The 15th Meeting of the Atmospheric Composition Virtual Constellation, June 10-12, 2019, Tokyo, Japan

Evaluation of Relationships Between Urban CO_2 and Air Quality from Ground to Space

Hayoung Park*, Su-Jong Jeong

Seoul National University

Why Cities?

Introduction

- Cities are home to more than half of the global population and are a major source of anthropogenic CO_2 emissions as well as other pollutants which have a great impact on the environment, air quality, and climate change.
- With the Paris Agreement and the Global Stocktake in 2023, reducing CO_2 emissions has become one of the biggest concerns of cities.
- While cities account for more than 70% of the global CO_2 emissions, they also have great potential to be the drivers of global CO_2 reduction.

Anthropogenic sources

in cities

Greenhouse gas

CO_2

Air pollutants

CO, NO_2, $PM_{2.5}$

Why Cities?

Introduction

Anthropogenic sources
in cities

Greenhouse gas
CO_2

Air pollutants
CO, NO_2, $PM_{2.5}$

In a local/city scale, what relationship do CO_2 and air pollutants have?

→ Can policies for mitigating urban greenhouse gases also reduce co-emitted air pollutants and improve air quality?

Can different city emission policies and air quality management bring different results globally?

→ What kind of synergies can we get with different satellite measurements in order to understand emission patterns of cities?

Approach

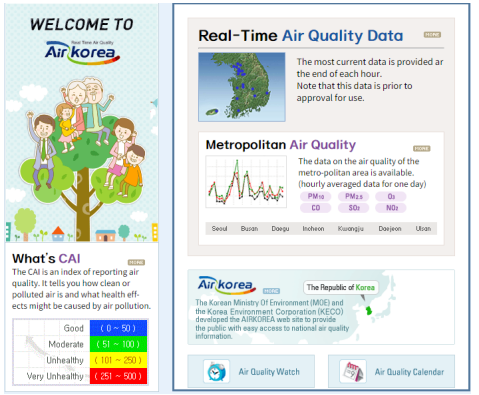
CO_2 vs. Air Pollutants

Local Scale

CO_2

Megacity Seoul CO_2 Project by Seoul National University

Air Pollutants (CO, NO_2, $PM_{2.5}$)

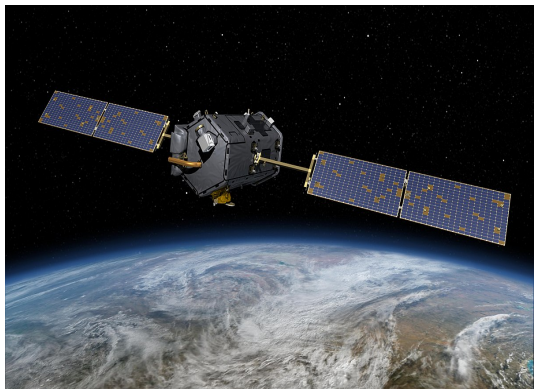


AirKorea by the Korean Ministry of Environment

환경부 Ministry of Environment

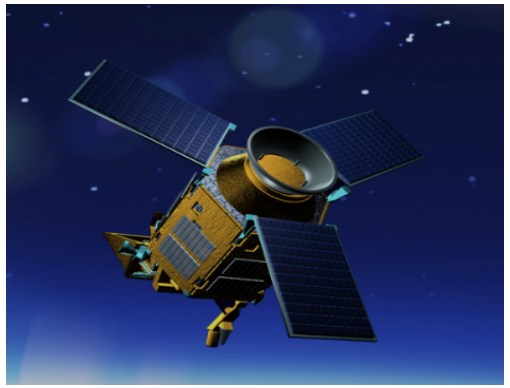
Global Scale

CO_2



Orbiting Carbon Observatory-2 by NASA
Data available: 2014/09 – ongoing

Air Pollutants (CO, NO_2)



Sentinel-5 Precursor TROPOspheric Monitoring Instrument by ESA
Data available: 2018/06 – ongoing

