The impact of long-term historical warming on the global terrestrial gross primary production

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The recent increase of carbon dioxide in the atmosphere from anthropogenic emissions resulted in the increase of carbon uptake by the global biosphere. The most uncertain contributor to the interannual global uptake variability is land, and the largest and primary land carbon flux is gross primary production (GPP). In this study, we aim to estimate the impact of the long-term (1951–2010) historical warming on the global terrestrial GPP. We use the Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data (BEAMS ver.1.3) [*Sasai et al.*, 2016] forced by historical and nonwarming simulation climates of the Database for Policy Decision making for Future climate change (d4PDF) [*Mizuta et al.*, 2017]. This is a pioneer study to apply a diagnostic GPP estimation approach on the large-size ensembles climate data to simulate the long-term global GPP.

First, we evaluated the surface d4PDF climatology in comparison with existing modern datasets, including reanalyses, and discussed the benefits and limitations of the database in the studies of the terrestrial carbon fluxes. Second, we validated the BEAMS GPP forced by d4PDF data against observations and evaluated the BEAMS performance against existing GPP grid-datasets by other approaches (data-driven datasets and process-driven models). Finally, we discussed the impact of the long-term historical warming on the global GPP in terms of decadal trends and density histograms.

We confirmed that d4PDF surface climatology is appropriate for use in the studies of the terrestrial carbon fluxes, and d4PDF historical climate data is comparable to existing modern datasets. BEAMS estimated both the magnitude and decadal trends of the global terrestrial GPP realistically by using the benefits of the diagnostic approach. The global long-term (1951–2010) mean GPP equaled 144.0 ±2.3 GtC $year^{-1}$ for historical and 140.3 ±1.3 GtC $year^{-1}$ for nonwarming climates. The accumulated increase of the historical warming-induced GPP equaled 184.8 ±5.8 GtC for the period of 1951–2010 and accounted for nearly half of all anthropogenic emissions. The GPP increase intensified over time. The density histogram analyses showed that the global GPP distribution in the present (2001–2010) share neither the mean nor spread of GPP in the nonwarming climate.
This study provides the evidence of the impact of long-term historical warming on the global GPP by a novel approach using the benefits of the diagnostic model and large-size ensemble climate data.

Keywords: GPP, climate change, BEAMS, diagnostic approach, large-size ensemble, d4PDF

