

# AQ impact study for increase in Shale Gas Productions since 2011

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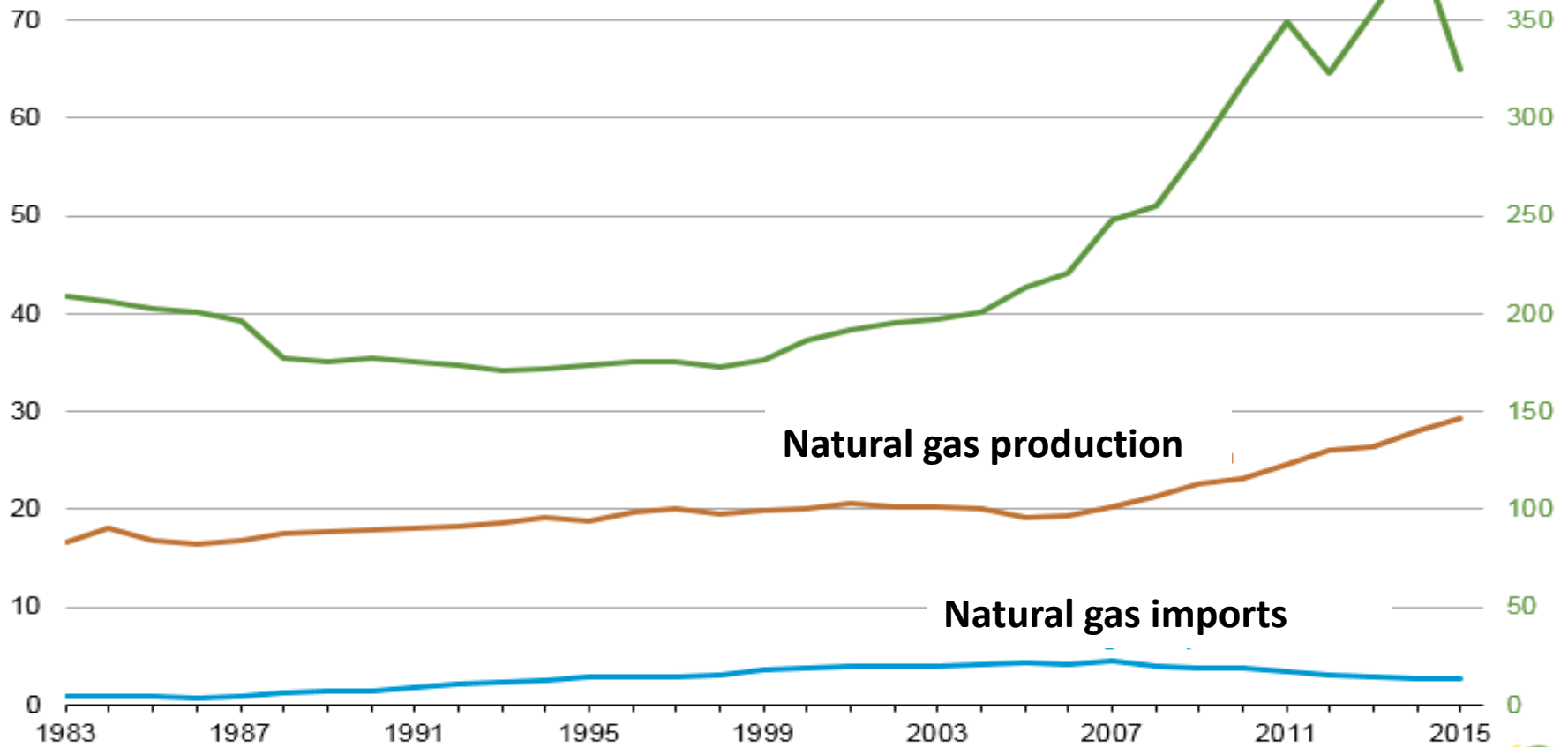
\*and the Cessna flight team led by Prof. Russ Dickerson, UMD  
Department of Environmental Engineering, U. Of Texas, Kingsville



**Production and imports**  
Trillion cubic feet

**Natural gas proved reserve**

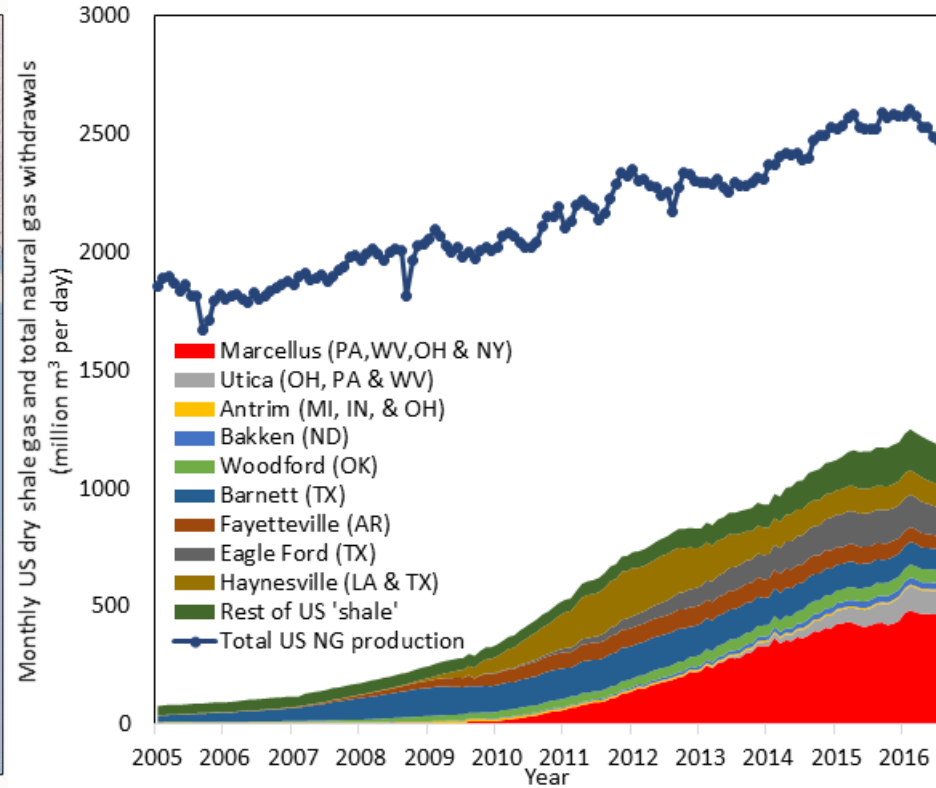
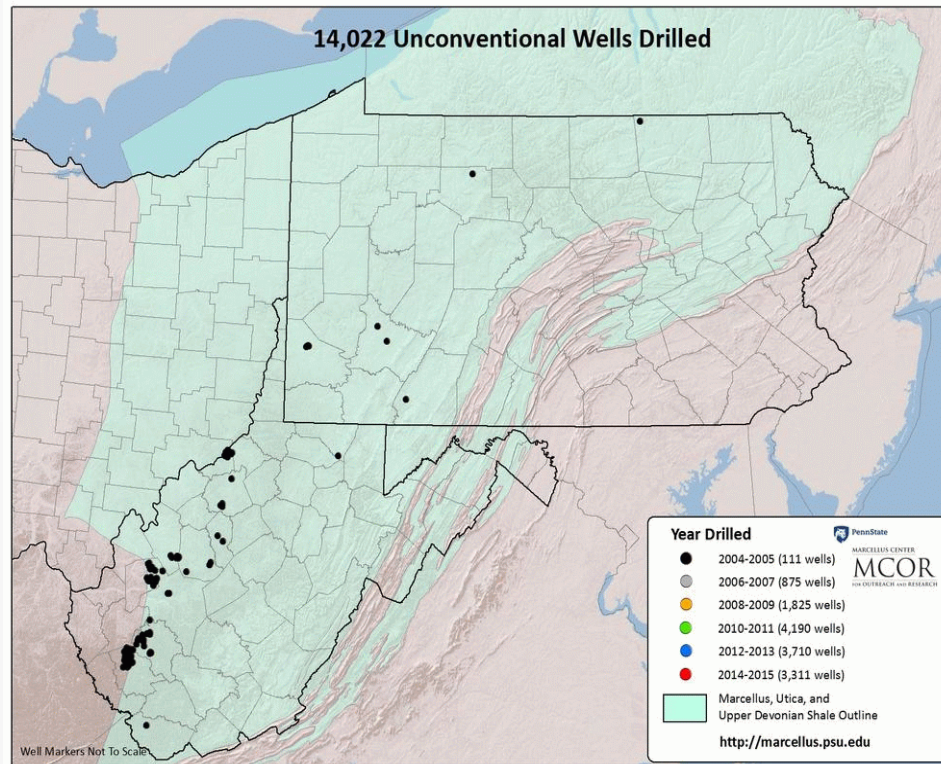
**Proved reserves**  
Trillion cubic feet



