

The background of the slide is a landscape photograph. In the upper half, there are dark, rugged mountains with some snow patches. Below the mountains is a calm body of water that reflects the sky and the mountains. In the foreground, there is a river with many small, winding channels, flowing through a green, marshy area.

# ICOS

● ● ●  
INTEGRATED  
CARBON  
OBSERVATION  
SYSTEM

## IMPROVEMENTS IN MEASUREMENTS AND ENERGY BALANCE CLOSURE

D. Papale, G. Nicolini, M. Op de Beeck, S. Sabbatini, M. Galvagno, B. Gielen, PIs of all the  
ICOS Class1 and Class2 labelled stations

# One of the Eddy Covariance mysteries


The energy balance closure issue

Boundary-Layer Meteorology (2020) 177:395–426  
<https://doi.org/10.1007/s10546-020-00529-6>

RESEARCH ARTICLE



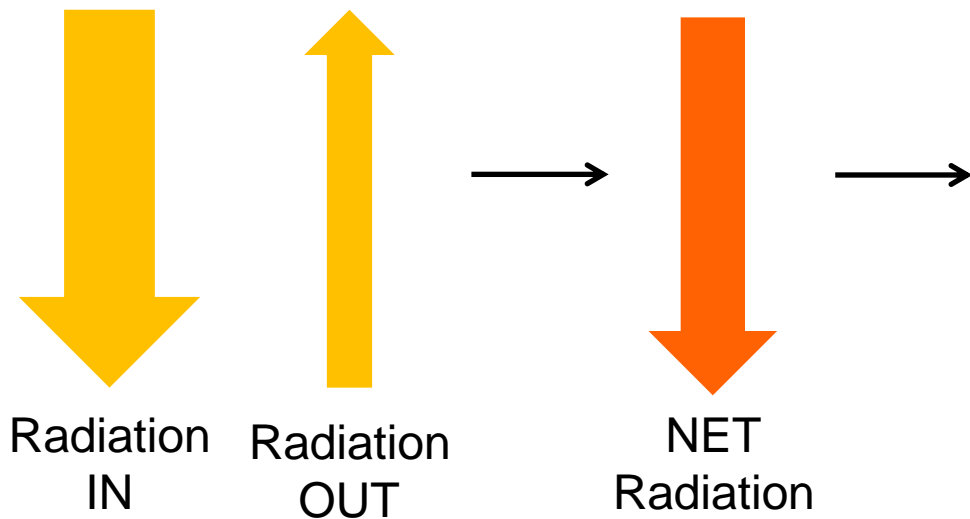
## Surface-Energy-Balance Closure over Land: A Review

Matthias Mauder<sup>1</sup>  · Thomas Foken<sup>2</sup> · Joan Cuxart<sup>3</sup>

Received: 25 November 2019 / Accepted: 2 May 2020 / Published online: 30 May 2020  
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# One of the Eddy Covariance mysteries

The energy balance closure issue



Latent Heat Flux (LE)

Sensible Heat Flux (H)

Heat in the soil (G)

Heat in the biomass

others minor

# One of the Eddy Covariance mysteries

The energy balance closure issue

$$\text{NETRAD} - \text{LE} - \text{H} - \text{G} - \dots = 0$$

# One of the Eddy Covariance mysteries

The energy balance closure issue

$$\text{NETRAD} - \text{LE} - \text{H} - \text{G} - \dots = 0$$

$$\text{NETRAD} - \text{LE} - \text{H} - \text{G} - \dots > 0$$

$$(\text{LE} + \text{H}) / (\text{NETRAD} - \text{G}) < 1$$

# One of the Eddy Covariance mysteries

Many different hypothesis on the reason(s) of the Energy Balance Unclosure

- Sensors and technique related (e.g. flow distortion, RH on water...)
- Calculation limits (e.g. averaging time, corrections...)
- Missing components (e.g. photosynthesis)
- Mesoscale transport

*Want an overview? Read the Mauder 2020 paper...*

# Conclusions

No, we do not have an answer and we didn't manage to close the energy balance



# However...

We can see how much of the EBC issue we can solve or improve through high quality measurements in order to help the research on the still missing part...

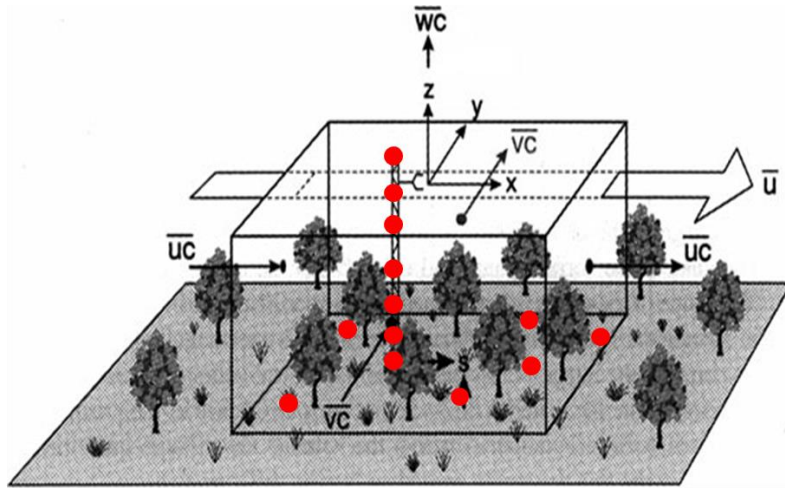


# The ICOS ecosystem network

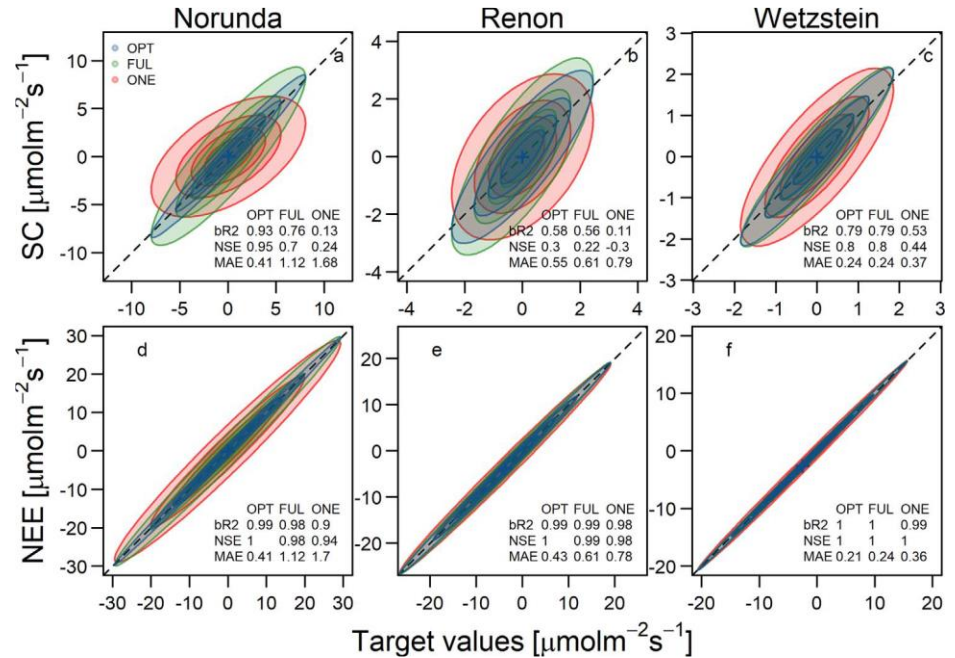
Highly standardized eddy covariance station,  
with the same EC system and

- Vertical profile for storage terms
- Soil Heat Flux and its storage
- Centralized processing

