Uncertainty associated with fossil fuel carbon dioxide (CO_2) gridded emission datasets

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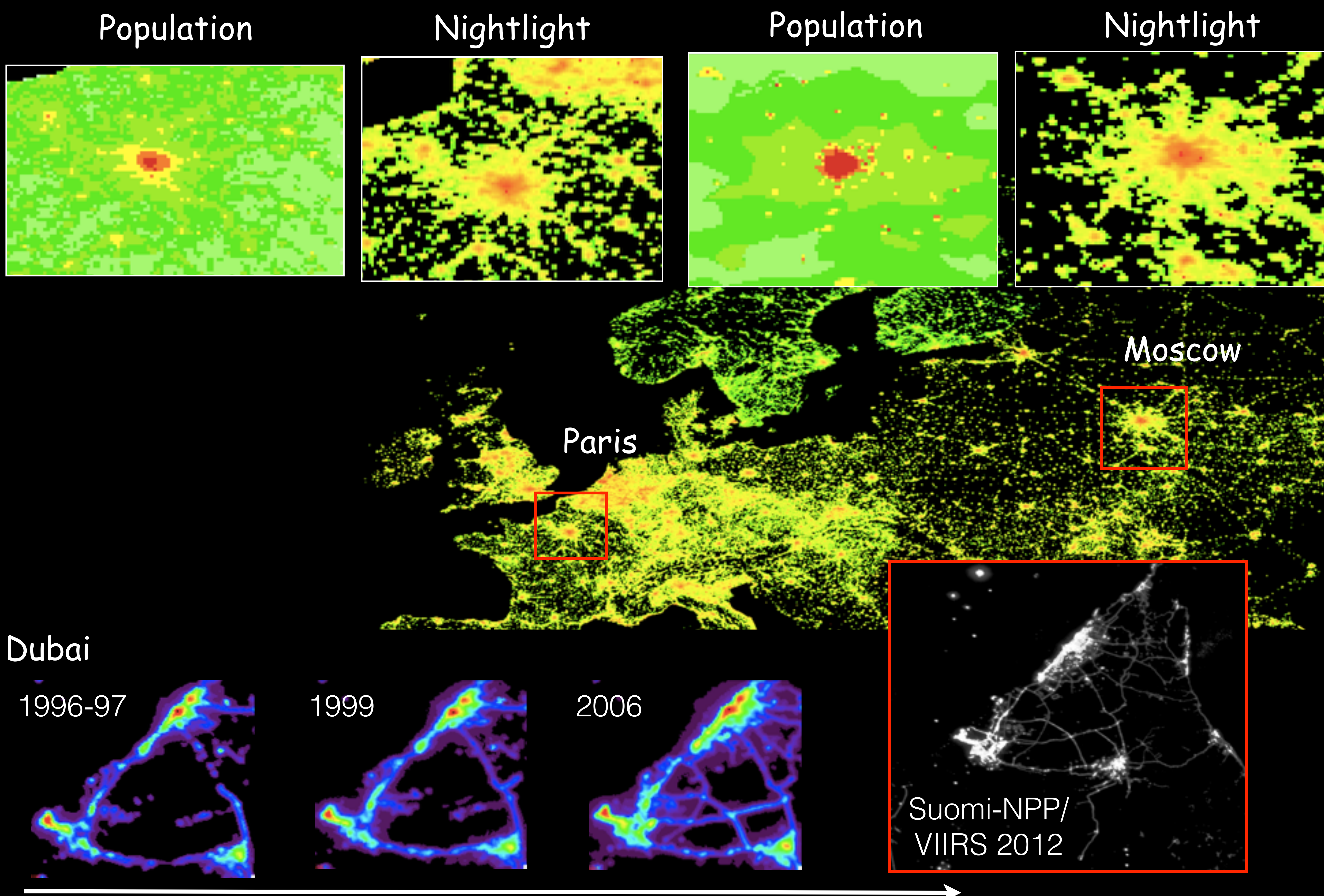
ODIAC - Global 1km fossil fuel emission model

