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Towards a global EDGAR-inventory of particulate matter with focus on elemental carbon

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Abstract

The Emissions Database for Global Atmospheric Research (EDGAR) provides technology based global anthropogenic emissions data of greenhouse gases and air pollutants by country and sector on a 0.1° x 0.1° spatial grid, on a timeline that ranges from 1970 to present days. As part of the constantly ongoing amendment and improvement of the database, a review of the available literature and emission inventory data has been conducted focusing on particulate emissions, with the aim of acquiring a comprehensive array of primary particle matter and carbonaceous particle emission factors (EF).

It was found, that emission factor data from different studies show large variation for a given fuel and technology. Furthermore it is plausible that a certain literature or measurement describes emission factors better in the region where it is originating from. With this in mind, a comparison has been made between the available emission factor datasets in a number of different regions, focusing on the power generation sector. The aim of this experiment is to select the most appropriate EF dataset for a given region.

1. Introduction

EDGAR provides a bottom up inventory of emissions that draws upon a number of input data sources, to calculate country, fuel and technology specific emissions. Data sources include international and national statistics (International Energy Agency for fuel share and activity data) other databases (Platts and Clean Coal for technology share) and scientific literature (for substance specific emission factors). Each data source contains and adds up to the uncertainty of the final calculated emission results, but there can be a particularly big variation between the emission factors implied by different literature.

In the process of acquiring new, additional particle matter and carbonaceous particle data for EDGAR, we sampled a number of literature tabulating emission factors for said compounds. From these sources EDGAR compatible datasets of PM10, black carbon and organic carbon emission factors were created. We then performed a comparison of these datasets, by calculating their respective emissions within the energy industry sector utilizing the same activity, technology and end-of-pipe data for each dataset, in order to verify the bottom-up emission calculation, to uncover the major differences & potential errors between EF datasets and to assist us in selecting the most appropriate EF dataset for a given region

2. Definition of discussed particulate matter compounds

Solid or liquid combustion products and airborne particles from anthropogenic activities or other sources form atmospheric particle matter (PM) that can be derived into multiple categories based on size, chemical composition or physical properties. The following section is to lay down a consistent terminology and define the particle matter compounds concerned within the scope of this paper.

Total Suspended Particles (TSP) comprises all airborne particles or aerosols.

PM10 is the fraction of PM/TSP with a mean particle diameter of 10microns or smaller.

PM2.5 is the fraction of PM/TSP with a mean particle diameter of 2.5microns or smaller.

A significant fraction of PM consists of **carbonaceous particles**, that largely contain different types of carbon compounds. They can be found in high concentrations especially in the submicron size range. [Kupiainen and Klimont 2004, Bond et al. 2004] Carbonaceous particles are mostly produced during incomplete combustion, and transported in the atmosphere. Throughout their atmospheric lifetime such particles are subjected to a number of different processes (condensation, coagulation, surface reactions) evolving their physical and chemical properties. [Vignati et. al. 2010].

Following the common terminology of the literature used for this work, carbonaceous particles that absorb solar radiation, and thus have a positive climate forcing effect are referred to as **black carbon** (BC) within this document. It should be noted however, that in measurement and quantification terminology “black carbon” may refer to the fraction of the above mentioned light absorbing carbonaceous particles that can be measured using optical methods while elemental carbon (EC) refers to the fraction observed with thermo-optical (refractory) methods. [Vignati et. al. 2010, Bond et. al 2004]

Organic carbon is the carbonaceous aerosol fraction with high organic compound content that is not black carbon, and has negative climate forcing effect

.

3. Methodology

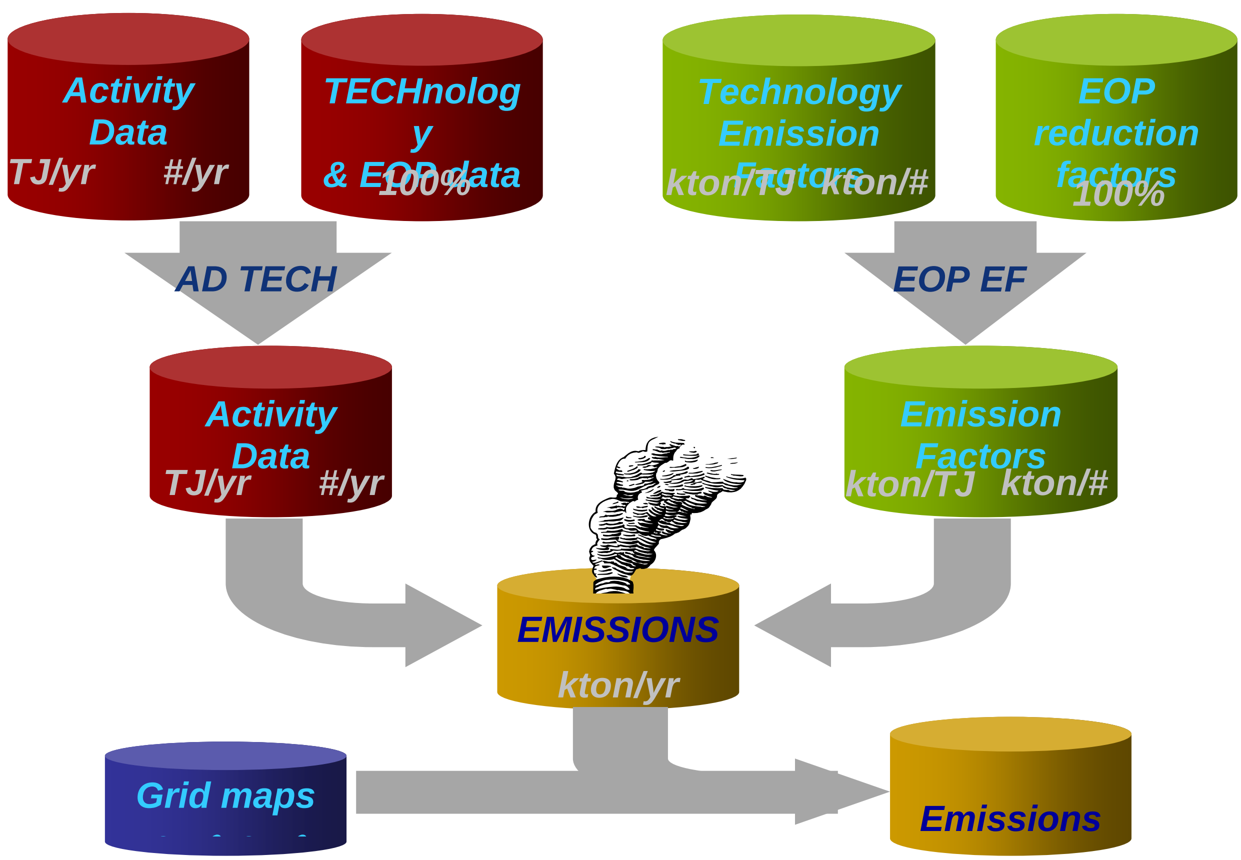
EDGAR uses a number of input data - such as emission factors, activity data (AD), abatement data, gridmaps - to calculate country and sector specific emissions:

Emissions (EM) for a country (C) are calculated for each compound (x) and sector (i) on an annual basis (y) by multiplying:

– the country-specific activity data (AD, quantifying the human activity for each of the sectors) with the mix of (j) technologies (TECH) for each sector, and with their abatement percentage by one of the (k) end-of-pipe (EOP) measures for each technology

– and country-specific emission factor (EF) for each sector and technology with relative reduction (RED) of the uncontrolled emission by installed abatement measures (k)

$$EM_C(y,x) = \sum_{i,j,k} \left[AD_{C,i}(y) * TECH_{C,i,j}(y) * EOP_{C,i,j,k}(y) * EF_{C,i,j}(y,x) * \left(1 - RED_{C,i,j,k}(y,x)\right) \right]$$



4. Literature sources for emission factors

Multiple sources of particulate EF data are available from a number of scientific literature, studies, emission inventories and guide books. From these sources multiple EF datasets have been derived that can be used for emission calculation input. The following is a short summary of the datasets examined within this document.

EMEP/EEA Guidebook, 2009

The United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution and the EU National Emission Ceilings Directive set up the Guidelines for Reporting Emission Data. Following these guidelines, the joint EMEP/EEA air pollutant emission inventory guidebook has been issued to provide guidance to compiling emission inventories.

The Guidebook provides estimation methods and emission factors at various levels of sophistication, known as Tiers. Whenever applicable, technology-specific Tier2 EFs were used in the dataset. Where technology specific data was not applicable or was not necessary, general (only fuel-specific) Tier1 EF-s were taken into account. Each EF value associated with the IPCC Code (or UNFCCC's Common Reporting Format) was matched with the appropriate EDGAR process codes to create the EF dataset. Values of PM10 and PM2.5 are available from this dataset.

GAINS

GHG-Air pollution INteractions and Synergies model was developed by Applied Systems Analysis (IIASA) as a tool for designing national and regional strategies that respond to global and long-term climate objectives. This EF dataset was assembled from the values provided by the GAINS-Europe model. It provides fuel-technology-country specific EFs as well as fuel-country specific ones.

Values of PM10, PM2.5, have been directly taken from the models database (Primes 2009 scenario for Germany), while, BC and OC EFs were calculated from TSP based on the fractions and method described in [Kupiainen and Klimont 2004]. Country specific EFs were used for European countries, while the rest of the world was assigned with the EFs of Spain, representing a generally higher rate of emissions.

Bond et al. 2004

The 2004 paper "A technology-based global inventory of black and organic carbon emissions from combustion" by T. Bond et. al. provides a comprehensive review of anthropogenic BC and OC emissions based on 1996 fuel consumption data.

With the methodology given in the paper, carbonaceous emission factors were calculated from the tabulated PM10 EFs using the given submicron and carbonaceous fractions data. PM10 emission factors of power and industry sectors were largely drawn from US EPA's report number AP-42. EFs were converted from g/kg units to kg/TJ units, by using fuel calorific values from 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The resulting emission factors are then associated with the appropriate EDGAR process codes depending on fuel and technology.

