Impacts of the Denver Cyclone on Regional Air Quality and Aerosol Formation in the Colorado Front Range during FRAPPÉ 2014

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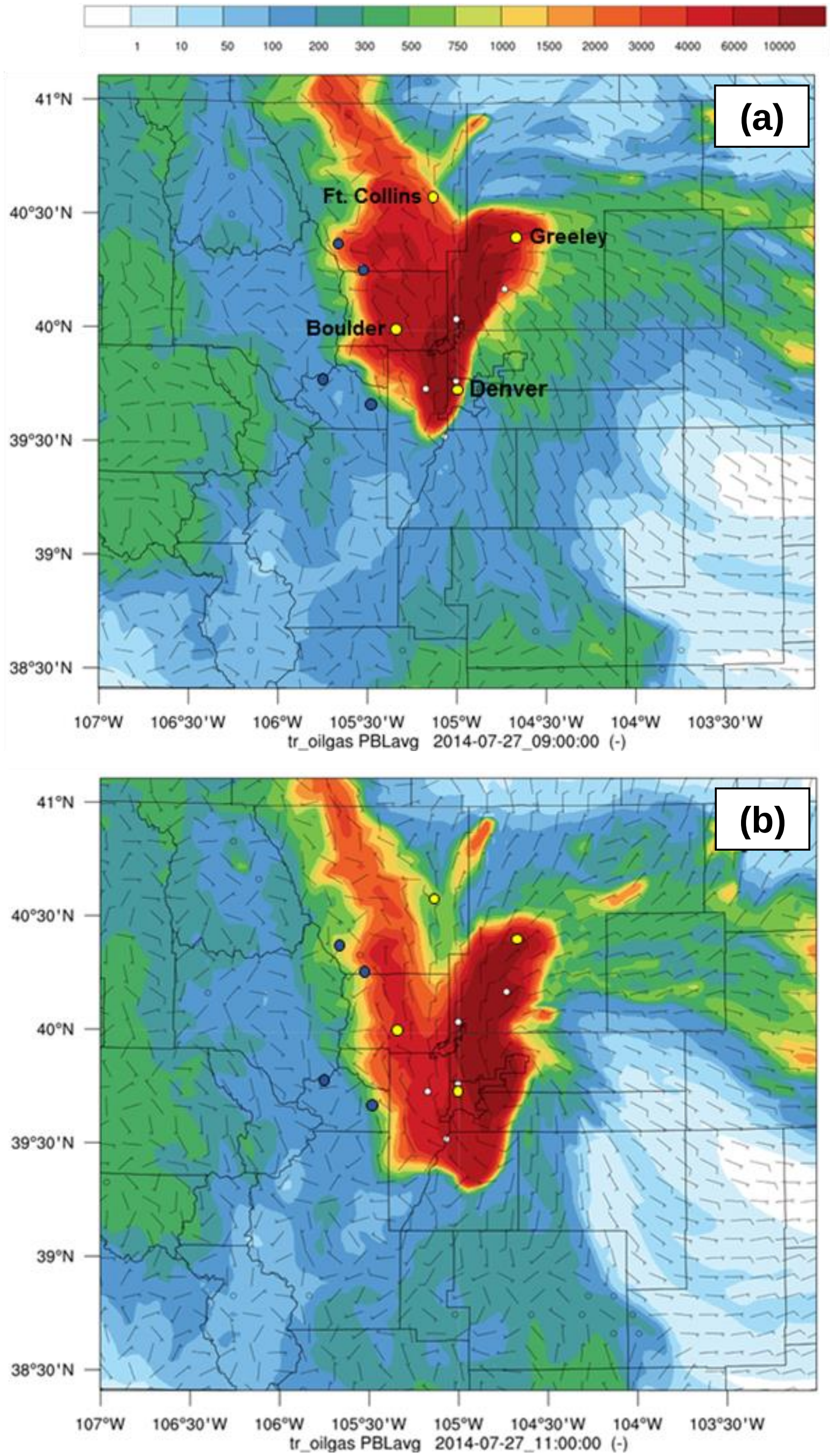
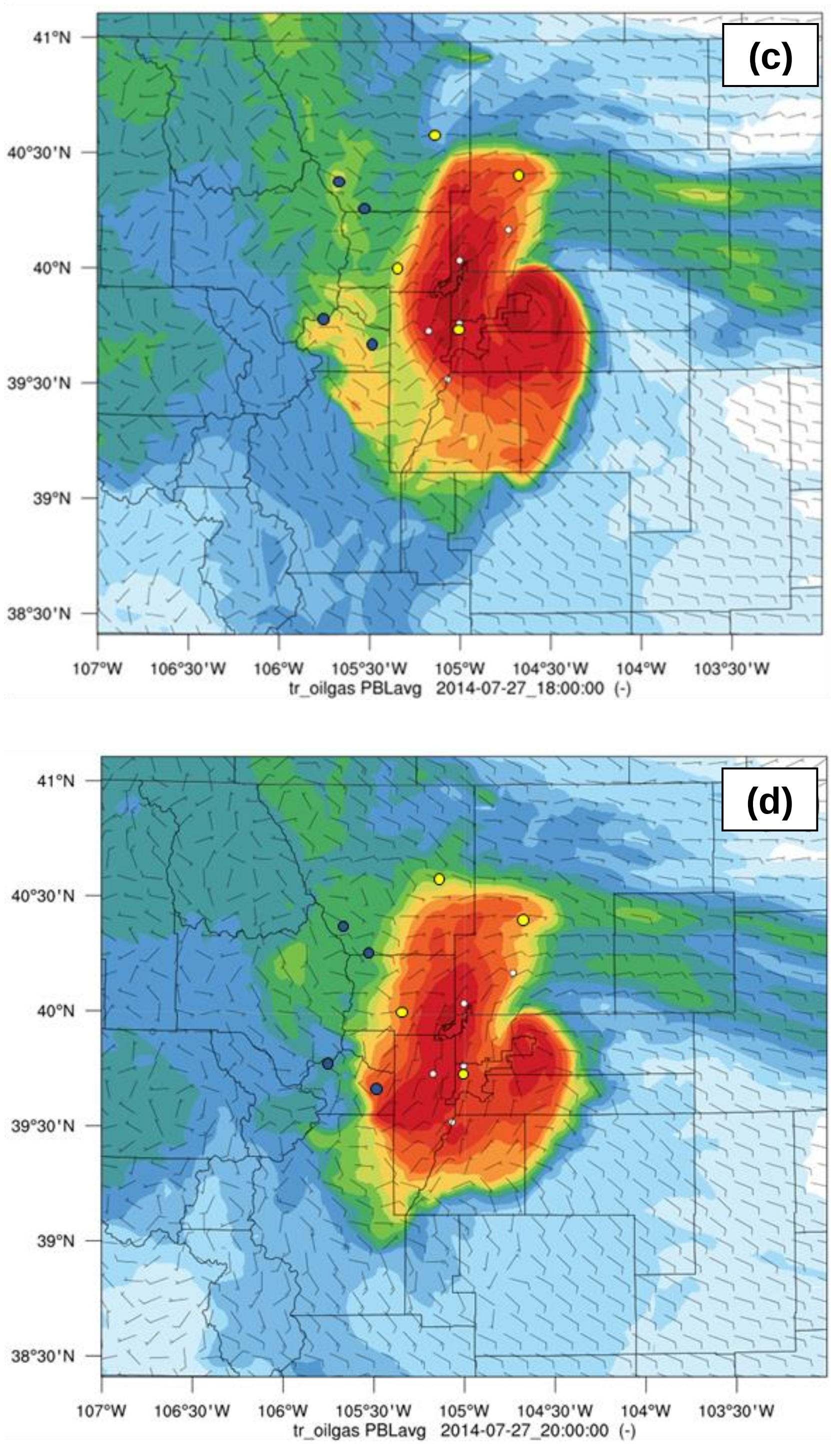
Supplementary Figures and Tables




