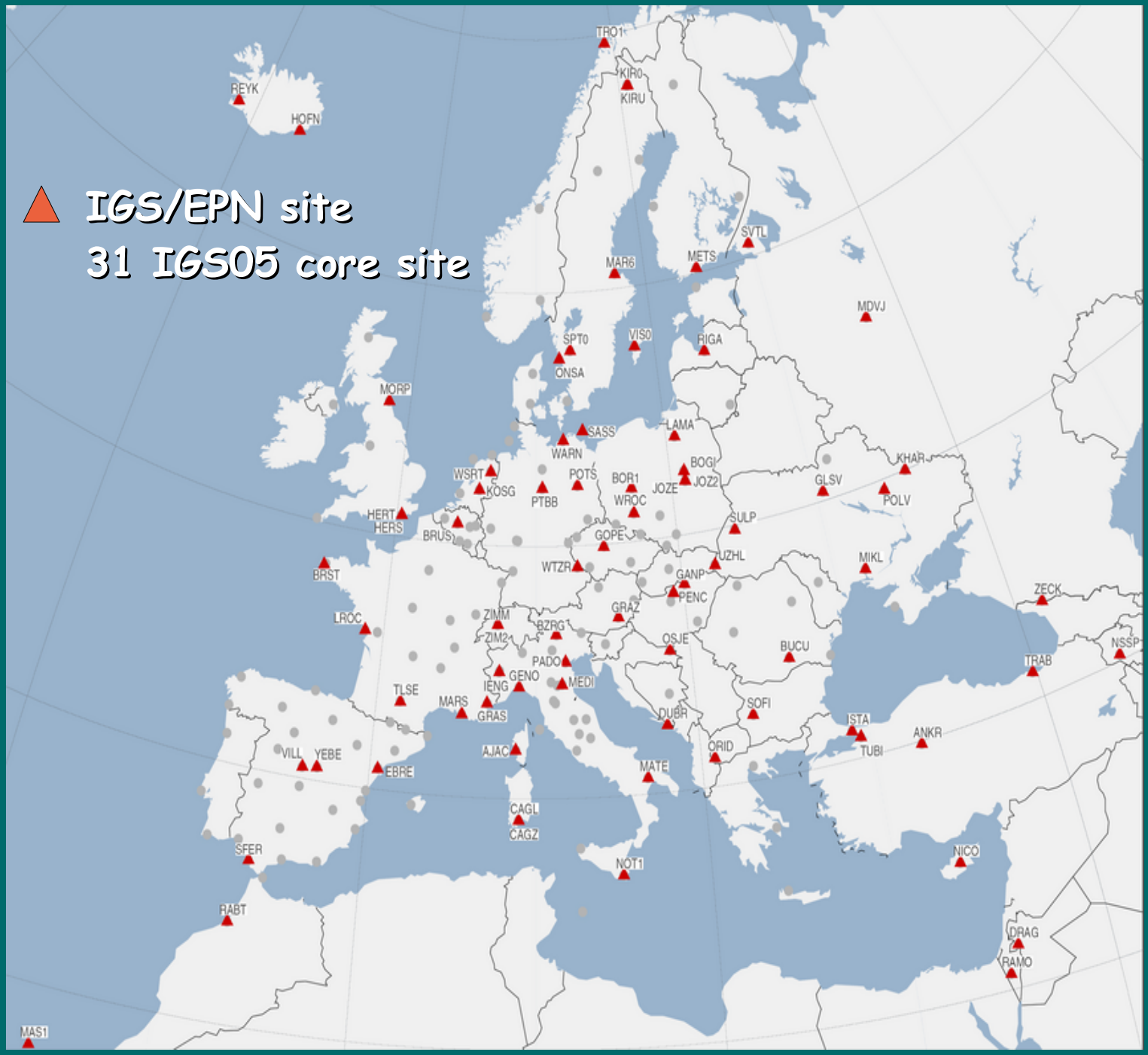
REGIONAL RE-ANALYSIS: expectations and experiences within the EPN

Kenyeres A. - Legrand J. - Bruyninx C. - Figurski M. - Habrich H.

IGS Analysis Center Workshop, 2-7 June 2008, Miami, FL, USA

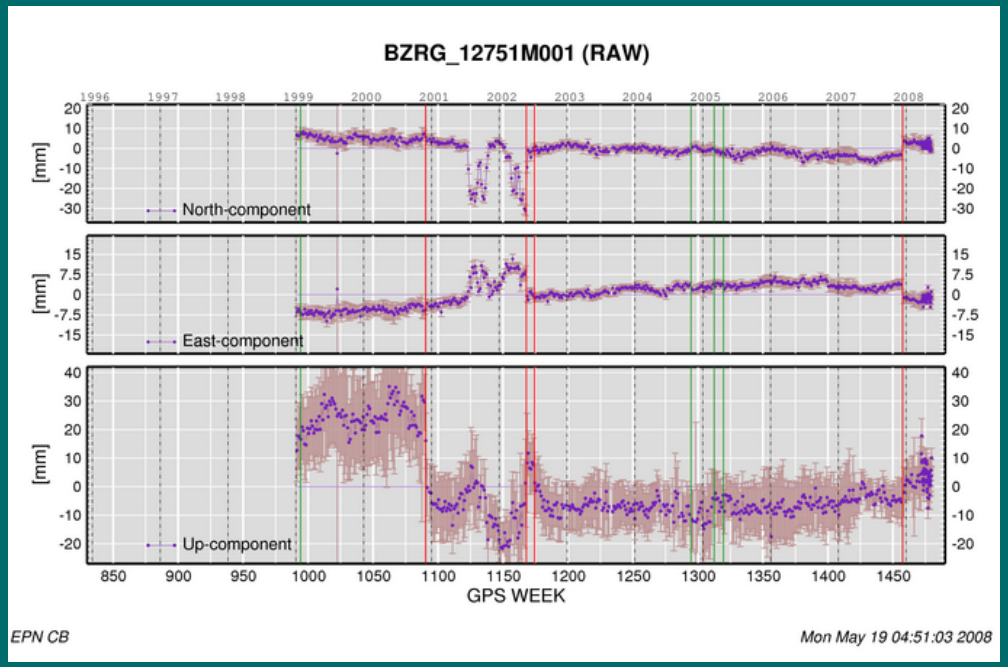
EPN: EUREF Permanent GPS Network



EPN GENERAL FACTS

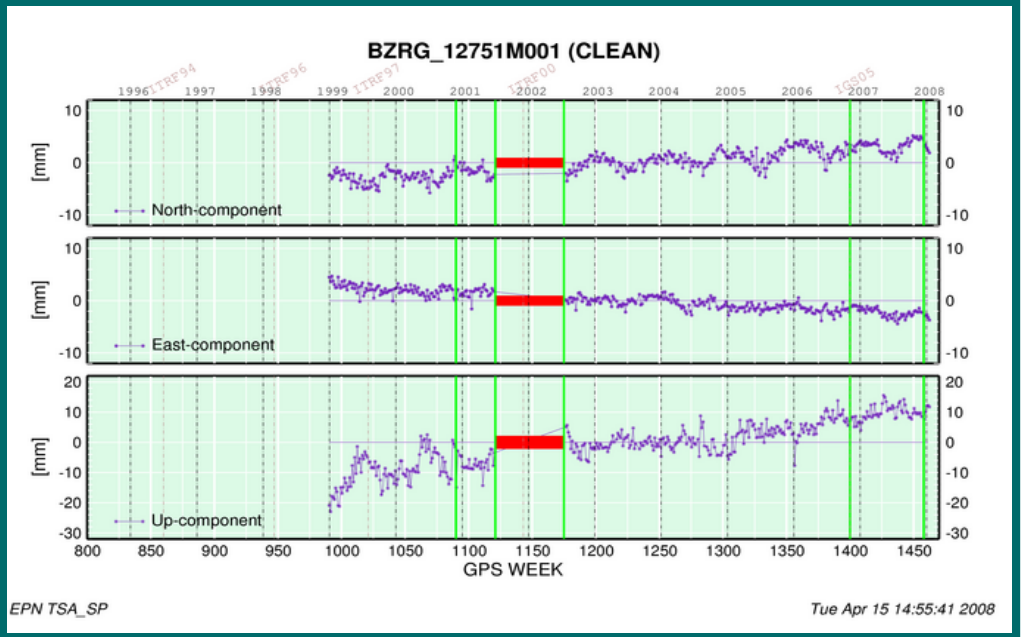
- operational since 1996
- currently ~200 GPS stations (34 in 1996)
- EPN Central Bureau (www.epncb.oma.be)
- 16 Local Analysis Centres + Combination Centre
- weekly combined SINEX files are available
- considered as regional densification of the IGS and ITRF networks
- EPN mostly follows IGS guidelines and recommendations

CURRENT EPN PRACTICE
ON TIME SERIES ANALYSIS



RAW combination:
show the series as they are,
no discontinuites are introduced,
no outliers are eliminated and
velocities are not estimated

CLEANED combination:
best quality cumulative solution,
discontinuites and outliers are applied,
velocities are estimated



EPN REPROCESSING INITIATIVE

- **OFFICIAL REPROCESSING**

  EPN WILL FOLLOW (AND WAIT FOR) IGS:

  - recommendations, models, rules
  - products (orbit, EOP)
  - schedule ! ITRF !

- **PILOT RE-ANALYSIS**
  - testing the current environment (database, tools, resources)
  - get insight into the expected improvements

EPN PILOT RE-ANALYSIS

COMPLETE EPN REPROCESSING

- **MUT** (Military University of Technology, Warsaw)

  Figurski M. – Kaminski P. – Kroszczynski K. – Gałuszkiewicz Z.

- **ROB** (Royal Observatory of Belgium)

  Legrand J. – Bruyninx C.

BERNESE 5.0 using the <u>current</u> EPN analysis standards (absolute PCV, 3° cut of angle, tropospheric gradient, JPL DE405 ephemeris, troposphere Niell mapping function . . .)

