Towards Measuring Atmospheric CO_2 Enhancements and Quantifying CO_2 Emissions from Wildfires – an Airborne Demonstration

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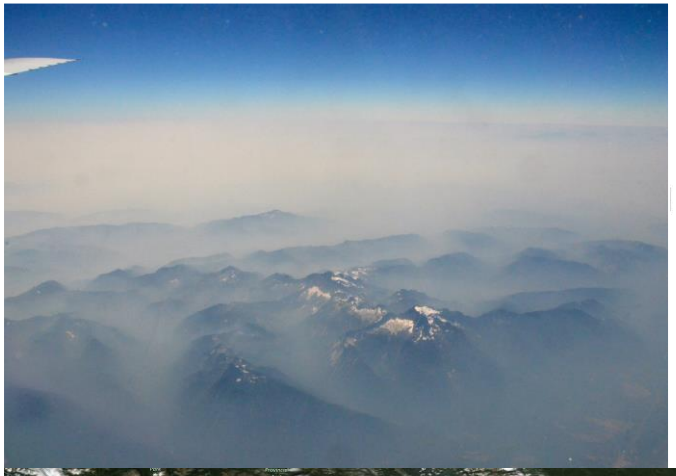
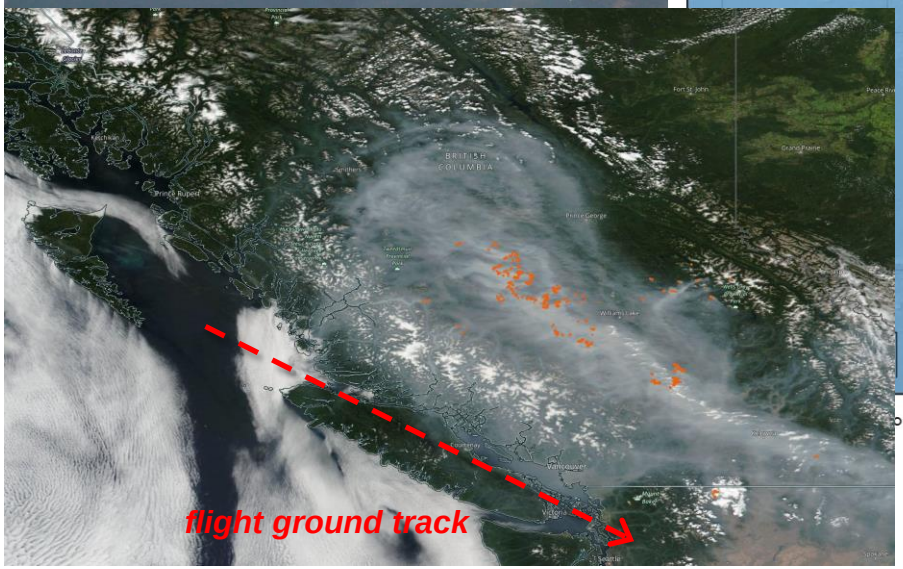
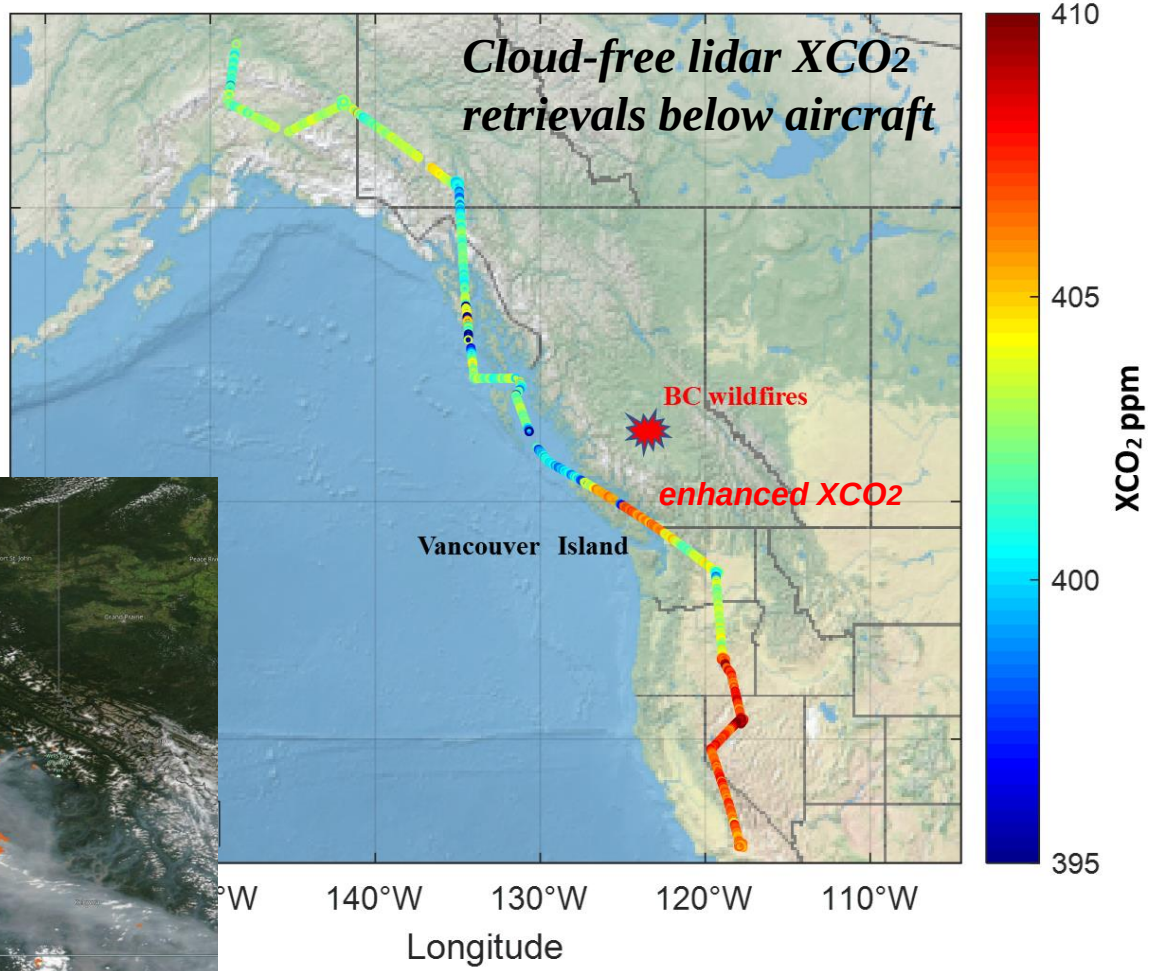


