The use of gridded fossil fuel CO_2 emissions (FFCO2) inventory for climate mitigation applications: Errors, uncertainties, and current and future challenges

Tomohiro Oda[1,2] (tom.oda@nasa.gov)

R. Bun (3,4), V. Kinakh (3), S. Maksyutov (5), J. Wang (2,6), S. R. Kawa (6), M. Roman (7), Z. Wang (7), G. Marland (8), M. Jonas (9), T. Lauvaux (10), S. Feng (10), L. Ott (1), S. Pawson (1)

1. GMAO, NASA GSFC; 2. GESTAR/USRA; 3. Lviv Polytechnic National University, Ukraine; 4. WSB University, Poland; 5. NIES, Japan; 6. Atmospheric Chemistry and Dynamics Laboratory, GSFC; 7. Terrestrial Information Systems Laboratory, GSFC; 8. Appalachian State; 9: IIASA, Austria; 10: Penn State,

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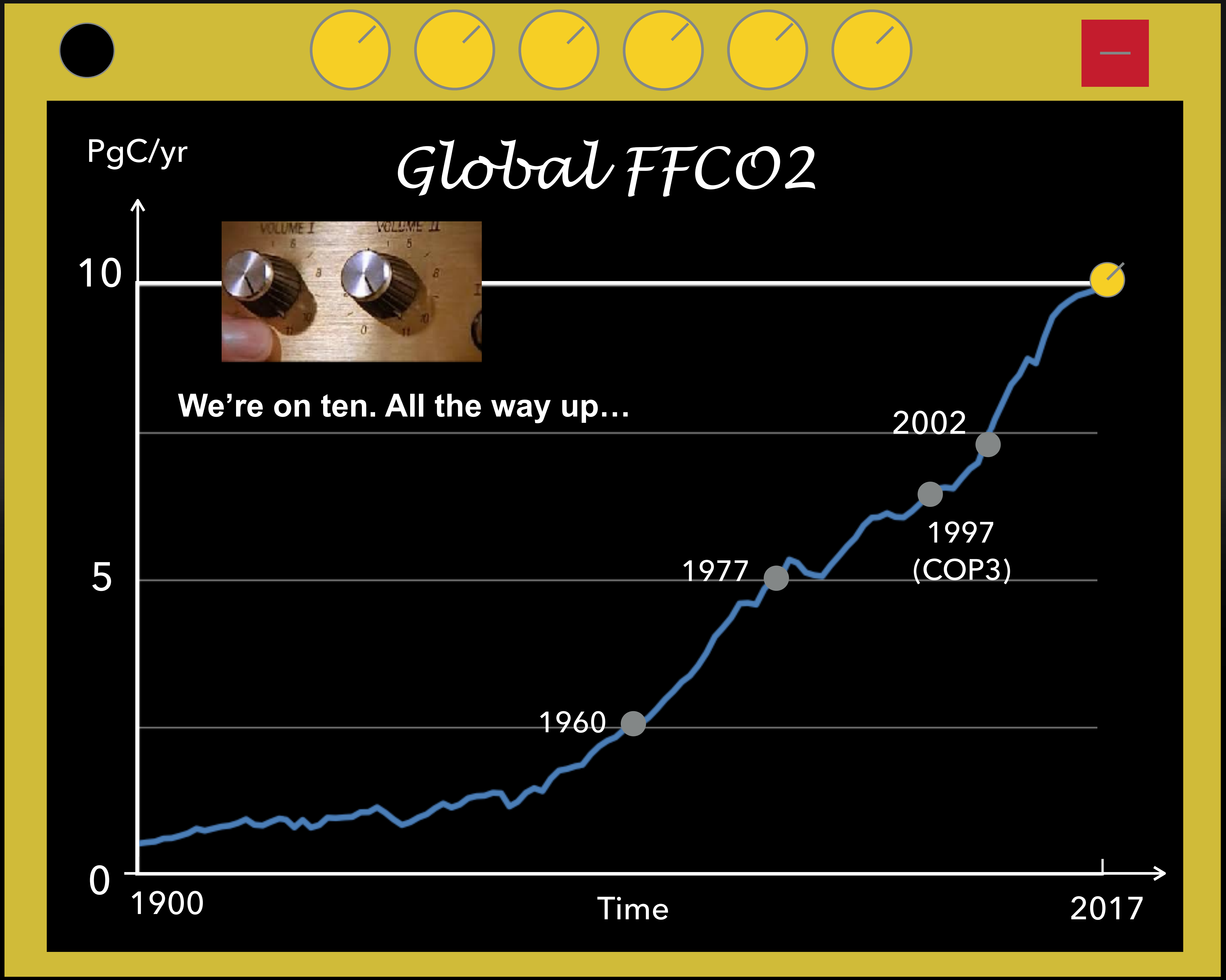
Up to Eleven? - Global FFCO2 hit 10PgC in 2017



Data sources: Boden et al. (2018); BP (2018); Wikipedia (2018)

You are at 10.... where should we go from here?

- The recent IPCC report suggests we need to reduce our emission by 45% below the 2010 level by 2030 to avoid the 1.5°C level.

  —> *Need to reduce FFCO2 to where levels were 41 years ago (1977)*

- How about 2°C target?

  —> *Need to reduce FFCO2 to where levels were 16 years ago (2002)*

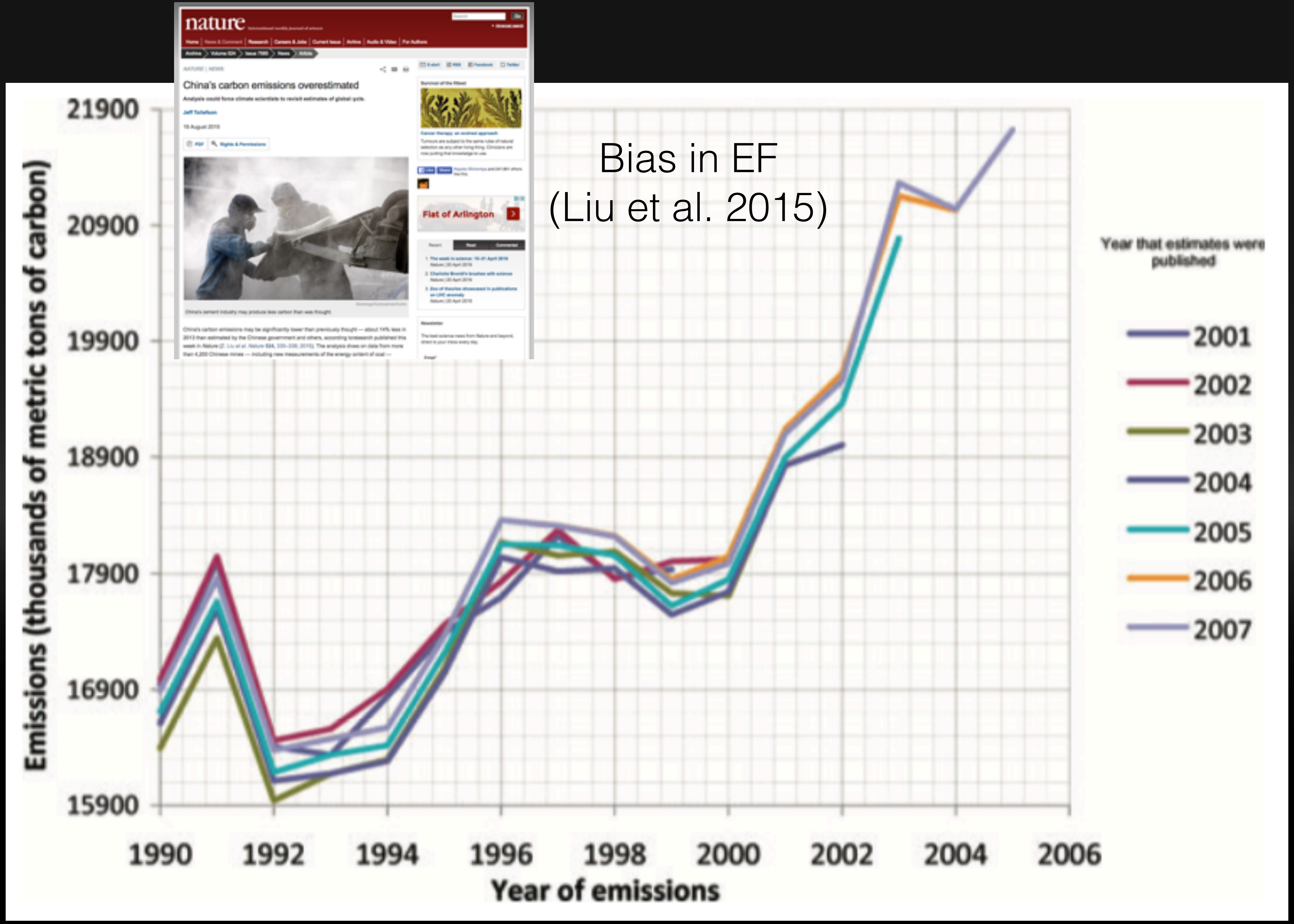
- Returning to 1977 level (1.2 tC/person, pop: 4.2b) means…

  —> going back to 1955 level (0.7 tC/person, pop: 2.7b)

The task of the emission reduction will be tougher if you wait longer…

Marland et al. submitted

Kyoto to Paris: Challenges in accounting emissions



Revisions to national inventories reported by Austria (Marland et al. 2009)

