



Observing world cities from space: progress and challenges

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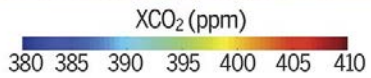
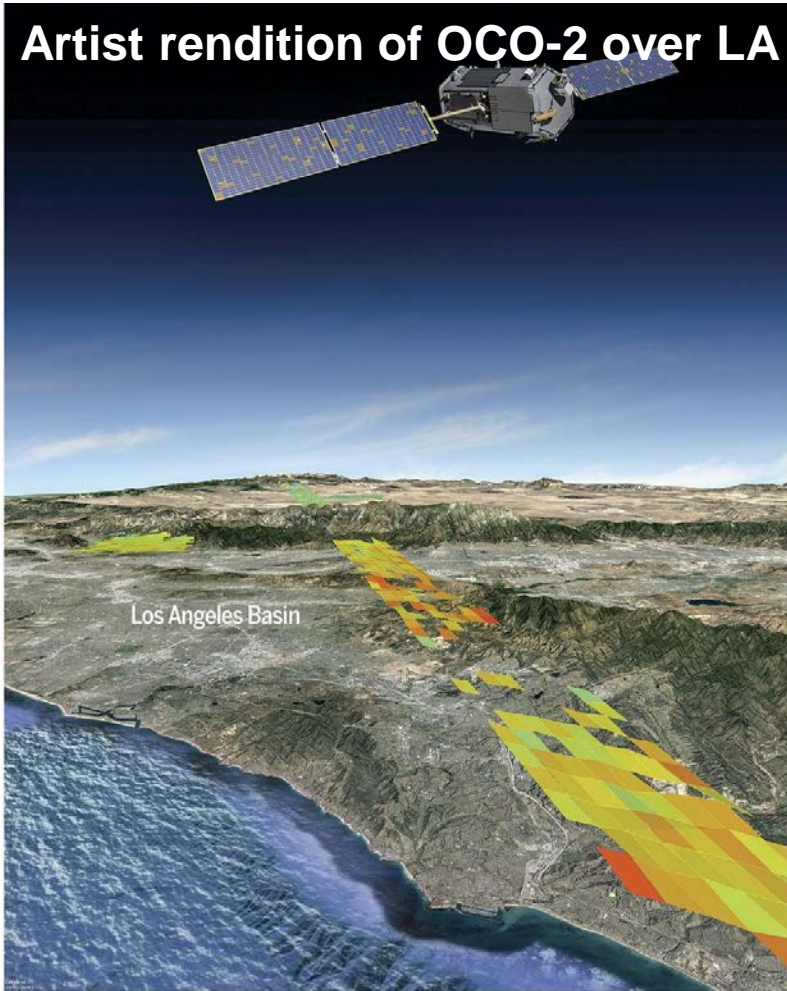
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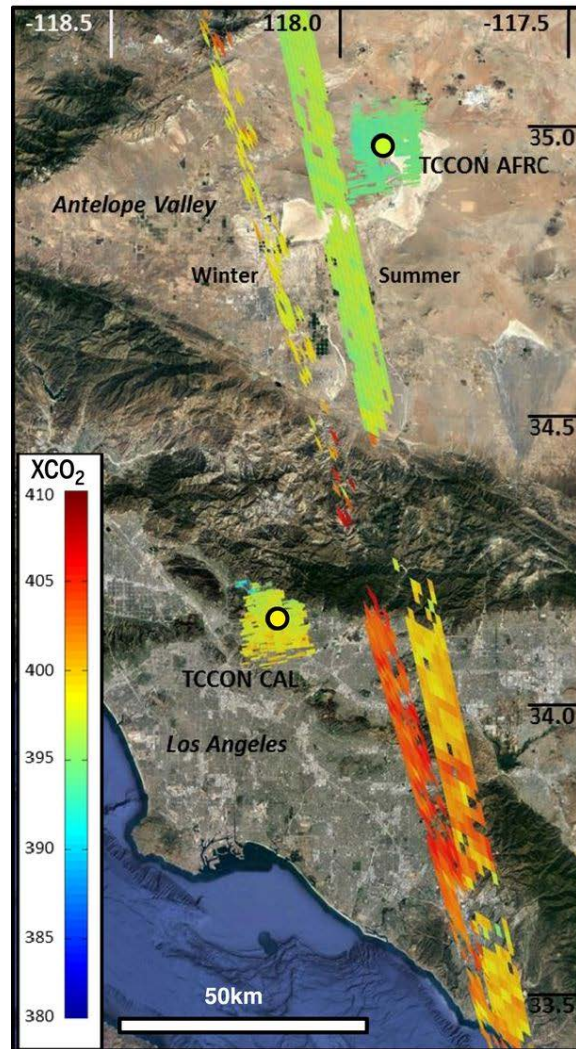
³Universities Space Research Association

