TCEQ Photochemical Modeling Update

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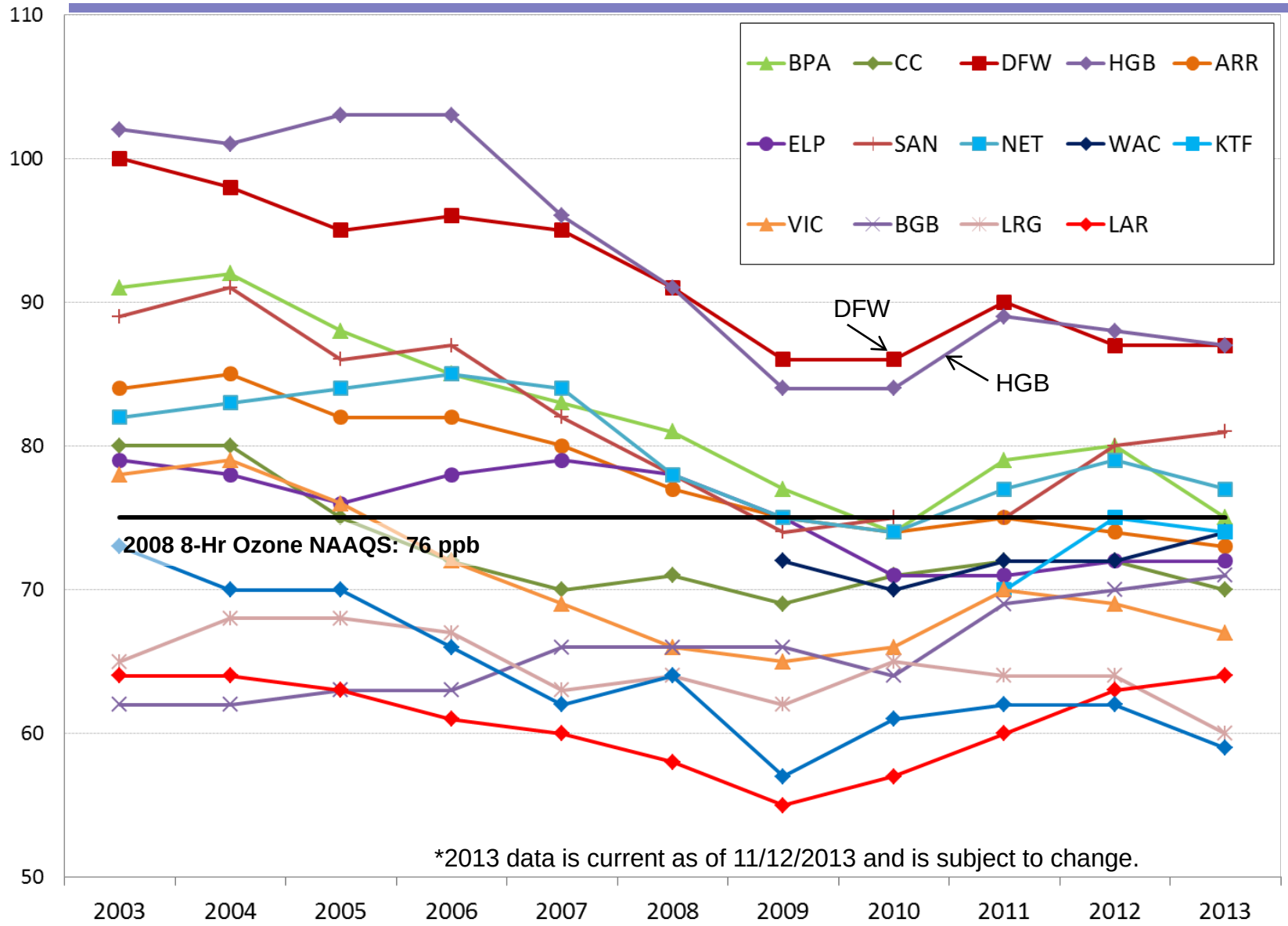
Southeast Texas Photochemical Modeling Technical Committee Meeting
Houston-Galveston Area Council Offices

July 21, 2014

Texas Design Values by Area 2003-2013*

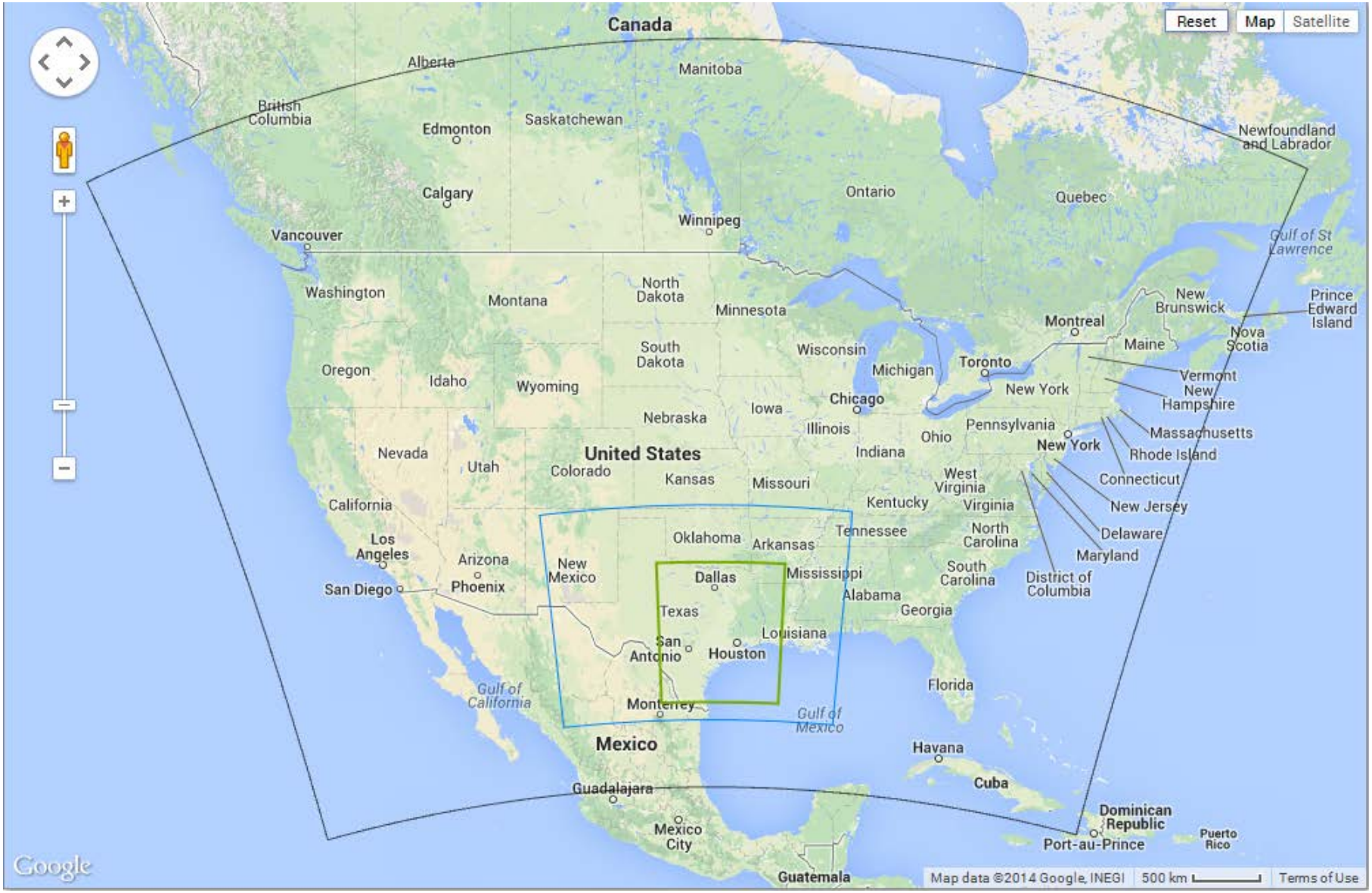


2014 HGB Preliminary Design Values*

Monitor Name	Current 2014 DV ppb	2014 4th high ppb	2014 4th high to exceed 75 ppb	2014 4th high to exceed 84 ppb
Manvel Croix Park C84	78	63	57	84
Conroe Relocated C78/A321	75	69	71	98
Houston Monroe C406	74	64	69	96
Northwest Harris Co. C26/A110/X154	74	60	66	93
Houston Westhollow C410	73	61	70	97
Houston Croquet C409	73	63	70	97
Lang C408	73	61	68	95
Houston Bayland Park C53/A146	73	61	70	97
Hou.DeerPrk2 C35/235/1001/AFH139FP239	72	62	74	101
Park Place C416	72	60	72	99
Seabrook Friendship Park C45	72	64	75	102
Houston East C1/G316	72	65	76	103
Houston Aldine C8/AF108/X150	71	66	79	106
Houston Texas Avenue C411	70	58	74	101
Galveston 99th St. C1034/A320/X183	70	65	83	110
Houston North Wayside C405	68	61	83	110
Clinton C403/C304/AH113	68	57	80	107
Channelview C15/AH115	67	64	90	117
Baytown Garth C1017	66	67	96	123
Lynchburg Ferry C1015/A165	66	59	89	116
Lake Jackson C1016	66	61	90	117

