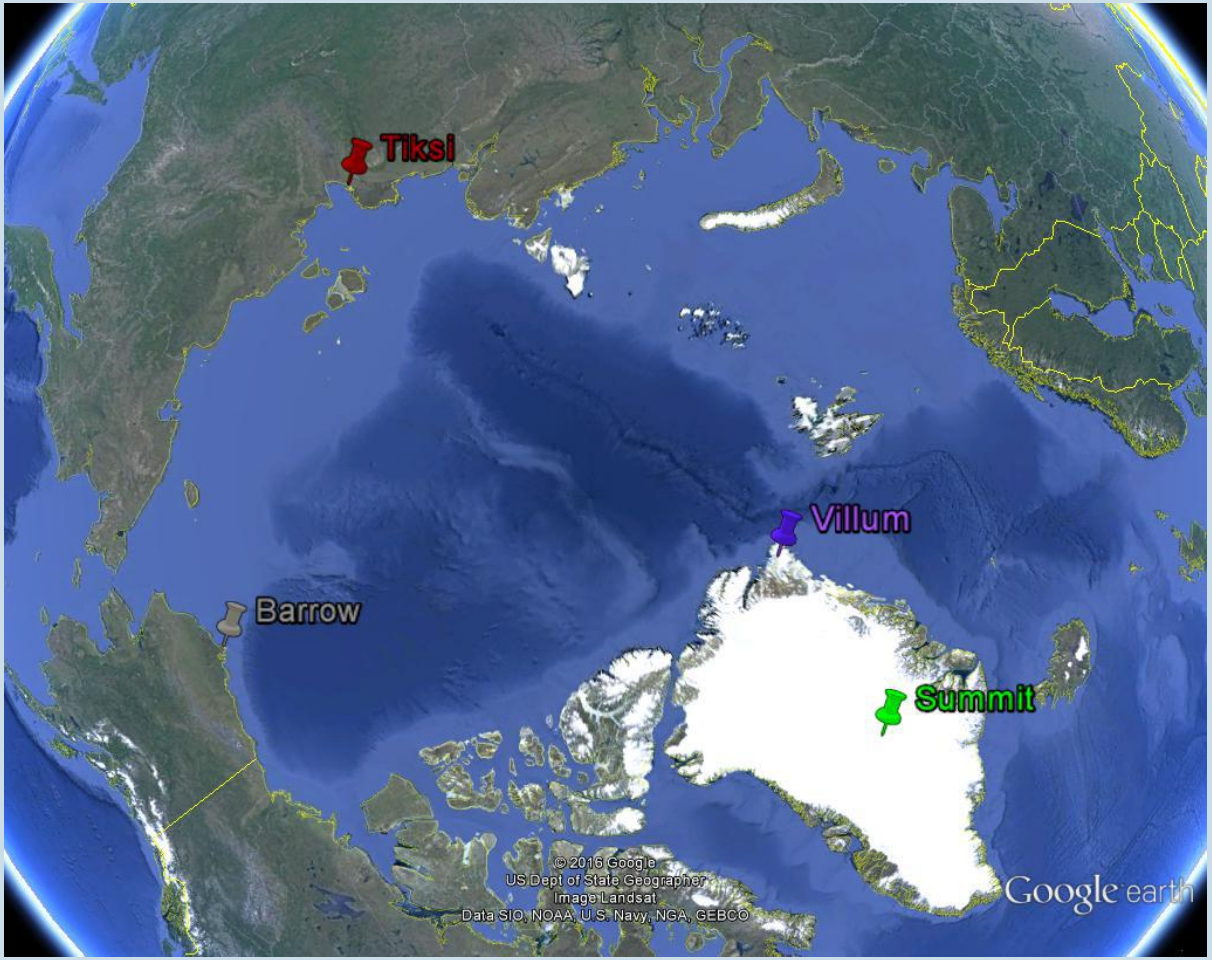
Geographical and Temporal Differences in NOAA Observed Ground-Level Ozone in the Arctic

A. McClure-Begley, S. Crepinsek, I. Petropavlovskikh, , T. Uttal, D. Hageman, S. Oltmans, H. Skov

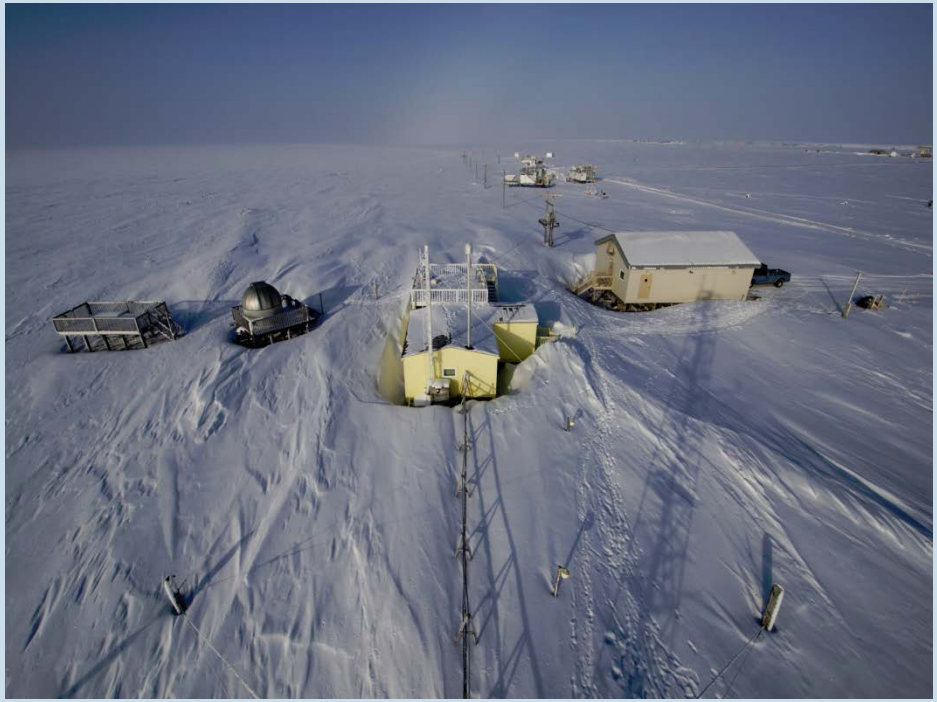
Topics of investigation:

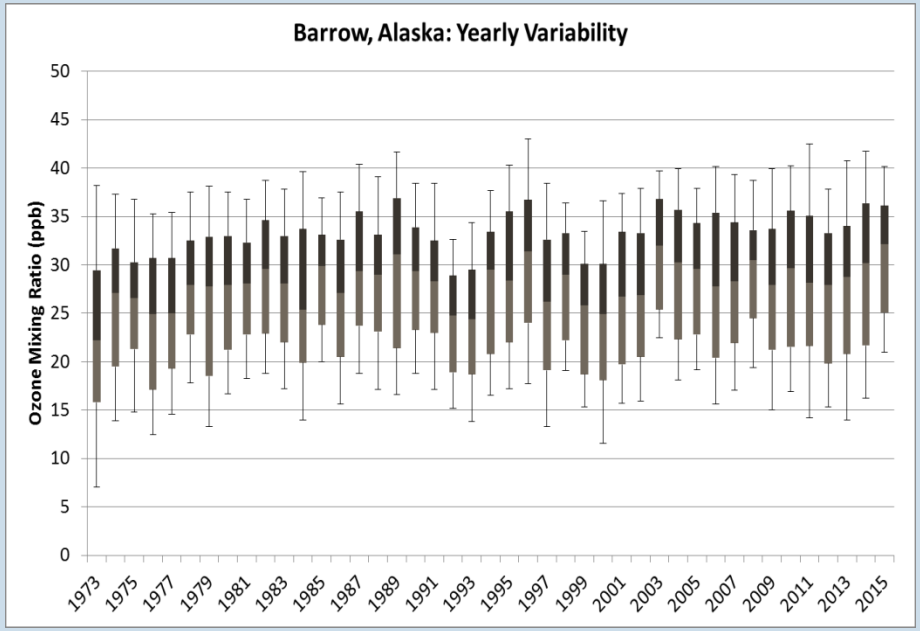
- Station information
- Instrumentation
- Data Collection and Processing
- Station Seasonality and Variability
- Arctic Ozone Depletion Events
- Arctic Pollution Episodes



Barrow, Alaska

71.323 N, 156.612 W 11 MASL





- Located on the Northern most point of United States
- NOAA Global Monitoring Division Observatory
- Maritime-Arctic station with dominant wind from east/north-east
- Measurements from 1973-Current
- Full suite of co-located measurements: Aerosols, Meteorology, Halocarbons, NMHC's, CO, Total Column O3, Radiation and others