LAC SPECIFIC contribution

MUT completed 1996 – 2006 (wk. 834 - 1410)

- reprocessed IGS orbit, EOP (Steigenberger et al, 2006)
- weekly combination by MC over translation parameters

ROB completed 1996 – 2003 (wk. 846 - 1270)

- original IGS orbit and EOP
- weekly combination by MC over translation parameters
- still in progress

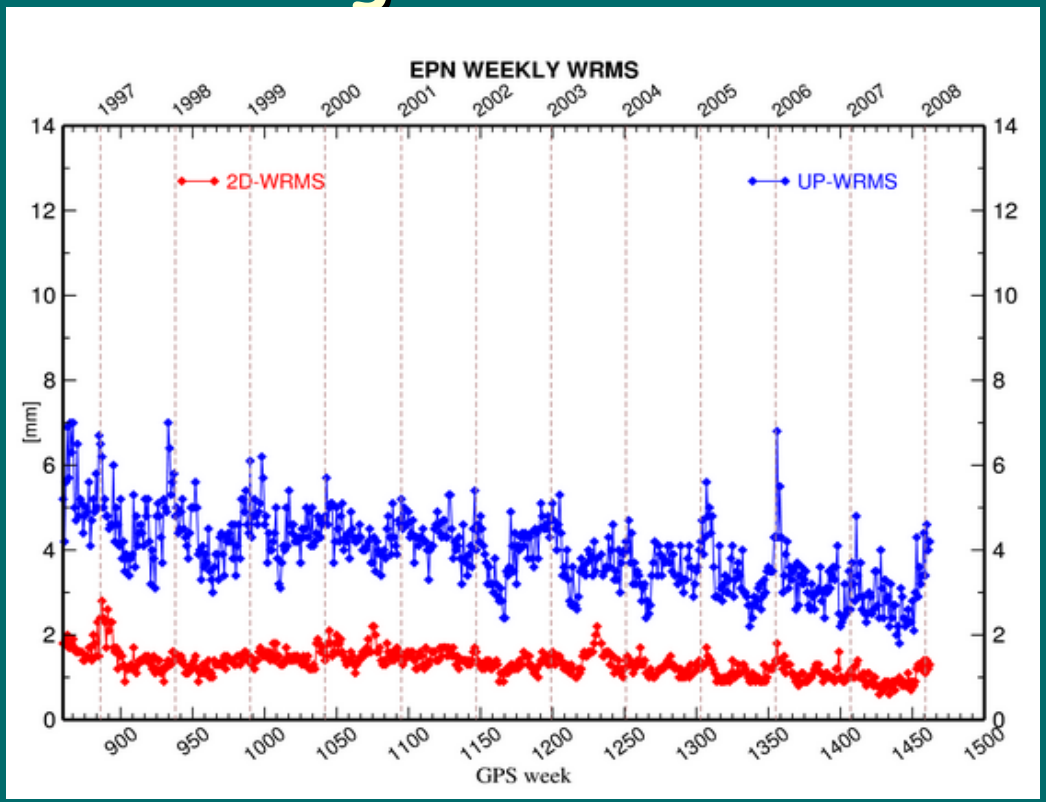
CUMULATIVE SOLUTION

- Weekly combined SINEX files are available
- Multiyear solution: CATREF (Altamimi et al 2004)
- Datum: ITRF2005_IGS-TRF.SNX

  IGS05_reprocessed.SNX
- Minimum Constraint (MC) approach, the frame is defined by 16 ITRF/EPN stations (28 soln)
- Discontinuities harmonized with IGS
- REGIONAL NETWORK (!)

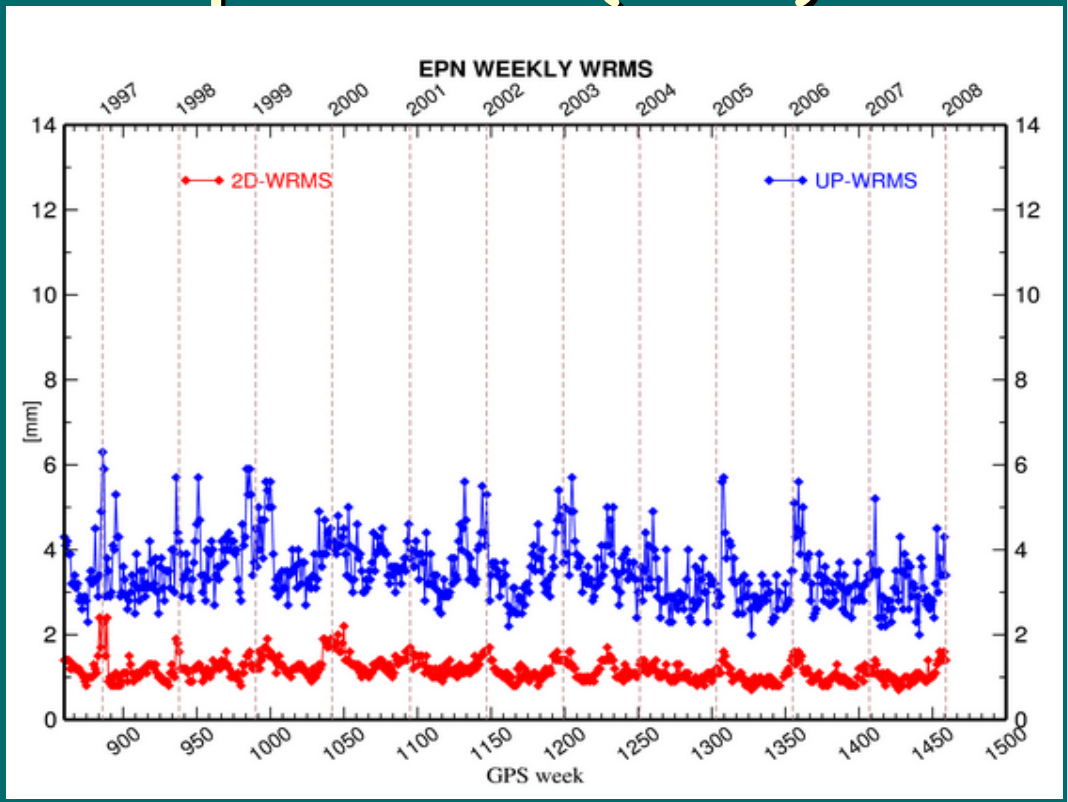
GENERAL RESULTS I.
weekly weighted RMS

original EPN



weekly solutions are averaged
over 16 LAC results
3-5 LAC per station

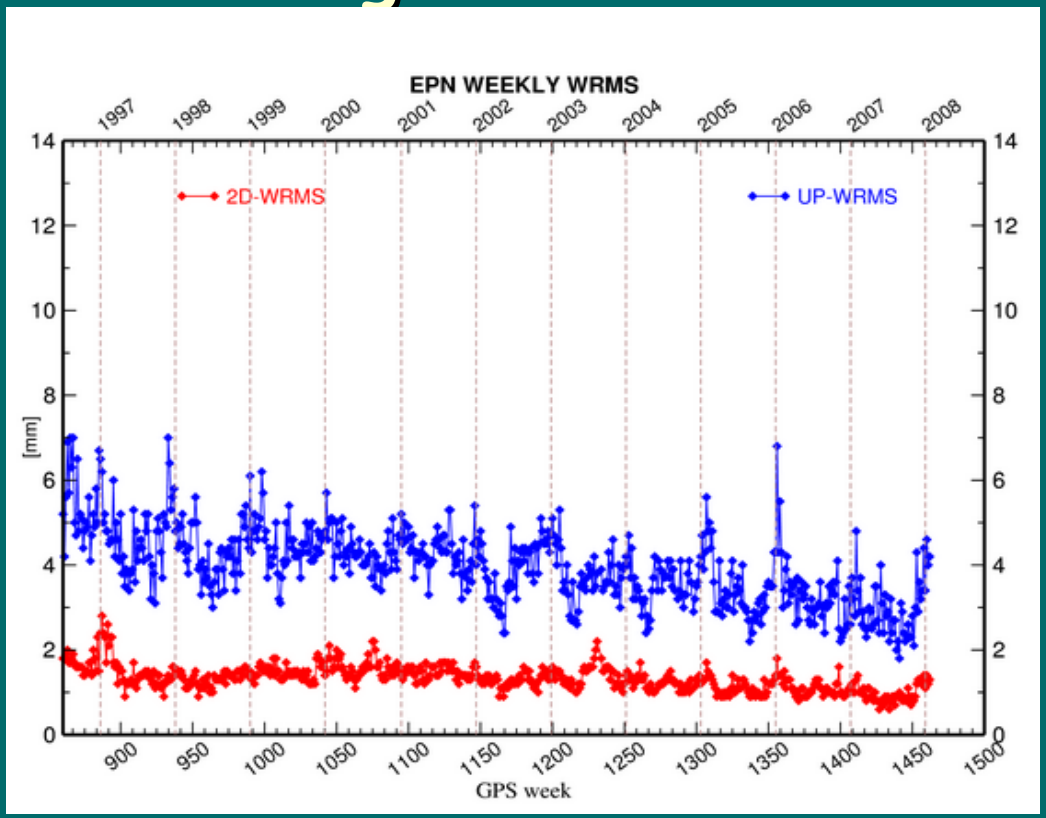
reprocessed (MUT)



