# Use of Photochemical Grid Modeling to Quantify Ozone Impacts from Fires in Support of Exceptional Event Demonstrations

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# Presentation Outline

- Background
  - Exceptional Events
  - Flint Hills Fires
- Methodology
  - BlueSky Gateway
  - Fire Emissions Processing
- Results
- Conclusions

# Smoke and Air Pollution

- Smoke from fires contains $PM_{2.5}$, $NO_x$, and VOCs, and other pollutants.
- Smoke from fires is associated with negative health effects.
- Fire events can trigger violations of the ozone and PM NAAQS.

Fire in Wabaunsee County, Kansas

# Exceptional Events

- Unusual or naturally occurring events that affect air quality but are not reasonably controllable or preventable.
- EPA has considered wildland and prescribed fires as exceptional events under some circumstances.
- States can flag data to be excluded from regulatory determinations by demonstrating to EPA's satisfaction that the measurements were influenced by an exceptional event.
- Technical evidence of such influences must be submitted to EPA as a **demonstration package**.

# Exceptional Event Demonstrations

- Must include analyses showing that *no NAAQS exceedance would have occurred* ***"but for"*** *the exceptional event*.

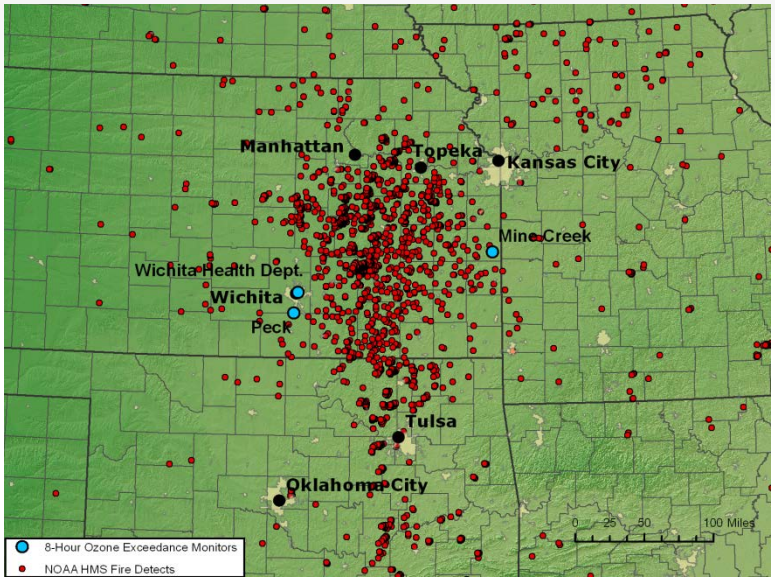
- "But for" demonstrations typically must provide quantitative assessment of ozone levels with and without fire.

- Because ozone is a secondary pollutant, meeting the "but for" requirement is particularly challenging.

- This talk describes **numerical modeling** used to support an exceptional event demonstration for the Kansas Department of Health and Environment (KDHE).

# Flint Hills Prescribed Burning

- Land management practice in the Kansas Flint Hills region.
- Approximately 2,000,000 acres of rangeland burned each spring (March and April).
- Several NAAQS exceedances for ozone in April 2011.
- Analysis focuses only on the scientific aspect of exceptional event demonstration.