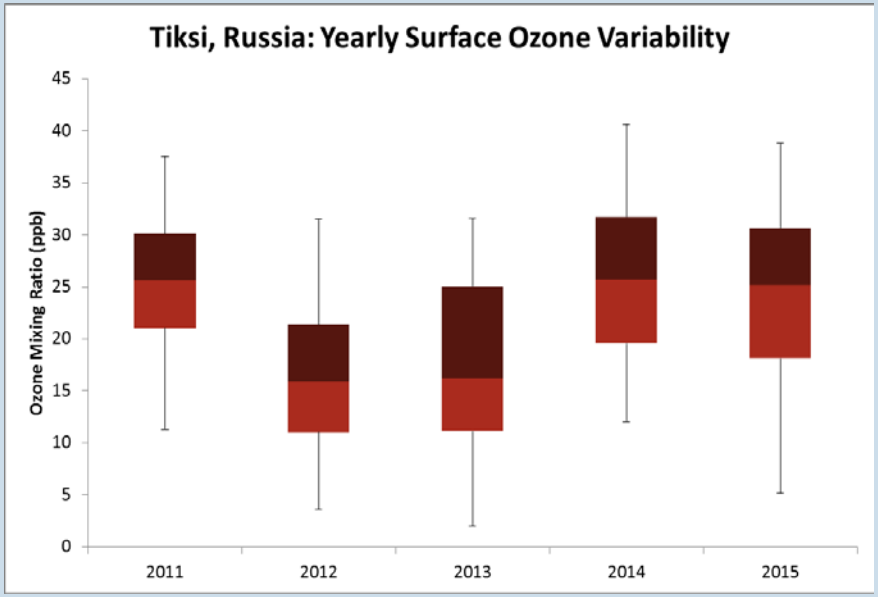
For the complete list of measurements and more information--
http://www.esrl.noaa.gov/gmd/obop/brw/summary.html

Tiksi, Russia

71.596 N, 128.889 E 30 MASL

- Collaboration between NOAA Physical Sciences Division, NOAA Global Monitoring Division, and Roshydromet
- Located on the coast of the Arctic ocean in Northern Siberia
- Measurements from 2010-current
- Co-located measurements: Radiation, Aerosols, Meteorology, Flux, CH4, CO2 and others

For the complete list of measurements and more information:
http://www.esrl.noaa.gov/psd/iasoa/stations/tiksi



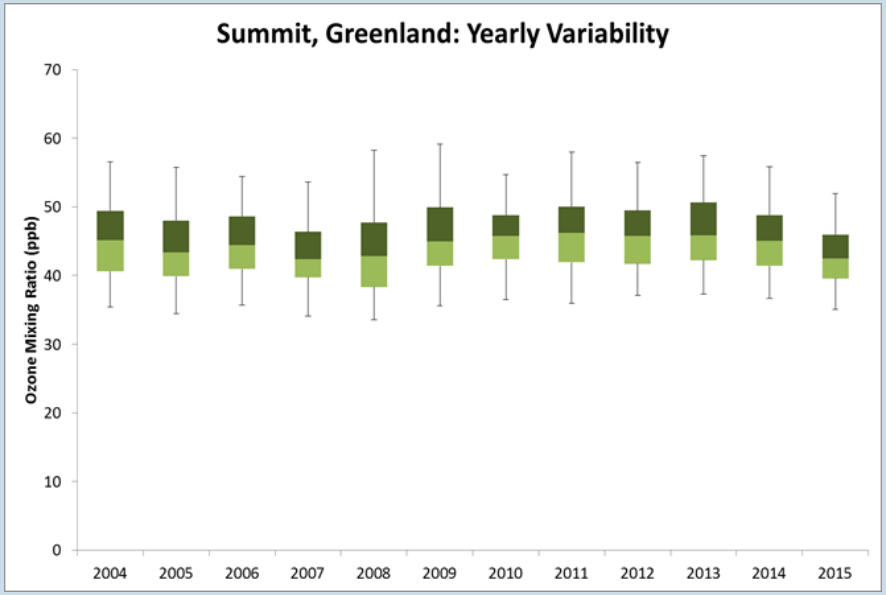
NOTE: THIS DATA IS PRELIMINARY AND HAS NOT BEEN THROUGH THE QA/QC PROCESS

Summit, Greenland

72.58 N, 38.48 W 3238 MASL

- Collaboration with GeoSummit (Greenland Environmental Observatory), CH2M HILL Polar Services, and National Science Foundation
- Located at the top of the Greenland Ice Sheet
- Measurements from 2000-current
- Co-located measurements: Aerosols, Meteorology, CO, CO2, Halocarbons, Celiometer, etc.

For the complete list of measurements and more information:
www.summitcamp.org/summit



Instrumentation

Instrument Specifications From: Thermo Fisher Scientific Ozone Instruction Manual 2007	
Range calibrated by NOAA	0-200 ppb
Precision	1%
Response time	20 Seconds
Drift	<1%
Temperature and Pressure	Internal compensation
Calibration	5 years NIST traceable

Thermo Scientific Model 49 UV Photometric Ozone Analyzer

- Operates on the absorption of UV light by ozone molecules at 254 nm
- Beer-Lambert Law relates absorbed light to ozone concentration

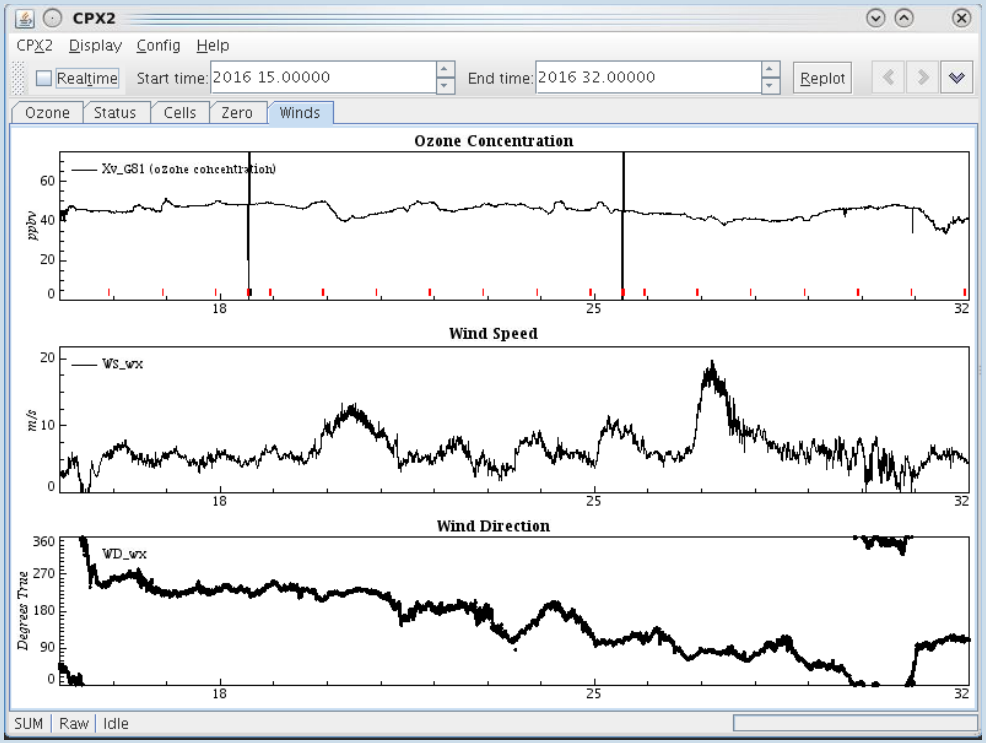
Data Collection and Processing

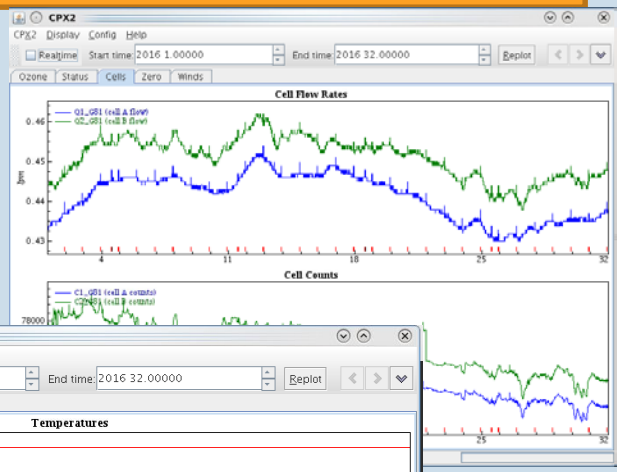
CPD Software by Derek Hageman

Time	Date	Flags	O3
21:35	2-Feb	--------	37.05
21:40	2-Feb	--------	37.23
21:45	2-Feb	--------	37.29

Raw Data and Instrument Diagnostics

Hour	Date	Flags	O3	Cell A	Cell B	Bench temp	Lamp temp	O3 lamp temp	Flow A	Flow B	Pressure
21:00	2-Feb	--------	37.23	60715	54339	34.8	56.7	71.2	0.679	0.695	760.3
22:00	2-Feb	--------	37.08	60735	54379	35	56.7	71.2	0.678	0.694	759.8





