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Interactive comment on "Abiotic versus biotic controls on soil nitrogen cycling in drylands along a 3200 km transect" *by* Dongwei Liu et al.

Anonymous Referee #2

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Review Biogeosciences Discussion BG-2016-226

The paper "Abiotic versus biotic controls on soil nitrogen cycling in drylands along a 3200 km transect" provides a great dataset on soil N cycling across a precipitation gradient in dryland ecosystems in China, based on the natural 15N (18O) abundances of bulk soils and ammonium and nitrate, and on the abundances of marker genes involved in N cycling. These novel data allow deep and unprecedented insights into the controls of inorganic N cycling of these ecosystems, and clear trends emerge in abiotic versus biotic controls.

The paper therefore addresses relevant questions within the scope of Biogeosciences. Methods and assumptions are valid, and the results definitely sufficient to support the interpretations and implications raised by the authors. The description of Materials and

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methods and calculations are sufficiently complete. The authors cited relevant work and demonstrate their novel contribution to the field. The title is concise and reflects the content of work, and the abstract concise and complete in summarizing the main points of this study. The presentation/manuscript is well structured and clear, but the language should be edited by a native speaker. The number and quality of references is fair and appropriate, and supplementary material is of high quality and appropriate.

Beyond that I have the following comments (according to the lines in the manuscript, the language corrections are by far not complete):

36: should read “driving” not driven 39: delete significantly 41: rewrite “the uptake preference for soil. . .” 42: soil nitrate loss could also occur by hydrological pathways (leaching) during heavy rain storms. 42: rewrite “our study suggests that the shift from abiotic. . .” 51: rewrite “factor” not factors 54: rewrite “still lack a full understanding of the. . .” 61: rewrite “over large scales” 67: change “are” to “become” 71: change “water-driven” to “hydrological losses by leaching” 73: change to “. . .alone is not..” 74: change to “processes that contribute” 77: what is the meaning of “integrate over their characteristics”? please be more concise. 79: rewrite “..provided evidence for. . .” 81: “they cover a different range” 83/84: rewrite “..to study the preferences for plant N uptake” 105: change to “gradient” 109: “gene abundances” 111/112: “with microbially regulated soil processes; and 3) how does soil N cycling. . .” 116: “the climate is. . .” 118: define the aridity index here 120: “. . .the three . . .” 124: how do the authors decide which is the peak of soil N transformations? Is that peak vegetation season? Or the short season where the majority of rainfall occurs? Please be more specific here. 131: correct “into” to “in”, twice. 134: “using a pH meter” 141: “based on the isotopic analysis of nitrous oxide” 142/143: change “into” to “to”, three times. 146: rewrite “samples” 148: change “to a Trace. . .” 168: change to “Pearson correlation analysis” 174: it should be “at” not “in” sites 175: “genes” 177: rewrite “that the soil N status and its controls could be different. . .” 185: “was significantly higher. . .”. By the way if I get the numbers correct in the arid zone bulk soil N (soil total N) would be 200 mg N/kg, with nitrate 87 mg

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N/kg and ammonium 4 mg N/kg, i.e. inorganic N would on average contribute 46% to soil total N, and only 54% on average is bound as organic N in humus? 188: “supports” 203: “15N depleted relative to their sources” 205: please specify what you mean with “via microbial and plant regulation”. 15N depletion of soil ammonium or less 15N enrichment can arise from microbial N mineralization (if this process exerts significant N isotope fractionation) or biological N fixation (causing inputs of N with d15N around 0 to -2 permil). ;Maybe also atmospheric ammonium/ammonia deposition. 207: rewrite “A positive correlation was. . .” 212: “genes” 213: “rewrite “was measured at all sites” 214: “were found to be . . .” 215 “in the gene abundance of all detected N cycling groups” 217: “dry at the time. . .”. “gene abundances in the semiarid zone were. . .” 218: “gene abundances of the five . . .” 219: “potential control of water availability on soil microbial N processes” 223: “water availability drives different patterns” is not meaningful. Please rephrase. 223: “at both sides of about MAP = 100 mm” is really not the best phrasing, maybe rather “above and below a MAP threshold of 100 mm” 224: “seems to lead to losses of N. . .” 226: “we found direct evidence” 226/227: of course denitrification is a kinetic process. So what? Simply say that denitrification exerts isotope fractionation against the isotopically heavier compounds, ranging between 5 and 25 permil. . .” 232/233: please specify this sentence on availability of N and O2 supply – to me the meaning is not clear. 235: “in addition, a preliminary study. . .. an increasing N2 loss via. . .” 240: “in some sites,. . .. pointing to losses of soil . . .” 241: “after heavy precipitation events” 239-245: the main pattern for soil nitrate at the arid sites is 15N depletion of nitrate relative to ammonium. Only a few sites had more positive d15N values in nitrate compared to ammonium. The explanation by enhanced denitrification during heavy rain or chemodenitrification is therefore ionly secondary. The main pattern has to be explained – why is soil nitrate 15N depleted relative to ammonium. My best guess is its production through nitrification which causes ammonium to become 15N enriched and nitrate 15N depleted (this is also an alternative explanation for the 15N enrichment of ammonium at many arid sites). I also would not expect large amounts of reduced iron (FeII) to be present at arid sites. Only in some places deni-