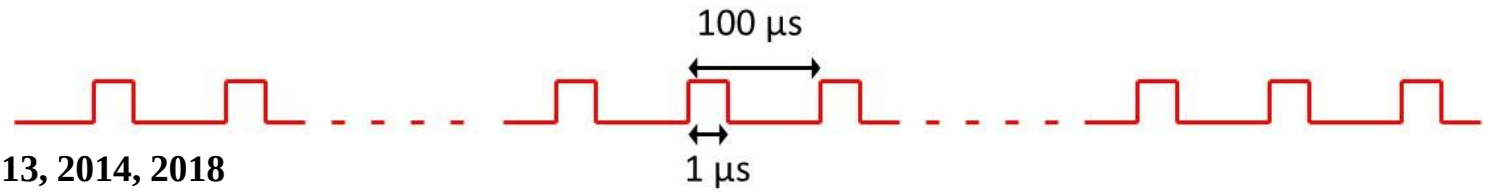




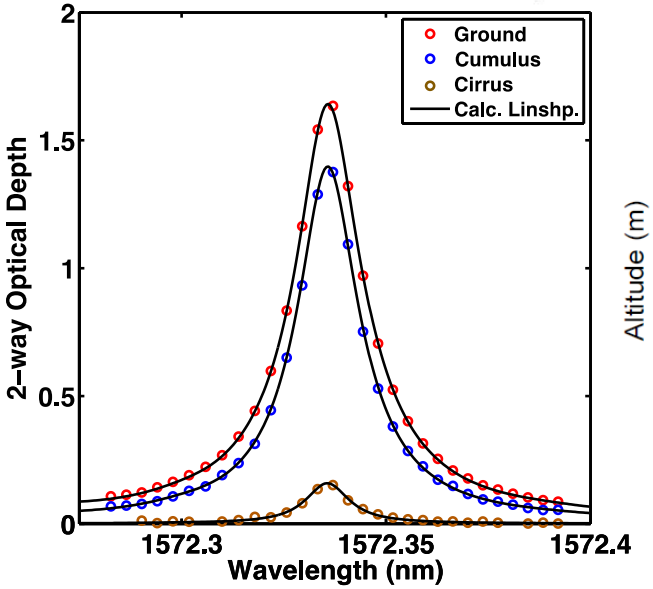
Mao et al., 2021, in review, GRL

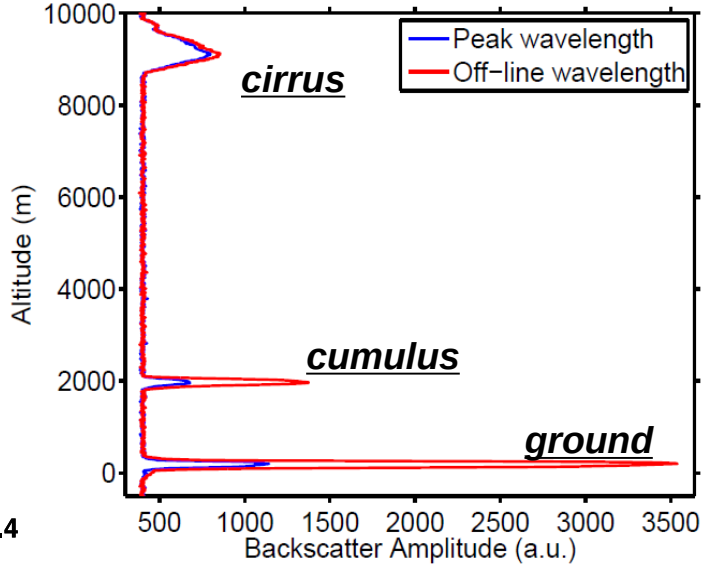
Goddard CO_2 Sounder Lidar

- ***Pulsed laser, 1-μs laser pulse width, 10 kHz pulse rate ~ a step of 100-μs***
- ***30 wavelengths scan the 1572.335 nm CO_2 line at 300 Hz laser scan rate***
