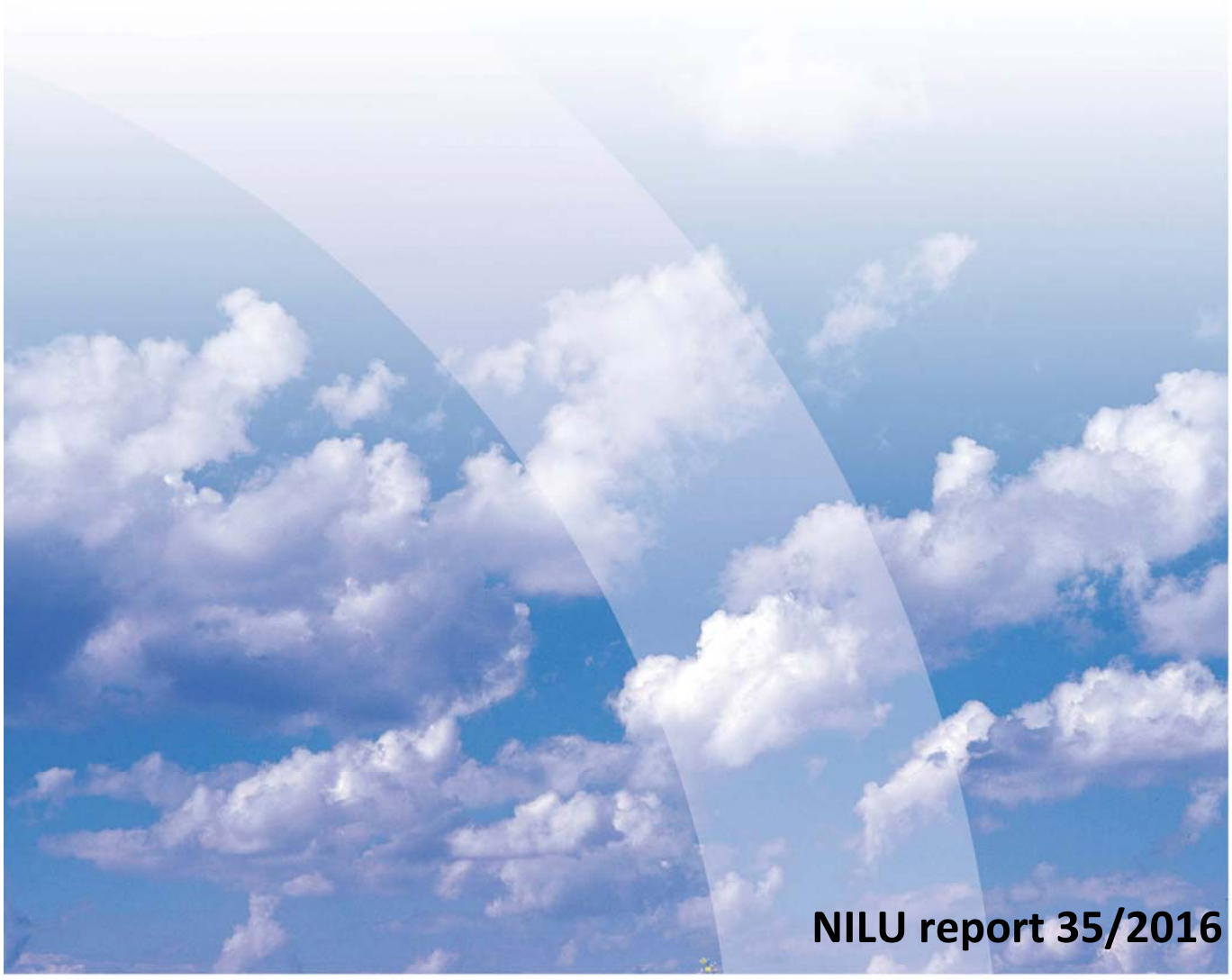
Norsk institutt for luftforskning
Norwegian Institute for Air Research

SVALBARDS MILJØVERNFOND

Air Quality in Ny-Ålesund

Monitoring of Local Air Quality 2014-2015

Mona Johnsrud, Ove Hermansen og Kjersti Tørnkvist



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ABSTRACT

The concentrations of the measured components are generally low and below national limit values for the protection of human health and critical levels for the protection of vegetation.

Wind from northern sectors gave the highest average concentrations of nitrogen oxides, which indicates the power station and the harbour as possible sources. From September 2014 to February 2015, volcanic eruptions at Iceland emitted large volumes of SO_2, which gave episodes of elevated concentrations in Ny-Ålesund. The measurement results for CO_2 show an annual variation with higher concentrations in the winter and lower in summer. Measured concentrations of CO were most likely caused by local snowmobile traffic and long-range transport of emissions from wildfires in North America.

NORWEGIAN TITLE

Luftkvalitet i Ny-Ålesund. Målinger av lokal luftkvalitet 2014-2015.

KEYWORDS

Luftkvalitet | Langtransporterte luftforurensninger | Polare områder

ABSTRACT (in Norwegian)

De målte konsentrasjonene var generelt lave for alle komponenter og under nasjonale grenseverdier for beskyttelse av menneskets helse og økosystemet.

Vind fra nordlige sektorer ga de høyeste gjennomsnittskonsentrasjonene av nitrogenoksider, noe som peker på kraftstasjonen og havnen som mulige kilder. Fra september 2014 til februar 2015 ga vulkanutbrudd på Island store utslipp av SO_2, som ga episoder med høye konsentrasjoner i Ny-Ålesund. Måleresultatene fro CO_2 viser en årlig variasjon, med høyere konsentrasjoner om vinteren og lavere om sommeren. Kilder for de målte konsentrasjonene av CO var mest sannsynlig lokal snøskutertrafikk og langtransporterte utslipp fra skogbranner i Nord-Amerika.

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Preface

The expressed mission of Ny-Ålesund is to serve as an international station for scientific research and monitoring. The activities are dependent on the near pristine environment and unique qualities of the Ny-Ålesund area, in particular research related to long range pollution, climate change and polar ecology.

Thus, it is essential to preserve the near pristine environment of the area and to keep local human environmental impacts at the lowest possible level so as not to jeopardise scientific research and monitoring. Ny-Ålesund is expected to be a prime example of the sustainable operation and development of a research station in the Polar Regions.

Comprehensive infrastructure and logistics are required to enable the extensive research activities in and around Ny-Ålesund. This cannot be done without any impact on the environment.

The project "Monitoring of Local Air Quality in Ny-Ålesund" ran from July 2008 until 2010. The main purpose of the project was to monitor a number of air pollutants to assess the impact of the activities in Ny-Ålesund on the environment and to detect possible influences on measurements in Ny-Ålesund and the nearby Zeppelin air monitoring station.

Funding from the Svalbard Environmental Protection Fund made it possible to start up again with the same type of measurements in the same location in 2014. It was planned to continue monitoring until mid-2015 to gather data for looking into changes since the previous project. It has since been decided to continue these activities while searching for possible sources of funding to enable permanent monitoring of local air quality in Ny-Ålesund.

Kings Bay AS set up the facilities needed for the instrumentation. Operation of instruments and samplers were carried out by the staff from the Norwegian Polar Institute at the Sverdrup station.

This report summarises the monitoring activities in 2014-2015 and presents the measurements and the results from the first comparisons with earlier measurements.

The measurement results will be freely available for scientists and others for use in further studies in the region.

Contents

Summary

NILU Norwegian Institute for Air Research are monitoring air quality and meteorology at the measurement station Nordpolhotellet in Ny-Ålesund, Spitsbergen. The main purpose of the project is to assess the impact of the activities in Ny-Ålesund and to detect possible influences on measurements in Ny-Ålesund and the nearby Zeppelin observatory.

The concentrations of the measured components are generally low and below national limit values for the protection of human health and critical levels for the protection of vegetation.

The highest average concentrations of nitrogen oxides were measured with wind from northern sectors, which indicates the power station and the harbour as possible sources.

From September 2014 to February 2015 volcanic eruptions at Iceland emitted large volumes of SO_2 which were transported with air masses and gave episodes of elevated concentrations several places, including Ny-Ålesund. For the total measurement period the highest average SO_2-concentrations occurs with wind from north-northeast, but also other sectors contribute.

The measurement results for CO_2 show an annual variation with higher concentrations in the winter and lower in summer. The maximum hourly concentration in the period was measured in December 2015 and the minimum in August 2015.

Measurements of CO gave higher concentrations in the spring, most likely caused by snowmobile traffic close to the station. In July 2015 an episode of elevated concentrations, most likely caused by long range transport of CO from wildfires in North America, was registered.

Air Quality in Ny-Ålesund
Monitoring of Local Air Quality 2014-2015

1 Background

NILU measures air quality and meteorological parameters at the measurement station Nordpolhotellet in Ny-Ålesund from June 2014. A corresponding measurement program was carried out at the same location in 2008-2010[1]. The purpose then and now is to investigate air pollution from local sources such as car traffic, the power station, boat traffic etc. Measurement results can be used to look at possible environmental impact from all activities in the area and to investigate any influence on scientific measurement activities in Ny-Ålesund and its surroundings.

The measurement results will be freely available for scientists and others for use in further studies in the region. This report gives an overview of the measurement program and a brief statistical summary of the results.

2 Measurement program

The measurement program is summarized in Table 1.

Table 1: Measurement program at Nordpolhotellet in Ny-Ålesund.

