Comments on Point Source emissions via Eddy Covariance etc

It is somewhat of a surprise that the eddy covariance and aerodynamic flux gradient methods were tested as fence line methods for point source emissions. Both of these micrometeorological methods are based on the atmospheric concentration conservation equation (atmospheric diffusion equation) applied to horizontally homogenous conditions. The diffusion equation can be written in the Reynolds averaging form as

$$\frac{\partial C}{\partial t} + U_j \frac{\partial C}{\partial x_j} + \frac{\partial \overline{u_j{'}c'}}{\partial x_j} = R + D + S$$

(1) (2a,b) (3a,b) (4) (5) (6)

(1) Change of pollutant concentration

(2a,b) Horizontal and vertical advection

(3a,b) Horizontal and vertical turbulent diffusion

(4) Chemical reactions-sources/sinks

(5) Deposition—sinks

(6) Emissions--sources

The assumptions for eddy covariance and related methods include steady state and horizontally homogeneous source areas with no chemistry and no deposition. This yields

$$\frac{\partial \overline{w'c'}}{\partial z} = S$$

Or

$$\overline{\overline{w'c'}} = \int S dz$$

However, for a steady constant point source, the horizontal advection and turbulent diffusion terms do not disappear so that the measured eddy covariance flux term (w'c') only represents a portion of the source and doesn't account for the horizontal advection or diffusion terms. The appropriate equation for a point source can be written as

$$U \frac{\partial C}{\partial x} + \left[\frac{\partial v'c'}{\partial y} + \frac{\partial w'c'}{\partial z} \right] = S$$

This equation explicitly treats the transport due to turbulent diffusion as the plume spreads horizontally. As such, measuring only the vertical eddy covariance will miss this horizontal spread and underestimate the emission source. This is also true for the aerodynamic flux gradient method since it is based on the same set of equations.

In this paper, both methods are shown to underestimate the methane emission rate which is consistent with the fact that the micro-met procedures are ignoring horizontal plume transport and diffusion. This is also consistent with the fact that the inverse Gaussian method yields better results since it is based on the point source version of the concentration conservation equation.

The authors need to address the fact that the micro-met methods are not appropriate for point source emissions and/or develop a way to account for the effects of horizontal plume spread that can make up the amount of underestimation. One approach would be to use the measured turbulence data to improve the diffusion coefficients used in the Gaussian inverse method or use the measured turbulence data with a Lagrangian stochastic model as an alternative to the Gaussian plume method.