Source: U.S. Energy Information Administration, Form EIA-23L, Annual Report of Domestic Oil and Gas Reserves; U.S. Department of Energy, Office of Fossil Energy, Natural Gas Imports and Exports



# Shale Oil and Gas due to Marcellus Play



Marcellus Play is generally considered to be able to produce dry natural gas : > 95% CH<sub>4</sub>  
 (Cox-Colvin 2017 ) [www.coxcolvin.com /the-marcellus-and-utica-shale-natural-gas-play-what-are-the-issues/](http://www.coxcolvin.com/the-marcellus-and-utica-shale-natural-gas-play-what-are-the-issues/)

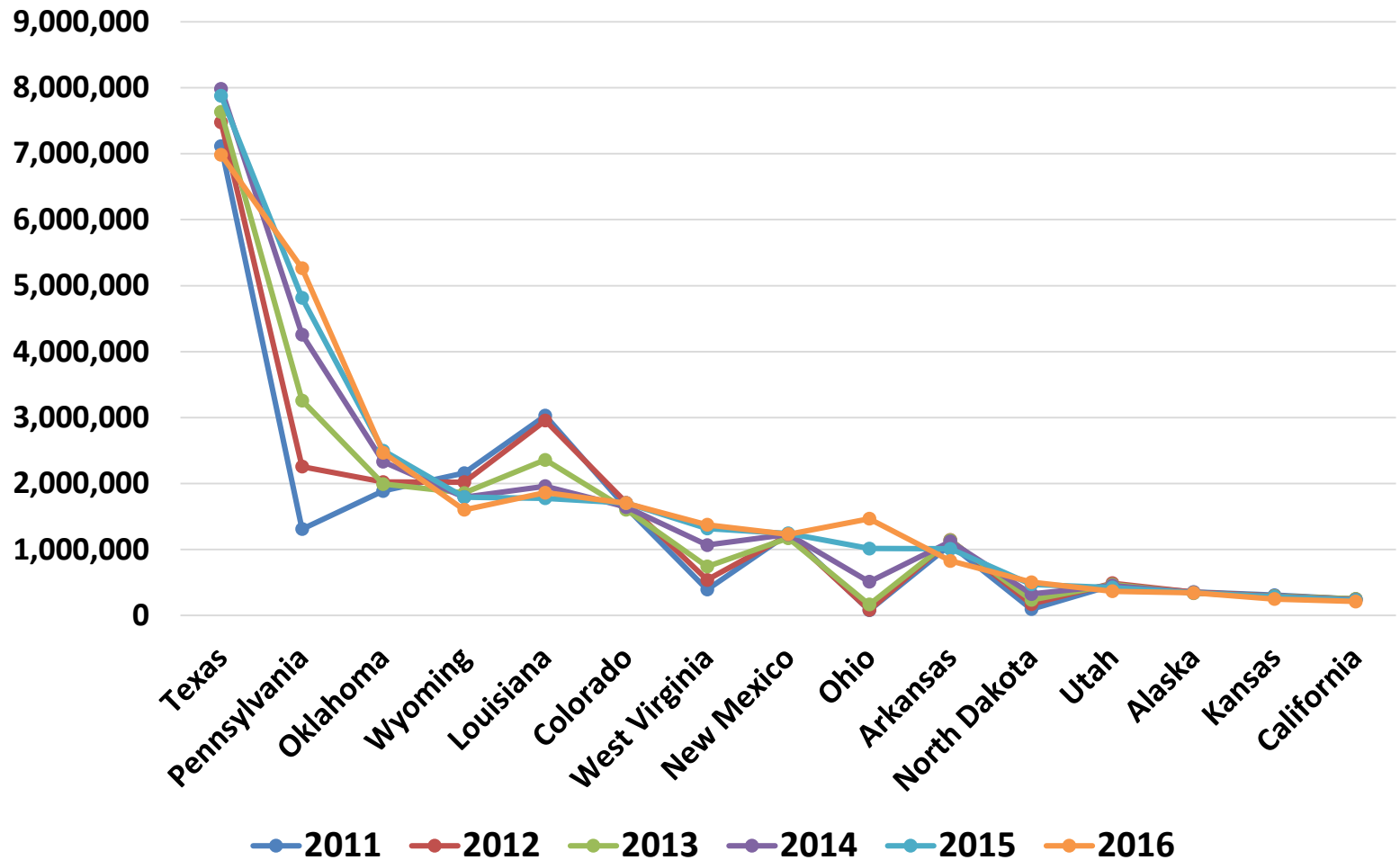


# 2014 Energy Information Administration on Shale Plays



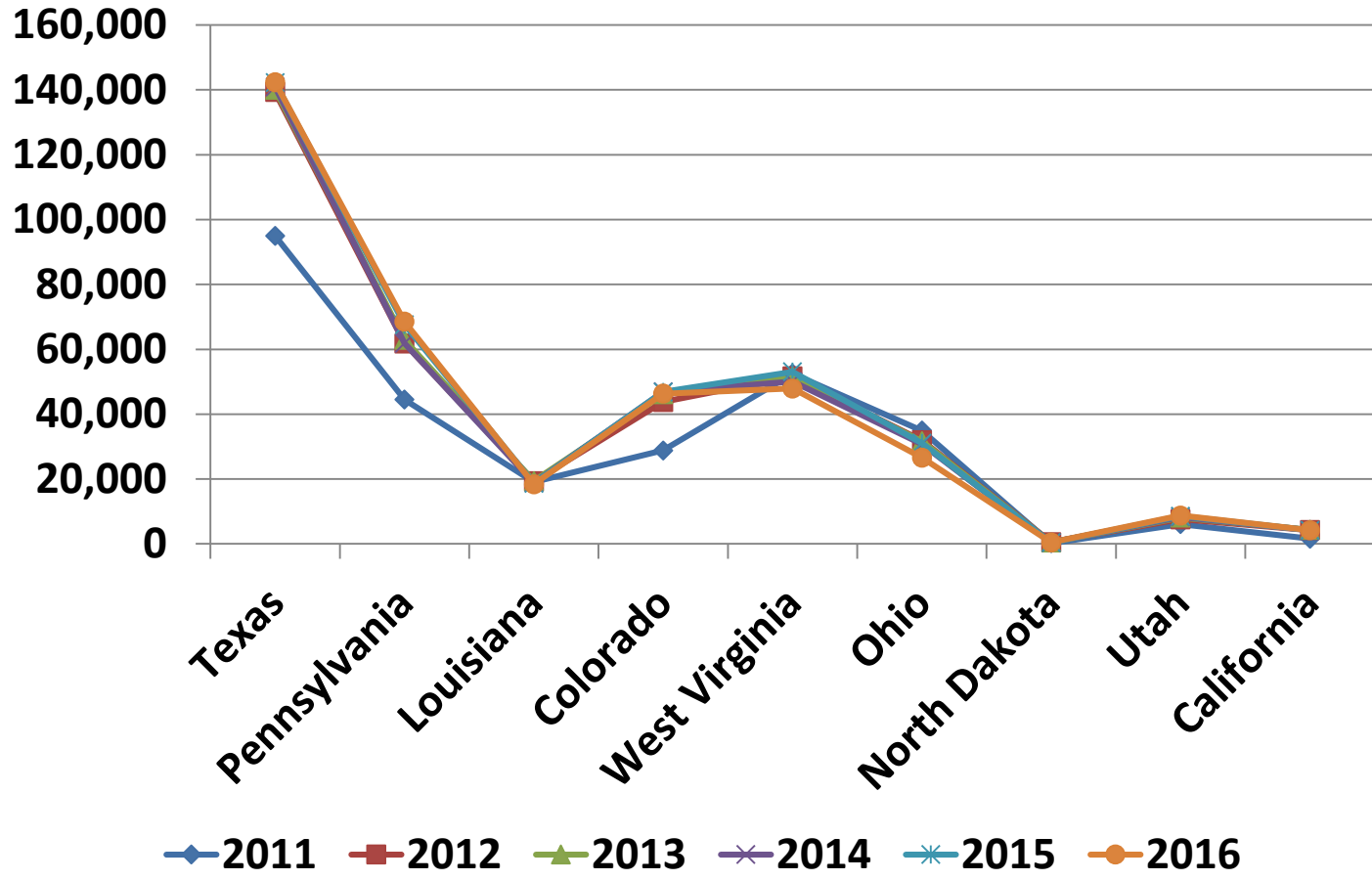
Source: [eia.gov/todayinenergy](http://eia.gov/todayinenergy)