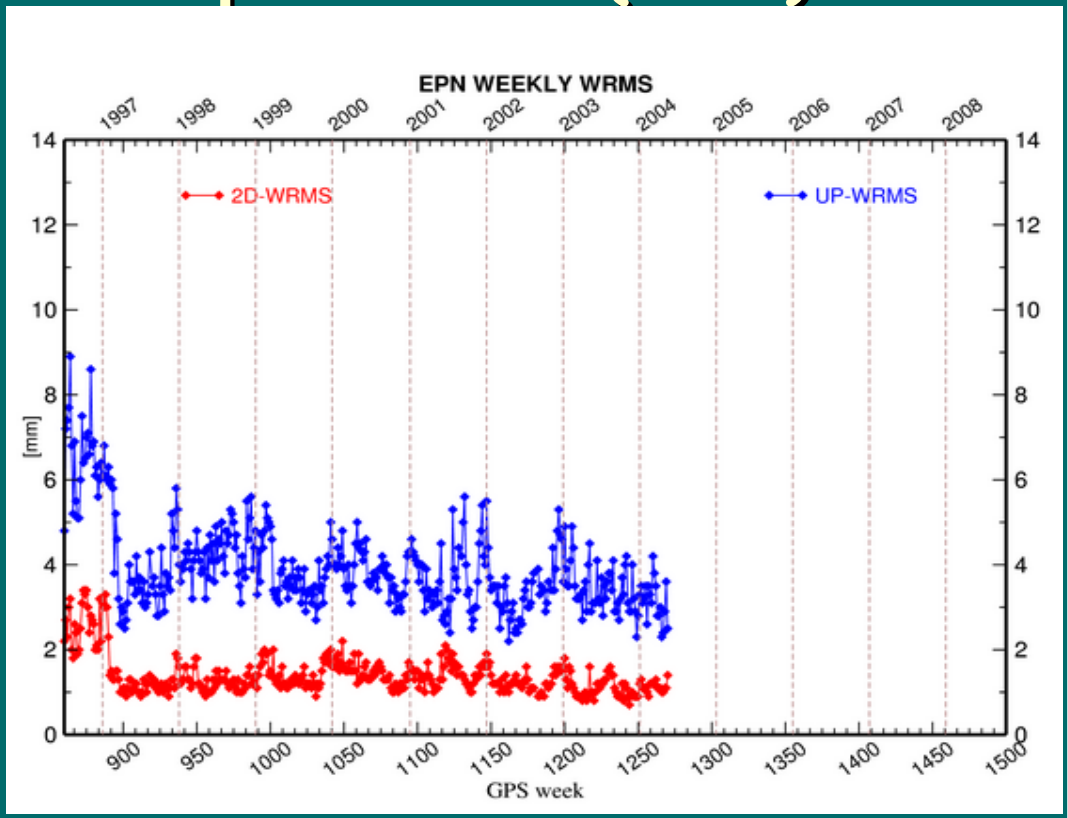
no averaging!
single LAC solution

GENERAL RESULTS I.
weekly weighted RMS

original EPN



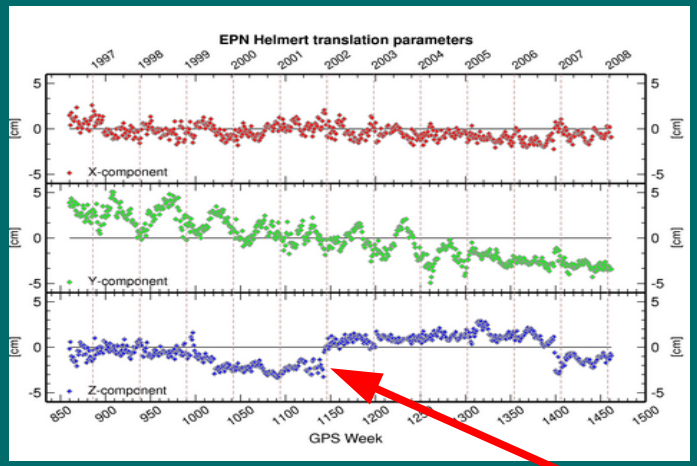
reprocessed (ROB)



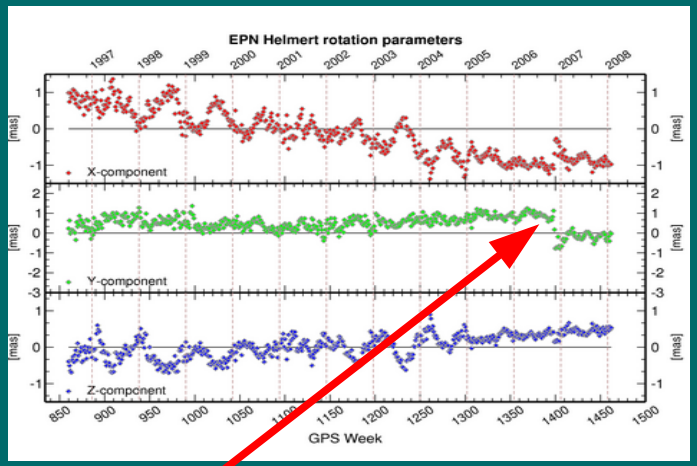
GENERAL RESULTS II.

Helmert-transformation parameters between the cumulative and weekly solutions

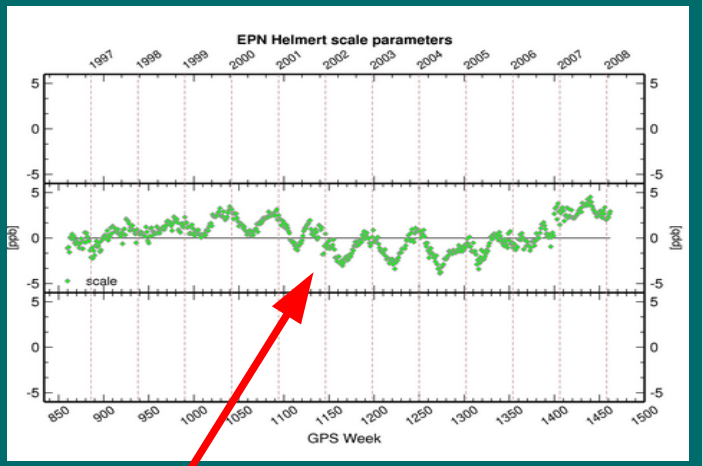
translation



rotation



scale

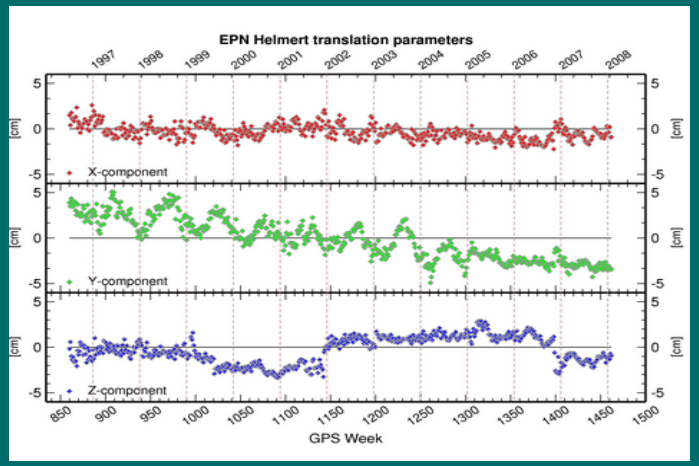


Reference frame changes,
Software modeling shortcomings,
Analysis strategy changes are seen

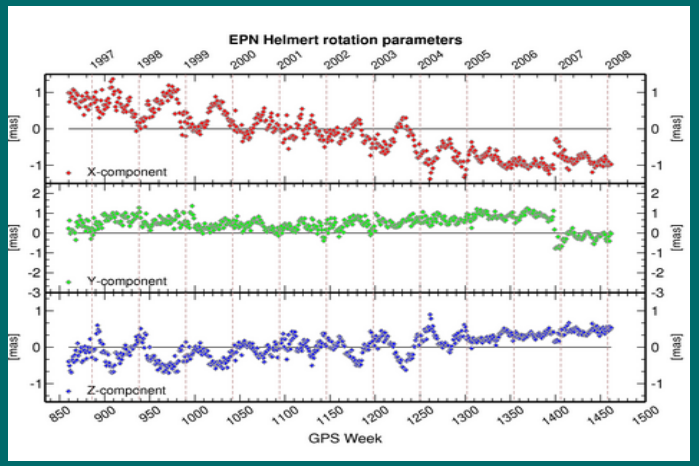
GENERAL RESULTS II.