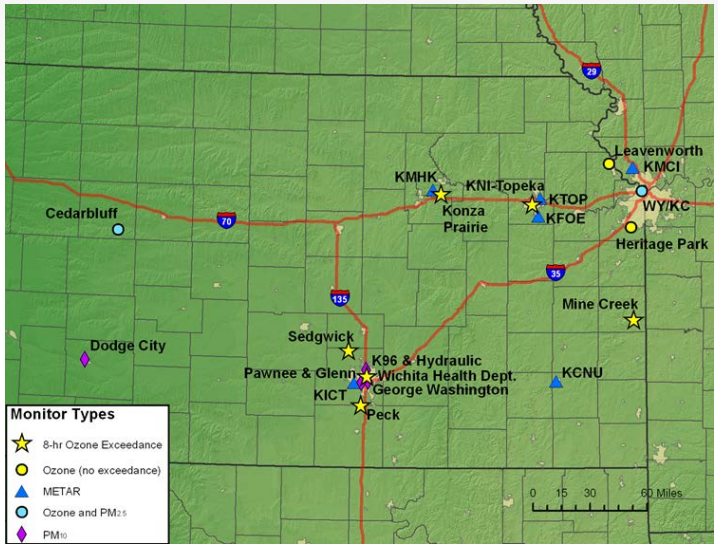



HMS fire detections on April 6, 2011

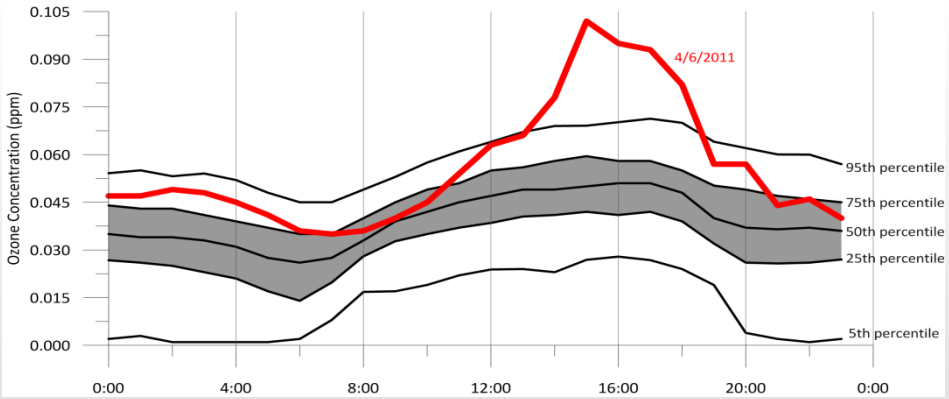
Prescribed burn in the Kansas Flint Hills

# Ozone NAAQS Exceedances

| Monitor | Date in 2011 | 8-hr $O_3$ Concentration (ppb) |
|---|---|---|
| Mine Creek | April 6 | 76 |
| Peck | April 6 | 82 |
| Wichita Health Dept. | April 6 | 79 |
| KNI-Topeka | April 12 | 84 |
| Konza Prairie | April 12 | 78 |
| Konza Prairie | April 13 | 79 |
| Peck | April 29 | 77 |
| Sedgwick | April 29 | 82 |

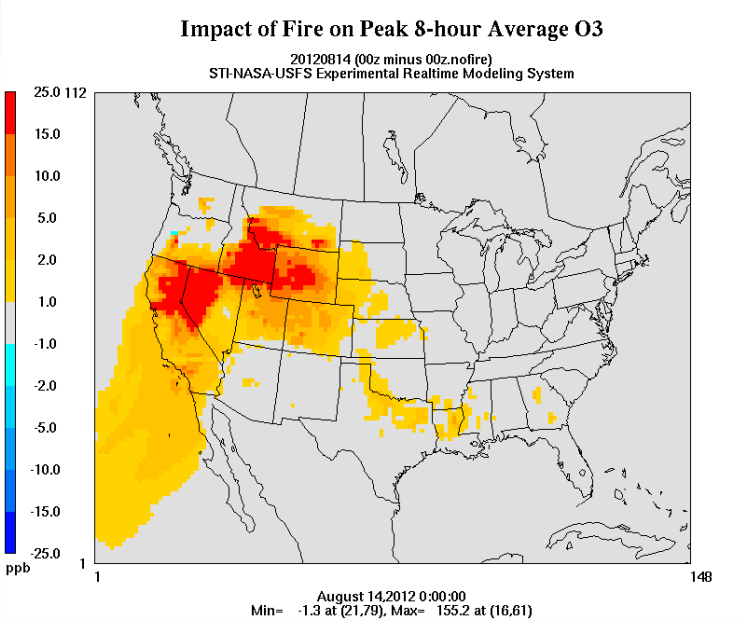



- Ozone values are historically unusual for this region in April (above 95th percentile)



# Modeling Methodology

- BlueSky Gateway
  - 36 km National RPO grid
  - MM5 v3.7, CMAQ v4.5
  - Daily runs initialized with prior results for carryover
  - Simulations with and without Flint Hills fires during April, 2011
- Fire Information and Emissions
  - SMARTFIRE outside Flint Hills
  - Special data for the Flint Hills
  - USFS BlueSky Framework




Ozone Impacts from Fires predicted by BlueSky Gateway on August 14, 2013.

