# Leveraging collaborative research toward the development of an Atmospheric Chemistry field course

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**EV431 @ COLORADO COLLEGE, MARCH 2023**

**FARE USERS' WORKSHOP – USER STORIES (TRACK 1)**

**NCAR-EOL, BOULDER, CO SEPT 18-22, 2023**

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# Collaborative Research at Storm Peak Lab

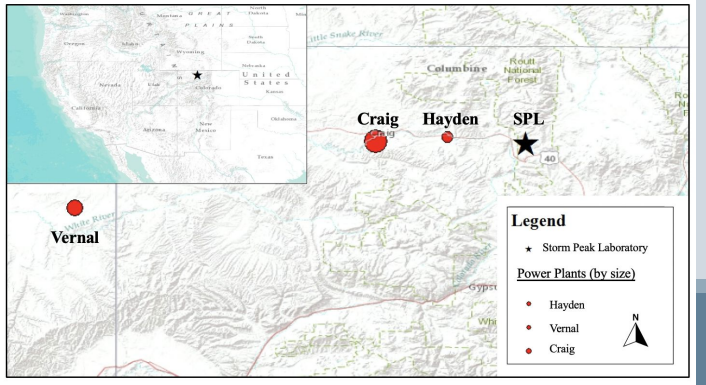
**Project (2020-2023): RUI: Mercury oxidation pathways in a continental atmosphere: High temporal resolution measurements of mercury and oxidants at the Storm Peak Laboratory**