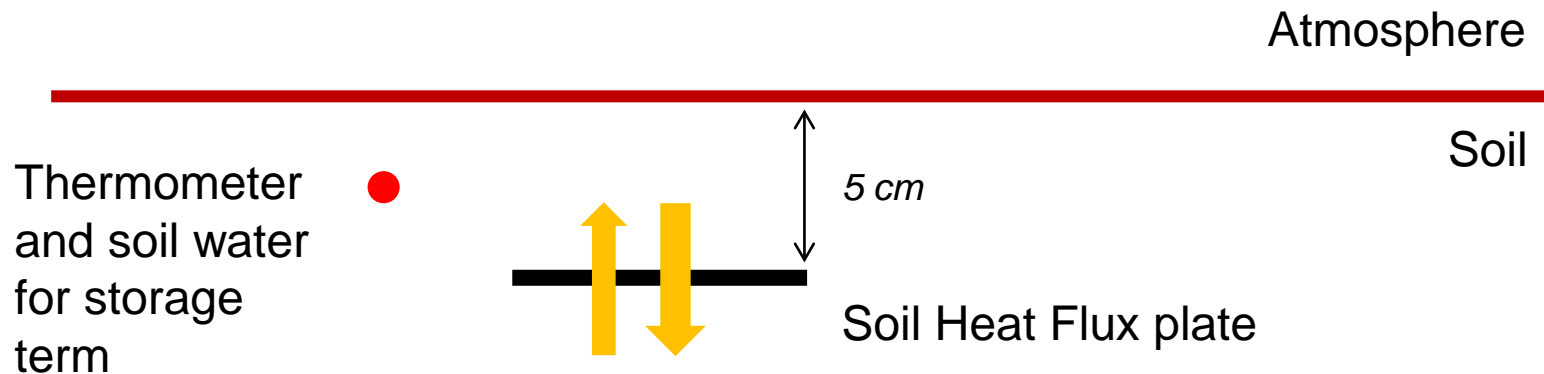
# The ICOS storage profile



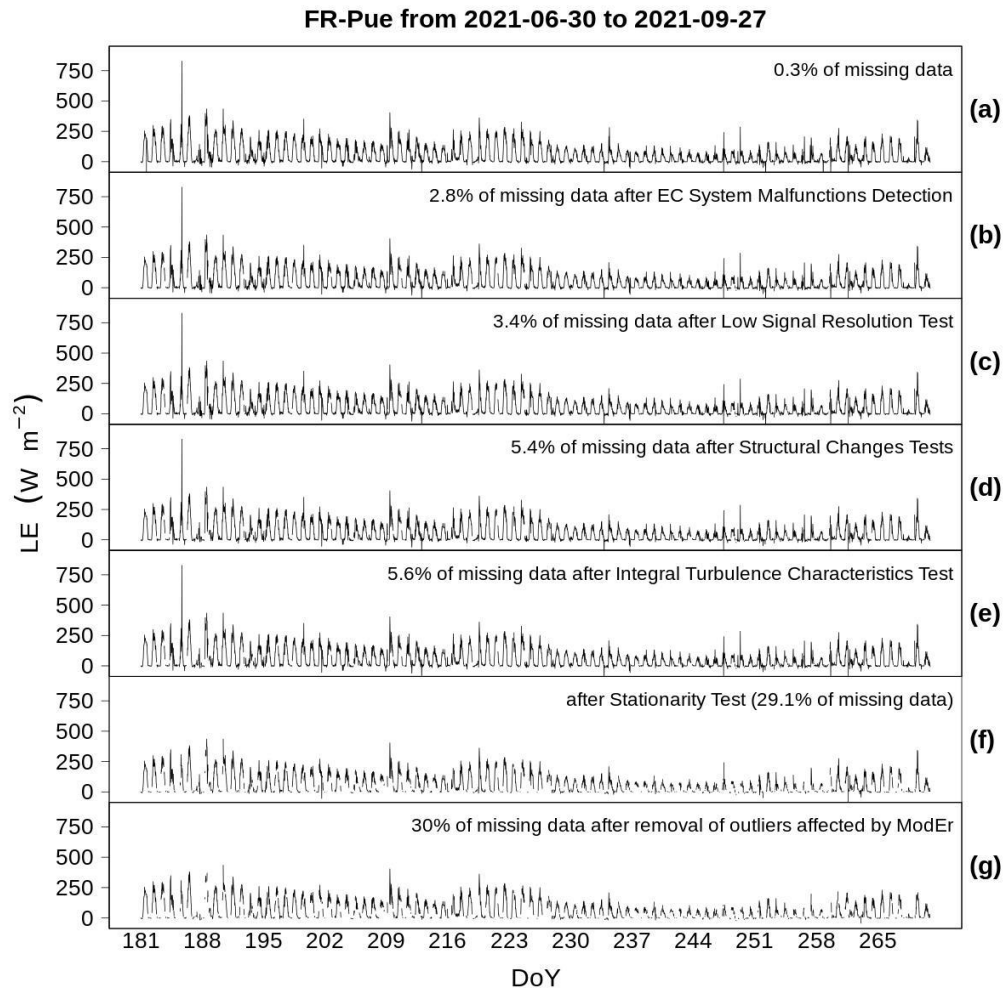
(Finnigan et al. 2003)



# The ICOS Soil Heat Flux



# The ICOS Data filtering



# ICOS Data Used

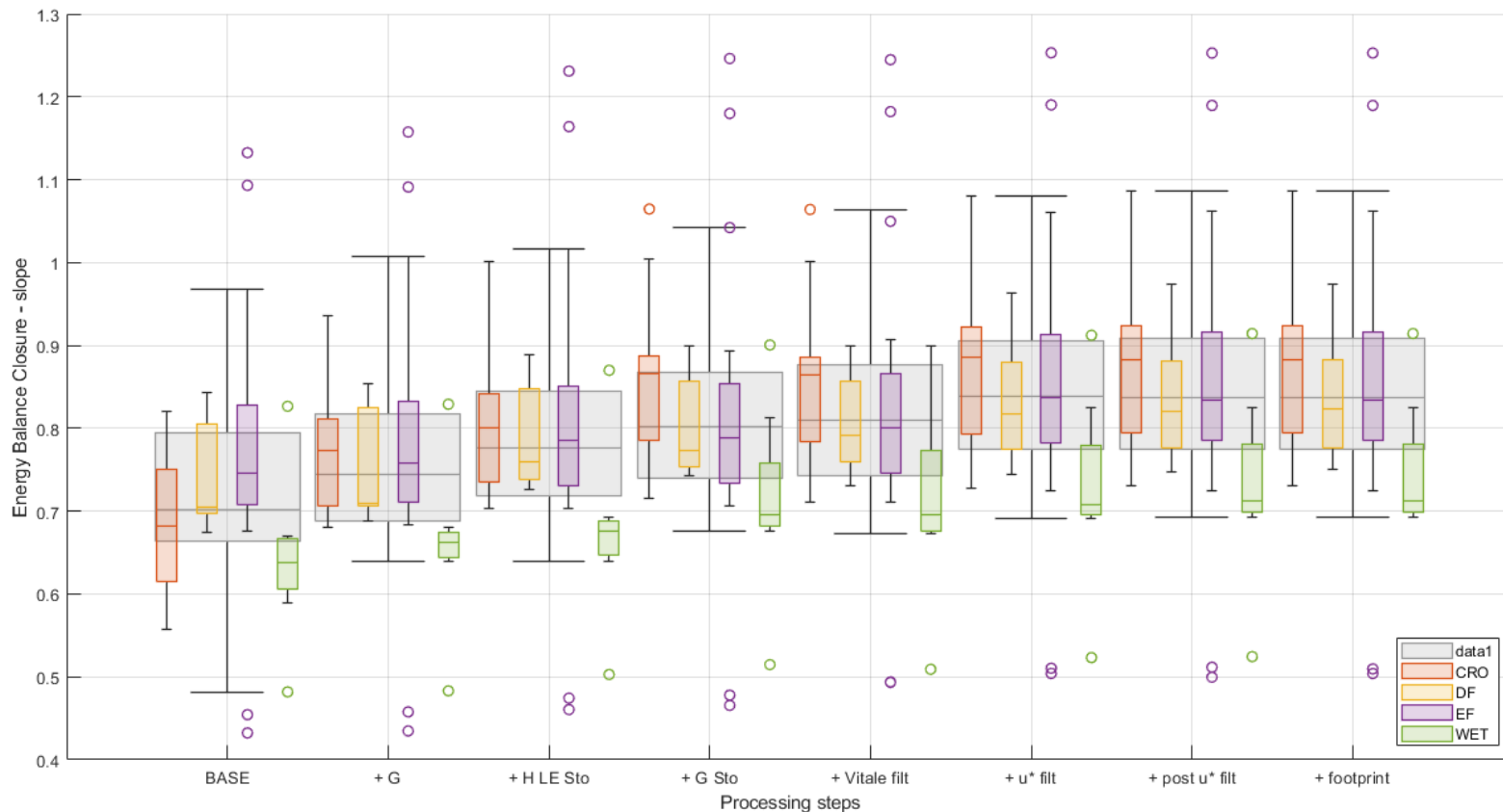
<b>CROPLAND</b>	<i>Site</i>	<b>BE-Lon</b>	<b>BE-Maa</b>	<b>DE-Geb</b>	<b>DE-RuS</b>	<b>DK-Vng</b>	<b>FR-Gri</b>	<b>FR-Lam</b>
	<i>Years</i>	4	3	2	4	2	1	2

