Quantifying urban CO_2 emissions using atmospheric CO_2: preparing for MicroCarb city-mode observations

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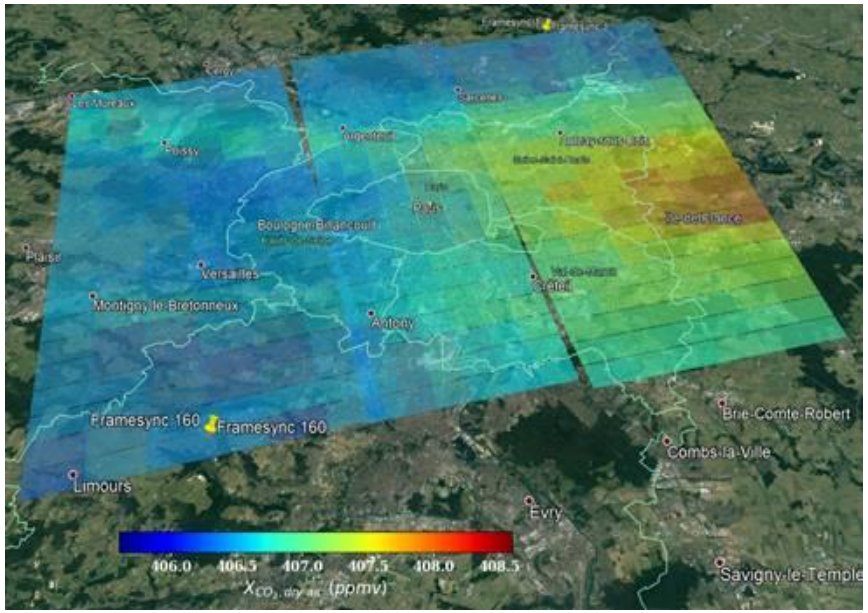
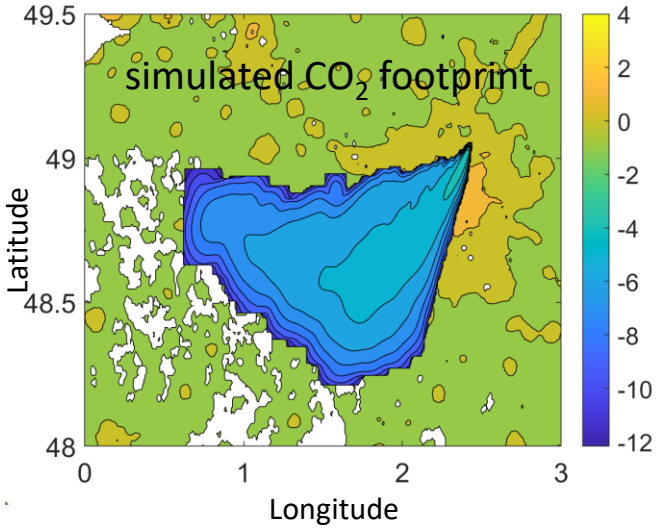
MicroCarb is a French-UK satellite designed to measure atmospheric CO_2. It will be launched in late 2022.

We are studying the efficacy of city-mode observations to quantify urban CO_2 emissions.



