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Towards highly resolved emissions in space and time in EDGAR

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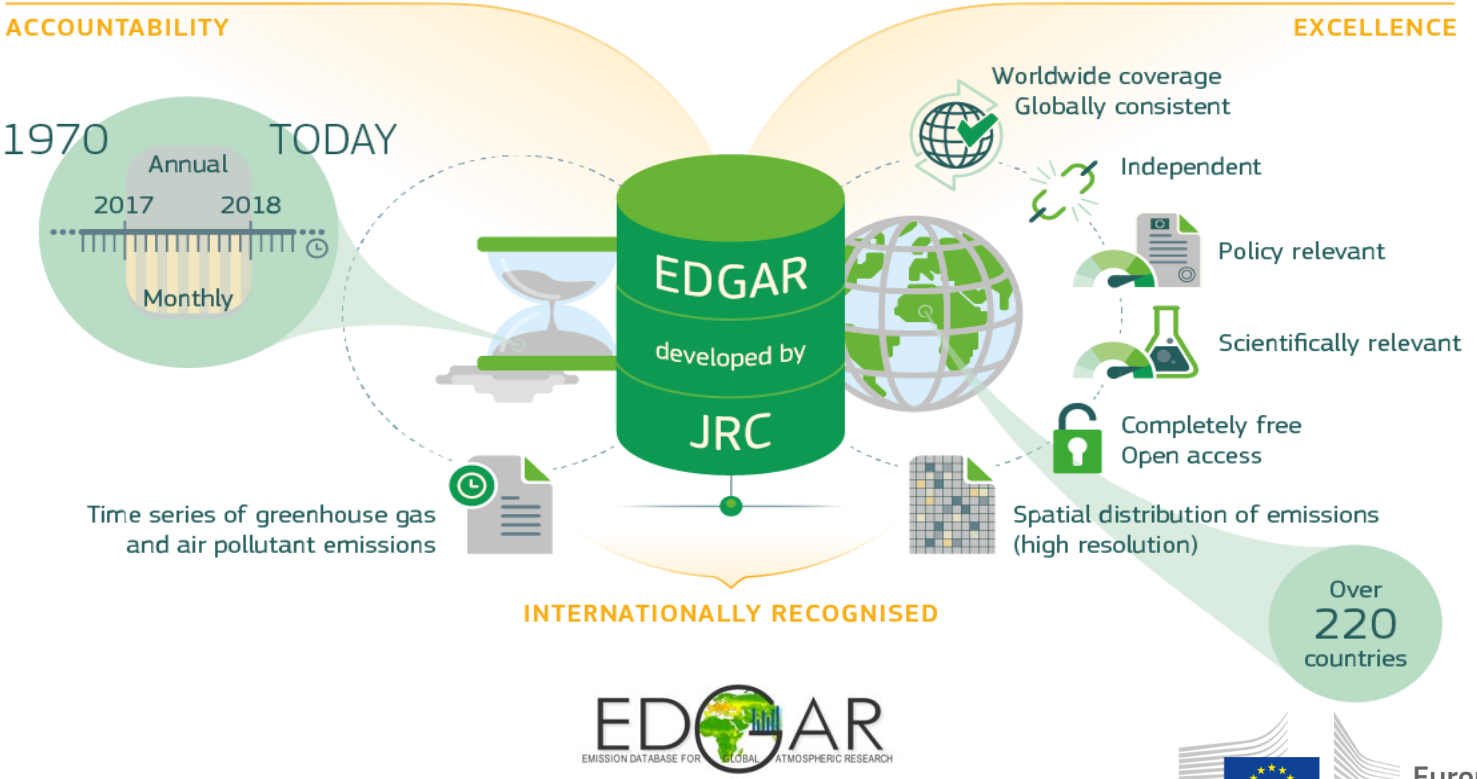
Outline

- ➢ **The Emissions Database for Global Atmospheric Research (EDGAR)**
- ➢ **Two new developments in EDGAR:**
- **High temporal resolution emissions:** Monthly and hourly emissions
- **New population based proxies**
- ➢ **Conclusions and outlook**

The Emissions Database for Global Atmospheric Research



EDGAR
EMISSION DATABASE FOR GLOBAL ATMOSPHERIC RESEARCH

https://edgar.jrc.ec.europa.eu/

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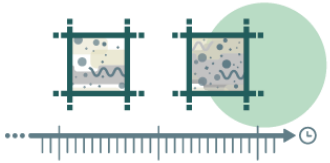
What EDGAR can be used for

Emission trend analysis and projections

International treaty reporting requirements (e.g. Paris Agreement)



Track emissions changes in emissions sources, fuels, technologies and abatement measures

Evaluate current and historical policy impacts at the EU and global scales

Global and regional modelling of atmospheric pollution and climate change

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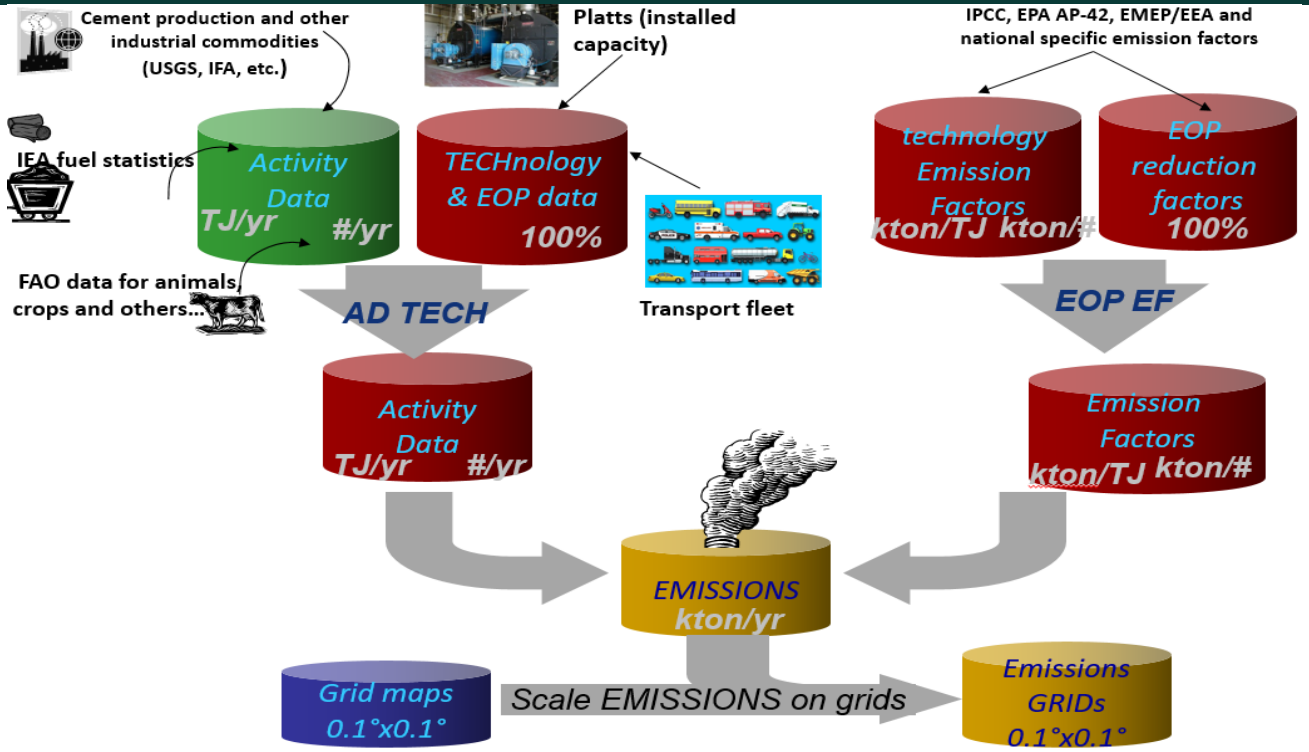
The EDGAR methodology



$$EM_{C}(t,x_1) = \sum_{i,j,k} \left[AD_{C,i}(t) * TECH_{C,i,j}(t) * EOP_{C,i,j,k}(t) * EF_{C,i,j}(t,x_1) * \left(1 - RED_{C,i,j,k}(t,x_1)\right) * f_{C,i,j}(x_1) \right]$$

Need of high temporal resolution emissions

- Describe the temporal variability of human activities and the corresponding emissions
- Model acute heavy pollution episodes
- Model the dynamics of atmospheric formation of pollution loadings during different periods of the year and hours of the day
- Global monitoring of the Earth through satellite-based measurements: time-varying mapping of human emissions

Support for policy makers: definition of more targeted mitigation measures and design more accurate policies.

