Meteorology and Spatial Variability Compromises in MOVES and SMOKE-MOVES

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Background

Operation modes for MOVES and SMOKE-MOVES:

Mode	(1) Inventory MOVES	(2) Emission Rate Mode	(3) SMOKE-MOVES
Model	MOVES	MOVES	MOVES, SMOKE-MOVES
Primary Usage	Emission inventory development	Sensitivity runs	Regional emission modeling
Strength	Local data, No post-processing required	Detailed emission processes	Detailed meteorology, Large scale modeling
Weakness	Generalized meteorology	Complex outputs in emission rates	Representative county, Difficult to operate
Resolution	County, Month	County, Month	Representative county, Fuel month
Challenges	SCCs	SCCs	SCCs, Relative humidity

Two Operation Modes

Either mode compromises in its operation:

- **Inventory MOVES – Meteorology compromise**
  - **monthly averaged meteorology**
- **SMOKE-MOVES – Spatial variability compromise**
  - **representative county approach**

Which compromise is more serious?

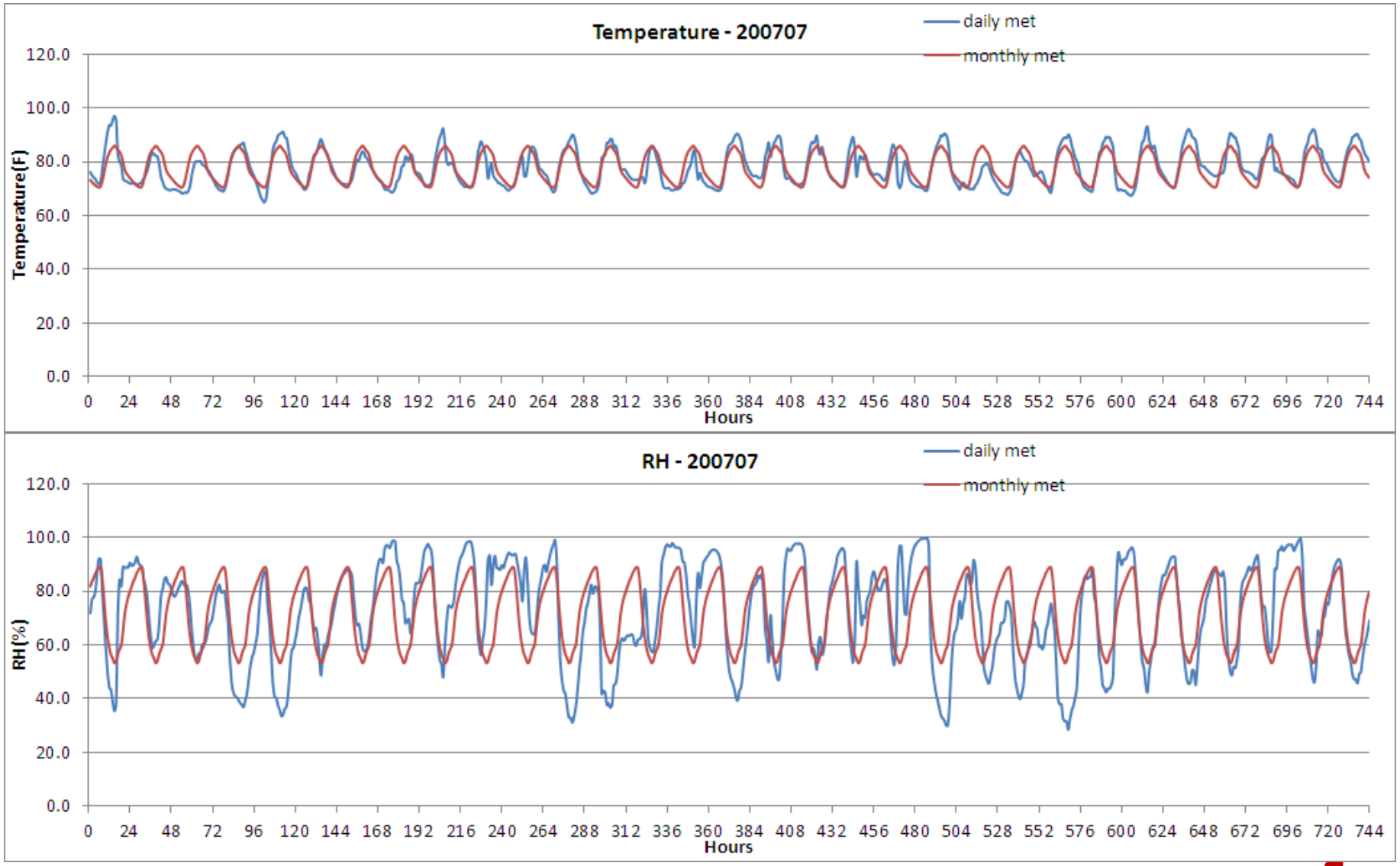
Meteorology Compromise

- GA and VA have each conducted separate and independent study on impact of meteorology on emission estimates
- Study involves conducting MOVES runs in inventory mode with two sets of meteorology
  - -- hourly meteorology (~SMOKE-MOVES practice)
  - -- monthly averaged meteorology (~MOVES practice)
- GA used 2007 data and VA used 2011 data
- Four counties and six different months throughout the year were examined:

  Fulton, GA;

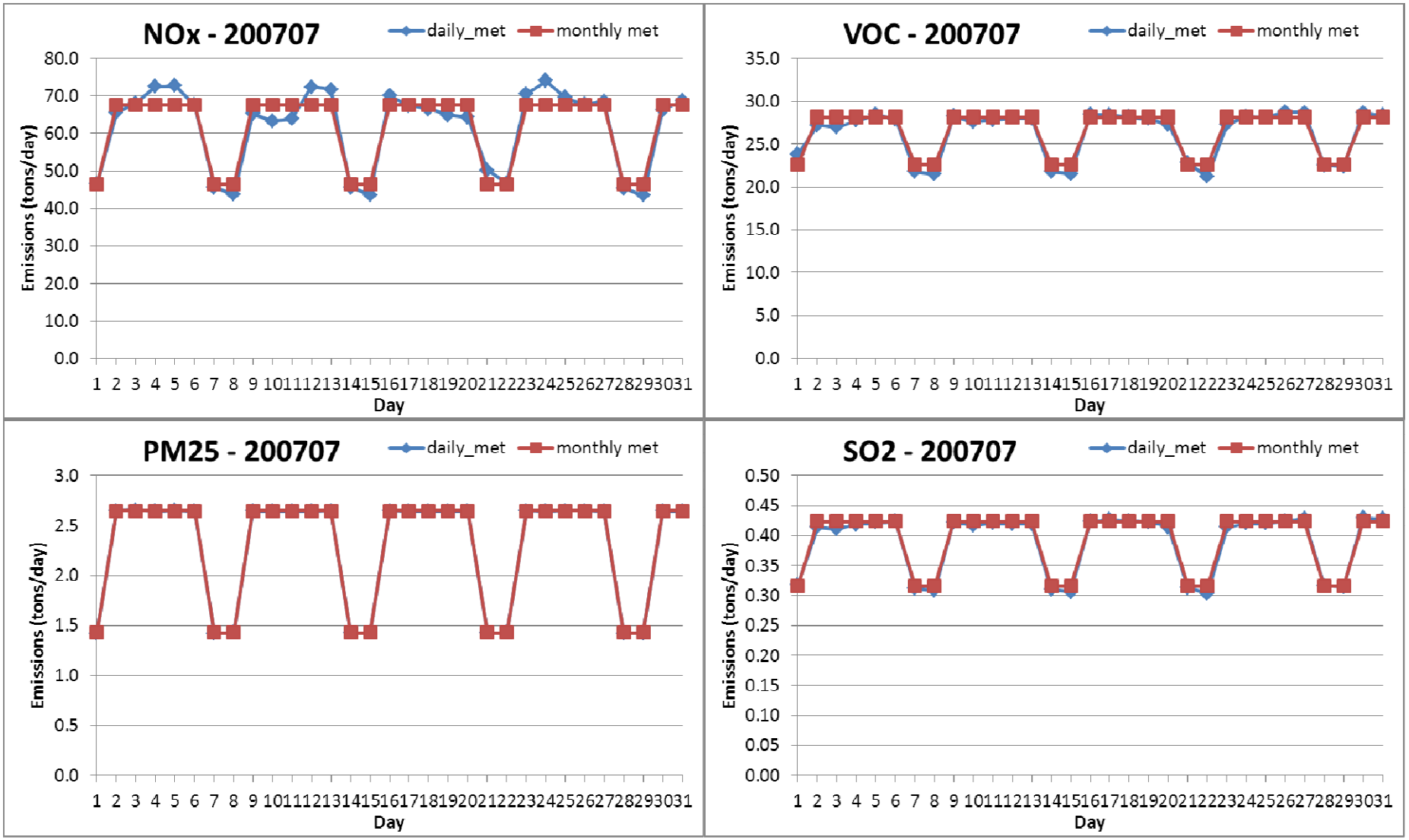
  Richmond/Fairfax/Virginia Beach, VA

Temperature and RH - July 2007 Fulton GA



Courtesy of GA August 12, 2013 presentation

Daily Emissions - July 2007 Fulton GA

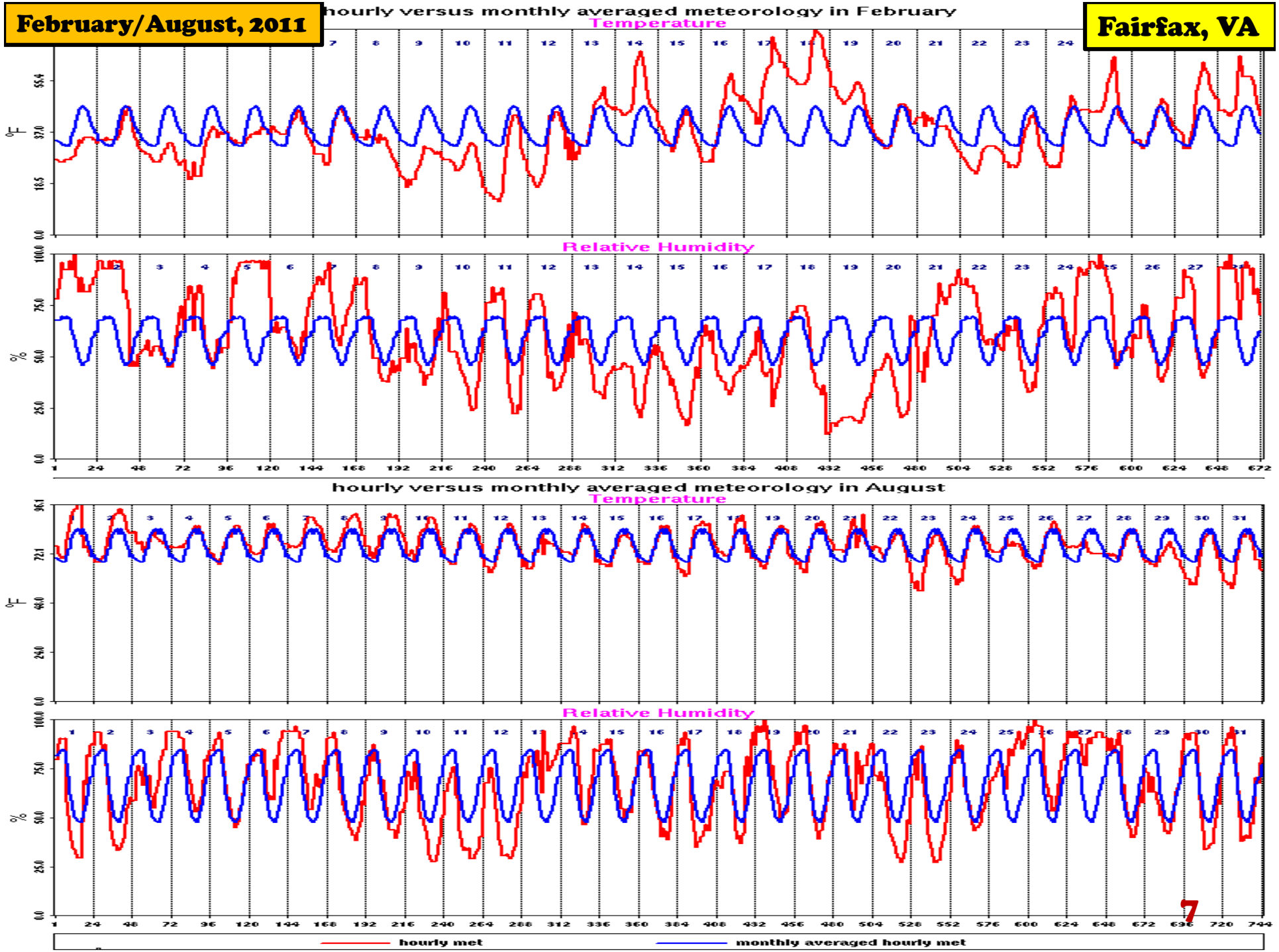


Daily emission differences between two sets of meteorology are small

Courtesy of GA August 12, 2013 presentation

February/August, 2011

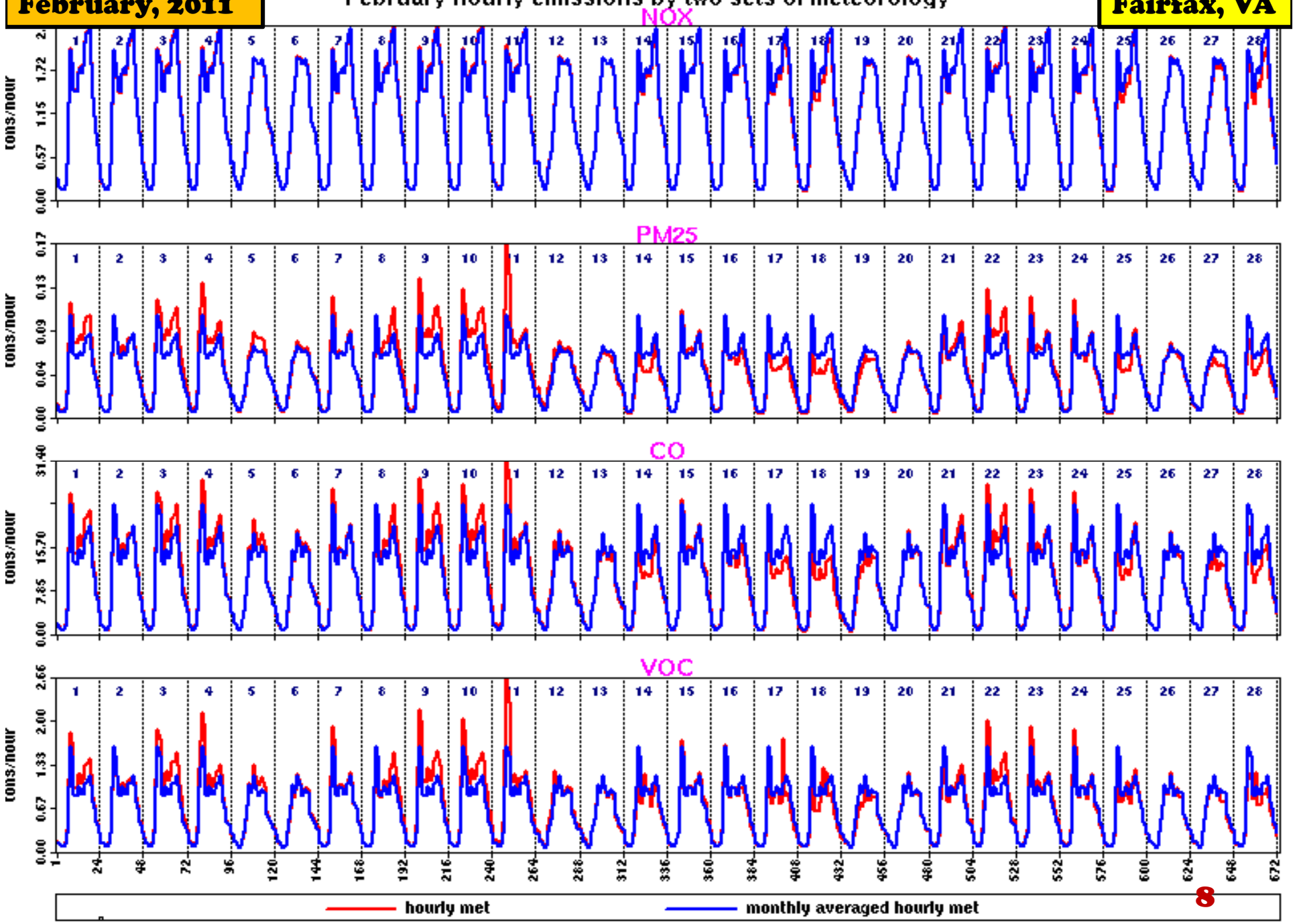
Fairfax, VA



February, 2011

February hourly emissions by two sets of meteorology

