Short-Range Model Distance Applicability Study

Bob Paine, AECOM

Presented at the 10th EPA Modeling Conference, March 15, 2012

Sponsored by EPRI ELECTRIC POWER RESEARCH INSTITUTE AECOM

Outline of Presentation

- Limitations of Short-Range Models
- Equivalency Between Puff and Plume Models (CALPUFF vs. AERMOD and ISC)
- Puff Trajectory Analysis: Steady-State vs. Non-Steady-State
- Concentration Comparison: Steady-State vs. Non-Steady-State
- Conclusions and recommendations

Limitations of Steady-State 1-Hour Dispersion Models

- Plumes are assumed to travel to infinite distances within 1 hour (“lighthouse beam” effect)
- Each hour, the previous hour’s emissions are replaced and forgotten
- Worst-case conditions, especially associated with low winds, are persisted to impossible distances
- Currently, though, US EPA considers these models to be applicable to a rather arbitrary distance of 50 km
- This study tried to more carefully quantify a reasonable distance for applicability of these models (such as AERMOD or ISC)

Equivalency Between AERMOD and CALPUFF

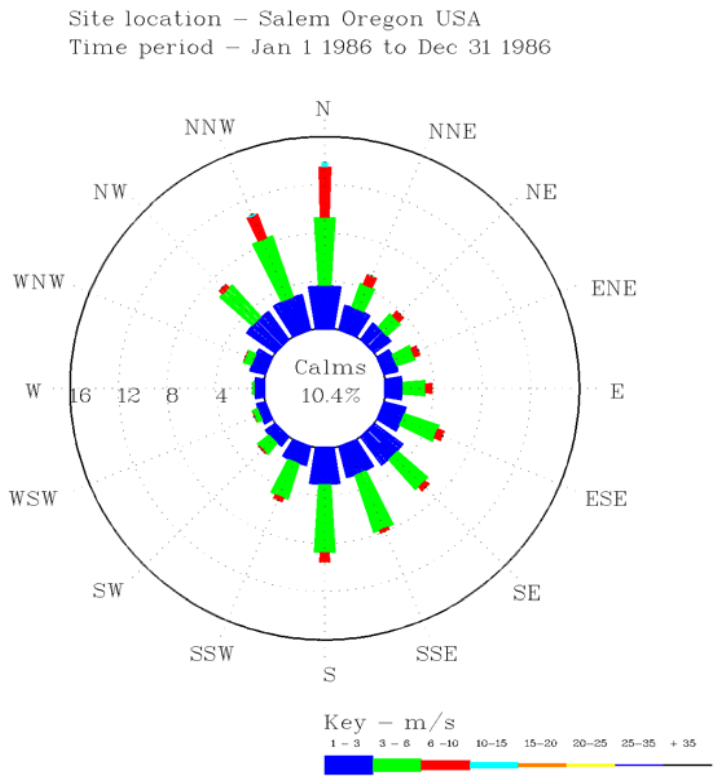
- One way to test the limits of steady-state models is to use a non-steady-state model (e.g., CALPUFF) that can be made equivalent to a steady-state model for constant meteorological conditions
- Then, running identical hourly met data through both models will provide an indication of distances where the model results significantly diverge
- Equivalence was not found to be possible between AERMOD and CALPUFF – model formulation differences are simply too great (especially for convective conditions)

Equivalency Between ISC and CALPUFF

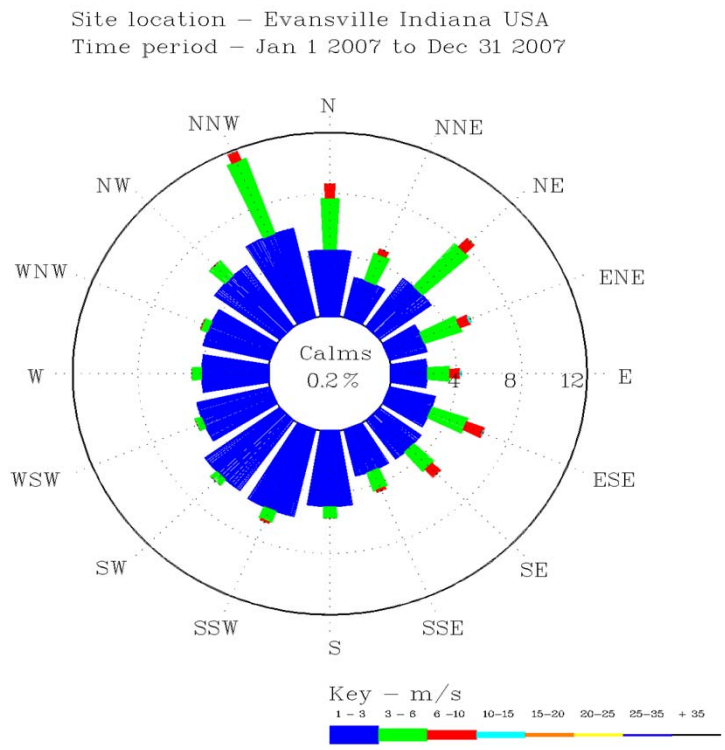
- Good results for equivalence between ISC and CALPUFF were obtained
- 108 met conditions were tested for various source types for distances out to 50 km – flat terrain assumed
- For these conditions, EPA has found that AERMOD and ISC have similar predictions
- Best results occurred for nonbuoyant sources, since there are some plume rise differences between the models
- Release heights of 35 and 100 meters showed good results; peak differences not exceeding 4% (and usually less than 2%) for distances beyond 2 km

Met Data Locations Tested

- Selected 2 sites: Salem, Oregon and Evansville, Indiana
- Salem features N-S valley channeling, while Evansville is flat



