QC in Slovenia

European Antelope User Group Meeting 2018

Procedures and tools for data quality and seismic network operation control in Slovenia

Izidor Tasič

May 7, 2018
Ljubljana, Slovenia

ARSO POTRESI

Typical seismic station

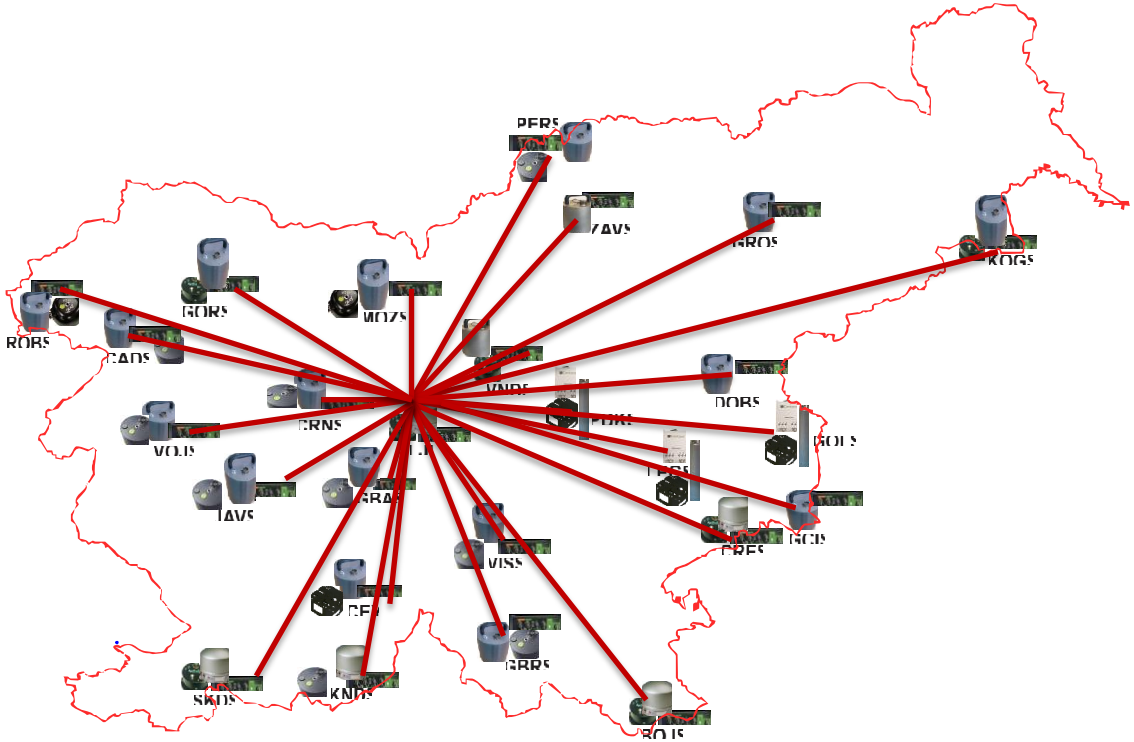
SUPPORT EQUIPMNET
-communication units
-power supply
-local seismic data storage
-…

UPS >20h

SEISMIC EQUIPMNET
-acquisition unit
-seismometer
-accelerometer

UPS >9 days

Seismic Network of the Republic of Slovenia

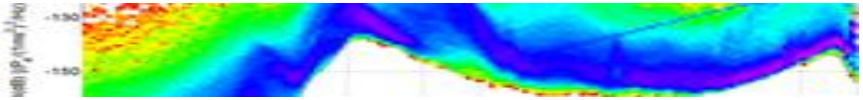


data centre : 2 x YES

SEISMIC DATA IS COMING { YES / NO }

THEY ARE RELIABLE { YES / NO }

procedures and tools



simple

complex

real time

post festum

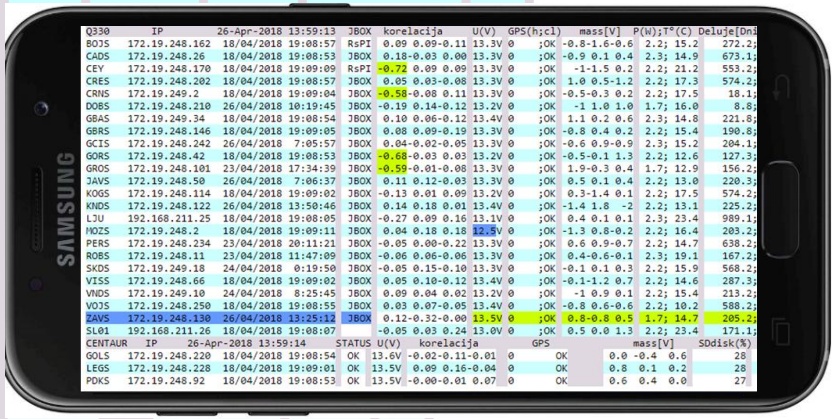
(‘better late than never’)

remotely

“on site”

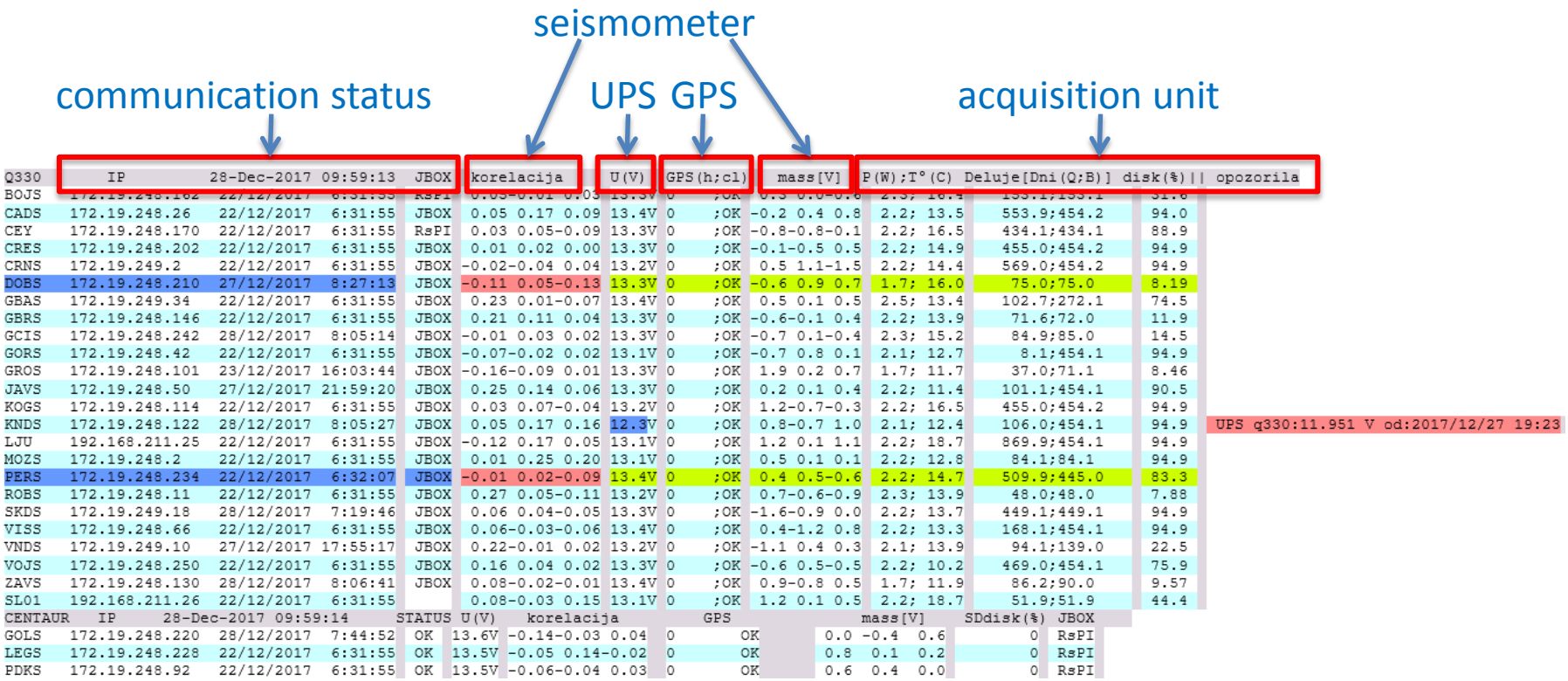
simple SOH monitor

Q330	IP	26-Apr-2018 13:59:13	JBOX	korelacija	U(V)	GPS(h;cl)	mass[V]	P(W);T°(C)	Deluje[Dni(Q;B)]	disk(%)||	opozorila
BOJS	172.19.248.162	18/04/2018 19:08:57	RsPI	0.09 0.09-0.11	13.3V	0 ;OK	-0.8-1.6-0.6	2.2; 15.2	272.2;272.2	50.1	
CADS	172.19.248.26	18/04/2018 19:08:53	JBOX	0.18-0.03 0.00	13.3V	0 ;OK	-0.9 0.1 0.4	2.3; 14.9	673.1;87.2	94.9	
CEY	172.19.248.170	18/04/2018 19:09:09	RsPI	-0.72 0.09 0.09	13.3V	0 ;OK	-1-1.5 0.2	2.2; 21.2	553.2;67.1	94.9	
CRES	172.19.248.202	18/04/2018 19:08:57	JBOX	0.05 0.03-0.08	13.3V	0 ;OK	1.0 0.5-1.2	2.2; 17.3	574.2;87.2	94.9	
CRNS	172.19.249.2	18/04/2018 19:09:04	JBOX	-0.58-0.08 0.11	13.3V	0 ;OK	-0.5-0.3 0.2	2.2; 17.5	18.1;87.2	95	
DOBS	172.19.248.210	26/04/2018 10:19:45	JBOX	-0.19 0.14-0.12	13.2V						
GBAS	172.19.249.34	18/04/2018 19:08:54	JBOX	0.10 0.06-0.12	13.4V						
GBRS	172.19.248.146	18/04/2018 19:09:05	JBOX	0.08 0.09-0.19	13.3V						
GCIS	172.19.248.242	26/04/2018 7:05:57	JBOX	0.04-0.02-0.05	13.3V						
GORS	172.19.248.42	18/04/2018 19:08:53	JBOX	-0.68-0.03 0.03	13.2V						
GROS	172.19.248.101	23/04/2018 17:34:39	JBOX	-0.59-0.01-0.08	13.3V						
JAVS	172.19.248.50	26/04/2018 7:06:37	JBOX	0.11 0.12-0.03	13.3V						
KOGS	172.19.248.114	18/04/2018 19:09:02	JBOX	-0.13 0.01 0.09	13.2V						
KNDS	172.19.248.122	26/04/2018 13:50:46	JBOX	0.14 0.18 0.01	13.4V						
LJU	192.168.211.25	18/04/2018 19:08:05	JBOX	-0.27 0.09 0.16	13.1V						
MOZS	172.19.248.2	18/04/2018 19:09:11	JBOX	0.04 0.18 0.18	12.5V						
PERS	172.19.248.234	23/04/2018 20:11:21	JBOX	-0.05 0.00-0.22	13.3V						
ROBS	172.19.248.11	23/04/2018 11:47:09	JBOX	-0.06 0.06-0.06	13.3V						
SKDS	172.19.249.18	24/04/2018 0:19:50	JBOX	-0.05 0.15-0.10	13.3V						
VISS	172.19.248.66	18/04/2018 19:09:02	JBOX	0.05 0.10-0.12	13.4V						
VNDS	172.19.249.10	24/04/2018 8:25:45	JBOX	0.09 0.04 0.02	13.2V						
VOJS	172.19.248.250	18/04/2018 19:08:55	JBOX	0.03 0.07-0.05	13.4V						
ZAVS	172.19.248.130	26/04/2018 13:25:12	JBOX	0.12-0.32-0.00	13.5V						
SL01	192.168.211.26	18/04/2018 19:08:07		-0.05 0.03 0.24	13.0V						
CENTAUR	IP	26-Apr-2018 13:59:14	STATUS	U(V) korelacija							
GOLS	172.19.248.220	18/04/2018 19:08:54	OK	13.6V -0.02-0.11-0.01							
LEGS	172.19.248.228	18/04/2018 19:09:01	OK	13.5V 0.09 0.16-0.04							
PDKS	172.19.248.92	18/04/2018 19:08:53	OK	13.5V -0.00-0.01 0.07	0	OK	0.6 0.4 0.0		27	RsPI	