<b>DECIDUOUS FOREST</b>	<i>Site</i>	<b>BE-Vie</b>	<b>DE-HoH</b>	<b>DK-Sor</b>	<b>FR-Fon</b>
	<i>Years</i>	2	3	1	3

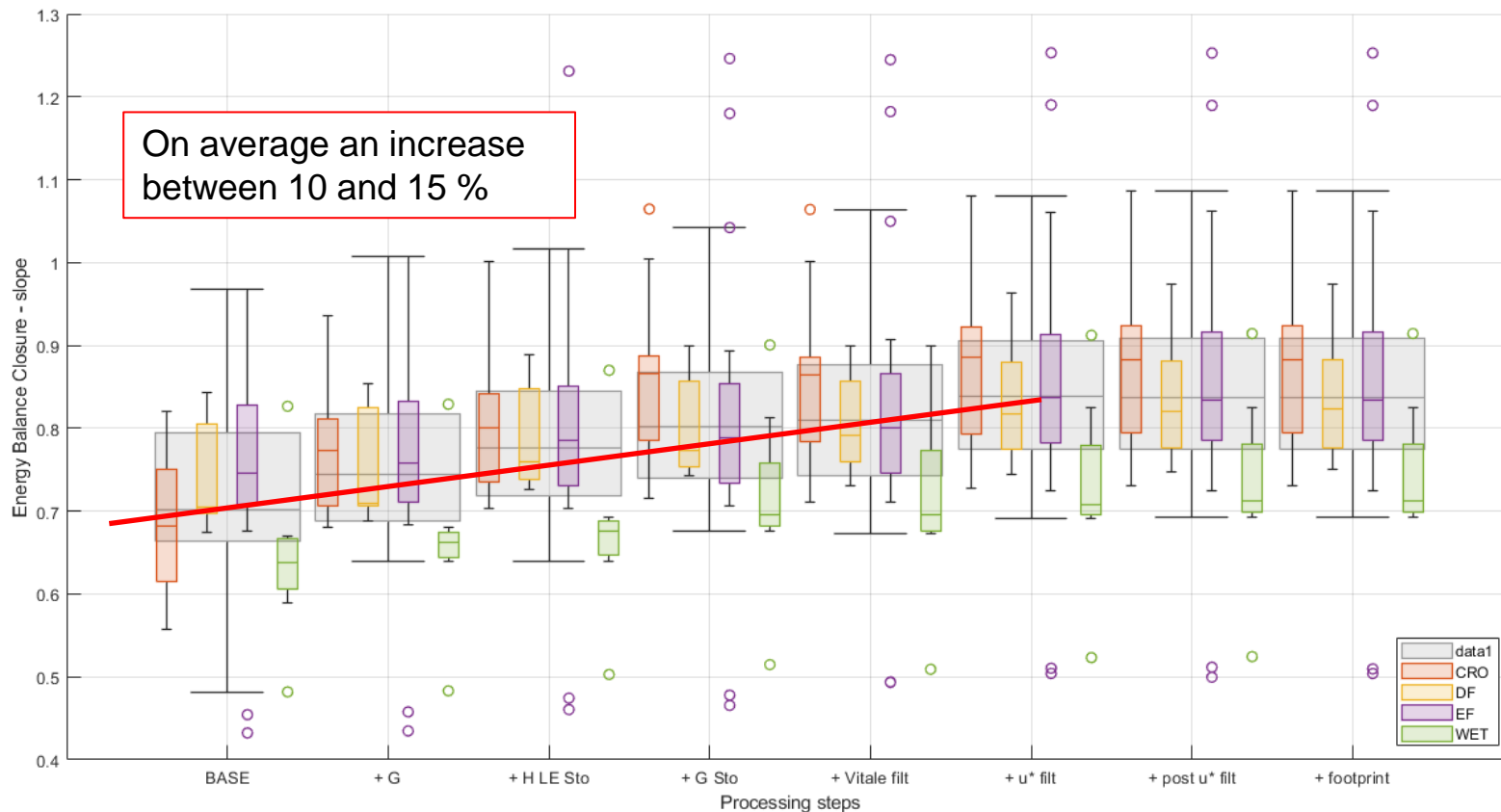
<b>EVERGREEN FOREST</b>	<i>Site</i>	<b>BE-Bra</b>	<b>CH-Dav</b>	<b>DE-Tha</b>	<b>FI-Hyy</b>	<b>FR-Bil</b>	<b>IT-Cp2</b>	<b>IT-SR2</b>	<b>SE-Htm</b>	<b>SE-Nor</b>	<b>SE-Svb</b>
	<i>Years</i>	1	2	1	4	2	2	2	3	3	3

<b>WETLAND</b>	<i>Site</i>	<b>FI-Sii</b>	<b>SE-Deg</b>	<b>UK-AMo</b>
	<i>Years</i>	4	3	1

