

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

## Short description

| Method     | AD    | EF       | Key Category for                      |
|------------|-------|----------|---------------------------------------|
| T1, T2, T3 | NS, M | CS, D, M | not included in key category analysis |

In NFR category 1.A.3.a i (ii) - *International 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

### Activity 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 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

source: Knörr et al. (2019c) <sup>1)</sup> & Gores (2019) <sup>2)</sup>

gallery size="medium" : 1A3ai(ii)\_AD.png [gallery](#)

### Emission factors

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

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 |
|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>NH<sub>3</sub></b> | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |      |
| <b>NMVO</b>           | 13.4 | 9.47 | 5.93 | 5.44 | 5.35 | 5.20 | 5.07 | 4.95 | 4.91 | 4.81 | 4.70 | 4.70 | 4.64 | 4.65 | 4.46 | 4.52 | 4.64 |      |
| <b>NO<sub>x</sub></b> | 308  | 313  | 319  | 330  | 331  | 334  | 335  | 339  | 346  | 349  | 354  | 354  | 354  | 354  | 359  | 361  | 362  |      |
| <b>SO<sub>x</sub></b> | 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 |      |
| <b>PM<sup>1</sup></b> | 3.98 | 4.19 | 4.33 | 4.11 | 4.07 | 4.02 | 3.95 | 3.91 | 3.87 | 3.84 | 3.81 | 3.78 | 3.72 | 3.72 | 3.74 | 3.74 | 3.76 |      |
| <b>BC<sup>2</sup></b> | 1.91 | 2.01 | 2.08 | 1.97 | 1.95 | 1.93 | 1.90 | 1.88 | 1.86 | 1.84 | 1.83 | 1.82 | 1.78 | 1.79 | 1.79 | 1.80 | 1.80 |      |
| <b>CO</b>             | 71.0 | 60.3 | 44.9 | 40.0 | 39.2 | 38.3 | 37.4 | 36.4 | 35.9 | 35.6 | 35.5 | 35.6 | 35.3 | 35.5 | 33.5 | 33.6 | 34.0 |      |

<sup>1</sup> EF(TSP) also applied for PM<sub>10</sub>, and PM<sub>2.5</sub>, (assumption: > 99% of TSP consists of PM<sub>2.5</sub>), <sup>2</sup> estimated via a f-BC of 0.48 as provided in <sup>5)</sup>, Chapter: 1.A.3.a, 1.A.5.b Aviation, page 49: "Conclusion".

**NOTE:** 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 <sup>6)</sup> and Eurocontrol's AEM model <sup>7)</sup>.

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    |
|-------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|
| ~ Submission 2020 | > 150,852 | > 187,855 | > 243,544 | > 288,819 | > 304,276 | > 315,598 | > 319,033 | > 310,713 | > 305,632 | > 291,248 | > 314,638 | > 320,599 | > 307,487  | > 306,766 | > 331,644 | > 365,499 |
| ~ Submission 2019 | > 152,682 | > 186,400 | > 243,292 | > 289,459 | > 305,085 | > 316,427 | > 319,258 | > 310,547 | > 304,170 | > 286,922 | > 313,516 | > 321,015 | > 307,488  | > 305,071 | > 330,738 | > 367,231 |
| ~ absolute change | > -1,830  | > 1,455   | > 252     | > -640    | > -809    | > -829    | > -224    | > 167     | > 1,462   | > 4,326   | > 1,122   | > -416    | > -0,79    | > 1,695   | > 907     | > -1,732  |
| ~ relative change | > -1.20%  | > 0.78%   | > 0.10%   | > -0.22%  | > -0.27%  | > -0.26%  | > -0.07%  | > 0.05%   | > 0.48%   | > 1.51%   | > 0.36%   | > -0.13%  | > -0.0003% | > 0.56%   | > 0.27%   | > -0.47%  |

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 <sup>8)</sup> and Eurocontrol's AEM model <sup>9)</sup>.

