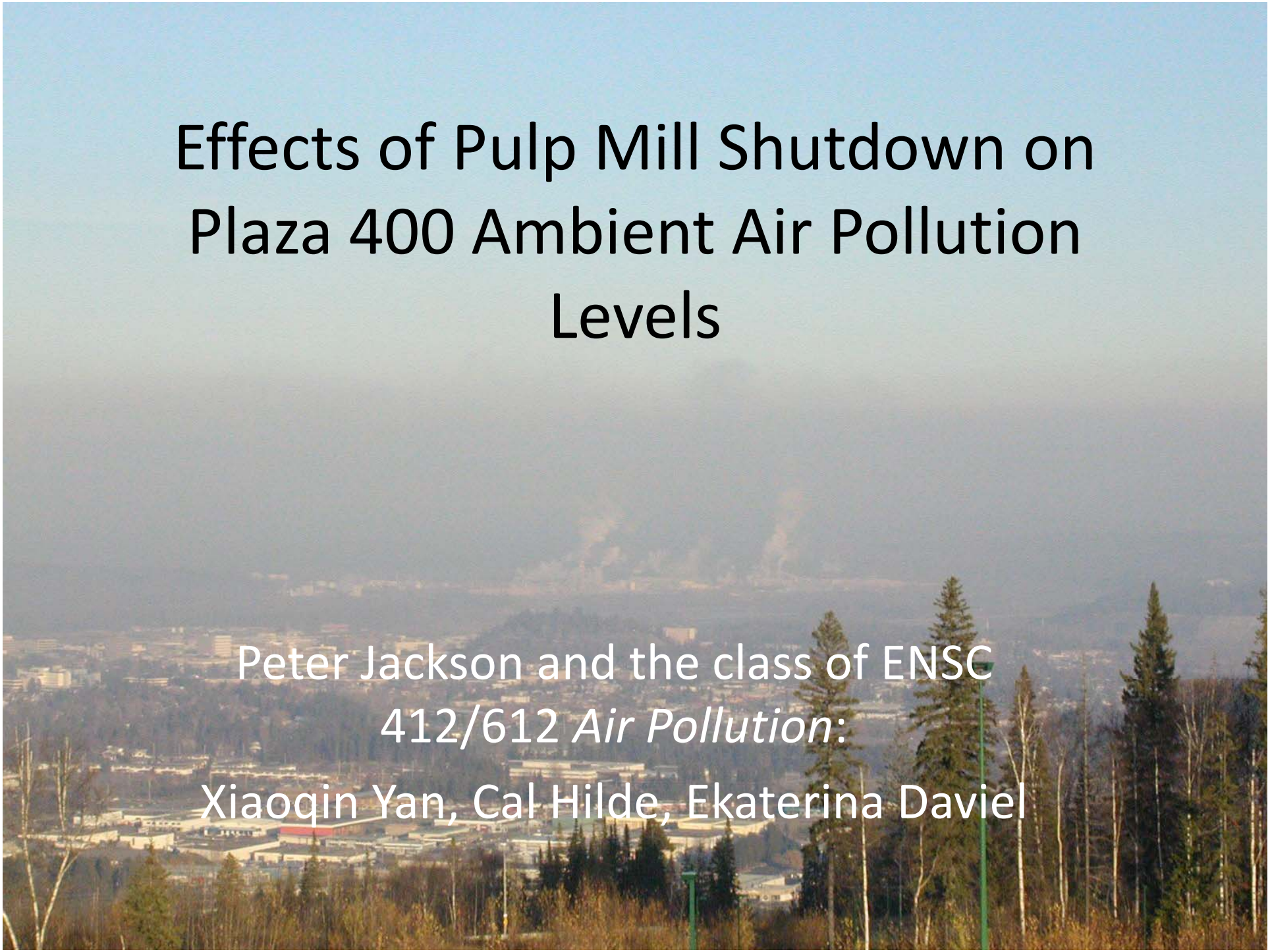
Effects of Pulp Mill Shutdown on Plaza 400 Ambient Air Pollution Levels

