Report on the EUREF Combined Solution Generation

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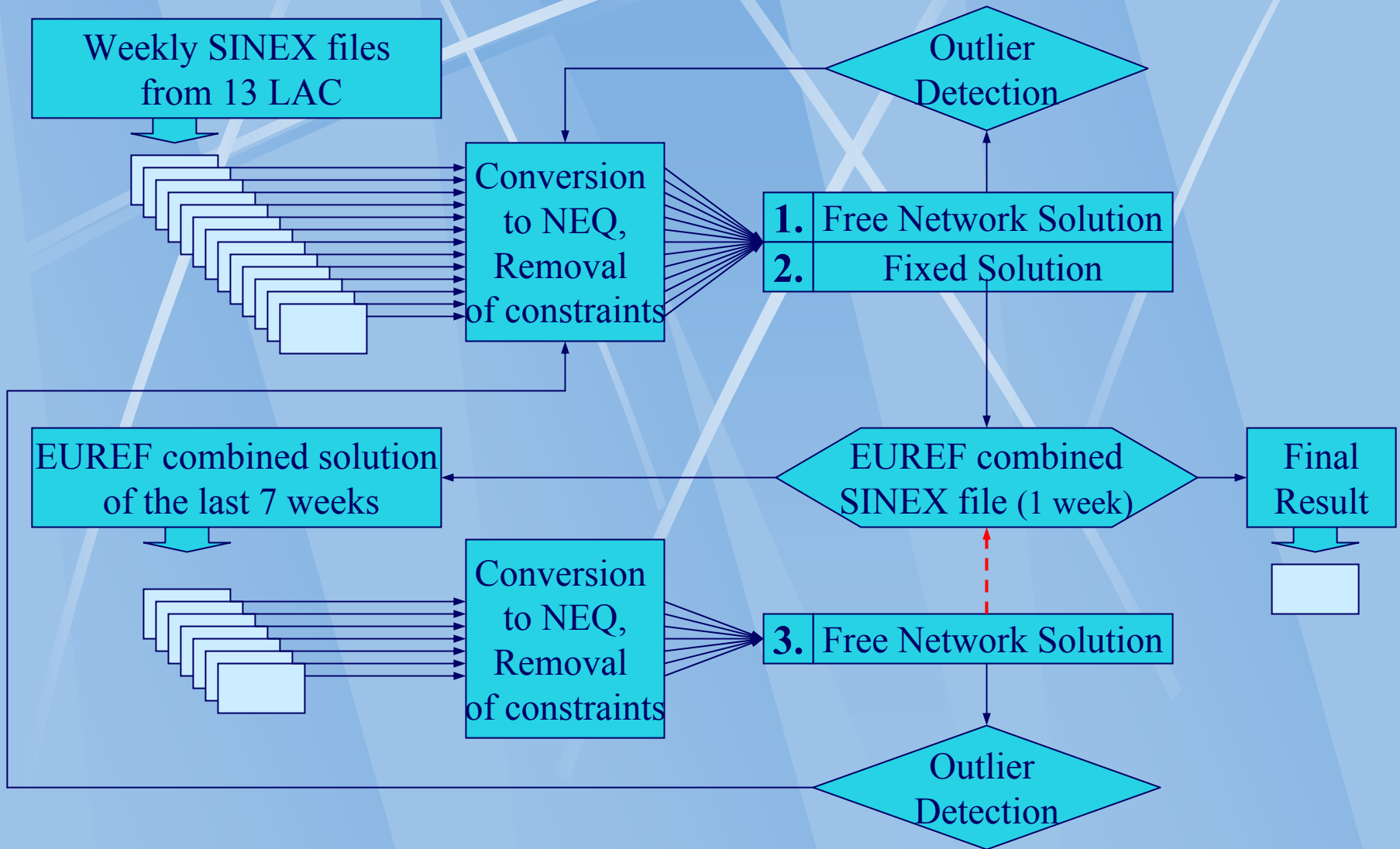
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EPN Local Analysis Center Workshop, 31 May - 1 June, 2001, Warsaw

Introduction

- Combination scheme

- Introduction of DEO Analysis Center

- Exclusion of stations

- Weighting of solutions

- Conclusion

Combination Scheme

Weekly SINEX files from 13 LAC → Conversion to NEQ, Removal of constraints → 1. Free Network Solution / 2. Fixed Solution → Outlier Detection

EUREF combined solution of the last 7 weeks → Conversion to NEQ, Removal of constraints → 3. Free Network Solution → Outlier Detection

EUREF combined SINEX file (1 week) → Final Result

Local Analysis Centers

1 ASI - Nuova Telespazio S.p.A., Space Geodesy Centre, Italy
2 BEK - International Commission for Global Geodesy of
     the Bavarian Academy of Sciences, Germany
3 BKG - Bundesamt fuer Kartographie und Geodaesie, Germany
4 COE - European solution created at CODE
     (Centre for Orbit Determination in Europe)
5 DEO - Delft Institute for Earth-Orientated Space Research,
     Delft University of Technology, Netherlands
6 GOP - Geodetic Observatory Pecny, Czech Republic
7 IGN - Institut Geographique National, France
8 LPT - Bundesamt fuer Landestopographie (L+T), Switzerland
9 NKG - Nordic Geodetic Commision
10 OLG - Observatory Lustbuehel Graz, Austria
11 ROB - Royal Observatory of Belgium
12 UPA - Universita di Padova, Italy
13 WUT- Warsaw University of Technology, Poland

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Introduction of the DEO Local Analysis Center

- DEO had submitted first solution for week 1095.

- First LAC using JPL's GIBSY software

- Combination on normal equation (NEQ) level not possible due to missing correlations

- Small changes in DEO's processing (combination of daily solution to weekly solution).

