CzechGeo workshop, IG ASCR, Prague, 22 November, 2017

Do West Bohemian earthquakes displace the surface ?

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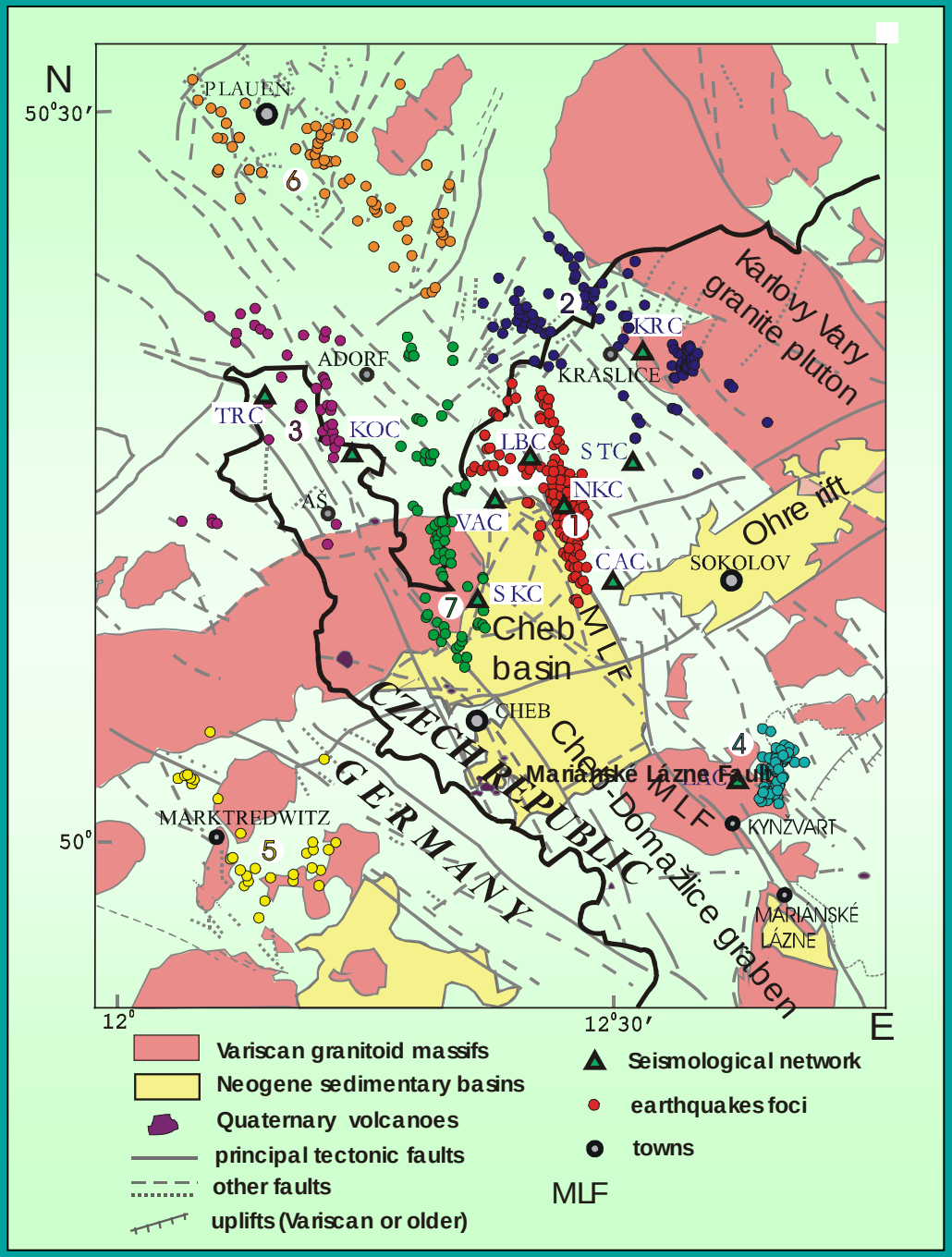
Institute of Geophysics ASCR, Prague, Czech Republic



West Bohemia seismoactive region

- Geology

- Seismicity

Epicentral zones of
1 – Nový Kostel
2 - Kraslice-Klingenthal
7 - Skalná

(Adopted after Horálek et al., 2000)

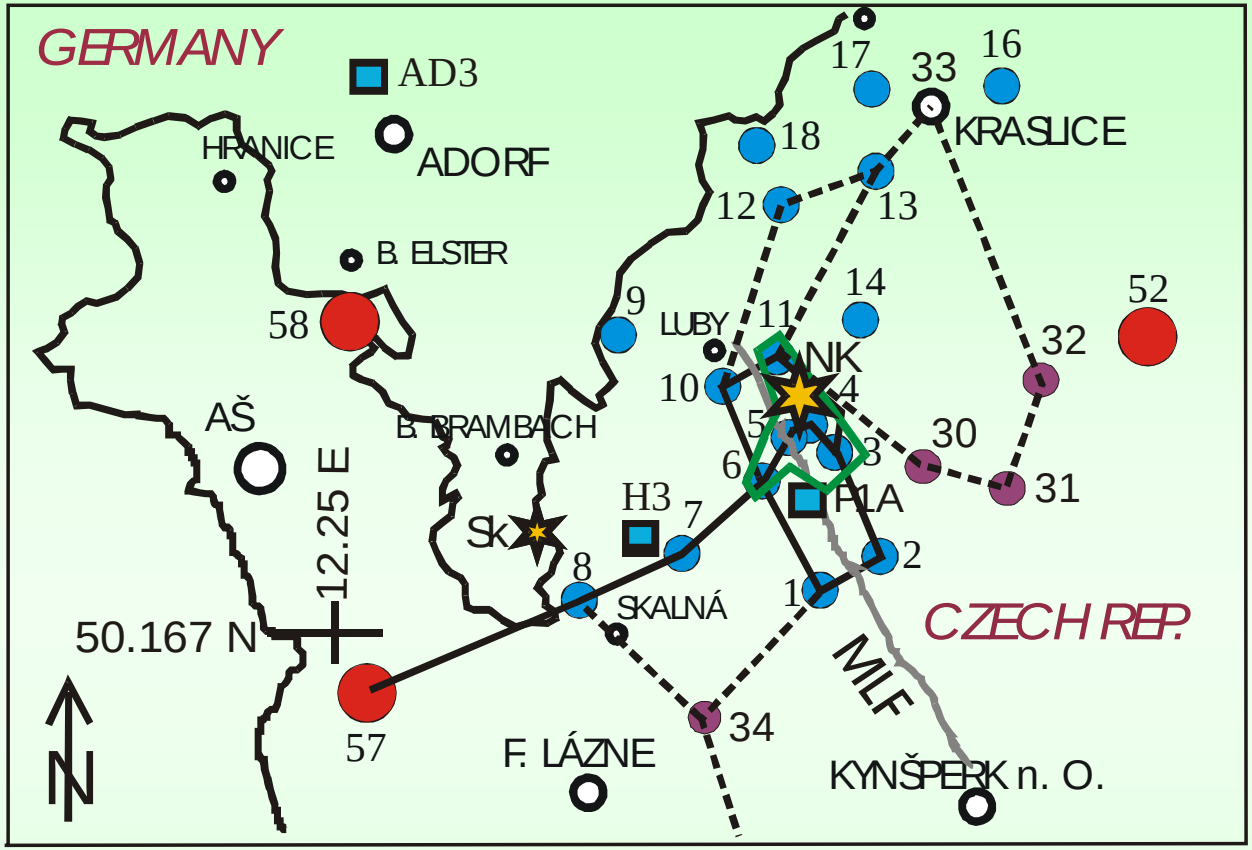
What non-seismological data we may need ?

- GPS, leveling, InSAR – surface dynamics
- Groundwater level, CO2 – fluids dynamics
- 4D Gravity – stress changes, pore pressure
- Tilts – blocks dynamics
- Volcanological research – magma activity
- DEM analysis, gravity survey, . . . - tectonics

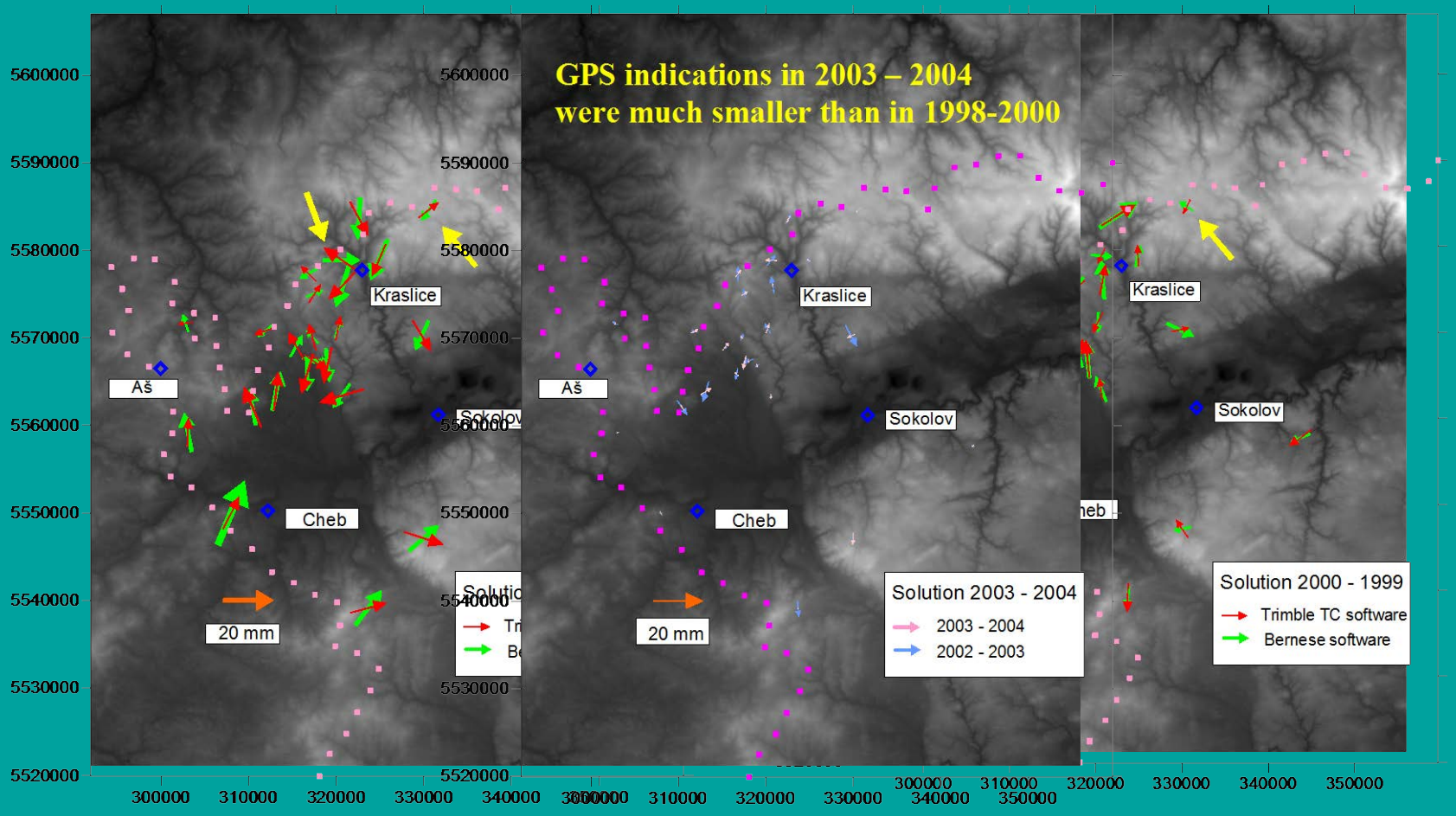
Thanks to EPOS/CzechGeo Project we could mainly improve the observation, data transfer and storage of:

GPS/GNSS, Tilts/Inclination, Groundwater level, Gravity, Precise levelling, Volcanic structures search

