Experiences and Challenges of 1-hour SO_2 Compliance Demonstration and Designations Modeling

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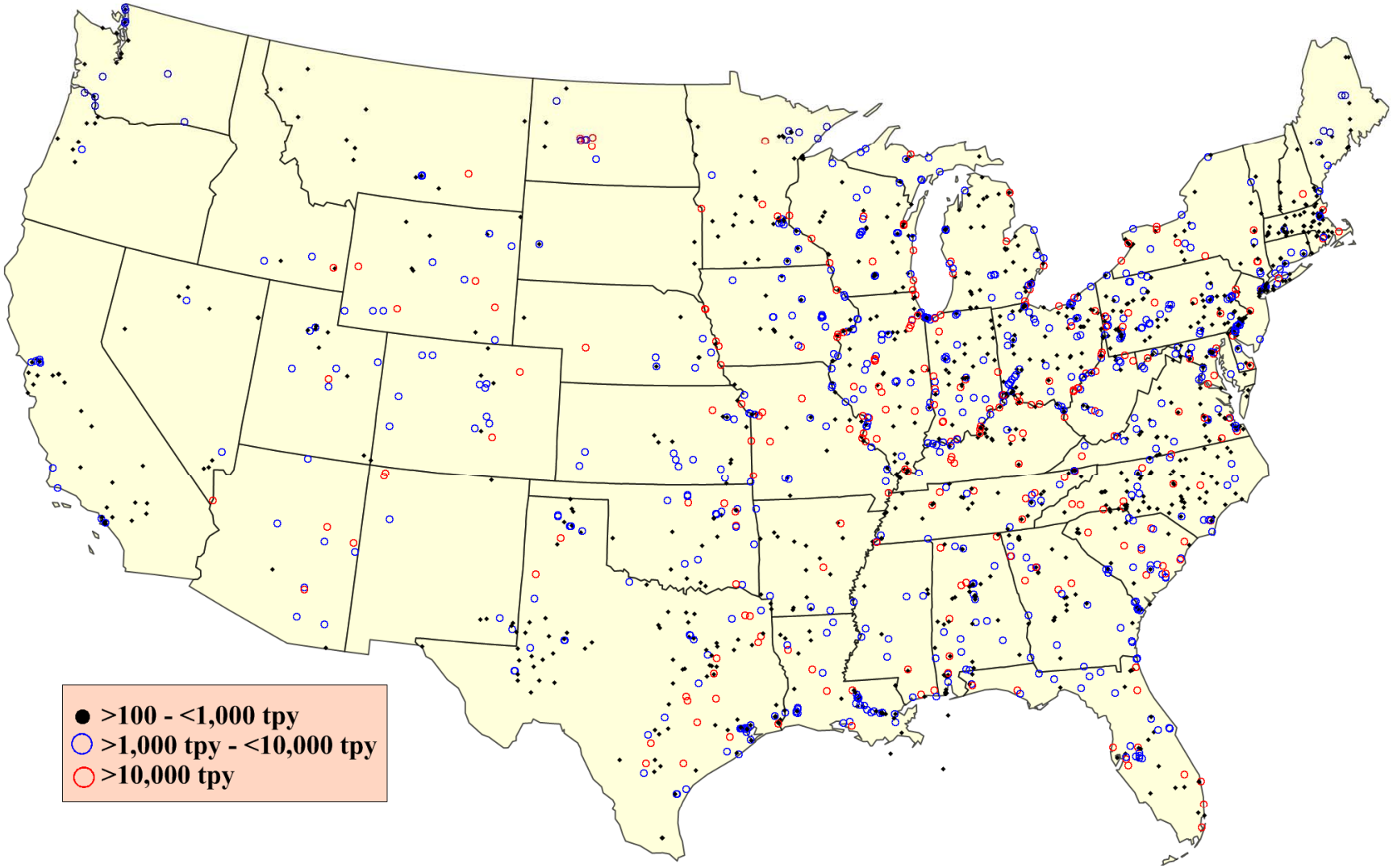
Topics