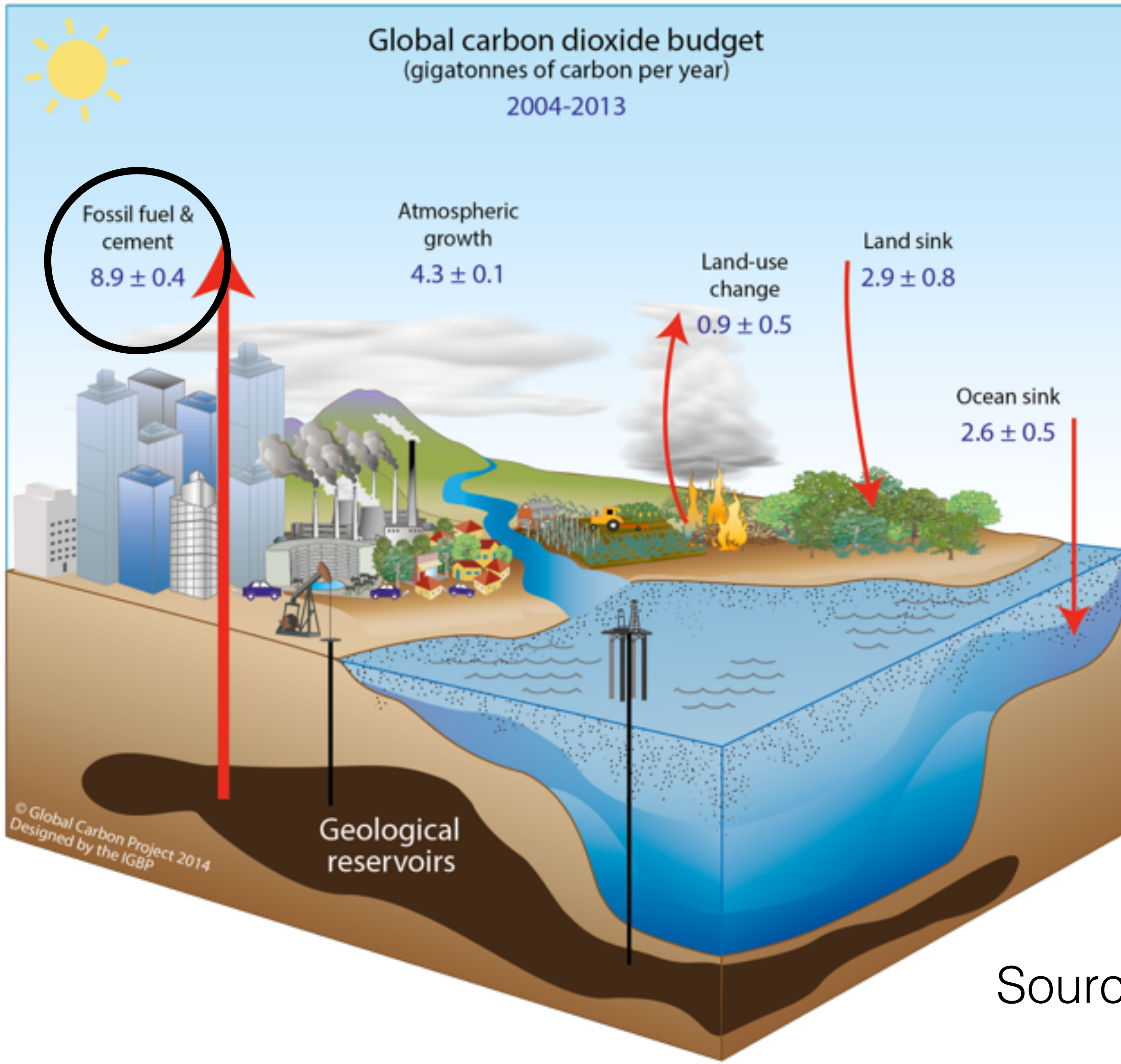
ODIAC FOSSIL FUEL EMISSIONS

Movie credit: NASA Megacities Carbon Project

Use of satellite obs for mapping emissions

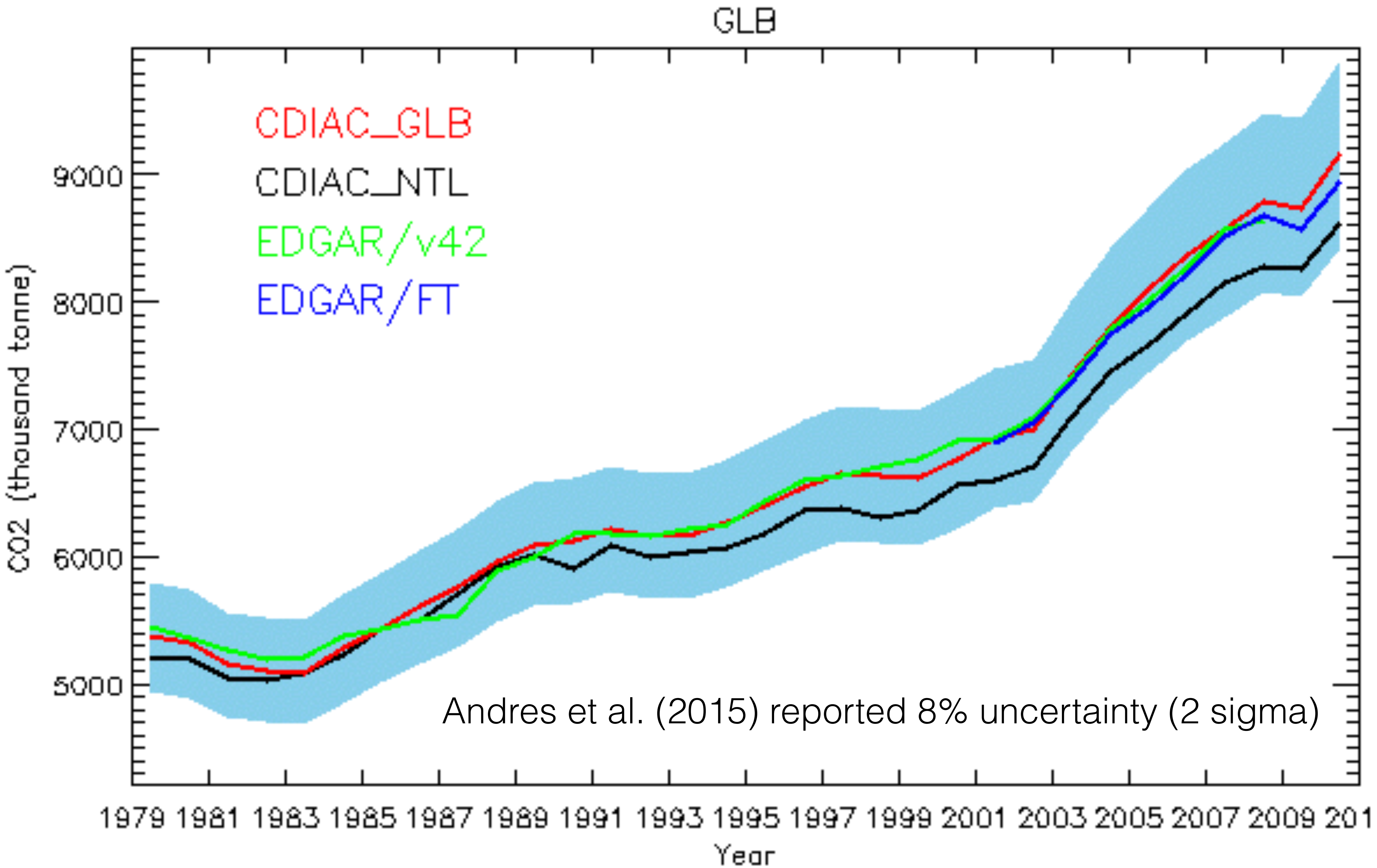


Global (N=1)



Source: GCP

FFCO2 agree on the global total



Disaggregation of national emissions

$$E_{i,j} = M_{Total} \times W_{i,j} \quad (1)$$

$$W_{i,j} = P_{i,j} / \sum_{i=1}^{m} \sum_{j=1}^{n} P_{i,j} \quad (2)$$

Emission fields

i,j	*i,j+1*
i+1,j	*i+1,j+1*

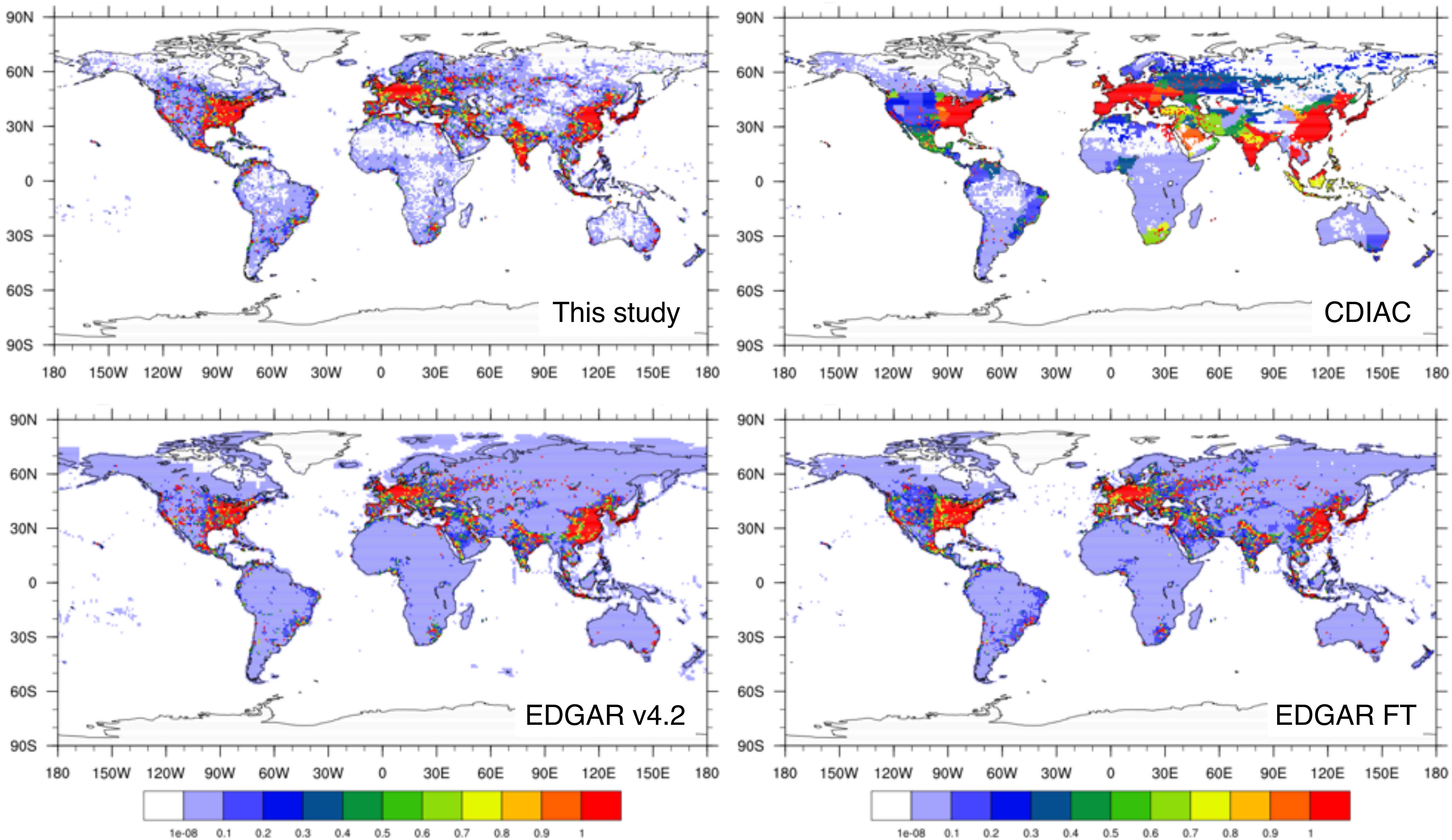
= 10 PgC x

Weight (proxy)

i,j	*i,j+1*
i+1,j	*i+1,j+1*

Note: This is really simplified view to emission modeling

When distributed in space (only land)



unit: 10^6 tonne C/yr

Caution: Highly depending on proxy used.

Uncertainty calculation

$$E_{i,j} = M_{Total} \times W_{i,j} \quad (1)$$

$$W_{i,j} = P_{i,j} / \sum_{i=1}^{m} \sum_{j=1}^{n} P_{i,j} \quad (2)$$

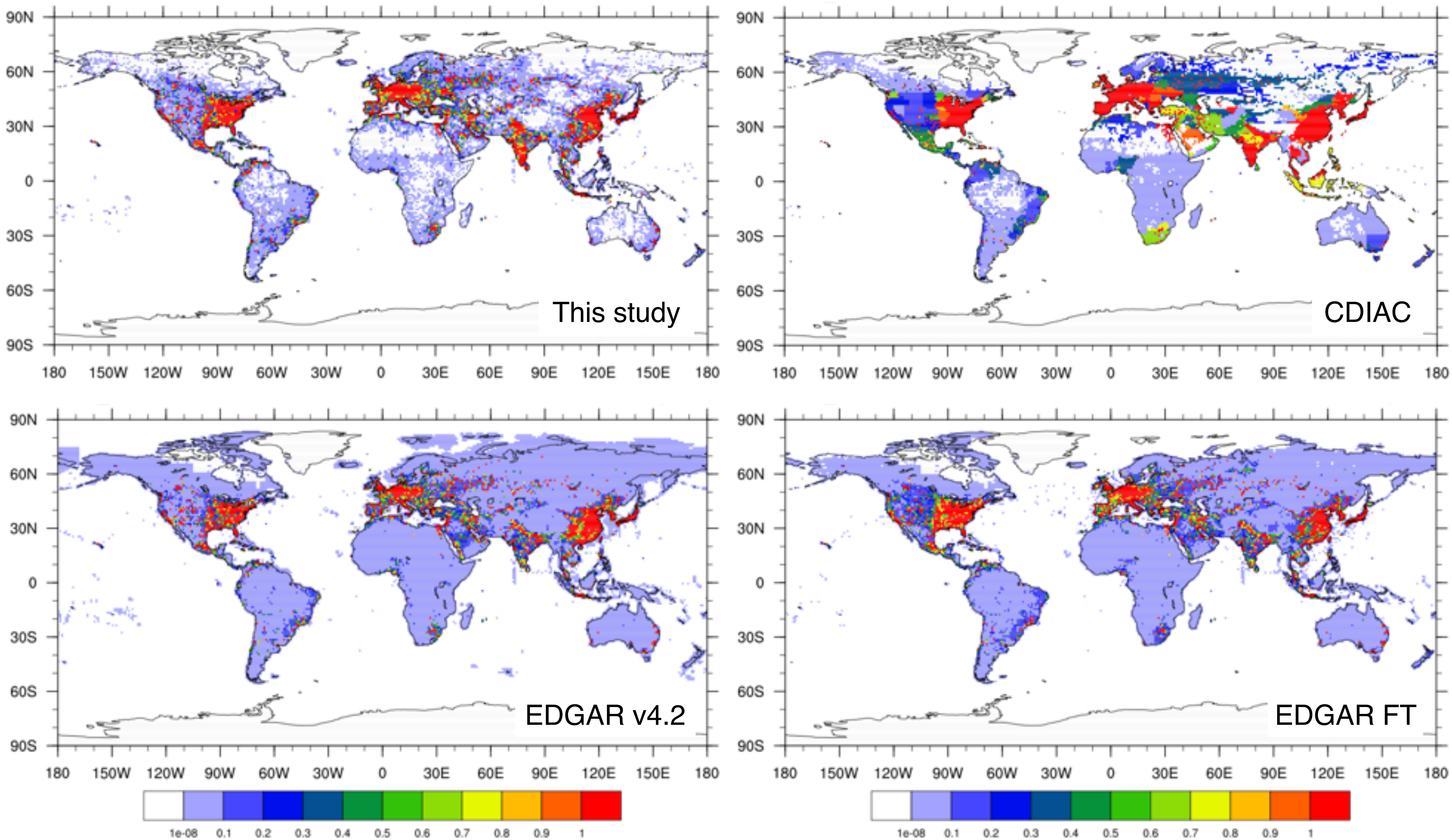
Using combined uncertainty rule…

$$\delta E_{i,j}/E_{i,j} = \sqrt{(\delta M_{Total}/M_{Total})^2 + (\delta W_{i,j}/W_{i,j})^2} \quad (3)$$