Reporting emission inventories (EIs)

- Emissions = Emission factor x Activity data
- Followed by common guidelines (e.g. IPCC)
- Emission estimates are aggregated numbers at national and/or national sectoral level

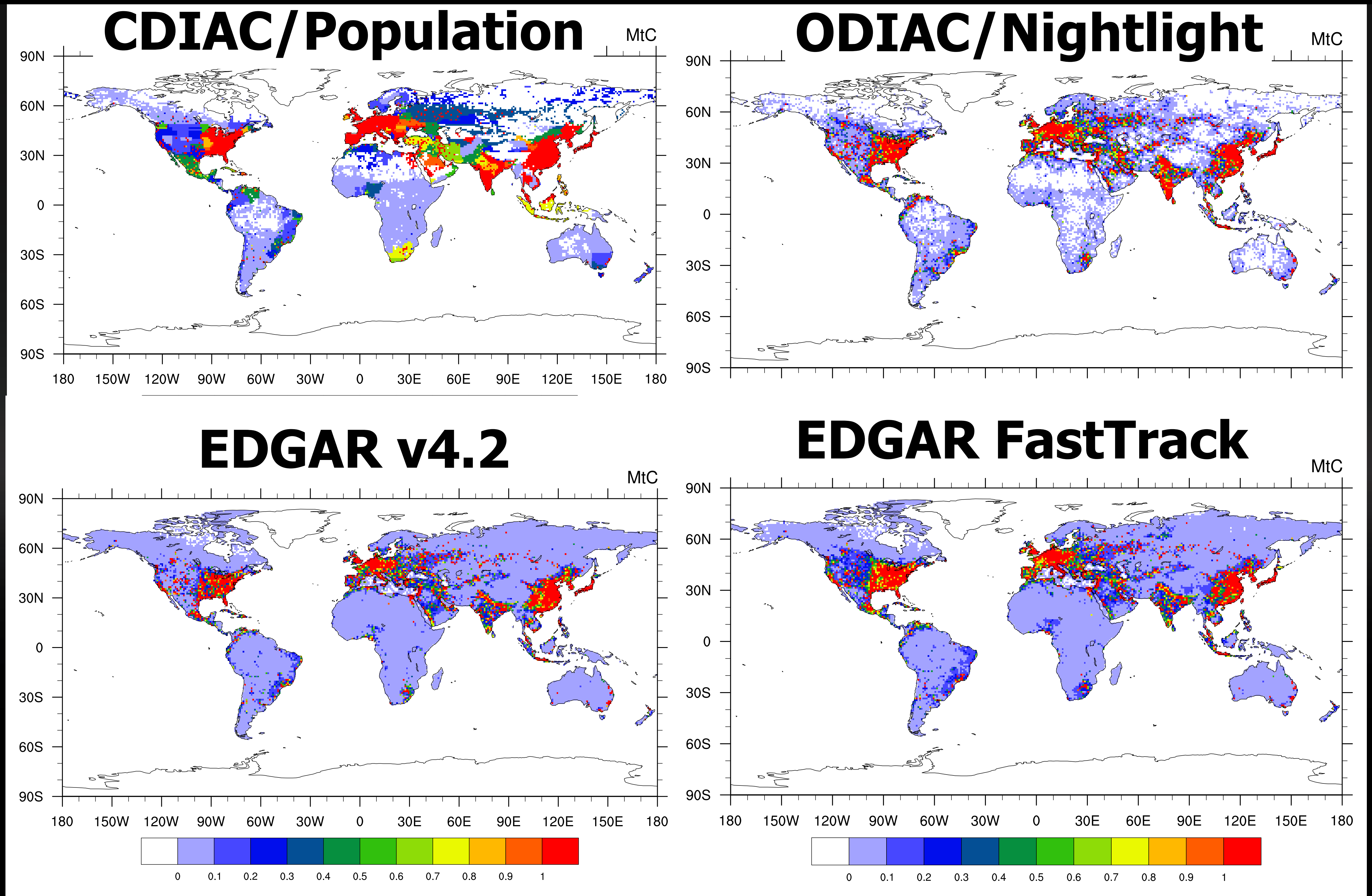
Known errors and biases in EIs

- Emission factors are not often ideal and/or locally specific
- Activity data are often subject to revisions
- EIs cannot fully assure the accuracy of the emission estimates by themselves

FFCO2 need to be accurately quantified to assess our emission reduction effort towards the Paris Agreement goal.

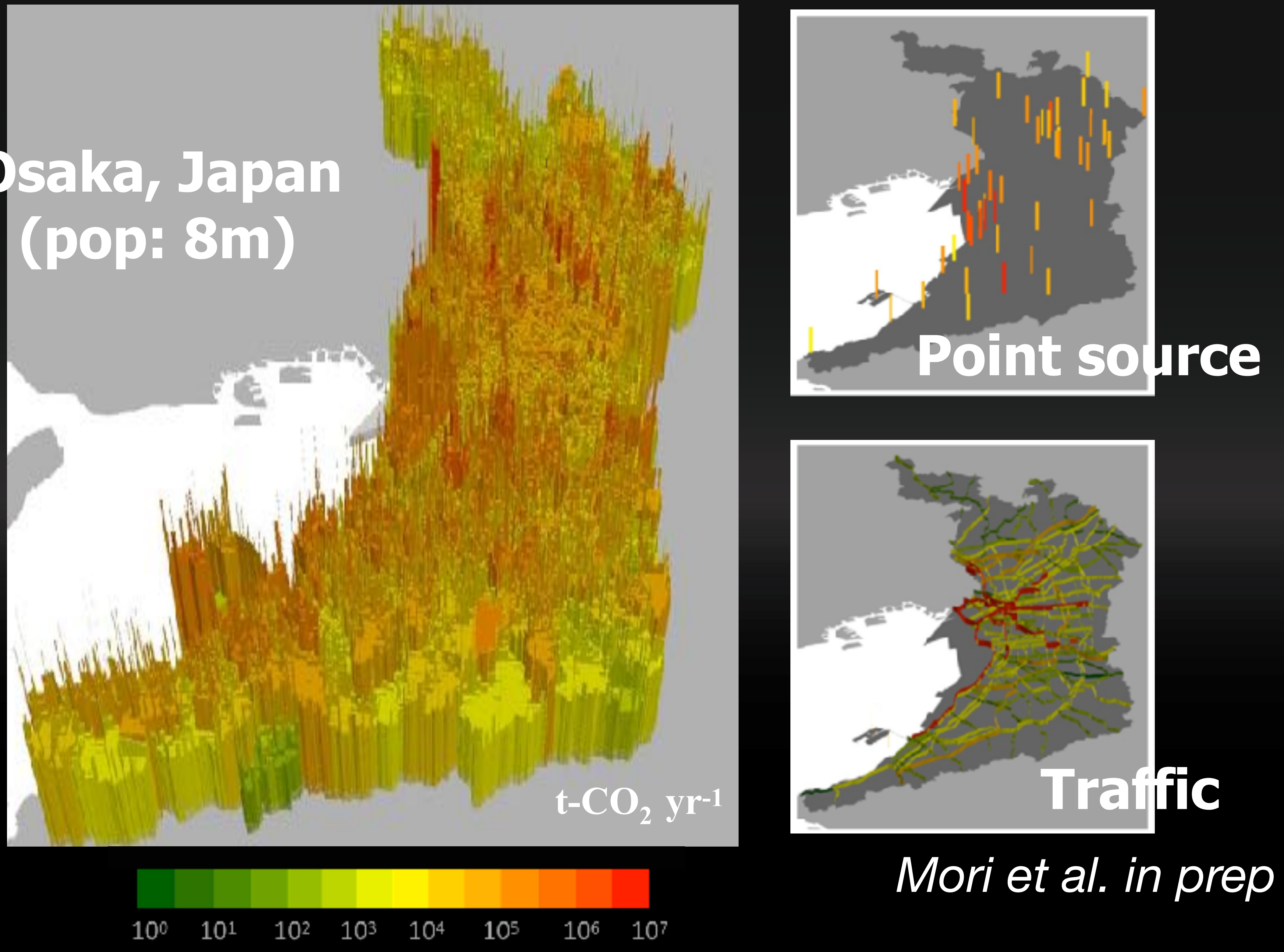
Beyond national scale: towards global 1km hourly emissions

Proxy approach (large system)



↔

Mechanistic approach (sub system)



