



Supplement of

Net ecosystem exchange (NEE) estimates 2006–2019 over Europe from a pre-operational ensemble-inversion system

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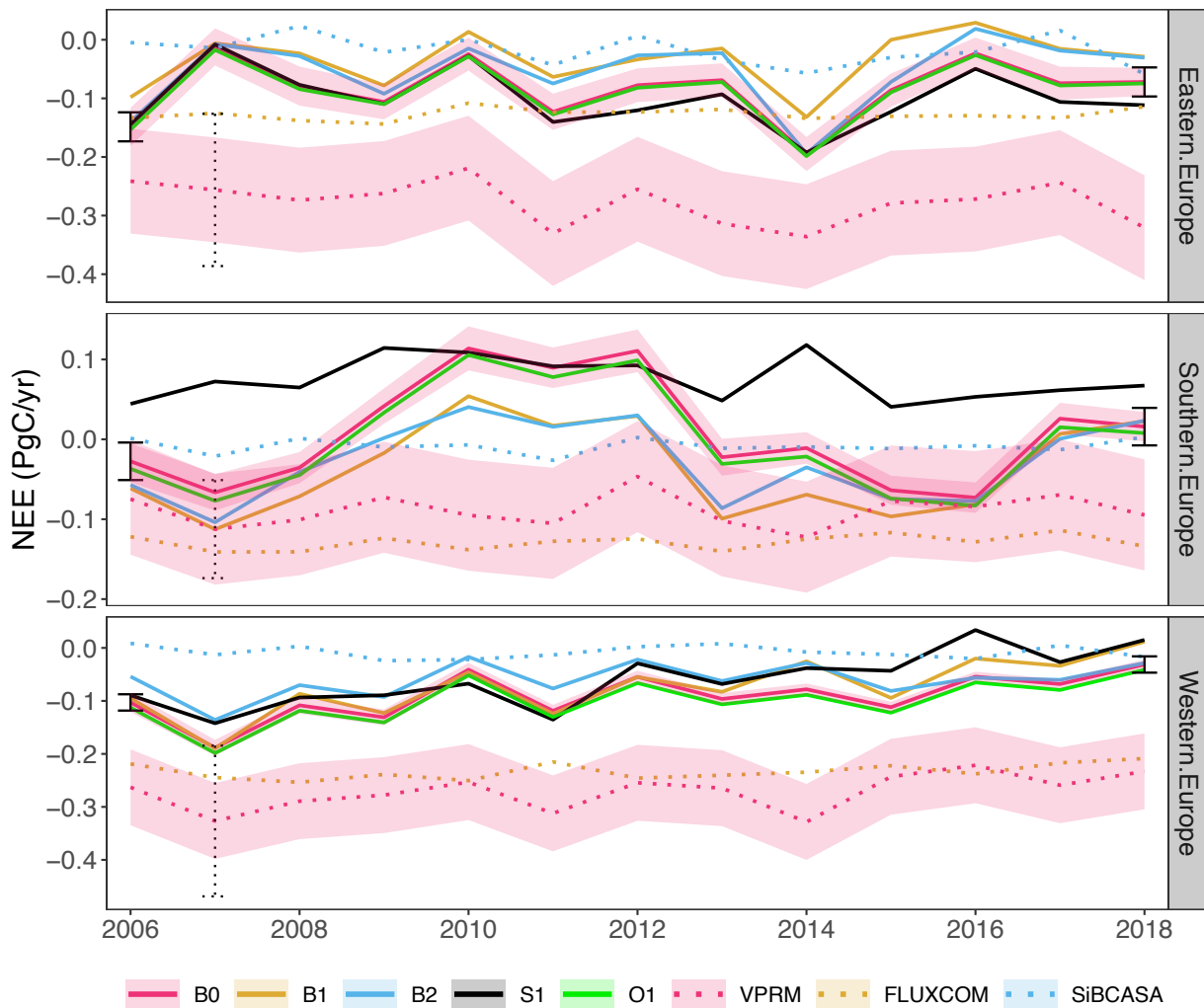
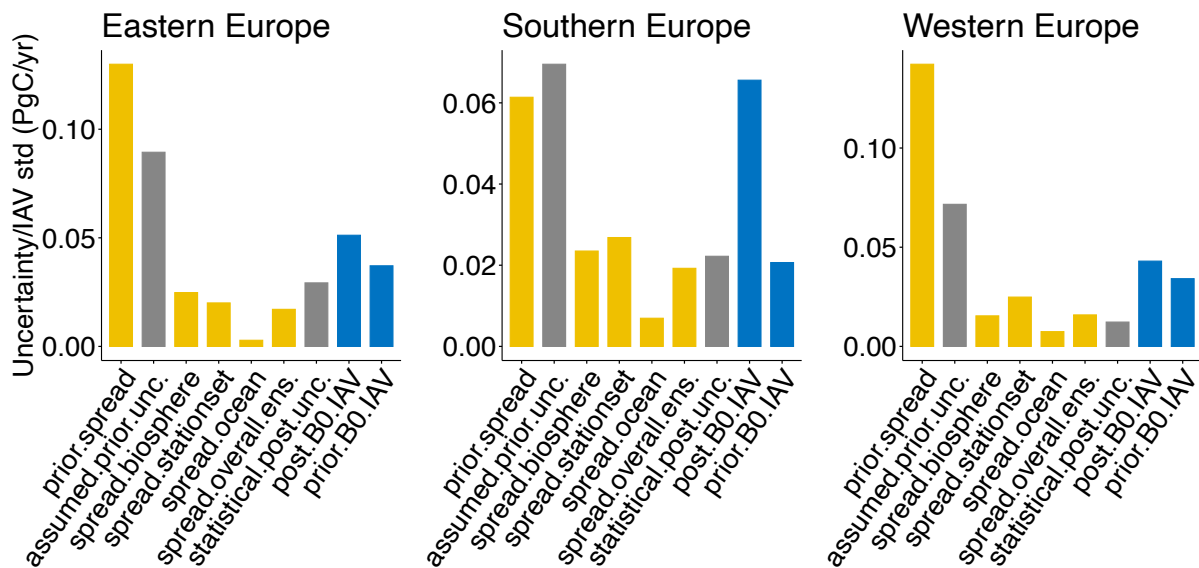


