NEW HOT PAPERS - 2009

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Antje M. Moffat talks with *ScienceWatch.com* and answers a few questions about this month's New Hot Paper in the field of Agricultural Sciences.

Article Title: Comprehensive comparison of gap-filling techniques for eddy covariance net carbon fluxes
Authors: Moffat, AM, *et al.*
Journal: AGR FOREST METEOROL, Volume: 147, Issue: 3-4, Page: 209-232
Year: DEC 10 2007
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SW: Why do you think your paper is highly cited?

As the result of a collaborative effort of 18 scientists, this paper provides the most up-to-date and comprehensive understanding of techniques used to perform an important data assimilation step, the "gap-filling." This step is necessary to infer daily to annual estimates of the carbon dioxide uptake of an ecosystem from fragmented half-hourly flux measurements.

These biosphere-atmosphere observations are taken by a worldwide network of hundreds of micrometeorological tower sites called "FLUXNET," which coordinates regional and global analysis. The flux tower sites use eddy covariance methods to measure the exchanges of carbon dioxide (CO_2), water vapor, and energy between terrestrial ecosystems and the atmosphere. Our study laid one important basis for harmonized data processing within the network and serves as a reference paper, reviewing and evaluating all of the commonly used gap-filling techniques.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

The paper is a synthesis of techniques devised over the last decade. It is not a new discovery, per se, but rather a powerful finding about the robustness of the algorithms we use to infer long-term carbon exchange from noisy, gap-filled, short-term observations.

SW: Would you summarize the significance of your paper in layman's terms?

CO_2, a major greenhouse gas, is emitted to the atmosphere from the burning of fossil fuels. Land and ocean ecosystems absorb about half of these emissions and scientists are trying to understand the mechanisms that control this uptake. To quantify the temporal dynamics, the variability to climate, and the sensitivity to future climate change, tower sites measuring the carbon flux over ecosystems have been installed in a wide range of vegetations and climate zones all over the world.

Unfortunately, these finicky, high temporal resolution measurements have inherent limitations, consequently becoming fragmented in time. Since these data gaps complicate our ability to infer the long-term variability of the ecosystem's carbon uptake, several groups of scientists worldwide have independently developed dozens of techniques to infer the missing data. This paper presents the first comprehensive evaluation of these techniques, quantifies the uncertainty induced by this data assimilation step, and finds that many of these techniques are robust and agree well with each other. This agreement strengthens prior findings that have been made about the ecosystem carbon exchange.

"Without well-calibrated, long-term observations of carbon exchange in diverse ecosystems, we lack the basis on which to evaluate and improve climate change predictions of future atmospheric CO2 and climate warming."

SW: How did you become involved in this research, and were there any problems along the way?

While working in industry, I decided to go back into science and begin a Ph.D. in environmental science. This very interdisciplinary field gives me the chance to apply my background in physics to my interests in plants and nature. After intensely working with the carbon flux data sets and developing my own gap-filling technique, I took the lead of this comparison study.

The main challenge was in collecting, organizing, and synthesizing the model run results of all the different techniques as well as the 17 valuable inputs, along with 17 different—and sometimes opposing—opinions, from my collaborators, into a coherent whole. After doing this by email, with me as the central node in a star network, I was glad to get funding for a workshop. It was so much easier and more effective to have roundtable discussions. The workshop also generated the groundwork for further collaboration and papers.

SW: Where do you see your research leading in the future?

Modeling complex ecosystem responses is one of the major challenges for understanding and predicting the effects of global change. Usually, these responses are implemented in models as prescribed functional relationships. In contrast, I am working on the development of a methodology that allows these relationships to be characterized directly from the data.

It is based on a very general non-linear function class, feedforward artificial neural networks, and not only makes use of their capability to empirically model the response, but also aims to answer the question of what controls the carbon flux in terrestrial ecosystems. In the future, I hope to make wider use of this methodology, working at the interface between modeling and experiment and gaining insight into the underlying plant physiology.

SW: Do you foresee any social or political implications for your research?

Not as an individual, but as part of a community concerned with the effects of climate change on terrestrial ecosystems. Depending on how plants and soils respond, changes in the magnitude of this uptake could further ameliorate or exacerbate the greenhouse effect.

Without well-calibrated, long-term observations of carbon exchange in diverse ecosystems, we lack the basis on which to evaluate and improve climate change predictions of future atmospheric CO_2 and climate warming.

By analogy to the meteorological observation networks laid in the 19th century to allow weather forecasts and now also climate change analysis, today, carbon cycle observation networks, such as the biosphere-atmosphere FLUXNET, are needed. These observations help to reduce the uncertainty in future climate scenarios and improve political decision-making regarding the best options to respond to negative effects of future warming.

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PDF

back to top

2009 : May 2009 - New Hot Papers : Antje M. Moffat