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Interactive comment on "Forest NEP is significantly driven by previous year's weather" *by* S. Zielis et al.

S. Zielis et al.

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–> We would like to thank both anonymous reviewers for their effort to improve the quality of the manuscript by providing critical thoughts and helpful suggestions. We revised the manuscript accordingly by addressing/improving as many of the critical points as possible. In the following we reply to the reviewers' criticism point by point and give information about the revisions made – replies by us are indicated by an arrow at the first paragraph of our response. We hope that the revised manuscript now fulfills the requirements of the reviewers and the journal editor.

Interactive comment on "Forest NEP is significantly driven by previous year's weather" by Zielis et al. Anonymous Referee #1 Received and published: 9 October 2013

General Comments: Zielis et al. provide a well written and succinct manuscript that demonstrates that annual forest carbon balance (i.e. Net Ecosystem Production) can be influenced by the current and previous year's weather. Clearly demonstrating this is important because most carbon cycle models do not incorporate legacy effects from previous year's weather or biology, and as a result, have had a difficult time modeling year-to-year variation in ecosystem carbon fluxes. These legacy effects are poorly understood and arise from the low frequency ecosystem processes (i.e. carbohydrate mobilization, nutrient mineralization, and soil water) that integrate over multiple years to influence higher frequency processes like photosynthesis and respiration. With the development of more long-term eddy covariance datasets, like the one analyzed here, researchers are gaining a greater appreciation for- and understanding of-the impact of these legacies on current forest carbon cycling. Elucidating these effects is the first step in incorporating these processes into ecosystem models and improving their predictive power over annual to decadal timescales.

Specific Comments: The manuscript is well written, the hypotheses are clearly stated, the data analyses are appropriate, and the conclusions are well supported. Consequently, my recommendations are mostly cosmetic and are intended to improve the clarity and flow of the paper.

–> We thank the reviewer for this positive judgment and hope we can address the recommendations below.

1. The topic sentence in the second paragraph has little context for its introduction. I would have liked to have seen more background information before you presented this hypothesis. Also, there are a number of current papers listed below that may be useful for you to include in the introduction and discussion.

Rocha, A.V. and M.L. Goulden (2008) Large interannual CO2 and energy exchange variability in a freshwater marsh under consistent environmental conditions. JGR-Biogeosciences. 113, G04019, doi:10.1029/2008JG000712

Rocha, A.V. and M.L. Goulden (2010) Drought legacies influence the long-term carbon balance of a freshwater marsh. JGR-Biogeosciences. 115, G00H02, doi:10.1029/2009JG001215.

Richardson AD, Carbone MS, Keenan TF, Czimczik CI, Hollinger DY, Murakami P, Schaberg PG, Xu X. (2013) Seasonal dynamics and age of stemwood nonstructural carbohydrates in temperate forest trees.New Phytologist197: 850–861.

Mariah S. Carbone, Claudia I. Czimczik, Trevor F. Keenan, Paula F. Murakami, Neil Pederson, Paul G. Schaberg, Xiaomei Xu,Andrew D. Richardson, (2013) Age, allocation and availability of nonstructural carbon in mature red maple trees, New Phytologist, 200:2

–> We now provided more background information on the possible ecophysiological reasons for the influence of previous year's weather on NEP to the introduction, which led to our hypothesis, e.g. relationships with stored C build-up in the previous year, the pre-formation of buds etc. Additionally, we included 3 of the 4 suggested publications either into the introduction or the discussion when appropriate. The beginning of the second paragraph of the introduction now reads as the following: The challenges of SVATs to precisely model inter-annual NEP may arise from their focus on immediate responses of forest ecosystems to current year weather (Hanson et al.,2004, Urbanski et al., 2007). However, forest ecosystems very likely do not only respond to immediately to actual changes in environmental conditions, but can also show delayed responses to legacy-effects or climate-vegetation feedbacks. Such delayed responses to seasonal weather conditions of the previous year (hereafter referred to as previous year′s weather) might include weather induced alterations of the built-up of stored C in the previous year's summer and/or fall used to fuel current year growth and metabolism (Carbone et al., 2013), the formation of buds in the previous year's fall and the accompanied implications for current year leaf area index (LAI), and thus GPP (Zweifel et al., 2006) as well as the compensation of respiratory C losses due to frost damages induced in winter and spring of the previous year. Therefore, we hypothesize that re-

sponses to previous year's weather affect climate-vegetation feedbacks by modulating CO2 release and/or uptake, and thus, will improve our ability to explain inter-annual variability of forest NEP. Such phenomena have been reported for both non-forest and forest ecosystems. Rocha et al. (2010) showed that negative effects on LAI and photosynthesis induced by an extreme drought lasted for several years in a freshwater marsh. Dendrochronological studies focusing on the tree scale, e.g. by Rocha et al. (2006), Pichler and Oberhuber (20079, and Babst et al. (2012), reported a significant influence of previous year's weather on current year radial tree growth.

2. Please specify the proximity to the nearby MeteoSwiss weather station.

–> We added information on the location of the MeteoSwiss weather station relative to the study site which is located approximately 1km to the south-east of the study site Davos Seehornwald. The text now reads: The annual mean temperature at the MeteoSwiss weather station Davos, approximately 1 km southeasterly of the Davos Seehornwald at 1594 m asl, is 3.6 °C, and the mean annual precipitation is 1035 mm (30-yr means, 1981-2010; MeteoSwiss).

3. Please specify how much gap filling was done to the dataset to get a continuous record for each year.

–> We added information on the range of the gap fraction in measured CO2 fluxes. The text now reads: Instrument failure and data filtering led to a gap fraction between 47% (2002) and 57% (2008).

4. On line 405-410 you state that "..is less likely to be responsible for 47% of inter-annual variability.." It is unclear where this number can from and how you calculated it.

–> We clarified the calculation of the 47% unexplained inter-annual variability in the revised version of the mss which now states "still leaving 47% (=100% - 53%) of the inter-annual variability of NEP unexplained".

5. I thought that the conclusions were a little weak and didn't really add anything to the paper. I would consider removing the conclusions section and incorporating the important parts into the discussion.

–> We rephrased the conclusion, yet, we keep them as individual section, since standalone conclusions are required by BG. The text now reads: We strongly suggest considering responses of NEP to previous year's weather in SVATs to allow for more precise estimates of annual C budgets in forest ecosystems. We expect this to be particularly true for forest ecosystems in cold climates, as shown here for the subalpine Davos forest. Moreover, assuming a continuing trend of increasing spring temperatures in Europe under future climate warming, we expect that the carbon sequestration potential of the Davos forest will further increase, unless other resources become limiting.

6. In the caption of Figure 3, please specify how many days were included in the smoothing.

–> We added this information in the caption of Figure 3. It now reads: Smoothing was done by fitting a local polynomial regression (LOESS) to the original mean daily values, using a 7-day and 18-day smoothing window for the fluxes and the soil temperature, respectively.

All in all, I thought that this was a really good manuscript and should be accepted with minor revisions.

Interactive comment on Biogeosciences Discuss., 10, 15587, 2013.