Great examples of viewing cities from space

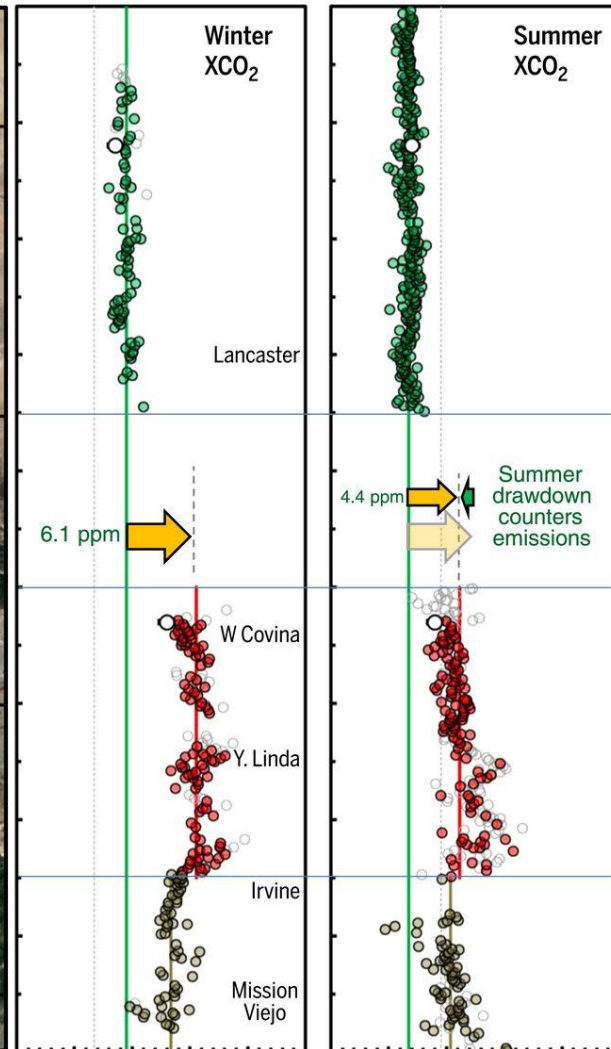
Artist rendition of OCO-2 over LA



A



Winter XCO₂ Summer XCO₂



Upwind of LA

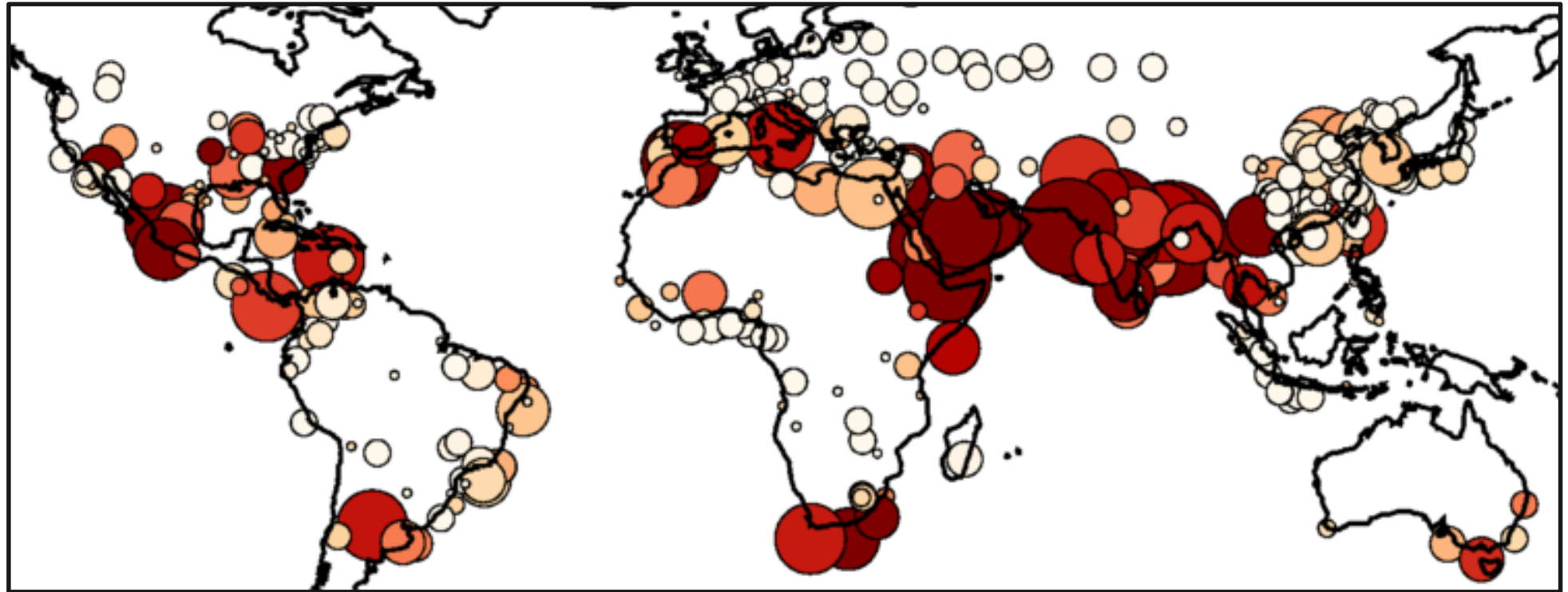
San Gabriel Mtns

Interior LA

Downwind

But how well do current satellites do over all cities?