(c)
41°N
40°30'N
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107°W
106°30'W
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104°W
103°30'W
tr_oilgas PBLavg 2014-07-27_18:00:00 (-)
(d)
41°N
40°30'N
40°N
39°30'N
39°N
38°30'N
107°W
106°30'W
106°W
105°30'W
105°W
104°30'W
104°W
103°30'W
tr_oilgas PBLavg 2014-07-27_20:00:00 (-)

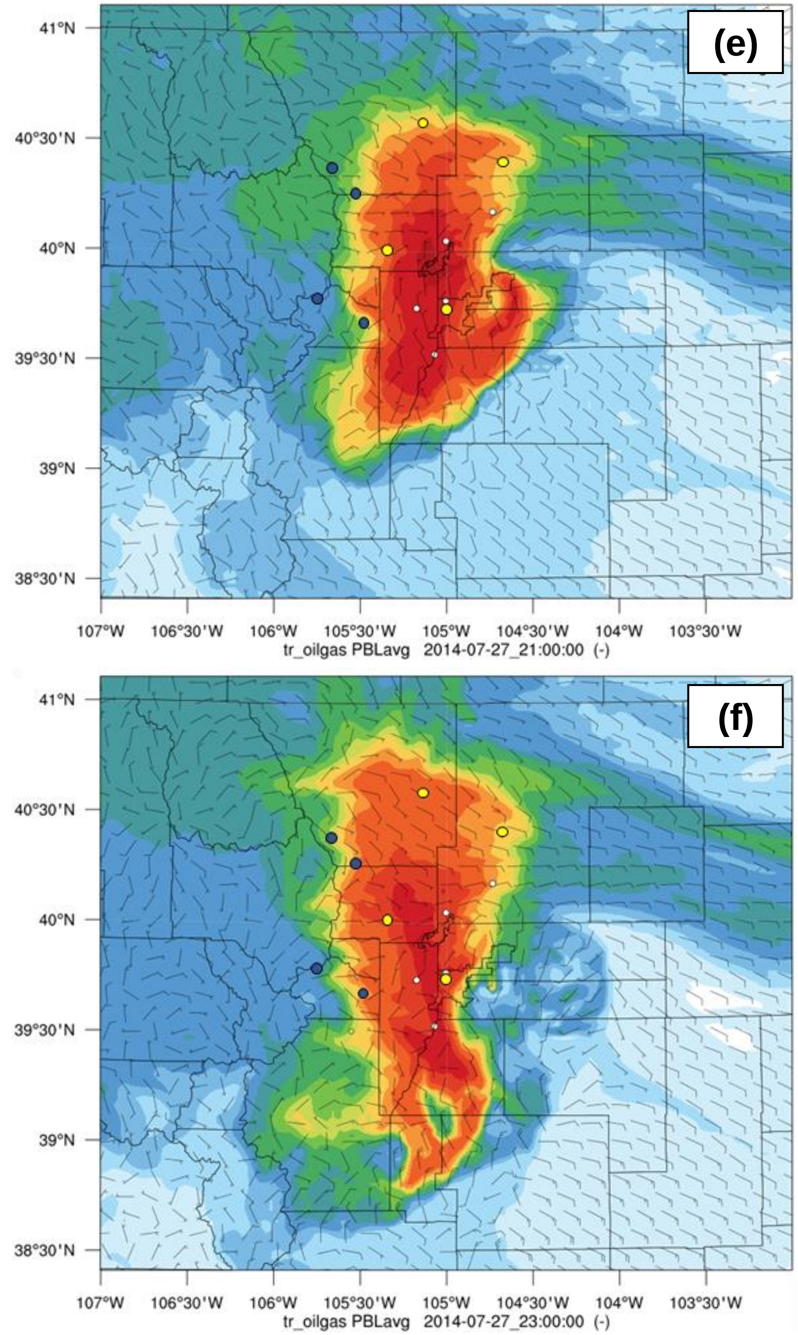

Figure S1. WRF-Chem Tracer 24-hr model results for Sunday, July 27, 2014 during the early to late developments of the Denver Cyclone. Oil and gas tracer mixing patterns within the modeled PBLH were forecasted during the advancement of the Denver Cyclone from (9 UTC - 23 UTC). Individual time-frames correspond to: **(a)** 9:00 UTC (2:00 MST), **(b)** 11:00 UTC (4:00 MST), **(c)** 18:00 UTC (11:00 MST), **(d)** 20:00 UTC (13:00 MST), **(e)** 21:00 UTC (14:00 MST), **(f)** 23:00 UTC (16:00 MST). Cities are represented by *yellow* markers, P-3 spirals during DISCOVER-AQ (*white*), and mountains sites (*blue*, from N to S; Longs Peak, Trail Ridge Road, Mines Peak, Squaw Mountain).

