The COW-Gas (Cal pOly Winter Gas) Campaign: Continuous Mobile and Stationary Methane Monitoring by In Situ and Column Measurements at the Cal Poly Research Dairy

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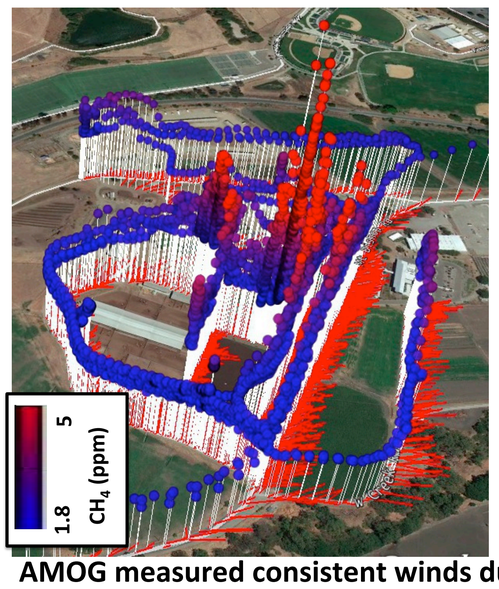
The Cal Poly Research Dairy, is located on the California Polytechnic State University campus in San Luis Obispo, California, with 300 head during the campaign. It is well-isolated from other dairies and other significant CH_4 sources. Feed barns are flushed four times a day into a waste lagoon with an overflow lagoon to the east.

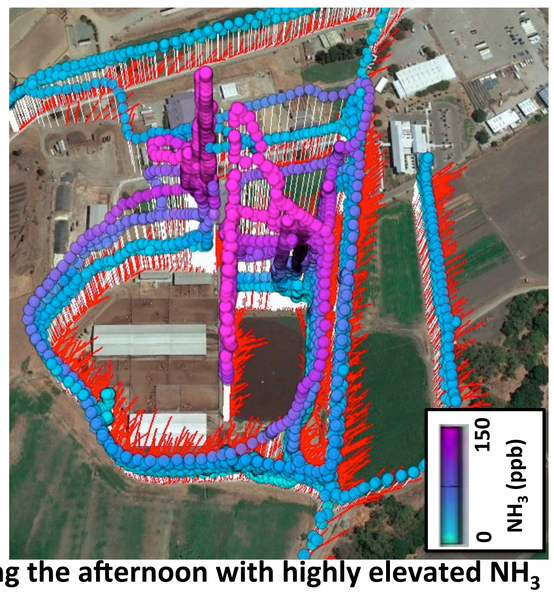
Experimental Methods

In situ **surface data were collected by the AMOG (Automobile Greenhouse Gas) Surveyor Vehicle (BRI) with several Off-Axis Integrated Cavity Output Spectroscopy instruments (LGR) that measured CH_4, CO_2, H_2O, NH_3, and NO_2 . A CO_2 isotope instrument (LGR) was installed in the MACLab Recreational Vehicle. Airborne *in situ* data were collected by the the AlphaJet aircraft (ARC) with a Cavity Ring Down Spectrometer (Picarro) for CH_4, CO_2, and H_2O. Column measurements were made by the Aerospace Corp. RamVan Mobile Laboratory with a zenith viewing FTIR Spectrometer for CH_4 and NH_3. Additional CH_4 column measurements were made by the Miniaturized--Laser Heterodyne Radiometer (Mini-LHR) (developed by GSFC).**

