1140 Supporting Text

UW I⁻ HR ToF CIMS Mass Assignments of C7H8O2

We see significant signal at the mass corresponding to $C_7H_8O_2$. There are at least two explanations for this mass: methylcatechol or guaiacol or any mixture in-between. The time series of $C_7H_8O_2$ suggests it is a primary emission (SI Figure 5 and SI Figure 6). Current BB emissions literature does not list methylcatechol as a detected gas-phase emission (Hatch et al.,

- 1145 2015; Koss et al., 2018), however emissions collected on Teflon filters with subsequent GCxGC analysis show evidence for methylcatechol (Hatch et al., 2018). Both guaiacol and methylcatechol are highly reactive to NO₃, OH, and O₃. Therefore, accurately determining its identity and thus mixing ratio, is important to both constraining the model and comparing it to observations. Collection of smoke during the Castle and Cow plume by a Tenax cartridge sampler with subsequent GCxGC analysis shows no evidence for methylcatechol or guaiacol above detection limits in the Castle plume, but some evidence for
- 1150 guaiacol at roughly ~0.06 ppbv in the Cow plume. Using calibrations for the UW I⁻ HR ToF CIMS $C_7H_8O_2$ signal for guaiacol and methylcatechol (described in the SI of Palm et al., 2020), we determined that methycatechol is the most likely assignment despite its absence by the Tenax cartridge sampler. If the mass was entirely due to guaiacol, then ~0.06 ppbv would appear as < 1 normalized count per second on the UW I⁻ HR ToF CIMS, while we observe 1,000 – 10,000 normalized counts per second. In other words, iodide is very weakly sensitive to guaiacol and we do not expect to detect a mixing ratio of 0.06 ppbv. Assigning
- 1155 $C_7H_8O_2$ to methylcatechol corresponds to observations of 0.1 1 ppbv (SI Figure 5 and SI Figure 6) and an emission ratio of 0.4 ppbv ppmv⁻¹ CO, or $1/3^{rd}$ that of the catechol emission ratio. This is consistent with the same assignment of $C_7H_8O_2$ and emission ratios observed in (Palm et al., 2020). Lastly, while we expect formation of methylcatechol from cresol oxidation by OH, our box model shows this formation pathway is negligible.

Expansion of Phenolic Mechanisms Description

- 1160 Phenol and cresol oxidation have been studied in greater detail than their oxidation products such as catechols and methylcatechols (Calvert et al., 2011). Thus, in order to update the phenolic chemistry, where literature values are unavailable we extrapolate phenol and cresol branching ratios, rate coefficients, and products for catechol, methylcatechol, and the three isomers of dimethylcatechol. As an example, SI Figure 12 shows our reaction mechanisms involving catechol. Reactions in black represent reactions already in the MCM, while reactions in brown represent added reactions.
- 1165 The reaction of phenol and cresol + OH is known to form catechol and methylcatechol, respectively, by OH addition to the ring (Olariu et al., 2002). Similarly, the formation of trihydroxybenzene from catechol was suggested by Nakao et al., 2011 and trihydroxy toluene was identified as an oxidation product from methylcatechol by Schwantes et al., 2017. Further, reactions of phenol and cresol with OH are also known to produce benzoquinones (Olariu et al., 2002) and Schwantes et al., 2017 identified hydroxymethyl benzoquinone from methylcatechol. Finewax et al., 2018 report the yield of nitrocatechol from OH