Helmert-transformation parameters between the cumulative and weekly solutions

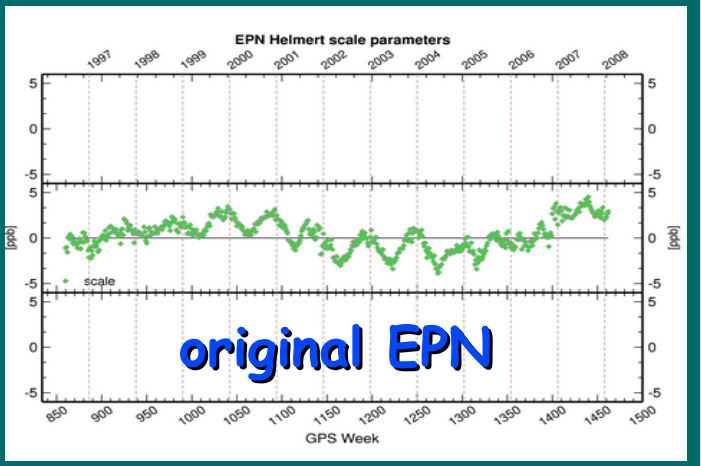
translation

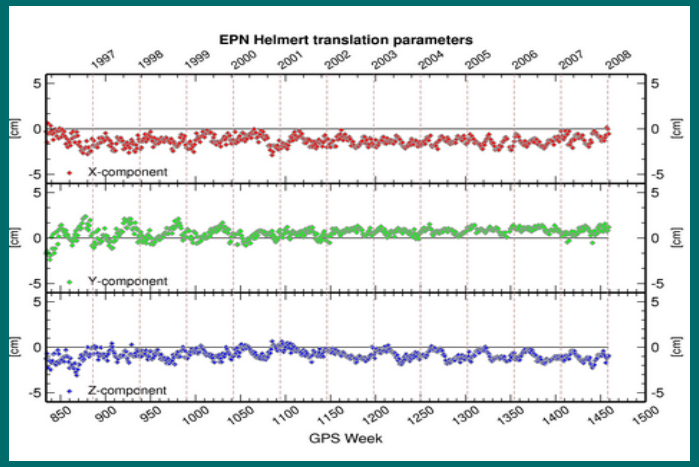


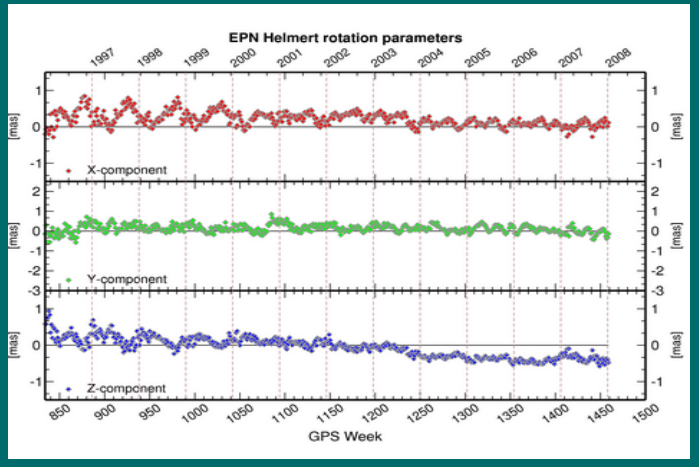
rotation

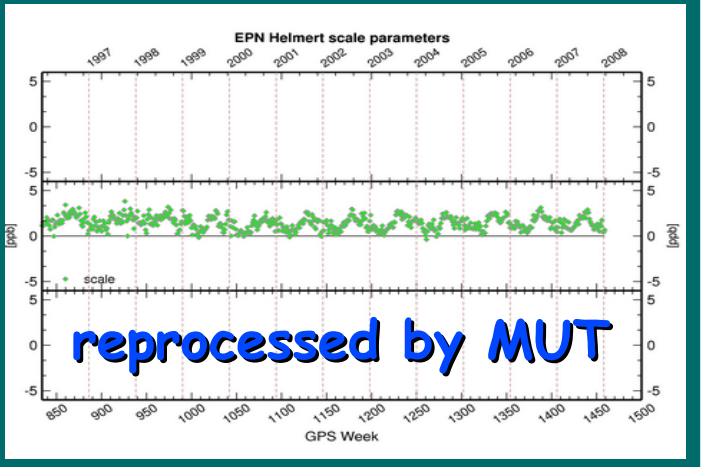


scale





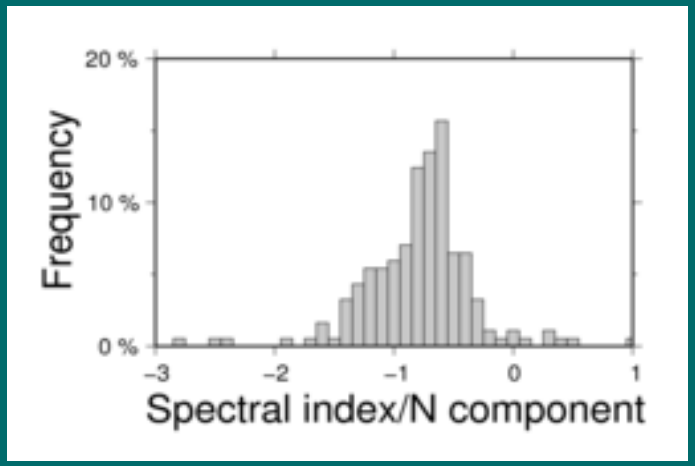




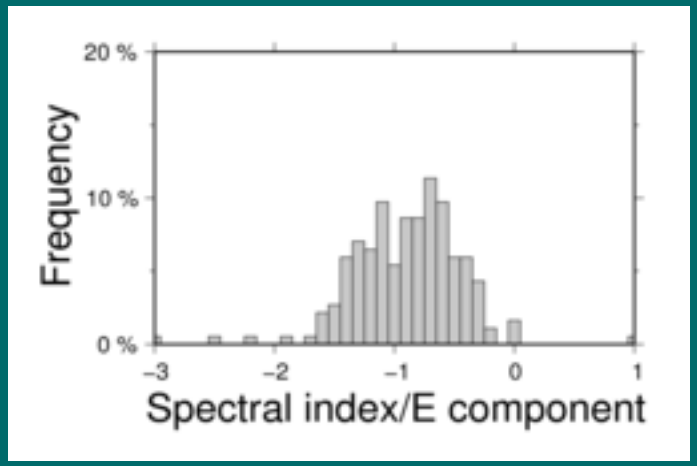
GENERAL RESULTS III.

Noise estimate by CATS_MLE (Williams et al.)

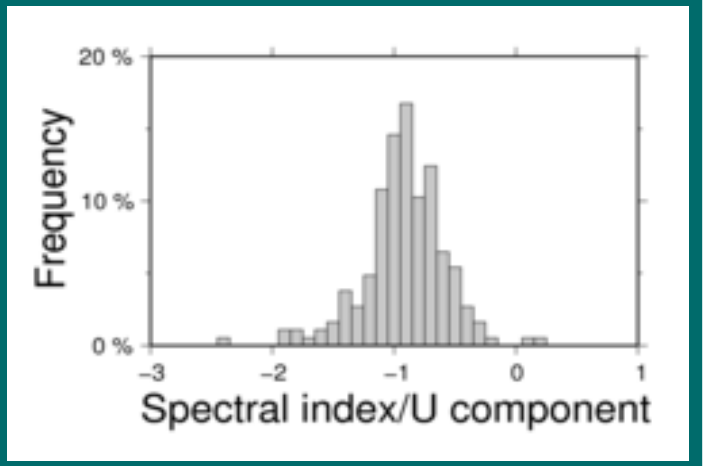
North



East



Up



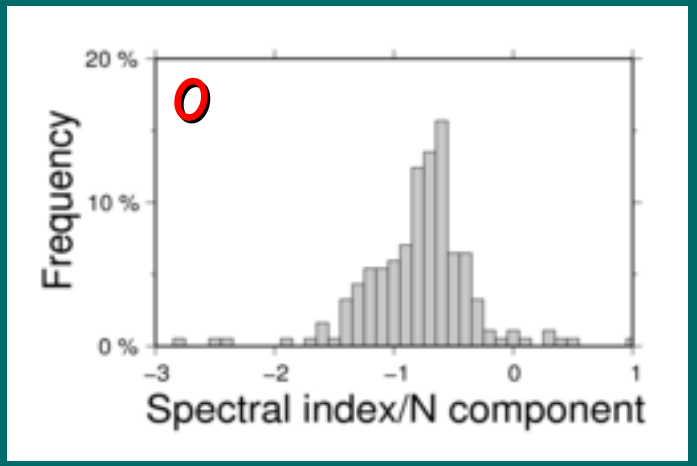
$$P_K(f) = P_0\left(\frac{f}{f_0}\right)^K$$

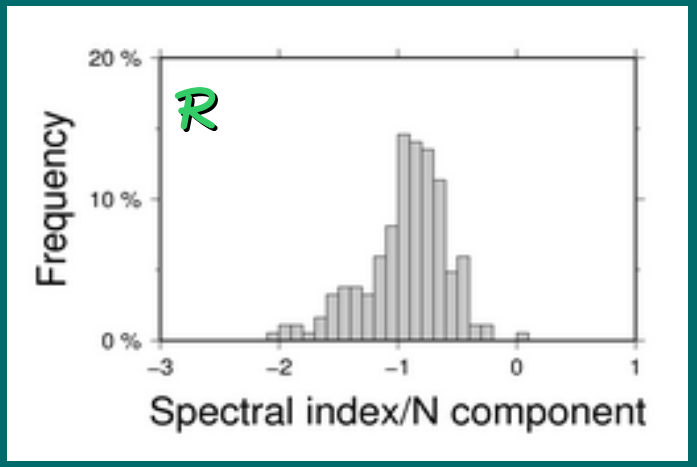
At the original EPN series the flicker-noise (K = -1) is dominating at each component

GENERAL RESULTS III.

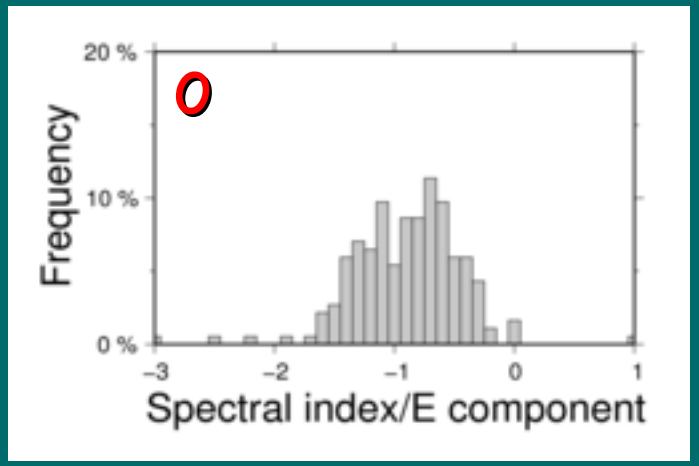
Noise estimate by CATS_MLE (Williams et al.)

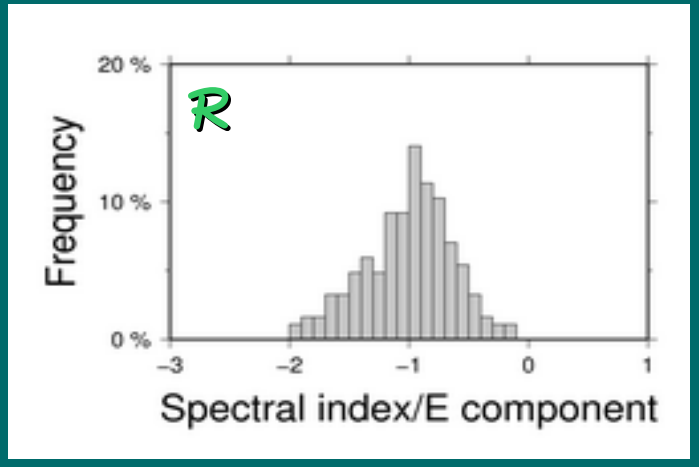
North



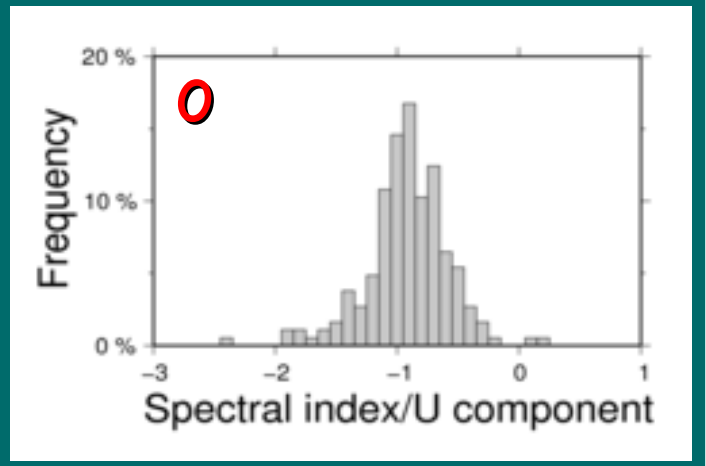


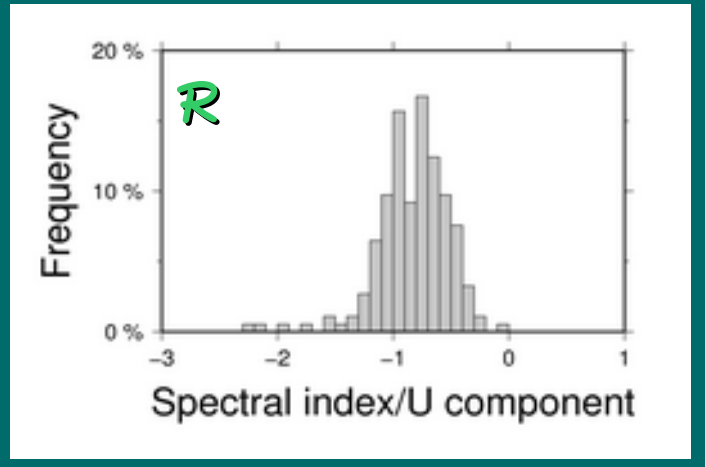
East





Up





GENERAL RESULTS IV.
HARMONIC ANALYSIS (CATS_MLE & PSD)