Salem, Oregon

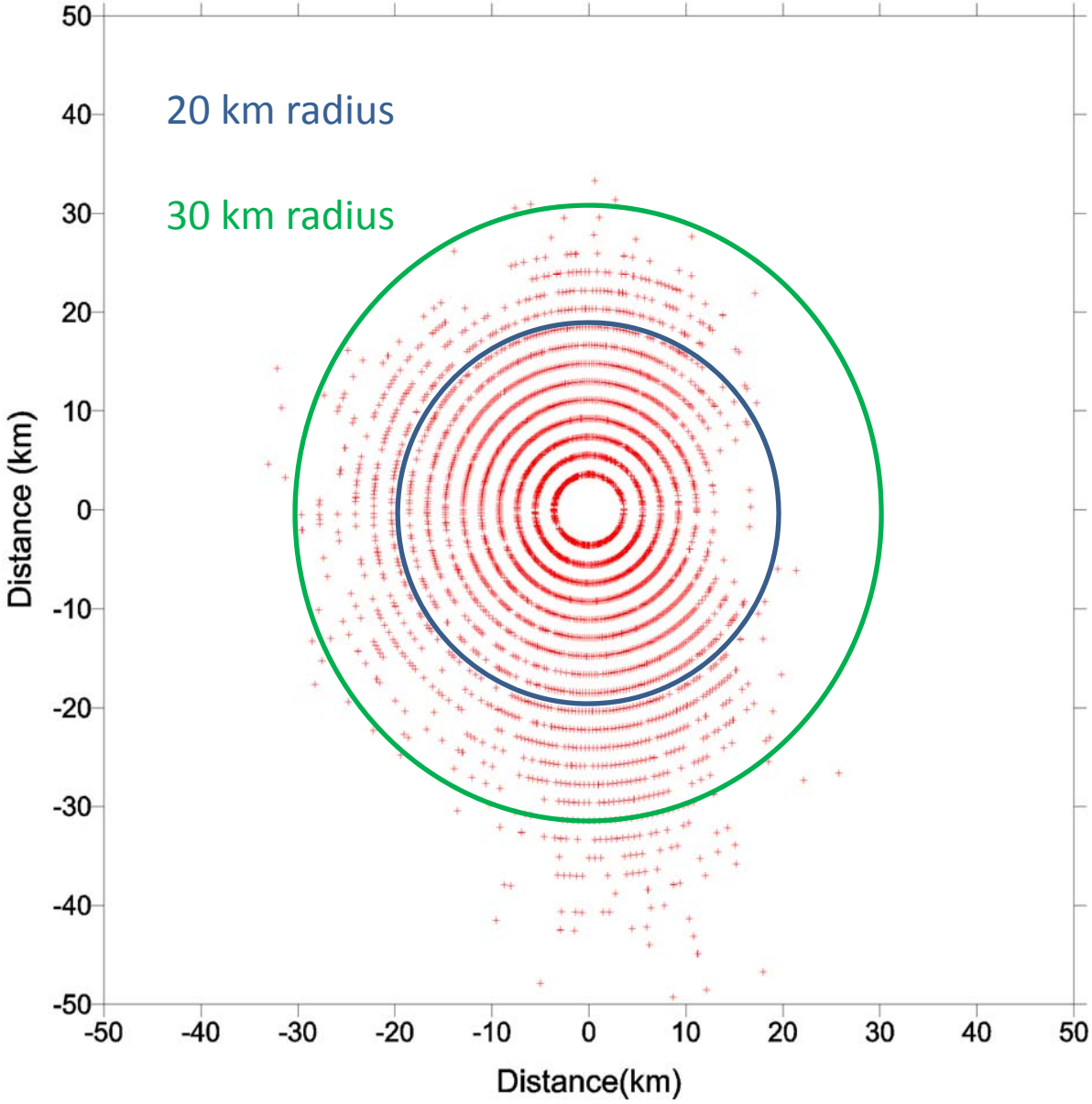


Evansville, Indiana

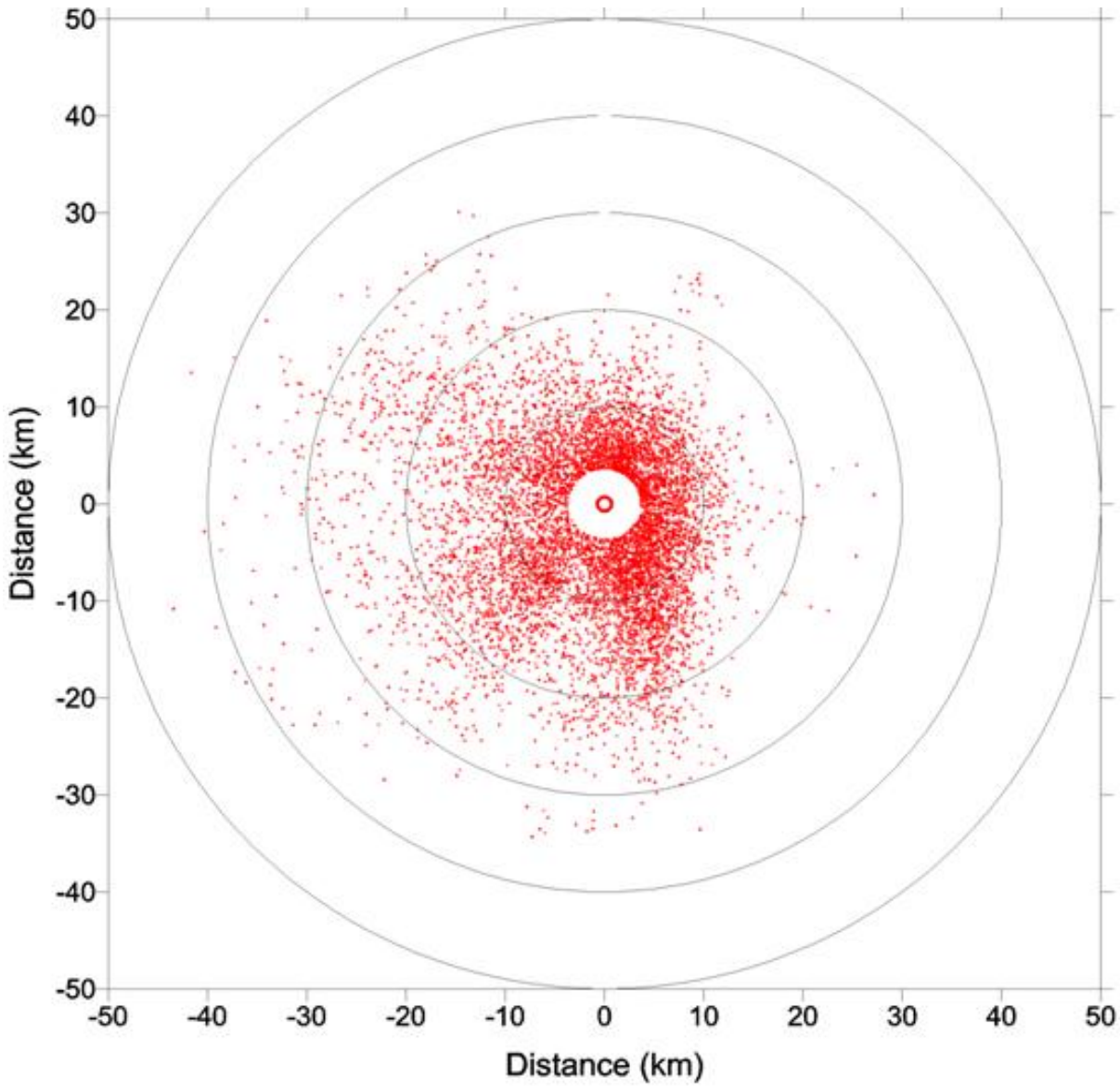
Transport Distances After "N" Hours

- We conducted a segmented plume analysis by connecting hourly time travel using the 10-m met data
- After the air parcels left a 100 km x 100 km domain, they were not further tracked
- We determined the distance traveled after N hours
- Basic findings:
  - Plume travel is generally limited to within 20-30 km or less within an hour (more than 90% of the time)
  - After several hours, the majority of air parcels can still be located within 50 km of the release point
  - These air parcels can certainly follow non-straight trajectories

