SESSION AGENDA

8:30 a.m. – Social half hour with light breakfast and coffee bar
9 a.m. – Welcome and Introduction by Dr. James Crooks
9:15-11 a.m. – Four Panel Speakers
11-11:45 a.m. – Q&A
11:45 a.m. – Closing statement

Welcome to the AIR QUALITY & CLIMATE CHANGE PANEL DISCUSSION

This event is brought to you by:

[Logos for Boulder County and Boulder County Public Health]
Please welcome

DETLEV HELMIG
Associate Research Professor
Institute of Arctic Research Research at the University of Colorado
News Releases

News Releases from Region 08

EPA reclassifies Denver area to “Serious” nonattainment for ozone

Reclassification requires additional control measures to reduce emissions

12/16/2019

Contact Information:
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303-312-6654

DENVER—The U.S. Environmental Protection Agency (EPA) today announced the agency is finalizing a determination to reclassify the Denver Metro/North Front Range ozone nonattainment area from Moderate to Serious nonattainment under the Clean Air Act.
Elevated levels of surface ozone can cause:

- Shortness of breath
- Chest pain when inhaling deeply
- Wheezing and coughing
- Increased susceptibility to respiratory infections
- Inflammation of the lungs and airways
- Increased risk of asthma attacks

... (American Lung Association)

→ Increased risk of death;
~ 5000-6000 premature deaths in US per year
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Also – Ozone in Greenhouse Gas:
1. CO₂ (60%)
2. Methane (15%)
3. Ozone (12%)
Figure 1. Ozone Nonattainment Areas (2008 Standard, 0.075 ppm) as of June 2018

Nonattainment areas are indicated by color. When only a portion of a county is shown in color, it indicates that only that portion of the county is within a nonattainment area boundary.


Notes: Nonattainment designations were based on 2008-2010 monitoring data in most cases. Eighteen of the 38 areas shown now have monitoring data indicating attainment of the standard, but, as of June 2018, had not completed administrative requirements to be reclassified to "attainment."

(https://www3.epa.gov/airquality/greenbook/map8hr_2015.html).
Ozone is **NOT** an Emission

How is Ozone ($O_3$) formed in the Atmosphere?

Ozone Precursor Sources

VOCs ...

Nitrogen Oxides (NOx)

OZONE
Ozone Behavior at Boulder Reservoir July 2019 (CDPHE data)

2015 8-hour National Ambient Air Quality Standard (NAAQS) (70 ppb)
Compliance with ozone NAAQS is determined by 3-year running mean of 4th highest annual 8-hour ozone average (truncated).
### 8-Hour Ozone

(Updated through September 30, 2018)

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**NOTE:** Values above the level of the 70 ppb 8-hour standard are highlighted in yellow, above the 75 ppb standard in orange.

**NOTE:** Data influenced by natural event values, if any, are included.
- Highest 8-hour ozone value was 89 ppb (highest ozone value seen 2018 in the Front Range)
- Stretch of 5 consecutive exceedance days in August
- 230 hours with ozone >70.9 ppb
- 100 hours with ozone 8-hour mean >70.9 ppb
- 32 days with 8-hour ozone >70.9 ppb
- Highest 8-hour ozone year in last ten years
How has ozone changed over time?

-> Trend Analysis
Ozone Monitoring in Colorado - NREL and Welby

Bien and Helmig, 2018
Ozone Trends at Golden and Welby
Figure 4. Trend analyses of ozone summer data from Welby and NREL, with trend results differentiated for the 5th percentiles, median, and 95th percentile data. For the box whisker plots, the horizontal lines show the median values, the boxes the 25 and 75 percentiles, the whiskers the 5th and 95th percentiles, and the crosses values that extend beyond two standard deviations from the median [Bien and Helmig, 2018]. The slope results in the legend represent the ozone trend in ppb/yr. At Welby, all ozone metrics show increasing ozone, with the 95th percentile being statistically significant trend. NREL has positive slopes for the 5th percentile and medians, and a negative slope for the high ozone distribution values.
**Figure 2.** Time series of the fourth-highest 8-hr average O₃ values for selected ozone monitoring by the CDPHE and NOAA (BAO) in the Colorado Front Range from 2000–2014 (data considered for the BAO are from 2009–2014). Monitoring locations are indicated in **Figure 1**.
Figure 6: Regional trend analysis of surface ozone observations from monitoring in the U.S. and Canada. These results reflect the 2000–2014 changes in summer ozone [Chang et al., 2017]. The arrow direction indicates the sign and magnitude of the ozone trend according to the scale given in the inset (i.e. downward arrows are indicative of declining ozone), and the color coding shows the statistical significance of the ozone change, with statistical significant changes (at P > 95%) indicated by the bold colors. The DMA/NCFR is indicated by the red circle. This figure is a partial reproduction of Figure 1 in Chang et al. (2017). DOI: https://doi.org/10.1525/elementa.398.f6
Influence of Oil and Gas Development on Colorado Ozone

