Quantifying Regional GHG Emissions from Atmospheric Measurements: HFC-134a at Trinidad Head

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Top-down approaches to emissions analysis provide a method of assessing bottom-up emission inventories and thus can be used to give confidence to the submitted inventory values. Here, the western US emissions of the greenhouse gas (GHG) HFC-134a are estimated using ground-based observations, an atmospheric dispersion model (NAME) and an inversion methodology. NAME (Numerical Atmospheric dispersion Modelling Environment) is a sophisticated Lagrangian atmospheric dispersion model that uses 3D meteorology from the UK Met Office numerical weather prediction model.

Mid-latitude Northern Hemisphere baseline concentrations of HFC-134a are determined using NAME and statistical post-processing of observations at the AGAGE (Advanced Global Atmospheric Gases Experiment) measurement station at Trinidad Head on the Northern California coast (41°N, 124°W). This station uses state-of-the art instrumentation to record gas concentrations in ambient air at high time resolution and high precision. The baseline is used to generate a time series of "polluted" (above baseline) observations at the measurement site.

In this application NAME is run backwards in time for ten days for each 3 hour period in 2006 releasing thousands of model particles at each observing site. For each 3 hour period, a map is produced estimating all of the surface (0-100m) contributions within ten days of travel arriving at each site during a 3 hour interval. The resulting matrix (number of geographical grids x number of 3h time intervals) records the dilution in concentration that occurs from a unit release from each grid as it travels to the receptor location (i.e. Trinidad Head). Inversion modelling with an iterative simulated-annealing algorithm is then carried out to generate an emission estimate that provides the best statistical match between the modelled time series and the observations. Uncertainty in the emission estimates is captured by starting from a randomly generated emission map, randomly perturbing the observations by a noise factor, and solving the inversion multiple times using different skill score (cost) functions.

The model results indicate that the combined emissions from the five western states of the US (California, Washington, Oregon, Nevada, and Idaho) for 2006 fall in the range 3.7 – 10 kt. If one assumes that the emissions of HFC-134a are relatively constant per head of population within the US, the emissions of HFC-134a for the US for 2006 are estimated to be 43kt (uncertainty range: 22-60 kt). The estimated emission distribution picks out most of the significant populated areas and estimates very low emissions from the ocean areas. This is consistent with the understanding that HFC-134a is emitted broadly in line with population as it is widely used as a refrigerant, e.g. in car air conditioners.

The method can be extended to utilize observations from multiple stations. Using more data from different geographical locations significantly improves the ability of the inversion process to estimate both the magnitude and the distribution of the emissions. Accordingly, a network of several well-located stations could be used to quantify regional emissions of all measured GHGs and their changes over time within a regulatory framework such as California's new Assembly Bill 32 legislation.