Norsk institutt for luftforskning
Norwegian Institute for Air Research

Air Quality in Ny-Ålesund

Monitoring of Local Air Quality 2019 and 2020

Mona Johnsrud, Ove Hermansen, Radovan Krejci and Kjersti Tørnkvist

NILU report 28/2021

NILU report 28/2021	ISBN: 978-82-425-3066-0 ISSN: 2464-3327	CLASSIFICATION: A – Unclassified (open report)
DATE 14.12.2021	SIGNATURE OF RESPONSIBLE PERSON Ole-Anders Braathen (sign.), Viseadministrerende direktør	NUMBER OF PAGES 32
TITLE Air Quality in Ny-Ålesund Monitoring of Local Air Quality 2019 and 2020		PROJECT LEADER Ove Hermansen NILU PROJECT NO. 114076
AUTHOR(S) Mona Johnsrud[1)], Ove Hermansen[1)], Radovan Krejci[2)] and Kjersti Tørnkvist[1)] [1)] NILU [2)] Stockholm University		QUALITY CONTROLLER Leif Marsteen
REPORT PREPARED FOR Kings Bay AS, 9173 Ny-Ålesund		CONTRACT REF. Per Erik Hanevold

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 and sulfur dioxide, which indicates the power station and the harbour as possible sources. We also see single episodes of long-range transport of sulfur dioxide.

NORWEGIAN TITLE

Luftkvalitet i Ny-Ålesund. Målinger av lokal luftkvalitet 2019 og 2020.

KEYWORDS

Air quality | Long-range transport of air pollutants | Polar regions

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 og svoveldioksid, noe som peker på kraftstasjonen og havnen som mulige kilder. Vi ser også enkelte episoder med langtransport av svoveldioksid.

PUBLICATION TYPE: Digital document (pdf)

COVER PICTURE: Source: NILU

Citation: Johnsrud, M., Hermansen, O., Krejci, R., Tørnkvist, K. (2021). Air Quality in Ny-Ålesund. Monitoring of Local Air Quality 2019 and 2020. (NILU report 28/2021). Kjeller: NILU.

NILU's ISO Certifications: NS-EN ISO 9001 and NS-EN ISO 14001. NILU's Accreditation: NS-EN ISO/IEC 17025.

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 transported 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 observatory.

Funding from the Svalbard Environmental Protection Fund made it possible to start up the project again, with the same type of measurements in the same location, in 2014 and continuing through 2015, to gather data for looking into changes since the previous project.

In 2016, NILU financed the continuation of the measurement program.

From 2017, contribution from Kings Bay AS has made it possible to establish the measurement activities on a more permanent basis, in connection with the project «Limits of Acceptable Change».

The contribution from Kings Bay AS includes providing the facilities needed for the instrumentation. Operation of instruments and samplers were carried out by staff from the Norwegian Polar Institute at the Sverdrup station as part of the agreement between NPI and NILU. NILU was responsible for the monitoring program and contributed with the instrumentation and data quality control. The air samples were analysed at the chemical laboratory at NILU. The measurements of black carbon are done by Department of Environmental Science and Analytical Chemistry (ACES), Atmospheric Science Unit, Stockholm University.

In November 2018, the measurement station was moved from Nordpolhotellet to Transformatorbua, both locations near the centre of Ny-Ålesund.

This report summarises the monitoring activities in 2019 and 2020 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

Preface **3**

Summary **5**

1 Background **6**

2 Measurement program **6**

3 Measurement station **8**

4 Results **10**

4.1 Data capture 10

4.2 Meteorology 10

4.3 Nitrogen oxides 13

4.4 Sulfur dioxide (SO_2) 15

4.5 Soot, black carbon 17

4.6 Filter sampling of inorganic compounds 17

5 Comparison with data from Zeppelin observatory **19**

6 Comparison with previous years **20**

7 Deposition **24**

8 References **25**

Appendix A Measurement data **27**

Summary

NILU - Norwegian Institute for Air Research are monitoring air quality and meteorology at a measurement station 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.

Continuous measurements of air quality and meteorology in Ny-Ålesund were started at measurement station Nordpolhotellet in 2014. In November 2018 the station was replaced by a new station, Transformatorbua, located about 30 m to the north.

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 and sulfur dioxide were measured with wind from northern sectors, which indicates the power station and the harbour as possible sources. We have also seen brief episodes of elevated sulfur dioxide concentrations, most likely due to long-range transport of air pollution.

Total deposition of sulfur and nitrogen at Ny-Ålesund is estimated (Aas et al., 2020) to be lower than on the Norwegian mainland, but may have an impact on biology in this pristine arctic environment.

Air Quality in Ny-Ålesund
Monitoring of Local Air Quality 2019 and 2020

1 Background

NILU have been measuring air quality and meteorological parameters in Ny-Ålesund continuously since June 2014. First at the measurement station Nordpolhotellet up to November 2018, since then at a new station, Transformatorbua, about 30 m north of the old. A corresponding measurement program was also carried out at Nordpolhotellet in 2008-2010 (Hermansen et al., 2011). 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 from 2014-2015, 2016-2017 and 2018 are described in previous reports (Johnsrud et al., 2016, Johnsrud et al., 2018, Johnsrud et al. 2019).

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 in 2019 and 2020 is summarized in Table 1. The instruments used in the measurement program at Transformatorbua are shown in Figure 1. The Picarro instrument, measuring CO and CO_2, broke down in May 2018 and has not been replaced.

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

Compound	Description	Sampler	Time resolution
$NO/NO_2/NO_x$	Nitrous oxides	Continuous monitor, API	1 hour
SO_2	Sulfur dioxide	Continuous monitor, API	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, EK	1 week
Particles and soot	BC	PSAP	1 hour
Meteorology	Temperature, wind direction, wind speed, relative humidity, barometric pressure, precipitation intensity	Automatic weather station, Vaisala	1 hour

Figure 1: Interior of the measurement station Transformatorbua with instruments and other necessary equipment. (Photo: Ove Hermansen, NILU).

3 Measurement station

The measurement station, Transformatorbua, is located close to the center of Ny-Ålesund, slightly downwind, to provide representative measurements of the air quality in Ny-Ålesund. A picture of the measurement station is shown in Figure 2. Data from the Zeppelin observatory for advanced scientific measurements, south of Ny-Ålesund, are also included in some of the figures in this report. The location of both stations is shown on the map in Figure 3.

Figure 2: Measurement station Transformatorbua in Ny-Ålesund. The measurement station is the small red building to the left, by the flagpole. (Photo: Ove Hermansen, NILU).

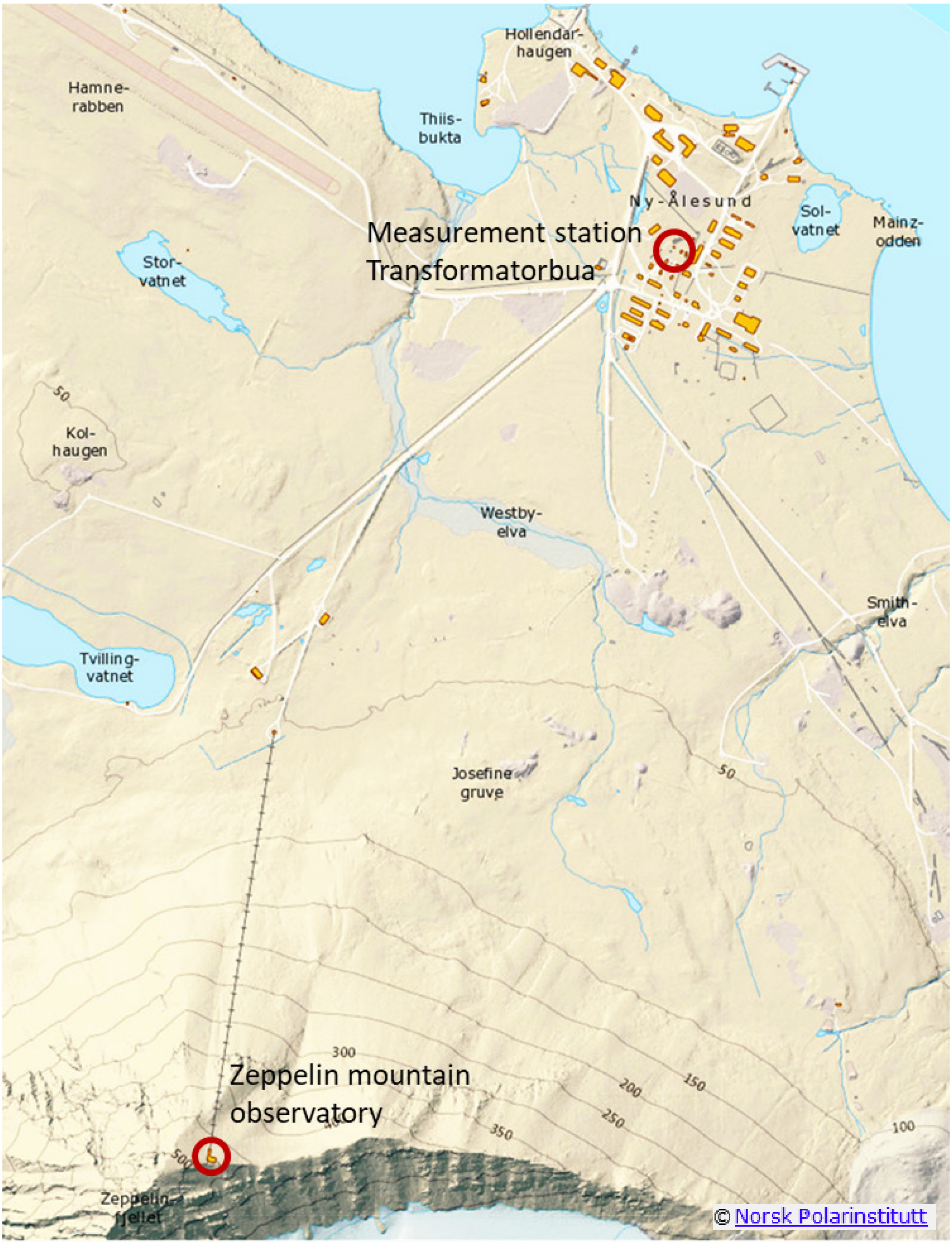


Figure 3: Location of the measurement station Transformatorbua and the Zeppelin mountain observatory in Ny-Ålesund.

4 Results

4.1 Data capture

For the calendar year 2019 and 2020, data capture for most measurements were in general good. Periods of missing data are listed in Table 2.

Table 2: Periods of missing data (24 or more consecutive hours) from Ny-Ålesund 2019 and 2020.

