Modeling Guidance for SO$_2$ Implementation

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SO$_2$ NAAQS

- SO$_2$ NAAQS revised June 2010
- Standard is 75 ppb based on 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour concentrations

SO$_2$ Implementation Guidance

- Draft guidance released via Notice of Availability in Federal Register Oct. 3, 2011
  - http://www.epa.gov/airquality/sulfurdioxide/implement.html
  - 30 day public comment period
  - Appendix A: Modeling guidance for attainment demonstration
    - Nonattainment areas
      - Area where monitoring data **or** an appropriate modeling analysis indicates a violation
    - Unclassifiable areas
      - Area has no monitored violations and lacks an appropriate modeling analysis or other appropriate information sufficient to support an alternate designation
  - Appendix C: Non-modeling technical guidance for attainment demonstration

SO$_2$ Implementation Modeling Guidance*

- Model Selection
  - AERMOD, EPA's preferred near-field dispersion model
- Modeling domain and sources to model
- Source inputs
- Meteorological inputs
- Background concentrations

*Examples shown here and in guidance are for illustrative purposes only

Model selection

- For SIP modeling, AERMOD should be used unless an alternative model can be justified (Section 3.2 of the *Guideline on Air Quality Models,* Appendix W)
  - AERMOD is EPA's preferred near-field dispersion model (promulgated in 2005)
  - As part of promulgation process, AERMOD was evaluated against 17 field study databases and performed well for SO_2 releases (see next slide)

AERMOD Performance for complex terrain

*http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2011/Presentations/7-Thursday_PM/7-4_SO2_Modeling_09June2011.pdf

LOVETT SO2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hour Concentrations
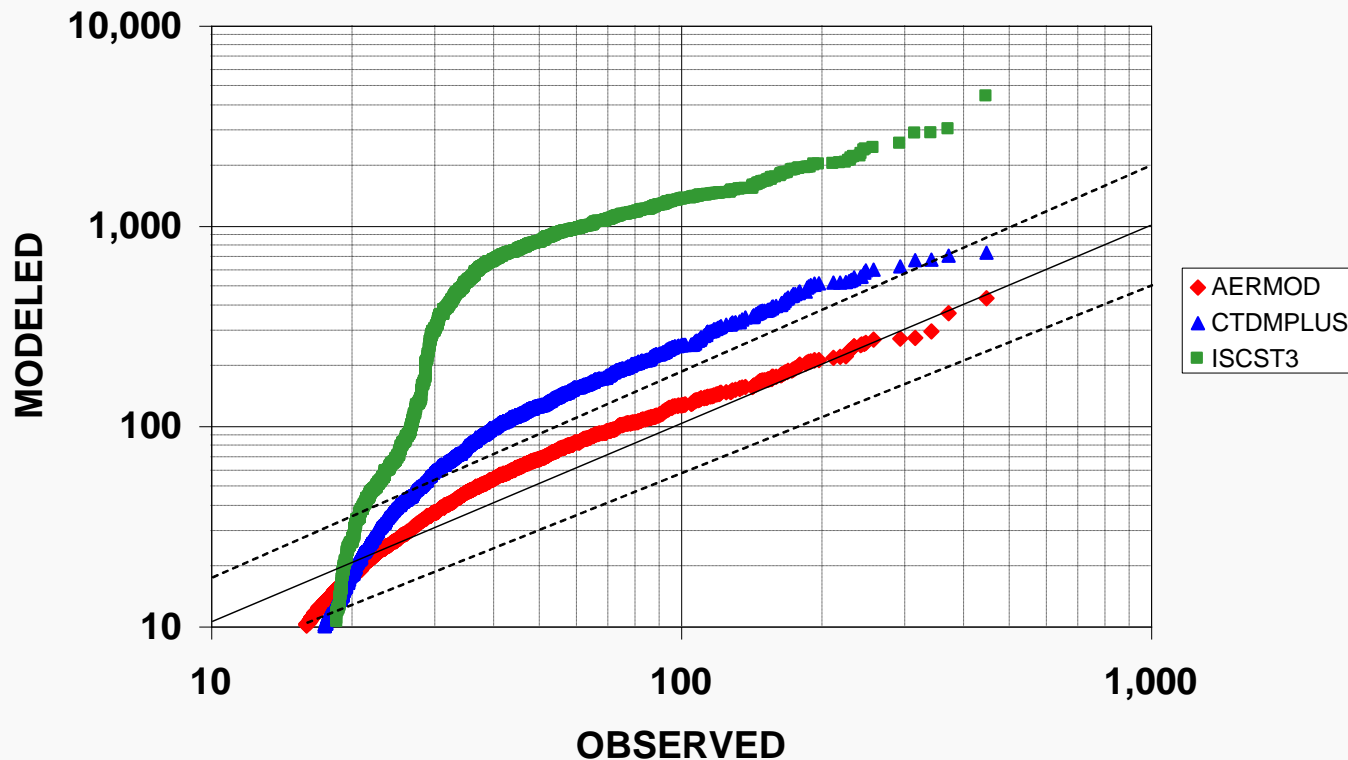
AERMOD modeling system