OCO-2 Observations over World Cities - DJF, 2016-2018



2 days ●

4 days ●

6 days ●

8 days ●



0

125

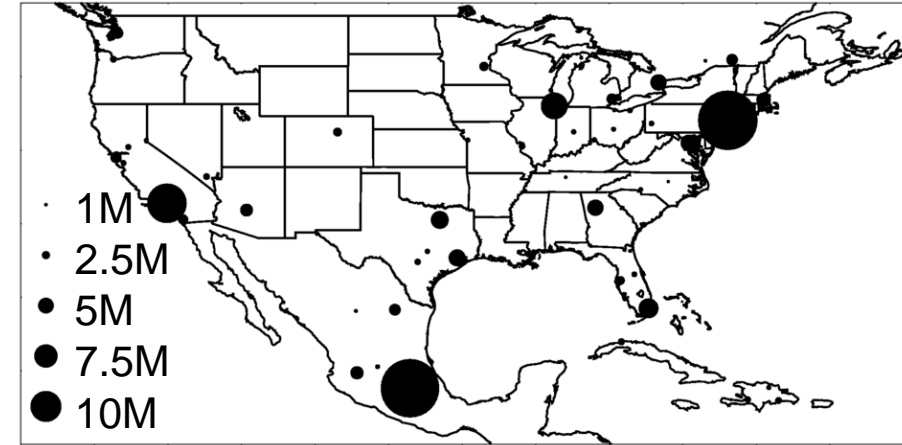
250

375

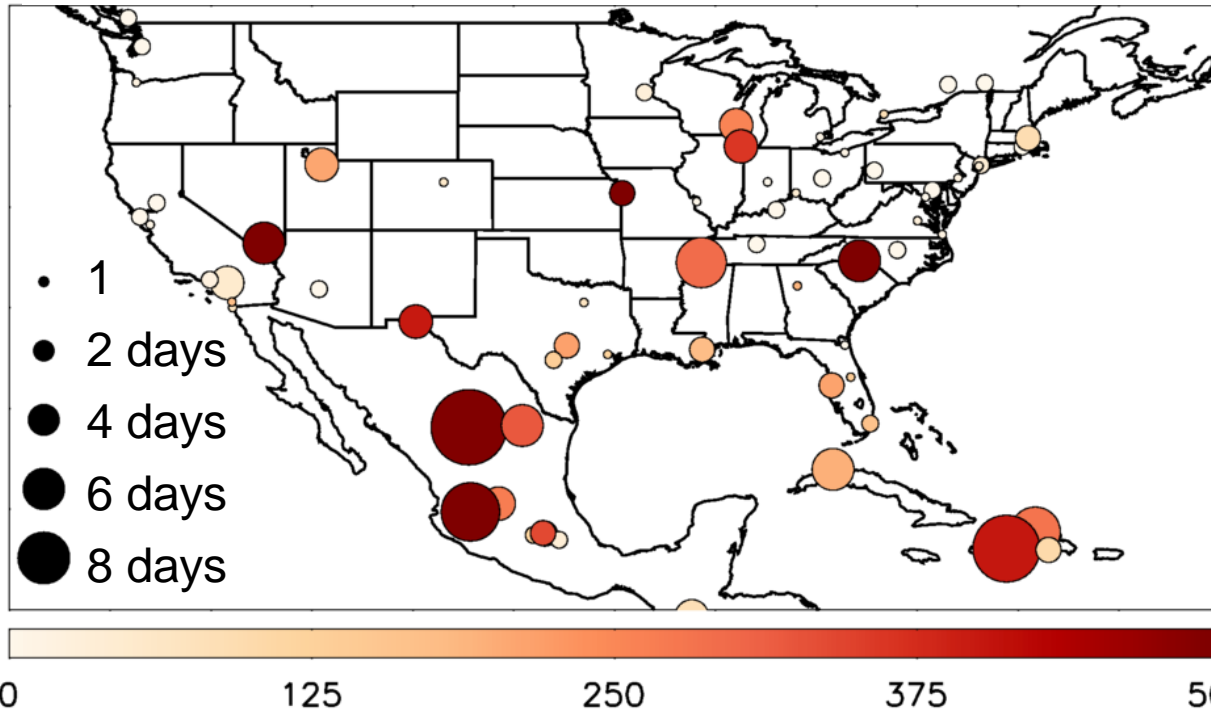
500

Seasonality matters – and we can't control when we get observations

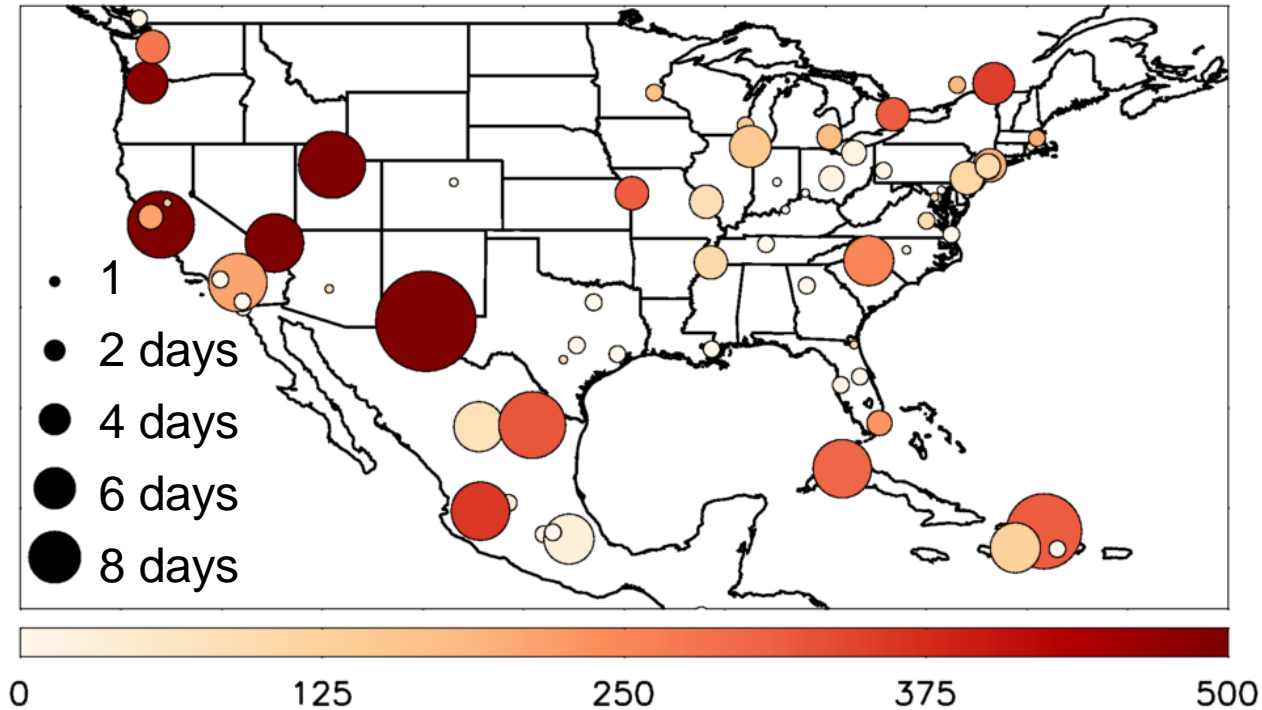
Population density



OCO-2 Observations over NA Cities - DJF, 2016-2018

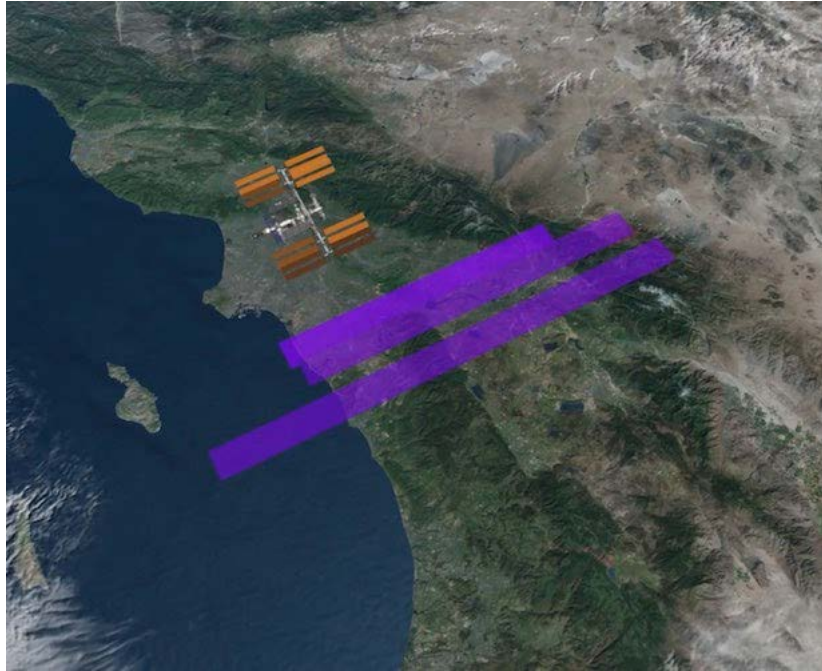


OCO-2 Observations over NA Cities - JJA, 2016-2018



