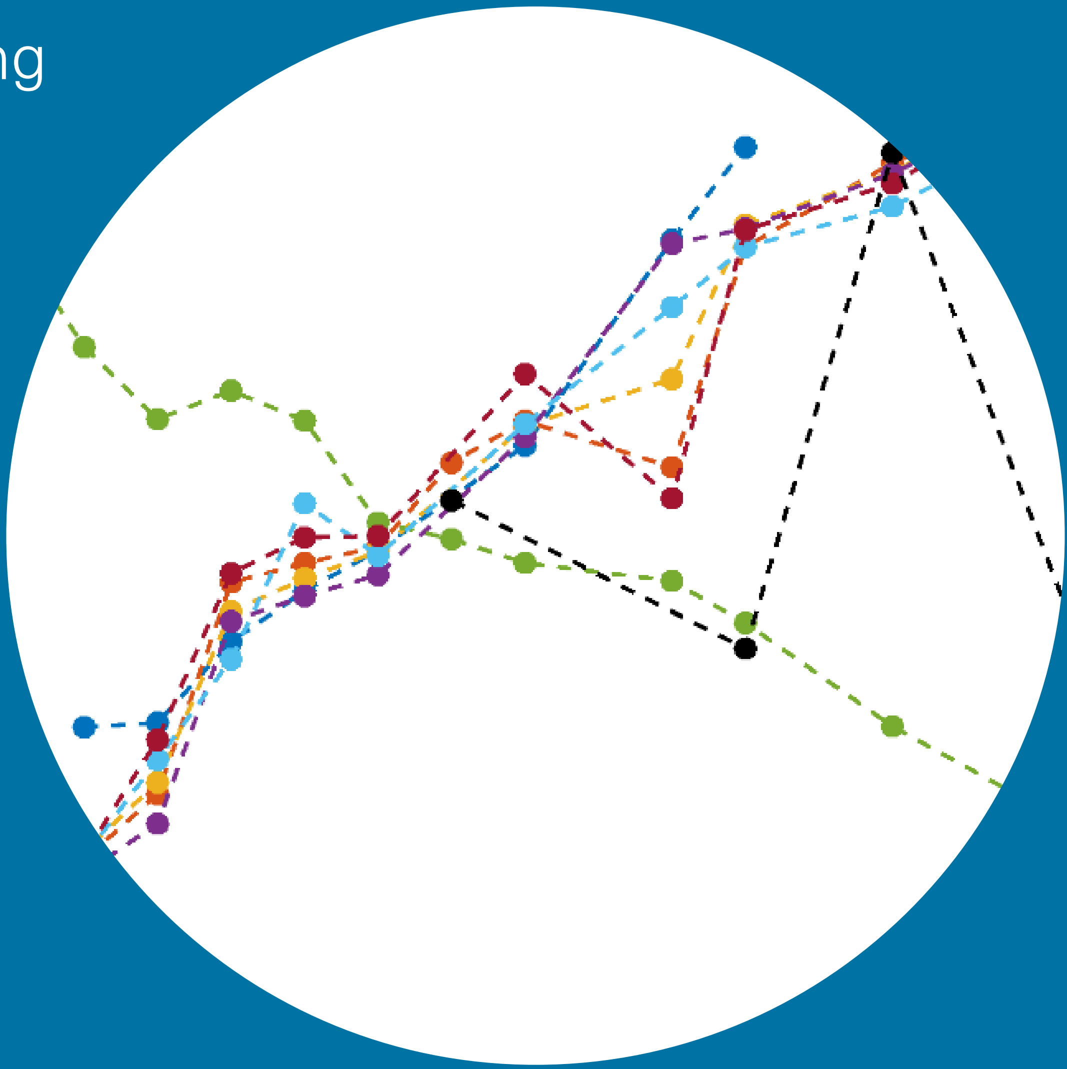
Styrelsen for Dataforsyning og Infrastruktur

DK CORS Stability Analysis



Georgiana Alexandra Sandulescu & Kristian Keller

GeoNotes 6
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2022-06-01

GeoNotes 6. Version 1, 2022-06-01

Georgiana Alexandra Sandulescu & Kristian Keller:

DK CORS Stability Analysis

Frontpage: Levelling analysis of GNSS station SULD. Excerpt from figure 2.2 in appendix 3.

This report was written during G.A. Sandulescu's internship at SDFE in 2018.

The *GeoNotes Series* is published by Styrelsen for Dataforsyning og Infrastruktur/Agency for Data Supply and Infrastructure (SDFI), Copenhagen, Denmark.

The publications in this series include working papers and preliminary reports from ongoing projects.

Hence, results and conclusions reported may be tentative and subject to change. Opinions expressed do not necessarily reflect the position of SDFI.

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Introduction

During the latest decades, GNSS technologies have been developing with an accelerating pace, gaining ground in a broad spectrum of applications, from surveying, mapping and GIS to climate change studies or even military use. Acknowledging the importance and the necessity of contributing to this global technological phenomenon, Denmark started to focus on the implementation and maintenance of a solid and reliable GNSS network that can be employed in various applications.

The Danish Ministry of Energy, Utilities and Climate is in charge of the administration and development of the existent GNSS national network, more specifically through the Spatial References department , within the Data Supply and Efficiency Agency. The GNSS permanent reference stations serve as geodetic infrastructure in Denmark, help connecting the Danish reference frame to the European and global ones, and constitute the basis for many modern research directions, for example the study and development of uplift models. Taking into consideration all these applications of the network makes the importance of checking the stability of the permanent stations and the reliability of the provided data obvious.

This report deals with the problem of stability of the Danish permanent reference stations and with the task of establishing how these stations should be measured, how often the measurements campaigns should be carried out, and which analysis/models should be employed in the study of the acquired data.

Background and used data

The present study uses data concerning 10 permanent stations from the GNSS network: Buddinge (BUDP), Smidstrup (SMID), Suldrup (SULD), Esbjerg (ESBC and ESBH)[1], Gedser (GESR), Hirtshals (HIRS), Ferring (FERR), Sj. Odde (HABY), Tejn (TEJH) and Fynshav (FYHA) – see Figure 1.

Figure 1 – GNSS permanent reference stations in Denmark

[1] Due to the instability of the ESBH station, a newer one was installed in the Esbjerg area – ESBC.

The monitoring of each permanent station is done using an additional number of benchmarks; these can be divided into three categories:

- Security benchmarks (in Danish: *sikringspunkter*)
- Near control benchmarks (in Danish: *nærkontrol punkter*)
- Remote control benchmarks (in Danish: *fjernkontrol punkter*)[2]
- Jessen point (in Danish: Jessenpunkt) one of the above points selected to be used as reference for the timeseries

The sikringspunkter are usually located on the concrete foundation of the permanent station, or, in some cases, in the near vicinity of it, and they are constituted of vertical bolts embedded in the concrete (in Danish: *lodret bolt*). The nærkontrol punkter are defined using either vertical bolts or screw pegs (in Danish: *skruepløk*) and they are situated close to the permanent stations at distances of 20-100 m. The fjernkontrol punkter are usually situated at a larger distance – between 1 and 4 km – and many times are a part of the Danish 5D network. A generalized overview of these benchmarks that are meant to be used for the monitoring of the permanent stations can be seen in Figure 2.

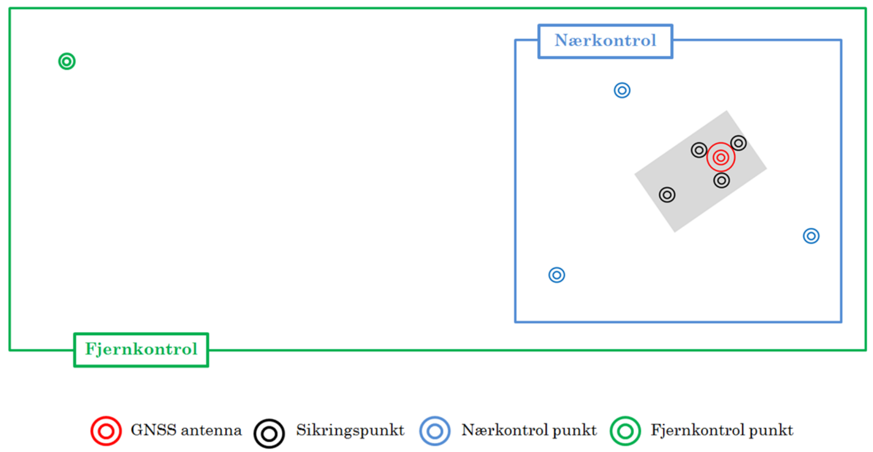


Figure 2 – General overview of the benchmarks used for the monitoring of a GNSS permanent reference station

There are three types of data acquired: levelling data (1D), total station measurements (2D) and GNSS measurements (3D). Each category of points mentioned above is measured differently, depending on the benchmark accessibility, as can be seen in Table 1.

Measurement type→ Point type ↓	1D Levelling	2D Total Station	3D GNSS
GNSS Antenna	x	x	-
Nærkontrol	x	x	x
Fjernkontrol	x	-	x
Bolter i fundament	x	-	-

Table 1 – Types of data acquired in every benchmark

[2] The rest of the report will use the Danish version of the words defining the benchmark categories (as no English terminology has been adopted at the moment).

From a temporal view, the data distribution for each station can be seen in Table 2.

Station→ Time series ↓	BUDP	SMID	SULD	GESR	HIRS	ESBC	ESBH	FERR	HABY	TEJH	FYHA
1998	-	1D	2D	-	-	-	-	-	-	-	-
1999	1D	2D	1D	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-
2001	1D 2D	1D 2D	1D 2D	-	-	-	-	-	-	-	-
2002	1D 2D	1D 2D	1D 2D	-	-	-	-	-	-	-	-
2003	1D 2D	1D 2D	1D 2D	1D	-	-	-	-	-	-	-
2004	1D 2D	1D 2D 3D	1D 2D	1D 2D	1D 2D	-	-	-	-	-	-
2005	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	-	-	-	-
2006	1D 2D 3D	1D 2D 3D	1D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	-	-	-	-
2007	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	1D 2D 3D	-	-	-	-
2008	3D	3D	3D	1D 2D	1D 2D	1D 2D	1D 2D	-	-	-	-
2009	1D 2D	1D 2D	1D 2D	3D	3D	3D	3D	1D 2D 3D	-	-	-
2010	-	1D 2D 3D	1D 3D	-	1D	1D 2D	1D 2D	1D 2D	1D 2D 3D	2D	-
2011	1D 2D 3D	2D 3D	2D	1D 2D 3D	-	-	-	3D	1D 2D 3D	2D 3D	2D
2012	1D	3D	1D 2D 3D	1D	1D 2D 3D	1D	1D 2D	1D 3D	1D	1D	1D 2D 3D
2013	2D	3D	-	1D	1D	1D 2D 3D	1D 2D 3D	1D 3D	1D 3D	1D 3D	1D 2D 3D
2014	2D 3D	3D	-	1D 2D 3D	1D	1D	1D 2D	1D	1D 3D	1D 2D 3D	1D 3D
2015	-	3D	1D 3D	1D	1D 3D	-	-	1D 3D	-	-	-
2016	-	1D 3D	-	-	-	1D 3D	1D 3D	-	-	-	1D 3D
2017	3D	3D	-	3D	-	-	-	-	3D	3D	-

Table 2 - Complete list of data used in the present study for each of the GNSS permanent stations

It is important to emphasis that the actual GNSS antenna requires special measurement procedures. The purpose of these measurements is to determine the position of a point defined as a vertical bolt or, in some cases, as the ARP (Antenna Reference Point). In order to determine the height of each station, the *opføring* procedure is used.[3] This can be performed both trigonometrically and geometrically, depending on the type of the point definition. Thus some of the stations are measured only trigonometrically (BUDP, SMID, SULD, ESBH), some are measured only geometrically (FERR, HABY, TEJH, FYHA), whereas for the rest of them (ESBC, GESR, HIRS) both procedures have been employed.

[3] The opføring procedure is performed according to the internal guidelines of the agency.

Methods

Several methods have been used in order to assess the stability of the GNSS stations and of the corresponding point group implicitly:

- Regression analysis

  Linear regression analysis is used in order to determine eventual trends and to approximate the annual height variation.

- Global congruence test

  The global congruence test is a geometric comparison analysis, based on two temporal stages of the same object/network. It is commonly used to determine movements and deformations of structures, by employing geodetic monitoring measurements; in this particular case it provides information about the relative displacements occurred in between the nærkontrol points.

- Strain analysis

  The strain analysis is derived from quantum mechanics and focuses on the displacements of the benchmarks relative to one another. The method provides information about the possible tensions present in a local area and shows which of the network points are predisposed towards instability.

- "A-test" developed by SDFE

  The mathematical description of the algorithm can be found in one of the following sections **Closer look to "A-test".**

More details referring to each method will not be presented in this report, but can be found in the references. The conclusions presented below rise from a combination of the performed analyses, together with a visual assessment of all the plots and representations. Comparing the stations/benchmarks behavior broadens the understanding of the process and helps identifying some patterns. The process of assessing the stability of the GNSS stations remains unfortunately very manual; many times insight from the surveyors is needed, data has to be discarded etc.

Observations about acquired data

This sections goal is to present the overall results of the analysis. The individual results obtained for each station can be found in the appendices.

Levelling data can be used in different analyses; a very useful feature would be a more detailed description of the measurement campaign / physical conditions at the time of the measurements. This could serve as an argument in eliminating some heights from the analysis and could also help in a more accurate determination of the heights uncertainty.

> ***Example:*** the 2009 levelling campaign provides unreliable heights for the station and the corresponding benchmarks, due to the weather, observer etc. These heights should be discarded in the assessment.

Total station data can be used in some classical deformation analyses. Acquiring this type of data from time to time (every 6 years) could provide insight into the absolute and relative deformations that can appear. Within an uncertainty of ±1 mm, assessing the planimetric coordinates obtained from total stations measurements could indicate displacements.

> ***Example:*** in the case of SMID station, the last determined coordinates date back to 2013 and they indicate a significant planimetric displacement (see Appendix 2 - Figure 3.1). A new determination of the point would help eliminate the doubt in this case.

GNSS data (coordinates obtained after measuring in the nærkontrol points) is very difficult to use in statistical analyses. If no way to employ this data is found, it shouldn't be measured anymore. If the 3D time series will be continued, they should be synchronized with the 2D measurements (many time historical coordinates cannot be compared because the measurements have been acquired in different years).

Final comments and recommendations

Based on all the performed analyses and on the comparison to the other stations/points behavior, the following conclusions can be drawn.

Stations **ESBC**, **HIRS**, **FYHA**, **FERR**, **TEJH** and **HABY** are considered stable.

- They can be measured with a larger than 3 years interval (possibly every 5 or 6 years).
- Total station measurements can be also made every 5 or 6 years. Even if at the moment there is a gap in the 2D time series, the data would be useable.
- Points to pay attention to in future campaigns: ESC1 (ESBC), HIR3 (HIRS), FYH2 (FYHA), HAB3 (HABY). There may not be anything wrong with these points, but a careful future determination (eventually some physical assessment of the points in the field) would eliminate any concerns.

Station **GESR** stability should be doubted.

- A subsiding trend is present during the last years (see Appendix 6 – Figure 2.4). An immediate measurement campaign would eliminate these concerns and would strengthen the decision regarding this station.
- The nærkontrol points GED3 and GED4 also seem to be unstable (see Appendix 6 – Figure 2.9, Figure 2.10). A decision should be made.

Station **SULD** is considered stable, but there are problems with the time series.

- Point SUL1 should be eliminated from the nærkontrol group.
- The Jessenpunkt is obviously unstable. All the analyses should be repeated after the change of the Jessenpunkt / recalculation of heights.
- If the influence of the Jessenpunkt is eliminated (see Figure 3) the station can be assessed as stable. Thus it can be measured with a larger than 3 years interval (possibly every 5 or 6 years).

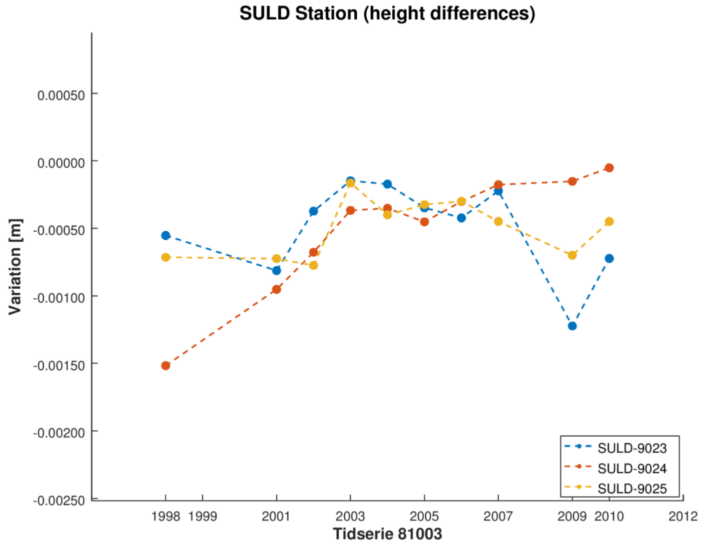


Figure 3 – SULD station variation pattern after eliminating the influence of the unstable Jessenpunkt

In the case of **SMID** and **BUDP** stations, no clear conclusions can be drawn.

- Both stations should be measured again with the same frequency or possibly more (two consecutive years) until a conclusion is achieved.
- In the case of SMID this would also be an advantage because it is the station with the largest time series and the most measurements of each type.
- In the case of BUDP, no pattern can be identified in the benchmarks/station variation; furthermore, the twin station should somehow be included in the analysis.

Closer look to "A-test"

The "A-test" is an algorithm developed within SDFE and employed for assessing the stability of a geodetic benchmark. This particular algorithm is applied only to the levelling data.

According to the description of the algorithm, a point will be considered stable if one of the two following two conditions is fulfilled:

- $\max z \; - \min z \; \leq \mathbf{0.4} \; mm$
- for all differences: $|z_i - z_j| \leq \mathbf{3} \cdot \sqrt{s_i^2 + s_j^2}$

A simpler and more visual description can be done as follows:

- The first condition implies that all the heights of the point are located in an interval not larger than the ignore limit (here 0.4 mm). An example can be seen in Figure 4, where the three green horizontal lines help marking this interval: the middle line depicts 0.0 mm variation, whereas the exterior lines depict -0.2 mm, respectively +0.2 mm.

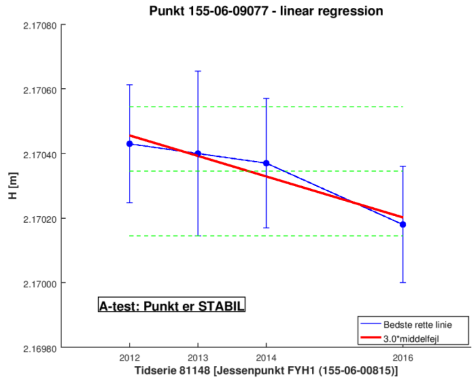


Figure 4 – Linear regression and stability check for point 155-06-09077

The second condition includes the mean error in the analysis. The point is considered stable if the 0.0 mm variation line (the middle horizontal line) intersects all the error bars (which represent 3 times the mean error for each elevation). An example can be seen in Figure 5, where the point is considered stable due to the second condition.

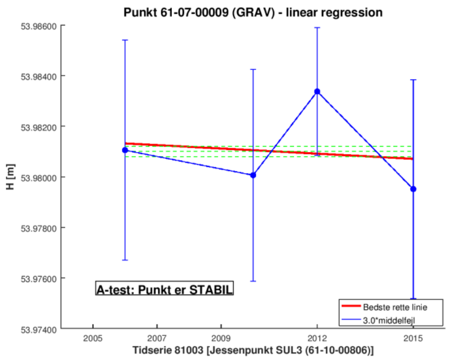


Figure 5 – Linear regression and stability check for point 61-07-00009

The parameters depicted with red are manually chosen, as input data before running the code:

- The first condition is related to the *–ilim* input parameter described in the code as *"-ilim <ignore_limit> Specify the 'ignore limit' for stability tests in [mm]."*
- The second condition is related to the *–sdi* input parameter described in the code as *"-sdi <ignore_limit> Specify the 'error interval' for stability tests, e.g. 2.0"*

Unfortunately using the same parameters for the GNSS stations analysis provides only negative results. Thus the reasoning behind choosing these limits has to be modified. For a better overview of the changes which appear when the ignore limit is modified, the analysis has been applied repetitively for all the reference stations and neighboring points.

The results from the SULD (Appendix 12 – Table 3) and ESBH (Appendix 12 – Table 4) stations will not be included in this assessment. In the case of SULD, there is a problem with the Jessenpunkt, thus all the points are considered unstable regardless of the chosen ignore limit. In the ESBH case, instability was expected. For the rest of the stations, the obtained results are presented in Appendix 12 - Table 1, Table 2, Table 5 to Table 11.

The following statistics only refer to the last 9 stations mentioned above (where no visible problems have been observed beforehand): SMID, BUDP, ESBC, HIRS, GESR, HABY, FYHA, FERR and TEJH.

Type	Stable	Procent
GPS Antenna	0 / 9	0.00%
Bolter i fundament	13 / 34	38.24%
Nærkontrol	11 / 27	40.74%
Fjernkontrol	7 / 9	77.78%

Table 3 – Test results for the A-test using 0.4 mm as an ignore limit

None of the stations are considered stable when using the ignore limit 0.4 mm. More than half of the concrete bolts and nærkontrol points are also considered unstable. The fjernkontrol points appear to be stable; however this case will be treated separately.

Based on a purely experimental assessment, the ignore limit used for the GNSS stations should not be the same as the one used for the other point categories. This approach also makes sense considering the measurement process in the case of the actual stations: difficult setting, indirect measurements etc.

Imposing an ignore limit of **1.5 mm for the GNSS reference stations** and one of **0.8 mm for the rest of the points**, the following results are obtained:

Type	Stable	Procent
GPS Antenna	5 / 9	55.56%
Bolter i fundament	20 / 34	58.82%
Nærkontrol	13 / 27	48.15%
Fjernkontrol	7 / 9	77.78%

Table 4 – Test results for the A-test using 1.5 mm as an ignore limit for the station and 0.4 for the other types of benchmarks

The reasoning behind choosing these two parameters remains a debatable issue; stronger arguments should be found, rather than using experimental practice.

In the case of the fjernkontrol points, the analysis doesn't seem to provide reliable results. 7 out of the 9 used fjernkontrol points are always stable, regardless of the chosen ignore limit. This particular behavior is due to the large mean errors: as the fjernkontrol points are situated at a considerable distance from the other points in the analysis, the obtained mean errors are large and always fulfill the second condition in the algorithm.

In conclusion, the algorithm should not be used for the fjernkontrol points. Moreover, the ignore limits should be modified (possibly 1.5 mm for GNSS stations and 0.8 mm for other categories).

Future work

All the insight provided by the analyses presented in the present report has to be combined and / or coordinated with the other types of models employed for the study of the permanent GNSS reference stations behavior.

A superficial comparison of the levelling and total station data results with the GNSS time series for each of the permanent stations shows that many of the displacements and variation patterns can also be depicted in the GNSS time series. Furthermore, if the absolute uplift model would also be included in the assessment, more insight would be available.

Thus, the above recommendations are only viable until further research on the matter is carried out. If the same results can be obtained by using exclusively GNSS data from the stations, classical levelling and total station measurements could be eliminated.

References

1. Least Squares Adjustment: Linear and Nonlinear Weighted Regression Analysis; Allan Aasbjerg Nielsen
2. Geodetic deformation analysis, Cüneyt Aydın (YTU Geodesy Division)
3. Ground-Based Deformation Monitoring, Axel Ebeling
4. GNSS time series for permanent GNSS stations in Denmark, Shfaqat Abbas Khan, 2018
5. Absolute uplift model calculations, DTU Space, 2016

APPENDIX 1 - BUDDINGE [BUDP]

Tidserie: 81007

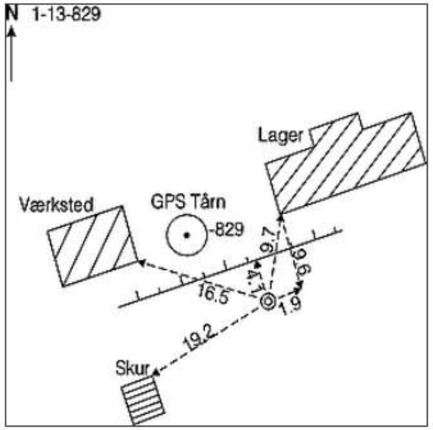
GPS Antenna	***BUDP 1-13-00829***
Nærkontrol	***BUD1 1-13-00001***
	BUD2 1-13-00830 81007 → **JessenPunkt**
	BUD3 1-13-00831
	BUDD 1-13-00821 1-13-00826 27658 9899/1
Bolter i fundament	***1-13-09113***
	1-13-09114
	1-13-09115

Notes:

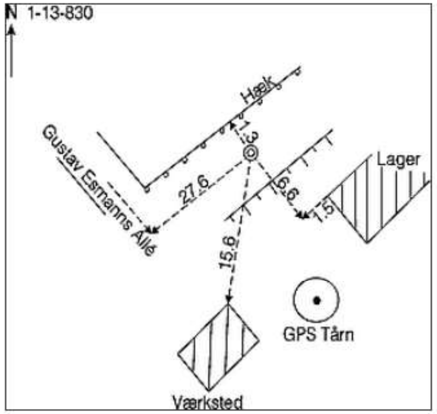
- All points around BUDP station are considered unstable by the A-test (even with higher limit parameters).
- Regression analysis provides a significant trend for the nærkontrol point BUD3 (1-13-00831): the point is subsiding with 0.21 ± 0.02 mm/year.
- In terms of planimetric coordinates: there seems to be displacements, especially on the Northing direction.
- The congruence test shows relative displacements between the nærkontrol points.
- Strain analysis indicates predisposition to instability.

1. Skitser:

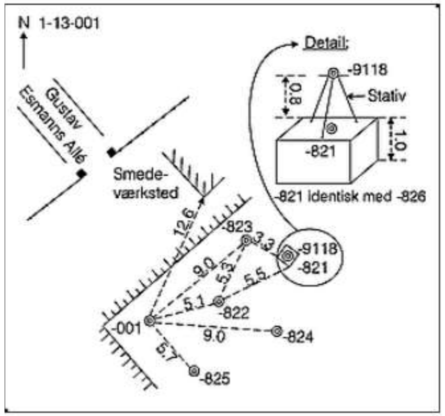
Figur 1.1



Figur 1.2



Figur 1.3

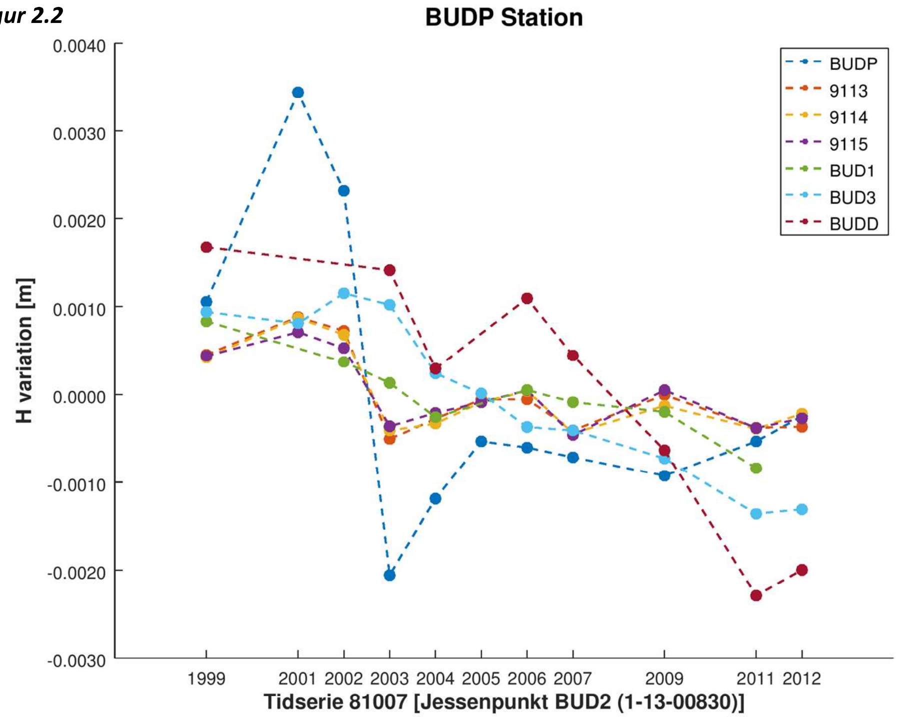


Figur 1.4

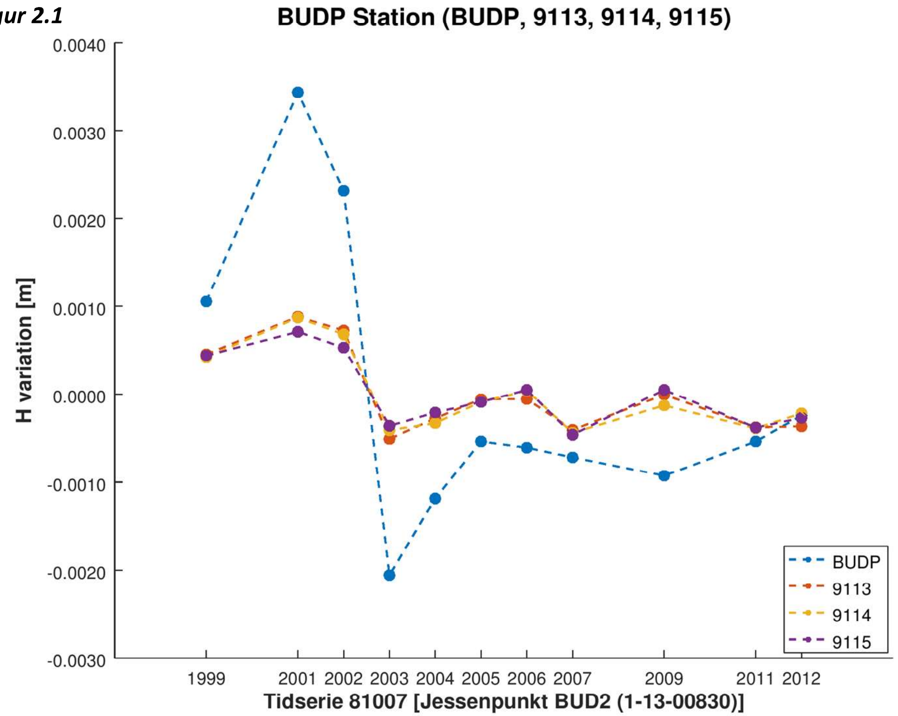
2. NIVELLEMENT

- *Initial plots*
- *Regression analysis*

Figur 2.2



Figur 2.1



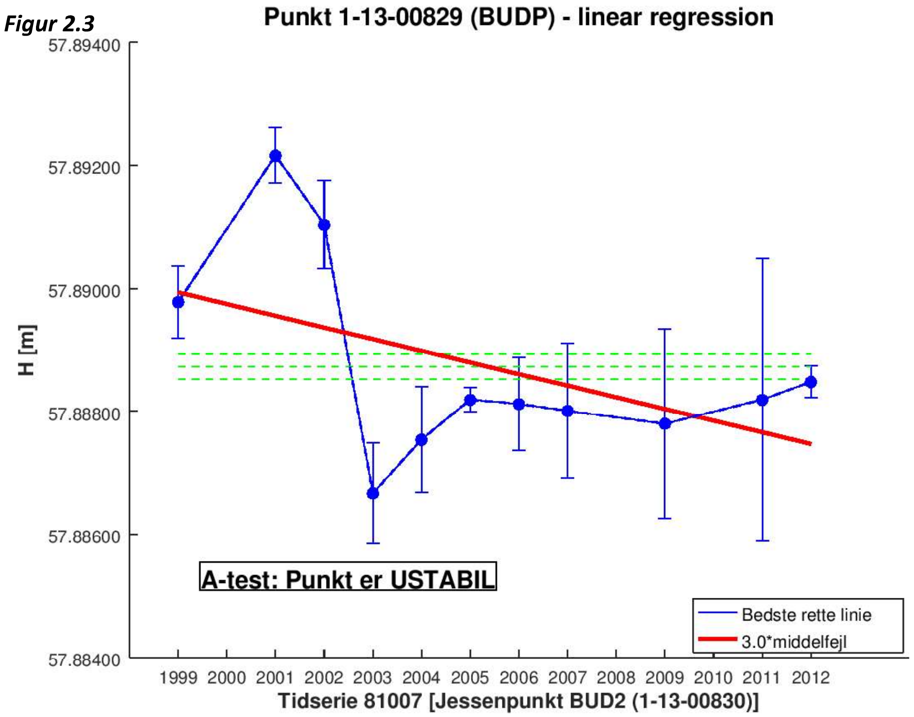
BUDDINGE (BUDP) Linear Regression analysis results

Type	Punkt	2 parameters regression model (linear fitting)			
		θ_1 [m/year]	$\sigma_{\theta 1}$ [m/year]	t - value	p -value
GPS Antenna	BUDP 1-13-00829	-0.000190	0.000114	-1.658600	0.131580
Bolter i fundament	1-13-09113	-0.000075	0.000029	-2.570300	0.030172
	1-13-09114	-0.000071	0.000028	-2.511800	0.033210
	1-13-09115	-0.000064	0.000024	-2.679200	0.025239
Nærkontrol	BUD1 1-13-00001	-0.000113	0.000022	-5.166000	0.002083
	BUD3 1-13-00831	-0.000211	0.000022	-9.592600	0.000005
	BUDD 1-13-00821	-0.000314	0.000060	-5.198900	0.002017

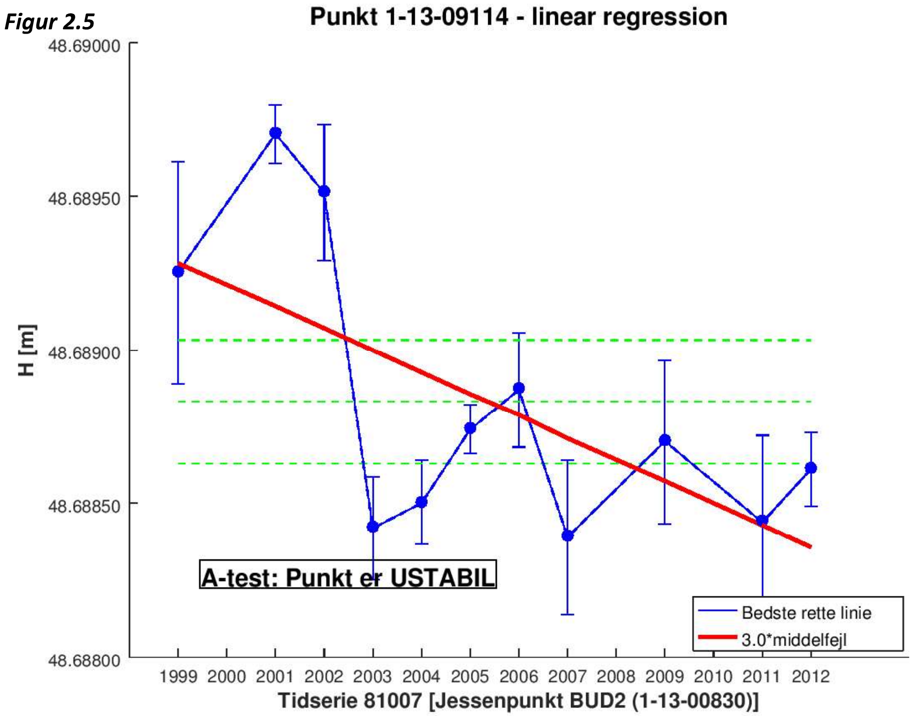
Statistically significant results --> Linear Regression

Type	Point	Behaviour	Variation [mm/year]	Std [mm/year]
Nærkontrol	BUD3 1-13-00831	↓	-0.21	0.02

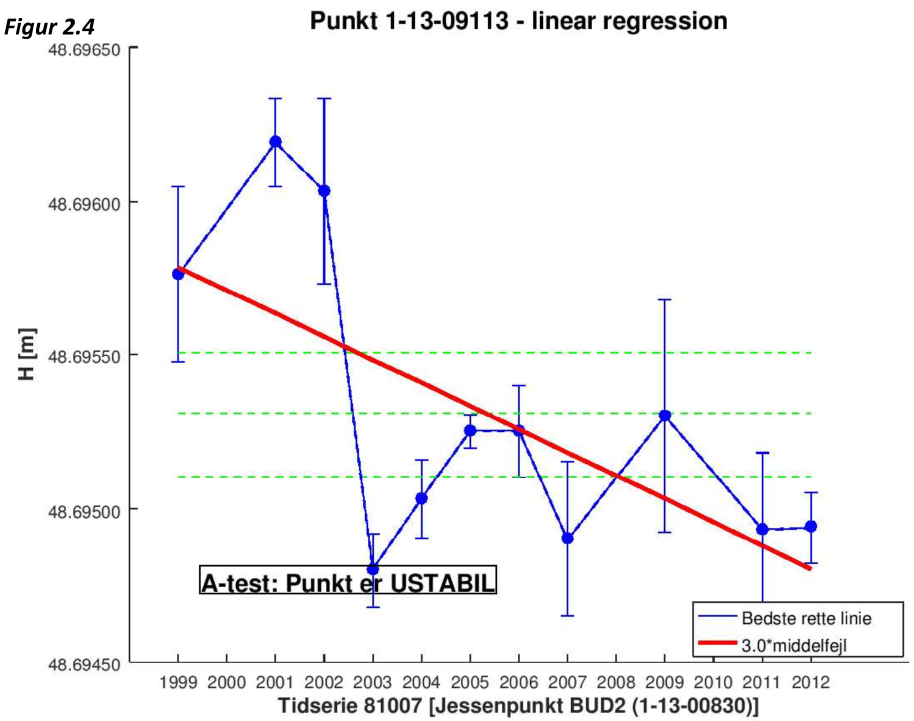
Figur 2.3



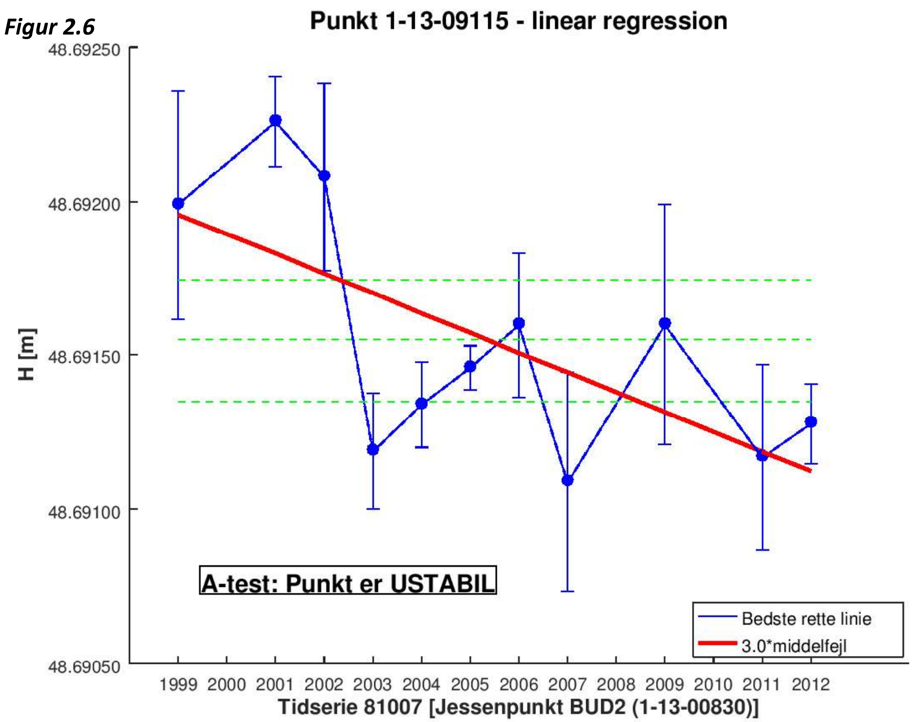
Figur 2.5



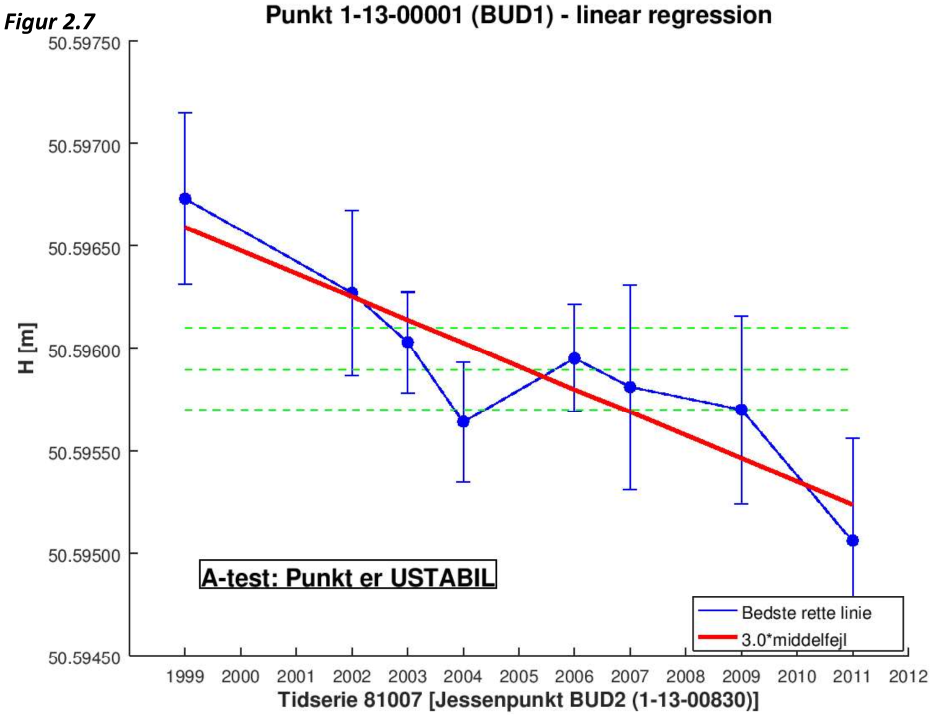
Figur 2.4



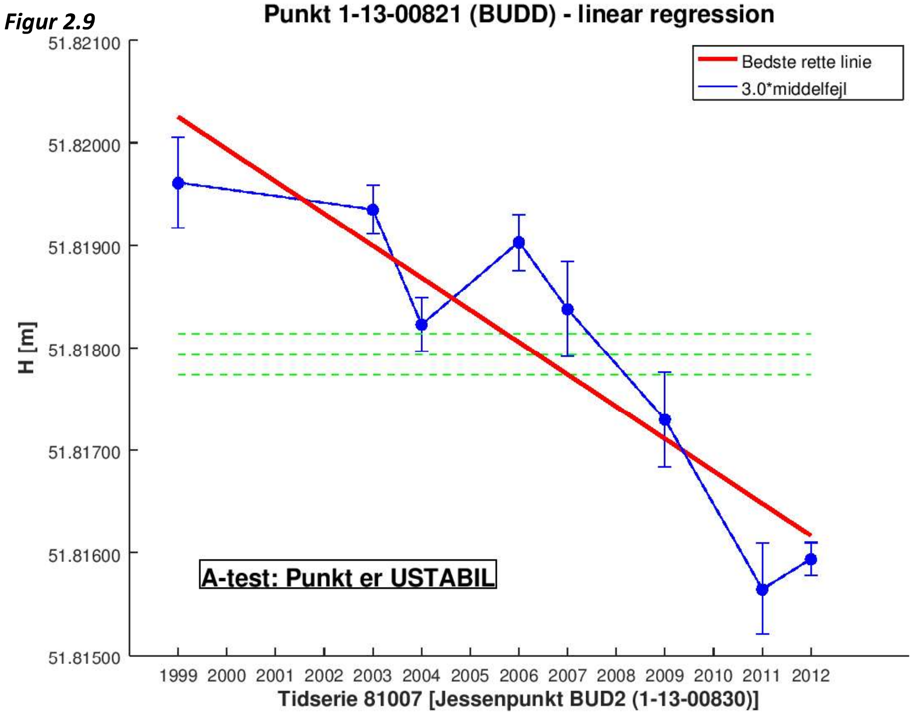
Figur 2.6



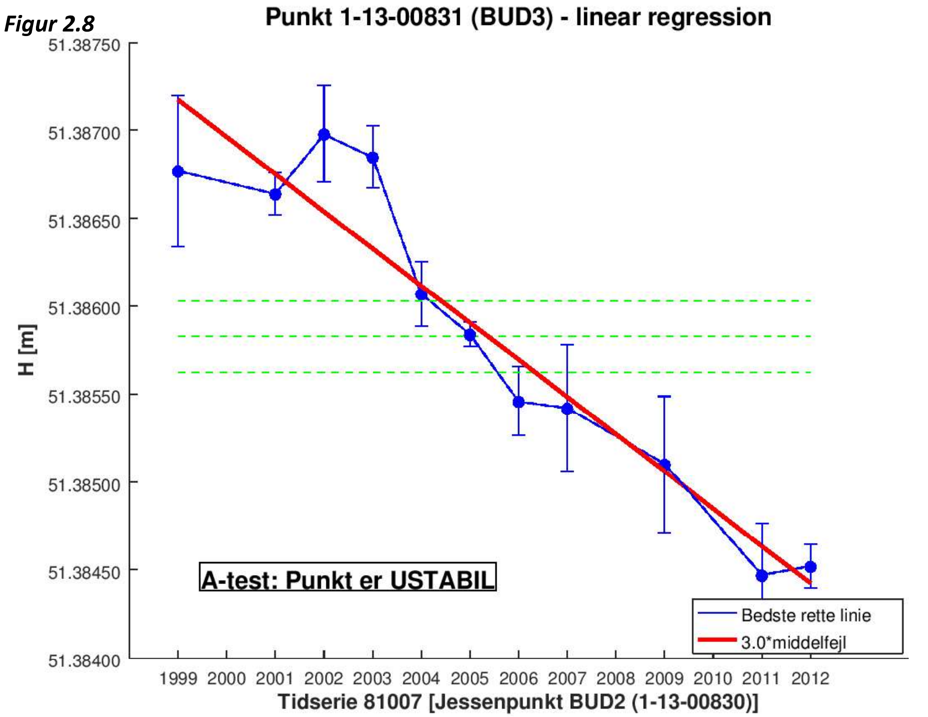
Figur 2.7



Figur 2.9



Figur 2.8



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

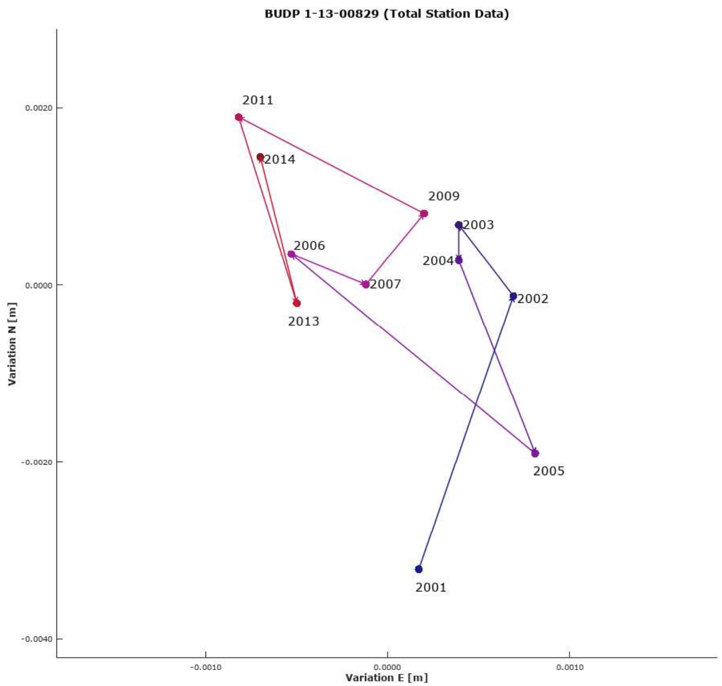
Constant Value [mm]	Station: BUDP						
	Antenna	Sikringspunkter			Nærkontrol		
	BUDP	9113	9114	9115	BUD1	BUD3	BUDD
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
1	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
1.5	ustabil	stabil	stabil	stabil	ustabil	ustabil	ustabil
2	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil

3. PLANIMETRIC ANALYSIS

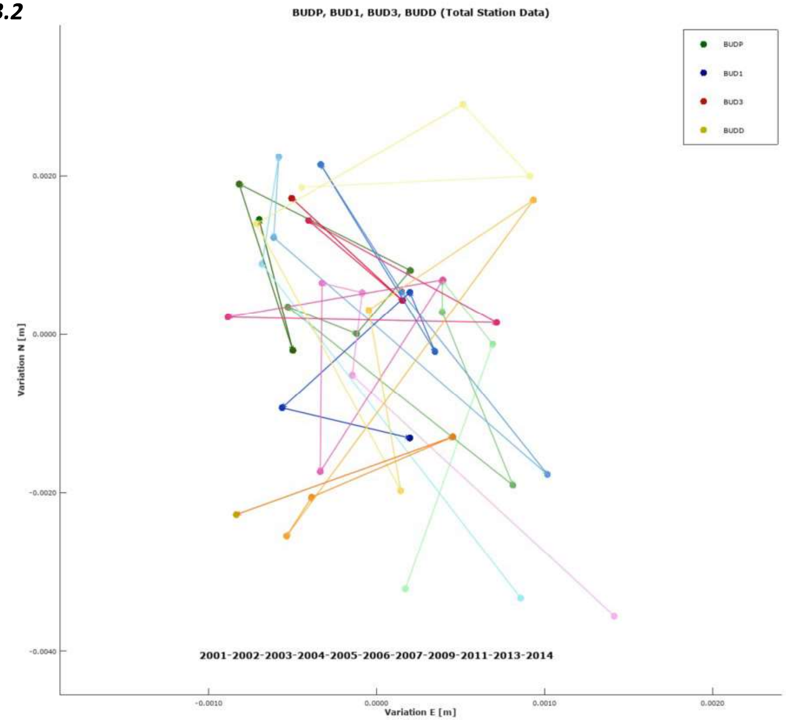
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! ***In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.***

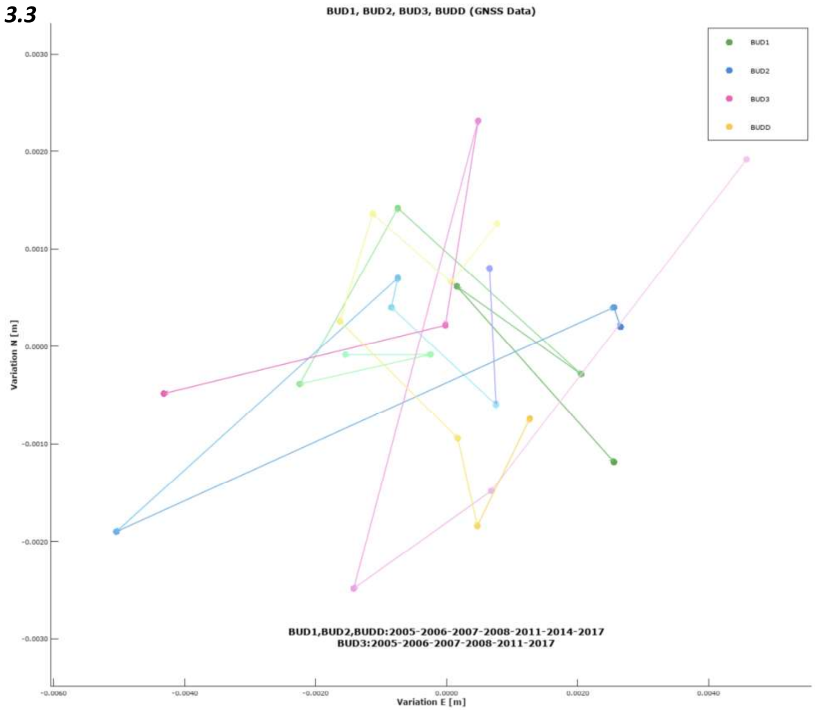
Figur 3.1



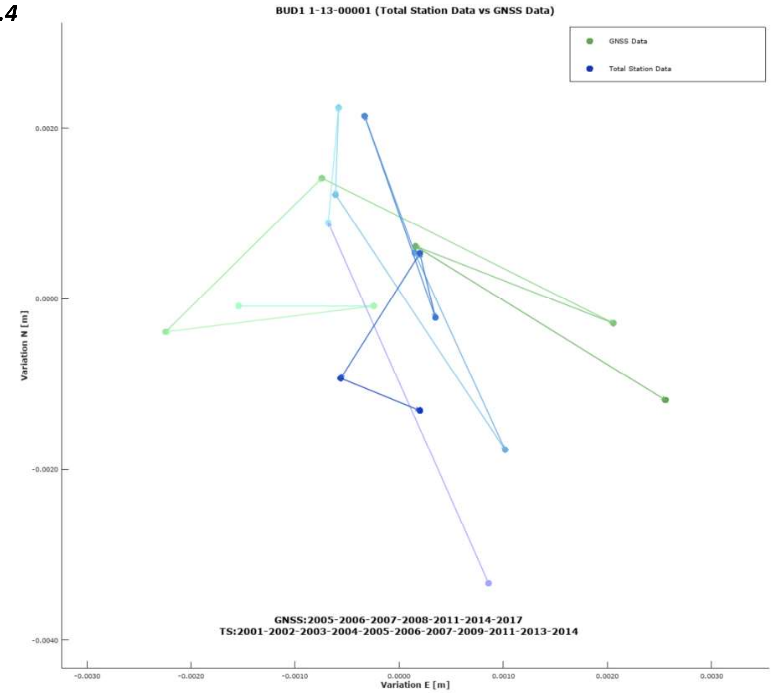
Figur 3.2



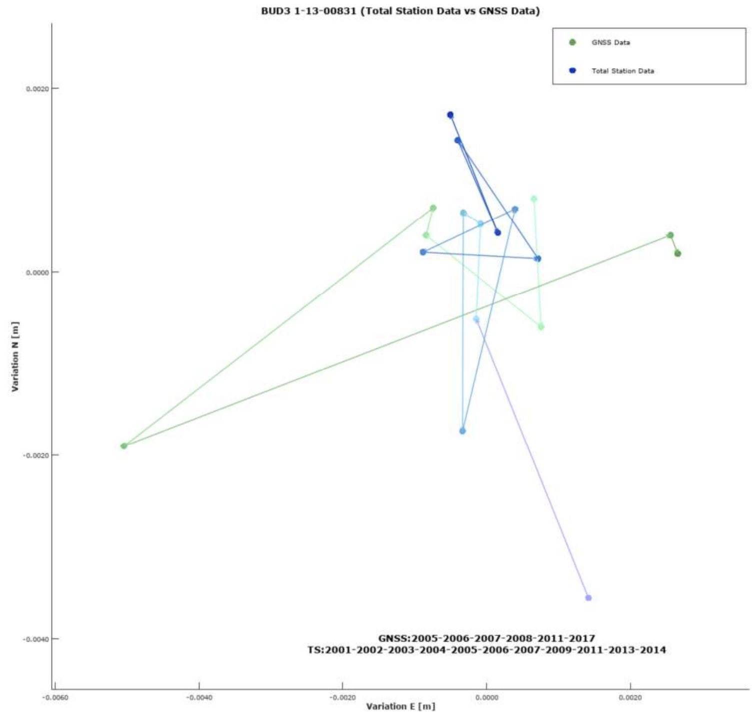
Figur 3.3



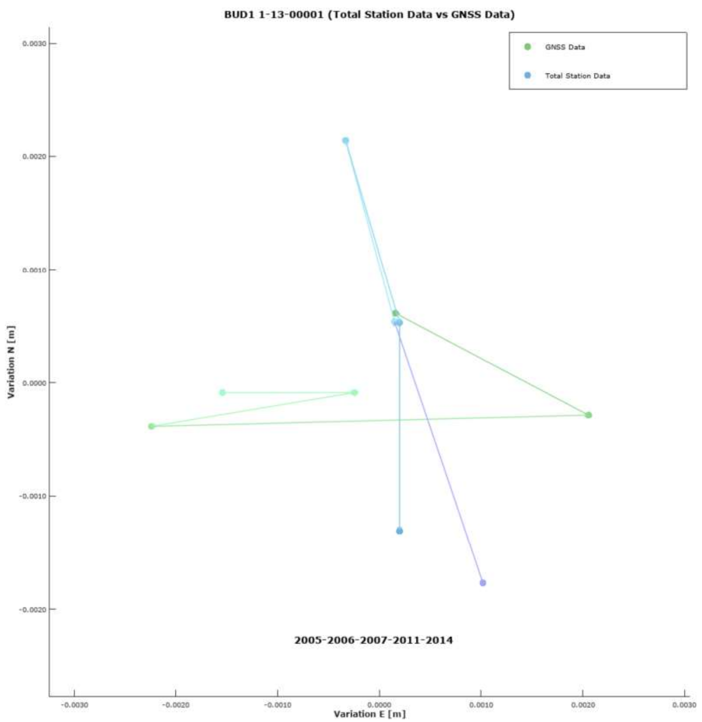
Figur 3.4



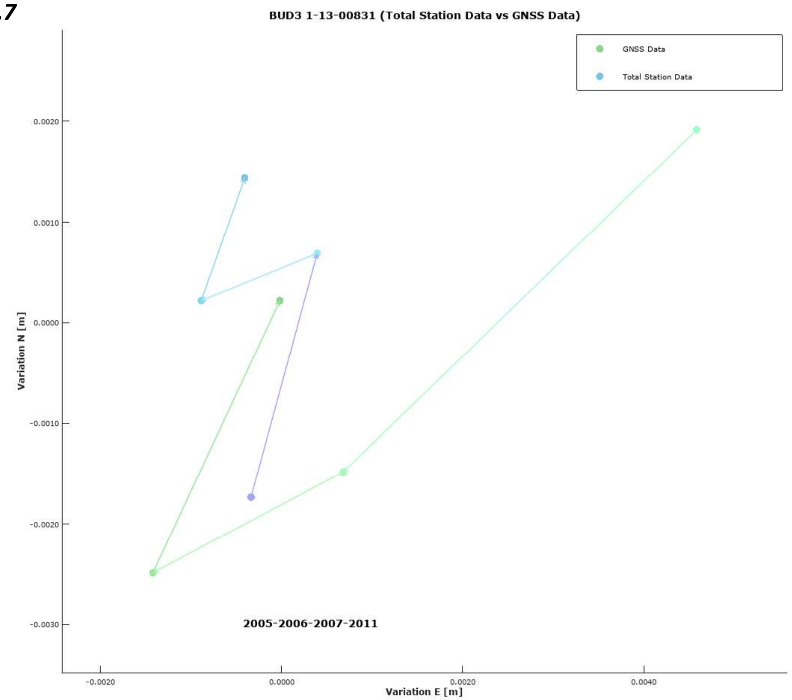
Figur 3.6



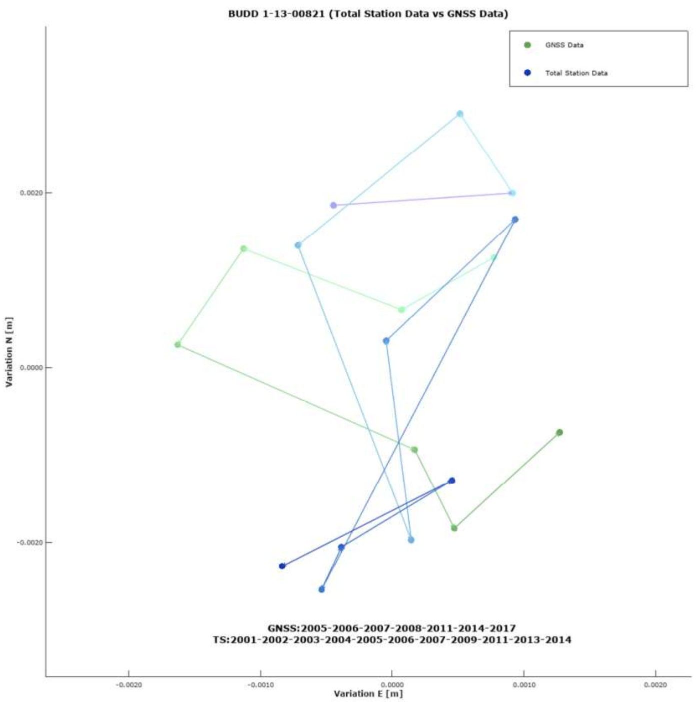
Figur 3.5



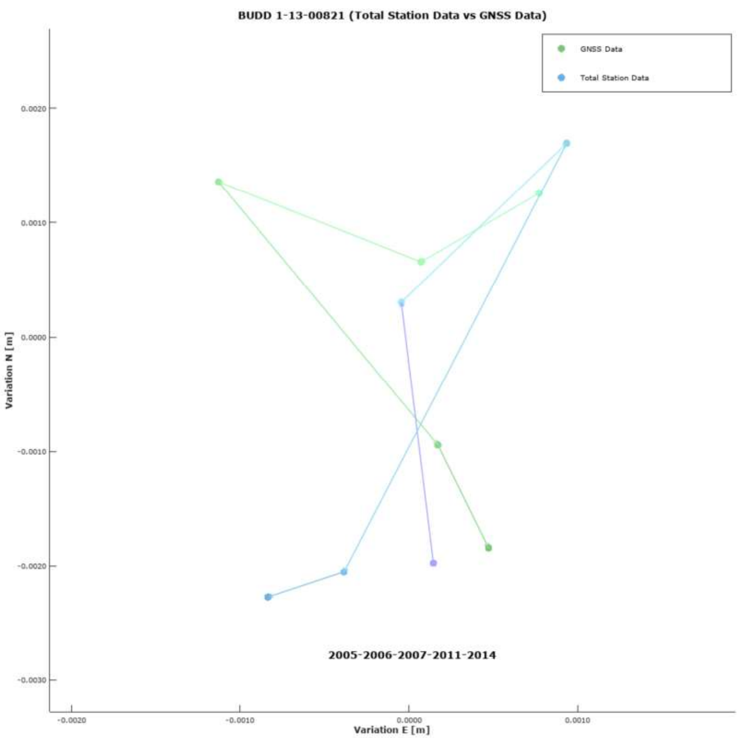
Figur 3.7



Figur 3.8

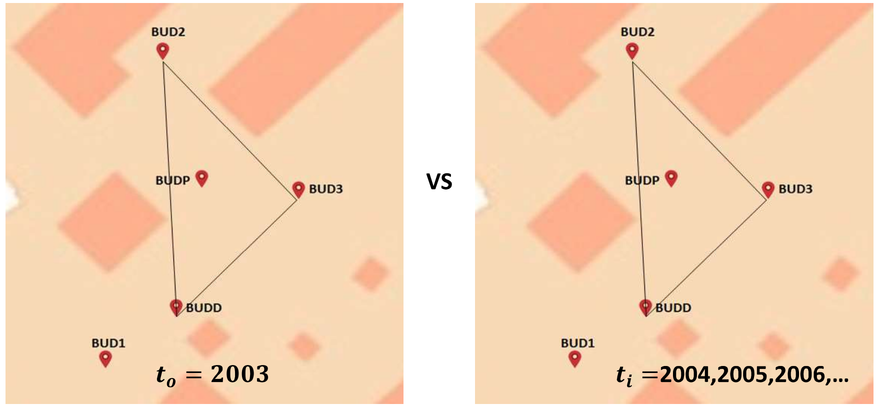


Figur 3.9



Global Congruence Test

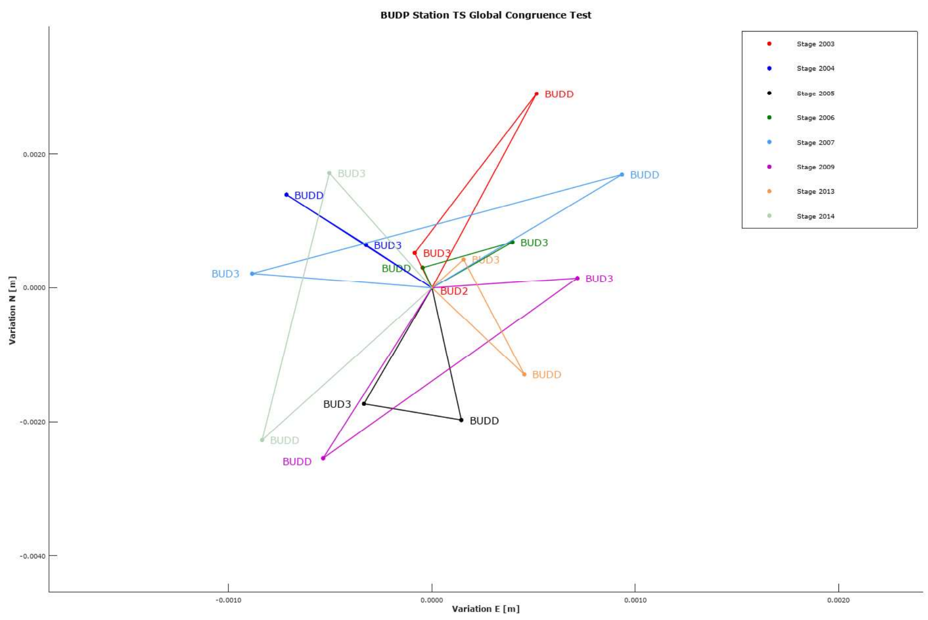
- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).



