

Supplementary Material for

**Investigation of the Influence of Transport From Oil and Natural Gas Regions
on Elevated Ozone Levels in the Northern Colorado Front Range**

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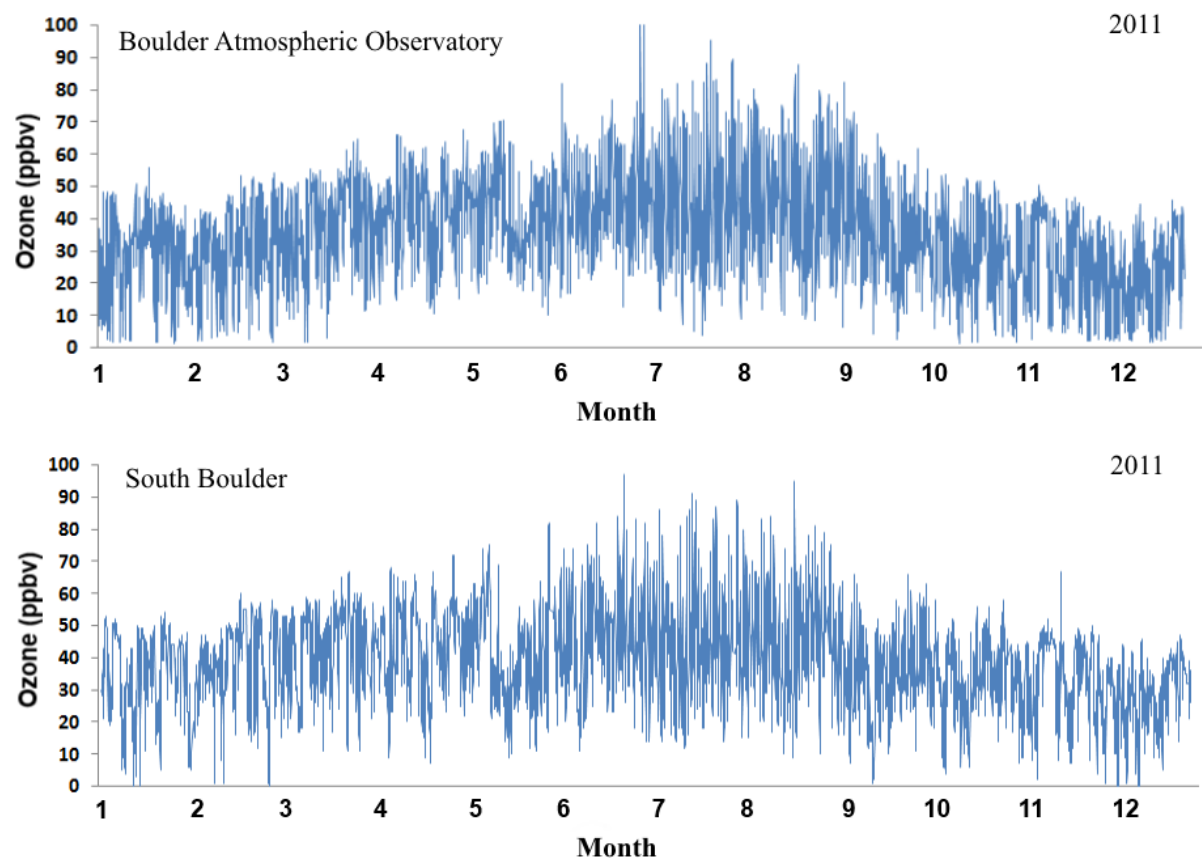
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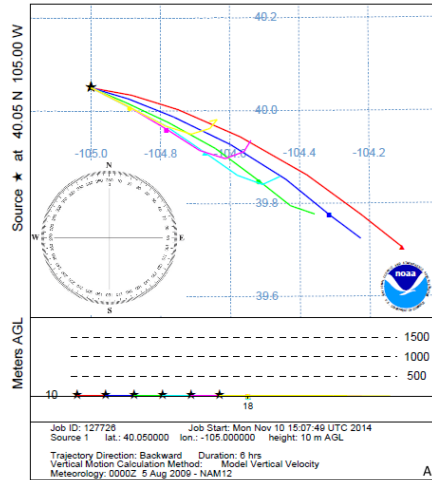