Compound/sampler	Periods missing data	Reason
$NO/NO_2/NO_x$, monitor	2020.06.05 07:00- 2020.06.17 19:00	Instrument failure
SO_2, monitor	2019.05.01 17:00-2019.05.02 18:00 2019.11.28 21:00-2019.11.30. 03:00 2020.01.23 12:00-2020.01.25 05:00 2020.02.02 16:00-2020.02.03 21:00 2020.02.17 22:00-2020.02.20 19:00 2020.02.27 17:00-2020.03.01 17:00	High indoor temperature affected instrument Instrument change
Main inorganic compounds, filter sampler	2019.02.18 07:00-2019.03.11 07:00 HNO^3, NH_4^+/NH_3, SO_2: 2019.11.04 07:00-2019.11.11 07:00 NO_3^-, NH_4^+, SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-: 2019.11.25 07:00-2019.12.02 07:00 All components: 2020.01.20 07:00-2020.01.27 07:00	Unspecified reason Unspecified reason Unspecified reason Mechanical problem
Particles and soot		
Meteorology: Temperature, relative humidity, barometric pressure, precipitation intensity	2019.03.27 09:00-2019.04.03 17:00	Instrument failure
Meteorology: Wind speed, wind direction	2019.03.27 09:00-2019.04.03 17:00	Instrument failure

4.2 Meteorology

Frequency of wind from 12 30-degrees sectors (wind roses) from Transformatorbua in Ny-Ålesund, and from Zeppelin mountain observatory, are presented for 2019 in Figure 4 and for 2020 in Figure 5. At Transformatorbua the prevailing wind direction is from east-southeast and the highest wind speeds are also registered from this sector. At Zeppelin mountain the prevailing wind direction is more from south and south-easterly directions than in Ny-Ålesund.

Comparing data from the two calendar years we find to a large extent the same pattern. At Transformatorbua there was a little less wind from south-southeast and slightly more from north-westerly directions in 2020 than in 2019.

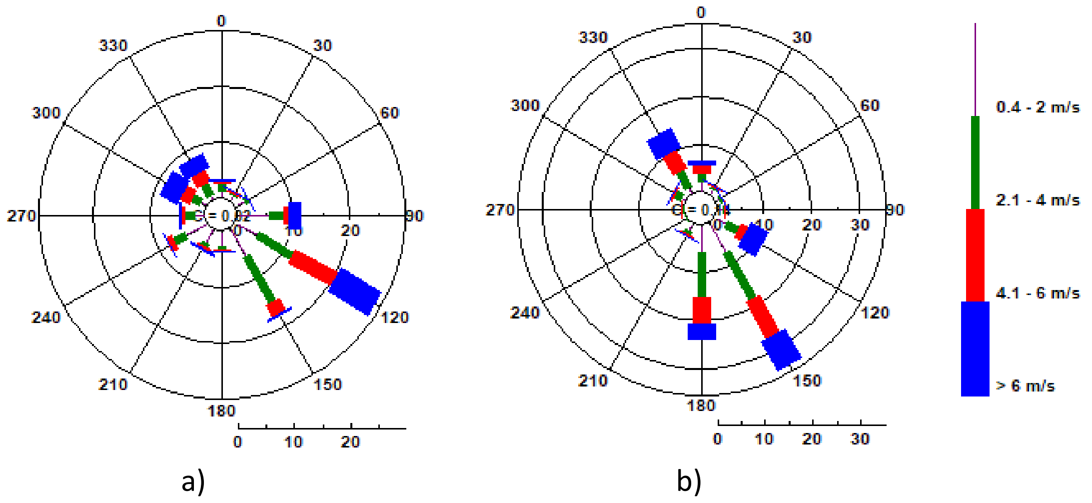


Figure 4: Wind roses from the measurement stations at Transformatorbua (a) and Zeppelin mountain observatory (b) from January to December 2019.

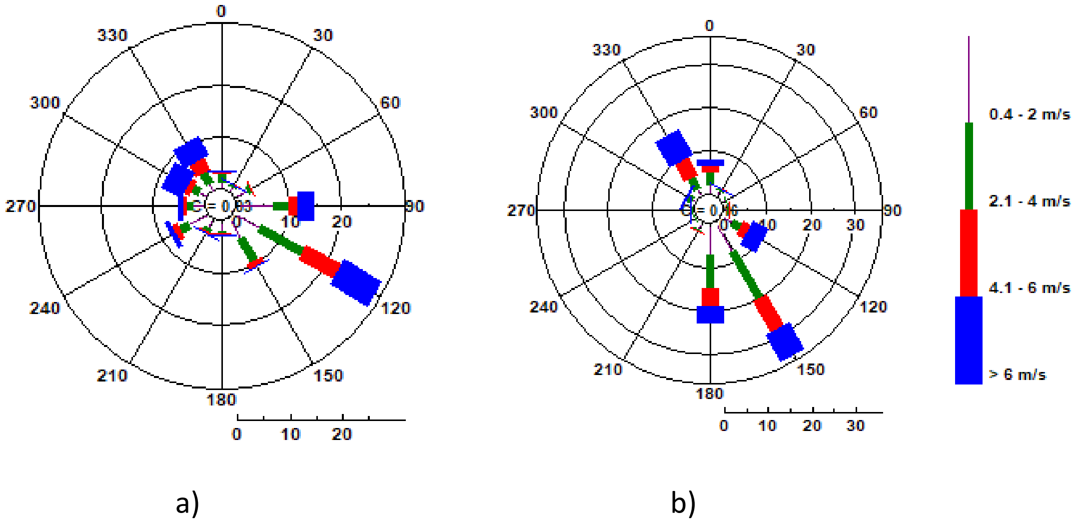


Figure 5: Wind roses from the measurement stations at Transformatorbua (a) and Zeppelin mountain observatory (b) from January to December 2020.

Monthly average, maximum and minimum temperature from Transformatorbua for the years 2019 and 2020 are presented in Figure 6. The figure also shows monthly average temperatures at the Zeppelin-mountain, as well as the monthly normal temperatures 1961-1990 and 1991-2020 from Ny-Ålesund, given by DNMI.

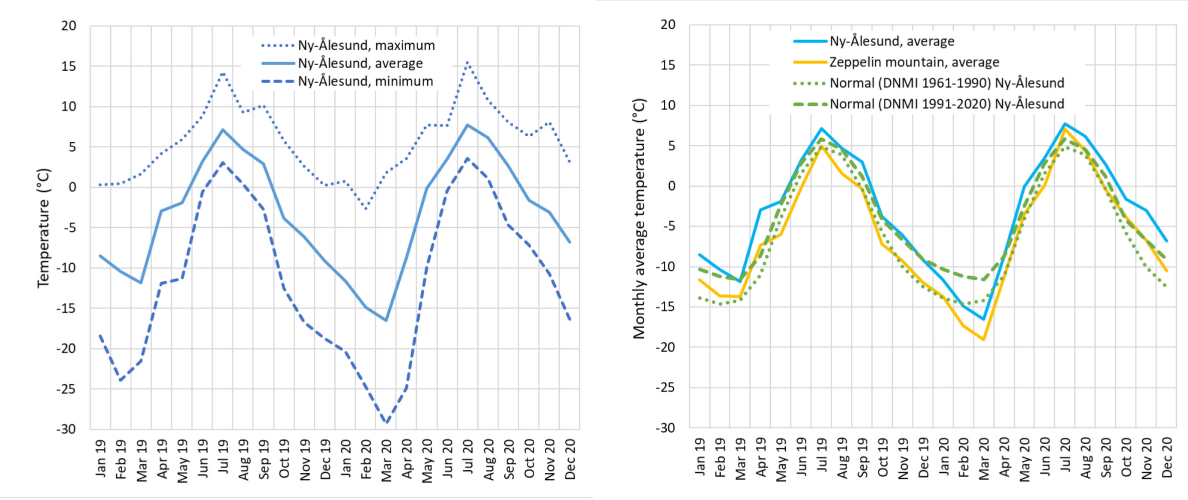


Figure 6: Monthly temperature statistics from Transformatorbua, Ny-Ålesund, and Zeppelin mountain observatory, from January 2019 to December 2020.

The temperatures at Zeppelin mountain and Transformatorbua show similar variation during the period, with the monthly average temperatures at the mountain some degrees colder than down in Ny-Ålesund. The highest temperatures registered in Ny-Ålesund during the two year period were in July 2020 with an average monthly temperature at 7.7 °C. March 2020 had the lowest monthly average, -16.5 °C, with the minimum, -29.3 °C, registered in the late evening of March 11. Even February 2020 was cold, and these were the first months since the continuous measurements started in 2014 that the monthly average temperatures were below the normal temperatures for Ny-Ålesund (1961-1990) given by DNMI.

For the rest of the period, the monthly average temperatures at Transformatorbua in Ny-Ålesund were higher than the normal temperatures given by DNMI. The largest deviation was found in April 2019, with 8˚C higher monthly average temperature than the normal from 1961-1990.

From 2021, new 30-year normal temperatures, 1991-2020, are given by DNMI to replace the normal from 1961-1990. The new normal average temperatures, shown in Figure 6, are higher than the previous for all months. We see that even with the new normal temperatures, the monthly averages registered in Ny-Ålesund are close to or above the normal most of the time. The exceptions are the very cold months of February and March 2020, and even March 2019 with a monthly average temperature slightly below the normal for 1991-2020.

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 monthly average and maximum values based on hourly measurements of NO_2 at Transformatorbua in Ny-Ålesund January 2019 to December 2020. Statistics are not calculated when monthly data coverage is below 75%.

Year	Month	Data coverage (%)	Average (µg/m³)	Maximum (µg/m³)	Time for maximum
2019	January	100	1.6	69.5	01.01.2019 02:00
	February	100	1.1	53.2	16.02.2019 23:00
	March	99	1.3	80.4	23.03.2019 23:00
	April	100	1.2	51.3	16.04.2019 17:00
	May	100	0.5	35.2	03.05.2019 11:00
	June	98	0.9	50.1	26.06.2019 08:00
	July	99	2.5	62.9	04.07.2019 09:00
	August	97	2.3	58.5	05.08.2019 15:00
	September	99	0.8	30.2	28.09.2019 20:00
	October	100	2.4	42.7	28.10.2019 14:00
	November	99	0.9	25.8	21.11.2019 04:00
	December	100	1.1	45.4	08.12.2019 19:00
2020	January	100	1.0	44.3	04.01.2020 00:00
	February	99	3.4	34.5	21.02.2020 06:00
	March	100	2.1	35.4	23.03.2020 15:00
	April	100	0.9	25.7	02.04.2020 02:00
	May	99	1.3	44.2	17.05.2020 14:00
	June	58	-	-	-
	July	100	1.6	88.4	31.07.2020 12:00
	August	99	2.2	66.4	04.08.2020 13:00
	September	100	1.0	35.1	11.09.2020 13:00
	October	99	2.2	54.7	17.10.2020 04:00
	November	99	2.7	53.7	24.11.2020 23:00
	December	100	0.8	37.6	11.12.2020 08:00
2019	Year	99	1.4	80.4	23.03.2019 23:00
2020	Year	96	1.9	88.4	31.07.2020 12:00

The NO_2-concentrations are generally very low compared to measurements in Norwegian cities and agglomerations. The highest monthly average was 3.4 µg/m^3 in February 2020.

