

WP3: Near-surface observations of aerosols, clouds and trace gases

Task 3.1: Improvement of instrumentation, standardization and quality assessment of essential climate and air quality variables

Objective

To maintain and consolidate provision of high quality data for the variables addressed by ACTRIS in order to assure the quality and stability of the network composed of more than 40 ACTRIS labelled stations around Europe

Aims:

- increase the amount and quality of delivered data
- implement existing SOPs and propose revisions

ACTRIS-1 tools:

regular control exercises through round-robin tests and inter-calibration campaigns

ACTRIS-2 tools:

~~inter-laboratory comparison exercises (round robin):~~ **will no longer be used**

~~use of ACTRIS TNA (WP8):~~ **will no longer be used**

???or external calibration facilities???

questionable due to WCC issues (funding/personnel)

Frequency of the QA/QC activities for gaseous compounds:

At least one exercise in 2 different years

WP3: Near-surface observations of aerosols, clouds and trace gases

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ACTRIS-2 tools:

target gases: monthly, all stations: a prerequisite for the ACTRIS label

→ VOCs: spiked NPL+compressed air = commercial breathing air (DWD)

→ NO: 100 ppb by synth. gases manufacturers (DWD)

practical issues to be solved: canister types/valves/shipment

travelling standards and calibration campaigns: on demand for:

- existing ACTRIS stations with quality issues for existing compounds,

- new stations

→ VOCs: re-use of round-robin canisters from ACTRIS-1 (stored at EMPA)

→ NO: re-use of round-robin canisters from ACTRIS-1 (stored at DWD)

Parallel sampling: biannual, all stations, a prerequisite for the ACTRIS label

→ VOCs: flask sampling during measurements (EMPA)

→ NO: travelling instrument (DWD)

Station audits:

- existing ACTRIS stations with quality issues for existing compounds,

- new stations

→ WCCs for VOCs and NO_x (under discussion)

ACTRIS-2:

WP3: Near-surface observations of aerosols, clouds and trace gases

New control procedures to be implemented in ACTRIS-2 for:

- New biogenic precursors and oxygenated VOCs
- Additional oxygenated reactive NO_x/NO_y components

Additional activities:

- Tailored campaigns at Hohenpeissenberg (biogenic VOCs/OVOCs and :
summer 2016: NO_x/NO_y
summer 2017: OVOC/terpenes

Budget for participants?

