Reply to comment by François Bourges *et al.* on “Carbon uptake by karsts in the Houzhai Basin, southwest China”

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Received 24 April 2012; revised 21 May 2012; accepted 26 May 2012; published 4 July 2012.

Citation: Yan, J., Y. P. Wang, G. Zhou, S. Li, G. Yu, and S. Wang (2012), Reply to comment by François Bourges *et al.* on “Carbon uptake by karsts in the Houzhai Basin, southwest China”, *J. Geophys. Res.*, *117*, G03007, doi:10.1029/2012JG002060.

[1] We thank *Bourges et al.* [2012] for their comment and interest, and we appreciate the opportunity to clarify our paper.

[2] In their commentary, *Bourges et al.* [2012] raise three points: (1) gaseous emissions from the Houzhai Basin are not included in the study of the Houzhai Basin; (2) surface CO_2 emissions as estimated by *Bourges et al.* [2012] are about one order of magnitude greater than the flux estimated by *Yan et al.* [2011]; (3) CO_2 content and aerodynamic regime in the Houzhai Basin can be monitored using a network of flux towers and CO_2 sensors to refine the carbon budget for the basin. In the following we will address each point in turn.

[3] The objectives of the study as outlined in *Yan et al.* [2011] are to understand the temporal variations of carbon uptake from carbonate dissolution and the major driver of that uptake. It *was not* our objective to construct a full carbon budget for the Houzhai Basin; therefore, gaseous emissions from the land surface were not included in the study (see Figure 1). This addresses point (1).

[4] The carbon budget of most terrestrial ecosystems can be represented by the influx of gross primary production (GPP), efflux of autotrophic and heterotrophic respiration (R_{eco}), and carbon loss from disturbance (L_{dis}), such as fire and wood harvest. The flux of CO_2 dissolved in runoff to rivers or other aquatic systems is usually several orders of magnitude smaller than GPP or R_{eco} and is therefore usually neglected in the carbon budget for most terrestrial ecosystems. However, the runoff CO_2 flux can be a significant component for terrestrial ecosystems in karst landscape because the amount of CO_2 dissolved in karst water can be two orders of magnitude greater than that in a natural water ($CO_2 - H_2O$) system [*Dreybrodt*, 1988]. The study [*Yan et al.*, 2011] estimated that the rate of carbon uptake by chemical weathering in all of karst terrain in China is about 12 Tg C yr^{-1}, which is about 57% of the rate of carbon accumulation by forest biomass in China from 1981 to 1998, suggesting that weathering of carbonate rocks is also an important carbon sink in China. That CO_2 flux via runoff, which depends on soil chemical properties, is sometimes called abiotic flux [*Serrano-Ortiz et al.*, 2010], and it cannot be measured directly by eddy covariance or other aerodynamic techniques. The study by *Yan et al.* [2011] provided one of few estimates for karst systems worldwide.

[5] The CO_2 released from soil respiration in karst terrain can diffuse out to the surface atmosphere via soil pores, macroscopic voids, and fissures, or be chemically taken up during carbonate dissolution. At steady state, the rate of soil respiration is equal to the sum of the rate of CO_2 diffusion to the surface atmosphere and abiotic flux via runoff. Because of the complex air passage in the vadose zone of a karst landscape, the rate of CO_2 diffusion is highly variable (see Figure 1). It is possible that a significant fraction of CO_2 diffusion can occur through macroscopic voids and fissures in a karst landscape, which is what *Bourges et al.* [2012] estimate. Therefore, it is more appropriate to compare the fluxes as estimated by *Bourges et al.* [2012] with the fluxes of ecosystem respiration (R_{eco}) than with the abiotic flux. The flux via diffusion can be much greater than the abiotic uptake via carbonate dissolution, as pointed out by *Bourges et al.* [2012] and others [*Kowalczk and Froelich*, 2010; *Serrano-Ortiz et al.*, 2010]. However, these two fluxes can play quite different roles in a regional carbon budget. Abiotic uptake of CO_2 can be transported to rivers in the form of bicarbonate that can be assimilated by some living organisms in aquatic systems [*Einsele et al.*, 2001; *Lerman and Mackenzie*, 2005; *Aufdenkampe et al.*, 2011]. Once assimilated, much of that carbon will remain in water for decades or even longer, therefore the assimilation of bicarbonate exported from runoff represents a carbon sink, whereas the CO_2 that diffuses out to the surface atmosphere represents a carbon loss from the karst landscape to atmosphere, or a carbon source for the regional carbon budget. This addresses point (2).

