In situ measurement of vertical distribution of CO_2 and CH_4 in the troposphere by aircraft and tethered balloon

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ABSTRACT

Several Satellites have been launched into space to monitoring the greenhouse gases concentration, by observing the back-scattered hyper-spectral radiance in the SWIR. Therefore the vertical profile of carbon dioxide and aerosol could greatly modulate the retrievals. So it is important to investigate how the interplay process of the CO_2 and aerosol scattering in the atmosphere, which is blamed for the uncertainty of the retrieval results of satellite. Knowledge of CO2 vertical distribution is crucial for the development of satellite-borne retrieval methods and algorithm. Aircraft in situ measurements of CO_2 and CH4 mixing ratio over Jiansanjiang (46.77 °N, 131.99 °N, August, 2018)and Dunhuang(94.68 °E, 40.09 °N, April and May, 2017), and tether-balloon measurement in Changshou (107.00° E, 29.84° N, January 2019) were conducted.

INSTRUMENT

GGA, Ultra-Portable Greenhouse Gas Analyzer (LGR, Los Gatos Research LGR)

Total Uncertainty (without calibration)	<1% (5-45℃)
Repeatability/precision (1-σ)	CH_4 : < 2 ppb (1 sec) CO_2 : < 300 ppb (1 sec)

King Air 350R

Delta Wing Aircraft

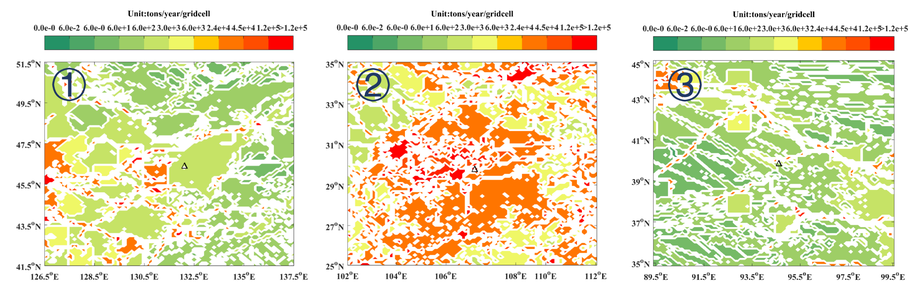
Tethered balloon system

Jiansanjiang, 47.11°N,132.66°E
- **7-11 Aug. 2018**
- **Altitude: 600 – 7000m**
- **Cruise speed: 441km/h**

Dunhuang, 47.11°N,132.66°E
- **April, May 2017**
- **Altitude: 0 – 5000m**

Changshou
- **11-13 Jan. 2019**
- **Altitude : 0 – 700 m**
- **ascension rate: 0.5-1 m s^{-1}**

EXPERIMENT SITE



CO_2 emission in 2012 (from EDGAR v4.3.2)

① Jiansanjiang(47.11 N, 132.66 E)
② Changshou (107.00 E, 29.84 N)
③ Dunhuang (94.68 E, 40.09 N)

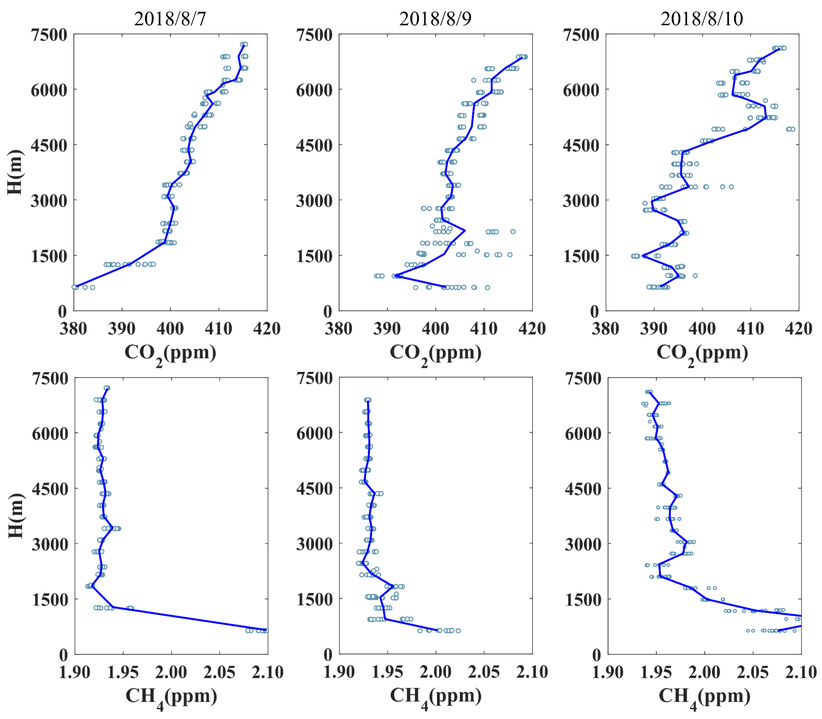
region	①	②	③
Average CO_2 emission	2.43×10^4	1.05×10^6	5.08×10^3