Mori et al. in prep

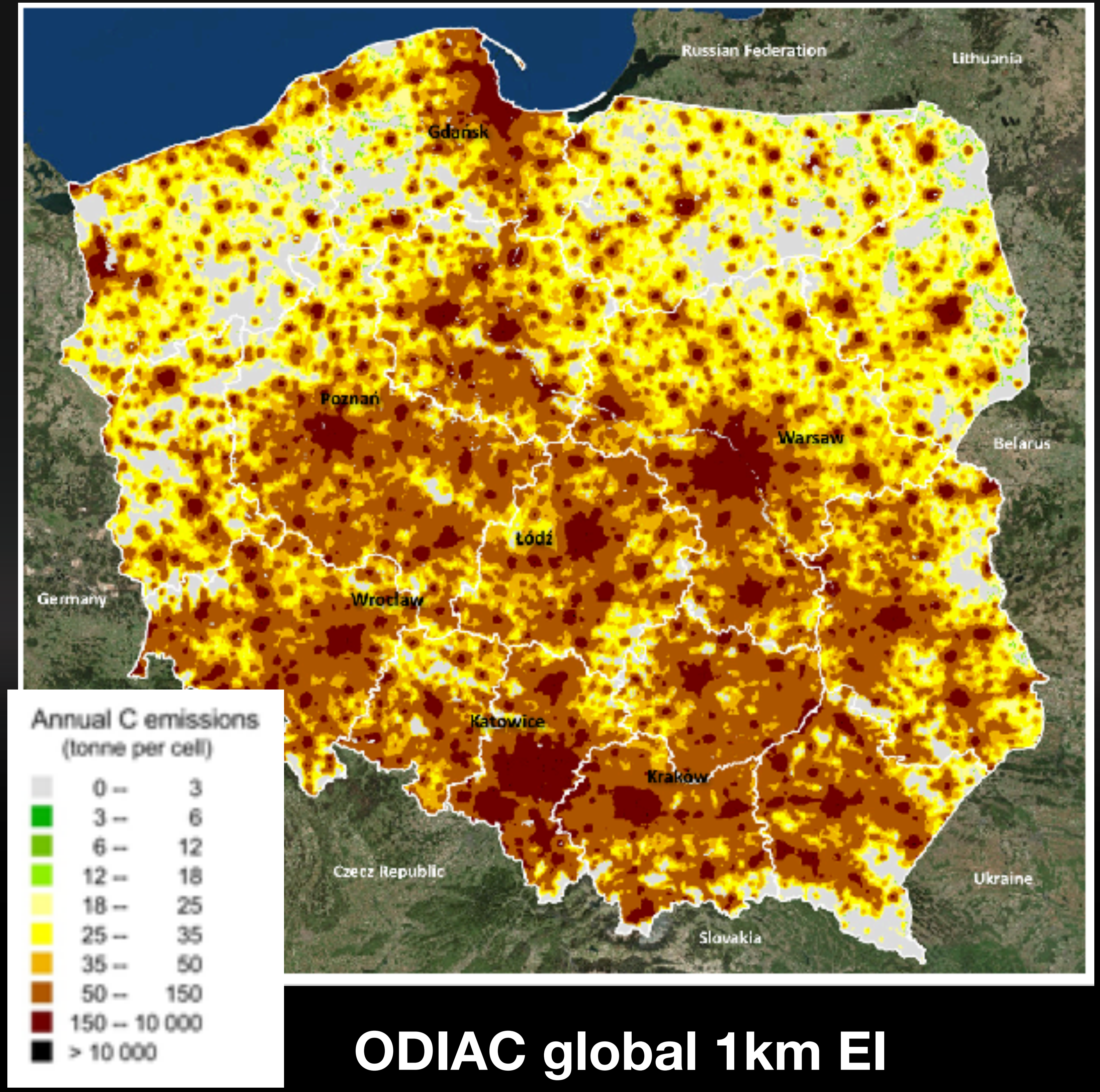
- Can be done globally in a timely and systematic manner
- Can be done using reported emissions

- More accurate representation of emissions and their drivers
- Extremely labor intensive, limited to small area and temporal coverage

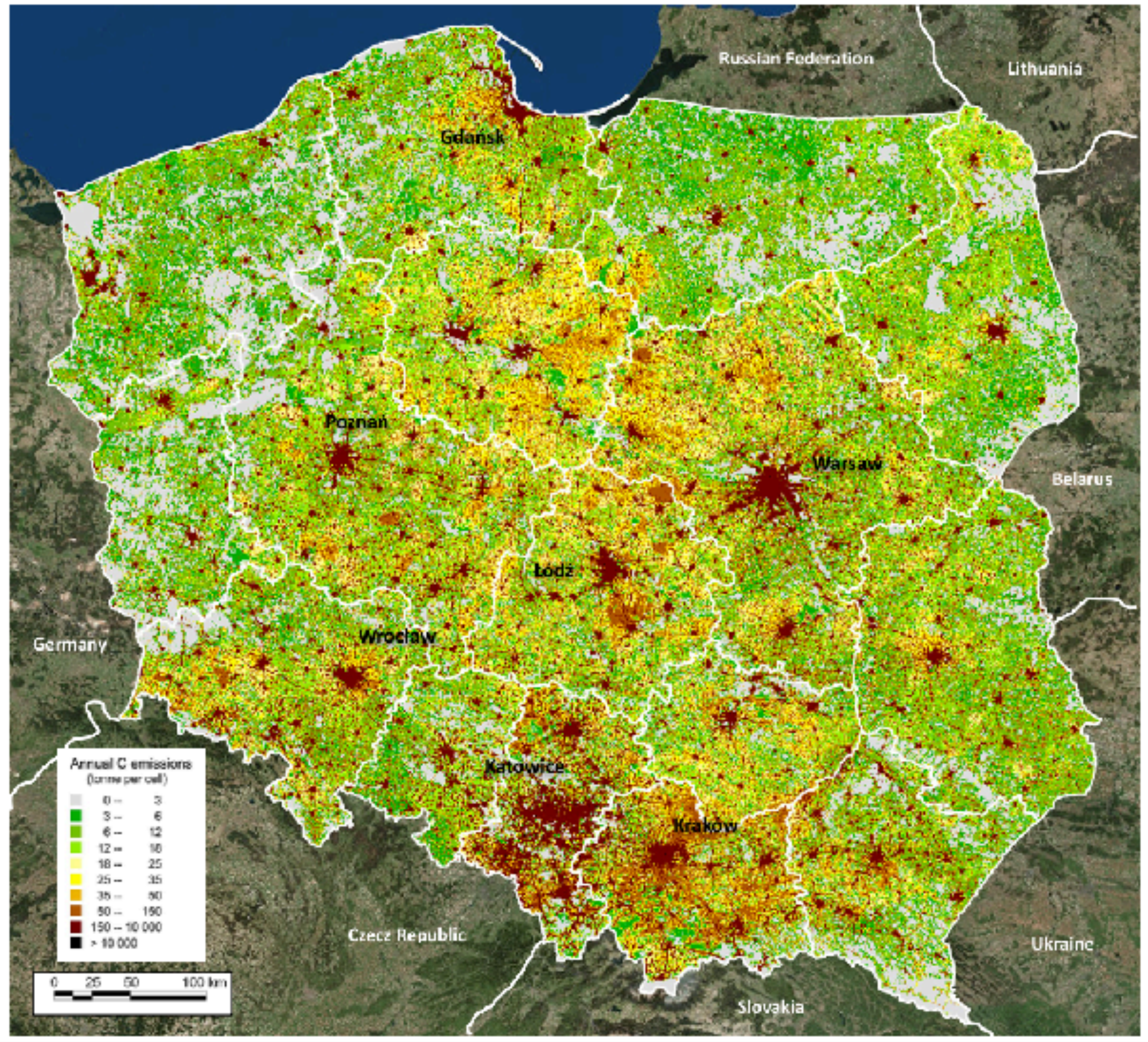
Those two approaches are complementary. Large scale systems can be calibrated using sub systems.

Comparison over Poland Comparison at Warsaw

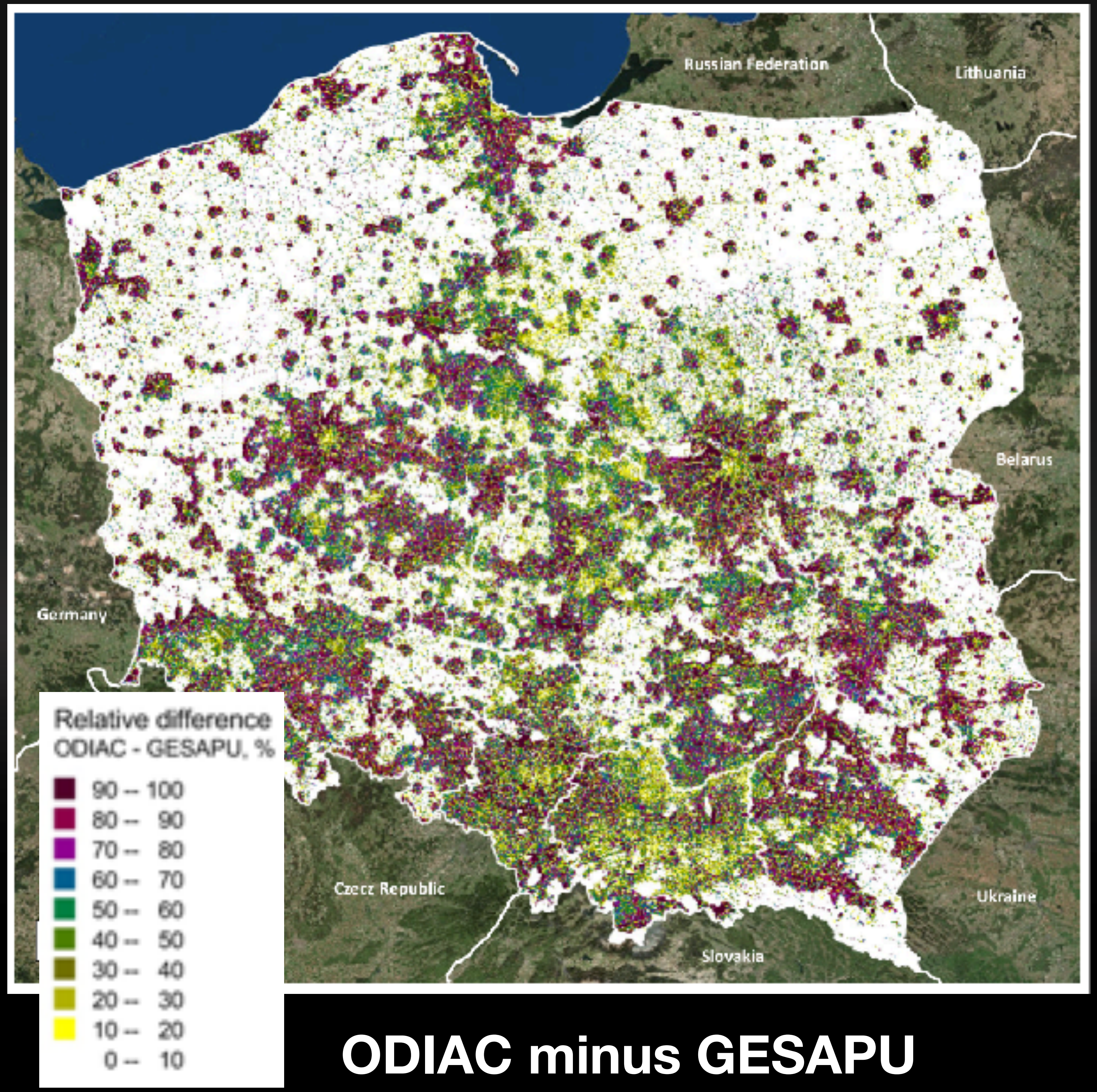
Large vs. sub systems exercise: Characterizing disaggregation errors in ODIAC



