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# ARM West Antarctic Radiation Experiment (AWARE) Fourier Transform Infrared Filter Sampling Systems Field Campaign Report

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September 2017; revised June 2019

ARM
CLIMATE RESEARCH FACILITY

## DISCLAIMER

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# ARM West Antarctic Radiation Experiment (AWARE) Fourier Transform Infrared Filter Sampling Systems Field Campaign Report

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# Acronyms and Abbreviations

| | |
|---|---|
| ARM | Atmospheric Radiation Measurement |
| AWARE | ARM West Antarctic Experiment |
| C | Celsius |
| CCN | cloud condensation nuclei |
| cm | centimeter |
| DOE | U.S. Department of Energy |
| DTGS | deuterated triglycine sulfate |
| FTIR | Fourier Transform Infrared |
| IR | infrared |
| m | meter |
| mm | millimeter |
| OM | organic mass |
| SIO | Scripps Institution of Oceanography |
| UCSD | University of California, San Diego |
| WAIS | West Antarctic Ice Shelf |

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# Figures

# 1.0 Summary

West Antarctica is one of the most rapidly warming regions in the world (*Bromwich et al.* 2013; *Steig et al.* 2009) and the warming can directly cause sea level rise (*King et al.* 2012). In situ measurements are needed to examine and quantify the meteorological conditions in order to precisely understand the effect of warm air and clouds on the West Antarctic Ice Shelf (WAIS). The U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) West Antarctic Radiation Experiment (AWARE) is designed to collect measurements with advanced cloud and aerosol instrumentation at West Antarctica.

The Fourier Transform Infrared (FTIR) filter sampling systems were deployed as part of the ARM West Antarctic Radiation Experiment (AWARE) campaign to measure organic aerosol characteristics at McMurdo Station. As a coastal station at the southern end of Ross Island, McMurdo Station has a meteorological relationship with the WAIS via circulation patterns in the Ross and Amundsen Seas. Thirteen months of continuous observations of aerosol particle composition extended from December 2016 to January 2017. Filter samples were collected at McMurdo on pre-scanned Teflon filters (Teflon, Pall Inc., 37mm diameter) behind PM1 sharp-cut cyclones (SCC2.229 PM1, BGI Inc). Samples were collected each week with approximately 50-90 $m^3$ air filtered per sample. Samples were frozen and transported below 0℃ to the Scripps laboratory for FTIR spectroscopy analysis. A Bruker Tensor 27 FTIR spectrometer with a deuterated triglycine sulfate (DTGS) detector (Bruker, Waltham, MA) was used to scan the filters both before and after sampling. An automated algorithm (*Takahama et al.* 2013) was applied to quantify the mass of the organic functional groups. Four groups (alkane, amine, alcohol, and carboxylic acid) had absorption peaks above the limits of quantification, and the sum of the mass of the four functional groups is the quantified organic mass (OM). Absorption peaks for other groups (organosulfate, organonitrate, aromatic, and alkene group) were identified and fit but they were below the limit of quantification for more than 90% of the samples and are excluded. Similar FTIR measurements has been conducted in dozens of field campaigns around the world, including arctic regions (*Russell et al.* 2011).

Local particle emissions from airports, diesel generators, and local transportation affected all aerosol measurements at various times during this project. The ARM Aerosol Measurement Science Group is aware of the issue and is working to develop algorithms to flag the data. This influence is evident in the FTIR measurements as it is associated with specific chemical signatures.

DOE and the National Science Foundation, which manages the U.S. Antarctic Program, supported this collaboration for AWARE.