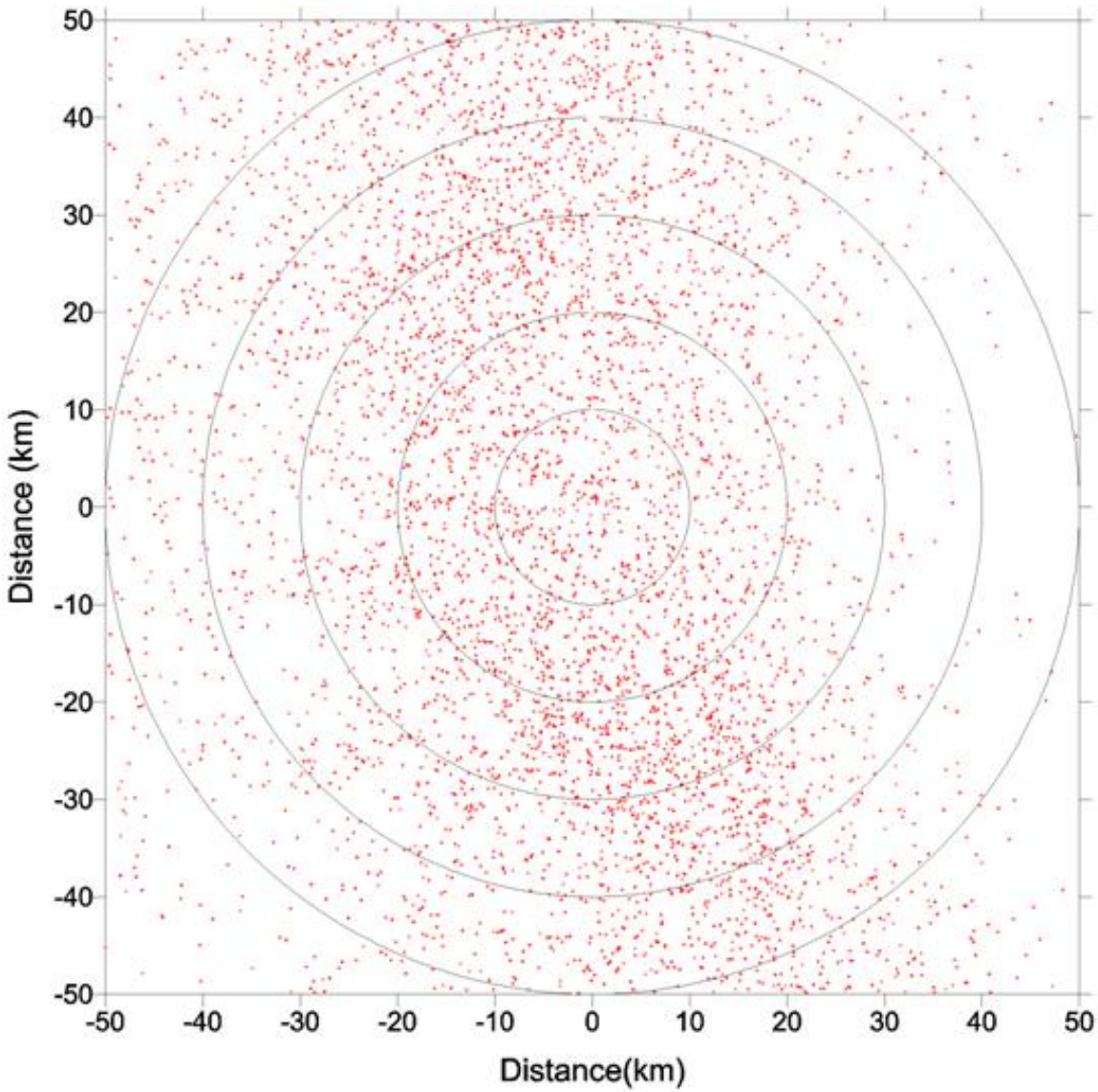
Trajectory Endpoints after 1 Travel Hour – Salem, OR Meteorology



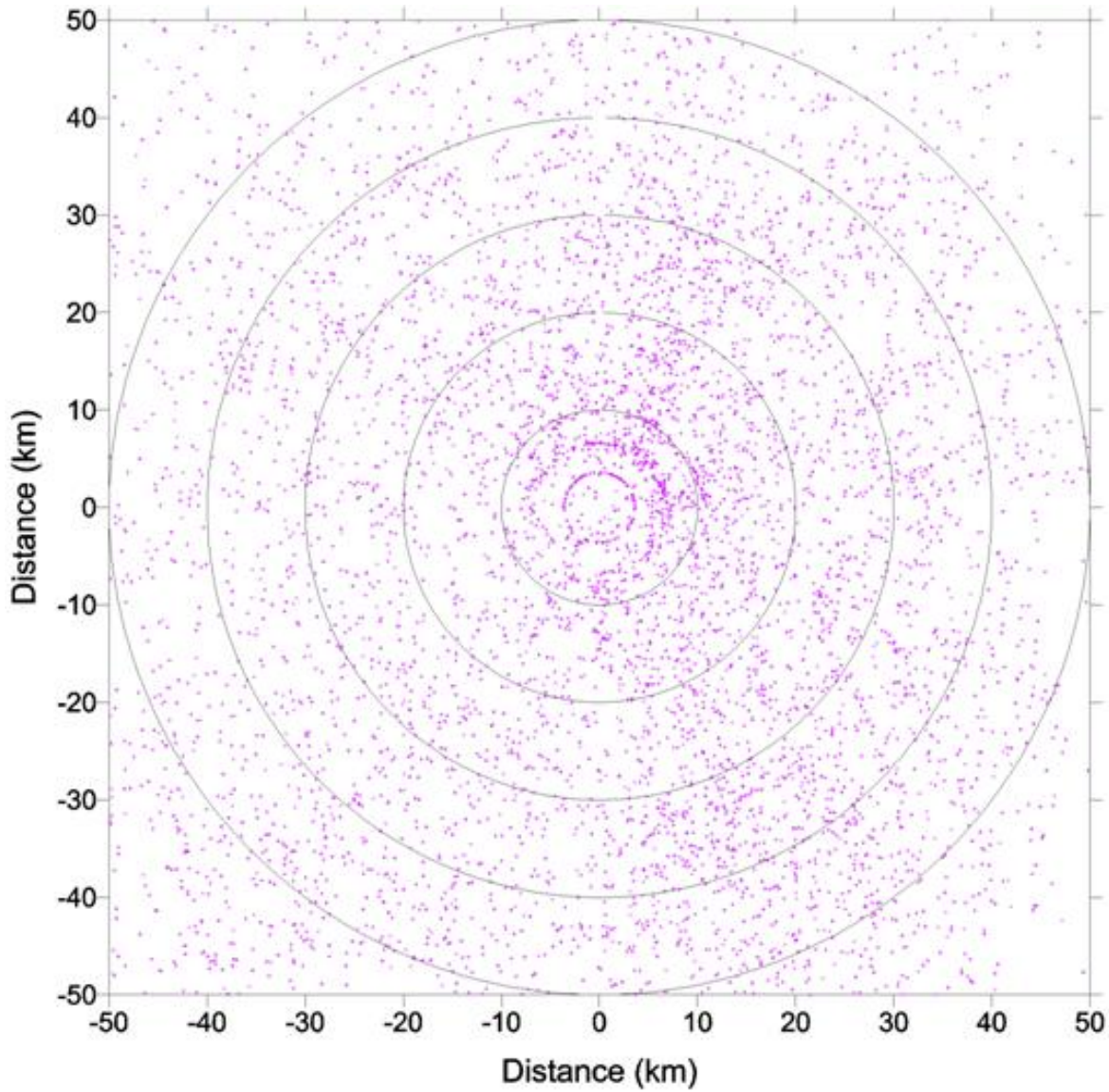
Trajectory Endpoints after 1 Travel Hour – Evansville, IN Meteorology