- DEO introduced into combined solution since week 1100

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Combination Difficulties of first DEO Solutions

- 2 combination approaches:

  - Helmert transformation between individual solutions and „reference solution"; combination of transformed solutions

    → Successful for DEO solutions

  - Conversion of SINEX files into NEQs; stacking of NEQs (e.g., ADDNEQ)

    → Failed for DEO solutions

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Helmert Transformation Approach

- Combination of 3 DEO solutions (weeks 1096-1098) by Remi Ferland (EMR, Canada)

- DEO solution versus combined solution (week 1096) ➡️

- Combination with ADDNEQ failed

Station	Δ Lat.	Δ Long.	Δ Height
ACOR	.6	−12.6	.1
ALAC	−2.7	3.8	−1.1
ALME	−4.9	1.3	−1.2
BELL	.8	5.9	.7
CANT	.3	−5.5	−1.4
CASC	−3.4	−9.4	−1.7
CHIZ	5.3	−3.0	4.4
CREU	1.5	9.0	4.3
EBRE	−.3	3.2	−.4
ESCO	1.3	3.0	1.0
GAIA	5.6	−2.0	6.6
LAGO	4.0	1.8	1.9
LLIV	1.0	4.9	.8
MALL	−1.8	9.8	.3
MARS	2.4	11.3	3.9
MAS1	−15.6	−15.1	8.4
PDEL	8.0	39.1	−9.8
SFER	−6.6	−6.6	−.8
VALE	11.6	−32.4	−12.4
VILL	−1.7	−2.9	−1.9
YEBE	−1.5	−2.1	−1.7
	mm	mm	mm

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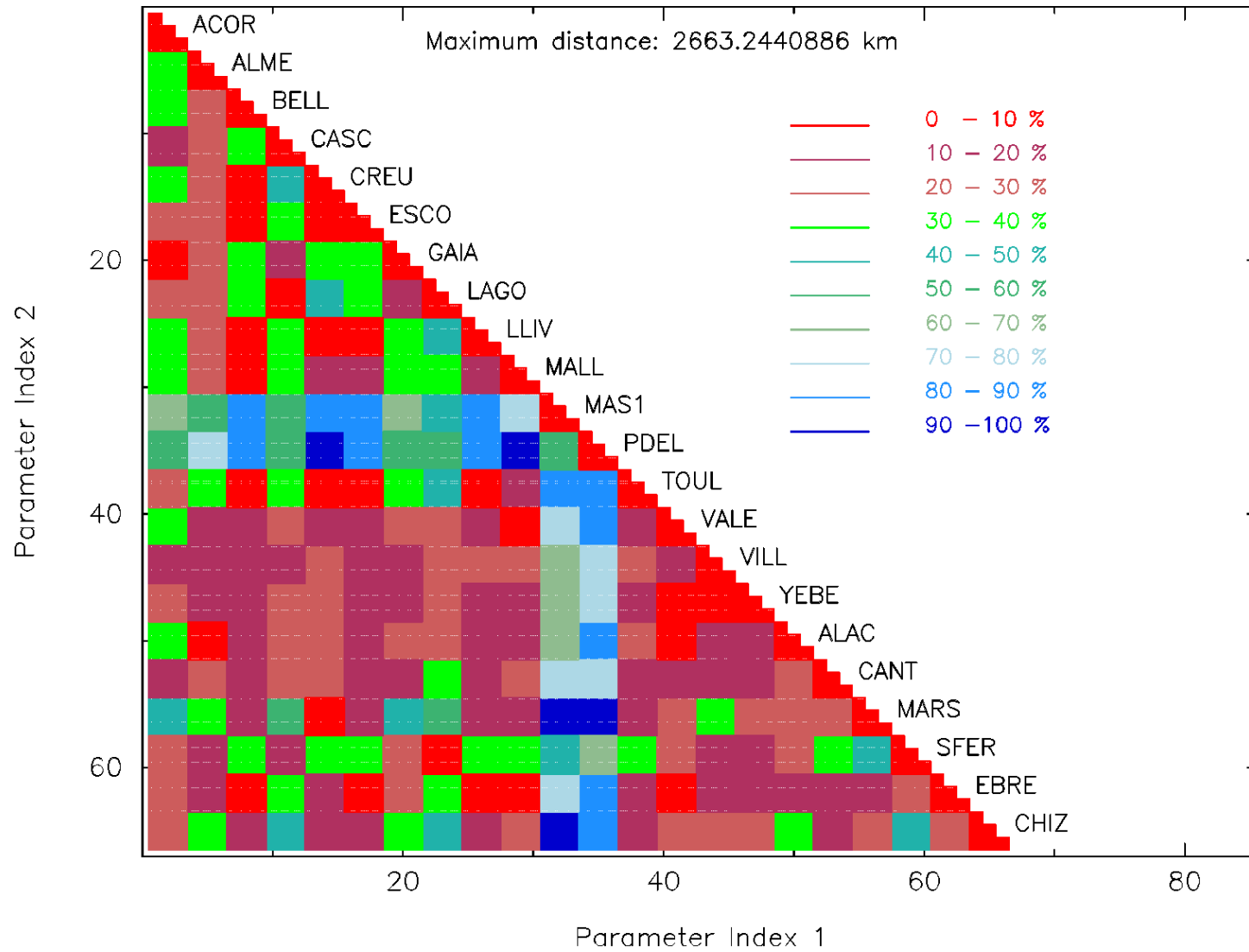
Correlation Coefficients — DEO10957.SNX
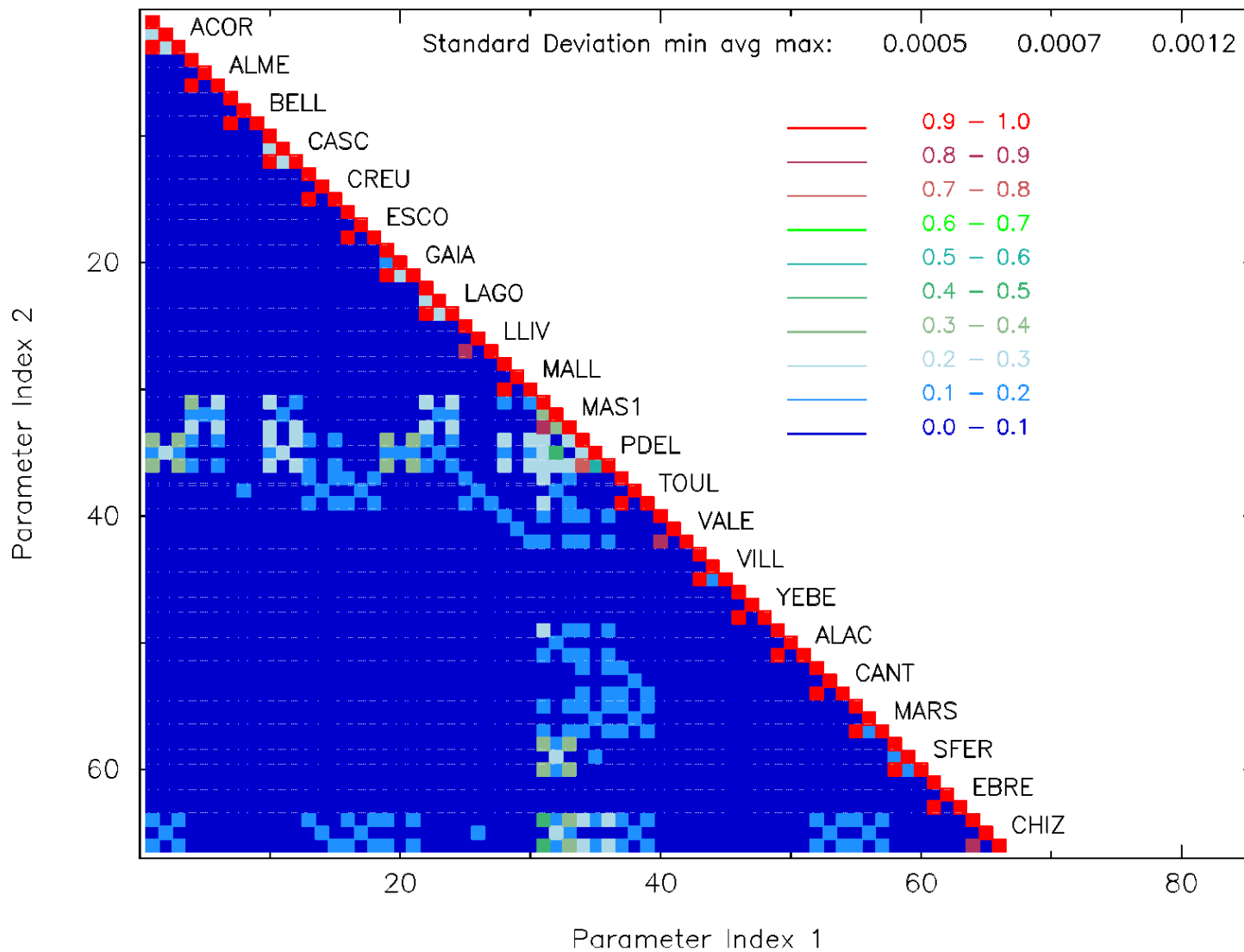
Distances in % of Maximun Distance — DEO10957.SNX

