# ACTRIS station requirements NOx and VOC

Instruments, instrument set up, suitable inlet lines, filter systems, material, gases, calibration and quality assurances procedures should be designed as recommended in the measurement guidelines for NOx (ACTRIS Deliverable 4.10, 2014) and VOCs (ACTRIS Deliverable 4.9, 2014 )

Further requirements:

- regularly calibrate the instrument with a certified calibration gas
- regularly perform zero gas measurements
- perform monthly measurements of target gases and submit the target gas results to EBAS
- submit data including uncertainty and precision to EBAS following the protocol, deadlines and use the submission templates
- participate at the annual data quality workshop
- provide feedback to the ACTRIS QC/QA process .

# ACTRIS-2:
# Task 3.1 gases: improve the data quality

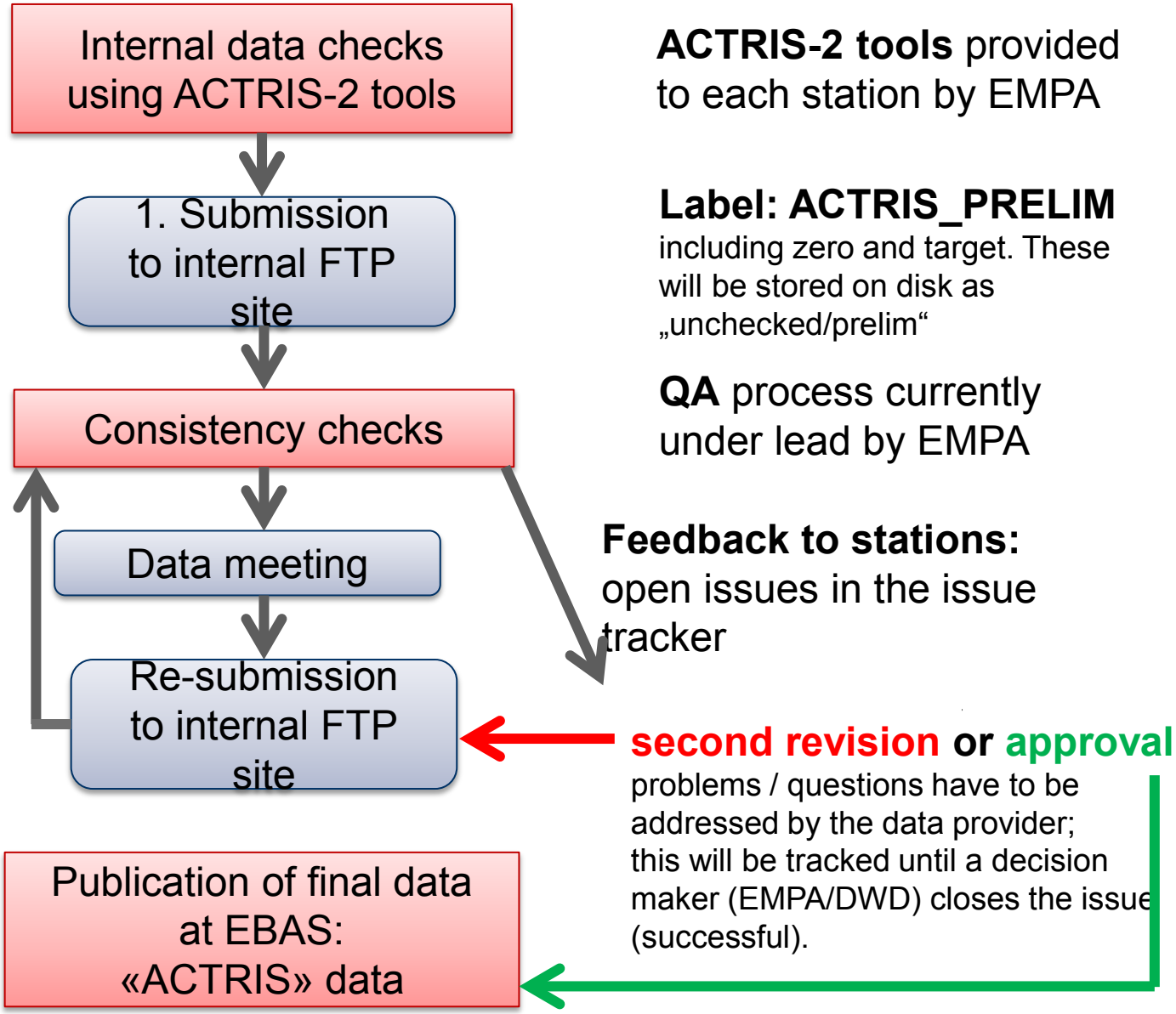
**Yearly meeting in the process of data submission**
**VOC/NOx-1: November 2015**
**VOC/NOx-2: May 2016**
**VOC/NOx-1: May 2017**
**VOC/NOx-1: April 2018**

Trackable revision process to be discussed at WP3 meeting with EBAS/EMEP

**→Feedback on data quality to the stations → action items**
**→revision of data**

**Discussion of data with CONTROL charts (Task 3.3)**
Monthly means
xy-ratio plots
A clever way to do so has to be discussed in the 1st WP 3 meeting also in conjunction with the WCCs.