**Co-Investigators:** Drs. Seth Lyman (USU), A. Gannet Hallar (U of Utah), Rainer Volkamer (CU/CIRES)

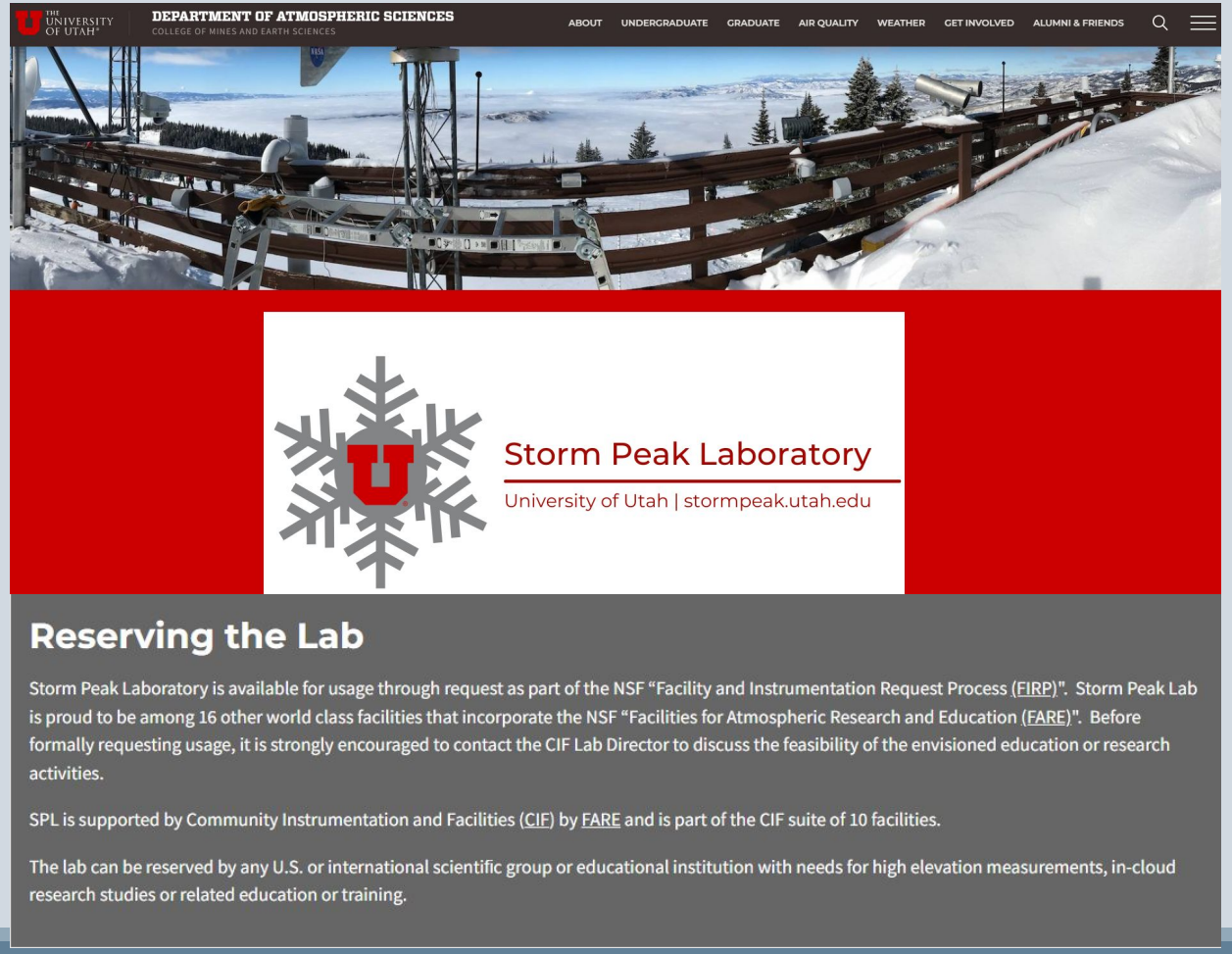
**Measurements (2021-2022):**

- Dual-channel Hg analyzer w/ automated calibrator
- MAX-DOAS (halogens, trace gases)
- Criteria gases ($O_3$, NOx, $SO_2$, CO)
- Aerosol properties, size distributions
- Meteorology

**Modeling:** FLEXPART, HYSPLIT, GEOS-Chem, F0AM



# **SPL** awarded an NSF FARE Community Instrumentation Facility (**CIF**) in Fall 2021




**My timeline:**

Field campaigns Spring-Summer 2021 & 2022
- 1-year sabbatical in AY 2021-22

Teaching in 2022-23:
- Atmospheric Dynamics (EV333) Blocks 2, 5
- Atmospheric Chemistry (EV431) Block 6

Submitted FIRP-Track 1 (Education & Outreach) proposal in May 2022

Funding awarded August 2022

Course preparation in fall 2022, early 2023

**Field course in March 2023**

# **Course history & format:** Why I chose CC's EV431 for field study

**The Block Plan at Colorado College:** 1 course for 3.5 weeks
- Unique opportunities for on or off campus field study

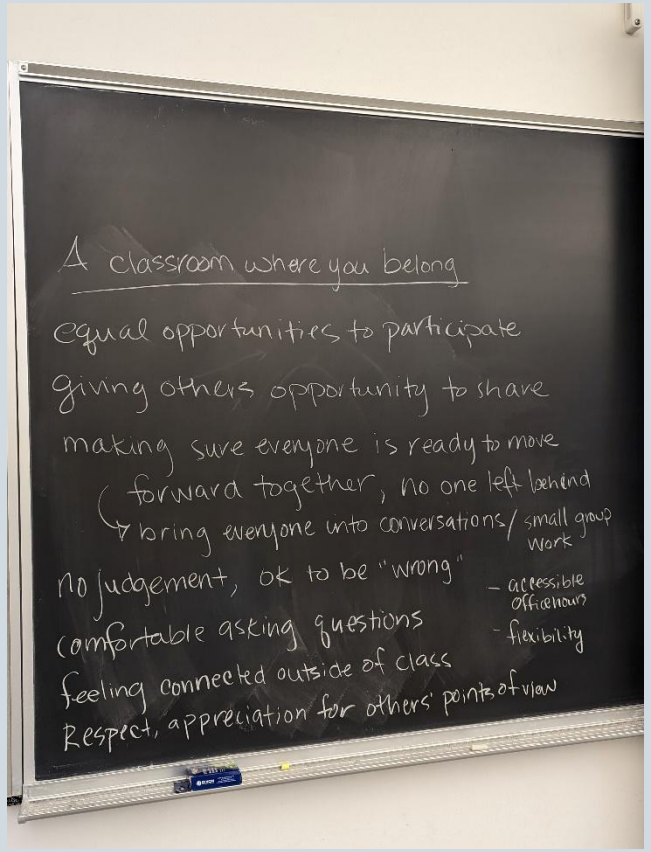
**The EV431 course:**
- Previously titled "Air: Atmospheric Physics & Chemistry"
- In 2018, became two courses:
  - *EV333:* Atmospheric Dynamics (required for majors)
  - *EV431:* Atmospheric Chemistry (upper level elective)
    - First offered in spring 2020… virtually ☹
    - Next offered in spring 2023… opportunity to redesign!!
      - 2 sections (blocks) of EV333 would precede it
      - Capped at 16 students

*EV333 students at Eagles Nest view point, learning about lapse rates in Block 2 2022*

*Photo credit: Frannie Nelson ('22)*

# Course Learning Goals

- Apply chemical and physical concepts (e.g. kinetics and radiative transfer) toward characterization of atmospheric composition;
- Understand the fundamental chemical mechanisms in different layers of the atmosphere;
- Improve ability to read and discuss primary literature;
- Develop oral and written scientific communication skills for diverse audiences.