- Regulatory components
    - AERMOD: dispersion model
    - AERMAP: terrain processor
    - AERMET: meteorological processor
    - BPIPPRIME: building processor
- Non-regulatory component
    - AERSURFACE: surface characteristics processor for AERMET
    - AERMINUTE: ASOS 1-minute wind processor for AERMET
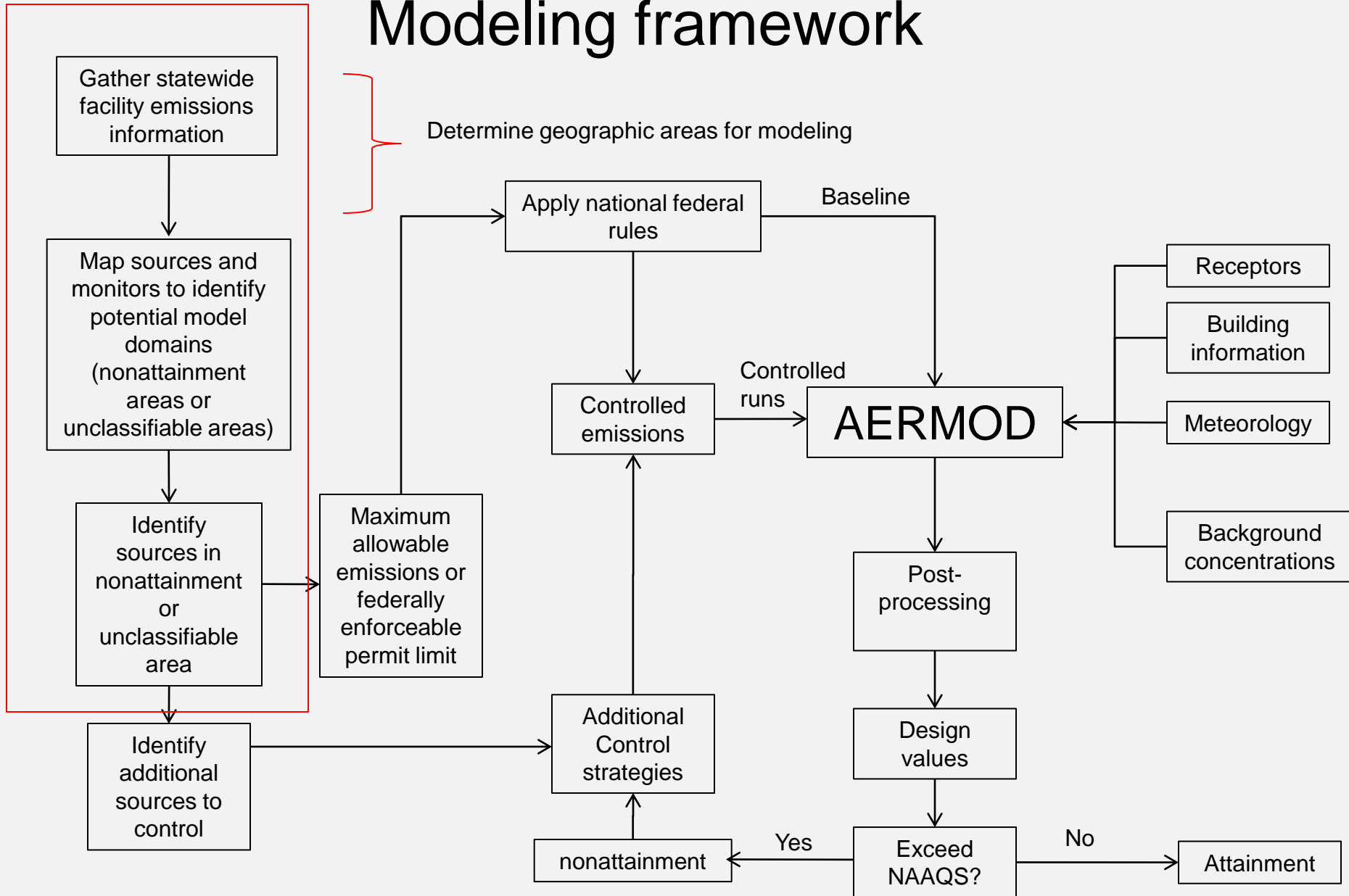   - AERSCREEN: screening version of AERMOD
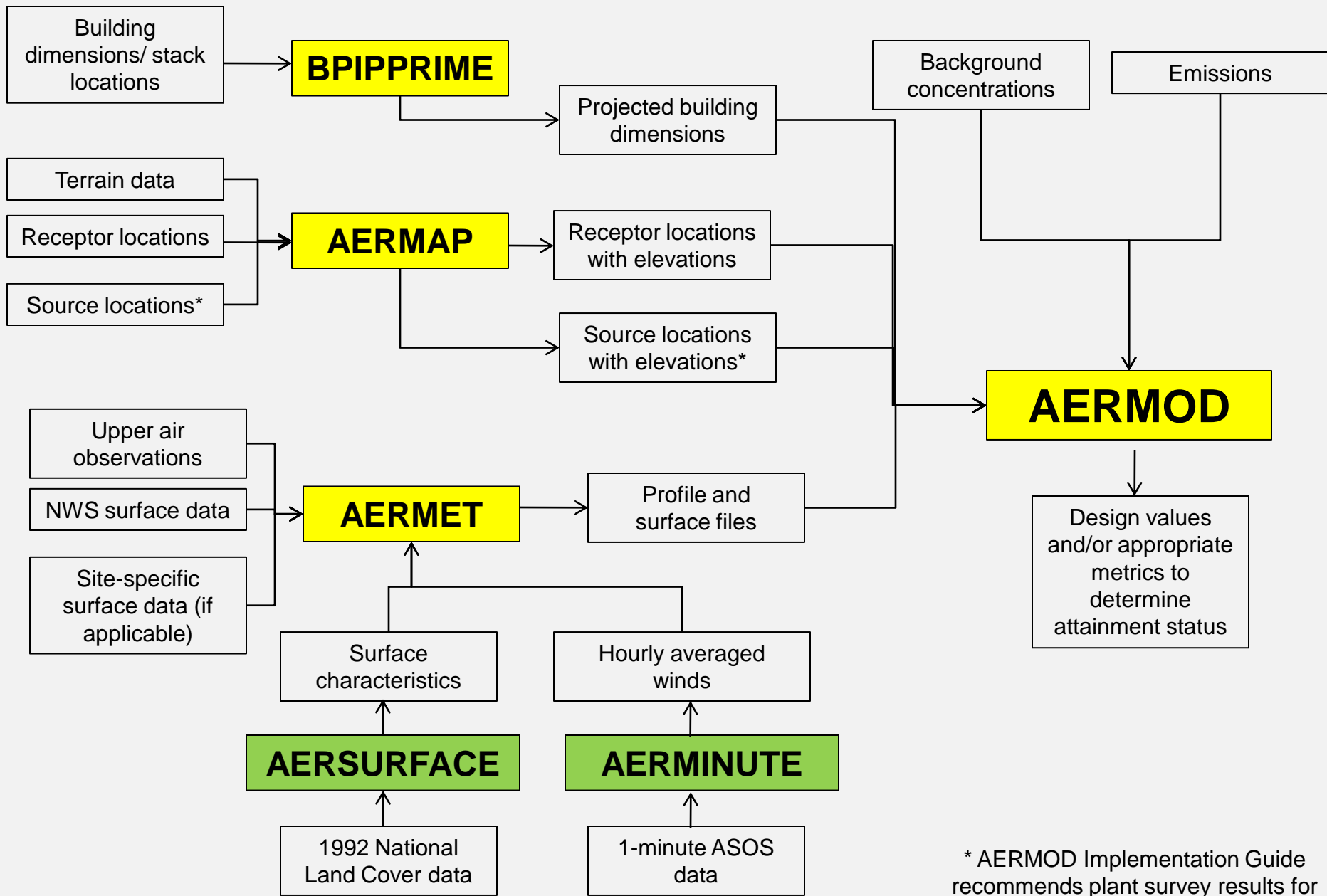
Modeling framework