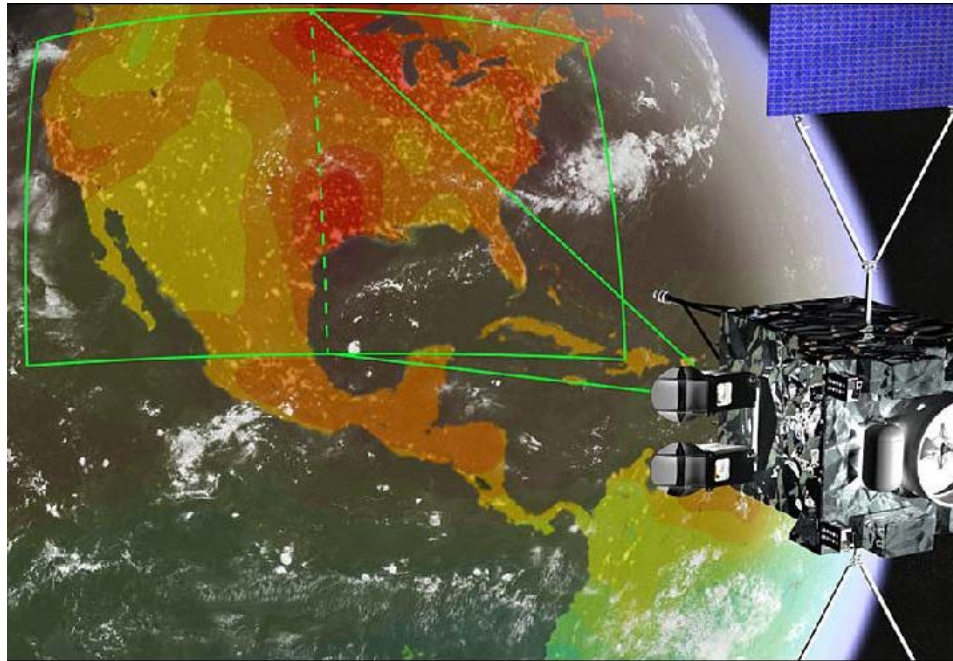
Future satellites will do better by having more chances to observe cities

OCO-3 – On ISS since May, 2019



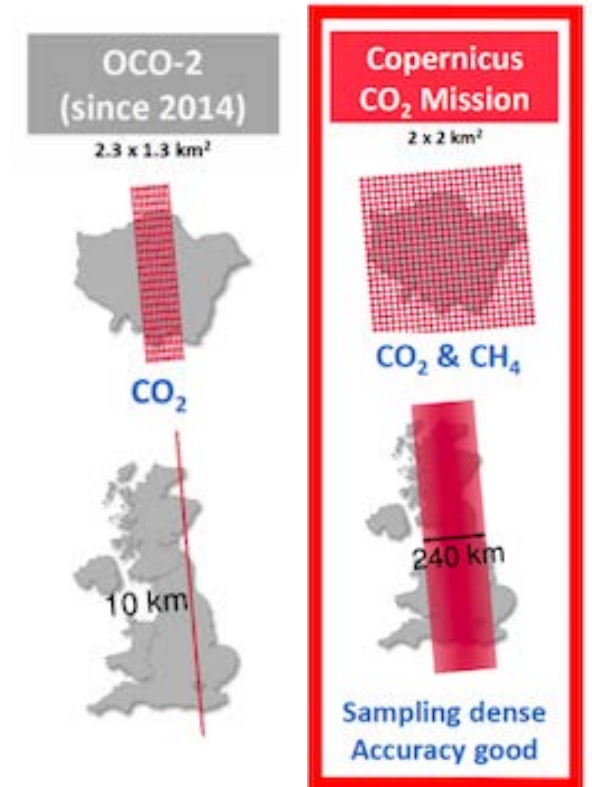
OCO-3's Snapshot Area Mode uses adaptive pointing to obtain denser observations over cities

GeoCarb – Planned launch in 2023



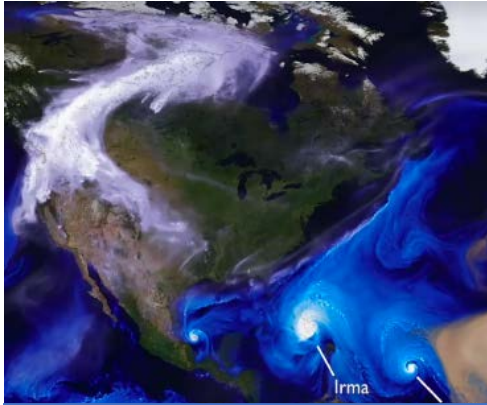
GeoCarb will be the world's first geostationary GHG satellite allowing daily scans over the America

