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

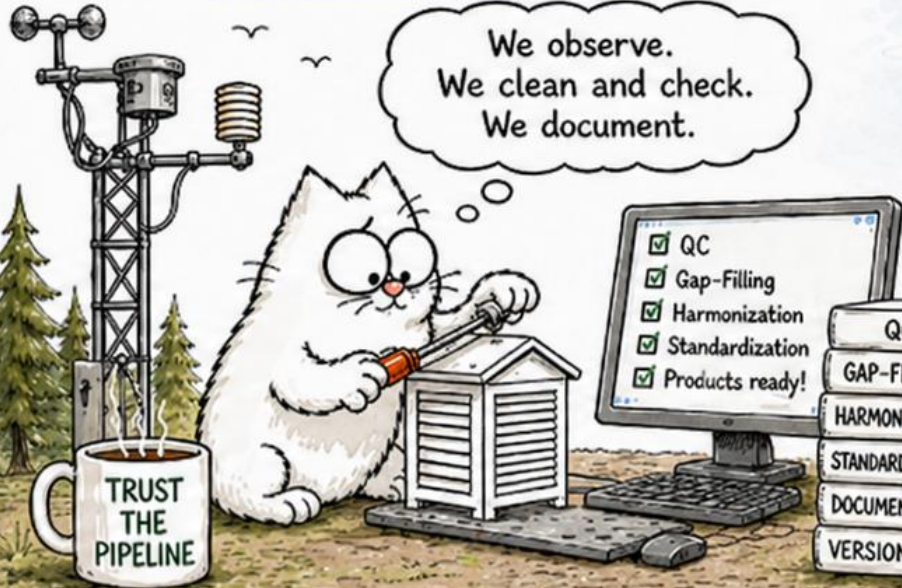


# EVERYONE USES IT. FEW QUESTION IT.

Different priorities. Same goal? **Not always.**

## DATA PRODUCER PERSPECTIVE

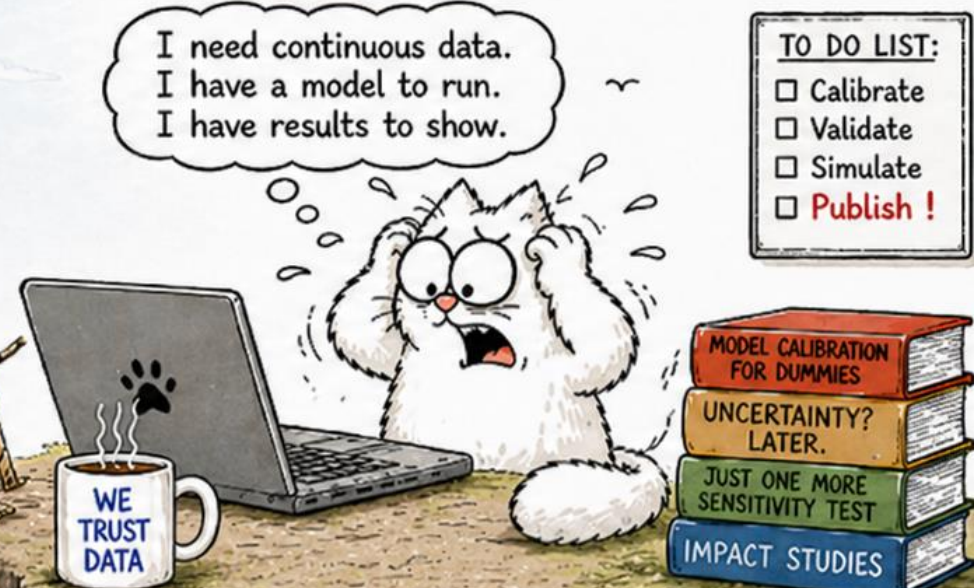
We observe.  
We clean and check.  
We document.



WE PROVIDE THE BEST DATA WE CAN.  
It's up to users how they use it.

## MODELLER PERSPECTIVE

I need continuous data.  
I have a model to run.  
I have results to show.



WE FOCUS ON THE MODEL.  
DATA IS JUST INPUT.  
(We don't have time for the details.)