Geodynamic network

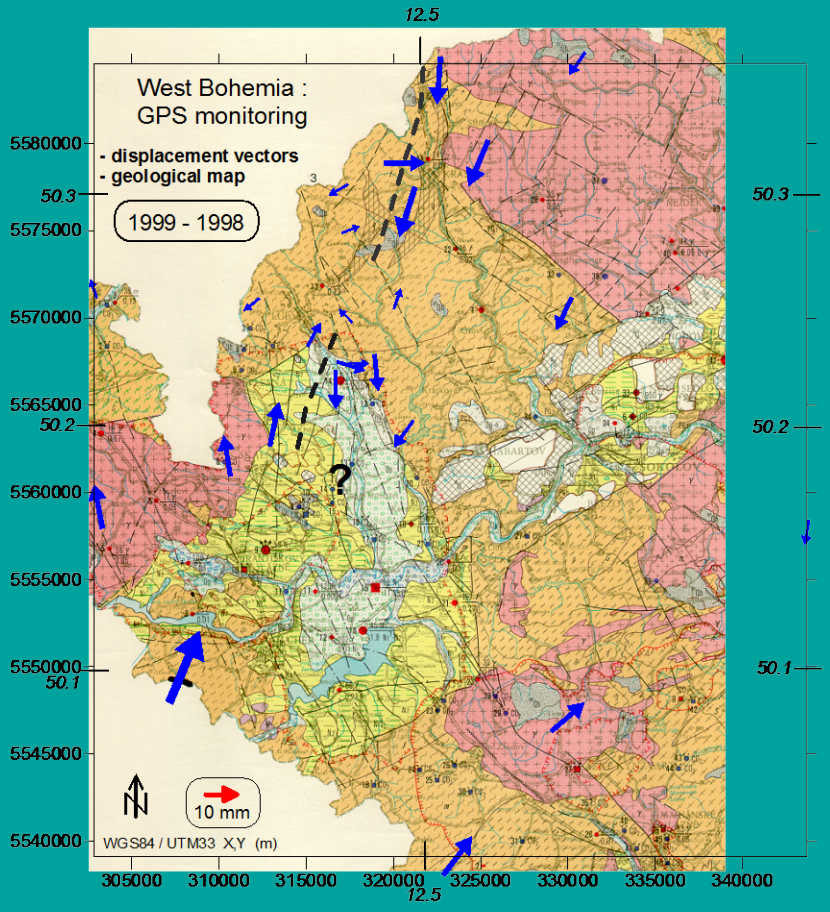


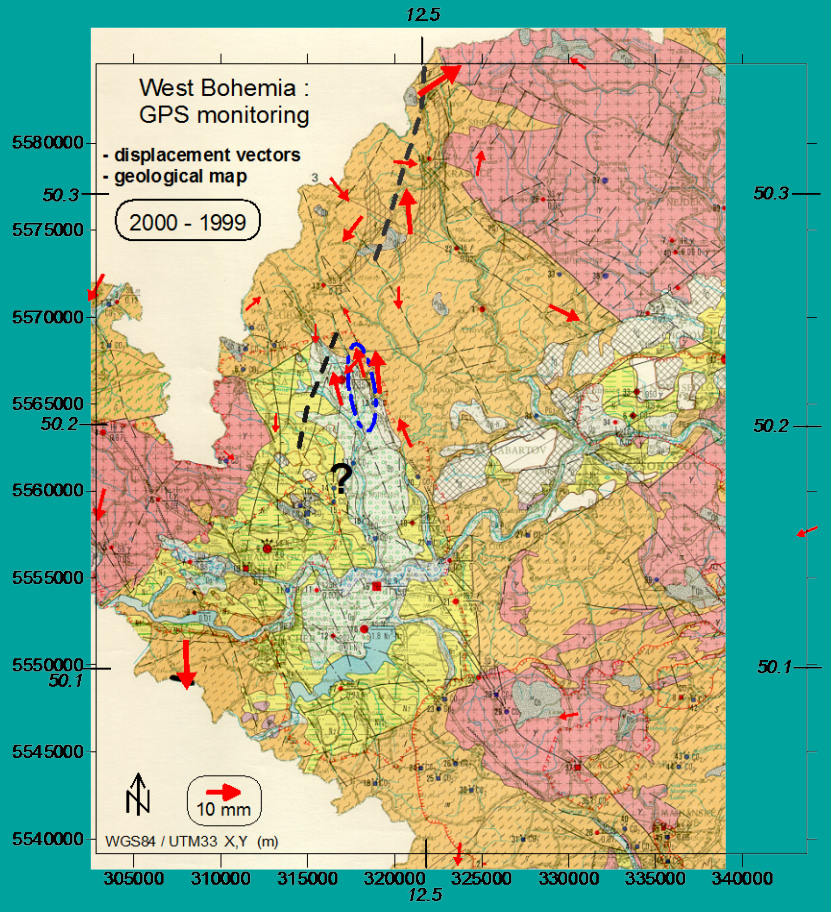
G P S 1998 - 2000



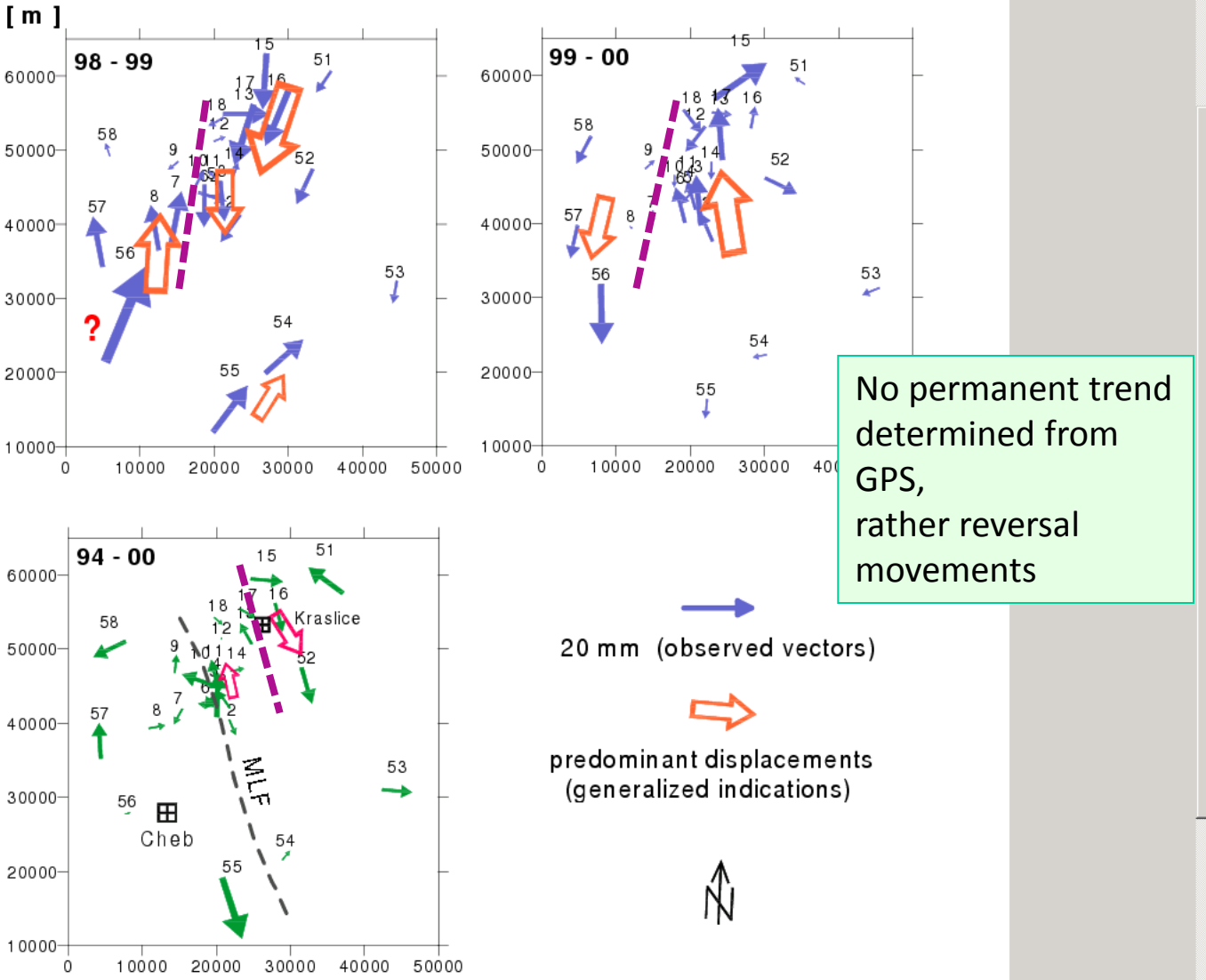
Indications of surface dynamics

From geological map the extent of the Tertiary Cheb basin (yellow) is evident, the basin is surrounded by metamophic rocks (orange) and granites (red). Complete GPS network is presented. The period 1998 – 2000 shows the most remarkable results. Despite no fault is derived from displacements, two black lines were used to highlight the boundary between indications of reverse movements. Blocks aside the division lines of N-S to NNE-SSW direction seem to exhibit dextral movements in 1998-99, and sinistral movements in 1999-2000. This fits the fault plane solutions of the earthquake swarm "Autumn 2000" which showed prevailing sinistral displacements as well (focal zone marked by blue dashed ellipse). Obviously, tectonic regime in the area is not characterized by a long term trend of displacements, but rather by reverse movements.

