Activities of the sub-working group on data homogenization

***Roeland Van Malderen**, Royal Meteorological Institute of Belgium (RMI) - Solar-Terrestrial Centre of Excellence (STCE)*
***Eric Pottiaux**, Royal Observatory of Belgium (ROB) – Solar-Terrestrial Centre of Excellence (STCE)*

and many others

Outline

- Context and Primary Objectives
- The reference dataset and its reference
- The first homogenization workshop at Brussels

Context

- From different presentations at different GNSS4SWEC workshops, it turned out that different groups were showing results from time series analyses, sometimes based on the same datasets.

- They were dealing/struggling with the homogenization of their datasets.

- A need for a common activity? ➔ send an EoI (22 responses) + Inquiry (17 participants).

Objectives

1. To work on one or two long-term reference datasets.

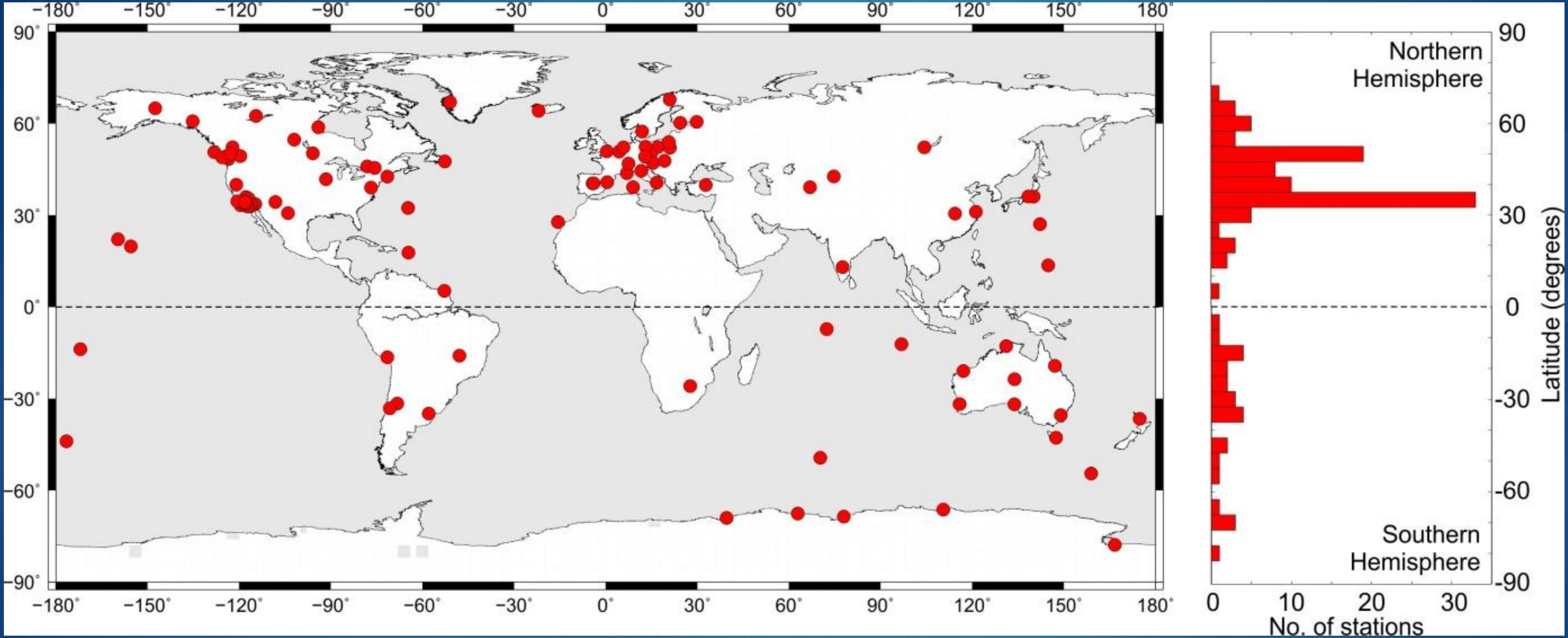
   - We start with the IGS repro 1 troposphere products screened and converted to IWV by O. Bock.

2. To work with different homogenization methods/ algorithms:

   - To inter-compare their results, advantages, drawbacks…
   - To build a list of commonly identified inhomogeneities (instrumental change, break points, auxiliary data jumps…).

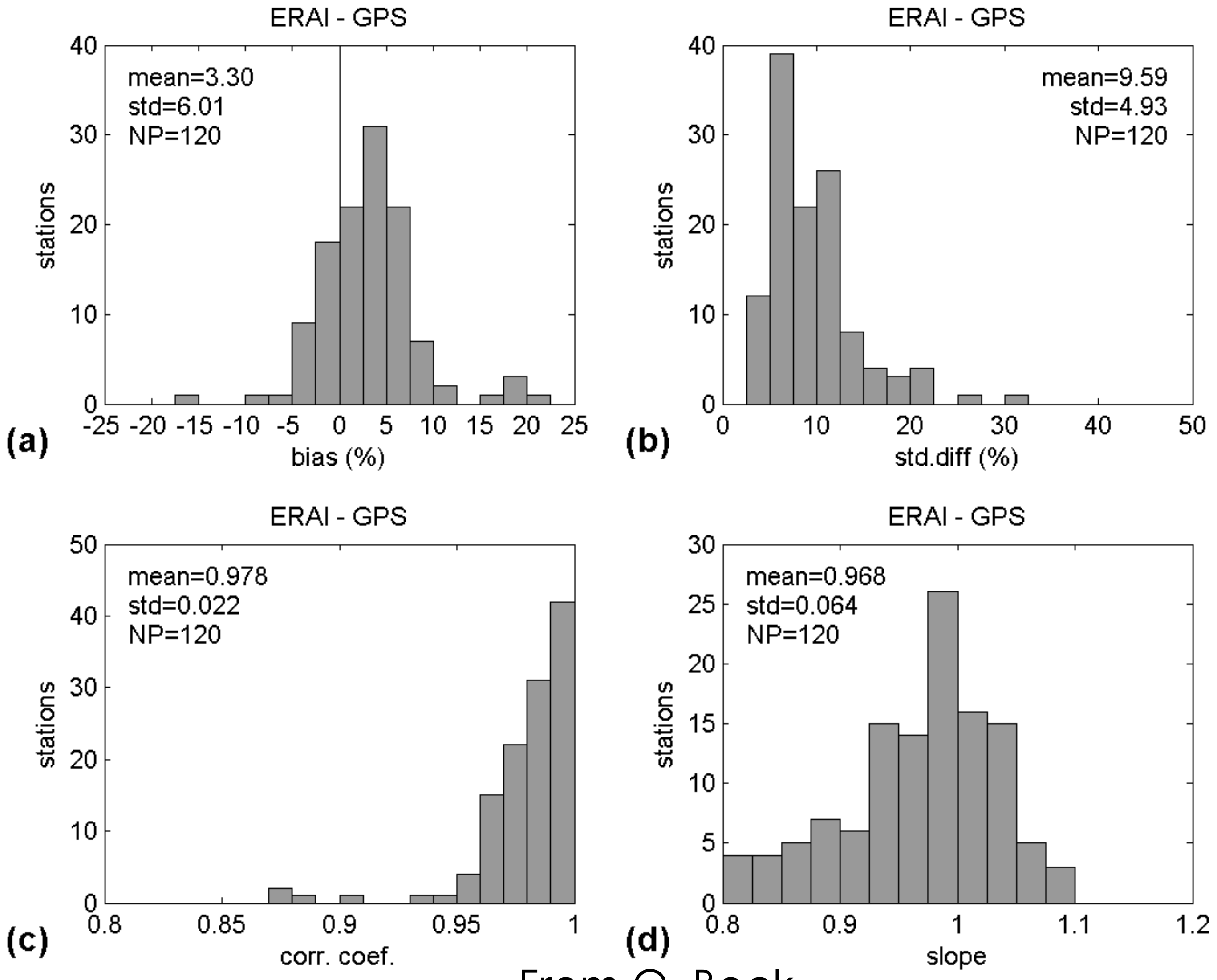
3. To come up with an homogenized version of the reference dataset that can be re-used to study climate trends and time variability by the community.

IGS Repro 1: 120 stations with data from 1995-2010



From A. Klos

Good correlation between IGS Repro 1 and ERA-interim



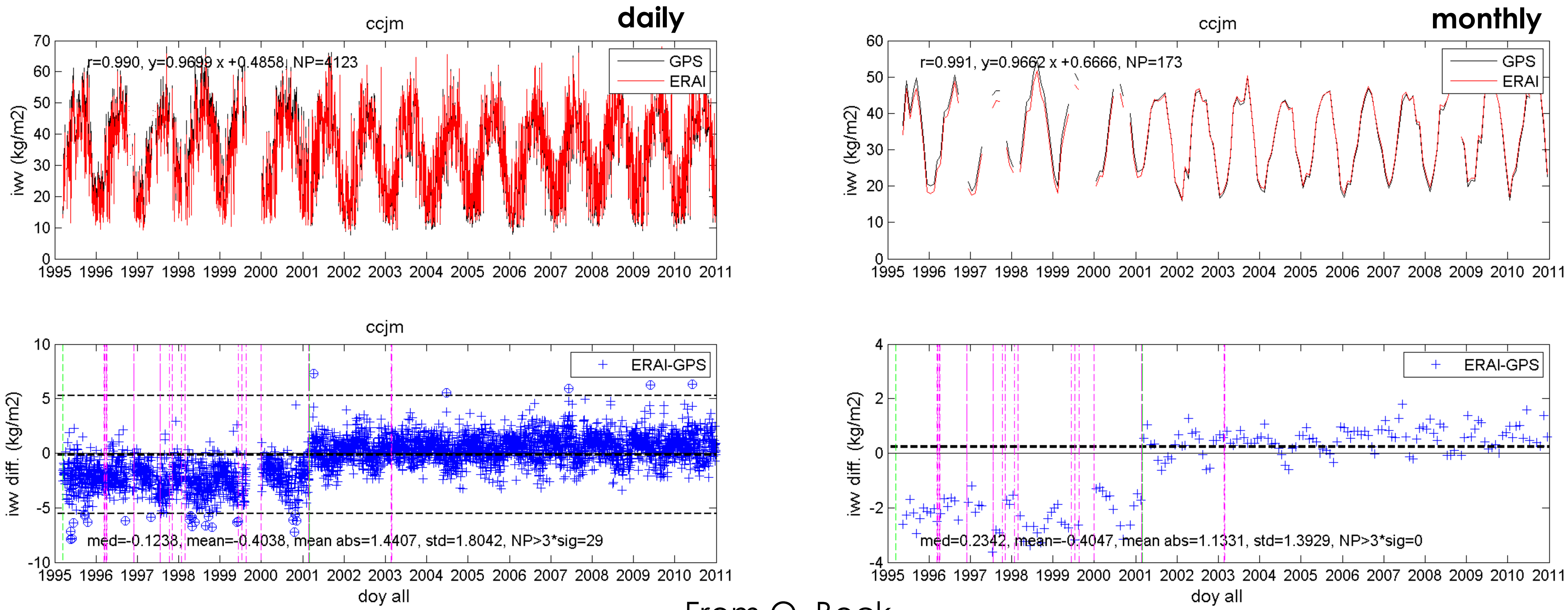
From O. Bock

Important note

- ERA-interim is used to screen the ZTD IGS repro 1 data
- To convert ZTD to IWV, ERA-interim is used
  - Surface pressure of ERA-interim
  - Weighted mean temperature calculated from pressure levels

Good correlation between IGS Repro 1 and ERA-interim

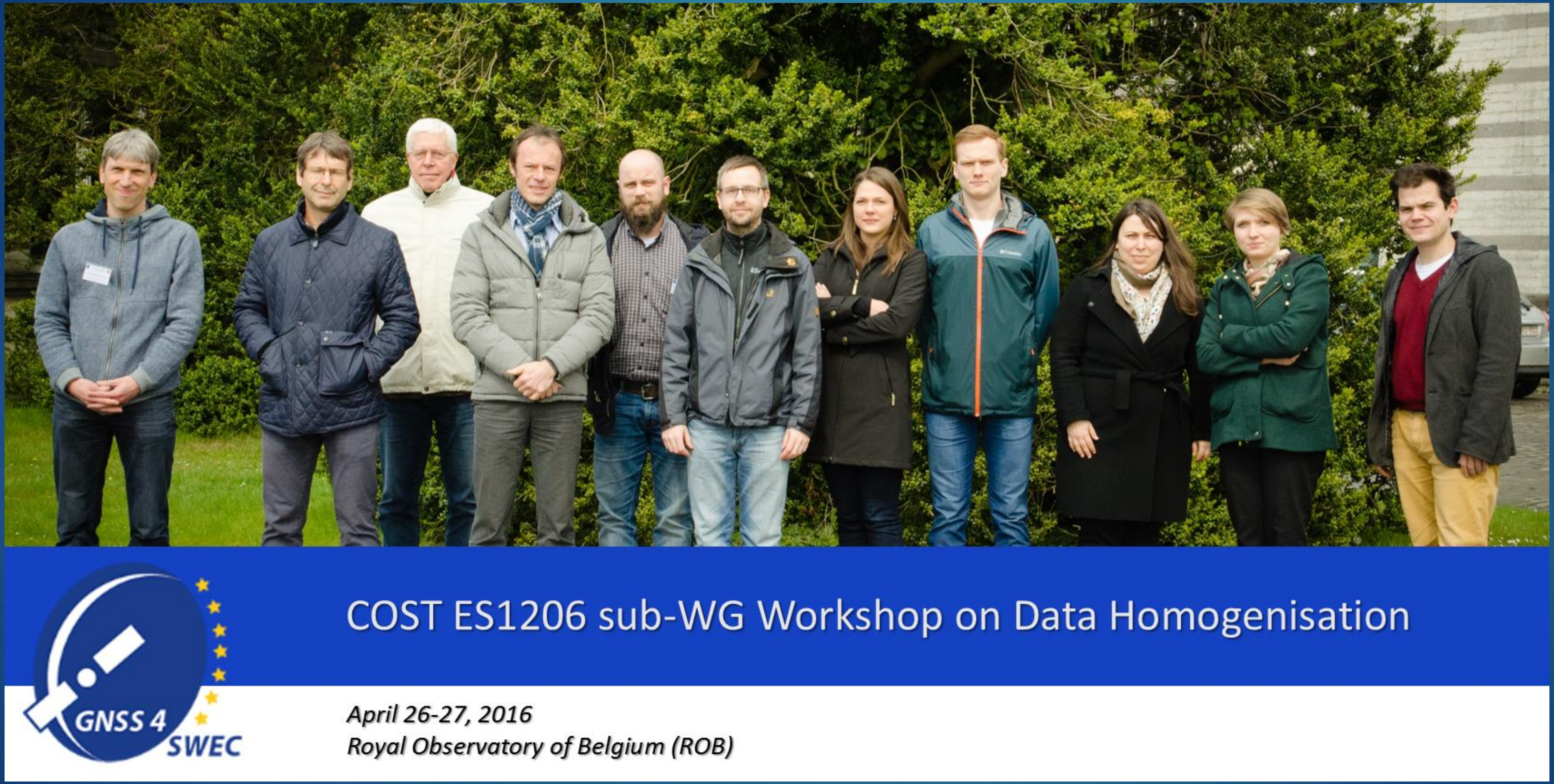
➔ breakpoint identification



From O. Bock

Dedicated Workshop in Brussels

10 Participants from our Action (not all could come) + 1 External Expert (E. Aguilar)



Dedicated Workshop in Brussels

	Ning	Elias		Van Malderen et al.		Bock et al.	KTU (Tanır Kay	Klos et al.	
	monthly	monthly	daily	monthly	daily	daily	daily	manual	
albh				15/10/2002	15/10/2002	2/05/1998	18/05/2002		
albh				15/03/2000		9/07/1998			
albh					15/02/2006	2/07/2000			
albh						12/03/2001			
albh						18/01/2005			
algo						7/02/2008	17/05/1997	12/10/2007	1
alic			20/04/2006	15/04/2006	15/04/2006	21/08/1999	26/10/2008	31/07/1999	1
alic				15/08/1999	15/08/1999	20/04/2006		15/06/2003	1
alic								6/05/2010	1
alic								11/10/1999	3
ankr	15/09/2000	15/10/2001	15/10/2001	15/10/2001	15/10/2001	3/01/2001	18/05/2005	7/02/1996	1
ankr				15/08/2000	15/09/2000	11/05/2008		23/07/1996	1
ankr				15/09/2008	15/09/2008			24/07/1997	1
ankr								16/09/1998	1
ankr								4/07/2000	1
ankr								24/11/2000	1
ankr								6/05/2008	1
ankr								4/06/1999	3
ankr								16/09/2000	3
ankr								26/11/2007	3

Dedicated workshop in Brussels

- breakpoints detected in metadata & visual inspection, but not by any of the groups?
- breakpoints detected by a number (all) tools, but no metadata information?
- time window! When are breakpoints coincident?

➡ Based on the expertise of E. Aguilar, we decided to focus first on the generation of a synthetic dataset in which known offsets are inserted (Anna Klos) and to collect as much as possible ("trustable") meta-data, before trying to homogenize our reference IGS repro 1 dataset.