Three-sweep city-mode observing mode

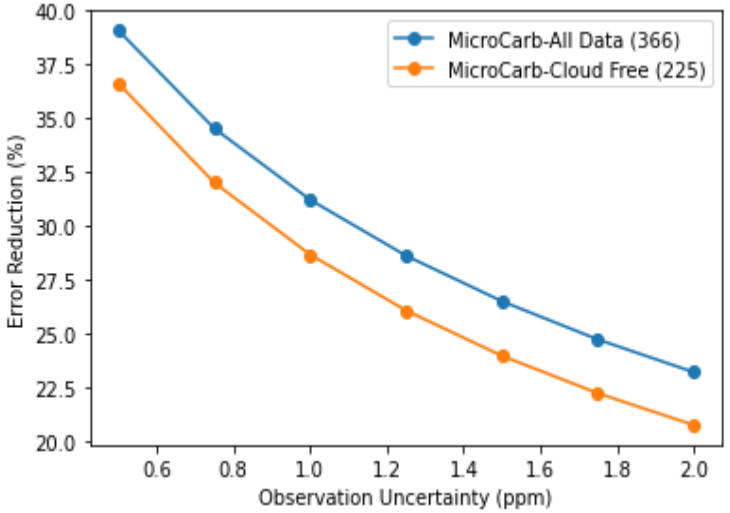


Methods

- We use X-STILT to model atmospheric transport within the context of an OSSE system.
- We statistically downscale cloud data to identify cloud-free scenes
- We estimate the uncertainty and size of CO_2 fluxes using MAP.

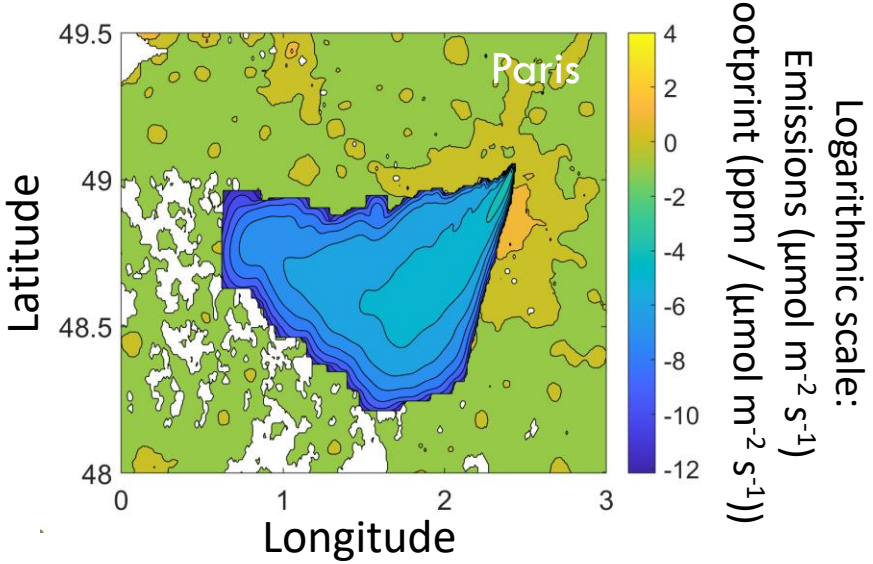
Results

- Outside growing season, MicroCarb can reproduce true CO_2 fluxes over Paris and London with error reductions of 25-30%
- Ongoing work to study influence of the land biosphere during growing season.



