Session G2.2
EGU23-3399

EGU General Assembly 2023

Vienna
24 April 2023

Toward a realistic spatio-temporal description of GNSS station position time series

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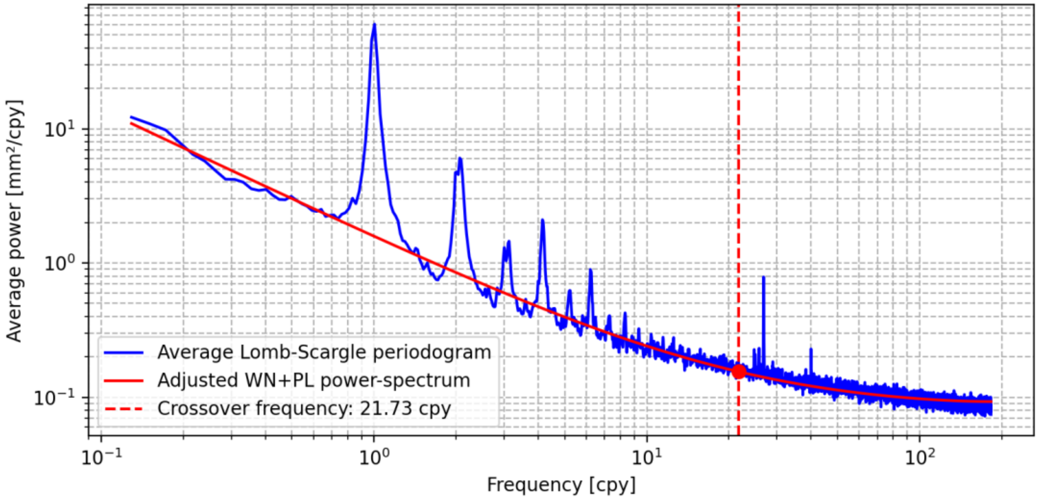
Correlations in GNSS position time series

Temporal correlation (Zhang et al, 1997)

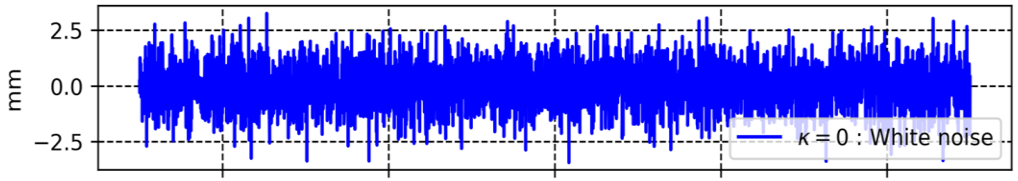
Average power spectrum of trajectory model residuals (+ periodic signals)



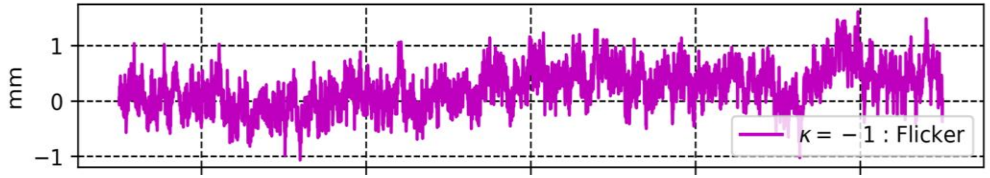
Example of average power-spectrum from the ULR repro3 solution (Gravelle et al., 2023)

Well-described by a **WN+FL model**

White noise (WN)



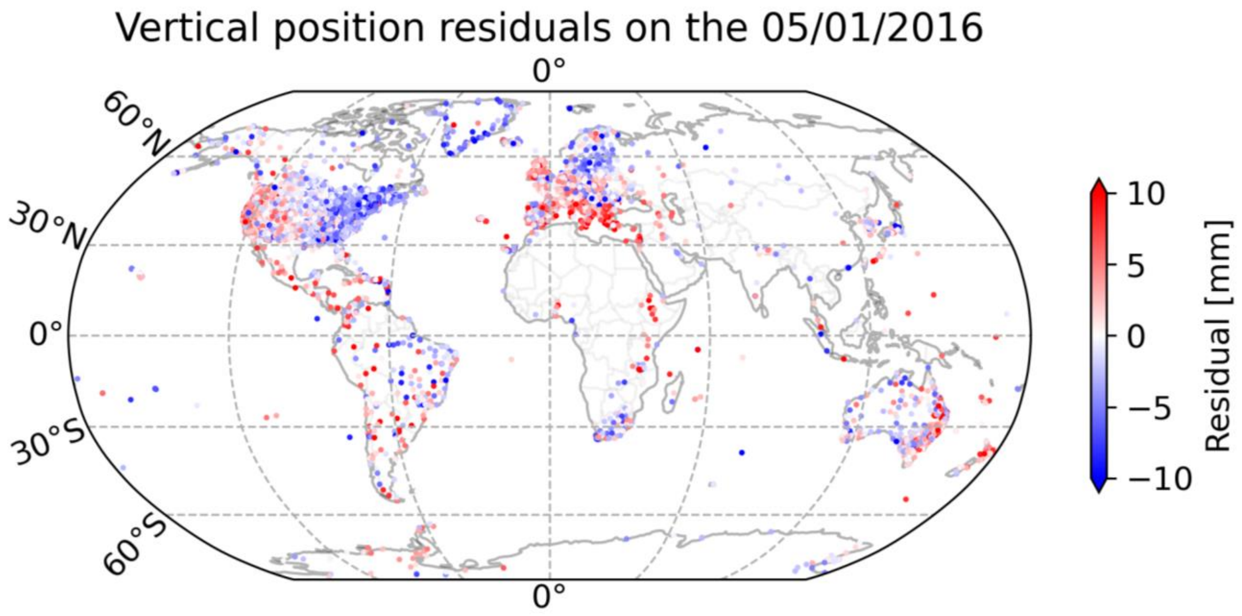
+ Flicker noise (FL)