Results of the homogenization tools on the synthetic benchmark IWV datasets

***Roeland Van Malderen**, Royal Meteorological Institute of Belgium (RMI) - Solar-Terrestrial Centre of Excellence (STCE)*
***Eric Pottiaux**, Royal Observatory of Belgium (ROB) – Solar-Terrestrial Centre of Excellence (STCE)*
***Anna Klos**, Military University of Technology, Warsaw, Poland*
***Olivier Bock**, IGN LAREG, University Paris Diderot, Sorbonne Paris, France*
***Janusz Bogusz**, Military University of Technology, Warsaw, Poland*
***Barbara Chimani**, Central Institute for Meteorology and Geodynamics, Austria*
***Michal Elias**, Research Institute of Geodesy, Topography and Cartography, Czech Republic*
***Marta Gruszczynska**, Military University of Technology, Warsaw, Poland*
***José Guijarro**, AEMET (Spanish Meteorological Agency), Spain*
***Selma Zengin Kazancı**, Karadeniz Technical University, Turkey*
***Tong Ning**, Lantmäteriet, Sweden*

Dedicated Workshop in Warsaw

12 participants from our Action + 2 "HOME" experts (B. Chimani + J. Guijarro)

MUT, 23-25 January 2017

scope:

analysis of the results of different tools on the synthetic datasets

Summary of the different tools

14 participants ➔ 6 different homogenization tools

Climatol **J. Guijarro**	HOMOP **B. Chimani**	PMTred **T. Ning**
Non-parametric tests **R. Van Malderen**	2-sample t-statistic **M. Elias**	Pettitt test **S. Zengin Kazancı, E. Tanir Kayikçi, V. Tornatore**

Summary of the different tools

Climatol

J. Guijarro

- Neighbor-based, based on orthogonal regression between standardized anomalies $(x-\mu_x)/\sigma_x$ and $(y-\mu_y)/\sigma_y$.
- Missing data are filled in, outliers removed.
- Varying amplitude of the corrected offsets (by including e.g. σ_x in the standardization, you might include seasonality in the amplitudes).
- The Standard Normal Homogeneity Test (SNHT) to find shifts in the mean is applied to the anomaly series in two stages.
- Detection of multiple change points by applying the test to the remaining segments.
- Runs on daily values, but might be also applied for monthly data.

Non-parametric tests

R. Van Malderen

- Non-parametric distributional tests that utilize ranks: the Mann-Whitney-Wilcoxon test and the Pettitt-Mann-Whitney test.
- The CUSUM test (based on the sum of the deviations from the mean) is also used an additional reference.
- Iterative procedure: if 2 out of those 3 tests identify a statistical significant breakpoint, the time series is corrected and the tests are applied again on the complete corrected time series.
- Runs on monthly and daily values.

Homogenization Methods and Contributions Available

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7
Operator	M. Elias	R. Van Malderen	R. Van Malderen	J. Guijarro	T. Ning	S. Zengin	B. Chimani
Method / SW	PMTred	2 of 3	PMW	CLIMATOL	PMTred	Pettitt	HOMOP
Daily/Monthly	D+M	D+M	D+M	D+M	D+M	D	X
Easy/Less/Full	E+L+F	E+L+F	E+L+F	L+F	E+L+F	E+L+F	E+F

- in the pipeline: P. Stepanek, O. Bock, M. Gruszczynska, manual detection?
- We welcome other contributions (e.g. SSA at GFZ → talk by Fadwa Alshawaf)
- also possible: try running existing homogenization tools (e.g. HOMER)

Assessment of the performance of the tools …

- … on the identification of the **epochs** of the inserted breakpoints (+ sensitivity analysis) in the synthetic datasets.

  → work done by Eric Pottiaux, Anna Klos & Janusz Bogusz, next talk by Eric.

- … on the estimation of the **trends** that were or were not imposed to the 3 sets of synthetic IWV differences.

  → work done by Anna Klos & Janusz Bogusz, presented by me.

Deriving Error Metrics for the Homogenization of Integrated Water Vapour (IWV) Time Series:

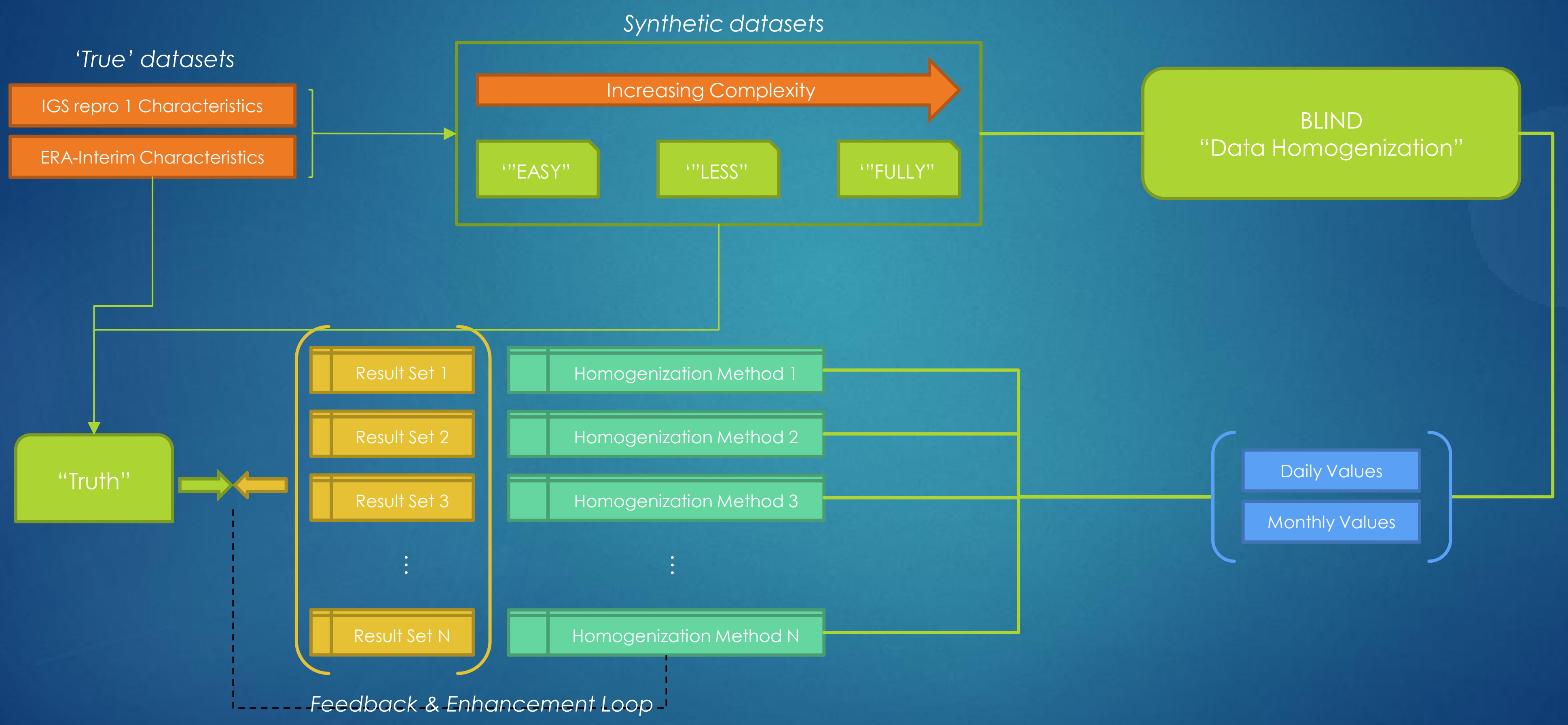
THE CASE OF THE SYNTHETIC BENCHMARK DATASETS.

***Eric Pottiaux**, Royal Observatory of Belgium (ROB) – Solar-Terrestrial Centre of Excellence (STCE)*
***Anna Klos**, Military University of Technology (MUT)*
***Roeland Van Malderen**, Royal Meteorological Institute of Belgium (RMI) – Solar-Terrestrial Centre of Excellence (STCE)*
***Janusz Bogusz**, Military University of Technology, Warsaw, Poland*
***Elias Michal**, Geodetic Observatory Pecny (GOP)*
***Jose A. Guijarro**, Spanish Meteorological Agency*
***Tong Ning**, Lantmateriett, Sweden*
***Barbara Chimani**, ZAMG*
***Selma Zengin Kazanci**, Karadeniz Technical University, Trabzon*

Deriving Error Metrics for the Homogenization of IWV Time Series

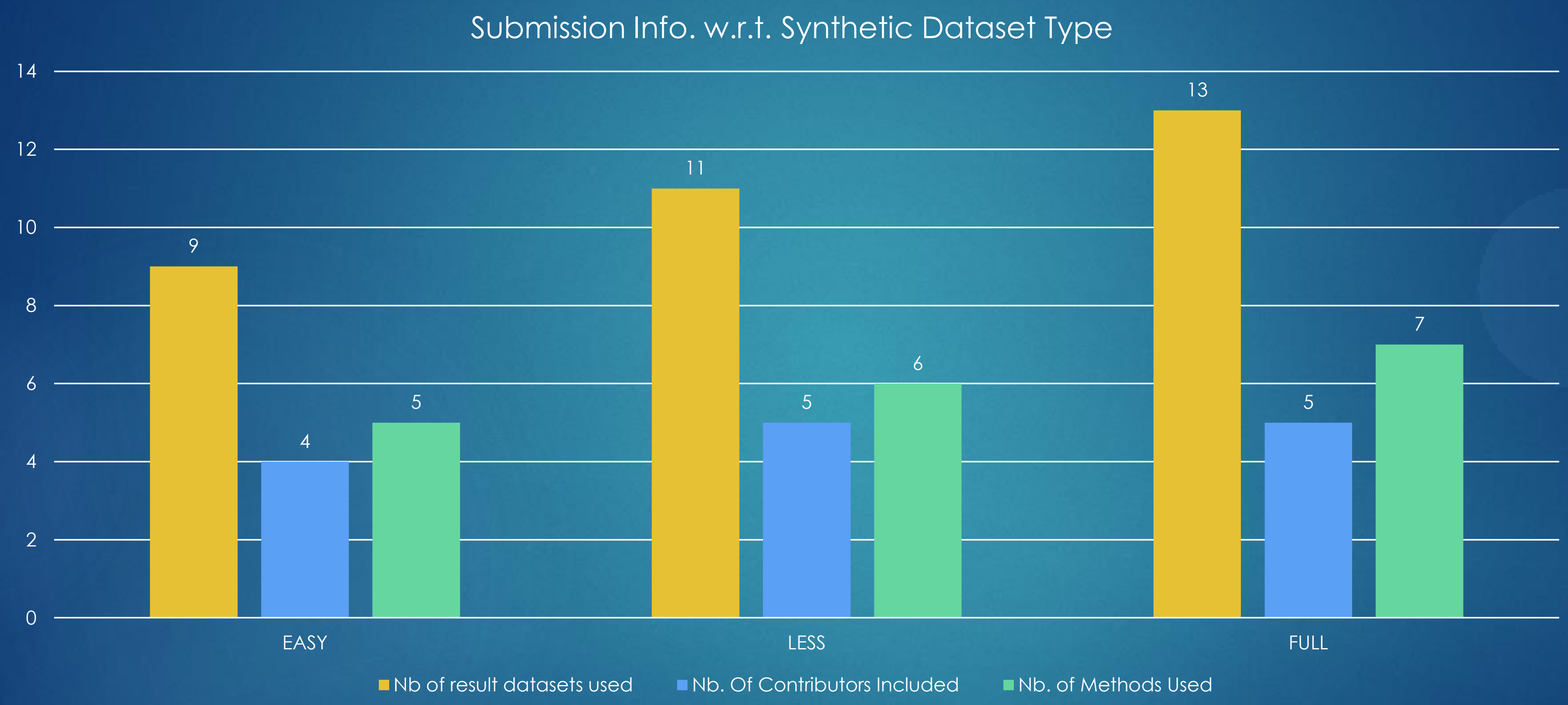
METHODOLOGY AND CONTRIBUTIONS

Global Methodology for Performance Assessment



- Results of the homogenization tools (Synthetic Benchmark)

Summary of Results Contributions



Results from Barbara Chimani not yet handled (technical reason)
Three more contributors expected (Olivier Bock, Petr Stepanek, Yingbo Li) – More are welcome !

Deriving Error Metrics for the Homogenization of IWV Time Series

METRICS FOR SENSITIVITY AND PERFORMANCE ASSESSMENT

Type of Metrics

Venema et al. (2012), Benchmarking homogenization algorithms for monthly data, Climate of the Past, 8, 89-115, doi:10.5194/cp-8-89-2012, 2012 (http://www.clim-ast.net/8/89/2012/).

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Clim. Past, 8, 89-115, 2012
http://www.clim-past.net/8/89/2012/
doi:10.5194/cp-8-89-2012

Volume 8, issue 1

Research article

10 Jan 2012

Benchmarking homogenization algorithms for monthly data

V. K. C. Venema[1], O. Mestre[2], E. Aguilar[3], I. Auer[4], J. A. Guijarro[5], P. Domonkos[3], G. Vertacnik[6], T. Szentimrey[7], P. Stepanek[8,9], P. Zahradnicek[8,9], J. Viarre[3], G. Müller-Westermeier[10], M. Lakatos[7], C. N. Williams[11], M. J. Menne[11], R. Lindau[1], D. Rasol[12], E. Rustemeier[1], K. Kolokythas[13], T. Marinova[14], L. Andresen[15], F. Acquaotta[16], S. Fratianni[16], S. Cheval[17,18], M. Klancar[6], M. Brunetti[19], C. Gruber[4], M. Prohom Duran[20,21], T. Likso[12], P. Esteban[20,22], and T. Brandsma[23]
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[15]Norwegian Meteorological Institute, Oslo, Norway
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[20]Grup de Climatologia, Universitat de Barcelona, Spain
[21]Meteorological Service of Catalonia, Area of Climatology, Barcelona, Catalonia, Spain
[22]Centre d'Estudis de la Neu i de la Muntanya d'Andorra (CENMA-IEA), Andorra
[23]Royal Netherlands Meteorological Institute, De Bilt, The Netherlands

Received: 23 Jul 2011 – Published in Clim. Past Discuss.: 12 Aug 2011
Revised: 11 Nov 2011 – Accepted: 22 Nov 2011 – Published: 10 Jan 2012

Abstract. The COST (European Cooperation in Science and Technology) Action ES0601: advances in homogenization methods of climate series: an integrated approach (HOME) has executed a blind intercomparison and validation study for monthly homogenization algorithms. Time series of monthly temperature and precipitation were evaluated because of their importance for climate studies and because they represent two important types of statistics (additive and multiplicative). The algorithms were validated against a realistic benchmark dataset. The benchmark contains real inhomogeneous data as well as simulated data with inserted inhomogeneities. Random independent break-type inhomogeneities with normally distributed breakpoint sizes were added to the simulated datasets. To approximate real world conditions, breaks were introduced that occur simultaneously in multiple station series within a simulated network of station data. The simulated time series also contained outliers, missing data periods and local station trends. Further, a stochastic nonlinear global (network-wide) trend was added.

Participants provided 25 separate homogenized contributions as part of the blind study. After the deadline at which details of the imposed inhomogeneities were revealed, 22 additional solutions were submitted. These homogenized datasets were assessed by a number of performance metrics including (i) the centered root mean square error relative to the true homogeneous value at various averaging scales, (ii) the error in linear trend estimates and (iii) traditional contingency skill scores. The metrics were computed both using the individual station series as well as the network average regional series. The performance of the contributions depends significantly on the error metric considered. Contingency scores by themselves are not very informative. Although relative homogenization algorithms typically improve the homogeneity of temperature data, only the best ones improve precipitation data. Training the users on homogenization software was found to be very important. Moreover, state-of-the-art relative homogenization algorithms developed to work with an inhomogeneous reference are shown to perform best. The study showed that automatic algorithms can perform as well as manual ones.

Citation: Venema, V. K. C., Mestre, O., Aguilar, E., Auer, I., Guijarro, J. A., Domonkos, P., Vertacnik, G., Szentimrey, T., Stepanek, P., Zahradnicek, P., Viarre, J., Müller-Westermeier, G., Lakatos, M., Williams, C. N., Menne, M. J., Lindau, R., Rasol, D., Rustemeier, E., Kolokythas, K., Marinova, T., Andresen, L., Acquaotta, F., Fratianni, S., Cheval, S., Klancar, M., Brunetti, M., Gruber, C., Prohom Duran, M., Likso, T., Esteban, P., and Brandsma, T.: Benchmarking homogenization algorithms for monthly data, Clim. Past, 8, 89-115, doi:10.5194/cp-8-89-2012, 2012.

