Supplementary Information for:

Optical properties of biomass burning aerosol during the 2021 Oregon fire season: comparison between wild and prescribed fires

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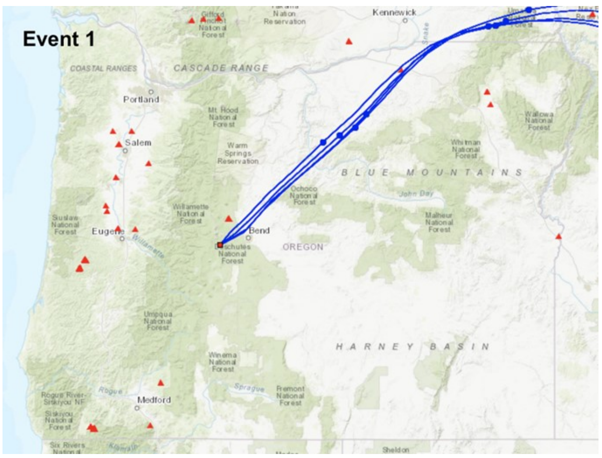
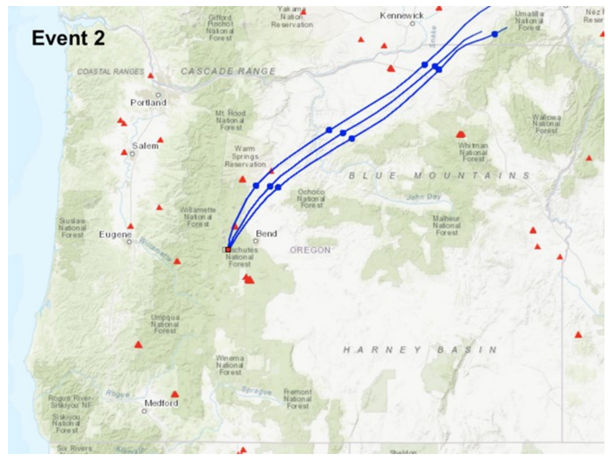
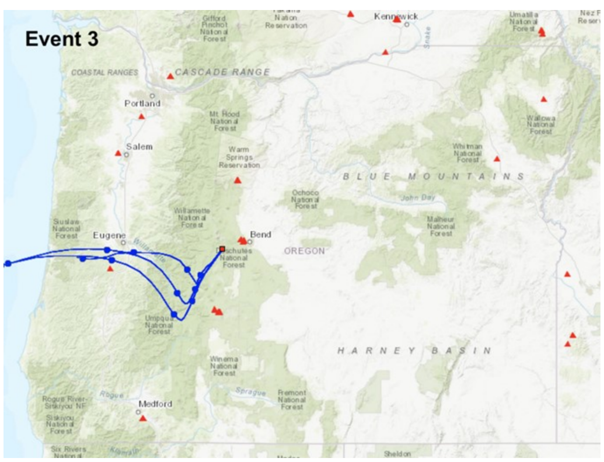
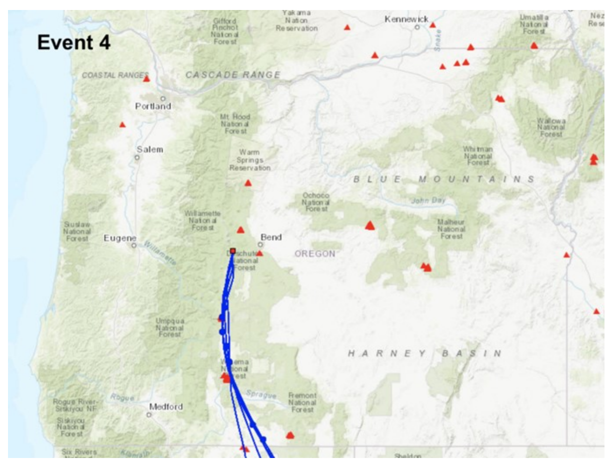
HYSPLIT back trajectories