1. Uncertainty in emissions (%)

2. Uncertainty in weight (%)

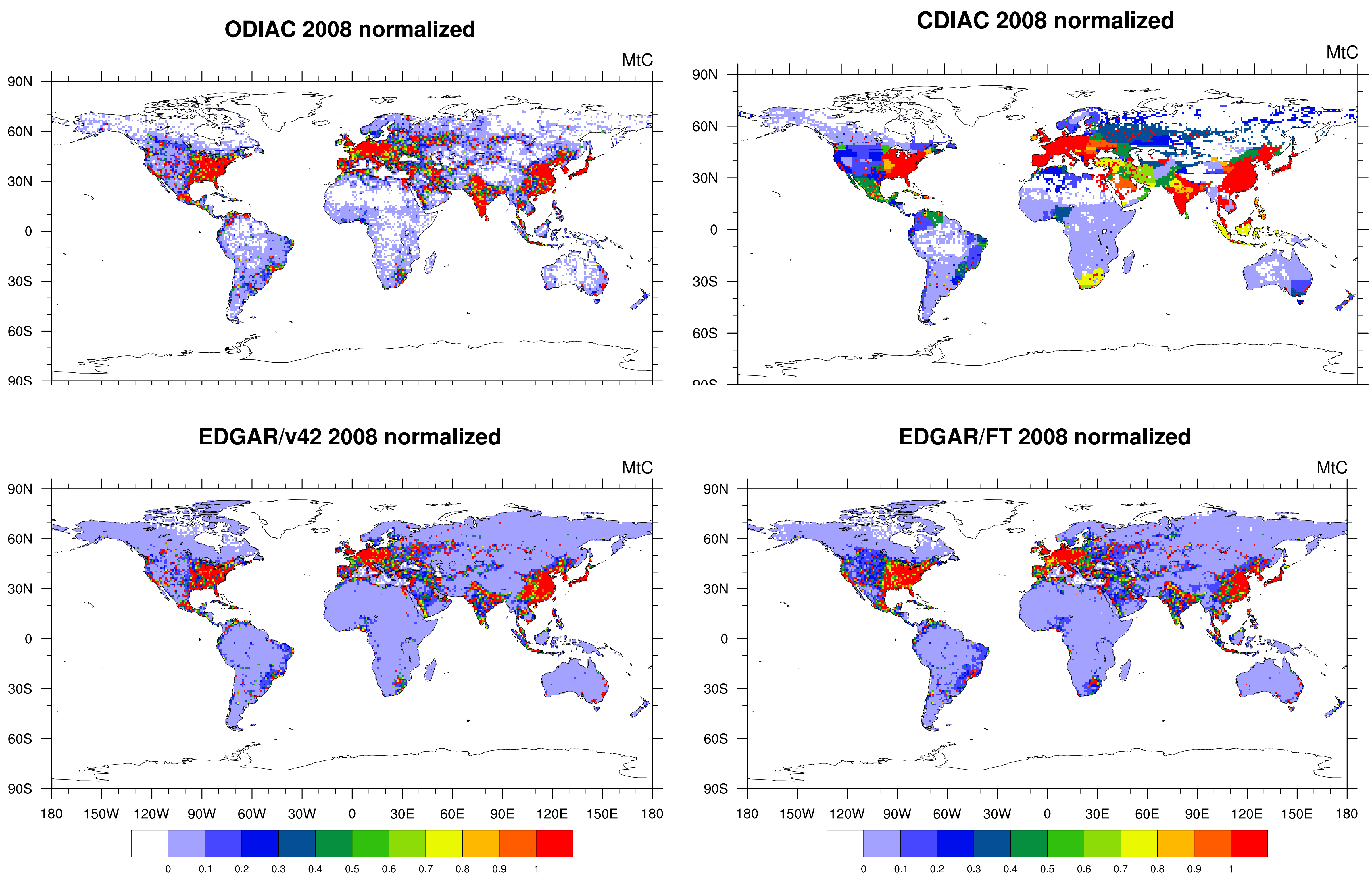
How can we deal with account for inter-model uncertainty?



unit: 10^6 tonne C/yr

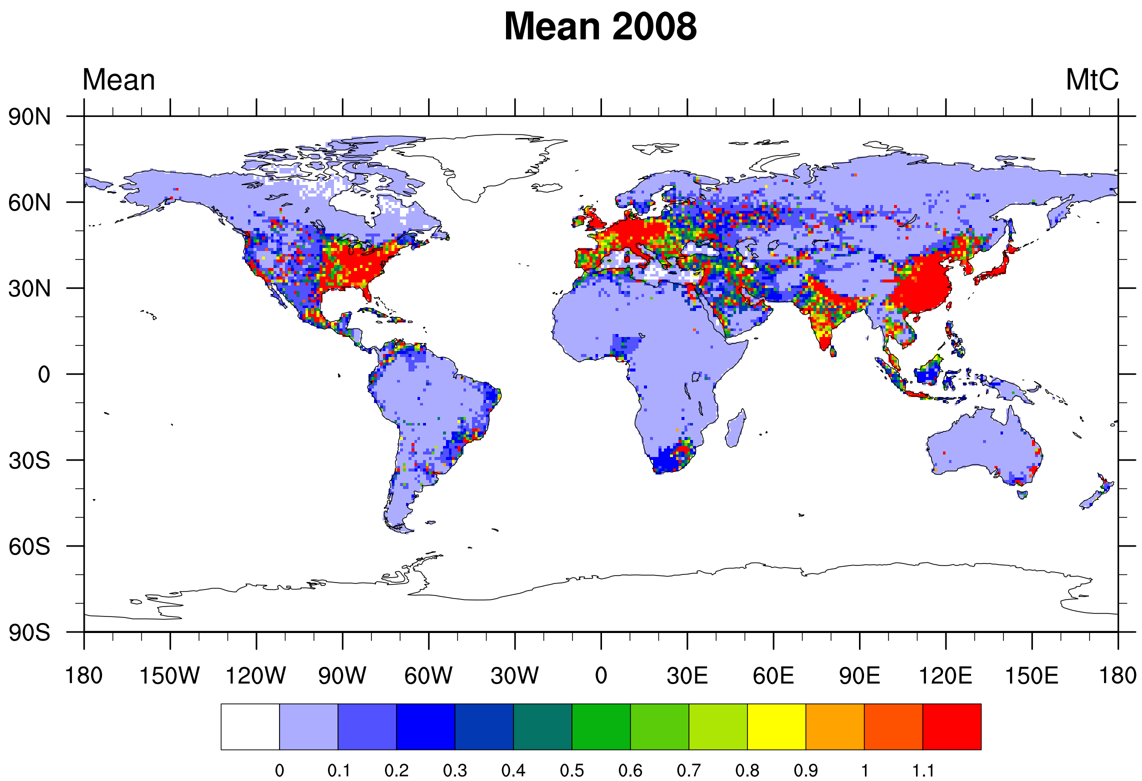
Caution: Highly depending on proxy used.

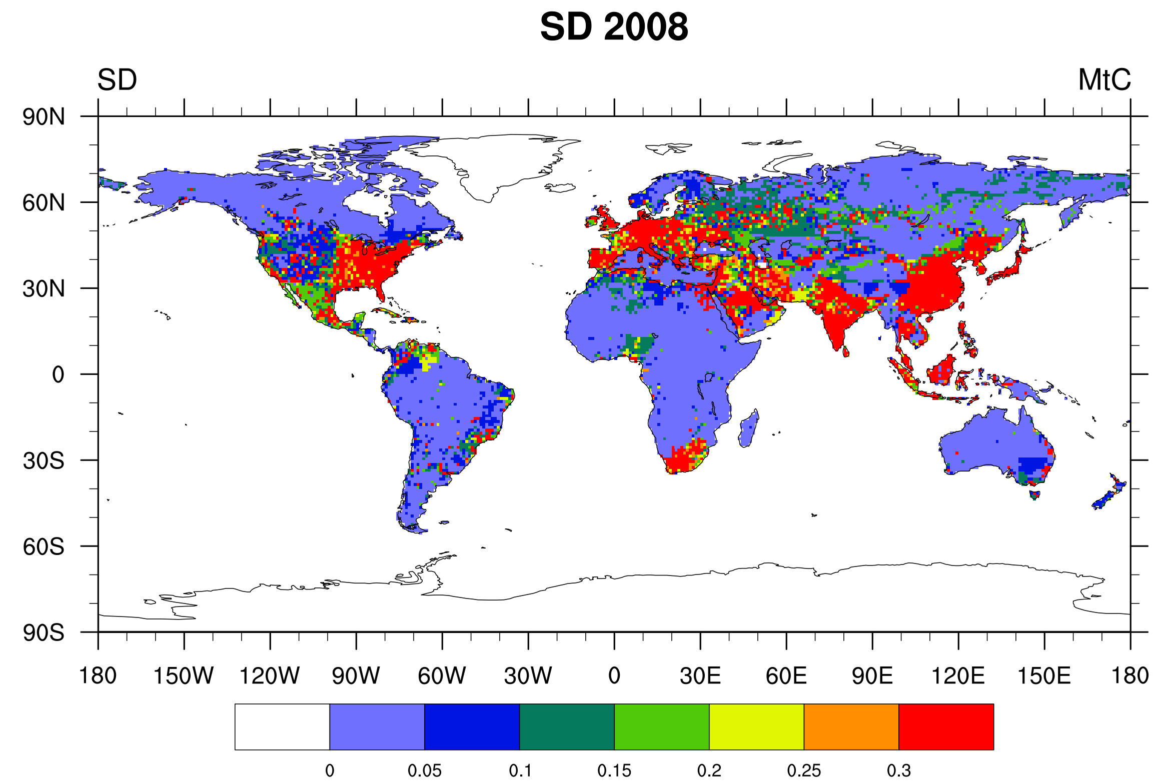
Normalized to the same total



Note: only emissions over land are shown.