Megacity Seoul CO_2 Project

Understanding CO_2 in Seoul

Climate Convergence Laboratory, Seoul National University (climatelab.snu.ac.kr)
Funded by the National Research Foundation of Korea

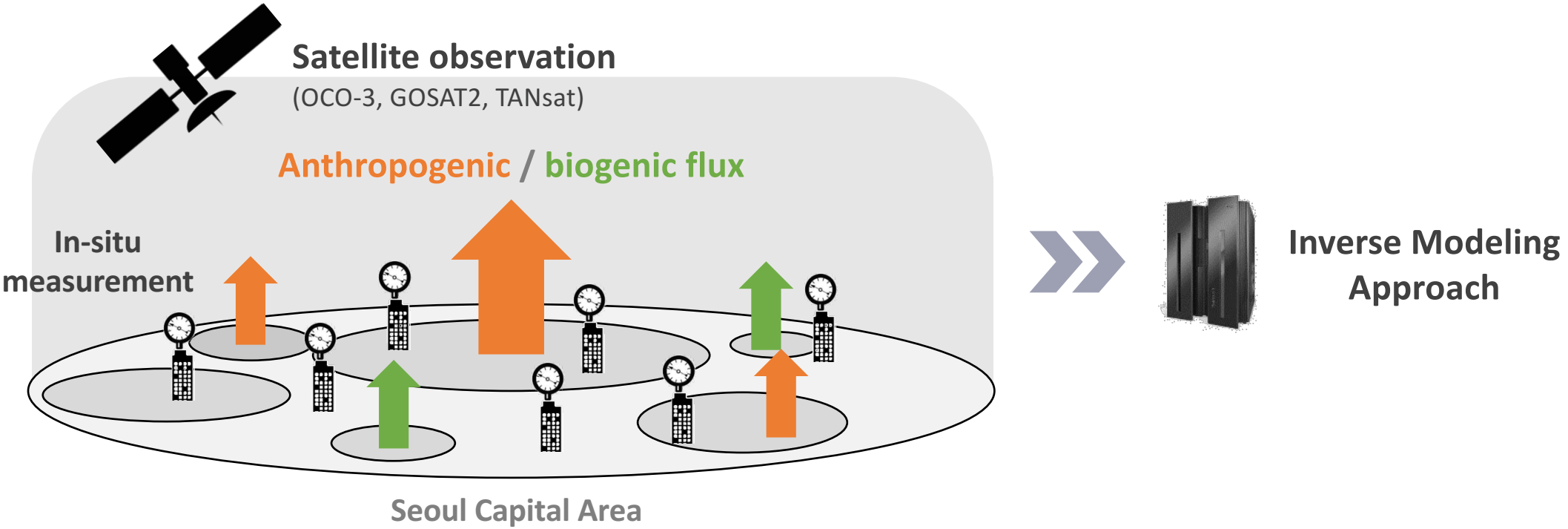
- ✓ How much **carbon dioxide** is in **Seoul**?
- ✓ How much of the total carbon dioxide emissions are **anthropogenic emissions?**

» Satellite data + Monitoring network + Modeling

Megacity Seoul CO_2 Project

Understanding CO_2 in Seoul

- ✓ Estimate reliable **ground carbon flux** by constructing an **inverse model** using ground observations and satellite data
- ✓ Quantify the effect of **anthropogenic and biogenic** factors on the variation of CO_2 in Seoul



