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Gaps in the Global Coverage of Atmospheric Monitoring of Controlled Substances and Options to Enhance such Monitoring

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UNEP/EU Pilot Project Steering Committee

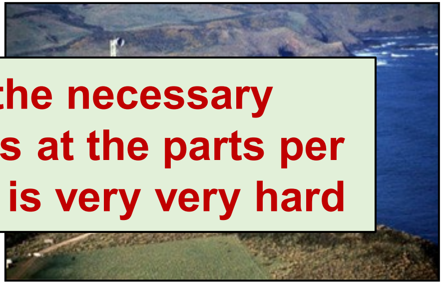
Some Critical Requirements:

- Air-Conditioned Lab
- Air Sampling Tower
- No Local Sources of Analytes
- Reliable Electric Power
- Reliable Internet
- Road Access

Making the necessary observations at the parts per trillion level is very very hard

Ireland, 52°N

Cape Matatula
American Samoa, 14°S



Cape Grim, Tasmania,
Australia, 41°S

The Importance of "Top-Down" Atmospheric Monitoring

"Bottom-Up" Approach (TEAP)

1. Collect information about different emission sources
2. Obtain information on emissions via either activity data or reporting.
3. Aggregate all data to calculate total emissions from regions and countries.

Advantage:

- Identify specific emission sources for action (if necessary)

Disadvantages:

- Missing sources
- Modeling emission of past consumption
- Intentional violations not reported
- Irregular reporting

"Top-Down" Approach (SAP)

1. Measure atmospheric concentration changes above background levels
2. Calculate air parcel trajectories that brought the air to the sampling sites.
3. Calculate emissions from "integrated" or broad source regions.

Advantages:

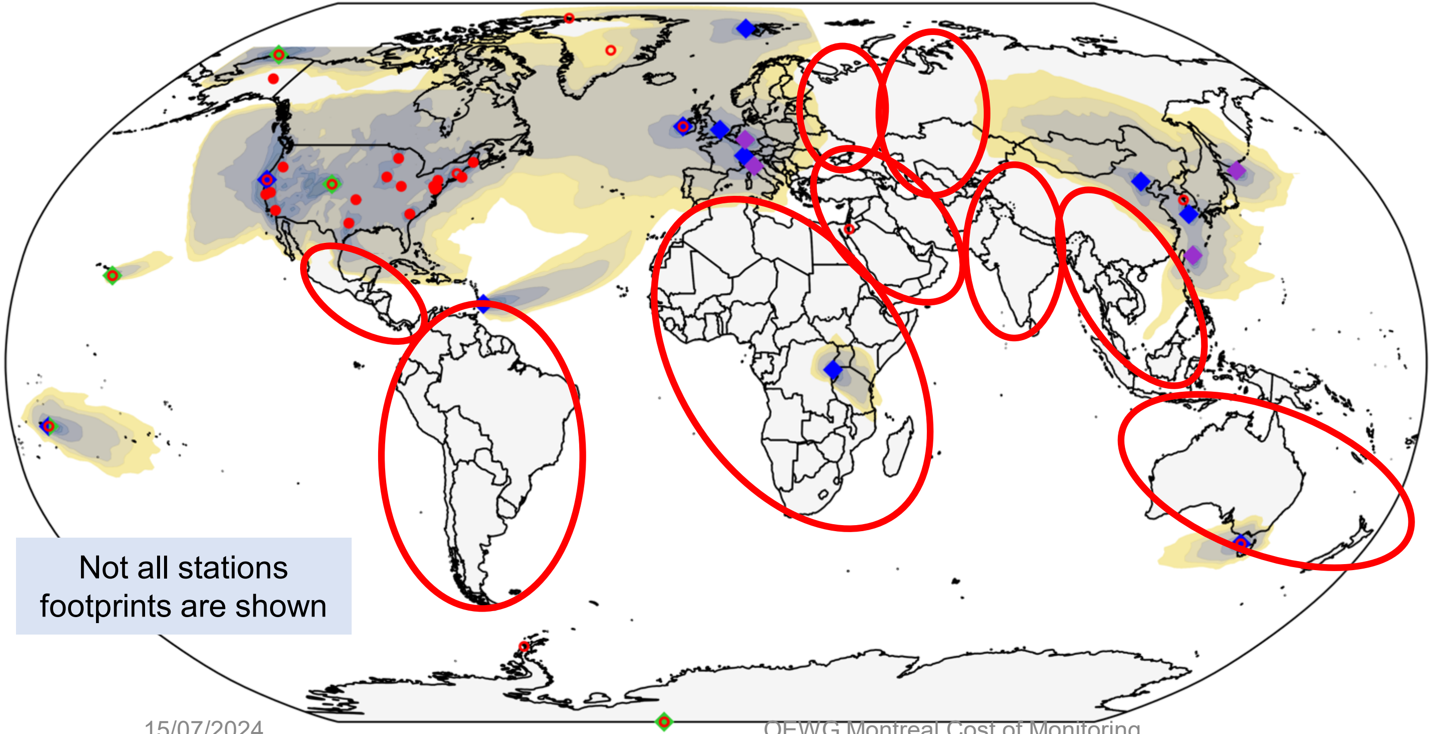
- Obtain total emissions from regions
- Obtain emission amounts as functions of time (seasons, years, etc.)

