Comparison of Methane (CH_4) Monitoring Methods at GEOSummit

D.P. Colegrove[1], D. Helmig[1], E. Dlugokencky[2], G. Dutton[2], J. Hueber[1], B. Blanchard[1]

[1]Institute of Arctic and Alpine Research (INSTAAR), University of Colorado Boulder, Boulder, Colorado, 80309
[2]NOAA Earth System Research Laboratory, Global Monitoring Division, Boulder, Colorado, 80305

INTRODUCTION

Our understanding of the global methane (CH_4) budget continues to have large uncertainties as methane is affected by both natural and anthropogenic sources that vary spatially and with time. Arctic observations of atmospheric methane are considered a critical component in deciphering the global methane budget and for investigating the potential for increasing methane sources in the Arctic from permafrost thawing. This study compares three independent atmospheric methane monitoring projects at the Greenland Environmental Observatory, Summit Station (GEOSummit), to determine consistency between measurements and for evaluation of research applications from these parallel data sets. The three methods are 1) in-situ gas chromatography-flame ionization detection (GC-FID) with 2-3 hour time resolution conducted by INSTAAR, 2) in-situ GC-with electron capture detection (ECD) with 1 hour time resolution on the NOAA GMD CATS GC, and 3) GC-FID analysis of bi-weekly whole air samples collected within the NOAA Cooperative Global Air Sampling Network after shipment to Boulder, CO.

MEASUREMENT METHODS

Whole air samples are collected weekly at GEOSummit in 2.5 liter glass flasks; each pair of flasks is filled in less than 10 minutes. During flight periods, the flasks are then shipped to NOAA in Boulder where GC-FID analysis of methane takes place. The two in-situ methods for methane monitoring are located in the Temporary Atmospheric Watch Observatory (TAWO) facility at GEOSummit. The INSTAAR GC-FID takes five samples in a row, eight times per day. The system uses a loop injection and a packed column with FID detection. The NOAA GMD CATS GC samples each hour and uses ECD to quantify methane.

Figure 1: An example of NOAA air sampling, using a case holding two flasks which are pressurized with air. A long rod holds the collection tubing above ground.

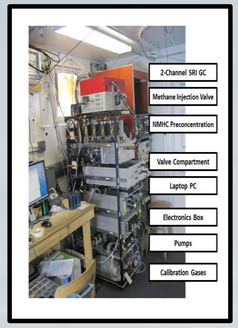

Figure 2: The INSTAAR in-situ GC instrument and sampling inlet inside TAWO at GEOSUmmit.

Figure 3: The NOAA GMD CATS in-situ GC with electron capture detection.

ANALYSIS AND RESULTS

Monthly medians and averages were calculated for each data set to compare agreement over time. All three measurement methods agree by -0.3 ± 2.8 nmol mol^{-1} (mean±1σ) (Table 1). The Theil-Sen estimator was used to calculate trends in each data set, with the average methane trend being 10.57 nmol mol^{-1} yr^{-1}. To compare the two in-situ methods (NOAA_CATS, INSTAAR_ARL), sample collection times were matched to those within 2 hours or less of each other. The average agreement between these two data sets were 0.68 ± 8.97 nmol mol^{-1} (mean±1σ) and their trends within 0.13 nmol mol^{-1} yr^{-1}.

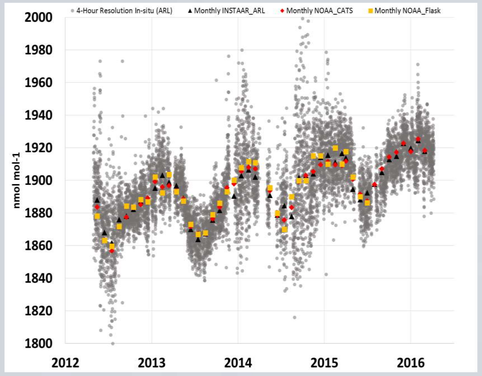

Figure 4: Time series of monthly medians by three measurement methods, underlain by 4-hour resolution in-situ INSTAAR data.