Correlation Coefficients DEO Solution 1095

- Combination using the NEQ approach requires „free network solution"

  ➜ Coordinates not constraint but highly correlated

- No correlation between coordinates in week 1095 solution from DEO

  ➜ NEQ approach failed

- Helmert transformation approach successful without correlations

Correlation Coefficients — DEO11007.SNX

Differences EUN11007.SNX — EUN+DEO11007.SNX, Green = Fixed in Ref. File
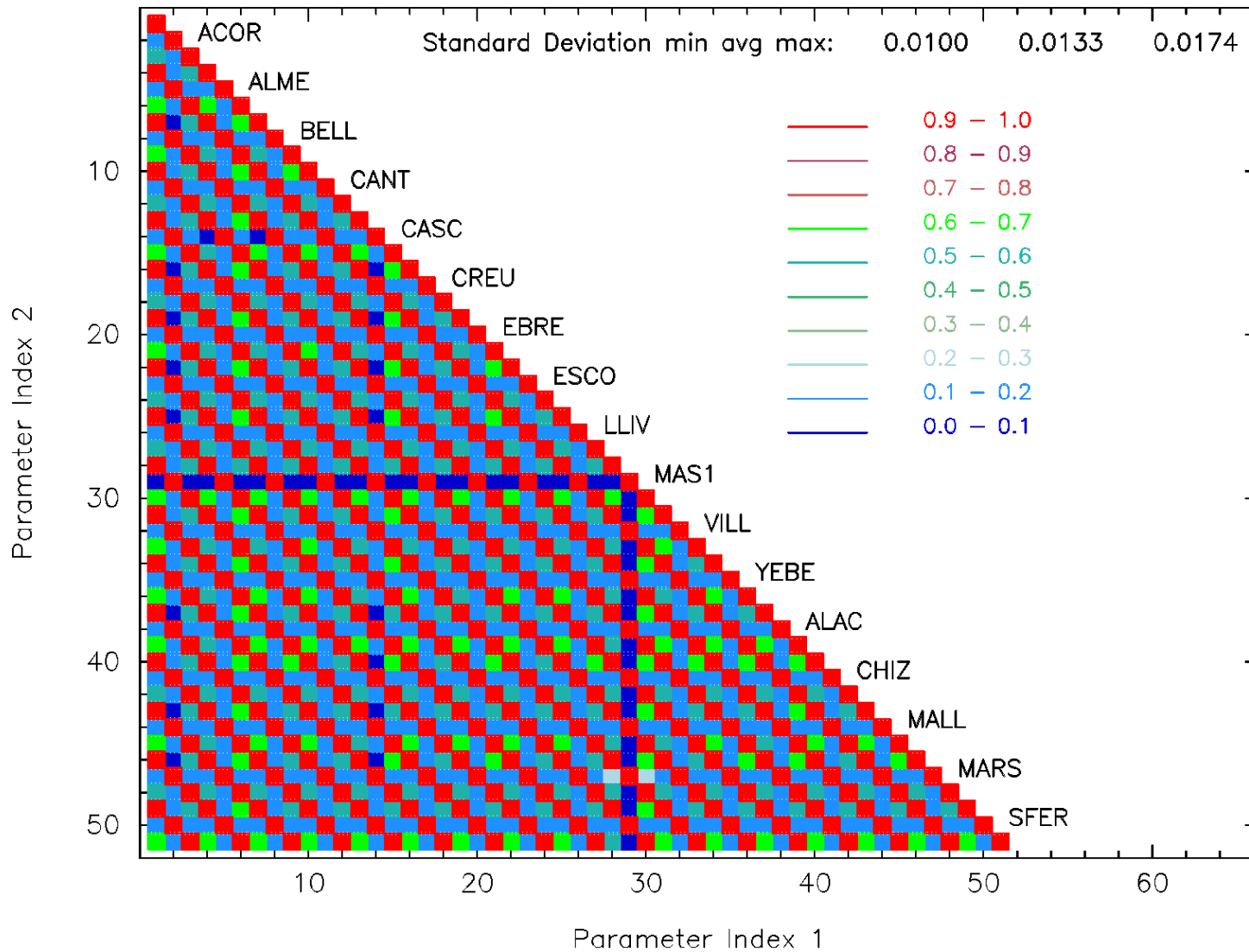
Changes caused by DEO introduction
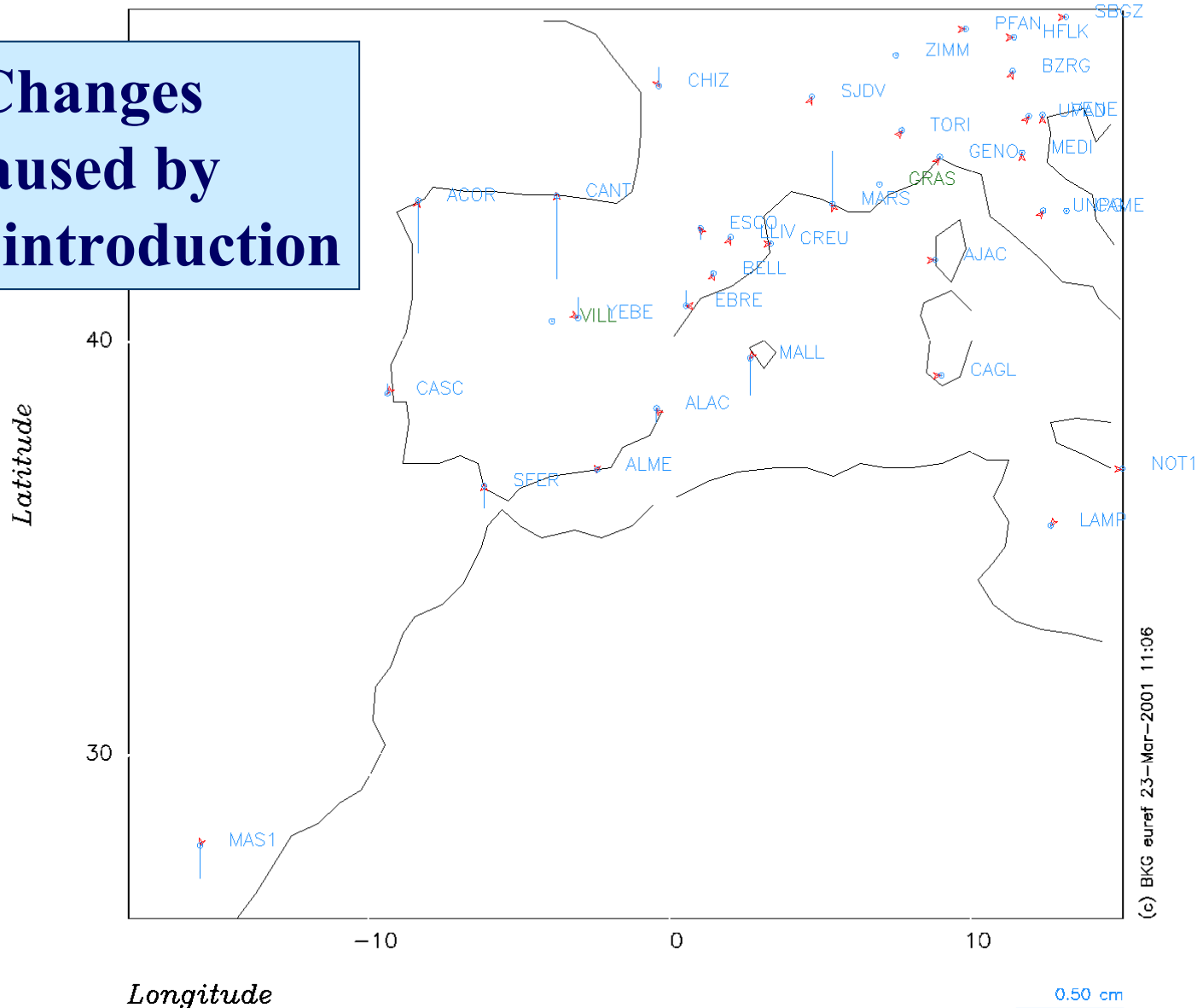
Exclusion of Stations

- Maximum residual between combined and LAC solution

  > 5mm/10mm for position/height ?