- 1170 oxidation of catechol to be $30 \pm 3\%$. Despite these recent studies, MCM v3.3.1 assumes, under high NO₂ conditions, a 100% yield of nitrocatechol and nitromethylcatechol from OH-initiated oxidation of catechol and methylcatechol, respectively. In the updated phenolic mechanism used here, the rate coefficients and branching ratios are taken from the literature when possible, but estimated from analogous reactions when unavailable. OH-initiated oxidation of catechol, methylcatechol, and dimethylcatechols is assumed to form 30% nitrocatechol, nitromethylcatechol, and nitrodimethylcatechol, respectively, under
- 1175 high NO₂ conditions as extrapolated from Finewax et al., 2018. The remaining 70% of products from OH-initiated catechol, methylcatechol, and dimethylcatechols produce trihydroxybenzene and hydroxybenzoquinone type products consistent with recent work for catechol and methyl catechol oxidation (Nakao et al., 2011 and Schwantes et al., 2017). To calculate the branching ratio between hydroxybenzoquinone and trihydroxybenzene from catechol + OH, we scale the yields found for each type from literature for phenol + OH (Nakao et al., 2011; Olariu et al., 2002). The result is an estimated 3% yield of hydroxybenzoquinone and a 67% yield of trihydroxybenzene. Similarly, for methylcatechol and dimethylcatechol + OH, we
- scale the yields from literature for each type from *o*-cresol + OH (Nakao et al., 2011; Olariu et al., 2002). Finewax et al., 2018 report the yield of nitrocatechol from NO₃ oxidation of catechol to be $91\pm6\%$. Olariu et al. also found benzoquinone formation from NO₃ + cresol (Olariu et al., 2013). The mechanism by which benzoquinones are formed by NO₃ oxidation of catechol is uncertain. Olariu et al. state that unpublished work finds no evidence for benzoquinone products from
- 1185 phenol + NO₃, while Bolzacchini et al. find evidence for benzoquinone production from NO₃ + phenol if O₃ is present (Bolzacchini et al., 2001). We assume catechol, methylcatechol, and dimethylcatechols + NO₃ forms 91% nitrocatechol type product and the remaining 9% a benzoquinone type product, as seen in SI Figure 12. For simplification in our box model, we group benzoquinone products.

Referring to SI Figure 12, OH and NO₃ reactions with catechol form a catechol radical (CATO), which can then react with

- 1190 either NO₂ or O₃. Reactions with NO₂ form nitrocatechol (NCATECHOL), while reactions with O₃ form a catechol-peroxy radical (CATO₂), which can subsequently react with HO₂ to form a catechol-hydroperoxide (CATOOH). The formation of CATOOH is reversible but our model runs find the lifetime of CATOOH is >100 hours meaning CATOOH acts as a permanent loss of CATO₂. While our catechol mechanism does not include heterogeneous reactions, it is likely that CATOOH will be lost through aerosol. We find that CATOOH is responsible for 17 26% of net CATO loss. In other words, 17 26% of
- 1195 potential nitrocatechol formation is lost to CATOOH. In all model runs, the fraction of potential nitrocatechol lost by O_3 increases as the plume ages.

For updates to both OH- and NO_3 - phenolic compound oxidation, we assume similar assumptions for later-generation products and end the oxidation at highly-functionalized products, which will likely form secondary organic aerosol. Below, we provide the mechanism in the form of FACSIMILE, which is a standard output format (.fac) from the MCM and is readable in F0AM 24.0

1200 v4.0.

Mechanism

Note: reactions in red are already in the MCM and will need to be replaced when used in conjunction with an MCM mechanism.

Catechols

% 1.0D-10*0.3 : CATECHOL + OH = CATEC1O ; 1205 % 1.0D-10*0.67 : CATECHOL + OH = H3BENZENE + HO2 ; % 1.0D-10*0.03 : CATECHOL + OH = HPBZQONE + HO2; % 3.00D-13 : HPBZQONE + NO3 = NBZQO2 ; % 4.6D-12 : HPBZQONE + OH = PBZQO2 ; % 1.0D-10*0.3 : H3BENZENE + OH = H3BENZENE1O : 1210 % 1.0D-10*0.67 : H3BENZENE + OH = H4BENZENE + HO2; % 1.0D-10*0.03 : H3BENZENE + OH = H2PBZQONE + HO2; % 3.00D-13 : H2PBZQONE + NO3 = NBZQO2 ; % 4.6D-12 : H2PBZQONE + OH = PBZQO2 ; % 2.08D-12 : H3BENZENE10 + NO2 = NH3BENZENE : 1215 % 2.86D-13 : H3BENZENE1O + O3 = H3BENZENE1O2 ; % KRO2HO2*0.770 : H3BENZENE1O2 + HO2 = HCATEC1OOH ; % KRO2NO : H3BENZENE1O2 + NO = H3BENZENE1O + NO2 : % KRO2NO3 : H3BENZENE1O2 + NO3 = H3BENZENE1O + NO2 ;