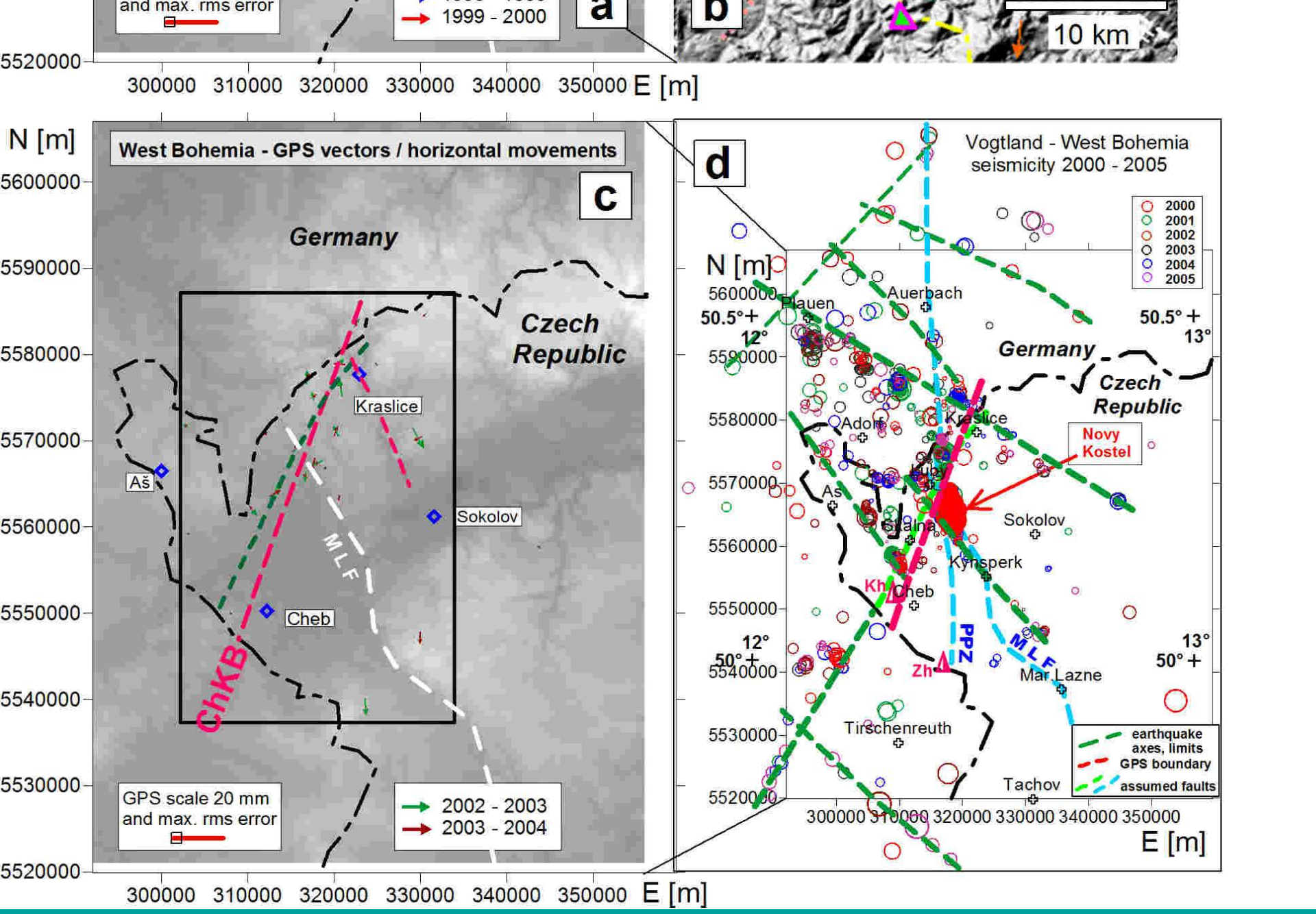




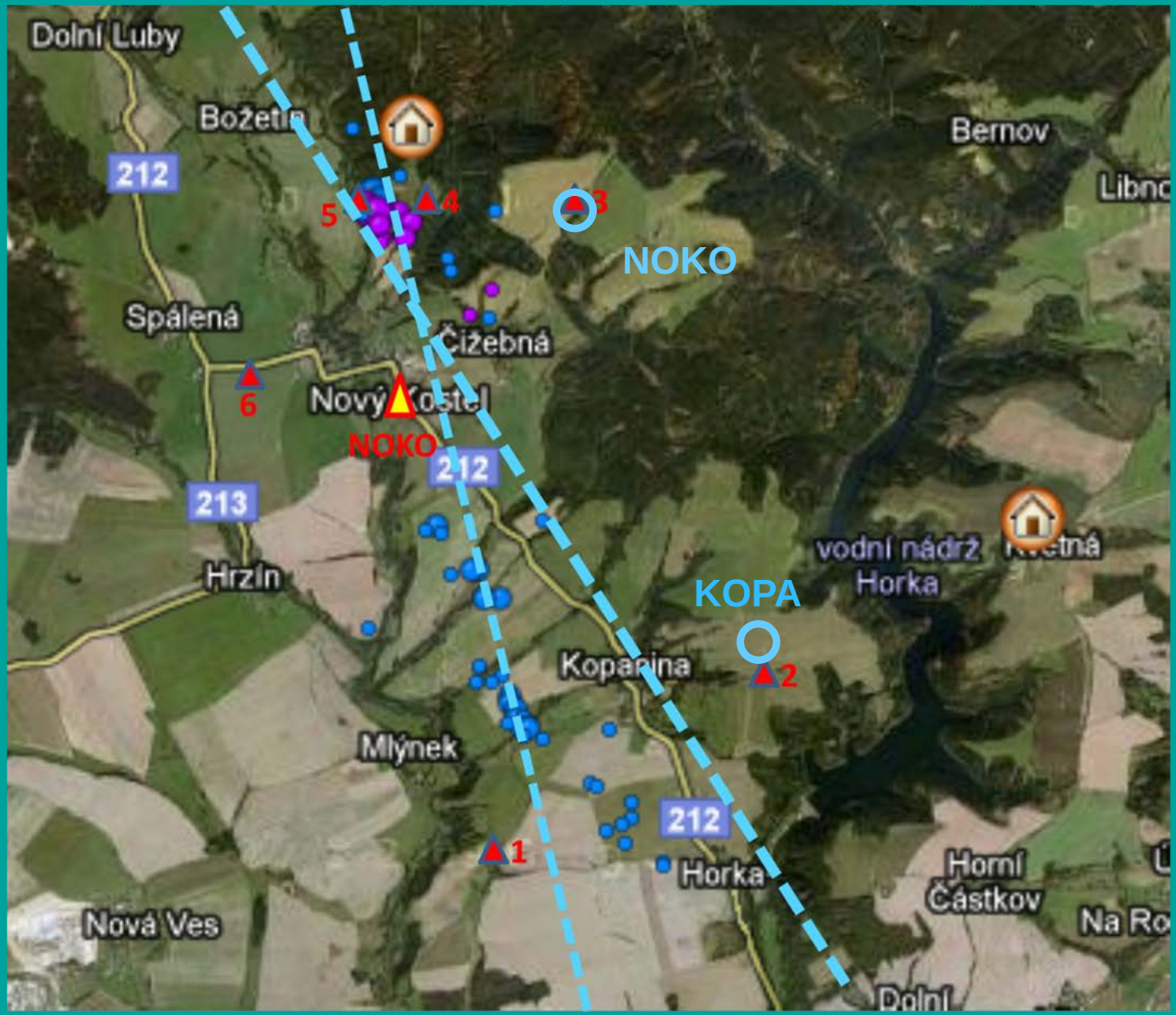
WEST BOHEMIA - horizontal displacements according to GPS period 1998 - 2000

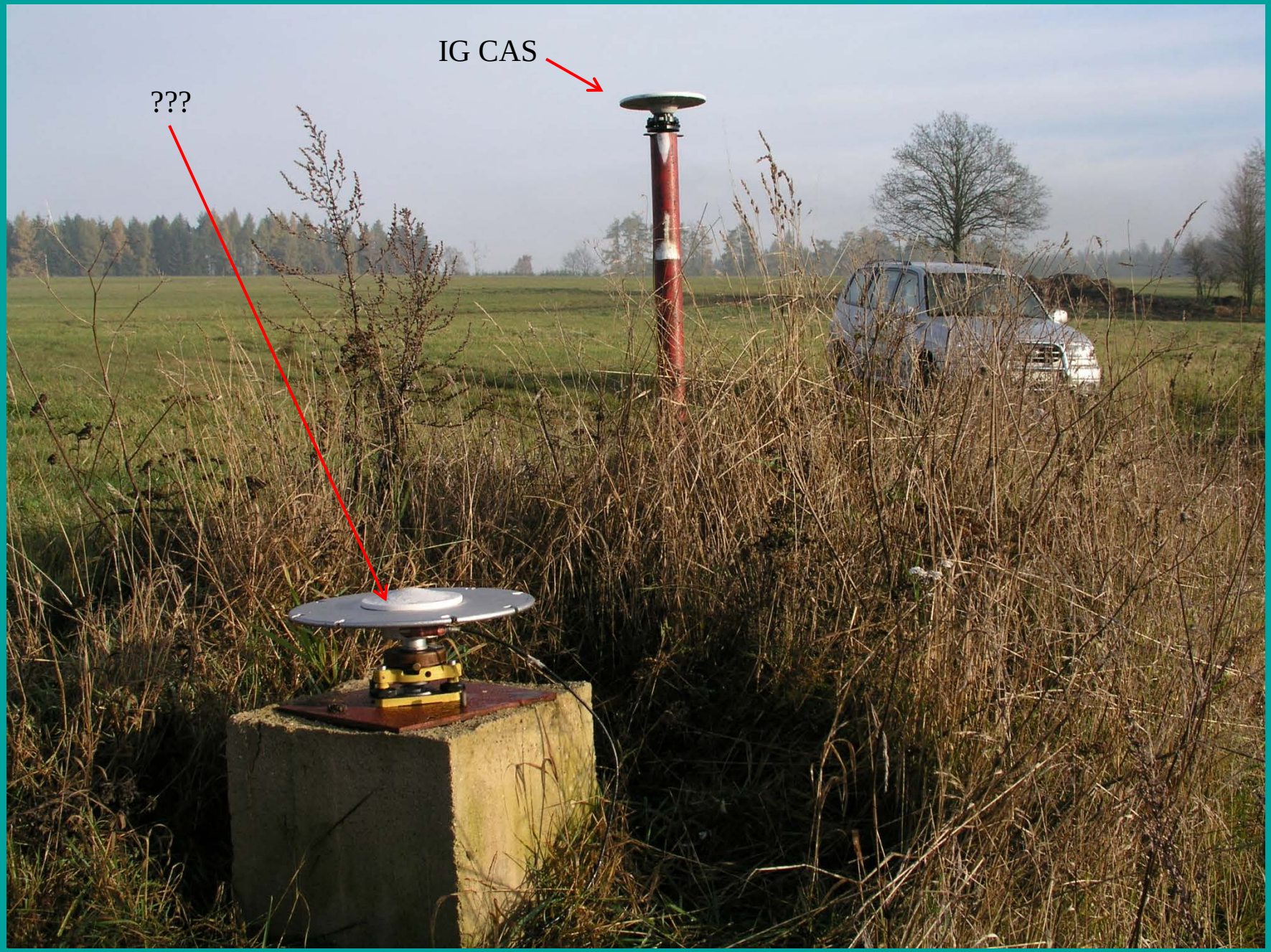


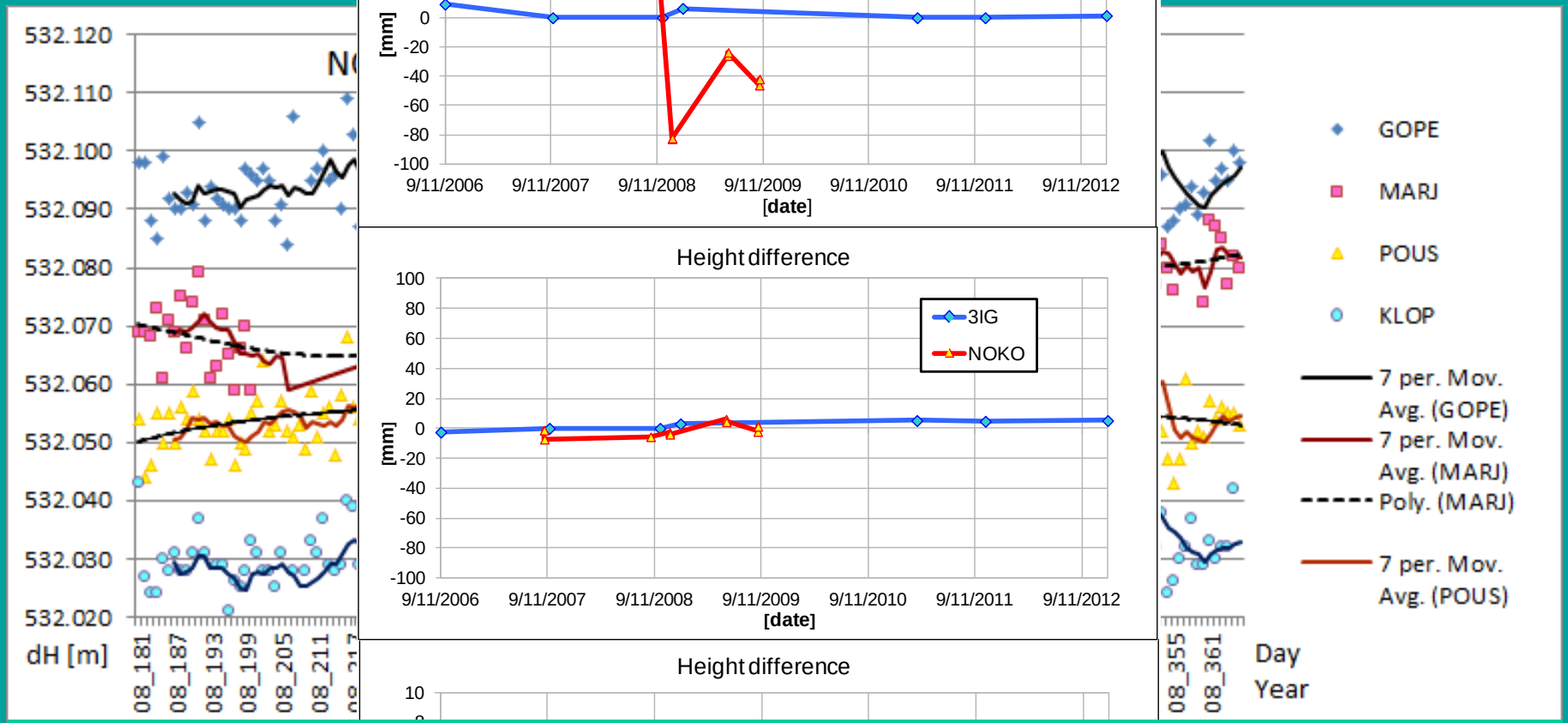
No permanent trend determined from GPS,
rather reversal movements


and max. rms error
1999 - 2000
a
b
10 km
5520000
300000 310000 320000 330000 340000 350000 E [m]
N [m]
West Bohemia - GPS vectors / horizontal movements
c
Germany
Czech Republic
Kraslice
Aš
Sokolov
Cheb
MLF
ChKB
GPS scale 20 mm
and max. rms error
2002 - 2003
2003 - 2004
d
Vogtland - West Bohemia
seismicity 2000 - 2005
2000
2001
2002
2003
2004
2005
Plauen
Auerbach
Adorf
Novy Kostel
Kynsperk
Cheb
Zh
PPZ
Mar Lazne
Tirschenreuth
Tachov
50.5°+
12°
13°
50°+
earthquake axes, limits
GPS boundary
assumed faults