Ground-based Observations

Seoul CO_2 Monitoring Network

Yongsan
(2018/10/18 -)
LI-COR
Lat/Lon:37.523/126.963
Altitude: 100m

Namsan
(2019/02/25 -)
LI-COR
Lat/Lon: 37.551/126.988
Altitude: 716m

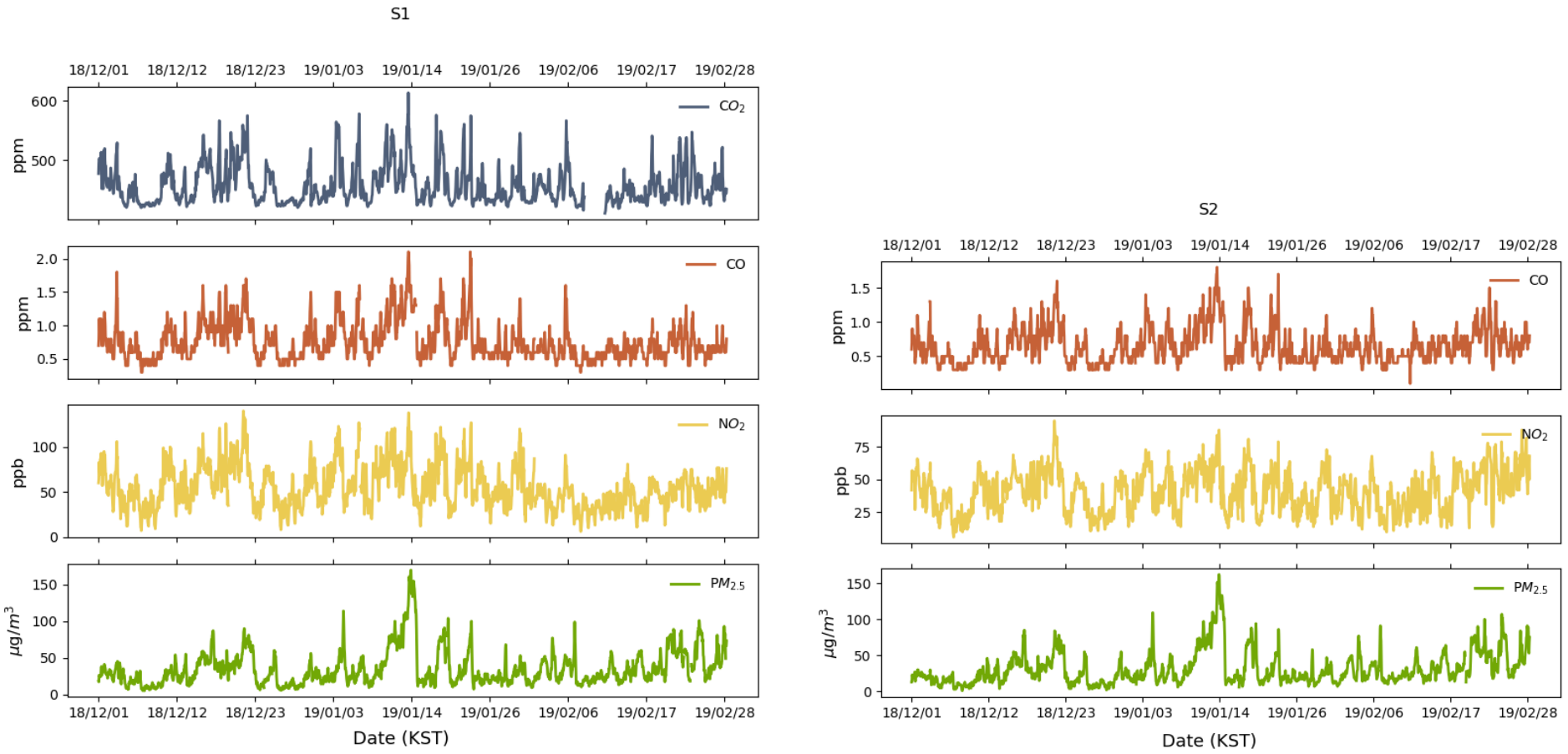
Gwanak mountain
(2019/05 -)
Picarro
Lat/Lon: 37.444/126.963
Altitude: 626m

Seoul National University
(will begin in 2019/08-)
EM27/SUN Series
Lat/Lon:37.462/126.954
Altitude: 80m
✓ **Observations will continue for more than 10 years**