1. If no attempts were made in the designations process to determine nonattainment/unclassifiable areas, then define areas to model by:
   - Gathering statewide facility emissions information (emissions, locations, etc.)
   - Mapping facilities and monitors to identify geographic clusters of sources and clusters around nonattaining monitors
2. Beginning with maximum allowable emissions or federally enforceable permit limits, apply federal control strategies to develop emissions inputs for modeling
3. Conduct modeling with controlled emissions, representative meteorology, representative background concentrations, and building downwash information to calculate design values for receptors based on cumulative concentrations (all sources and background)
4. If no predicted exceedances, then successful attainment demonstration
5. If exceedances, additional control strategies may need to be applied on sources and additional re-runs of the model may be necessary
   - Continue to apply additional controls until no exceedances

Modeling framework

Gather statewide facility emissions information

→ Map sources and monitors to identify potential model domains (nonattainment areas or unclassifiable areas)

→ Identify sources in nonattainment or unclassifiable area

→ Identify additional sources to control

Determine geographic areas for modeling

Apply national federal rules

→ Baseline

→ Controlled emissions

→ Controlled runs

Maximum allowable emissions or federally enforceable permit limit

AERMOD

Receptors

Building information

Meteorology

Background concentrations

Additional Control strategies

Post-processing

Design values

nonattainment ← Yes — Exceed NAAQS? — No → Attainment

Determining Geographic Areas for SIP Demonstration

- Gather state-wide information about SO_2 sources:
  - Emissions, locations, building information
  - Reasonable to focus on actual emissions and most significant sources of SO_2 (e.g., > 100 tons/year)
    - Note that refined dispersion modeling will be based on allowable or permit emissions. Sources may have actual emissions much lower than allowable limits so it may be prudent to map sources less than 100 tons (e.g., > 50 tpy actual emissions)
    - Also, bear in mind that smaller sources with short stacks or sources located in complex terrain may cause or contribute to a NAAQS violation
  - States should use best professional judgment or act in consultation with Regional Office modeler to determine emissions threshold for mapping
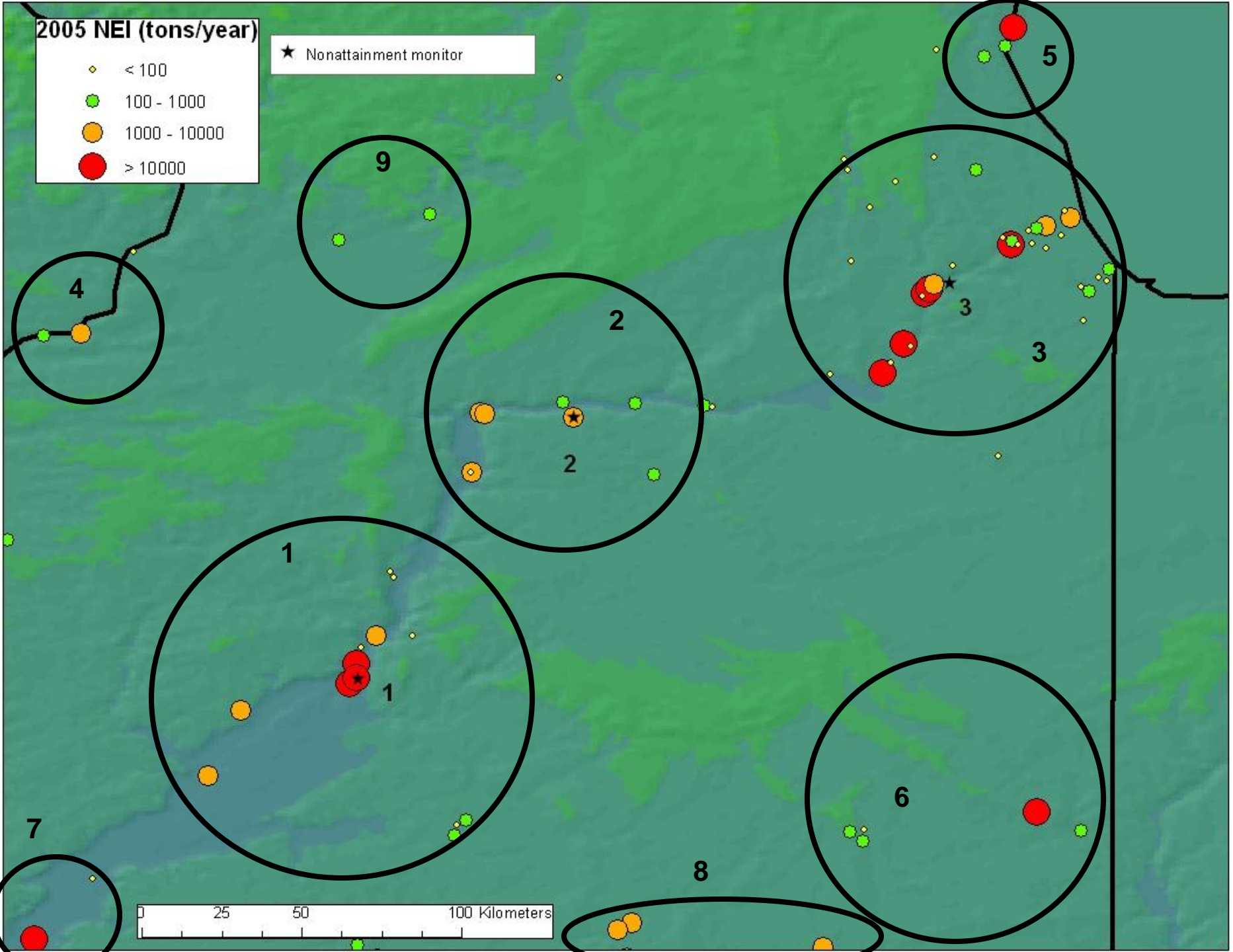
Determining Geographic Areas for SIP Demo

