Air Dispersion Modeling for State Implementation Plans (SIPs): Challenges and Lessons Learned

Farah Mohammadesmaeili, Ph.D, P.E.
Technical Analysis Unit
Air Quality Division
ADEQ

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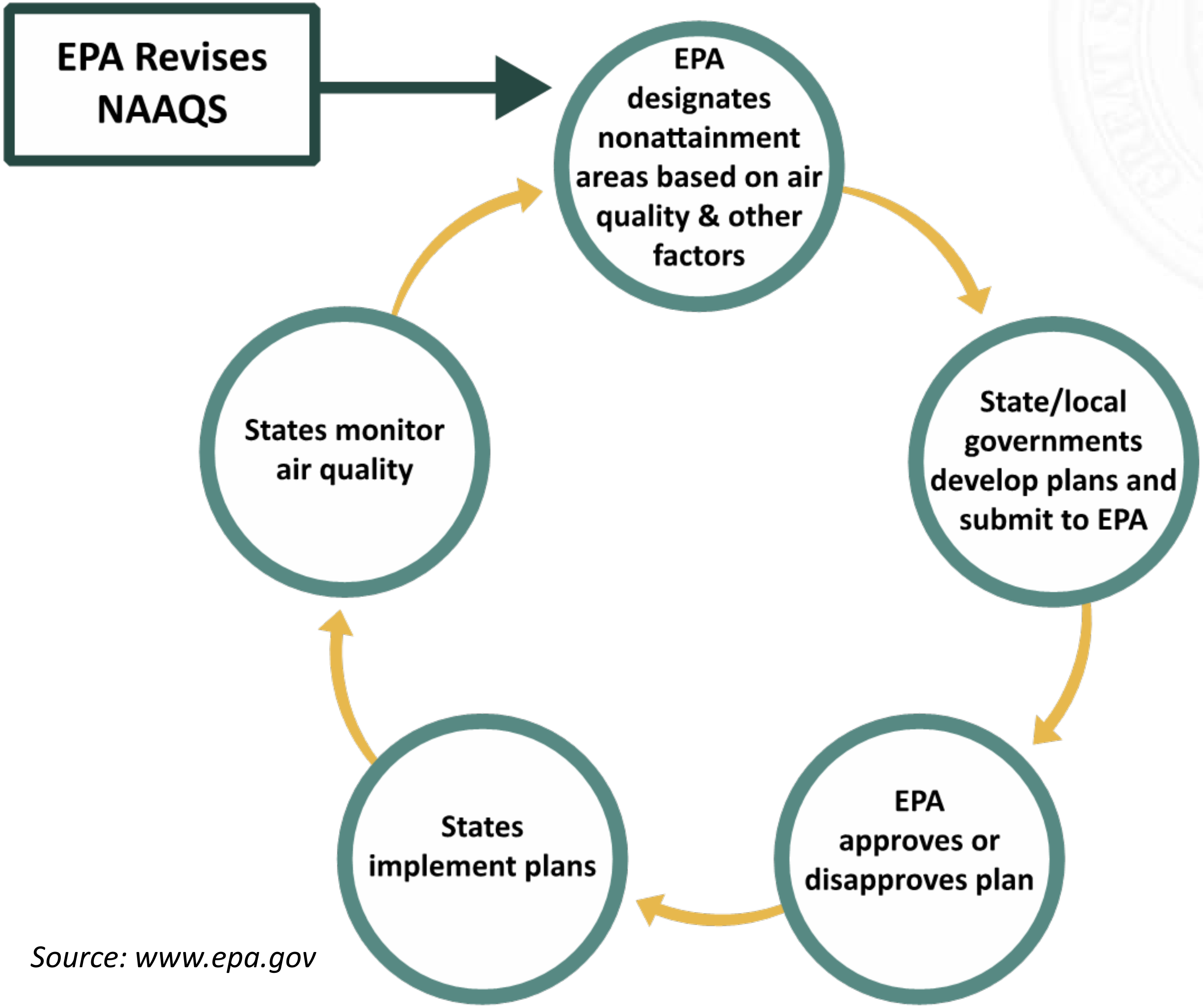
Arizona Department of Environmental Quality

National Ambient Air Quality Standards

- The Clean Air Act (CAA) gives the EPA authority to establish national ambient air quality standards (NAAQS) and regulations to protect public health and the environment.
- National standards have been established for 6 pollutants: ozone, $PM_{2.5}$ and PM_{10}, Carbon Monoxide (CO), Lead, Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2).
- EPA is required to review the standards every 5 years.

