

AERMOD Sensitivity Evaluation

NYSDEC

EPA/State/Local Modelers Workshop

Virginia Beach, May 15-17, 2007

AERMOD Sensitivity Tests

- 1. Area versus volume source representation
- 2. Urban option effects of population
- 3. Effects of cloud cover substitution

1. Area versus volume source

- Due to excess run time and/or very low winds, AIG (9/27/05) recommends volume source approach for certain receptors near area sources.
- NYSDEC DAR-10 prefers the area source method and recommends case by case review of results, if necessary.
- Tested the effects of representing 6 area sources of size from 25mx25m to 250mx250m as 4 to 16 multiple volume sources of size 12.5m to 25m. Initial dispersion per ISC3 user's guide (Table 1-6 of Volume II). Assumes ground level sources, but tested case of elevated release.

Area versus Volume Source (continued)

- Receptor grid starting at a distance equal to side dimension of area source.
- Also placed 4 receptors on the edge of area source at the cardinal directions.
- 1992 Syracuse meteorological data.
- Calculate ratios of area to volume source maxima for 1, 3, 24 hour and annual averages at the two set of receptors.

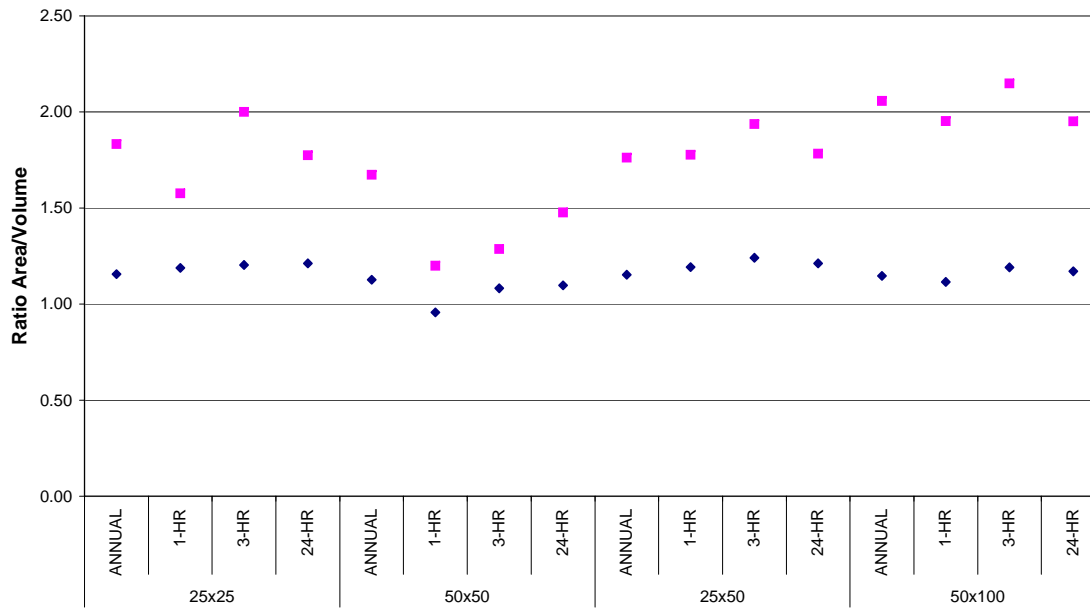
ISC versus AERMOD: Wastewater Treatment Plant

PC: Micron Pentium 4/3.2 GHz/2.93 GB/Single processor

	1	2	3	4	5	6	7	8	9	10
		Model	Hours of Met Data		Number of Sources			Number of	Model Run Time	
ROW	Model	Version	Used in Model	File Details	Point	Volume	Area	Receptors	24-hrs met data	1-yr met data
1	ISC	02035	24 hrs	Original ISC/24-hrs of hourly met data	1	1	137	2386	0.5 min	3.2 hours (est.)
2	ISC	02035	1 yr (hourly)	Original ISC/1-year of hourly met data	1	1	137	2386		3.3 hours (actual)
3	AERMOD	04300	24 hrs	Same as ISC above/24-hrs of met data	1	1	137	2386	11.5 min	70 hours (est.)
4	AERMOD	04300	24 hrs	Same ISC set-up/Refined grid/24-hrs of met data	1	1	137	5568	26.3 min	160 hours (est.)
5	AERMOD	04300	24 hrs	Revised source set-up/Refined grid/24-hrs of met data	1	1	38	5568	7 min 48 s	47.5 hours (est.)
6	AERMOD	04300	24 hrs	Revised source set-up/Refined grid/24-hrs of met data	1	1	38	1548	1 min 50 s	11.15 hours (est.)

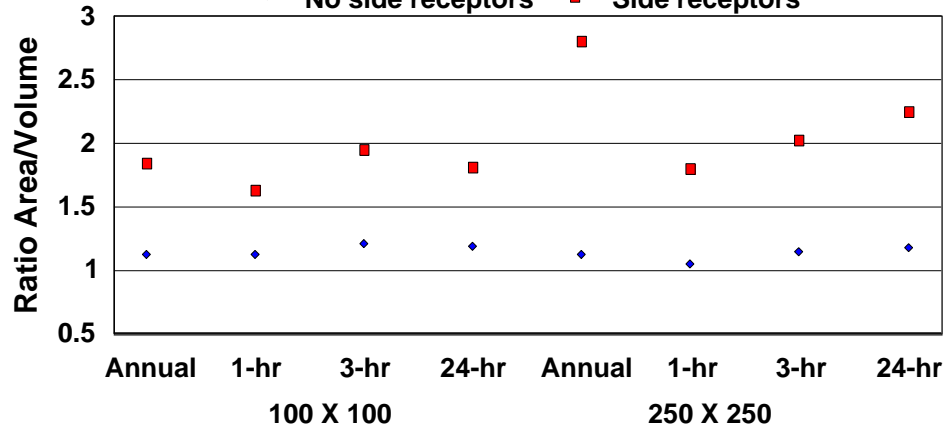
**Area versus Volume Source Study
Max Value Ratios**

◆ no side receptors ■ side receptors



**Area vs. Volume Source Study
Max Value Ratios**

◆ No side receptors ■ Side receptors



Area versus Volume Source Conclusions

- At properly placed receptors (at and beyond the distance equal to side of area source), volume source approach underestimates area source method by maximum of 25%.
- At receptors on the side of the area source, volume source method underestimates the area source approach by a factor of about 2.
- Sensitivity run of 50x100m area source case with a release height of 10m results in a average ratio of 0.8 for area to volume source maxima. Sensitivity run of 25x25m case with 10m height, but as a single volume source, results in an average ratio of 0.66 for area to volume maxima.
- Run times higher for area versus multiple volume sources by factor of 3 (about 1 versus 3 minutes). The area run time is a factor of 10 faster than EPA's 2003 reported value, but could be partly due to smaller area sizes in our modeling.