Figure S1: NEE fluxes estimated using B0, B1, B2, S1, and O1 inversions for the 2006-2018 period over Eastern Europe (top), Southern Europe (middle), and Western Europe (bottom). Posterior fluxes are plotted with solid lines and their a-priori in the dotted lines. Priors and posteriors of the biogenic ensemble are distinguished by identical colours for each modelled scenario. Light red shadowing denotes the statistical uncertainty and error bars indicate the spread among the biosphere inversions' ensemble.



10 **Figure S2: Spread uncertainties calculated from 3 inversion ensembles of biosphere, ocean, and station set (yellow bars) over Eastern Europe, Southern Europe, and Western Europe. Grey bars refer to the statistical uncertainties, and blue bars denote the standard deviations of IAV.**

Validation test on posterior IAV

To compare the IAV of posterior flux estimates with independent results, we include flux estimates from the EUROCOM project results reported in Monteil et al. (2020) calculated from LUMIA inversion for the domain of Europe (identical with the domain of our results). Figure S3 shows the anomalies of posterior NEE estimated using B0 set-up of the CSR inversions (shown in Fig. S3 as “csr”) and LUMIA inversion over 10 years (2006-2015) as an overlapping time with the EUROCOM results. The IAV indicates good agreement between both independent estimates over the full domain of Europe, although there are differences between both models such as: 1) definition of measurement and prior uncertainties, 2) atmospheric transport models, 3) prior flux models, and 4) number of observational sites. This finding confirms that the posterior IAV is data-driven. Therefore, the response of biosphere fluxes to climate variations can be inferred from the atmospheric signal through the inverse modelling tools. Petrescu et al (2021) have also conducted a comparison on NEE estimates calculated using ensembles of inversions within EUROCOM, GCB 2019, and CarboScopeReg (CSR) for the overlapping period of time. They show the IAV of NEE estimated from both bottom-up and top-down models over the EU27+UK regions.

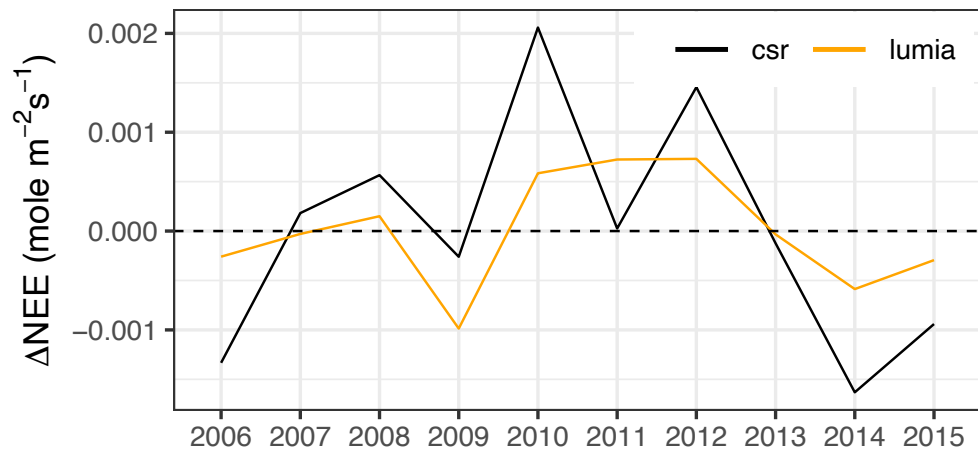


Figure S3: Anomalies of NEE estimated using: 1) B0 set-up of the CSR inversions (black line, csr) and 2) LUMIA inversion (orange line, lumia) conducted by Monteil et al, (2020) through EUROCOM study. LUMIA fluxes are downloaded from the ICOS Carbon Portal (<https://doi.org/10.18160/G068-1T09>).