# 2.0 Results

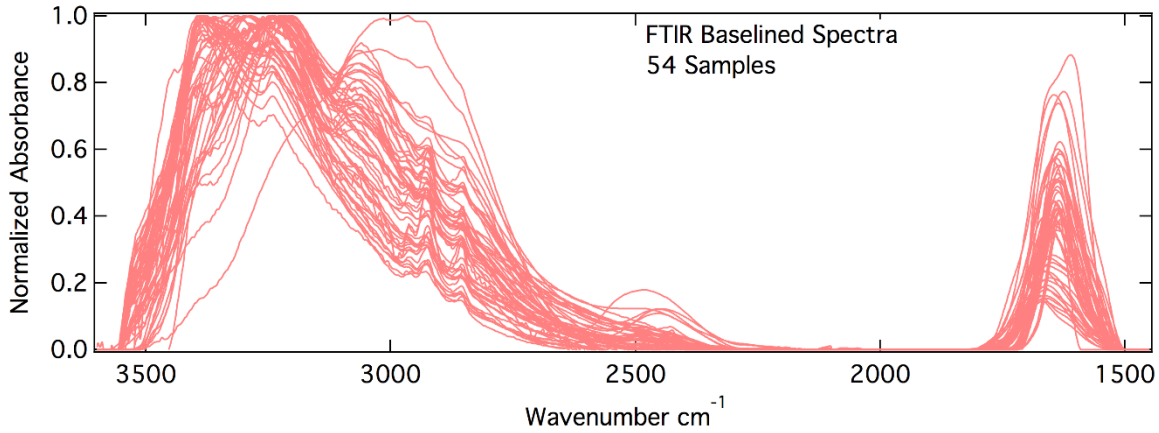


**Figure 1**. Baselined FTIR spectra of 54 samples collected during AWARE.

The FTIR spectra of the 54 filters were baselined using the algorithm described by Takahama et. al. (2013) (Figure 1). Absorption peaks for alkane, amine, alcohol, and carboxylic acid groups are clear in most of the spectra. Non-acid carbonyl, a functional group identifiable and quantifiable in other field campaigns (*Russell et al.* 2011), including at Arctic sites (*Frossard et al.* 2011, *Leaitch et al.* 2017), was not present during the AWARE campaign as there was no absorption in the ~1720 $cm^{-1}$ carbonyl region. Carbonyl groups were associated with biogenic organic aerosol from terrestrial biogenic emissions [*Corrigan et al.* 2013, *Schwartz et al.* 2010, *Takahama et al.* 2011) as well as biomass burning (*Corrigan et al.* 2013, *Hawkins and Russell* 2010). The lack of carbonyl groups in Antarctica is consistent with low terrestrial biogenic emissions and lack of long-range transported emissions from other continents.

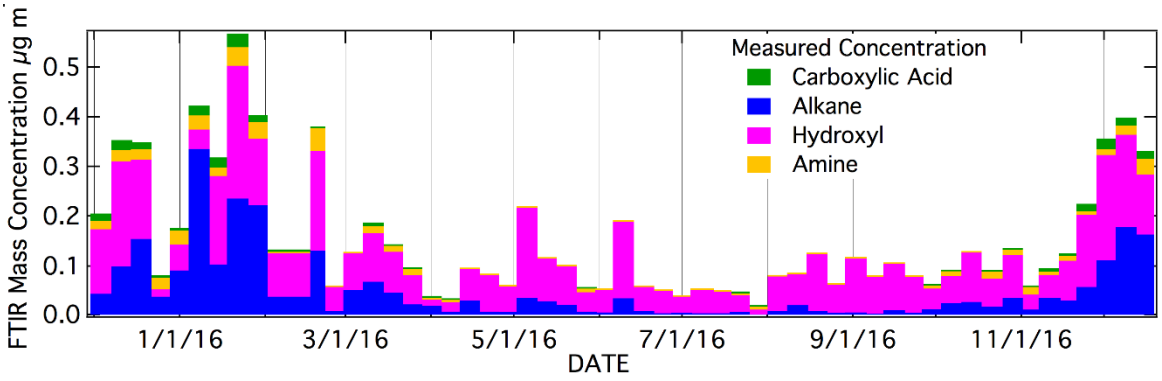


**Figure 2**. FTIR functional group concentrations for AWARE samples.

Figure 2 shows the mass concentration of each functional group quantified from the infrared (IR) spectra. Mass concentrations were high during the two summers (0.16 µg $m^{-3}$, December 2015 to March 2016 and October 2016 to December 2017) and decreased to background levels in the winter (0.04 µg $m^{-3}$, April to September 2016). Hydroxyl and alkane are the two functional groups that had consistently high fractions of organic mass throughout the year while carboxylic acid and amine are more abundant in the summer.