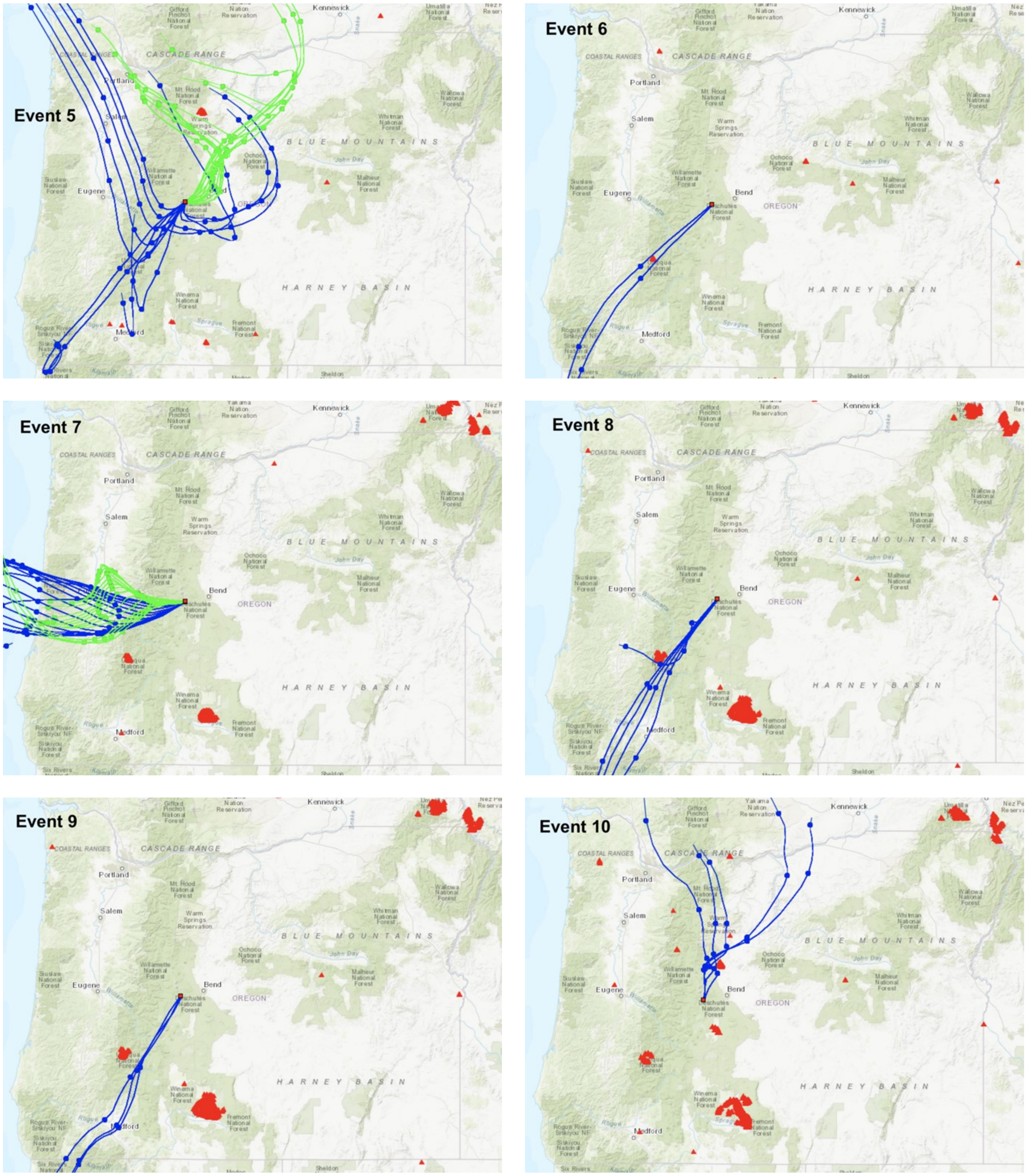
HYSPLIT back trajectory plots for each BB event are shown below. The plots were generated in AirNow-Tech Navigator (https://www.airnowtech.org/navigator/index.cfm). All trajectories were calculated using 12 km NAM meteorology with a runtime of 24 h. A new trajectory was initiated for each hour during the duration of the event. Trajectories in blue were initiated at 1500 a.m.g.l., while trajectories in green were initiated at 500 a.mg.l. to reflect upslope flow to MBO (Sect 2.4). Also shown are active fire locations identified by the NOAA Hazard Mapping System (HMS) Fire and Smoke Product (red triangles).