Fairfax, VA



Fairfax Comparison (2011 February/August)

MOVES Run	CO	NH3	NOX	PM10	PM25	SO2	VOC
February Hourly met (tons)	7165.96	28.01	778.95	45.57	32.91	7.20	482.28
February Monthly met (tons)	7080.45	28.01	785.82	44.25	31.69	7.19	457.98
Difference (tons)	85.51	0.00	-6.87	1.33	1.22	0.01	24.30
Difference (%)	1.2%	0.0%	-0.9%	3.0%	3.9%	0.1%	5.3%
August Hourly met (tons)	3796.56	29.03	698.27	33.34	21.31	7.43	375.88
August Monthly met (tons)	3756.87	29.03	695.24	33.24	21.22	7.42	368.75
Difference (tons)	39.69	0.00	3.04	0.10	0.09	0.01	7.13
Difference (%)	1.1%	0.0%	0.4%	0.3%	0.4%	0.2%	1.9%

-- Differences are very small for all pollutants between two sets of meteorology
-- The largest difference percentage-wise (<6%) are VOCs and PM in winter month

Monthly NOx differences < 1%

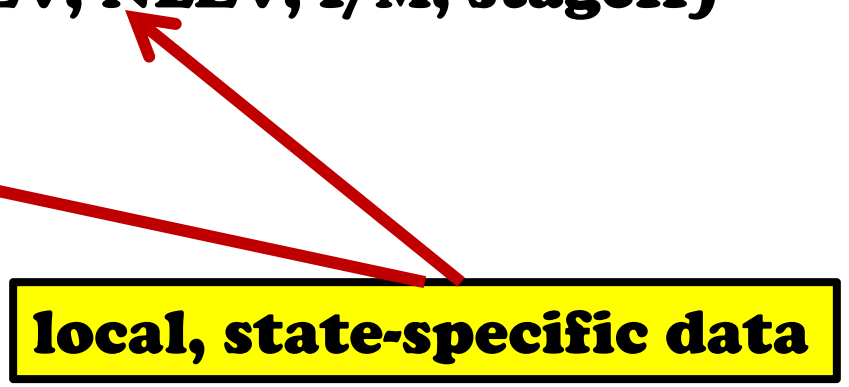
Summary on Meteorology Compromise

- **Four counties in GA and VA using either 2007 or 2011 data all show similar minor differences in emission estimates**
- **Monthly (=MOVES resolution) differences in NOx < 2%**