ESA Sentinel 7 – First launch in 2025



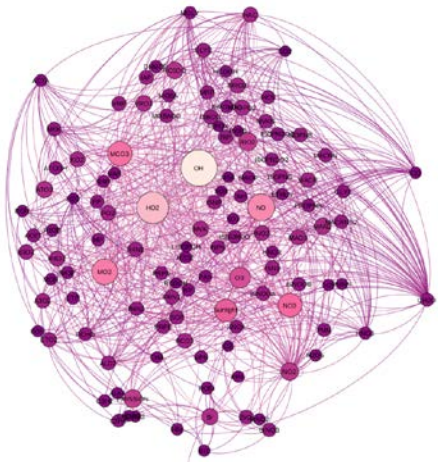
Sentinel 7 will include 3 spacecraft, increase swath width, full coverage every 2-3 days

The case for global models in cities



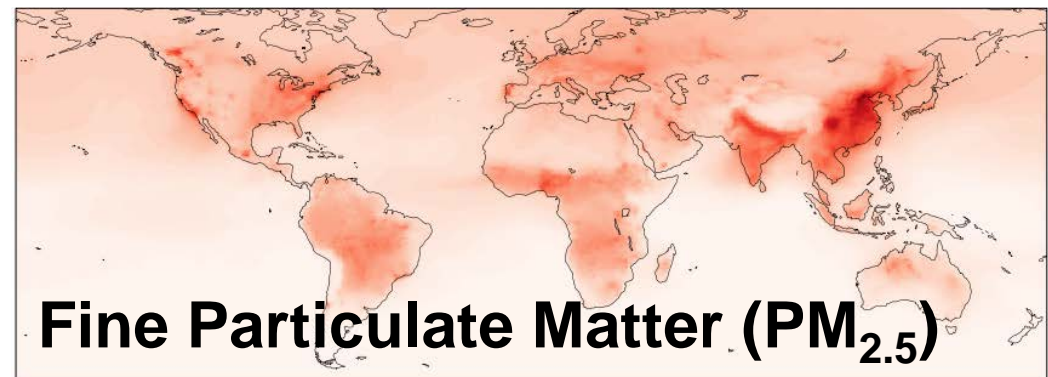
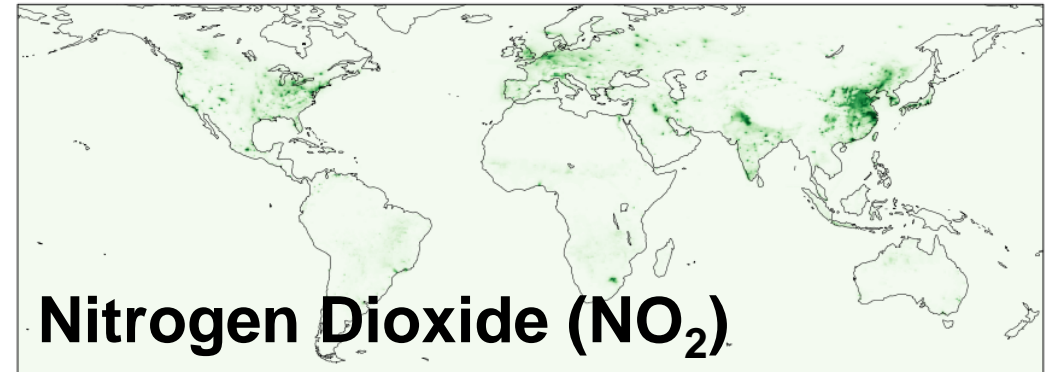
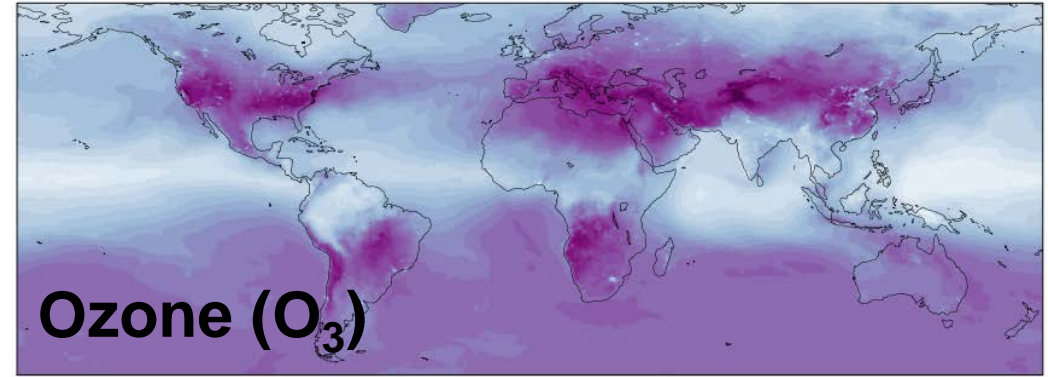
Irma