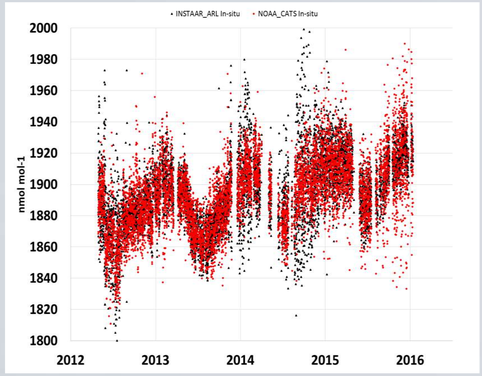

Figure 5: INSTAAR and NOAA_CATS in-situ data matched to within 2 hours or less of each other.

Table 1: Yearly means and medians of methane for each data set and calculated trends.

	Mean/Median CH_4 2013 nmol mol^{-1}	Mean/Median CH_4 2014 nmol mol^{-1}	Mean/Median CH_4 2015* nmol mol^{-1} *Flask to 2015.7	Trend 2012.5-2016.2* nmol mol^{-1} yr^{-1} *Flask to 2015.7
Flask	1887.10 / 1889.93	1899.62 / 1900.00	1905.19 / 1910.00	10.46 nmol mol^{-1} yr^{-1}
CATS In-situ	1886.21 / 1891.22	1897.30 / 1903.09	1906.73 / 1909.35	10.70 nmol mol^{-1} yr^{-1}
INSTAAR In-situ	1885.66 / 1889.91	1897.02 / 1902.23	1907.17 / 1911.97	10.57 nmol mol^{-1} yr^{-1}

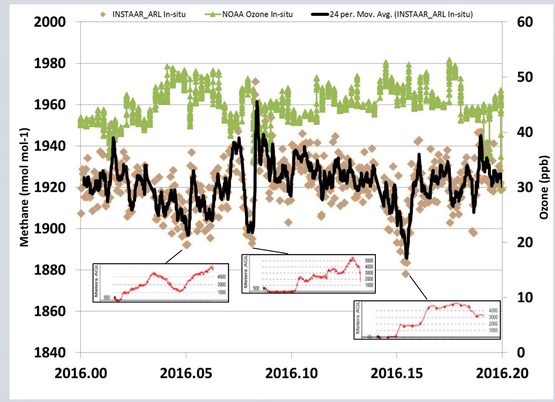

Figure 6: Early 2016 INSTAAR_ARL 4-hour resolution in-situ data, portraying variability in methane mixing ratios of 30-40 nmol mol^{-1} from mean seasonal values in transport events. Hourly NOAA in-situ ozone (O_3) data and back trajectory elevation profiles are also plotted to highlight instances of lower methane and elevated ozone.

TRANSPORT EVENTS

While flask sampling provides snapshots of atmospheric conditions, in-situ monitoring provides high time resolution data that show enhancements and reductions in methane on the order of 30-40 nmol mol^{-1} from mean seasonal methane levels, illustrating the influence of transport of air from different source regions with elevated/depleted methane to GEOSummit. Two week back trajectories of air masses were run to investigate these events. Periods of low methane were observed when air masses on their way to GEOSummit were >4000 meters above ground level (3200 meters at GEOSummit). These observations of lower methane and heightened ozone (O_3) (Figure 5), are evidence of stratospheric intrusion events. These ozone/methane anti-correlations demonstrate that the in-situ data have the quality and resolution to investigate transport events and sources and sinks for elevated/depleted methane at GEOSummit. Future research will focus on investigating periods with enhanced methane with the goal to characterize contributions and changes of Arctic methane sources.

ACKNOWLEDGMENTS

This research was funded by the National Science Foundation Arctic Observing Network (AON) grant # 1108391. The authors gratefully acknowledge the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model. Thank you to the GEOSummit Science Techs and CH2M Hill for their support on site.