Compound	Description	Sampler	Time resolution
$NO/NO_2/NO_x$	Nitrous oxides	Continuous monitor	1 hour
SO_2	Sulphur dioxide	Continuous monitor	1 hour
Picarro*	Carbon monoxide, carbon dioxide	Continuous monitor	1 hour
Main inorganic compounds	Gaseous and particle bound inorganic compounds; HNO_3/NO_3^-, NH_4^+/NH_3, SO_2, SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCl	Filter sampler	1 week
Meteorology	Temperature, wind direction, wind speed, relative humidity, barometric pressure, precipitation intensity	Automatic weather station	1 hour

*From 16. March 2015.

[1] Hermansen, O., Wasseng, J., Bäcklund, A., Ström, J., Noon, B., Hennig, T., Schulze, D., Barth, V. L. (2011) Air Quality Ny-Ålesund, Monitoring of Local Air Quality 2008-2010, Measurement Results. Kjeller (NILU OR-19/2011).

The program in 2008-2010 also had measurements of aromatic compounds and black carbon (particles and soot).

3 Measurement station

The measurement station is located close to the center of Ny-Ålesund, slightly downwind, to provide representative measurements of the air quality in Ny-Ålesund. The location of the measurement station is shown in Figure 1. Data from the measurement station for advanced scientific measurements, at the top of the Zeppelin mountain south of Ny-Ålesund, are also included in some figures.

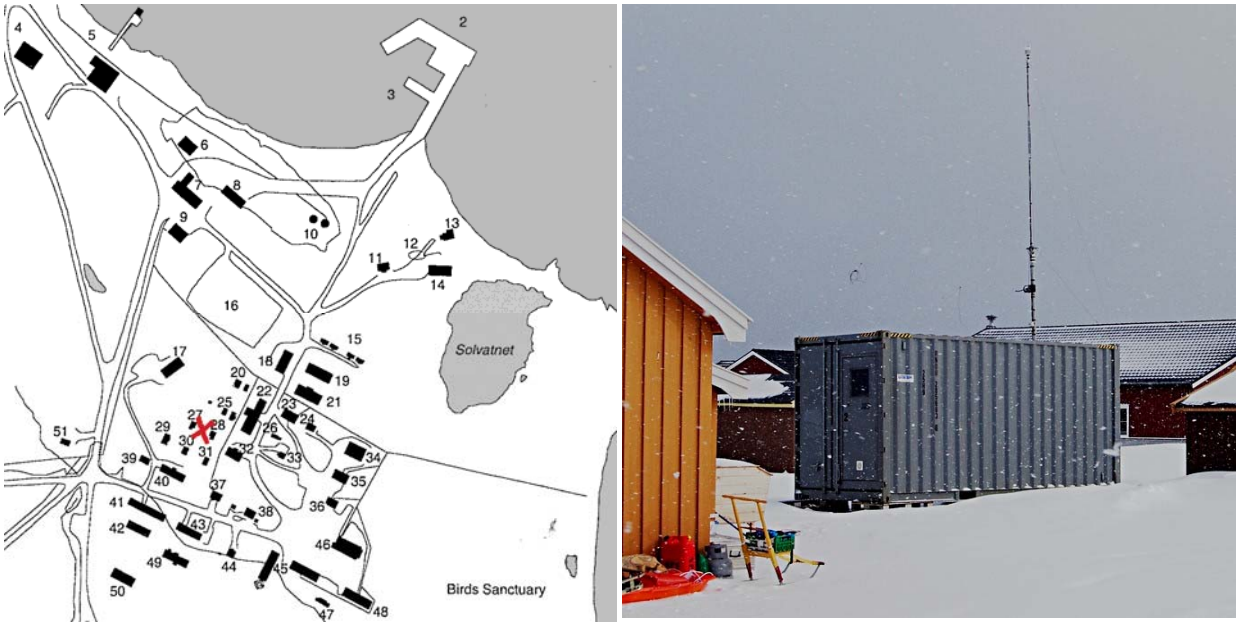


Figure 1: Location of the measurement station Nordpolhotellet in Ny-Ålesund.

4 Results

4.1 Data capture

During the period from the measurements started in June 2014 to the end of December 2015 the data capture was generally good, but there were a few periods missing data as summarised in Table 2.

Table 2: Periods of missing data from Nordpolhotellet from June 2014 to December 2015.

Compound/sampler	Periods missing data
$NO/NO_2/NO_x$, monitor	13.-14.11.2014 8.-15.12.2014 18.-20.12.2014 26.1.-18.2.2015 18.-19.10.2015 9.-12.11.2015 7.-10.12.2015
SO_2, monitor	19.-22.9.2014 26.1.-18.2.2015 18.-19.10.2015 9.-12.11.2015 7.-10.12.2015
CO_2, Picarro	Start in March 2015 17.-19.3.2015 9.-12.11.2015
CO, Picarro	Start in March 2015 17.-19.3.2015 9.11.-31.12.2015
Main inorganic compounds, filter sampler	18.-22.9.2014 8.-15.12.2014 22.12.2014-5.1.2015
Meteorology: Temperature, relative humidity, barometric pressure, precipitation intensity	26.1.-18.2.2015
Meteorology: Wind speed, wind direction	26.1.-10.3.2015

4.2 Meteorology

Frequency of wind from 12 30-degrees sectors (wind roses) from Nordpolhotellet and Zeppelin mountain are presented in Figure 2. At Nordpolhotellet the prevailing wind direction is from east-southeast and the highest wind speeds are also registered from this sector. At Zeppelin mountain the wind direction is more from south and south-easterly directions than in Ny-Ålesund.

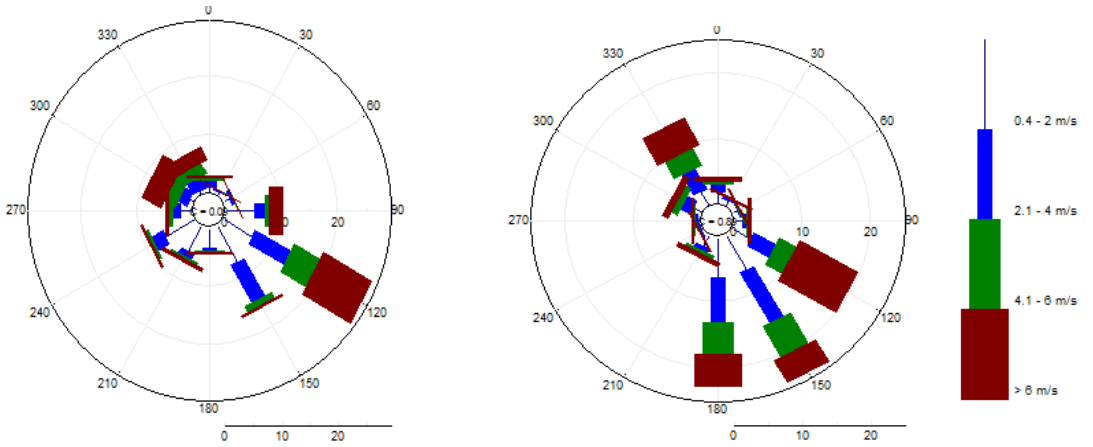


Figure 2: Wind roses from the measurement stations at Nordpolhotellet (a) and Zeppelin mountain (b) from June 2014 to December 2015.

Monthly average, maximum and minimum temperature from Nordpolhotellet is presented in Figure 3. The figure also shows monthly average temperature at Zeppelin mountain as well as the monthly normal temperature 1961-1990 from Ny-Ålesund given by DNMI.

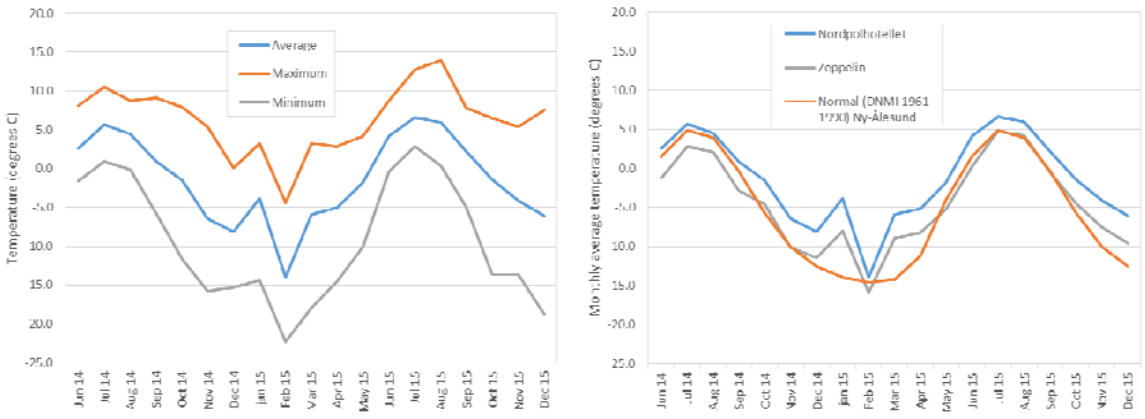


Figure 3: Monthly temperature statistics from Ny-Ålesund and Zeppelin mountain from June 2014 to December 2015.

4.3 Nitrogen oxides

Hourly concentrations of nitrogen oxides and nitrogen dioxide are shown as time series plots in Appendix A. Measurements of nitrogen dioxide are summarized in Table 3.

Table 3: Summary of hourly measurements of NO_2 at Nordpolhotellet June 2014 to December 2015. When monthly data coverage is below 75% no statistics are calculated.