Level 1.a

Statistical Scores

e.g. number of Hits, Misses, …

Level 1.b

Probabilistic and Skill Scores

e.g. the Probability of Detection, False Alarm Rate, Critical Success Index, Pierce Skill Score

Level 2

Tailored Metrics (focused on App)

e.g. impact on trend estimates and their uncertainties

Results of the homogenization tools (Synthetic Benchmark)

4 Basic Statistical Scores

True Positive (TP) – “Hits”

“offset reported by the homogenization method which corresponds to a true synthetic offset within a certain time window“

True Negative (TN) – “no break present, nor predicted”

“no offset reported by the homogenization method when no offset was inserted in the synthetic dataset”

“Accuracy of Detection”

False Positive (FP) – “False Alarms”

“offset reported by the homogenization method when no offset was inserted in the synthetic dataset”

False Negative (FN) – “misses”

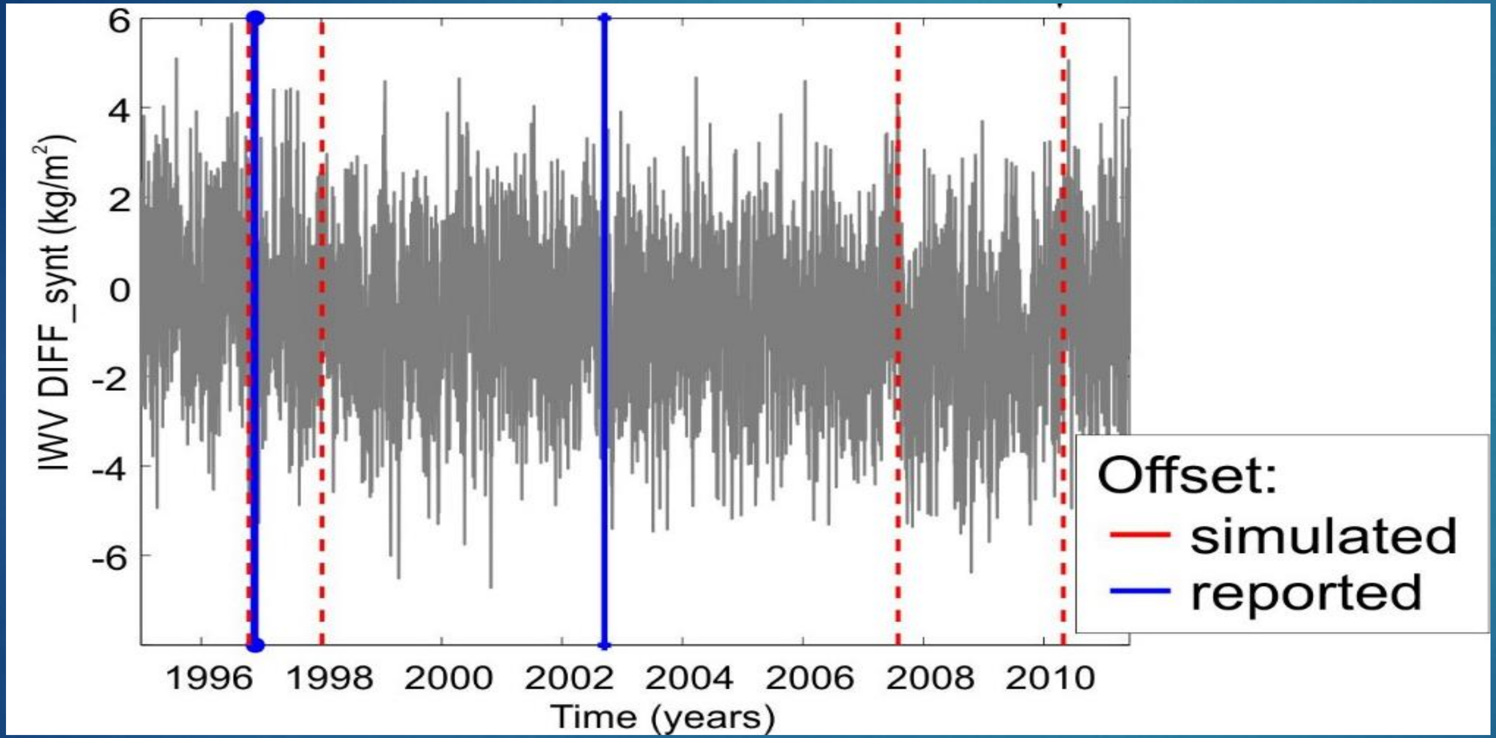
“no offset reported by the homogenization method while an offset was inserted in the synthetic dataset”

The 4 Basic Statistical Scores by Example

True Positive (TP)

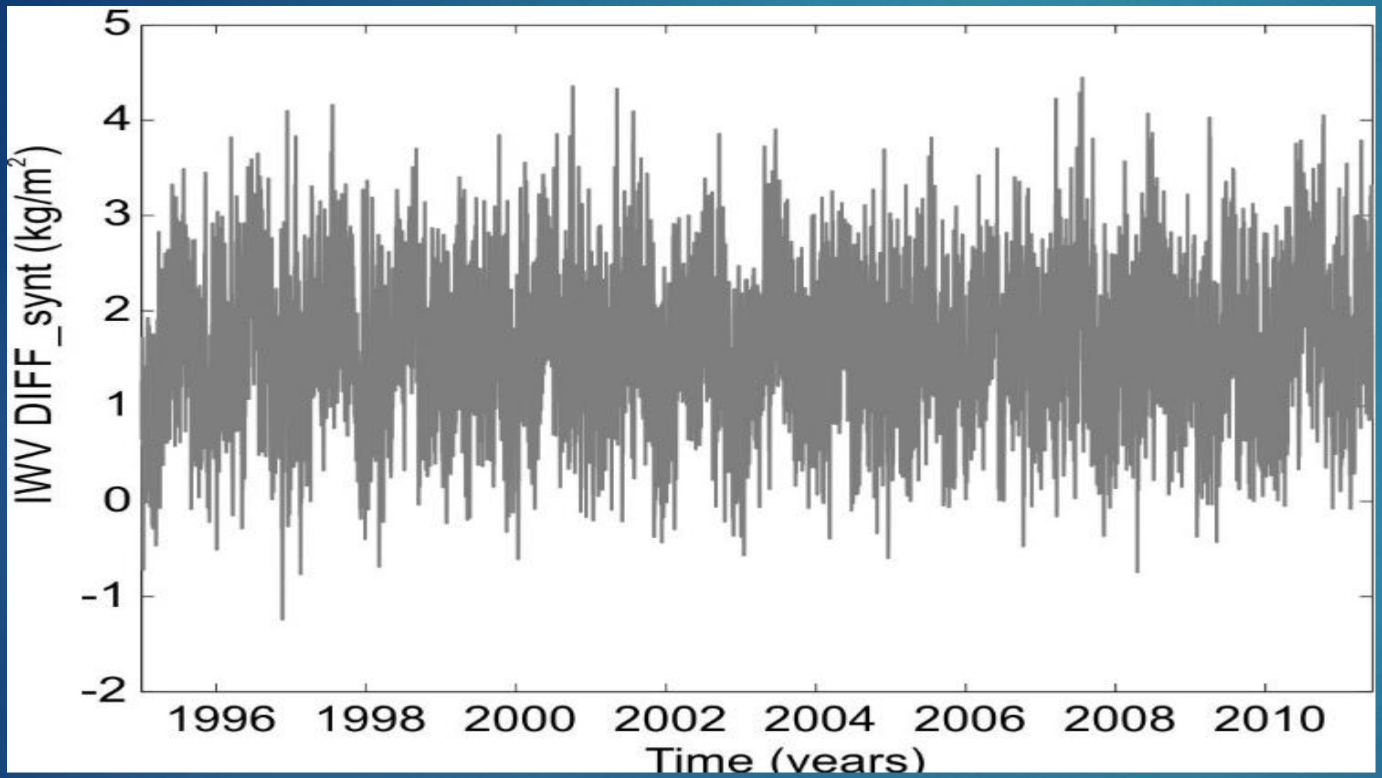
False Positive (FP)

False Negative (FN)



The 4 Basic Statistical Scores by Example

True Negative (TN)

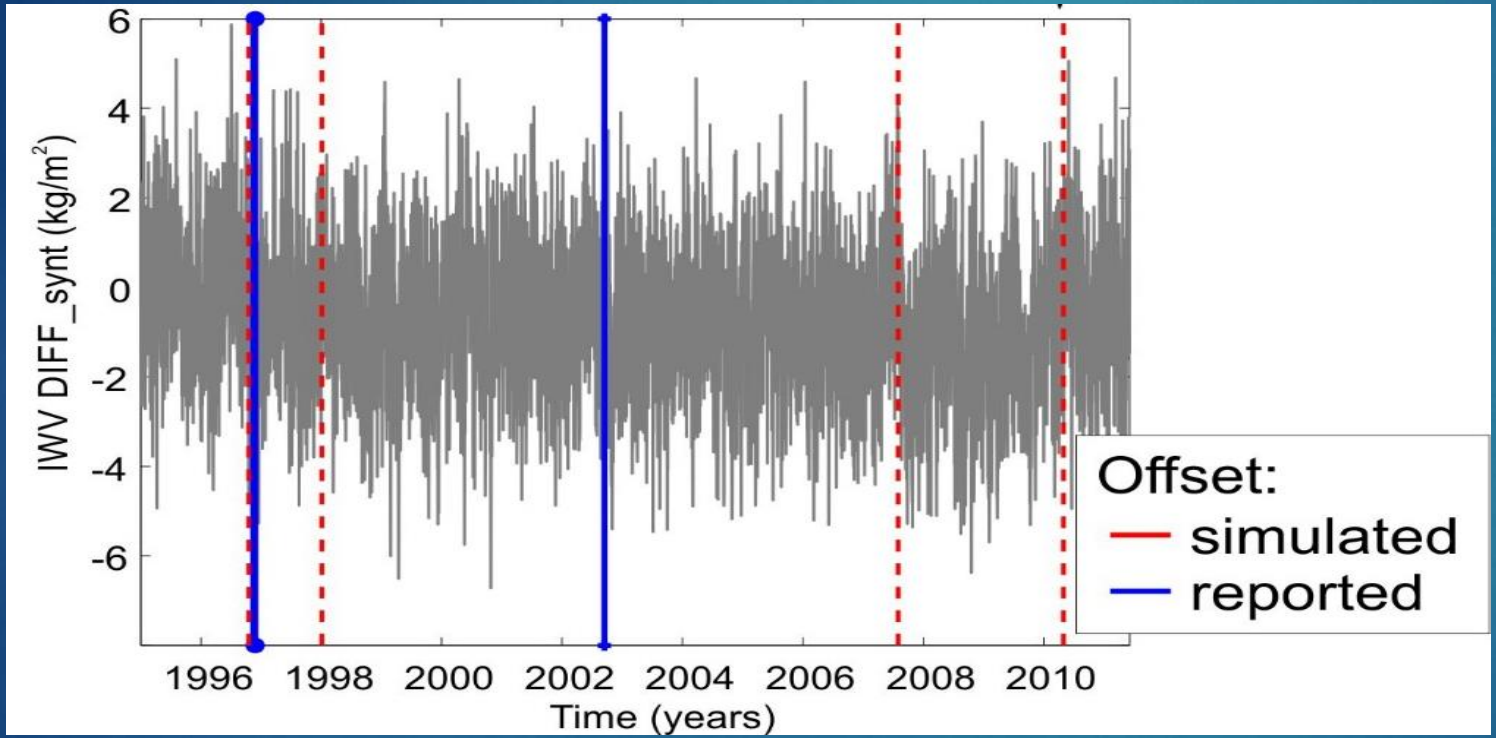


The 4 Basic Statistical Scores by Example

True Positive (TP)

False Positive (FP)

False Negative (FN)

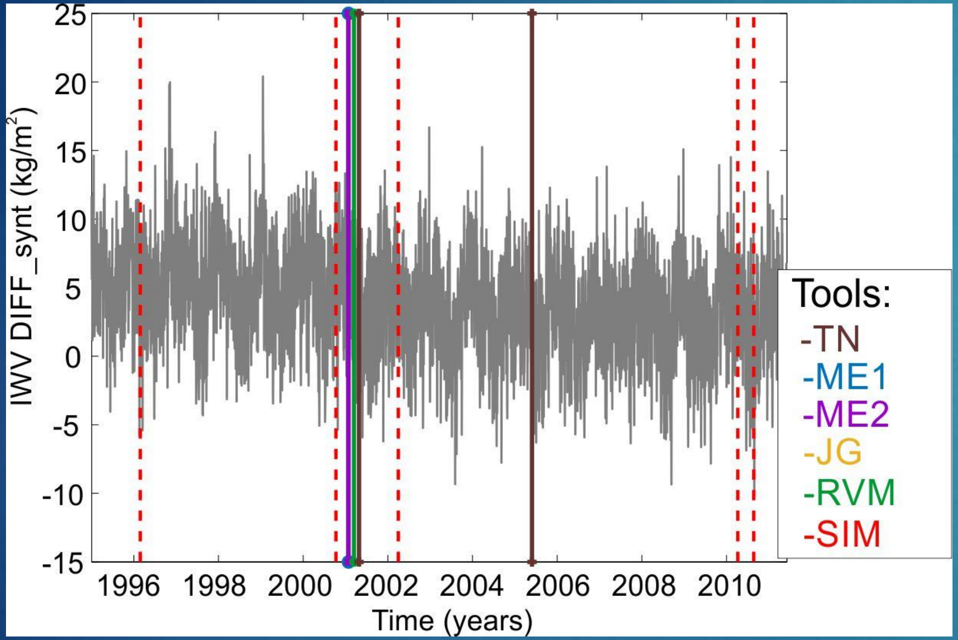


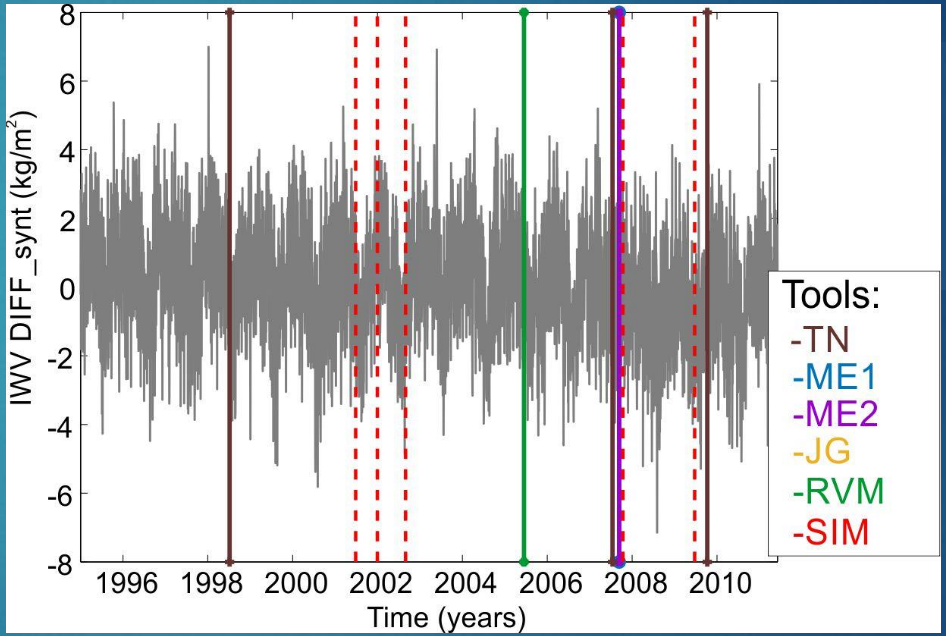
→ Need to define a proper time window for offset matches !!!

Results of the homogenization tools (Synthetic Benchmark)

Other examples: results from various tools

FULLY-COMPLICATED





→ Need to define a proper time window for offset matches !!!

Deriving Error Metrics for the Homogenization of IWV Time Series

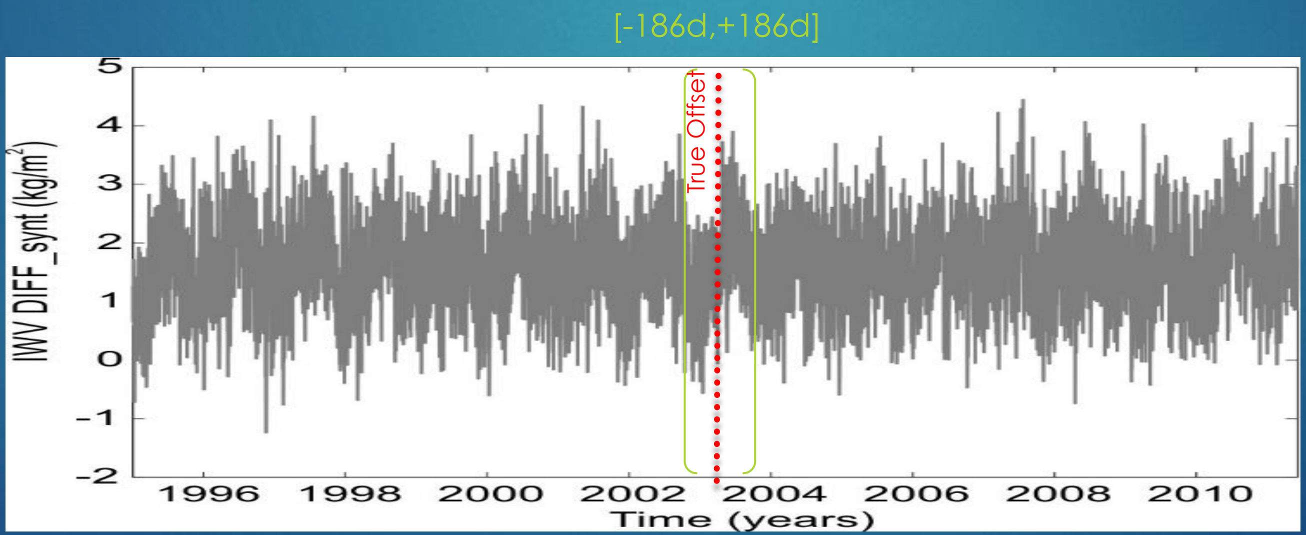
DEFINING THE PROPER TIME WINDOW

Time Window to Find "Matches" (TP)

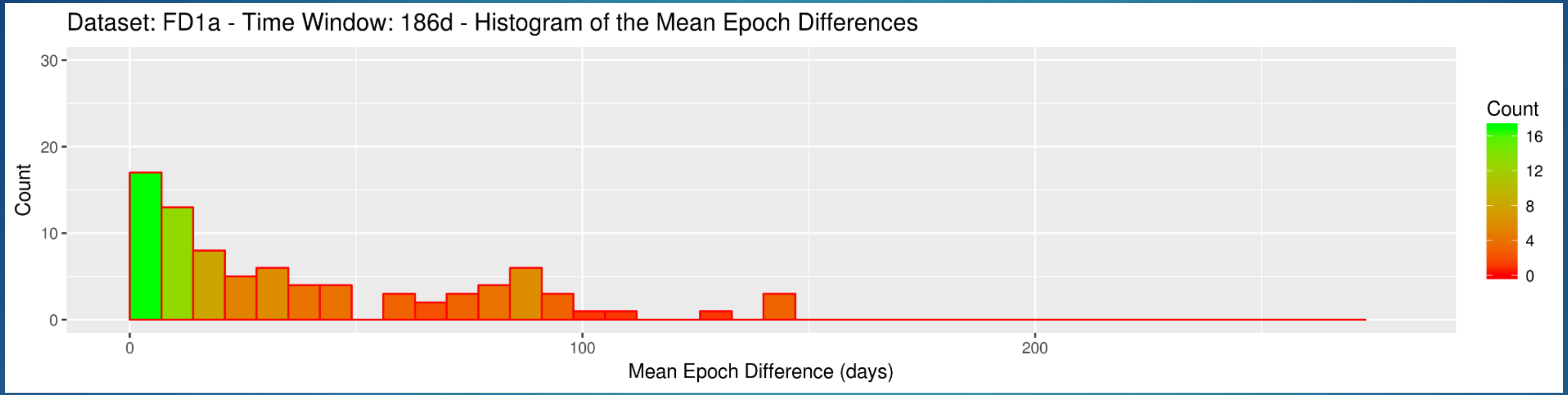
- To find potential matches between estimated offsets and the true offsets inserted in the synthetic dataset, it is mandatory to fix some time window.