2. AERMOD URBAN SCHEME

- $H_u = \alpha \rho c_p \Delta T_{u-r} u_*$
- $\Delta T_{u-r} = \Delta T_{\max} [0.1 \ln (P/P_o) + 1]$
- Where $\Delta T_{\max} = 12^\circ\text{C}$ and $P_o = 2\text{million}$
- $Z_{iu} = Z_{iuo} (P/P_o)^{1/4}$
- $w_{*u} = (g/\rho c_p T_{\text{ref}})^{1/3} \times (H_u Z_{iu})^{1/3}$
- Effects for low level sources by u_{*eff} at $z=7z_o$

Urban Parameter Effects

Urban Popult. in Millions	0.05	0.15	0.5	1.0	2	5	10
Effect of: $[0.1\ln(P/P_0)+1]$	0.63	0.74	0.86	0.93	1	1.09	1.16
Effect of: $(P/P_0)^{1/4}$	0.4	0.52	0.71	0.84	1	1.26	1.5
Effect of: $(H_u Z_{iu})^{1/3}$	0.63	0.73	0.85	0.92	1	1.11	1.2

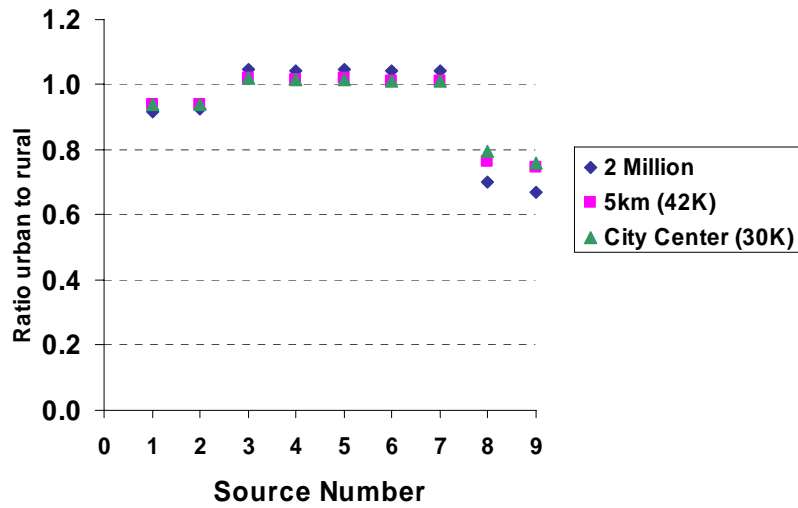
Urban Source Sensitivity

- Jamestown 2002 and Syracuse 1992 meteorology (limited additional data tested)
- For population use: i) City “center”
ii) 5km radius and iii) 2 million
- Polar grid receptors on flat terrain
- $z_0=1\text{m}$ for URBANOPT (for u_{*eff})
- Calculate ratios of urban to rural impacts for 1, 3, 24 hour and annual maxima

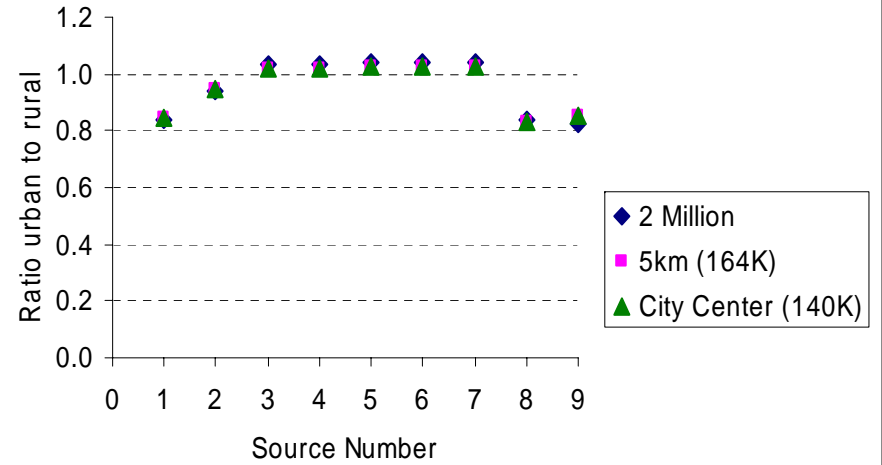
Set of Point Sources Modeled

Source No.	Stack Height(m)	Temperature (K)	Velocity (m/s)	Diameter(m)	Building Dimensions(m)
S1	10	300	2.5	0.5	8x10x10
S2	10	350	5	1.0	8x10x10
S3	25	350	5	2.5	20x30x30
S4	25	400	10	2.5	20x30x30
S5	50	450	5	2.5	40x50x50
S6	50	450	10	5.0	40x50x50
S7	50	550	10	5.0	40x50x50
S8	75	450	10	5.0	50x60x60
S9	75	600	15	5.0	50x60x60

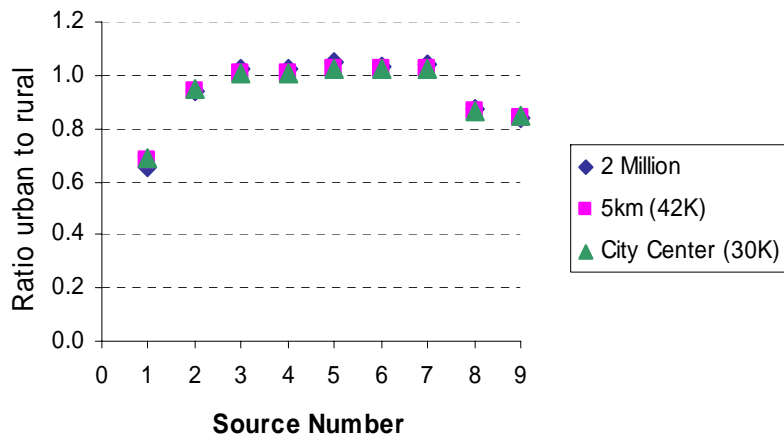
Jamestown 2000 Meteorology
Annual maximum impacts, with downwash