* as of July 7, 2014

Texas RPO Modeling Domains



Modeling Setup

February 27, 2014 PMTC Update vs Current TCEQ Modeling

CAMx Photochemical Model

- v6.00a → v6.10p1
- CB6 → CB6r2
- Satellite-based monthly Leaf Area Index

Meteorological Model – WRF v3.2

- No changes

Biogenic Emission Model – MEGAN v2.10

- New urban Leaf Area Index

Modeling Setup

February 27, 2014 PMTC Update vs Current TCEQ Modeling

Point Sources

- Texas: latest 2006 State of Texas Air Reporting System (STARS)
- Non-Texas: 2008 NEI
- 2018 Projection using 2012 STARS, 2013 Air Markets Program Data, CAIR Phase II, HECT, MECT, and EPA's 2018 Modeling Platform

Added:

- Base case FINN fires from http://bai.acd.ucar.edu/Data/fire/

Oil and Gas

- 2013 Railroad Commission of Texas production used for projection

Area/Non-road

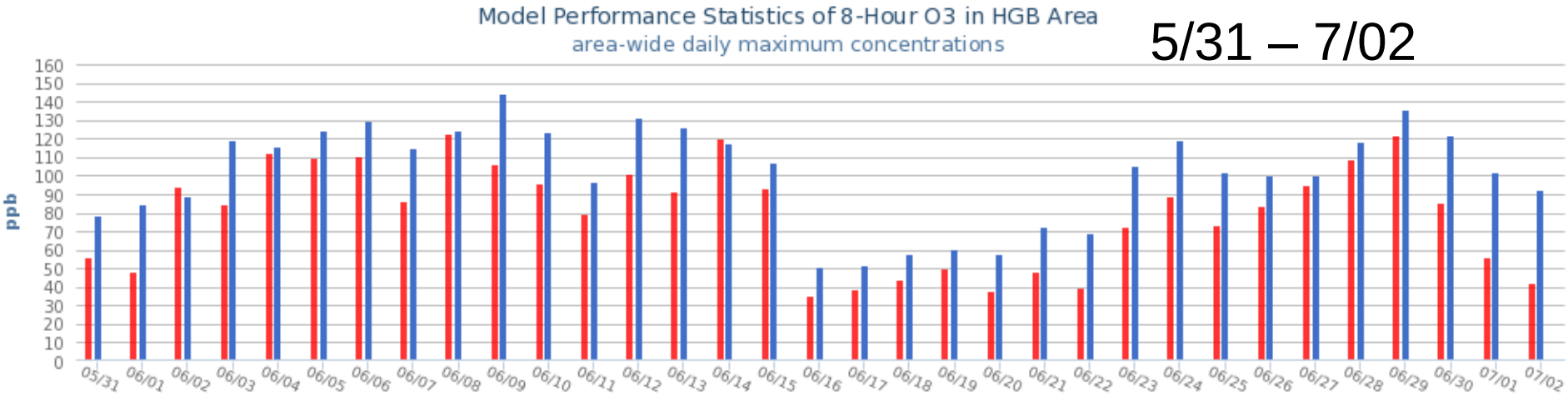
- No changes

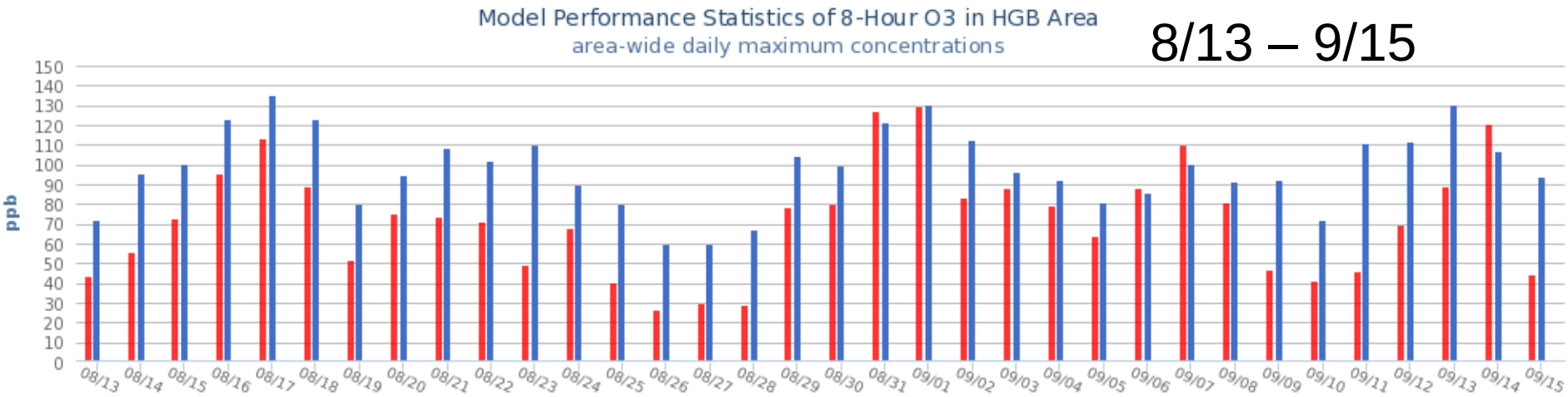
2006 & 2018 HGB 8-County Estimated* Anthropogenic Emissions

Summer Weekday Emissions (tons per day)	**2006 Baseline**		**2018 Baseline**	
	NO_X	**VOC**	**NO_X**	**VOC**
On-Road	270.28	105.07	103.39	50.77
Non-Road	75.40	55.86	31.09	27.63
Area	25.69	261.36	27.19	269.38
Off-Road – Locomotives & Airports & Comm. Marine	28.08	2.99	23.30	2.62
Oil and Gas - Production	2.85	102.15	2.13	67.86
Oil and Gas - Drill Rigs	2.44	0.17	0.40	0.00
Point Sources	202.33	208.95	146.50	143.66
Total	**607.07**	**736.55**	**334.00**	**561.92**

*Based on current DFW AD SIP modeling work

2006 Base Case Performance*





Observed

camx610p1_cb6r2.tx.bc06_06aqs1.reg2h.2006_5layer_YSU_WSM6_3dsfc1h_fddats_gq_sfc_0.tx_4km

*Based on current DFW AD SIP modeling work

Estimated / Unofficial 2018 HGB Future Design Values (ppb)

Sitename	2018 DVf – 30 ppm Sulfur	2018 DVf – 10 ppm Sulfur	2018 DVf – CSAPR Estimate
Bayland Park	82.68	81.96	82.59
Deer Park	81.76	81.40	81.67
Monroe	79.11	78.65	79.01
Westhollow	77.86	77.09	77.80
Manvel Croix	76.51	75.94	76.40
Seabrook Friendship Park	75.18	74.90	75.11
Croquet	74.85	74.24	74.76
Houston Northwest	74.01	73.26	73.89
Aldine	72.81	72.27	72.72
Channelview	72.63	72.29	72.56
Lynchburg Ferry	71.80	71.48	71.74
Houston East	70.36	70.01	70.28
Regional Office	69.18	68.74	69.10
Conroe	69.12	68.47	68.96
Clinton Drive	69.09	68.72	69.01
Texas Avenue	68.88	68.45	68.81
Galveston Airport	67.92	67.67	67.84
North Wayside	66.42	66.00	66.34
Lang	66.18	65.59	66.14
Lake Jackson	66.01	65.68	65.92

Model of Emissions of Gases and Aerosols from Nature (MEGAN)

The MEGAN model requires inputs by model grid cell area of:

- Emission factors for 19 chemical compounds/groups;
- Plant Functional Types (PFTs);
- Fractional Vegetated Leaf Area Index (LAIv);

- Meteorological information including air and soil temperatures, photosynthetically active radiation (PAR), barometric pressure, wind speed, water vapor mixing ratio, and accumulated precipitation.