Lei et al. 2011

The study “Primary anthropogenic aerosol trends for China, 1990-2005” provides technology based emission data that largely draws on Chinese literature, which makes it a valuable source for acquiring country specific EFs. A set of fuel and technology specific PM emission factors is available from the paper, that is combined –in the case of the power sector- with the carbonaceous fractions used in [Bond et al 2004]. The actual EF dataset was created by taking the dataset based on Bond et al. 2004 and updating it with the available data from Lei et al. 2011.

EDGAR-HTAP

EDGAR-HTAP is not an emission factor dataset, but a compilation of different (official) emission inventories from EMEP, UNFCCC, EPA (USA), GAINS (China) and REAS, gap-filled with global emission data of EDGARv4.1 making it a harmonized global air pollution emission dataset for 2000 to 2005, providing PM10, PM2.5, BC and OC emission data. [Janssens-Maenhout et al. 2011]

Summary of data sources and dataset names

Source	Short name	EDGAR dataset name (user)
EDGAR-HTAP	EDGAR-HTAP	HTAP_V1(edgar_HTAP)
Bond et al., 2004	BOND	BOND_EM_ENE_17-04-2012(andras
GAINS model, 2010	GAINS	GAINS_EM_ENE_17-04-2012(andras)
EMEP/EEA Guidebook, 2009	EMEP/EEA	CORINAIR_PM10_EM_ENE_14-05-2012(andras)
EMEP/EEA Guidebook, 2009 without including EDGAR EoP data in the calculation	EMEP/EEA no EoP	CORINAIR_PM10_EM_NoEOP_14-05-2012(andras)

5. Comparison of emissions resulting from each emission factor dataset

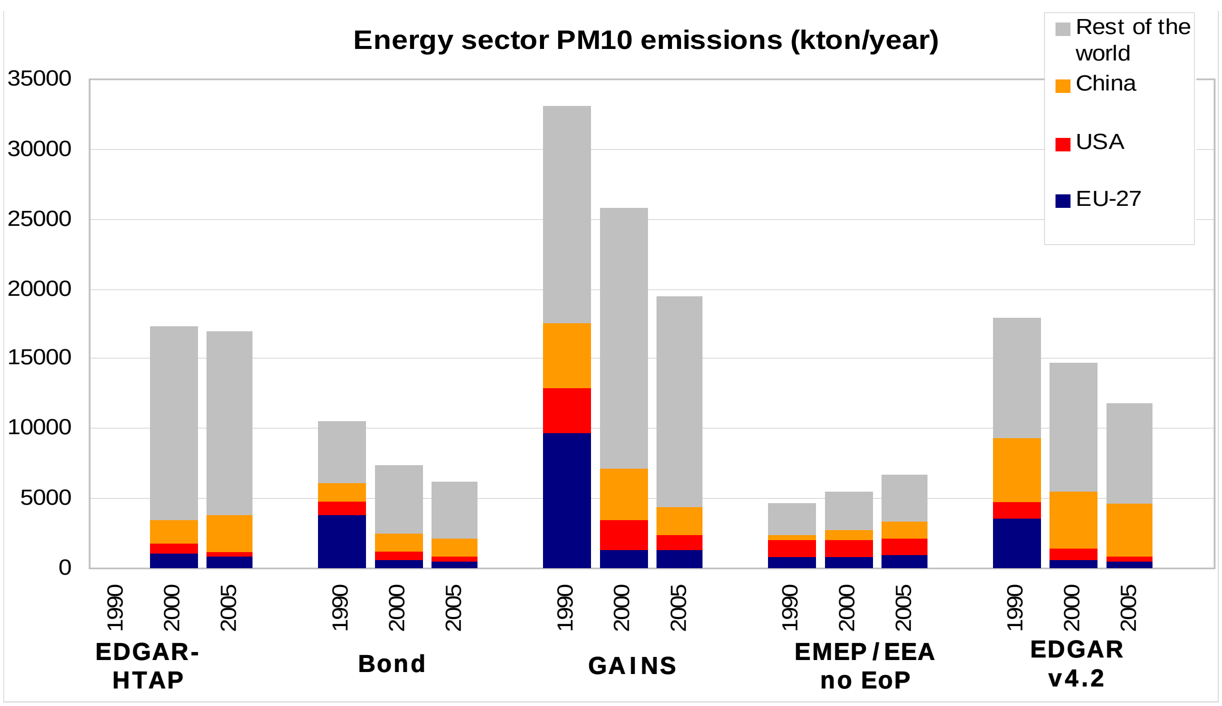
3.1 Description of the comparison process

It is clear, that the EF datasets differ in their origin of data and the studies they rely on. This can have an effect on their regional applicability. E.g. a dataset acquired from European sources and factors, may not fit well with technological circumstances in China. For this reason a comparison has been made between the datasets to reveal these differences, and at the same time to point to any possible errors.

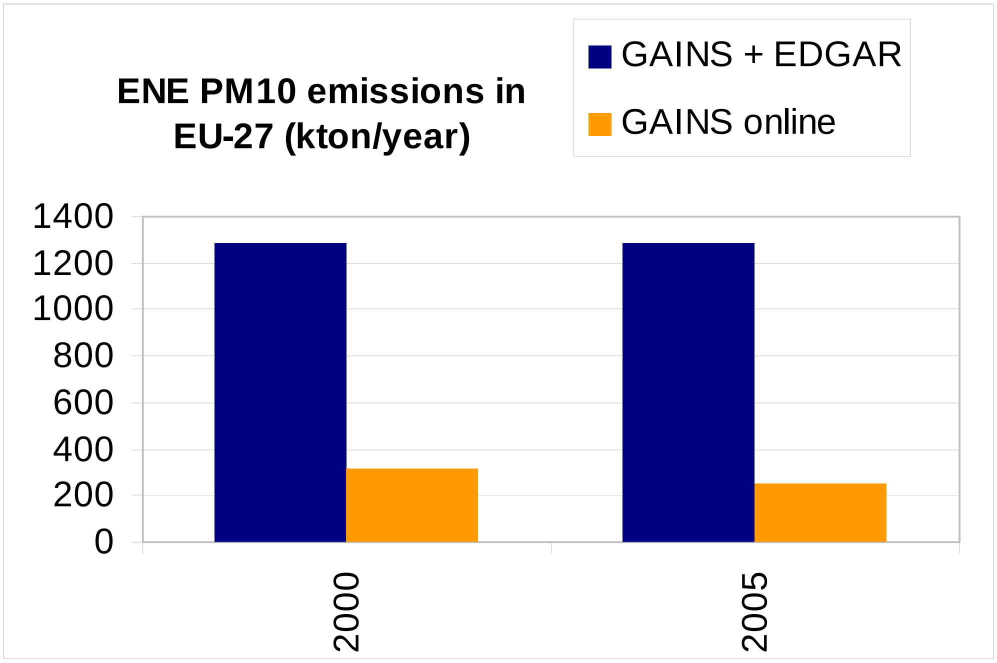
The same EDGAR technology activity dataset (v4.2_T_AD_emitting_final300911) and emission reductions dataset (v4.2_EOP) was applied to all the previously discussed EF datasets, and the resulting emission datasets (named after the EF dataset used for their calculation) were examined for Europe, USA, and China, concentrating on the power generation sector. The only exception is the EDGAR-HTAP emissions dataset that is not calculated by EDGAR, it is compiled from preexisting emission reports.

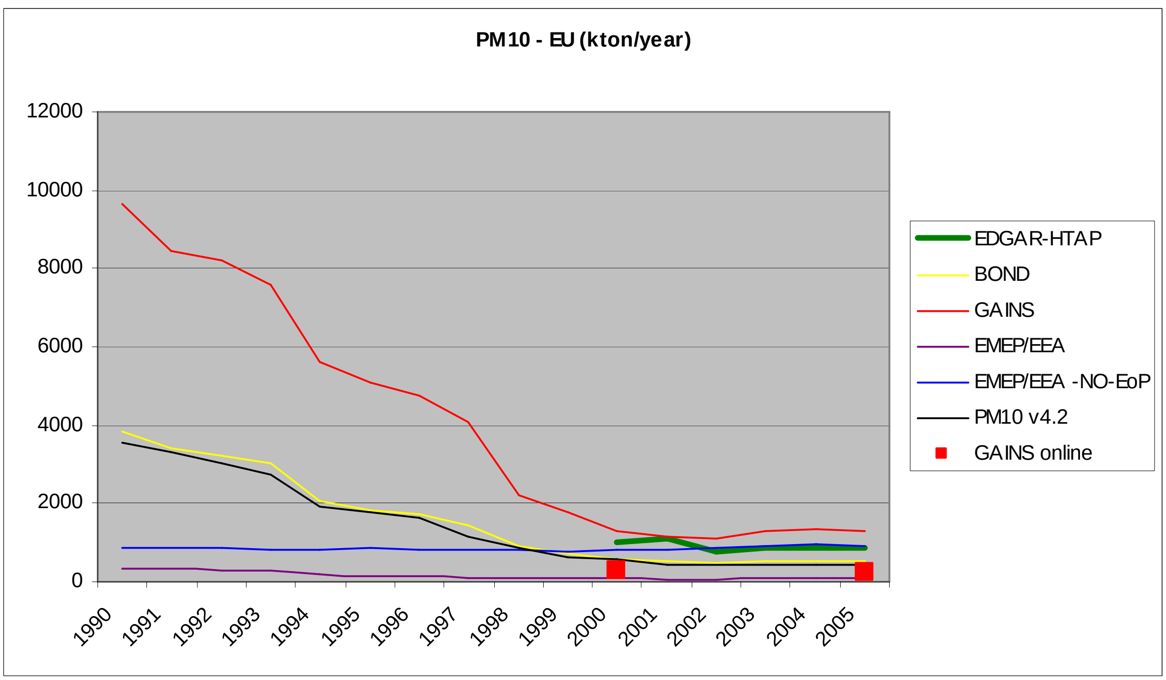
We chose the power generation as the subject of this experiment, because we have a good number of available EF datasets for this field, and have a more comprehensive and concise understanding of the technologies, abatements and trends of this sector, which makes the comparison of emission data more robust and representative.

3.1.1 PM10



GAINS values are consequently higher then the rest of the datasets, probably due to the fact that EDGAR uses a less strong set of end of pipe reduction factor dataset, then GAINS online. Using the same EF data of GAINS, our calculations are many factors higher then the online data of GAINS.