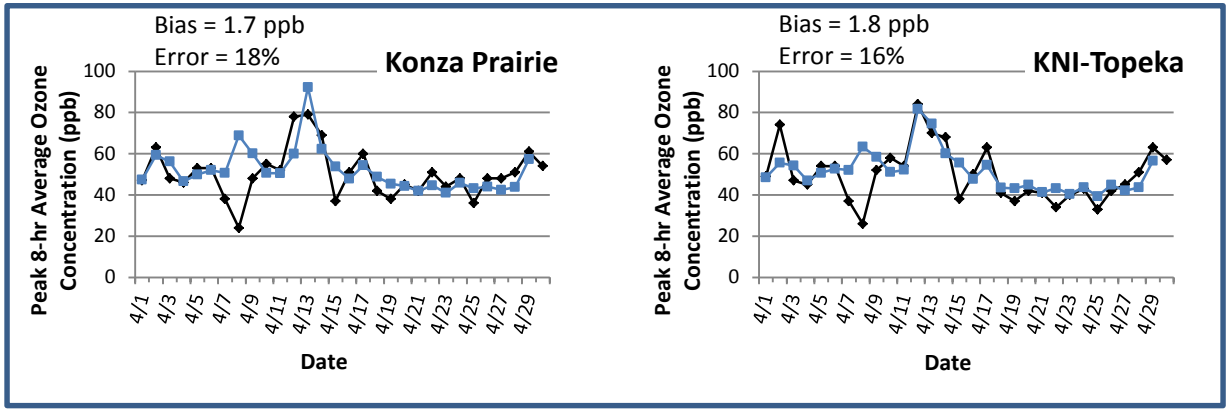
# Modeling Methodology

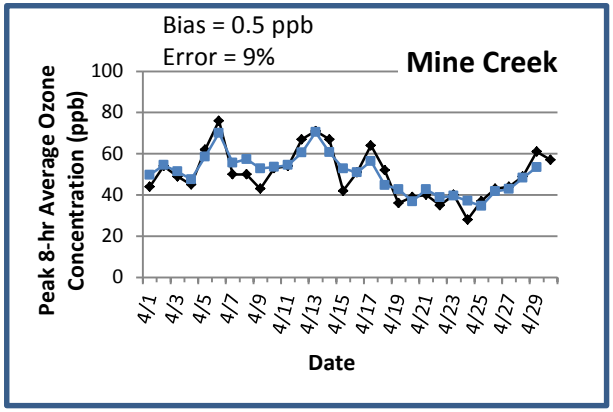
- Daily, county-level burn acreages from Kansas State Univ. burn scar analyses, allocated to model grid cells based on typical burn practices.
- Local fuel loading data provided by KDHE.
- BlueSky Framework processing with standard pathway endorsed by USFS.
- Default diurnal profile replaced by a top-hat profile that allocates fire emissions from 10 a.m. to 6 p.m.
- 2008 NEI used for non-fire sources.

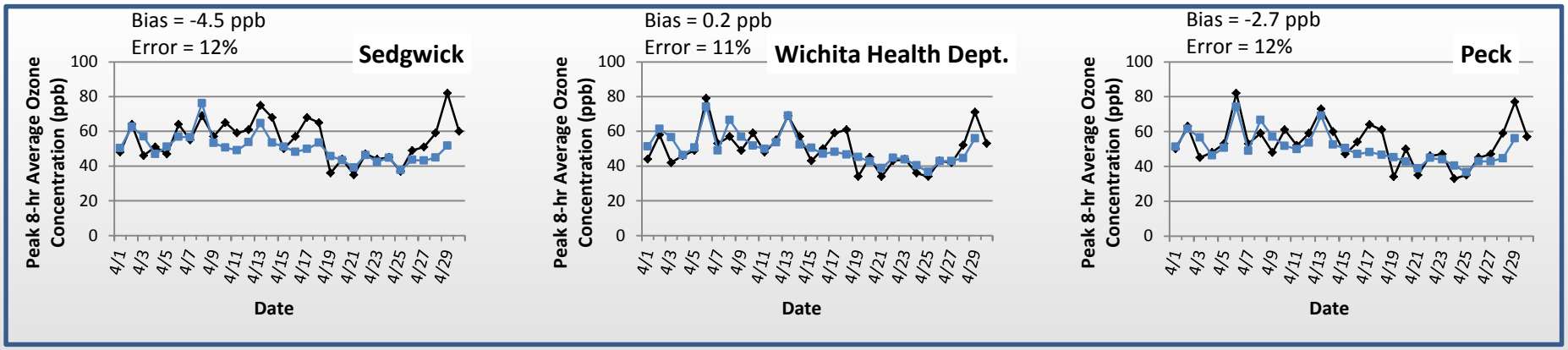
Burn scar from a Flint Hills rangeland fire