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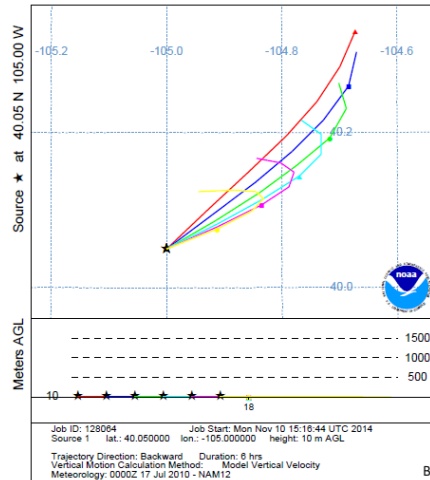
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4 **Figure S1.** Time series of hourly ozone mole fractions for the 2011 year at the Boulder Atmospheric Observatory and South Boulder
5 monitoring sites.

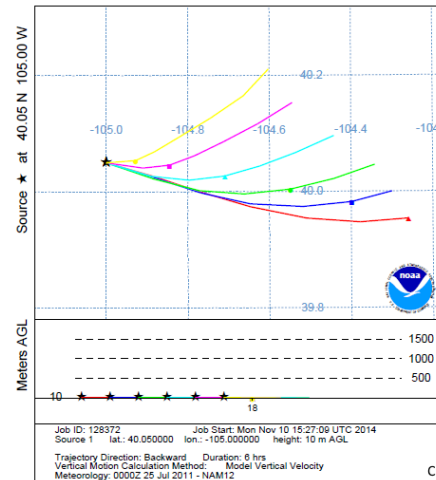
NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 05 Aug 09
NAM Meteorological Data



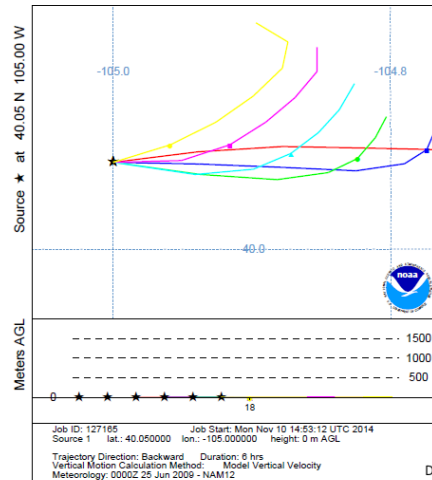
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Backward trajectories ending at 0000 UTC 17 Jul 10
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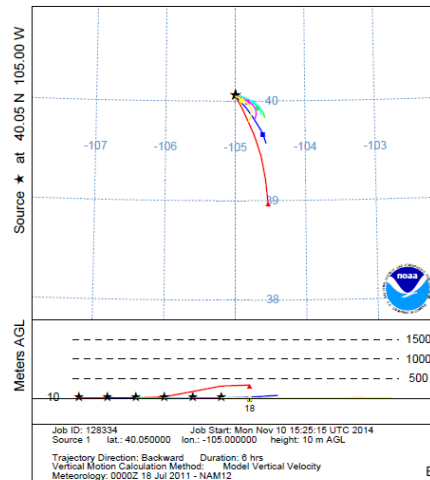
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Backward trajectories ending at 0000 UTC 25 Jul 11
NAM Meteorological Data



NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 25 Jun 09
NAM Meteorological Data



