Book of Abstracts, IACPES Symposium Day, May 25, 2015

T1: **Quantifying anthropogenic sources of methane**

Sabour Baray, Centre for Atmospheric Chemistry and Chemistry Department, York University

Of the compounds most influential in radiative forcing, methane is 3rd overall next to water and carbon dioxide. While background levels of methane have been relatively stable since the 1980's, a recent and poorly-understood increase in the mixing ratio has been observed as of 2007. In these studies sources of methane were investigated in both industrial and urban environments. In the summer of 2013 during the Oil Sands field study led by Environment Canada, aircraft and ground-site measurements of multiple species, including CO_2, CH_4, CO and H_2O were made by a Picarro cavity ring-down spectrometer (CRDS) instrument. Methane peak concentrations of up to 4.3 parts per million were observed, and ongoing analysis aims to a) construct a three dimensional map of emissions b) identify individual sources and c) quantify their emission rates.

T2: **Measurement of atmospheric concentration of CO_2 in the Hudson Bay Lowlands: An application of a Lagrangian Particle Dispersion Model (STILT)**

Olalekan Balogun, Richard Bello, Kaz Higuchi, Geography Graduate Program, York University

Accurate measurements of atmospheric concentrations of greenhouse gases are crucial to the understanding of climate change dynamics and processes. The operation and maintenance of regional atmospheric observational networks provide the much needed data for analysis and interpretation of greenhouse gas measurements. Information about diurnal and seasonal patterns, as well as annual trends can be determined from these datasets. Furthermore, atmospheric transport models can be used to interpret atmospheric tracer observations by using footprints to link fluxes from upstream sources and sinks with the tracer observations. In this study, we determine surface fluxes of CO_2 from measured mixing ratios at two [tower] locations in the Hudson Bay Lowlands – the second largest semi-continuous wetland region in the world covering an area of 320,000 km^2. Here, we employ a Lagrangian particle dispersion model (STILT) coupled to the North American Regional Reanalysis (NARR) dataset to derive information about surface sources and sinks of CO_2 in Churchill, Manitoba and Fraserdale, Ontario. Some of the main objectives of this research project are to: (1) Calculate and map the footprints of upstream sources and sinks; (2) Compute their associated contribution to the measured mixing ratios at the towers; (3) Provide estimates of the location and magnitude of CO_2 fluxes based on the atmospheric measurement at the towers.

T3: **Climate-biosphere mediation of surface ozone in North America**

Sarah Kavassalis, Jennifer Murphy, University of Toronto, Department of Chemistry

Ozone pollution events have observationally been linked to elevated temperatures and drought in North America, but these events are not always fully captured by chemical transport models (CTMs). We offer observational evidence from the EPA's Clean Air Status and Trends Network showing a strong correlation between summer time afternoon ozone and vapour pressure deficit (VPD), a quantity that serves as a useful surrogate for the stomatal conductance of ozone. Based on a statistical analysis of 28 years of ground level ozone and meteorological data, we observe that, in many regions that have traditionally been poorly represented in CTMs, like the southeastern United States, a significant amount of the day-to-day ozone variability can be attributed to climate dependent dry deposition. In environments with high leaf area indices (LAI), daily ground level ozone concentrations are strongly associated with VPD and soil moisture in the summer, suggesting that reduced stomatal conductance is a significant factor in summer time ozone episodes. We propose that the role of a meteorologically dependent dry deposition sink for ozone has been underappreciated in the interpretation of ambient ozone data from North America and this work will motivate the improvement of CTM dry deposition schemes.

T4: **Vertical profiles of SO_2 and NO_2 in the Alberta oil sands: MAX-DOAS measurements, comparison to in-situ instrumentation and model sensitivity studies**

Zoe Davis, Akshay Lobo, and Robert McLaren Centre for Atmospheric Chemistry, York University, Toronto, Canada (zoeywd@yorku.ca)

