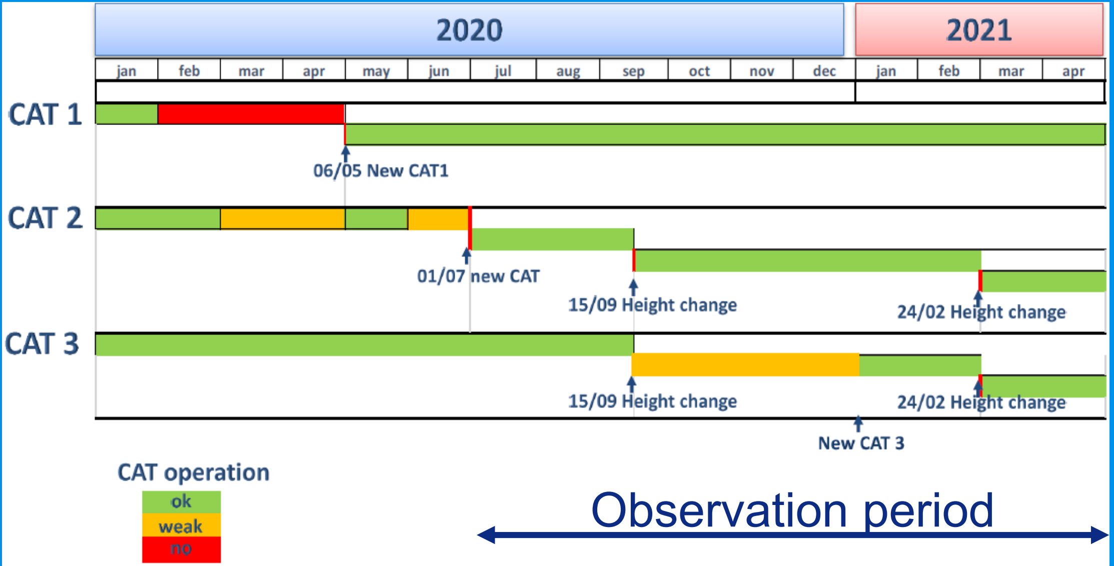
- Wish to exploit new methods and technologies for maintaining governmental responsibility
  - Satellite-based deformation monitoring of artificial reflectors installed by geodetic infrastructure one solution?
- Expected applications e.g.:
  - Referencing relative, Sentinel-1-based deformations to “absolute” geodetic reference frame realized by GNSS infrastructure
  - Optimized planning of locations for new infrastructure
  - Monitoring geodetic infrastructure