THE  
MISSING  
LINK

Reality  
(often  
unknown)

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

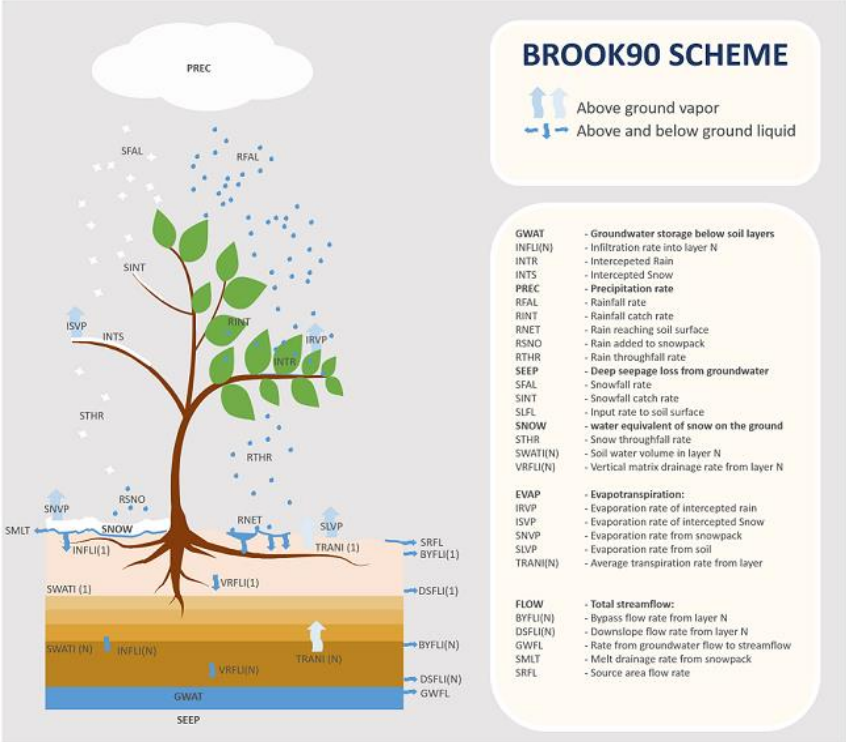
- Mature Norway spruce stand (~140 years, 30 m canopy height)
- **Micro-meteorological** measurements (since 1996 in FLUXNET)