Results

Local Scale

Ground Measurements in Seoul – CO_2 vs. CO, NO_2, $PM_{2.5}$

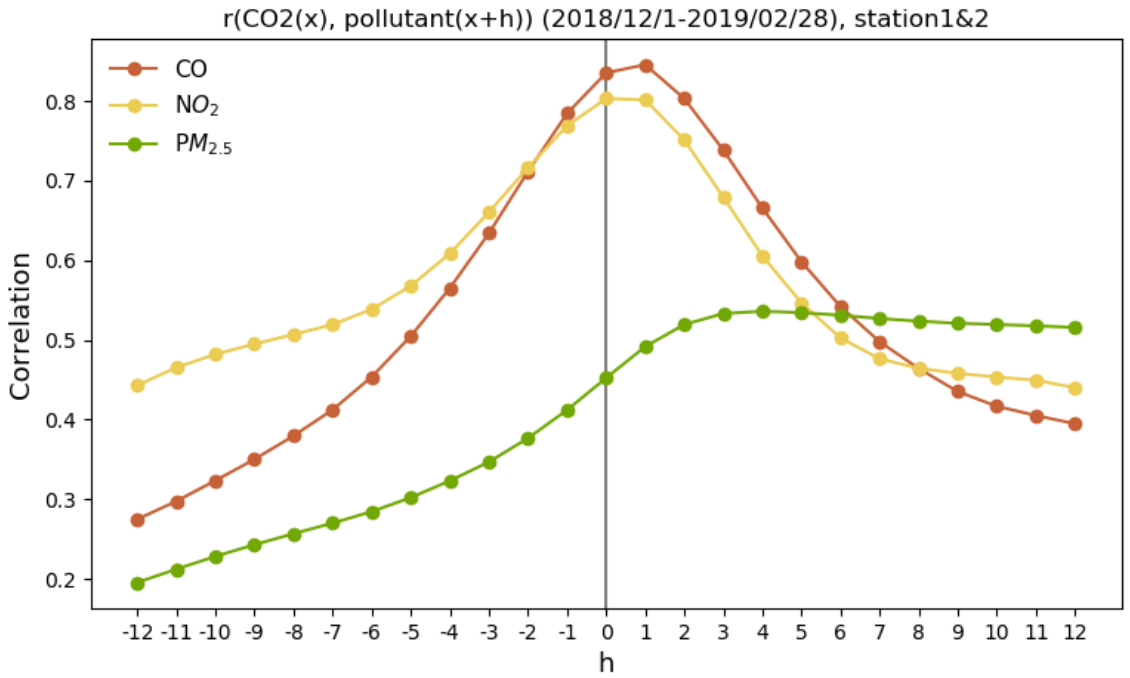


- Examined relationships of CO_2 & pollutants CO, NO_2, and $PM_{2.5}$ using ground measurements from Yongsan (LI-COR 850, run by SNU) and AirKorea(run by the Korean MoE) respectively.
- S1 and S2 are the two nearest AirKorea stations to the Yongsan measurement site.
- The time series of CO_2, CO, NO_2, and $PM_{2.5}$ show peaks at a similar time.