Air Quality Management Cycle



Source: www.epa.gov

What is a State Implementation Plan (SIP)?

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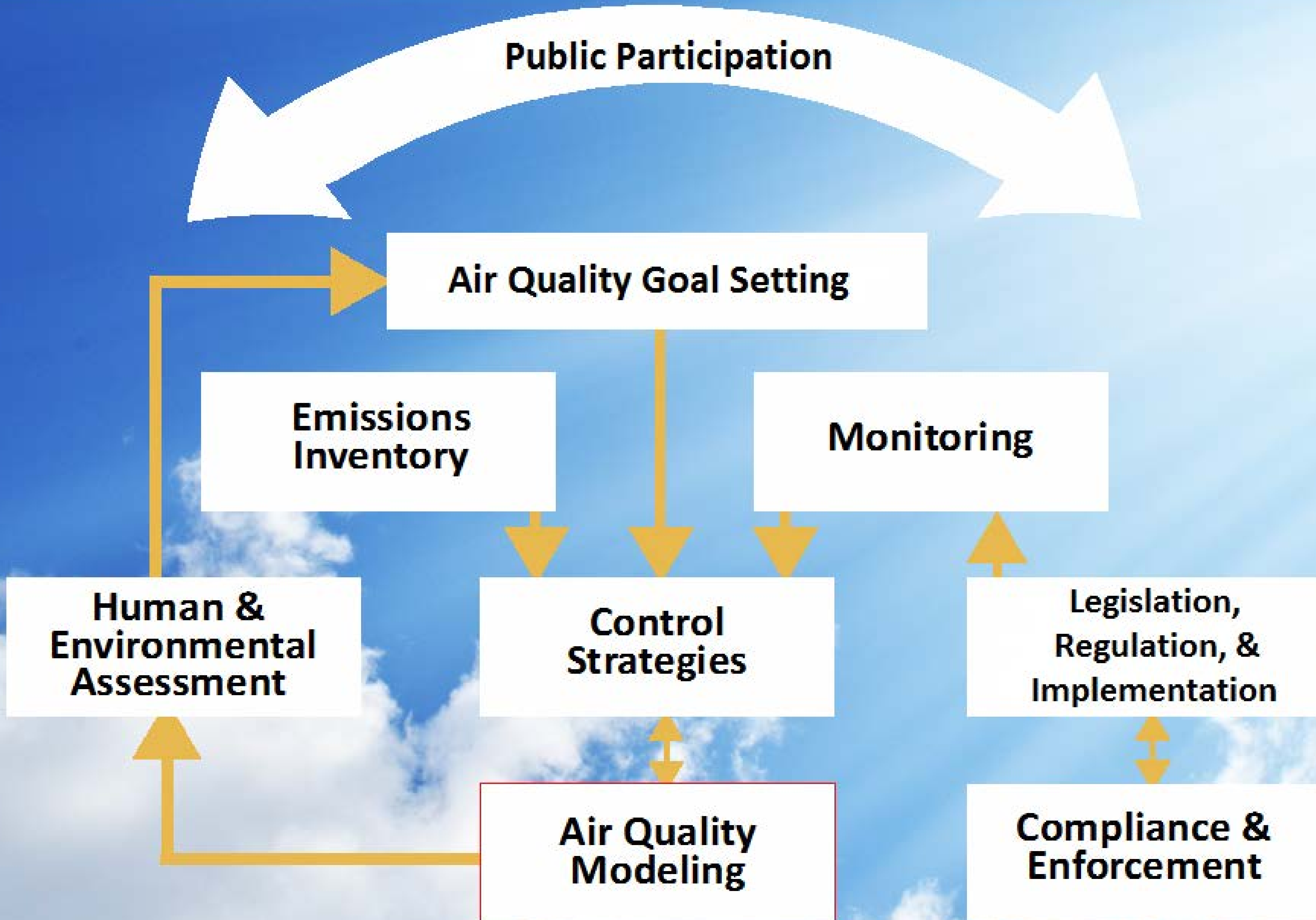
- It's a comprehensive plan for clean air
- A collection of programs, policies and rules that are adopted to attain and maintain the NAAQS
- Each state is responsible for developing plans to demonstrate how standards will be achieved, maintained, and enforced after designation .
- After EPA approval, SIPs and associated control measures are enforceable at both the state and national levels

What if a SIP Revision is not Submitted or is Disapproved?