# Data flow ACTRIS-2 for VOCs



# VOC Measurement Guidelines – from ACTRIS Drafts to GAW Recommendations

Christian Plass-Dülmer (DWD)
Stefan Reimann (Empa)

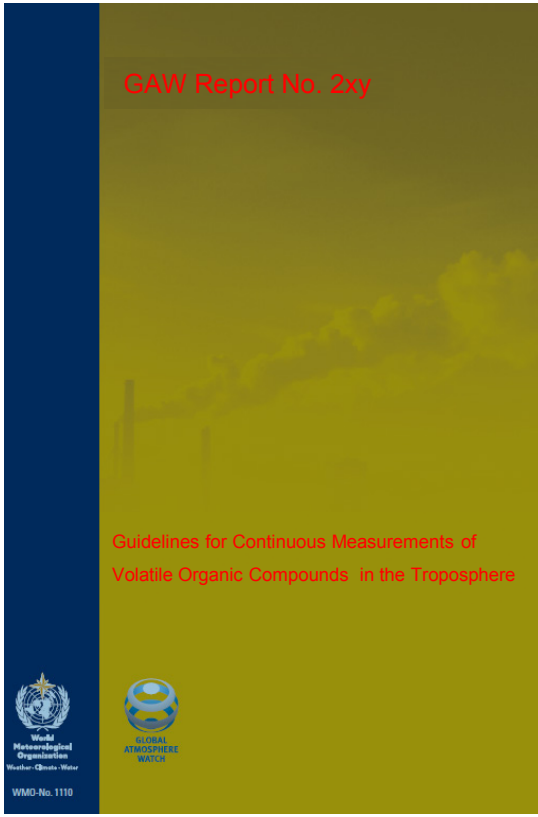
Guidelines for Continuous Measurements of

Deliverable WP4 / D4.9
(42)
Version: 2014/09/30

## WP4- NA4: Trace gases networking: Volatile organic carbon and nitrogen oxides
## Deliverable D4.9: Final SOPs for VOCs measurements

**Summary:**

This SOP provides a guideline for good measurement practice for the analysis of volatile organic compounds (VOCs) under the EU FP7 infrastructure project ACTRIS. Only active sampling is part of this SOP. For passive sampling respective guidelines from the EU should be used.
The SOP contains the following topics:




Deutscher Wetterdienst
Wetter und Klima aus einer Hand

EMPA
Materials Science & Technology

# ACTRIS data quality objectives proposed for WMO/GAW

Table 1 Data quality objectives for the measurements of VOCs

| | Old GAW uncertainty | Old GAW repeatability | enhanced GAW uncertainty | Enhanced GAW repeatability |
|---|---|---|---|---|
| alkanes | 10% | 5% | 5% | 2% |
| alkenes incl. isoprene | 20% | 15% | 5% | 2% |
| monoterpenes | 20% | 15% | 10% | 5% |
| alkynes | 15% | 5% | 5% | 2% |
| aromatics | 15% | 10% | 5% | 2% |
| mole fraction <0.1 nmol/mol (ppb) (monoterpenes) | 0.02 ppb | 0.015 ppb | 0.005 ppb (0.010 ppb) | 0.002 ppb (0.005 ppb) |

