



GEORGIA
DEPARTMENT OF NATURAL RESOURCES

ENVIRONMENTAL PROTECTION DIVISION

Review of Georgia On-Road Mobile Source Emissions in NEI 2014: Georgia EPD Inventory vs. EPA SMOKE-MOVES Methodologies

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PURPOSE

- Quality assure on-road mobile emissions in NEI2014v1 estimated using SMOKE-MOVES
 - Compare with Georgia EPD estimates developed using MOVES2014a inventory mode with NEI2014v1 submitted inputs
- Investigate remaining issues identified in NEI2011 review
 - Difference of $PM_{2.5}$ and NH_3 emissions estimated by SMOKE-MOVES and MOVES inventory mode
 - Month to month variations
- Test MOVES2014a
 - Evaluate new 2014 inputs
 - Identify potential issues with model (e.g., starts per day)

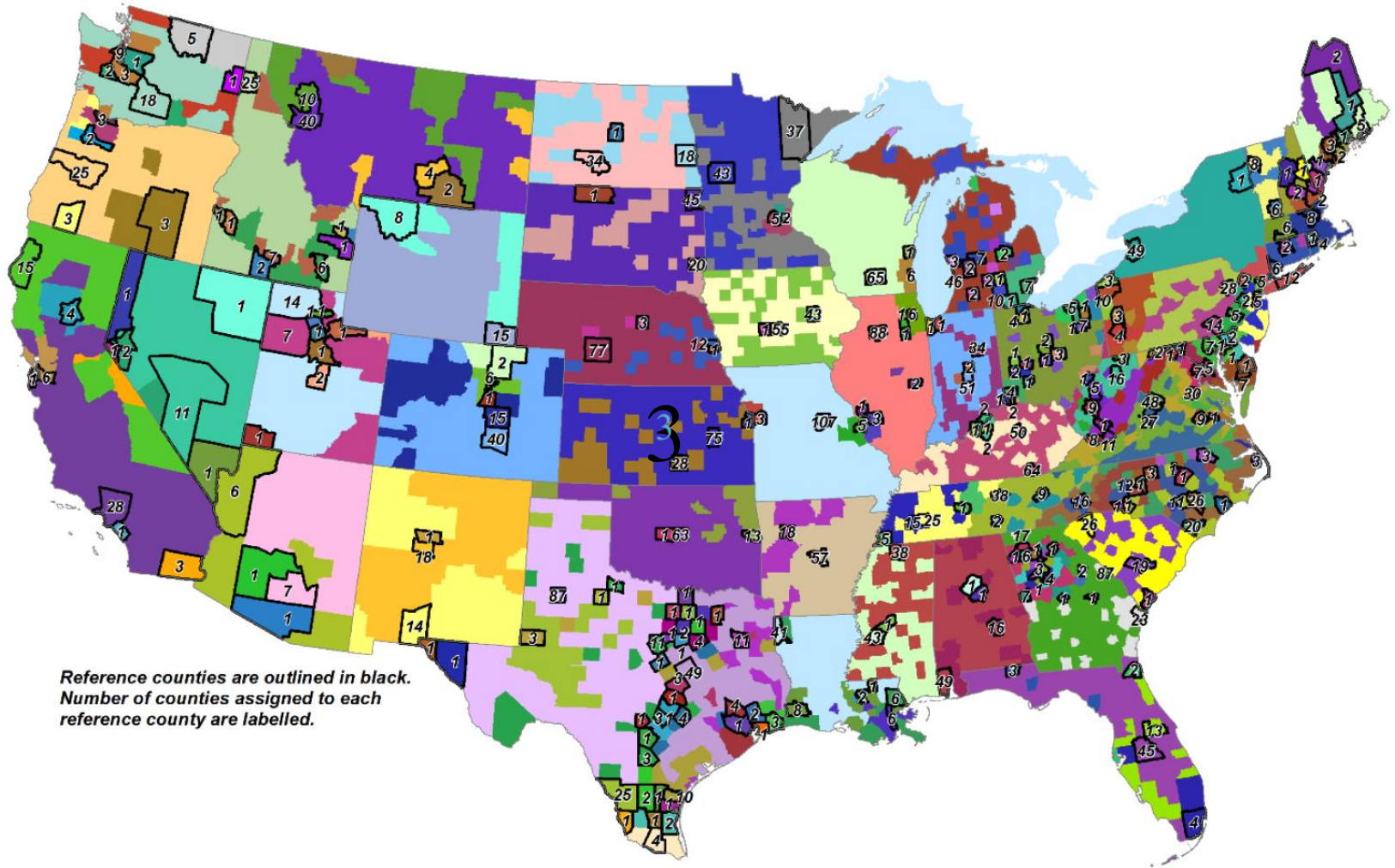


SMOKE-MOVES

- **Emissions = (EF) x (County-level Activity)**
- County-level activity: VMT, vehicle pop, starts, hoteling
- Emission Factors (EF) Tables are developed for representative counties by running MOVES in Rate Mode
 - Representative counties: fleet age, I/M program, fuel blends, ramp fractions
 - RPD (vehicle/road type, T, RH, speed, fuel month etc.), RPP, RPV
 - 2 fuel seasons (winter/summer)
- EFs for a county are calculated in SMOKE by adjusting EFs for the corresponding representative county
 - Hourly meteorology at grid cell level from WRF
 - Speed, month, day, hour, vehicle and road type, pollutant

