Anthropogenic influence to continental land surface stocks and fluxes

Lakes, cities & carbon dioxide

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Photo from twitter.com/qa6ar911

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ECMWF

CO_2 Human Emissions

LAND

OCEAN

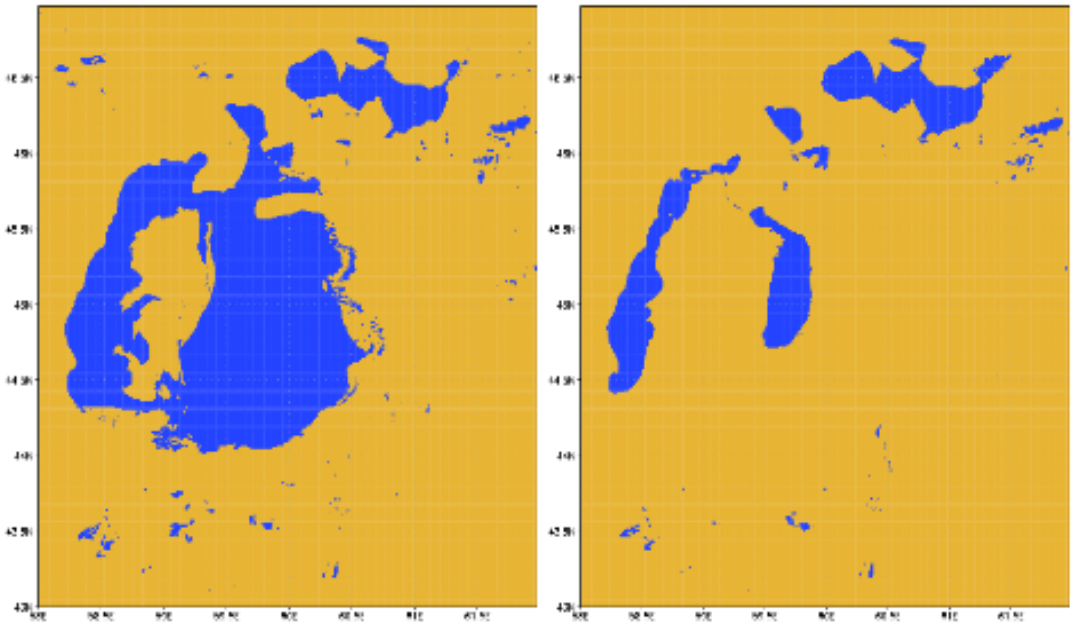
INLAND WATER

Changes in inner water distribution

Aral Sea (45°N, 60°E)

GlobCover2009 (operational)
Water surface area of 1998:
28'687 sq.km

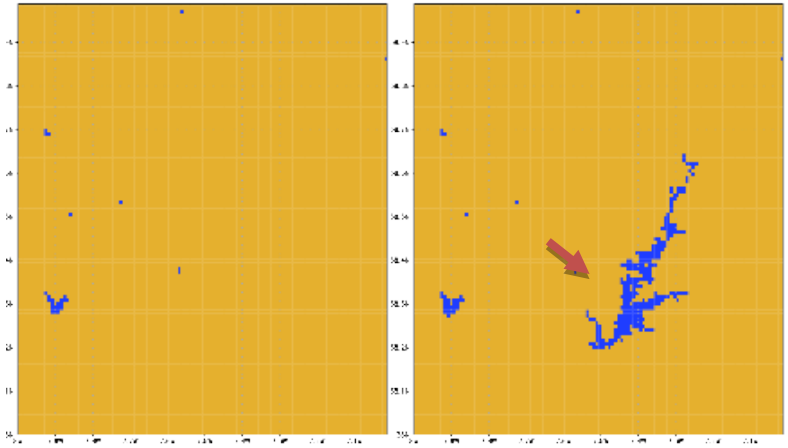
JRC (permanent water*)
Water surface area of 2008:
3'300 sq.km



Alqueva Reservoir (38.4°N, 7.4°W)
Built in 2002, completely filled in 2010

GlobCover2009 (oper)

