Mathias Disney

Measuring carbon cycling

GCSE key words
Carbon cycling
Climate change
Data logging

Mathias Disney explains how to measure parts of carbon cycling as it happens in forests.

Scientists devise novel instruments and equipment to observe and record aspects of carbon cycling. Here are two systems they use.

Flux towers

Variations in carbon dioxide concentration are caused by changes in the balance between photosynthesis (carbon dioxide uptake) and soil and plant respiration (carbon dioxide released). Measurements of this flux of carbon dioxide, taken using instruments on tall towers, assume that air turbulence mixes up the air close to the ground. As a result, air flowing past the sensor contains a well-mixed sample of atmospheric gases from within the forest canopy. We also make assumptions about where measured carbon dioxide fluxes originate from — roughly 100 metres distant for every metre height of the tower. So a 10-metre high tower measures carbon dioxide fluxes originating from within 1 kilometre upwind.

Normally we want to measure fluxes from a specific area (e.g. a piece of forest), so we fix the tower so that it just clears the forest canopy (Figure 1). The sonic anemometer measures wind speed and direction. Samples of air are captured and fed into an infrared gas analyser (IRGA).

Measurements are made every few seconds, 24 hours a day all year round, to build up a picture of the carbon balance of the forest system. Solar panels provide power. Measurements are either downloaded manually, or transmitted via a mobile phone connection. Radiation sensors on the tower measure changing light levels which can be related to changes in photosynthesis (and hence to carbon dioxide).

Soil chambers

To determine how much carbon dioxide is taken up by the trees, we need to separate soil and canopy respiration. For that we use soil chambers (Figure 2).

The shallow collar (with a circular opening) is fixed to the soil surface, not cutting any roots. Every hour the dark chamber closes automatically for about 2 minutes. This makes an airtight seal over the soil collar, trapping ambient air inside. Carbon dioxide released by respiration of soil microbes and roots is trapped, causing carbon dioxide in the chamber to increase during closure time.

The air is circulated in a loop between the chamber and an infrared gas analyser (IRGA), which measures this rise in carbon dioxide every second. This tells us how much of the carbon dioxide in the air is coming from the soil. After a measurement is made, the chamber opens in order to allow the soil system to be exposed to ambient conditions.

IRGA is short for infrared gas analyser. It is set up here to measure carbon dioxide concentrations.

Figure 1 *Taking flux tower measurements*

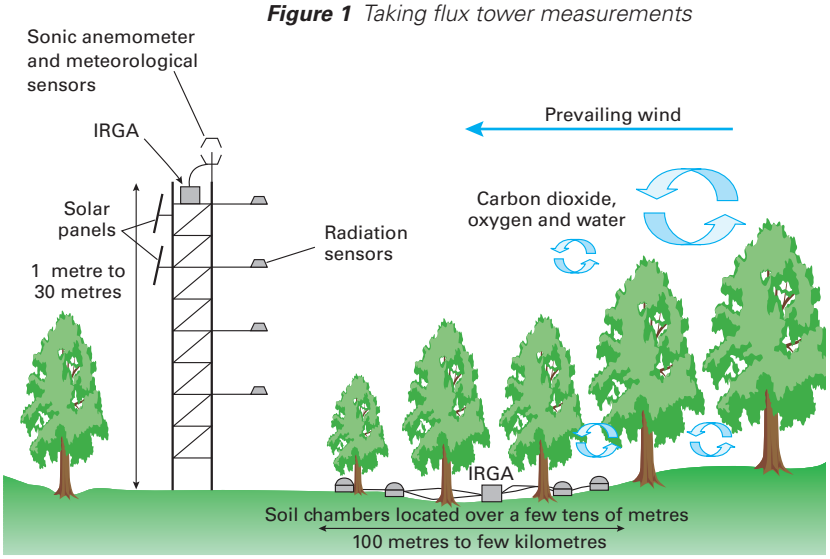
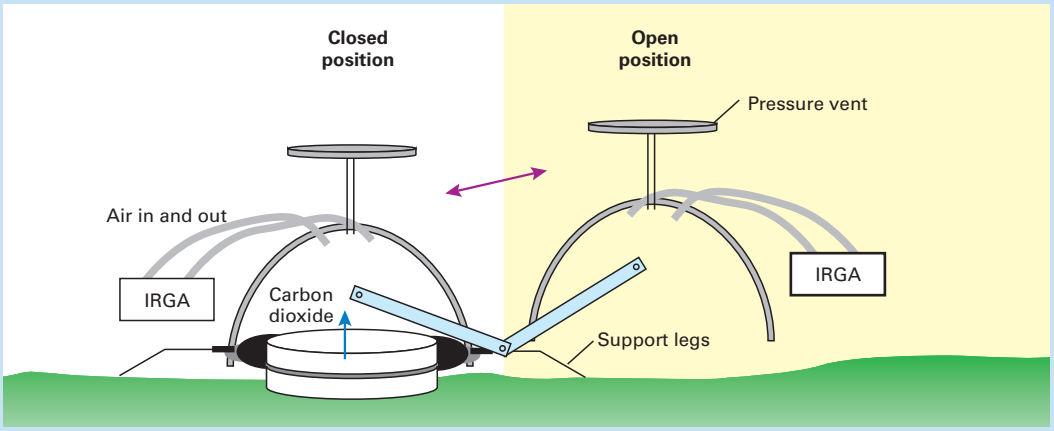


Figure 2 *A soil chamber with infrared gas analysers*

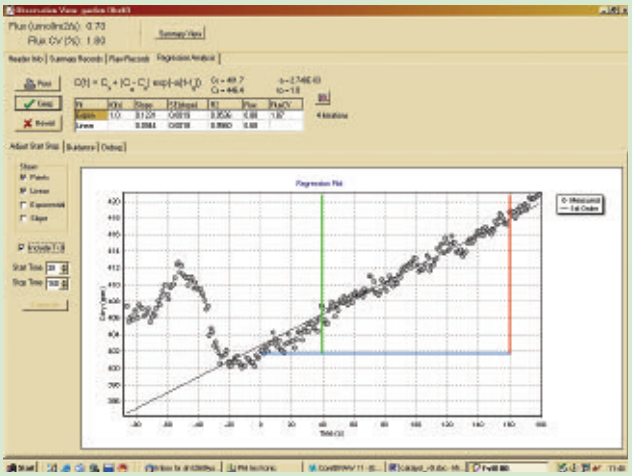



Closed soil chamber


Open soil chamber

Above: *Multiple chambers connected to a single IRGA in an 'Octopus' configuration*


Batteries and IRGA



Right: *Data from an IRGA. When the chamber closes carbon dioxide concentration rises steadily as a result of 'soil' respiration*