Data Adjustments and Final Format

CPD Software by Derek Hageman

Data Adjustments

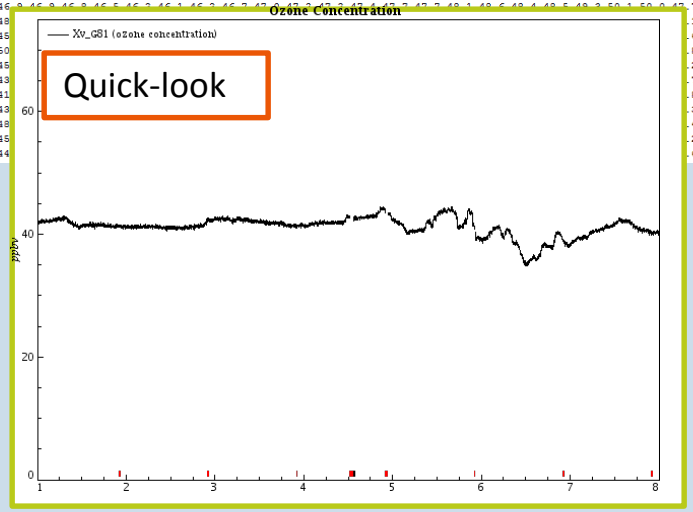
- Apply NIST Calibration Coefficient
- Remove level checks and zero checks
- Remove data from instrumental problems
- Ensure all instrument diagnostics are within operation limits
- Remove any extreme outliers and document for investigation

Monthly

MIXING RATIO OF SURFACE OZONE IN PARTS PER BILLION
STATION SUMMIT, GREENLAND
MONTH JANUARY YEAR 2016
EQUIPMENT Thermo49c

GMT DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	MEAN	MAX
1	42.1	42.2	42.2	42.3	42.4	42.5	42.5	42.7	42.1	41.7	41.4	41.3	41.5	41.5	41.6	41.5	41.6	41.6	41.5	41.4	41.3	41.3	41.3	41.3	41.8	42.7
2	41.3	41.2	41.3	41.3	41.3	41.3	41.3	41.3	41.2	41.2	41.1	41.1	41.2	41.1	41.1	41.1	41.2	41.2	41.2	41.4	41.4	42.0	42.2	42.5	41.4	42.5
3	42.6	42.6	42.6	42.6	42.2	42.4	42.5	42.4	42.4	42.2	42.1	42.1	42.1	42.0	41.9	41.9	41.9	41.9	41.7	41.5	41.5	41.5	41.5	41.5	42.1	42.6
4	41.4	41.6	41.7	41.8	41.9	41.9	41.9	42.0	41.9	42.0	42.0	42.8	42.9	42.7	42.7	42.8	42.8	42.9	43.0	43.2	44.0	44.1	43.4	42.9	42.5	44.1
5	42.3	41.9	41.5	40.6	40.4	40.5	40.6	40.8	41.0	42.1	41.7	42.8	43.5	43.8	43.9	44.1	43.8	41.8	41.4	42.1	43.8	42.6	39.6	39.3	41.9	44.1
6	39.3	39.6	40.4	41.0	41.2	39.9	40.4	40.4	38.9	38.4	37.1	35.5	35.4	36.1	36.1	36.5	38.1	38.2	38.0	38.7	40.3	39.7	38.6	38.2	38.6	41.2
7	38.7	39.2	39.5	39.6	39.6	40.3	40.5	40.7	40.8	41.2	41.3	41.5	42.0	42.3	42.2	42.1	41.8	41.2	41.0	40.7	40.6	40.4	40.3	40.4	40.7	42.3
8	40.2	40.0	40.1	40.4	40.2	40.0	39.9	40.0	39.8	39.8	39.7	39.7	39.8	39.8	39.7	39.8	40.1	40.5	40.6	40.7	40.7	40.9	40.9	40.9	40.2	40.9
9	41.3	41.5	41.3	41.5	43.1	44.9	43.4	46.1	46.9	45.5	45.8	46.5	46.6	46.6	46.7	45.8	46.0	46.2	46.3	45.8	45.9	45.2	44.8	45.0	44.9	46.9
10	45.3	45.5	45.5	45.8	45.8	45.5	45.1	44.9	44.9	44.5	42.2	43.4	43.6	42.7	42.9	43.5	43.5	43.7	42.4	41.8	42.0	42.5	42.6	43.6	43.9	45.8
11	43.4	42.2	42.3	43.1	44.3	44.5	44.2	42.4	41.9	41.5	43.6	44.1	44.1	42.6	43.0	43.3	43.3	43.3	43.1	42.7	42.5	42.1	41.7	41.7	43.0	44.5
12	41.5	41.5	41.4	41.0	41.0	41.7	41.9	42.3	42.0	40.8	40.4	41.1	42.0	42.0	41.5	41.8	41.1	41.5	41.6	41.6	41.7	41.7	41.8	41.7	41.5	42.3
13	41.7	41.7	41.7	41.3	41.6	41.6	41.6	41.8	41.8	41.8	41.9	41.8	41.8	41.7	42.4	42.3	42.2	42.9	43.3	43.1	43.5	43.8	44.0	44.1	42.3	44.1
14	44.1	45.0	44.8	45.7	45.8	46.2	46.5	46.2	46.7	46.6	46.9	47.5	47.4	46.3	48.1	48.2	47.7	47.1	47.0	46.6	46.2	46.9	46.5	46.5	46.5	48.2
15	45.6	46.0	46.0	46.8	48.3	48.7	48.3	47.2	47.2	47.2	47.0	47.0	46.5	46.4	46.3	46.4	46.5	46.3	46.5	46.5	46.5	46.3	45.9	45.6	46.7	48.7
16	45.6	45.9	45.8	45.8	45.8	45.7	45.9	46.0	46.3	48.3	49.0	49.2	48.9	48.0	47.5	47.7	47.5	47.0	46.7	46.1	46.1	47.4	50.4	52.0	47.3	52.0
17	51.5	50.9	49.7	49.0	48.8	48.8	48.6	48.5	48.5	48.8	49.1	49.1	49.2	49.2	49.2	49.1	49.1	49.3	49.3	49.5	50.0	50.6	51.6	51.4	49.5	51.6
18	50.7	50.1	49.9	49.9	49.9	49.8	49.7	49.6	49.6	49.6	49.6	49.7	49.8	49.5	49.6	49.9	50.0	50.0	50.2	50.3	50.5	50.6	50.7	50.3	50.0	50.7
19	49.9	49.7	49.6	49.5	49.5	49.2	49.1	48.7	48.5	48.2	48.0	47.8	47.6	47.6	47.9	48.5	49.4	50.2	50.7	50.8	50.9	51.2	51.2	51.0	49.4	51.2
20	49.6	47.8	46.6	45.3	43.1	42.3	41.4	41.2	41.0	41.8	42.9	43.6	42.8	42.6	42.6	42.7	43.0	43.4	44.2	44.5	44.7	44.7	44.9	45.1	43.8	49.6
21	45.2	45.5	45.6	45.8	46.1	46.5	47.2	47.6	47.7	47.8	47.5	46.4	47.2	49.2	49.8	50.3	51.1	51.0	50.2	50.3	50.3	50.7	50.8	50.7	48.4	51.1
22	50.0	48.6	47.1	46																						50.1
23	49.9	49.5	49.0	48																						50.2
24	47.4	46.6	45.9	45																						51.2
25	48.0	50.4	51.0	50																						51.0
26	45.0	45.1	45.1	45																						45.1
27	41.9	41.6	42.5	43																						43.4
28	42.2	42.1	42.0	41																						43.4
29	41.9	43.5	44.0	43																						48.0
30	48.0	47.8	48.2	48																						49.7
31	47.8	47.5	46.3	45																						47.8
MEAN	44.7	44.7	44.5	44																						52.0

Quick-look



STN	YEAR	MON	DAY	HR	MIN	O3(PPB)
344	2016	01	01	00	00	41.77
344	2016	01	01	00	01	42.18
344	2016	01	01	00	01	9999.99
344	2016	01	01	00	03	42.41
344	2016	01	01	00	04	41.92
344	2016	01	01	00	05	42.09
344	2016	01	01	00	06	41.92
344	2016	01	01	00	07	41.94
344	2016	01	01	00	08	42.31
					09	42.22
					10	42.02