Methodology for high temporal resolution emissions

Annual emissions | Monthly share | Daily share | Hourly share

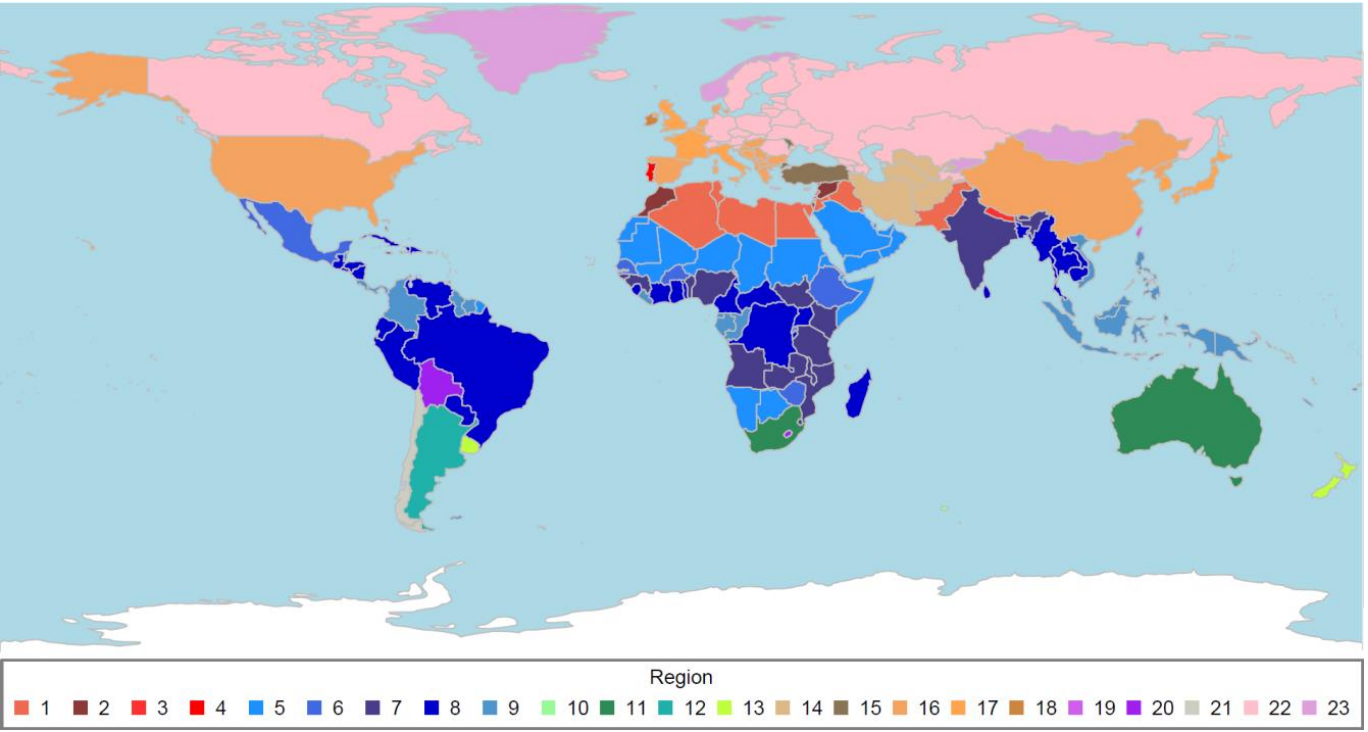
$$E_{i,s,h} = \sum_{c=1}^{n} \left(E_{i,c,s,j} \frac{x_{c,s,j,m}}{\sum_{m=1}^{12} x_{c,s,j,m}} \frac{7}{n_{m,j}} \frac{y_{c,s,d}}{\sum_{d=1}^{7} y_{c,s,d}} \frac{z_{c,s,d,h,t}}{\sum_{h=1}^{24} z_{c,s,d,h,t}} \right)$$

Driving forces for temporal variation of activities

Sector	Monthly variation	Daily variation	Hourly variation
Power plants 	Electricity production NEW! time varying profiles Temperature	Load curves	Load curves
Industrial combustion plants (and processes) 	Production rate Fuel use Temperature	Working times Holidays	Working times (Shift times)
Small combustion plants 	Heating degree days NEW! ECMWF ERA5 atmospheric reanalysis	User behavior	User behavior
Road transport 	Traffic counts	Traffic counts	Hourly traffic

source: IER database (Pregger et al., 2007), Huang et al. (2018); **Crippa et al. (2019)**.

Regional yearly profiles



Yearly profiles are defined for 23 world regions:

- climate zones
- heating degree days
- ecological zones

Crippa et al. (2019)

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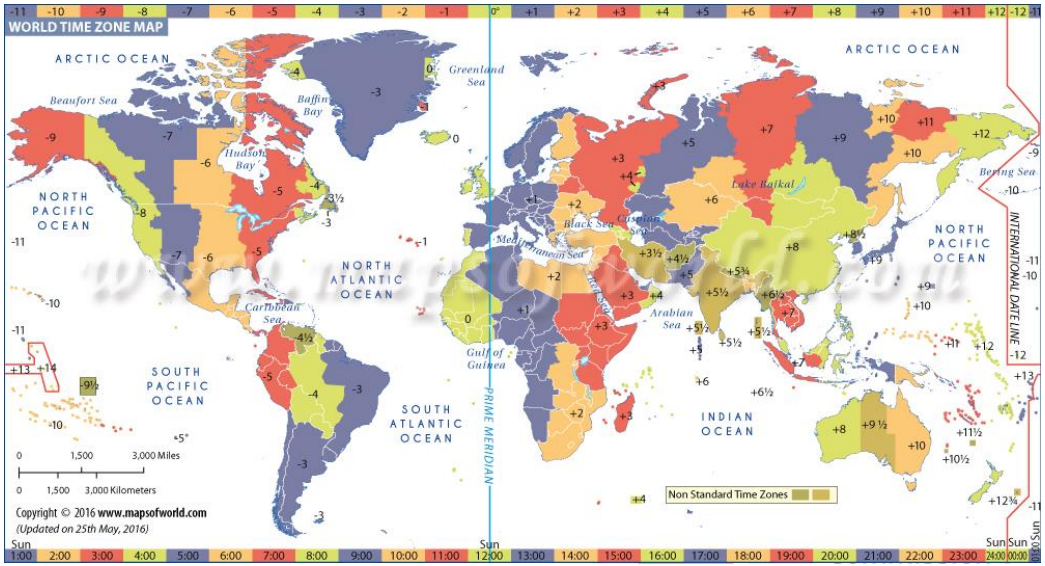
Weekly, daily and hourly emission distribution