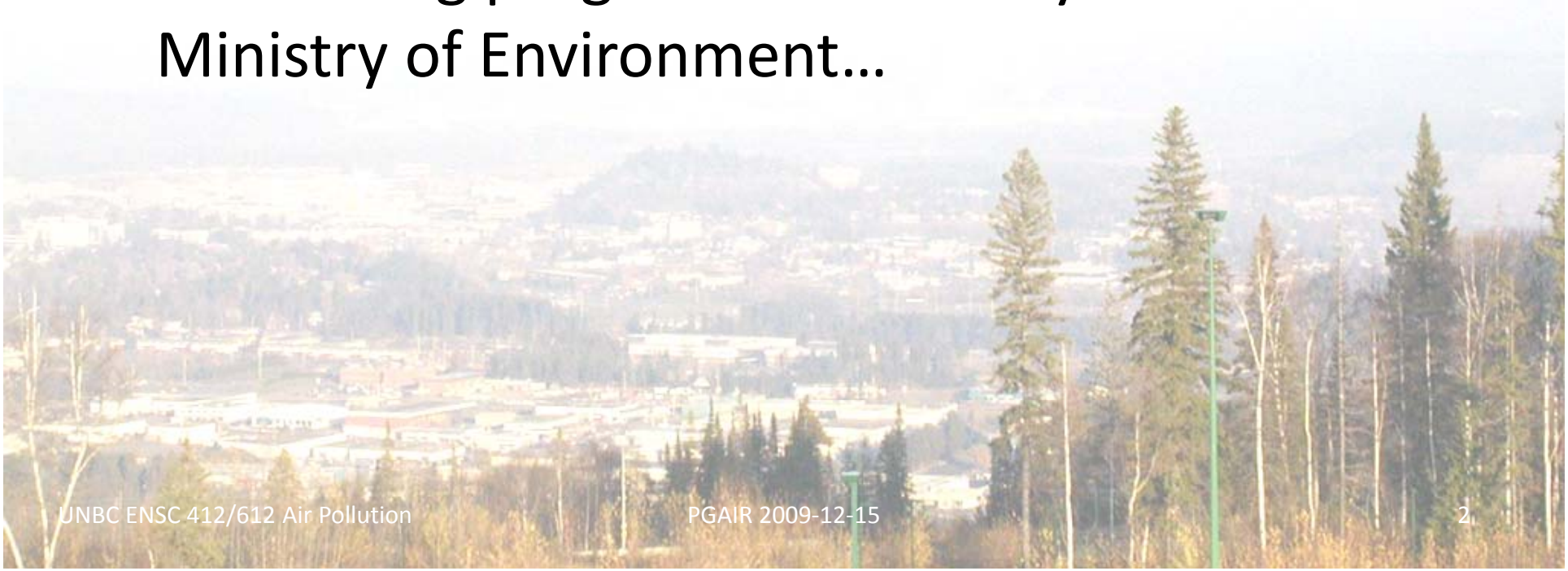


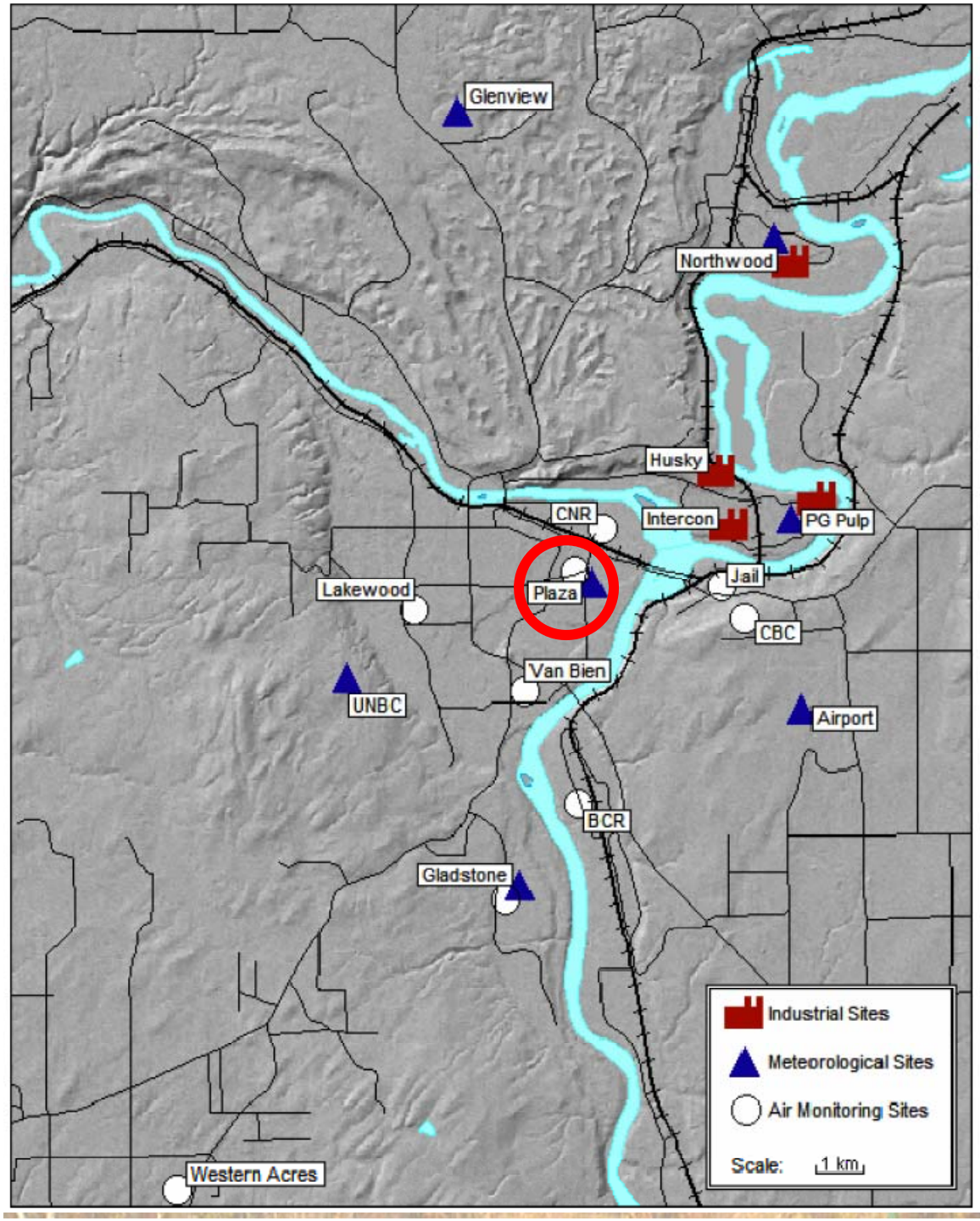
Peter Jackson and the class of ENSC 412/612 *Air Pollution*:

Xiaoqin Yan, Cal Hilde, Ekaterina Daviel

What are the effects of Pulp Mills on Ambient Air Quality?

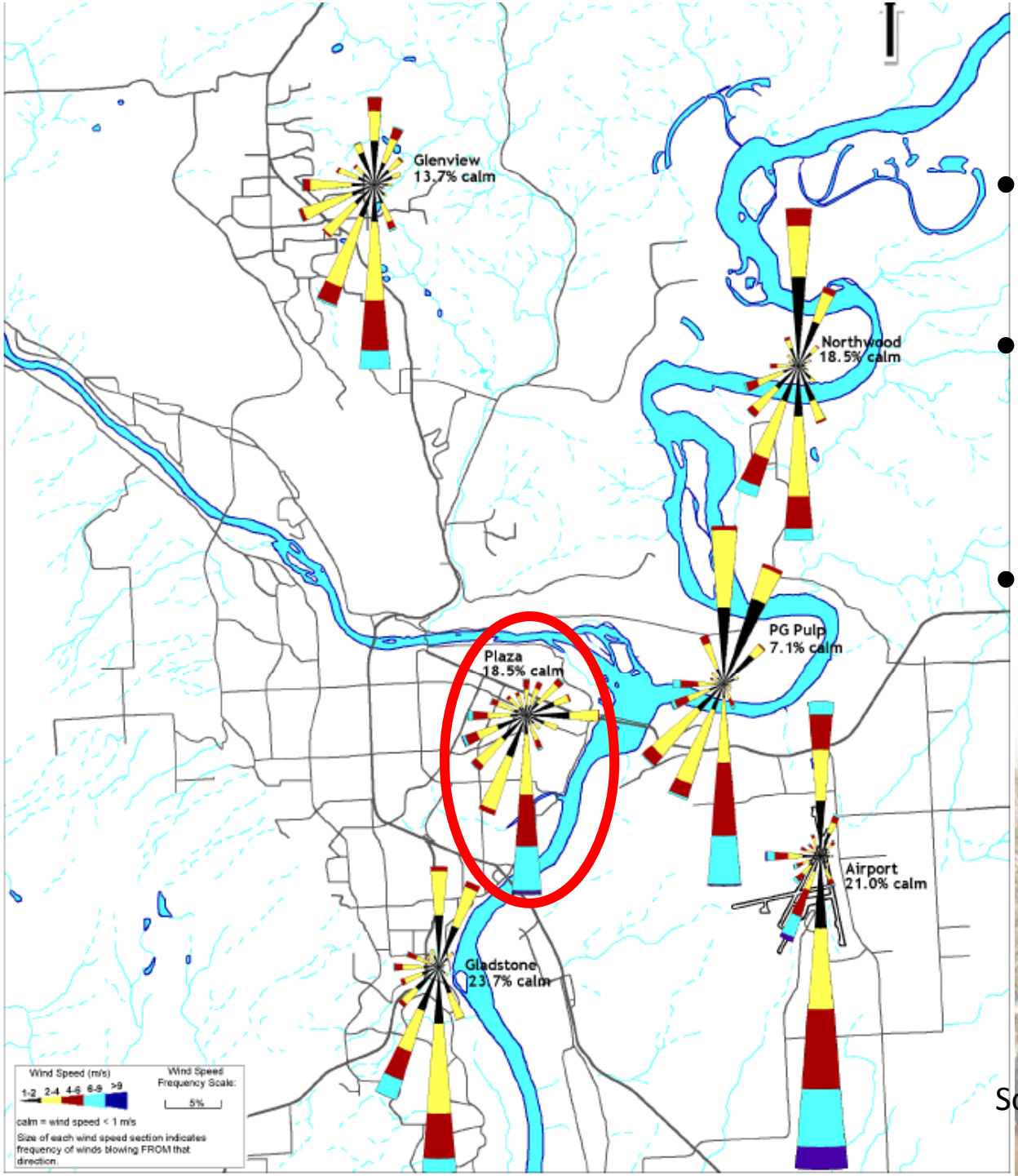
- Can determine this to a certain extent by looking at ambient air monitoring data collected as part of the ambient AQ monitoring program overseen by the BC Ministry of Environment…





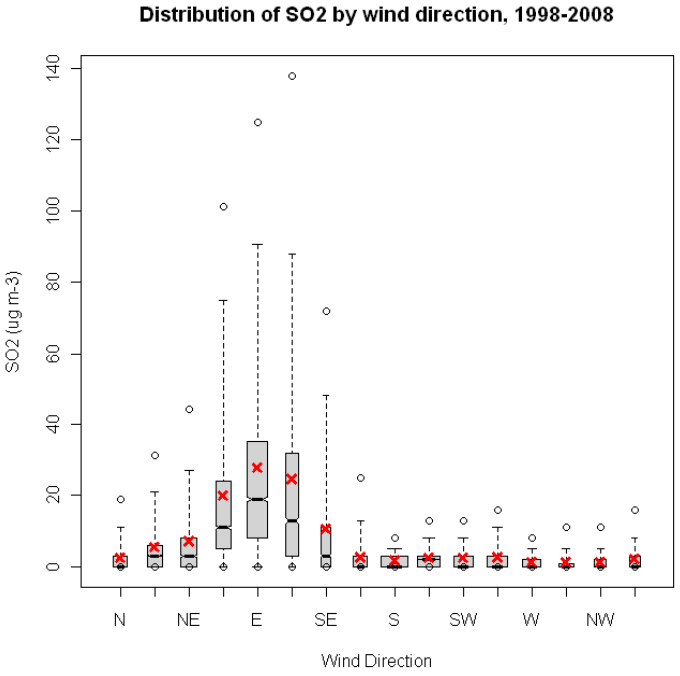
PG Topography

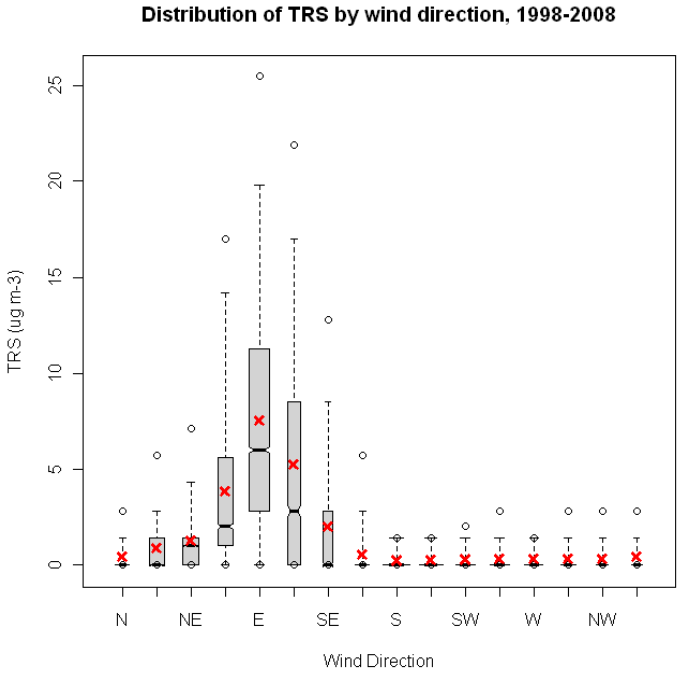
- PG in a “bowl”
- “bowl” restricts free mixing of air and dilution of pollution
- especially under inversion conditions and light winds
- Plaza 400 monitoring station is well-suited to detect air pollutants from heavy industrial sector under northerly or easterly winds

