



Tracking NO₂ trends with satellite data for use in Texas air quality applications

Mark J. Estes
Senior Air Quality Scientist
Air Quality Division
Texas Commission on Environmental
Quality

Presented to HAQAST4, University of Wisconsin
July 16, 2018



How can states use satellite data in state implementation plans?

- Trend analyses
 - Contrast to highly-localized trends measured at surface monitors
 - Quantify trends in unmonitored locations
- Identify sources in unmonitored areas
- Examine international emission sources



TCEQ presented NO₂ trend data from OMI satellite in Houston-Galveston Ozone State Implementation Plan

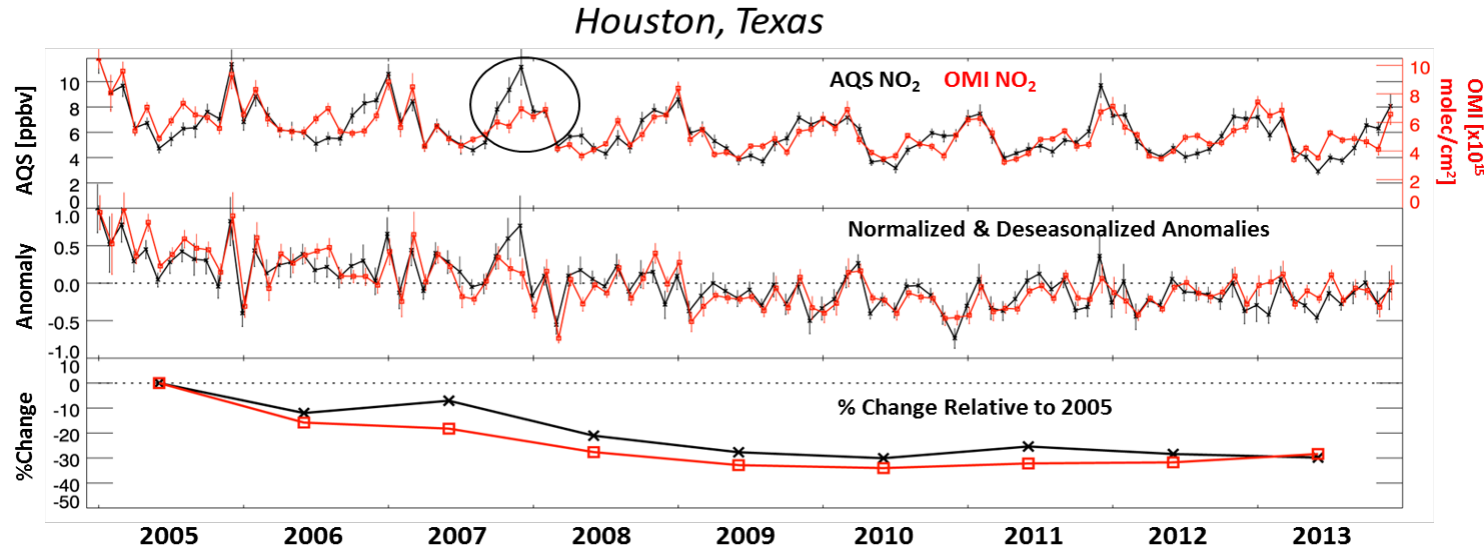


Figure 5-6: Trends in Houston Nitrogen Dioxide Concentrations, as Measured by Satellite (OMI) and Surface Monitoring (AQS), from 2005 through 2013. (Top) A comparison of U.S. EPA AQS surface NO₂ data (ppbV) to OMI column densities ($\times 10^{15}$ molecules/cm²) that are averaged over the Houston metropolitan area. (Middle) The normalized, deseasonalized anomalies for both datasets. (Bottom) The percent change in NO₂ relative to 2005 for both datasets.



