Topical Editor Decision: Revision (19 Jul 2018) by Axel Don

Comments to the Author:

Dear Dr Lee and Co-authors,

Two reviewers have evaluated the manuscript very carefully and in detail and suggested several points to improve the manuscript. Thank you for taking up most of these points in your reply and a revised version. Please not that a revised version is generally only due after the paper discussion period and the editorial board decision on the paper.

Two major aspects (raised also by the reviewers) need some further attention in order to make this paper consistent and sound:

We appreciate the comments from the topical editor. Please find our responses below. All changes have been marked in the revised manuscript.

1.) The classification into agriculture and non-agriculture requires better justification. The main management driver for mineral N in soils is fertilisation. Agricultural land that does to receive fertilisation, e.g. some grazed land, may therefore behave more like non-agricultural land than like agricultural land.

We fully agree that fertilizer application is an important management driver for soil NH_4^+ and NO_3^-, and this is the case especially for cropping systems and improved pasture in Western Australia, South Australia, Victoria and southern New South Wales.

As pointed out, some sites under production from relatively natural environments receive no external N input. Soil controls and mineral N dynamics in semi-natural pasture may be similar to those in the non-agricultural region, despite disturbance by grazing animals. There would be little inputs through excretion by animal (e.g., dung and urine) across the vast area of grazing pasture. Based on the BASE data, these sites are located in central Australia (see Figure 1) and characterized by low vegetation and soil N stocks in arid- and semi-arid climate. Nevertheless, the majority of the N that animals ingest from herbage is returned to the pasture via excreta (e.g., at least 75% by cattle, see Whitehead 1995), which is a key component that influences the distribution of soil mineral N. Production from relatively natural environments includes forested agricultural land as well, where considerably larger biomass input occurs during commercial production from forests. Thus, these sites may behave more like intensive agricultural land as opposed to semi-natural pasture. Please note the term “forested” mean “trees” or “sparse trees” with a crown cover of > 20% according to the recent Land use of Australia.

Due to the scarcity of data and the difficulty in grouping land use classes, we were not able to further detail broad land uses by main management driver, such as fertilization. In this study, we have used the classification of broad land uses according to the Australian Land Use and Management Classification, which seem to be the most objective.

This is why we decided to analyze and simulate the data by the two regions, “agricultural” and “non-agricultural”. Again, this decision was made by full consideration of data size for each of the broad and detailed land uses (see Table 1 and Table S1).

To further justify our classification, we have included the following statement following our definition of the regions: “**A total of 469 sites were retained for 10 data analyses (Fig. 1), and we performed the analyses on (1) all samples, (2) the samples from the sites that originate <u>mainly</u> from dryland and irrigated cropping, and from improved and native pastures used for animal grazing (hereafter referred to as the “agricultural” region), and (3) the samples from the protected sites and those in natural environments outside of the agricultural production zones (referred as the “non-agricultural” region). The agricultural region (160 sites) covers the main grain-cropping zones of Australia, which differs by climate and soil regimes, and farming practices. <u>Sites used for</u>**

agricultural production from relatively natural environment did not receive external N fertilization but some N excretion by grazing animals or biomass inputs from commercial production."

2.) I agree with reviewer 2 that climate and geology are important drivers for continental scale variability in soil properties. If this study ignores these large scale drivers (primary drivers) but focusses on "proximal drivers" such as TOC and pH, the manuscript has to be revised to clarify and explain this to the reader. This refers to the whole manuscript and particular on the title and the objectives.

Climate and geological attributes are potentially important for continental scale distribution of soil mineral N. And we did not ignore these factors. In fact, they were considered to predict the soil properties from the soil maps in our spatial simulations.

In the section 2.1, we stated "**The approaches used to produce the maps were described in detail in Viscarra Rossel et al. (2015). When the soil maps were produced at the fine spatial scale, auxiliary environmental data were already considered in the spatial modeling. These variables represent proxies for the main environmental factors of soil formation, which were related to parent material, climate, biota and vegetation, and terrain and landscape position**."

More importantly, we intended to assess soil controls over soil mineral N contents without confounding effects of climate or other variables in Cubist modeling. In addition, the coarse resolution of climate data (usually 25 km after downscaling) does not match with the fine resolution of soil measurements (25 m).

As suggested, we have changed the title as: "**Continental soil drivers of ammonium and nitrate in Australia**".

Please note that our objectives are set out very clearly - we have focused on soil controls only. Throughout the manuscript, our results and discussion are limited to the potential controls of 10 soil properties obtained from the BASE data and our recent soil maps. We went over the whole manuscript again to make sure that we are following this comment.

Please also provide more details on the actual analysis and extraction method of nitrate and ammonia that was used.

After soil drying and sieving (< 2 mm), the contents of mineral N were determined colorometrically after extraction with 1 M potassium chloride. We have added the sentence: "**The contents of mineral N were determined colorimetrically on dried soil samples < 2 mm after extraction with 1 M KCl.**"

We are looking forward to a revised version of your manuscript.

Yours sincerely
Axel Don

Additional reference

Whitehead DC (1995) 'Grassland nitrogen.' (CAB International: Wallingford, UK)

Additional technical corrections:

We have added the units of measured soil properties of the BASE data and values from the soil maps in the section 2.1. NH_4^+ and NO_3^- were reported in mg N/kg. Organic C, total N, total P, and texture were reported in %. Bulk density and exchangeable CEC were reported in g/cm^3 and meq/100 g, respectively. Thus, we have corrected the term "concentration" to "content" for soil mineral N as determined by the mass of sample throughout the manuscript.