Supplemental Information for:

Arctic Tropospheric Ozone Seasonality, Depletion, and Oil Field Influence

Evelyn M. Widmaier,[ab†] Andrew R. Jensen,[a†] Kerri A. Pratt[ac*]

[a]Department of Chemistry, University of Michigan, Ann Arbor, MI, USA
[b]Now at: Department of Chemistry, University of Wisconsin, Madison, WI, USA
[c]Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI, USA

[†]Contributed Equally
*Corresponding Author: Kerri A. Pratt
Department of Chemistry, University of Michigan
930 N. University Ave.
Ann Arbor, MI 48109
prattka@umich.edu
(734)-763-2871

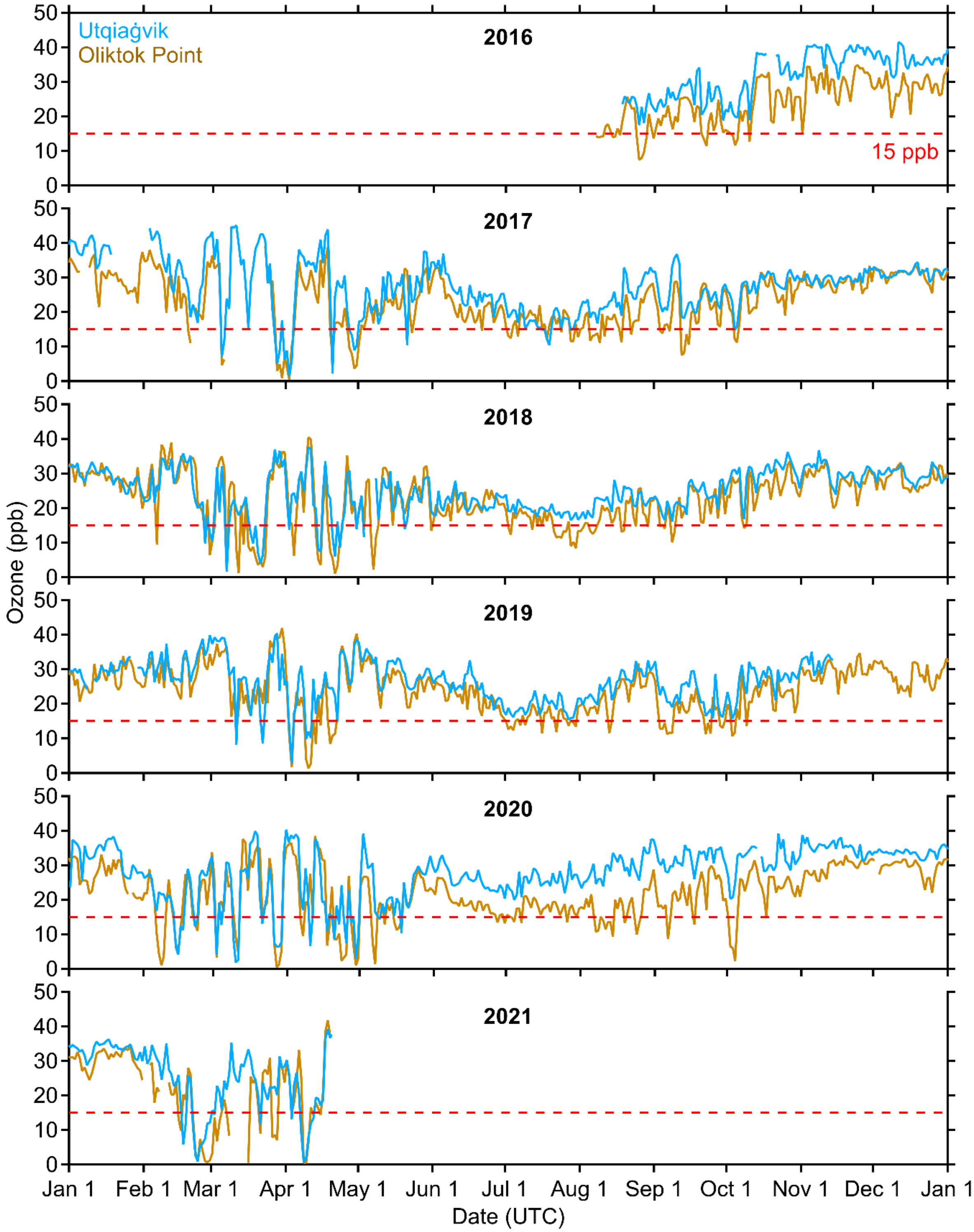

Figure S1. Daily averaged ozone mole ratios (ppb) separated by year. The red dashed lines represent the 15 ppb threshold used to identify ODEs.