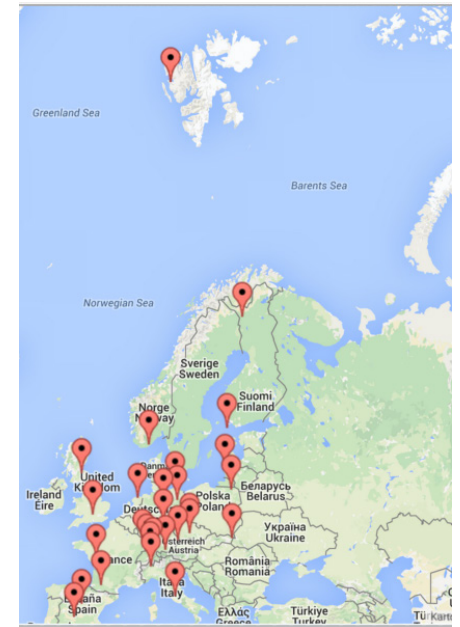
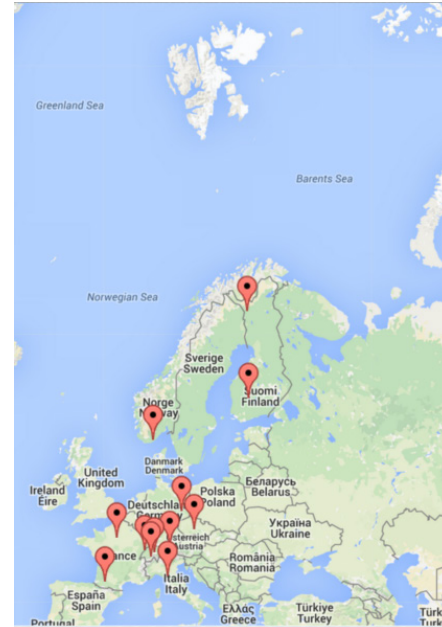
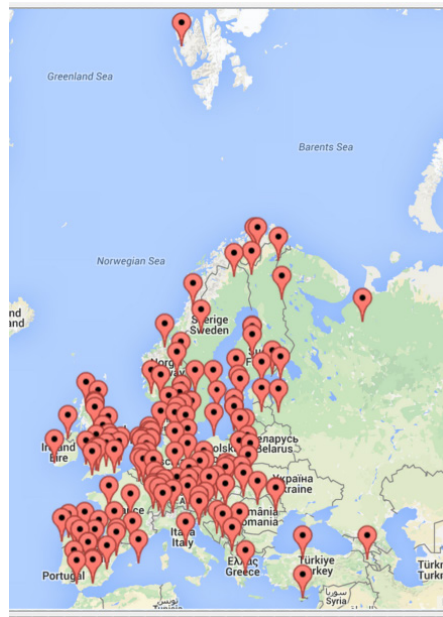
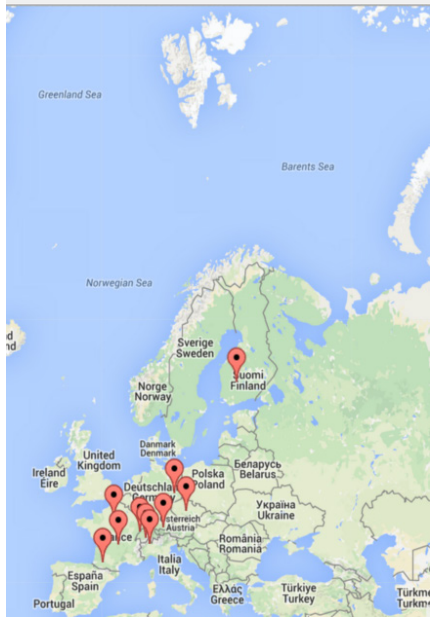
- EMEP intensive campaigns?
participation, calibration

ACTRIS-2:

Task 3.1 gases: improve the number of sites

NO₂

VOCs



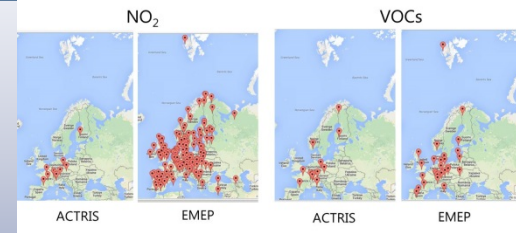
ACTRIS

EMEP

ACTRIS

EMEP

ACTRIS-2: Task 3.1 gases: improve the number of sites



VOCs status EBAS November 2015

actual status
Data 2014
Submission 2015

	GC cont	PTR-MS	Steel canister	2011	2012	2013	2014	PI	DS	
Hohenpeissenberg	x							A.Claude/D.Kubistin	A.Claude	
Jungfraujoch	x							M.Hill/S.Reimann	M.Hill/T.Seitz	
Rigi	x							M.Hill/S.Reimann	M.Hill/T.Seitz	
Monte Cimone	x							I.Arduini	I.Arduini	
Ny-Ålesund	x							C.Lunder/N.Schmidbauer	AM.Fjåraa	
Birkenes		x		NA		NA	NA	C.Lunder/W.Aas		Instrument not in operation, NILU contact Wenche Aas.
SIRTA			x	NA	NA	at NILU	at NILU	V.Gros/N.Bonnaire	N.Pascal/N.Bonnaire	Errors in format, waiting for 3.rd party
La Tardiere			x				at NILU?	S.Sauvage	S.Sauvage	In import queue
Peyrusse Vieille			x				at NILU?	S.Sauvage	S.Sauvage	In import queue
Kosetice			x	at NILU	at NILU	at NILU	at NILU	M.Vana/J.Diskova	J.Pekarek	New 2011-2014 dataset in import queue
Auchencort	x				NA	NA	at NILU	C.Braban	K.Vincent	In import queue
Harwell	x						at NILU	C.Braban	K.Vincent	In import queue
Pallas			x				at NILU	H.Hakola	M.Vestenius	In import queue
Hyytiälä		x		at NILU	at NILU	at NILU	at NILU	M.Kajos/P.Rantala	M.Kajos/P.Rantala	New 2011-2014 dataset in import queue, errors in format
Cape Verde	x			NA	NA	at NILU	at NILU	J.Hopkins	S.Punjabi	In import queue, errors in format