Results

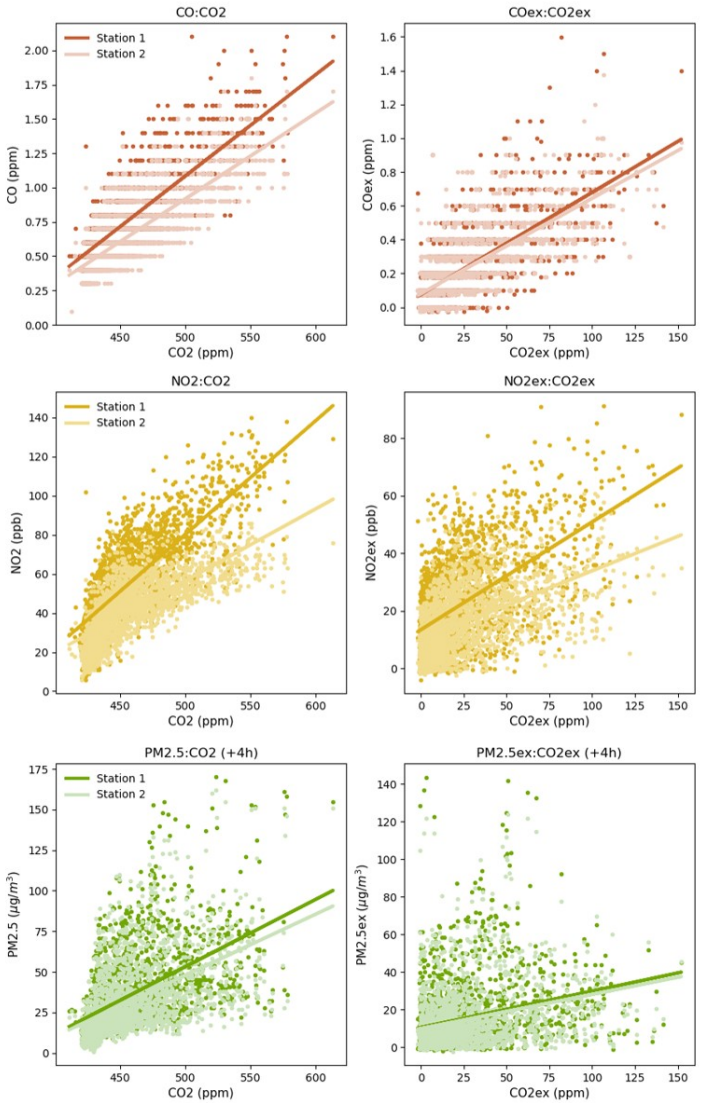
Local Scale

Correlation between CO_2 and air pollutants before and after h time



- At 0 h, NO_2 show highest correlation with CO_2, while CO shows highest correlation at 1 h. $PM_{2.5}$ shows highest correlation at 4h.
- CO and NO_2 are observed to act as precursors for $PM_{2.5}$.
- This could mean that CO_2 and air pollutants could have been transported in the same air or emitted from the same sources.
- The pollutants with the highest correlation between CO_2 is in the order CO > NO_2 > $PM_{2.5}$.

Multispecies linear regressions between CO_2 and pollutants by station & local enhancement