- **New World: 1-hour SO_2 NAAQS – It Goes Without Saying**
- **What is the Same? What is Different?**
- **Two Anecdotes**
- **Chernyshevsky: What is to be Done?**

Sources to be Modeled
SO_2 > 100 TPY ACTUAL Based on 2005 NEI



Sensitivity Analysis – Auxiliary Boiler/Process Heater

NAAQS SO2

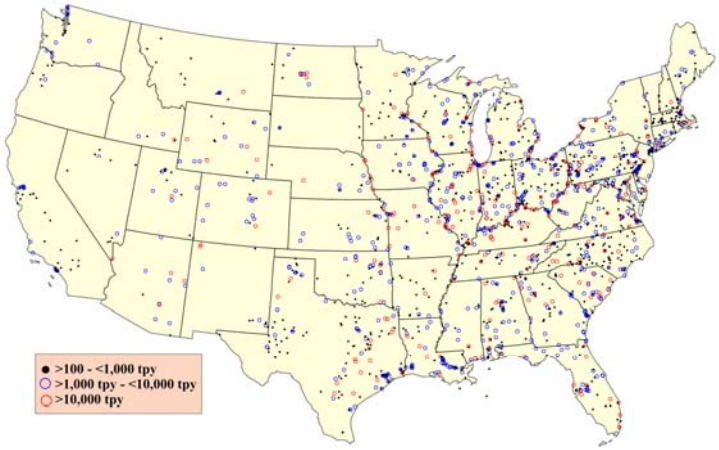
No Background

lbs/hr:	2	6	23	114	228		2	6	23	114	228	
Tons/yr:	10	25	100	500	1000		10	25	100	500	1000	
Height/ft:												
30	35	89	354	1771	3541	No Downwash	72	181	723	3616	7233	With Downwash
50	11	27	109	545	1090		48	120	481	2404	4809	
75	6	15	61	307	613		29	72	288	1440	2880	
100	4	11	45	223	446		19	48	193	964	1927	
150	3	6	25	126	253		12	29	118	588	1175	
200	2	4	15	75	150		9	23	92	460	920	
250	1	3	11	57	114		7	17	68	339	678	
300	1	2	9	47	94		6	14	56	278	557	

