# Open-path Mid-infrared Dual-comb Spectroscopy for Measurement of Ambient Ethane and Propane

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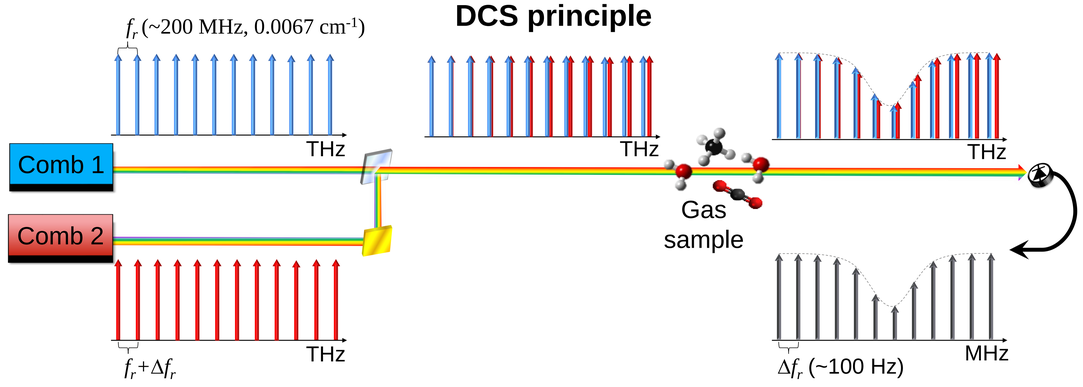
## Why Dual-comb Spectroscopy (DCS)?

- Extremely high resolution (0.0067 $cm^{-1}$)
- No moving parts
- No instrument line shape
- Broad spectral coverage = multi-species detection (can extract dry mixing ratios)
- Well-suited to outdoor studies
  - Can propagate >1 km with spatial coherence
  - Fast (20 second) time resolution
  - Ability to average for minutes to hours
  - Low sensitivity to air path turbulence

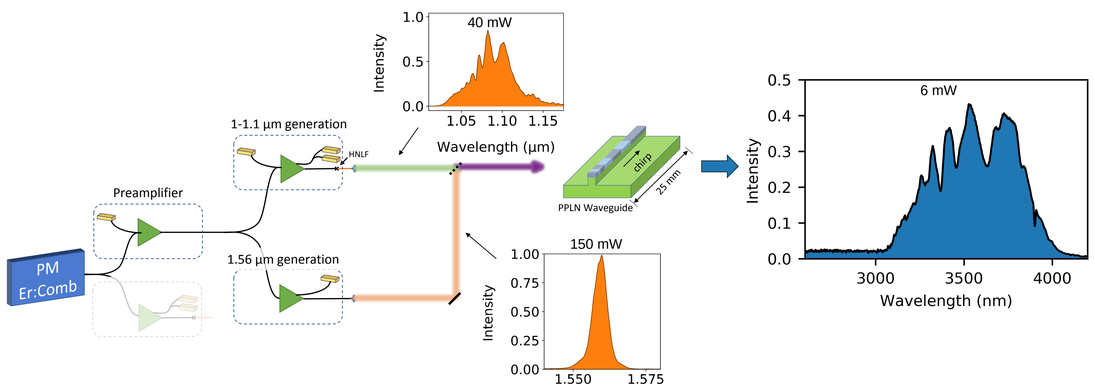
**Here, we demonstrate DCS across long open-air paths in the mid-infrared and show detection of controlled releases of acetone and isopropanol across a 162-m path, measurement of methane and NMHCs across a 1-km path for several days, and preliminary measurements of CO, $N_2O$, and $O_3$.**