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Event 6
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Event 8
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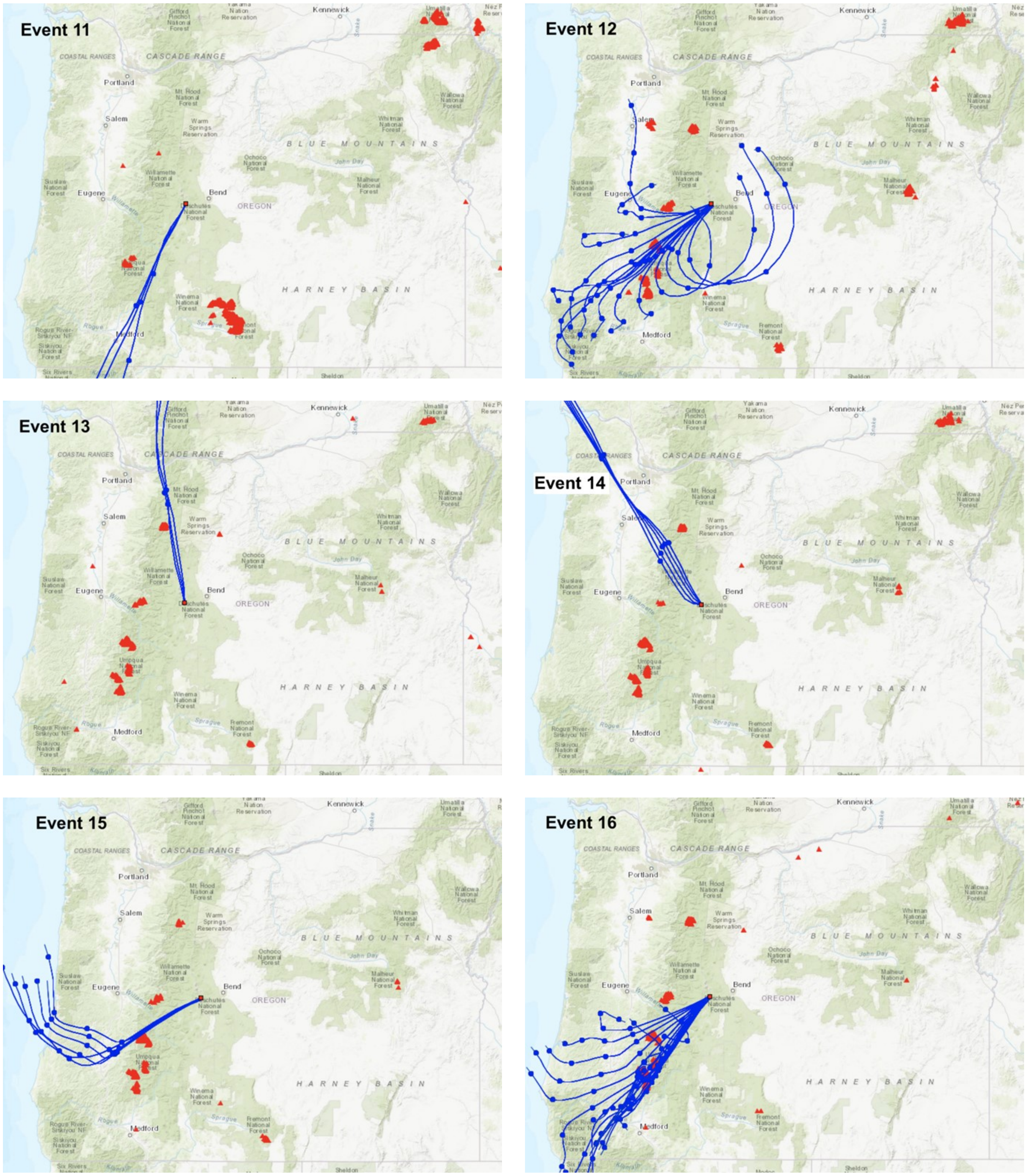
OREGON
Portland
Salem
Eugene
Bend
Medford
Kennewick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Event 15
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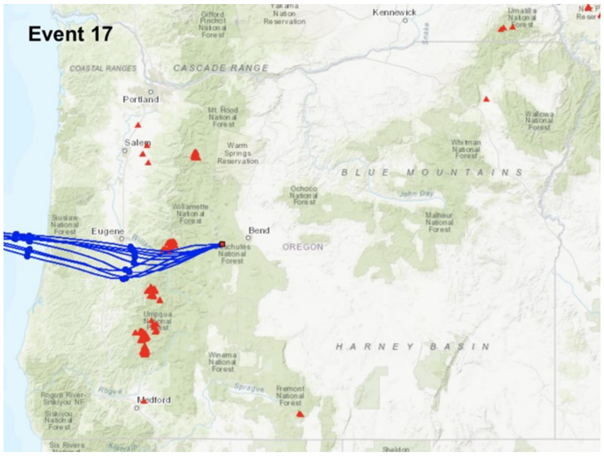
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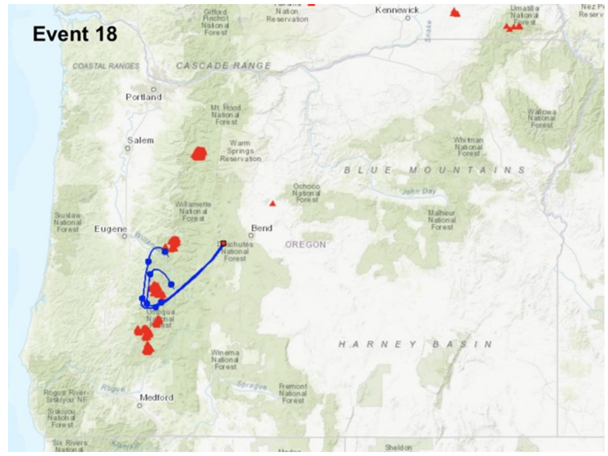
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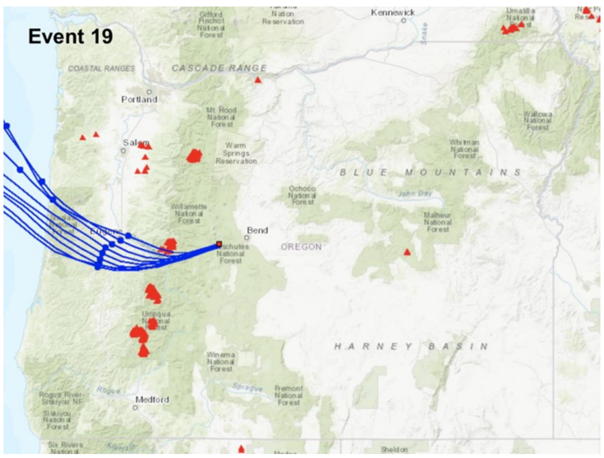
