Carbon balance shifts controlled by land use change and ENSO in Southeast Asia

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Human activity and climate variability induce large variations in net carbon flux in the pantropics, shifting the direction of flux either to the land or to the atmosphere. In Southeast Asia, land use change (LUC) emissions account for a major fraction globally and climatic conditions are directly influenced by El Niño Southern Oscillation (ENSO). However, the variability of net carbon flux in Southeast Asia is not fully understood, and there has been no detailed studies addressing effects of the LUC and climate on flux variability. In this study, we used multiple terrestrial biosphere models and atmospheric carbon dioxide (CO_2) inversions to investigate the decadal variability of net carbon flux in Southeast Asia over the past 30 years, with an aim to identify underlying factors controlling the decadal variability of net carbon flux. We show that terrestrial biosphere models, which consider LUC, yield an interannual and decadal variability of net carbon flux that are consistent with the result of atmospheric CO_2 inversions, indicating trends towards a net source from the 1980s to the 1990s, and towards a net sink from the 1990s to the 2000s. We found that increased LUC emissions during the 1990s was the major attribution for the trend found in the period 1980s–1990s, and the absence of strong El Niño events during the 2000s was the cause for the trend towards a net sink in the period 1990s–2000s. Our findings suggest that increases in temperature, associated with El Niño events, induce a strong carbon release in Southeast Asia, giving rise to large anomalous emissions in 1982/1983, 1987/1988, and 1997/1998. A further analysis suggests anomalous carbon emissions by recurring strong El Niño events after 2009, which in turn implies that net carbon flux in the 2010s may shift again towards a net source if LUC emissions are not suppressed.

Keywords: Carbon Balance, Southeast Asia, El Nino, Land Use Change