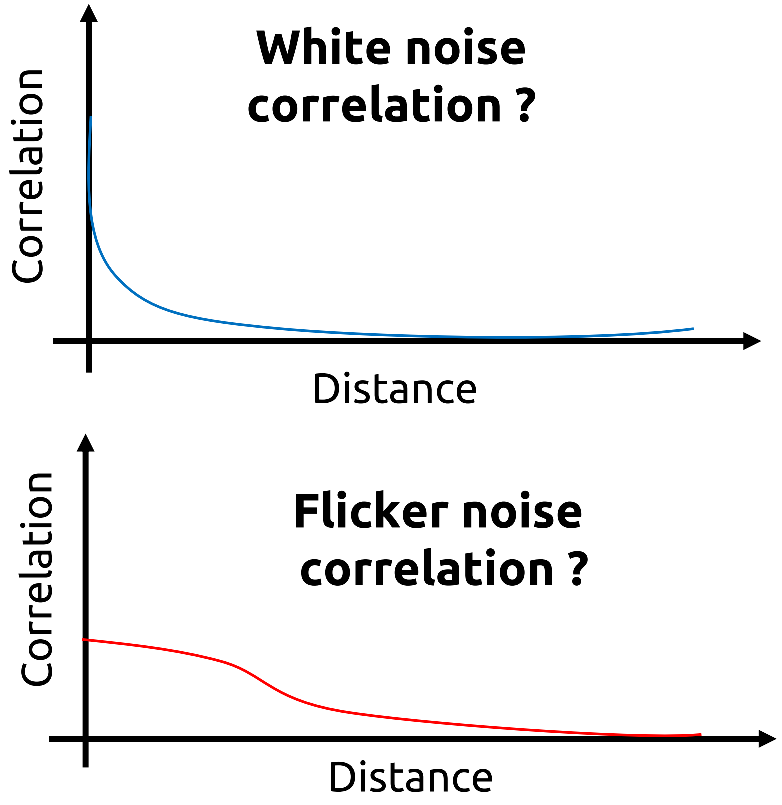
Parameters estimated using VCE methods

Correlations in GNSS position time series

Spatial correlation (Wdowinski et al, 1997)



Corrected for GFZ non-tidal loading model
(NTAL+NTOL+HYDL+SLEL)



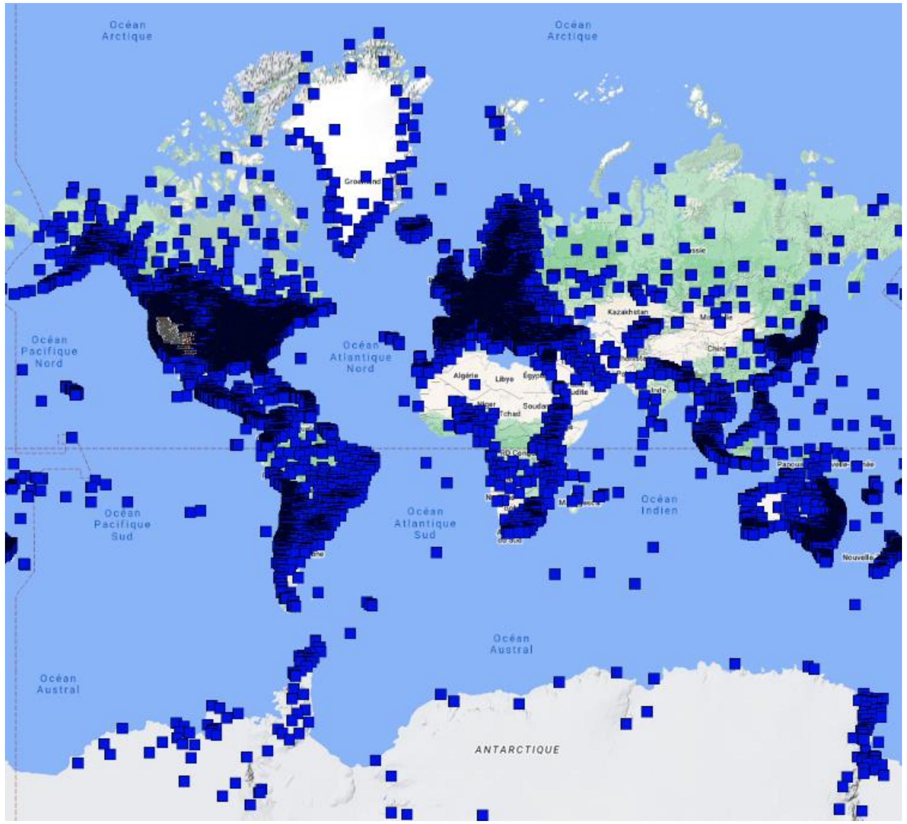
Each stochastic process could have specific spatial correlations (Niu et al, 2023)

Dataset

Nevada Geodetic Laboratory (NGL) dataset analysis

- Selection of **11 151 stations** with more than 1000 estimates and no apparent postseismic deformation.
- **North, East,** and **Vertical** coordinates (only the vertical is presented in detail here).
- **Corrected for GFZ non-tidal loading model** (NTAL+NTOL+HYDL+SLEL, Dill and Dobslaw, 2013) **.**