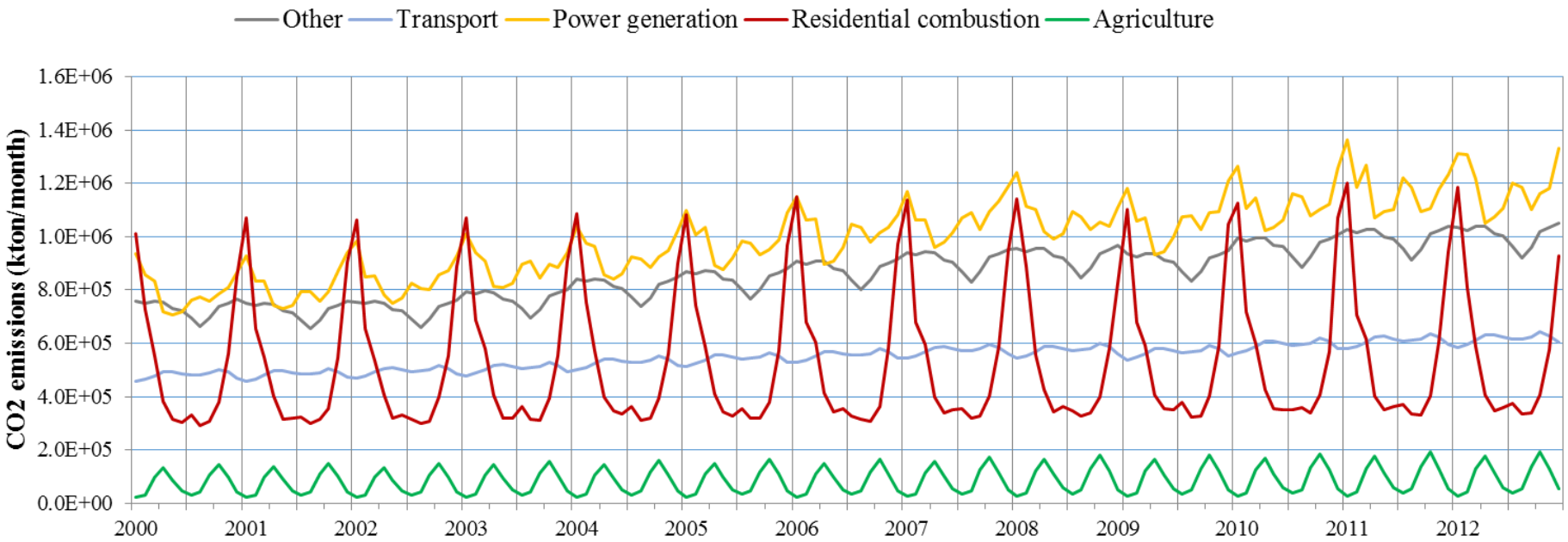
System to represent hourly emissions in a specific day or pollution episode in one global map

Country specific weekly and daily profiles: cultural differences among countries (i.e. working days and weekends definition, holidays, etc.).

Integration of the time zone information:
UTC and summertime shift (1970 – nowadays)



Global monthly variation of CO2 emissions



The monthly variation of global CO2 emissions is determined by the seasonal variation of the Northern Hemisphere.

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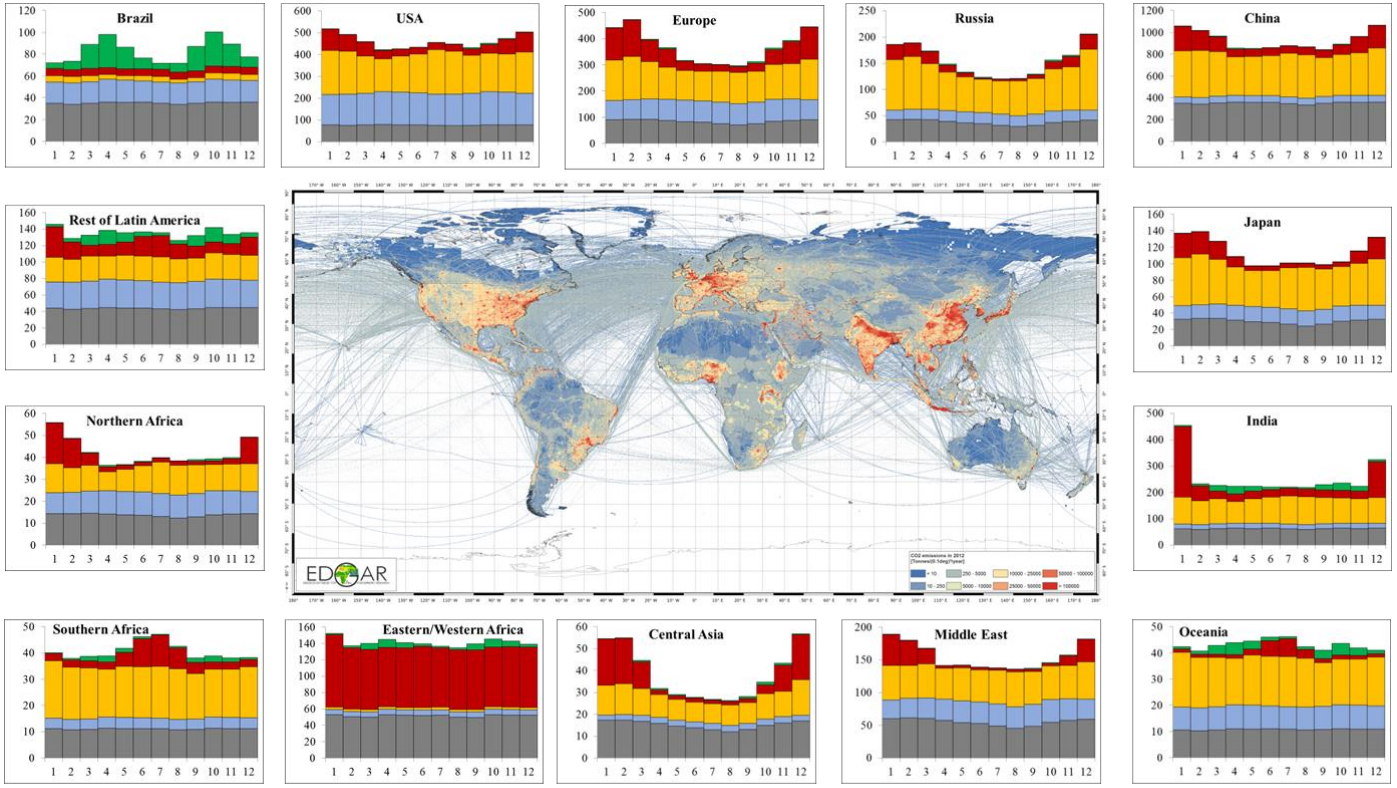
Monthly CO2 emissions by region



The highest CO2 contributions happen in the Northern Hemisphere during cold months (fuel combustion in power and residential sectors)

To identify when the highest emissions happen in specific months of the year for each region.

(Crippa et al., 2019)