To get inter-inventory uncertainty

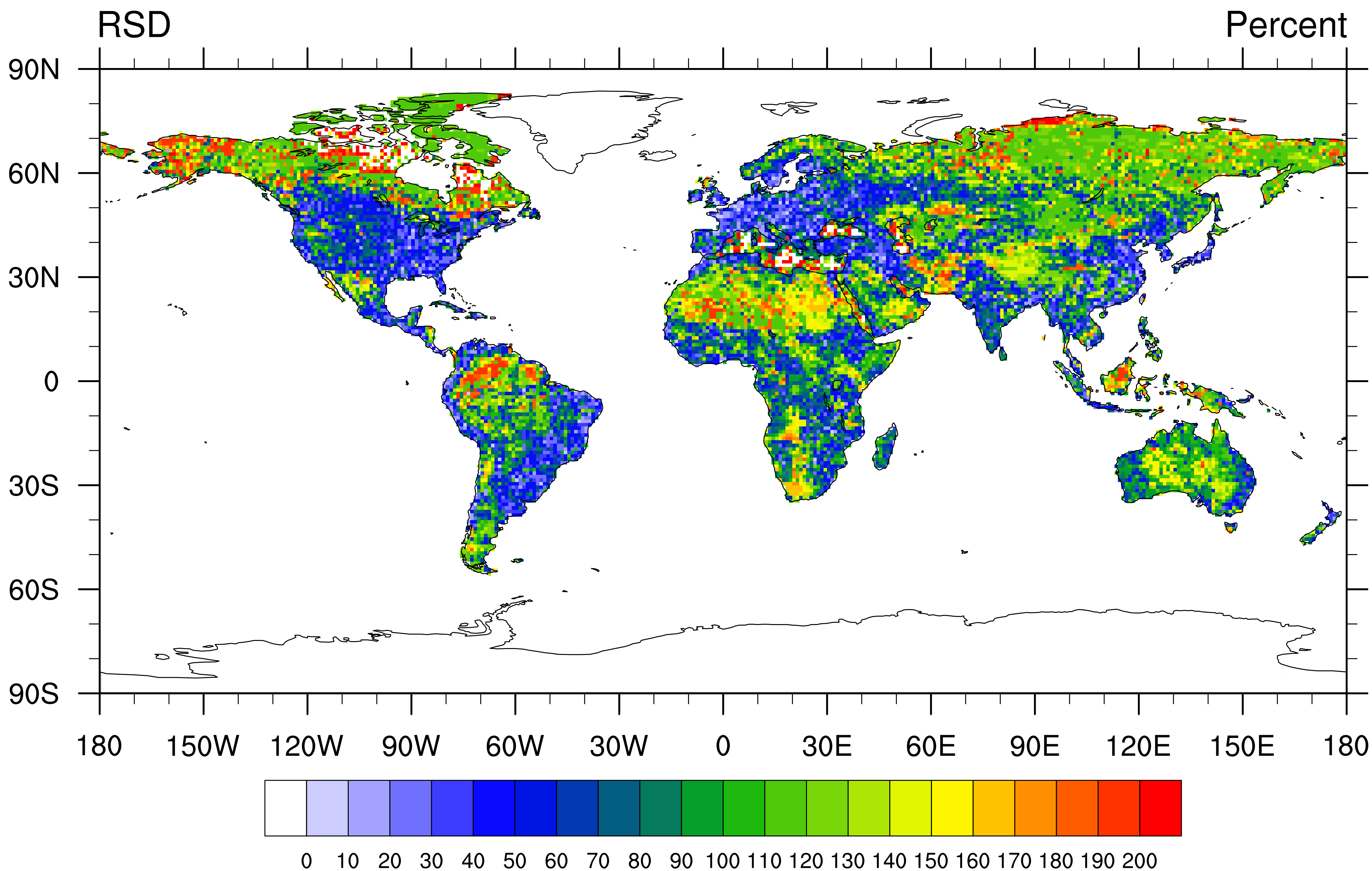




$$\delta E_{i,j}/E_{i,j} = \sqrt{(\delta M_{Total}/M_{Total})^2 + (\delta W_{i,j}/W_{i,j})^2} \quad (3)$$

