Performance of various homogenization tools on a synthetic benchmark dataset of GPS and ERA-interim IWV differences

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Motivation & Introduction:

1. COST action **GNSS4SWEC** „Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate", WG3: Use of GNSS tropospheric products for climate monitoring.
2. A **proper homogenization** of tropospheric dataset is indispensable, as the parameters of deterministic part, e.g. **trend** will be influenced by undetected breaks.
3. Different groups / different methods / different estimates – **the truth is not known**.
4. A synthetic benchmark dataset: a way to quantify results given by various algorithms.

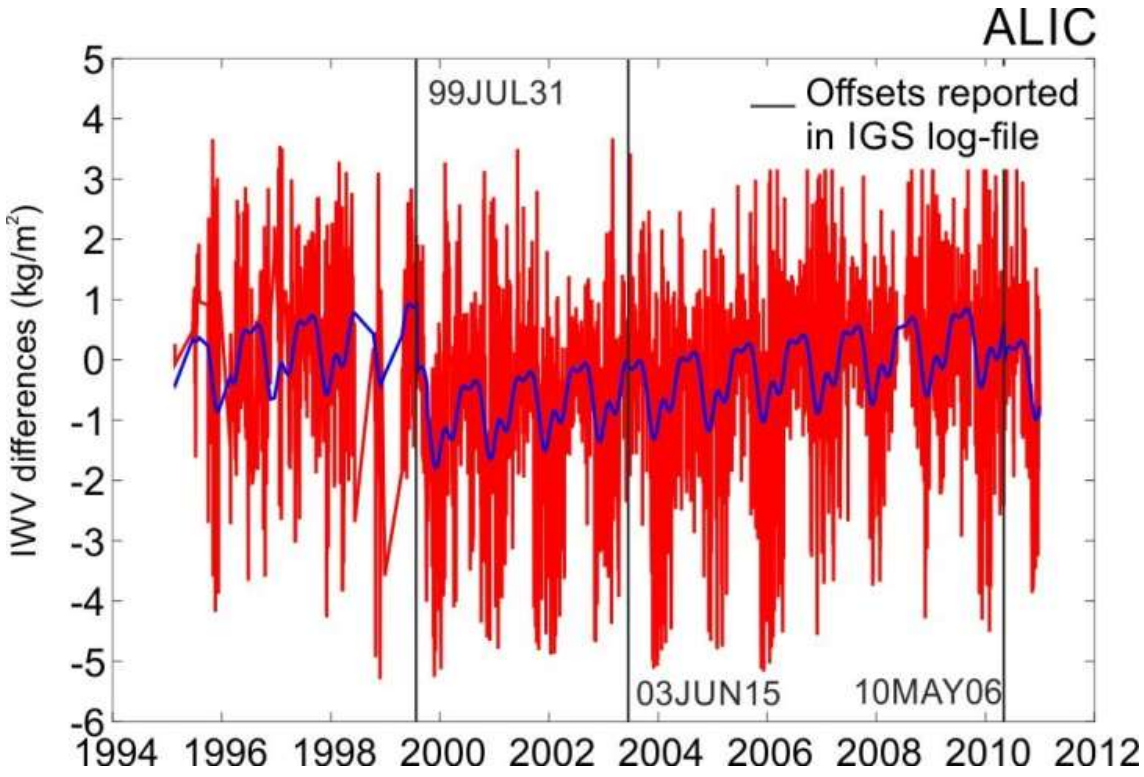
Motivation & Introduction:

How does it look in practice?

A change in trend possible and **very likely**!

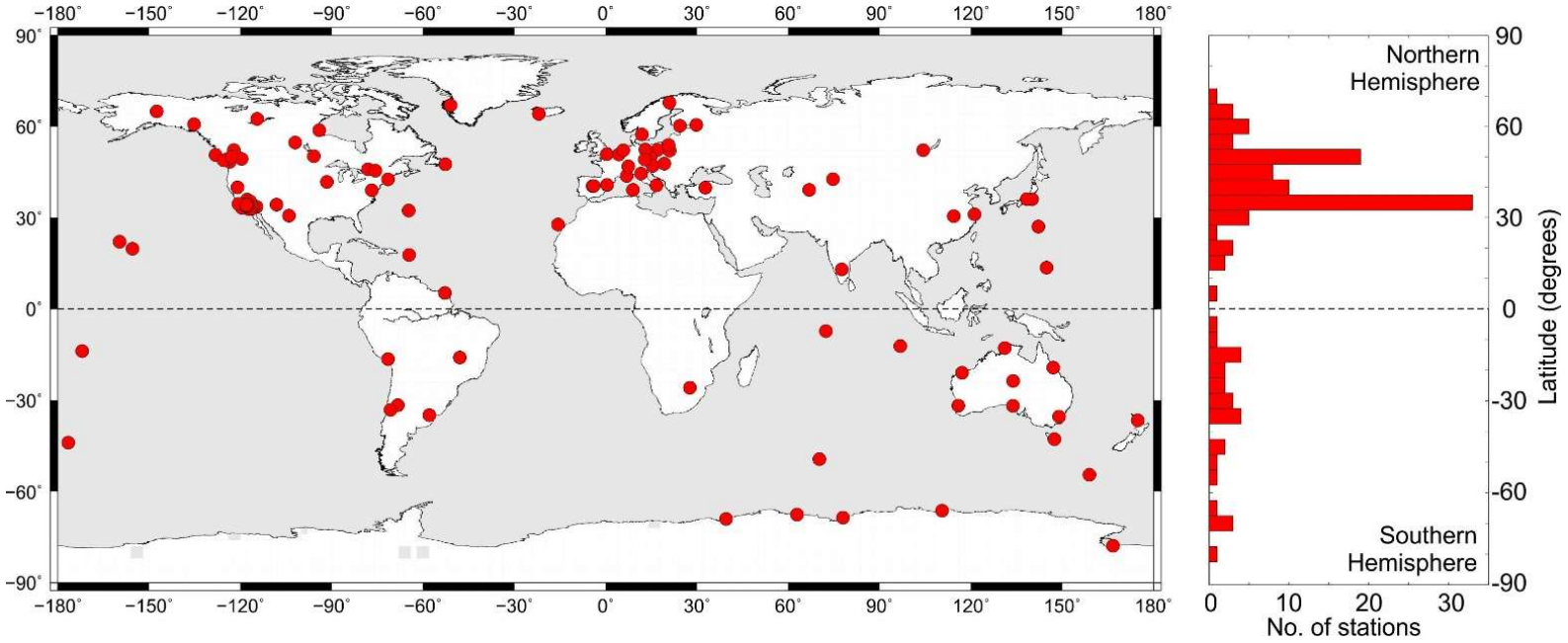
Can anyone see more offsets?