- If a state fails to submit an approvable plan or if EPA disapproves a plan, EPA is required to develop a federal implementation plan (FIP).
- New Source Review (NSR) permitting sanctions and highway funding sanctions may apply.

A complete and approvable SIP is a product of cooperation between the state and stakeholders that can bring a nonattainment area to attainment and enhance public health and the environment.

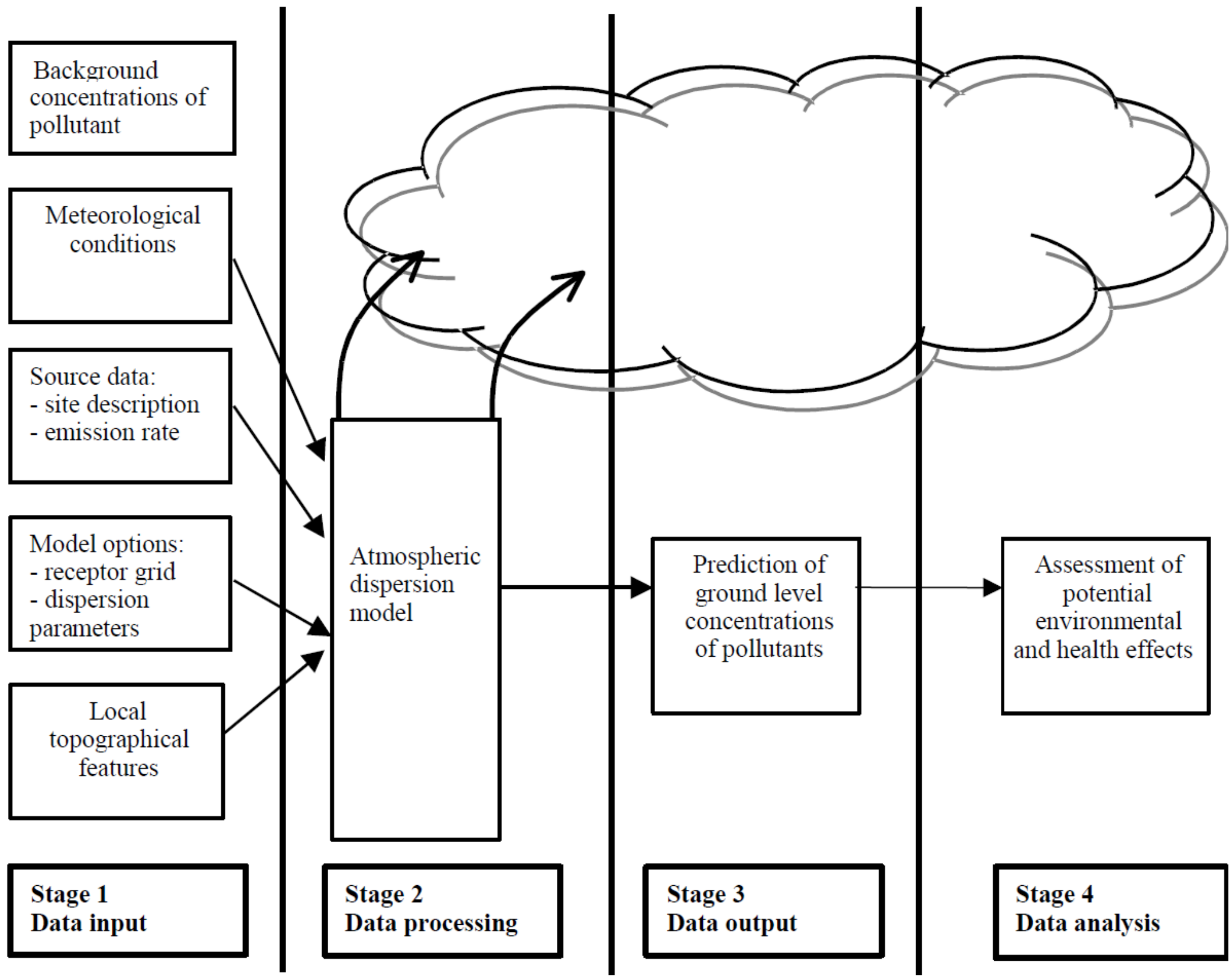
SIP Activities



What is Air Dispersion Modeling?

- Dispersion modeling provides a visual mathematical simulation of how air pollutants disperse in the ambient atmosphere.
- Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations.
- Air dispersion models are used to determine compliance with the NAAQS and other regulatory requirements.
- SIP modeling includes the following categories:
  - Demonstrate effectiveness of control measures used to demonstrate attainment with the NAAQS (for nonattainment areas)
  - To show that attainment areas will continue to meet the standard for at least 10 years, as required by CAA