Caution: Many limitations are present

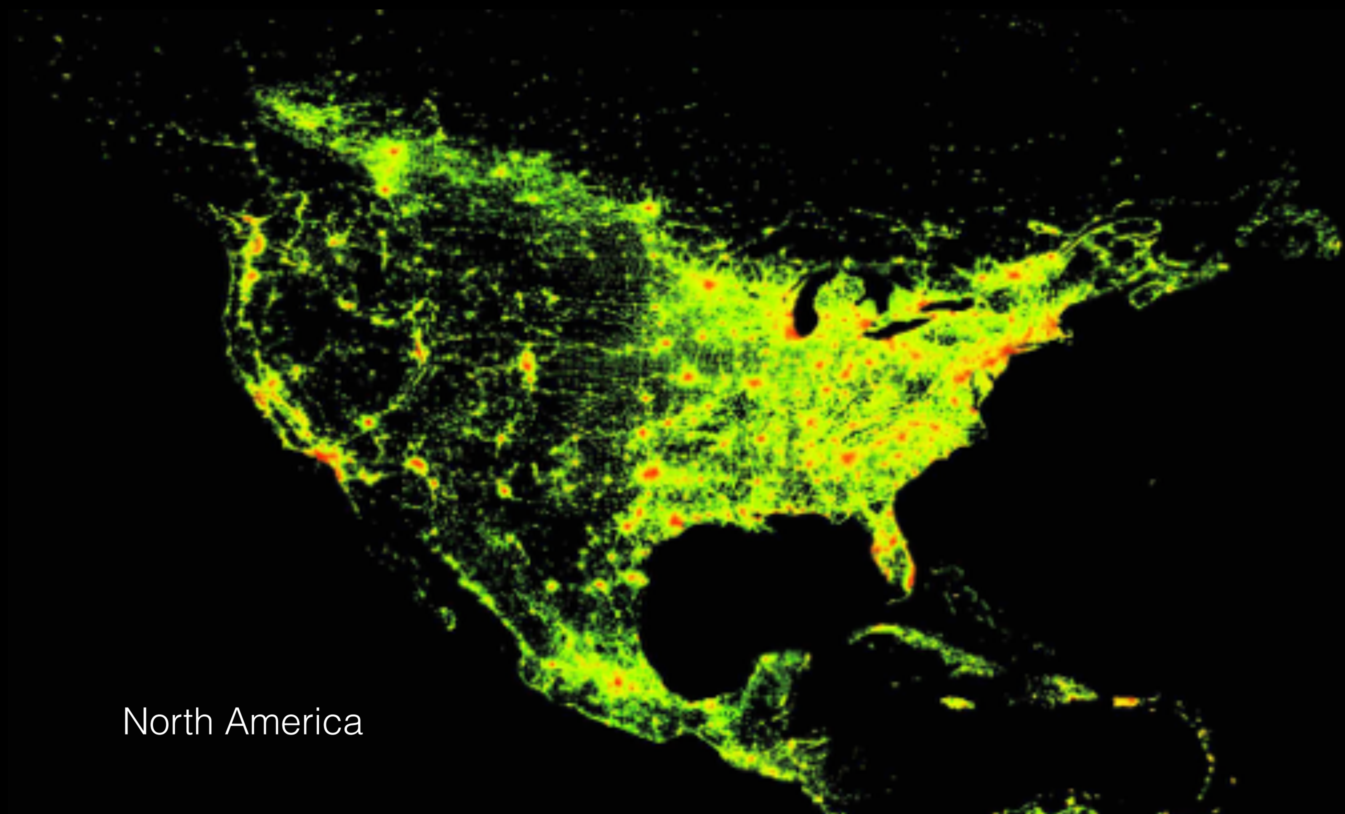
1x1 degree FFCO2 uncertainty map

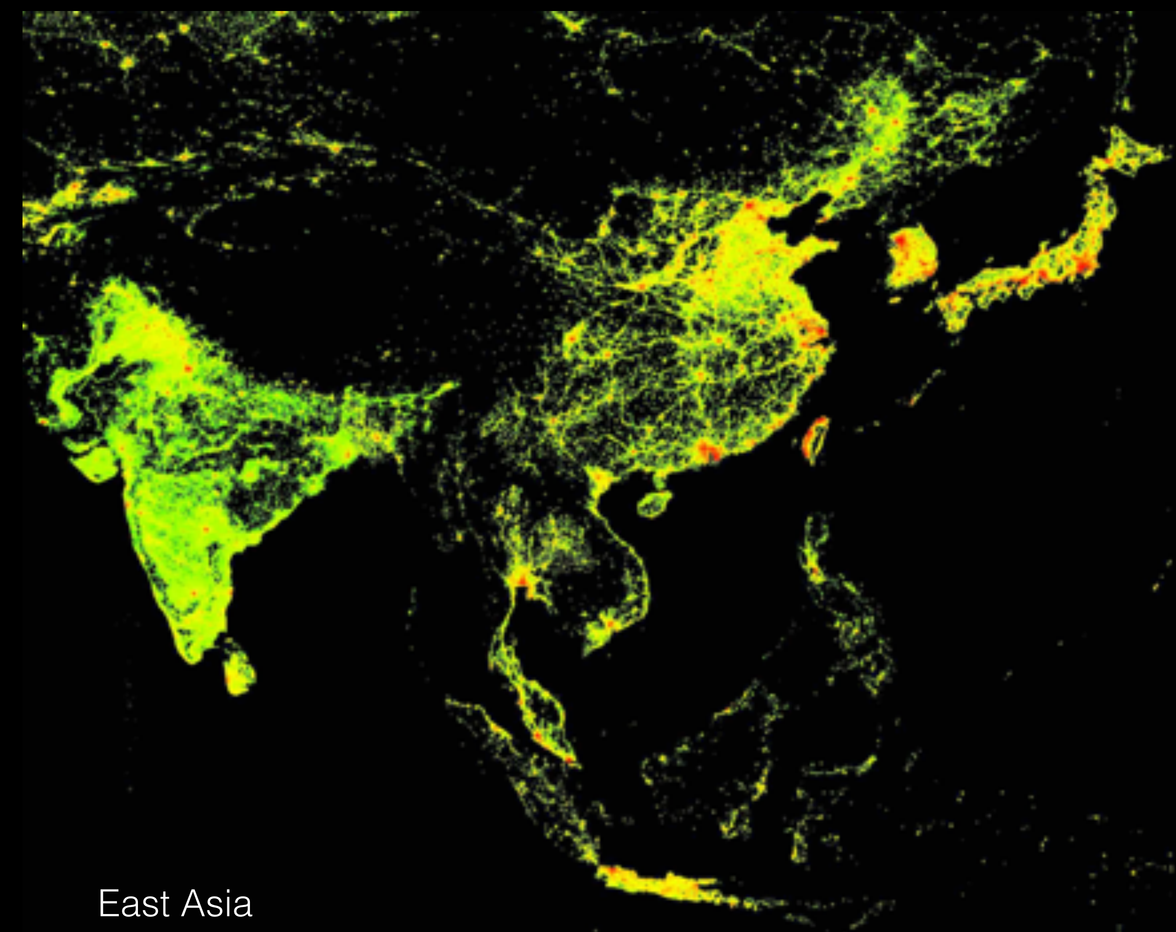


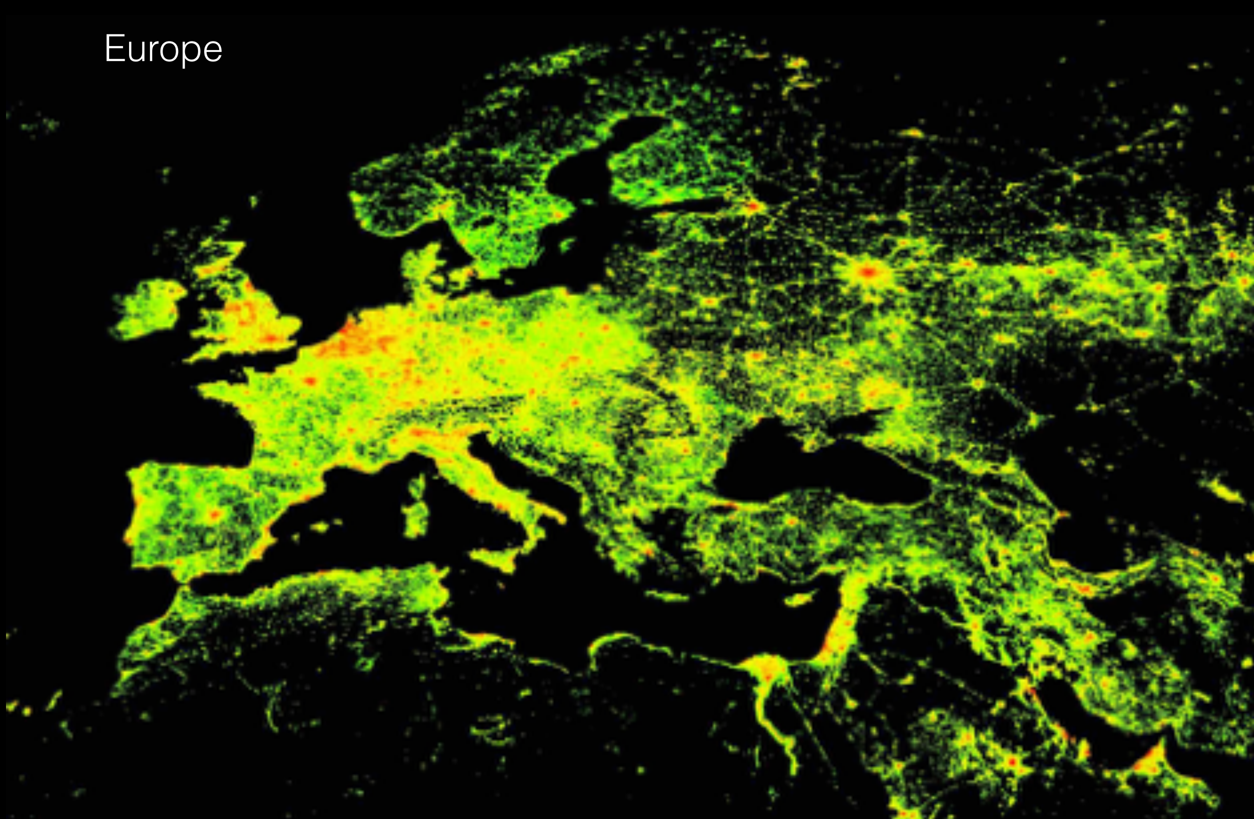
Note: This is not yet combined with the 8% emission uncertainty

Oda 2015 in prep

What can we do at a high spatial resolution?