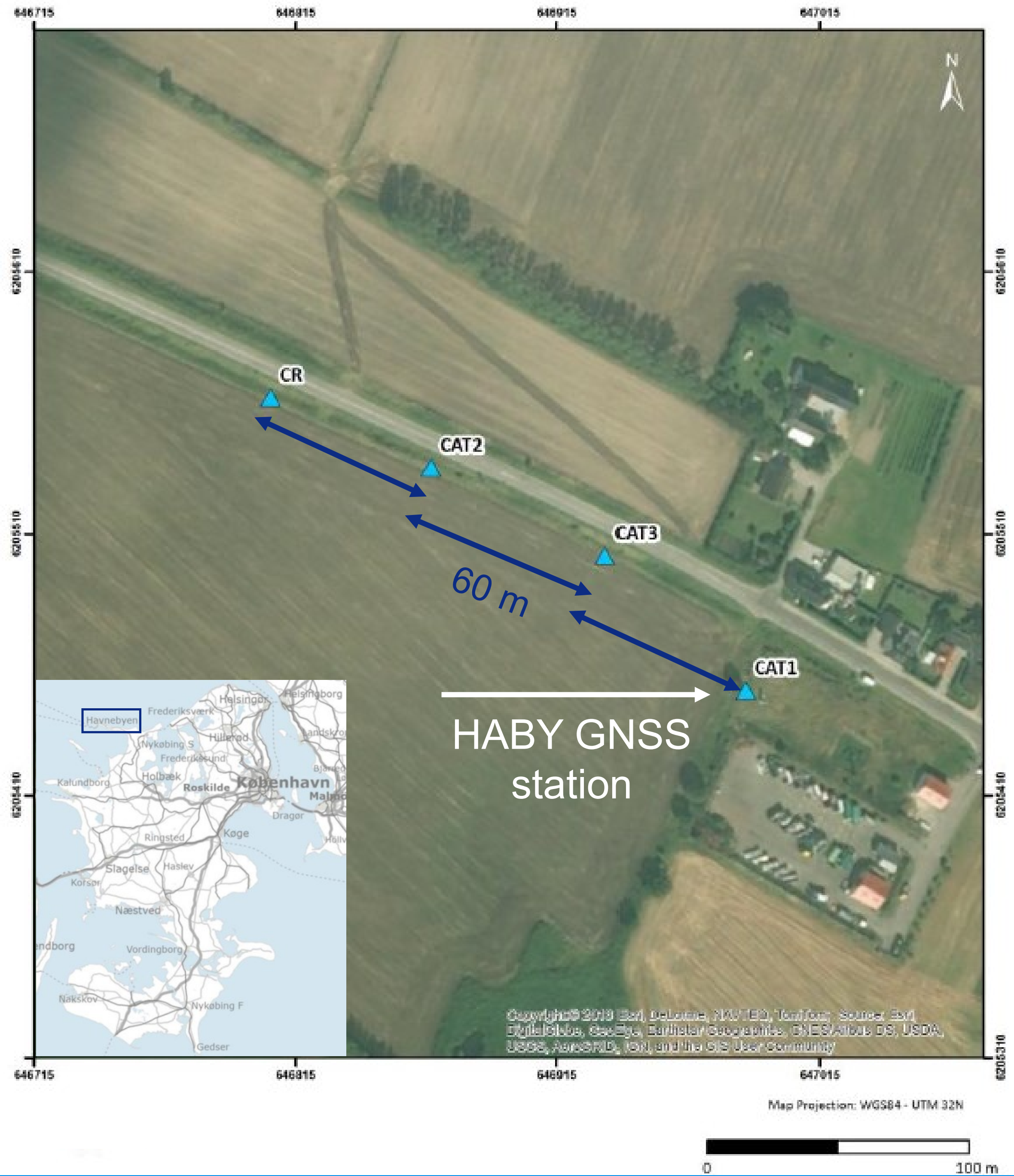
Validation exercise

- Installed four artificial reflectors by HABY GNSS station
- Manual deformations applied to two instruments
- Continuous precision leveling
- Comparison of deformation rates derived from precision levelling and all available Sentinel-1 imagery
  - Processing using SARPROZ
  - LOS velocities re-projected to vertical
  - 2D vertical
  - No a priori knowledge about manual deformations

Validation exercise

- Manual deformations:
  15/9-19: CAT-2: -3.9 mm,CAT-3: +7.4 mm
  24/2-20: CAT-2: -14 mm, CAT-3: +15 mm
- CAT-1 and -2 results presented here





Artificial reflectors

Corner reflector (CR)

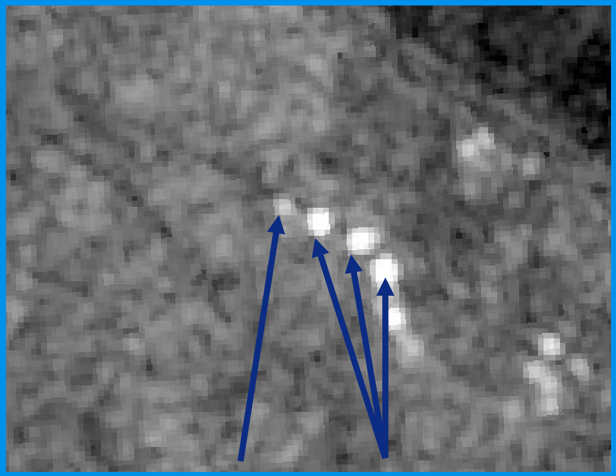
- Passive instrument – well-known
- Double back-flipped square trihedral (inner leg length = 65 cm)
- Used as reference point

CATs (CAT1 – 3)

- Active instrument – new
- Commercial product developed by Metasensing
- Size: 65 x 40 x 33 cm
- CAT-1 installed on HABY foundation

General:

- Installed December 2019
- CATs powered with 230V via GNSS station
- Levelling bolts mounted on plate corners