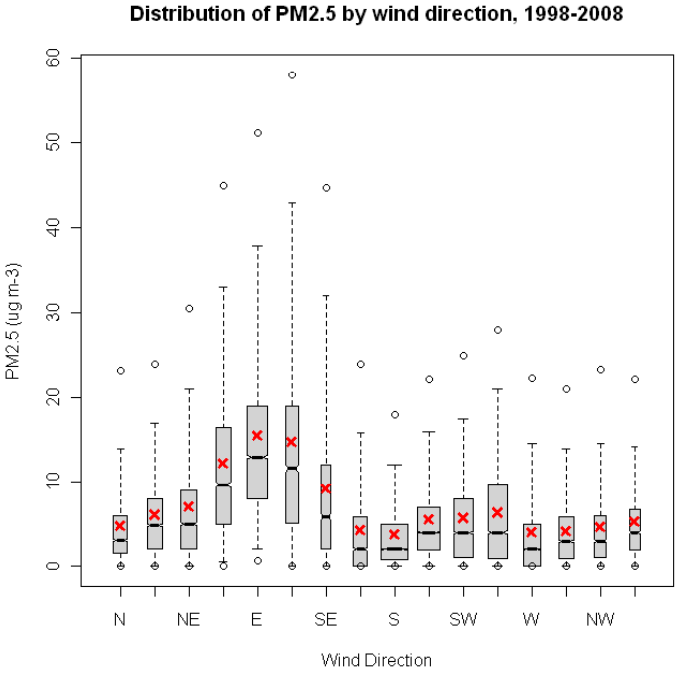


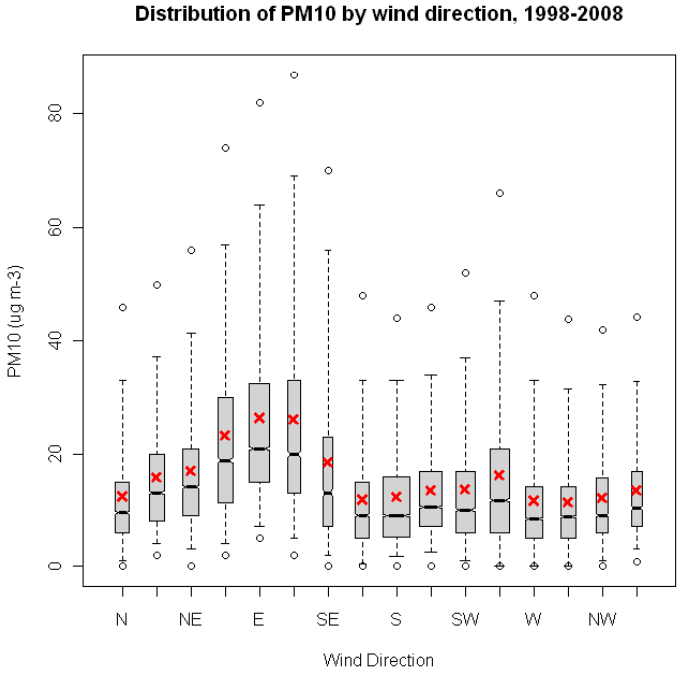
- Annual wind roses
- Dominant wind directions are from the south
- Northerly winds flowing down the Fraser valley are turned by terrain to approach Plaza from the East

Source: BCMOE Annual AQ Report

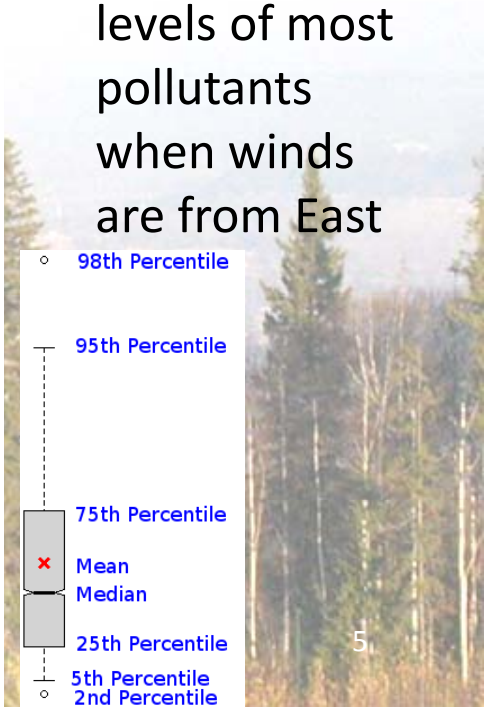








- Plaza 400 site distributions by wind direction of SO2, TRS, PM2.5, PM10
- Similar to wind sector analysis conducted by MOE
- Note elevated levels of most pollutants when winds are from East



Pulp mill Shutdowns: an opportunity to investigate the effects of facilities on ambient levels

Year	Northwood	Intercontinental	PG Pulp
1998	Apr. 02 - 09 Dec. 24 - 27	May 4 - 12	Sept. 14 - 20
1999	June 05 - June 11	May 10 – 17; Sept. 15	Sept. 26 - Oct. 1
2000	May 28 - June 05	Apr. 26 - May 4; Sept. 13	Apr. 1 -13
2001	Sept. 23 - 28	May 3 - 16	Apr. 8 - 17
2002	Sept. 20 - Oct. 2	May 25 - June 2	Apr. 8 -17
2003	Sept. 25 - Oct. 9	June 1 - 7	June 15 - 22
2004	Sept. 20 - 24	May 1 -10	Sept. 26 - Oct. 4; Oct 29 - 31
2005	-	Mar. 8 – 11; Sept. 25 - Oct. 2	Oct 3-8
2006	-	May 1- 10	-
2007	-	-	March 19 - 23; Sept. 22 - Oct. 11
2008	**Dec. 19-29**	Sept. 29 - Oct. 6; **Dec. 19-29**	Oct. 28 – 30; **Dec. 19-29**

- most pulp mills partially shut down for a week or two each Spring or Fall for annual maintenance
- normal shutdowns are never at the same time in PG

- one exception to this occurred December 19-29 2008 when all three Pulp Mills shut down at the same time, and the shutdowns were nearly complete.
- this provides an opportunity to examine the contribution of these facilities to ambient AQ

Partial shutdowns: Fall and Spring Median AQ levels during shut off and non-shut off periods from 1998 to 2008.
Bold indicates statistically significant differences. (Not including the December 2008 period.)

	TRS		SO2		PM2.5		PM10		Sample size	
Fall	Shut off	Non-shut off	Shut off	Non-shut off	Shut off	Non-shut off	Shut off	Non-shut off	Shut off	Non-shut off
1998	9.2	5.7	25.5	29	18.45	16.5	34.5	24.5	40	188
1999	***2.8***	7.1	***8***	21	12.62	15.53	***22***	26.5	48	166
2000	6.4	2.8	21	16	16.99	10.68	30.5	19	12	139
2001	8.5	2.8	35	16	17	10.68	27.5	16.93	16	83
2002	2.8	2.8	13	13	***5***	12	***10***	20	19	97
2003	9.9	4.3	35	5	17	10	25	19	63	134
2004	1.4	2.8	**5**	13	***5***	9	15	18	17	114
2005	5.7	1.4	25.5	16	6	12	25	23.5	25	117
2007	1.4	2.8	8	7	***5.15***	9.4	***13.65***	21.9	28	92
2008	3	4	***4***	11	10.5	9	27	20	56	127
Total	4.3	4.3	13	13	12	12	25	21	324	1257

	TRS		SO2		PM2.5		PM10		Sample size	
Spring	Shut off	Non-shut off	Shut off	Non-shut off	Shut off	Non-shut off	Shut off	Non-shut off	Shut off	Non-shut off
1998	***1.4***	2.8	11	13	11.65	10.68	28	25	85	367
1999	***1.4***	2.8	11	11	***6.8***	11.65	***17***	29	60	284
2000	***0***	1.4	**5**	11	***5.86***	10.19	***14***	18	77	338
2002	2.8	1.4	11	8	***7***	9	***13***	16	47	295
2003	***0***	2.8	**3**	5	10.5	10	19.5	19	60	381
2004	2.8	1.4	5	5	10.5	11	***18***	21	32	444
2005	7.1	1.4	13	9.5	10.5	6	23.5	17	26	301
2006	0.7	1.4	**3**	8	4.4	6.9	24.1	21.25	13	305
2007	2.8	1.4	0.75	9.5	6.7	6.8	***12.65***	21.5	8	332
Total	***1.4***	1.4	***8***	8	***7.77***	9	***18***	20	408	3047