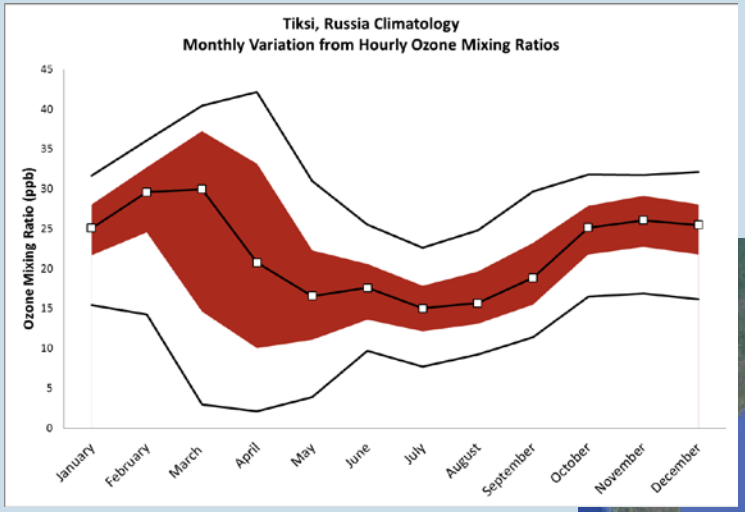
Minute/5 minute

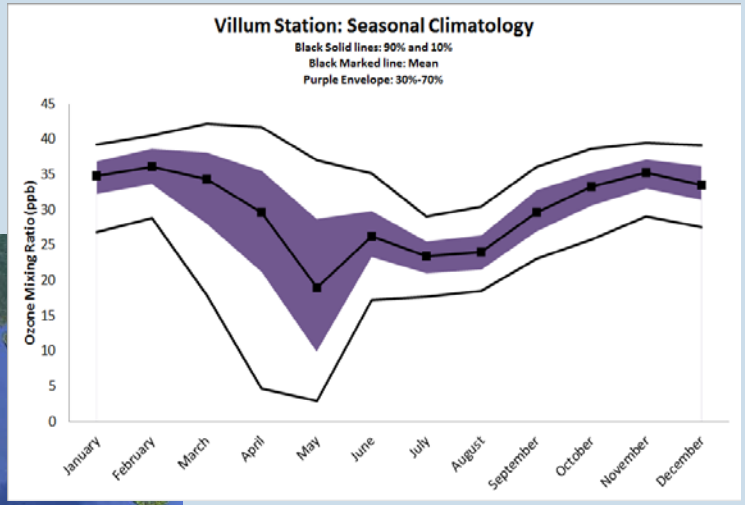
STN	YEAR	MON	DAY	HR	O3(PPB)
344	2016	01	01	00	42.11
344	2016	01	01	01	42.23
344	2016	01	01	02	42.19
344	2016	01	01	03	42.26
344	2016	01	01	04	42.40
344	2016	01	01	05	42.51
344	2016	01	01	06	42.51
344	2016	01	01	07	42.71
344	2016	01	01	08	42.12
			01	09	41.74
			01	10	41.44

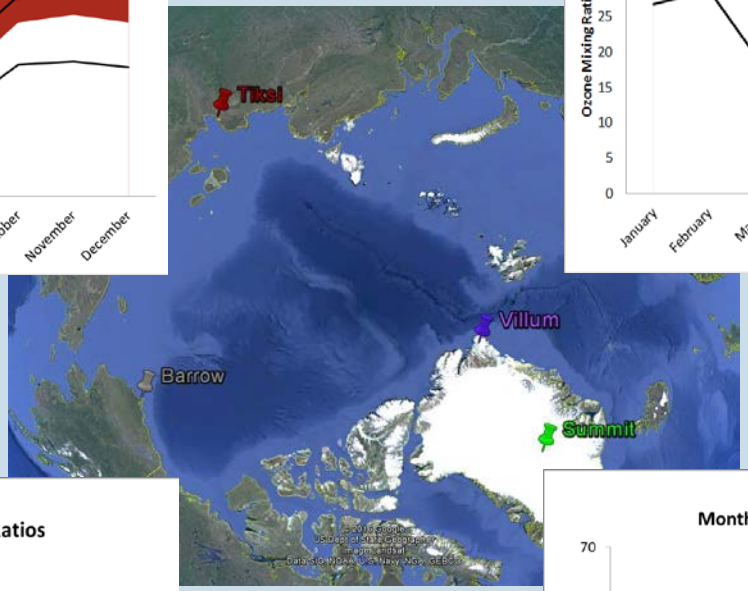
Hourly

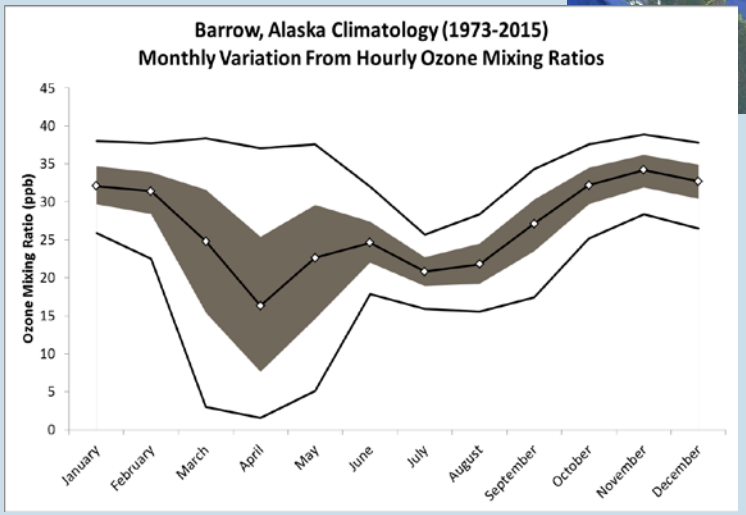
Data can be accessed open and free from:
ftp://aftp.cmdl.noaa.gov/data/ozwv/SurfaceOzone/
Data is also made available through WDCGG/WDCRG