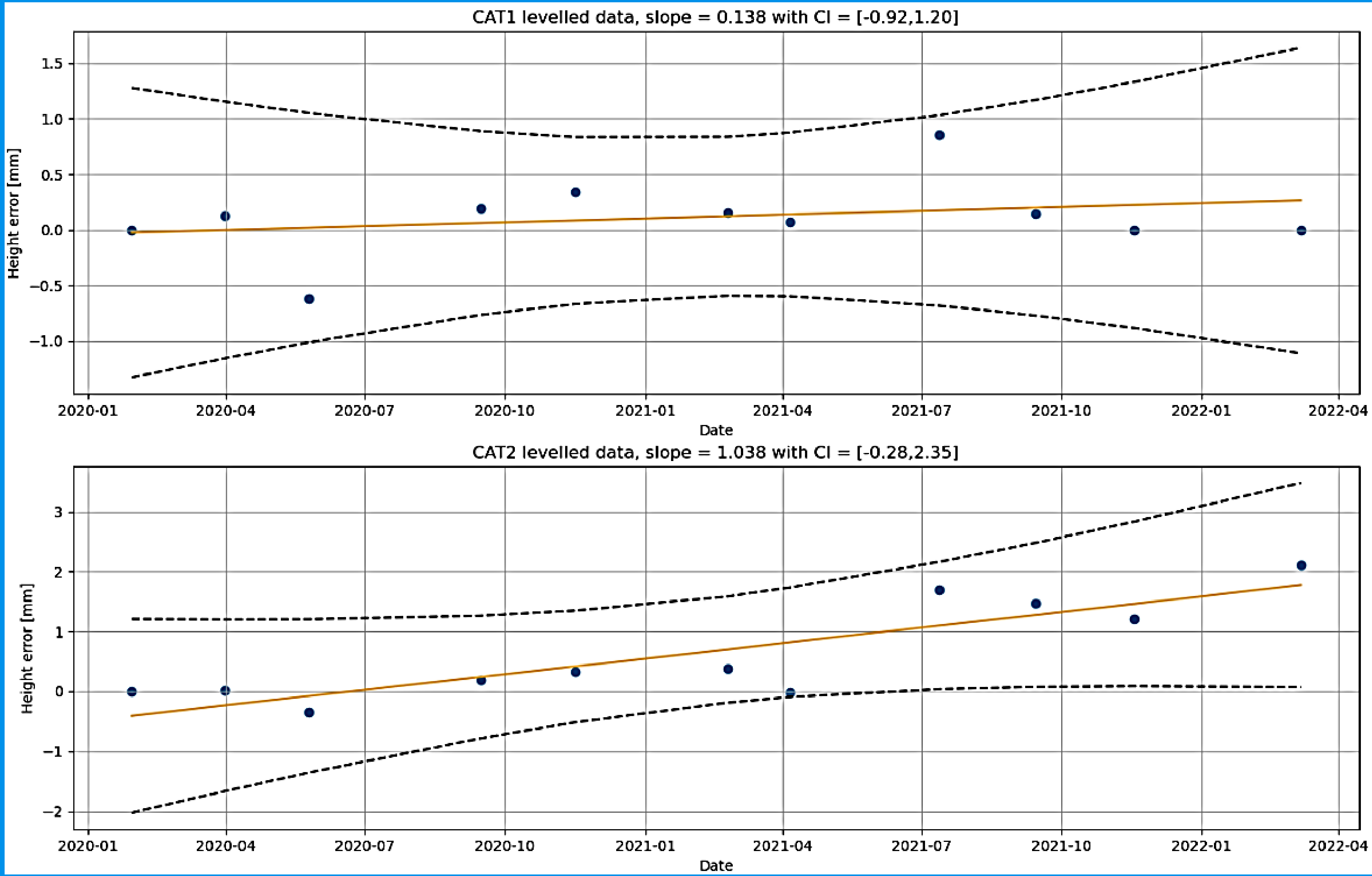


Results

