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# Systematic errors in a land surface model across biomes inferred from eddy covariance observations on multiple time scales

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Characterization of model bias in land surface models (LSM) can highlight model deficiencies and provide great insights for model development. In this study, we use neural networks to evaluate the portion of model bias in a particular flux from a land surface model (ORCHIDEE: ORganising Carbon and Hydrology in Dynamic EcosystEms) that can be described as a non-linear function of the simulated flux and simultaneous meteorological drivers. Multi-year flux measurements made over 125 eddy covariance sites, which cover 7 different plant function types (PFTs) and 5 climate groups, provides an excellent opportunity to characterize the model bias in ORCHIDEE. In this study, we determined whether the model bias in five flux variables (H: sensible heat, LE: latent heat, NEE: net ecosystem exchange, GPP: gross primary productivity and Reco: ecosystem respiration) are transferable within and between three different time scales (diurnal, annual and interannual), and between sites (categorized by PFTs and climate groups).

Within each timescale at the site level, the transferability of model bias (or error transferability) is larger for annual and interannual timescales than for the diurnal timescale, but little error transferability is found across timescales in all flux variables examined. Thus, model evaluation at multiple timescales is therefore essential for diagnostics and future development. For all PFTs, variables and timescale components, model bias is found to be transferable between sites within the same PFT and climate group, suggesting that model improvements based on specific eddy covariance sites can be used to enhance model performance at other sites within the same PFT and climate group. However, the transferability of model bias across all PFTs or climate groups is not always found on annual and interannual time scales, in contrast to transferability on diurnal timescales and the original time series. In addition, some error transferability is also found between water and carbon fluxes on both original time series and reconstructed time series on diurnal timescale.