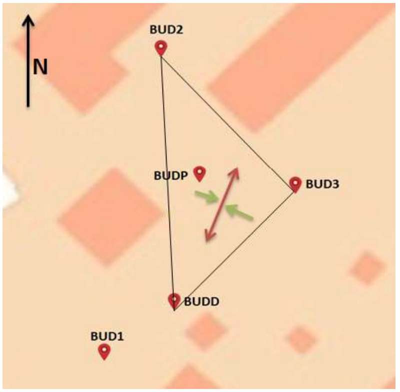
Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2003 vs **2004**	dN BUD2	-2.80	2.80	>	2.31	Unstable
	dE BUD2	1.76	1.76	<		
	dN BUD3	2.61	2.61	>		Unstable
	dE BUD3	1.50	1.50	<		
	dN BUDD	-1.87	1.87	<		Unstable
	dE BUDD	-2.79	2.79	>		
2003 vs **2005**	dN BUD2	0.22	0.22	<	2.31	Unstable
	dE BUD2	2.96	2.96	>		
	dN BUD3	1.52	1.52	<		Unstable
	dE BUD3	-3.04	3.04	>		
	dN BUDD	-2.84	2.84	>		Unstable
	dE BUDD	0.39	0.39	<		
2003 vs **2006**	dN BUD2	-2.16	2.16	<	2.31	Unstable
	dE BUD2	3.71	3.71	>		
	dN BUD3	3.32	3.32	>		Unstable
	dE BUD3	-1.07	1.07	<		
	dN BUDD	-3.71	3.71	>		Unstable
	dE BUDD	-2.02	2.02	<		
2003 vs **2007**	dN BUD2	1.11	1.11	<	2.31	Unstable
	dE BUD2	3.30	3.30	>		
	dN BUD3	1.19	1.19	<		Unstable
	dE BUD3	-4.37	4.37	>		
	dN BUDD	-3.11	3.11	>		Unstable
	dE BUDD	1.32	1.32	<		

Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2003 vs **2009**	dN BUD2	-1.39	1.39	<	2.31	Stable
	dE BUD2	1.16	1.16	<		
	dN BUD3	1.45	1.45	<		Stable
	dE BUD3	0.47	0.47	<		
	dN BUDD	-1.21	1.21	<		Stable
	dE BUDD	-1.37	1.37	<		
2003 vs **2012**	dN BUD2	-3.59	3.59	>	2.31	Unstable
	dE BUD2	11.95	11.95	>		
	dN BUD3	8.73	8.73	>		Unstable
	dE BUD3	-7.24	7.24	>		
	dN BUDD	-11.75	11.75	>		Unstable
	dE BUDD	-3.04	3.04	>		
2003 vs **2013**	dN BUD2	-2.10	2.10	<	2.31	Unstable
	dE BUD2	7.61	7.61	>		
	dN BUD3	5.45	5.45	>		Unstable
	dE BUD3	-4.82	4.82	>		
	dN BUDD	-7.47	7.47	>		Unstable
	dE BUDD	-1.74	1.74	<		
2003 vs **2014**	dN BUD2	-4.02	4.02	>	2.31	Unstable
	dE BUD2	11.15	11.15	>		
	dN BUD3	8.54	8.54	>		Unstable
	dE BUD3	-5.99	5.99	>		
	dN BUDD	-11.00	11.00	>		Unstable
	dE BUDD	-3.53	3.53	>		

Figur 3.10



Strain Analysis



- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.

Principal strain components for a 2D deformation

ε_{NN}	-0.000004		
ε_{EE}	0.000007		
ε_{simple}	-0.000013		
ε_{pure}	-0.000006		
ε_{MAX}	0.000016	+ extension	1.6 ppm
ε_{MIN}	-0.000013	- contraction	-1.3 ppm
2θ	53.8337		
θ	226.9169	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 2 - SMIDSTRUP [SMID]

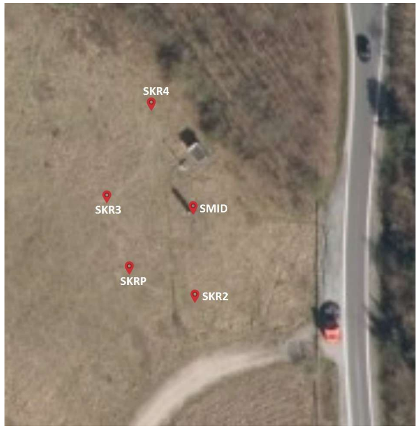
Tidserie: 81006

GPS Antenna	***SMID 117-05-00810***
Nærkontrol	***SKR2 117-05-00806*** ***SKRP 117-05-00807*** ***SKR3 117-05-00808*** → **JessenPunkt** ***SKR4 117-05-00809***
Fjernkontrol	***VEJL G.I.2210 117-06-00007*** ***KORE G.I.2294 114-02-00808***
Bolter i fundament	***117-05-9058*** ***117-05-9059*** ***117-05-9060***

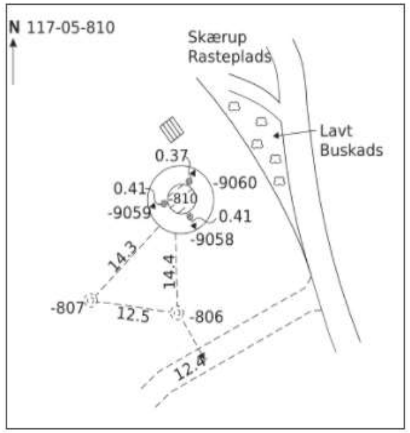
Notes:

- Most of the points are considered unstable according to the A-test.
- The nærkontrol point SKR2 (117-05-00806) is unstable, subsiding with a rate of approximately 0.10 ± 0.02 mm/year.
- In terms of planimetric coordinates: check 2013. Maybe measure one more time with TS.
- The congruence test confirms some relative displacements between the nærkontrol points in 2013.
- Strain analysis doesn't indicate predisposition to local instability.

1. Skitser:



Figur 1.1

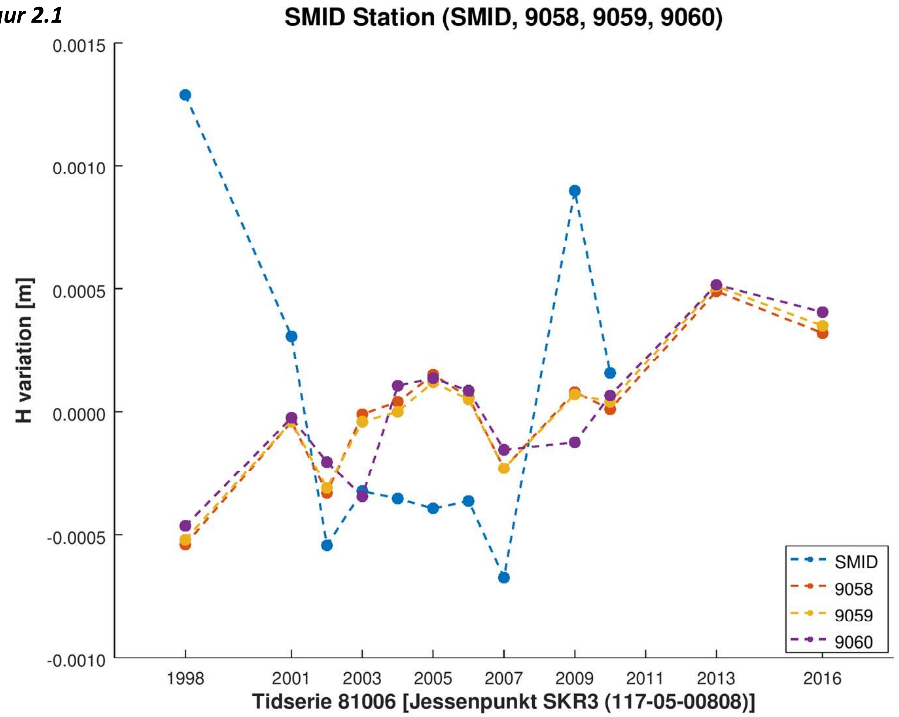


Figur 1.2

2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

Figur 2.1



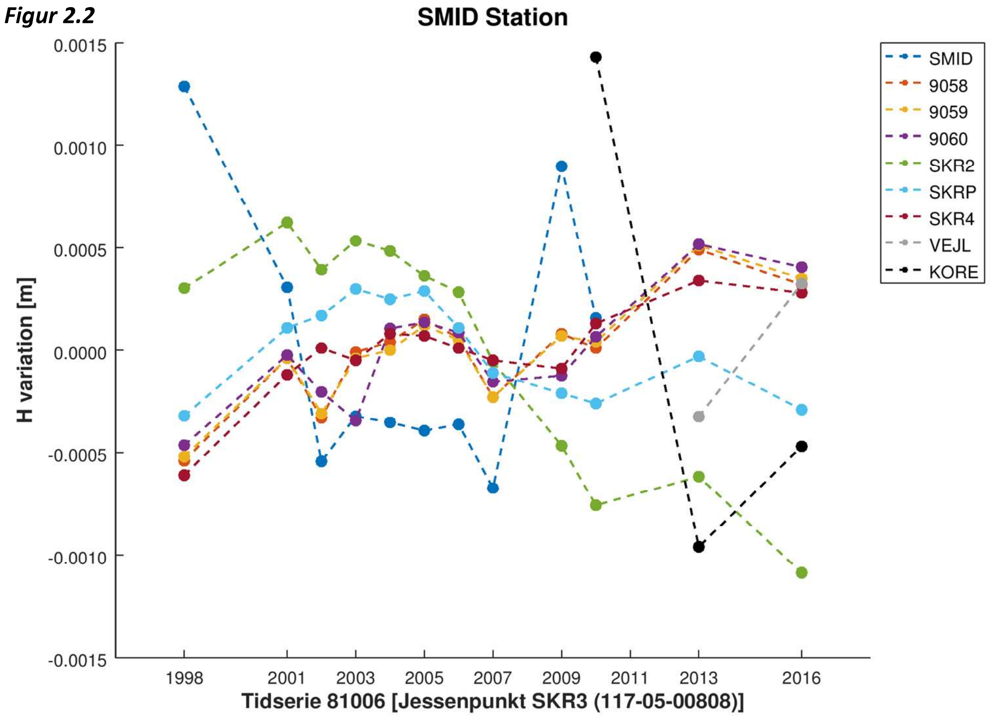
SMIDSTRUP (SMID) Linear Regression analysis results

Type	Punkt	2 parameters regression model (linear fitting)			
		θ_1 [m/year]	$\sigma_{\theta 1}$ [m/year]	t - value	p -value
GPS Antenna	SMID 117-05-00810	-0.000040	0.000061	-0.662070	0.526540
Bolter i fundament	117-05-09058	0.000042	0.000010	4.051020	0.002320
	117-05-09059	0.000044	0.000010	4.550800	0.001057
	117-05-09060	0.000043	0.000011	4.064440	0.002270
Nærkontrol	SKR2 117-05-00806	-0.000101	0.000016	-6.489610	0.000070
	SKRP 117-05-00807	-0.000018	0.000013	-1.361060	0.203380
	SKR4 117-05-00809	0.000037	0.000009	4.139560	0.002013
Fjernkontrol	VEJL 117-06-00007 G.I.2210	Not enough input data (need more heights in the time series)			
	KORE 114-02-00808 G.I.2294	-0.000317	0.000277	-1.142670	0.457670

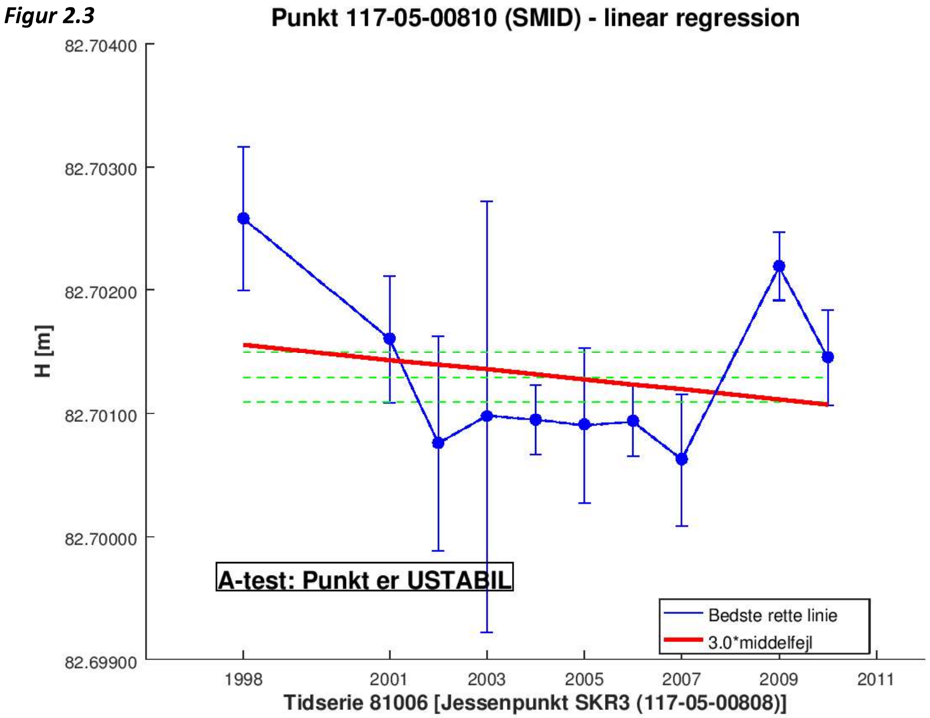
Statistically significant results --> Linear Regression

Type	Point	Behaviour	Variation [mm/year]	Std [mm/year]
Nærkontrol	SKR2 117-05-00806	↓	-0.10	0.02

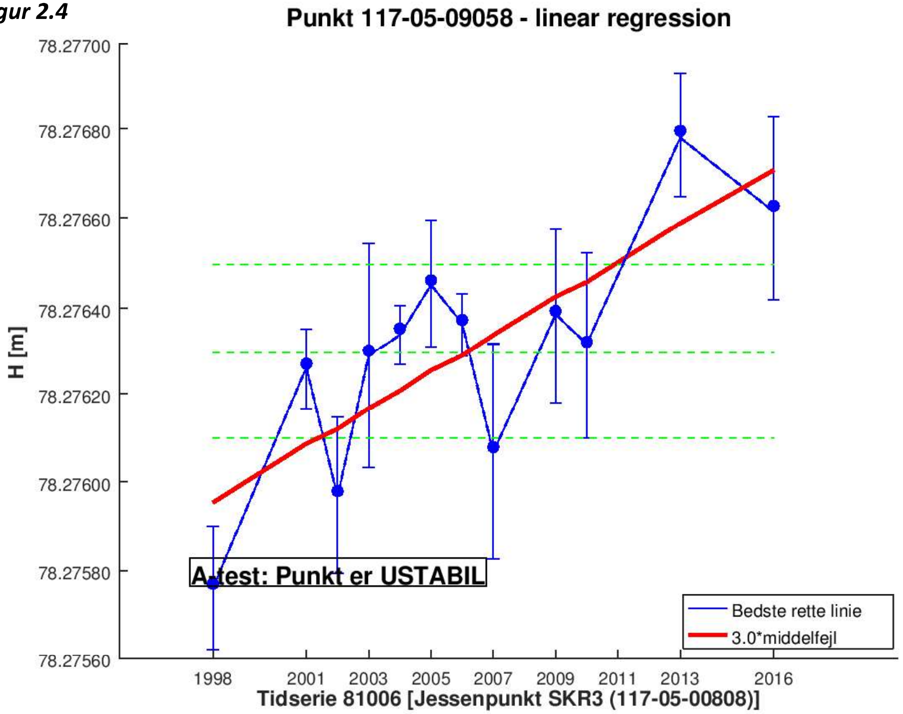
Figur 2.2



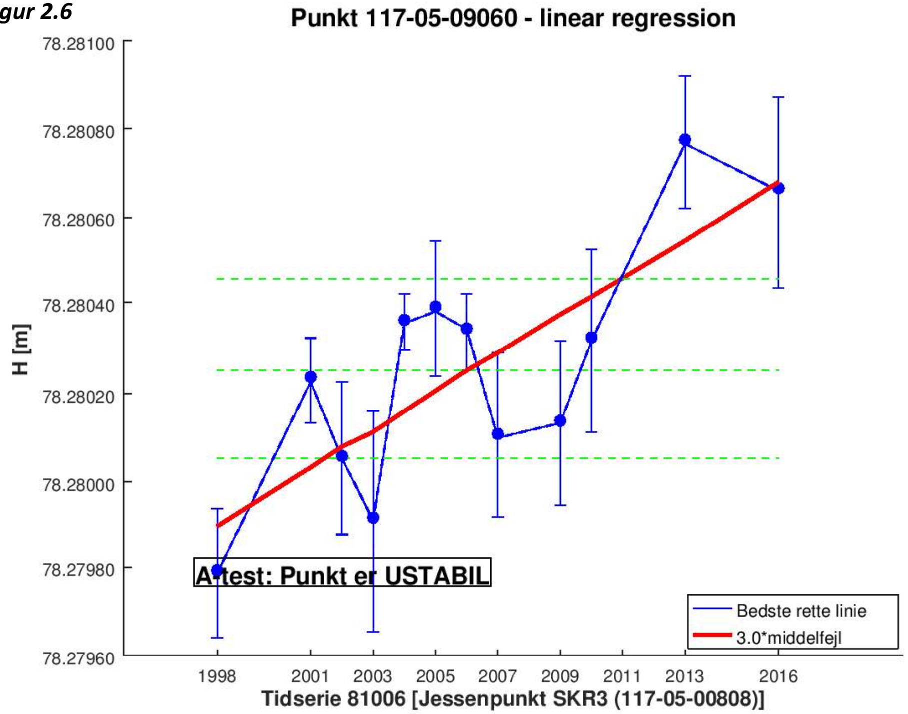
Figur 2.3



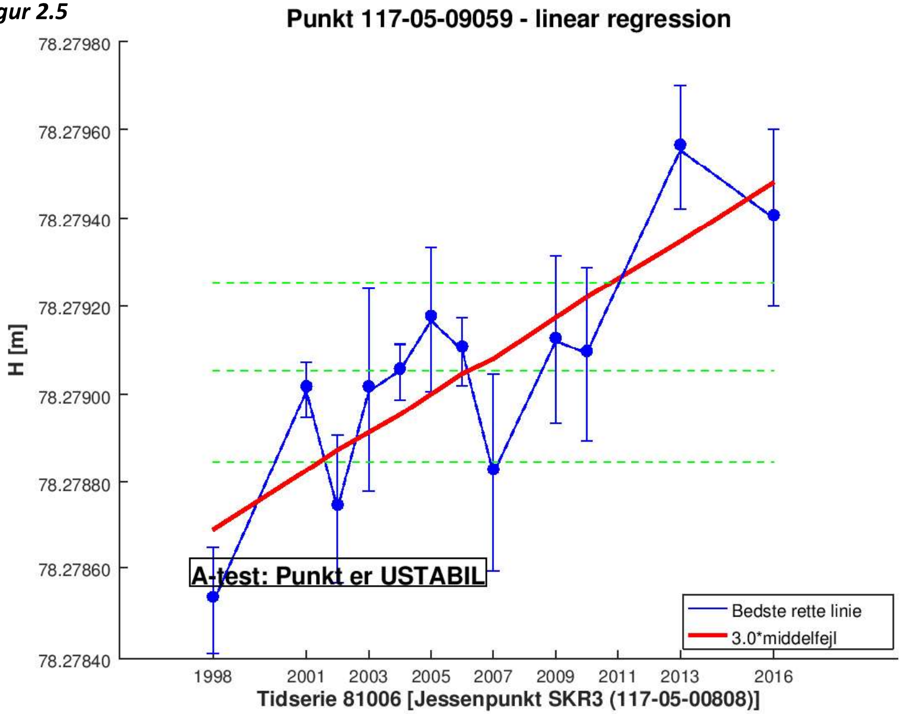
Figur 2.4



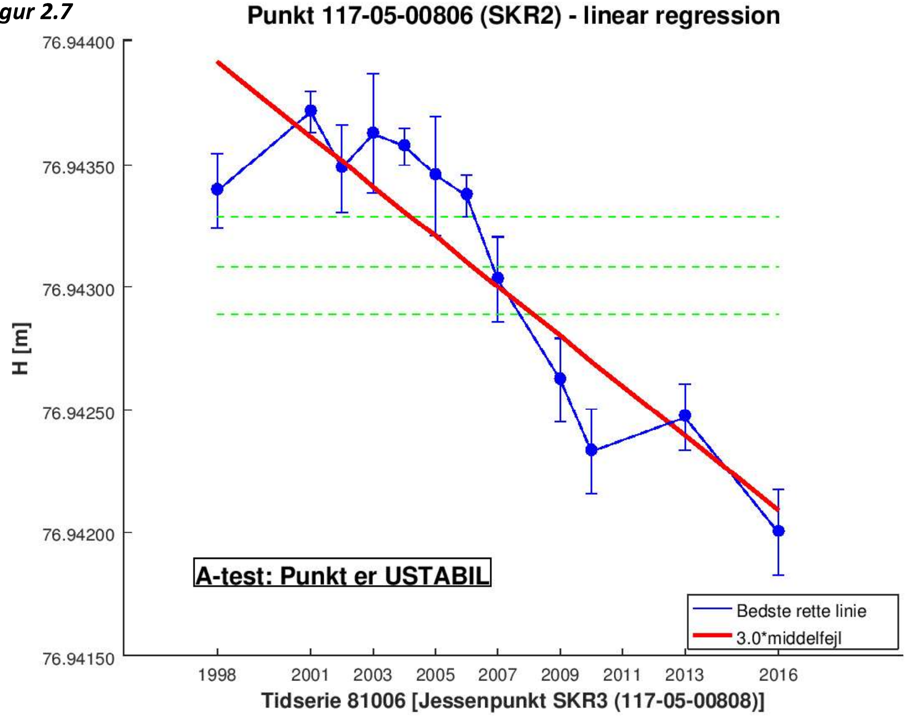
Figur 2.6



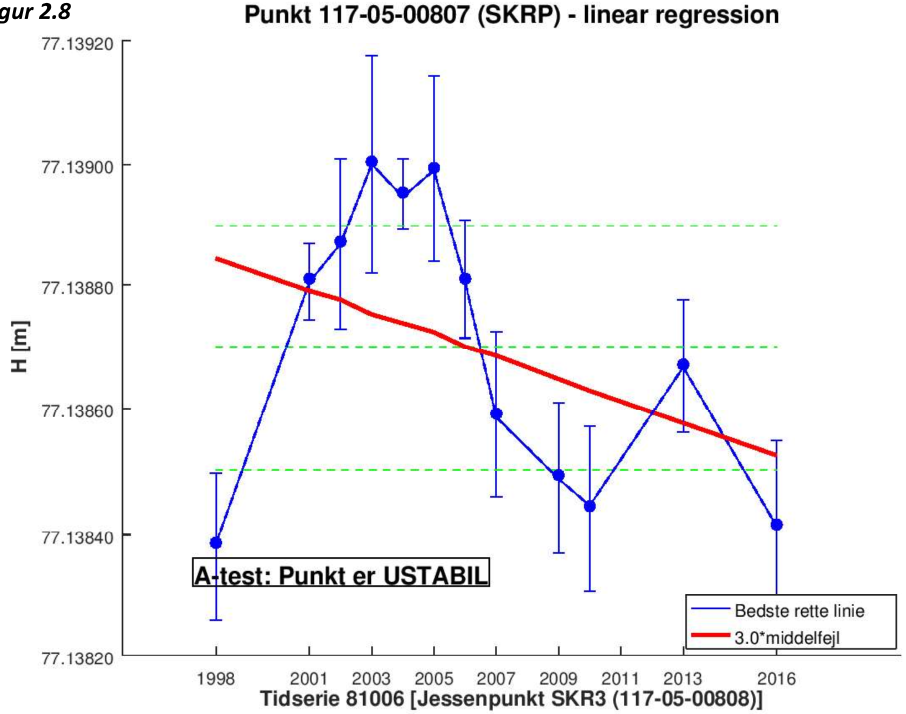
Figur 2.5



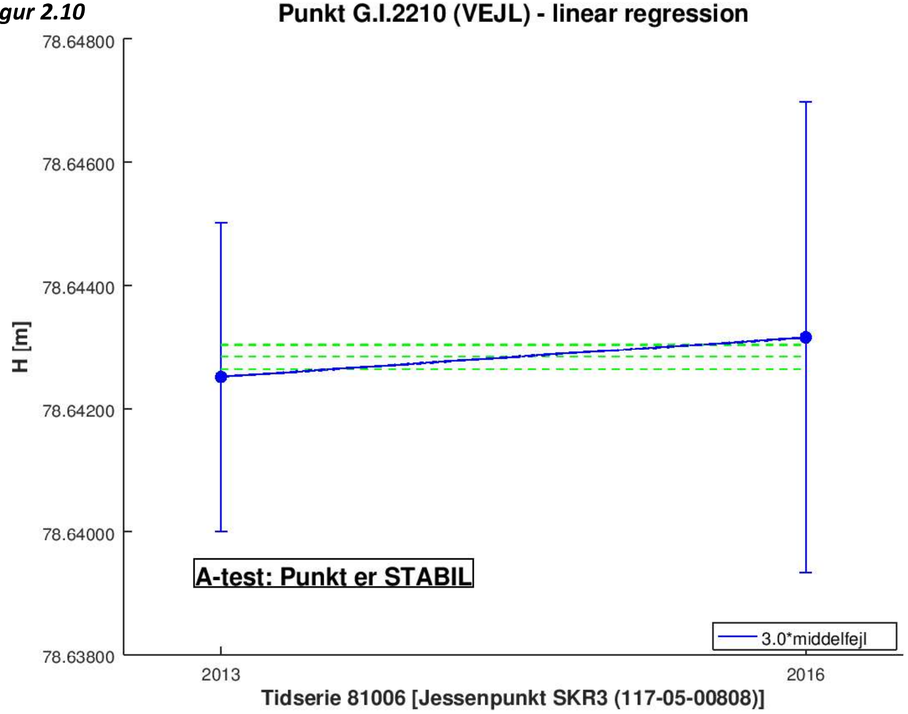
Figur 2.7



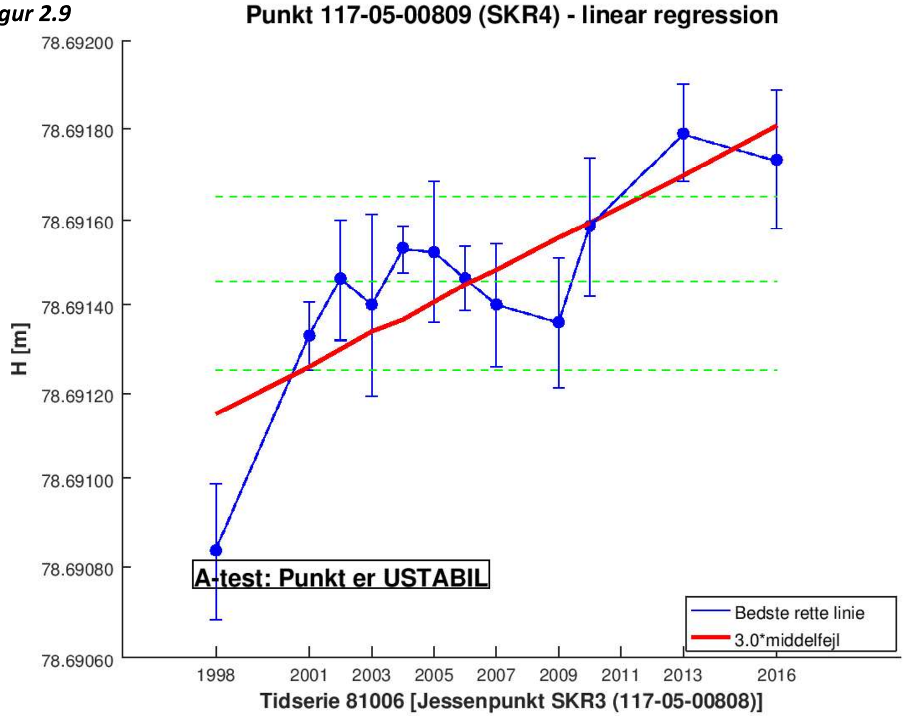
Figur 2.8



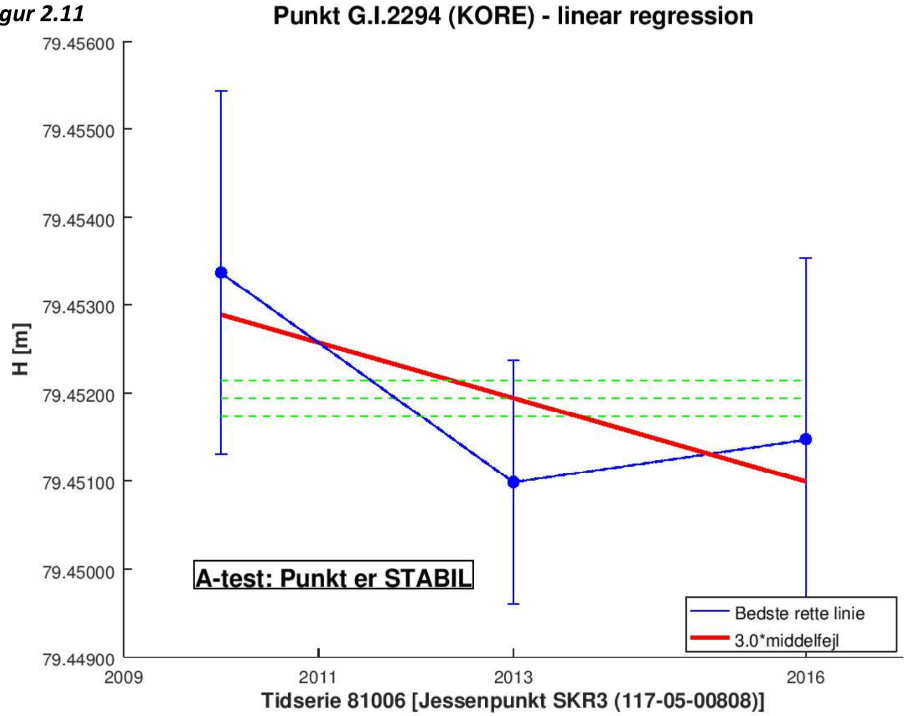
Figur 2.10



Figur 2.9



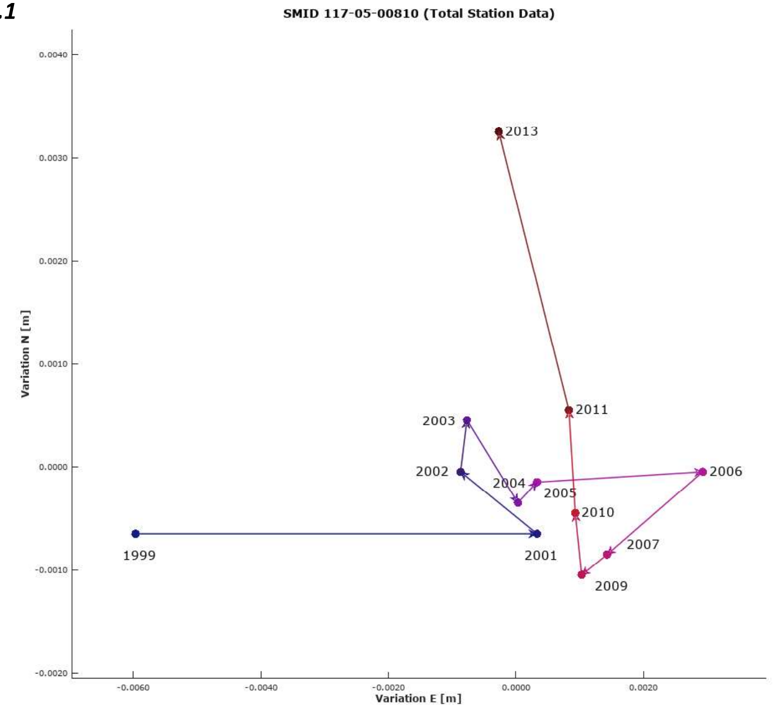
Figur 2.11



Tests: ‘Ignore limit’ for stability test [previously 0.4 mm]

Constant Value [mm]	Station: SMID								
	Antenna	Sikringspunkter			Nærkontrol			Fjernkontrol	
	SMID	9058	9059	9060	SKR2	SKRP	SKR4	VEJL	KORE
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	ustabil	stabil	stabil
1	ustabil	ustabil	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil
1.5	ustabil	stabil	stabil	stabil	ustabil	stabil	stabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

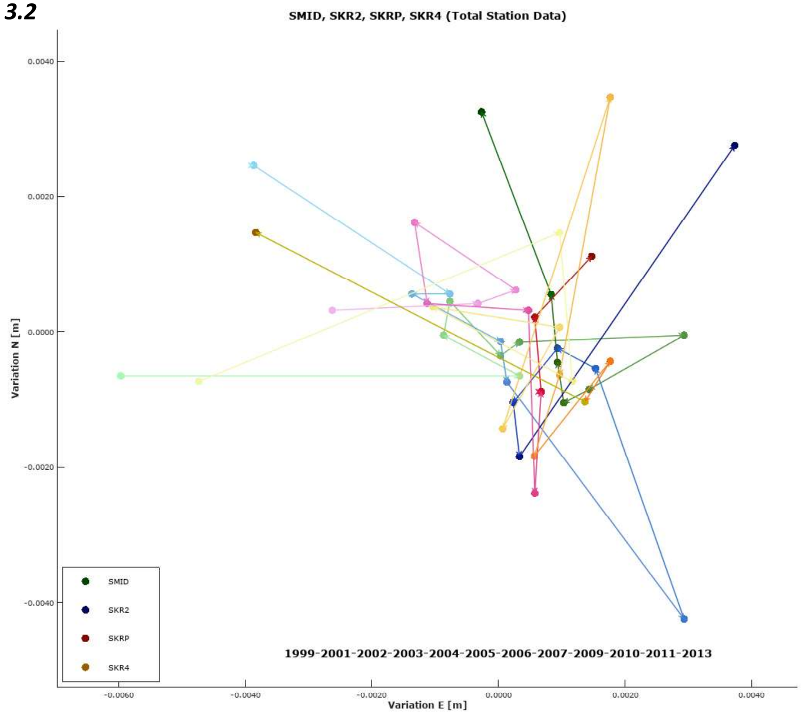
Figur 3.1



3. PLANIMETRIC ANALYSIS

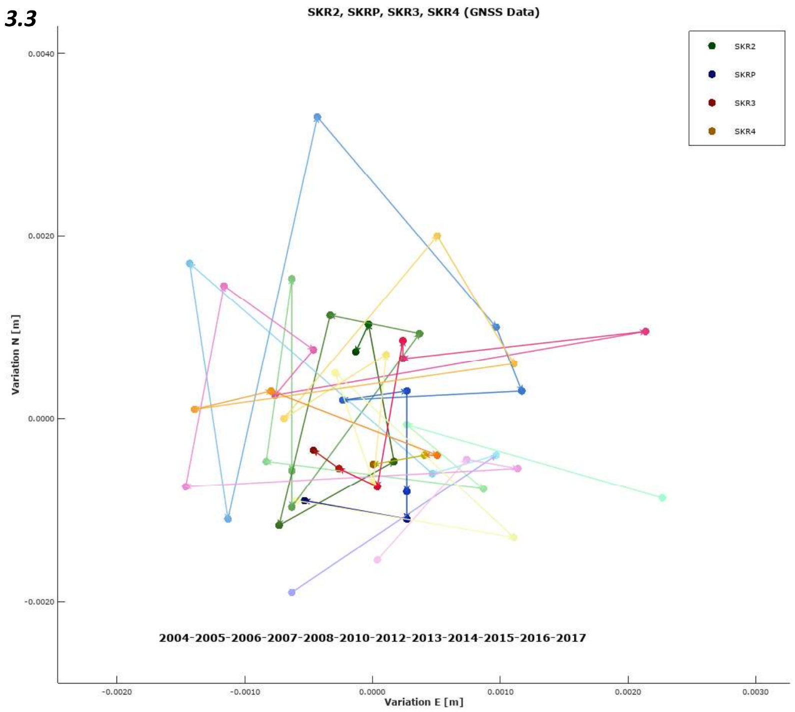
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

Figur 3.2

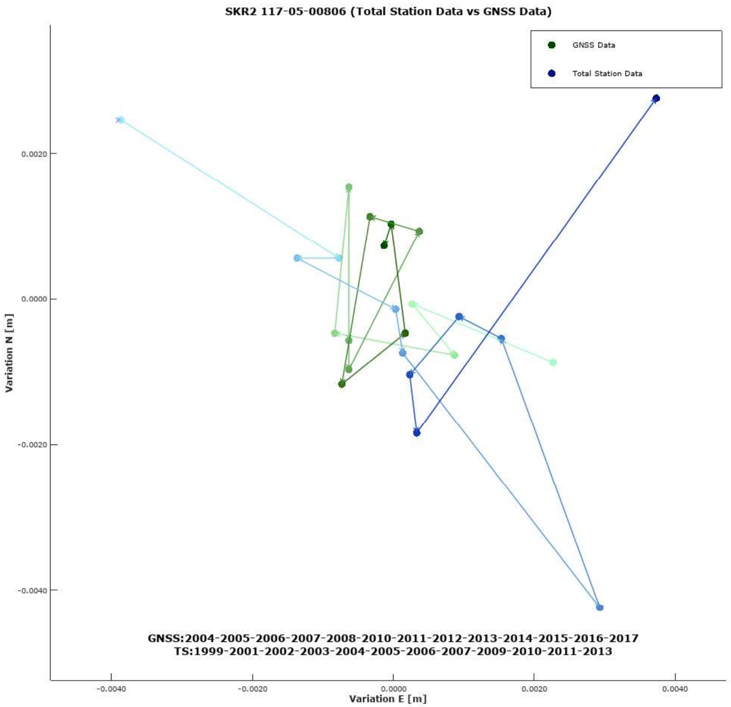


!! ***In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.***

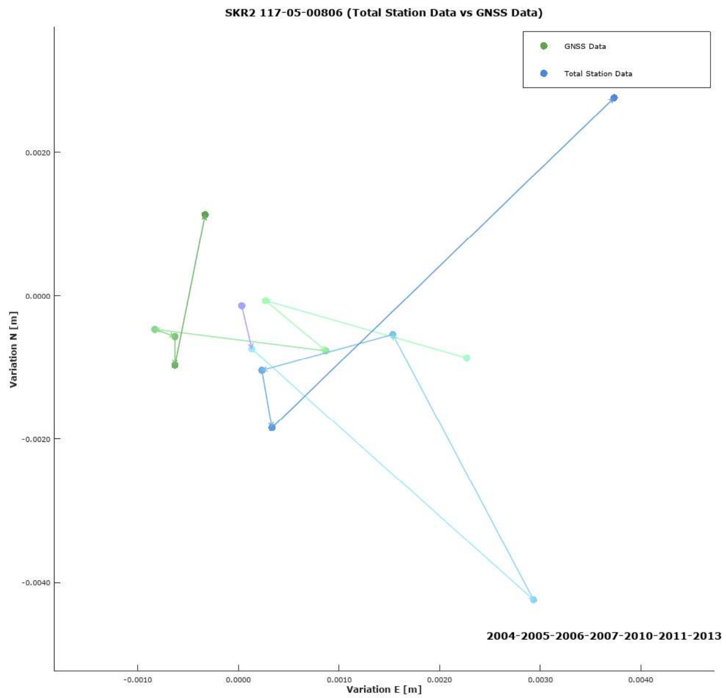
Figur 3.3



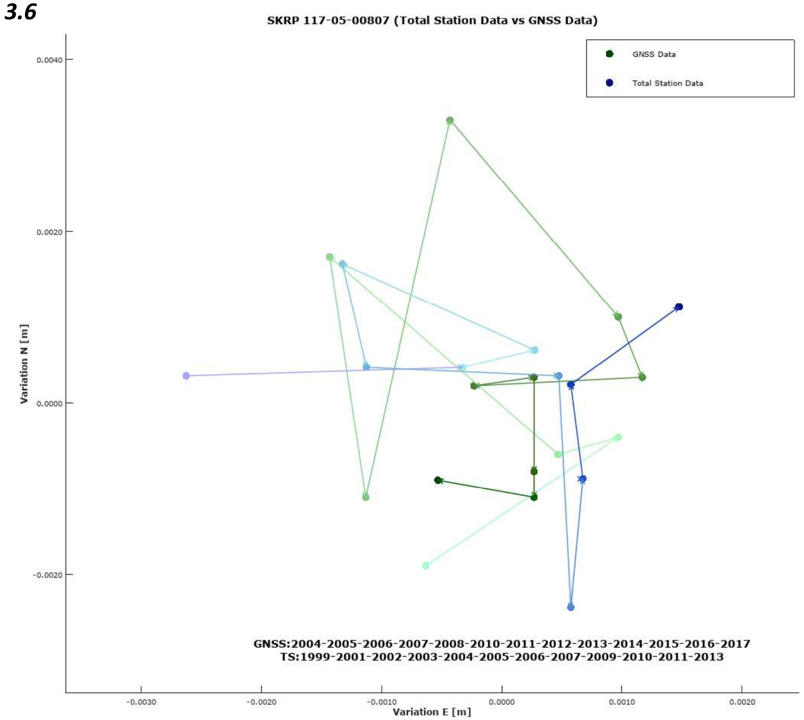
Figur 3.4



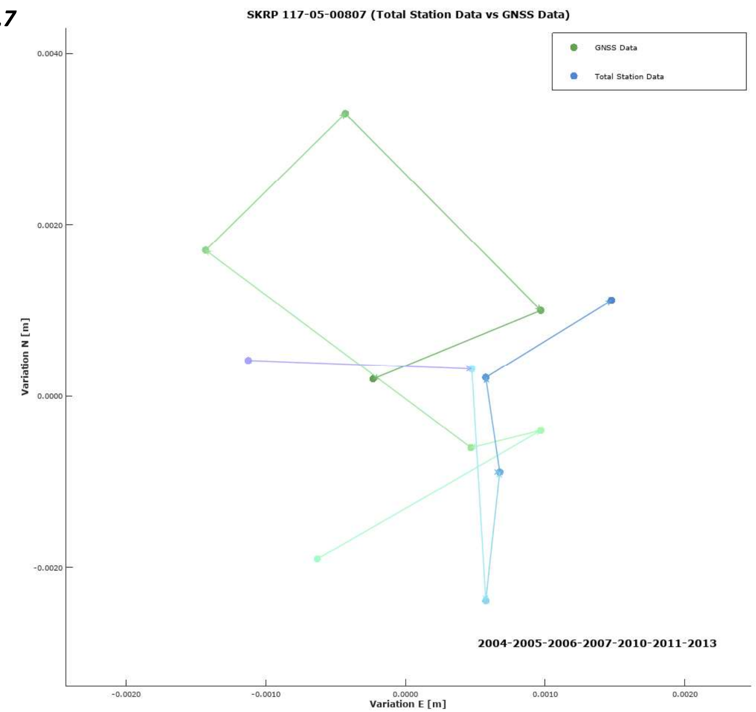
Figur 3.5



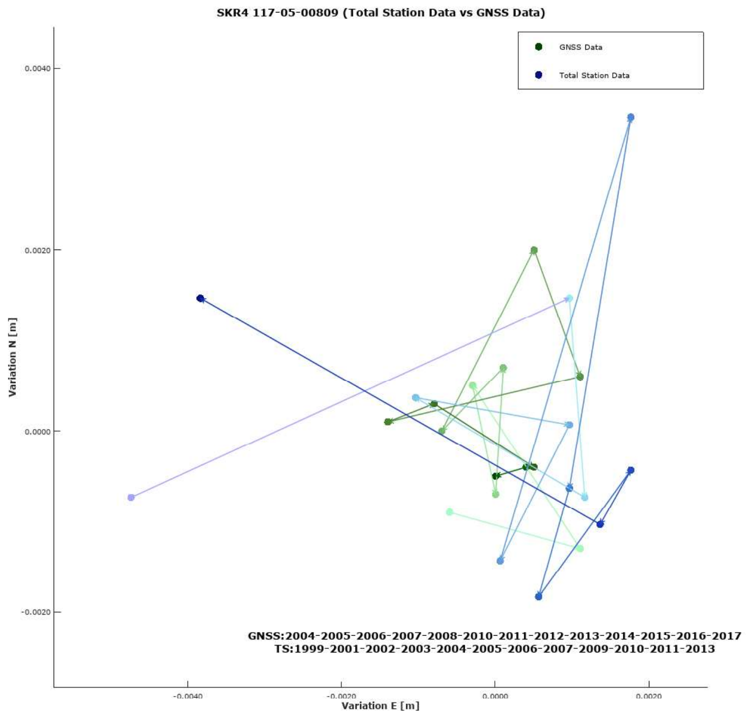
Figur 3.6



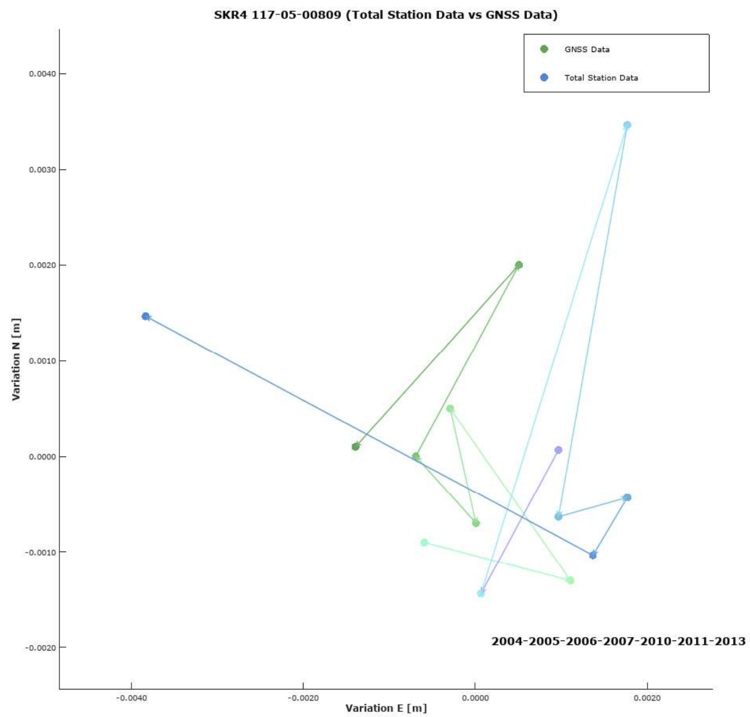
Figur 3.7



Figur 3.8

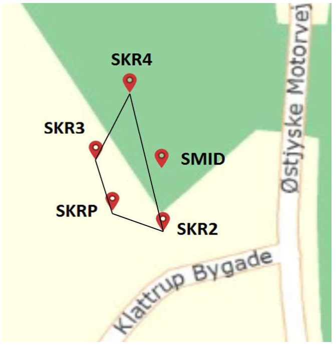


Figur 3.9



Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).



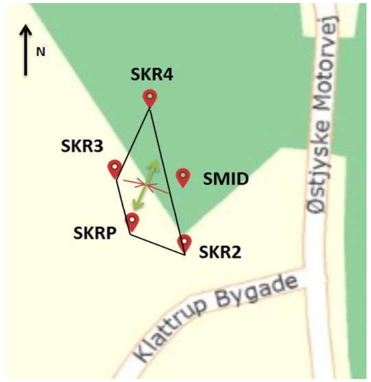
*Stage 1 - **2003***					*Stage 2 - **2005***				
From	**To**	**Horizontal directions**		**Average**	**From**	**To**	**Horizontal directions**		**Average**
SKR2	SKRP	313.5828	313.5838	313.5833	SKR2	SKRP	103.3918	103.3929	103.3924
	SKR3	341.4710	341.4720	341.4715		SKR3	131.2754	131.2763	131.2759
	SKR4	373.3133	373.3112	373.3123		SKR4	163.1127	163.1119	163.1123
SKRP	SKR2	64.5091	64.5086	64.5089	SKRP	SKR2	239.1581	239.1554	239.1568
	SKR3	319.1620	319.1615	319.1618		SKR3	93.8049	93.8067	93.8058
	SKR4	346.9454	346.9447	346.9451		SKR4	121.5838	121.5827	121.5833
SKR3	SKR2	56.5067	56.5096	56.5082	SKR3	SKR2	205.9853	205.9874	205.9864
	SKRP	83.2732	83.2707	83.2720		SKRP	232.7472	232.7497	232.7485
	SKR4	330.8321	330.8349	330.8335		SKR4	80.3104	80.3083	80.3094
SKR4	SKR2	361.2605	361.2633	361.2619	SKR4	SKR2	26.5385	26.5405	26.5395
	SKRP	383.9693	383.9671	383.9682		SKRP	49.2499	49.2478	49.2489
	SKR3	3.7498	3.7515	3.7507		SKR3	69.0276	69.0300	69.0288

Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2003 vs 2005	dN SKR2	-3.45	3.45	>	2.31	Unstable
	dE SKR2	1.26	1.26	<		
	dN SKRP	2.00	2.00	<		Stable
	dE SKRP	-0.53	0.53	<		
	dN SKR3	1.16	1.16	<		Stable
	dE SKR3	1.23	1.23	<		
	dN SKR4	-1.49	1.49	<		Unstable
	dE SKR4	-2.70	2.70	>		
2003 vs 2006	dN SKR2	-1.92	1.92	<	2.31	Stable
	dE SKR2	1.11	1.11	<		
	dN SKRP	0.34	0.34	<		Stable
	dE SKRP	-1.17	1.17	<		
	dN SKR3	1.41	1.41	<		Unstable
	dE SKR3	2.61	2.61	>		
	dN SKR4	-1.33	1.33	<		Unstable
	dE SKR4	-2.60	2.60	>		
2003 vs 2007	dN SKR2	-0.49	0.49	<	2.31	Stable
	dE SKR2	1.58	1.58	<		
	dN SKRP	-0.31	0.31	<		Stable
	dE SKRP	-1.28	1.28	<		
	dN SKR3	1.43	1.43	<		Stable
	dE SKR3	-0.20	0.20	<		
	dN SKR4	-1.71	1.71	<		Stable
	dE SKR4	-0.65	0.65	<		

Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2003 vs 2009	dN SKR2	-0.69	0.69	<	2.31	Stable
	dE SKR2	1.95	1.95	<		
	dN SKRP	-0.55	0.55	<		Stable
	dE SKRP	-1.30	1.30	<		
	dN SKR3	2.04	2.04	<		Stable
	dE SKR3	-0.78	0.78	<		
	dN SKR4	-2.36	2.36	>		Unstable
	dE SKR4	-0.80	0.80	<		
2003 vs 2010	dN SKR2	-1.03	1.03	<	2.31	Stable
	dE SKR2	0.48	0.48	<		
	dN SKRP	-0.49	0.49	<		Stable
	dE SKRP	0.42	0.42	<		
	dN SKR3	1.57	1.57	<		Stable
	dE SKR3	-0.57	0.57	<		
	dN SKR4	-1.40	1.40	<		Stable
	dE SKR4	-1.13	1.13	<		
2003 vs 2013	dN SKR2	-2.62	2.62	>	2.31	Unstable
	dE SKR2	1.66	1.66	<		
	dN SKRP	1.19	1.19	<		Stable
	dE SKRP	-2.16	2.16	<		
	dN SKR3	1.22	1.22	<		Unstable
	dE SKR3	4.02	4.02	>		
	dN SKR4	-1.37	1.37	<		Unstable
	dE SKR4	-3.28	3.28	>		

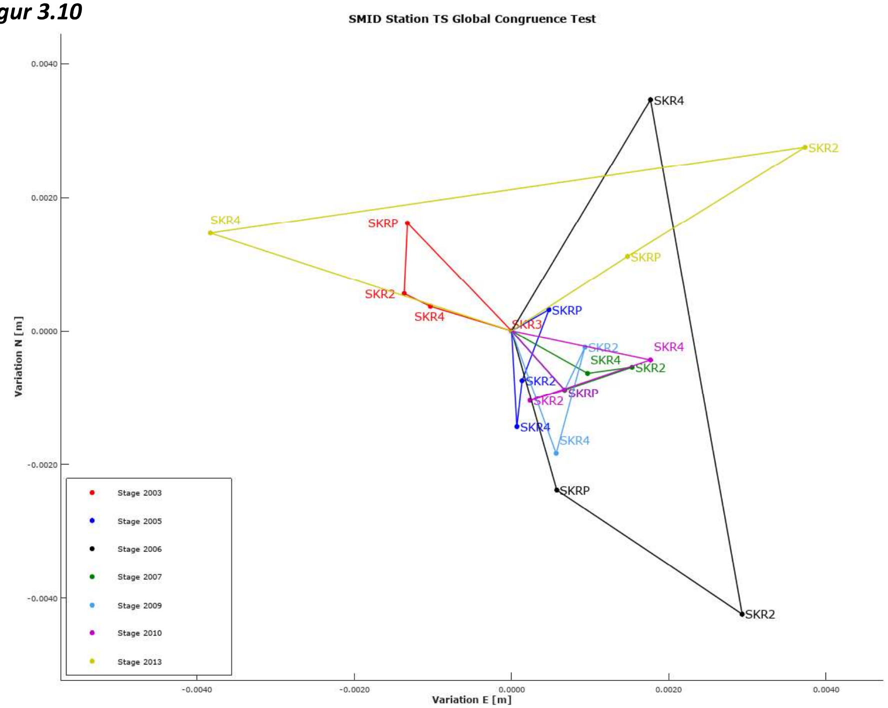
Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000002		
ε_{EE}	0.000000		
ε_{simple}	0.000007		
ε_{pure}	0.000001		
ε_{MAX}	0.000008	+ extension	0.8 ppm
ε_{MIN}	-0.000006	- contraction	-0.6 ppm
2θ	80.4111		
θ	40.2056	direction of the maximum principal axis, clockwise from N-axis	

Figur 3.10



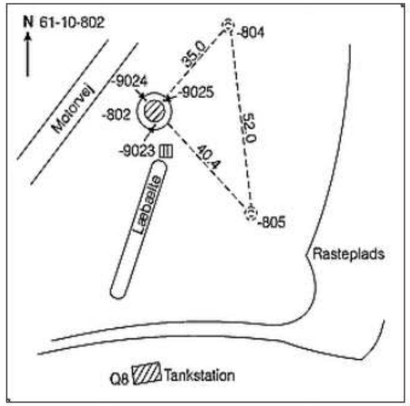
APPENDIX 3 - SULDRUP [SULD]

Tidserie: 81003

GPS Antenna	***SULD 61-10-00802***
Nærkontrol	***SUL1 61-10-00804***
	SUL2 61-10-00805
	SUL3 61-10-00806 → **JessenPunkt**
	SUL4 61-10-00803
Fjernkontrol	***GRAV G.I.2257 61-07-00009***
Bolter i fundament	***61-10-09023***
	61-10-09024
	61-10-09025

1. Skitser:

Figur 1.1



Figur 1.2

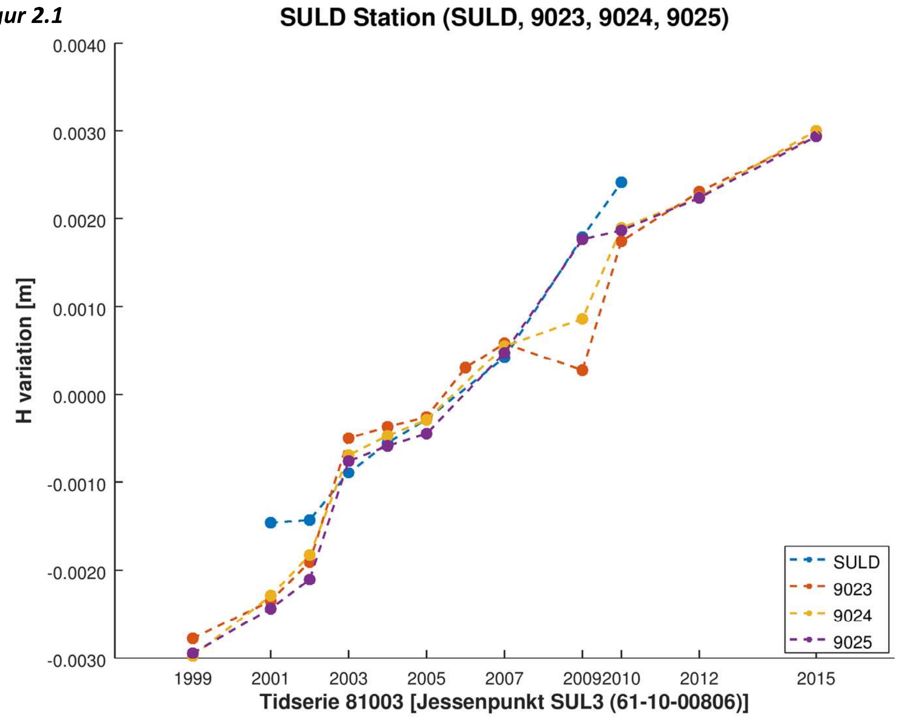
Notes:

- The Jessenpunkt SUL3 (61-10-00806) is unstable, subsiding with a rate of approximately 0.38 ± 0.03 mm/year.
- The nærkontrol point SUL1 (61-10-00806) presents a discordant behavior, thus is considered to be unstable. The trend cannot be deduced from this analysis; regression analysis should be performed again, using a stable Jessenpunkt.
- In terms of planimetric coordinates: check 2012. Maybe measure one more time with TS.
- The congruence test doesn't show reliable results (because of the unstable Jessenpunkt).
- Strain analysis doesn't indicate predisposition to local instability.