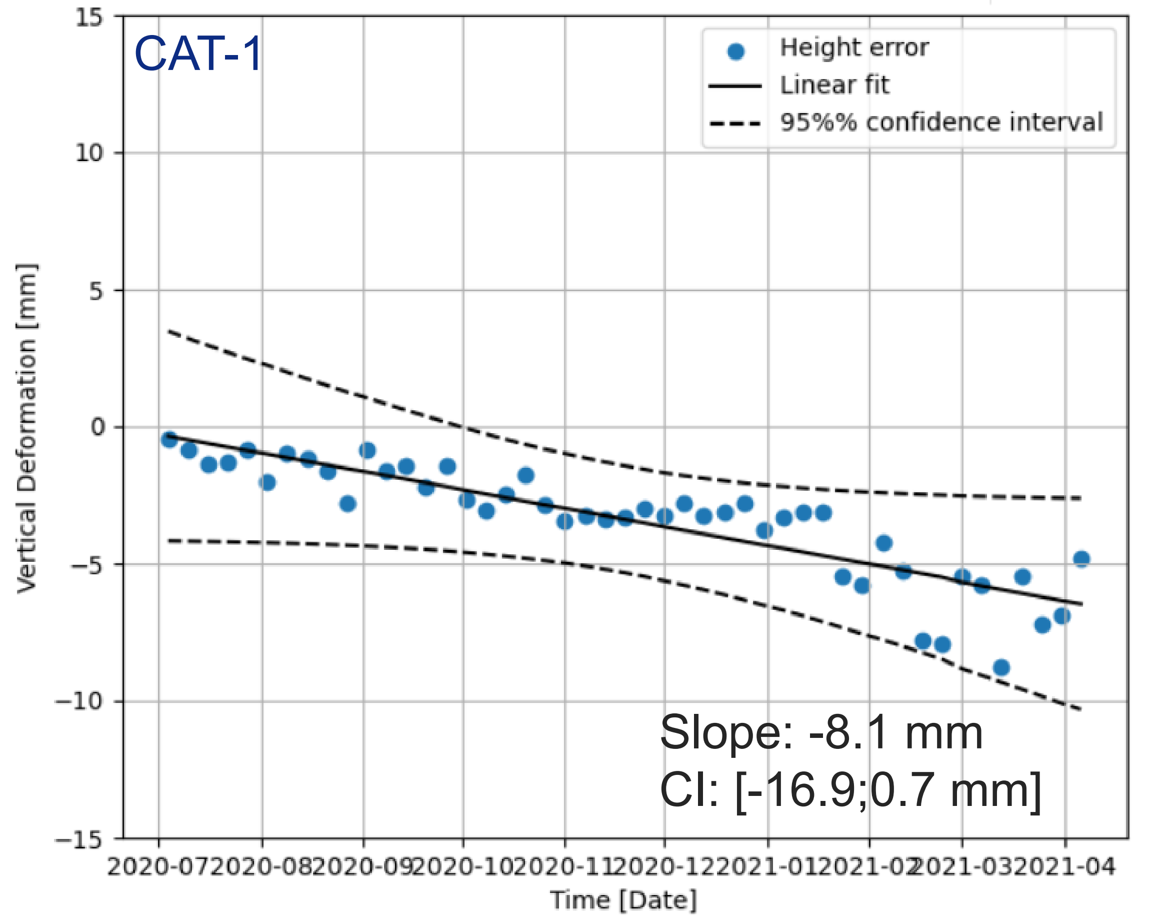
(CAT-1 and -2)