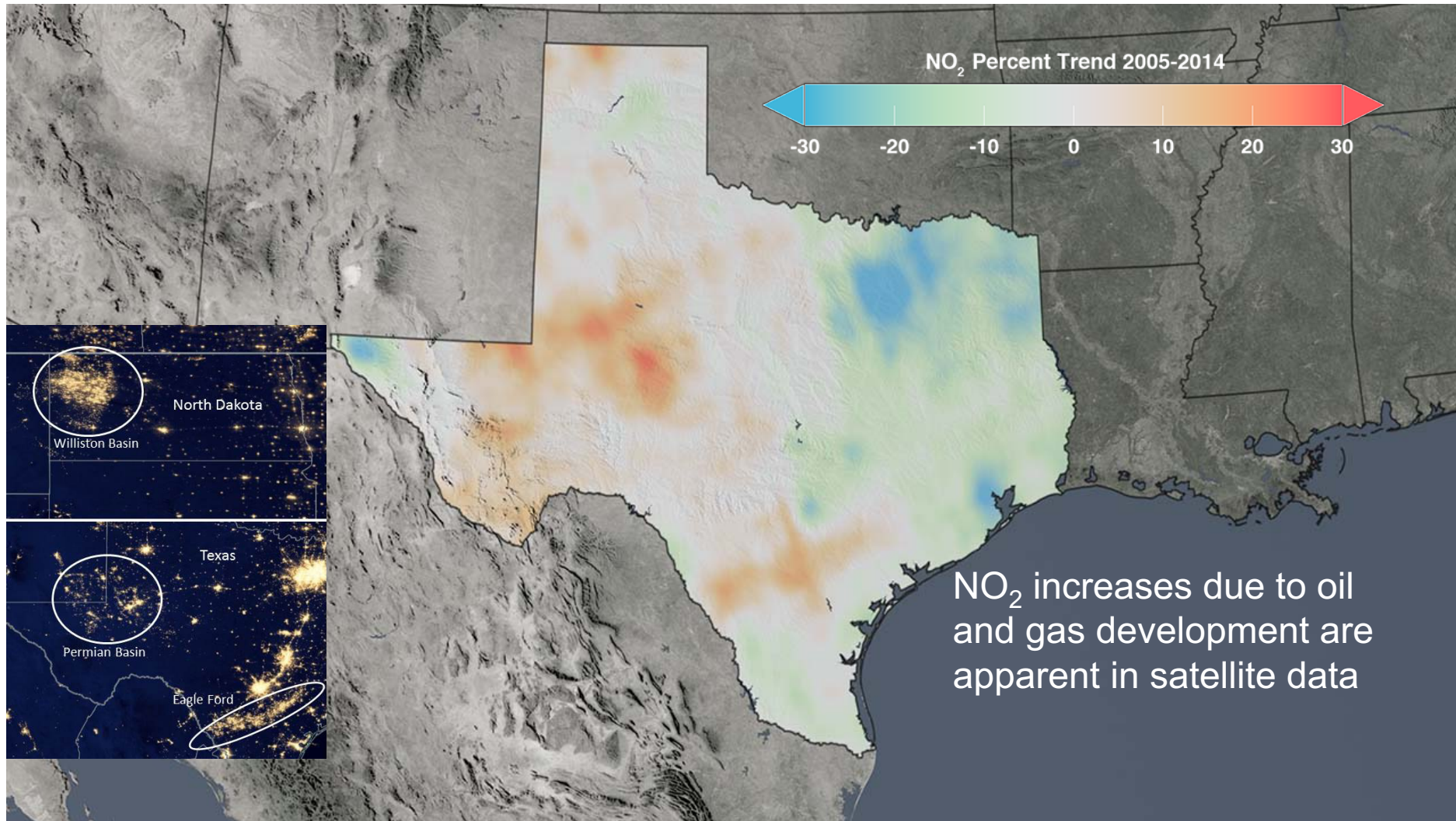
Table 5-2: Satellite Observations of Nitrogen Dioxide Columns in the HGB Metropolitan Area between 2002 and 2013

Document Source	Period	Annual rate (%)	Cumulative decrease (%)	Piecewise changes in NOx (%)
Russell et al. (2012)	2005-2011	-4.67	-27.99	2005-2007: -7.65 2007-2009: -7.74 2009-2011: +0.30
Schneider et al. (2015)	2002-2012	-5.4 ± 1.6	--	--
Tong et al. (2015): OMI AQS	2005-2012	-3.4 -3.6	-24 -25	--
Lamsal et al. (2015)	2005-2013	-5.63	-39.4 ± 4.9	2005-2008: -7.9 ± 1.4 2010-2013: +0.5 ± 0.3
Lu et al. (2015): OMI AQS	2006-2013	-5.1 ± 2.1 -4.8	-49 -38.4	--