ARSO POTRESI

simple SOH monitor



Q330	IP	28-Dec-2017 09:59:13	JBOX	korelacija	U(V)	GPS(h;cl)	mass[V]	P(W);T°(C)	Deluje[Dni(Q;B)]	disk(%)||	opozorila
BOJS	172.19.248.162	22/12/2017	6:31:55	RsPI	0.03-0.01 0.03	13.3V	0	;OK	0.3 0.0-0.6	2.3; 16.4	153.1;153.1	31.6	
CADS	172.19.248.26	22/12/2017	6:31:55	JBOX	0.05 0.17 0.09	13.4V	0	;OK	-0.2 0.4 0.8	2.2; 13.5	553.9;454.2	94.0	
CEY	172.19.248.170	22/12/2017	6:31:55	RsPI	0.03 0.05-0.09	13.3V	0	;OK	-0.8-0.8-0.1	2.2; 16.5	434.1;434.1	88.9	
CRES	172.19.248.202	22/12/2017	6:31:55	JBOX	0.01 0.02 0.00	13.3V	0	;OK	-0.1-0.5 0.5	2.2; 14.9	455.0;454.2	94.9	
CRNS	172.19.249.2	22/12/2017	6:31:55	JBOX	-0.02-0.04 0.04	13.2V	0	;OK	0.5 1.1-1.5	2.2; 14.4	569.0;454.2	94.9	
DOBS	172.19.248.210	27/12/2017	8:27:13	JBOX	-0.11 0.05-0.13	13.3V	0	;OK	-0.6 0.9 0.7	1.7; 16.0	75.0;75.0	8.19	
GBAS	172.19.249.34	22/12/2017	6:31:55	JBOX	0.23 0.01-0.07	13.4V	0	;OK	0.5 0.1 0.5	2.5; 13.4	102.7;272.1	74.5	
GBRS	172.19.248.146	22/12/2017	6:31:55	JBOX	0.21 0.11 0.04	13.3V	0	;OK	-0.6-0.1 0.4	2.2; 13.9	71.6;72.0	11.9	
GCIS	172.19.248.242	28/12/2017	8:05:14	JBOX	-0.01 0.03 0.02	13.3V	0	;OK	-0.7 0.1-0.4	2.3; 15.2	84.9;85.0	14.5	
GORS	172.19.248.42	22/12/2017	6:31:55	JBOX	-0.07-0.02 0.02	13.1V	0	;OK	-0.7 0.8 0.1	2.1; 12.7	8.1;454.1	94.9	
GROS	172.19.248.101	23/12/2017	16:03:44	JBOX	-0.16-0.09 0.01	13.3V	0	;OK	1.9 0.2 0.7	1.7; 11.7	37.0;71.1	8.46	
JAVS	172.19.248.50	27/12/2017	21:59:20	JBOX	0.25 0.14 0.06	13.3V	0	;OK	0.2 0.1 0.4	2.2; 11.4	101.1;454.1	90.5	
KOGS	172.19.248.114	22/12/2017	6:31:55	JBOX	0.03 0.07-0.04	13.2V	0	;OK	1.2-0.7-0.3	2.2; 16.5	455.0;454.2	94.9	
KNDS	172.19.248.122	28/12/2017	8:05:27	JBOX	0.05 0.17 0.16	12.3V	0	;OK	0.8-0.7 1.0	2.1; 12.4	106.0;454.1	94.9	UPS q330:11.951 V od:2017/12/27 19:23
LJU	192.168.211.25	22/12/2017	6:31:55	JBOX	-0.12 0.17 0.05	13.1V	0	;OK	1.2 0.1 1.1	2.2; 18.7	869.9;454.1	94.9	
MOZS	172.19.248.2	22/12/2017	6:31:55	JBOX	0.01 0.25 0.20	13.1V	0	;OK	0.5 0.1 0.1	2.2; 12.8	84.1;84.1	94.9	
PERS	172.19.248.234	22/12/2017	6:32:07	JBOX	-0.01 0.02-0.09	13.4V	0	;OK	0.4 0.5-0.6	2.2; 14.7	509.9;445.0	83.3	
ROBS	172.19.248.11	22/12/2017	6:31:55	JBOX	0.27 0.05-0.11	13.2V	0	;OK	0.7-0.6-0.9	2.3; 13.9	48.0;48.0	7.88	
SKDS	172.19.249.18	28/12/2017	7:19:46	JBOX	0.06 0.04-0.05	13.3V	0	;OK	-1.6-0.9 0.0	2.2; 13.7	449.1;449.1	94.9	
VISS	172.19.248.66	22/12/2017	6:31:55	JBOX	0.06-0.03-0.06	13.4V	0	;OK	0.4-1.2 0.8	2.2; 13.3	168.1;454.1	94.9	
VNDS	172.19.249.10	27/12/2017	17:55:17	JBOX	0.22-0.01 0.02	13.2V	0	;OK	-1.1 0.4 0.3	2.1; 13.9	94.1;139.0	22.5	
VOJS	172.19.248.250	22/12/2017	6:31:55	JBOX	0.16 0.04 0.02	13.3V	0	;OK	-0.6 0.5-0.5	2.2; 10.2	469.0;454.1	75.9	
ZAVS	172.19.248.130	28/12/2017	8:06:41	JBOX	0.08-0.02-0.01	13.4V	0	;OK	0.9-0.8 0.5	1.7; 11.9	86.2;90.0	9.57	
SL01	192.168.211.26	22/12/2017	6:31:55		0.08-0.03 0.15	13.1V	0	;OK	1.2 0.1 0.5	2.2; 18.7	51.9;51.9	44.4	

CENTAUR	IP	28-Dec-2017 09:59:14	STATUS	U(V)	korelacija	GPS		mass[V]			SDdisk(%)	JBOX
GOLS	172.19.248.220	28/12/2017 7:44:52	OK	13.6V	-0.14-0.03 0.04	0	OK	0.0	-0.4	0.6	0	RsPI
LEGS	172.19.248.228	22/12/2017 6:31:55	OK	13.5V	-0.05 0.14-0.02	0	OK	0.8	0.1	0.2	0	RsPI
PDKS	172.19.248.92	22/12/2017 6:31:55	OK	13.5V	-0.06-0.04 0.03	0	OK	0.6	0.4	0.0	0	RsPI

ARSO POTRESI

Example: 3 events

communication breakdown between the central and **acquisition unit**

Q330	IP	28-Dec-2017 09:59:13	JBOX	korelacija	U(V)	GPS(h;cl)	mass[V]	P(W);T°(C)	Deluje[Dni(Q;B)]	disk(%)||	opozorila
BOJS	172.19.248.162	22/12/2017 6:31:55	RsPI	0.05-0.01 0.03	13.3V	0 ;OK	0.3 0.0-0.6	2.3; 16.4	153.1;153.1	31.6	
CADS	172.19.248.26	22/12/2017 6:31:55	JBOX	0.05 0.17 0.09	13.4V	0 ;OK	-0.2 0.4 0.8	2.2; 13.5	553.9;454.2	94.0	
CEY	172.19.248.170	22/12/2017 6:31:55	RsPI	0.03 0.05-0.09	13.3V	0 ;OK	-0.8-0.8-0.1	2.2; 16.5	434.1;434.1	88.9	
[illegible]	172.19.248.202	22/12/2017 6:31:55	JBOX	0.01 0.02 0.00	13.3V	0 ;OK	-0.1-0.5 0.5	2.2; 14.9	455.0;454.2	94.9	
[illegible]	[illegible]	[illegible]	JBOX	-0.02-0.04 0.04	13.2V	0 ;OK	0.5 1.1-1.5	2.2; 14.4	569.0;454.2	94.9	
DOBS	172.19.248.210	27/12/2017 8:27:13	JBOX	-0.11 0.05-0.13	13.3V	0 ;OK	-0.6 0.9 0.7	1.7; 16.0	75.0;75.0	8.19	
[illegible]	[illegible]	[illegible]	JBOX	0.23 0.01-0.07	13.4V	0 ;OK	0.5 0.1 0.5	2.5; 13.4	102.7;272.1	74.5	
GBRS	172.19.248.146	22/12/2017 6:31:55	JBOX	0.21 0.11 0.04	13.3V	0 ;OK	-0.6-0.1 0.4	2.2; 13.9	71.6;72.0	11.9	
GCIS	172.19.248.242	28/12/2017 8:05:14	JBOX	-0.01 0.03 0.02	13.3V	0 ;OK	-0.7 0.1-0.4	2.3; 15.2	84.9;85.0	14.5	
GORS	172.19.248.42	22/12/2017 6:31:55	JBOX	-0.07-0.02 0.02	13.1V	0 ;OK	-0.7 0.8 0.1	2.1; 12.7	8.1;454.1	94.9	
GROS	172.19.248.101	23/12/2017 16:03:44	JBOX	-0.16-0.09 0.01	13.3V	0 ;OK	1.9 0.2 0.7	1.7; 11.7	37.0;71.1	8.46	
JAVS	172.19.248.50	27/12/2017 21:59:20	JBOX	0.25 0.14 0.06	13.3V	0 ;OK	0.2 0.1 0.4	2.2; 11.4	101.1;454.1	90.5	
KOGS	172.19.248.114	22/12/2017 6:31:55	JBOX	0.03 0.07-0.04	[illegible]	0 ;OK	1.2-0.7-0.3	2.2; 16.5	455.0;454.2	94.9	
KNDS	172.19.248.122	28/12/2017 8:05:27	JBOX	0.05 0.17 0.16	12.3V	0 ;OK	0.8-0.7 1.0	2.1; 12.4	106.0;454.1	94.9	UPS g330:11.951 V on:2017/12/27 19:23
LJU	192.168.211.25	22/12/2017 6:31:55	JBOX	-0.12 0.17 0.05	[illegible]	0 ;OK	1.2 0.1 1.1	2.2; 18.7	869.9;454.1	94.9	
[illegible]	[illegible]	[illegible]	JBOX	0.01 0.25 0.20	[illegible]	0 ;OK	0.5 0.1 0.1	2.2; 12.8	84.1;84.1	94.9	
PERS	172.19.248.234	22/12/2017 6:32:07	JBOX	-0.01 0.02-0.09	13.4V	0 ;OK	0.4 0.5-0.6	2.2; 14.7	509.9;445.0	83.3	
[illegible]	[illegible]	[illegible]	JBOX	0.27 0.05-0.11	13.2V	0 ;OK	0.7-0.6-0.9	2.3; 13.9	48.0;48.0	7.88	
SKDS	172.19.249.18	28/12/2017 7:19:46	JBOX	0.06 0.04-0.05	13.3V	0 ;OK	-1.6-0.9 0.0	2.2; 13.7	449.1;449.1	94.9	
VISS	172.19.248.66	22/12/2017 6:31:55	JBOX	0.06-0.03-0.06	13.4V	0 ;OK	0.4-1.2 0.8	2.2; 13.3	168.1;454.1	94.9	
VNDS	172.19.249.10	27/12/2017 17:55:17	JBOX	0.22-0.01 0.02	13.2V	0 ;OK	-1.1 0.4 0.3	2.1; 13.9	94.1;139.0	22.5	
VOJS	172.19.248.250	22/12/2017 6:31:55	JBOX	0.16 0.04 0.02	13.3V	0 ;OK	-0.6 0.5-0.5	2.2; 10.2	469.0;454.1	75.9	
ZAVS	172.19.248.130	28/12/2017 8:06:41	JBOX	0.08-0.02-0.01	13.4V	0 ;OK	0.9-0.8 0.5	1.7; 11.9	86.2;90.0	9.57	
SLOL	192.168.211.26	22/12/2017 6:31:55		0.08-0.03 0.15	13.1V	0 ;OK	1.2 0.1 0.5	2.2; 18.7	51.9;51.9	44.4	