- ***Backscatter profiles have up to 1.5 m vertical resolution with 10 ns receiver bin width***
- ***This technique enables accurate estimates of XCO_2 through cirrus and aerosols and to the cloud tops in addition to the ground***



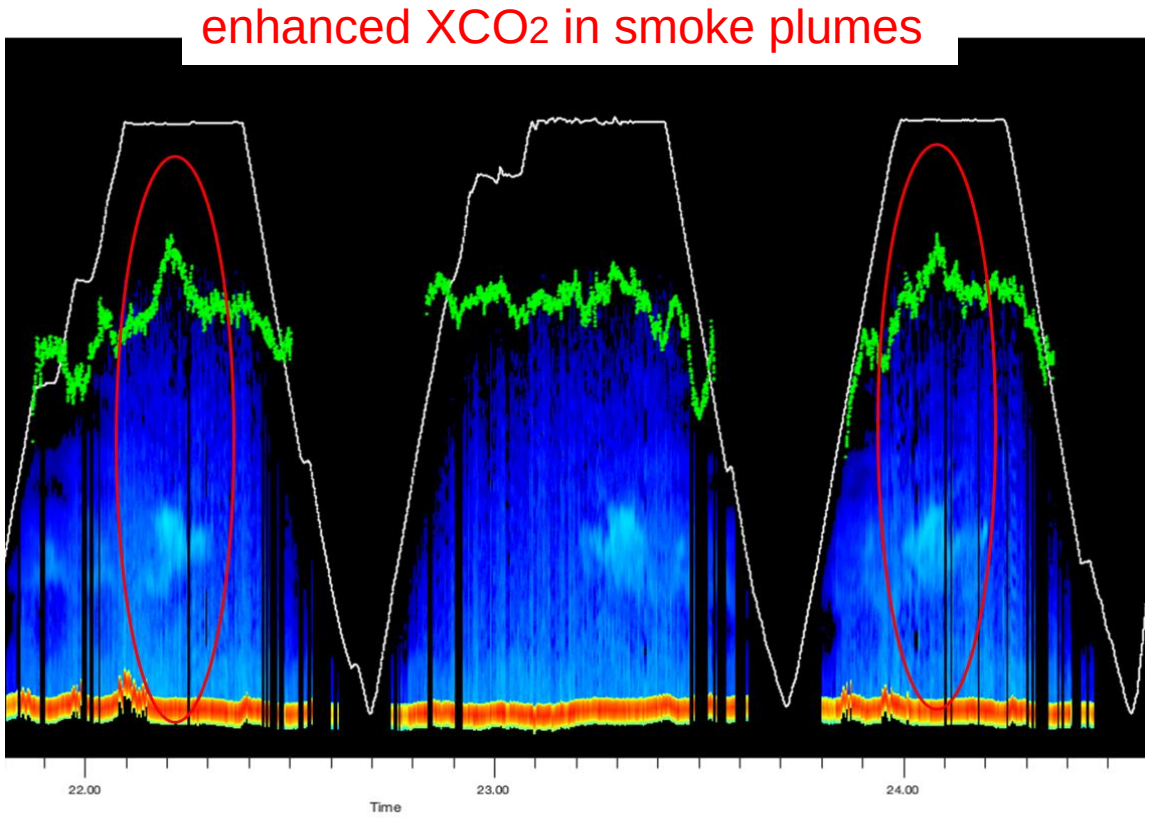
Abshire et al., 2010, 2013, 2014, 2018
Kawa et al., 2010, 2018
Mao et al., 2018, 2021
Ramanathan et al., 2015, 2018
Sun et al., 2021