  (Redundancy within network required)

- STACRUX.EUR file used (Bernese Software)

- Number of exclusions checked with graphical visualization

- Information of exclusions in AC report and summary file

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Exclusions ASI Analysis Center — Solution for Week 1086 — 1106

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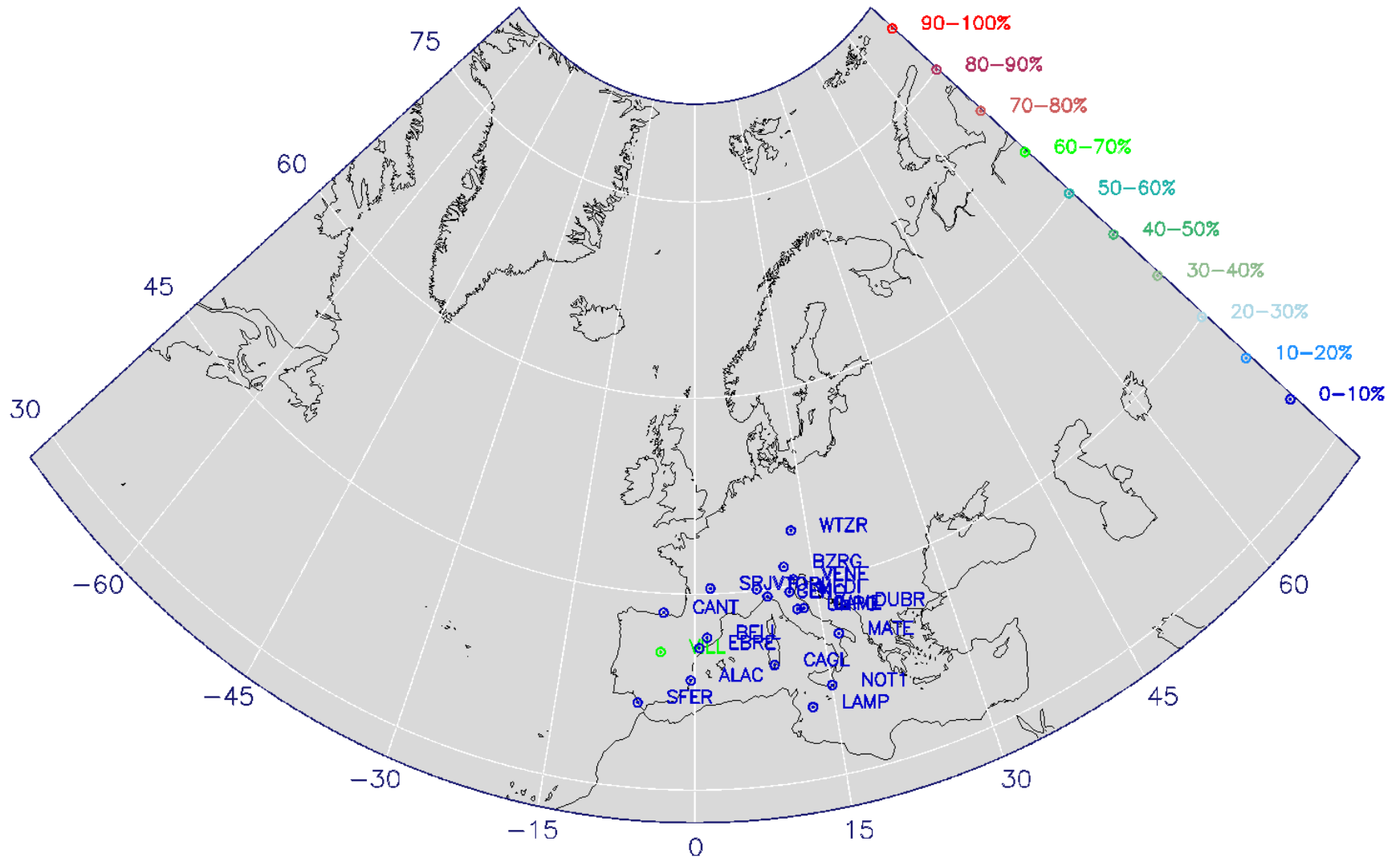
LAC Report File of Week 1102

```
...
EXCLUSION OF SITES FROM COMBINATION:


 -->    EXCLUDE STATION:         153 VILL 13406M001    TO     -1 VILL
    SCRATCHASI


...
                                    ASI     BEK    BKG    COE    DEO
 NUM    STATION        #FIL C    RMS     1      2      3      4      5 ...
...


 153    VILL 13406M001     4   N   123.8   214.4   -0.2          -0.2   -0.2
                           E    28.1   -48.6    0.1          -0.2   -2.4
                           U   106.7   184.4   -2.8           1.6   11.1
...
```

ASI Analysis Center versus Combined Solution— Station VILL

IGS-Mail 3344:
Receiver problems since day 100 (gpsweek 1109)
Receiver outage since day 112 (gpsweek 1111)

Legend:
North
East
Up
Excluded in combination

Residual [mm]

