**DRAFT EMEP MONITORING STRATEGY, 2020-2029**

This document defines the monitoring strategy for the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) for the period 2020–2029. It was developed through a revision process led by the EMEP Chemical Coordinating Centre (CCC) in cooperation with the EMEP Task Force on Measurements and Modelling (TFMM), as mandated by the 3rd joint session of the EMEP Steering Body and the Working Group on Effects in 2017.

**I. INTRODUCTION**

1. The 1979 Convention on Long-Range Transboundary Air Pollution specifies the number of areas where close collaboration between its Parties is important to achieve its goals. These areas include i) requirements with respect to instrumentation and other techniques for monitoring ambient concentrations of air pollutants, ii) the need to exchange meteorological and physico-chemical data relating to the processes during transmission and iii) the need to use standardized or comparable procedures for monitoring and for the establishment of monitoring stations. The monitoring strategy specifies the detailed requirements for monitoring activities of the Parties to EMEP.

2. The main objectives of EMEP are:

(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 the understanding of chemical and physical processes relevant to assessing the effects of air pollutants on ecosystems, human health, materials and climate 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.

3. The EMEP observations and model calculations are important elements in assessing the air pollution situation in the United Nations Economic Commission for Europe (UNECE) region and provide links both to global and to urban scales. Since air pollution is addressed also by other conventions and programs, EMEP will collaborate closely with these to ensure harmonized approaches and efficient use of resources.

4. The CLRTAP Executive Body adopted at its twenty-second session a Level-based monitoring strategy for the period 2004–2009 (EB.AIR/GE.1/2004/5) and made a decision concerning its implementation (ECE/EB.AIR/83/Add.1, decision 2004/1). The decision urged Parties within the geographic scope of EMEP to make resources available for the full implementation of the strategy at the national level without undue delay. It requested CCC to provide technical support to the Parties and the Steering Body to follow the implementation of the strategy closely, to review it and to keep the Executive Body informed on the progress. The strategy was revised for the period 2010-2019 (ECE.EB.AIR.GE.1.2009.15), with minor adjustments compared to the 2004-2009 version.

**II. GENERAL OBJECTIVES AND REQUIREMENTS**

5. The monitoring strategy for 2020–2029 consolidates the established approaches and aspirations for monitoring activities in order to provide consistent and adequate observational data supporting the EMEP objectives. Further it introduces some minor changes to the specific requirements in order to meet the needs of EMEP for the coming decade.

6. The monitoring activities aim to ensure:

(a) Adequate ongoing long-term monitoring of concentrations and deposition fluxes to assess exposure and impacts on health, ecosystems, vegetation, materials, and climate;

(b) Adequate spatial coverage in the geographical domain of EMEP and improved access to information from areas that have been insufficiently covered up to now;

(c) Sufficient temporal resolution to allow investigation of atmospheric processes driving transport and transformation of pollution, guide model improvements as well as to allow the analysis of individual pollution events;

(d) Co-located and concurrent monitoring of the relevant atmospheric variables, the adoption and use of standardized methodologies, and adequate quality assurance procedures;

(e) A level of ambition which is affordable for all Parties, but also taking advantage of the scientific developments and emerging capabilities.

7. EMEP monitoring is the core framework for regional-scale monitoring of atmospheric constituents throughout the EMEP domain. Observations are made at remote and regional background sites and allow, in combination with other monitoring efforts within the UNECE area, the evaluation and assessment of regional and transboundary contributions to local air pollution.

8. EMEP observations are further important for understanding the role of intercontinental and global scale transport of short- and long-lived species playing a role in air pollution and climate change processes. The measurement program include radiative forcing agents (also named short-lived climate forcers) e.g. aerosols (including black carbon) and ozone and their precursors (including methane). EMEP monitoring supports, in an integrated way, information needs associated with coupling between atmospheric composition and deposition rates with the climate system and its variability, as well as the coupling between the carbon and nitrogen cycles.

9. Furthermore, EMEP observations are well-suited to serve as complementary and reliable data for calibration and validation data to airborne and satellite-based remote sensing instrumentation.

