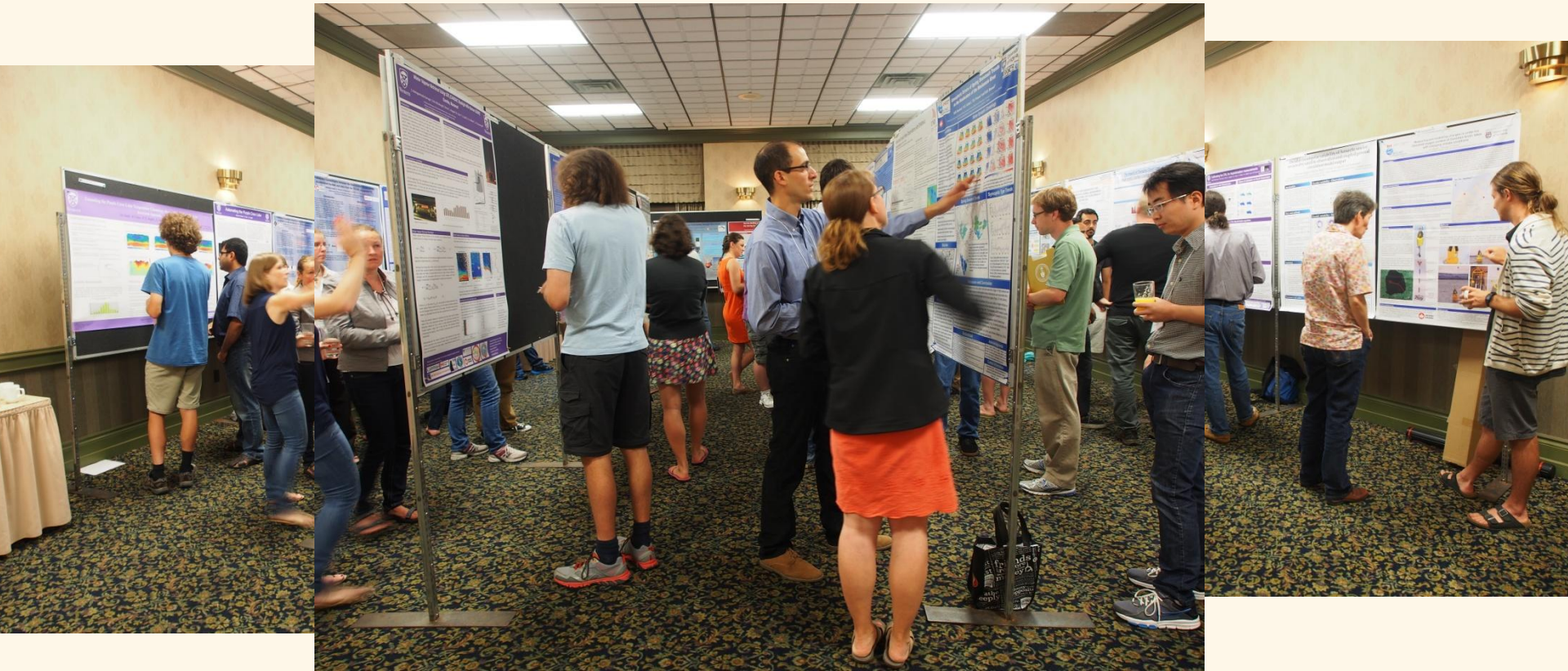


# 2014 Connaught Summer Institute in Arctic Science




***Poster session winners***

# **MSc Winners**

# Winner Catherine Phillips-Smith (U of Toronto)

## Identifying the Origins of Trace Metals in Particulate Matter in the Athabasca Oil Sands Region

Authors: Catherine Phillips-Smith<sup>1</sup>, C.H. Jeong<sup>1</sup>, R. Healy<sup>1</sup>, G.J. Evans<sup>1</sup>  
<sup>1</sup> Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto, Toronto, Ontario, Canada



### Background

PM<sub>2.5</sub> is particulate matter that is smaller than 2.5 µm in diameter. These particles are a mixture of primary and secondary aerosols and are linked to climate and health impacts. Metals within PM<sub>2.5</sub> are related to their source and some are associated with health risks (Bzdek et al.).