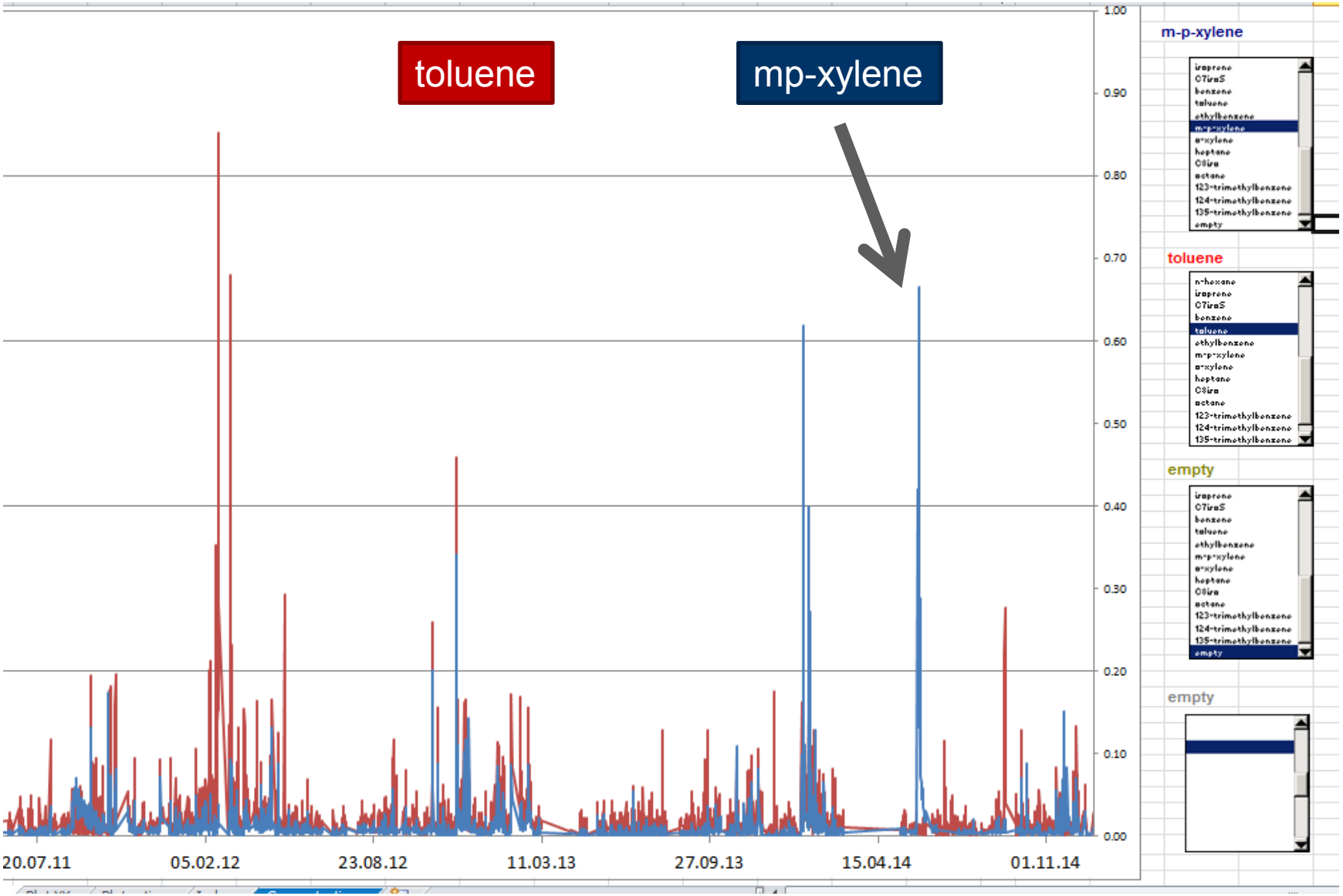
| | | | | |
|---|---|---|---|---|
| OVOC (<0.1 ppb) | 20% 0.02 | 15% 0.015 | 10% 0.01 | 5% 0.005 ppb |

Rename „enhanced GAW …“ in „GAW uncertainty DQO“
Rename „old GAW...“ in „basic station preformance DQO“ (according to former GAW DQO, GAW Report Geneva meeting)