2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

Figur 2.1



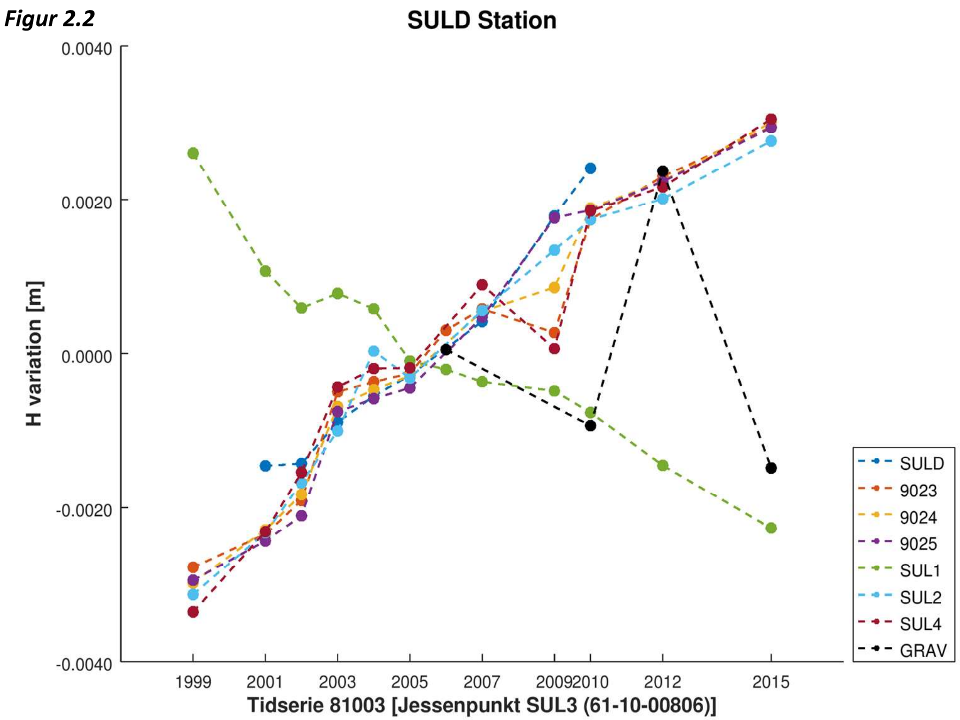
SULDRUP (SULD) Linear Regression analysis results

Type	Punkt	2 parameters regression model (linear fitting)			
		θ_1 [m/year]	$\sigma_{\theta 1}$ [m/year]	t - value	p -value
GPS Antenna	SULD 61-10-00802	0.000434	0.000031	14.138600	0.000008
Bolter i fundament	61-10-09023	0.000364	0.000029	12.688200	0.000000
	61-10-09024	0.000381	0.000022	17.496700	0.000000
	61-10-09025	0.000397	0.000026	15.000600	0.000000
Nærkontrol	SUL1 61-10-00804	-0.000257	0.000022	-11.559300	0.000000
	SUL2 61-10-00805	0.000373	0.000027	13.566600	0.000000
	SUL4 61-10-00803	0.000373	0.000038	9.867300	0.000004
Fjernkontrol	GRAV 61-07-00009 G.I.2257	Not enough input data (need more heights in the time series)			

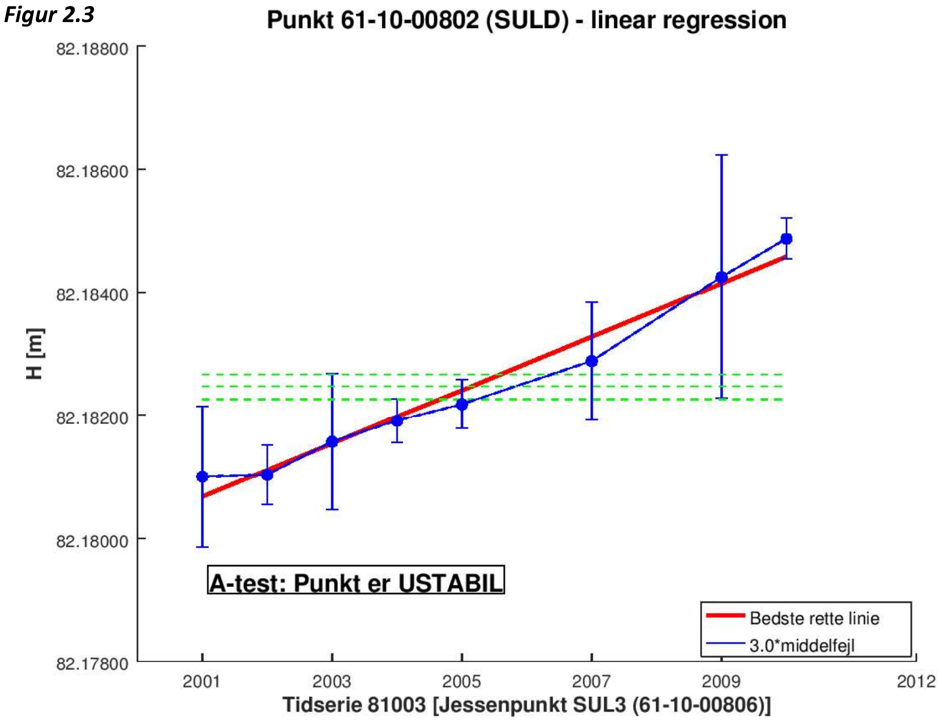
Statistically significant results --> Linear Regression

Type	Point	Behaviour	Variation [mm/year]	Std [mm/year]
GPS Antenna	SULD 61-10-00802	↑	0.43	0.03
Bolter i fundament	61-10-09023	↑	0.36	0.03
	61-10-09024	↑	0.38	0.02
	61-10-09025	↑	0.40	0.03
Nærkontrol	SUL1 61-10-00804	↓	-0.26	0.02
	SUL2 61-10-00805	↑	0.37	0.03
	SUL4 61-10-00803	↑	0.37	0.04

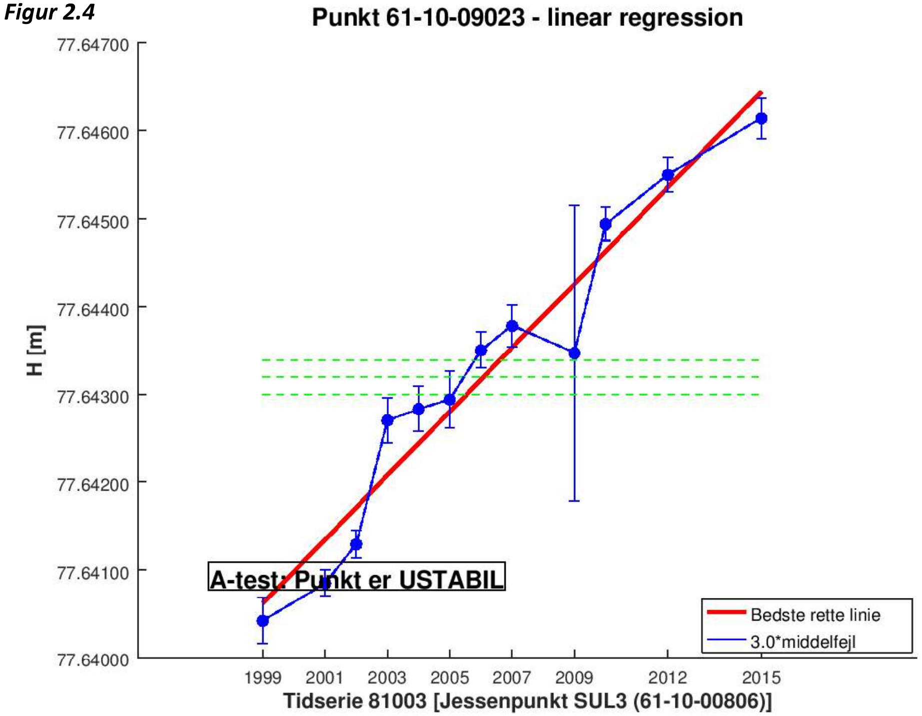
Figur 2.2



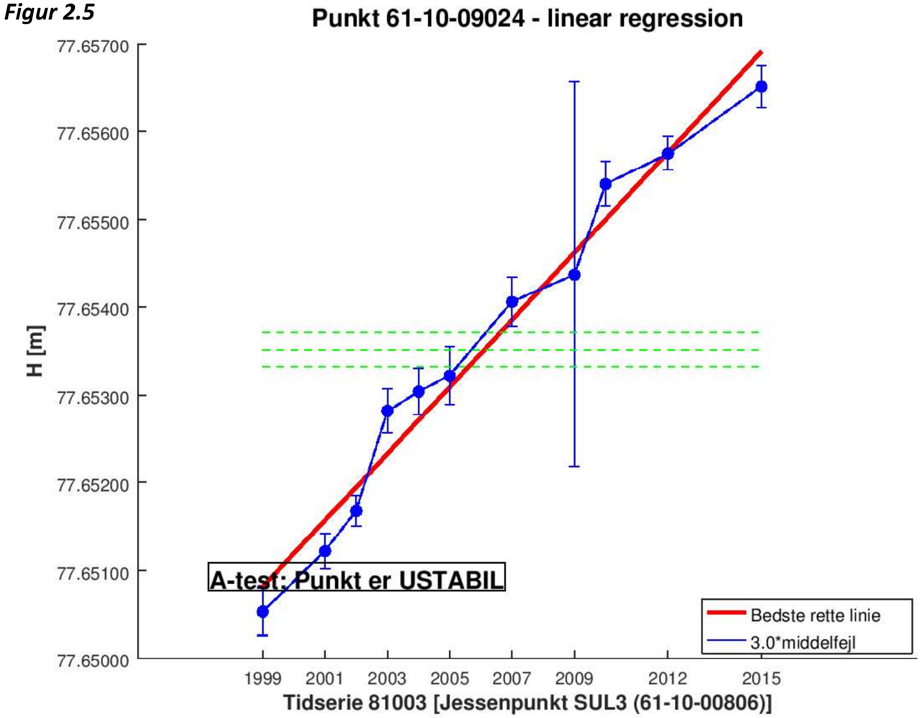
Figur 2.3



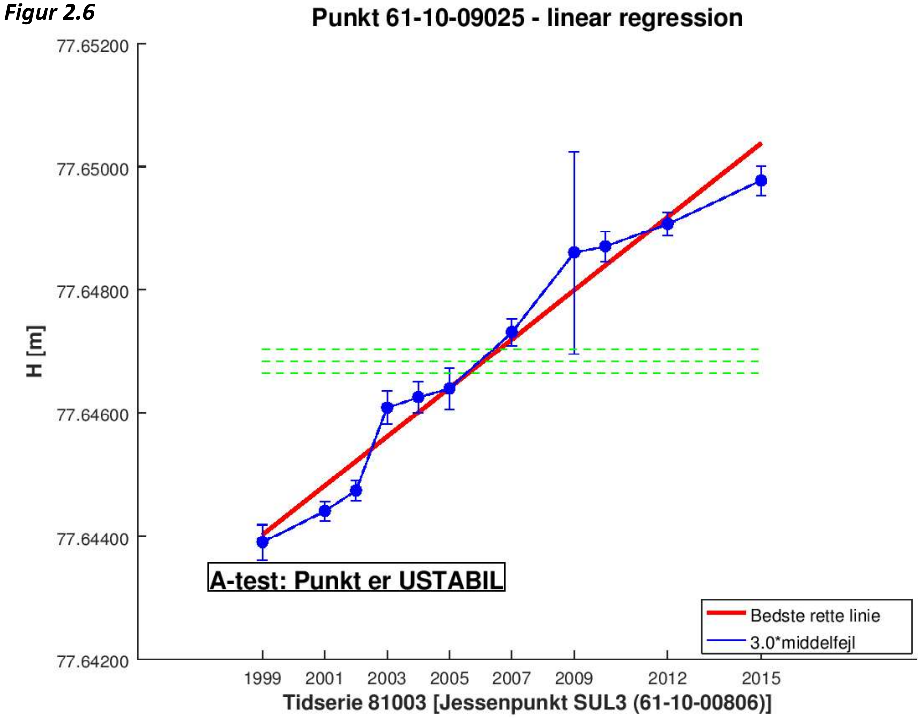
Figur 2.4



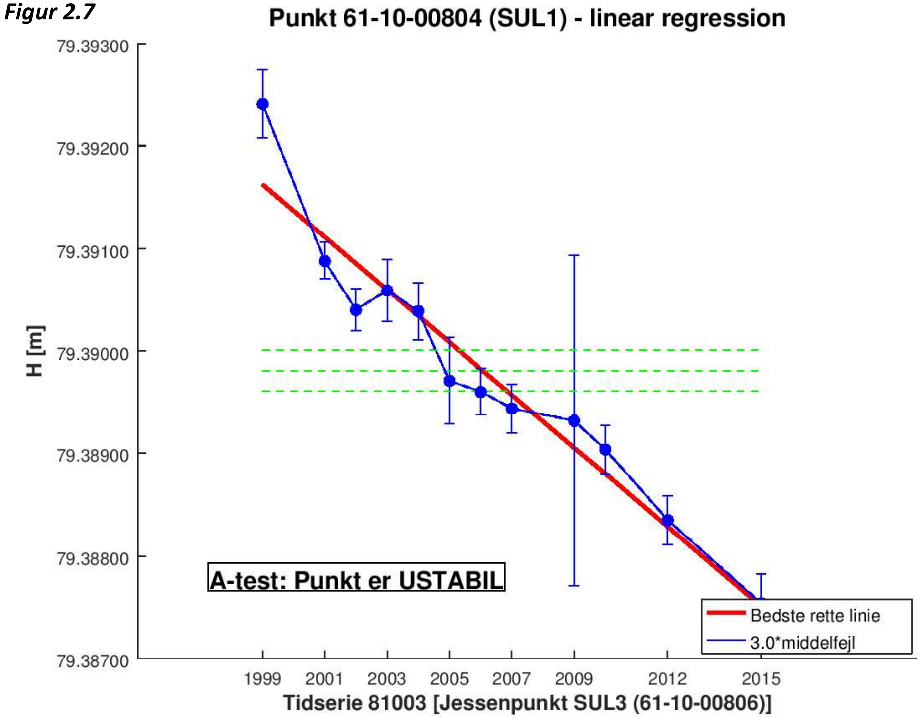
Figur 2.5



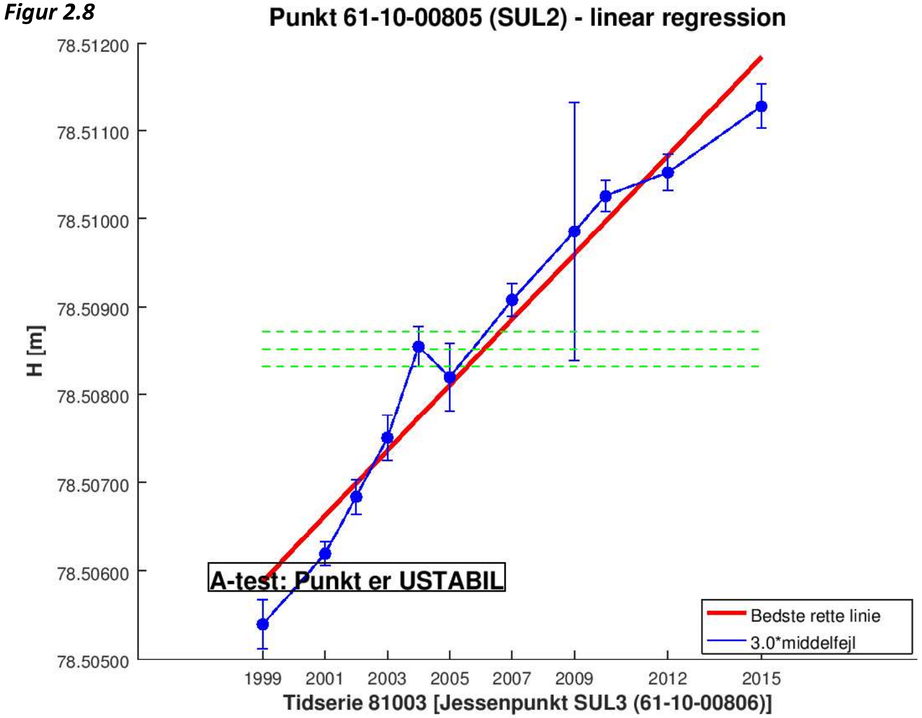
Figur 2.6



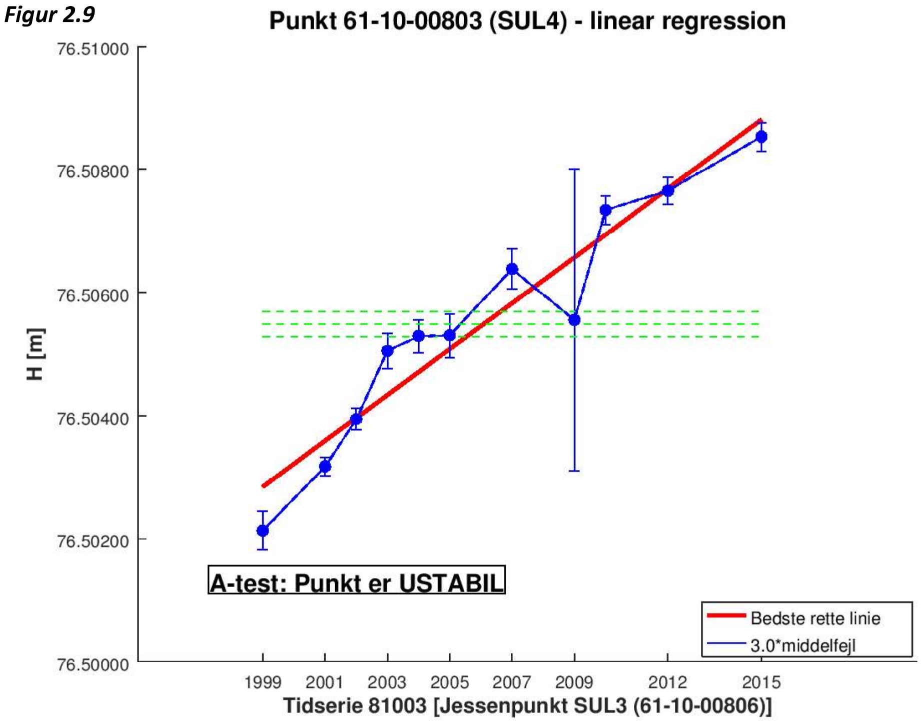
Figur 2.7



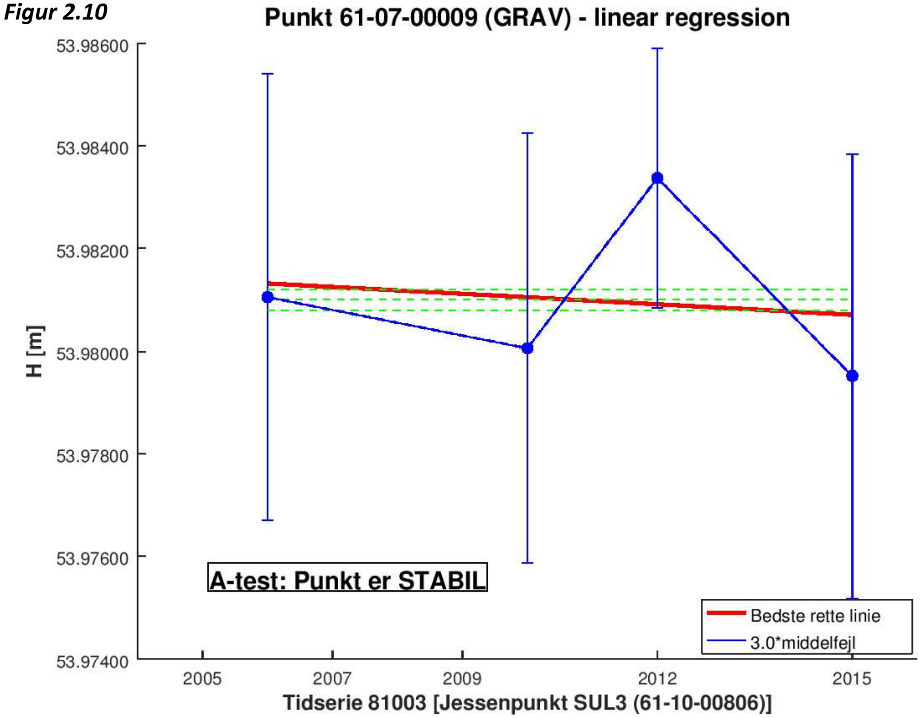
Figur 2.8



Figur 2.9



Figur 2.10



Tests: ‘Ignore limit’ for stability test [previously 0.4 mm]

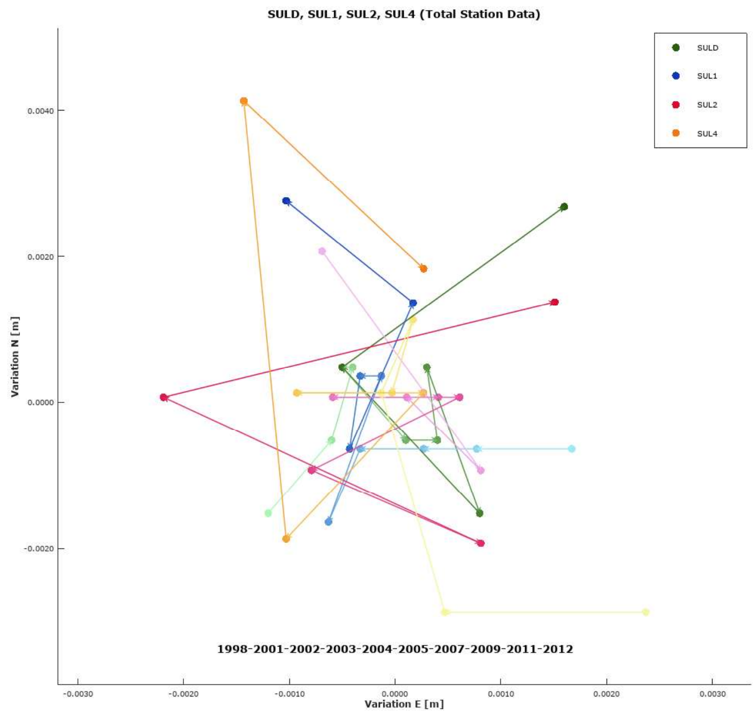
Constant Value [mm]	Station: SULD							
	Antenna	Sikringspunkter			Nærkontrol			Fjernkontrol
	SULD	9023	9024	9025	SUL1	SUL2	SUL4	GRAV
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
1	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
1.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
2	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil

3. PLANIMETRIC ANALYSIS

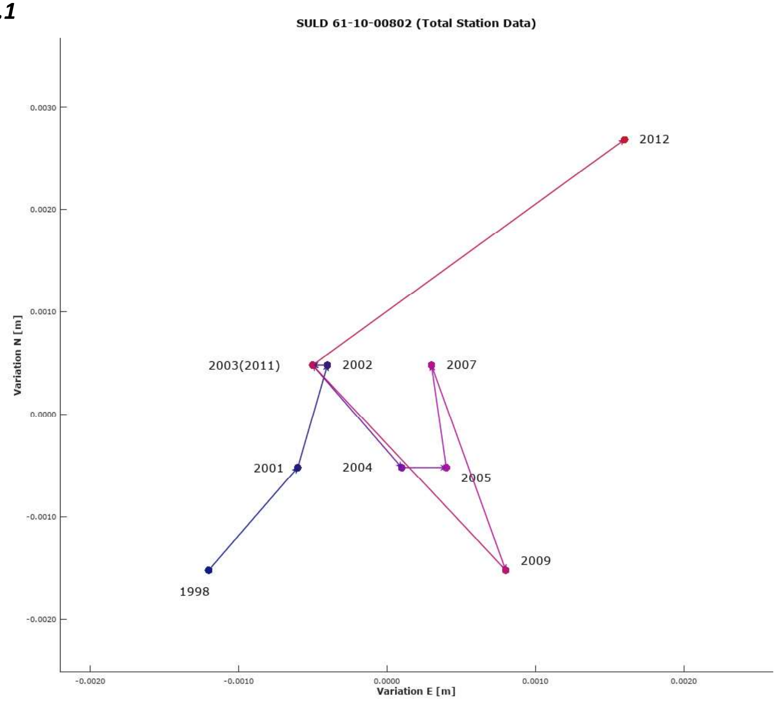
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.

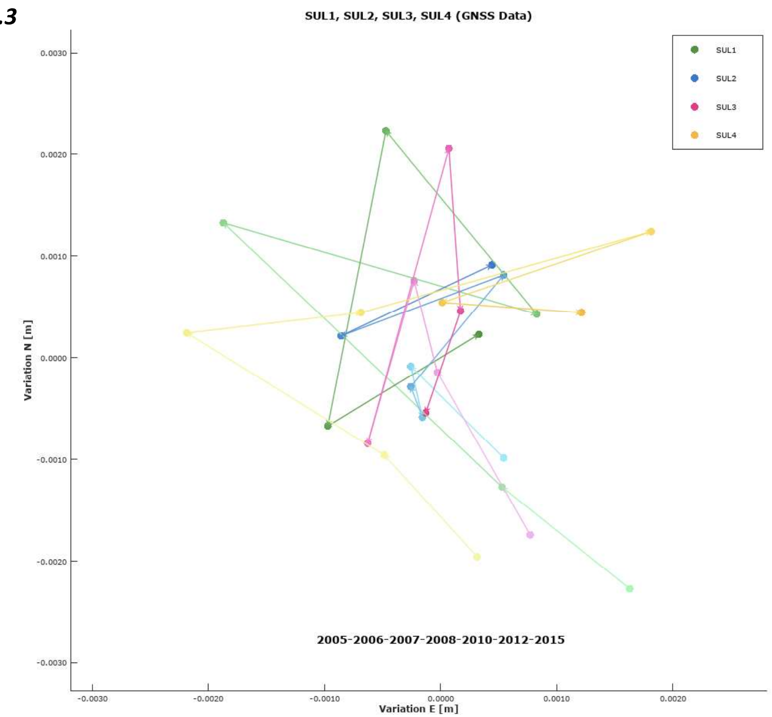
Figur 3.2



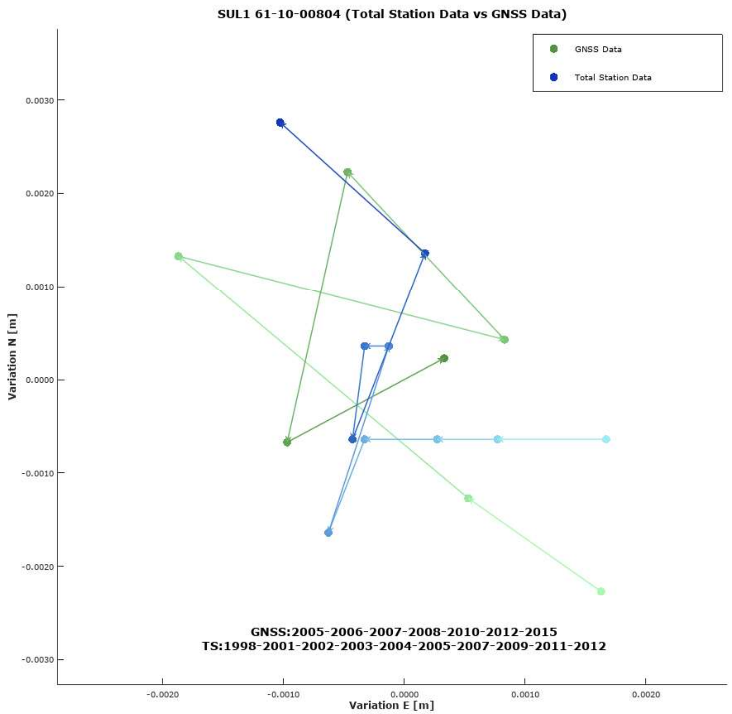
Figur 3.1



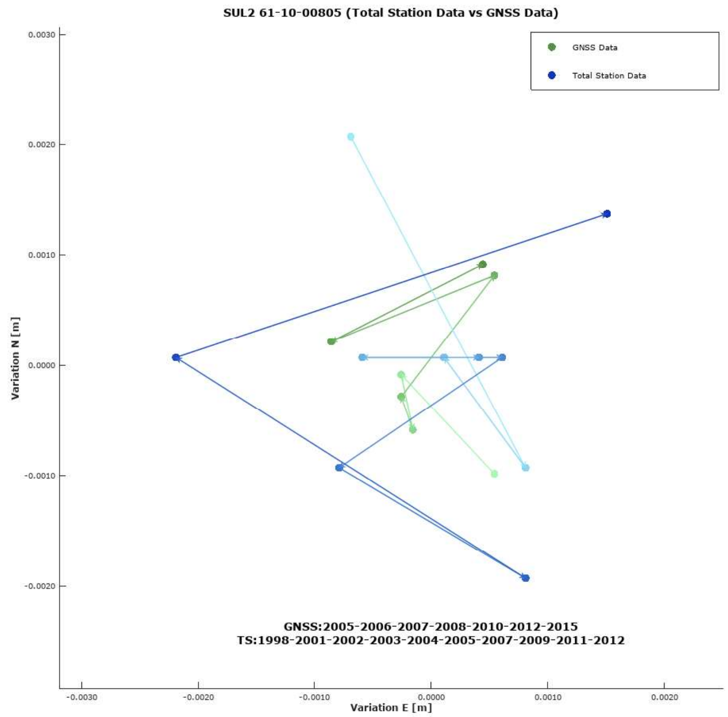
Figur 3.3



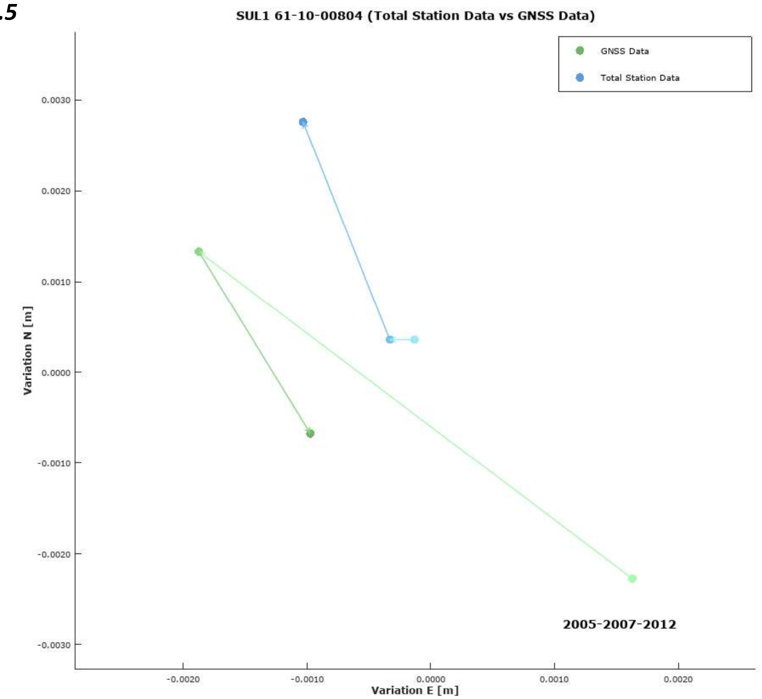
Figur 3.4



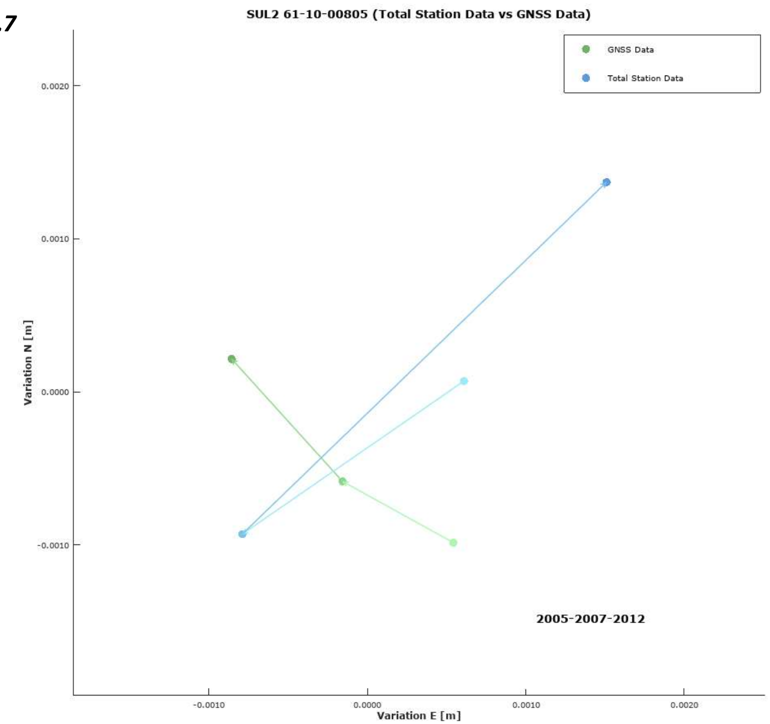
Figur 3.6



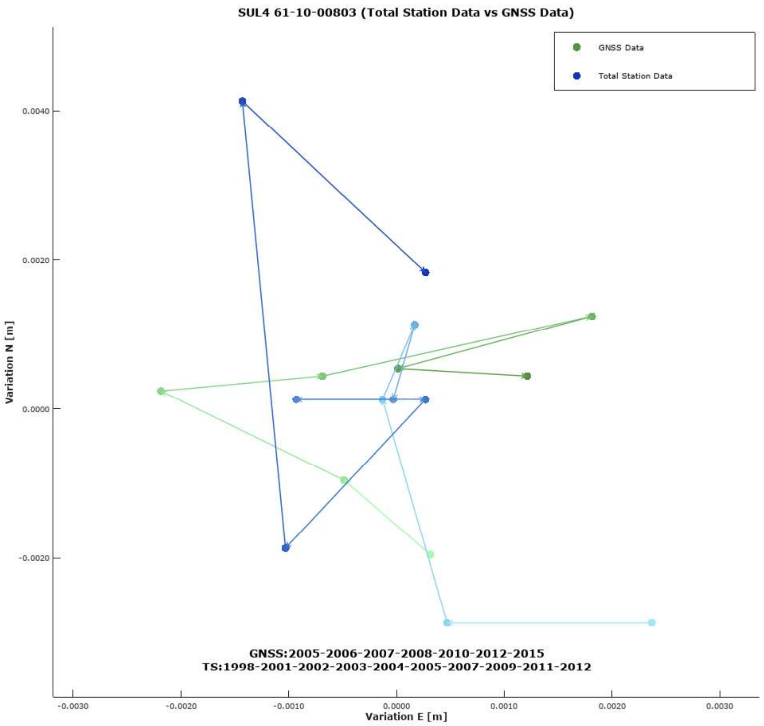
Figur 3.5



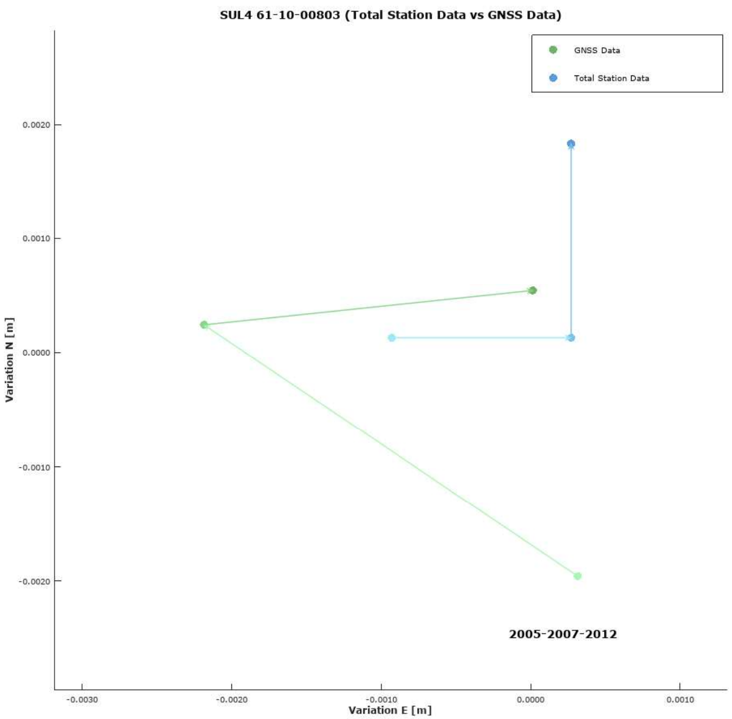
Figur 3.7



Figur 3.8

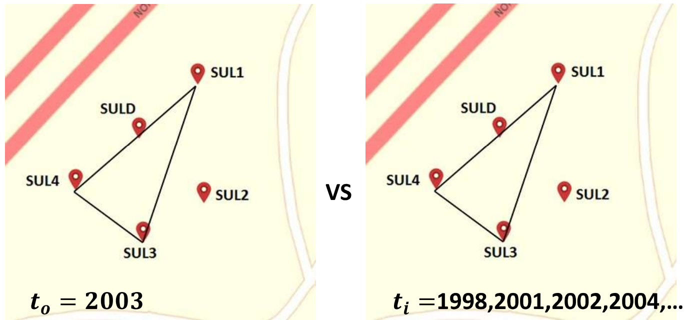


Figur 3.9



Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

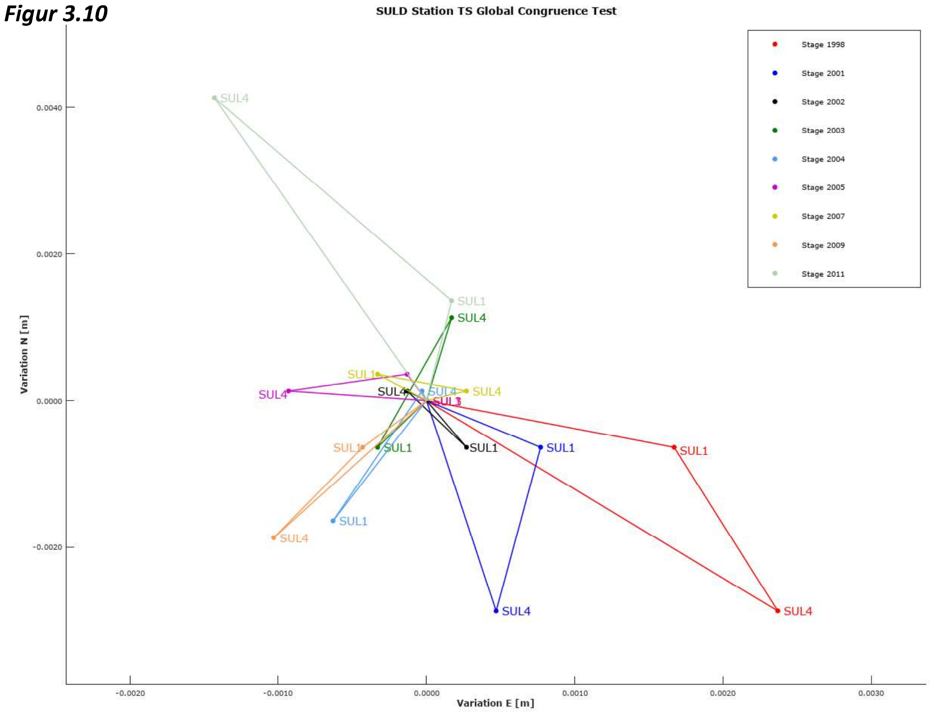


Stage 1 - 2003					*Stage 2 - **2002***				
From	**To**	**Horizontal directions**		**Average**	**From**	**To**	**Horizontal directions**		**Average**
SUL1	SUL3	97.6436	97.6427	97.6432	SUL1	SUL3	104.8864	104.8868	104.8866
	SUL4	130.9450	130.9449	130.9450		SUL4	138.1880	138.1878	138.1879
SUL3	SUL1	95.1062	95.1017	95.1040	SUL3	SUL1	354.9814	354.9810	354.9812
	SUL4	15.9437	15.9461	15.9449		SUL4	275.8196	275.8198	275.8197
SUL4	SUL1	332.1199	332.1199	332.1199	SUL4	SUL1	152.0834	152.0839	152.0837
	SUL3	19.6584	19.6596	19.6590		SUL3	239.6216	239.6205	239.6211

Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2003 vs **1998**	dN SUL1	2.86	2.86	>	2.31	Unstable
	dE SUL1	3.96	3.96	>		
	dN SUL3	3.75	3.75	>		Unstable
	dE SUL3	-3.16	3.16	>		
	dN SUL4	-3.95	3.95	>		Unstable
	dE SUL4	2.08	2.08	<		
2003 vs **2001**	dN SUL1	20.40	20.40	>	2.31	Unstable
	dE SUL1	70.99	70.99	>		
	dN SUL3	76.04	76.04	>		Unstable
	dE SUL3	-28.69	28.69	>		
	dN SUL4	-60.96	60.96	>		Unstable
	dE SUL4	1.12	1.12	<		
2003 vs **2002**	dN SUL1	-0.68	0.68	<	2.31	Unstable
	dE SUL1	13.56	13.56	>		
	dN SUL3	15.82	15.82	>		Unstable
	dE SUL3	-1.34	1.34	<		
	dN SUL4	-10.17	10.17	>		Unstable
	dE SUL4	-5.14	5.14	>		
2003 vs **2004**	dN SUL1	-0.67	0.67	<	2.31	Stable
	dE SUL1	0.05	0.05	<		
	dN SUL3	0.25	0.25	<		Stable
	dE SUL3	0.60	0.60	<		
	dN SUL4	0.18	0.18	<		Stable
	dE SUL4	-0.81	0.81	<		

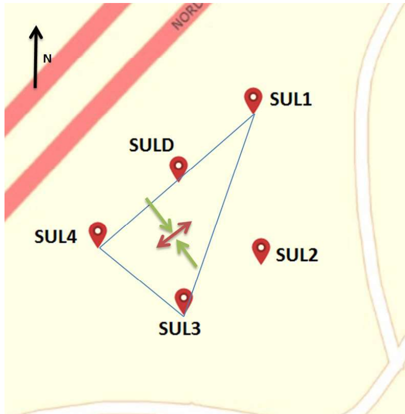
Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2003vs **2005**	dN SUL1	-1.14	1.14	<	2.31	Stable
	dE SUL1	2.00	2.00	<		
	dN SUL3	2.62	2.62	>		Unstable
	dE SUL3	0.74	0.74	<		
	dN SUL4	-1.16	1.16	<		Stable
	dE SUL4	-1.97	1.97	<		
2003 vs **2007**	dN SUL1	0.61	0.61	<	2.31	Stable
	dE SUL1	0.86	0.86	<		
	dN SUL3	0.82	0.82	<		Stable
	dE SUL3	-0.68	0.68	<		
	dN SUL4	-0.86	0.86	<		Stable
	dE SUL4	0.44	0.44	<		
2003 vs **2009**	dN SUL1	-2.25	2.25	<	2.31	Unstable
	dE SUL1	70.33	70.33	>		
	dN SUL3	81.69	81.69	>		Unstable
	dE SUL3	-8.13	8.13	>		
	dN SUL4	-53.15	53.15	>		Unstable
	dE SUL4	-25.14	25.14	>		
2003 vs **2011**	dN SUL1	-1.07	1.07	<	2.31	Stable
	dE SUL1	-1.69	1.69	<		
	dN SUL3	-1.65	1.65	<		Stable
	dE SUL3	1.21	1.21	<		
	dN SUL4	1.64	1.64	<		Stable
	dE SUL4	-0.71	0.71	<		

Figur 3.10



Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	-0.000006		
ε_{EE}	-0.000007		
ε_{simple}	0.000011		
ε_{pure}	0.000001		
ε_{MAX}	0.000005	+ extension	0.5 ppm
ε_{MIN}	-0.000018	- contraction	-1.8 ppm
2θ	94.0447		
θ	47.0224	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 4 - ESBJERG H [ESBH]

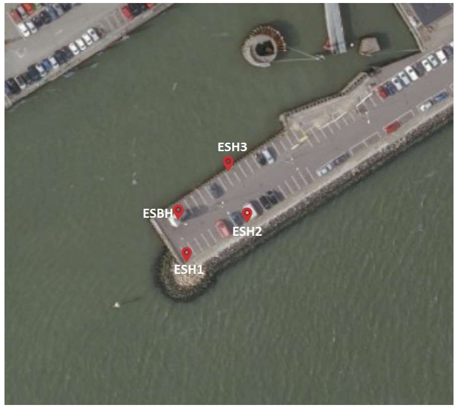
Tidserie: 81001

GPS Antenna	***ESBH K-75-00959***
Nærkontrol	***ESH1 K-75-00956*** → **JessenPunkt**
	ESH2 K-75-09394
	ESH3 K-75-09395
Fjernkontrol	***HAVN K-75-00957 G.I.2109***
Bolter i fundament	***135-08-09881***

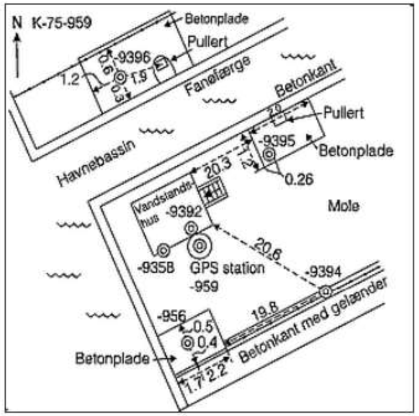
Notes:

- Regression analysis provides significant trends for:
  - The GNSS antenna ESBH (K-75-0959) → subsiding with a rate of approximately 1.51 ± 0.11 mm/year
  - The nærkontrol point ESH2 (K-75-09394) → subsiding with a rate of approximately 0.65 ± 0.03 mm/year
- All of the points are considered unstable by the A-test (regardless of the chosen parameters).
- All the results showed by the other analyses were as expected.

1. Skitser:



Figur 1.1

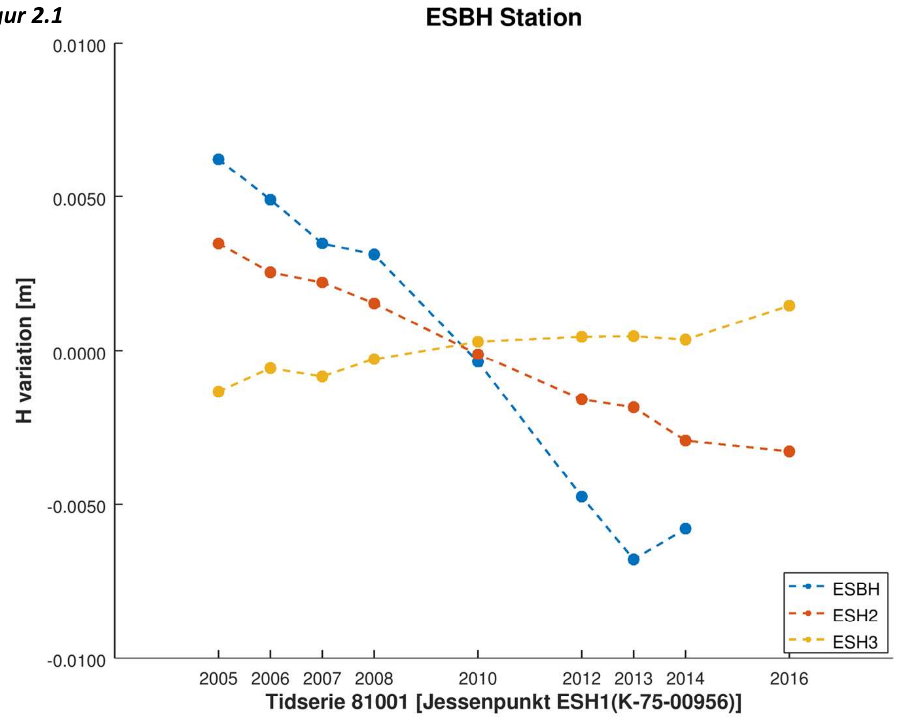


Figur 1.2

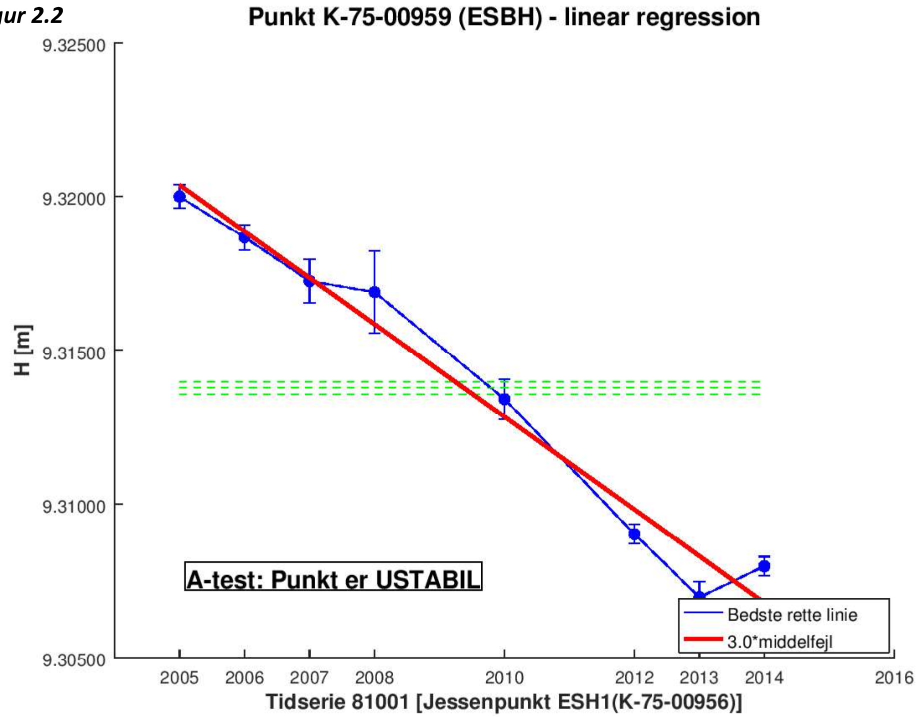
2. NIVELLEMENT

- *Initial plots*
- *Regression analysis*

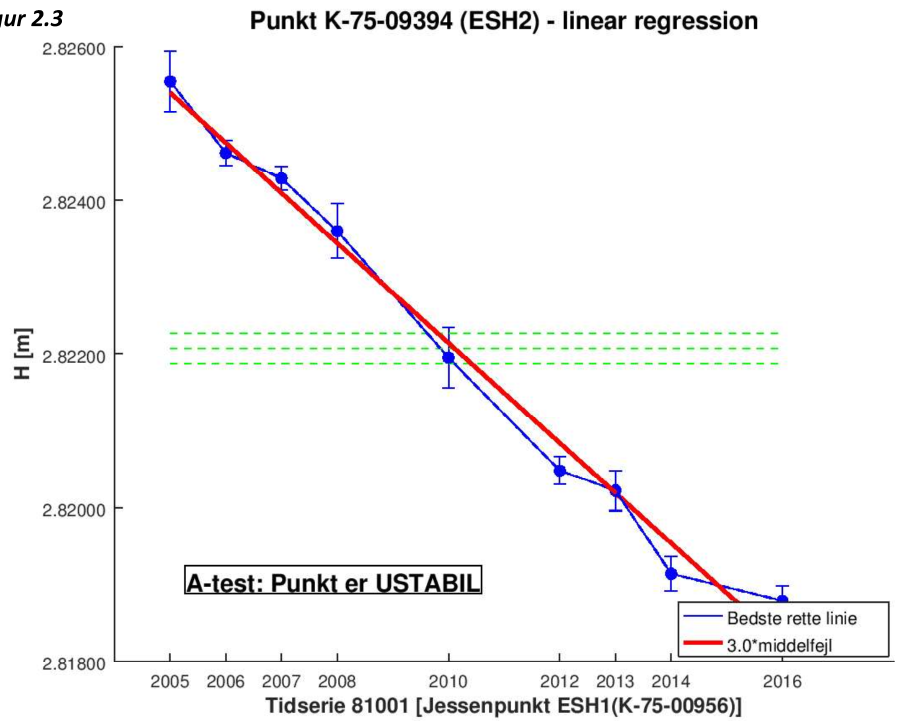
Figur 2.1



Figur 2.2



Figur 2.3



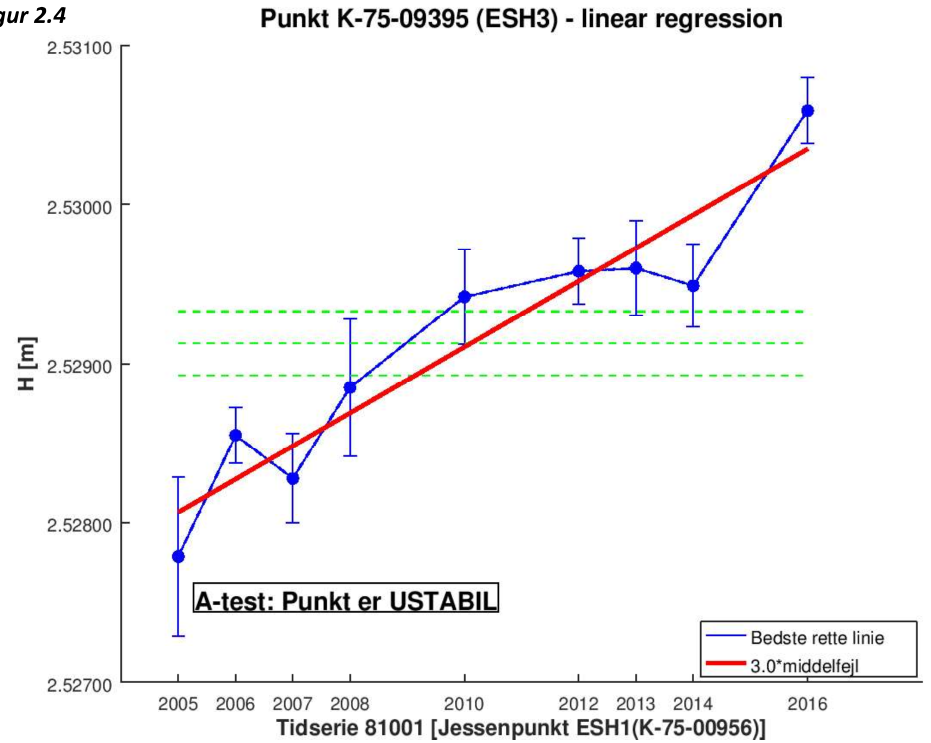
EsbjergH (ESBH) Linear Regression analysis results

Type	Punkt	2 parameters regression model (linear fitting)			
		θ_1 [m/year]	$\sigma_{\theta 1}$ [m/year]	t - value	p -value
GPS Antenna	ESBH K-75-00959	-0.001507	0.000106	-14.193800	0.000008
Nærkontrol	ESH2 K-75-09394	-0.000650	0.000030	-21.958300	0.000000
	ESH3 K-75-09395	0.000207	0.000027	7.758700	0.000111

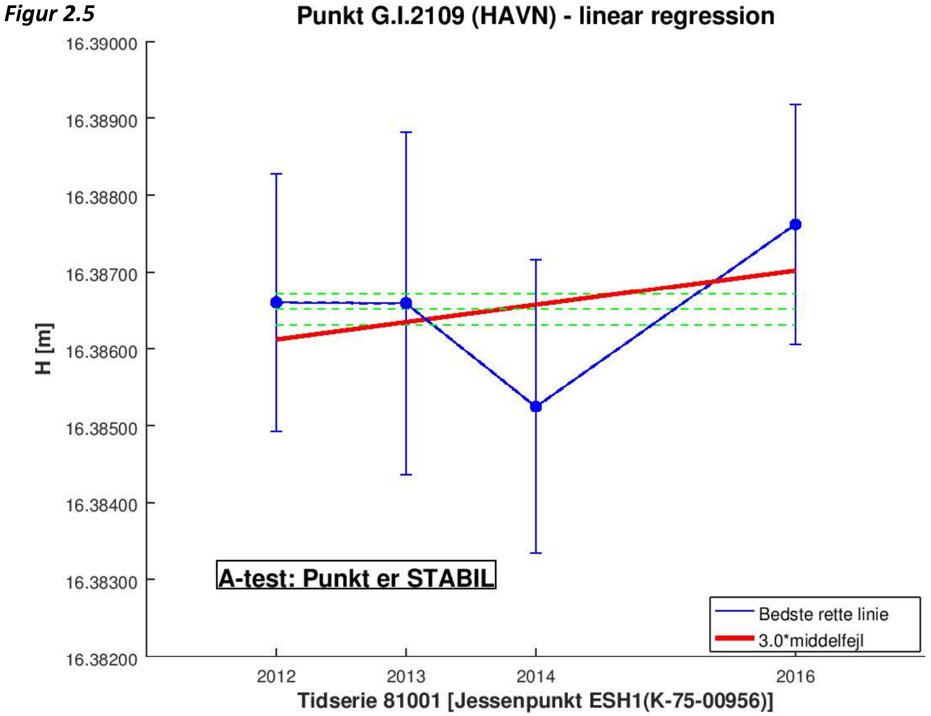
Statistically significant results --> Linear Regression

Type	Point	Behaviour	Variation [mm/year]	Std [mm/year]
GPS Antenna	ESBH K-75-00959	↓	-1.51	0.11
Nærkontrol	ESH2 K-75-09394	↓	-0.65	0.03

Figur 2.4



Figur 2.5



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

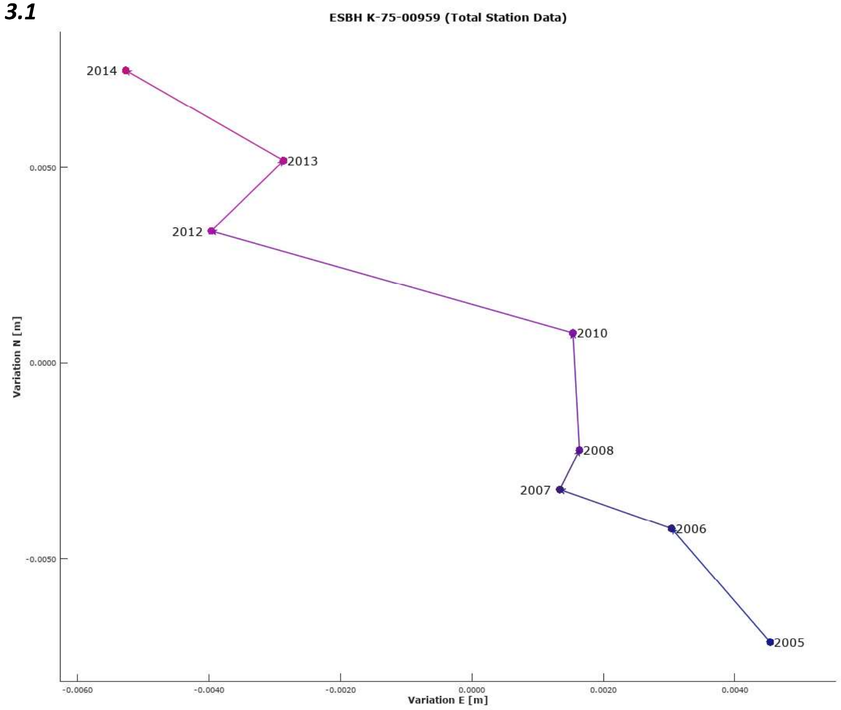
Constant Value [mm]	Station: ESBH			
	Antenna	Nærkontrol		Fjernkontrol
	ESBH	ESH2	ESH3	HAVN
0.3	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	ustabil	stabil
0.8	ustabil	ustabil	ustabil	stabil
1	ustabil	ustabil	ustabil	stabil
1.5	ustabil	ustabil	ustabil	stabil
2	ustabil	ustabil	ustabil	stabil

3. PLANIMETRIC ANALYSIS

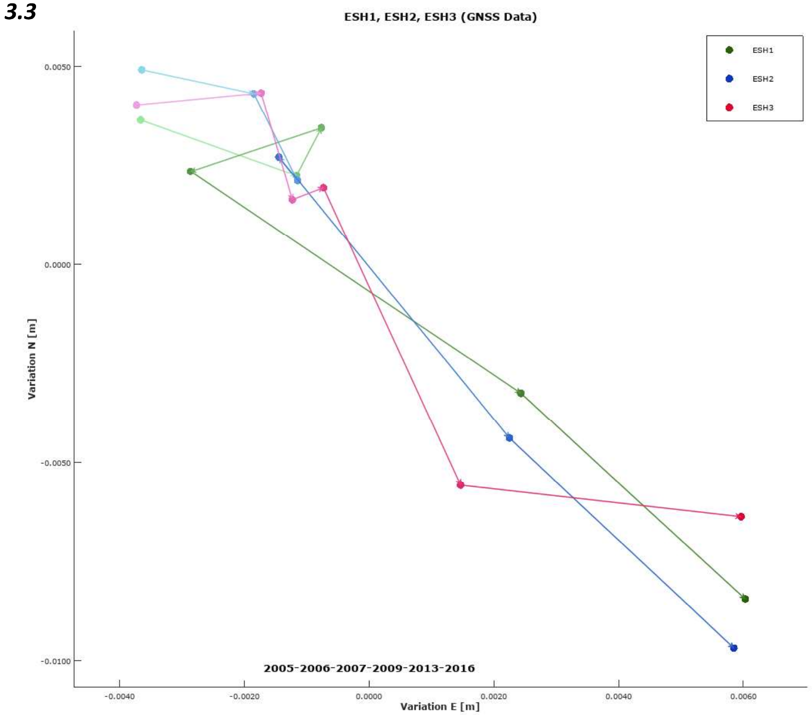
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! ***In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.***

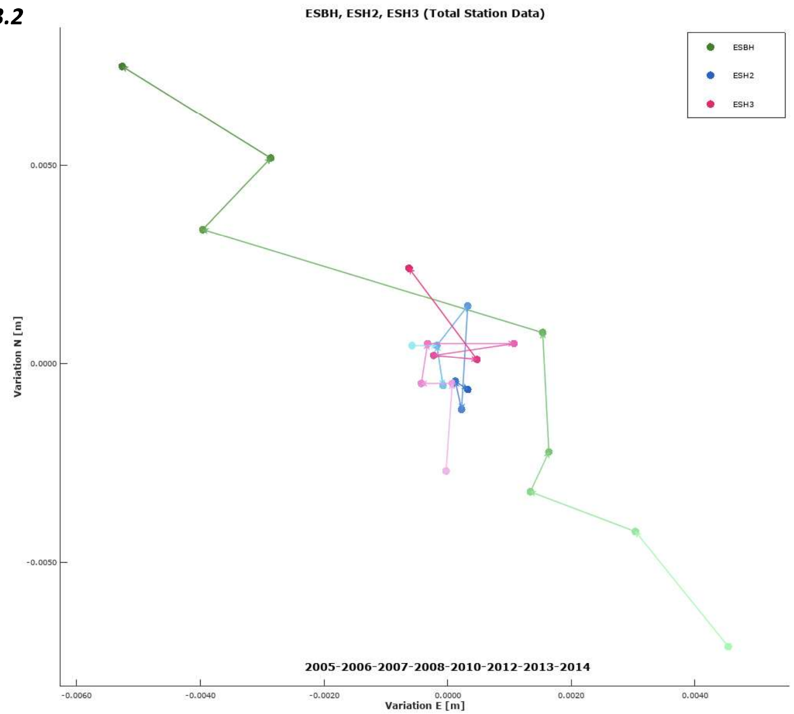
Figur 3.1



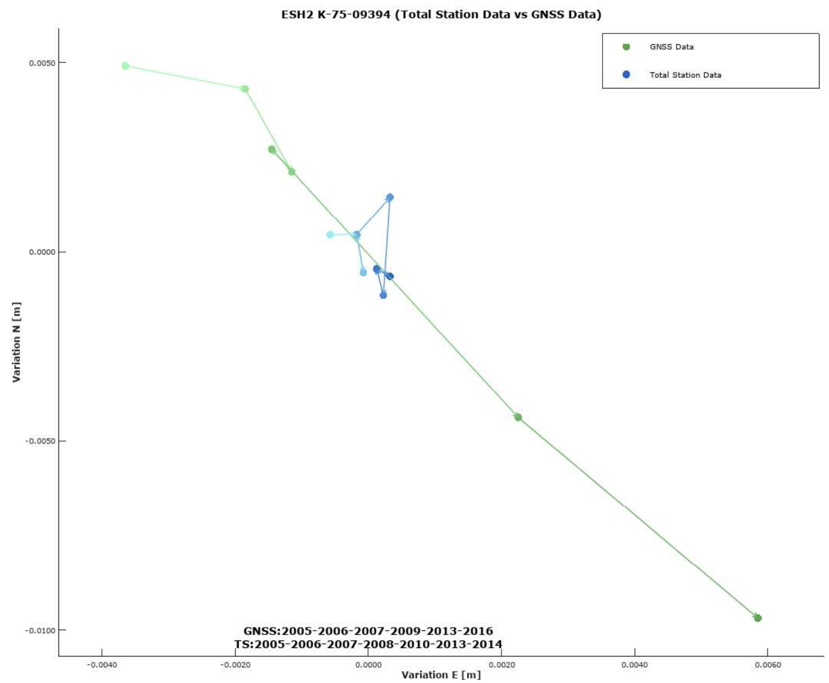
Figur 3.3



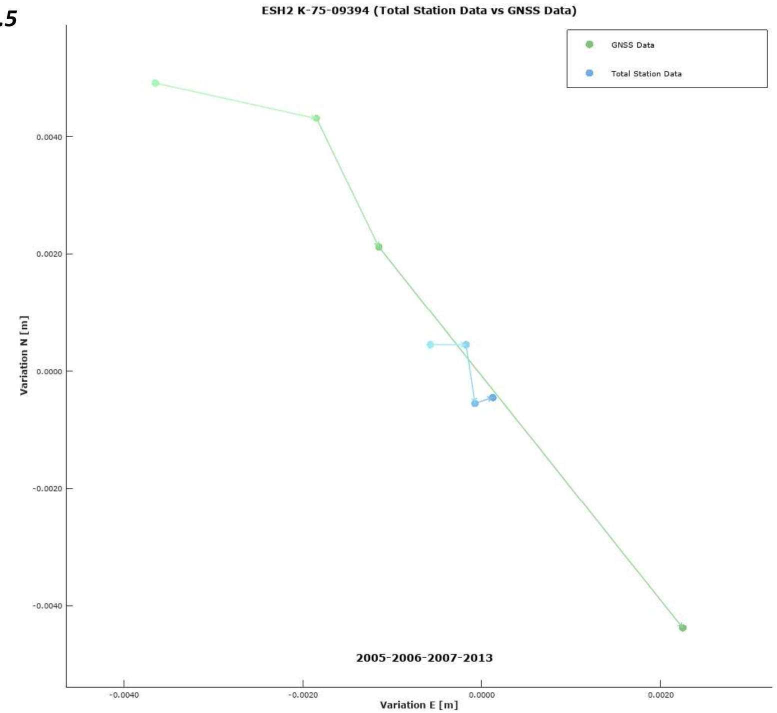
Figur 3.2



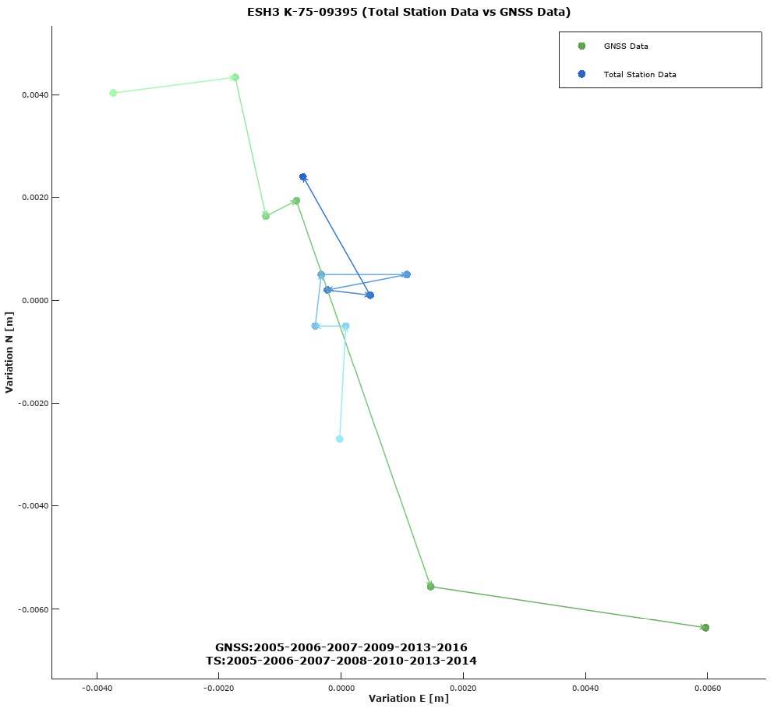
Figur 3.4



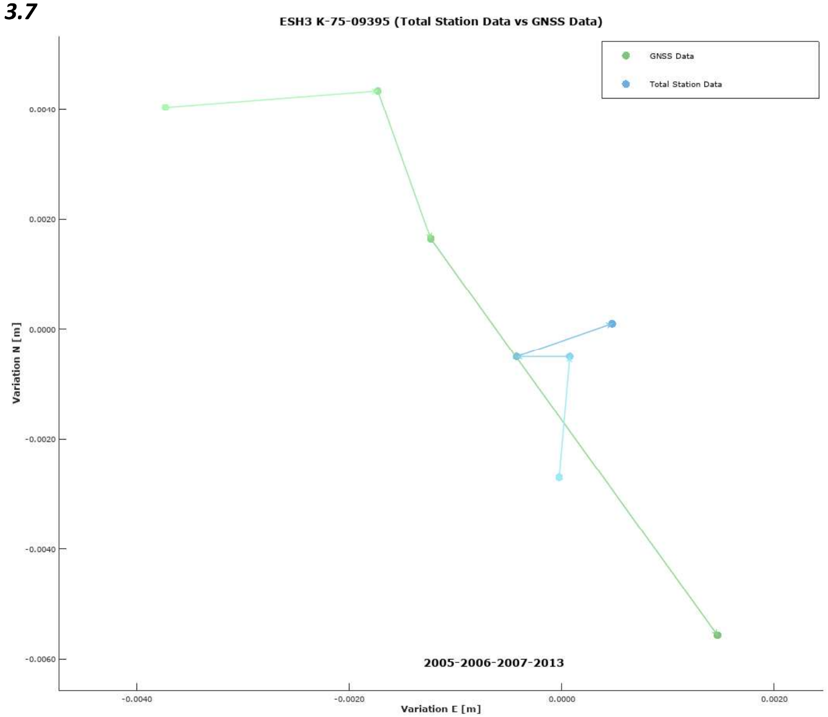
Figur 3.5



Figur 3.6

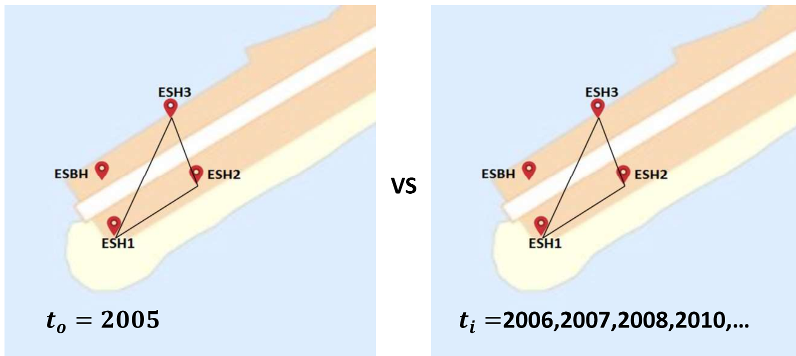


Figur 3.7



Global Congruence Test

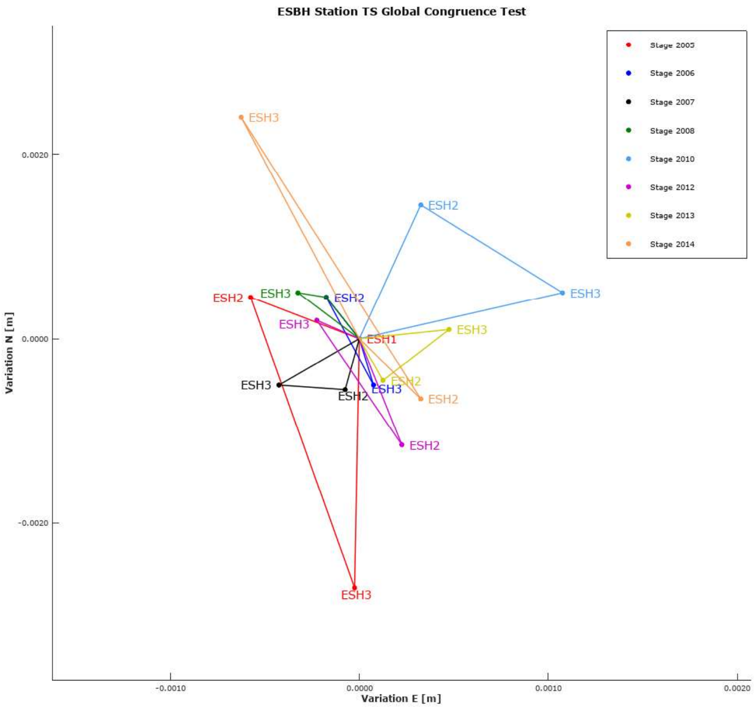
- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).