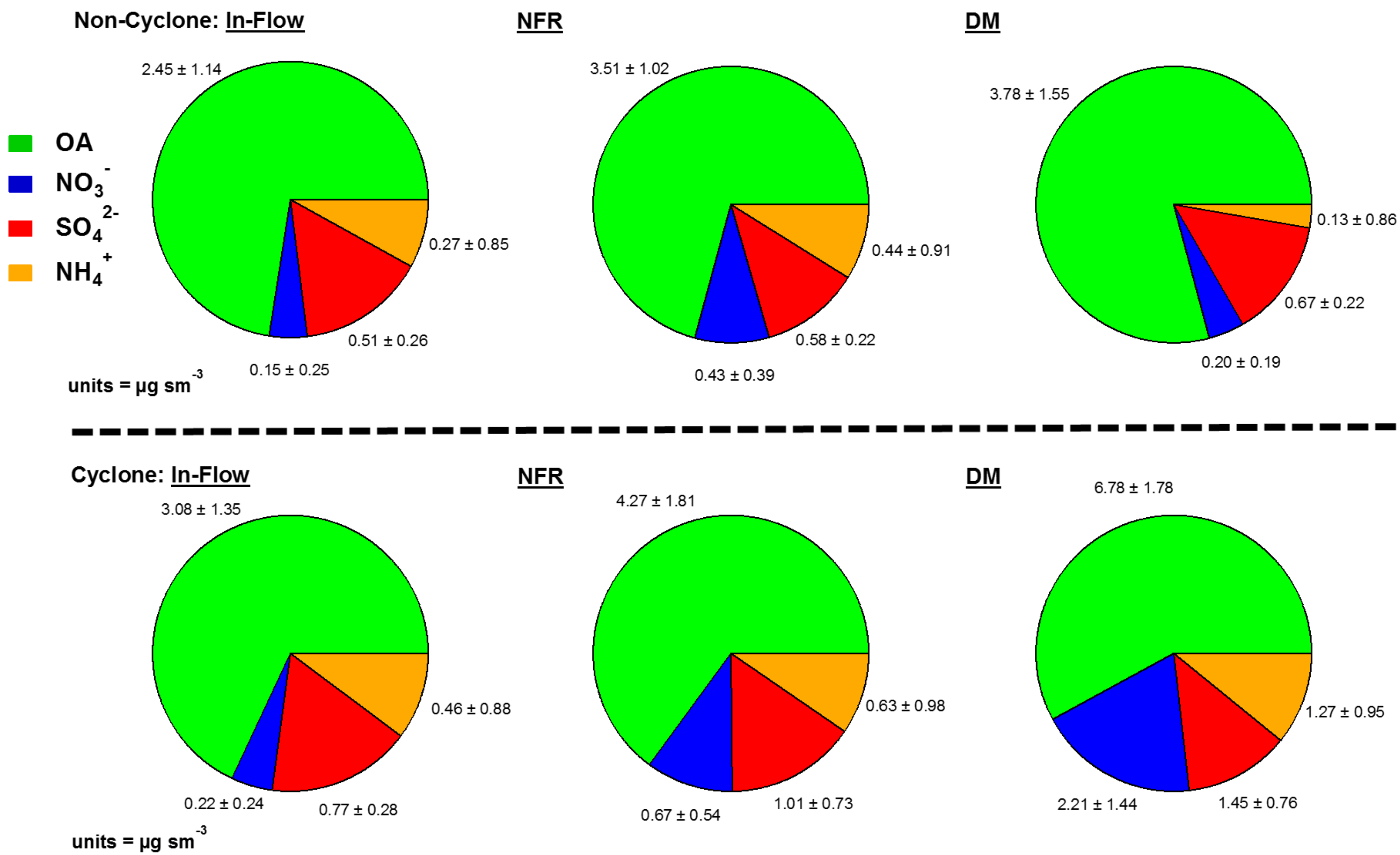

Figure S2. Average chemical composition of NR-PM_1 for different regions during the non-cyclone **(top)** and cyclone episodes **(bottom)** within the three study regions of the Front Range. Chloride (Cl^-), not shown, was below the instrument detection limit.

Scenario	Input					Output		Calc.
	NO_3^- + HNO_3 Aer.[a] + (g)[b]	SO_4^{2-} Aer.[a]	NH_4^+ + NH_3 Aer.[a] + (g)[b]	RH (%)	T (K)	HNO_3 Aer.[a]	HNO_3 (g)[b]	f_{NO3} Aer.[a]
Non-Cyclone - NFR	2.1	0.6	12.2	38.3	296	0.10	2.00	0.05
Non-Cyclone - DM	2.8	0.7	2.8	34.0	297	0.02	2.74	0.01
Cyclone - NFR	2.0	1.1	10.1	55.6	295	0.33	1.67	0.16
Cyclone - DM	4.2	1.5	7.4	64.2	294	1.51	2.68	0.36
Non-Cyclone - NFR w/ ***cyclone RH & T***	2.1	0.6	12.2	**55.6**	**295**	0.29	1.81	0.14
Non-Cyclone - DM w/ ***cyclone RH & T***	2.8	0.7	2.8	**64.2**	**294**	0.15	2.61	0.05

[a] aerosol-phase = Aer., µg sm^{-3} air
[b] gas-phase = (g), µg sm^{-3} air

Table S1. Summary table of the ISORROPIA II input parameters and output values in a forward based calculation, with all aerosol species assumed to be in a metastable state. Inorganic nitrate partitioning calculations is reported as a fraction of nitrate present in the aerosol phase (fNO_3). Highlighted in *blue* are RH and T parameters from the cyclone period used, with the non-cyclone aerosol mass concentration inputs to determine the thermodynamic influence on fNO_3.

