Development and Evaluation of AERMINUTEPlus and Sub-Hourly AERMOD (SHARP*)

*Sub-Hourly AERMOD Run Procedure

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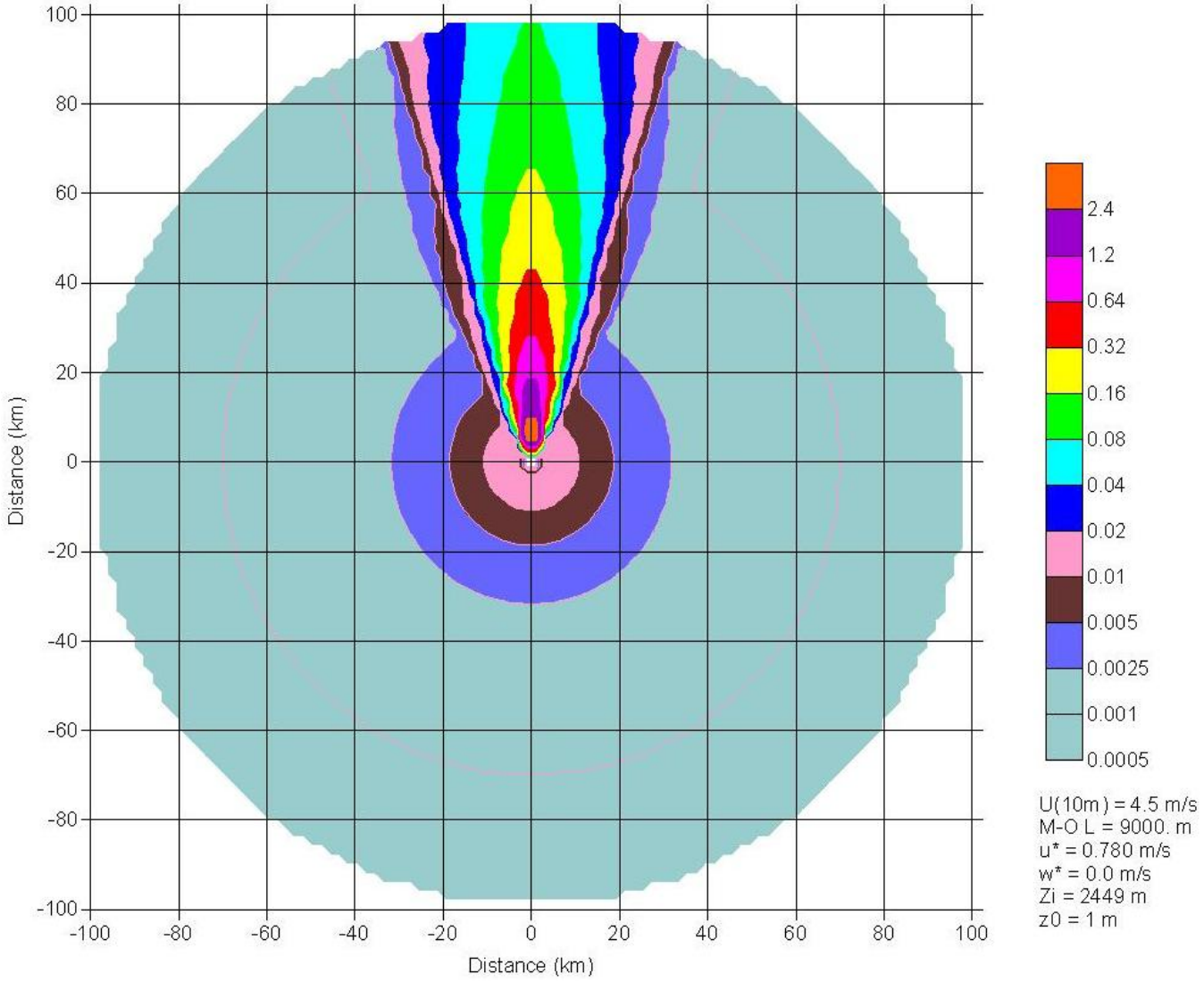
Outline of Presentation

- Development of AERMINUTEPlus and SHARP
- Databases Selected for Limited Evaluation of SHARP
- Test Procedures using standard AERMOD vs. SHARP
- Preliminary Evaluation Results

Why develop a sub-hourly AERMOD Capability?

