ECMWF Anthropogenic CO_2 emission uncertainties

CO_2 Human Emissions

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Background

In **2015** average concentration of **CO_2 ~40% higher than in mid-1800s** - average **growth of 2 ppm/year** in last 10 years.

Fossil-fuel emissions are concentrated **in cities** or **close to power plants** - **largest** sources are **electricity & heat production** and **road transport**.

Global greenhouse gases **datasets** of **human emissions** (HE): EDGAR, CDIAC, EIA, IEA, etc.

Uncertainty of global inventory is determined by the data **quality of** the **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).

Necessity of CO_2 HE fluxes **global uncertainties** correct representation on the gridded map – **sector- + fuel- + country-specific approach** is needed.

IPCC → EDGAR → ECMWF grouping

Anthropogenic CO_2 emission **dataset** used is **EDGARv4.3.2_FT2015** – based on EDGARv4.3.2 source distribution and CO_2 emissions of 2015.

Energy sector is **divided into Super** and **Average power plant** emissions based on CO_2 **flux** threshold of **8.3E-06 kg/m²/s**.

Coal CO_2 emissions were calculated **from CH4 emissions** of brown and hard coal from **underground mining** (only grid-boxes with 6 and more zero neighbours were used) **multiplied** by (**5.9/18.0**) **ratio**.

Fossil Fuel Fires sector is **not used** as data in this sector is quite uncertain.

All **70 IPCC activities**, used in EDGAR sectors, are combined **into 7 ECMWF groups** taking into account:
- activity **type** (point sources, 3D field, etc.);
- amount of **knowledge** for the activity (uncertainty value);
- **geographical** distribution (e.g. over urban areas only);
- **size** of covariance **matrix** (optimal size is less than 10x10);
- use for CO_2 **co-emitting species** (e.g. CH4, CO, NO2).

ECMWF's anthropogenic CO_2 emission group **uncertainties** are **based on**:
- emission **budgets** per country per group;
- **uncertainty basic values** from IPCC Tier 1 approach based on error propagation method (+ correction if half-range uncertainty [100; 230]%):
  - ✓ separate values **for countries with well** (WDS) and with **less developed statistical systems** (LDS);
  - ✓ taking into account **most typical fuel** values:
    - ❑ aviation – Jet Kerosene;
    - ❑ railways – Diesel;
    - ❑ road/off-road transport – typical uncertainty for Emission Factor;
    - ❑ shipping – 80% Gas / Diesel Oil & 20% Residual Fuel Oil.
- way of defining **lognormal distribution** for **non-negative emissions** (applied if lower half-range of uncertainty ≥ 50%).

European human CO_2 emissions in 2015

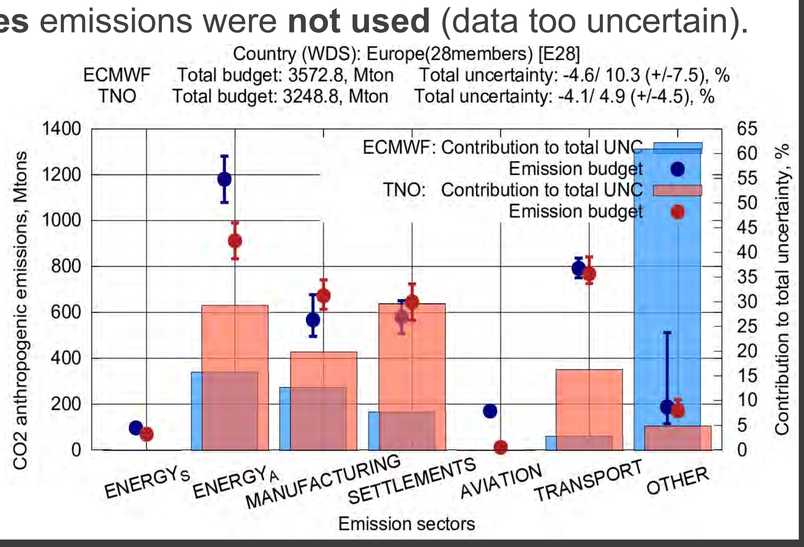
In order to **compare uncertainty** calculations for **ECMWF groups** based on EDGAR **global** emission budgets **regional** (for European countries only) **more detailed** anthropogenic CO_2 emission budgets of 2015 provided by Netherlands Organisation for Applied Scientific Research (**TNO**) were used.