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NAM Meteorological Data



NOAA HYSPLIT MODEL
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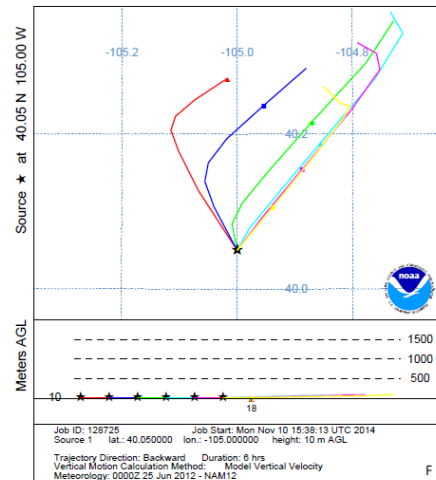
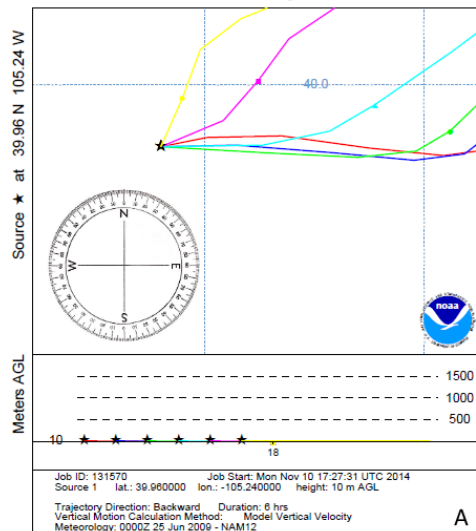
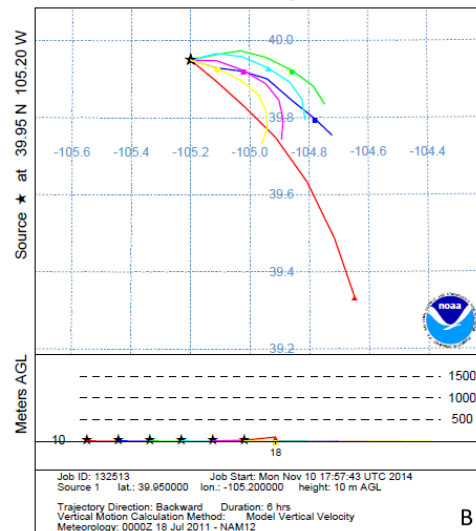


Figure S2 (previous page). Six examples of hourly HYSPLIT 6 hour back trajectories on days during the summer when ozone > 75 ppbv was recorded for more than two hours at BAO. Please see Table S3 for a listing of all ozone events and for identification of the six examples shown. Back trajectories were started at 18:00 hrs (red), 17:00 hrs (blue), 16:00 hrs (green), 15:00 hrs (light blue), 14:00 hrs (pink), and 13:00 hrs (yellow) MST. Please note the differences in geographical scales between graphs.