MEGAN Emission Factors (EF) ($\mu g m^{-2} h^{-1}$)

Broadleaf Deciduous Temperate Tree

Compound Class	EF1	EF2	EF3	EF4	EF5	EF6	EF7	EF8	EF9	EF10	EF11	EF12	EF13	EF14	EF15
Isoprene	600	3000	1	7000	10000	7000	10000	11000	2000	4000	4000	1600	800	200	1
Myrcene	70	70	60	80	30	80	30	30	30	50	30	0.3	0.3	0.3	0.3
Sabinene	70	70	40	80	50	80	50	50	50	70	50	0.7	0.7	0.7	0.7
Limonene	100	100	130	80	80	80	80	80	60	100	60	0.7	0.7	0.7	0.7
3-Carene	160	160	80	40	30	40	30	30	30	100	30	0.3	0.3	0.3	0.3
t-β-Ocimene	70	70	60	150	120	150	120	120	90	150	90	2	2	2	2
α-Pinene	300	300	200	120	130	120	130	130	100	150	100	1.5	1.5	1.5	1.5
α-Pinene	500	500	510	600	400	600	400	400	200	300	200	2	2	2	2
Other Monoterpenes	180	180	170	150	150	150	150	150	110	200	110	5	5	5	5
α-Farnesene	40	40	40	60	40	60	40	40	40	40	40	3	3	3	4
β-Caryophyllene	80	80	80	60	40	60	40	40	50	50	50	1	1	1	4
Other Sesquiterpenes	120	120	120	120	100	120	100	100	100	100	100	2	2	2	2
232-MBO	700	60	0.01	0.01	0.01	0.01	0.01	2	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Methanol	900	900	900	500	900	500	900	900	900	900	900	500	500	500	900
Acetone	240	240	240	240	240	240	240	240	240	240	240	80	80	80	80
CO	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Bidirectional VOC	500	500	500	500	500	500	500	500	500	500	500	80	80	80	80
Stress VOC	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Other VOC	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140

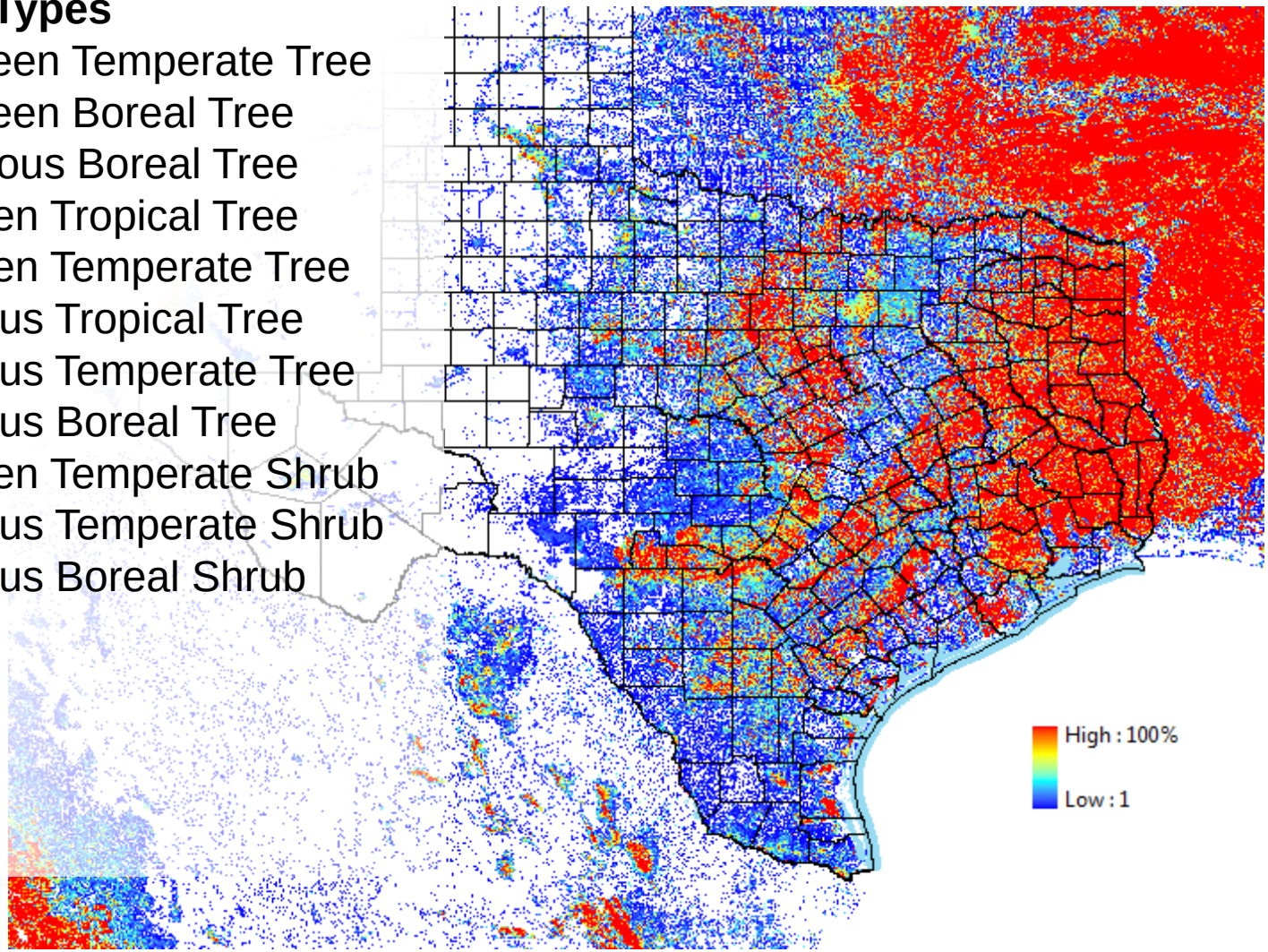
Adapted from Guenther et al, 2012

MEGAN Plant Functional Types (PFT)

Plant Functional Types

- Needleleaf Evergreen Temperate Tree
- Needleleaf Evergreen Boreal Tree
- Needleleaf Deciduous Boreal Tree
- Broadleaf Evergreen Tropical Tree
- Broadleaf Evergreen Temperate Tree
- Broadleaf Deciduous Tropical Tree
- Broadleaf Deciduous Temperate Tree
- Broadleaf Deciduous Boreal Tree
- Broadleaf Evergreen Temperate Shrub
- Broadleaf Deciduous Temperate Shrub
- Broadleaf Deciduous Boreal Shrub
- Arctic C3 Grass
- Cool C3 Grass
- Warm C4 Grass
- Crop

Broadleaf Deciduous Temperate Trees



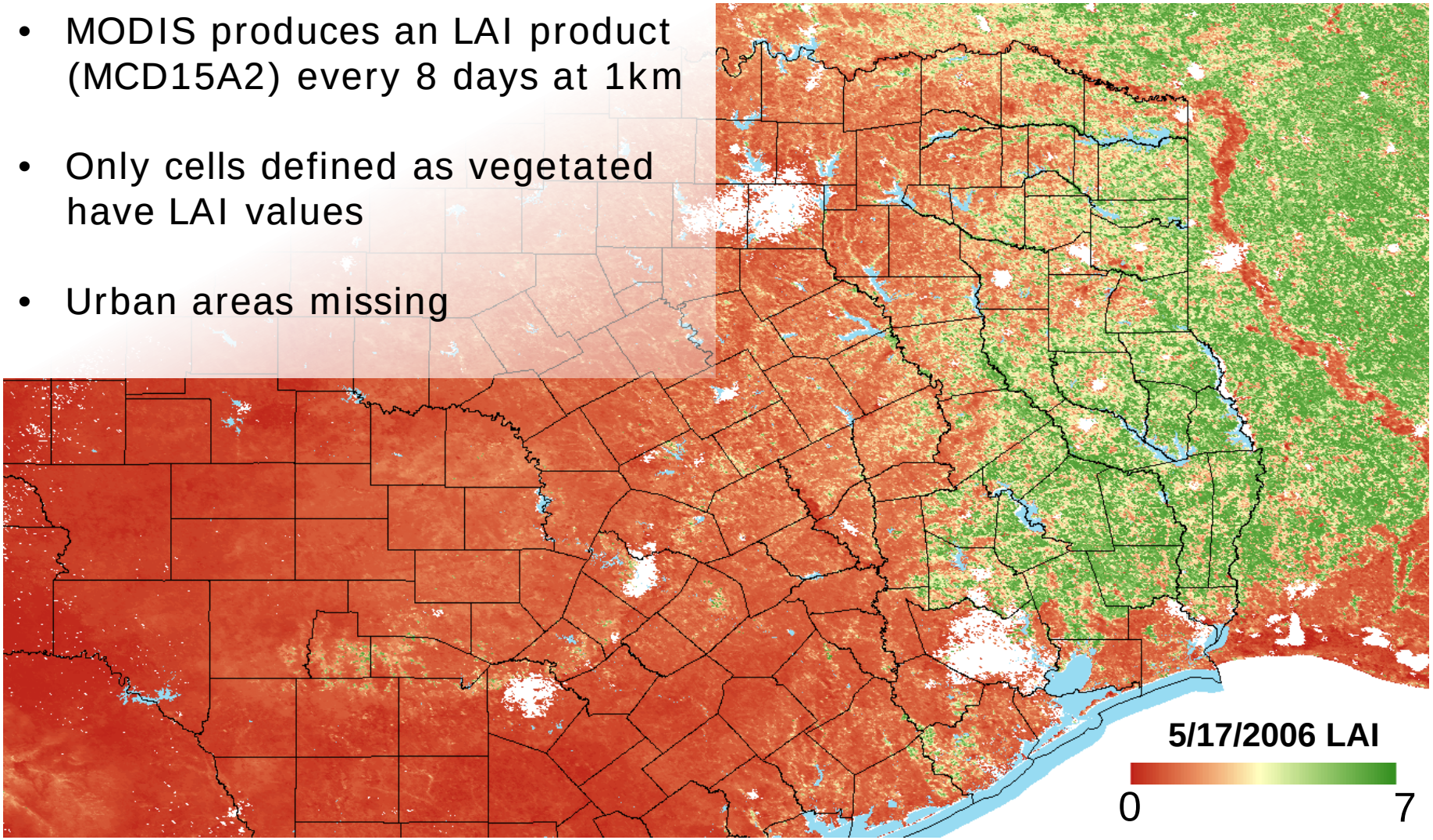
MEGAN Fractional Vegetated Leaf Area Index (LAIv)