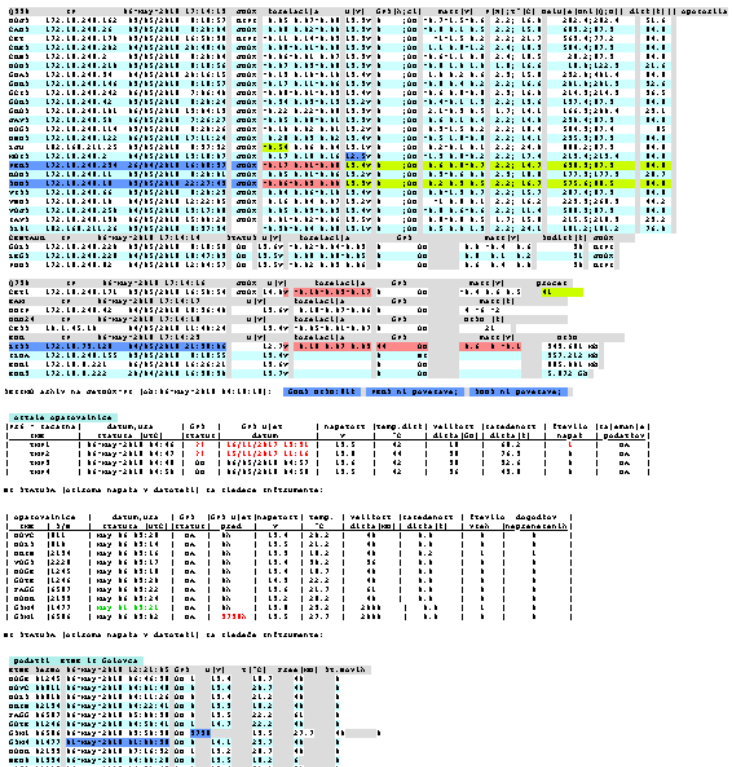
CENTAUR	IP	28-Dec-2017 09:59:14	STATUS	U(V)	korelacija	GPS	mass[V]	SDdisk(%)	JBOX
GOLS	172.19.248.220	28/12/2017 7:44:52	OK	13.6V	-0.14-0.03 0.04	0 OK	0.0 -0.4 0.6	0	RsPI
LEGS	172.19.248.228	22/12/2017 6:31:55	OK	13.5V	-0.05 0.14-0.02	0 OK	0.8 0.1 0.2	0	RsPI
PDKS	172.19.248.92	22/12/2017 6:31:55	OK	13.5V	-0.06-0.04 0.03	0 OK	0.6 0.4 0.0	0	RsPI

communication breakdown between the central and **seismic stations**

no 230VAC power

ARSO POTRESI

simple SOH monitor



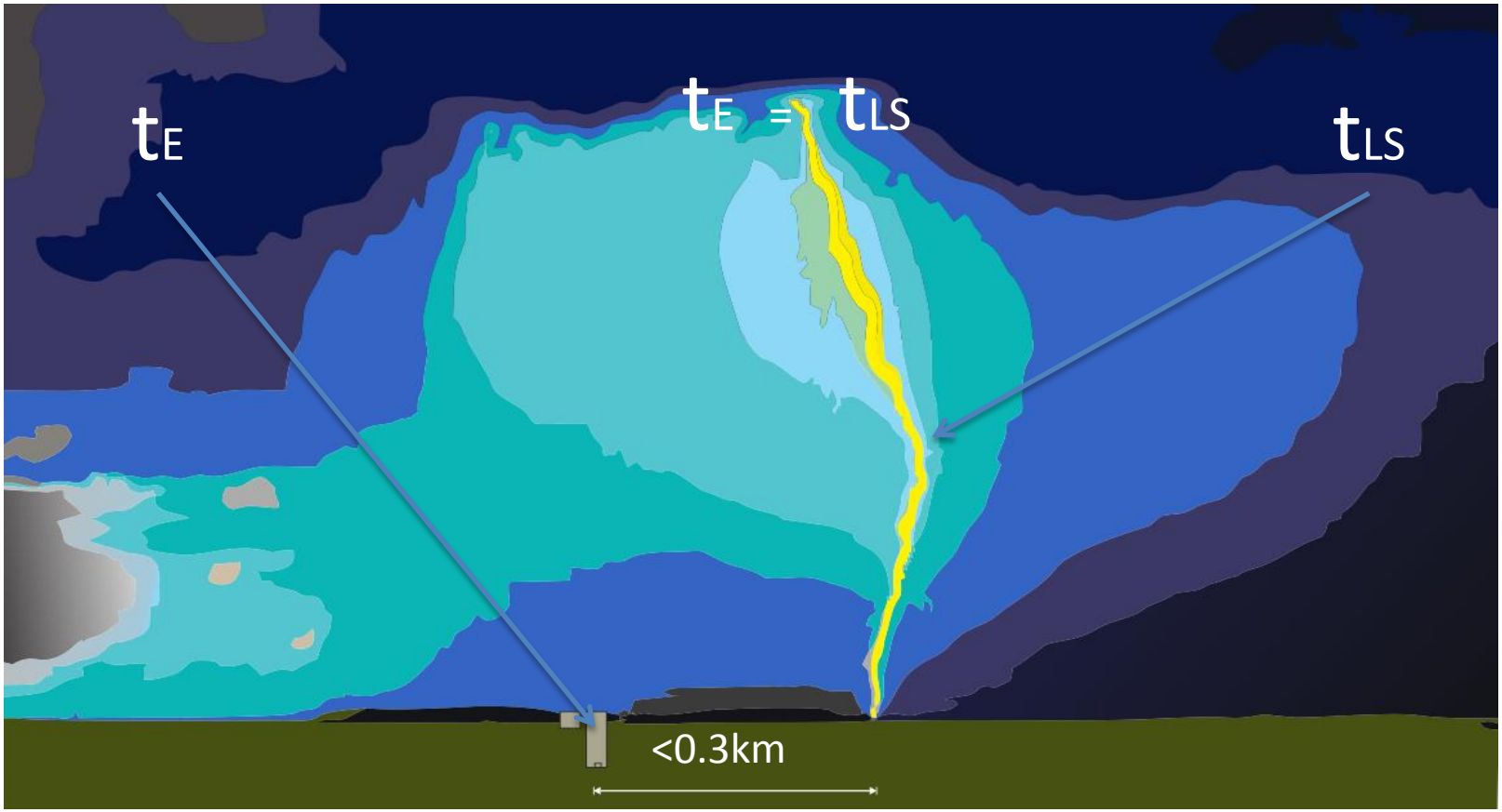
Seismic Network of the Republic of Slovenia

temporary and other locations

accelerograph

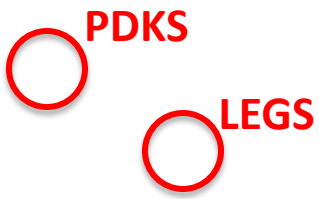
EXAMPLE: lightning strike

Event:
-equipment failure
-communication failure



ARSO POTRESI

EXAMPLE: lightning strike



lightning strikes (LEGS) : 2017-06-25

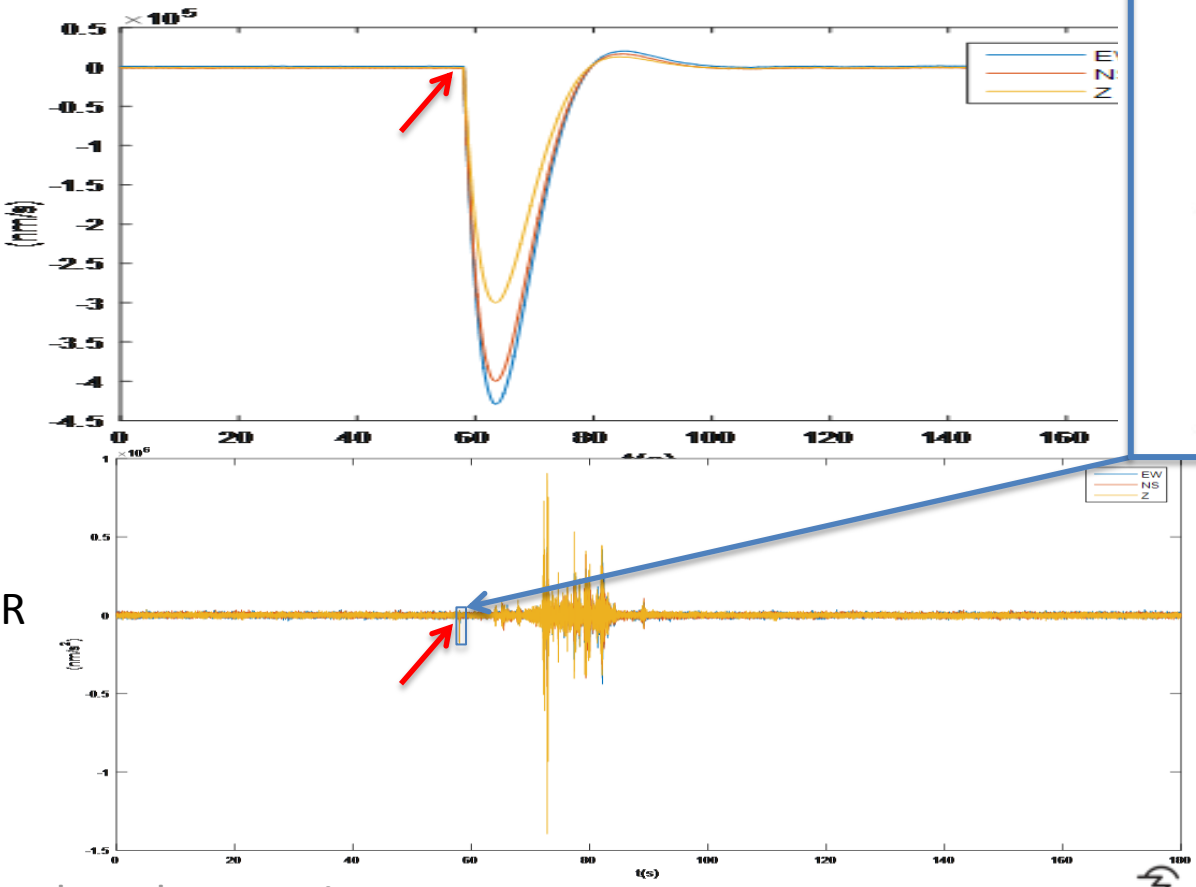
Time (UTC)	Distance	Description
11:41	0.14 km	modem failure
16:38	0.26 km	GPS antenna failure

