Contributions to Regional Haze in the Northeast and Mid-Atlantic United States: Q/d Update with 2011 Emissions

Mid-Atlantic/Northeast Visibility Union (MANE-VU) Updated Contribution Assessment

DRAFT September 9, 2015

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1. INTRODUCTION

NESCAUM performed preliminary analyses to assess the contribution from states and regions on the visibility impairment on Class I areas in the MANE-VU region. NESCAUM designed the analyses to serve as updates to those performed for the report, *Contribution to Regional Haze in the Northeast and Mid-Atlantic United States* (NESCAUM, 2006). In that report, NESCAUM used a suite of analysis tools to assess the absolute and relative contribution of states for the 2002 baseline year.

This report is the second update and mimics distance the approach of the previous released in 2012 using emissions data through 2008. This report provides a baseline analysis by providing an initial assessment of the contributions from states in 2011.

2. SUPPORTING A N A L Y S E S

2.1. Haze-associated pollutant emissions

This section explores the origin and quantity of haze-forming pollutants emitted in the eastern United States. The pollutants that affect fine particle formation, and thus contribute to regional haze, are sulfur oxides (SO_x) , nitrogen oxides (NO_x) , volatile organic compounds (VOCs), ammonia (NH_3) , and directly emitted particles with an aerodynamic diameter less than or equal to 10 and 2.5 μ m (i.e., primary PM₁₀ and PM_{2.5}). The data analyzed in this update examined USEPA's National Emissions Inventory (NEI) to determine the contribution from different states.

2.2. Emissions Divided by Distance

This section provides methods and results for the emissions over distance (Q/d) approach.

This approach is described in the original analysis (NESCAUM, 2006), but a brief summary of methods is presented here.

The geographic domain of the sources included in the Q/d study consisted of states in four regional planning organizations: CENRAP, MANE-VU, MWRPO, and VISTAS. Emissions data were obtained from the USEPA's 2011 National Emissions Inventory (NEI) version 2, and consisted of point sources, nonpoint sources (or area sources), non-road sources, and on-road sources. Because regional 2018 emissions inventories were not yet available for the MANE-VU or other U.S. regions, NESCAUM used data from the 2011 NEI as a reasonable approximation, however the intent is to update again with the 2018 projections. The previous update included Canadian emissions, this was not included this time around.

Results were calculated for eight receptors: Acadia National Park, Brigantine Wilderness Area in the Forsythe National Wildlife Refuge, Dolly Sods Wilderness Area, Great Gulf Wilderness Area, James River Face Wilderness Area, Lye Brook Wilderness Area, Moosehorn Wilderness Area, and Shenandoah National Park. The locations used are presented in Appendix A. The James River Face Wilderness Area is a new addition to the analysis and was added because a MANE-VU state is considered a contributor to this Class I area.

The empirical formula that relates emission source strength and estimated impact is expressed through the following equation:

$$I = C_i (Q/d)$$

In this equation, the strength of an emission source, Q, is linearly related to the impact, I, that it will have on a receptor located a distance, d, away. As in the previous analysis, distances were computed using the Haversine function, using an earth radius of 6371 km.² The effect of meteorological prevailing winds can be factored into this approach by establishing the constant, C_i , as a function of the "wind direction sectors" relative to the receptor site. By establishing a different constant for each wind direction sector, based on prior modeling results—in this case, CALPUFF results—we are in effect "scaling" Q/d results by CALPUFF-calculated source impacts. The absolute impacts produced are then dependent on the CALPUFF results. The relative contributions, however, of each source within a wind direction sector is established completely independent of the CALPUFF calculation, yielding a quasi-independent method of apportionment to add to our weight-of-evidence approach.

² The Haversine function is an algorithm to calculate the distance between two points along the surface of a perfect sphere. It is discussed in greater detail in the previous report (NESCAUM, 2006).

The same values for C_i as were used in the previous analysis were used in this analysis, with the exception of James River Face since it was not previously used Shenandoah and Dolly Sods C_i values were tested. Therefore, this analysis essentially uses 2002 meteorology to process the 2011 estimated emissions. By using wind vector factors derived from 2002 meteorology, we have a common set of conditions to compare potential changes in relative contributions among upwind states between 2002, 2007 and 2011 looking at changes in emissions alone. The C_i constants are presented in Appendix A it should be noted that the wind vectors are relative to a counter-clock wise direction with east being equal to zero degrees. Appendix B contains the detailed directions for replicating or re-running the analysis and Appendix C is the full set of results exported into excel.

As with the previous analysis, to calculate the impact that each state had on a given receptor, the point, area and mobile source SO_2 emissions were summed across the entire state, and calculated the distance to the receptor site for those emission sources based on that state's geographic center, adjusted for population density. State population centers for 2010 were obtained from the U.S. Census Bureau (2011) for the 2012 report. In this way, we treated the area source emissions as a single point source located at the population-weighted center of each state, the latitude and longitudes used are presented in Appendix A and are the same as the 2012 report since the census data is still the most current.¹

In the 2012 report states that contributed to any MANE-VU receptor above $0.10 \,\mu g/m^3$ were noted as significant for SO₂ Q/d only. This threshold was selected as a starting point for discussion only and needs to be evaluated and decided by states with Class I areas. To ensure further reductions that are needed to meet the next 10 years goals, a new threshold is needed; 1% and 2% contribution of the monitored annual average ammonia sulfate concentrations are considered below see Figures 2-1(a)-(g).

The first round of regional haze SIPs focused primarily on SO_2 reductions due to the fact that these emissions were the primary drivers of poor visibility in the region. A review of the latest monitoring data from the Class I areas determined that sulfate continues to be the predominate driver of visibility degradation see Figure 1. Contributions of sulfur dioxide emissions were analyzed on a state total basis (with the exception of natural emissions)¹ provided in the graphics and table below. Table 2-1 shows the top 5 contributing states to the Class I areas in the region. Figures 2-1(a)-(g) show the corresponding Q/d rankings across a set of Northeast and Mid-Atlantic Class I areas in or near the MANE-VU region.