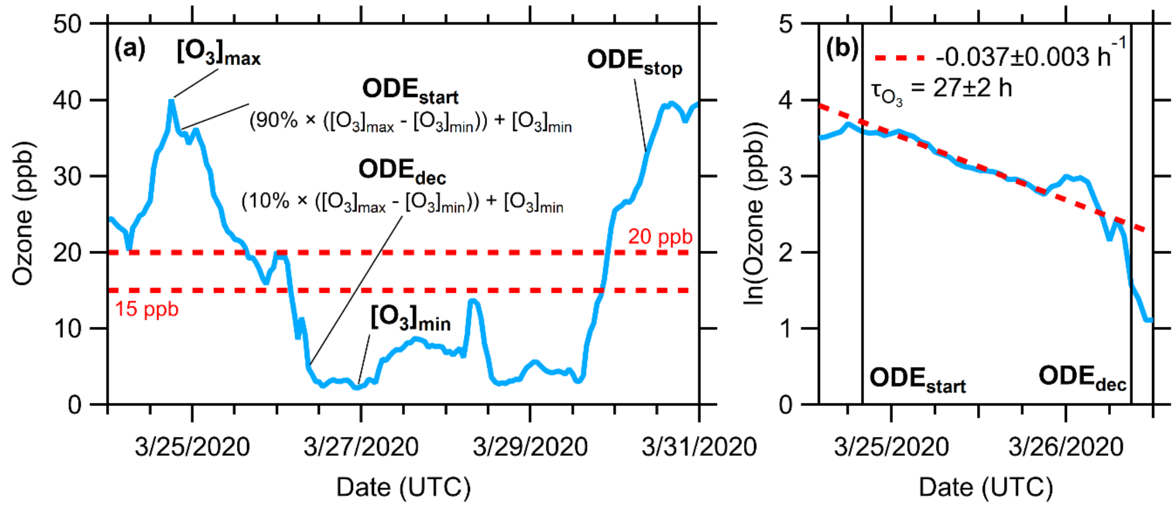

Figure S2. Hourly ozone mole ratios during an example ODE in spring 2020 at Utqiaġvik showing (a) the ODE parameters defined in Section 2.2 and (b) the least-squares linear regression used to calculate the ozone depletion timescale. The red dashed lines in (a) denote the 15 ppb and 20 ppb thresholds for defining the onset and end of ODEs, respectively. The linear fit in (b) is bounded by ODE_{start} and ODE_{dec} as designated by the vertical lines.