Overview of the Air Dispersion Modeling



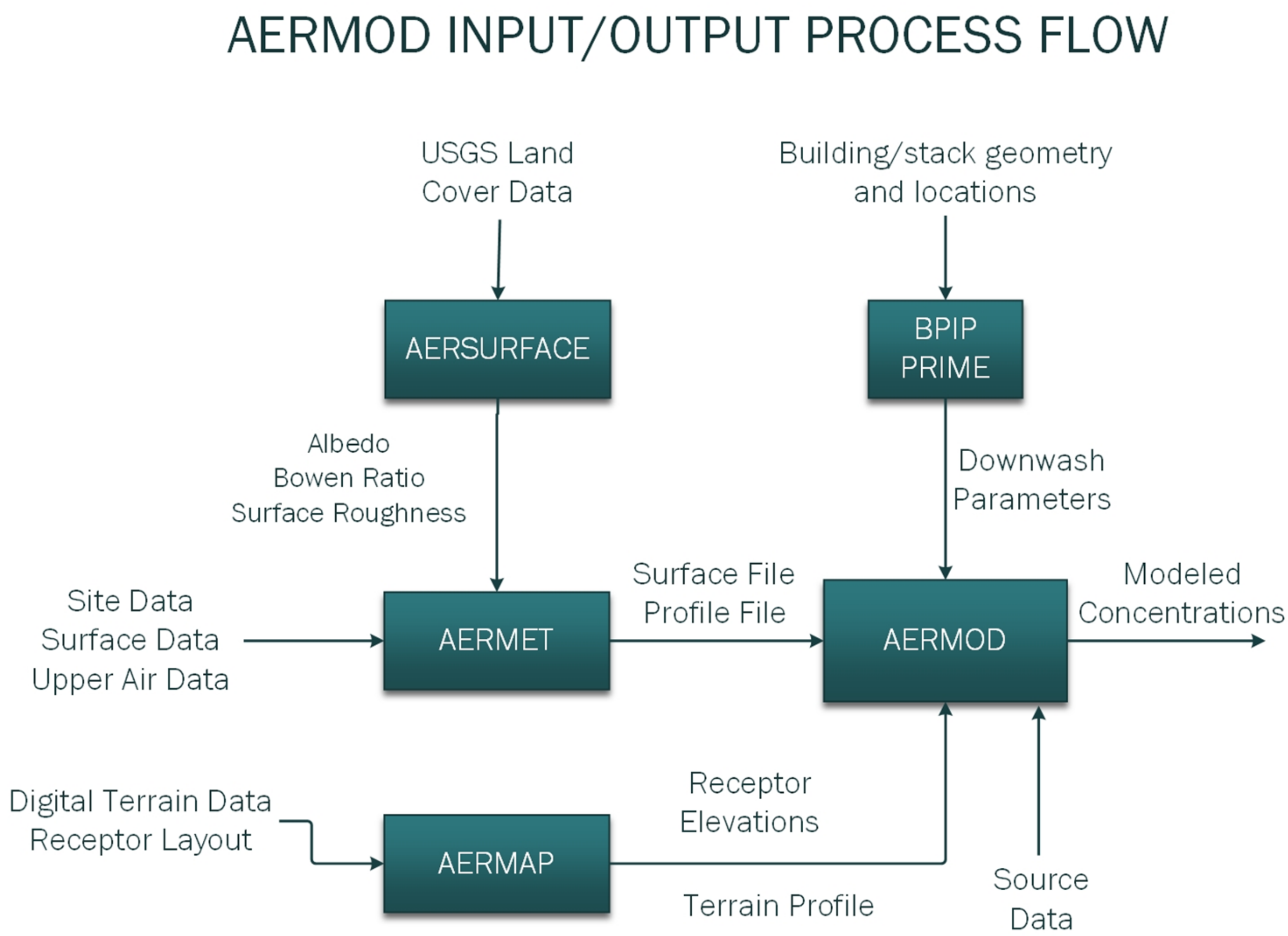
Source: www.mfe.govt.nz

Air Dispersion Modeling Analysis Components

1. Model Selection

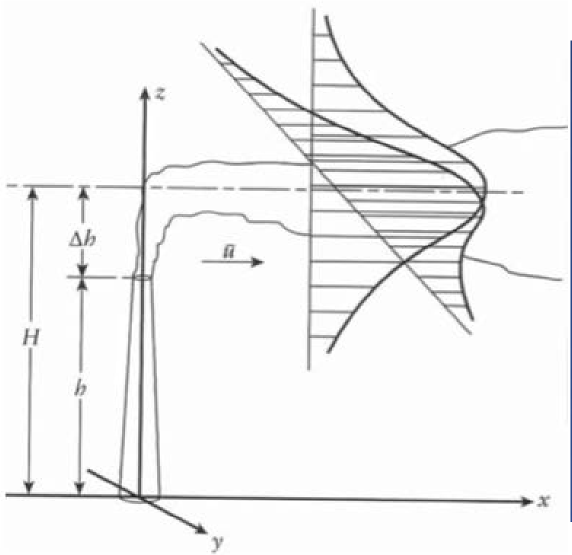
- EPA approved models (AERMOD, BLP, CALINE3, CTDMPLUS, OCD)
- Alternative models, which are evaluated by EPA on a theoretical and performance basis and approved on a case-by-case basis (CALPUFF, ISC3)
- Typically, there is not much opportunity to challenge the choice of the dispersion model, as AERMOD is almost always used.
  - Stands for American Meteorological Society/Environmental Protection Agency Regulatory Model
  - EPA-preferred model for near field (<50 km)
  - Steady-state Gaussian plume model
  - Can handle simple and complex terrain
  - Incorporates advanced building downwash algorithms

AERMOD Components



Gaussian Dispersion

- Spread of pollution is horizontal and vertical.
- Concentration at any point depends on the probability of dispersion of the particle there



How much will it disperse?

Model Selection Continued

- Challenges of Model Selection for a recent SIP project:
  - Complex emission sources configuration including five fugitive roof vents (buoyant line sources)
  - At the time of performing modeling analysis, AERMOD was not equipped with EPA's preferred treatment of buoyant line sources to account for enhanced plume rise
  - On the other hand, BLP (Buoyant Line and Point Source) does not treat complex terrain or perpendicular line sources

Model Selection Continued

- Solution: Using a Hybrid Modeling Approach:
  - Applied BLP (code was modified to treat perpendicular lines) to estimate hourly line source final plume rise, based on line source buoyancy parameters, physical dimensions, and source orientation
  - Applied the BLP-predicted final plume heights in AERMOD and model as volume sources using hourly source height adjustment factors
  - Hybrid approach is more time and resource intensive, as it requires two meteorological data preprocessors (RAMMET for BLP and AERMET for AERMOD)