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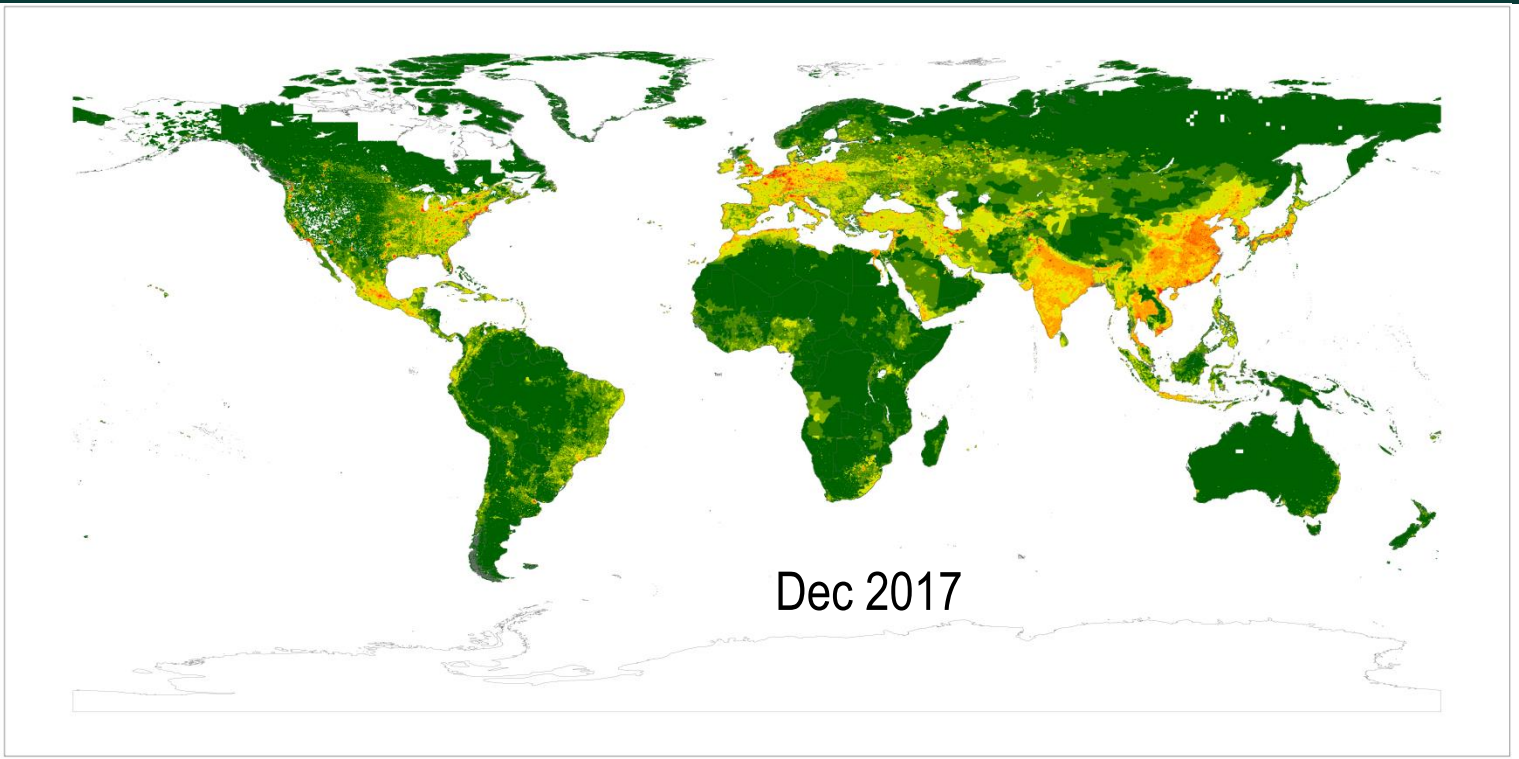
Residential combustion: CO2 monthly emissions



High seasonal variability reflecting the climatic conditions of each country

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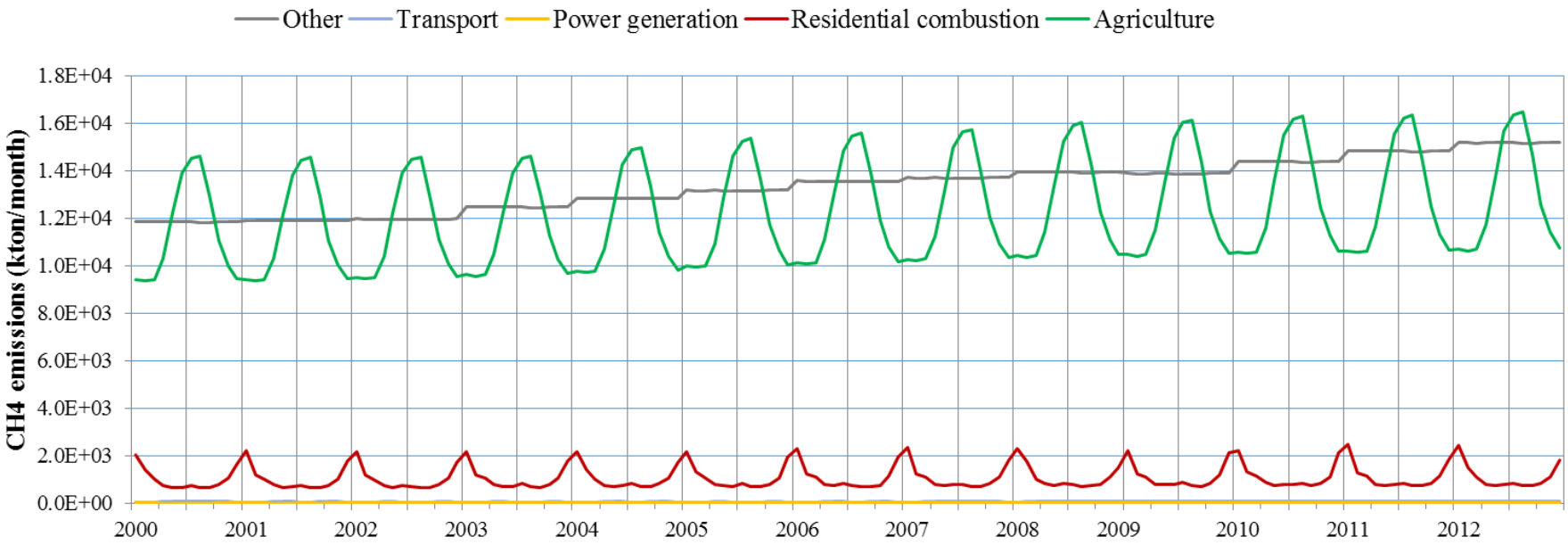
Global monthly variation of CH4 emissions



Seasonality of agriculture (rice cultivation) anti-correlated with combustion sources

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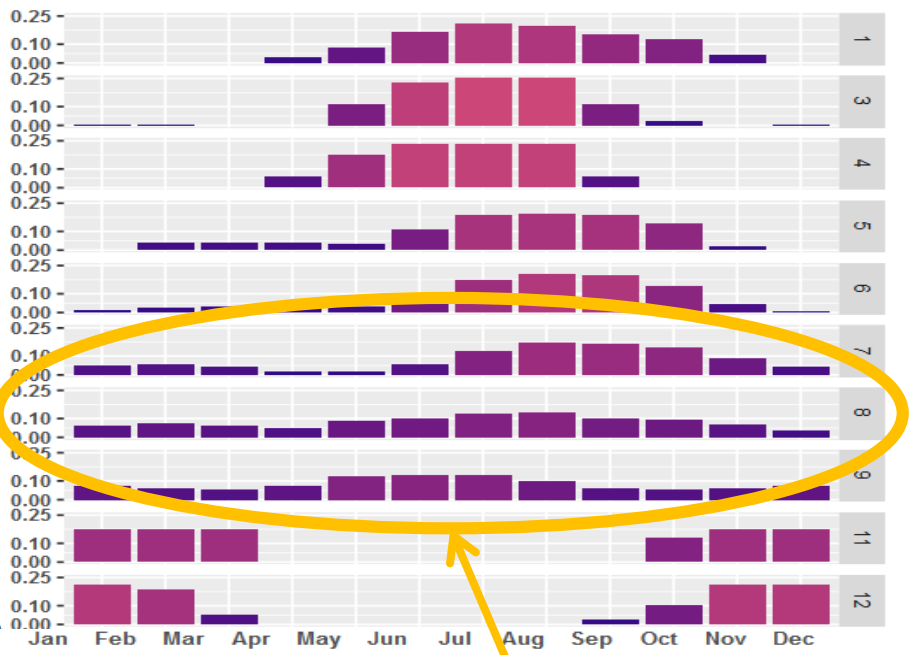
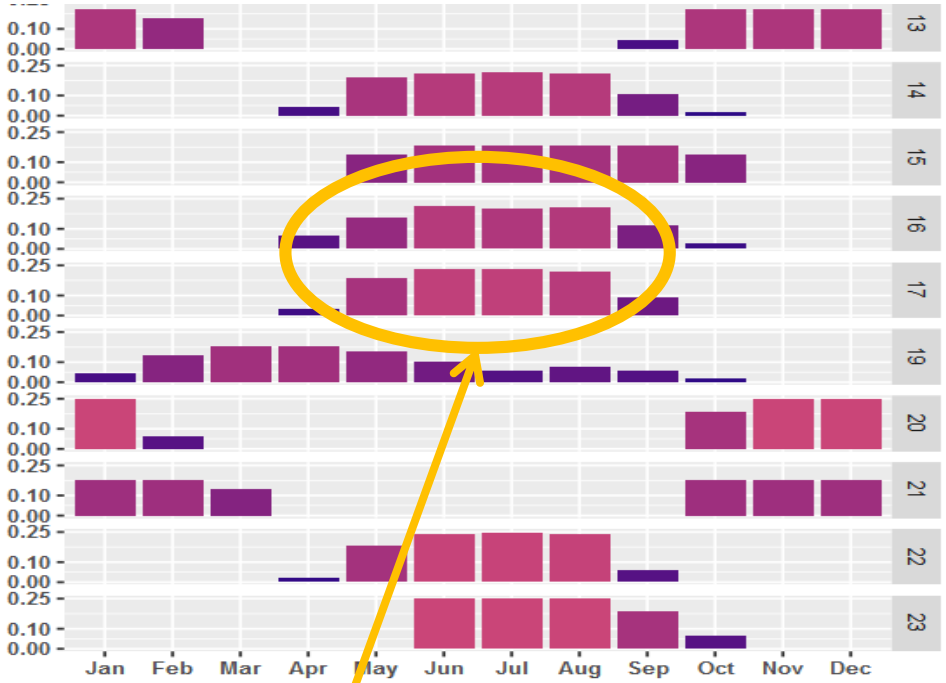
Monthly regional profiles for rice cultivation