Hohenpeißenberg (Germany): current status of station/instrument

C2-C8 HC (Sep 1998 ongoing)

Daily 1:00 + 13:00 CET

C2: Ethane, Ethene, Acetylene

C3: Propane, Propene, Propyne

C4: i-Butane, n-Butane, 1-Butene, i-Butene, c-2-Butene, 1,3-Butadien

C5: i-Pentane, n-Pentane, t-2-Pentene, 1-Pentene, c-2-Pentene, Isoprene

C6: n-Hexane, 2-M-Pentane, 3-M-Pentane, 2,3-DiM-Butane, M-Cyclopentane+2,2-DiM-Butane

C7: n-Heptane, M-Cyclohexan+2,2,3-TriM-Butan

C8: n-Octane

Aromatics: Benzene, Toluene, ethylbenzene, p,m-Xylene



Quality assurance:

Instrument: GC-FID

Preconcentration: glass beads in 1/8" SS, custom built, trap at -185 °C

Sample volume: 0.75 liter

Water removal: 1/8" Silcosteel cold trap -40°C

Scale: NPL, 2ppb standard, 30-components +

Calibration interval: monthly: station standard, after each sample: synth. Reference gas

Quality checks: daily: GC param. + chromatogr., weekly: zero, monthly: cal. + 1st data evaluation, yearly: final data evaluation

Database: WDCGG, EBAS

Measurement instruction: yes

Other issues: compar.: other GC + flasks Helmig

Hohenpeißenberg (Germany): current status of station/instrument

Terpenes + C5-C12 HC (since 2000)

Daily 1:00 + 13:00 CET

C5: n-pentane, i-pentane, 1-pentene, t-2-pentene, isoprene, c-2-pentene, C-pentane

C6: n-hexane, 2-M-pentane, 3-M-pentane, M-C-pentane, C-hexane

C7: n-heptane, 2-M-hexane, M-C-hexane

C8: n-octane, i-octane ...

C9-C14: n-alkanes

Aromatics:

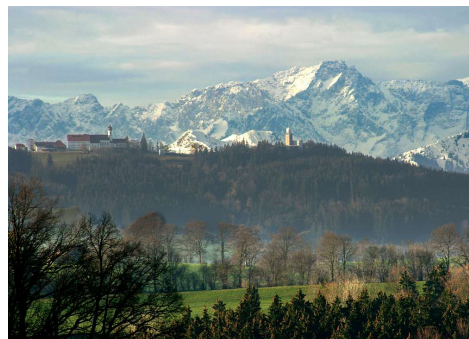
Benzene, toluene, ethylbenzene, p,m-xylene, o-xylene, C9-aromatics

Terpenes:

a-thujene, tricyclene, a-pinene, camphene, sabinene, myrcene, b-pinene, a-phellandrene, 3-carene, a-terpinene, m-cymene, c-ocimene, p-cymene, limonene, b-phellandrene, eucalyptol, g-terpinene, terpinolene, camphor

Acetone, methacroleine, methylvinylketon, methyl-ethyl-keton, benzaldehyde

CFC-113, CS₂, F11, CH₂Cl₂, CHCl₃, CH₃CCl₃, CCl₄, C₂HCl₃, C₂Cl₄



Quality assurance:

Instrument: GC-MS/FID

Preconcentration: Tenax TA, Carboxen 569 in 1/4" glass tube

Water removal: no

Scale: NPL (Terpenes: a-pinene, myrcene, 3-carene, c-ocimene, p-cymene, limonene, eucalyptol, camphor)

Calibration interval: monthly (NPL), each measurement (synth. Lab reference)

Quality checks: daily: GC param. + chromatogr., weekly: zero, monthly: cal. + 1st data evaluation, terpene decomp., yearly: final data evaluation

