Chapter 6
Issues in Establishing In Situ Atmospheric Greenhouse Gas Monitoring Networks in Europe and in Regions of Interest to Europe

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6.1 Introduction: General Problems of In Situ Greenhouse Gas Monitoring

The atmospheric concentration of greenhouse gases can be measured in situ to great precision. However, can the emission and uptake fluxes of these greenhouse gases be inferred from these measurements? Just as a wolf sniffs the wind, so sources of emissions can be measured at every scale from local to global and then quantified by modelling. However, as monitoring equipment is usually static, measurements only apply to air masses which have passed through the station. Several problems emerge:

- Emission sources can be numerous and hard to distinguish. Seasonality may be muted. Thus, very high standards of precision are needed at the in situ stations accompanied by very careful inter-comparison between stations.
- At the risk of pushing the wolf analogy too far, pack hunters have advantages over solitary predators. A network of strategically placed in situ sampling stations can monitor and assess emissions within a region far more effectively than a whole series of independent stations acting alone.

In building an effective network of complementary in situ monitoring stations, the first problem is to ensure that the data from all the stations are inter-compared. This is not easy even for a single integrated network, but has been achieved by a multinational network in Europe with careful round-robin programmes (e.g. MethMonitEUr 2005 for methane).

Local and specific emissions within access (‘sniffing range’) of stations can be determined by various techniques. Under certain conditions, the local natural ground source emission of $^{222}\text{Rn}$ can be used as a proxy for assessing footprint and inversion height—the atmospheric concentration of $^{222}\text{Rn}$ can, in effect, provide a measure of the volume into which the emission is diluted. Similarly on a local scale, ‘ratios of mixing ratios’ can be used very effectively (e.g. Levin et al. 1999; Lowry et al. 2001). If CO$_2$ emission inventories are relatively well-known in a city (e.g. from petrol sales and heating emissions), then the CH$_4$/CO$_2$ ratio gives the CH$_4$ emission (which may be harder to inventory) and N$_2$O:CO$_2$ can
provide an independent check. The underlying assumption in both $^{222}\text{Rn}$ and CO$_2$ studies is that there is adequate knowledge of the emission rate of the proxy parameter.

Regional studies must be able to observe changes as measured against a changing background. Although the basic background information must come from global networks, such as the US NOAA (National Oceanic and Atmospheric Administration) programme, these have limitations particularly since their coverage of the tropical landmass is poor. Strong meteorological control on natural and anthropogenic sources, with meteorologically linked feedbacks, requires continued campaigns of process studies on both regional and local scales.

### 6.1.1 Key Issues

The difficulties of establishing greenhouse gas monitoring networks (Nisbet 2007) are frequently discussed at specialist workshops and meetings (e.g. Worthy and Huang 2005) but rarely mentioned in the scientific literature. Logistical problems such as shipping gas cylinders or maintaining high-quality data sets in remote locations are central problems of monitoring, yet tend to be taken as trivial by those using results.

Some key issues relevant to the establishment of a European network are

- Purpose of monitoring
- Choice of concentrations and isotopes to be measured
- How to measure
- Site location.

Then there are the data quality issues:

- Calibration of stations
- Inter-comparison around the network.

Next come the deeper issues:

- Usefulness: types of result
- Robustness of science
- Robustness of financial and political support.

Arguably, the robustness issues are the most important. The technology and methodology must be strong so that the network delivers good dependable measurements. Financial support for a network must be steady and sustainable—better not to attempt too much than to imperil long-term time series by a programme that is initially too ambitious.

Long-term monitoring of environmental systems is not glamorous and may not immediately deliver first-author research publications. But, it is vital if we are to understand and assist the health of our planet. It is impossible to go back and take measurements in hindsight. Change can only be observed if long-term monitoring time series are protected.