Extreme rainfall: Unravelling the importance of new climate-rhizosphere feedbacks across contrasting land use systems

This project will determine how extreme rainfall leading to soil saturation affects climate feedbacks operating in the root zone. The project will:

Determine how soil water saturation affects organisation of the rhizosphere and soil microbiomes

Determine how climate feedbacks in contrasting land use systems are affected by seasonal timing and duration of soil water saturation

Summary

Terrestrial ecosystems play major roles in determining global climate-ecosystem feedbacks, through exchange of greenhouse gases (GHG), and carbon (C) storage in soil and vegetation. There is mounting evidence that climate change is resulting in increased frequency of extreme weather. Studies of the impacts of extreme weather on climate-ecosystem feedbacks are limited because of their unpredictable nature, and our inability to predict events in space and time. However, evidence is building that climate extremes have significant impacts on a range of vital ecosystem functions.

Plant roots are associated with diverse microbial communities which constitute the rhizosphere 'microbiome', the composition and function of which varies significantly between land uses, reflecting differences in the dominant plant species, the intensity of management practices, and consequent differences in soil physico-chemical characteristics. Almost nothing is known of the way in which extreme weather affects the rhizosphere microbiome, and the consequences for climate-ecosystem feedbacks. Climate change is predicted to increase the frequency of intense rainfall events, which can result in soil saturation via flooding or rise in groundwater, leading to hypoxic or anoxic conditions which promote GHG production, and change microbial communities. We were able to study the effect of a natural extreme rainfall event in 2012, the wettest year since records began, on the rhizosphere microbiome, in the field, for the first time. We revealed that prolonged saturation in an agroforestry system reduced the abundance and diversity of beneficial ectomycorrhizal fungi, while increasing abundance of pathogenic and saprotrophic fungi.

We hypothesise that these effects will have profound and previously unrecognised impacts on climate-ecosystem feedbacks, operating through altered plant-soil C flux, GHG emissions and plant productivity. We anticipate that these feedbacks will depend on the extent and longevity of O_2 depletion (reflecting seasonal timing and duration of rainfall) and Interaction with ecosystem parameters, including rhizosphere microbiome composition, which vary according to land use system and management intensity. Here we will unravel these feedbacks and interactions for the first time.

We will simulate growing season and non-growing season saturation typical of long term (4 week) and extreme (8 week) durations. We will investigate the effect of saturation

treatments on the response and recovery of GHG emissions and the rhizosphere microbiome. We will focus on the frequency, abundance and connectivity of communities at both taxonomic and functional levels. Importantly we will consider communities in a holistic manner, allowing us to compare responses of eukaryote (eg fungi, protists, nematodes), bacterial and archaeal groups to saturation. In this way we will provide fundamental new understanding of community responses to disturbance events. We will label plants with a stable isotope of C which can be differentiated from background C. This will allow us to investigate the long term effect of saturation on the amount of C which flows from the plant to the soil, the proportion retained as soil C or respired, amounts retained in the microbial biomass, and the effects of saturation on 'priming' of C release form native soil C.

The programme will characterise previously overlooked effects of extreme weather on climate-rhizosphere feedbacks, delivering a step-change in our fundamental understanding of the responses of ecosystems to extreme weather, and the role of land use, including management intensity, in mediating these responses.