- % 8.80D-13*RO2 : H3BENZENE1O2 = H3BENZENE1O ;
- % 9.9D-11*0.91 : CATECHOL + NO3 = CATEC1O + HNO3 ; % 9.9D-11*0.09 : CATECHOL + NO3 = HPBZQONE + HO2 + HNO3 ; % 9.9D-11*0.91 : H3BENZENE + NO3 = H3BENZENE1O + HNO3 ; % 9.9D-11*0.09 : H3BENZENE + NO3 = H2PBZQONE + HO2 + HNO3 ;

1225 Methylcatechols

1220

% 2.0D-10*0.3 : MCATECHOL + OH = MCATEC1O ; % 2.0D-10*0.64 : MCATECHOL + OH = H3TOLUENE + HO2; % 2.0D-10*0.06 : MCATECHOL + OH = HPTLQONE + HO2; % 1.00D-12 : HPTLQONE + NO3 = NPTLQO2 ; % 2.3D-11 : HPTLQONE + OH = PTLQO2 ; 1230 % 2.0D-10*0.3 : H3TOLUENE + OH = H3TOLUENE1O ; % 2.0D-10*0.64 : H3TOLUENE + OH = H4TOLUENE + HO2; % 2.0D-10*0.06 : H3TOLUENE + OH = H2PTLQONE + HO2; % 1.00D-12 : H2PTLQONE + NO3 = NPTLQO2 ;

% 2.3D-11 : H2PTLQONE + OH = PTLQO2 ; 1235 % 2.08D-12 : H3TOLUENE1O + NO2 = NH3TOLUENE ; % 2.86D-13 : H3TOLUENE1O + O3 = H3TOLUENE1O2 ;

- % KRO2HO2*0.820 : H3TOLUENE1O2 + HO2 = HMCATEC1OOH ;
- % KRO2NO : H3TOLUENE1O2 + NO = H3TOLUENE1O + NO2 ;
- 1240 % KRO2NO3 : H3TOLUENE1O2 + NO3 = H3TOLUENE1O + NO2 ;
 - % 8.80D-13*RO2 : H3TOLUENE1O2 = H3TOLUENE1O ;

% 1.7D-10*0.91 : MCATECHOL + NO3 = MCATEC1O + HNO3 ;

- % 1.7D-10*0.09 : MCATECHOL + NO3 = HPTLQONE + HO2 + HNO3 ;
- % 1.7D-10*0.91 : H3TOLUENE + NO3 = H3TOLUENE1O + HNO3 ;
- 1245 % 1.7D-10*0.09 : H3TOLUENE + NO3 = H2PTLQONE + HO2 + HNO3 ;

Dimethylcatechols

% 2.05D-10*0.3 : OXYCATECH + OH = OXCATEC1O ;

% 2.05D-10*0.64 : OXYCATECH + OH = H3OXYLENE + HO2;

% 2.05D-10*0.06 : OXYCATECH + OH = HOXYQONE + HO2;

1250 % 1.00D-12 : HOXYQONE + NO3 = NOXYQO2 ;

% 2.35D-10 : HOXYQONE + OH = OXYQO2 ;

% 2.05D-10*0.3 : H3OXYLENE + OH = H3OXYLENE1O ;

% 2.05D-10*0.64 : H3OXYLENE + OH = H4OXYLENE + HO2;

% 2.05D-10*0.06 : H3OXYLENE + OH = H2OXYQONE + HO2;

1255 % 1.00D-12 : H2OXYQONE + NO3 = NOXYQO2 ;

% 2.35D-10 : H2OXYQONE + OH = OXYQO2 ;

% 2.08D-12 : H3OXYLENE10 + NO2 = NH3OXYLENE ;

% 2.86D-13 : H3OXYLENE10 + O3 = H3OXYLENE1O2 ;

% KRO2HO2*0.859 : H3OXYLENE1O2 + HO2 = HOCATEC1OOH ;