Metal	Source	Risks
Calcium	Crustal	
Lead	Anthropogenic	Toxic
Arsenic	Anthropogenic	Toxic
Vanadium	Anthropogenic	Lung Irritant
Strontium	Anthropogenic	Toxic
Copper	Anthropogenic/Crustal	Lung Irritant

### Objectives

Identify and quantify metals in particles emitted from oil sands activities  
 Identify the pollutant mixture associated with oil sands activities

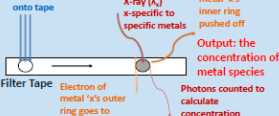
### Methodology

Instrument  
 Xact625 (Cooper Environmental)

An X-ray fluorescence device that takes hourly measurements of 23 aerosol metals in PM<sub>2.5</sub>:

S, Si, Rb, As, Ni, Pb, Ca, Cd, Se, Mn, Ba, K, Br, Ti, V, Cr, Fe, Co, Cu, Zn, Ag, Sn, Sr

Particles pumped onto tape



Filter Tape

### Location

Fort McKay, Athabasca Region, Alberta  
 Wood Buffalo Environmental Association Site AMS 13: Fort McKay South

### Sampling Period

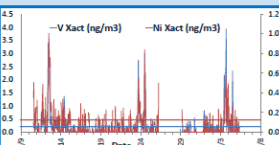
August 10 - September 5, 2013

### Data Output

Quality Control and Analysis

- Daily blank check to remove base line
- Comparison to metal standards and daily filter samples
- Only metals that were over 10% above the minimum detection limit were included for analysis:

S, Si, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Se, Br, Sr

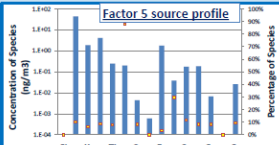
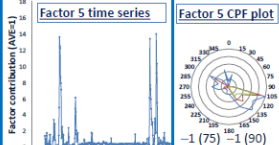
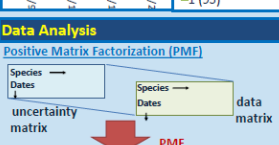


### Results

Following PMF and CPF analysis 5 factors were found and were compared to other chemical species such as SO<sub>2</sub> and NO<sub>2</sub>. This helps to enable source identification. The sources identified are:

- Elemental Sulphur
- Soil
- Road Dust
- Mining Activities
- Oil Burning

Source	Defining Metals	Correlative Aerosol
sulphur	S	SO <sub>2</sub>
Soil	Si, K, Fe, Ca, Mn	NO <sub>2</sub> , NO <sub>x</sub>
Road dust	Mn, Fe, Ca	NO <sub>2</sub> , NO <sub>x</sub>
Mining	Cu, K, Ca	
Oil	S, V	SO <sub>2</sub>

### Data Analysis

Positive Matrix Factorization (PMF)

Species → data matrix  
 Dates → data matrix

uncertainty matrix + PMF = Factors → F matrix, Dates → G matrix

$X = GF + E$

E = residuals, G = factor matrix, X = data matrix, F = species matrix

The goal of PMF is to separate the chemical species into factors, while minimizing the "Q" factor, as defined by the following equation (Jeong et al.):

$$Q = \sum_{i=1}^n \sum_{j=1}^m \frac{a_{ij}^2}{\sigma_{ij}^2}$$

σ = uncertainty matrix  
 Conditional Probability Function (CPF)

Taking the wind direction of a mass concentration over time allows the source direction to be found:

$$CPF = \frac{n_{\theta}}{n_{\theta} + n_{\theta+90}}$$

n<sub>θ</sub> is the factor contribution, and n<sub>θ+90</sub> is the number of times a wind came from one direction

The higher the CPF value, the more likely it comes from that direction (Wang et al.).

### Conclusions

Particulate metals in the oil sands have been quantified using an Xact625 XRF device during the summer of 2013

These metals come from 5 sources; elemental sulphur, soil, road dust, mining activities and oil combustion.