What we aim at?
Only real breakpoints not regime-like shifts should be corrected!



Data:

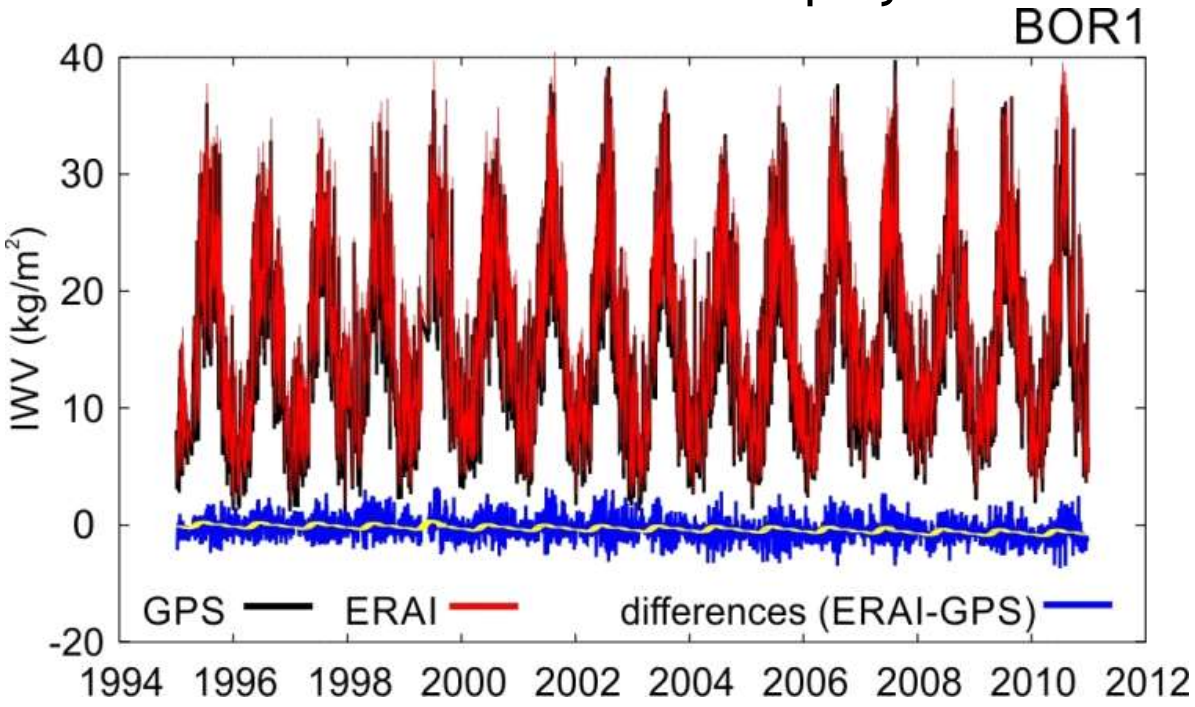
1. IGS „repro1” troposphere products screened and converted to Integrated Water Vapor (IWV) by O. Bock.
2. 120 stations, daily observations, a period of 1995-2010.



Dataset available at: https://doi.org/10.14768/06337394-73a9-407c-9997-0e380dac5590.

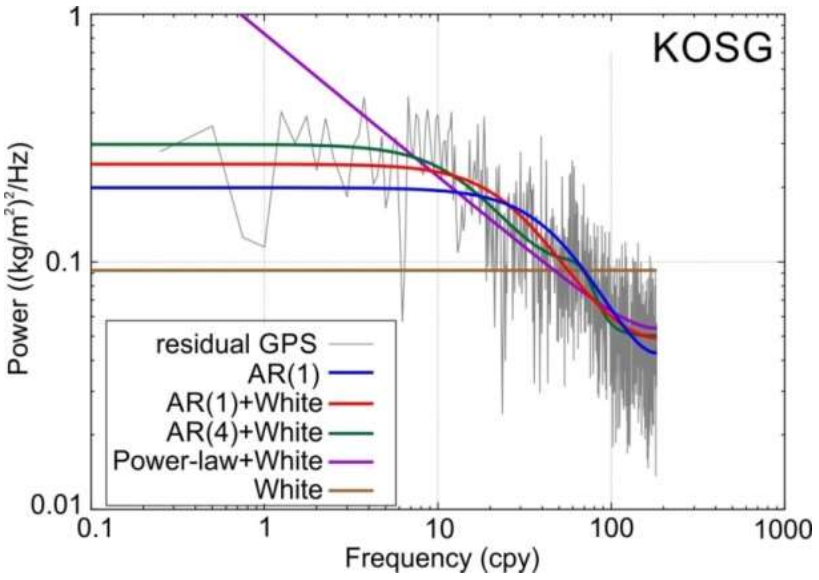
Data:

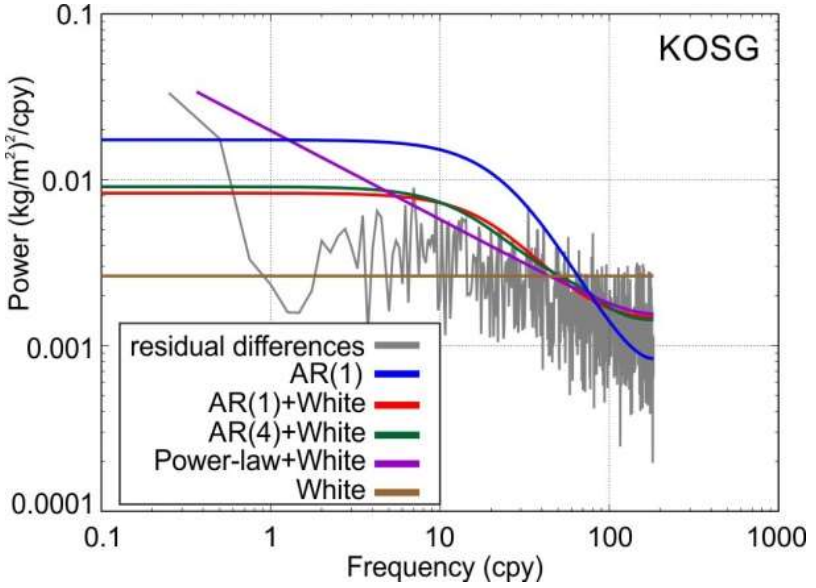
1. IGS „repro1” troposphere products screened and converted to Integrated Water Vapor (IWV) by O. Bock.
2. 120 stations, daily observations, a period of 1995-2010.
3. The IWV differences: ERAI-GPS were employed.



Real data analysis:

1. Manual homogenization + IGS log files: **221 epochs**.
2. Analysis of significant frequencies: **Power Spectral Densities.**
3. **Maximum Likelihood Estimation** (MLE) employed.
4. Noise analysis: **AR(1)+WN** chosen as the preferred noise model.

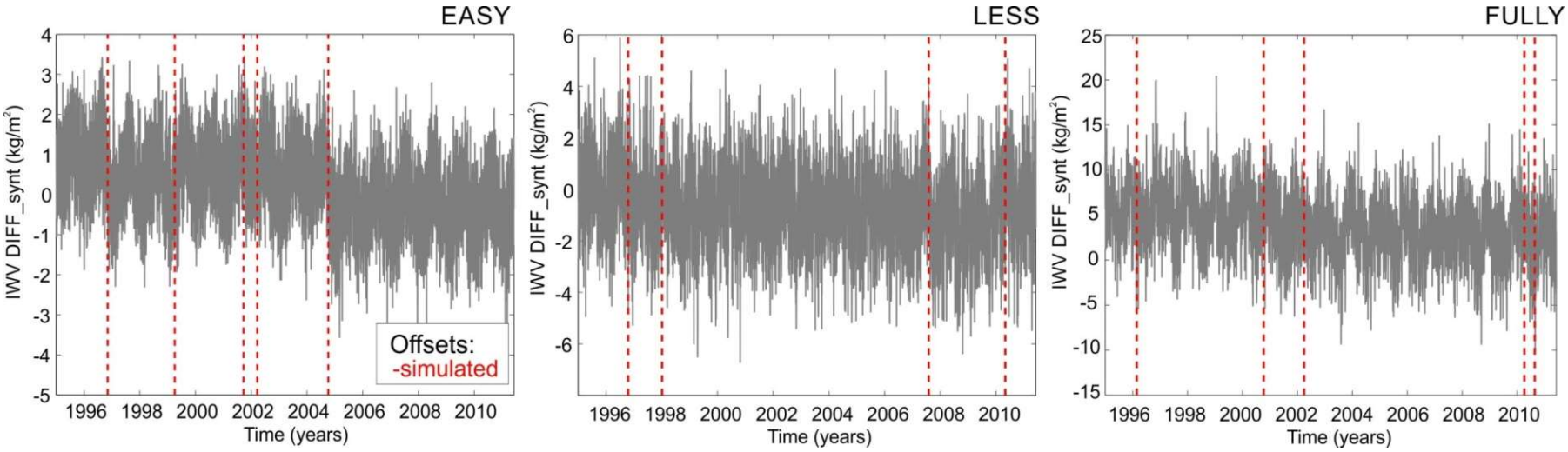




Generation of the benchmark:

3 variants of synthetic time series were generated:

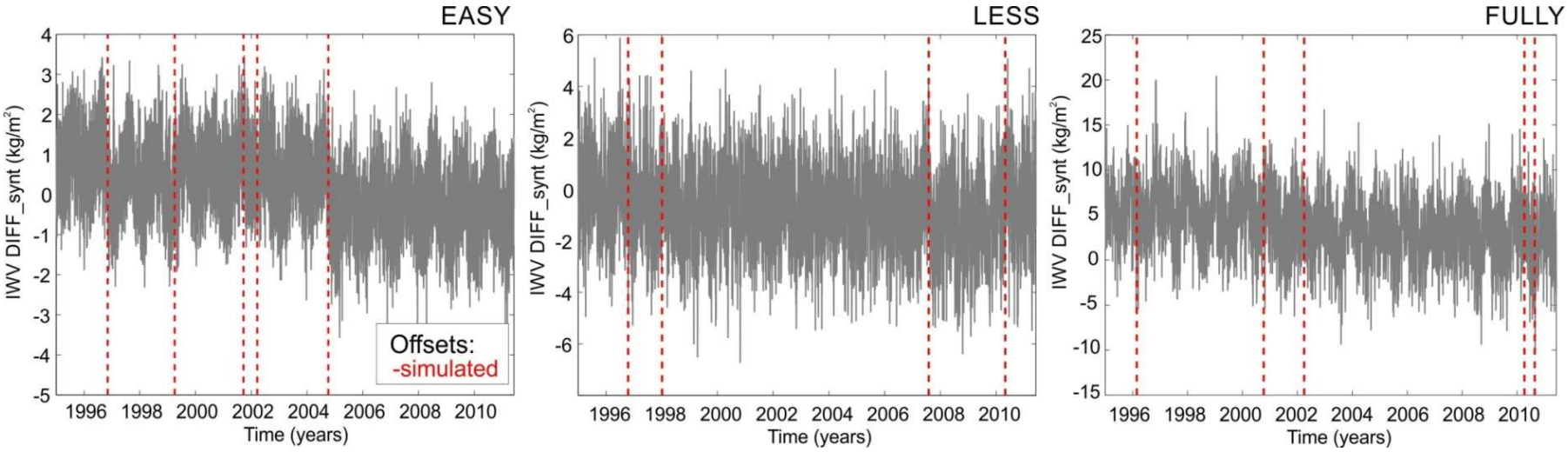
1. **EASY** dataset: seasonal signals + offsets + white noise (WN),
2. **LESS COMPLICATED** dataset: same as 1. + autoregressive process of the first order (noise model = AR(1)+WN),
3. **FULLY COMPLICATED** dataset: same as 2. + trend + gaps (up to 20% of missing data).



Generation of the benchmark:

1. **120 series in each synthetic dataset** simulated.
2. Deterministic model of data taken directly from real differences: trend, seasonal signals, noise.
3. Offsets simulated **randomly**.
4. Number of offsets and exact epochs are **blinded**.

Can anyone see more offsets?

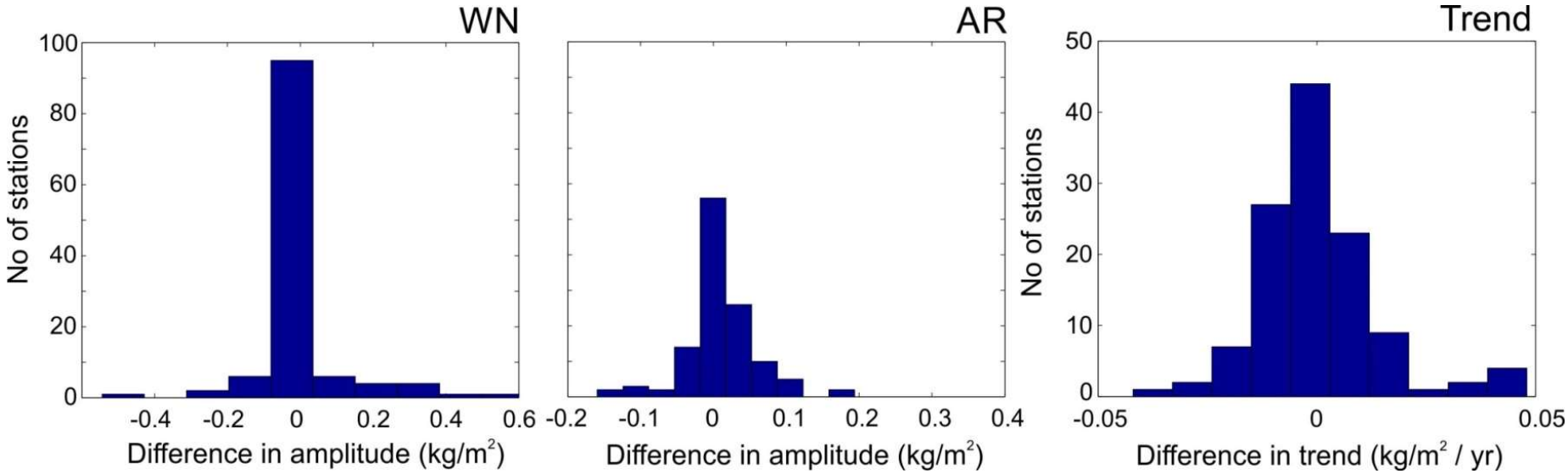


Verfication of the benchmark:

FULLY-COMPLICATED

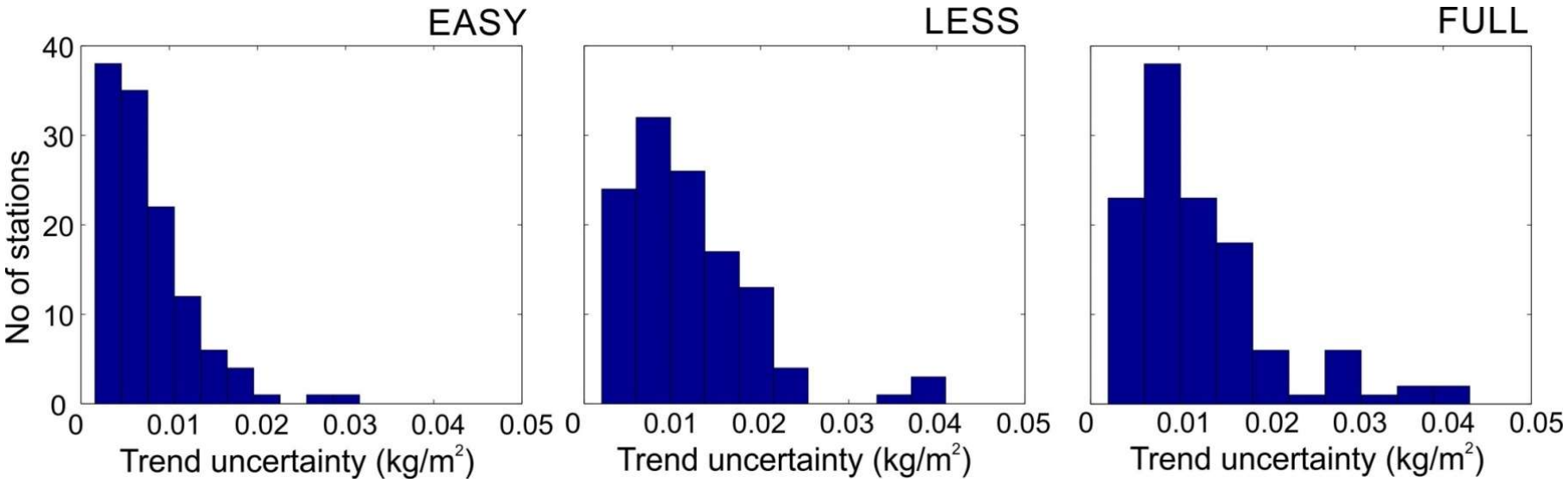
Coefficients of AR agree within 0.05.

Amplitudes & trends agree with – see histograms.



Expected trend uncertainty:

Preliminary estimation of which trend uncertainty can be expected from real differences, based on synthetic differences.



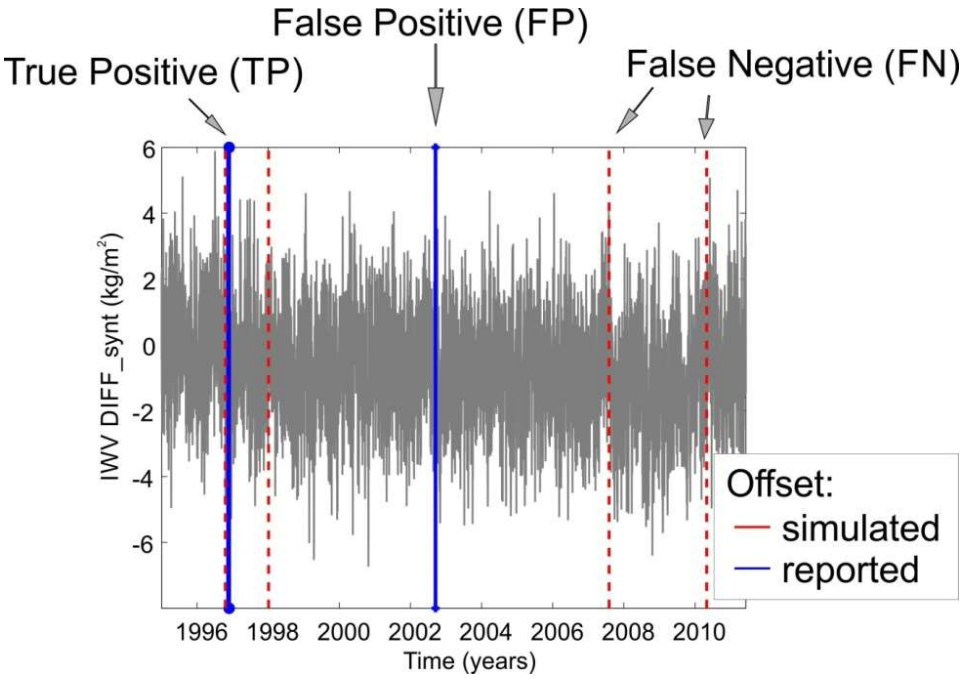
Algorithms:

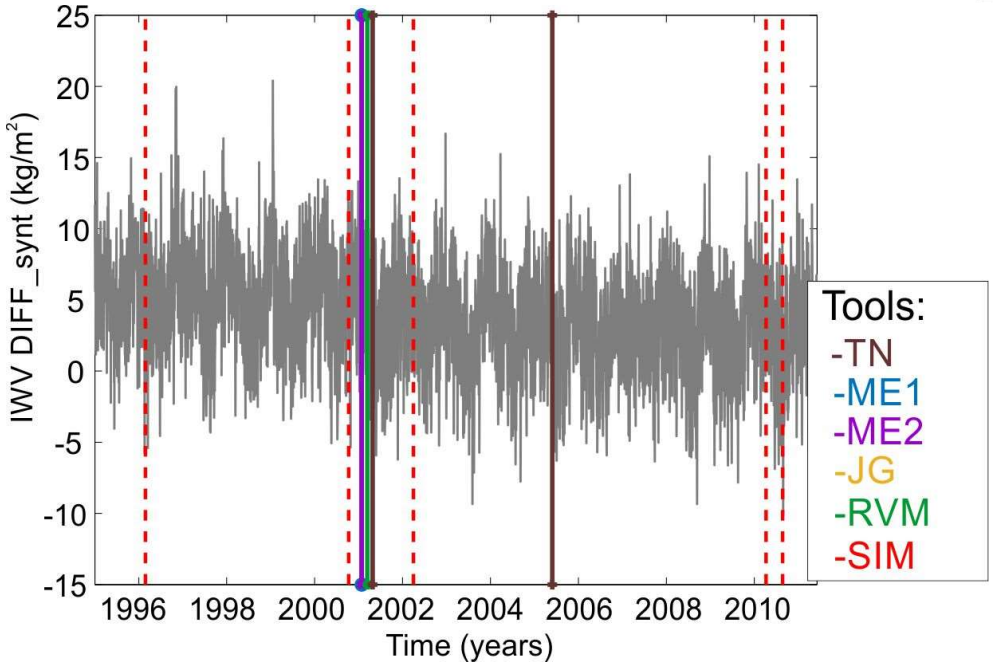
1. Sensitivity analysis: the identification of the **epochs** of the inserted breakpoints.
2. Estimates of the **trends** of the 3 sets of synthetic IWV differences.