1260 % KRO2NO : H3OXYLENE1O2 + NO = H3OXYLENE1O + NO2;

% KRO2NO3 : H3OXYLENE1O2 + NO3 = H3OXYLENE1O + NO2 ;

% 8.80D-13*RO2 : H3OXYLENE1O2 = H3OXYLENE1O ;

% 2.01D-10*0.91 : OXYCATECH + NO3 = OXCATEC1O + HNO3 ;

% 2.01D-10*0.09 : OXYCATECH + NO3 = HOXYQONE + HO2 + HNO3 ;

1265 % 2.01D-10*0.91 : H3OXYLENE + NO3 = H3OXYLENE1O + HNO3 ;

% 2.01D-10*0.09 : H3OXYLENE + NO3 = H2OXYQONE + HO2 + HNO3 ;

% 2.05D-10*0.3 : PXYCATECH + OH = PXCATEC1O ;

% 2.05D-10*0.64 : PXYCATECH + OH = H3PXYLENE + HO2;

1270 % 2.05D-10*0.06 : PXYCATECH + OH = HPXYQONE + HO2;

% 1.00D-12 : HPXYQONE + NO3 = NPXYQO2 ;

% 2.35D-11 : HPXYQONE + OH = PXYQO2 ;

% 2.05D-10*0.3 : H3PXYLENE + OH = H3PXYLENE1O ;

% 2.05D-10*0.64 : H3PXYLENE + OH = H4PXYLENE + HO2;

- 1275 % 2.05D-10*0.06 : H3PXYLENE + OH = H2PXYQONE + HO2;
 % 1.00D-12 : H2PXYQONE + NO3 = NPXYQO2 ;
 % 2.35D-11 : H2PXYQONE + OH = PXYQO2 ;
 % 2.08D-12 : H3PXYLENE10 + NO2 = NH3PXYLENE ;
 % 2.86D-13 : H3PXYLENE10 + O3 = H3PXYLENE102 ;
 1280 % KRO2HO2*0.859 : H3PXYLENE102 + HO2 = HPCATEC10OH ;
 % KRO2NO : H3PXYLENE102 + NO = H3PXYLENE10 + NO2 ;
 % KRO2NO3 : H3PXYLENE102 + NO3 = H3PXYLENE10 + NO2 ;
 % 8.80D-13*RO2 : H3PXYLENE102 = H3PXYLENE10 ;
 % 2.01D-10*0.91 : PXYCATECH + NO3 = PXCATEC10 + HNO3 ;
- 1285 % 2.01D-10*0.09 : PXYCATECH + NO3 = HPXYQONE + HO2 + HNO3 ;
 % 2.01D-10*0.91 : H3PXYLENE + NO3 = H3PXYLENE1O + HNO3 ;
 % 2.01D-10*0.09 : H3PXYLENE + NO3 = H2PXYQONE + HO2 + HNO3 ;

% 2.05D-10*0.3 : MXYCATECH + OH = MXCATEC1O ;

1290 % 2.05D-10*0.64 : MXYCATECH + OH = H3MXYLENE + HO2: % 2.05D-10*0.06 : MXYCATECH + OH = HMXYQONE + HO2; % 1.00D-12 : HMXYOONE + NO3 = NMXYOO2 : % 2.35D-11 : HMXYQONE + OH = MXYQO2 ; % 2.05D-10*0.3 : H3MXYLENE + OH = H3MXYLENE1O ; 1295 % 2.05D-10*0.64 : H3MXYLENE + OH = H4MXYLENE + HO2; % 2.05D-10*0.06 : H3MXYLENE + OH = H2MXYQONE + HO2 ; % 1.00D-12 : H2MXYQONE + NO3 = NMXYQO2 ; % 2.35D-11 : H2MXYQONE + OH = MXYQO2 ; % 2.08D-12 : H3MXYLENE10 + NO2 = NH3MXYLENE ; 1300 % 2.86D-13 : H3MXYLENE1O + O3 = H3MXYLENE1O2 ; % KRO2HO2*0.859 : H3MXYLENE1O2 + HO2 = HMXCTEC1OOH ; % KRO2NO : H3MXYLENE1O2 + NO = H3MXYLENE1O + NO2 : % KRO2NO3 : H3MXYLENE1O2 + NO3 = H3MXYLENE1O + NO2 ;