### Future Work

#### Oil Sands Campaign

- Compare campaign results to those of the 3 year off-line filter campaign results
- Compare results to those observed in literature
- Locate the sources of the 5 factors
- Compare the factor time series other chemical species

#### 2014-2015 Arctic Campaign

- In Alert, Nunavut, each winter there are an estimated 66 snowfalls between October and May (Climatemps)
- While snow cores have been previously studied, this study will capture freshly fallen snow on a snow table.
- There will be 5 samples taken per snow fall for analysis of the following:
  - Elemental Carbon/Organic Carbon
  - Metals
  - Size, chemical composition (ATOFMS)
  - Soot (SP2)
  - Black Carbon containing particles (SP-AMS)
- Snow samples will be shipped in insulated containers from Alert to the University of Toronto, Ontario





### References

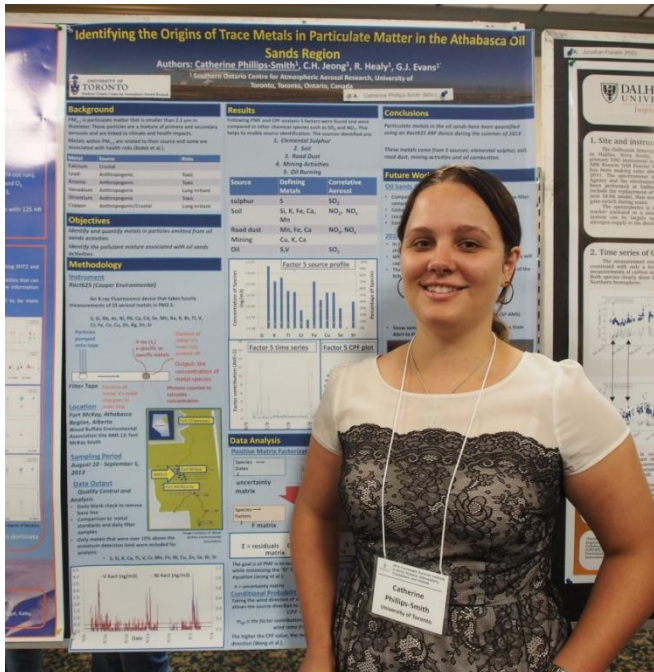
- Jeong et al., 2011. Receptor model based identification of PM<sub>2.5</sub> sources in Canadian cities. *Atmospheric Pollution Research* 2, 158-171.
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- Wang et al., 2013. Effect of the shutdown of a large coal-fired power plant on ambient mercury species. *Chemosphere*, in press.
- 2009-2014, Climate of Alert, Nunavut, Canada Average Weather. Available: <http://www.alert.climatemps.com/>

### Acknowledgements

We would like to thank Ewa Dabek-Zlotorzynska, Valbona Celio and Jeffery Brook from Environment Canada.



We would also like to thank members of SOCAAR for all their help and support



“Identifying the Origins of Trace Metals in Particulate Matter in the Athabasca Oil Sands Region”