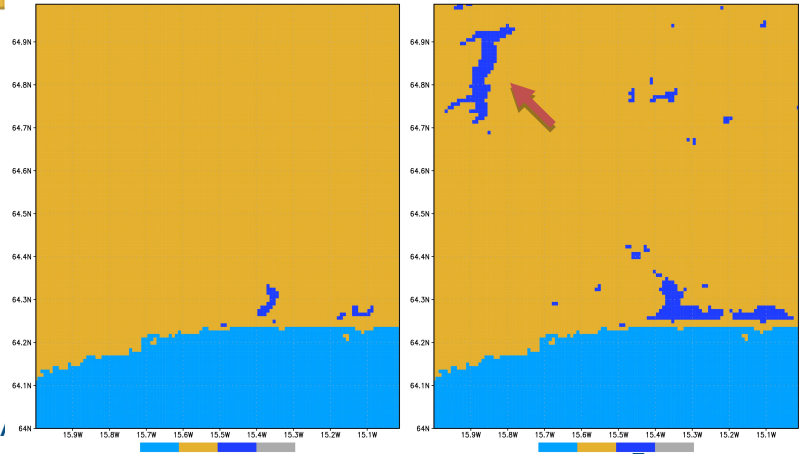
JRC (permanent water*)



Halslon Reservoir (64.8°N, 15.8°W)
Built in 2006

GlobCover2009 (oper)

LC, Icelandic Met Office



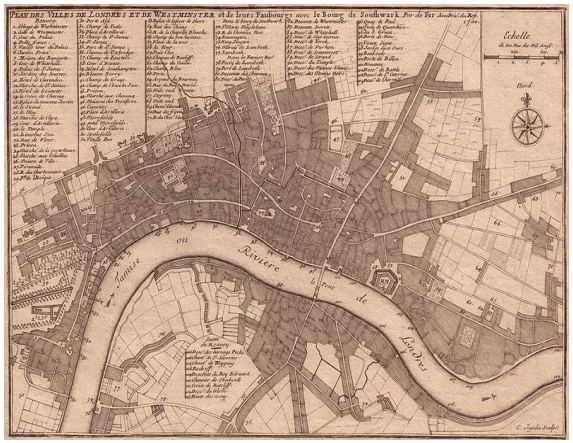
Lakes influence the local weather conditions and local climate.

Water classes used from **JRC Water Transitions map** with different water classes combinations: * **permanent water** combination of 1. Permanent, 2. New Permanent and 7. Seasonal to Permanent; ** **seasonal water** - 4. Seasonal, 5. New Seasonal and 8. Permanent to Seasonal; *** **ephemeral water** - 9. Ephemeral Permanent and 10. Ephemeral Seasonal

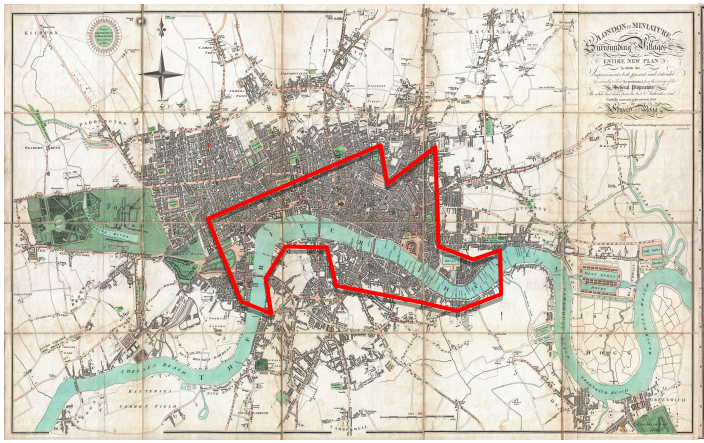
Changes in human settlement distribution example of London

Urban area should be included in a land surface model though parametrization.