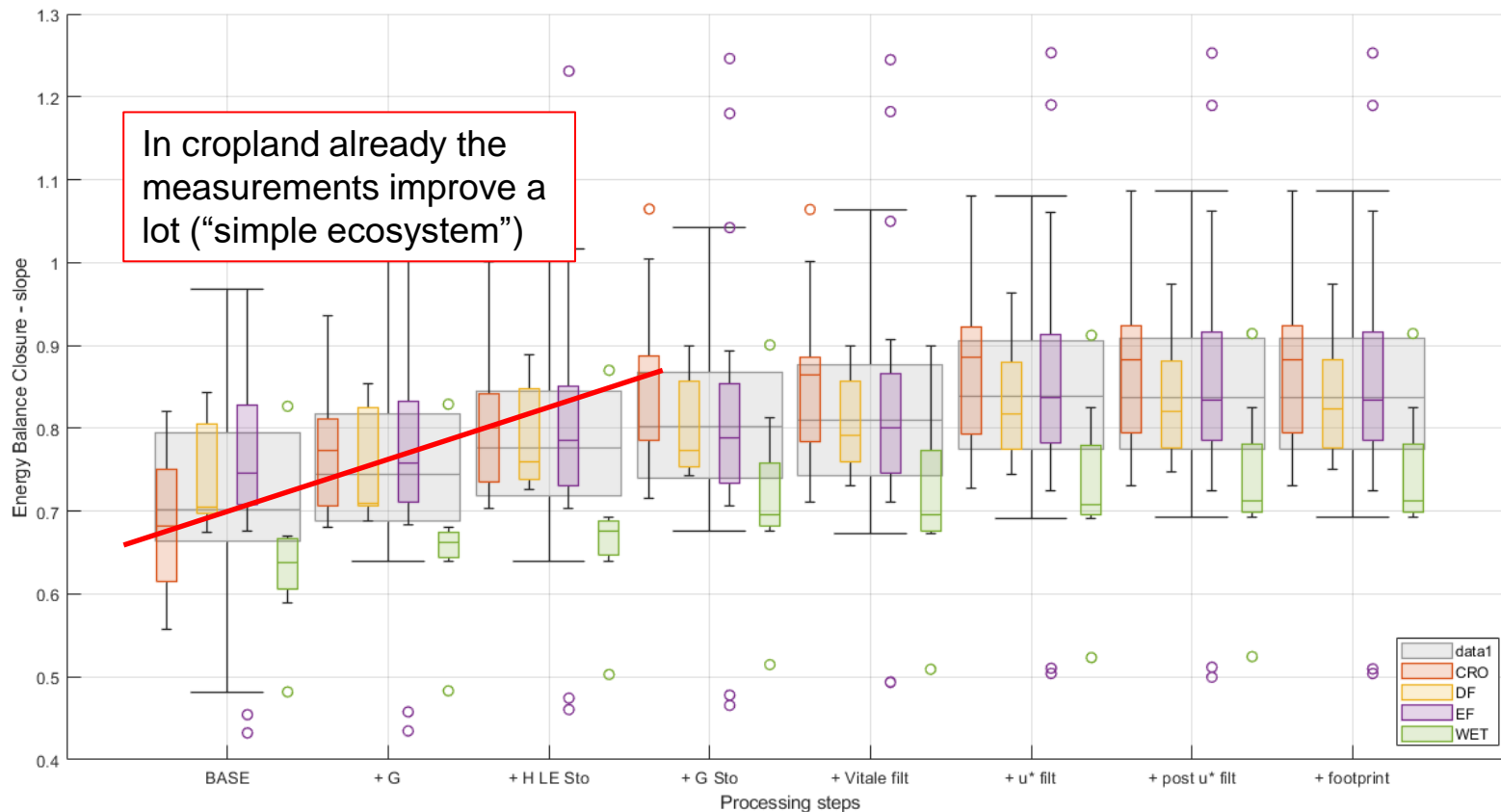
# The EBC development



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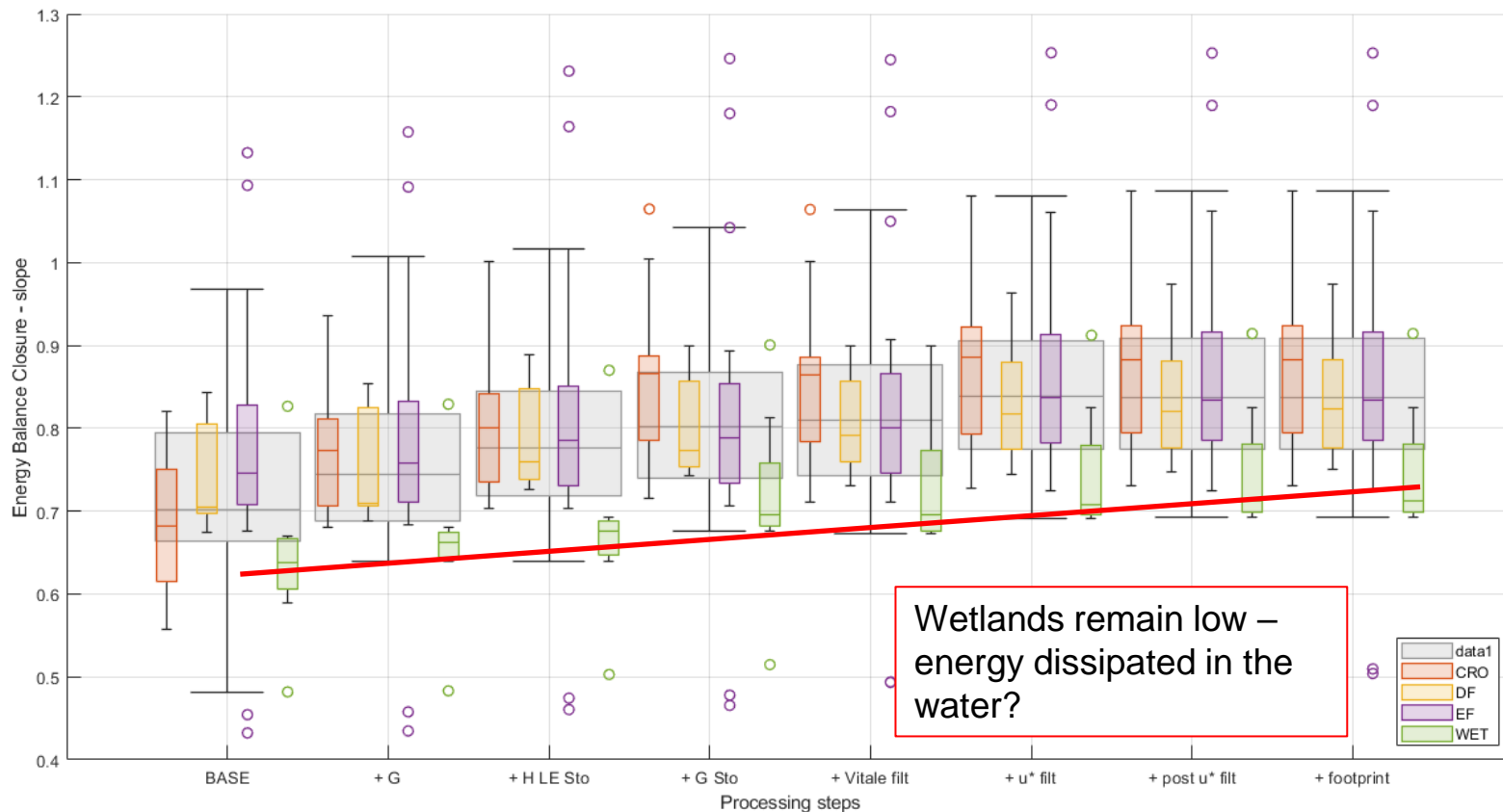