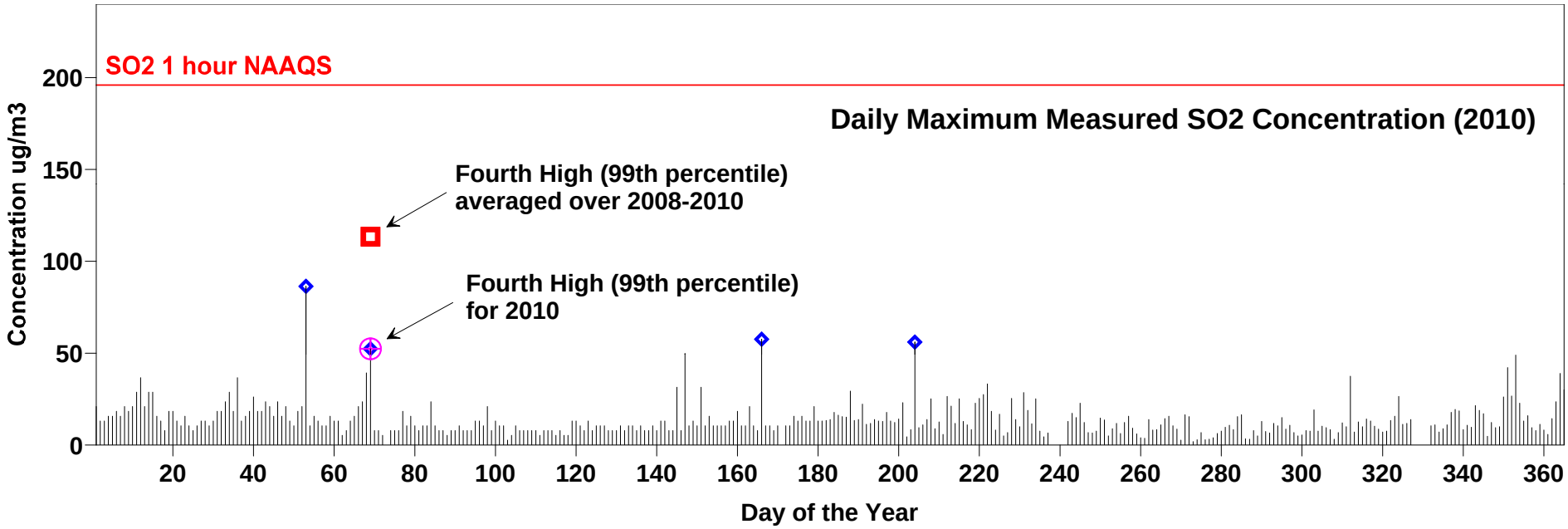
Background = 50% NAAQS

30	129	183	448	1865	3635	No Downwash	166	275	817	3710	7327	With Downwash
50	105	121	203	639	1184		142	214	575	2498	4903	
75	100	109	155	401	707		123	166	382	1534	2974	
100	98	105	139	317	540		113	142	287	1058	2021	
150	97	100	119	220	347		106	123	212	682	1269	
200	96	98	109	169	244		103	117	186	554	1014	
250	95	97	105	151	208		101	111	162	433	772	
300	95	96	103	141	188		100	108	150	372	651	

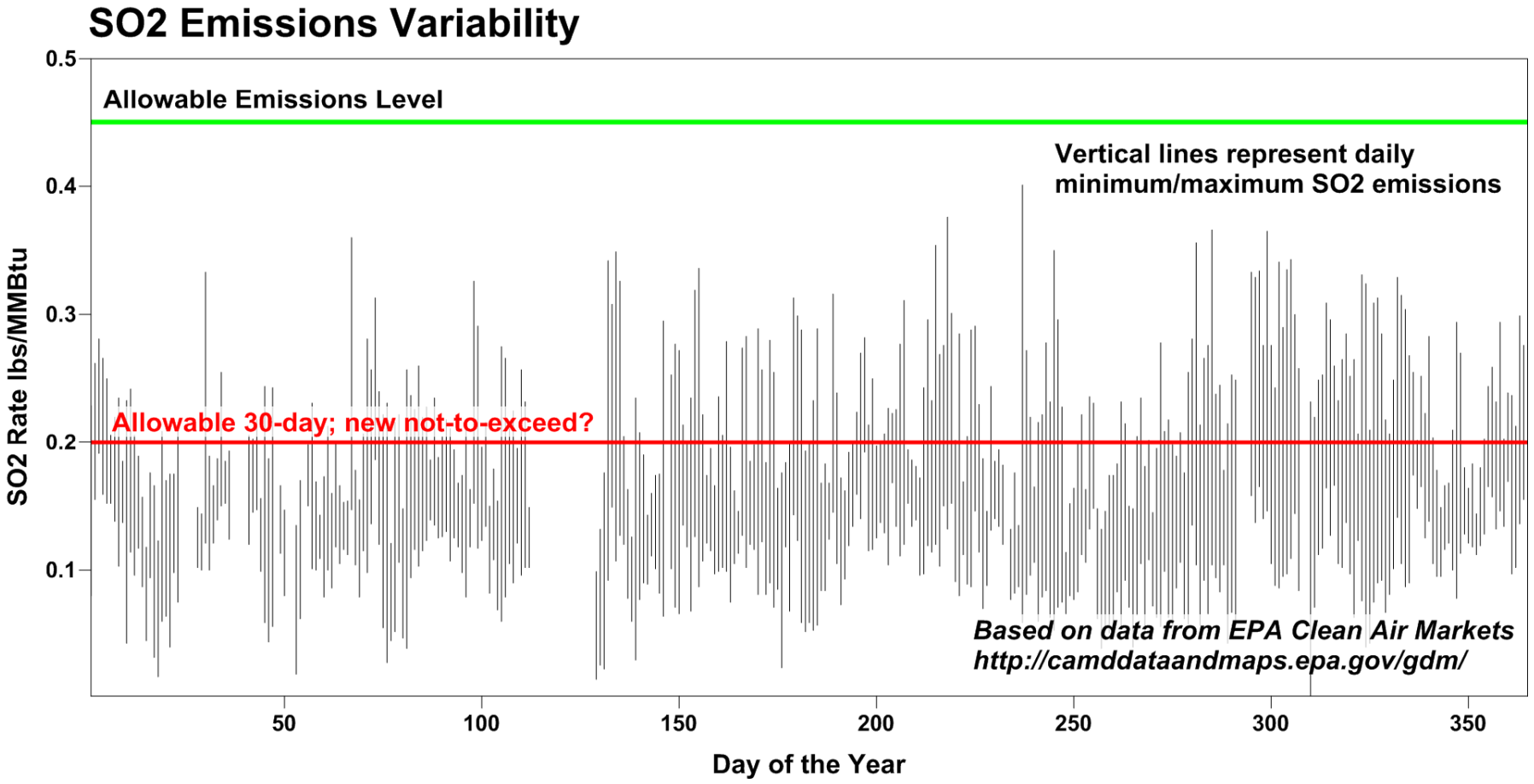
green <50%NAAQS; yellow >50% NAAQS; red >NAAQS