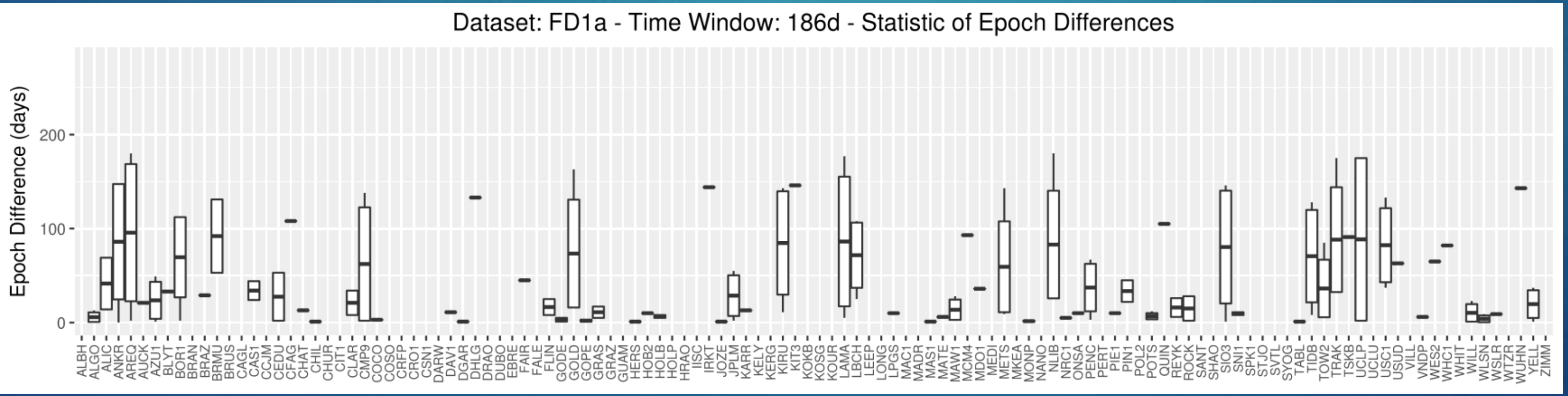
Defining the proper Time Window

- At the moment, it has been done quite empirically
  - Starting with a large time window of ±186 days (~ ±6 months) around the true offset epoch
  - Studying the distribution of epoch differences (estimated vs. truth)



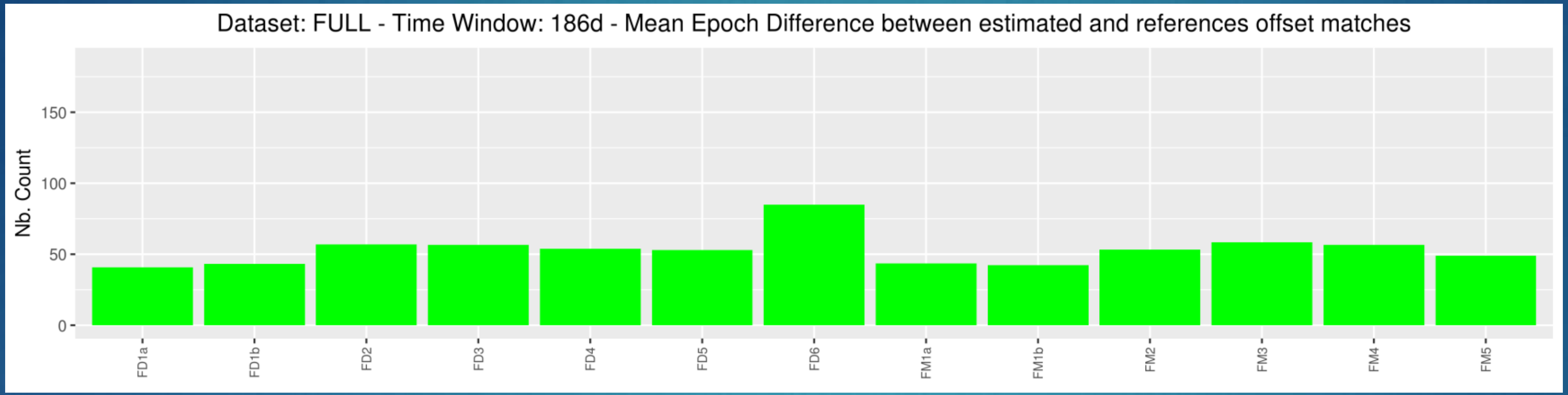
Defining the proper Time Window





➤ Results of the homogenization tools (Synthetic Benchmark)

Defining the proper Time Window



- We decided (somehow arbitrary) that
  - A time window of 62 days is convenient for deriving metrics for both, daily and monthly mean values from the synthetic datasets.
  - A time window of 31 days can be convenient when working with daily values.

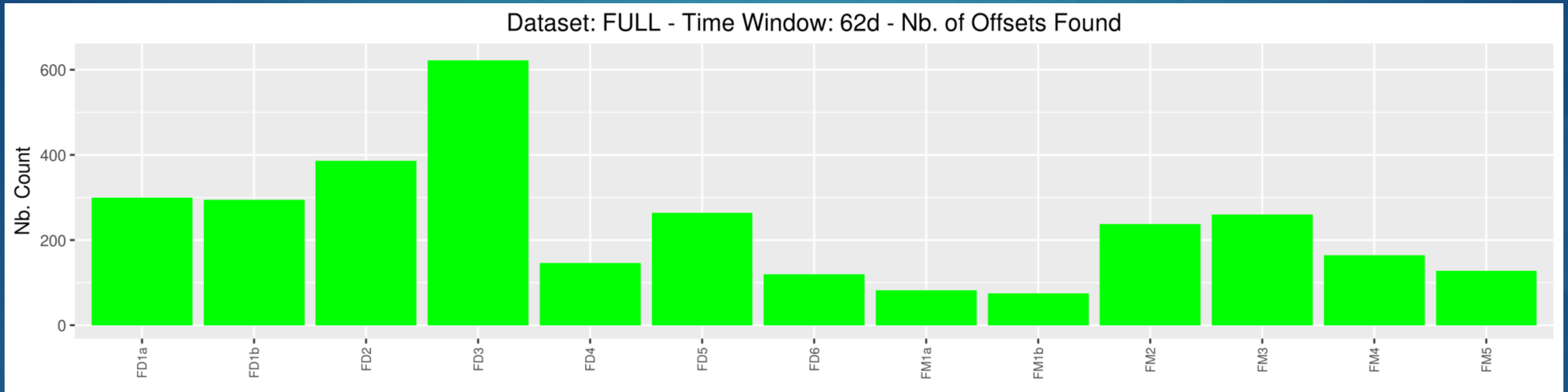
Deriving Error Metrics for the Homogenization of IWV Time Series

HOW MUCH OFFSET ARE DETECTED VERSUS THE TRUE NUMBER ?

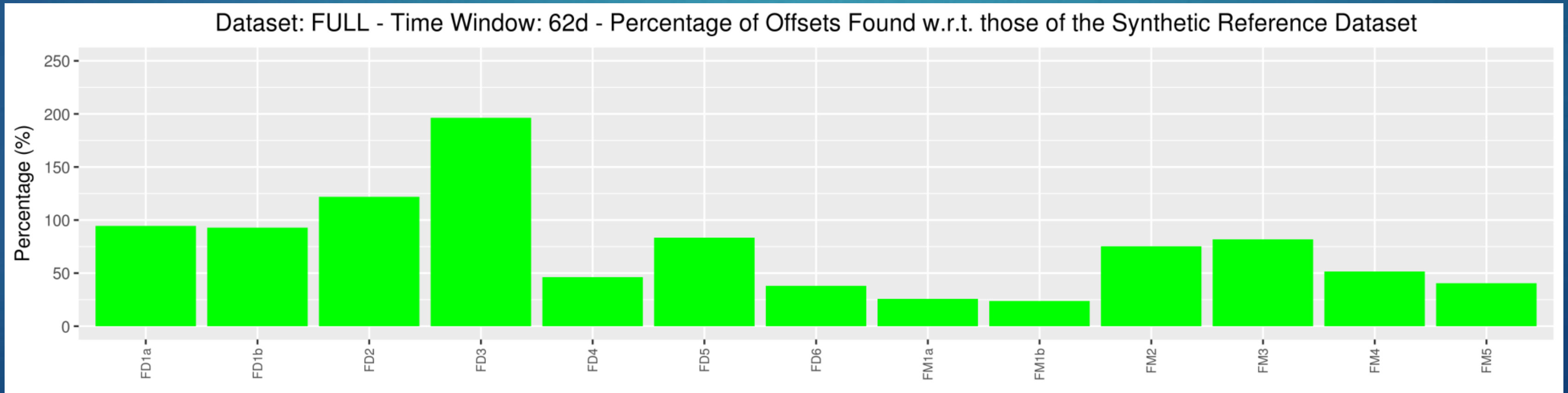
Number of Offset Estimated

➤ Results of the homogenization tools (Synthetic Benchmark)

Absolute Values

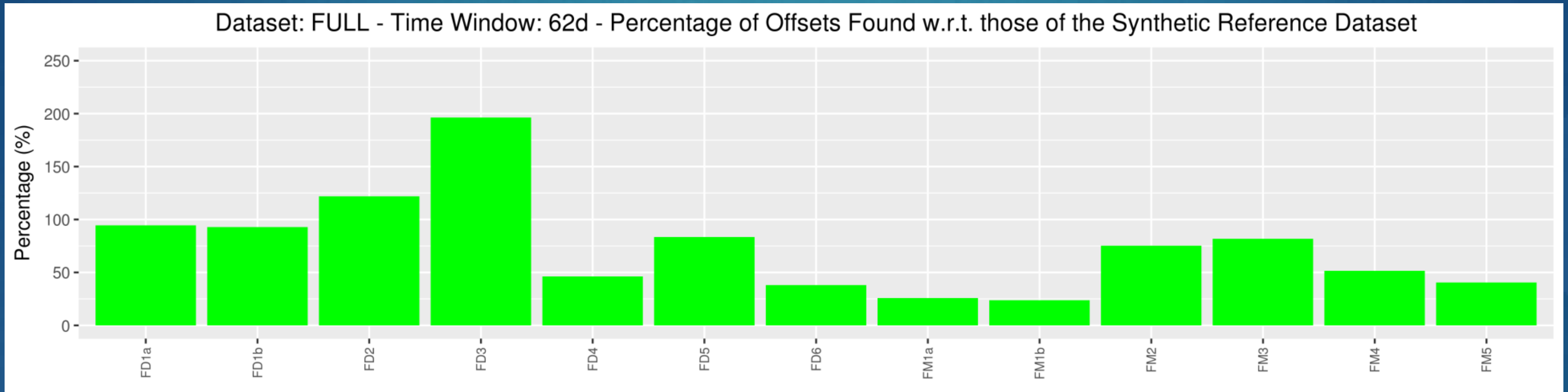


Ratio Estimated/True Offset Nb.



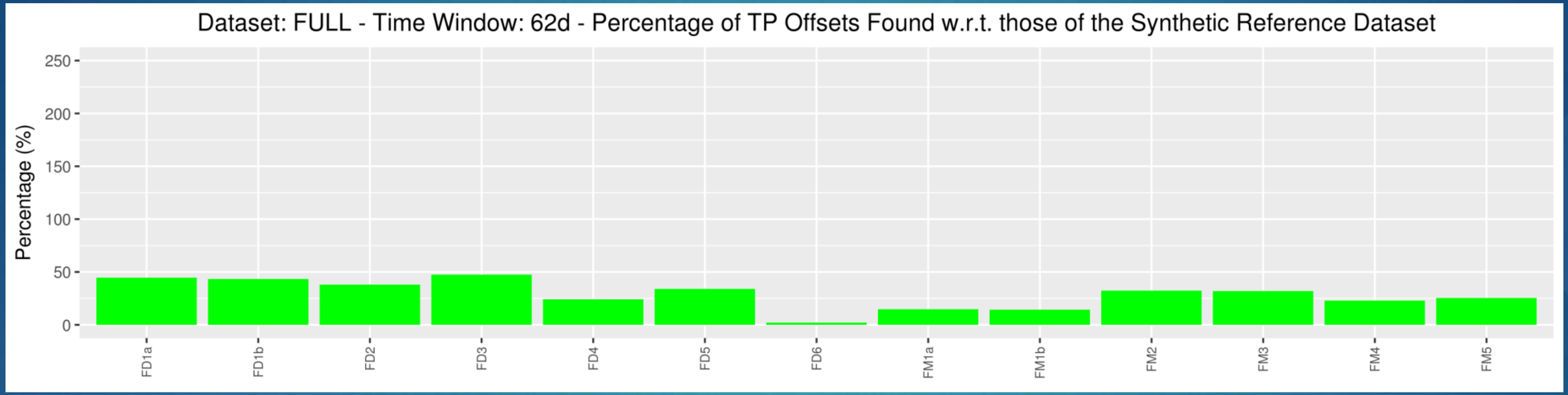
Number of Offset Estimated

Ratio Estimated/True Offset Nb.

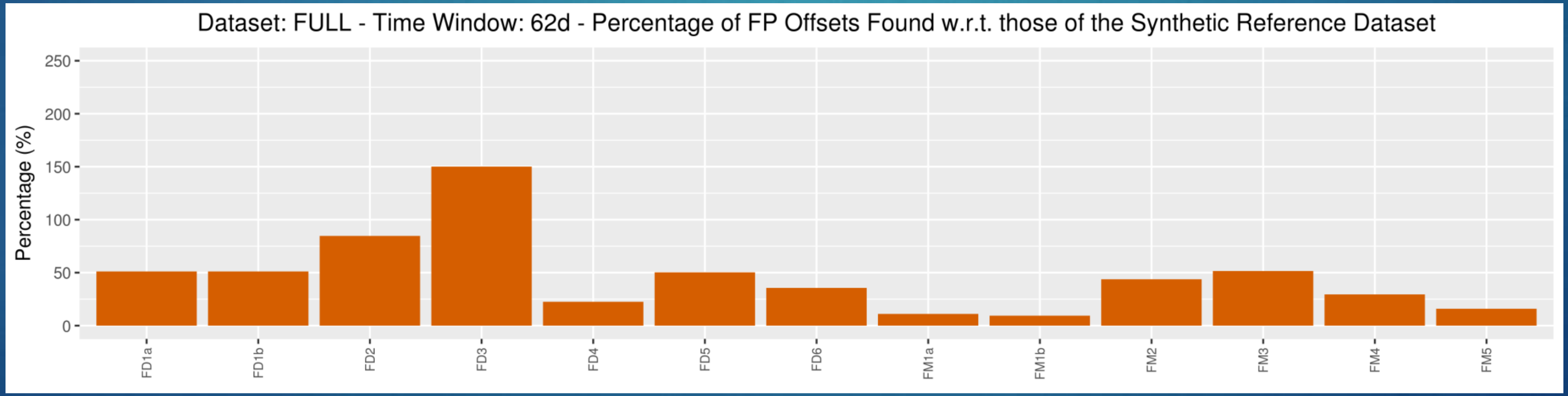


Number of Offset Estimated

Ratio Estimated/True Offset Nb.



Ratio Estimated/True Offset Nb.



- Results of the homogenization tools (Synthetic Benchmark)

Deriving Error Metrics for the Homogenization of IWV Time Series

QUESTIONS AND OBJECTIVES

Some Questions and Objectives

Sensitivity

What is the sensitivity of the homogenization methods w.r.t.