# The EBC development

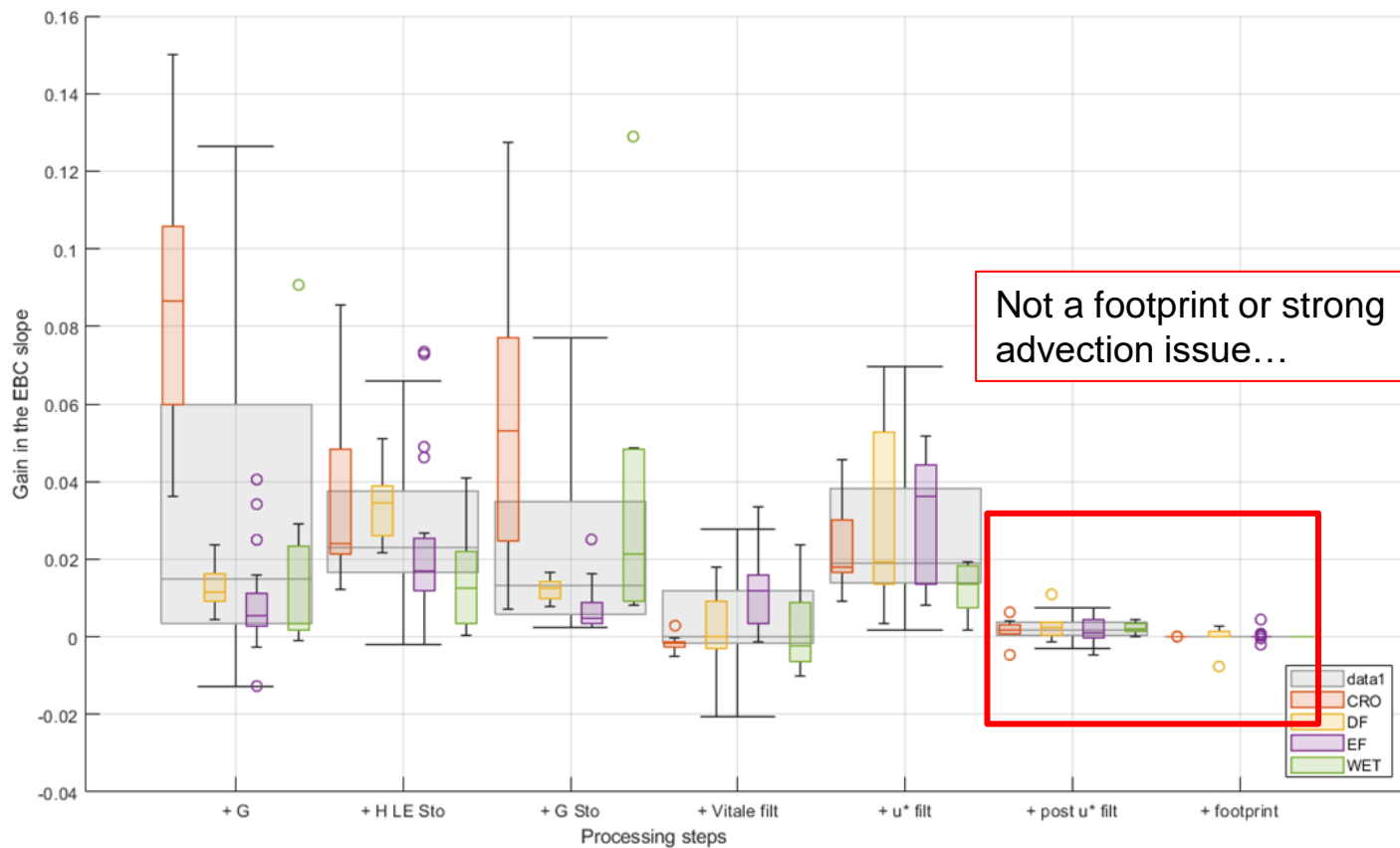




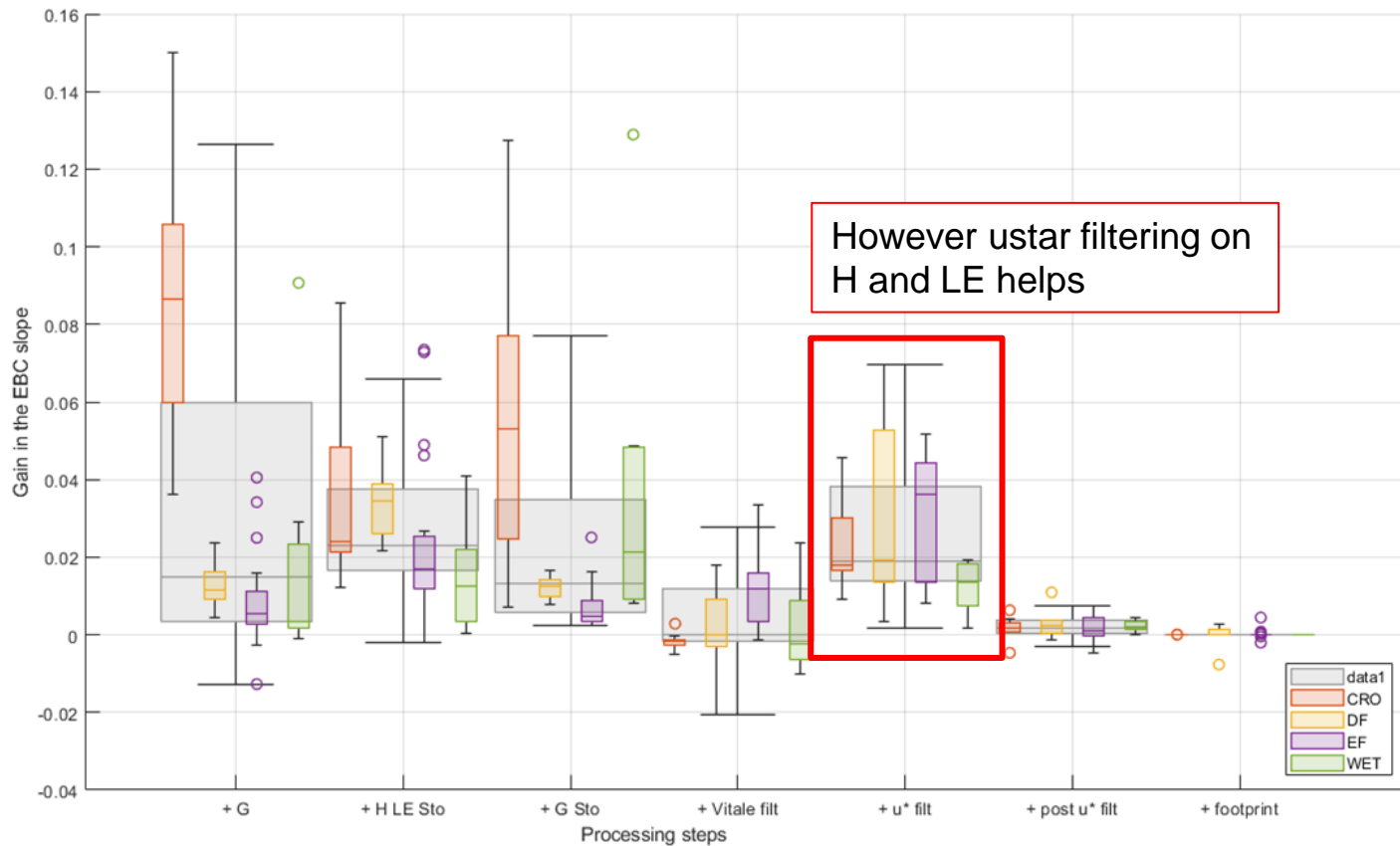
# The EBC development



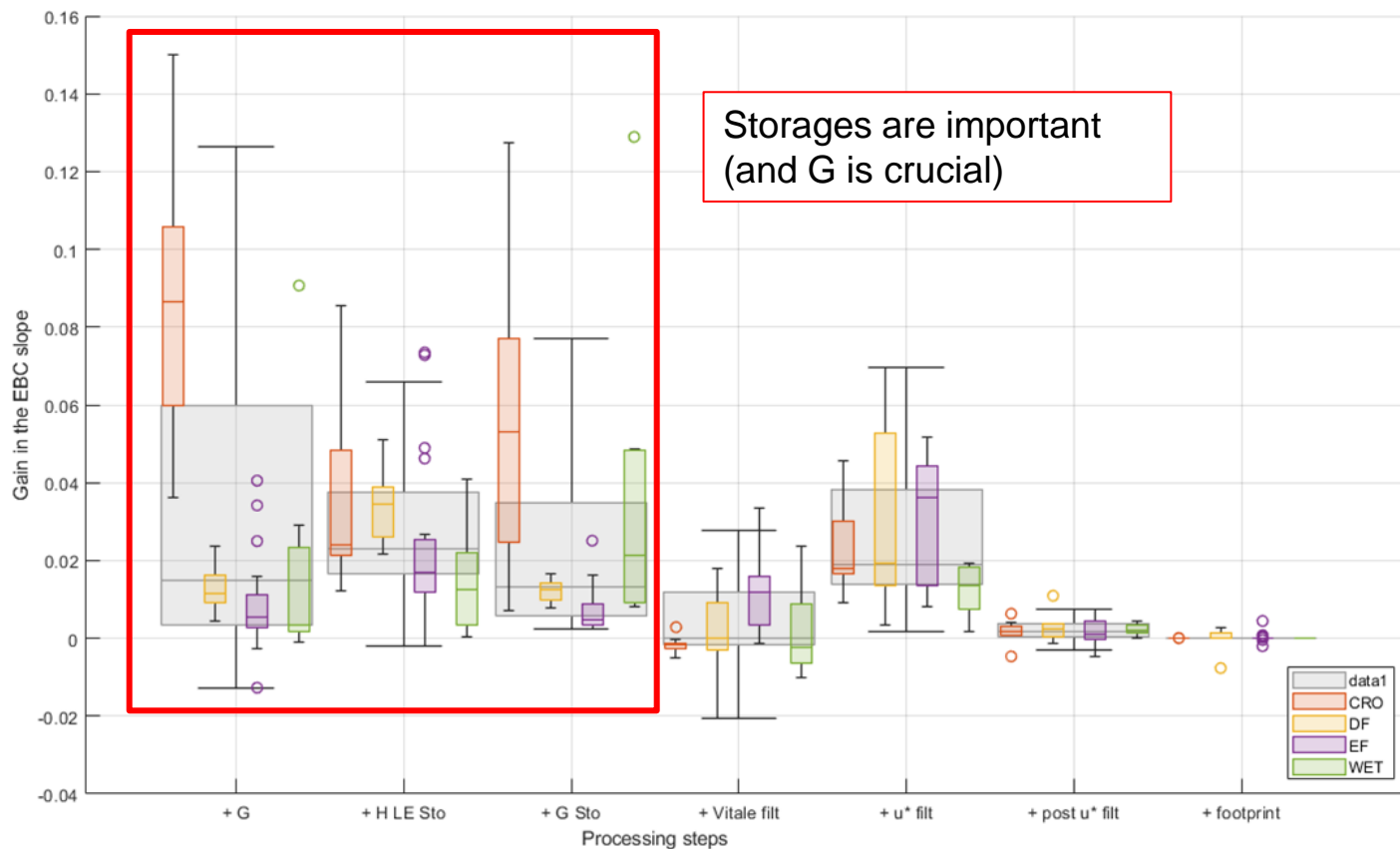