GPWEEK
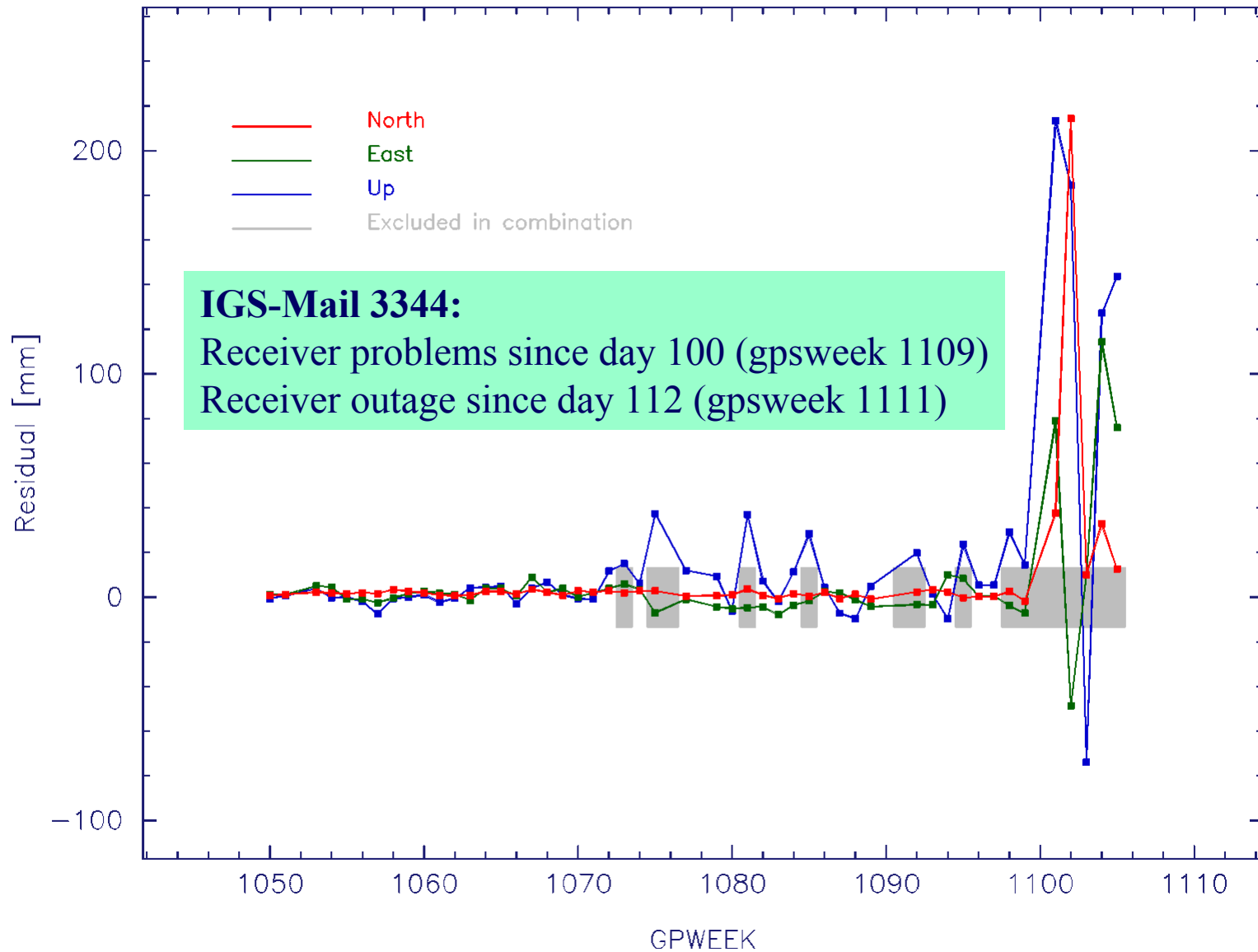
Correlation Coefficients – ASI11007.SNX

Correlation Coefficients — ASI11027.SNX