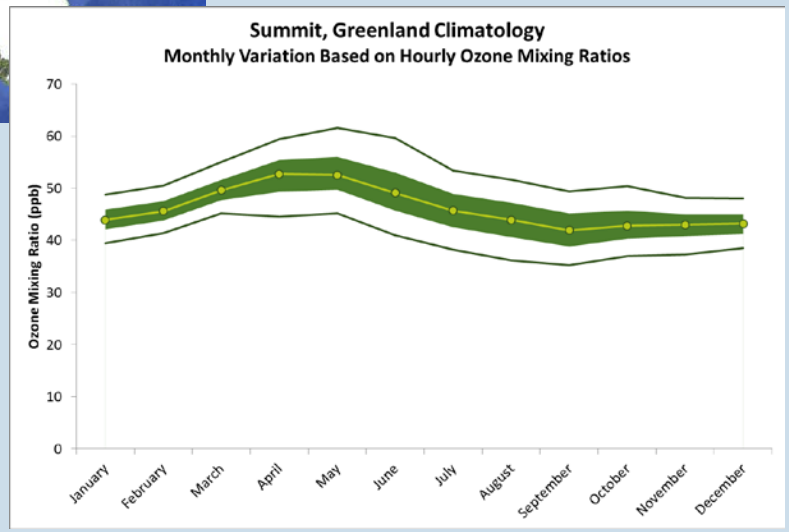
Station Climatology Comparison



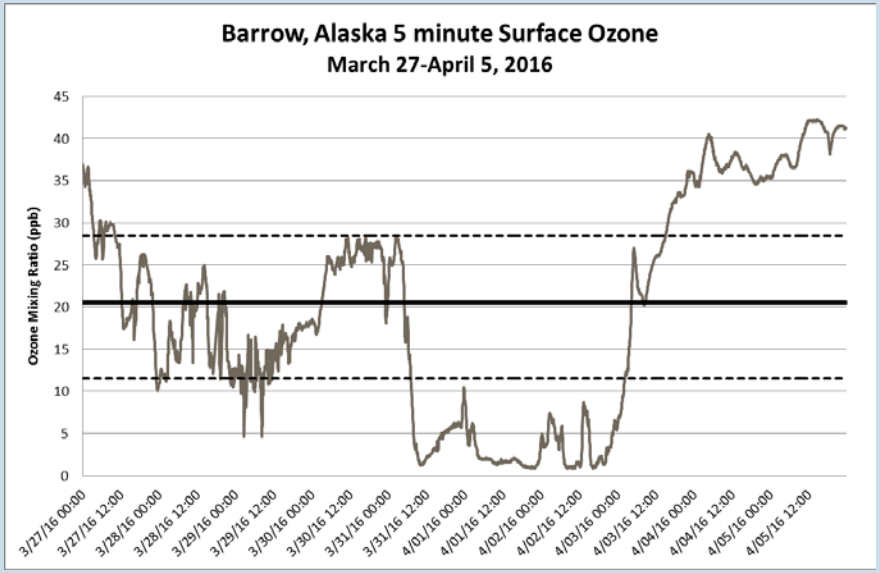




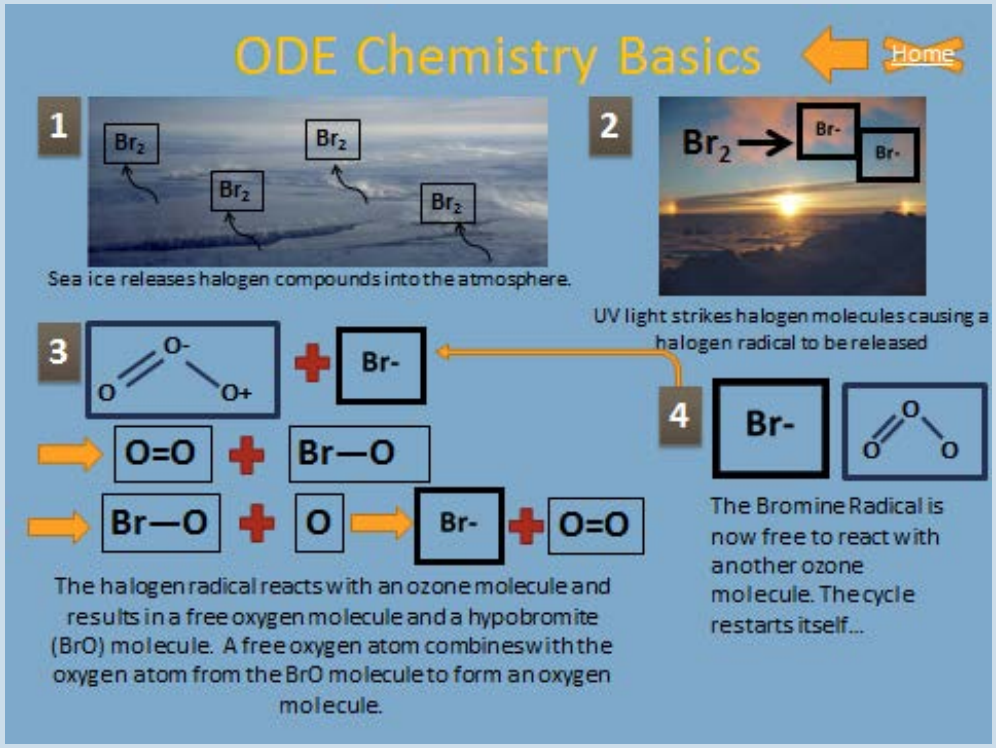




Arctic Ozone Depletion Events (ODE)



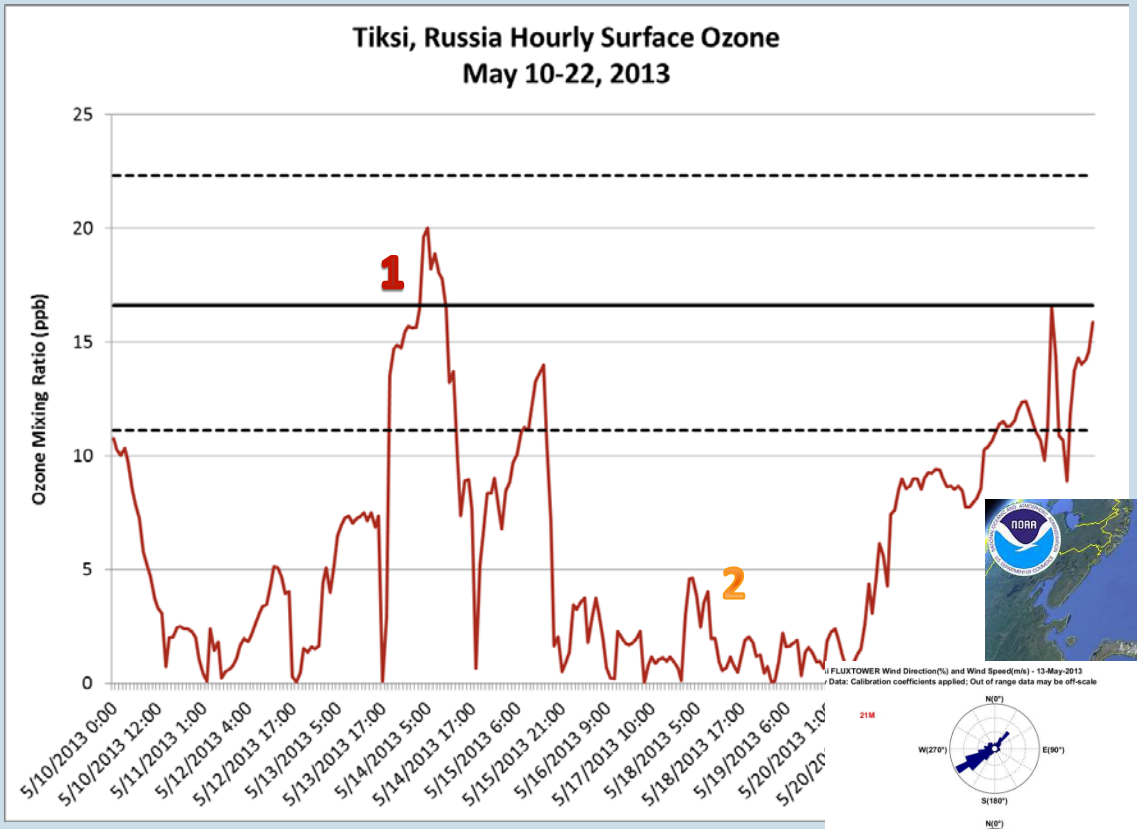
Reference lines are calculated from the entire ODE season record
Dashed lines: 30th and 70th percentiles, solid: Mean

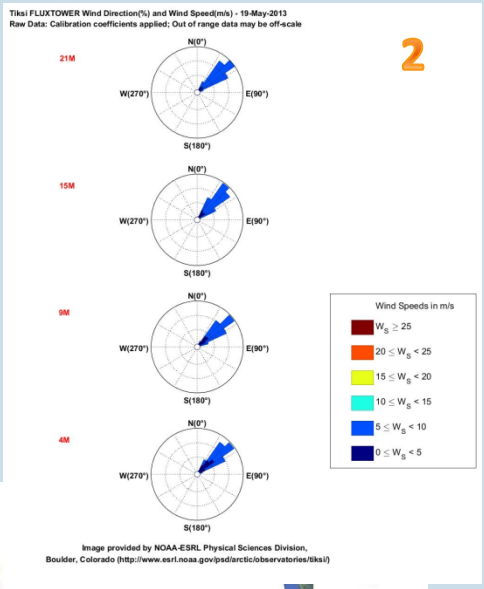


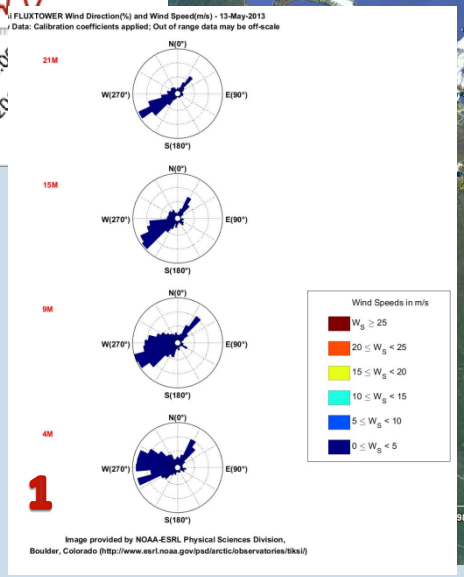
Introduction to ODE:

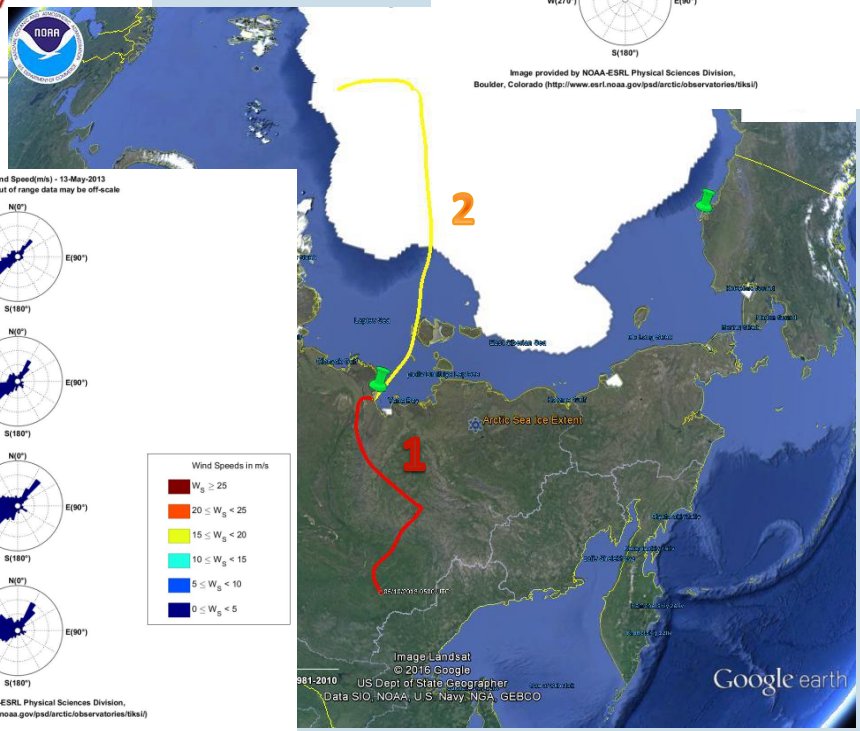
- Occur yearly during the spring season
- Variability of ODE depends strongly on the frequency of the air coming from the Arctic ocean
- Ozone depletion is the result of the reaction of ozone and halogens (released during the sea ice melt)

