Atmospheric Long-Range Transport of Pollutants as Indicator Process for Monitoring Global Change Processes

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Background

The third assessment report of the Intergovernmental Panel on Climate Change (IPCC) stated: *"…anthropogenic emissions are with a great probability the main cause of the ongoing observed global climate change… It is expected, that human influences will continue to alter atmospheric composition and the delicate climate equilibrium throughout the 21st century".*

Thus, many climate experts expect that, due to large scale anthropogenic emissions (e.g. Carbondioxide, various volatile chemicals, aerosols etc.) the global temperature regime will alter and consequently global change processes (climate change, meteorology etc) will occur. As a part of the comprehensive abatement strategies developed to assess and control possible internationally co-ordinated global response in an stage of the process already when minimal signals are detected.

Long-range transport

The polar regions of our globe are considered to day as important deposition areas for contamination transport by atmopsheric long-range transport. Thus, it can be expected that contaminant distribution to and in the Arctic regions will change due to global change processes.

Therefore, long-range transport (LRT) models and assessments aiming to predict transport mechanisms and fate of contaminants on a regional scale are expected to play an important role in the ongoing scientific assessment of "climate change" (CC) in the Arctic environment. Especially atmospheric transport processes are expected to be directly influenced by CC (*Figure 1*).

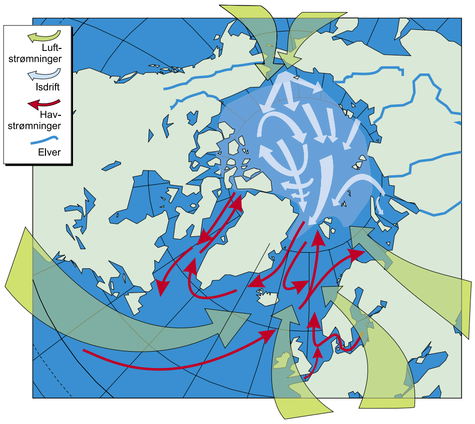

Fig. 1. Atmospheric transport processes in the Arctic.

Scenarios

CC and LRT processes are closely linked to each other since principal parameters like, light-conditions, meteorology, temperature, hydrology etc. are of crucial importance for both mechanisms. Depending on the physico-chemical properties of the respective chemicals, LRT over large distances into the Polar Regions are known for selected contaminants (AMAP 1998). The following scenarios related to CC may be envisaged in the future with direct impact on LRT of contaminants

1. Significant changes in average temperature, humidity, precipitation (snow) or light conditions will directly effect the atmospheric transport patterns, residence time and transformation pathways of xenobiotics in the Arctic
2. CC-induced changes in ice cover will occur all over the Arctic (presumably with some variability in magnitude) and will not only increase contaminant evaporation but will also cause evaporation/release and subsequent biomagnification of contaminants that would have remained isolated for decades, if not centuries, in a colder climate regime (Macdonald et al 2000, Li et al. 2002).
3. CC may result in a resurgence of 'legacy' contaminants, or certainly increased use of 'current' insecticides to combat increasing pest problems in temperate latitudes and subsequent transport into the Arctic (recently increased use of methoxychlor to reduce spreading of the West Nile virus in the eastern USA).
4. CC will influence the distribution of contaminants in the Arctic food web by altering the bioavailability and the food web structures. It is predicted that the frequency of forest fires are likely to increase in sub-Arctic regions due to drier conditions with a subsequent increased transfer of polycyclic aromatic hydrocarbons (PAHs) into the Arctic atmosphere during the summertime incursion.

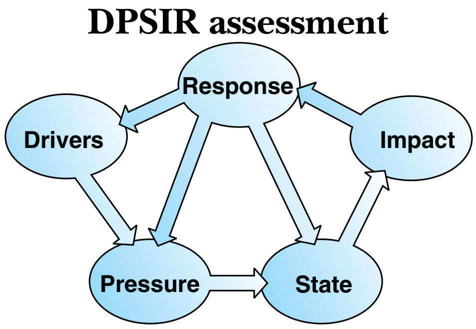

Fig. 1. DPSIR assessment.