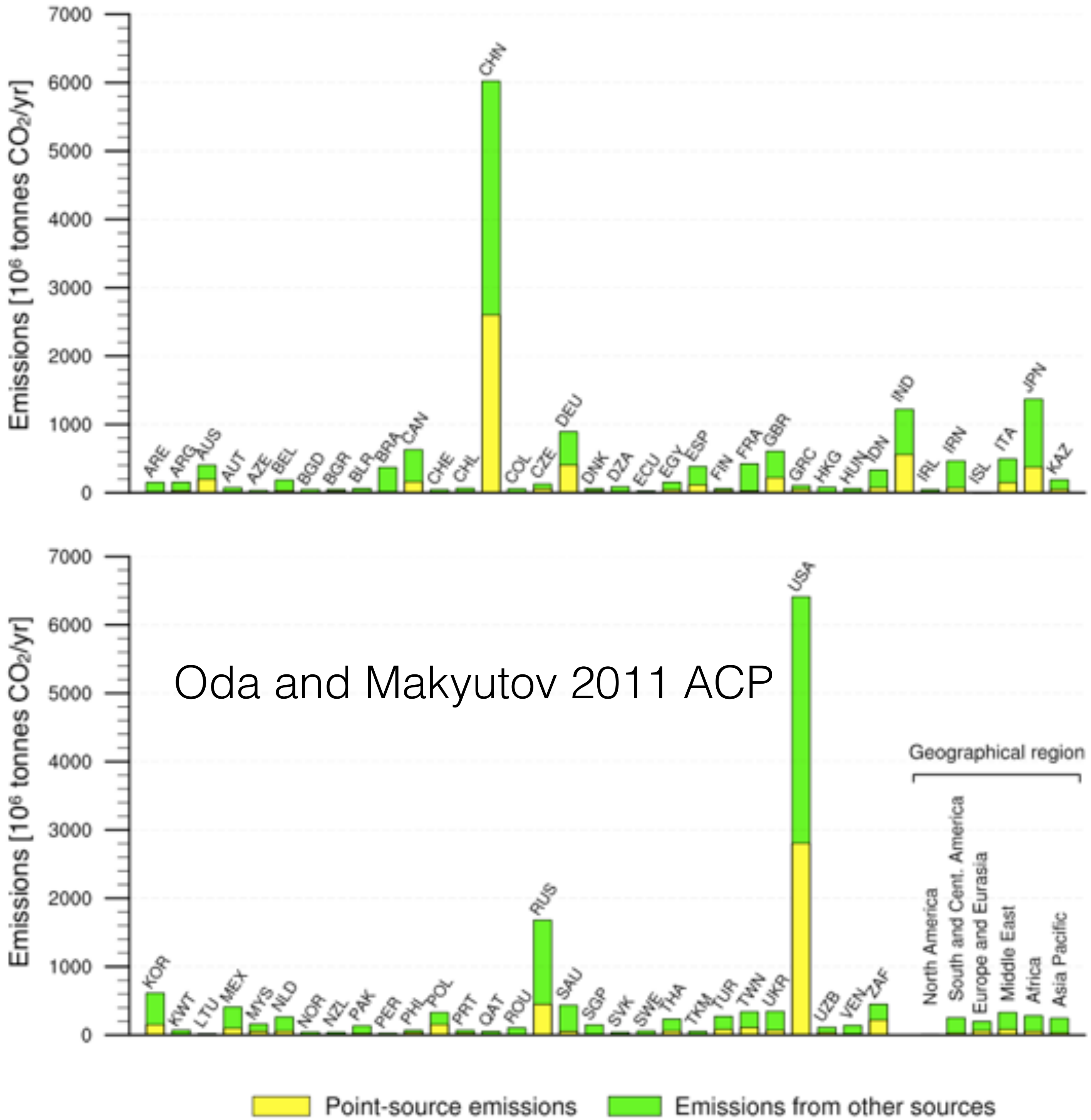




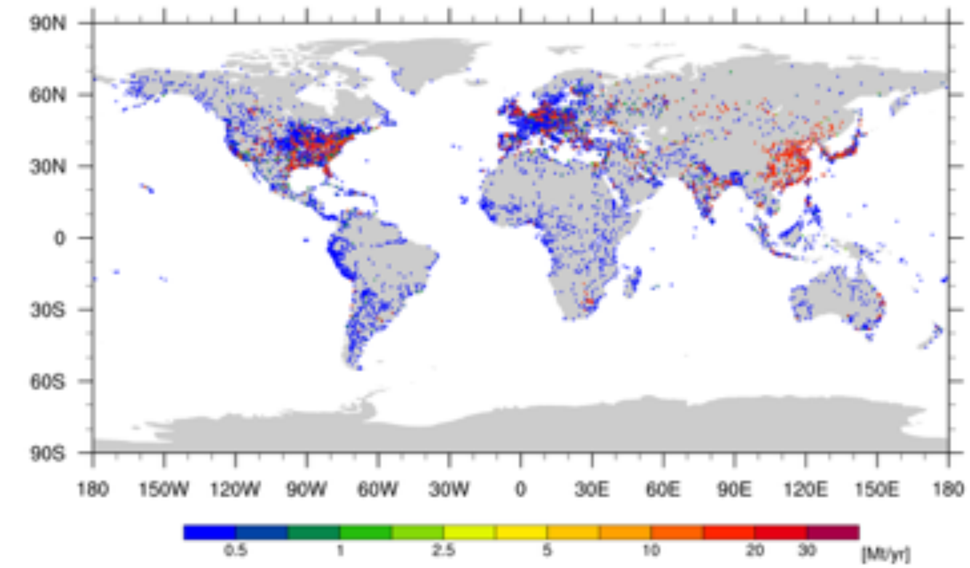


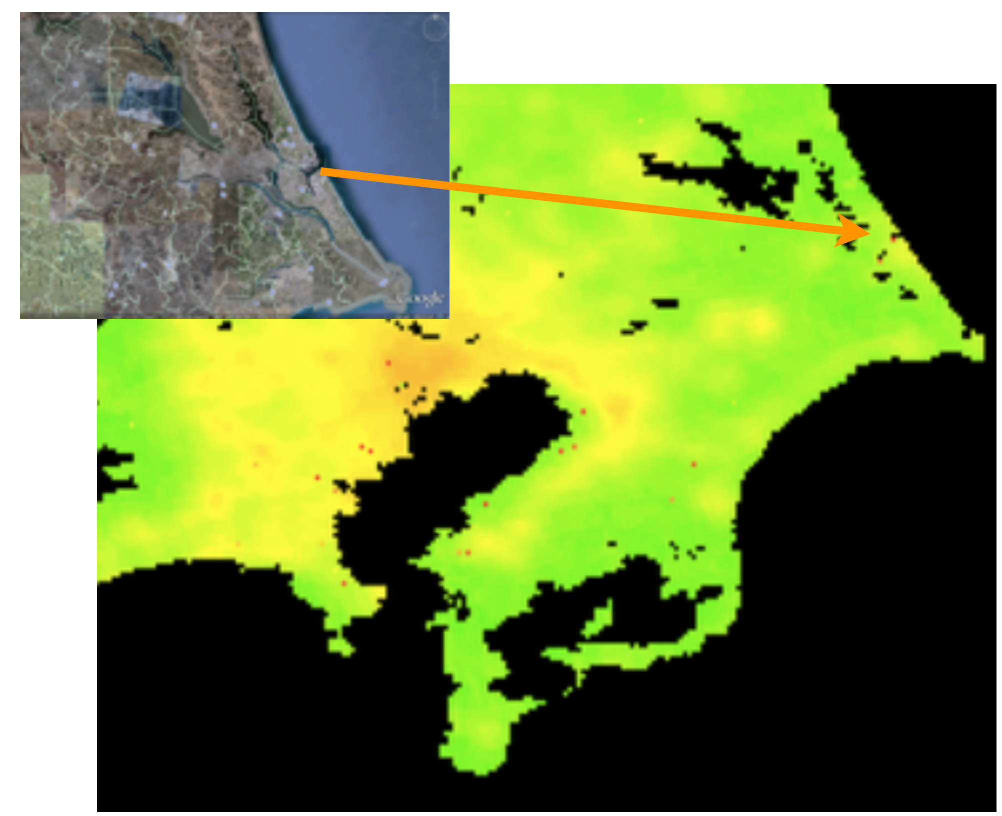
ODIAC fossil fuel CO2 Emission: Emissions from fossil fuel combustion is the largest input in the global carbon cycle over decadal time scales and is the main contributor to the recent increased atmospheric CO2. The Open-source Inventory for Anthropogenic CO2 (ODIAC) model employes satellite-observed nighttime lights to keep track of the emissions that are rapidly changing in space and time. The ODIAC model also utilizes geolocation of intense point sources such as power plants. The high-resolution (1x1km) ODIAC emission information will be used for the carbon cycle analysis using high-density CO2 data collected by NASA's Orbiting Carbon Observatory 2 (OCO2).