GPS micro-net NOKO

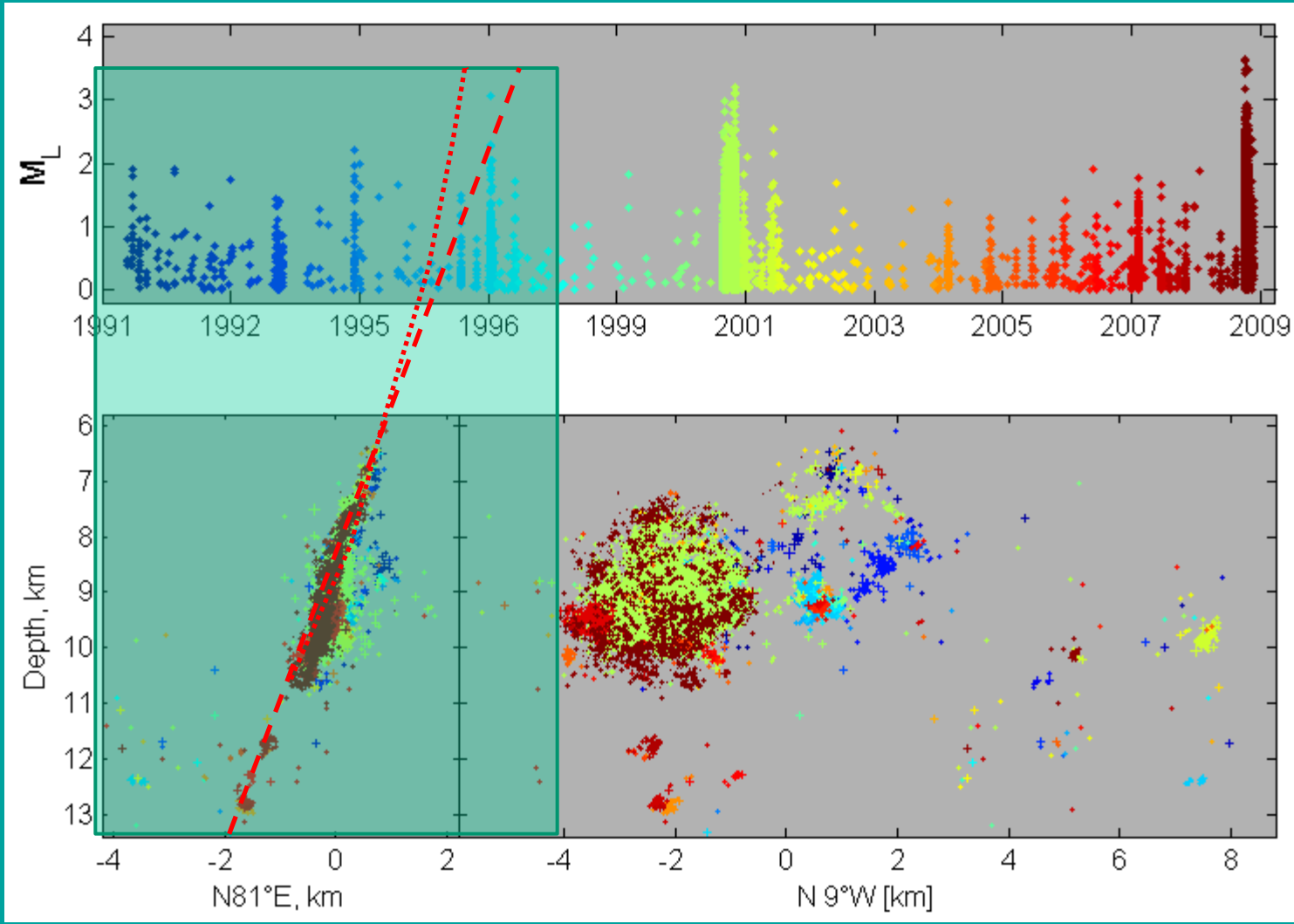



IG CAS
???

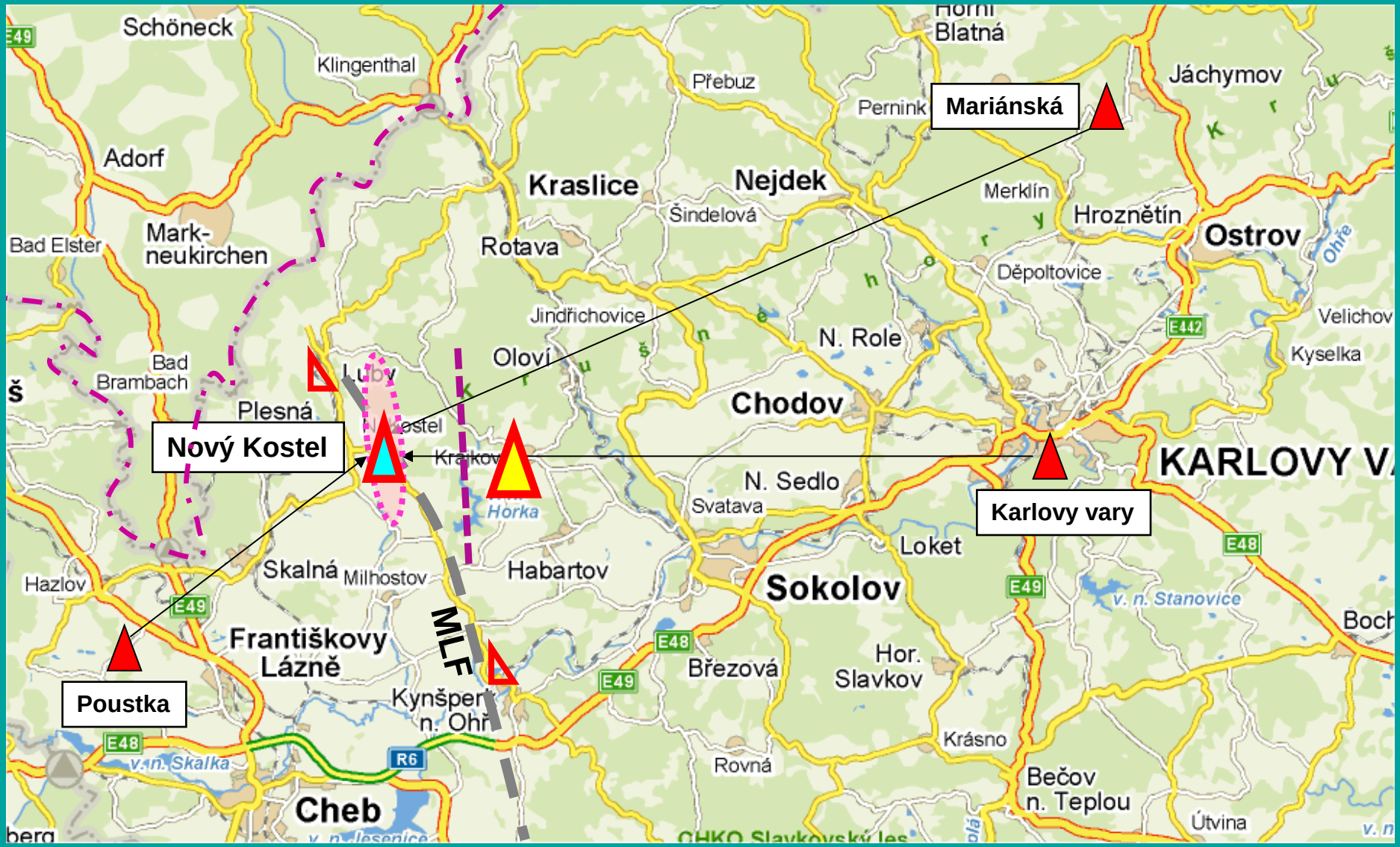


Unfortunately, we don't see any significant vertical displacement over 10 mm in the studied period

Fault projection to surface



Installation of permanent GPS station in Novy Kostel



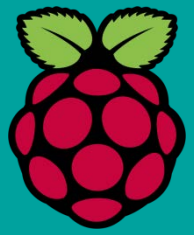
Within *CzechGeo* we intend to set up new permanent GNSS station east of Novy Kostel (east of fault ?)

Updating of GNSS data transfer form permanent observatory NKOS

Trimble 5700 Receiver
- measuring GPS data in 15s interval

Teltonika RUT955
- Linux LTE Router

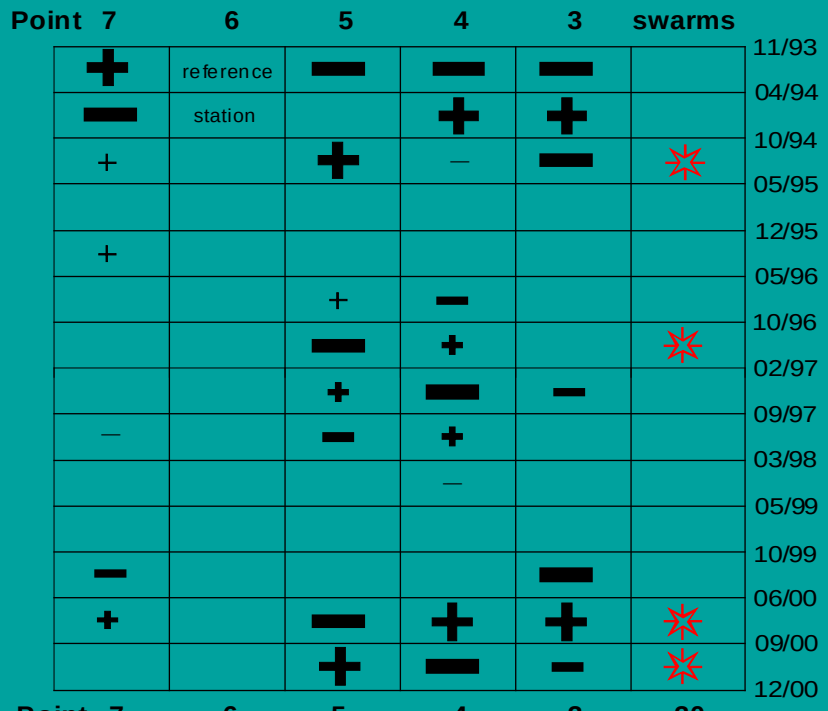
GFU FTP server

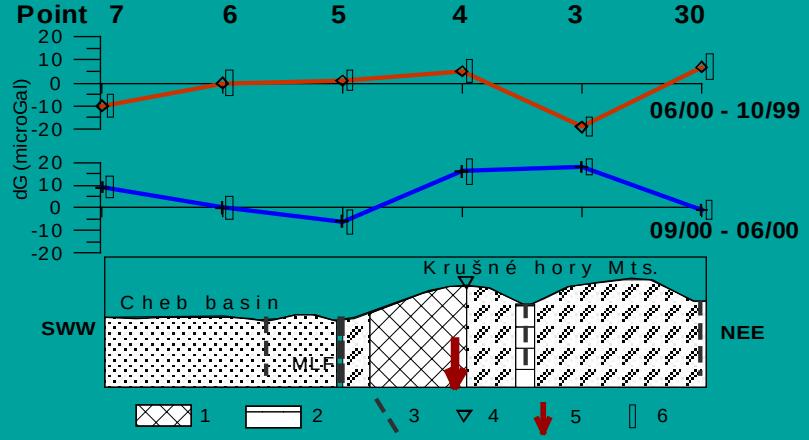


RPI Linux computer
- 6h logging data from receiver
- upload to GFU FTP server

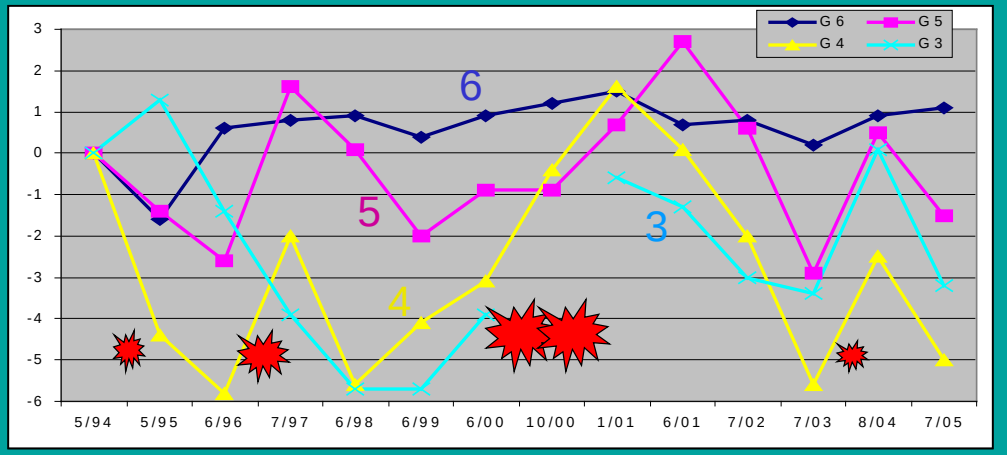
TELIS Linux processing server
with GAMIT/GLOBK