Year	Month	Data coverage (%)	Average (µg/m³)	Maximum (µg/m³)	Time for maximum
2014	June	71	-	-	-
	July	99	2.1	36.5	26.07.2014 15:00
	August	99	2.3	40.9	12.08.2014 09:00, 17:00
	September	99	1.0	39.4	07.09.2014 07:00
	October	99	0.5	17.6	01.10.2014 01:00
	November	94	1.2	22.3	10.11.2014 02:00
	December	69	-	-	-
2015	January	83	0.6	10.5	04.01.2015 16:00
	February	37	-	-	-
	March	99	0.9	26.3	03.03.2015 16:00
	April	100	1.1	30.7	02.04.2015 23:00
	May	98	1.1	18.0	16.05.2015 13:00
	June	99	1.7	45.1	24.06.2015 20:00
	July	99	2.7	60.7	11.07.2015 13:00
	August	99	2.3	29.0	26.08.2015 01:00
	September	99	1.5	20.3	29.09.2015 20:00
	October	97	1.5	50.5	25.10.2015 20:00
	November	90	0.9	28.0	21.11.2015 00:00
	December	90	2.4	32.0	26.12.2015 17:00

The NO_2-concentrations are generally very low compared to measurements in cities and agglomerations. The highest monthly average was measured to 2.7 µg/m^3 in July 2015. There are some episodes when the concentrations are elevated compared to the average concentrations of the station. The highest hourly average, measured to 60.7 µg/m^3, was registered at the 11. July from 12-13. Measurements from this episode are shown in Figure 4 with simultaneous wind direction measurements and registration of ships at the harbour.
The highest concentrations occurred with a light to gentle breeze from north. From the cruise calls registrations there seems to be a boat on its way into the harbour, but these registrations are not as exactly timed as the measurements.

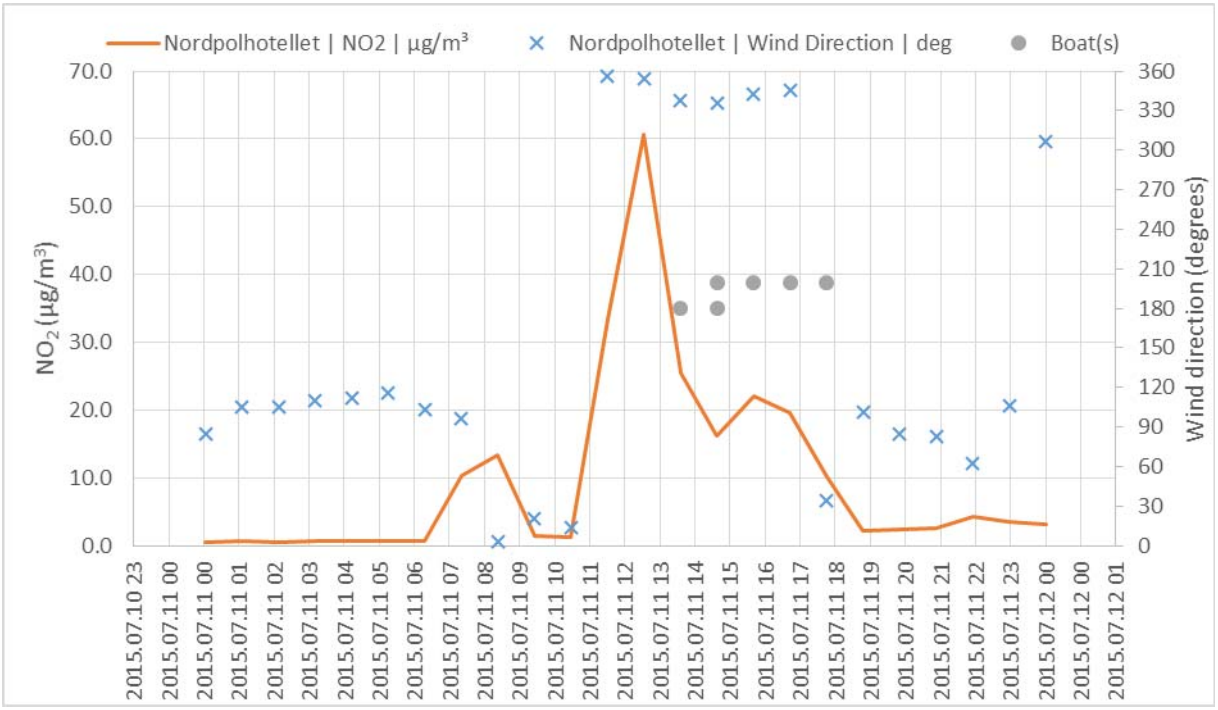


Figure 4: Hourly average concentrations of NO_2 and hourly registrations of wind direction at Nordpolhotellet and registration of ships at the harbour of Ny-Ålesund on 11. July 2015.

Average concentrations of NO_x and NO_2 from 12 wind direction sectors at Nordpolhotellet are shown in Figure 5 and Figure 6. The figures illustrates that the highest average concentrations occurs with wind from north and northern directions.

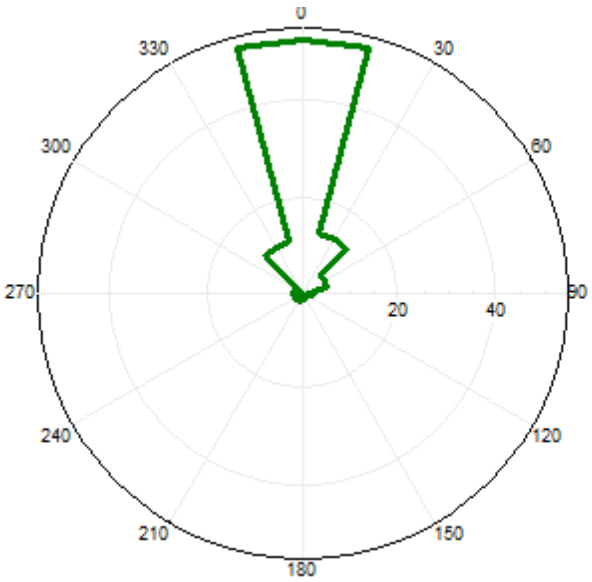


Figure 5: Average concentrations of NO_x (µg/m³) with wind from 12 30 degrees sectors at Nordpolhotellet, June 2014 to December 2015.

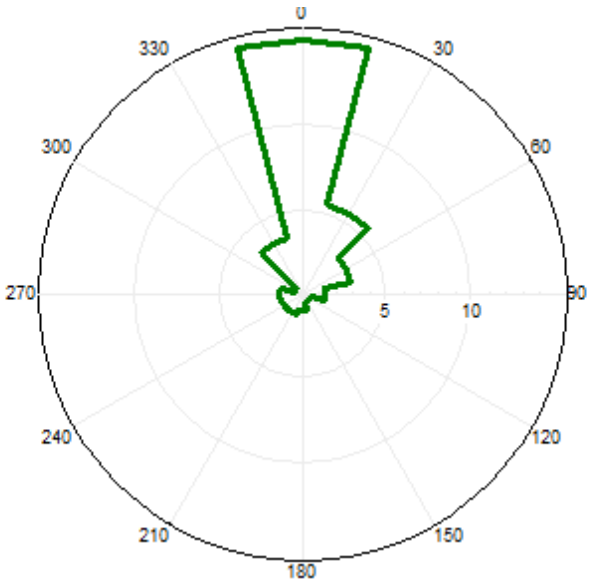


Figure 6: Average concentration of NO_2 (µg/m^3) with wind from 12 30 degrees sectors at Nordpolhotellet, June 2014 to December 2015.

4.4 Sulphur dioxide

Hourly concentrations of sulphur dioxide are shown as time series plots in Appendix A. Measurements of sulphur dioxide are summarized in Table 4.

Table 4: Summary of hourly measurements of SO_2 at Nordpolhotellet June 2014 to December 2015. When monthly data coverage is below 75% no statistics are calculated.

Year	Month	Data coverage (%)	Average (µg/m³)	Maximum (µg/m³)	Time for maximum
2014	June	71	-	-	-
	July	98	0.1	6	16.07.2014 15:00
	August	98	1.0	3	25.08.2014 07:00, 28.08.2014 16:00
	September	87	2.1	111	13.09.2014 08:00
	October	99	0.9	24	04.10.2014 23:00
	November	98	0.6	15	22.11.2014 10:00
	December	98	1.0	7	01.12.2014 01:00
2015	January	81	1.2	18	22.01.2015 12:00
	February	37	-	-	-
	March	97	-0.2	3	08.03.2015 08:00
	April	97	0.9	4	18.04.2015 18:00
	May	98	3.4	7	23.05.2015 08:00, 10:00, 11:00
	June	98	1.8	6	02.06.2015 07:00
	July	99	0.8	3	24.07.2015 13:00
	August	98	0.5	3	06.08.2015 13:00
	September	98	0.1	4	29.09.2015 20:00
	October	96	0.1	3	25.10.2015 19:00
	November	88	0.6	3	01.11.2015 21:00
	December	89	1.2	5	25.12.2015 15:00

The SO_2-concentrations are generally very low. Most of the time the values are close to, or below, the detection limit of the continuous monitor and the uncertainty is high at this low concentration level. The method is however good at capturing episodes of higher concentrations and this is why this instrumentation is included in the program. The highest monthly average, based on the hourly measurements, was 3.4 µg/m³ in May 2015, but this value is very uncertain.