10. The monitoring strategy of EMEP aims to utilize new developments in observational methods, new technologies and techniques to integrate observations from measurement platforms (e.g. in situ, profiles, satellite remote sensing and methods for integrating observational data with modelling through, for example, data assimilation and measurement model fusion approaches.

11. EMEP will where relevant and appropriate, continue its efforts to increase the monitoring and reporting of parameters and data at timeliness allowing more rapid access to air pollution information (“Near Real Time” or “Real Real Time” data delivery). Such efforts will be based on voluntary contributions from Parties and will follow the guidance of the EMEP Steering Body.

**III. COORDINATION AND COOPERATION**

12. Due to the significant interactions between the suite of chemical constituents and the associated physical properties of air pollutants, as well as the synergies in abatement measures, national and international monitoring efforts should be closely coordinated. Such an approach will be pursued by EMEP to ensure a sound observational basis by combining resources and avoiding duplication of efforts.

13. Taking into account the complexity and costs of atmospheric composition monitoring, EMEP will, as far as possible, continue to harmonize with and make use of relevant data compiled under other conventions and frameworks. In particular, such observations would include local air quality, climate change, water quality, and biodiversity. As a result, there is a significant overlap in technical infrastructures at national levels, i.e. that most EMEP level 2 sites (see below) represents core infrastructures for observations supporting related initiatives. Within CLRTAP there is a close collaboration with the Working Group on Effects and the International Cooperative Programmes (ICPs), where EMEP observations are used to derive pollution exposure data to assess impacts and effects.

14. On the European scale, EMEP observations are fundamental in relation to the EU-Air Quality Directive and the National Emission Ceilings Directive (NECD), and there are close links in relation to EMEP monitoring requirements in the Directives. Also the assessments of the Air Quality situation in Europe by the EEA makes use of EMEP observations, and EMEP sites typically deliver parts of their data also to the EEA-database.

15. There is a close scientific and technical cooperation between EMEP and WMO Global Atmosphere Watch Programme in Europe. It comprised harmonization of guidelines, observational practices, data quality control, quality assurance, and data exchange. Through the efforts of GAW, EMEP observations are also harmonized with efforts in other parts of the world, and EMEP data contribute to GAWs services to the society.

16. Examples of other initiatives and frameworks related to pollution include international programmes and Conventions like the Arctic Monitoring and Assessment Programme (AMAP), the Baltic Marine Environment Protection Commission (HELCOM), the Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Commission), the United Nations Framework Convention on Climate Change, the Stockholm Convention on Persistent Organic Pollutants and the Minamata Convention on Mercury under the United Nations Environment Programme (UN Environment), and others.

17. EMEP observations are also made available to users and stakeholders though initiatives like the Global Earth Observation System of Systems (GEOSS) and the European Union's Earth Observation Program (COPERNICUS).

**IV. SPECIFICATION OF THE MONITORING PROGRAMME (2020–2029)**

**Organization of the monitoring network**

18. The monitoring programme is organized to allow for monitoring stations to operate at three different levels of scope and complexity, each targeting EMEP objectives in different but complementary ways. In addition, EMEP will make use of other relevant supplementary data of adequate quality at relevant spatial representativeness, e.g. the observations from the collaborating programmes and initiatives mentioned above.

19. The main objective of monitoring at level 1 is to provide long-term basic chemical and physical measurements of the basic EMEP parameters. Level 1 activities should be the first priority when extending the network in areas with few sites like Eastern Europe, Caucasus and Central Asia (EECCA) and in South-Eastern Europe (SEE). By undertaking a more demanding monitoring programme, a subset of the level 1 stations should gradually be upgraded to include variables required for level 2.

20. Level 2 variables provide a more complete description of the physical/chemical speciation of relevant constituents that is necessary for assessing the air pollution including long-range transport of air pollutants and thus represent an essential supplement to the level 1 activities. The aim is to operate at least 30 sites providing level 2 data throughout the EMEP domain. Level 2 variables are defined according to topics that Parties may choose to focus on considering their national priorities with the understanding that unless relevant, not all topics need to be covered. A site extending its programme to include both level 1 and level 2 requirements will be identified as an “EMEP supersite”; this is an important motivation factor and provides appropriate recognition of the data providers. The target of Level 2 observations is to provide long-term continuous monitoring data using measurement methods traceable to established international quality standards, as it is for Level 1 observation’s data.