Europe

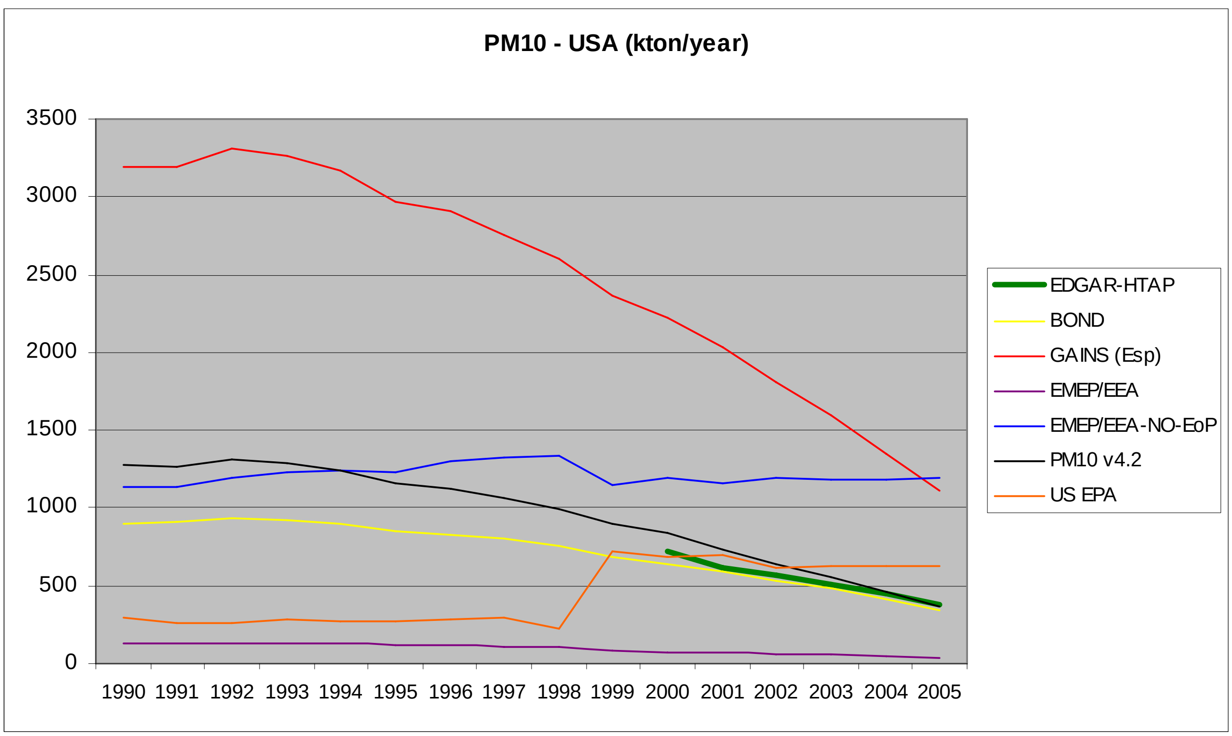
In the case of EU-27 countries the EDGAR-HTAP dataset contains PM10 emission data that have been officially reported within the frame of the EMEP program by the nations that are parties to the LRTAP Convention. For this reason, these emissions may serve as a good point of reference in the comparison of different datasets.

One of the first issues to notice is that the emissions of the power sector calculated with the EMEP/EEA EF dataset are multiple factors lower compared to other scenarios, which leads to the assumption that the EFs provided by EMEP/EEA guidebook are already abated values. No written reference was found in the EMEP/EEA guidebook to verify this, but through personal communication with Visschedijk we could confirm it. Thus in the process of emission calculation, applying EDGAR's own end of pipe data to these abated EMEP/EEA EF values results in abnormally low emission figures.

For this reason a separate emission factor dataset was created using the same EMEP/EEA EFs, but leaving out the step of applying EDGAR's end of pipe data (or more precisely: using an EoP dataset that assumes 0 reduction for all abatement technologies). The thus calculated emissions show good agreement with EDGAR-HTAP, but the trend lacks the influence of the abatement technology implementation taking place over time. For this reason, it is advisable to only use the EMEP/EEA-NO-EoP dataset for assessing post 2000 emissions

The BOND dataset produces 40% lower emissions compared to EDGAR-HTAP, while GAINS goes more than 50% over the country report based HTAP emissions data. As a result of abatement technology penetration in the power sector, both cases show a steadily declining trend, that stabilizes around the year 2000.

USA



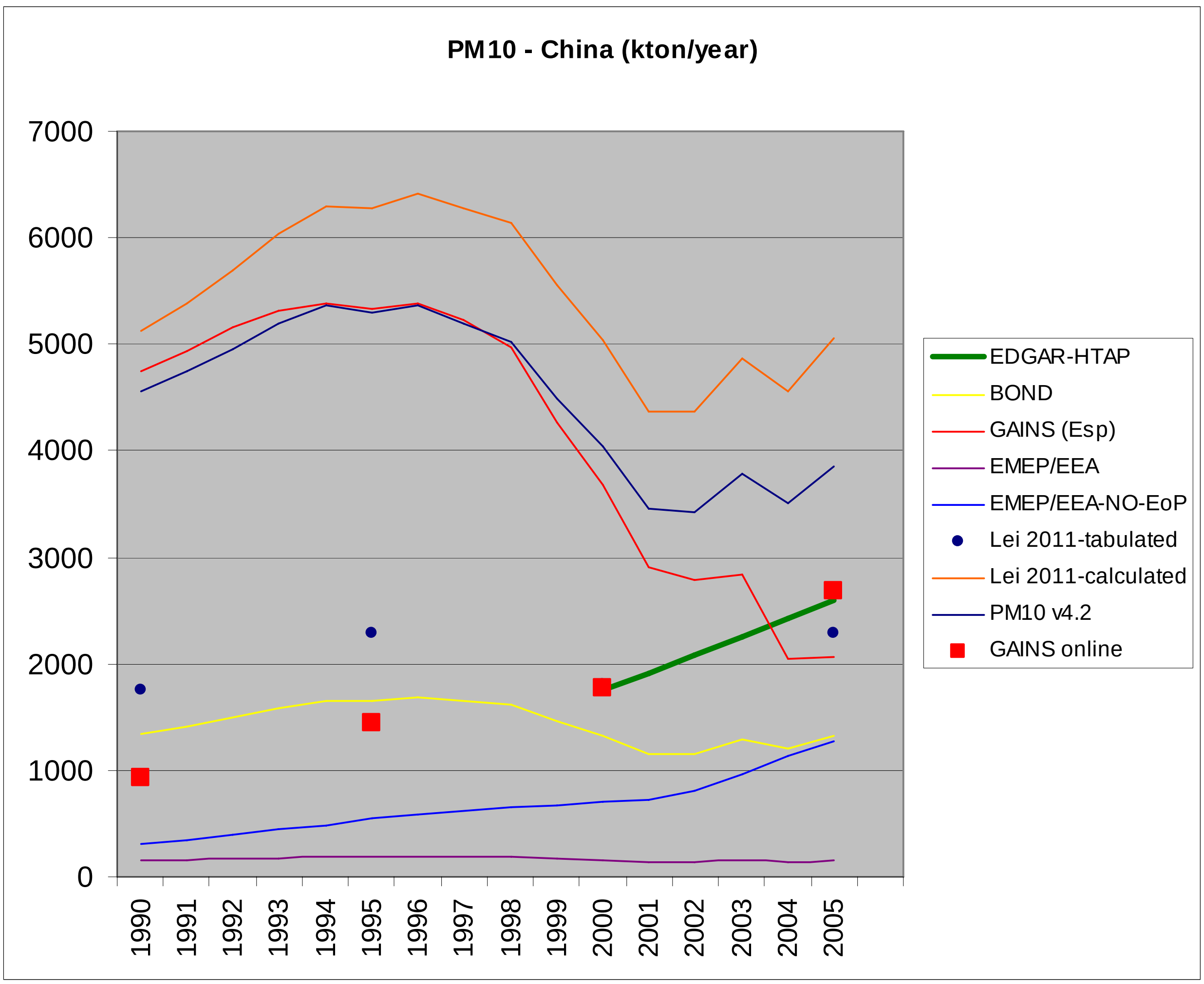
For USA, the EDGAR-HTAP dataset uses US EPA PM10 emission data. Additionally, PM10 data available from the EPA website (http://www.epa.gov/ttn/chief/trends/index.html) have also been tabulated (US EPA trend line). The sudden increase in emissions from 1999 is due to a change in methodology, namely the inclusion of condensable particulate matter in the inventory.

The EMEP/EEA dataset continues to provide low emissions, which the corrected EMEP/EEA-NO-EoP dataset counterweights, but again does not represent the trends of abatement measure penetration

The GAINS EF dataset associated the higher Spanish figures with this region, and this results in higher emission, that reaches the upper uncertainty range of the US EPA data only at the end of the time scale (assuming an uncertainty factor of 2).

The EDGAR-HTAP and BOND datasets show excellent agreement, most probably due to the fact that Bond relied mainly on the EPA's PM10 emission factors.