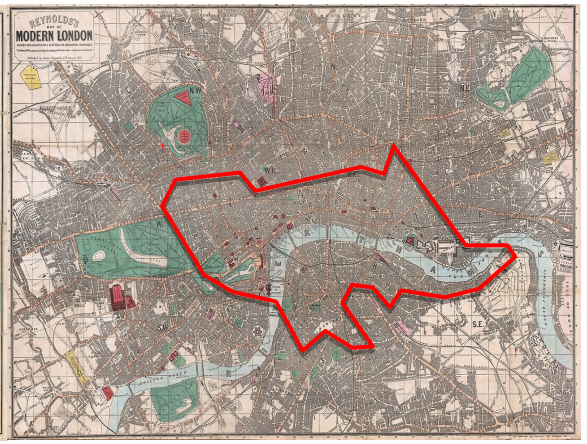
1700, 600'000 inhabitants



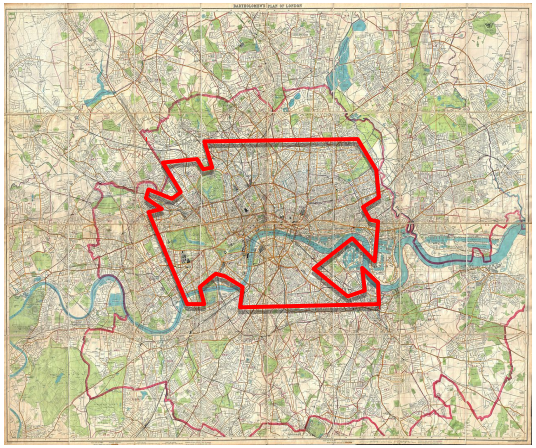
1806, 885'000 inhabitants



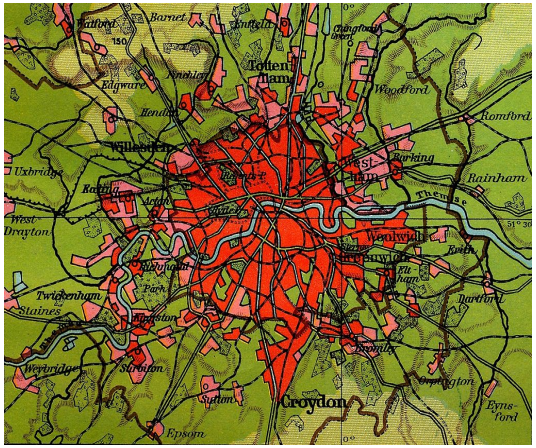
1862, 2.8M inhabitants



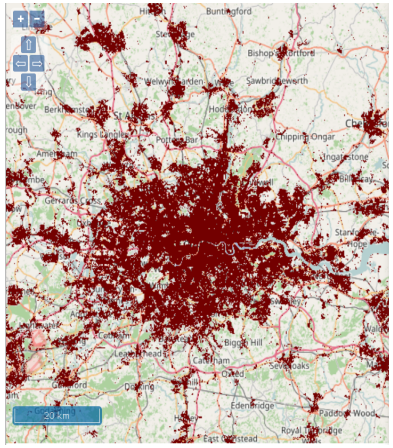
1900, 4.7M inhabitants



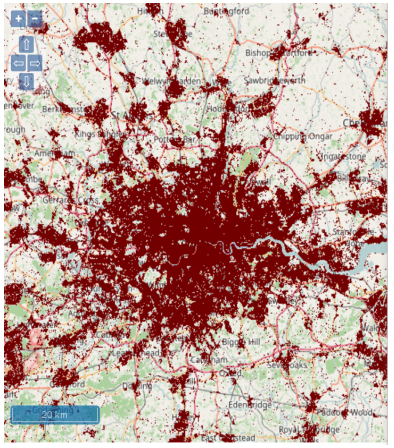
1930, 8.0M inhabitants



1975, 6.8M inh.



2015, 9.7M inh.