- LAI is the one-sided leaf coverage over the same area of land. (0 – 7.0 m^2/m^2)
- Fractional vegetated Leaf Area Index (LAIv) is the LAI divided by the fraction of land defined as vegetated. (0 – 10.0 typical)
- LAIv is input to MEGAN. Files for every eight-day period of 2008 are provided on the MEGAN website.

From Google Maps near Johnson Space Center

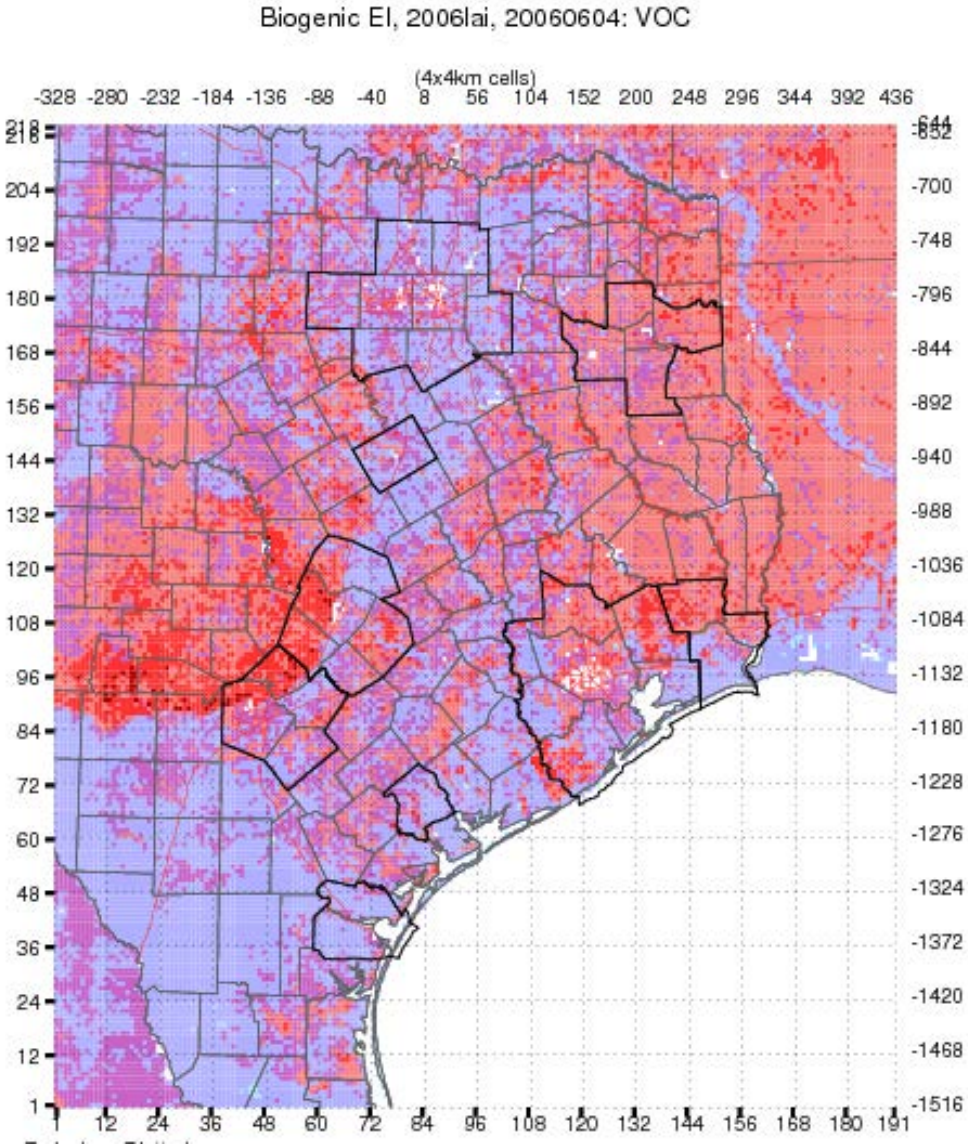
MEGAN LAIv Processing

- MODIS produces an LAI product (MCD15A2) every 8 days at 1km
- Only cells defined as vegetated have LAI values
- Urban areas missing



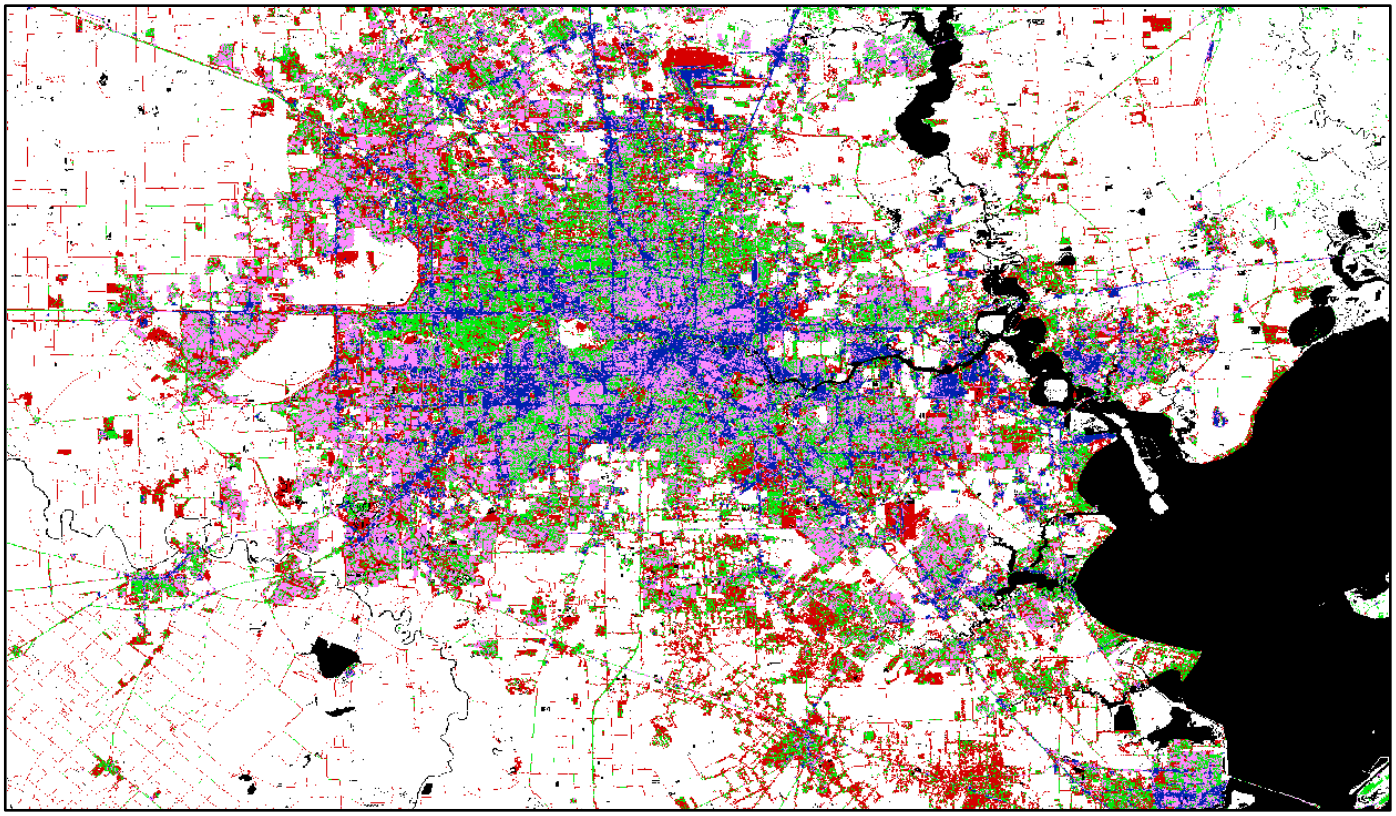
MEGAN LAIv Processing: Missing Urban Emissions

- Without LAI in urban areas, MEGAN produces zero VOC emissions.
- Dry deposition in CAMx would also be limited in urban areas without LAI.
- Urban areas have parks, shade trees, vegetation.



