# A homogenization of GNSS tropospheric data with autoregressive process

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1. Homogenisation – offsets detection and subtraction.
2. Offsets in GNSS arise from:
    1. Hardware change,
    2. Earthquake,
    3. Unknown reason.

These can be also seen in IWV series retrieved from GNSS.

Hardware changes are reported in log-files, however some may be **unreported.**

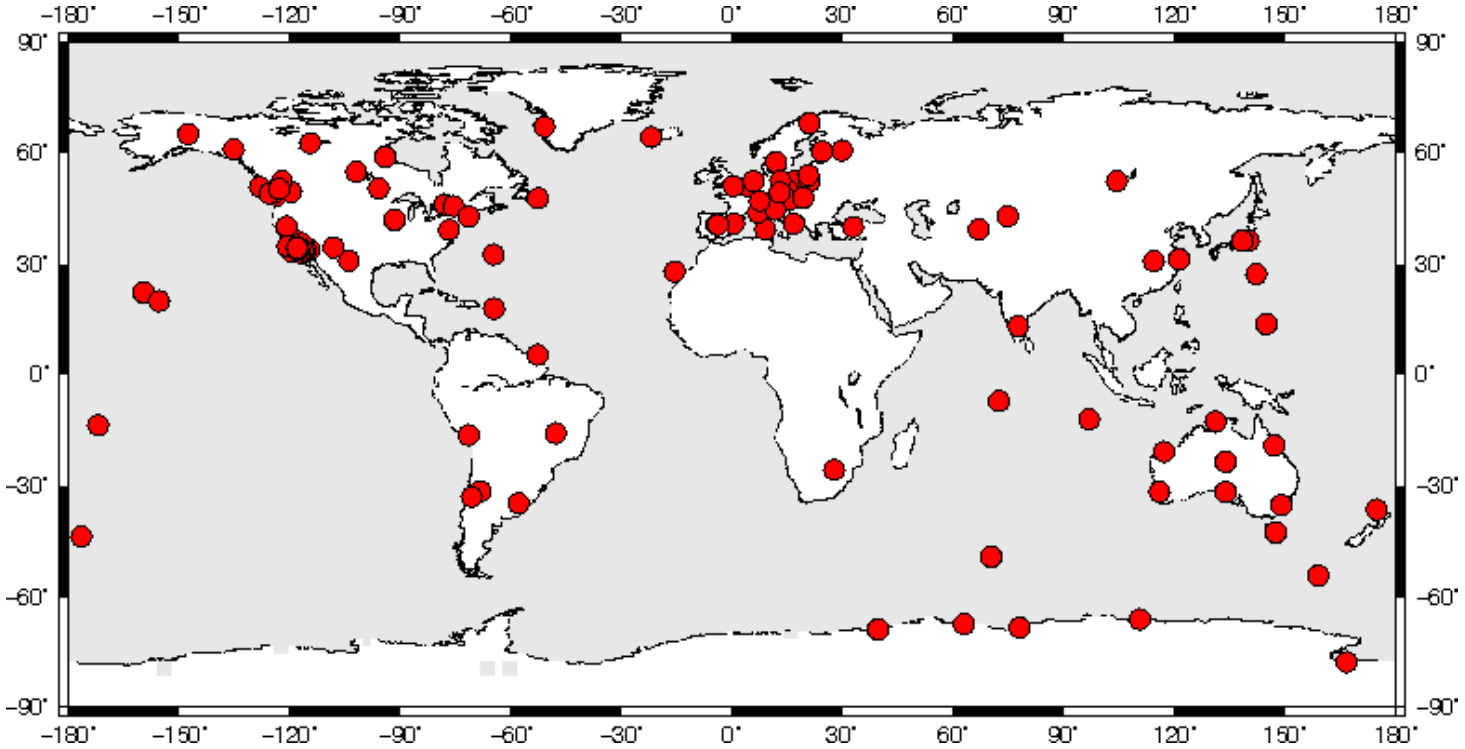
Relative homogenisation methods are most effective to detect offsets in time series.

Here we use IWV differences (**GPS - ERA-Interim reanalysis)**.

## 3. What is the plan?

1. Analyse the common data set provided for homogenisation sub-WG3 working group,
2. Use the amplitudes of seasonal changes, values of trend and character of stochastic part to create a benchmark (simulation of a synthetic dataset): GPS, ERAI and GPS-ERAI
3. Simulate offsets,
4. Perform blind tests to detect simulated changes manually and with different statistical approaches,
5. Decide on the optimum method to report real offsets (not ones related to autoregressive behaviour of data),
6. Use this method to IWV retrieved from GNSS data.

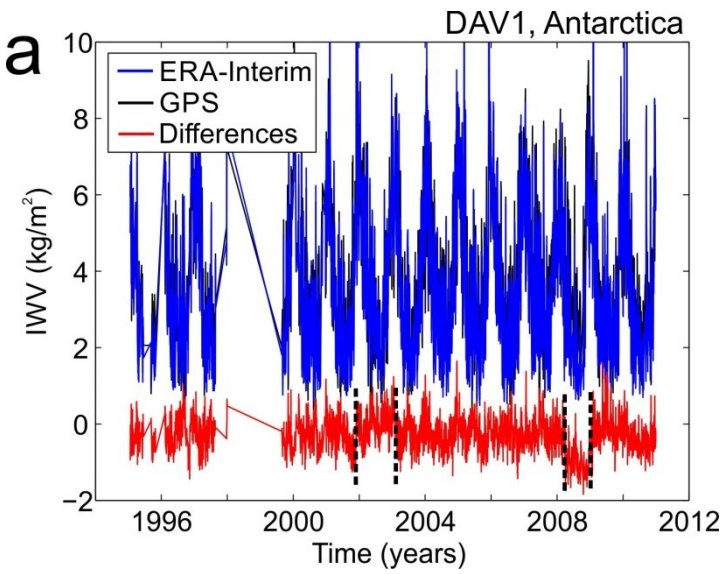
A **common dataset** provided for homogenisation group (sub-WG3 group).

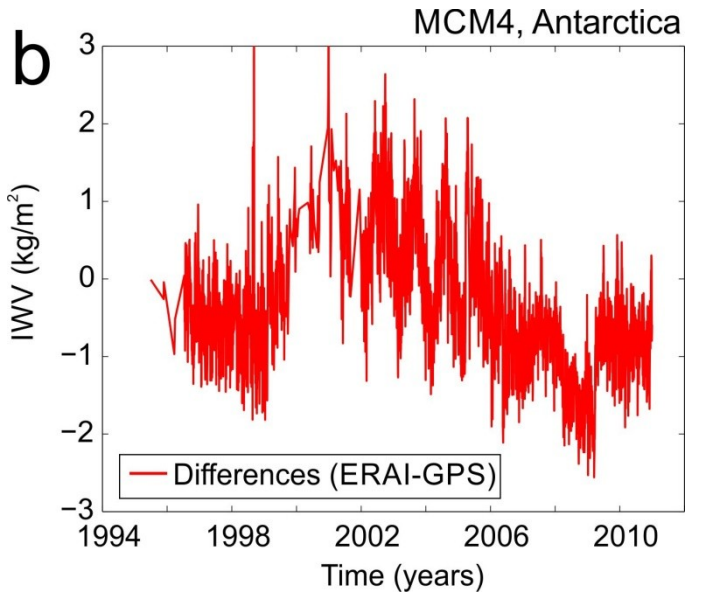



**Daily differences of IWV** from **GPS** and **ERA-Interim** for period 01.01.1995-31.12.2010 for 120 stations.

**Homogenisation** of common dataset:

1. 600 offsets reported in log-files of GNSS stations (common data set),
2. 41 offsets reported manually in differences of IWV (ERAI-GPS) (a),
3. Few stations included in a special class: cases where visual detection of offsets is not reliable (GOPE: Czech Republic, KOUR: French Guiana, LONG: USA and MCM4: Antarctica) (b).