[6] Because of many macroscopic voids, numerous fissures, and caves across the Houzhai Basin or similar karst landscape, air passage in the vadose zone is more complicated than in many other landscapes, and surface CO_2 emissions can be extremely variable (see Figure 1). Estimates of CO_2 emission rates from field measurements at the cave opening as recommended by *Bourges et al.* [2012] can be highly uncertain, as

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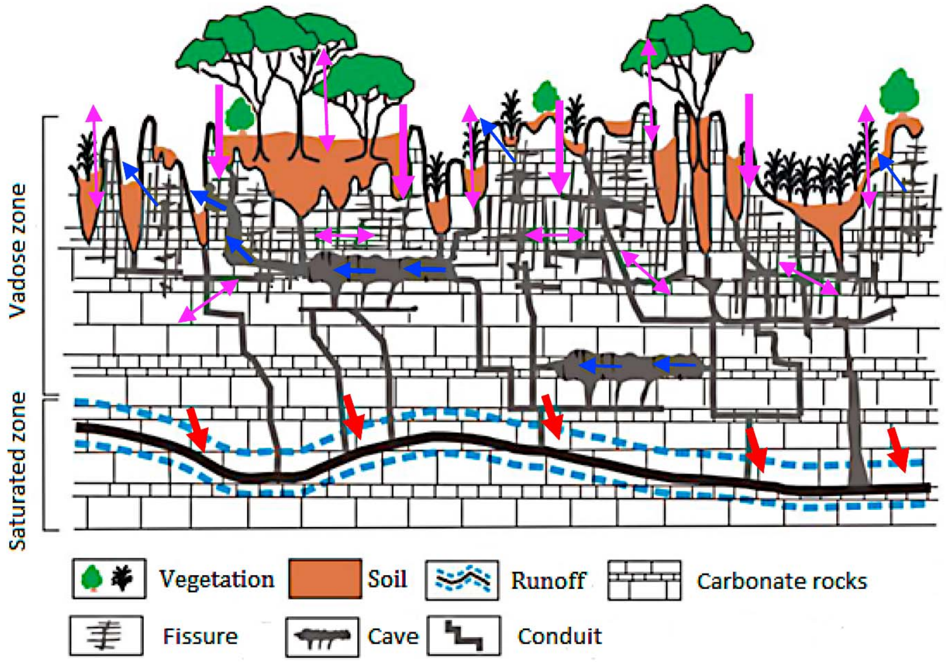

Figure 1. A schematic diagram of the karst landform and CO_2 flow in a karst terrain. The arrows indicate the directions of CO_2 flow. The blue arrows indicate CO_2 emission from macroscopic voids, numerous fissures, and caves, as referred to by *Bourges et al.* [2012]. The red arrows indicate the uptake of CO_2 during rock weathering, and the rate of uptake was estimated by *Yan et al.* [2011] for the Houzhai Basin. The pink arrows indicate the complexity of air passage within the vadose zone in a karst terrain.

the area that contributes to the CO_2 emission at the opening is highly uncertain. We agree that a comprehensive network is required to quantify the carbon budget of the Houzhai Basin using a combination of various techniques. This is the aim of one of our ongoing projects in the Houzhai Basin. This addresses point (3).

[7] **Acknowledgments.** We thank Zaihua Liu, Xiaoyong Bai, and Tao Peng of the Institute of Geochemistry (CAS) for their helpful discussions.

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