Atmospheric CO₂ Data Filtering Method and Characteristics of the Mole Fractions at Wutaishan Station in Shanxi of China

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ABSTRACT

Wutaishan (WTS) Station on Wutai Mountain (2208 m a.s.l.), which is also known as the “North China Roof,” in Shanxi Province, is surrounded by lush forest vegetation and situated far (30 km) from industrial emission sources. This study filtered online observation data of the atmospheric CO₂ (G2301; Picarro) at WTS Station from March 2017 till February 2018 using both robust extraction of the baseline signal (REBS), and meteorological data (MET) in order to obtain the average background concentration, which is representative of the region (Shanxi Province and the surrounding areas). The background concentration of CO₂ averaged $(410.9 \pm 6.4) \times 10^{-6}$ (mole ratio, the same below), and the daily variation ranged from 2.4×10^{-6} to 4.8×10^{-6} , which is relatively low, across the four seasons. The concentration and the surface wind speed displayed negative correlations during spring and winter, with R being −0.44 and −0.46, respectively. Analyzing the backward trajectories, we concluded that wind from the SE–S–SW sector noticeably increased the local CO₂ concentration by transporting from high altitudes (i.e., high air masses) or along the surface.

Keywords: Carbon dioxide; Regional representative; Observation data selection; Backward trajectory.

INTRODUCTION

As one of the main greenhouse gases in the atmosphere, CO₂ contributes about 66.0% of the radiation forcing from long-lived greenhouse gases, and its contribution to the increase of radiation forcing is about 82.0% in the past five years (Butler *et al.*, 2018). In recent decades, the global CO₂ concentration has been increasing. In 2017, the global average CO₂ concentration is $(405.5 \pm 0.1) \times 10^{-6}$ (mole ratio, the same below), which is 146.0% of that before the Industrial Revolution (1750) (WMO, 2018), which is mainly caused by the carbon emissions of human activities, especially the burning of fossil fuels, the unreasonable use of land resources, the destruction of forest resources, etc. (Keeling *et al.*, 1989; Houghton, 2003; Kuc *et al.*, 2003; Zhou *et al.*, 2004; Peters *et al.*, 2011).

Since 1950, the relevant institutions from various countries have established observation stations in different

regions to carry out long-term monitoring of CO₂ and have accumulated a large amount of basic observation data (Haszpra *et al.*, 2008; Keeling, 2008; Sirignano *et al.*, 2010; Pu *et al.*, 2012). One of the purposes is to study the global carbon cycle by combining the spatio-temporal variation of CO₂ with the inversion model (Tans *et al.*, 1989; Keeling and Whorf, 2004). The construction of greenhouse-gas observation stations in China started relatively late. By 2013, seven atmospheric background stations had been built, including Waliguan (WLG) in Qinghai, Shangdianzi (SDZ) in Beijing, Lin'an in Zhejiang, Longfengshan in Heilongjiang, Shangri-La in Yunnan, Jinsha in Hubei and Akedala in Xinjiang.

Due to the varied geographical locations, topographies and environmental conditions of different stations, the spatio-temporal representativeness of observation data is quite different. It is necessary to accurately extract the global or regional representative background values during the analysis (Artuso *et al.*, 2009). Therefore, the data filtering is very important in the analysis of the CO₂ background concentration. Different methods have been adopted to filter the background/non-background concentration according to the unique characteristics of each station over the world. Bousquet *et al.* (1996) from Ireland filtered the observed