Arctic Ozone Depletion Events (ODE)



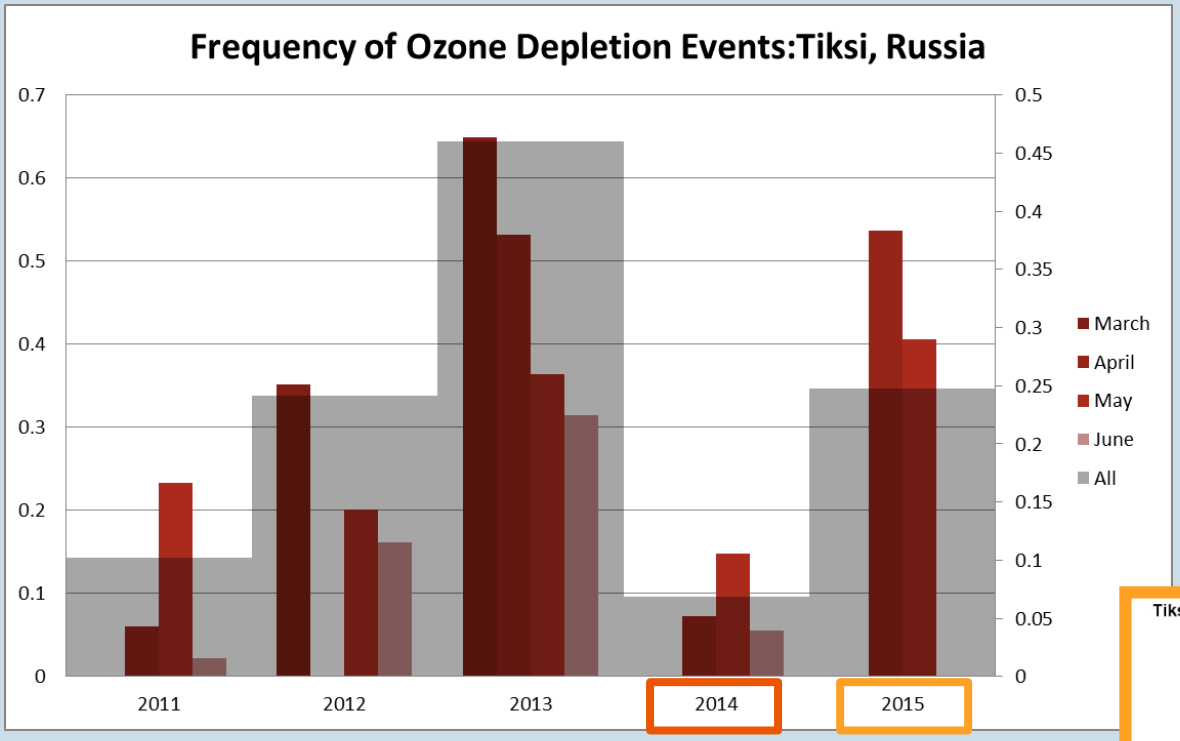


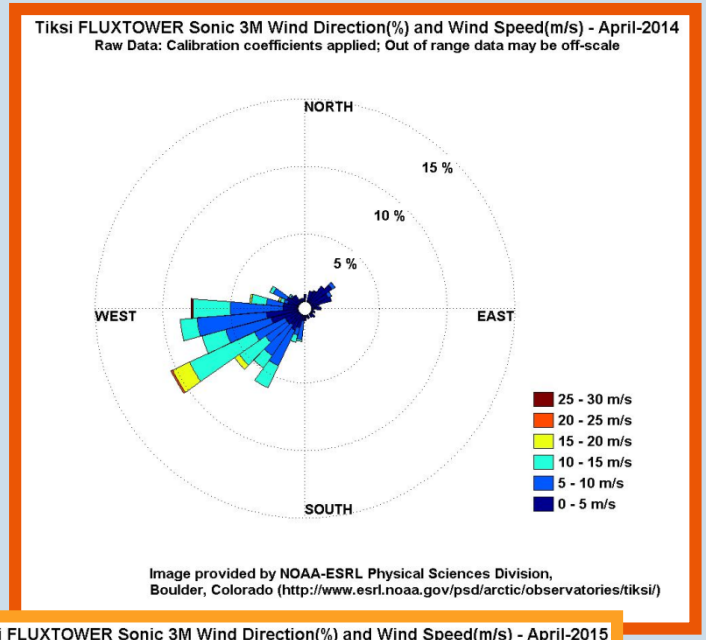


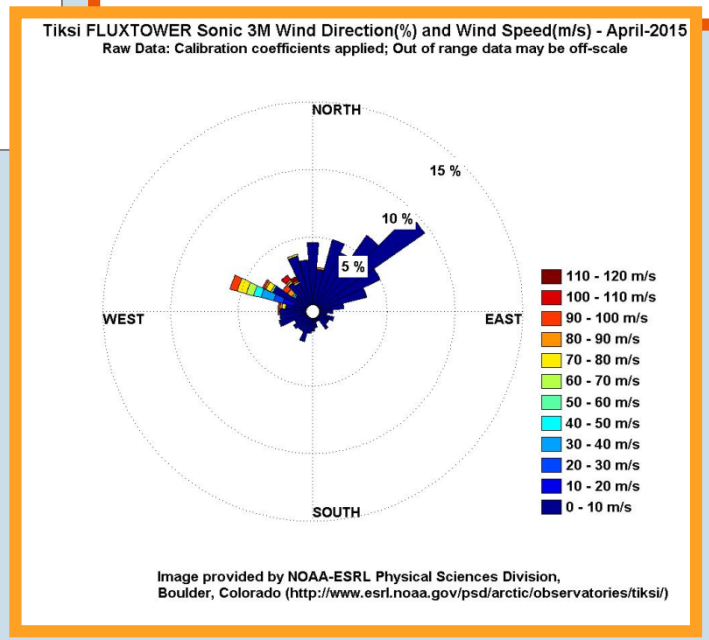


NOAA Hysplit back trajectory and sea ice extent overlay show the path the air mass traveled before reaching the measurement station. Wind plots confirm the direction which the air mass came from. The depleted ozone air mass was influenced by the bromine released by the melting ice.