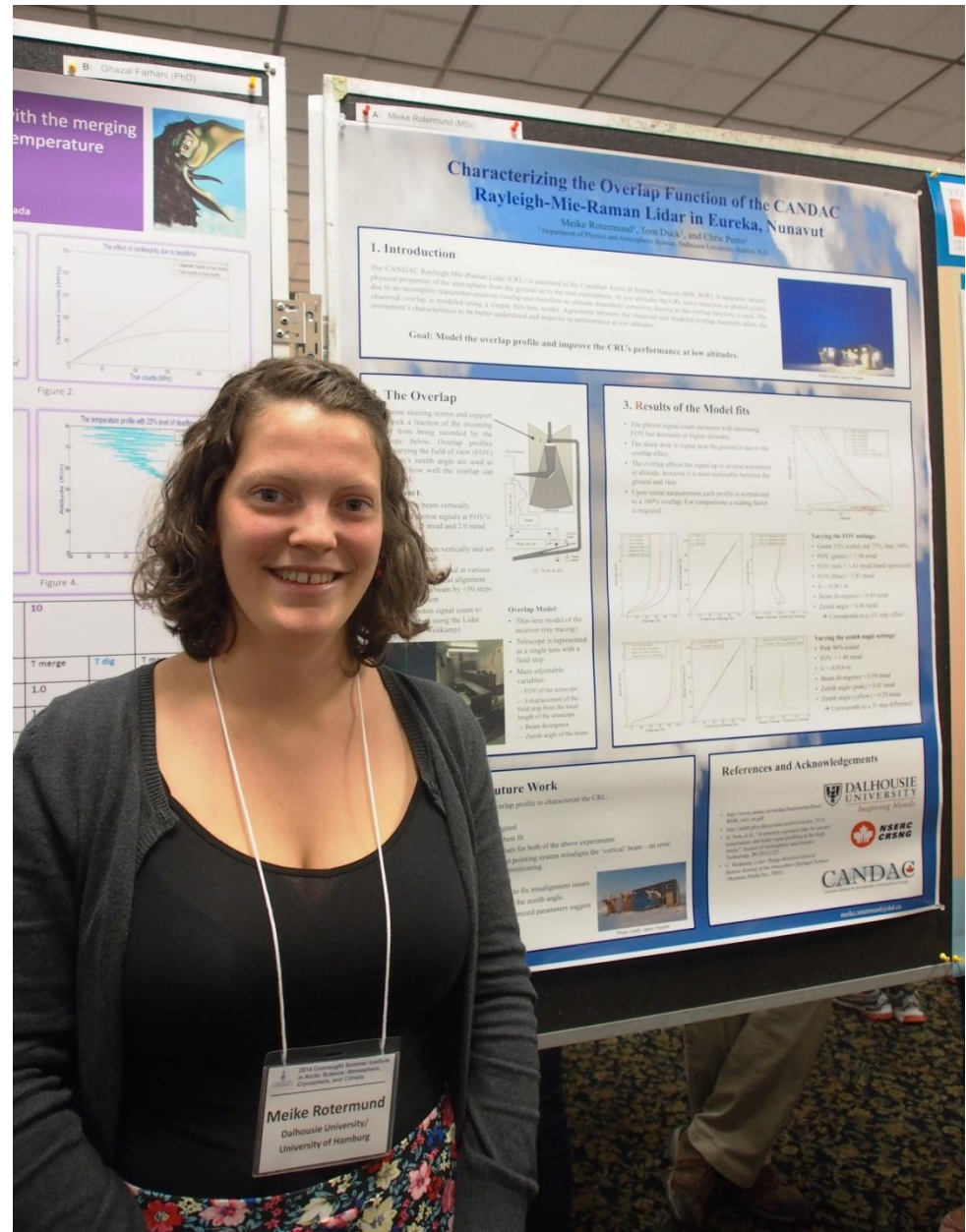
# Winner

# Meike

# Rotermund

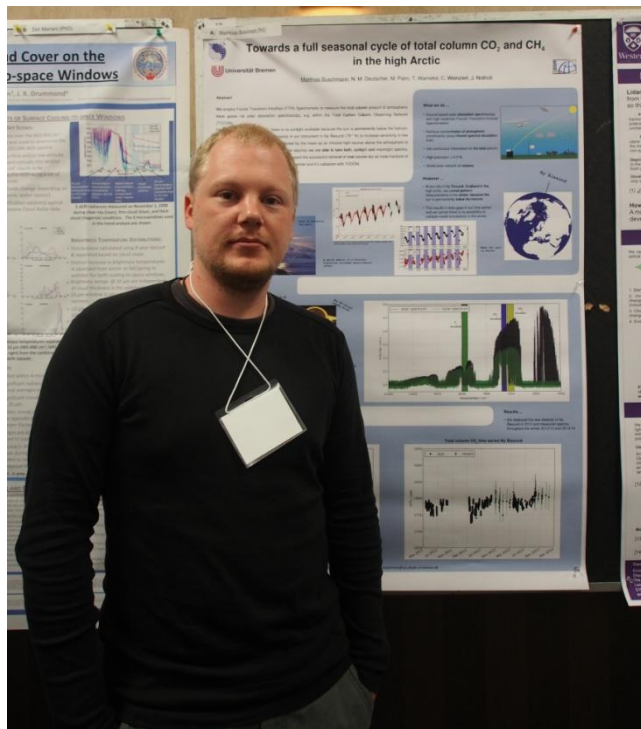
(Dalhousie U)