Disadvantage:

- Cannot give specific activities that led to the emissions.`

Measurement Stations and Instrumentation for the "Top-Down" Approach: Current Capabilities

Existing atmospheric monitoring network modeled emissions sensitivity "footprints" from the White Paper (UNEP/OzL/Conv.ResMgr/11(II)/4)



Not all stations footprints are shown

2020 Ozone Research Managers Report: "… coverage of eastern Europe, western, southern and central Asia, all of South America, portions of North America, large parts of Southeast Asia, Australia and New Zealand, and most of Africa is largely absent."

NOAA sites are green and red, **AGAGE** sites are blue and purple.

Flask Sampling and High-Frequency Measurement

Two major approaches to quantifying emissions:

- Flask sampling at a station followed by concentration analysis at a central facility
- High-frequency measurements by analytical instrumentation at the sampling location

Flask sampling and high-frequency measurements are not mutually exclusive:

- Initial flask sampling (survey) to establish best sampling sites
- The measurement expertise is similar but distributed differently
- There are many commonalities in needs and some of the costs are similar or the same

A holistic approach is needed to take advantage of synergies with other scientific and non-scientific infrastructures.

There are commonalities and differences between monitoring MP and greenhouse gases:

- There are some major differences among concentrations and measurement technologies
- Backgrounds from natural sources are different

What does it take to quantify emissions?

Informed from Ongoing Work:

- Reliable calibration standards
- Observation System Simulation Experiments (OSSEs)
- Various current monitoring stations and networks
- Example of flask sampling from Bhola Island

Workshop for Estimating the Costs:

- Components for measurement systems
- Description of the online workshop
- Description of cost estimates.

Workshop on Costs of Monitoring MP and Related Gases

Motivation:

- A request of the Parties to refine the cost estimates associated with enhancing such monitoring is included in decision XXXV/14 adopted at the 35th Meeting of the Parties to the MP in October 2023.
- The Steering Committee overseeing the implementation of the Pilot Project was requested by the Ozone Secretariat to provide further information on the costs of establishing monitoring stations, including information gained during the implementation of the Pilot Project.

Overview (23 February 2024):

- The video workshop included 35 attendees with expertise or interest in the measurement of atmospheric MP gases and/or in developing stations for these observations, as well as in related measurements.
- Discussions followed presentations from the Steering Committee on the needs and approaches, including flask sampling and high-frequency on-site measurements.
- Attendees provided cost information based on their experiences with the establishing sites and with the measurements carried out by them.

