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/CIMAS)

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

Reserving the Lab

Storm Peak Laboratory is available for usage through request as part of the NSF “Facility and Instrumentation Request Process (FIRP).” Storm Peak Lab is proud to be among 16 other world class facilities that incorporate the NSF “Facilities for Atmospheric Research and Education (FARE).” Before formally requesting usage, it is strongly encouraged to contact the CIF Lab Director to discuss the feasibility of the envisioned education or research activities.

SPL is supported by Community Instrumentation and Facilities (CIF) by FARE and is part of the CIF suite of 10 facilities.

The lab can be reserved by any U.S. or international scientific group or educational institution with needs for high elevation measurements, in-cloud research studies or related education or training.
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

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
News & Views Articles:
Reading & communicating atmospheric chemistry research from mountaintop observatories

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

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

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

Lucy Capone & Sophia Jacober, on McClure & Jaffe (2018)
Course Structure: Weeks 3-4 in the Field

<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
<td>Morning (8:30-12:00)</td>
<td>Afternoon (12:00-3:00)</td>
<td>Evening</td>
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<tr>
<td>3/13</td>
<td>Travel to Steamboat Springs – depart campus 8:30am for ~3.5 hour drive with a break</td>
<td>Orientation to the Yampa Valley w/ YVSC (2:00-3:30pm, location TBD)</td>
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<td>3/14</td>
<td>SPL welcome, orientation, &amp; safety discussion; Transit to lab</td>
<td>Lunch &amp; SPL facility tour</td>
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<td>3/15</td>
<td>Data exercise – finding temperature inversions &amp; their relation to ozone, PM</td>
<td>Lunch &amp; data analysis</td>
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<tr>
<td>3/16</td>
<td>Data exercise – Comparing mountain vs. valley ozone &amp; NOx</td>
<td>Lunch &amp; data analysis</td>
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<tr>
<td>3/17</td>
<td>Checkout 10:00am, depart Steamboat Springs</td>
<td>Lunch break; Return to campus by 3pm</td>
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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

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Frannie Nelson (CC paraprofessional)
16 incredible CC undergraduate students