- while shut down AQ levels are generally lower than during the operating periods the differences if they exist are small and are often not statistically significant

Partial Shutdowns: Differences by Mill

Spring	Northwood shutdown	PG shutdown	Intercon shutdown	Overall shutdown	Overall non-shutdown
TRS	1.1	***0.6***	***1.0***	***0.9***	**1.5**
SO2	***5.6***	***3.4***	***5.4***	***5.0***	**6.2**
PM2.5	7.6	7.0	8.0	7.7	**7.8**
PM10	20.8	***16.4***	22.2	20.5	**19.6**

Fall	Northwood shutdown	PG shutdown	Intercon shutdown	Overall shutdown	Overall non-shutdown
TRS	2.6	1.7	2.1	2.1	**1.7**
SO2	10.4	6.3	5.6	7.5	**7.6**
PM2.5	12.6	7.7	8.3	9.3	**8.8**
PM10	22.6	20.5	25.7	21.8	**19.5**

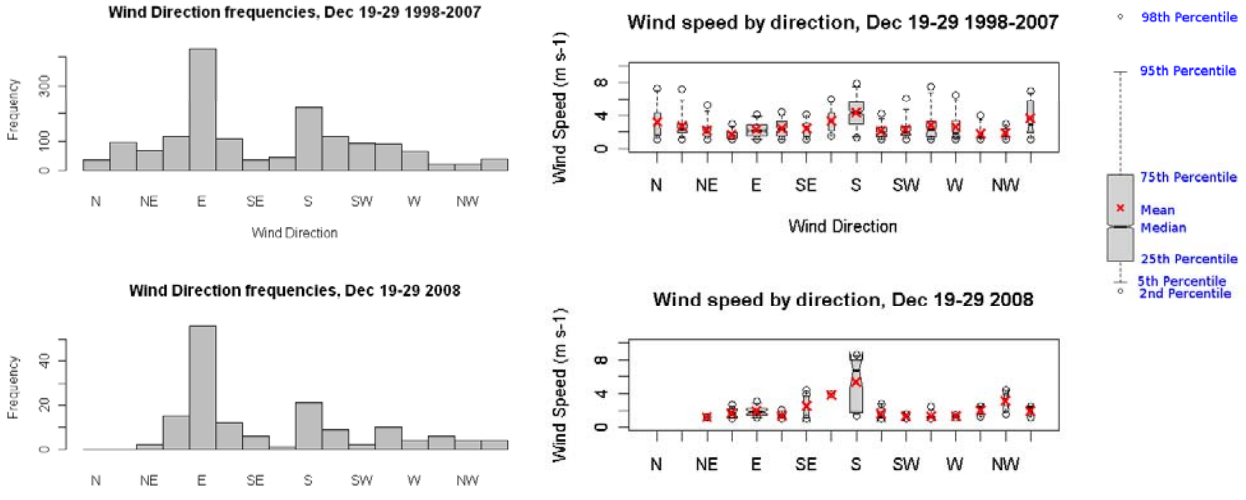
- differences in average levels by mill for all wind directions (top)

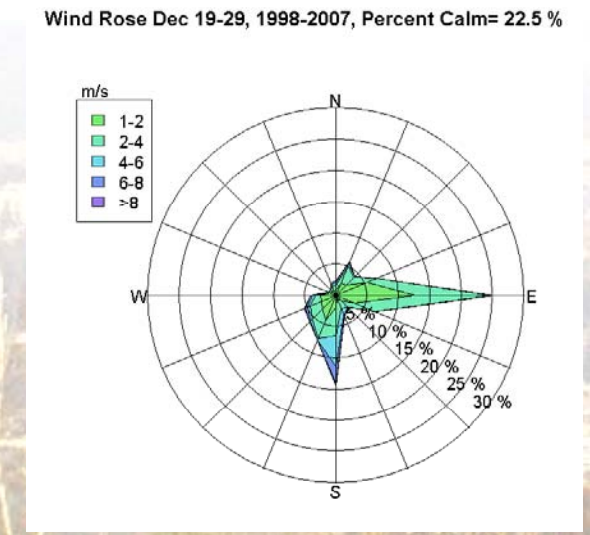
Spring	Northwood shutdown	PG shutdown	Intercon shutdown	Overall shutdown	Overall non-shutdown
TRS	***3.5***	***2.6***	***3.9***	***3.5***	**5.4**
SO2	***18.5***	***10.9***	***18.7***	***16.9***	**19.0**
PM2.5	14.1	13.4	15.0	14.4	**14.3**
PM10	28.6	27.6	34.4	31.7	**28.7**

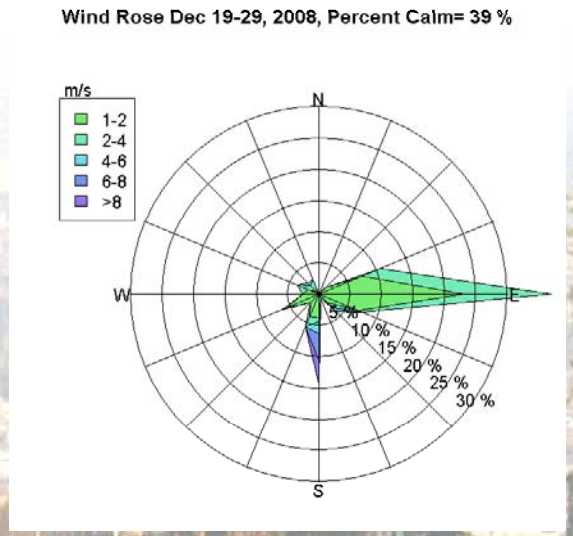
Fall	Northwood shutdown	PG shutdown	Intercon shutdown	Overall shutdown	Overall non-shutdown
TRS	11.1	6.9	5.3	7.6	**6.5**
SO2	44.1	***20.1***	***12.3***	25.1	**25.5**
PM2.5	27.9	14.8	15.0	18.4	**16.9**
PM10	41.6	30.2	40.3	35.3	**31.2**

- differences in average levels by mill for only easterly winds (bottom)
- significant differences are highlighted.

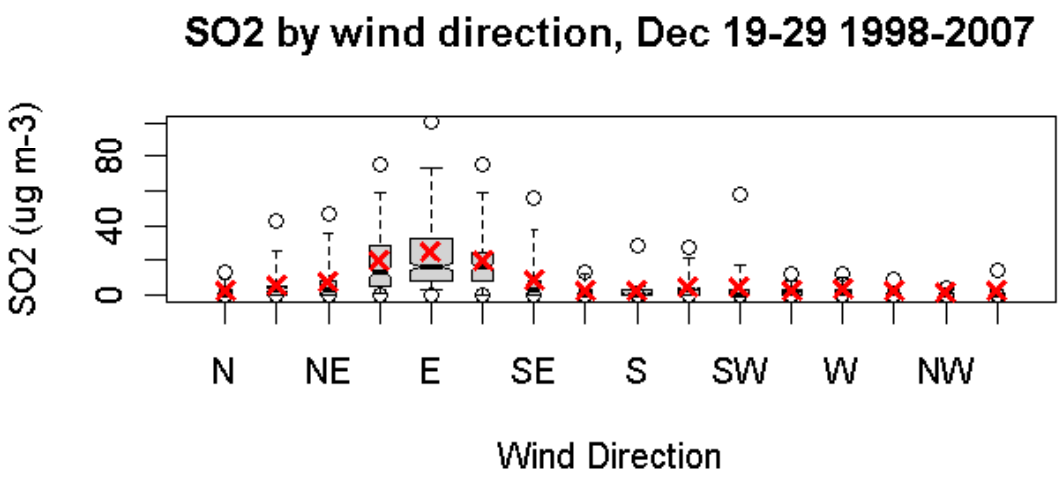
Analysis of the Pulpmill Shutdown event December 19-29 2008