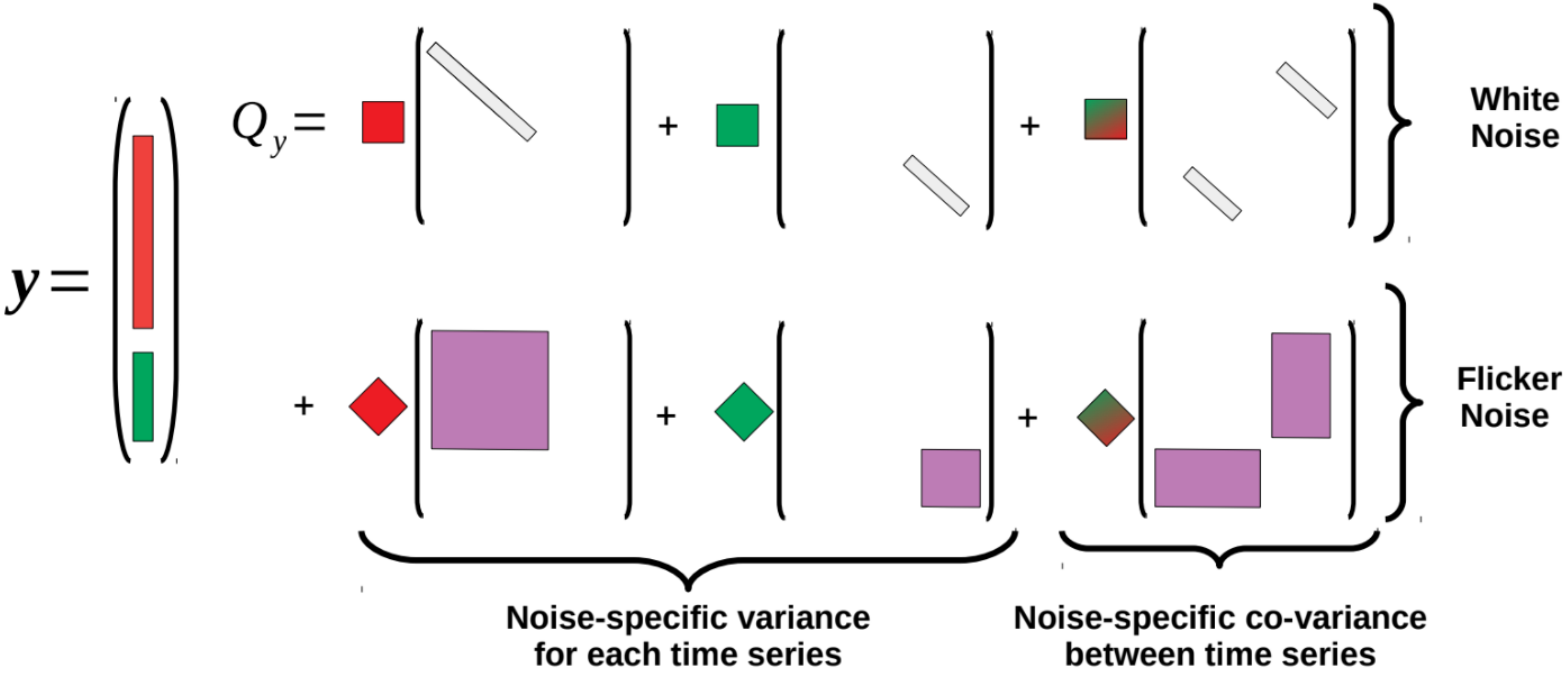
All stations processed by NGL
(geodesy.unr.edu, Blewitt et al., 2018)



Time series modelling strategy

- **Automatic discontinuity detection** (Gobron et al, 2021)
- Accounting for **multiple periodic signals** (annual, GPS draconitic year and their harmonics; fortnightly periods).
- Adjustment of a **WN+FL stochastic model** to each series.

Pairwise spatial covariance modelling – Amiri-Simkooei (2009)

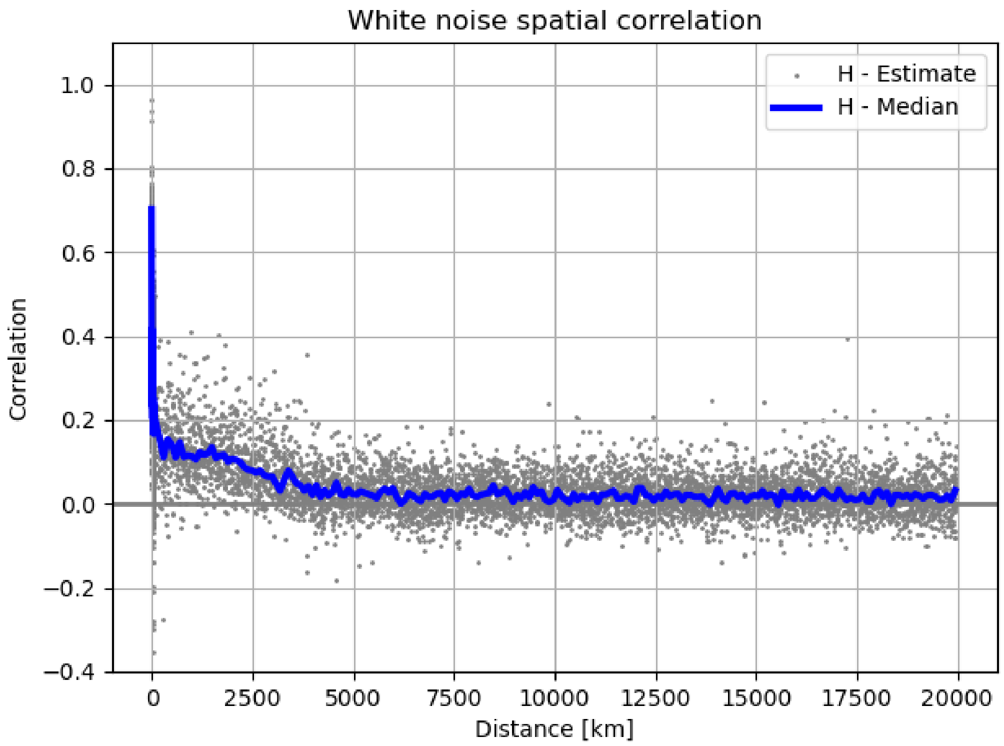


Unknown factors estimated using the restricted maximum likelihood (computationally expensive)