- The complexity of the synthetic dataset, i.e. w.r.t.
  - Addition of A.R. noise (from EASY to LESS)
  - Addition of gaps and trend (from LESS to FULL)
- The 'observation' frequency of the time series (daily vs. monthly)

Feedback

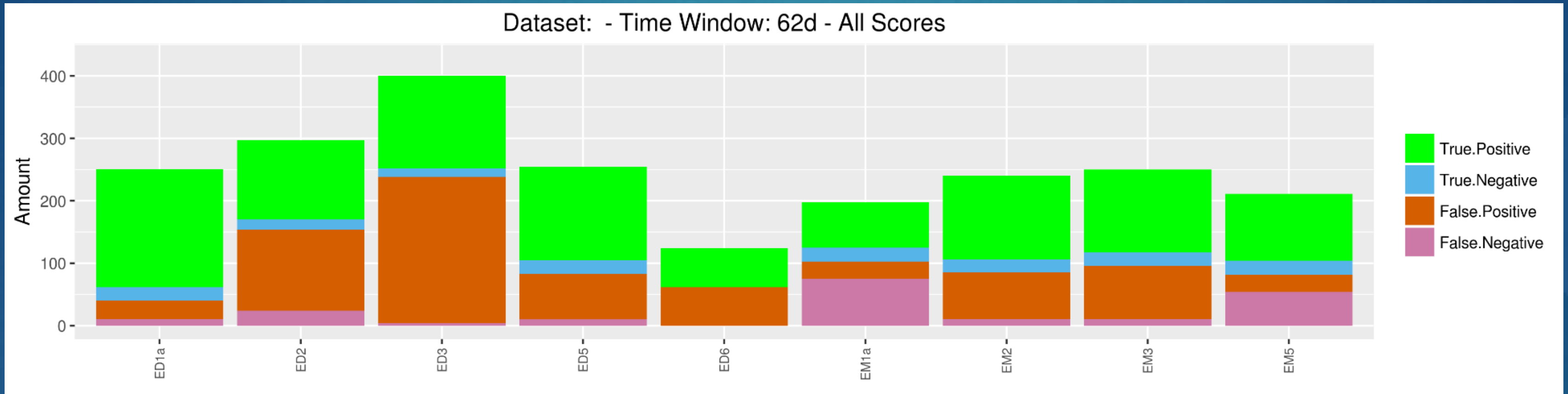
What are the performances of the homogenization methods w.r.t.

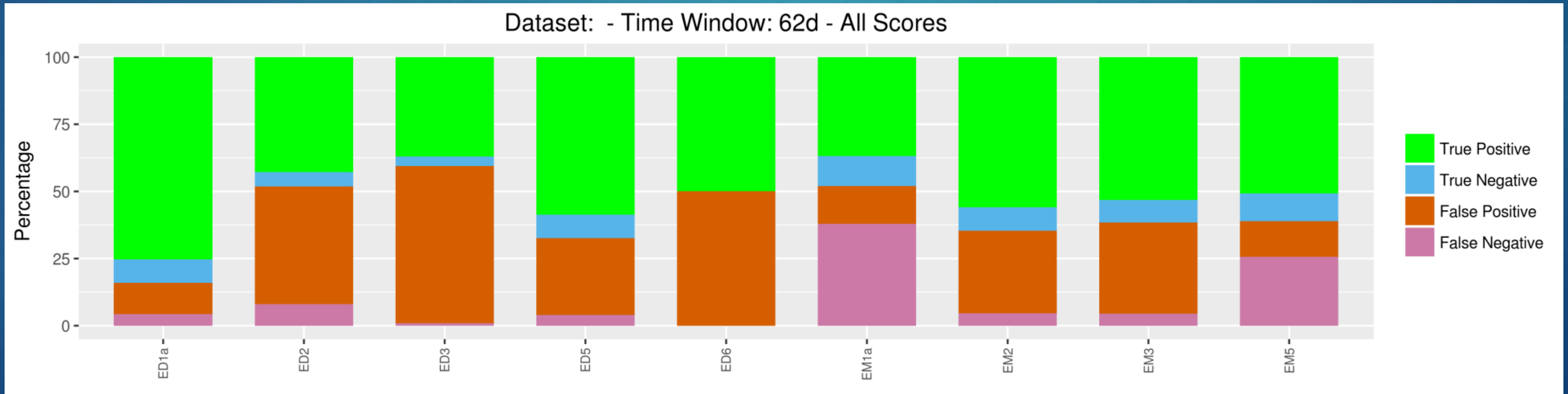
- The timing of the estimated offset epochs (accuracy)
- The amplitude of the estimated offsets (accuracy)
- To the geographical location (more/less TP/FP/FAR in some regions?)
- The station time series characteristics (noises, signals, gaps, trends correlation?)
- Edges vs. 'inside' of the station time series (e.g. ranking vs. T-test based methods)

Deriving Error Metrics for the Homogenization of IWV Time Series

SENSITIVITY W.R.T. THE SYNTHETIC DATASET COMPLEXITY

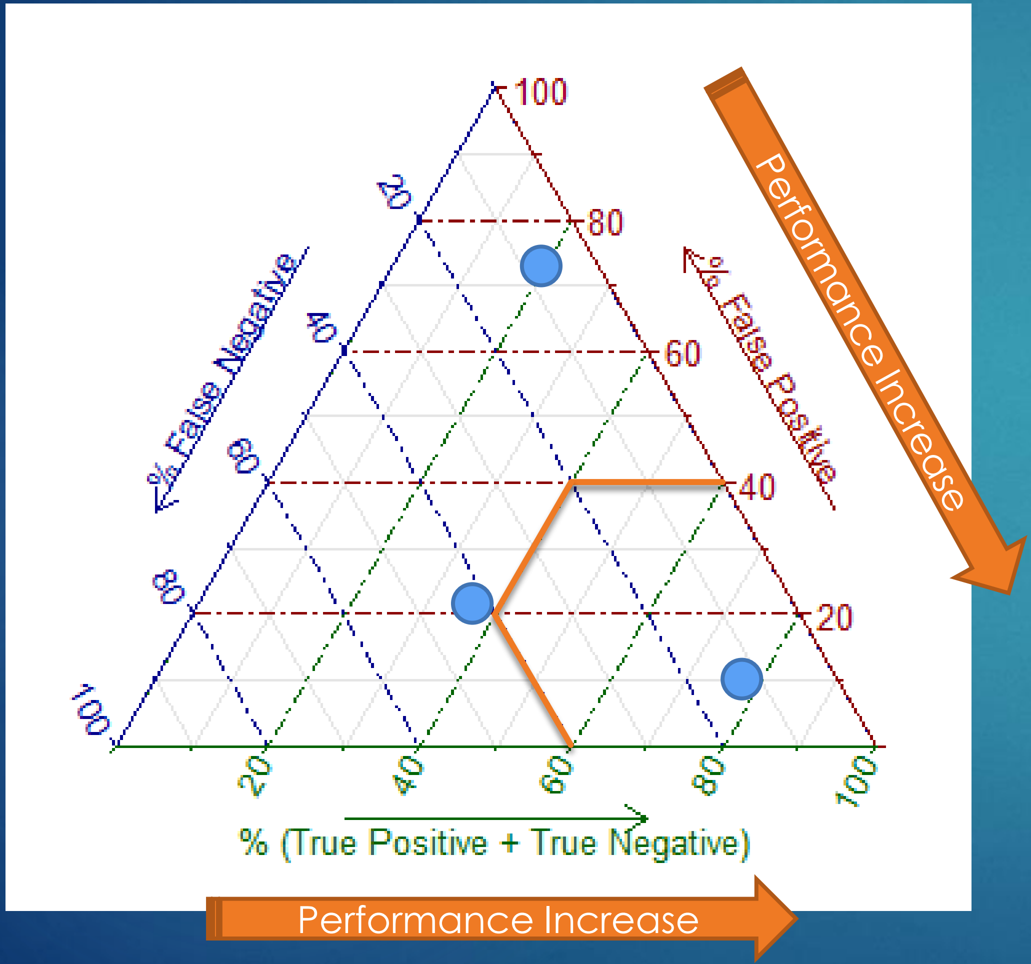
Scores from the EASY Synthetic Dataset





Ternary Graphs Example

Gazeaux et al. 2013, Detecting offsets in GPS time series: First results from the detection of offset in GPS experiment, JGR



Need to define performance criteria, such as:

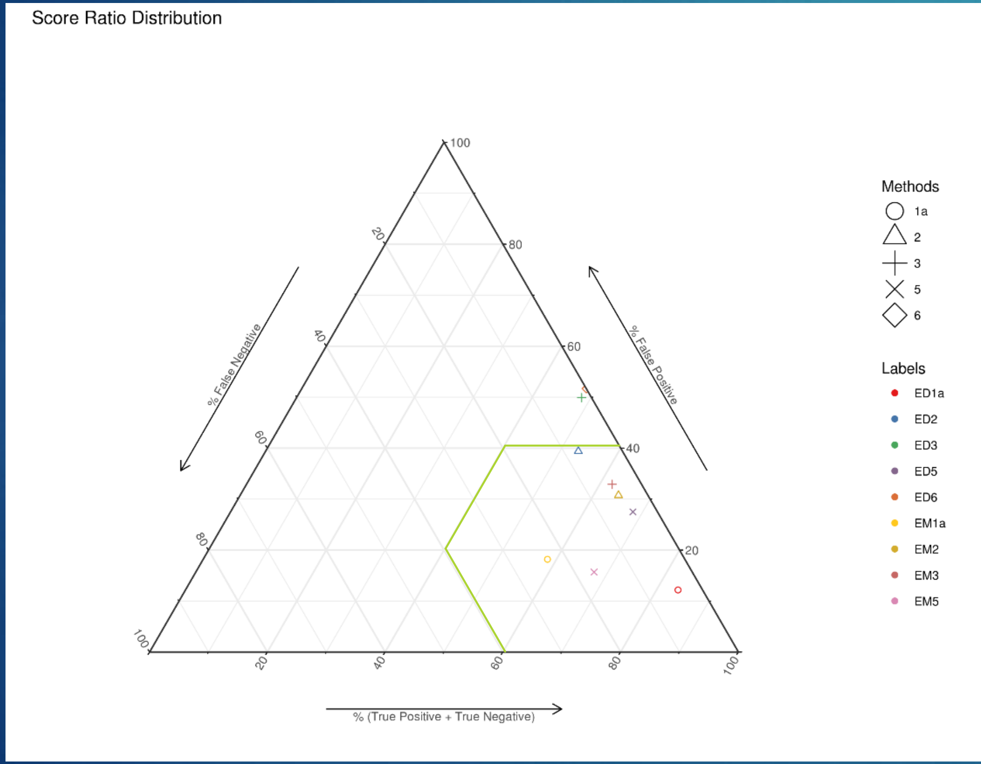
- True Positives + Negatives > 40 %
- False Negatives < 40%
- False Positives < 40%

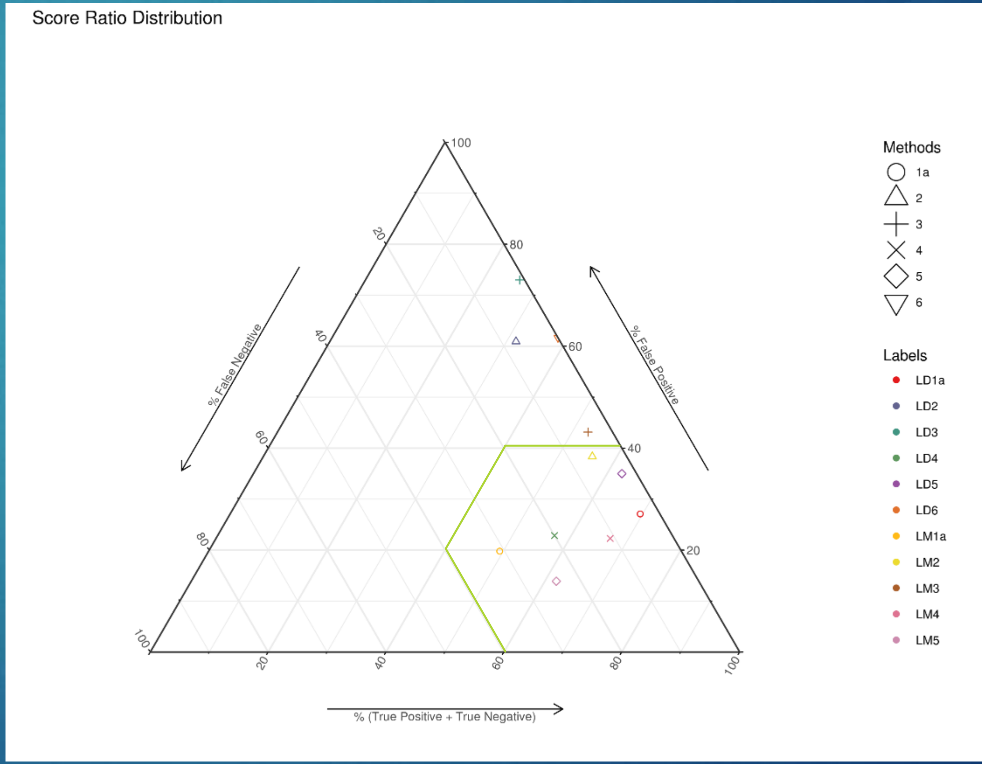
Sensitivity w.r.t. to the Synthetic Dataset Complexity

EASY

+ A.R. Noise

LESS Complicated



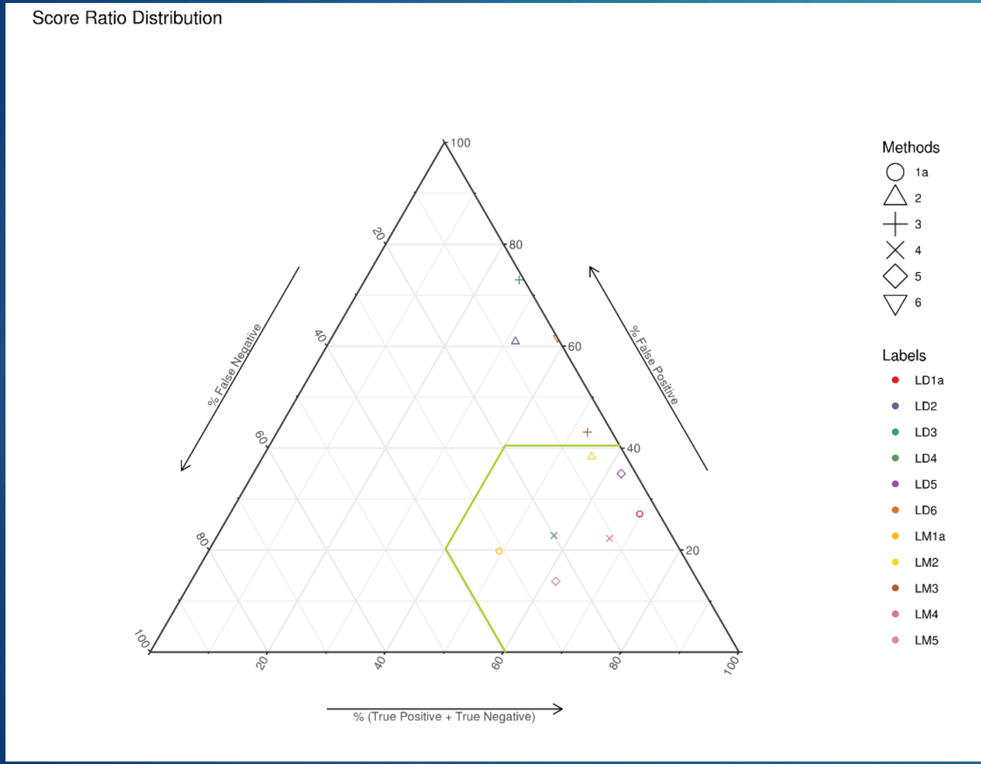


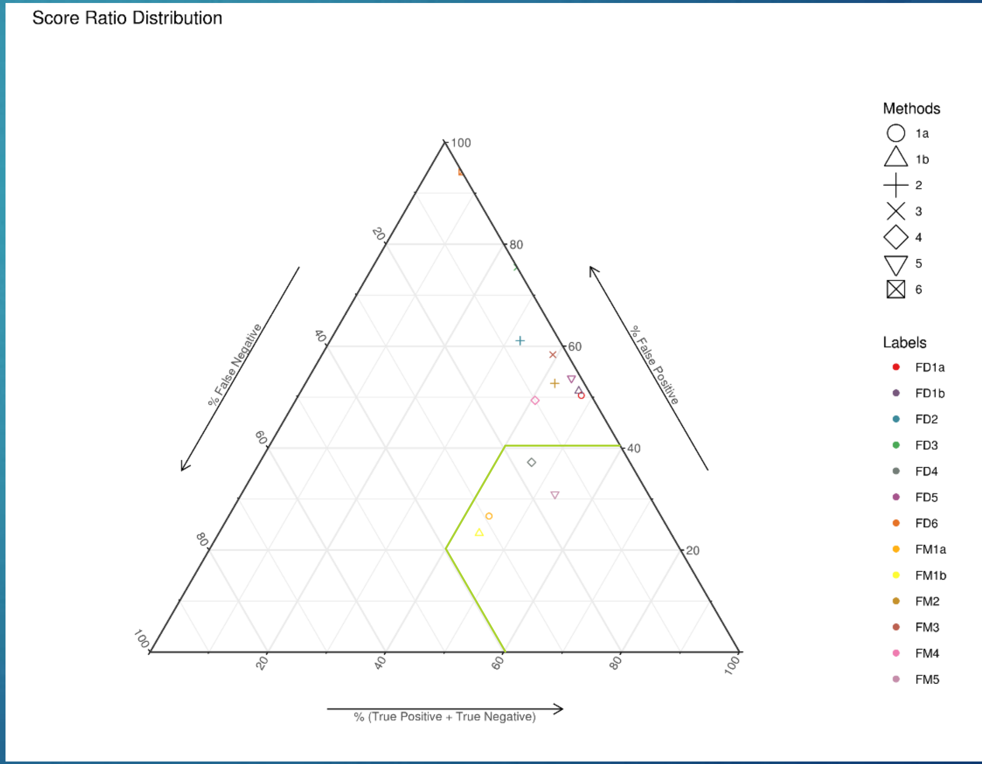
Sensitivity w.r.t. to the Synthetic Dataset Complexity

LESS Complicated

+ gap and trend

FULLY Complicated



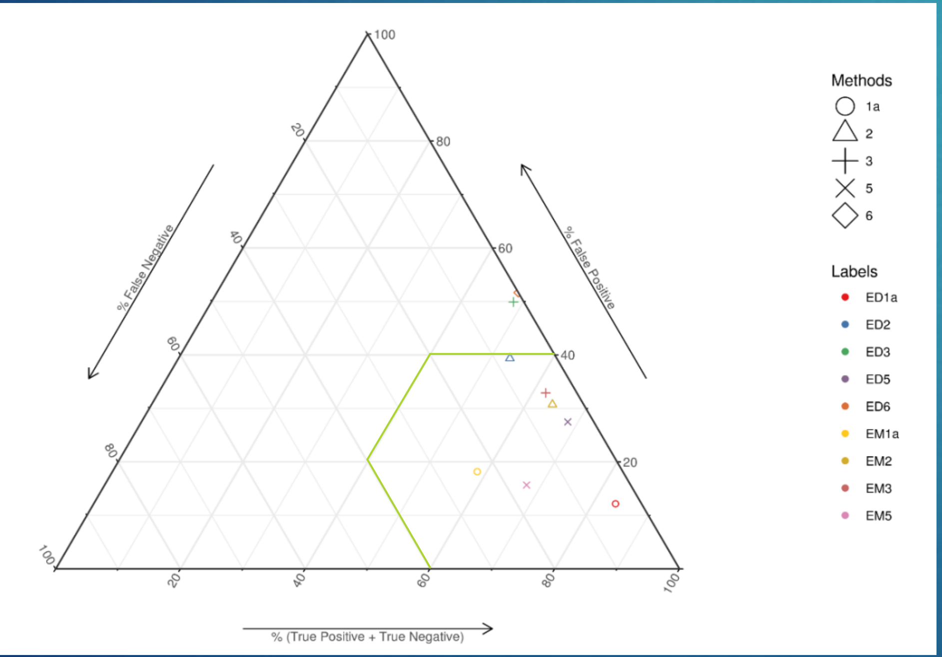


Deriving Error Metrics for the Homogenization of IWV Time Series

FEEDBACK AND METHODOLOGY ENHANCEMENTS

Feedback : From Blind Homogenization to Optimization

- Releasing the 'truth' about the different synthetic dataset (already done on demand for "EASY") can help fine-tuning the homogenization methods.

