Successful Strategies for Using Lidar for Particle Characterization of Point and Diffuse Area Sources

Randy Martin\textsuperscript{2}, Kori Moore\textsuperscript{1,2}, Michael Wojcik\textsuperscript{1}

\textsuperscript{1} Energy Dynamics Laboratory, Utah State University Research Foundation
\textsuperscript{2} Dept. of Civil and Environmental Engineering, Utah State University

randy.martin@usu.edu (435) 797-1585

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Particulate Sampling Paradigms

- **Point Sampling**
  - Small volume
  - Fixed location
  - Long sample times (esp. filtered-based)
  - Low cost
  - The standard for policy, regulation, and management

- **Remote Sensing**
  - Large volume
  - Fixed or mobile
  - Short sample times
  - Higher cost
  - Must locally calibrate against point sensors
Aglite Air Quality Measurement System

- Air quality facility monitoring and emissions measurement system for particles and select gases
- Developed for USDA-Agricultural Research Service to characterize emissions from agricultural activities
- In-situ characterization of size-segregated particulate matter (PM$_{2.5}$, PM$_{10}$ and TSP)
Aglite Measurement System: Particles

- **Remote Sensor: Aglite Lidar** maps and tracks particle concentrations
  - 10 kHz pulsed Nd:YAG laser with 3 wavelengths (355/532/1064 nm)
  - Capable of scanning 280° in azimuth and -5° to 45° in elevation
  - Easily mobile, generator powered
  - Eye safe at 0.5 km

- **Point Sensors: Collocated point sensors** arrayed around the facility/source of interest
  - Optical Particle Counters (OPCs)
  - MiniVols (PM$_1$, PM$_{2.5}$, PM$_{10}$, TSP)
  - Chemical characterization (insitu & post-test)

- **Lidar is calibrated to local PM characteristics** using point sensors at an upwind location
Facility Emissions Calculations

- **Mass balance approach to Lidar data**
  - Lidar creates a virtual box around the source/area of interest
    \[ \text{Out} - \text{In} = \text{Facility emission} \]

- **Inverse modeling**
  - \( \text{PM}_{\text{Downwind}} - \text{PM}_{\text{Upwind}} = \text{measured facility-produced PM levels} \)
  - Run ISCST3 and AERMOD (former and current EPA recommended air dispersion models) with an estimated emission rate

\[ E_{\text{derived}} = E_{\text{seed}} \left( \frac{C_{\text{measured}}}{C_{\text{modeled}}} \right) \]
Field Experience History

- **2005**
  - Hog farm near Ames, IA
  - Dairy farm in Cache Valley, UT

- **2006**
  - Two non-agriculture sites

- **2007**
  - Fall tillage sequences (CMP vs. Conventional) near Los Banos, CA

- **2008**
  - Spring tillage sequences (CMP vs. Conventional) near Hanford, CA
  - Dairy farm near Hanford, CA

- **2009**
  - Two non-agriculture sites
  - Successful creation of time resolved, 2-D and 3-D, size-fractionated (TSP, PM\(_{10}\), PM\(_{2.5}\), PM\(_{1}\)) concentration maps, with on-site calibration. Derived emission rates generally agree well with available literature values.
Successful Strategies

- Characterization of local meteorology
  
  *We didn’t have local met and didn’t know the predictions would be bad*

- Deployment of a small, temporary meteorological station with cellular based communication

- Data provide a sense of directional/diurnal reliability
  
  - Essential for successful deployment of instruments

- Comparison of forecasts vs. observed
  
  - Especially important for intermittent activities

Almond orchard, San Joaquin Valley, CA
Successful Strategies

Point sensor placement
- Don’t place upwind sensors too close – may still be impacted
- Don’t place downwind sensors too close – may be overloaded
- Avoid potential plume edge effects
- Collocated OPC with filter-based samplers helps to identify and quantify potential contamination
  - Data quality check
  - Especially helpful at upwind locations
Successful Strategies

- **Lidar sampling**
  - Safety always 1st (humans and animals)
  - Area topography (‘shadow effects’)
  - Line-of-sight access to facility and several point sampler locations
  - Stay away from hard targets
    - Interference sometimes hard to see during sampling
  - Erratic large values likely due to scatter from the calibration tower
  -- need to be aware of possible aiming alignment limitations
Successful Strategies

General

- Ideal site and conditions are difficult (impossible) to find in the real world
- Potential confounding activities
  - Minimize as much as possible
  - Record any sources/activities that might impact sampling
- Record keeping
  - Detail-oriented field notebook
  - Pictures!
Leapfrogging…..to Conclusions

- Combined remote sensing and point sensors form EDL/USU’s Aglite Measurement System successfully able to quantify particulate (and select gaseous compounds) concentrations and emissions
  - Advancing data fusion techniques for remote and point sensors
  - Capable of providing high spatial and temporally resolved PM concentration maps and plume tracking
    - “whole facility” and moderate urban scales

- Successful sampling strategies for field campaigns learned through experience include:
  - Characterization of local meteorology and its predictability
  - Placement of point sensors to prevent contamination and overloading
  - Positioning of the lidar & beam plane for safety hard target interferences
  - Awareness of potential confounding sources
  - Usefulness of photographic and written observational data
Thank you. Questions?

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