# Gas Production (Million Cubic Feet)



Source: [useenergydevcorp.com](http://useenergydevcorp.com) and Energy Information Administration (EIA)

# Number of production wells

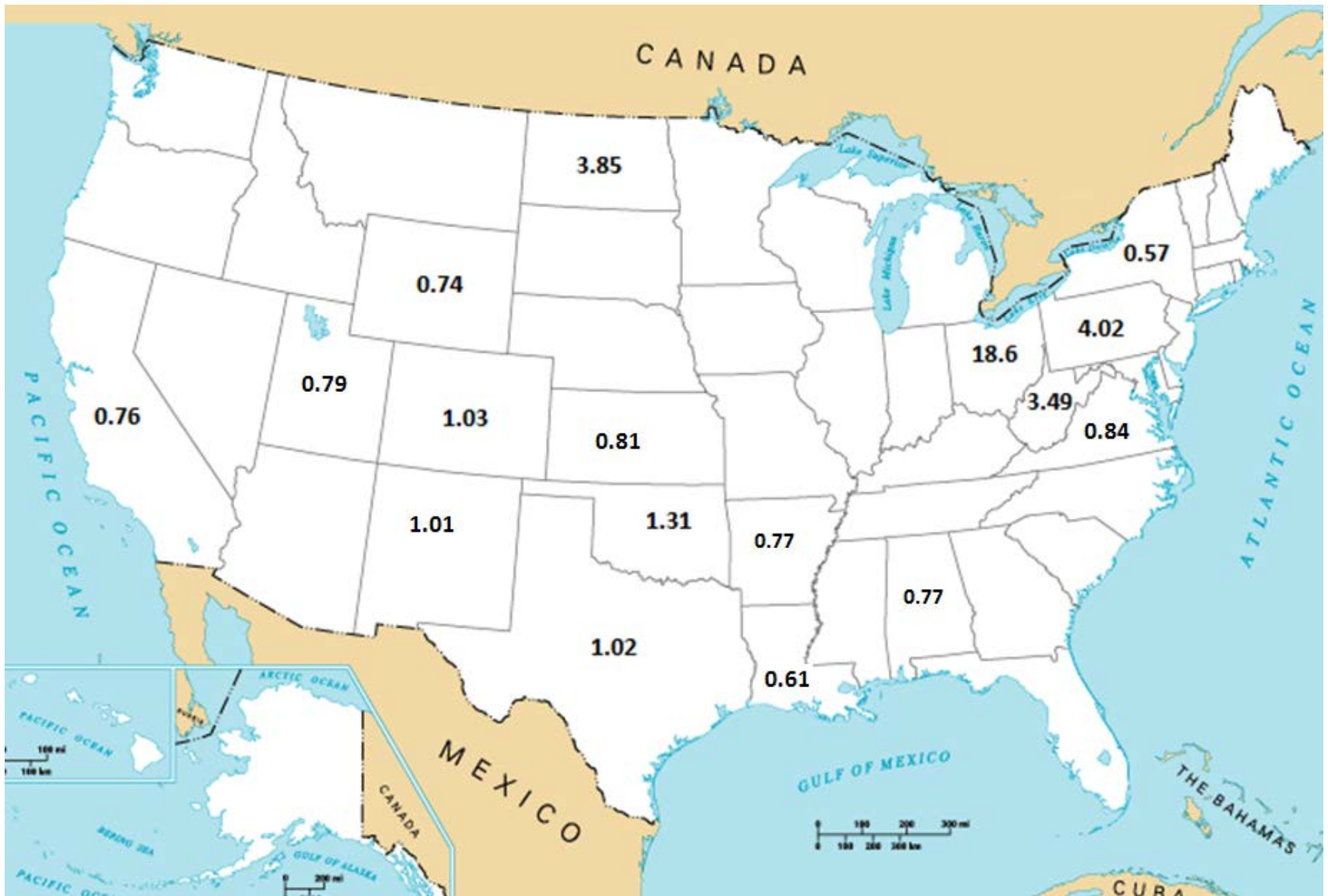


## Variation of state-wide top production rate and well-numbers between 2011 to 2016

	Well numbers			Million cubic feet		
Year	2011	2016	2016/2011	2011	2016	2016/2011
<b>Texas</b>	95,014	142,368	1.50	7,112,863	6,985,576	1.02
<b>Pennsylvania</b>	44,500	68,536	1.54	1,310,592	5,263,973	4.02
<b>Louisiana</b>	19,137	18,382	0.96	3,029,206	1,861,187	0.61
<b>Colorado</b>	28,813	46,322	1.61	1,637,576	1,703,277	1.03
<b>West Virginia</b>	52,498	47,938	0.91	394,125	1,375,108	3.49
<b>Ohio</b>	34,931	26,599	0.76	78,858	1,466,854	18.60
<b>North Dakota</b>	188	462	2.46	97,102	504,672	3.85
<b>Utah</b>	6,075	8,739	1.44	457,525	367,251	0.79
<b>California</b>	1,580	4,209	2.66	250,177	211,451	0.76
<b>Σ</b>	282,736	363,555	1.29	14370035	19741365	1.38