¹ March 21, 2012 Report: Contributions to Regional Haze in the Northeast and Mid-Atlantic United States: Preliminary through 2007

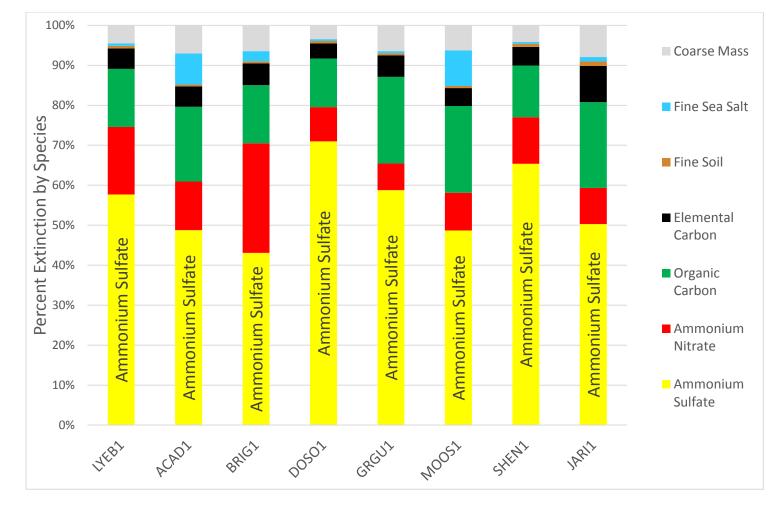


Figure 1. 2013-2014 Monitored Extinction on 20 Haziest Days, Expressed as Percentage of Extinction

Receptor	State	Contribution			
	Ohio	0.110722	•		
lia	Pennsylvania	0.076393			
Acadia	Indiana	0.056531			
Ac	Michigan	0.043586			
	Illinois	0.035447			
υ	Pennsylvania	0.144185			
Brigantine	Ohio	0.122695			
Jan	Maryland	0.062602			
Brig	Indiana	0.054433			
	Kentucky	0.051057			
s	Ohio	0.285194			
300	West Virginia	0.140909			
Dolly Sods	Pennsylvania	0.13217			
loC	Indiana	0.096535			
	Kentucky	0.070214			
۲, F	Ohio	0.097926			
Great Gulf	Pennsylvania	0.062172			
sat	Indiana	0.048236			
J.G.	Michigan	0.038705			
	Illinois	0.029948			
C	Ohio	0.209511	<shen< th=""><th>Ohio</th><th>0.21814</th></shen<>	Ohio	0.21814
Га	Pennsylvania	0.095895	Dolly>	West Virginia	0.09889
es	West Virginia	0.094978		Indiana	0.0889
James Face	Indiana	0.085382		Pennsylvania	0.08838
<u> </u>	Kentucky	0.070312		Kentucky	0.07321
×	Pennsylvania	0.132424			
Lye Brook	Ohio	0.116413			
B A	Indiana	0.05447			
L yé	New York	0.053722			
	Kentucky	0.033723			
L L	Ohio	0.079613			
eho.	Indiana	0.057955			
OSe	Illinois	0.036654			
Moosehorn	Michigan	0.030354			
	Texas	0.029351			
Jah	Ohio	0.205847			
Jdc	Pennsylvania	0.14796			
Jar	Indiana	0.079393			
Shenandoah	West Virginia	0.079183			
St.	Virginia	0.068504			

Table 2-1. Top 5 2011 SO₂ CALPUFF-scaled emissions over distance impacts ($\mu g/m^3$) at Northeast and Mid-Atlantic Class I areas

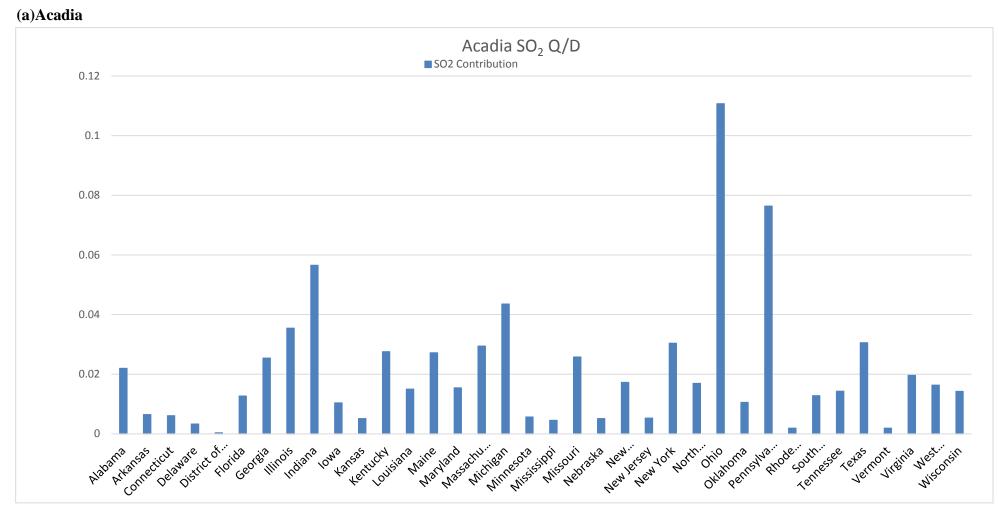
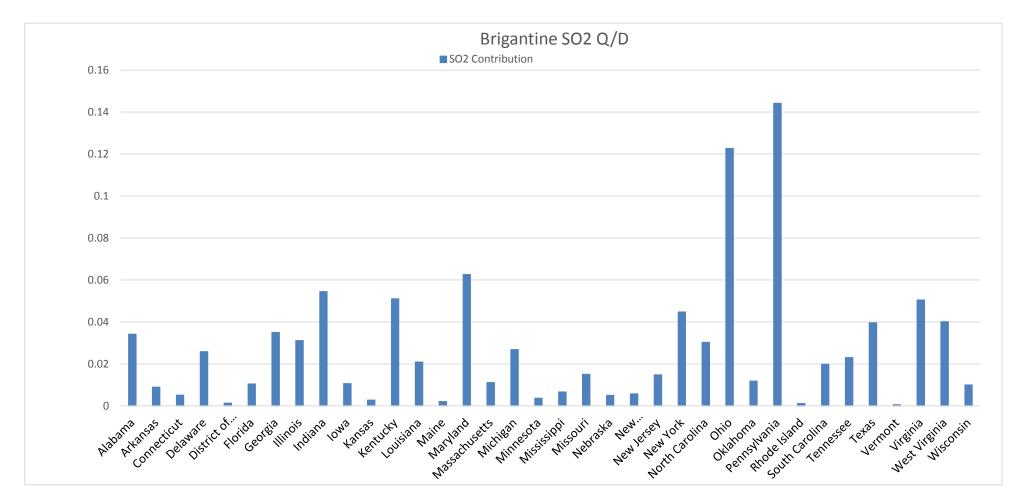
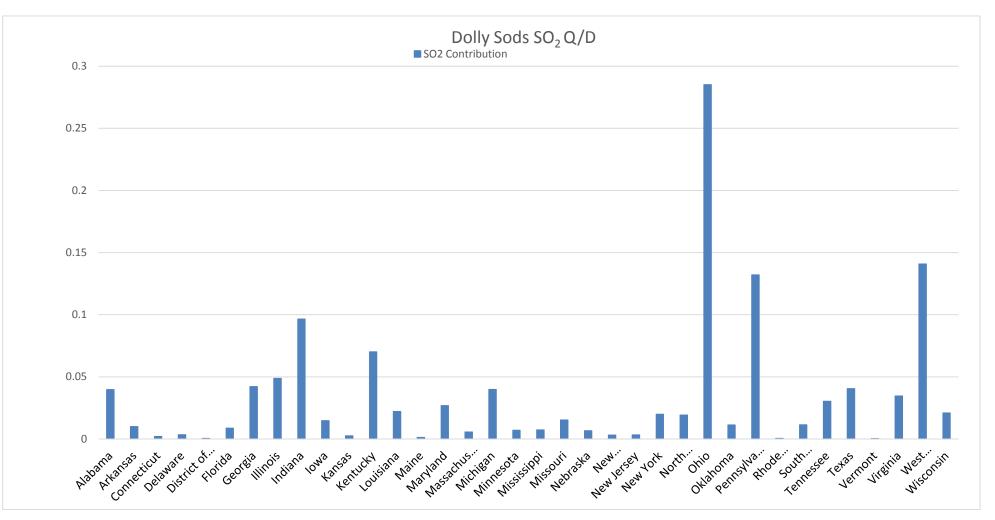