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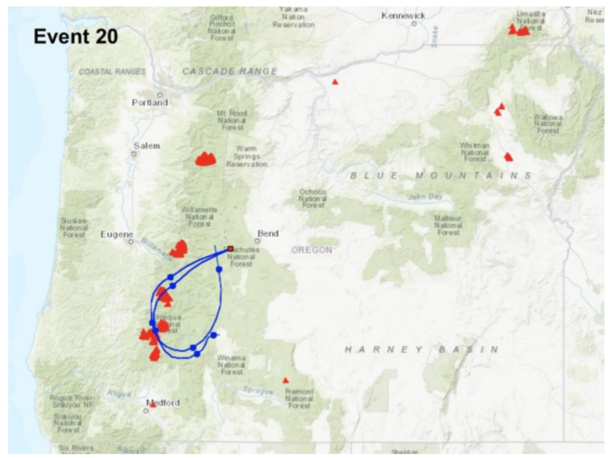
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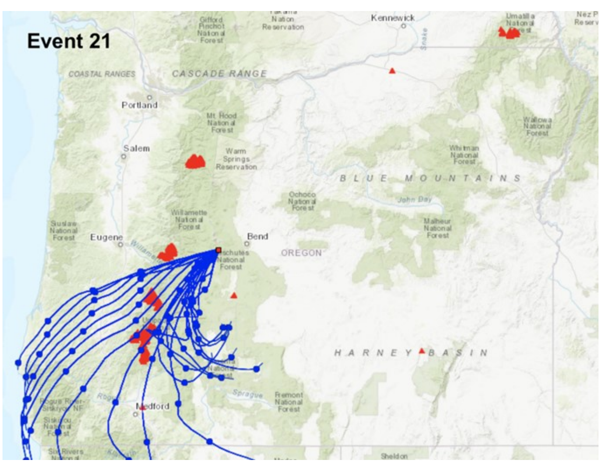
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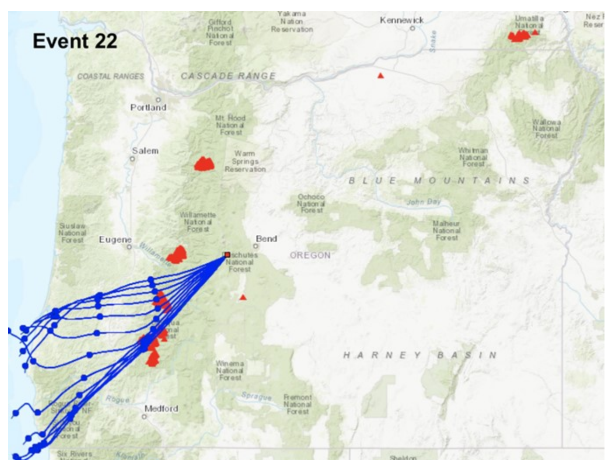
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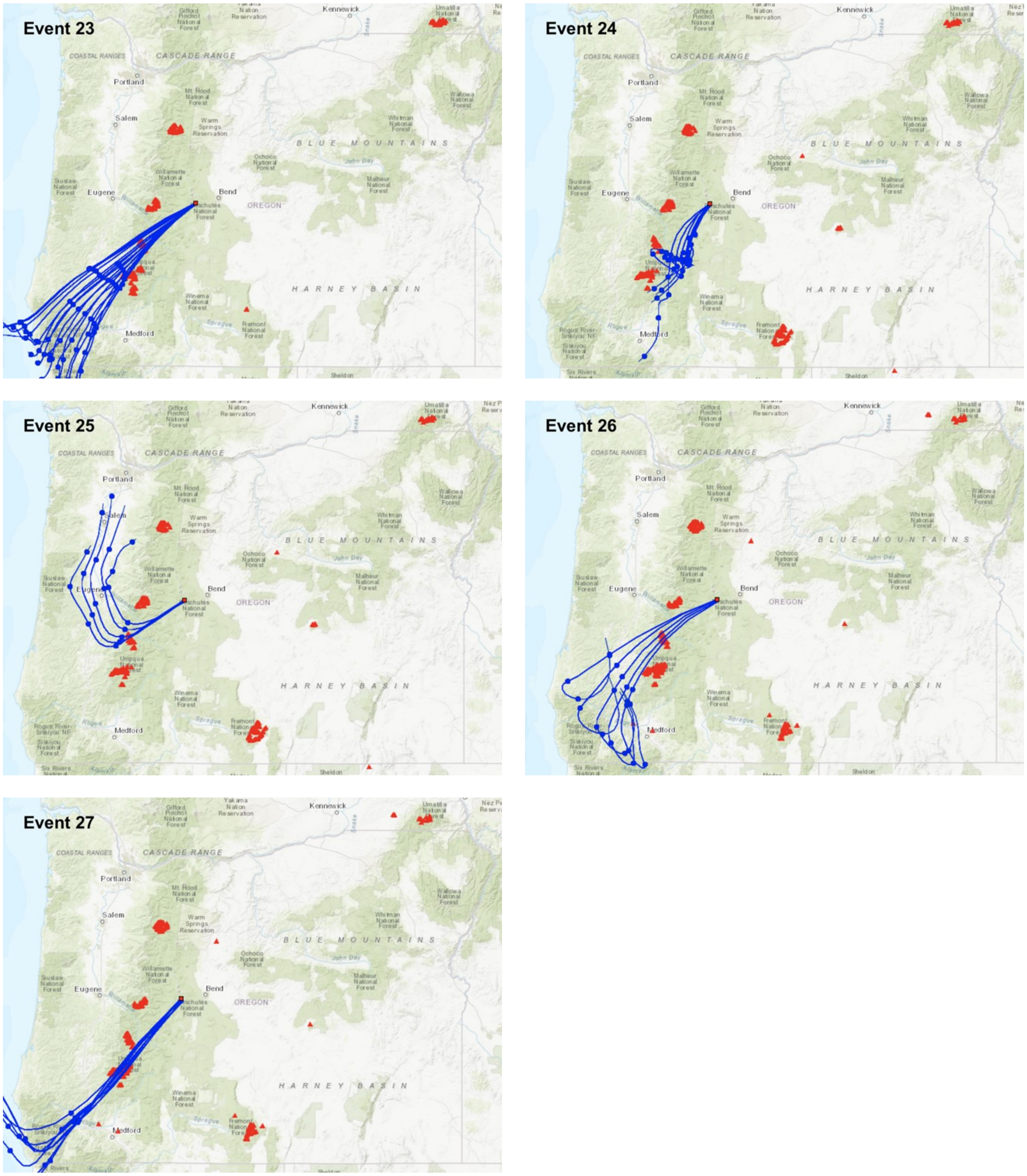
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Event 27
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Kennewick
Portland
Salem
Eugene
Bend
Medford
OREGON
BLUE MOUNTAINS
HARNEY BASIN