MEGAN LAIv Processing: Using TCEQ Urban Landcover Classes

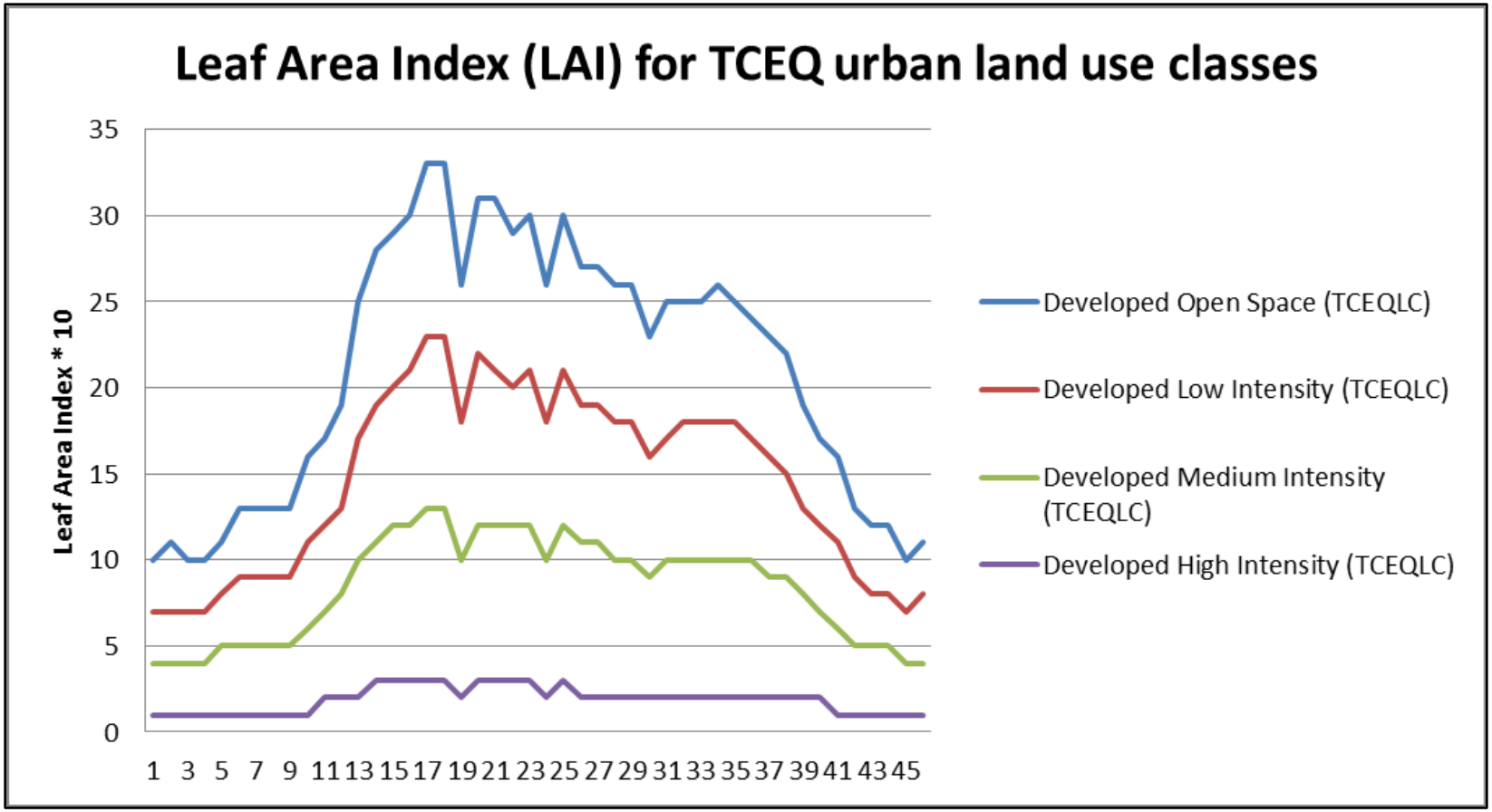
- TCEQ Landcover has four unique urban categories:



Open Areas
Low Intensity Development
Medium Intensity Development
High Intensity Development

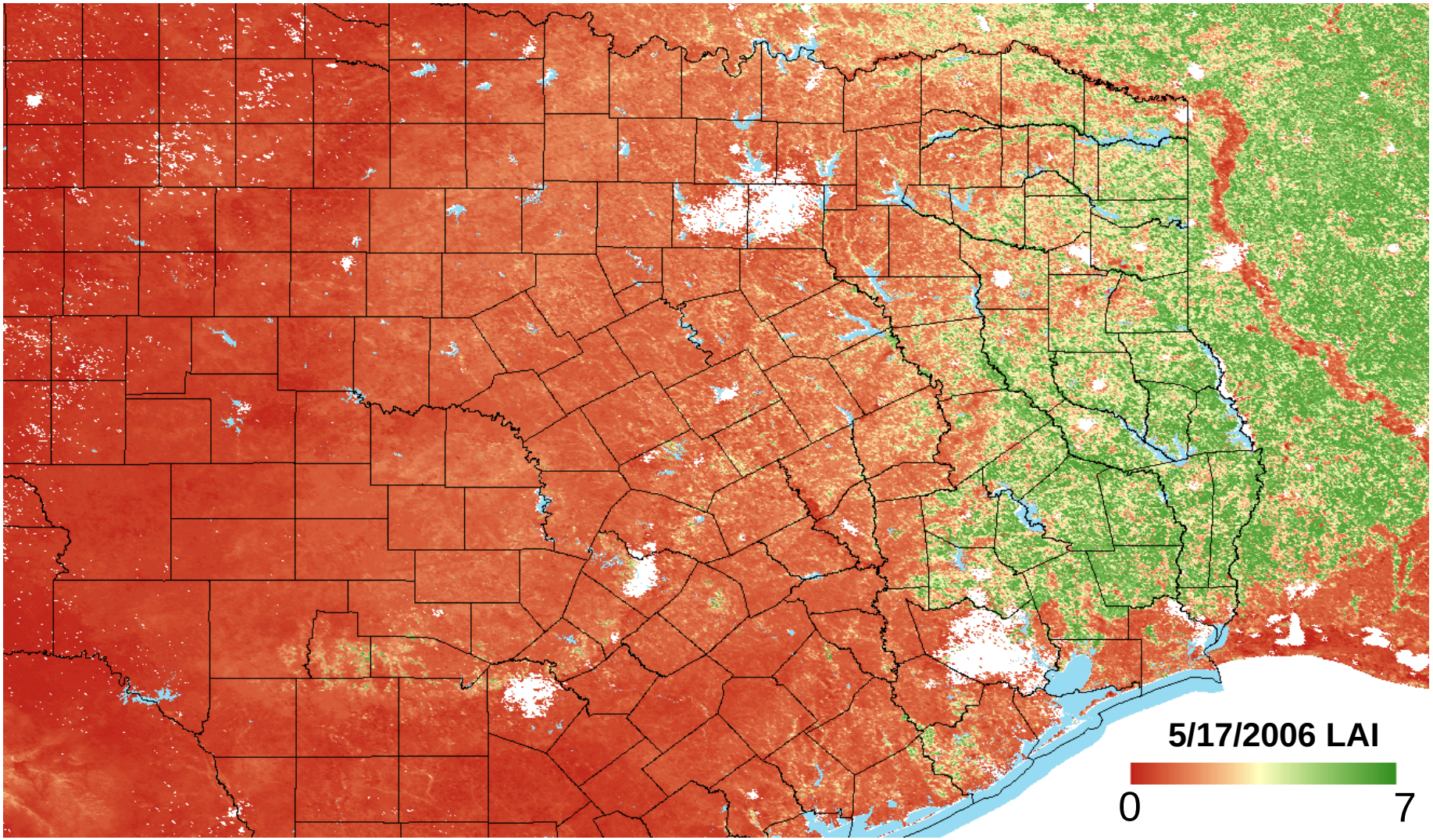
MEGAN LAIv Processing: Assigning LAI to Urban Classes

- Loughner et al, 2012[1] used **3.31** for urban tree LAI in WRF- urban canopy modeling work that was based on the USGS "deciduous broadleaf forest" land cover type.