Understanding the levels of industrially emitted gas pollutants in the Alberta oil sands is essential to making quality environmental management decisions but is currently limited due to scarcity of top-down quantification studies. Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) measurements of nitrogen dioxide (NO2) and sulfur dioxide (SO2) , important tropospheric trace gas pollutants, contributes to improved knowledge of these pollutants' levels, vertical distributions and chemical transformations. A mini-MAX-DOAS instrument measured spectra at multiple viewing elevation angles in order to retrieve NO2 and SO2 differential slant column densities (dSCDs) at an Environment Canada research site north of Fort McMurray, Alberta in the fall of 2013. For the first time in the oil sands, tropospheric vertical profiles of NO2 and SO2 were retrieved by applying the optimal estimation technique to the MAX-DOAS measurements. Tropospheric vertical column densities (VCDs) and vertical profile retrievals of NO2, SO2 and aerosol extinction during significant pollution events will be illustrated. Trace gas vertical profiles exhibited significant variability between days and at different times of day and were often spatially complex (e.g. elevated layers). Retrieved trace gas vertical profiles were compared with aircraft composite profiles from flights over the site. Trace gas surface retrievals

were compared with results from a co-located active-DOAS instrument. Significant observed pollution events were associated with particular meteorological conditions such as South-Westerly winds. Maximum observed SO2 and NO2 retrieved mixing ratios were 250ppb and 60ppb, respectively, at approximately 300m above the surface while maximum surface concentrations measured by the active-DOAS were 77ppb and 20 ppb, respectively. A preliminary sensitivity study of the trace gas retrievals to a-priori profile choice in the optimal estimation model is presented. The observed spatial complexity in the trace gas profiles indicates that comprehensive air quality monitoring in the oil sands requires instruments with boundary layer spatial profiling capabilities.

T5: **Spectroscopic and visual evidence of perchlorate deliquescence under Martian conditions**

George Nikolakakos, Department of Physics and Astronomy, York University, Toronto, Canada

One of the key findings during the Phoenix and Mars Science Laboratory landed Mars missions has been the detection of perchlorate, a highly deliquescent salt. Perchlorates are of great interest on Mars due to their high affinity for water vapour as well as their ability to greatly depress the freezing point of water when in solution. This has intriguing biological implications as resulting brines could potentially provide a habitable environment for living organisms. Additionally, it has been speculated that these salts may play a significant role in influencing the hydrological cycle on Mars. In order to experimentally study water exchange processes between the surface and atmosphere on Mars and assess the feasibility of a future landed detection tool, a stand-off Raman spectroscopy instrument and environmental simulation chamber have been developed at York University. A sample of magnesium perchlorate consistent with the size of patches found at the Phoenix site has been subjected to the low water vapour pressure and temperatures found at polar Martian latitudes. Results indicate that at a water vapour pressure of ~2 Pa (-55 C frost point temperature), Raman spectroscopy is able to detect the onset of brine formation and provide a relative estimate of the quantity of water taken up by the sample until complete deliquescence is reached. Significant uptake of water from the atmosphere is observed to occur prior to the frost point temperature being reached and on time scales relevant to the Martian diurnal cycle. This result suggests that perchlorates in the Martian regolith can contribute to the hydrological cycle, pre-emptively reducing the water vapour pressure before saturation is reached.

T6: **Potential impacts of windfarms in Lake Erie: Some preliminary 1-D modelling using COHERENS**

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More than 90% of the world's offshore wind is installed in Europe and China, although there are plans in the USA (Atlantic - Cape Cod and Lake Erie - Cleveland) and Taiwan. There are also extensive plans for additional wind farms in Europe. If there were large scale offshore wind farm development in the Great Lakes, what impacts would they have? Although there are no wind turbines in the waters of Lake Erie at the present time, the lake has a significant wind energy resource potential, extensive areas with moderate water depth and proximity to major cities and industries with substantial electricity demands. The presence of significant numbers of large turbines in wind farms will lead to reduced wind speeds and wind stresses in the wakes within and downwind of the farms. This in turn will impact currents and mixing in lake waters, generally allowing increased surface temperatures and reduced summer time mixed layer depths. The potential magnitude of these impacts is investigated with a 1-D application of the COHERENS model for three different water depths using observed meteorological data as input.