2. Model Setup/Switches

- Each dispersion model has a variety of switches that are basically options for making different decisions
  - Standard options: regulatory options that do not require any approval by the regulatory authority
  - Beta options: non-regulatory options that need further justification and approval
- Challenge Example: ADEQ used the Beta option to process the meteorological data in AERMET to adjust surface friction velocity (ADJ_U*) for a power plant site specific MET data for 1-hr SO_2 designation modeling
  - It is known that AERMOD is intended to over-predict ambient concentrations during stable boundary layer conditions under low wind speeds
  - The over-prediction is partially resulted from the underestimation of U* in AERMET meteorological processor that can be adjusted using the Beta option in data processing

3. Source Inputs- Emissions Inventory

- The emissions inventory contains information about the sources to include in the model. Typically this information is provided by the source:
  - Has the modeling analysis accounted for all of the appropriate sources?
  - Do we need to consider offsite sources?
  - Does the modeling analysis address the proper emission rates?
  - Startup/shutdown emissions need to be addressed
- For SIP attainment demonstration, we need to model future state projected emissions with consideration of all control measures that are defined to bring the area into attainment

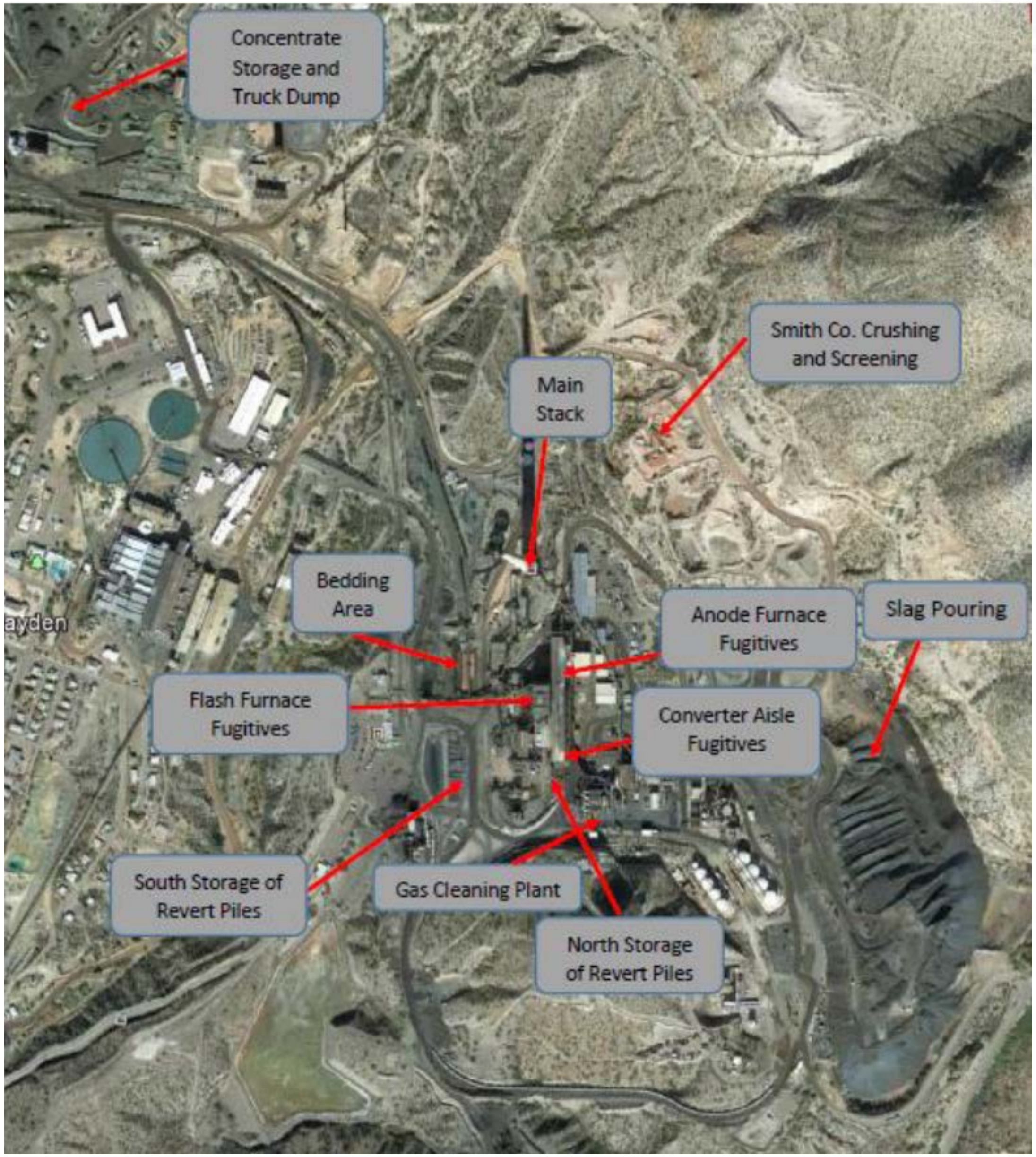
The more accurate the emission inventory is, the more accurate the model predictions are!