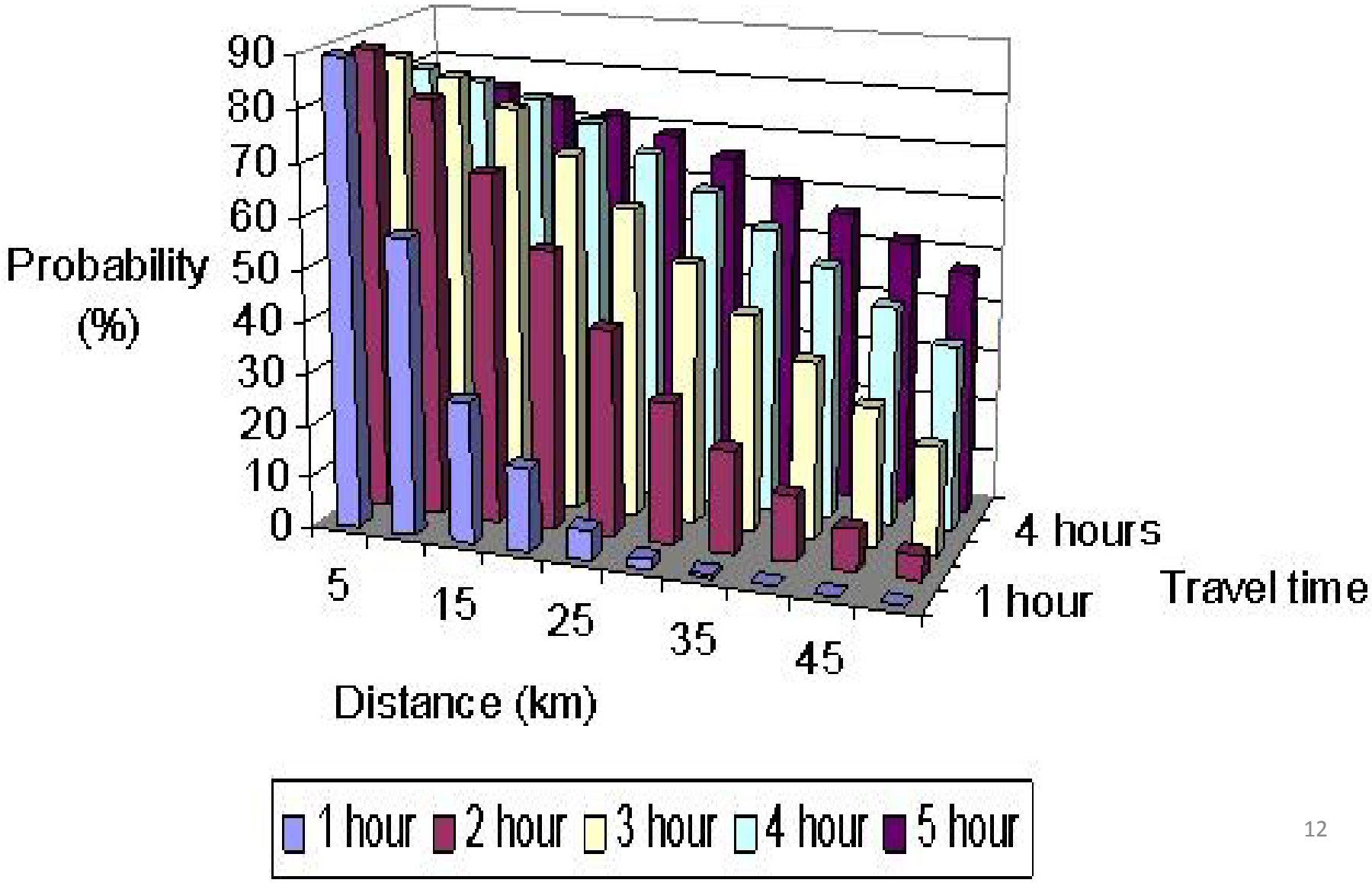
Trajectory Endpoints after 5 Travel Hours – Salem, OR Meteorology