A **homogenized common data set** provided for homogenisation group (sub-WG3 group):

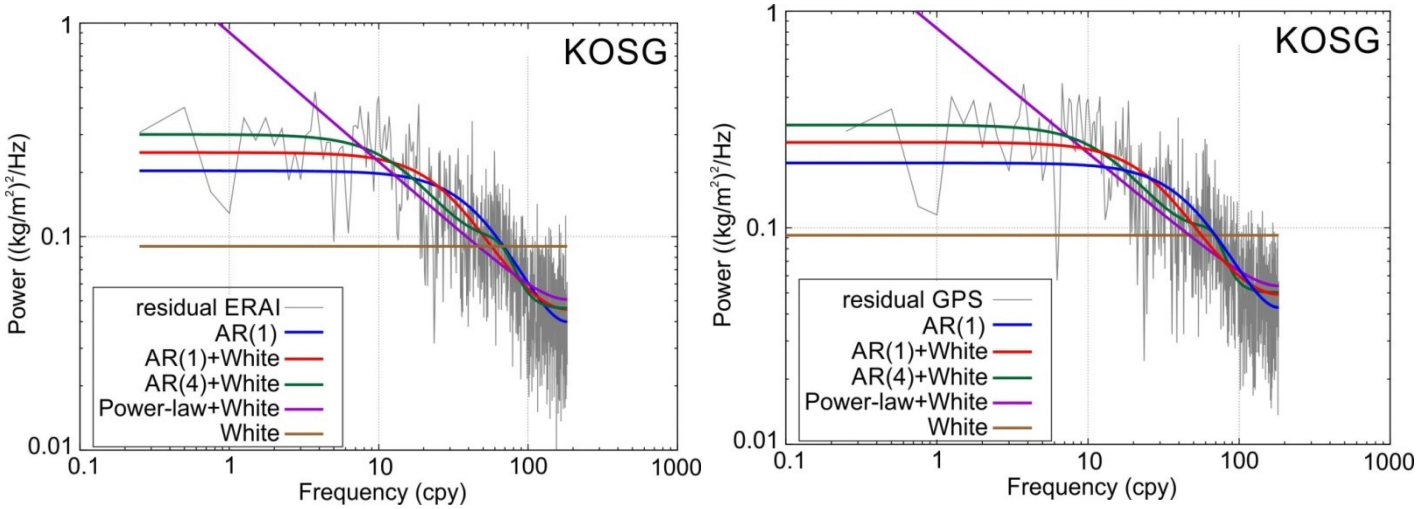
1. We fitted a least-squares model as:

$$ZTD(t_i) = a + b \cdot (t_i - t_0) + c \cdot \sin(2\pi \cdot (t_i - t_0)) + d \cdot \cos(2\pi \cdot (t_i - t_0)) + \varepsilon_{ZTD_i}$$

and removed trend and annual curve to examine on stochastic part character $\varepsilon_{ZTD}$.

A **homogenized common data set** provided for homogenisation group (sub-WG3 group):

2. We analysed on a character of stochastic part:




3. Autoregressive of first order plus white noise (AR(1)+WN) chosen as a most appropriate for daily IWV data, basing on AIC criterion plus time of computation:

AR(1)+WN:

$$\varepsilon_{ZTD_t} = \varphi_1 \varepsilon_{ZTD_{t-1}} + a_t$$

AR(4)+WN:

$$\varepsilon_{ZTD_t} = \varphi_1 \varepsilon_{ZTD_{t-1}} + \varphi_2 \varepsilon_{ZTD_{t-2}} + \varphi_3 \varepsilon_{ZTD_{t-3}} + \varphi_4 \varepsilon_{ZTD_{t-4}} + a_t$$

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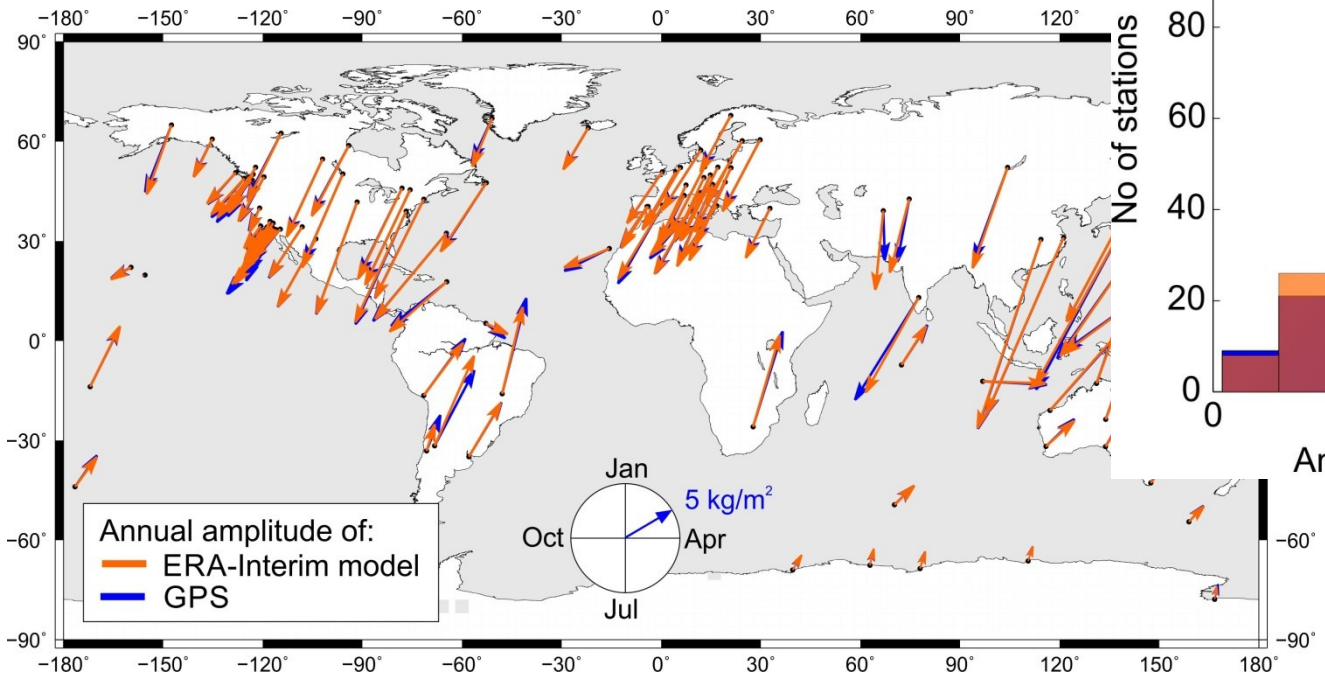
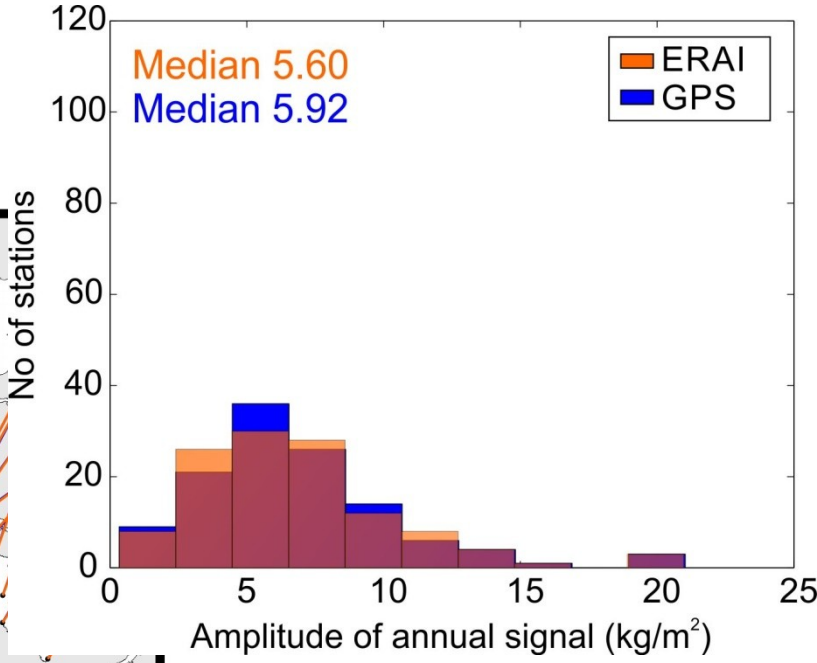
A **homogenized common data set** provided for homogenisation group (sub-WG3 group):

4. We examined on amplitudes of seasonal changes, values of trend and AR(1)+WN with Maximum Likelihood Estimation (MLE) in Hector Software (Bos et al., 2013).