# Which component improves the EBC



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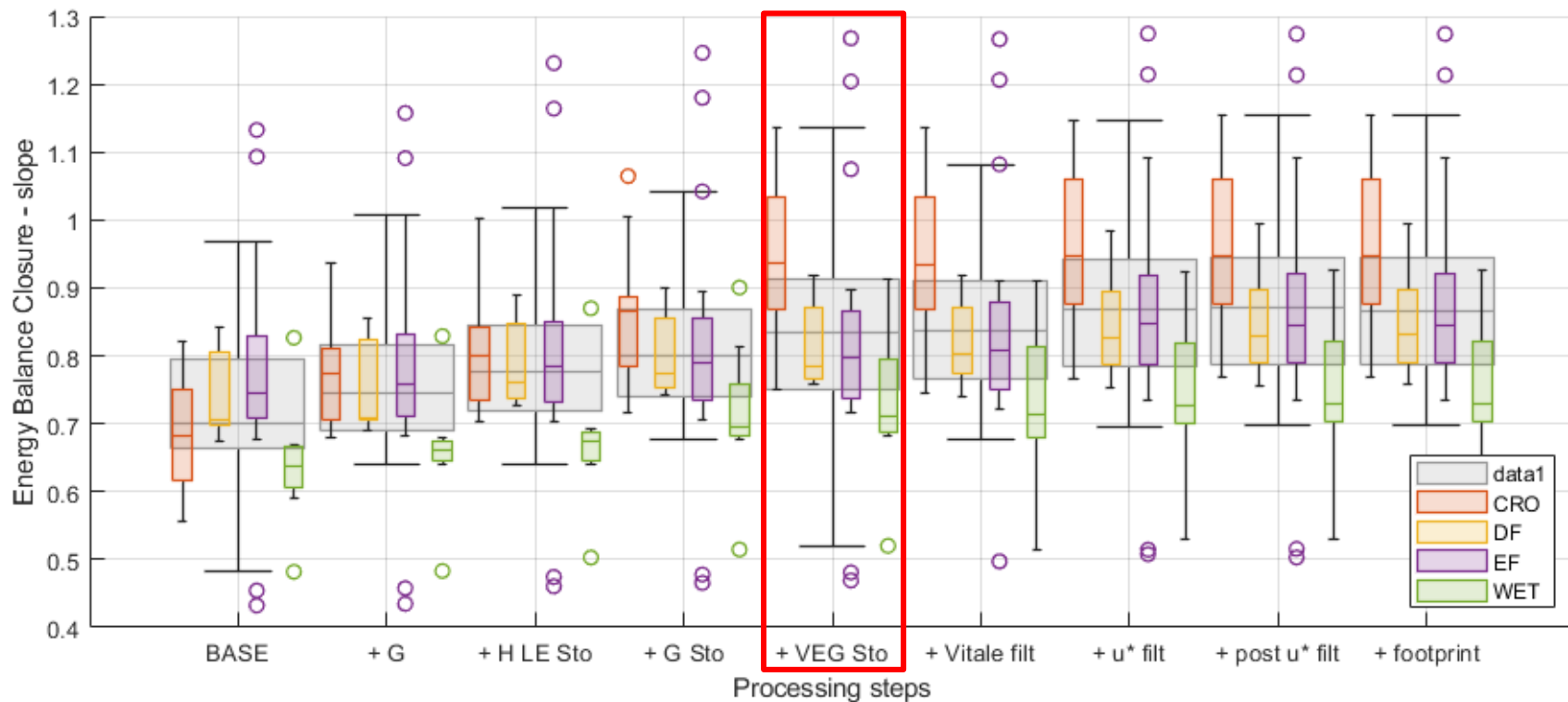