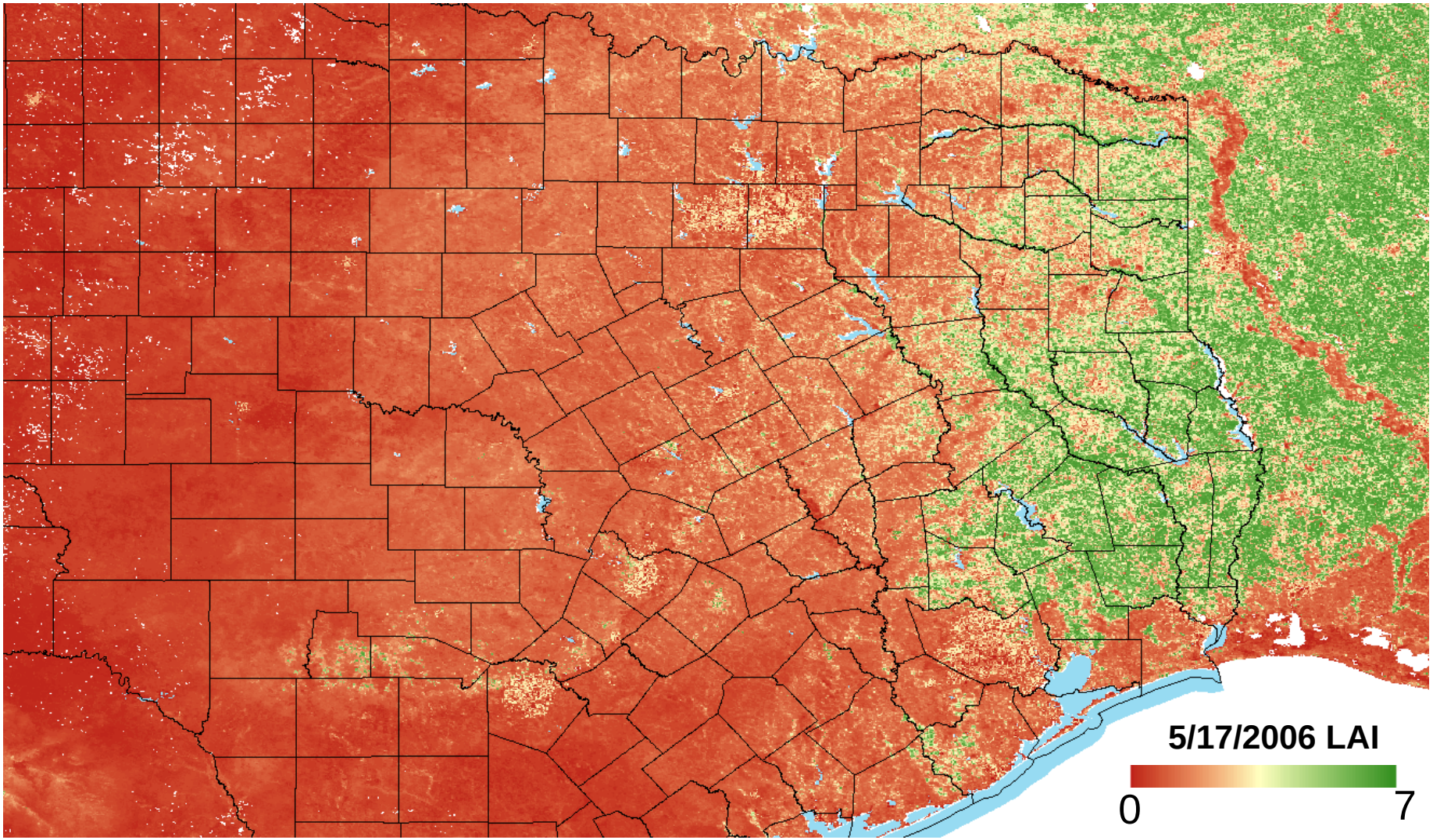


1. Loughner, Christopher P., Dale J. Allen, Da-Lin Zhang, Kenneth E. Pickering, Russell R. Dickerson, Laura Landry, 2012: Roles of Urban Tree Canopy and Buildings in Urban Heat Island Effects: Parameterization and Preliminary Results. J. Appl. Meteor. Climatol., 51, 1775–1793.

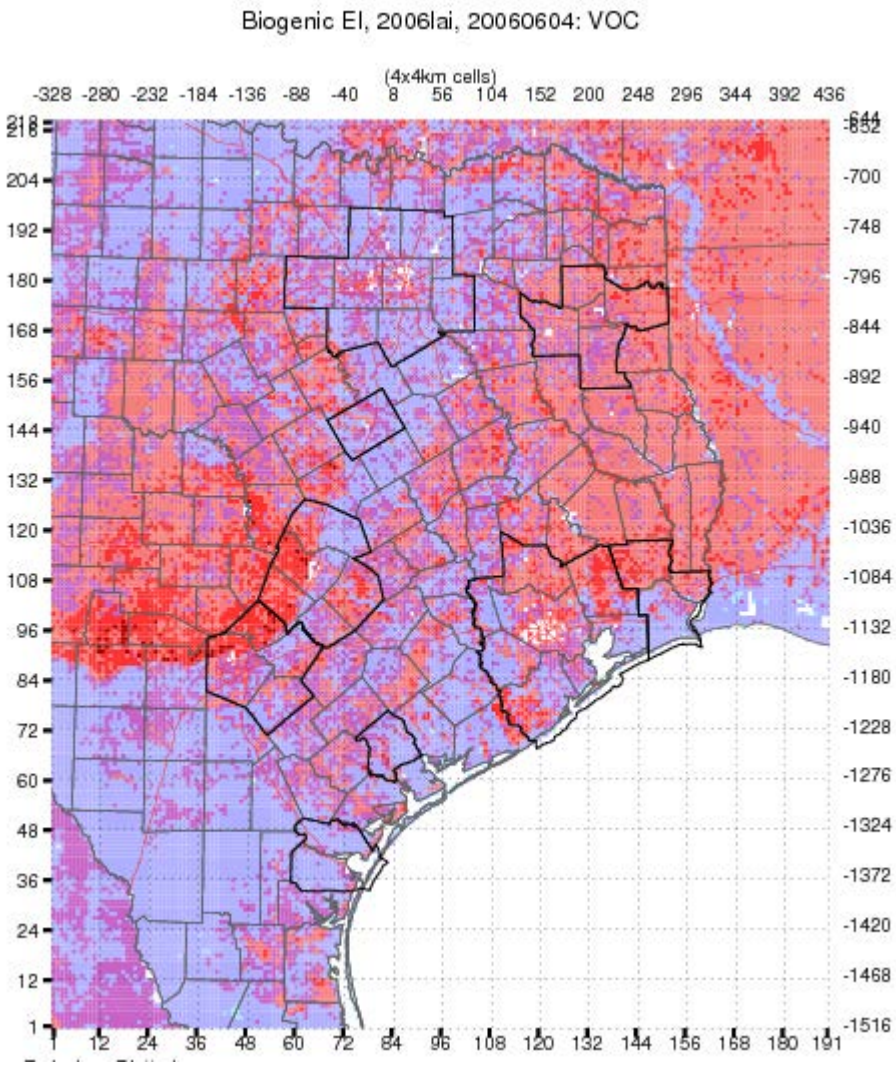
MEGAN LAIv Processing: Urban Holes



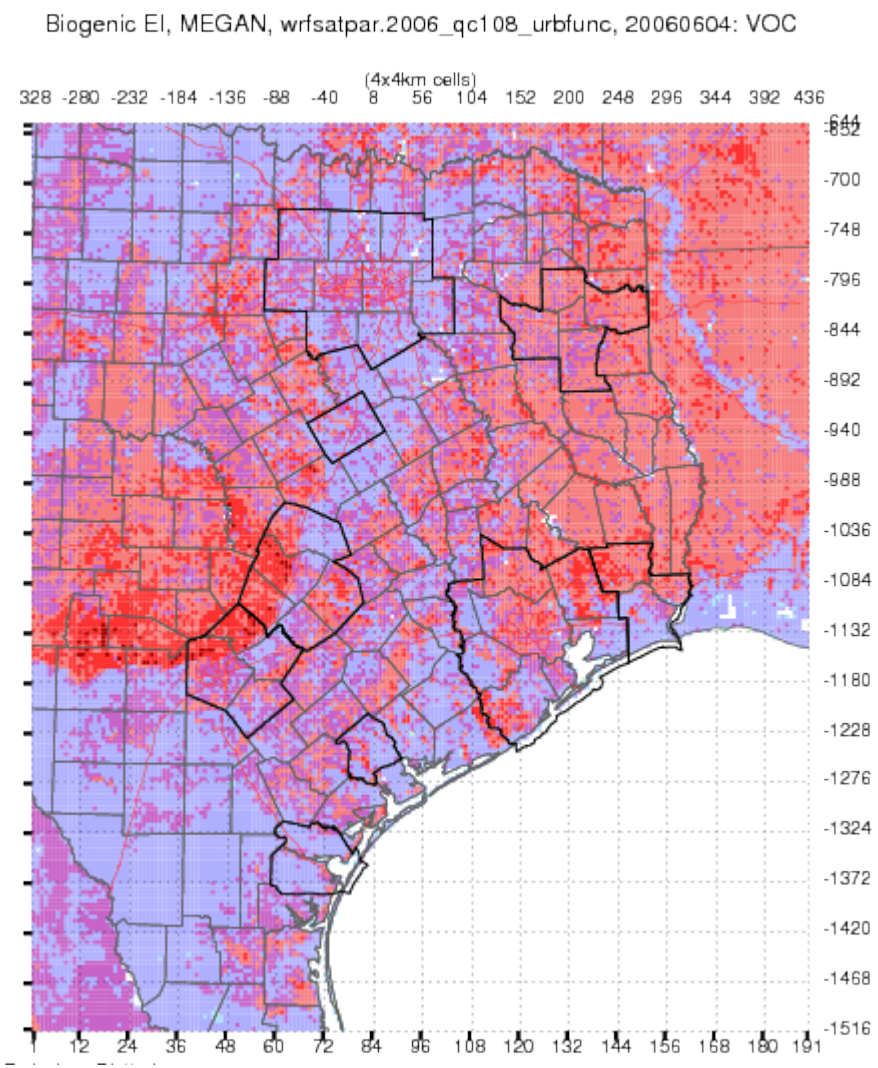
MEGAN LAIv Processing: Applied TCEQ Urban Class LAI