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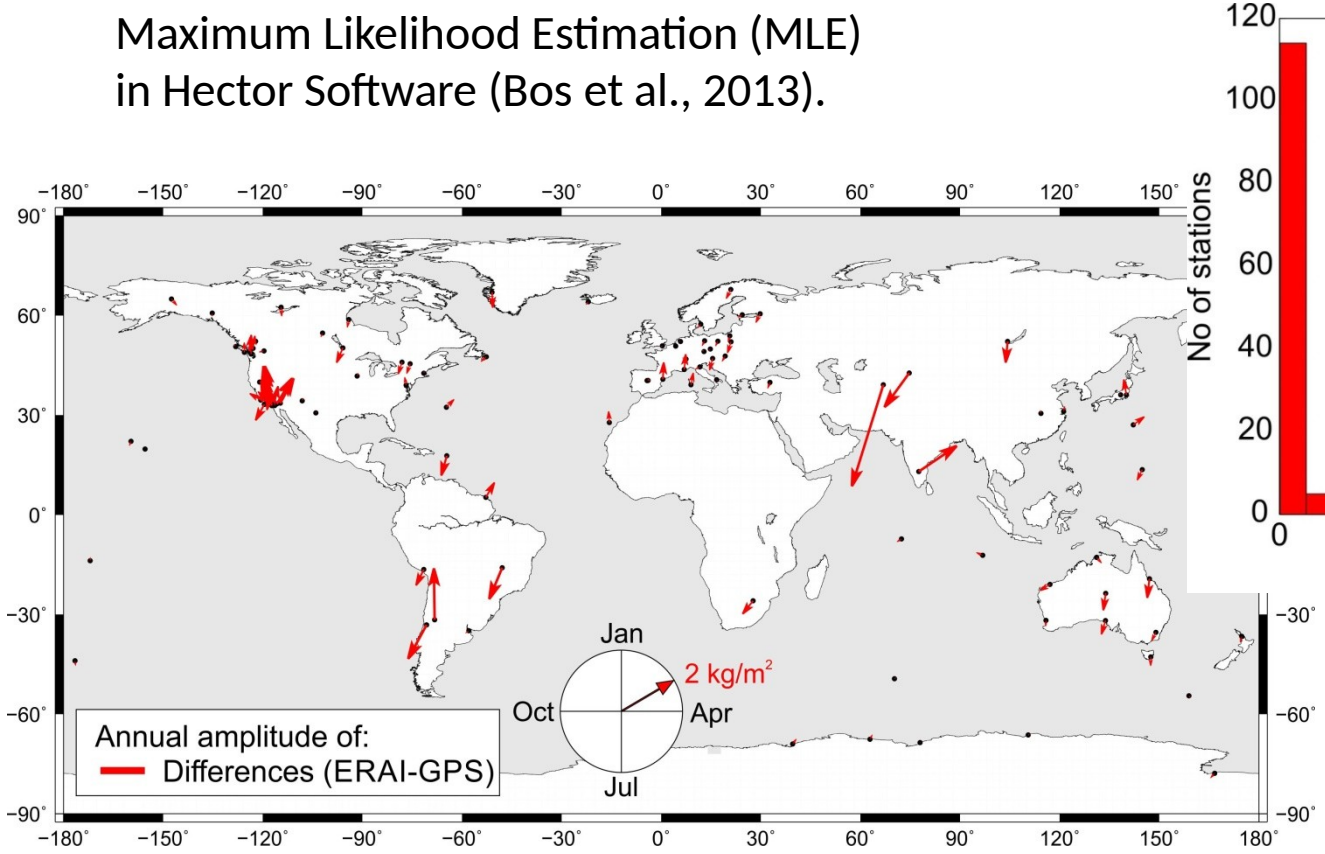


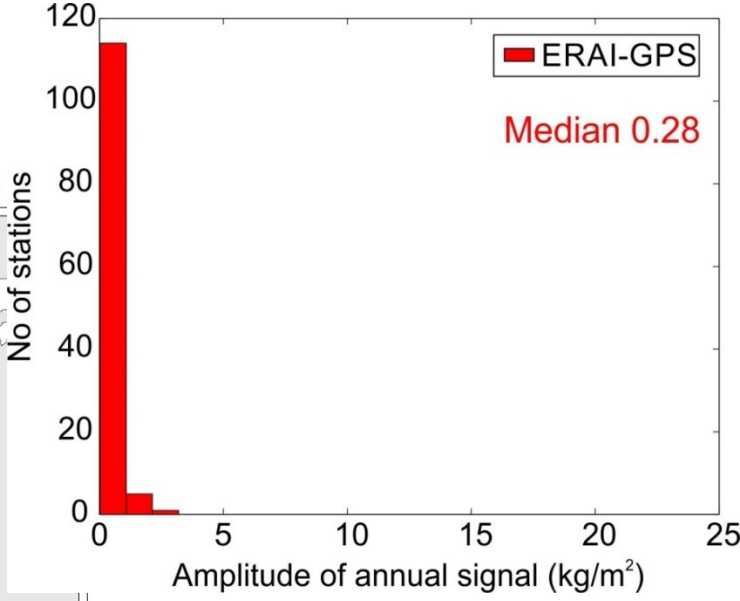

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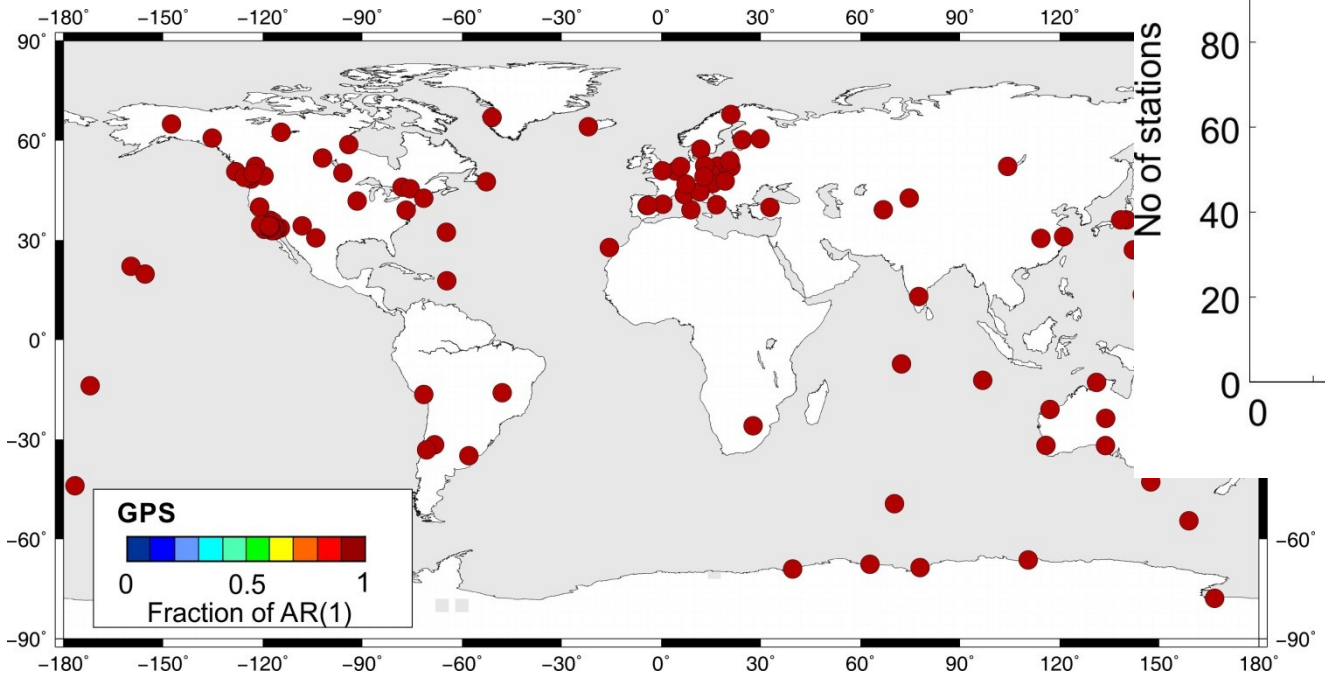