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CO₂ data according to the influence factors such as diurnal variation and surface wind. Tsutsumi *et al.* (2006) used CO as the tracer in the background/non-background filtering of the online observation CO₂ data when studying the observation data at Yonaguni-jima Station in Japan. Inoue and Matsueda (2001) from Japan used the bias between the observation data and the fitting curve to filter the background data. Zhou *et al.* (2002, 2003) took the statistical average data of surface wind as one of the filtering factors for the background data of atmospheric CO₂ and put forward a method suitable for the inland plateau of China. Zhang *et al.* (2013) promoted the filtering method proposed by Thoning *et al.* (1989) and applied it to the filtering of atmospheric CO₂ in the inland plateau of China, and used the results in the source/sink analysis. In addition, robust extraction of the baseline signal (REBS) is also commonly used for filtering data at global atmospheric background stations (Ruckstuhl *et al.*, 2012). Fang *et al.* (2015a, b) filtered the atmospheric CO₂ concentration at Longfengshan Station in Heilongjiang Province and Lin'an Station in Zhejiang Province by auxiliary tracing (AUX), black carbon tracing (BC), REBS and meteorological data (MET), and it is concluded that the applicability of different filtering methods varies at different stations. Some stations combined several methods in filtering. For example, Derwent *et al.* (2002) filtered out the non-background concentration affected by local conditions according to the characteristics of Mace Head surface wind direction and wind speed, and then the filtered data is used to filter the background and non-background concentrations according to the backward trajectory model. Pu *et al.* (2014) studied the CO₂ concentration at Lin'an in Zhejiang Province by the BC and MET methods.

Shanxi Province, as a major coal province in China, has a carbon emission intensity of 0.397 kg yuan⁻¹ (Zhang, 2018) and high CO₂ emissions. Therefore, it is of great significance to grasp its background concentration for implementing effective emission reduction measures. Shanxi Province took the lead in constructing a greenhouse-gas observation station network in the whole province. Now six stations have been built, five of which are built in cities, and only Wutaishan (WTS) Station is built on a high mountain with an altitude of 2208 m. There are no obvious industrial sources, and there is rich vegetation around. In this paper, WTS Station is selected to carry out the research on background concentration in Shanxi Province. Two methods (REBS and MET) are combined to filter the online observation data for the background and non-background CO₂ concentration from March 2017 to February 2018 at WTS. The variation characteristics of the CO₂ mole fractions at WTS and the influence factors are analyzed. The influence of air-mass transmission in different seasons on the observation results of CO₂ at WTS is discussed by using the backward-trajectory clustering analysis.

RESEARCH METHODS

Station Introduction

Wutaishan in Shanxi Province is on the eastern edge of the Loess Plateau, known as the “North China Roof,” and it is also a famous tourist attraction, which belongs to the north

end of the forest steppe climate zone of warm-temperate semiarid type. The annual average temperature is -4.2°C and the annual average precipitation is 500–600 mm at WTS Station (113.52°E, 38.95°N, 2208 m a.s.l.). The geographical location of the station is shown in Fig. 1. Due to the high altitude and low temperature at the station, the boiler is used for heating from the beginning of October to the end of April in the next year. The boiler room is 23.6 m to the southeast of the sampling tower. There is a small temple (Puji Temple) 2.6 km to the southeast of the station. The town of Taihuai (the main scenic spot of Wutai Mountain) is 9.1 km to the northeast of the station. The town of Doucun is 17.6 km to the southwest of the station. The city of Xinzhou is about 90 km away from the station along the southwest direction, and the city of Taiyuan is about 150 km away. There is no large city or industrial area within 30 km of the station, and the surrounding area is well covered by the forest vegetation. Due to the unique geographical location and environmental conditions of WTS, its observation results can represent the CO₂ concentration level in this region.