China



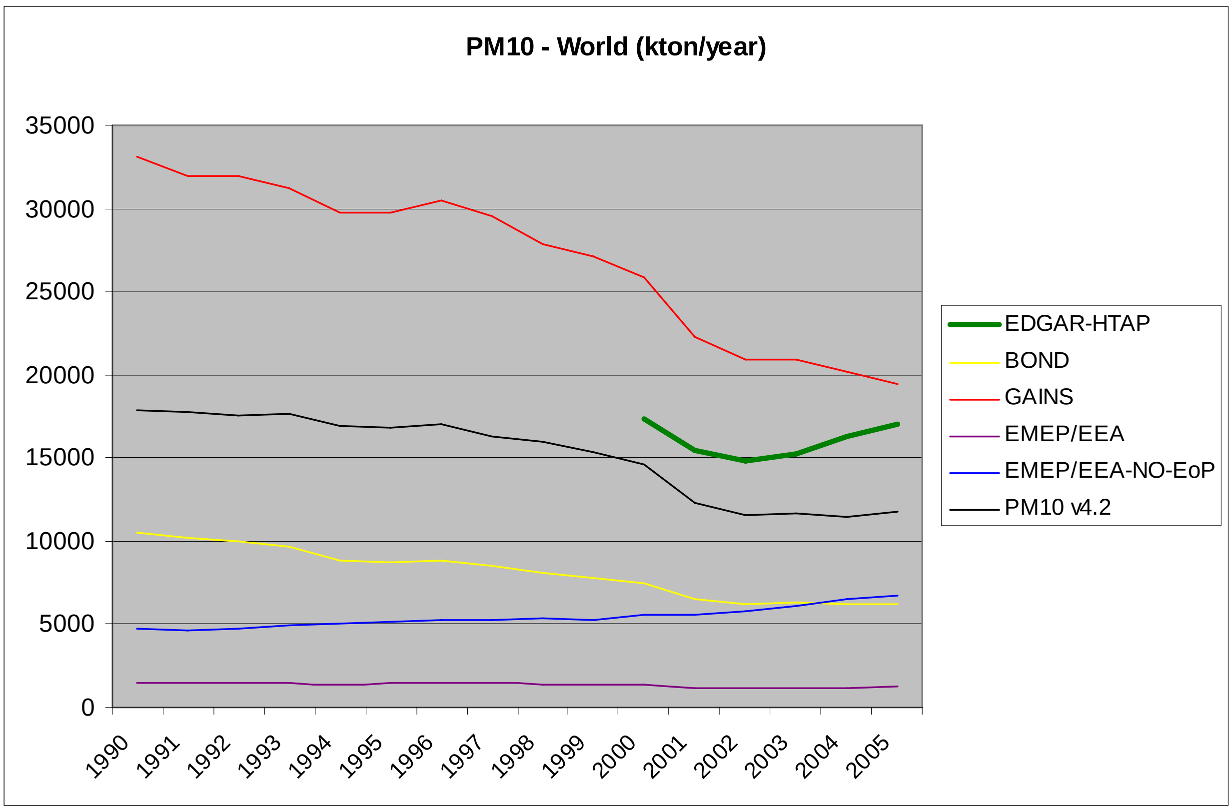
The 2011 work of Lei et al. provides a good point of reference, since it tabulates PM10 emission factors that are specific for the power sector of China. Namely the factors of pulverized and grate fired coal combustion were derived from Zhang et al., and these emission factors are 2-3 times higher than the values provided by the BOND or EMEP/EEA datasets. (Fuel oil and natural gas EF values in Lei et al. 2011. were taken from US EPA.) Using these factors we calculated the *Lei 2011-calculated* EM dataset, and at the same time included in the comparison the power sector emission values that Lei et al. 2011. provides (*Lei 2011-tabulated)* for 1990, 1995, 2000 and 2005 (i.e. these figures have been calculated by Lei et al. with their own activity and EoP data).

It's notable that *Lei 2011-tabulated* shows good agreement with the EDGAR-HTAP values, which in turn have been derived from GAINS China emission data [Janssens-Maenhout et al. 2011]. The significant difference between the Lei calculated and tabulated datasets derive from the significantly differing activity, technology and abatement data used.

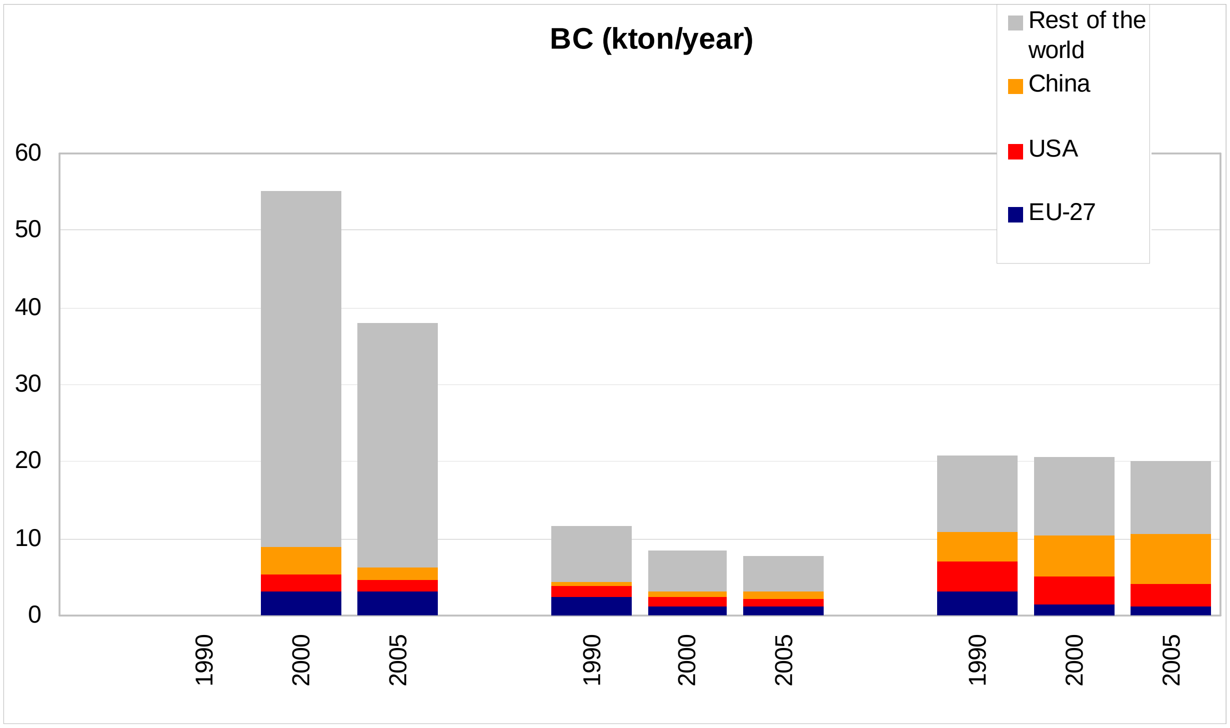
The GAINS dataset – utilizing Spanish emission factors also in the case of China – continues to give high emissions, while BOND values also remain consequently moderate compared to EDGAR-HTAP and Lei 2011-tabulated values.

It should also be noted, that this time EMAP/EEA-no-EoP emissions don't surpass the BOND values as they consequently did in the case of Europe and USA.

