Miguel D. Mahecha et al., 2010 Science paper:
"Global Convergence in the Temperature Sensitivity of Respiration at Ecosystem Level."

What is the context of this study?
The "natural" exchange of CO_2 between the atmosphere and the land surface is controlled on the one hand by photosynthesis (CO_2 uptake), partly counterbalanced on the other hand by the sum of CO_2 losses due to respiratory processes of all organisms in the ecosystem. Our study is focusing on the latter, the so called "ecosystem respiration". We are particularly interested in the question how short-term fluctuations (e.g. day-to-day or weekly variability) in temperature determine the intensity of ecosystem respiration. *Quantifying the short term "sensitivity" of ecosystem respiration to temperature is of paramount importance for testing current, and building future models of the global carbon cycle.* In climate-modeling studies the temperature sensitivity of respiration has been shown to be a key parameter influencing the climate-carbon cycle feedback and hence the future-world CO_2 concentrations and temperatures.

What is the particular problem behind this study?
Field studies generally report very high sensitivities of ecosystem respiration to temperature and suggest that this sensitivity changes systematically with temperature range or ecosystem types. So far such findings were difficult to interpret, since no sound theory could explain them. As a consequence, field results could often not easily be transferred to process based models simulating the terrestrial carbon cycle. Nonetheless, several attempts in this direction were made. The scientific controversy behind the scenes was further enhanced by the fact that some models simulate the main features of the carbon cycle correctly, despite of some simplistic assumptions such as globally constant (and relatively low) sensitivities of ecosystem respiration to temperature.

In our study we revisited the pending paradox between modeling studies and observational evidence by critically revisiting the analysis principles of the field data. We showed that a conventional analysis of long term ecosystem respiration data is subject to confounding effects. Thus, our challenge was to develop a method capable to disentangle the intrinsic sensitivities when the observations contain signals from confounding processes. We called our method "Scale dependent parameter estimation" (SCAPE), and believe that it offers perspectives for understanding the time scale dependence of sensitivities of various processes also in other branches of earth system sciences.

What motivated you to embark upon this study?
Ecosystem observations usually integrate information from a variety of processes and influencing factors. *We were attracted by the idea of analyzing open problems with innovative statistical methods under the premise that ecological processes often act on different time scales.* In the presented study, respiration is driven by temperature at short time scales (e.g. days to weeks), while the response to water availability and soil carbon stocks takes place on longer time scales (months to years).

We were exited by bringing together our theoretical considerations and methodological advances with the unprecedented opportunity to analyze global monitoring data (FLUXNET, see below). We were suddenly prepared to revisit important questions such as "how to quantify the short term sensitivity of ecosystem respiration to temperature fluctuations".

What are the key findings?

Our key finding is that the short term temperature sensitivity of ecosystem respiration to air temperature is converging to a single global value (obviously associated with some uncertainty). Opposed to previous studies, we show that the sensitivity of ecosystem respiration to temperature variations seems to be independent from external factors and is constant across ecosystems. To put it in other words: *we found a general relationship between variation in temperature and ecosystem respiration.* Other than previously hypothesized, we do not need complicated theories, e.g. on the adaptation of respiration to explain the observations. *Our findings reconcile the apparent contradictions of modeling and field studies.*

However, while we solve one important problem in this study (the quantification of the sensitivity at ecosystem level), we also reveal that the long term turn-over of carbon in the ecosystems is hardly understood. *The paper clearly indicates that future research must focus on the question how carbon is mediated by slow transformations in soils. We see clear indications that the role of other factors than temperature need to receive more attention in ongoing research. For instance the water availability may play a crucial role for ecosystem carbon balances at longer temporal scales*. A wide range of nontrivial feedbacks of global change await careful investigations.

Where did this study emerge?

The presented study would not have been possible without the global collaboration within the FLUXNET network. FLUXNET is an international initiative to collect monitoring data of CO_2 exchanges between ecosystems and the atmosphere (http://www.fluxnet.ornl.gov; http://www.fluxdata.org) which has been launched more than 10 years ago by Prof. Baldocchi (UC Berkeley, USA) and Prof. Valentini (Univ. Viterbo, Italy). The fluxes are measured at towers along with a series of meteorological parameters. These data provide scientists all over the world with a unique observational basis to scrutinize our current understanding of the "breathing of the biosphere" (D. Baldocchi, 2008). *We can use FLUXNET to obtain novel insights to the role of ecosystems in the global climate system.* At present over 500 tower sites are continuously operated. Vegetation types such as temperate conifer and broadleaved (deciduous and evergreen) forests, tropical and boreal forests, crops, grasslands, chaparral, wetlands and tundra are monitored. Most sites are associated with regional or domain networks. Flux towers operate on five continents and their latitudinal distribution ranges from 70 degrees north to 30 degrees south (see Fig. 1).

Furthermore, the establishment of the Biogeochemical Model-Data Integration Group by the German Max-Planck Society allowed us to build new strategies of extracting information from complex observational data for biogeochemical models.