T7: **Analysis of alkyl nitrates at ambient concentration levels by gas chromatography and thermal dissociation cavity ring-down spectroscopy with preconcentration**

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Alkyl nitrates (AN, molecular formula $RONO_2$) play a crucial role in the troposphere as temporary reservoirs of nitrogen oxides ($NO_x = NO + NO_2$) and by acting as chain terminators in the photochemical production of ozone. Mixing ratios of $RONO_2$ in ambient air are commonly quantified by gas chromatography with electron capture or mass spectrometric detection (GC-ECD or GC-MS) coupled to purge-and-trap preconcentration, usually on Tenax sorbent, to improve the detection limits. The analysis, however, is quite laborious as there are many alkyl nitrates that are low in individual abundance (often less than 1 parts-per-trillion by volume, pptv) and that exhibit different instrumental response factors.

An alternative method is to determine alkyl nitrates as a sum (ΣAN) by thermal dissociation (TD) to a common fragment (NO_2), which can then be quantified with a uniform response factor by optical absorption, for example by cavity ring-down spectroscopy (CRDS). However, the determination of ΣAN by TD-CRDS is hampered by its relatively high detection limits (several hundred parts-per-trillion by volume) and secondary chemistry following TD that results in both negative and positive interferences and depends on the composition of the ambient air sampled.

In this work, recently assembled GC-ECD and TD-CRDS each equipped with a Tenax pre-concentration unit are described. Matrix effects are minimized in the TD-CRDS as the samples are desorbed from the Tenax in a background of ECD grade nitrogen (N_2). The performance of both instruments, in particular the recovery from the Tenax sorbent, was evaluated by sampling laboratory-generated mixtures of alkyl and peroxyacyl nitrates. Advantages and disadvantages of both methods are discussed.

T8**: Analysis of halogen species using chemical ionization mass spectrometry**

Natasha Garner, Department of Chemistry, University of Calgary

The chemistry of halogen radicals and their reservoirs (e.g., chlorine nitrate, $ClNO_3$) is well established for the stratosphere. Less is known about the abundances and chemistry of these molecules in the troposphere. Here, halogen radical reactions can influence the oxidative capacity in polluted coastal areas, can lead to ozone depletion events in the polar boundary layer, and have been linked to the formation of ultrafine particles in the marine boundary layer. However, our understanding of this chemistry is still incomplete.[1] The development of methods to measure concentrations of halogen reservoir species will be crucial to gain a more complete understanding of tropospheric halogen chemistry.

This project aims to develop chemical ionization mass spectrometry (CIMS) methods to quantify halogen reservoir species. A previously described CIMS[2] will be operated with several different reagent ions (I^- and SF_5^-/ SF_6^-), whose effectiveness for the analysis of molecular chlorine, bromine and iodine and cross-halogen species, along with halogen containing reservoir species such as $ClNO_2$ and $ClNO_3$, will be evaluated. Halogen permeation sources are calibrated by trapping the analytes in aqueous solution containing excess thiosulfate, and by analyzing the anions generated using ion chromatography. CIMS measurements will be complimented by measurements of molecular iodine using cavity enhanced absorption spectroscopy (CEAS). Field studies will be conducted at the Amphitrite Observatory near Ucluelet on Vancouver Island, British Columbia, in July 2015.

References:

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T9: **Method Development for Concentration Measurements of SVOCs - Analysis of Ambient Samples**

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Many pollutants in the atmosphere are classified as semi-volatile organic compounds (SVOCs) with intermediate vapour pressures and can therefore exist in both the gas phase and in particulate matter (PM) in the atmosphere. This makes accurate quantification of total (gas and particle phases) concentration of SVOCs in the atmosphere challenging. The three important classes of SVOCs that this project focuses on and are suspected to be directly emitted or formed from Oil Sands related activities are phenols, polycyclic aromatic hydrocarbons (PAHs) and n-alkanes. Despite the increasing importance of the Alberta Oil Sands in the global energy market, there are limited comprehensive assessments of the pollutants emitted from the industrial development in peer-reviewed literature (Simpson et al., 2010). As such, the extent of the potential impact of Oil Sands mining on air quality remains largely unknown (Hazewinkel et al., 2008). Therefore, well-characterized techniques that allow measurement of total concentration of SVOCs in the atmosphere can be very useful in order to fully understand the atmospheric yield of these pollutants. Recently, a new methodology that allows sampling and analysis of the total concentration of SVOCs in the atmosphere has been developed in our research group (Moukhtar et al., 2011 and Saccon et al., 2013) and was tested on a class of SVOC (nitrophenols). The newly developed method is based on a sorbent impregnated filter (SIF) technique using conventional high-volume air samplers, extraction and analysis by GC-MS. In this project the newly developed SIF technique has been modified and validated for ambient measurements of other classes of SVOCs like PAHs and n-alkanes. Preliminary results, where the modified SIF technique was applied for analysis of samples collected in the Alberta's Oil Sands region (summer of 2013), showed relatively higher concentrations for the three classes of SVOCs for the samples impacted by the plume. The carbon preference index (CPI) values obtained from Oil Sands samples also indicate a more anthropogenic than biogenic impact even for the samples collected on relatively clean days.