Meteorology compromise is minor

Spatial Variability Compromise

- SMOKE-MOVES is conducted by representative county
- Counties are grouped into representative county according to three criteria:
  - -- Control programs (CALEV, NLEV, I/M, stageII)
  - -- Fuel parameters
  - -- Fleet age distribution

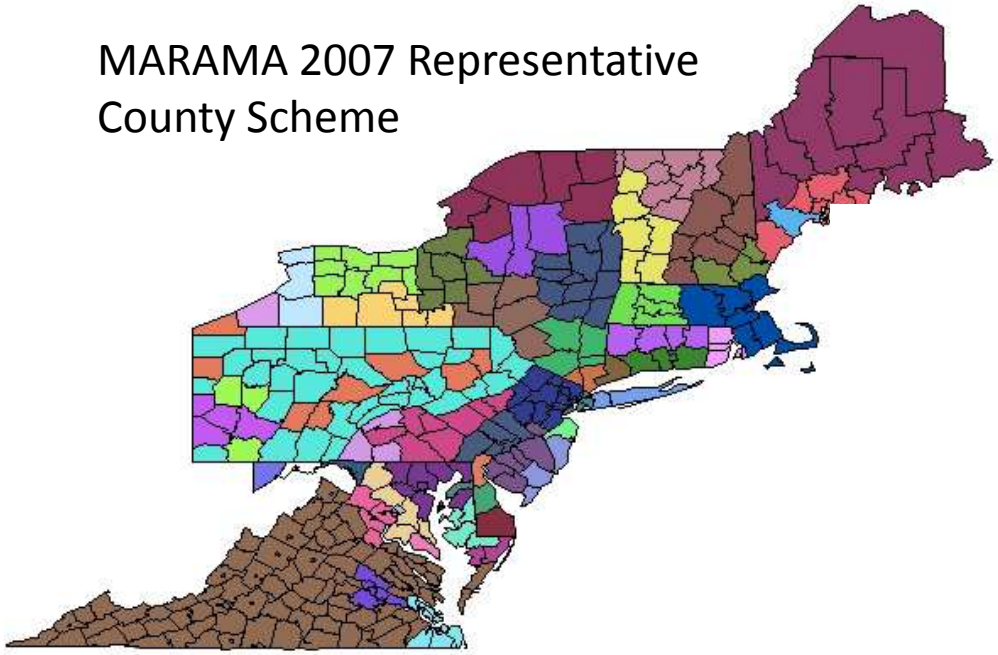


- MOVES data of the representative county are then used as inputs for model runs (non-local, non-state specific data)