**Ensure an inclusive learning environment & sense of belonging.**

- **Course survey before the block to explain field trip, gauge comfort levels, determine accessibility to gear, etc.**
- **Transparent expectations**

# Course Structure: Weeks 1-2 on campus

**Building Foundational Knowledge**

- *Content (morning class periods):* gas-phase chemistry of the stratosphere & troposphere

- *Skills (twice-weekly afternoon labs):*
  - Operating instrumentation, measuring local air quality
  - HYSPLIT
  - Statistical & graphical analysis
  - RStudio OpenAir wind/pollution roses

- *Assignments & other activities:*
  - Problem sets
  - News & Views articles using pubs from MBO, SPL, or WFMFS
  - Virtual intro to SPL instrumentation from students in HART Lab

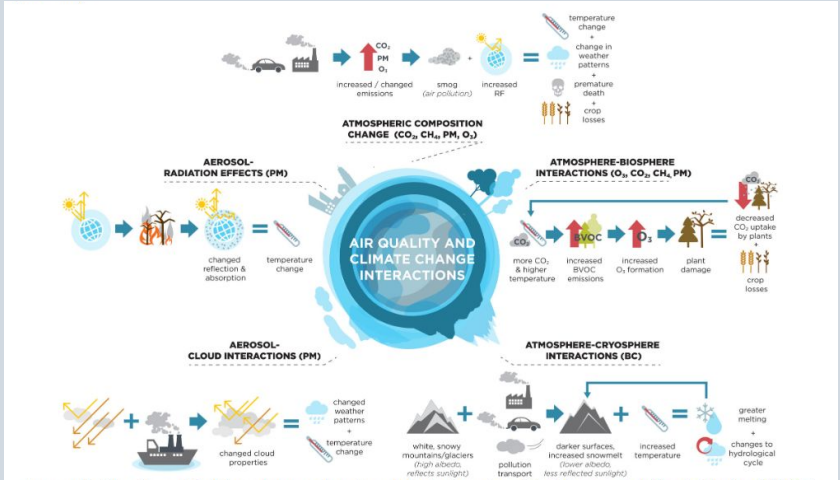
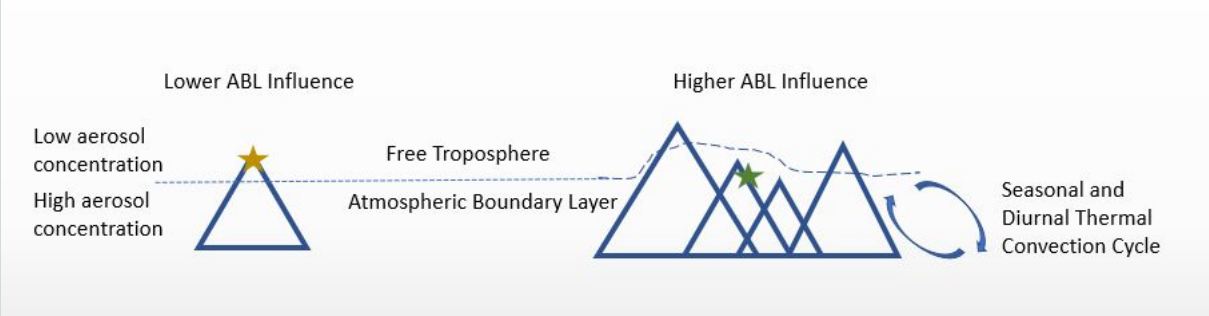


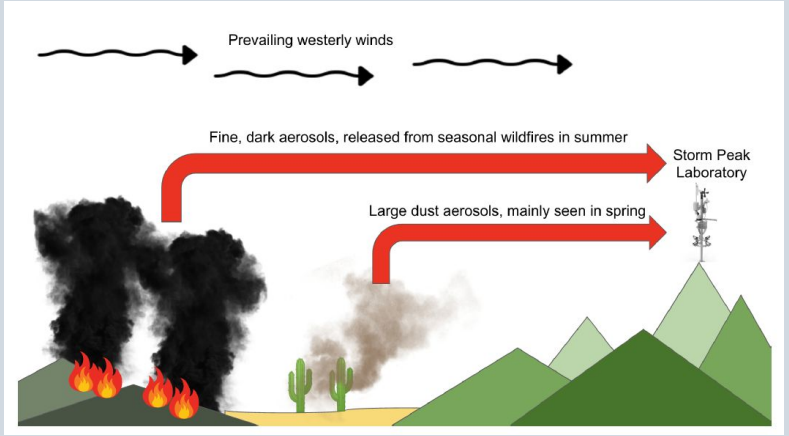

*Image credit:* "Chemistry and the linkages between air quality and climate change", von Schneidemesser et al., Chemical Reviews (2015)