Analysis Method and Data Processing

The main engine of the online CO₂-concentration observation system is the G2301 (Picarro, USA) high-precision CO₂/CH₄/H₂O analyzer based on wavelength-scanned cavity ring-down spectroscopy (WS-CRDS), which is designated as the international comparison standard instrument for monitoring CO₂ by the World Meteorological Organization (WMO). The sampling port is set on the top of the 30-m outdoor sampling tower. The outdoor sample gas is firstly controlled by pressure and flow; then, most of the moisture will be removed through the ultra-low-temperature cold trap (operating temperature: -50°C; SP Scientific, USA). To enable the sample gas to quickly replace in the sampling pipeline, eliminate the dead volume and reduce the influence

Fig. 1. Geographical location of WTS.

of the sample gas lag on the observation data, a small secondary pressure releaser is installed at the back of the glass condenser, and the flow rate is set as 200 mL min^{-1} . Eventually, the sample gas can enter the valve box of the system. The valve box is equipped with eight valves for selecting samples (eight inlets and one outlet), which can connect the sample gas and the working gas with different concentrations. When the system is working, the eight valves automatically rotate to select analyzing the air or the standard gas.

When analyzing atmospheric samples, two bottles of working standard gas (high-/low-concentration standard gas [WH/WL]) are used for quantitative analyses. Each bottle is injected with the standard gas for 5 minutes every time, and the average of data within 5 minutes is used for calculation. The sample concentration is linearly determined by the instruments' output values of adjoining WH and WL and the standard-gas concentration. To further monitor the quality of the analysis system, a bottle of standard gas (target gas [T]) with a known concentration is used to access the analysis system, and the setting accuracy of the system is determined by comparing the system setting concentration with the standard-gas concentration. The WH, WL and T gases used in the system are all standardized by the Chinese Academy of Meteorological Sciences, and all of them can be traced back to the primary standard-gas series from the WMO Global Atmosphere Watch (GAW).

Before the observation data is used for analyses, the obvious unreasonable data caused by system failures, livestock interference and other reasons was eliminated, and 94.6% of the data was retained as the effective data. The effective average concentration in 5 minutes is calculated to the hourly average concentration. The surface wind direction and wind speed are automatically measured by the DZZ5 automatic meteorological station produced by Huayun

Sounding Meteorological Technology Co., Ltd. (Beijing).

RESULTS AND DISCUSSION

Average Diurnal Variation

The diurnal variations of hourly average CO_2 concentration in spring (March, April and May), summer (June, July and August), autumn (September, October and November) and winter (January, February and December) are shown in Fig. 2. The near-surface CO_2 concentration is generally affected by regional sources/sinks and the short-to medium-distance transmission (Artuso *et al.*, 2009). In terms of the diurnal variation amplitude, different from the obvious diurnal variations in Lin'an (Pu *et al.*, 2012) and Shangri-La (Li *et al.*, 2012) in different seasons, the diurnal variations of CO_2 concentration at WTS are relatively insignificant in four seasons. In spring, summer and autumn, the CO_2 concentration at WTS is low in the daytime while high at night. After sunrise, the vertical movement of the atmosphere strengthens with the rise of surface temperature, and the atmosphere is mixed evenly. The photosynthesis of vegetation begins, and the CO_2 concentration gradually decreases, reaching the bottom in 10:00–16:00 (Beijing Time, the same below). In the evening, the stable boundary layer appears; then, CO_2 gradually accumulates and its concentration rises under the impact of the weak vertical transport process and the plant respiration, with the peak appearing in the early morning or before sunrise. During the heating period in winter, as the influence of green vegetation is weak, the CO_2 concentration is also high in the daytime. In accordance with conclusions of some current researches (Wang *et al.*, 2003; Fang *et al.*, 2011; Pu *et al.*, 2012), the highest CO_2 concentration at WTS appears in winter, followed by spring, autumn and summer in turn. On the whole, the diurnal variation amplitudes in the four seasons are 2.6×10^{-6} ,

Fig. 2. Diurnal variation curves of CO_2 concentration in different seasons at WTS. Error bars indicate one standard deviation (1σ).

4.8×10^{-6} , 2.9×10^{-6} and 2.4×10^{-6} , and it is significantly less than that in other regions of China (Li et al., 2012; Pu et al., 2012; Luan et al., 2014).