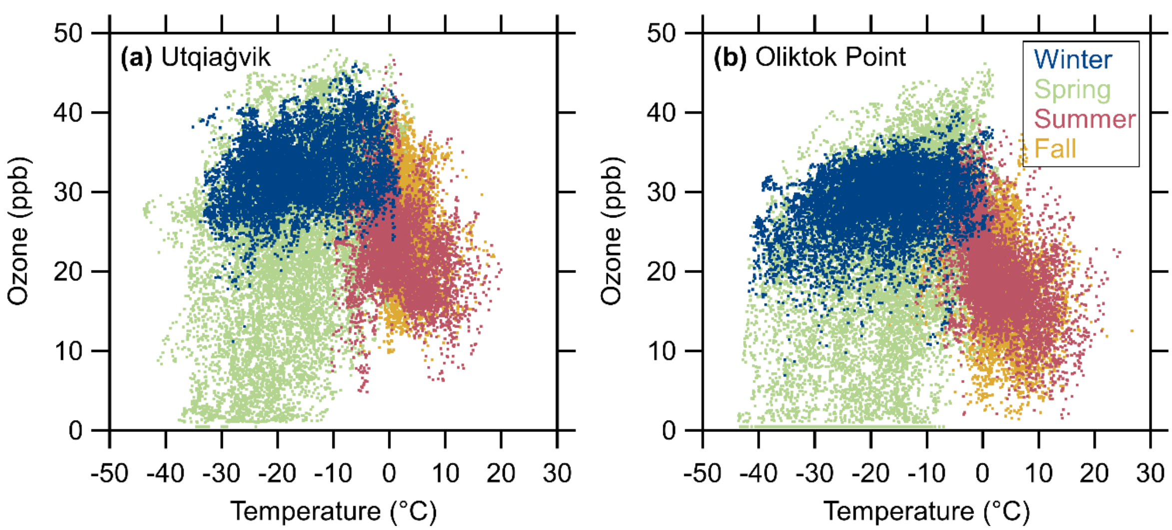

Figure S3. Hourly averaged ozone behavior with relation to temperature and season at (a) Utqiaġvik and (b) Oliktok Point. Both sites display similar seasonality. Seasons were defined as: winter (1 November–31 January), spring (1 February–15 May), summer (16 May–31 July), and fall (1 August–31 October).

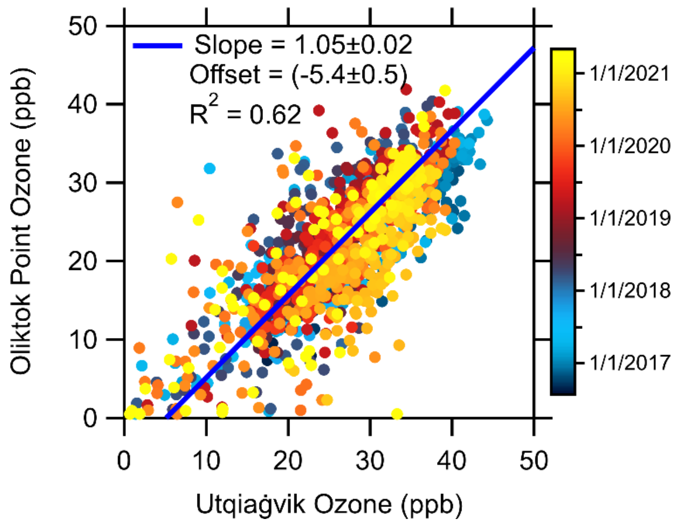

Figure S4. Correlation of daily averaged ozone mole ratios at Utqiaġvik and Oliktok Point for all data considered in this study. The linear fit is an orthogonal distance regression.