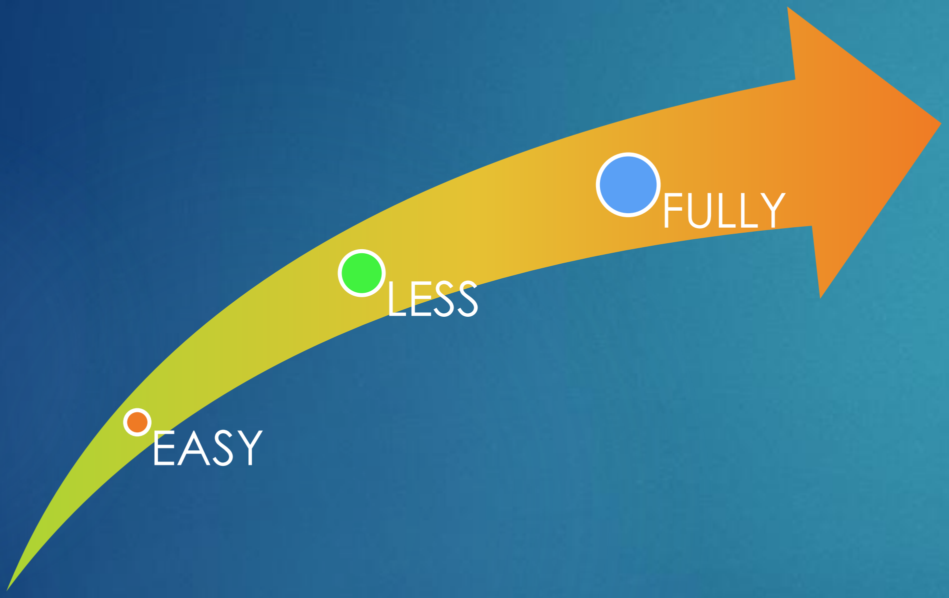


Deriving Error Metrics for the Homogenization of IWV Time Series

FEEDBACK: ACCURACY OF THE TIMING OF THE ESTIMATED OFFSETS

Accuracy of the Estimated Offset Epochs

W.r.t. the complexity of the synthetic dataset



Results of the homogenization tools (Synthetic Benchmark)

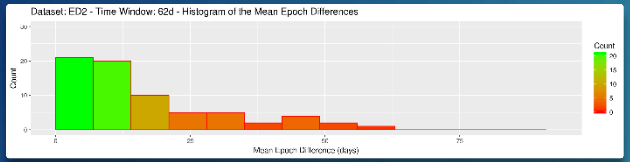
Accuracy of the Estimated Offset Epochs

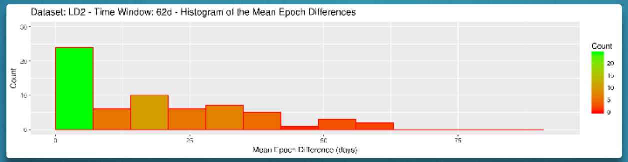
W.r.t. the complexity of the synthetic dataset

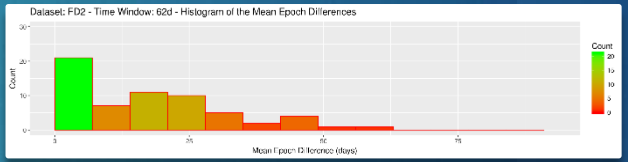
Results of the homogenization tools (Synthetic Benchmark)

Easy | Less | Full

Daily







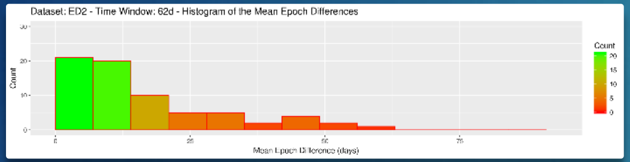
Decreased Accuracy of the Timing

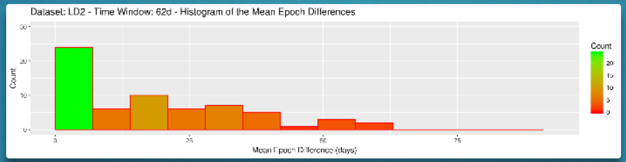
Accuracy of the Estimated Offset Epochs

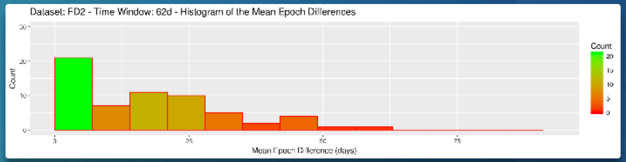
W.r.t. daily versus monthly mean values from the synthetic dataset

Easy | Less | Full

Daily

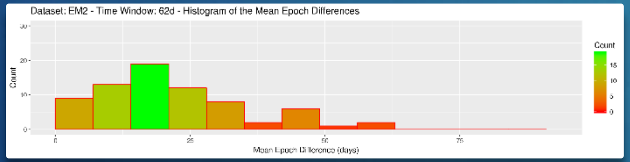


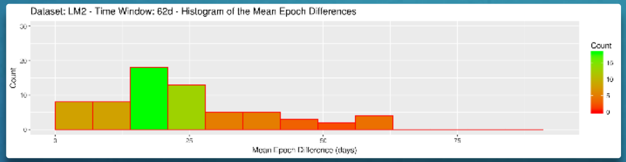


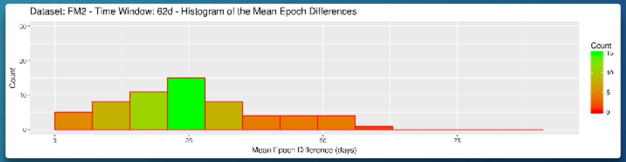


Decreased Accuracy of the Timing

Monthly

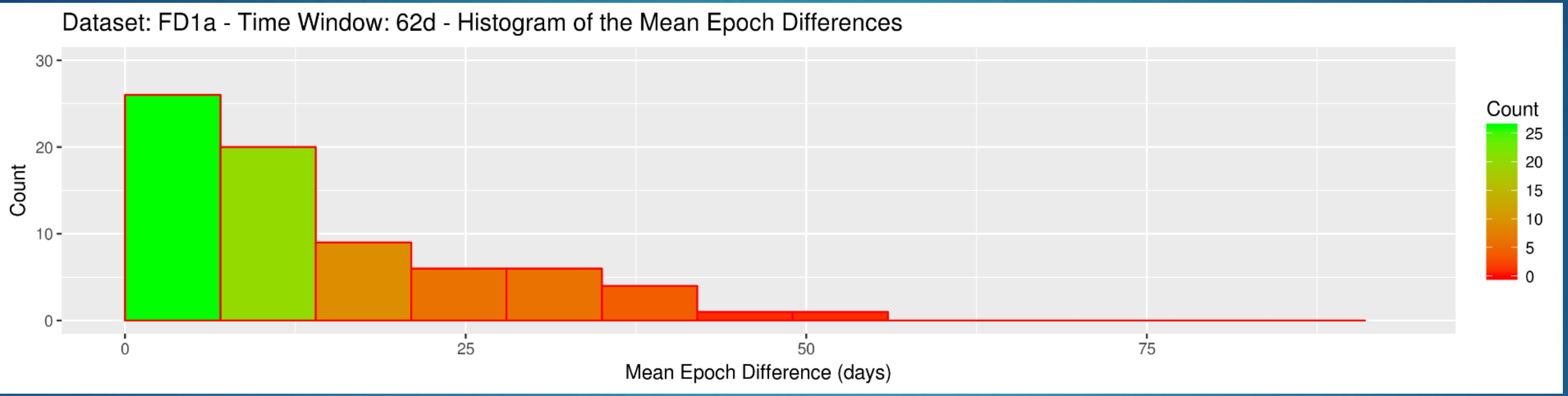


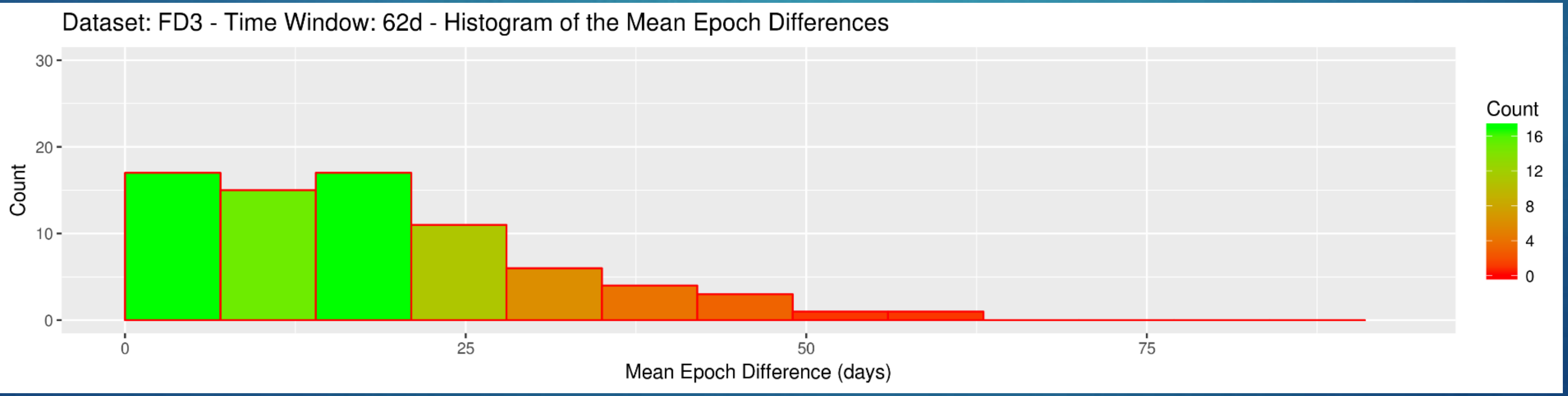




Accuracy of the Estimated Offset Epochs

W.r.t. homogenization method





➤ Results of the homogenization tools (Synthetic Benchmark)

Accuracy of the Estimated Offset Epoch

- Depends on
  - The complexity of the synthetic dataset.
  - The frequency of the synthetic dataset values (daily versus monthly means).
  - On the homogenization method.

Deriving Error Metrics for the Homogenization of IWV Time Series

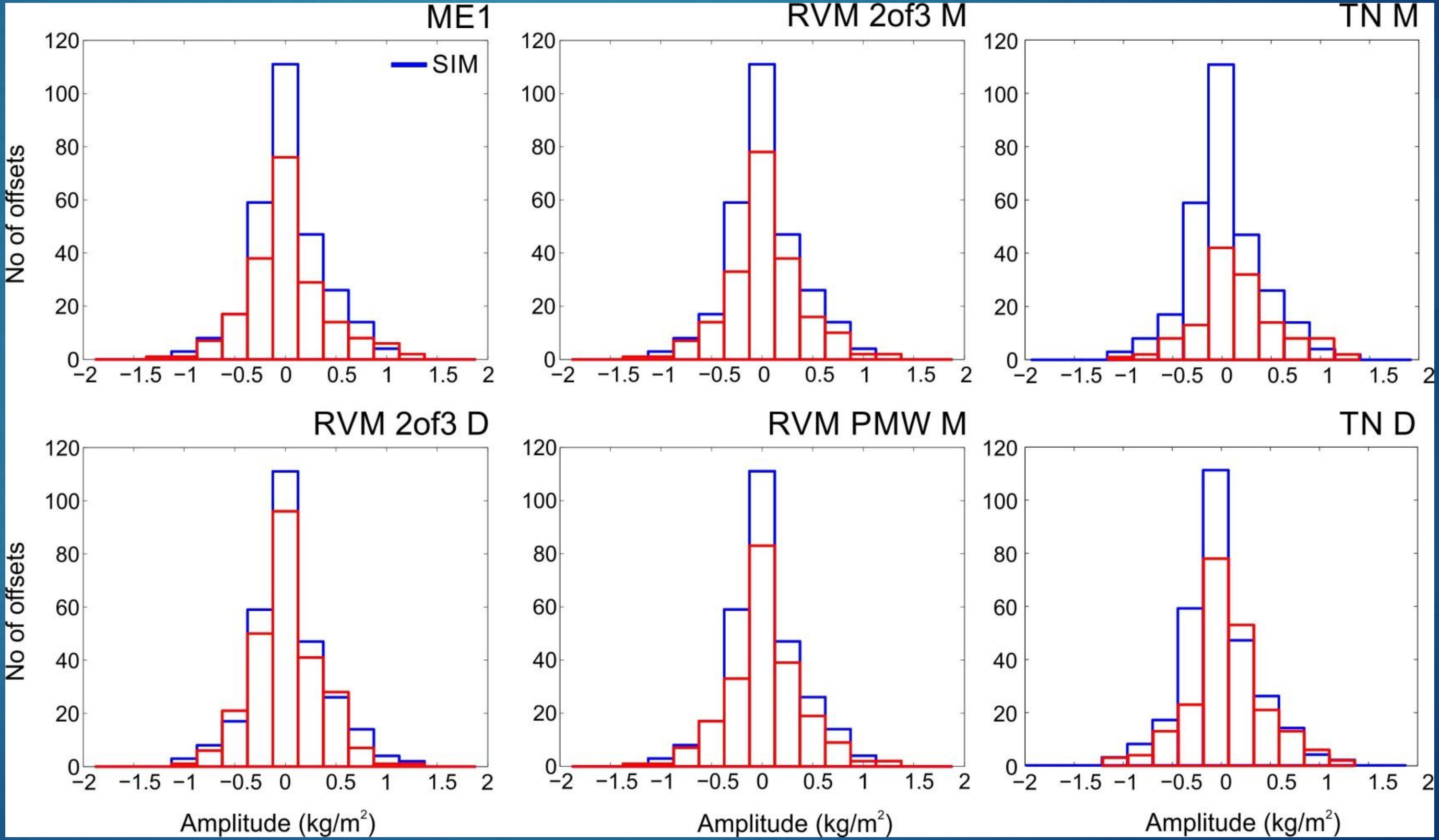
FEEDBACK: ACCURACY OF THE OFFSET AMPLITUDE ESTIMATED

Accuracy of the Estimated Offset Amplitude

Amplitudes of reported offsets

EASY (SIM: 291)