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7
Symbol	● ⬭	▲	+	×	◆	▼	-
Operator	M. Elias	R. Van Malderen	R. Van Malderen	J. Guijarro	T. Ning	S. Zengin	B.Chimani
Method / SW	2-sample t-test	2 of 3 (non-parametric tests)	PMW	CLIMATOL	PMTred	Pettitt test	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

How to classify breaks?

Defining a proper time window – **2 months**





Offsets:

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7
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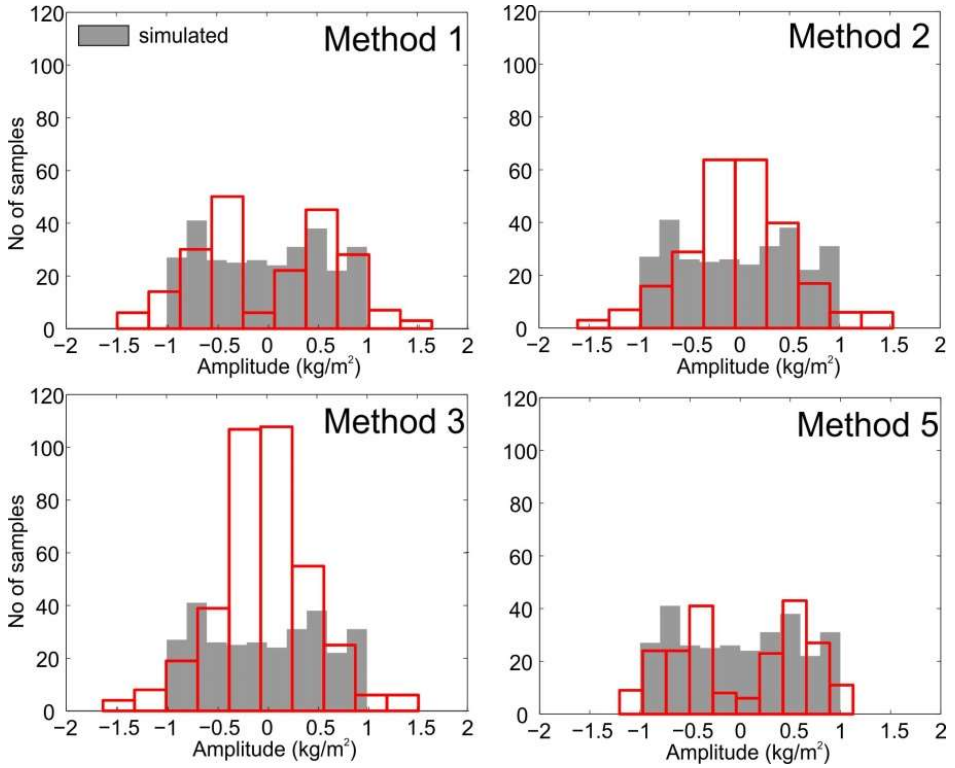
Daily/Monthly	D+M	D+M	D+M	D+M	D+M	D	X
Easy/Less/Full	E+L+F	E+L+F	E+L+F	L+F	E+L+F	E+L+F	E+F

Amplitudes of reported offsets:

EASY, DAILY (SIM: 291):

- method 1: 211,
- method 2: 252,
- method 3: 377,
- method 5: 216.



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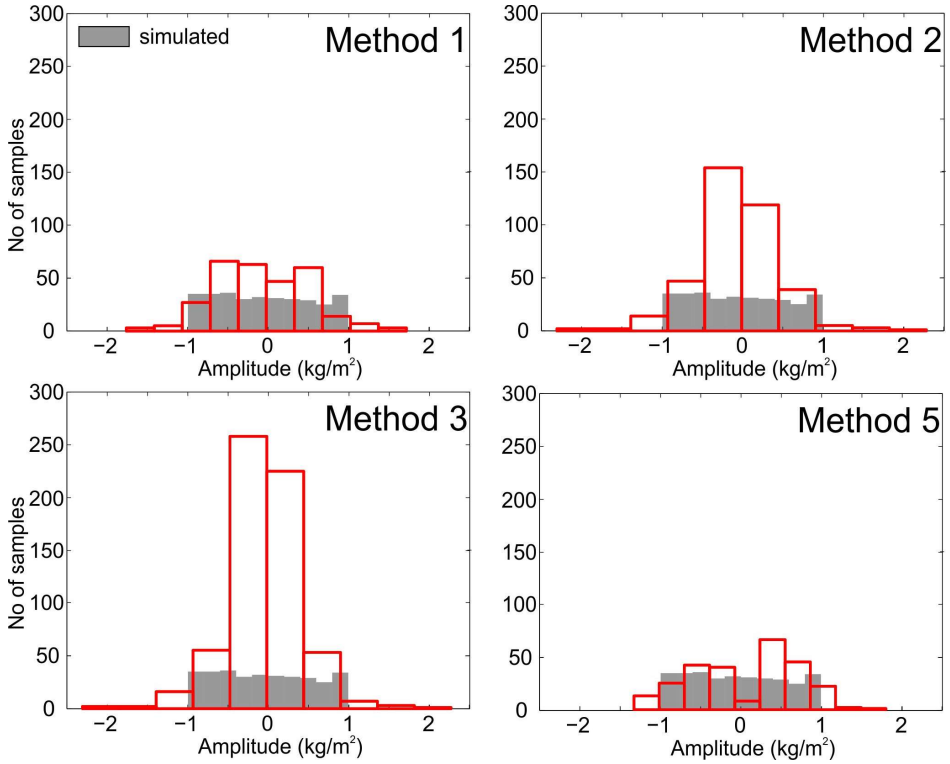
Easy/Less/Full	E+L+F	E+L+F	E+L+F	L+F	E+L+F	E+L+F	E+F