Stages	STUDENT TEST	t_i	$\|t_i\|$		t_{lim}	Stability
2005 vs 2006	dN ESH1	1.84	1.84	<	2.31	Unstable
	dE ESH1	2.85	2.85	>		
	dN ESH2	-2.62	2.62	>		Unstable
	dE ESH2	-1.74	1.74	<		
	dN ESH3	2.82	2.82	>		Unstable
	dE ESH3	-1.24	1.24	<		
2005 vs 2007	dN ESH1	5.02	5.02	>	2.31	Unstable
	dE ESH1	3.46	3.46	>		
	dN ESH2	-4.56	4.56	>		Unstable
	dE ESH2	0.94	0.94	<		
	dN ESH3	3.89	3.89	>		Unstable
	dE ESH3	-4.83	4.83	>		
2005 vs 2008	dN ESH1	1.68	1.68	<	2.31	Unstable
	dE ESH1	2.53	2.53	>		
	dN ESH2	-2.34	2.34	>		Unstable
	dE ESH2	-1.49	1.49	<		
	dN ESH3	2.50	2.50	>		Unstable
	dE ESH3	-1.16	1.16	<		
2005 vs 2010	dN ESH1	1.67	1.67	<	2.31	Unstable
	dE ESH1	3.88	3.88	>		
	dN ESH2	-3.14	3.14	>		Unstable
	dE ESH2	-3.28	3.28	>		
	dN ESH3	3.69	3.69	>		Unstable
	dE ESH3	-0.70	0.70	<		

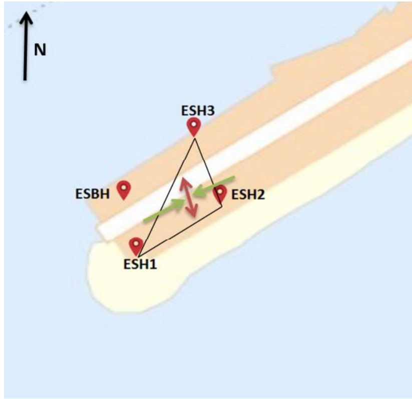
Stages	STUDENT TEST	t_i	$\|t_i\|$		t_{lim}	Stability
2005 vs 2012	dN ESH1	3.96	3.96	>	2.31	Unstable
	dE ESH1	3.75	3.75	>		
	dN ESH2	-4.21	4.21	>		Unstable
	dE ESH2	-0.60	0.60	<		
	dN ESH3	3.97	3.97	>		Unstable
	dE ESH3	-3.47	3.47	>		
2005 vs 2013	dN ESH1	4.22	4.22	>	2.31	Unstable
	dE ESH1	4.94	4.94	>		
	dN ESH2	-5.04	5.04	>		Unstable
	dE ESH2	-1.89	1.89	<		
	dN ESH3	5.06	5.06	>		Unstable
	dE ESH3	-3.38	3.38	>		
2005 vs 2014	dN ESH1	7.35	7.35	>	2.31	Unstable
	dE ESH1	8.06	8.06	>		
	dN ESH2	-8.46	8.46	>		Unstable
	dE ESH2	-2.56	2.56	>		
	dN ESH3	8.33	8.33	>		Unstable
	dE ESH3	-6.08	6.08	>		

Figur 3.8



Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	-0.000016		
ε_{EE}	0.000005		
ε_{simple}	0.000017		
ε_{pure}	-0.000011		
ε_{MAX}	0.000014	+ extension	1.4 ppm
ε_{MIN}	-0.000026	- contraction	-2.6 ppm
2θ	-42.2661		
θ	178.8670	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 5 - ESBJERG C [ESBC]

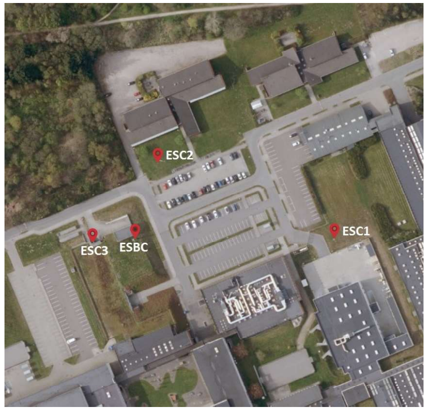
Tidserie: 81004

GPS Antenna	***ESBC 135-08-00932***
Nærkontrol	***ESC1 135-08-00936***
	ESC2 135-08-00935 81004 → **JessenPunkt**
	ESC3 135-08-09880
Fjernkontrol	***HAVN K-75-00957 G.I.2109***
Bolter i fundament	***135-08-09881***
	135-08-09882
	135-08-09883
	135-08-09884

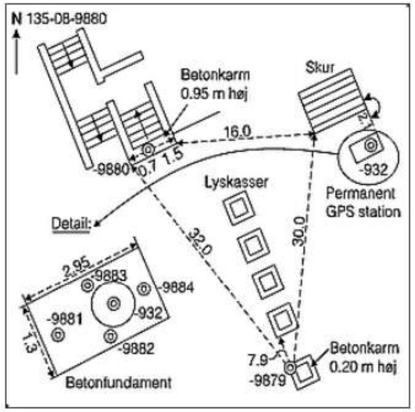
Notes:

- The A-test shows instability. However, manual analysis indicates the station is stable.
- Pay attention to ESC1 and its future determined elevations.
- In terms of planimetric coordinates: the TS data shows a curious behaviour (Figur 3.2). Maybe take another TS measurement.
- The congruence test shows relative stability between the points.
- Strain analysis doesn't indicate predisposition to local instability.

1. Skitser:



Figur 1.1



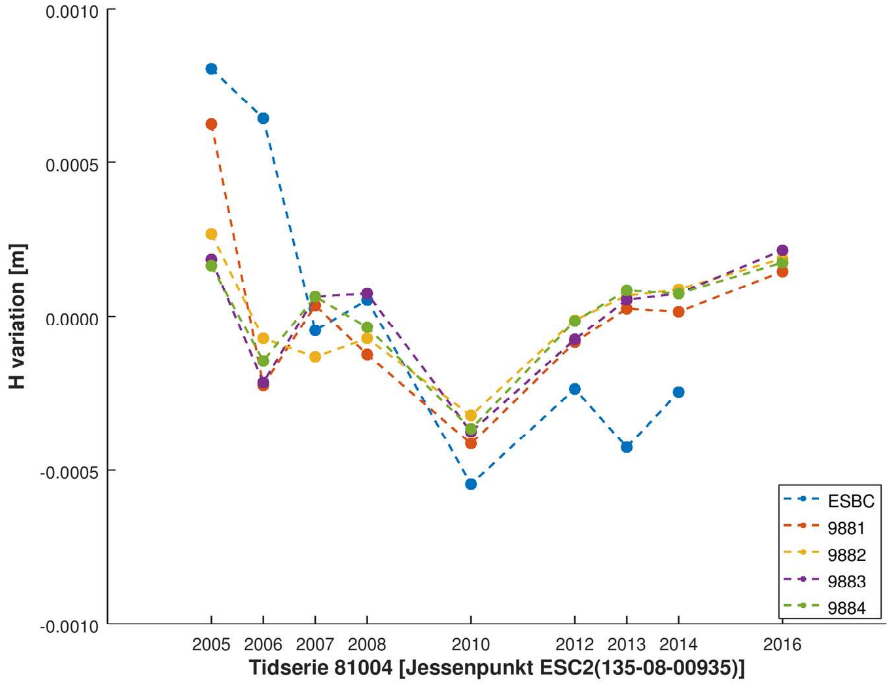
Figur 1.2

2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

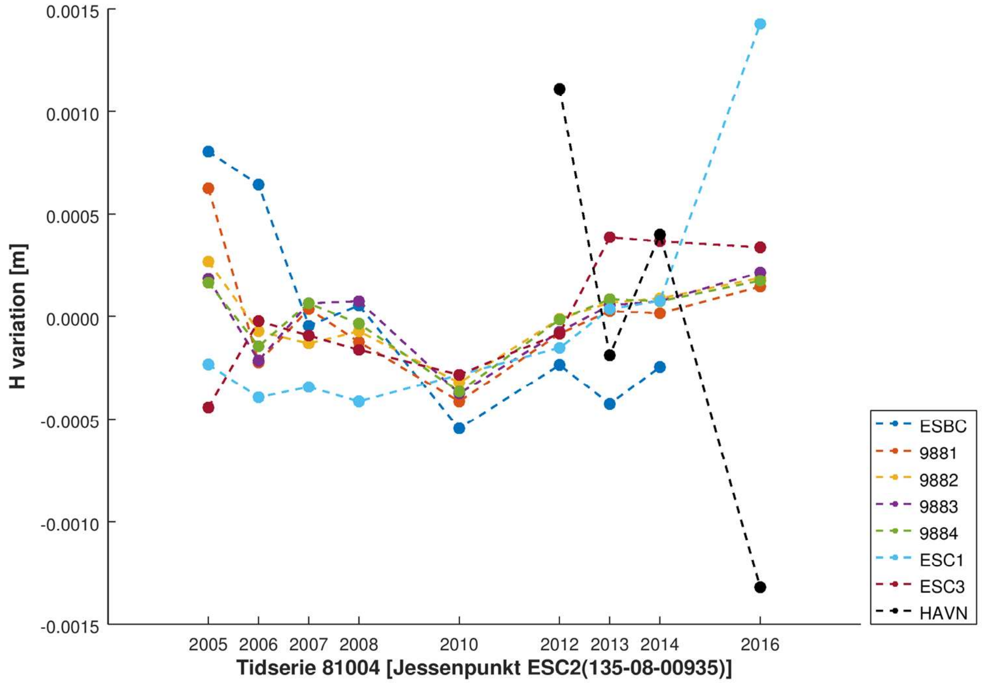
Figur 2.1

ESBC Station (ESBC, 9881, 9882, 9883, 9884)



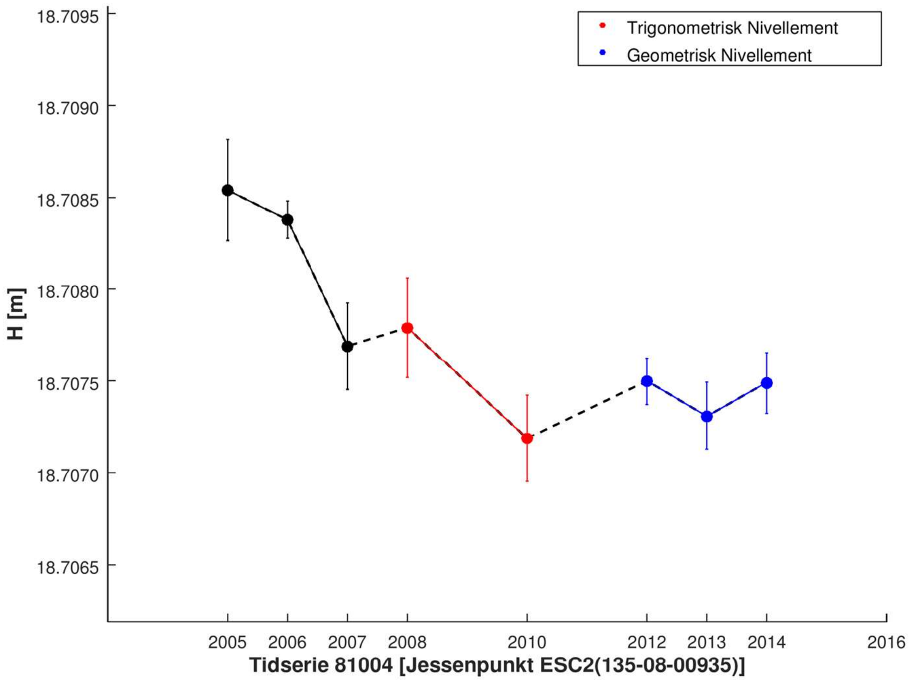
Figur 2.3

ESBC Station



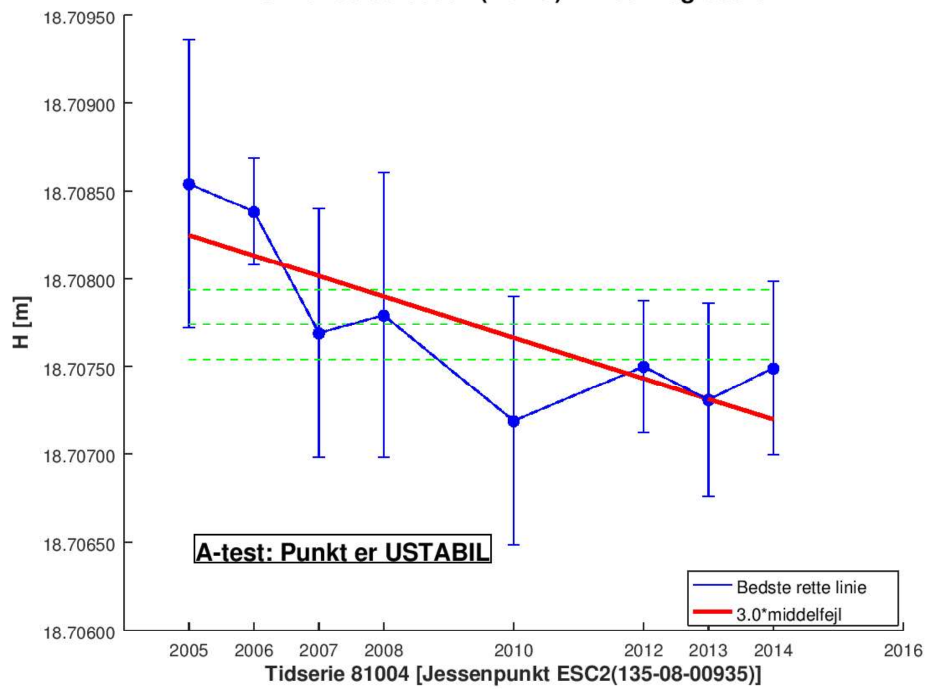
Figur 2.2

ESBC Station (135-08-09881)

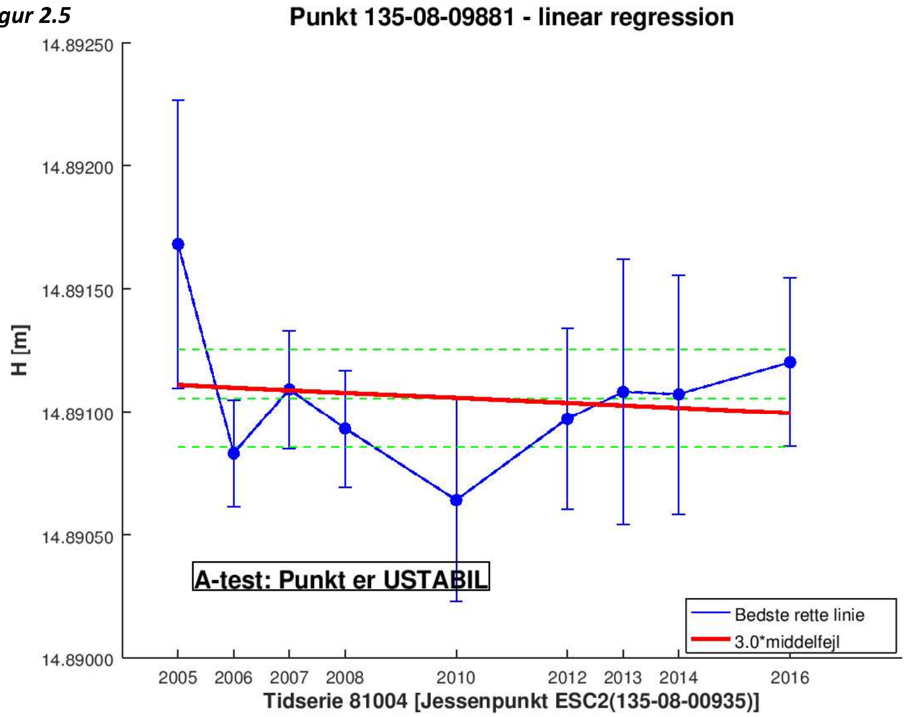


Figur 2.4

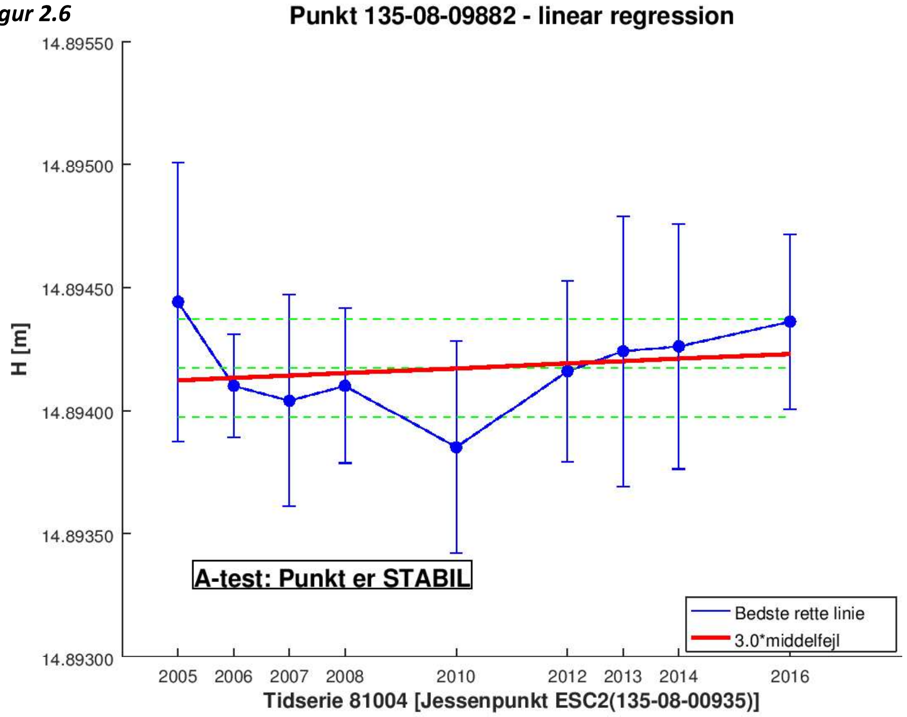
Punkt 135-08-00932 (ESBC) - linear regression



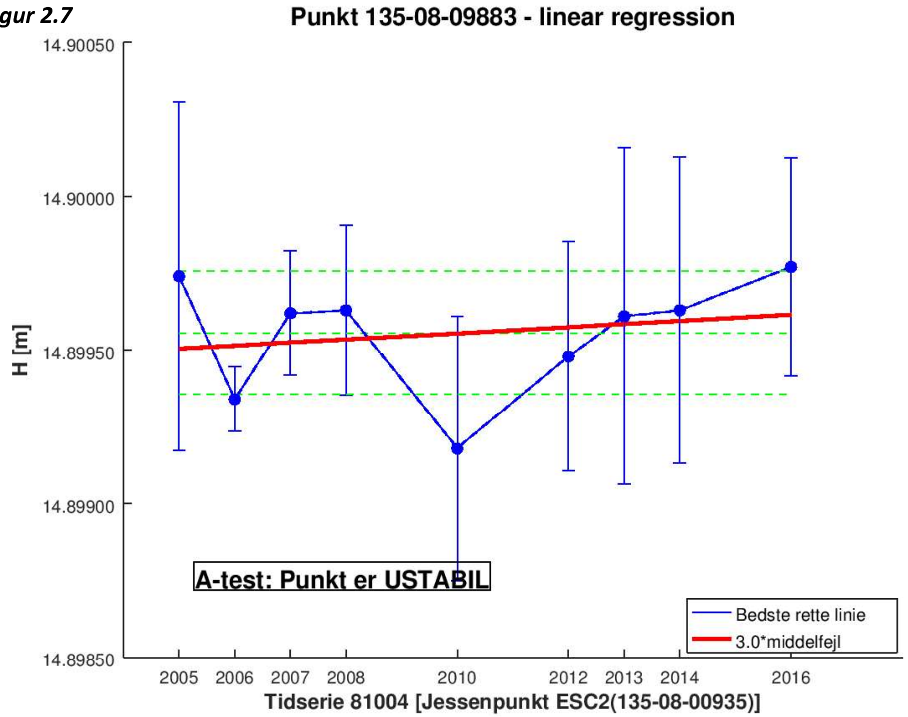
Figur 2.5



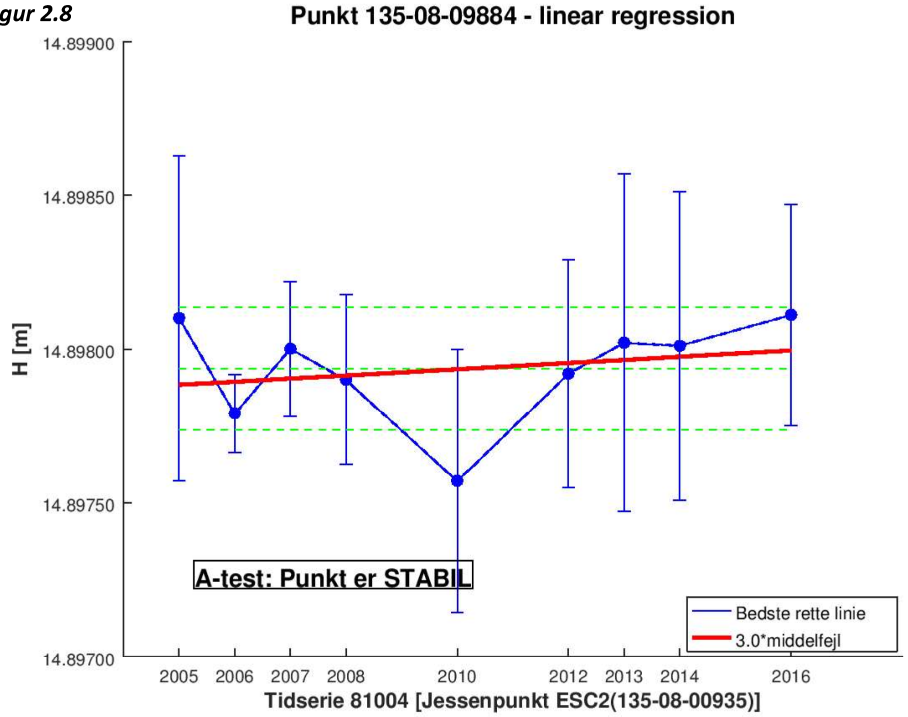
Figur 2.6



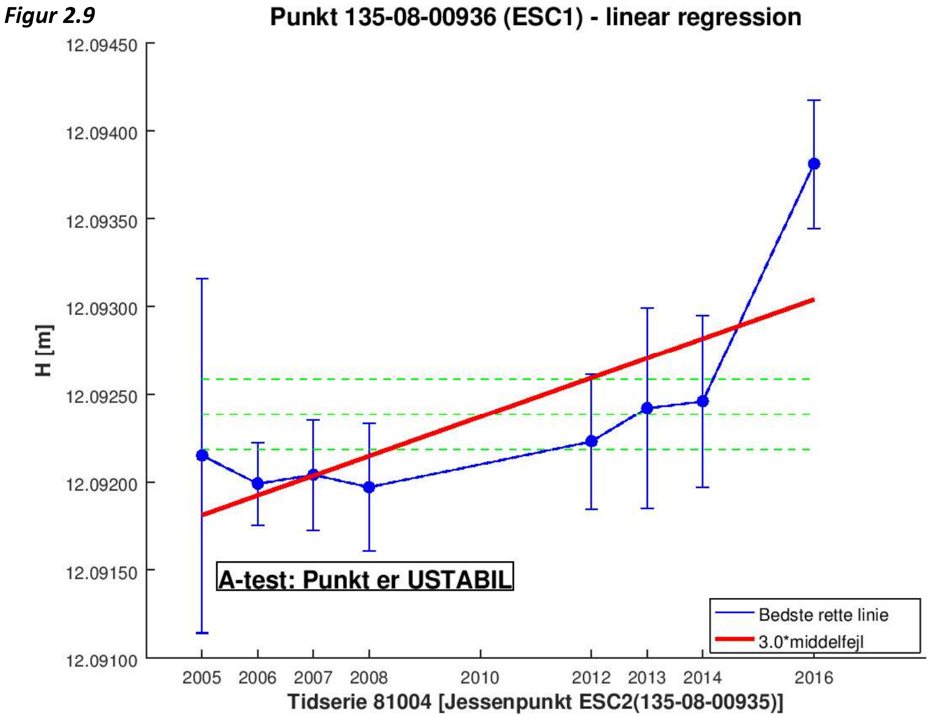
Figur 2.7



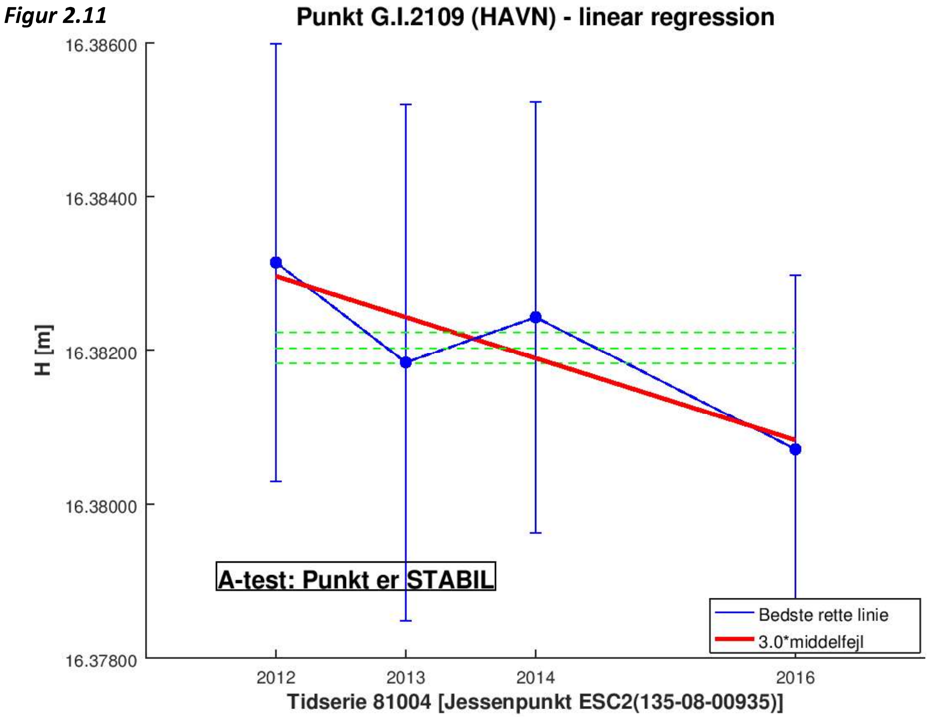
Figur 2.8



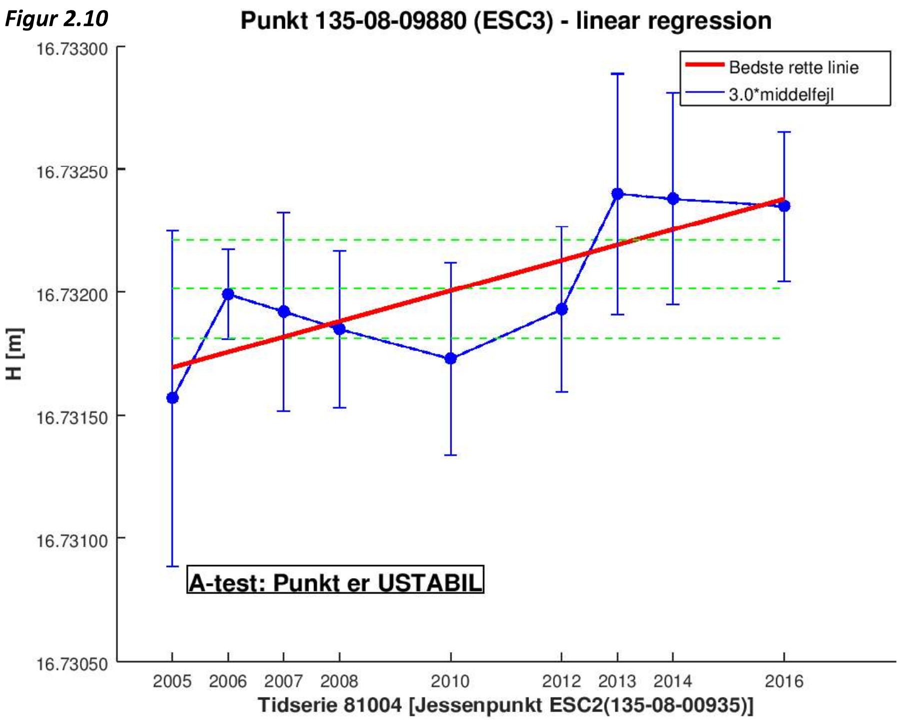
Figur 2.9



Figur 2.11



Figur 2.10



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

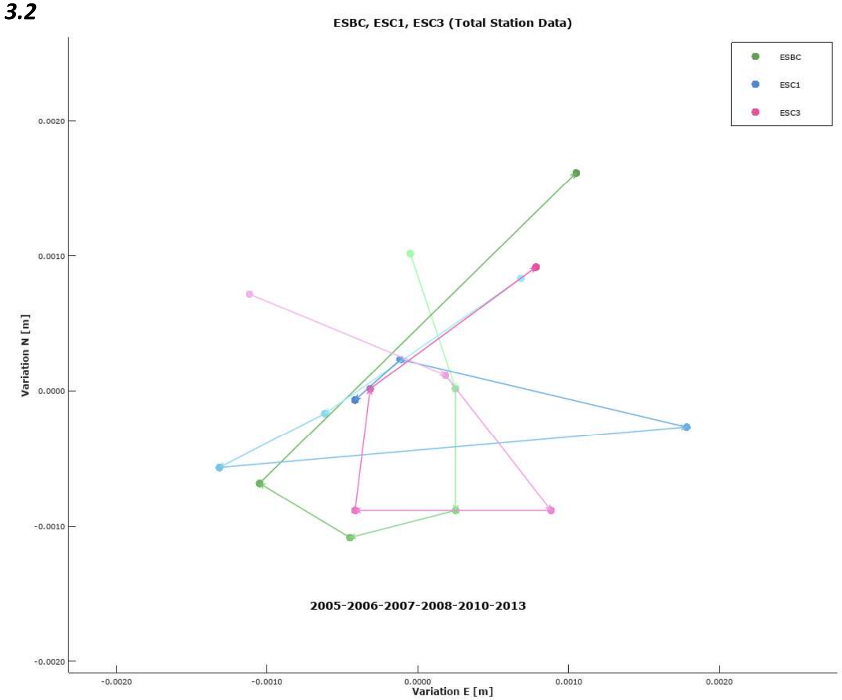
Constant Value [mm]	Station: ESBC							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	ESBC	9881	9882	9883	9884	ESC1	ESC3	HAVN
0.3	ustabil	ustabil	stabil	ustabil	stabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	stabil	ustabil	stabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	stabil	ustabil	stabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	stabil	stabil	stabil	ustabil	ustabil	stabil
0.8	ustabil	ustabil	stabil	stabil	stabil	ustabil	ustabil	stabil
1	ustabil	ustabil	stabil	stabil	stabil	ustabil	stabil	stabil
1.5	stabil	stabil	stabil	stabil	stabil	ustabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

3. PLANIMETRIC ANALYSIS

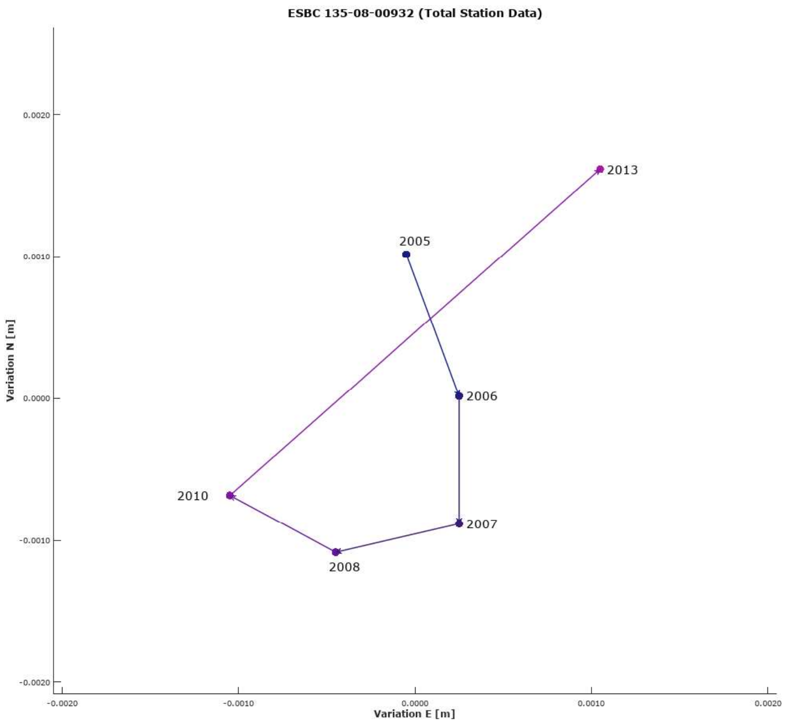
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! ***In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.***

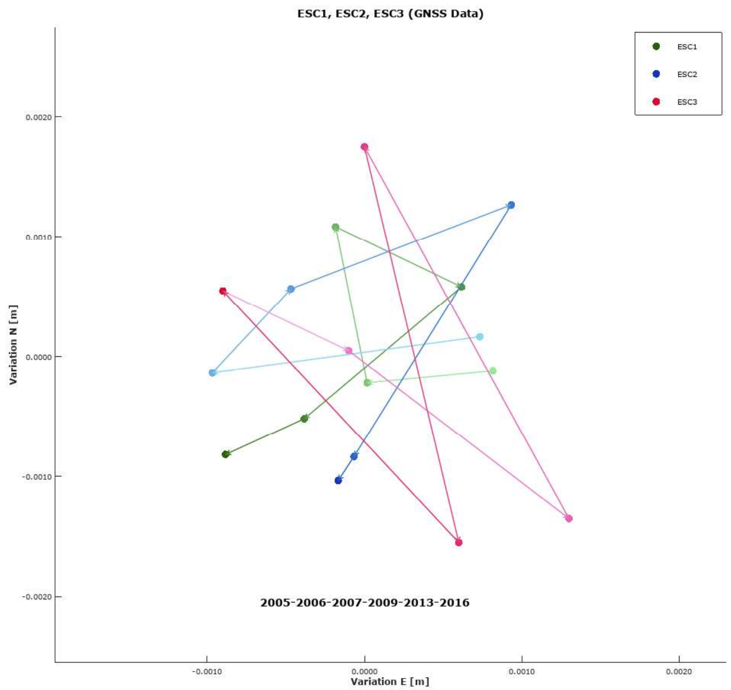
Figur 3.2



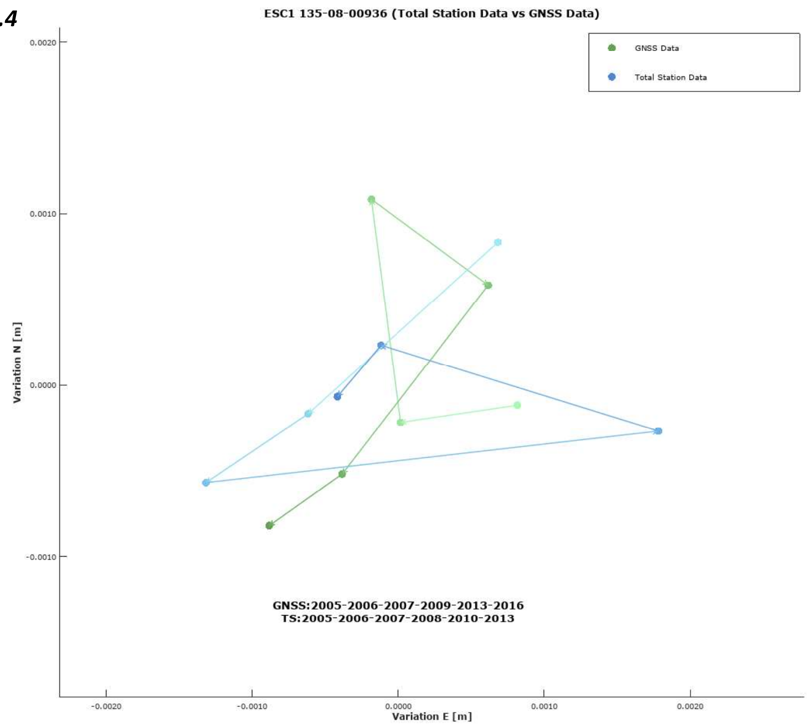
Figur 3.1



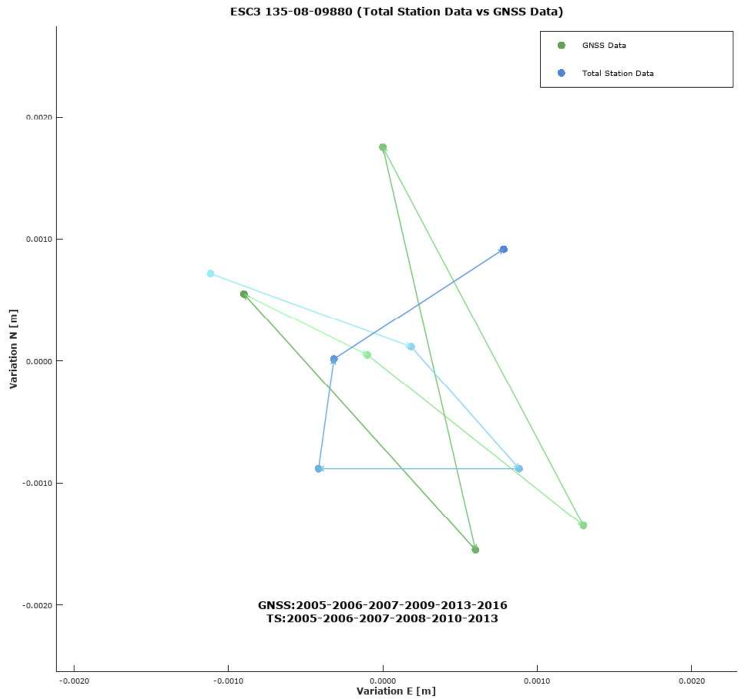
Figur 3.3



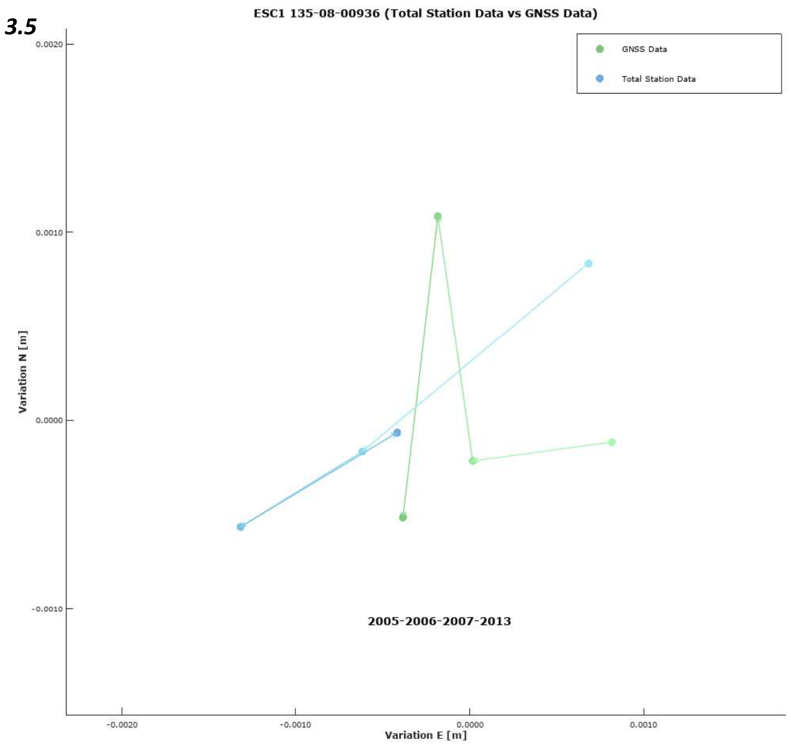
Figur 3.4



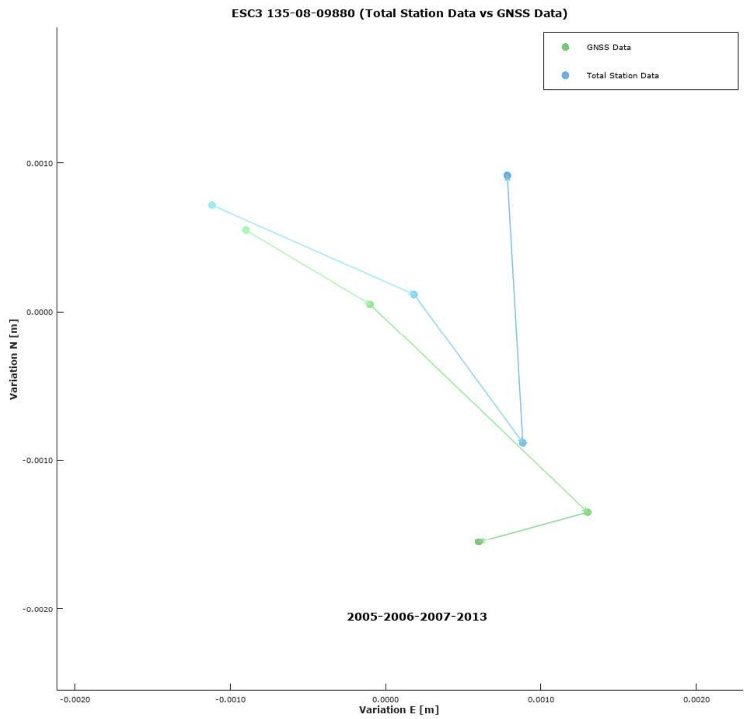
Figur 3.6



Figur 3.5



Figur 3.7

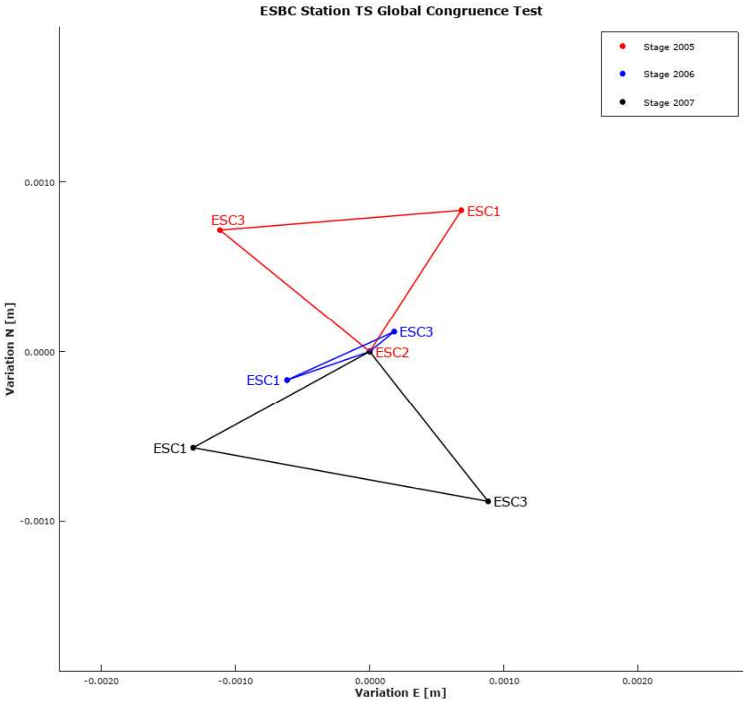


Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

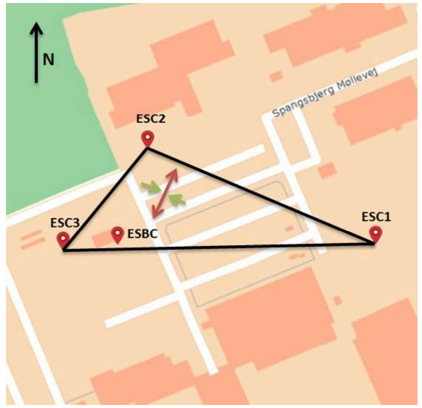
Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2005 vs **2006**	dN ESC1	-2.60	2.60	>	2.31	Unstable
	dE ESC1	0.84	0.84	<		
	dN ESC2	0.21	0.21	<		Stable
	dE ESC2	-1.64	1.64	<		
	dN ESC3	0.54	0.54	<		Stable
	dE ESC3	2.17	2.17	<		
2005 vs **2007**	dN ESC1	-3.99	3.99	>	2.31	Unstable
	dE ESC1	0.35	0.35	<		
	dN ESC2	1.45	1.45	<		Stable
	dE ESC2	-1.84	1.84	<		
	dN ESC3	-0.18	0.18	<		Unstable
	dE ESC3	2.93	2.93	>		
2005 vs **2008**	dN ESC1	-0.73	0.73	<	2.31	Stable
	dE ESC1	0.58	0.58	<		
	dN ESC2	-0.35	0.35	<		Stable
	dE ESC2	-0.71	0.71	<		
	dN ESC3	0.52	0.52	<		Stable
	dE ESC3	0.76	0.76	<		
2005 vs **2010**	dN ESC1	-0.79	0.79	<	2.31	Stable
	dE ESC1	0.61	0.61	<		
	dN ESC2	-0.36	0.36	<		Stable
	dE ESC2	-0.75	0.75	<		
	dN ESC3	0.54	0.54	<		Stable
	dE ESC3	0.81	0.81	<		

Figur 3.8



Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000002		
ε_{EE}	0.000000		
ε_{simple}	0.000002		
ε_{pure}	0.000001		
ε_{MAX}	0.000004	+ extension	0.4 ppm
ε_{MIN}	-0.000002	- contraction	-0.2 ppm
2θ	60.2103		
θ	30.1051	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 6 - GEDSER [GESR]

Tidserie: 81005

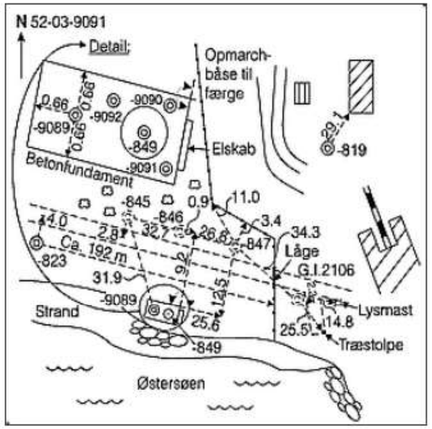
GPS Antenna	***GESR 52-03-00849***
Nærkontrol	***GED1 52-03-00843***
	GED2 52-03-00845 → **JessenPunkt**
	GED3 52-03-00846
	GED4 52-03-00847
	GED6 52-03-00853
Fjernkontrol	***GEDN 52-03-00850 G.I.2242***
Bolter i fundament	***52-03-09089***
	52-03-09090
	52-03-09091
	52-03-09092

Notes:

- The A-test shows instability for most of the considered points. Manual analysis shows that the concrete bolts are stable. However there are problems with the nærkontrol points and *possibly* with the station.
- Pay attention to GED3 and GED4 and their future determined elevations.
- In terms of planimetric coordinates: no large displacements can be observed.
- The congruence test shows relative stability between the points.
- Strain analysis doesn’t indicate predisposition to local instability.

1. Skitser:

Figur 1.1

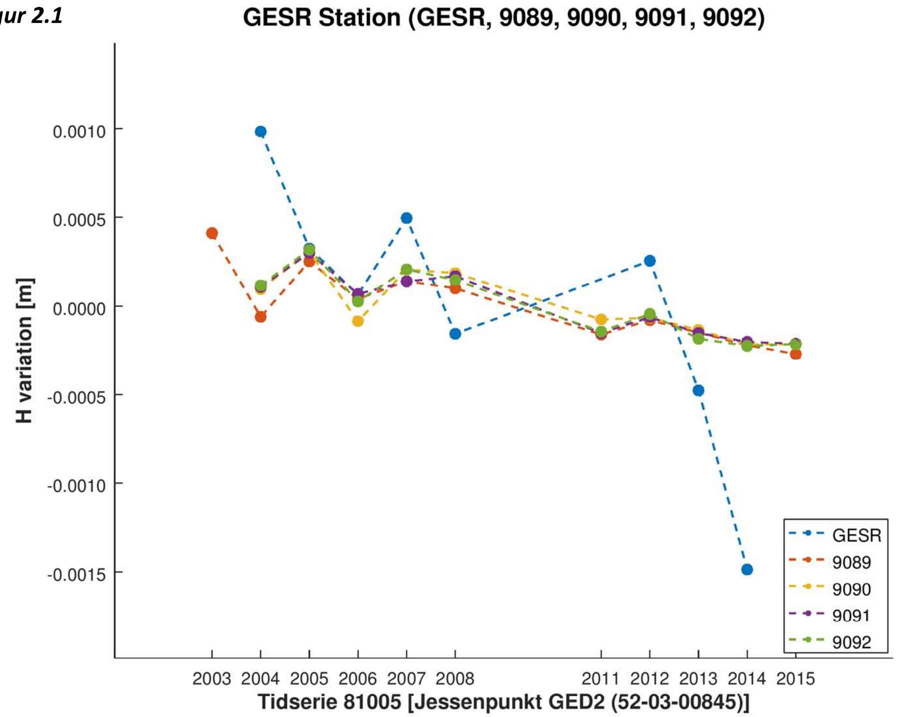


Figur 1.2

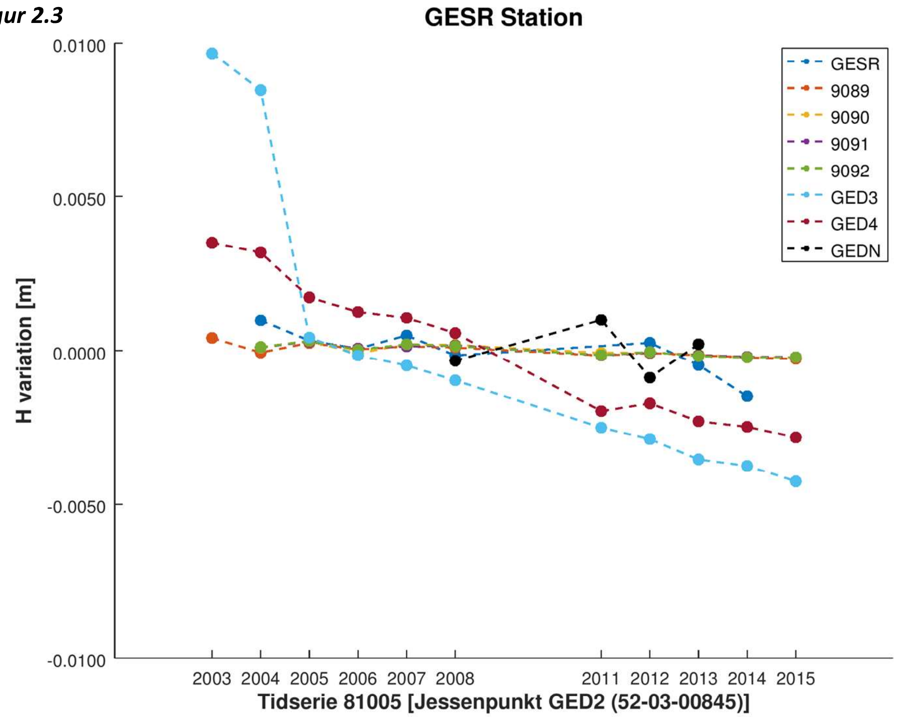
2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

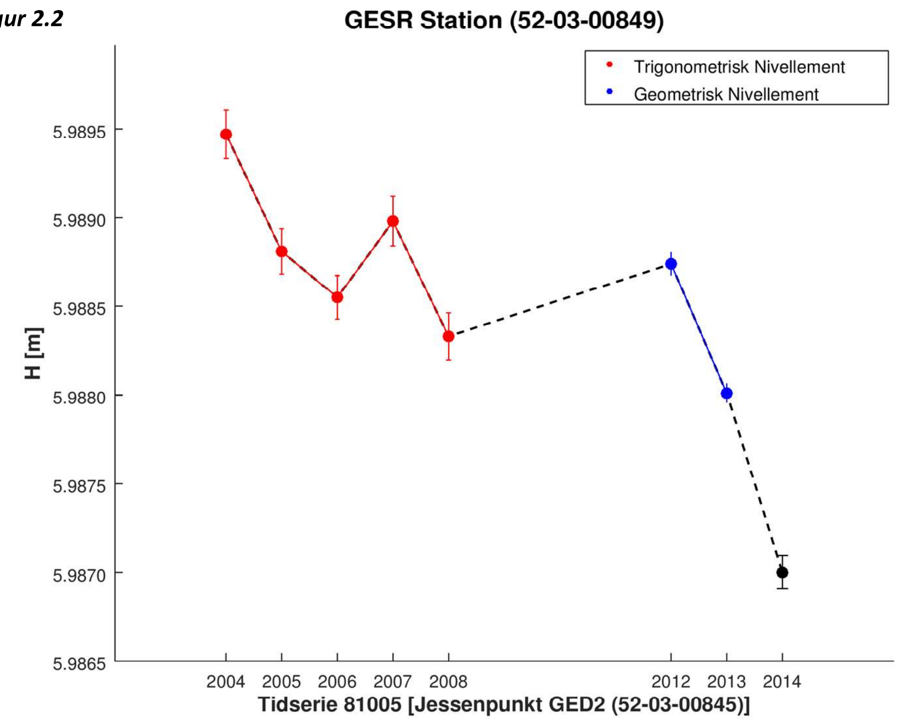
Figur 2.1



Figur 2.3



Figur 2.2



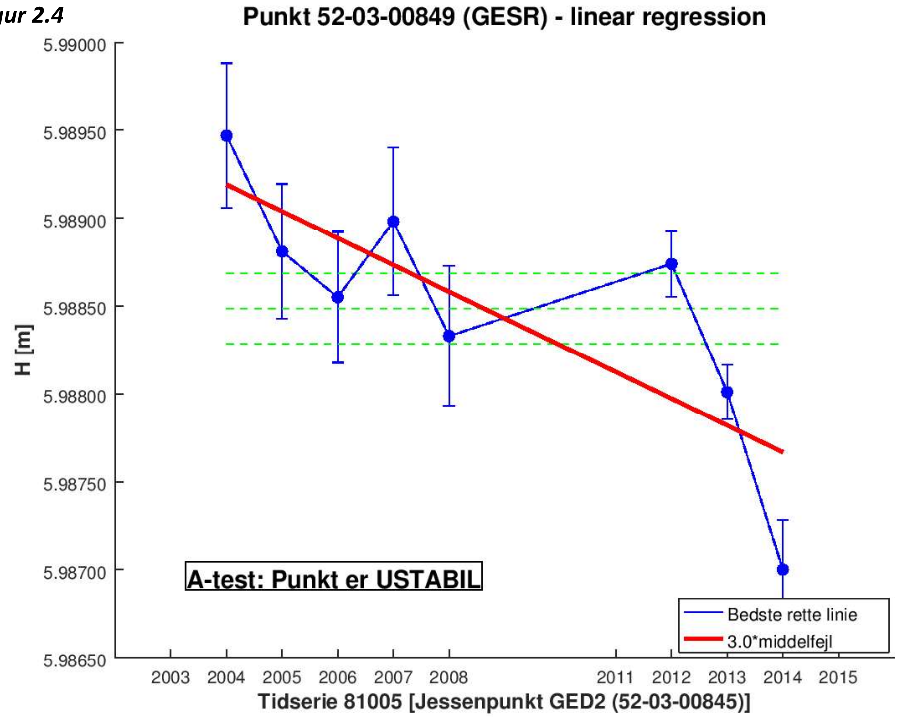
GEDSER (GESR) Linear Regression analysis results

Type	Punkt	2 parameters regression model (linear fitting)			
		θ_1 [m/year]	σ_{θ_1} [m/year]	t - value	p -value
GPS Antenna	GESR 52-03-00849	-0.000152	0.000048	-3.168600	0.019354
Bolter i fundament	52-03-09089	-0.000042	0.000009	-4.720100	0.001089
	52-03-09090	-0.000037	0.000010	-3.774900	0.005428
	52-03-09091	-0.000040	0.000007	-5.801800	0.000404
	52-03-09092	-0.000042	0.000008	-5.252800	0.000771
Nærkontrol	GED3 52-03-00846	-0.000949	0.000196	-4.832600	0.000931
	GED4 52-03-00847	-0.000542	0.000032	-17.035500	0.000000

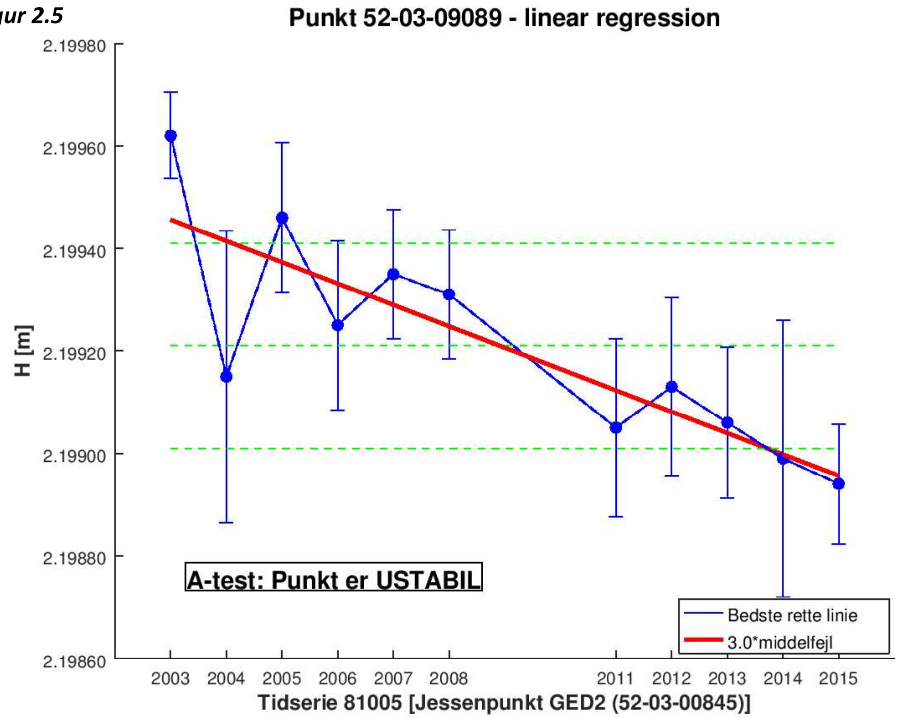
Statistically significant results --> Linear Regression

Type	Point	Behaviour	Variation [mm/year]	Std [mm/year]
Nærkontrol	GED4 52-03-00847	↓	-0.54	0.03