Figure 2-1 Ranked state percent summed contributions to Class I area Receptors in NE region based on 2011 emissions divided by distance (Q/d) results

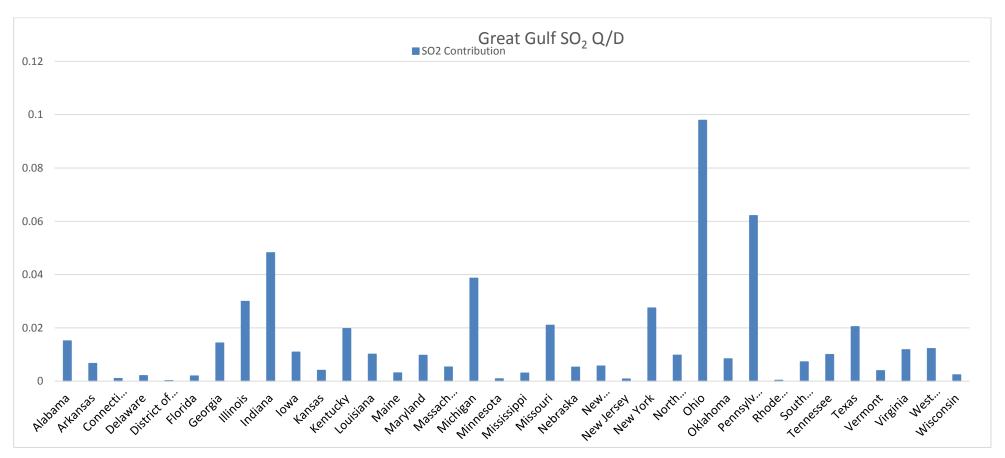
(b)Brigantine



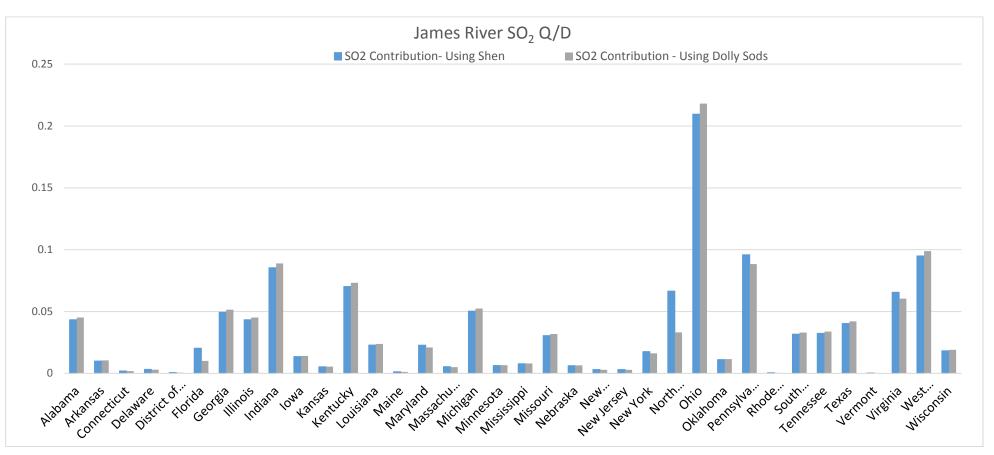




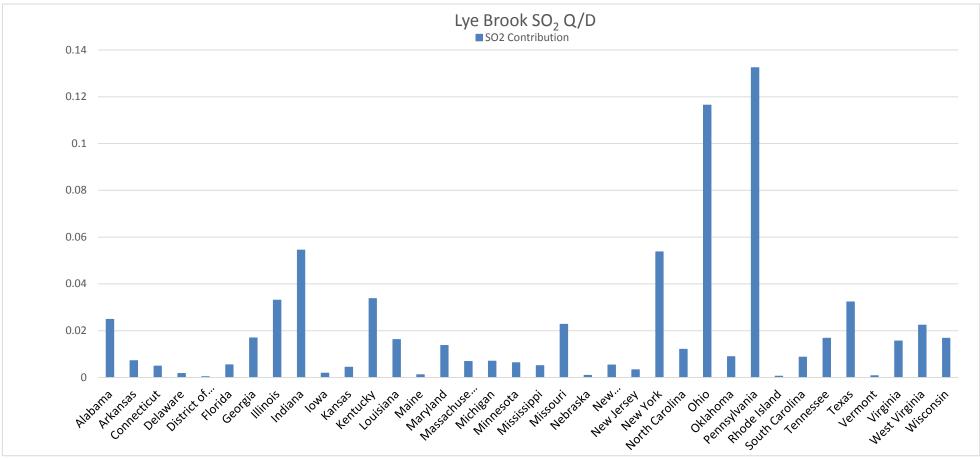
(d)Great Gulf



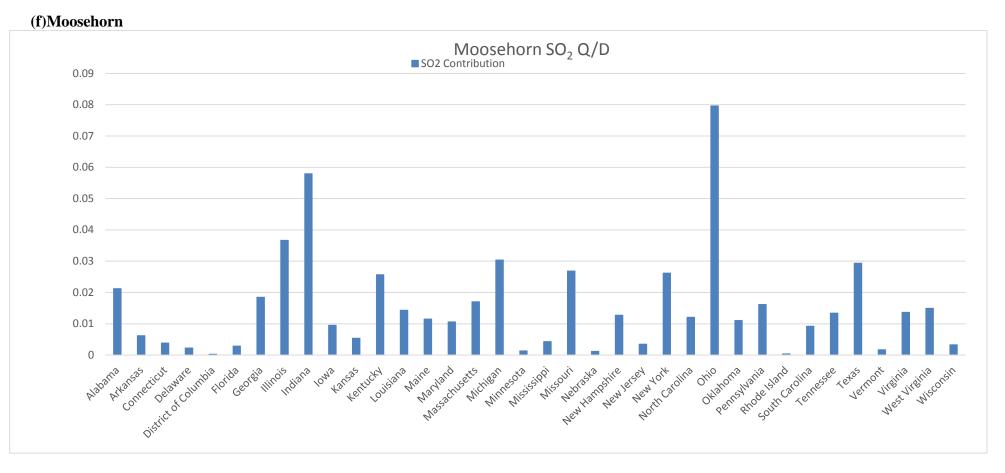
(e)James River Face



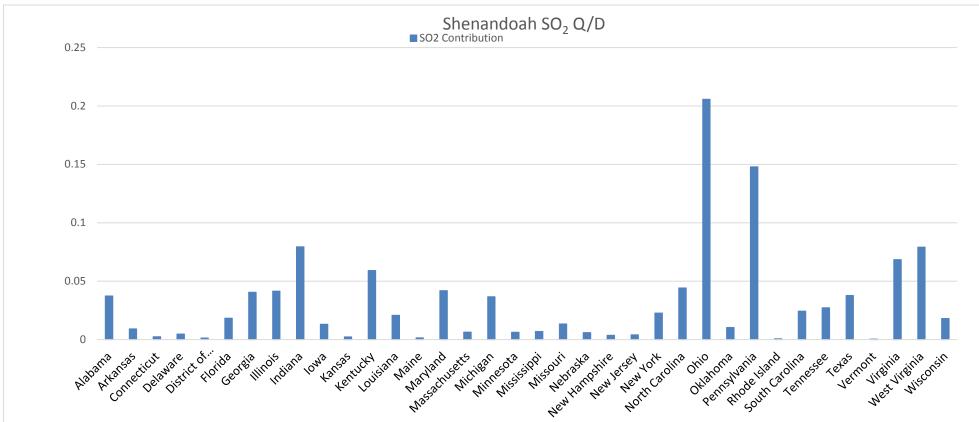








(g)Shenandoah



Appendix A: Inputs to the emissions over distance approach

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This appendix presents inputs used in the emissions over distance approach (Q/d).

State	Latitude	Longitude
Alabama	33.008097	-86.756826
Arkansas	35.14258	-92.655243
Connecticut	41.497001	-72.870342
Delaware	39.358946	-75.556835
District of Columbia	38.91027	-77.014468
Florida	27.822726	-81.634654
Georgia	33.376825	-83.882712
Illinois	41.286759	-88.390334
Indiana	40.149246	-86.259514
Iowa	41.946066	-93.036629
Kansas	38.464949	-96.462812
Kentucky	37.824499	-85.248467
Louisiana	30.722814	-91.508833
Maine	44.29995	-69.736482
Maryland	39.140769	-76.797763
Massachusetts	42.272291	-71.36337