Background: Not Much Room



Emissions Variability: Pseudo-nonattainment (not even 1,000 monitors)



What is the Likely Outcome?

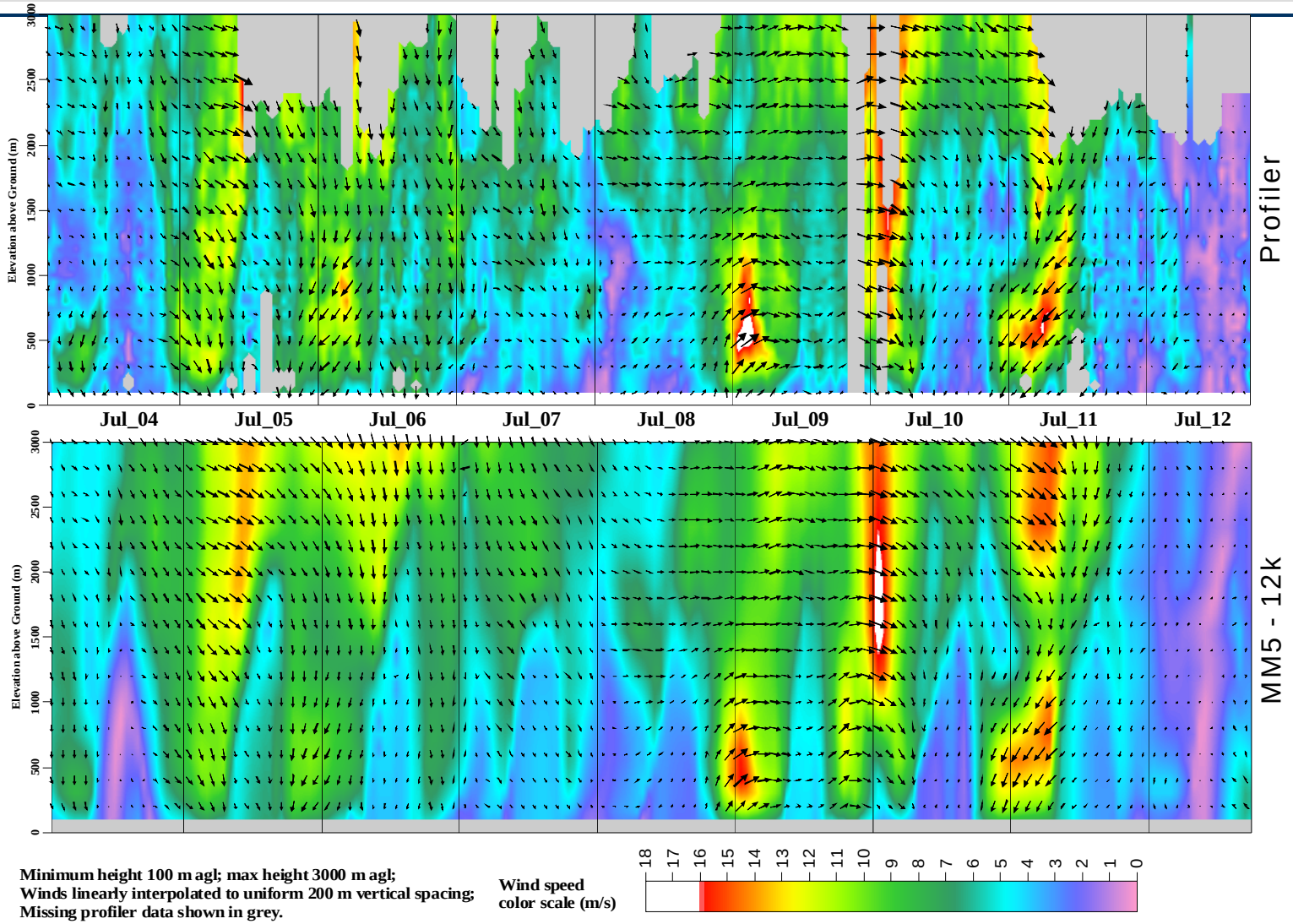
- **Significantly greater nonattainment than current situation based on monitoring, due to conservative approach (modeling) plus conservative inputs (potential emissions) plus conservative background**
- **1 hour modeling results tend to point directly at individual facilities, not to regional scale emissions (e.g. ozone, PM2.5)**
- **Modeled non-attainment tends to be limited to small geographic areas "hot spots"**
- **Potential for "pseudo" nonattainment areas**