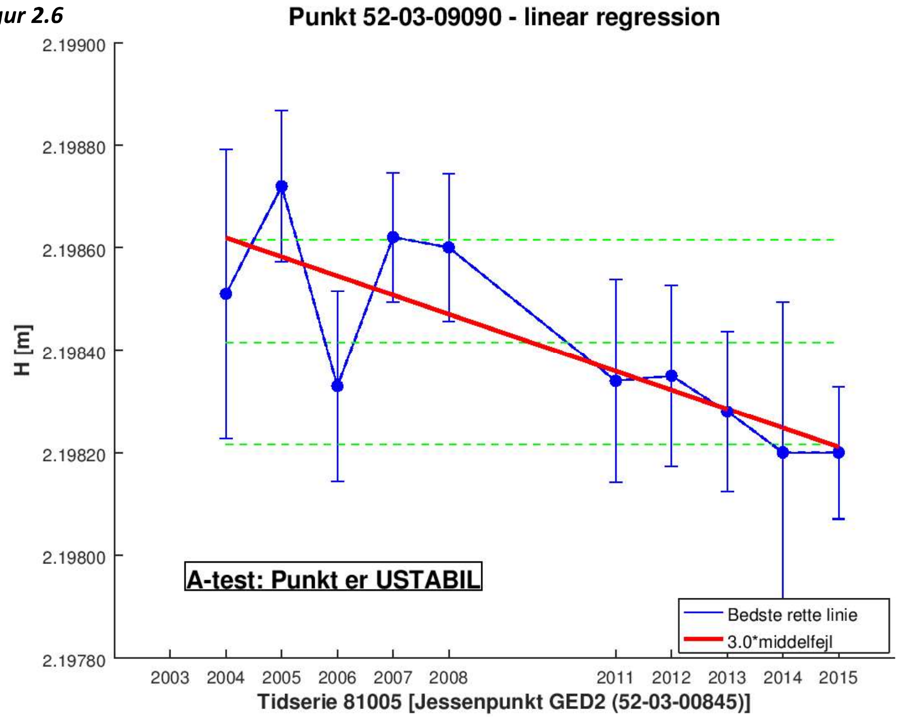
Figur 2.4



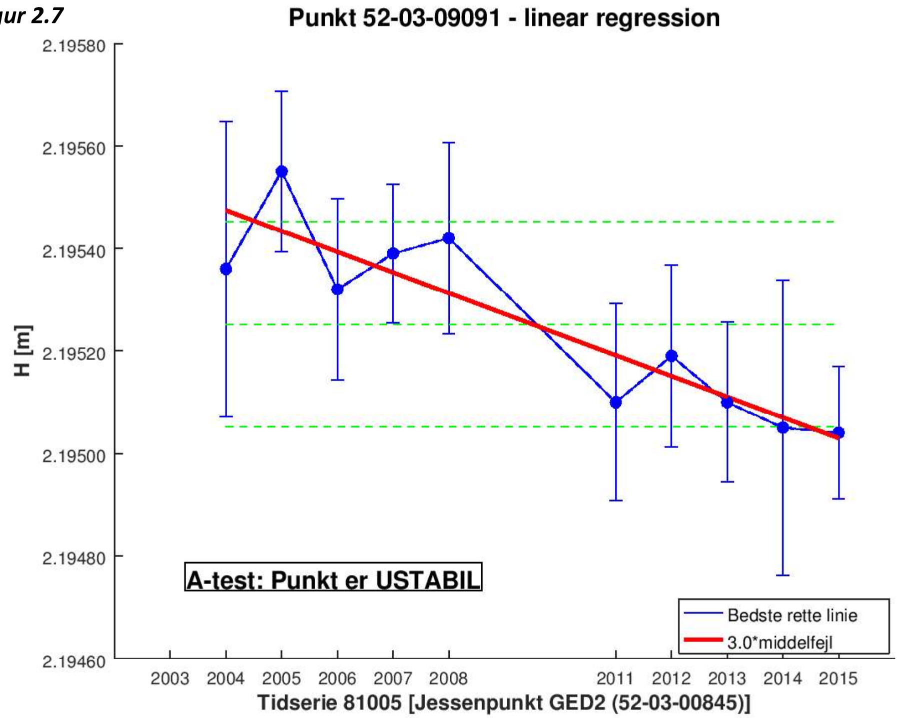
Figur 2.5



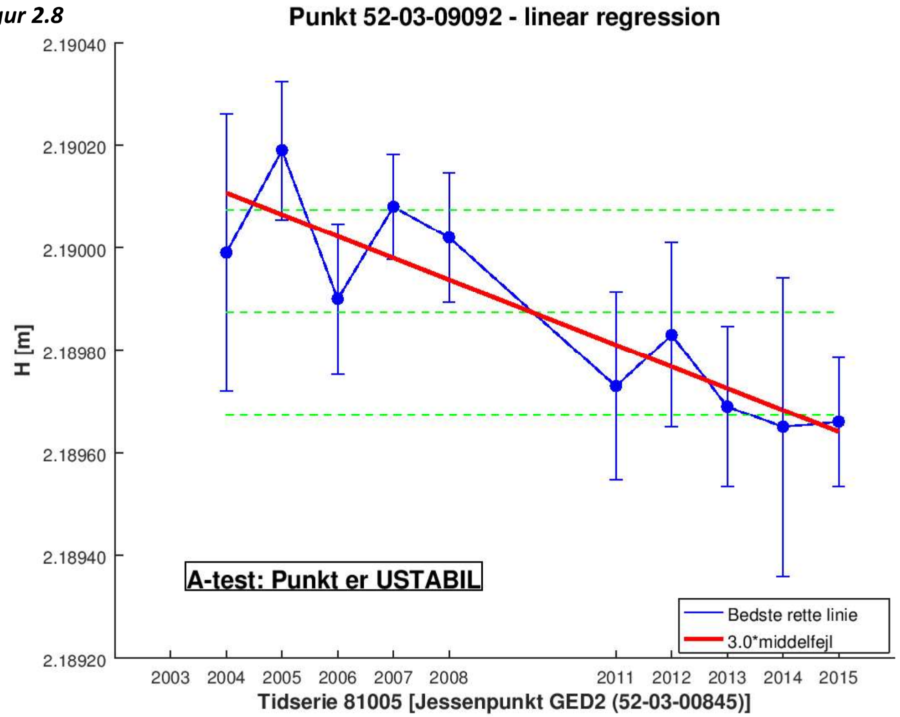
Figur 2.6



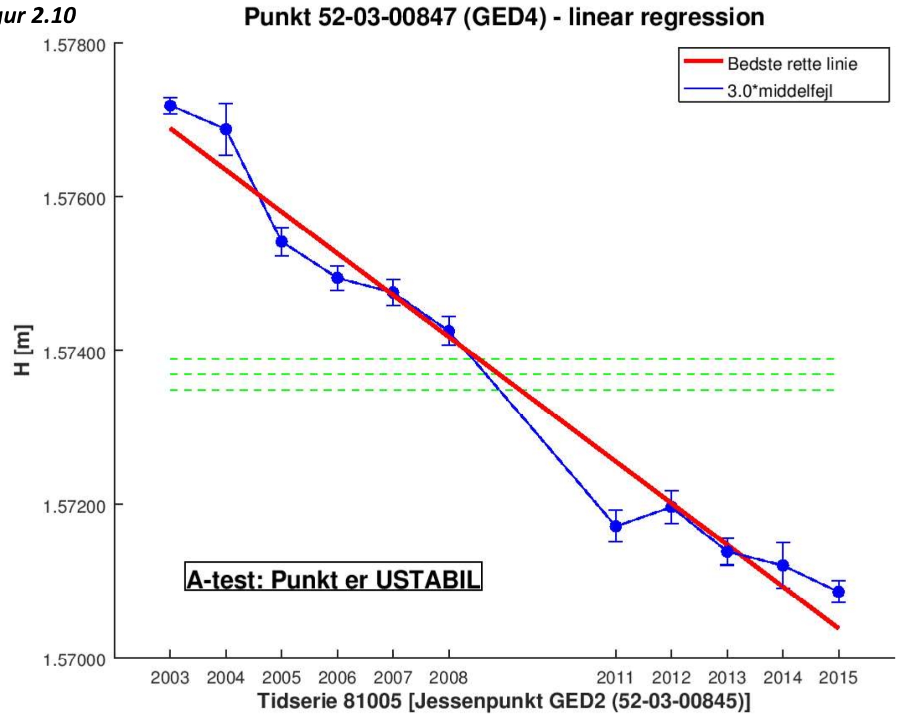
Figur 2.7



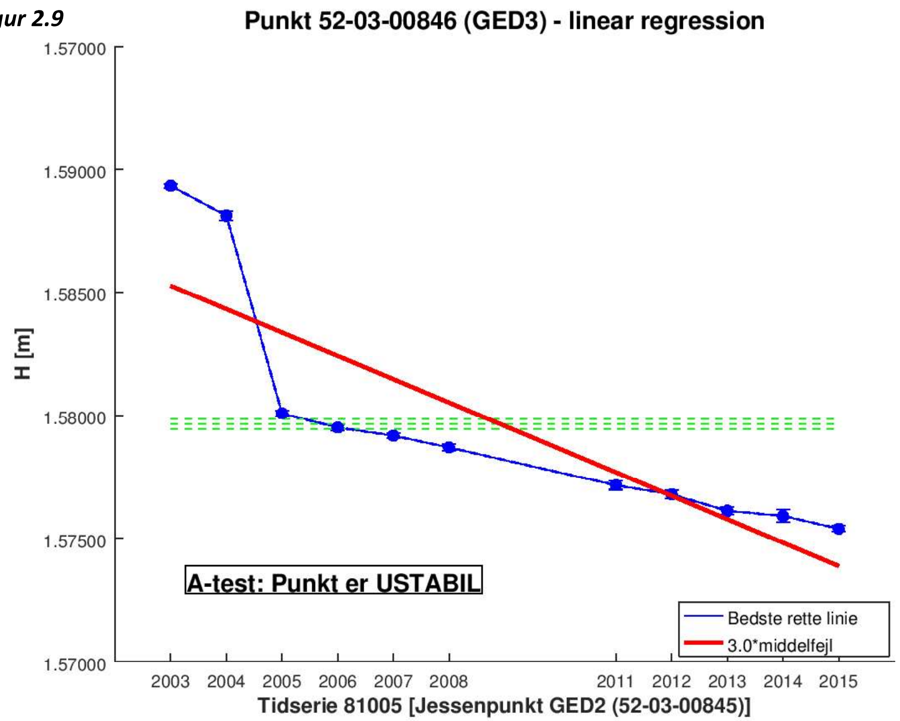
Figur 2.8



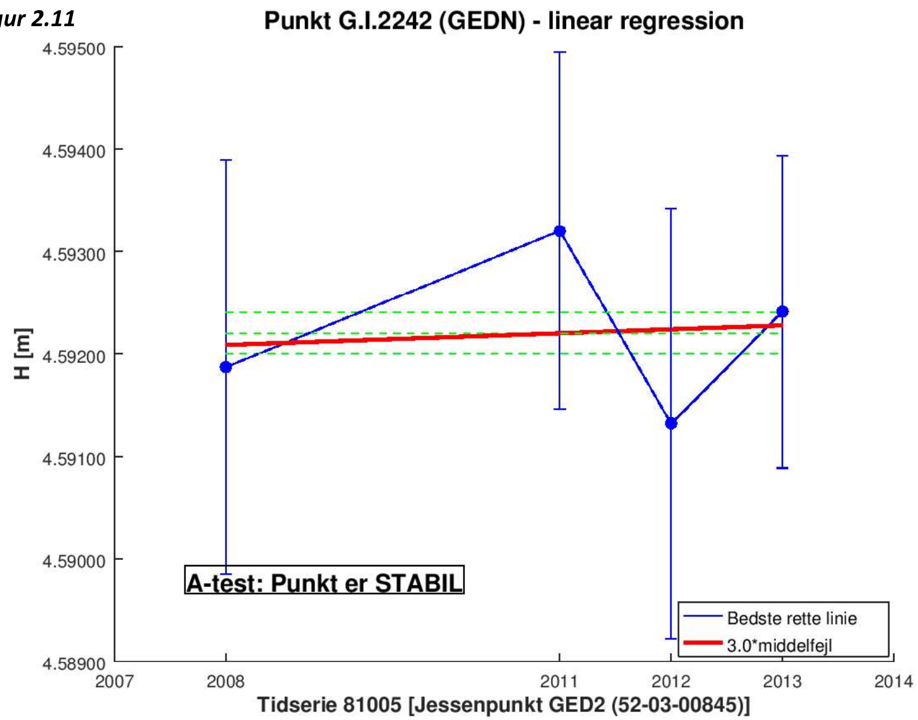
Figur 2.10



Figur 2.9



Figur 2.11



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

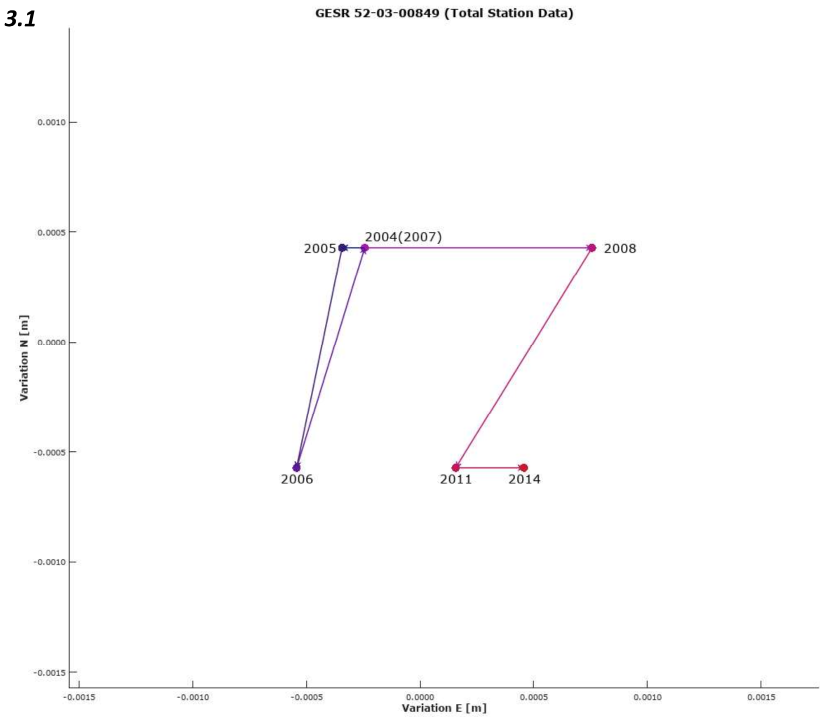
Constant Value [mm]	Station: GESR							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	GESR	9089	9090	9091	9092	GED3	GED4	GEDN
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	stabil	stabil	stabil	ustabil	ustabil	stabil
0.8	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil
1	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil
1.5	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil
2	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil

3. PLANIMETRIC ANALYSIS

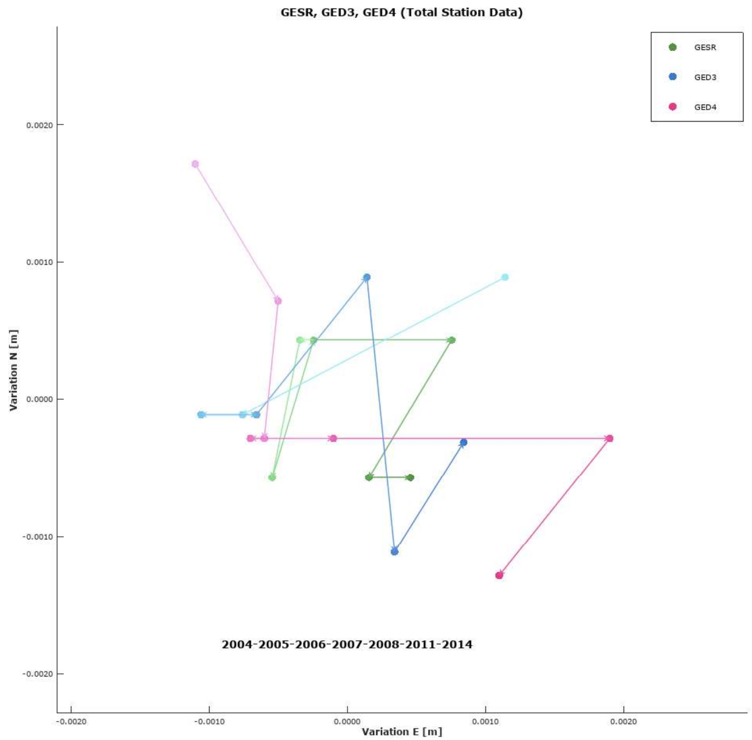
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! *In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.*

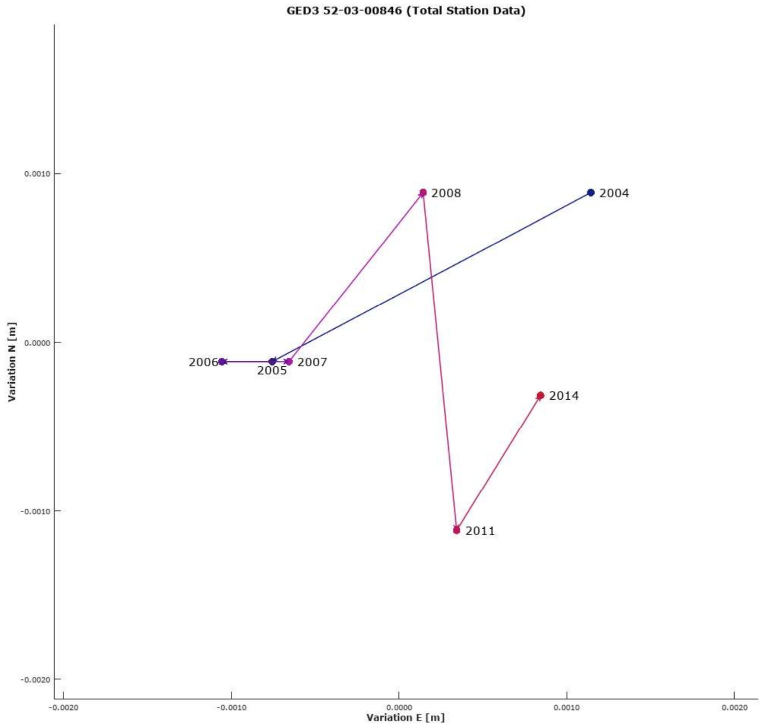
Figur 3.1



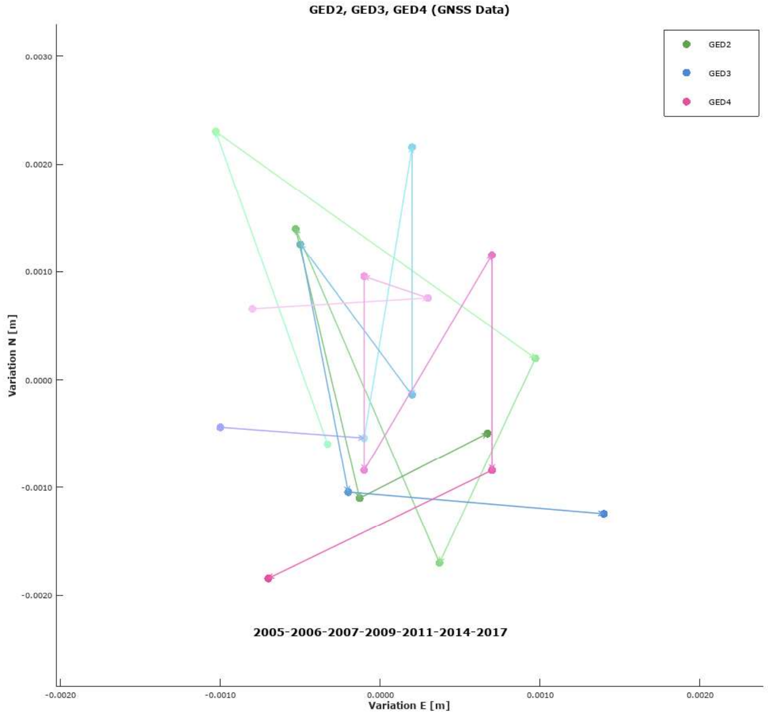
Figur 3.2



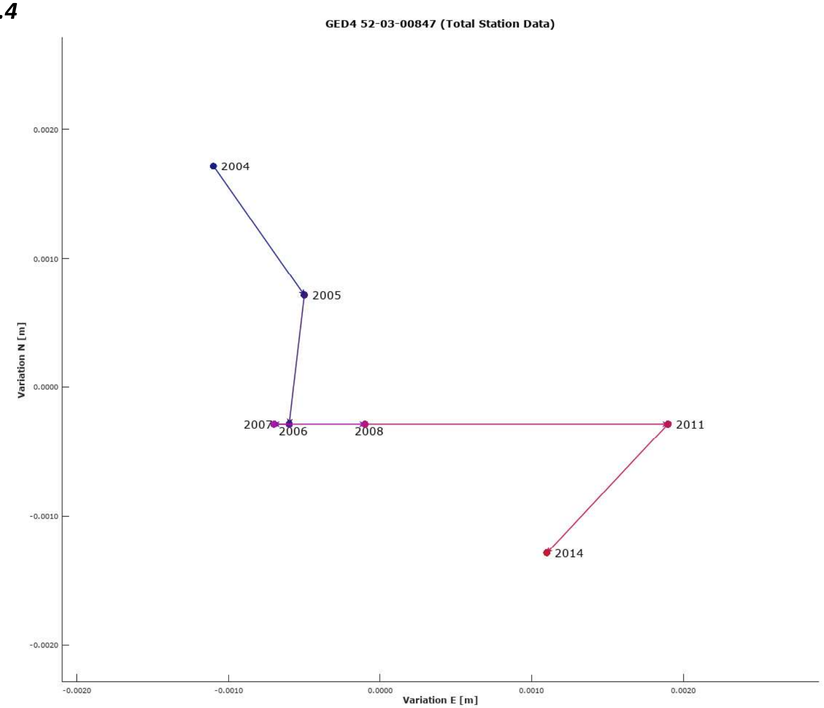
Figur 3.3



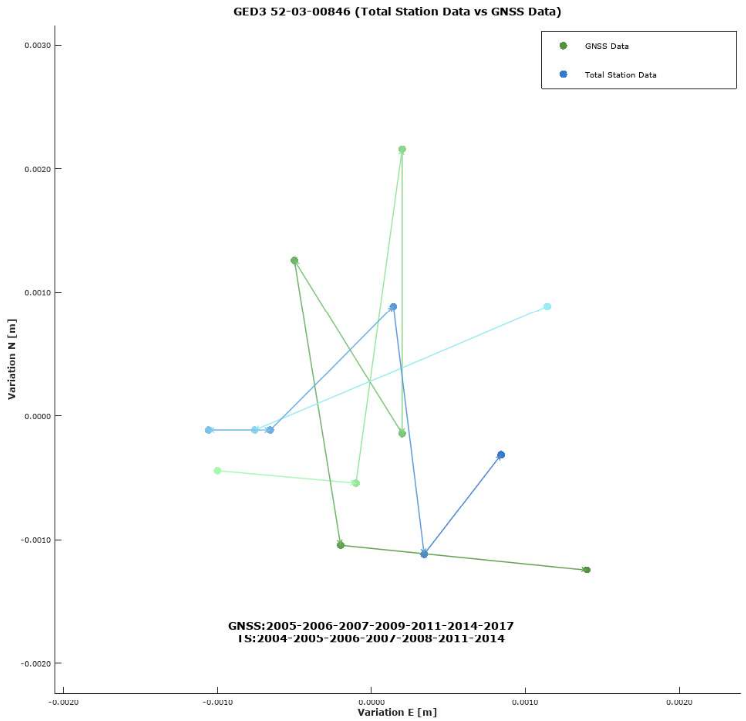
Figur 3.5



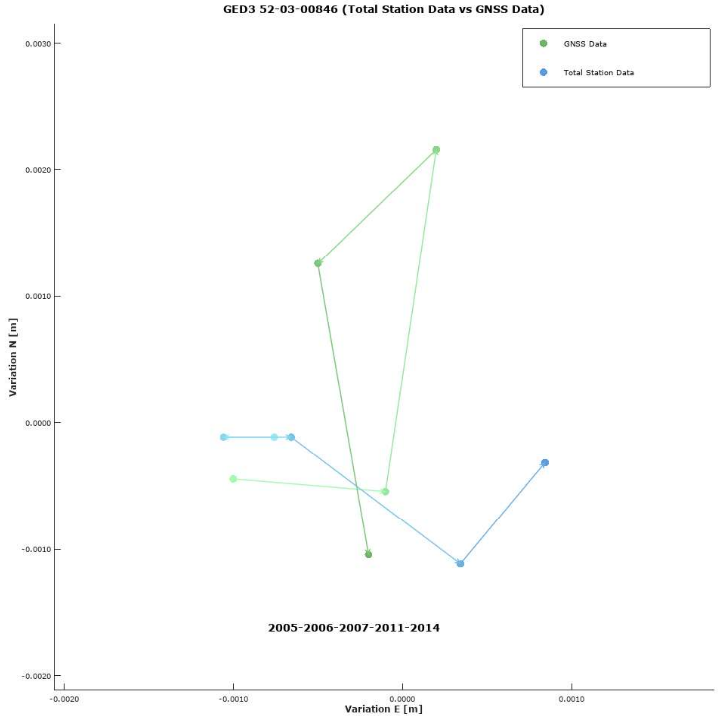
Figur 3.4



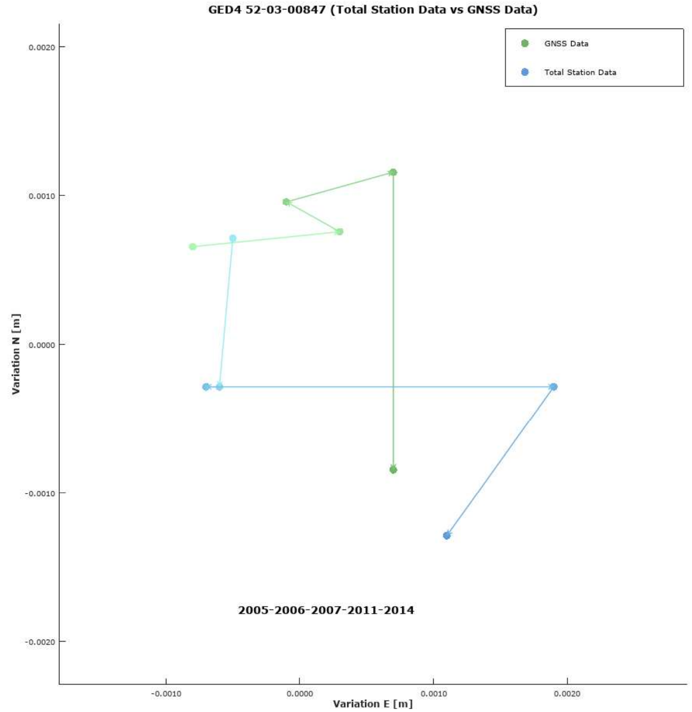
Figur 3.6



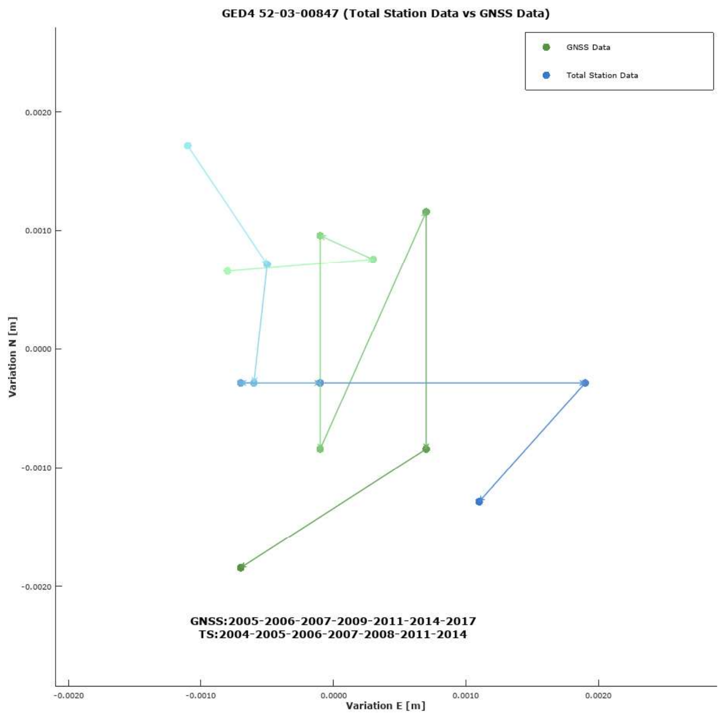
Figur 3.7



Figur 3.9



Figur 3.8



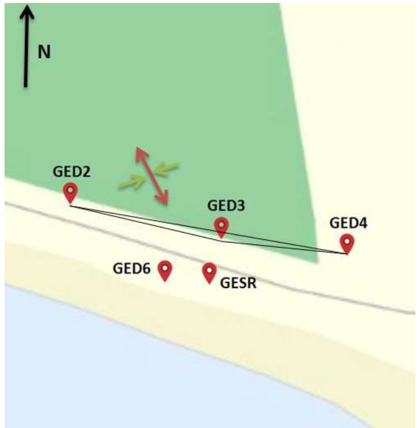
Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2005 vs **2006**	dN GED2	-1.94	1.94	<	2.31	Stable
	dE GED2	1.73	1.73	<		
	dN GED3	1.99	1.99	<		Stable
	dE GED3	-1.73	1.73	<		
	dN GED4	-2.07	2.07	<		Stable
	dE GED4	1.73	1.73	<		
2005 vs **2007**	dN GED2	-1.81	1.81	<	2.31	Stable
	dE GED2	1.54	1.54	<		
	dN GED3	1.89	1.89	<		Stable
	dE GED3	-1.54	1.54	<		
	dN GED4	-1.99	1.99	<		Stable
	dE GED4	1.55	1.55	<		
2005 vs **2008**	dN GED2	-0.84	0.84	<	2.31	Stable
	dE GED2	0.45	0.45	<		
	dN GED3	0.95	0.95	<		Stable
	dE GED3	-0.46	0.46	<		
	dN GED4	-1.10	1.10	<		Stable
	dE GED4	0.46	0.46	<		
2005 vs **2011**	dN GED2	-1.92	1.92	<	2.31	Stable
	dE GED2	1.93	1.93	<		
	dN GED3	1.91	1.91	<		Stable
	dE GED3	-1.93	1.93	<		
	dN GED4	-1.89	1.89	<		Stable
	dE GED4	1.93	1.93	<		

Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000116		
ε_{EE}	-0.000126		
ε_{simple}	-0.000334		
ε_{pure}	0.000121		
ε_{MAX}	0.000350	+ extension	35.0 ppm
ε_{MIN}	-0.000360	- contraction	-36.0 ppm
2θ	-60.1458		
θ	369.9271	direction of the maximum principal axis, clockwise from N-axis	

- Disregard results: the conformation of the triangle is not optimal!

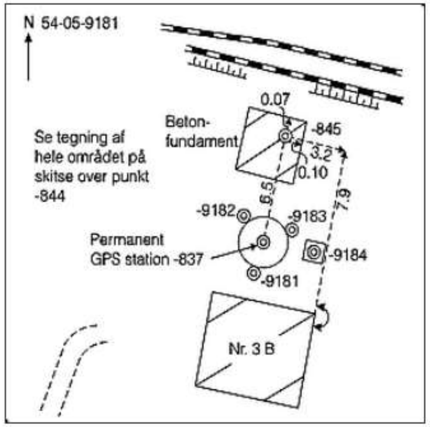
APPENDIX 7 - HIRTSHALS [HIRS]

Tidserie: 81002

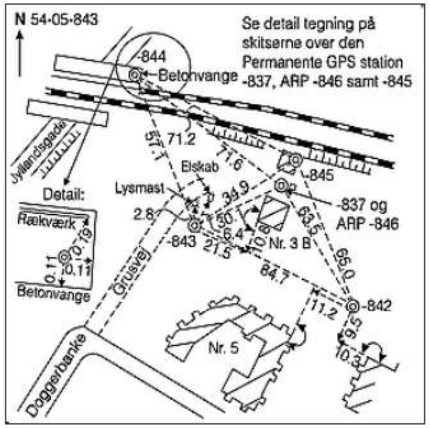
GPS Antenna	***HIRS 54-05-00837***	
Nærkontrol	***HIR2 54-05-00843***	→ **JessenPunkt**
	HIR3 54-05-00842	
	HIR4 54-05-00845	
Fjernkontrol	***HHLS 54-05-00832 G.I.2256***	
Bolter i fundament	***54-05-09181***	
	54-05-09182	
	54-05-09183	
	54-05-09184	

1. Skitser:

Figur 1.1



Figur 1.2



Figur 1.3

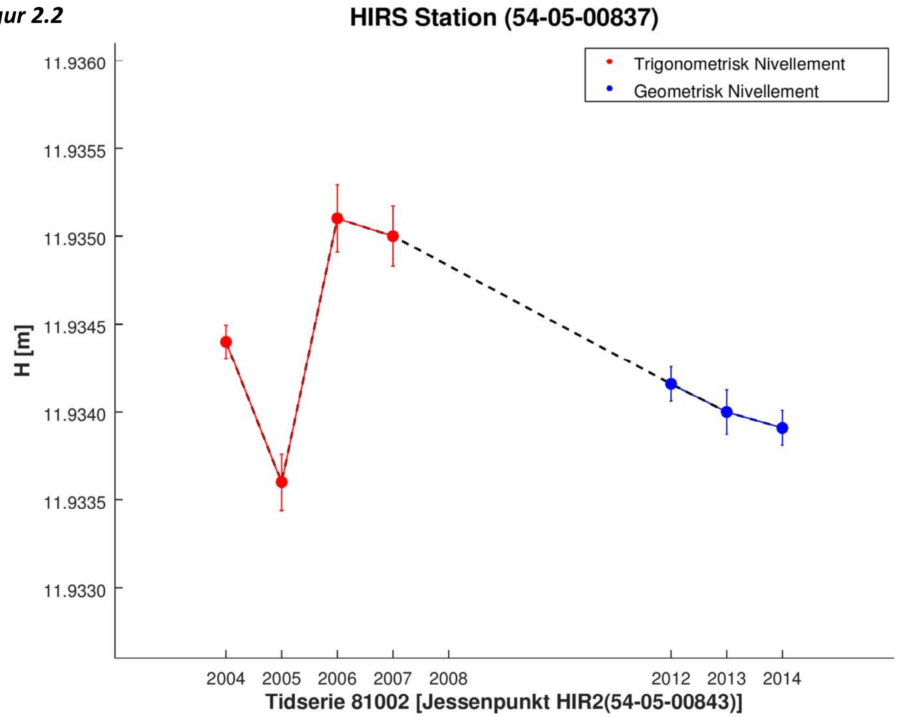
Notes:

- The A-test shows instability. However, manual analysis indicates the station is stable.
- Pay attention to HIR3 and its future determined elevations.
- In terms of planimetric coordinates: no large displacements can be observed.
- The congruence test shows relative stability between the points.
- Strain analysis doesn't indicate predisposition to local instability.

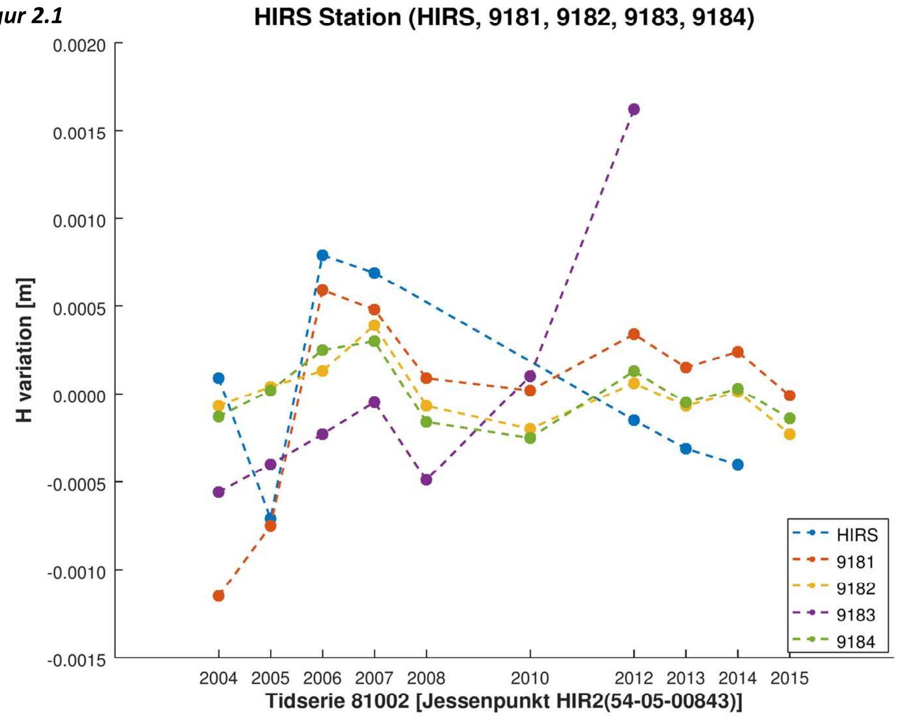
2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

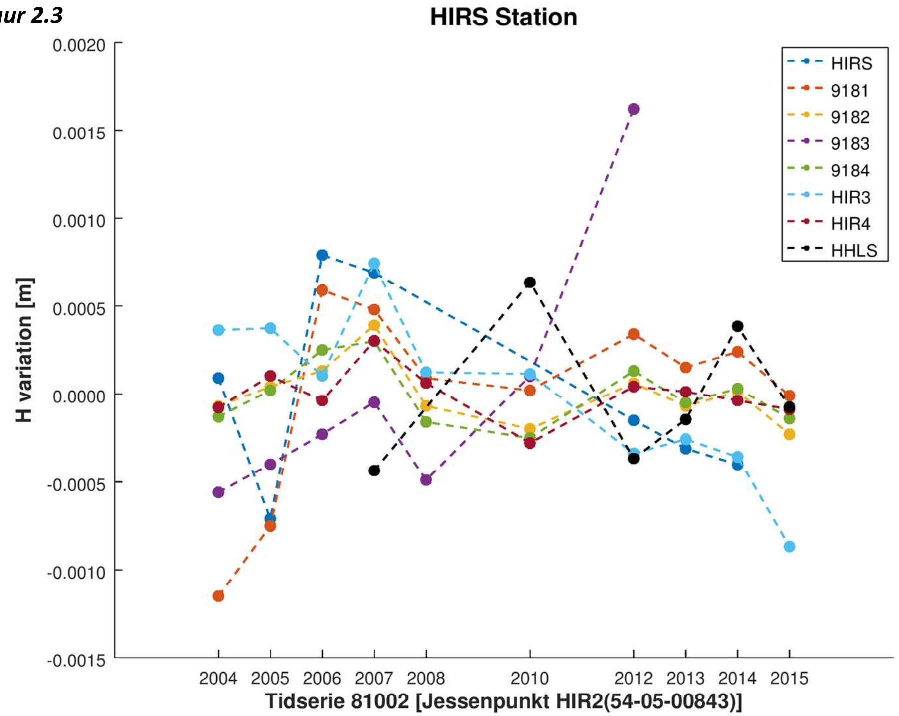
Figur 2.2



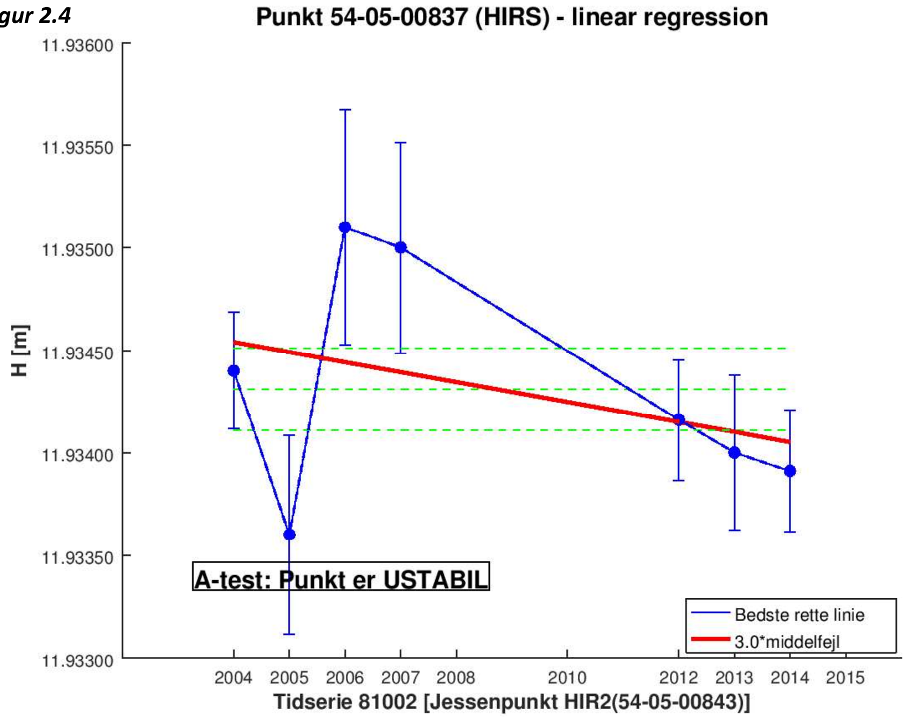
Figur 2.1



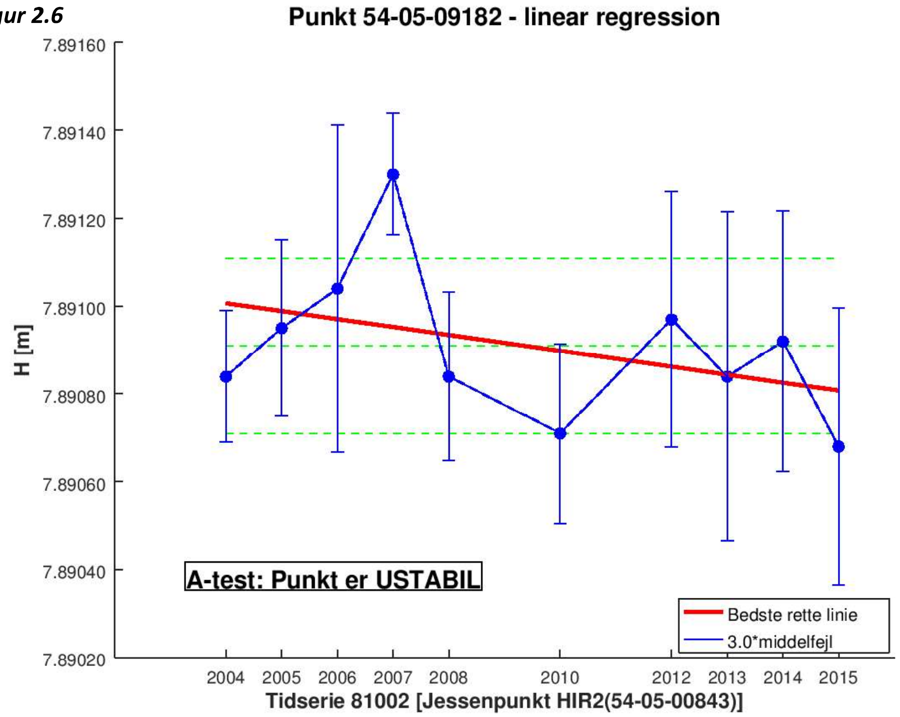
Figur 2.3



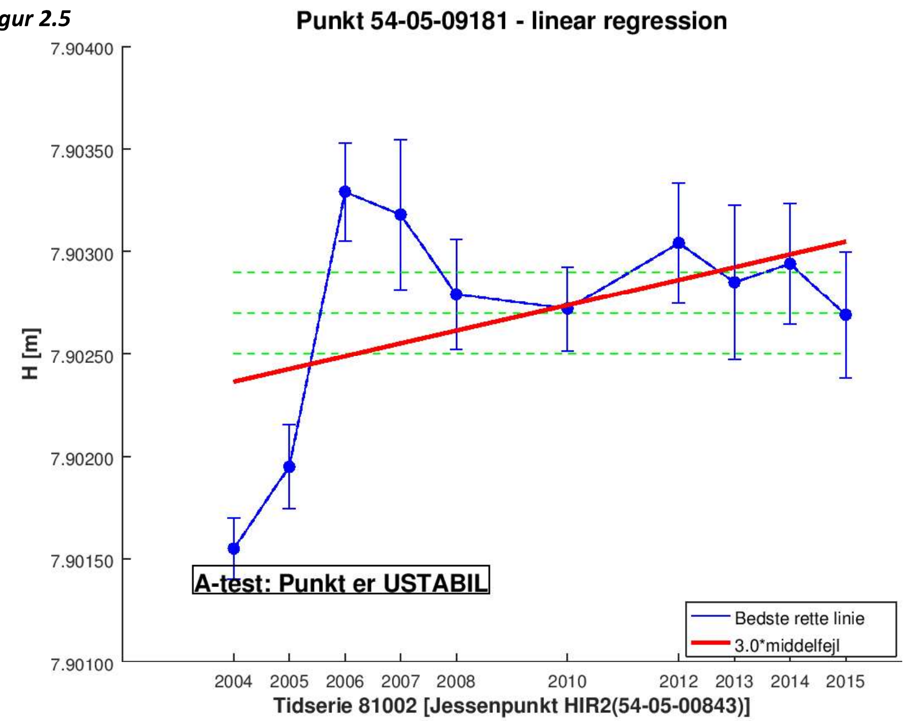
Figur 2.4



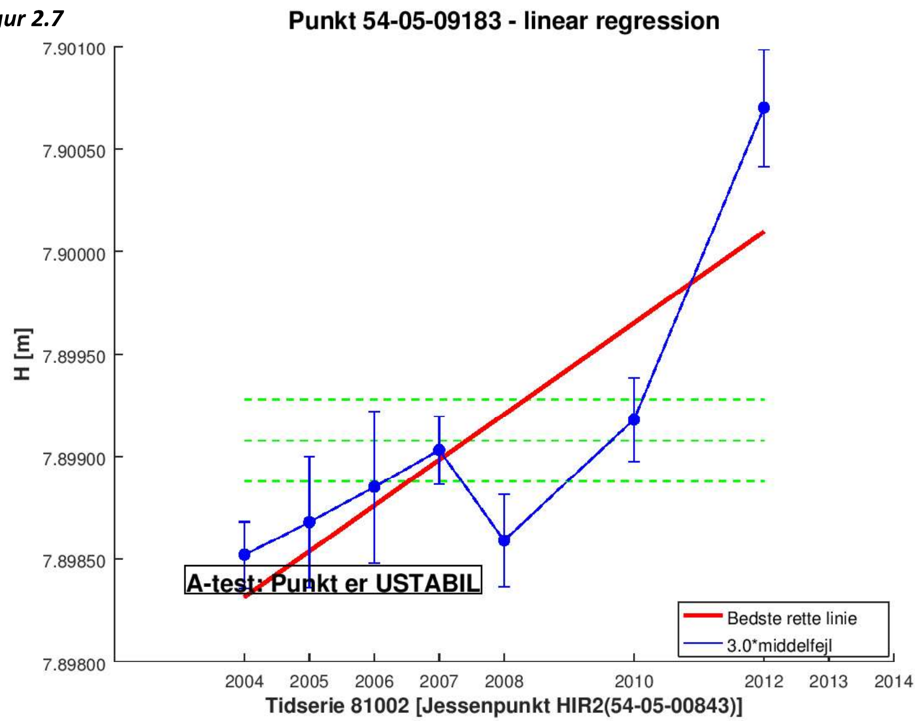
Figur 2.6



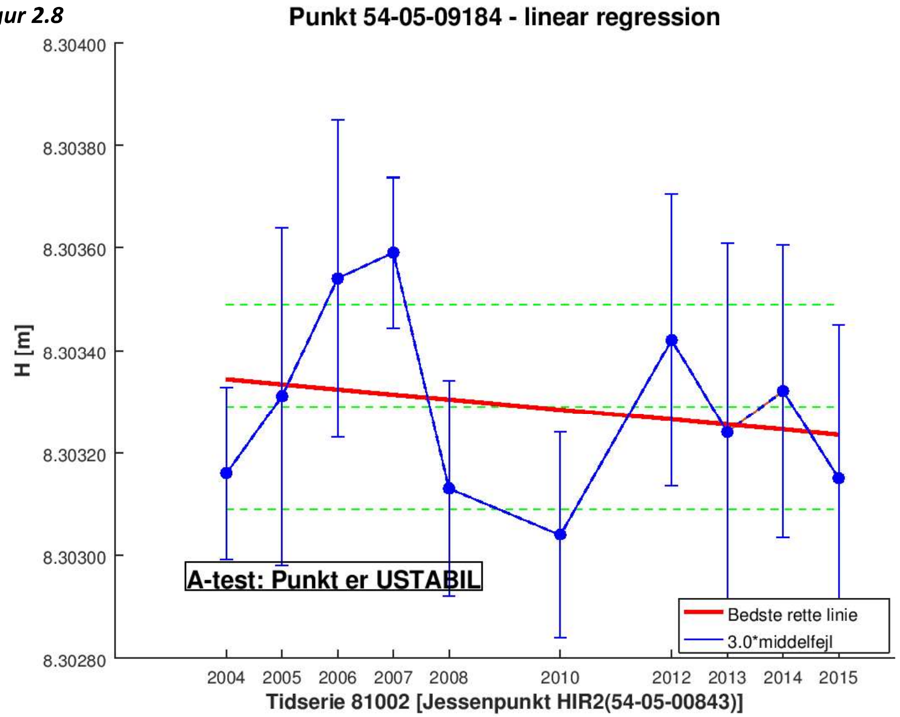
Figur 2.5



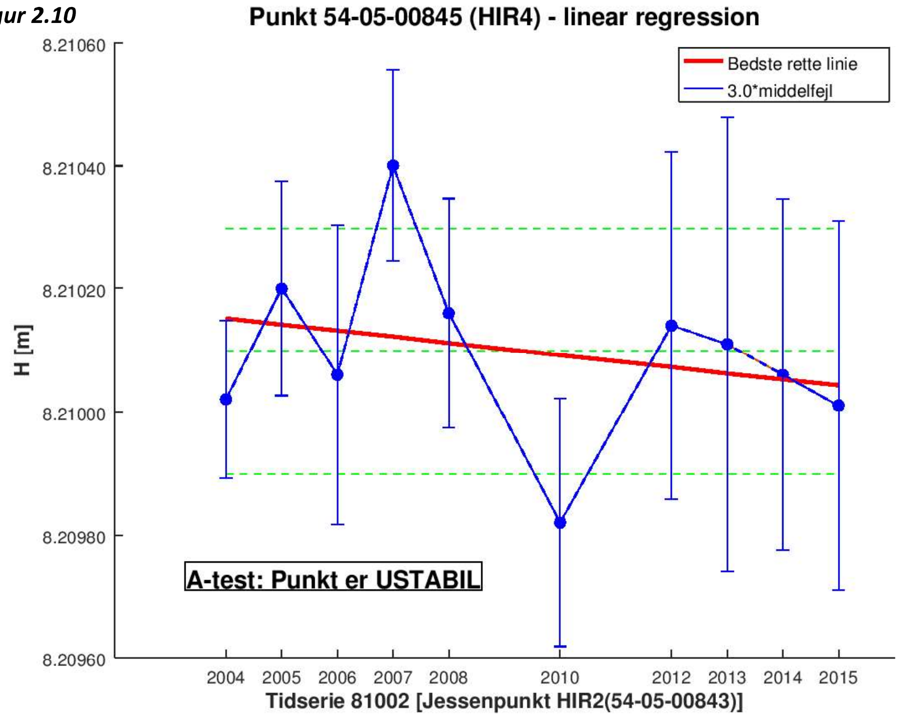
Figur 2.7



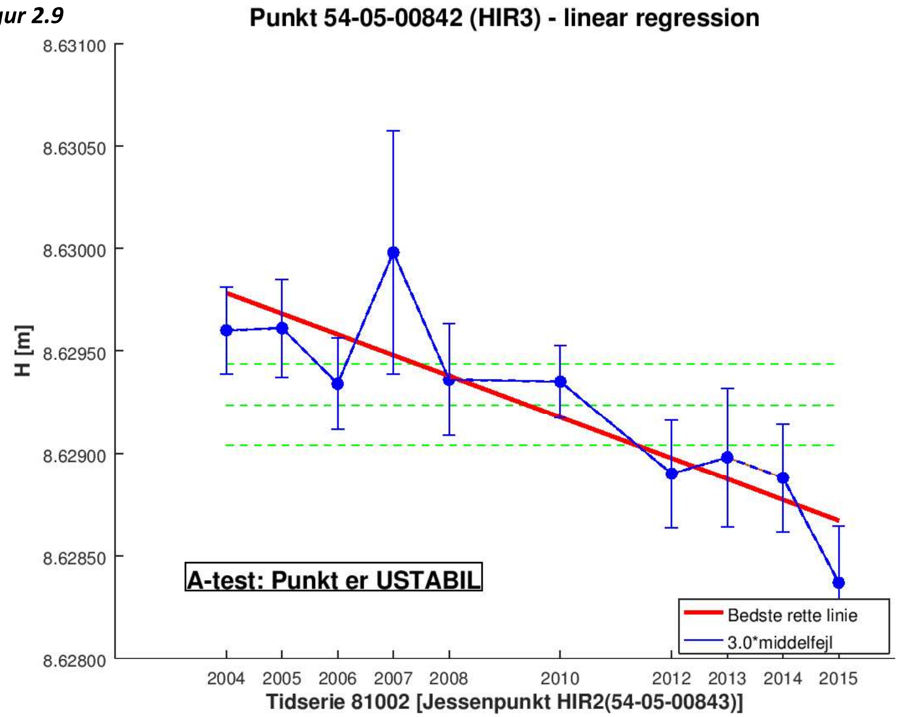
Figur 2.8



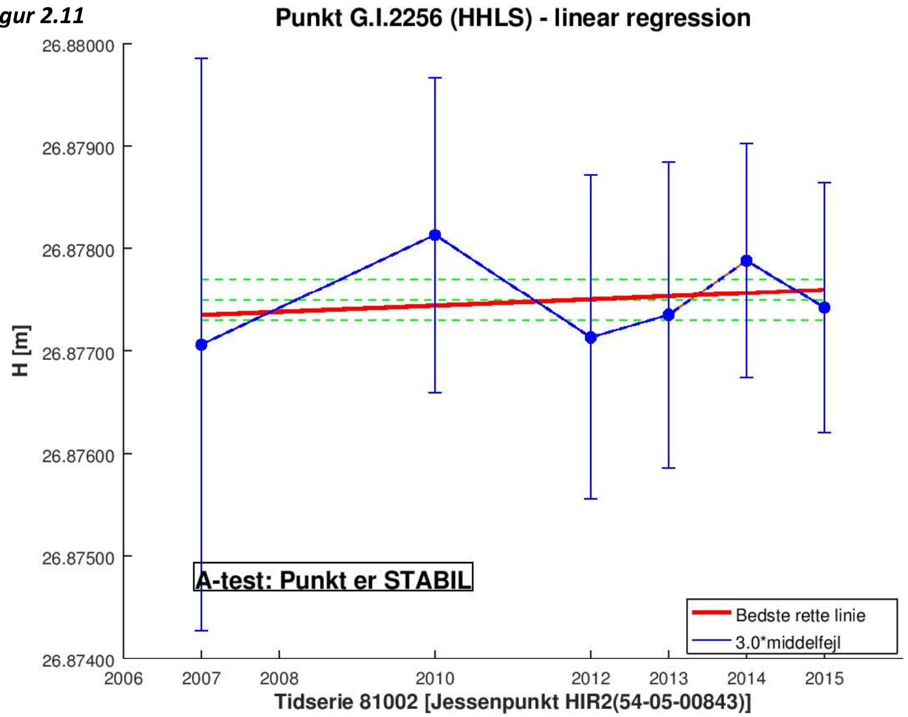
Figur 2.10



Figur 2.9



Figur 2.11



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

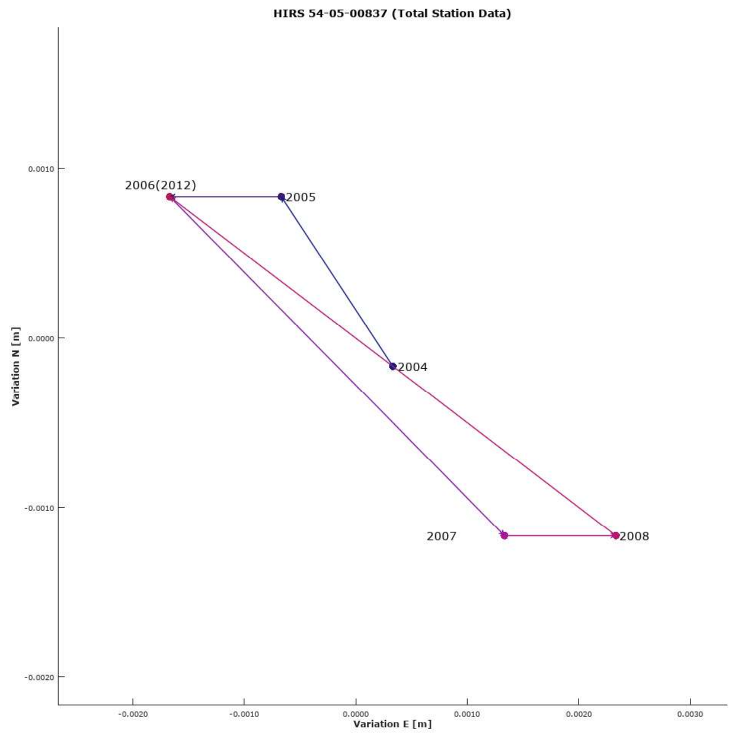
Constant Value [mm]	Station: HIRS							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	HIRS	9181	9182	9183	9184	HIR3	HIR4	HHLS
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	ustabil	ustabil	stabil	ustabil	stabil	stabil
0.8	ustabil	ustabil	stabil	ustabil	stabil	ustabil	stabil	stabil
1	ustabil	ustabil	stabil	ustabil	stabil	ustabil	stabil	stabil
1.5	ustabil	ustabil	stabil	ustabil	stabil	ustabil	stabil	stabil
2	stabil	stabil	stabil	ustabil	stabil	stabil	stabil	stabil

3. PLANIMETRIC ANALYSIS

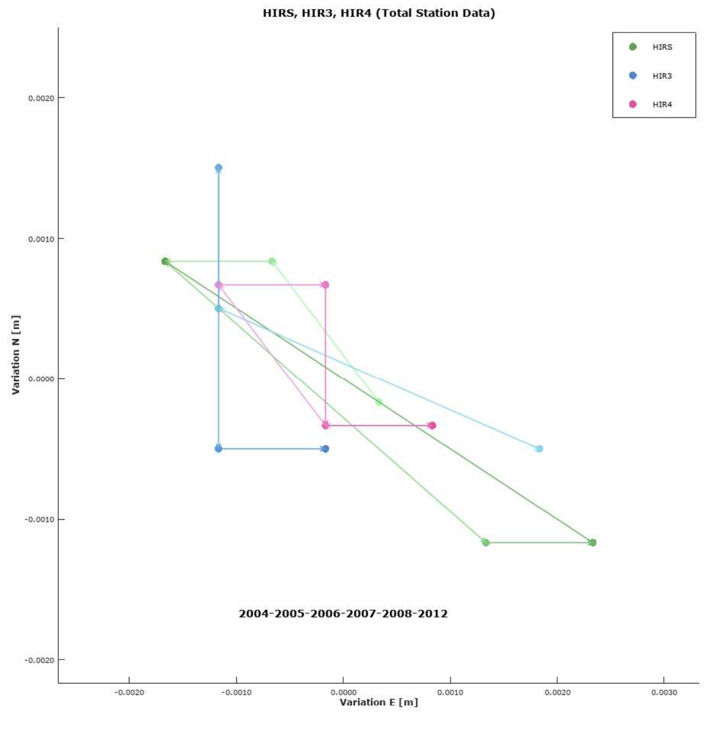
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! ***In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.***

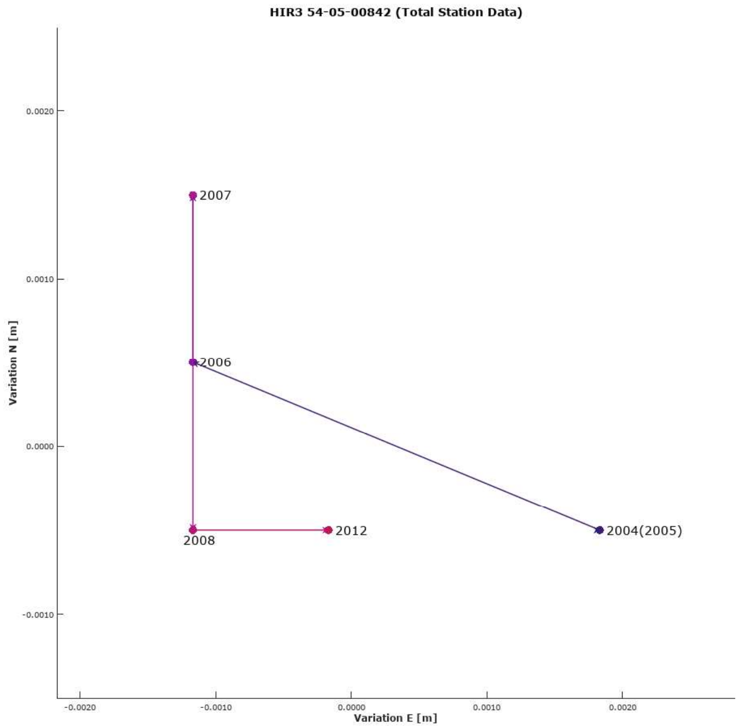
Figur 3.1



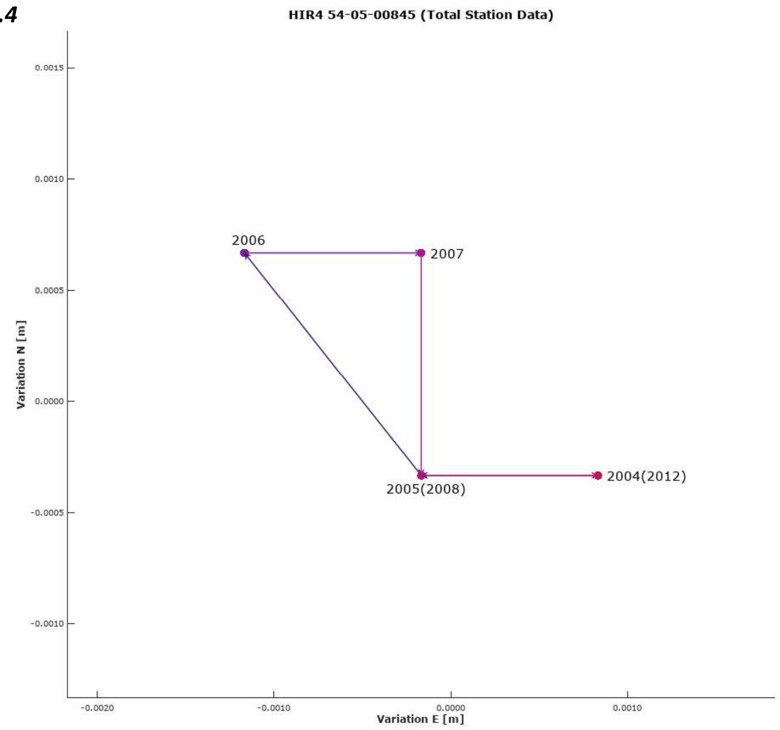
Figur 3.2



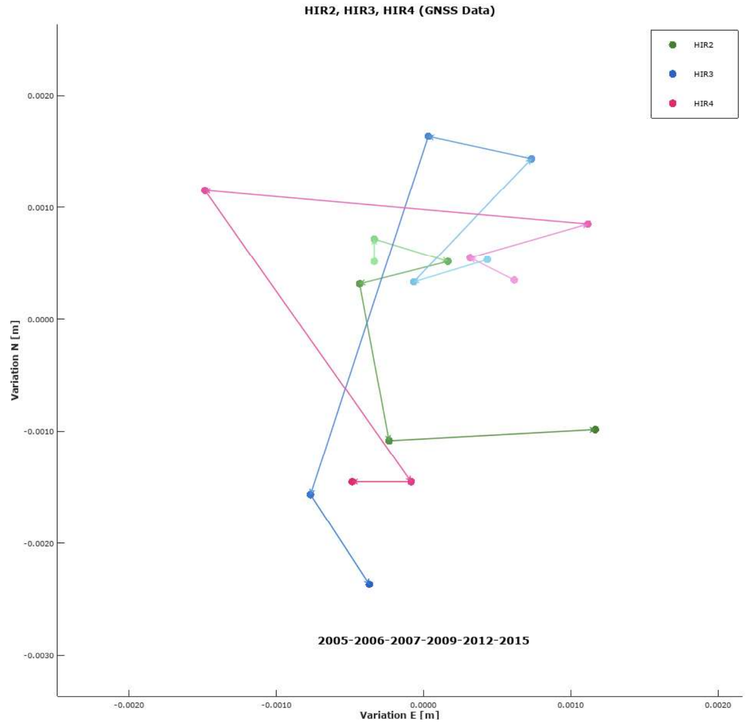
Figur 3.3



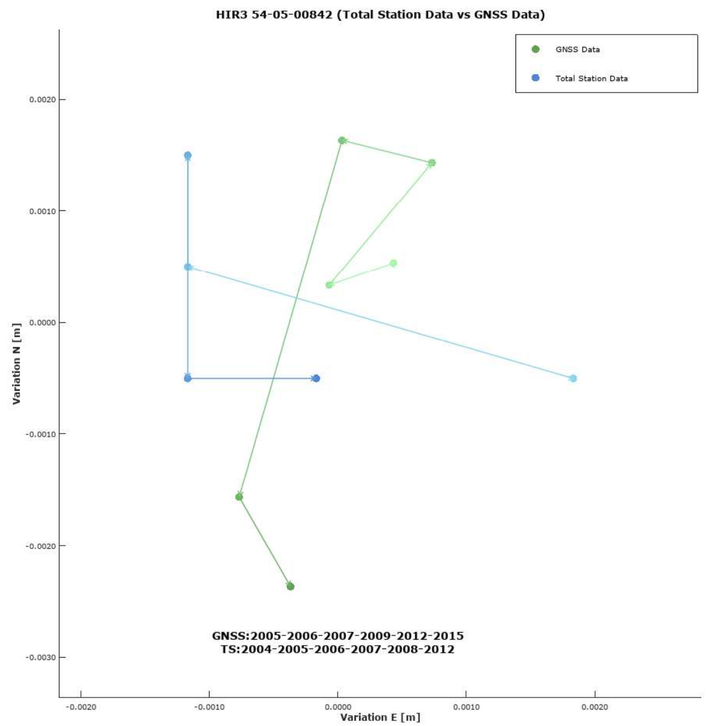
Figur 3.4



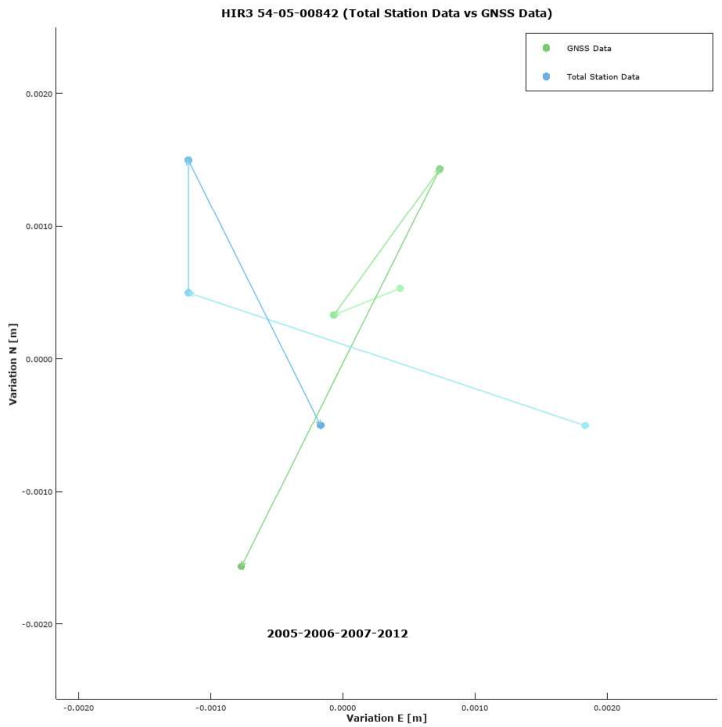
Figur 3.5



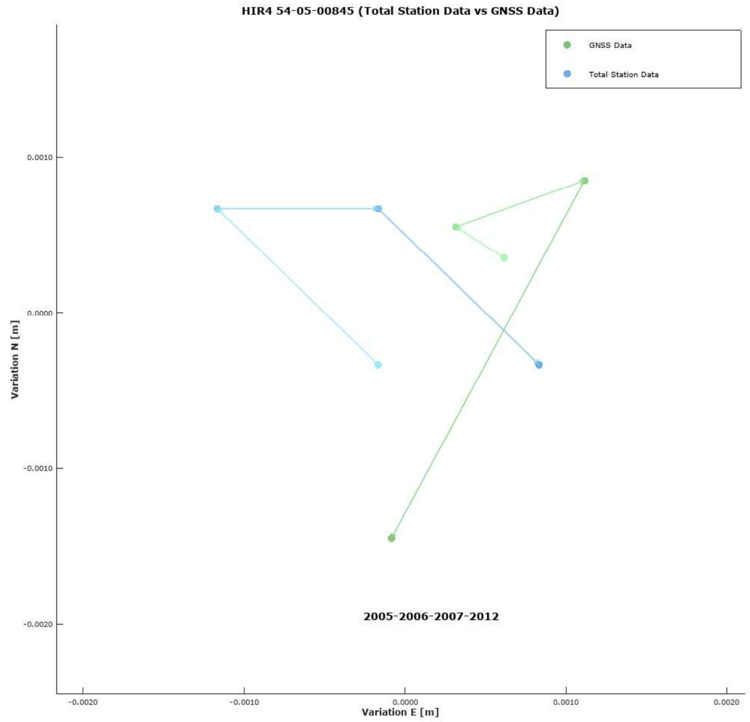
Figur 3.6



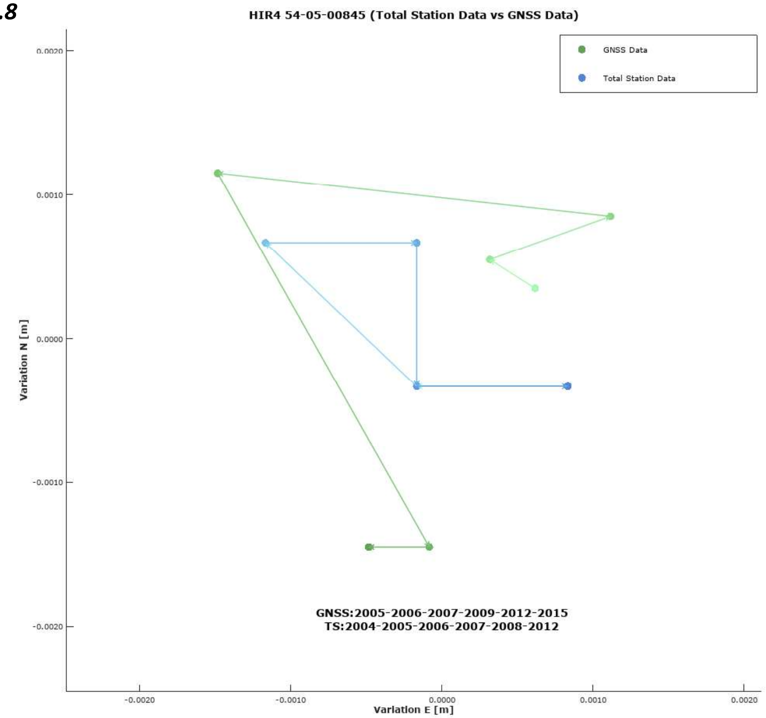
Figur 3.7



Figur 3.9



Figur 3.8



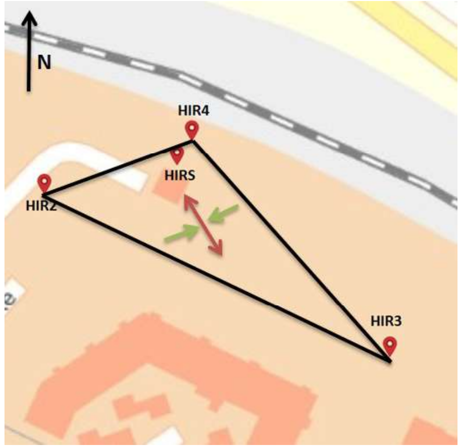
Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

Stages	STUDENT TEST	t_j	$\lvert t_j \rvert$		t_{lim}	Stability
2006 vs **2007**	dN HIR2	0.70	0.70	<	2.31	Stable
	dE HIR2	0.65	0.65	<		
	dN HIR3	-0.57	0.57	<		Stable
	dE HIR3	0.73	0.73	<		
	dN HIR4	-0.33	0.33	<		Stable
	dE HIR4	-0.68	0.68	<		
2006 vs **2008**	dN HIR2	0.27	0.27	<	2.31	Stable
	dE HIR2	0.92	0.92	<		
	dN HIR3	-1.02	1.02	<		Stable
	dE HIR3	0.59	0.59	<		
	dN HIR4	0.61	0.61	<		Stable
	dE HIR4	-0.83	0.83	<		
2006 vs **2012**	dN HIR2	1.03	1.03	<	2.31	Stable
	dE HIR2	1.07	1.07	<		
	dN HIR3	-0.98	0.98	<		Stable
	dE HIR3	1.12	1.12	<		
	dN HIR4	-0.35	0.35	<		Stable
	dE HIR4	-1.10	1.10	<		

Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000000		
ε_{EE}	0.000002		
ε_{simple}	0.000002		
ε_{pure}	-0.000001		
ε_{MAX}	0.000004	+ extension	0.4 ppm
ε_{MIN}	-0.000001	- contraction	-0.1 ppm
2θ	-61.0614		
θ	169.4693	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 8 - FERRING [FERR]

Tidserie: 81051

GPS Antenna	*FERR 125-03-00804*
Nærkontrol	*FER1 125-03-00006* *FER2 125-03-00007* *FER3 125-03-00008* *FER4 125-03-00009*
Fjernkontrol	*BFYR 125-09-00008 G.I.2271*
Bolter i fundament	*125-03-09027* *125-03-09028* *125-03-09029* *125-03-09030*

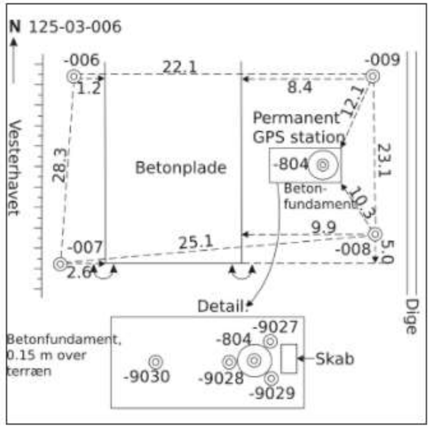
JessenPunkt: G.I.2178

Notes:

- The A-test shows instability. However, manual analysis indicates the station is stable. The slight variations seem to be caused by the Jessenpunkt.
- In terms of planimetric coordinates: no large displacements can be observed. Same can be observed from the congruence test.
- Strain analysis doesn't indicate predisposition to local instability.

