A new leaf turns in carbon science

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Understanding the exchange of gases, including CO2 and water vapour is especially significant to science because of its relevance to global management of carbon emissions. Image credit - Willen van Aken, CSIRO

(PhysOrg.com) -- A new insight into global photosynthesis, the chemical process governing how ocean and land plants absorb and release carbon dioxide, has been revealed in research that will assist scientists to more accurately assess future climate change.

In a paper published today in *Nature*, a team of US, Dutch and Australian scientists have estimated that the global rate of photosynthesis , the chemical process governing the way ocean and land plants absorb and release CO2, occurs 25% faster than previously thought.

From analysing more than 30 years of data collected by Scripps Institution of Oceanography, UC San Diego including air samples collected and analysed by CSIRO and the Bureau of Meteorology from the Cape Grim Air Pollution Monitoring Station, scientists have deduced the mean rate of photosynthesis over several decades and identified the El Nino-Southern Oscillation phenomenon as a regulator of the type of oxygen atoms found in CO2 from the far north to the south pole.

"Our analysis suggests that current estimates of global primary production are too low and the refinements we propose represent a new benchmark for models to simulate carbon cycling through plants," says co-author, Dr Colin Allison, an atmospheric chemist at CSIRO's Aspendale laboratories.

The study, led by Dr Lisa Welp from the Scripps Institution of Oceanography, California, traced the path of oxygen atoms in CO2 molecules, which tells researchers how long the CO2 has been in the atmosphere and how fast it had passed through plants. From this, they estimated that the global rate of photosynthesis is about 25 percent faster than previously thought.

"It's difficult to measure the rate of photosynthesis for forests, let alone the entire globe. For a single leaf it's straightforward, you just put it in an instrument chamber and measure the CO2 decreasing in the chamber air," said Dr Welp.

"But you cannot do that for an entire forest. What we have done is to use a naturally occurring marker, an oxygen isotope, in atmospheric CO2 that allows us to track how often it ended up inside a plant leaf, and from oxygen isotopic CO2 data collected around the world we can estimate the mean global rate of photosynthesis over the last few decades."

In other studies, analysis of water and oxygen components found in ocean sediments and ice cores have provided scientists with a 'big picture' insight into carbon cycling over millions of years, but the search for the finer details of exchanges or uptake through ocean algae and terrestrial plant leaves has been out of reach.

The authors said that their new estimate of the rate of global photosynthesis will help guide other estimates of plant activity, such as the capacity of forests and crops to grow and fix carbon, and help re-define how scientists measure and model the cycling of CO2 between the atmosphere and plants on land and in the ocean.

Dr Allison said understanding the exchange of gases, including CO2 and water vapour, in the biosphere – oceans, land and atmosphere – is especially significant to climate science, and to policymakers, because of its relevance to global management of carbon emissions.

"Quantifying this global production, centred on the exchange of growth-promoting CO2 and water vapour, has been historically difficult because there are no direct measurements at scales greater than leaf levels.

"Inferences drawn from atmospheric measurements provide an estimate of ecosystem exchanges and satellite-based observations can be used to estimate overall primary production, but as a result of this new research we have re-defined the rate of biospheric carbon exchange between atmosphere, land and ocean.

"These results can be used to validate the biospheric components included in carbon cycle models and, although still tentative, may be useful in predicting future climate change," Dr Allison said.

CSIRO's Dr Roger Francey was a co-author on the project, led by Scripps' Drs Welp and Ralph Keeling. Other co-authors of the study are Harro Meijer from the University of Groningen in the Netherlands; Alane Bollenbacher, Stephen Piper and Martin Wahlen from Scripps; and Kei Yoshimura from the University of Tokyo, Japan.

Dr Allison said a critical element of the research was access to long data sets at multiple locations, such as Cape Grim, Mauna Loa and South Pole, extending back to 1977 when Cape Grim was established in Tasmania's north-west, together with more recent samples from facilities such as Christmas Island, Samoa, California and Alaska. The Cape Grim Baseline Air Pollution Station provides vital information about changes to the atmospheric composition of the Southern Hemisphere.

Provided by CSIRO