CDPHE, 2008 and Helmig, 2018
Footprint Analysis for High Ozone at the Boulder Reservoir

**Probability $O_3 > 50$th percentile**
(Apr 2017-Dec 2018)

**Probability $O_3 > 70$ ppb standard**
(Apr 2017-Dec 2018)
Footprint Analysis for High Ozone at the Boulder Reservoir

Probability $\text{O}_3 > 70$ ppb standard
(Apr 2017-Dec 2018)
Pfister et al., 2017: “On average, oil and gas emissions show a stronger influence in the northern part of the NFRMA and the northern foothills, while mobile emissions dominate farther south and in the southern foothills. Both sectors contribute, on average, 30-40% each to total NFRMA ozone production on high ozone days.”

Evans et al., 2017: “Transport from upwind areas associated with abundant O&NG operations accounts for on the order of 65% (mean for both sites) of 1-hr averaged elevated ozone levels, while the Denver urban corridor accounts for 9%.”

Cheadle et al., 2017: “On individual days, oil and gas $O_3$ precursors can contribute in excess of 30 ppb to $O_3$ growth and can lead to exceedances of the EPA $O_3$ National Ambient Air Quality Standard.”

Oltmans et al., 2019: “The association of high $O_3$ days at the BAO tower with transport from sectors with intense oil and natural gas production toward the northeast suggests emissions from this industry were an important source of $O_3$ precursors and are crucial in producing peak $O_3$ events in the NCFR.”
Observed relationships of ozone air pollution with temperature and emissions

Bryan J. Bloomer, Jeffrey W. Stehr, Charles A. Piety, Ross J. Salawitch, and Russell R. Dickerson

Received 14 January 2009; revised 11 March 2009; accepted 27 March 2009; published 5 May 2009.

Higher temperatures caused by increasing greenhouse gas concentrations are predicted to exacerbate photochemical smog if precursor emissions remain constant. We perform a statistical analysis of 21 years of ozone and temperature observations across the rural eastern U.S. The climate penalty factor is defined as the slope of the ozone/temperature relationship. For two precursor emission regimes, before and after 2002, the climate penalty factor was consistent across the distribution of ozone observations. Prior to 2002, ozone increased by an average of \( \sim 3.2 \text{ ppbv/}^{\circ}\text{C} \). After 2002, power plant NO\(_x\) emissions were reduced by 43%, ozone levels fell \( \sim 10\% \), and the climate penalty factor dropped to \( \sim 2.2 \text{ ppbv/}^{\circ}\text{C} \). NO\(_x\) controls are effective for reducing photochemical smog and might lessen the severity of projected climate change penalties. Air quality models should be evaluated against these observations, and the climate penalty factor metric may be useful for evaluating the response of ozone to climate change. Citation: Bloomer, ship has been investigated in the past [Sillman and Samson, 1995; Sillman, 1999]. However, questions remain regarding how this relationship changes over time, by location, and with precursor emissions.

Modeling studies suggest a penalty in ozone air quality resulting from forecast climate changes. Wu et al. [2008] forecast a penalty of 2 to 5 ppbv in daily maximum 8-hour averaged surface ozone amounts in parts of the eastern U.S., offsetting expected air quality improvement from emission reductions, between 2000 and 2050. Jacob and Winner [2009] provide a review of recent modeling of air quality changes under various scenarios of forecasted global climate change and indicate a climate change penalty from 1 to 8 ppbv ozone is likely in the eastern U.S. this century.

Air quality models need evaluation using observations to assess model performance and to establish confidence in the effect of climate change on surface ozone.
With everything else (emissions, meteorology) the same:

-> More ozone in a warmer climate!