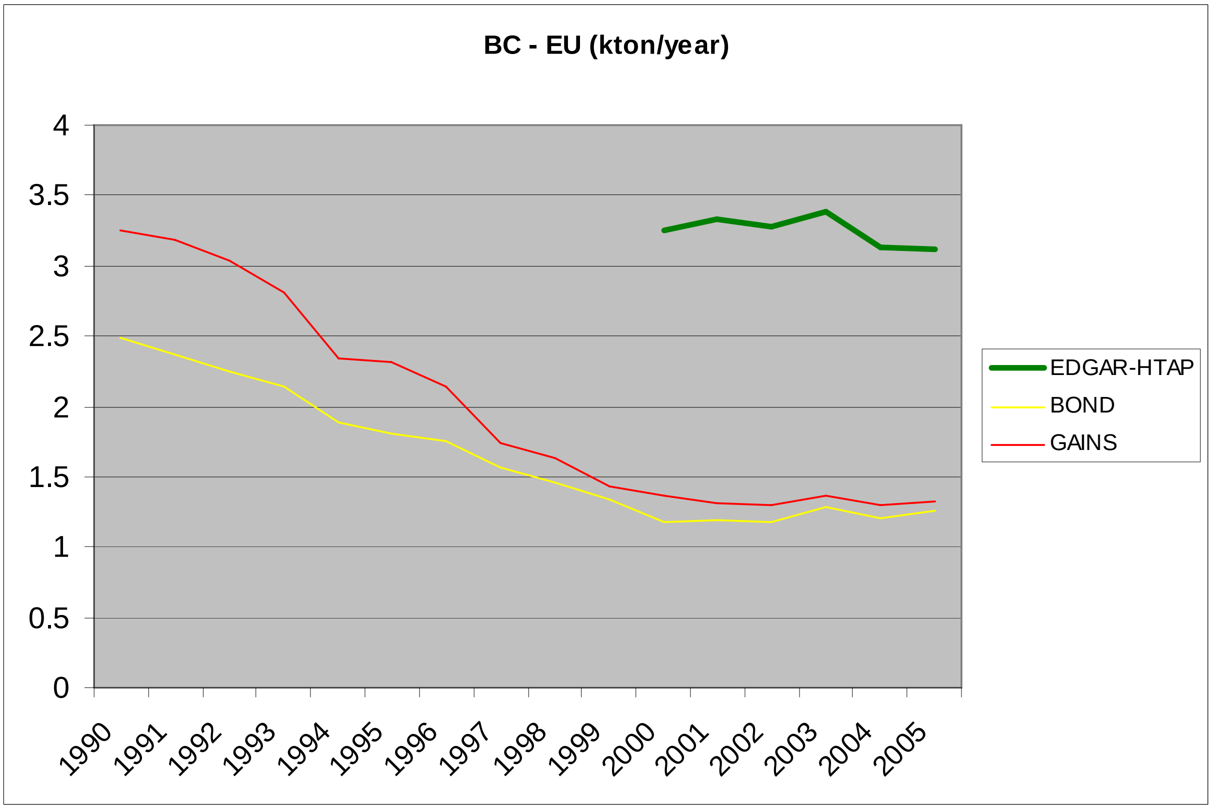
World



3.1.2 BC

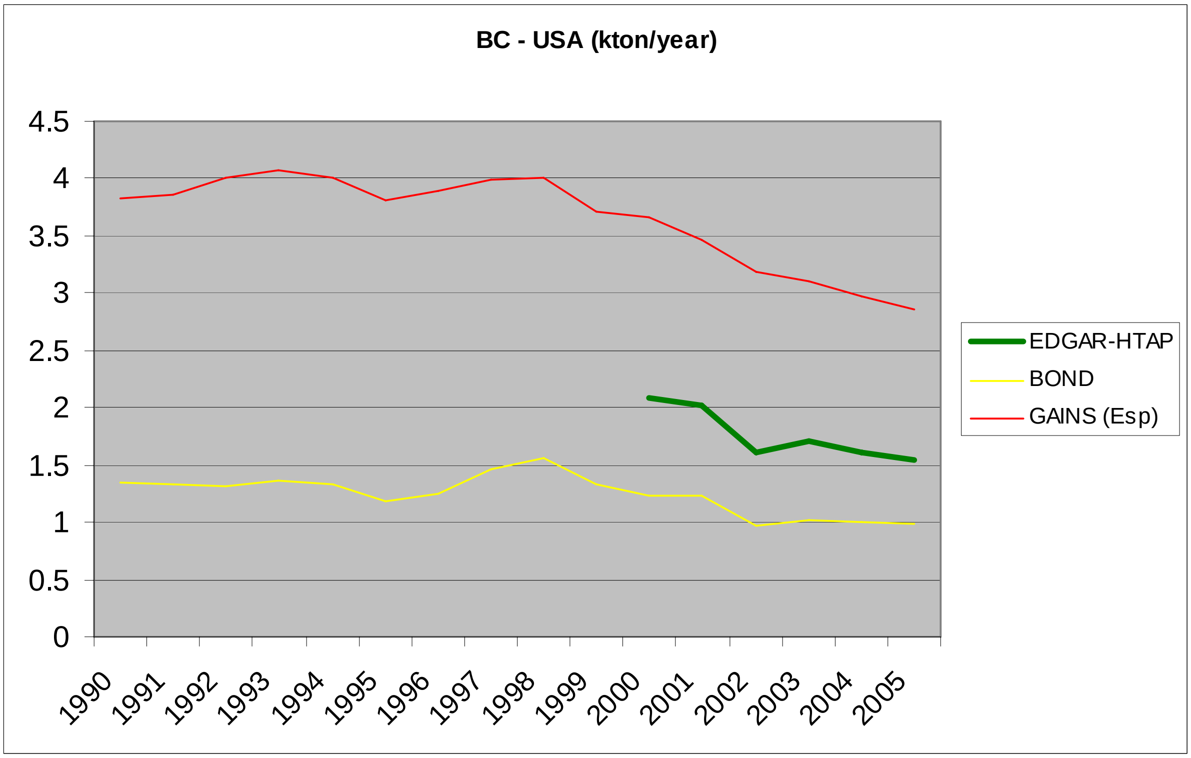


BC (kton/year)
Rest of the world
China
USA
EU-27
60
50
40
30
20
10
0
1990
2000
2005
1990
2000
2005
1990
2000
2005

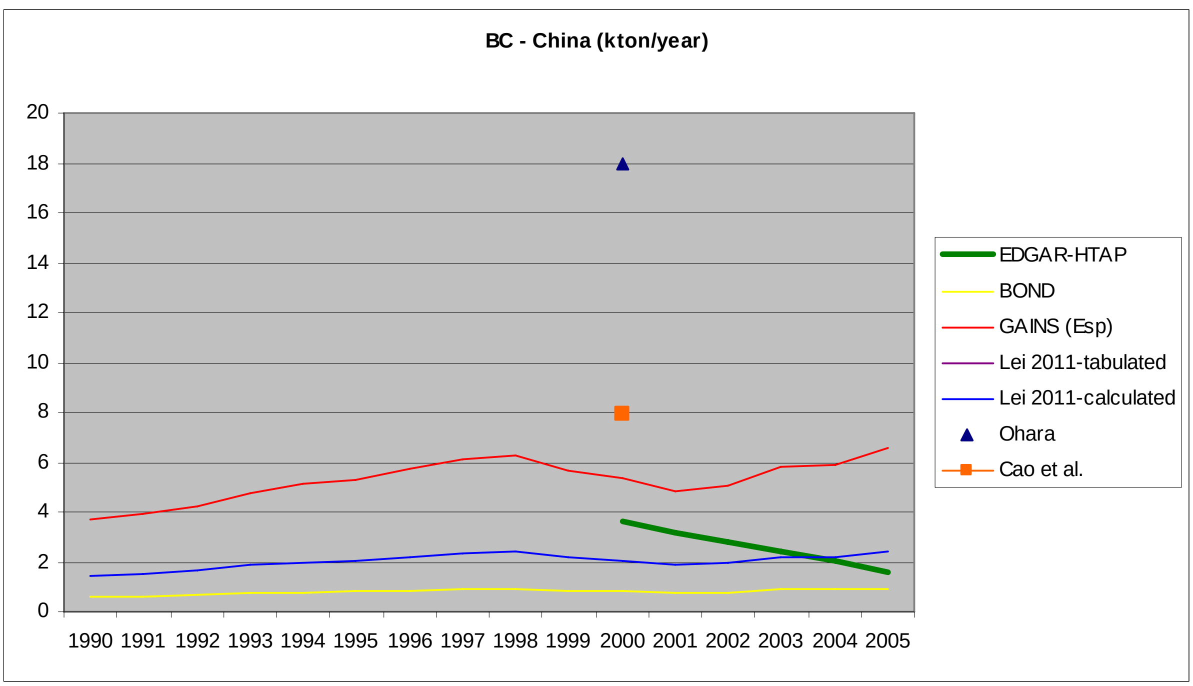


EDGAR-HTAP carbonaceous emissions for Europe and USA were gapfilled from EDGAR v4.1, thus they should be considered preliminary data. For China, GAINS data was used in the HTAP dataset.

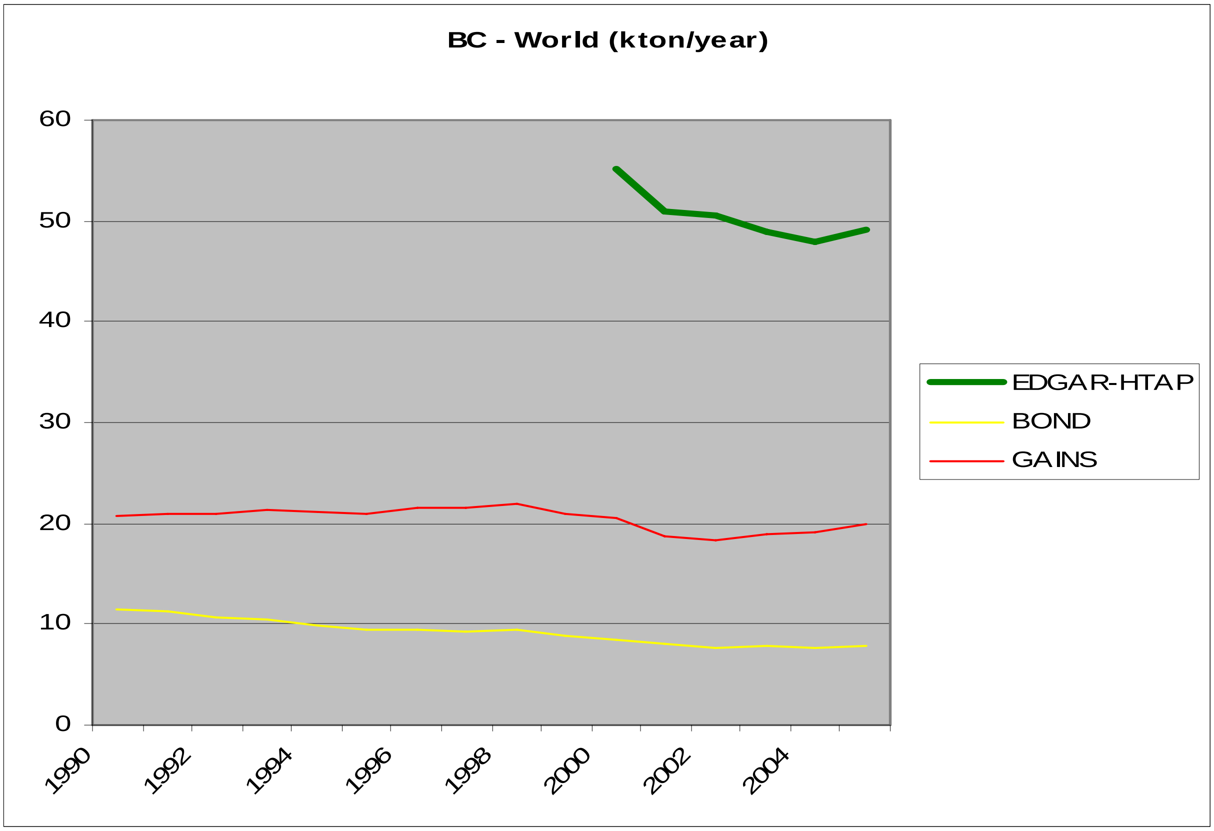
GAINS, BOND datasets however show good agreement for the EU-27, but show bigger differences in the USA.



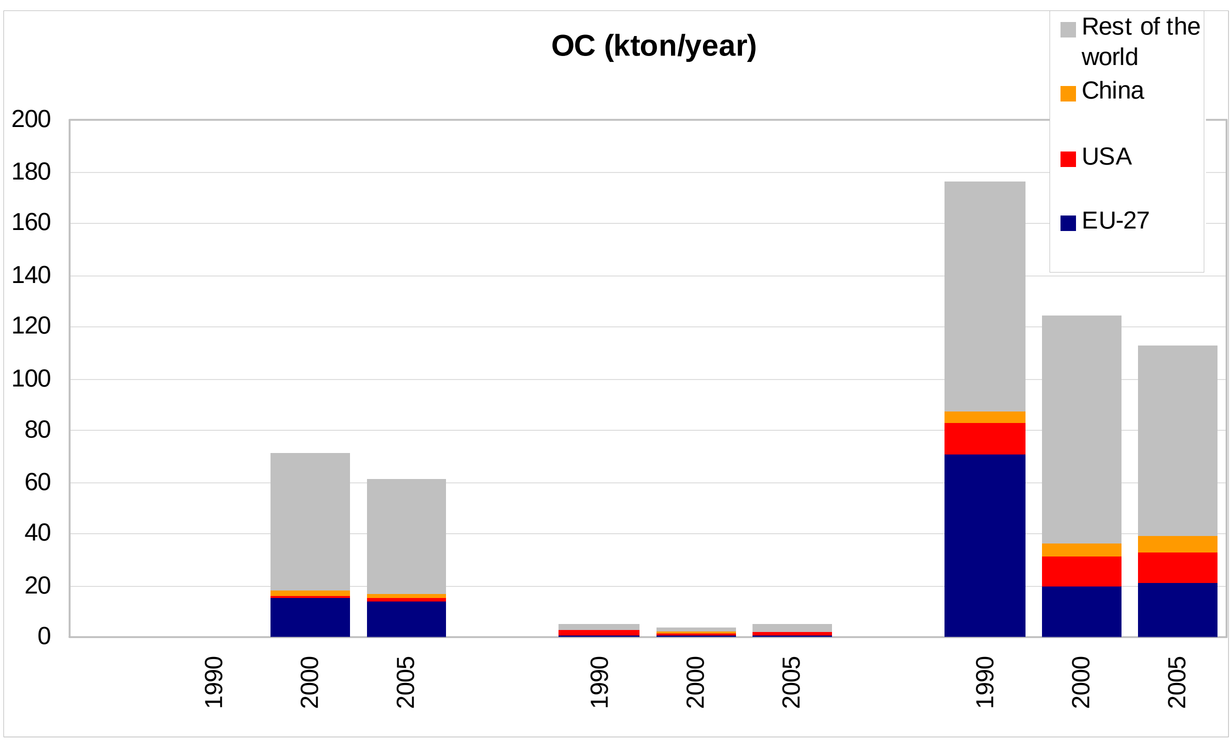
In China the tabulated Lei et al. 2011. values are too coarse to be used as reference (rounded up to a single value), instead, EDGAR-HTAP values supply regional data from the GAIN China model.