Multiple crops



Concentrated crops

(Laborte et al., 2017)

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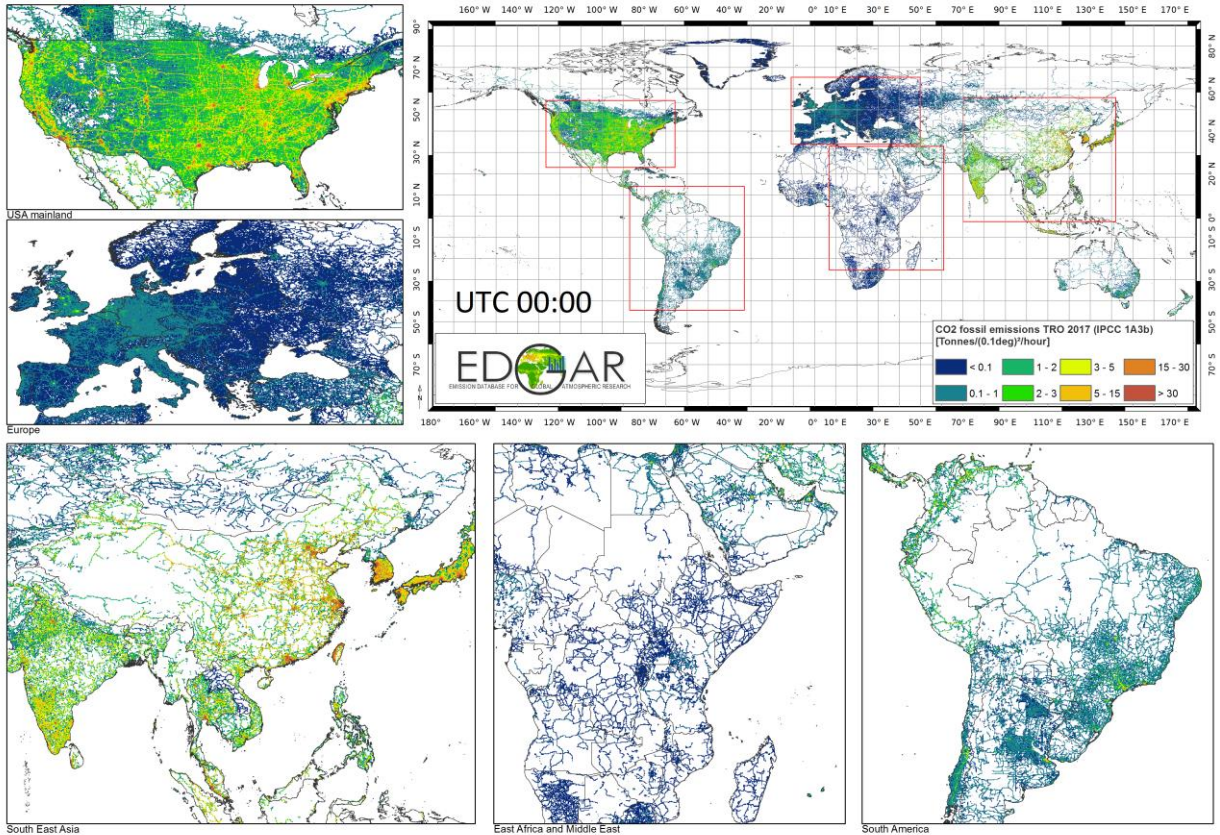
Road transport hourly CO2 emissions (17th Jan 2017)



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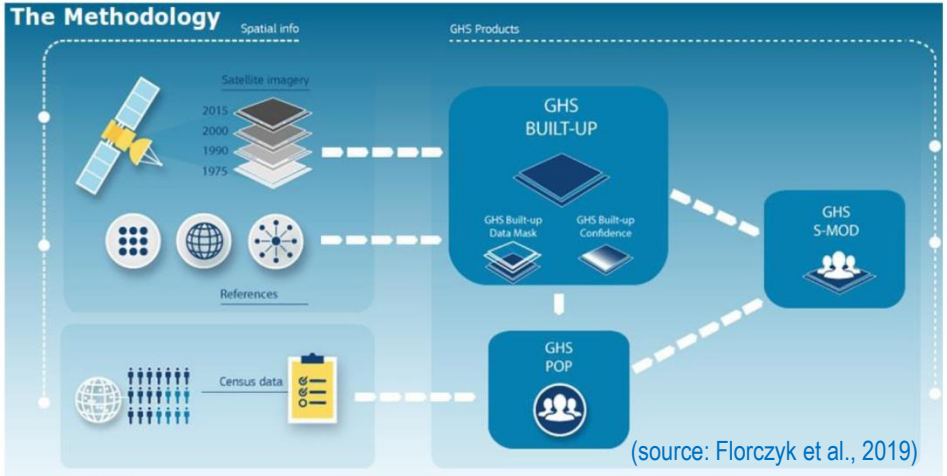
Population- based spatial proxies in EDGAR

Population distribution (urban and rural) is a fundamental proxy in EDGAR to spatially distribute anthropogenic emissions from different sectors.



(source: Florczyk et al., 2019)

https://ghsl.jrc.ec.europa.eu/

The "new" EDGAR population proxy is based on the JRC Global Human Settlements Layer work: latest population census data (CIESIN GPWv4) + satellite imagery of built up areas (Landsat 8).

Six categories of human settlements: **mostly uninhabited rural, dispersed rural areas, villages, towns, suburbs and urban centres** for 1975, 1990, 2000, 2015 ("Refined Degree of Urbanization" (Degurba+)).