Table S1. Calculated aerosol optical properties ± precision uncertainty for the 27 BB events listed in Table 1. Events 1–4 are PFs and the rest are WFs. Values in parentheses are total uncertainties. WC ("weak correlation") in the MSE and MAE columns indicates that the correlation between PM_1 and σ_{abs} or σ_{abs} was less than 0.50. ND ("no data") indicates missing σ_{abs} data for events 24 and 25. The AAE was not calculated for events marked with ND* due to low CLAP filter transmittance (see Sect. 2.3).

Event number	$\Delta\sigma_{scat550}/\Delta CO$ (Mm^{-1} $ppbv^{-1}$)	$\Delta\sigma_{abs467}/\Delta CO$ (Mm^{-1} $ppbv^{-1}$)	$\Delta\sigma_{abs528}/CO$ (Mm^{-1} $ppbv^{-1}$)	$\Delta\sigma_{abs652}/\Delta CO$ (Mm^{-1} $ppbv^{-1}$)	MSE_{550} (m^2 g^{-1})	MAE_{528} (m^2 g^{-1})	SSA_{528}	$AAE_{467–652}$	$SAE_{450–550}$
1	1.66 ± 0.19 (0.30)	0.16 ± 0.02 (0.06)	0.12 ± 0.01 (0.04)	0.08 ± 0.01 (0.03)	3.51 ± 0.39 (0.64)	0.28 ± 0.03 (0.10)	0.93 ± 0.01 (0.03)	2.13 ± 0.30 (1.75)	1.75 ± 0.25 (0.37)
2	1.79 ± 0.20 (0.32)	0.17 ± 0.02 (0.06)	0.13 ± 0.01 (0.04)	0.08 ± 0.01 (0.03)	4.38 ± 0.49 (0.80)	0.32 ± 0.04 (0.11)	0.94 ± 0.01 (0.03)	2.21 ± 0.31 (1.09)	1.76 ± 0.25 (0.37)
3	0.89 ± 0.11 (0.17)	0.13 ± 0.02 (0.05)	0.11 ± 0.01 (0.04)	0.08 ± 0.01 (0.03)	3.87 ± 0.43 (0.70)	0.45 ± 0.05 (0.16)	0.89 ± 0.02 (0.05)	1.66 ± 0.23 (0.82)	1.86 ± 0.26 (0.39)
4	1.41 ± 0.15 (0.25)	0.30 ± 0.03 (0.10)	0.24 ± 0.03 (0.08)	0.17 ± 0.02 (0.06)	3.68 ± 0.41 (0.67)	0.54 ± 0.06 (0.19)	0.86 ± 0.03 (0.07)	1.73 ± 0.24 (0.86)	1.92 ± 0.27 (0.41)
5	2.25 ± 0.25 (0.41)	0.27 ± 0.03 (0.10)	0.21 ± 0.02 (0.07)	0.14 ± 0.02 (0.05)	4.03 ± 0.45 (0.73)	0.41 ± 0.05 (0.14)	0.91 ± 0.01 (0.04)	1.60 ± 0.23 (0.79)	1.89 ± 0.27 (0.40)
6	1.00 ± 0.12 (0.19)	0.18 ± 0.02 (0.06)	0.13 ± 0.02 (0.05)	0.07 ± 0.01 (0.03)	WC	WC	0.89 ± 0.02 (0.05)	2.74 ± 0.39 (1.36)	2.36 ± 0.33 (0.50)
7	1.07 ± 0.12 (0.19)	0.12 ± 0.01 (0.04)	0.08 ± 0.01 (0.03)	0.05 ± 0.01 (0.02)	3.75 ± 0.42 (0.68)	0.26 ± 0.03 (0.09)	0.93 ± 0.01 (0.03)	2.04 ± 0.29 (1.01)	2.13 ± 0.30 (0.45)
8	1.33 ± 0.16 (0.25)	0.16 ± 0.02 (0.06)	0.11 ± 0.01 (0.04)	0.06 ± 0.01 (0.02)	WC	WC	0.93 ± 0.01 (0.03)	3.35 ± 0.47 (1.66)	2.24 ± 0.32 (0.48)
9	1.16 ± 0.14 (0.22)	0.20 ± 0.03 (0.07)	0.13 ± 0.02 (0.05)	0.07 ± 0.01 (0.02)	4.34 ± 0.48 (0.79)	0.40 ± 0.04 (0.14)	0.90 ± 0.02 (0.05)	3.29 ± 0.47 (1.63)	2.24 ± 0.32 (0.48)
10	0.92 ± 0.11 (0.17)	0.20 ± 0.03 (0.07)	0.16 ± 0.02 (0.06)	0.11 ± 0.01 (0.04)	3.29 ± 0.37 (0.60)	0.41 ± 0.05 (0.15)	0.86 ± 0.03 (0.07)	1.63 ± 0.23 (0.81)	1.94 ± 0.27 (0.41)
11	0.79 ± 0.09 (0.14)	0.07 ± 0.01 (0.03)	0.05 ± 0.01 (0.02)	0.03 ± 0.00 (0.01)	5.07 ± 0.57 (0.92)	0.34 ± 0.04 (0.12)	0.94 ± 0.01 (0.03)	2.01 ± 0.28 (0.99)	2.02 ± 0.29 (0.43)
