In situ ammonia measurements in wildfire and agricultural fire plumes in the US

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Abstract

Emissions of trace gases and particles from fires have a major impact on climate, visibility, air quality, and public health. Biomass burning emissions include reactive nitrogen gases and , in particular, also ammonia (NH_3). NH_3 is a short-lived gas that acts as precursor for secondary aerosols formed in the downwind plume. Herein, we will present initial results from airborne NH_3 measurements, which we made in wildfire and agricultural fire plumes during the NASA-NOAA FIREX-AQ campaign.

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NH_3 measurements by PTR-ToF-MS

FIREX-AQ

The Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) mission in summer 2019 sampled plumes from wildfires and agricultural fires over the continental US.

FIREX-AQ was a joint mission by NASA and NOAA, with the NASA DC-8 Airborne Science Laboratory being the main sampling platform.

The DC-8 research aircraft was based in Boise (Idaho) and Salina (Kansas) during the summer fire season. During the campaign, 14 large wildfires and roughly 90 small agricultural fires were sampled.

Ammonia

NH_3 is a basic gas that rapidly reacts with acidic constituents in the fire plume to form secondary inorganic particles (*e.g.*, ammonium nitrate particles). This process is still poorly constrained.

Optimized PTR-ToF-MS instrument

We used a modified proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS) instrument to measure NH_3 at a frequency of 1Hz.

The following instrument modifications were made to improve the instrumental time response:

i) a high inlet flow (~60 slpm) through a heated (60°C) PFA inlet tube was used for sampling,

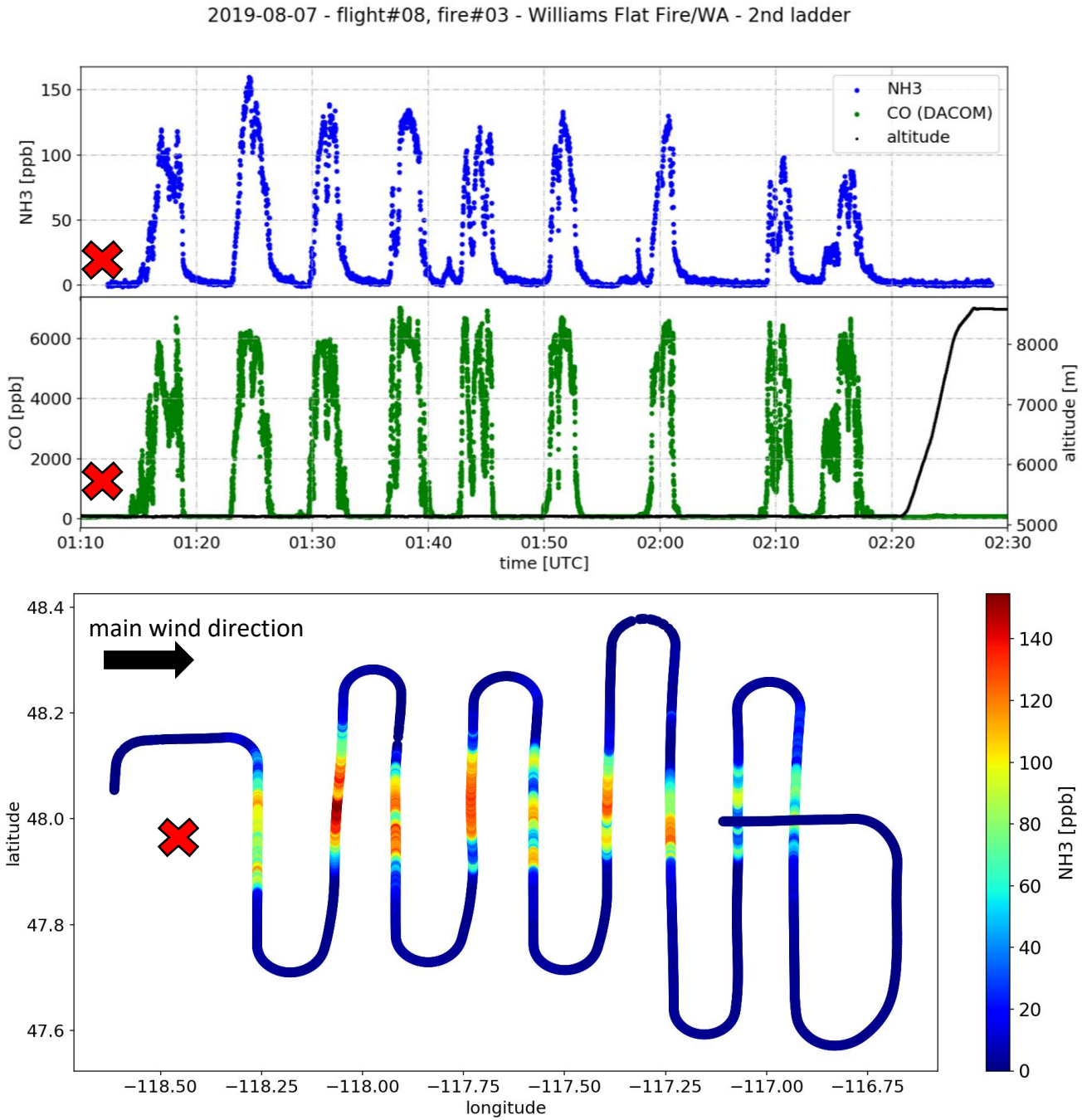
ii) the drift tube was surface-passivated and heated to 120°C,

iii) the subsampling flow into the drift tube was increased to 130 sccm.