FORWARD MODEL

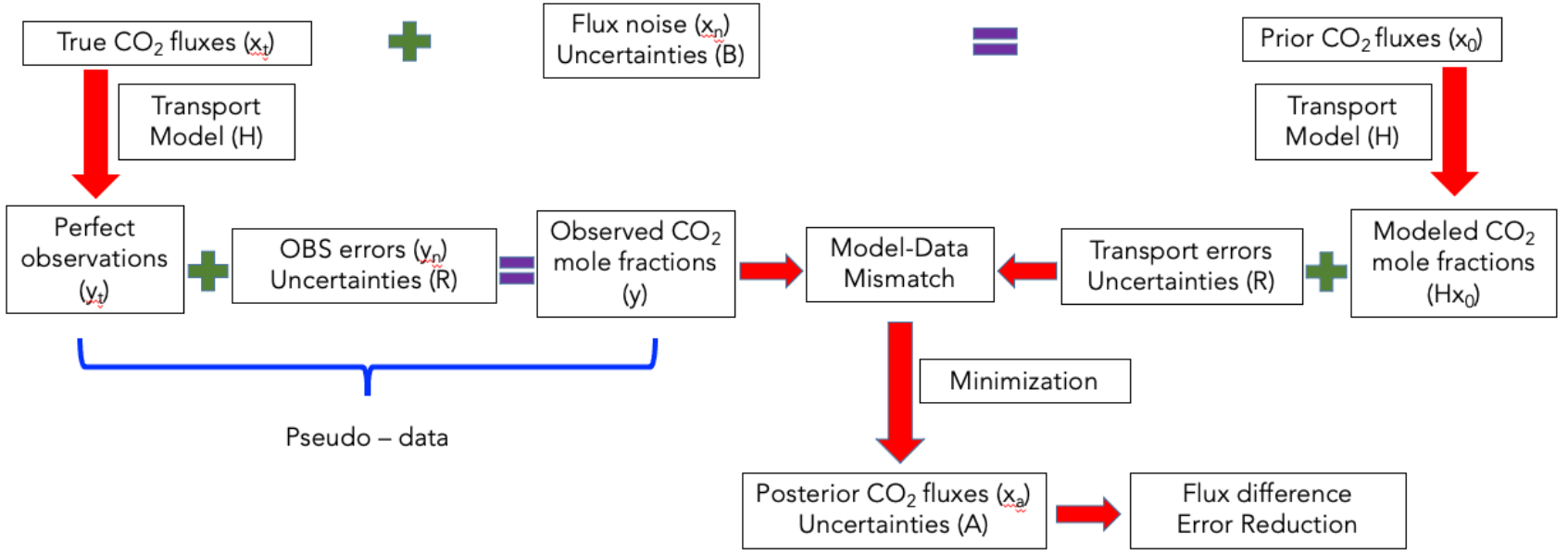
A CO_2 footprint using the X-STILT model (6 hours backward trajectory)



- X-STILT: an atmospheric transport model to link surface fluxes to the simulated column-averaged CO_2 mole fractions.
- Global Forecast System 0.25 degree (GFS0.25) meteorological data are used to drive the model.
- Open-source Data Inventory for Anthropogenic CO_2 (ODIAC) at 1 km resolution is used as the truth.

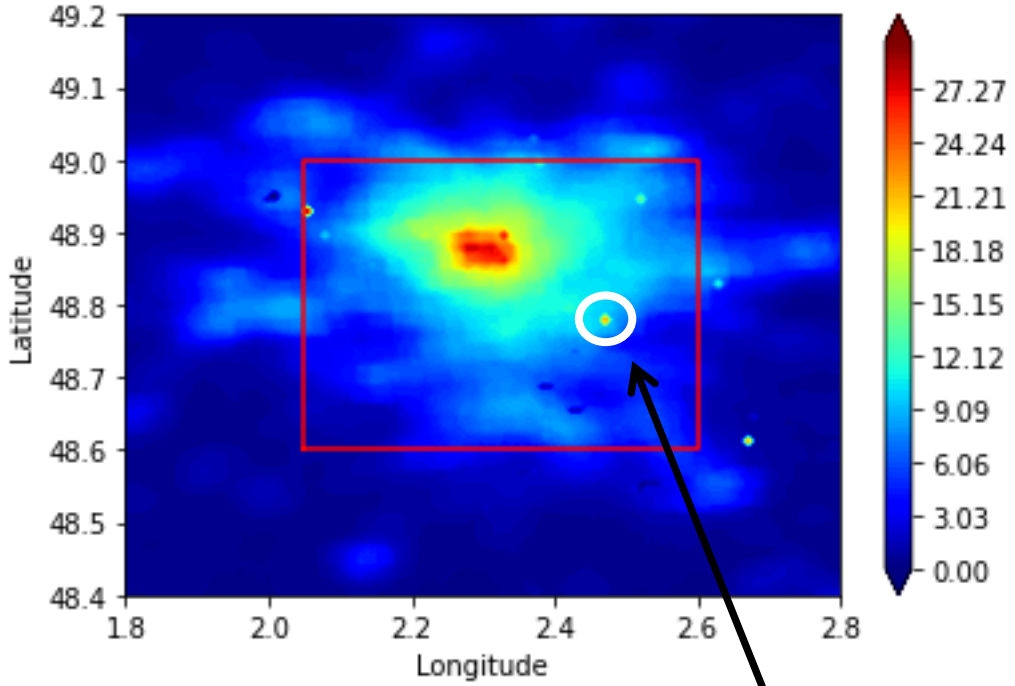
OSSE/INVERSE METHOD

- We use an OSSE approach
- We take into account prior and measurement noise to define the difference between the prior and true state.
- We characterize our posterior solution.