GEOS NWP



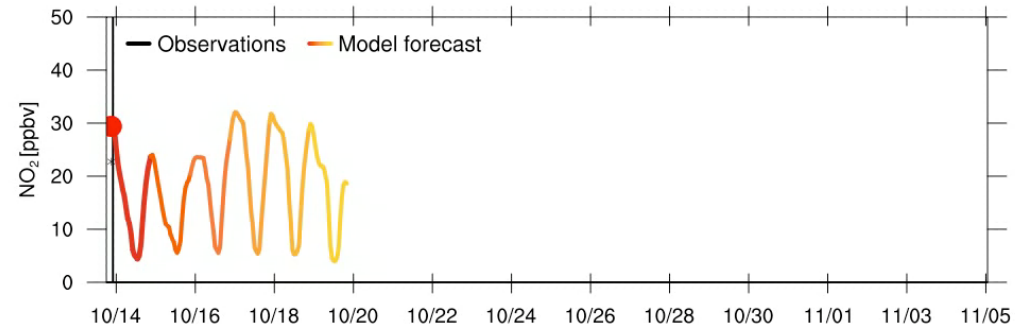
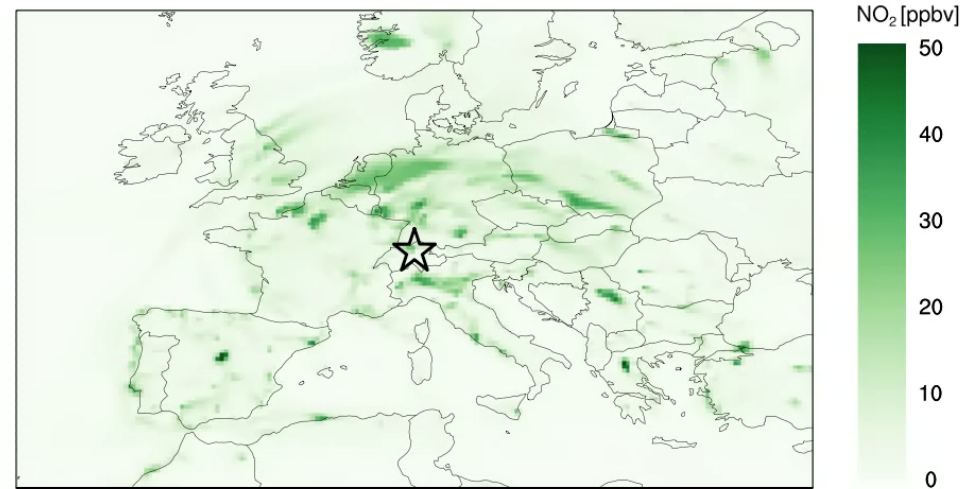
GEOS - Chem

- ❖ 250 Chemical Species
- ❖ 725 Chemical Reactions

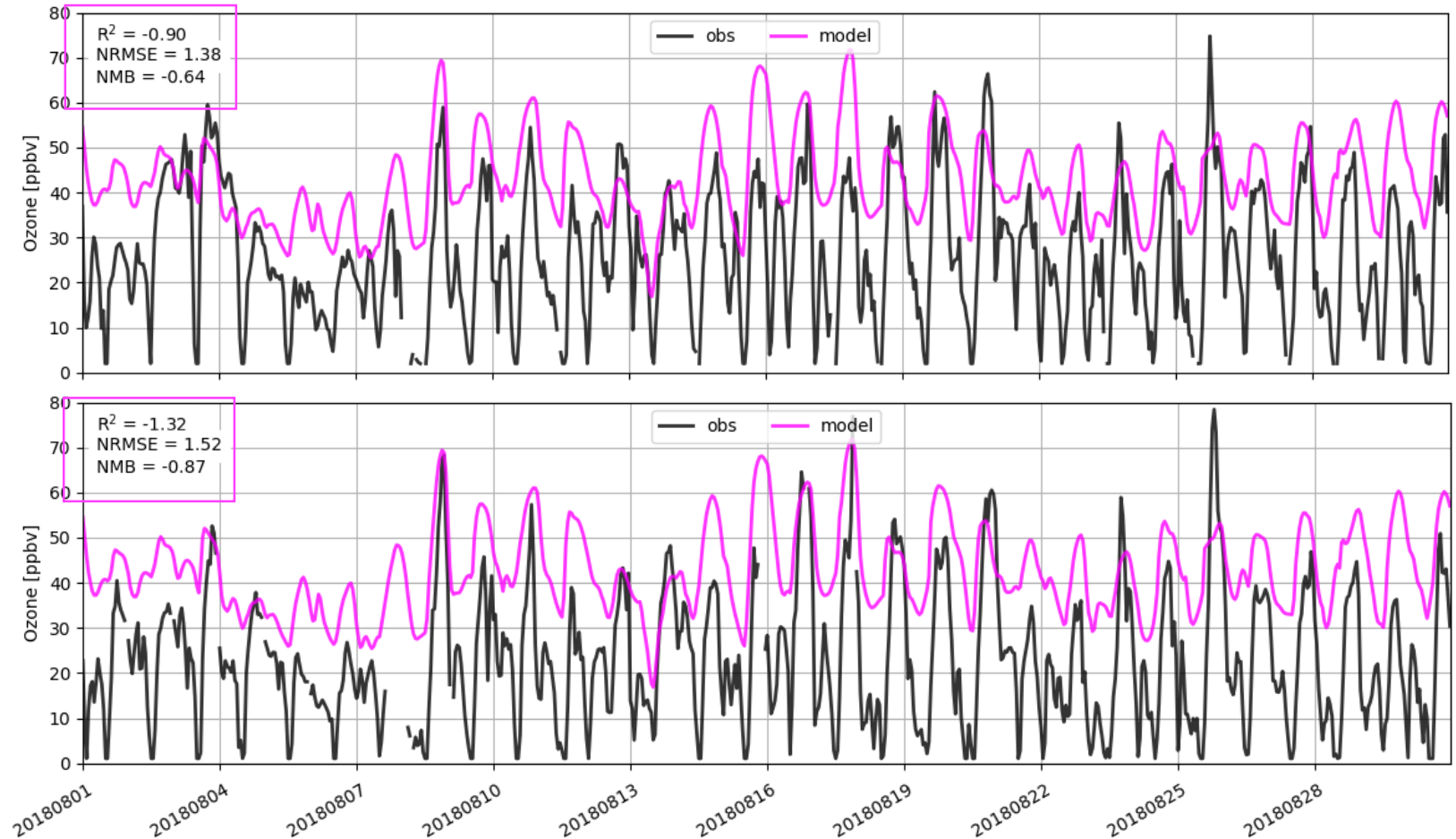
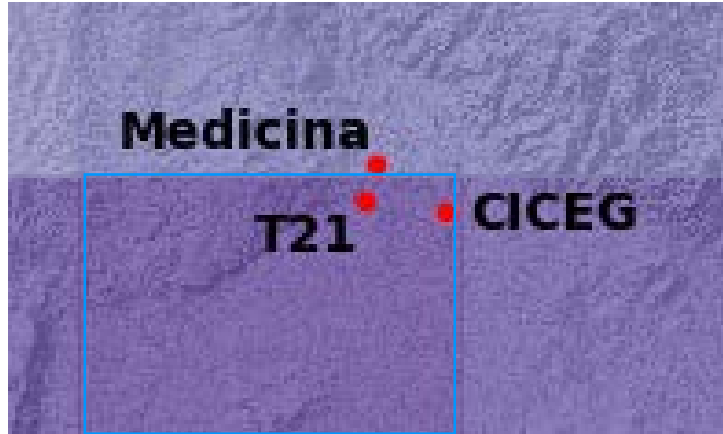