In the autumn of 2014 episodes of relatively high hourly SO_2-concentrations were registered, the first, and also the highest, on 13. September at 07-08, measured to 111.6 µg/m³. This concentration is higher than what is normally found in cities and agglomerations in Norway, and closer to what is found at sites influenced by local industrial emissions. It is likely that the SO_2 originates from the volcanic eruption at Holuhraun, Iceland, which began on August 29, 2014 and ended on February 27, 2015, and during this time emitted large volumes of

SO_2. An air mass trajectory to Zeppelin mountain, Ny-Ålesund from 13.09.2014 illustrating this is given in Figure 7.

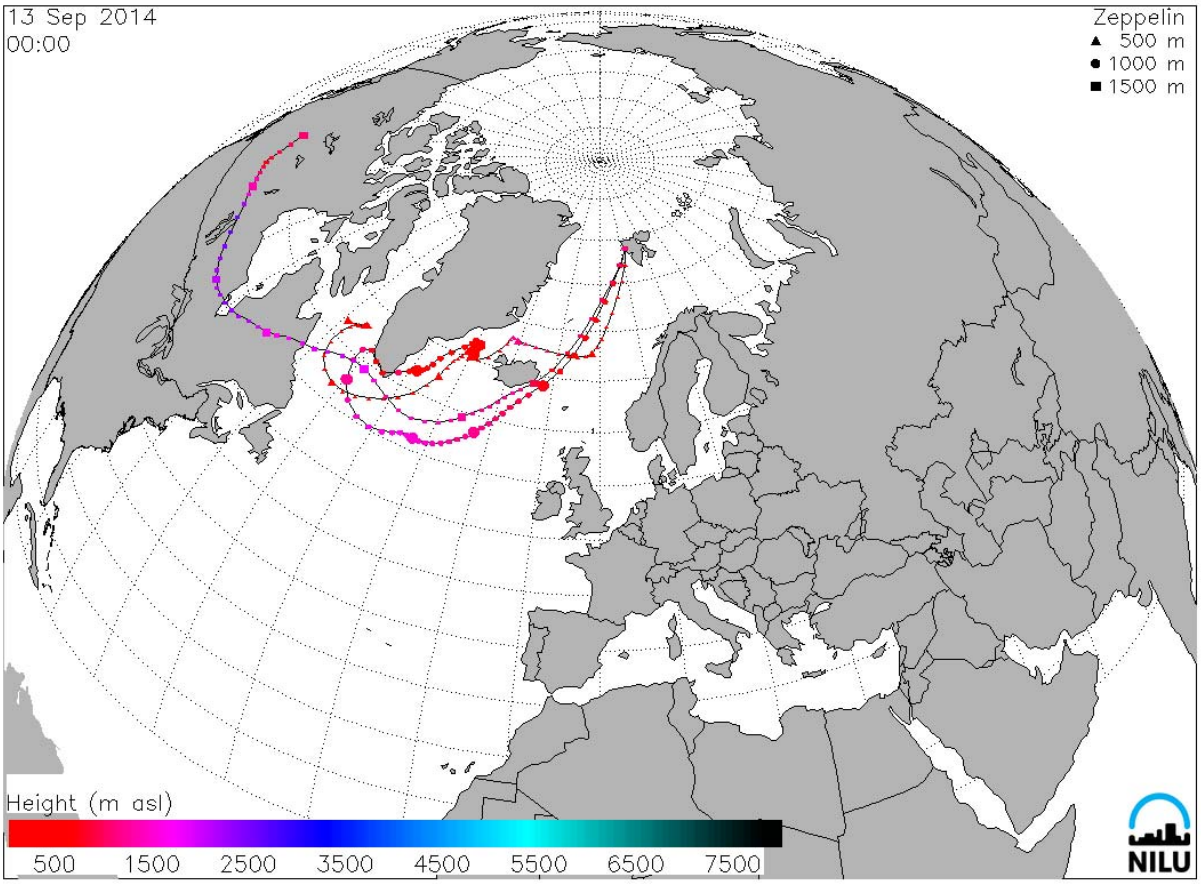


Figure 7: Air mass trajectories for Zeppelin mountain, Ny-Ålesund from 13.09.2014.

Average concentrations of SO_2 from 12 wind direction sectors at Nordpolhotellet are shown in Figure 8. The highest average concentrations occurs with wind from north-northeast and north, but also other sectors contribute.

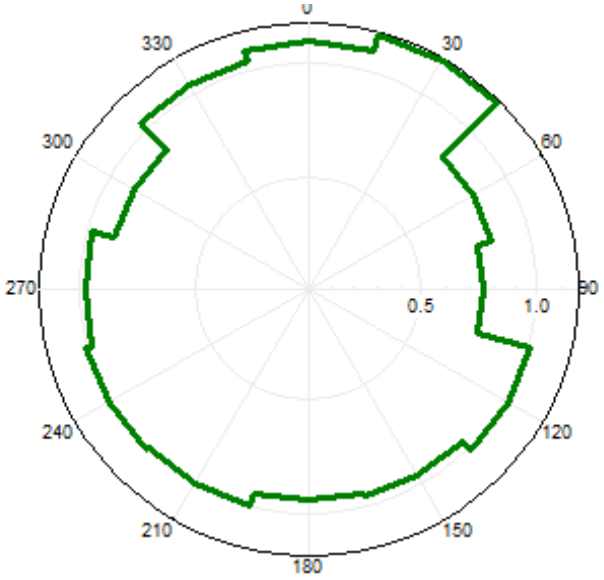


Figure 8: Average concentration of SO_2 (µg/m^3) with wind from 12 30 degrees sectors at Nordpolhotellet, June 2014 to December 2015.

4.5 Carbon monoxide and carbon dioxide

Hourly concentrations of carbon monoxide and carbon dioxide measured with the Picarro instrument at Nordpolhotellet are shown as time series plots in Appendix A, along with simultaneous measurements with the same method at Zeppelin mountain.

The measurement results for CO_2 show an annual variation with higher concentrations in the winter and lower in summer. The maximum hourly concentration at Nordpolhotellet was measured 06.12.2015 to 412 ppm and the minimum hourly concentration was measured 17.08.2015 to 386 ppm.

The CO-measurements at Nordpolhotellet show the highest concentrations and more variation in the hourly results in the spring, with the maximum measured 15.05.2015 to 448 ppb. The higher concentrations are measured during daytime and are most likely caused by human activity with snowmobiles in the vicinity of the measurement station. The data from Zeppelin mountain does not show these elevated daytime concentrations.

There was also registered an episode with elevated concentrations of CO on both measurement stations starting on 10.07.2015. This episode is most likely caused by long range transport of emissions from wildfires in North America. An air mass trajectory plot from 10.07.2015 illustrating this is shown in Figure 9.

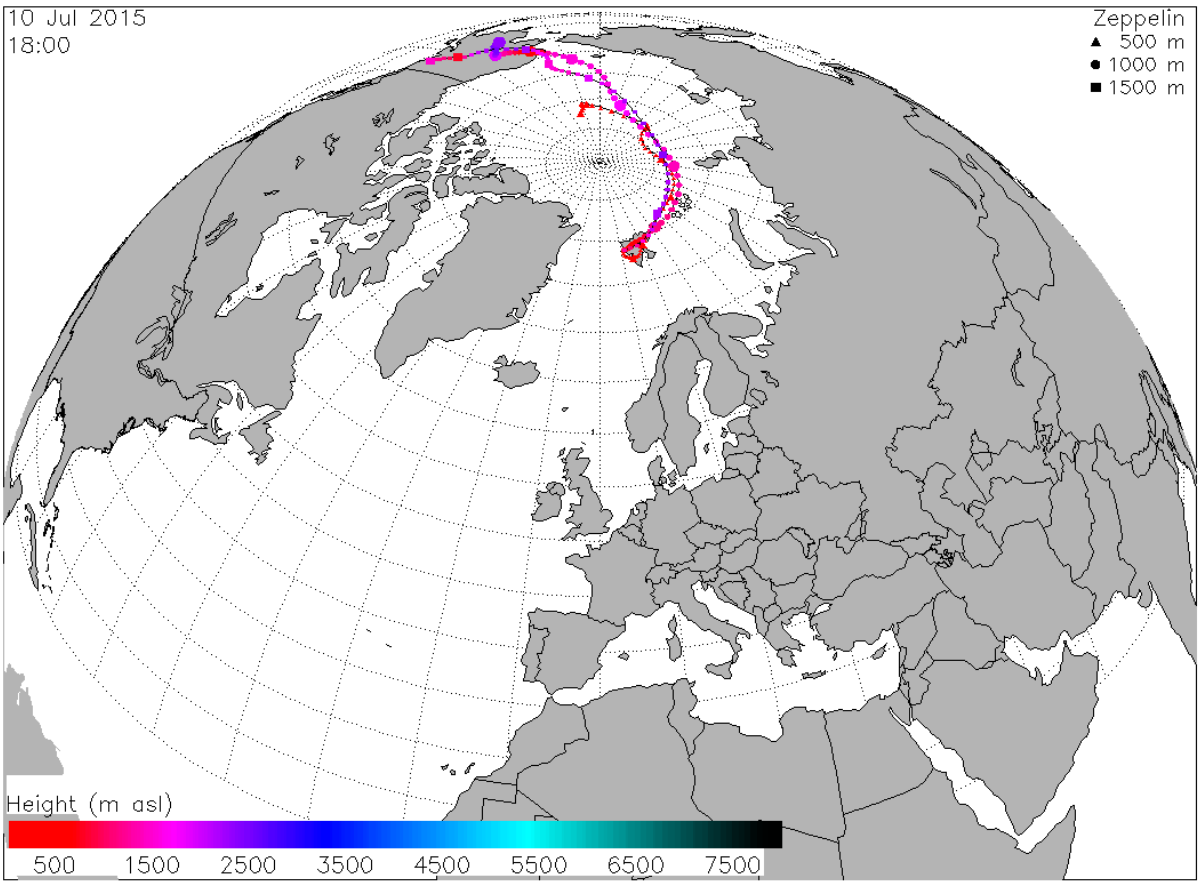


Figure 9: Air mass trajectories for Zeppelin mountain, Ny-Ålesund from 10.07.2015.