MEGAN LAIv Processing: With and Without Urban Emissions



Without urban LAI



With urban LAI

Current Ozone Modeling Plans and Known Future Changes

- Emission estimate updates:
  - MOVES 2014
  - Reprocess biogenic emissions if plant functional types for Texas are updated.
- Chemical mechanism:
  - Evaluate CB6 changes
- Meteorological modeling:
  - Continue to evaluate the latest WRF runs.
- EPA Modeling Guidance updates

Modeling Web Sites

- SET PMTC: Presentations and past meeting information
  http://www.tceq.state.tx.us/airquality/airmod/committee/pmtc_set.html

- Interactive Air Quality Modeling Results (New)
  http://www.tceq.texas.gov/airquality/airmod/data/results

- Proposed HGB and DFW EI SIP Revision for the 2008 Eight-Hour Ozone Standard (12/11/2013)
  http://www.tceq.texas.gov/airquality/sip/hgb/hgb-latest-ozone

- Current Eight-Hour Ozone SIP Modeling Details
  http://www.tceq.texas.gov/airquality/airmod/rider8/rider8Modeling

- Current Modeling File FTP Site
  ftp://amdaftp.tceq.texas.gov/pub/TX/

Questions?

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The Air Modeling & Data Analysis Section contributed to these results.

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air modeling data analysis

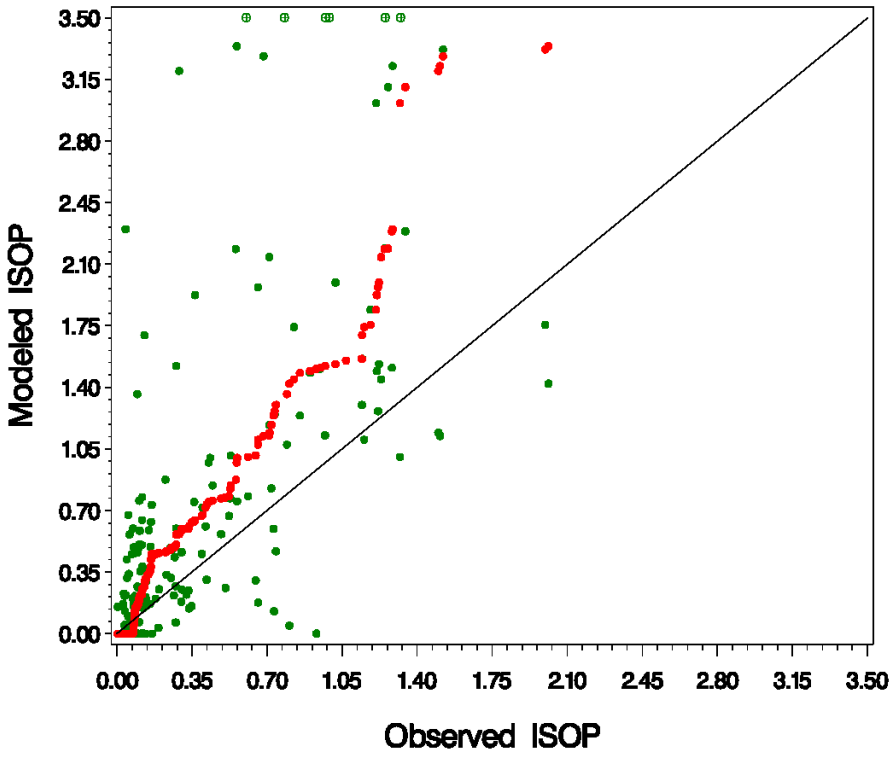
Backup Slides

air modeling data analysis

GloBEIS vs MEGAN
TexAQS II Aircraft Comparison

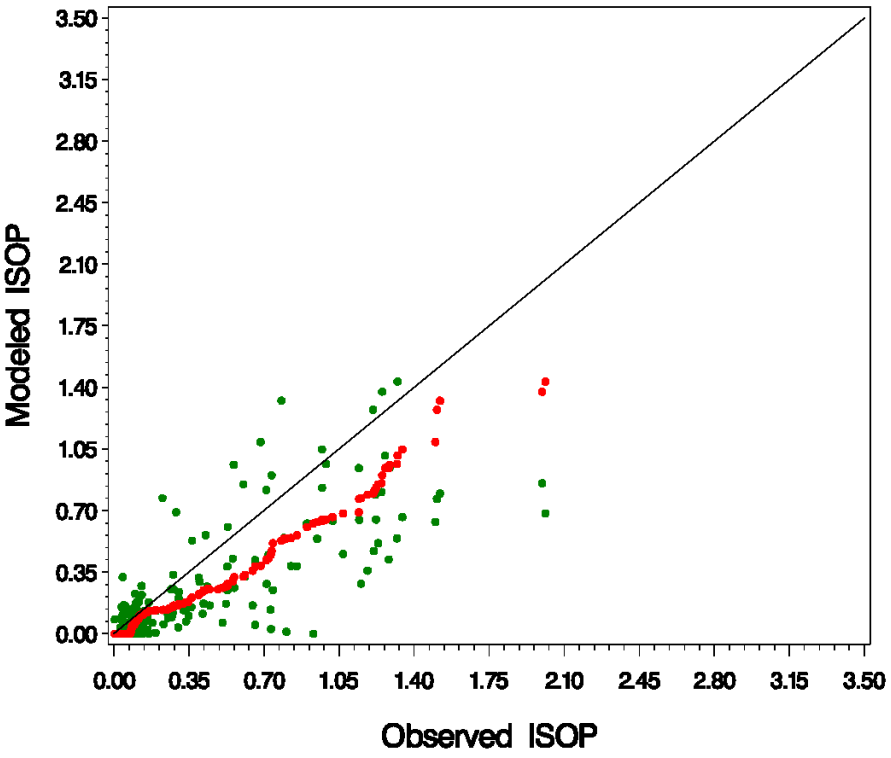
GloBEIS

Modeled vs. Observed ISOP Mixing Ratios
15SEP 12:59 to 15SEP 16:26, 1 Minute Averages



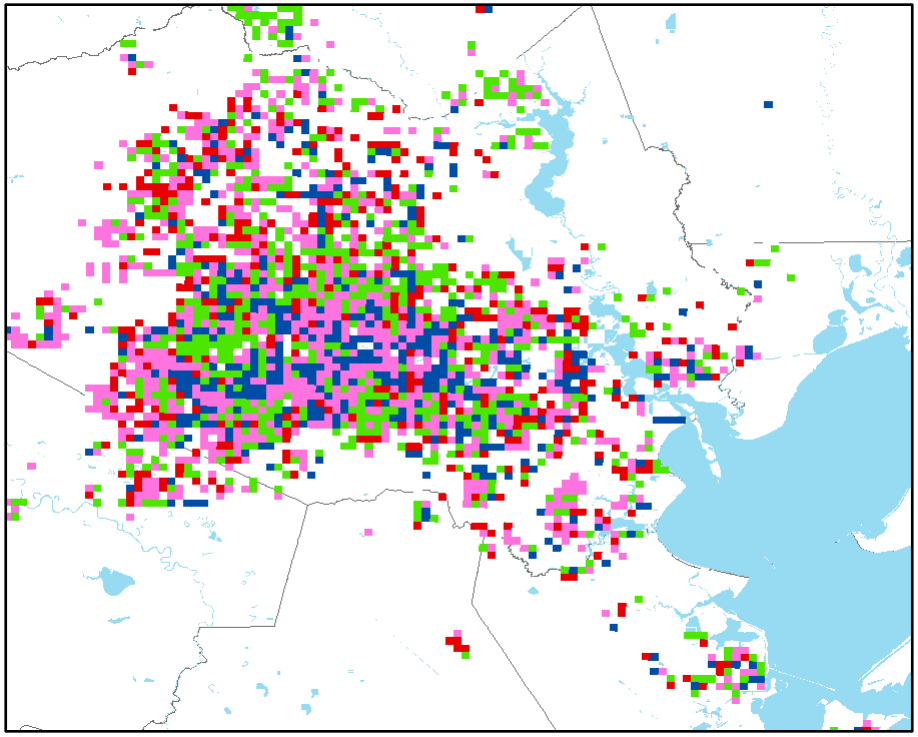
MEGAN

Modeled vs. Observed ISOP Mixing Ratios
15SEP 12:59 to 15SEP 16:26, 1 Minute Averages



