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Emission factors for aircraft taxing and LTO cycle

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Introduction

The determination of particle emissions from aviation in the vicinity of airports was targeted in recent field studies by extensive measurement campaigns (Wey et al., 2007; Herndon et al., 2008; Mazaheri et al., 2009; Yu et al., 2010). Field study data, however, are difficult to use for building emission inventories. Therefore we decided to follow the approach originally developed by Wayson et al. (2009) and accepted in the currently valid IACO Airport Air Quality Manual (ICAO, 2011).

The FOA approach uses the IACO Engine Emissions Data Bank which is accessible at the EASA website for download (visit http://easa.europa.eu/environment/edb/aircraft-engine-emissions.php). EUROSTAT data on aircraft activity at European airport (access was arranged by TNO) were used for the determination of arrivals and departures from Amsterdam Airport. Real time-in-mode data for Amsterdam Airport were received from NLR. Based on times-in-mode (TIM) and airport activity data, the First Order Approximation (FOA) Version 3 (CAEP, 2008) was used to calculate emission factors for all species and compounds listed in the IACO Engine Emissions Data Bank. The emission factors for the airport machinery were calculated in accordance with the aircraft emissions following an approach developed by Cambridge University and MIT (Stettler et al., 2011). This approached is based on a min/max estimation of ground vehicle emission factors from Zurich airport.

Recommended emission factors

Recommended emission factors for specific aircraft types and times in mode are listed in the document *Emissions_Aviation_AMS_R1*.

Table 1 summarizes the flight statistics for the airport Amsterdam-Schiphol (ICAO code EHAM) calculated with different approaches. EUROSTAT EHAM no. of flights per day and month had to be calculated from EUROSTAT data based on the listed number of passengers per aircraft type. This number of passengers per aircraft type was converted into a number of arriving and departing aircraft by using the average number of seats per aircraft type as listed in databases on aircraft in the web. Detailed movement data for Amsterdam Schiphol were obtained from TNO. As can be depicted from Table 1, the approximation of aircraft from passenger seat statistics agrees very well with detailed data for one specific airport. Hence, we conclude that your approach can be successfully applied to other airports as well.

Table 2a summarizes the obtained emission factors for listed species when using the EUROSTAT aviation activity data. Analyses were performed for true times-in-mode data for EHAM and for time.in-mode data given in the ICAO LTO cycle (ICAO, 2011). Differences between true time-in-mode data and LTO data are small, so that LTO data can be used for airports if detailed information on times-in-mode data is not available. Related uncertainties can be estimated from Table 2a.

Table 1: Statistics used for Emission Factors

Statistics 2005	Month	
	January	July
EUROSTAT EHAM no. of flights/day	957	1217
EUROSTAT EHAM no. of flights/month	29656	37738
Total EHAM (TNO data) flights/month	29877	36922
∆ TNO-EUROSTAT, %	0.74%	-2.21%

Table 2a: Emissions of respective species calculated from the sum over all departing and arriving aircraft for months January and July; calculations were performed for detailed EHAM times-in-mode (TIM column) and for LTO times-in-mode (LTO column)

Emitted species	**Emissions Aviation, kg/month**				TIM-LTO
	TIM_January	TIM_July	LTO_January	LTO_July	%
NOx (as NO2)	172226.5	213642.1	187806.7	235381.3	-9.7%
CO	131095.8	162045.6	164428.7	203204.9	-25.4%
HC	15241.7	18749.7	19123.3	23525.8	-25.5%
EC	355.0	501.0	413.6	586.5	-16.8%
OC	628.3	777.8	736.6	914.9	-17.6%
SO4	307.9	390.2	355.3	451.2	-15.5%
PM10 (= EC+OC+SO4)	1291.2	1669.1	1505.5	1952.6	
N_soot, #	7.24E+18	9.42E+18	8.47E+18	1.11E+19	-17.2%

Table 2b: Emissions of respective species from Ground Service Equipment for nominal emission factors (NOM) and maximum emission factors (MAX) for months January and July.

Emissitted species	**Emissions GSE, kg/month**			
	NOM_January	NOM_July	MAX_January	MAX_July
NOx (as NO2)	6741.5	8688.0	46788.4	60351.9
CO	2430.5	3133.7	11198.0	14444.7
HC	622.1	802.5	4976.9	6419.9
EC				
OC				
SO4				
PM10 (= EC+OC+SO4)	418.1	538.9	3596.7	4639.1

Table 2c: Ratio of emissions from GSE vs. emissions from aviation, nominal (NOM) and maximum (MAX) emission factors for months January and July; PM10 from aviation is calculated as EC+OC+SO4.

Emissitted species	**GSE/Aviation**			
	NOM_January	NOM_July	MAX_January	MAX_July
NOx (as NO2)	3.9%	4.1%	27.2%	28.3%
CO	1.9%	1.9%	8.5%	8.9%
HC	4.1%	4.3%	32.7%	34.2%
EC				
OC				
SO4				
PM10 (= EC+OC+SO4)	32.4%	32.3%	279%	278%

Table 2b lists the emission factors of ground support equipment following the approach by Stettler et al., (2011), whereas Table 2c lists the difference in emissions from aviation and from ground support equipment for selected species. It appears that particle emissions from aviation exceed PM emissions from ground support equipment only for the assumption of maximum emissions from airside vehicles.

The calculation of emission factors uses the EXCEL File *Emissions_Aviation_AMS_R1*. Please refer to the instructions given in this document and to the detailed emission factors listed there.

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