ODIAC global 1km EI



GESAPU multi-resolution EI for Poland



ODIAC minus GESAPU

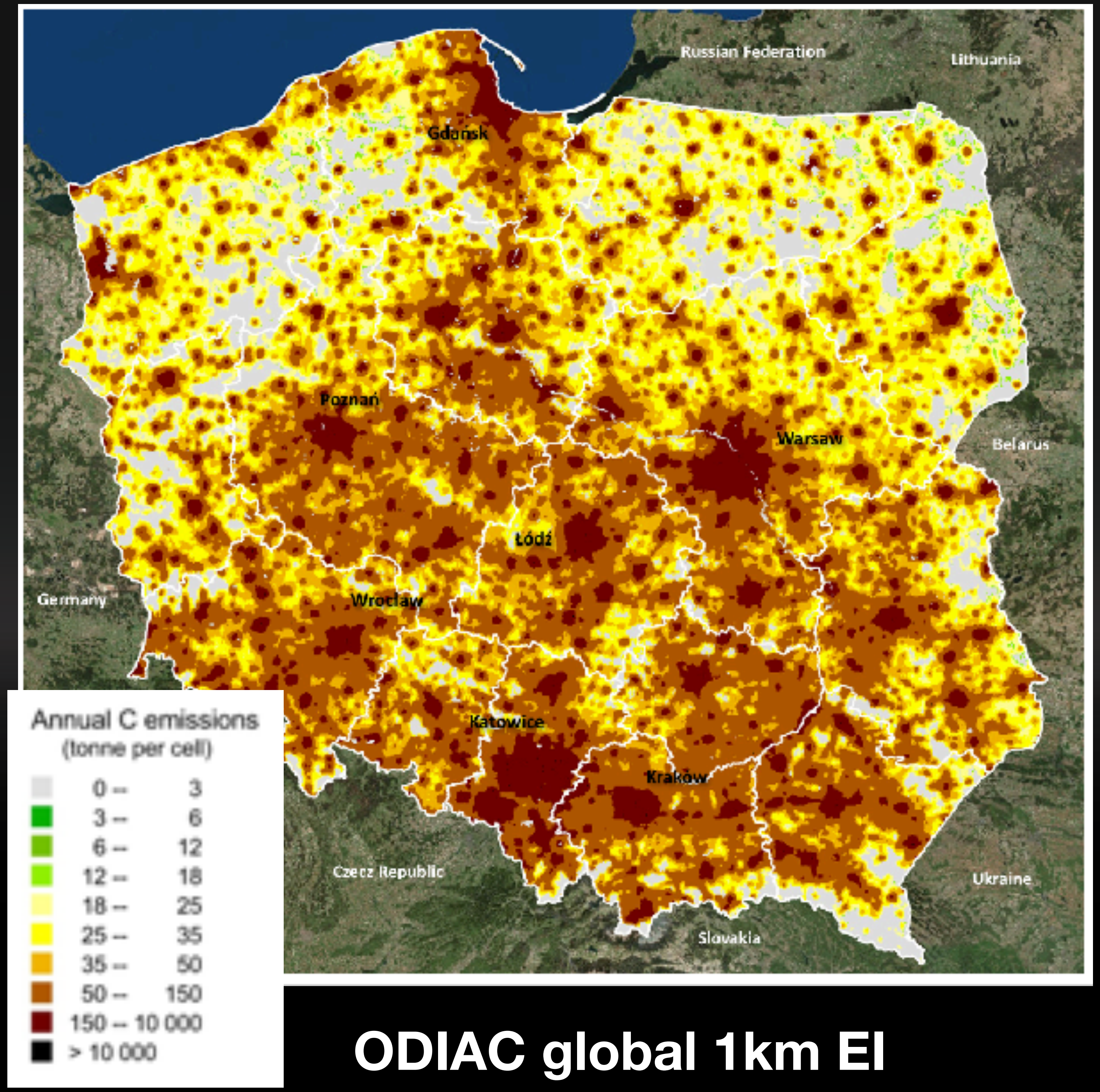
* (O-G) / (O+G)

	ODIAC (% of the total)	GESAPU (% of the total)	Difference (in %)
Total	87,502	85,612	1,890 (2.2%)
Point	42,687 (48.8%)	42,721 (49.9%)	-34 (-0.1%)
Non-point	44,815 (51.2%)	42,891 (50.1%)	1,924 (4.5%)

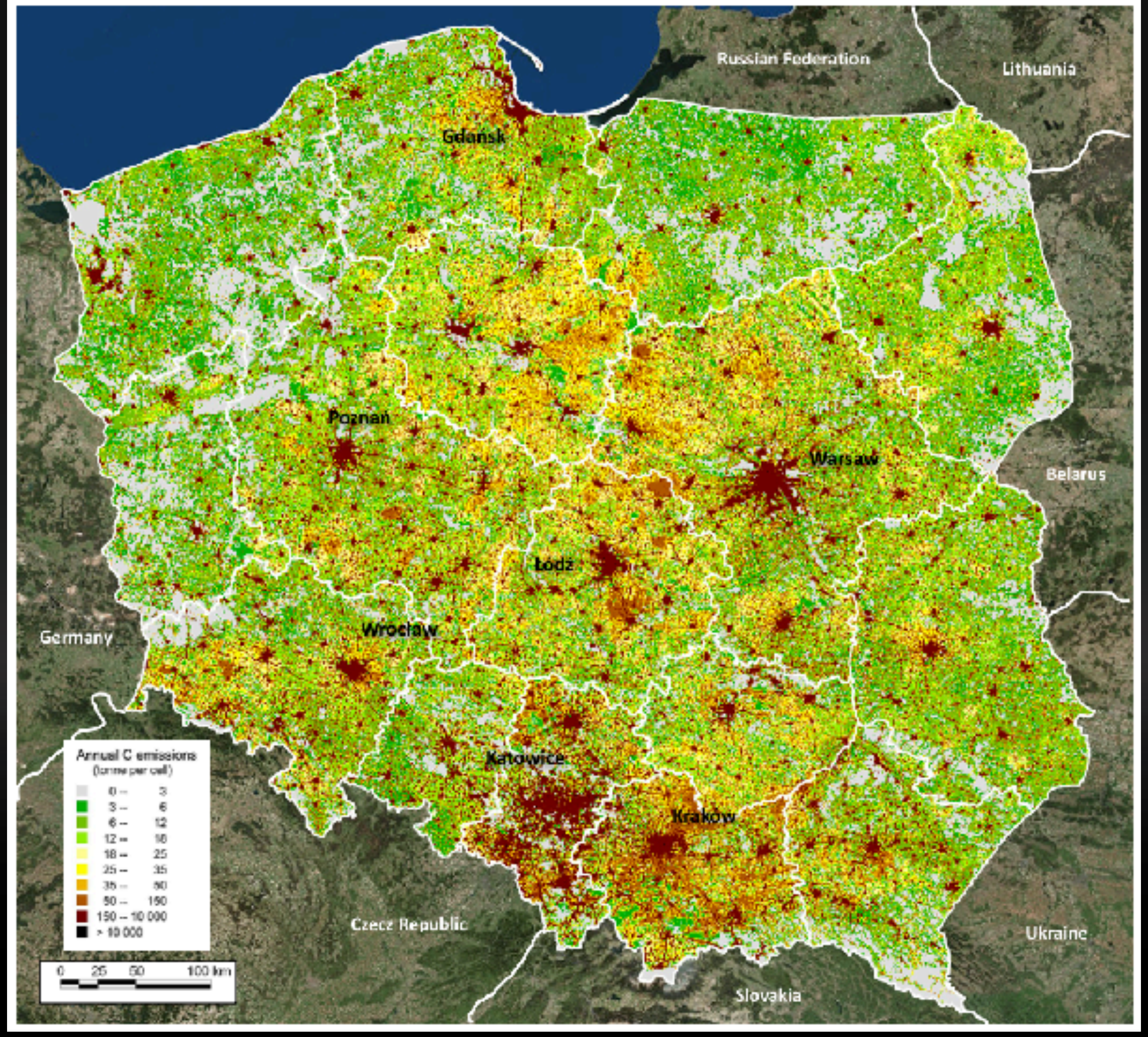
(ktC/yr)