There are some occurrences of short-term episodes where the concentrations are elevated compared to the general concentration level at the station. The highest hourly average in 2019, 80.4 µg/m^3, was registered on 23 March 2019 from 22.00-23.00. Observations from this episode are shown in Figure 7 with simultaneous SO_2-and wind direction-measurements. The figure shows that the maximum concentration occurred with wind from north. There were no registration of ships visiting the harbour at this time.

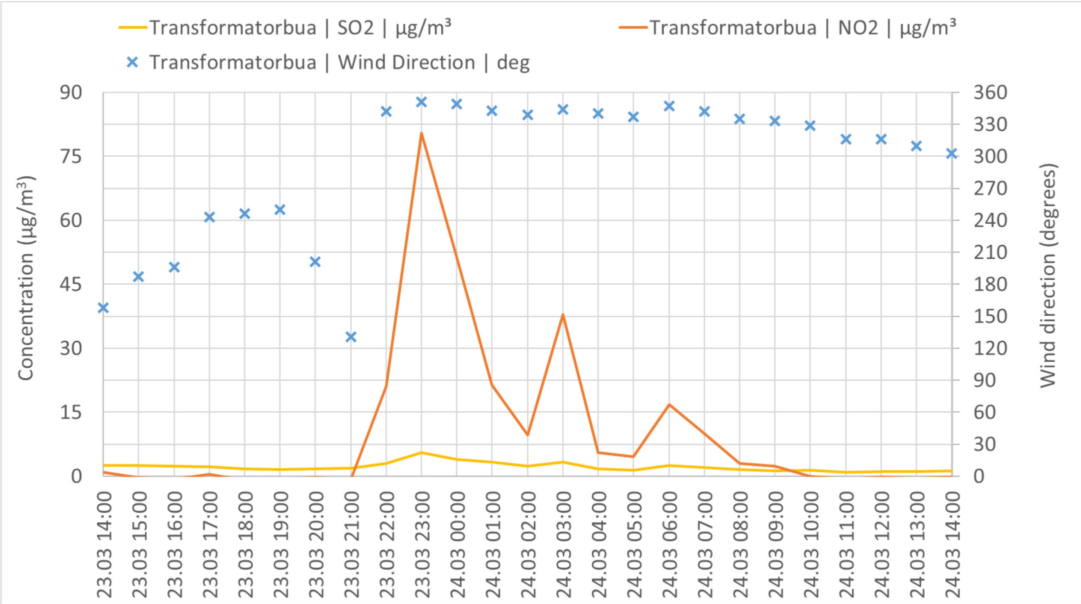


Figure 7: Hourly average concentrations of NO_2 and SO_2 and hourly registrations of wind direction at Transformatorbua, Ny-Ålesund on 23-24 March 2019.

Observed concentrations of NO_2 and SO_2 with simultaneous wind direction observations, presented in Figure 8, illustrates the period with the highest hourly NO_2-concentrations in 2020. The maximum hourly concentration, 88.4 µg/m^3 was registered on 31 July from 11.00-12.00. Even in this example, the highest NO_2-concentrations occur with wind from northern directions, suggesting the harbour and the power station as possible sources. The ship log for the period has, however, only registered one boat, visiting in the afternoon of 2 August.

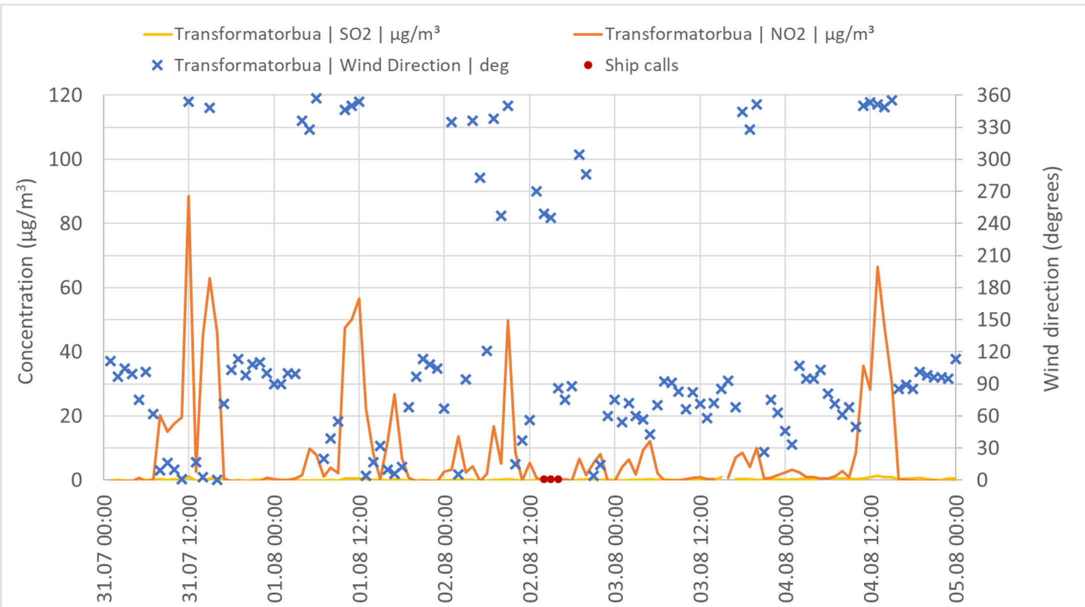


Figure 8: Hourly average concentrations of NO_2 and SO_2 and hourly registrations of wind direction at Transformatorbua, Ny-Ålesund on 31 July to 5 August 2020.

Average concentrations of NO_x and NO_2 from 12 wind direction sectors at Transformatorbua for the calendar years 2019 and 2020 are shown in Figure 9. The figure illustrates that the data from the two calendar years show the same pattern and that the highest average concentrations at Transformatorbua occurs with wind from north.

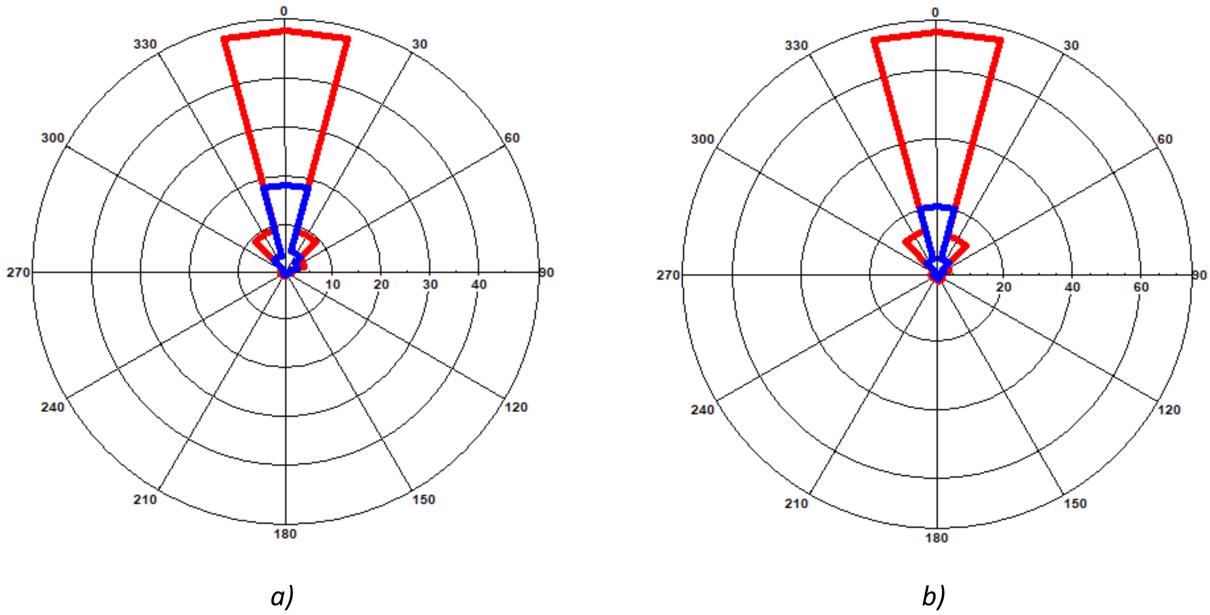


Figure 9: Average concentrations of NO_2 (µg/m^3) (in blue colour) and NO_x (µg/m^3) (in red colour) with wind from 12 30-degrees sectors at Transformatorbua, January to December 2019 a) and January to December 2020 b).

4.4 Sulfur dioxide (SO_2)

At Transformatorbua, SO_2 is measured with two different methods, a filter sampler giving weekly averages, and a continuous monitor giving hourly averages. The concentrations are generally low, and the filter sampling method is more accurate than the continuous monitor at such low concentrations. The disadvantage of the filter sampling method compared to the continuous monitor is the time resolution. The method gives no information on when episodes of higher concentrations occur within the weekly sampling period.

Most of the time the values are close to, or below, the detection limit of the continuous monitor, and the uncertainty of the method is high at this low concentration level. The method is, however, good at capturing episodes of higher concentrations, which is why the instrumentation is included in the program. 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.

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

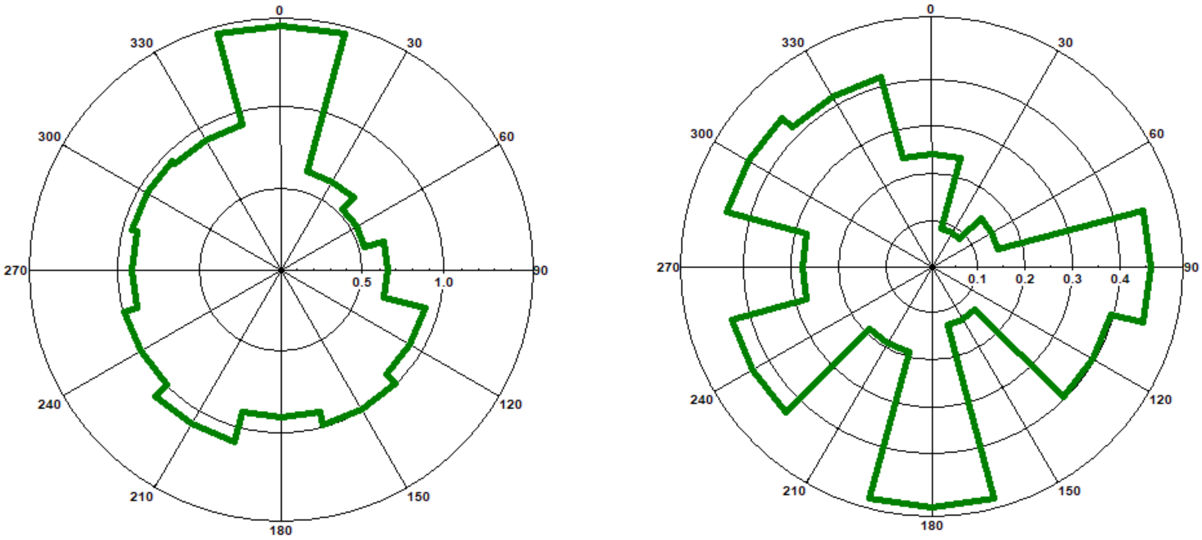
Table 4: Summary of monthly average values based on filter sampling and maximum hourly values based on monitor measurements of SO_2 at Transformatorbua January 2019 to December 2020. Statistics are not calculated when monthly data coverage is below 75%.

