Response letter to S. Tyler (Referee #1)

(Responses of authors are marked in yellow)

This is a well written and interesting development to quantify excessive nitrate concentrations in arid aquifers. The use of O-17 is novel and the work should be published. One area I would like the authors to consider is their model for infiltration of nitrate (and other soluble salts) during "flood" events. The manuscript presents a conceptual model of increased runoff, with overland flow of both water and solutes. While this certainly occurs in many hyper-arid regions and will move solutes to low lying areas, this would also tend to produce much more heterogeneous distribution of groundwater salinity and nitrate, as groundwater flow in the region appears quite slow. Rather, I would suggest the authors consider periodic infiltration events during wetter climates, in which nitrate and chloride are leached from below the near surface and rooting zone if it exists, and migrated downward through the vadose zone to the water table. This will results in a much more uniform distribution of salinity and nitrate in groundwater similar to what the authors see. This type of climate controlled recharge is well documented in arid regions, both for the chloride as well as nitrate, and has been seen by Edmunds and Gaye (1997), Tyler et al. (1997), Hartsough et al. (2001) and Walvoord et al. (2003). It clearly shows that migration of stored salinity and nitrogen in arid vadose zones is episodic, but responds to longer periods of moisture, rather than the occasional flash flood.

Edmunds, WM and Gaye, CB. 1997. Naturally high nitrate concentrations in groundwaters from the Sahel. Journal of Environmental Quality, 26, 1231-1239.

Tyler, S.W., J. B. Chapman, S. Conrad, D. Hammermiester, D. Blout, J. Miller, M. Sully and J. Ginanni. 1996. Soil Water Flux on the Nevada Test Site: Temporal and Spatial Variations over the Last 120,000 Years. Water Resources Research. Vol. 32(6): 1481-1499.

Hartsough, P., S.W. Tyler, J. Sterling and M. Walvoord. 2001. A 14.6 kyr record of nitrogen flux from desert soil profiles as inferred from vadose zone pore waters. Geophysical Research Letters. Vol. 28(15):2955-2958.

Walvoord, M.A., Phillips, F.M., Stonestrom, D.A., Evans, R.D., Hartsough, P.C., Newman, B.D., and Striegl, R.G., 2003, A reservoir of nitrate beneath desert soils: Science, v. 302, no. 7, p. 1021-1024

1. The comments of Scott Tyler are greatly appreciated, and the ms is revised accordingly. Moreover the references are added:

Revised Text (in Abstract):
"… are caused by a sudden wash out of accumulated disposition of atmospheric NO_3^- on plants, soil surfaces and in vadose zones within humid-wet cycles"

Revised Text (in Chapter 5):
"$\Delta^{17}O_{NO3}$ maximum values are caused by a wash out of dry deposition of atmospheric NO_3^-, which was accumulated through long term arid conditions to which plant and soil surfaces have been exposed. Periodic infiltration events enhanced the leaching of accumulated NO_3^- from plant and soil surfaces and also from below the near surface and rooting zone. Accordingly, the NO_3^- enriched solutions migrated downward through the vadose zone to the water table and correspondingly high NO_3^- concentrations occur in

the recharging groundwater (see also Edmunds and Gaye, 1997; Tyler et al., 1997; Hartsough et al., 2001; Walvoord et al., 2003; Chiwa et al., 2010).
For the present case, it is proposed that dry periods have alternated with periodic infiltration events during wetter climates."

Revised Text (in Chapter 6):
"Past alternating arid periods and infiltration events occurred. The accumulated $NO_3^-{}_{,atm}$ is washed out from plant and soil surfaces as well as below the near surface and rooting zone downward through the vadose zone to the water table."