- Map sources and SO_2 monitor locations to identify any geographic clusters as potential areas to model

    - Nonattaining monitors or large sources can be center of potential modeling domain for each area

- Next slide provides an example of this mapping exercise with facilities and monitor locations plotted

2005 NEI (tons/year)

★ Nonattainment monitor

◇ < 100
● 100 - 1000
● 1000 - 10000
● > 10000

Determining sources to model within each area

- Once the areas to model have been identified, the next step is to define the domain size and identify sources that are to be explicitly modeled
  - Some sources may be represented by background monitors
  - Some sources may screen out via AERSCREEN
  - Modeling domain may not always extend out 50 km

Screening sources to be explicitly modeled

- Screening can be done using AERSCREEN to determine whether to explicitly model source

  – AERSCREEN recommended screening model (April 11, 2011 AQMG memorandum)

- AERSCREEN does not output an SO_2 design value but does output the maximum hourly concentration for an individual emission point

- Consider modeling source with source specific surface characteristics and surface characteristics of refined modeling meteorological site to determine a *de minimis* concentration
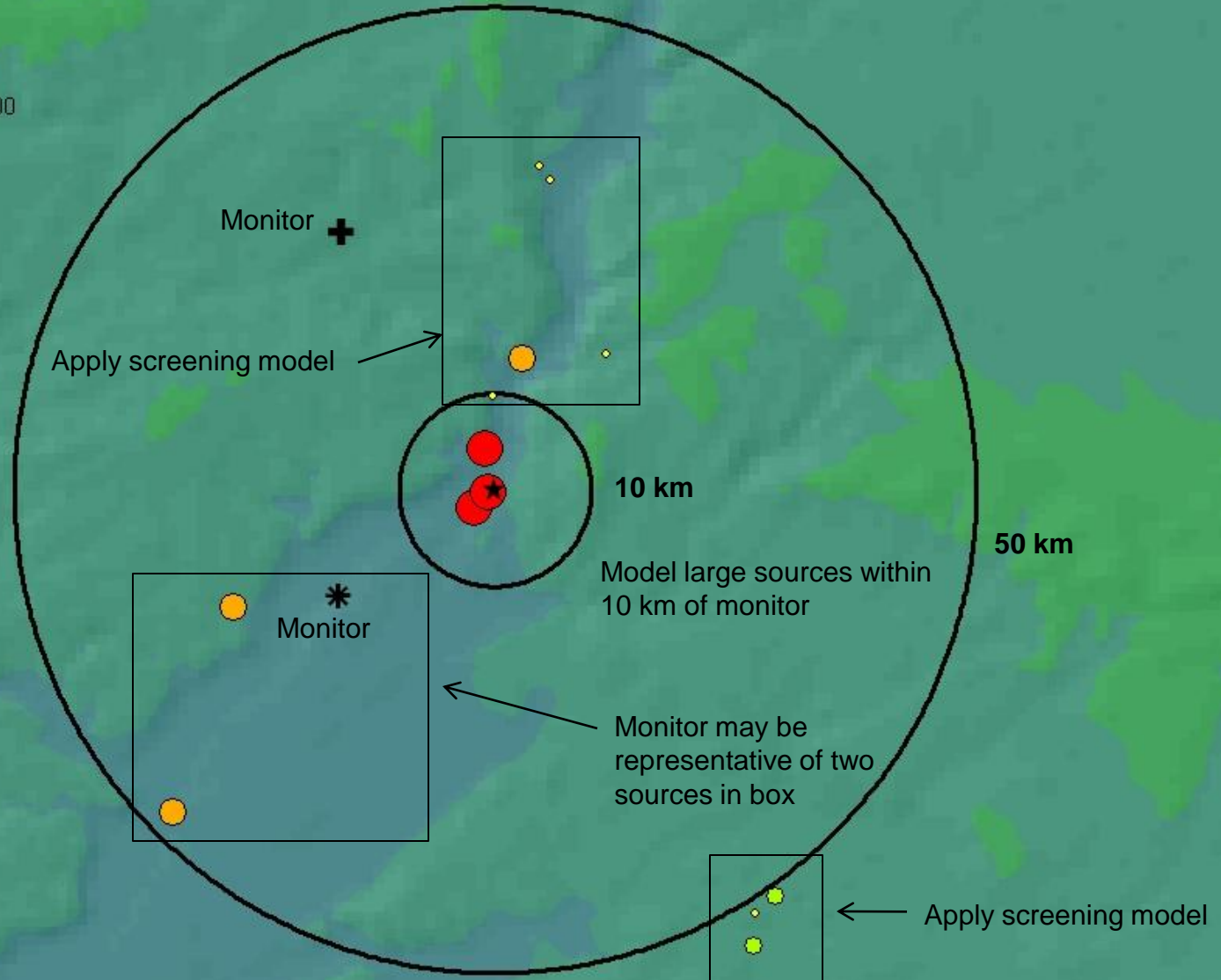
Screening scenarios