Capturing the impact of traffic over Zurich

Zurich, Switzerland, 2017-10-14 00:00 UTC



Improve local forecasts using statistical bias correction

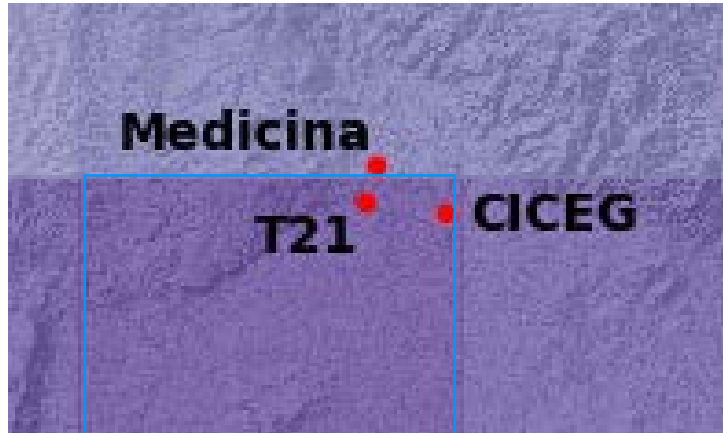


Observations **Model**

Two observation sites in the same grid box

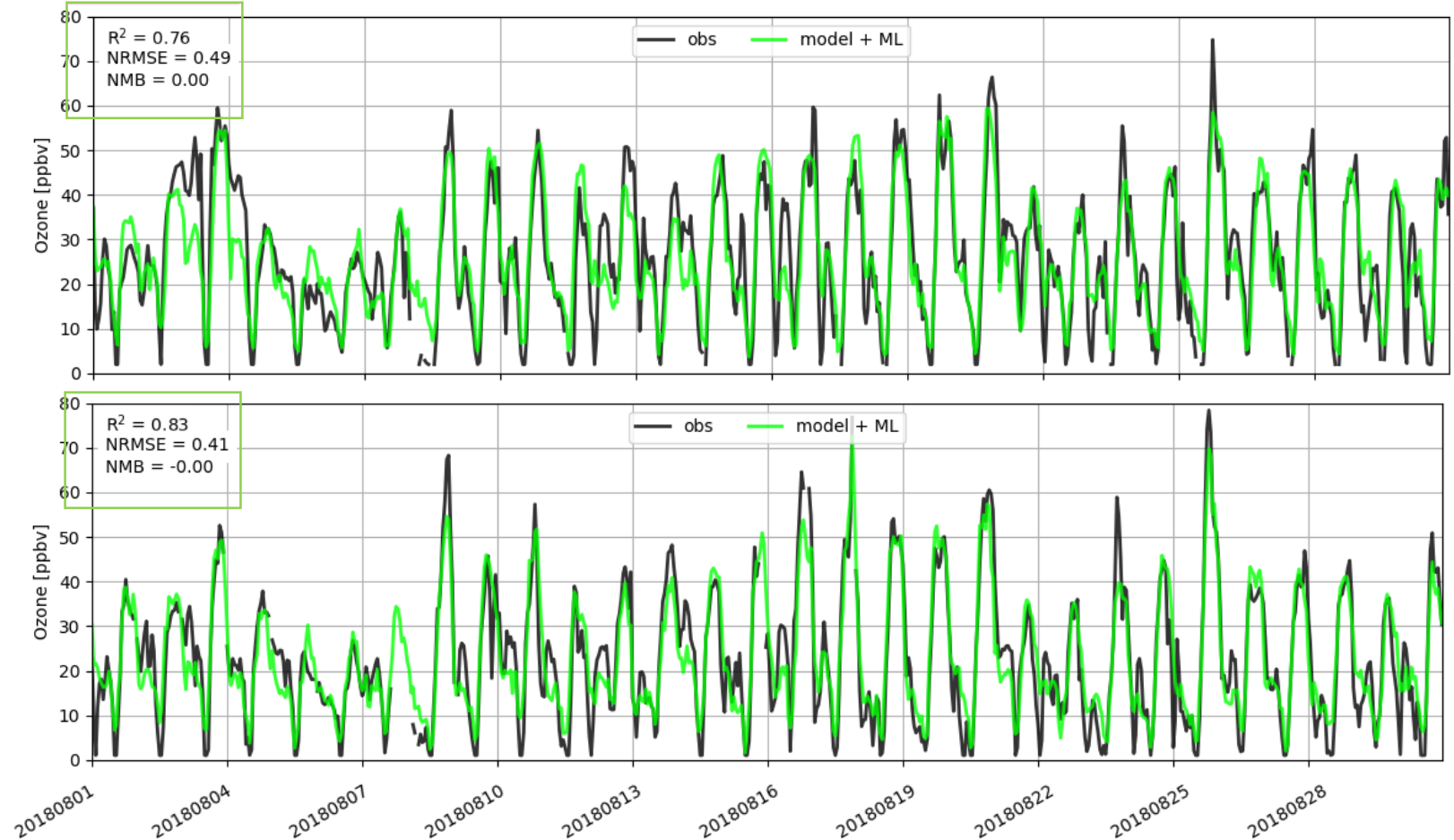
➤ GEOS-CF generally overestimates

Improve local forecasts using statistical bias correction



Two observation sites in the same grid box

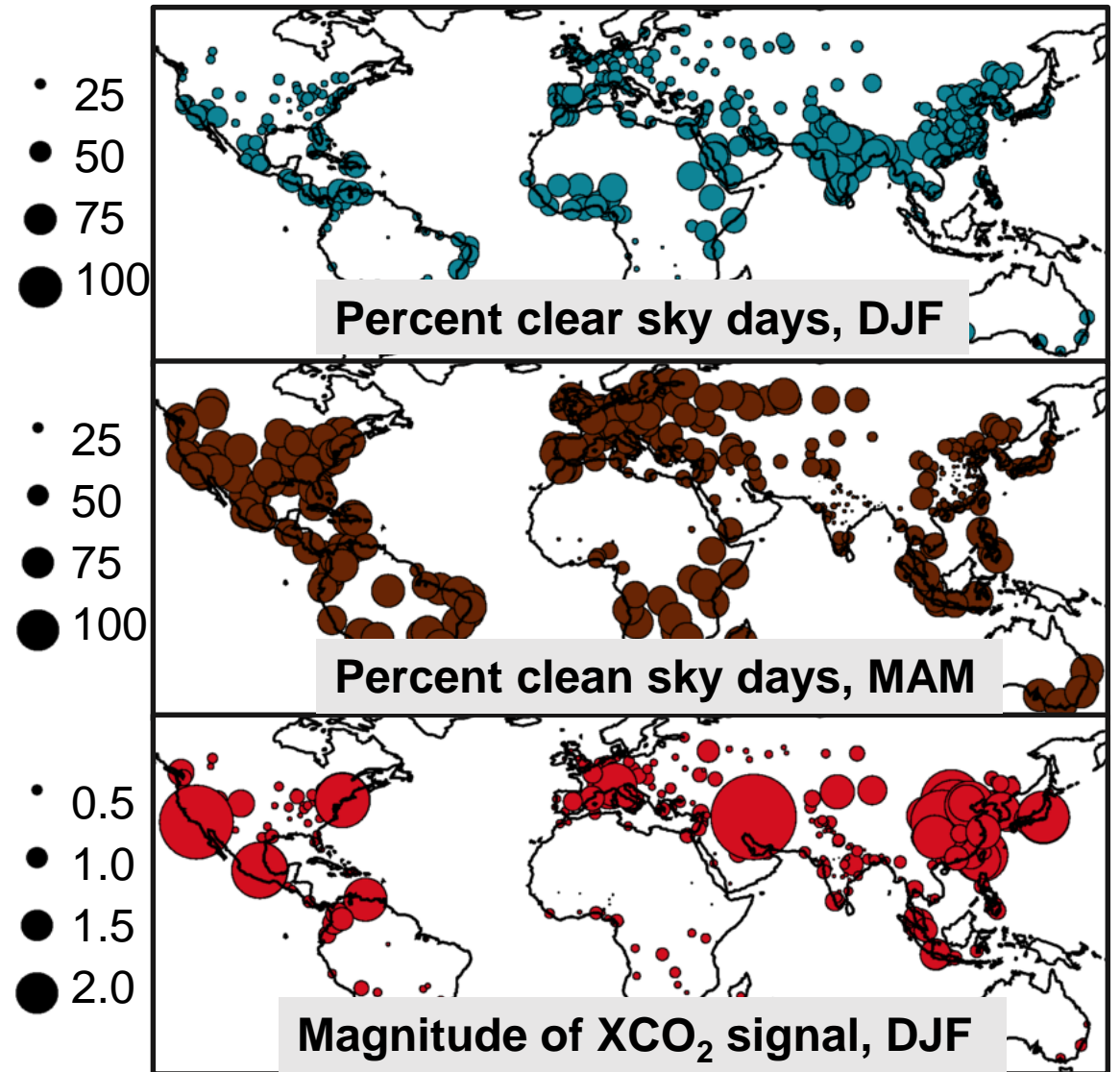
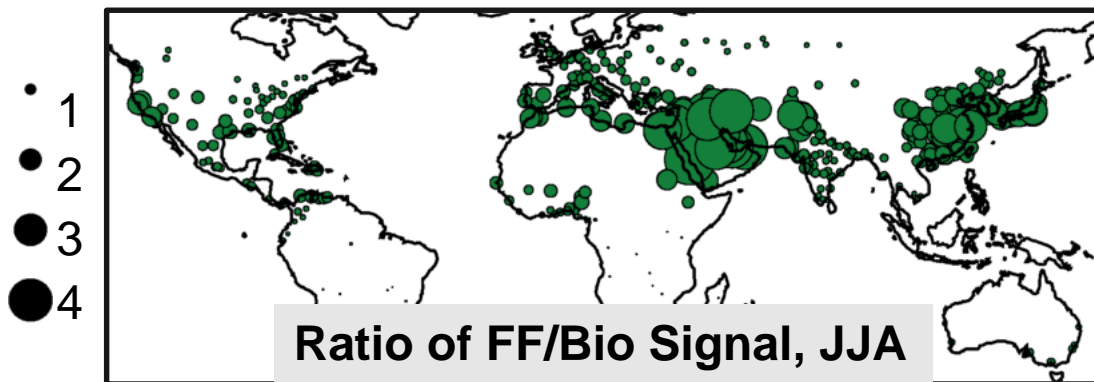
- GEOS-CF+ML captures diurnal variability at sub-grid scale



Observations **Model + ML**

Using modeling tools to plan better observations

Using high-resolution global model runs from GEOS and the flexible resolution OLAM models, we've devised a series of metrics to assess how readily fossil fuel emissions in urban areas could be detected





Summary and next steps

- Satellite XCO₂ observations from OCO-2 provide examples of urban CO₂ enhancements, but in most cities only a handful of days contain observations due to clouds and limited sampling opportunities
- Next generation satellites (OCO-3, GeoCarb, Sentinel 7) will provide more opportunities to view cities in support of greenhouse gas monitoring
- Model-based planning tools are helping us plan better observing strategies by identifying cities where we could do a better job – and identifying cities where we don't have a chance
- We're also working hard on global models to make them relevant at urban scales.
- Great opportunities for collaboration
 - Improving regional emission datasets
 - Using global model boundary fields as boundary conditions for regional models
 - Developing strategies for using proxy datasets (CO, NO₂)
 - Machine learning approaches to correct biases