The Influence of Surface Wind

In order to study the influence of surface wind on the observed CO₂ concentration, the arithmetic means of hourly CO₂ concentration and wind speed at the sixteen wind directions at WTS in different seasons are calculated, and the rose diagrams of CO₂ concentration, wind speed and wind direction are drawn, as shown in Fig. 3. There are 2187, 2208, 2163 and 2160 pieces of valid data in spring, summer, autumn and winter, respectively. There is a significant negative correlation between the wind speed of sixteen directions and the CO₂ concentration in spring and winter. The correlation coefficients (R) are -0.44 and -0.46 , respectively. In spring and winter, due to the weakening of ecosystem respiration, the surface wind may be the main factor determining the variation of CO₂ concentration at this station. This result is similar to the study of Li et al. (2012) on the Shangri-La background station.

In general, the main wind directions that are likely to cause the high concentration of CO₂ in each season are: east (E), southeast (SE) and south-southwest (SSW) in spring; SE, west-southwest (WSW) and south (S) in summer; WSW, east-southeast (ESE) and southwest (SW) in autumn; and

south-southeast (SSE), E and ESE in winter. It can be seen that the corresponding wind directions of high-concentration CO₂ in four seasons are mostly in the east–southeast–southwest (E–SE–SW) sector, corresponding to the boiler and temple in the SE of the station. Comparing the average CO₂ concentration in each season, the wind can uplift the CO₂ concentration in spring, summer, autumn and winter by 2.4×10^{-6} , 3.0×10^{-6} , 1.9×10^{-6} and 11.6×10^{-6} , respectively. In winter, the SSE sector can increase the CO₂ concentration mostly due to the fact that the average temperature of WTS in winter is -11.9°C and the ecosystem has little impact on the CO₂ concentration. During that period, the boiler firing coal for heating, which is closest to the SE of the sampling tower, becomes the main source of CO₂. In addition, the average wind speed of SSE wind in winter is only 1.3 m s^{-1} , leading to a great increase of CO₂ concentration in this wind direction. Therefore, the CO₂ concentration observed at WTS may be mainly controlled by near-surface sources and surface wind.

Table 1 shows the occurrence frequency of each wind level and the corresponding average CO₂ concentration (classified according to the Beaufort Wind Scale) in different seasons. The influence of the horizontal-wind-speed variation on the CO₂ concentration varies in different seasons. The higher the wind speed in spring and winter is, the lower the CO₂ concentration will be, that is to say, the higher wind speed is conducive to the diffusion of local CO₂. Thus it

Fig. 3. Rose diagrams of CO₂ concentration, wind speed and wind direction in different seasons at WTS.

Table 1. Occurrence frequency of each wind level and corresponding average CO₂ concentrations in different seasons ($\times 10^{-6}$).

Frequency (%)	Season	Average CO ₂ concentrations in different seasons ($\times 10^{-6}$)									
		<0.3	0.3–1.5	1.6–3.3	3.4–5.4	5.5–7.9	8.0–10.7	10.8–13.8	13.9–24.4		
		Calm	Light air	Light breeze	Gentle breeze	Moderate breeze	Fresh breeze	Strong breeze	Moderate gale and above		
	Spring	1.0	4.7	23.0	33.2	24.7	9.2	3.0	1.2		
	Summer	0.0	8.9	34.1	37.1	16.2	3.0	0.6	0.0		
	Autumn	0.1	6.8	20.9	29.2	24.8	12.1	4.3	1.9		
	Winter	0.0	1.9	10.4	21.3	28.9	22.1	9.9	5.5		
Average CO ₂ concentration ($\times 10^{-6}$)	Spring	418.0	417.1	415.6	414.4	414.0	413.1	411.7	411.3		
	Summer	–	401.6	400.8	402.5	404.9	405.2	406.4	–		
	Autumn	417.9	412.1	409.6	411.3	413.1	413.9	413.8	412.1		
	Winter	–	422.4	420.1	419.3	416.8	416.4	415.3	413.9		

further shows that the high CO₂ concentration in the SE–SW sector during these two seasons may be caused by local source emissions. However, in summer, the higher the wind speed is, the higher the CO₂ concentration is, indicating that the transmission around WTS Station may contribute to the CO₂ concentration. In general, when the wind speed is high enough in spring, autumn and winter, the CO₂ concentration will decrease.