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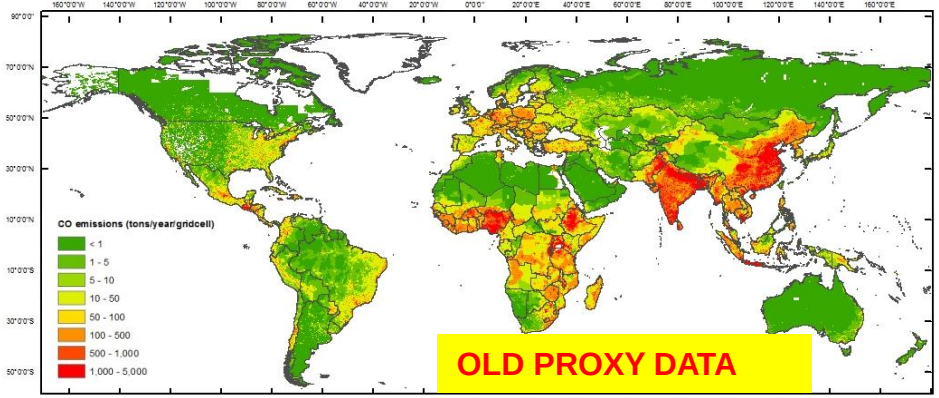
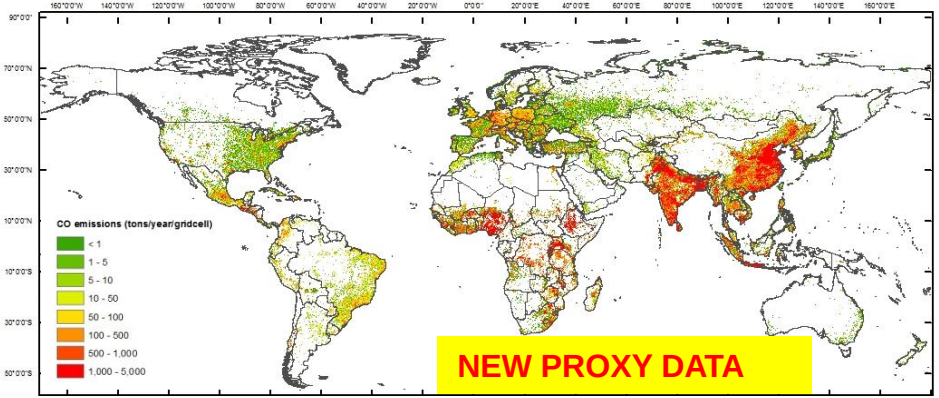
CO emissions from residential combustion in 2017





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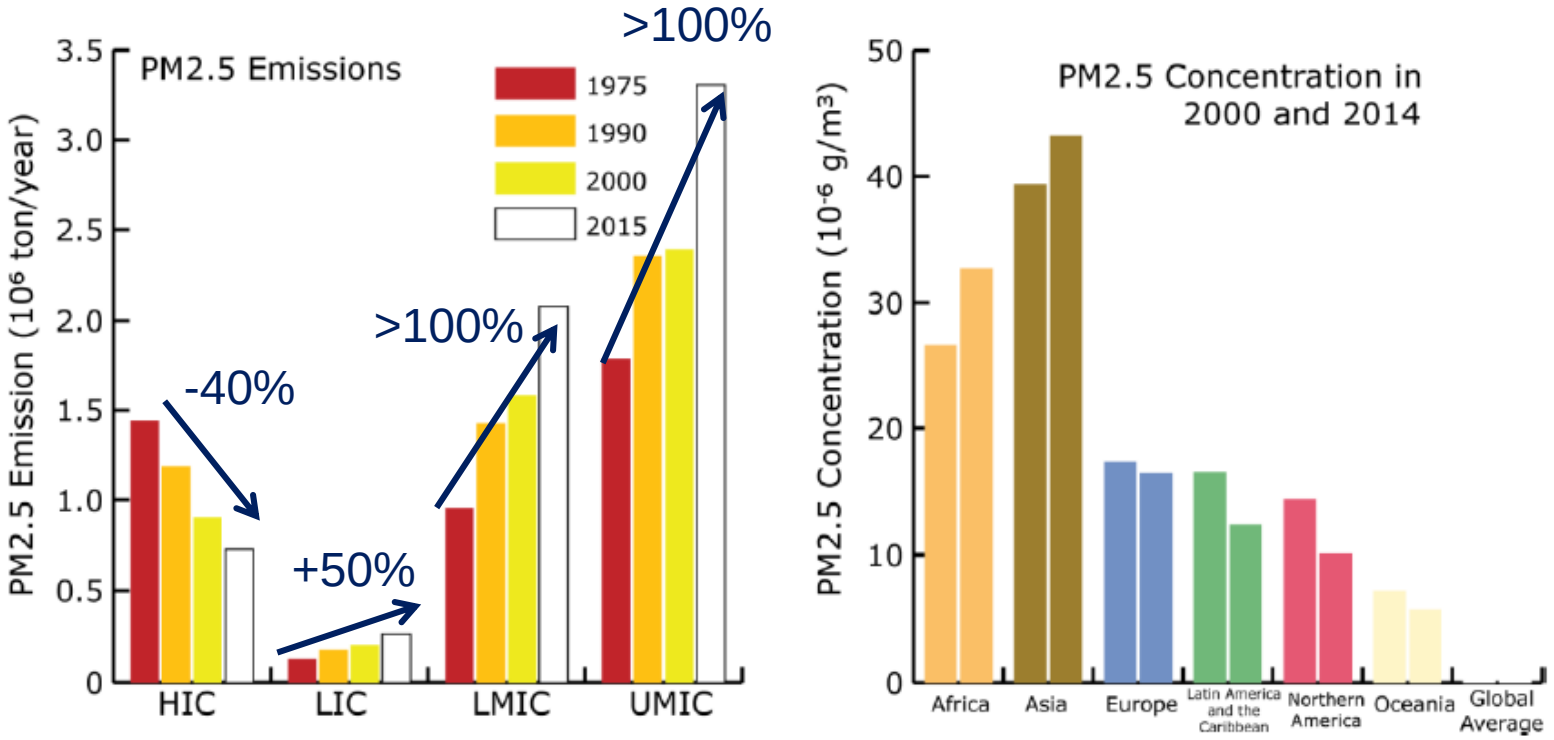
PM2.5 emissions in urban centres by income group



(Source: EDGAR contribution to the "Atlas of Human Planet 2018")

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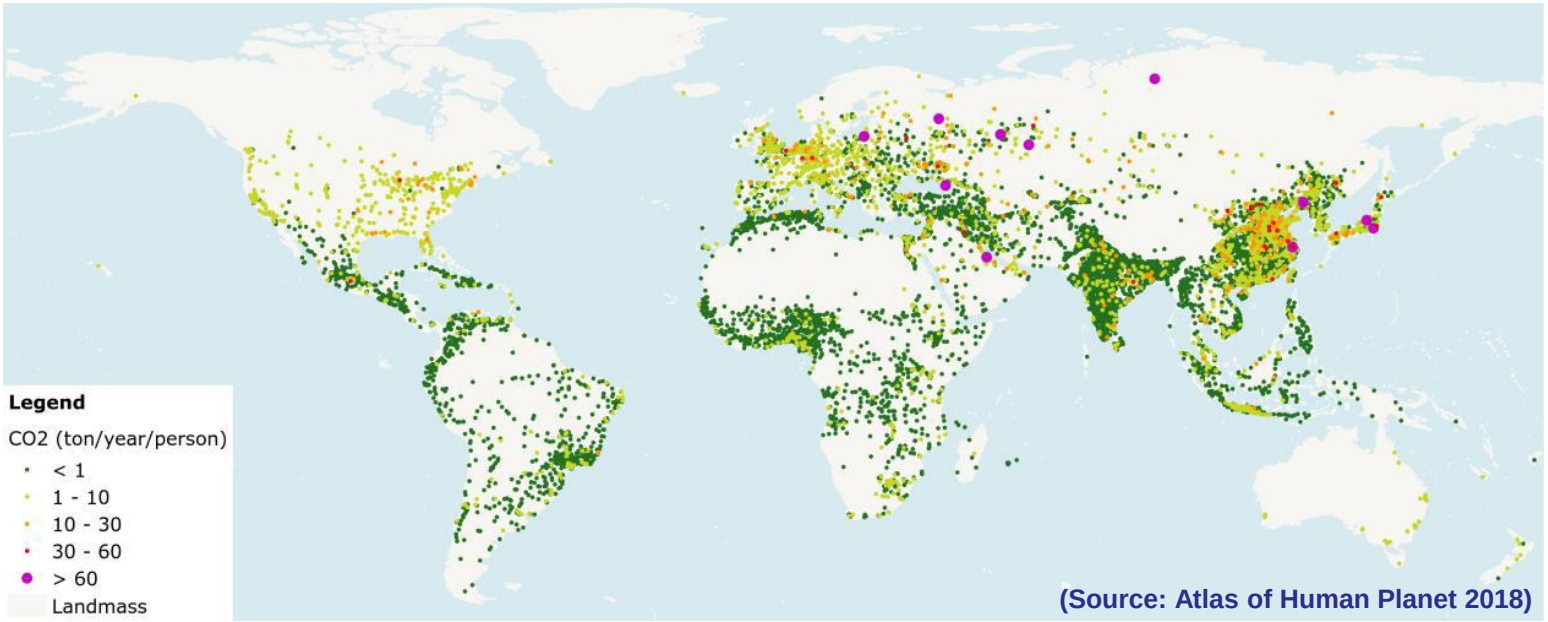
Per capita CO2 emissions across urban centres in 2012



-CO2/cap in urban centres is higher in North America, Europe, and NE Asia than in the rest of the world.

