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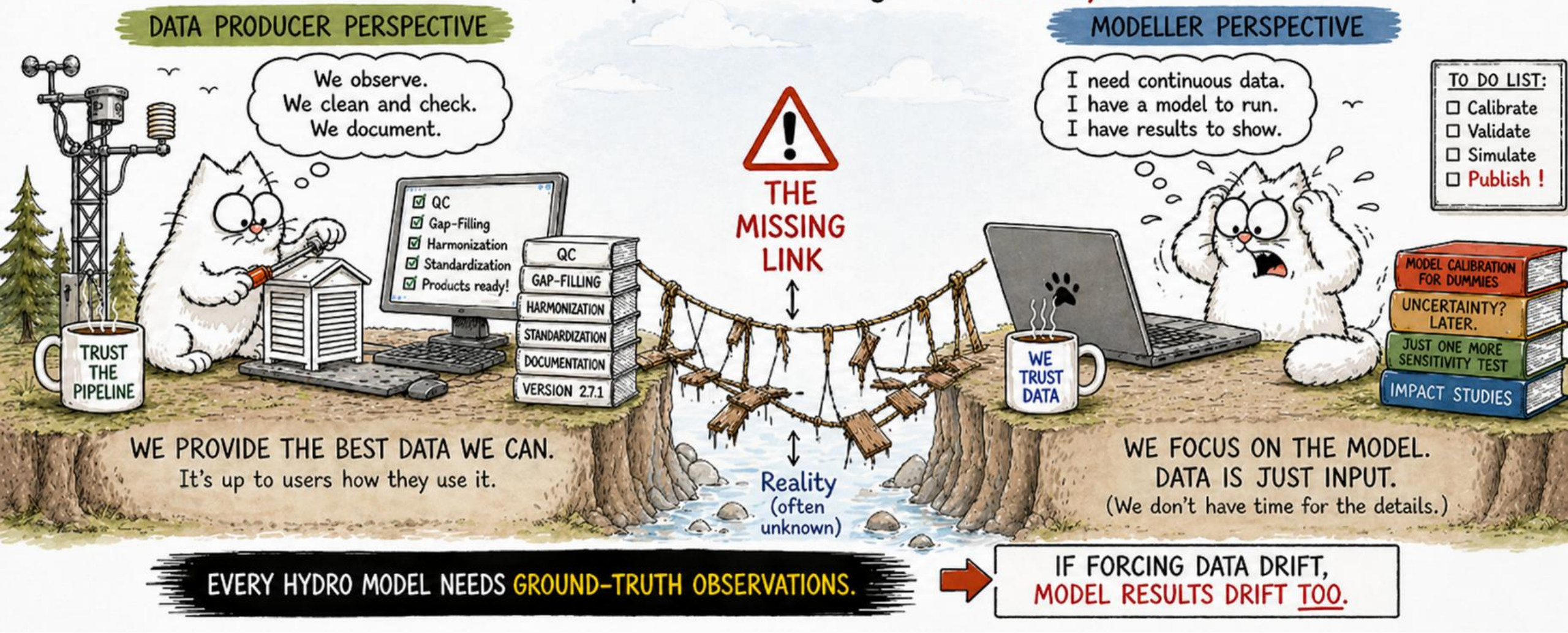
Assessing micro-meteorological flux network data quality: implications for water and energy flux modelling

03.05.2026; EGU26 in Vienna

EVERYONE USES IT. FEW QUESTION IT.

Different priorities. Same goal? Not always.



EVERY HYDRO MODEL NEEDS GROUND-TRUTH OBSERVATIONS.

IF FORCING DATA DRIFT, MODEL RESULTS DRIFT TOO.