Gravity changes





Vertical displacements

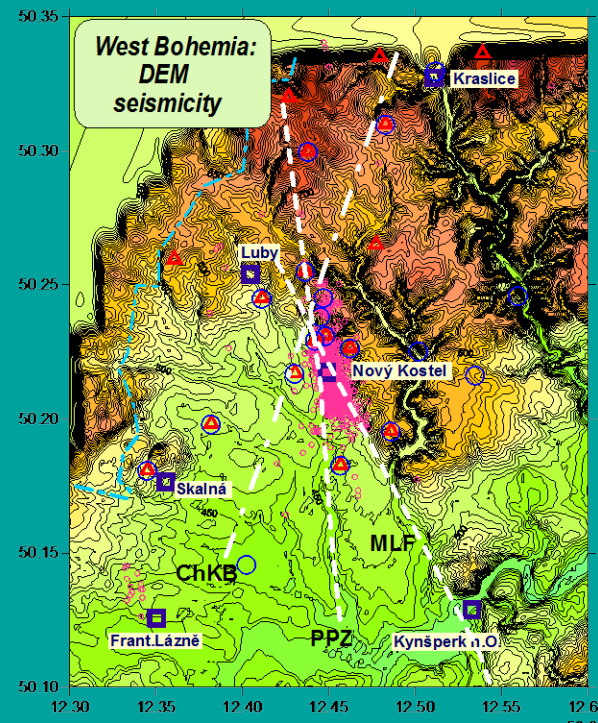


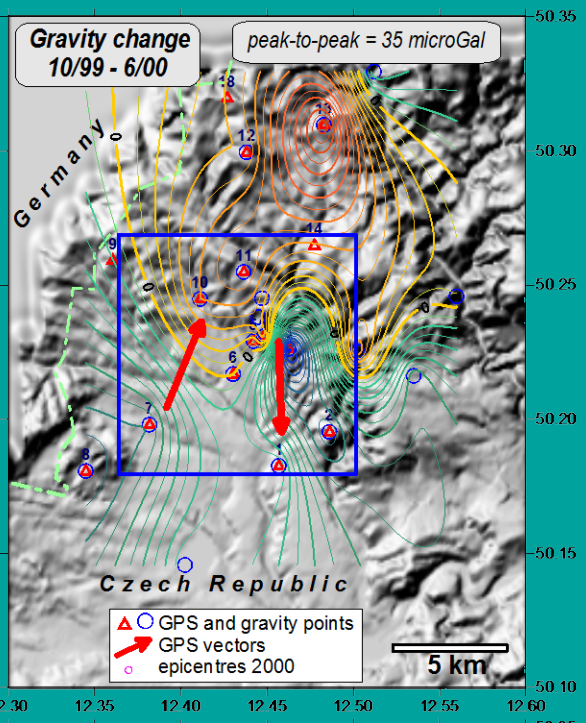
Gravity changes are not caused by vertical movements

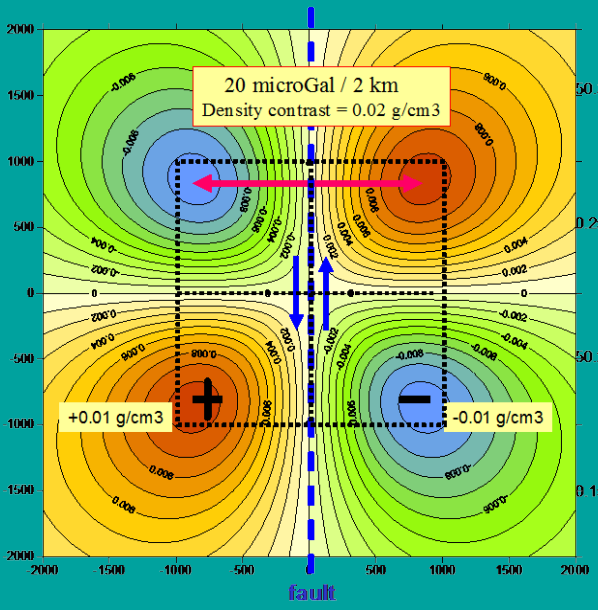
West Bohemia:

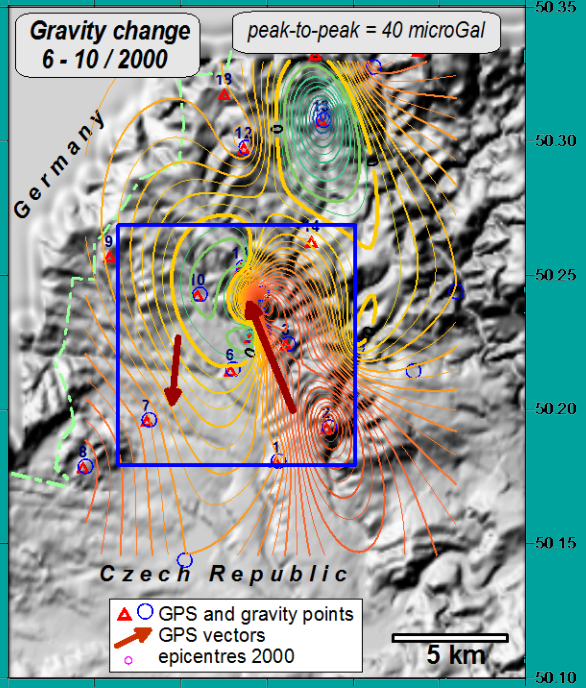
Relation of
- Gravity changes
- GPS displacements
- Seismicity

Within ***CzechGeo*** frame
we wish to install
a permanent gravimeter
in Novy Kostel