Frequency of ODE: Tiksi



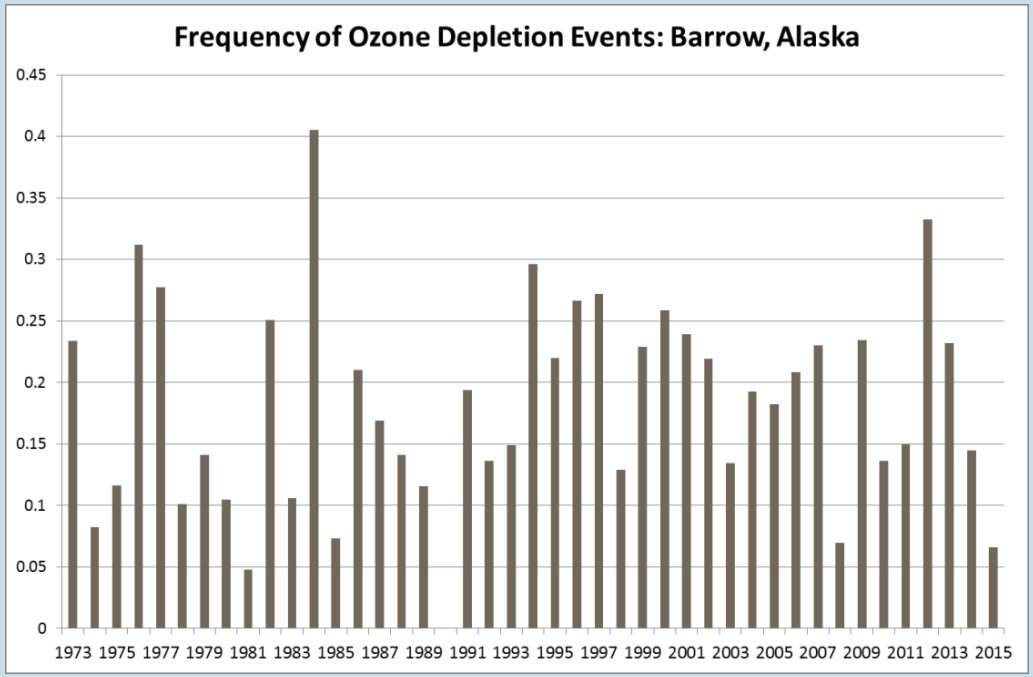


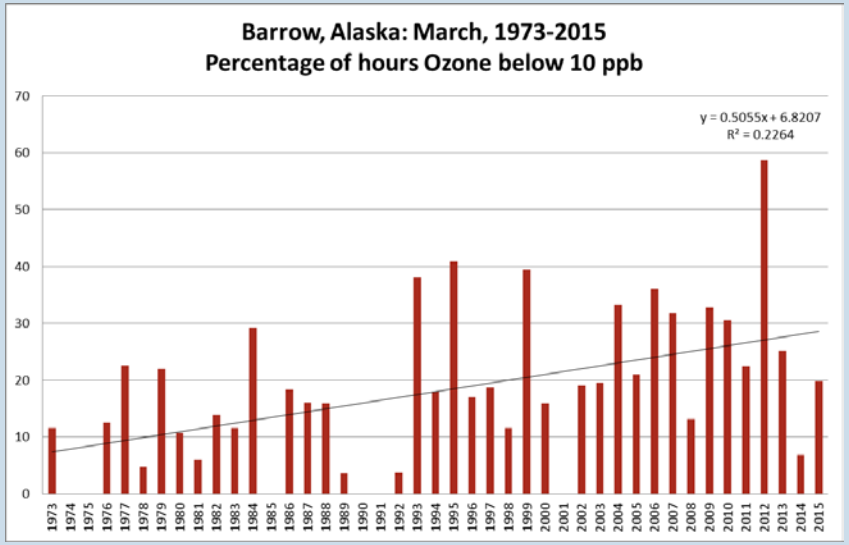


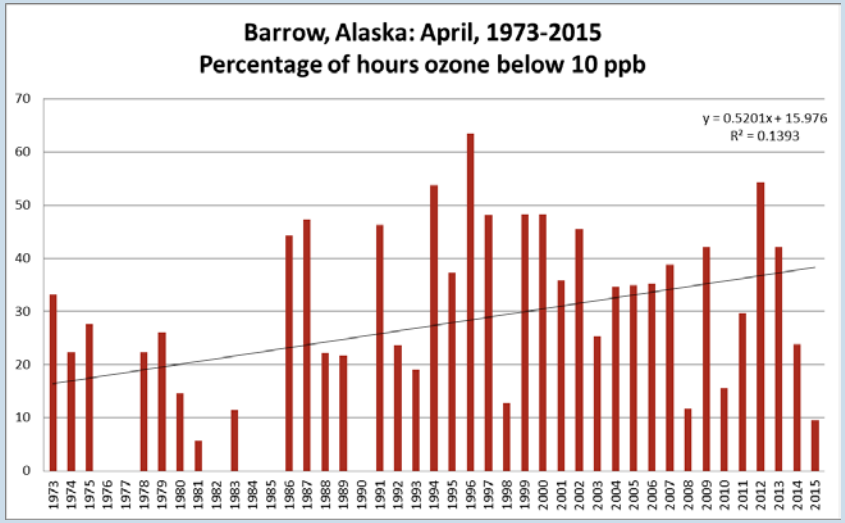
The Frequency of hours ozone at the surface was below 10 ppb is shown for each month of the spring ODE season with the total frequency displayed in grey.

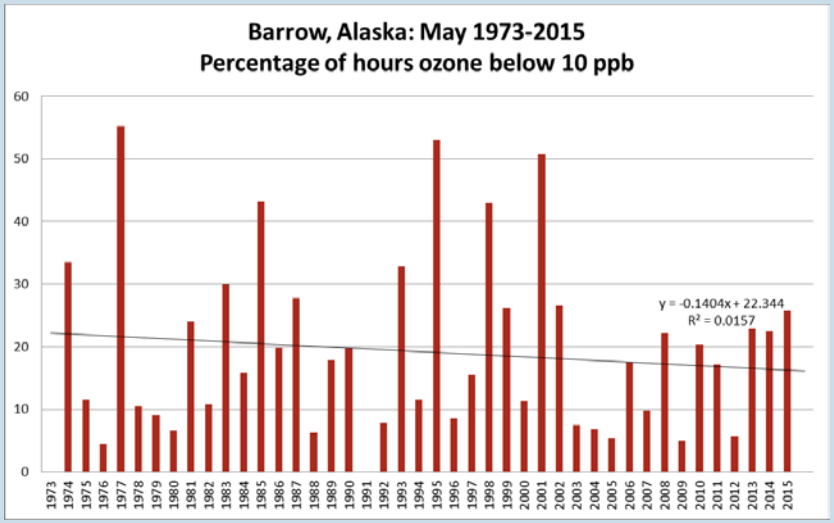
Sonic 3m wind direction plots for April of 2014 and 2015 demonstrate the influence of wind direction on the ozone depletion detected at Tiksi. 2014 shows a dominant flow from land origins. In contrast, 2015 reveals a strong influence from the North bringing in air influenced by the Arctic sea.

Frequency of ODE: Barrow

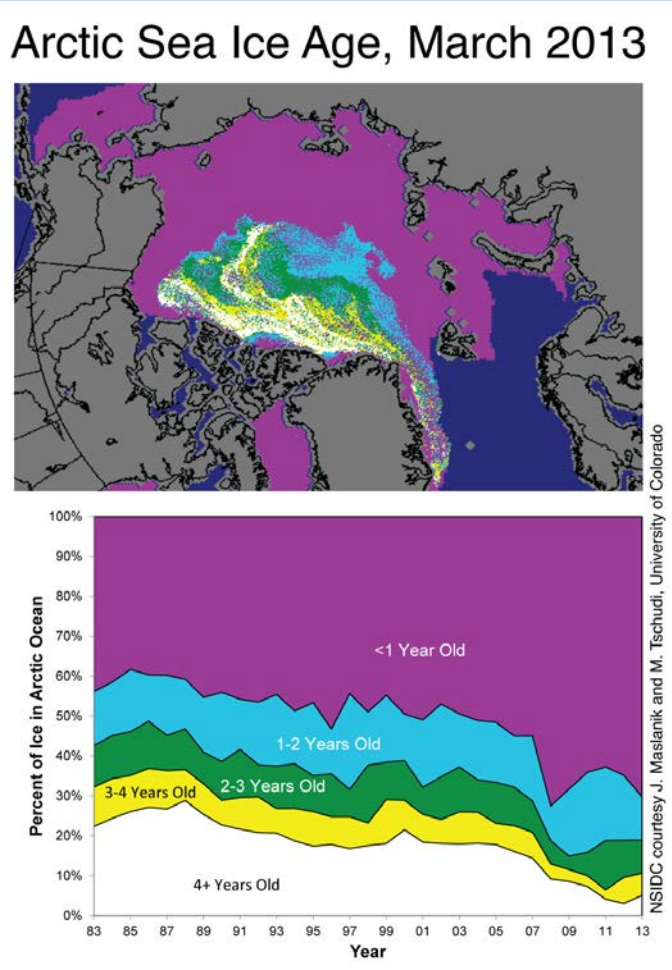


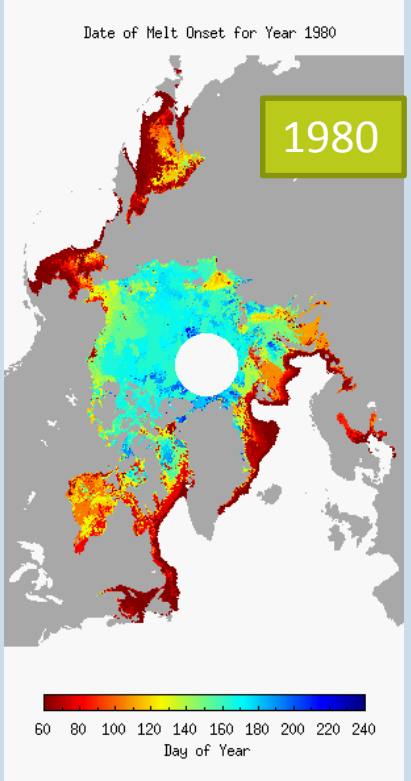


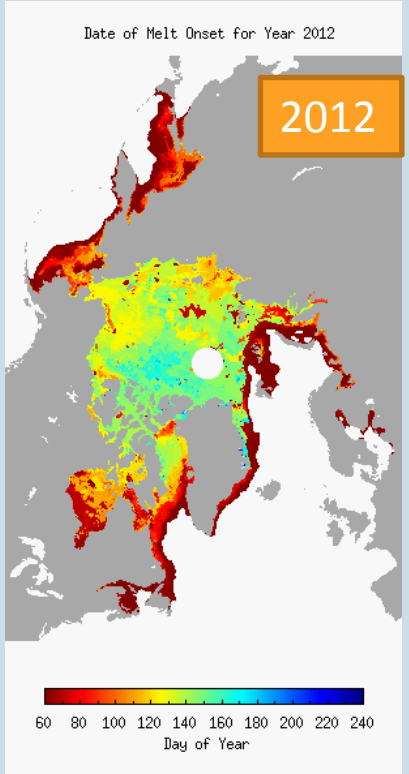




Frequency of ODE: Early Season Trend

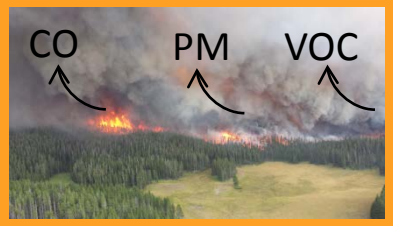






The increase in frequency of ODE's is detected in the early portion of the season, likely due to the earlier sea ice melt and the increase in first year sea ice. NASA Snow Melt onset imagery shows the changing regime of snow melt in this region. The yearly variation in ODE frequency is due to seasonal conditions, dominant wind direction, and sea ice conditions.