% 8.80D-13*RO2 : H3MXYLENE1O2 = H3MXYLENE1O ;

1305 % 2.01D-10*0.91 : MXYCATECH + NO3 = MXCATEC1O + HNO3 ;

% 2.01D-10*0.09 : MXYCATECH + NO3 = HMXYQONE + HO2 + HNO3 ;
% 2.01D-10*0.91 : H3MXYLENE + NO3 = H3MXYLENE10 + HNO3 ;
% 2.01D-10*0.09 : H3MXYLENE + NO3 = H2MXYQONE + HO2 + HNO3 ;

Supporting Figures

Measurements Used	Method	Platform	Sample Frequency	Reference		
HONO, C ₆ H ₆ O, C ₇ H ₈ O, C ₆ H ₆ O ₂ , C ₇ H ₈ O ₂ , C ₆ H ₅ NO ₄ , C ₇ H ₇ NO ₄ , C ₆ H ₅ NO ₃ , C ₇ H ₇ NO ₃ .	University of Washington Iodide High Resolution Time of Flight Chemical Ionization Mass Spectrometer (UW I ⁻ HR ToF CIMS)	Twin Otter	2 Hz	(Lee et al., 2014)		
Guaiacol and methylcatechol.	Tenax cartridge sampler with subsequent GCxGC analysis	Twin Otter	~ 5 min	(Hatch et al., 2015; Mondello et al., 2008)		
СО	Picarro G2401-m, cavity ringdown spectrometer.	Twin Otter	0.5 Hz	(Crosson, 2008)		
NO, NO ₂ and O_{3} .	NCAR chemiluminescence instrument	Twin Otter	1 Hz	(Sparks et al., 2019)		
Aerosol surface area	Ultra-high sensitivity aerosol spectrometer (UHSAS)	Twin Otter	1 Hz	(Kupc et al., 2018)		
jNO ₂	Meteorologie Consult, GmbH upward and downward facing jNO ₂ filter radiometers	Twin Otter	1 Hz	(Kupc et al., 2018; Warneke et al., 2016)		
СО	Tunable diode laser spectrometer	DC-8	1 Hz	(Sachse et al., 1991)		
СО	Cavity enhanced spectrometer	DC-8	1 Hz	(Eilerman et al., 2016)		
NO_2 , NO_y , and O_3	NOAA chemiluminescence	DC-8	1 Hz	(Pollack et al., 2010; Ridley et al., 1992; Stedman et al., 1972)		
NO ₂	NOAA broadband Airborne Cavity Enhanced Spectrometer (ACES)	DC-8	1 Hz	(Min et al., 2016)		
NO	NOAA laser induced fluorescence	DC-8	1 Hz	(Rollins et al., 2020)		
HONO, C ₆ H ₆ O ₂ , C ₆ H ₅ NO ₄	NOAA Iodide Time of Flight Chemical Ionization Mass Spectrometer (I ⁻ ToF CIMS)	DC-8	1 Hz	(Neuman et al., 2016; Veres et al., 2020)		
peroxyacetyl nitrate (PAN)	Thermal dissociation Chemical Ionization Mass Spectrometer	DC-8	1 Hz	(Ro Lee et al., 2020)		
Aerosol Size Distribution and Derived Surface Area	Scanning mobility particle sizer (SMPS) Laser Aerosol Spectrometer (LAS)	DC-8	60 sec 1 Hz	(LAS, n.d.; Moore et al., 2021; SMPS, n.d.)		
Photolysis rates listed in SI Table 3	Charged-coupled device Actinic Flux Spectroradiometer (CAFS)	DC-8	1 Hz	(Shetter and Müller, 1999)		

SI Table 1: List of instruments and measurements used in this analysis.



1315 SI Figure 1: Flight map and photos of the Castle plume. Photos indicate the Ikes and Castle fires, which burned near each other and eventually mixed plumes. The first four (of 8) transects of the Castle plume are unmixed with the Ikes plume.