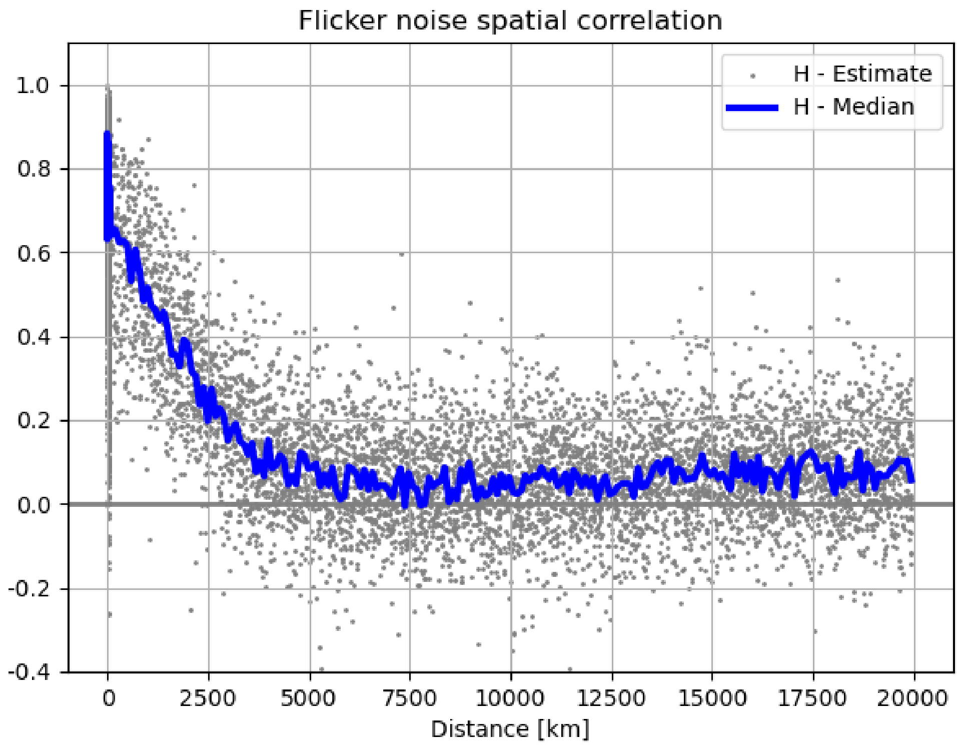
From these (co)variance factors, one can compute spatial correlation coefficients for each process, separately.

Estimated spatial correlations in vertical

White noise spatial correlations



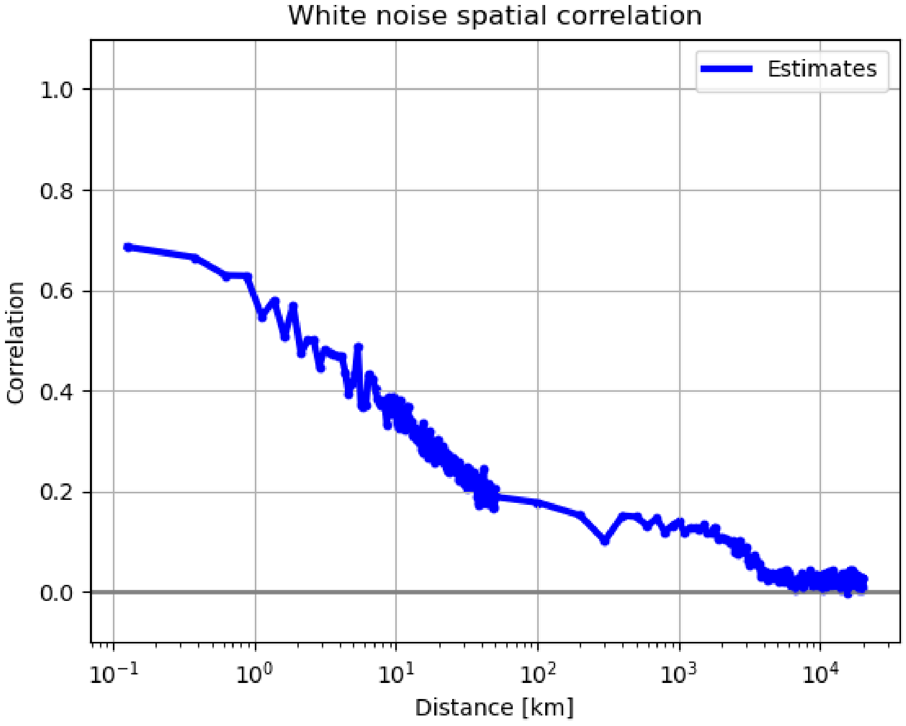
Flicker noise spatial correlations



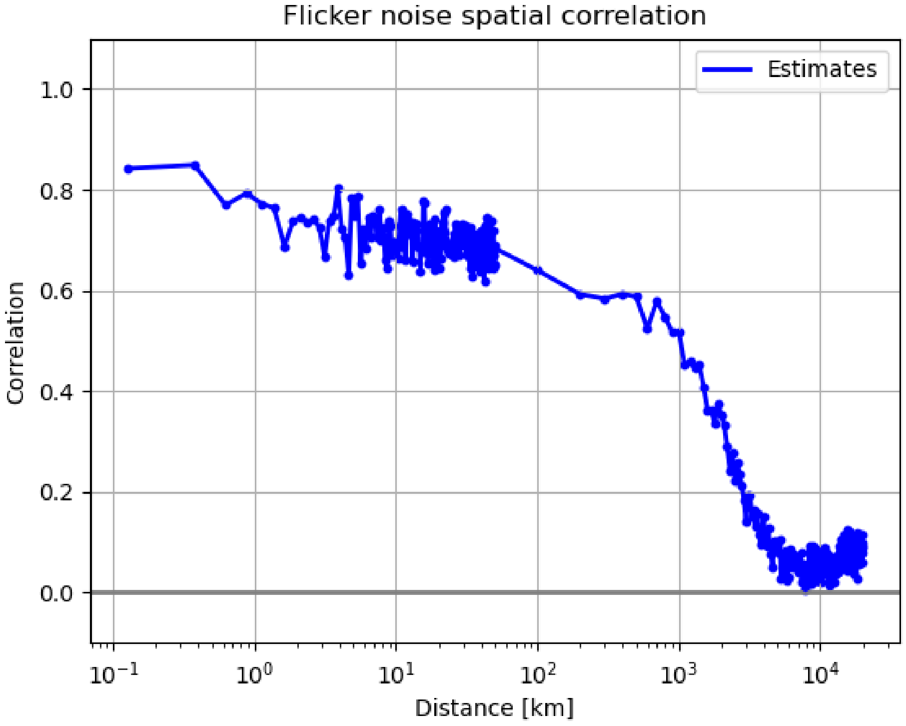
- **Major differences** between white noise and flicker noise, consistent with **Niu et al. (2023)**
- **Three spatial correlation regimes** (station-specific, short-scale, and large scale)
- Correlations tend to **small positive constants at very long distances** (global common mode due to errors in alignment in scale to ITRF?)

