Monitoring of long range transported air pollution

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Air pollution and impacts

**SOURCES**
- Energy
- Agriculture & forestry
- Industry
- Traffic
- Terrestrial ecosystems

**TRACE GASES**
- SO₂
- NH₃
- CO₂
- N₂O
- NOₓ
- VOC
- CO
- CH₄
- CFC, HFC, SF₆…

**ISSUES**
- Acidification
- Nitrogen Eutrophication
- Effects of elevated CO₂
- Climate change
- Regional O₃
- Free tropos. O₃
- Toxicity

**RECEPTORS/TARGETS**
- Groundwater
- Lakes
- Terrestrial ecosystems
- Marine environment
- Agriculture & forestry
- Humans and animals

**Topics**
- Agriculture & forestry
- Traffic
- Terrestrial ecosystems
- Industry
- Energy

**Issues**
- Acidification
- Nitrogen Eutrophication
- Effects of elevated CO₂
- Climate change
- Regional O₃
- Free tropos. O₃
- Toxicity
UN-ECE Convention on Long-Range Transboundary Air Pollution (1979)

The first legal binding instrument to deal with problems of air pollution on a broad regional scale

8 protocols, where EMEP is the first (42 parties)

European Monitoring and Evaluation Programme (EMEP)

*science based and policy-driven*

- Emission inventories and projections
- Monitoring
- Modelling activities
- Integrated assessment
Large improvements over the last decades

- One extra year of average life expectancy in Europe (reductions on PM and peak $O_3$)
- Declining acidification in lakes has led to fish stocks recovering
Still large challenges

Health

Biodiversity

- climate change
- New contaminants

Eutrophication

Loss in crop yields
Directives, protocols and conventions that set the monitoring agenda

**European**
- EU’s air quality directives
- OSPARCOM (and HELCOM) marine conventions
- UNECE LRTAP, its protocols and the EMEP Monitoring Strategy

**Global**
- Minamata Convention on Mercury
- Stockholm convention on POPs
- Paris agreement
- Montreal Protocol on Substances that Deplete the Ozone Layer
EMEP objectives

a) To provide observational and modelling data on air pollutant concentrations, deposition rates, emissions and **transboundary fluxes on the regional scale** and identify the trends in time;

b) To identify the sources of the pollution concentrations and depositions and to assess the response to changes in emissions;

c) To **improve our understanding** of chemical and physical processes relevant to assessing the effects of air pollutants on ecosystems and human health in order to support the development of cost-effective abatement strategies;

d) To explore the environmental concentrations of **new chemical substances** that might require the attention of the Convention in the future.
CLRTAP – EMEP

Focus areas:

✓ Major inorganics in air and precipitation (~1972->)
✓ Surface ozone, NOx, VOCs (~1977->)
✓ Heavy metals in air and precipitation (~1973->)
✓ POPs in air and precipitation (~1992->)
✓ Aerosol physical and optical properties (~1999->)
✓ Tracers, and long-lived species (~2000->)
The development of the program

- 1984 EMEP Protocol
- 1988 Sofia Protocol on Nitrogen Oxides
- 1994 Oslo Protocol on Sulphur
- 1999 Gothenburg Protocol on sulphur, NOx, VOCs and ammonia
- 1985 Helsinki Protocol on Sulphur
- 1991 Geneva Protocol on VOC
- 1998 Aarhus Protocols on Heavy Metals and POPs
Monitoring Strategy 2020-2029

Strategy from 2004, revised in 2009 and now in 2019:
https://projects.nilu.no/ccc/monitoring_strategy/index.html

- Parties to EMEP responsibility to implement the Strategy
Strategy for building a good observational system

- **Long term commitments.** Takes long time to obtain a useful time series - at least ten year
  - Shorter periods for screening and research
- **Adequate spatial resolution**
  - Enough stations to observe regional differences, especially important in regions with strong meteorological variations
- **Adequate temporal resolution**
  - Hours or days necessary to study sources and transport.

**Adequate data quality**
- Harmonized methods with international/national standards and use of reference methods and standard operational procedures
  - Regularly checked
- **Co-located** measurements
  - Many different components at the same sites. Cost efficient and better understanding of atmospheric processes and sources

Monitoring and research in close cooperation
- Use of same infrastructure (sites, lab, database)
- Dependent on each other
Level approach

Level 1, to provide long-term basic chemical and physical measurements of the traditional EMEP parameters.