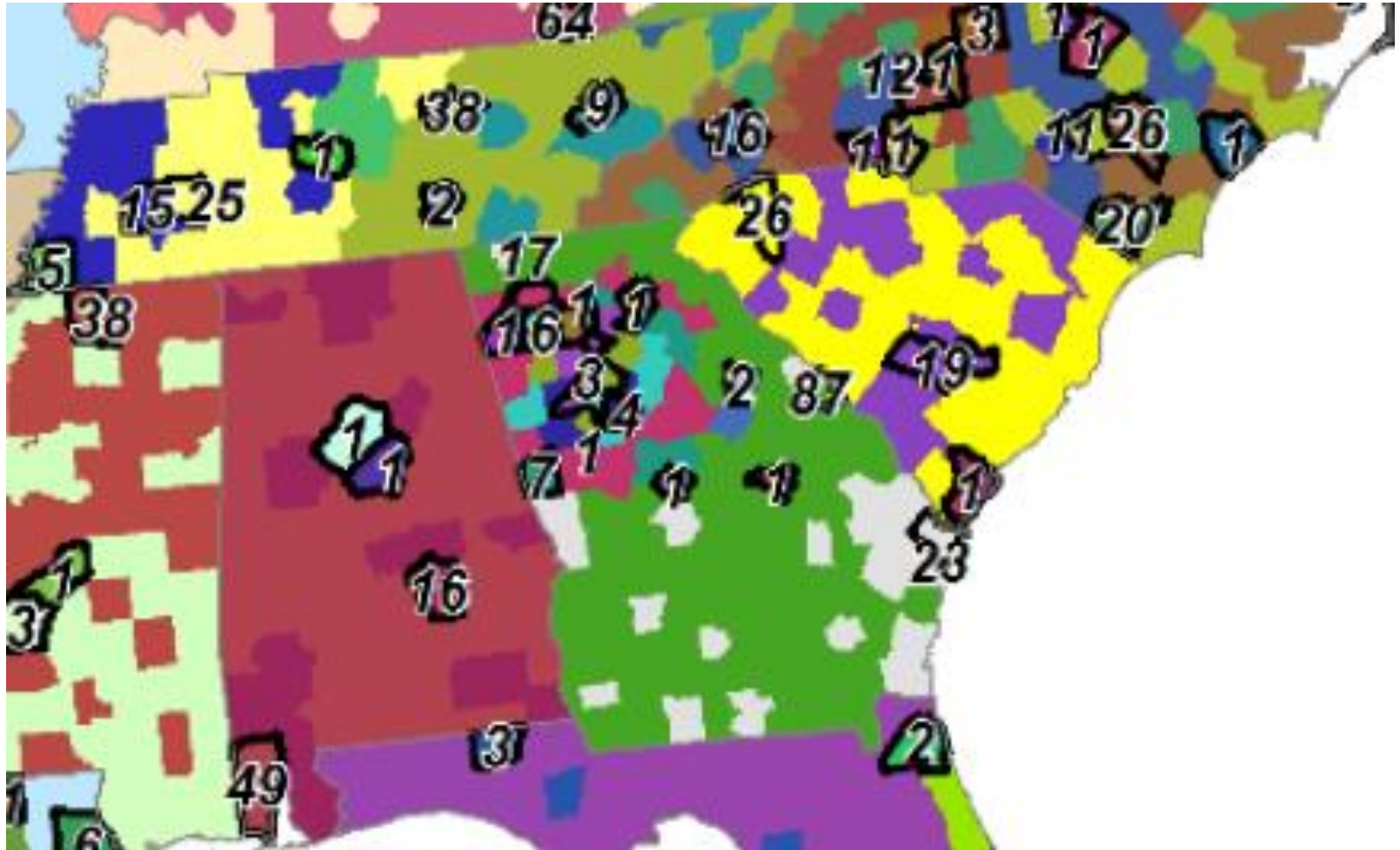


REPRESENTATIVE COUNTIES (CONUS)





REPRESENTATIVE COUNTIES (GA)





MOVES INVENTORY

- Georgia EPD ran MOVES in inventory mode for all 159 counties in Georgia
 - Emissions produced directly in output
- Monthly diurnal meteorology from nearby monitoring stations
- Monthly default fuel inputs in MOVES2014a (no fuel season simplification, different fuel inputs for transition months April/October)
- Average speed distributions weighted over 16 bins
- County level input databases directly used



PREVIOUS WORK WITH NEI2011

- Meteorology
 - Using hourly WRF meteorology vs. monthly diurnal meteorology has minimal impact on annual and monthly emission totals
 - Using hourly WRF can have a significant impact on specific hours on specific days
 - WRF meteorology can have significant biases when compared to observations.
- Hoteling & Ramp Fractions
 - Identified issue with long haul hoteling and ramp fractions. Issue has been addressed by EPA.



NEI2014 APPROACH

- EPA SMOKE-MOVES for 2014 NEIv1
- Georgia ran MOVES in inventory mode for all 159 counties in Georgia using “identical” inputs
- Inventory vs. SMOKE-MOVES
 - Annual Comparisons
 - Monthly Comparisons



INVENTORY vs. SMOKE-MOVES

- $(\text{SMOKE-MOVES}) - (\text{Inventory}) / (\text{Inventory})$
 - **RED** → $(\text{SMOKE-MOVES}) > (\text{Inventory})$
 - **BLUE** → $(\text{SMOKE-MOVES}) < (\text{Inventory})$
 - Less than 5% difference
 - “Good” performance
 - Between 5-10% difference
 - “Acceptable” performance, but will take a look
 - More than 10% difference
 - Needs additional investigation!!

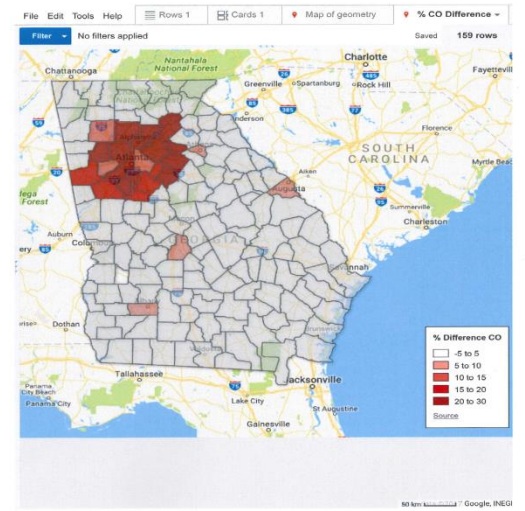
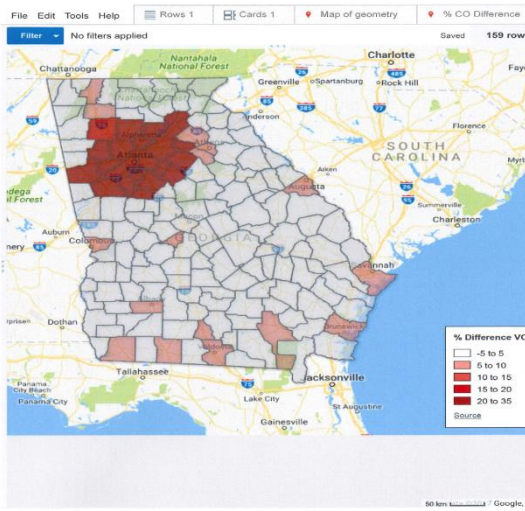
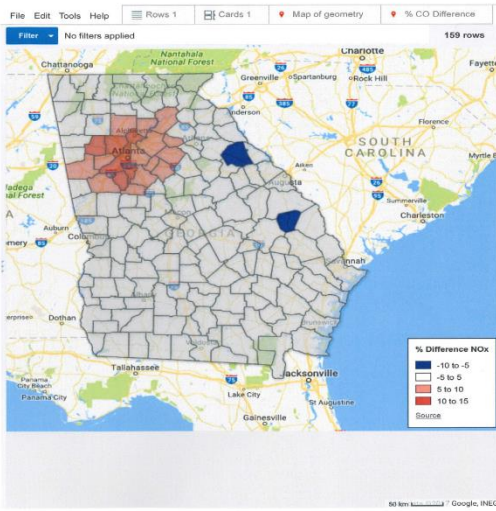


MOVES2014a STARTSPERDAY ISSUE

- NO_x, VOC, and CO maps: Up to 35% difference as indicated by dark red areas
 - Counties where local data for starts per day provided instead of defaults
 - Difference in emissions by process: EPA starts 12 times higher
- Causes of the issue
 - EPA SMOKE-MOVES: 1 month per run
 - GA EPD MOVES Inventory Mode: 12 months per run
 - MOVES2014a divides startspersperday by months in run!
- After correction: Most annual differences <5%



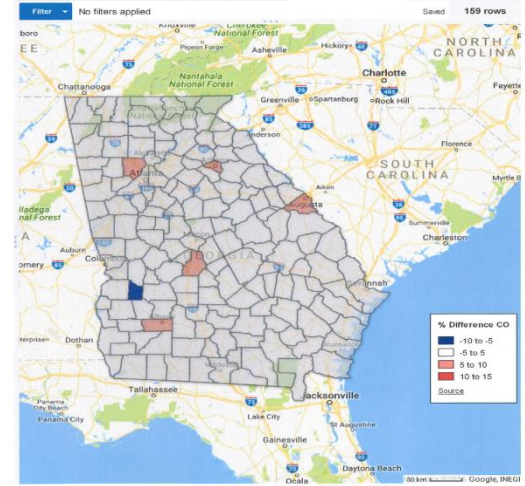
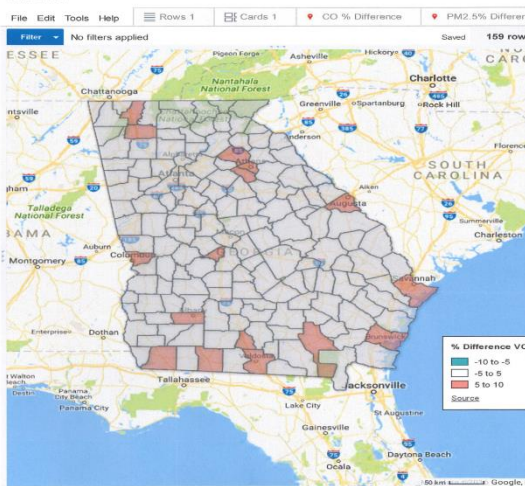
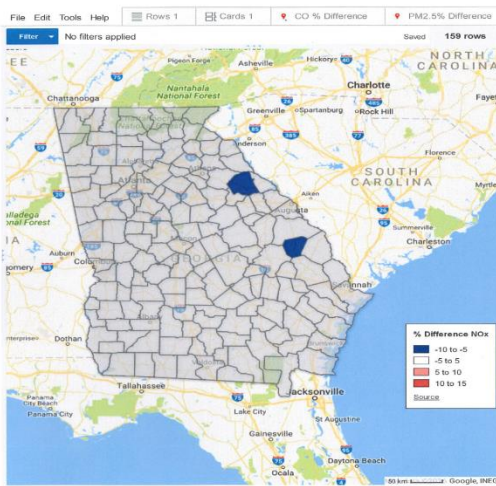
STARTSPERDAY CORRECTION