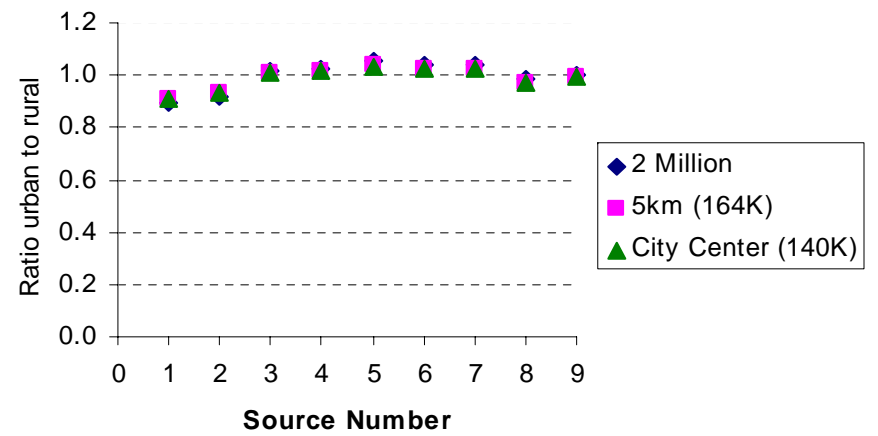
Syracuse 1992 Meteorology
Annual maximum impacts, with downwash



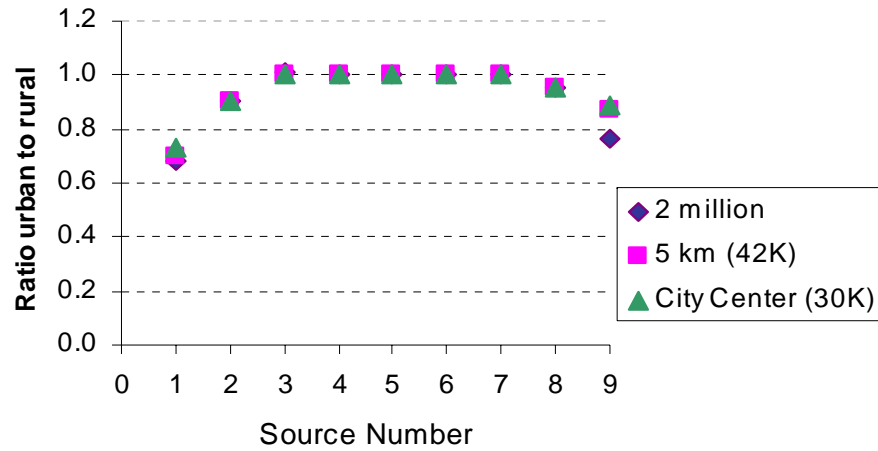
Jamestown 2000 Meteorology
24 hour maximum impacts, with downwash



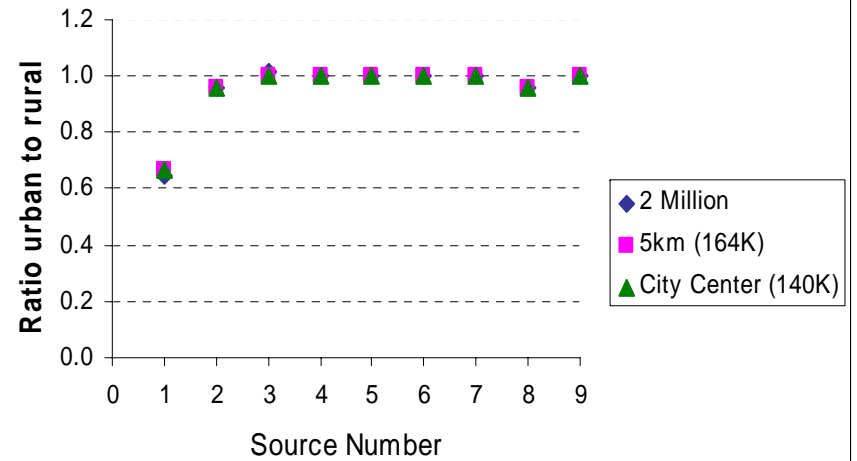
Syracuse 1992 Meteorology
24 hour maximum impacts, with downwash



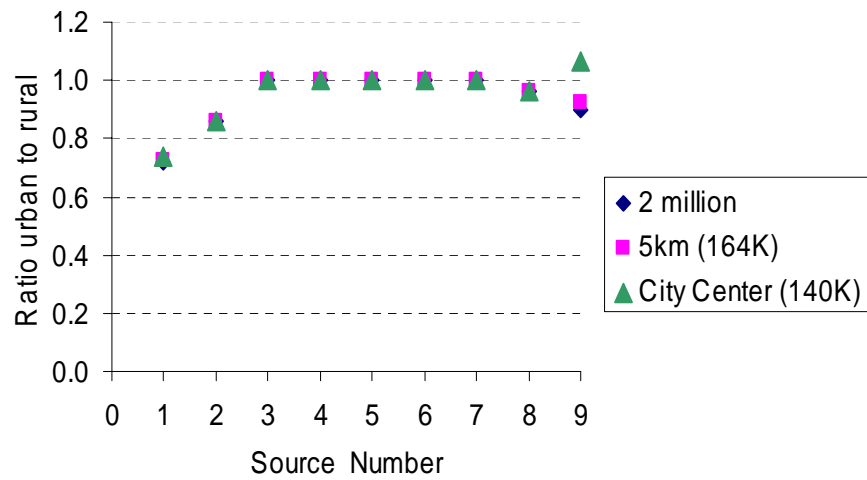
Jamestown 2000 Meteorology
3 hour maximum impacts, with downwash



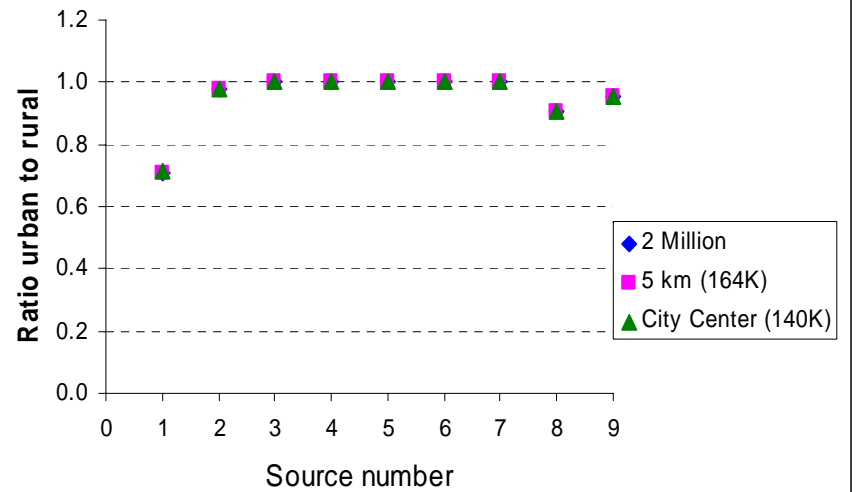
Syracuse 1992 Meteorology
3 hour maximum impacts, with downwash