The 1x1 deg approach not going to work at a high-resolution



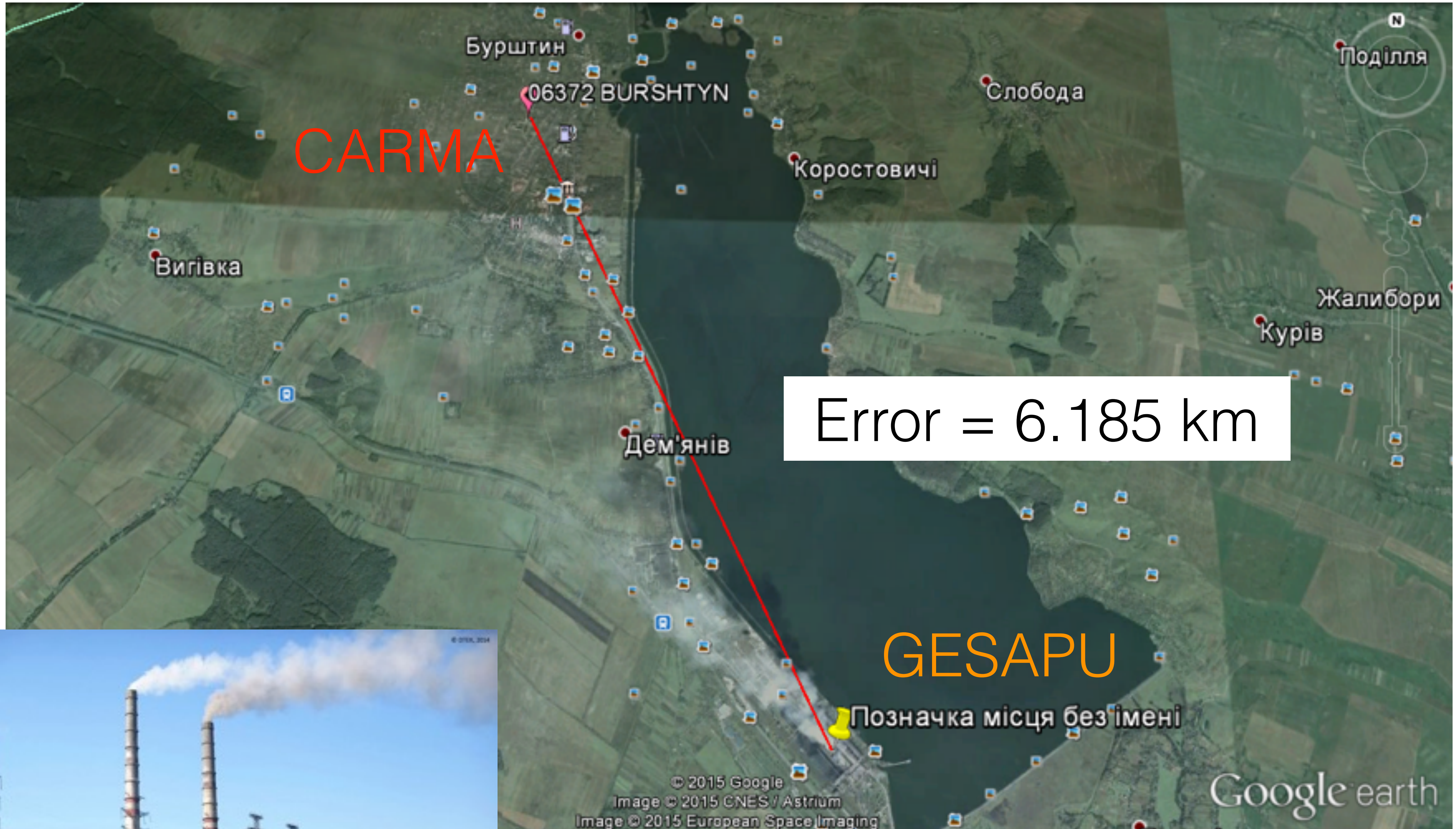
Oda and Makyutov 2011 ACP





Emissions from different sources need to be treated in appropriate ways

Case in Ukraine

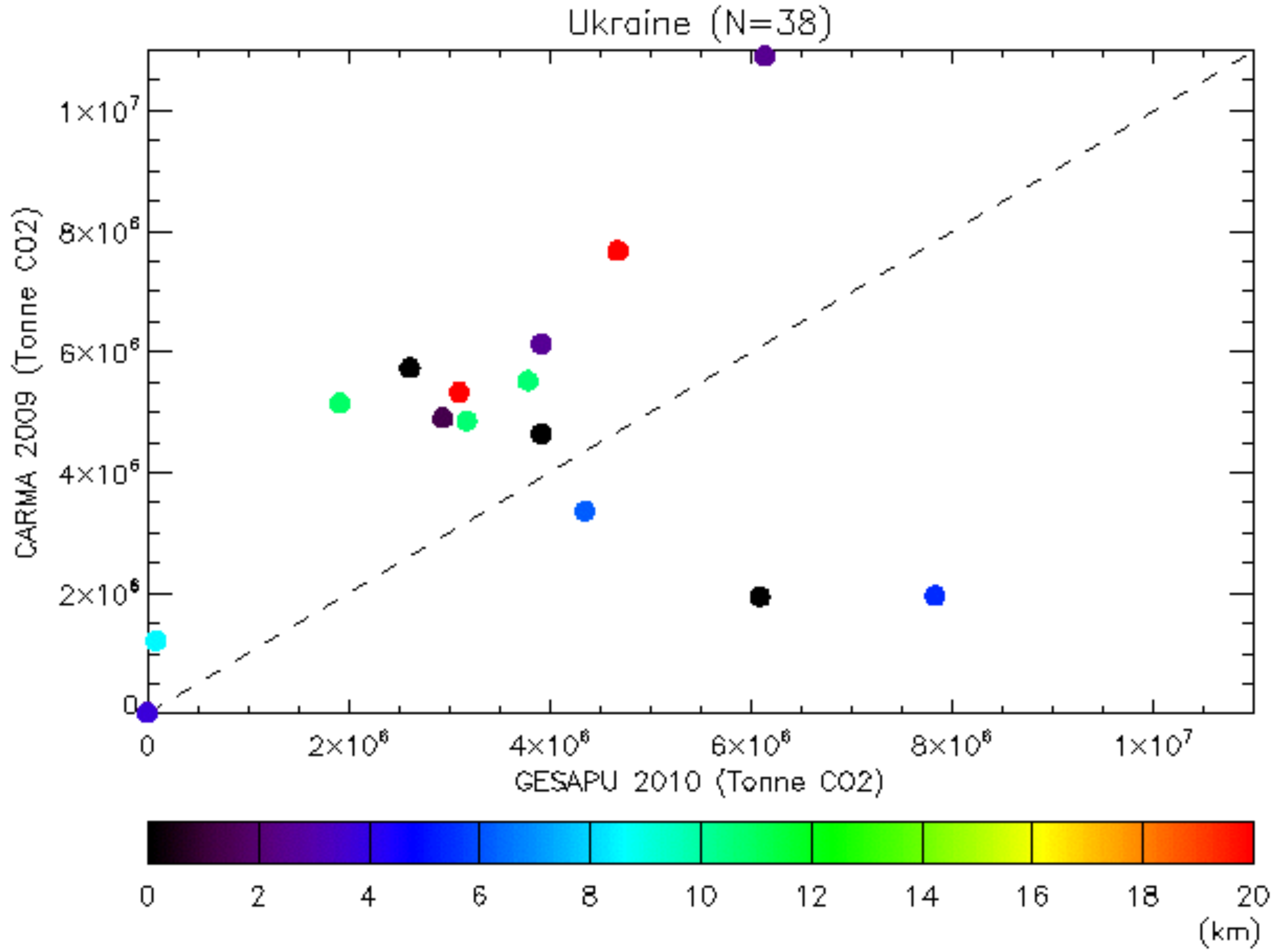


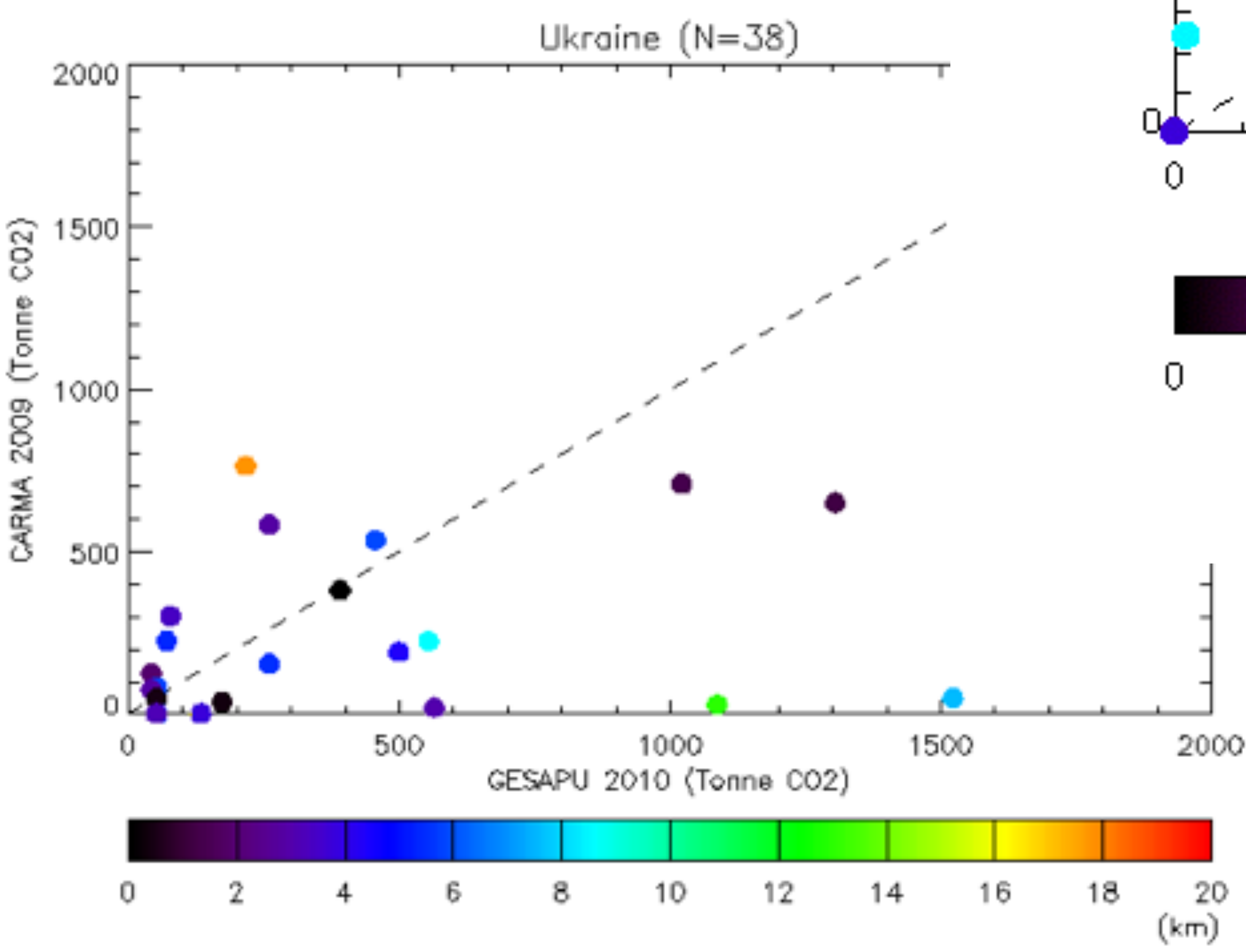
Work by Topylko and Halushchak

Case in Ukraine

Emission correlation = 0.77

Emission abs. error in % = 77 %

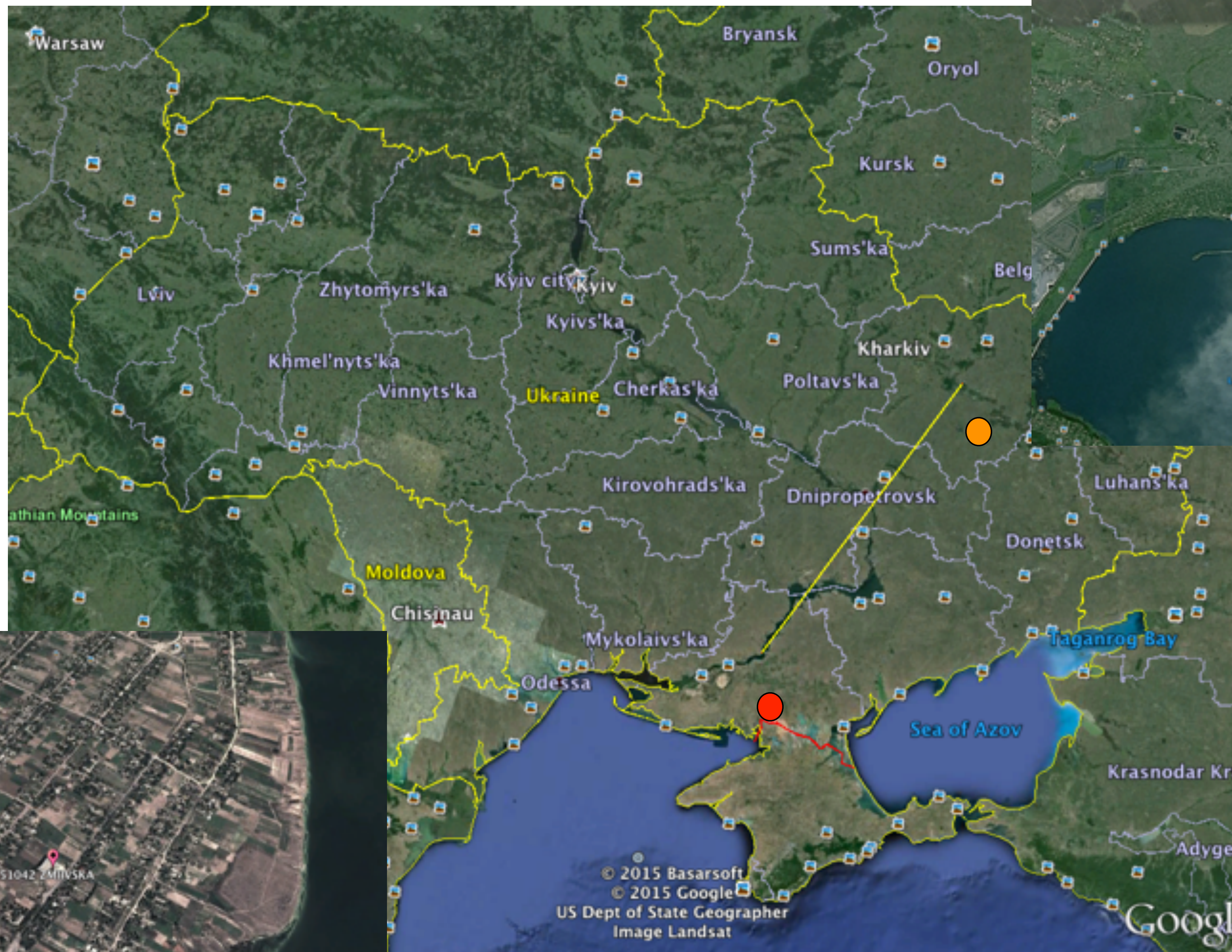




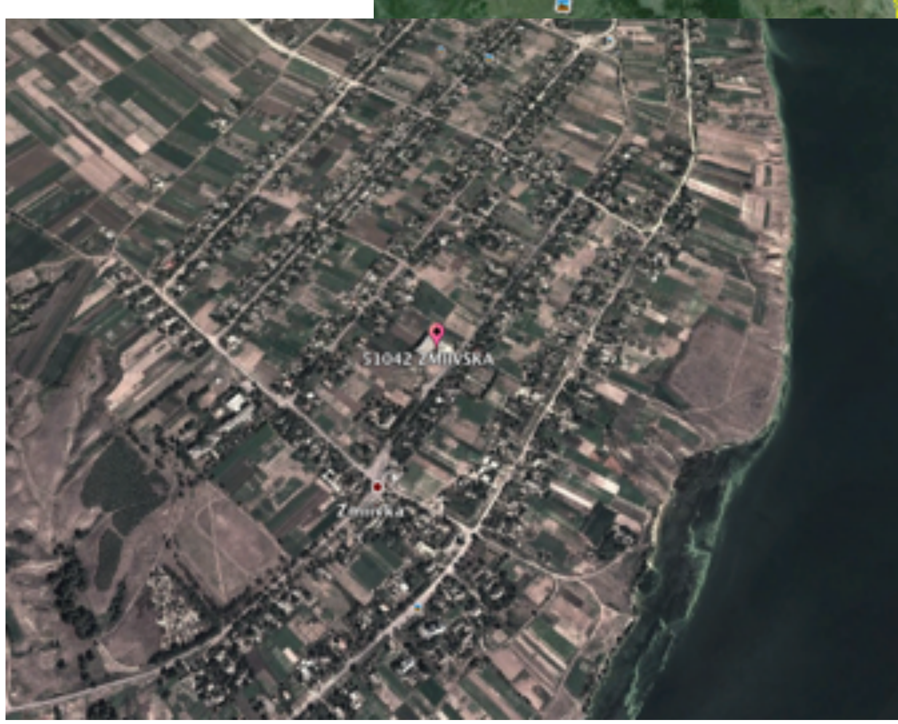
Oda, Topylko, Halushchak et al. working progress