12	1.19 ± 0.13 (0.22)	0.05 ± 0.01 (0.02)	0.04 ± 0.00 (0.01)	0.02 ± 0.00 (0.01)	6.46 ± 0.72 (1.18)	0.29 ± 0.03 (0.10)	0.97 ± 0.00 (0.01)	2.32 ± 0.33 (1.15)	1.46 ± 0.21 (0.31)
13	1.73 ± 0.19 (0.31)	0.10 ± 0.01 (0.03)	0.10 ± 0.01 (0.04)	0.09 ± 0.01 (0.03)	5.87 ± 0.66 (1.07)	0.28 ± 0.03 (0.10)	0.95 ± 0.01 (0.02)	ND*	1.59 ± 0.22 (0.34)
14	0.76 ± 0.08 (0.14)	0.04 ± 0.01 (0.01)	0.02 ± 0.00 (0.01)	0.02 ± 0.00 (0.01)	3.97 ± 0.44 (0.72)	0.15 ± 0.02 (0.05)	0.97 ± 0.00 (0.01)	ND*	1.56 ± 0.22 (0.33)
15	1.10 ± 0.12 (0.20)	0.06 ± 0.01 (0.02)	0.04 ± 0.00 (0.01)	0.02 ± 0.00 (0.01)	6.00 ± 0.67 (1.09)	0.21 ± 0.02 (0.08)	0.97 ± 0.01 (0.01)	3.05 ± 0.43 (1.51)	1.56 ± 0.22 (0.33)
16	1.15 ± 0.12 (0.21)	0.07 ± 0.01 (0.02)	0.04 ± 0.00 (0.01)	0.02 ± 0.00 (0.01)	5.56 ± 0.62 (1.01)	0.27 ± 0.03 (0.1)	0.97 ± 0.00 (0.01)	3.11 ± 0.44 (1.54)	1.63 ± 0.23 (0.35)
17	1.04 ± 0.11 (0.19)	0.07 ± 0.01 (0.02)	0.05 ± 0.01 (0.02)	0.03 ± 0.00 (0.01)	4.56 ± 0.51 (0.830	0.25 ± 0.03 (0.09)	0.96 ± 0.01 (0.02)	2.85 ± 0.44 (1.41)	1.93 ± 0.27 (0.41)
18	1.25 ± 0.15 (0.23)	0.10 ± 0.02 (0.04)	0.08 ± 0.01 (0.03)	0.04 ± 0.01 (0.02)	3.99 ± 0.45 (0.73)	0.33 ± 0.04 (0.12)	0.94 ± 0.01 (0.03)	ND*	2.11 ± 0.30 (0.45)
19	1.13 ± 0.13 (0.21)	0.06 ± 0.01 (0.02)	0.03 ± 0.00 (0.01)	0.02 ± 0.00 (0.01)	4.74 ± 0.53 (0.86)	0.21 ± 0.02 (0.07)	0.97 ± 0.00 (0.01)	ND*	1.68 ± 0.24 (0.36)
20	1.37 ± 0.15 (0.25)	0.16 ± 0.02 (0.06)	0.10 ± 0.01 (0.03)	0.04 ± 0.00 (0.02)	5.34 ± 0.60 (0.97)	0.32 ± 0.04 (0.11)	0.94 ± 0.01 (0.03)	3.77 ± 0.53 (1.87)	1.75 ± 0.25 (0.37)
21	1.35 ± 0.15 (0.24)	0.11 ± 0.02 (0.04)	0.08 ± 0.01 (0.03)	0.04 ± 0.00 (0.02)	6.31 ± 0.71 (1.15)	0.28 ± 0.03 (0.1)	0.95 ± 0.01 (0.02)	2.72 ± 0.38 (1.35)	1.55 ± 0.22 (0.33)
22	1.29 ± 0.14 (0.23)	0.09 ± 0.01 (0.03)	0.07 ± 0.01 (0.03)	0.04 ± 0.00 (0.02)	7.42 ± 0.83 (1.35)	0.39 ± 0.04 (0.14)	0.95 ± 0.01 (0.02)	2.76 ± 0.39 (1.37)	1.35 ± 0.19 (0.29)
23	1.30 ± 0.14 (0.23)	0.07 ± 0.01 (0.03)	0.07 ± 0.01 (0.02)	0.05 ± 0.01 (0.02)	6.01 ± 0.67 (1.09)	0.35 ± 0.04 (0.12)	0.95 ± 0.01 (0.02)	ND*	1.57 ± 0.22 (0.33)
24	0.86 ± 0.09 (0.16)	ND	ND	ND	4.23 ± 0.47 (0.77)	ND	ND	ND	1.80 ± 0.25 (0.38)
25	0.68 ± 0.07 (0.12)	ND	ND	ND	4.05 ± 0.45 (0.74)	ND	ND	ND	1.81 ± 0.26 (0.38)
26	1.17 ± 0.13 (0.21)	0.11 ± 0.02 (0.04)	0.07 ± 0.01 (0.03)	0.04 ± 0.00 (0.02)	4.17 ± 0.47 (0.76)	0.27 ± 0.03 (0.1)	0.94 ± 0.01 (0.02)	2.99 ± 0.42 (1.48)	1.97 ± 0.28 (0.42)
27	1.04 ± 0.11 (0.19)	0.09 ± 0.01 (0.03)	0.06 ± 0.01 (0.02)	0.03 ± 0.00 (0.01)	3.98 ± 0.45 (0.72)	0.31 ± 0.03 (0.11)	0.95 ± 0.01 (0.02)	3.12 ± 0.44 (1.54)	2.18 ± 0.31 (0.46)