Jamestown 2000 Meteorology
1 hour maximum impacts, with downwash



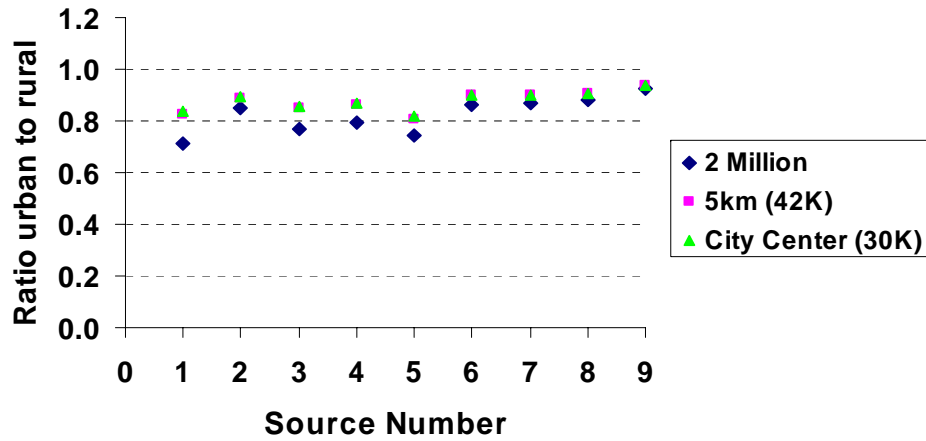
Syracuse 1992 meteorology
1 hour maximum impacts, with downwash



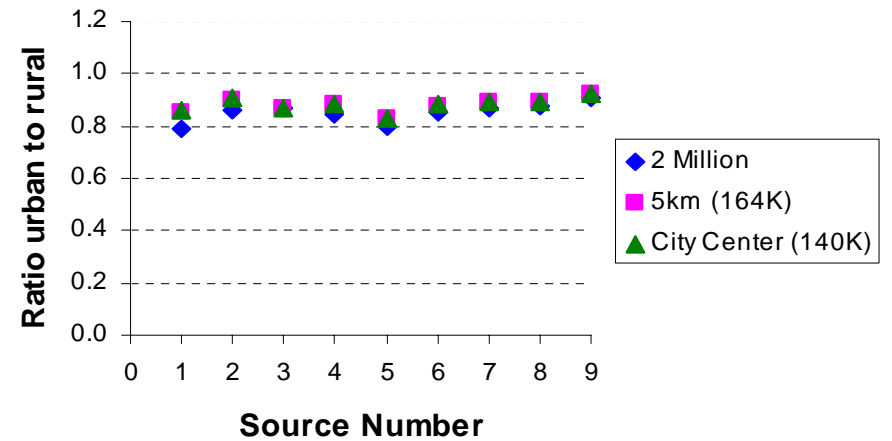
Observations on Downwash Cases

- Urban maxima are essentially equivalent or close to rural values in vast majority of cases - likely due to dominance of downwash effects.
- For many sources (S3 to S6), the urban and rural impacts are identical for the 1 and 3 hour cases and the associated meteorology occur in daytime- i.e. no urban effect. On the other hand, although the ratios for the 24 hour cases are very close to 1 for these same sources, the days of 24 hour urban versus rural impacts are different. However, for a given source and averaging time, the urban maxima share the same hours/days for essentially all short term impacts regardless of population.
- In most cases, the sources with lowest height (S1 and S2) and the tallest height (S8 and S9) have lower urban impacts than rural. The receptors of the rural maxima in these cases are different than for the urban impacts per source, but there is commonality of receptors of urban maxima. There is also more variability in the met hours/days of the rural versus urban maxima, but for a given source, the meteorological conditions for the short term impacts are very similar between rural and urban cases (e.g. for S1, stable-low winds while for S9, high winds-neutral).

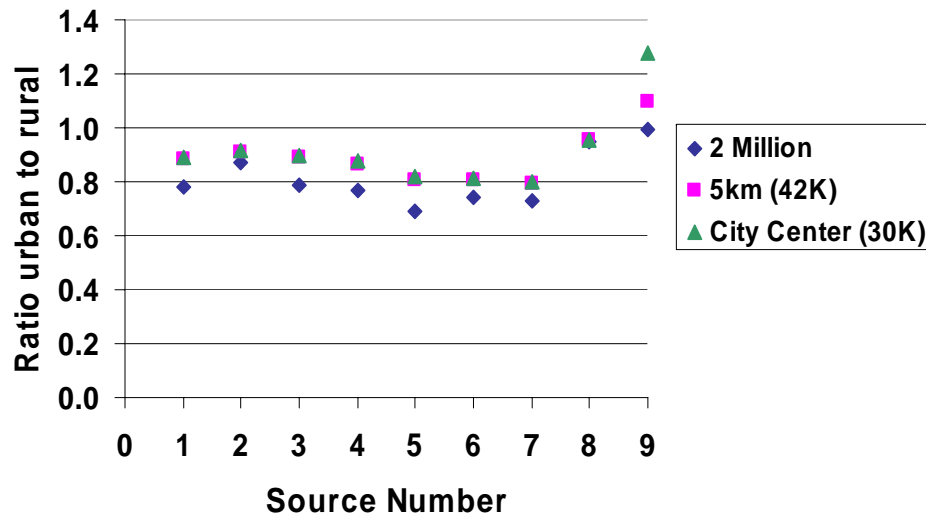
Jamestown 2000 Meteorology
Annual maximum impacts, no downwash



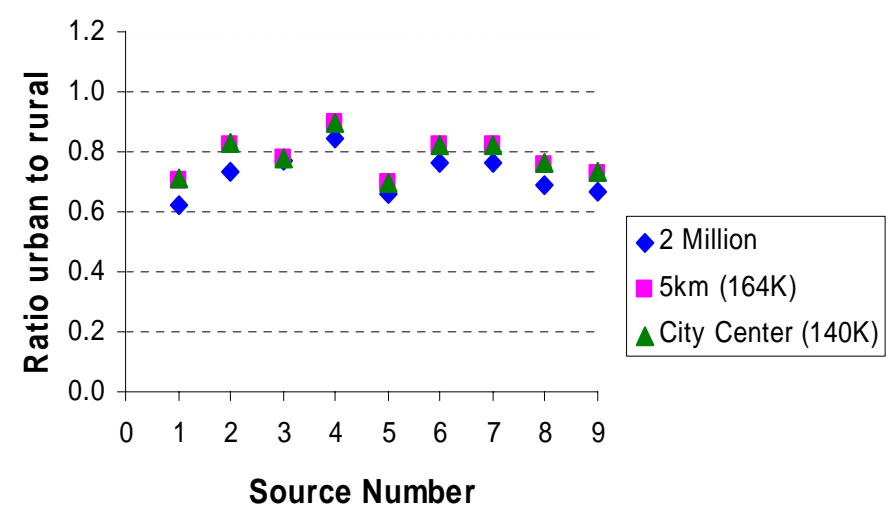
Syracuse 1992 Meteorology
Annual maximum impacts, no downwash