Maximum hourly concentration	Outcome
> 75 ppb	Include in refined modeling
> Interim Significant Impact Level (SIL)* of 3 ppb and < 75 ppb	Include in refined modeling
< Interim SIL of 3 ppb	May not have to be included in refined modeling. However, the facility should not be excluded on the sole basis of being below the SIL without first looking at surrounding sources and their maximum 1-hour concentrations.

*States or reviewing authorities may have their own SIL. The EPA interim SIL is not meant to supersede any interim SIL of a state.

Emissions (tons/year)
- < 100
- 100 - 1,000
- 1,000 - 10,000
- > 10,000

Monitor

Apply screening model

10 km

50 km

Model large sources within 10 km of monitor

Monitor

Monitor may be representative of two sources in box

Apply screening model

02.55 10 15 20
Kilometers

17

Receptor grid

- Receptor grid is unique to modeling domain depending on complexity of terrain, sources modeled, etc.
- Receptors should be placed in areas considered ambient air and of such density to detect significant concentration gradients.
  - Fine spacing near sources with coarser spacing farther out in domain
- States may have existing receptor placement strategies for NSR/PSD programs
  - If this is considered adequate for the implementation modeling, states may continue with their respective strategies

Emissions and source characterization

- Maximum allowable emissions or federally enforceable limits should be basis of emissions used in modeling
  - Follow Section 8.1 of Appendix W
  - Emission input data can be calculated using Table 8-1
  - Federal Rules expected to be in place by attainment date can be factored in emissions
  - Use of allowables or permits consistent with current SO_2 guidance (1994)
- Source characterization
  - Source release parameters should reflect modeled emissions levels
  - If modeling controlled emissions for attainment demonstration, release parameters should reflect source "with controls in place"
  - Accurate locations
    - Sources and Buildings (if needed for downwash)
  - Urban vs. rural classification
    - Important in determining dispersion coefficients
    - AERMOD includes a 4-hour half-line for urban SO_2 sources

TABLE 8–1.—MODEL EMISSION INPUT DATA FOR POINT SOURCES [1]

Averaging time	Emission limit (#/MMBtu) [2]	×	Operating level (MMBtu/hr) [2]	×	Operating factor (e.g., hr/yr, hr/day)
Stationary Point Source(s) Subject to SIP Emission Limit(s) Evaluation for Compliance with Ambient Standards (Including Areawide Demonstrations)					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.		Actual operating factor averaged over most recent 2 years.[3]
Short term	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.[4]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]
Nearby Source(s) [6][7] Same input requirements as for stationary point source(s) above.					
Other Source(s) [7] If modeled (subsection 8.2.3), input data requirements are defined below.					
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.[6]		Annual level when actually operating, averaged over the most recent 2 years.[3]		Actual operating factor averaged over the most recent 2 years.[3]
Short term	Maximum allowable emission limit or federally enforceable permit limit.[6]		Annual level when actually operating, averaged over the most recent 2 years.[3]		Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]

[1] The model input data requirements shown on this table apply to stationary source control strategies for STATE IMPLEMENTATION PLANS. For purposes of emissions trading, new source review, or prevention of significant deterioration, other model input criteria may apply. Refer to the policy and guidance for these programs to establish the input data.

Good Engineering Practice (GEP) stack height

- Model minimum of actual stack height or GEP

- If modeling at GEP, use other actual stack parameters (temperature, diameter, exit velocity)

- If stack height is below GEP, downwash must be considered

Meteorology

- 5-years of representative National Weather Service data or at least one year of site-specific data (Appendix W)
  - 3-year standard does not pre-empt use of 5 years of NWS data
  - Calculate design values for modeled period , not 3-year averages
    - Example: Modeling 2005-2009, do not need to calculate 3-year averages for 2005-2007, 2006-2008, and 2007-2009
  - Recommend use of AERMINUTE hourly averaged winds to supplement standard NWS observations to reduce calms and missing data that will be important for modeling of an hourly standard
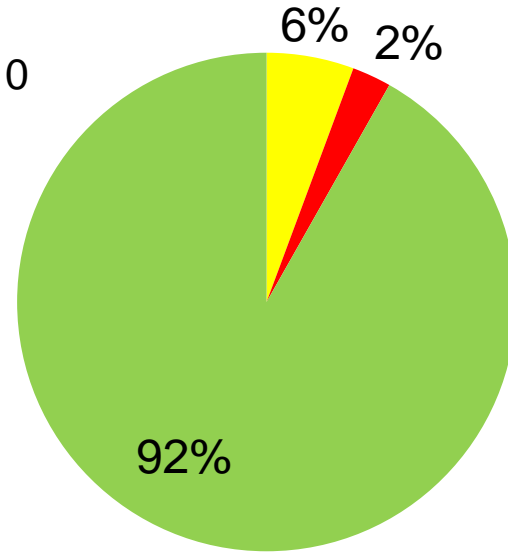
AERMINUTE