# Model Performance Analysis

- Gateway captured general ozone trends for April 2011.
- Mean bias: -4.5 to 1.8 ppb
- Normalized mean error: 9 to 18%

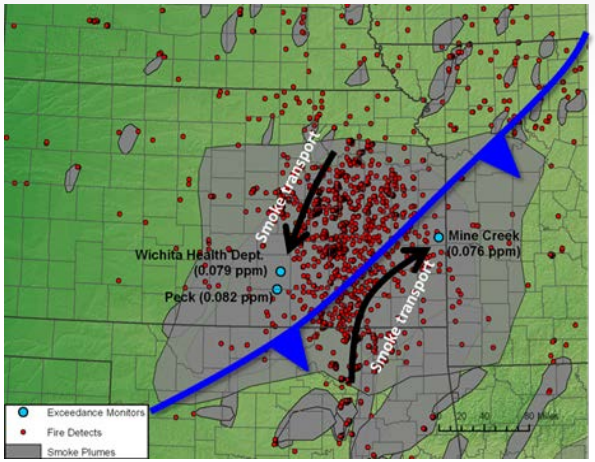


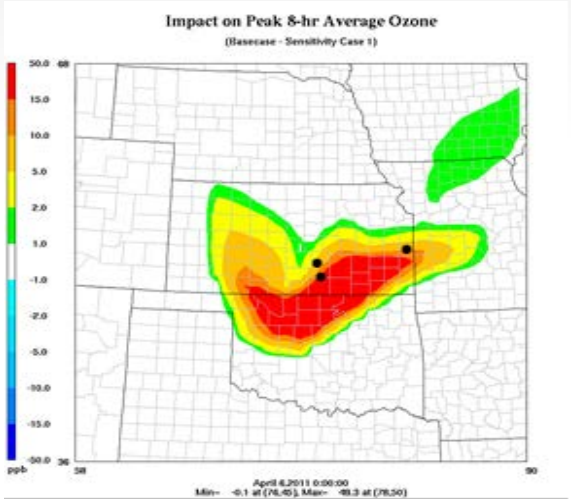



# April 6, 2011

- 248,000 acres burned.
- Complex flow pattern due to midday frontal passage.
- Ozone would not have exceeded 75 ppb "but for" the smoke.



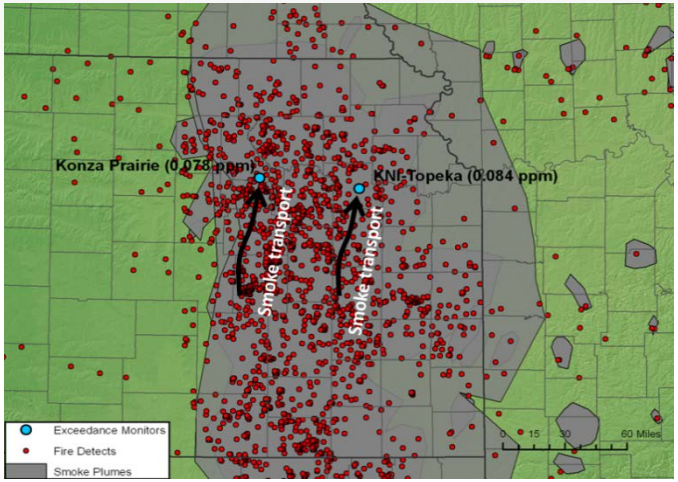



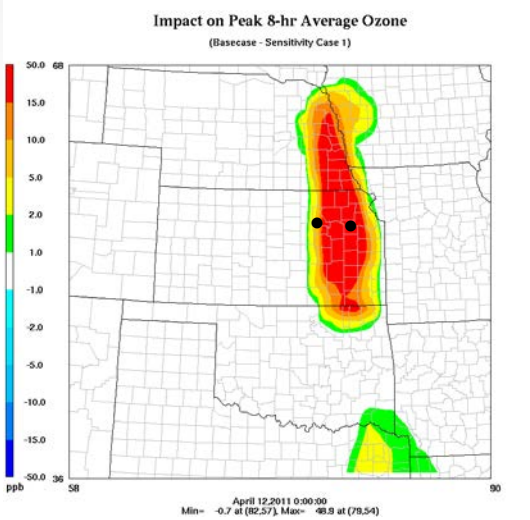

Modeled impact of Flint Hills fires on 8-hour average ozone (ppb)

| Monitor | Observed | CMAQ All Fires | CMAQ No Flint Hills Fires | Impact of Flint Hills Fires |
|---|---|---|---|---|
| Mine Creek | 76 | 70 | 60 | **10** |
| Wichita | 79 | 74 | 54 | **20** |
| Peck | 82 | 74 | 54 | **20** |

# April 12, 2011

- 298,000 acres burned.
- Smoke transport by southerly winds.
- Ozone would not have exceeded 75 ppb "but for" the smoke.