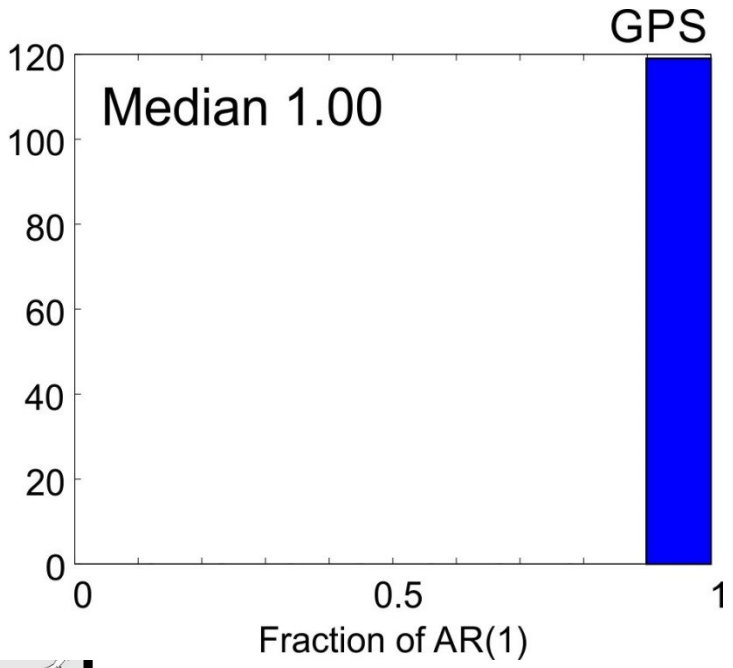

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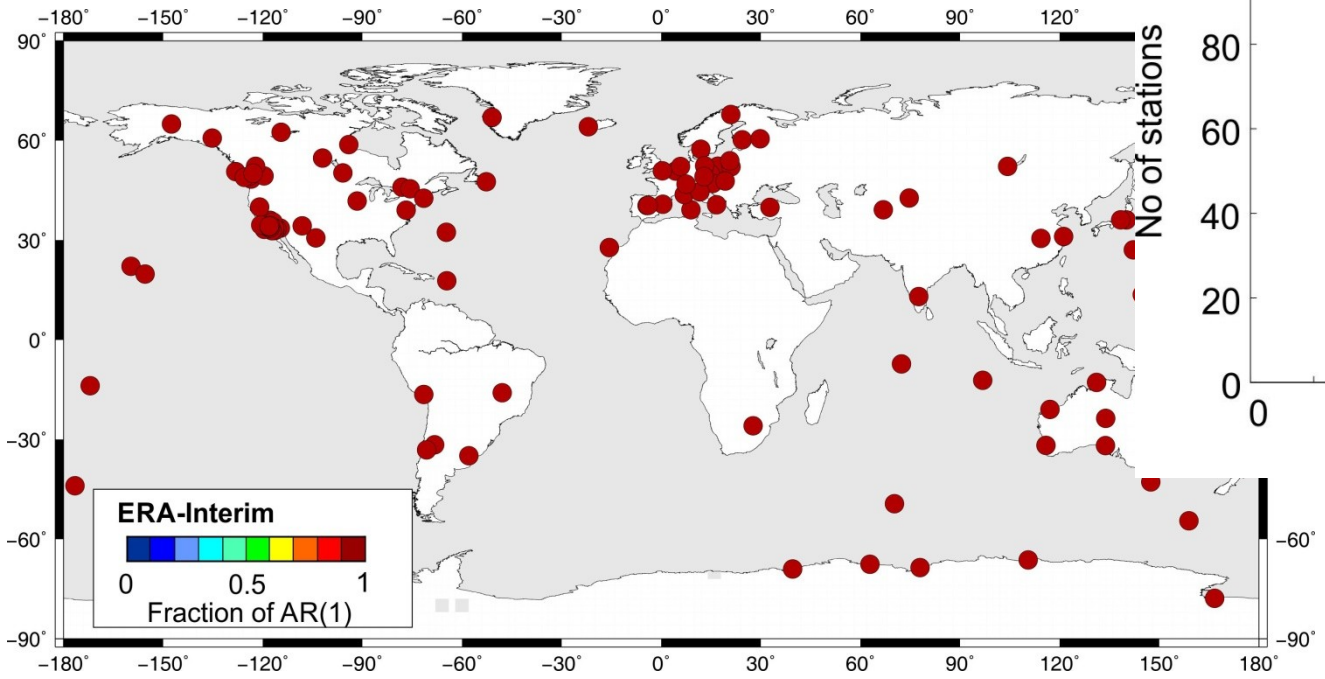


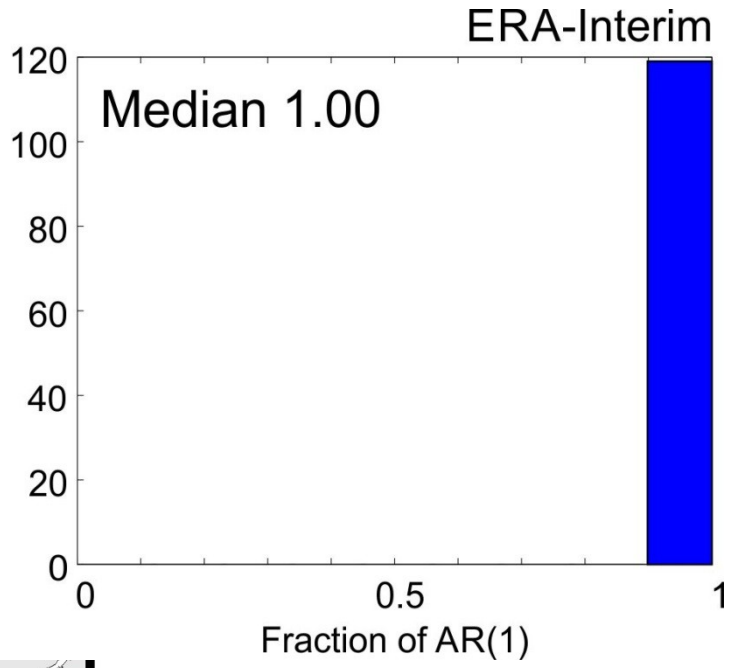

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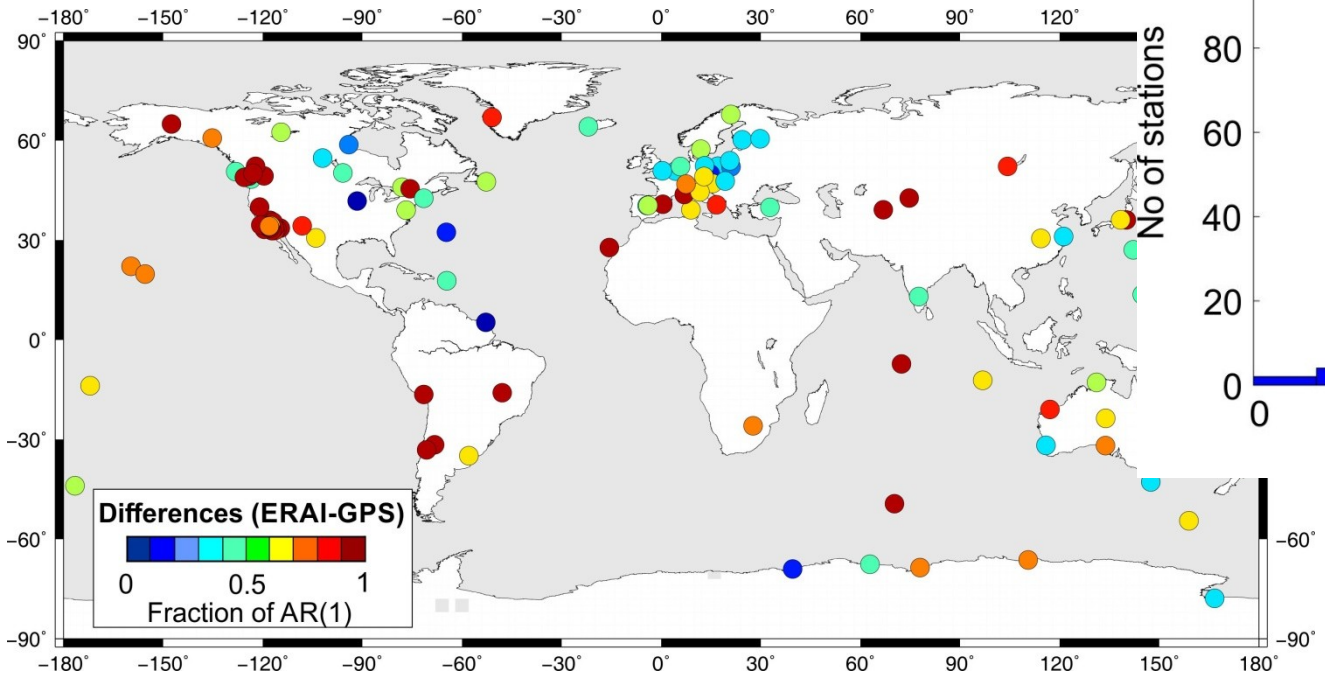