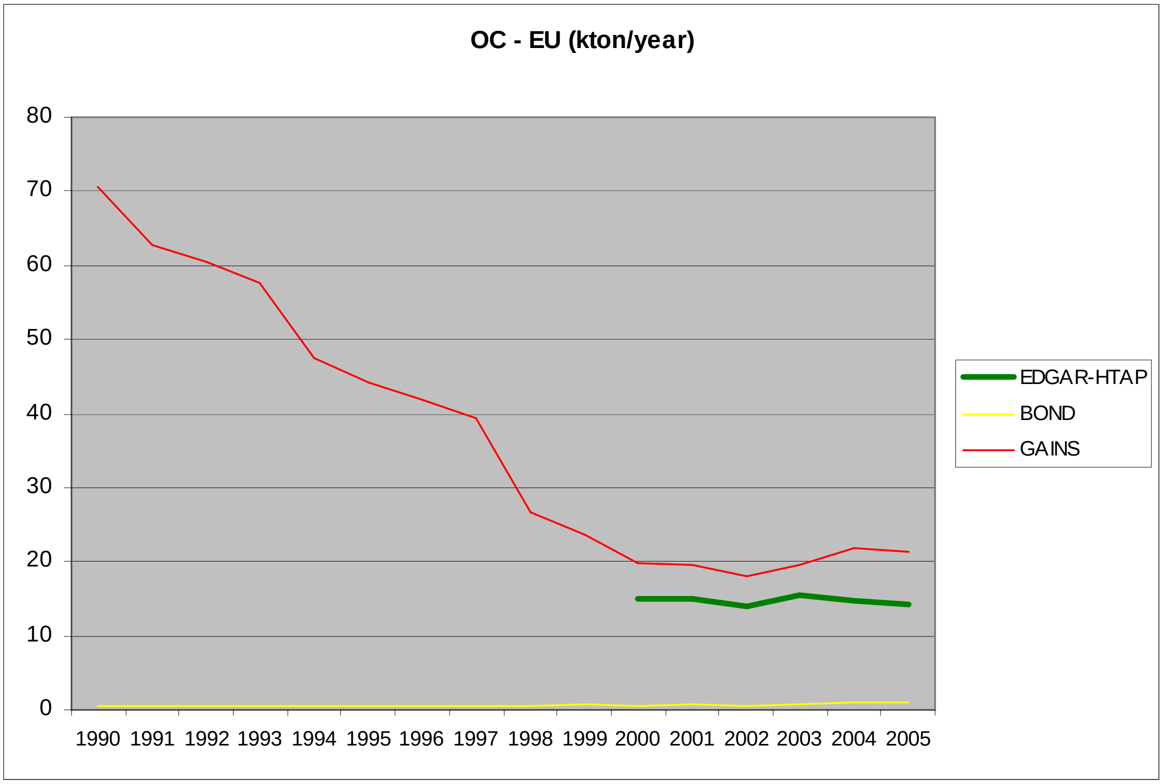
The Lei 2011-calculated BC emissions consequently scale above the trend lines of the EMEP/EEA and BOND datasets. Controversially EMEP/EEA-no-EoP emissions turn out lower then the ones calculated with emission reduction data.

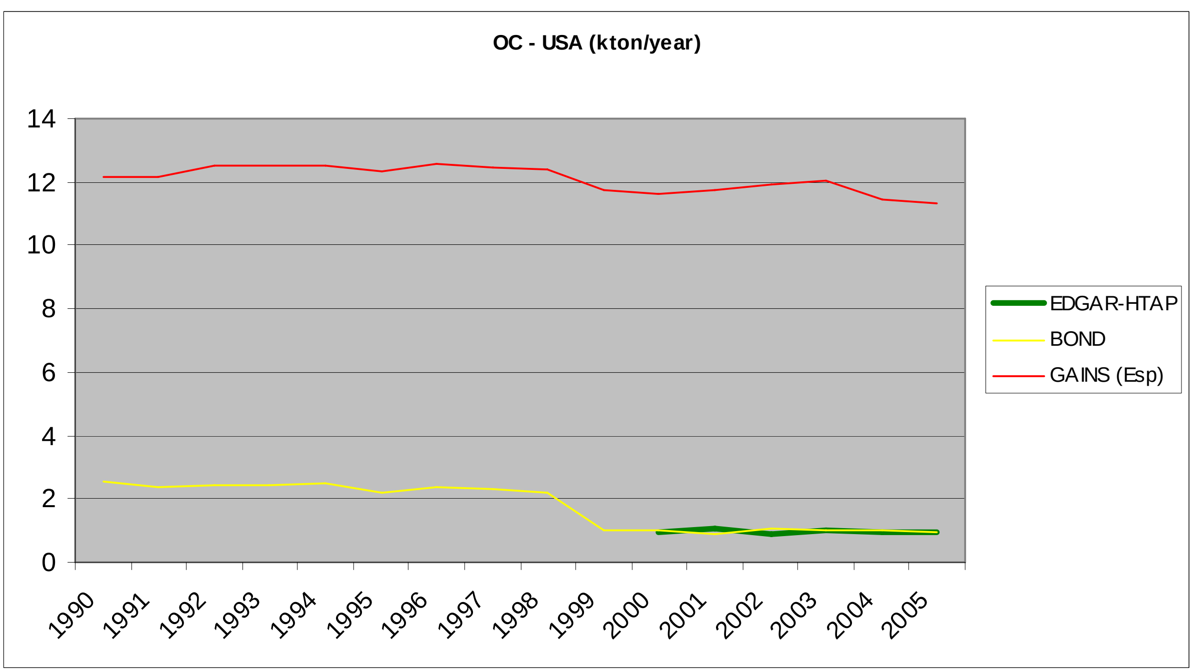

BC - World (kton/year)
60
50
40
30
20
10
0
1990
1992
1994
1996
1998
2000
2002
2004
EDGAR-HTAP
BOND
GAINS

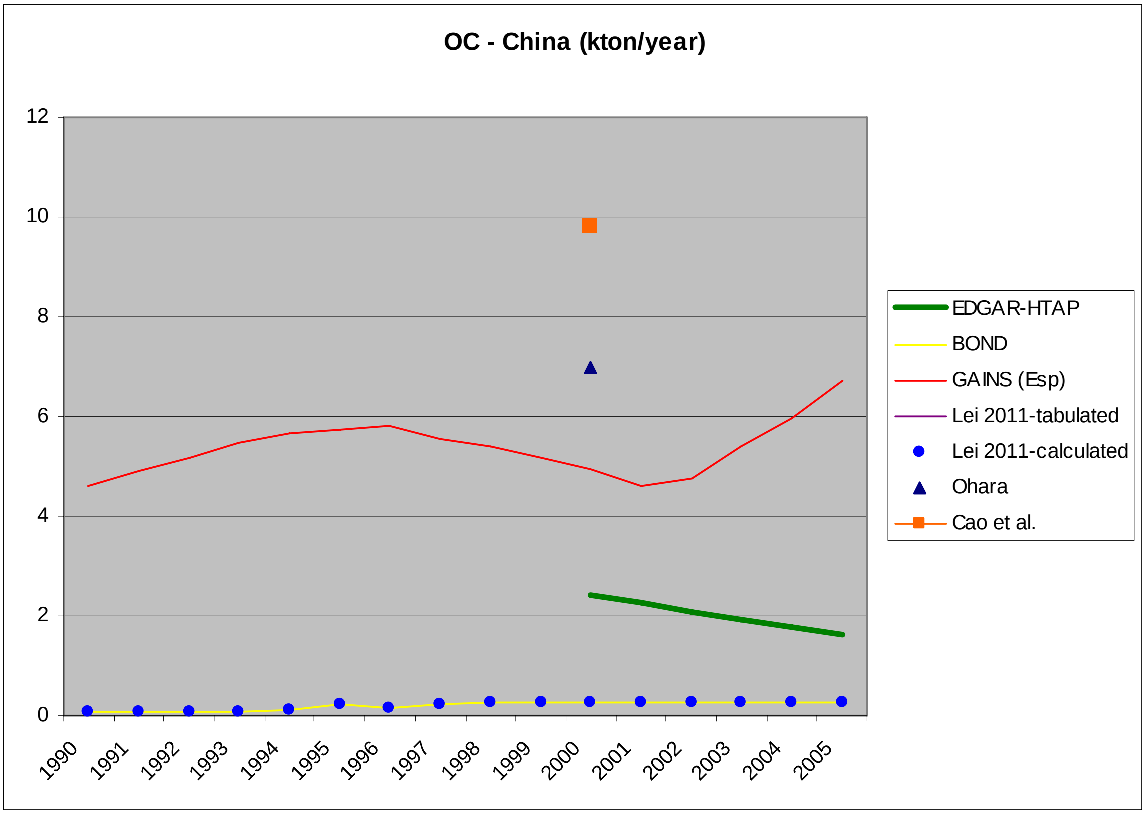
3.1.3 OC

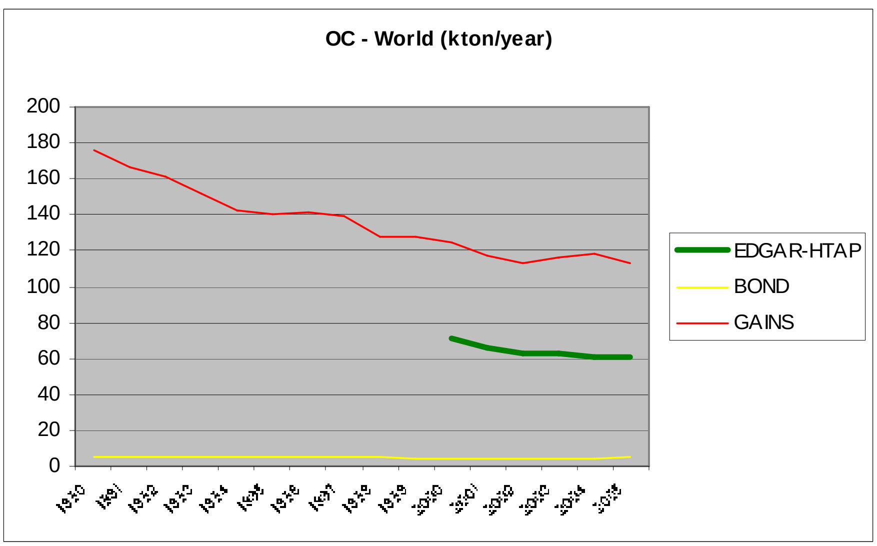

OC (kton/year)
Rest of the world
China
USA
EU-27
200
180
160
140
120
100
80
60
40
20
0
1990
2000
2005
1990
2000
2005
1990
2000
2005