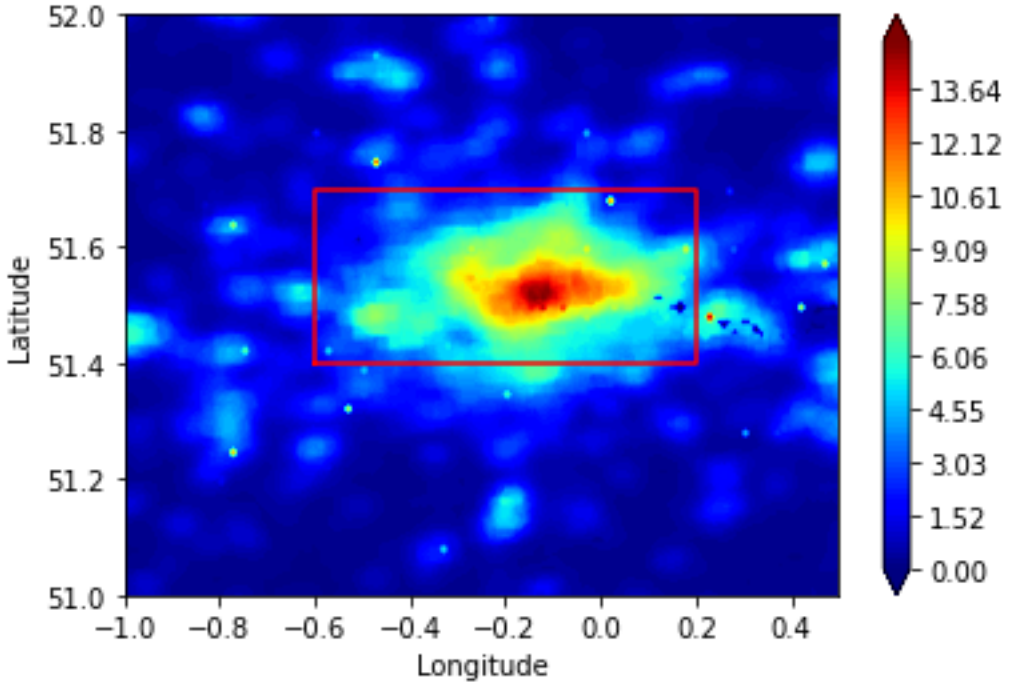


Define the city area

Paris, ODIAC APR 2018



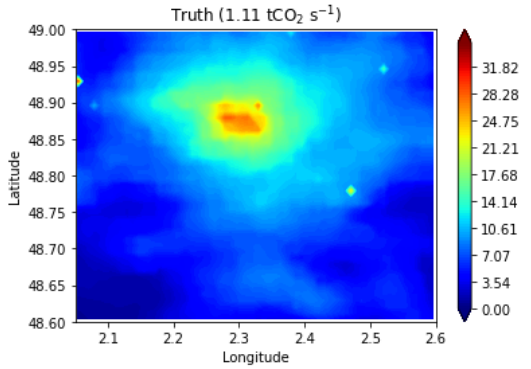
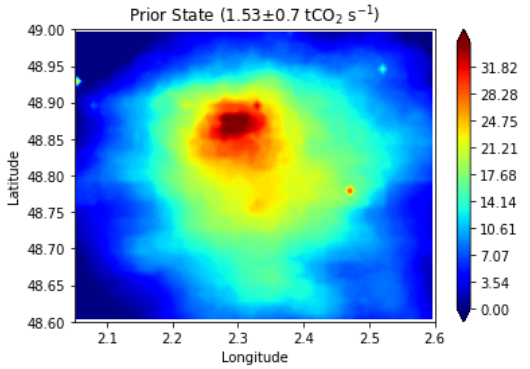
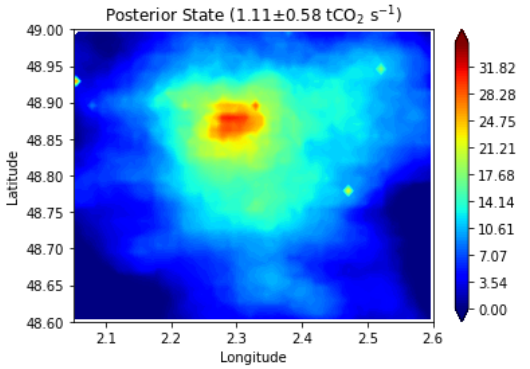