## Technique

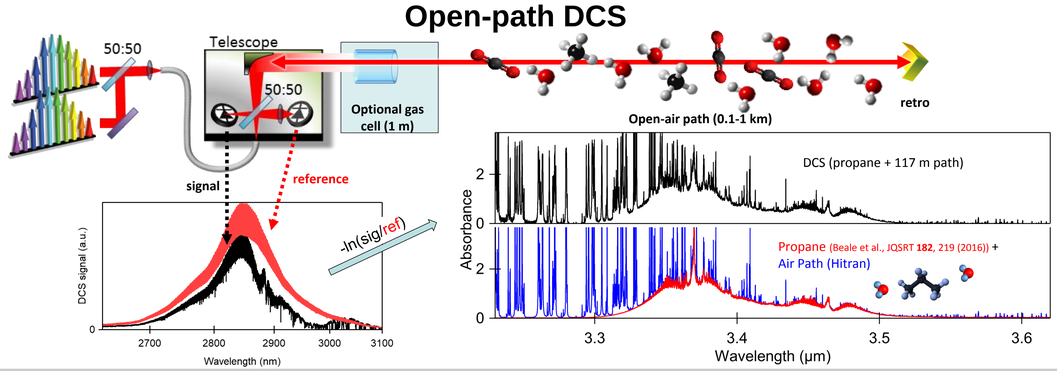
### DCS principle




### Mid-infrared frequency comb



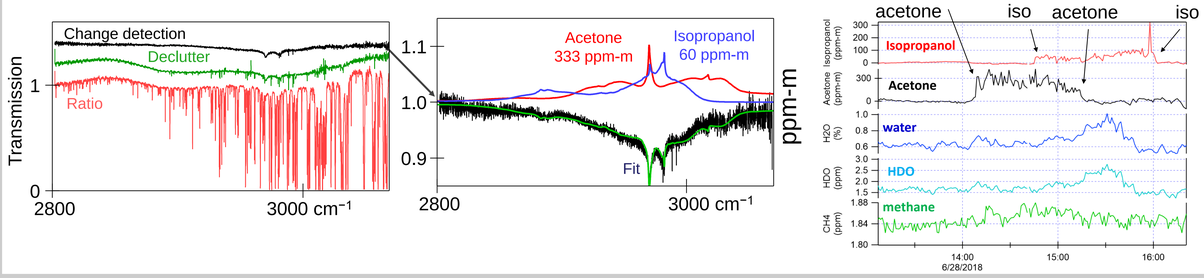

### Open-path DCS



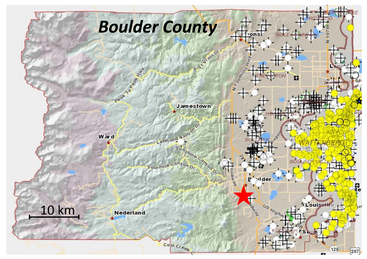

## Results

### Detection of VOCs

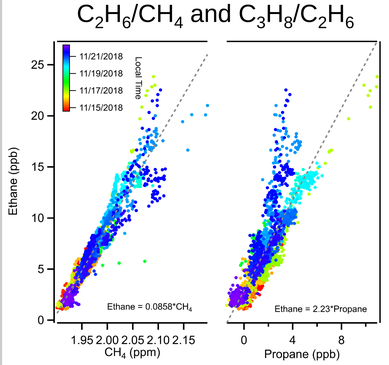

- 162 m path
- Add trays of acetone and/or isopropanol
- "declutter" = fit $H_2O$, $CO_2$, $CH_4$, and isotopologues using HITRAN
- "change detection" = reference to first spectra without acetone or isopropanol

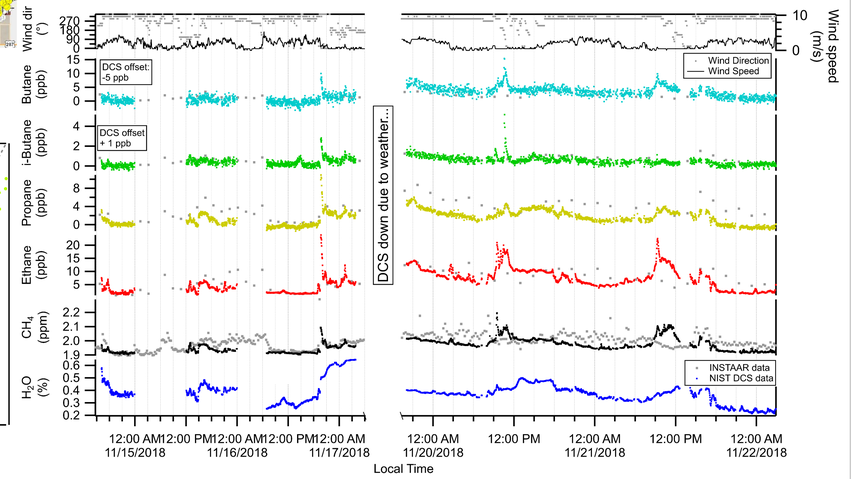



### Measurement of ambient NMHCs



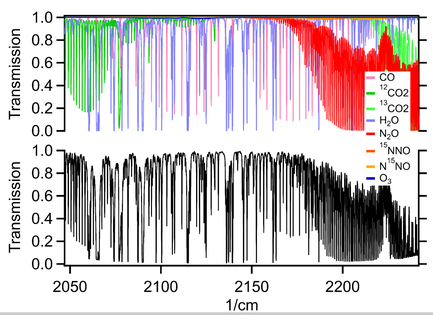

- 1 km path length
- Automatic telescope pointing servo
- Piecewise polynomial baseline removal
- Fit $H_2O$, $CO_2$, $CH_4$, and isotopologues using HITRAN
- Fit other species with "differential" cross sections based on PNNL

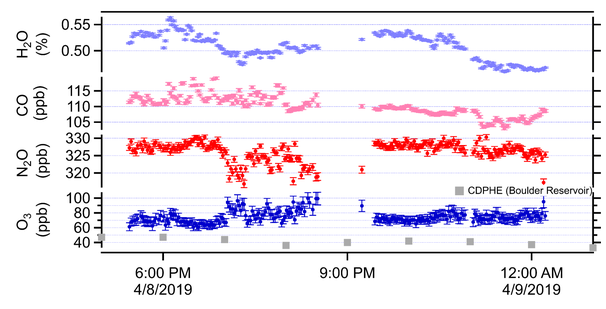



### 4.5-5 μm measurements (preliminary)

- 1 km path length
- Piecewise polynomial baseline removal
- All species fit using HITRAN
- Need to investigate $O_3$ bias, possibly due to database?

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