Michigan	42.873187	-84.203434
Minnesota	45.203555	-93.571903
Mississippi	32.590954	-89.579514
Missouri	38.423798	-92.198469
Nebraska	41.1743	-97.315578
New Hampshire	43.154858	-71.461974
New Jersey	40.43181	-74.432208
New York	41.501299	-74.620909
North Carolina	35.543075	-79.658232
Ohio	40.455191	-82.773339
Oklahoma	35.598464	-96.836786
Pennsylvania	40.456756	-77.00968
Rhode Island	41.753609	-71.450869
South Carolina	34.025176	-81.011022
Tennessee	35.80809	-86.359136
Texas	30.905244	-97.365594
Vermont	44.094874	-72.816417
Virginia	37.810313	-77.81116
West Virginia	38.795594	-80.731308
Wisconsin	43.721933	-89.018997

Table A-1. Geographic coordinates used for "center of state" locations

Class I Area	Area Abbreviation	Latitude	Longitude
Acadia National Park	ACAD	44.3771	-68.2612
Moosehorn Wilderness Area	MOOS	45.1259	-67.2661
Great Gulf Wilderness Area	GRGU	44.3082	-71.2177
Brigantine Wilderness Area	BRIG	39.465	-74.4492
James River Face Wilderness Area	JARI	37.6266	-79.5125
Lye Brook Wilderness Area	LYBR	43.1481	-73.1267
Shenandoah National Park	SHEN	38.5228	-78.4347
Dolly Sods Wilderness Area	DOSO	39.1069	-79.4262