Estimated spatial correlations in vertical

White noise spatial correlations



Flicker noise spatial correlations



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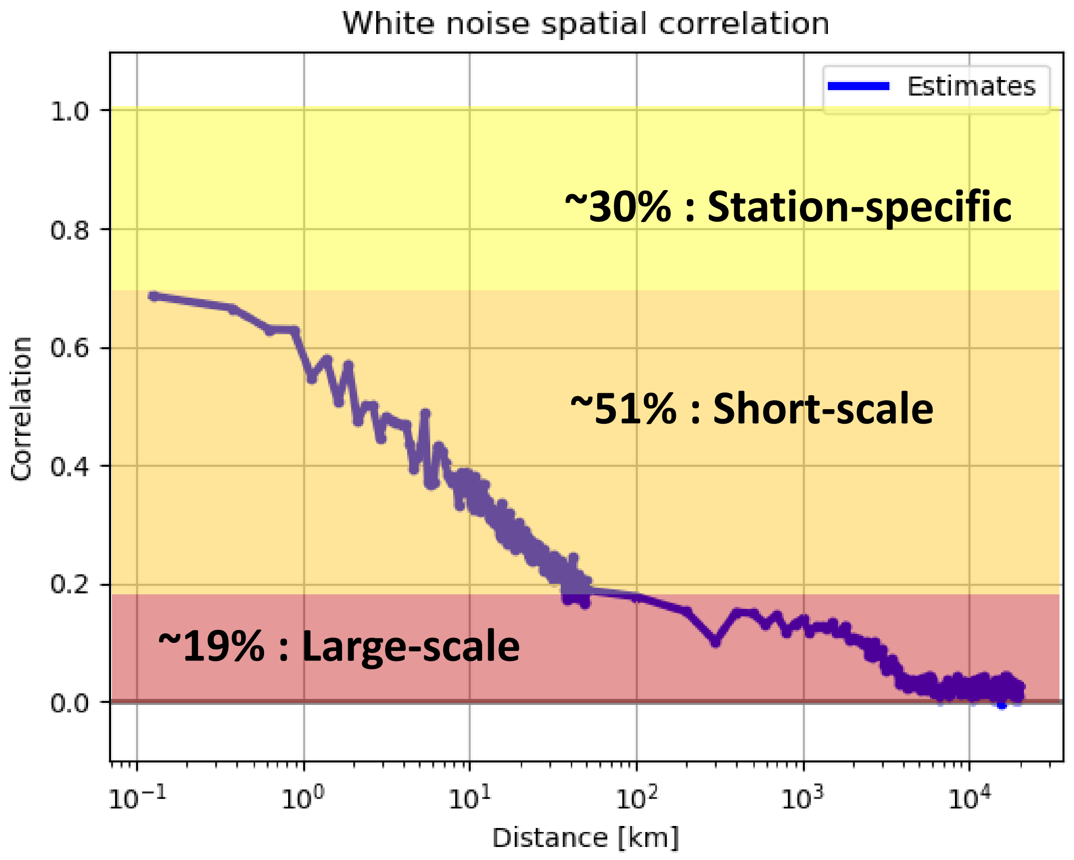
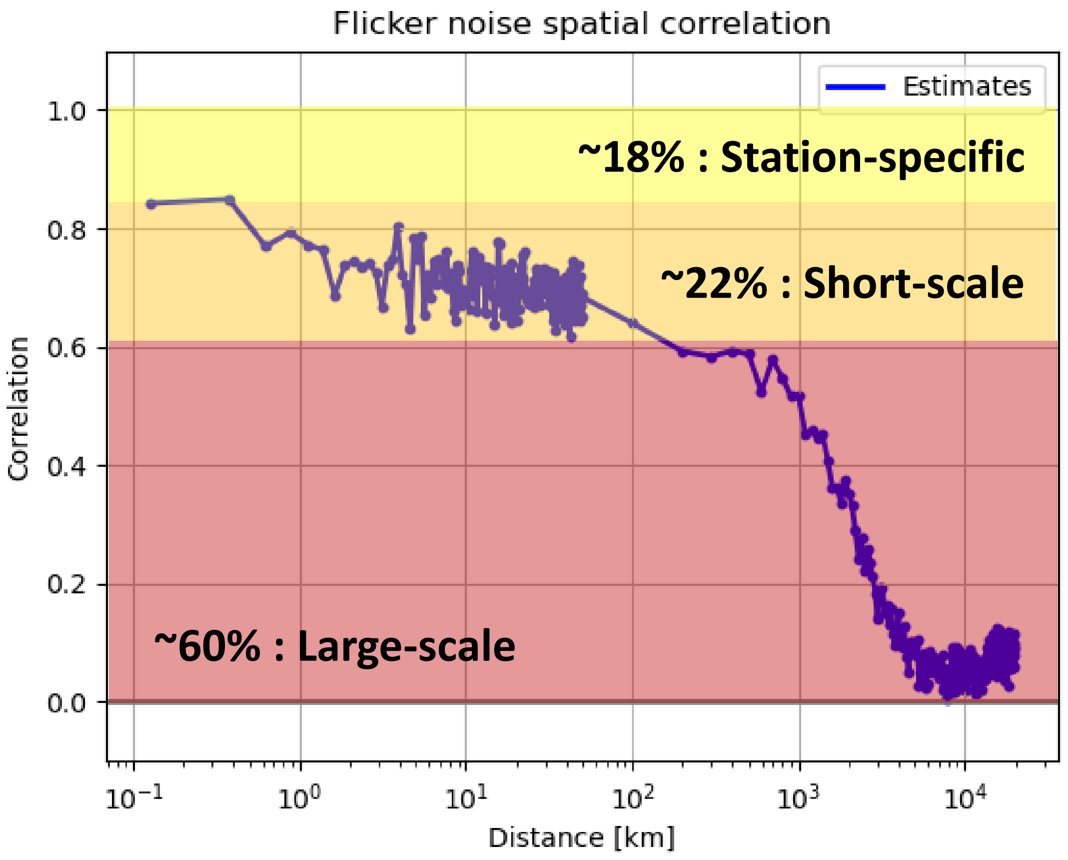
Insights into the sources of stochastic variations