Excerpt from Chapter 5 of HOUSTON-GALVESTON BRAZORIA ATTAINMENT DEMONSTRATION STATE IMPLEMENTATION PLAN REVISION FOR THE 2008 EIGHT-HOUR OZONE STANDARD NONATTAINMENT AREA, December 15, 2016



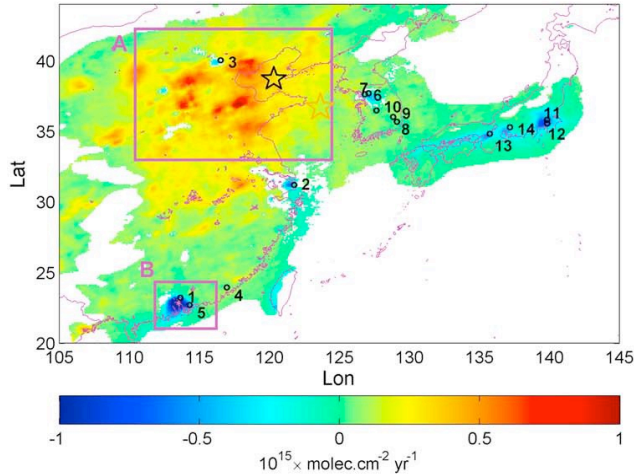
Satellites allow trends to be tracked where there are few NO₂ measurements



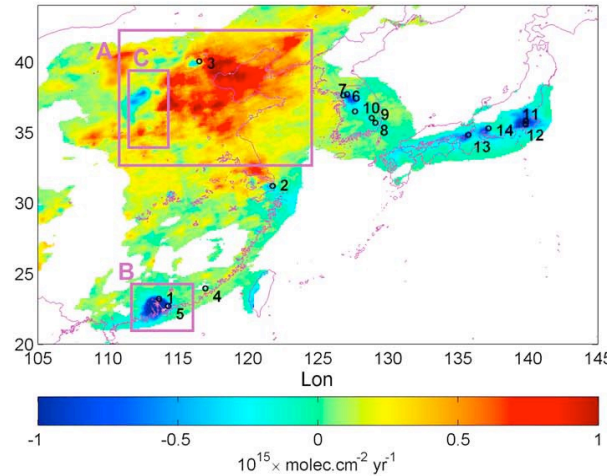


Strong interest in attributing Texas O₃ to international sources. But since 2010, Chinese NO_x emissions have been decreasing

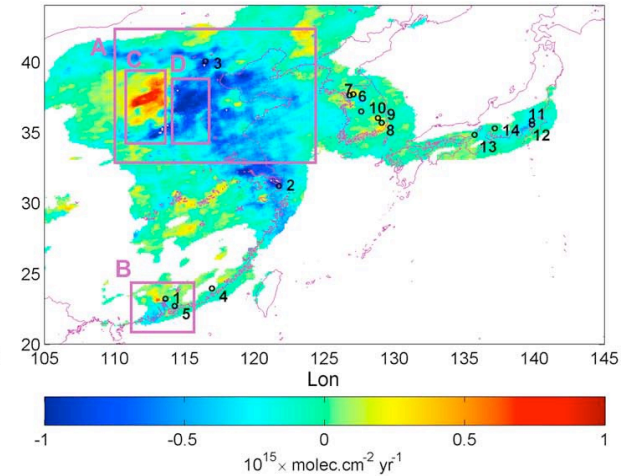
Tropospheric NO₂ Trends (2005-2014)



Tropospheric NO₂ Variability (2005-2010)



Tropospheric NO₂ Variability (2010-2014)



From Souri et al. JGR 2017.

Left: Satellite-observed NO₂ trends in China are upward from 2005-2014, indicating large increases in NO_x emissions. Increases are largest in NE China.

Center: Most of the NO₂ increases, however, occurred between 2005-2010. The Pearl River Delta and cities in Japan had substantial decreases in NO_x during the same period.

Right: From 2010-2014, the trend has reversed in NE China, so that large decreases in NO_x emissions have occurred. Although emissions are still higher than they were in 2005, control measures by China have proven effective in reducing NO_x. The increase of NO₂ in western China (i.e., Sha'anxi province) is probably due to efforts to increase economic development in the western provinces.