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Strong carbon sink of monsoon tropical seasonal forest in Southern Vietnam

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Comparison between anthropogenic emission of carbon dioxide and atmospheric carbon pool change displays that only half of emitted CO_2 remains in air, leaving so-called ‘missing sink’ of carbon. Terrestrial biosphere and ocean accumulate each about a half of this value (Gifford, 1994). Forest biomes play the decisive role in ‘missing sink’ because of high primary production flux and large carbon pool. Almost all the sink belongs to boreal forests, because warming and wetting coupled with increasing CO_2 concentration and N deposition gives more favorable conditions for boreal ecosystems. On the contrary, tropical climate changes effect on forests is not obvious, probably cause more drought conditions; tropical forests suffer from 1.2 % per year area reduction and disturbance. Whether primary tropical forests act as carbon sink is still unclear. Biomass inventories at 146 forest plots across all the tropics in 1987–1997 revealed low carbon sink in humid forests biomass of 49 (29–66; 95% C.I.) g C m-2 year-1 on average (Malhi, 2010). Estimates for undisturbed African forests are close to global (Ciais et al., 2008). Eddy covariance (EC) observations with weak-turbulence correction in Amazonia reveal near-zero or small negative (i.e. sink) balance (Clark, 2004). Three EC sites in SE Asia primary forests give near-zero balance again (Saigusa et al., 2008; Kosugi et al., 2012). There are two main groups of explanations of moderate tropical carbon sink: (a) recovering of large-disturbance in the past or (b) response to current atmospheric changes: increase of CO_2 concentration and/or climate change. So, strong carbon accumulation is not common for primary tropical forests.

In this context sink of 402 g C m-2 in 2012 at EC station of Nam Cat Tien (NCT), Southern Vietnam (N 11°27’, E 107°24’, 134 m a.s.l.) in primary monsoon tropical forest looks questionably. EC instrument set at NCT consists of CSAT3 sonic anemometer and LI-7500A open-path gas analyzer. All the standard EC procedures were applied to the raw 10-Hz data, including time-lag compensation, block average, WPL-correction, planar fit, low- and high-frequency corrections etc. in EddyPro software (LI-COR Inc., USA). Calculated fluxes with bad quality flags (more than 6 of 9) were excluded. Spikes due to rains, instrument malfunction were removed too. Storage of CO_2 from the surface to the measurement level which is very significant in tall tropical forest was added to the flux. Then low-turbulence correction was applied with u*-threshold of 0.178 m s-1. After these steps only 43 % of 30-min data of 2012 still presented, so the rate of gaps was 57 % (mainly at night and in rains). Data were gap-filled using on-line tool at the web-site of Max-Plank Institute, Germany and Flux-Analysis Tool, Japan. Different gap-filling procedures (non-linear regressions, look-up tables, model evaluation, artificial gaps-method) as well as u*-threshold shifting from 0 to 0.25 resulted in drift of 2012 net carbon exchange total from -296 to -612 g C m-2 (strong carbon sink still remain).

Unfortunately, the situation of more then 50 % of gaps in CO_2 flux is usual for tropical EC stations because of frequent calm nights. So, a gap-filling algorithm is extremely important for evaluation of long-term totals. We found for Vietnamese data that even few spikes which were not removed before gap-filling can change all-year total by up to 20-50 g m-2 year-1. Especially ‘powerful’ are big positive values at night in rare-occurred good turbulence. Possibly these values are physical. But they influence regressions in look-up table method dramatically because amount of data in peak of rainy season in night-time is too small. So, the gap-filling algorithm happened to be very sensitive to spikes.

Additionally, striking was the fact that storage of CO_2 appeared to be the main factor influencing 1-year totals after gap-filling procedure. Taking storage into account shifted the 2012 sum from +182 to -402 g m-2 year-1, from carbon source to the strong sink. Storage total for all the year was near-zero, but in our case including of storage resulted in gap-filling regression changes with corresponding change in total carbon balance. Probably the only way for proper net carbon balance evaluation for NCT site is chamber-measurements of night respiration of

different ecosystem components, as used at Pasoh EC station, Malaysia.
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