Urban Function LAI applied to Urban Classes

- TCEQ Landcover has four unique urban categories:



Open Areas
Low Intensity Development
Medium Intensity Development
High Intensity Development

Tier 3 and 10 ppm Gasoline Sulfur Standards for Light-Duty On-Road Vehicles

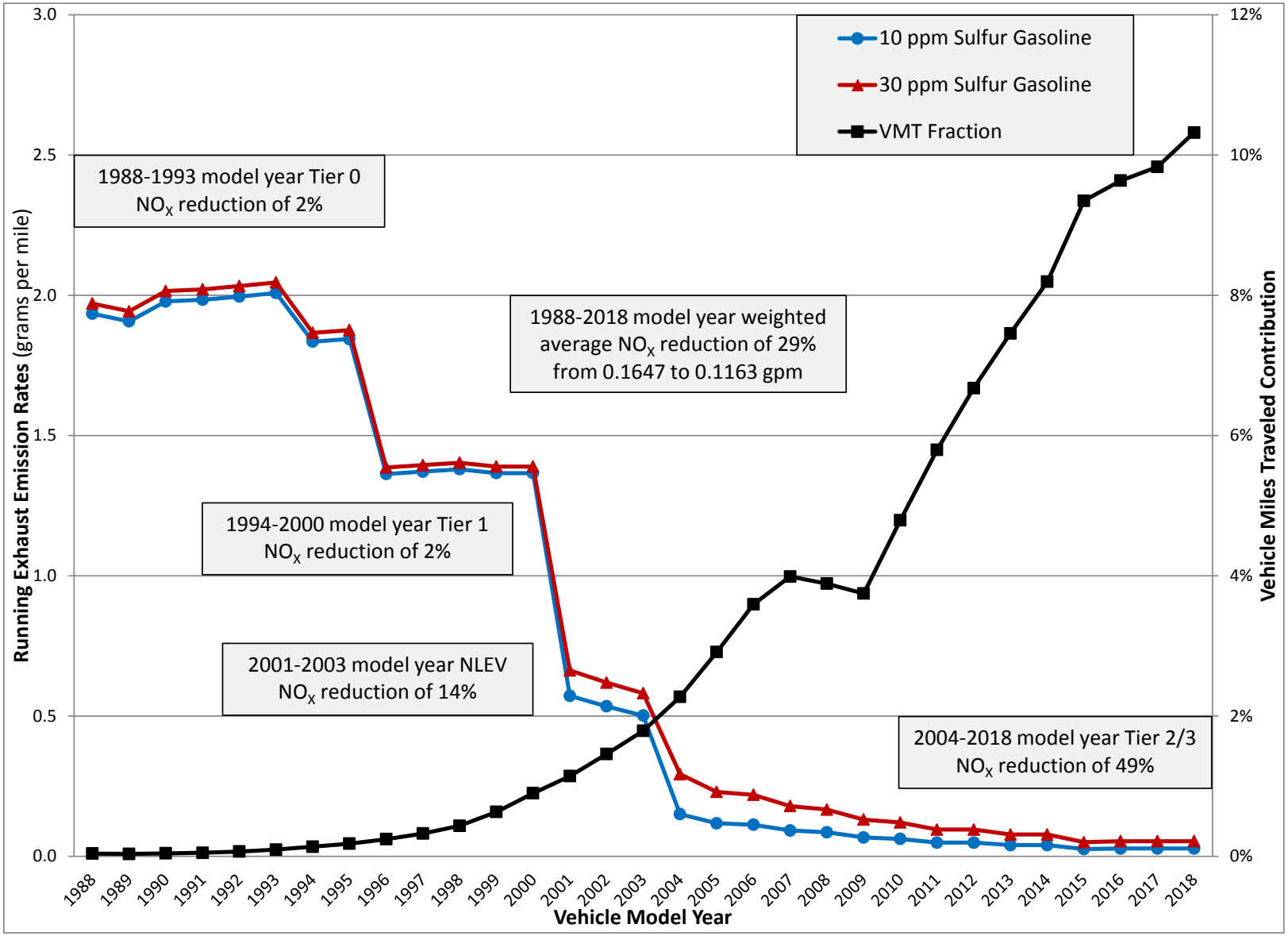
- Current proposal by EPA (http://www.epa.gov/otaq/tier3.htm) is to require:
  - more stringent Tier 3 standards for light-duty vehicles phasing in between the 2017-2025 model years; and
  - 10 parts per million (ppm) gasoline sulfur instead of the current 30 ppm level.

- Overall on-road fleet benefits accrue from both:
  - introduction of tighter standards with the 2017 model year; and
  - lower sulfur levels increasing catalytic converter effectiveness, which reduces emissions from in-use vehicles.

- Excerpt from page 12 of EPA's Tier 3 air quality modeling technical support document (http://www.epa.gov/otaq/documents/tier3/454r13006.pdf):
  - **"The maximum projected decrease in an eight-hour ozone design value in 2017 is 1.09 ppb in Tarrant County, Texas…"**

- Estimating Tier 3 on-road emission benefits for the 2018 attainment year:
  - the current MOVES2010b model does not include Tier 3 benefits;
  - MOVES2013 will include them and is scheduled for release after Tier 3 rule finalization;
  - TCEQ obtained the MOVEST3NPRM database available from EPA as part of the Tier 3 proposed rulemaking;
  - TCEQ ran 2018 gasoline scenarios for the current 30 ppm and the proposed 10 ppm levels; and
  - TCEQ applied ratios of the results by vehicle type, pollutant, and emission process (e.g., running exhaust versus start exhaust) to the 2018 on-road inventories based on 30 ppm.

Gasoline Passenger Car Running Exhaust NO_X Emission Rates in 2018 for 10 and 30 ppm Sulfur Gasoline



Source: 2018 Dallas County default runs of MOVES2010b by model year with the T3NPRM database. Refer to *Updates to MOVES for the Tier 3 NPRM Analysis*, U.S. EPA Office of Transportation and Air Quality, March 2013.

Estimated 10 ppm Sulfur Gasoline Reductions to 2018 Summer Weekday On-Road Emissions

Geographic Area	2018 Summer Weekday On-Road Emissions (tpd) Use of Current 30 ppm Sulfur Gasoline for In-Use Fleet						
	NO	NO_2	HONO	NO_X	VOC	CO	SO_2
Ten-County DFW	95.80	16.51	0.91	113.21	63.61	670.82	1.04
Eight-County HGB	87.01	15.50	0.83	103.34	57.88	656.24	1.55
236 Attainment Counties	344.32	58.84	3.25	406.41	181.18	1,925.78	3.03
Texas Total (254 Counties)	527.13	90.85	4.98	622.96	302.66	3,252.84	5.62
Non-Texas U.S. (2,856 Counties)	7,173.34	1,194.80	67.49	8,435.63	4,159.52	46,377.90	65.53
Southern Canada (10 Provinces)	406.42	66.50	3.81	476.73	483.56	8,201.72	18.31
Northern Mexico (562 Municipios)	91.77	15.73	0.87	108.37	196.27	833.96	2.90
Grand Total	8,198.65	1,367.89	77.15	9,643.69	5,142.02	58,666.41	92.36

Geographic Area	2018 Summer Weekday On-Road Emission Reductions (tpd) Use of Proposed 10 ppm Sulfur Gasoline for In-Use Fleet						
	NO	NO_2	HONO	NO_X	VOC	CO	SO_2
Ten-County DFW	8.46	1.43	0.08	9.98	2.39	13.25	0.54
Eight-County HGB	7.79	1.35	0.07	9.21	2.25	12.66	0.87
236 Attainment Counties	22.89	3.86	0.22	26.97	5.52	27.74	1.41
Texas Total (254 Counties)	39.14	6.65	0.37	46.16	10.16	53.65	2.83
Non-Texas U.S. (2,856 Counties)	588.39	104.59	5.59	698.57	126.58	873.91	34.96
Southern Canada (10 Provinces)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Mexico (562 Municipios)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	627.54	111.24	5.96	744.73	136.74	927.56	37.79