Atmospheric LRT as CC assessment tool

The effectiveness and velocity of long-range transport is highly depended on the average ambient temperature. As a direct correlation, changes in the ambient temperature regime are expected as a direct result of global change processes. It is well-known that atmospheric long-range transport into Arctic regions is influenced by meteorological conditions like the position of the polar front system and the precipitation regime along the movement sector of the contaminated air masses transporting contaminants into the Arctic. Thus, interdisciplinary scientific evaluation of atmospheric long-range transport patterns involving meteorology, atmospheric chemistry, trace analysis, as well as transport modelling may be significant tools for monitoring global change processes.

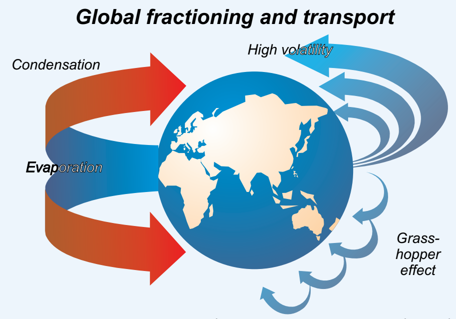

Fig 3. Transport models. (Wania, F. & D. Mackay (1995): A global distribution model for persistent organic chemicals. - Sci. Tot. Environ. 160/161: 211-232.)

Risk evaluation

DPSIR assessment: The "Drivers-Pressures-State-Impact-Response" (DPSIR) reporting framework is based on a limited set of relevant key indicators developed for decison makers. Indicator-based input reports give time-trend information that need to be updated regularly. The purpose of this type of evalaution is to structure data and information on different environmental problems. The purpose of environmental indicators for DPSIR evalaution is to communicate such environmental information to policy-makers and the public (*Figure 2*).

Transport models: Combined with DPSIR assessment, various models describing the atmospheric transport and distribution of contaminants in the environment are available for evaluation of transport velocity, deposition, fate of indicator contaminants (*Figure 3*).

A combination of modeling and empirically derived information is needed for a comprehensive evaluation of CC influences on LRT processes (*Figure 4*).

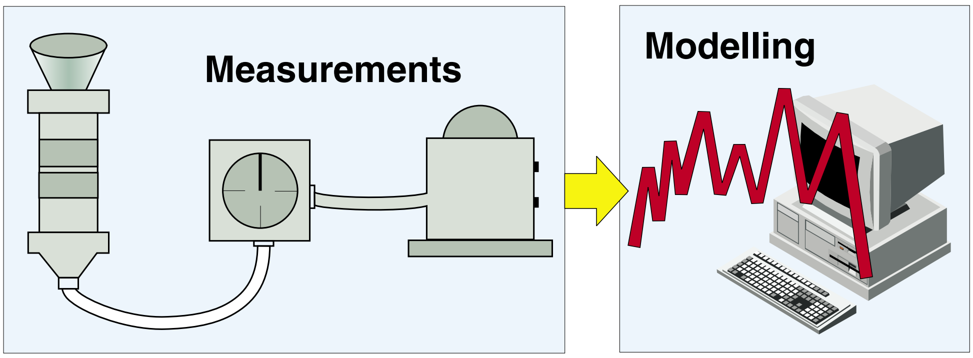

Fig. 4. Combination of modeling and empirically derived information.

References:

- AMAP (1998): **AMAP Assessment Report: Arctic Pollution issues, Arctic Monitoring and Assessment Programme**, Oslo, Norway. pp. 859.
- MacDonald RW, Barrie LA, Bidlemann TF, Diamond ML, Gregor DJ, Semkin RG, Strachan WMJ, Li YF, Wania F, Alaee M, Alexeeva, LB, Backus SM, Bailey R, Bewers JM, Gobeil C, Halsall CJ, Harner T, Hoff JT, Jantunen LMM, Lockhart WL, Mackay D, Muir DCG, Pudykiewicz., Reimer KJ, Smith JN, Stern GA, Schroeder WH, Wagemann R and Yunker MB (2000) **Contaminants in the Canadian Arctic: 5 years of progress in understanding sources, occurrence and pathways.** Sci Tot. Environ. 254: 93-234.