T10: **Modelling secondary organic aerosol formation observed during a flight above the Alberta oil sands**

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Secondary organic aerosol (SOA) can make up a significant portion of fine particulate matter in the lower troposphere. SOA is formed by the oxidation of organic precursor gases followed by the gas-to-particle partitioning of the lower volatility organic products. Particulate matter absorbs and scatters solar radiation and influences cloud formation, playing a central role in climate. Additionally, particulate matter plays an important role in air quality and visibility. Known concentrations of SOA precursors are unable to account for the SOA observed above the oil sands. A Lagrangian box model was used to assess the aerosol formation that was observed during Flight 19 of an aircraft campaign in summer 2013 that was undertaken in support of the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring. The model uses the Statewide Air Pollution Research Center (SAPRC-07) chemical mechanism with updated isoprene chemistry. SOA formation from volatile organic compounds is treated using a four bin volatility basis set approach while SOA formation from semi-volatile and intermediate volatility species is approximated using pentadecane as a surrogate for unspeciated emissions from non-road diesel. The discrepancy that remains between observed and modelled organic aerosol is hypothesized to be due at least partially to SOA formation from intermediate volatility organic compounds associated with bitumen and bitumen processing.

T11: **Airborne Lidar Measurements of Aerosol and Ozone above the Alberta Oil Sands Region**

Monika Aggarwal, Department of Physics and Astronomy, York University, Toronto, Canada

Lidar measurements of ozone and aerosol were conducted from a Twin Otter aircraft above the oil sands region of northern Alberta. The field campaign was carried out with a total of five flights out of Fort McMurray, Alberta during the period between August 22 and August 26, 2013. Significant amounts of aerosol were observed within the boundary layer, up to a height of 1.1 km above ground level, but the ozone concentration remained at or below background levels (40 ppbv). On August 24th the lidar observed a separated layer of aerosol above the boundary

layer, at a height of 1.8 km above ground level, in which the ozone mixing ratio increased to 70 ppbv. Backward trajectory calculations revealed that the air containing this separated aerosol layer had passed over an area of forest fires.

T12: **Determination of the kinetic isotope effect of light VOC with the hydroxyl radical**

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A 3 month exchange was completed at the Forschungszentrum Jülich to conduct kinetic experiments of reactions of atmospheric volatile organic compounds (VOC). During the last decade, the number of publications using carbon isotope ratio measurements in studies of atmospheric VOC has been increasing substantially. Knowing the kinetic isotope effects (KIE) for the atmospheric reactions of VOC is essential for the use of isotope ratio measurement in understanding and differentiation of chemical and physical processes in the atmosphere, such as chemical reactions, dilution and transport. Ethane, the second-most abundant hydrocarbon in the background atmosphere, was chosen as the target compound since it is the only compound in which a global transport model has been made based on isotope ratios. Compared to most other VOC, the exceptionally low rate constant of ethane with the OH radical along with its high volatility have made the KIE of ethane difficult to quantify. This presentation will present the method development in the determination of the KIE of light VOC.

T13: **Use of stable carbon isotope composition as a tool to differentiate photochemical processing of ambient VOC**

Anna Kornilova and Jochen Rudolph, Centre for Atmospheric Chemistry and Department of Chemistry, York University

In the atmosphere, VOC can undergo both photochemical oxidation and physical processing, however since ambient air is a dynamic system, it is close to impossible to distinguish them using classical analytical methods. Recently it was demonstrated that the use of stable carbon isotope ratios can be a valuable tool in their differentiation and identification.

