Measuring GLAS Emissions

Direct Methods

Quasi-Direct Methods

Indirect Methods
Direct Methods

- Actually measuring the quantity of interest
- No such animal in the case of GLAS
- Methods that get closest:
  - Eddy accumulation
  - Flux chambers (!)
Indirect Methods

- Measuring something other than the quantity of interest (e.g., concentration)
- Inferring the emission rate from a model relationship
- Sensitive to errors in the measurements and the governing assumptions

\[ Q = \frac{C}{Atmospheric\ Dispersion} \]
PM$_{10}$ Flux: Inverse Dispersion

- AP-42: $280 \times (PM_{10}/TSP) = 70$ lb/1,000 hd-d
- S. Parnell et al. (1994): $9.2$ lb/1,000 hd-d
- C. B. Parnell et al. (1999): $15$ lb/1,000 hd-d
- CARB (2004): $29$ lb/1,000 hd-d
- J. Lange et al. (2007):
  - $16\pm8$ lb/1,000 hd-d (ISCST3)
  - $11\pm5$ lb/1,000 hd-d (AERMOD)
- Wanjura et al. (2004): $42$ lb/1,000 hd-d
  - Pen surface: $6$ (14%)
  - Unpaved roads: $36$ (86%)
Summary

• **Direct** measurement of fugitive emission rates from GLAS is difficult & expensive

• Many **indirect** methods available; no single method is best for all scenarios

• *Model contingency raises red flags*

• *Multiple independent methods should converge on a narrow range of estimates*
PM$_{10}$ Flux: Other Methods

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Box Model – The General Idea
Integrated Horizontal Flux
(a special case of the box model)

Both wind speed and mass concentration vary with elevation
Feedyard A
17-20,000 head

Amarillo Dec – Feb

Amarillo Mar – Nov
Feedyard E
17-24,000 head

Amarillo Dec – Feb

Amarillo Mar – Nov
Feedyard A - H$_2$S Emission Rate from Pens
Diurnal Emissions Pattern

Feedyard A - March 07

Feedyard A - April 07

Feedyard A - May 07

Feedyard A - June 07
Is the Emission Flux Constant?

Measured Net PM$_{10}$ Concentrations
Feedyard E, April 29, 2008

1-hr Net Concentration (µg/m$^3$)

Time of Day (hr)
Is the Emission Flux Constant?

Measured and Modeled Net PM$_{10}$ Concentrations
Feedyard E, April 29, 2008

- Blue line: C24(meas) = C24(pred)
- Green line: Measured

1-hr Net Concentration (µg/m$^3$)

Time of Day (hr)
Is the Emission Flux Constant?

Measured and Modeled Net PM$_{10}$ Concentrations
Feedyard E, April 29, 2008

- Red: $Q: C_p^\text{meas} = C_p^\text{pred}$
- Green: Measured

1-hr Net Concentration (µg/m$^3$)

Time of Day (hr)
Is the Emission Flux Constant?

Measured and Modeled Net PM\textsubscript{10} Concentrations
Feedyard E, April 29, 2008

1-hr Net Concentration (\textmu g/m\textsuperscript{3})

Time of Day (hr)
Modeling Flux: Achilles’ Heel

• Under normal circumstances, no single value of PM$_{10}$ emission flux will reproduce measured concentrations exactly
  – Matching the 24-hr average, $C_{\text{meas,24}}$, underpredicts $C_{\text{peak}}$
  – Matching $C_{\text{peak}}$ overpredicts $C_{\text{meas,24}}$
• Even if we must have a 24-hr emission factor, we shouldn’t use it for dispersion modeling
Fugitive Dust Control Strategies

• Source control techniques
  - Moisture management
    • Pen surface sprinkling
    • Stocking density manipulation
  - Manure harvesting
  - Surface amendments (mulches, binders, etc.)

• Edge-of-feedyard or downwind control techniques
  - Water curtain
  - Shelterbelts
Moisture Management
Target Moisture Content?

Net PM$_{10}$ Concentrations vs. Pen Surface Moisture Content.
Pen Surface Sprinkling

• Application of water to pen surfaces (solid-set, tanker-mount, “reel rain”)

• Efficacy
  – Reduced net PM$_{10}$ concentration by 30 to 55%

• Readiness for adoption
  – Ready for producer implementation
  – Need to refine design and management procedures
Stocking Density Effect on Water Balance

Dust Season Averages  Annual Maxima

-27%  -56%  -26%  -55%

Water Use (gal/hd/d)
Projected Water Use (30k hd)
(Pacific Northwest rain shadow)
Sprinkler Water Demand: Summary

- Spreadsheet exercise ONLY
- Assumed $ET_{fy} = 0.35 ET_o$
  - Marek thesis: $ET_{fy}$, $Et_o$ not well correlated
  - Feedyard evaporation is water-limited, not energy-limited
  - Bottom-line sprinkler demand figure of 1/8”/d is artificially low
- 2x stocking density effect on WB appears minimal
Manure Harvesting

• Frequent removal of the uncompacted surface layer

• **Efficacy**
  – Dust emission potential of manure layer decreases with decreasing manure depth
  – Manure harvesting can reduce the amount of water needed for dust control
  – Yields highest fuel value

• **Readiness for adoption**
  – Ready for producer implementation
  – Need to refine management procedures
  – Law of diminishing returns
Surface Amendments

- Surface application of crop residue or other materials
- **Efficacy**
  - Application of wheat straw or sawdust reduced the dust emission potential of a manure surface
- **Readiness for adoption**
  - Promising but needs to be validated at the field level
Oil-in-Water Emulsions

- Water is the “continuous phase”
- “Oil” at $2.05/gal, 20% v/v, 0.25” applied
Stocking Density Manipulation

- Cross-fencing (solid or electric)
- Preserve 100% of bunk space
- **Efficacy**
  - Doubling the effective stocking density reduced net PM$_{10}$ **concentrations** at the corral fence line by 20%
  - No conclusive proof of reduced emission **rate**
  - Anecdotal evidence from producers
Water Curtain

• Open-air wet scrubber
• **Efficacy**
  – Prototype reduced near-field PM$_{10}$ concentration 20-40%
  – Used as much water as a solid-set sprinkler system (1 gpm/ft)
• **Readiness for adoption**
  – Is not cost-effective
Shelterbelts

- Vegetation system downwind of a facility
- **Efficacy**
  - Effective in mitigating odor and dust generated from swine facilities and roads
- **Readiness for adoption**
  - Promising but needs field evaluation
Summary

• A surface moisture content of 20% may be a critical threshold for dust control.

• Strategies ready for producer implementation but need refinement
  – Pen surface sprinkling
  – Frequent manure removal

• Promising strategies that need further development or evaluation
  – Pen surface treatments
  – Shelterbelts
  – Increased stocking density with pen surface sprinkling