->-> More ozone will cause a warmer climate!!
Please welcome

GABRIELLE PETRON
Atmospheric Scientist
Cooperative Institute for Research in Environmental Sciences
PROTECTING OUR AIR:

A CASE FOR TRANSDISCIPLINARY RESEARCH TO SUPPORT EFFECTIVE POLICYMAKING

Gabrielle Pétron
CU BOULDER CIRES
NOAA Global Monitoring Division
Contact: Gabrielle.Petron@noaa.gov

January 16, 2020
AQ-Climate-Health Forum - Denver
Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of their employers and sponsors.
Our Atmosphere has Vital Roles

- Without it, Earth mean surface temperature would be -18°C (0°F)
- It absorbs dangerous solar radiation
- It carries energy and water around
Emissions from human activities are changing the air composition at multiple scales:

- GHG
- Stratospheric Ozone Depleting Substances (ODS)
- Ground-level Ozone Precursors
- Particulate Matter (PM10 and PM2.5)
- Air Toxics
High-quality Multiple Species Air Monitoring is ESSENTIAL

- **Background Air Composition:**
  - Document large scale (clean continental and marine air) “baseline” and how it changes
  - Can be used to study drivers and attribute large scale changes to natural or human causes
  - Can be used to evaluate emission inventories and atmospheric dispersion
  - Can be used directly to model and study climate response
Why now is a critical time?

Measurements of air trapped in ice cores, firn air, and surface air from cooperative scientific sampling programs.

End of 2019
Global mean
$\sim 411$ ppm

The world and societies as we know them have never seen such high levels of GHG.

We have known this for a while.  
1988-2018 30 yr anniversary of J. Hansen Senate Testimony

“J. Hansen was correct to claim that greenhouse warming had been detected”

Global fossil fuel CO$_2$ emissions: 1988-2018 + 70%  
In billion tonnes, 1960s: 10; late 1980s: 20; 2019: 37

Natural drivers and natural variability cannot explain the observed rise in global mean temperature over land and oceans.
2010-2019
Annual CO₂ growth rate > 2ppm/yr

~ Half of anthropogenic CO₂ emissions stay in the atmosphere. The other half is taken up by plants and the oceans.

- Will these natural sinks keep up?
- What will happen to the carbon buried in the melting permafrost?

Atmospheric CO₂ annual increase has crept up over the past 40 years, as fossil fuel burning emissions have increased.
Estimates of US CH₄ emissions from natural gas systems still disagree by A LOT!

EDF coordinated 16 scientific studies of CH₄ emissions from US O&G systems. Studies covered different scales and used an array of instrumentation. Several companies participated and provided site access.

Major studies reveal 60% more methane emissions

Extensive research led by EDF from 2012 to 2018 shows methane leaks in the U.S. are a far greater threat than the government's estimate suggests.

https://www.edf.org/climate/methane-studies
High-quality Air and Emission data for Cities, Counties and States are also ESSENTIAL

- **Regional / Urban Air Composition:**

  Do we have enough high quality data to assess pollution and impacts?

- **Regional / Urban Emissions:**

  How accurate are emission inventories and estimated trends?
Colorado GHG Emission Inventory and non-binding Future Targets

State uses EPA State Inventory Tool (ie. set of spreadsheets).

- The accuracy of inventory results is not known.

Projected emissions are much higher than targets.

How is the State (country!) going to tackle this huge challenge?

Which expertise and buy-ins are needed to lead to lasting meaningful decisions and actions?

We cannot continue to fail “miserably”.

Colorado’s Greenhouse Gas Emissions vs. Climate Action Plan Targets

Millions of Metric Tons of CO₂-Equivalent (MMTCO₂e)

- Historical Estimate
- Current Projection
State O&G VOC emissions have been very likely underestimated for a while.

- Measurement-based scientific studies have found VOC and benzene emissions from O&G in NE Colorado are at least double what is in the State inventory (see Figure).

- Need for transparency, objective evaluation and reconciliation

**What could be wrong?**
- Underestimated emissions and/or missing sources
- Outdated emission composition profiles, most predate Niobrara drilling
Looking beyond Denver: Colorado NE Front Range transformation

- O&G operations and vehicles are the largest contributors to surface ozone in CO ozone non-attainment area.
- Population and O&G sites and production have been soaring in Colorado NE over the past ten years.