Amplitudes of reported offsets:

FULLY-COMPLICATED, DAILY (SIM: 317):

- method 1: 295,
- method 2: 386,
- method 3: 622,
- method 5: 264.



Tools perfor-mance:

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7
Symbol	● ⬭	▲	+	×	◆	▼	-
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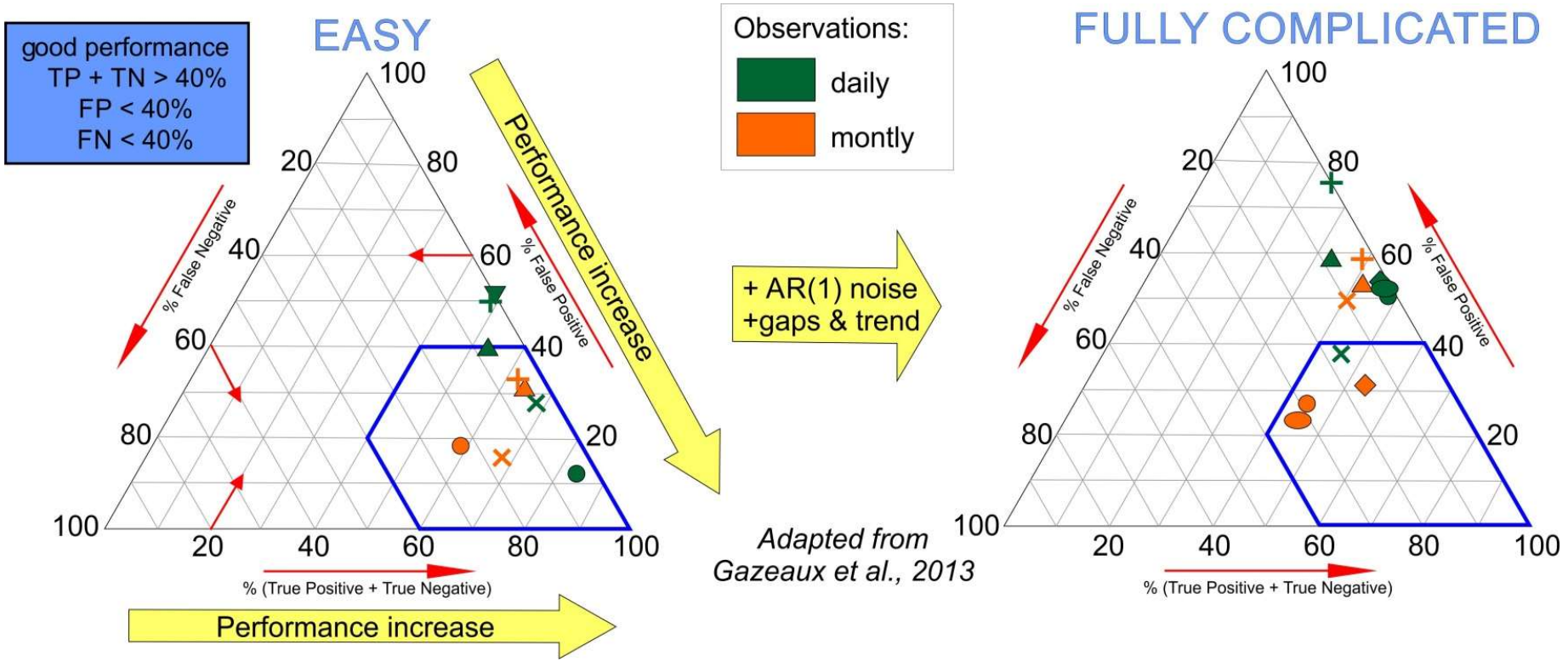
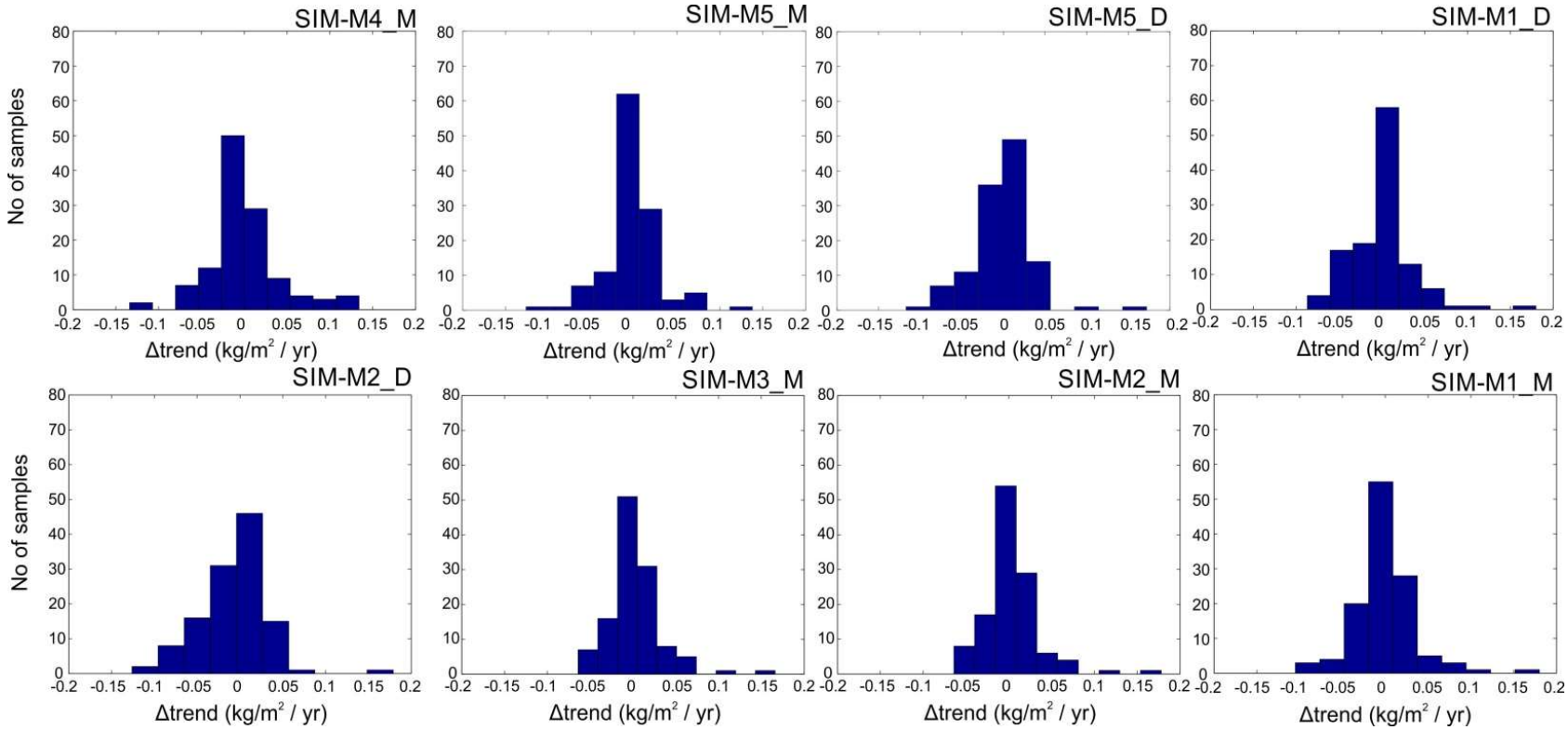