1. Skitser:

Figur 1.1

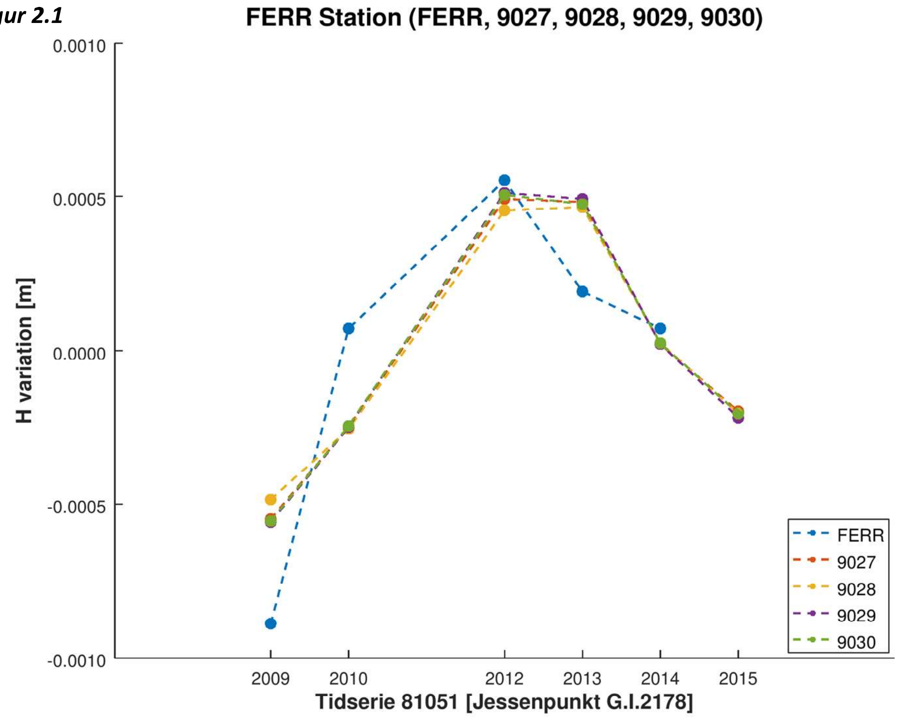


Figur 1.2

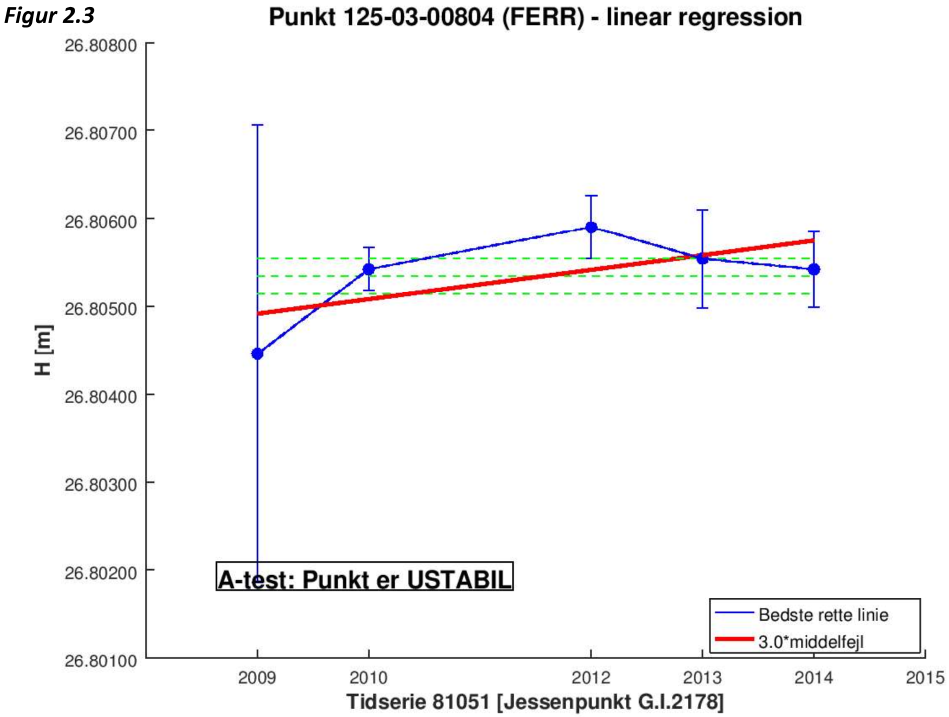
2. NIVELLEMENT

- *Initial plots*
- *Regression analysis*

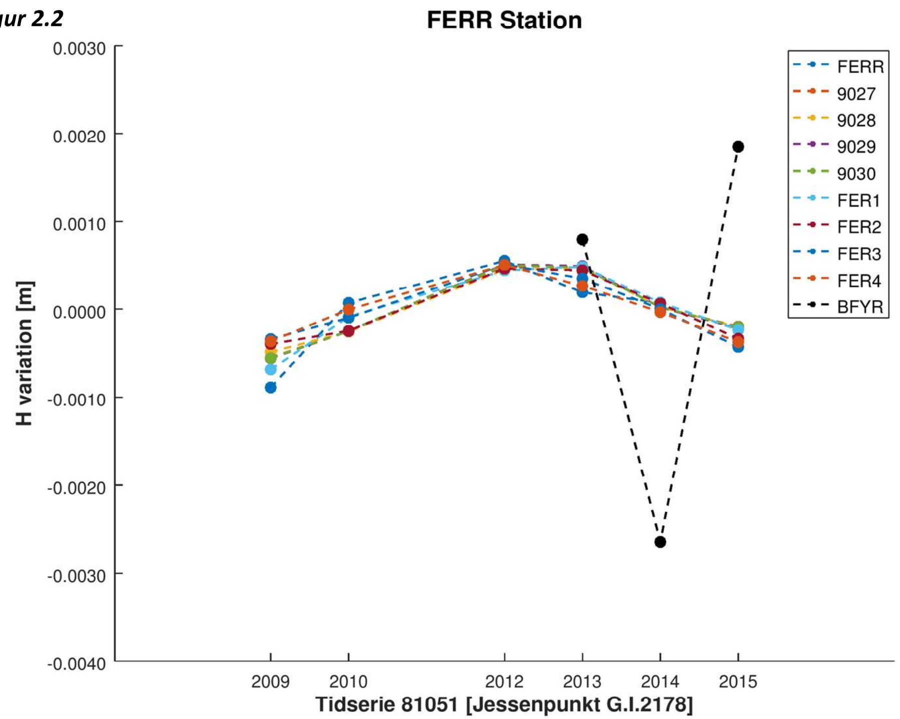
Figur 2.1



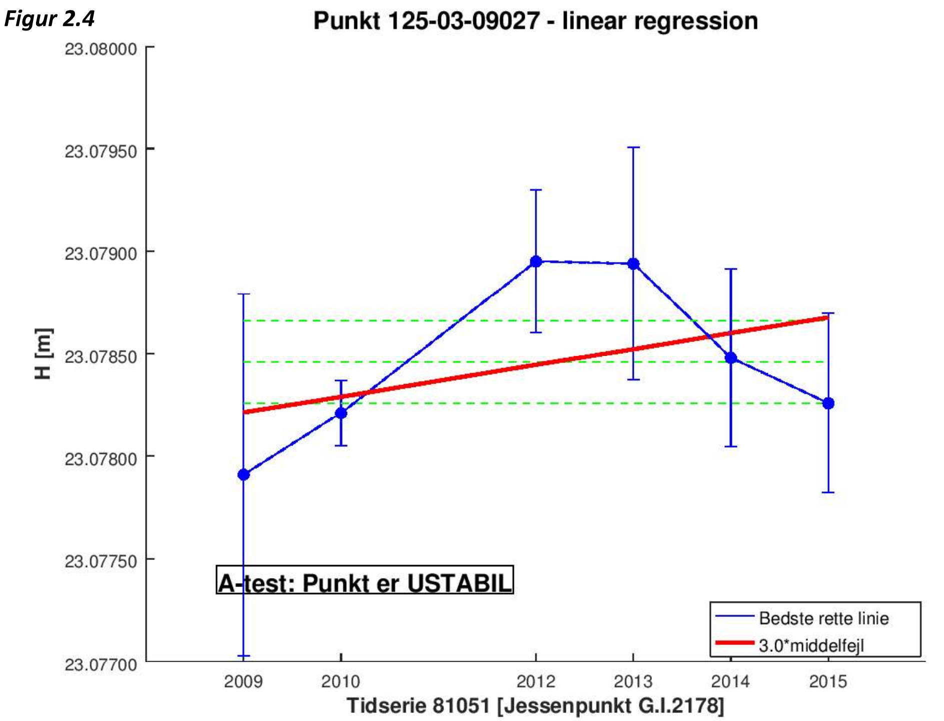
Figur 2.3



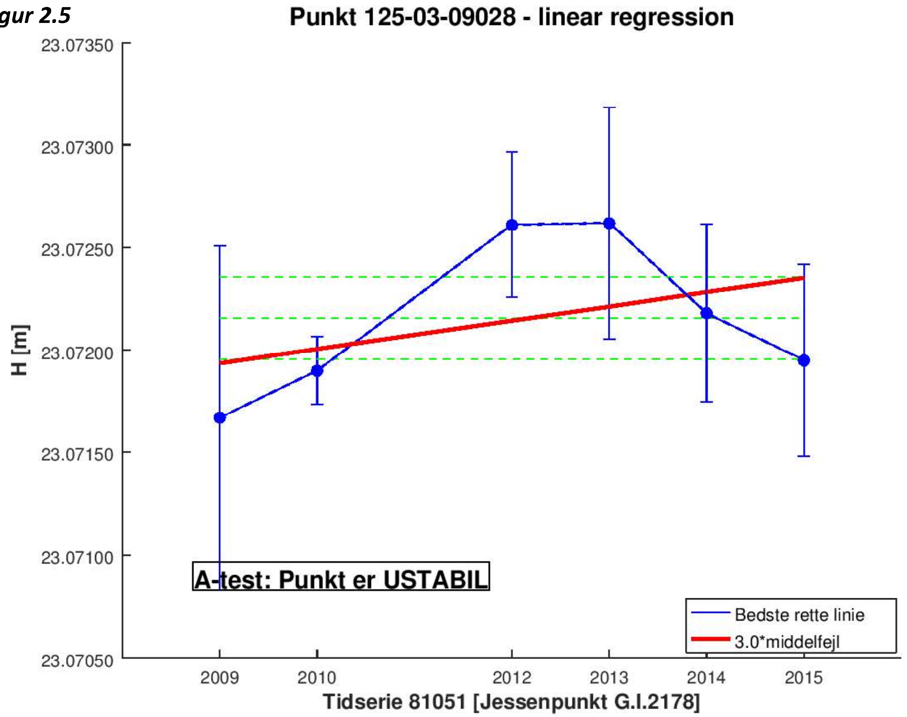
Figur 2.2



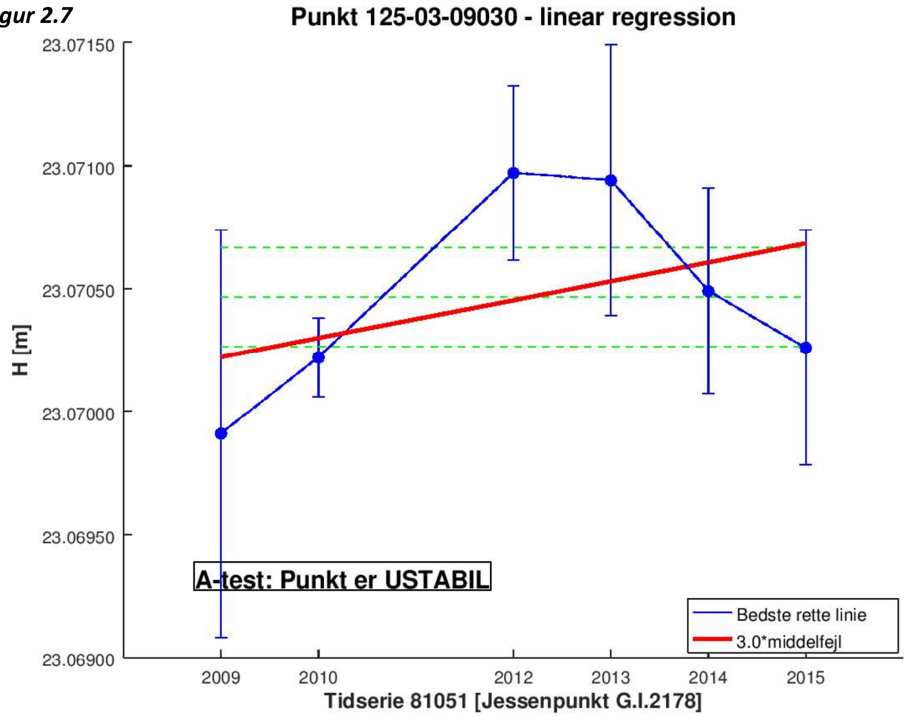
Figur 2.4



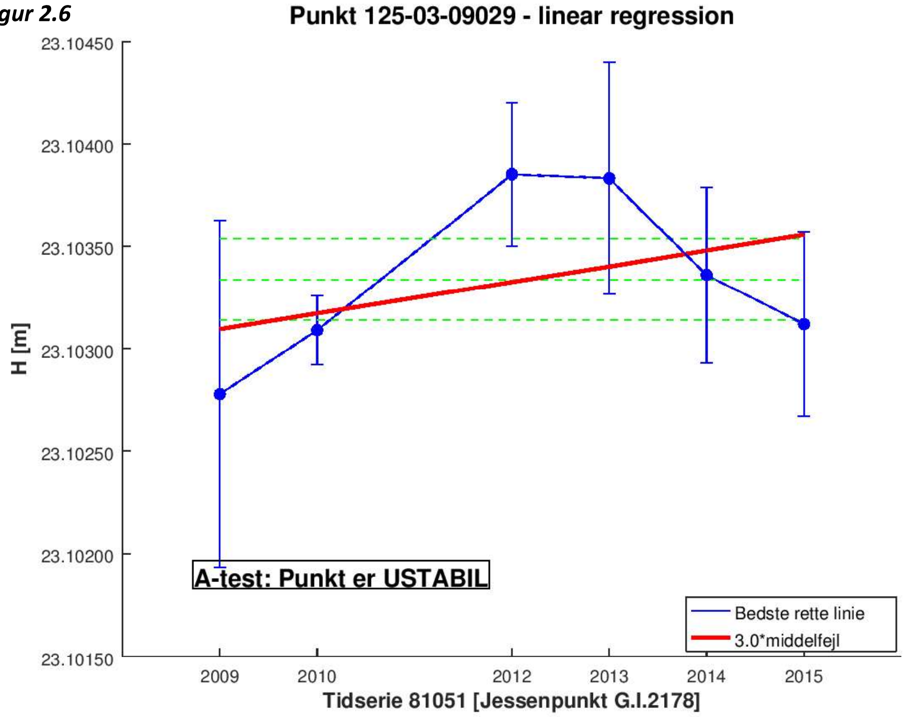
Figur 2.5



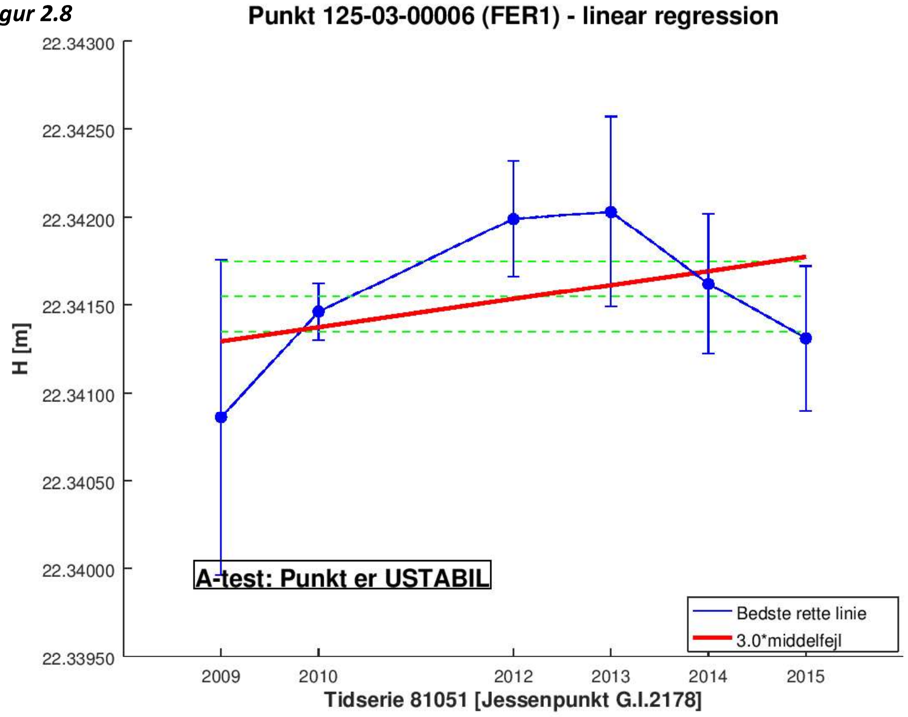
Figur 2.7



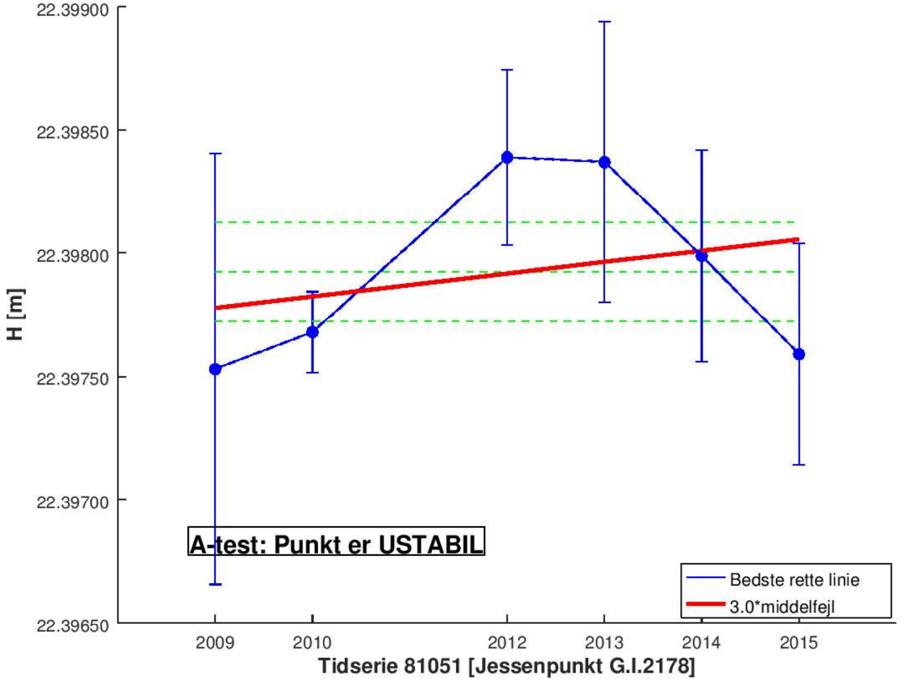
Figur 2.6



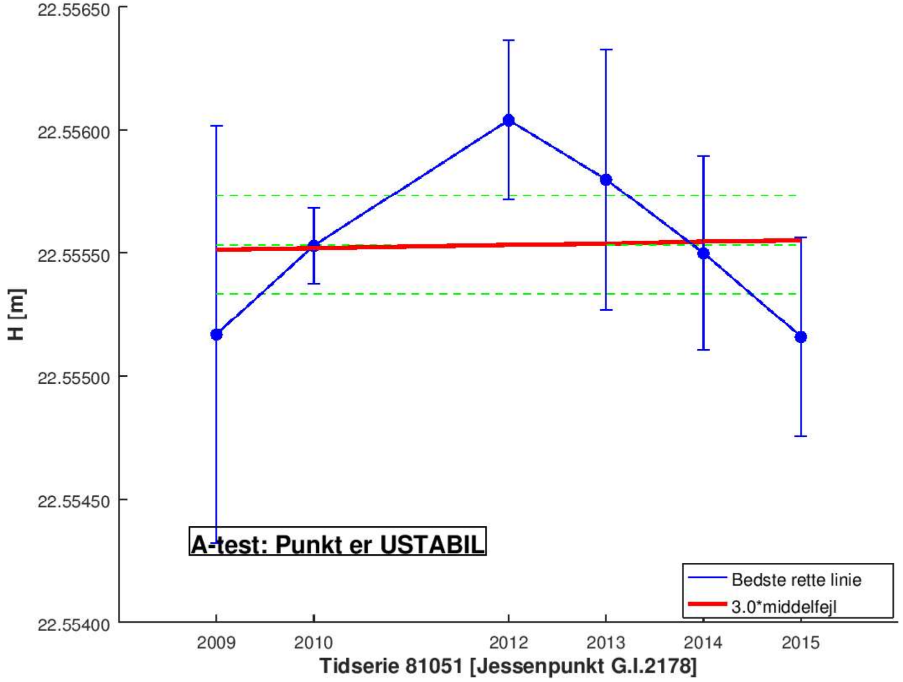
Figur 2.8



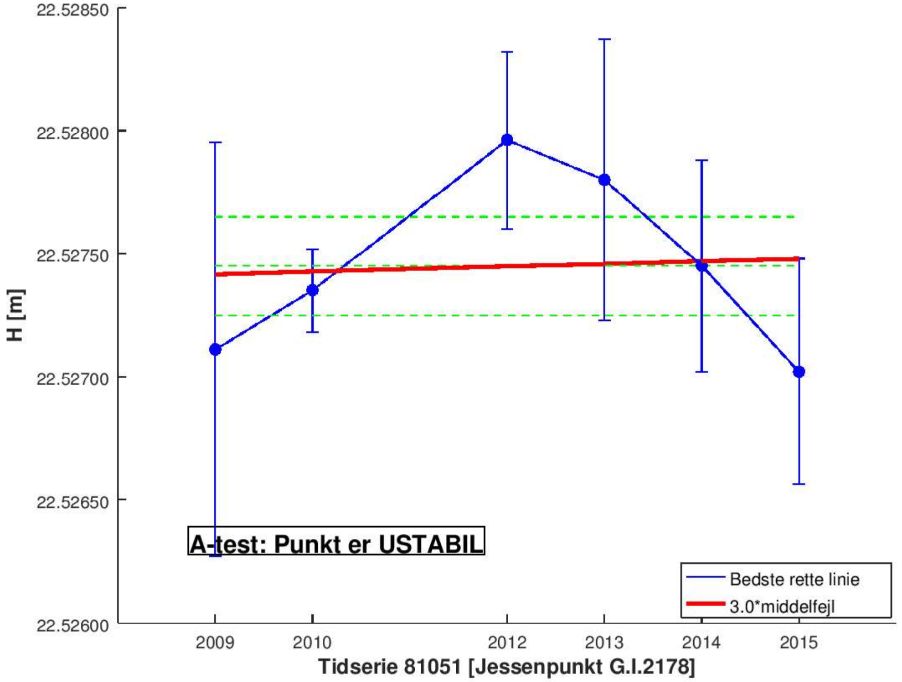
Figur 2.9



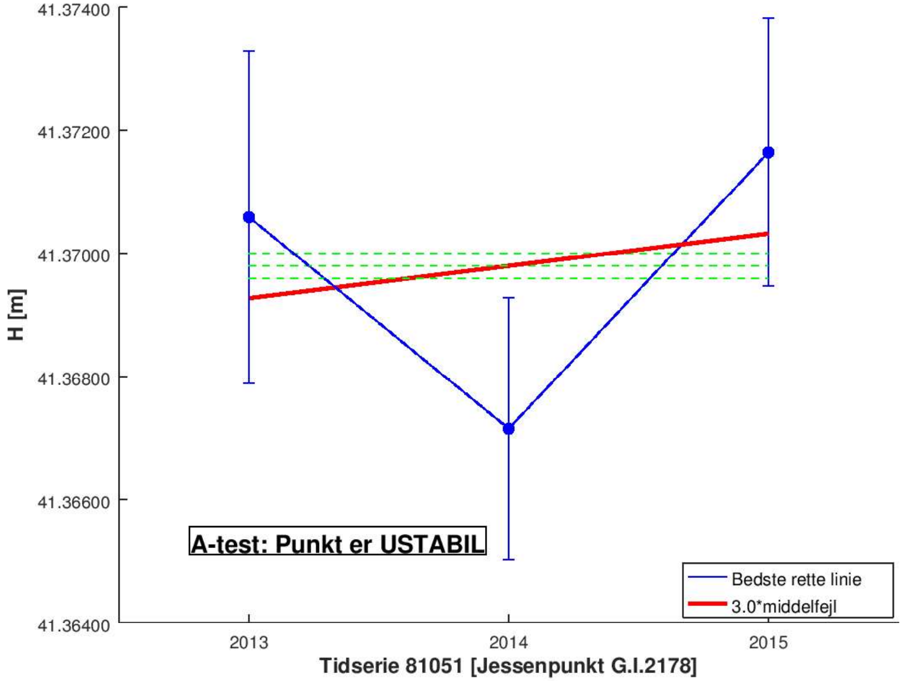
Figur 2.11



Figur 2.10



Figur 2.12



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

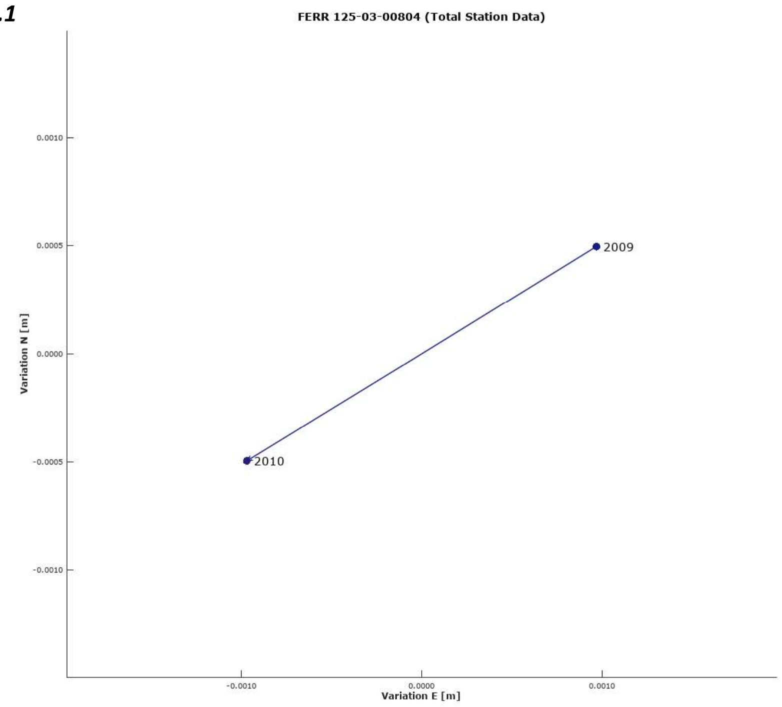
Constant Value [mm]	Station: FERR									
	Antenna	Sikringspunkter				Nærkontrol				Fjernkontrol
	FERR	9027	9028	9029	9030	FER1	FER2	FER3	FER4	BFYR
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
1	ustabil	ustabil	stabil	ustabil	ustabil	ustabil	stabil	stabil	stabil	ustabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil

3. PLANIMETRIC ANALYSIS

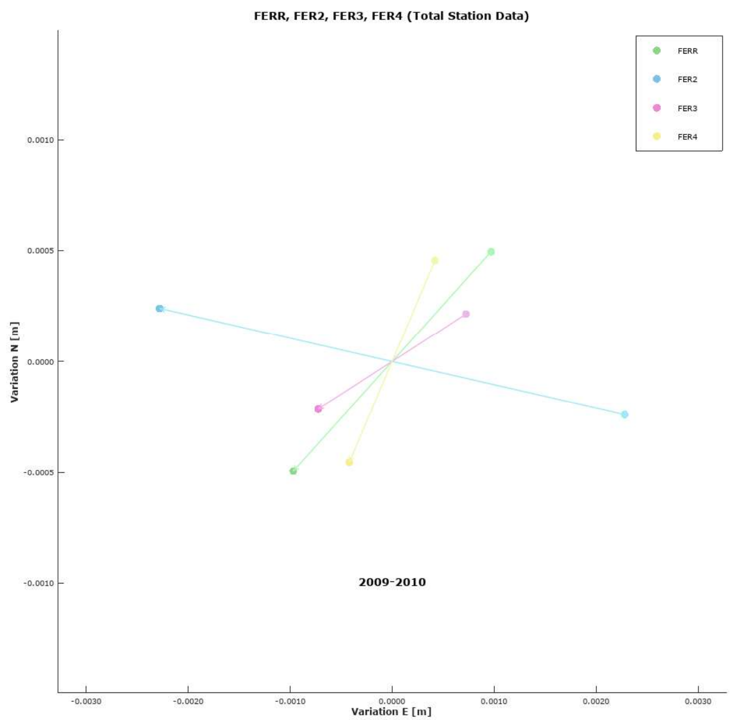
- ***Initial plots TS***
- ***Initial plots GNSS***
- ***Comparison GNSS vs TS***
- ***Global Congruence Test***
- ***Strain Analysis***

!! ***In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.***

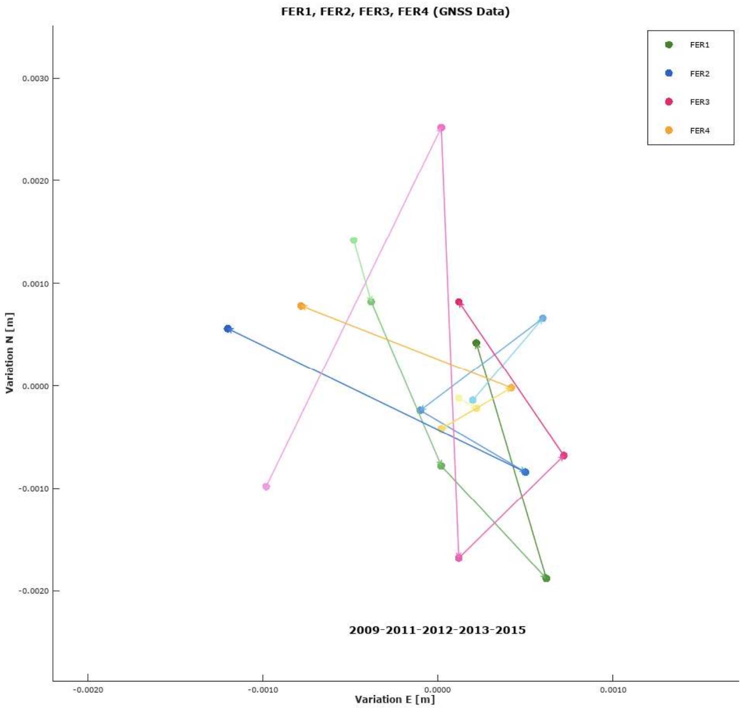
Figur 3.1



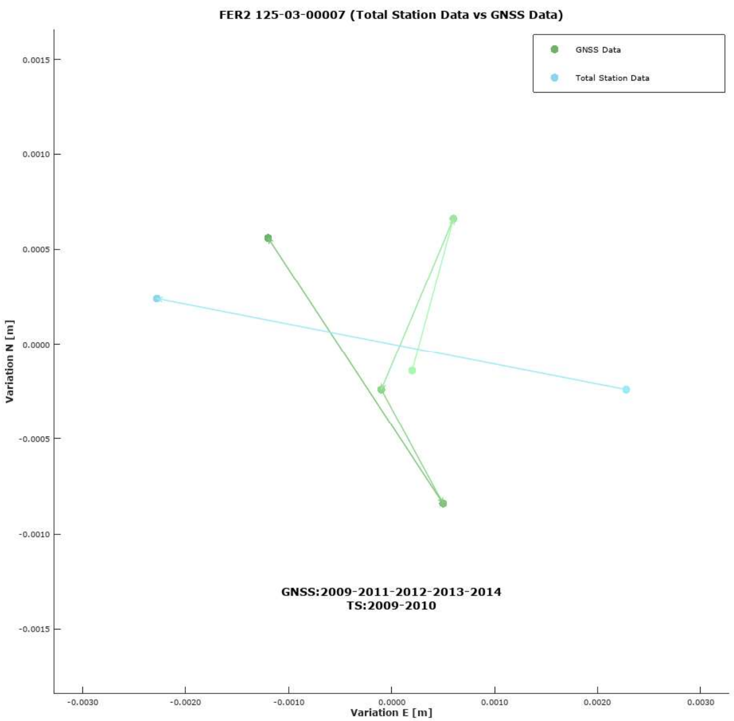
Figur 3.2



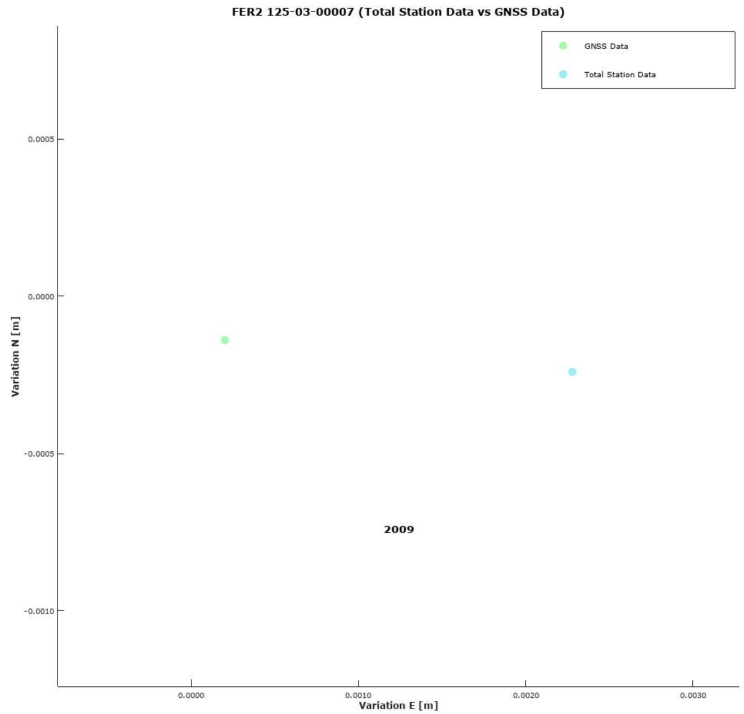
Figur 3.3



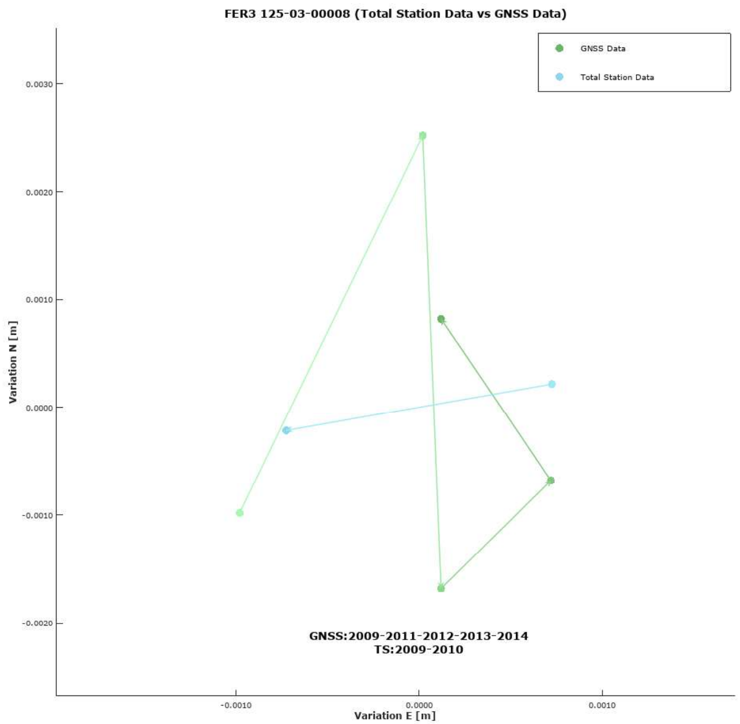
Figur 3.4



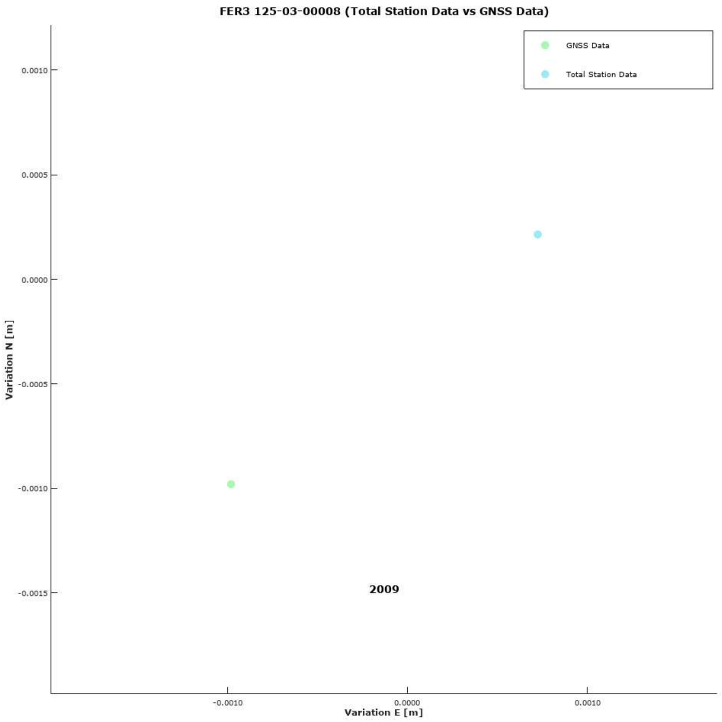
Figur 3.5



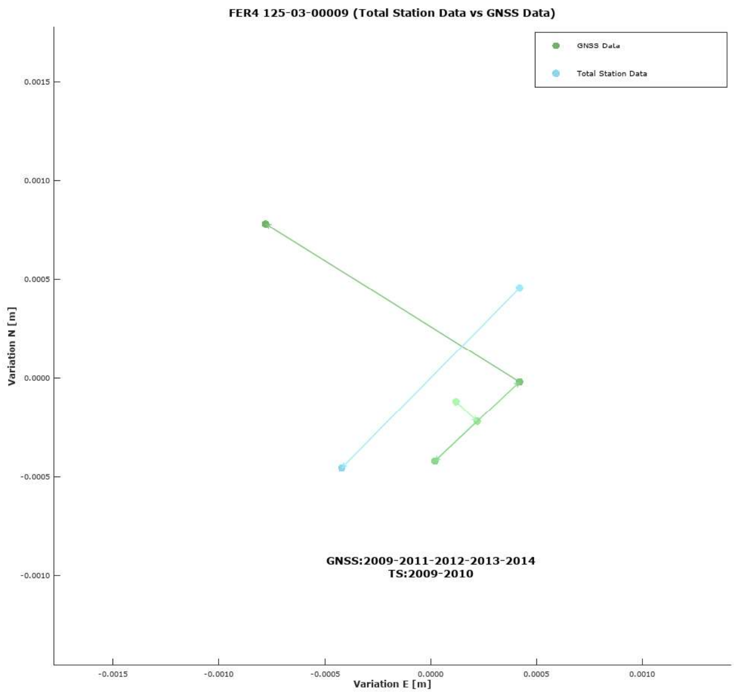
Figur 3.6



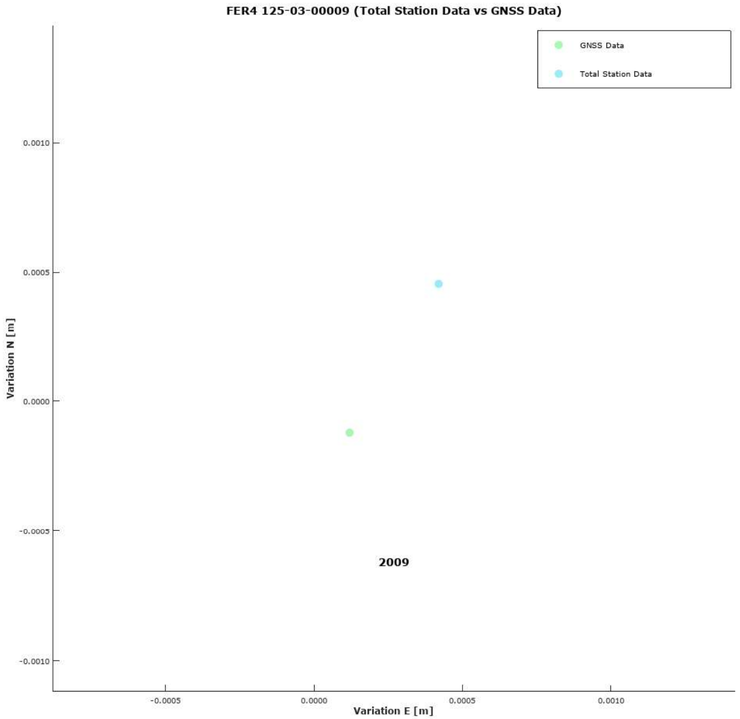
Figur 3.7



Figur 3.8



Figur 3.9

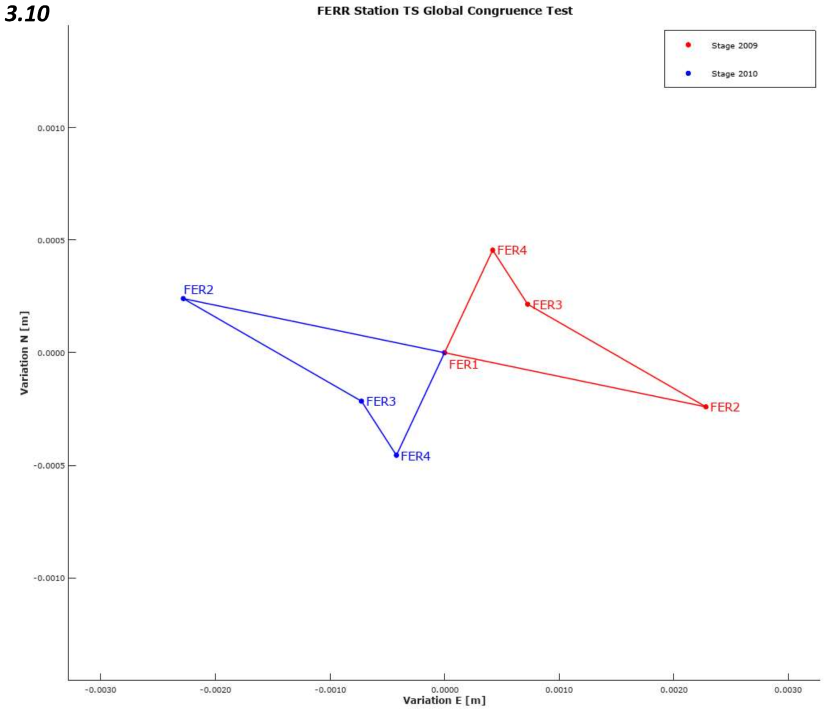


Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

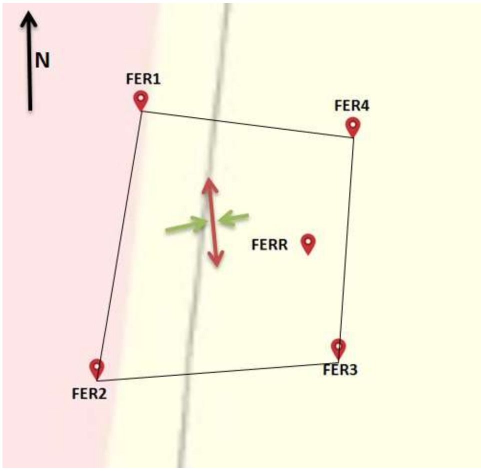
Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2009 vs **2010**	dN FER1	-2.76	2.76	>	2.31	Unstable
	dE FER1	0.77	0.77	<		
	dN FER2	0.68	0.68	<		Unstable
	dE FER2	-3.77	3.77	>		
	dN FER3	2.16	2.16	<		Unstable
	dE FER3	2.69	2.69	>		
	dN FER4	-0.49	0.49	<		Stable
	dE FER4	0.17	0.17	<		

Figur 3.10



Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000005		
ε_{EE}	-0.000005		
ε_{simple}	-0.000002		
ε_{pure}	0.000005		
ε_{MAX}	0.000006	+ extension	0.6 ppm
ε_{MIN}	-0.000006	- contraction	-0.6 ppm
2θ	-14.0252		
θ	392.9874	direction of the maximum principal axis, clockwise from N-axis	

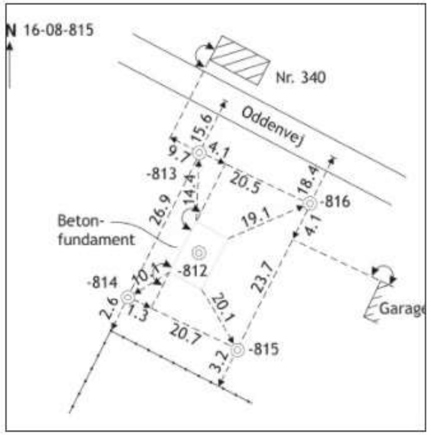
APPENDIX 9 - HAVNEBYEN [HABY]

Tidserie: 81141

GPS Antenna	*HABY 16-08-00812*
Nærkontrol	*HAB1 16-08-00813*
	HAB2 16-08-00814
	HAB3 16-08-00815 → JessenPunkt
	HAB4 16-08-00816
Fjernkontrol	*HBYK 16-08-00810 G.I.2123*
Bolter i fundament	*16-08-09031*
	16-08-09032
	16-08-09033
	16-08-09034

1. Skitser:

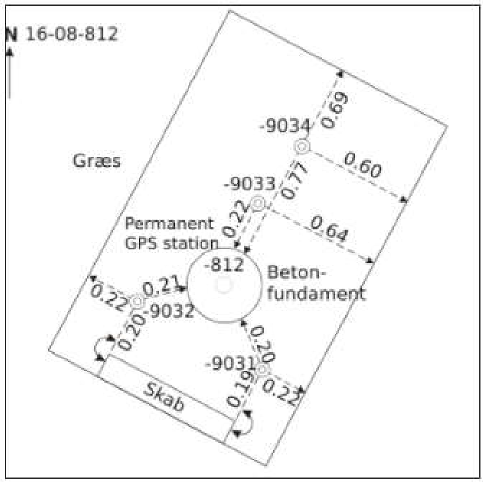
Figur 1.1



Figur 1.2

Notes:

- The A-test shows stability for the majority of the points.
- In terms of planimetric coordinates: no large displacements can be observed.
- The congruence test shows a slight displacement for the Jessenpunkt (HAB3). Pay attention to it and its future determinations.
- Strain analysis doesn't indicate predisposition to local instability.

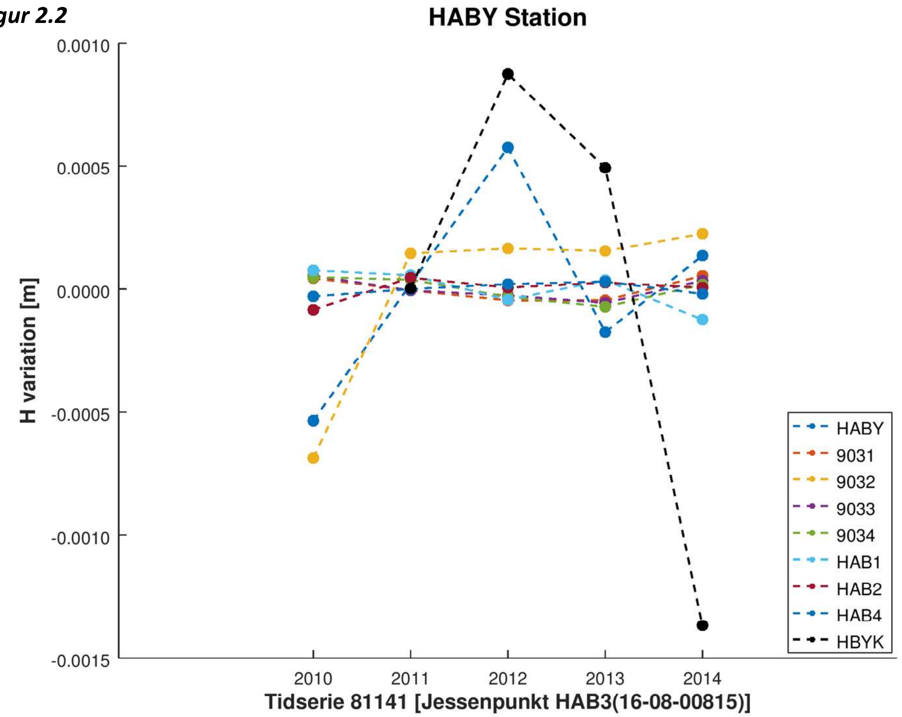


Figur 1.3

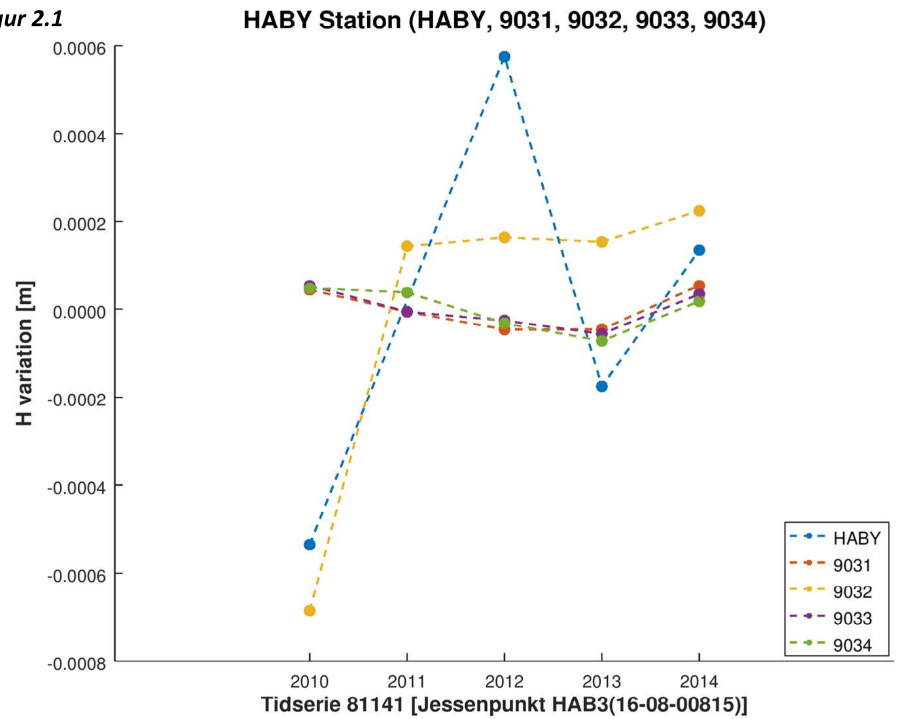
2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