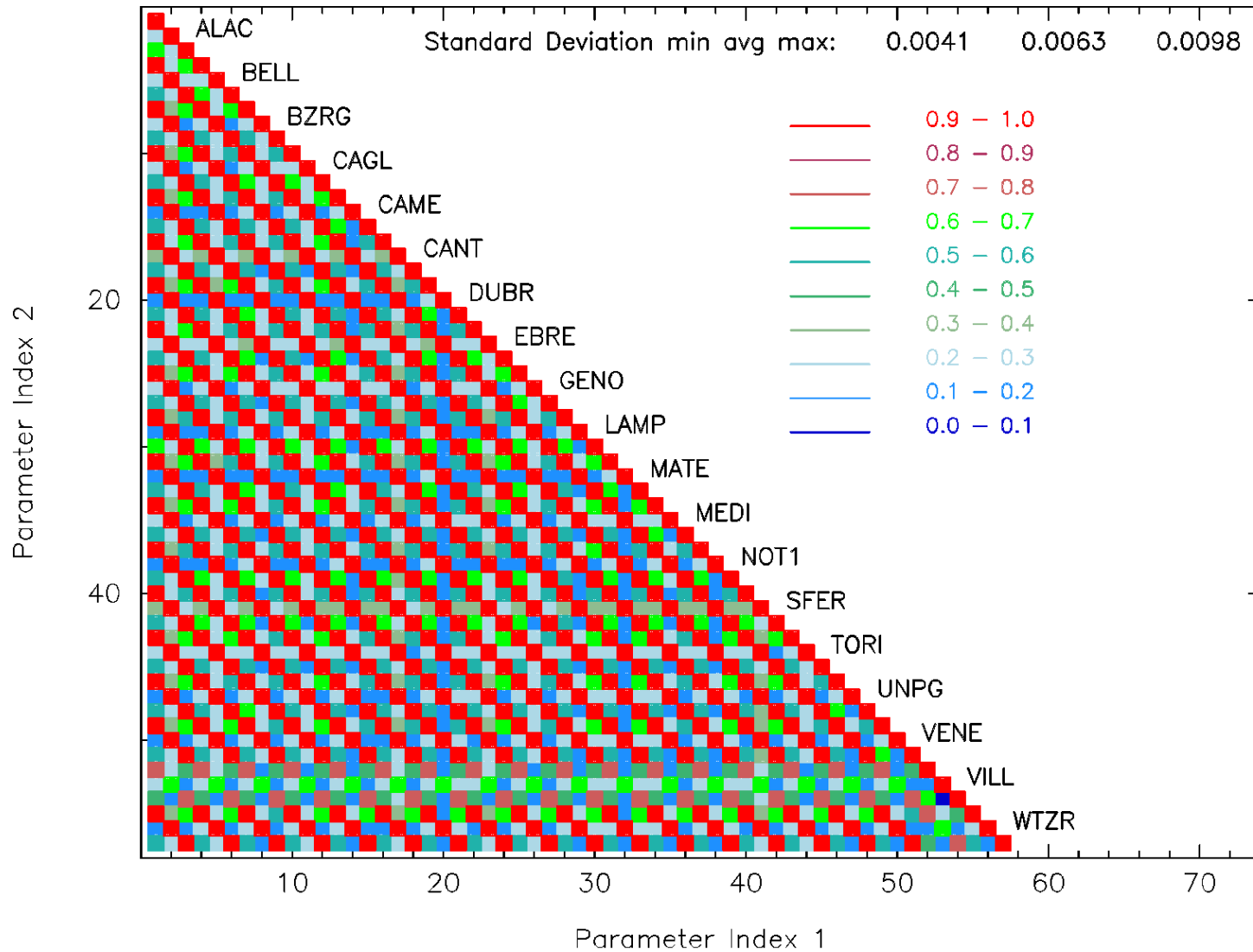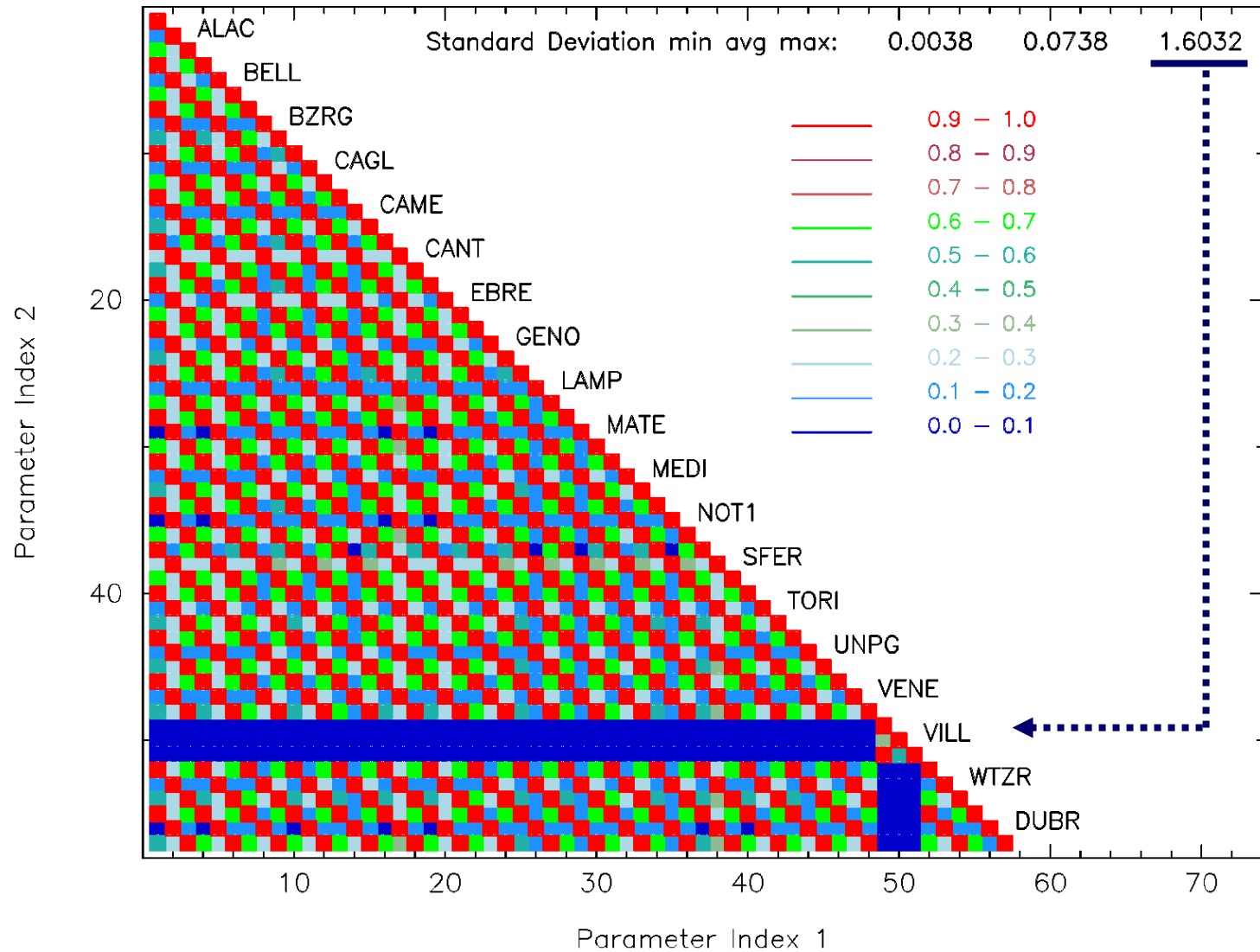Correlation Coefficients – COE11027.SNX