Could/Should State deploy new air quality monitors in the O&G region?
Large multi-well pads are the new normal esp. in urban/suburban drilling

22 well pad in West Greeley, 2018
Ambient benzene regulation in the US has focused on refineries and vehicle emissions.

Oil and Natural Gas Extraction Sites and Waste Disposal Facilities

Oil and Natural Gas Refining/Processing

Gasoline and Natural Gas Distribution and Consumption

- US benzene content in gasoline ~ 1%
- Benzene in cities has gone down
- 52 countries have ambient benzene standards, the US is not one of them.

VERY few exposure studies for/near O&G upstream operations!
University of Wyoming Mobile lab study found very high BTEX (10s to >100ppb benzene) downwind of Produced Water Injection Facilities, confirming finding from a few grab samples during 2014 FRAPPE.

Edie et al., in preparation
Air Toxic Studies (papers in preparation)

24/7 monitoring of BTEX for several weeks near 2 new large wellpads (early production and drilling) show variable hourly mean levels: sub-ppb to > 9 ppb.

Mielke-Maday et al., Madronich, Mund, Handley et al., Both in preparation
Scientific evidence

- The accuracy of State and National inventories for GHG, ozone precursors and air toxics is poorly known.
- Air toxics O&G sources and exposure levels for workers and nearby population in CO are still poorly known.
- The CO Northern Front Range has been non-attainment for ozone for 15 years.

Other Factors

Growing population and economic activities bring new environmental challenges.
Public perceptions of risks and impacts are valid and need adequate responses.

Hypothesis: Air pollution and climate change present real and likely growing risks for the State population, ecosystems and economy.

How could scientific inquiry, methods and findings further support local and State air resource management and sustainability programs?
There is a need to better integrate public input, scientific investigation and different pieces of evidence into policy development

- Start with an objective scientific evaluation of existing AQ measurements (long-term and field studies)
  - Data quality? Is method okay? How representative are they?
- Identify and analyze other “useful” data sets
  - LDAR reports from inspectors versus company self reporting
- Evaluate and improve accuracy of emission inventories
- Prioritize Future Research
  - New measurements and analyses
  - Improve methods, data management, and transparency
Please welcome

JOHN PUTNAM
Director of Environmental Programs
Colorado Department of Public Health & Environment
Colorado Air Quality and Public Health

Status and Upcoming Efforts

John E. Putnam,
Director of Environmental Programs
# Air Pollution and Health in Colorado

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Effects</th>
<th>Major Laws and Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground level ozone</td>
<td>Respiratory, Cardiovascular</td>
<td>H.B. 19-181 Reclassification to Serious</td>
</tr>
<tr>
<td>Climate Change (CO2, methane, hydrofluorocarbons, etc.)</td>
<td>Heat stress, wildfire smoke, ozone, infectious disease, economic stresses, etc.</td>
<td>H.B. 19-1261 S.B. 19-096 S.B. 19-236</td>
</tr>
<tr>
<td>Air toxics (benzene, etc.)</td>
<td>Wide array of acute and chronic, including cancer, respiratory, neurological</td>
<td>S.B. 19-181</td>
</tr>
<tr>
<td>Particulate Matter – Fine PM</td>
<td>Respiratory, Cardiovascular</td>
<td>In compliance with federal ambient standards Are they sufficiently protective? Co-benefits with other laws</td>
</tr>
<tr>
<td>Indoor air quality</td>
<td>Wide range of acute and chronic effects</td>
<td>Co-benefits with other laws Asbestos and radon</td>
</tr>
</tbody>
</table>
## Denver Metro/North Front Range AQ Status