3. Source Inputs- Modeling Parameters

- Point source - stacks:
  - Release height, diameter, exit temperature, exit velocity, emission rate
- Volume source – e.g. loading/unloading vehicles:
  - Emission rate, initial vertical and lateral dimensions (δz, δy)
- Area source – e.g. storage piles:
  - Source dimensions (area), release height, emission rate
- Line volume source – e.g. haul roads:
  - Road and vehicle parameters, emission rate
- Flares:
  - Effective exit velocity, effective exit temperature, inside diameter, emission rate
  - The stack height and inside diameter are adjusted to account for the flame height and buoyancy of the plume using the heat release

The more accurate the source parameters are, the more accurate the model predictions are!

Emission Inventory, Continued



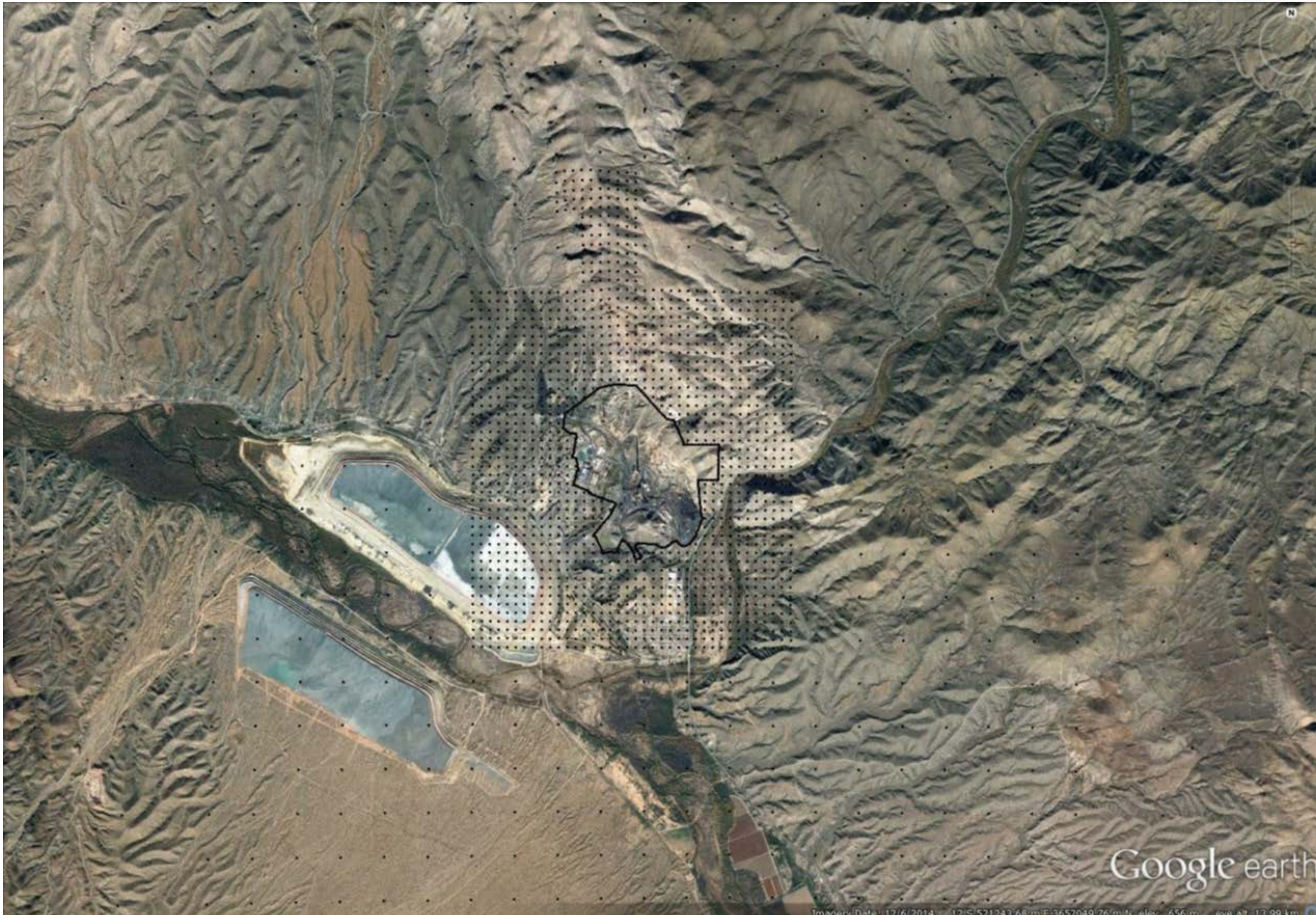
4. Meteorological Data

- Minimum meteorological data (MET data) requirements include wind speed, wind direction, and temperature
- Must be the most recent data and representative of MET conditions of the modeled area
- Minimum 1-year dataset for on-site MET data and 5-year dataset for NWS data
- Challenge Example:
  - Complex source configuration including a 1000 ft stack, three roofline fugitive sources, and various low level and ground level sources
  - The on-site MET data was representative of the stack but not of the ground level sources
  - ADEQ used a hybrid approach to model the stack and rooflines with Camera Hill MET data and the ground level sources with Hayden Old Jail MET data
  - Additional post processing analyses were applied to combine the two modeling results and calculate the final model concentrations.

5. Receptors

- Receptors are user-defined points at the model predicts a concentration. Receptors are defined by X and Y coordinates as well as their elevation above sea level.
- Receptors are placed in ambient air which excludes the area owned or controlled by the source and also an area to which public access is precluded by a fence or other effective physical barrier