1 of 1 5/4/17, 10:55 / 1 of 1

1 of 1 5/4/17, 11:05 / 1 of 1

1 of 1 5/4/17, 11:10 AM / 1 of 1



1 of 1 12/2/2016 2:02 / 1 of 1

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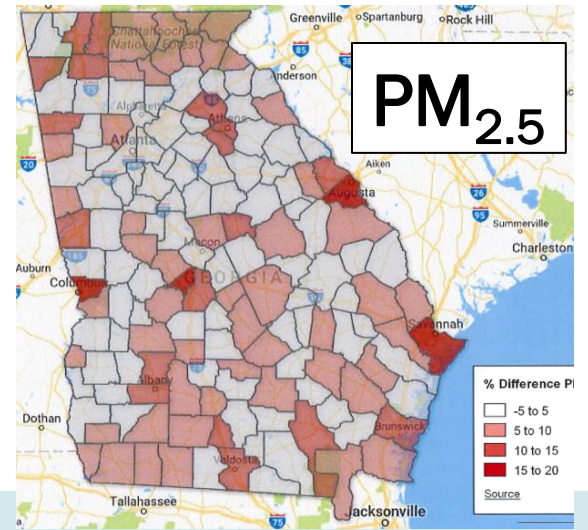
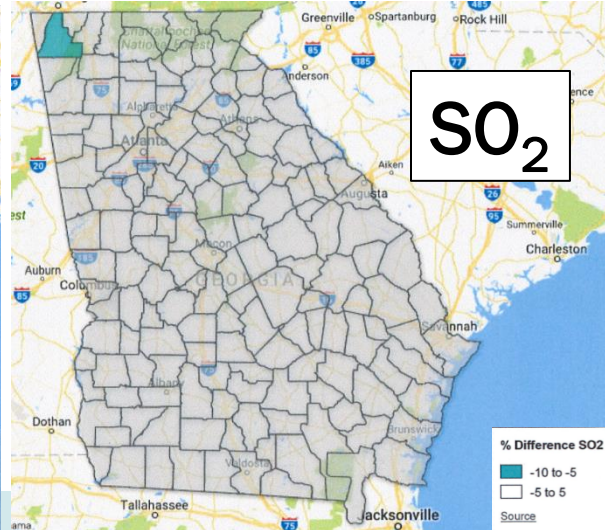
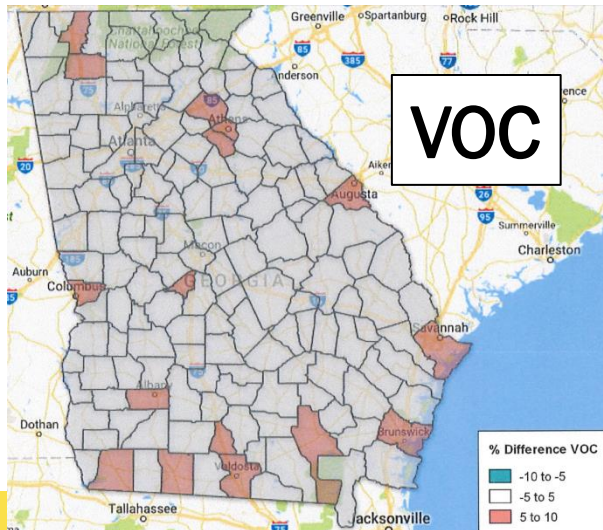
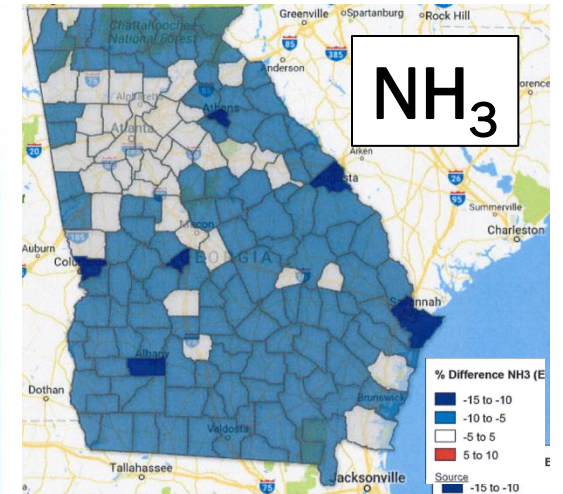
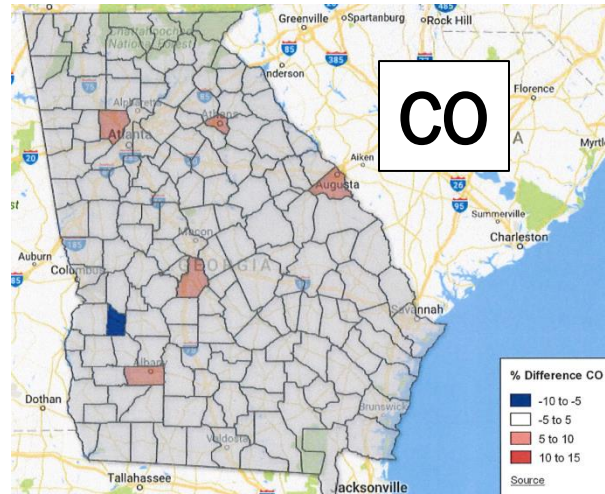
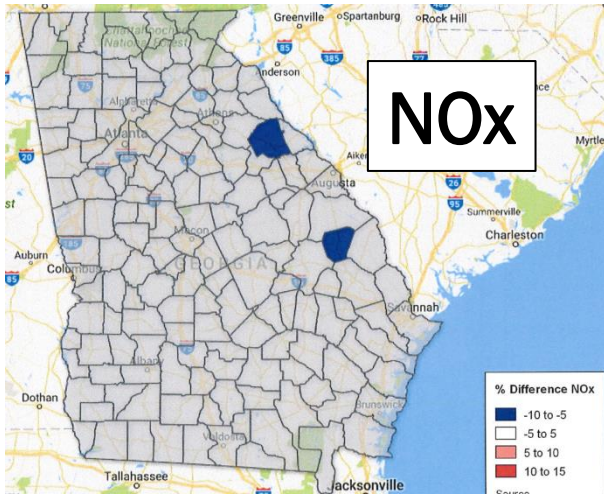
NO_x