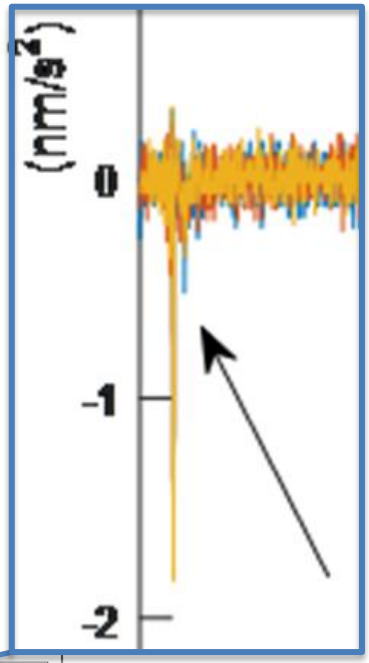
lightning strike (PDKS) : 2017-09-16

Time (UTC)	Distance	Description
18:17:58,0	5 km	pulse (seismometer)

SEISMOMETER

ACCELEROMETER





after such an event, the relay remains open

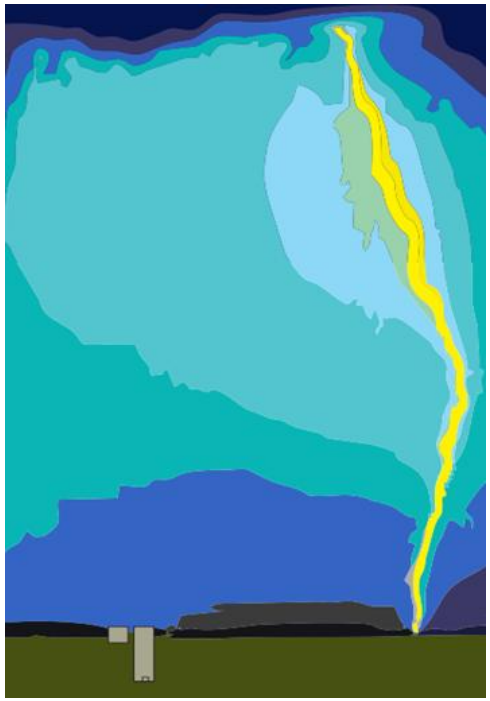
ARSO POTRESI

Correlation coefficients

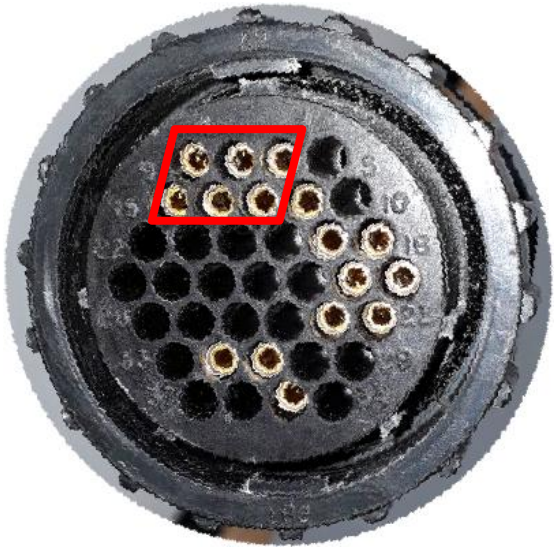
(measure linear dependence between components)

Q330	IP	28-Dec-2017 09:59:13	JBOX	korelacija	U(V)	GPS(h;cl)	mass[V]	P(W);T°(C)	Deluje[Dni(Q;B)]	disk(%)	
BOJS	172.19.248.162	22/12/2017 6:31:55	RsPI	[illegible]	13.3V	0 ;OK	0.3 0.0-0.6	2.3; 16.4	153.1;153.1	31.6	
CADS	172.19.248.26	22/12/2017 6:31:55	JBOX	0.05 0.17 0.09	13.4V	0 ;OK	-0.2 0.4 0.8	2.2; 13.5	553.9;454.2	94.0	
CEY	172.19.248.170	22/12/2017 6:31:55	RsPI	0.03 0.05-0.09	13.3V	0 ;OK	-0.8-0.8-0.1	2.2; 16.5	434.1;434.1	88.9	

CMG-40TB & LIGHTENING



Q730 CONNECTOR



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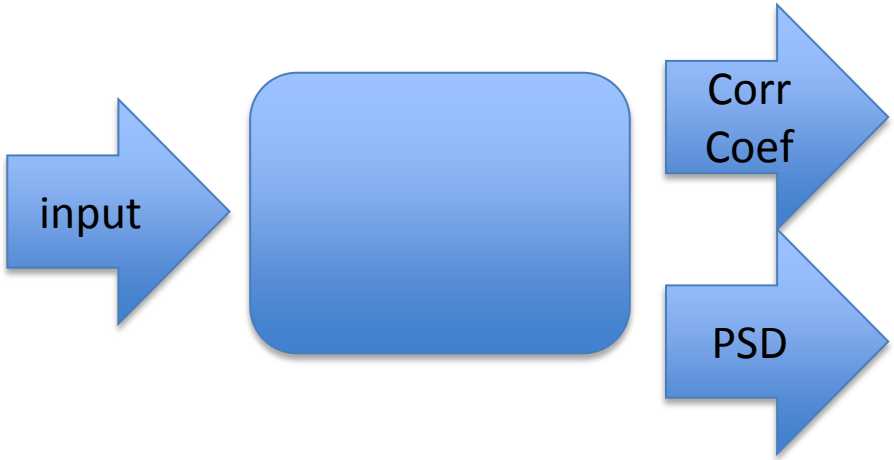
CorrCoeff & PSD

(calculated for each previous hour)



Inputs:

- **seismic data** with a length of one hour

Outputs:

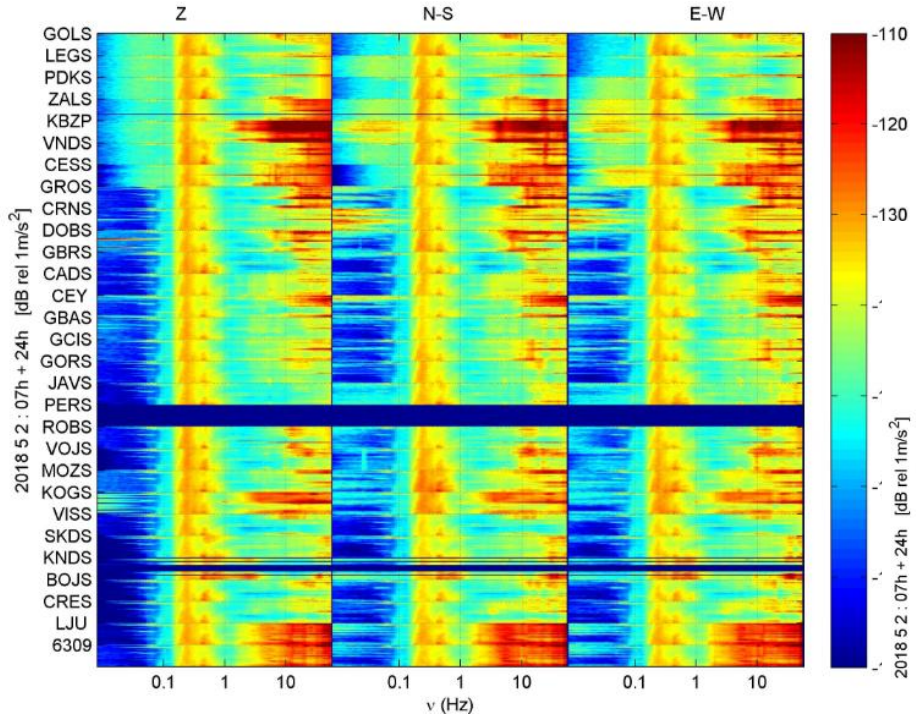
- **Correlation Coefficients** (CorrCoef) are calculated between EW, NS and Z components of seismometer

-**Power Spectral Density estimates** (PSD) are calculated for all seismic inputs (Seismometer, accelerometer)