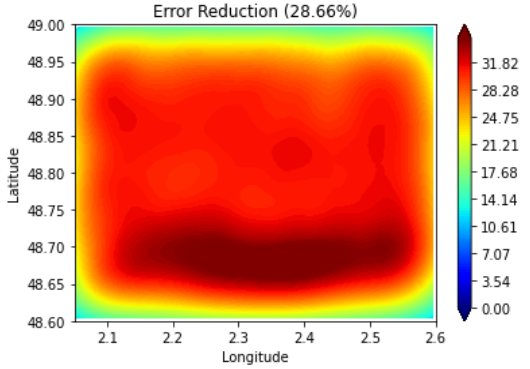
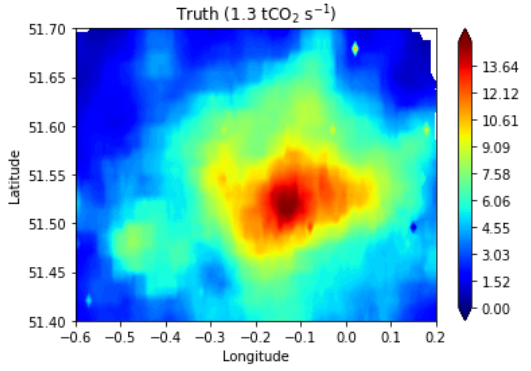
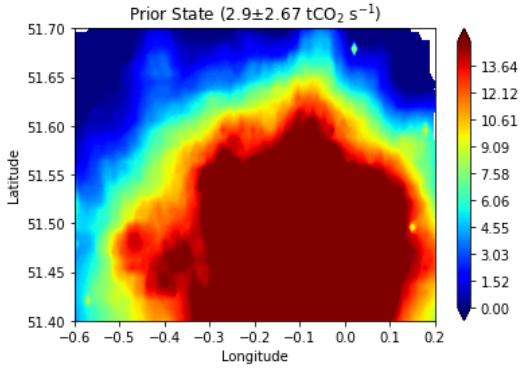
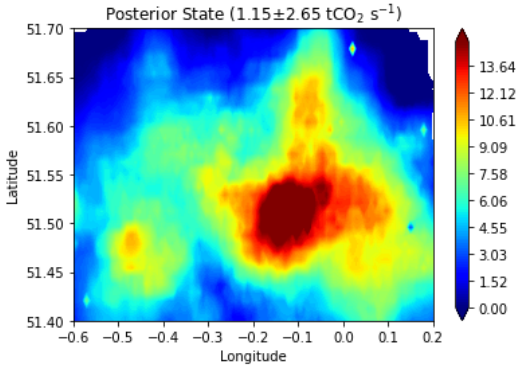
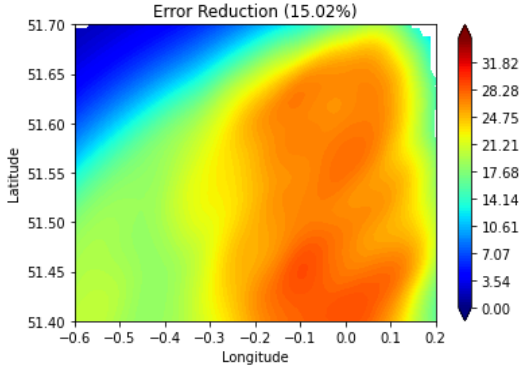
London, ODIAC APR 2018