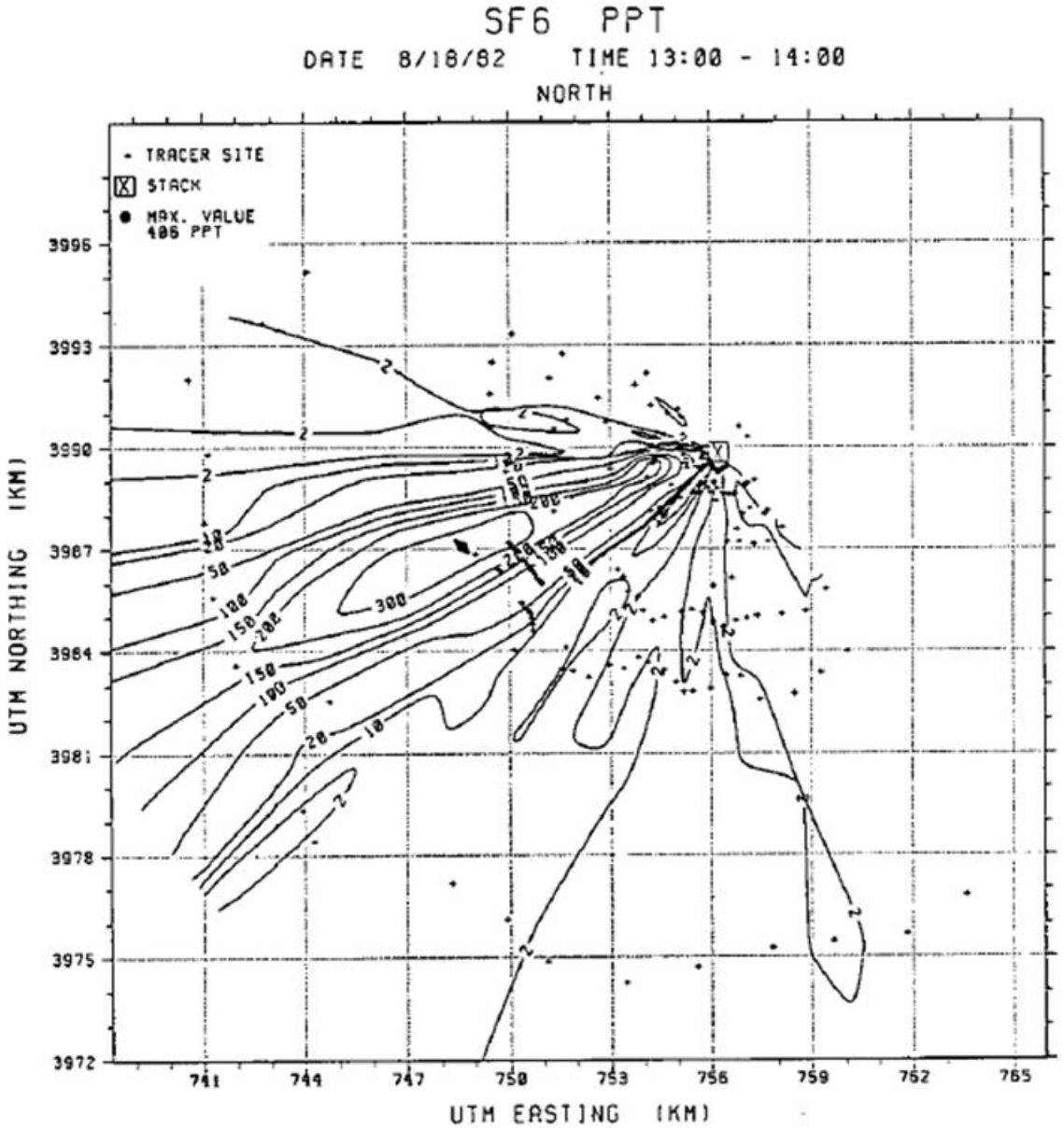
- Sub-hourly meteorological data is now routinely available from both on-site met and 1-minute ASOS
- Hourly AERMOD predictions for low wind speeds overstate impacts from coherent plume
- In low winds, winds can go in several directions during an hour, resulting in multiple concentration "lobes"