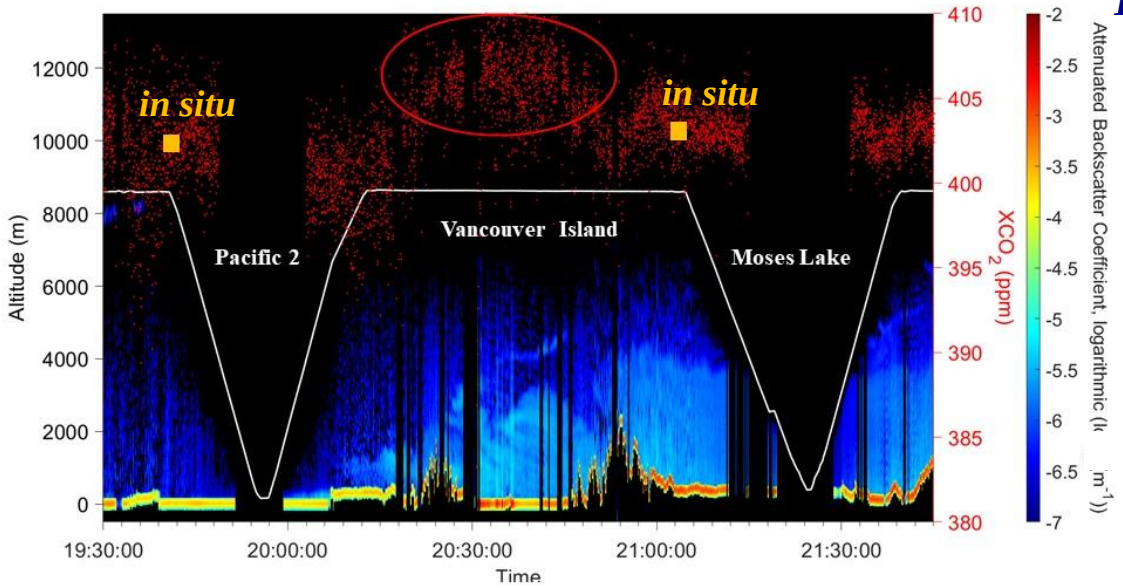
Detwiler Wildfires in the Central Valley 7/21/2017

Right: smoke plumes from the Detwiler wildfires near the Yosemite National Park during the calibration flight on July 21, 2017. Image from MODIS/Aqua Fires and Thermal Anomalies.