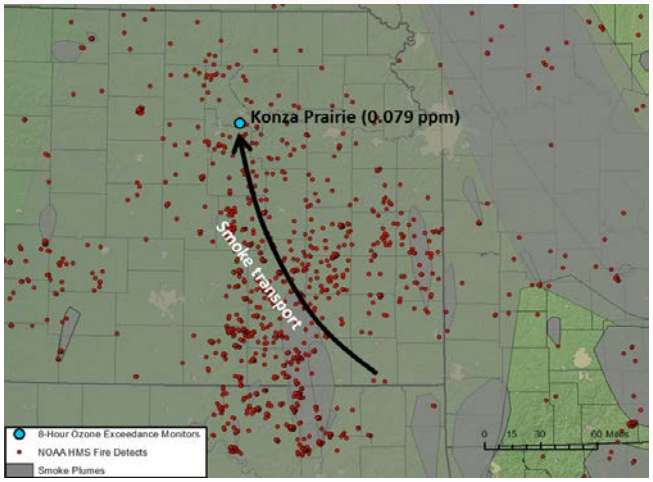



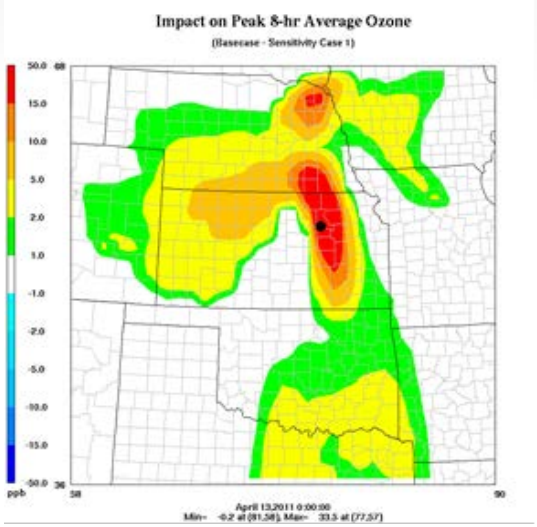

Modeled impact of Flint Hills fires on 8-hour average ozone (ppb)

| Monitor | Observed | CMAQ All Fires | CMAQ No Flint Hills Fires | Impact of Flint Hills Fires |
|---|---|---|---|---|
| KNI-Topeka | 84 | 82 | 54 | **28** |
| Konza Prairie | 78 | 60 | 53 | **7** |

# April 13, 2011

- 291,000 acres burned.
- Southeast winds transported smoke to Konza Prairie. Smoke carryover from prior days also important.
- Ozone would not have exceeded 75 ppb "but for" the smoke.