Depiction of AERMOD Coherent and Meander Plume Impacts in Low Winds

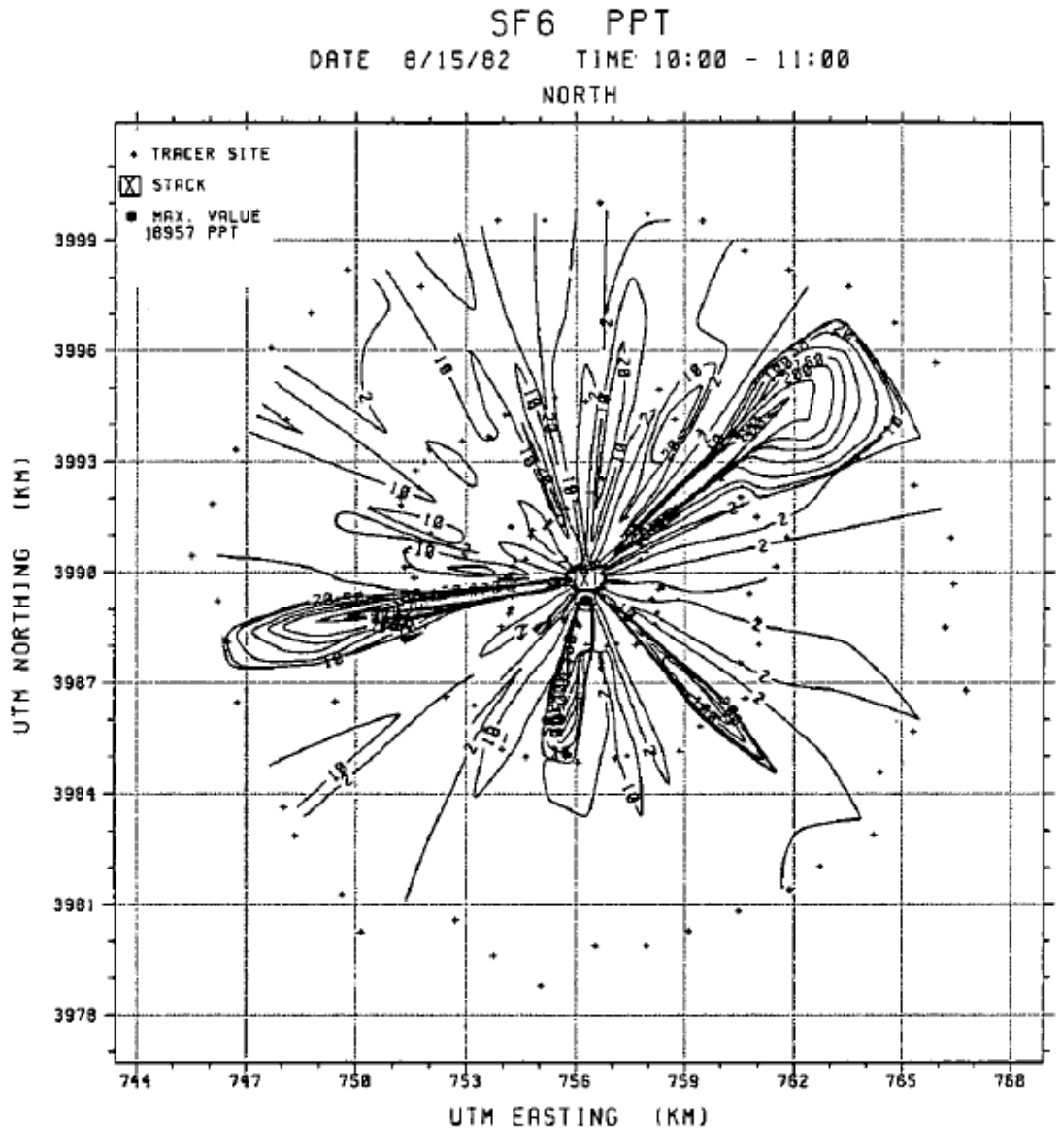


*source: slide #48 presented by Joe Scire at EPA's Ninth Modeling Conference, available at http://www.epa.gov/ttn/scram/9thmodconf/scire_calpuff.pdf