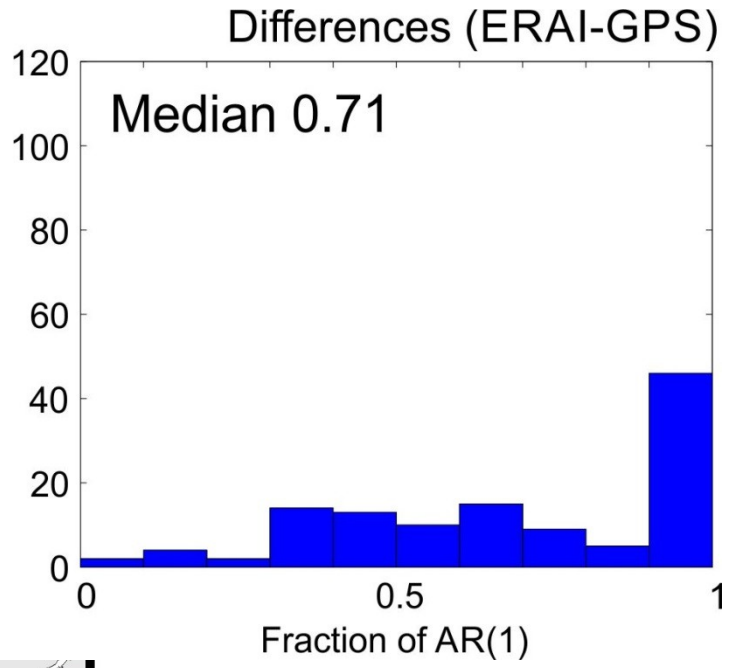

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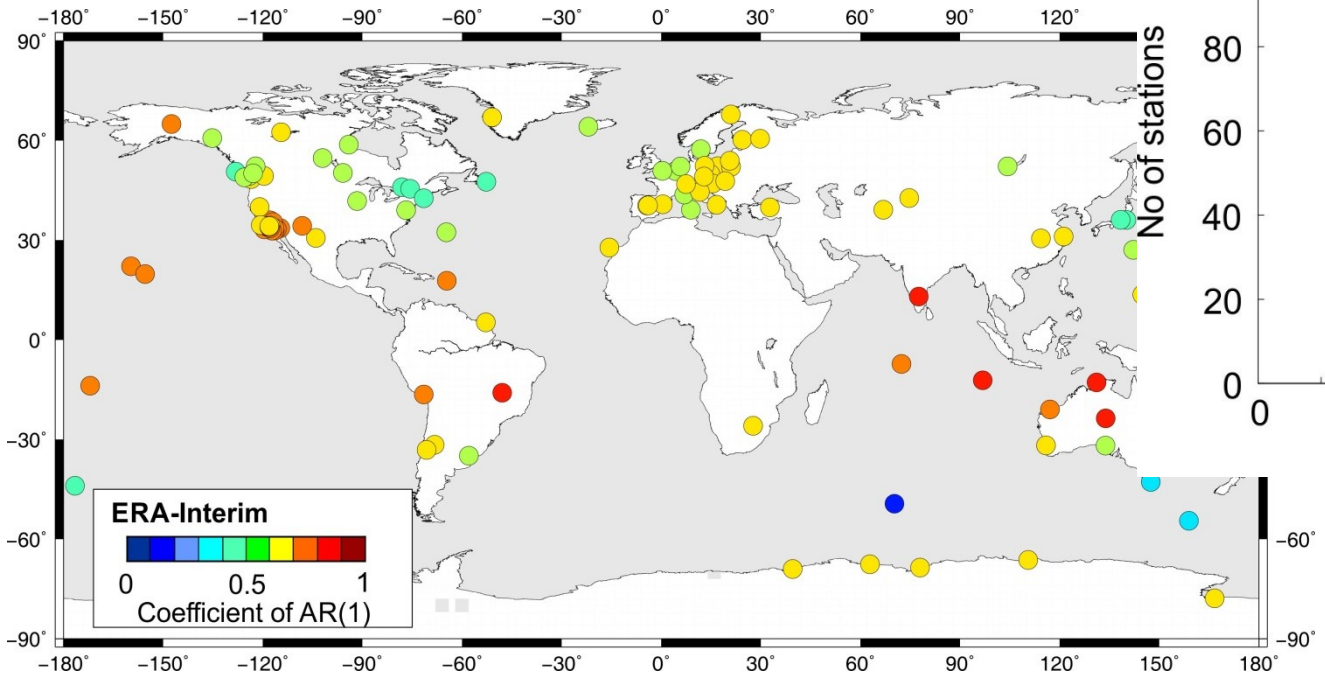


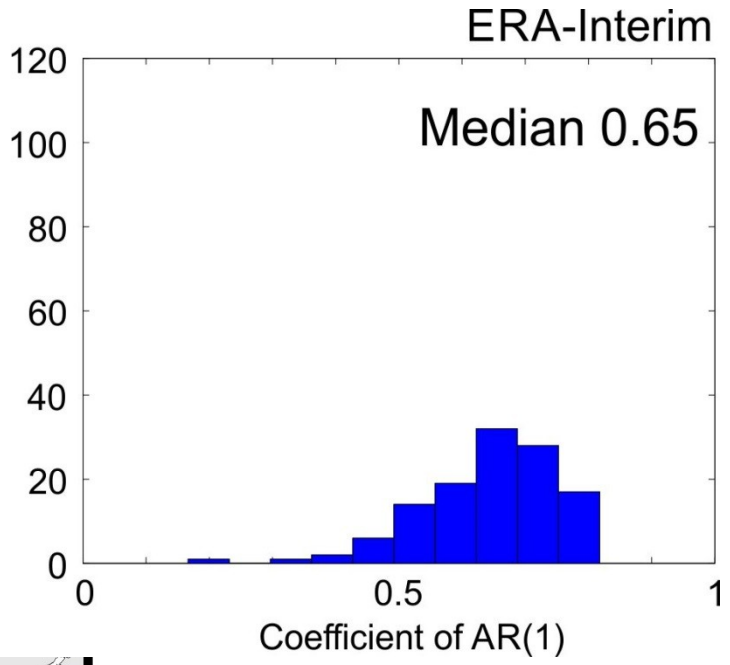

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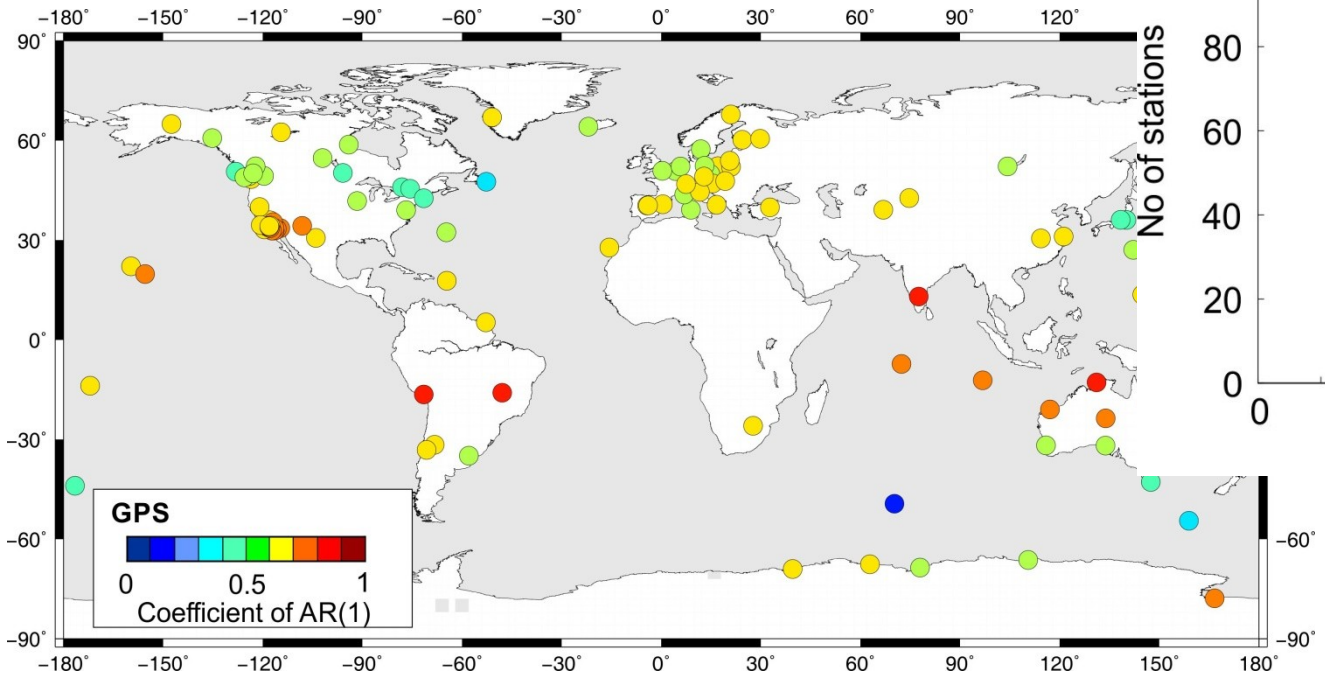