C. Plass-Duelmer, GAW-VOC-Expert Group, South Korea, Oct 2014

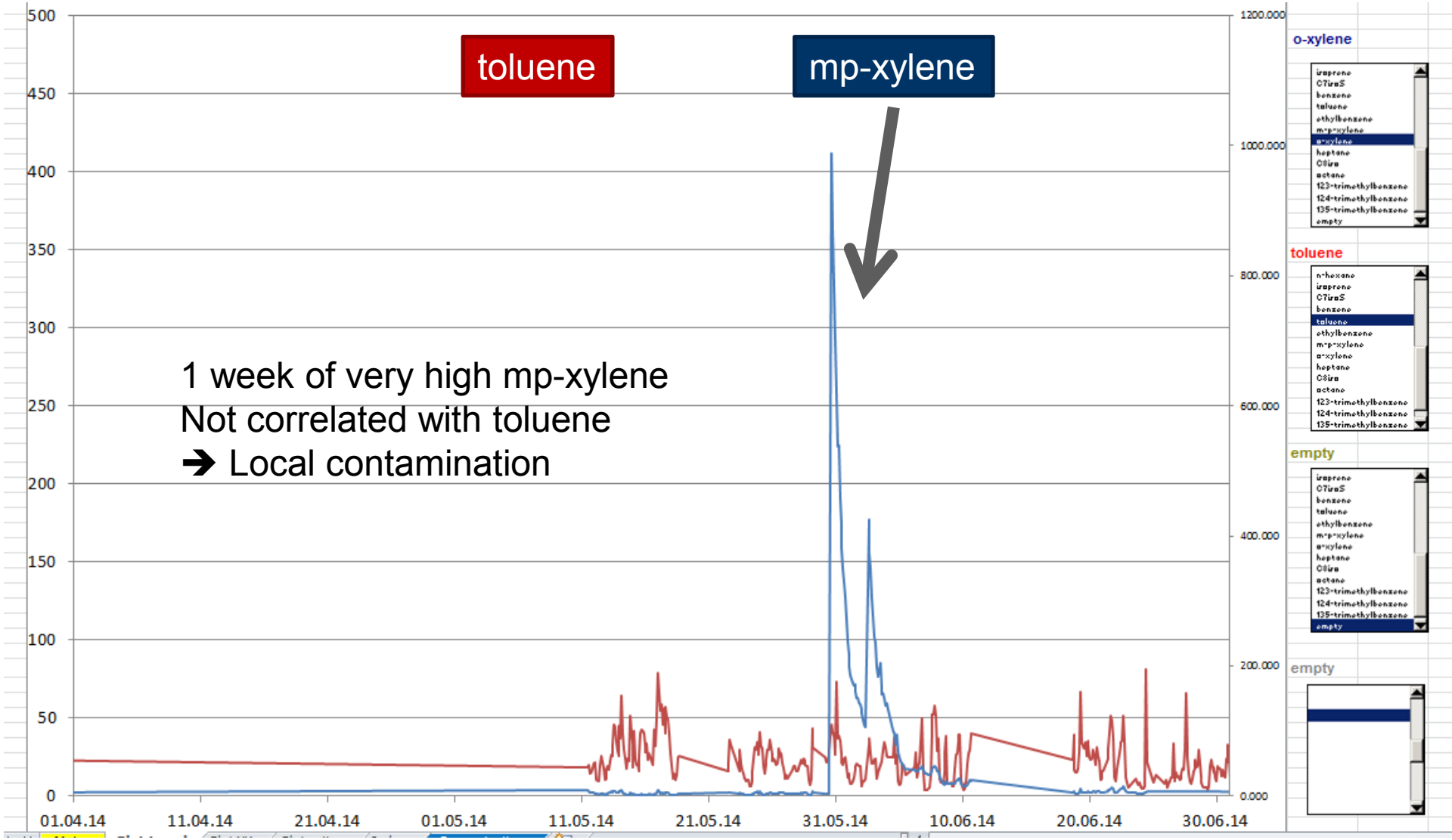
# Examples of the QA tool for VOCs developed by Empa/DWD

## Interspecies correlation



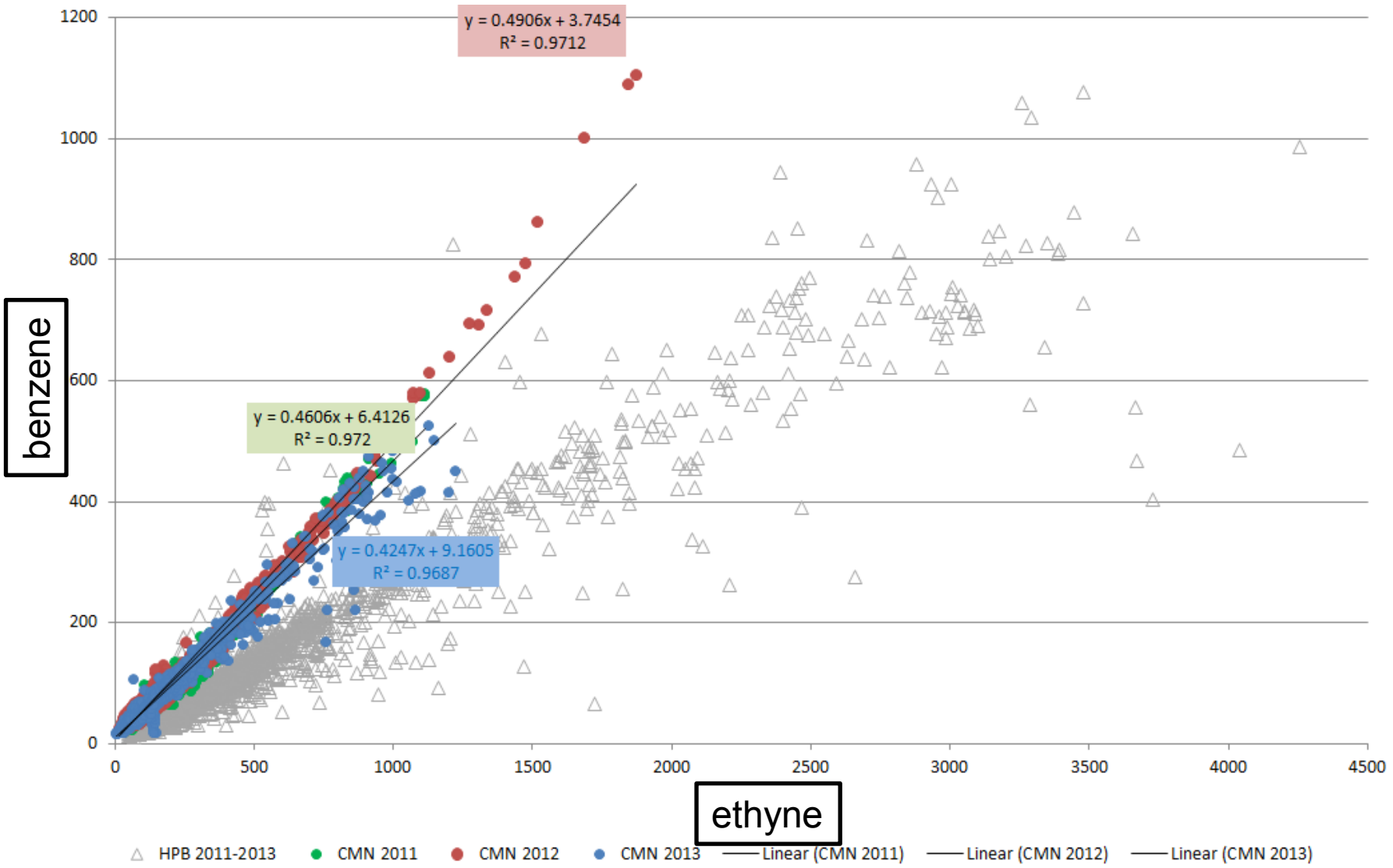
# Examples of the QA tool for VOCs developed by Empa/DWD