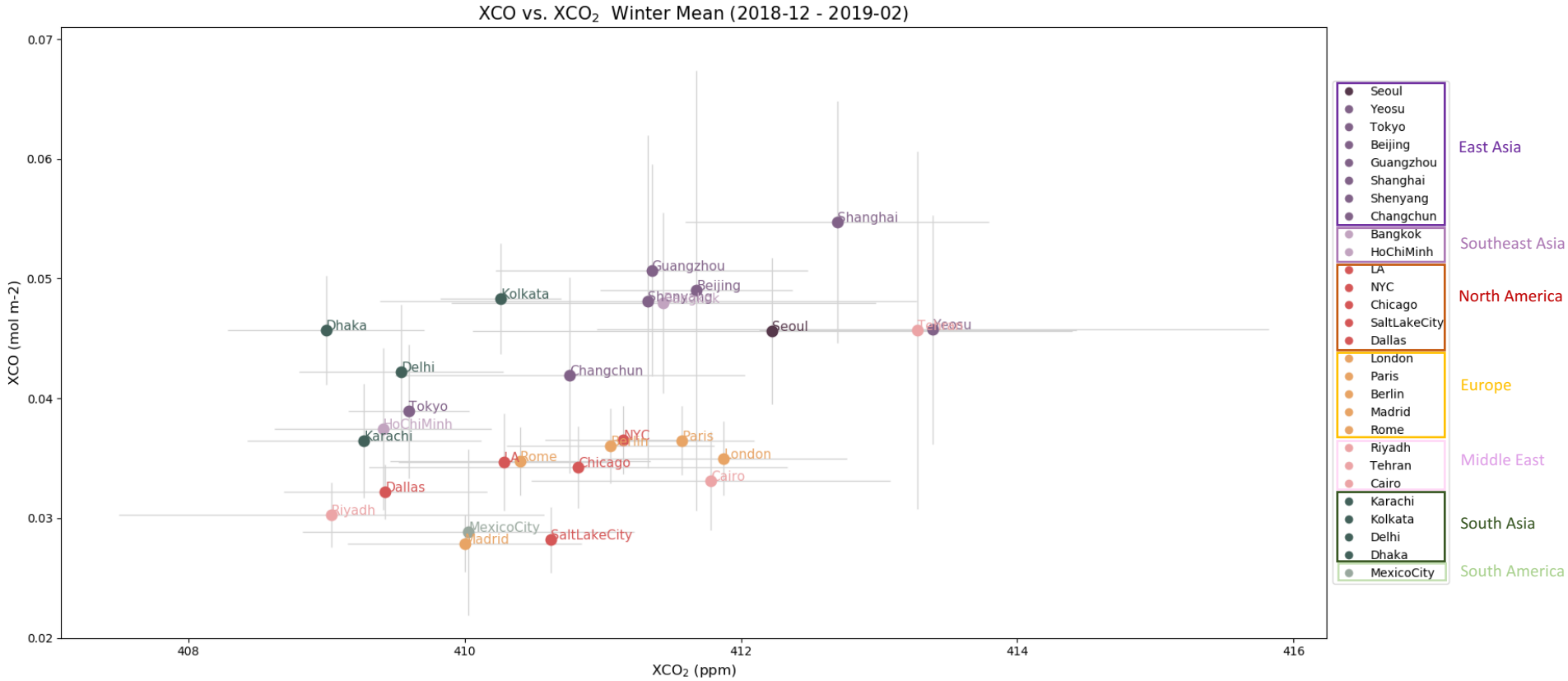


Results

Global Scale

Satellite Observations of Cities in the Northern Hemisphere

CO_2 vs. CO



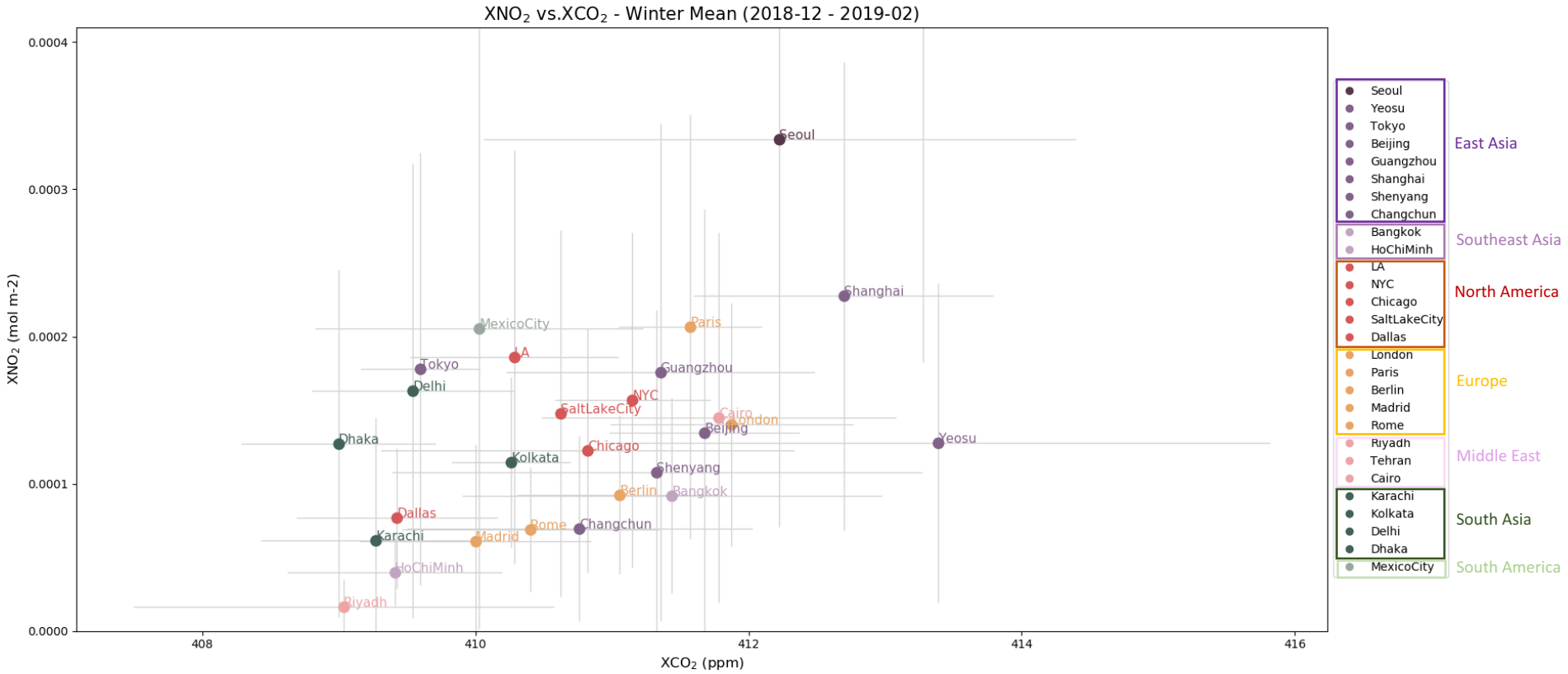
- East Asian cities show the highest CO_2 & CO concentrations.
- South Asian cities like Dhaka and Kolkata have a higher concentration of CO per CO_2 compared to other cities.
- Cities in Europe and North America show high concentrations of CO_2 but a lower concentration of CO per CO_2 compared to East Asian countries.
- Cities like Beijing & Guangzhou show a higher CO concentration compared to Paris and London despite similar concentrations of CO_2.