# Adjustment factor applied to NEI2011 oil and gas area source sector



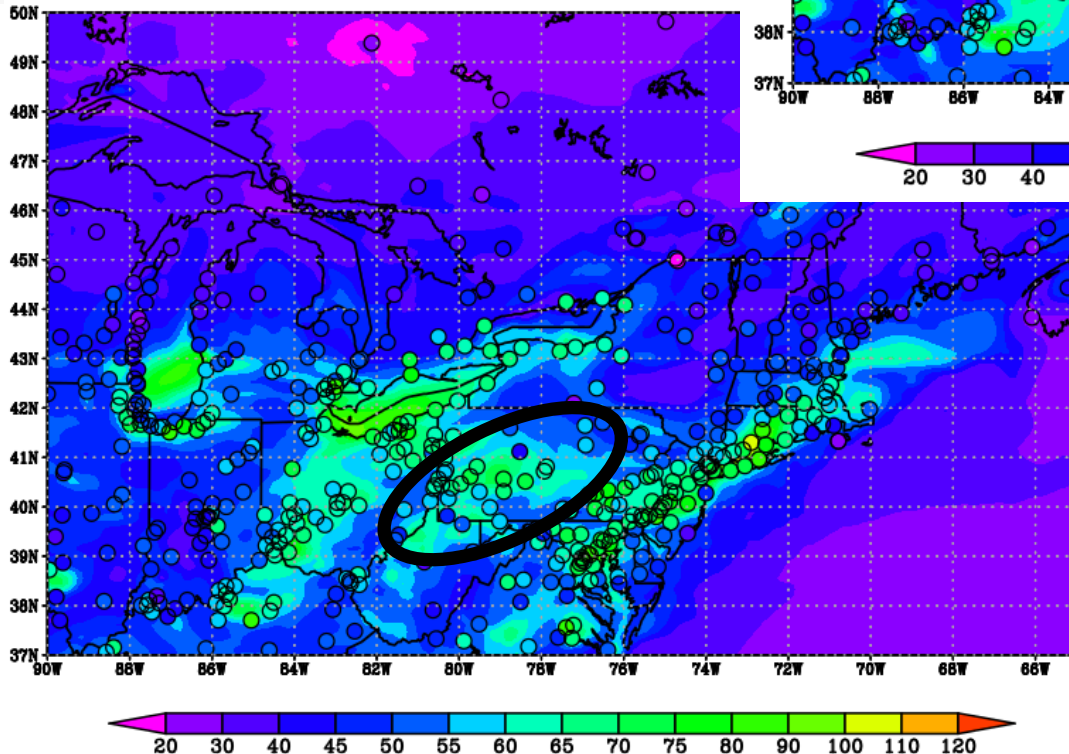
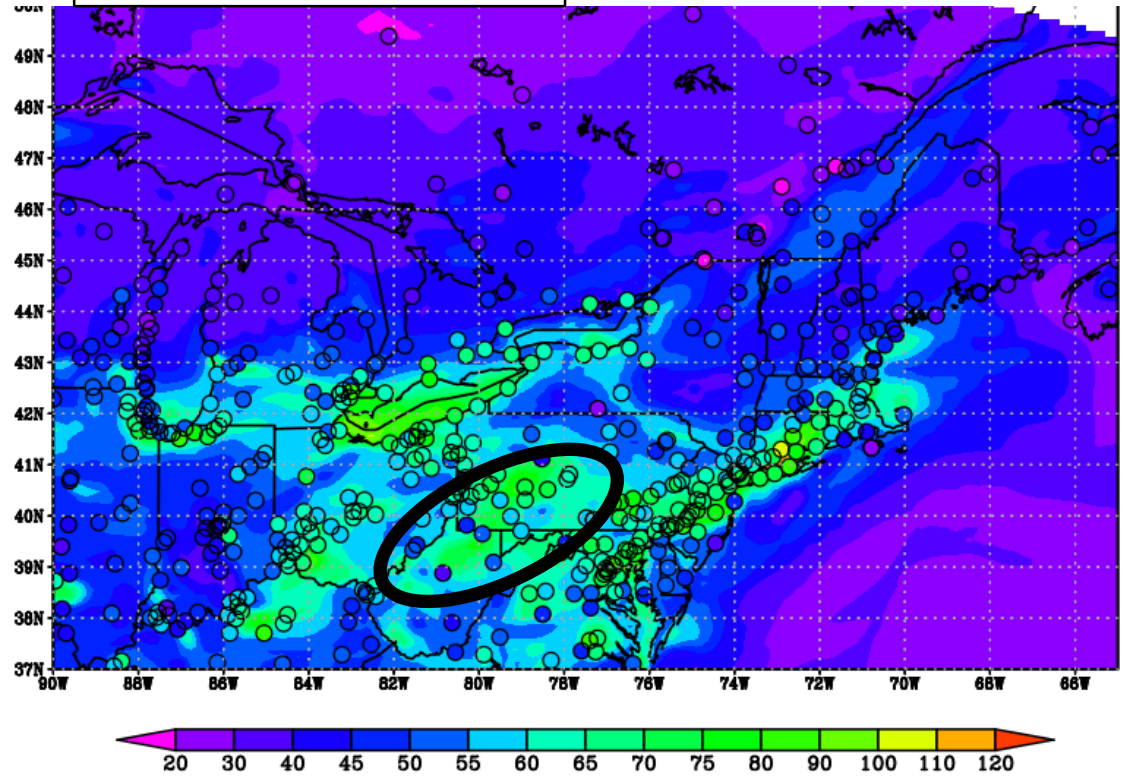


## Species scaled to reflect enhanced emission from increased oil and gas exploration/production due to fracking

<b>CMAQ species</b>	<b>Species category</b>	<b>Activities attributed to emission</b>
<b>NOx +HONO</b>	<b>Nitrogen oxides</b>	<b>Compression, drilling, transportation</b>
<b>ALD, ALD2</b>	<b>And other higher aldehydes</b>	<b>Processing and drilling</b>
<b>Alkane, alkene</b>	<b>Paraffin and Olefin &amp; HC</b>	<b>Product and processing</b>
<b>XYL TOL TERP</b>	<b>VOC</b>	<b>Product and processing</b>
<b>Benzene</b>	<b>And other aromatics</b>	<b>Product and transportation</b>
<b>SO2, SULF</b>	<b>Sulfur compounds</b>	<b>Product and processing</b>
<b>PEC</b>	<b>Elemental carbon (soot) etc</b>	<b>Processing, drilling and compression</b>
<b>PMFINE</b>	<b>Other emitted particulate</b>	<b>Processing, compression, transportation</b>

**Verification plots for hr  
Surface O3** for (left) upgraded  
Oil and gas production from  
EIA reports and (bottom) no  
Upgrade from NEI2011 on  
Oil and gas industry emission