-Emissions of CO2 in cities in Europe and North America is decreasing,while in other regions it is growing (e.g. fastest growth in Asia).

Conclusions

- High time resolution emissions are needed to model heavy pollution episodes, seasonal trends and time-dependant processes.
- A harmonized emission temporal distribution for global and regional atmospheric modellers is created to promote homogeneity of results in inter-comparison exercises.
- Country specific weekly and hourly profiles accounting for different cultural behaviours are developed within EDGAR.
- Power generation and small combustion emissions have a strong seasonal pattern often subjected to inter-annual variability.
- New population based proxies can better represent where people leave and help in designing local policies

Outlook

- Hourly emissions: developed a system to import local (ad-hoc) profiles to represent specific pollution events or local sources ➡ expected input and feedback from EDGAR users and national emission inventories developers

- Comparison of hourly profiles against measurements ➡ validation

- Energy hourly profiles available for Europe: Fraunhofer Institute for Solar Energy Systems ISE

Thanks for your attention!

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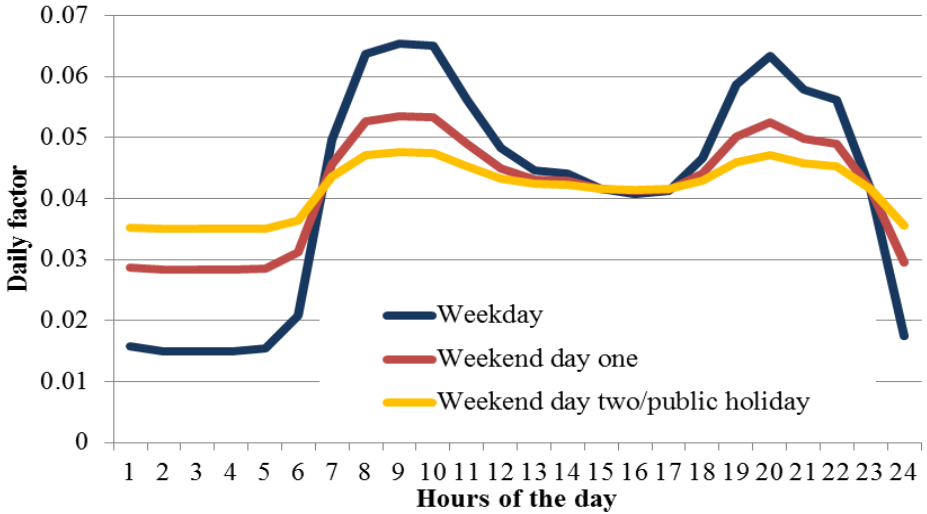
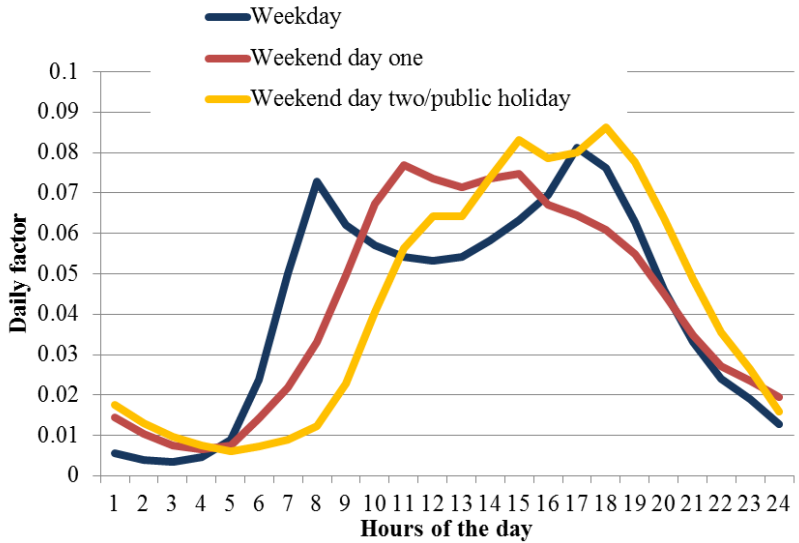
Hourly emission profiles

Residential sector



Road transport



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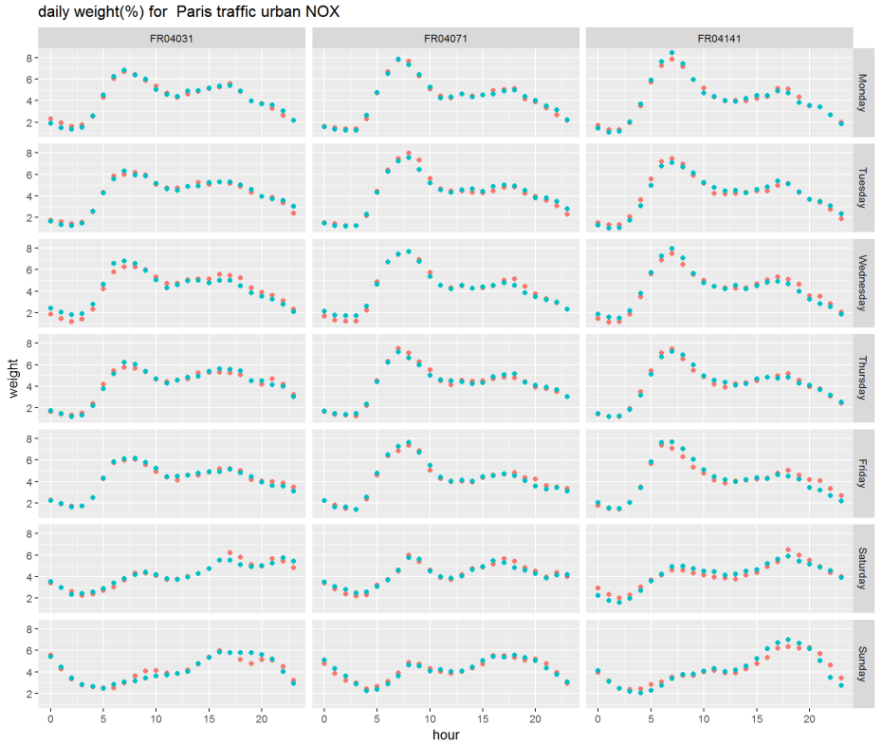
Comparison against measurements (1)



Variability (by urban-traffic stations) of hourly weights (%) by years and stations for Paris, based on hourly NOx measurements at three roadside stations. The station codes are put on the top of each graph. The hourly weights from Monday (top) to Sunday (bottom) of a week are shown