VOC

CO

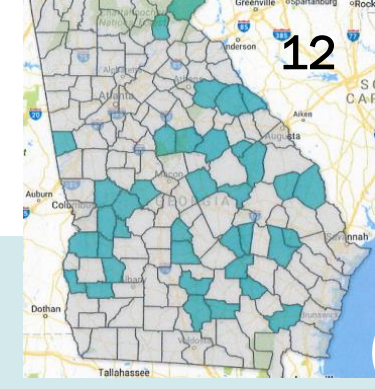
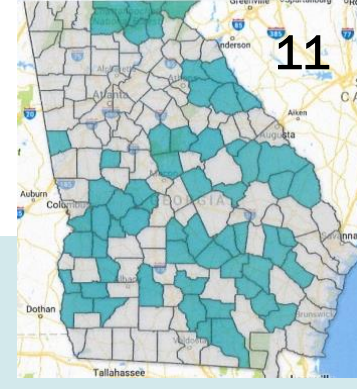
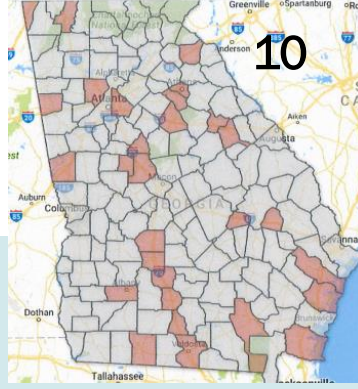
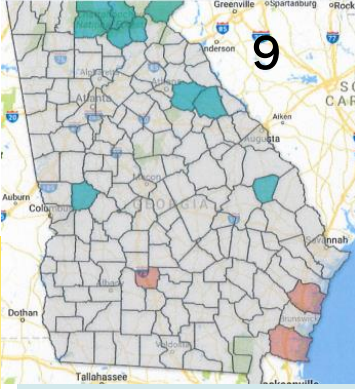
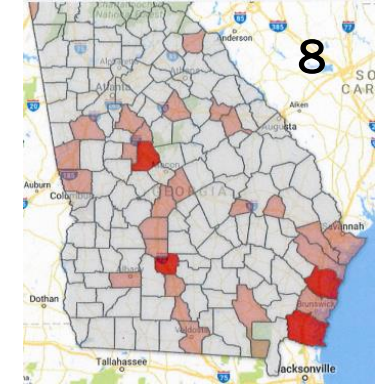
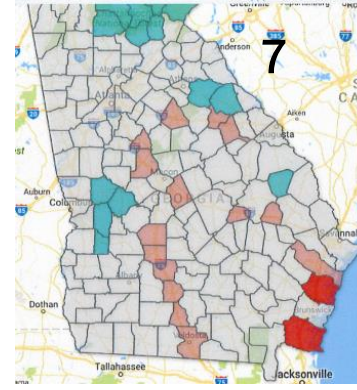
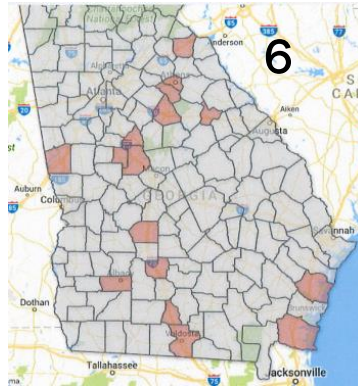
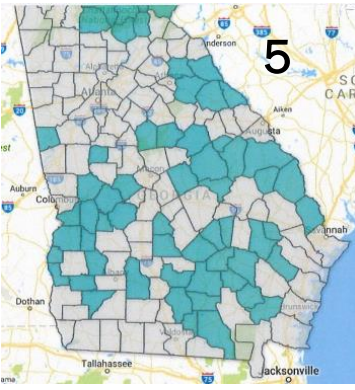
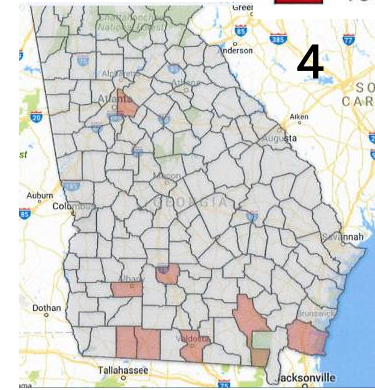
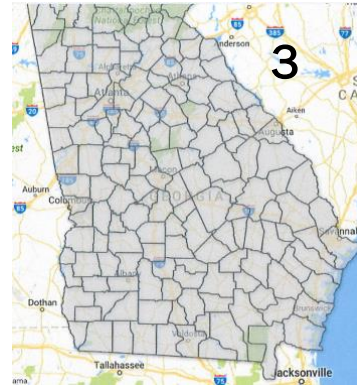
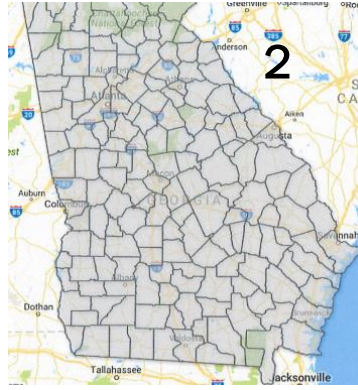
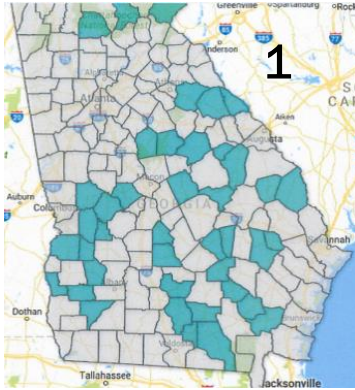
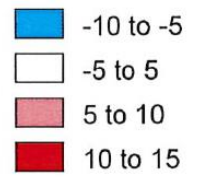


ANNUAL EMISSIONS DIFFERENCE (%)



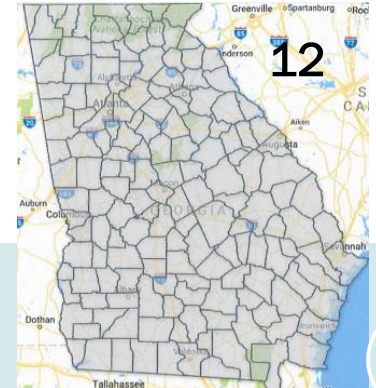
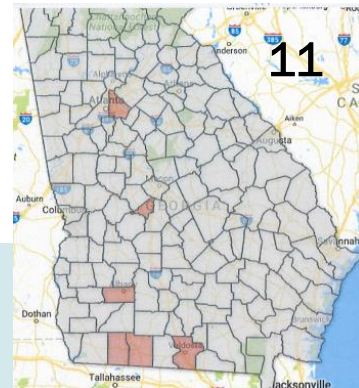
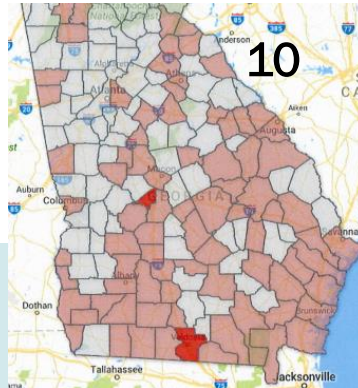
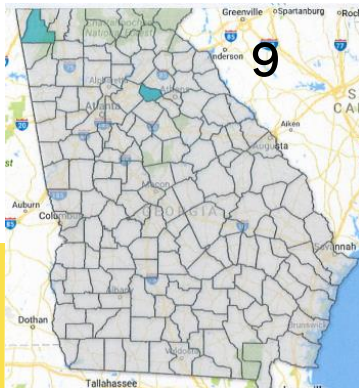
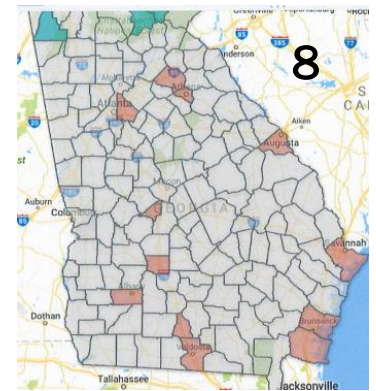
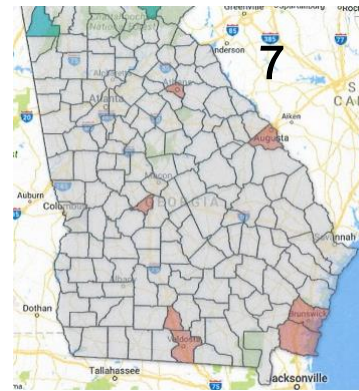
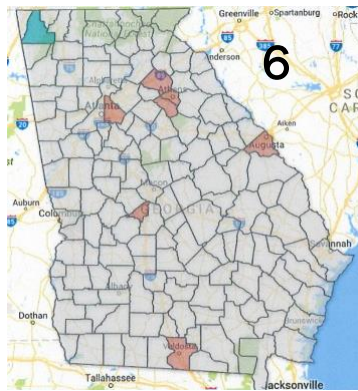
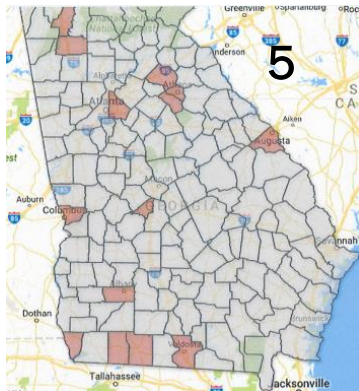
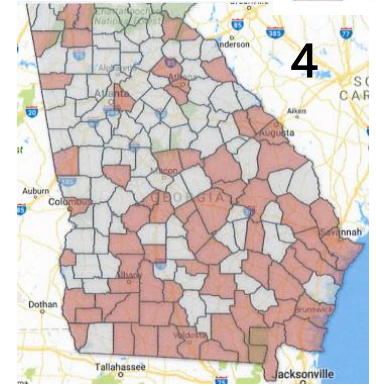
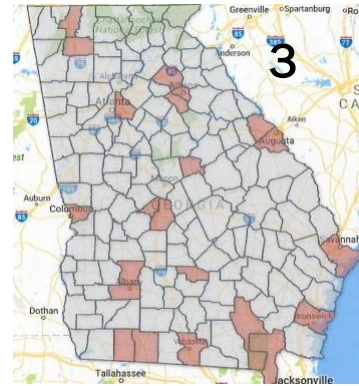
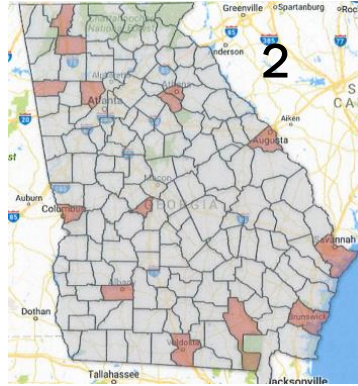
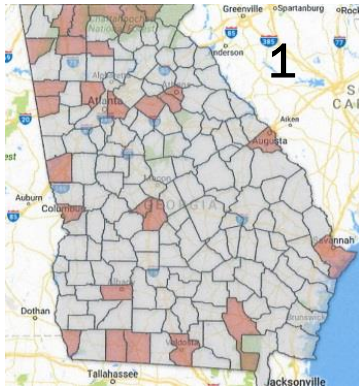
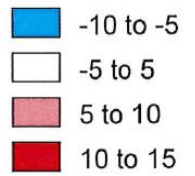