**Oil and gas from EIA**

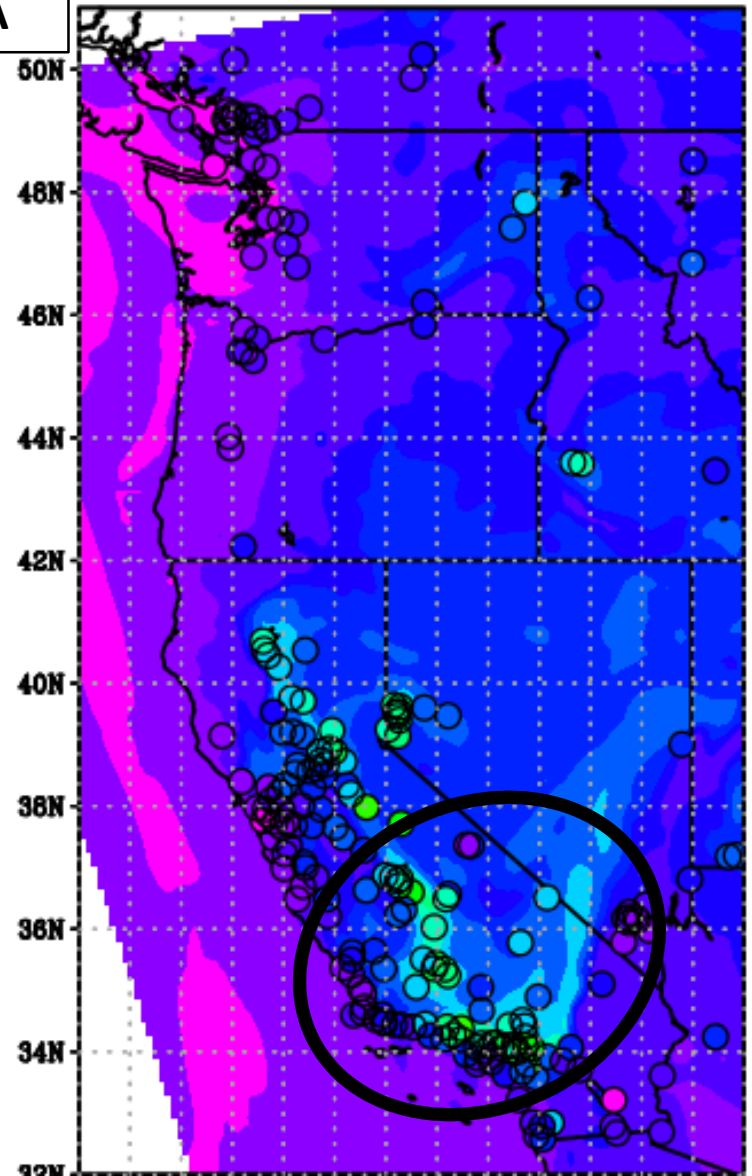
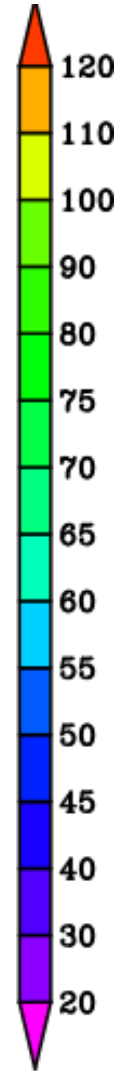
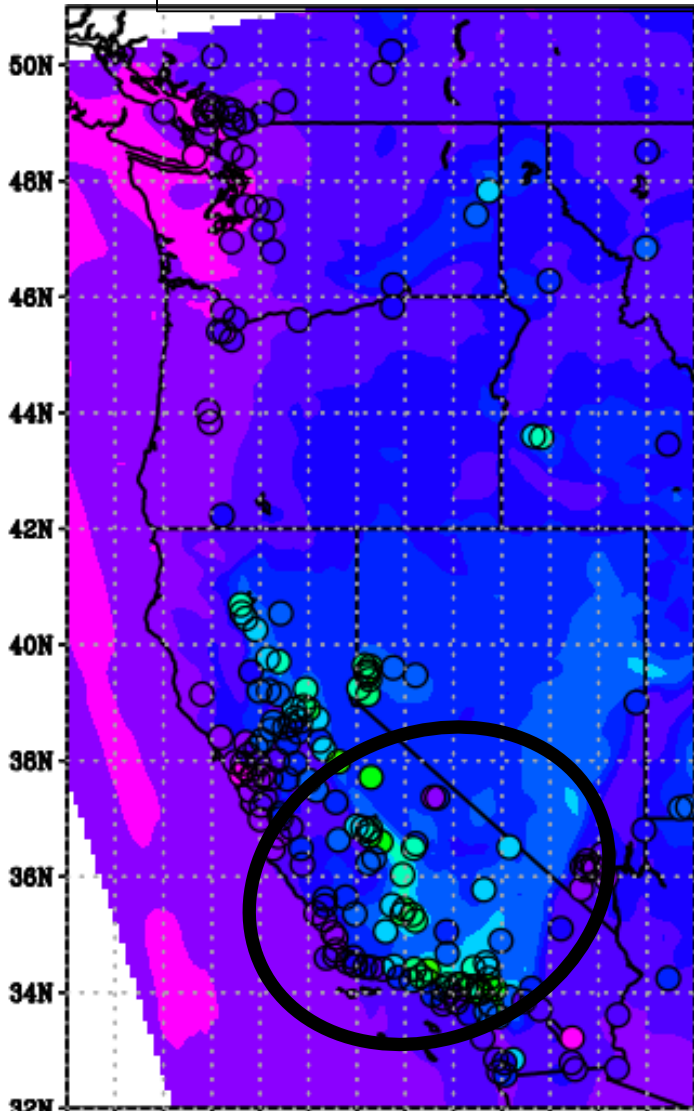


**Oil and gas from NEI2011**

Oil and gas from EIA

# Verification plots for hr Surface O3

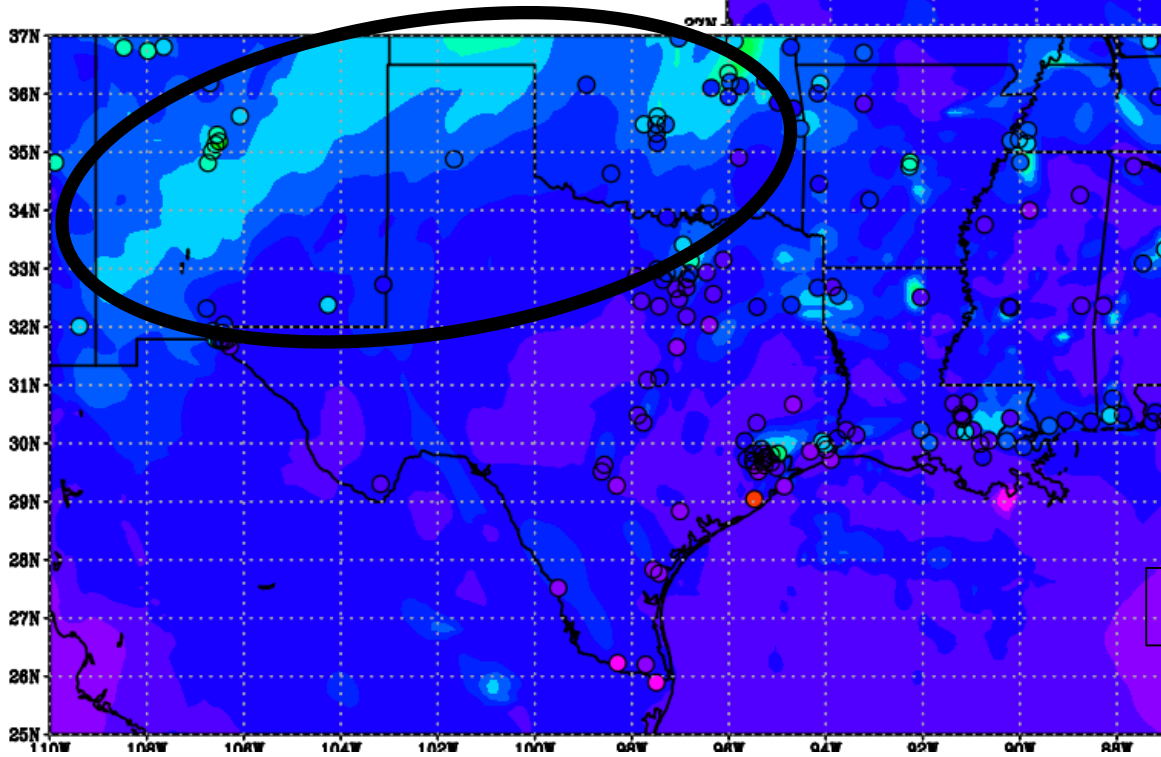
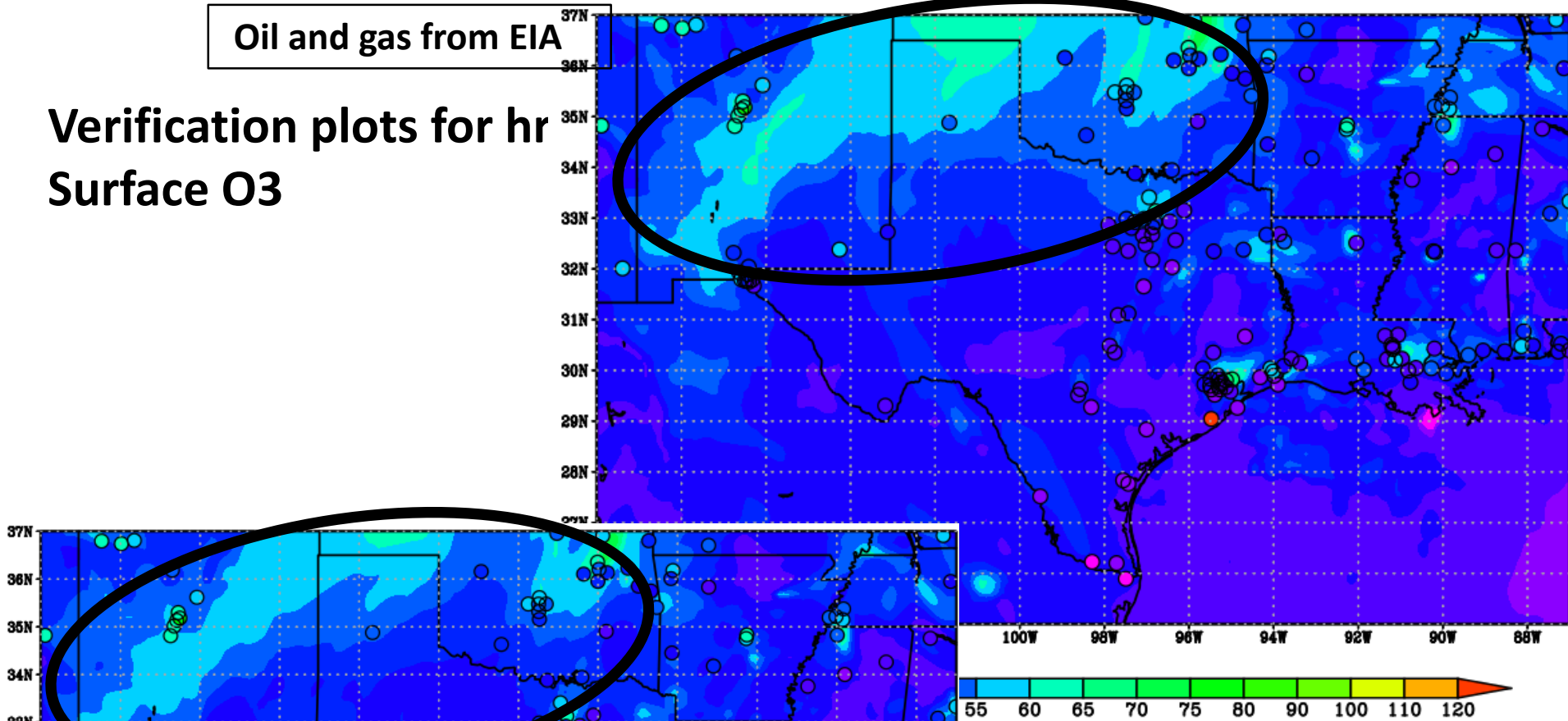
Oil and gas from NEI2011