- SEASONAL SIGNAL (amplitude / phase by CATS)

  PRELIMINARY RESULTS:

  - AVERAGE 30% REDUCED AMPLITUDE N / E / U
    (ONLY AT HALF OF THE STATIONS (!))
  - PHASE CHANGES: HIGH SCATTER OF DIFFERENCES

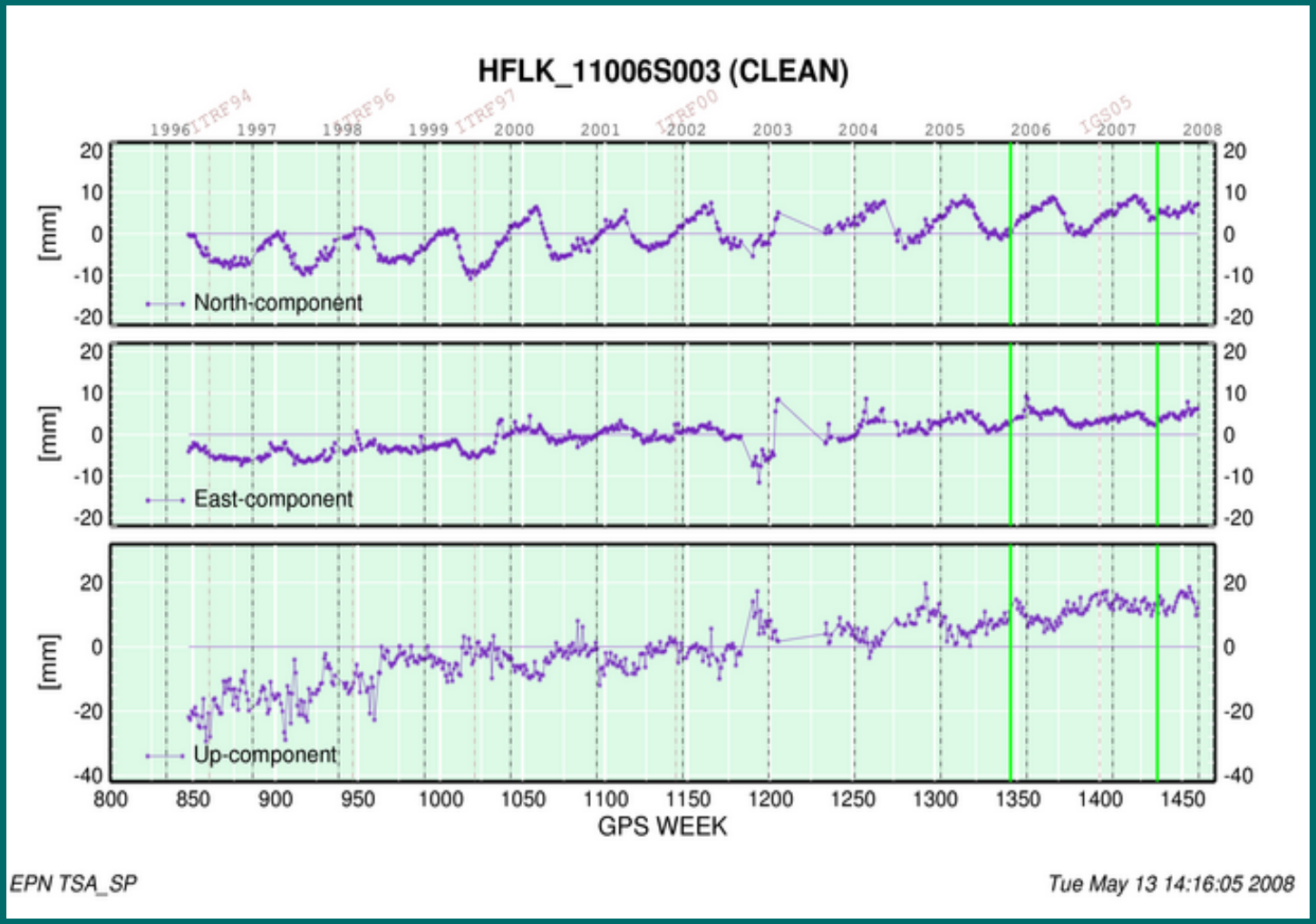
  FURTHER DETAILED INVESTIGATIONS (STATISTICAL ANALYSIS, CORRELATIONS – equipment, environment) ARE FORESEEN!

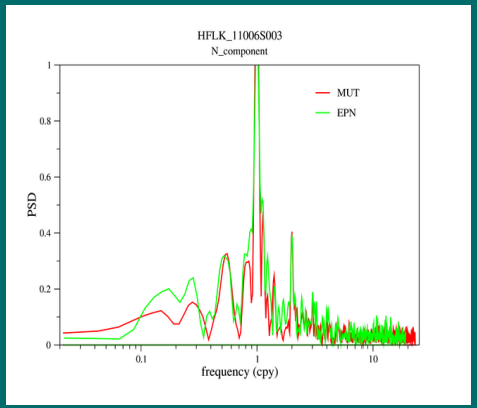
- POWER SPECTRAL DENSITY (Lomb-periodogram)

