Utilizing Public Transit for Urban Atmospheric Monitoring in Denver, CO

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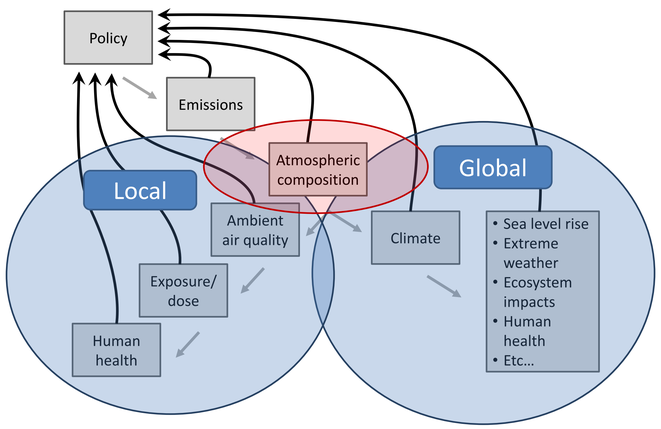
1. Introduction

Denver, Colorado suffers from poor air quality, which is likely to degrade further as the climate warms.

- Denver and the surrounding suburbs are consistently out of the 2008 EPA mandated ozone 8 hour standard (75 ppb), according to the Colorado Department of Public Health and Environment (CDPHE)
- Denver has obtained a delay for the 2015 EPA mandated standard (70 ppb) to assess methods to mitigate the problem (CDPHE)
- Regardless of the standard, elevated ozone poses significant health risks within the Denver urban region
- Colorado's current and former Governors have implemented strong new emissions regulations for vehicles in Colorado, in order to reduce carbon emissions in compliance with the Paris Agreement
- Monitoring ozone and greenhouse gas emissions is critical to identifying the most effective means of emission reduction, as well as assessing the effectiveness of regulations aimed at reducing emissions

2. Science Meets Policy – Air Quality and Greenhouse Gas Monitoring to Address Denver's Unhealthy Air



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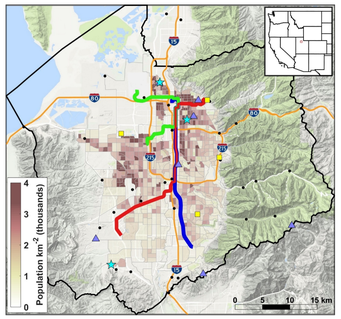
People at Risk In 25 Most Ozone-Polluted Cities

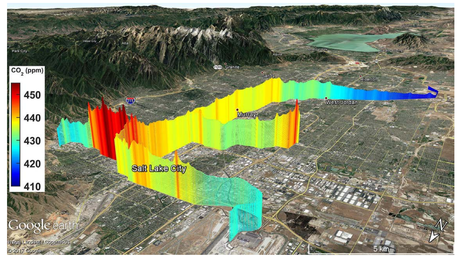
2019 Rank[1]	Metropolitan Statistical Areas	Total Population[2]	Under 18[2]	65 and Over[2]	Pediatric Asthma[4,5]	Adult Asthma[2,6]	COPD[2]	CV Disease[6]	Poverty[2]
1	Los Angeles-Long Beach, CA	18,788,800	4,317,234	2,511,924	267,954	1,142,240	636,210	7,806	1,479,796
2	Visalia, CA	464,493	143,726	51,669	8,921	25,149	13,466	193	30,984
3	Bakersfield, CA	893,119	259,120	95,307	16,083	49,617	26,076	373	60,013
4	Fresno-Madera-Hanford, CA	1,296,246	365,661	155,133	22,695	73,023	39,469	540	90,788
5	Sacramento-Roseville, CA	2,598,377	598,140	399,007	37,124	158,830	92,789	1,079	216,432
6	San Diego-Chula Vista-Carlsbad, CA	3,337,685	728,528	454,826	45,217	205,392	113,301	1,389	261,785
7	Phoenix-Mesa, AZ	4,790,771	1,155,134	738,748	93,121	360,835	227,133	2,243	372,324
8	San Jose-San Francisco-Oakland, CA	9,658,361	2,098,636	1,400,989	130,254	598,339	340,714	4,015	793,588
9	Houston-The Woodlands, TX	7,078,523	1,883,271	773,341	149,026	383,590	242,452	3,571	604,115
10	New York-Newark, NY-NJ-CT-PA	23,035,605	4,945,052	3,552,752	448,996	1,651,293	996,592	13,532	1,881,665
11	Redding-Red Bluff, CA	243,847	54,095	48,761	3,357	15,277	9,848	101	23,119
12	Denver-Aurora, CO	3,515,374	802,822	443,992	63,790	253,103	115,044	1,440	193,028
13	Las Vegas-Henderson, NV	2,248,281	521,582	330,243	40,464	180,576	118,876	1,047	175,054
14	Salt Lake City-Provo-Orem, UT	2,559,350	771,143	252,835	46,981	159,617	68,111	662	121,102
15	El Centro, CA	182,830	52,296	23,042	3,246	10,266	5,654	76	13,022