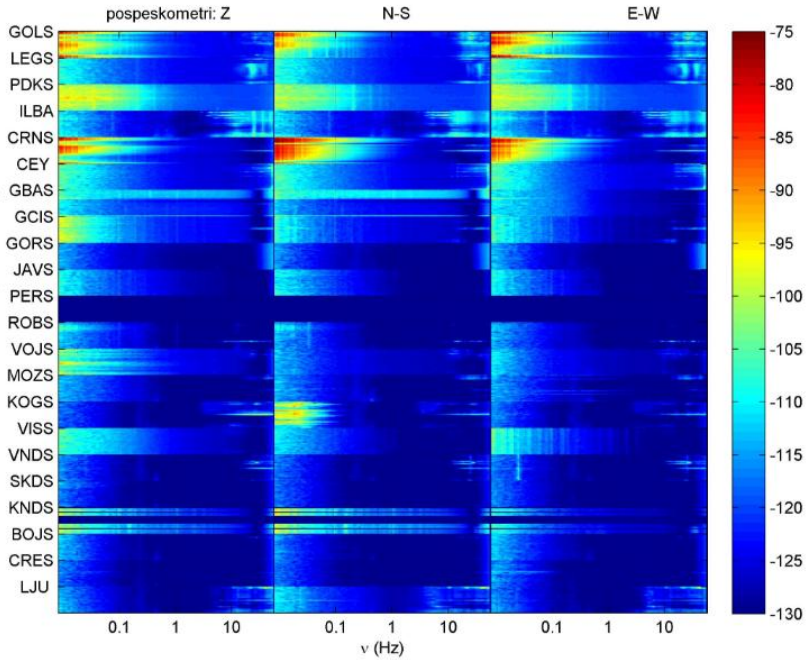
PSD

(last 24 hours - <u>simple SOH monitor)</u>

SEISMOMETER



ACCELEROMETER



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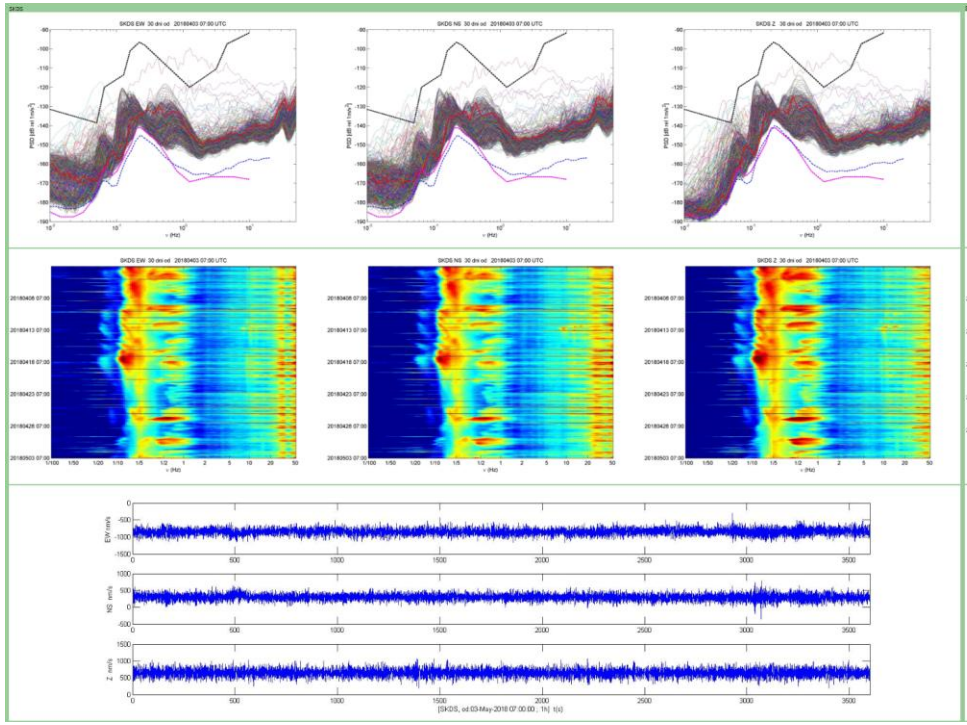
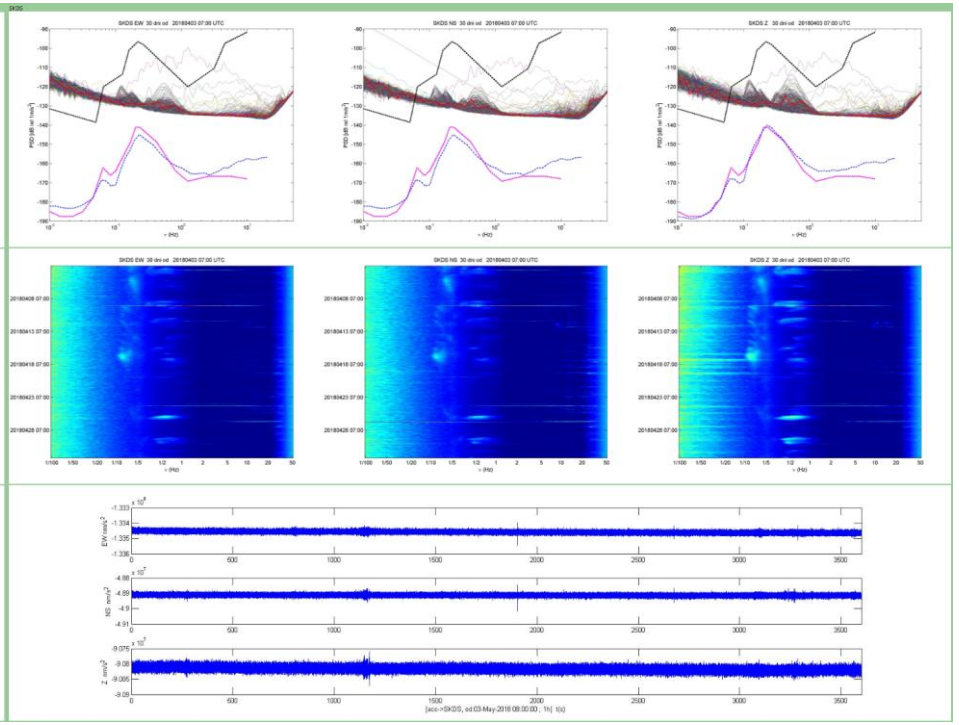
PSD monitor – last 30 days

SEISMOMETER

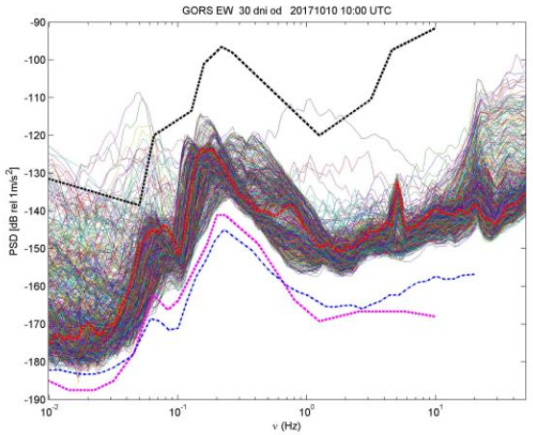


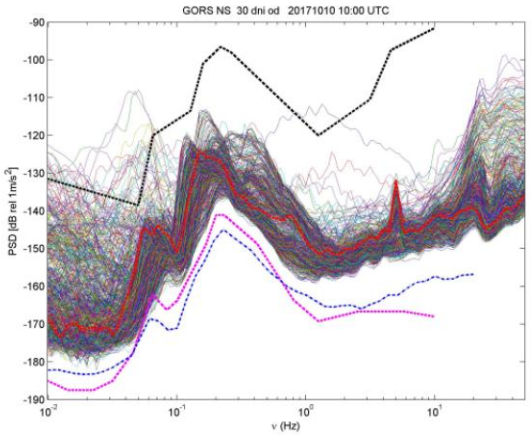
ACCELEROMETER

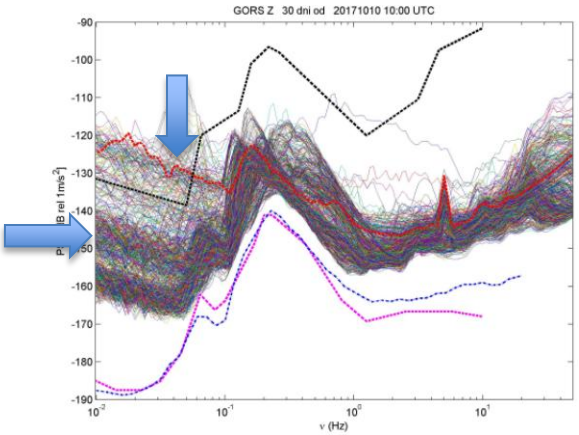


PSD monitor- We Liked

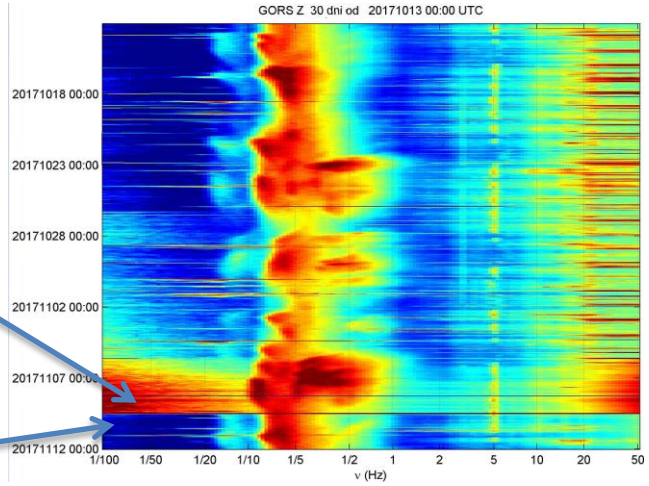
to detect (atypical) errors







CMG-3T seismometers: an abnormally increased instrumental noise at one component



Solution (often but not always): lock / unlock

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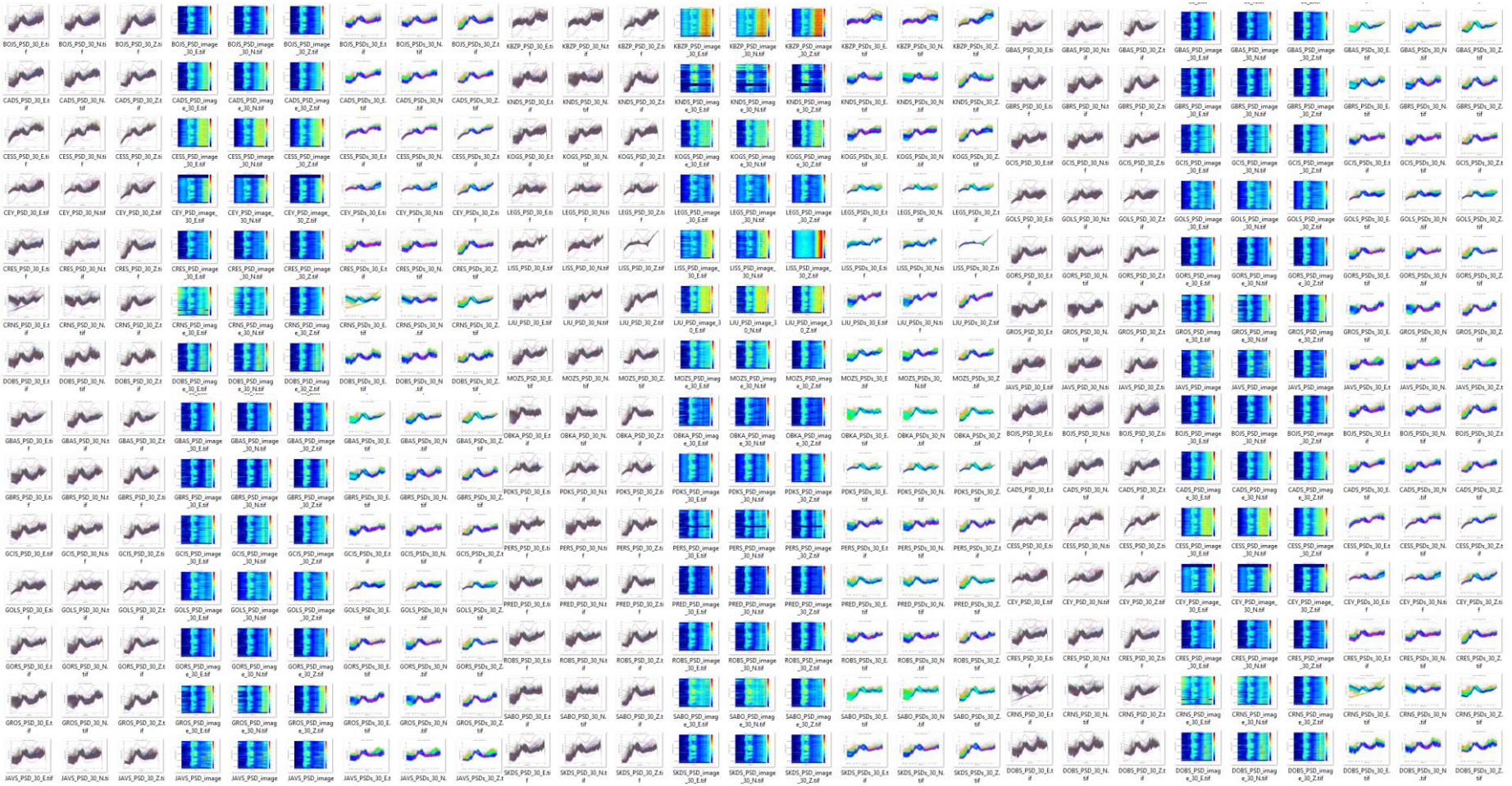
PSD monitor- We Disliked

minor errors can be overlooked



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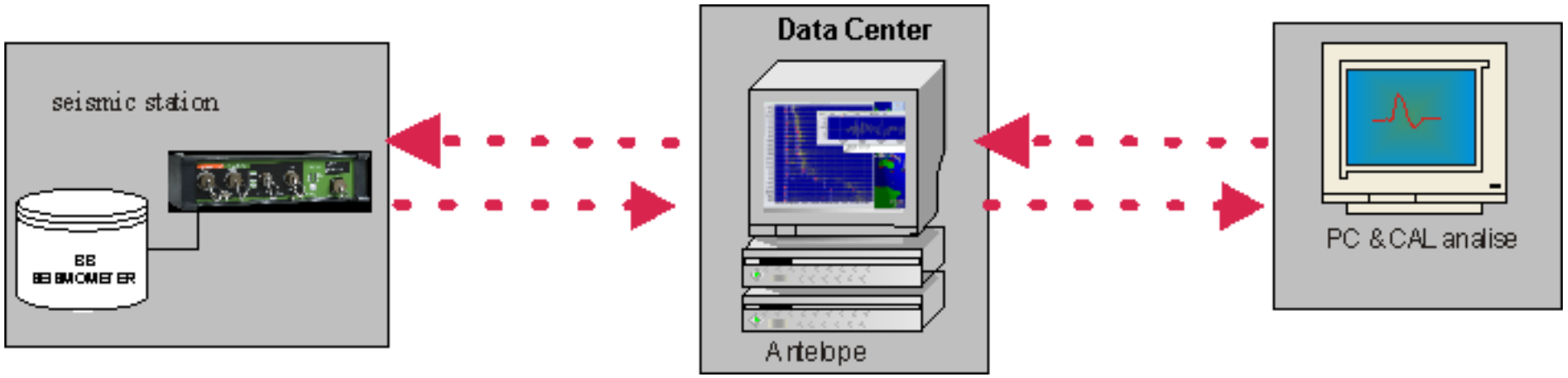
USE OF TEST (calibration) SIGNALS