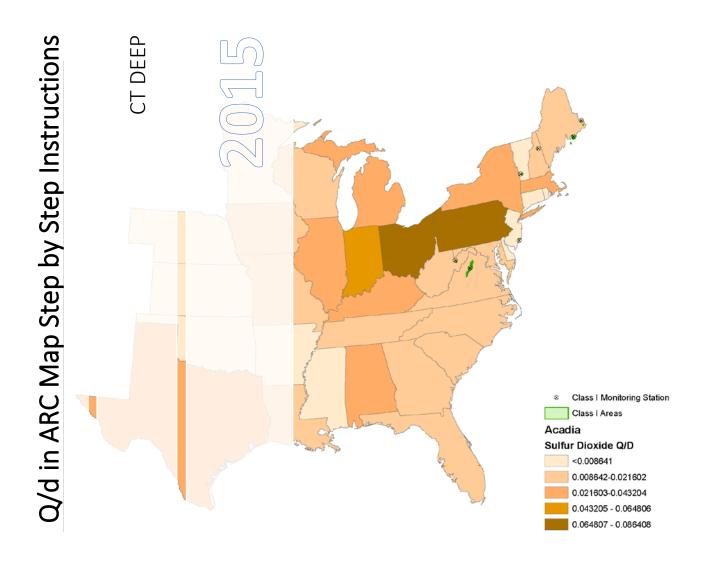
Table A-2.	Geographic co	oordinates used	for Class]	l area locations
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Table A-3. Wind direction sector constants

Class I Area Abbreviation	Minimum Angle	Maximum Angle	Constant (Ci)
ACAD	0	171	0.00016071
ACAD	172	197	0.00020593
ACAD	198	216	0.00016071
ACAD	217	226	0.00019667
ACAD	227	360	0.00016071
DOSO	0	140	0.00008446
DOSO	141	254	0.00013503
DOSO	255	355	0.00006458
DOSO	356	360	0.00006458
BRIG	0	33	0.0000882
BRIG	34	156	0.0000882
BRIG	157	179	0.00012905
BRIG	180	189	0.00017808
BRIG	190	237	0.00016108
BRIG	238	360	0.0000882
GRGU	0	170	0.00002371
GRGU	171	203	0.00014956
GRGU	204	236	0.00009968
GRGU	237	289	0.00002371
GRGU	290	360	0.00002371
LYBR	0	143	0.00002303
LYBR	144	225	0.00014575
LYBR	226	240	0.00010289
LYBR	241	299	0.00005815
LYBR	300	360	0.00002303
MOOS	0	173	0.00003842
MOOS	174	184	0.00015274
MOOS	185	196	0.00022409

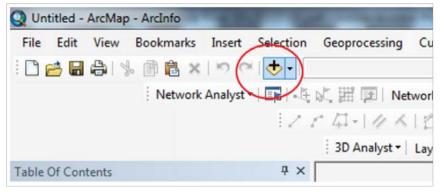
Class I Area Abbreviation	Minimum Angle	Maximum Angle	Constant (<i>Ci</i>)
MOOS	197	209	0.00015967
MOOS	210	211	0.00003842
MOOS	212	212	0.00016344
MOOS	213	215	0.00012298
MOOS	216	225	0.00015147
MOOS	225	360	0.00003842
SHEN	0	133	0.00009164
SHEN	134	280	0.00012969
SHEN	281	311	0.00006097
SHEN	312	360	0.00006097

Note: Above angles are measured in degrees counterclockwise, with east equal to zero degrees. Also note James River Face Wilderness was run twice once using Dolly Sods Ci values and once using Shenandoah values.

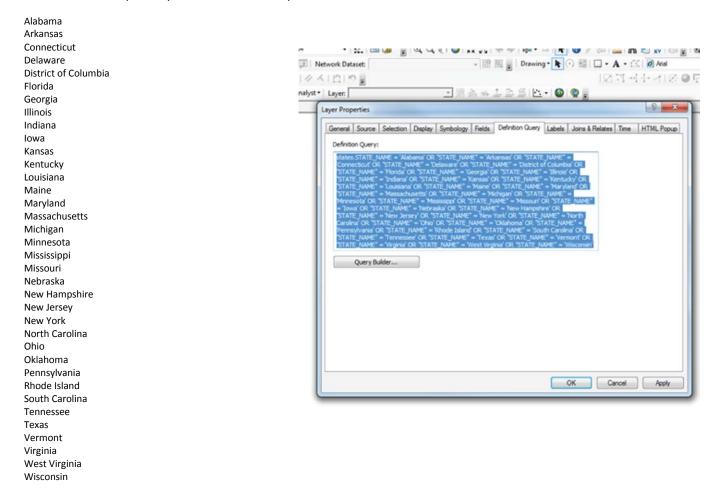


Outlined in the attached pages is the step by step instructions for the Q/d analysis as performed in ARC Map.

- 1. In new map import state out line shape file. The most up to date shape file can be downloaded at https://www.census.gov/geo/maps-data/data/tiger-line.html
 - a. To import select the add data button circled below.



b. Set definition query to limit view to the states you wish to anlayze. For the 2015 Q/D up date this list of states was used. – Doing this step will save you from memory limits and speed up the calculation steps later on.