MONTHLY NO_x DIFFERENCE (%)



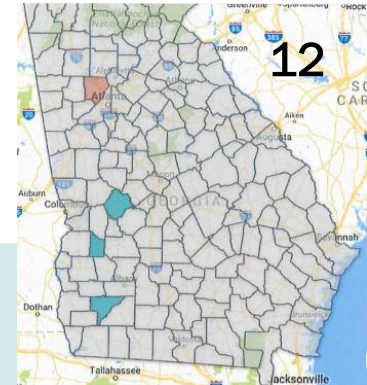
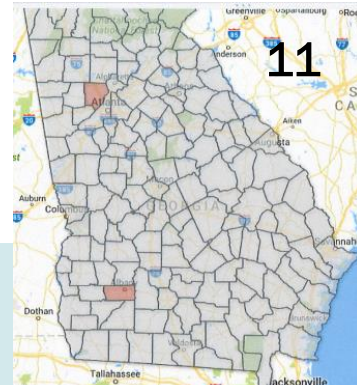
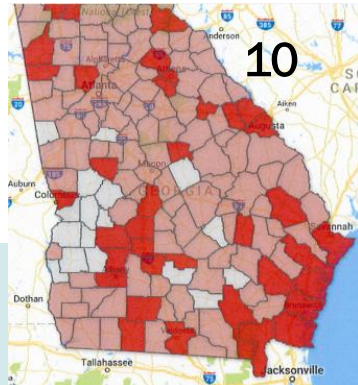
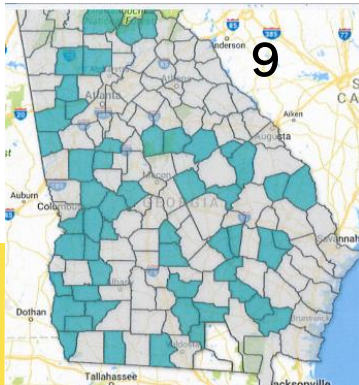
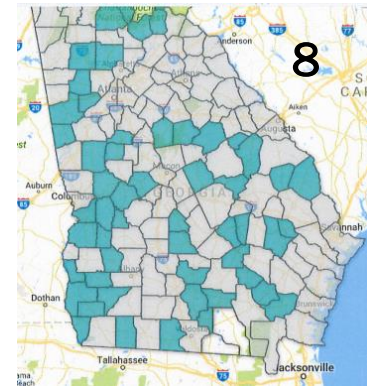
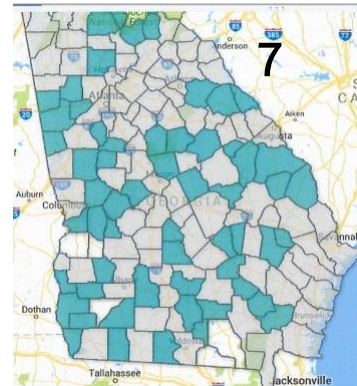
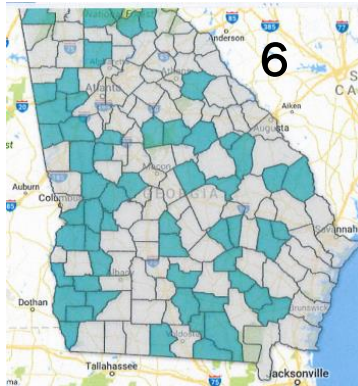
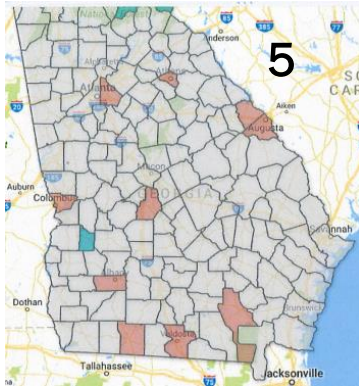
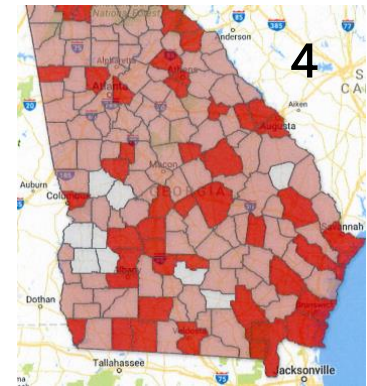
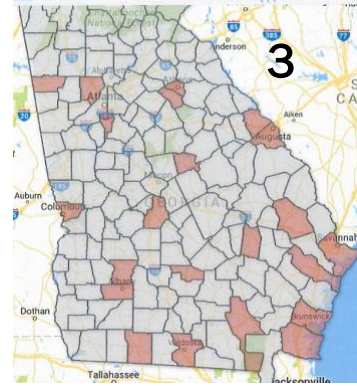
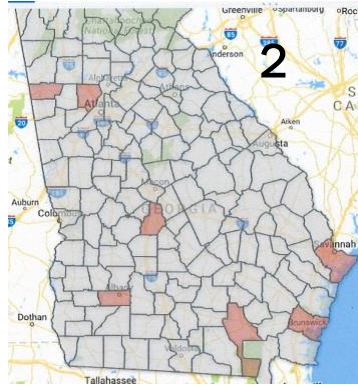
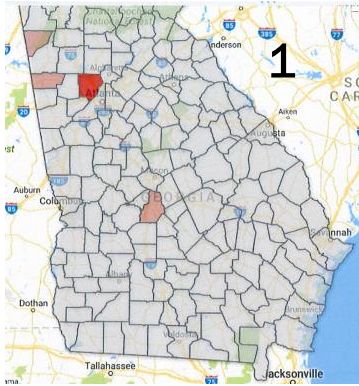
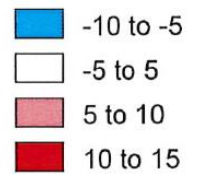