Real observations meet process-based modelling

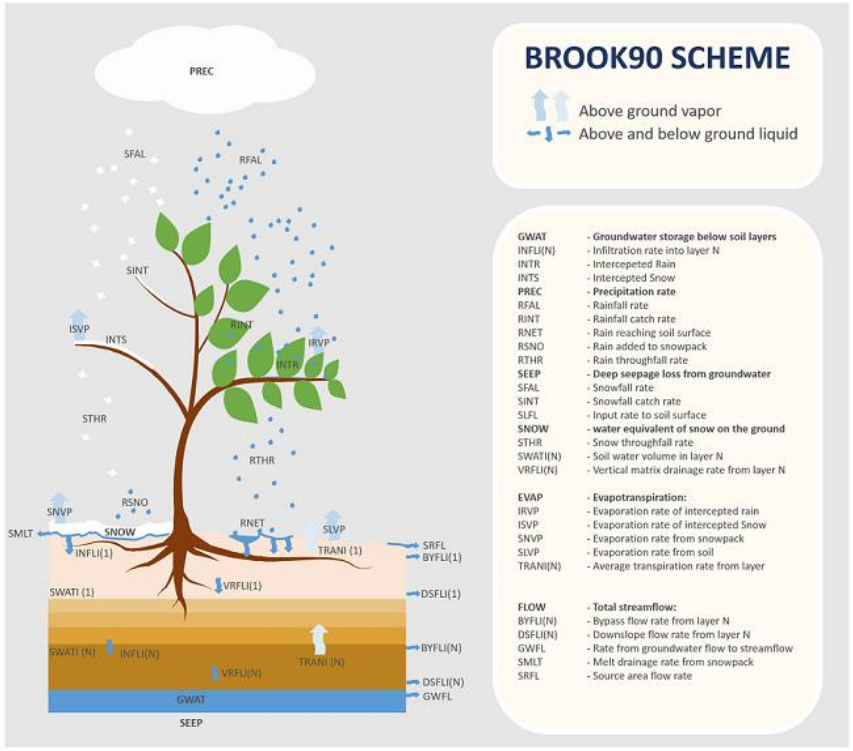
ICOS **Ecosystem Station DE-Tha,** in Tharand Forest, Germany

- Mature **Norway spruce** stand (~140 years, 30 m canopy height)
- **Micro-meteorological** measurements (since 1996 in FLUXNET)

Datasets

- **ARCHIVE L2** from ICOS portal: 2020-2025, 30 min
- **Reference dataset** from raw measurements for 2024
- **Gap-filling chain**: measured data -> MDS -> ERA-Interim