Exclusions WUT Analysis Center – Solution for Week 1050 – 1102

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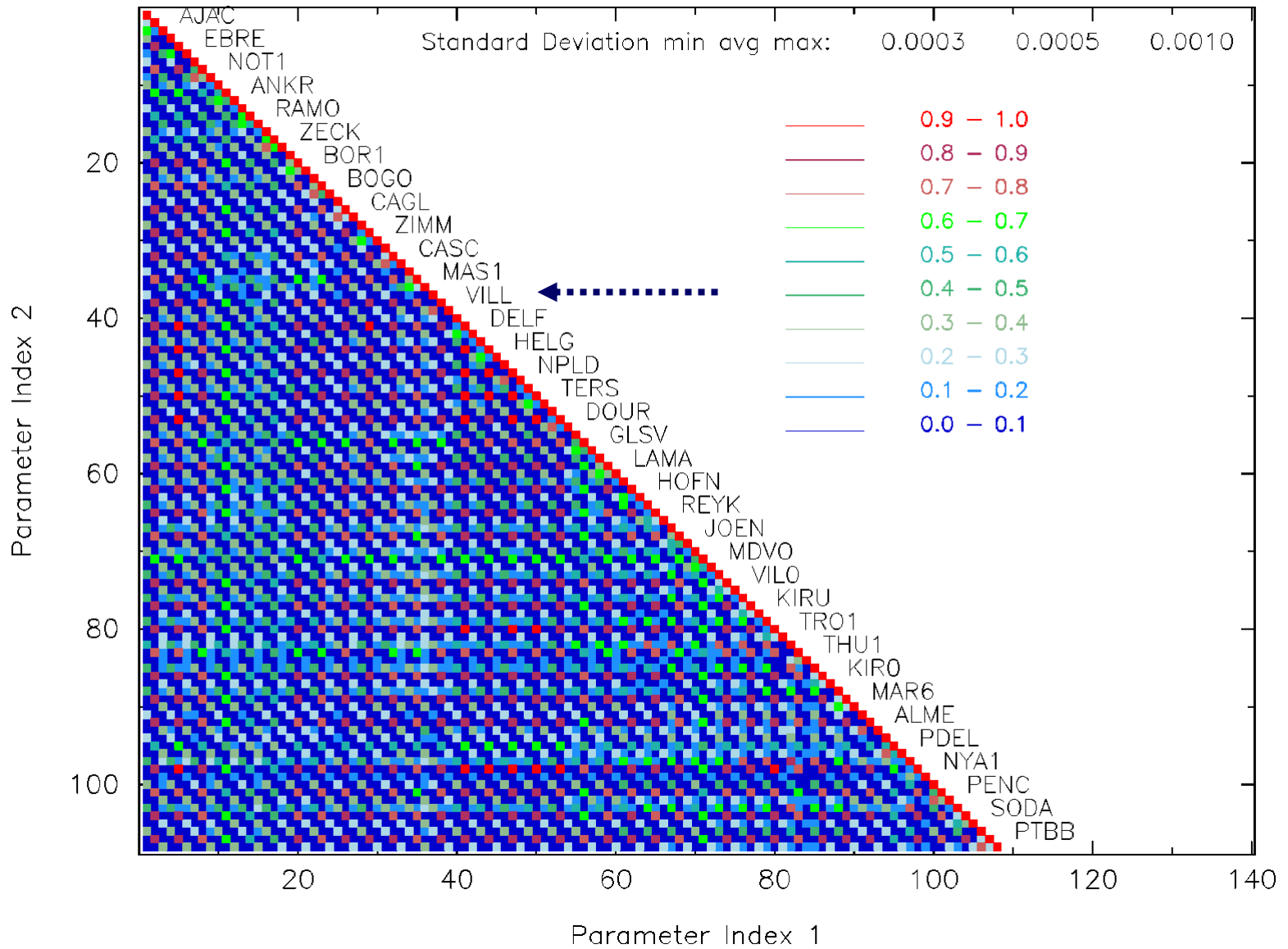
Weighting of Solutions