21. The main objective of Level 3 observations is to improve the scientific understanding of the relevant physico-chemical processes in relation to regional air pollution and its control. Level 3 activities will typically be based on short-term campaign data. Level 3 efforts are often based on methods and approaches for which standardized methods and procedures have not yet been established, and where decadal or multi-decadal time series is not realistic. Level 3 observations are a voluntary part of the monitoring activity and will be implemented in collaboration with the broader researchers' community.

**Specification of observations and variables**

22. The specification of variables at the different levels of monitoring is as follows:

(a) Level 1: Measurements at level 1 include parameters required to describe basic aspects of tropospheric chemistry and deposition rates of substances involved in the atmospheric cycling of particulate matter, photochemical oxidants, acidifying and eutrophying compounds and heavy metals. Requirements also include standard meteorological parameters, but these may be taken from a distant meteorological site if representative.

(b) Level 2: Measurements of level 2 parameters should be made at a subset of sites at which level 1 measurements are made. The potential additional parameters include higher time resolution, reliable gas/particle distribution information for semi-volatile compounds, speciation of precursors to photochemical oxidants (nitrogen oxides (NOx) and volatile organic compounds (VOCs)), physical and optical characterization of aerosols (including “black carbon”), aerosol optical depth, further chemical speciation of particles (elemental and organic carbon in PM10, mineral dust), tracers to address air mass origin and the role of anthropogenic versus natural influence, methane (CH4) and halocarbons. For heavy metals, the level- 2 program includes air concentrations of cadmium (Cd) and lead (Pb) (with copper (Cu), zinc (Zn), arsenic (As), chromium (Cr) and nickel (Ni) as a secondary priority) and mercury (Hg) in precipitation and air (total gaseous mercury (TGM)). POPs monitoring in level 2 should ideally include measurements both in air and in precipitation (PAHs, PCBs, HCB, chlordane, HCHs, DDT/DDE, and preferably congener or isomer specific). A full implementation of all parameters listed above is however not required in order to comply with the monitoring strategy.

(c) Level 3: Level 3 measurements are research-driven and may partly be available at locations other than sites offering level 1 and level 2 data. Interesting parameters for EMEP include: dry deposition flux measurements (sulphur, nitrogen, ozone, VOCs, Hg, others); vertical profiles of ozone and aerosols (soundings or lidar, observations of POPs and Hg in other compartments than in the atmosphere; chemical speciation of organic carbon (OC) in aerosols, carbon dioxide (CO2) and nitrous oxide (N2O) measurements made at EMEP sites in association with other monitoring frameworks; and isotope information on OC and VOCs. The list is not exclusive and other parameters may be added to this list as they become relevant for EMEP.

23. Table 1 in the annex to the present document summarizes the parameters recommended to be monitored at the three respective levels, as well as the recommended time resolution for measurements.

24. Since the different compounds studied under EMEP are intrinsically linked, it is important that the EMEP monitoring network consists of co-located and concurrent measurements in both precipitation and air. It is recognized, however, that some measurements may not always be co-located with level 1 sites.

**Time resolution – measurement frequency**

25. The temporal resolution for the EMEP mandatory monitoring programme should be sufficient to support the analysis of chemical and physical characteristics of synoptic-scale transport. Thus, the temporal resolution should generally not exceed 24 hours. Higher temporal resolution is recommended where appropriate methods exist. However, Parties can undertake to monitor at a lower time resolution when the measurement activity requires significant financial resources making a continuous time-integrated sampling at 24-hour resolution unrealistic. Similarly, longer sampling times should be considered if concentrations levels are so low that detection levels represents a problem. It should be noted that special considerations should be made to avoid sampling time resolution affecting data quality, e.g. if methods are subject to sampling artifacts. In such cases, it is recommended to continue the current practice of limiting the sampling to a few short-time integrated samples per week as opposed to long sampling times (e.g. weekly or monthly sampling for POPs and VOCs is not recommended).