- Addresses issue of calm and missing winds with NWS data
  - Concentrations not calculated in AERMOD for hours with calm or missing meteorological data
  - Light wind conditions may be controlling factor in some cases due to limited dilution
- AERMINUTE reads ASOS 1-minute winds and calculates hourly averaged winds for input into AERMET
- Purpose of AERMINUTE is not to increase conservatism but to "reclaim" data that was lost due to METAR reporting in NWS data
- Makes meteorological data more representative
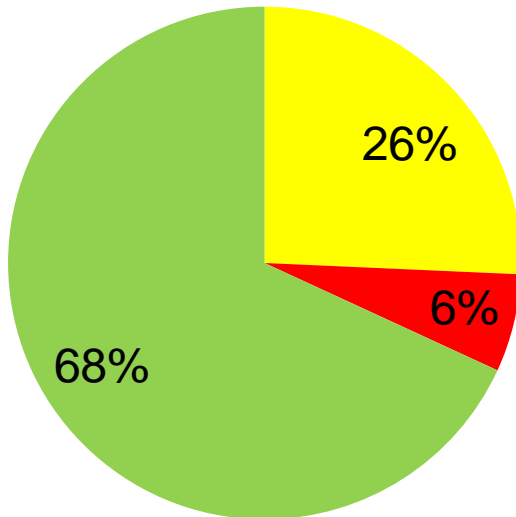
Concord, NH 2005-2010

	Without AERMINUTE	With AERMINUTE
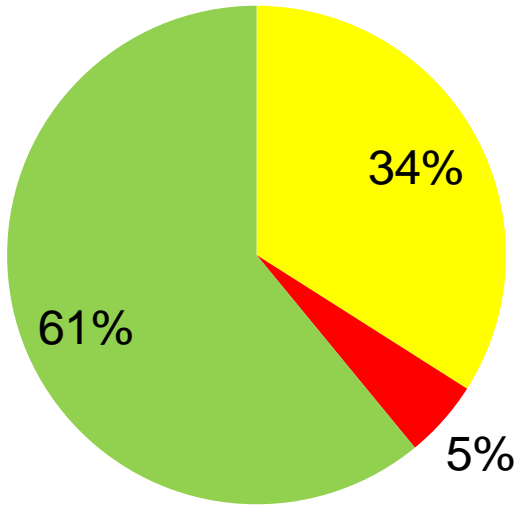
Concord, NH 2005-2010

- Calms — 34%
- Missing — 5%
- Valid — 61%

- Calms — 6%
- Missing — 2%
- Valid — 92%

Without AERMINUTE

With AERMINUTE

Zanesville, OH 2005-2010

- Calms — 26%
- Missing — 6%
- Valid — 68%
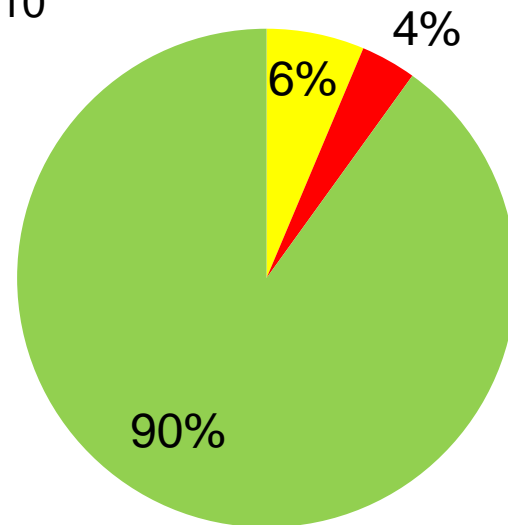
- Calms — 6%
- Missing — 4%
- Valid — 90%

Background concentrations

- August 23, 2010 memo "Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard
  - Recommended first tier use of maximum 1-hour monitored concentration
  - Simple and straightforward but may be overly conservative
- March 1, 2011 memo "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS" (applicable to SO_2)
  - Recommended new first tier of monitored design values added to modeled design values
  - Specifically, use temporally varying concentrations based on 99th percentile monitored concentrations by hour of day and season added to modeled design values.
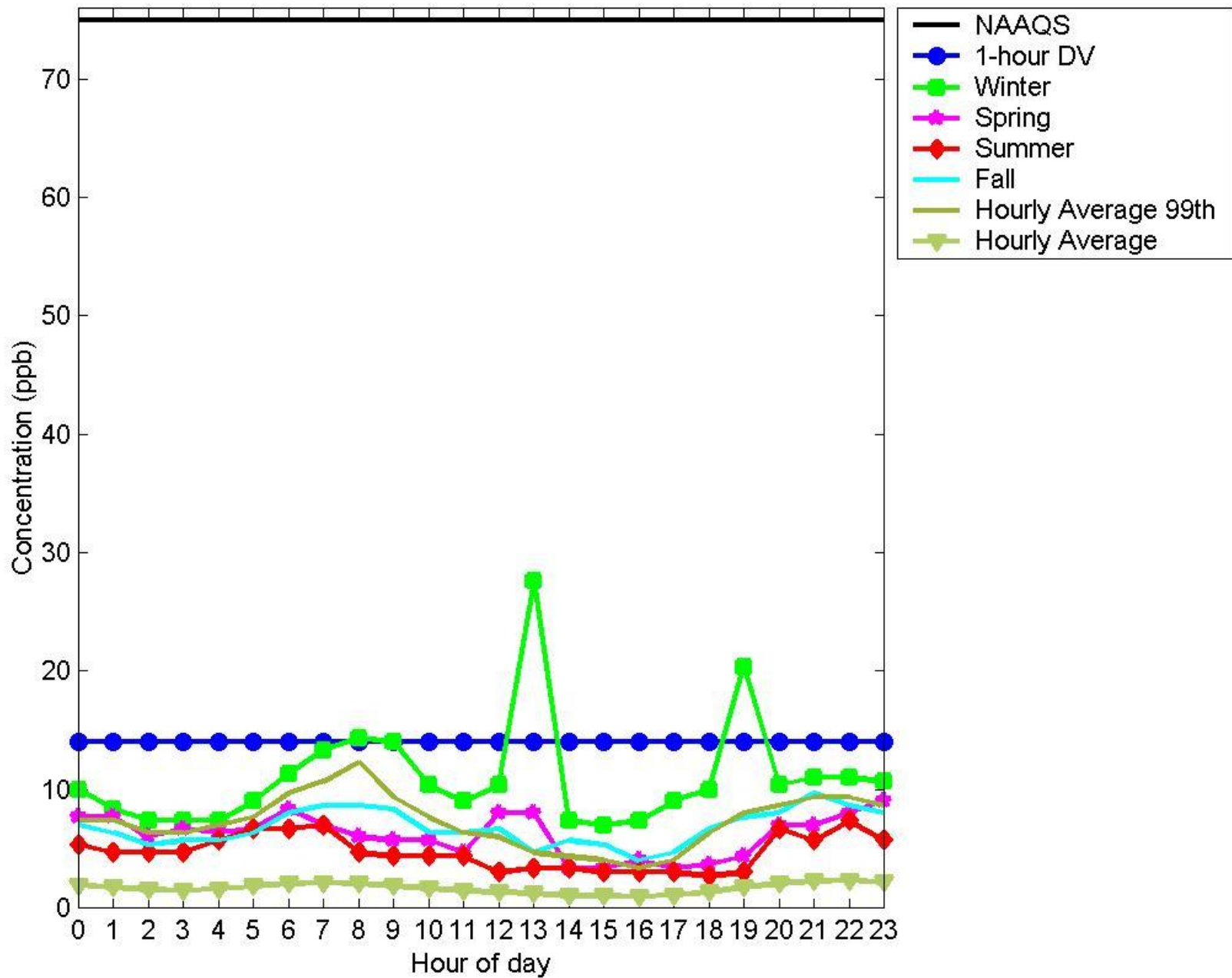
Calculating SO$_2$ design values