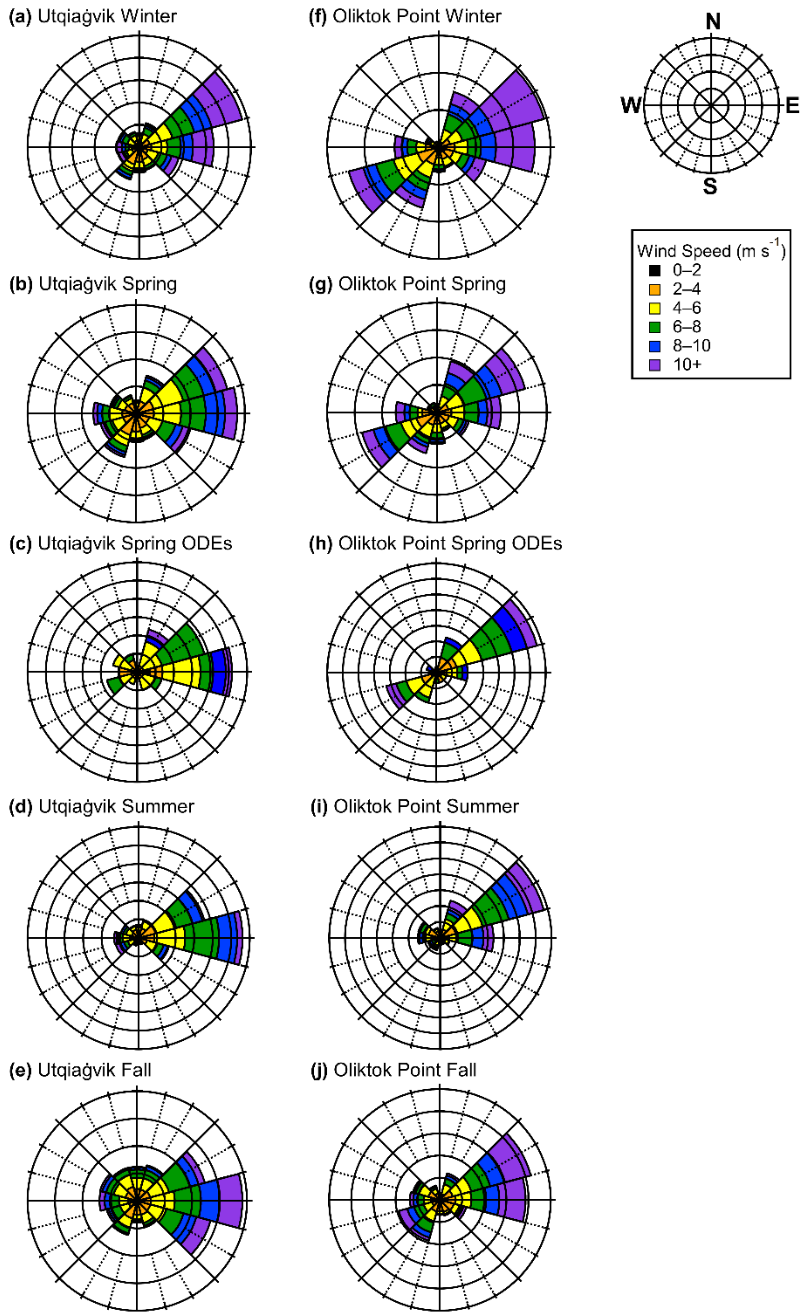

Figure S5. Seasonal wind rose plots depicting wind direction and speed at (a–e) Utqiaġvik and (f–j) Oliktok Point from fall 2016–spring 2021. Radius units represent the relative fraction of time (0.05 increments) wind came from that direction at that speed. Wind roses were calculated using hourly wind speed and direction. Wind rose plots during springtime ODEs (c and h) use averaged wind direction and speed over the full duration of each ODE (ODE_{start} to ODE_{stop}). Seasons were defined as: winter (1 November–31 January), spring (1 February–15 May), summer (16 May–31 July), and fall (1 August–31 October).

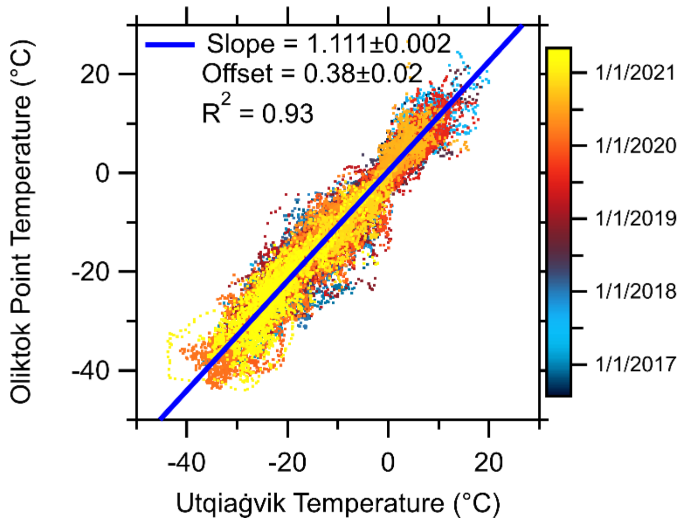

Figure S6. Correlation of hourly temperature at Utqiaġvik and Oliktok Point for all data considered in this study. The linear fit is an orthogonal distance regression.