*“Characterizing the Overlap Function of the CANDAC Rayleigh-Mie-Raman Lidar (CRL) in Eureka, Nunavut”*



**PhD/PDF winners**

# Winner Matthias Buschmann (U of Bremen)



Universität Bremen

## Towards a full seasonal cycle of total column CO<sub>2</sub> and CH<sub>4</sub> in the high Arctic



Matthias Buschmann, N. M. Deutscher, M. Palm, T. Warneke, C. Weinzierl, J. Notholt

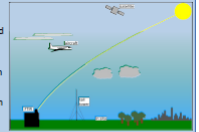
### Abstract

We employ Fourier Transform InfraRed (FTIR) Spectrometry to measure the total column amount of atmospheric trace gases via solar absorption spectroscopy, e.g. within the Total Carbon Column Observing Network (TCCON).

During winter in the high Arctic, there is no sunlight available because the sun is permanently below the horizon. We deployed a new near-infrared detector in our instrument in Ny Ålesund (79° N) to increase sensitivity in low light conditions and use the sunlight reflected by the moon as an infrared light source above the atmosphere to perform absorption spectroscopy. At autumn equinox we are able to take both, sunlight and moonlight spectra, thus validating the new approach. Here we present the successful retrieval of total column dry air mole fractions of CO<sub>2</sub> and CH<sub>4</sub> in the 2012/2013 and 2013/2014 winter and it's validation with TCCON.

### What we do ...

- Ground based solar absorption spectroscopy with high resolution Fourier-Transform Infrared Spectrometers
- Retrieve concentration of atmospheric constituents using infrared spectral absorption lines
- Get continuous information on the total column
- High precision: < 0.2%
- World wide network of stations



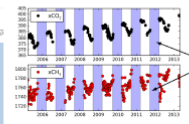
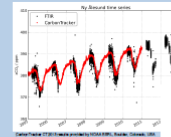
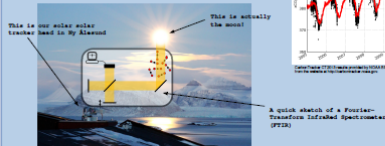
### However ...

- At our site in Ny Ålesund, Svalbard in the high arctic, we cannot perform measurements in the winter, because the sun is permanently below the horizon.
- This results in data gaps in our time series and we cannot there is no possibility to validate model simulations in the winter.



### What to do about the lack of sunlight?

- Use the moon as light source



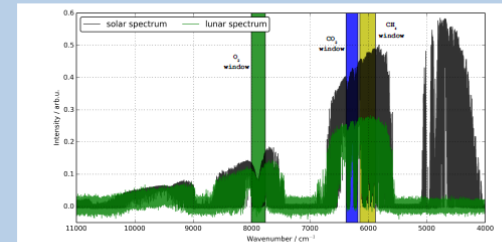
### This required ...

- Much lower intensity requires reduction of spectral resolution and ...
- A new thermo-electrically cooled InGaAs detector with better signal-to-noise ratio



### And we get spectra ...

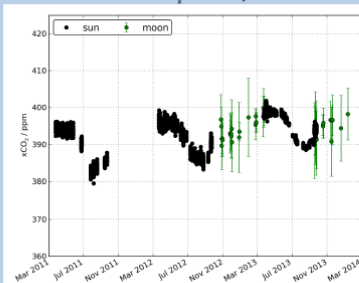
- That are still quite noisy, S/N about 10 times less than from solar spectra, ...
- But good enough to perform a profile scaling retrieval



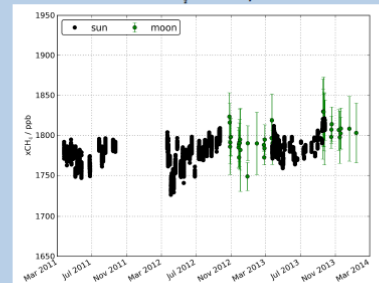
### Results ...