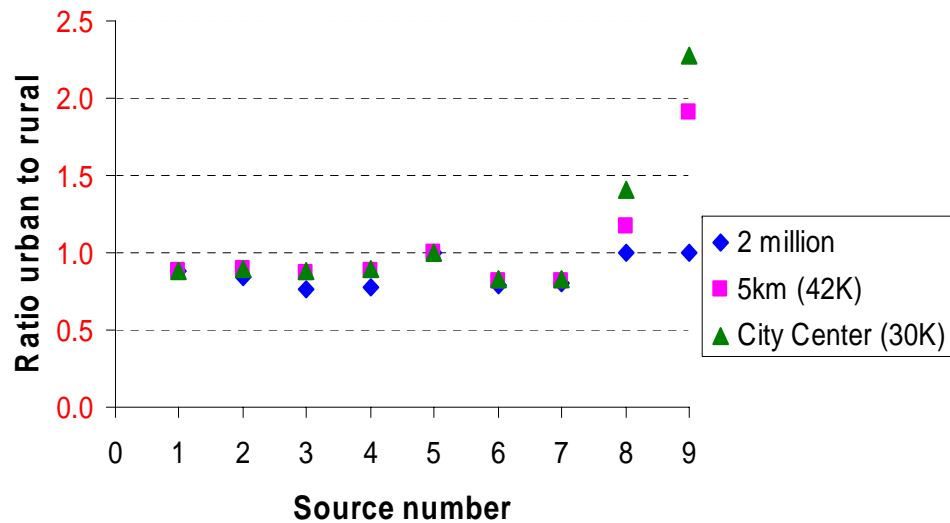
Jamestown 2000 meteorology
24 hour maximum impacts, no downwash



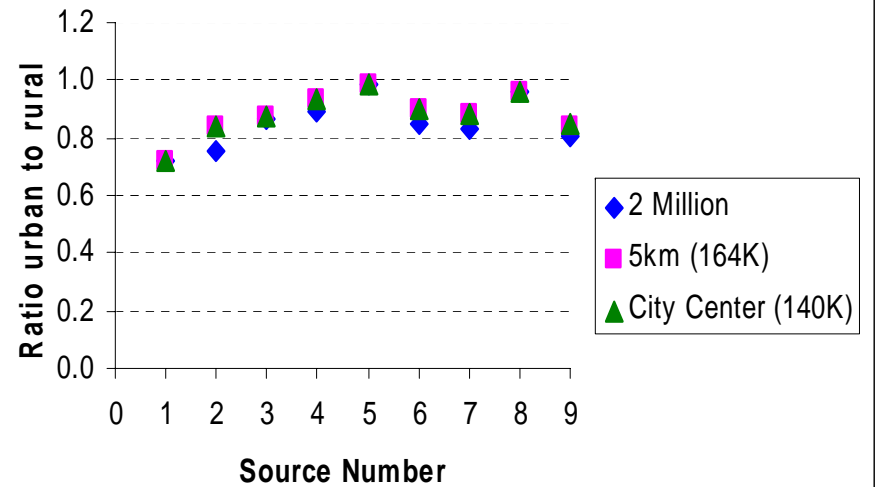
Syracuse 1992 Meteorology
24 hour maximum impacts, no downwash



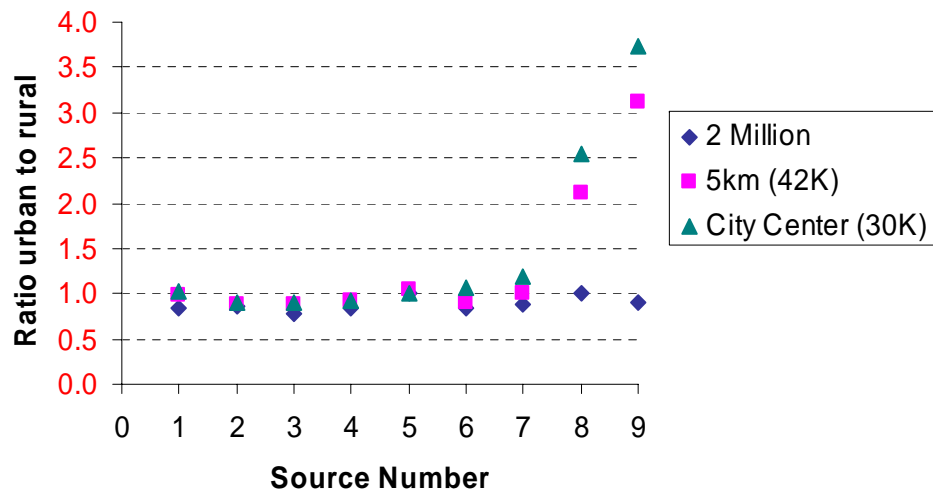
Jamestown 2000 Meteorology
3 hour maximum impacts, no downwash



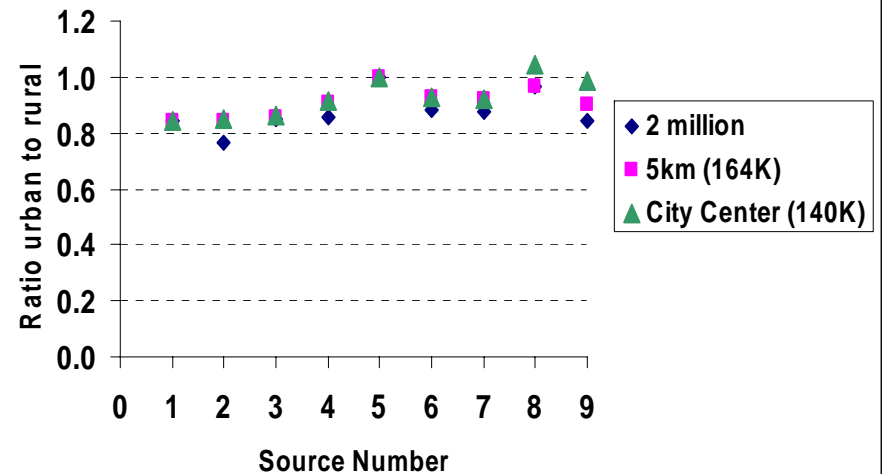
Syracuse 1992 meteorology
3 hour maximum impacts, no downwash