SI Figure 2: Time series of CO (black filled) as a function of emission time. Red markers indicate the top 5 % of CO during a single 1320 transect. Filled circles indicate observations chosen to constrain a model run and crosses indicate unused observations.



SI Figure 3: Exponential fit $(y = Ae^{x/r} + y_0)$ to normalized excess mixing ratios (NEMR) of CO used as our best-guess estimate of dilution for each model run. Filled circles indicate observations used to constrain the model run, while open circle indicate observation that are not used.

Compound	WF1	WF2	Castle	Cow
CO (ppmv)	0.089	0.080	0.124	0.070
NO (ppbv)	0.0	0.0	0.0	0.0
NO ₂ (ppbv)	0.0	0.1	0.1	0.06
HONO (ppbv)	0.0	0.0	0.0	0.0
O ₃ (ppbv)	96.25	84.2	90	60.7
$k_{dil} (\times 10^{-5} s^{-1})$	10.5	4.5	60.0	7.7

SI Table 2: Table of background mixing ratios of CO, NO, NO₂, HONO, and O₃ for all model runs. The Dark model run has the 1330 same conditions as the WF2 model run.

Photolysis Rates Used to Co	onstrain the WF1	and WF2 Model Runs
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$jNO_2 \rightarrow NO + O^3(P)$	$jCH_2O \rightarrow H + HCO$	jCHOCHO →HCO + HCO
$jO_3 \rightarrow O_2 + O^1(D)$	$jCH_3CHO \rightarrow CH_3 + HCO$	j CHOCHO \rightarrow CH ₂ O + CO
$jH_2O_2 \rightarrow 2OH$	$jpropanal \rightarrow CH_2CH_3 + HCO$	j2,3,butadione
$jNO_3 \rightarrow NO_2 + O^3(P)$	$jMeONO_2 \rightarrow CH_3O + NO_2$	$jMEK \rightarrow CH_3CO + CH_2CH_3$
$jNO_3 \rightarrow NO + O_2$	$jEthONO_2 \rightarrow CH_3CH_2O + NO_2$	$jCH_3COCHO \rightarrow CH_3CO + HCO$
$jHNO_2 \rightarrow OH + NO$	jMVK	$jHNO_3 \rightarrow OH + NO_2$
$jCH_2O \rightarrow H_2 + CO$	jCHOCHO → $H_2 + 2CO$	

SI Table 3: List of photolysis rates measured on the DC-8 and used to constrain the WF 1 and WF2 model runs.

	V	WF1	V	WF2	Cast	le	Cow		
	ppbv	ppbv ppmv ⁻¹							
CO	8259	-	8329		1954		2618		
NO	28.0	3.4	57.0	6.8	8.4	4.3	16.8	6.4	
NO_2	7.0	0.8	0.0	0.0	3.6	1.8	4.2	1.6	
HONO	8.0	1.0	30.0	3.6	3.0	1.5	22.5	8.6	
O ₃	53.9	-	38.3	-	81.3	-	43.2	-	

SI Table 4: Table of initial mixing ratios of CO, NO, NO₂, HONO, and O₃ for all model runs. The Dark model run has the same conditions as the WF2 model run.

	WF1	WF2	Castle	Cow
Average O ₃ Upwind	57.8±0.4	48.9 ± 7.5	72 ± 1	-
(ppbv)				
Average O ₃ Outside	53 ± 3	58 ± 8	82 ± 2	53 ± 3
of transects (ppbv)				

SI Table 5: Table of observed background O₃ during an upwind transect and outside of the plume edges.