# 3.0 Publications and References

The measurements are posted and available at http://www.arm.gov/research/campaigns/amf2015awarefil/. In addition, they are curated at the UCSD Digital Archives.

## 3.1 Paper in Preparation

Summertime Maximum of Organic Functional Group Concentrations and High Organic Nitrogen from Ocean Biogenic Aerosols at Coastal West Antarctica during AWARE, Jun Liu, Jeremy Dedrick, Lynn M Russell, Gunnar Senum, Janek Uin, Chongai Kuang, Stephen R. Springston, and Dan Lubin, manuscript in preparation.

## 3.2 Planned Presentations

Summertime Maximum of Organic Functional Group Concentrations and High Organic Nitrogen from Ocean Biogenic Aerosols at Coastal West Antarctica during AWARE, Jun Liu, Jeremy Dedrick, Lynn Russell, Andy Vogelmann, Gunnar Senum, Stephen Springston, Chongai Kuang, Janek Uin, Dan Lubin, and Anne Jefferson, Poster, American Association for Aerosol Research annual meeting, Raleigh NC, October 2017.

Summertime Maximum of Organic Functional Group Concentrations and High Organic Nitrogen from Ocean Biogenic Aerosols at Coastal West Antarctica during AWARE, Jun Liu, Jeremy Dedrick, Lynn M Russell, Gunnar Senum, Janek Uin, Chongai Kuang, Stephen R. Springston, and Dan Lubin, Session A046: Gas-phase and Aerosol Processes and Characteristics in the Remote Troposphere, American Geophysical Union Fall Meeting, New Orleans LA, December 2017.

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Takahama, S, RE Schwartz, LM Russell, AM Macdonald, S Sharma, and WR Leaitch. 2011. "Organic functional groups in aerosol particles from burning and non-burning forest emissions at a high-elevation mountain site." *Atmospheric Chemistry and Physics* 11(13): 6367-6386, doi:10.5194/acp-11-6367-2011.

# Appendix A

# Revision: June 2019

## A.1 Summary

With support from the National Science Foundation AWARE proposal, we collected PM1 samples at McMurdo Station as part of ARM Field Campaign AFC06793, and we analyzed these filters by FTIR and XRF. To do this, we installed a filter sampling system in the AMF aerosol-sampling van and provided training on the operation of the system for the ARM technicians and scientists. One filter was collected each week. We pre-loaded 40 filter holders, which were shipped back to us to refill as needed. The filters were stored cold after sampling and in transit back. We used the log flow rates to calculate air volume for each filter. We calculated and reported concentrations of organic mass and organic functional groups.

## A.2 Results

We used the measurements from the filters to complete an analysis of AWARE seasonal variability of submicron OM, particle number, and cloud condensation nuclei (CCN) concentrations. Local anthropogenic emissions, a large source of contamination at this particular site, were found to be non- hygroscopic and had little contribution to the CCN concentrations. Episodes of extreme local contamination can be identified and omitted from climatological and source partitioning analysis. Natural sources included marine sea spray and seabird emission, and comprised 56% of OM in summer but only 3% in winter.

## A.3 Publications and References

This work has been published in *Atmospheric Chemistry and Physics* (Liu et al. 2018), and is part of Jun Liu's PhD thesis (successfully defended in February 2018). The data are archived and accessible at https://doi.org/10.6075/J0WM1BKV. A summary of these results was also used for comparison to arctic conditions in the AWARE overview paper (Lubin et al. 2019).

Liu, J, J Dedrick, LM Russell, GI Senum, J.Uin, C Kuang, SR Springston, WR Leaitch, AC Aiken, and D Lubin. 2018. "High summertime aerosol organic functional group concentrations from marine and seabird sources at Ross Island, Antarctica, during AWARE." *Atmospheric Chemistry and Physics* 18(12): 8571–8587, doi:10.5194/acp-18-8571-2018.

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## A.4 Lessons Learned

Since local emissions from McMurdo Station activities were a large source of contamination at this particular site, we would have preferred to set up conditional sampling to eliminate high-condensation-nuclei periods from filter collection. This would have required additional support from ARM personnel to feed the condensation nuclei measurements to our laptop, which could then be used to cut off the pump during contaminated times.


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