2017 International EI Conference,  
Aug14-18 2017, Baltimore

Oil and gas from EIA

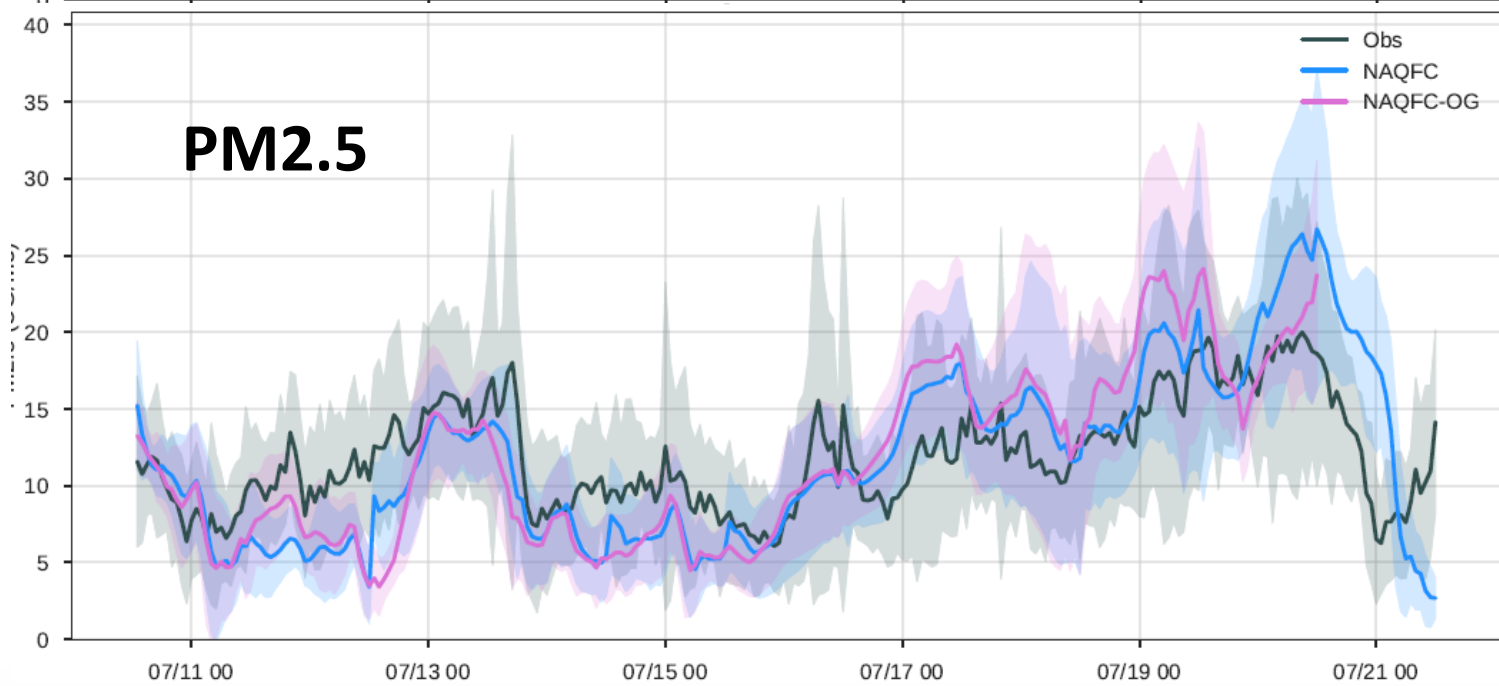
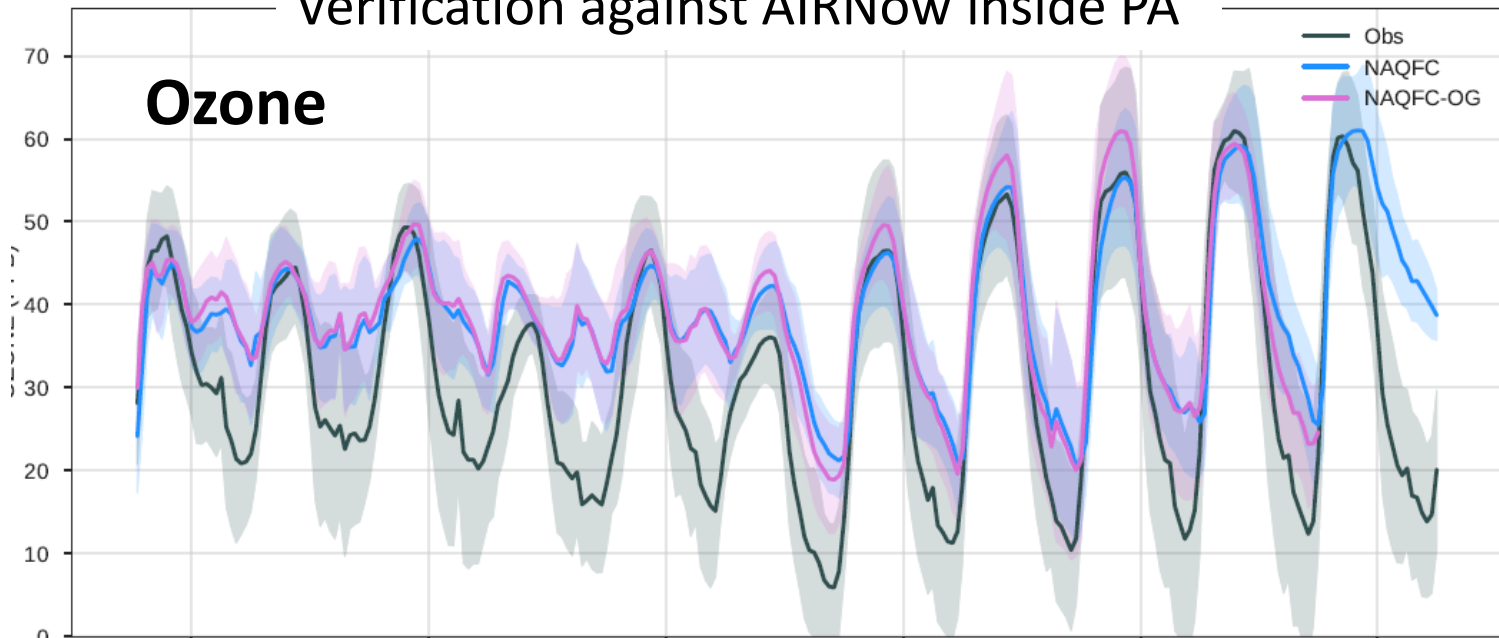
# Verification plots for hr Surface O3