Upper row and first two lower row maps from www.citymetric.com

Maps from http://ghsl.jrc.ec.europa.eu

Simulating human settlements

Urban heat island (UHI): city **doesn't release** its **heat as** fast as the **surrounding** country side - increased daytime temperatures, reduced night-time cooling, higher air pollution levels.

Main causes: structural and land cover differences of urban and rural areas - cities are

- **rough with buildings** extending above ground level,
- **dry and impervious** with construction materials extending **across natural soils and vegetation**.

Affect: hydrological cycle (**evaporation, condensation, transpiration**), abundance of short- and long-wave **radiation**. City has **less vegetation** (less CO2 sinks!).

Influence model performance and **determine** surface parameters:

- **albedo** (asphalt, buildings, glass),
- **emissivity** (central heating),
- **roughness** (building height, turbulent flux),
- **porosity** (artificial drains) and
- **thermal conductivity of the soil**.

Important: heat and moisture release from **people** and their **activities**. Urban canopy models account for **anthropogenic heat** (QF):
QF = QFv + QFb + QFm + QFi, where sources are **v**ehicular, **b**uilding, human **m**etabolic (negligible to **v** & **b**) and **i**ndustrial heat emissions.

Anthropogenic CO2 emissions

In **2015** average concentration of **CO2 ~40% higher than in mid-1800s** - average **growth of 2 ppm/year** in last 10 years.

- **CO2** is a minor gas, which comprise **only 0.039% of the atmosphere**.
  !!! absorb infrared radiation - second most **important GHG**!

- **Sources** of CO2: **burning of** organic carbon compound (**wood**) **or** fossilized organic matter (**coal, oil, or natural gas**) **in presence of O2**, **respiration** of seawater, land plants, animals, and soils.
  Sinks of CO2: **absorption by seawater** and **photosynthesis by** ocean-dwelling **plankton** and land **plants**, (including forests, grasslands).

- **Photosynthesis** occurs **only during daylight** hours **in** the **growing season**.
  Respiration occurs **at all times**, at reduced rate in winter outside the tropics.
  Fossil-fuel fluxes in the same location are often **smaller**, **except** in **cities** or close to **power plants** where fossil-fuel **emissions are concentrated**.

- **Largest source** of anthropogenic CO2 emissions - **use of energy**:
  emissions from "**fuel combustion**" (the large majority) and "**fugitive emissions**" (release of gas during production, processes, transmission, storage and use of fuels).

Anthropogenic CO2 emission sectors

- **Energy** – power industry, combustion for manufacturing, energy for buildings, oil refineries and transformation industry, aviation climbing & descent, aviation cruise, aviation landing & take off, railways, pipelines, off-road transport, shipping, road transportation;
- **Fugitive** (based on fuel production statistics, supplemented nightlight observations) – fuel exploitation;
- **Industrial processes** (use the volume of industrial product produced (and traded) from the industry statistics) – production and use of cement (!), lime, …, chemical processes, iron and steel production, non energy use of fuels, non-ferrous metals production, non-metallic minerals production;
- **Solvents and products use** (based on a combination of population and solvents statistics) – solvents in paint, degreasing and dry cleaning, chemical products;
- **Agriculture** (based on agricultural statistics) – agricultural soils, agricultural waste burning;
- **Waste** (based on a combination of population and solid and liquid waste product statistics) – solid waste incineration;
- **Other** (direct emissions from coal fires & the Kuwait oil fires) – fossil fuel fires.

Emissions from electricity and heat production and from road transport dominate global trends.

Estimation of CO2 emissions from fuel combustion

Tier 1 (simplest methodology) – concept of **conservation of carbon, from the fuel combusted into CO2**.

Estimation of CO2 emissions from fuel combustion for a given fuel (E_{Fuel}):

$$E_{Fuel} = FC * F_E, \text{ where:}$$

Fuel consumption (FC) – amount of fuel combusted;
Emission factor (F_E) – default emission factor (country-specific biomass burning CO2 emission - difficult to ascertain).

To obtain national totals **emissions are summed across** all fuels **and** all **sectors** of consumption.

