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Short communication

Preliminary study of atmospheric carbon dioxide in a glacial area of the Qilian Mountains, west China

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HIGHLIGHTS

- Concentration of CO_2 and seasonal variation amplitude were low at QSS.
- Shorter duration with decreasing CO_2 than other WMO/GAW stations was detected.
- Higher annual increase of CO_2 than global mean value was discovered at QSS.
- Anthropogenic activities have influences on the CO_2 at QSS, especially in summer.

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ABSTRACT

Carbon dioxide represents the most important contribution to increased radiative forcing. The preliminary results of the atmospheric carbon dioxide mole fraction from the glacial region in the Qilian Mountains area, in the northeast of the Qinghai-Xizang (Tibetan) Plateau during July, 2009 to October, 2012 are presented. The annual mean CO_2 mole fractions in 2010 and 2011 were 388.4 ± 2.7 ppm and 392.7 ± 2.6 ppm, respectively. These values were consistent with the CO_2 mole fractions from the WMO/GAW stations located at high altitudes. However, both the concentration and seasonal variation were significantly lower than stations located adjacent to megacities or economic centers at low latitudes in eastern China. Shorter durations of photosynthesis of the alpine vegetation system that exceeded respiration were detected at the Qilian Mountains glacial area. The annual mean increase during the sampling period was 2.9 ppm yr^{-1} and this value was higher than the global mean values. Anthropogenic activities in the cities adjacent to the Qilian Mountains may have important influences on the CO_2 mole fractions, especially in summer, when north and north-north-west winds are typical.

1. Introduction

Greenhouse gases (CO_2, CH_4, N_2O, etc.) are currently playing the most important roles in forcing climate changes (IPCC-AR5, 2013). Among the constituents, carbon dioxide (CO_2) represents the most important contribution to increased radiative forcing (IPCC-AR5, 2013). Since the industrial revolution, the atmospheric CO_2 mole fraction has increased by ~110 ppm and is unequivocally associated with human activities (Fang et al., 2014; Keeling, 1993). Fossil fuel burning and land-use changes are the main causes for the increase, while oceans and terrestrial ecosystems act as sinks for atmospheric CO_2 and absorb approximately half of the anthropogenic emissions (Ballantyne et al., 2012; Houghton, 2003; Peters et al., 2012). To better understand the carbon cycle in different ecosystems (e.g., continents and oceans), it is necessary to quantitatively assess the existing sources and sinks and their potential influences on the carbon cycle (Peters et al., 2007; Tans et al., 1990). Since 1958, CO_2 mole fractions have been continuously analyzed at Mauna Loa Observatory in Hawaii (Keeling et al., 1976; Keeling, 2008). More than 150 sites worldwide have been equipped to monitor the variations of the atmospheric CO_2 and study the potential influences of local sources (Artuso et al., 2009; Dlugokencky et al., 1995; Necki et al., 2003; Sirignano et al., 2010; Tans et al.,

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1990). However, the density of the sites are unevenly distributed; some places with relatively dense sampling sites (e.g., North America and Western Europe) allow us to constrain regional fluxes using inverse models (Fang et al., 2014; Gourdji et al., 2012), while it is difficult to obtain convincible data on the CO_2 budget at sites with sparse sampling networks (e.g., northeastern Asia) (Peylin et al., 2013; Sirignano et al., 2010).

Since the early 1980s, the China Meteorological Administration has established several background stations: the Shangdianzi (SDZ) station, Lin'an (LAN) station, Longfengshan (LFS) station and Waliguan (WLG) station, etc (Liu et al., 2014; Zhou et al., 2003). All the background stations were added to the World Meteorological Organization's Global Atmosphere Watch (WMO/GAW) network. Since then, these stations have provided us with large amount of valuable results on the atmospheric greenhouse gases in China (Fang et al., 2014; Liu et al., 2014, 2009; Zhou et al., 2003; Zhou et al., 2004). However, the current distribution of the monitoring sites is still not adequate to assess the national emissions and the related regional influences (Fang et al., 2014). Thus, additional stations representing different background conditions are needed.

Since July 2009, the sampling research for atmospheric greenhouse gases was initiated at the Qilian Shan Station of Glaciology and Ecologic Environment (QSS, 39.5 °N, 96.5 °E, 4214 m a.s.l.). QSS is located at the glacial region in the northeastern area of the Qinghai-Xizang (Tibetan) Plateau and at the terminal area of the largest glacier (Laohugou No.12 Glacier) in the eastern Qilian mountain range (Fig. 1). The background conditions (e.g., geographic and climatic conditions) at QSS are different from those at WLG, SDZ, LAN and LFS (Fang et al., 2014; Xu et al., 2013). Here, we present the preliminary atmospheric CO_2 mole fraction results for 2009–2012.