4.6 Filter sampling of inorganic compounds

Main inorganic compounds are measured with a filter sampler on a weekly basis. A summary of the results are given in Table 5.

Table 5: Monthly averages of main components in air measured at Nordpolhotellet June 2014 to December 2015. Concentrations are given in µg/m^3. Value is not given when data capture is below 75%.

Year	Month	SO_2	SO_4-S	Sum NO_3-N	Sum NH_4-N	Mg	Ca	K	Cl	Na
2014	June									
	July	0.06	0.14	0.04	0.19	0.07	0.11	0.02	0.31	0.24
	August	0.05	0.14	0.03	0.15	0.10	0.12	0.04	0.99	0.60
	September									
	October	0.95	0.34	0.02	0.12	0.12	0.16	0.04	0.70	0.80
	November	1.41	0.91	0.12	0.22	0.34	0.62	0.09	2.15	1.59
	December									
2015	January	0.59	0.31	0.04	0.07	0.12	0.07	0.05	1.38	0.94
	February	0.93	0.32	0.03	0.10	0.16	0.07	0.06	1.55	1.02
	March	0.18	0.32	0.03	0.09	0.13	0.06	0.05	1.31	0.91
	April	0.02	0.24	0.06	0.14	0.08	0.05	0.03	0.74	0.62
	May	0.02	0.16	0.13	0.20	0.04	0.05	0.02	0.29	0.24
	June	0.02	0.09	0.13	0.22	0.08	0.16	0.02	0.64	0.38
	July	0.02	0.10	0.09	0.25	0.07	0.15	0.02	0.53	0.33
	August	0.04	0.08	0.04	0.18	0.05	0.06	0.01	0.40	0.26
	September	0.01	0.07	0.03	0.07	0.07	0.06	0.02	0.83	0.50
	October	0.02	0.08	0.02	0.05	0.12	0.11	0.03	1.21	0.74
	November									
	December	0.15	0.15	0.02		0.13	0.11	0.05	1.70	1.00

The SO_2-concentrations measured with weekly filter sampling will differ from the concentrations measured with the continuous monitor described in section 4.4. This is expected. The concentrations are generally low and the filter sampling method is more accurate than the continuous monitor on low concentrations. The disadvantage of the filter sampling method compared to the continuous monitor is the time resolution. The method gives weekly results and no information on when episodes of higher concentrations occur within the period. The higher time resolution of results, as given by the continuous monitor, is especially important when studying impact from sources that are active for short periods of time and/or close to the measurement station.

The highest monthly average SO_2-concentration was measured in November 2014 to 1.44 µg/m^3. This month also had the highest monthly concentrations of magnesium, calcium, potassium, sodium and chloride. The nitrate and ammonium concentrations were also elevated, but for these components higher concentrations were found in the spring and summer months of 2015.

The week when the highest hourly concentration of SO_2 was detected with the continuous monitor, the filter sampler was unfortunately down.

5 Comparison with previous measurements

Monthly maximum SO_2-concentrations from 2008-2010 and 2014-2015 are presented in Figure 10 and monthly average SO_2-concentrations from the same periods are presented in Figure 11. The highest hourly concentrations occur in the period September 2014 to January 2015, which coincides with the volcanic eruption at Holuhraun, Iceland. Part from this period, the highest hourly concentrations seems to be in winter and early summer months, with the maximum in June 2009. Unfortunately there were some technical problems with the filter sampler in September and December 2014, so there is no monthly average SO_2 for these months.

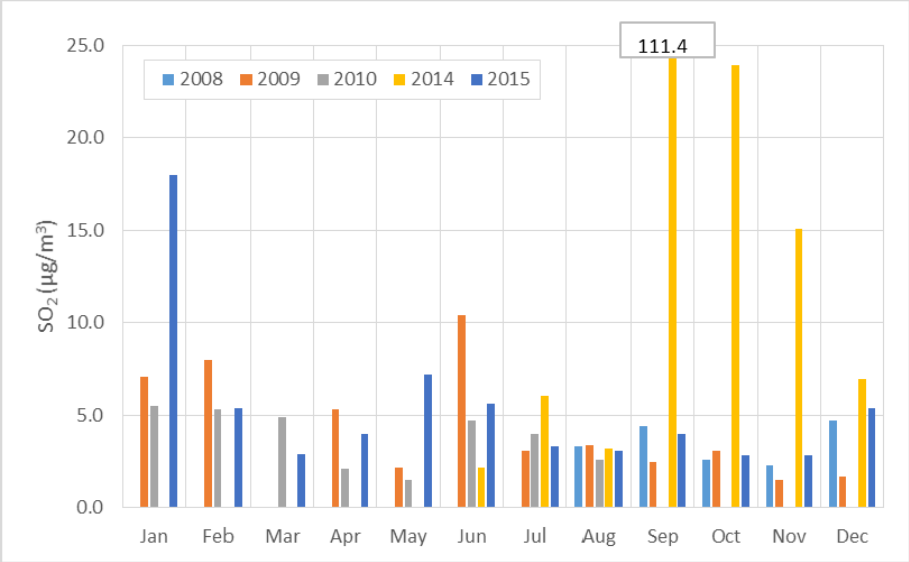


Figure 10: Monthly maximum hourly SO_2-concentrations from Nordpolhotellet for two periods: 2008-2010 and 2014-2015. Data from continuous monitor.

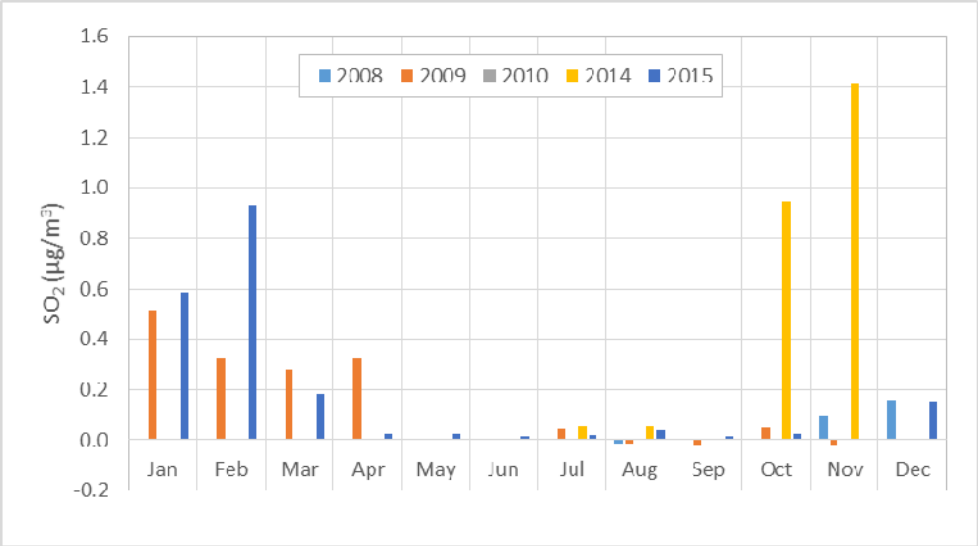


Figure 11: Monthly average SO_2-concentrations from Nordpolhotellet for two periods: 2008-2010 and 2014-2015. Data from filter sampler.

Monthly maximum NO_2-concentrations from 2008-2010 and 2014-2015 are presented in Figure 12 and monthly average NO_2-concentrations from the same periods are presented in Figure 13.

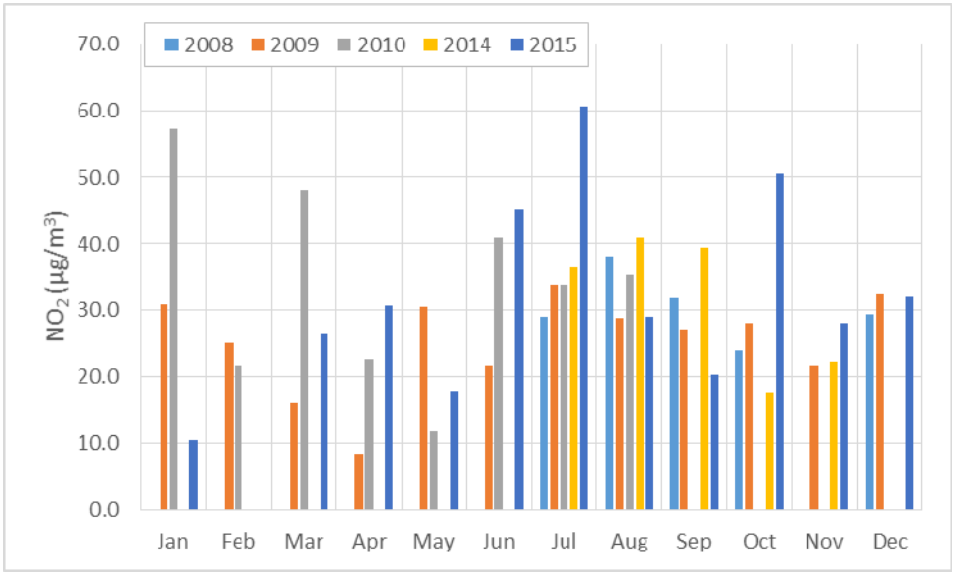


Figure 12: Monthly maximum hourly NO_2-concentrations from Nordpolhotellet for two periods: 2008-2010 and 2014-2015. Data from continuous monitor