## Interspecies correlation



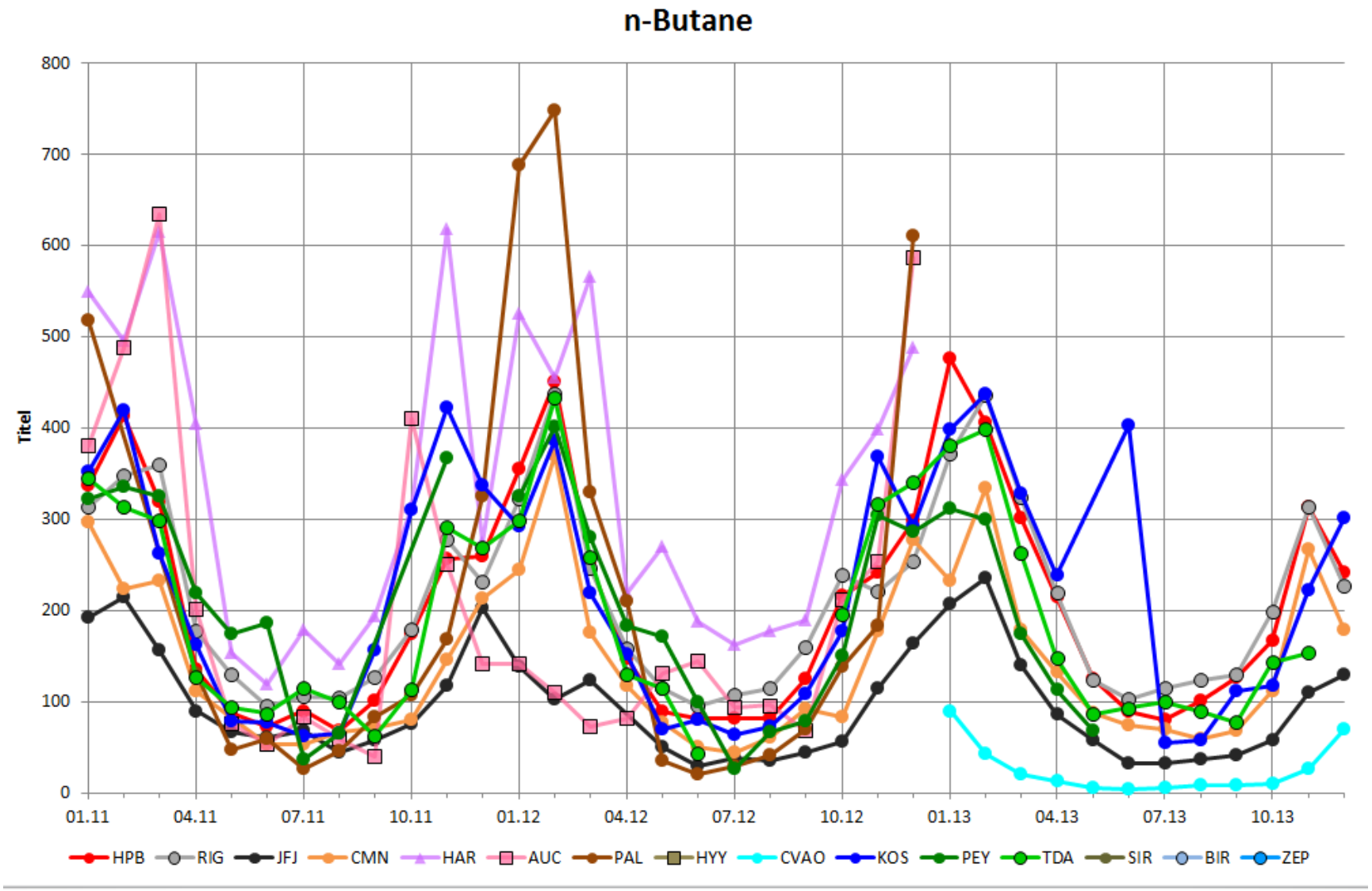
# Examples of the QA tool for VOCs developed by Empa/DWD

