Ph.D. Defense Announcement
Kira Shonkwiler
January 29, 2018 at 1:30pm

Kira Shonkwiler
Ph.D. Defense

Monday, January 29, 2018
1:30pm

Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Jeff Collett (advisor)
Jay Ham (co-advisor, Soil and Crop Sciences)
Sonia Kreidenweis
Russ Schumacher
Shawn Archibeque (Animal Sciences)

Micrometeorological Studies of a Beef Feedlot, Dairy, and Grassland: Measurements of Ammonia, Methane, and Energy Balance Closure

Ammonia (NH3) emissions from concentrated animal feeding operations (CAFOs; most of which are beef feedlots) near the Colorado Front Range are suspected to be a large regional input of reactive nitrogen which has been found to accumulate and cause deleterious effects in nearby downwind Class I areas like Rocky Mountain National Park. Methane (CH4) is a strong greenhouse gas (GHG) emitted in large amounts from dairy anaerobic lagoons used for liquid manure management. Lagoon systems account for over half of the manure management-based CH4 emissions from agriculture in the US. There is a strong need for more emissions measurements from CAFOs like feedlots and dairies. For these data to be trusted, well-developed techniques must be utilized at emissions measurement sites and such techniques should be validated in ideal scenarios.

Three micrometeorological studies were performed involving measurement of emissions using micrometeorological methods in the surface layer. Results from two livestock operations will be discussed in detail, with the third study on energy balance closure briefly introduced.

The first study involved estimating summertime NH3 emissions from a 25,000-head beef feedlot in Northern Colorado. Two different NH3 sensors were used: a cavity ring down spectroscopy analyzer collected data at a single point while a long-path FTIR collected data along the same fenceline. Concentration data from these systems were used with two inverse dispersion models (FIDES, an inverse solution to the advection dispersion equation; and WindTrax, a backward Lagrangian stochastic model). Point sensor concentrations of NH3 were similar to line-integrated sensor concentrations suggesting some spatial uniformity in emissions. Emissions had a diurnal pattern (i.e., afternoon peak with minimum in early morning) that was driven by temperature. Emissions predicted by WindTrax were 25.2% higher than those from FIDES. Point vs. long-path measurements of NH3 had minimal effect on predicted emissions. The mean NH3 emission factor (EF) was 80 ± 39 g NH3 per head per day, with 40.0% of dietary-N emitted as NH3.

The second study involved using eddy covariance and WindTrax to quantify CH4 emissions from a 3.9-ha anaerobic lagoon serving a 1400-head dairy in northern Colorado. Methane emissions followed a strong seasonal pattern correlated with temperature of the organic sludge layer on the bottom of the lagoon. Fluxes started increasing in late spring (May; ~10°C), increased rapidly in Jun (10-15°C) peaked in the summer (Jul/Aug; ~18-20°C) and remained high until mid-autumn (late Oct/early Nov; ~10°C). Fluxes then decreased and remained consistently low (~10 times less than peak emissions) until microbial activity ramped up again in May. The EC signal was very dependent on wind direction, with highest concentrations and fluxes associated with the direction of the lagoon. Gap-filled data showed a slight diurnal pattern to all seasons, with tenfold increases in diurnal values for summer over winter. Additionally, EFs for the lagoon varied by season with lows in the winter and highs in the summer with an annual mean of 819 ± 774 g CH4 per head per day. WindTrax overestimated EC for the lagoon, but this may be attributable to differences in the sampling footprint. IPCC Tier 2-calculated EFs were extremely close to EC-based measurements and WT-based estimates.

The third study involved using eddy covariance in an ideal environment (tallgrass prairie in Kansas) to test the reasons behind the “energy balance (EB) closure problem” at two landscape positions. This problem can cast uncertainty on flux measurements made by EC. On average, EB closure was 0.88 and 0.94 at the upland and lowland sites, respectively. Closure was not correlated with friction velocity or the stability of the surface boundary layer. Given high confidence in non-turbulent measurements, that turbulent fluxes depend directly on vertical velocity (w), and the fact that a systematic underestimation of w was recently found in literature, data suggest lack of closure could be related to anemometer-based underestimates of w.