	Input					Output		Calc.
Scenario Cyclone – DM Only	**NO_3^-+ HNO_3 Aer.[a]+ (g)[b]**	**SO_4^{-2} Aer.[a]**	**NH_4^+ +NH_3 Aer.[a]+ (g)[b]**	**RH (%)**	**T (K)**	**HNO_3 Aer.[a]**	**HNO_3 (g)[b]**	**f_{NO3} Aer.[a]**
(Baseline) DM w/obs. total SO_4^{-2}	4.2	**1.5**	**7.4**	64.2	294	1.52	2.67	0.36
DM w/o total SO_4^{-2}	4.2	**0.0**	**6.8**	64.2	294	4.19	3.0E-4	0.99
DM w/obs. total SO_4^{-2} @ RH 85%	4.2	**1.5**	**7.4**	**85.0**	294	3.09	1.10	0.74
DM w/obs. total SO_4^{-2} @ RH 35%	4.2	**1.5**	**7.4**	**35.0**	294	0.41	3.78	0.10

Total NH_x= NH_4^+ (aer.) +NH_3 (g) was calculated to fully neutralized total SO_4^{-2}
[a] aerosol-phase = Aer., µg sm^{-3} air
[b] gas-phase = (g), µg sm^{-3} air

Table S2. Sulfate summary table of aerosol sulfate and RH variation with ISORROPIA II input parameters and output values in a forward based calculation, with all aerosol species assumed to be in a metastable state. Inorganic nitrate partitioning calculations is reported as a fraction of nitrate present in the aerosol phase ($f$$NO_3$). Highlighted in *red* are variations of sulfate concentration input, *orange* is the calculated ammonium associated to fully neutralize sulfate present, and *blue* is the RH variation inputs.