(Units: µmol m^{-2} s^{-1})

Hot spots (power plants) are not currently included

Overview of control inversion using cloud-free data on 12 APR 2020

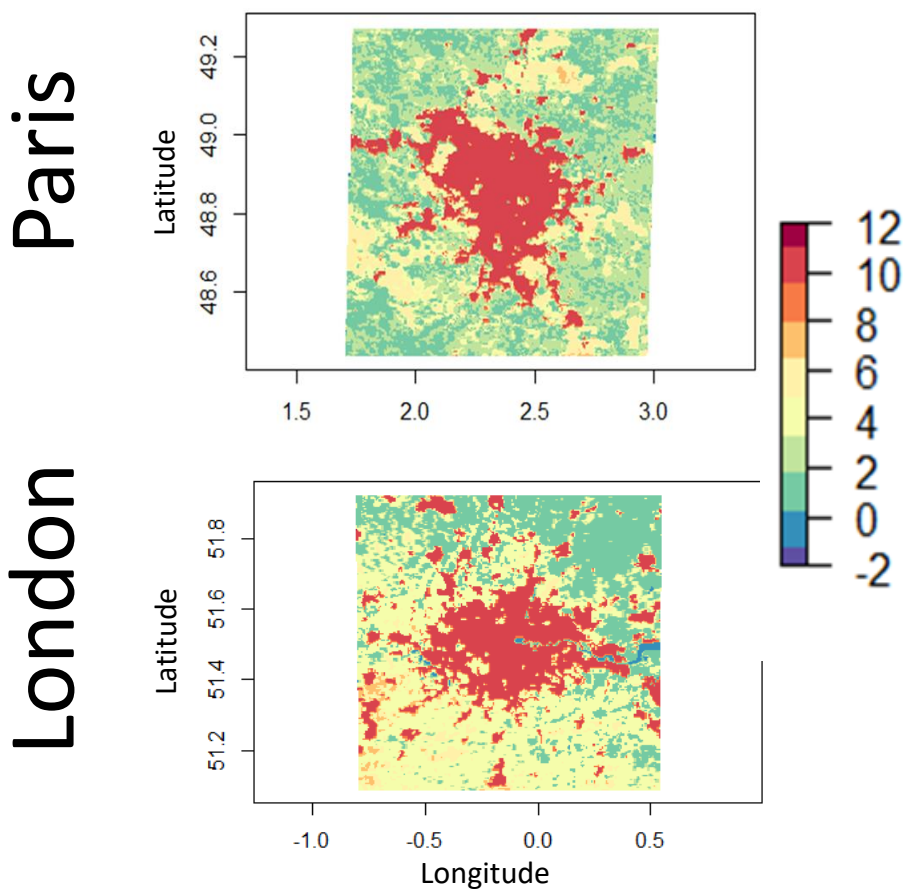
	Truth	Prior	Posterior	Error reduction
Paris (225 OBS)				
	(Units: μmol m^{-2} s^{-1})			(Units: %)
London (117 OBS)				

Observation error = 1 ppm, prior flux random error = 5 μmol m^{-2} s^{-1}, spatial correlation length = 10 km
Prior flux systematic error (bias, distributed spatially using prior error covariance) = 3 μmol m^{-2} s^{-1}