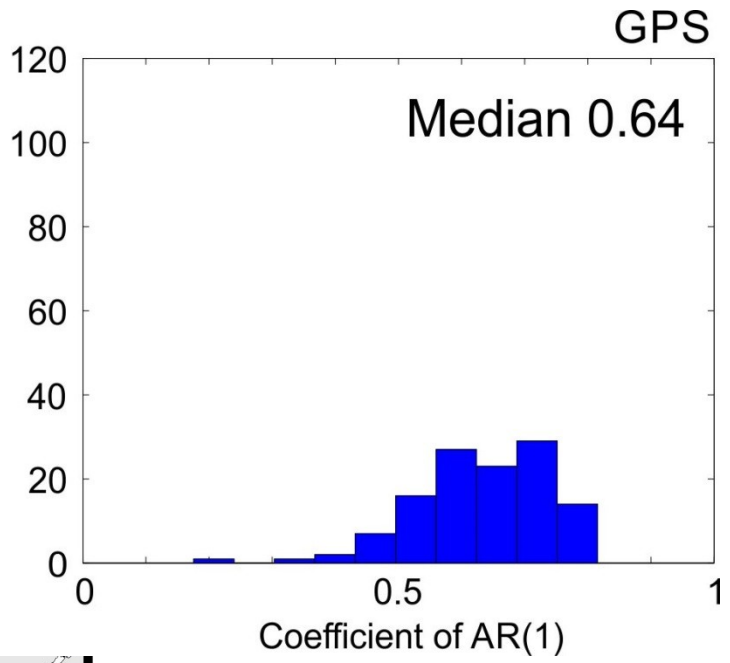

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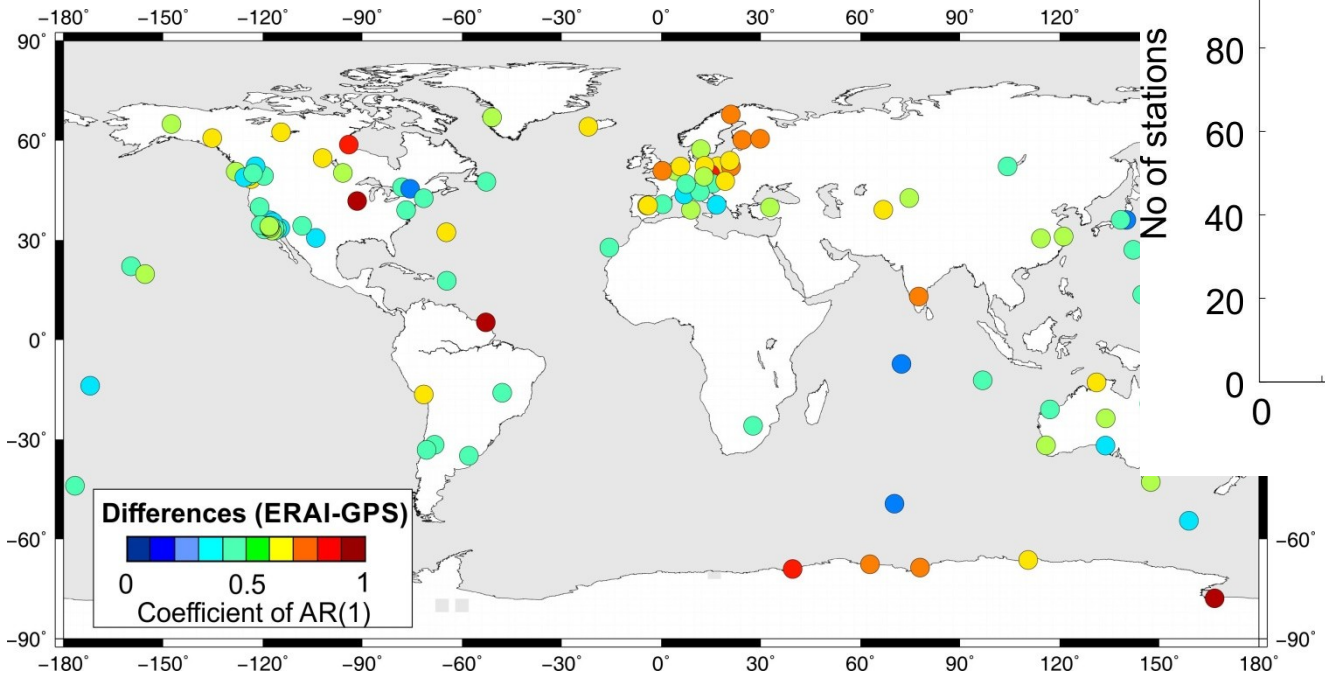


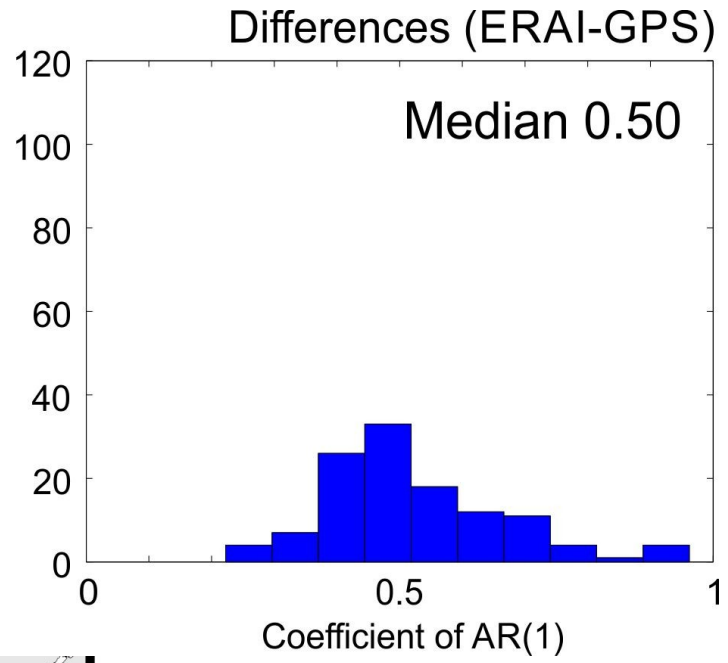

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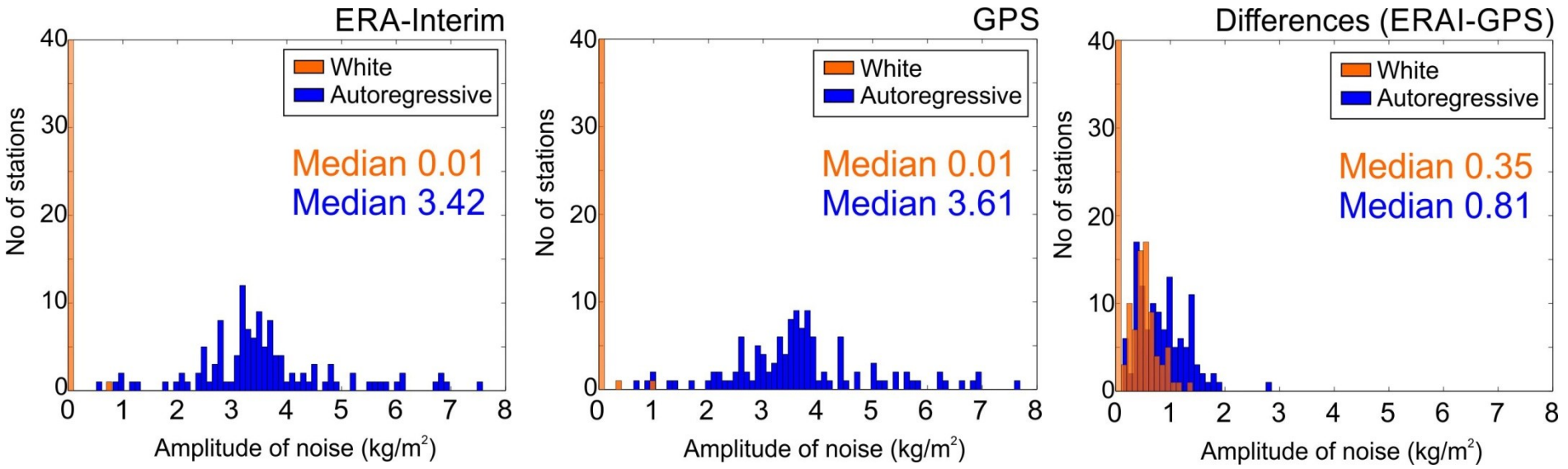


Synthetic data:

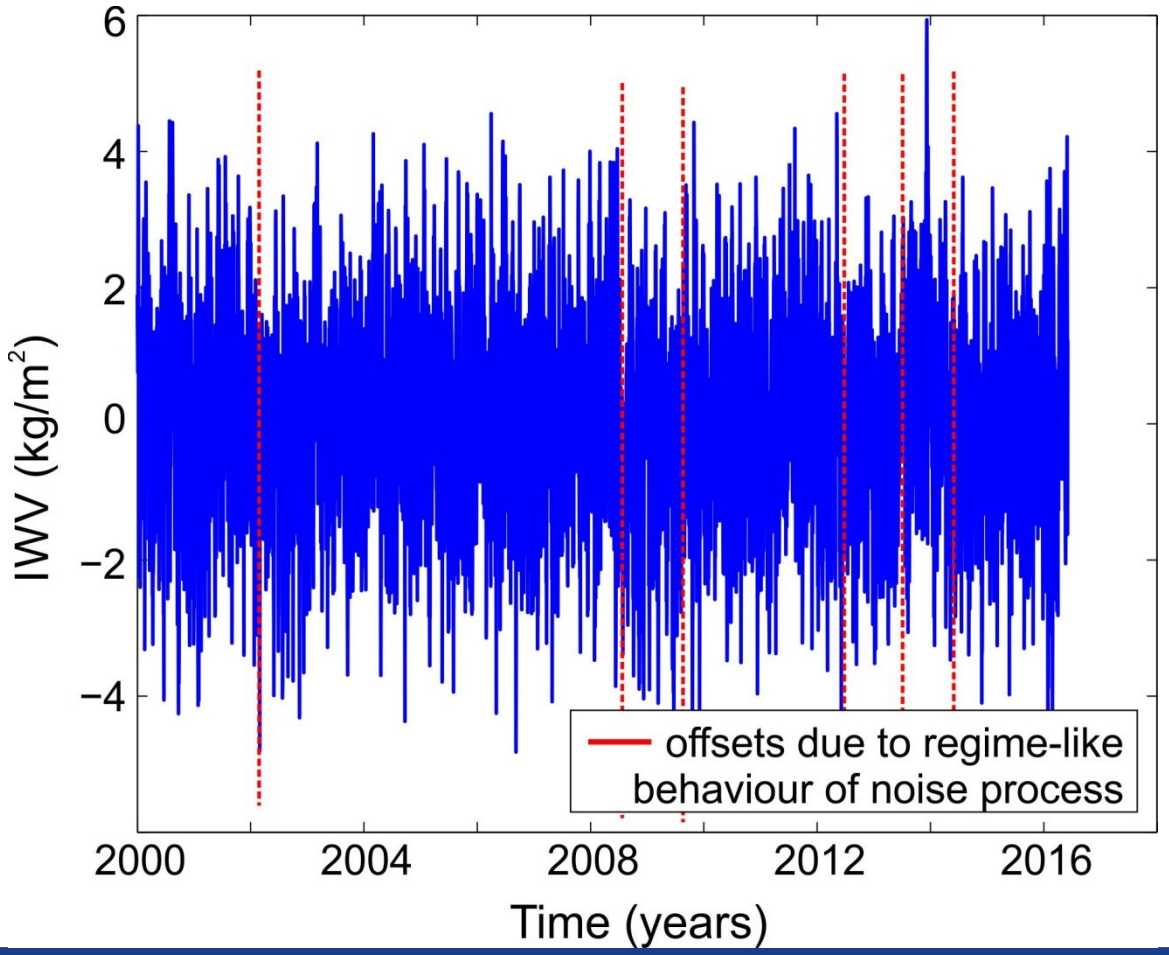
We simulated the synthetic dataset with parameters derived from ERA-Interim, GPS and differences ERAI-GPS.