Trends:

	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7
Symbol	● ⬭	▲	+	×	◆	▼	-
Operator	M. Elias	R. Van Malderen	R. Van Malderen	J. Guijarro	T. Ning	S. Zengin	B.Chimani
Method / SW	2-sample t-test	2 of 3 (non-parametric tests)	PMW	CLIMATOL	PMTred	Pettitt test	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



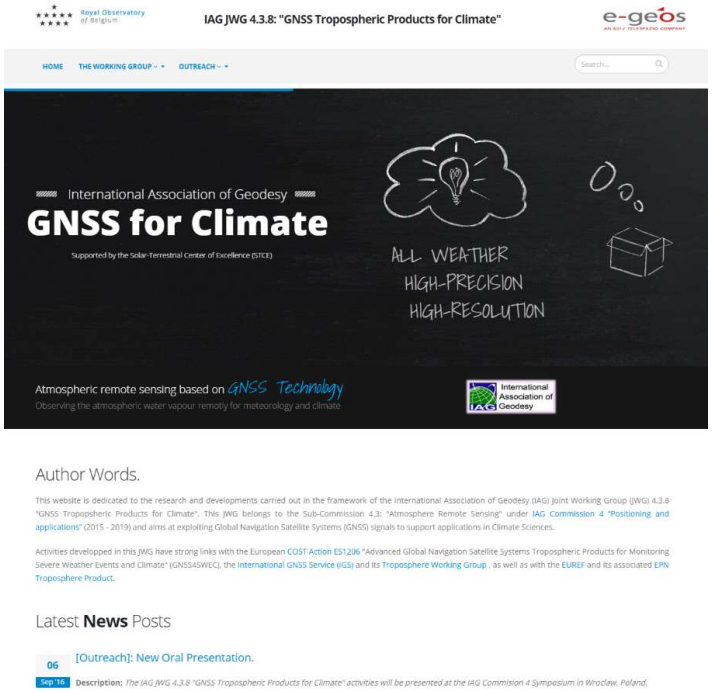
What's next?

1. A detailed assessment of tools – their sensitivity.
2. Now – epochs were given to the participants to fine-tune their methods.
3. Still looking for other contributions. Interested? Contact Roeland: roeland@meteo.be, Eric: eric.pottiaux@observatoire.be or me: anna.klos@wat.edu.pl
4. A next generation of synthetic benchmark is ongoing.
5. New results of blind homogenization by the September/October.
6. Next homogenization workshop following two previous ones in Brussels (in 2016) and Warsaw (in 2017). If interested in partcipating – please, contact us ☺

And then…

1. The best performing tools are going to be employed to homogenize the IGS repro1.
2. A need to define the reliable strategy for homogenization.

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



Acknowledgments

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The map was drawn in the Generic Mapping Tool (Wessel et al., 2013).

Thank you!