Table S2. RAVE FRP statistics for the fires sampled at MBO during the 2021 Oregon fire season. The first 4 fires are PFs and the rest are WFs. "Dates active" and "number of days active" columns include days with FRP data; different from official fire start/containment dates. Total fire radiative energy (FRE; the time-integral of FRP) is expressed in terajoules (TJ). Note that burning in the Jack fire area continued after 8/1/21 as part of the Rough Patch Complex.

Fire	East/West slope of Oregon Cascades?	MBO BB event(s) influenced	Coordinates	Dates active	Number of days active	Maximum FRP (MW)	Mean FRP ± SD (MW)	Median FRP (MW)	Maximum FRP density (MW km-2)	Mean FRP density ± SD (MW km-2)	Median FRP density (MW km-2)	Total FRE (TJ)
PF 1	East	1	44.12, -121.71, 44.30, -121.50	4/14/21–4/16/21	3	593	174 ± 176	99	21.98	9.10 ± 5.76	7.57	12.54
PF 2	East	2	44.12, -121.71, 44.30, -121.50	4/21/21	1	116	67 ± 39	71	12.88	7.44 ± 4.31	7.85	0.964
PF 3	East	3	43.25, -121.80, 43.40, -121.62	4/28/21	1	358	243 ± 114	279	16.85	9.66 ± 4.23	8.49	5.258
PF 4	East	4	42.62, -121.92, 42.80, -121.71	5/4/21–5/6/21	3	1042	331 ± 294	223	27.29	13.21 ± 6.55	11.44	40.49
S-503	East	5	45.02, -121.50, 45,20, -121.32	6/18/21–6/21/21	4	3841	949 ± 998	440	42.68	20.86 ± 10.97	18.66	198.1
Jack	West	6–9, 11	43.19, -122.76, 43.37, -122.52	7/5/21–7/31/21	26	9974	696 ± 1272	258	110.82	16.45 ± 18.42	9.49	864.1
Grandview	East	10	44.33, -121.50, 44.54, -121.32	7/11/21–7/13/21	3	5590	1503 ± 1387	1313	126.11	29.31 ± 24.25	26.15	286.8
Skyline Ridge Complex	West	12	42.65, -123.27, 42.98, -122.94	8/2/21–8/17/21	15	2794	447 ± 538	270	53.19	13.71 ± 10.30	11.69	339.7
Bull Complex	West	13, 14	44.72, -122.22, 45.02, -121.92	8/2/21–9/17/21	47	9533	667 ± 1032	273	105.92	15.55 ± 15.39	10.57	1523
Middle Fork Complex	West	12, 15–27	43.83, -122.52, 44.09, -122.22	7/29/21–9/17/21	51	4837	311 ± 541	125	111.88	9.82 ± 13.10	5.98	500.0
Rough Patch Complex	West	12, 15–27	43.10, -122.73, 43.67, -122.52	8/1/21–9/18/21	49	14848	730 ± 1543	243	169.75	12.08 ± 18.10	6.88	1723
Devil's Knob Complex	West	12, 15–27	42.80, -122.94, 43.22, -122.58	8/2/21–9/18/21	48	21645	1250 ± 2425	421	316.39	15.91 ± 20.42	10.19	3681
PF mean ± SD					2 ± 1	527 ± 395	204 ± 111	168 ± 99	19.75 ± 6.25	9.85 ± 2.43	8.84 ± 1.78	14.81 ± 17.77
WF mean ± SD					30 ± 21	9133 ± 6428	819 ± 399	418 ± 376	129.59 ± 85.47	16.71 ± 6.04	12.45 ± 6.73	1139 ± 1176
Eastern Cascades mean ± SD					3 ± 1	1923 ± 2253	545 ± 563	404 ± 465	41.30 ± 42.82	14.93 ± 8.52	13.36 ± 7.52	90.68 ± 121.6
Western Cascades mean ± SD					39 ± 15	10605 ± 6866	684 ± 322	265 ± 94	144.66 ± 91.88	13.92 ± 2.58	9.13 ± 2.23	1439 ± 1228

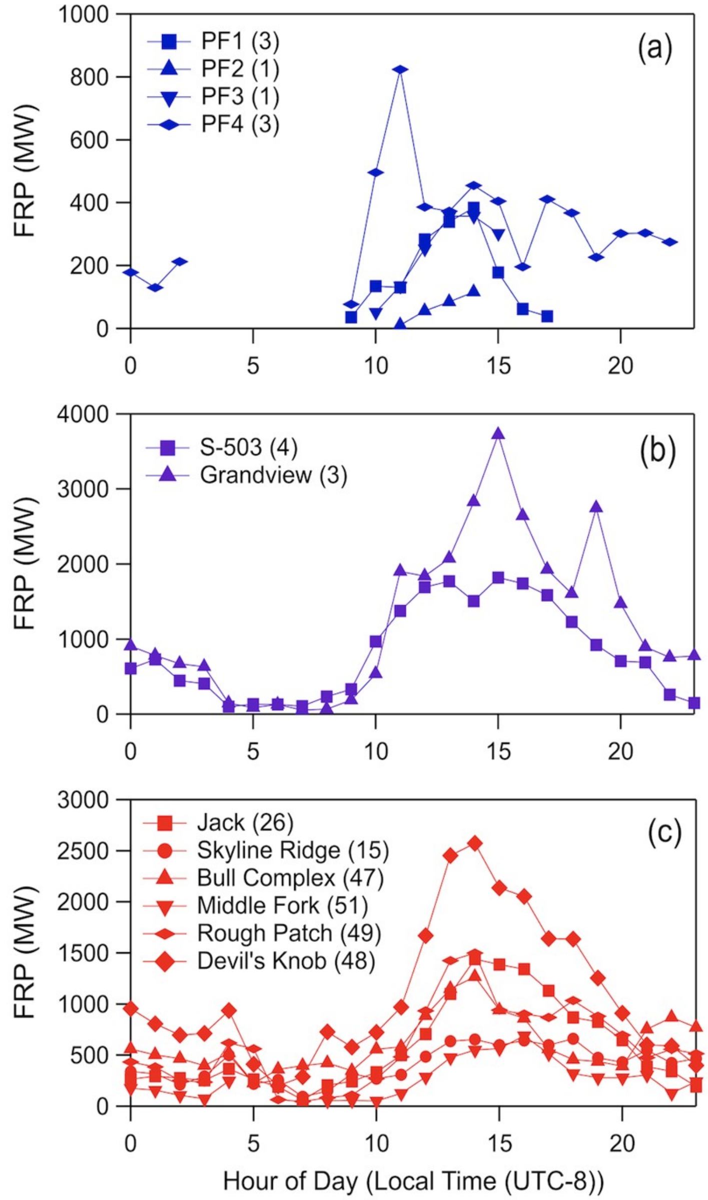

Figure S1. Diurnal cycles of RAVE FRP for (a) PFs, (b) eastern Cascades WFs, and (c) western Cascades WFs listed in Table S2. Each point corresponds to the mean FRP for that hour of day across all days with FRP > 0. Values in parenthesis are the number of days with FRP > 0 for each fire.