MONTHLY VOC DIFFERENCE (%)



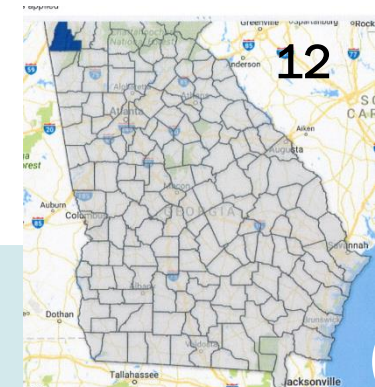
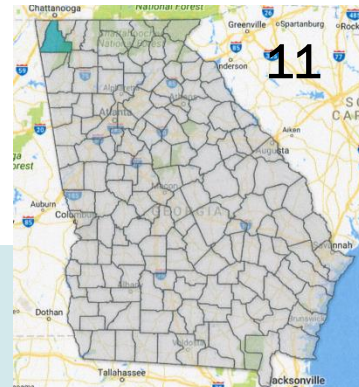
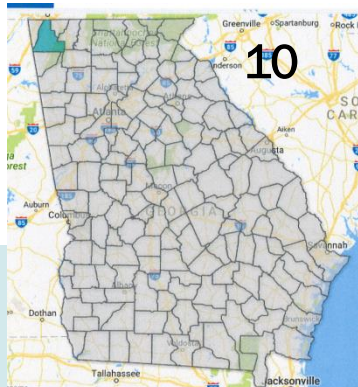
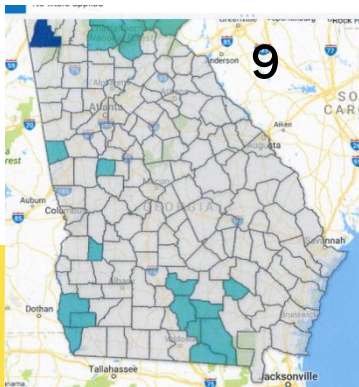
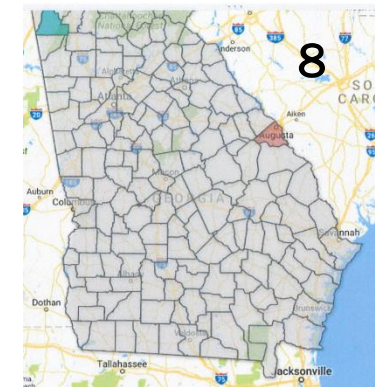
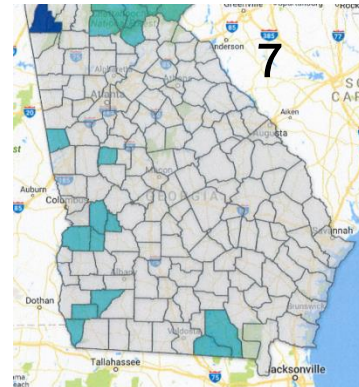
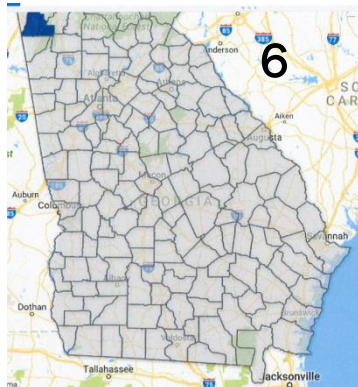
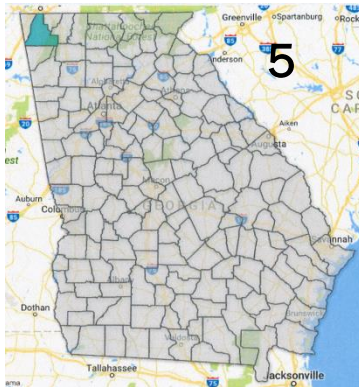
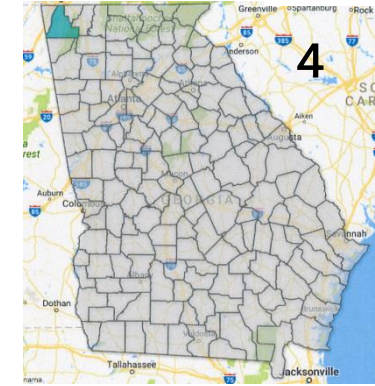
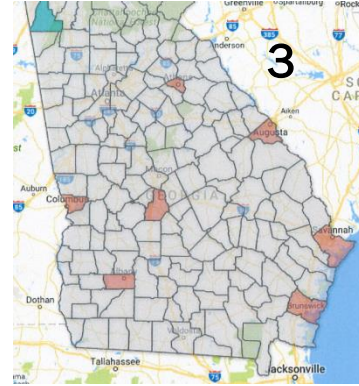
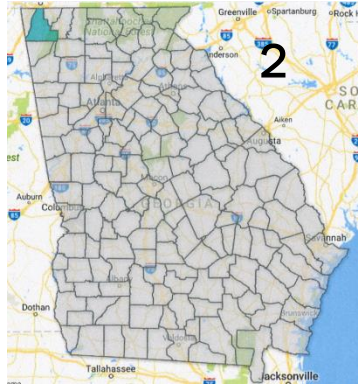
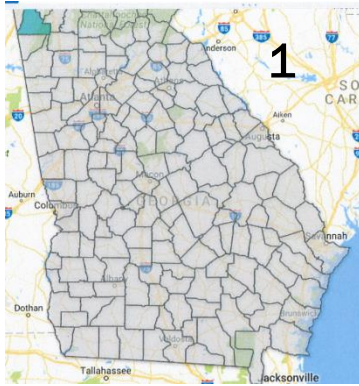
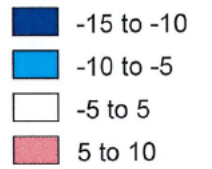


MONTHLY CO DIFFERENCE (%)