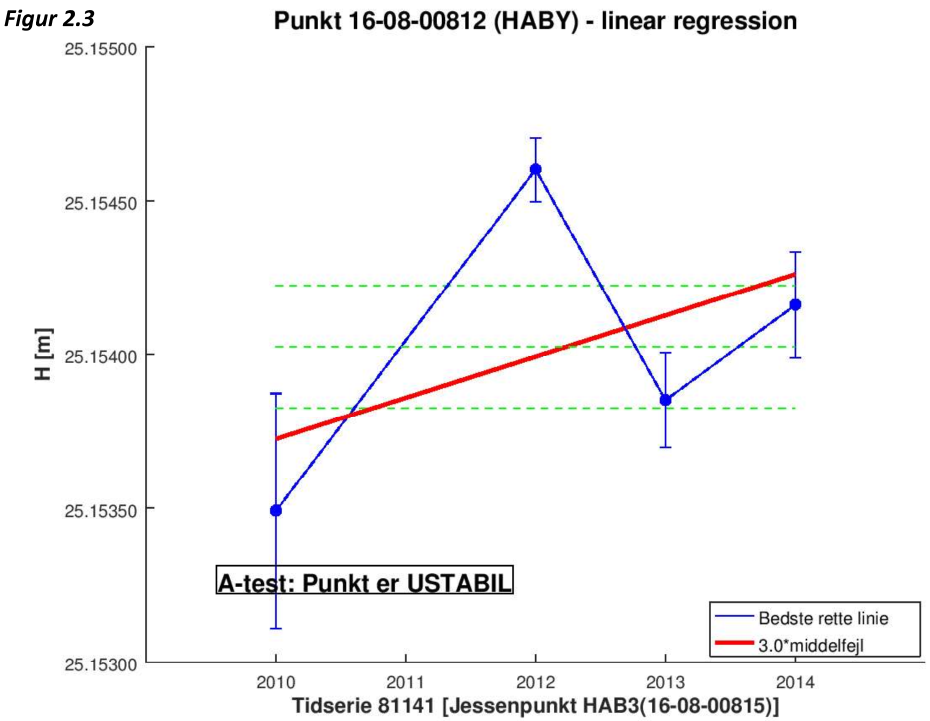
Figur 2.2



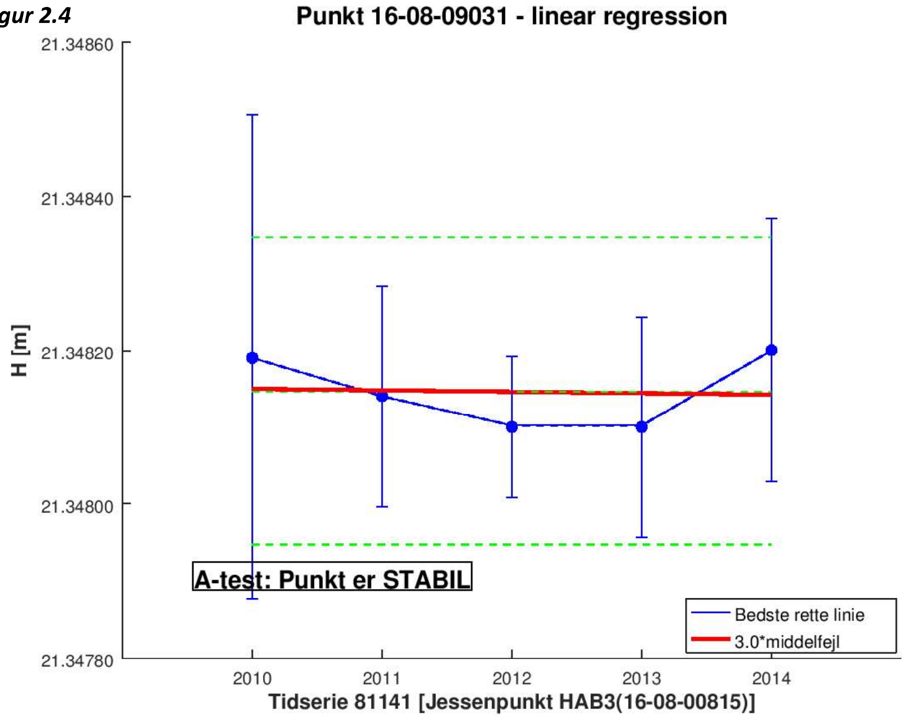
Figur 2.1



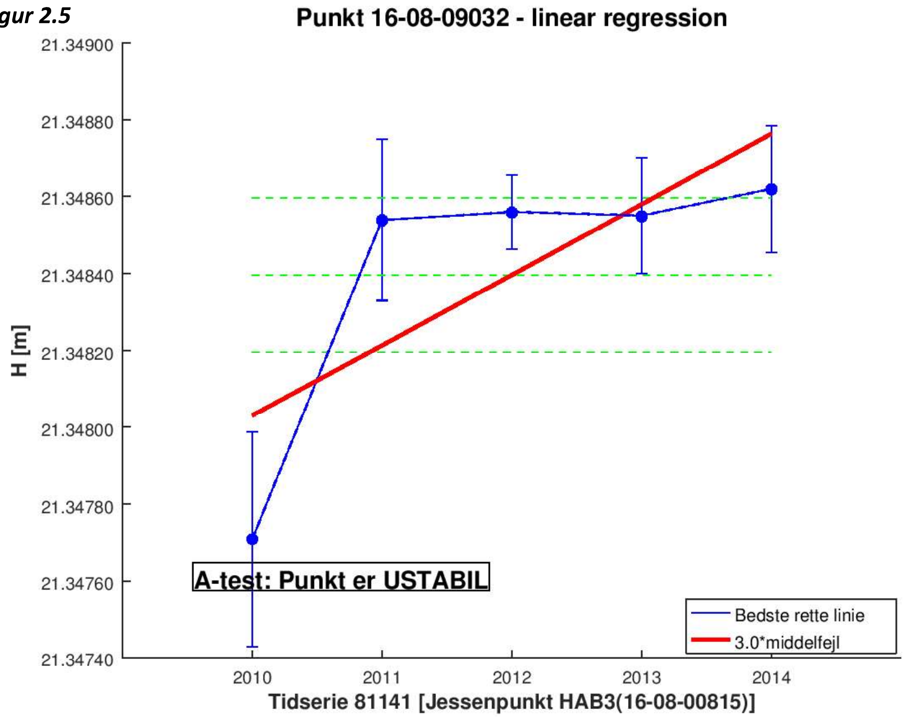
Figur 2.3



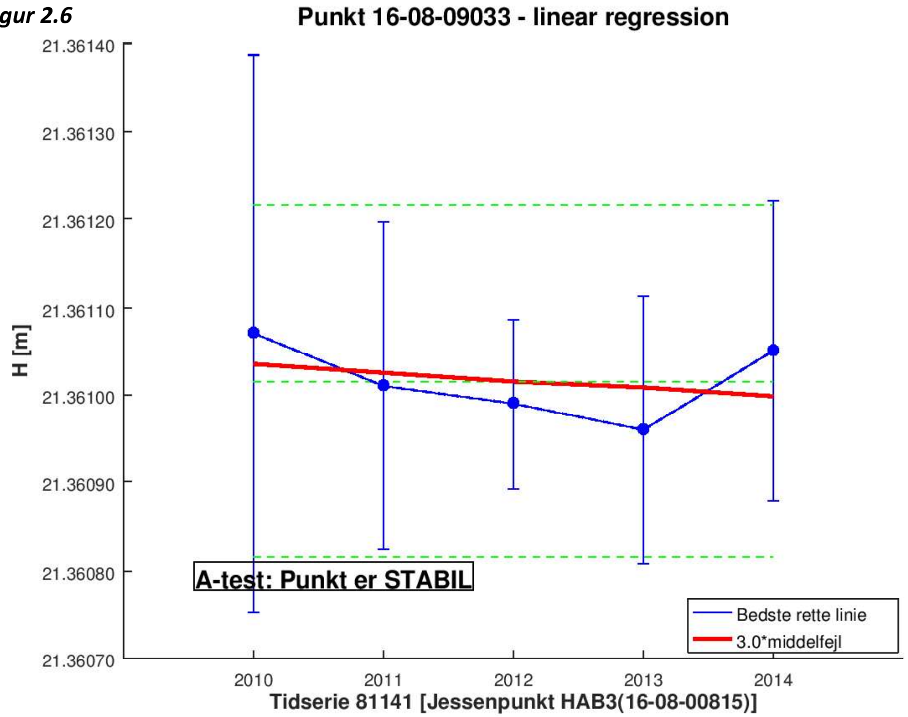
Figur 2.4



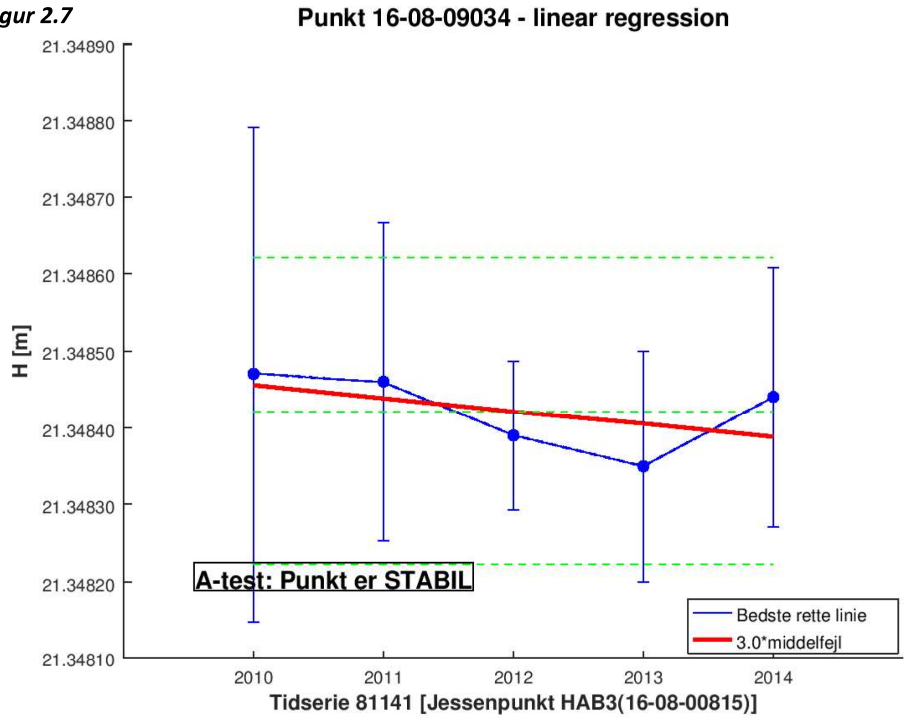
Figur 2.5



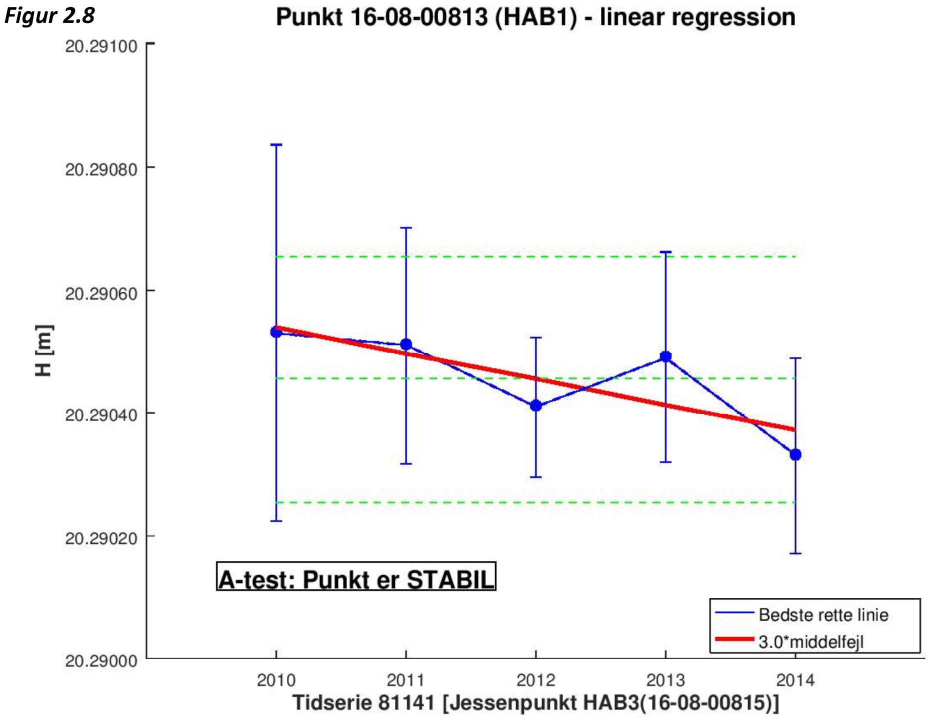
Figur 2.6



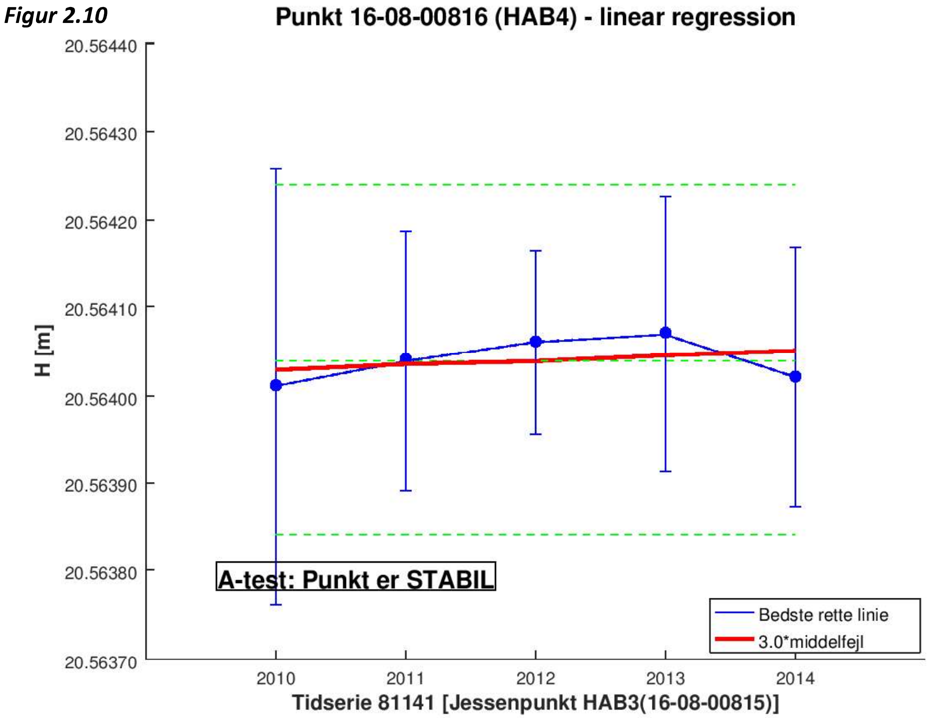
Figur 2.7



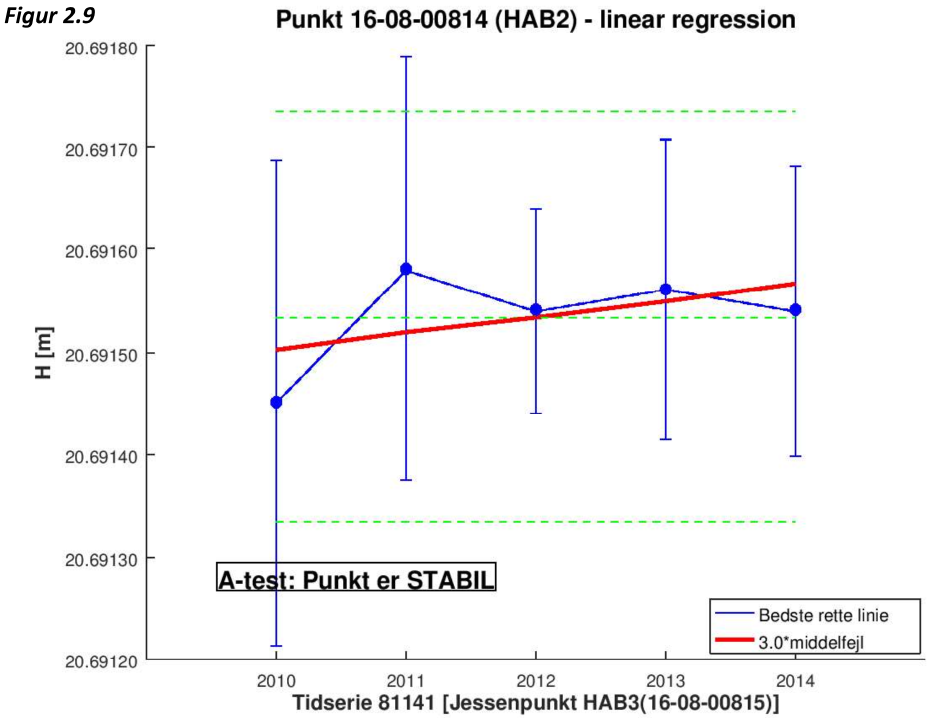
Figur 2.8



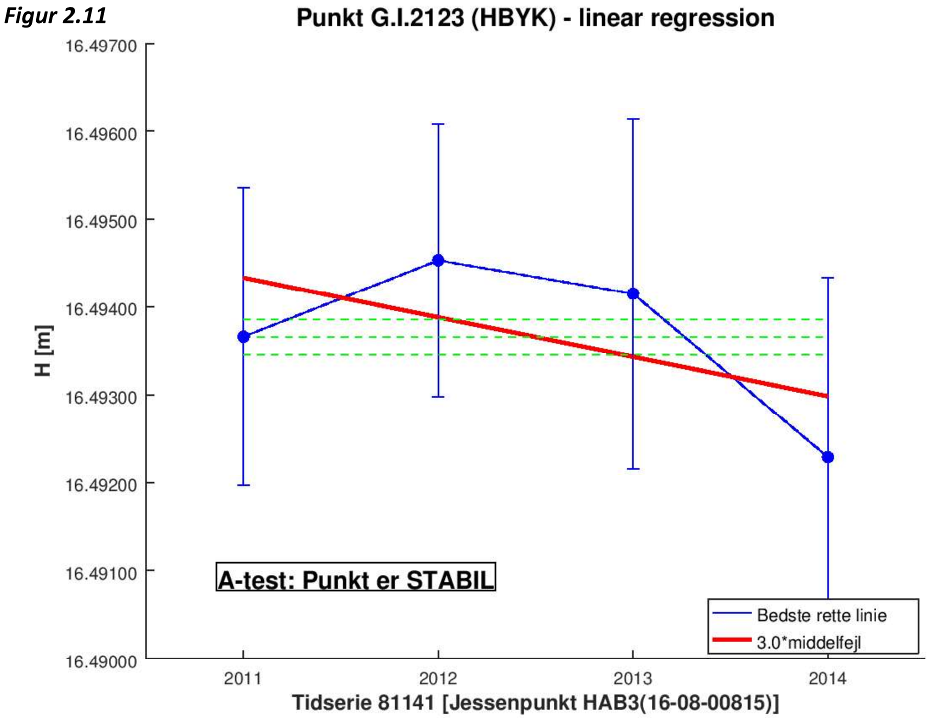
Figur 2.10



Figur 2.9



Figur 2.11



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

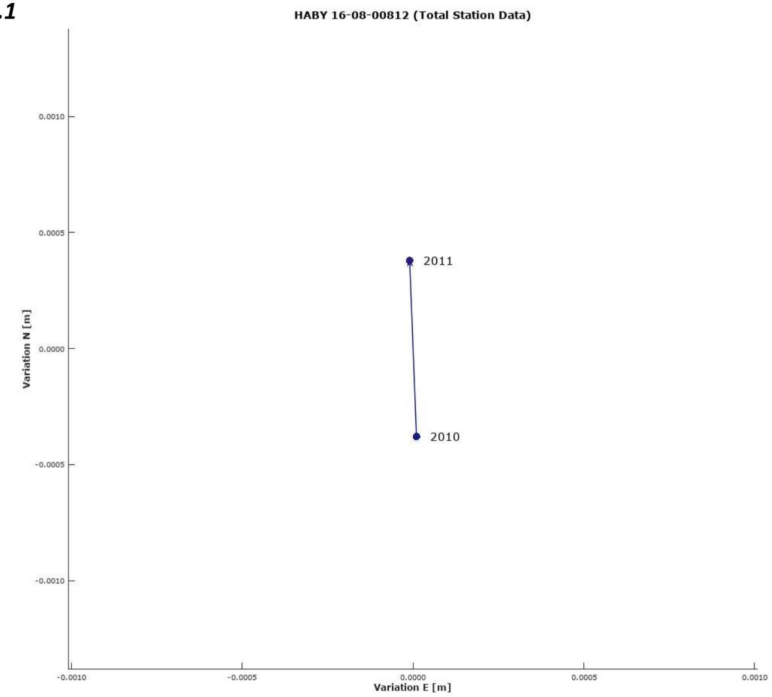
Constant Value [mm]	Station: HABY								
	Antenna	Sikringspunkter				Nærkontrol			Fjernkontrol
	HABY	9031	9032	9033	9034	HAB1	HAB2	HAB4	HBYK
0.3	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.4	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.5	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.6	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.8	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
1	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

3. PLANIMETRIC ANALYSIS

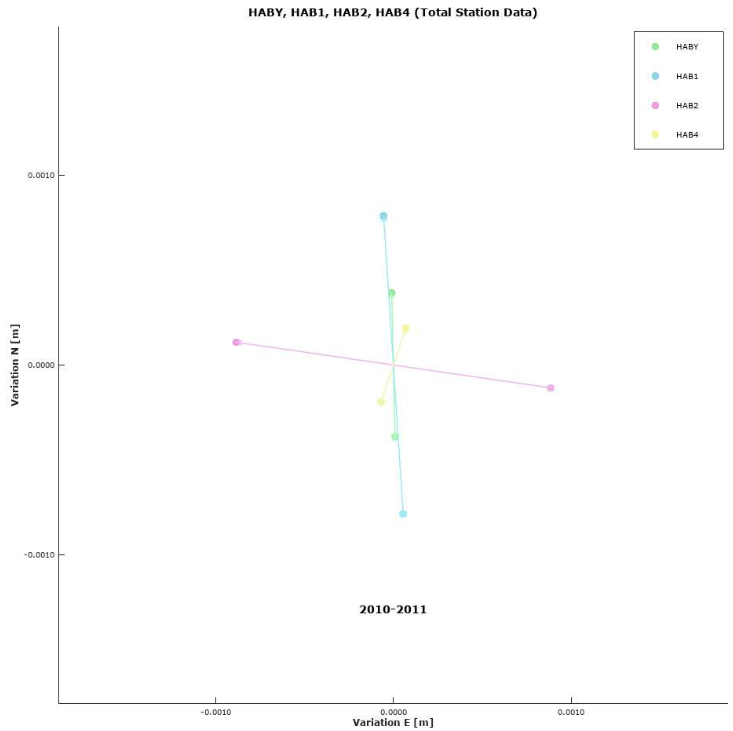
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! *In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.*

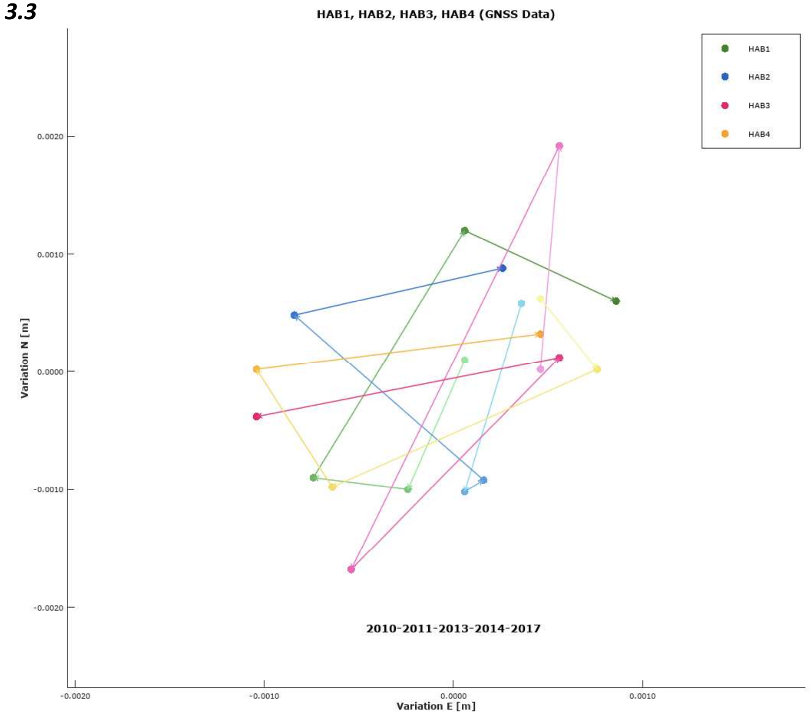
Figur 3.1



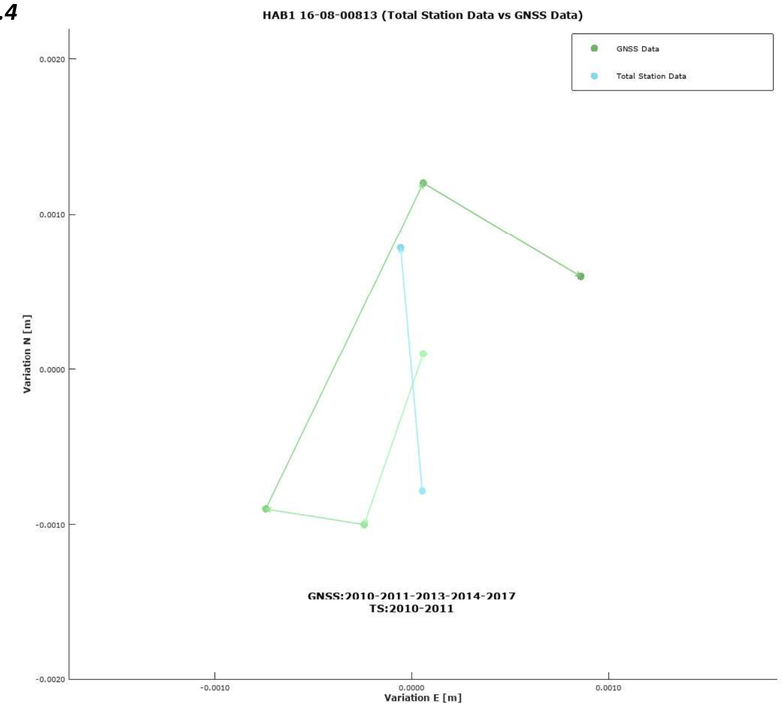
Figur 3.2



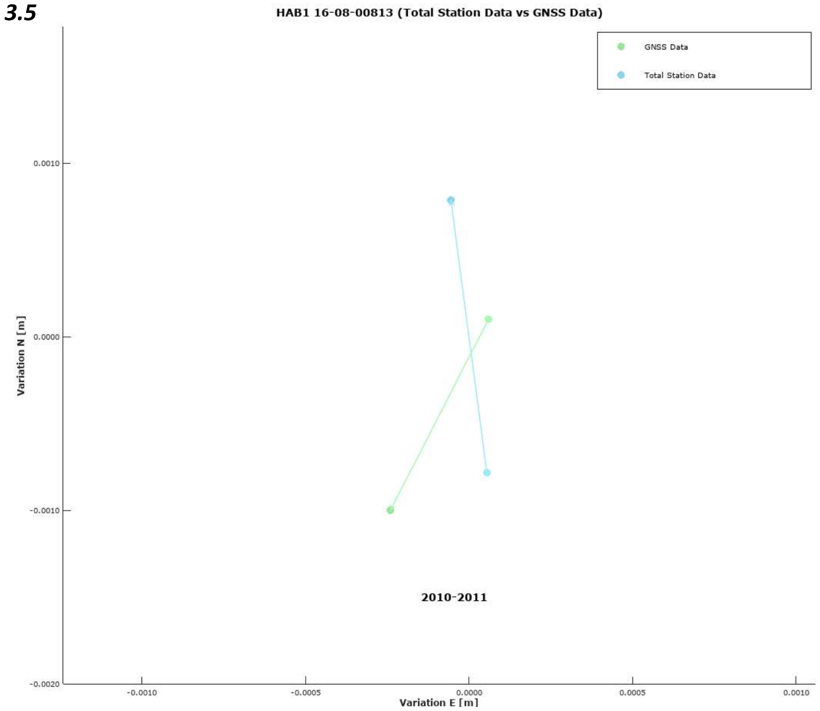
Figur 3.3



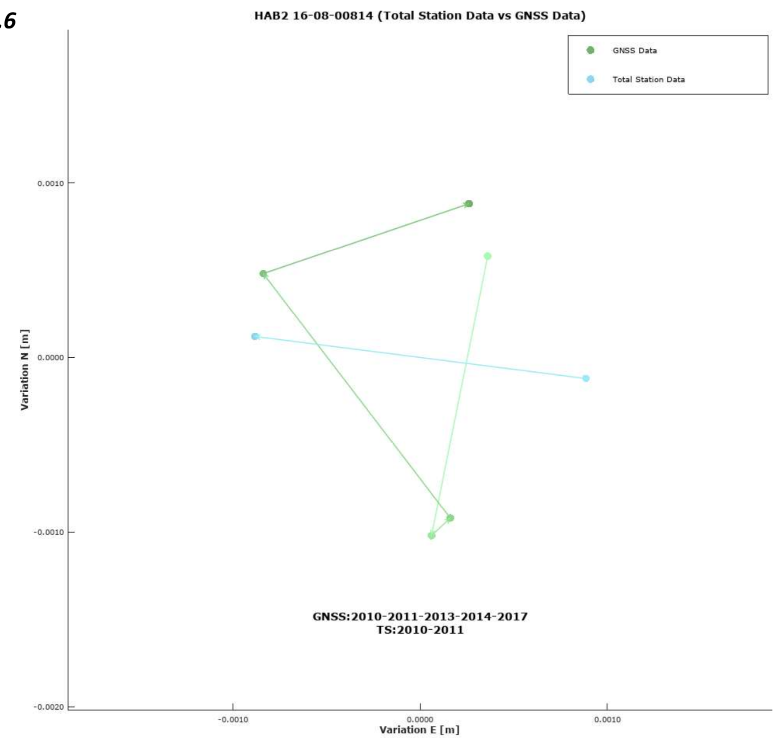
Figur 3.4



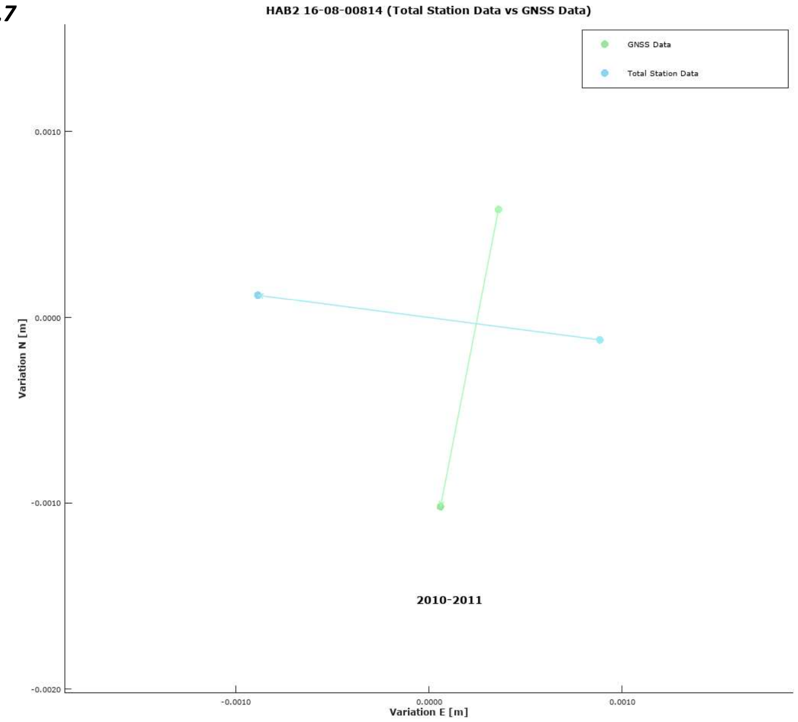
Figur 3.5



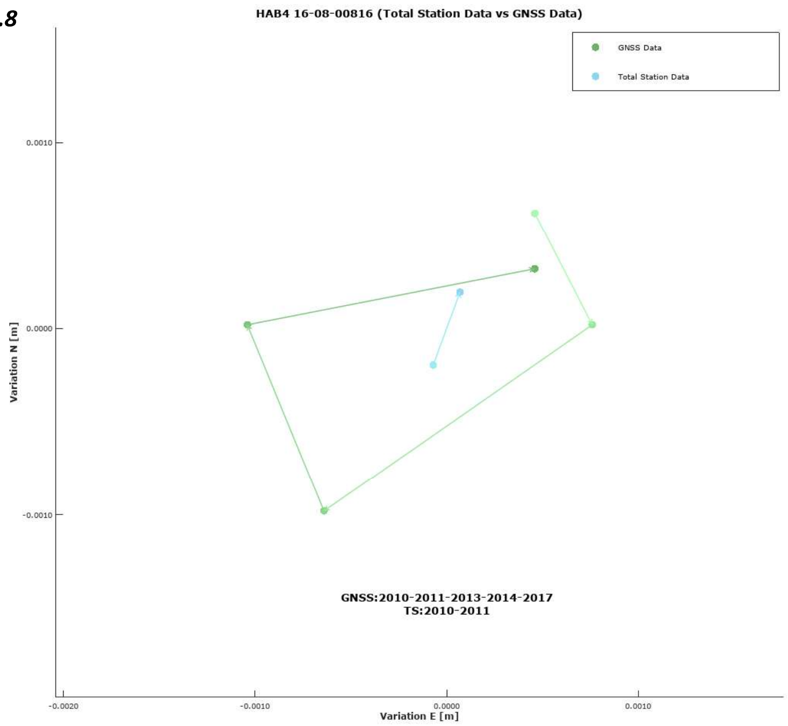
Figur 3.6



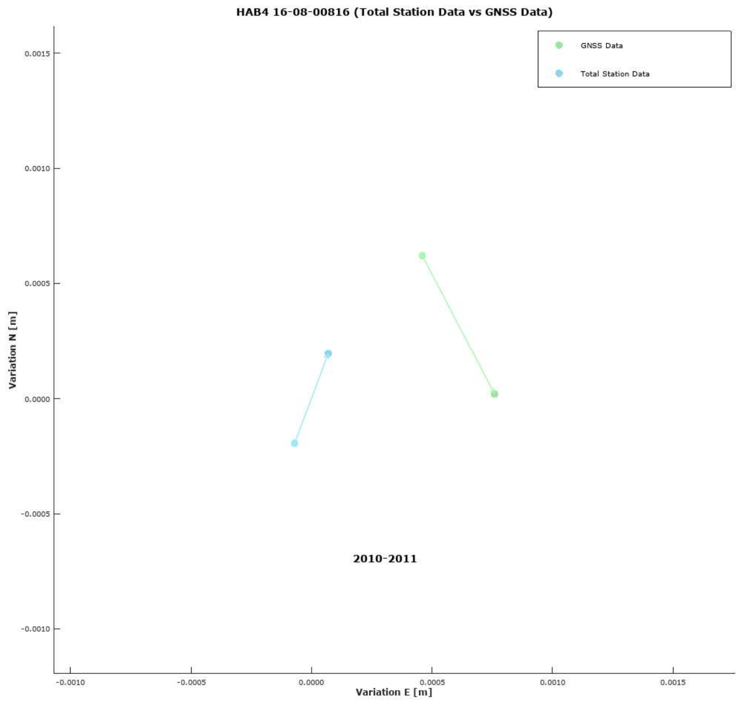
Figur 3.7



Figur 3.8



Figur 3.9

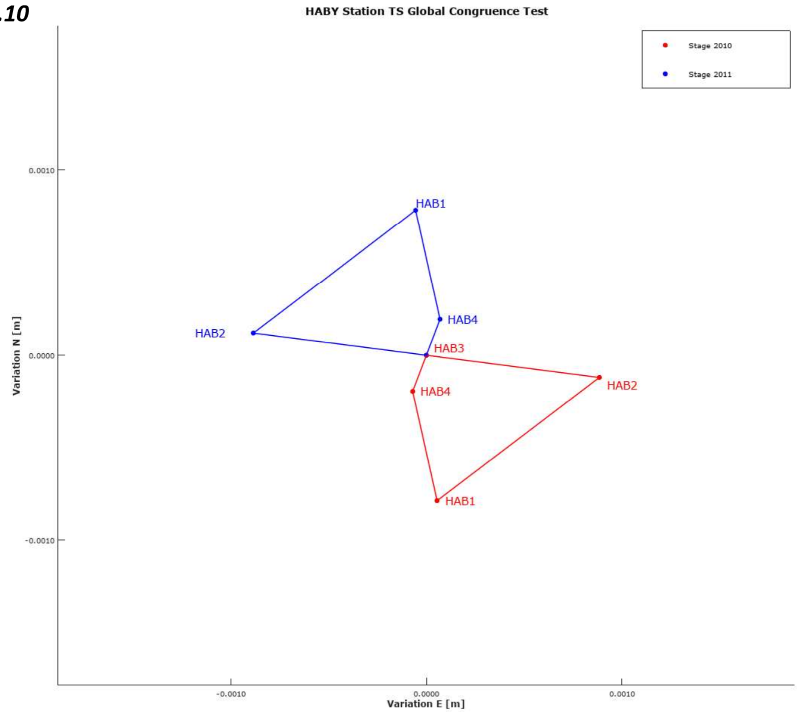


Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

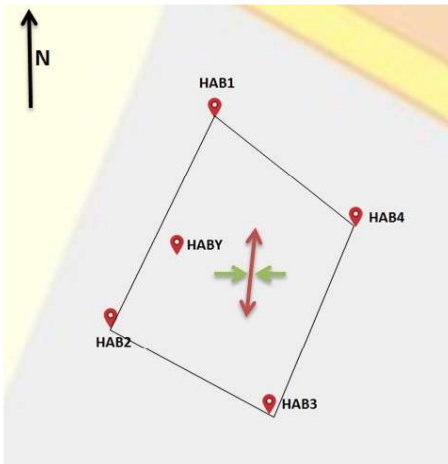
Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2010 vs **2011**	dN HAB1	1.77	1.77	<	2.31	Stable
	dE HAB1	-1.05	1.05	<		
	dN HAB2	-1.00	1.00	<		Stable
	dE HAB2	-1.11	1.11	<		
	dN HAB3	3.83	3.83	>		Unstable
	dE HAB3	1.01	1.01	<		
	dN HAB4	-2.93	2.93	>		Unstable
	dE HAB4	1.23	1.23	<		

Figur 3.10



Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000002		
ε_{EE}	-0.000004		
ε_{simple}	0.000002		
ε_{pure}	0.000003		
ε_{MAX}	0.000003	+ extension	0.3 ppm
ε_{MIN}	-0.000004	- contraction	-0.4 ppm
2θ	21.3938		
θ	10.6969	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 10 - TEJN [TEJH]

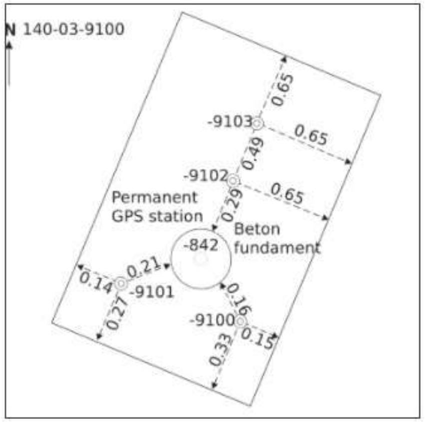
Tidserie: 81152

GPS Antenna	*TEJH 140-03-00842*
Nærkontrol	*TEJ2 140-03-00838*
	TEJ3 140-03-00841 G.I.2278
	TEJ4 140-03-00840
	TEJ5 140-03-00839
	TEJN 140-03-00835
Fjernkontrol	*BORR 140-04-00001 G.I.2373*
Bolter i fundament	*140-03-09100*
	140-03-09101
	140-03-09102
	140-03-09103

JessenPunkt: 140-03-09106

1. Skitser:

Figur 1.1



Figur 1.2

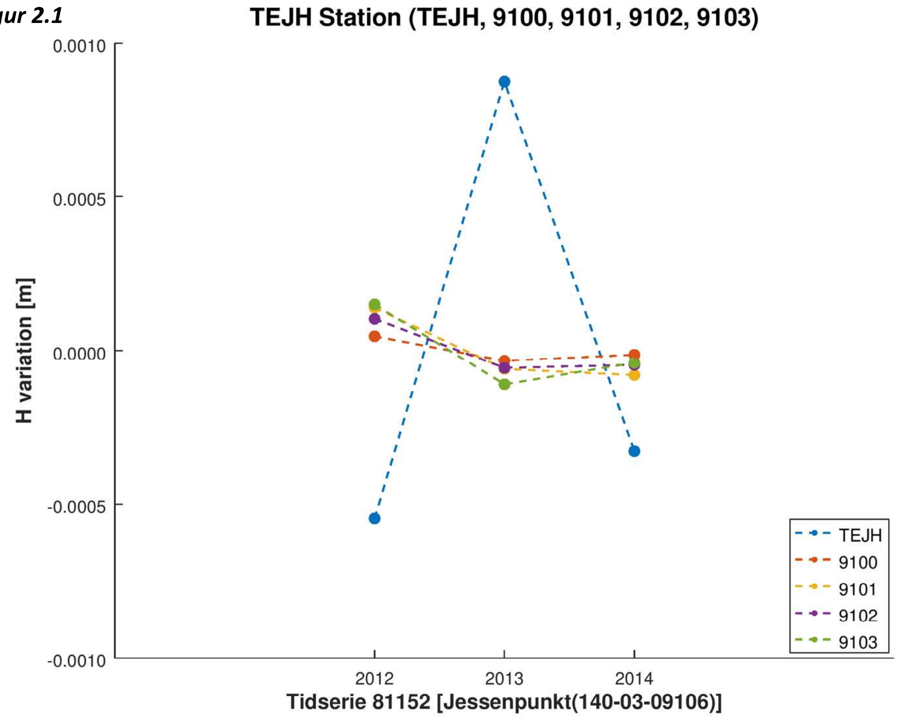
Notes:

- The A-test shows stability for the majority of the considered points. Manual analysis indicates the station is also stable.
- In terms of planimetric coordinates: no large displacements can be observed.
- The congruence test shows relative stability between the points.
- Strain analysis doesn’t indicate predisposition to local instability.

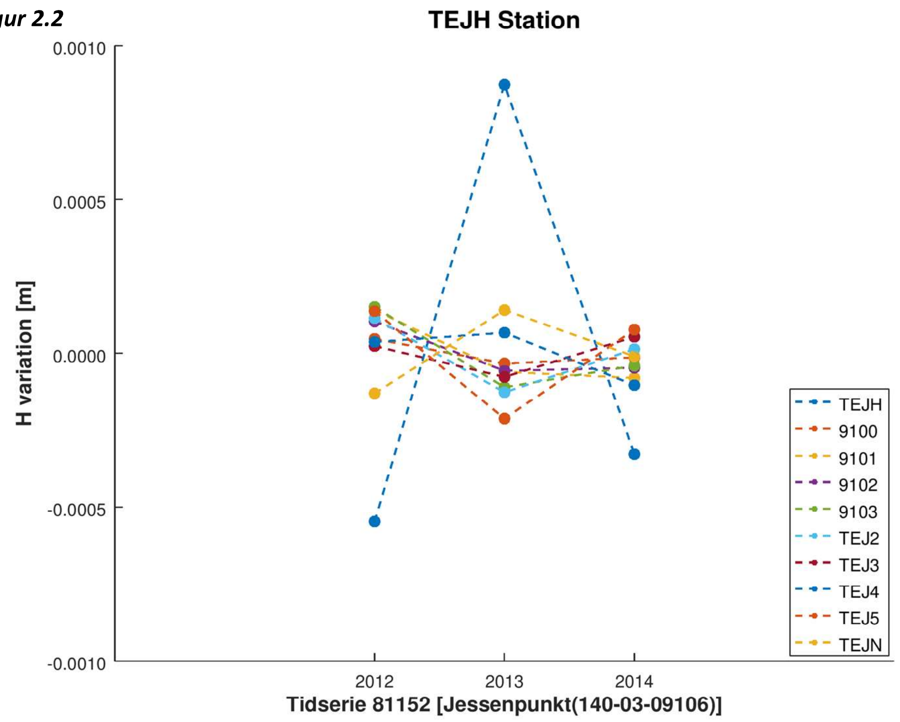
2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

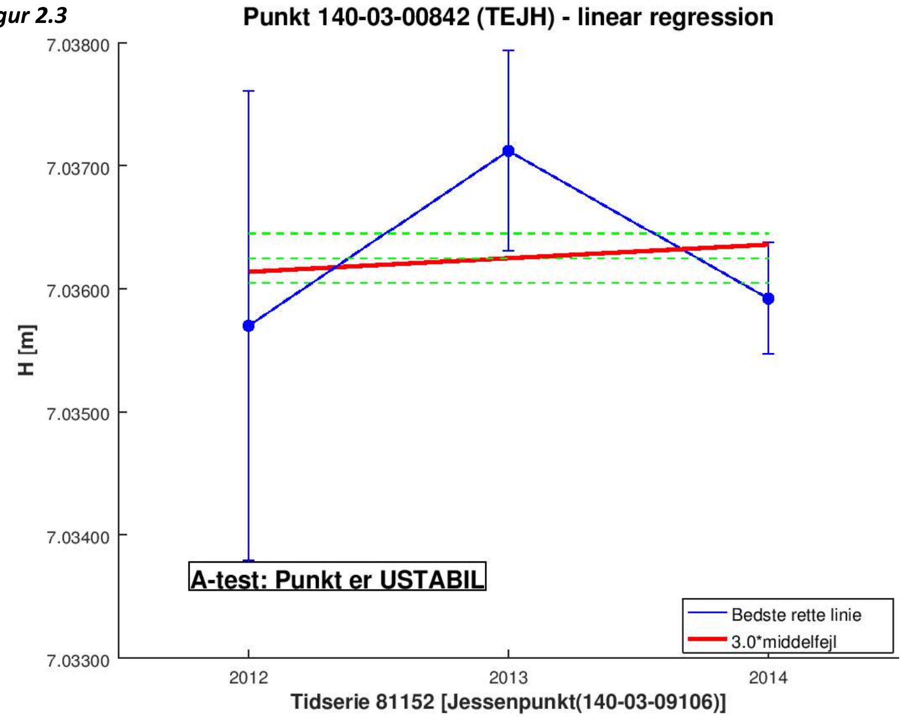
Figur 2.1



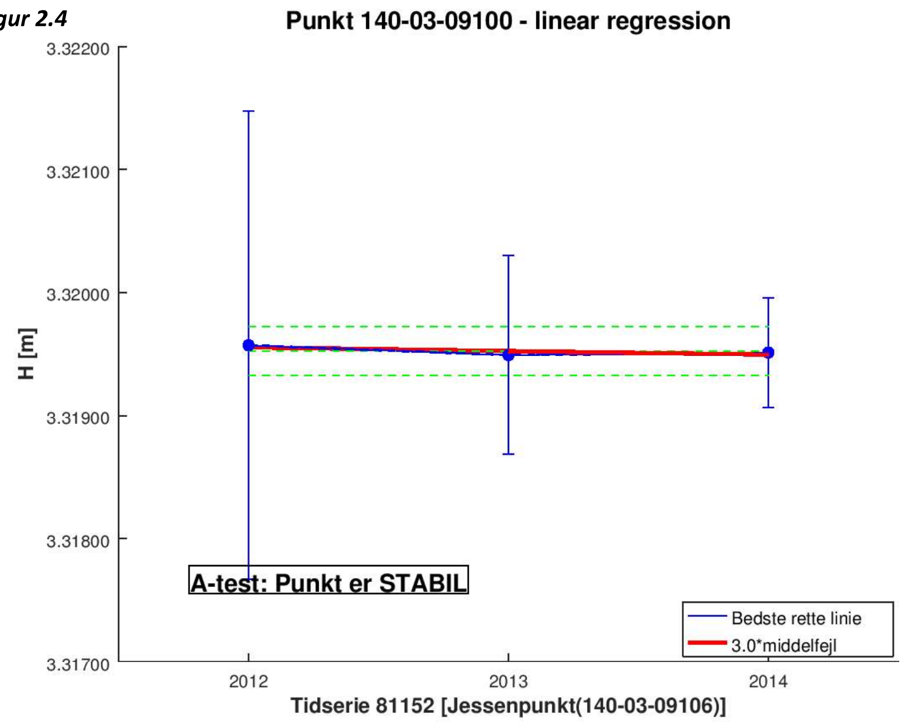
Figur 2.2



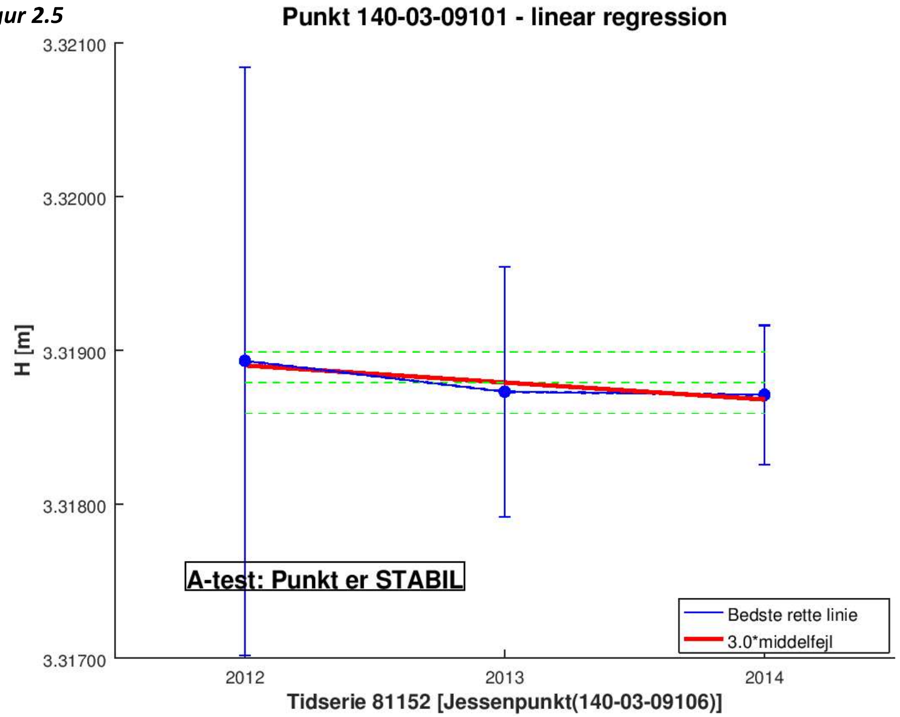
Figur 2.3



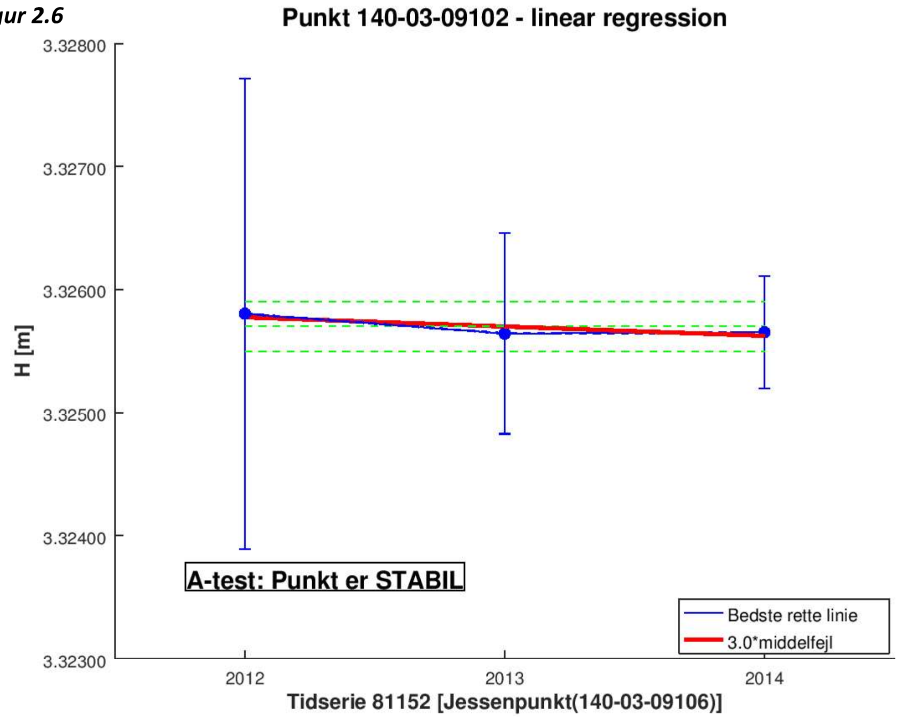
Figur 2.4



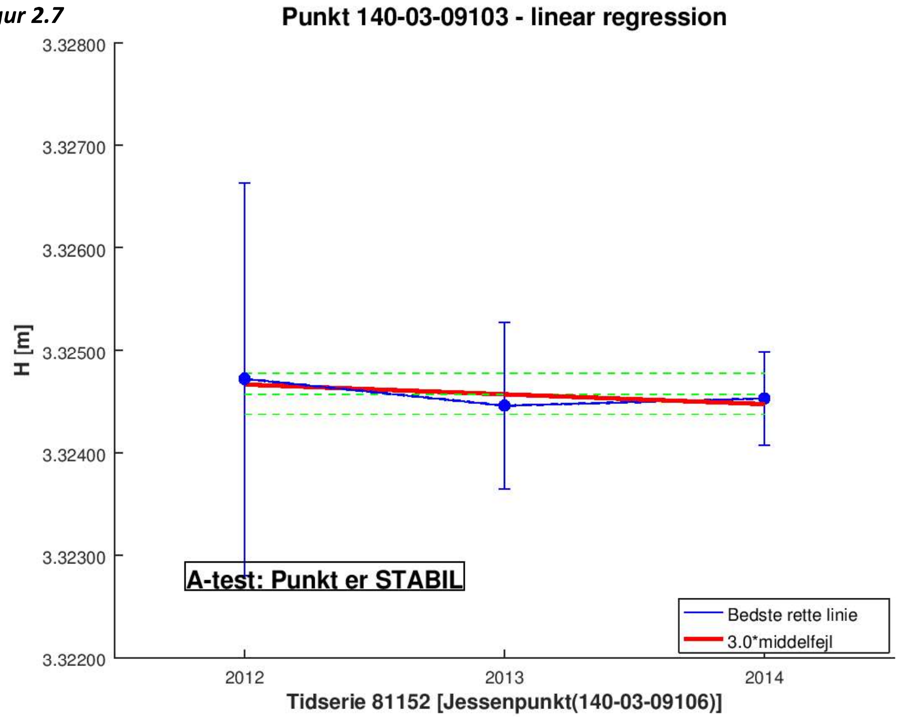
Figur 2.5



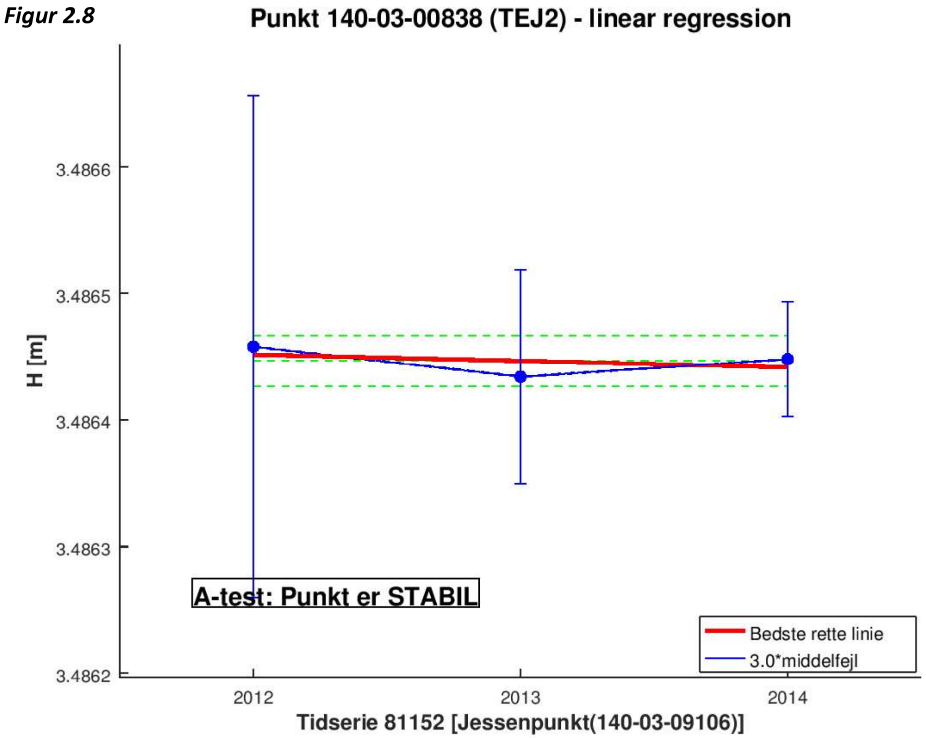
Figur 2.6



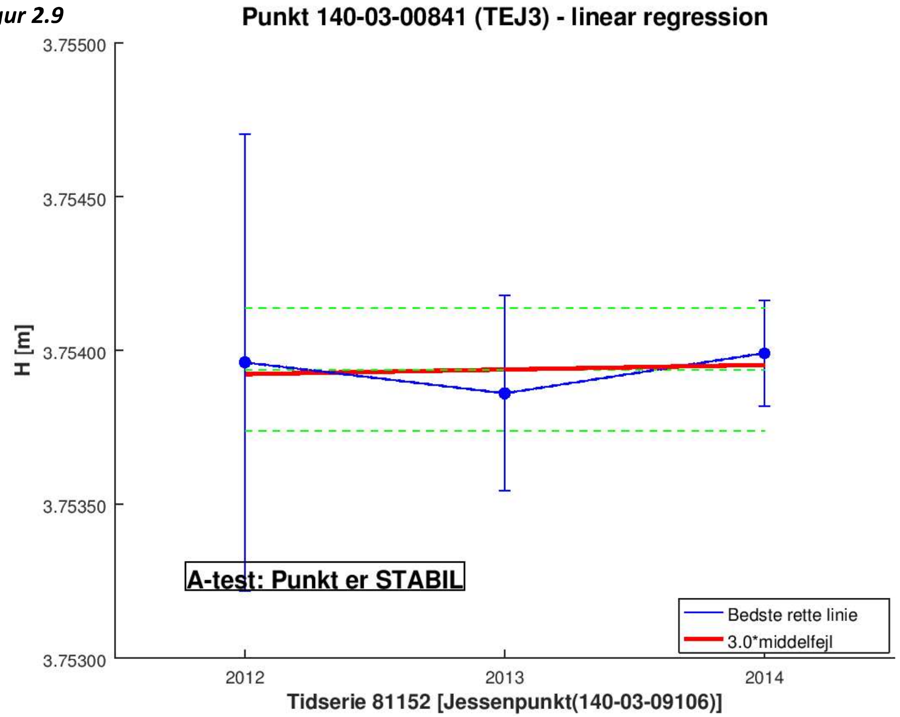
Figur 2.7



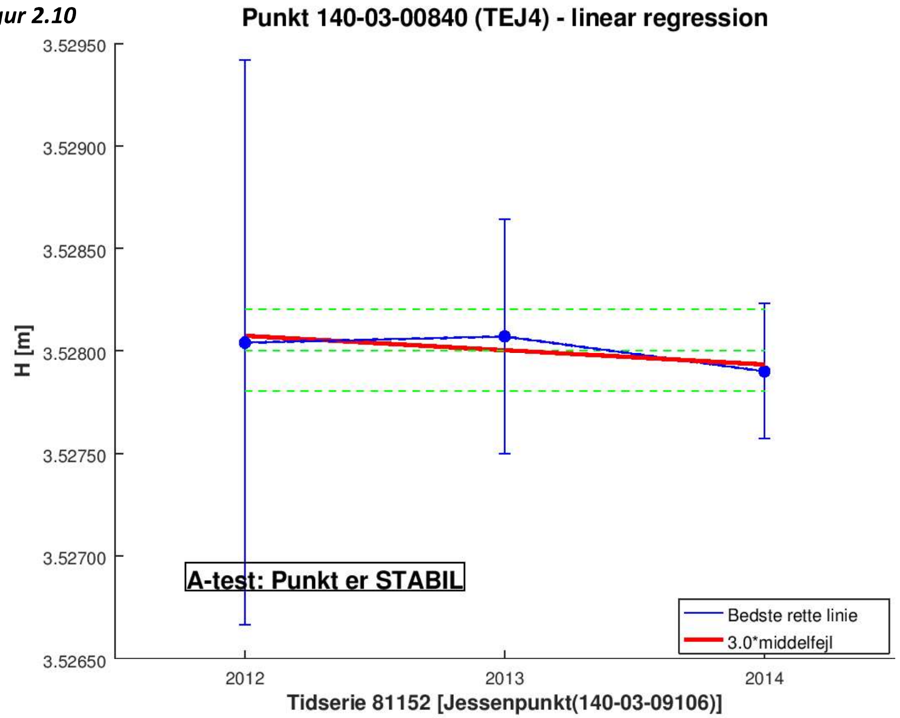
Figur 2.8



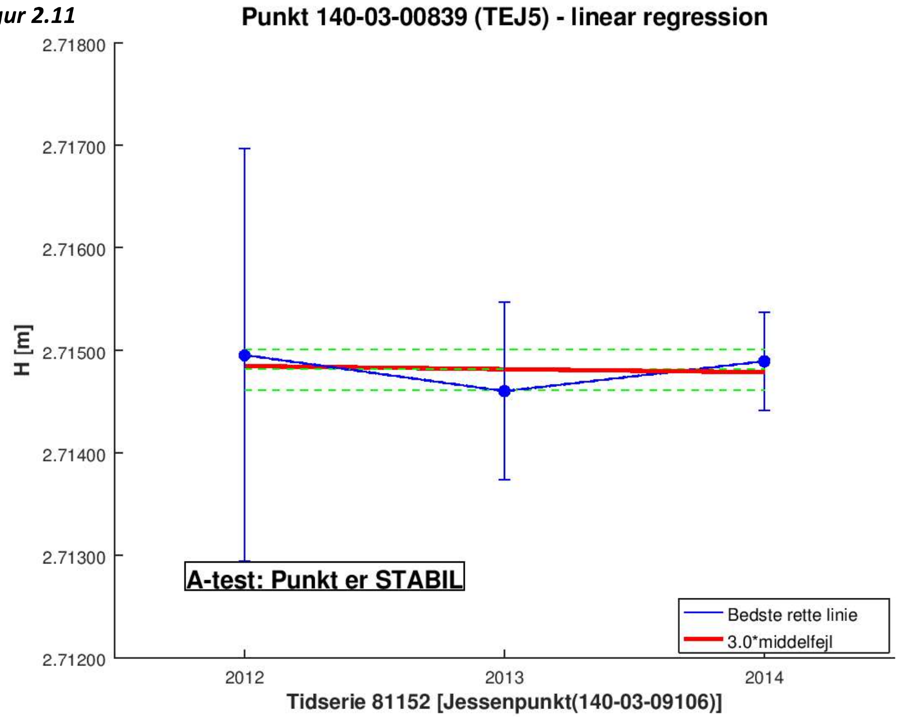
Figur 2.9



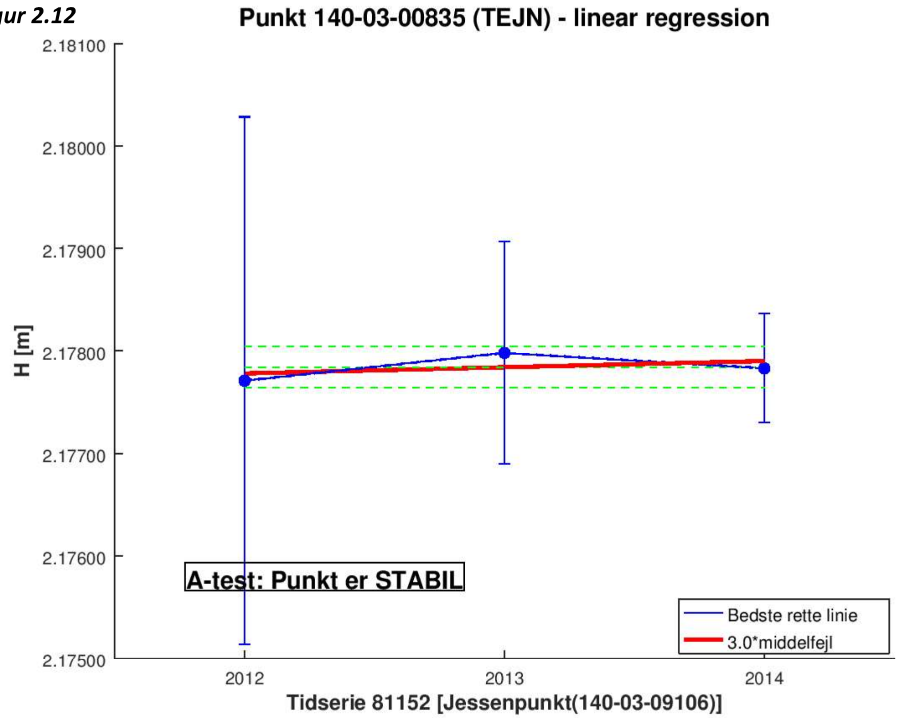
Figur 2.10



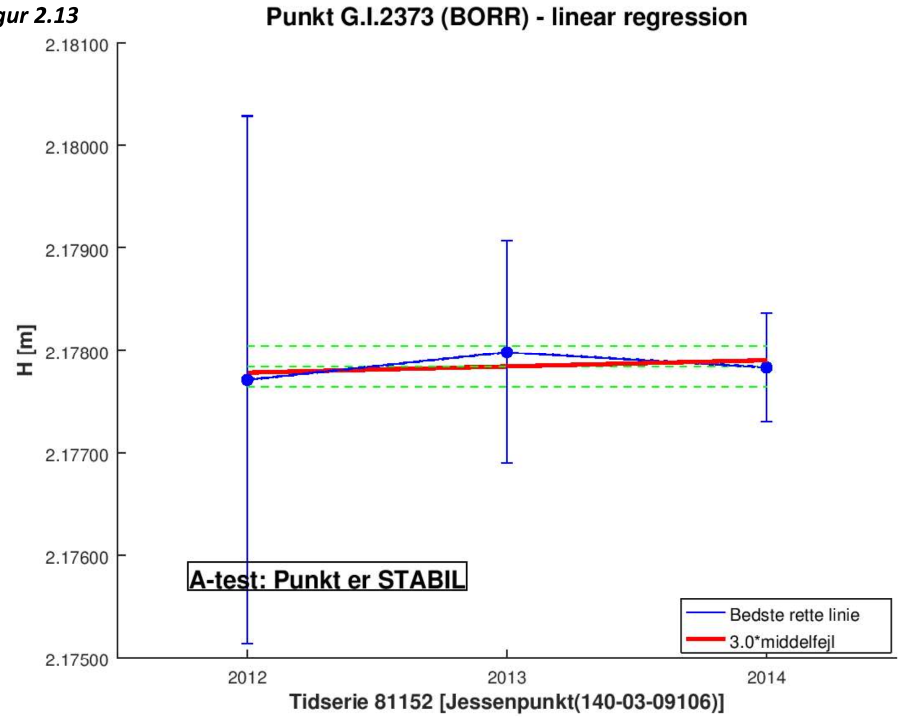
Figur 2.11



Figur 2.12



Figur 2.13



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

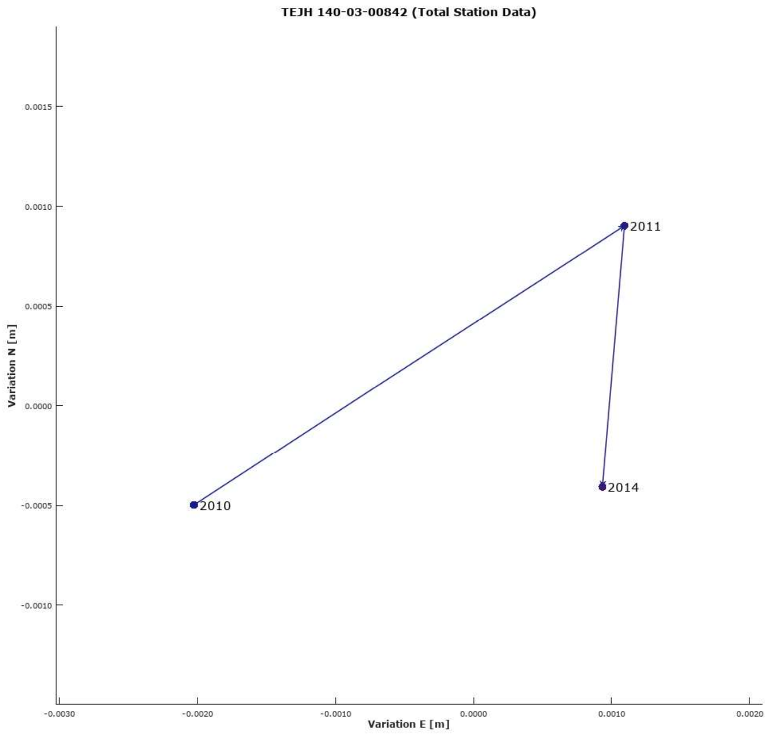
Constant Value [mm]	Station: TEJH										
	Antenna	Sikringspunkter				Nærkontrol					Fjernkontrol
	TEJH	9100	9101	9102	9103	TEJ2	TEJ3	TEJ4	TEJ5	TEJN	BORR
0.3	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.4	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.5	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.6	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.8	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
1	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

3. PLANIMETRIC ANALYSIS

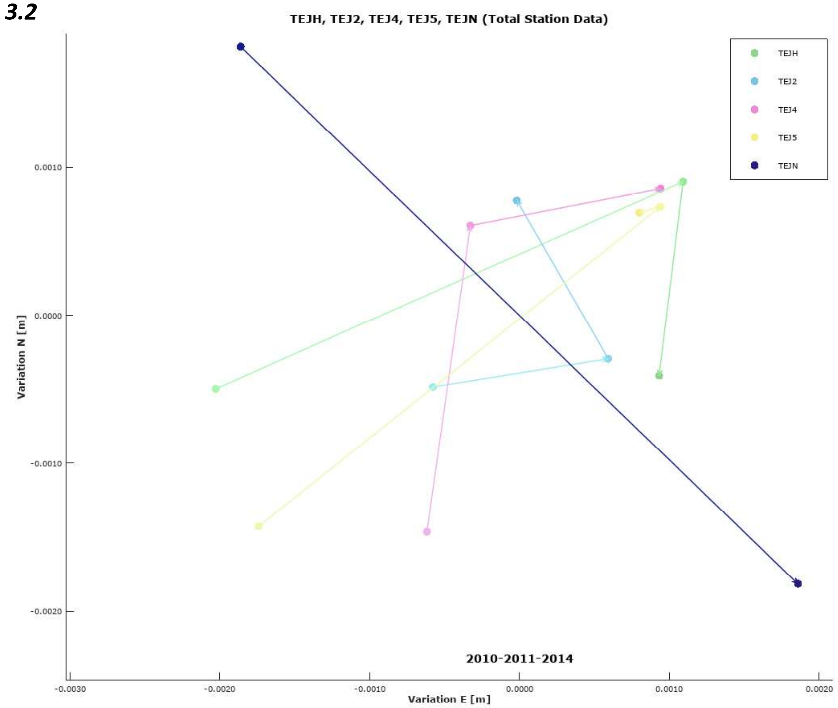
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.