OC emissions from BOND virtually exclude themselves from the comparison, since much of the coal combustion related OC emission factors (namely pulverized coal) are considered to be 0 according to Bond et al. 2004, and this leads to miniscule emission rates.

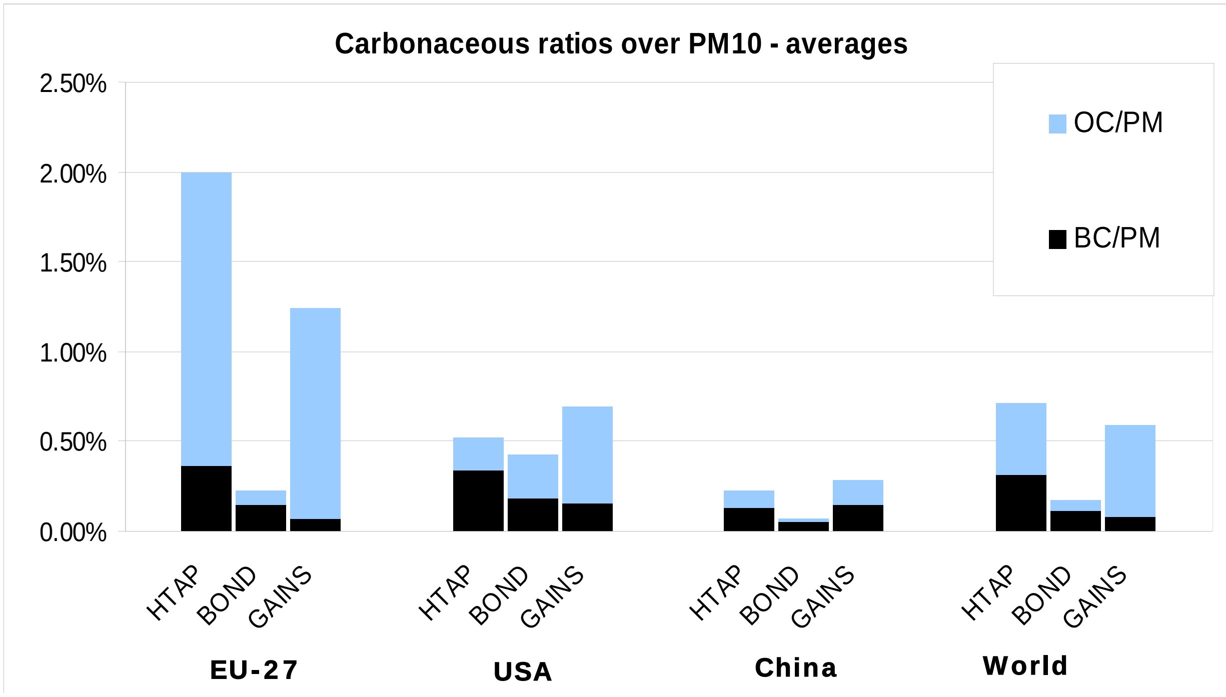








3.2 Discussion of the differences in PM inventories



BOND: Because PM10 emission factors of the power sector were largely drawn from US EPA's AP-42 report, this dataset shows good agreement with EDGAR-HTAP in the US and lies also closest to the inventory values of the US EPA. Thus this dataset is a good choice for describing USA power sector emissions for PM10.

References

Andreae, M. O. and Merlet., P.: Emission of trace gases and aerosols from biomass burning, Global Biogeochem. Cy., 15,955–966, 2001.

Andreae, M. O. and Gelencs´er, A.: Black carbon or brown carbon?The nature of light-absorbing carbonaceous aerosols, Atmos.Chem. Phys., 6, 3131–3148, 2006,http://www.atmos-chem-phys.net/6/3131/2006/.

Bond, T. C., Streets, D. G., Yarber, K. F., Nelson, S. M., Woo, J.H., and Klimont, Z.: A technology-based global inventory ofblack and organic carbon emissions from combustion, J. Geophys.Res.-Atmos., 109, D14203, doi:10.1029/2003JD003697,2004.

Bond, T. C. and Bergstrom, R. W.: Light absorption by carbonaceous particles: An investigative review, Aerosol Sci. Tech., 40,1-41, 2006.

Chung, S. H. and Seinfeld, J. H.: Global distribution and climate forcing of carbonaceous aerosols, J. Geophys. Res., 107(D19), 4407, doi:10.1029/2001JD001397, 2002.

Cofala, J., Amann, M., Klimont, Z., Kupiainen, K., and H¨oglund-Isaksson, L.: Scenarios of global anthropogenic emissions of air pollutants and methane until 2030, Atmos. Environ., 41, 8486–8499, 2007

Dentener, F., Kinne, S., Bond, T., Boucher, O., Cofala, J., Generoso,S., Ginoux, P., Gong, S., Hoelzemann, J. J., Ito, A., Marelli, L.,Penner, J. E., Putaud, J.-P., Textor, C., Schulz, M., van der Werf,G. R., and Wilson, J.: Emissions of primary aerosol and precursor gases in the years 2000 and 1750 prescribed data-sets for AeroCom, Atmos. Chem. Phys., 6, 4321–4344, 2006,http://www.atmos-chem-phys.net/6/4321/2006/.

Echalar, F., Artaxo, P., Martins, J. V., Yamasoe, M., Gerab, F.,Maenhaut, W., and Holben, B.: Long-term monitoring of atmospheric aerosols in the amazon basin: Source identification and apportionment, J. Geophys. Res.-Atmos., 103, 31849–31864, 1998.

Guillaume, B., Liousse, C., Rosset, R., Cachier, H., Van Velthoven,P., Bessagnet, B., and Poisson, N.: ORISAM-TM4: A new global sectional multi-component aerosol model including SOA formation - Focus on carbonaceous BC and OC aerosols, Tellus B, 59, 283–302, 2007.

IPCC: The Physical Science Basis, in: Contribution of Working Group I ot the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, ISBN 978 0521 88009-1 Hardback; 978 0521 70596-7 Paperback, 2007.

Jacobson, M. Z.: Global direct radiative forcing due to multicomponent anthropogenic and natural aerosols, J. Geophys. Res.-Atmos., 106, 1551–1568, 2001.

Jacobson, M. Z.: Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming, J. Geophys. Res.-Atmos., 107(D19), 4410,doi:10.1029/2001JD001376, 2002.

Junker, C. and Liousse, C.: A global emission inventory of carbonaceous aerosol from historic records of fossil fuel and biofuel consumption for the period 1860-1997, Atmos. Chem. Phys., 8, 1195–1207, 2008, http://www.atmos-chem-phys.net/8/1195/2008/.

Koch, D., Bond, T. C., Streets, D., Unger, N., and van der Werf, G. R.: Global impacts of aerosols from particular source regions and sectors, J. Geophys. Res.-Atmos., 112, D02205, doi:10.1029/2005JD007024, 2007.

Matsumoto, K., Uematsu, M., Hayano, T., Yoshioka, K., Tanimoto, H., and Iida, T.: Simultaneous measurements of particulate elemental carbon on the ground observation network over the western North Pacific during the ACE-Asia campaign, J. Geophys. Res.-Atmos., 108(D23), 8635, doi:10.1029/2002JD002744, 2003.

Penner, J. E., Eddleman, H., and Novakov, T.: Towards the development of a global inventory for black carbon emissions, Atmos.Environ. A-Gen, 27, 1277–1295, 1993.

Schaap, M., Denier Van Der Gon, H. A. C., Dentener, F. J., Visschedijk,A. J. H., Van Loon, M., ten Brink, H. M., Putaud, J. P.,Guillaume, B., Liousse, C., and Builtjes, P. J. H.: Anthropogenic black carbon and fine aerosol distribution over Europe, J. Geophys. Res.-Atmos., 109, D18207, doi:10.1029/2003JD004330, 2004.

Annex 1. Details for the Bond 2004 EF dataset

1. *Power sector relevant technologies:*

Technology definitions		Reference/ chapter	Associated EDGAR technology
stoker	Stokers, coal beds - coal is burned on grates, with various feeding and airflow mechanisms, not used for modern powerplants, but still employed in smaller applications, and developing coutries	5.2.2	GF0
traditional	Large stoker boilers for building heat, common in Europe	5.6.2	
	Bark and wood boilers for process heat and power industry	5.6.2	PD0
	Large industrial traditional ovens in developing countries for example drying and processing food	5.62	
cyclone	Cyclone furnaces, fuel particles are suspended in the oxidizer	5.2.1	
pulverized	Pulverized coal furnace , fuel particles are suspended in the oxidizer	5.2.1	PD0
all (heavy fuel oil)	Residual fuel oil, termed 'heavy fuel oil,'' is burned in **external** combustion devices such as furnaces and boilers.	5.5	BO0, GT0, IC0
industry/power	Middle distillates are burned in **external** combustion devices such as furnaces and boilers.	5.5	GT0, IC0
generator	Middle distillates can also be used for small-scale heat or electricity production in stationary **internal** combustion generators - fine fraction and speciation data are taken from diesel automobiles	5.5	
external combustion	Middle distillates are burned in **external** combustion devices such as furnaces and boilers.	5.5	BO0
all (solid waste)	No size-resolved data; used fraction of total filterable PM from stokers, which is the most similar combustion.	5.7, table 5. footnote	PD0,GF0
all (natural gas)		5.5	BO0, GT0, IC0

- For GT0 and IC0 the Bond emission factors of *"industry/power-middle distillates"* were used instead of the *"generator-middle distillates"*, because generator emission values did not resemble the power industry related values of CORINAIR or GAINS (Bond values are probably for small scale/commercial/industrial/residential).
- Updated EF PM and fraction values were used for "stoker-hard coal" from Bond 2007.