- 2. Set the projection for the map
 - a. Right click in the map and select Data Frame Properties.
 - b. Select the Coordinate System Tab
 - c. Select a projection in the projected folder. Depending on your area there may be a different projection that is best suited to your area, but make sure to use one that represents distances correctly, if you do not your distance calculation could be signifigantly skewed. For the purposes of the 2015 Q/d the region USA contigious Equidistant conical. This best represented the states selected and preserved the quality of the distances.

rrent coordnate system: SA_Contiguous_Equadistant_Conic respection: Equadistant_Conic respection: Equadistant_Conic respective: Equadistant_Conic Instander_Preadel_133.0000000 Instander_Preadel_133.0000000 Instander_Preadel_133.0000000 In	eature Cache	Annotation Group	bent Indicators	Frame	Size	and Position
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Add To Pavorites	Datum: D_Nor	th_American_1983		*	and an	- Kenn
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		Y		-	-	

3. Select the add data button again and import the population weighted state centroids.



a. You can calculate geographic centroids through the calculate geometery when adding a field in the polygons of interests table. For the 2015 update this was not done and centroids were used from <u>Appendix A of the</u> <u>Contributions to Regional Haze in the Northeast and Mid-Atlantic United States:</u> <u>Preliminary Update Through 2007</u>, this table was pasted into excel file with state total NH3, SO2, NOX, PM2.5 primary and VOC emissions totals¹ for each state (minus biogenic/natural totals) and a shape file was made from this appendix.

b. To create shapefile from csv or excel:

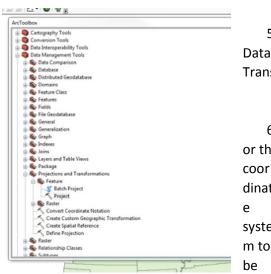
i. Right click on file in the catalog list select create feature class then select from xy table

ii. Identify the coodinate system- the coordinates in appendix A are WGS 84.

¹ NEI 2011 version 2 (April, 2015 download)

c.

- d. Import new shapefile into the map and check the transformation is correct WGS 1984 into North american 1983 is what was used.-Repeat with Class I area monitors coordinates.
- 4. This takes the shape file which is in WGS84 and places it in the correct NAD 83 position; now you must convert your shapfiles to the NAD83 datum so that the distance will result in meters and not the angle from the center of the earth (degrees).



the best for calculating distance. In this case we used USA Contiguous Equidistant Conic.prj. (If including Canada in furture I would suggest selecting North America Equidistant Conic) Repeat for the other feature.

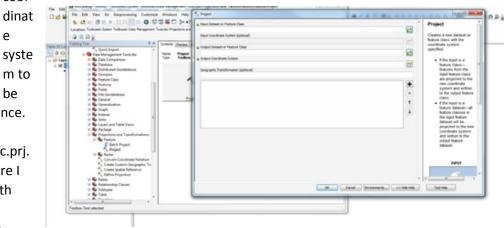
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 Image: Coordinate System: Surning

 The following data source use a geographic coordinate system that is different to one used by the data finate you are address the state is the source one and source one address of the source one addressource one address of the source one address of the source one add

5. To convert each shapefile to the projection needed open Data Management Tools>Projections and Transformations>Feature>Project (see image at left)

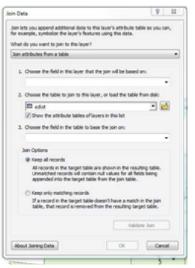
6. Select one of your features (State Centroids with Emissions or the Park Monitors) as the Input Data Set. Select output



7. To ensure your transformation took check the units in the lower right , if you are in NAD 83 projected they should be in meters not DD. If it did not take go into data management tools and

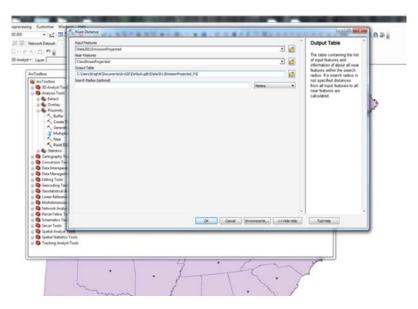
projections and retry the projection. Use this tool to project the geometric layer into a projected.

- 8. Calculate distance
 - a. Open Arc tool box and select analysis tools and proxmity tool set. The input feature was state centroids. Make sure to use the newly create shape file that is projected into the flat projection not your WGS 84 file.
- 9. Do a quick does this make sense check- by joining the features and new output table to get the context. Right click on your newly created distance table select Joins and Relates and then Join. Your input feature was your states. First Select the States feature for box 2. Box 1 is choices of columns from your new distance table input_FID is the state tables object ID select this column and Object Id should auto populate for selection three if it doesn't select it. Then select validate join. Then select ok. It will tell you the number of joins created this will enable you



to notice an error immediately. Too many , too little? Often this is result of formating error. You will need to edit the layer to match the format of one of those columns to match the other. Which you choose to edit doesn't matter as long as they are the same and retain all their digits.

10. Repeat the join for the parks but this time use Near FID column to match the object ID in the parks shapefile.



11. Distance is output in m recalculate in km

- a. Add new field to newly created distance table.
- b. Title it and field type should be double
- c. Right click new column and select field calculator and insert equation [distance]/1000