White noise



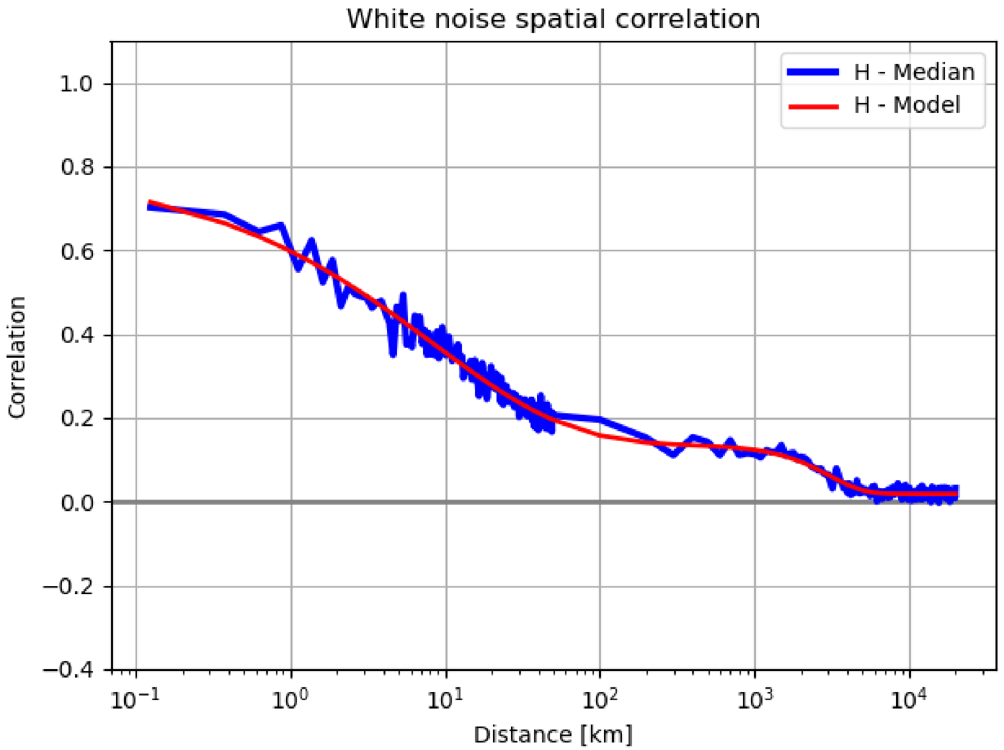
Flicker noise

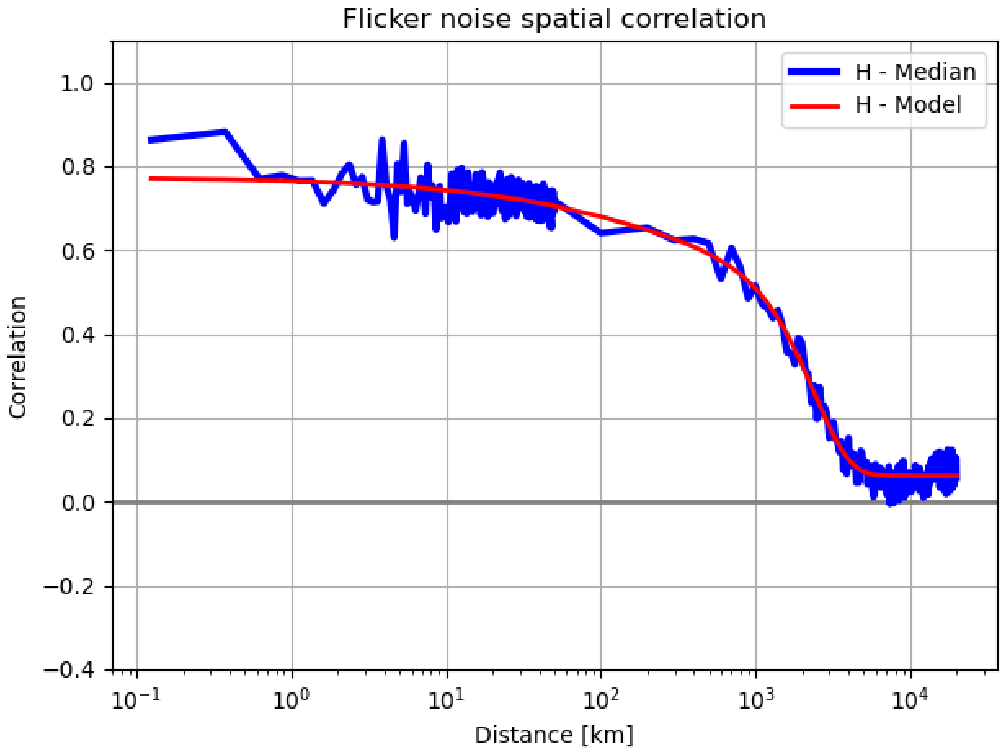


Spatial covariance models for each stochastic process

Difficulty: covariance functions must be **positive-definite**, and we work on the sphere.