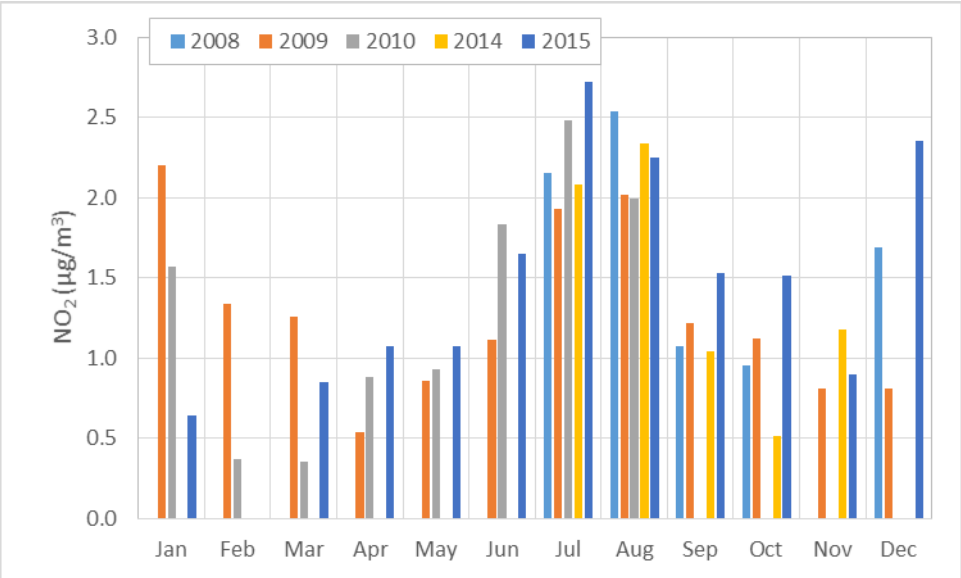


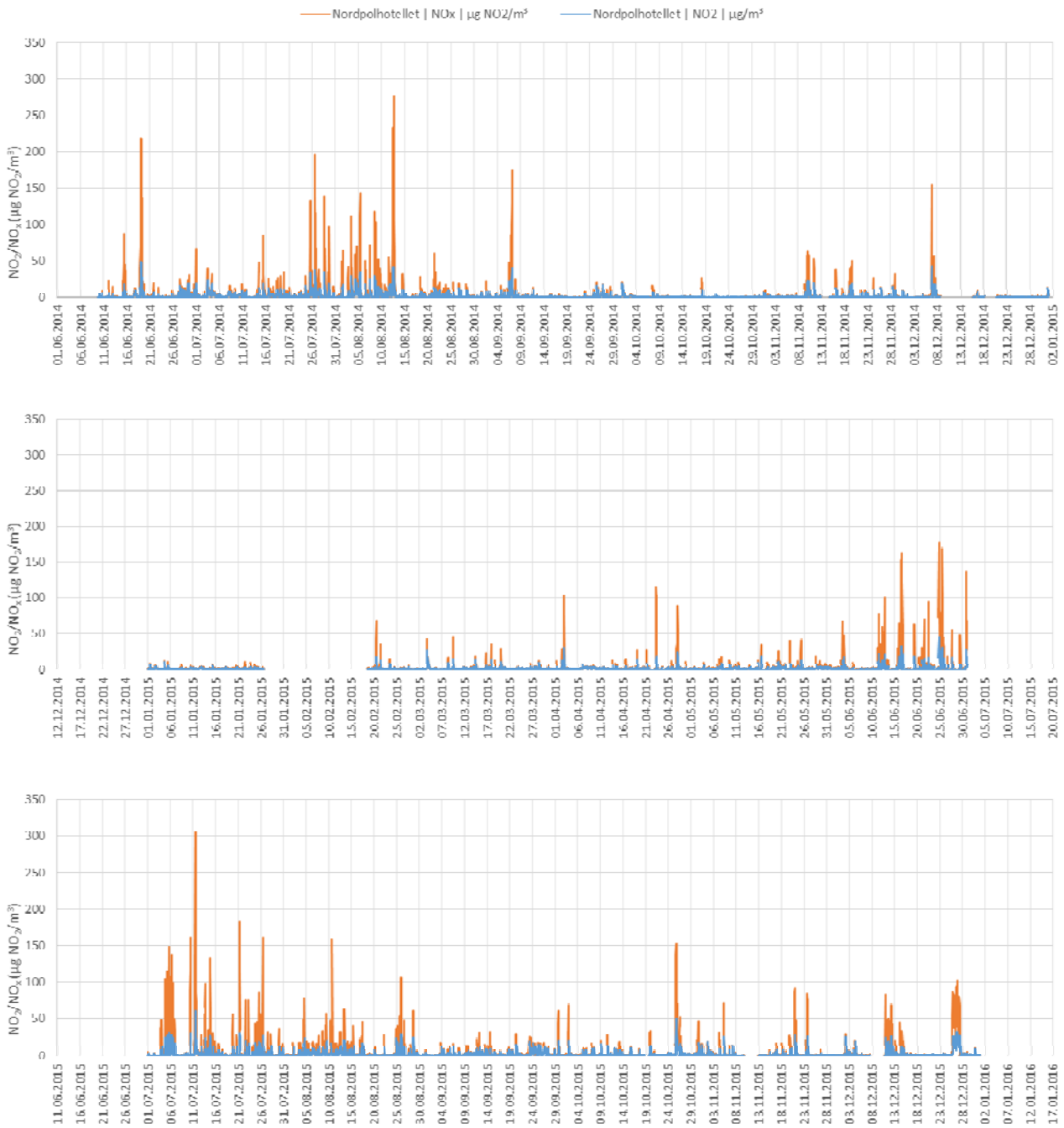
Figure 13: Monthly average NO_2-concentrations from Nordpolhotellet for two periods: 2008-2010 and 2014-2015. Data from continuous monitor

The highest hourly concentration was measured in July 2015. The monthly average NO_2 concentrations seems to have a yearly variation with higher averages in the summer months July and August, and the winter months December and January. The concentrations, both average and maximum in the autumn of 2015 seems to be a bit higher than measured the previous years.