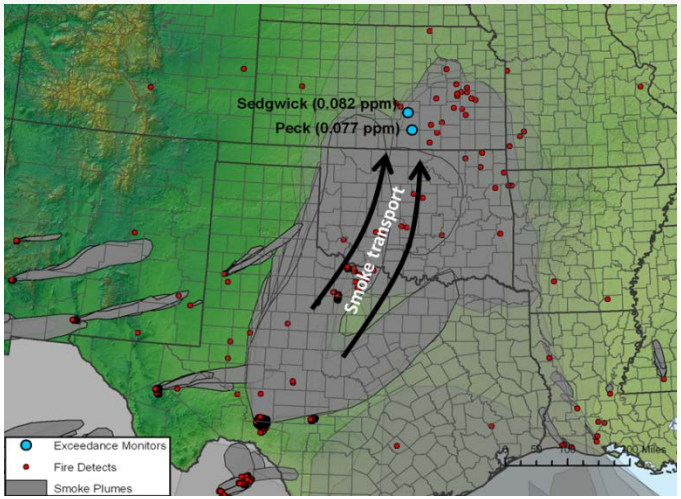



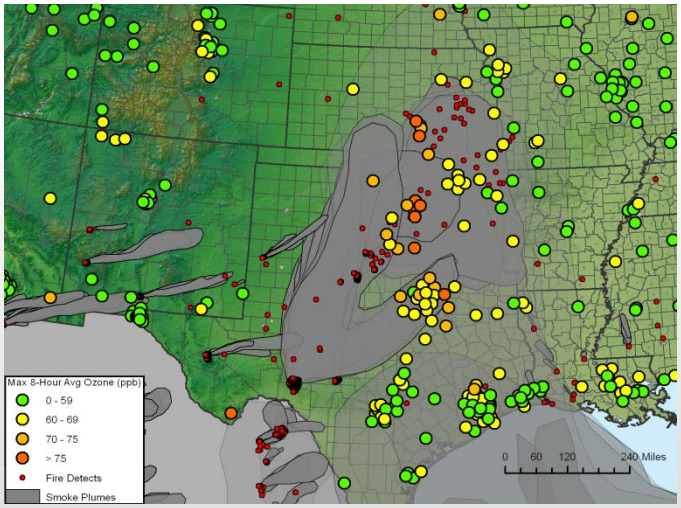

Modeled impact of Flint Hills fires on 8-hour average ozone (ppb)

| Monitor | Observed | CMAQ All Fires | CMAQ No Flint Hills Fires | Impact of Flint Hills Fires |
|---|---|---|---|---|
| Konza Prairie | 79 | 92 | 62 | **30** |

# April 29, 2011

- Only 19,000 acres burned in the Flint Hills.
- Numerous large fires in Texas and Mexico, with region-wide ozone enhancement.
- Modeling showed no ozone impact due to Flint Hills fires. Ozone enhancement at the Kansas monitors was due to long range smoke transport
- Ozone would not have exceeded 75 ppb "but for" the smoke, based on non-modeling analyses.



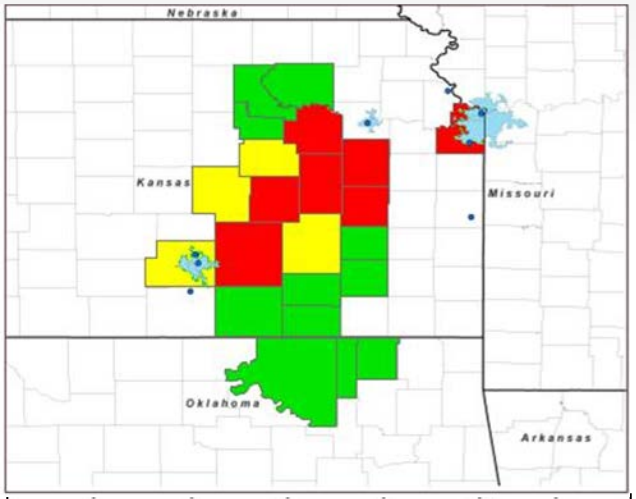



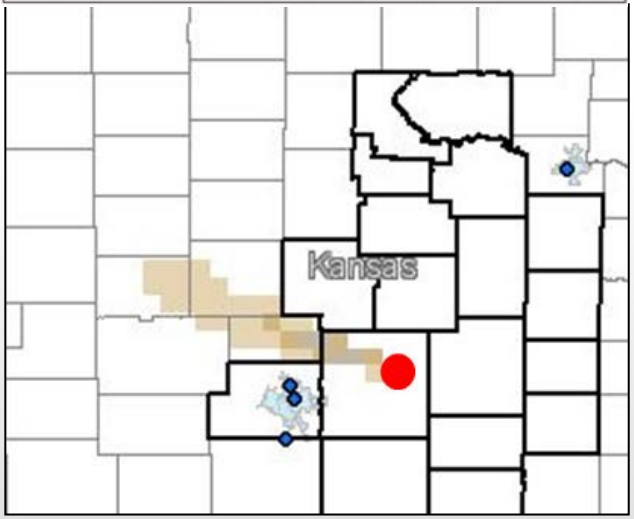
# Conclusion

- Photochemical modeling (BlueSky Gateway) was successfully applied to support an exceptional event analysis. EPA concurred that the analysis satisfied the exceptional event demonstration requirements.
- For 3 of 4 NAAQS exceedance days in Kansas, modeling analysis helped demonstrate that NAAQS ozone exceedances would not have occurred "but for" the smoke from Flint Hills fires.
- On April 29, additional analyses were used to satisfy the but-for requirement.
- Modeled fire impacts on 8-hour ozone levels ranged from 5 to 30 ppb at Kansas monitors during April, 2011.

# Conclusion

- KDHE has developed a Smoke Management Plan to mitigate smoke impacts on urban areas.
- STI has worked with KDHE to develop guidance tools to support burn/no-burn decisions.
- Guidance tools and website are operating during the current Flint Hills fire season.



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