- **Short-scale spatial correlations** modelled by a modified **exponential function**.
- **Large-scale spatial correlations** modelled by a modified **Bessel function** (Lantuéjoul et al., 2019).
- **Constant correlation at large distances** modelled by a **constant function**.

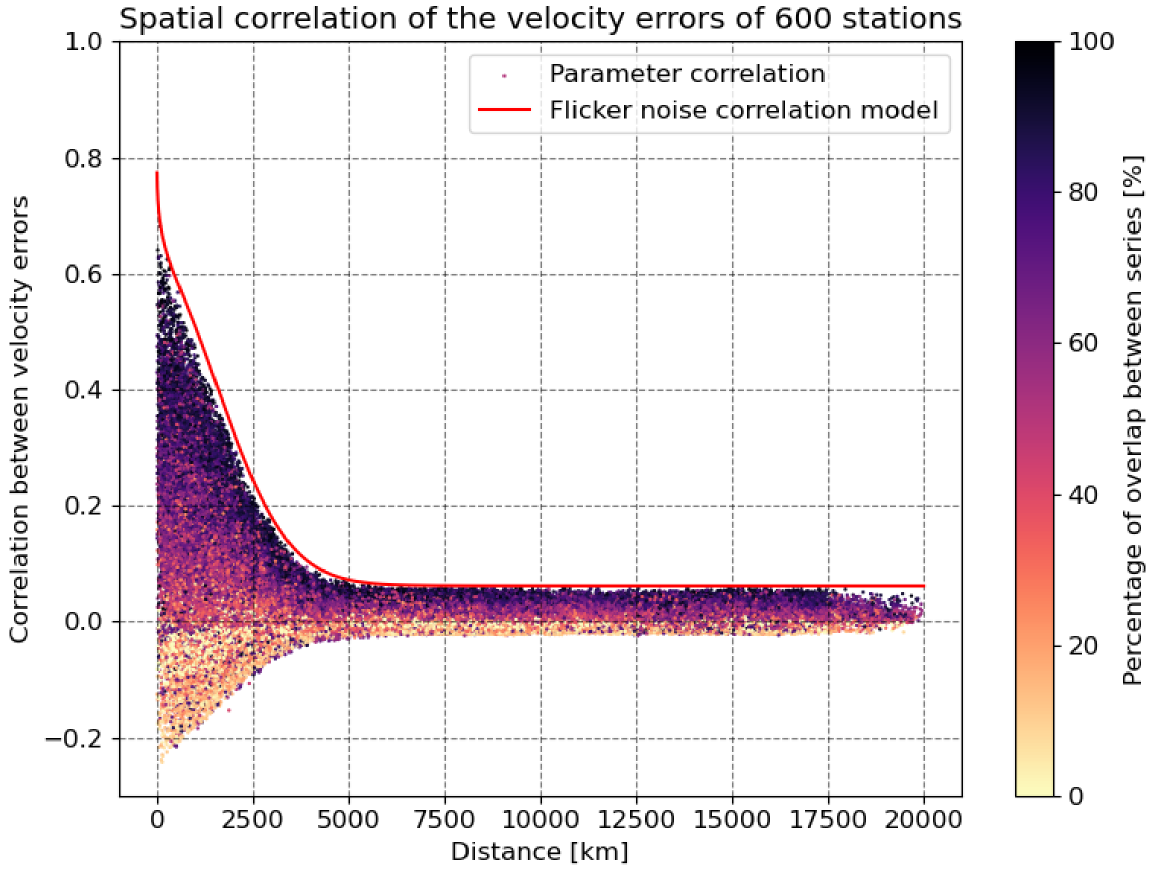




Impact on velocity uncertainties in vertical

Spatial correlation of the noise imply spatially correlated errors on velocity estimates

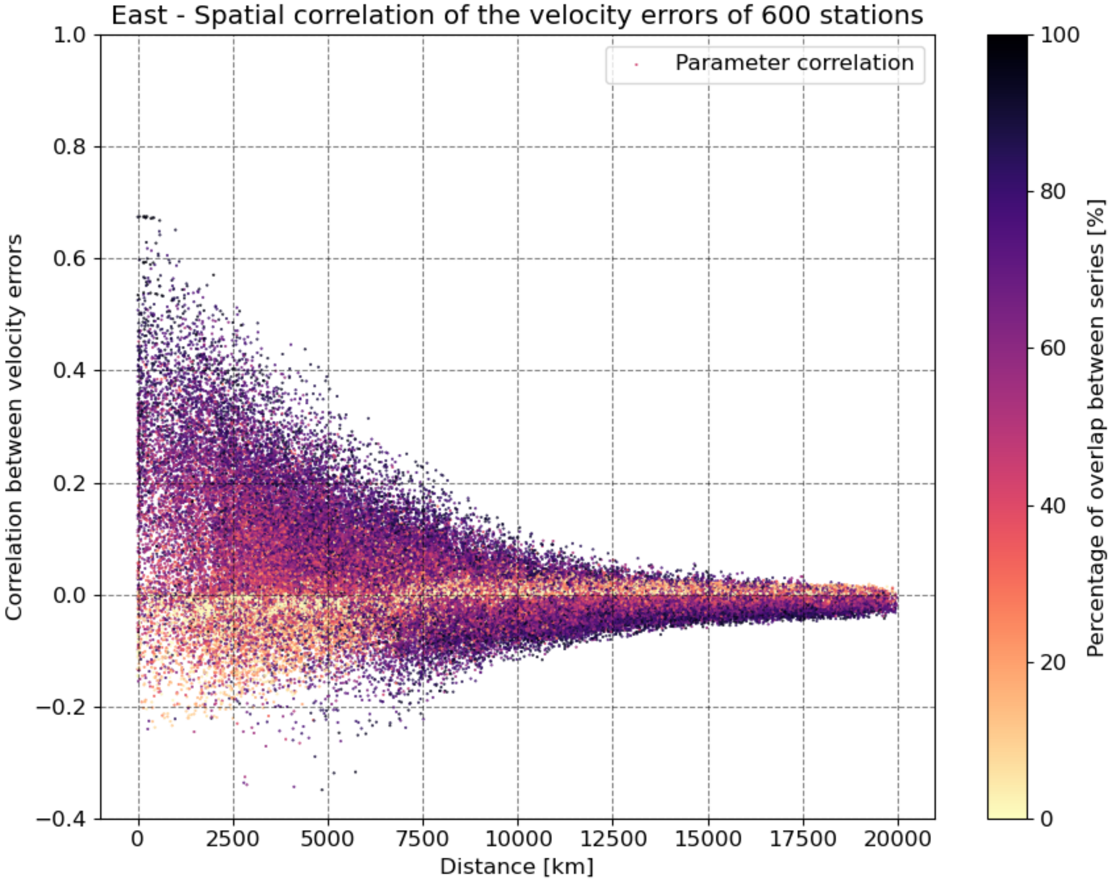
- **Non-trivial** propagation.
- Essentially **controlled by the spatial correlation of the flicker noise**.
- **Negative correlations are possible**, even if the spatial correlation of the flicker noise is strictly positive.
- Correlations between velocity estimates depend at lot on the **overlap between series**.