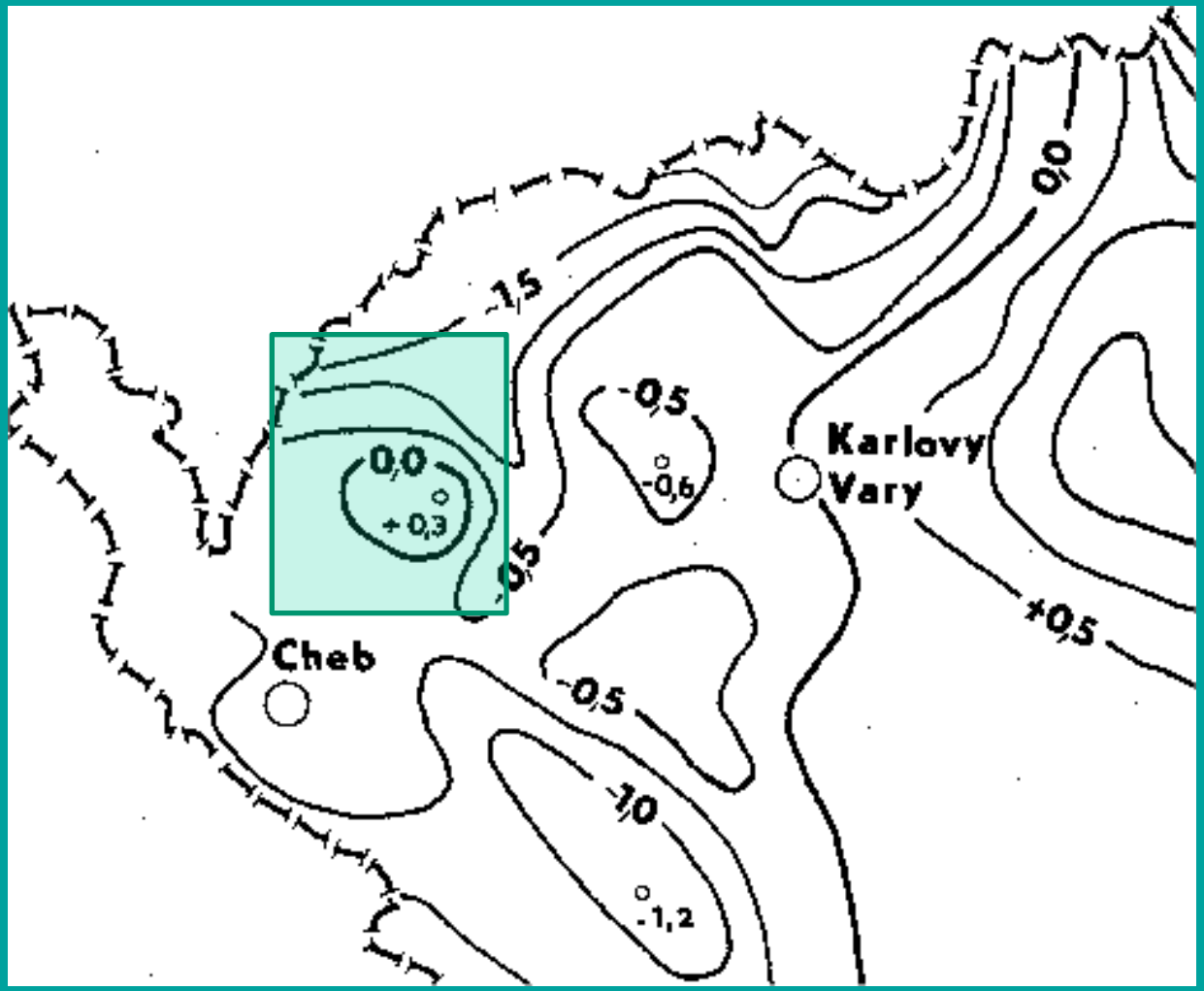




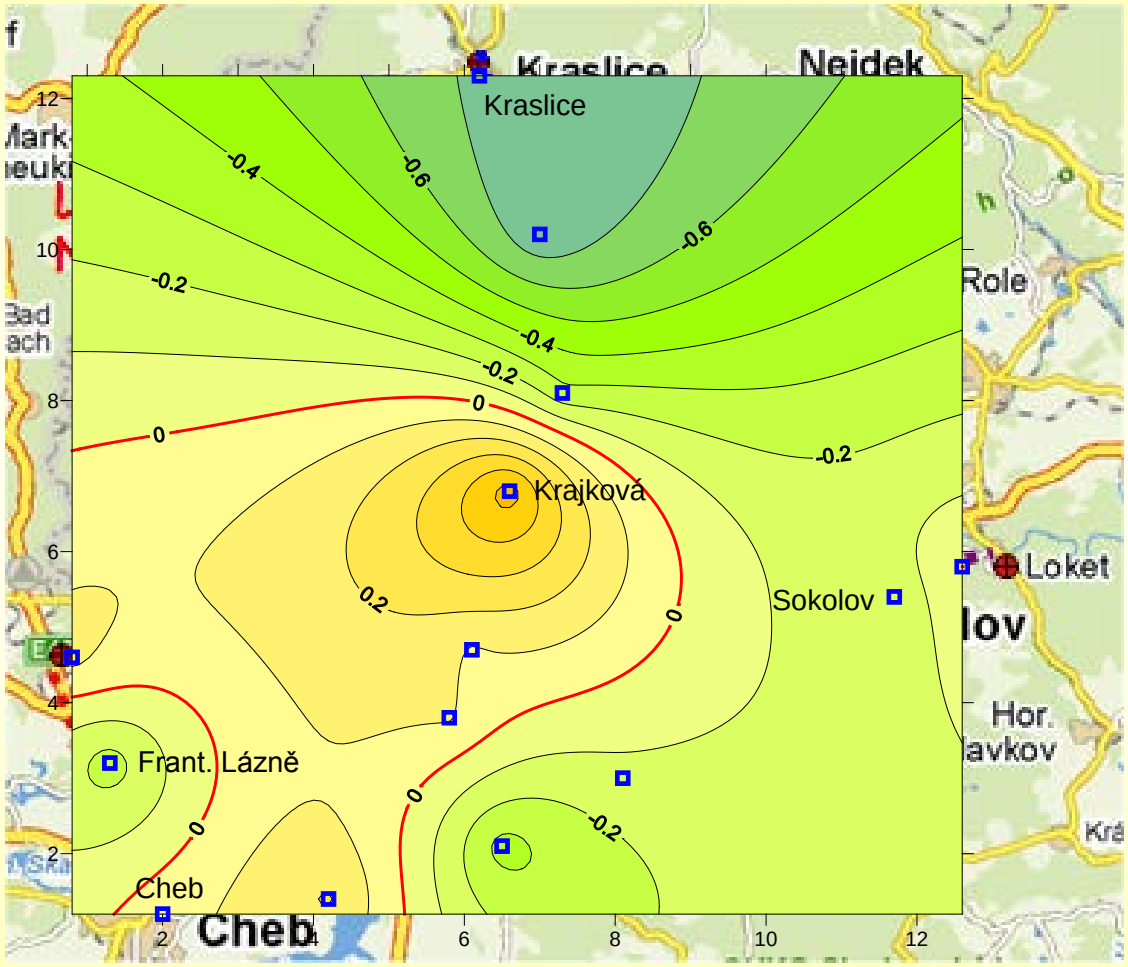




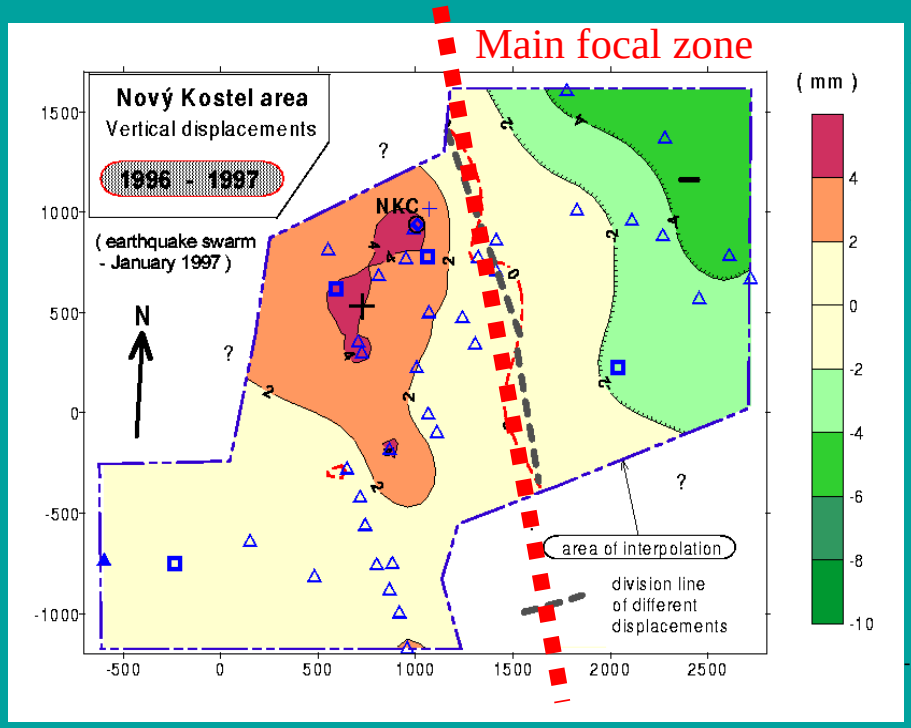
Historical precise levelling

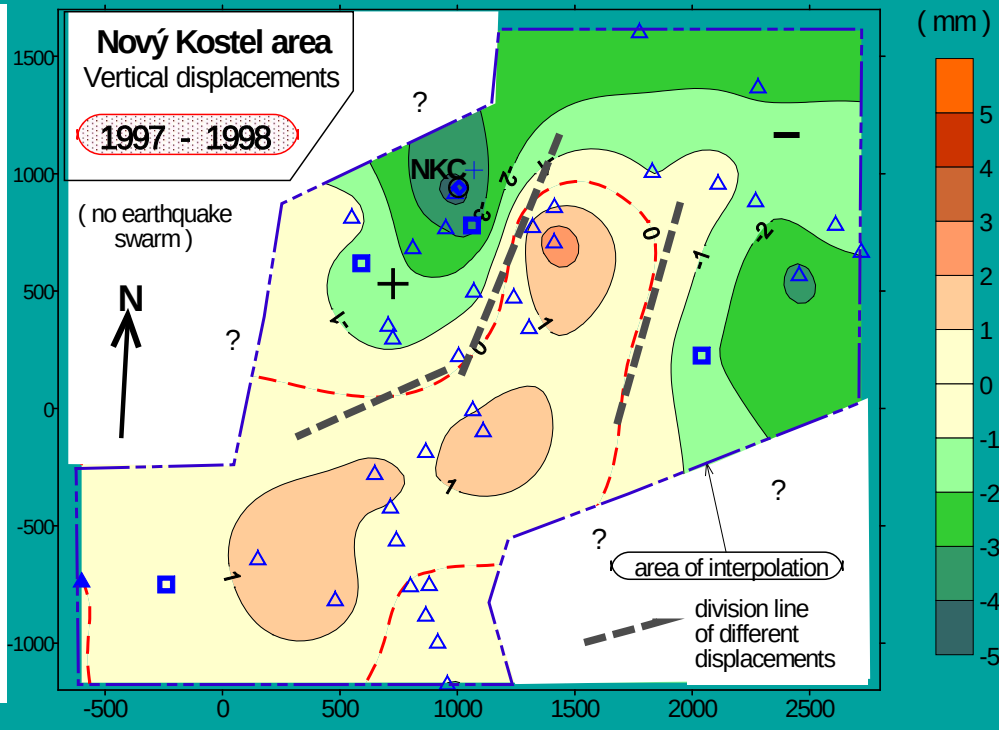


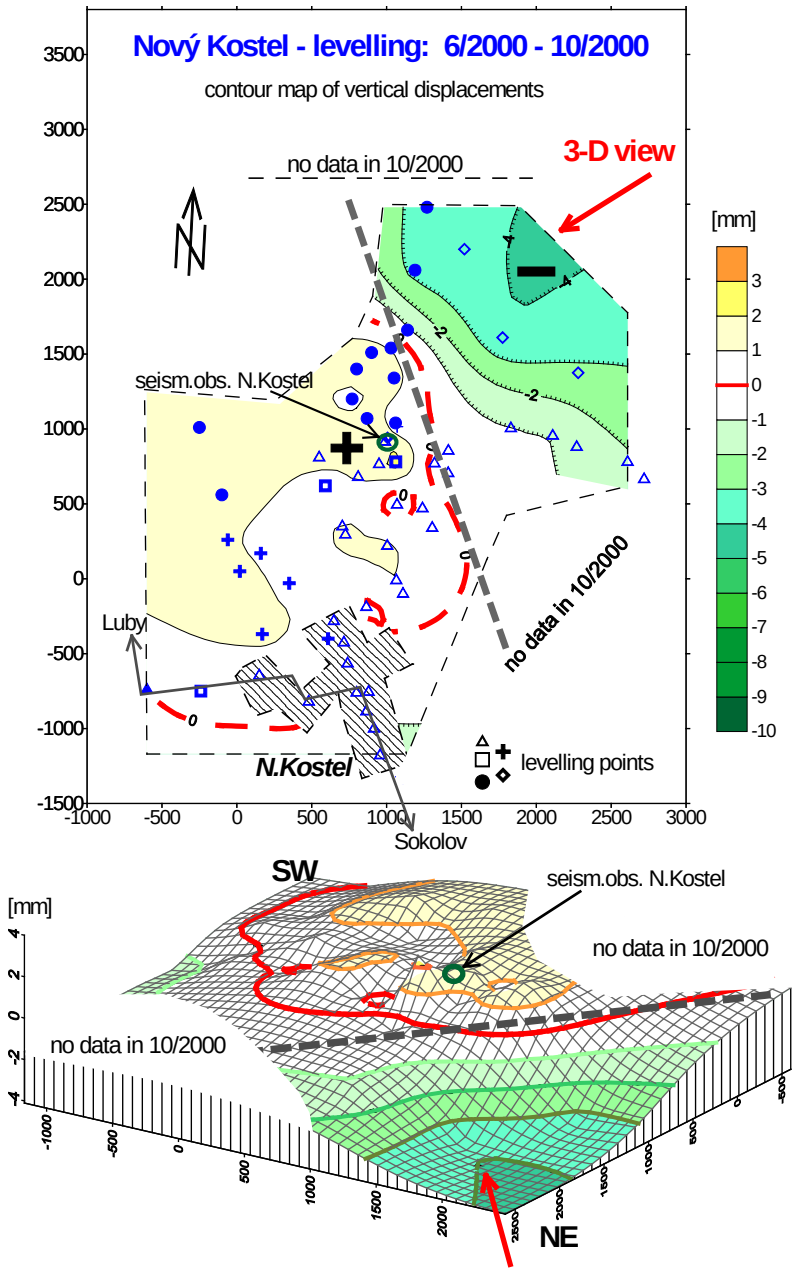
1967-1956


Kraslice
Krajková
Sokolov
Frant. Lázně
Cheb
Loket
Role
-0.6
-0.4
-0.2
0
0.2
12
10
8
6
4
2
2
6
8
10
12

Precise levelling



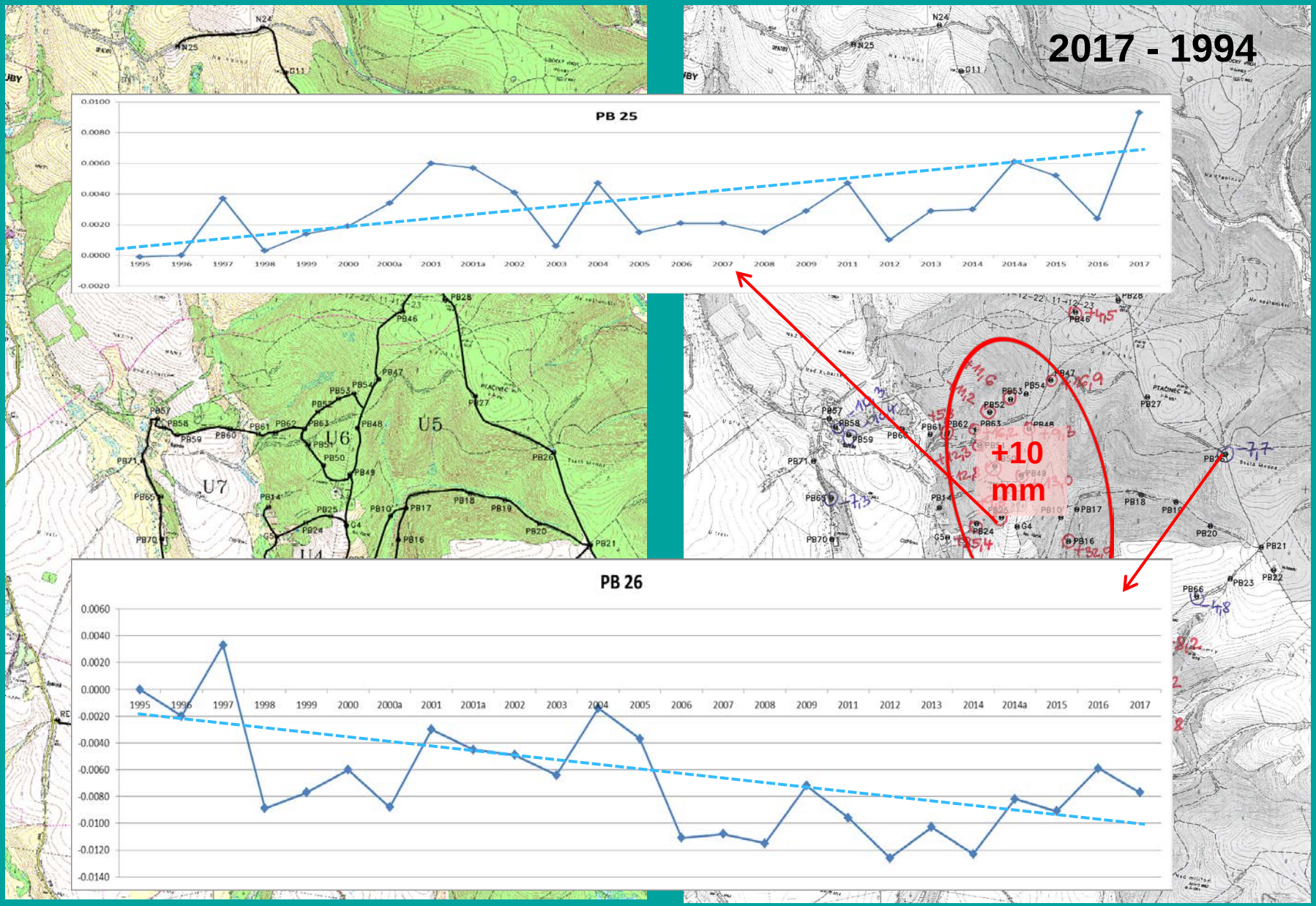




Earthquake swarm "Autumn 2000"

Similar vertical surface movements like in January 1997

Novy Kostel precise levelling network



?

Does this mean that even small earthquake swarms may produce recordable geodynamic signals ???

With support of CzechGeo,
our Group of Geodynamics constructed a prototype
of a **new 2-component tide-sensitive tiltmeter** in 2016-2017 !

SKALNA – tilts in February 2007: earthquakes swarms periods

(1.) F4M3.O * složka S-J * [".1E-4] N-S tilts
(2.) F5M3.O * složka V-Z * [".1E-4] E-W tilts
(3.) B2M1.O * tlak vzduchu * [0.1hPa] Barometric pressure

12000 (1.)
10000 (2.)
9800 (3.)