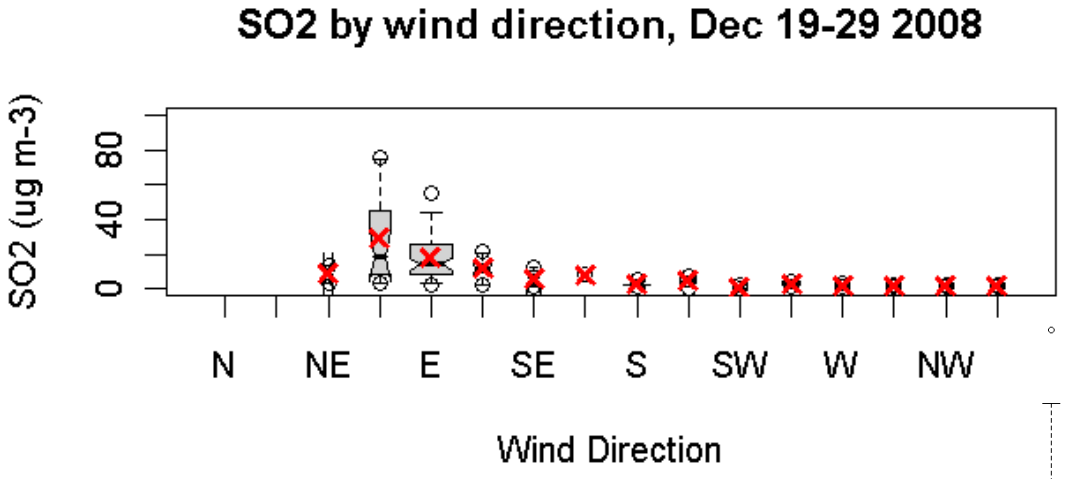


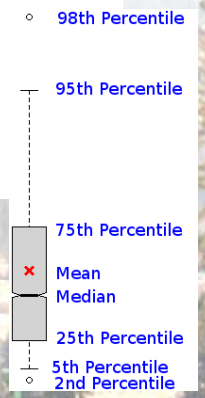




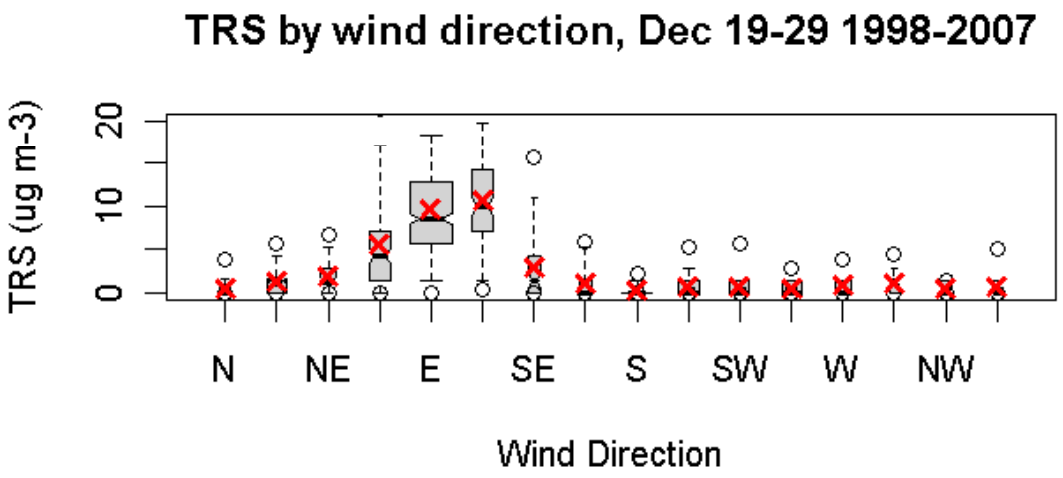
- Event was unique in that all 3 mills shut down at same time
- Distribution of winds in 2008 similar to other years
- Average precipitation during the period 1998-2007 was **10.1**mm on **4 days**(range is 0 – 9 precip days), 2008 had **10.7** mm on **7 days.**

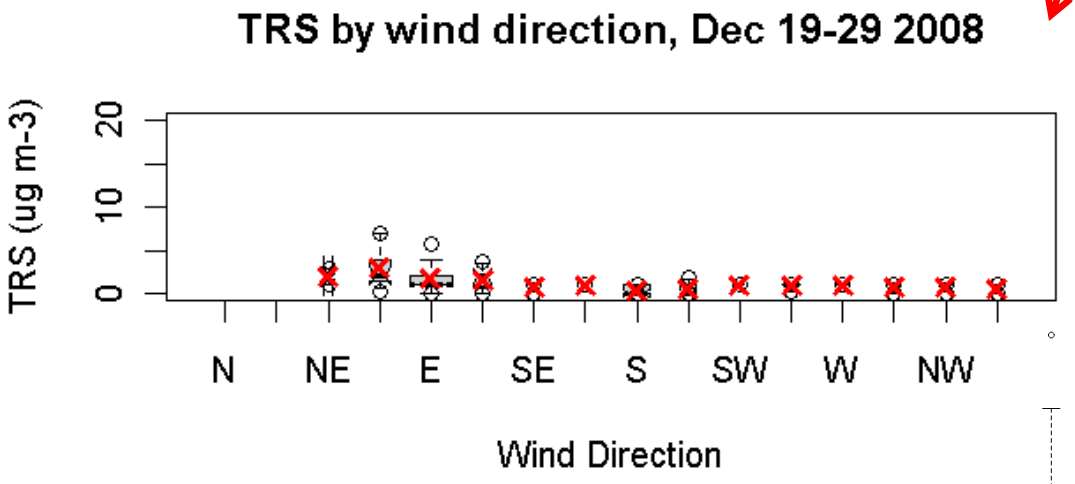


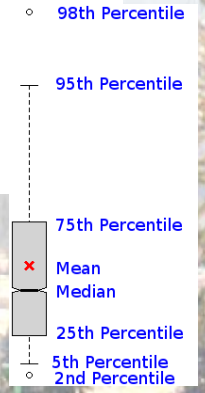




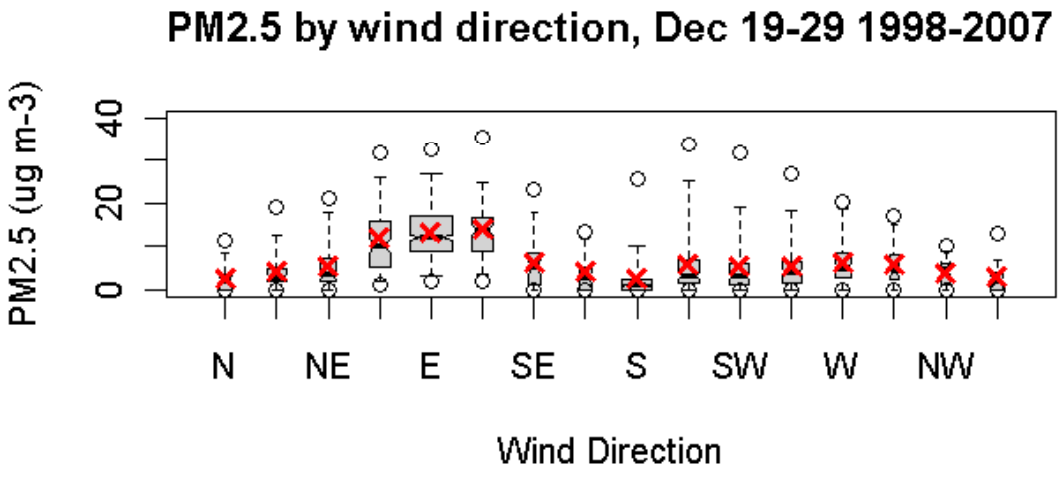
- SO2 by wind direction for the ten non-shutdown years (upper) and for the 2008 shutdown year (lower)
- Ambient SO2 levels decreased in 2008 when winds are from the E and ESE directions, with similar to higher levels for the ENE direction – possibly related to emissions from the Oil Refinery which was not shutdown and is located more to the northeast of the Plaza monitoring location.