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

| < NMVOC                            |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
|------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| ~ Submission 2020                  | > 13.4   | > 9.5    | > 5.9    | > 5.4    | > 5.3    | > 5.2    | > 5.1    | > 5.0    | > 4.9    | > 4.8    | > 4.7    | > 4.7    | > 4.6    | > 4.7    | > 4.5    | > 4.5    |
| ~ Submission 2019                  | > 13.5   | > 9.0    | > 5.6    | > 5.2    | > 5.1    | > 4.9    | > 4.8    | > 4.7    | > 4.7    | > 4.6    | > 4.4    | > 4.5    | > 4.5    | > 4.5    | > 4.4    | > 4.5    |
| ~ absolute change                  | > -0.05  | > 0.48   | > 0.36   | > 0.24   | > 0.27   | > 0.29   | > 0.30   | > 0.25   | > 0.25   | > 0.24   | > 0.26   | > 0.23   | > 0.14   | > 0.19   | > 0.02   | > 0.00   |
| ~ relative change                  | > -0.39% | > 5.36%  | > 6.42%  | > 4.62%  | > 5.31%  | > 5.98%  | > 6.26%  | > 5.24%  | > 5.37%  | > 5.27%  | > 5.75%  | > 5.23%  | > 3.18%  | > 4.18%  | > 0.39%  | > 0.07%  |
| < NO <sub>x</sub>                  |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| ~ Submission 2020                  | > 308    | > 313    | > 319    | > 330    | > 331    | > 334    | > 335    | > 339    | > 346    | > 349    | > 354    | > 354    | > 354    | > 354    | > 359    | > 361    |
| ~ Submission 2019                  | > 313    | > 317    | > 329    | > 335    | > 336    | > 339    | > 341    | > 344    | > 350    | > 352    | > 359    | > 364    | > 368    | > 374    | > 378    | > 380    |
| ~ absolute change                  | > -5.05  | > -3.50  | > -9.68  | > -5.31  | > -5.00  | > -5.19  | > -5.11  | > -4.91  | > -4.69  | > -3.15  | > -5.07  | > -10.16 | > -13.33 | > -19.30 | > -19.11 | > -19.37 |
| ~ relative change                  | > -1.61% | > -1.10% | > -2.94% | > -1.58% | > -1.49% | > -1.53% | > -1.50% | > -1.43% | > -1.34% | > -0.89% | > -1.41% | > -2.79% | > -3.62% | > -5.17% | > -5.05% | > -5.09% |
| < Sulphur oxides - SO <sub>x</sub> |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| ~ Submission 2020                  | > 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   |
| ~ Submission 2019                  | > 25.1   | > 15.2   | > 8.5    | > 6.3    | > 5.9    | > 5.5    | > 5.1    | > 4.7    | > 4.7    | > 4.7    | > 4.7    | > 4.7    | > 4.7    | > 4.7    | > 4.7    | > 4.7    |
| ~ absolute change                  | > -5.45  | > 4.30   | > 11.08  | > 13.28  | > 13.71  | > 14.13  | > 14.55  | > 14.98  | > 14.98  | > 14.98  | > 14.98  | > 14.98  | > 14.98  | > 14.98  | > 14.98  | > 14.98  |
| ~ relative change                  | > -21.7% | > 28.2%  | > 131%   | > 209%   | > 232%   | > 257%   | > 287%   | > 322%   | > 322%   | > 322%   | > 322%   | > 322%   | > 322%   | > 322%   | > 322%   | > 322%   |
| < Black carbon - BC                |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| ~ Submission 2020                  | > 1.91   | > 2.01   | > 2.08   | > 1.97   | > 1.95   | > 1.93   | > 1.90   | > 1.88   | > 1.86   | > 1.84   | > 1.83   | > 1.82   | > 1.78   | > 1.79   | > 1.79   | > 1.80   |

|                                     |          |         |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
|-------------------------------------|----------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| ~ Submission 2019                   | > 2.23   | > 2.23  | > 2.23  | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   | > 2.23   |
| ~ absolute change                   | > -0.32  | > -0.22 | > -0.15 | > -0.26  | > -0.28  | > -0.30  | > -0.33  | > -0.36  | > -0.37  | > -0.39  | > -0.40  | > -0.42  | > -0.45  | > -0.44  | > -0.44  | > -0.44  |
| ~ relative change                   | > -14.3% | > -9.8% | > -6.8% | > -11.6% | > -12.5% | > -13.5% | > -15.0% | > -16.0% | > -16.7% | > -17.5% | > -18.0% | > -18.7% | > -20.1% | > -19.9% | > -19.7% | > -19.5% |
| <b>&lt; Particulate matter - PM</b> |          |         |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| ~ Submission 2020                   | > 3.98   | > 4.19  | > 4.33  | > 4.11   | > 4.07   | > 4.02   | > 3.95   | > 3.91   | > 3.87   | > 3.84   | > 3.81   | > 3.78   | > 3.72   | > 3.72   | > 3.74   | > 3.74   |
| ~ Submission 2019                   | > 4.65   | > 4.65  | > 4.65  | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   | > 4.65   |
| ~ absolute change                   | > -0.67  | > -0.46 | > -0.32 | > -0.54  | > -0.58  | > -0.63  | > -0.70  | > -0.74  | > -0.78  | > -0.81  | > -0.84  | > -0.87  | > -0.93  | > -0.93  | > -0.91  | > -0.91  |
| ~ relative change                   | > -14.3% | > -9.8% | > -6.8% | > -11.6% | > -12.5% | > -13.5% | > -15.0% | > -16.0% | > -16.7% | > -17.5% | > -18.0% | > -18.7% | > -20.1% | > -19.9% | > -19.7% | > -19.5% |
| <b>&lt; Carbon monoxide - CO</b>    |          |         |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| ~ Submission 2020                   | > 71.0   | > 60.3  | > 44.9  | > 40.0   | > 39.2   | > 38.3   | > 37.4   | > 36.4   | > 35.9   | > 35.6   | > 35.5   | > 35.6   | > 35.3   | > 35.5   | > 33.5   | > 33.6   |
| ~ Submission 2019                   | > 72.0   | > 59.8  | > 44.3  | > 40.2   | > 39.2   | > 38.2   | > 37.1   | > 36.8   | > 36.4   | > 36.2   | > 35.8   | > 35.6   | > 35.1   | > 35.1   | > 35.1   | > 35.5   |
| ~ absolute change                   | > -0.97  | > 0.48  | > 0.55  | > -0.21  | > 0.00   | > 0.17   | > 0.32   | > -0.41  | > -0.47  | > -0.59  | > -0.28  | > -0.05  | > 0.19   | > 0.40   | > -1.55  | > -1.90  |
| ~ relative change                   | > -1.35% | > 0.81% | > 1.24% | > -0.53% | > 0.01%  | > 0.44%  | > 0.87%  | > -1.11% | > -1.29% | > -1.63% | > -0.78% | > -0.14% | > 0.54%  | > 1.15%  | > -4.42% | > -5.35% |



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.

### bibliography

: 1 : Knörr, W., Schacht, A., & Gores, S. (2010): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOT-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 (TREMOT AV) 2019 - Revision des Modells zur Berechnung des Flugverkehrs (TREMOT-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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