Database: no

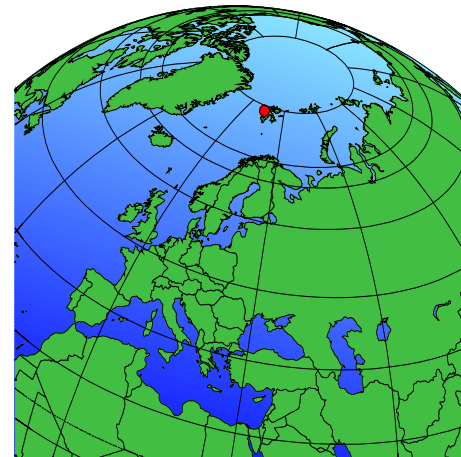
Measurement instruction: yes

Other issues: NOMHICE, AMOHA, GAW comp.

Zeppelin Norway, Spitsbergen

NMHCs (cont. 2010 ff.)

ethane,
propane,
n-butane, isobutane,
n-pentane, isopentane
benzene
toluene
ethylbenzene
m + p -xylenes
o-xylene



Quality assurance:

Instrument: GCMS

Preconcentration: MEDUSA

Sample volume: 2 liter, trap at -170 °C, trap material Hayesep D

Water removal: Nafion dryer

Scale: EMPA/SIO/NPL, 4ppb standard, 30-components

Calibration interval: 3-hourly

Quality checks:

routine checks: daily - weekly

final checks: yearly

Database: WDCGG, AGAGE

Measurement instruction: yes/no

Monte Cimone (Italy): current status of station/instrument

NMHCs (cont. 2004 /2008 ff.)

C3: propane, propene

C4: n-butane, isobutane, 1-butene, 2-butene, 1-3-butadiene

C5: n-pentane, isopentane, isoprene

C6: n-hexane, methyl-pentanes

C7: n-eptane,

C8: iso octane

Arom: benzene, toluene, xylenes, ethyl benzene;

Other VOCs could be added to the list after a deep investigation of the retention time of every compound: typical ions (m/z 41, 43, 51, 54, 56, 57) are detected along the chromatogram. Performance test has not been performed for the VOCs, but we are quite confident of the linearity of the trapping system as reported by the manufacturer (same system is sold as US-EPA TO14/15 and O-17 compliant)



Quality assurance:

Instrument: GCMS

Preconcentration: Markes – Unity2

Sample volume: 1 liter, trap at -30 °C, multibed trap:

Carbograph/CarosieveS3/Carboxen1003

Water removal: Nafion dryer

Scale: not calibrated! Working std are traceble back to 2007; additional information for some compounds (C4, C5, and aromatics) might be available back to 2004

Calibration interval: every 2 hours

Quality checks:

routine checks: daily

final checks: yearly

Database: AGAGE but not for VOCs

Measurement instruction: no

Jungfrauoch (Switzerland): in EBAS current status of station/instrument

NMHCs (cont. 2008ff.)

C2: ethane,

C3: propane,

C4: n-butane, isobutane,

C5: n-pentane, isopentane

C6:

C7+:

Arom: benzene, toluene



Quality assurance:

Instrument: GCMS

Preconcentration: MEDUSA

Sample volume: 2 liter, trap at $-170\text{ }^{\circ}\text{C}$, trap material Hayesep D

Water removal: Nafion dryer

Scale: NPL, 4ppb standard, 30-components

Calibration interval: 3-hourly

Quality checks:

routine checks: daily

final checks: yearly

Database: WDCGG, AGAGE

Measurement instruction: yes/no

Other issues: xxx

Rigi (Switzerland): current status of station/instrument

C2-C8 HC (2003 ongoing)

Hourly (continuous)

C2: Ethane, Ethene, Acetylene

C3: Propane, Propene

C4: i-Butane, n-Butane, sum of Butenes, 1,3-Butadien

C5: i-Pentane, n-Pentane, sum of Pentenes, Isoprene

C6: n-Hexane, sum of Isohexanes

C7: sum of Isoheptanes

C8:

Aromatics: Benzene, Toluene, ethylbenzene, p,m-Xylene, o-xylene



Quality assurance:

Instrument: GC-FID

Preconcentration: 3-stage trap, -44 °C

Sample volume: 1 liter

Water removal: Nafion Dryer

Scale: NPL, 4ppb standard, 30-components

Calibration interval: monthly: station standard,

Quality checks: daily: GC param. + chromatogr.,

yearly: final data evaluation

Database: WDCGG,

Measurement instruction: yes

Other issues:

Auchencorth (UK): current status of station/instrument

NMHCs (cont. 2006ff.)