Oda, Bun et al. not yet submitted

Large vs. sub systems exercise: Characterizing disaggregation errors in ODIAC



ODIAC global 1km EI



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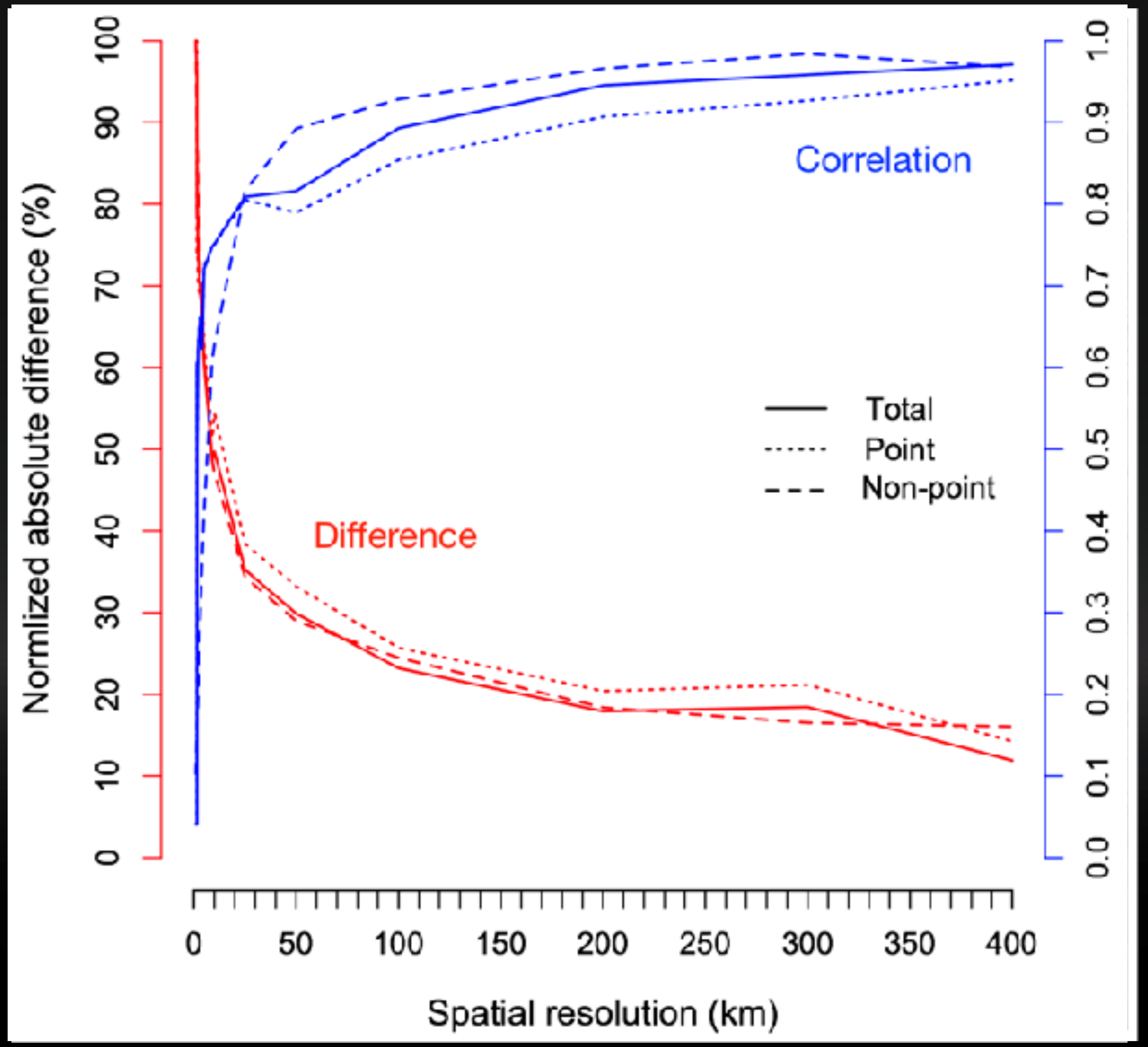

The error can be mitigated by 50% at 10km and 80% at 200km

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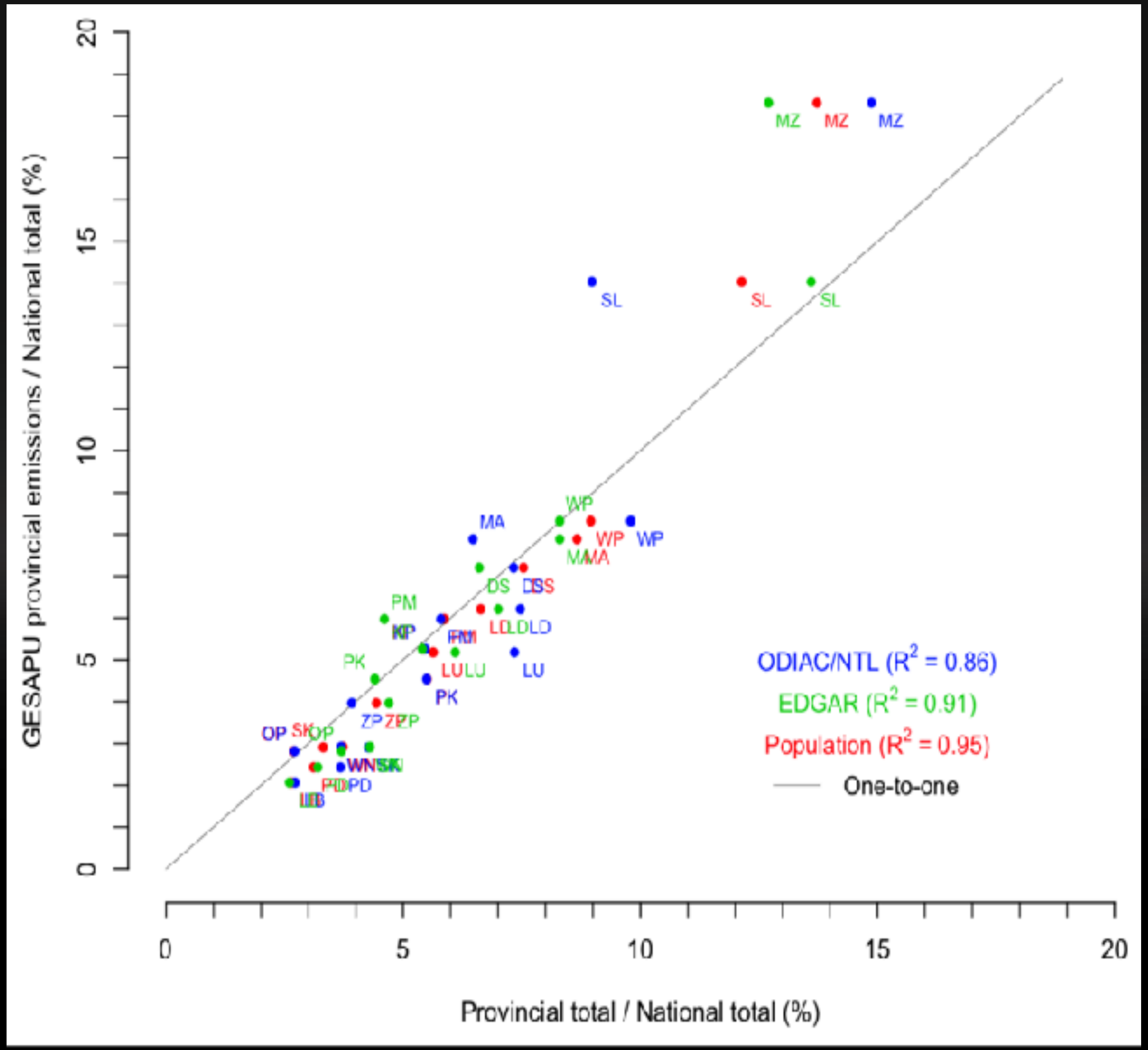
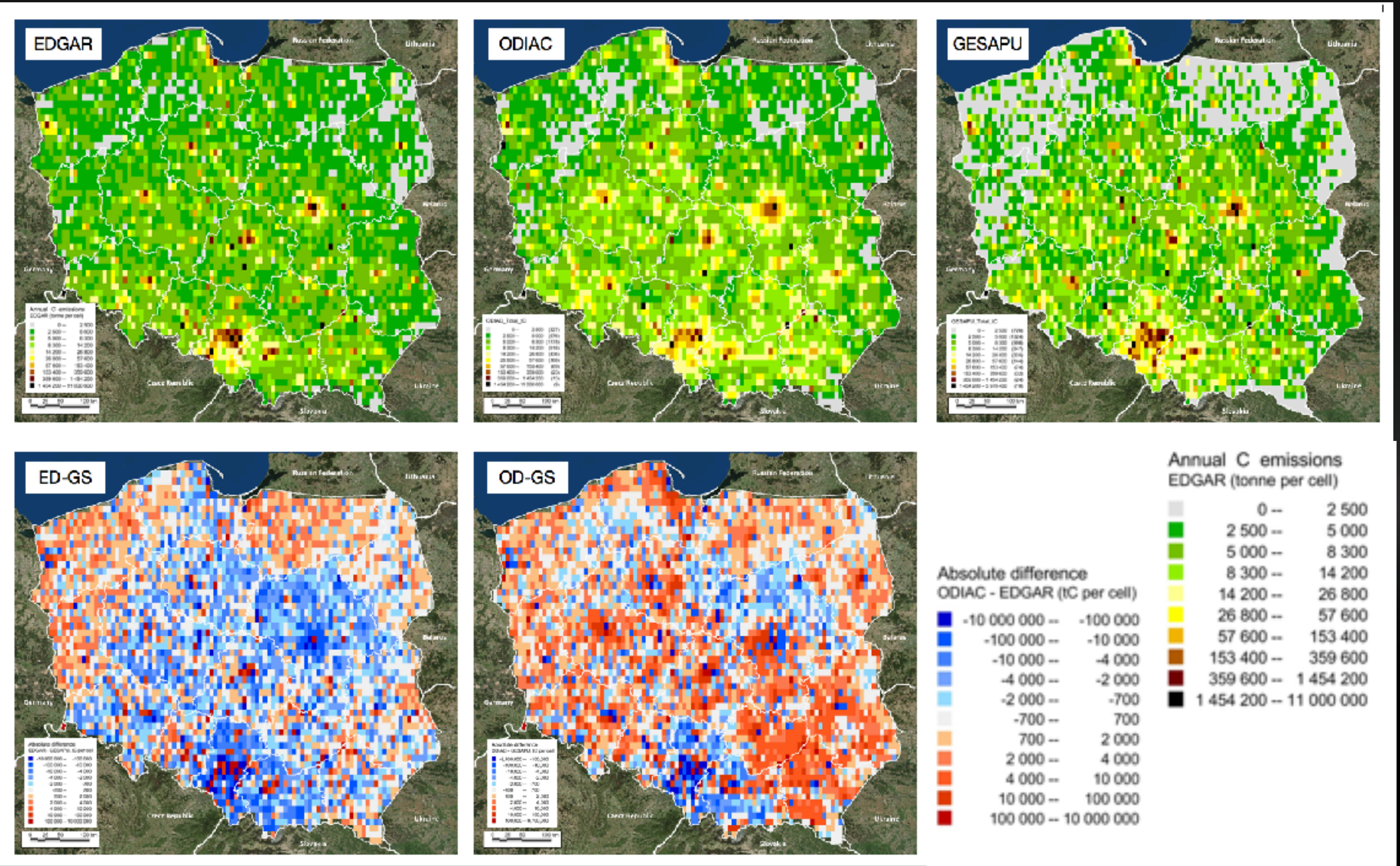
Comparison over Poland