built into the acquisition units

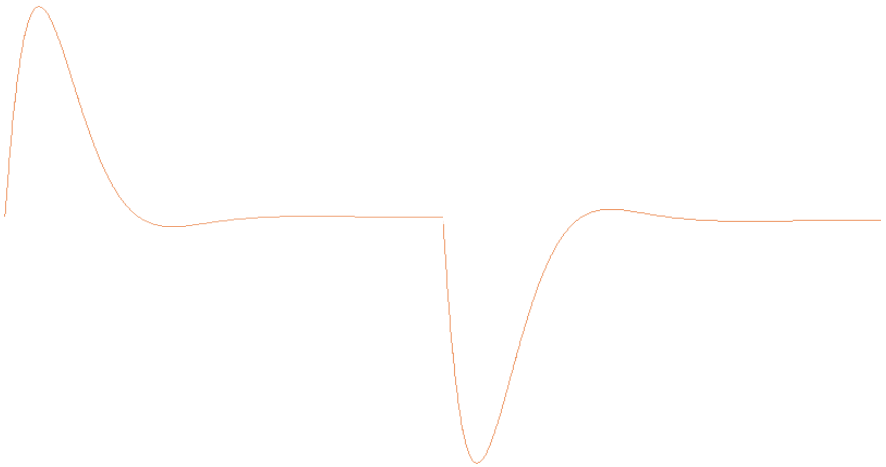


The start of the process is on demand,
everything else is done by automation,
including the analysis of the response

TEST SIGNAL - STEP

input

response



output

To, β

To, β

STEP- We Liked

we can detect errors in the Host Box (STS-2)

"OK Host Box"

U:	↑	To[s]:	119.7 ;	β:	0.7098 ;
U:	↓	To[s]:	119.7 ;	β:	0.7103 ;
V:	↑	To[s]:	120.6 ;	β:	0.7085 ;
V:	↓	To[s]:	120.7 ;	β:	0.7085 ;
W:	↑	To[s]:	120.6 ;	β:	0.7084 ;
W:	↓	To[s]:	120.7 ;	β:	0.7086 ;

"defective Host Box"

U:	↑	To[s]:	114.5 ;	β:	0.6745 ;
U:	↓	To[s]:	119.9 ;	β:	0.7123 ;
V:	↑	To[s]:	119.5 ;	β:	0.7113 ;
V:	↓	To[s]:	119.8 ;	β:	0.7113 ;
W:	↑	To[s]:	119.2 ;	β:	0.7045 ;
W:	↓	To[s]:	120.6 ;	β:	0.7116 ;

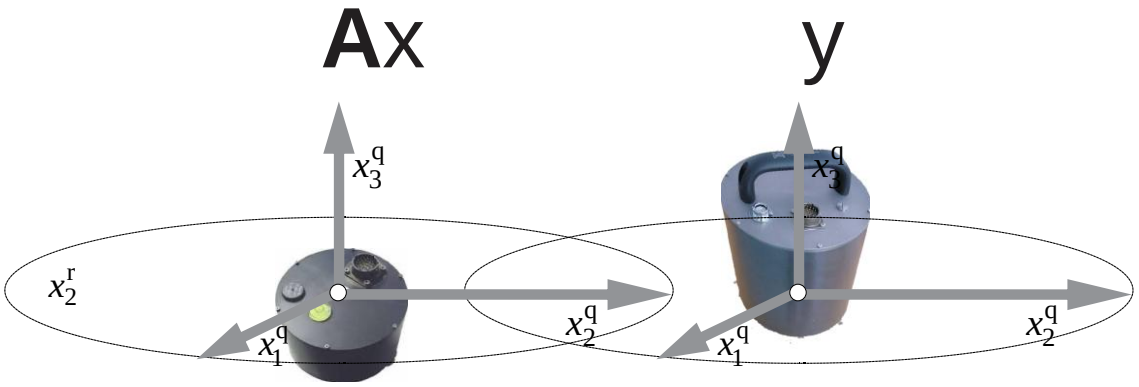
-the problem is humidity
-3/5 defective HOST BOX were identified

STEP- We Disliked

- some critical errors can be overlooked (e.g. cable failure)

- there are no seismic data at the time of the test

quality control of seismometer and accelerometer



A - the transformation matrix that maps the detection of accelerometer into the space of seismometer detection

Estimated parameters from the transformation matrix **A:**

- amplitude correction factors
- orientation misalignment
- …

QC example: STS-2, EpiSensor

regional earthquakes

SKDS

Date	amplitude correction			α
	EW	NS	Z	
2016-08-24	0.99	0.99	0.99	-0.3°
2016-10-26	0.99	0.99	0.99	-0.3°
2016-10-30	0.99	0.99	0.99	-0.3°
2017-01-18	0.99	0.99	0.99	-0.3°

QC example: STS-2, EpiSensor

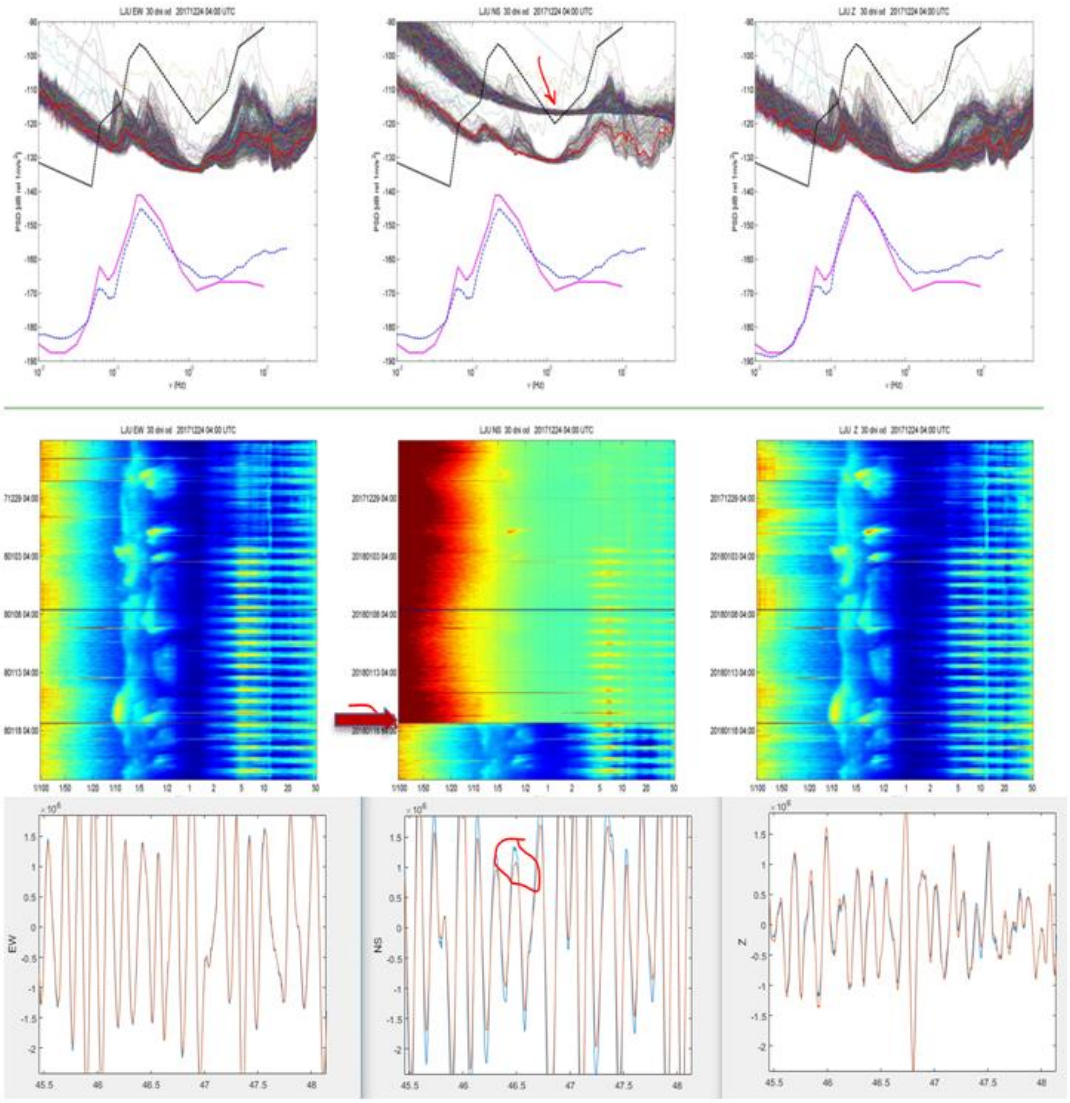
regional earthquakes

BOJS

Date	amplitude correction			α
	EW	NS	Z	
2016-08-24	0.98	0.99	0.99	3.0°
2016-10-26	**0.57**	0.98	0.99	~~5.1°~~
2016-10-30	0.98	0.99	0.99	11.4°
2017-01-18	0.98	0.99	0.99	-1.6°

QC example: STS-2, EpiSensor (LJU)

local earthquake - conditional suitable



Date	M_w	LJU amplitude correction			α
		EW	NS	Z	
2018-01-17	3.5	1.00	**1.25**	1.00	~~0.3°~~

NS component of EpiSenosr:
-must be multiplied by 1.25
-PSD was unusual high.