**Spatial resolution**

26. The monitoring spatial density should reflect the residence time of the individual pollutants in the atmosphere and be sufficient to resolve the actual spatial gradients in concentrations and deposition on the regional scale. The site density is defined for each level, whilst providing for some flexibility.

27. For level 1 variables, at least one to two sites per 100,000 km2 is recommended. All Parties with an area larger than 10,000 km2 are requested to operate at least one site. It is recommended that small countries with large gradients in geography and climate increase site densities further, taking into account that gradients in mountainous regions should also be monitored.

28. For level 2 variables, all Parties with a land area larger than 50,000 km2 should operate at least one site. As introduced in paragraph 20, Parties have the possibility to choose and focus on variables reflecting their national priorities. Possibilities for regional collaboration on the operation of sites should be explored if obstacles or financial constraints for implementation of monitoring programme exist. Most of the existing level 2 sites are contributing to ACTRIS, the European Research Infrastructure for the observation of Aerosol, Clouds and Trace Gases.

29. Level 3 measurements are voluntary, and no specific requirements are given with respect to site densities. Most Parties already operate sites addressing level 3 components, and efforts should be made to involve relevant scientific groups in the EMEP work. Traditionally, EMEP TFMM has arranged a number of intensive campaigns, which have proven to be an essential contribution to EMEP pogramme developments. The level 3 measurements can to some extent address priority pollution issues for different sub-regions, and the availability of data might depend on the availability of research funds and interest of these regions to share resources and data.

**Data quality and exchange**

30. EMEP will maintain and further improve its quality assurance programme to make sure that observation data are of known quality and adequate for their intended use as defined in section II. Field intercomparisons and laboratory ring tests are important, as well as the maintenance of good communication between national data providers and the EMEP centers. These activities can be strengthened through collaboration with the central quality assurance facilities in the European Union (e.g. AQUILA and CEN), in the WMO-GAW Programme and with ACTRIS. Close links to the services offered by the metrology community (EURAMET) are also important.

31. Measurements have to satisfy requirements for quality assurance, quality control, and data reporting. Reporting formats, as well as criteria for instrumentation and analytical methods, are also defined and provided at CCC website (<https://ebas-submit.nilu.no/Standard-Operating-Procedures>). However, other methods may be used provided that data quality can be proven equivalent.

32. For all data from the monitoring efforts at EMEP levels 1, 2 and 3 an open data policy will apply. Data will be available to all interested users, together with information about metadata on data originator, QA-measures, etc. to achieve the most efficient and transparent use of observations in support of the Convention needs.

**V. IMPLEMENTATION AND FURTHER EVOLUTION OF THE MONITORING STRATEGY**

33. All Parties are requested to ensure the full implementation of the monitoring strategy.

34. It is essential to extend the implementation of the programme throughout the UNECE region, in particular in EECCA and SEE, starting with level 1 variables.

35. Due to a large number of parameters to be measured, and the proposed site density, some Parties might for various reasons have different priorities or have difficulties in conducting all activities defined at level 1 and level 2. EMEP will thus accept information not fully satisfying the level-oriented requirements. Any major change or deviation in the monitoring programme of any Party should be made in consultation with CCC. Parties with economies in transition that have not been able to operate an adequate EMEP monitoring site in the past are encouraged to enter the programme as soon as possible, and if necessary at a lower level of ambition, e.g. by implementing only parts of the programme in the beginning. CCC is committed to providing guidance to the Parties on priorities with respect to which parameters to monitor.

36. The EMEP monitoring strategy must be ready to adapt to new needs and requirements identified by EMEP and the Convention. At the same time, consistent long-term time series need to be maintained to monitor trends in atmospheric composition. This requires the strategy and its implementation to be regularly reviewed and, as appropriate, revised. The CCC will coordinate reviews and together with the Task Force on Measurements and Modelling, the EMEP Centers and other relevant bodies, present the recommendations for revisions to the EMEP Steering Body.