Comparison at Warsaw

Proxy biases at subnational level



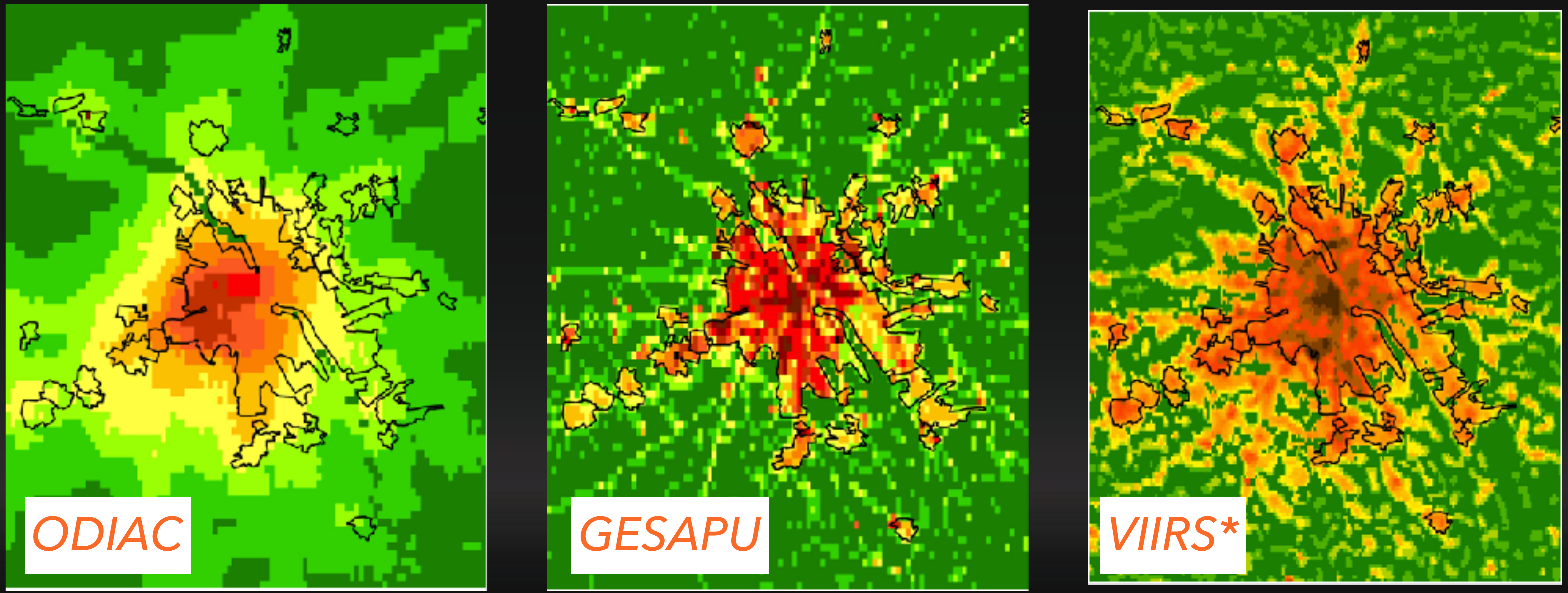
Disaggregation bias at provincial level (140km²)



EDGAR, ODIAC and GESAPU on common 0.1 deg (upper) & absolute differences (lower)

Oda, Bun et al. not yet submitted, but modified

Mapping urban emissions using nightlights

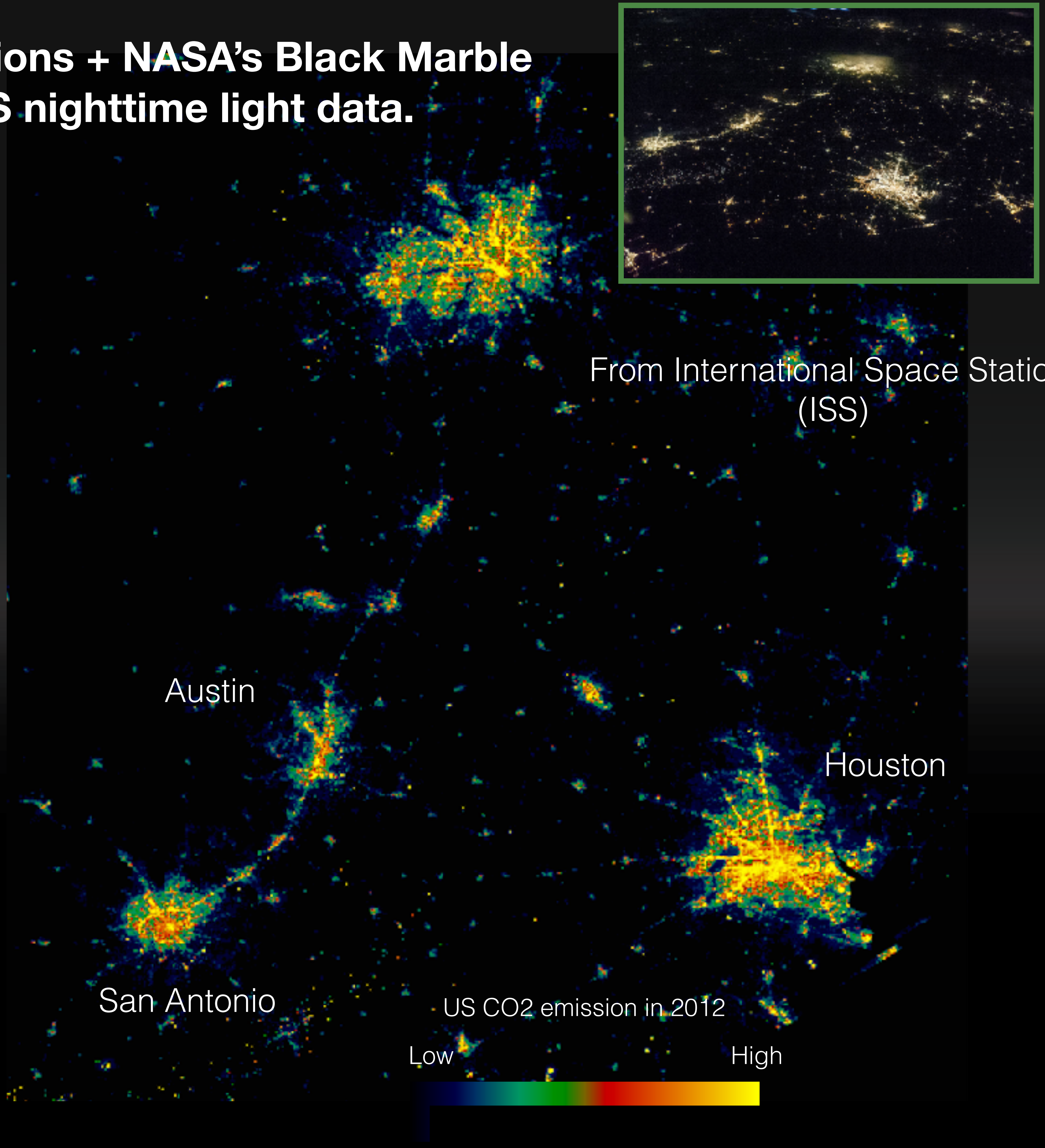


Oda, Bun et al. in prep

ODIAC, GESAPU and VIIRS-Nightlight* at Warsaw

- 3,638 ktC in GESAPU and 2,554 ktC in ODIAC (30% diff.)
- Need to establish the National-City relationship (Zhao et al. A43R-3462)
- The use of VIIRS is promising in depicting spatial patterns of urban emissions
- Improved emission spatial structures will help urban CO_2 simulations and inverse estimation (e.g. Oda et al. 2017)