Largely engages governmental agencies and institutes and is based on long-term funding. Standardized methods and data products. QAQC internal, partly overlap with EU-Directives based monitoring. Data reported to EMEP.

Level 2, provide a more complete description of the physical/chemical speciation of relevant components that is necessary for assessing the air pollution Do also rely in research institutes/universities, close links to RI-initiatives. Standardized methods and data products, external QAQC may occur. Data reported to EMEP.

Level 3, typically research oriented. Often no standard methods or QAQC systems in place. Often no permanent long-term commitment. Also other locations and «representativeness» than at Level 1 and level 2. Data reported to EMEP, but with exceptions (national network data)
# Level 1 parameters

Variables to be measured at all basic EMEP sites. Level 1 activities should be the first priority when extending the network in areas with few sites.

<table>
<thead>
<tr>
<th>Component group</th>
<th>Species</th>
<th>resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic compounds in precipitation</td>
<td>( \text{SO}_4^{2-}, \text{NO}_3^- , \text{NH}_4^+ , \text{H}^+ (\text{pH}), \text{Na}^+ , \text{K}^+ , \text{Ca}^{2+}, \text{Mg}^{2+}, \text{Cl}^- ), amount</td>
<td>24h</td>
</tr>
<tr>
<td>Inorganic compounds in air</td>
<td>( \text{SO}_2, \text{SO}_4^{2-}, \text{NO}_3^- , \text{HNO}_3, \text{NH}_4^+ , \text{NH}_3, (\text{sNO}_3, \text{sNH}_4), \text{HCl}, \text{Na}^+ , \text{K}^+ , \text{Ca}^{2+}, \text{Mg}^{2+} )</td>
<td>24h</td>
</tr>
<tr>
<td>Elemental and Organic Carbon</td>
<td>EC and OC in PM2,5</td>
<td>24h/7d</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>( \text{NO}_2 )</td>
<td>1h/24h</td>
</tr>
<tr>
<td>Ozone</td>
<td>( \text{O}_3 )</td>
<td>1h</td>
</tr>
<tr>
<td>PM mass concentration</td>
<td>PM2.5, PM10</td>
<td>24h</td>
</tr>
<tr>
<td>Heavy metals in precipitation</td>
<td>( \text{Cd}, \text{Pb} , (1\text{st priority}), \text{Cu}, \text{Zn}, \text{As}, \text{Cr}, \text{Ni} , (2\text{nd priority}) )</td>
<td>7d</td>
</tr>
<tr>
<td>Meteorology</td>
<td></td>
<td>1h</td>
</tr>
</tbody>
</table>
Level 1 (status 2016)

Quite good spatial coverage though lack measurements in the most Eastern part of Europe and some areas in south of Europe
Several sites with long term commitments

Example of SO$_2$ and SO$_4$ at Zeppelin in Spitsbergen:
Level 2 parameters

Oxidant precursors and gaseous SLCPs
- Nitrogen oxide
- Light hydrocarbons: C2-C5, BTEX (Benzene, Toluene, Ethylbenzene, and Xylene)
- OVOCs: Aldehydes and ketones
- Hydrocarbons: C6-C12
- Methane: CH4
- Carbon Monoxide: CO

Aerosol properties
- PM mass: PM1
- Elemental and Organic Carbon in air: EC and OC in PM10
- Mineral dust in PM10: Si, Al, Fe, Ca
- Particle light absorption/ekv. black carbon: Light absorption coefficient, eBC
- Particle number concentration: dp >10nm
- Particle number size distribution: dN/dlogDp, (sub/supermicrometer)
- Particle light scattering coefficients: Light scattering coefficient, Light backscatter coefficients (multi-wavelenghts)
- Particle chemistry speciation: Non-refractory organic and inorganic composition (ACSM, AMS)
- Aerosol Optical Depth: AOD at 550 nm