What is The Same?

- **AERMOD is still "just a model"**
  - Extraordinarily complex atmospheric processes simulated by a simple steady state model
  - Lagrangian processes "trapped" in a steady-state model
- **Representativeness of meteorological data is still a difficult issue (always has been…)**
- **Inevitable that model sensitivities will produce results in some circumstances that are physically unrealistic**

"Just a model"

Fort Meade, MD July 2002: Comparison of Profiler and MM5 data



What is Different?

- **Low concentration levels of new 1-hour NAAQS**
- **Use of models for attainment designations**
- **More complex treatment of transport and dispersion in the boundary layer leads to more instances of unusual model behaviour**
- **Consequences of "pressing the easy (conservative) button" are considerably more severe than ever**
- **Leads to a more critical need for creative approaches, careful consideration of case-specific sensitivities, actual emissions, model performance**

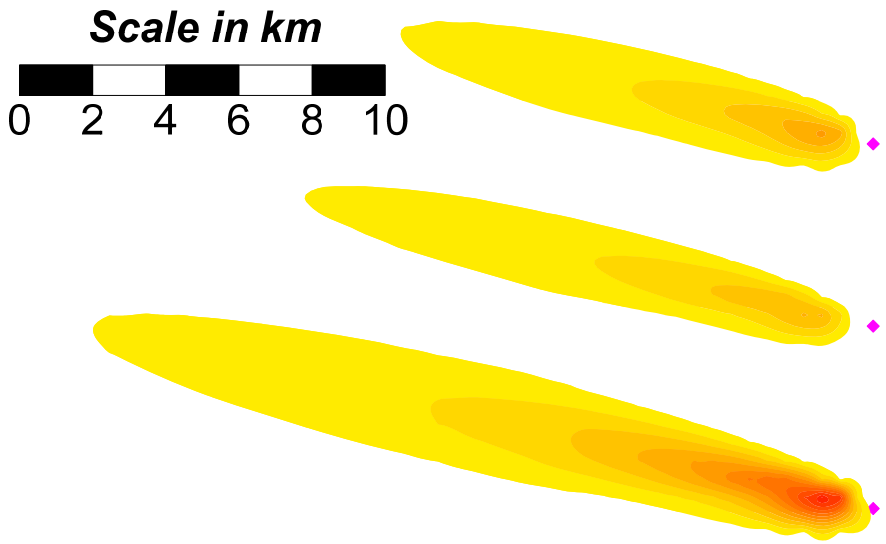
Anecdote # 1: Low Wind Speeds

Power Plant Stack; Urban Setting: hour typical of "design concentration"