With all optimizations in place, the instrumental response time was less than 3 seconds.

NH_3 in wildfire plumes

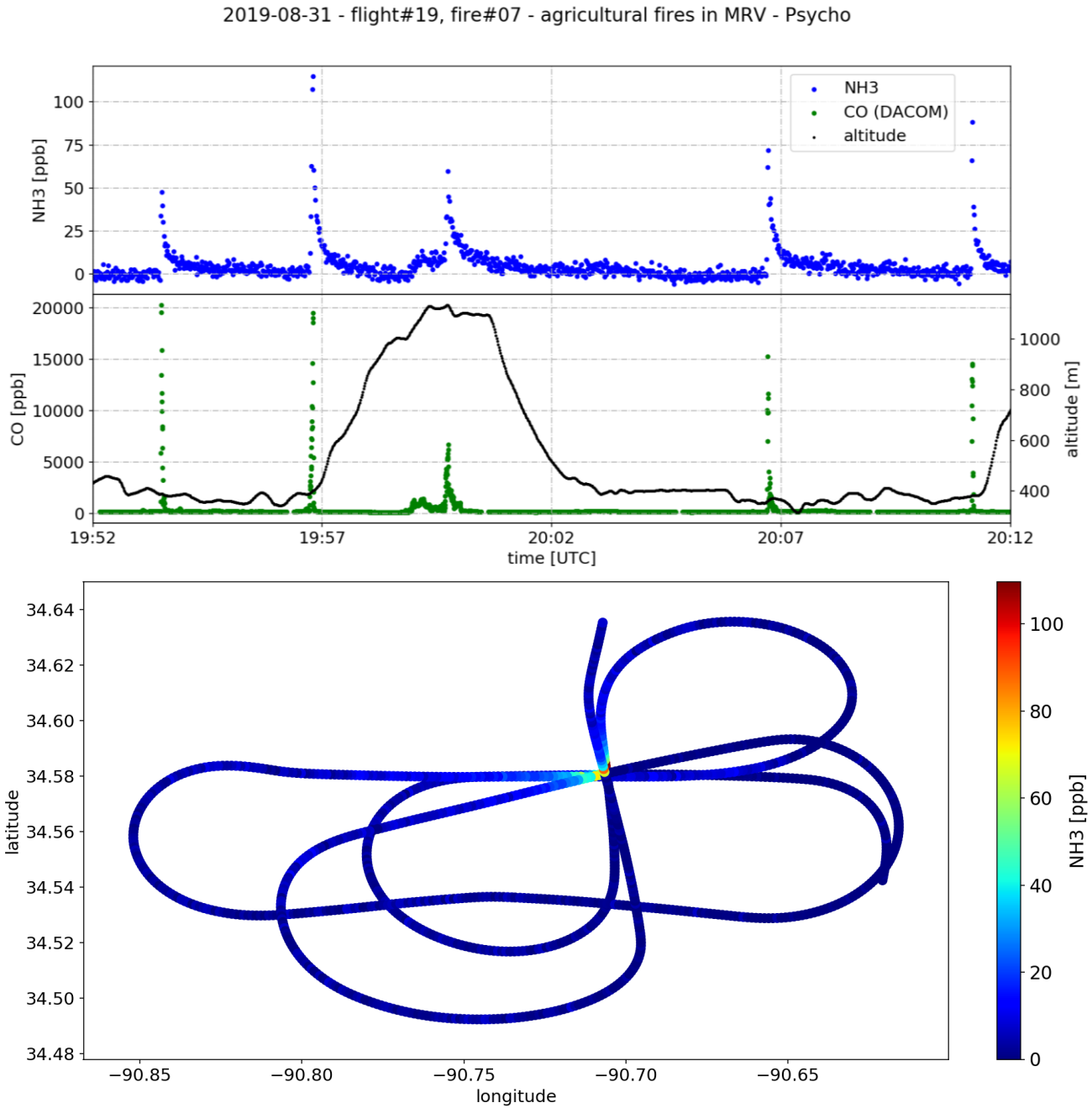
- We are showing exemplary NH_3 data (time series and lat/lon plot) as measured downwind the Williams Flat Fire in the state of Washington on 7 August 2019.
- The DC-8 aircraft typically flew meandering manoeuvres for characterizing the emissions close to the source (marked with a red cross) and for studying the evolution of air pollutants in the downwind plume.
- High levels of NH_3 (up to 160 ppb) were observed near the fire, and mixing ratios slowly decreased further downwind. The NH_3 trend correlates with the biomass burning tracer CO.



CO from Glenn Diskin (DACOM group, NASA LaRC)

NH_3 in agricultural fire plumes

- We are showing exemplary NH_3 data as measured in proximity of an agricultural fire in the Mississippi River Valley on 31 August 2019.
- The DC-8 aircraft typically sampled the emissions from an agricultural fire multiple times. A large number of agricultural fires burning on different fuel types (*e.g.*, rice, straw, grass, stumps) and under different conditions were investigated.
- NH_3 mixing ratios again exceeded 100 ppb, indicating that small agricultural fires are also strong NH_3 emitters.
- Due to the short burn time, the NH_3 from agricultural fires is not transported far from the source.



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NH_3 in fire plumes

Conclusion and Outlook

We collected a large set of NH_3 data in plumes from different fires (wildfires, agricultural fires, and prescribed burns) that burned under different conditions. We found that NH_3 is emitted in large quantities. The next steps in our analysis are to derive NH_3 emission factors and to investigate the fate of NH_3 in the downwind plume.

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