The concrete principles of the novel analysis method were identified during some lengthy discussion in the favorite pubs of the first four authors, two lovely places in Jena one called “Grünowski” (http://www.gruenowski.de) and the other “Theater Café”.

What observations were used?

In this study we used CO_2 flux data from 60 towers across the world. The so called “eddy covariance method” allows to measure directly and continuously the net CO_2 exchange between the ecosystem and the atmosphere in a nondestructive way (Figs. 2-4). As this study focuses on the respiratory fluxes (the CO_2 release to the atmosphere) we were restricted to nighttime data where CO_2 uptake via photosynthesis does not play a role. *The towers are located in a wide range of ecosystems, for instance we have observation from towers in tropical forests, savannahs, and boreal regions amongst others (Fig. 1).*

What are the actual implications of your findings for people everyday?

Given that the sensitivity of ecosystem respiration is a critical determinant for the CO_2 release from the biosphere our findings are relevant to climate change research. *With this study we provided a small but important piece to our understanding of the global carbon cycle.* As an additional output of this research we also can use these results to evaluate those models used in the context of climate predictions.

Interested in FLUXNET more activities?

A nice introduction on FLUXNET is given here: http://www.fluxnet.ornl.gov/fluxnet/introduction.cfm
Images of various eddy covariance towers are here:
http://www.fluxnet.ornl.gov/fluxnet/fluxpictures.cfm
If you are interested in the communication within the scientific community we recommend skimming through this site:
http://www.fluxnet.ornl.gov/fluxnet/newsletters.cfm
Overall, FLUXNET was created

- to provide a central gateway to access data on ecosystem-atmosphere exchanges of CO_2 (and other fluxes) and therefore to promote global synthesis studies;
- to provide the infrastructure for a central database of site characteristics (land cover, climate, meteorology, plant, and soil data);
- to maintain information about the availability of flux data along with links to the flux data at individual towers or at networks;
- to archive flux data associated with manuscripts, workshops, as well as site characteristics and ancillary data about flux tower sites;
- to compile, archives, and distributes carbon, water and energy flux measurements for unaffiliated sites and others, as requested; and
- to provide information for evaluating remote sensing products, such as primary productivity, evaporation, albedo, and energy absorption.

As once written by Prof. Dennis Baldocchi from the University of California, FLUXNET is “a global network of collaborating regional networks” which is significantly contributing to our knowledge on ecosystem functioning (the statement by D. Baldocchi is cited from *Australian Journal of Botany*, 2008, 56, 1–26).

Figures

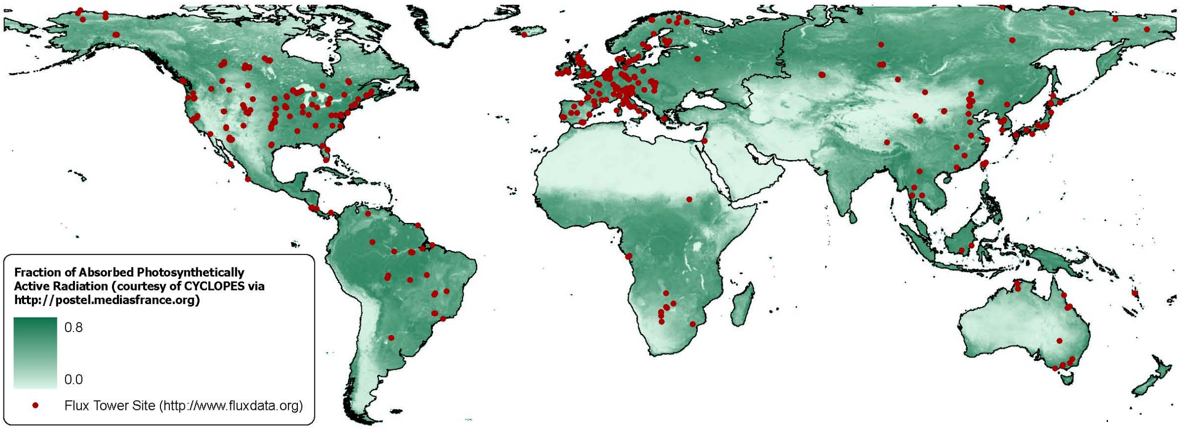

Figure 1 *Locations of eddy covariance towers over the globe (this figure can be used reproduced in the context of this paper. Please include image credit to © Max Planck Institute for Biogeochemistry, Jena).*

Figure 2 *Eddy covariance measurement system at the Hainich tower, Germany (this figure can be used reproduced in the context of this paper. Please include image credit to © Max Planck Institute for Biogeochemistry, Jena).*

Figure 3 *Eddy covariance measurement tower at the Hainich forest, Germany (this figure can be used reproduced in the context of this. Please include image credit to © Max Planck Institute for Biogeochemistry, Jena).*

Figure 4 *Webcam view from the eddy covariance tower in Harvard forest (this figure can be used reproduced in the context of this paper. Please include image credit to © Andrew D. Richardson, Harvard University).*

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