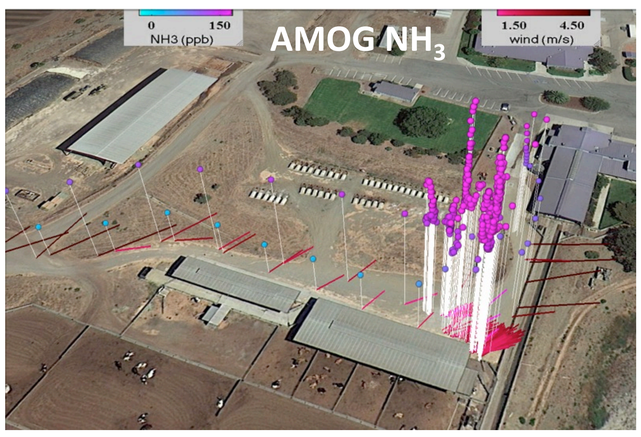
AMOG CH4



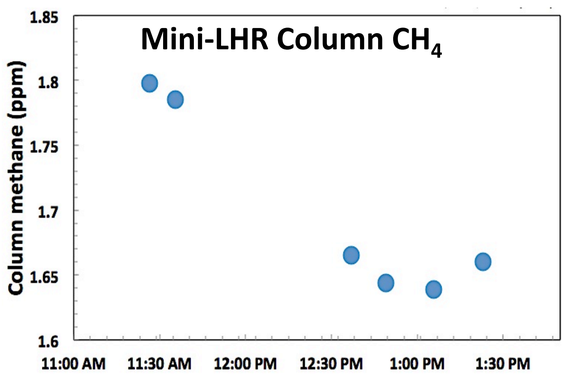
AMOG NH3



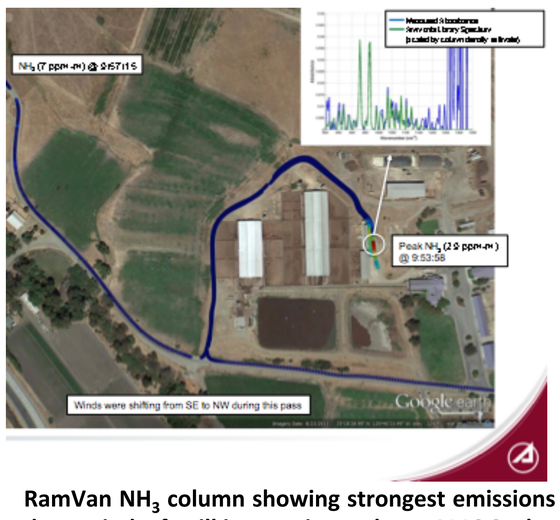
AMOG measured consistent winds during the afternoon with highly elevated NH_3 and CH_4 from the feed barns and waste lagoon (aerator), and a strong NH_3 plume from downwind of the milking barn.



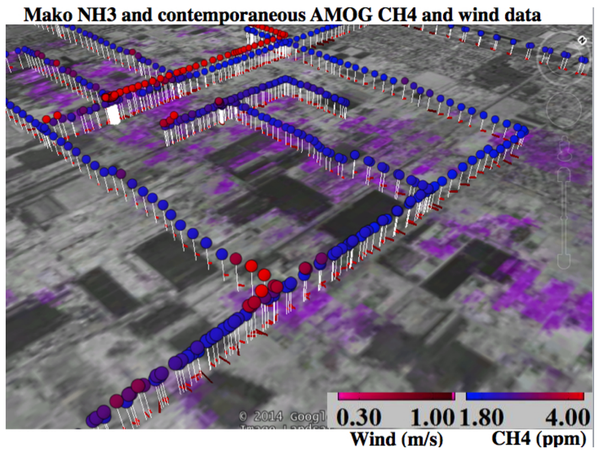
The strongest NH3 was observed near the milking station by AMOG (and RamVan), where high methane values also were observed. The difficulty of *in situ* NH_3 measurements is highlighted by the "latency" of the NH_3 signal on the arrival/departure transits due to its molecular "stickiness."



Preliminary **(Cloud Uncorrected, uncalibrated) mini-LHR CH_4 column during COWGAS showing a steady decrease in emission strength consistent with decreasing emissions after a noted mid-day waste flushing.**