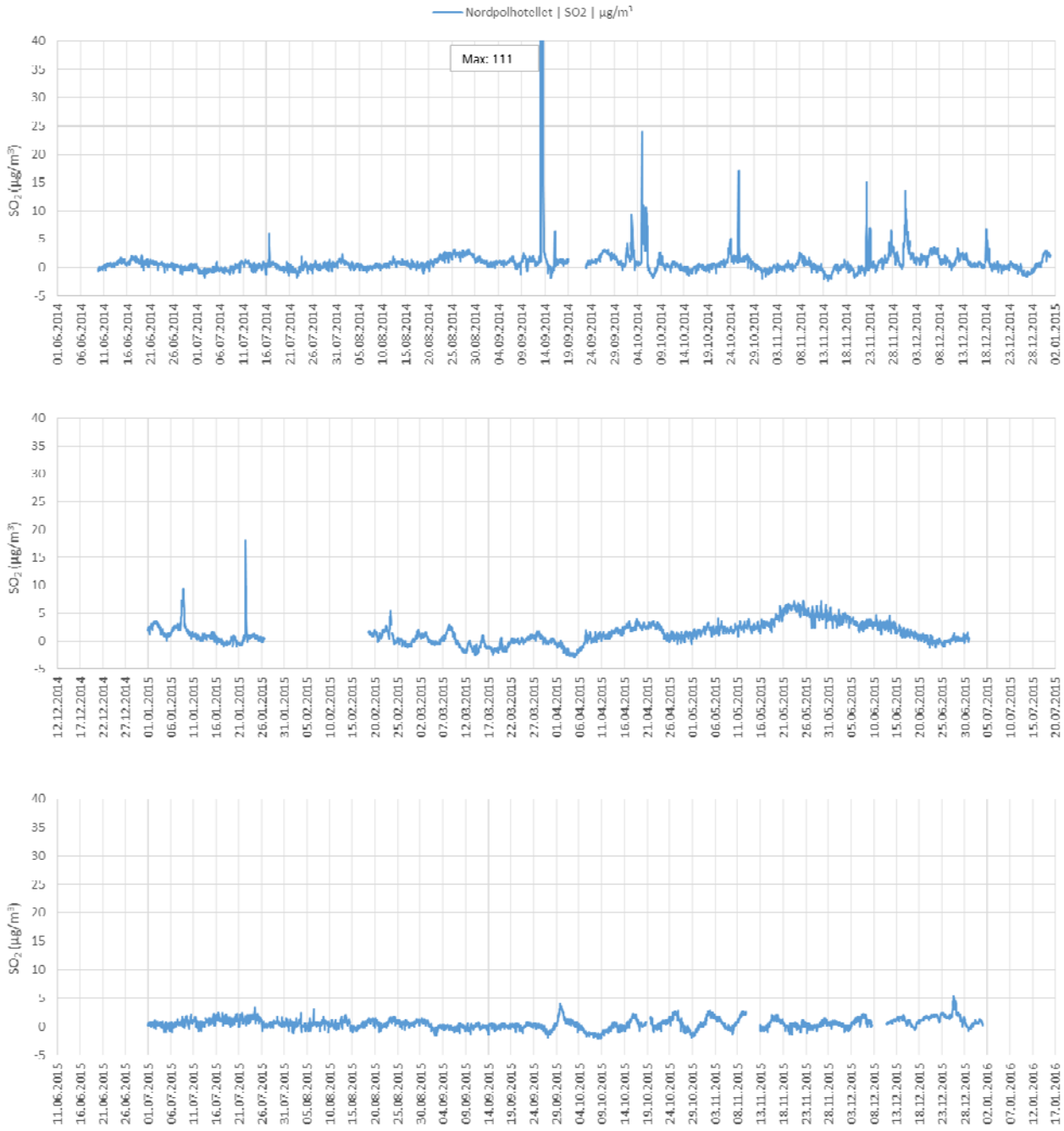
Appendix A

Measurement data

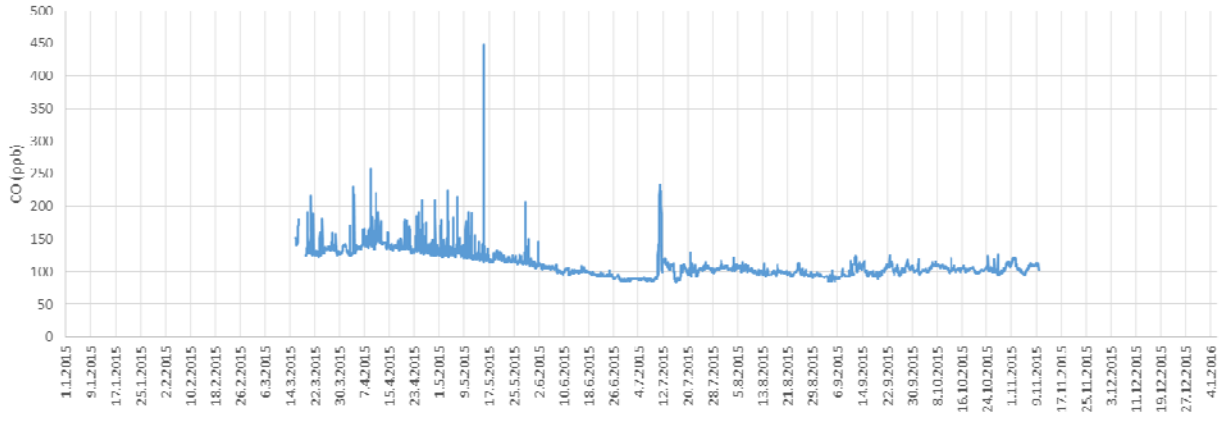
Hourly measurement data for NO_x and NO_2 at Nordpolhotellet, Ny Ålesund 10.6.2014-31.12.2015. NO_x as µg NO_2/m^3.



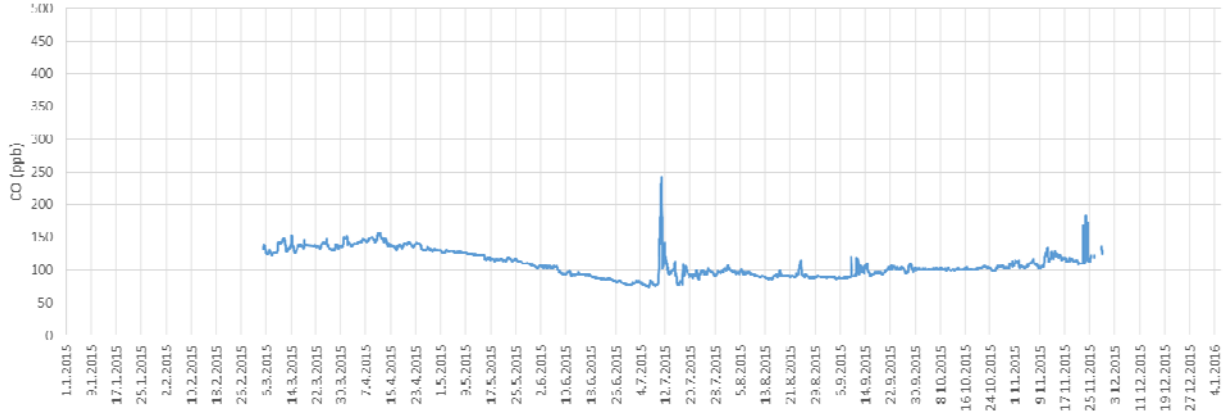
Hourly measurement data for SO_2 at Nordpolhotellet, Ny Ålesund 10.6.2014-31.12.2015.



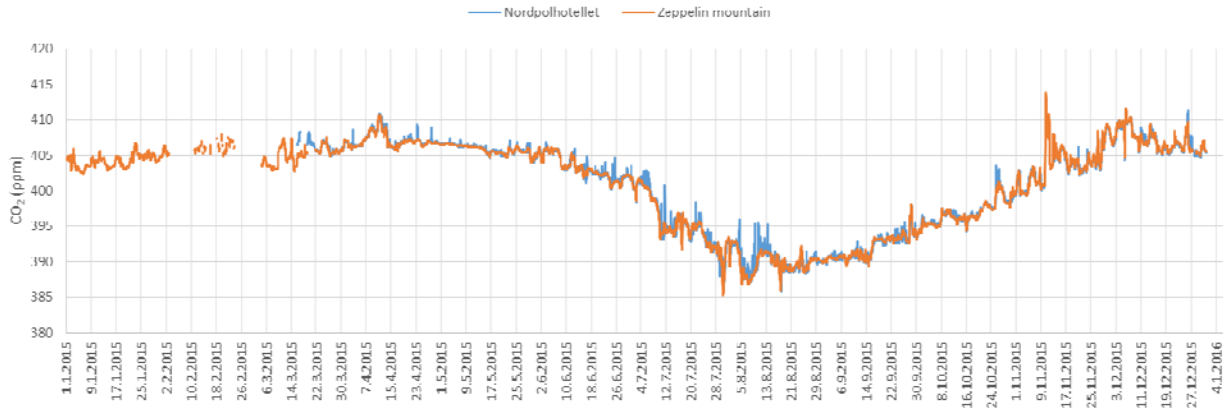
Hourly measurement data for CO at Nordpolhotellet, Ny Ålesund, 16.3.-31.12.2015.



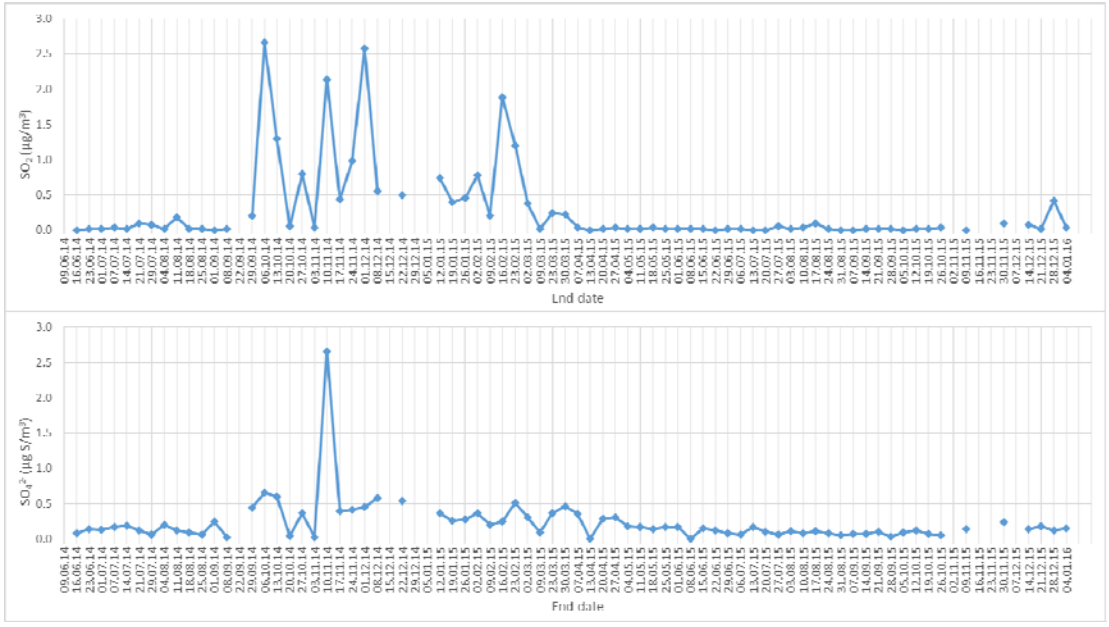
Hourly measurement data for CO at Zeppelin mountain, 16.3.-31.12.2015.