ICOS DE-Tha station Saxony, Germany

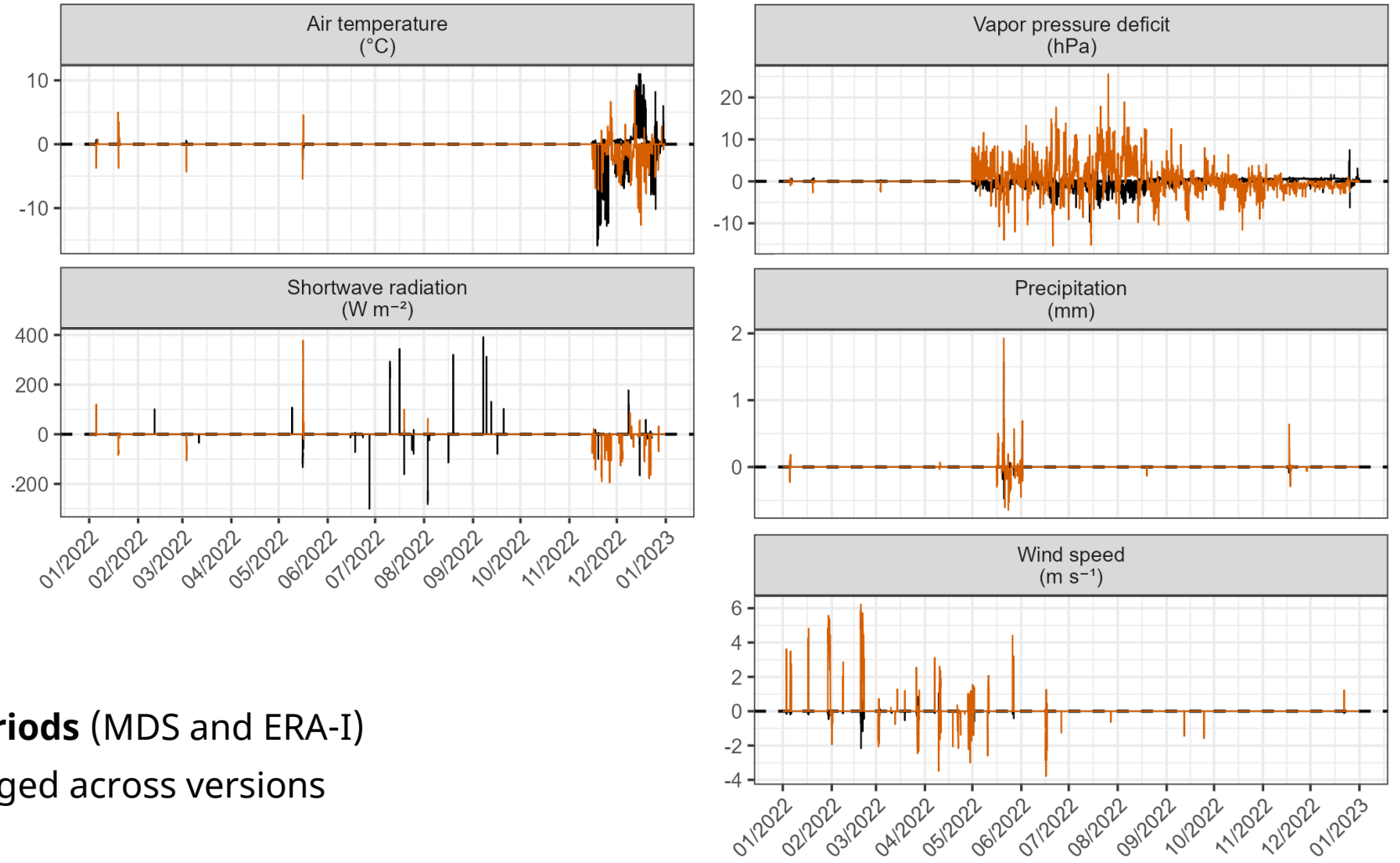


BROOK90 flow-chart

- **Process-based 1D** ecohydrological model
- Subdaily **water** and **energy** flux partitioning
- Detailed **atmosphere–plant–soil** interactions
- Sensitive to forcing data **quality and resolution**
- Input forcing: **TA · P · VPD · WS · SW-IN · G**

Same site
Same year
ICOS versions

Differences between ICOS Archive L2 versions for 2022 (DE-Tha, 30 min).
Orange: 03/2025 – 11/2024
Black: 11/2025 – 11/2024

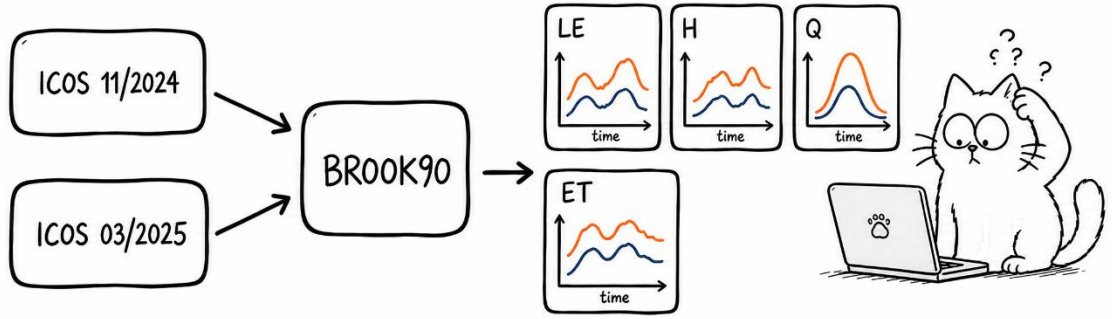


- Changes mainly occur in **gap-filled periods** (MDS and ERA-I)
- **Measured data** (QC=0) stayed unchanged across versions
- **Soil heat flux** was nearly unchanged
- **Max. differences in 2022**

  TA 15 °C · **VPD** 25 hPa · **SW_IN** 400 W m⁻² · **P** 2 mm · **WS** 6 m s⁻¹

ICOS updates do **not only extend** time series: they **alter historical** period as well.