Jamestown 2000 Meteorology
1 hour maximum impacts, no downwash

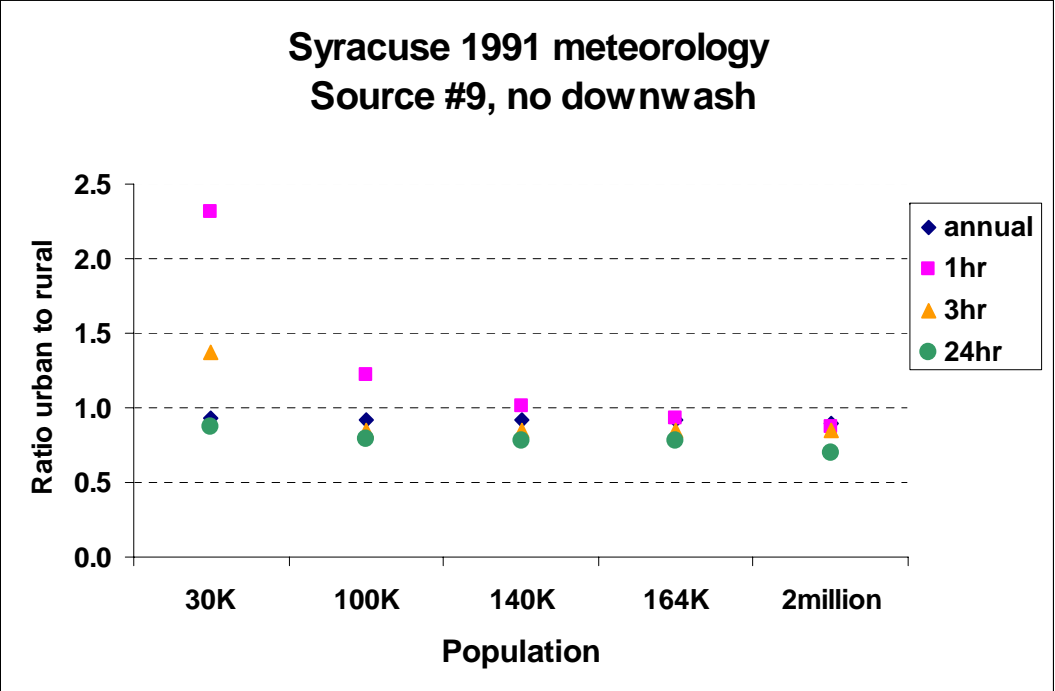
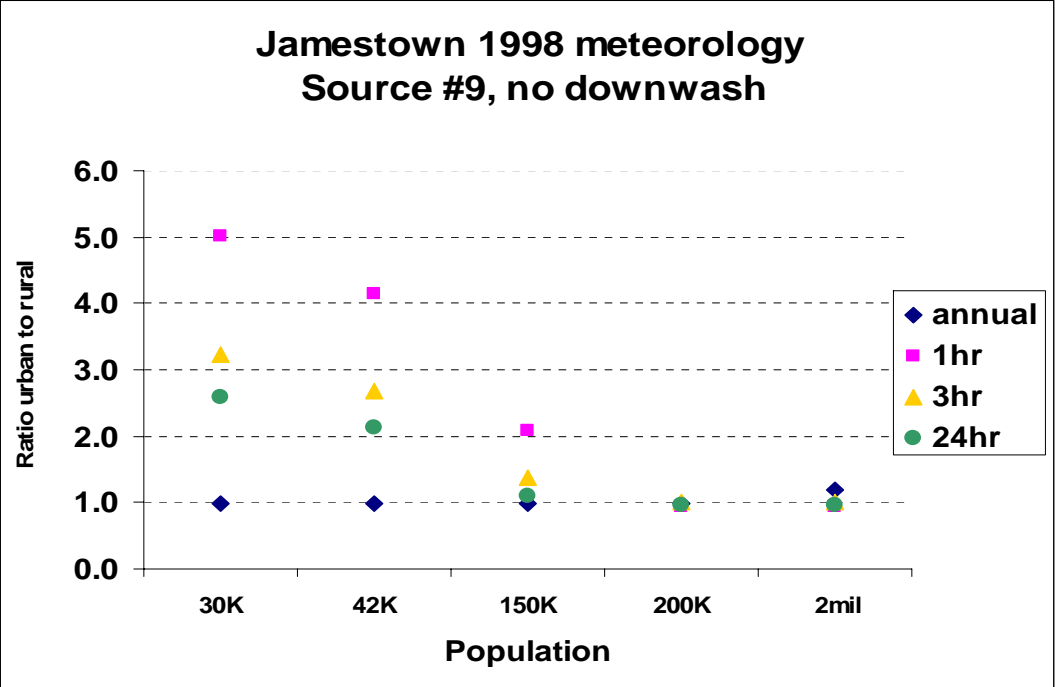


Syracuse 1992 meteorology
1 hour maximum impacts, no downwash



Observations on non-downwash cases

- For both data sets, essentially all cases show lower than 1 ratios for urban versus rural impacts (average of 0.8), except for the short term impacts for taller sources with Jamestown data.
- For the most part, impacts do not seem to be sensitive to population, with two exceptions: i) at Jamestown many cases show a noticeable, but small decrease in impacts as population increases to 2 million for the lower height sources, and ii) the short term impacts at Jamestown show considerable increase in impact in urban versus rural ratios (above 1) for sources S8 and S9 (tallest stacks) as population decreases. The latter seems unrealistic and also contrary to above results.
- Results for S8 and S9 were rerun with another year of Jamestown (1998) and Syracuse (1991) data and showed the same pattern of ratios as above, indicating it was not a meteorological data problem. Meteorological data for the 1 and 3 hour cases with high ratios correspond to low wind speeds ($<1.5\text{m/s}$), low mechanical mixing depth ($Z_m < 50\text{m}$) and very stable conditions (low +L).
- The meteorological hours/days of the rural versus urban short term impacts vary considerably more than in the downwash cases, but population does not have a significant effect on these conditions for a given source/averaging time.