- At each receptor:
  1. For each modeled day, determine maximum 1-hour total (from all modeled sources + background) concentration
     - Results in 365 concentrations per year (366 for leap year)
  2. For each modeled year, determine 4th highest of the 365 (366) hourly concentrations
     - If modeling 5 years of data, results in 5 concentrations
  3. If modeling 5 years, average concentrations from step 2 to calculate design value

- Among all receptors, determine if any design values exceed NAAQS

AERMOD output options for SO_2 modeling

- **MAXDAILY**
  - Output of daily maximum 1-hour concentrations for each receptor and day of modeling period.

- **MXDYBYYR**
  - For each receptor, output daily maximum 1-hour concentrations by year for each rank specified on the RECTABLE keyword

- **MAXDCONT**
  - Output source group contributions to high ranked values for a target source group, paired in time and space
  - User can specify a series of ranks to analyze or a high rank and threshold value to analyze until no receptors exceed threshold

AERMOD output options for SO$_2$ modeling Examples

- MAXDAILY

  OU MAXDAILY ALL MAXDAILY.DAT

- MXDYBYYR

  OU RECTABLE 4 8
  OU MXDYBYYR ALL MAX_DAY_YEAR.DAT   Output for ranks 4 and 8 will be included

- MAXDCONT

  Range of ranks: Output for ranks 4 through 8 will be included

  OU MAXDCONT ALL 4 8 CONTRIBUTIONS.DAT
  Threshold:
  OU MAXDCONT ALL 4 196 CONTRIBUTIONS.DAT

Summary

- AERMOD should be used for SIP modeling

- Sources should be modeled with maximum allowable 1-hour or short-term emission rates in the SIP modeling based on continuous operations at the source

- It is reasonable to initially focus on larger emitters, i.e. 100 tons or more per year
  - Smaller sources, especially those with short stacks and/or located in complex terrain can possibly cause or contribute to NAAQS violations

- Modeling should be done with 5 years of representative NWS meteorological data or at least one year of site specific meteorology

- Background concentrations can be included as:
  - "First tier" approach based on monitored design values added to modeled design values; or
  - Temporally varying based on the 99th percentile monitored concentrations by hour of day and season added to modeled design values

- States should work with EPA Regional Modeler to develop a modeling protocol

- At any time during the SIP process when there are questions regarding modeling or implementation modeling guidance, the appropriate EPA Regional Modeling Contact should be consulted.

Relevant Guidance

- Guideline on Air Quality Models (Appendix W)
- Memoranda
  - Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010
  - Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard, March 1, 2011
  - Area designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, March 24, 2011.
- AERMOD Implementation Guide
- AERMOD, AERMET, AERMAP, AERMINUTE, AERSCREEN, and AERSURFACE user's guides

Web Links of Interest

- Support Center for Regulatory Atmospheric Modeling (SCRAM)
    - http://www.epa.gov/scram001/
    - Links to AERMOD modeling system
        - http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod
    - SO_2 implementation modeling webpage
        - http://www.epa.gov/ttn/scram/so2_modeling_guidance.htm
    - Clarification memorandum, Guideline on Air Quality Models
- SO_2 implementation page
    - http://www.epa.gov/airquality/sulfurdioxide/implement.html

