# Verifying urban $CO_2$ emissions over the Seoul Capital Area by using OCO-3 $XCO_2$

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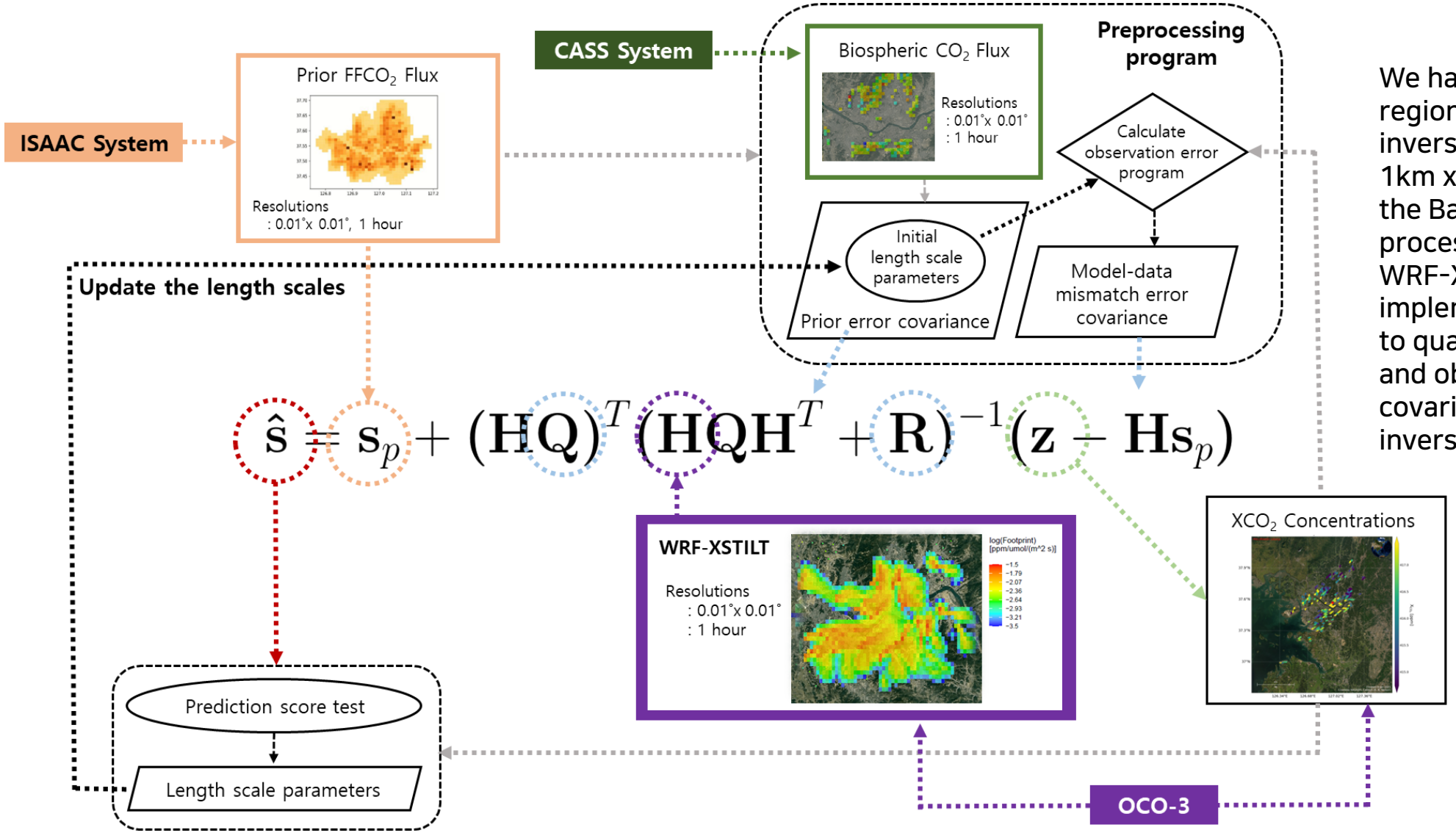
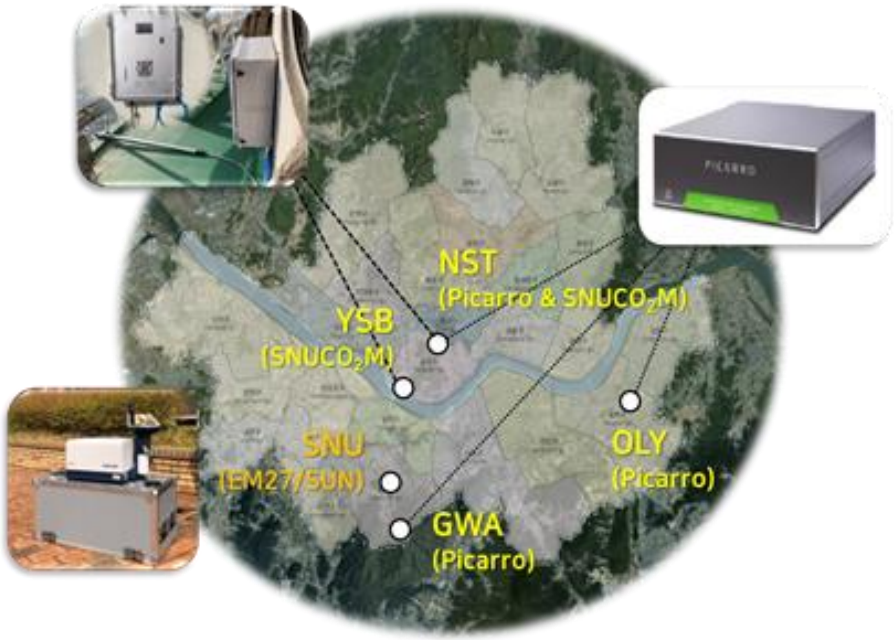
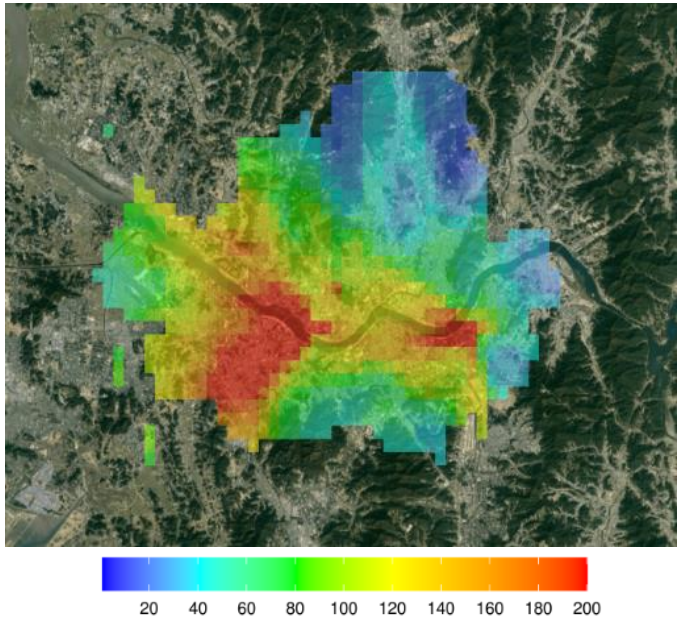