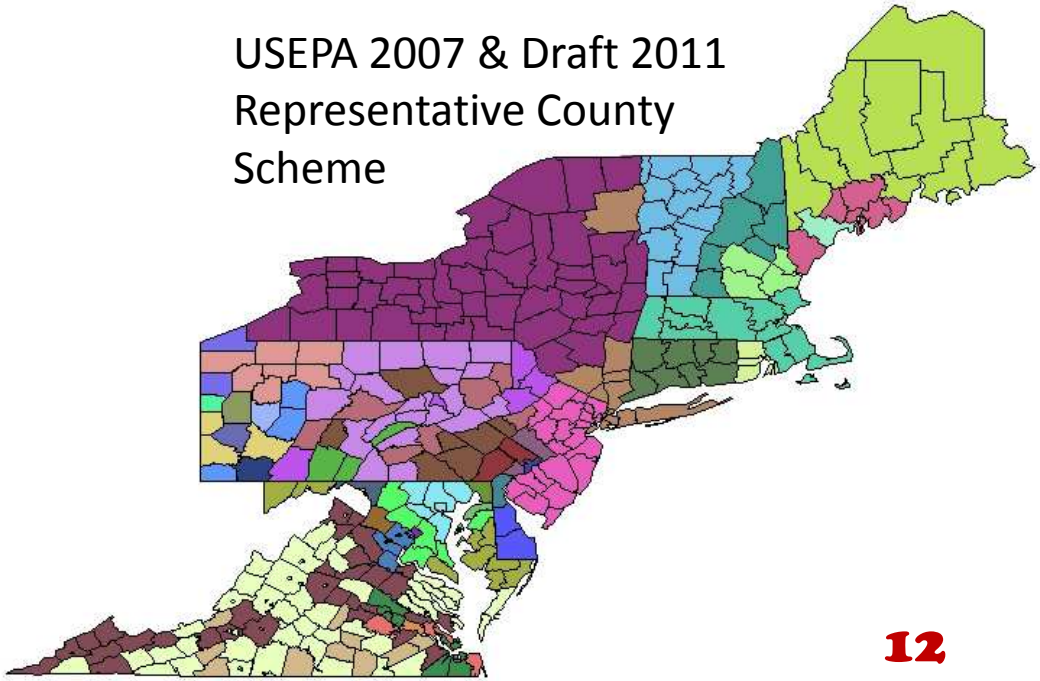
Spatial Variability Compromise

(1) Representative County Grouping

MARAMA 2007 Representative County Scheme

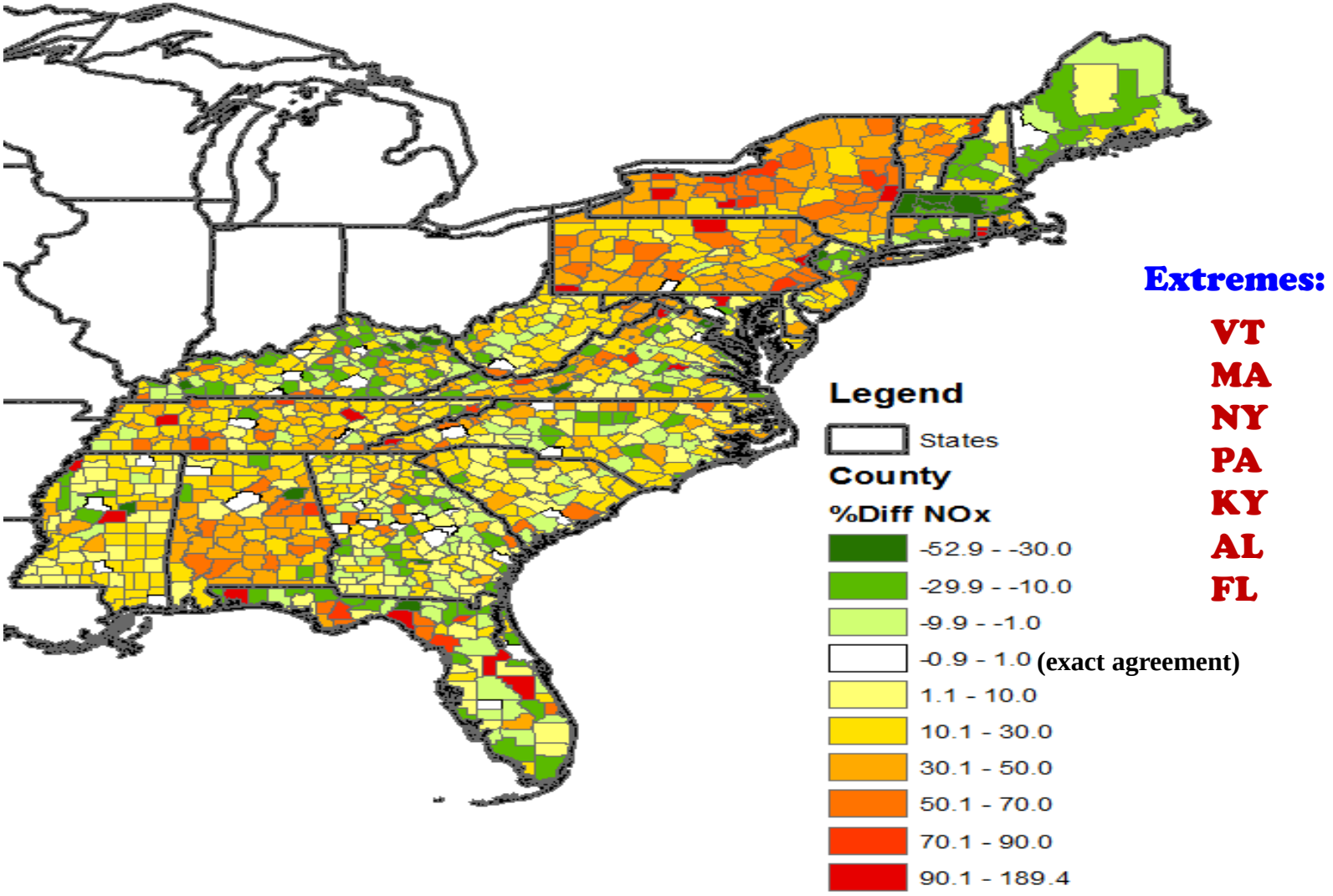


USEPA 2007 & Draft 2011 Representative County Scheme



2007 RPOs versus 2007 EPA – SMOKE-MOVES

NOx (%) = (2007RPO – 2007EPA) *100 / 2007EPA



Extremes:

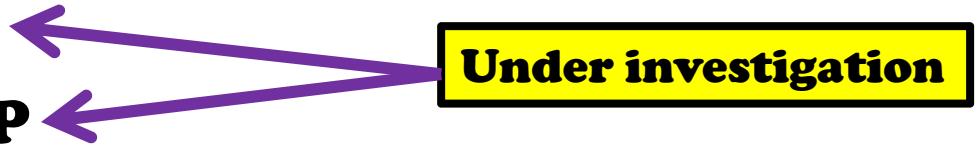
VT
MA
NY
PA
KY
AL
FL

Very large spatial variability in NOx is seen between RPOs and EPA estimates. Differences range from -50% to +200%.