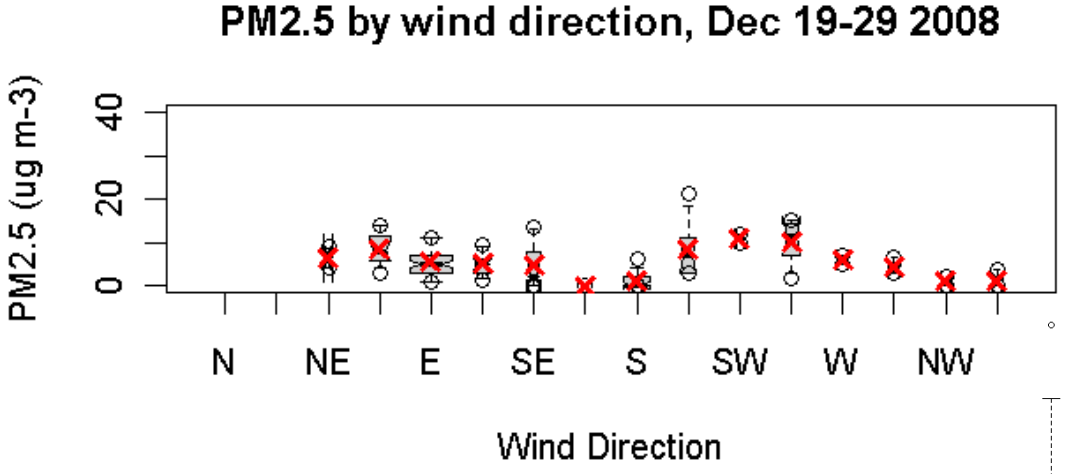


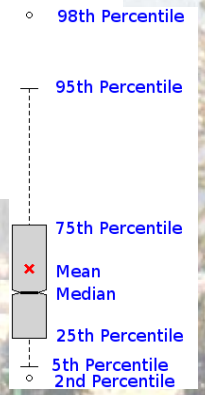




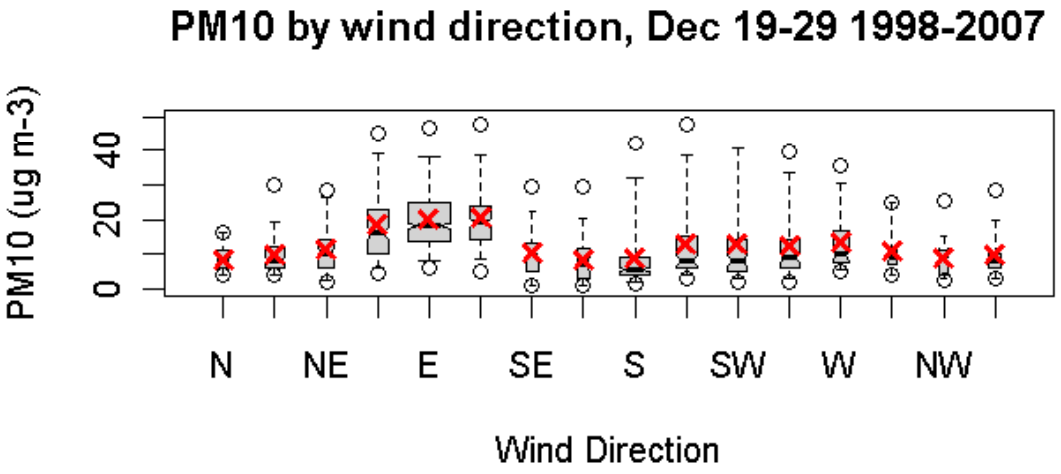
- TRS by wind direction for the non shutdown years (upper) and for 2008 (lower).
- Ambient TRS levels are significantly decreased in 2008 when winds are from the E and ESE in the shutdown year (2008)
- however there are some elevated TRS levels with winds from the ENE and NE, again possibly related to the Oil Refinery's continued operations.
- The reduced TRS levels perhaps point to fugitive sources at the Pulp Mills as the most significant source of TRS, rather than the bio-treatment basins which would not be expected to have dramatically reduced emissions during the shutdown.

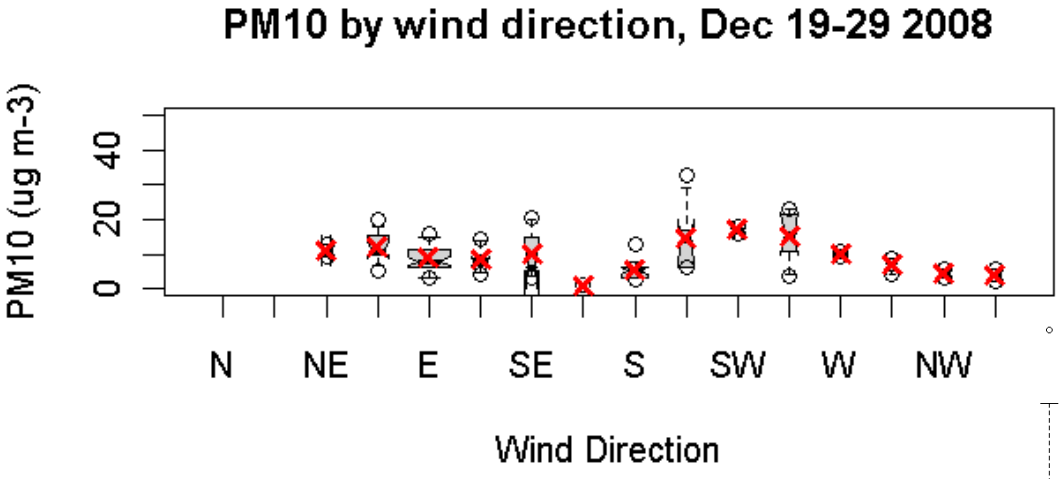


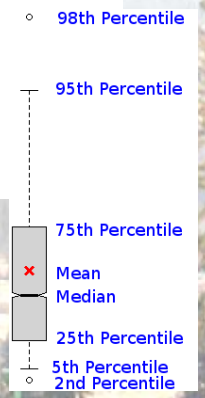




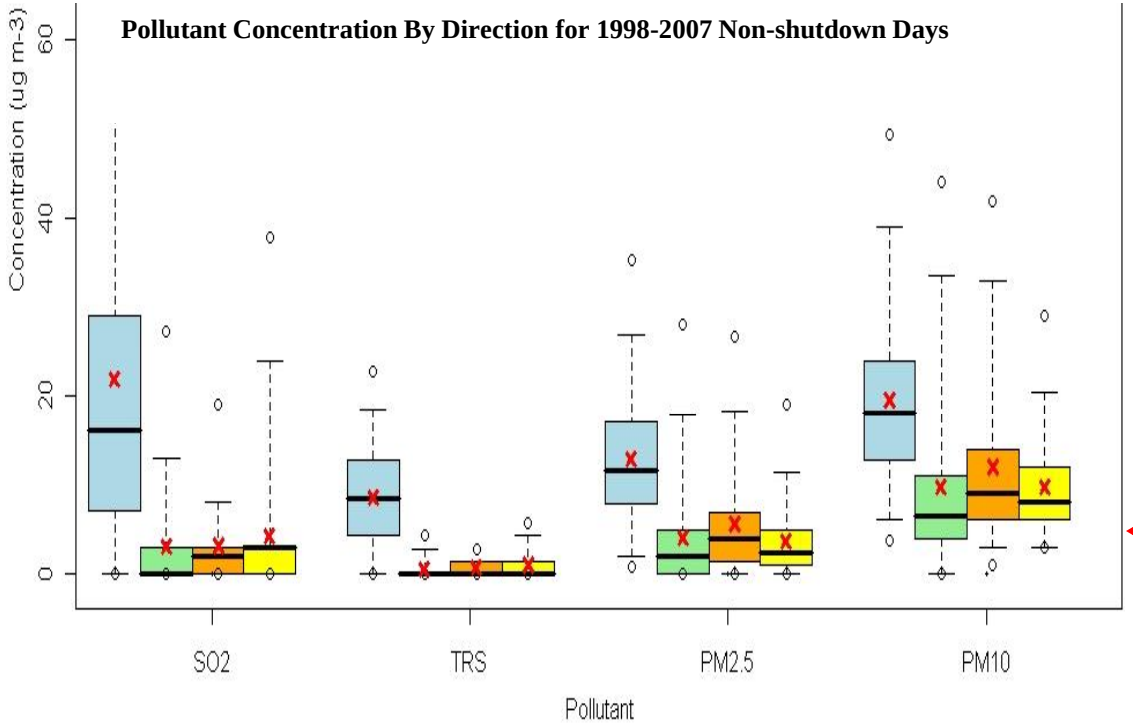
- PM2.5 by wind direction for the non-shutdown years (upper) and for 2008 (lower)
- PM2.5 levels are significantly reduced during 2008, especially when the winds are from the E and ESE directions.