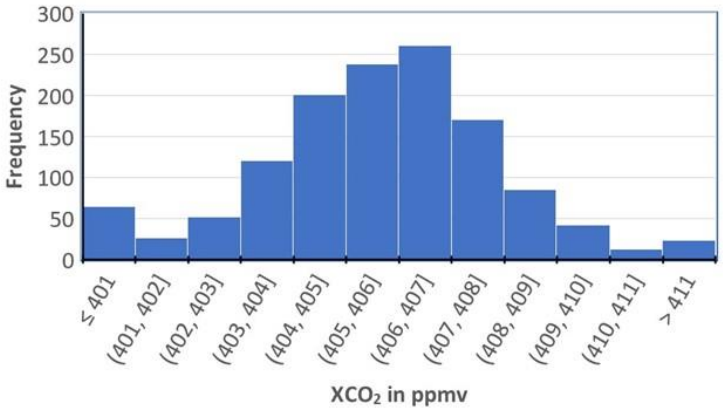


Left: lidar XCO_2 (green) and backscatter profiles (blue and red) from the calibration flight. The flight altitudes are marked in white line.

British Columbia Wildfires, 8/8/2017

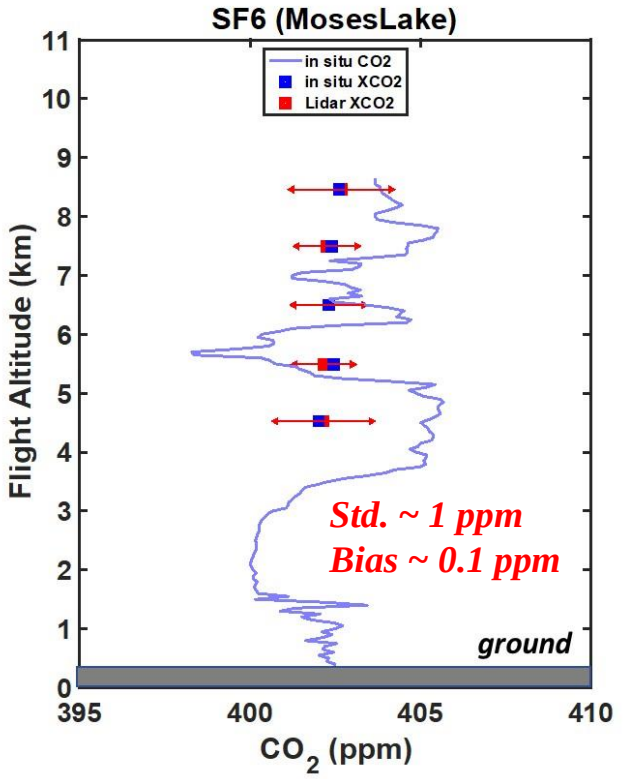


Histogram of XCO_2 *in red circle*



1-s retrievals, ~200-m horizontal resolution

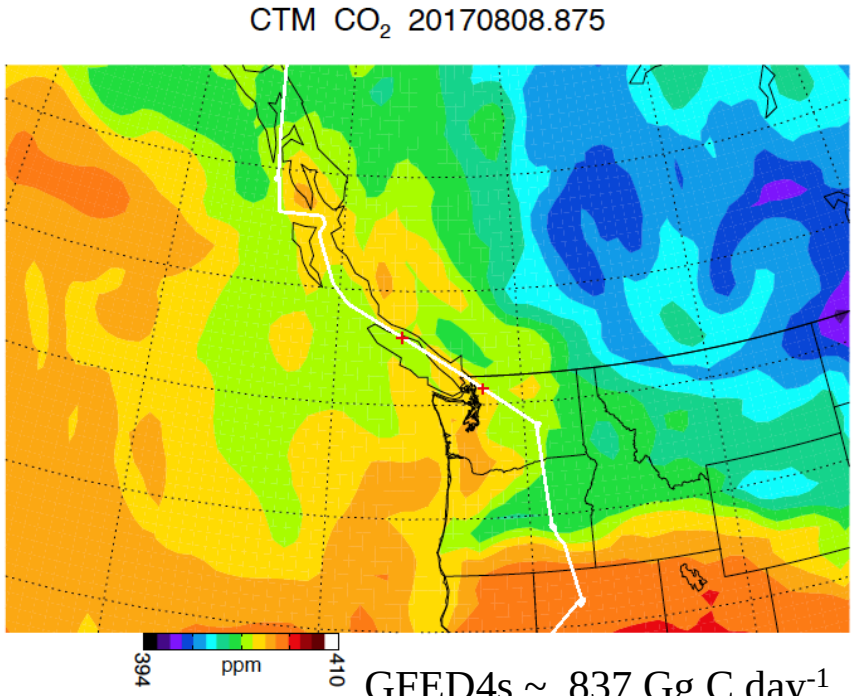
Lidar XCO_2 validation against in situ data



Median Lidar XCO_2 ~ 406 ppm
Background in situ XCO_2 ~ 402 ppm
Enhancement ~ 4 ppm, very significant!