Spatial Variability Compromise

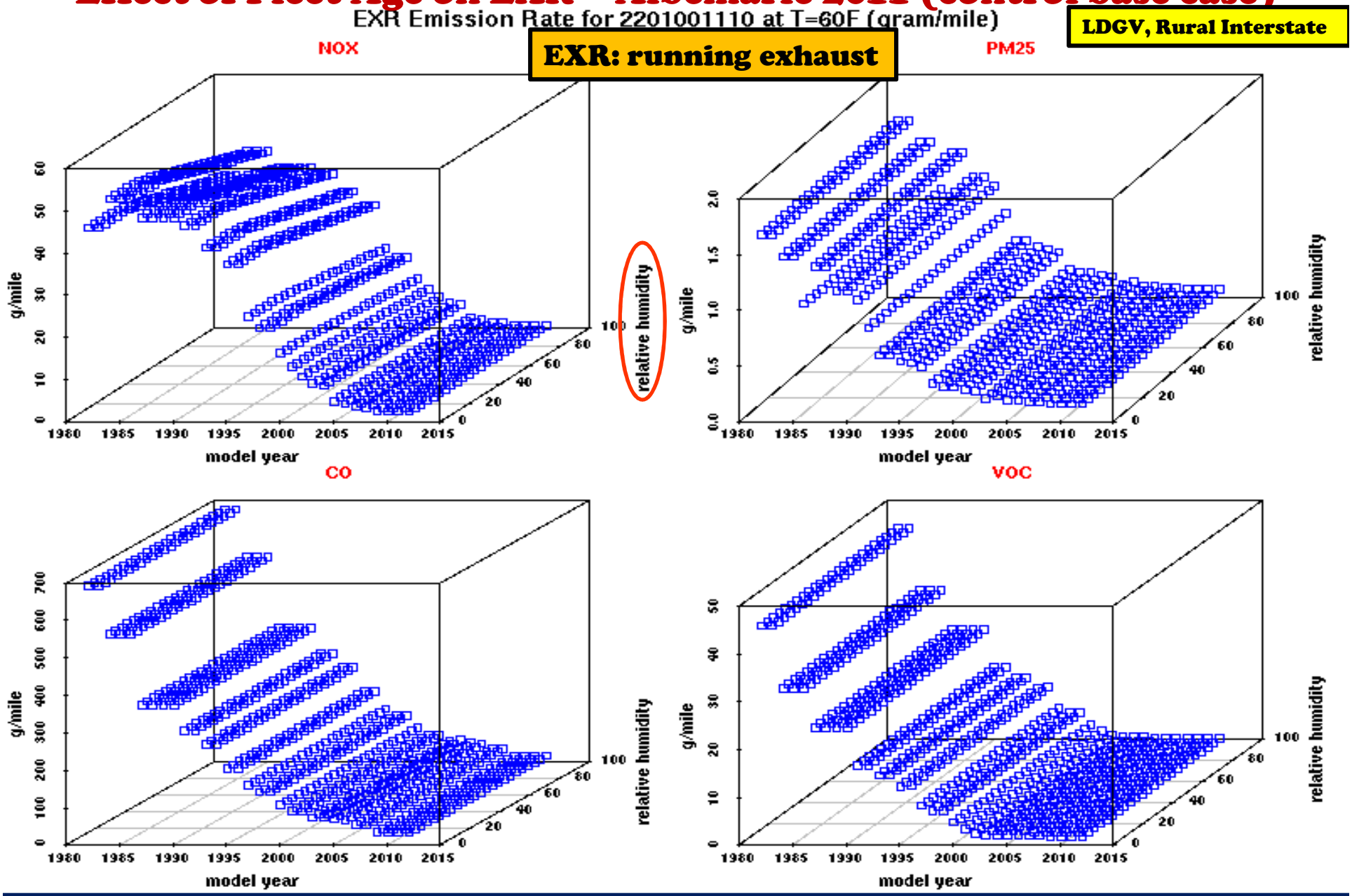
(2) Individual or Aggregated Inputs

- After counties have been grouped into representative county, the next question is what inputs should be used in MOVES runs to "represent" the entire county group?
- Individual county inputs versus aggregated inputs:
  - -- VMT
  - -- VPOP
  - -- Fleet age distribution