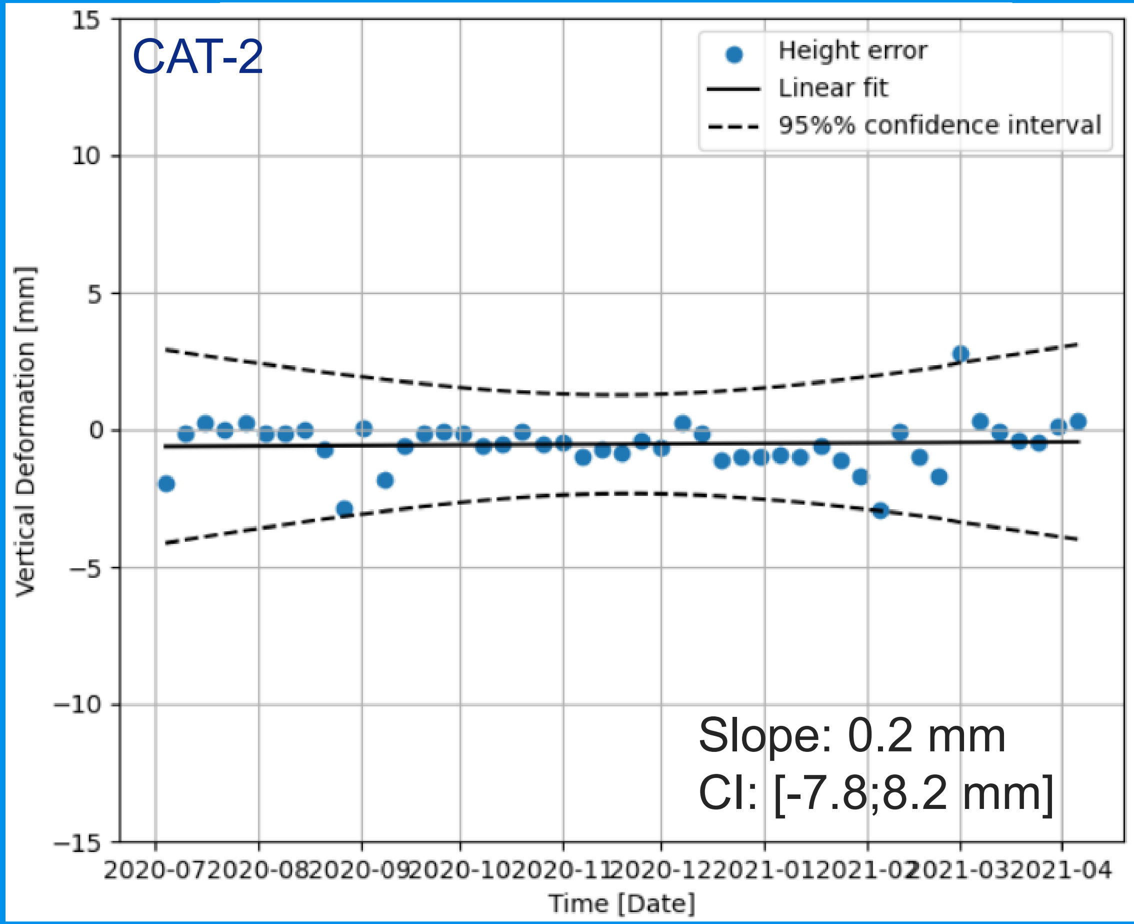
Levelling

- Without manual deformations of CAT-2
- Accuracy: mm and sub-mm level



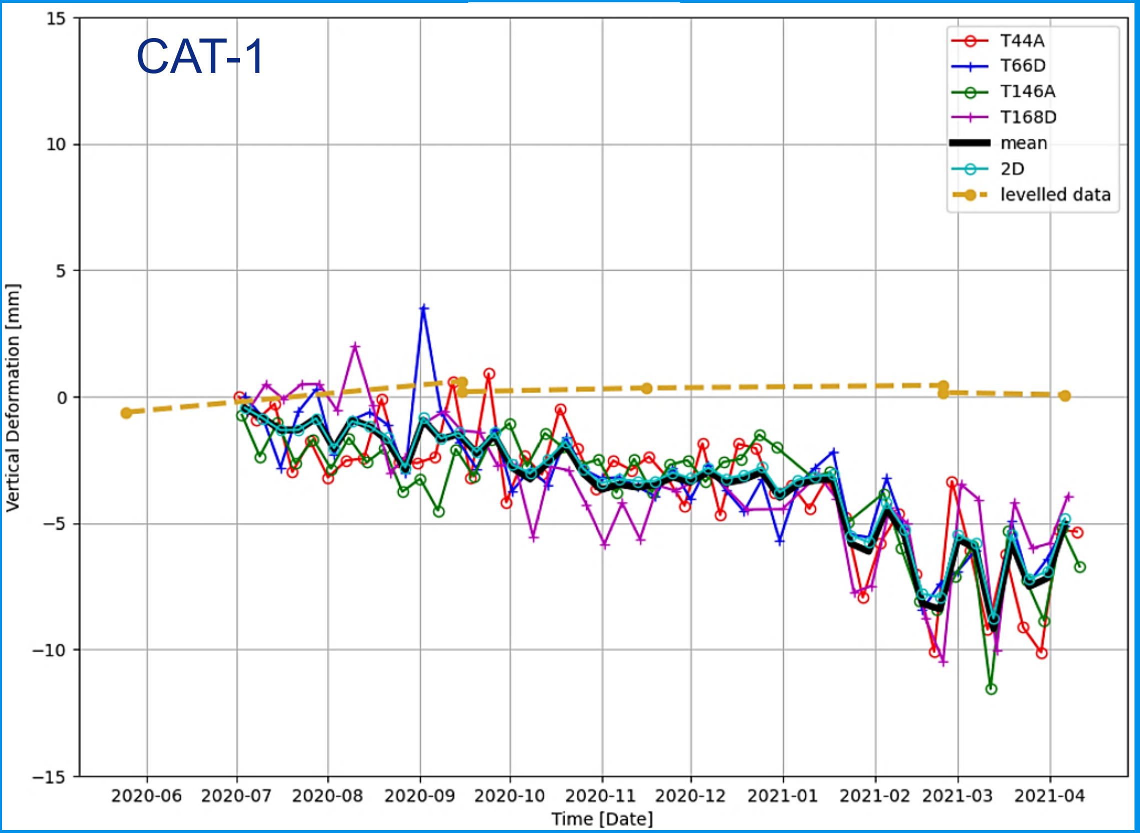
Error in deformation rates (S1: 2D vert – leveling)

