Geophysical Research Abstracts
Vol. 17, EGU2015-12160, 2015
EGU General Assembly 2015

Towards an purely data driven view on the global carbon cycle and its spatiotemporal variability

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Constraining carbon (C) fluxes between the Earth's surface and the atmosphere at regional scale via observations is essential for understanding the Earth's carbon budget and predicting future atmospheric C concentrations. Carbon budgets have often been derived based on merging observations, statistical models and process-based models, for example in the Global Carbon Project (GCP). However, it would be helpful to derive global C budgets and fluxes at global scale as independent as possible from model assumptions to obtain an independent reference. Long-term in-situ measurements of land and ocean C stocks and fluxes have enabled the derivation of a new generation of data driven upscaled data products. Here, we combine a wide range of in-situ derived estimates of terrestrial and aquatic C fluxes for one decade. The data were produced and/or collected during the FP7 project GEOCARBON and include surface-atmosphere C fluxes from the terrestrial biosphere, fossil fuels, fires, land use change, rivers, lakes, estuaries and open ocean. By including spatially explicit uncertainties in each dataset we are able to identify regions that are well constrained by observations and areas where more measurements are required. Although the budget cannot be closed at the global scale, we provide, for the first time, global time-varying maps of the most important C fluxes, which are all directly derived from observations. The resulting spatiotemporal patterns of C fluxes and their uncertainties inform us about the needs for intensifying global C observation activities. Likewise, we provide priors for inversion exercises or to identify regions of high (and low) uncertainty of integrated C fluxes. We discuss the reasons for regions of high observational uncertainties, and for biases in the budget. Our data synthesis might also be used as empirical reference for other local and global C budgeting exercises.