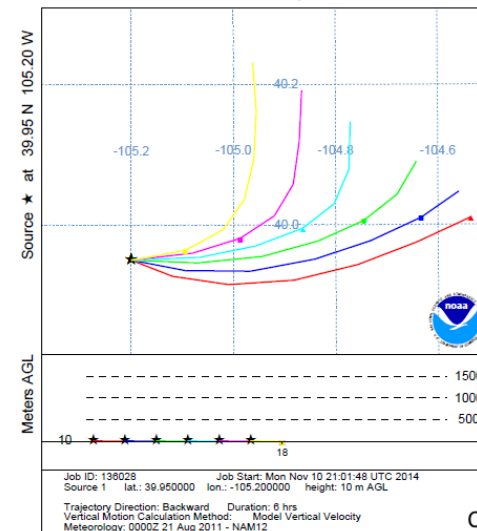
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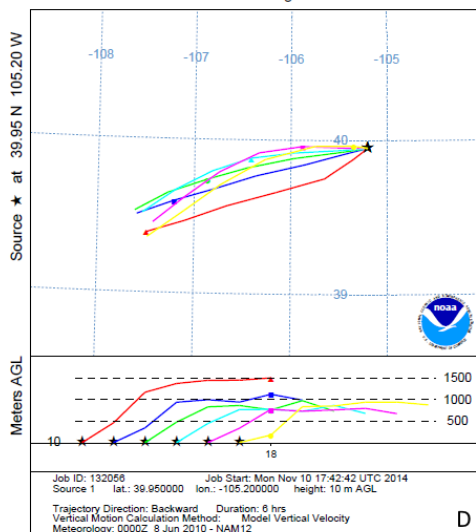
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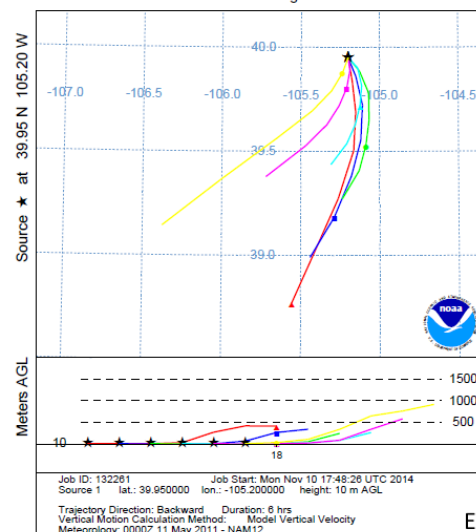
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NAM Meteorological Data



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Backward trajectories ending at 0000 UTC 08 Jun 10
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NAM Meteorological Data



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NAM Meteorological Data

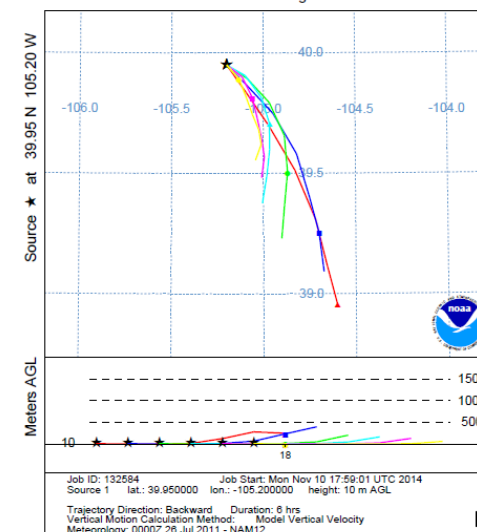


Figure S3 (previous page). Six examples of hourly HYSPLIT 6 hour back trajectories on days during the summer when ozone > 75 ppbv was recorded for more than two hours at South Boulder. Please see Table S2 for a listing of all ozone events and for identification of the six examples shown. Back trajectories were started at 18:00 hrs (red), 17:00 hrs (blue), 16:00 hrs (green), 15:00 hrs (light blue), 14:00 hrs (pink), and 13:00 hrs (yellow) MST.

Table S1

Table of yearly weighted ozone exceedances at various ozone monitoring sites along the NCFR. A multiplication factor of 1 was given for exceedances of $75 \leq \text{ozone} < 80$ ppbv, 2 for exceedances $80 \leq \text{ozone} < 85$ ppbv, and 3 for ozone ≥ 85 ppbv. The five largest 8-hr exceedances, as reported by CDPHE, were considered for each site per year.

Site	2007	2008	2009	2010	2011	2012	Total
Weld Co Tower	1	2	0	2	6	10	11
Fort Collins West	12	6	2	1	7	11	28
Fort Collins CSU	0	0	0	0	0	5	5
South Boulder	12	4	3	2	5	8	26
Rocky Flats	19	6	9	5	12	17	51
Welby	4	6	6	0	6	8	22
Carriage	5	2	2	0	4	10	13
Highland	3	0	0	3	7	12	13
BAO	--	--	0	0	5	6	17*
NREL	11	7	3	3	14	12	50
Welch	8	6	1	1	7	10	33
Chatfield	10	8	5	6	13	17	59

*2007 and 2008 data were unavailable for BAO and thus the final average score was multiplied by 1.5 to compensate for this data gap.

