1.A.3.a i (ii) - Internatinal Civil Aviation: Cruise

Short description

Category Code	Method					AD					EF				
1.A.3.a i (ii)	T1, T2, T3					NS, M					CS, D, M				
Key Category	**SO_2**	**NO_x**	**NH_3**	**NMVOC**	**CO**	**BC**	**Pb**	**Hg**	**Cd**	**Diox**	**PAH**	**HCB**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
1.A.3.a i (ii)	*not included in key category analysis*														

In NFR category *1.A.3.a i (ii) - Internatinal Civil Aviation: Cruise* emissions from international flights from German airports during cruise stage (above 3,000 feet of altitude) are reported.

In the following, information on sub-category specific activity data, (implied) emission factors and emission estimates are provided.

Methodology

Actitvity Data

Specific jet kerosene consumption during LTO-stage is calculated within TREMOD AV as described in the superordinate chapter on civil aviation.

Table 1: annual jet kerosene consumption during cruise-stage, in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	219
Jet kerosene	149.007	189.185	240.680	285.709	301.032	312.607	316.629	307.916	304.544	292.898	314.325	319.548	308.755	307.982	331.809	363.932	374.434	371.552
Avgas	464	161	173	91,6	87,2	76,8	82,5	75,8	76,8	68,1	60,4	48,6	40,0	58,5	16,2	16,2	12,1	6,55

source: Knörr et al. (2019c) [1)] & Gores (2019) [2)]

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Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 [3)] and have since then been compiled, revised and maintained in TREMOD AV [4)].

For more information, please see superordinate chapter on civil aviation.

Table 2: Annual country-specific emission factors, in kg/TJ

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
JET KEROSENE																		
NH_3	3,98	3,95	3,95	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97	3,97
NMVOC	13,3	8,96	5,98	5,27	5,15	5,02	4,89	4,77	4,66	4,53	4,39	4,39	4,71	4,35	4,17	4,23	4,32	4,25
NO_x	313	317	329	338	338	342	343	346	352	354	360	362	362	366	370	372	373	375
SO_x	19,7	19,5	19,5	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6	19,6
PM^1	1,89	1,96	2,03	1,93	1,91	1,89	1,85	1,83	1,81	1,80	1,79	1,77	1,74	1,73	1,73	1,74	1,75	1,75
BC^2	3,94	4,08	4,23	4,02	3,98	3,93	3,86	3,81	3,77	3,74	3,72	3,69	3,62	3,59	3,61	3,62	3,64	3,65
CO	73,8	61,6	47,7	42,4	41,5	40,6	39,7	38,6	37,8	37,3	37,0	36,8	40,1	36,2	34,2	34,2	34,7	34,6
AVGAS																		
NH_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NMVOC	468	498	477	462	452	451	461	470	460	523	519	518	506	515	430	437	449	467
NO_x	103	109	103	100	98	97	99	100	97	111	109	110	104	108	68,7	69,8	73,7	82,2
SO_x	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46	0,46
BC	0,40	0,42	0,41	0,40	0,40	0,40	0,41	0,41	0,41	0,44	0,44	0,44	0,45	0,44	0,47	0,47	0,47	0,46
$PM_{2.5}$	2,69	2,80	2,74	2,68	2,65	2,67	2,70	2,76	2,74	2,96	2,96	2,93	2,97	2,95	3,11	3,14	3,13	3,08

PM_{10}	2,69	2,80	2,74	2,68	2,65	2,67	2,70	2,76	2,74	2,96	2,96	2,93	2,97	2,95	3,11	3,14	3,13	3,08
TSP	17,9	18,0	17,9	17,9	17,8	17,8	17,9	17,9	17,9	18,1	18,1	18,1	18,1	18,1	18,3	18,3	18,3	18,2
CO	20.915	22.610	21.827	21.055	20.659	21.024	21.402	22.335	22.225	25.229	25.303	24.882	25.753	25.200	29.832	30.337	30.216	29.108

[1] EF(TSP) also applied for PM_{10} and $PM_{2.5}$ (assumption: > 99% of TSP consists of $PM_{2.5}$)
[2] estimated via a f-BC of 0.48 as provided in [5)], Chapter: 1.A.3.a, 1.A.5.b Aviation, page 49: “Conclusion”.

For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

Trend discussion for Key Sources

> NFR 1.A.3.a i (ii) - International Civil Aviation - Cruise is **not included in the national emission totals** and hence **not included in the key category analysis**.

Recalculations

Activity data have been revised for all years within TREMOD AV to keep in line with information available from the 2019 EMEP/EEA Guidebook [6)] and Eurocontrol's AEM model [7)].

Table 3: Revised kerosene usage in 1.A.3.a i (ii), in terajoules

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	

In parallel, the majority of **country-specific emission factors** has been revised within TREMOD AV based on information available from the 2019 EMEP/EEA Guidebook [8)] and Eurocontrol's AEM model [9)].

Table 4: Revised country-specific emission-factors, in [kg/TJ]

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NON-METHANE VOLATILE ORGANIC COMPUNDS - NMVOC																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
NITROGEN OXIDES																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
SULPHUR OXIDES																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
BLACK CARBON - BC																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	

PARTICULATE MATTER - PM																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	
CARBON MONOXIDE - CO																	
Submission 2021																	
Submission 2020																	
absolute change																	
relative change																	

For more information on recalculated emission estimates for Base Year and 2018, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations].

Uncertainties

For uncertainties information, please see main chapter on civil aviation.

Planned improvements

For information on planned improvements, please see main chapter on civil aviation.

FAQs

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bibliography

: 1 : Knörr, W., Schacht, A., & Gores, S. (2010): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV) : Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung; Berlin & Heidelberg, 2012. : 2 : Knörr et al. (2019c): Knörr, W., Schacht, A., & Gores, S.: TREMOD Aviation (TREMOD AV) 2019 - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2019. : 3 : Gores (2019): Inventartool zum deutschen Flugverkehrsinventar 1990-2018, im Rahmen der Aktualisierung des Moduls TREMOD-AV im Transportemissionsmodell TREMOD, Berlin, 2019. : 4 : EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019 - Copenhagen, 2019 : 5 : Eurocontrol (2019): Advanced emission model (AEM); https://www.eurocontrol.int/model/advanced-emission-model; 2019 bibliography

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[1)] (bibcite 2)
[2)] (bibcite 3)
[3)] (bibcite 1)
[4)] (bibcite 2)
[5)] (bibcite 4)
[6)] (bibcite 4)
[7)] (bibcite 5)
[8)] (bibcite 4)
[9)] (bibcite 5)