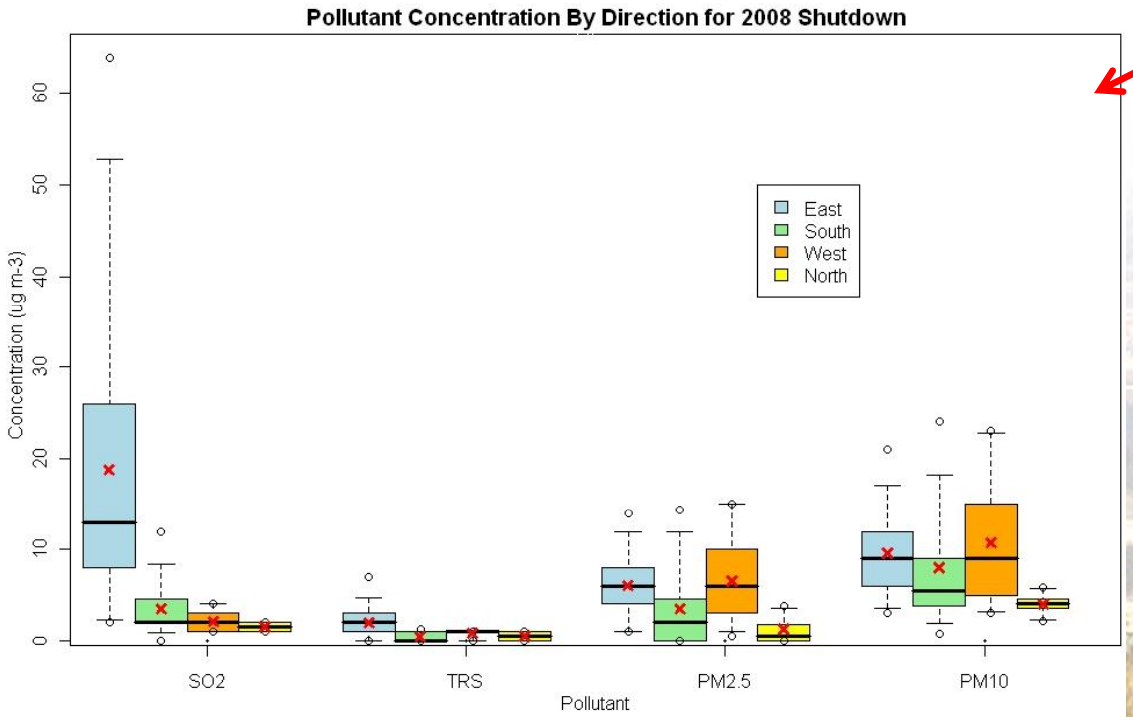






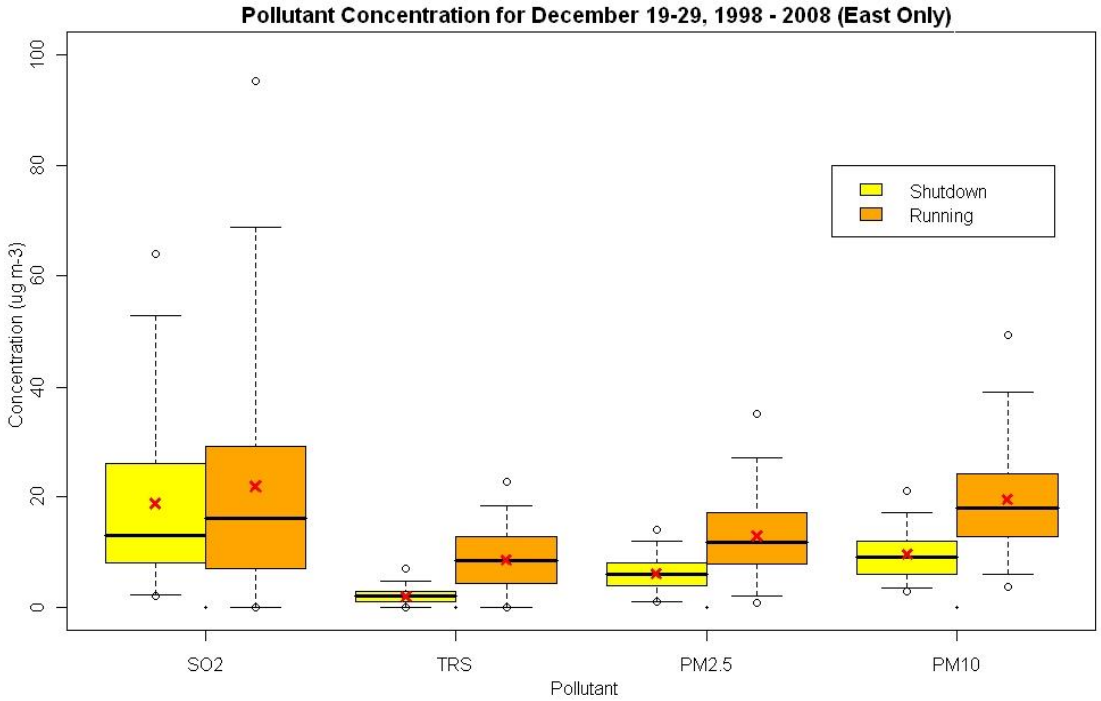
- PM10 at Plaza 400 by wind direction for the non-shutdown years (upper) and for 2008 (lower)
- As for PM2.5, PM10 levels are also significantly reduced during the shutdown year, especially when winds are from the E and ESE.





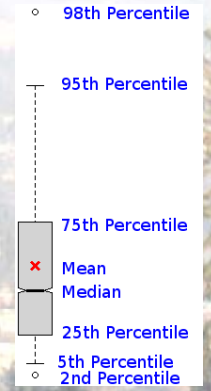
- Summary of ambient levels by wind direction for non-shutdown years (top) and for 2008 (bottom)
- Greatest differences are for winds from the east…

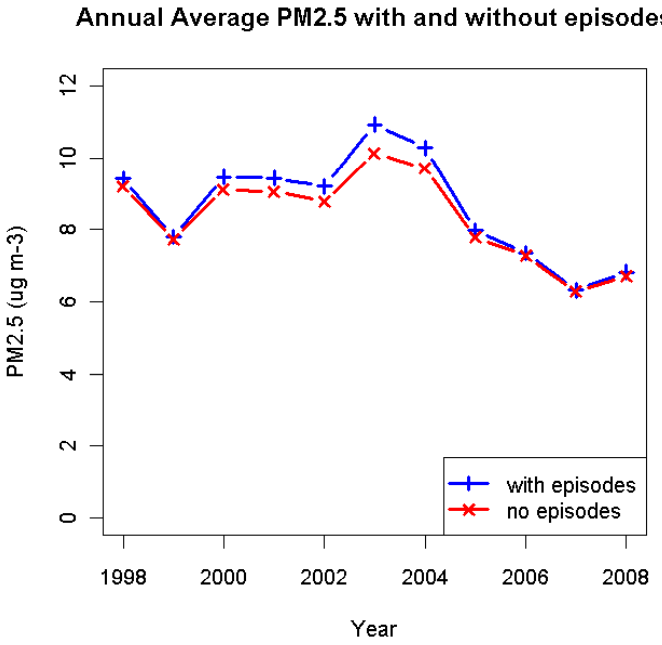
Summary of differences for easterly winds

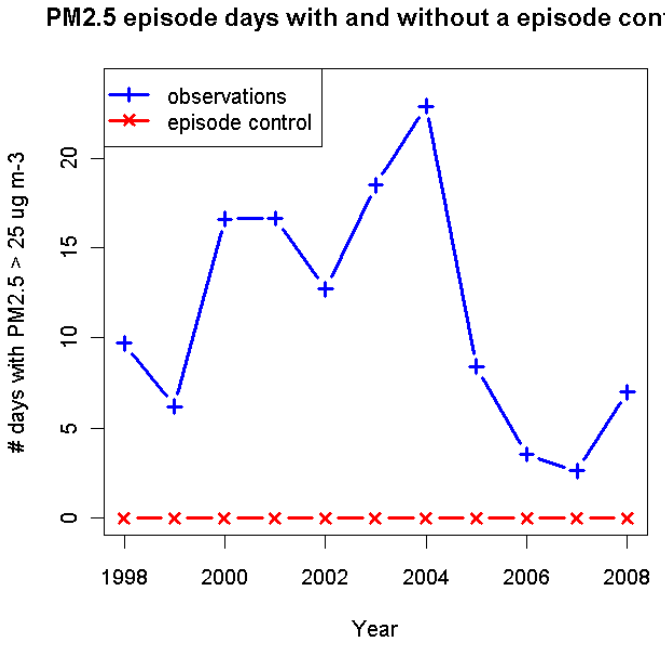


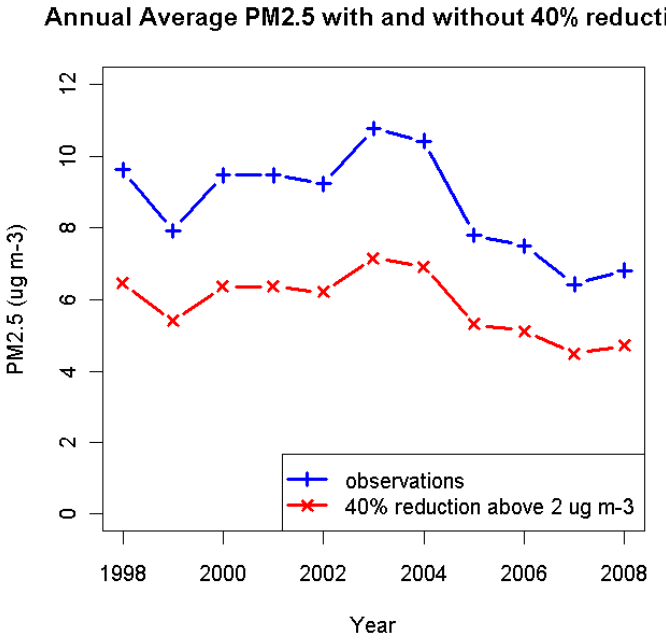
- Differences are statistically significant and also large in magnitude for all except SO2, presumably because Oil Refinery SO2 emissions are still significant