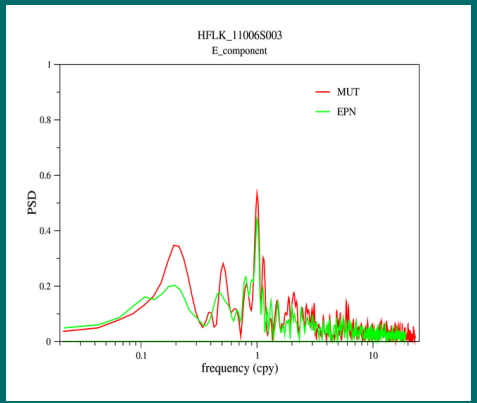
LOMB PERIODOGRAM EXAMPLES

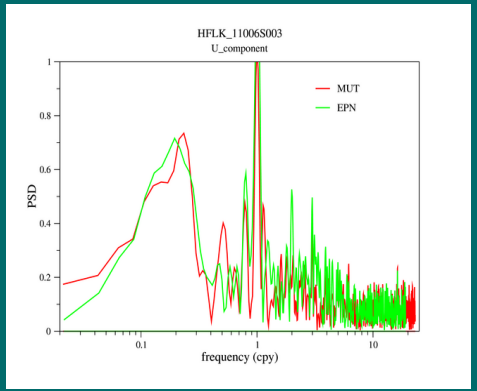
NO CHANGE: UNCALIBRATED ANTENNA/RADOME

TRM29659.00 **GRAZ**



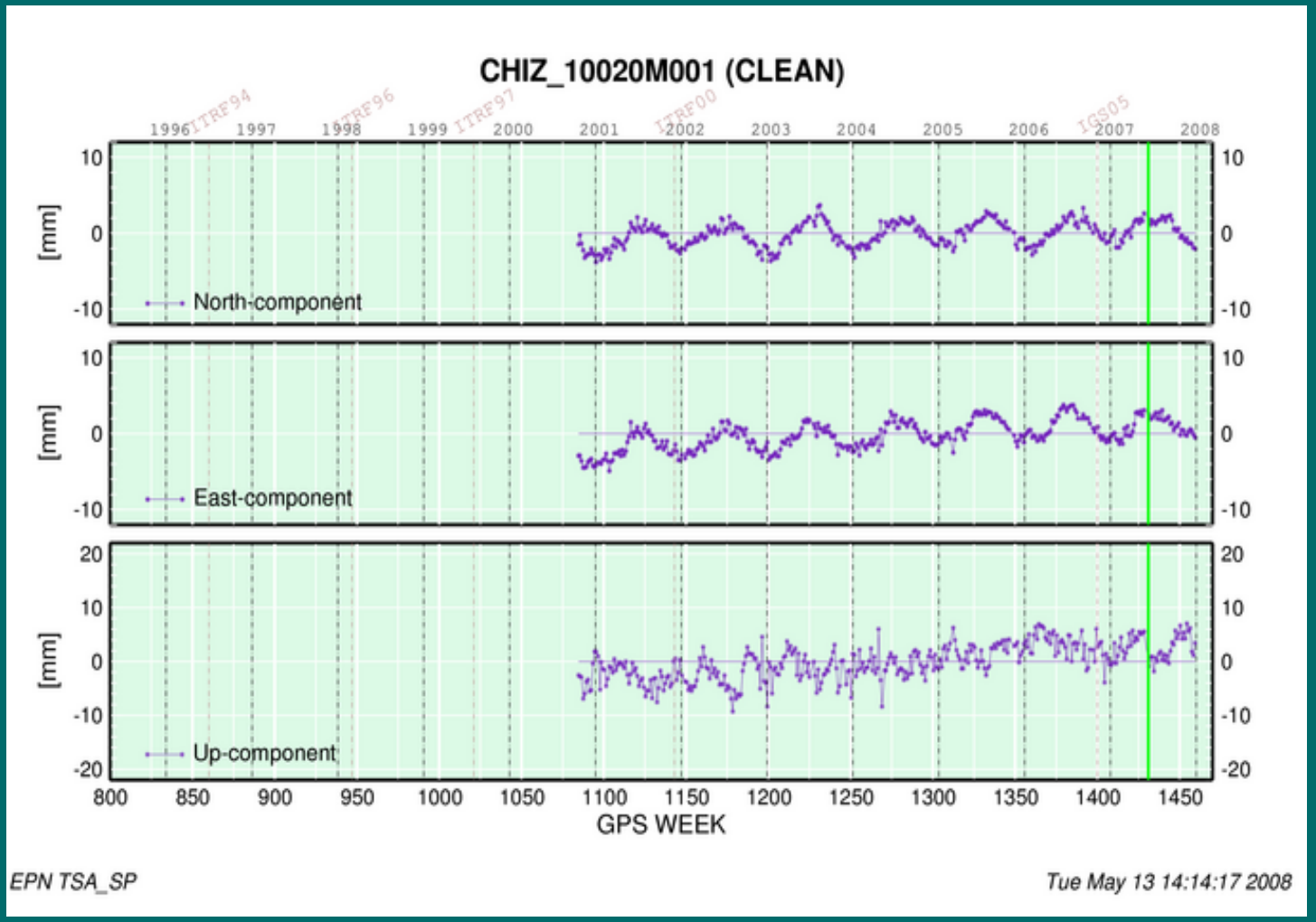


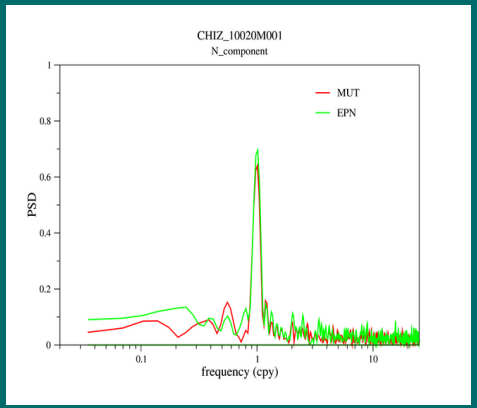


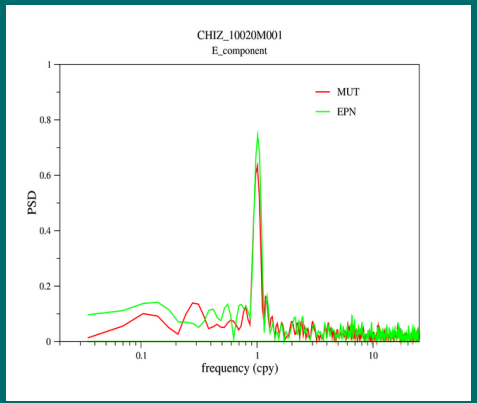


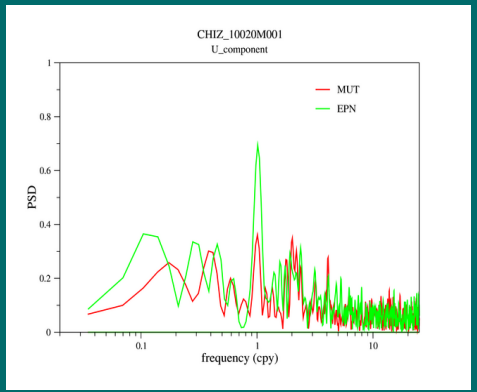
LOMB PERIODOGRAM EXAMPLES
SEASONAL SIGNAL PARTIALLY REMAINS

CHIZ: concrete bunker of World War II.