- We deployed the new detector in Ny Ålesund in 2012 and measured spectra throughout the winter 2012/13 and 2013/14

### Total column CO<sub>2</sub> time series Ny Ålesund



### Total column CH<sub>4</sub> time series Ny Ålesund



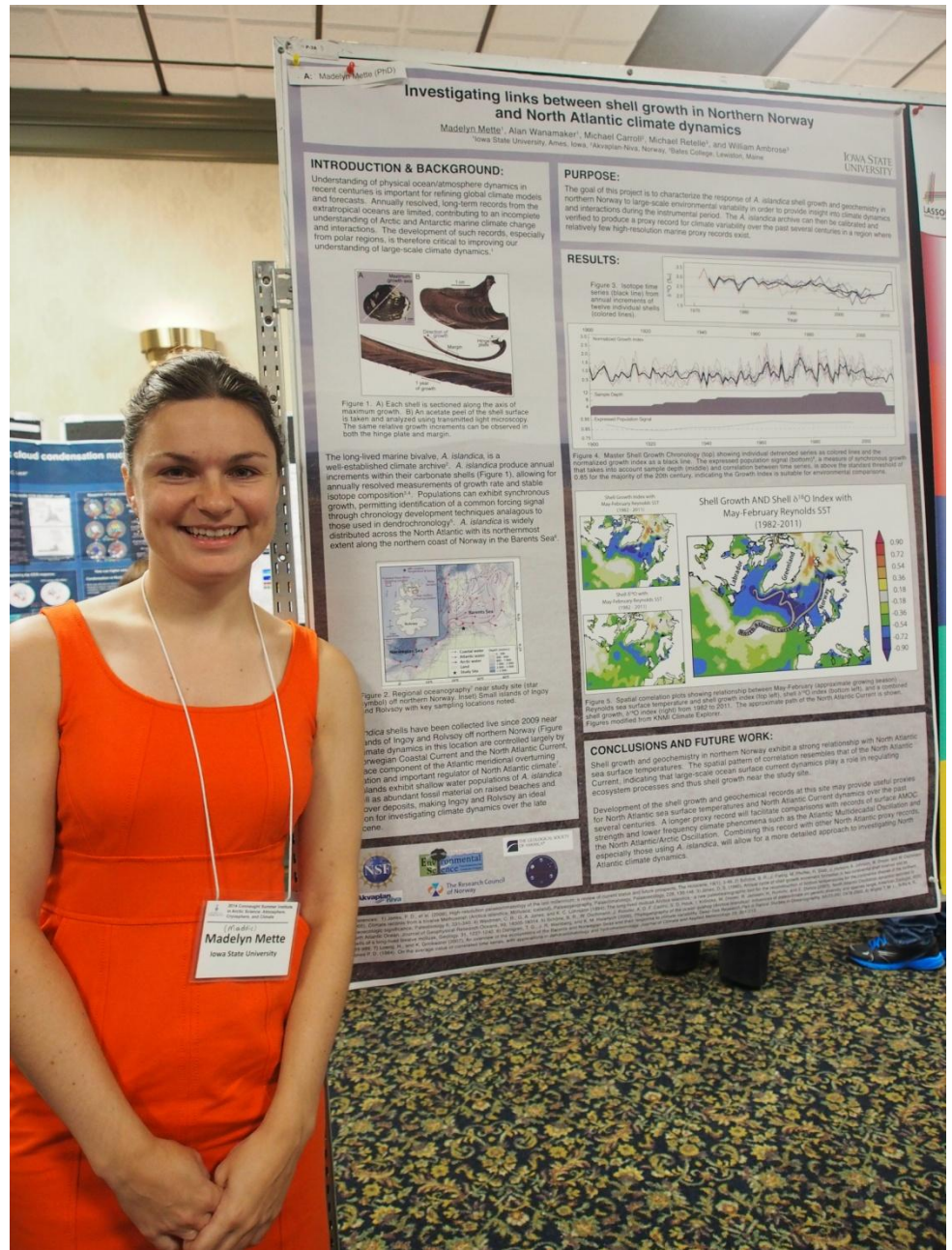
Contact: Matthias Buschmann, Institute of Environmental Physics, University of Bremen, Bremen, Germany, m\_buschmann@iup.physik.uni-bremen.de