In this presentation, the application of the stable carbon isotope composition technique will be shown using data collected from ambient compounds sampled in Toronto (2009-2010). The distinction between dilution, mixing and chemical processing will be presented for benzene, toluene, ethylbenzene, p,m- and o-xylenes using correlations of their mixing ratios and isotope ratio-determined photochemical ages. It will be shown that while an air mass is viewed as one entity, its constituents have or may have been processed differently and have different photochemical lifetimes. While concentration-based methods do not allow for the differentiation of freshly emitted and aged compounds, use of stable carbon isotopes and mixing ratios together can provide more information on the origin of a compound, its atmospheric lifetime and contribution of major local and remote emission sources in an overall air mass quality.

T14: **Use of stable carbon isotope composition as a tool to differentiate photochemical processing of ambient VOC**

Jeffrey Geddes, IACPES Postdoctoral Fellow, Department of Physics & Atmospheric Science, Dalhousie University, Visiting Postdoctoral Fellow, Department of Civil & Environmental Engineering, MIT

Biogenic emissions of NOx from soils and reactive hydrocarbons from vegetation affect the oxidative capacity of the atmosphere, while physical removal by dry deposition over vegetated land depends on canopy properties. Large-scale tree mortality that is predicted as a result of insects and disease may therefore have unexplored feedbacks on atmospheric chemistry and air quality. In order to investigate this, I created a new module for a chemical transport model (GEOS-Chem) that would facilitate simulations involving changes to the land surface. Previously, the description of land-atmosphere exchange in GEOS-Chem was static and driven by a variety of potentially conflicting land surface data. For the first time, we are now able to simulate the impacts of land cover change consistently across all biogenic sources and sinks in the model, and explore changes to subsequent tropospheric chemistry. This module was used to test the impact of national-scale tree mortality predicted by the USDA over the next 15 years. Initial results show quantifiable impacts on the abundance of important constituents like O_3, PAN, and organic aerosol. The simulations suggest that future changes in biosphere-atmosphere exchange must be considered when predicting future air quality and climate, and point to important uncertainties that need to be addressed by additional observations.

T15: **(Relatively) simple models of flow in complex terrain and PEIWEE**

Peter Taylor (1, 2), Wensong Weng (2), and Jim Salmon (2) (1) York University, (2) Zephyr North

The term, "complex terrain" includes both topography and variations in surface roughness and thermal properties. The scales that are affected can differ and there are some advantages to modeling them separately. In studies of flow in complex terrain we have developed models of atmospheric PBL boundary layer flow over roughness changes, appropriate for longer fetches than most existing models. These "internal boundary layers" are especially important for understanding and predicting wind speed variations with distance from shorelines, an important factor for wind farms around, and potentially in, the Great Lakes. The models can also form a base for studying the wakes behind woodlots and wind turbines. This month's Wind Energy Experiment experiment in PEI (PEIWEE) involves data collection for these studies.

Some sample calculations of wind speed evolution over water and the reduced wind speeds behind an isolated woodlot, represented simply in terms of an increase in surface roughness, will be presented. We can use the model to deal with 3-D roughness variations and will describe applications to both on-shore and off-shore situations around the Great Lakes. The linear Mixed Spectral Finite- Difference (MSFD) and non-linear (NLMSFD) models have been extended to planetary boundary-layer flow over topography. This allows their use for larger scale regions and increased heights. The models have been applied to successfully simulate the Askervein hill experimental case and we will show examples of applications to more complex terrain, typical of some Canadian wind farms. Output from the model can be used for input to wind farm design software.

T16: **High resolution model simulations of the Canadian oil sands with comparisons to field study observations**

P.A. Makar, C. Stroud, J. Zhang, M. Moran, A. Akingunola, W. Gong, S. Gravel, P. Pabla, P. Cheung, Q. Zheng, G. Marson, S.M. Li, J. Brook, K. Hayden, J. Liggio, R. Staebler, A. Darlington

The governments of Canada and the province of Alberta carried out a joint monitoring intensive study of the emissions, transport and downwind chemistry associated with the Canadian Oil Sands industrial region during the summer of 2013. As part of that effort, Environment Canada’s Global Environmental Multiscale – Modelling Air-quality And CHemistry (GEM-MACH) system was reconfigured for the first time to create nested forecasts of air quality at model grid resolutions down to 2.5 km, with the highest resolution domain including the Canadian provinces of Alberta and Saskatchewan. The forecasts were used to direct an airborne research platform during the monitoring intensive. Subsequent work with the modelling system has included an in-depth comparison of the model predictions to the field intensive airborne and surface supersites, and to monitoring network observations. The initial air-quality forecasts, subsequent comparisons to observations, and consequent improvements to both the model and its input emissions data will be discussed. The relative impact of different model versions and processes will be compared. The comparisons will include the impact of feedbacks between weather and air-quality at high resolution on the model predictions relative to observations, and the impact of different emissions estimates. Model-based predictions of human-health and ecosystem impacts for the region will also be described and compared to the available observations.