ME1: 199
RVM 2of3 M: 202
RVM 2of3 D: 252
RVM PMW M: 213
TN D: 216
TN M: 130



Accuracy of the Estimated Offset Amplitude

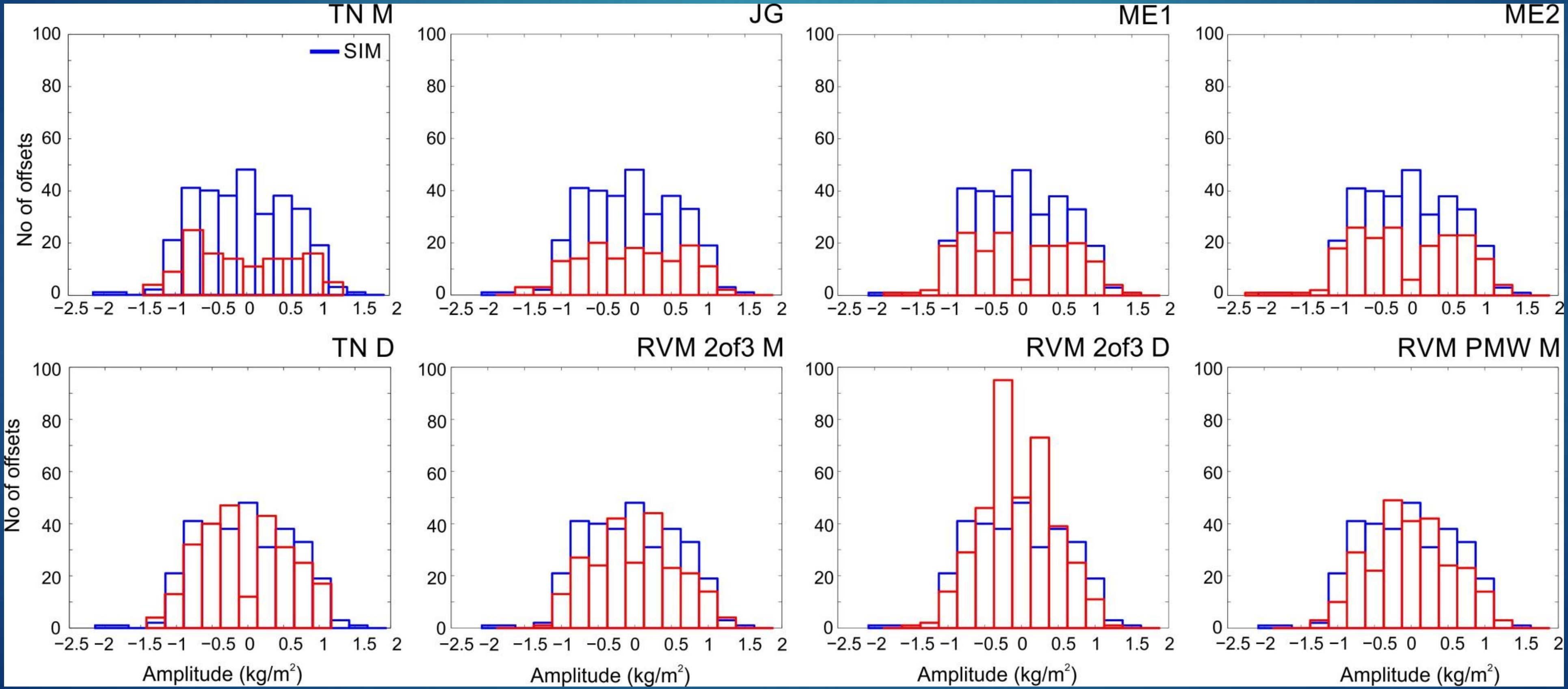
Amplitudes of reported offsets

FULLY-COMPLICATED (SIM: 317)

JG: 146
ME1: 170
ME2: 185

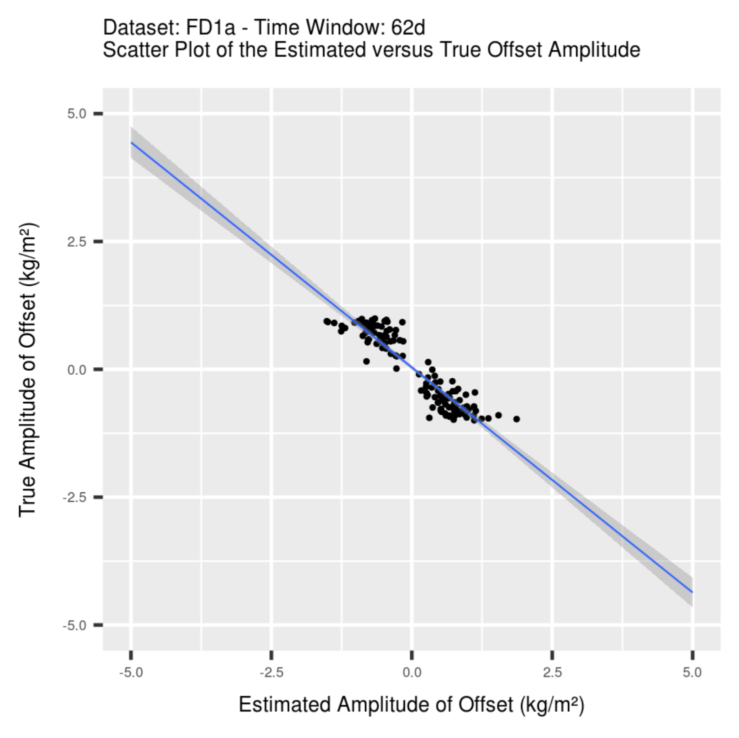
TN D: 264
TN M: 128

RVM 2of3 M: 238
RVM 2of3 D: 386
RVM PMW M: 260

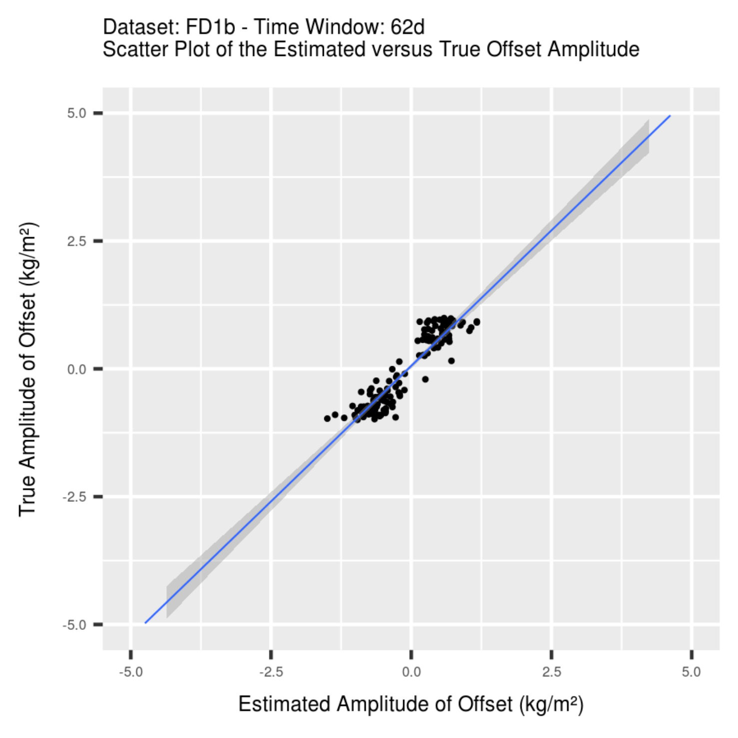


Accuracy of the Estimated Offset Amplitude

Without Gap Filling



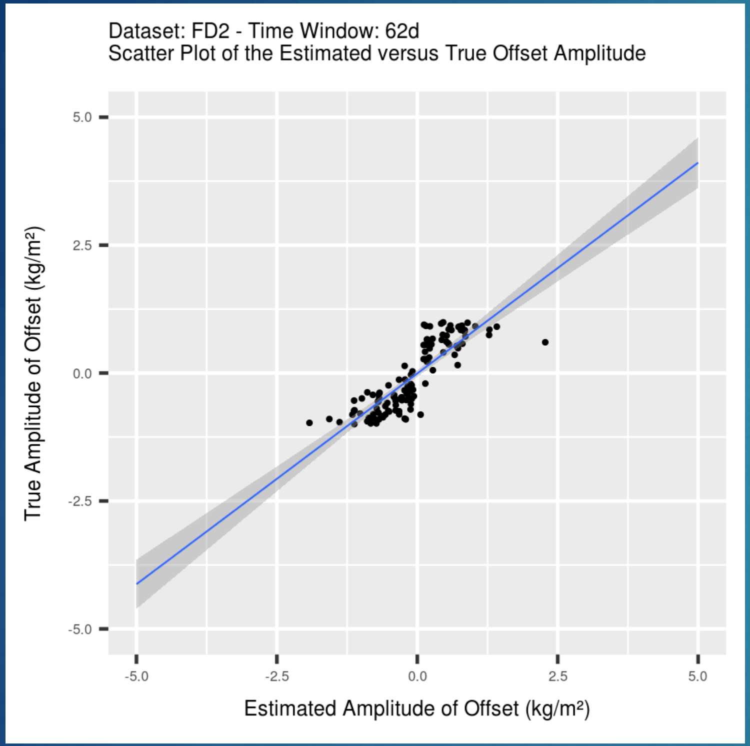
With Gap Filling



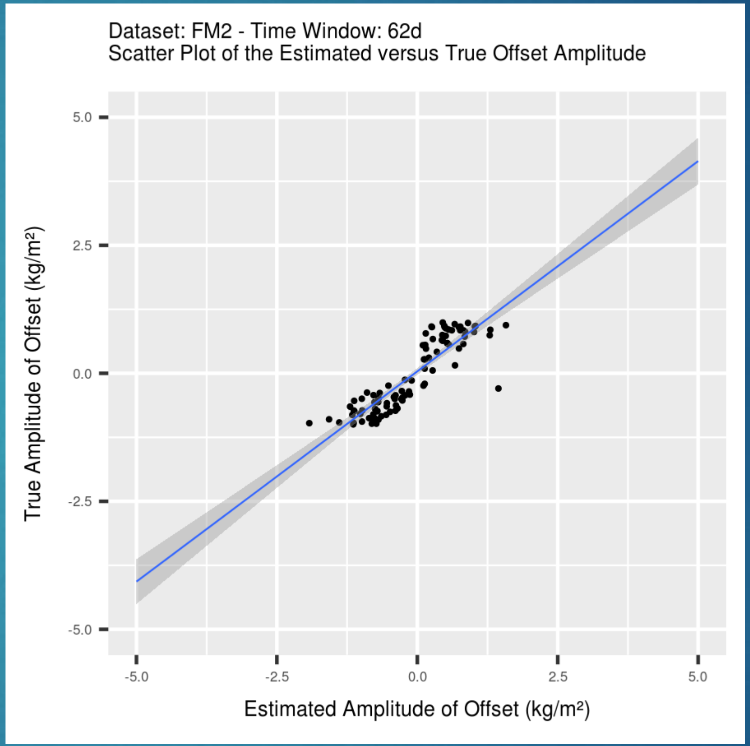
- Slope quite close to a 1:1 relationship and even slightly closer when filling gap.
- Similar method, same operator but opposite sign
  (matter of convention, not too much of concerns for trends).

Accuracy of the Estimated Offset Amplitude

Daily



Monthly



- Slope seems rather insensitive to daily versus monthly mean values (at least for this method).
- Systematic underestimation of the offset amplitude
  (related to the timing accuracy ?).

Deriving Error Metrics for the Homogenization of IWV Time Series

FINDING THE ORIGINS OF PERFORMANCE DEGRADATIONS

Feedback : From Blind Homogenization to Optimization

- Ongoing work : more elaborated feedback like studying the sensitivity of the performances w.r.t. the synthetic dataset characteristics using a bi-variate correlation analysis :

Noise model, coefficient and amplitude

Signal Cycle (Annual, Semi-Annual, Ter-Annual, Quarter-Annual) amplitude and phase

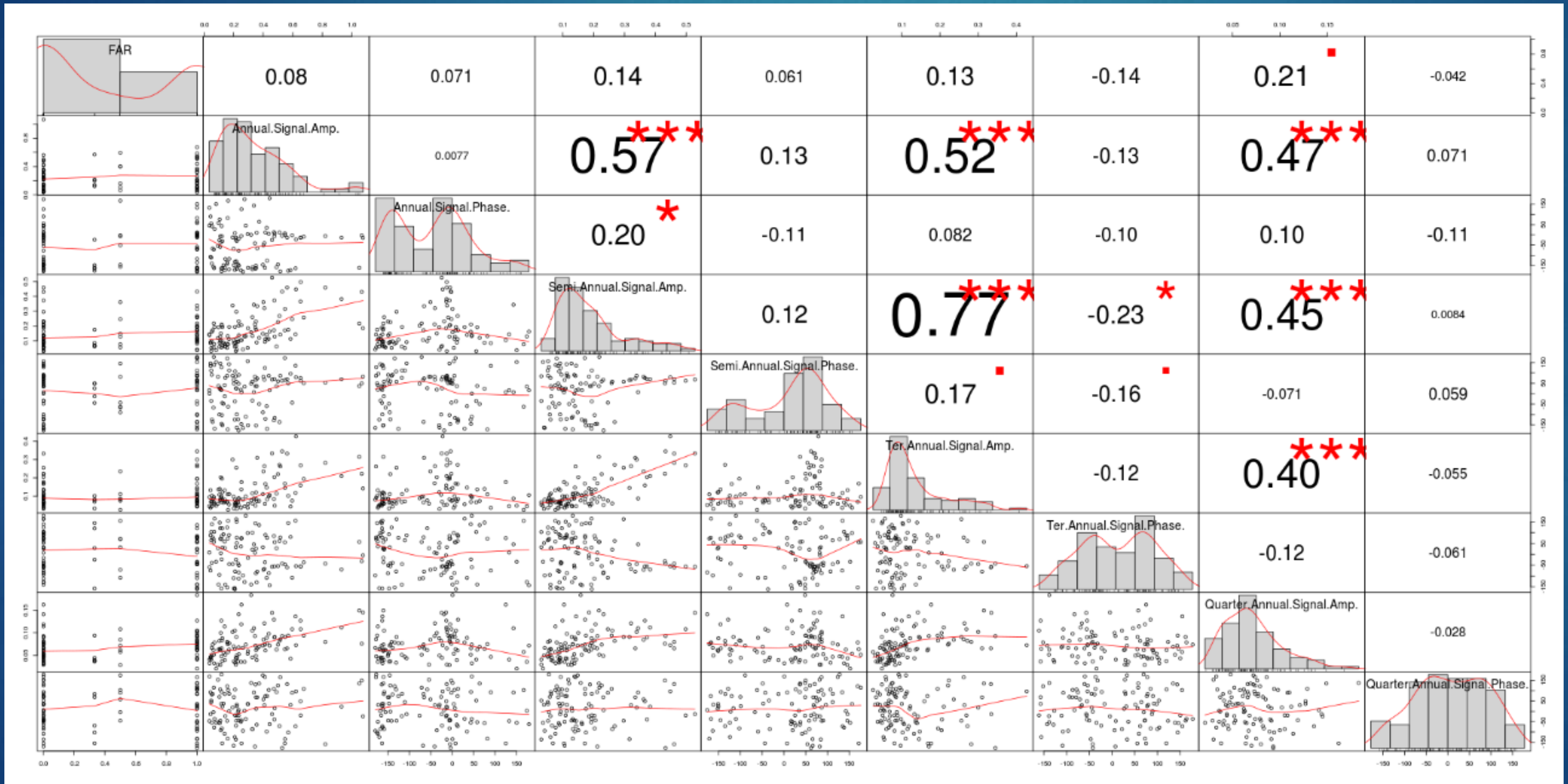
Percentage of gaps

Trend (number and amplitude)

Example of Bi-Variate Correlation Analysis

Dataset: FD5

FAR versus Signal's Amplitude and Phase



Deriving Error Metrics for the Homogenization of IWV Time Series

TREND AND TREND UNCERTAINTIES AS PERFORMANCE METRICS

Methodology

1. For each of the provided solutions, we characterized the number of epochs found and calculated the amplitudes of those offsets (consistency!)

2. We corrected the time series with the amplitudes found and we run (HECTOR) the Maximum Likelihood Estimation (MLE) with the epochs found by different tools.

3. We cross-compared the values of trend, seasonal signals and parameters of noise when different epochs were applied.

The number, amplitudes and epochs of offsets may change:

1. Value of trend.
2. The character of the stochastic part ➔ trend uncertainty.

They will not affect:

Amplitudes of seasonal signals.

Changes in seasonals and noise

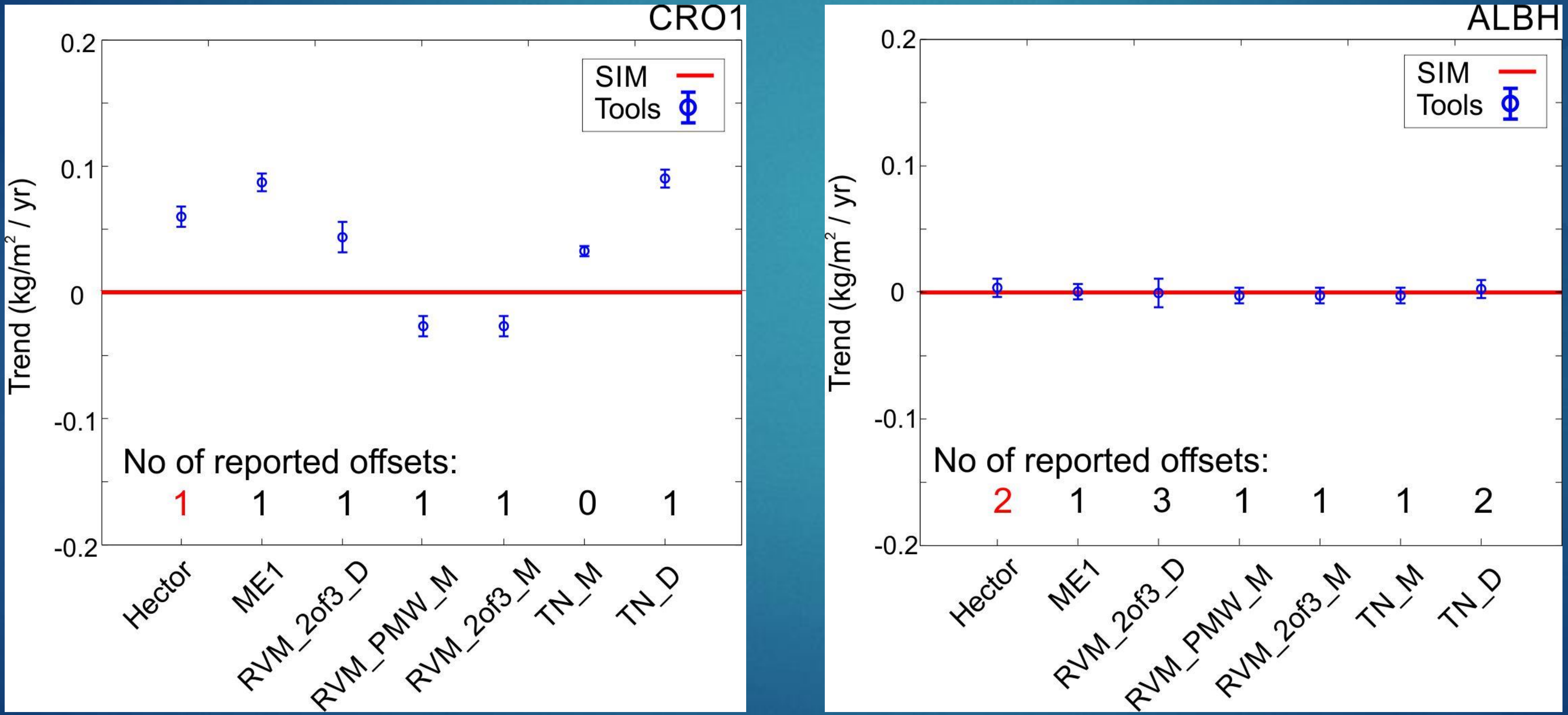
- Maximum change in the **annual amplitude** of 0.1 mm.