Oil and gas from NEI2011

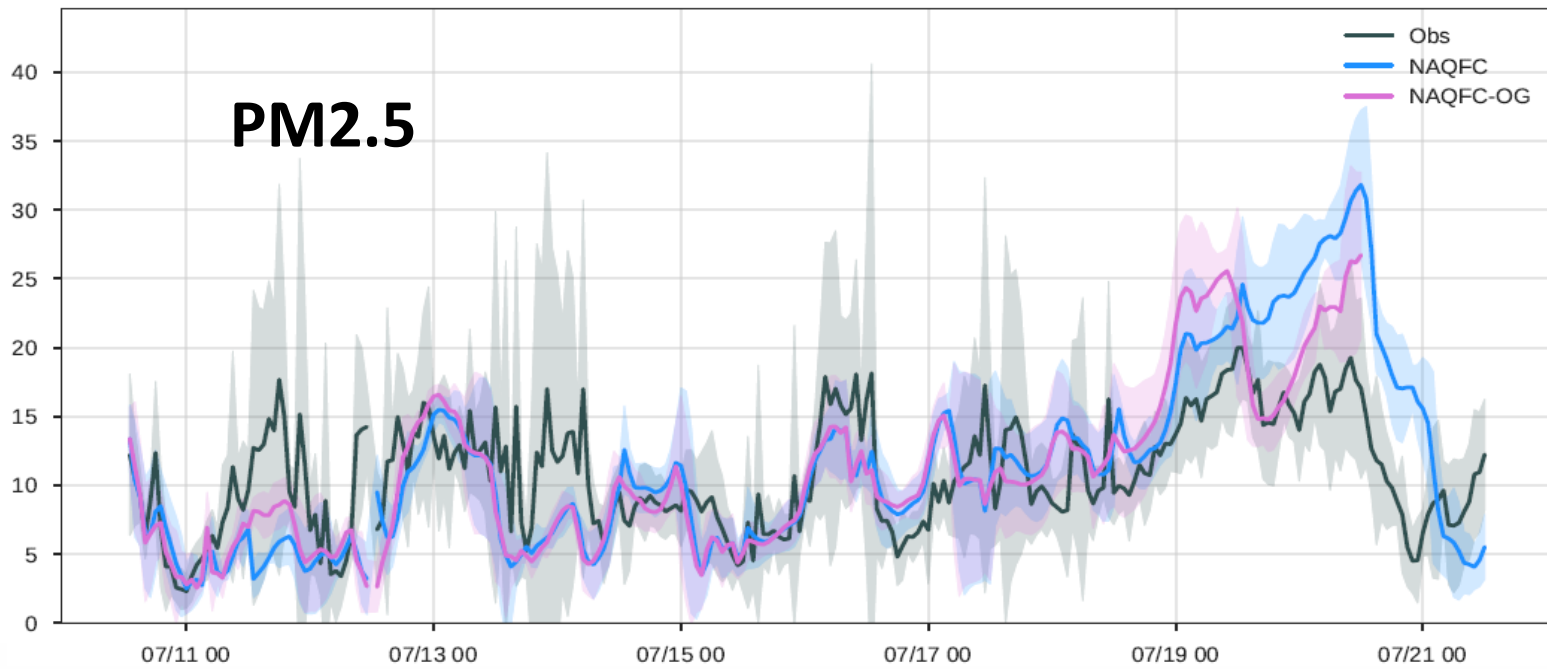
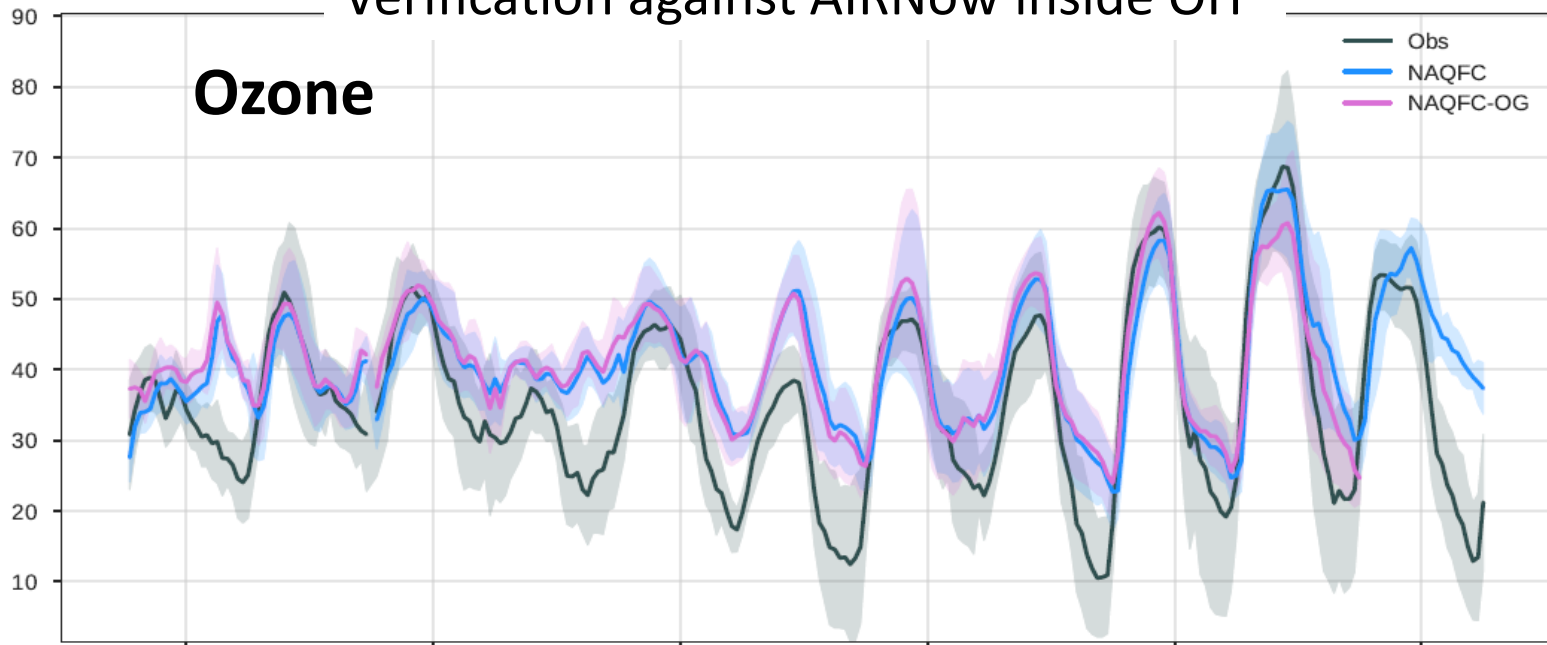