# Which component improves the EBC

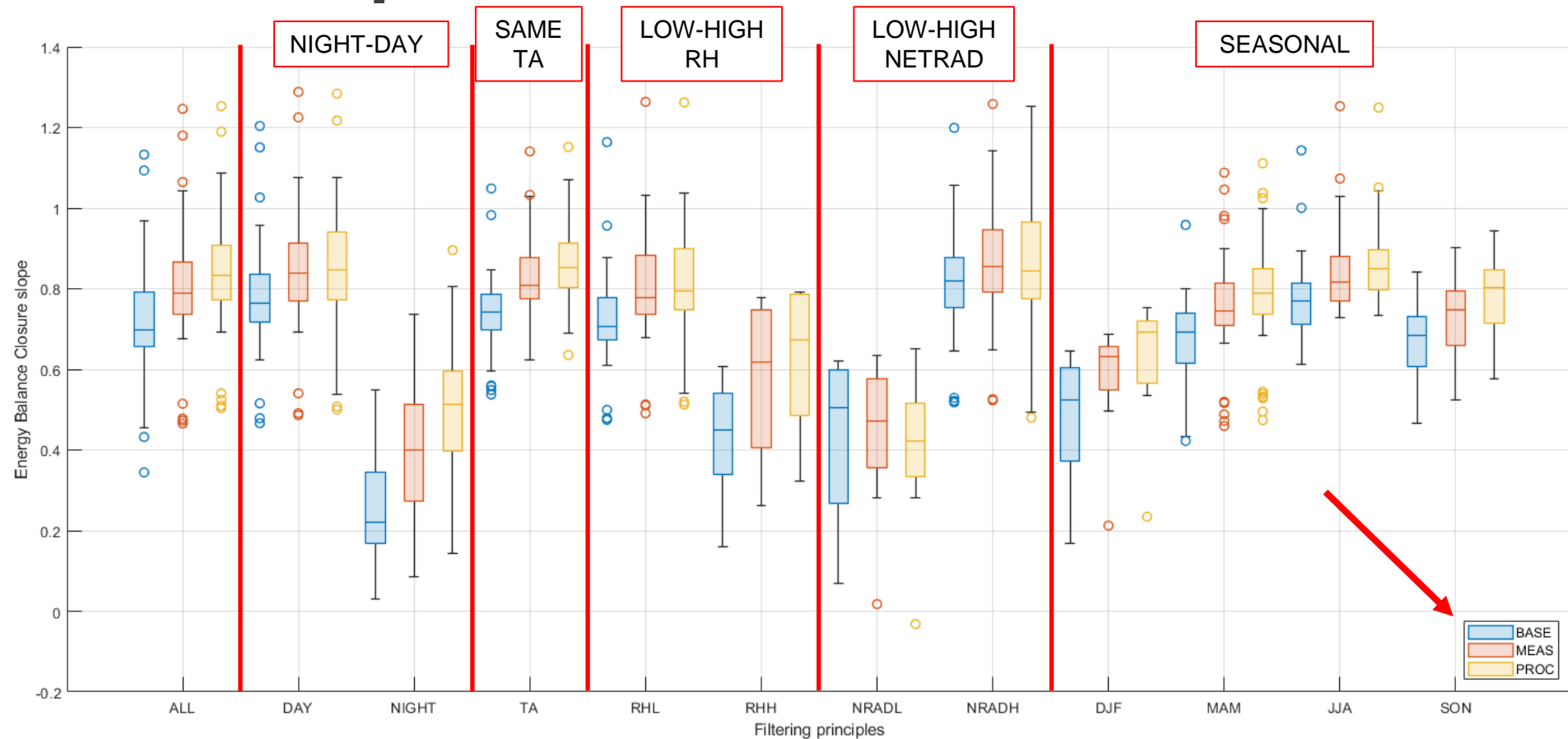


# Adding a proxy of vegetation heat flux

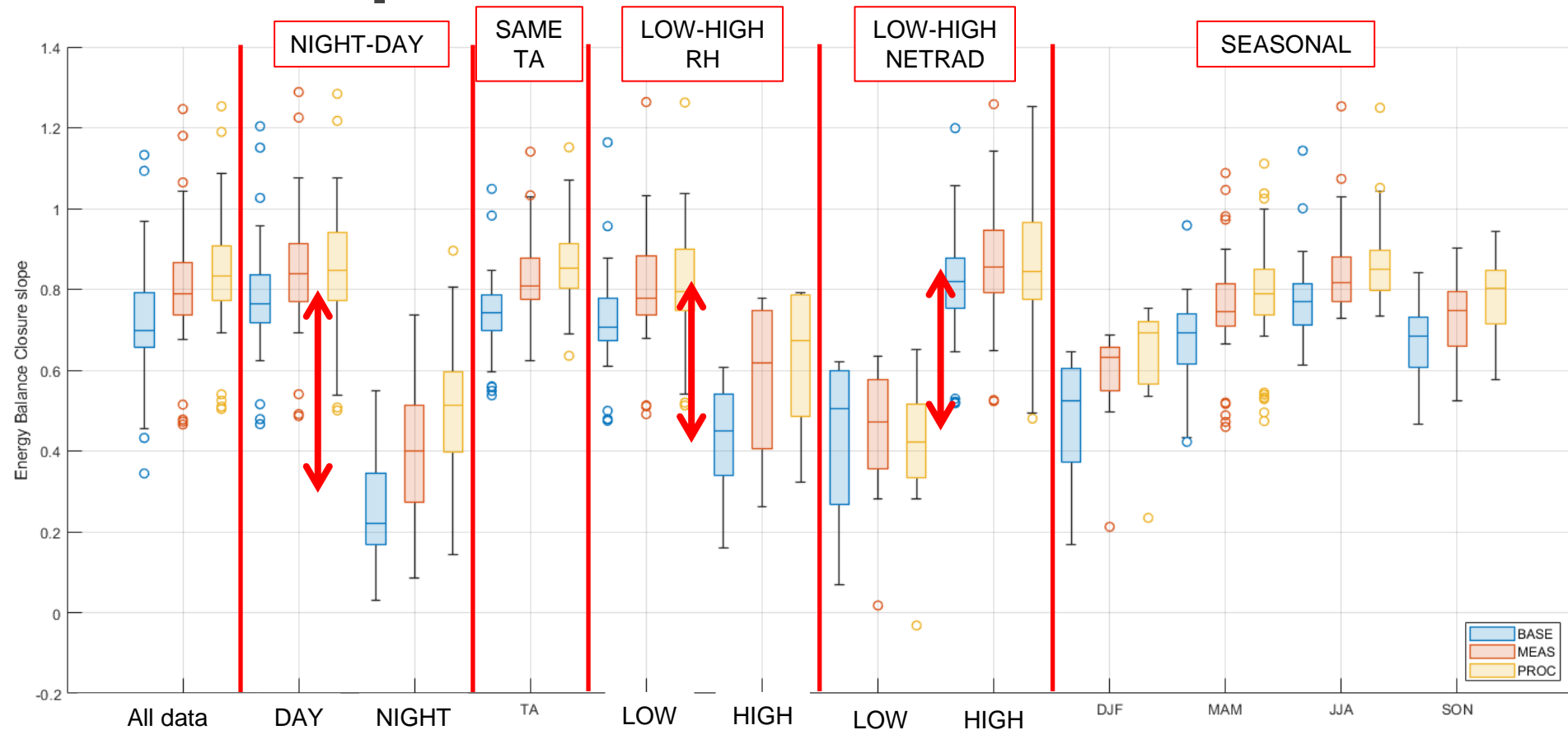
Added 50% of the soil heat flux...



# EBC in specific conditions

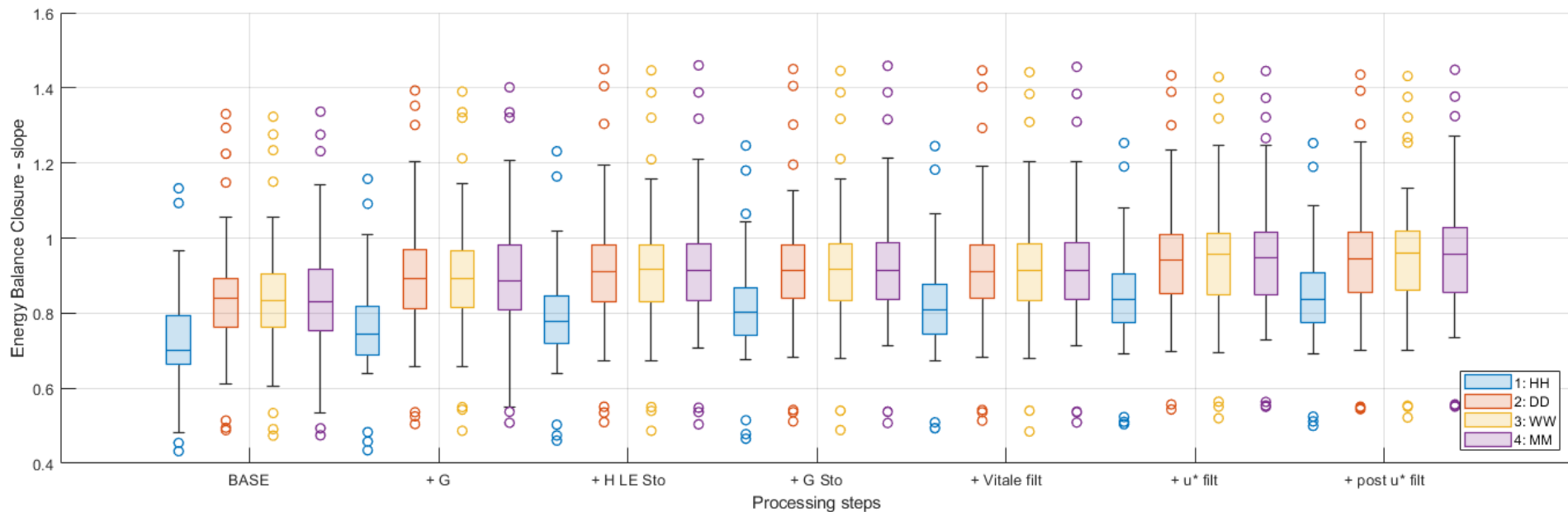


# EBC in specific conditions



# The time scale component

Gapfilled (MDS), so there is also this effect...