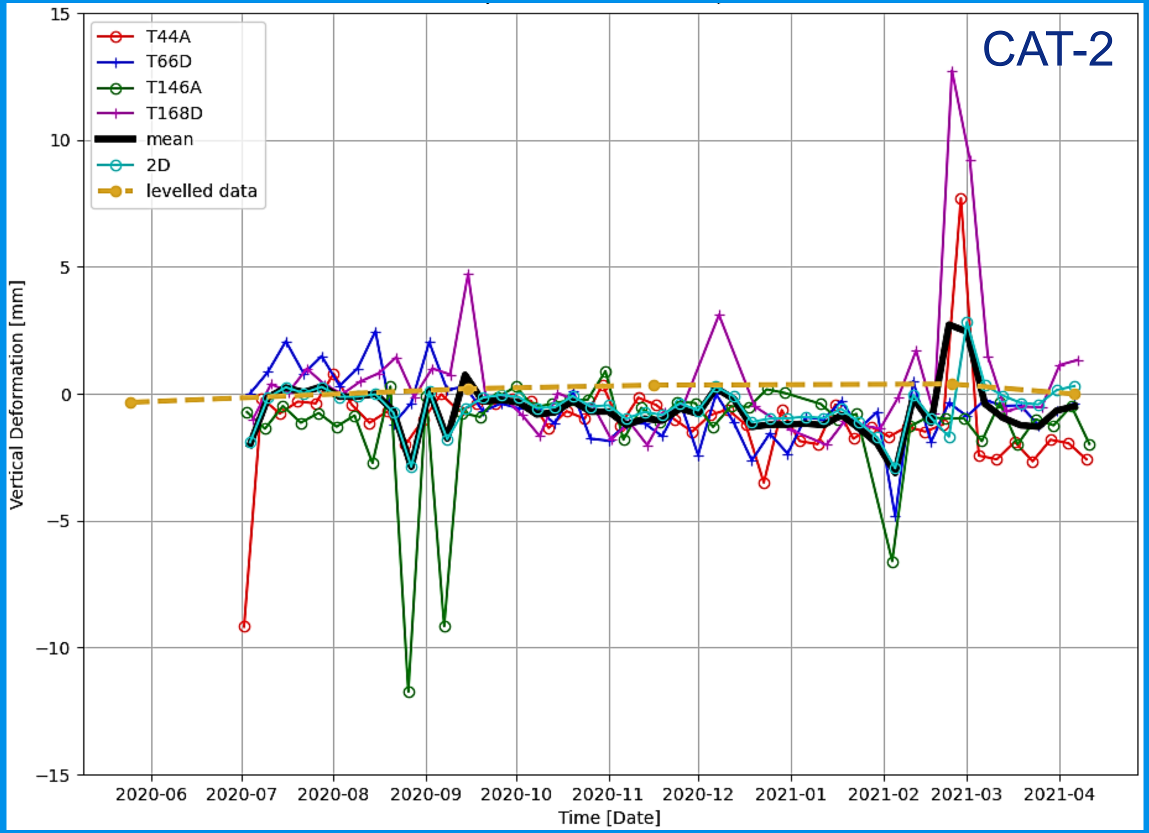




- Significant subsidence of ”stable” CAT-1 (left); smaller subsidence of CAT-2 – why is that?
- Similar signal for each relative orbit, although greater variability in CI
- Slight winter minimum, particularly for CAT-1; no clear effect of CAT location within track (near/ far-range)