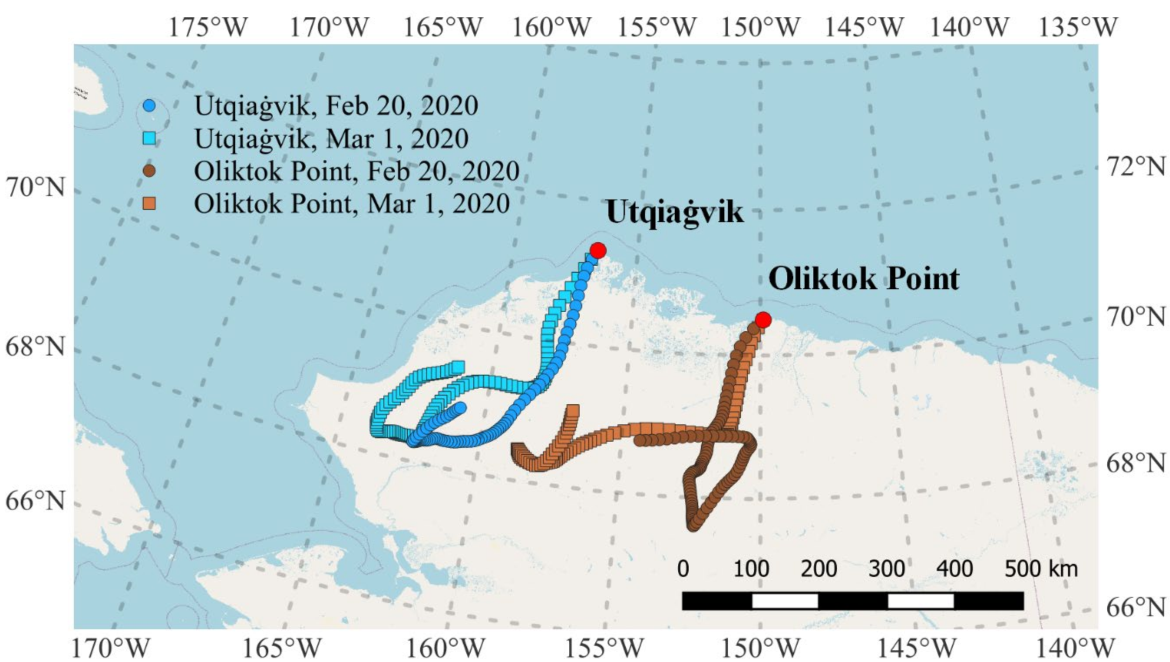

Figure S7. Backwards air mass trajectories for the two example ODEs presented in Figure 3 of the main text. Points represent 1 hour resolution. The setup for the HYSPLIT model is described in Section 3.3 of the main text. The trajectories at Utqiaġvik and Oliktok Point were initialized at the ozone measurement heights of 6 m and 10 m above ground level, respectively. There were negligible differences for trajectories initialized at 50 m above ground level.

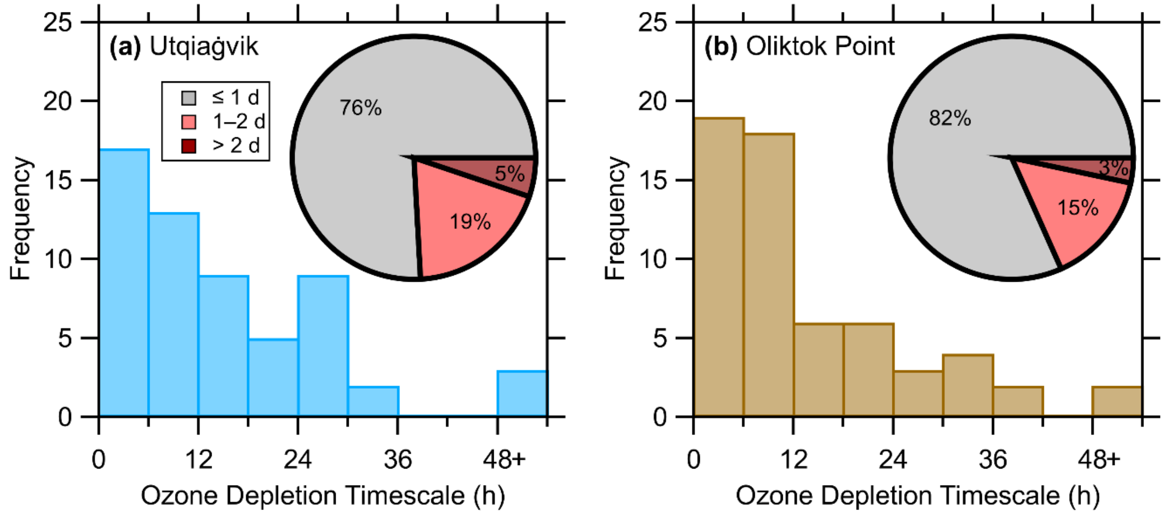

Figure S8. Histogram of springtime ODE timescales observed at (a) Utqiaġvik and (b) Oliktok Point. Timescales were grouped into 6-hour bins with longer timescales (≥ 2 d) grouped together. The inset pie charts break these distributions into short timescales (≤ 1 d) indicating transport of an ozone-depleted air mass, moderate timescales (1–2 d) suggesting ozone depletion via local bromine chemistry, and longer timescales (≥ 2 h) indicating poor mixing.