Nový Kostel swarm
9-10 Februry, M=1.5

Skalná - Plesná swarm
17-20 Februry, M=1.3

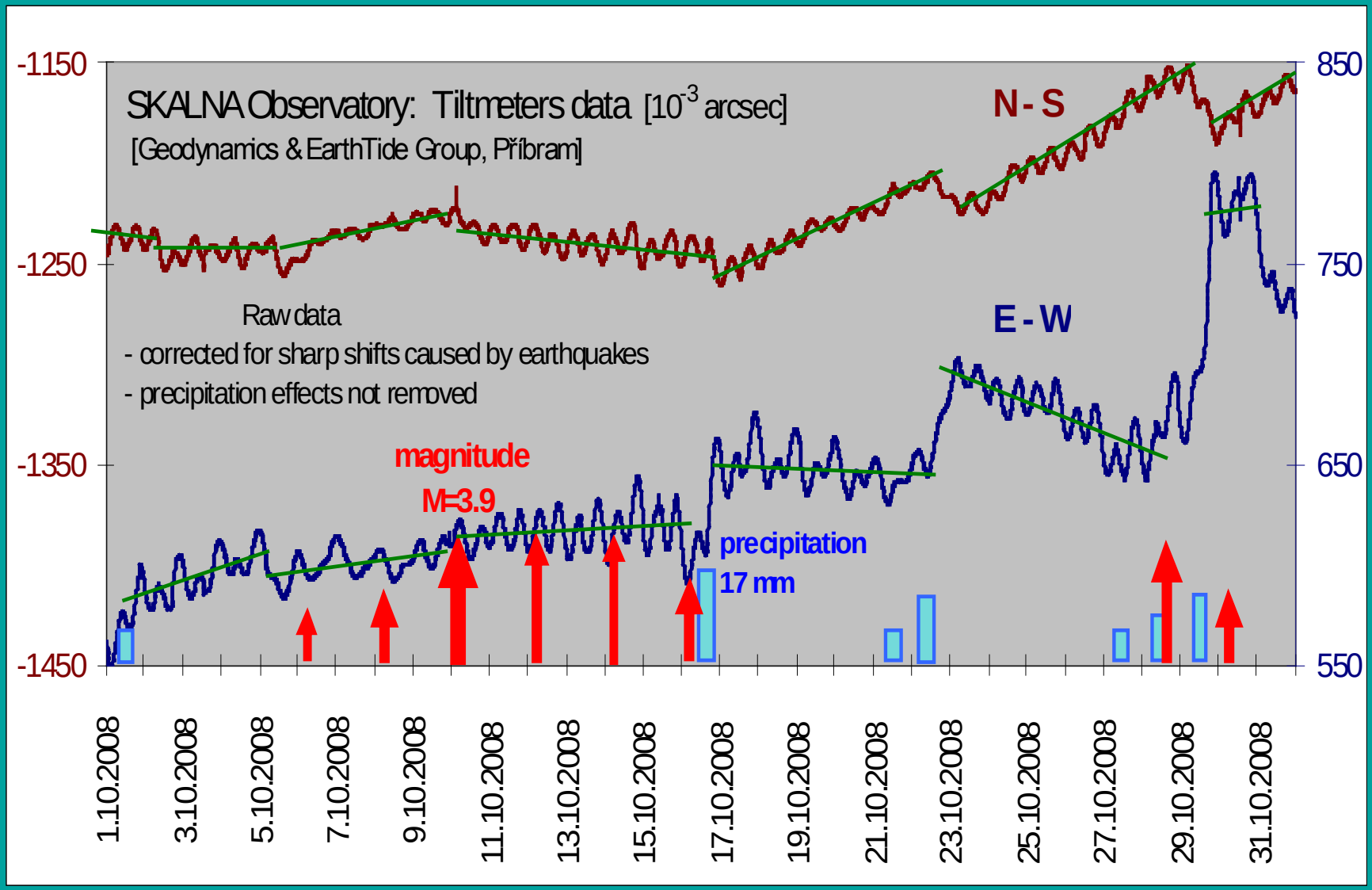
M=0.7

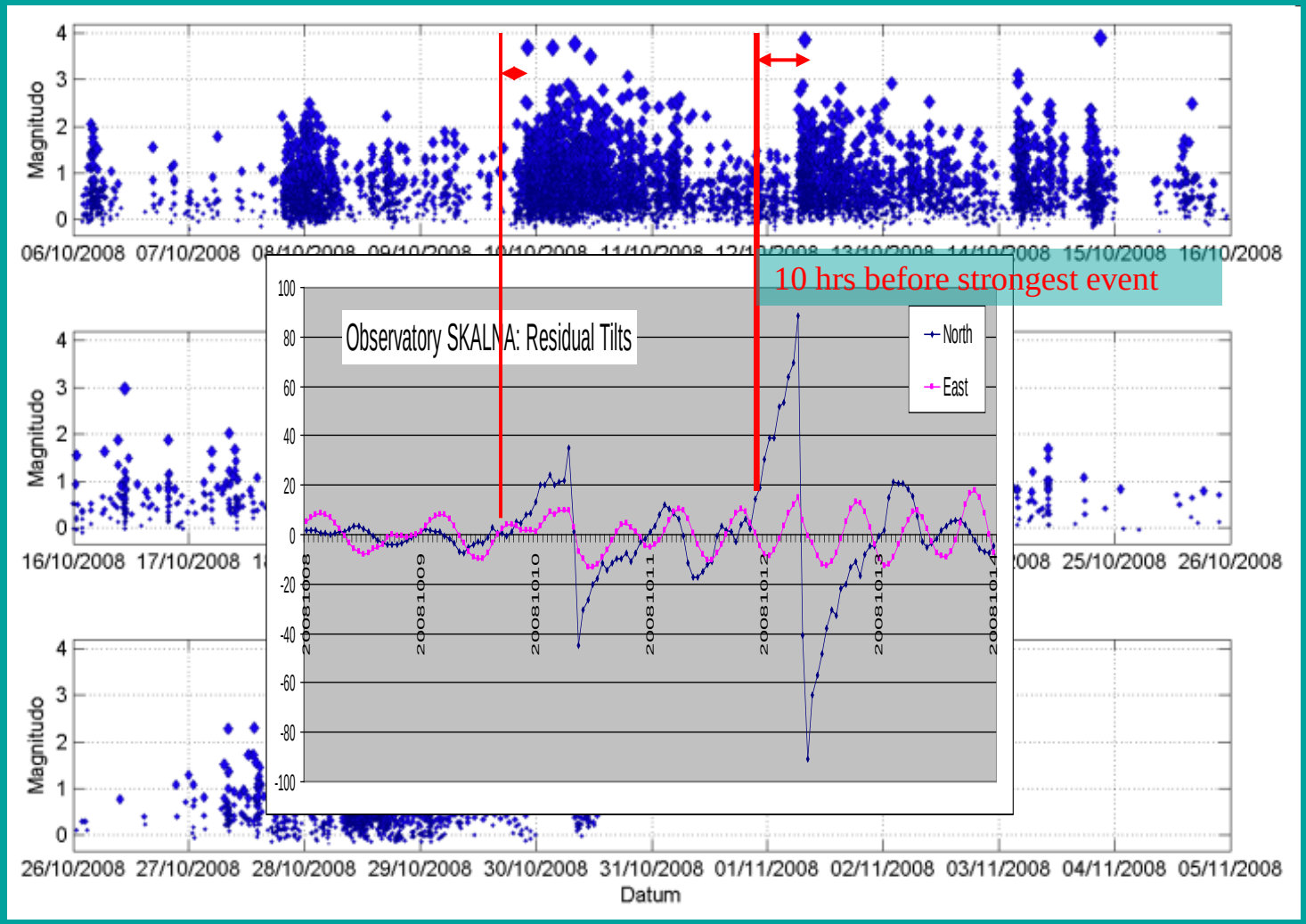
Anomalous tilt to SW

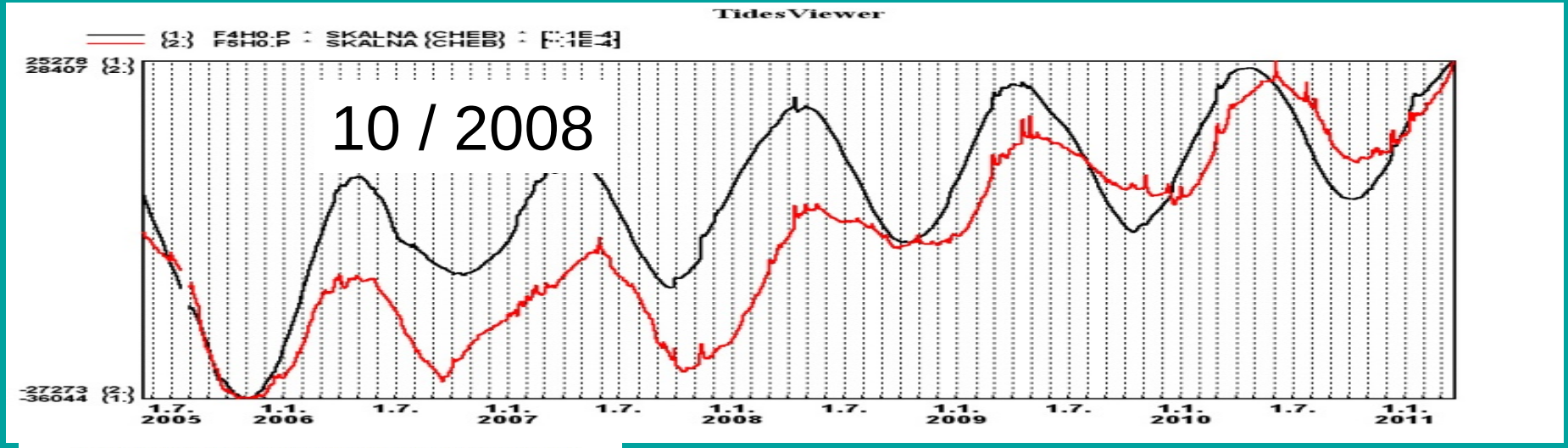
8800 (3.)
2000 (2.)
4000 (1.)

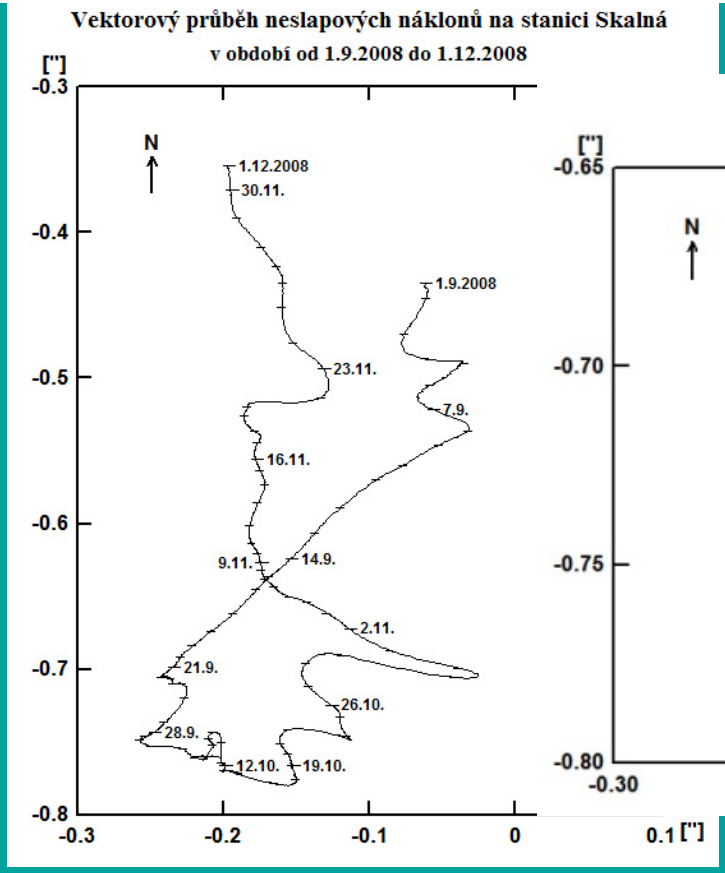
1.2. 2007 | 3.2. | 5.2. | 7.2. | 9.2. | 11.2. | 13.2. | 15.2. | 17.2. | 19.2. | 21.2. | 23.2. | 25.2. | 27.2. | 1.3.

