Response to Referee #1

General comments

The review of the article “Constraining the soil carbon source to cave-air CO₂: evidence from the high-time resolution monitoring soil CO₂, cave-air CO₂ and its δ₁³C in Xueyudong, Southwest China” by Min Cao, Yongjun Jiang, Jiaqi Lei, Qiufang He, Jiaxin Fan, Ze Zeng. The authors present the data on CO₂ in the soil, cave stream, and cave atmosphere (Xueyu Cave, China) and its surrounding. The data were gathered during the period of 2015-2016. The aim of the article is (1) to understand the quantitative relationship between all the forms of CO₂, (2) to reveal their sources, and (3) to understand the factors that control the cave air CO₂ variations. The topic of the article is important and is worthy of publication. In the article, however, there are some aspects that require revision and other ones that could be substantially improved before publishing. My main reservation is that the conclusions should be better proved by a data analysis (e.g., Cross-correlation Analysis). The results of the data analysis should be presented and discussed in detail. The data sets are nice, but they could be much better presented. The x-axis should be more extended in order to be better distinguishable individual fluctuations in the variables.

Answer to general comments:

We would like to thank the referee for his generally positive comments. We will pay more attention in presenting and explaining our data in the final version.

We posted a table of the correlation analysis:

Table 1 The correlation matrix of environmental parameters in Xueyu system

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* P<0.01, ** P<0.00, Soil M=Soil moisture, Soil T=Soil temperature, Prep=Precipitation, Cave T=Cave temperature

We updated the text in the discussion part ‘4.3 Environmental parameters and their correlation’.
There are significant correlations between stream pCO$_2$ and cave air CO$_2$, especially at LF site ($R^2=0.95$, $p<0.01$). The correlation between soil CO$_2$ and soil temperature is significant too ($R^2=0.64$, $p<0.01$).

We put more details in the study area part, the method part and discussion part, and refined the conclusions too:

1) Two-year monitoring study of soil CO$_2$, subterranean stream and cave air CO$_2$ concentration reveals that a dynamic equilibrium between CO$_2$ sources and sinks. Seasonal dynamics took place with the minimum cave air CO$_2$ concentrations during winter and peaks in November.

2) High-resolution monitoring of CO$_2$ concentrations in the soil and cave system may allow us to estimate the potential cave air CO$_2$ sources in Xueyu Cave (subterranean stream, air from vadose/soil zone). Throughout the year, $\delta^{13}$C$_{DIC}$ showed higher values in winter but lower values in summer. $\delta^{13}$C of different endmembers showed that soil CO$_2$ made more contribution of C to the cave air CO$_2$ in June (75.6%) than in November (65.9%), and the second source was the degassing of stream. The accumulation of cave air CO$_2$ concentration maintains the high values in summer due to the confined space.

3) The seasonal variations in cave air CO$_2$ concentration were very similar to that in stream pCO$_2$, showing which shows high but fluctuated values in summer and steady but low values in winter. Stream water seems to be a constant source of CO$_2$ as an increase of up to 5800 ppm in 2 hours was observed and CO$_2$ degassing occurred after strong rain events. In winter, stream water is the carbon sink of cave CO$_2$.

4) Cave air CO$_2$ concentrations are similar at different sites in Xueyu Cave. The anthropogenic impact of visitors to cave air CO$_2$ concentrations is evident from the hourly fluctuations, but not significant on daily or longer time scales.

**Other comments:** Throughout the text, it is important to distinguish CO$_2$ itself from CO$_2$ concentration and pCO$_2$ (e.g., the lines/paragraph 85). The expression “PCO$_2$ in the water” (stream pCO$_2$ is acceptable only as an abbreviation in the text. Furthermore, it is important to explain that it means pCO$_2$ of gaseous CO$_2$ that would be in equilibrium with aqueous carbonates. In principle, pCO$_2$ is dimensionless variables (or it has units of pressure). If the CO$_2$ quantity is given in ppmv units, it means “CO$_2$ concentration”.
Some soil characteristics should be given in the paragraph Study Area. More detail information should be given in monitoring/calculating of the stream CO₂ in the paragraph Methods and Materials.

The x-axes in the plots (Fig. 2, 3, 4, 5) should be better divided (e.g., by one month, three months, etc.). The secondary y-axis in Fig. 4 should represent “Precipitation”. I do not understand what the conceptual model in Fig. 7 brings new/beneficial. In the text, there are missing the citation: Liu and Zhao 2000, and Baker et al., 1998 and 2014, referenced in the Reference list.

Answer to other comments:

1. We checked the use of CO₂ itself and pCO₂, CO₂ concentration to make sure that they are expressed in the correct form in the revised text. Actually, pCO₂ has unit, such as Pa, but we use ppm in CO₂ quantity to make it simple and comparable between air and water.

2. In most cases, it is not in equilibrium with aqueous carbonates, which can be seen in Fig. 8.

3. The x-axis had been adjusted in order to be better distinguishable individual fluctuations in the variables. The figures 2 and 3 can be seen in the supplementary material.

4. Regarding to the references, we checked all the manuscript to make sure that the citations in the maintext are all consistent with the ones in the reference list. References by Liu and Zhao 2000, and Baker et al., 1998 and 2014 were cited in the previous manuscript but then cancelled in the maintext without removing from the reference list.

5. In the revised version, we cancelled the following part:


**Figure 1** (A) Chongqing Municipality, SW China and geographical location of study area (red shape), (B) Monthly air and precipitation in Xueyu Cave, (C) The location of the Xueyu Cave, its surrounding strata and the soil sampling site (modified from Wu et al. (2015)), (D) Sketch map of the Xueyu Cave and locations of the monitoring sites: X1 and X5 for cave air and stream pCO₂ monitoring.

**Figure 2** Cross section of Xueyu Cave passages and the sampling locations, Chongqing, SW China.
Figure 3: (a) Precipitation, (b) air temperature and soil temperature, (c) soil moisture, (d) $pCO_2$ values in the soil air, cave air and stream water of Xueyu system in the years 2015-2016.

Figure 4 Variations of monitoring items (precipitation, temperature, $\delta^{13}C$ and $pCO_2$) during rainfall events in October-November, 2014 and June 2015.

Figure 5 Conceptual model for subsurface carbon cycling in Xueyu karst cave. CO$_2$ respired in soils is transported into caves by gaseous form or infiltrated in rainwater. Changes of ventilation patterns which might be correlated to soil moisture overlying can help to accumulate cave air CO$_2$ or make it dispersed in summer and winter. Sketch of the seasonally controlled airflow of the Xueyu Cave system and resulting in $pCO_2$ changes.

Figure 6 The $pCO_2$ variability ($\theta(pCO_2) = pCO_2(\text{stream}) - pCO_2(\text{air})$) in the Xueyu stream and cave air system.

Figure 7 The relationships between $\delta^{13}C_{V-PDB}$ and 1/CO$_2$ during the occurring of rainfall events in November (A) and June (B).
Figure 3

(A) Temperature (°C)

(B) Precipitation (mm)

(C) Soil moisture (%)

(D) $\rho$CO$_2$ (ppmv)

- Soil T
- Air T
- Cave air T

- Soil
- Stream
- Cave air