C2: ethane, ethene, ethyne

C3: propane, propene

C4: n-butane, isobutane, 1,3-butadiene, 1-butene, cis/trans-2-butene

C5: n-pentane, isopentane, cis-2-pentene, isoprene

C6: n-hexane, 2/3-methyl pentane

C7+: n-heptane, n-octane, isooctane

Arom: benzene, toluene, xylenes, trimethyl benzene, ethyl benzene



Quality assurance:

Instrument: GC-FID

Preconcentration: PE TurboMatrix

Sample volume: 0.6 liter, trap at -30 °C, trap material CarbosorbB/Carbosieve SIII

Water removal: Nafion dryer

Scale: NPL, ppb standard, 30-components

Calibration interval: 4x 1h every 2 wk

Quality checks:

routine checks: daily chromatography

final checks: quarterly

Database: UKAIR, EMEP

Measurement instruction: no

Other issues: operated remotely by VNC

Harwell (UK): current status of station/instrument

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-----  
Period code:    1y  
Resolution code: 1h  
Laboratory code: GB02L  
Instrument type:  online_gc  
Instrument name:  VOC02  
Method ref: GB02L_voc_1  
File name: GB0036R.20140101.20150731.butadiene.air.1y.1h.nas  
Comment:      NA
```

start_time	end_time	value	numflag
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0.041667	0.083333	30	0.000000000
0.083333	0.125	30	0.000000000
0.125	0.166667	40	0.000000000
0.166667	0.208333	30	0.000000000
0.208333	0.25	30	0.000000000
0.25	0.291667	30	0.000000000
0.291667	0.333333	30	0.000000000
0.333333	0.375	50	0.000000000
0.375	0.416667	40	0.000000000
0.416667	0.458333	50	0.000000000
0.458333	0.5	40	0.000000000
0.5	0.541667	40	0.000000000
0.541667	0.583333	30	0.000000000
0.583333	0.625	30	0.000000000
0.625	0.666667	30	0.000000000
0.666667	0.708333	40	0.000000000
0.708333	0.75	30	0.000000000
0.75	0.791667	50	0.000000000
0.791667	0.833333	10	0.781000000
0.833333	0.875	40	0.000000000
0.875	0.916667	50	0.000000000
0.916667	0.958333	20	0.000000000
0.958333	1	30	0.000000000
1	1.041667	20	0.000000000
1.041667	1.083333	30	0.000000000
1.083333	1.125	40	0.000000000
1.125	1.166667	50	0.000000000
1.166667	1.208333	40	0.000000000

Harwell (UK): current status of station/instrument

NMHCs (cont. 2006ff.)

C2: ethane, ethene, ethyne

C3: propane, propene

C4: n-butane, isobutane, 1,3-butadiene, 1-butene, cis/trans-2-butene

C5: n-pentane, isopentane, cis-2-pentene, isoprene

C6: n-hexane, 2/3-methyl pentane

C7+: n-heptane, n-octane, isooctane

Arom: benzene, toluene, xylenes, trimethyl benzene, ethyl benzene



Quality assurance:

Instrument: GC-FID

Preconcentration: PE TurboMatrix

Sample volume: 0.6 liter, trap at -30 °C, trap material CarbosorbB/Carbosieve SIII

Water removal: Nafion dryer

Scale: NPL, ppb standard, 30-components

Calibration interval: 4x 1h every 2 wk

Quality checks:

routine checks: daily chromatography

final checks: quarterly

Database: UKAIR, EMEP

Measurement instruction: no

Other issues: operated remotely by VNC

SIRTA (France): 2 samples a week

NMHCs

C2:

C3:

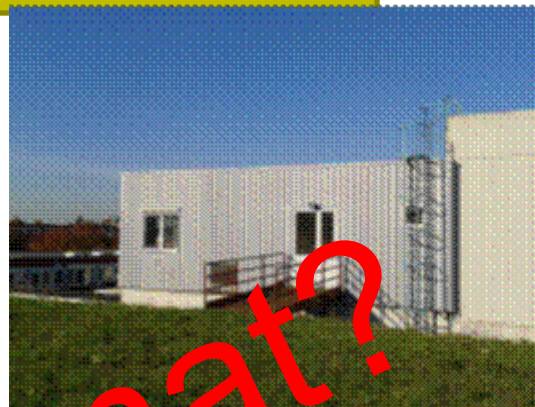
C4: Isobutane,

C5: 2-Pentene, (Z)-, 1-Pentene,

C6: Pentane, 2-methyl-,

C7+: Heptane, Octane, Pentane, 2,2,4-trimethyl-,

Arom: benzene, toluene, p & m-Xylene, o-Xylene, 1,3,5-TMB, 1,2,4-TMB, 1,2,3-TMB, Benzene 1,3-dimethyl, Ethylbenzene,



Quality assurance:

Instrument: GCMS

Sampling system : SASS Autosampler, trap material TENAX TA, Volume : 0.7 L

Preconcentration: ATD 300, TurboMatrix thermal Desorbers, Cold trap at 0°C with Carbosieve SIII (C2 to C6) and Carpack B (C5 to C12)

Water removal: No

Scale: NPL, 4ppb standard, 30-components

Calibration interval: before cartridge analysis

Quality checks: Autotune, each week for Air/Water Check and calibration in mass

Database: ? (NILU)

Measurement instruction: yes

Other issues: xxx

NMHCs (off-line cont.)

C2: ethane, ethene, ethyne

C3: propane, propene

C4: n-butane, isobutane, butenes

C5: n-pentane, isopentane, dimethylpropane, pentenes, isoprene

C6: hexane, cyclohexane, hexene, dimethylbutane, methylbutane

C7+: n-heptane, isoheptane, dimethylpentane, octane

Arom: benzene, toluene, xylenes, ethylbenzene, trimethylbenzenes

Valerie Gross/Nicolas Bonnaire



Perusse Vieille



Quality assurance:

Sampling system : stainless steel canister + AVOCS andersen, volume 6 liters, 2/week

Instrument: GC/2FID Chrompak CP9001

Preconcentration: ENTEC P7100

homemade traps trap1 glass+tenax -120 °C, trap2 tenax -50°C, capillary -50°C

Water removal: yes

Scale: NPL, 4ppb standard,

Calibration interval: weekly

Quality checks: Canister cleaning check

Quality control/dual sampling : 2/year

routine checks: monthly final checks: yearly

Database: EMEP

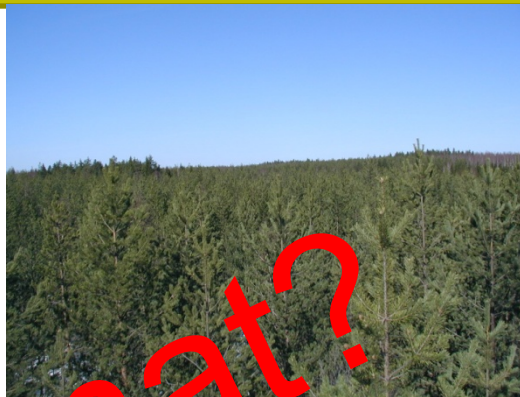
Measurement instruction: yes (for sampling)

Hyytiälä (Finland): current status of station/instrument

Isoprene,
benzene,
toluene

University of Helsinki

Rantala, Pekka; Kajos, Maija



Format?

Quality assurance:

Instrument: PTRMS

Preconcentration: no

Water removal: dry purge

Scale: liquid standards in adsorbent tubes

Calibration interval: weekly

Quality checks:

routine checks: weekly

final checks: yearly

Database:

Measurement instruction: yes (in Finnish)

Other issues:

Pallas-Sodankylä (Finland): current status of station/instrument

NMHCs

C2: ethane,

C3: propane,

C4: n-butane, isobutane,

C5: n-pentane, isopentane

C6:

Arom: benzene, toluene

FMI

Hannele Hakkola



Quality assurance:

Instrument: GCFID

Preconcentration: Adsorbent trap

Sample volume: 1.2 liter, trap at $-40\text{ }^{\circ}\text{C}$, trap material Perkin Elmer air monitoring trap, mixed bed carbon

Water removal: Nafion dryer

Scale: NPL, 4ppb standard, 30-components

Calibration interval: weekly

Quality checks:

routine checks: weekly

final checks: yearly

Database: EMEP

Measurement instruction: no

Cape Verde: current status of station/instrument

NMHCs (cont. 2007)

C2: ethane, ethene, acetylene