Same model
Same year
Different fluxes

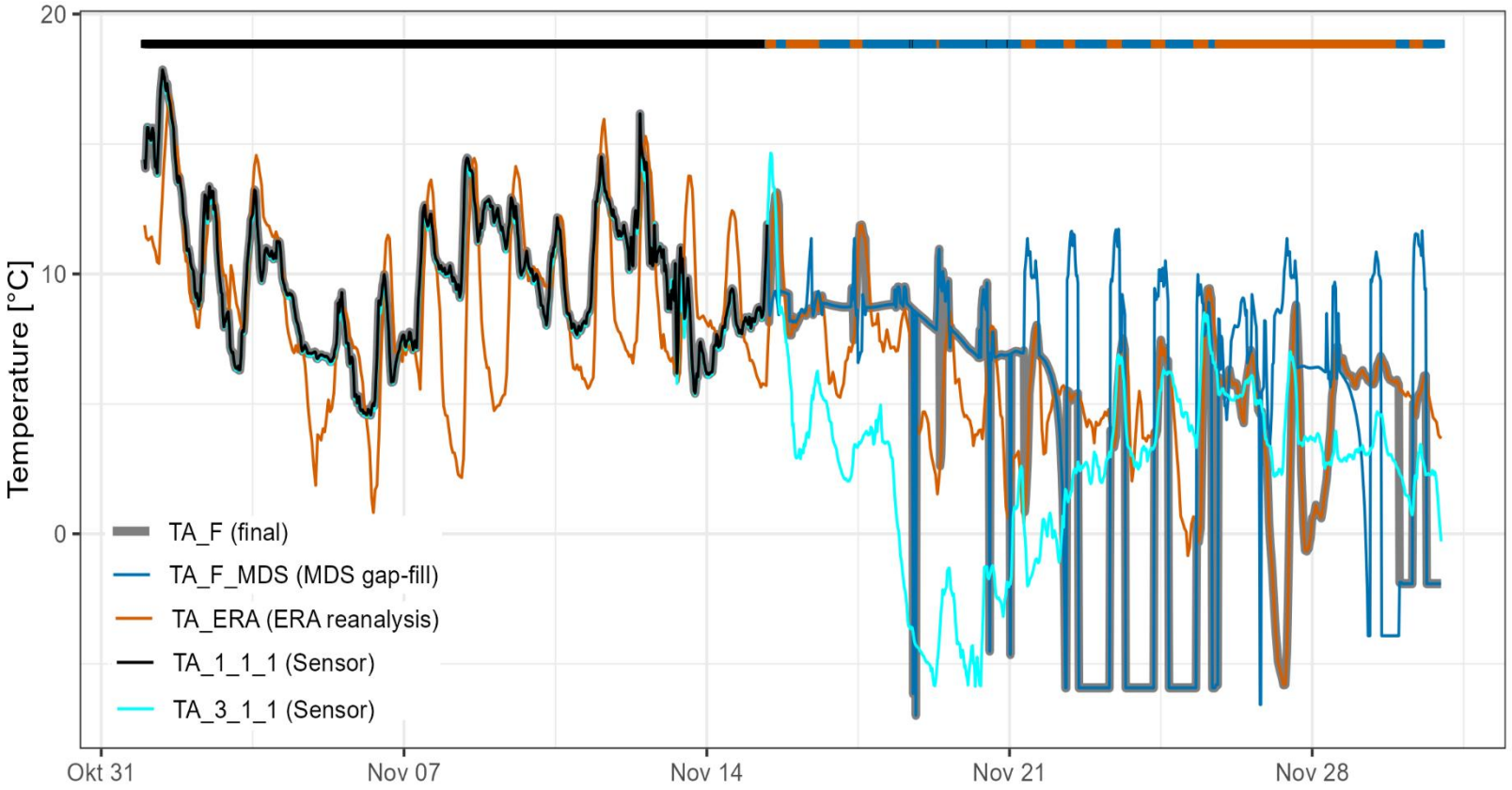


Annual sums of water and energy fluxes in **2022**:
observed and simulated with two versions ICOS data

	Observed		**Simulated**				
	LE [MJ m⁻²]	H [MJ m⁻²]	LE [MJ m⁻²]	H [MJ m⁻²]	Interception [mm]	Transpiration [mm]	Soil ET [mm]
Old version (11/2024)	1176	1845	1289	1793	191	291	44.4
New version (03/2025)	1179	1853	1382	1729	216	303	45.4
Difference [%]	+0.2	+0.4	+6.7	-3.7	+11.6	+4.0	+2.1

Dataset **versioning** becomes part of **model reproducibility**.