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trification may also play a role, where nitrate was 15N enriched relative to ammonium. Another input of nitrate is atmospheric deposition, but its isotopic composition for that region is most probably unknown (Fig 5(a) indicates that atmospheric nitrate lies between 0 and 5 permil). 243: “chemodentrification is an abiotic process..” 244: change “preserveed” to “present” 247: “suggesting losses of . . .” 248: what is the meaning of “ammonia volatilization can be strong for the ammonium loss”??? 249: “The isotope effect of . . .” 250 “significant negative. . .” 250/251: the alternate explanation is that nitrification can also cause 15N enrichment of ammonium, and 15N depleted nitrate in many arid soils actually point to a significant role of this process, aside of ammonia volatilization. 252/253: what does “suggesting the net ammonium gain” mean? Please rephrase. 252: soil ammonium “became” gradually 15N depleted relative to. . . 252-270: the main pattern of spoil ammonium is that it becomes 15N depleted with higher MAP in semiarid sites. This CANNOT be explained with consumption processes such as plant uptake and nitrification, as in both cases (plants and nitrifiers) exert an isotope effect meaning that plants or nitrate become 15N depleted and soil ammonium 15N enriched. An inverse isotope effect has never been shown for any biological process involved in the (production) consumption of ammonium. Lines 268-270 therefore are wrong because microbes will not prefer 15N enriched ammonium during immobilization. The whole paragraph therefore is misleading and has to be rewritten. The explanation can therefore only come from 15N depleted N inputs (biological N fixation, 0 to -2 permil; atmospheric ammonium/ammonia deposition, isotope range for the region unknown?) or its production through mineralization of organic N. Though the isotope effect of N mineralization is most often said to be low or negligible, it might be high if one looks at enzymes and their isotope effects that are most likely involved in deamination of organic N forms in cells (they can be as high as 20 permil). Please consult the respective N isotope reviews such as Werner and Schmidt Phytochemistry 61 (2002) 465–484. 259: “prefer soil ammonium over nitrate” 263: “demonstrates the ammonium preference of plants 265: sentence is meaningless – “soil nitrification have been observed to be enhanced with more water widely. . .”? 271: “we detected anammox

genes in these dryland ecosystems" 275: "water-logged" 275/276: "studies of anammox process rates so far failed to..." 280: "responsible for gaseous losses..." 282: "aeolian" 285: "observed the highest..." 287: besides small deposition as dissolved nitrate in rainwater or snow. 288: "since the d18O ..." 289: "depends on the d18O..." 290: "from the areas closest to..." 291: "ranged from ... to ..." 294: I don't understand the reasoning behind this sentence, why is atm. O2 and its d18O important. It is not directly expressed in the d18O of NO3- formed in the atmosphere because this is more 18O enriched. So....? 285-311: as said before there is also evidence for nitrification in the data set, as in many arid soils nitrate is 15N depleted relative to ammonium, which indicates nitrification also to contribute to soil nitrate accumulation, aside of atmospheric deposition. There are several typos in this paragraph. 316-318: what does this coincidence of KIE denitrification and d18O of nitrate mean? This is totally disconnected. Delete. 319-323: the gradual 15N depletion of ammonium in itself, but also relative to soil total N indicates that mineralization is the main input process of soil ammonium, and that N mineralization causes 15N fractionation. Obviously nitrification also occurs, but as long as only a small fraction (like 10-20%) of soil ammonium is oxidized by autotrophic nitrifiers ammonium would still be 15N depleted relative to bulk soil. Heterotrophic nitrification is another explanation, as stated by the authors. 337: why do the authors believe that soil ammonification was stimulated with higher MAP? Where is the evidence for that? Only the ammonium concentrations? 347: was the precipitation range really large? 355: what is phytochemical nitrate loss? 360: what is "provided lighter N isotope for soil ammonium? And as this sentence states "increasing ammonification reduced ammonia volatilization". How should that happen?

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