## Interspecies correlation and comparison with standard (HPB)



# Examples of the QA tool for VOCs developed by Empa/DWD

## Interstation comparison



# Data reporting under EBAS:
# User friendliness needs to be improved

Issue 1: alphabetic order of substances in EBAS

Issue 2: row names are not identical with names in header and are sometimes not unique

Issue 3: flags for uncertainty and precision make no sense

# Issue 1: alphabetic order of substances in EBAS

| EBAS | RIG | HPB |
|---|---|---|
| 1-2-3-trimethylbenzene | ethane | ethane |
| 1-2-4-trimethylbenzene | ethene | ethene |
| 1-3-5-trimethylbenzene | propane | propane |
| 1-3-butadiene | propene | propene |
| 1-butene | 2-methylpropane | 2-methylpropane |
| 1-butyne | n-butane | ethyne |
| 1-hexene | ethyne | n-butane |
| 1-pentene | 2-methylbutane | trans-2-butene |
| 2-2-3-trimethylbutane | n-pentane | 1-butene |
| 2-2-4-trimethylpentan | 1-3-butadiene | 2-methylpropene |
| 2-2-dimethylbutane | C6isoS | cis-2-butene |
| 2-2-dimethylpentane | n-hexane | cyclopentane |
| 2-2-dimethylpropane | isoprene | 2-methylbutane |
| 2-3-dimethylbutane | C7isoS | n-pentane |
| 2-3-dimethylpentane | benzene | propyne |
| 2-4-dimethylpentane | toluene | 1-3-butadiene |
| 2-methylbutane | Ethylbenzene | trans-2-pentene |
| 2-methylhexane | m-p-xylene | 1-pentene |
| 2-methylpentane | o-xylene | cis-2-pentene |
| 2-methylpropane | | methyl-cyclopentane |
| 2-methylpropene | | cyclohexane |
| 3-3-dimethylpentane | | 2-3-dimethylbutane |
| 3-methyl-1-butene | | 2-methylpentane |
| 3-methylheptane | | 3-methylpentane |
| 3-methylpentane | | n-hexane |
| benzene | | isoprene |
| butenes | | 1-hexene |
| cis-2-butene | | methyl-cyclohexane |
| cis-2-pentene | | 2-3-dimethylpentane |
| cyclo-hexane | | 2-methylhexane |
| cyclo-pentane | | n-heptane |
| ethane | | benzene |
| ethene | | 2-2-4-trimethylpentane |

Suggested order for EBAS:

1. Alkanes
2. Alkenes
3. Alkines
4. Aromatics
5. OVOCs/others

C2<C3<C4 …

# Issue 2: row names are not identical with names in header and are sometimes not unique

```
ropene, ppt, Statistics=accuracy
umflag propene, no unit, Statistics=accuracy
ropene, ppt, Statistics=arithmetic mean
umflag propene, no unit, Statistics=arithmetic mean
ropene, ppt, Statistics=precision
umflag propene, no unit, Statistics=precision
ropyne, ppt, Statistics=accuracy
umflag propyne, no unit, Statistics=accuracy
ropyne, ppt, Statistics=arithmetic mean
umflag propyne, no unit, Statistics=arithmetic mean
ropyne, ppt, Statistics=precision
umflag propyne, no unit, Statistics=precision
oluene, ppt, Statistics=accuracy
umflag toluene, no unit, Statistics=accuracy
oluene, ppt, Statistics=arithmetic mean
umflag toluene, no unit, Statistics=arithmetic mean
oluene, ppt, Statistics=precision
umflag toluene, no unit, Statistics=precision
rans-2-butene, ppt, Statistics=accuracy
umflag trans-2-butene, no unit, Statistics=accuracy
rans-2-butene, ppt, Statistics=arithmetic mean
umflag trans-2-butene, no unit, Statistics=arithmetic mean
rans-2-butene, ppt, Statistics=precision
umflag trans-2-butene, no unit, Statistics=precision
rans-2-pentene, ppt, Statistics=accuracy
umflag trans-2-pentene, no unit, Statistics=accuracy
rans-2-pentene, ppt, Statistics=arithmetic mean
umflag trans-2-pentene, no unit, Statistics=arithmetic mean
rans-2-pentene, ppt, Statistics=precision
umflag trans-2-pentene, no unit, Statistics=precision
```

```
tarttime endtime C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9
3-dimethylpentane flag_2-3-dimethylpentane 2-4-dimethylpentane flag_2-4-dimethylpentane 2-4-dimethylpentane flag_2-4-dimethylpentane 2-4-dimethylpentane flag_2-4-dimethylpentane 2-4-dimethylpentane f
exane flag_cyclo-hexane cyclo-hexane flag_cyclo-hexane C5H8 flag_C5H8 C5H8 flag_C5H8 C5H8 flag_C5H8 C2H6 flag_C2H6 C2H6 flag_C2H6 C2H6 flag_C2H6 C2H4 flag_C
 flag_trans-2-butene trans-2-butene flag_trans-2-butene C5H10 flag_C5H10 C5H10 flag_C5H10 C5H10 flag_C5H10
  2.5   2.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.000    21 0.000     1.0138890 0.000  1 0.000  10 0.000   4.000000 0.000  18.000000 0.000  335 0.000    8.013889 0.000  1 0.000  15 0.000  4 0.000
  6.5   6.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  22 0.000  4.000000
0000000 0.000    18 0.000     4.0000000 0.000  3 0.000  32 0.000   6.000000 0.000  12.000000 0.000  223 0.000    9.000000 0.000  0 0.781    5 0.781  4 0.781
  9.5   9.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  20 0.000  1.013889
0000000 0.781     5 0.781     4.0000000 0.781  3 0.000  29 0.000   5.000000 0.000  12.000000 0.000  220 0.000    9.000000 0.000  0 0.781    5 0.781  4 0.781
 13.5  13.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  13 0.000  1.013889
0000000 0.000    18 0.000     4.0000000 0.000  3 0.000  32 0.000   6.000000 0.000  25.000000 0.000  474 0.000  15.000000 0.000  1 0.000  13 0.000  4 0.000
 16.5  16.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  25 0.000   5.000000 0.000  25.000000 0.000  475 0.000  15.000000 0.000  1 0.000  11 0.000  4 0.000
 20.5  20.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  1 0.000  14 0.000   4.000000 0.000  17.000000 0.000  313 0.000  11.000000 0.000  1 0.000  14 0.000  4 0.000
 23.5  23.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  10 0.000  1.013889
0000000 0.781     5 0.781     4.0000000 0.781  1 0.000  16 0.000   4.000000 0.000  18.000000 0.000  332 0.000    8.013889 0.000  0 0.781    5 0.781  4 0.781
 27.5  27.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  0 0.781    5 0.781   4.000000 0.781  17.000000 0.000  322 0.000  11.000000 0.000  0 0.781    5 0.781  4 0.781
 30.5  30.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  14 0.000  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  24 0.000   2.013889 0.000    6.000000 0.000  115 0.000    6.000000 0.000  1 0.000  12 0.000  4 0.000
 34.5  34.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  19 0.000  1.013889
0000000 0.781     5 0.781     4.0000000 0.781  0 0.781    5 0.781   4.000000 0.781  15.000000 0.000  285 0.000  10.000000 0.000  0 0.781    5 0.781  4 0.781
 37.5  37.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  11 0.000  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  24 0.000   5.000000 0.000  26.000000 0.000  488 0.000  15.000000 0.000  1 0.000  16 0.000  4 0.000
 41.5  41.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  12 0.000  4.000000
0000000 0.000    27 0.000     2.0138890 0.000  1 0.000  13 0.000   4.000000 0.000  18.000000 0.000  344 0.000  12.000000 0.000  1 0.000  11 0.000  4 0.000
 44.5  44.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  18 0.000   5.000000 0.000   3.000000 0.000   58 0.000    5.000000 0.000  0 0.781    5 0.781  4 0.781
 48.5  48.513889  1 0.781   5 0.781  4 0.781   1 0.000   11 0.000   4 0.000  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  22 0.000  1.013889
```