Year	Month	Data coverage (%) (monitor)	Maximum (µg/m³) (monitor)	Time for maximum (monitor)	Average (µg/m³) from filter sampler
2019	January	94	10.2	01.01.2019 01:00	0.49
	February	97	5.8	18.02.2019 11:00	-
	March	89	9.4	03.03.2019 19:00	-
	April	95	2.9	02.04.2019 14:00	0.11
	May	96	3.5	03.05.2019 11:00	0.18
	June	98	4.9	27.06.2019 20:00	0.02
	July	99	4.6	07.07.2019 14:00	0.03
	August	99	3.5	21.08.2019 02:00	0.03
	September	99	3.7	28.09.2019 20:00	0.03
	October	100	3.8	19.10.2019 05:00 28.10.2019 06:00	0.02
	November	95	4.9	11.11.2019 18:00	0.02
	December	95	2.8	11.12.2019 14:00 13.12.2019 04:00	0.15
2020	January	88	4.5	02.01.2020 22:00 02.01.2020 23:00	0.23
	February	72	-	-	0.37
	March	97	20.3	22.03.2020 15:00	0.46
	April	100	16.6	15.04.2020 13:00	0.06
	May	99	1.5	13.05.2020 07:00	0.02
	June	99	0.9	17.06.2020 22:00	0.04
	July	100	1.1	31.07.2020 12:00	0.07
	August	99	1.4	04.08.2020 13:00	0.05
	September	99	1.6	23.09.2020 22:00	0.02
	October	99	1.3	09.10.2020 17:00	0.06
	November	99	1.2	15.11.2020 07:00	0.05
	December	95	1.1	Several	0.06
2019	Year	96	10.2	01.01.2019 01:00	0.12
2020	Year	96	20.3	22.03.2020 15:00	0.12

The highest monthly average SO_2-concentrations based on the filter sampling results were found from mid-winter to spring with the maximum measured in January 2019 to 0.49 µg/m³.

The highest hourly SO_2-concentration was measured to 20.3 µg/m³ on 22 March 2020 from 14-15. At this time the wind was shifting from east to west-southwest. Trajectories show transport of air masses over Iceland reaching the station, indicating emissions from volcanic activity as a possible origin of the measured concentrations. Even over a couple of days in the middle of April 2020 elevated concentrations of SO_2 were observed, with a maximum of 16.5 µg/m³ on 15. April at 12-13. This time with wind from east. During this episode trajectories indicated air masses from western Russia, transported over the Murmansk region and Kola peninsula, indicating long-range transport of emissions from industries in this region as possible sources of the measured concentrations.

Average concentrations of SO2 from 12 wind direction sectors at Transformatorbua from January to December 2019 and from January to December 2020, based on hourly data from the continuous monitor, are shown in Figure 10. Mark the different axes in the two plots. In 2019 the highest average concentration came with wind from north. In 2020 the picture is not so clear and the values are more spread, but the concentrations are also lower, which increases the relative uncertainty of the values from the continuous monitor.



a) *b)*

Figure 10: Average concentration of SO_2 (µg/m^3) with wind from 12 30-degrees sectors at Transformatorbua from January to December 2019 a) and from January to December 2020 b). Note the different concentration axes in the two plots. 280471 23439

4.5 Soot, black carbon

Measurements of the light absorbing aerosol were carried out at Nordpolhotellet at Ny-Ålesund using custom-built Particle Soot Absorption Photometer (PSAP) [Bond et al., 1999].

The analysis of the data for the period 2019-2020 is not yet completed. The data will be included in the report for 2021.

4.6 Filter sampling of inorganic compounds

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

Table 5: Monthly and annual averages of main components in air measured at Transformatorbua in Ny-Ålesund in 2019 and 2020. Concentrations are given in µg/m³. When monthly data coverage is below 75% statistics are not calculated.

Year	Month	SO_2	SO_4-S	Sum NO_3-N	Sum NH_4-N	Mg	Ca	K	Cl	Na
2019	January	0.49	0.21	0.02	0.07	0.09	0.04	0.04	1.06	0.68
	February	-		-	-	-	-	-	-	-
	March	-		-	-	-	-	-	-	-
	April	0.11	0.23	0.03	0.11	0.11	0.32	0.04	0.93	0.65
	May	0.18	0.25	0.03	0.10	0.06	0.06	0.02	0.41	0.34
	June	0.02	0.10	0.03	0.07	0.06	0.06	0.01	0.44	0.32
	July	0.03	0.08	0.03	0.11	0.04	0.07	0.10	0.21	0.17
	August	0.03	0.06	0.02	0.13	0.04	0.05	0.01	0.27	0.18
	September	0.03	0.09	0.01	0.09	0.08	0.05	0.06	0.95	0.60
	October	0.02	0.09	0.02	0.07	0.08	0.12	0.02	0.68	0.44
	November	0.02	0.05	-	-	0.02	0.02	0.01	0.35	0.20
	December	0.15	0.16	0.02	0.04	0.08	0.10	0.02	0.76	0.52
2020	January	0.23	0.12	0.02	0.04	0.07	0.10	0.02	0.50	0.25
	February	0.37	0.03	0.02	0.04	0.02	0.01	0.01	0.17	0.04
	March	0.46	0.21	0.03	0.09	0.12	0.05	0.05	1.00	0.72
	April	0.06	0.22	0.03	0.09	0.14	0.10	0.06	1.41	0.92
	May	0.02	0.17	0.03	0.10	0.09	0.13	0.03	0.72	0.50
	June	0.04	0.08	0.02	0.05	0.06	0.06	0.01	0.65	0.42
	July	0.07	0.22	0.03	0.17	0.08	0.16	0.02	0.54	0.40
	August	0.05	0.12	0.03	0.10	0.06	0.10	0.01	0.60	0.39
	September	0.02	0.07	0.02	0.07	0.05	0.06	0.02	0.65	0.43
	October	0.06	0.09	0.02	0.07	0.08	0.11	0.04	0.66	0.40
	November	0.05	0.09	0.02	0.04	0.12	0.14	0.03	1.49	0.85
	December	0.06	0.09	0.02	0.04	0.08	0.04	0.02	1.04	0.62
2019	Year 2019	0.12	0.15	0.02	0.08	0.07	0.09	0.04	0.65	0.45
2020	Year 2020	0.12	0.13	0.03	0.08	0.08	0.09	0.03	0.79	0.50

The SO_2-concentrations are discussed further in chapter 4.4.

The highest monthly average sulphate concentrations were measured during the winter and spring months January to May, with the maximum in May 2019. In 2020 elevated sulphate concentrations were observed even in July. Slightly higher monthly concentrations of nitrates were found in the spring and summer months of March to August. Sum ammonia was found to be highest in July 2020. April 2020 had the highest concentrations of magnesium and sodium. Even the chloride concentrations were elevated this month, but with a slightly higher monthly average in November, later the same year. The highest monthly average calcium concentration was found in April 2019 and the highest monthly average potassium concentration was found in July the same year.

5 Comparison with data from Zeppelin observatory

Main inorganic compounds in air are also measured at the nearby observatory on Zeppelin mountain. One of the main purposes of the project is to detect possible influences of the activities in Ny-Ålesund on measurements at Zeppelin observatory. With the low concentration levels measured at both sites, more extensive data analysis is needed to conclude on this.

Annual averages of main components in air measured at Zeppelin observatory and at Transformatorbua down in Ny-Ålesund in 2019 and 2020 are presented in Figure 11.

At both locations the measured concentrations are very low and close to the detection limit of the method. The station in Ny-Ålesund is closer to the sea and the concentrations of the sea-salt components are higher at this location.

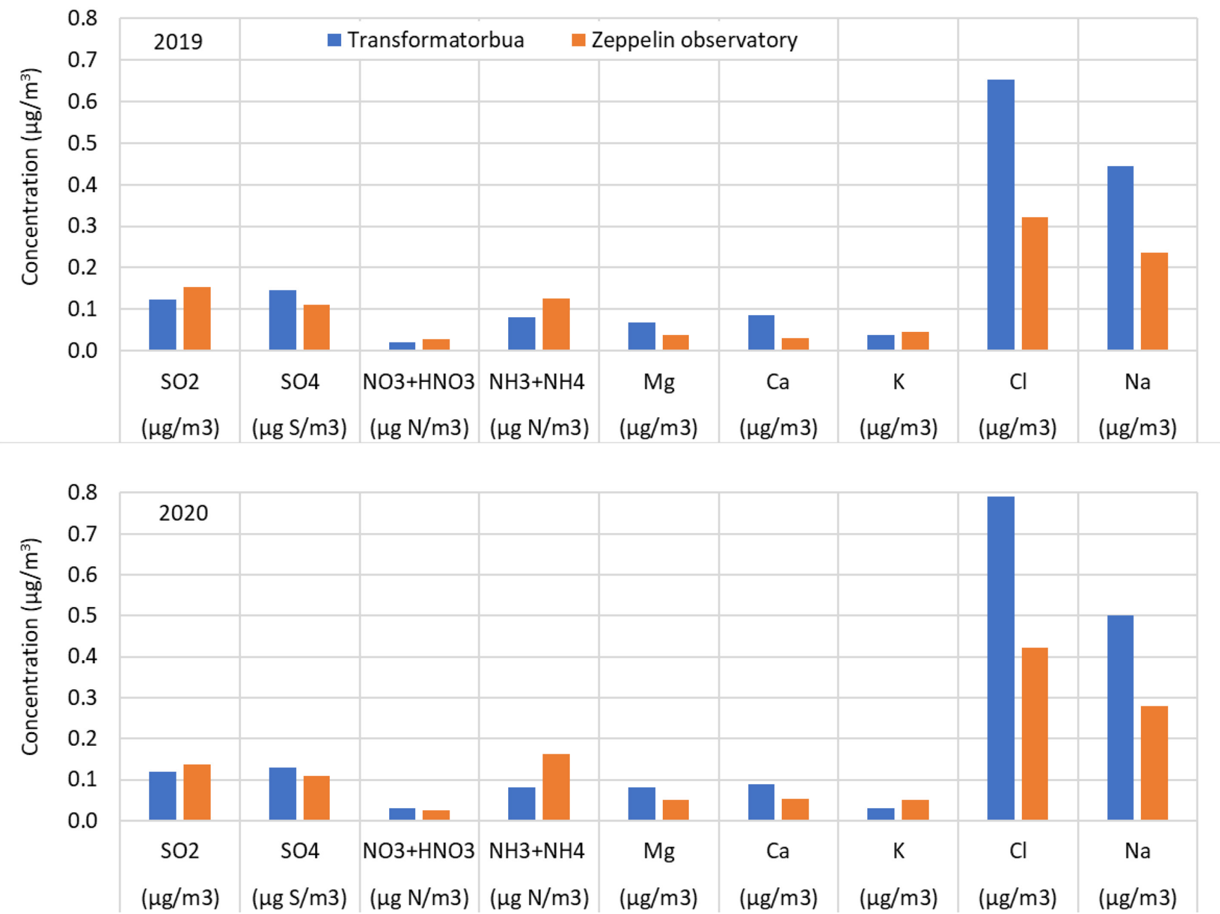


Figure 11: Annual average concentrations of main inorganic components in air measured at Transformatorbua and Zeppelin observatory in 2019 and 2020.