### 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

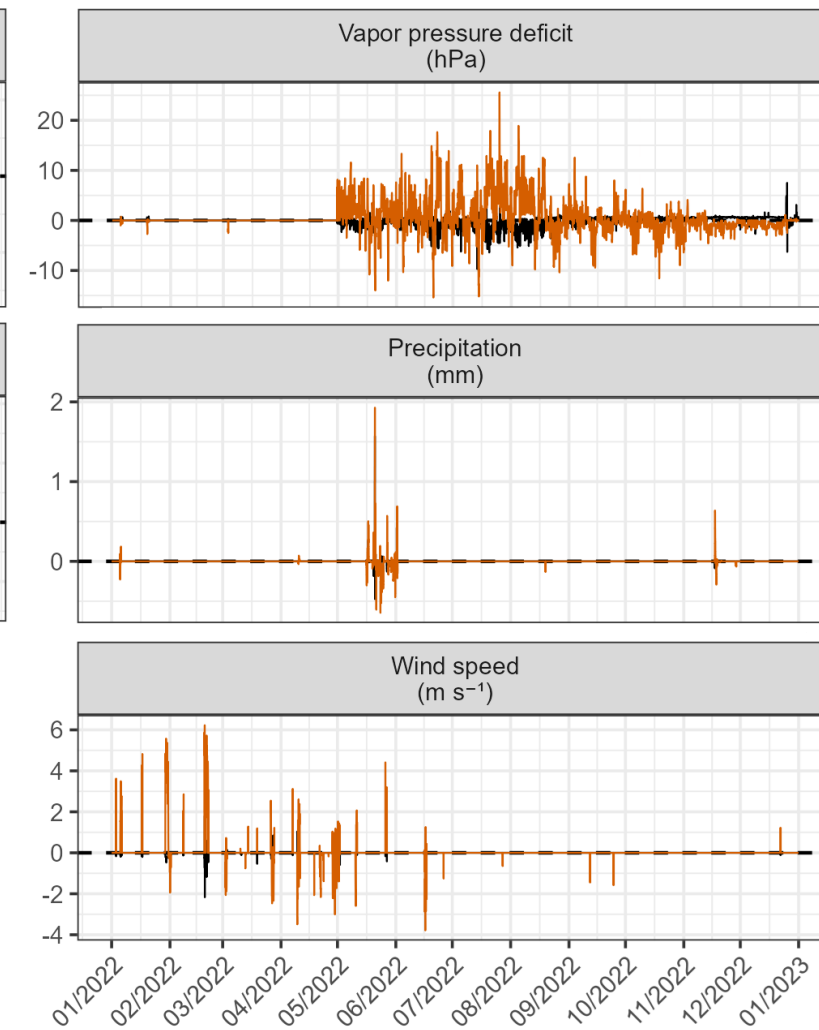
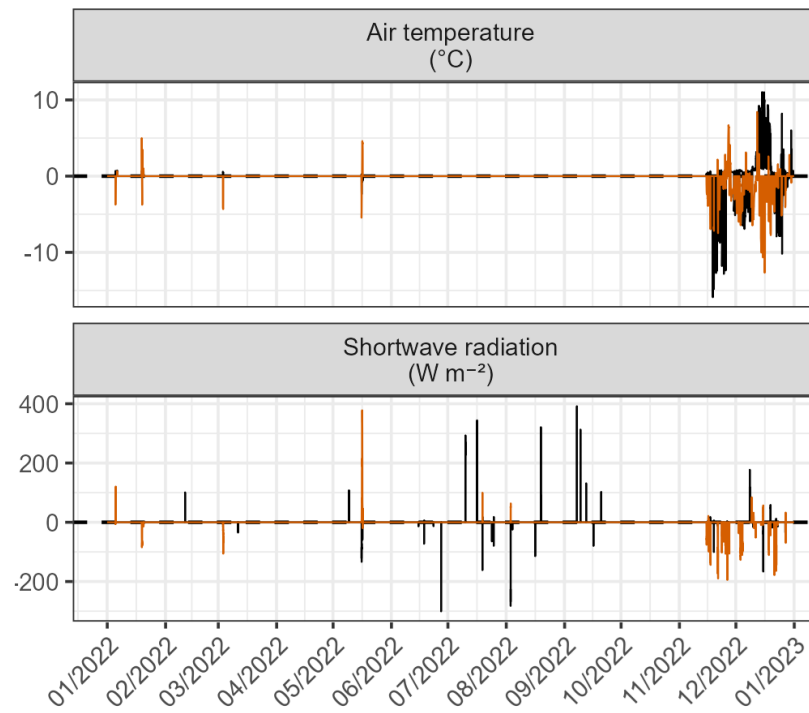
- **Process-based 1D** ecohydrological model
- Subdaily **water** and **energy** flux partitioning
- Detailed **atmosphere–plant–soil** interactions
- Sensitive to forcing data **quality and resolution**
- Input forcing: **TA · P · VPD · WS · SW-IN · G**