Laohugou No. 12 Glacier is the greatest valley glacier in the Qilian Mountain, and a recent measurement shows that its area is approximately 21 km^2 with a terminal elevation of 4260 m; the highest peak (Daxueshan) is 5483 m asl (Xu et al., 2013; Zhao et al., 2012). The climate of QSS is dominated by the westerlies in winter and by the combined East-Asian monsoon and westerlies in summer. A variety of local currents are closely related to the specific structure of the valley, for instance, the typical wind direction is north in the day and southeast at night during the East-Asian monsoon (Xu et al., 2013). Controlled by the mid-latitude westerlies, the local climate is typically continental (dry and arid) with sparse precipitation occurring from May to September. The annual precipitation is approximately 350 mm, and the average annual temperature is approximately −6 °C (Fig. 2). Arid and semi-arid regions surround this region: Tarim Basin (Taklimakan Desert) is

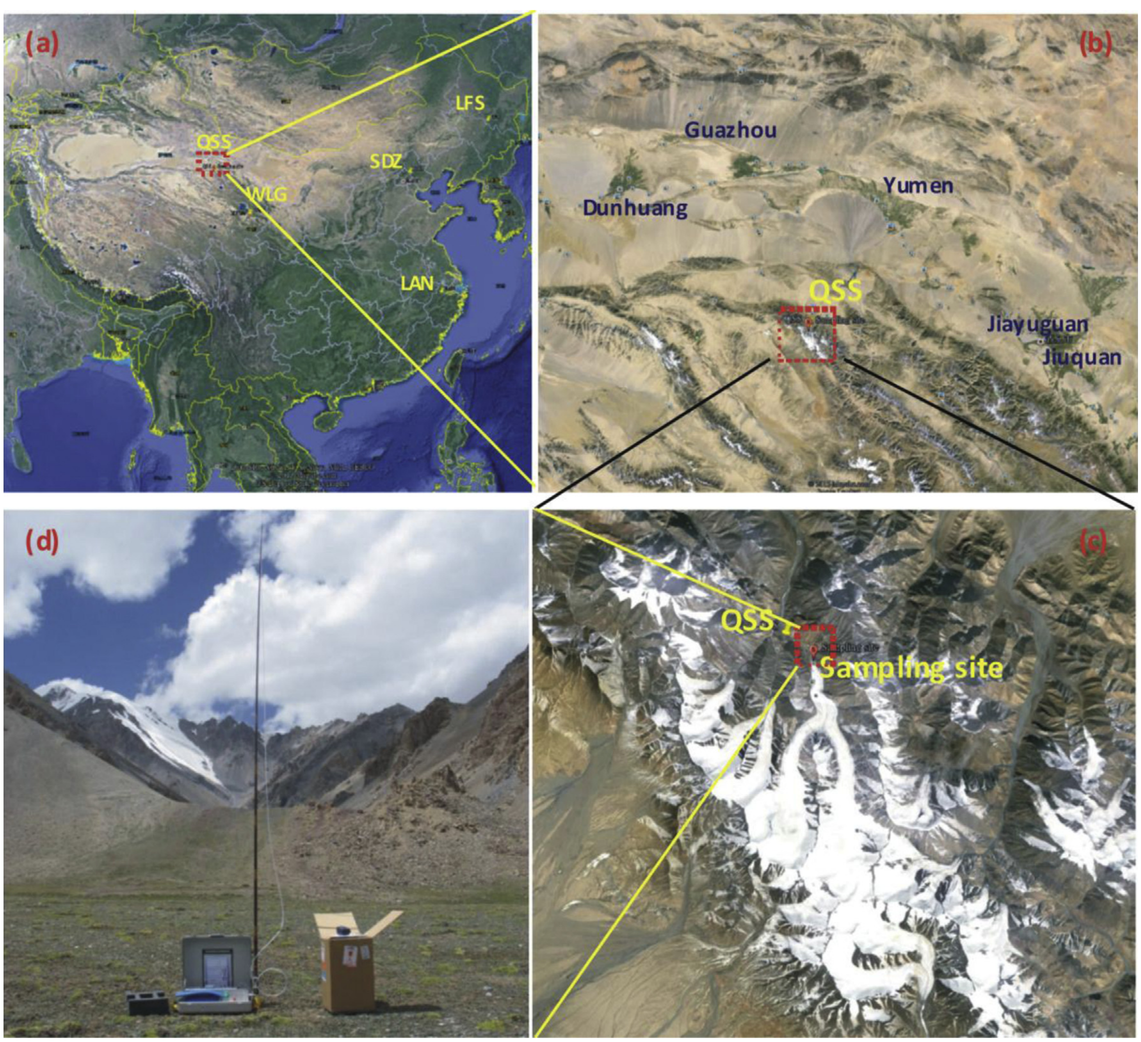

Fig. 1. Topographic map of China and location map of (a) Qilian Mountain Station (QSS), Waliguan (WLG), Shangdianzi (SDZ), Longfengshan (LFS) and Lin'an (LAN), (b) QSS and the nearby cities, (c) the glacier distribution around QSS and the sampling site, and (d) photograph at the sampling site near QSS.