Each **TNO sector** was **matched** with one or several IPCC activity → EDGAR sector → **ECMWF group** for further comparability of obtained results.

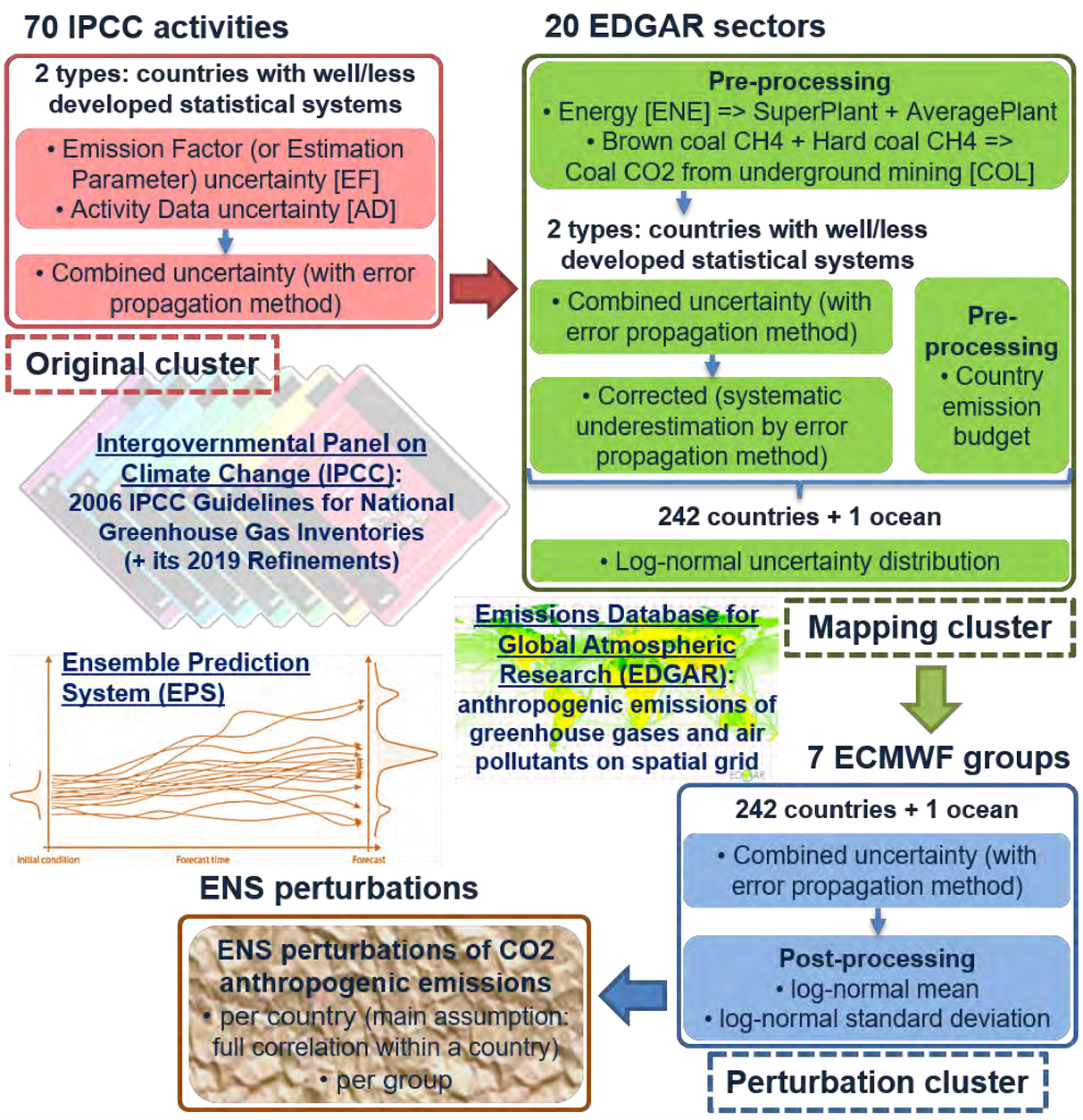
All **TNO activities** that **don't result** in CO_2 **long-cycle C** production, or, where **IPCC** suggests to **neglect** CO_2 emissions when using most basic Tier1 approach for uncertainty calculations, were **omitted**.