The Influence of Air-mass Transmission on Observation Results

To explore the influence of air-mass transmission on observation results of CO₂ in different seasons, the isentropic backward trajectory of air mass every hour in four seasons is studied. Based on the Hybrid Single-Particle Lagrangian Integrated Trajectory Model (HYSPLIT) from the National Oceanic and Atmospheric Administration of the United States (NOAA) and the meteorological data from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR), the clustering analysis of 72-h backward trajectory is carried out, and the hourly average CO₂ concentration corresponding to each cluster is calculated as well. Thus, the CO₂ concentration load of each cluster is shown in Fig. 4.

The CO₂ concentration was mainly affected both by northeast (NE) and northwest (NW) long-distance-transported air masses and short-distance-transported air masses from Shanxi Province and neighboring provinces in the four seasons. And the specific information is as follows.

Compared with the average value in spring, the CO₂ concentration loads of long-distance NW Cluster 2 and 3 passing through Mongolia are lower, while that of west (W) Cluster 1 is slightly higher, and that of close Cluster 4 (accounting for 12.9%) from S of Shanxi Province is higher by 2.5×10^{-6} . In summer, except for Cluster 2, the CO₂ concentration loads of NW and NE long-distance Cluster 1 and 4 passing through Mongolia and Inner Mongolia Autonomous Region are lower, while that of close SE Cluster 3 (accounting for 32.8%) from the S of Hebei Province (a neighboring province) is higher by 1.3×10^{-6} . In autumn, the CO₂ concentration load of long-distance Cluster 1 in the NW is slightly lower than the average value of the season, while that of close SW Cluster 2 accounting for 32.2% in the north (N) of neighboring Shaanxi Province is equivalent to the average value of the season. In the winter of 2017, all of the clusters are NW long-distance air masses, in which the CO₂ concentration load of Cluster 2 is slightly higher than the average value of this season by 0.8×10^{-6} .

In general, the CO₂ concentrations carried by the long-distance air masses are lower than the CO₂ seasonal average values, but they cannot effectively reduce the local CO₂ concentrations. On the contrary, the short-distance air masses from the SE–S–SW sector of neighboring provinces or Shanxi Province can significantly raise the CO₂ concentration at this station. This result is similar to the study of Fang *et al.* (2016) on the regional background station of Shangdianzi. The wind from SE–S–SW can effectively increase the native CO₂ concentration, whether it is the transmission from high air masses or surface wind.

Fig. 4. Average CO₂ concentrations corresponding to different cluster levels of 72-h air-mass backward trajectory at WTS in different seasons.

Background Data Filtering

Extracting the observation data which is not directly affected by local factors and can reflect the atmospheric background condition is the basis of studying regional CO₂ background characteristics and other related analyses. The filtering method based on REBS is to estimate the observation value in a period of time with the long-term or short-term slight variations of CO₂ concentration (seasonal and diurnal variations) taken into account, gradually approaching the regression fitting. In this way, the variables closely related to the time series, such as long-term trend, seasonal variation and cycle variation, will not affect the hourly value (Ruckstuhl *et al.*, 2001), and the missing data will not affect the accuracy of REBS (Ruckstuhl *et al.*, 2012). In addition, the surface wind is also one of the important factors affecting the surface CO₂ concentration. Based on the comprehensive analysis of factors such as the surface wind direction, surface wind speed, CO₂ sources and sinks around the station, the MET method for CO₂ filtering is established (Zhou *et al.*, 2004, 2005; Fang *et al.*, 2014).