<table>
<thead>
<tr>
<th>Air Pollutant</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Particulates (PM$_{2.5}$)</td>
<td>Attaining</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO$_{2}$)</td>
<td>Attaining</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO$_{2}$)</td>
<td>Attaining</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>Attaining</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>Attained in 1996 – Maintenance Area</td>
</tr>
<tr>
<td>Coarse Particulates (PM$_{10}$)</td>
<td>Attained in 1993 – Maintenance Area</td>
</tr>
<tr>
<td>Ozone (O$_{3}$)</td>
<td></td>
</tr>
<tr>
<td>1979 1-hour standard: 125 ppb</td>
<td>Attained 1987 (Standard Revoked)</td>
</tr>
<tr>
<td>1997 8-hour standard: 84 ppb</td>
<td>Attained in 2009 (Standard Revoked)</td>
</tr>
<tr>
<td>2008 8-hour standard: 75 ppb</td>
<td>Out of compliance</td>
</tr>
<tr>
<td>2015 8-hour standard: 70 ppb</td>
<td>Out of compliance</td>
</tr>
</tbody>
</table>
Ozone: Denver and North Front Range

Design Value Trend in the Denver Metro North Front Range

- 3-yr Avg of Annual 4th Max 8hr at Highest Site (ppb)
- NREL
- RFN
- CHAT

For 1997 Standard
DMNFR: Marginal Area
Attained in 2010
EPA Revoked Standard in April 2015

For 2008 Standard
DMNFR: Marginal Area - Failed to attain
Bumped to Moderate (2016)
Bumped to Serious in 2019?

For 2015 Standard
DMNFR: Marginal Area

*Design Value = 3-yr average of the annual 4th highest daily 8-hour maximum ozone concentration*
NOx Emissions Inventory and Controls (Denver and North Front Range)

- New car/truck standards
- Cleaner fuels/Alternative fuels
- Inspection/maintenance programs
- Diesel retrofits
- New vehicle technologies
- Transportation/land use policies
- Travel reduction programs
- Power Plants
  - Clean Air Clean Jobs Act
  - Regional Haze program
  - Renewable energy/energy efficiency programs
- Small engine standards
- Non-road engine standards
- Locomotive engine standards
- Emissions Standards for Large Engines and Boilers

2017 NOx Sources (234 tpd)

- Emissions Reduced (2011 to 2017) (86 tpd)
- Oil and Gas (66 tpd)
- Point (40 tpd)
- On-Road (73 tpd)
- Non-Road (55 tpd)
VOC Emissions Inventory and Controls (Denver and North Front Range)

- New car/truck standards
- Cleaner fuels/Alternative fuels
- Inspection/maintenance programs
- New vehicle technologies
- Transportation/land use policies
- Travel reduction programs
- Oil and Gas (O&G)
  - New regulations established by Air Quality Control Commission in Feb. 2014
- Lawn and garden equipment change-out programs
Total Ozone for Top 10 Days = 70.7 ppb

- Contribution Outside Colorado: 54.8 ppb (76%)
- Nonattainment Area: 14.7 ppb (20%)
- Rest of Colorado: 2.4 ppb (3.4%)

Contributions by Source:
- On-Road: 5.2 ppb (7.3%)
- Oil and Gas: 2.9 ppb (4.1%)
- Non-Road: 2.0 ppb (4.2%)
- Area: 1.1 ppb (1.5%)
- Natural: 0.3 ppb (0.4%)
- EGU: 0.6 ppb (0.8%)
- Oil and Gas: 0.4 ppb (0.6%)
- EGU: 0.4 ppb (0.6%)
- Point (Non-EGU): 0.1 ppb (0.2%)
- Area: 0.1 ppb (0.2%)