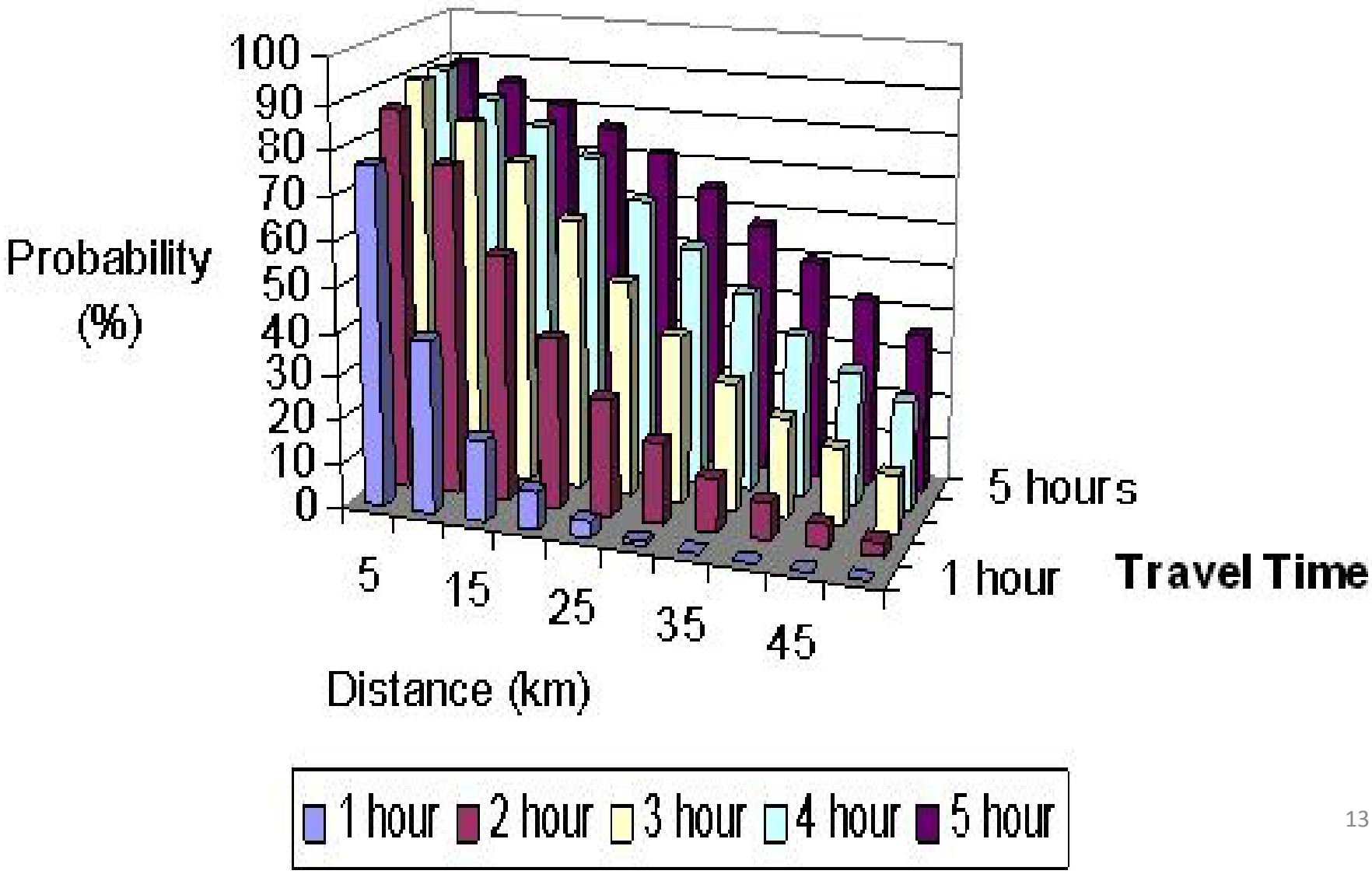
Trajectory Endpoints after 5 Travel Hours – Evansville, IN Meteorology



Probability that 10-m winds reach various distances for Salem, OR 1986 met data



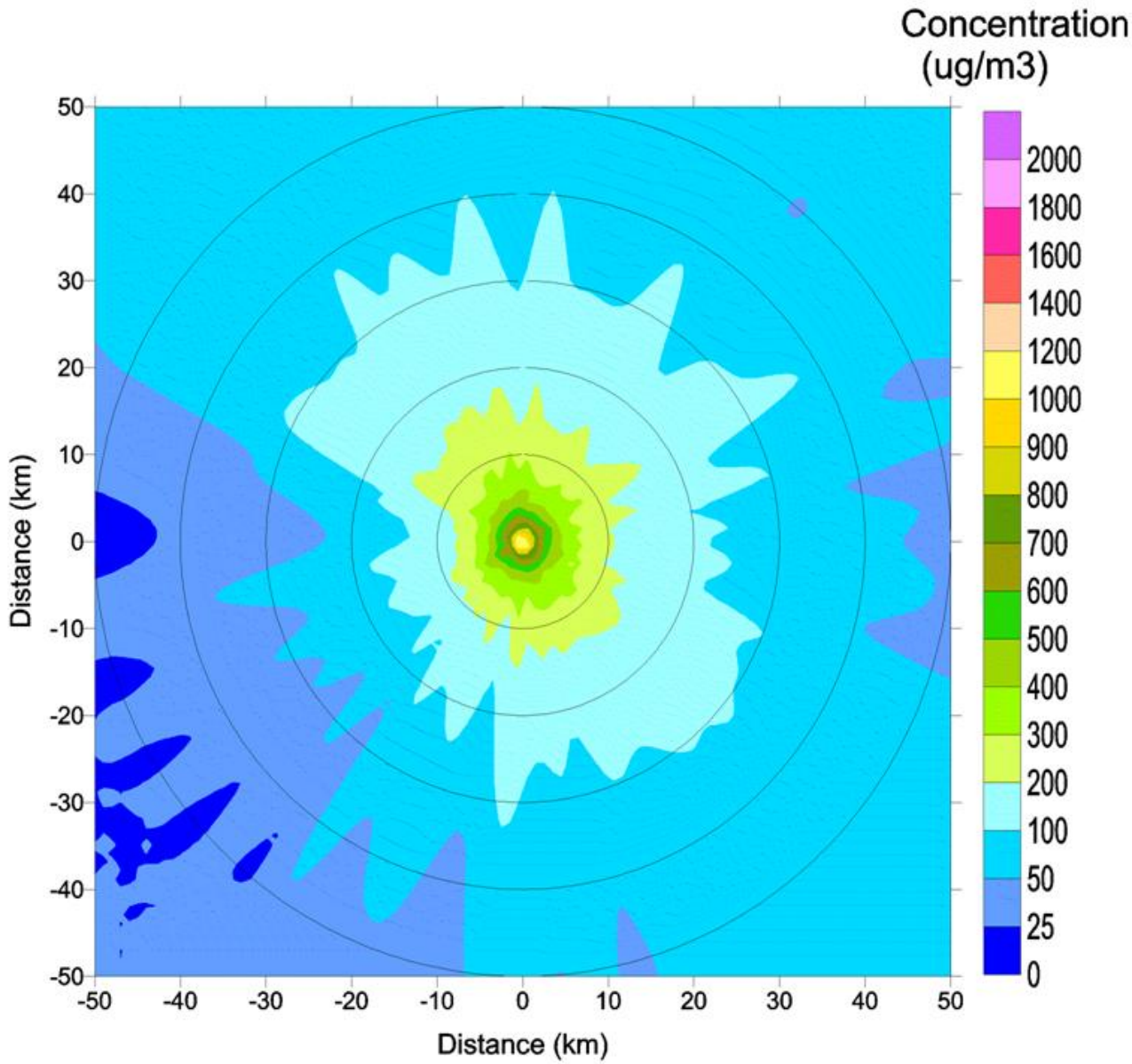
Probability that 10-m winds reach various distances for Evansville, IN 2007 met data