6 Comparison with previous years

Monthly maximum SO_2-concentrations from 2008 to 2010 and 2014 to 2020 are presented in Figure 12, and monthly average SO_2-concentrations from the same years are presented in Figure 13. The highest hourly concentrations occur in the period September 2014 to January 2015, which coincides with the volcanic eruption at Holuhraun, Iceland. In 2020 we found two episodes, the first in March, the second in April, when the maximum hourly concentrations were high, and up to the same level as found during the volcanic eruption in 2014-2015. Trajectories show transport of air masses over Iceland during the episode in March and over north-western Russia and the Kola peninsula during the episode in April, both indicating long-range transport of air pollution as probable explanations for the measured concentrations. The following months of 2020 the maximum hourly SO_2-concentrations were very low compared to previous years. The previous years we have also seen episodes of elevated hourly concentrations during the summer period, but these were lower than in winter.

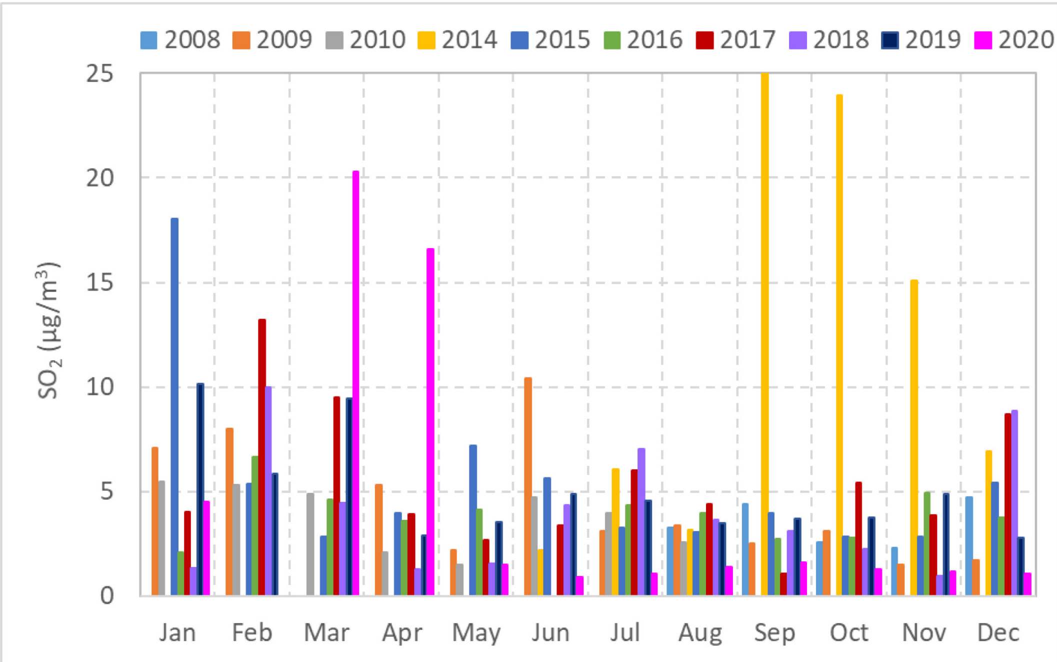


Figure 12: Monthly maximum hourly SO_2-concentrations at Nordpolhotellet for 2008-2010 and 2014-2018 and at Transformatorbua for 2019 and 2020. Data from continuous monitor.

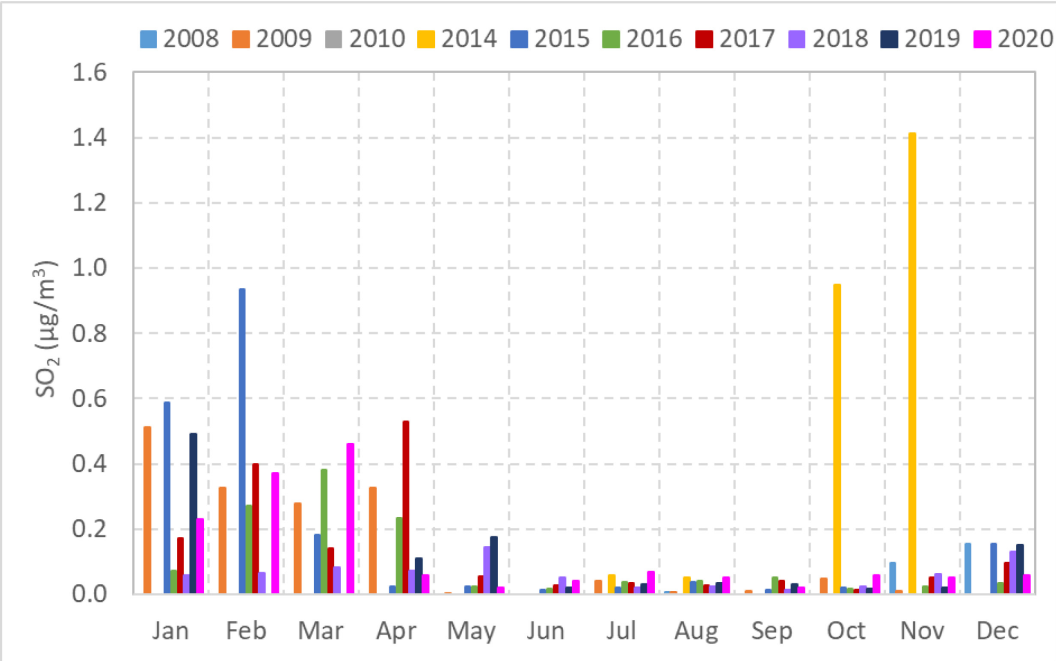


Figure 13: Monthly average SO_2-concentrations at Nordpolhotellet 2008-2010 and 2014-2018 and from Transformatorbua for 2019 and 2020. Data from filter sampler.

Except for the period when the measurements were influenced by the volcanic eruptions, higher monthly average SO_2-concentrations are more likely to be found during the months December to April, even in May, while the average concentrations are generally lower during the summer and autumn months June to November. The monthly average in January 2019 and in March 2020 is a bit high compared to the years before, but broadly the SO_2 monthly averages from 2019 and 2020 show the same variation as results from previous years.

Monthly maximum NO_2-concentrations from 2008-2010 and 2014-2020 are presented in Figure 14 and monthly average NO_2-concentrations from the same period are presented in Figure 15.

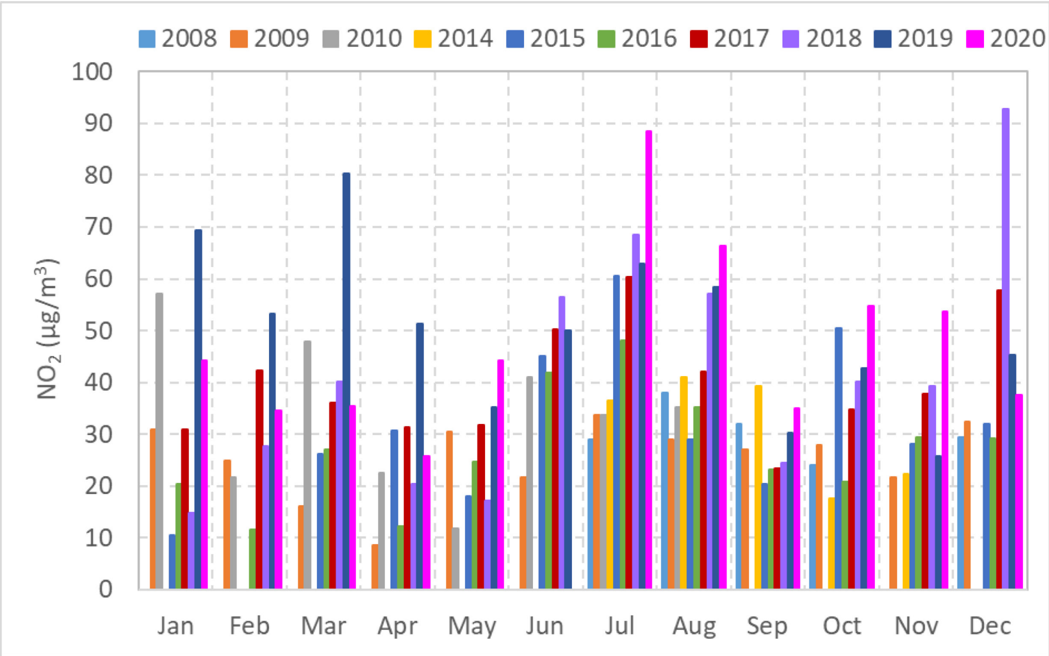


Figure 14: Monthly maximum hourly NO_2-concentrations at Nordpolhotellet for 2008-2010 and 2014-2018 and at Transformatorbua for December 2018 to December 2020. Data from continuous monitor.

Following the relocation of the measurement station from Nordpolhotellet to Transformatorbua, effective from December 2018, we see a general tendency for increased maximum hourly NO_2-concentrations. The average concentrations from twelve wind direction sectors in Figure 9 show that the source of the measured NO_2-concentrations are located north of the measurement station. The new location is about thirty meters north of the old, and the increase in short term concentrations measured may indicate that it is better suited for capturing the maximum concentrations from the local emissions in Ny-Ålesund. There may also be other explanations, for example increased emissions and/or different meteorological conditions.

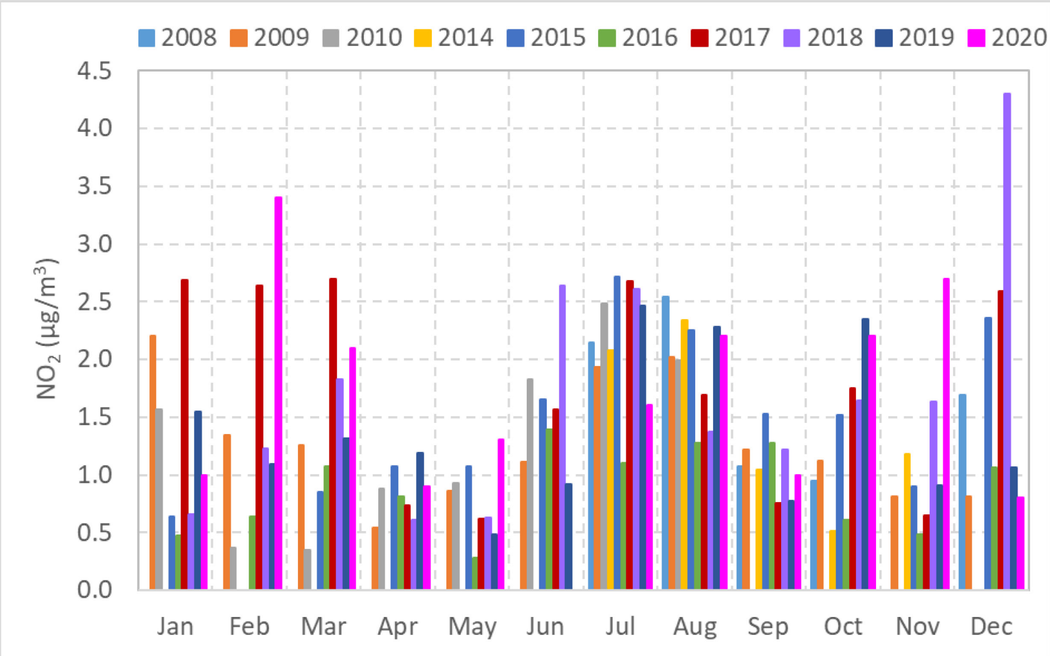


Figure 15: Monthly average NO_2-concentrations at Nordpolhotellet for 2008-2010 and 2014-2018 and at Transformatorbua for December 2018 to December 2020. Data from continuous monitor.