For **fuel dependant activities** the most **typical fuel** (**or Emission Factor**) was used. **Fossil Fuel Fires** emissions were **not used** (data too uncertain).

TNO emission **budgets** are **more detailed** so they are usually **less uncertain** than ECMWF ones. More detailed knowledge about rather uncertain activity budgets prior to combining with more certain ones leads to a reduction in combined CO_2 emission uncertainty.



IPCC methodology & input data chain

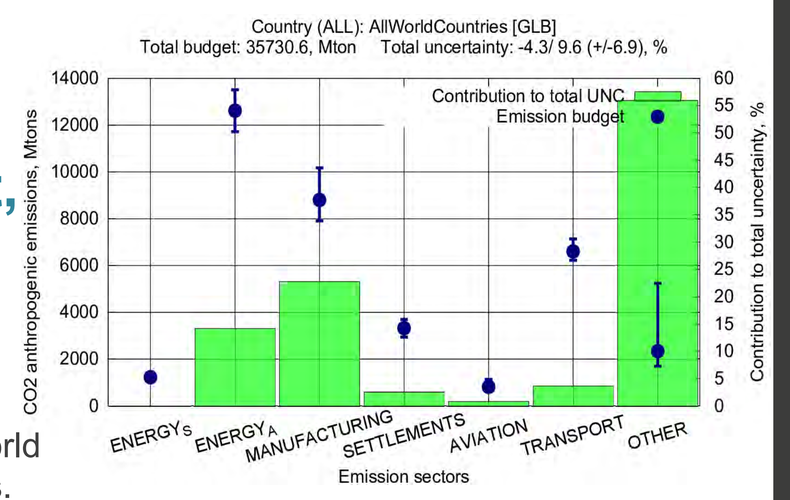


IPCC → EDGAR → ECMWF uncertainties

№	ECMWF group	EDGAR sector	EDGAR sector note	WDS countries		LDS countries	
				Lower	Upper	Lower	Upper
1	ENERGY_S	ENE	Power industry: SUPER emitting power plants	8.60	3.00	12.21	3.00
2	ENERGY_A	ENE	Power industry: AVERAGE emitting power plants	8.60	8.60	12.21	12.21
		SWD_INC	Solid waste incineration	40.31	40.31	41.23	41.23
3	MANUFACTURING	IND	Combustion for manufacturing	8.60	8.60	12.21	12.21
		IRO	Iron and steel production	37.08	37.08	37.08	37.08
		NFE	Non-ferrous metals production	73.17	73.17	73.17	73.17
		NEU	Non energy use of fuels	121.72	121.72	124.04	124.04
		NMM	Non-metallic minerals production	70.93	70.93	93.02	93.02
		CHE	Chemical processes	107.76	89.88	107.76	89.88
4	SETTLEMENTS	RCO	Energy for buildings	12.21	12.21	25.96	25.96
5	AVIATION	TNR_Aviation_CRS	Aviation cruise	5.54	6.44	50.06	106.79
		TNR_Aviation_CDS	Aviation climbing&descent	5.54	6.44	50.06	106.79
		TNR_Aviation_LTO	Aviation landing&takeoff	5.54	6.44	50.06	106.79
6	TRANSPORT	TRO	Road transportation	5.39	5.39	7.07	7.07
		TNR_Ship	Shipping	5.43	5.12	50.04	50.01
		TNR_Other	Railways, pipelines, off-road transport	50.33	106.87	50.54	106.99
7	OTHER	REF_TRF	Oil refineries and Transformation industry	54.35	149.29	57.70	151.43
		PRO	Fuel exploitation	191.10	339.06	210.90	364.47
		COL	Coal production	115.81	300.54	115.81	300.54
		AGS	Agricultural soils	70.71	0.00	70.71	0.00
		PRU_SOL	Solvents and products use	25.00	25.00	50.00	50.00

Global human CO_2 emissions in 2015: budget, uncertainties & contributions

Good **agreement** globally **with reported** country & world total and per sector budgets.



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Acknowledgements

This poster reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Supported by CO_2 Human Emission (CHE) project. The CHE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776186.