INTRODUCTION

- Global economic development has given rise to steady increase of atmospheric CO₂ during the past 200 year, which has significant contributions to climate change.
- Cities are responsible for about 70% of the global energy-related CO₂ emissions. Accurate estimations of CO₂ emissions over urban area is a crucial need for independent verification of urban emissions from fossil-fuel energy consumption.
- Space-based observations of the total column averaged CO₂ concentration (XCO₂) are expected to have an important role in constraining the surface CO₂ fluxes using atmospheric inversion methods.
- Although the potential of satellite XCO₂ for global or regional scale flux inversions has been examined, only few studies demonstrated their potential applicability at urban scale.

OBJECTIVES

- Evaluate the availability of OCO-2 retrievals for detecting urban emission signals.
- Taking transport model error and boundary inflow into consideration, we discuss the implications of the detected signals on constraining urban fossil-fuel CO₂ emissions.
- Investigate the potential of XCO₂ measurements retrieved from the NASA Orbiting Carbon Observatory-2 (OCO-2) in the context of urban inversions of CO₂.

DATA & METHODS

- Enhancements in XCO₂ induced by urban fossil-fuel CO₂ emissions and atmospheric transport are examined using OCO-2 L2 Lite products for Sept 2014 to Aug 2015.
- Forward transport model simulations
  - Weather Research and Forecasting model with chemistry (WRF-Chem)
  - Urban emission: Open-source Data Inventory for Anthropogenic CO₂ (ODIAC).

RESULTS

- Imprint of Urban CO₂ Emissions observed by OCO-2
  - OCO-2 tracks overpassing Riyadh, Saudi Arabia are shown. The overpassing time is about 10:00 UTC. 7 dates among our study period are chosen to show the general XCO₂ distribution along tracks, with some enhancements of XCO₂ possibly due to urban emissions. Maps demonstrate the average urban CO₂ emissions in corresponding months according to the Open-source Data Inventory for Anthropogenic CO₂ (ODIAC). Vectors represent surface wind field using the NCEP FNL (Final) Operational Global Analysis data.

- Model resolution and emission structure
  - Four one-way nested domains are used in the forward simulation with 27-, 9-, 3-, and 1-km horizontal resolutions.
  - The structure of urban emission field interpolated onto the model grid is related to the grid resolution as well as the emission center location (marked by ‘*’). This will result in differences in the CO₂ plumes reproduced by simulation along with the transport differences due to grid resolution.

- Simulated XCO₂ by WRF-Chem and implications to inverse modeling
  - Two cases are chosen to show the typical scenarios of the reproduction of CO₂ plumes by the forward simulation. In the case on Dec 29 2014, the observed CO₂ enhancement is generally consistent with the simulated values, which will lead to an effective constraint of emissions by inversion method. In the other case on Jan 28 2015, the observed enhancement will yield into unrealistic enhanced emissions in its footprint area.
  - For the case on Dec 29 2014, a scaling factor is used to optimize the emissions in Riyadh. The 9-km resolution results give us the best possible optimization, which shows the dependence of inversion on model resolution. Note that this result is also method dependent.

SUMMARY AND FUTURE WORK

- OCO-2 XCO₂: provide a promising dataset to improve estimation of emissions, although for urban-scale the spatial and temporal availability is limited due to the narrow swath width and the contamination of aerosols and clouds.
- The potential for emission optimization has relation to model resolution, which can differ the gridded emission structure and meteorological condition.
- We are currently developing a framework to estimate the potential for emission optimization in urban area statistically.

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