Research Overview

Our aim is to understand anthropogenic impact on atmospheric composition within the context of pollution and climate.

One focus is on chemical mechanisms that control concentrations of ozone ($O_3$) and secondary organic aerosol (SOA), secondary pollutants with profound effects on climate, human health, and the environment. This work aims at providing detailed understanding of how anthropogenic emissions influence rate of chemical processes in the atmosphere as well as the resulting product formation. This is important for predicting future conditions, but also for understanding the pre-industrial state of the atmosphere, which is the most commonly used starting point for defining human-induced changes and the role of the Anthropocene.

Another focus is understanding how differences in key physical and chemical properties of materials determine their radiative properties and chemical reactivity in the aerosol phase. This work develops fundamental scientific understandings for assessing the merits and risks of injections of stratospheric aerosol, suggested as a means to complement mitigation in moderating climate change and, perhaps, even bolstering stratospheric ozone recovery. This work requires new laboratory measurements of heterogeneous reaction rates under stratospheric conditions, and of the optical properties of solids with modern instrumentation.

Scientific Approach

- Field campaigns
- Instrument development
- Laser spectroscopy
- Organic synthesis
- Computer modeling
- Chamber experiments

Instrument Development and Spectroscopy

New laser and mass-spectrometric instrumentation enable new types of measurements and provide new insights

Formaldehyde Laser-Induced Fluorescence

HCHO is one of the most abundant gas phase carbonyls in the atmosphere (0.2–20 ppbv) and joins glyoxal as a tracer for VOC oxidation

A fiber laser is tuned to a resonant line around 353 nm which excites the formaldehyde to the first electronic excited state. Once the pulse is turned off, a photomultiplier tube measures the fluorescence signal which is proportional to the mixing ratio of HCHO in the atmosphere.

Hydroxyl Radical Sequential Two-Photon Laser Induced Fluorescence (TP-LIF)

OH is the dominant oxidizing species in the earth’s atmosphere and its direct measurement is crucial to our understanding of atmospheric oxidation.

Recent papers have shown poorly understood instrument artifacts in published OH measurements using single photon LIF. Our goal is to develop the first field-capable OH TP-LIF instrument that isolates or even eliminates instrument-generated OH interference.

Geoengineering

Can modification of the chemical composition of the stratosphere influence solar radiation reaching the surface? Can we “design” aerosols for solar radiation management?

Planned laboratory kinetics experiments of surface photocatalytic reactions and aging of aerosols in addition to possible small-scale field experiments.

Field Campaigns

We deploy our formaldehyde and (methyl)glyoxal instruments to collect land, sea and air measurements, in areas dominated by both anthropogenic and biogenic emissions.

These field campaigns allow us to test our knowledge of atmospheric reaction mechanisms across all ranges of conditions and environments. It is crucial for our models to make accurate predictions in any situation, particularly in an era with rapidly shifting emission inventories for both the developing and developed world.

Group Members

Back: Adam Birdault, Frank Keutsch, John Dykema, Alex Zaytsev
Front: Jean Rivera, Zhen Dai, Josh Shutter

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