

Figure S1. Comparison between AMS mass and SMPS mass concentrations during the cold pollution event at the CTC site. The AMS mass concentration is summed from OA, sulfate, nitrate and ammonium. The SMPS mass is derived from number size distribution assuming aerosol density of 1.3-1.5 g/cm<sup>3</sup>, dependent on aerosol composition.



Figure S2. Comparison between AMS mass and SMPS mass concentrations during the cold pollution event at the House site. The AMS mass concentration is summed from OA, sulfate, nitrate and ammonium. The SMPS mass is derived from number size distribution assuming aerosol density of 1.5 g/cm<sup>3</sup>.



Figure S3 Rapid sulfate increase events during February and November of 2020. Panel (a) and (b) show OA, sulfate, nitrate, ammonium, chloride mass concentrations and the ratio of sulfate to OA from ACSM, as well as hourly  $PM_{2.5}$  mass from Beta Attenuation Mass Monitor (Met One BAM 1020) for the pollution episode in February and November of 2020. Panel (c) and (d) show ambient measurements of measured SO<sub>2</sub> and NO<sub>x</sub> volume mixing ratio from ADEC.



Figure S4 Same as Figure S3, but for two pollution episodes in January and February of 2021.



Figure S5 Same as Figure S3, but for two pollution episodes in December of 2021.



Figure S6 Correlation plot between  $SO_4/OA$  mass ratio from ACSM and hourly  $PM_{2.5}$  data from the BAM at ADEC in three winters. Each dot represents an hourly-averaged measurement and is color-coded based on ambient temperature.