Nitrogen: gas/aerosol
- Gas particle ratio of N-species: NH3/NH4+, HNO3/NO3 - (artifact-free methods)
- Gas particle ratios of N-species: NH3, NH4+, HNO3, NO3- (HCl, J)(complementing the filter pack sampling)

Heavy metals
- Mercury in precipitation: Hg
- Mercury in air: Hg (TGM)
- Heavy metals in air: Cd, Pb (1st priority), Cu, Zn, As, Cr, Ni (2nd priority)

Persistent organic pollutants observations contributes to the assessment of persistent organic pollutants
- POPs in precipitation: PAHs, PCBs, HCB, chlordane, HCHs, DDT/DDE
- POPs in air: PAHs, PCBs, HCB, chlordane, HCHs, DDT/DDE

Tracers
- Halocarbons: CFCs, HCFCs, HFCs, PFCs, SF6

- Additional to level 1 measurements
- 1 -2 sites per country
- Not necessarily all parameters (national priorities)
For aerosol properties there has been a large improvements the last decade. Close cooperation with other programmes like ACTRIS and WMO/GAW.

Improvements seen in the spatial coverage of VOC measurements.

Tracers, few sites.
Level 2, status 2016 (II)

- Relatively good coverage of heavy metals except in Eastern Europe
- Mercury and most POPs mainly measured in northern and central Europe
- Measurements of PAHs (BaP) have quite good coverage due to EU AQD
There has been projects to establish EMEP sites in the EECCA region.
Azerbaijan: Xizi

Kazakhstan: Borovoye

Moldova: Leovo

Armenia: Amberd
Status monitoring in the EECCA region

Measurement programme
- RU, BY, MD, AR measure and report data from sites in rural areas. But it is not complete level 1 measurements at any sites.
- GE, AZ and KZ do have an EMEP site but do not measure/report

Quality assurance and standardized methods
- Encourage to take part in lab inter-comparison (some countries do)
- Participation at EMEP and GAW training courses
Expectations, EECCA countries

A very important region
- High emissions
- Strategic area for hemispheric transport issues
- Little monitoring today

Expected that most countries will sign the EMEP protocol.

Need to establish EMEP level 1 sites in each country. Support can be found, i.e. from foreign aid money, EU, UNECE. Training and capacity building is necessary.

Being part of an international monitoring programme, as on transboundary air pollution, will in addition, give competence and awareness on other environmental issues.
Data availability, open access:
http://ebas.nilu.no/
Near Real time data

http://ebas-nrt-showcase.nilu.no
New visualization tool with EMEP trends (developed by MSC-W)

- EMEP model with sector contribution.
- Currently PM$_{10}$ and PM$_{2.5}$
- More components to be included
- Observations to be added

https://www.emep.int/mscw/
EMEP in Scientific literature

Total Publications: 751
- 1999: 5, 2018: 90

h-index: 69

Sum of Times Cited: 22,501
- Without self citations: 20,538

Citing articles: 15,135
- Without self citations: 14,648

EMEP in «Title», «topic» or «funding»

Chart showing the increase in citations per year from 1992 to 2018.
Download of data by country

EMEP - Datasets by user country (2016/1/1 - 2018/29/04)

Double Click to zoom on the map, and move your mouse over a bubble to get the exact count

UK: 140,000
Data submission

- Specific templates need to be used
- Data submitted via a tool, which also allows for checking your data
- Contact ebas@nilu.no for any questions
Guidelines and SOPs

- Guideline for good measurement practice
- Methodologies, guidelines and SOPs recommended and harmonised between EMEP, ACTRIS and WMO/GAW
- https://ebas-submit.nilu.no/Standard-Operating-Procedures
Training courses and assistance

- CCC assists with technical help, inter-comparison exercises, support letters etc
- Training courses arranged regularly.

Note, upcoming hands on course in WMO/GAW: https://www.gawtec.de
Application: 1 June
Summary

- A new monitoring strategy for 2020-2029 to be accepted this year
- Data from EMEP is extensively used
- Improvements needed
  - Spatial coverage (EECCA specifically)
  - In the species measured
- Continuous focus on data quality
  - Inter-comparisons
  - Training courses
  - Reference laboratories
- Data reporting improvements
  - Tools and templates to assist reporting
  - Traceability
  - Extended metadata information
Thank you for the attention!

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