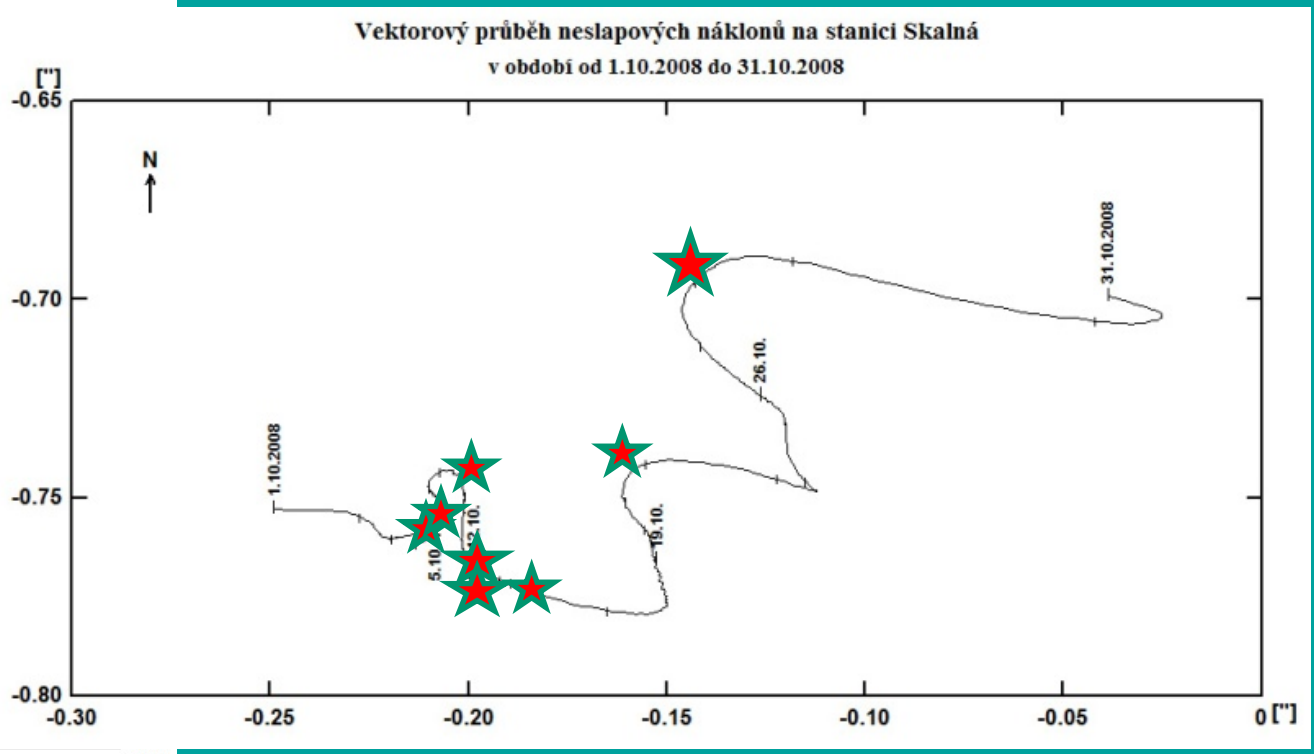
1.2.2007 (0) - 1.3.2007 (0)

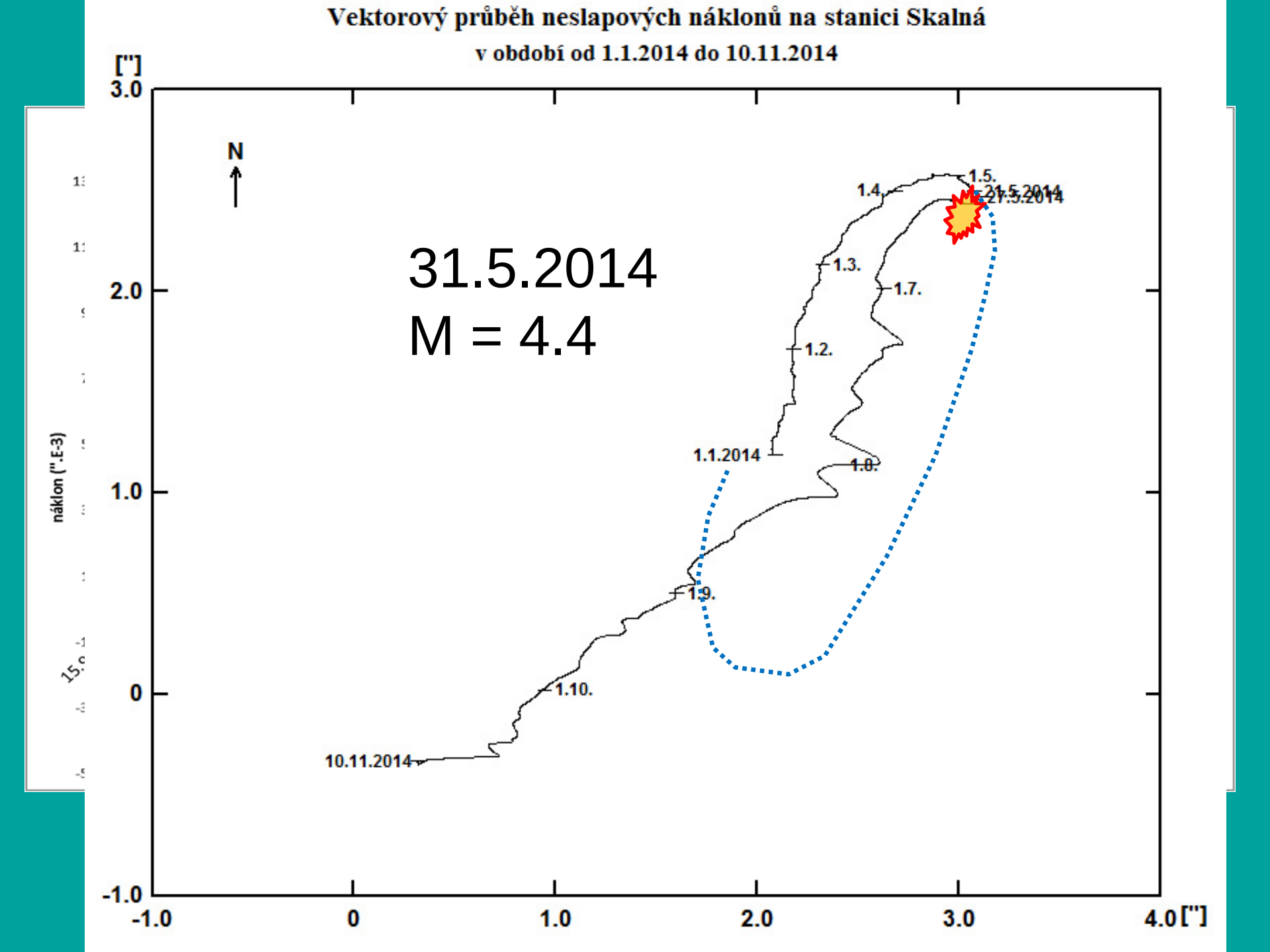

SKALNA Observatory: Tiltmeters data [10-3 arcsec]
[Geodynamics & EarthTide Group, Příbram]
N - S
E - W
Raw data
- corrected for sharp shifts caused by earthquakes
- precipitation effects not removed
magnitude
M=3.9
precipitation
17 mm
-1150
-1250
-1350
-1450
850
750
650
550
1.10.2008
3.10.2008
5.10.2008
7.10.2008
9.10.2008
11.10.2008
13.10.2008
15.10.2008
17.10.2008
19.10.2008
21.10.2008
23.10.2008
25.10.2008
27.10.2008
29.10.2008
31.10.2008


Magnitudo
06/10/2008 07/10/2008
15/10/2008 16/10/2008
10 hrs before strongest event
Observatory SKALNA: Residual Tilts
North
East
16/10/2008 17/10/2008
25/10/2008 26/10/2008
26/10/2008 27/10/2008 28/10/2008 29/10/2008 30/10/2008 31/10/2008 01/11/2008 02/11/2008 03/11/2008 04/11/2008 05/11/2008
Datum


TidesViewer
{1:} F4H0.P : SKALNA (CHEB) : [:1E-4]
{2:} F5H0.P : SKALNA (CHEB) : [:1E-4]
25278 {1:}
28407 {2:}
-27273 {2:}
-36044 {1:}
10 / 2008
1.7. 2005
1.1. 2006
1.7.
1.1. 2007
1.7.
1.1. 2008
1.7.
1.1. 2009
1.7.
1.1. 2010
1.7.
1.1. 2011


Vektorový průběh neslapových náklonů na stanici Skalná
v období od 1.9.2008 do 1.12.2008
["]
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
N
1.12.2008
30.11.
1.9.2008
23.11.
7.9.
16.11.
9.11.
14.9.
2.11.
21.9.
26.10.
28.9.
12.10.
19.10.
-0.3
-0.2
-0.1
0
0.1 ["]

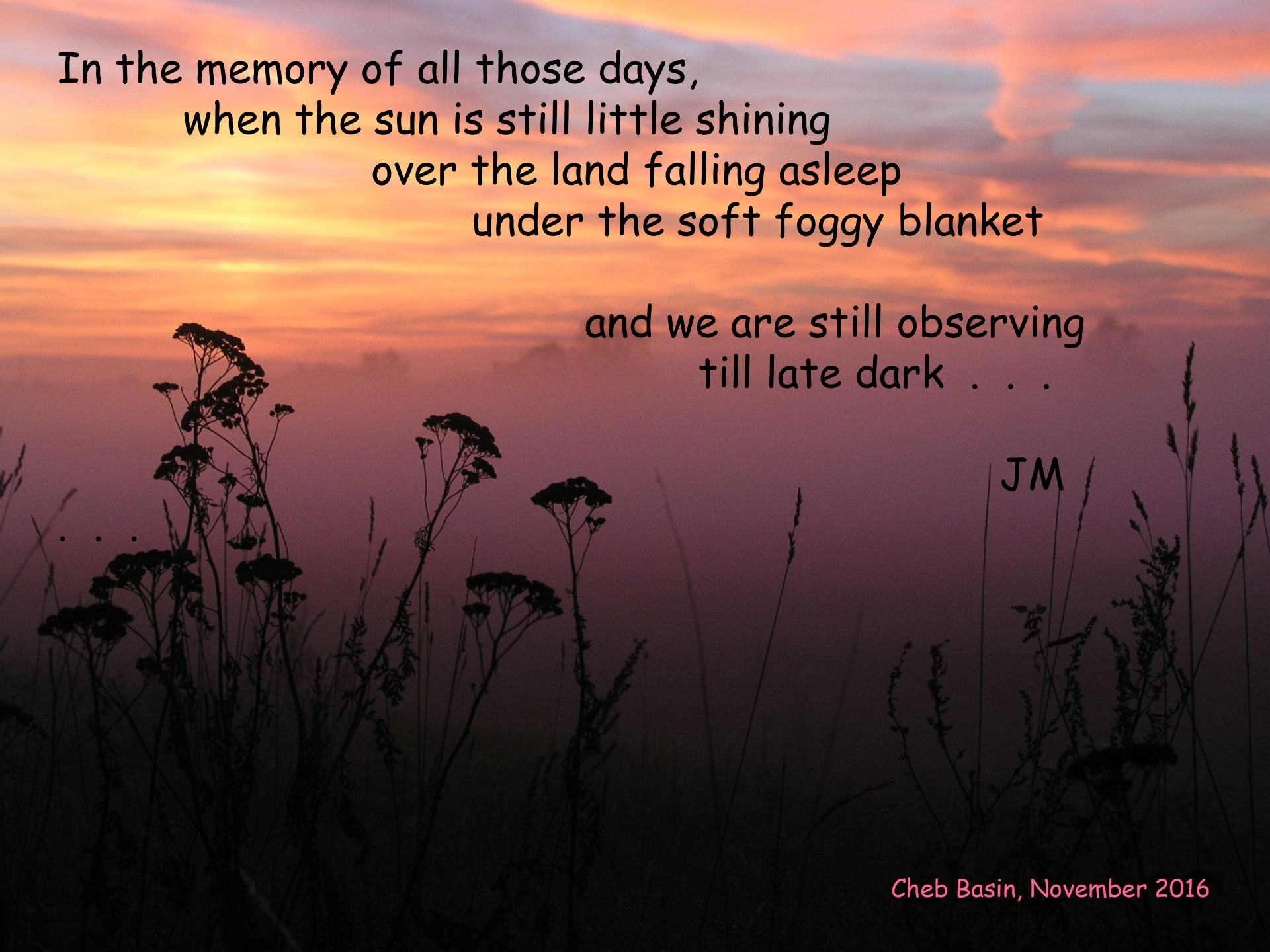

Vektorový průběh neslapových náklonů na stanici Skalná
v období od 1.10.2008 do 31.10.2008
["]
-0.65
-0.70
-0.75
-0.80
N
31.10.2008
26.10.
1.10.2008
5.10.
12.10.
19.10.
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0 ["]


Vektorový průběh neslapových náklonů na stanici Skalná
v období od 1.1.2014 do 10.11.2014
['']
3.0
2.0
1.0
0
-1.0
N
31.5.2014
M = 4.4
1.5.
1.4.
21.5.2014
27.5.2014
1.3.
1.7.
1.2.
1.1.2014
1.8.
1.9.
1.10.
10.11.2014
-1.0
0
1.0
2.0
3.0
4.0 ['']
náklon ('' .E-3)

We have the following Partners to progress with dynamic, structural and tectonic models building

- GPS, leveling, InSAR – surface dynamics (IG ASCR, GFZ)
- Groundwater level, CO2 – fluids dynamics (IG ASCR, GFZ)
- 4D Gravity – stress changes, pore pressure (IG ASCR, . . .)
- Tilts – blocks dynamics (Uni Jena, IG ASCR, Russian Academy)
- Volcanological research – magma activity (IG ASCR, GFZ, Uni Leipzig, Museum Goerlitz, Bavarian Geol. Survey)
- DEM analysis, gravity survey, . . . - tectonics (IG ASCR, . . .)

. . . and use the results for ICDP drilling planning, but also for practical use – spa, CO2 control, search for volcanoes, . . .


In the memory of all those days,
when the sun is still little shining
over the land falling asleep
under the soft foggy blanket
and we are still observing
till late dark . . .
JM
. . .
Cheb Basin, November 2016