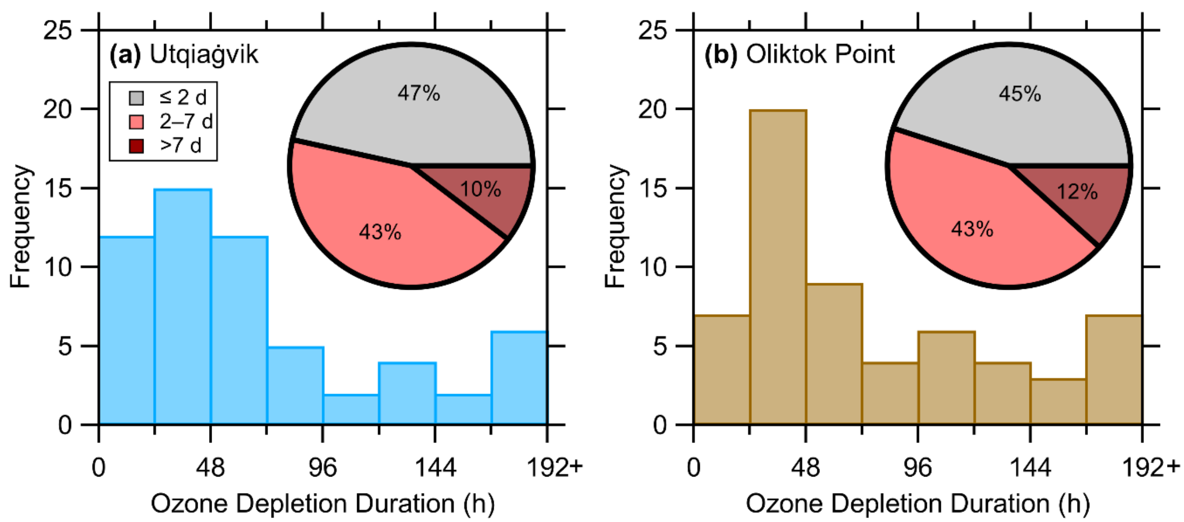

Figure S9. Histogram of springtime ODE durations observed at (a) Utqiaġvik and (b) Oliktok Point. Timescales were grouped into 1-day bins with longer timescales (≥ 7 d) grouped together. The inset pie charts break these distributions into short (≤ 2 d), moderate (2–7 d), and longer (≥ 7 d) durations.

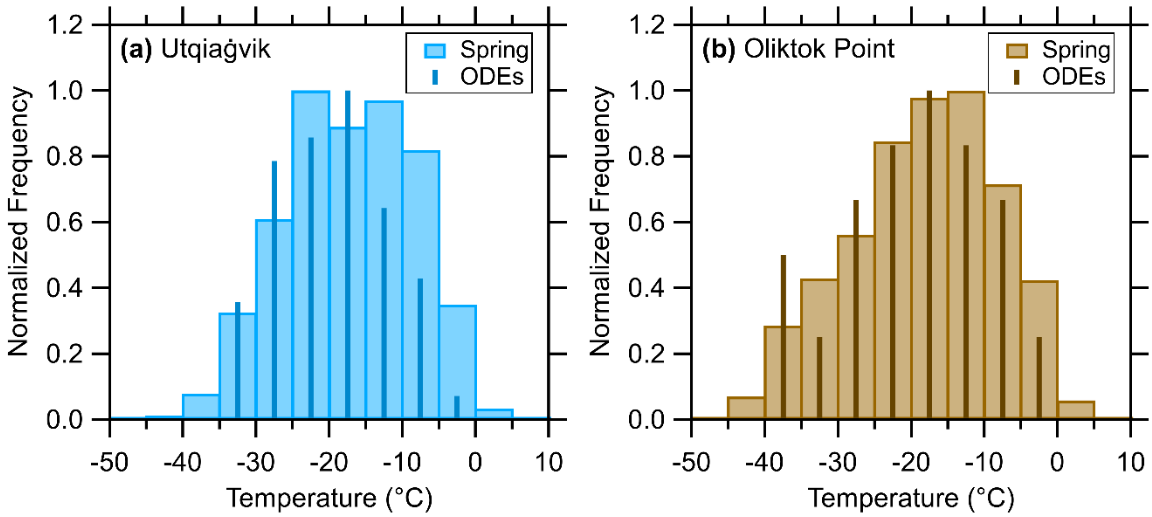

Figure S10. Histogram of hourly temperatures measured at (a) Utqiaġvik and (b) Oliktok Point for all springtime data and all springtime ODE data. Temperatures were grouped into 5°C bins. ODE temperatures were averaged across the duration of each ODE (ODE_{start} to ODE_{stop}). ODEs represent a smaller subset of spring. The histograms are normalized to better compare the distributions.