Coherent Plume Concentration Footprint from EPRI 1982 Bull Run Field Study



Fluctuating Plume Concentration Footprint from EPRI 1982 Bull Run Field Study



New Procedure: AERMINUTEPlus

- AERMINUTE has been enhanced to output sub-hourly wind averages – we call this "AERMINUTEplus"
- Wind averaging procedures are consistent with EPA's AERMINUTE
- Sub-hourly periods are user-specified – from as high as 30 minutes each to as low as 2 minutes each
- Multiple output files look like hourly data, but represent a specific portion of each hour

New Procedure: Sub-Hourly AERMOD Run Procedure (SHARP)

- Step 1: Output from AERMINUTEplus is used to run AERMOD multiple times for each portion of hour
- Step 2: Output concentration files are averaged using AECOM's "BINMERGE"
- BINMERGE configured to process calm periods consistent with AERMOD's approach
- Step 3: Resulting merged concentration file is input to "POST1HR" to obtain required design concentrations for AERMOD

Evaluation of SHARP: Database Selection Process

- Requirements
  - involve tracer release from single stack, avoid building downwash issues
  - Need sub-hourly meteorological data
- Desirable attributes of databases
  - Significant plume meander cases
  - Mixture of low-level and elevated sources
  - Mixture of stable and unstable conditions
  - Predominance of light winds

Initial Databases Selected

- Three Mile Island SF_6 tracer releases (1971)
  - Very stable conditions, light winds
  - Low-level release, some non-downwash cases
  - Sub-hourly meteorology available
  - 5 hours of releases available; one sampling arc
  - Smoke releases helped to determine plume transport
- Bull Run SF_6 tracer releases (1982)
  - Dominated by unstable conditions, light winds
  - Tall stack releases, no downwash
  - 5-minute meteorological data available
  - 162 hours in developmental portion of database
  - Several sampling arcs from 0.5 to 50 km
  - Since hourly AERMOD is known to perform well, this is a large challenge for SHARP

TMI Depiction of SF_6 Conc. and Wind Directions:

Sample trial: the "spoke" lengths are proportional to concentrations

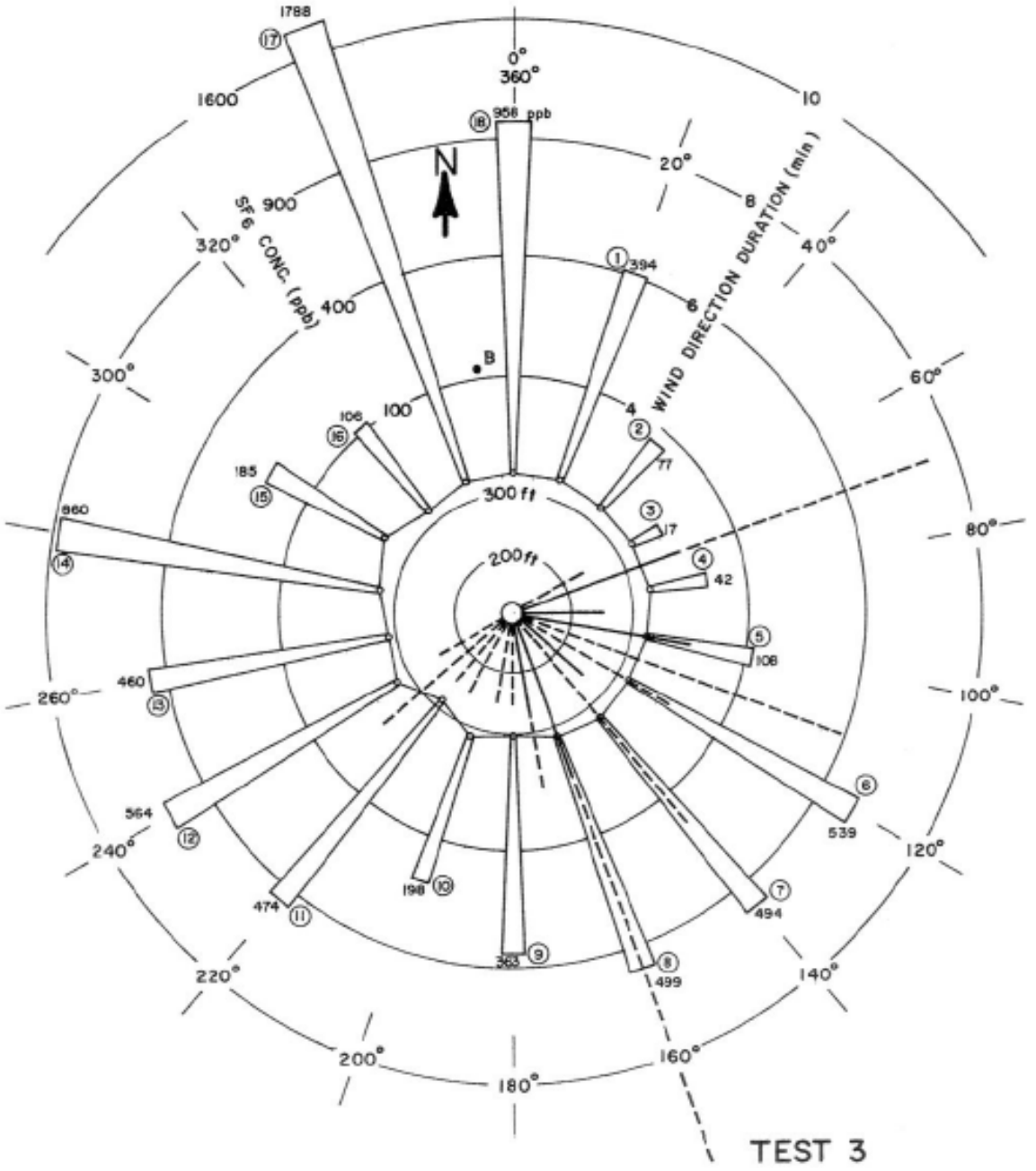


Figure 9
SF_6 Concentrations and Wind Direction Durations: Test 3

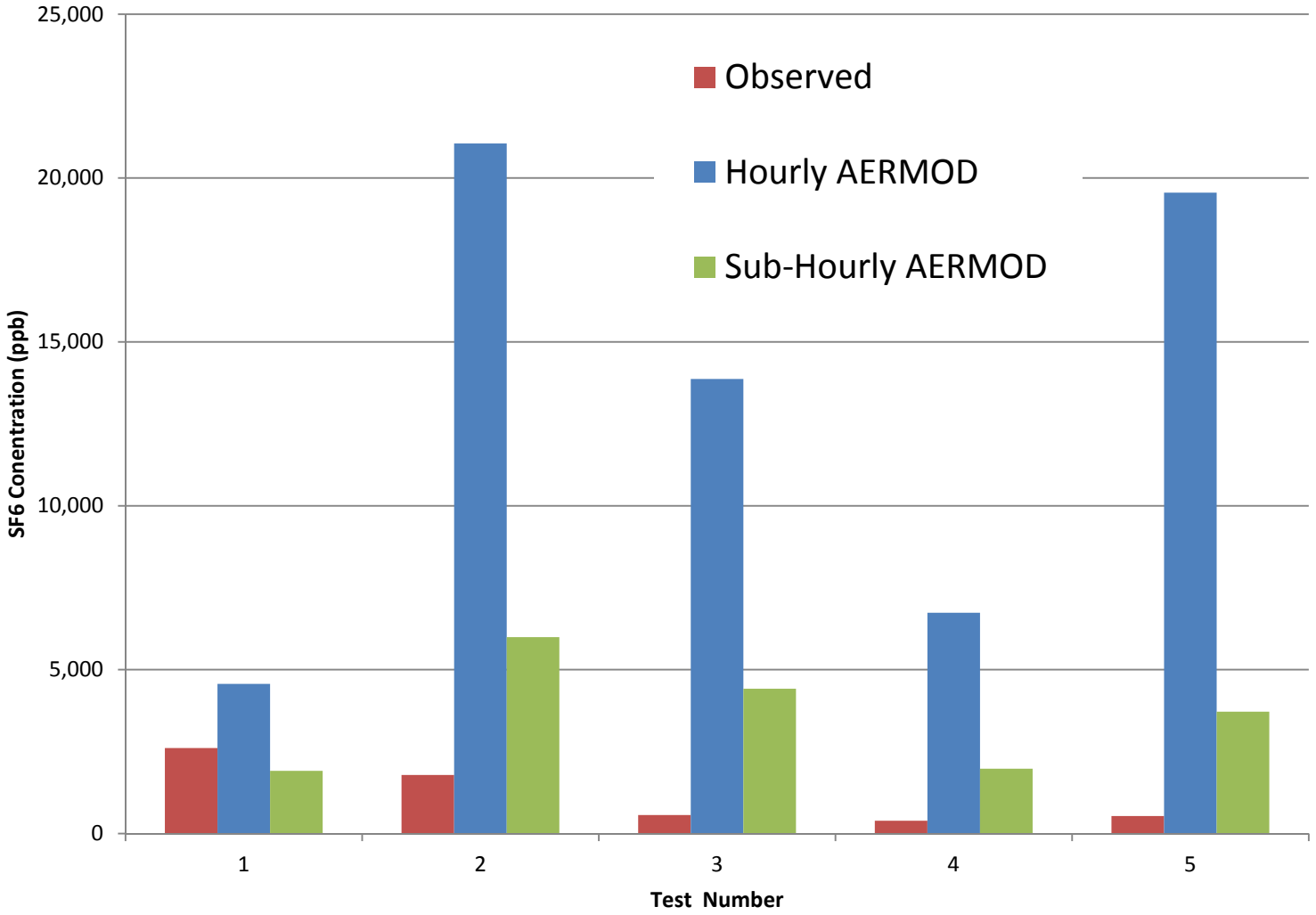
Modeling Procedures

- Ran AERMOD for both hourly average meteorology and sub-hour meteorology (5-minute periods)
- For hourly runs, directed the plume toward the sampler with the highest observation
- For sub-hourly runs, did not vary the wind directions in order to take advantage of the additional wind meandering information

Model Performance Testing

- For each sampling arc and hour, determined the peak observed and predicted concentration (C_o and C_p)
- Over all hours and arcs, determined the following statistics for observed vs. predicted peaks:
  - Fractional bias = 2* avg(C_p – C_o) / avg (C_p + C_o)
  - Percent of predictions within a factor of 2 of observed
  - Normalized Mean Square Error = avg[(C_p-C_o)^2] / [avg(C_p) * avg(C_o)]
- For all concentrations on each arc, tested "goodness of fit": is observed plume footprint wider or narrower than predicted plume footprint?

Results for Three Mile Island: Maximum Concentration on Arc



Three Mile Island Overall Results

- Average predicted/observed ratio:
  - 12.6 for hourly model
  - 3.7 for 5-minute sub-hourly model
- Goodness of fit results for plume footprint coverage: % of values (pre. or obs.) on arc with conc. more than 50% of peak:
  - Observations: ~14% of the values
  - Hourly model: ~7% of the values (footprint too “tight”)