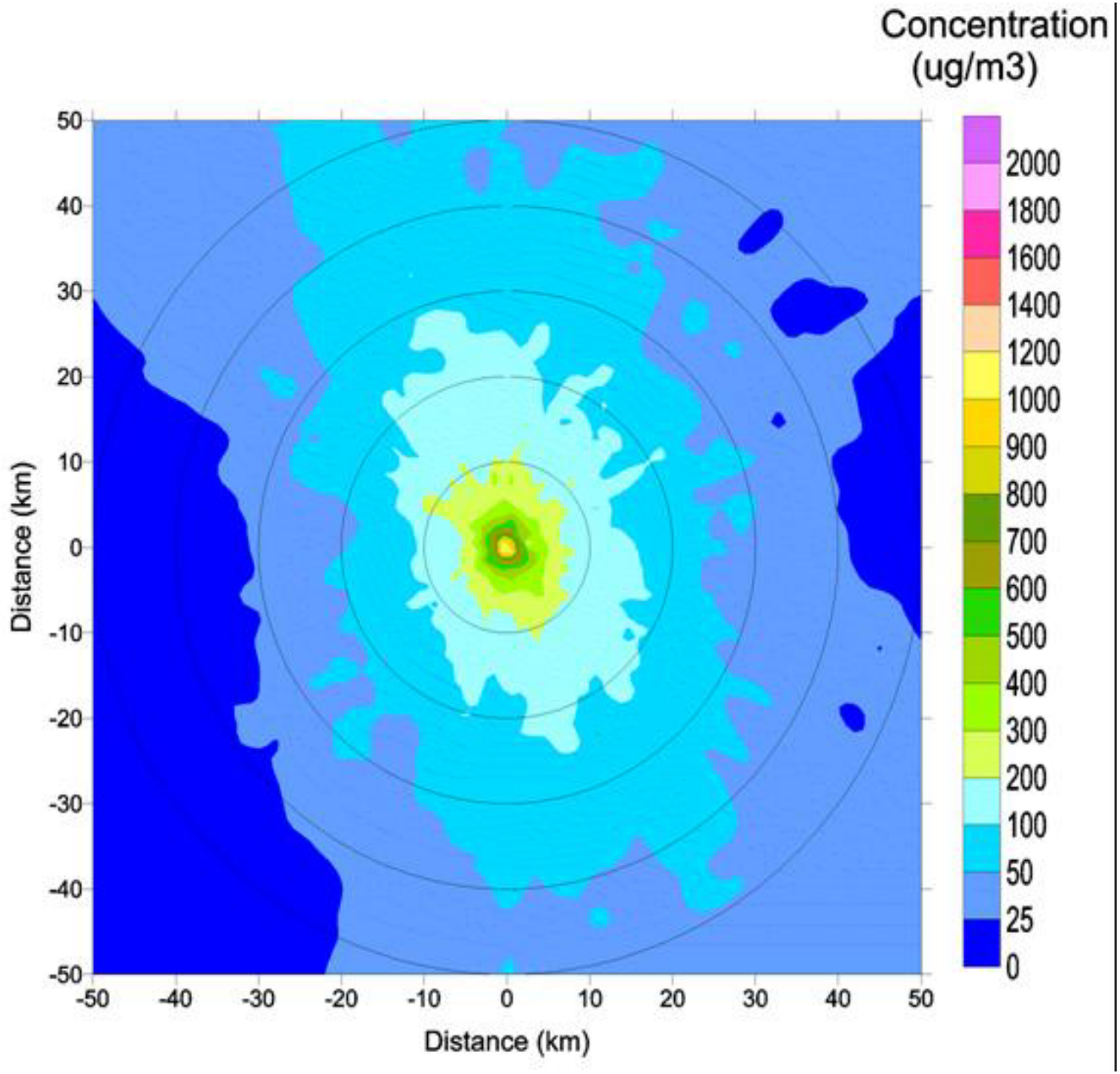
Comparison of Model Predictions

- CALPUFF was run in ISC-equivalent mode along with ISC for Salem and Evansville met, assuming flat terrain
- Reference emission rate of 100 g/s from non-buoyant 35-m stack was modeled
- Polar receptors extended to 50 km
- 100th, 99th, and 98th daily 1-hour max concentrations were computed at each receptor
- Comparisons between the two model results are shown below for the 99th percentile (4th highest) values