2017 NREL – CO SOURCE & REGION CONTRIBUTIONS
Rest of state ozone trend

<table>
<thead>
<tr>
<th>AQS #</th>
<th>Site Name</th>
<th>2017 4th Maximum 8-Hour Average Value (ppb)</th>
<th>2018 4th Maximum 8-Hour Average Value (ppb)</th>
<th>2019 4th Maximum 8-Hour Average Value (ppb)</th>
<th>2017-2019 3-Year Average 4th Maximum Value (ppb)</th>
<th>2020 Highest Allowable 4th Maximum 8-Hour Average Value (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08-029-0007</td>
<td>HU M - Paonia (started 4/6/18)</td>
<td>---</td>
<td>54</td>
<td>59</td>
<td>---</td>
<td>99</td>
</tr>
<tr>
<td>08-041-0013</td>
<td>Colo. Spgs.- USAF Academy</td>
<td>69</td>
<td>73</td>
<td>65</td>
<td>69</td>
<td>74</td>
</tr>
<tr>
<td>08-041-0016</td>
<td>Manitou Springs</td>
<td>70</td>
<td>72</td>
<td>64</td>
<td>68</td>
<td>76</td>
</tr>
<tr>
<td>08-045-0012</td>
<td>Rifle - Health</td>
<td>59</td>
<td>65</td>
<td>57</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>08-051-5991</td>
<td>EPA - Gothic CASTNET</td>
<td>66</td>
<td>69</td>
<td>67</td>
<td>67</td>
<td>76</td>
</tr>
<tr>
<td>08-067-1004</td>
<td>USFS - Shamrock (thru n/a)</td>
<td>66</td>
<td>71</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>08-067-7001</td>
<td>SUT - Ignacio</td>
<td>69</td>
<td>67</td>
<td>63</td>
<td>66</td>
<td>82</td>
</tr>
<tr>
<td>08-067-7003</td>
<td>SUT - Bondad</td>
<td>69</td>
<td>67</td>
<td>63</td>
<td>66</td>
<td>82</td>
</tr>
<tr>
<td>08-077-0020</td>
<td>Palisade - Water</td>
<td>64</td>
<td>69</td>
<td>63</td>
<td>63</td>
<td>81</td>
</tr>
<tr>
<td>08-083-0006</td>
<td>Cortez</td>
<td>59</td>
<td>67</td>
<td>60</td>
<td>62</td>
<td>85</td>
</tr>
<tr>
<td>08-083-0101</td>
<td>NPS - Mesa Verde NP</td>
<td>66</td>
<td>72</td>
<td>65</td>
<td>67</td>
<td>75</td>
</tr>
<tr>
<td>08-097-0007</td>
<td>Aspen/Pitkin</td>
<td>65</td>
<td>64</td>
<td>63</td>
<td>64</td>
<td>85</td>
</tr>
<tr>
<td>08-103-0006</td>
<td>BLM - Rangely</td>
<td>64</td>
<td>68</td>
<td>64</td>
<td>65</td>
<td>80</td>
</tr>
</tbody>
</table>

NOTE: Values above the 3-year average 4th maximum 8-hour standard of 70 ppb are highlighted in red, above the 75 ppb standard in orange.

Remainder of State (ROS)
2017 VOC Emissions (430 tons/day)
2015 GHG by Sector - 127 MMT CO2e

- Heating: 20%
- NG & Oil: 12%
- Agriculture: 9%
- Transportation: 22%
- Electric Power: 29%
- Other: 8%

2015 Other Sectors:
- Coal Mining: 1.5%
- Industrial Processes: 3.6%
- Waste Management: 3.3%
Major Rulemaking and Planning Initiatives in 2020

• SB 19-096 Inventory and Reporting Rule
• GHG Reductions Roadmap
• SB 19-181 Rules
• SB 19-236 Utility Coordination
• Regional Haze Rulemaking
• Ozone SIP
• Hydrofluorocarbons
• Coal Methane
State Air Quality Opportunities and Constraints

• Political will and support
  • Governor Polis’ direction to be bold on air quality and ozone
  • New legislation

• Legal authority
  • New authorities (S.B. 19-181, H.B. 19-1261, S.B. 19-236)
  • But, elements of “go slow” statutory provisions remain

• Resources
  • APCD kept very lean for years
  • No new resources for ozone, oil and gas in 2019-2020 budget
  • Seeking to double oil and gas stationary unit
  • Seeking funds for mobile monitoring capability

• Science and research
  • Lack of consistent, comprehensive funding program in recent past
  • Need better engagement with policy-relevant research
  • Critical for rulemaking, operations, planning
Role of Local Public Health and Governments

- PHIP update
- Public health and air quality data
  - Local monitoring (direct and by permit)
  - Complaints and health data
  - Standardization
  - Support
- Local Initiatives
  - GHG/sustainability plans
  - Built environment (transportation, structures, indoor)
  - Transportation
THANKS!

More questions?
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Please welcome

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Director of Climate Science
Union of Concerned Scientists
Climate and Air Quality

Brenda Ekwurzel, Ph.D.

