Why the Front Range?

- The Denver urban area is one of the most out-of-compliance with national air quality standards for O3 in the summer months.
- In contrast to the northern US, many western locations have positive daytime summer O3 trends.

Possible reasons include increases in:
- Western wildfires
- Stratospheric O3 intrusions
- Pollution transport from Asia
- Changes in regional Urban and Oil and Natural Gas (O&NG) Emissions

RESEARCH GOAL: DETERMINE THE CONTRIBUTION OF REGIONAL EMISSION SOURCES TO OZONE IN THE COLORADO FRONT RANGE

Why Ozone?

- Tropospheric ozone (O3) is a health hazard and greenhouse gas that alters the radiation balance of Earth's atmosphere.
- Emissions and subsequent oxidation of NOx (NO + NO2) in the presence of volatile organic compounds (VOC) is the only known mechanism for tropospheric O3 production.

ANALYSIS METHOD #1: OBSERVED OZONE PRODUCTION EFFICIENCY

O3 Production Efficiency (OPE): Slope of O3 (ppbv) against NOx (ppbv) and NOy (ppbv) as a measure of O3 production efficiency. FRAPPE (2014) Results—

- Alkanes and aromatics are not photochemically oxidized (OPE ~0), whereas alkenes and alkynes have OPEs ~1.
- OPEs are highly variable in space and time, limiting the use of OPEs as a single metric for ozone production.

Methods to Differentiate OPEs from Different Regional Emission Sources...

a) Wind Direction, Sped, and History

- Advantages: simple, urban influenced air flows from the south and O&NG from the north.
- Challenges: Front Range air masses are highly mixed.

FRAPPE data—Individual OPEs (15-minute resolution) plotted by wind direction, for FRAPPE base cases (15-30 ppmv CO, 0.05 ppmv NOy)

- Individual OPEs indicate that OPEs from the south are lower than the north east and north west.
- OPEs from the north are lower for O&NG activity, but higher for O&NG VOC Emissions.

At the BAO Tower: NOx, NOy, CH4

Possible ways to evaluate NOy are:

- Alkenes+Alkynes
- Aldehydes+Ketones
- Aromatics
- Biogenics
- O&NG VOC fraction
- O&NG VOC fraction from the observed Base Case is within 10% of the observed O&NG VOC fraction.

Model Results

- On Average, O3 production efficiency of O&NG VOC Emissions is ~16%.
- The northern Front Range Meteorological Region of Colorado is in a NOx sensitive regime.

SUMMARY, CONCLUSIONS, AND ACKNOWLEDGEMENTS

1. Field measurements from the Boulder Atmospheric Observatory have been used with a photochemical box model to understand air pollution and photochemistry in a region currently out of compliance with national air quality standards for O3.
2. Observed Ozone Production Efficiencies are ~5, but do not distinguish urban from O3 and Natural Gas O3.

The author would like to thank Samuel Hall (NCAR) for his research, and David Angendick for his research data at BAO for FRAPPE 2014.

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