C3: propane, propene

C4: n-butane, isobutane, 1-butene, cis-2-butene, iso-butene, trans-2-butene, 1,3-butadiene

C5: n-pentane, isopentane, cyclopentane, isoprene

C6: n-hexane, 2+3-methylpentane

C7+: n-heptane

Arom: benzene, toluene, ethylbenzene, m+p xylene, o-xylene



Quality assurance:

Instrument: dual channel GC-FID

Preconcentration: OPTIC (Ai Qualitek)

Sample volume: 1 litre, trap at -20 °C, trap material: Carboxen 100 and carbotrap B

Water removal: glass cold finger (-30 °C)

Scale: NPL, 4ppb standard, 30-components

Calibration interval: fortnightly

Quality checks:

routine checks: daily

final checks: yearly

Database: WDCGG, BADC

Measurement instruction: yes/no

Other issues:

Kosetice (Czech Republic): current status of station/instrument

NMHCs (1993 up to now)

ethane
ethene,
propane
propene
i-butane
n-butane
acetylene
total butanes
i-pentane
n-pentane
total pentenes,
i-hexane
n-hexane
isoprene
i-heptane
n-heptane
benzene
toluene
ethylbenzene
m,p-xylene
o-xylene



Format?

Quality assurance:

Instrument: steel canister

Preconcentration: UNITY - Thermal Desorber, oven temperature 120 °C, trap temperature -20 °C, transfer line temperature 120 °C, gas type air, trap flow 40 ml/min, split 20 ml/min

Water removal: No

Scale: detection and determinableness limits are specified for each measured compound

Calibration interval: 3 months

Quality checks:

routine checks: daily

final checks: yearly

Database: EMEP, CHMI

Measurement instruction: yes

Puy de Dôme (France): current status of station/instrument

NMHCs (campaigns 2010, 2011 and from 2012 : 2 samples/weeks)

N-butane
Iso-butane
1-pentene
Isopentane
N-pentane
T2-pentene
C2-pentene
1-hexene
N-hexane
Benzene
Isooctane
N-heptane
Toluene
N-octane
Ethylbenzene
M+p xylene
O-xylène
1.3.5 trimethylbenzene
1.2.4 trimethylbenzene
1.2.3 trimethylbenzene

For ACTRIS:

Twice a week (to be discussed)
1 sample/day at 10:00 UTC;
1 sample/night 22:00 UTC;.



Quality assurance:

Instrument: GCMS

Preconcentration: Adsorbent-tube sampling (250 mg of Tenax TA 60-80 mesh, 150 mg of Carsieve III). . Sampling during 3 hours at 100mL/min, Tube Conditioning: 4h at 300°C with pure nitrogen.

Water removal: none

Scale: NPL, 4ppb standard, 30-components

Calibration interval: 1 standard/every 10 samples

Quality checks: flow, leak, repetability, blanks

Database: no

Measurement instruction: no

Other issues: xxx

No data submitted

Peyrusse-Vieille (>2000), La Tardière (>2003) and Donon (1993-2007), Corsica (>2011): EMEP (GAW regional in progress)

NMHCs (off-line cont.)

C2: ethane, ethene, ethyne

C3: propane, propene

C4: n-butane, isobutane, butenes

C5: n-pentane, isopentane, dimethylpropane, pentenes, isoprene

C6: hexane, cyclohexane, hexene, dimethylbutane, methylbutane

C7+: n-heptane, isoheptane, dimethylpentane, octane

Arom: benzene, toluene, xylenes, ethylbenzene, trimethylbenzenes