Action: off/on the accelerometer

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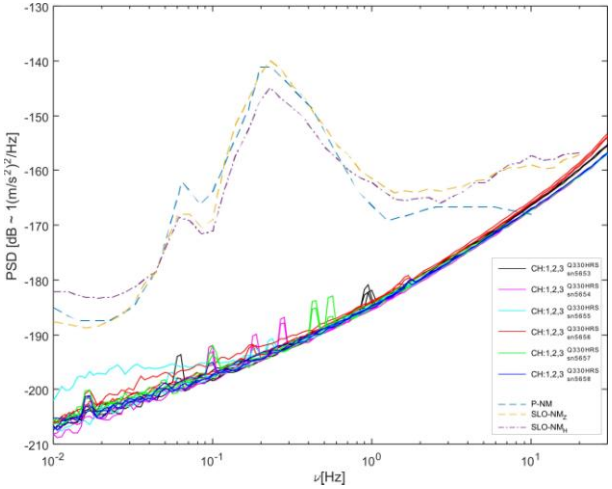
QC - We Liked

- a large number of seismic stations data can be processed precisely in a relatively short time

QC - We Disliked

- a strong seismic signal is needed

control of new/’from repair’ systems



individual approach

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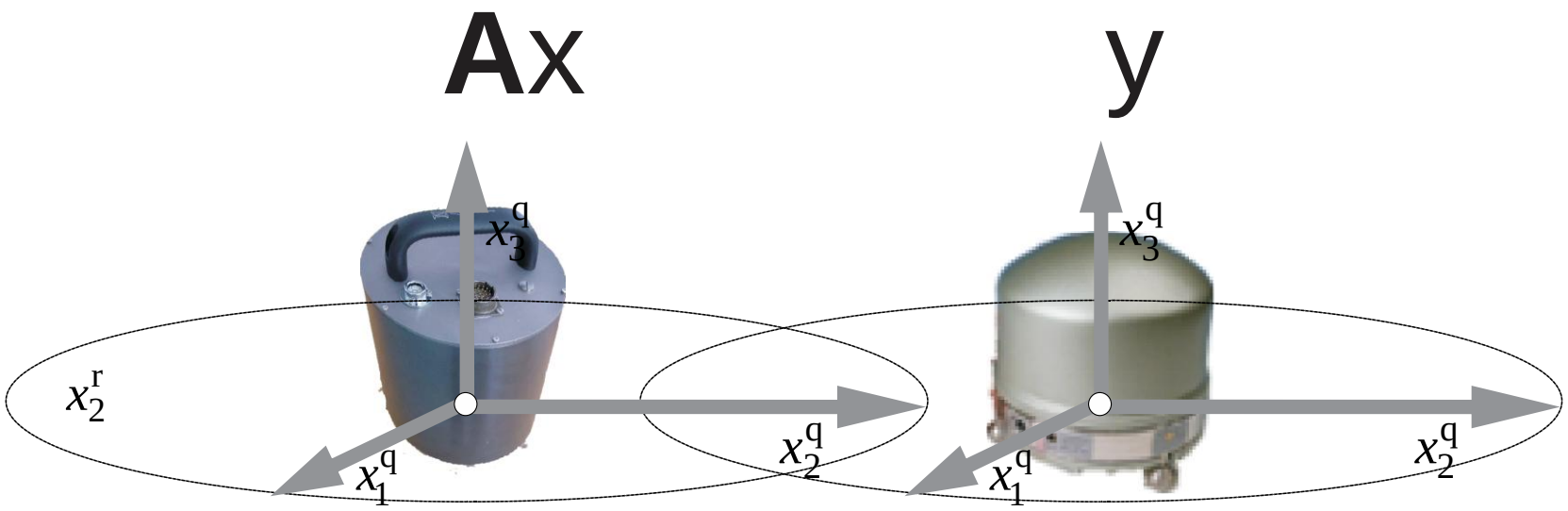
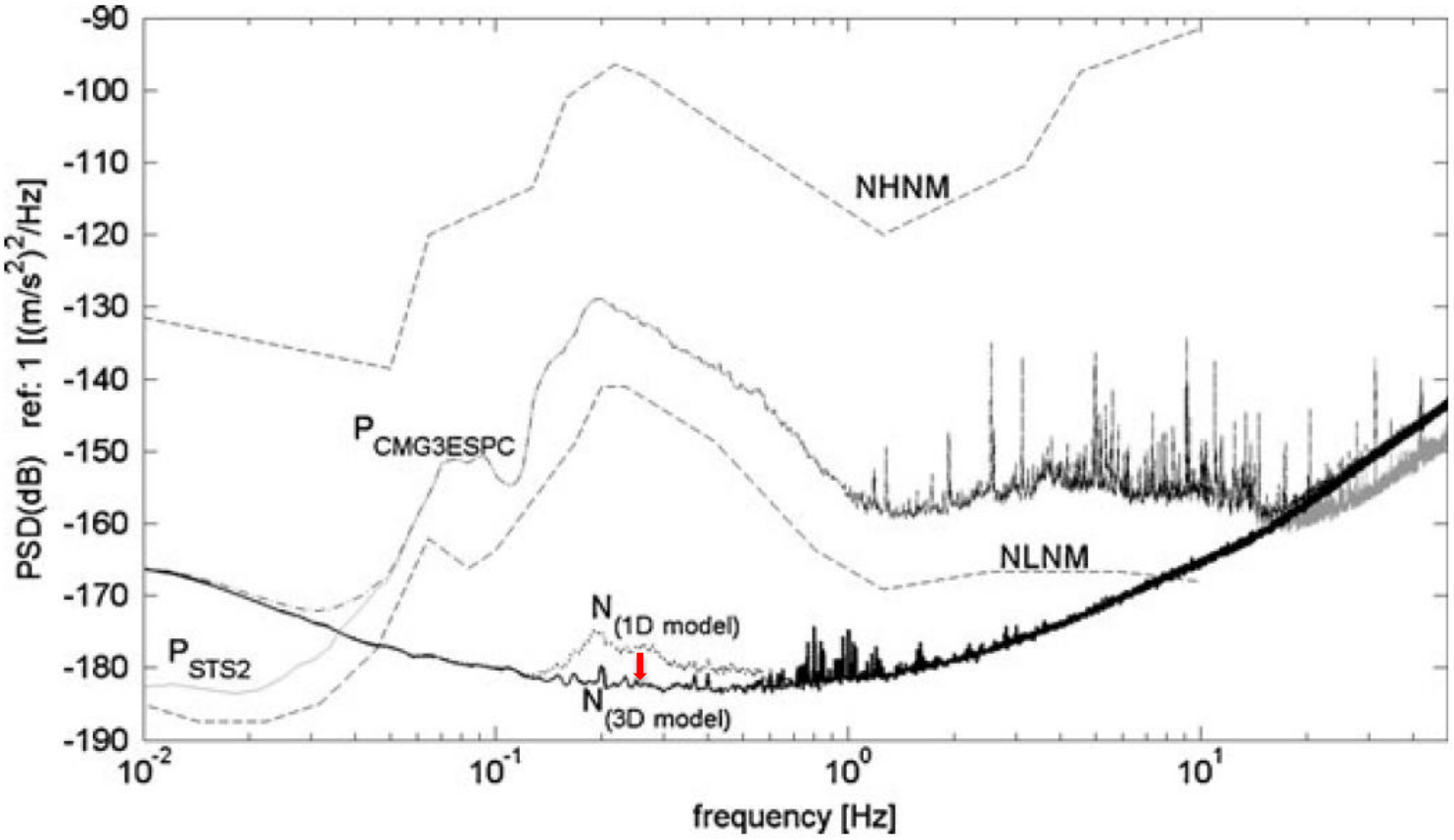
control of new/’from repair’ seismometer



Tasič, Runovc: the development and analysis of 3D transformation matrices for two seismometersL; Journal of seismology, (DOI: DOI: 10.1007/s10950-014-9429-0)

control of new/'from repair' seismometer



Tasič, Runovc: Seismometer self-noise estimation using a single reference instrument, Journal of seismology, (DOI: 10.1007/s10950-012-9355-y)

2 x STS-2 seismometer

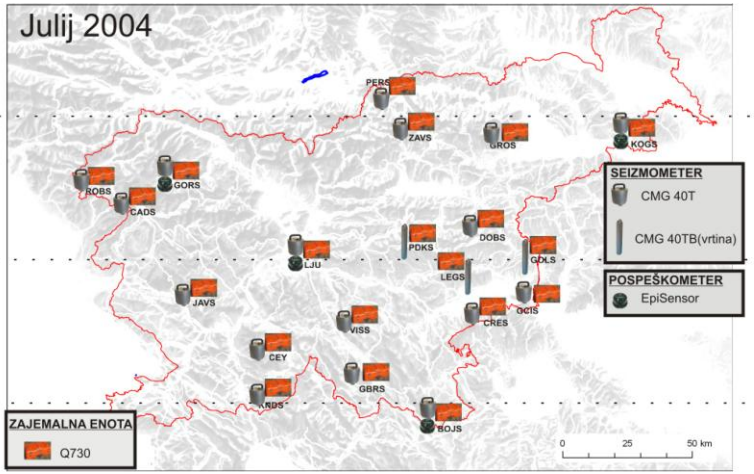
$$\mathbf{A}_{qr} = \begin{bmatrix} 1.00849 & 0.00134 & -0.00021 \\ -0.00171 & 1.01109 & 0.00068 \\ -0.00038 & -0.00049 & 1.00938 \end{bmatrix}; \mathbf{A}_{rq}^{-1} = \begin{bmatrix} 1.00849 & 0.00134 & -0.00021 \\ -0.00171 & 1.01109 & 0.00068 \\ -0.00038 & -0.00049 & 1.00938 \end{bmatrix}$$

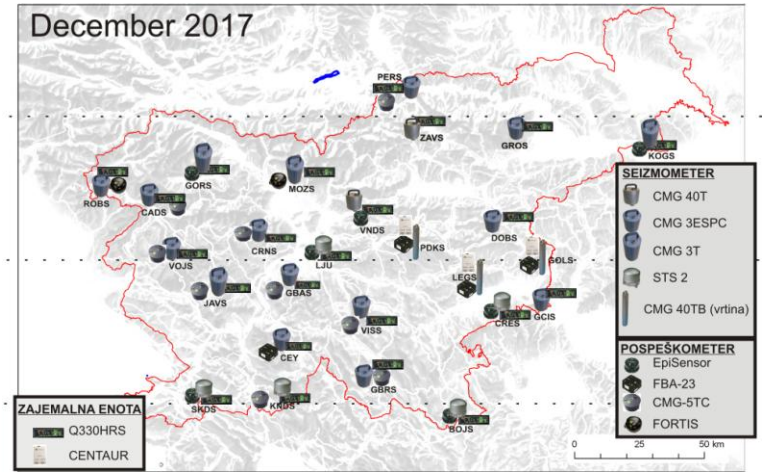
$$\mathbf{I} = \begin{bmatrix} 1.00000 & 0.00000 & 0.00000 \\ 0.00000 & 1.00000 & 0.00000 \\ 0.00000 & 0.00000 & 1.00000 \end{bmatrix}; \quad \mathbf{K}_G = \begin{bmatrix} 1.00000 & -0.00037 & -0.00059 \\ 0.00000 & -1.00000 & -0.00019 \\ 0.00000 & 0.00000 & -1.00000 \end{bmatrix}$$

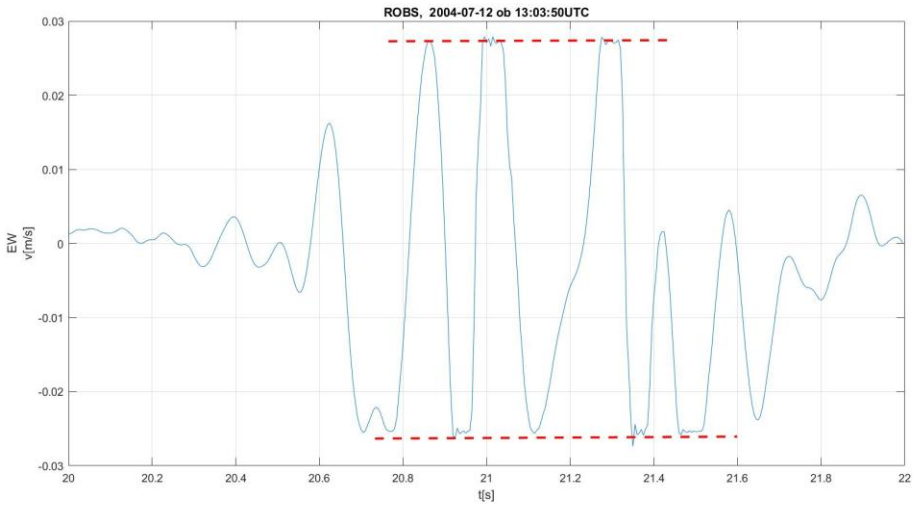
Matrices $\mathbf{A}_{qr}$, $inv(\mathbf{A}_{rq})$, $\mathbf{I}$ and $\mathbf{K}_G$ in the $[i,j,k]$ orientation, calculated for a pair of two STS-2 seismometers