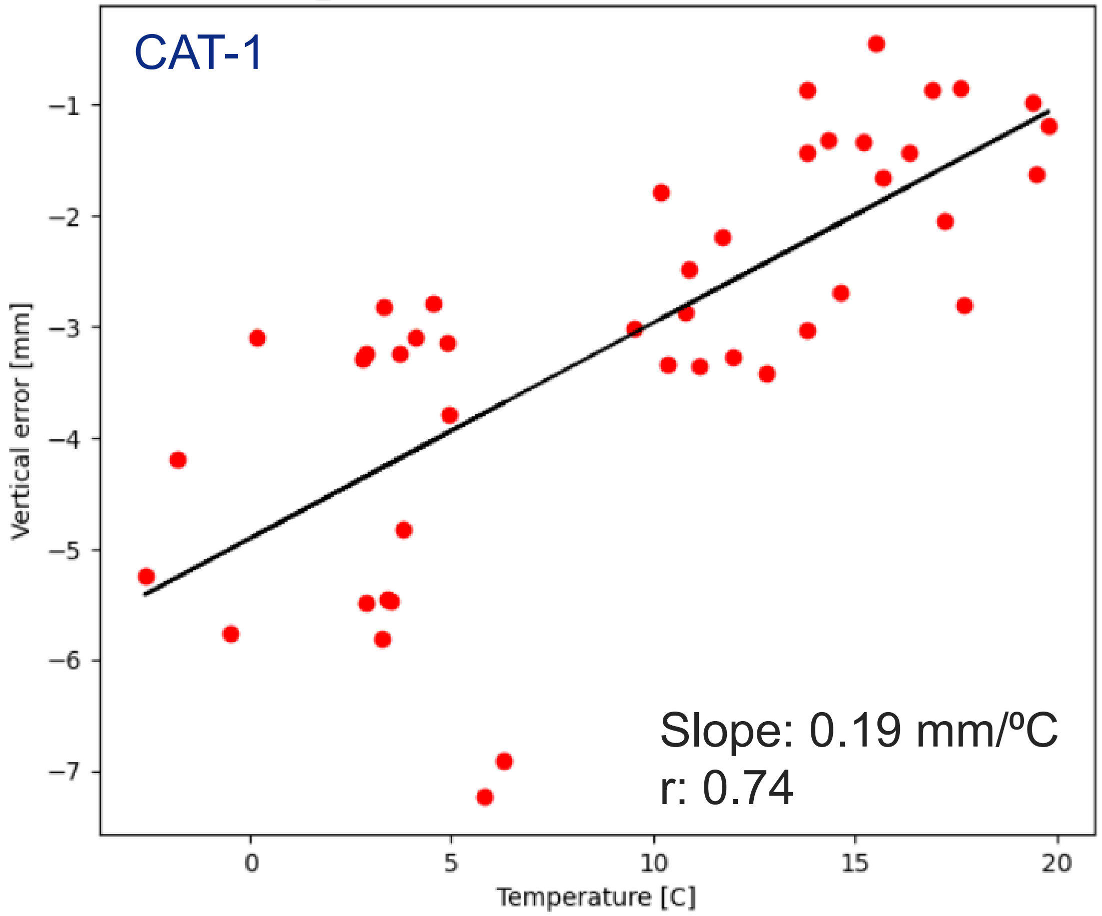
Estimated deformation rates (S1 vs. leveling)