1340

	Castle WF1							WF	2	2 Cow						
	(ppbv) (%)		%)	(pp	bv)	(%)		(ppbv)		(%)		(ppbv)		(%)		
	Avg	Med	Avg	Med	Avg	Med	Avg	Med	Avg	Med	Avg	Med	Avg	Med	Avg	Med
CO	80.5	69.9	6.8	6.5	307.4	328.2	13.1	11.7	243.1	243.1	4.1	4.2	37.8	39.7	2.8	2.8
NO_2	0.5	0.4	15.8	6.8	2.0	2.0	126.1	32.2	2.0	2.0	5.0	5.1	1.4	0.9	12.0	8.3
NO	0.3	0.2	54.9	47.6	0.4	0.1	944.6	99.8	1.0	1.0	43.7	40.5	0.1	0.1	100.0	100.0
O_3	1.6	1.7	2.0	2.1	6.1	6.3	6.5	6.2	3.4	3.4	29.7	27.2	0.4	0.3	0.8	0.8
HONO	0.3	0.4	21.6	21.8	0.9	0.8	961.4	53.3	3.4	3.4	16.9	18.8	0.5	0.4	5.5	6.6

 HONO
 0.3
 0.4
 21.6
 21.8
 0.9
 0.8
 961.4
 53.3
 3.4
 3.4
 16.9
 18.8
 0.5
 0.4
 5.5
 6.6

 SI Table 6: Comparison of model outputs and observations used (as seen in Figure 2) as the average (Avg) or median (Med) in absolute (ppbv) and percent difference (%) for all compounds used to iterate the model.



SI Figure 4: Observed normalized excess mixing ratios (NEMRs) of NO, NO₂, HONO, and O₃ for all plumes.



SI Figure 5: Model outputs (black line) and observations (red circles) of the Castle plume where model compounds are indicated by the name and observations by chemical formula. Observations are made by the University of Washington I⁻ HR ToF CIMS. Detection limits for calibrated compounds are shown as horizontal red lines. For compounds without calibrations we report arbitrary units on the right axis for the purpose of comparing time evolution.



SI Figure 6: Similar to SI Figure 5, but for the Cow plume.



1355 SI Figure 7: Model outputs (black line) and observations (red circles) of the WF1 plume where model compounds are indicated by the name and observations by chemical formula. Observations are made by the NOAA I⁻ CIMS. We report arbitrary units on the right axis for the purpose of comparing time evolution.



SI Figure 8: Model outputs (black line) and observations (red circles) of the WF2 plume where model compounds are indicated by the name and observations by chemical formula. Observations are made by the NOAA I⁻ CIMS for C₆H₆O₂ and C₆H₅NO₄ and by the GT CIMS. For uncalibrated compounds, we report arbitrary units on the right axis for the purpose of comparing time evolution.



SI Figure 9: Similar to SI Figure 5 (Castle), but in the form of normalized excess mixing ratios (NEMRs)



SI Figure 10: Similar to SI Figure 6 (Cow), but in the form of normalized excess mixing ratios (NEMRs).



1370 SI Figure 11: Left: total reactivity (s⁻¹) of BBVOCs (blue) and N₂O₅/NO₃ heterogenous uptake reactivity using a $\gamma_{N_2O_5} = 10^{-2}$ and a $\gamma_{NO_3} = 10^{-3}$ (red). Right: Relative reactivity (%) of N₂O₅/NO₃ heterogenous uptake compared to total reactivity (heterogenous uptake + BBVOCs) for $\gamma_{NO_3} = 1, 10^{-1}$, and 10^{-3} . In all model runs, BBVOCs overwhelmingly control NO₃ loss.



SI Figure 12: Subset of phenolic mechanism expansion showing catechol related reactions only. Reactions that are in the MCM are shown in black, and added reactions are shown in brown. Compounds that we boxed are lumped in the mechanism. Compound names correspond to the provided FACSIMILE provided in the SI.



1380 SI Figure 13: Oxidation metrics of all phenolic compounds for WF1 model run (A), WF2 and dark model runs (B), Castle model run (C), and Cow model run (D). Left axis: relative oxidation of phenolics for NO₃ (blue), OH (yellow), and O₃ (orange). Right log axis: absolute total oxidation (white line). Bar: Relative integrated rate of oxidation of phenolics for NO₃ (blue), OH (yellow), O₃ (orange) and the remaining phenolics at the model end (red).



SI Figure 14: Similar to SI Figure 13, but for furans and furfurals.



1390 SI Figure 15: Similar to SI Figure 13, but for alkenes.



SI Figure 16: Similar to Figure 10 in the main text, but for the Dark model run.