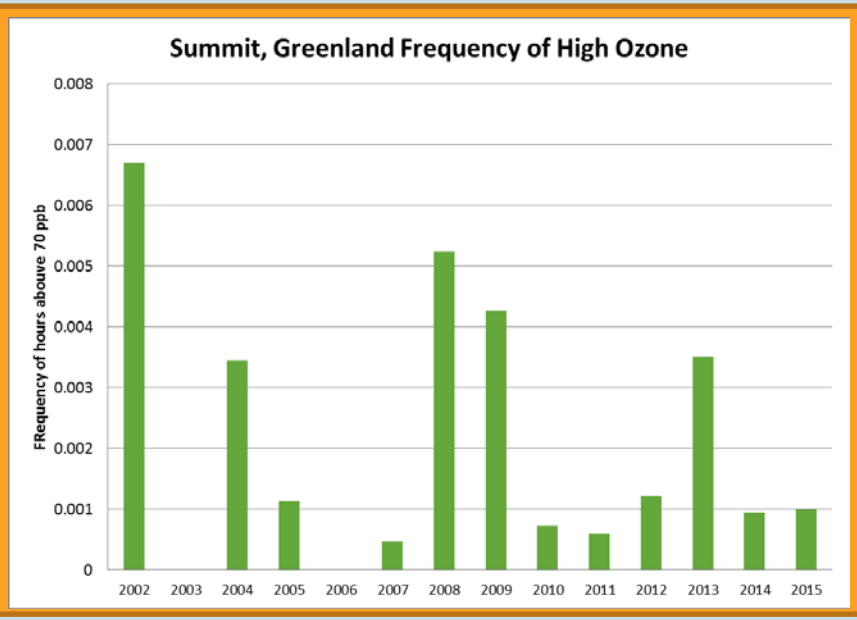
Arctic High Ozone Events



OZONE

Investigate an episode

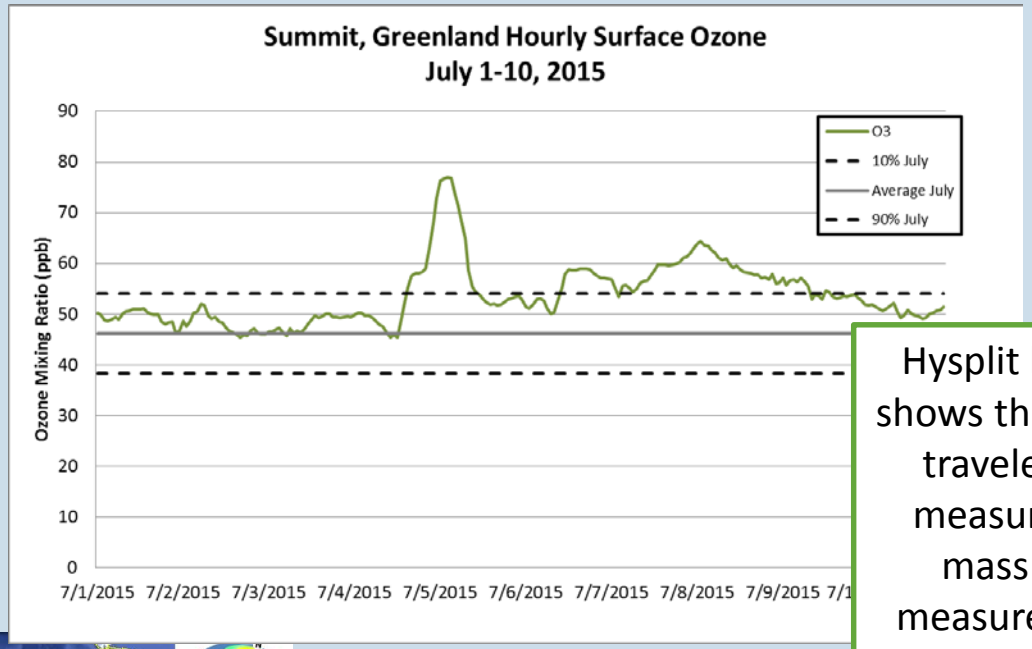
Ozone is a secondary atmospheric pollutant produced by the reaction of VOC's, CO. and NOx in the presence of UV radiation.



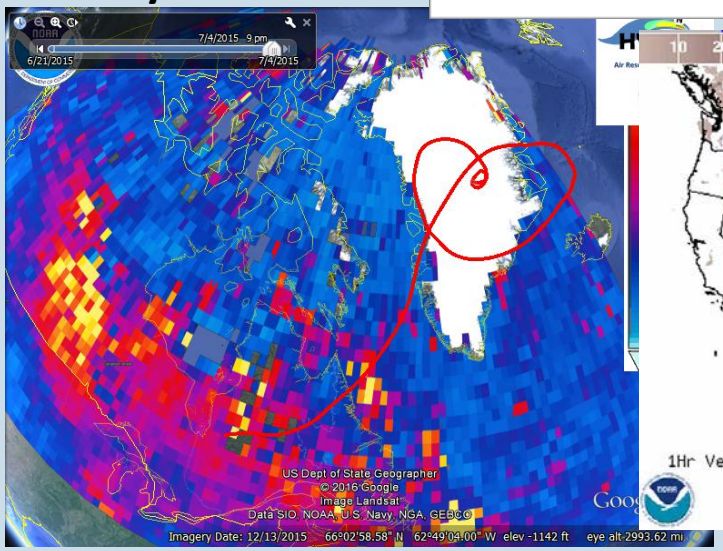
- High levels of ozone at surface level have been proven to have negative impacts on ecosystem functioning and human health.
- High ozone levels are often influenced by anthropogenic emissions which can be transported long distances.
- Precursor compounds to ozone production are often released from gas and oil production and extraction, wild fires, vehicles, agriculture, and others.
- The extent to which ozone is produced and accumulated at ground-level is a result of complex interactions between meteorological conditions, emission sources, photochemical properties of the atmosphere, and transport of air masses.

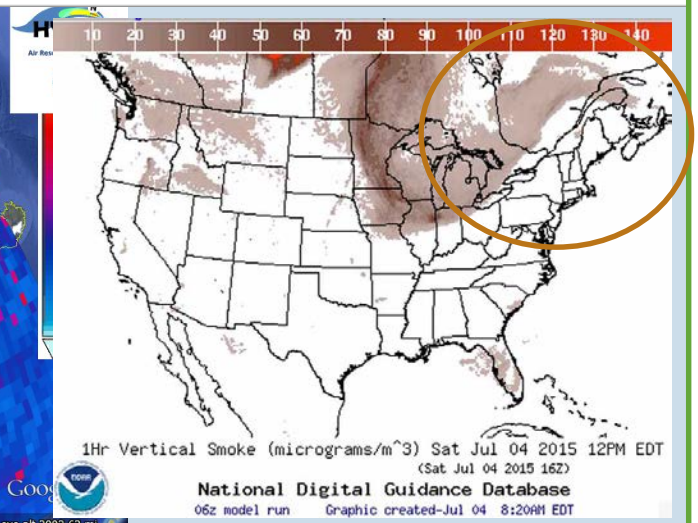
High Ozone Event:
Summit-July 2015

July 5, 2015 Summit Greenland Ozone was enhanced due to interactions with wildfire related pollutants. Hourly ozone mixing ratios from July 1st to July 10th 2015 are graphed with the 10th percentile, 90th percentile, and average for reference.



July 5th 2015





Hysplit back trajectory analysis shows the path that the air parcel traveled before reaching the measurement station. The air mass that arrived and was measured in Summit on July 5th was influenced by wildfires in North East Canada and associated compounds from the smoke plumes. Modis Aerosol Optical Depth overlay displays the interaction of the air mass and particulates released from the fires. NOAA Smoke Forecast confirms the presence of smoke in the region.

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Thank you for your time and interest!

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MODIS- NASA Aerosol Optical Depth Product

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