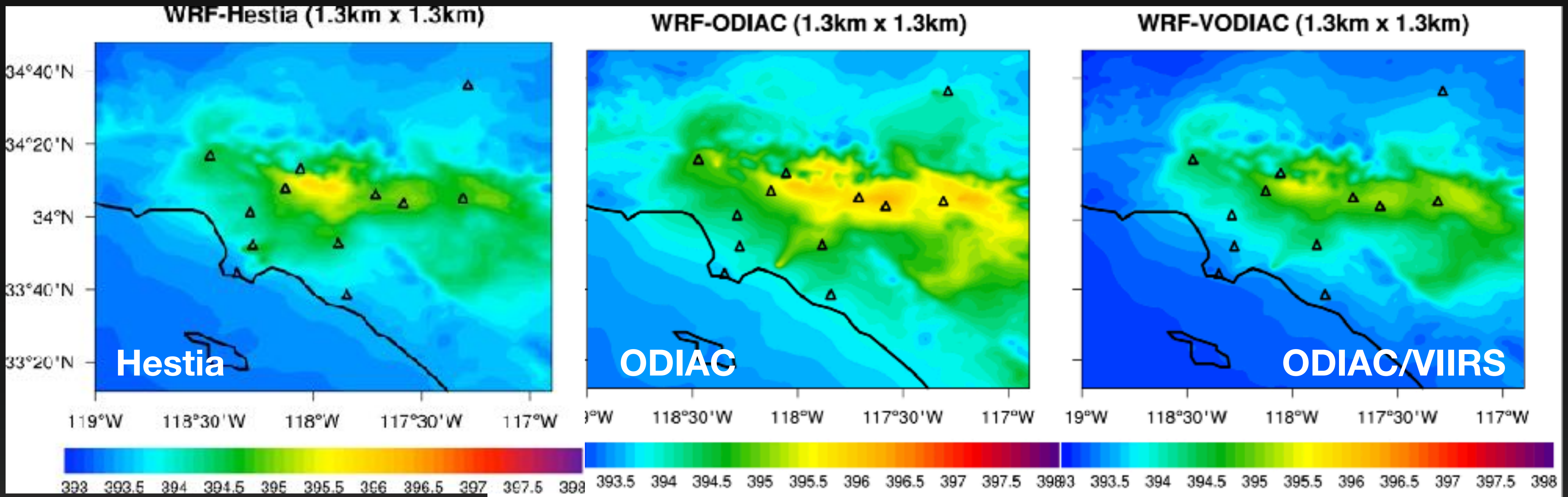
EPA emissions + NASA's Black Marble VIIRS nighttime light data.

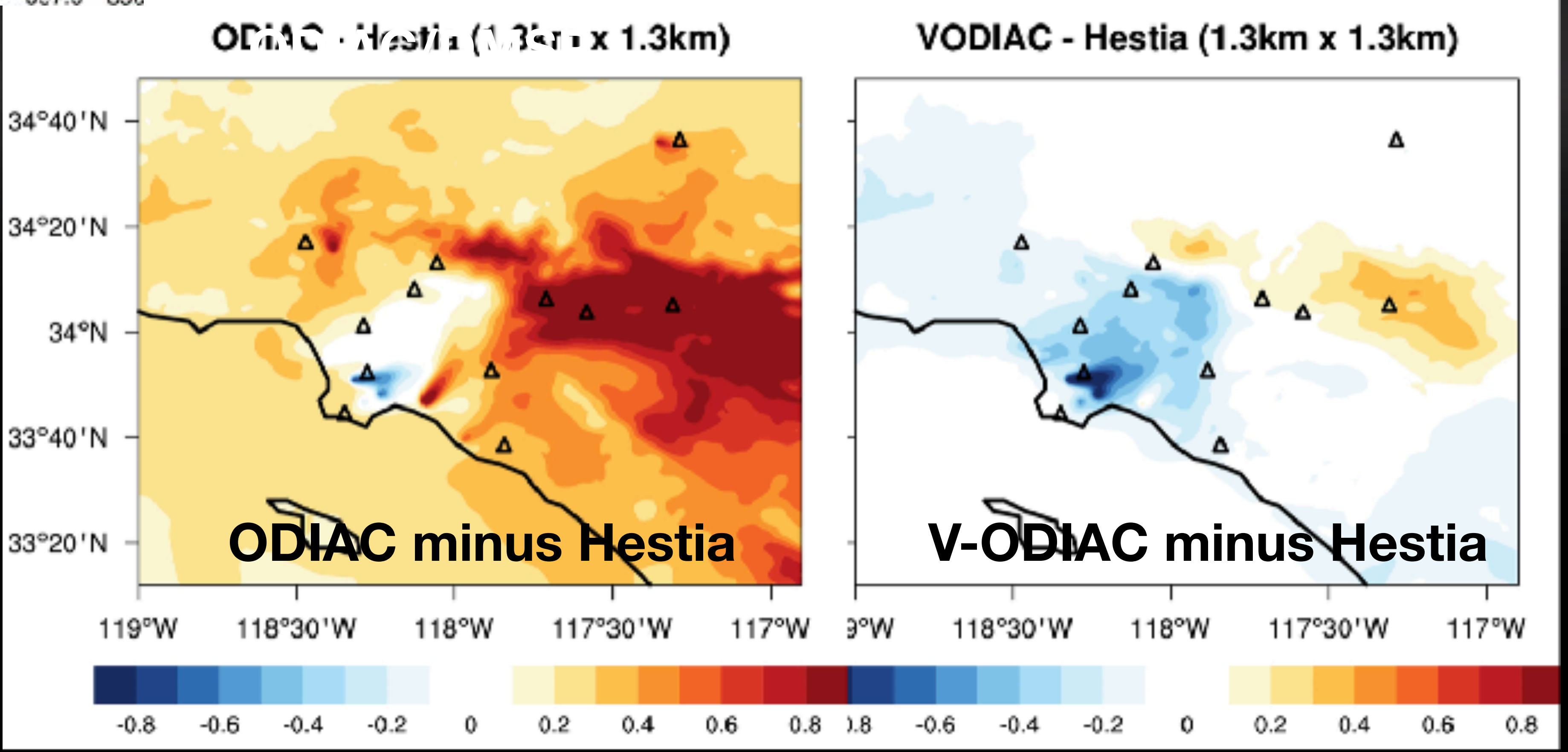


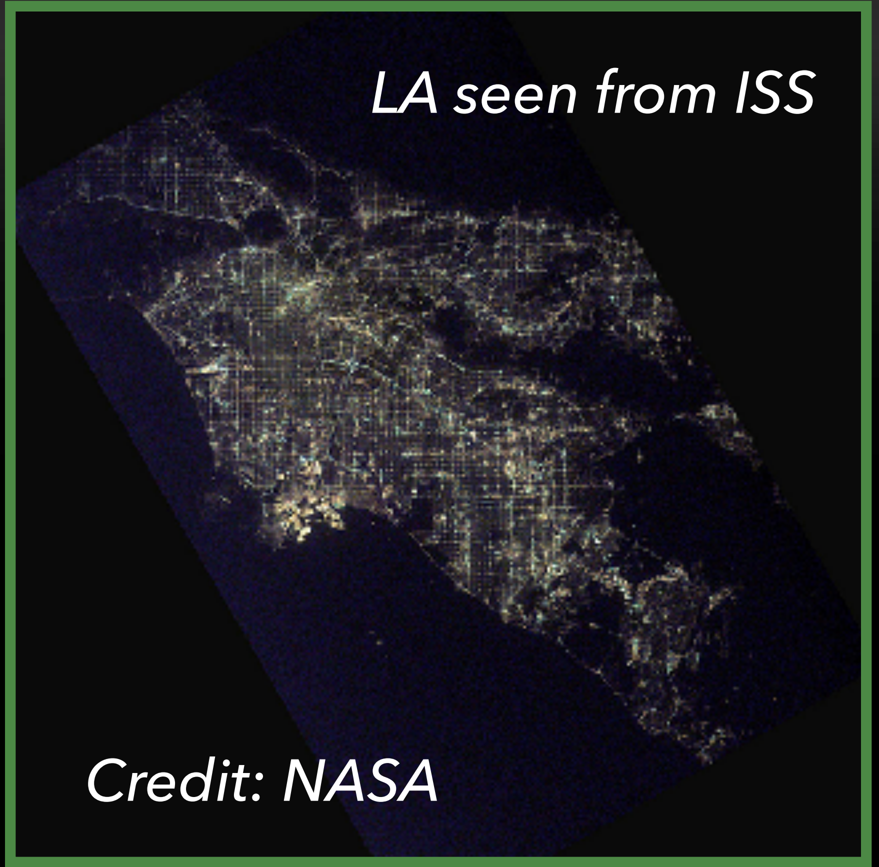
From International Space Station (ISS)