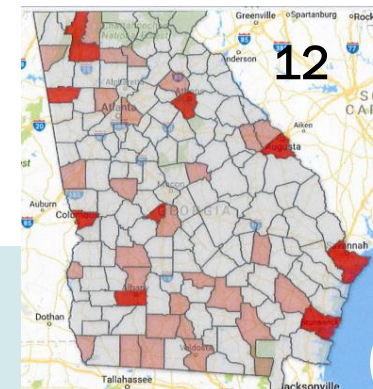
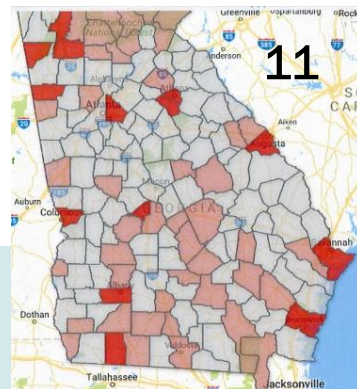
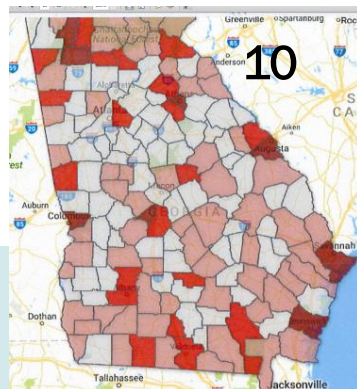
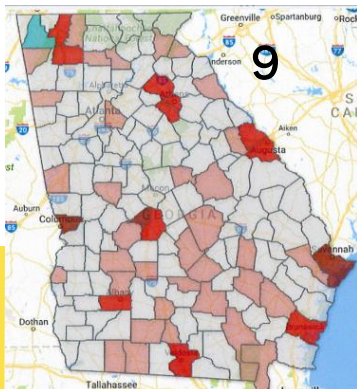
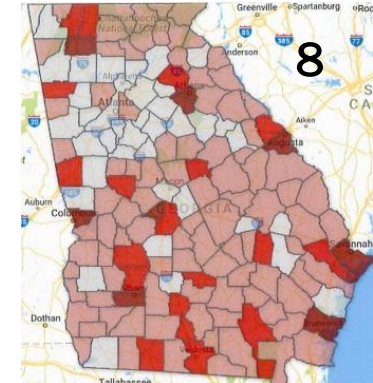
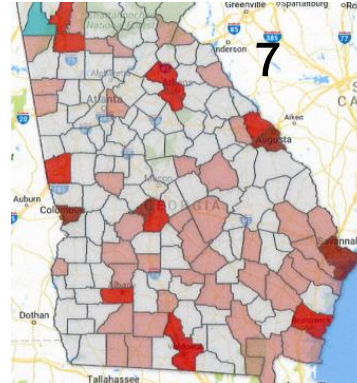
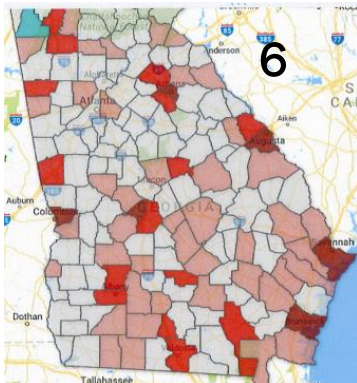
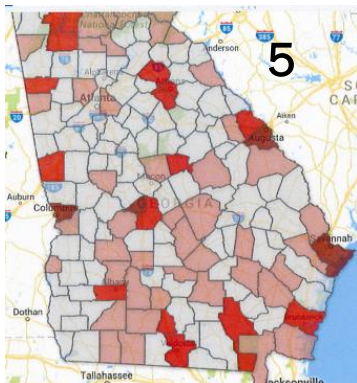
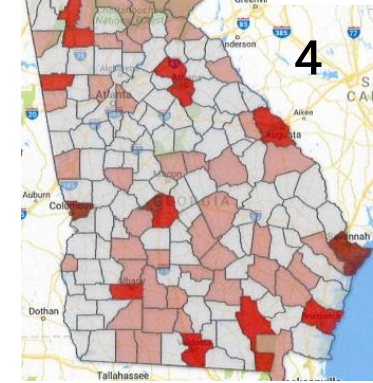
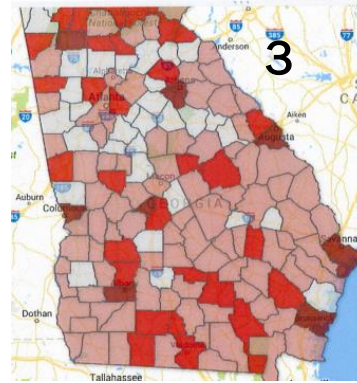
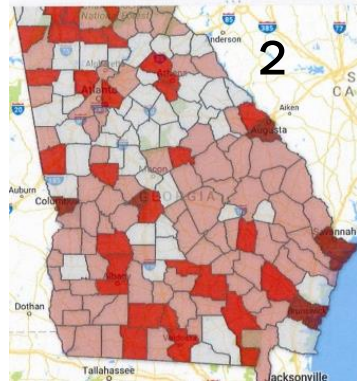
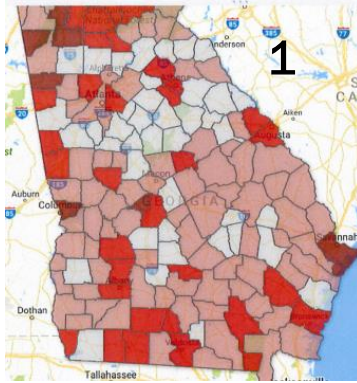
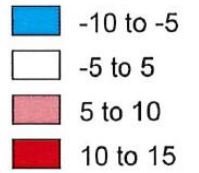


MONTHLY SO₂ DIFFERENCE (%)



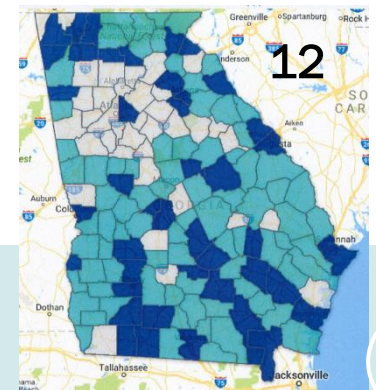
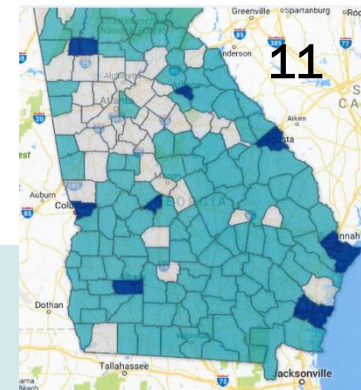
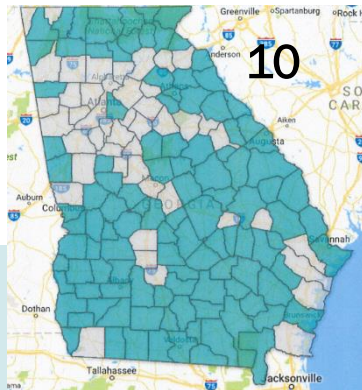
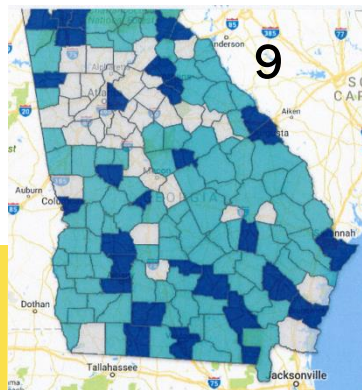
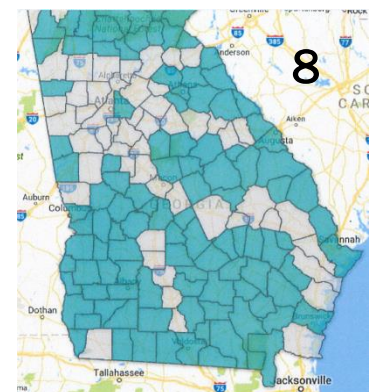
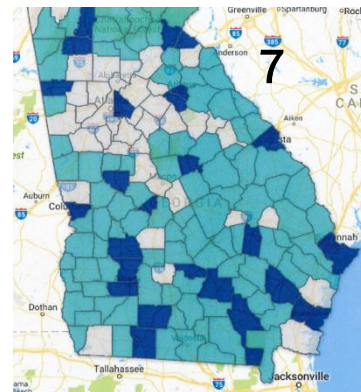
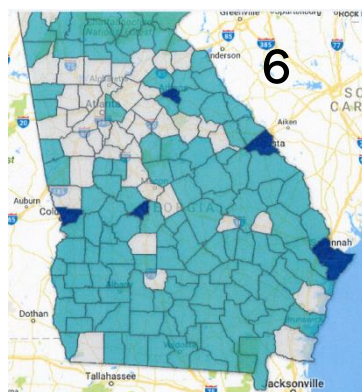
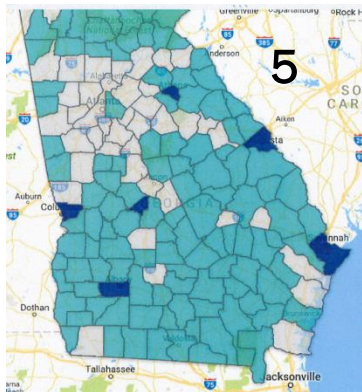
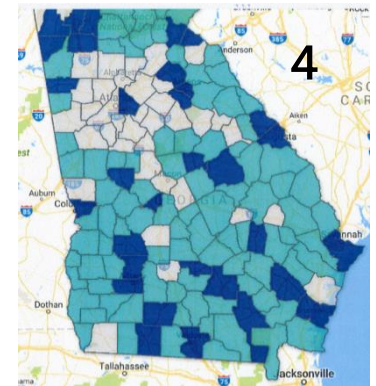
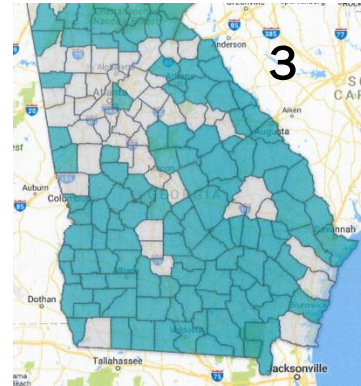
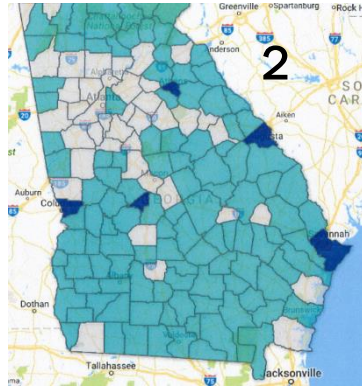
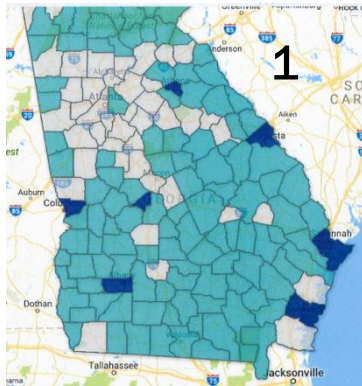