The monthly average NO_2 concentrations show an annual variation with higher averages in the summer months June to August, lower in April, May and September and often higher but more varied in the winter months October to March. For example in 2020 we see relatively high monthly NO_2-averages in February and November, to a less degree in March, compared to the same month previous years.

The measurements in December 2018 show a clearly elevated monthly average. There may be several explanations for the elevated concentrations. The occurrence of wind from 12 30° sectors, as given in Figure 16, show a higher frequency of wind from north-northwest in December 2018 compared to the same month other years. This may be one of the explanations for the elevated concentrations. The increased concentrations in December 2018 may also be explained by increased human presence and activity level in Ny-Ålesund in connection with several rocket launches. Starting from mid-November 2018 the measurements are done at the new location, Transformatorbua. There was a concern that the elevated concentrations might be a result of the new station being more exposed to the emissions. Even though we see a tendency to higher short time averages at the new station location, we don't find it likely that this is the single explanation for the elevated monthly average of NO_2 measured in December 2018.

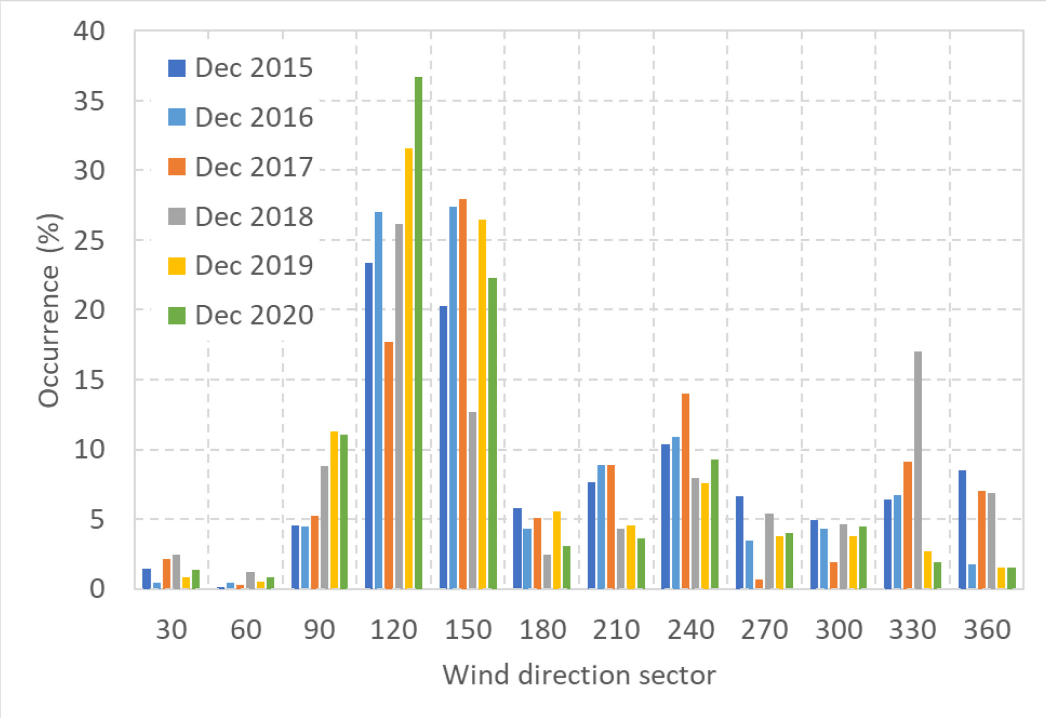


Figure 16: Frequency (% of the time) of wind from 12 30-degrees wind direction sectors at Nordpolhotellet for December 2015 to 2017 and from Transformatorbua for December 2018 to 2020.

7 Deposition

Aas et.al. (2020) present estimates of the total dry deposition of sulfur and nitrogen compounds and the measured wet deposition in the growing season from May to October (summer) and winter months from January to April and November to December, as shown in Figure 17. The values given for Ny-Ålesund consist of estimated values for dry deposition, based on the concentrations measured at the Zeppelin observatory, and wet deposition measured at the Sverdrup station in Ny-Ålesund. The figures illustrate the decrease in deposition load moving from Birkenesobservatoriet in southern Norway to Svalbard in the far north.

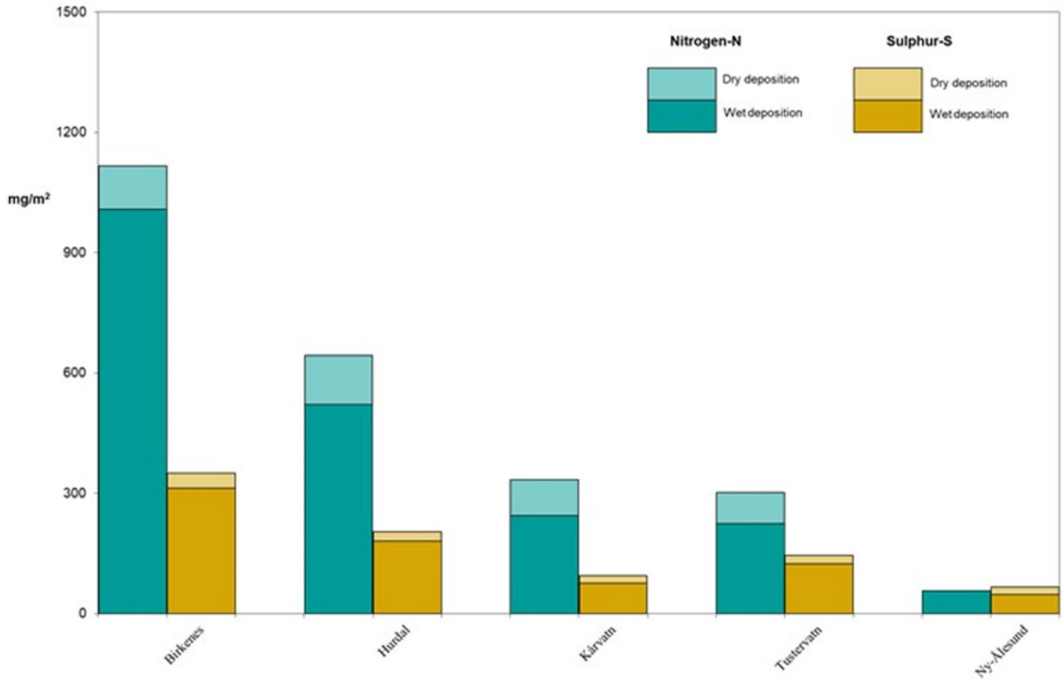


Figure 17: Total deposition (wet+ dry) of sulfur-S (SO_2, SO_4^{2-}) and nitrogen-N (NO_2, NH_4^+, NH_3, NO_3-, HNO_3) at Norwegian background stations 2019. (Aas et al., 2020, Figure 3.5)

8 References

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 (NILU OR, 19/2011).

Johnsrud, M., Hermansen, O., Tørnkvist, K. (2016) Air Quality in Ny-Ålesund, Monitoring of Local Air Quality 2014-2015. Kjeller, NILU (NILU Report, 35/2016).

Johnsrud, M., Hermansen, O., Tørnkvist, K. (2018) Air Quality in Ny-Ålesund, Monitoring of Local Air Quality 2016-2017. Kjeller, NILU (NILU Report, 30/2018).

Johnsrud, M., Hermansen, O., Krejci, R., Tørnkvist, K. (2019) Air Quality in Ny-Ålesund, Monitoring of Local Air Quality 2018. Kjeller, NILU (NILU Report, 21/2019).

Bond, T. C., T. L. Anderson, and D. Campbell (1999) Calibration and intercomparison of filter-based measurements of visible light absorption by aerosols. *Aerosol Science and Technology, 30*, 582-600.

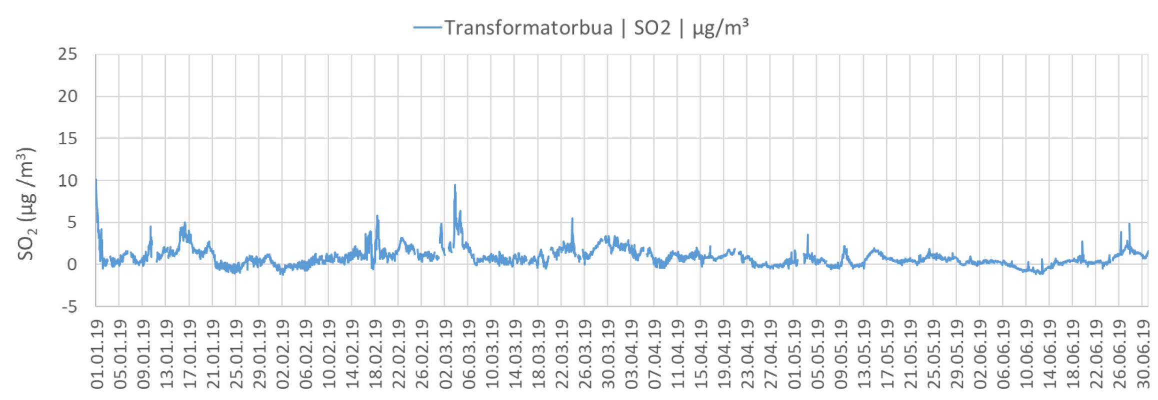
Aas, W., Eckhardt, S., Fiebig, M., Solberg, S., Yttri, K.E. (2020) Monitoring of long-range transported air pollutants in Norway, Annual Report 2019. Kjeller, NILU (Miljødirektoratet rapport, M-1710/2020) (NILU report, 4/2020).