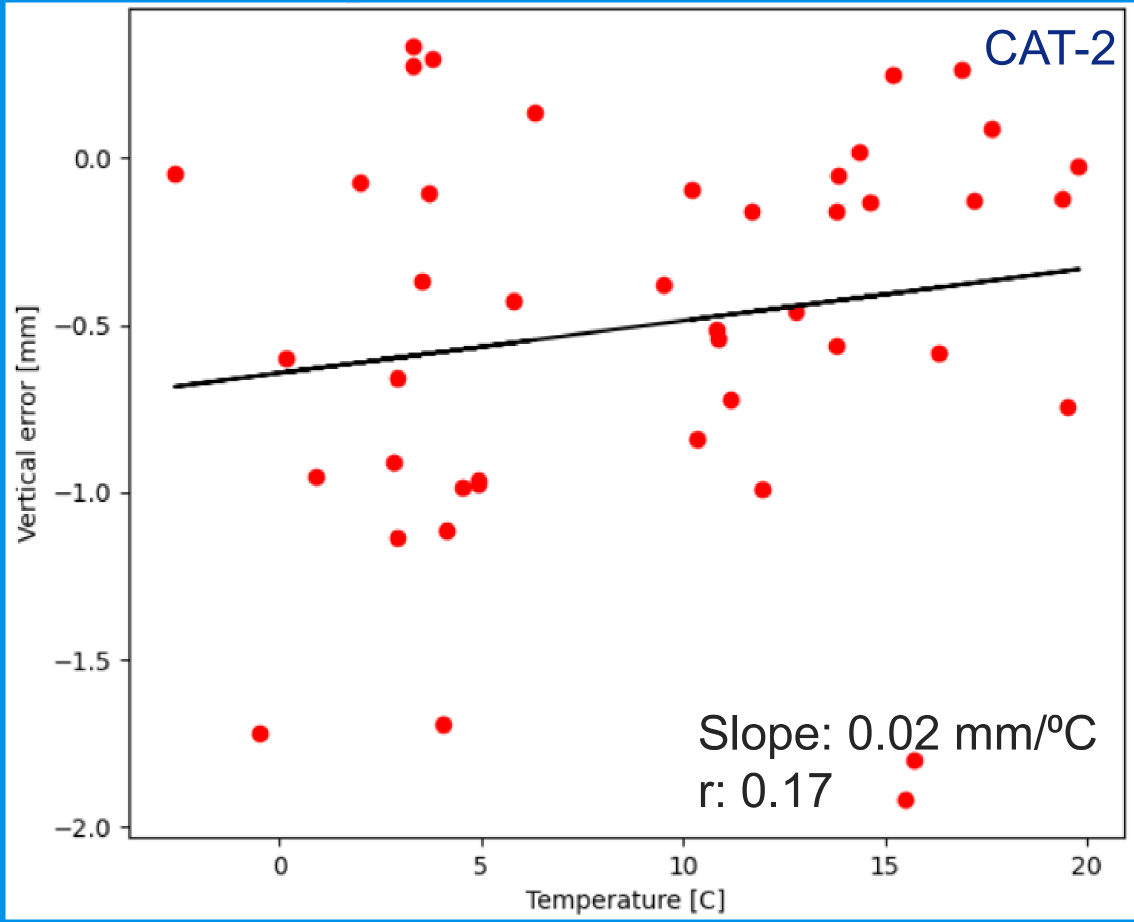




- Significant subsidence of ”stable” CAT-1 (left); smaller subsidence of CAT-2 – why is that?
- Slight winter minimum, particularly for CAT-1

Temperature offset: 2D vertical





Temp. data from DMI

- Note: different y axes!
- Larger offsets for lower temp
- Values vary for different relative orbits (CAT-1: 0.16 – 0.26 mm/ºC; CAT-2: 0.01 – 0.07 mm/ºC)

Outlook

- Thorough test of artificial reflector performance with many useful learnings
- CRs work
- CAT performance:
  - Significant difficulties in obtaining fully functioning and continuously operating instruments: leakage of water, sudden failures/ deaths, temperature offsets, etc.
  - Temperature offset increases with lower temp and differs for each instrument
  - Instruments periodically stable: mm and sub-mm accuracy found for limited time periods
- CATs may be cheap to acquire but require significant efforts for applicability for long-term deformation monitoring
- Potential in satellite-based deformation monitoring of artificial reflectors installed by geodetic infrastructure? Using CRs? Yes. Using CATs? No (not yet).