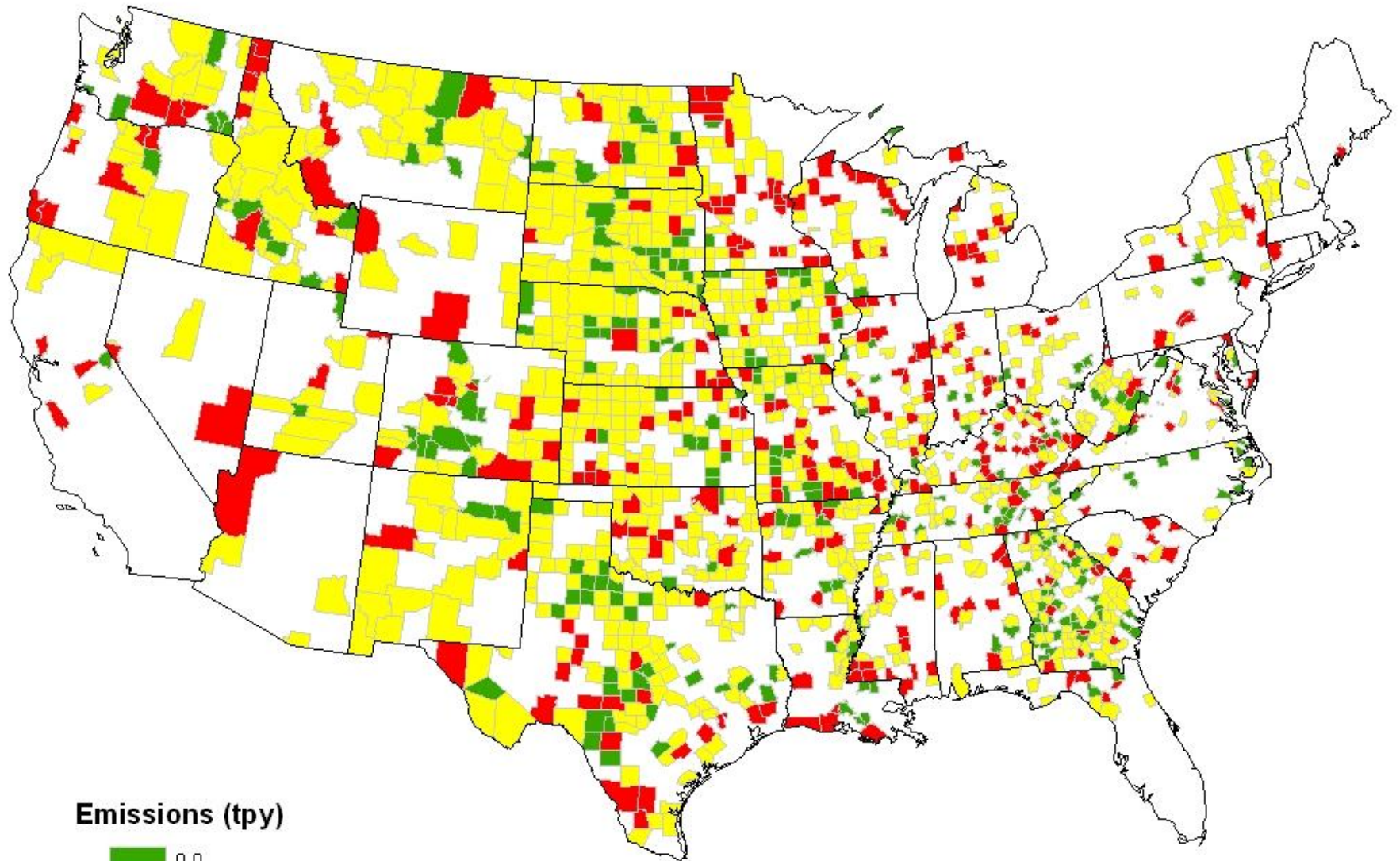# Non-modeling technical demonstration of attainment

Background information

- SO_2 screening modeling indicates no clear and simply relationship between emissions and violation of new 1-hour standard

  - Other influential factors such as source configuration, terrain, downwash effects, etc.

- Need to address what technical demonstration is sufficient for attainment determination in lieu of modeling for areas with no or few small sources.

- Therefore, we are proposing an approach that can be followed by states for consideration by the EPA reviewing authority
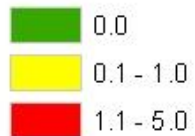
Guidance for technical demonstration of attainment without modeling

- Complete modeling for nonattainment areas and any unclassifiable areas with 100+ ton sources and/or smaller sources that could cause or contribute to nonattainment
- Determine nonattainnment and unclassifiable areas based on modeling results
- For remainder of state with small or no sources, use results from prior modeling to map and aid in demonstrating attainment. If a source or sources model NAAQS violations, consider the following:
  - How far do the violations extend from the source?
  - How far is the source from the target county?
  - If the source's violations do not extend to the target county, then it is a reasonable conclusion that source may not contribute to nonattainment in the target county
- If no modeling already performed for counties around the target county and no plans to model, then best professional judgment will be needed. The source should be mapped and the following issues considered:
  - How far are sources from the target county?
  - What are the maximum allowable emissions?
  - What are the stack parameters?
  - Would downwash or terrain play a role in dispersion toward the county?
  - What is the meteorology? A wind rose would be of use here.
- Answers to those questions can aid in demonstrating attainment status
- Note, screening model may still be necessary in some cases to verify a hypothesis that a source will not cause/contribute to a NAAQS violation in the target county.

Locations of zero and low emission counties
(Point sources only)

Emissions (tpy)

- 🟩 0.0
- 🟨 0.1 - 1.0
- 🟥 1.1 - 5.0

* Based on 2005 NEI

50 km buffer around county

Moore
4056.422366
Hutchinson
5815.9681
30.6546 Roberts
Hemphill
66.172175
Dewey
1.38325 Roger Mills
Custer
3.342125
son
5289.678 Gray
0.5466 Wheeler
Beckham
231.206375
Randall
111.854
0.1482 Armstrong
0.006 Donley
0.007725 Collingsworth
Greer
30.190644
0.00375 Kiowa
0.04625 Swisher
0 Briscoe
0.00725 Hall
0 Childress
Harmon
0.01
0.677 Jackson
Comanche
0.54125 Hardeman
0.0275 Floyd
0 Motley
0 Cottle
0 Foard
0 5 10 20 30 40 Kilometers

Facility emissions (tpy)
- 0 - 40
- 41 - 100
- 101 - 186470

county_point_emis