**Synthetic series basing on median parameters of GPS & ERAI:**

**AR(1)**: fraction = 1.00,

sigma = 3.50 kg/m$^2$,

AR(1) = 0.60±0.03.




**Can anyone see more offsets?**

Synthetic data:

We simulated the synthetic dataset with parameters derived from ERA-Interim, GPS and differences ERAI-GPS.

**Synthetic series basing on median parameters of GPS & ERAI:**

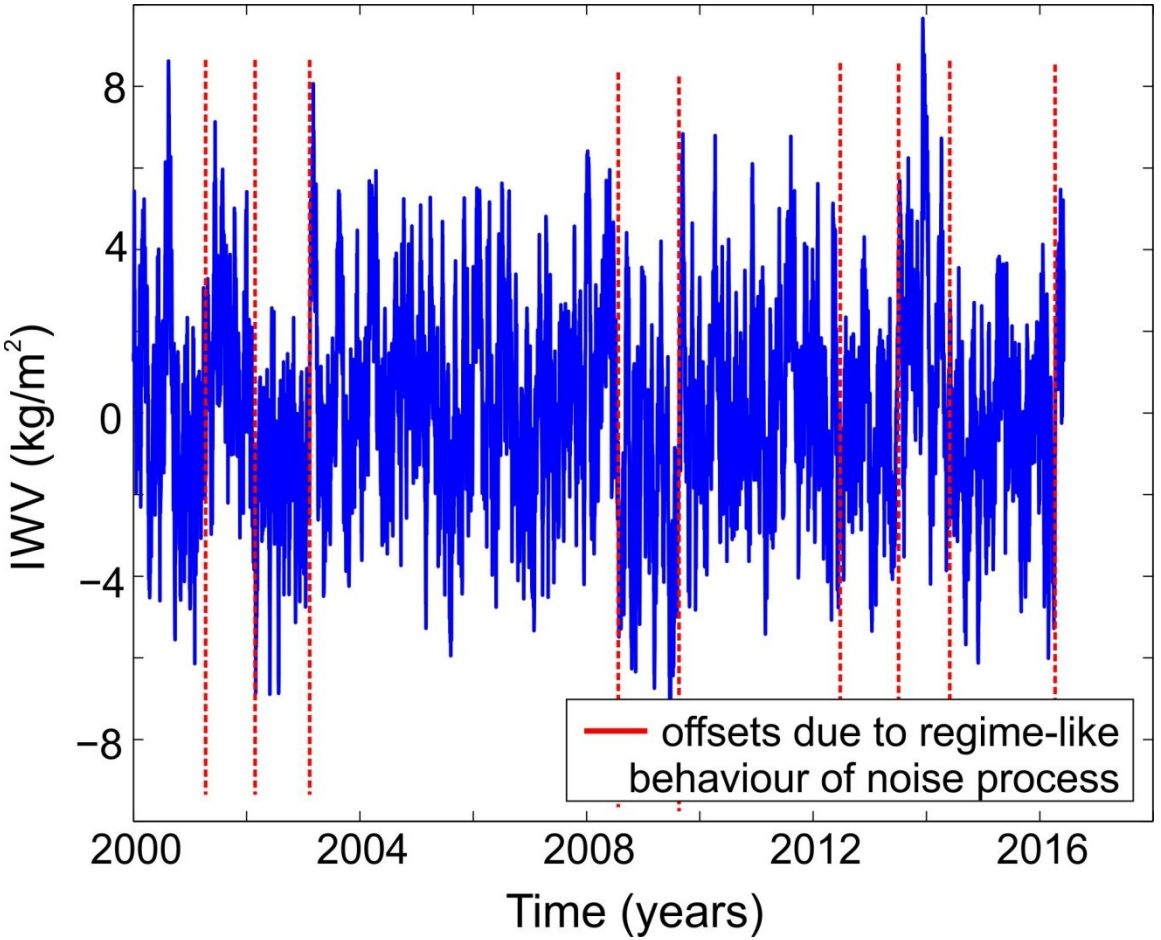
**AR(2)**: fraction = 1.00,

sigma = 3.50 kg/m$^2$,

AR(1) = 0.60±0.03,

AR(2) = 0.3 ±0.03.

**Can anyone see more offsets?**



Synthetic data:

We simulated the synthetic dataset with parameters derived from ERA-Interim, GPS and differences ERAI-GPS.

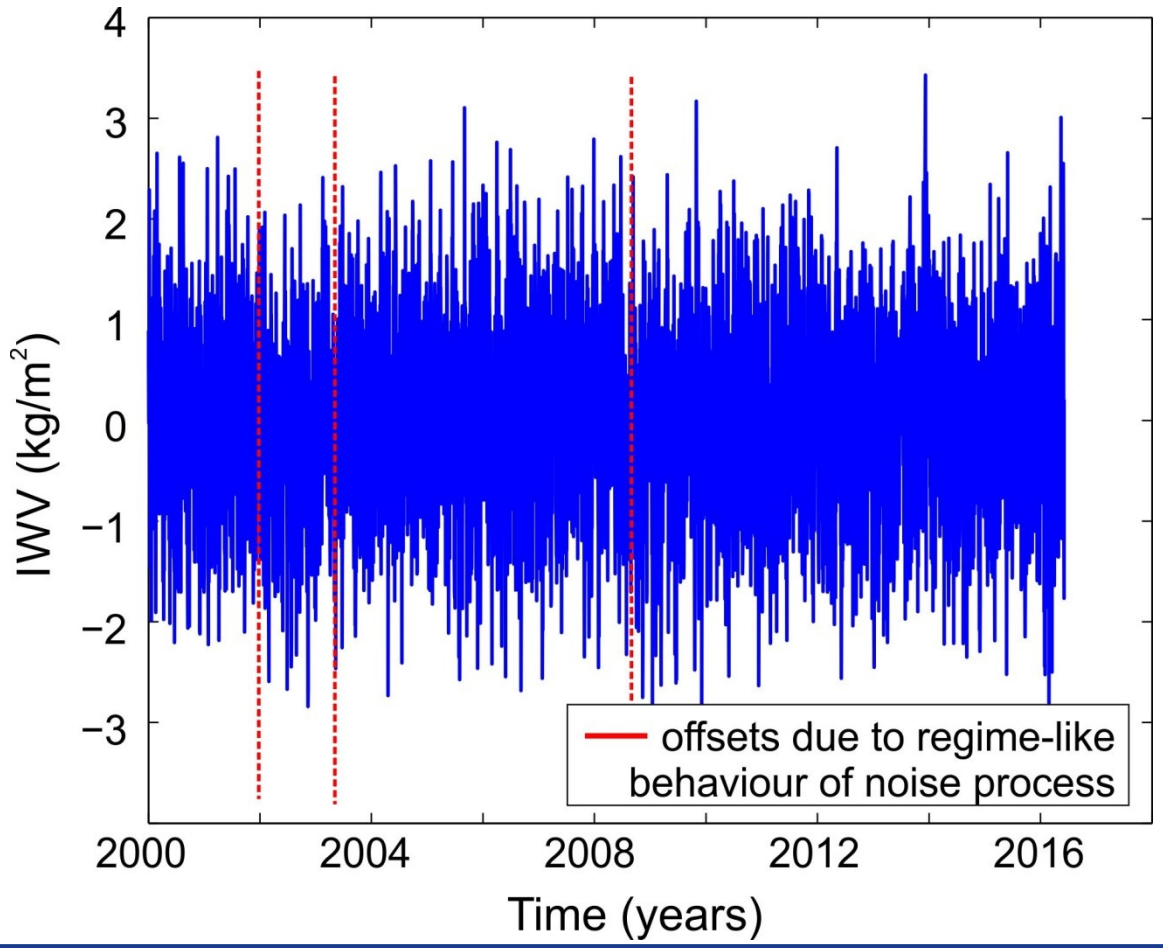
**Synthetic series basing on median parameters of differences (ERAI-GPS):**

**AR(1)**: fraction = 0.71,

sigma = 0.81 kg/m$^2$,

AR(1) = 0.50±0.03.