Roman et al. (2018) RSE; Oda, Roman et al. in prep

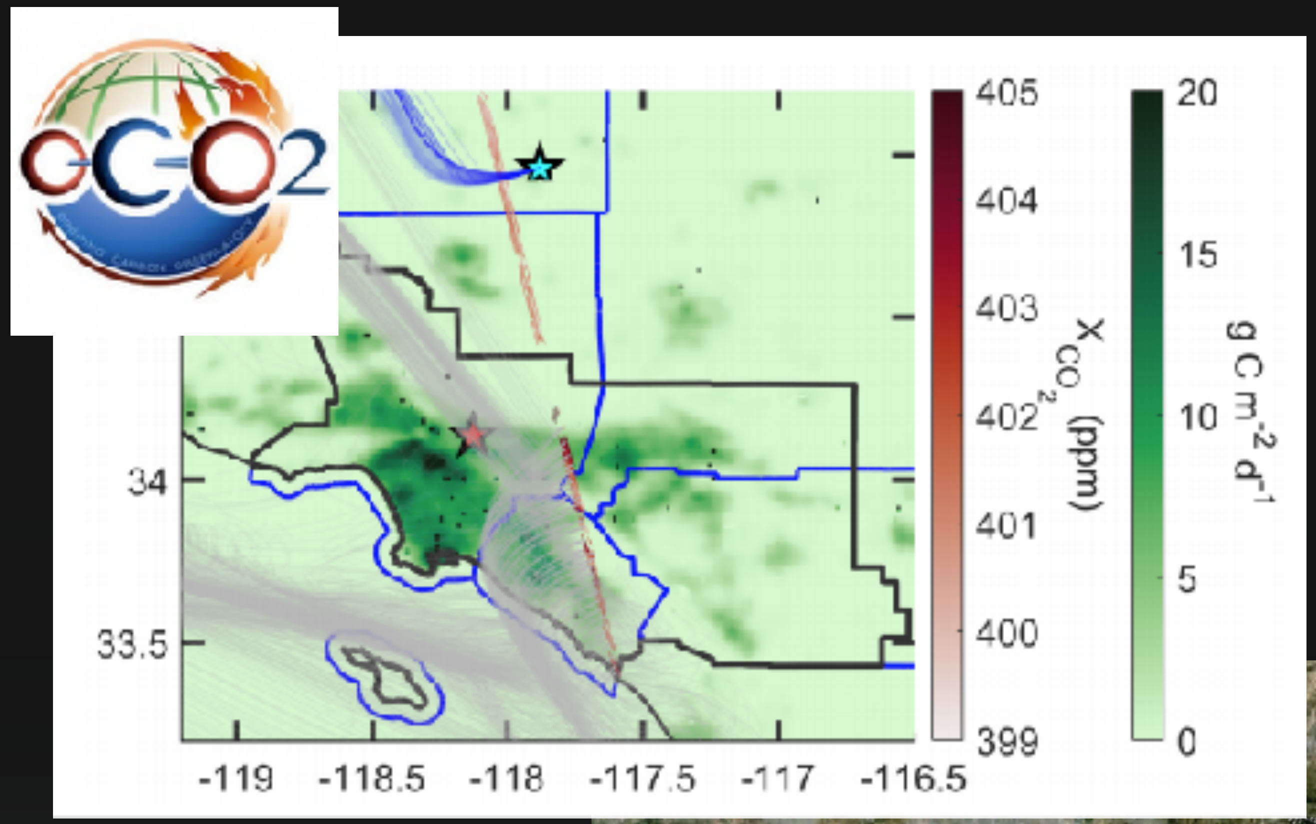
Towards global top-down city emission estimation



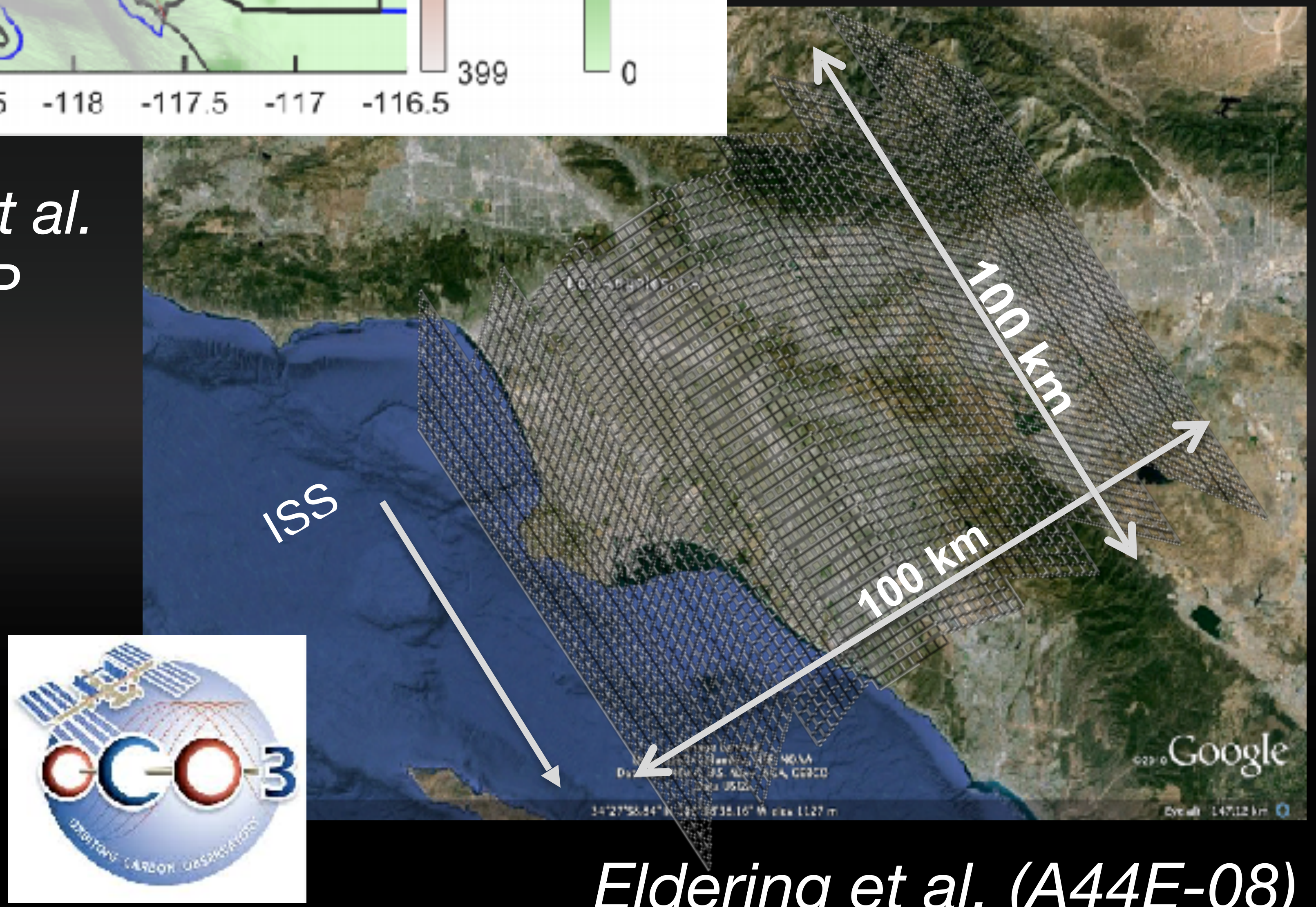




High-res. WRF CO_2 simulations over LA using Hestia, ODIAC and ODIAC/VIIRS



Hedelius et al. (2018) ACP



Eldering et al. (A44E-08)

- The use of VIIRS significantly improves the agreement with Hestia (+/- 0.8ppm in XCO2).
- VIIRS-ODIAC will be promising as a prior emission for urban emission estimation problems.

Summary, ongoing work and future plans

- ***Kyoto to Paris -*** *Need to beat down the systematic biases in EIs. Assure the accuracy via top-down vs. bottom-up exercise.*
- ***Spatially-explicit emission inventory*** *- Will be a key dataset in the use of atmospheric measurements and modeling to support the emission accounting activities. An improved data collection system will be extremely helpful.*
- ***Large & sub systems -*** *Towards global 1km hourly emissions, a synergic effort of large and sub system (~100km^2) developments will help us to transfer the emission knowledge to the assessment of our mitigation effort.*
- ***The remote sensing data for GHG modeling -*** *The use of VIIRS nightlight data will be promising for providing prior emissions for global cities.*
- ***Ongoing work & future plans -*** *Reducing emission representation errors (e.g. 3D emissions), Including CO_2 emissions from reduced carbon species, Including co-emitted species, such as CO, NOx, etc.…*

ODIAC FOSSIL FUEL EMISSIONS

http://db.cger.nies.go.jp/dataset/ODIAC/

Oda and Maksyutov (2011) ACP; Oda et al. (2018) ESSD

CDIAC at APPSTATE Carbon Dioxide Information Analysis Center

https://energy.appstate.edu/CDIAC

tom.oda@nasa.gov #odiac