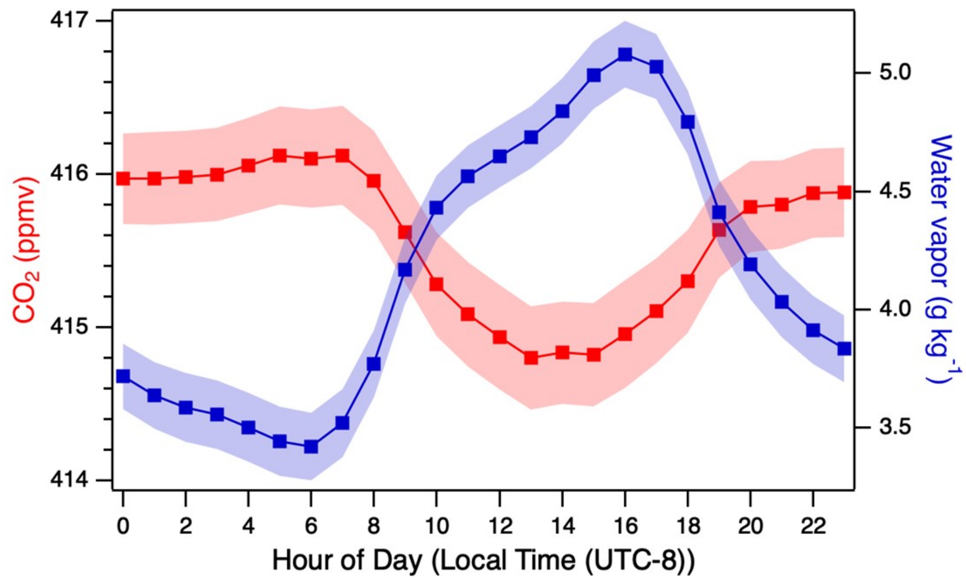

Figure S2. Diurnal cycles of CO_2 and water vapor at MBO for the April–September 2021 study period. Water vapor mixing ratio was calculated from relative humidity measurements. Each point corresponds to the mean concentration for that hour of day, and shading shows the standard error of the means. Air during the night is dryer and higher in CO_2 (representative of free troposphere influence). Upslope winds during the daytime bring boundary layer-influenced air (lower in CO_2 and higher in water vapor) up to the observatory.

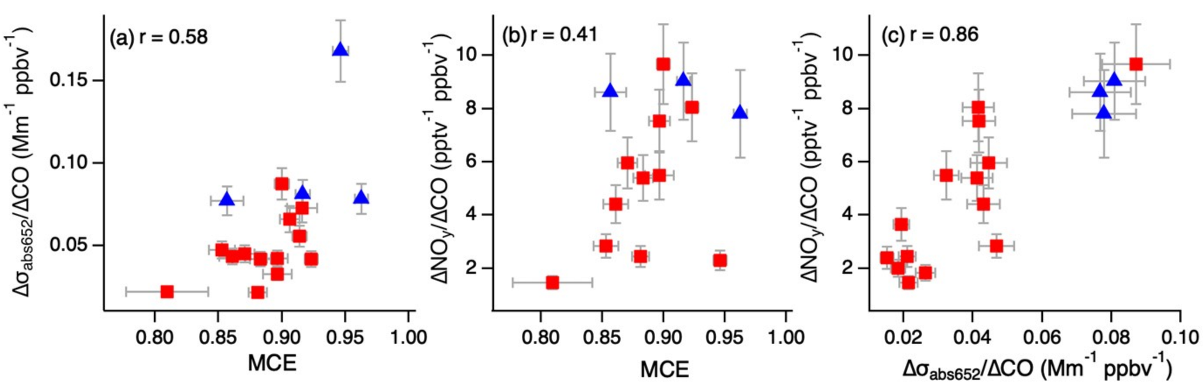

Figure S3. Comparison of combustion conditions proxies: (**a**) $\Delta\sigma_{abs652}/\Delta CO$ as a function of modified combustion efficiency (MCE), (**b**) $\Delta NO_y/\Delta CO$ as a function of MCE, and (**c**) $\Delta NO_y/\Delta CO$ as a function of $\Delta\sigma_{abs652}/\Delta CO$. Error bars show precision uncertainty. Pearson's correlation coefficient (*r*) is included for each relationship. Events are shaped according to their origin in the same way as in Figure 3 in the main text. Note that the two eastern Cascades WF events (Events 5 and 10) are not displayed because no MCE or NO_y data was available.

Table S3. Same as Table 2 in the main text except events are sorted based on ecoregion (eastern vs. western slope of the Oregon Cascades).

	Eastern Cascades events	Western Cascades events	*P* value
Number of events	6	21	
Estimated transport time (h)	6.8 ± 6.5	5.1 ± 3.5	0.396
ΔPM_1 (µg m-3)	81 ± 45	181 ± 129	0.075
MCE	0.92 ± 0.05	0.89 ± 0.03	0.159
$\Delta NO_y/\Delta CO$ (pptv ppbv^{-1})	6.90 ± 3.20	4.18 ± 2.56	0.087
$\Delta PM_1/\Delta CO$ (µg m^{-3} ppbv^{-1})	0.28 ± 0.08	0.16 ± 0.03	<0.001
$\Delta\sigma_{scat550}/\Delta CO$ (Mm^{-1} ppbv^{-1})	1.49 ± 0.52	1.13 ± 0.24	0.024
$\Delta\sigma_{abs467}/\Delta CO$ (Mm^{-1} ppbv^{-1})	0.21 ± 0.07	0.10 ± 0.05	<0.001
$\Delta\sigma_{abs528}/\Delta CO$ (Mm^{-1} ppbv^{-1})	0.16 ± 0.05	0.07 ± 0.03	<0.001
$\Delta\sigma_{abs652}/\Delta CO$ (Mm^{-1} ppbv^{-1})	0.11 ± 0.04	0.04 ± 0.02	<0.001
SSA_{528}	0.90 ± 0.03	0.95 ± 0.02	0.001
$AAE_{467–652}$	1.83 ± 0.27	2.86 ± 0.49	<0.001
$SAE_{450–550}$	1.85 ± 0.08	1.83 ± 0.30	0.870
MSE_{550} (m^2 g^{-1})	3.79 ± 0.39	5.04 ± 1.07	0.010
MAE_{528} (m^2 g^{-1})	0.40 ± 0.09	0.29 ± 0.07	0.004