# 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

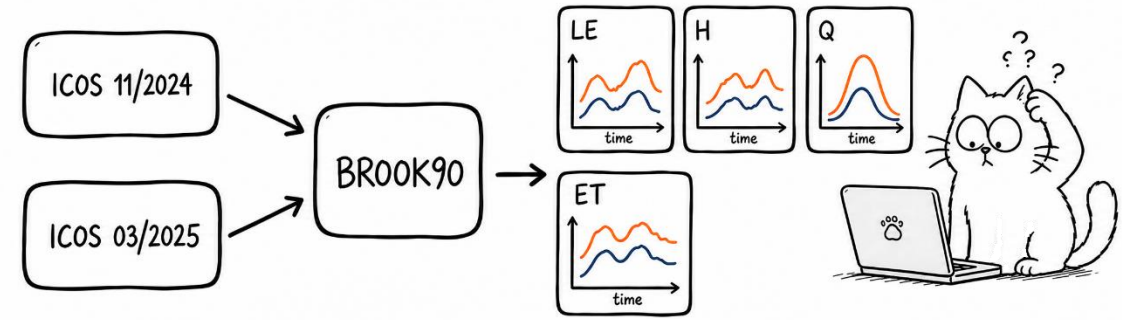


- Changes mainly occur in **gap-filled periods** (MDS and ERA-I)
- **Measured data** (QC=0) stayed unchanged across versions
- **Soil heat flux** was nearly unchanged
- **Max. differences in 2022**

TA 15 °C · VPD 25 hPa · **SW\_IN** 400 W m<sup>-2</sup> · **P** 2 mm · **WS** 6 m s<sup>-1</sup>