When corrected data stop being physically correct



Air temperature at 42 m, DE-Tha, November 2022

- Corrected **data mix**

  measured + MDS + ERA-I values
- Source transitions can create **artificial jumps**
- Largest **30 min jumps** across variables (2020-2025)**:**

  TA > 15 °C

  VPD > 10 hPa

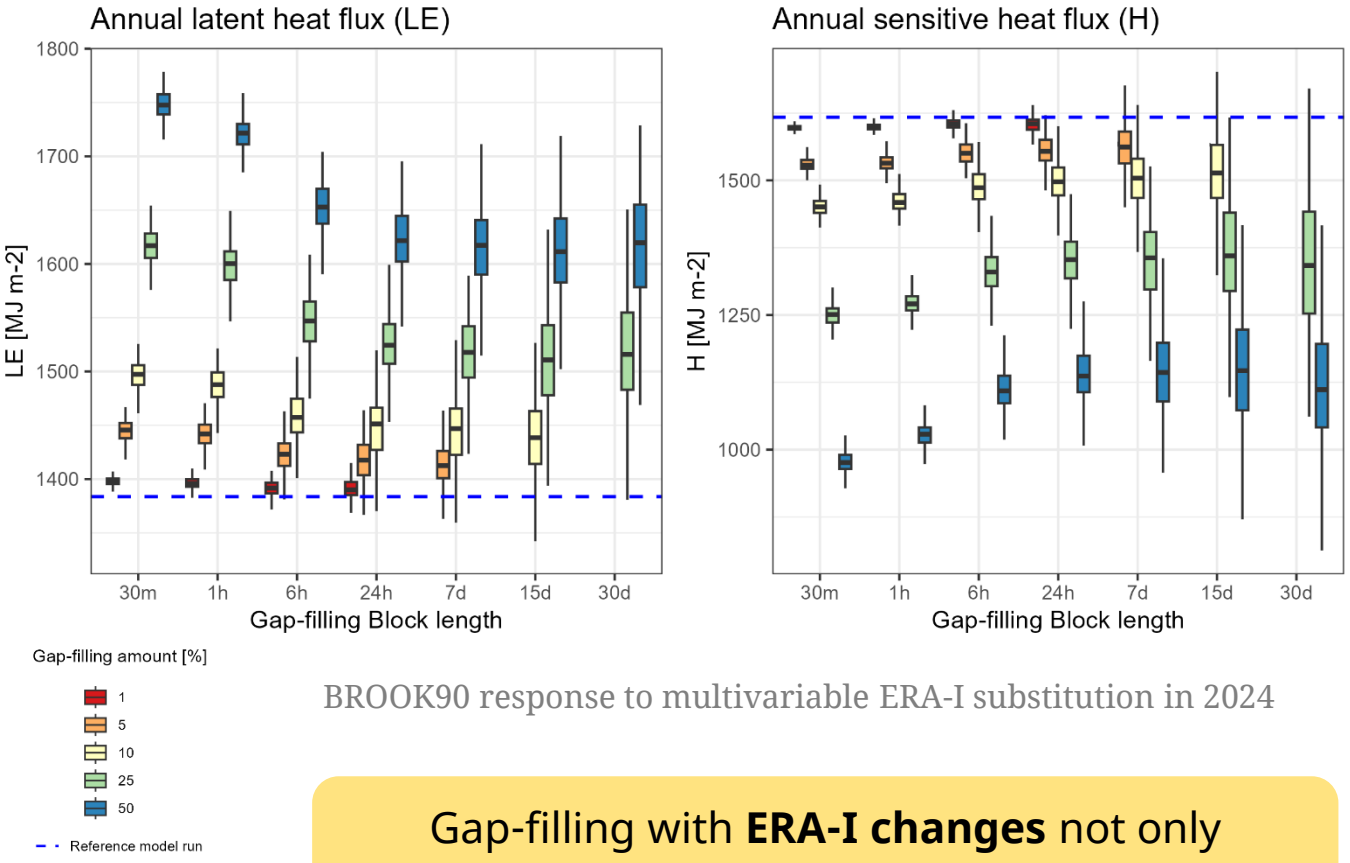
  WS > 30 m s^{-1}

  SW_IN > 500 W m^{-2}

  G > 30 W m^{-2}
- Some periods show abnormally **low variability** under ERA-I filling
- **Similar artefacts were found at many other ICOS/FLUXNET sites**