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2. *Fuels:*

In comparison with the original EDGAR fuel classification, for compatibility reasons the following modifications were applied:

- Peat is considered as “Bond - brown coal”
- *Bagasse* and *Black Liquor* are considered to be solid biomass
- *Biodiesel* and *biogasoline* are considered as “Bond - light oils”
- *Liquid biomass* and *Other liquid biofuels* are classified as “Bond - heavy fuel oils”
- All gaseous fuels are classified as “Bond natural gas”.

Name	Code	group		Name	Code	group
Anthracite	ANT	Hard coal		Natural Gas	NGS	Natural Gas
Other Bituminous Coal	BTC	Hard coal		Blast Furnace Gas	BFG	Natural Gas
Coking Coal	CKC	Hard coal		Gas Works Gas	GGS	Natural Gas
Coal Tar	CLT	Hard coal		Elec/Heat Output from Non-spec. Manuf. Gases	MNG	Natural Gas
Gas Coke	GCK	Hard coal		Coke Oven Gas	OGS	Natural Gas
Hard Coal (if no detail)	HDC	Hard coal		Refinery Gas	RGS	Natural Gas
Coke Oven Coke	OCK	Hard coal		Oxygen Steel Furnace Gas	SGS	Natural Gas
Patent Fuel	PAT	Hard coal		Charcoal	CHA	Solid biomass
Sub-Bituminous Coal	SBC	Hard coal		Dung	DNG	Solid biomass
BKB/Peat Briquettes	BKB	BKB		Industrial Waste	IWS	Solid biomass
Brown Coal (if no detail)	BRC	Brown coal		Municipal Waste (Renew)	MWR	Solid biomass
Lignite/Brown Coal	LGN	Brown coal		Non-specified Combust. Renewables + Wastes	NSF	Solid biomass
Peat	PEA	Brown coal		Primary Solid Biomass (non-specified)	SBI	Solid biomass
Municipal Waste (Non-Renew)	MWN	Solid waste		Vegetal waste	VWS	Solid biomass
Bitumen	BIT	Heavy oils		Wood	WOD	Solid biomass
Crude/NGL/Feedstocks (if no detail)	CNF	Heavy oils		Biodiesel	BDS	Light oils

Crude Oil	CRU	Heavy oils	Biogasoline	BGL	Light oils
Gas/Diesel Oil	DIE	Heavy oils	Bagasse	BGS	Solid biomass
Residual Fuel Oil	HFO	Heavy oils	Black Liquor	BLI	Solid biomass
Lubricants	LUB	Heavy oils	Liquid Biomass	LBI	Heavy oils
Other Hydrocarbons	NCR	Heavy oils	Other Liquid Biofuels	OLB	Heavy oils
Petroleum Coke	PCK	Heavy oils	Biogas	GBI	Derived gases
Paraffin Waxes	PWX	Heavy oils	Electricity	ELE	Energy carrier
Refinery Feedstocks	RFD	Heavy oils	Heat	HEA	Energy carrier
Additives/Blending Components	ADD	Light oils	Heat Output from non-specified comb fuels	HNS	Energy carrier
Aviation Gasoline	AVG	Light oils	Other fuel sources of electricity	OFS	Energy carrier
Ethane	ETH	Light oils	Geothermal	GEO	Renewable
Gasoline Type Jet Fuel	GJE	Light oils	Hydro	HYD	Renewable
Kerosene Type Jet Fuel	JET	Light oils	Solar Photovoltaics	SLP	Renewable
Liquefied Petroleum Gases (LPG)	LPG	Light oils	Solar Thermal	SLT	Renewable
Motor Gasoline	MOG	Light oils	Tide, Wave and Ocean	TID	Renewable
Naphtha	NAP	Light oils	Wind	WIN	Renewable
Natural Gas Liquids	NGL	Light oils	Nuclear	NUC	Nuclear
Kerosene	OKE	Light oils			
Non-specified Petroleum Products	OPR	Light oils			
White Spirit & SBP	WSP	Light oils			

3. *Methodology*

PM 10 emission factors and fraction values were extracted from the Bond 2004 paper, table 5. These values were used to calculate BC and OC EFs, using the equations from the paper. These EFs are converted from g/kg units to kg/TJ units, by using fuel calorific values from IPCC.
The emission factors are then disaggregated and matched to the appropriate EDGAR process codes, based upon fuel and technology.

GAINS dataset summary

				GAINS - calculated EU 27				GAINS - Report			
Fuel		**Tech**	**TSP**	**PM1**	**BC**	**OC**	**[kg/Tj]**	**PM1**	**BC**	**OC**	**BC/OC**
GAS	AVERAGE		0.100	0.100	0.007	0.075		0.100	0.007	0.075	0.093333
LF	AVERAGE		2.022	0.202	0.101	0.016	MLT higher values	0.22-0.36	0.11-0.18	0.018-0.029	6.25
HF	AVERAGE		20.700	8.280	0.890	0.393	MLT and GRC higher values	6.9-7.8	0.74-0.84	0.33-0.37	2.263158
BKB	AVERAGE		228.599	11.430	0.076	1.257	I used the % in TSP from brown coal				0.060606
brown coal	AVERAGE	FB0	16854.456	842.723	0.000	105.340	data from PD0				0
brown coal	AVERAGE	GF0	7490.869	374.543	7.491	29.963		40-400	4.5	18.0	0.25
brown coal	AVERAGE	PD0	15993.988	799.699	0.000	99.962		150-1250	0.0	100.0	0
hard coal	AVERAGE	FB0	7017.512	56.140	3.656	0.702		20-100	4.0	1.0	5.21
hard coal	AVERAGE	GF0	3124.381	156.219	9.373	4.687		40-200	6.0	3.0	2
hard coal	AVERAGE	PD0	6428.749	128.575	2.025	2.764	large dif. among countries	50-200	2.0	3.0	0.732558
solid biomass1 - OS1	AVERAGE	FB0	238.444	11.922	1.192	1.192		12.0	1.2	1.2	1
solid biomass1 - OS1	AVERAGE	GF0	238.444	119.222	9.538	14.307		120.0	9.6	14.4	0.666667
solid biomass1 - OS1	AVERAGE	PD0	238.250	11.913	1.191	1.191	data from FB0				1
solid biomass2 - OS2	AVERAGE	FB0	142	7.1	0.71	0.71					1
solid biomass2 - OS2	AVERAGE	GF0	142	71	5.68	8.52					0.666667
solid biomass2 - OS2	AVERAGE	PD0	142	7.1	0.71	0.71	data from FB0				1

OS1	CHA	OS2	DNG	HF	LBI
	SBI		IWS		OLB
	WOD		MWR		
			NSF		
			VWS		
			BGS		
			BLI		

OS2, FIN, EF was corrected (from 2620 to 142 as all the countries)

Bond dataset summary

	Technology		Average values kg/Tj			data source	
Fuel	**Bond**	**EDGAR**	**PM10**	**BC**	**OC**	**PM10**	**BC, OC**
GAS	all		0.04	0.00	0.02		
LF	external comb.		5.64	1.47	0.66		
	ind/power	GT0/IC0	11.06	0.59	0.18		
HF		all	26.00	0.94	0.35		
BKB	grate firing	GF0	120.77	0.30	0.60		
	pulverized	PD0	120.77	1.18	0.00	GF0 EF for all BKB the technologies	bond brown coal pd0
		FB0	120.77	1.18	0.00	GF0 EF for all BKB the technologies	bond brown coal pd0
brown coal		FB0	2436.97	1.18	0.00	PM10:bond pd0	BC, OC: Bond PD0 brown
brown coal	grate firing	GF0	1428.57	7.86	103.70		
brown coal	pulverized	PD0	2436.97	1.18	0.00		
hard coal		FB0	449.44	0.22	0.00	PM10: bond pd0	BC, OC: bond pd0
hard coal	grate firing	GF0	176.03	7.04	1.76	Updated rfom (Bond 2007)	Updated rfom (Bond 2007)
hard coal	pulverized	PD0	449.44	0.22	0.00		
solid biomass1 - OS1		FB0	189.66	2.82	11.54	PM10: bond gf0	BC, OC: Bond table 9-10 power sector wood
solid biomass1 - OS1	grate firing	GF0	189.66	8.16	32.62		
solid biomass1 - OS1	pulverized	PD0	189.66	2.82	11.54	PM10: bond gf0	BC, OC: Bond table 9-10 power sector wood
waste		FB0	1086.21	0.19	0.01		
waste	grate firing	GF0	1086.21	0.19	0.01		
waste	pulverized	PD0	1086.21	0.19	0.01		
removed:		VGS	BLI	CHA	DNG	VWS	WOD

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Abstract

The Emissions Database for Global Atmospheric Research (EDGAR) provides technology based global anthropogenic emissions data of greenhouse gases and air pollutants by country and sector on a 0.1° x 0.1° spatial grid, on a timeline that ranges from 1970 to present days. As part of the constantly ongoing amendment and improvement of the database, a review of the available literature and emission inventory data has been conducted focusing on particulate emissions, with the aim of acquiring a comprehensive array of primary particle matter and carbonaceous particle emission factors (EF).

It was found, that emission factor data from different studies show large variation for a given fuel and technology. Furthermore it is plausible that a certain literature or measurement describes emission factors better in the region where it is originating from. With this in mind, a comparison has been made between the available emission factor datasets in a number of different regions, focusing on the power generation sector. The aim of this experiment is to select the most appropriate EF dataset for a given region.

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