Steps for setting up a monitoring station

Identification of location of observation station

Production
Export/import data-
Consumption
estimates

Suitable for sampling emissions from interested regions?

Carry out OSSEs

Is infrastructure available?

Building, security, and road?
Electricity, AC, and telecommunication?
Tower >20 meters?

Does the host country agree? Provide Support?

Cost sharing?
Sample collection and shipping?
Analytical facility?

Identify analytical facility

Willing to analyze samples?

Carry out survey flask measurements?

Increase to daily or more frequent sampling.
Is the station suitable?

high-frequency sampling?

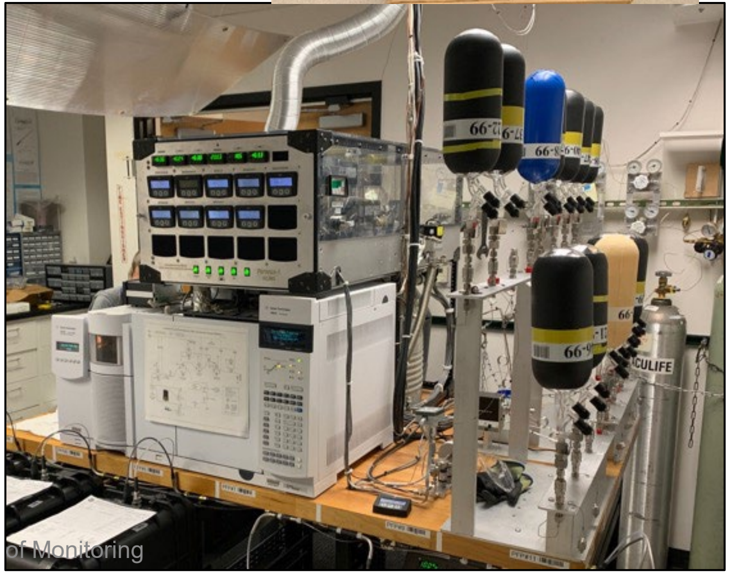
Daily flask sampling?

Eventual Goal:
Daily or more frequent flask sampling
and/or
high-frequency sampling

Flask Observation System Components

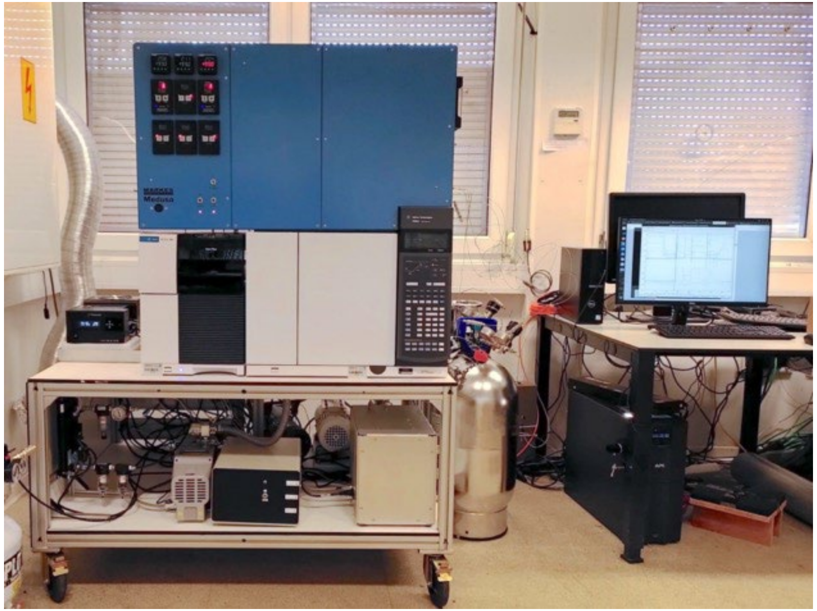
Flasks in Automated Filling Case (upper right). NOAA Laboratory , Boulder, Colorado, US

Flask Measurement GC-MS Instruments: M4 (lower left) and Perseus (lower right).