  - Example Challenge: assuring EPA of efficient ambient air boundary for FMMI and Asarco Copper Smelters, which needed additional investigation and document preparation
- Receptor spacing criteria

Receptors, Continued



6. Background Concentration

- The predicted concentrations must be added to a background concentration to determine the total concentration. The background concentration is included to account for impacts from natural sources, nearby sources not included in the modeled inventory, and unidentified sources.
- The challenges include:
  - Selection of representative monitor
  - Gathering of monitor data
  - Processing the monitor data
  - Unrealistic background concentration may lead to unrealistic attainment or nonattainment modeling results

Model Review Process for SIP Projects

- Modeling Protocol
  - Document submitted to EPA (in advance of performing the model) describing the modeling approach and supporting methodologies used.
- Modeling Report
  - Organizes and tabulates results, compares and discusses results relative to a standard (e.g. NAAQS) and also any specific issues or deviations from protocol.

Questions?

Farah Mohammadesmaeili, Ph.D, P.E.
Technical Analysis Unit
Air Quality Divsion

E-mail: fm4@azdeq.gov

Office: 602-771-2350

FARAH MOHAMMADESMAEIL, PE, Ph.D.
Senior Environmental Engineer
Arizona Department of Environmental Quality
1110 W. Washington Street
Phoenix, AZ 85007

Phone: 602.771.2350
fm4@azdeq.gov

- Ms. Farah Mohammadesmaeili is a licensed Environmental Engineer and has worked with Arizona Department of Environmental Quality for more than five years. Farah has been performing air quality modeling for state implementation plan (SIP) projects for more than three years.
- Ms. Mohammadesmaeili has a bachelor degree in Chemical Engineering and Masters and PhD degrees in environmental engineering. Before joining ADEQ, Farah worked as a researcher at ASU, adjunct faculty member at Phoenix College, and project engineer in consulting companies.
- Ms. Mohammadesmaeili's other experience includes pollution prevention, environmental impact assessment, and drinking water research projects such as reverse osmosis brine management.