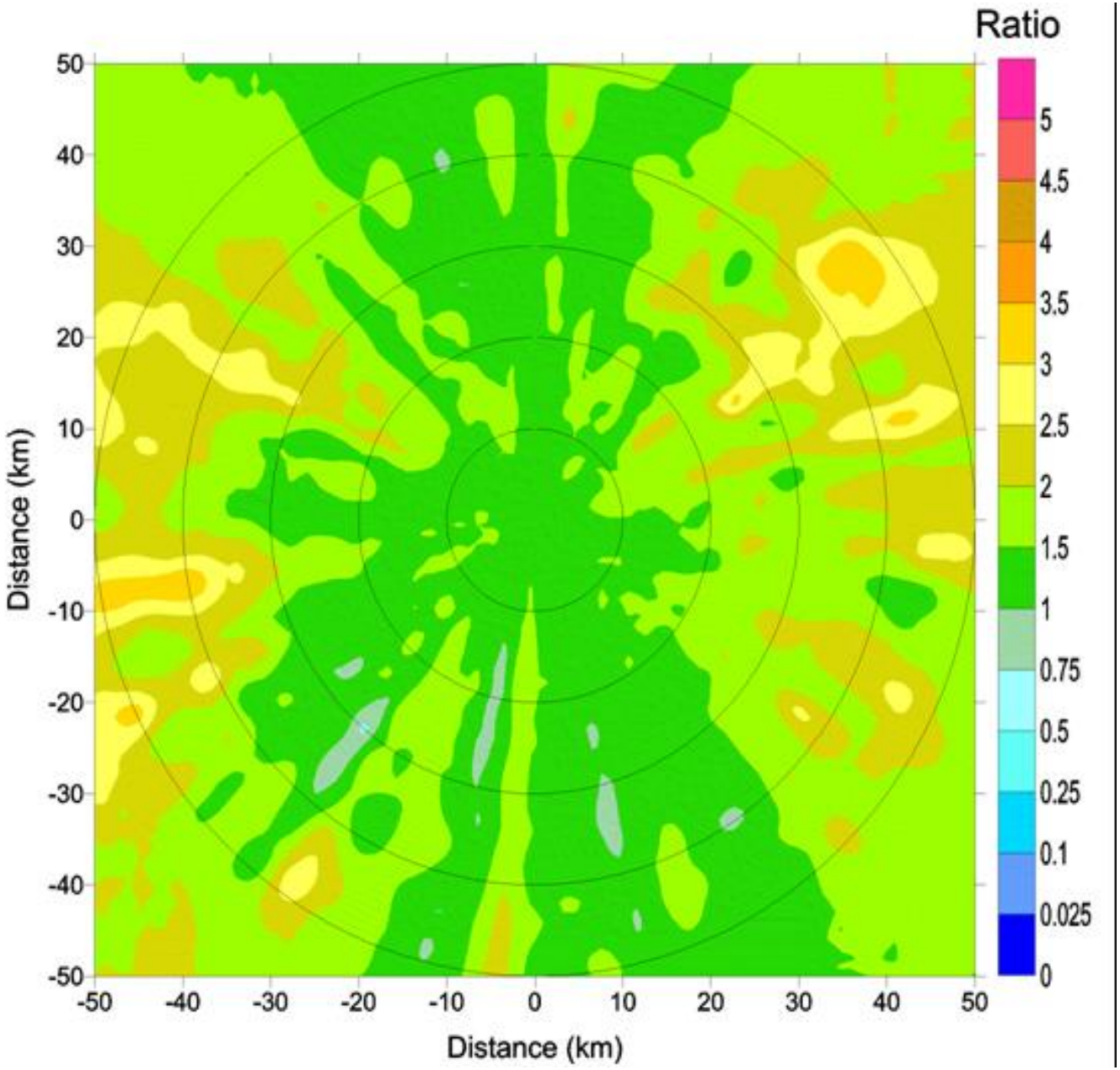
H4H 1-hr ISC Concentrations: Salem, OR



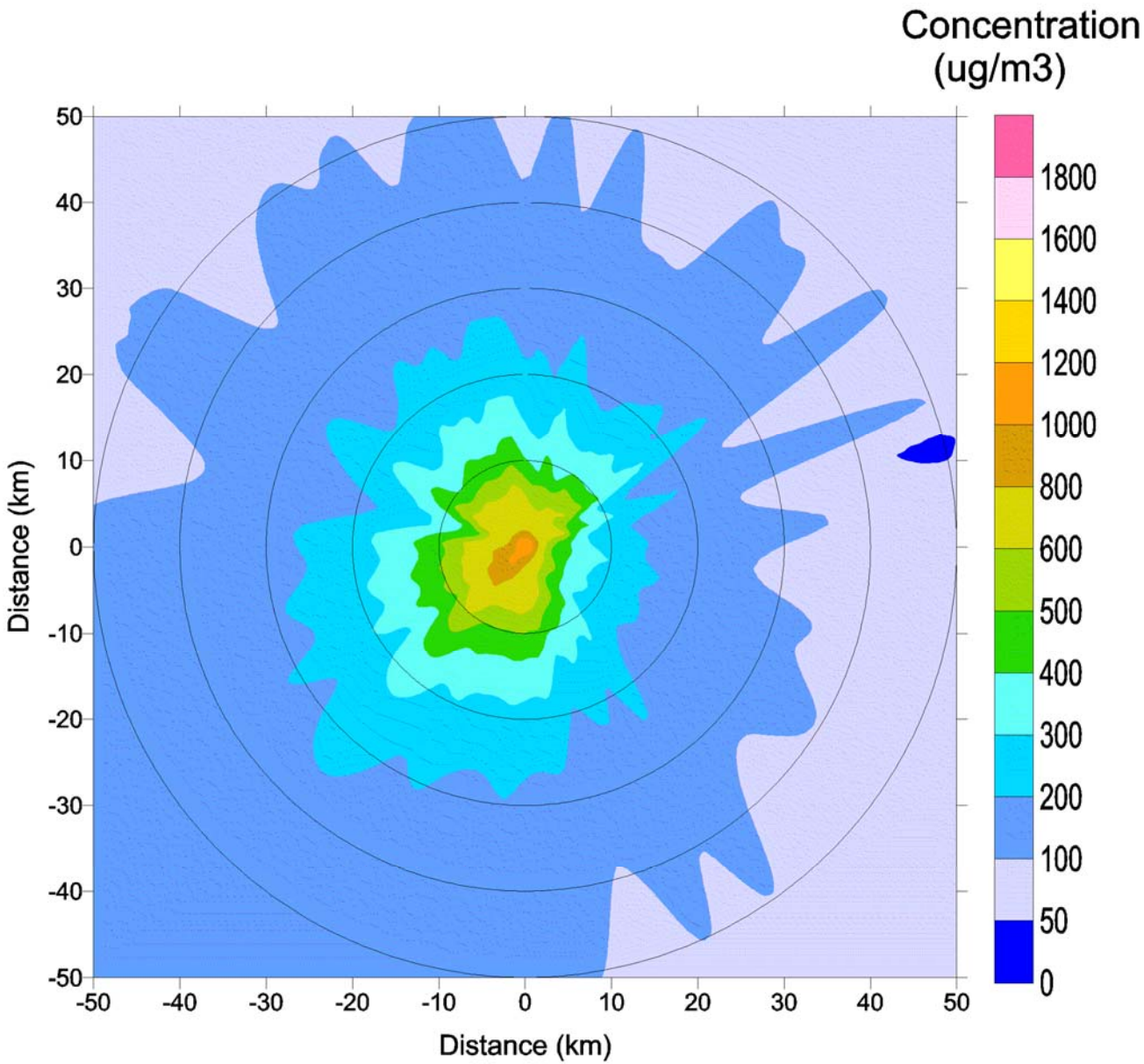
H4H 1-hr CALPUFF Concentrations: Salem, OR



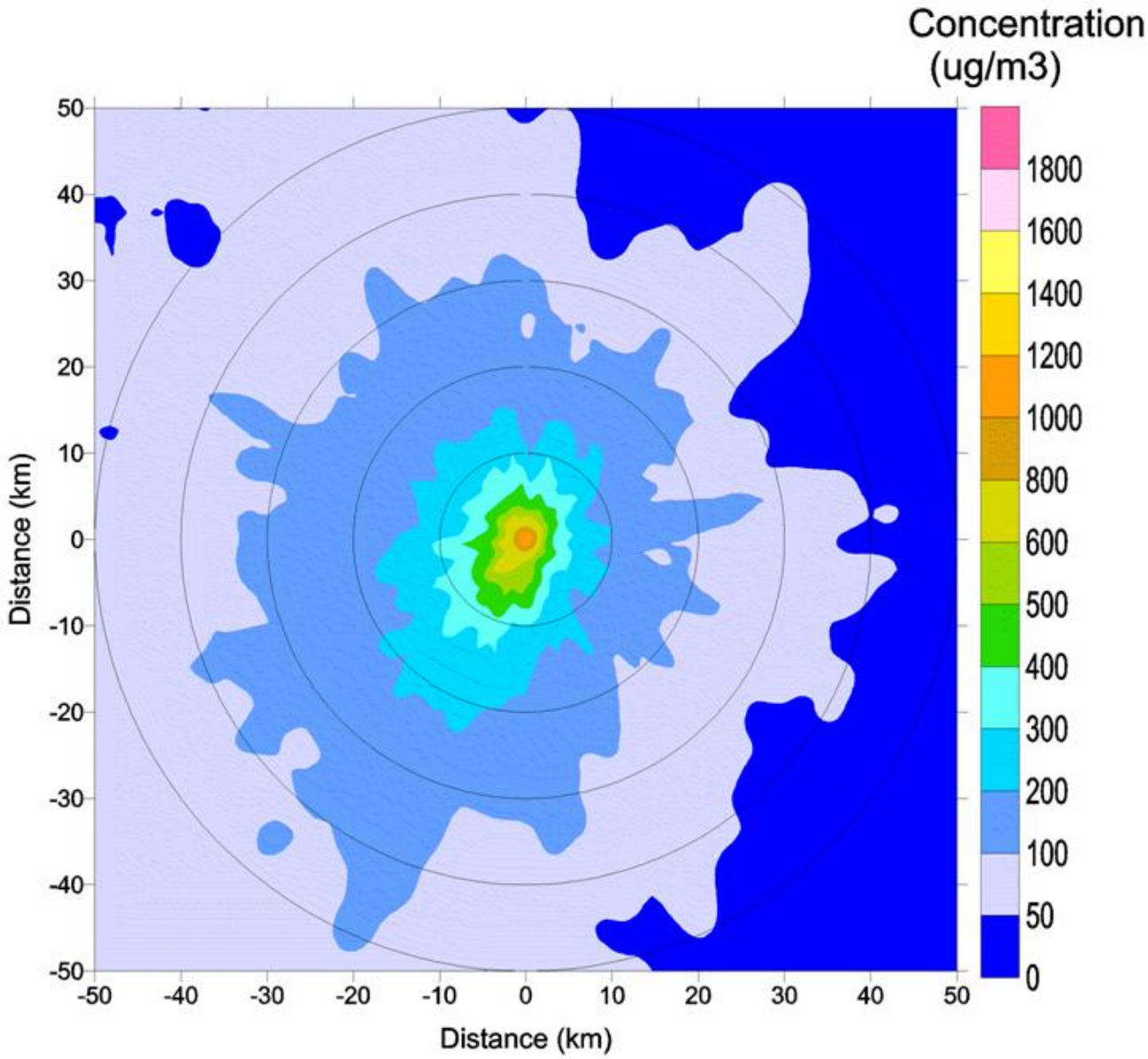
Ratio: ISC/CALPUFF H4H 1-hr at Salem, OR