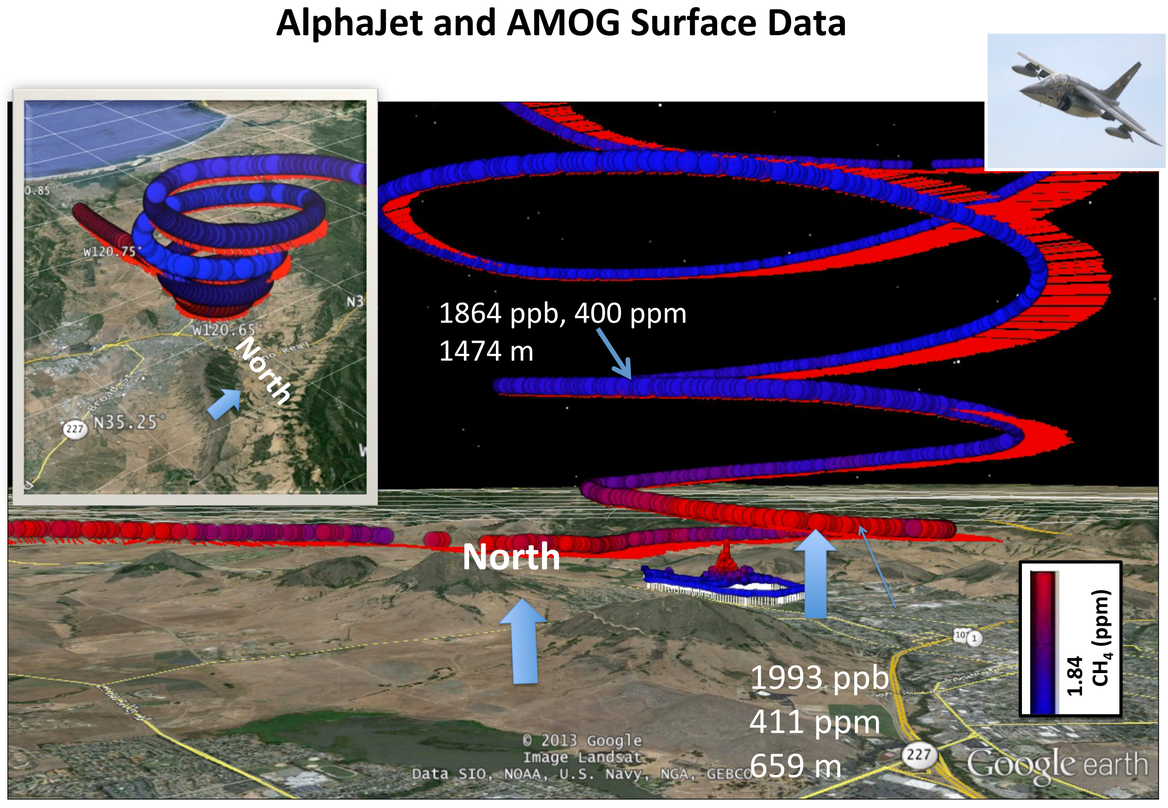


RamVan NH_3 column showing strongest emissions downwind of milking station, where AMOG also saw strongest in situ NH_3.



Chino Dairy Complex, Los Angeles Basin, showing AMOG CH_4 and airborne TIR-derived column NH_3 by the Mako imaging spectrometer (Aerospace Corp.)

AlphaJet and AMOG Surface Data



AlphaJet captures by airborne *in situ* measurements the dynamics of the methane plume, several kilometers downwind (onboard measure) of the Cal Poly Dairy, also mapping the boundary layer at ~900 m height. Surface winds were from Northwest.

Findings

In Situ **CH_4 and NH_3 plumes were successfully mapped by AMOG and were spatially segregated on a sub-dairy scale.**

In Situ **CH_4 and NH_3 plume ratios varied spatially with distinct signatures related to dairy operations.**

The waste lagoon was a major emission source with its strongest emissions focused on the aerator.

In Situ **NH_3 and CH_4 strong plumes correlated with strong mobile NH_3 column measurements from RamVan.**

The CH_4 plume from the Cal Poly Dairy was mapped by the Alphajet (NASA ARC) during multiple transects ~5-km downwind.

A very strong column CH_4 plume was observed by the Mini-LHR (NASA GSFC) ~250 m downwind from the dairy feed barns and waste lagoon.

COWGAS demonstrated that the controlled, accessible, and well described environment of a research dairy can greatly aid in the interpretation of commercial dairy CH_4 and NH_3 emission data, linking dairy operations and emissions, enabling smarter dairy operations.

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