In this study, three steps are used to filter the CO₂ concentration data during the observation period. First, REBS method is used to filter the original CO₂ concentration data during the observation period. With the help of IDPmisc package in R software (The R Development Core Team, 2009), the effective observation data are filtered based on the REBS algorithm for the background and non-background data (Ruckstuhl *et al.*, 2012). Considering the seasonal variation of CO₂ concentration, the bandwidth is set to 60 days. After three iterations, the fitting curve converges and the standard deviation, δ , is obtained. The observation data

between the fitting value $\pm 2\delta$ are considered as the background values, and the data beyond the fitting value $\pm 2\delta$ are taken as the non-background values. The background value accounts for 81.6% of the original data. Second, taking the research results in “the influence of the surface wind” on the CO₂ concentration in this paper into account, and then filtering out the wind directions corresponding to the top three arithmetic-mean values of CO₂ concentration in each season, the background values which accounts for 79.1% of the original data remain. Finally, the hourly CO₂ concentrations corresponding to Wind Scale 0 (calm wind) and 1 (light air) in each season (which are greatly affected by the local factors) are filtered out, and the remaining data are background values, accounting for 94.3% of the original data.

Wutaishan CO₂ data filtering uses a combination of REBS and MET. Compared with the single REBS method, the addition of the MET method can combine the corresponding relationship between wind direction, wind speed and CO₂ concentration to further exclude the influence of local sources and sinks on CO₂ concentration, so that the data after filtering can represent the regional background CO₂ concentration.

After the above three steps, 5352 pieces of background concentration data at the station, accounting for 64.6% of the original data, are got, which can well reflect the background situation of CO₂ concentration in this region. There are 1571, 982, 984 and 1815 pieces of data in four seasons, accounting for 71.2%, 44.5%, 45.1% and 84.0% of the total data in each season, respectively. The filtering results are shown in Fig. 5. The black and red dots represent the background data and non-background data (local pollution)

Fig. 5. Hourly average CO₂ concentration at WTS.

at this station, respectively. The average concentration during the observation period is $(411.9 \pm 9.0) \times 10^{-6}$ at WTS, and the average background concentration after filtering is $(410.9 \pm 6.4) \times 10^{-6}$, which is about 5.4×10^{-6} higher than the global CO₂ concentration in 2017 (WMO, 2018) and 5.7×10^{-6} lower than the average CO₂ concentration at Beijing's Shangdianzi atmospheric background station (at the same latitude with WTS) during the same period. The seasonal mean background concentrations of CO₂ in four seasons are $(412.9 \pm 2.9) \times 10^{-6}$, $(401.4 \pm 5.5) \times 10^{-6}$, $(409.2 \pm 5.4) \times 10^{-6}$ and $(415.2 \pm 2.8) \times 10^{-6}$, respectively.

Fig. 6 shows the comparison of the monthly average CO₂ concentration at WTS Station with the ones at WMO GAW international stations during the observation period. The data at Anmyeondo (AMY), Ryori (RYO) and WLG is downloaded from the World Data Centre for Greenhouse Gases (WDCGG), and the data at SDZ is obtained from the Meteorological Observation Center (MOC) of the China Meteorological Administration (CMA) (which have been approved by the owners of the data at each station). Among them, RYO in Japan and AMY in South Korea are coastal background stations, WLG and SDZ both in China are inland background stations, and WTS Station also is an inland station. WTS Station has the same seasonal variation trend with the stations at the same latitude. The CO₂ concentration is higher in winter while lower in summer, which is mainly affected by the terrestrial biosphere in the Northern Hemisphere (Nevison *et al.*, 2008). The CO₂ concentration at all stations reach the bottom of the whole year in August, and reach peak in February of the next year, except for that at Waliguan Station. The monthly variation amplitude of the CO₂ concentration at WTS Station is 18.0×10^{-6} , which is similar to RYO Station. In July and August, the monthly average CO₂ concentration at WTS Station is close to that at RYO Station, but much lower than those at the other three