Some countries use more sophisticated methods:
Tier 2 – more detailed statistics should be collected,
Tier 3 – includes modelling.

For more detailed explanation of emission calculation see **IPCC2006 Guidelines**.

Picture from http://ghginstitute.org

Global anthropogenic emissions of greenhouse gases datasets

	EDGARv4.3.2	CDIAC	EIA	IEA	BP
Time-series	1970-2012, fast track to 2015	1751-2014	1980-2011	1971-2014	1965-2015
Spatial resolution	0.1x0.1 deg				
Temporal resolution	annual, monthly for 2010	annual	annual	annual	annual
Geo-coverage	226 countries	224 countries	224 countries	137 countries, 3 regions	67 countries, 5 regions
Activity split	150 activities, 42 fossil and 15 bio fuels	5 main sectors, 42 fuel types	6 main sectors, 42 fuel types	64 activities, 42 fossil and 15 bio fuels	8 activities, 3 fossil and 3 other fuel types

- **Uncertainty of global inventory** is determined by the data **quality of largest emitting countries**.
- **High uncertainty** of global total GHG emissions:

i) **increasing** share of **emissions from countries with less developed statistical** infrastructure,
ii) **decreasing** share of **emissions from** the **well measured activities** (e.g. coal power plants).

CO2 Human Emission project: separating human impact from the natural carbon cycle

CO_2 Human Emissions

www.che-project.eu

- **22 partners** from eight European countries (United Kingdom, Netherlands, Sweden, Norway, Germany, France, Switzerland, Italy)
- explore the development of a **European system** to **monitor human** activity related **CO2 emissions across the world**
- efficient complimentary **use of** land and satellite **observations**, **modelling** and **data assimilation** methodologies

Necessity
of correct representation
of global uncertainties in CHE fluxes on the gridded map:
sector- + fuel- + country-specific approach is needed.

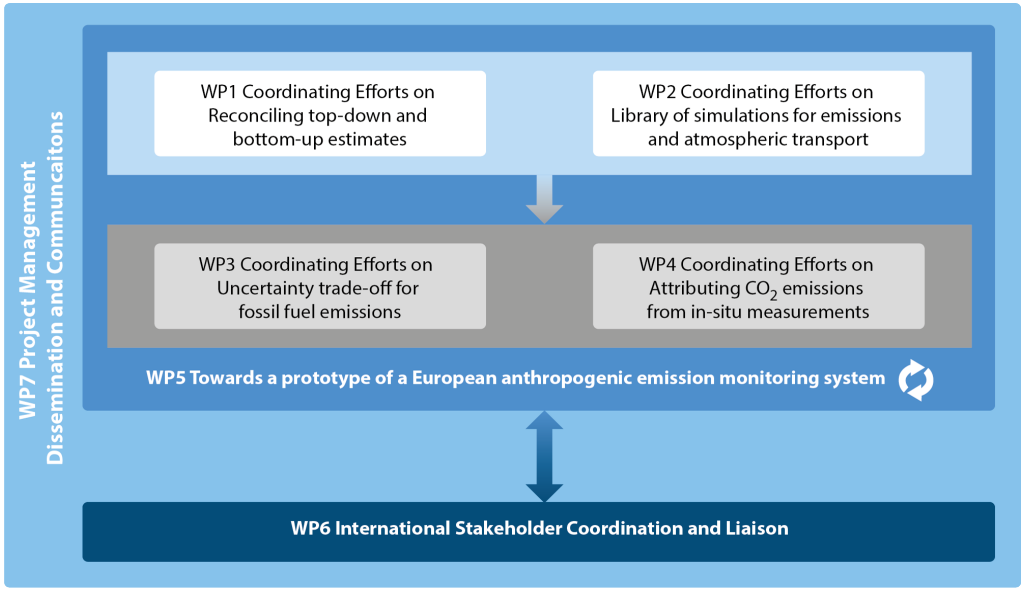


Diagram from www.che-project.eu

Thank you for your attention!

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Photo from www.neolaia.gr