Director of Climate Science

Union of Concerned Scientists

Denver, Colorado  January 16, 2020
Projections based on future emissions scenarios

Adapted from Wuebbles et al. 2017
Difference between 1986–2016 and 1901–1960 average temperature

**Fig. 25.1:** Temperature Has Increased Across the Southwest
About the Killer Heat analysis

Killer Heat report available at www.ucsusa.org/killer-heat

Heat Index
Above 90°F

Outdoor workers become more susceptible to heat-related illness.
Head
- headache
- dizziness
- irritability
- loss of coordination
- confusion
- delirium
- anxiety
- loss of consciousness
- seizures
- stroke
- coma

Mouth
- intense thirst
- dry mouth

Heart
- rapid heartbeat
- irregular heartbeat
- reduced bloodflow to the heart
- heart attack

Lungs
- increased breathing rate
- worsened allergies and asthma
- worsened chronic obstructive pulmonary disease

Arms and Legs
- heat cramps
- muscle spasms
- weakness

Liver
- liver injury

Kidneys
- kidney disease
- kidney failure

Skin
- flushed and clammy skin
- profuse sweating
- heat rash

General Physiology and Unique Circumstances

General
- dehydration
- electrolyte imbalance
- vomiting
- drop in blood pressure

Pregnant People
- fetal nutrition deficits
- preterm delivery
FIGURE 8. Frequency of Extreme Heat by Late Century Depends on the Choices We Make

Late Century No Action

Late Century Rapid Action

Heat Index 90°F +

Average Days per Year

0-1
>1-10
>10-25
>25-50
>50-100
>100-200

Killer Heat report available at www.ucsusa.org/killer-heat
Denver County, CO
Above 90°

Historically
1971-2000 average
5 days per year
Late Century No Action

Heat Index 100°F +

Late Century Rapid Action

Average Days per Year

Killer Heat report available at www.ucsusa.org/killer-heat
EXTREME TEMPERATURE MORTALITY

58% REDUCTION

Annual damages: $141 billion
58% reduction
LABOR

48% REDUCTION
NO\textsubscript{x} + VOC + Heat & Sunlight = Ozone

Ground-level or “bad” ozone is not emitted directly into the air, but is created by chemical reactions between NO\textsubscript{x} and VOCs in the presence of heat and sunlight.

Emissions from industrial facilities and electric utilities, motor vehicles, gasoline, and chemical solvents are some of the major sources of oxides of nitrogen (NO\textsubscript{x}) and volatile organic compounds (VOCs).
People who do not suffer from lung conditions often fail to appreciate what they feel like, how dangerous they are, and why the quality of life for the sufferer can be compromised. This is what breathing ozone can feel like if you have a lung condition: you may find it difficult to breathe deeply and vigorously; you may be short of breath and be in pain when taking a deep breath; you may cough, wheeze, and have a chronically sore or scratchy throat; and your asthma attacks may become more frequent. Inside your body, repeated ozone exposures may inflame and damage your lung lining and make the lungs more susceptible to infection.
Waldo Canyon Fire 2012

Fig. 25.4: Climate Change Has Increased Wildfire
COMMUNITIES OF COLOR
Some communities of color living in risk-prone areas face cumulative exposure to multiple pollutants.

Adaptation plans that consider these communities and improve access to healthcare help address social inequities.

OLDER ADULTS
Older adults are vulnerable to extreme events that cause power outages or require evacuation.

Checking on neighbors and emergency contact can save lives.

CHILDREN
Children have higher risk of heat stroke and illness than adults.

Comprehensive disaster management can improve resiliency for people with limited resources.

LOW INCOME COMMUNITIES
Low income families are vulnerable to physical and mental health issues during flooding and in poor shelter conditions.

Adults can lessen risk by monitoring exertion and hydration.
Key Message #2

Under scenarios with high emissions and limited or no adaptation, annual losses in some sectors are estimated to grow to hundreds of billions of dollars by the end of the century.

Source: adapted from EPA 2017

(in 2015 dollars)
Who Pays for Damages and Adaptation?
Debris flow covers US Highway 14 (Poudre Canyon) after the High Park Fire in 2012

Photo: Justin Pipe, Colorado Department of Transportation
1.5 °C or 2 °C World
(2.7 °F or 3.6 °F)
“common but differentiated responsibilities” among nations

UNFCCC 1992
Contribution of National Emissions to Global Warming

Matthews et al 2014
Public Opinion in Colorado on Climate Accountability
54% of Colorado adults think global warming is harming their local community.
57% of Colorado adults think fossil fuel companies are responsible for global warming damages

Survey data collection and analysis conducted by the Yale Program on Climate Change Communication
56% of Colorado adults support fossil fuel companies paying for global warming damages.