Results

Global Scale

Satellite Observations of Cities in the Northern Hemisphere

CO_2 vs. NO_2



- East Asian cities once again show the highest CO_2 & NO_2 concentrations.
- Cities like Tokyo, LA, and Mexico City show high amounts of NO_2 per CO_2 concentration despite their low CO_2 concentration compared to other cities.
- Aside from Paris, cities in Europe show a lower NO_2 per CO_2 concentration pattern despite their high CO_2 emission rates.
- Seoul and Yeosu both show similar amounts of CO concentrations, but Seoul has a higher amount of NO_2 per CO_2 concentration than Yeosu. This shows the characteristics of cities within a country (e.g. Seoul – megacity, Yeosu – industrial area).

Summary

- From ground measurements on a local scale in Seoul, we find that there is a high correlation between CO_2, CO, NO_2, and $PM_{2.5}$.
- CO_2 and air pollutants CO, NO_2, and $PM_{2.5}$ show peaks at a similar time.
- At 0 - 1h, CO and NO_2 show highest correlation with CO_2 and act as a precursors for $PM_{2.5}$
- Using satellite data on a global scale, we could see that cities in the Northern Hemisphere show a linear pattern in the relationship between CO_2 and CO & NO_2 concentrations.
- Regionally, cities show different emission patterns and relationships between CO_2 and pollutants.
- Satellite data and ground-based observations are important in understanding and measuring local emissions in cities.
- Higher spatial and temporal resolution data both from ground and space are still in great need.

Discussion

- Ground measurements at a local scale have limitations as monitoring can be discontinuous and can only measure one point. Thus, a large network of ground measurements are needed.
- Satellite data can cover a larger global scale, yet there are limitations in spatial samples and clear retrievals of greenhouse gases and pollutants especially over urban areas like cities due to cloud cover and aerosols.
- With the launch of OCO-3, GOSAT-2, S5P(TROPOMI), and other GHG monitoring satellites like GK-2B(GEMS) and the Copernicus Sentinels (S4, S5, CO2M), we will be able to understand and measure CO_2 emission patterns of cities and their relationships with air pollutants more clearly.
- With these satellite missions, there will be synergies in observing the relationship between CO_2, CO, and NO_2 in other cities in different regions.

OCO-3

GOSAT-2

GK-2B(GEMS)

S5P(TROPOMI)


THANK YOU