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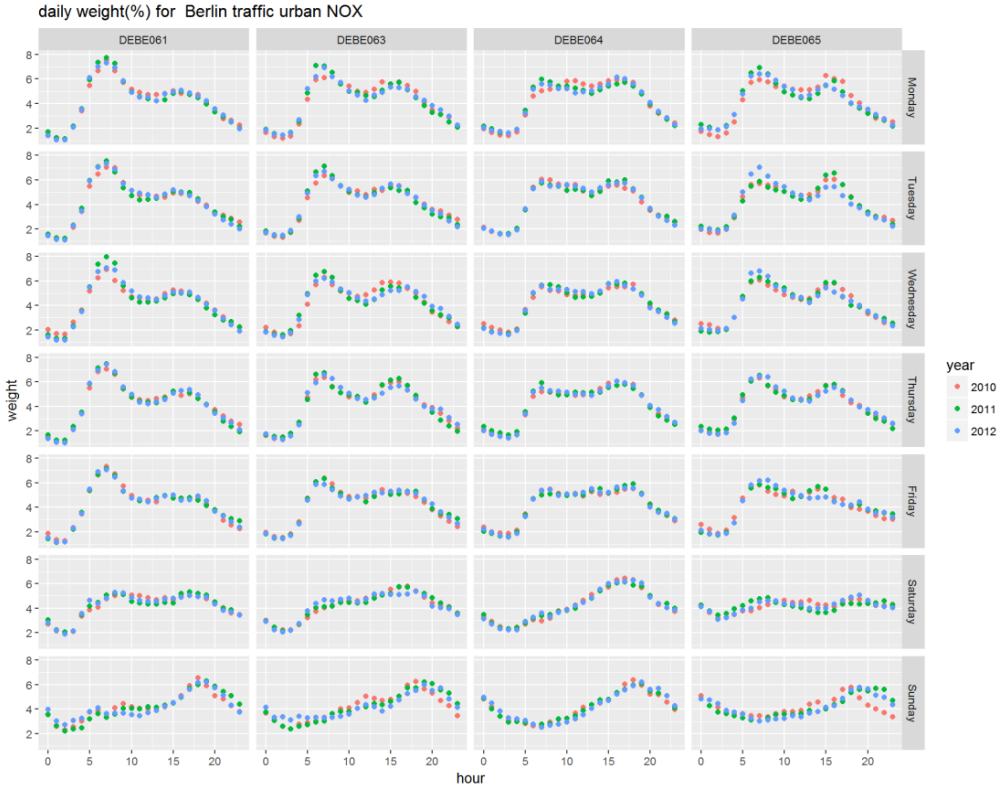
Comparison against measurements (2)



Variability (by urban-traffic stations) of hourly weights (%) by years and stations for Berlin, based on hourly NOx measurements at three roadside stations. The station codes are put on the top of each graph. The hourly weights from Monday (top) to Sunday (bottom) of a week are shown

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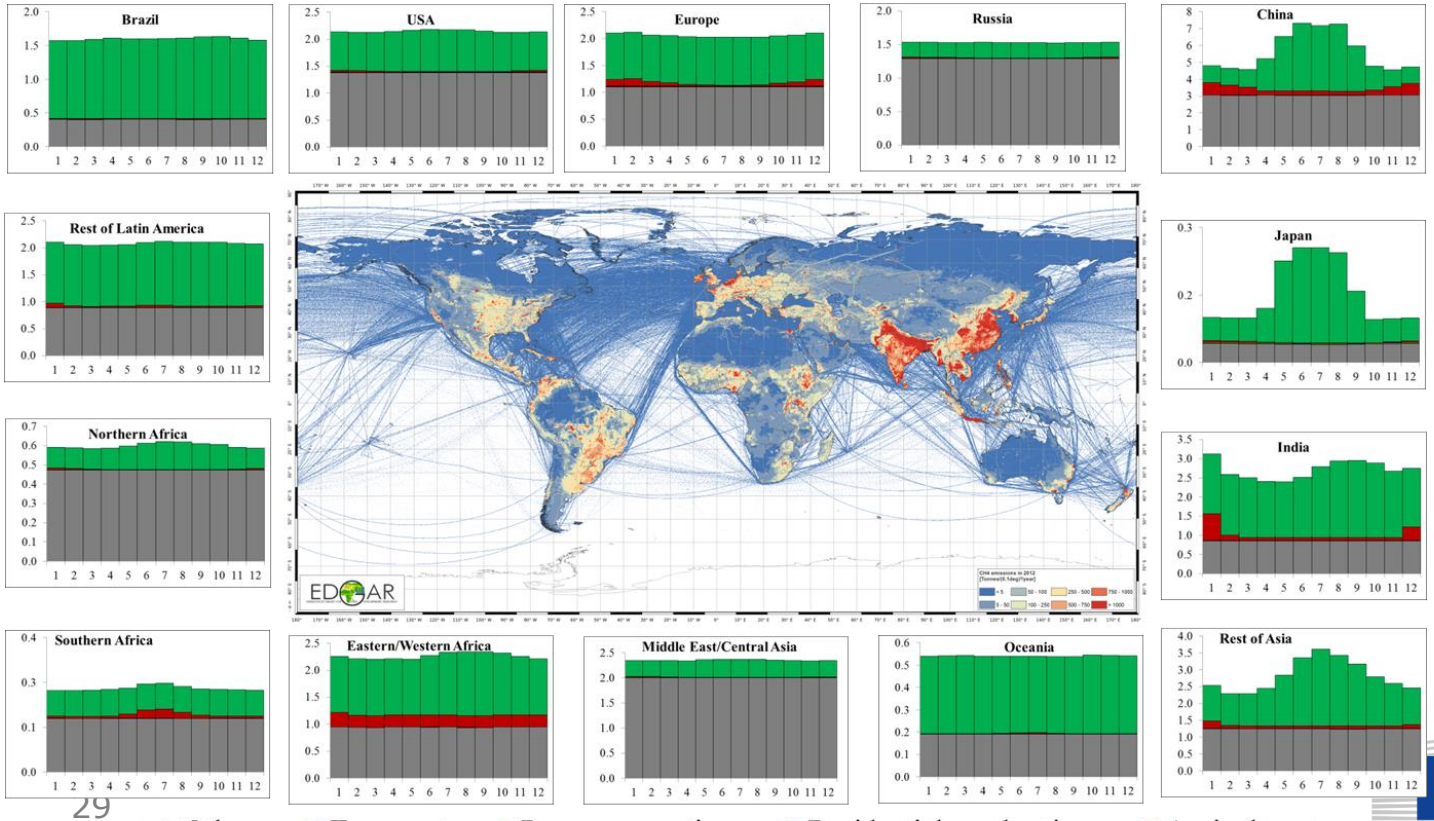
Monthly CH4 emissions by region



(Crippa et al., 2019)

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The Emissions Database for Global Atmospheric Research (1)

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Population- based spatial proxies in EDGAR

Population distribution (urban and rural) is a fundamental proxy in EDGAR to spatially distribute anthropogenic emissions from different sectors.

The "old" EDGAR population proxy was based on CIESIN population density dataset with an in-house methodology to distinguish between the rural and urban fractions.

The "new" EDGAR population proxy is based on the JRC Global Human Settlements Layer work which combines spatial information from the latest population census data (CIESIN GPWv4) and satellite imagery of built up areas (Landsat 8).

https://ghsl.jrc.ec.europa.eu/

The JRC product "Refined Degree of Urbanization" (Degurba+) defines **six categories of human settlements**: **mostly uninhabited rural, dispersed rural areas, villages, towns, suburbs and urban centres for 1975, 1990, 2000, 2015.**

Key novelties of the EDGAR temporal profiles

- country/region- and sector- specific yearly profiles for all EDGAR emissions
- Monthly emissions: time varying yearly profiles for power generation and residential combustion
- Hourly emissions: country specific weekly and daily profiles taking into account cultural differences among countries (i.e. working days and weekends definition, country-specific holidays, etc.).

Harmonized emission temporal distribution for global and regional atmospheric modellers -> it eliminates a source of discrepancy in model runs and promotes results homogeneity in inter-comparison exercises.