Examples of Commercially Available High Frequency Instruments

Commercialized Medusa-type Instrumentation (used in AGAGE network) for Automated High-Frequency Measurements of ODSs, HFCs and Other High-GWP GHGs



Markes/Bristol (UK) Medusa GC-MS
at Taunus Station, North of Frankfurt, Germany

Huanaco/Fudan (China) ODS5-Pro GC-MS
at Dongtan Station, East of Shanghai, China

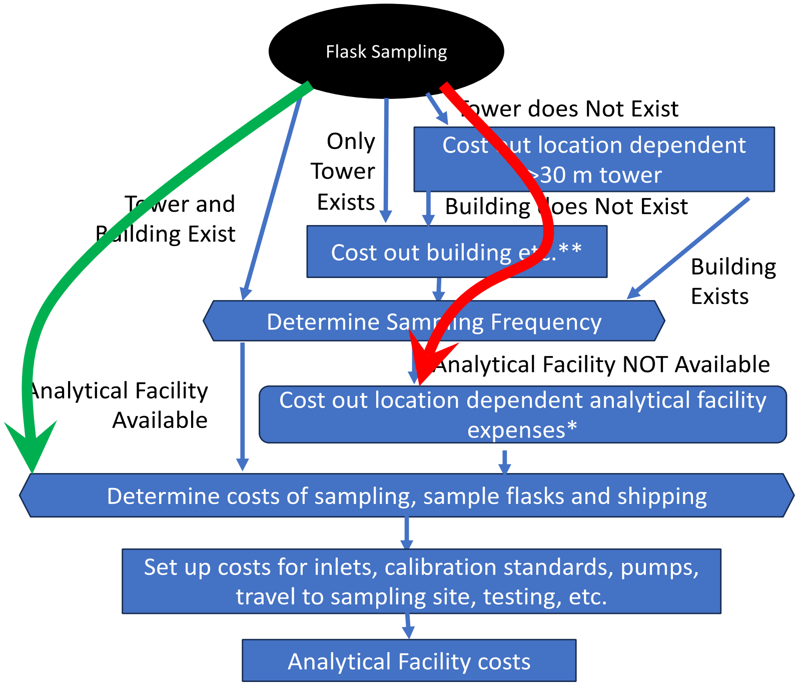
Flask cost flow chart

Low cost path

high cost path

Costs of Flask Sampling & Measurements

Assume that OSSEs are done. Cost of OSSEs.



* Cost of GC/MS, pre-concentration units, computers, communication facilities, plumbing, etc.
** Need to add costs of electricity, communication (WiFi or cell connections if automated sampling), etc. if they do not exist
*** Need to identify personnel for sampling AND personnel for analytical facility.

These components were evaluated using inputs from the participants of the workshop.

Presented to the ORM and endorsed by ORM.