  - 5-minute sub-hourly model: about ~16% of the values
  - Based upon overall results, larger sub-hourly period (e.g., 10 minutes) might have a better match to observed fit

Bull Run Overall Results

- Most cases feature convective conditions; hourly AERMOD model performs well due to fairly large plume spreading
- Range of predicted/observed ratio for arcs between 1-20 km (upper portion of observations):
  - 0.7 to 1.8 for hourly model
  - 0.5 to 1.2 for 5-minute sub-hourly model
- Goodness of fit results for plume footprint coverage - % of values (pre. or obs.) with conc. more than 50% of peak (2-km arc):
  - Observations: ~25% of the values
  - Hourly model: only ~18% of the values (footprint too “tight”)
  - 5-minute sub-hourly model: about 29% of the values
  - Based upon overall results, larger sub-hourly period (e.g., 10 minutes) could be tested for a better match to observed fit (and more unbiased predictions)

Concluding Remarks

- Sub-hourly AERMOD capability has been developed
- Limited evaluation has been done on two databases
- Stable, light wind database clearly shows need to correct AERMOD overpredictions for hourly averaged data – consistent with other research
- AERMOD hourly predictions perform much better in unstable conditions, but some cases with scattered winds could benefit from sub-hourly modeling
- Hourly predicted plume footprint “too tight”, especially in stable conditions
- 5-min sub-hourly plume footprint “too loose”
- Best sub-hourly averaging time might be ~10 minutes
- Further testing is recommended