Note Plume Travel Times:

0.39 m/s approx 9 hours;

1.0 m/s approx. 3 hours



a	b	c	
0.39	1.0	0.39	Wind Speed m/s
0.012	0.033	0.012	Friction Velocity m/s
3.0	14.0	3.0	Mixing Depth m
1.0	3.8	1.0	Monin-Obukhov length m
n/a	n/a	58	Sigma-theta
3.02	1.04	1.35	Max Concentration

Anecdote # 1: Low Wind Speeds

Rank	Concentration	Friction Velocity (m/s)	Mechanical mixing depth (meters)	Wind Speed (m/s)
1	11.56	0.012	3.0	0.37
2	11.56	0.012	3.0	0.35
3	11.01	0.013	3.0	0.41
4	11.00	0.012	3.0	0.29
5	10.21	0.014	4.0	0.40
6	9.68	0.015	4.0	0.50
7	9.32	0.016	5.0	0.45
8	9.31	0.016	5.0	0.36
9	9.20	0.016	5.0	0.46
10	9.17	0.016	5.0	0.38
90	5.57	0.029	12.0	0.70
91	5.54	0.028	11.0	0.79
92	5.50	0.028	14.0	0.62
93	5.45	0.031	13.0	0.67
94	5.43	0.029	11.0	0.82
95	5.42	0.029	11.0	0.80
96	5.41	0.012	3.0	0.36
97	5.36	0.031	13.0	0.69
98	5.34	0.028	11.0	0.84
99	5.32	0.028	11.0	0.87
100	5.28	0.030	12.0	0.79

Anecdote # 2: Terrain (Tall Stack >Short Stack)

Tall Stack	Short Stack	Short Descr.	Description
0.00	0.70	FB	buoyancy flux
11.64	11.43	FM	momentum flux
3.13	2.41	UStk	Wind speed @ stack top
0.141	0.147	TGS	Temperature gradient @ stack top
0.141	0.147	TGP	Temperature gradient @ plume ht
0.00	9.84	DHP_St_use	Plume rise
3.11	2.41	UEFF_St	Effective wind speed
53.87	65.01	HE_Stable_Af	plume height
2.52	2.50	SZAMB_St	sigma z - ambient
36.22	57.17	SYAMB_St	sigma y - ambient
0.00	2.78	SZB_St	sigma z - buoyancy
36.22	57.24	SY_St	sigma y - effective
2.23	3.74	SZ_St	sigma z - effective
106.74	129.22	HILLHT	Hill height
58.32	90.70	HCRIT	Critical dividing streamline height
0.98	1.00	PHEE	percent of plume below hcrit
0.99	1.00	FOPT	wrap part of plume
571.19	300.87	CHIst_W	wrap concentration
564.63	300.87	CHIst_W*FOPT	wrap concentration - effective
0.00	0.00	CHIst_L	lift concentration
0.00	0.00	CHIst_L*FOPT	lift concentration - effective
564.63	300.87	Chi_st_TOT	Total concentration
564.63	300.87	Chi_Coherent	Coherent concentration
13.77	8.10	Chi_Random	Random concentration
0.01	0.02	FRAN	percent random
558.87	295.68	Chi_Overall	Final concentration prediction

Chernyshevsky: What is to be Done?

- **Some Simple Solutions**
  - Low Wind Speeds: Limit dilution speed to 1.0 m/s
  - Background: Seasonal/hour approach is helpful; should use average (per Appendix W 8.2.2b):

    For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors not impacted by the source in question, should be ***averaged*** for each separate averaging time to determine the average background value.

Chernyshevsky: What is to be Done?

- **Specifically for SO_2 1-hour modeling:**
  - Always include sensitivity analyses; allow time for consideration of case-by-case model sensitivity
  - Always pay close attention to meteorological conditions and model "details" associated with high concentrations
  - Allow for use of actual emissions:
    - in the form of a distribution (e.g. max monthly for each month)
    - Monte Carlo simulations where data are available
- **Modify AERMOD to more easily identify met conditions and model details**
  - Promote broader understanding of sensitivites and case-specific model attributes