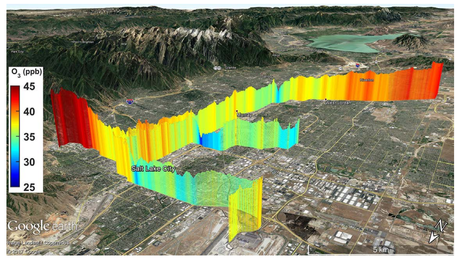
- Denver cannot meet current EPA 8 hour ozone standards.
- Denver has committed to reductions in GHG emissions of 30% by 2025 and 80% by 2050. Electric vehicle registrations will increase to 30% by 2030.
- Constant monitoring of ozone and GHG's is critical for assessing progress toward improving Denver's air quality through reduction of emissions.

3. The TRAX Urban Emissions Program

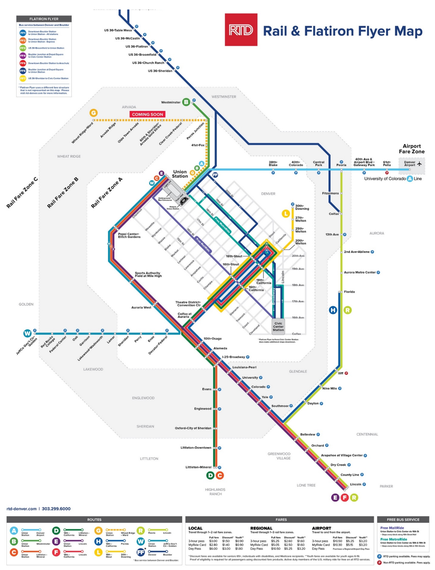
- Highly successful project using public transit for an observation platform.
- Operates on the Utah Transit Authority (UTA) TRAX light rail system:
- We will model the Denver observation program from the TRAX Program.
- Measures CO_2, CH_4, $PM_{2.5}$, O_3, and NO_2.
- Dec 2014 to present. 2nd rail car in Jan 2016.
- Sensors and sampling on roof, ~4m above ground.







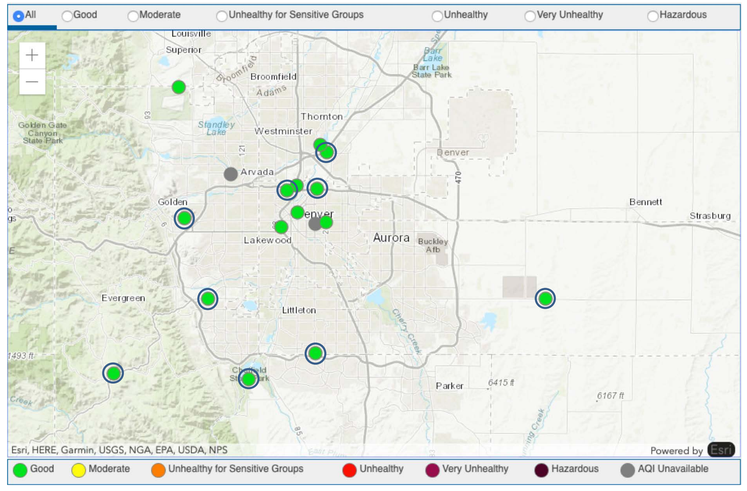
4. Denver's RTD Light Rail System



- Denver's Light Rail system covers Denver north and south along I-25, a major freeway
- A-Line runs to Airport – This will be important for characterizing transport of particles from oil and gas operations to in north east Colorado – Potentially a large source of ozone precursors (e.g. Baier et al., 2017)
- H- and R- Lines run into Aurora – Highest ozone non-attainment
- C-,E-, and F- Lines run along I-25 – capture heavy and standstill traffic emissions (In particular large trucks).

5. Denver's Current Air Quality Monitoring

- Ozone measured at 9 (circled) of the 16 sites around the Denver area and one in the mountains (left in figure below).
- Improved monitoring will help to better identify regions of highest need for mitigation
- For example ➔ Aurora ➔ highest levels of ozone as reported by State of the Air Report (lower left panel) ➔ however, no monitoring sites



6. Proposed Work Plan

- We have acquired support for the project from Colorado's Department of Health and Environment
- Meeting with RTD to discuss feasibility and support
- Seeking State level interaction
- Once funded ➔ Outfit rail cars with sensor packages
- Data collection ➔ real-time air quality displays
- Monthly maintenance and calibration checks
- Large modeling effort ➔ University of Utah ➔ understand the ground-level, mobile data
- Outreach ➔ Each monitoring package equipped car will have real-time data as well as general facts and explanations displayed on an onboard monitor.

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