**Can anyone see more offsets?**



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**Synthetic series basing on median parameters of differences (ERAI-GPS):**

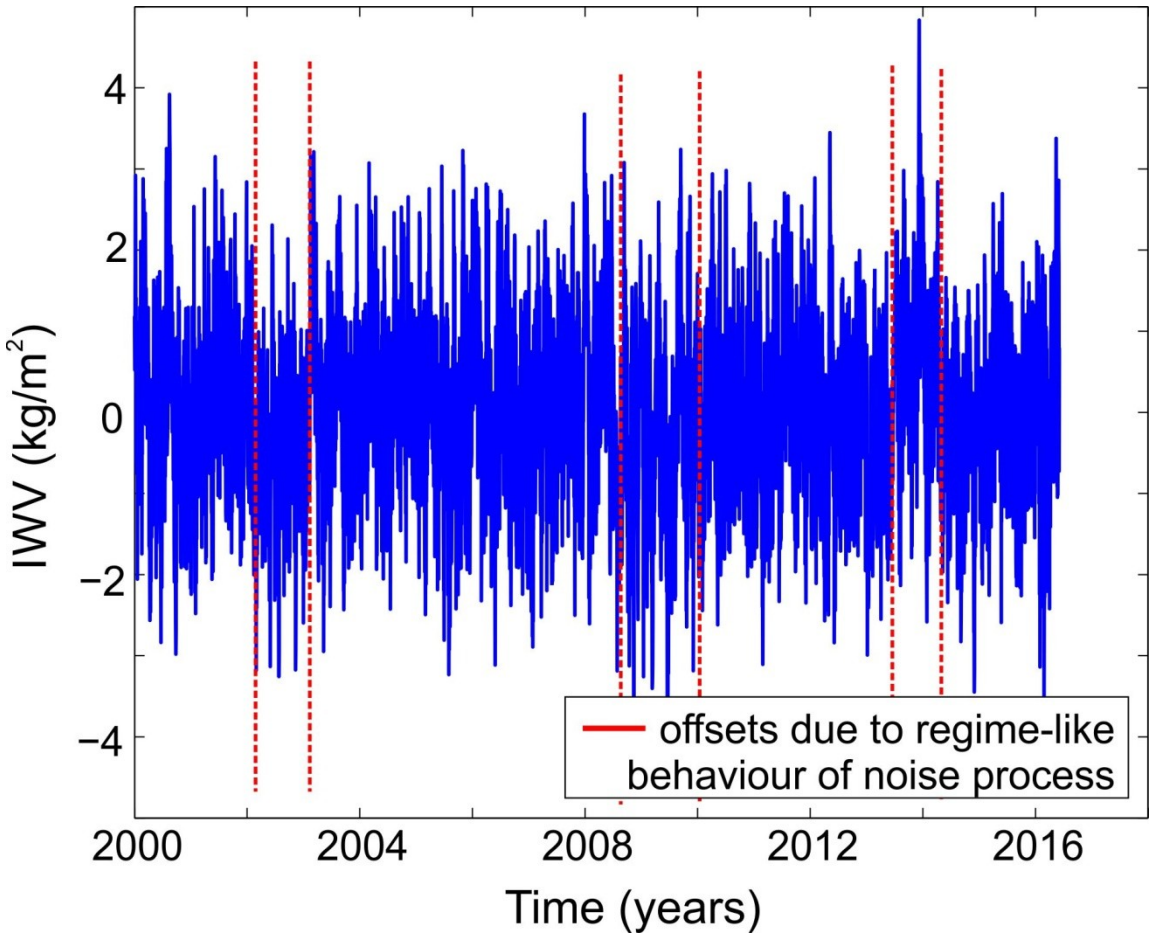
**AR(2)**: fraction = 0.71,

sigma = 0.81 kg/m$^2$,

AR(1) = 0.50±0.03,

AR(2) = 0.30 ±0.02.

**Can anyone see more offsets?**



Synthetic data:

We simulated the synthetic dataset with parameters derived from ERA-Interim, GPS and differences ERAI-GPS.

**Synthetic series basing on**

**AUCK (New Zealand):**

**AR(4)**: fraction = 0.73,

sigma = 3.18 kg/m$^2$,

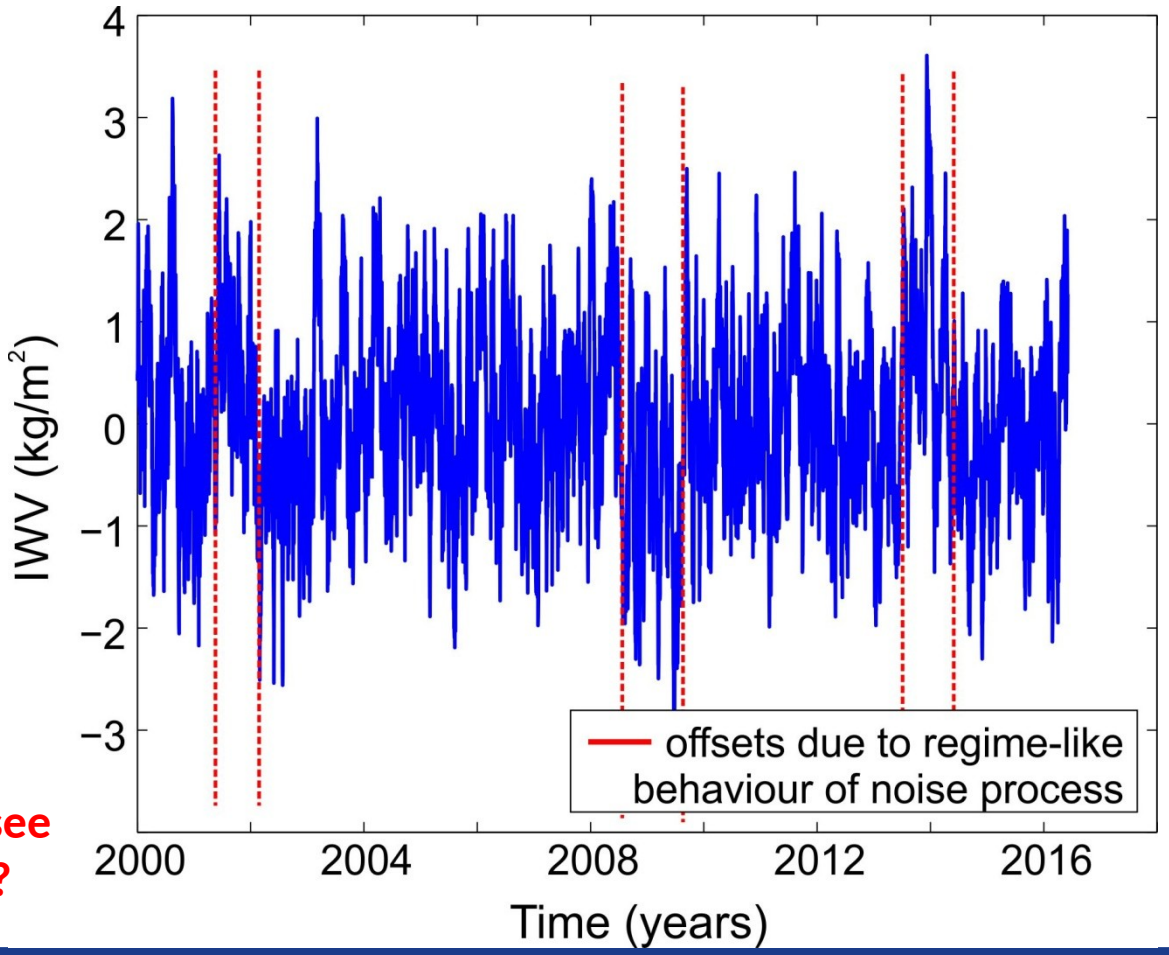
AR(1) = 0.77±0.03,

AR(2) = 0.17±0.02,

AR(3) = 0.02±0.015,

AR(4) = -0.01±0.00

**Can anyone see more offsets?**



7. Conclusions and Perspectives:

a) We delivered a **homogenized dataset** of ERAI, GPS and differences (ERAI-GPS).

b) We derived **parameters** of a common dataset.

c) We performed a **manual homogenisation of synthetic dataset** to prove, that we can report offsets due to **regime-like behaviour of AR process**.

d) Next step: **simulate offsets** in 1 000 of synthetic series.

e) Future: **Test different statistical homogenisation methods**

Potential major issue: can offsets be efficiently detected with statistical approaches, being aware of the autoregressive noise in a stochastic part of the IWV data?

f) Use these methods to homogenize IWV GNSS data

# THANK YOU FOR ATTENTION

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## ACKNOWLEDGEMENTS:

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