CAN VISIBILITY MEASURES BE USED TO ESTIMATE FEEDYARD DUST CONCENTRATIONS?

Brent W. Auvermann and Appala N. Paila
Texas Agricultural Experiment Station
Amarillo, TX

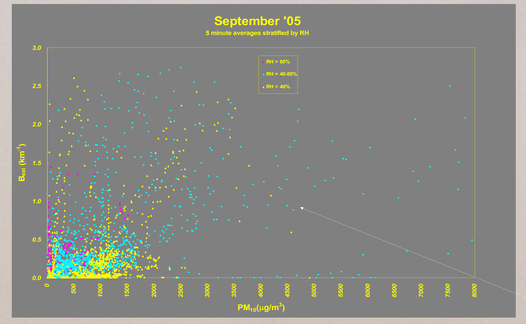
MOTIVATION

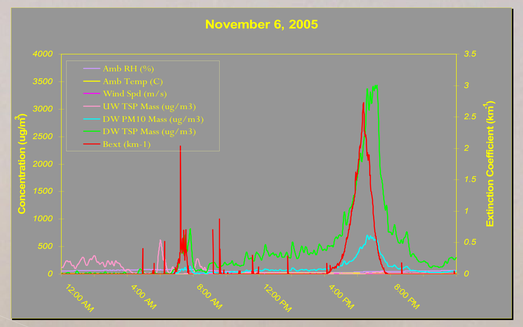
Changes in visibility are the most intuitive means by which humans detect changes in air quality resulting from feedyard dust. Gravimetric measurements of suspended dust, which yield mass concentration data, are much less intuitive to the average citizen or feedyard operator but have important regulatory implications. We want to know if visibility measurements can serve as a surrogate for gravimetric measurements so that feedyard operators can make wise air-quality management decisions on the basis of more intuitive measures of feedyard air quality.

APPROACH

One scientific measure of visibility is *atmospheric extinction*, which is often measured by long-path transmissometry. A long-path transmissometer consists of a high-intensity source of green light (540 nm) at one end of an open path and a specially designed photometer at the other. Gases and particles between the lamp and the photometer absorb and reflect the green light, and the higher the concentration of particles in the air, the less green light is detected at the photometer. In other words, the voltage output of the photometer decreases with increasing atmospheric extinction, and vice-versa.

We installed a long-path transmissometer (Model LPV-3, Optec, Inc.) along the downwind edge of a commercial cattle feedyard in the Texas Panhandle. The 800-meter open path between source and receiver passes within a few meters of real-time, gravimetric monitors that measure PM_{10} and TSP mass. Each instrument measures one-minute average values of atmospheric extinction (B_{ext}, km^{-1}) and mass concentration (C, $\mu g\ m^{-3}$). The slope of a line fitting the data pairs (C, B_{ext}) is approximately equal to the *extinction efficiency* of the dust fraction of interest.





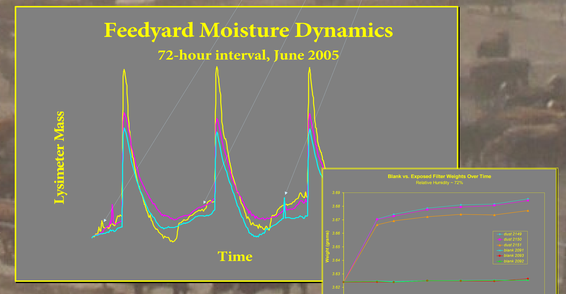
FINDINGS

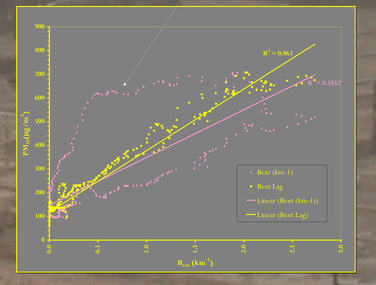
In 2004-2005, preliminary comparisons of atmospheric extinction and mass concentration data:

- Confirmed that PM_{10} from feedyards has a greater proportional effect on visibility than TSP;
- Showed that the atmospheric extinction efficiency of feedyard PM_{10}, 0.5-0.6 $m^2\ g^{-1}$, is on the same order as that of Malm's "coarse particles" classification (Malm, 1999); and
- Suggested that the *hygroscopicity* of feedyard dust (its tendency to adsorb atmospheric water vapor in response to increasing relative humidity) influences its extinction efficiency to a significant extent.

In 2006, we began to stratify our data by relative humidity ranges (0-40%, 40-80% and 80-100%) and as yet have been unable to quantify the influence of RH on extinction efficiencies of PM_{10} and TSP. As the graph to the left implies, however, the correlation exists; our remaining task is to determine how to select the data that we can reliably use for the regression analysis.

We have noted that the concentration peaks for PM_{10} and TSP tend to lag behind the peak in B_{ext} (see graph to left). By artificially lagging the B_{ext} data such that the peaks coincide (as they ought to do), we have shown that the poor correlations shown in the scatter plot (far left) can be dramatically improved. The chart below shows how lagging the B_{ext} data improves the R^2 and significantly reduces the apparent hysteresis in the uncorrected data.





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