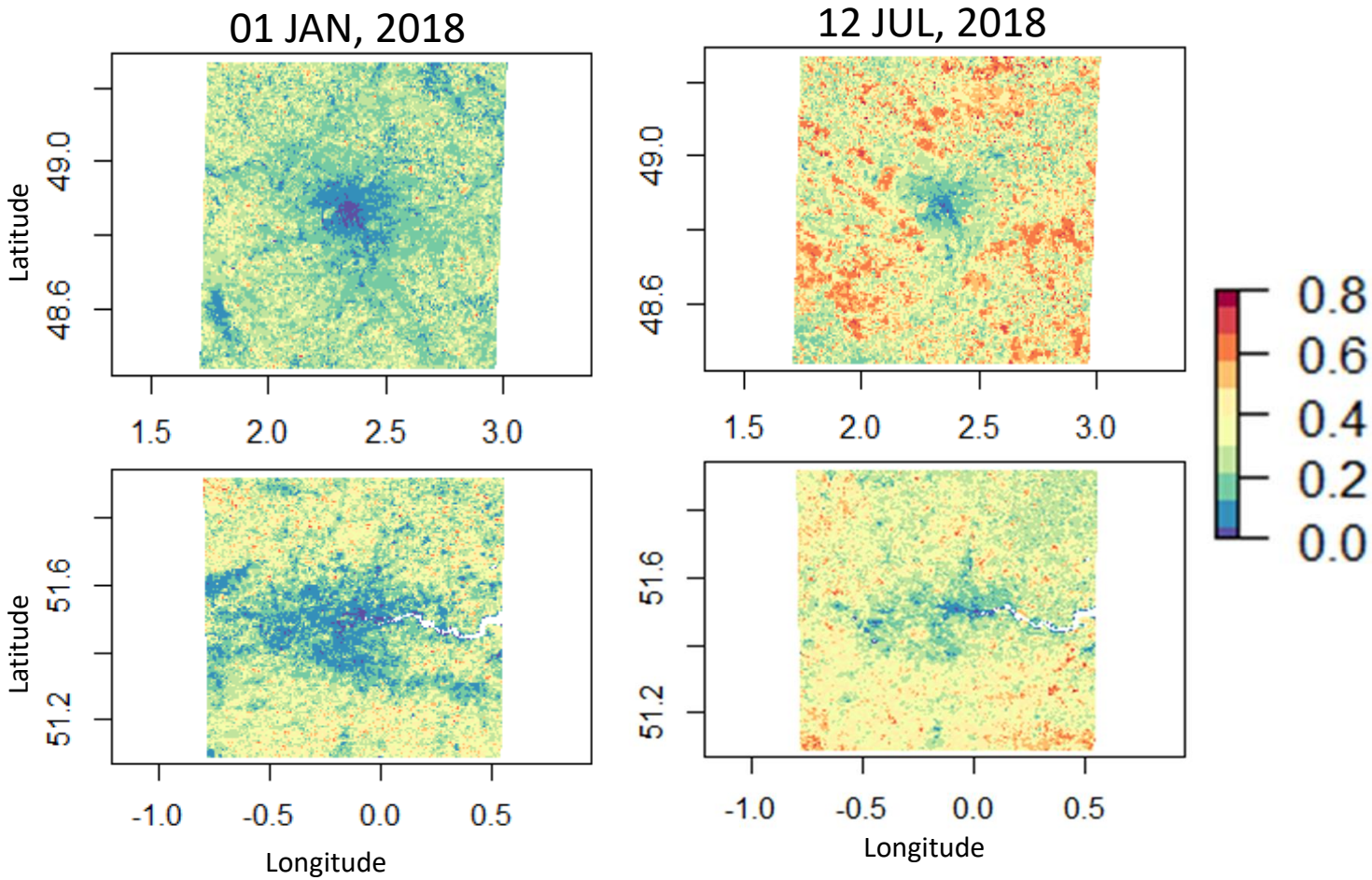
- The urban CO_2 inversion system reduces prior flux errors and retrieve the spatial structure of the truth
- More data improves the inversion performance and remove more random flux error, as expected.

Work in progress:
During the growing season how much will the land biosphere signal dampen the CO_2ff signal?

MODIS land cover data based on LAI at 500 m resolution in 2018



MODIS Enhanced Vegetation Index (EVI) at 250 m resolution



Green: grasses/cereal crops (1), shrubs (2)
Yellow: savanna (4), evergreen broadleaf forest (5), deciduous broadleaf forest (6)

- Land cover types are similar around Paris and London, but the distribution and fraction are different.
- London appears to be greener during winter. CO_2bio fluxes are non-ignorable.