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Biogenic Fluxes of Carbon and Nitrogen in Arid and Semi-arid Ecosystems

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Anthropogenic activities have lead to the increase in emissions of trace gases and aerosols into the atmosphere. These emissions have altered the atmospheric chemistry and lead to changes in nutrient deposition, which have consequences for nutrient cycling in natural ecosystems. Initially studies focused on understanding these anthropogenic inputs; however subsequent to this emissions from natural ecosystems were found to contribute significantly to atmospheric chemistry both at a global and regional scale. For many years now the focus, in terms of biogenic fluxes, has been on tropical ecosystems due to their dominant contribution to global biogenic emission budgets. The major controllers of biogenic emissions are temperature, light intensity and moisture, thus the high solar radiation and high rainfall found in tropical regions is the main reason for enhanced emission rates. Further more, these warm, moist conditions exist for several months, and often the entire year, thus increasing the annual emissions compared to those from more seasonal ecosystems.

At the other end of the scale are the arid and semi-arid environments. These ecosystems are characterized by low, erratic rainfall, high temperatures, periodic droughts and they often have low to no vegetation cover. Arid and semi-arid zones experience an interannual rainfall variation of 50-100% and 20-50% respectively. Thus these ecosystems have long periods of no rainfall and low to no microbial activity. Global models indicate that emissions from arid and semi-arid systems are insignificant. The small amount of carbon and nitrogen emission data that is available for these ecosystems

indicates that emissions are much lower than in other ecosystems; however data is minimal and uncertainties are large. What is more important though than confirming emission rates is determining the way the arid and semi-arid ecosystems respond to environmental changes. We may have a good understanding of the emission response of tropical and subtropical ecosystems to environmental controlling factors, but are these responses the same, or of the same magnitude, as in arid and semi-arid ecosystems?

It is the sudden changes from the dry to wet season in these arid and semi-arid regions that makes them unique and potentially important. The long dry season often leads to a build up of nutrients in the system, particularly in the soil. Rain acts as a switch, as once there is rain microbial activity begins immediately. A huge pulse of NO emissions is seen, which has been shown to be a factor of 10 to 100 higher than the dry season flux. Further more, these arid ecosystems sit in the zone where soil consumption can change to production and *visa versa*. During dry periods arid and semi-arid zones are generally sinks for CH_4, however they can change to become CH_4 sources in the wet season. Data does not indicate that there is a sudden pulse of CH_4 emissions after rainfall, as with NO and N_2O, but rather a slow change over the wet season has been indicated. There is very little data on this and so there is a lot of uncertainty regarding the emission of CH_4 from arid and semi-arid ecosystems. Not only do soil microbes become active after rain, but the vegetation also is revived and begins to produce new leaves and shoots. This in turn has consequences for the VOC emissions, which will also be very seasonal due to the low leaf mass density during the dry periods. VOC emissions from vegetation are influenced by water stress. In a water stressed environment it may be expected that carbon and water losses from a plant are low, and that the percentage of fixed carbon lost as VOCs would be low; however this is not always the case. As is the case with NO, N_2O and CH_4, there is very little data on VOC emission rates from arid or semi-arid plants. Also more data is required on how VOC emissions from arid and semi-arid species respond to water stress, as plants that are adapted to water stress behave differently from those that aren't.

Studies have indicated that the pulsing of NO after rain is insignificant at the global scale; however there are numerous regional studies that suggest these pulsing events are extremely important for regional atmospheric chemistry. For example, it has been suggested that biogenic emissions from southern Africa during spring time, both the NO from pulsing and VOC from increased leaf density, could have an important contribution towards the annual austral spring mid-tropospheric ozone maxima over the tropical south Atlantic. Further more, determining whether arid and semi-arid ecosystems are partial sources instead of complete sinks for CH_4, and when and how this change occurs, has important consequences for the global CH_4 and carbon budget.

This presentation will give an overview of nitrogen and carbon fluxes from arid and semi-arid ecosystems, discussing both the emission rates and the responses to controlling factors. Southern Africa will be used as the main case study, although other examples will be given where necessary. The importance of arid and semi-arid ecosystems, as well as future research directions in terms of biogenic emissions and nutrient cycling in arid ecosystems will be highlighted.