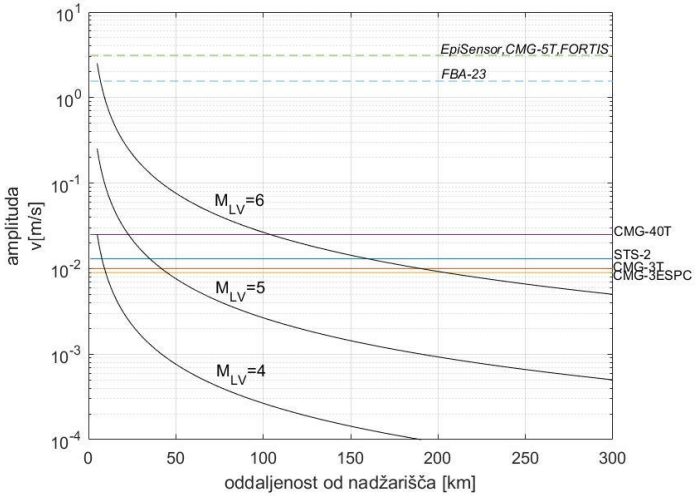
Tasič, Runovc:Determination of a seismometer's generator constant, azimuth and orthogonality in three-dimensional space using a reference seismometer, Journal of seismology,(DOI: 10.1007/s10950-012-9355-y)

Improvements - Seismic Network of the Republic of Slovenia









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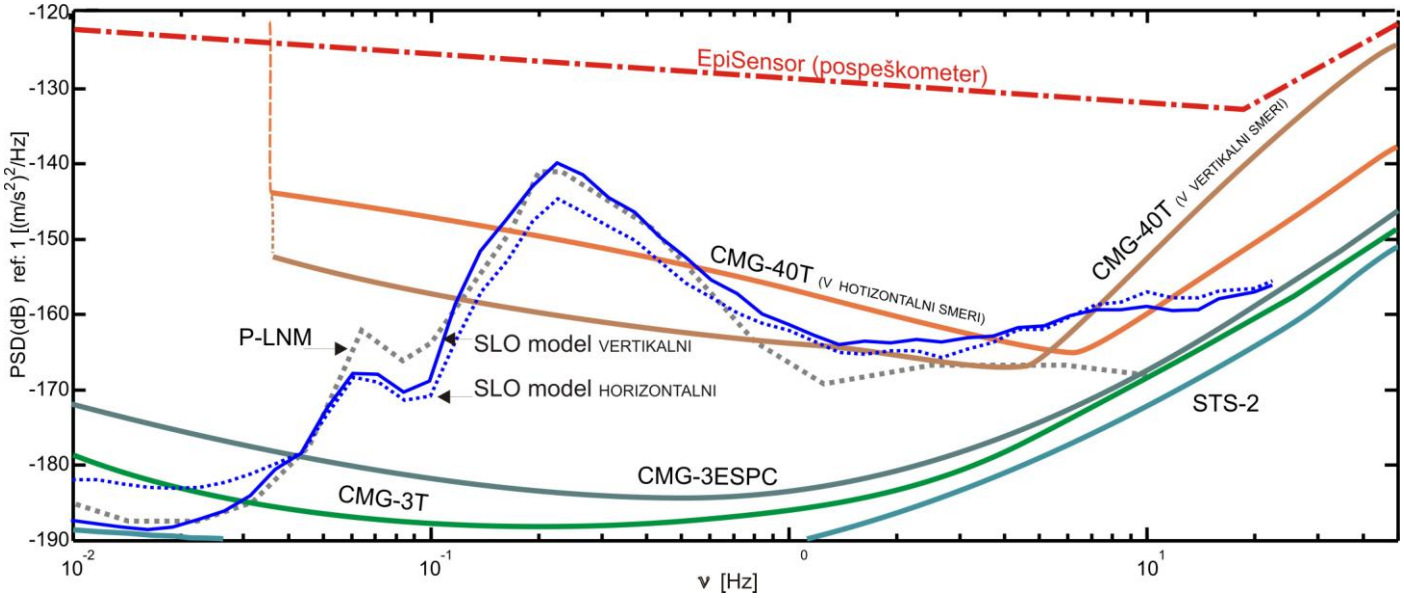
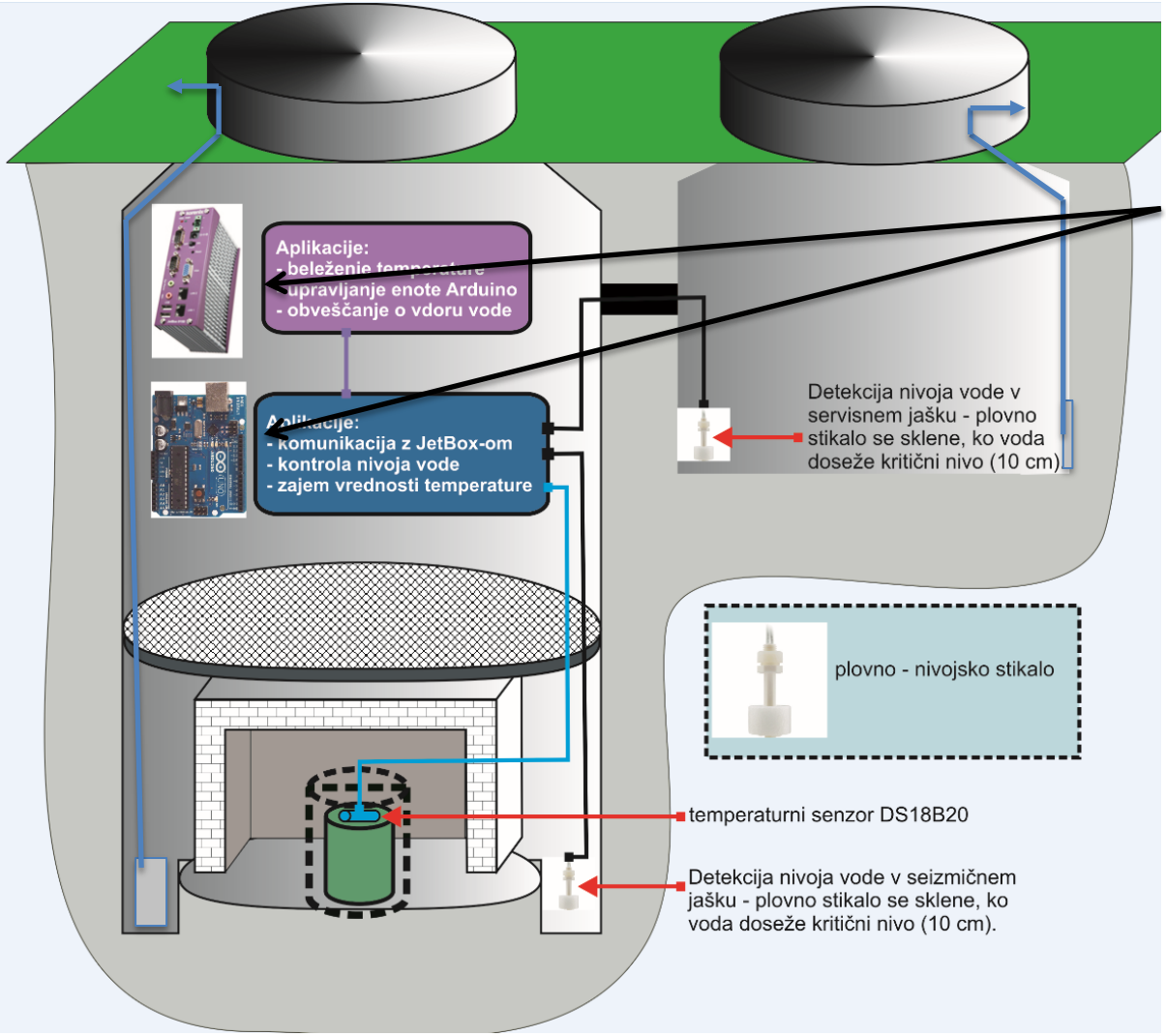
Improvements - Seismic Network of the Republic of Slovenia



seismometer	max. amplitude
CMG-40T	2,5 cm/s
STS-2	1,3 cm/s
CMG-3T	1,1 cm/s
CMG-3ESPC	0,9 cm/s

waterproof

waterproof



- additional archive backup
- modem control
- water-level control
- temperature monitoring
-...

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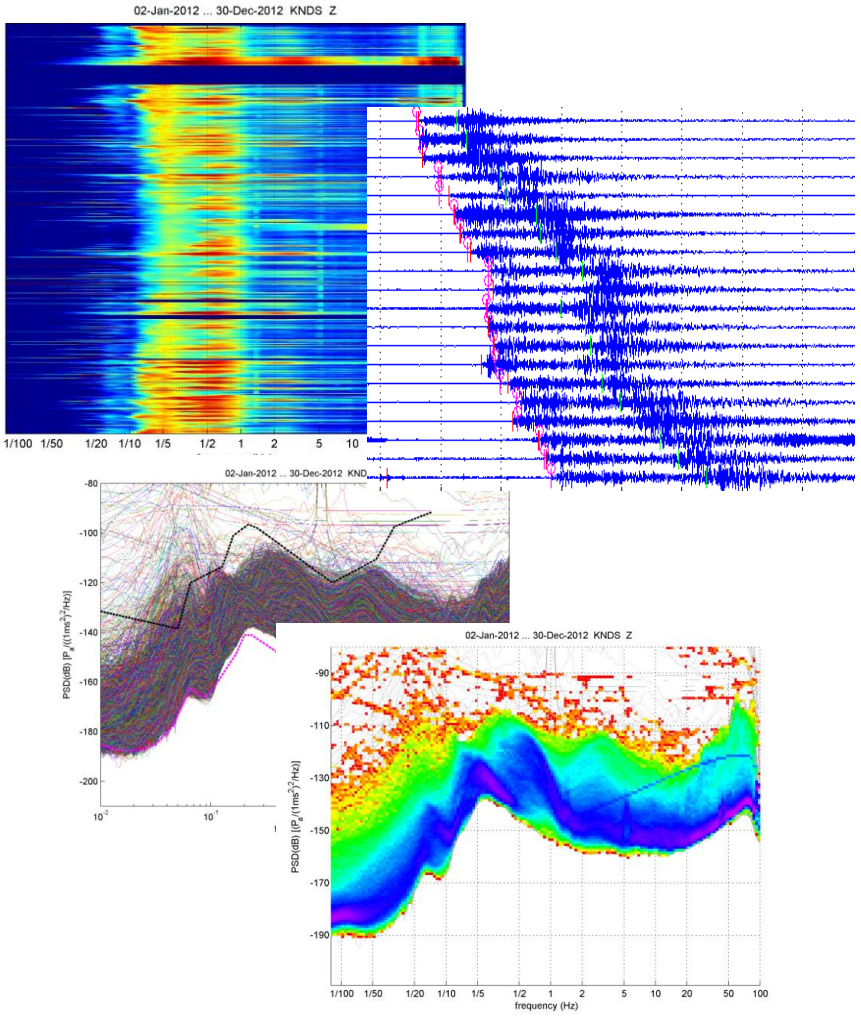
ANNUAL ANALYISIS

(in the end of the year)



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….of course there are many more small tasks….

thank you