- Maximum change in **coefficient of autoregressive noise** of 0.2 (Less complicated) & of 0.3 (Fully complicated).

Changes in trends

EASY

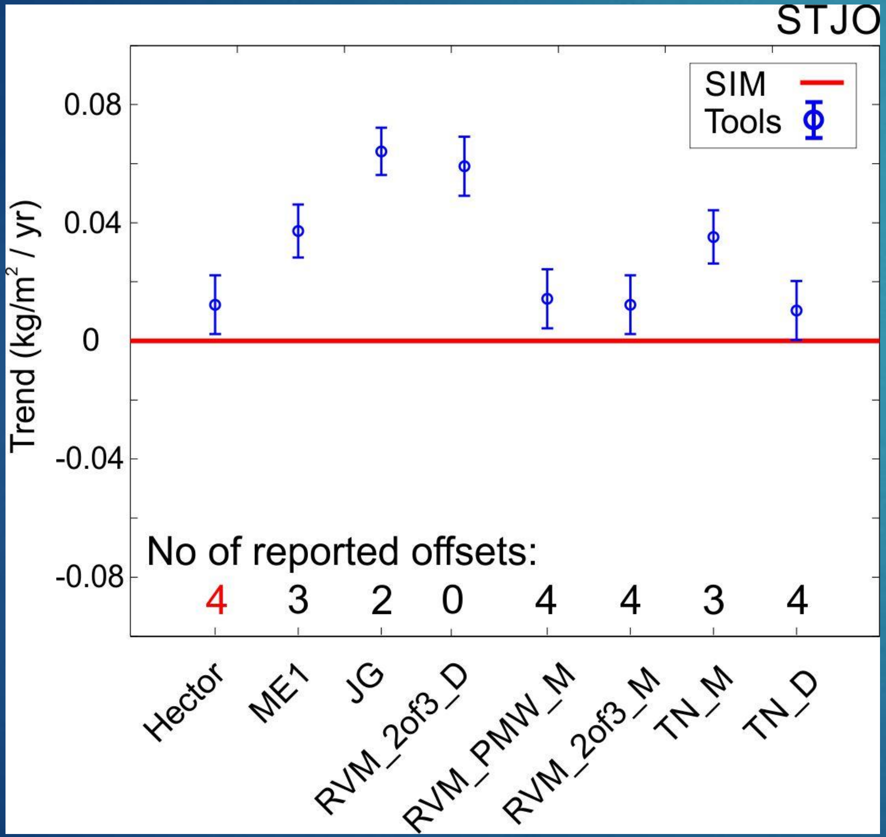
"Hector " = output from MLE with simulated offsets

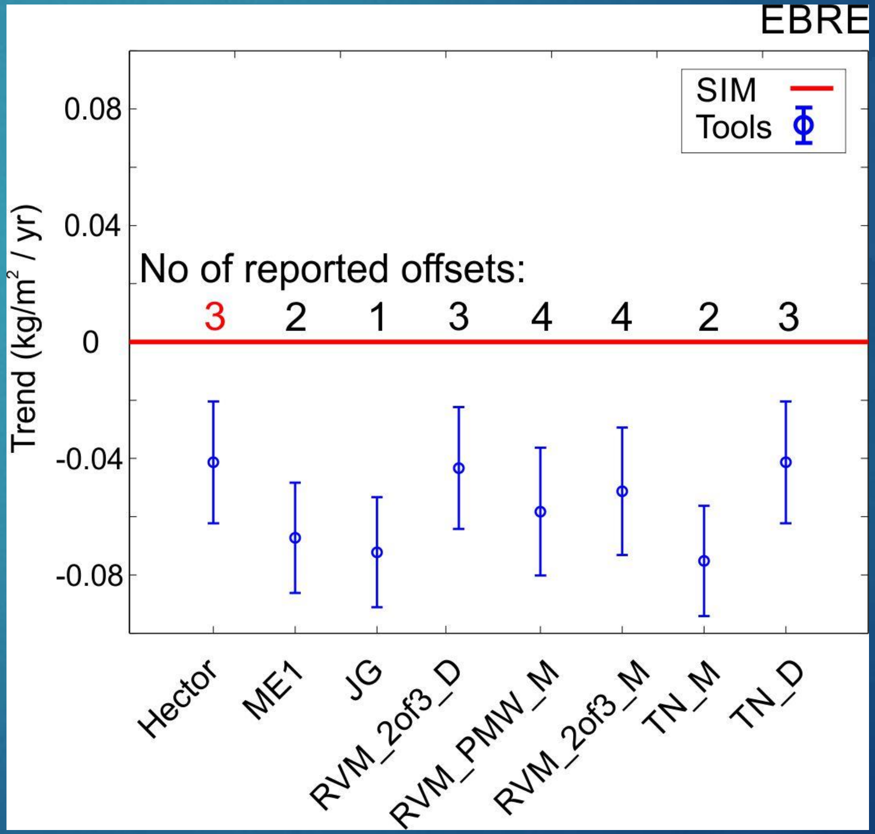


Changes in trends

LESS COMPLICATED

"Hector " = output from MLE with simulated offsets

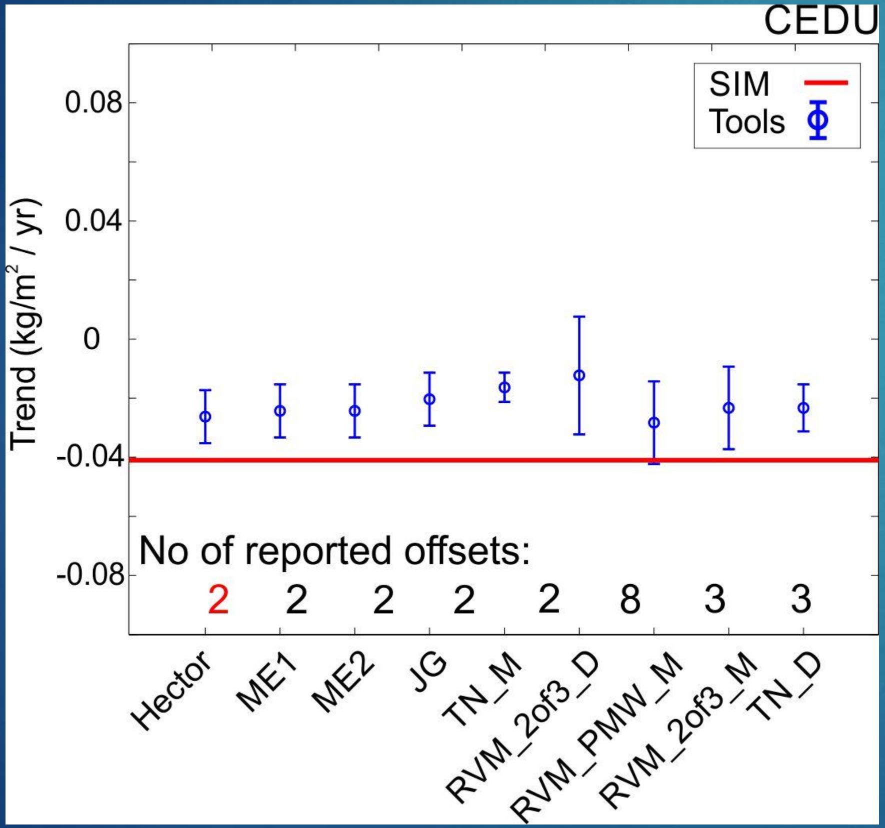


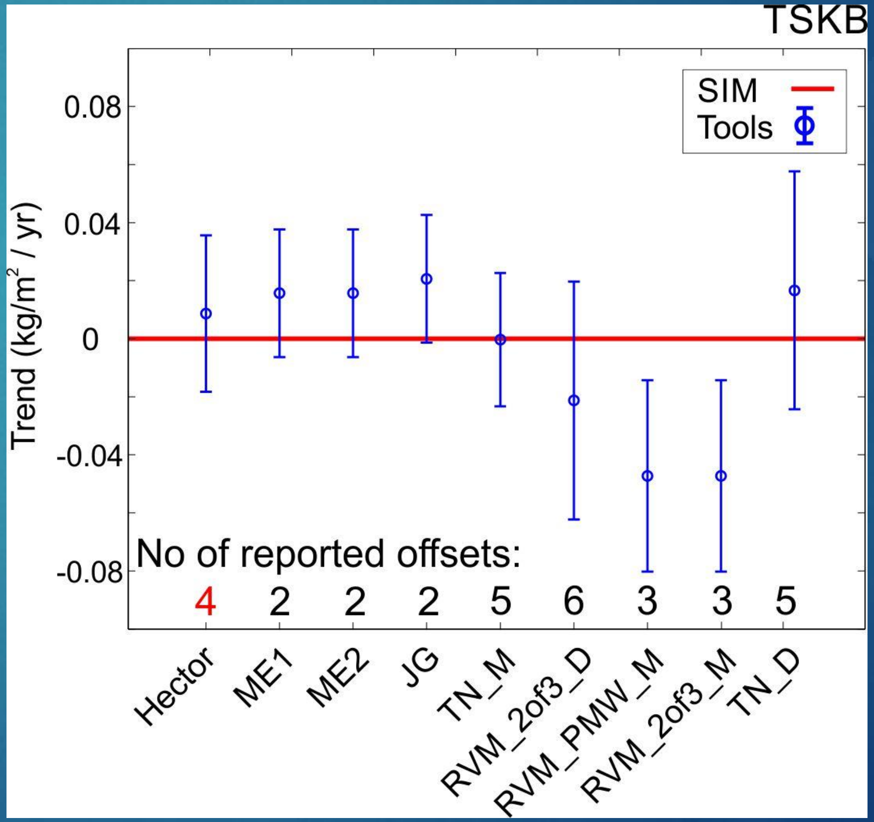


Changes in trends

FULLY COMPLICATED

"Hector " = output from MLE with simulated offsets

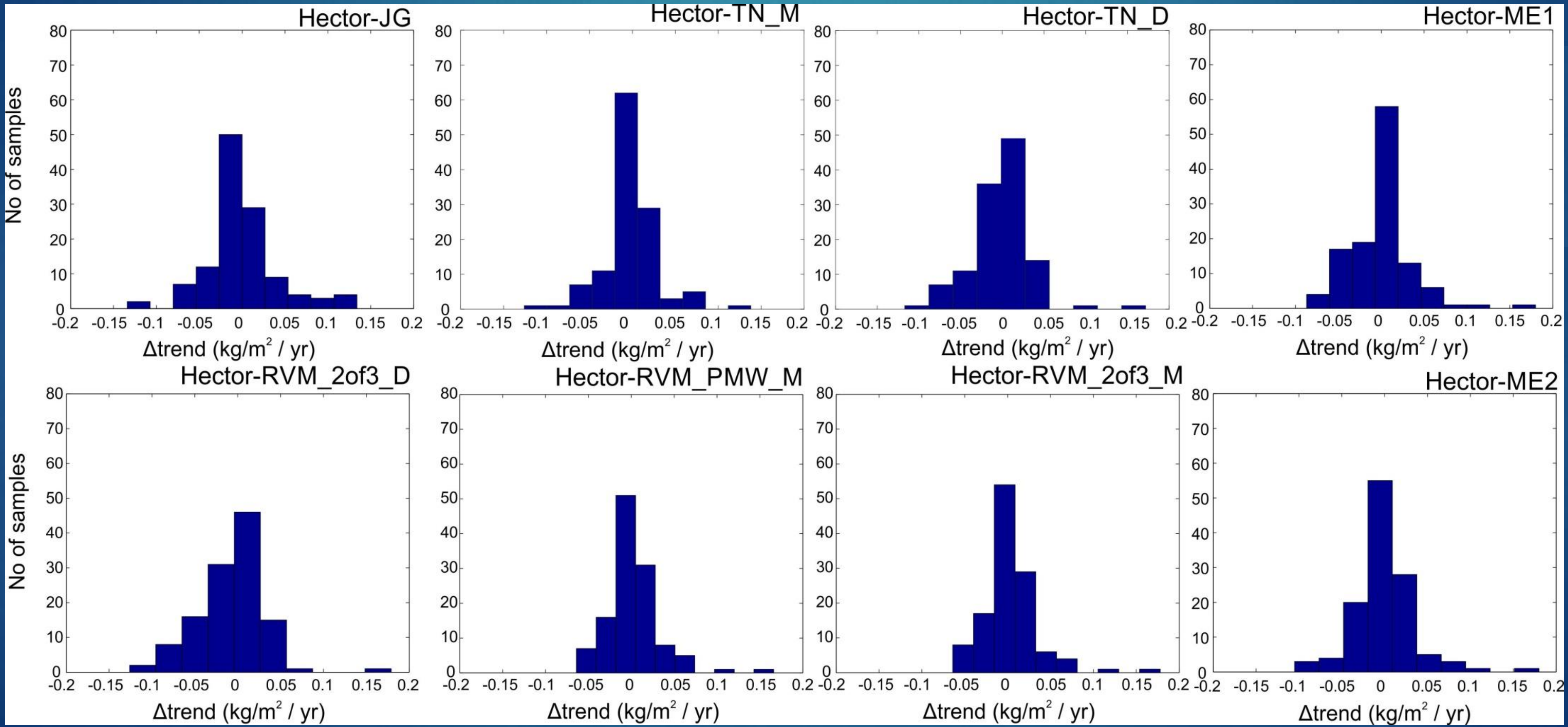




Changes in trends

FULLY COMPLICATED

"Hector " = output from MLE with simulated offsets



Results of the homogenization tools (Synthetic Benchmark)

Future

ACTIVITIES OF THE SUB-WORKING GROUP ON DATA HOMOGENIZATION

***Roeland Van Malderen**, Royal Meteorological Institute of Belgium (RMI) - Solar-Terrestrial Centre of Excellence (STCE)*
***Eric Pottiaux**, Royal Observatory of Belgium (ROB) – Solar-Terrestrial Centre of Excellence (STCE)*

And many others

Royal Observatory of Belgium

Solar-Terrestrial Centre of Excellence

RMI

Assessment Criteria

- In terms of scores:
  - Highest level of True Positive (“Hits”) possible.
  - Lowest level of False Negative (“False Alarms”) possible.
- In terms of estimated offset characteristics:
  - Estimated offset epoch as close as possible to the epoch of true offset.
  - Estimated offset amplitude as close as possible to the amplitude of the true offset.
- In terms of trends and their uncertainties:
  - Introducing the selected offset should improve the trend estimation and lower (if possible) the associated trend uncertainties.

Workplan

- Work on the **assessment** of the tools and provide feedback to the participants.
- The participants who provided their solutions, will receive in the coming weeks the true offsets and amplitudes of the synthetic datasets.
  ➔ **fine-tuning** of the tools by the different participants.
- A **next generation** of a fully complicated **synthetic dataset** will be available in May:
  - Fully complicated II ?
  - Gaps decoupled from trends?
  - Based on the difference of the synthetic IGS repro 1 minus the real ERA-interim?
- A second round of **blind homogenization** on this next generation dataset(s) will end in September.
- Application of the good performing tools on the **IGS repro 1**.

Workplan

- Define **a common strategy** to correct the IGS repro 1. Which criteria should be used then? Examples:
  - Break points should be detected by a minimum number of techniques.
  - Break points should be present in the metadata logfiles.
  - The amplitude of the offset should be above a certain limit.
  - Break points should be detected in other IWV difference series (e.g. IGS – NCEPNCAR).
  - …
- **Validate** the community corrected IGS repro 1 with other datasets:
  - Radiosondes.
  - ERA-interim/NCEPNCAR.
  - Climate models (regional and global).
  - Satellite datasets.
  - VLBI/DORIS.
  - Ground-based networks (AERONET, MWR, …).

Workplan & outreach

- **Validate** the community corrected IGS repro 1 with alternative corrections of the IGS repro 1 dataset (manual correction based on log files, combining statistical homogenization & metadata information).
- A **third homogenization workshop** will be organized at the end of this year (Brussels? Other candidates?)
- The homogenization activity will be **presented at workshops/conferences** related to GNSS and homogenization.
- The outcome of this activity will be published as a **series of papers** in the GNSS4SWEC Special Issue (submission deadline: 31 May 2018).
- You still want to participate? Contact us! roeland@meteo.be, eric.pottiaux@oma.be

Long-term Perspectives

- Some of the data homogenization activities will not be finished by the end of the COST Action, especially those related to a second reference dataset (EPN repro 2).

- BUT… there will a possibility to continue this work within the IAG JWG 4.3.8:
  "GNSS tropospheric products for Climate"! (chaired by R. Pacione and E. Pottiaux)

- Refinement of the metadata format and exchange within this IAG JWG.

http://iag-gnssclimate.oma.be/index.php