Table S2

Site coordinates and elevation of stations from which meteorological data were considered.

Site	Latitude	Longitude	Elevation	Time Period
KBDU (Boulder)	40.03°	-105.23°	1593 m	May 2011 - May 2015
KBJC (Broomfield)	39.91°	-105.12°	1717 m	May 2009 - May 2015
KDEN (Denver)	39.86°	-104.67°	1636 m	May 2009 - May 2015
KEIK (Erie)	40.01°	-105.05°	1551 m	May 2010 - May 2015
KGXY (Greeley)	40.44°	-104.63°	1420 m	May 2009 - May 2015
KLMO (Longmont)	40.16°	-105.16°	1535 m	Jan 2012 - May 2015
CO051(Greeley)	40.42°	-104.73°	1445 m	May 2009 - May 2015
GRWLD (Greeley)	40.44°	-104.79°	1444 m	May 2009 - May 2015

Table S3

Comparison of transport analyses using HYSPLIT back trajectories and wind direction data recorded on the BAO tower on high ozone days (> 75 ppbv for at least two hours). The 16:00 hrs ozone is listed in column 2, inferred HYSPLIT transport direction and local wind speed during the same time window are given in columns 3 and 4, respectively. Letters in [] behind the date listing refer to the trajectory graphs shown in Figure S2.

Date	Ozone (ppbv)	BAO		Difference
		HYSPLIT Transport Direction	Wind Direction	
6/24/2009 [D]	75	100	14	86
7/15/2009	78	90	68	22
8/4/2009 [A]	59	110	101	9
8/22/2009	64	90	70	20
6/9/2010	79	70	359	71
6/24/2010	71	185	93	92
6/29/2010	67	165	161	4
7/16/2010 [B]	68	65	47	18
8/22/2010	57	140	120	20
5/10/2011	65	120	211	91
7/1/2011	80	95	122	27
7/24/2011 [C]	73	110	86	24
7/17/2011 [E]	80	155	23	132
8/9/2011	75	270	203	67
4/10/2012	68	75	77	2
4/28/2012	69	80	124	44
5/27/2012	67	360	335	25
6/22/2012	89	280	5	85
6/24/2012 [F]	62	345	34	49

Table S4

Comparison of transport analyses using HYSPLIT back trajectories for South Boulder and wind direction data (in degree) recorded at Marshall Mesa on high ozone days (> 75 ppbv for at least two hours). The 15:00-16:00 hrs mean ambient ozone is listed in column 2, inferred HYSPLIT transport direction and local wind speed during the same time window are given in columns 3 and 4, respectively. Letters in [] behind the date listing refer to the trajectory graphs shown in Figure S3.

South Boulder				
Date	Ozone (ppbv)	HYSPLIT Transport Direction	Wind Direction	Difference
6/24/2009 [A]	66	95	61	34
7/15/2009	84	70	77	7
8/11/2009	71	105	101	4
8/22/2009	90	85	64	21
6/7/2010 [D]	62	260	165	95
6/24/2010	96	285	40	115
6/29/2010	65	140	116	24
7/16/2010	65	55	60	5
8/26/2010 [B]	77	115	75	40
5/10/2011 [E]	74	150	349	161
6/24/2011	97	135	87	48
7/1/2011	77	290	55	125
7/17/2011	62	75	277	158
7/25/2011 [F]	64	130	80	50
8/9/2011	78	270	83	173
8/20/2011 [C]	95	95	67	28
4/10/2012	87	85	63	22
5/27/2012	69	280	299	19
6/18/2012	69	120	42	78