We have been developing a regional urban $FFCO_2$ flux inversion system of Seoul at 1km x 1km resolution through the Bayesian inversion processing system based on WRF-XSTILT. For this, we implement iterating systems to quantify appropriate prior and observation error covariances which impact the inversion accuracy.

# Why is the OCO-3 $XCO_2$ data essential to the regional inversion system of Seoul?



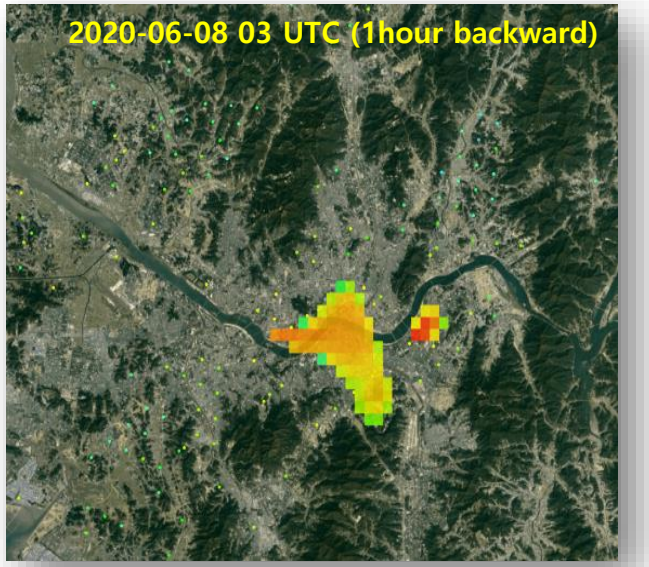

**$CO_2$ Ground Measurements Network in SCA**



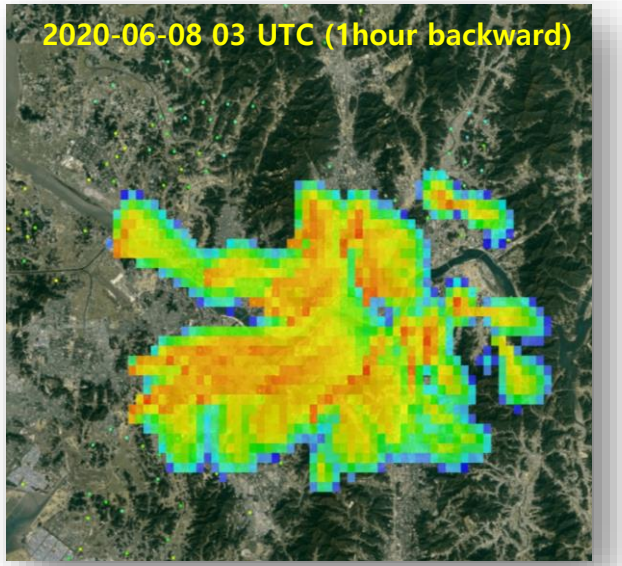

**Number of footprints existing per grid for a month**

In the Seoul capital area (SCA), 5 different ground observation sites deploying low-cost measurement instruments (SNUCO2M), Li7815, Picarro G2131-i and EM27/SUN measure $CO_2$ concentrations. Observed $CO_2$ concentrations are used to analyze urban $CO_2$ variation and assess the $FFCO_2$ fluxes as atmospheric constraints. However, the number of hourly footprints data existing per grid shows that our current ground observation network are difficult to verify the flux of the northeastern SCA. The footprints represent the level of surface $CO_2$ flux contribution toward $CO_2$ concentration of a receptor. We produce them utilizing WRF- STILT.