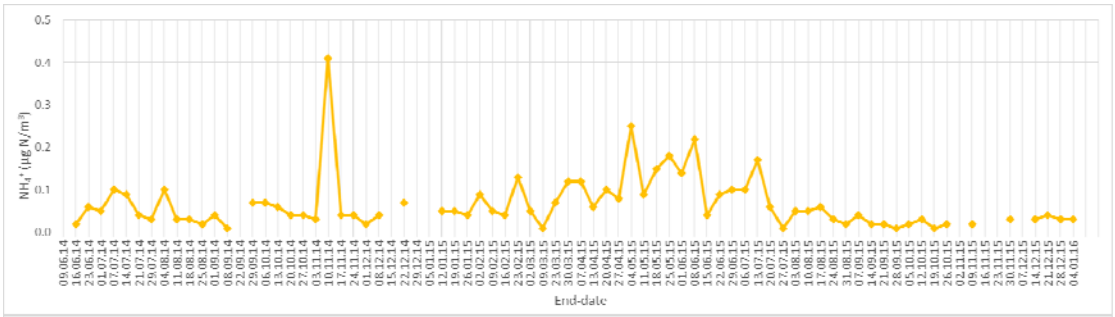


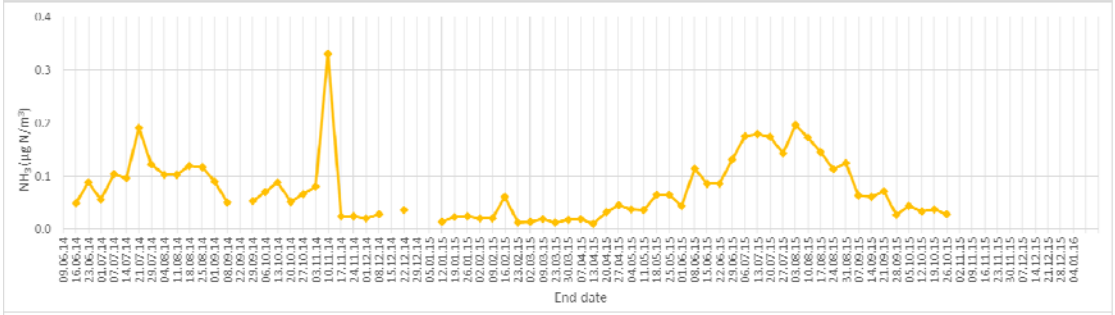
Hourly measurement data for CO_2 at Nordpolhotellet, Ny Ålesund and at Zeppelin mountain, 16.3.-31.12.2015.

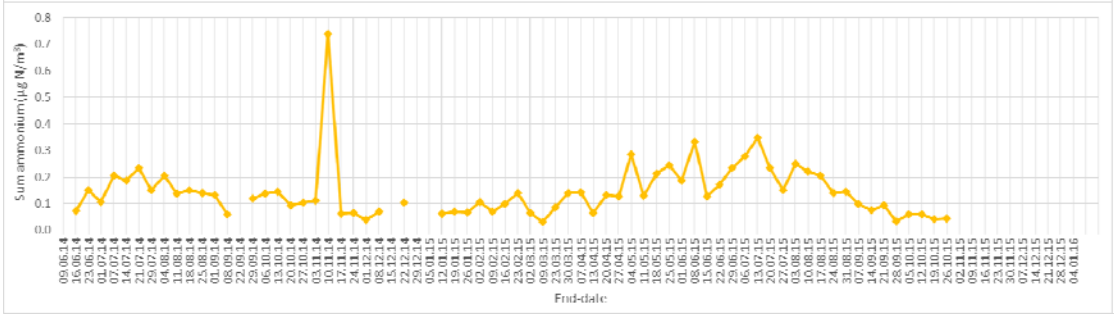


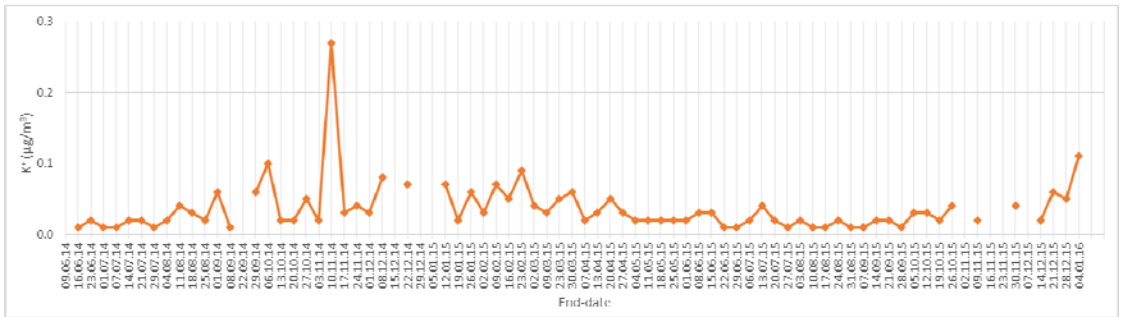
Analysis results of weekly filter sampling at Nordpolhotellet, Ny Ålesund 01.6.2014-31.12.2015.

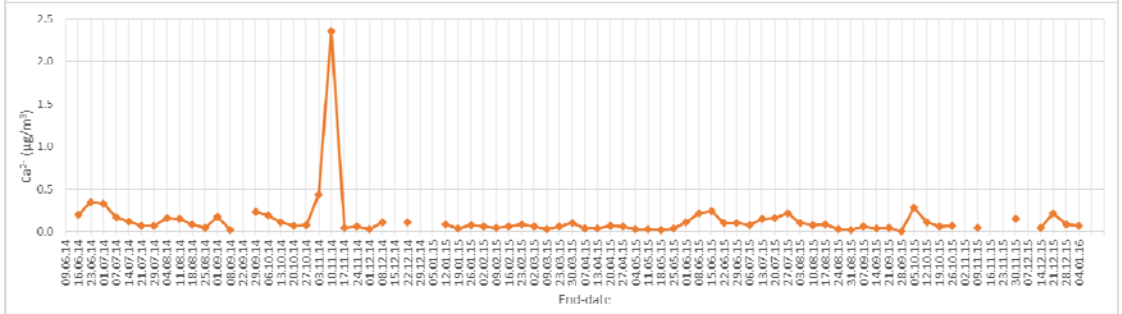


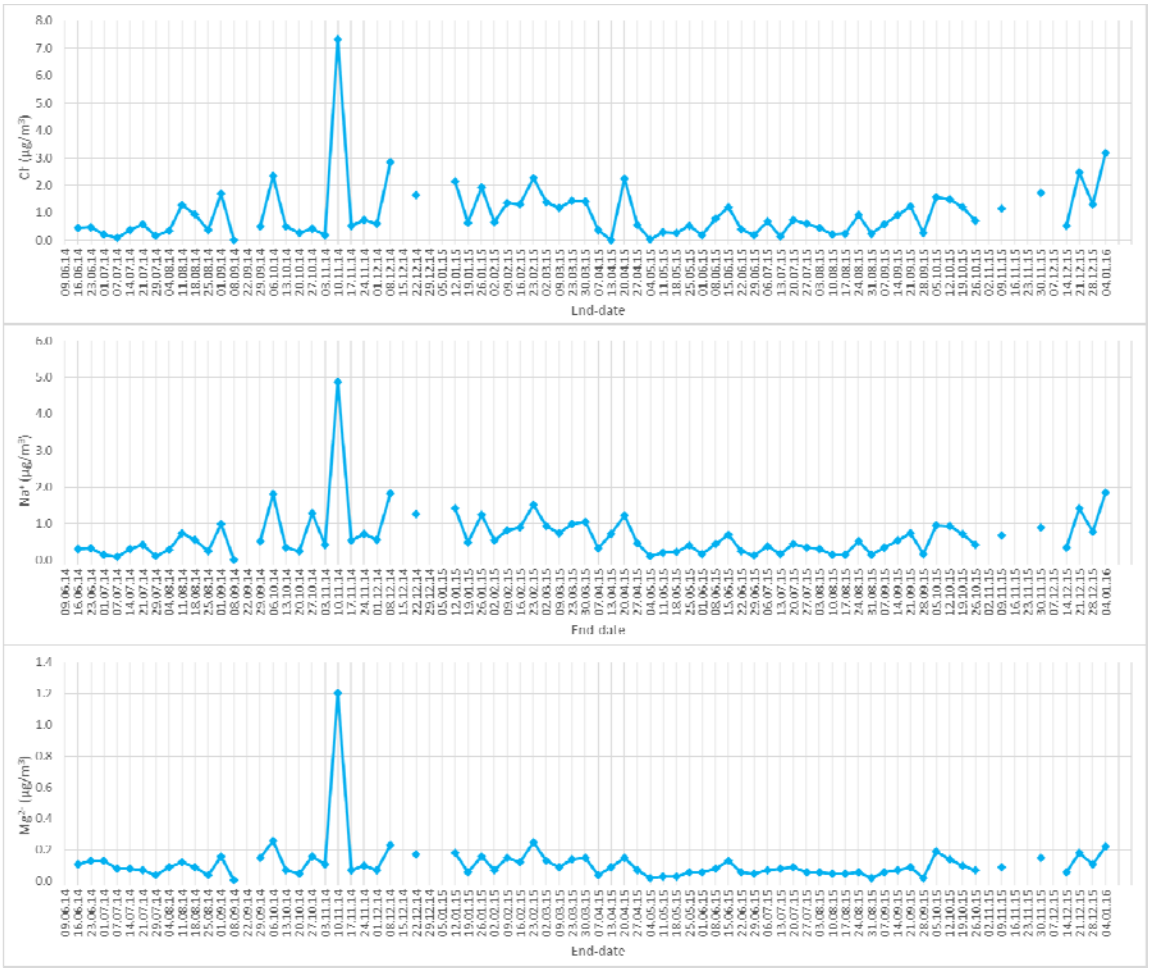

NH_4^+ (µg N/m³)
End-date


NH_3 (µg N/m³)
End date


Sum ammonium (µg N/m³)
End-date


K^+ (µg/m³)
End-date


Ca^{2+} (µg/m³)
End-date


Cl⁻ (µg/m³)
End-date
Na⁺ (µg/m³)
End date
Mg²⁺ (µg/m³)
End-date

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