# Verification against AIRNow inside PA



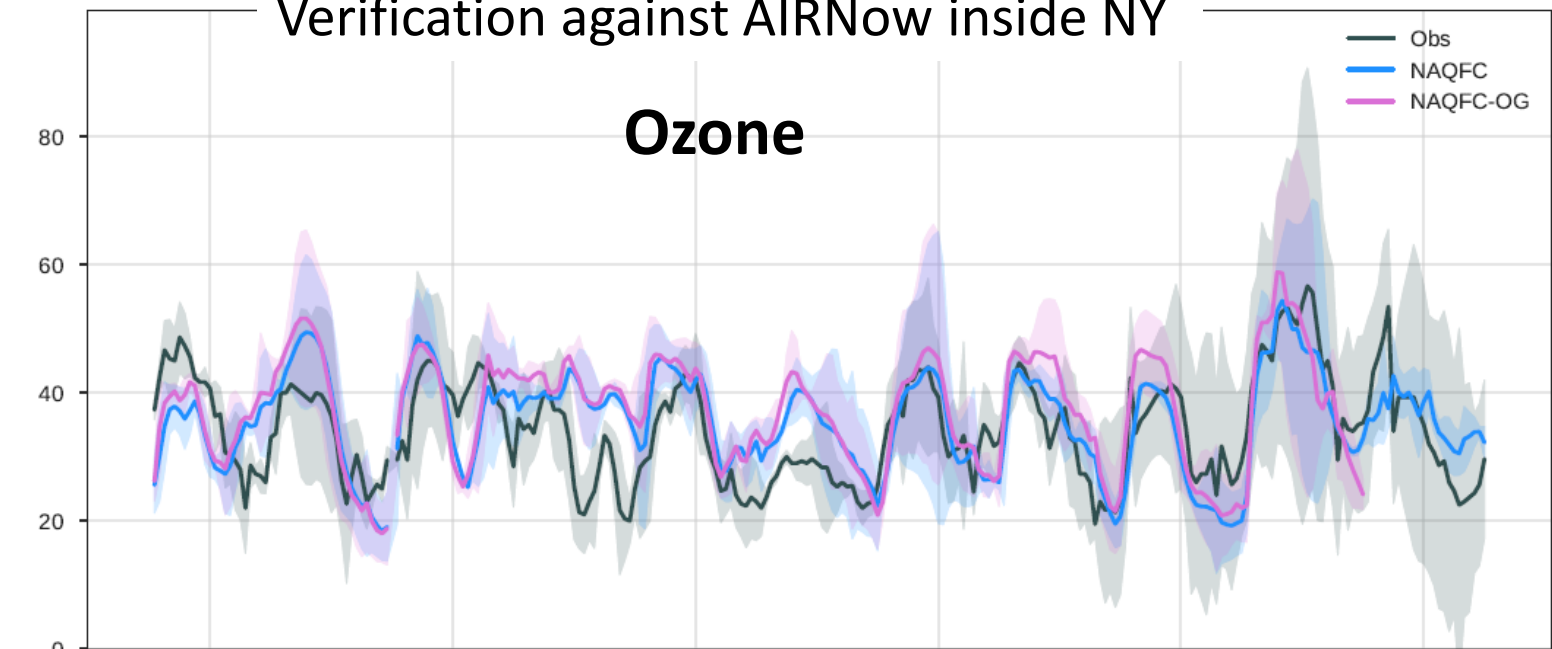


# Verification against AIRNow inside OH

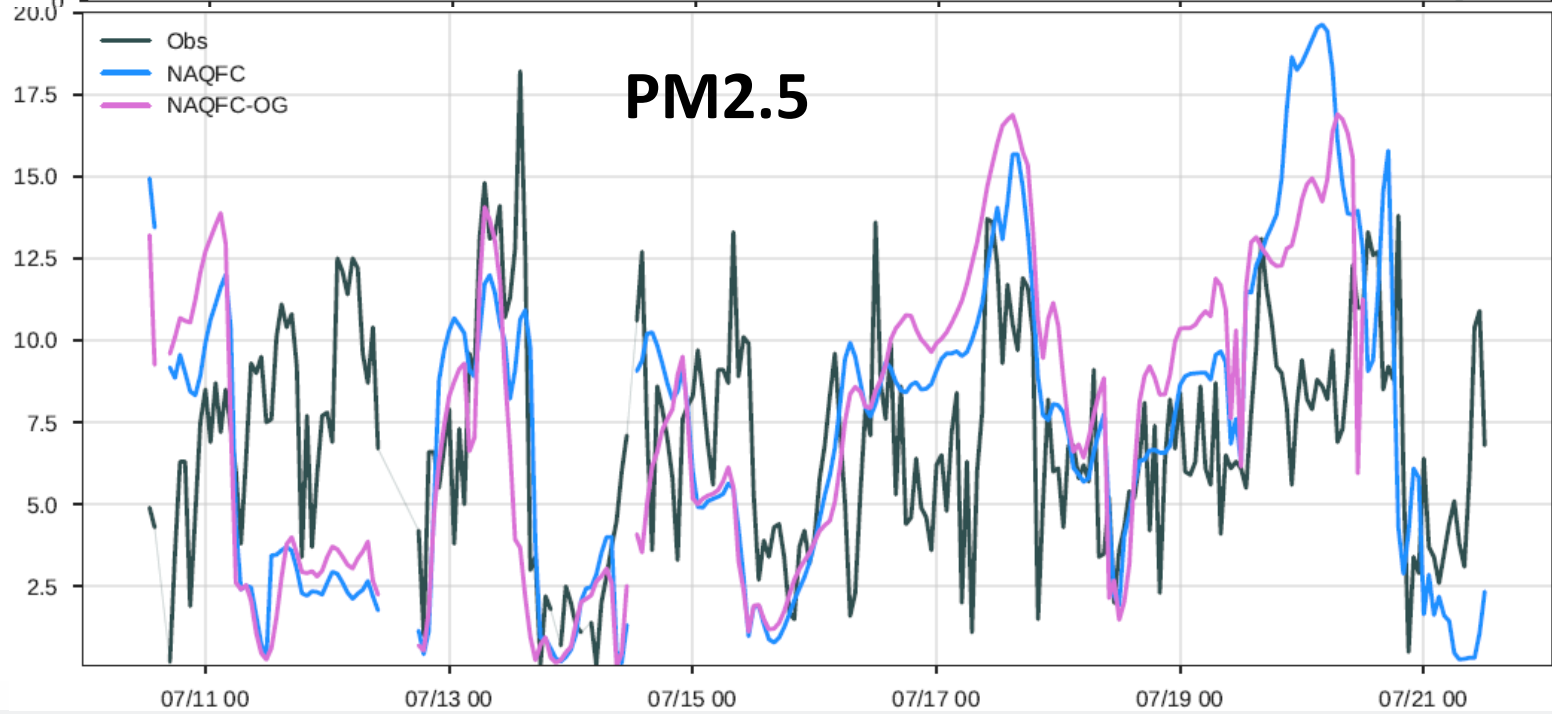


# Verification against AIRNow inside NY

## Ozone



## PM2.5



# Scale shale play production as oil/gas sector

- ❖ **Large plays: Barnett, Eagle Fort & Haynesville (TX) and Marcellus (PA)**
  - Behavior is rather different between the various shale plays;  
NEI2011 already accounted for that, therefore locale-spec scaling OK
- ❖ **Focus on the exceptional productive Marcellus Play**
  - Large reserve as well as dry gas;
  - Good prospects for additional Marcellus-like plays: e.g. Mancos CO.
- ❖ **Sporadic wet gas signature?**
  - UMD flights had detected coal-bed associated emissions;
- ❖ **Nation wide Oil and Gas production trend: levelling off**
  - Large reserves in multiple locations but price incentive is low;
  - Oil and Gas production can be a long term phenomenon;
- ❖ **State-specific scaling for Shale Play as Oil\_n\_Gas area source**
  - July 11-21 sensitivity run confirmed that Marcellus area O<sub>3</sub> increased;
  - Under-prediction in O<sub>3</sub> in the Marcellus area was reduced;
  - However the over-prediction in O<sub>3</sub> elsewhere was exacerbated

Extra slides