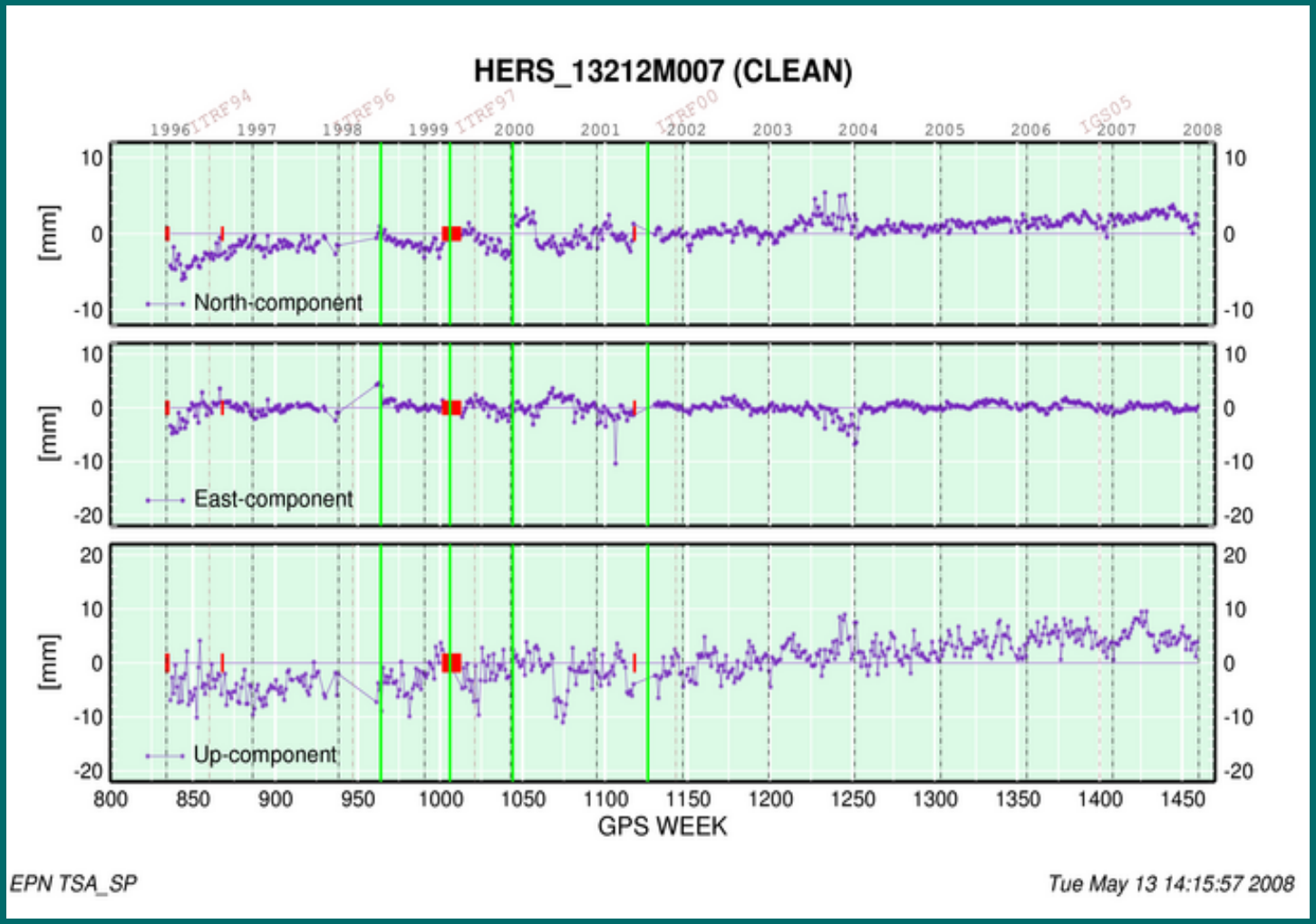


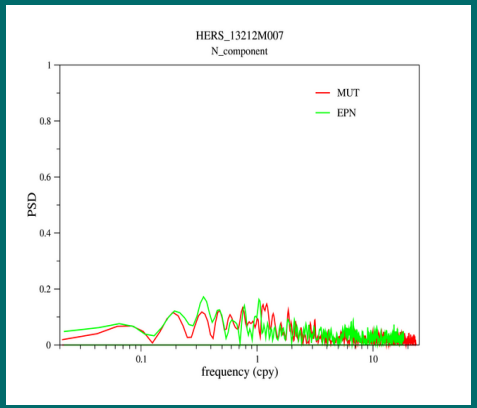


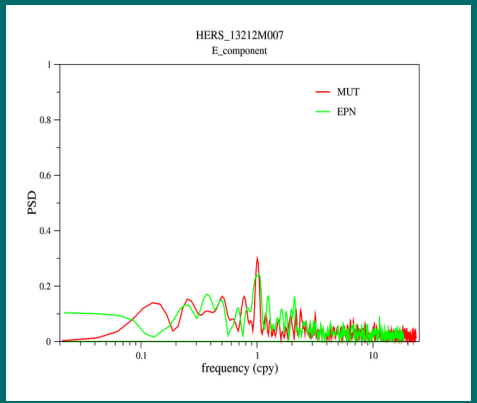


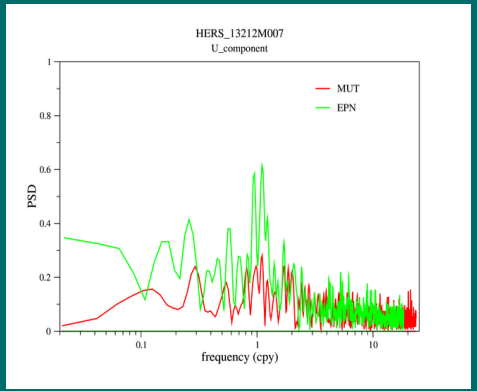
LOMB PERIODOGRAM EXAMPLES

SEASONAL SIGNAL DECREASED





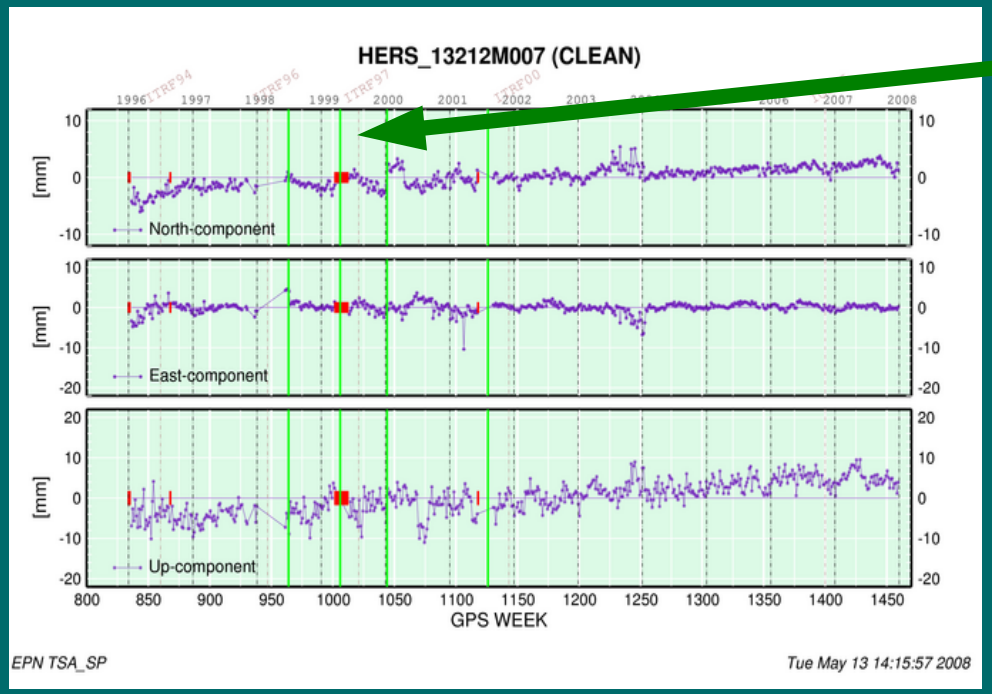


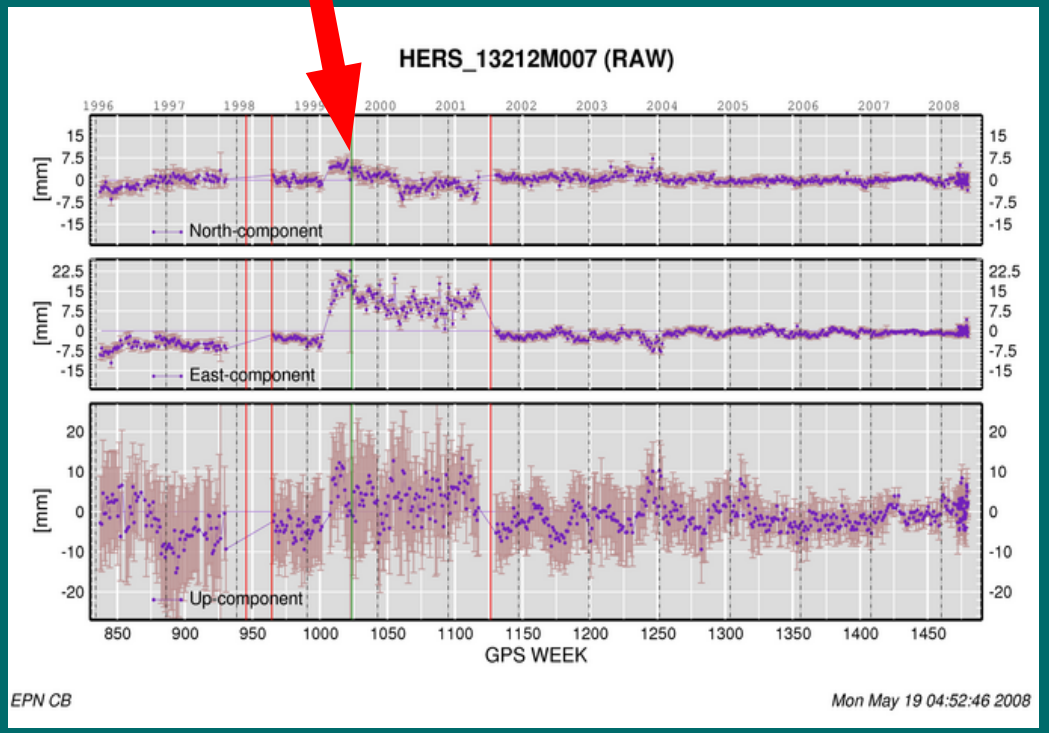


UNEXPECTED REPROCESSING RESULT

DECREASED SENSITIVITY TO ANTENNA PROBLEMS?

ANTENNA MALFUNCTION
(ASH700936E)