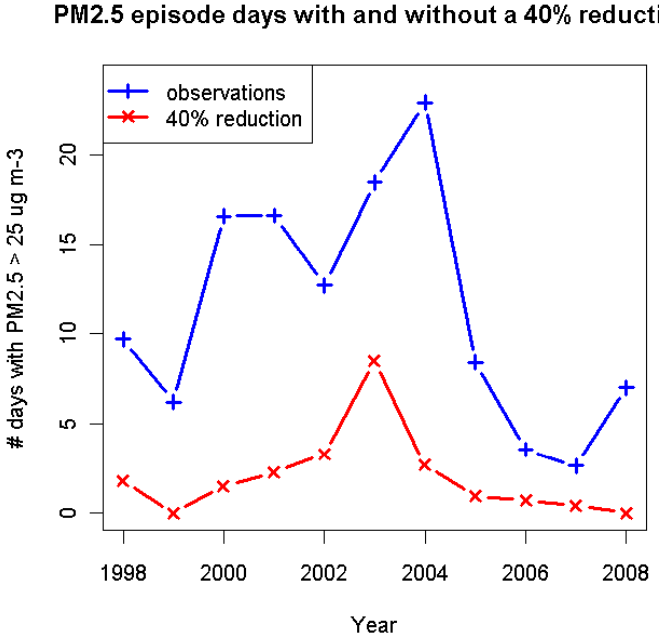
Pollutant	Difference between medians	p-value	Significant difference
TRS	**6.5 µg m^{-3}**	1.631 x 10^{-7}	yes
SO2	3 µg m^{-3}	.9881	no
PM2.5	**6 µg m^{-3}**	.04859	yes
PM10	**9 µg m^{-3}**	1.333 x 10^{-6}	yes





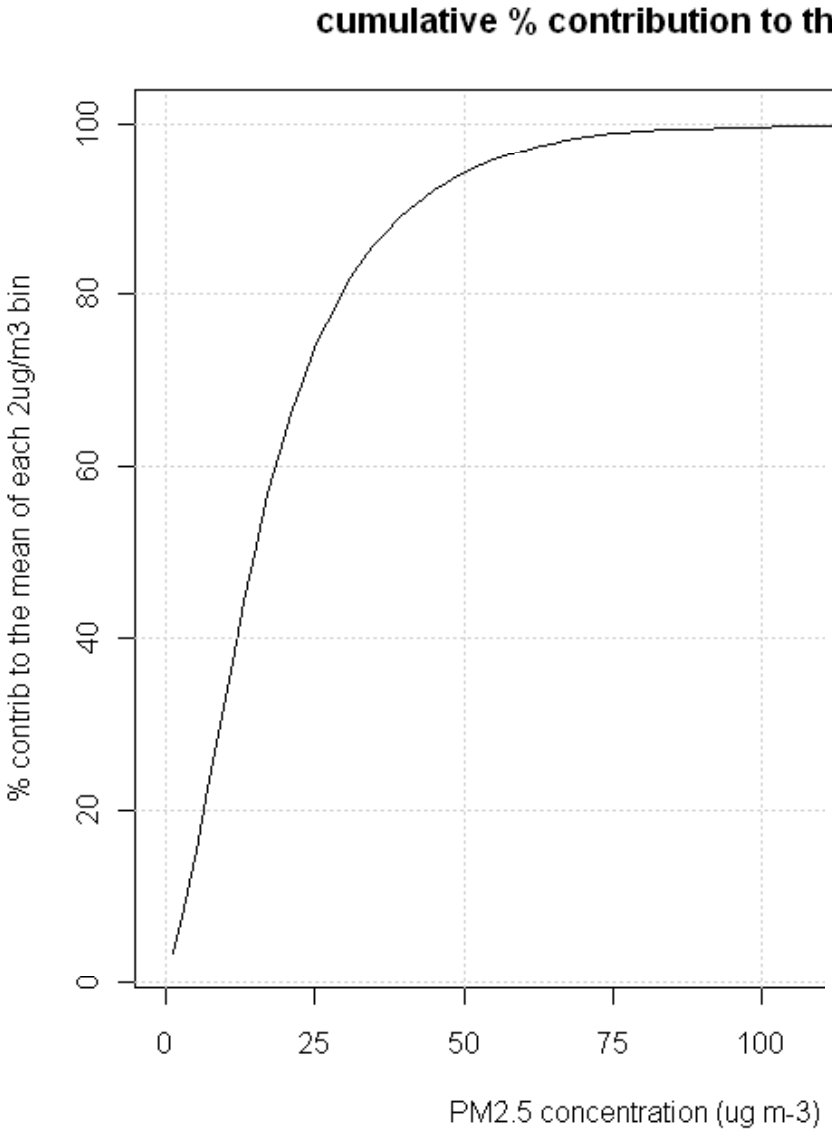


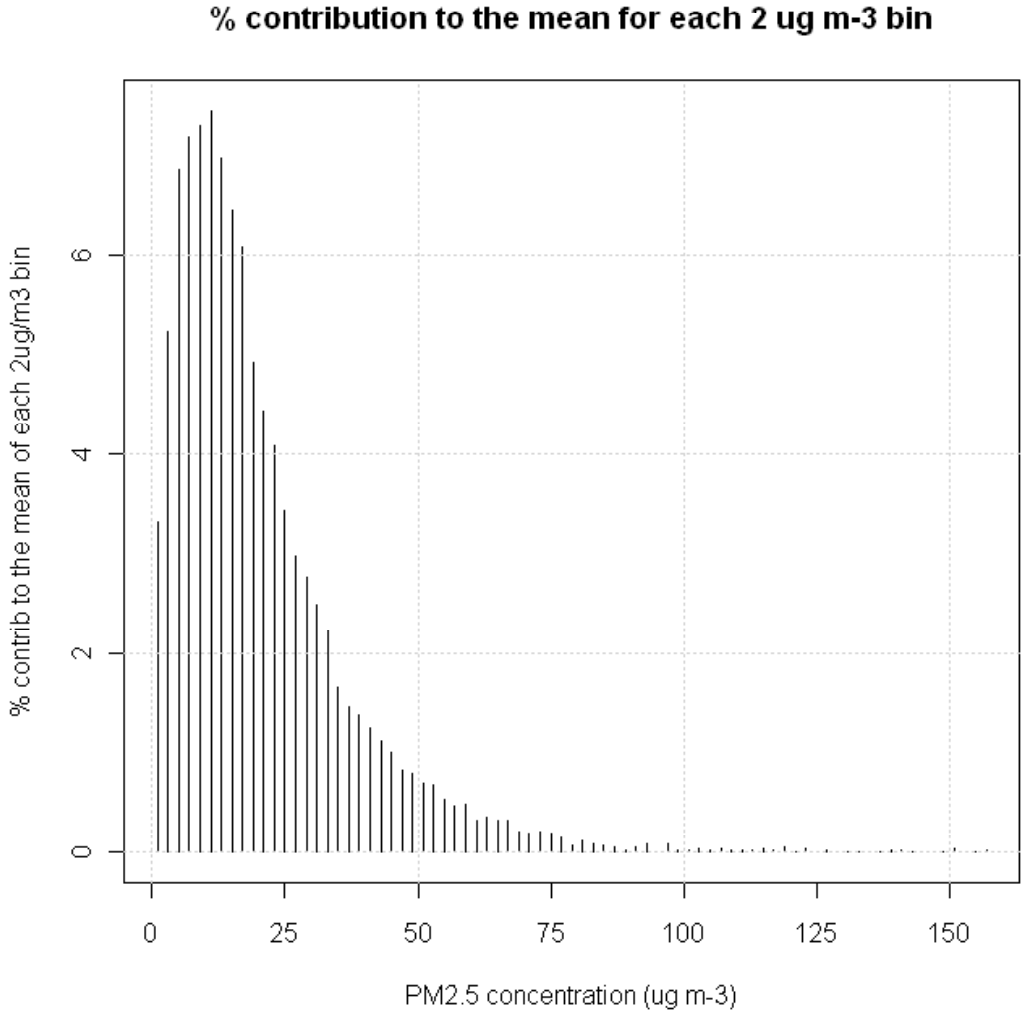




- Strategies for PM2.5 reduction
- Episode control vs. overall reductions based on Plaza data

(episodes are defined as 24 h averages >25 µg m^{-3})





- The higher concentrations do not contribute too much to the annual mean