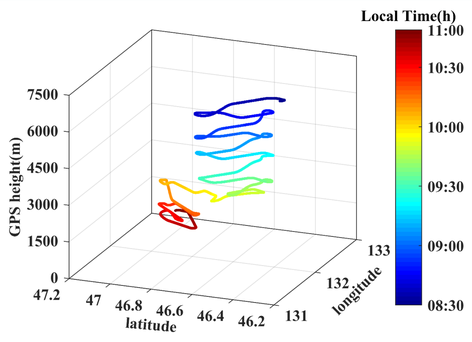
1 Jiansanjiang:
- **Large plantation: photosynthesis**
- **population density: 18 per km^2**
- **little industrial industrial activity**

2 Changshou:
- **Industrial park**
- **population density : 350 per km^2**
- **much industrial activity**

◆ Calibration with standard gases Before and after each flight

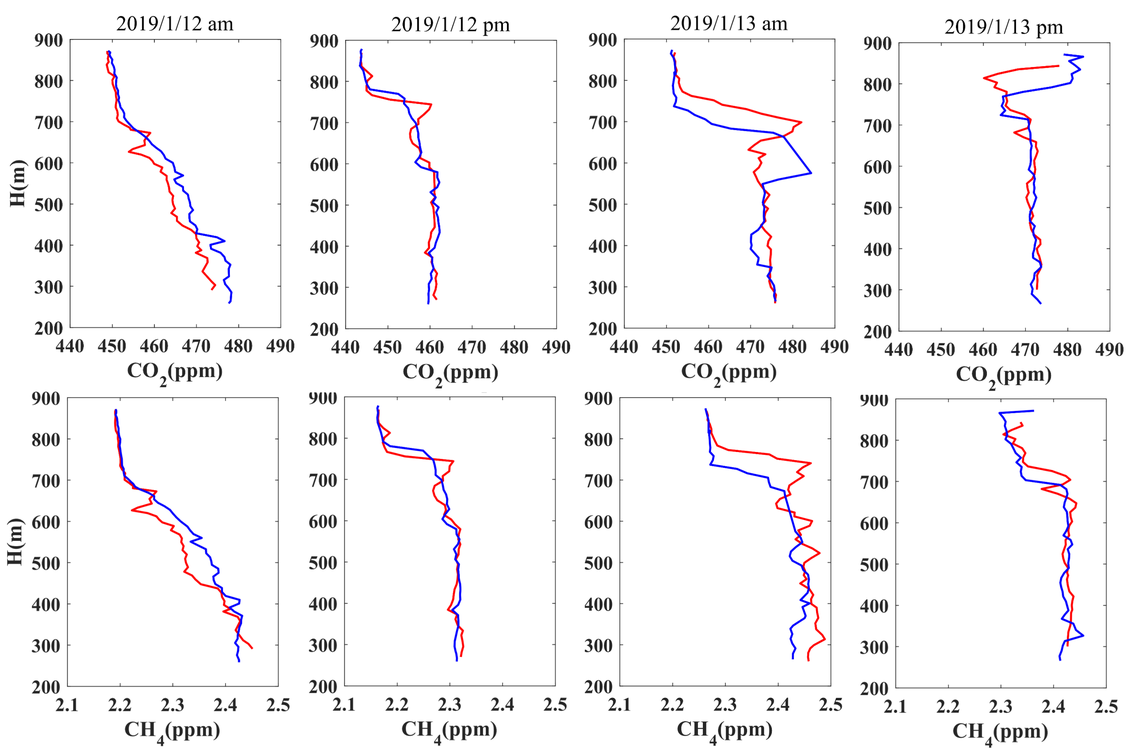
PROFILES AND DISCUSSION





7 Aug. trajectory of aircraft spiral down from 7000 to 600m, covering area 1.5°×0.5°

◆ Vertical distribution: CO_2 concentration increased with height, CH_4 varied little >1 km
◆ Little Ground anthropogenic activity influence at I km higher
◆ Sink of CO_2 and source of CH_4



Tethered balloon Flight
- **Release twice a day**
- **Ascending/descending profiles**
- **low wind speed: GGA almost right to ground**

◆ Vertical distribution: CO_2 and CH_4 change day to day compared to higher altitude
◆ Ground anthropogenic activity influence
◆ Same Shape of profile for both CO2 & CH4

COMPARISON

Table 1. XCO2 from aircraft , OCO-2 & Tansat over JSJ (Site 1 on Aug.7)

	7 August	difference	
aircraft	403.0	satelite-aircraft	$\frac{\text{satelite}-\text{aircraft}}{\text{aircraft}}\cdot 100\%$
TanSat	395.4	-7.6	-1.89
OCO-2	396.9*	-6.1	-1.51

*** oco-2 only had observation data over jiansanjiang on August 5 in the 10 days before and after 7 August. So XCO2 data on August 5 are given here.**

SUMMARY

Flight measurement of CO_2 and CH_4 were conducted from 7 to 10 Aug. over rice planting area over Jiansanjiang, northeast of China. And profiles of CO_2 & CH_4 over Changshou, located in heavily polluted industrial park, are given by tethered balloon from 11 to 13 Jan., 2019. Over Jiansanjian, increasing value of CO2 with height maybe result from the photosynthesis of the growing rice. And the increased value of CH4 near the surface may also be explained by agricultural activities. While over Changshou, large CO2 and CH4 are due to the industrial activities, the large value at 600 and 900m on 13 Jan. may assume to be the effect of transportation, but more evidence are needed to verify these phenomena. Comparison between aircraft measurement and satellite showed a relatively lower XCO2 of satellite from both TanSat and OCO-2.