ы.	8 - 1 8 8 0 # x								
_		A second second							×
-	Select By Attributes	DISTANCE	OBJECTID*	State	Latitude	Longitude	Ammonia	Nitrogen_Oxides	PM10_P
100	Clasr Selection	1 2031944.671577	1	Alabama	33.008097	-86.756826	77409.093764	359835.790178	406105
1		1 2308506.489105	2	Arkatsas	35.14258	-92.655243	132991.701013	232268.42157	46904
8	Switch Selection	1 492848.548289	3	Connecticut	41,497001	-72.870342	5204.147551	72840 263411	39156
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	Arrange Tables	1 2020575 356906	10	lowa	41.946066	-93.036629	288248.84406	240310.67126	572080
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	Restore Default Column Widths	1 1592368.706269		Kentucky	37.824499	-05.240467	58130.201353	327821.147234	251587
	Restore Default Field Order	3 2532602.243436		Louisiana	30.722814	-91.508833	75863.88239	531068 535475	432023
	Joins and Relates	1 117821.273405		Maine	44.29995	-69.736482	8084.827837	59830.74092	49958
		914701.323106		Maryland	39,140769	-76.797763	26894 265781	165477.358272	77594
	Related Tables	3 342964.847123		Massachusetts	42.272291	-71,36337	7252.200787	130950.424417	163439
10	Create Graph	1 1292823.837938		Michigan	42.873187	-84.203434	65902.069811	444530.661798	422026
		1 1997787.663727		Minnesota	45.203555	-93.571903	209100.778629	316619.507601	500549
	Add Table to Layout	2257275.631507		Masiasippi	32.590954	-89.579514	65601.171916	205923.535846	82
2	Reload Cache	3 2091947.06173		Masouri	38.423798	-92.198469	138847.487612	373049.643977	925240
-		3 2385566 228393		Nebraska	41.1743	-97.315578	185234,92077	217221.590425	527319
8	Print	290813.249596		New Hampshire	43.154858	-71,461974	2690.059922	36574 88598	33434
	Reports	609218.87673		New Jersey	40.43181	-74.432208	8330.752162	168439.379971	\$1412
		1 607901.363638		New York	41.501299	-74.620909	51521 225329	387379.480149	291349
	Export	1 1376680.862479		North Carolina	35.543075	-79.658232	175501.518534	369596.638797	244004
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Г	13	2	1	2308506.489105	2	Arkansas	35.14258	-92.655243	132991 701013	232268.42157	48904
Г	20	3	1	492848.548289	3	Connecticut	41.497001	-72.870342	5204.147551	72640.263411	39156
E	27	4	1	820768.244198	4	Delaware	39.358946	-75.556835	5784.094568	29457.806581	15194
L	34	5	1	945735.335034		District of Columbia	38.91027	+77.014468	329.752029	9402.978353	3410
Г	41	6	1	2189037.893024	6	Florida	27.622726	-61.634654	68054.307484	008445.171288	456450
L	48	7	1	1814780.006521	7	Georgia	33.376825	-83.682712	111589.098011	452639.956991	822707
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L	104	15	1		15				6894 265781	185477.358272	77594
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Q/d in ARC Map Step by Step Instructions

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Q/d in ARC Map Step by Step Instructions

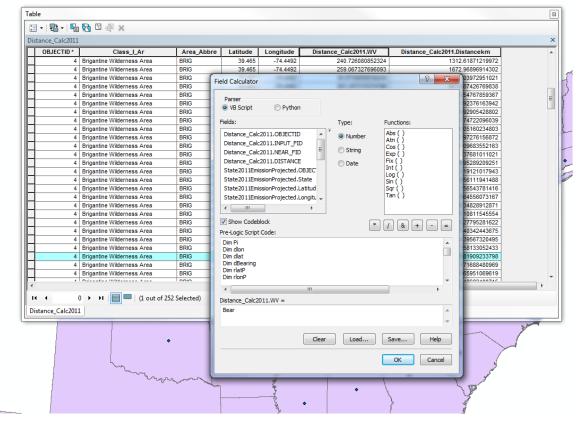
- 12. Calculate the wind vector that the state falls in for each Class I monitor
 - a. Create new field in state table (type=double)
 - b. Load or select code book and write an equation for calculating bearing from Class I area to state. For the 2015 update this code was written. Should your column titles be different than Longitude, Latitude. Latitude_1 and longitude_1 it is easiest to open the script file in note pad first and do a find and replace to rename each appropriately as your columns are named in your files.

Dim Pi Dim dlon Dim dlat **Dim dBearing** Dim rlatP **Dim rlonP** Dim rlatS Dim rlonS Dim Xr Dim Yr Pi=4 * Atn (1) dlon=(([Longitude] * (Pi/180))-([Longitude 1] *(Pi/180))) dlat=(([Latitude] *(Pi/180))-([Latitude 1] *(Pi/180))) rlatP= [Latitude 1] *(Pi/180) rlonP= [Longitude_1] *(Pi/180) rlatS= [Latitude] *(Pi/180) rlonS= [Longitude] *(Pi/180) Yr=Cos (rlatP) * Sin (rlatS) - Sin (rlatP) * Cos (rlatS) * Cos (dlon) Xr=Sin (dlon) * Cos (rlatS) If dlon>0 AND dlat>0 then dBearing=(90*Pi/180)-Atn(Yr/Xr) Elself dlon>0 AND dlat<0 then dBearing=(90*Pi/180)+Abs(Atn(Yr/Xr)) Elseif dlon<0 AND dlat<0 then dBearing=(Pi)+Atn(Xr/Yr) Elself dlon<0 AND dlat>0 then dBearing=(270*Pi/180)+Abs(Atn(Yr/Xr)) Else dBearing=0

End If

Bear=dBearing*(180/Pi)

13. Then add new field (again type is double). Q/d Right click and select field calculator and divide emissions by distance in km repeat until each desired Q/d is done. Note – with primary pollutants like PM2.5 use d²



14. Add another field (type=double) because the Ci from appendix A of the

<u>"Contributions to Regional Haze in the Northeast and Mid-Atlantic</u> United States: Preliminary Update Through 2007"

Uses the due east coordinate as 0 degrees and in a counter clockwise direction your bearing will need to be slide 90 degrees and rotated to apply the correct Ci. The Ci were developed with this counter clockwise, see image below for the Acadia example. Add this script in the field calculator to account for this. Open in notepad first and replace the appropriate title of your bearing column (replacing [Distance_Calc2011.WV] with your title)

dim WVE

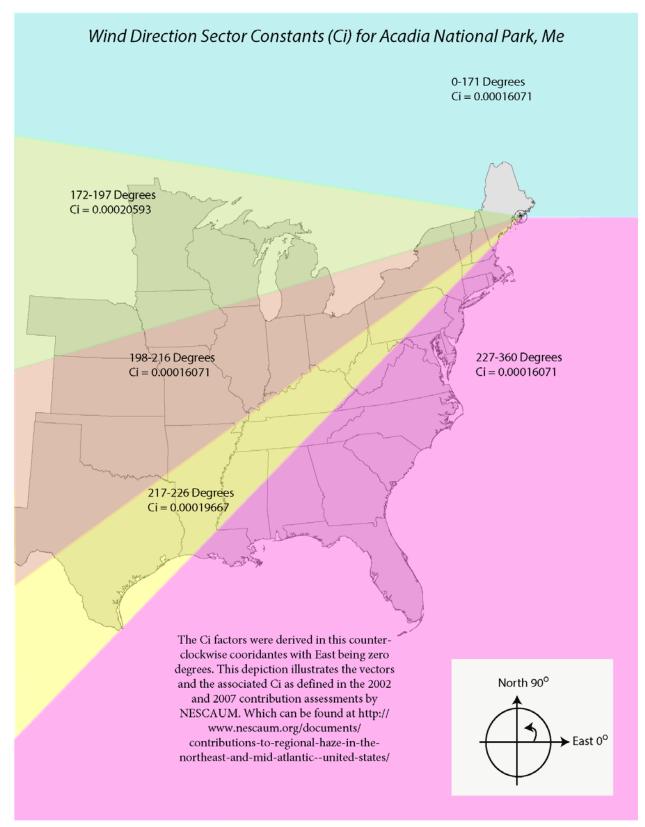
If [Distance_Calc2011.WV] < 90 then

```
WVE=90 - [Distance_Calc2011.WV]
```

