Characterizing On-Road Heavy-Duty Diesel Truck Emissions

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Increasingly stringent emissions standards
Controls & regulations drive down emissions

Diesel Particle Filters (DPF): filter traps PM emissions
Engine-out NO is oxidized to NO$_2$ to aid in filter regeneration
Can increase tailpipe NO$_2$ emission

Selective Catalytic Reduction (SCR): NO$_x$ control via reaction with NH$_3$
Urea-water mixture yields NH$_3$, which reduces NO$_x$ to N$_2$
Can increase tailpipe NH$_3$ and N$_2$O emissions

Accelerated adoption of DPFs via retrofit or replacement
All trucks statewide must now be DPF-equipped
By 2023, all trucks statewide will be equipped with 2010+ engines
On-road measurements of tailpipe emissions

- Using a customized research platform, measured emission rates of pollutants from thousands of trucks in the Bay Area over many years.
On-road measurements of tailpipe emissions

• Research-grade analyzers with fast response time (1 Hz or faster) captured individual truck plumes in real-time
Plume capture, carbon balance method

\[ E_p = \frac{\int_{t_1}^{t_2} ([P]_t - [P]_{t_1}) dt}{\int_{t_1}^{t_2} ([CO_2]_t - [CO_2]_{t_1}) dt} \times \frac{44}{12} \ W_c \]

(units: g pollutant emitted per kg diesel consumed)
NO\textsubscript{x} emissions from SCR-equipped trucks reduced by \(~90\%\) versus pre-2004 engines

Preble et al. (ES&T, 2019)
Use of DPF increases NO$_2$ 3–4× baseline values; SCR mitigates this increase

Preble et al. (ES&T, 2019)
SCR significantly increases N$_2$O emissions

Preble et al. (ES&T, 2019)
SCR can significantly increase NH$_3$ emissions

Preble et al. (ES&T, 2019)
2010+ engines emit 95% less BC than pre-2004 engines and 80% less than 2007–2009 engines.

Preble et al. (ES&T, 2018)
SCRs can be warming, but DPFs mean net cooling

Preble et al. (ES&T, 2019)
Converting to DPF+SCR leads to large social benefit

Preble et al. (ES&T, 2019)

Change in Annual Statewide Social Cost of Emissions from Equipping Trucks with DPF and SCR (10^9 2018 USD y⁻¹)
Many trucks exceed the national emission standards

- Even with large reductions, we measure ~40% of trucks emit BC and NO$_x$ in excess of the emission standards.
- The dirtiest 10% of trucks emit ~70–80% of the BC from the entire truck fleet.

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Conclusions & on-going work

- DPF and SCR systems significantly reduce emitted BC and NO$_x$ by the on-road fleet; can increase NO$_2$, N$_2$O, and NH$_3$ emissions
- Climate & social cost benefits achieved with DPF and SCR use
- “High-emitters” dominate remaining fleet emissions
- We are developing a remote, automated sensing method that can efficiently identify the most polluting trucks in the on-road fleet, which could be used as a screening tool to direct further inspection and maintenance