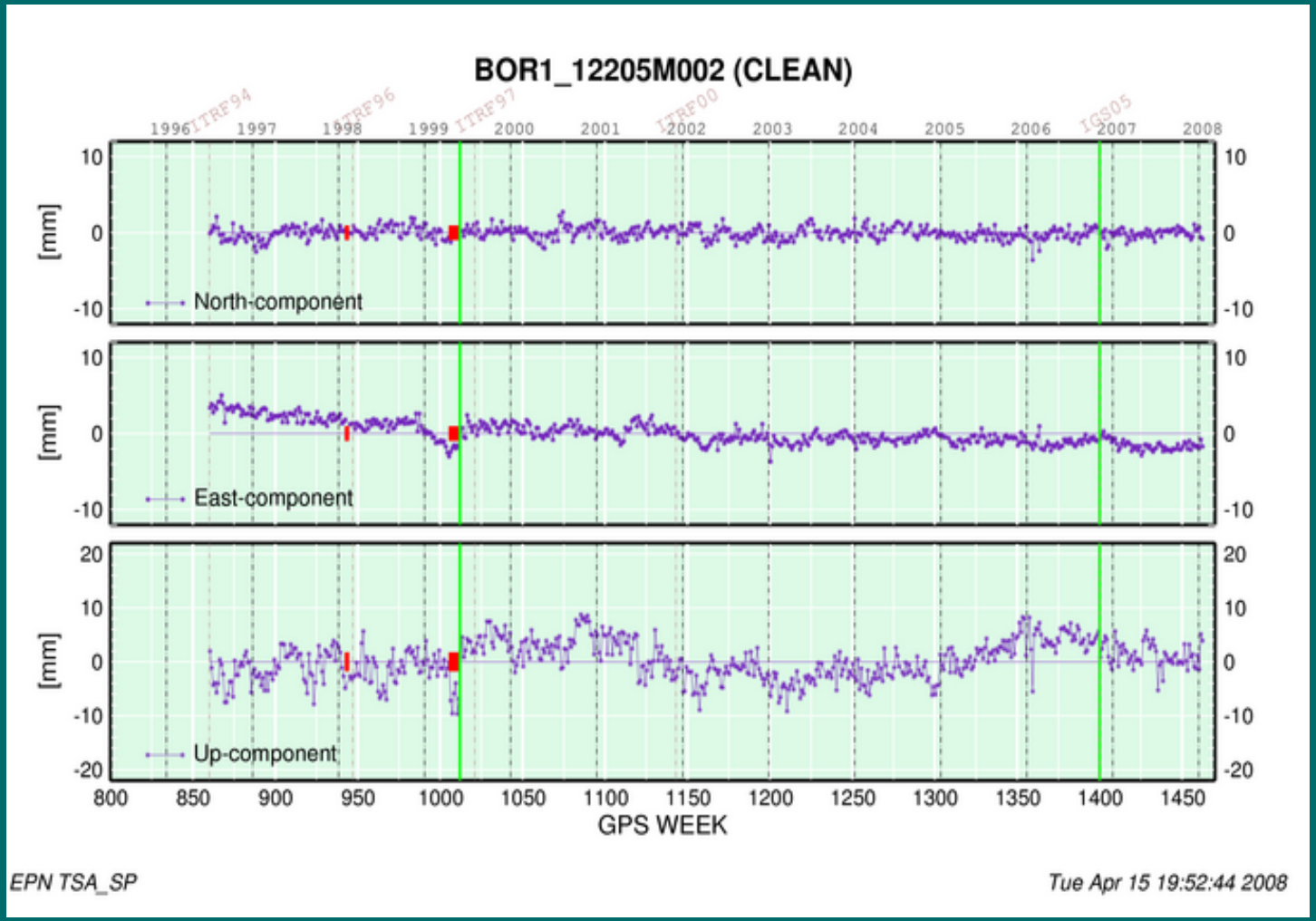


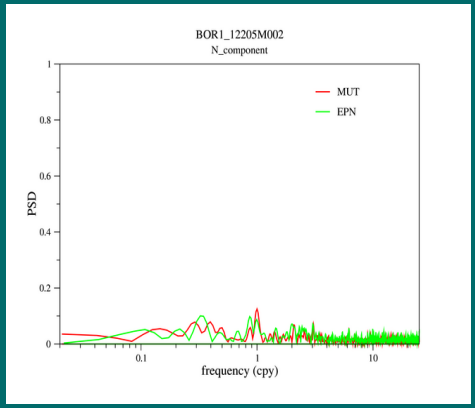


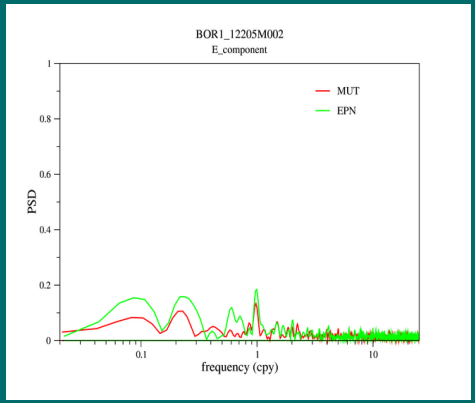
LOMB PERIODOGRAM EXAMPLES

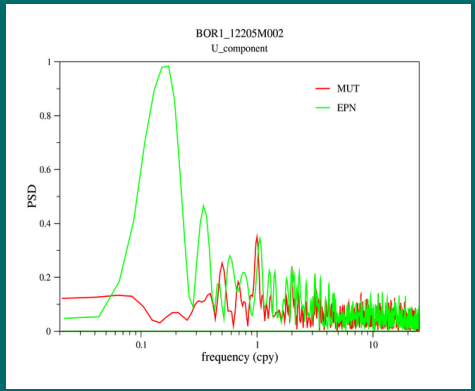
UP COMPONENT LONG TERM SIGNAL DECREASED

ORIGINAL EPN SERIES









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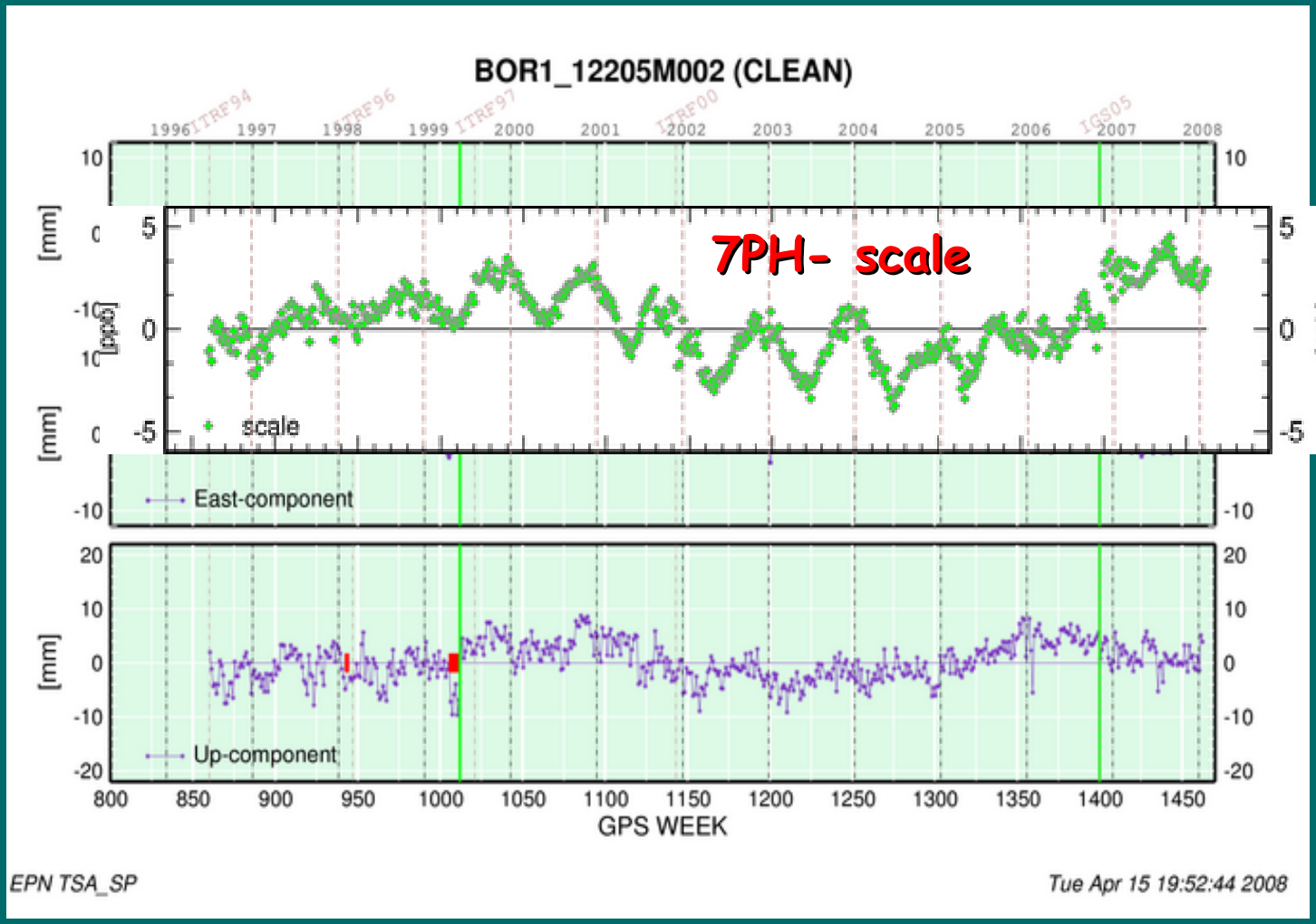
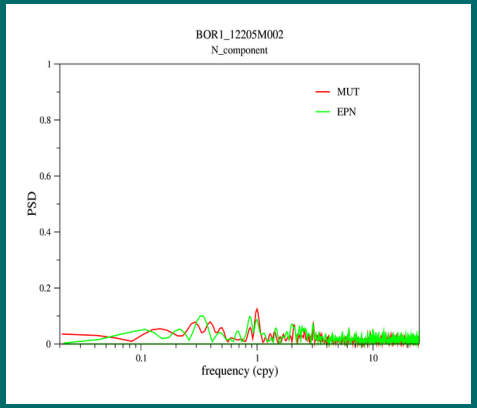
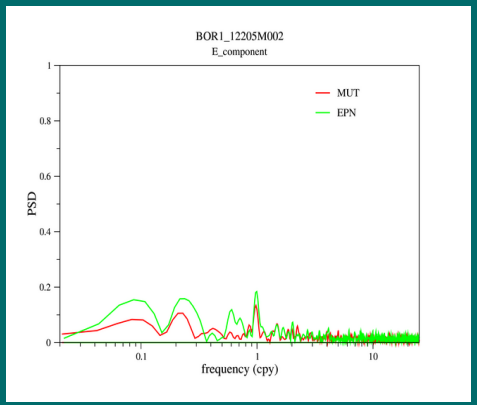
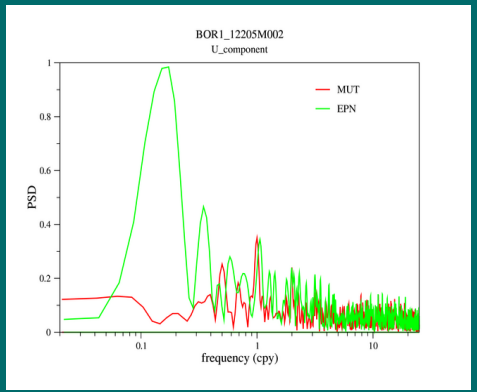
UP COMPONENT LONG TERM SIGNAL DECREASED

ORIGINAL EPN SERIES



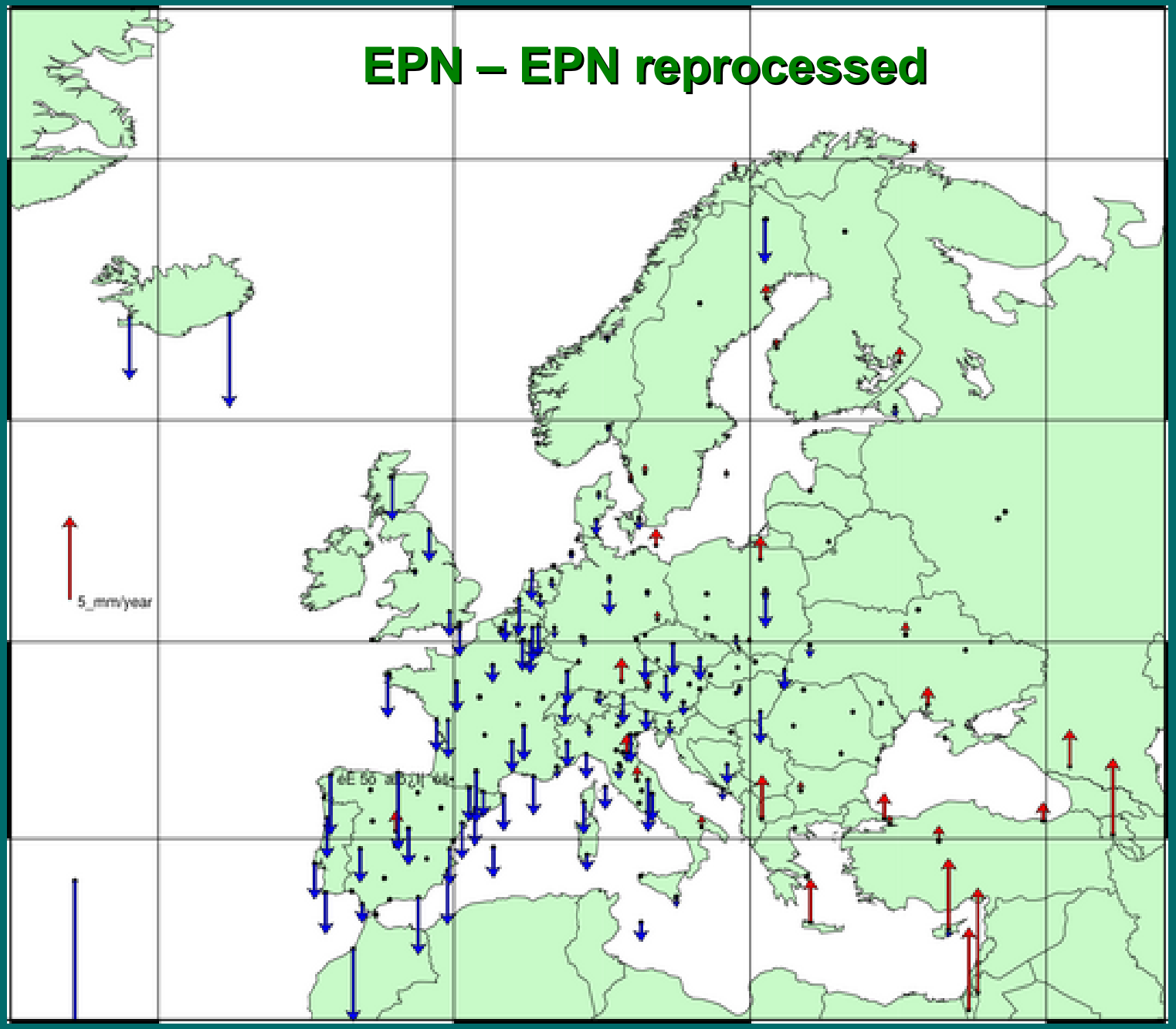






DIFFERENCES IN VELOCITY ESTIMATE (UP)

(THE HORIZONTAL DIFFERENCES ARE NEGLECTABLE!)



CONCLUSIONS

RE-PROCESSED CUMULATIVE SOLUTION

- REDUCED WRMS

  >10% overall (>30% before week 900)

- 'STABLE' HELMERT TRANSFORMATION PARAMETER SERIES,
- NO DISCONTINUITY AT GPSWEEK 1400 !
- REFERENCE FRAME: HOMOGENOUS TIME SERIES

CONCLUSIONS cont'd

- FLICKER NOISE IS STILL DOMINATING
- SEASONAL SIGNAL: DECREASED AMPLITUDE, BUT NON-HOMOGENOUS PHASE CHANGES

  FURTHER STATISTICAL ANALYSIS REQUIRED (CORRELATIONS, SIGNIFICANCE TESTS)
- SIGNIFICANT CHANGES IN VERTICAL VELOCITY ESTIMATES (need to be verified – regional network)

EPN RECOMMENDATIONS

- PROVIDE REAL ABSOLUTE PCV FOR ALL ANTENNA TYPES
- STANDARD PRODUCT: DAILY SINEX SOLUTIONS DUE TO DECREASED NOISE LEVEL
  - → BETTER DISCONTINUITY MODELING
  - → HIGHER RESOLUTION HARMONIC ANALYSIS
- FULLY HARMONIZED DISCONTINUITY TABLE
- SPEED UP THE RE-ANALYSIS → NEW ITRFyy