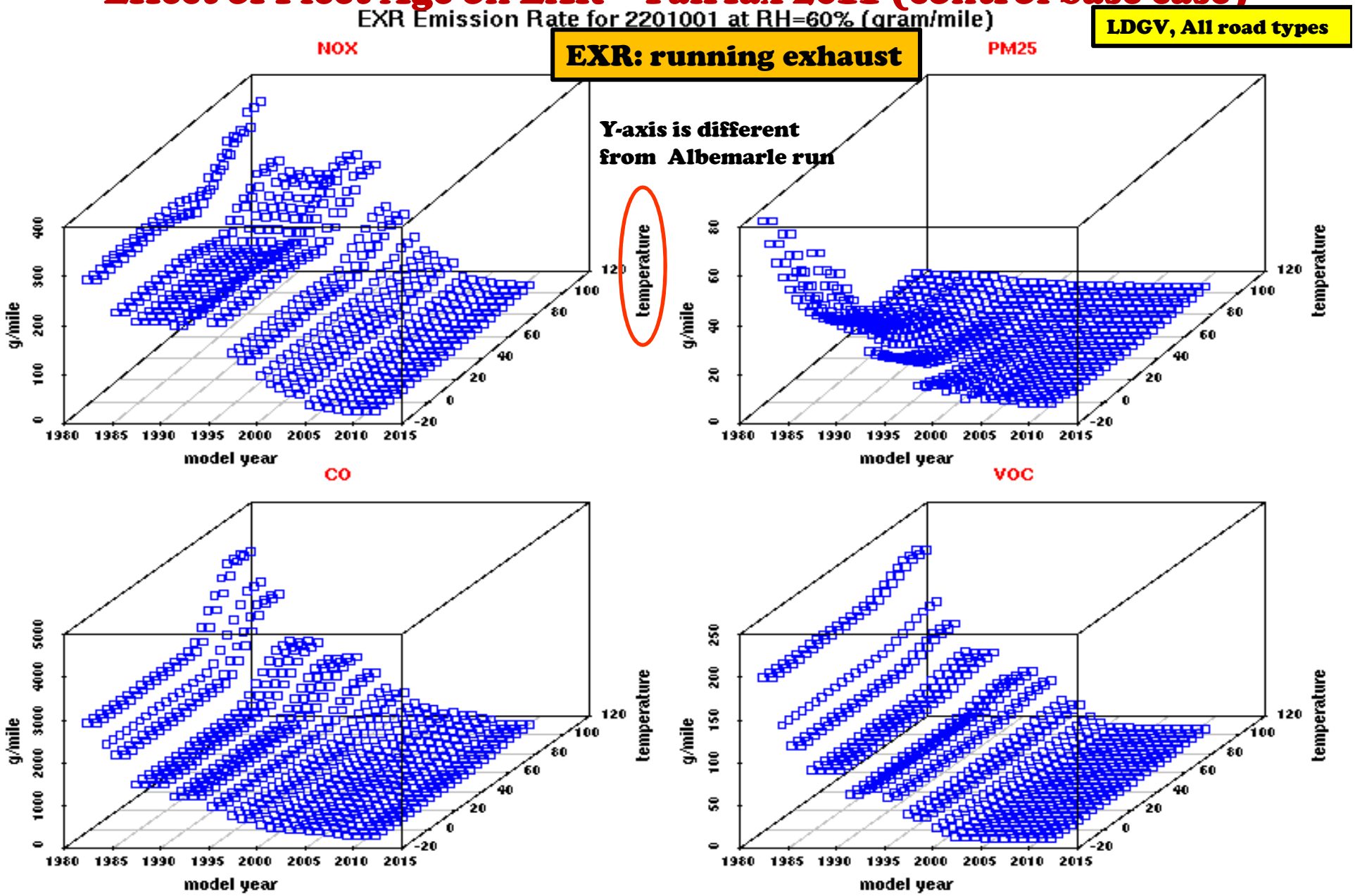
SMOKE-MOVES in EPA approach uses data of the representative county directly for MOVES runs

Effect of Fleet Age on EXR – Albemarle 2011 (control base case)



-- Age of LDGV fleet spans 31 years from model year 1981 to model year 2011.
-- Emission rates are higher for older vehicles (i.e., older cars are dirtier).

Effect of Fleet Age on EXR – Fairfax 2011 (control base case)



-- Age of LDGV fleet spans 31 years from model year 1981 to model year 2011.

-- Emission rates are higher for older vehicles (i.e., older cars are dirtier.) Different counties (Fairfax vs Albemarle) show similar trends.

Summary on Spatial Variability Compromise

- **Representative county grouping and choice of MOVES inputs (individual versus aggregated) affect emission estimates considerably**
- **Fuel month and representative county implemented in SMOKE-MOVES have reduced modeling resolutions -- both temporally and spatially**

Spatial variability compromise is significant and cannot be ignored

Conclusions

- Meteorology compromise in Inventory MOVES is minor
- Spatial variability compromise in SMOKE-MOVES is much more serious than meteorology compromise
- Many methodologies implemented in SMOKE-MOVES have greatly deviated from MOVES original design:
  - -- county grouping (resolution incorrectly reduced)
  - -- non-local, non-county-specific MOVES inputs
  - -- SCC flaws, fixed RH, inconsistent speed treatment
- Inventory MOVES can be and should be used to evaluate SMOKE-MOVES approach
- States are encouraged to run inventory MOVES to compare upcoming release of EPA NEI v1