NMHCs on-line campaigns

Peyrusse Vieille 2009 (2 months)



Peyrusse Vieille



Quality assurance:

Sampling system : stainless steel canister + AVOCS andersen, volume 6 liters, 2/week

Instrument: GC/2FID Chrompak CP9001

Preconcentration: ENTEC P7100

homemade traps trap1 glass+tenax -120 °C, trap2 tenax -50°C, capillary -50°C

Water removal: yes

Scale: NPL, 4ppb standard,

Calibration interval: weekly

Quality checks: Canister cleaning check

Quality control/dual sampling : 2/year

routine checks: monthly final checks: yearly

Database: EMEP

Measurement instruction: yes (for sampling)

Environmental Research Station Schneefernerhaus (Germany): current status of instrument

NMHCs (starting 11/2011)

at least until 08/2012

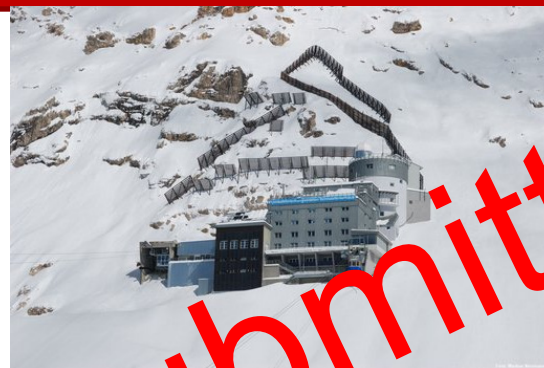
C2 – C10 NMHCs

Alkanes

Alkenes

Alkynes

Aromatics



Quality assurance:

Instrument: GC-FID

Preconcentration: Thermo Desorption

Sample volume: 600ml, trap at -30 °C, trap material: PE Air Toxics (graphitized carbon black and carbon molecular sieve)

Water removal: Nafion dryer

Scale: NPL, 4ppb standard, 30 components;

Restek EPA-TO14, 55 components

Calibration interval: tbd

Quality checks:

routine checks: daily

No data

Submitted

Mace Head (Ireland): current status of station/instrument

NMHCs (continous-2005)

C2: ethane,

C3: propane,

C4: n-butane, isobutane,

C5: n-pentane, isopentane

C6:

C7+:

Arom: benzene, toluene



No data

Quality assurance:

Instrument: GCMS

Preconcentration: MEDUSA

Sample volume: 2 litre, trap at $-170\text{ }^{\circ}\text{C}$, trap material Hayesep D

Water removal: Nafion dryer

Scale: NPL (D45 7238D45)

Calibration interval: 3-hourly

Quality checks:

Routine checks: daily

Final checks: yearly QA

Database: AGAGE

Measurement instruction: yes

Other issues:

UK FAAM146 research aircraft: current status of station/instrument

NMHCs (“sporadically” since 2009)

C2: ethane, ethene, acetylene

C3: propane, propene

C4: n-butane, isobutane, 1-butene, cis-2-butene, iso-butene, trans-2-butene, 1,3-butadiene

C5: n-pentane, isopentane, cyclopentane, isoprene

C6: n-hexane, 2+3-methylpentane

C7+: n-heptane

Arom: benzene, toluene, ethylbenzene, m+p xylene, o-xylene



Quality assurance:

Instrument: dual channel GC-FID

Preconcentration: OPTIC (Ai Qualitek)

Sample volume: 1 litre, trap at -20 °C, trap material: Carboxen 100 and carbotrap B

Water removal: glass cold finger (-30 °C)

Scale: NPL, 4ppb standard, 30-components

Calibration interval: monthly plus before and after each groups of analyses

Quality checks:

routine checks: daily

final checks: yearly

Database: BADC

Measurement instruction: yes/no

Other issues:

No data submitted

Additional sites for VOCs???

SMEAR by FMI (measurements on-going)

Birkenes by NILU (stopped in 2013)

Pico Mountain (Azores) Detlev Helmig, INSTAAR (USA)

Starina (Slovakia)

German EMEP stations measured by Schmücke

Finokalia

Ispra