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Biogeosciences Discussions

Interactive comment on "Biogeochemical response of alpine lakes to recent changes in dust deposition" *by* A. P. Ballantyne et al.

Anonymous Referee #1

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The role of dust in buffering acid rain has been studied in several regions oft he world (Rogora et al. 2004. Tellus 56B, 426–434) and is of special importance for sensitive alpine lakes (Psenner, R. 1999. Water, Air, Soil Poll. 112: 217-227, and references therein). Atmospheric deposition of nutrients, especially phosphorus, is a major factor for the limnology of alpine lakes, e.g. in the Sierra Nevada, Spain (Morales Baquero, R. et al. 2006. Limnol. Oceanogr. 51, 830–837; Pulido-Villena, E. et al. 2008. Aquat. Sci. 70, 1-9; Reche, I. et al. 2009. Limnol. Oceanogr. 54, 869–879) but the general impact on the biogeochemistry of high elevation watersheds is much less studied. Thus, the study of Ballantyne and coworkers on alpine watersheds in the Western US is an interesting contribution to an important topic.

To disentangle the effects of watershed erosion and deposition from long-range trans-

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port, the authors compared two alpine lakes in Southern Colorado, characterized by different watershed to lake area ratios. To judge the significance of their approach one has to ask three questions: Do they convincingly show that (i) dust is the main component of the sediment; (ii) the anticipated increase in dust deposition since the beginning of the last century is stored in the sediment record, and (iii) the ratio of erosion to deposition does significantly affect nutrient levels and ratios?

Question 1 has been answered positively, also the answer to question 2 is convincing. Consequently, also question 3 must be answered positively. I have, however, some problems with the selection of sites etc. and request a convincing reply to my concerns.

In my view, the selection of sites and methods is O.K., the presentation of diatom values, however, looks rather scarse – but this is not the main objective of the authors.

My biggest concern is that the lakes or tarns are extremely shallow (<1m) which is in sharp contrast to the rules usually followed by paleolimnologists, i.e. to sample undisturbed sediments from water bodies deeper than several meters. Generally, a water level below ∼2m means that the sediment is freezing, and may thus be heavily disturbed, every winter. I am, thus, not astonished by the large differences in C,N, and P contents of both tarns (Fig. 4). Senator Beck sediments obviously are very low in organic content, supposedly caused by disturbance of the sediment through freezing, wind mixing, UV radiation etc. I am puzzled, therefore, by the dating curves in Fig. 2 which look quite "normal“, although this is difficult to judge from just three 14C values. A comparison with a high elevation lakes in the Alps of comparable watershed characteristics (i.e. mainly rocks) but a low catchment to lake area ratio of 3 showed a sediment accumulation of 1590 mm during the Holocene (Ilyashuk et al. 2011, Quart. Sci. Rev. 175-191), while Porphyry and Senator Beck, though having much larger catchment to lake are ratios (Porphyry=24; Senator Beck = 13), had only 500 and 200 mm, respectively. For this reason, I suspect that some part of the sediment is missing, likely owing to the shallow depth and the resulting disturbances.

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7, C4658–C4660, 2011

How do you interpret the C:P curves in Fig. 4? While C:N curves look quite normal, i.e. the higher C the higher the N value, the C:P ratio seems to behave differently: in Porphyry and Senator Beck it is 60 and 45 at the C and P maximum, 44 and 42 at the C minimum, and 75 and 150 at the P minimum, respectively. I suggest to present N:C and P:C ratios (not C:N or C:P) along the core depth and to remove instead Fig. 3 which is explained in the text and shown by Table 1.

You should say how representative were dust deposition data (From how many snowpack samples collected where and when? Was there an influence of local dust particles?). What about N (nitrate, ammonium) and P concentrations in wet deposition and snowpack? Can you show some lake water parameters (pH, conductivity, alkalinity, major ions, nutrients)?

Did you take the sediment core in Porphyry from a greater depth than in Senator Beck? Can you add lake maximum depths or lake morphometry?

Fig. 6 Where are the "red arrows“?

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