Location error > 350km

GESAPU

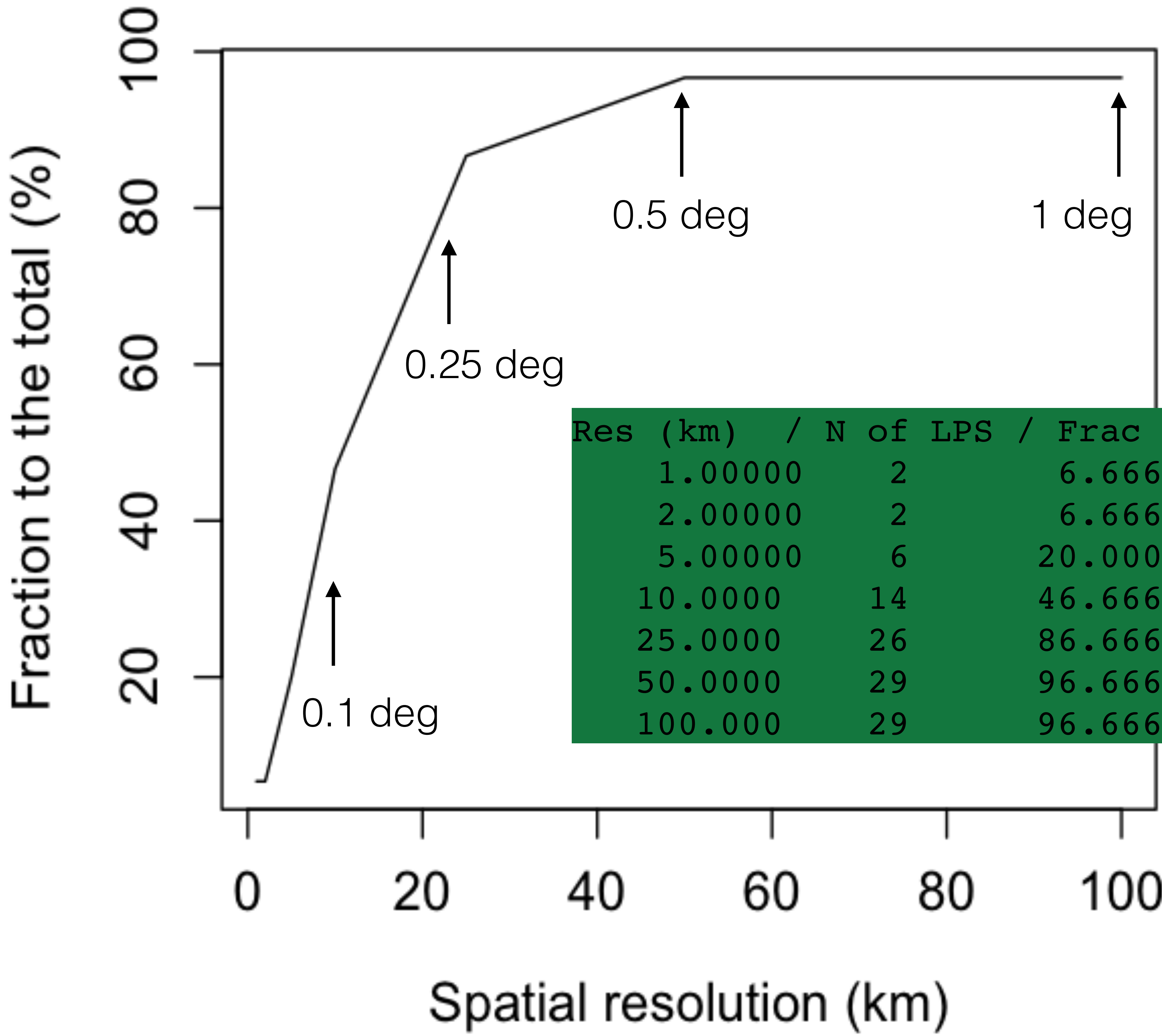


CARMA



Biases needs to be understood and fixed.

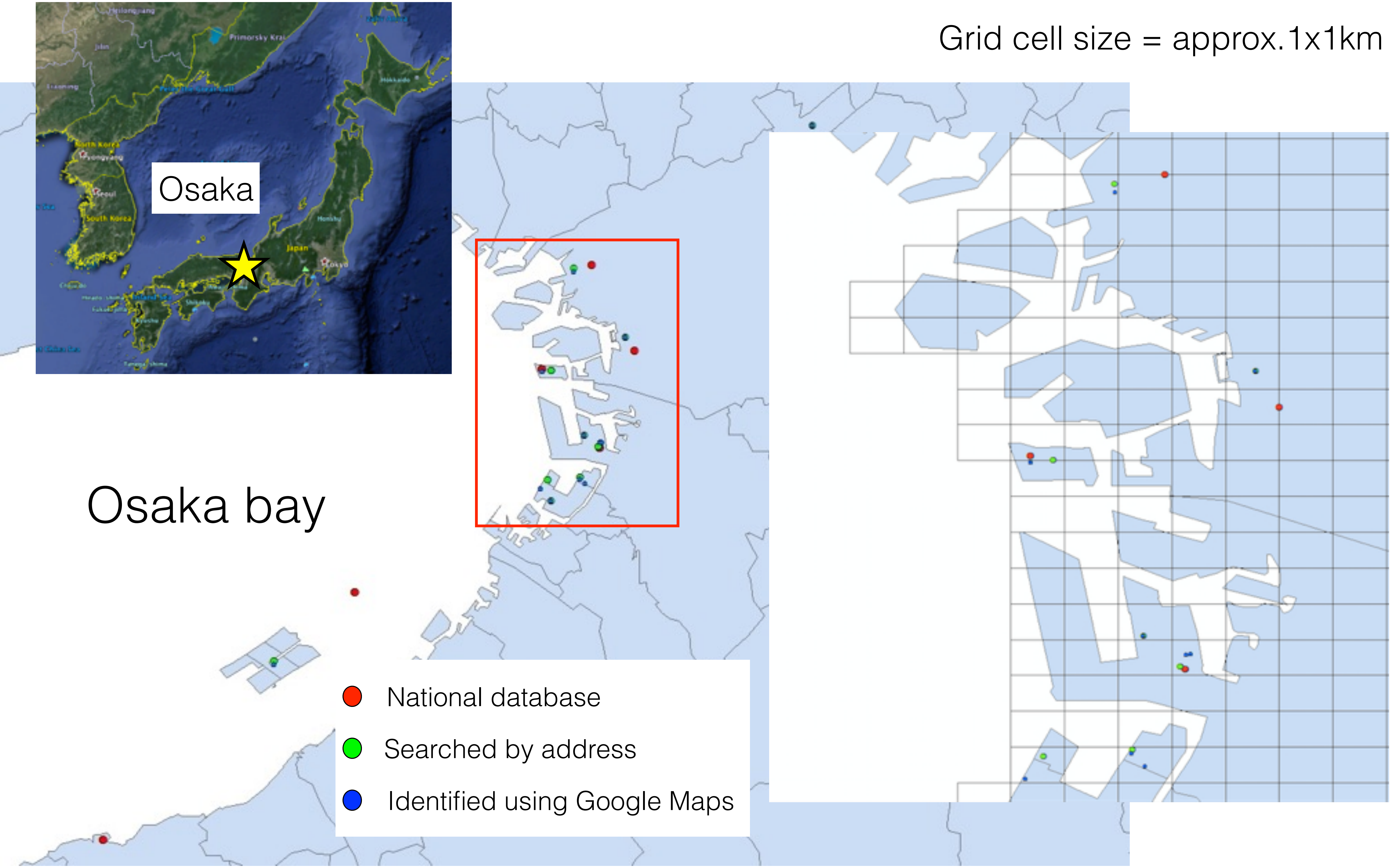
Uncertainty in ODIAC LPS emissions over Ukraine



Res (km)	/ N of LPS	/ Frac N (%)	/ Frac E (%)
1.00000	2	6.66667	0.451177
2.00000	2	6.66667	0.451177
5.00000	6	20.0000	10.9757
10.0000	14	46.6667	34.2735
25.0000	26	86.6667	81.9918
50.0000	29	96.6667	90.7263
100.000	29	96.666	90.7263

Case in Japan

Grid cell size = approx.1x1km



Mori and Oda working progress

Data collection is not for our purpose: eGRID

Independent Statistics & Analysis
U.S. Energy Information Administration

FORM EIA-860
INSTRUCTIONS
ANNUAL ELECTRIC
GENERATOR REPORT

Approval: OMB No. 1905-0129
Approval Expires: 05/31/2017
Burden: 9.29 Hours

PURPOSE Form EIA-860 collects data on the status of existing electric generating plants and associated equipment (including generators, boilers, cooling systems and air emission control systems) in the United States, and those scheduled for initial commercial operation within 5 or 10 years, as applicable. The data from this form appear in EIA publications and public databases. The data collected on this form are used to monitor the current status and trends of the electric power industry and to evaluate the future of the industry.

Note: Data is not collected for emission modeling

Summary

- A method for calculating uncertainty associated with spatial distributions is proposed and implemented at a 1x1 degree.
- The uncertainty calculation method allows us to take into account the inter-dataset differences due to proxy data used. This is particularly useful for analyses where FFCO2 is assumed to be perfect.
- The magnitude of uncertainty at 1x1 degree typically ranges from 40-180% inversely correlated with emission magnitude.
- At high resolution, ideally we should stay away from proxy based methods as possible (e.g. location should be determined) for both improving our modeling ability and reducing error/uncertainty.
- Currently our ability for assessing uncertainty at high resolution seems to be very, very limited (e.g. data and method). We should educated data collectors about what we can do and what we need.

Any question? tom.Oda@nasa.gov