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Interactive comment on "Regional-scale lateral carbon transport and CO_2 evasion in temperate stream catchments" *by* Katrin Magin et al.

Katrin Magin et al.

magi6618@uni-landau.de

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Anonymous Referee #2:

Accurate estimation of aquatic carbon export is essential to understand the role of natural ecosystems and geochemical processes in global carbon cycles in the context of climate change and increasing anthropogenic activities. In this manuscript, the authors integrate the analysis of downstream export of riverine carbon and CO2 evasion to the atmosphere from more than 200 local catchments of variable sizes in temperate Europe along with the model estimation of ecosystem production. Based on this large dataset, the authors try to establish a carbon budget in a local scale and discuss the ecologic factors controlling the aquatic carbon export. Overall, the integration of the large dataset of riverine carbon concentrations spanning over last several decades is

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technically sound and strengthens the arguments in the manuscript.

We would like to thank the reviewer for her/his positive evaluation and the very helpful comments and suggestions. Below we reply on each specific comment.

- My biggest concern arises from the estimation of the downstream export of riverine carbon. The riverine carbon concentrations adopted in this investigation were obtained during 1977-2011, which is significantly longer than NPP of 2000-2013. Investigations have already showed a decadal increasing DIC export in boreal and subtropical rivers due to the climate change and anthropogenic activities (Walvoord, M. A., and R. G. Striegl, 2007, Increased groundwater to stream discharge from permafrost thawing in the Yukon River basin: Potential impacts on lateral export of carbon and nitrogen, Geophys. Res. Lett., 34, L12402, doi:10.1029/2007GL030216; Raymond, P.A., Oh, N.-H., Turner, R.E., Broussard, W., 2008. Anthropogenically enhanced fluxes of water and carbon from the Mississippi River. Nature 451, 449-452). Therefore, I would suggest using the environment monitoring dataset during the last 10 years or so, which is consistemt with NPP estimation, to estimate the riverine carbon export.

Reply: Using only the monitoring data during the last 10 years would reduce the number of valid samples from currently 8020 to 5070. We compared DIC measured in the time periods 1977-1999 and 2000-2011 for all Strahler orders. The DIC did not change significantly. We would provide this information in a revised version of the manuscript and also point towards the trends observed in other regions, as mentioned by the reviewer.

- Secondly, it seems that the data points for the flux estimation is sparse as indicated in the section 2.2 (see Page 3 Line 83-86: ": : :: : :at least one measurement was available for each season: : :: : :"). Therefore, I will be happy to see the error or uncertainty analysis of the flux estimation with the method using the mean concentration and total river discharge (see Page 4 Line 94-95). Moreover, a comparison with other flux estimation methods, such as the one using flow-weighted mean concentration and

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discharge, the one based on the regression of instantaneous flux and discharge, and other methods (see Warnken, K.W., Santschi, P.H., 2004. Biogeochemical behavior of organic carbon in the Trinity River downstream of a large reservoir lake in Texas, USA. Sci. Total Environ. 329, 131-144), will be helpful to validate the flux estimation.

Reply: Unfortunately, the only available discharge data are annual mean values derived using data-driven regionalization of discharges from 125 gauging station from the period of 1979-1998. Time-resolved discharge measurements or data for the sampling times and sites, which could be used for flow-weighted estimates of DIC export and CO2 evasion, are not available. For an uncertainty analysis, we would use the more extensive analysis of Raymond et al. (2013), where uncertainties were derived based on comparisons of estimates obtained using similar approaches as we used with direct measurements of CO2 concentration. For a density of sampling locations of 0.02 sites per km2 they derived an uncertainty of 30%. Similarly, Butman and Raymond (2011) estimated uncertainties of overall flux estimates of 33%, based on Monte Carlo simulation of similar data for hydrographic units in the United States. In addition to errors associated with sampling and interpolation, our estimates are subject to a number of systematic errors. The neglect of carbon burial in sediments, carbon export and evasion as methane and under-sampling of high-discharge events, probably result in an underestimation of the carbon exported from the catchments in our study. We will discuss these uncertainties at greater detail in the revised manuscript.

- What do you mean “interpolating pCO2 for all river segments without direct measurement” (Page 4 Line 95-97)? Please clarify in the text.

Reply: The explanation is provided in the following sentence (Line 97-98): For this, the mean concentrations were averaged by stream order and assigned to all stream segments of the river network (Butman and Raymond, 2011). To clarify this, we would join the two sentences in a revised manuscript.

- For DOC, there are 64 observations (Table 1) in 54 sampling sites (Page 3 Line

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90- 91). On average, there are less than 2 observations in each site. Usually, DOC concentrations in rivers could vary seasonally with river discharge by couples of times. Therefore, the representativeness of the single DOC data in each catchment remains a critical question which may induce the great deviation of DOC flux estimation from the real value. Before resolving this issue, the statements that DOC load only made up 4% total carbon load (Page 5 Line 146-148) and that the error would be comparably small when neglecting the DOC term (Page 6 Line 159-162) seem arbitrary.

Reply: 54 is a mistake in writing, which we will correct. There are seasonally averaged DOC observations at 64 sampling sites; all values are averaged over several measurements covering all seasons.

- The authors extensively discuss the aquatic carbon export/NPP ratio in the manuscript (See Table 3 and text in Section 4.1s). They state in the manuscript:" By combining CO2 evasion and downstream C-export by stream discharge, we estimated that 2.7 % of terrestrial NPP (13.9 g C m2 yr-1) are exported from the catchments by streams and rivers, in which both evasion and discharge contributed equally to this flux (Page 7 Line 193-195)". Then they compare their results with some other studies of catchment ecosystems (see text in Section 4.2). However, what I understand is riverine DIC export flux is closely related to the weathering regimes and intensity in catchments (See Cai, W.-J., Guo, X., Chen, C.-T.A., Dai, M., Zhang, L., Zhai, W., Lohrenz, S.E., Yin, K., Harrison, P.J., Wang, Y., 2008. A comparative overview of weathering intensity and HCO3- flux in the world's major rivers with emphasis on the Changjiang, Huanghe, Zhujiang (Pearl) and Mississippi Rivers. Continental Shelf Research 28, 1538-1549; and Raymond, P.A., Bauer, J.E., Caraco, N.F., Cole, J.J., Longworth, B., Petsch, S.T., 2004. Controls on the variability of organic matter and dissolved inorganic carbon ages in northeast US rivers. Marine Chemistry 92, 353-366) although NPP could contribute part of DIC export flux through the respiration of DOM. Therefore, the aquatic carbon export/NPP ratio would be expected to be larger than the real contribution of NPP.

Reply: Our analysis of aquatic C-export in relation to NPP was inspired by studies

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where correlations between aquatic C export and terrestrial NPP or NEP have been observed at different spatial scales and different landscapes (e.g. Butman et al., 2015;Maberly et al., 2013; and other studies listed in Table 3). The reason for a lack of correlation in our study could be related to weathering, as pointed out by the reviewer. 16% of the study area contain carbonate bedrock. In our study area, the DIC concentration in the water increased with the proportion of carbonate containing bedrock in the catchment ($R2=0.33$, $p<0.001$). In the discussion of the revised manuscript, we would list this as an uncertainty and add estimates of the contribution of weathering found in other studies.

References:

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