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# A comparison of methods for gap-filling sensible and latent heat fluxes in different climatic conditions

Erkka Rinne (erkka.rinne@fmi.fi), Henriikka Vekuri, Mika Aurela & Juha-Pekka Tuovinen

Eddy covariance flux measurements need to be gap-filled when utilising the data for the calculation of annual balances. The measurement technique itself is prone to errors and technical failures may also lead to gaps of various lengths. Gap-filling of the flux time series is typically based on estimating statistically representative values based on various environmental variables through linear regression, lookup tables or machine learning methods.

A large number of methods for the imputation of energy fluxes have been applied and compared in recent literature (Zhu et al., 2022; Mahabbati, 2022; Khan, Jeon, and Jeong, 2021; Foltýnová, Fischer, and McGloin, 2019). Both latent and sensible heat fluxes are strongly driven by the incoming solar radiation, and it is usually used as an independent variable in gap-filling methods. Vekuri et al. (2023) showed that marginal distribution sampling (MDS), a widely used method for gap-filling carbon dioxide fluxes, creates a systematic bias in higher latitudes, where the distribution of incoming radiation is highly skewed.

# Results

- MDS produces a systematic negative error increasing towards higher latitudes for both sensible and latent heat flux, more pronounced during the daytime.
- The modified version, MDS\_DT reduces the systematic error and results in closer to zero biases overall.
- XGB machine learning algorithm performs best of the studied methods.



We assessed the performance of MDS in predicting sensible (H) and latent heat (LE) fluxes and also compared against a machine learning algorithm (XGB) as well as simple linear regression (LR). Measurement data is from the Northern hemisphere sites in the FLUXNET2015 dataset (Pastorello et al., 2020).

## **Gap-filling methods used**

Method	Description	Cross- validation
MDS	Marginal distribution sampling lookup table (Reichstein et al., 2005). Drivers: SW_IN, VPD and TA	Each point
MDS_DT	Modified version of MDS taking into account radiation skewness	Each point
XGB	Gradient boosted decision trees using the eXtreme Gradient Boosting library and a whole year for training (see Vekuri et al., 2023). Drivers: SW_IN, VPD and TA	100 fold
LR	Localised linear regression against incoming radiation, training window at least 20 samples and up to 28 days wide.	20 fold

## Sensible heat flux





- should update the processing pipelines to avoid systematic under- or overestimation of the heat fluxes or evapotranspiration during gap-filling.

 $(o_{i}, o_{j}, o_{i}, o_{j}, o_{j},$ Latitude (degrees north) Latitude (degrees north)

10,0,0,0,0,0,0,0,0,0)

### References

Bias

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