Conclusions on Urban AERMOD Sensitivity

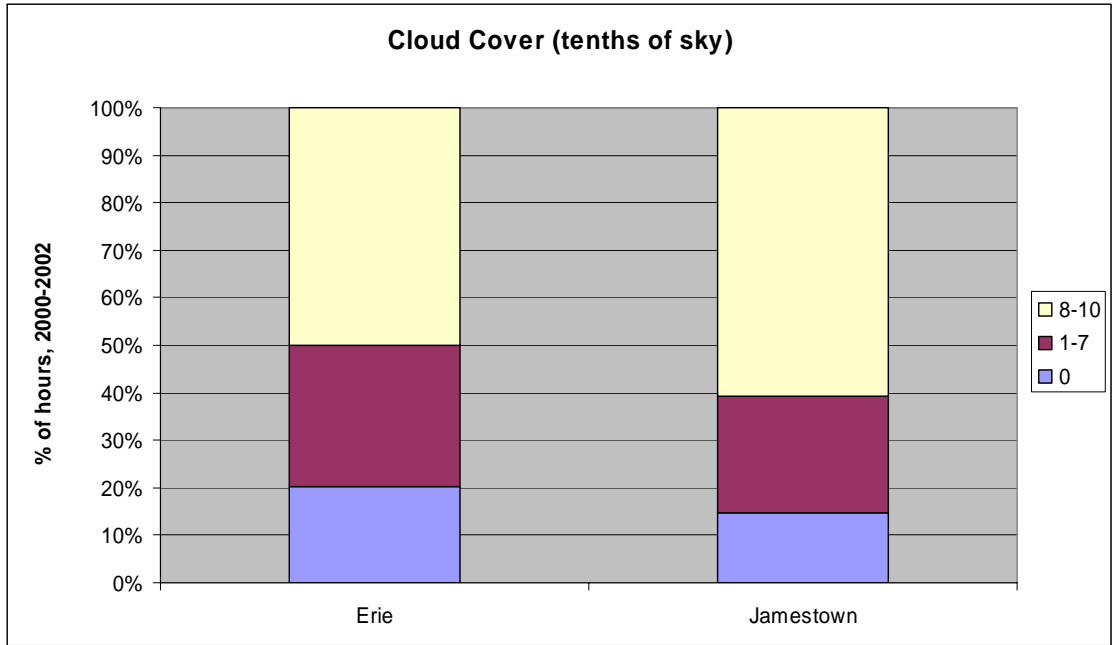
- The urban option of AERMOD has little effect in downwash dominated cases.
- For non-downwash cases, the effect of urban option is to reduce impacts relative to rural cases on a scale compatible with the heat island formulations and is likely due to increased σ_y versus σ_z effects. This is somewhat contrary to previous modeling experience and expectation in an urban setting. In the long term, addition of roughness effects and other modifications should be tested with expanded monitored data bases.
- There is a model artifact which needs to be corrected for low population and higher source heights.

3. Effects of Cloud Cover

- Unstable cases: opaque cloud cover used to define solar radiation and net long wave radiation which, in turn, define net radiation
- Stable cases: opaque cloud cover used to calculate temperature scale which affects definition of friction velocity, then both used to calculate heat flux

Effects of Cloud Cover (Continued)

- Model sources S1, S4, S7, S9 from previous Table
- Two met sites with 3 concurrent years of data (2000-02) from Jamestown (JHW) and Erie, PA (ERI) assumed to be representative of source site
- Replace only hourly cloud cover in Erie, PA raw met data with corresponding Jamestown data and visa-versa and rerun AERMET/AERMOD



Albedo

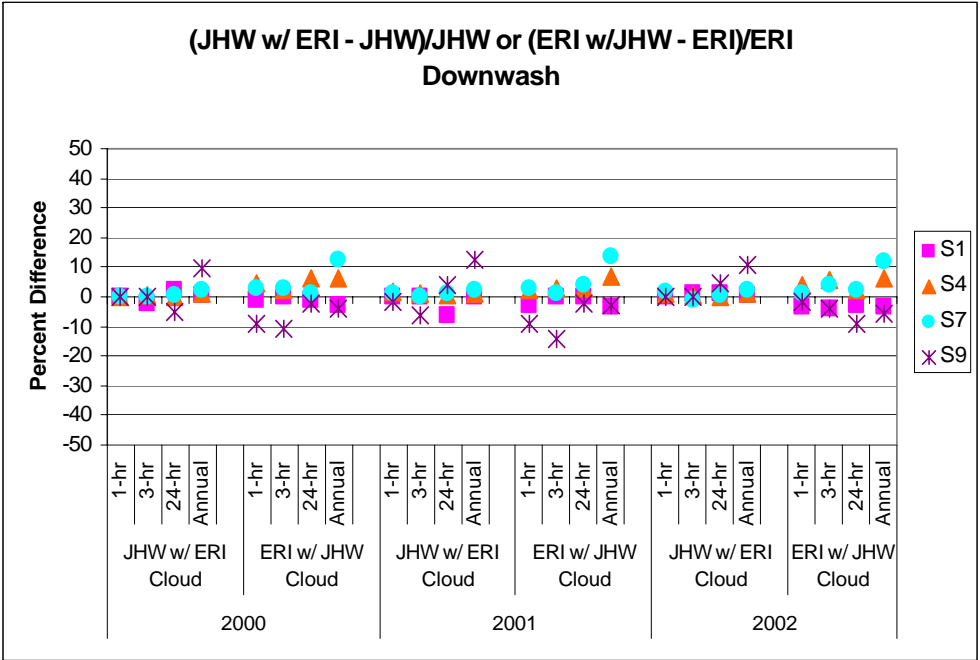
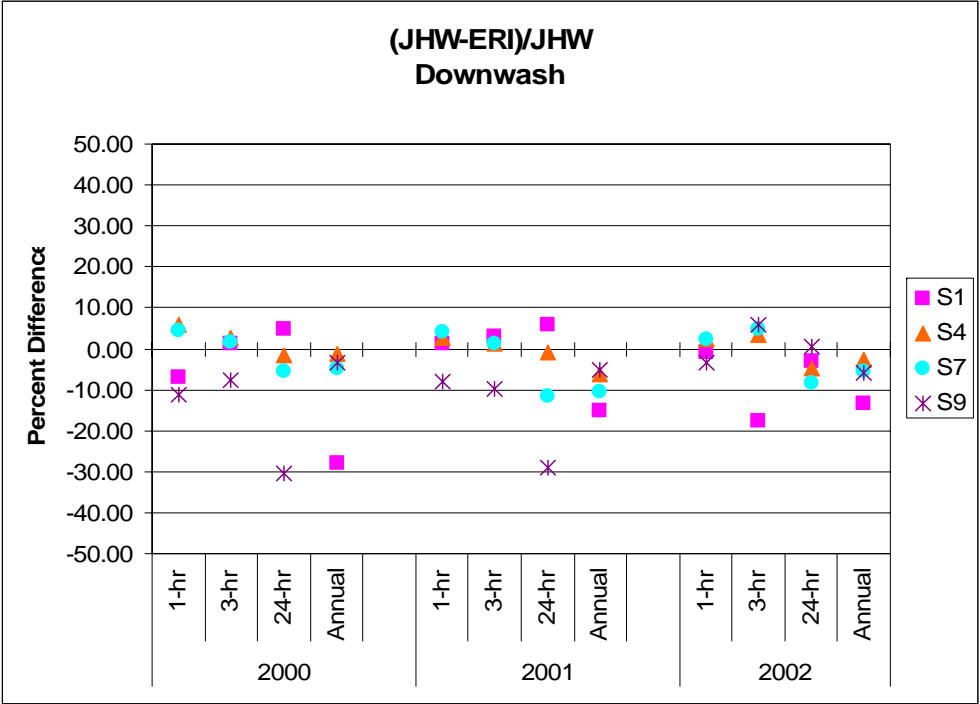
Month	Jamestown	Erie Sec 1	Erie Sec 2
1	0.53	0.52	0.31
2	0.53	0.52	0.31
3	0.13	0.52	0.31
4	0.13	0.15	0.13
5	0.13	0.15	0.13
6	0.14	0.15	0.12
7	0.14	0.15	0.12
8	0.14	0.15	0.12
9	0.14	0.15	0.12
10	0.14	0.16	0.15
11	0.14	0.16	0.15
12	0.53	0.52	0.31