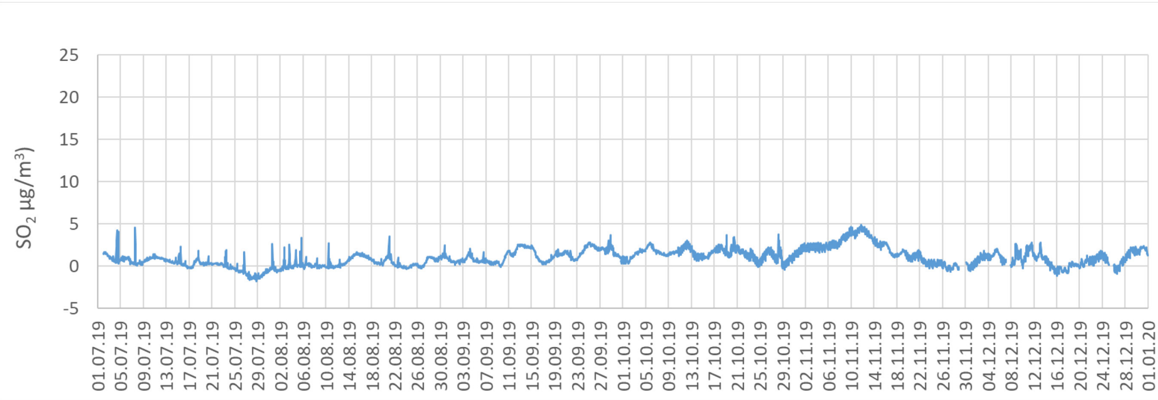
Appendix A

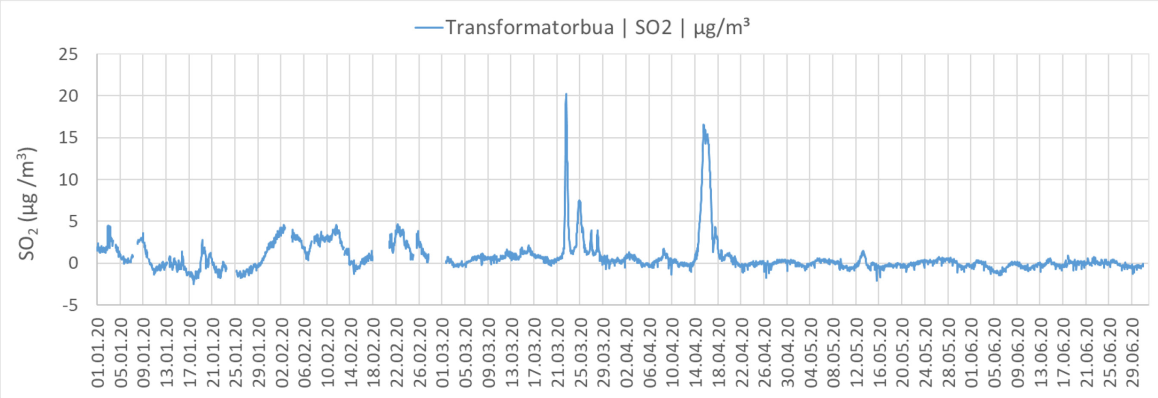
Measurement data

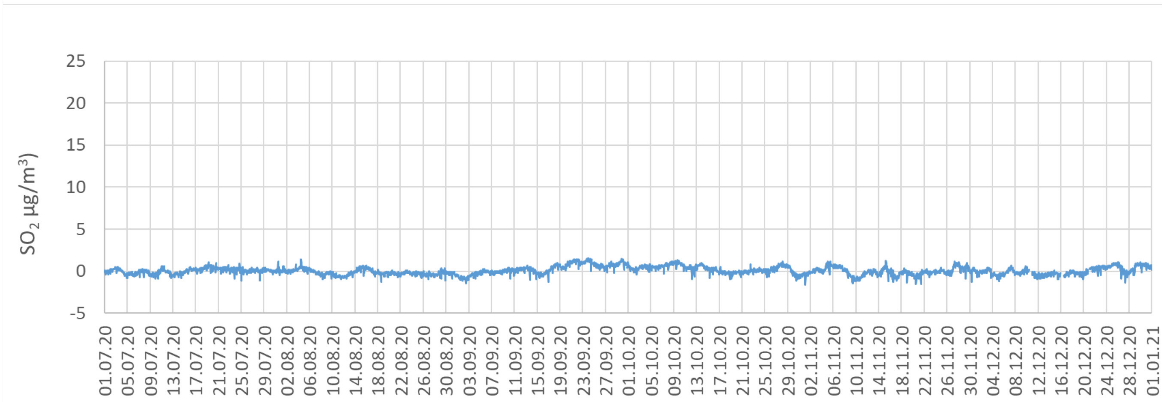
Hourly measurement data for NO_x and NO_2 at Transformatorbua, Ny-Ålesund 1.1.2019-31.12.2020. NO_x as µg NO_2/m^3.

Hourly measurement data for SO_2 at Transformatorbua, Ny-Ålesund 1.1.2019-31.12.2020.