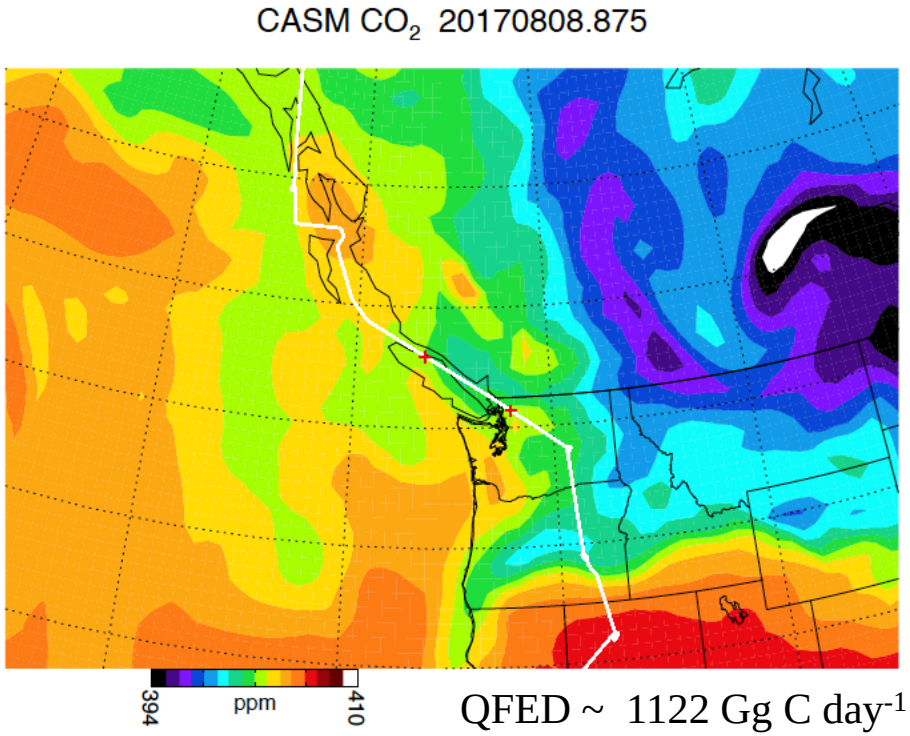
Simulations of XCO_2 below aircraft from the Goddard global models

the Parameterized Chemical Transport Model (Kawa et al., 2004)



GFED4s ~ 837 Gg C day^{-1}

the GEOS GCM Low-order Flux Inversion (Weir et al., 2020)



QFED ~ 1122 Gg C day^{-1}

Modeled XCO_2 enhancements near Vancouver Island are not significant, suggesting a large underestimate of CO_2 emissions in both GFED and QFED

Summary

- ✓ **The 2017 ASCENDS/ABoVE airborne science campaign was unprecedented and provided us a great opportunity to demonstrate the robustness of the instrument performance and retrieval data quality with this active remote sensing approach**
- ✓ **Lidar XCO_2 data has been released to public**
  - **https://www-air.larc.nasa.gov/cgi-bin/ArcView/ascends.2017**
- ✓ **The campaign also provided us an opportunity to demonstrate lidar measurement capability in smoke plumes from wildfires**
- ✓ **CO_2 lidar measured ~ 4 ppm XCO_2 enhancements from the record-breaking wildfires in British Columbia, Canada over Vancouver Island at flight altitude of ~9 km on August 8, 2017, which was twice more than PTCM model simulated based on CO_2 emissions from GFED and QFED**
- ✓ **The results indicate that a future spaceborne XCO_2 lidar mission with this capability will better constraint fire emission factors and improve fire emission modeling.**