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

# Same model Same year Different fluxes

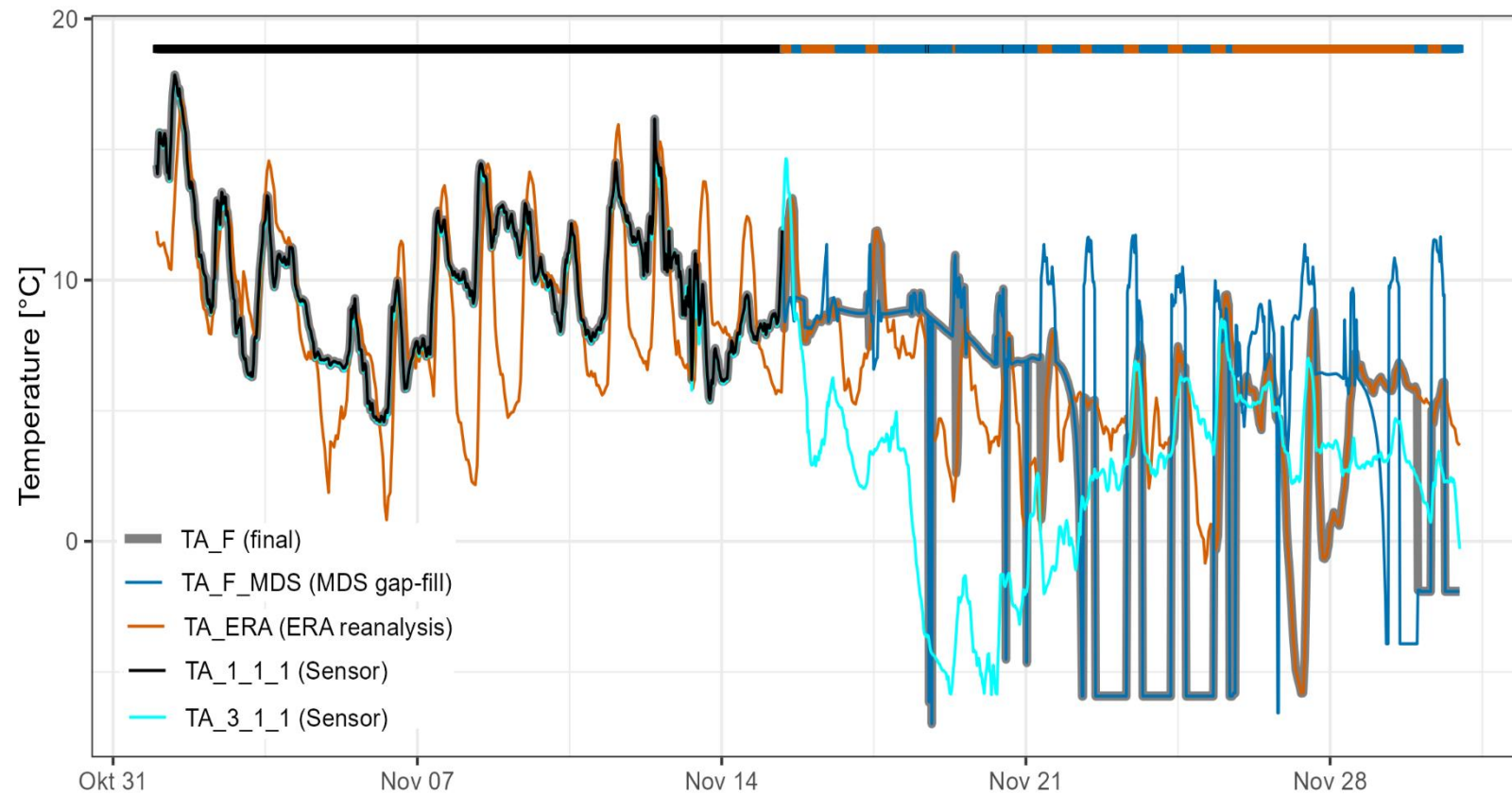


ANNUAL SUMS OF WATER AND ENERGY FLUXES IN **2022**:  
OBSERVED AND SIMULATED WITH TWO VERSIONS ICOS DATA

	Observed		Simulated				
	LE [MJ m <sup>-2</sup> ]	H [MJ m <sup>-2</sup> ]	LE [MJ m <sup>-2</sup> ]	H [MJ m <sup>-2</sup> ]	Interception [mm]	Transpiration [mm]	Soil ET [mm]
<b>Old</b> version (11/2024)	1176	1845	1289	1793	191	291	44.4
<b>New</b> 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



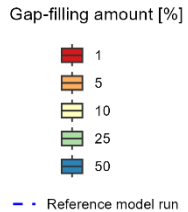
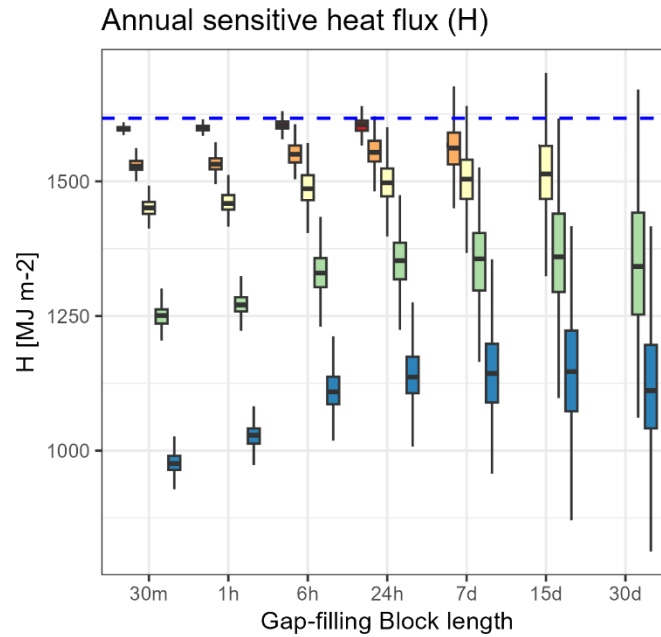
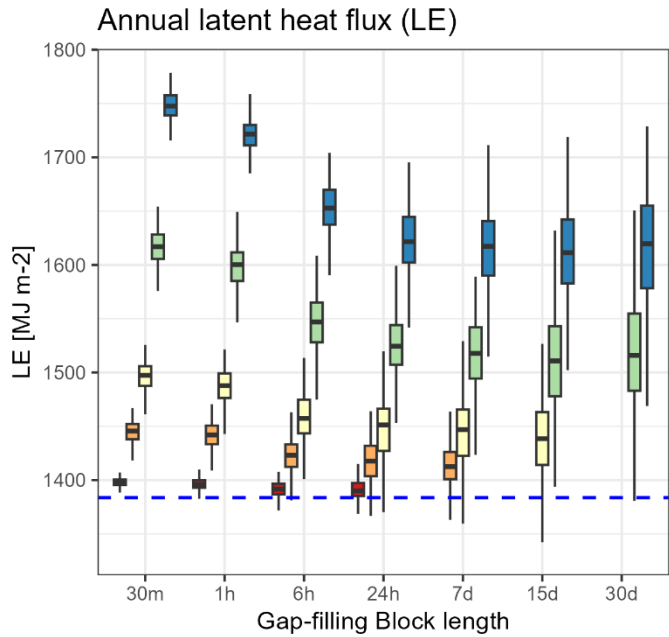
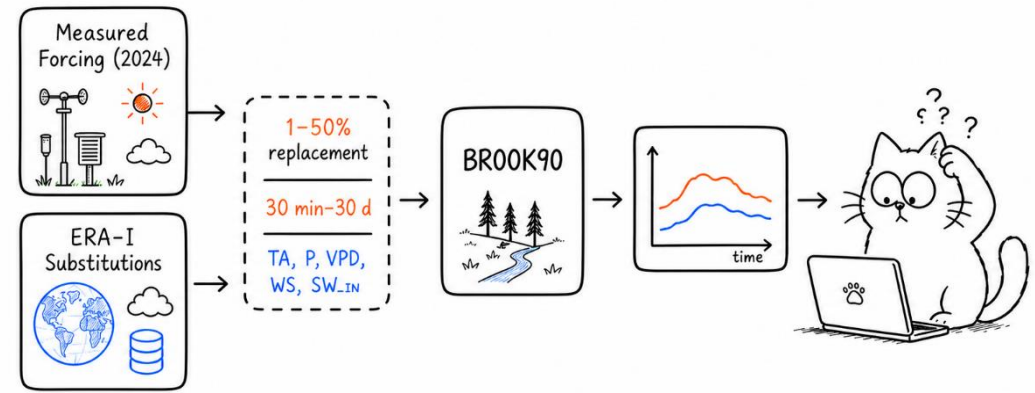
AIR TEMPERATURE AT 42 M, DE-THA, NOVEMBER 2022