# News & Views Articles:

## Reading & communicating atmospheric chemistry research from mountaintop observatories

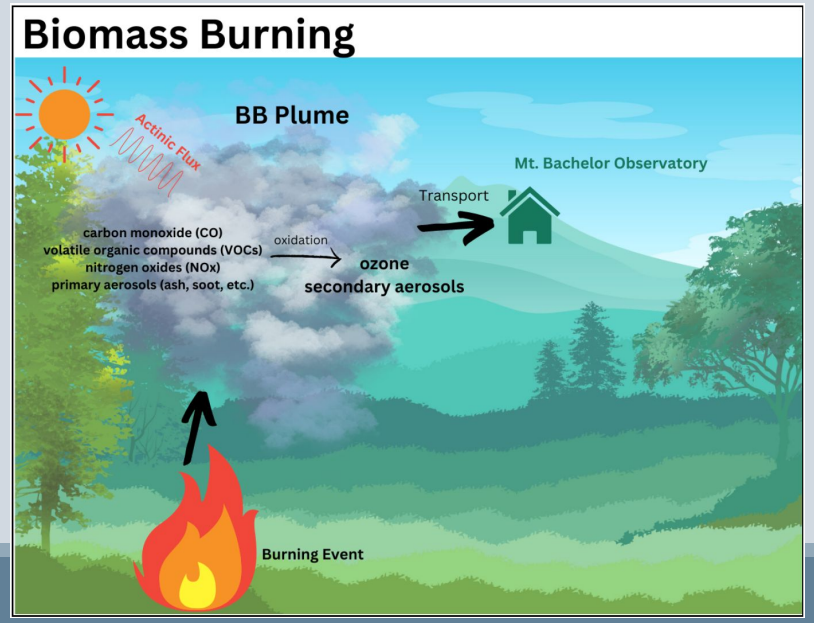


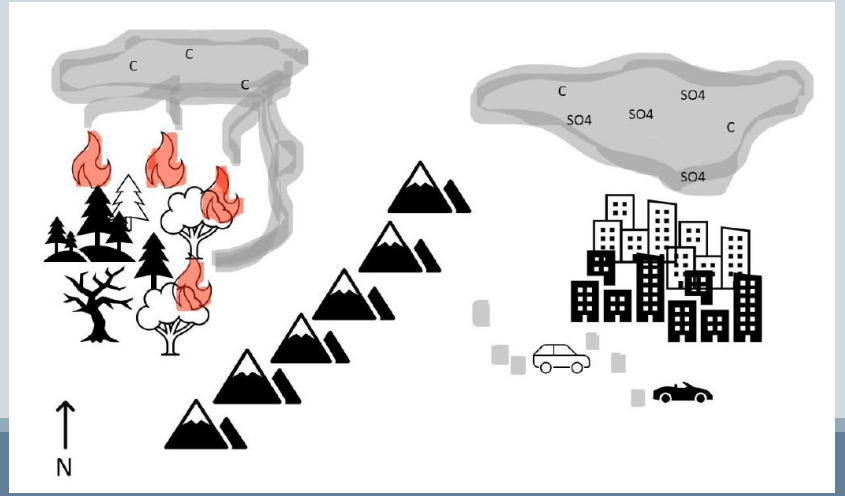

*Rikki Held & Jordan Cosgrove, on Collaud-Cohen et al. (2018)*




*Sean Dunbar & Mark Reiss, on Japngie-Green et al. (2019)*

*Amy Cotter & Jasmine Sone, on Baylon et al. (2018)*




*Lucy Capone & Sophia Jacober, on McClure & Jaffe (2018)*

# Course Structure: Weeks 3-4 in the Field

| Week 3: Field trip to Storm Peak Laboratory, Steamboat Springs, CO | | | |
|---|---|---|---|
| **Date** | **Morning (8:30-12:00)** | **Afternoon (12:00-3:00)** | **Evening** |
| 3/13 | Travel to Steamboat Springs – depart campus 8:30am for ~3.5 hour drive with a break | Orientation to the Yampa Valley w/ YVSC (2:00-3:30pm, location TBD) | Dinner in lodges;<br>present News & Views figures |
| 3/14 | SPL welcome, orientation, & safety discussion;<br>Transit to lab | Lunch & SPL facility tour | Dinner in lodges;<br>workshop final presentation proposals |
| 3/15 | Data exercise – finding temperature inversions & their relation to ozone, PM | Lunch & data analysis | Optional visit to Strawberry Hot Springs (6:00-8:00pm);<br>Dinner in lodges |
| 3/16 | Data exercise –<br>Comparing mountain vs. valley ozone & NOx | Lunch & data analysis | Drs. Gratz & Hallar – public lecture in town (6:30-8pm);<br>Group dinner (location TBD) |
| 3/17 | Checkout 10:00am, depart Steamboat Springs | Lunch break;<br>Return to campus by 3pm | |