Else

WVE=360 - [Distance_Calc2011.WV]- 90

End If



15. Add another field (type=double) and calculate Q/d*C depending on vector calculated earlier. The below scipt was used for 2015 update. Repeated for other pollutants if desired, this study experimented with the other precursors of PM2.5 but in the end found these results to be unreliable and not a priority and were therefore removed. Again easiest way to replace column titles is to open the scrip in Note pad first and find and replace all of that name with the appropriate column names. Remember to use the azimuth corrected created in step 14.

```
Dim QDC
If [Area Abbreviation] ="ACAD" then
If [Azimuth] >=171.5 AND [Azimuth] <197.45 then
QDC=[VOCQoD] *0.00020593
Elself [Azimuth] >=216.5 AND [Azimuth] <226.5
then
QDC= [VOCQoD] *0.00019667
Else
QDC= [VOCQoD] *0.00016071
End If
Else
If [Area Abbreviation] = "DOSO" then
If [Azimuth] <140.5 then
QDC= [VOCQoD] *0.00008446
ElseIf [Azimuth] >=140.5 AND [Azimuth] <254.5
then
QDC= [VOCQoD] *0.00013503
Else
QDC= [VOCQoD] *0.00006458
End If
Else
If [Area Abbreviation] = "BRIG" then
If [Azimuth] <156.5 then
QDC= [VOCQoD] *0.0000882
Elself [Azimuth] >=156.5 AND [Azimuth] <179.5
then
QDC= [VOCQoD] *0.00012905
Elself [Azimuth] >=179.5 AND [Azimuth] <189.5
then
QDC= [VOCQoD] *0.00017808
Elself [Azimuth] >=189.5 AND [Azimuth] <237.5
then
QDC= [VOCQoD] *0.00016108
Else
QDC= [VOCQoD] *0.0000882
End If
Else
```

If [Area Abbreviation] = "GRGU" then

Q/d in ARC Map Step by Step Instructions

```
If [Azimuth] <171 then
QDC= [VOCQoD] *0.00002371
Elself [Azimuth] >=170.5 AND [Azimuth] <203.5
then
QDC= [VOCQoD] *0.00014956
Elself [Azimuth] >=203.5 AND [Azimuth] <236.5
then
QDC= [VOCQoD] *0.00009968
Else
QDC= [VOCQoD] *0.00002371
End If
Else
If [Area Abbreviation] = "LYBR" then
If [Azimuth] <143.5 then
QDC= [VOCQoD] *0.00002303
Elself [Azimuth] >=143.5 AND [Azimuth] <225.5
then
QDC= [VOCQoD] *0.00014575
Elself [Azimuth] >=225.5 AND [Azimuth] <240.5
then
QDC= [VOCQoD] *0.00010289
Elself [Azimuth] >=240.5 AND [Azimuth] <299.5
then
QDC= [VOCQoD] *0.00005815
Else
QDC= [VOCQoD] *0.00002303
End If
Else
If [Area Abbreviation] = "MOOS" then
If [Azimuth] <173.5 then
QDC= [VOCQoD] *0.00003842
Elself [Azimuth] >=173.5 AND [Azimuth] <184.5
then
QDC= [VOCQoD] *0.00015274
Elself [Azimuth] >=184.5 AND [Azimuth] <196.5
then
QDC= [VOCQoD] *0.00022409
Elself [Azimuth] >=196.5 AND [Azimuth] <209.5
then
QDC= [VOCQoD] *0.00015967
Elself [Azimuth] >= 209.5 AND [Azimuth] < 211.5
then
QDC= [VOCQoD] *0.00003842
Elself [Azimuth] >= 211.5 AND [Azimuth] < 212.5
then
```

Q/d in ARC Map Step by Step Instructions

```
QDC= [VOCQoD] *0.00016344
Elself [Azimuth] >=212.5 AND [Azimuth] <215.5
then
QDC= [VOCQoD] *0.00012298
Elself [Azimuth] >=215.5 AND [Azimuth] <225.5
then
QDC= [VOCQoD] *0.00015147
Else
QDC= [VOCQoD] *0.00003842
End If
Else
If [Area_Abbreviation] = "SHEN" then
If [Azimuth] <133.5 then
QDC= [VOCQoD] *0.00009164
Elself [Azimuth] >=133.5 AND [Azimuth] <280.5
then
QDC= [VOCQoD] *0.00012969
Else
QDC= [VOCQoD] *0.00006097
End If
Else
QDC=0
End If
```

Distance_Calc2011 X 084CTDP / Brgantine Widemess Area BRI0 39.465 -74.4492 2274.1530071109 240.15 4 Brgantine Widemess Area BRI0 39.465 -74.4492 130.8300031957 250.07 4 Brgantine Widemess Area BRI0 39.465 -74.4492 130.8300031957 250.07 4 Brgantine Widemess Area BRI0 39.465 -74.4492 130.8300031957 250.07 4 Brgantine Widemess Area BRI0 39.465 -74.4492 130.8300031957 250.07 4 Brgantine Widemess Area BRI0 19.97 <th>Table</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>B</th> <th></th>	Table						B	
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16. Final step export table to CSV for charts (can do in ARC map as well but more workable format for large group in excel)