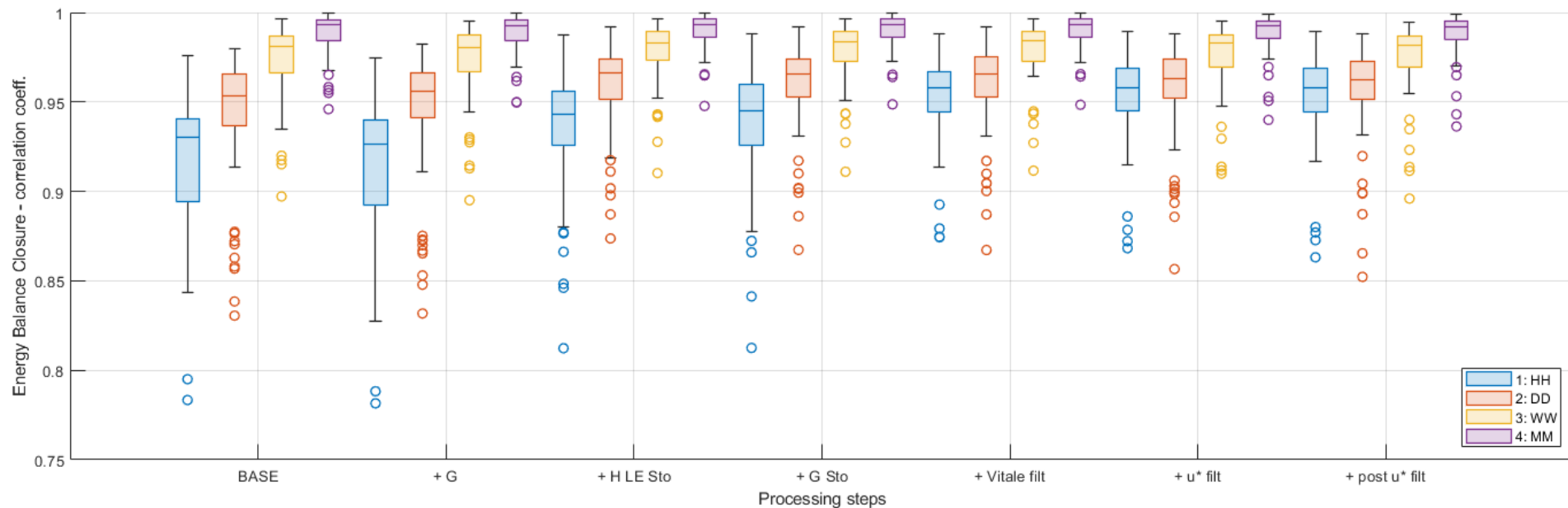


No big differences between daily and monthly, but better than half-hourly

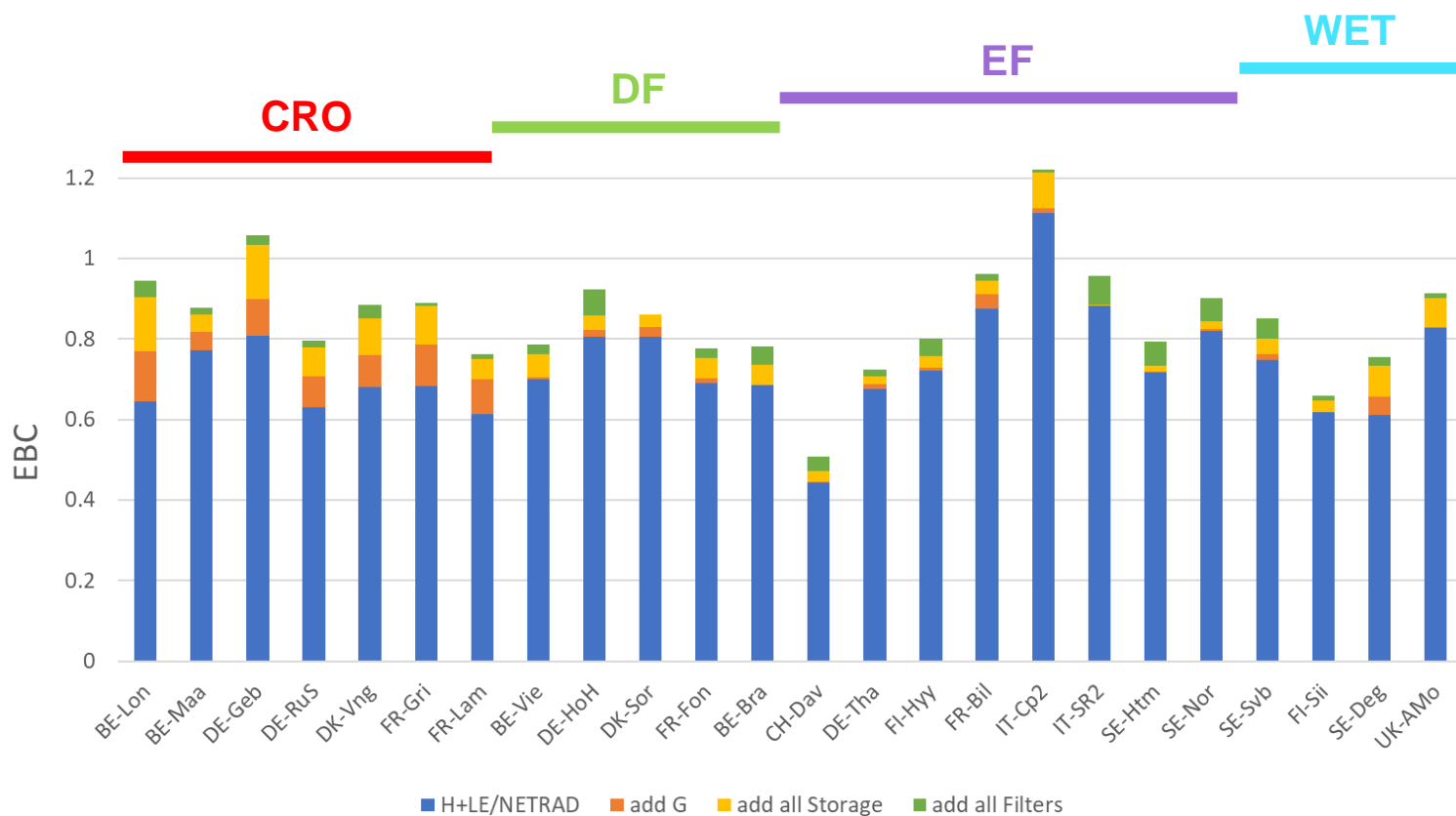
In the DD-MM improvements adding G and filtering for ustar



# The time scale component - correlation



# Inter-site variability (in EBC and components role)



# Conclusions

- Considering the storage components and filtering also LE and H for low turbulence conditions lead to a better closure
- “simpler” ecosystems like cropland in general have a better closure – biomass heat storage?
- In wetland very complex for the water heat transfer
- Aggregating daily already improves the EBC
- Still a lot to do but in a multi-factors issue like this it is crucial to start from the best possible data
- Heterogeneity across sites: a network approach helps

# Do you want to try?

ICOS Data are freely available under CC-BY data license, you visit the ICOS Carbon Portal and download the ICOS products!

[www.icos-cp.eu](http://www.icos-cp.eu)

Or, contact me in case you have ideas and what to participate to this study...

# Thanks

[darpap@unitus.it](mailto:darpap@unitus.it)