MONTHLY PM_{2.5} DIFFERENCE (%)





MONTHLY NH₃ DIFFERENCE (%)





PM_{2.5} AND NH₃ DIFFERENCES

- PM_{2.5} and NH₃ differences > 5% for many counties
 - Up to 13% for NH₃
 - Up to 19% for PM_{2.5}
 - No seasonality
- Lower emissions differences: Local speed data, rural roads, especially interstates
- Higher emissions differences: Default speed data, urban roads
- Small speed variation on rural interstates versus urban
- PM_{2.5} and NH₃ react oppositely to speed change within moderate speed profile (e.g., 35-55mph)



MATCHING INPUTS

- VMT fraction and hourly speed mismatches found
 - Different default sources for average speed distributions between EPD and EPA
 - Default hourly split based on VTRIS not EPD submission
- Conducted test with matched default speed distribution, hourly split
 - Reran MOVES: 4 worst case counties, 1 rural county
 - 2 of 4 “worst cases” representative counties



County/ FIPS ID	Pollutant	Original Difference (EPA-EPD, %)	With Adj AvgSpeed and HrVMT (%)
Chatham* 13051	VOC	5.8	2.7
	CO	4.6	2.5
	NH3	-10.5	-8.7
	NOx	1.3	0.8
	SO2	3.6	0.5
	PM2.5	16.6	7.9
Muscogee 13215	VOC	-8.7	2.5
	CO	4.7	2.6
	NH3	-10.5	-8.6
	NOx	1.4	0.8
	SO2	3.6	0.5
	PM2.5	16.9	8.5
Peach 13225	VOC	6.4	2.0
	CO	0.3	-0.4
	NH3	-10.6	-9.6
	NOx	-0.8	-0.8
	SO2	2.5	-1.1
	PM2.5	16.4	7.6
Richmond* 13245	VOC	6.1	3.1
	CO	5.8	3.5
	NH3	-10.6	-8.4
	NOx	1.2	0.7
	SO2	3.9	0.9
	PM2.5	15.2	7.3
Candler 13043	VOC	0.9	0.9
	CO	1.0	-1.0
	NH3	-1.7	-1.5
	NOx	2.1	-0.1
	SO2	0.4	-1.2
	PM2.5	0.7	1.5

- PM_{2.5} difference halved
- NH₃ small improvement
- Other pollutants match better
- Still something missing...



AVERAGE SPEED DISTRIBUTION

- For average speed at given hour, get emission factor:
 - SMOKE-MOVES interpolates between 2 speed bins
 - MOVES inventory internally from 16 speed bins, weighted by fraction at each speed bin
- Reran MOVES for same 5 counties, modifying average speed distribution to replicate 2 speed bins approach in SMOKE-MOVES



TWO WAYS TO DESCRIBE 39 MPH

MOVES Inventory			SMOKE-MOVES Equivalent		
SpeedBin	AvgSpeed	Fraction	SpeedBin	AvgSpeed	Fraction
1	2.5	0.15983	1	2.5	0
2	5	0.01767	2	5	0
3	10	0.02459	3	10	0
4	15	0.02228	4	15	0
5	20	0.02824	5	20	0
6	25	0.04318	6	25	0
7	30	0.0429	7	30	0
8	35	0.03601	8	35	0.119294
9	40	0.03314	9	40	0.880706
10	45	0.03022	10	45	0
11	50	0.19586	11	50	0
12	55	0.06734	12	55	0
13	60	0.29116	13	60	0
14	65	0.00757	14	65	0
15	70	0	15	70	0
16	75	0	16	75	0



County/ FIPS ID	Pollutant	With Previous Corrections (EPA-EPD, %)	Add Speed Bin Correction (%)
Chatham* 13051	VOC	2.7	1.6
	CO	2.5	1.8
	NH3	-8.7	-0.3
	NOx	0.8	0.6
	SO2	0.5	-0.1
	PM2.5	7.9	0.1
Muscogee 13215	VOC	2.5	1.5
	CO	2.6	1.9
	NH3	-8.6	-0.2
	NOx	0.8	0.4
	SO2	0.5	-0.2
	PM2.5	8.5	0.9
Peach 13225	VOC	2.0	1.6
	CO	-0.4	1.8
	NH3	-9.6	-0.3
	NOx	-0.8	0.6
	SO2	-1.1	-0.1
	PM2.5	7.6	0.1
Richmond* 13245	VOC	3.1	1.8
	CO	3.5	2.2
	NH3	-8.4	-0.2
	NOx	0.7	-0.2
	SO2	0.9	0.0
	PM2.5	7.3	0.4
Candler 13043	VOC	0.9	1.4
	CO	-1.0	1.5
	NH3	-1.5	-0.1
	NOx	-0.1	0.7
	SO2	-1.2	-0.2
	PM2.5	1.5	-3.1

PM_{2.5} and NH₃ now differ by <1%!



CONCLUSIONS

- Comparing SMOKE-MOVES to Inventory MOVES is a critical QA step.
- MOVES2014a incorrectly handles new startsperday input table for multiple month run, can produce up to 35% error
- Simplifying to 2 speed bins for EFs in SMOKE-MOVES causes significant differences, especially for $PM_{2.5}$ and NH_3
- Other differences from:
 - Using only 2 fuel seasons in SMOKE-MOVES
 - Variation between representative county and group members (ramp fraction an example for Atlanta and Chattanooga)
 - Mismatched inputs (average speed, VMT fractions)
- Meteorology impact limited
 - Small seasonal variation for NO_x , CO differences?



LOOKING TO THE FUTURE...

- Most states can run MOVES in inventory mode, very few states can run SMOKE-MOVES
- GA EPD feels that running MOVES in inventory mode is preferred to running SMOKE-MOVES since there are no additional simplifying assumptions.
 - The “Gold Standard” should be inventory MOVES runs with hourly meteorology from WRF or from observations
- GA EPD Hybrid Approach
 - Run inventory MOVES with monthly diurnal meteorology for attainment counties and run inventory MOVES with hourly meteorology for nonattainment counties.
 - Then, need to run inventory MOVES outputs through SMOKE for photochemical modeling.



CONTACT INFORMATION

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