- 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<sup>-1</sup>
  - SW\_IN > 500 W m<sup>-2</sup>
  - G > 30 W m<sup>-2</sup>
- Some periods show abnormally **low variability** under ERA-I filling

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

- **Similar artefacts were found at many other ICOS/FLUXNET sites**

# Gap-filling is not just filling the gaps



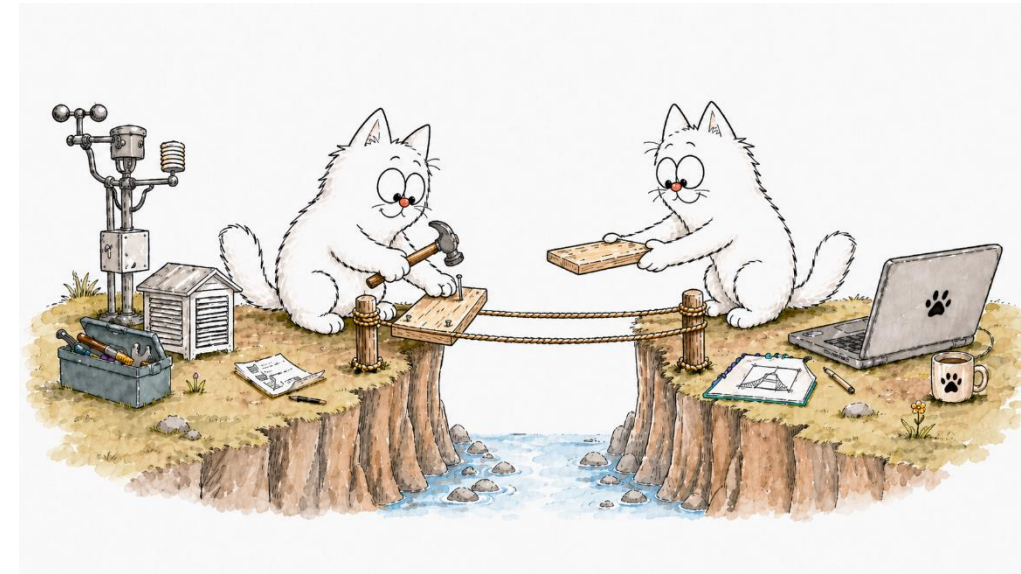
BROOK90 RESPONSE TO MULTIVARIABLE ERA-I SUBSTITUTION IN 2024

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?