- Each solution of a LAC may be scaled by a factor before the combination (weighting)

- Increasing request for correct weighting because of multiple software packages

- Estimation of variance-covariance components not activated in Bernese software

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Weighting of Solutions in Bernese Software

Weighting Comparisons

Introduced Weight File (first line)
Estimated Covariance Factors (second line)

ASI	BEK	BKG	COE	DEO	GOP	IGN	LPT	NKG	OLG	ROB	UPA	WUT

Sigma scaling + equal weights:

ASI	BEK	BKG	COE	DEO	GOP	IGN	LPT	NKG	OLG	ROB	UPA	WUT
0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
0.76	0.58	0.58	1.70	0.33	0.55	0.39	0.67	0.59	0.48	0.61	0.28	0.70

No sigma scaling + equal weights:

ASI	BEK	BKG	COE	DEO	GOP	IGN	LPT	NKG	OLG	ROB	UPA	WUT
0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
0.77	1.18	1.18	1.31	0.26	1.11	0.80	1.34	1.18	0.98	1.23	0.58	1.41

Sigma scaling + individual weights:

ASI	BEK	BKG	COE	DEO	GOP	IGN	LPT	NKG	OLG	ROB	UPA	WUT
0.016	0.020	0.020	0.004	0.100	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
0.72	0.62	0.62	0.81	0.79	0.59	0.41	0.71	0.62	0.51	0.64	0.29	0.75

No sigma available

Poor solution

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Statistics in SINEX Files

LAC	Statistic Information			Covarinace Matrix							A-Priori Covariance Matrix		Network	Crontraint Classification
	RMS of Unit Weight [m]	Mean Standard Deviation [m]	Type	Mean Correlation Coefficients							Mean Standard Deviation [m]	Number of Constrained Stations	Longest Distance [km]	
				x-x	y-y	z-z	x-y	y-z	x-z					
ASI	-	0.0055	CORR	0.98	0.97	0.98	0.16	0.19	0.60	-	-	2180	?
BEK	0.0019	0.0019	COVA	0.95	0.96	0.95	0.36	0.36	0.76	0.0096	2	5437	tight
BKG	0.0026	0.0021	COVA	0.94	0.94	0.95	0.41	0.46	0.77	1.2899	all	4770	loose
COE	0.0022	0.0005	COVA	0.39	0.70	0.25	0.05	0.04	0.09	5.6645	all	6706	loose
DEO	-	0.0133	COVA	0.99	0.99	0.99	0.14	0.15	0.60	-	-	2535	?
GOP	0.0020	0.0010	COVA	0.81	0.93	0.75	0.11	0.11	0.20	0.0044	6	4275	tight
IGN	0.0024	0.0038	COVA	0.98	0.99	0.98	0.13	0.07	0.77	-	-	3578	?
LPT	0.0020	0.0004	COVA	0.28	0.30	0.29	0.15	0.14	0.31	0.0000	2	1159	tight
NKG	0.0024	0.0007	COVA	0.68	0.90	0.47	0.03	0.03	0.11	0.0012	4	4907	tight
OLG	0.0024	0.0006	COVA	0.47	0.38	0.46	0.35	0.33	0.44	0.0000	1	4338	tight
ROB	0.0023	0.0004	COVA	0.25	0.45	0.26	0.09	0.09	0.24	0.0001	2	2210	tight
UPA	0.0023	0.0006	COVA	0.41	0.53	0.35	0.42	0.36	0.39	0.0000	1	1722	tight
WUT	0.0016	0.0009	COVA	0.78	0.56	0.68	0.49	0.45	0.71	0.0008	1	6007	tight

Weighting of Solutions
- Action Items -

- Information for scaling with $1/\delta^2$ for some LACs missing
  - → Request to LACs

- Currently mixed scaling strategy realized
  - → Strategy has to be reviewed

- Interaction of δ, standard deviations and correlations should be studied

- Declarations within the weight file:
  - → Currently empirical determined values used
  - → Values should be defined following a rational background

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Conclusions

- 13 LACs and 3 Software packages contribute to EPN

- Plot of correlations is a helpful tool to check SINEX files

- Redundancy within the network allows the detection of center-specific processing errors (used for exclusion of stations)

- Correct weighting of the solutions has to be studied

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