(27-240329-A) **Constraining Biospheric Carbon Dioxide Fluxes by Combined Top-down and Bottom-up Approaches**

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There are large uncertainties in the magnitude and distribution of the net flux of carbon dioxide from the biosphere to the atmosphere, the net ecosystem exchange (NEE). Approaches to estimate NEE can be described by their 'point of view': top-down approaches, usually Bayesian atmospheric inversions, are constrained by atmospheric data and bottom-up approaches which rely on process-based or data-driven models constrained by land-surface observations or through inventories. Both approaches have known strengths and limitations. Top-down models produce estimates of NEE that are consistent with the growth rate and interannual variability of atmospheric CO_2, but lack the ability to resolve fine-scale spatial variability, being highly uncertain at sub-regional scale. Bottom-up data-driven models, such as those trained on eddy-covariance measurements (e.g., FLUXCOM*) match ecosystem-level observations of NEE and provide increasing insight into the spatial variability of NEE, but do not align well with independent estimates of global NEE when upscaled and integrated globally.

Here we combine the two approaches in a single framework, with the goal of combining the strengths from both approaches. We do this by building a data-driven (FLUXCOM-like) model trained on eddy-covariance observations. We then add a second constraint from regional integrals of NEE derived from an ensemble of atmospheric inversions. To achieve this, we implement a statistical modeling structure which can connect the flux density at a limited number of locations within a region to the regional integrals of NEE from atmospheric inversions.

We find that the resulting data-driven flux model with the dual constraint produces spatially robust and globally consistent estimates of NEE. Unlike a top-down approach, the model can be directly compared with the eddy-covariance record, where its accuracy is similar to a model trained only on eddy-covariance data. Regionally and at a global scale, mean NEE and the inferred seasonality are more consistent with top-down and independent estimates of NEE than a pure eddy-covariance based model. This performance across spatial scales demonstrates the potential for combining top-down and bottom-up approaches in a data-driven flux model.

*Nelson, J. A. *et al.* X-BASE: the first terrestrial carbon and water flux products from an extended data-driven scaling framework, FLUXCOM-X. *EGUsphere* 1–51 (2024) doi:10.5194/egusphere-2024-165.

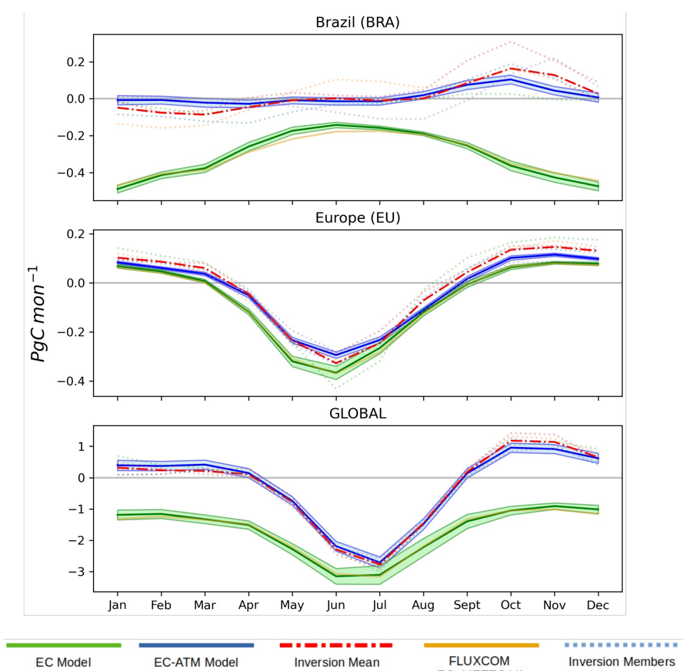

Figure 1. Mean seasonal cycle of ensemble mean of monthly NEE (Pg C per month) for a representative tropical region (Brazil, BRA), extratropical region (Europe, EU), and the globe for the years 2001–2017. The solid line shows the ensemble mean, and the shaded region is the mean ± the ensemble standard deviation.