Bowen Ratio

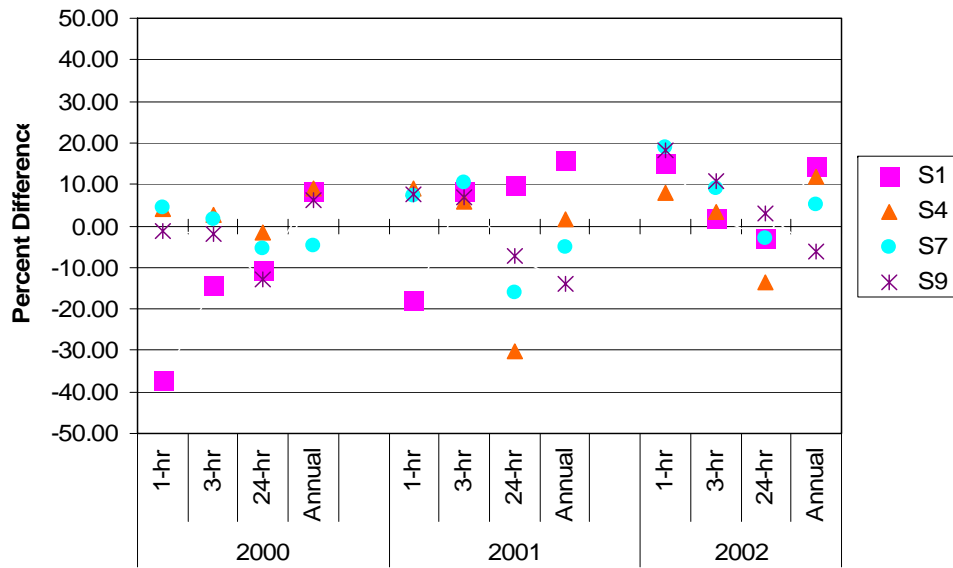
Month	Jamestown	Erie Sec 1	Erie Sec 2
1	1.50	1.50	1.50
2	1.50	1.50	1.50
3	0.55	1.50	1.50
4	0.55	0.62	0.28
5	0.55	0.62	0.28
6	0.39	0.77	0.32
7	0.39	0.77	0.32
8	0.88	0.77	0.32
9	2.00	0.77	0.32
10	0.94	1.15	0.46
11	0.94	1.15	0.46
12	1.50	1.50	1.50

Roughness Length

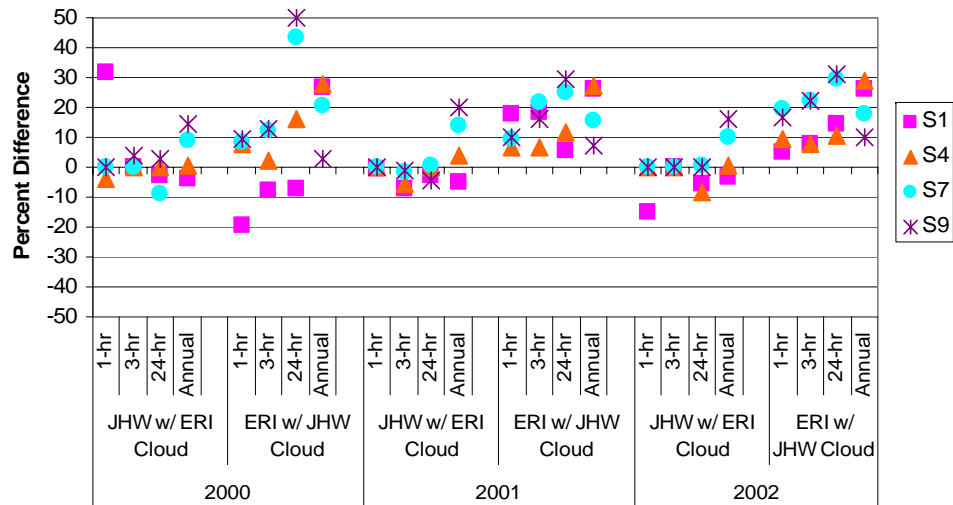
Month	Jamestown	Erie Sec 1	Erie Sec 2
1	0.36	0.31	0.11
2	0.36	0.31	0.11
3	0.68	0.31	0.11
4	0.68	0.43	0.15
5	0.68	0.43	0.15
6	0.91	0.51	0.17
7	0.91	0.51	0.17
8	0.91	0.51	0.17
9	0.56	0.51	0.17
10	0.56	0.38	0.14
11	0.56	0.38	0.14
12	0.36	0.31	0.11



**(JHW-ERI)/JHW
No Downwash**



**(JHW w/ERI - JHW)/JHW or (ERI w/JHW - ERI)/ERI
No Downwash**



Observations on cloud cover effects

- Variability in the results in the two met sites within expected range and randomly distributes for both downwash and non-downwash cases, although more scatter for non-downwash cases. The larger differences in specific cases (e.g. 24 hour for S9 in downwash and S4 in non-downwash modes for 2001) due to more persistence of met conditions.
- For downwash cases, the substitution of cloud cover has minimal effect on the maxima relative to the respective original data set. For non-downwash cases, there is noticeably bigger effect, especially in the instance of Erie data with replaced cloud cover from Jamestown, but no consistent pattern is seen in most cases. The bigger effects are for the taller sources, which is in line with expectation.
- In the case of consistent change of over 30% in all three years, sources S7 and S9 show an increase in 24 hour impacts when cloud cover from Jamestown is substituted for Erie data. A review of meteorological and land use data for hours of contribution for S9 in 2000 and 2001 indicates similar conditions (large L, high winds, similar Z_0 , low H), except some more cloudy hours with the substituted data. Thus, re-ran S9 day of maxima with all hours with clouds and again all hours clear, but the impacts were hardly effected.
- Conclusion: there might be some subtle effects of choosing one cloud cover site over another for certain non-downwash sources, but no *a priori* way to tell what the results will be.