Survey data collection and analysis conducted by the Yale Program on Climate Change Communication.
Fig. 25.10: Projected Increases in Extreme Heat

BCP8.5: Temperature exceeds 90°F (32°C) by 2036–2065 vs 1976–2005
Fig. 3.1: Billion-Dollar Weather and Climate Disaster Events in the United States

(a) Number of Events

(b) Estimated Damages

Combined Total of Tropical Cyclones, Floods, & Droughts

Year


 Hurricanes Harvey, Irma, Maria

Hurricane Katrina

Cost (billions of dollars)

Annual Global CO₂ Emissions from Fossil Fuel and Cement, 1751–2015

- 737 GtCO₂ emitted, 1751–1979 (38%)
- 743 GtCO₂ emitted, 1980–2015 (62%)

Data source: Boden, Marland, and Andres 2013; Image source: Union of Concerned Scientists
"Detection of change" is the process of demonstrating that an observed change in climate is highly unusual in a statistical sense, but does not provide a reason for the change. "Attribution" is the process of establishing cause and effect relations, including the testing of competing hypotheses.”
Global Warming of 1.5°C

An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.
The maps show estimated changes in annual net mortality due to extremely hot and cold days in 49 U.S. cities for 2080–2099 as compared to 1989–2000. Across these cities, the change in mortality is projected to be an additional 9,300 deaths each year under a higher scenario (RCP8.5) and 3,900 deaths each year under a lower scenario (RCP4.5). Assuming a future in which the human health response to extreme temperatures in all 49 cities was equal to that of Dallas today (for example, as a result of availability of air conditioning or physiological adaptation) results in an approximate 50% reduction in these mortality estimates. For example, in Atlanta, an additional 349 people are projected to die from extreme temperatures each year by the end of century under RCP8.5. Assuming residents of Atlanta in 2090 have the adaptive capacity of Dallas residents today, this number is reduced to 128 additional deaths per year. Cities without circles should not be interpreted as having no extreme temperature impact. Data not available for the U.S. Caribbean, Alaska, or Hawai’i & U.S.-Affiliated Pacific Islands regions. Source: adapted from EPA 2017. 

Source: adapted from EPA 2017.
Detection of change

“Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.” – IPCC 2013
Attribution

“It is extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century.”

*extremely likely = 95-100% probability of an outcome or result.
Fig. 25.3: Severe Drought Reduces Water Supplies in the Southwest

- **Colorado River Flow**
  - Time series showing variations in river flow from 1900 to 2020.

- **Lakes Powell and Mead Water Volume**
  - Graph indicating changes in water storage from 1900 to 2020, with key events marked:
    - Start filling Lake Mead
    - Start filling Lake Powell
    - End of filling
    - Drought begins

- **Upper Colorado Basin Temperature**
  - Temperature changes from 1900 to 2020, with a trend line indicating warming.

- **Upper Colorado Basin Precipitation**
  - Precipitation variations from 1900 to 2020, showing fluctuations over time.
High temperatures due mainly to climate change have contributed to lower runoff and to 17%–50% of the record-setting streamflow reductions between 2000 and 2014.
Boulder Flood September 2013

Boulder Flood September 2013

Clusius–Clapeyron relation (6%–7%)
One day increase in precipitation volume compatible with < 6%

(i.e. Hoerling et al., (2013) null and an increase in accordance with the Clausius-Clapeyron relation as suggested by Trenberth et al., 2015) - Eden et al., 2016, ERL
Species to LOSE OVER HALF of their climatically determined GEOGRAPHIC RANGE for global warming

+2°C
- INSECTS: 18%
- PLANTS: 16%
- VERTEBRATE: 8%

+1.5°C
- INSECTS: 9.6%
- PLANTS: 8%
- VERTEBRATE: 4%

IPCC SR15 2018 SPM
Fig. 21.3: Drying Effect of Warmer Air on Plants and Soils

- Cooler air can hold less water → Less moisture demand on plants
- Warmer air can hold more water → More moisture demand on plants

50% relative humidity

Air water vapor
Deficit in air water vapor
Leaf tissue water vapor
What questions do you have?
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