T17: **Oceans: An underestimated driver in ice cloud formation?**

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The oceans cover 70% of the planet and hence they are a great source of atmospheric aerosol particles. Marine aerosol particles are known to act as cloud condensation nuclei and therefore are recognized as an important driver for liquid water cloud formation. However, it is not well understood if aerosol particles from marine origin hold the abilities to act as ice nucleating particles (INPs). If marine aerosol particles are found to be widely prevalent as ice cloud forming INPs, they can significantly influence the hydrological cycle and the Earth's radiative balance. With the aim to improving our understanding of the ice nucleating properties of marine aerosol, field measurements and laboratory experiments were conducted as part of the NETCARE (NETwork on Climate and Aerosols: Addressing key uncertainties in Remote Canadian Environments) project.

Sea surface microlayer (SML) waters from the Pacific, the Atlantic and the Arctic oceans were carefully characterized and their abilities to nucleate mixed-phase and ice clouds were investigated. It was found that the SML from the three oceans were enriched in INPs compared to subsurface waters. Additionally, X-ray and spectroscopic analyses of SML samples indicate that the INPs are likely from biological origin [Wilson and Ladino et al. 2014]. Ambient measurements conducted on the west coast of Vancouver Island (BC, Canada) in August 2013 showed that the INP concentrations at -40°C and RH_{ice} of 139% varied from 0.2 L^{-1} to 3.3L^{-1} in the sub-micron size range. Correlations conducted between the INP concentrations and several physical, chemical and meteorological variables suggested that the measured INPs are likely from marine origin. Laboratory experiments with aerosol particles which are ubiquitous in marine environments indicate that the likely source of the measured INPs are living-organics or their exudates from the sea surface microlayer [Ladino et al. 2015].

References

T.W. Wilson, and L.A. Ladino et al. (2014): Ice nucleating particles in the sea surface microlayer. *Under review for publication in Nature.*

Ladino, L.A. et al. (2015): Identifying the Aerosol Particles that Act as Deposition Ice Nuclei in Marine Environments. *In preparation for ACP*.

POSTERS

P1: NO_2, SO_2 and HONO mixing ratios in a forested region of Alberta impacted by oil sands processing facilities

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During the summer of 2013, measurements of NO_2, SO_2 and HONO were made at a ground site in a rural forested region of Alberta known to be impacted by several oil sands processing facilities. Such sources are known to be the main sources of NO_x and SO_x emissions in the region. Nitrous acid (HONO) can be emitted directly from combustion sources in addition to being formed from the heterogeneous hydrolysis of NO_2 on moist surfaces. The measurements were made by Differential Optical Absorption Spectroscopy (DOAS) along a 2.304 km optical return path through the forest canopy using a 30-corner cube reflector. The methodology for spectral fitting of HONO using (DOASIS) will be discussed in some detail, as will both night-time and daytime mixing ratios of the pollutants. Nitrous acid (HONO) is of particular relevance to atmospheric chemistry as it can contribute to photochemical production of the OH radical, the main daytime oxidant in the troposphere, which was estimated to exceed $1 \cdot 10^7$ molec cm^{-3} on several days during the study. Typically in urban areas HONO mixing ratios accumulate during the night, and are lost the next morning due to photolysis ($HONO + h\nu \rightarrow OH + NO_2$). During this study, HONO mixing ratios were quite low at night, typically less than 300ppt. A noticeable negative trend in the HONO mixing ratio was also observed. This is thought to be caused by possible temperature drift in the Xe lamp used in active measurement or accumulation of an unknown pollutant on the optical components over the course of the study. Variation of the lamp spectra over the course DOASIS fitting, and use of a two lamp fit-scenario acted to decrease this observed trend. However, observed mixing ratio for HONO were still found to be low. This is attributed to the very low nighttime NO_2 precursor levels, which had a median nighttime mixing ratio of ~1.1 ppb. The low nighttime mixing ratios of NO_2 and SO_2 were driven by limited nocturnal mixing of elevated plumes down to the surface, while high daytime levels of NO_2 and SO_2 were episodic and frequently driven by daytime fumigation the elevated plumes to the surface, with additional contribution from surface sources of NO_x.