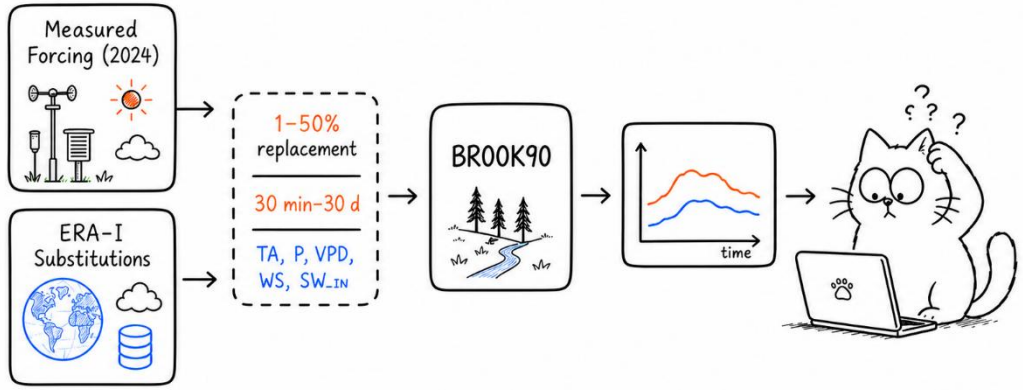
Gap-filling **preserves continuity**, but **breaks** temporal **consistency**.

Gap-filling is not just filling the gaps



BROOK90 response to multivariable ERA-I substitution in 2024

Gap-filling with **ERA-I changes** not only simulated **fluxes**, but **process interpretation**.



- **Uncertainty** ↑ with both gap-filling amount and block length
- Frequent **short gaps** are **more dangerous** than continuous ones
- **Water-energy** partitioning **changes**:
- LE ↑ 25% · H ↓ 40%

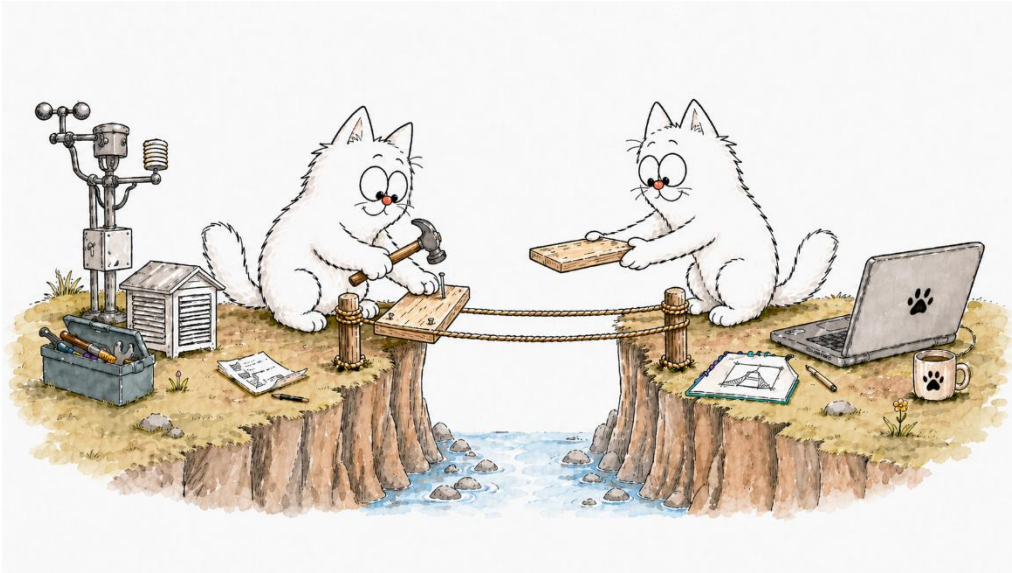
  interception ↑ 70%

  soil evaporation ↑ 22%

  transpiration ↓ 5%
- Spikes can cause **process misrepresentation**

Take-home messages

- ICOS / FLUXNET **post-processing changes historical forcing data** (through versioning and gap-filling)
- These **changes propagate into modelling results** and affect reproducibility and energy and water flux estimates
- **Forcing-data uncertainty** should be treated as model uncertainty and reported explicitly by modellers
- **Better gap-filling** and **stronger post-processing** QC are needed to improve temporal consistency of final datasets



Dataset **versioning** becomes part of **model reproducibility**.

Gap-filling with **ERA-I changes** not only simulated **fluxes**, but **process interpretation**.





Thank you!
Any questions?