**Objectives for field component:**

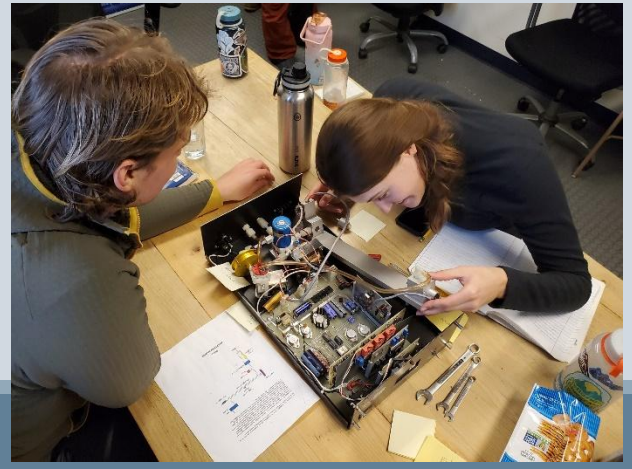
- See how atmospheric chemistry measurements are collected, interpreted;
- Apply classroom knowledge to real studies of the atmosphere
- Collect (or appreciate prior collection of) data for final projects;
- Visit an internationally-recognized research station within driving distance of campus;
- Build connections with an R1 university;
- Incorporate my research into the classroom.

# Field Activities @ SPL

*Orientation to the lab*

*Learning how instruments work*

*Snow sampling*



# Outreach activities in Steamboat Springs

*Orientation to local environmental issues & actions from the Yampa Valley Sustainability Council (YVSC)*


*Community-facing presentation about SPL and recent research by Drs. Gratz and Hallar, hosted by the YVSC*

# Student Research Projects

**Objective:** With a partner (and guidance from Drs. Gratz and Hallar), devise a research question using existing QA/QC'd data from 2021-22 campaigns at SPL; incorporate concepts & tools developed in class

**Deliverables:** Extended abstract & oral presentation

**Timeline (block plan style… whew!):**

- *Thursday:* work day @ SPL – explore, finalize topic w/ guidance
- *Friday:* Return to campus
- *Saturday-Sunday:* work with partner
- *Monday:* work day, 1:1 meetings with Prof. Gratz
- *Tuesday:* final presentations (Prof. Hallar via Zoom), peer review of extended abstracts
- *Wednesday:* extended abstract due, class ends.

# Final Project Topics

"Origins of ozone at Storm Peak Laboratory in Steamboat Springs, CO in the Springtime of 2021 and 2022"

"Spikes in $SO_2$ Concentration at Storm Peak Laboratory in 2022"

"Varying Diurnal Patterns in NOx and Ozone at Two Sites: Storm Peak Laboratory and Steamboat Springs in the Yampa Valley" (*Note: data collected during field course*)

"The effect of local and regional wildfire conditions on aerosol properties and persistence at a Colorado mountain-top observatory"

"Comparison of pollutant concentrations in two local wildfire events at Storm Peak Laboratory"

"Biomass burning impacts on atmospheric composition during three events at SPL"

"Variations in ozone and NOx concentrations between atmospheric layers"

"Modified Combustion Efficiency at Storm Peak Lab in September 2022"

# Course takeaways

Field trips with (16!) students are a lot of work, with big rewards.

Showing students how scientific research happens in real life is very meaningful, for everyone.

Field study can be accessible to all students – with expectations clearly set ahead of time.

NSF FIRP award was crucial for funding support staff, lodging, meals, gear, etc.

*Strengths:* course design, applied field study

- "The field trip to SPL was an amazing hands on learning experience, and a great chance to see what a career in atmospheric sciences and research could look like"

*Weaknesses:* compressed format (depth vs. breadth; time to do thorough research)

# Acknowledgments

NSF Award # 2228770

Prof. A. Gannet Hallar (U of Utah; SPL Director)

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HART Lab members – Nic Hofmann, Gerardo Carrillo-Cardenas, Grace Liu, Angelina Miller

Darren Ceckanowicz (CC Technical Director)

Frannie Nelson (CC paraprofessional)

16 incredible CC undergraduate students