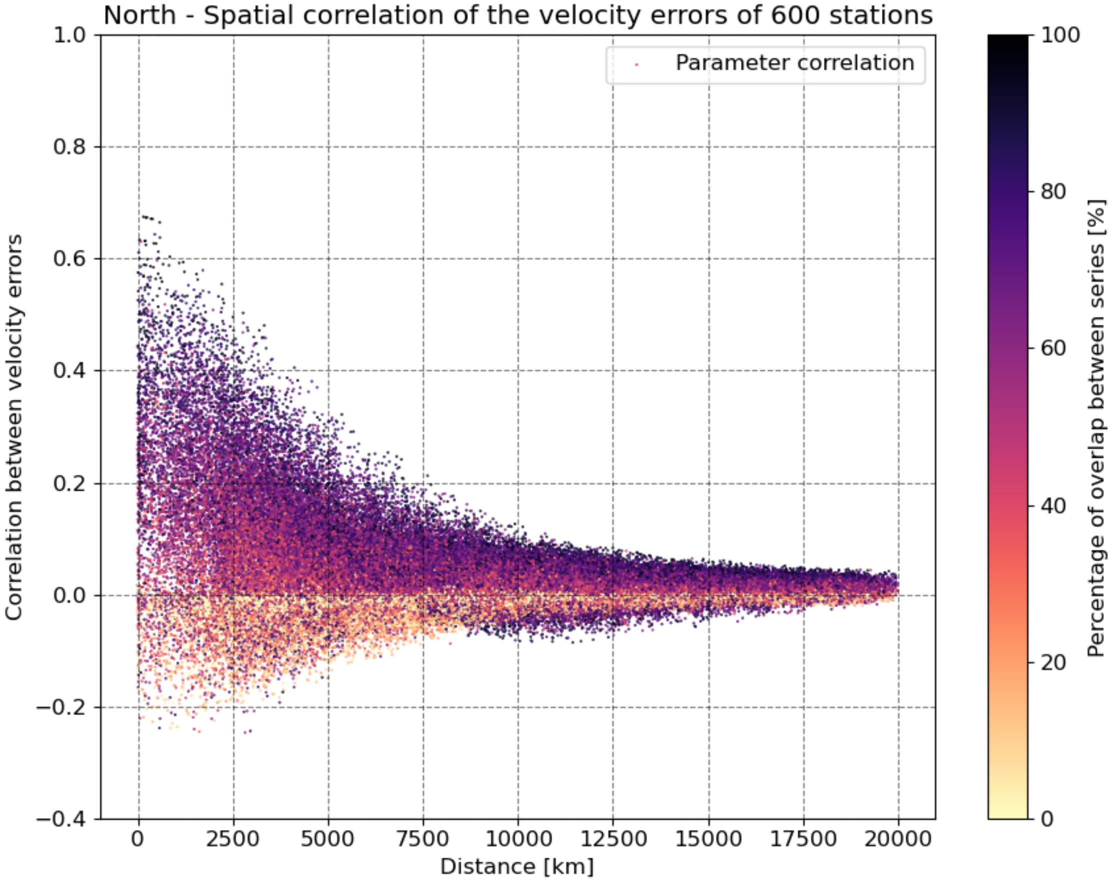


Impact on velocity uncertainties in horizontal

Horizontal spatial covariance model requires more precautions:

-> EGU23 presentation by **P. Rebischung** on **Wednesday (15:15) – Session G1.5**





Conclusions

- **White noise** and **flicker noise** processes have **different spatial fingerprints**.
- **Spatio-temporal correlation regimes** provide new **insights into “noise” sources**.
- They have **significant (and counter-intuitive) influence** on the **spatial correlation of velocity errors**.
- A realistic model for spatio-temporal correlations could have a **major impact** on many **geodetic and geophysical applications,** including the **realisation of TRFs**, and their uncertainty assessment.
- Unique to NGL solution? No: **similar spatio-temporal correlations** are observed in the **TU-Graz repro3 solutions** (not presented here).

Thank you!

References

- Zhang et al, (1997) - https://doi.org/10.1029/97JB01380
- Wdowinski et al, (1997) - https://doi.org/10.1029/97JB01378
- Amiri-Simkooei, (2009) - https://doi.org/10.1007/s00190-008-0251-8
- Dill and Dobslaw, (2013) - https://doi.org/10.1002/jgrb.50353
- Blewitt et al., (2018) - https://doi.org/10.1029/2018EO104623
- Lantuéjoul et al., (2019) - https://doi.org/10.1007/s11004-019-09799-4
- Gobron et al., (2021) - https://doi.org/10.1029/2021JB022370
- Gravelle et al., (2023) - https://doi.org/10.5194/essd-15-497-2023
- Niu et al., (2023) - https://doi.org/10.1007/s00190-023-01703-7