“Towards a full seasonal cycle of total column CO<sub>2</sub> and CH<sub>4</sub> in the high Arctic”

# Winner Madelyn Mette

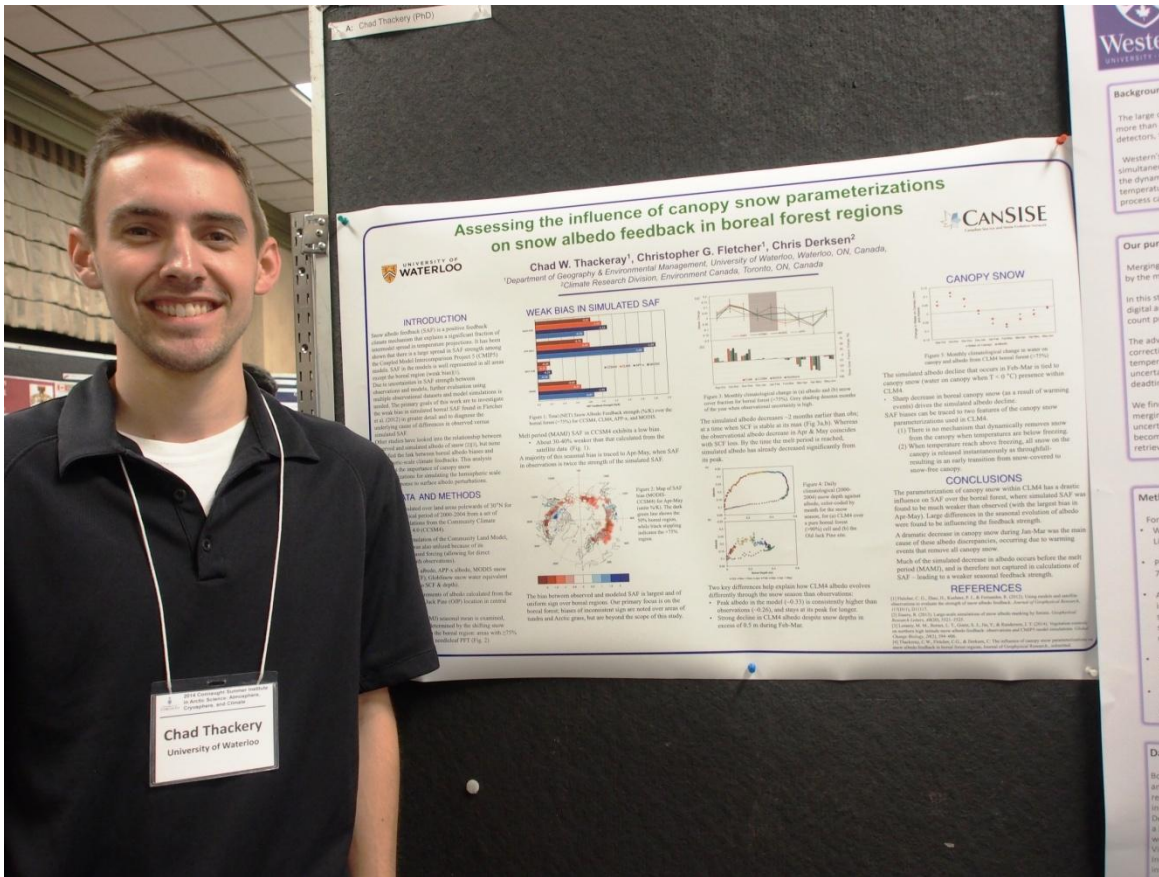
(Iowa State U)

*“Investigating links between shell growth in Northern Norway and North Atlantic climate dynamics”*



# Winner

# Chad Thackery (U of Waterloo)



*“Assessing the influence of canopy snow parameterizations on snow albedo feedback in boreal forest regions”*



## ***Thank you to our judges:***

PhD and PDF poster judges:  
Mark Flanner, Christian Haas,  
Jochen Halfar, and Lisa Miller

MSc poster judges:  
Jo Browse, Reinel Sospedra-Alfonso,  
Bajish Chevooruvallappil Chandran,  
and Gerrit Holl