# Why OCO-3 $XCO_2$ data are essential to the regional inversion system of Seoul?



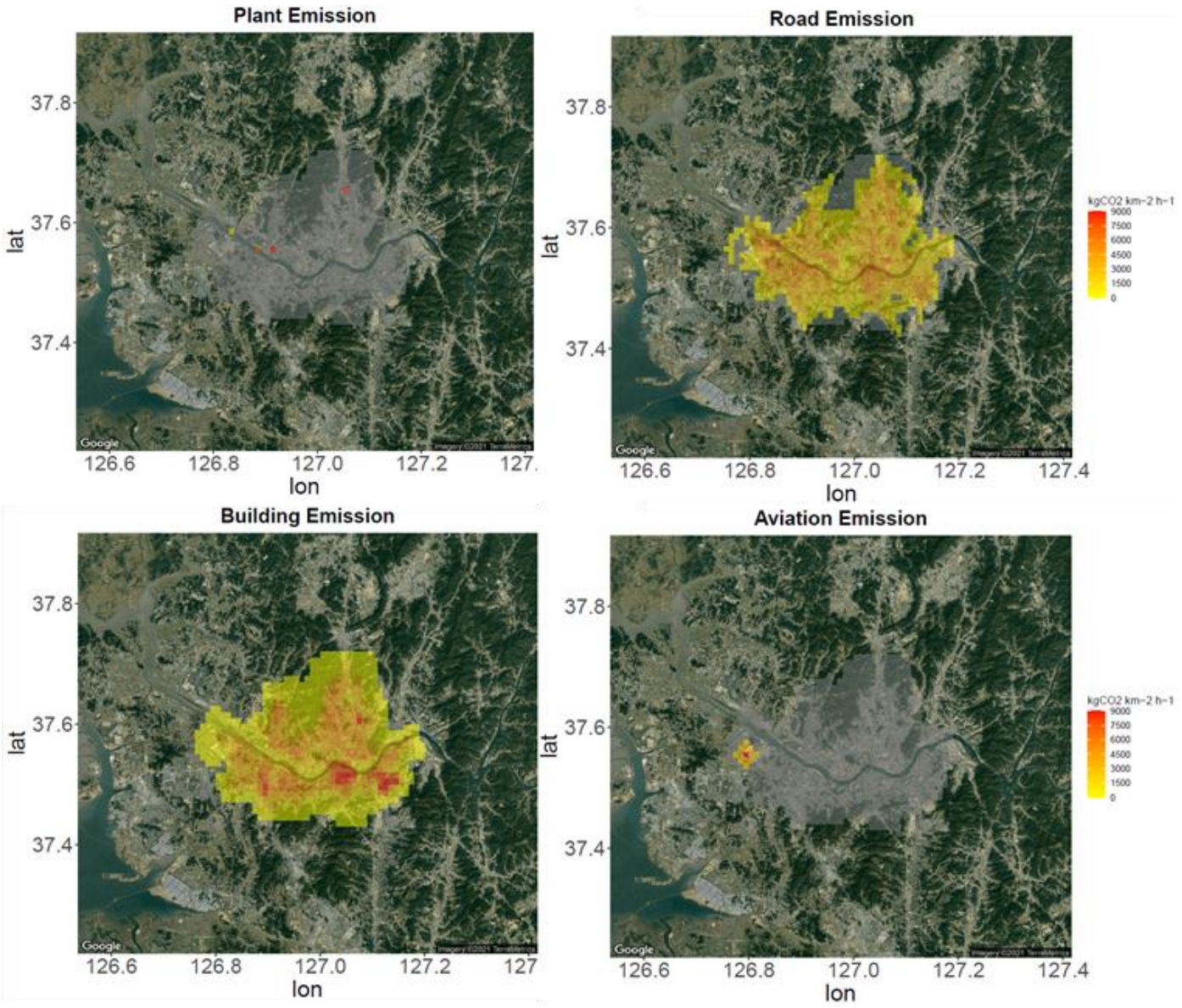

**Footprints of the receptors from ground measurement sites (STILT)**




**Footprints of the receptors from OCO-3 data (X-STILT)**

With OCO-3 $XCO_2$ data, we can overcome the limitations of the spatial coverage that the ground observations have. The above two figures present footprints calculated from ground measurement site information and OCO-3 measurement site information for the same specific time. With the $CO_2$ concentration data from ground networks, we can only re-estimate $FFCO_2$ fluxes in some areas. However, OCO-3 data allows the fluxes for the entire area of Seoul to be covered in the assimilation. Since the establishment of $FFCO_2$ inversion using OCO-3 $XCO_2$ is still in progress, the results of the inversion will be presented in a follow-up paper.

# Inventory System for Accounting Anthropogenic $CO_2$ (ISAAC)




ISAAC is a system that calculates the prior $FFCO_2$ flux inventory with a bottom-up approach. ISAAC uses fossil fuel usage provided by the Seoul Metropolitan Government as raw data. It is largely divided into four parts: traffic, buildings, power plants and airports. Traffic emissions are interpolated using machine learning techniques. Building emissions are calculated based on land register information, and power plant emissions are concentrated on each of the power plants without distributions. There are three cogeneration plants and one coal-fired power plant in Seoul. Finally, in the case of airports, emissions are calculated based on the combustion volume of fuel consumed by the airplane from the take-off and landing point of all aircrafts within 3 km.

# CArbon Simulator from Space (CASS) system

Seoul is a structurally complex Megacity with a mixture of residential, industrial, commercial, and several mountainous areas. Therefore, obtaining $FFCO_2$ contributions from atmospheric $CO_2$ concentrations requires high-resolution biospheric $CO_2$ flux grid data from SCA. CASS provides high-resolution biospheric $CO_2$ flux data of SCA by applying machine learning techniques. The figure below illustrates a brief diagram of CASS.