Atmospheric CO\textsubscript{2} Variability Observed from ASCENDS Flight Campaigns

Bing Lin\textsuperscript{1}, Edward Browell\textsuperscript{1}, Joel Campbell\textsuperscript{1}, Yonghoon Choi\textsuperscript{1}, Jeremy Dobler\textsuperscript{1}, Tai-Fang Fan\textsuperscript{1}, F. Wallace Harrison\textsuperscript{1}, Susan Kooi\textsuperscript{1}, Zhaoyan Liu\textsuperscript{1}, Byron Meadows\textsuperscript{2}, Amin Nehriri\textsuperscript{1}, Michael Olland\textsuperscript{1}, Jim Planti\textsuperscript{1}, Melissa Yang\textsuperscript{1}
\textsuperscript{1}NASA Langley Research Center, \textsuperscript{2}NASA Langley Research Center STARSS II Affiliate, Science System and Application, Inc, \textsuperscript{3}Harris Corp.

Introduction

- Atmospheric CO\textsubscript{2} is the major climate forcing for the changing climate. Its concentration (or volume mixing ratio XCO\textsubscript{2}) has significantly increased from about 280 ppm in pre-industrial era to ~395 ppm at present.
- There is a lack of quantitative knowledge of atmospheric CO\textsubscript{2} variability in various spatiotemporal scales. A large part of carbon assessed within the Earth’s carbon cycle cannot be accounted for even in observed global annual means.
- U.S. National Research Council has directed the need of better understanding of atmospheric carbon sources and sinks. NASA Langley Research Center (LaRC) and Harris Corp. are jointly assessing the space measurement capability using airborne CO\textsubscript{2} laser absorption lidars (LCLs).

Measurement Characteristics

- **Multifunctional Fiber Laser Lidar (MFLL):**
  - Laser power: 5 W
  - Fiberoptic diameter: 0.283 mm
  - Detector dark current: 2.85 x 10\textsuperscript{-6} A
  - Signal integration time: 0.5 s
  - Modulation scheme: 5 kHz
  - Normalization and calibration: reference signals

- In Situ Sensor (AVOCET):
  - Atmospheric CO\textsubscript{2}: XCO\textsubscript{2}
  - Meteorological state: T/p/q and winds

Lidar CO\textsubscript{2} Retrieval

- Integrated path differential absorption
  \[ \frac{r}{r_0} = \frac{1}{2} \ln(\frac{XCO_2}{XCO_{2,0}}) \]

- CO\textsubscript{2} volume mixing ratio (XCO\textsubscript{2})

Airborne Flight Campaigns

- **2013 Winter:** 18 Feb – 5 March
- **2014 Summer:** 14 Aug – 2 Sept

Observations

- Cornfield CO\textsubscript{2} drawdown
- Regional CO\textsubscript{2} changes

Methodology for validation

- In-situ measured XCO\textsubscript{2} (in-situ derived XCO\textsubscript{2})
- Comparison with in-situ data

Conclusions

- The CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.
- During winter period, CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.
- During summer period, CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.
- The CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.

Future Work

- Analyzing CO\textsubscript{2} variability from AAT-Americas mission data
- Evaluating large spatial scale CO\textsubscript{2} variability using collocated airborne and DCO-2 measurements
- Similar study to obtain insights of the driving forces of CO\textsubscript{2} changes

Acknowledgement

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Vertical profiles: CA

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<thead>
<tr>
<th>Date</th>
<th>Flight Pattern</th>
<th>Measurement</th>
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<tbody>
<tr>
<td>2013 AVOCT in Situ CO2</td>
<td>2014 AVOCT in Situ CO2</td>
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<tr>
<td>09/37/14</td>
<td>09/37/14</td>
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Column CO\textsubscript{2} measurements over Midwest farms showed much larger drawdown signal in 2011 (≈8 ppm) compared with measurements in 2014 (≈3 ppm).

Atmospheric CO\textsubscript{2} profiles measured during the winter 2013 and summer 2014 ASCENDS Flight campaigns over California. Winter building and summer drawdowns of CO\textsubscript{2} around 3 to 5 ppm below associated with low CO\textsubscript{2} tracks were observed. Daytime CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.

- In atmospheric CO\textsubscript{2} measurements, significant CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.

Flight and landform impact

- Significant CO\textsubscript{2} variability was observed in various spatiotemporal scales during the flights campaigns.

Air quality drawdown signals in 2011 (~8 ppm) compared with measurements in 2014 (~3 ppm).