



Supplement of

Impacts of the Denver Cyclone on regional air quality and aerosol formation in the Colorado Front Range during FRAPPÉ 2014

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Figure S1. C-130 flight tracks during FRAPPÉ. Selective cities are represented as *yellow* star markers, with the *red* arrow pointing towards Denver. Major highways are shown with *black* lines and *brown* markers represent the location of active oil and gas wells in the region with data available from the Colorado Oil and Gas Conservative Commission.



Figure S2. RAP model analysis runs at 13 km resolution for (a-b) July 26, 2014 (12:00 UTC (5:00 MST), 21:00 UTC (14:00
5 MST), respectively) and (c-d) August 02, 2014 (12:00, 21:00 UTC, respectively). Arrows show surface wind vectors while the color scale represents surface specific humidity at 2m.



Figure S3. RAP model analysis runs at 13 km resolution for the Denver Cyclone on Sunday, July 27, 2014 at (a) 10:00 UTC
(3:00 MST), (b) 12:00 UTC (5:00 MST), (c) 15:00 UTC (8:00 MST), and (d) 18:00 UTC (11:00 MST). Arrows show surface wind vectors while the color scale represents surface specific humidity at 2m.











Figure S4. 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 Poad, Mines Peak, Squary Mountain).

30 (blue, from N to S; Longs Peak, Trail Ridge Road, Mines Peak, Squaw Mountain).



Figure S5. Average chemical composition of NR-PM₁ 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.

	Input					Output		Calc.
Scenario	$\frac{NO_3 + HNO_3}{Aer.^a + (g)^b}$	SO4 ²⁻ Aer. ^a	$\overline{NH_4^+ + NH_3}$ Aer. ^a + (g) ^b	RH (%)	Т (К)	HNO3 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 (fNO₃). 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 fNO₃.

	Input					Output		Calc.
Scenario	$NO_3 + HNO_3$	SO4 ⁻²	$NH_4^+ + NH_3$	RH	T	HNO ₃	HNO_3	f _{NO3}
Cvclone – DM Only	Aer. ^a + (g) ^b	Aer.ª	Aer. ^a + (g) ^b	(%)	(K)	Aer. ^a	$(g)^b$	Aer.ª
(Baseline) DM w/obs. total SO_4^{-2} DM w/o total SO_4^{-2}	4.2 4.2	1.5 0.0	7.4	64.2 64.2	294 294	1.52 4.19	2.67 3.0E-4	0.36 0.99
<i>DM w/obs. total SO</i> ₄ ⁻² @ <i>RH</i> 85% <i>DM w/obs. total SO</i> ₄ ⁻² @ <i>RH</i> 35%	4.2	1.5	7.4	85.0	294	3.09	1.10	0.74
	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., $\mu g \text{ sm}^{-3}$ air ^b gas-phase = (g), $\mu g \text{ sm}^{-3}$ air

Table S2. 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 10 nitrate present in the aerosol phase (fNO₃). 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.