P2: **High frequency measurements of ammonia with QC-TILDAS for eddy covariance fluxes**

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Ammonia (NH_3) is a key component in the global nitrogen cycle and of great importance for atmospheric chemistry, neutralizing atmospheric acids and leading to the formation of aerosol particles. For understanding the role of NH_3 in both natural and anthropogenically influenced environments, the quantification of surface-atmosphere exchange fluxes of NH_3 is essential. While measurements of accurate NH_3 fluxes still remain a great challenge, especially the determination of bi-directional exchange, i.e. where the net flux is often close to zero, is difficult. The presented work assesses the quality of high frequency measurements using a Quantum Cascade Tunable Infrared Laser Differential Absorption Spectrometer (QC-TILDAS) for the determination of eddy covariance fluxes of NH_3. As surface adsorption is a major issue for high frequency measurements of NH_3, the evaluation of the system focuses on the time response and methods to improve it. The presented results give valuable information for the operation of an eddy covariance systems for NH_3 under field conditions.

P3: **Vertical Profiles of SO_2 and NO_2 in the Alberta Oil Sands: MAX-DOAS Measurements and Comparison to in-situ Instrumentation**

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Understanding the levels of industrially emitted gas pollutants in the Alberta oil sands is essential to making quality environmental management decisions but is currently limited due to scarcity of top-down quantification studies. Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) measurements of nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) , important tropospheric trace gas pollutants, contributes to improved knowledge of these pollutants' levels, vertical distributions and chemical transformations. A mini-MAX-DOAS instrument measured spectra at multiple viewing elevation angles in order to retrieve NO_2 and SO_2 differential slant column densities (dSCDs) at an Environment Canada research site north of Fort McMurray, Alberta in the fall of 2013. For the first time in the oil sands, tropospheric vertical profiles of NO_2 and SO_2 were retrieved by applying the optimal estimation technique to the MAX-DOAS measurements. Tropospheric vertical column densities (VCDs) and vertical profile retrievals of NO_2, SO_2 and aerosol extinction during significant pollution events will be illustrated. Trace gas surface retrievals were compared with results from a co-located active-DOAS instrument. Significant observed pollution events were associated with particular meteorological conditions such as South-Westerly winds. Maximum observed SO_2 and NO_2 retrieved mixing ratios were

250 ppb and 60 ppb, respectively, at approximately 300m above the surface while maximum surface concentrations measured by the active-DOAS were 77 ppb and 20 ppb, respectively. A preliminary sensitivity study of the trace gas retrievals to a-priori profile choice in the optimal estimation model is presented. The observed spatial complexity in the trace gas profiles indicates that comprehensive air quality monitoring in the oil sands requires instruments with boundary layer spatial profiling capabilities.

P4: **Title: Arctic surface ozone depletions from ozone soundings and surface measurements**

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Episodes of ozone depletion in the lowermost Arctic atmosphere (0-2 km) in the polar spring are understood to result from catalytic reactions involving bromine derived from sea salt. Arctic sites consistently show ozone depletion in the surface boundary layer throughout the spring months, sufficient at some sites to markedly affect the annual cycle, and produce an ozone minimum in spring. Although this is a natural phenomenon -- the long ozonesonde record at Resolute shows depletions since the beginning of the record in 1966 – it appears to be changing: the (recently re-evaluated) Resolute record also shows an increase in their frequency over the period 1966-2013 of 6.8 □ 3.7% per decade (95% confidence limits). In addition, surface sites show a shift toward increasing frequency earlier in the year. These changes are examined in the context of other changes in the Arctic boundary layer.

P5: Irena Ivanova, Environment Canada, Global modeling of stratospheric ozone in GEM-MACH (Modelling Air Quality and Chemistry) model

P6: Cynthia Whaley, Environment Canada, Modelling atmospheric PAHs in an urban environment

Note: List of posters to be presented incomplete.

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