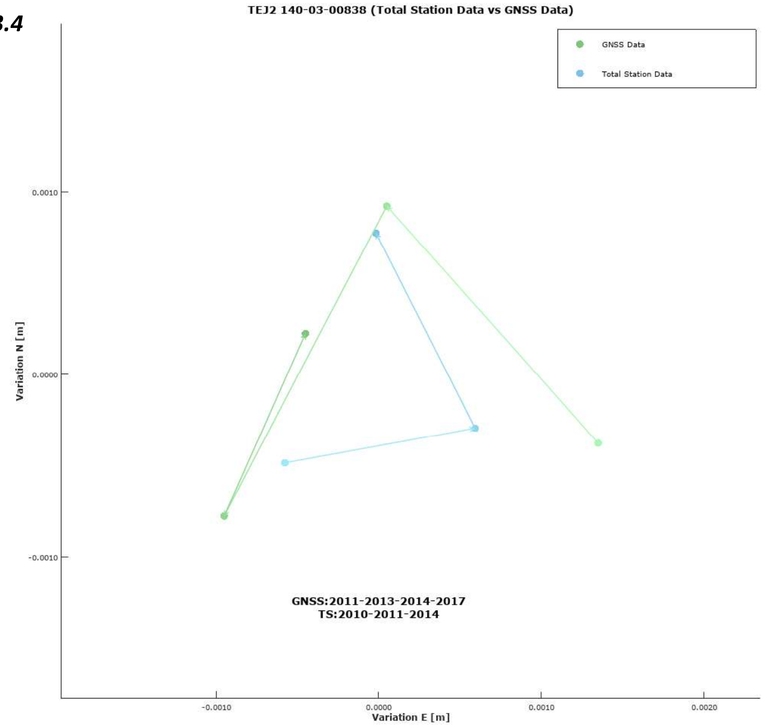
Figur 3.1



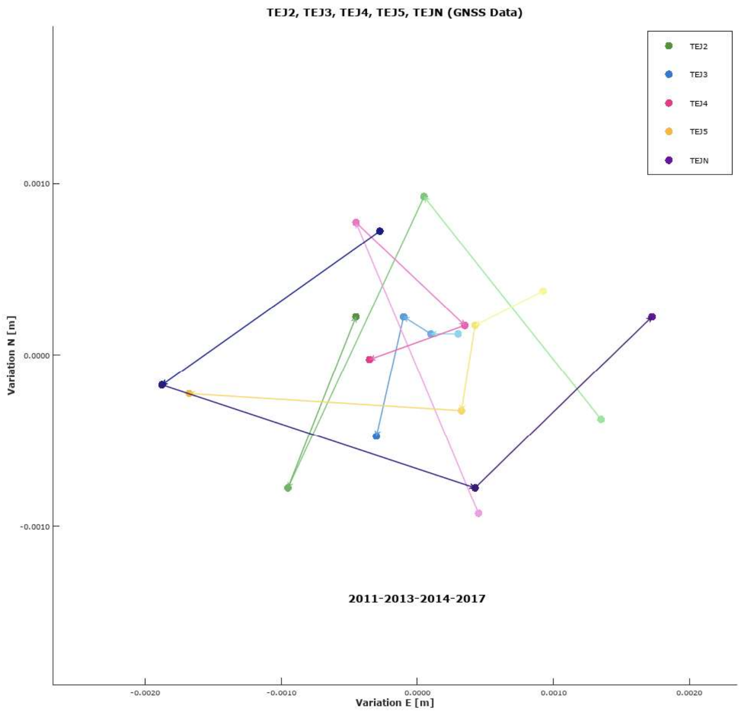
Figur 3.2



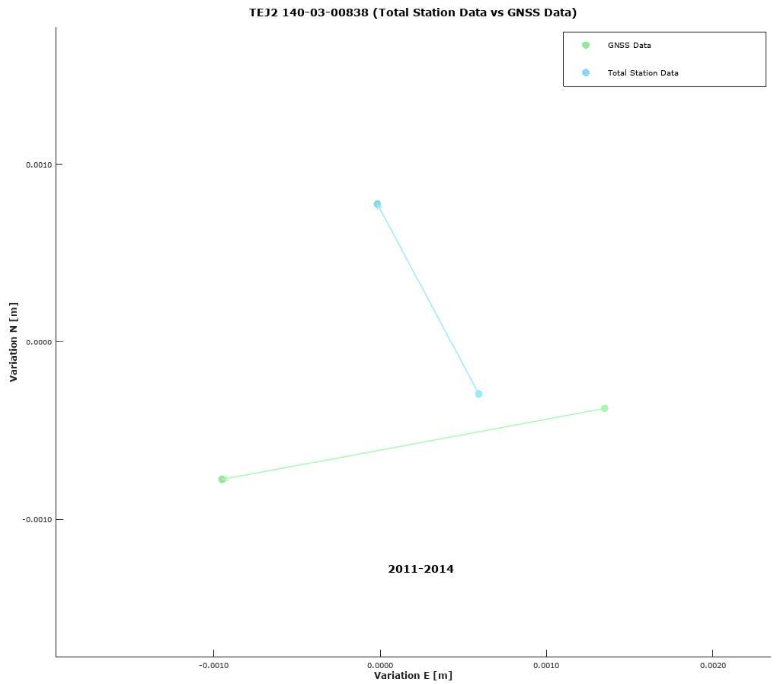
Figur 3.4



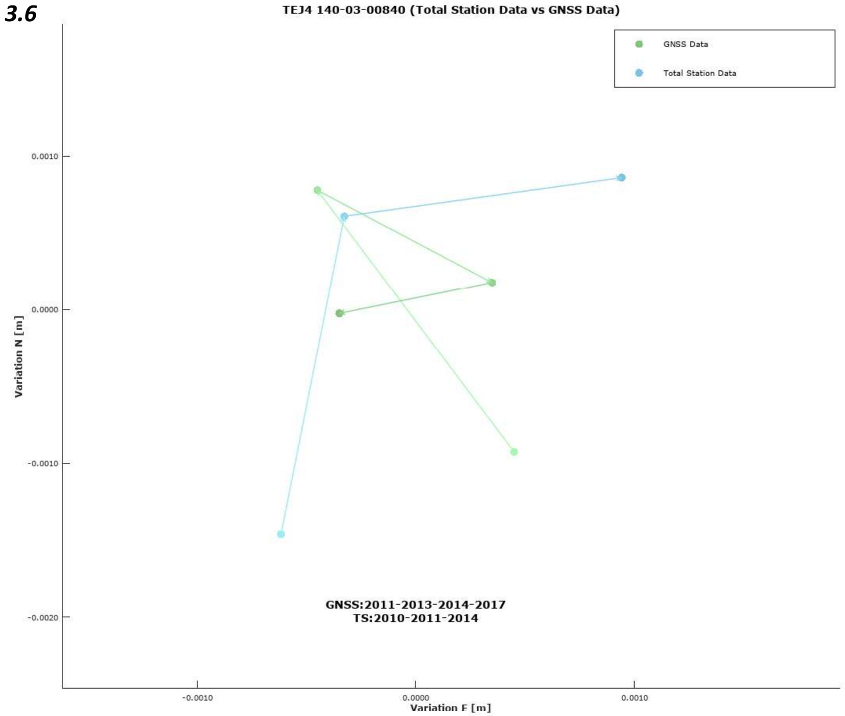
Figur 3.3



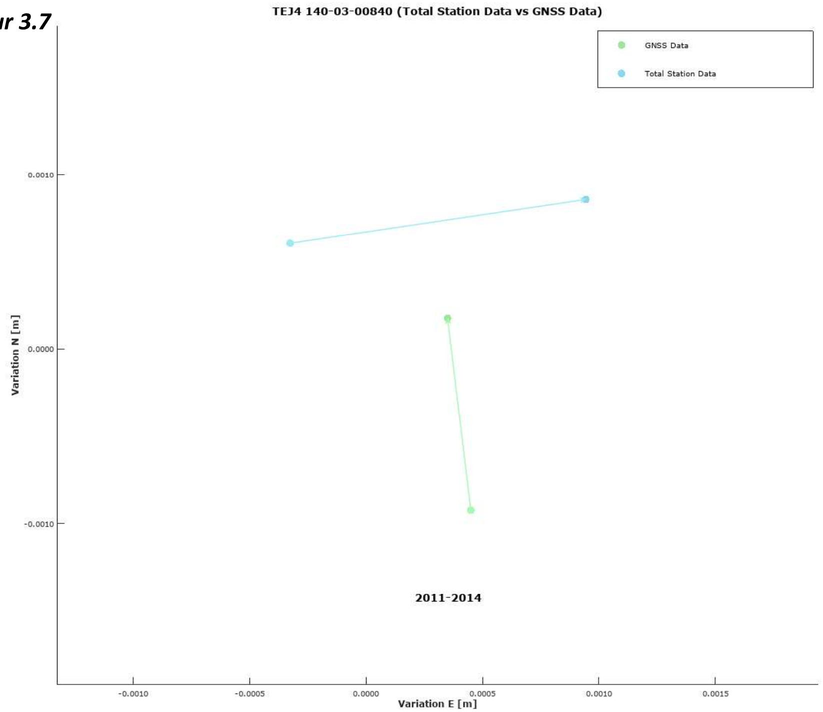
Figur 3.5



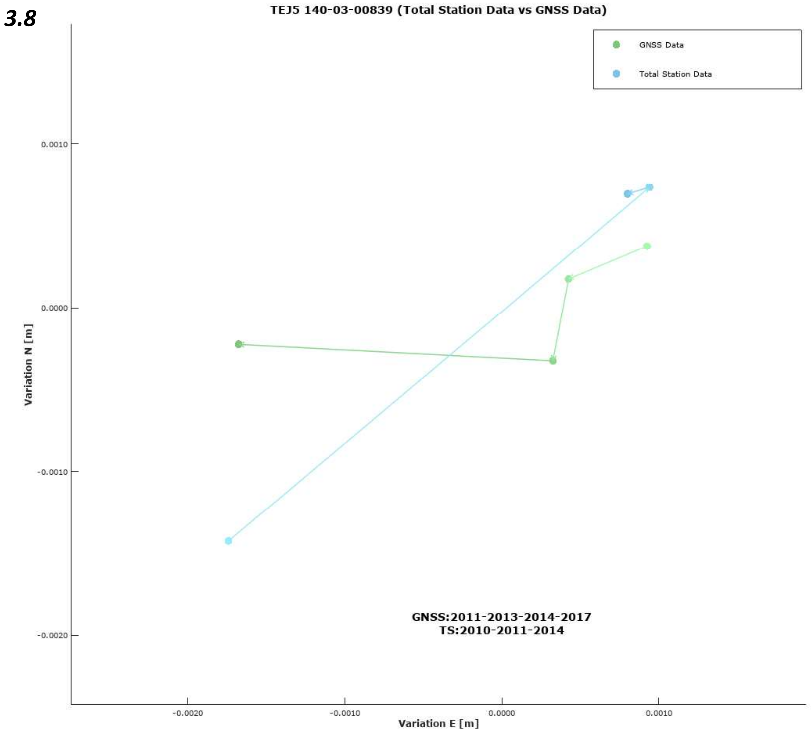
Figur 3.6



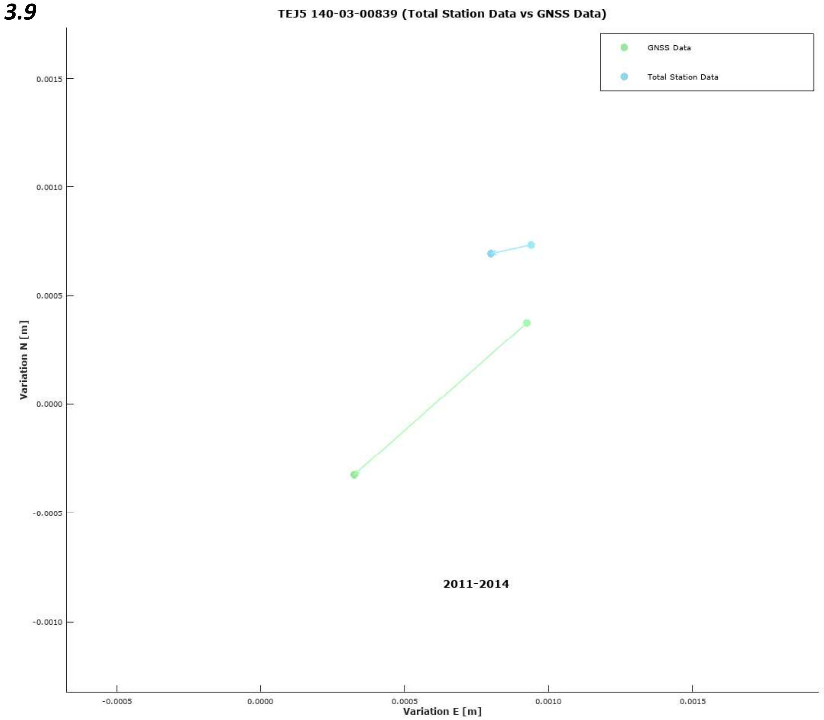
Figur 3.7



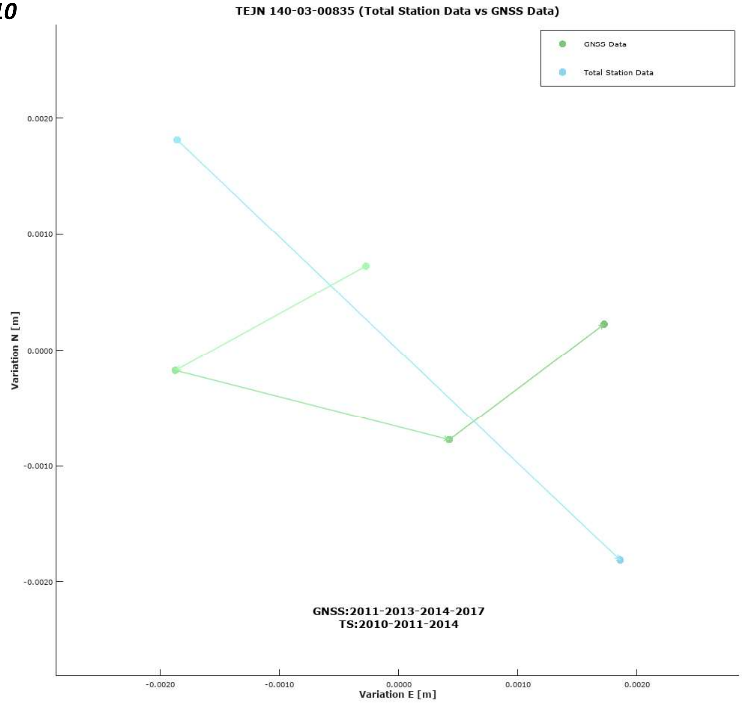
Figur 3.8



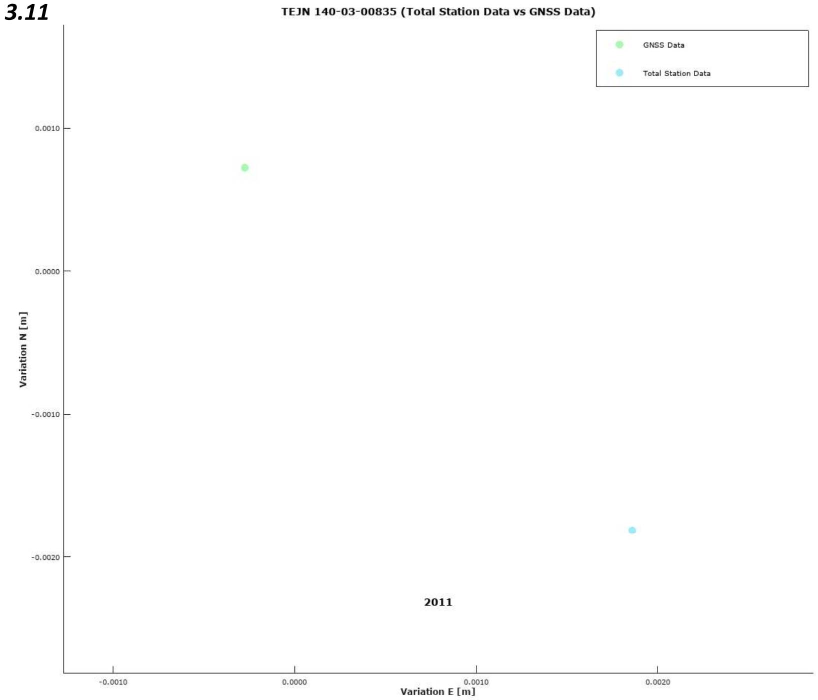
Figur 3.9



Figur 3.10



Figur 3.11



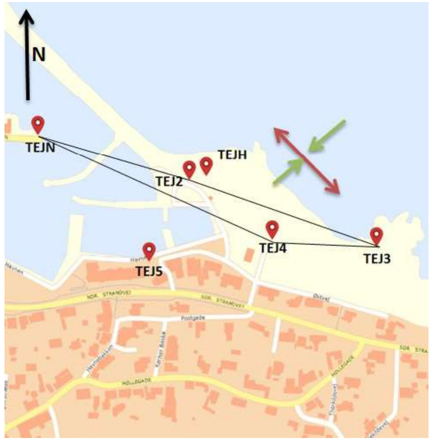
Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2010 vs **2011**	dN TEJ2	-0.74	0.74	<	2.31	Stable
	dE TEJ2	0.85	0.85	<		
	dN TEJ3	0.87	0.87	<		Stable
	dE TEJ3	-1.00	1.00	<		
	dN TEJ4	-0.19	0.19	<		Stable
	dE TEJ4	0.97	0.97	<		
	dN TEJN	0.89	0.89	<		Stable
	dE TEJN	-0.92	0.92	<		
2010 vs **2014**	dN TEJ2	-0.52	0.52	<	2.31	Stable
	dE TEJ2	0.68	0.68	<		
	dN TEJ3	0.40	0.40	<		Stable
	dE TEJ3	-0.92	0.92	<		
	dN TEJ4	0.07	0.07	<		Stable
	dE TEJ4	1.03	1.03	<		
	dN TEJN	0.64	0.64	<		Stable
	dE TEJN	-0.80	0.80	<		

Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	0.000008		
ε_{EE}	0.000020		
ε_{simple}	0.000030		
ε_{pure}	-0.000006		
ε_{MAX}	0.000044	+ extension	4.4 ppm
ε_{MIN}	-0.000016	- contraction	-1.6 ppm
2θ	-75.4476		
θ	162.2762	direction of the maximum principal axis, clockwise from N-axis	

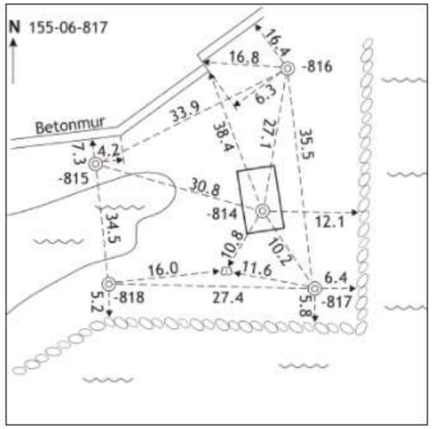
APPENDIX 11 - FYNSHAV [FYHA]

Tidserie: 81148

GPS Antenna	***FYHA 155-06-00814***
Nærkontrol	***FYH1 155-06-00815*** → **JessenPunkt**
	FYH2 155-06-00816
	FYH3 155-06-00817
	FYH4 155-06-00818
Fjernkontrol	***FHAV 155-06-00813 G.I.2113***
Bolter i fundament	***155-06-09075***
	155-06-09076
	155-06-09077
	155-06-09078

1. Skitser:

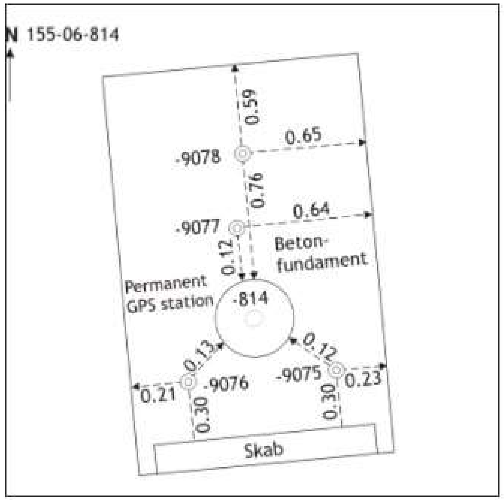
Figur 1.1



Figur 1.2

Notes:

- The A-test shows stability for the majority of the considered points. Manual analysis indicates the station is also stable.
- In terms of planimetric coordinates: pay attention to FYH2. The congruence test also shows relative instability for FYH2.
- Strain analysis doesn't indicate predisposition to local instability.



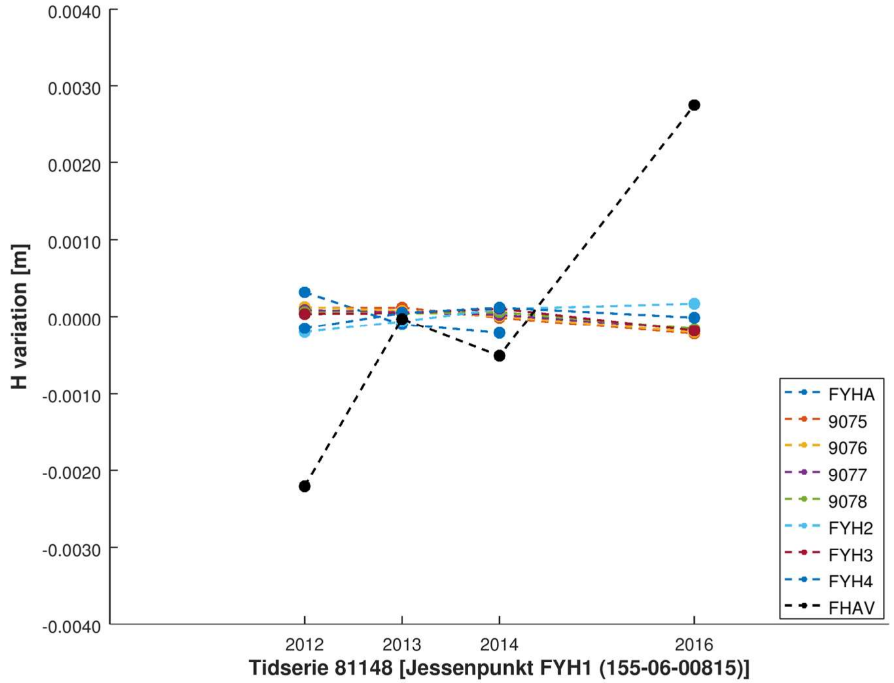
Figur 1.3

2. NIVELLEMENT

- ***Initial plots***
- ***Regression analysis***

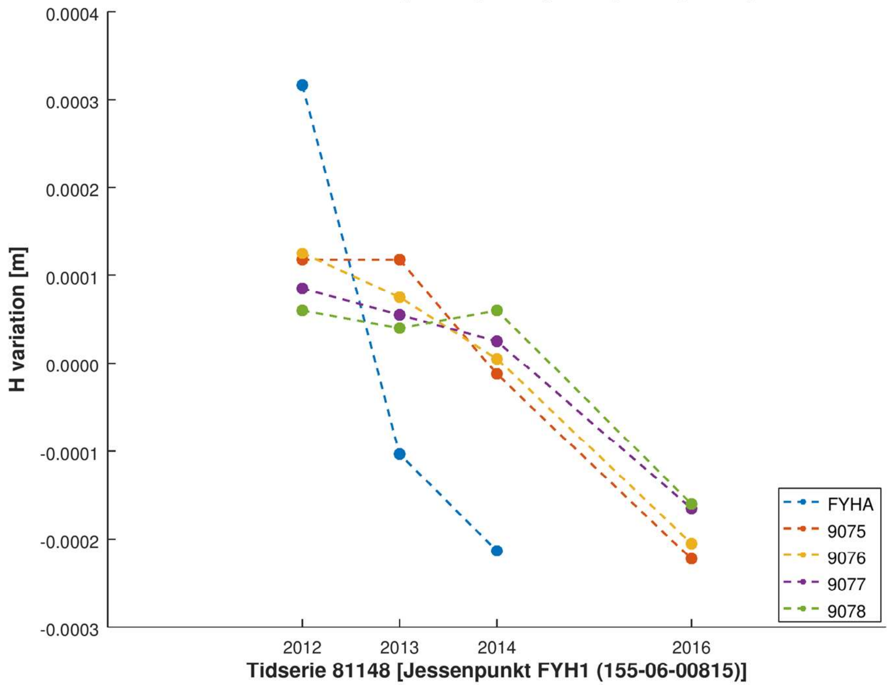
Figur 2.2

FYHA Station



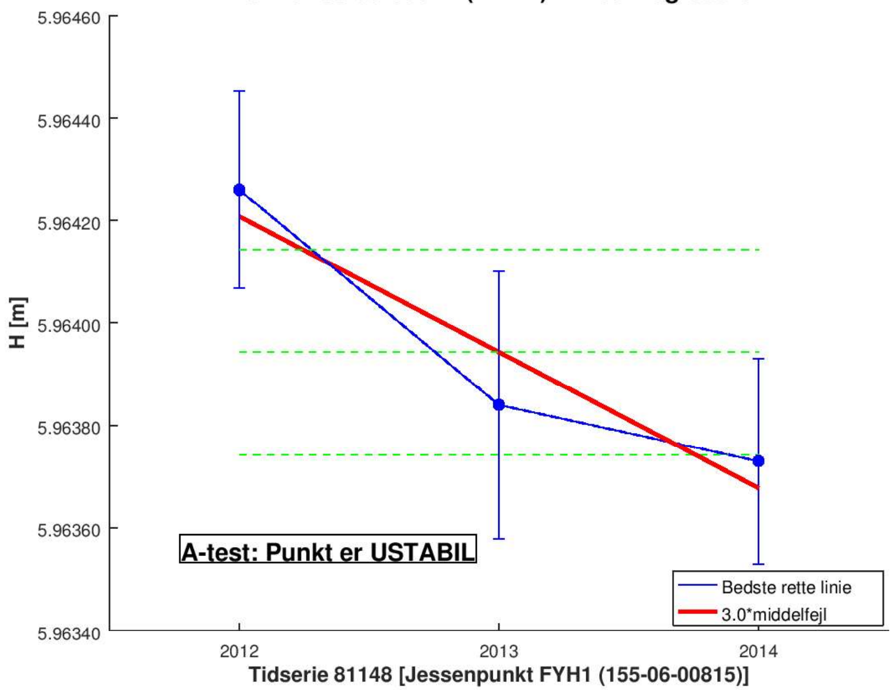
Figur 2.1

FYHA Station (FYHA, 9075, 9076, 9077, 9078)

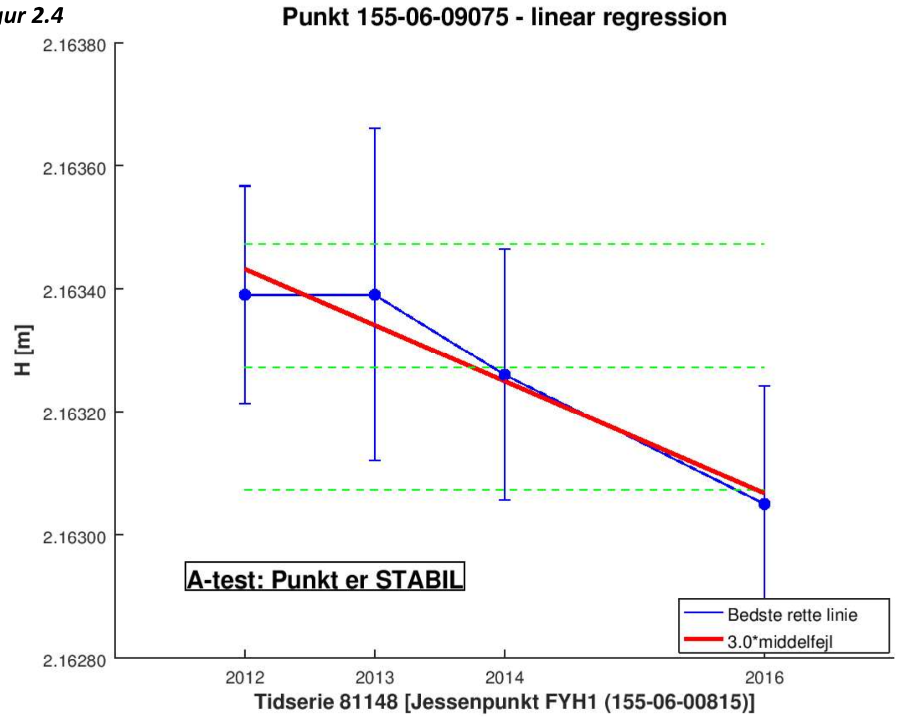


Figur 2.3

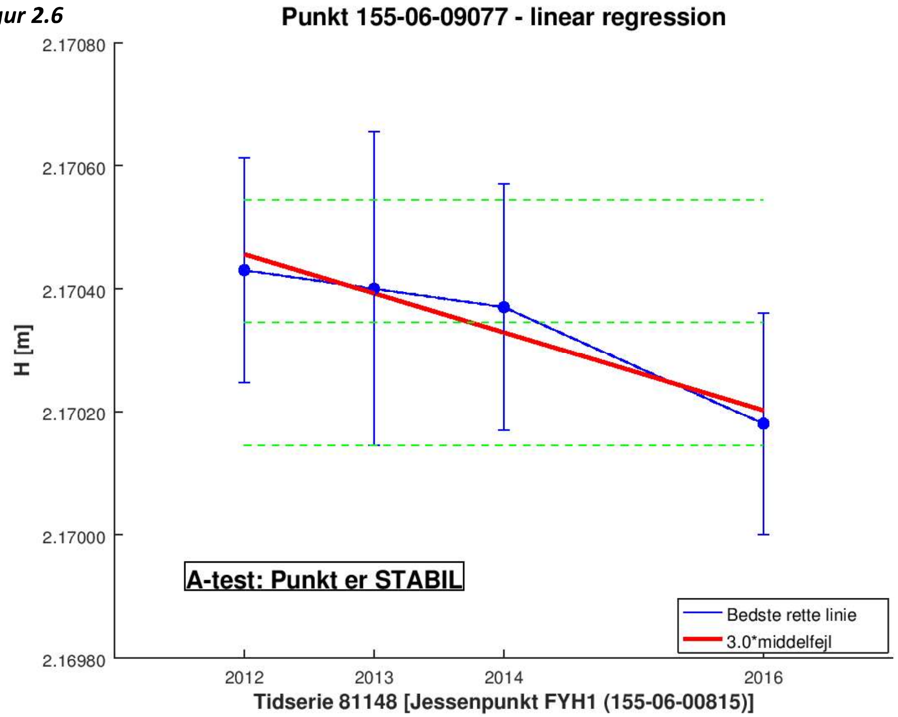
Punkt 155-06-00814 (FYHA) - linear regression



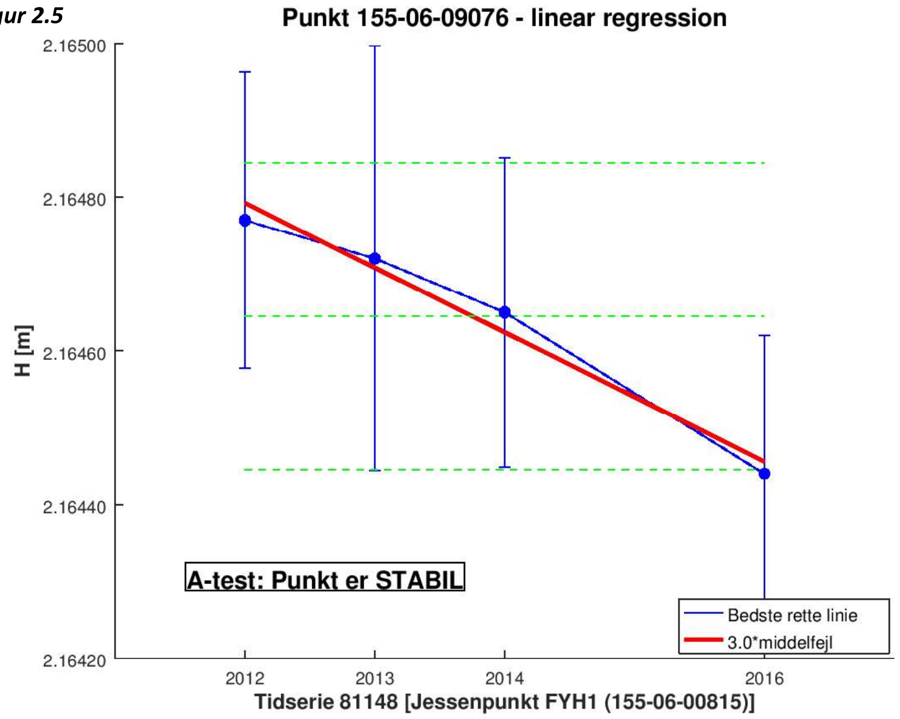
Figur 2.4



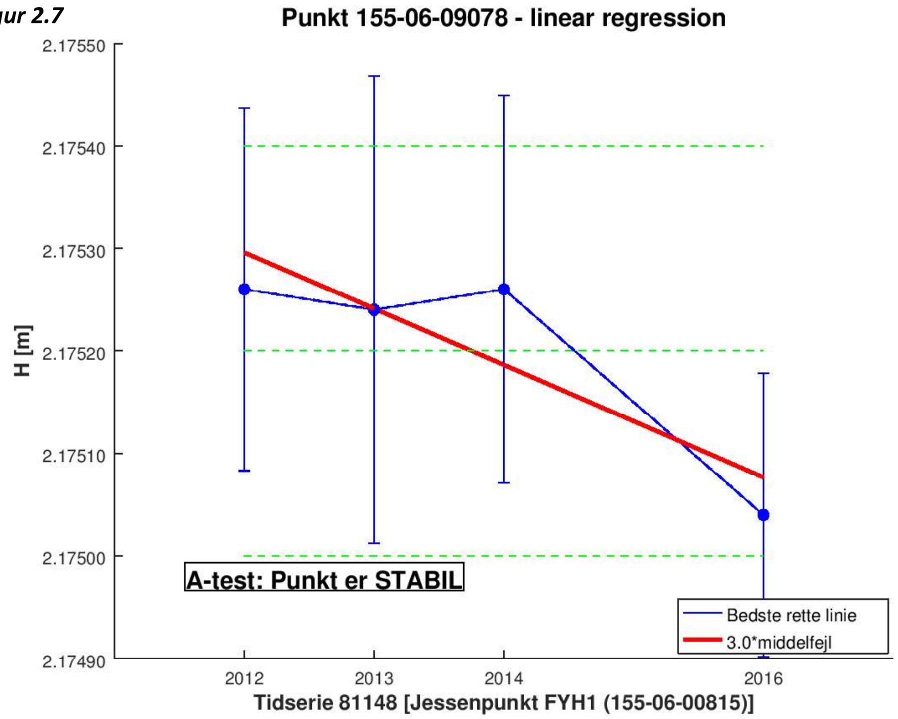
Figur 2.6



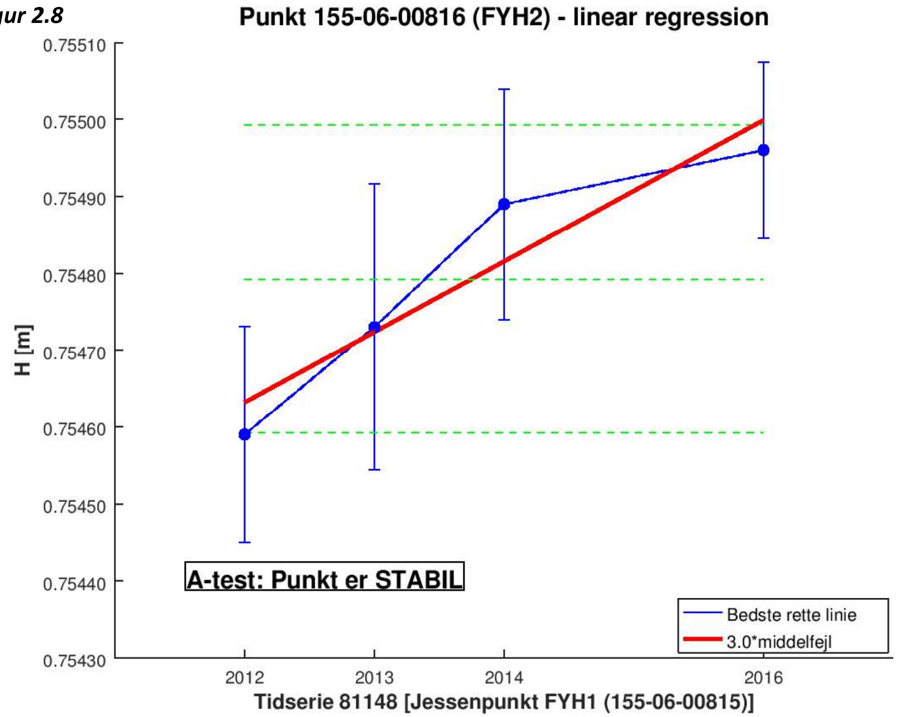
Figur 2.5



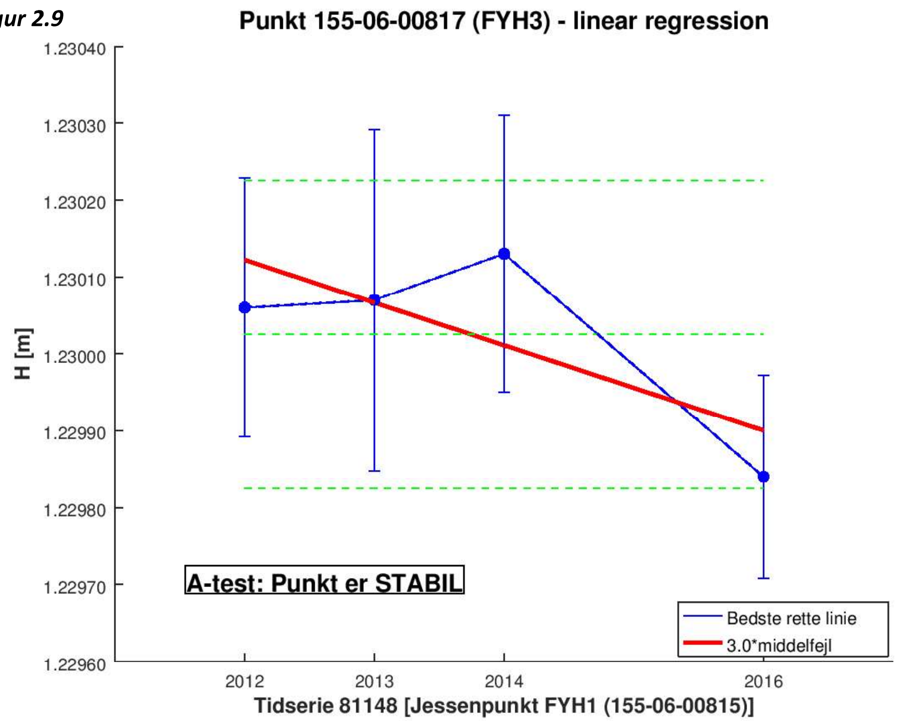
Figur 2.7



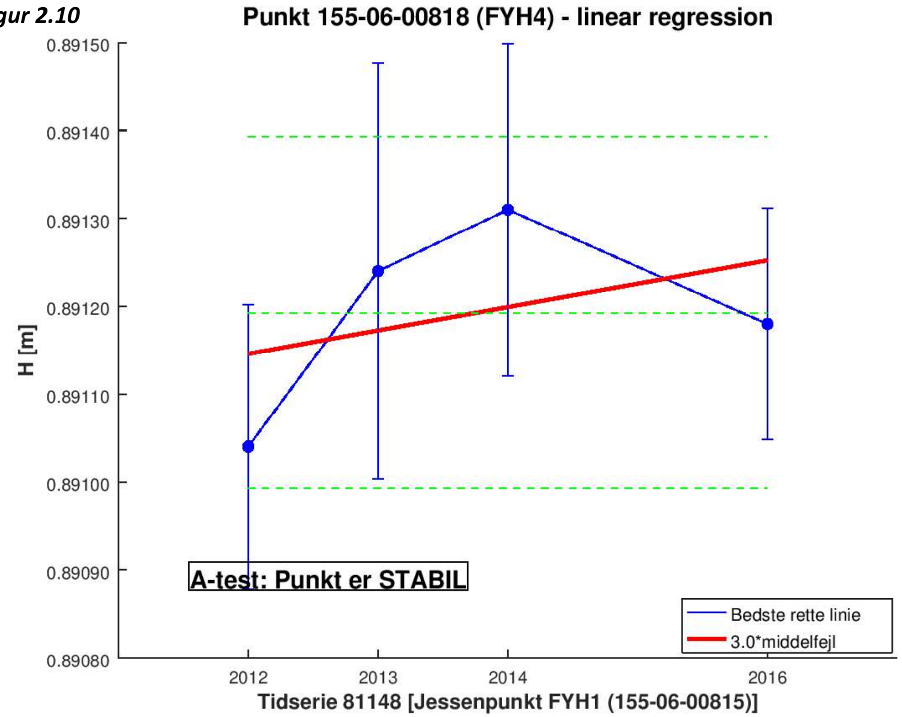
Figur 2.8



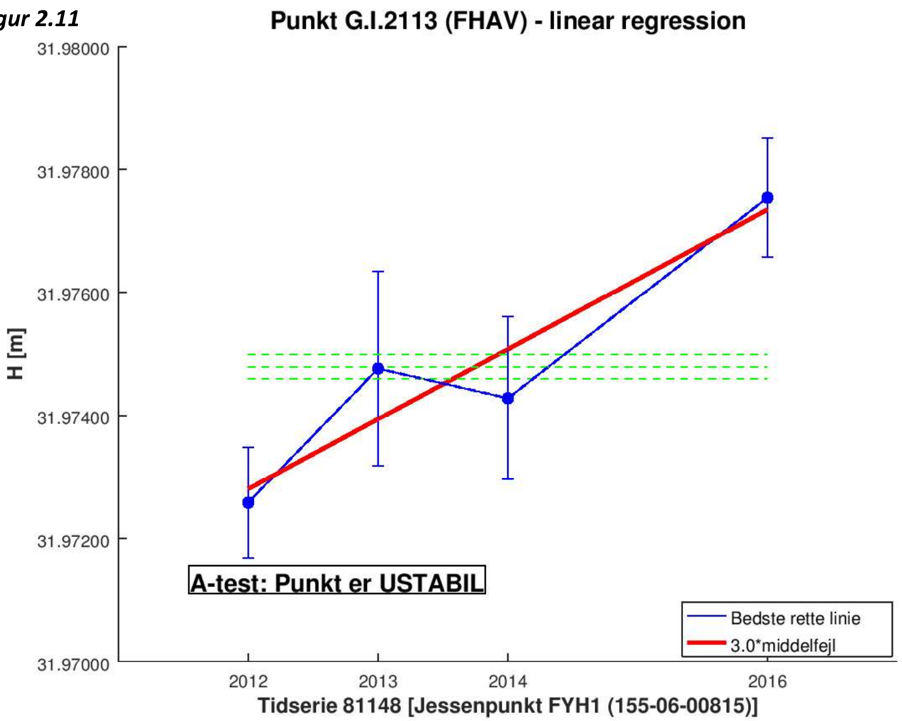
Figur 2.9



Figur 2.10



Figur 2.11



Tests: 'Ignore limit' for stability test [previously 0.4 mm]

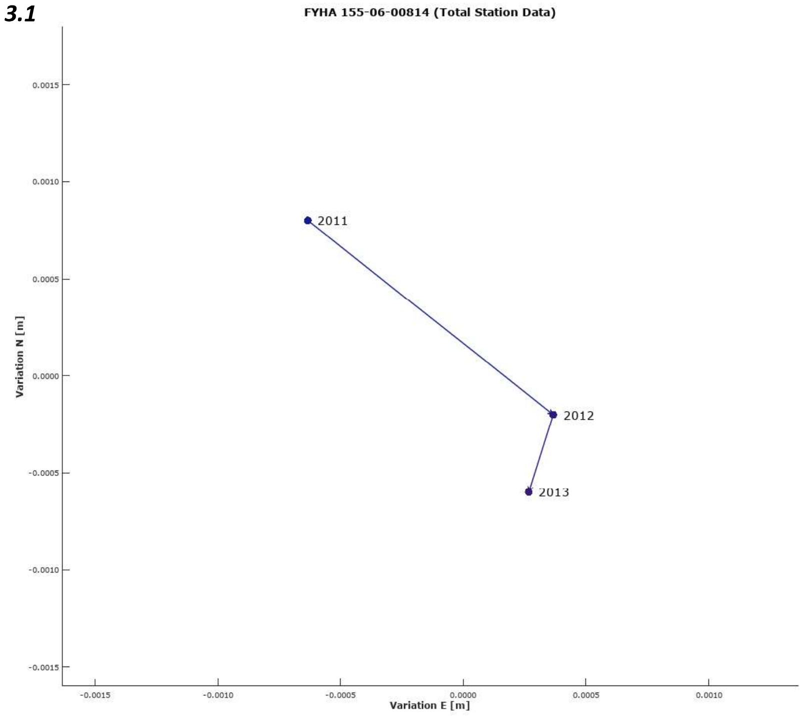
Constant Value [mm]	Station: FYHA								
	Antenna	Sikringspunkter				Nærkontrol			Fjernkontrol
	FYHA	9075	9076	9077	9078	FYH2	FYH3	FYH4	FHAV
0.3	ustabil	ustabil	ustabil	stabil	stabil	ustabil	stabil	stabil	ustabil
0.4	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
0.5	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
0.6	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
0.8	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
1	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil

3. PLANIMETRIC ANALYSIS

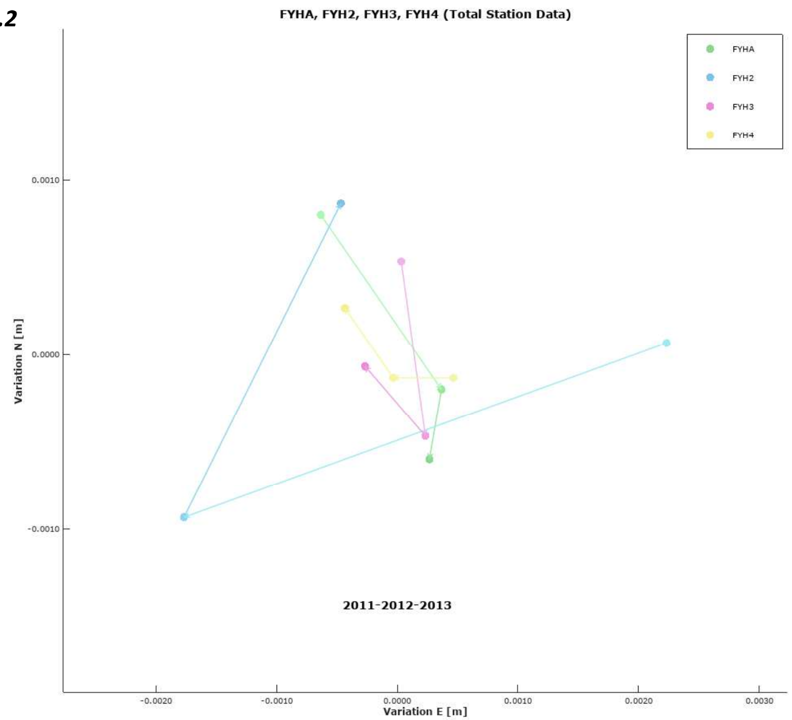
- *Initial plots TS*
- *Initial plots GNSS*
- *Comparison GNSS vs TS*
- *Global Congruence Test*
- *Strain Analysis*

!! In order to avoid too many labels, in the following plots, different color nuances are used to depict the evolution of the time series, from a light color to a dark color. Ex: the series starts from light green for the first year and ends with dark green for the last.

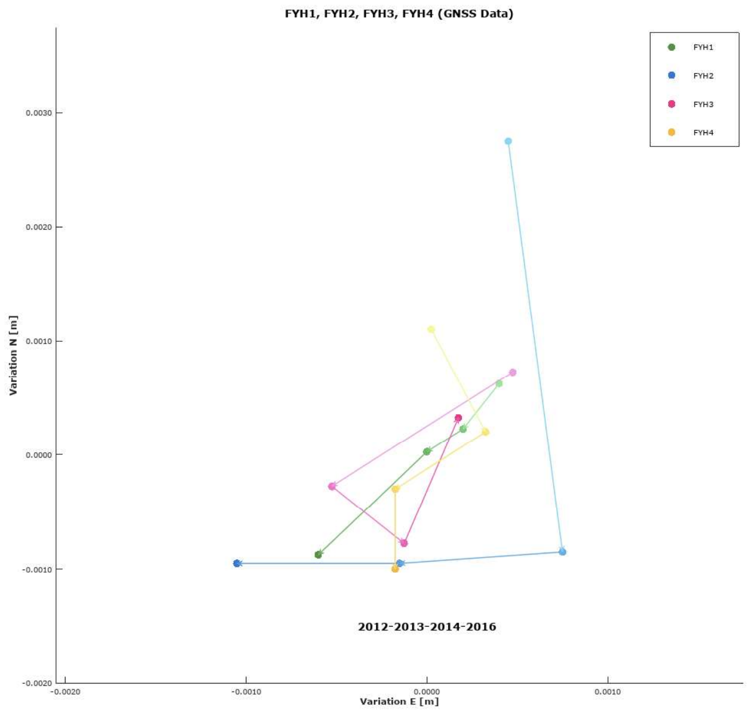
Figur 3.1



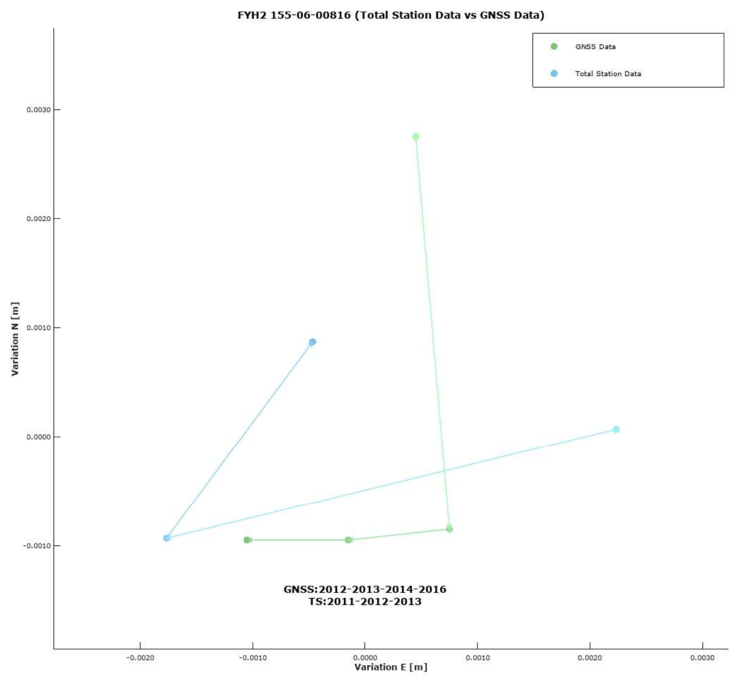
Figur 3.2



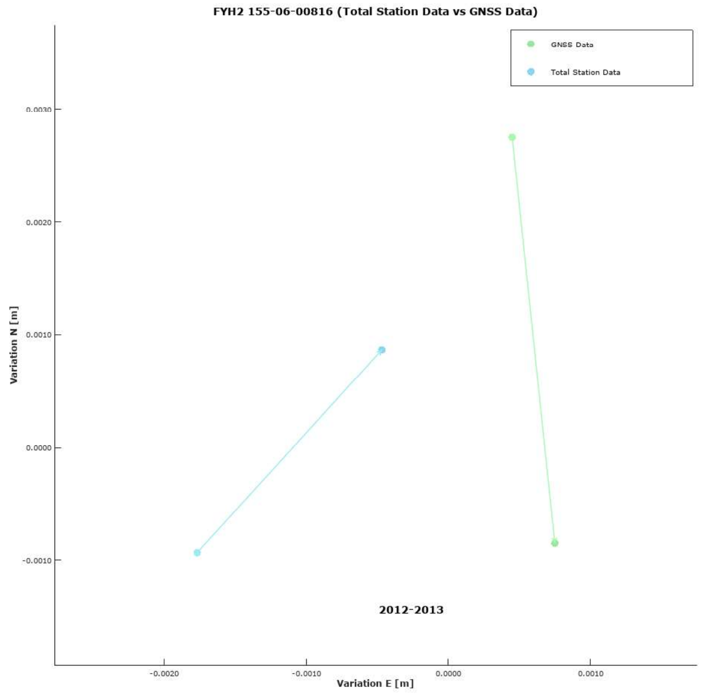
Figur 3.3



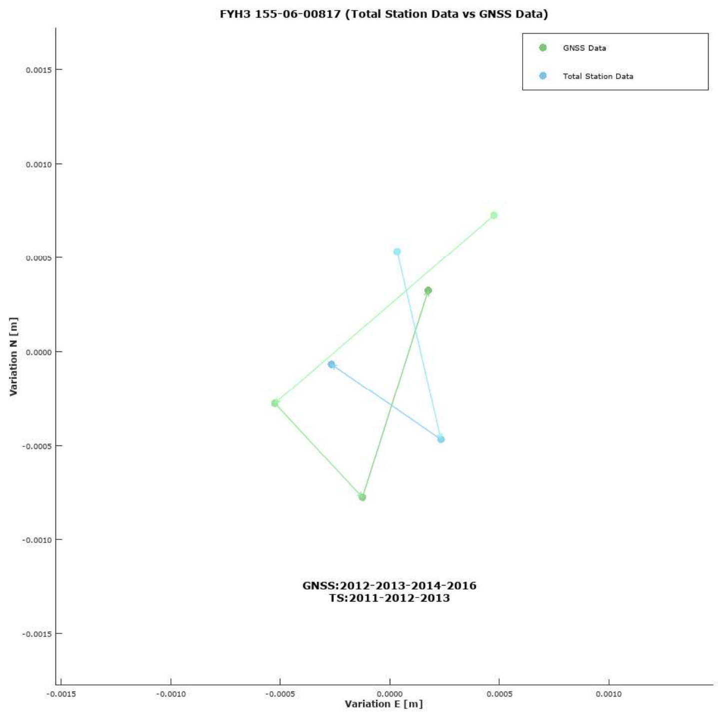
Figur 3.4



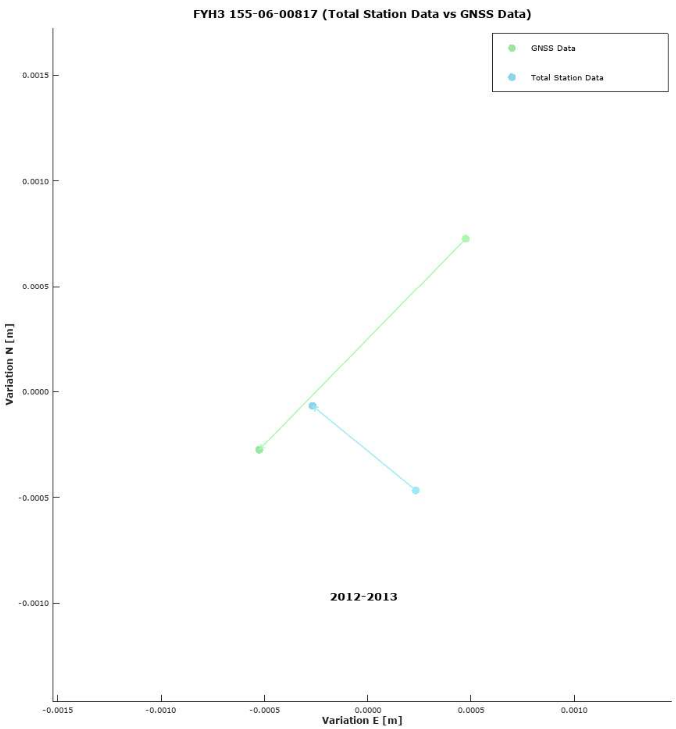
Figur 3.5



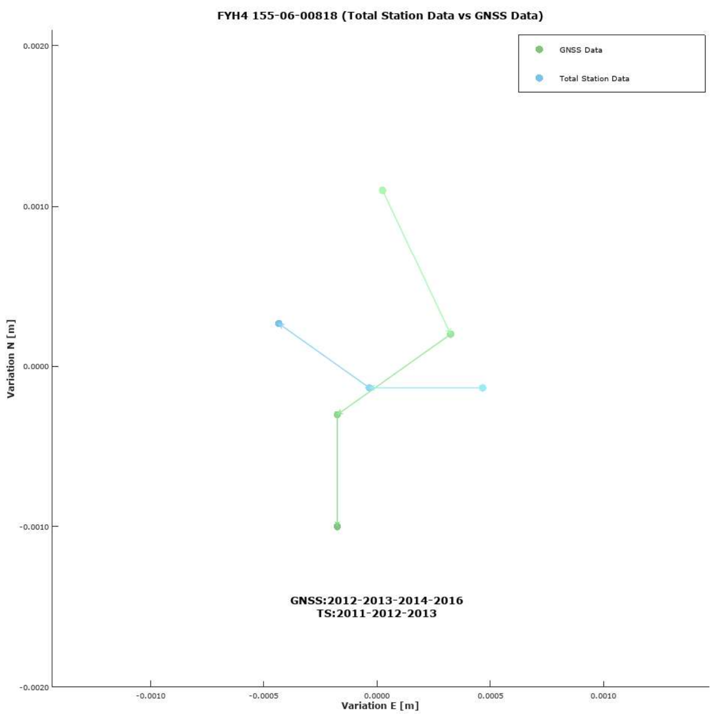
Figur 3.6



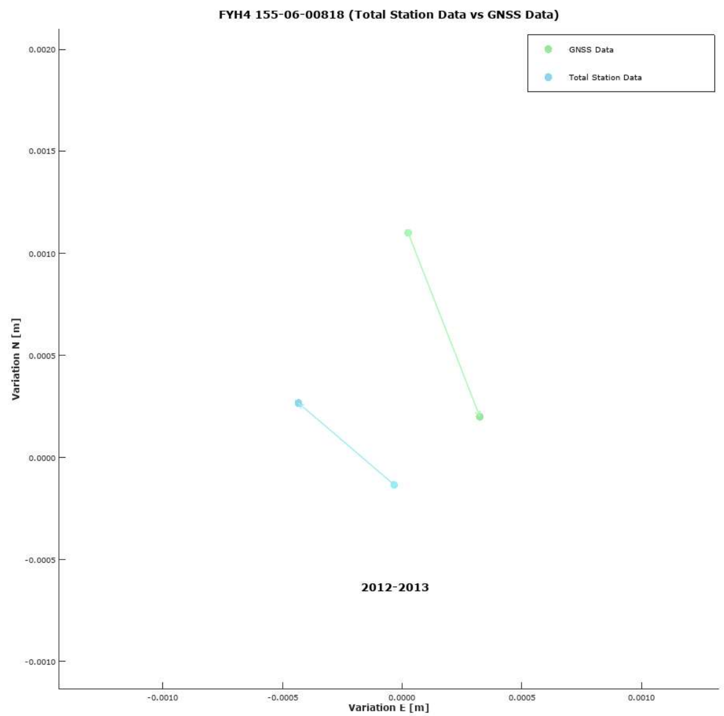
Figur 3.7



Figur 3.8



Figur 3.9

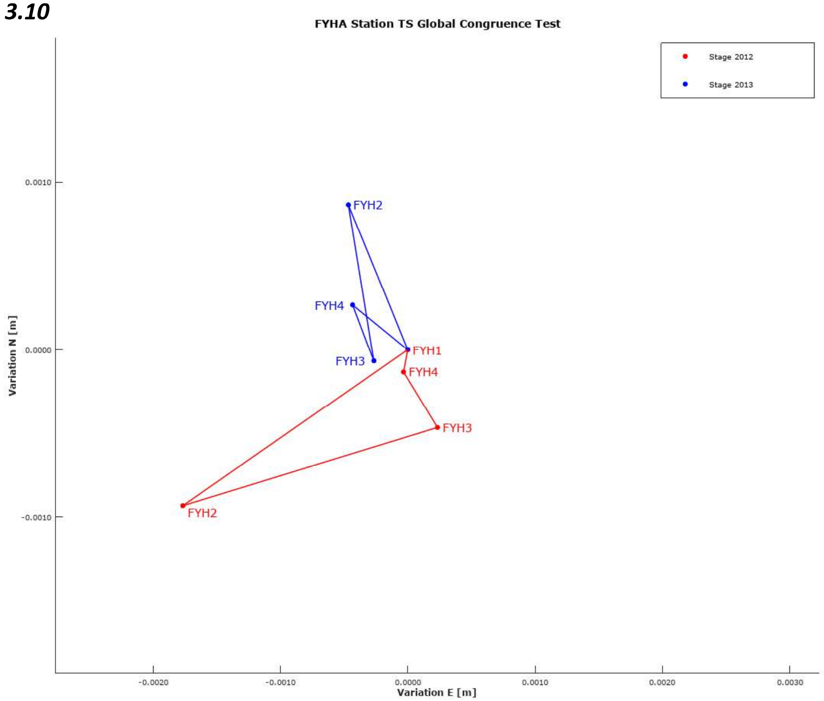


Global Congruence Test

- Compares the geometry of a network at two different stages in time;
- Uses only measured horizontal directions;
- Shows if any of the points are unstable (their position changed significantly between the two stages).

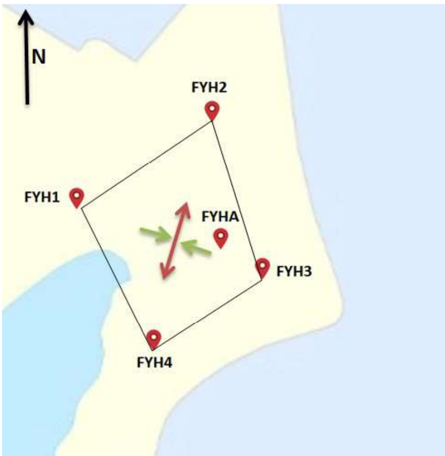
Stages	STUDENT TEST	t_j	$\|t_j\|$		t_{lim}	Stability
2012 vs **2013**	dN FYH1	-2.69	2.69	>	2.31	Unstable
	dE FYH1	0.55	0.55	<		
	dN FYH2	3.05	3.05	>		Unstable
	dE FYH2	1.94	1.94	<		
	dN FYH3	-0.36	0.36	<		Stable
	dE FYH3	-2.31	2.31	<		
	dN FYH4	1.02	1.02	<		Stable
	dE FYH4	-0.21	0.21	<		

Figur 3.10



Strain Analysis

- Provides information about the possible tensions present in a local area;
- Uses only point coordinates in two temporal stages;
- Indicates in which direction the network points are predisposed to instability.



ε_{NN}	-0.000001		
ε_{EE}	0.000001		
ε_{simple}	-0.000002		
ε_{pure}	-0.000001		
ε_{MAX}	0.000003	+ extension	0.3 ppm
ε_{MIN}	-0.000002	- contraction	-0.2 ppm
2θ	53.3730		
θ	226.6865	direction of the maximum principal axis, clockwise from N-axis	

APPENDIX 12 – Stability algorithm testing

Constant Value [mm]	Station: BUDP						
	Antenna	Sikringspunkter			Nærkontrol		
	BUDP	9113	9114	9115	BUD1	BUD3	BUDD
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
1	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
1.5	ustabil	stabil	stabil	stabil	ustabil	ustabil	ustabil
2	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil

Table 1 – Test results for BUDP station

Constant Value [mm]	Station: SMID								
	Antenna	Sikringspunkter			Nærkontrol			Fjernkontrol	
	SMID	9058	9059	9060	SKR2	SKRP	SKR4	VEJL	KORE
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	stabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	stabil	ustabil	stabil	stabil
1	ustabil	ustabil	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil
1.5	ustabil	stabil	stabil	stabil	ustabil	stabil	stabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

Table 2 – Test results for SMID station

Constant Value [mm]	Station: SULD							
	Antenna	Sikringspunkter			Nærkontrol			Fjernkontrol
	SULD	9023	9024	9025	SUL1	SUL2	SUL4	GRAV
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
1	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
1.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
2	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil

Table 3 – Test results for SULD station

Constant Value [mm]	Station: ESBH			
	Antenna	Nærkontrol		Fjernkontrol
	ESBH	ESH2	ESH3	HAVN
0.3	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	ustabil	stabil
0.8	ustabil	ustabil	ustabil	stabil
1	ustabil	ustabil	ustabil	stabil
1.5	ustabil	ustabil	ustabil	stabil
2	ustabil	ustabil	ustabil	stabil

Table 4 – Test results for ESBH station

Constant Value [mm]	Station: ESBC							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	ESBC	9881	9882	9883	9884	ESC1	ESC3	HAVN
0.3	ustabil	ustabil	stabil	ustabil	stabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	stabil	ustabil	stabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	stabil	ustabil	stabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	stabil	stabil	stabil	ustabil	ustabil	stabil
0.8	ustabil	ustabil	stabil	stabil	stabil	ustabil	ustabil	stabil
1	ustabil	ustabil	stabil	stabil	stabil	ustabil	stabil	stabil
1.5	stabil	stabil	stabil	stabil	stabil	ustabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

Table 5 – Test results for ESBC station

Constant Value [mm]	Station: GESR							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	GESR	9089	9090	9091	9092	GED3	GED4	GEDN
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	stabil	stabil	stabil	ustabil	ustabil	stabil
0.8	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil
1	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil
1.5	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil
2	ustabil	stabil	stabil	stabil	stabil	ustabil	ustabil	stabil

Table 6 – Test results for GESR station

Constant Value [mm]	Station: HIRS							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	HIRS	9181	9182	9183	9184	HIR3	HIR4	HHLS
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	stabil
0.6	ustabil	ustabil	ustabil	ustabil	stabil	ustabil	stabil	stabil
0.8	ustabil	ustabil	stabil	ustabil	stabil	ustabil	stabil	stabil
1	ustabil	ustabil	stabil	ustabil	stabil	ustabil	stabil	stabil
1.5	ustabil	ustabil	stabil	ustabil	stabil	ustabil	stabil	stabil
2	stabil	stabil	stabil	ustabil	stabil	stabil	stabil	stabil

Table 7 – Test results for HIRS station

Constant Value [mm]	Station: FERR								
	Antenna	Sikringspunkter				Nærkontrol			Fjernkontrol
	FERR	9027	9028	9029	9030	FER1	FER2	FER3	FER4	BFYR
0.3	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.4	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.5	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.6	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
0.8	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil	ustabil
1	ustabil	ustabil	stabil	ustabil	ustabil	ustabil	stabil	stabil	stabil	ustabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil

Table 8 – Test results for FERR station

Constant Value [mm]	Station: HABY							
	Antenna	Sikringspunkter				Nærkontrol		Fjernkontrol
	HABY	9031	9032	9033	9034	HAB1	HAB2	HAB4	HBYK
0.3	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.4	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.5	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.6	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
0.8	ustabil	stabil	ustabil	stabil	stabil	stabil	stabil	stabil	stabil
1	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

Table 9 – Test results for HABY station

Constant Value [mm]	Station: TEJH										
	Antenna	Sikringspunkter				Nærkontrol					Fjernkontrol
	TEJH	9100	9101	9102	9103	TEJ2	TEJ3	TEJ4	TEJ5	TEJN	BORR
0.3	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.4	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.5	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.6	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
0.8	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
1	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil

Table 10 – Test results for TEJH station

Constant Value [mm]	Station: FYHA							
	Antenna	Sikringspunkter				Nærkontrol			Fjernkontrol
	FYHA	9075	9076	9077	9078	FYH2	FYH3	FYH4	FHAV
0.3	ustabil	ustabil	ustabil	stabil	stabil	ustabil	stabil	stabil	ustabil
0.4	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
0.5	ustabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
0.6	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
0.8	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
1	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
1.5	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil
2	stabil	stabil	stabil	stabil	stabil	stabil	stabil	stabil	ustabil

Table 11 – Test results for FYHA station

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