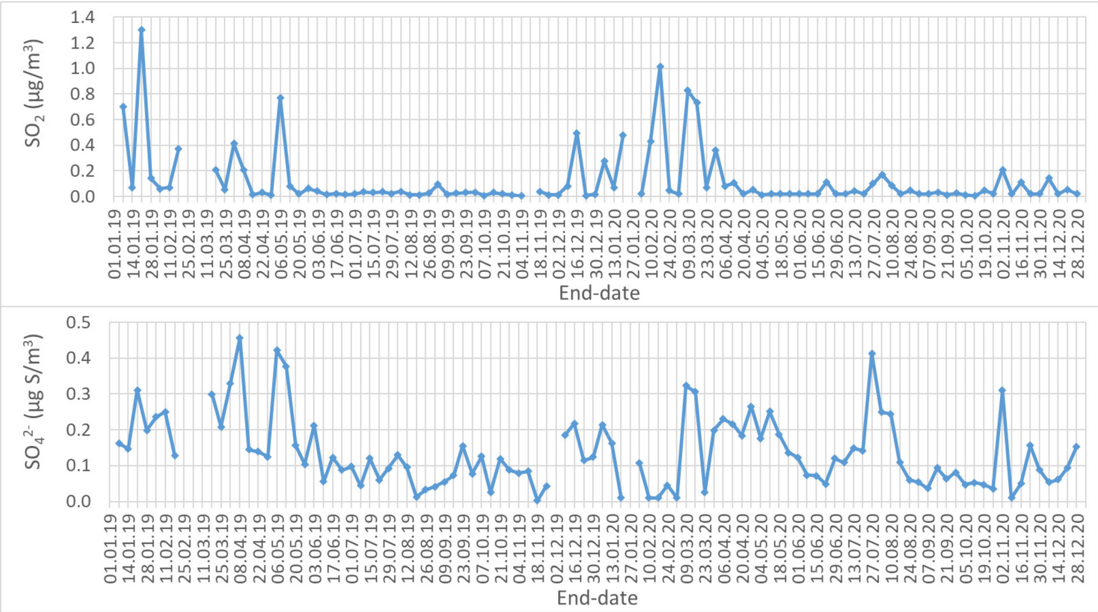


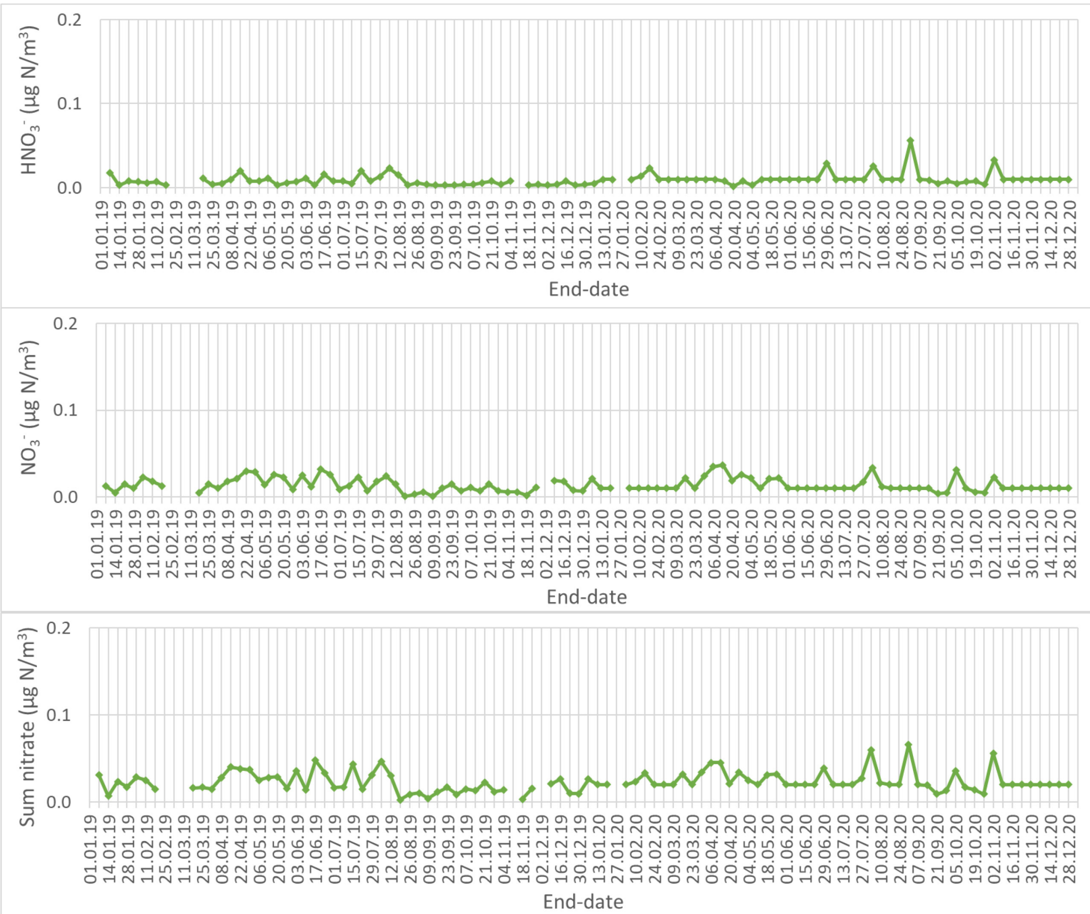


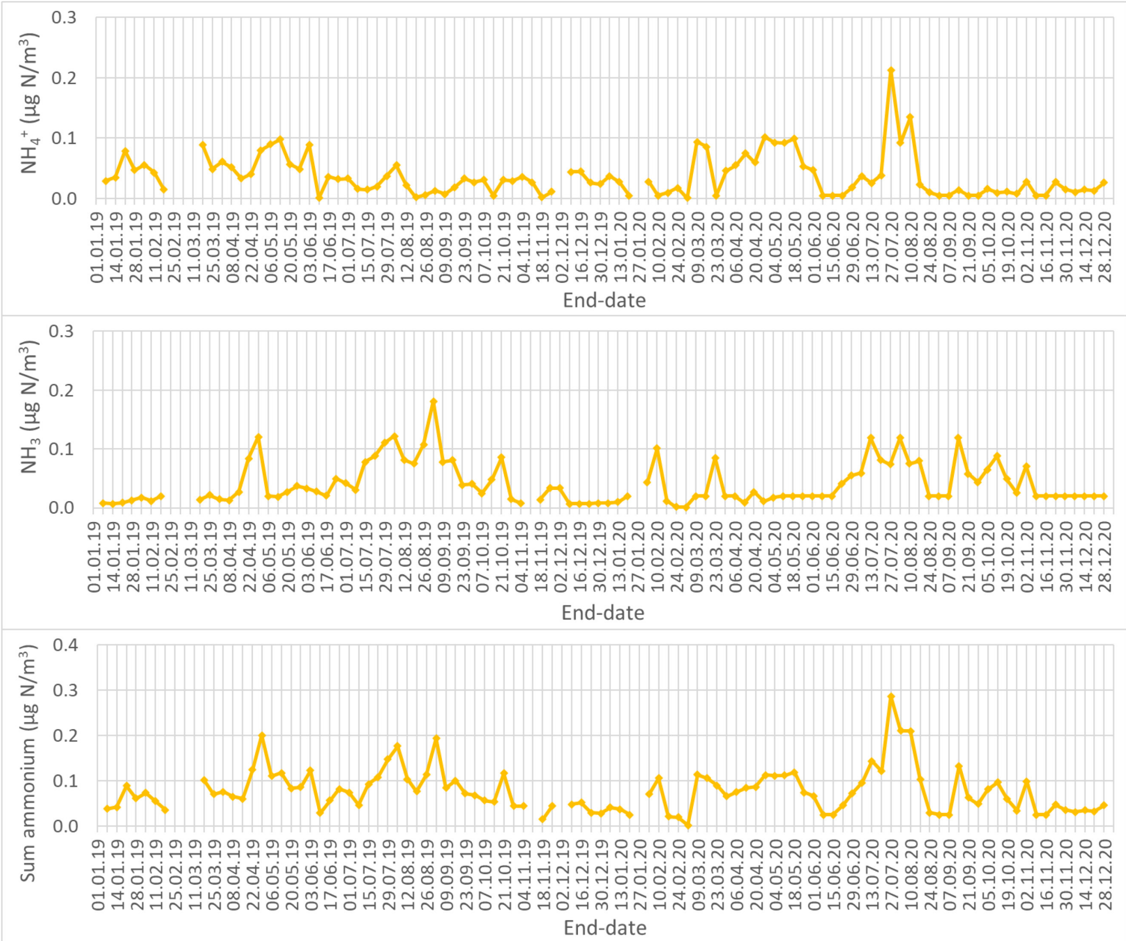


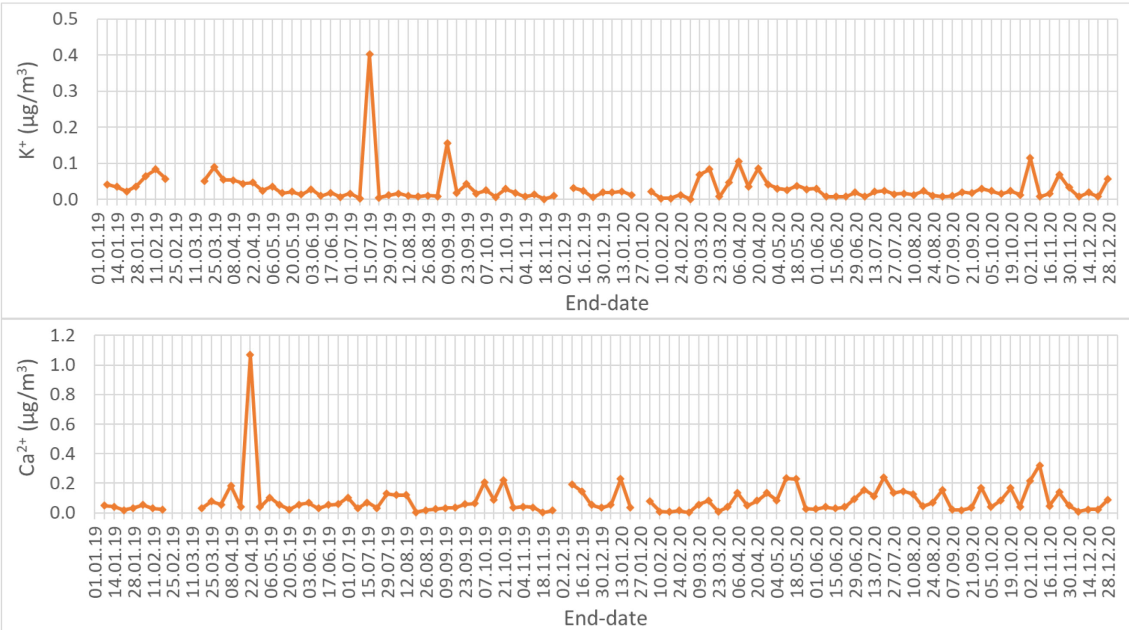


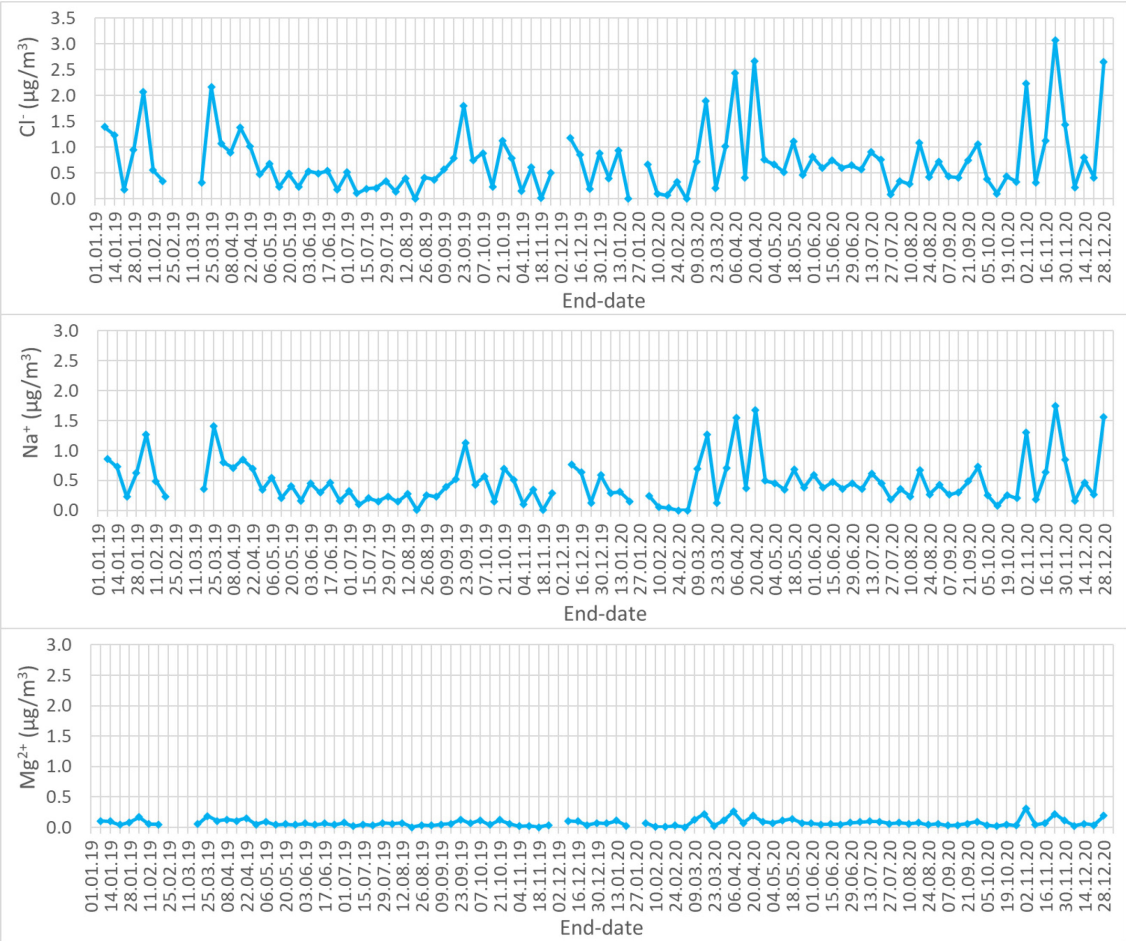
Analysis results of weekly filter sampling at Transformatorbua, Ny-Ålesund 1.1.2019-31.12.2020.






0.3
0.2
0.1
0.0
NH_4^+ (µg N/m³)
NH_3 (µg N/m³)
0.4
Sum ammonium (µg N/m³)
01.01.19 14.01.19 28.01.19 11.02.19 25.02.19 11.03.19 25.03.19 08.04.19 22.04.19 06.05.19 20.05.19 03.06.19 17.06.19 01.07.19 15.07.19 29.07.19 12.08.19 26.08.19 09.09.19 23.09.19 07.10.19 21.10.19 04.11.19 18.11.19 02.12.19 16.12.19 30.12.19 13.01.20 27.01.20 10.02.20 24.02.20 09.03.20 23.03.20 06.04.20 20.04.20 04.05.20 18.05.20 01.06.20 15.06.20 29.06.20 13.07.20 27.07.20 10.08.20 24.08.20 07.09.20 21.09.20 05.10.20 19.10.20 02.11.20 16.11.20 30.11.20 14.12.20 28.12.20
End-date


0.5
0.4
0.3
0.2
0.1
0.0
K^+ (µg/m³)
1.2
1.0
0.8
0.6
Ca^{2+} (µg/m³)
01.01.19 14.01.19 28.01.19 11.02.19 25.02.19 11.03.19 25.03.19 08.04.19 22.04.19 06.05.19 20.05.19 03.06.19 17.06.19 01.07.19 15.07.19 29.07.19 12.08.19 26.08.19 09.09.19 23.09.19 07.10.19 21.10.19 04.11.19 18.11.19 02.12.19 16.12.19 30.12.19 13.01.20 27.01.20 10.02.20 24.02.20 09.03.20 23.03.20 06.04.20 20.04.20 04.05.20 18.05.20 01.06.20 15.06.20 29.06.20 13.07.20 27.07.20 10.08.20 24.08.20 07.09.20 21.09.20 05.10.20 19.10.20 02.11.20 16.11.20 30.11.20 14.12.20 28.12.20
End-date


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

NILU – Norwegian Institute for Air Research

NILU – Norwegian Institute for Air Research is an independent, non-profit institution established in 1969. Through its research NILU increases the understanding of climate change, of the composition of the atmosphere, of air quality and of hazardous substances. Based on its research, NILU markets integrated services and products within analyzing, monitoring and consulting. NILU is concerned with increasing public awareness about climate change and environmental pollution.

NILU's values: *Integrity - Competence - Benefit to society*
NILU's vision: *Research for a clean atmosphere*

NILU – Norwegian Institute for Air Research
P.O. Box 100, NO-2027 KJELLER, Norway

E-mail: nilu@nilu.no
http://www.nilu.no

ISBN: 978-82-425-3066-0
ISSN: 2464-3327

Norsk institutt for luftforskning
Norwegian Institute for Air Research