stations. The monthly mean CO₂ concentration data of each station are averaged, and the average values of each station during the observation period from high to low are $(416.6 \pm 7.0) \times 10^{-6}$ at SDZ, $(412.7 \pm 4.3) \times 10^{-6}$ at AMY, $(409.9 \pm 6.0) \times 10^{-6}$ at WTS, $(409.7 \pm 6.4) \times 10^{-6}$ at RYO and $(407.1 \pm 3.6) \times 10^{-6}$ at WLG. Compared with WMO GAW stations in the same latitude, the atmospheric CO₂ concentration of WTS Station is equivalent to that of each station, which can represent the background concentration of atmospheric CO₂ in Shanxi Province and the surrounding areas.

CONCLUSIONS

During the observation period, the amplitudes of the diurnal variation in the CO₂ concentration at WTS Station across the four seasons were relatively small: 2.6×10^{-6} , 4.8×10^{-6} , 2.9×10^{-6} and 2.4×10^{-6} .

The concentration and the surface wind speed displayed negative correlations during spring and winter. Using the average seasonal concentrations as a baseline, among the sixteen wind directions, the E, SE, WSW and SSE were the largest contributors to the concentrations during spring, summer, autumn and winter, respectively, producing maximum increases of 2.4×10^{-6} , 3.0×10^{-6} , 1.9×10^{-6} and 11.6×10^{-6} .

Although long-range-transported air masses from the NW generally contained lower concentrations than the seasonal averages at WTS Station, they did not significantly reduce the level of CO₂ at this site. By contrast, short-range-transported air masses from the SE–S–SW sector, which originated in either Shanxi Province or neighboring provinces, substantially raised the concentration at the station, as wind blowing from these directions transported CO₂ from high altitudes (i.e., high air masses) or along the surface.

The original data collected during the observation period

Fig. 6. Comparison of monthly average CO₂ concentration at WTS Station, China (inland; 38.95°N, 113.52°E, 2208 m a.s.l.), with those at other stations with the same latitude during the observation period: the global background station at Waliguan (WLG), China (inland; 36.29°N, 100.90°E, 3810 m a.s.l.); the regional background station at Anmyeondo (AMY), South Korea (coastal area; 36.54°N, 126.33°E, 46 m a.s.l.); the regional background station at Ryori (RYO), Japan (coastal area; 39.03°N, 141.82°E, 260 m a.s.l.), and the regional background station at Shangdianzi (SDZ), China (inland; 40.65°N, 117.12°E, 294 m a.s.l.).

was filtered by overlapping methods, one being REBS and the other involving MET, and 64.6% of it was used for the final background data. The average background CO₂ concentration obtained for WTS Station, $(410.9 \pm 6.4) \times 10^{-6}$, is representative of the region (Shanxi Province and the surrounding areas).

ACKNOWLEDGEMENTS

We are grateful to the staff of the WTS greenhouse-gas observation station in Shanxi Province for their daily maintenance of the online greenhouse-gas observation system. We also thank NOAA/ESRL and WDCGG (Ryori Station and Anmyeondo Station) for their data support. (Anmyeondo GAW station data are funded by the Korea Meteorological Administration Research and Development Program under Research and Development for KMA Weather, Climate, and Earth System Services [1365003041]).

This paper is supported by the Climate Change Program of the China Meteorological Administration (CCSF202023), the Key Research and Development (R&D) Projects of Shanxi Province (201803D31220), the Open Research Project of Shangdianzi National Atmospheric Background Station (SDZ2020617), and the General Program of Shanxi Provincial Meteorological Bureau (SXXMSDW20205215).

DISCLAIMER

The views and interpretations in this publication are those of the authors.

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Received for review, January 18, 2020

Revised, May 28, 2020

Accepted, May 30, 2020