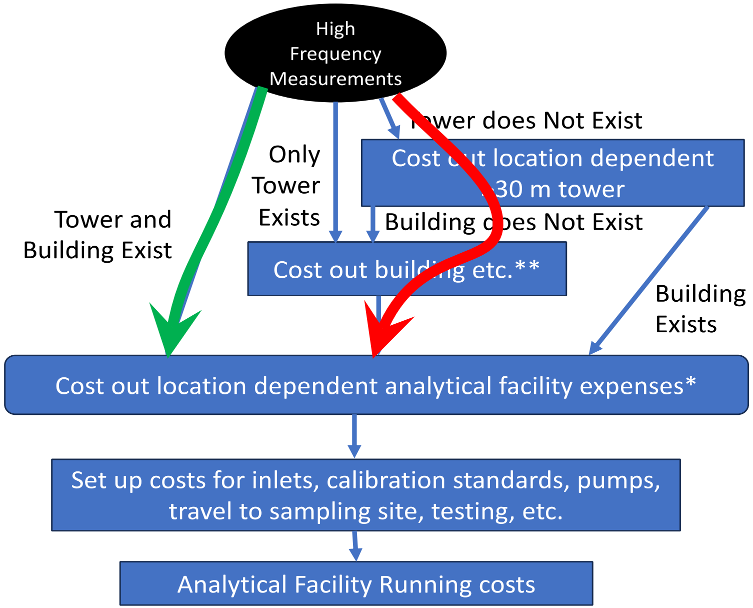
Costs of High-Frequency Measurements

Assume that OSSEs are done. Cost of OSSEs.

High-frequency cost flow chart

Low cost path

high cost path



* Cost of GC/MS, pre-concentration units, computers, communication facilities, plumbing, etc.

** Need to add costs of A/C, electricity, communication (WiFi or cell connections), etc. if they do not exist

*** Need to identify personnel for on-site analytical facility.

Summary of monitoring station costs

Items	On-site Measurements (High-Frequency)	Flask Sampling
Collection facility & tower (without land acquisition and roads), includes yearly maintenance.	$0 to $370,000	$0 to $370,000
Land acquisition and road (only if necessary)	None to $170,000	None to $170,000
Chemical analytical facility	$400,000 to $500,000	Either new at $400,000 to $500,000 ($0 if using an existing centralized lab)
Calibration standard and associated costs	$35,000 initially and $3000/year in subsequent years	$0 to $35,000 initially. $3000/year in subsequent years only if calibration services are not included in the per-sample analysis cost.
Material and supplies for analysis	Materials for analyses (gases, tubing, connectors, etc.): $8000 per year	Sampling Flasks: $20-120K initially for flasks, pumps, tubing, etc. Sample collection costs: $85K (including labor, transportation, etc.) Sample analysis costs: ~$13-100K (weekly to daily for 1 year) Shipping Costs: $10-30K
Total costs*	**$456,000 - $1,245,000**	**~$50,000 - $1,245,000**

*Total costs are rounded numbers!

A Few Important Points to Note

- There are highly variable facility costs, personnel costs, shipping costs, etc. (very location-dependent).
- These are startup costs.
- Many costs may be unnecessary if there is existing infrastructure.
- Co-opting facilities would greatly reduce costs
- Operational costs are noted as ranges in USD, again dependent on location.
- Costs not included the cost estimation:
  - Annually recurring personnel costs (variable from place to place and in the future).
  - OSSE studies
  - Data analyses
  - Information dissemination, including publications and presentations

Strategy

- Identify emission source regions;
- Identify regions of with monitoring gaps;
- Identify local infrastructure that could be used;
- Ensure commitments by relevant countries;
- Start project development and fundraising;
- Ensure Cooperation with other international programmes and networks

Steps in gray discussed earlier.

Step-by-step approach

- Individual sites are identified and assessed (OSSEs)
- Monitoring sites are developed from available funding
- If a few sites are developed at any given time, demand for funds is manageable, and funds could be sourced through existing trust funds.
- Must consider the long-term operating costs as well as the upfront capital investment.

Key Points and Challenges

- Cost-sharing and in-kind reduce costs: existing facilities use (especially towers) can also greatly reduce costs. The Bhola Island Pilot Project is an example
- Working with other observation programs (WMO GHGs, CTBTO, Air Quality monitoring, etc. ICOS) can help identify potential sites and infrastructures, while developing synergies
- Staff training and capacity building, including exchanges of graduate students and post-docs is essential
- Calibration scale propagation and national metrology institute – scales are more important than absolute accuracy because of the need to take full advantage of measurement precision.
- Data sharing is essential. instrumental level data sharing needed for for diagnosis of instrument performance and maintenance.
- Peer review of data and analyses is crucial to science credibility

Thank You!

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