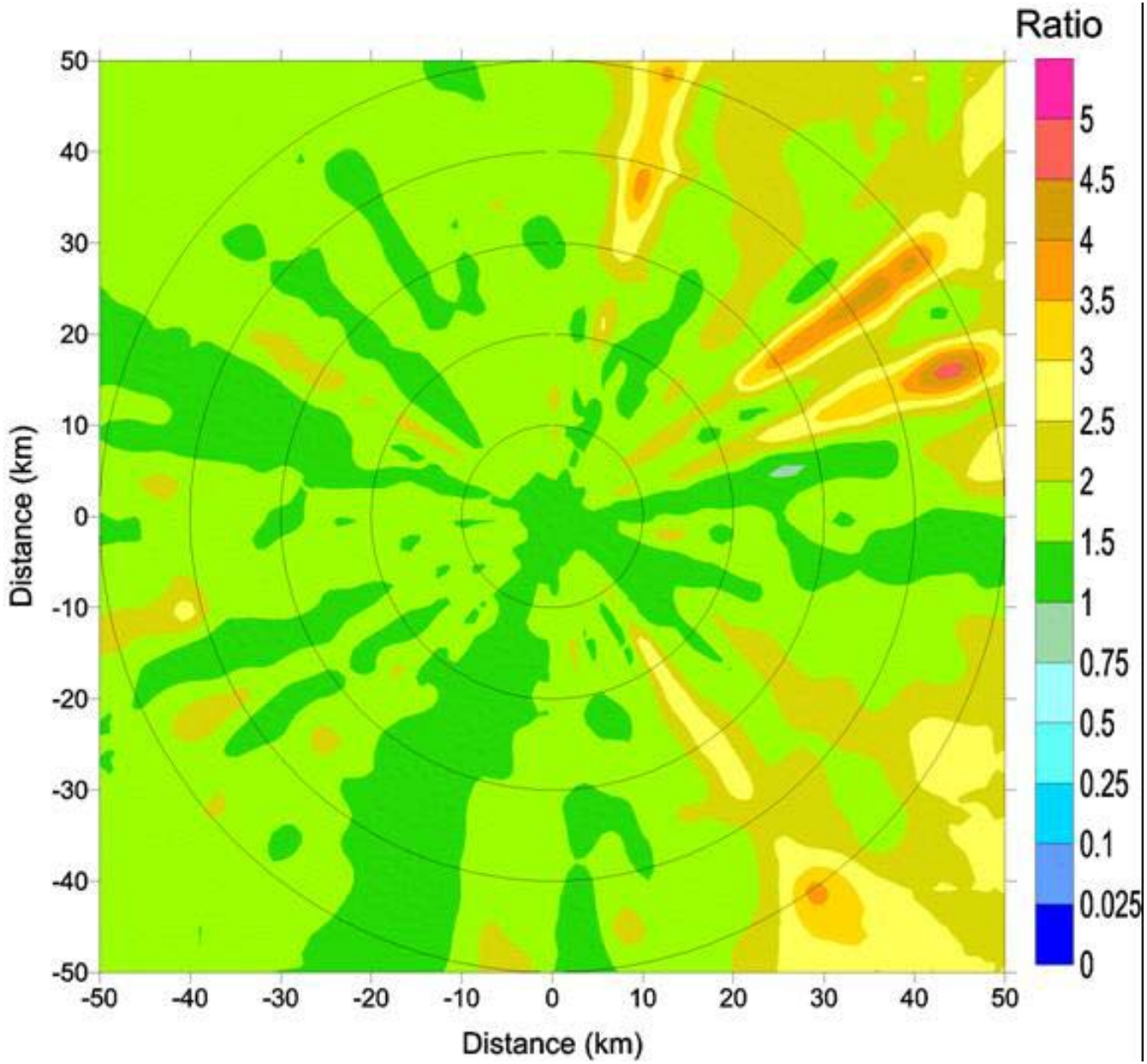
H4H 1-hr ISC Concentrations: Evansville, IN



H4H 1-hr CALPUFF Concentrations: Evansville, IN



Ratio: ISC/CALPUFF H4H 1-hr at Evansville, IN



Conclusions

- Results were similar for both met databases
- ISC/CALPUFF concentration ratios are close to 1 within 5 km and within a factor of 2 within 20 km
- Beyond 20 km, there are some directions where this ratio can significantly exceed 2 – higher differences may be possible for real terrain applications
- 20-30 km is the extent a single hour's travel for most of the hours
- Even after 4-5 hours, more than half of air parcels followed with a 10-m wind are still on the 50-km modeling domain

Conclusions - continued

- Results suggest that a 20-km limit seems more appropriate for steady-state model (e.g., AERMOD) applicability rather than the current limit of 50 km
- AERMOD should provide information to users regarding hourly plume travel time
- We are working on providing this information in an enhanced version of AERMOD to be provided to EPA
- Useful information will be provided for each source for each hour of simulation, referencing the distance to the receptor with the peak modeled impact