# Issue 3: do flags for uncertainty and precision make sense?

```
ropene, ppt, Statistics=accuracy
umflag propene, no unit, Statistics=accuracy
ropene, ppt, Statistics=arithmetic mean
umflag propene, no unit, Statistics=arithmetic mean
ropene, ppt, Statistics=precision
umflag propene, no unit, Statistics=precision
ropyne, ppt, Statistics=accuracy
umflag propyne, no unit, Statistics=accuracy
ropyne, ppt, Statistics=arithmetic mean
umflag propyne, no unit, Statistics=arithmetic mean
ropyne, ppt, Statistics=precision
umflag propyne, no unit, Statistics=precision
oluene, ppt, Statistics=accuracy
umflag toluene, no unit, Statistics=accuracy
oluene, ppt, Statistics=arithmetic mean
umflag toluene, no unit, Statistics=arithmetic mean
oluene, ppt, Statistics=precision
umflag toluene, no unit, Statistics=precision
rans-2-butene, ppt, Statistics=accuracy
umflag trans-2-butene, no unit, Statistics=accuracy
rans-2-butene, ppt, Statistics=arithmetic mean
umflag trans-2-butene, no unit, Statistics=arithmetic mean
rans-2-butene, ppt, Statistics=precision
umflag trans-2-butene, no unit, Statistics=precision
rans-2-pentene, ppt, Statistics=accuracy
umflag trans-2-pentene, no unit, Statistics=accuracy
rans-2-pentene, ppt, Statistics=arithmetic mean
umflag trans-2-pentene, no unit, Statistics=arithmetic mean
rans-2-pentene, ppt, Statistics=precision
umflag trans-2-pentene, no unit, Statistics=precision
```

```
tarttime endtime C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9H12 flag_C9H12 C9
3-dimethylpentane flag_2-3-dimethylpentane 2-4-dimethylpentane flag_2-4-dimethylpentane 2-4-dimethylpentane flag_2-4-dimethylpentane 2-4-dimethylpentane flag_2-4-dimethylpentane f
exane flag_cyclo-hexane cyclo-hexane flag_cyclo-hexane C5H8 flag_C5H8 C5H8 flag_C5H8 C5H8 flag_C5H8 C2H6 flag_C2H6 C2H6 flag_C2H6 C2H6 flag_C2H6 C2H4 flag_C
 flag_trans-2-butene trans-2-butene flag_trans-2-butene C5H10 flag_C5H10 C5H10 flag_C5H10 C5H10 flag_C5H10
  2.5   2.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.000    21 0.000     1.0138890 0.000  1 0.000  10 0.000   4.000000 0.000  18.000000 0.000  335 0.000    8.013889 0.000  1 0.000  15 0.000  4 0.000
  6.5   6.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  22 0.000  4.000000
0000000 0.000    18 0.000     4.0000000 0.000  3 0.000  32 0.000   6.000000 0.000  12.000000 0.000  223 0.000    9.000000 0.000  0 0.781    5 0.781  4 0.781
  9.5   9.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  20 0.000  1.013889
0000000 0.781     5 0.781     4.0000000 0.781  3 0.000  29 0.000   5.000000 0.000  12.000000 0.000  220 0.000    9.000000 0.000  0 0.781    5 0.781  4 0.781
 13.5  13.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  13 0.000  1.013889
0000000 0.000    18 0.000     4.0000000 0.000  3 0.000  32 0.000   6.000000 0.000  25.000000 0.000  474 0.000  15.000000 0.000  1 0.000  13 0.000  4 0.000
 16.5  16.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  25 0.000   5.000000 0.000  25.000000 0.000  475 0.000  15.000000 0.000  1 0.000  11 0.000  4 0.000
 20.5  20.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  1 0.000  14 0.000   4.000000 0.000  17.000000 0.000  313 0.000  11.000000 0.000  1 0.000  14 0.000  4 0.000
 23.5  23.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  10 0.000  1.013889
0000000 0.781     5 0.781     4.0000000 0.781  1 0.000  16 0.000   4.000000 0.000  18.000000 0.000  332 0.000    8.013889 0.000  0 0.781    5 0.781  4 0.781
 27.5  27.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  0 0.781    5 0.781   4.000000 0.781  17.000000 0.000  322 0.000  11.000000 0.000  0 0.781    5 0.781  4 0.781
 30.5  30.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  14 0.000  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  24 0.000   2.013889 0.000    6.000000 0.000  115 0.000    6.000000 0.000  1 0.000  12 0.000  4 0.000
 34.5  34.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  19 0.000  1.013889
0000000 0.781     5 0.781     4.0000000 0.781  0 0.781    5 0.781   4.000000 0.781  15.000000 0.000  285 0.000  10.000000 0.000  0 0.781    5 0.781  4 0.781
 37.5  37.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  11 0.000  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  24 0.000   5.000000 0.000  26.000000 0.000  488 0.000  15.000000 0.000  1 0.000  16 0.000  4 0.000
 41.5  41.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  12 0.000  4.000000
0000000 0.000    27 0.000     2.0138890 0.000  1 0.000  13 0.000   4.000000 0.000  18.000000 0.000  344 0.000  12.000000 0.000  1 0.000  11 0.000  4 0.000
 44.5  44.513889  1 0.781   5 0.781  4 0.781   1 0.781    5 0.781   4 0.781  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   0 0.781    5 0.781  4.000000
0000000 0.781     5 0.781     4.0000000 0.781  2 0.000  18 0.000   5.000000 0.000   3.000000 0.000   58 0.000    5.000000 0.000  0 0.781    5 0.781  4 0.781
 48.5  48.513889  1 0.781   5 0.781  4 0.781   1 0.000   11 0.000   4 0.000  1 0.781    5 0.781  4 0.781 9 0.999 9 0.999 9 0.999   1 0.000  22 0.000  1.013889
```