Anthropogenic emissions of highly reactive VOCs (HRVOCs) inferred from oversampling of OMI formaldehyde (HCHO) columns

And its application to Houston-Galveston-Brazoria (HGB) area

OMI HCHO 2006 JJA average

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Relating HCHO columns to HRVOCs

\[
\text{VOC}_i \xrightarrow{\text{oxidation}} HCHO \xrightarrow{h\nu (340 \text{ nm}), \text{OH}} \text{HCHO}
\]

\[
\Omega_{\text{HCHO}} = \sum_{i} y_i E_i
\]

In absence of horizontal wind, mass balance for HCHO column \( \Omega_{\text{HCHO}} \):

but wind smears this relationship

Beyond this distance, HCHO is mainly contributed by long-lived VOCs

\( \Omega_{\text{HCHO}} - \Omega_0 \)

**Graph:**

- **VOCs source**
- **Distance downwind**
- **HCHO**
- **Isoprene**
- **Propylene**
- **Ethylene**
- **methanol**
Oversampling approach to detect point sources

- **Oversampling:** temporal averaging of the satellite data on a spatial grid **much finer** than the pixel resolution of the instrument

- Takes advantage of the spatial offset and changing geometry of the satellite pixels from day to day

- **Trades** temporal for spatial resolution

- Achieves higher signal-to-noise ratio data

**Optimize smoothing radius:**
- Too fine (12 km): Increase noise
- Too coarse (36 km): Lose spatial features

A satellite pixel $24 \times 13 \text{km}^2$

2005-2008 MJJAS

26028 pixels in a $1^\circ \times 1^\circ$ box
Results: Oversampling of OMI HCHO pixels

OMI HCHO column, 2005-2008, MJJA

Barnett Shale

Dallas

Fairfield

Austin

San Antonio

Houston

Port Arthur

OMI HCHO column (molec./cm²)

HCHO = exp(0.113*T + 2.616)

R² = 0.64

R² = 0.08

Biogenic

OMI HCHO column, 2005-2008, MJJA

Oversampling approach enables detection of anthropogenic HRVOCs from point/urban sources and gas operations.
Reactivity-weighted HRVOCs emissions in HGB area based on top-down approach

Integration of HCHO columns over HGB

\[ E^{Top-down}_{HRVOCs} = k \int \int (\Omega - \Omega_0) \, dA \]

HCHO VCD

HCHO loss rate

HCHO VCD from long-lived VOCs

Reactivity-weighted HRVOCs in HGB

Top-down constraint: **13.7±5.2** Gg C/year
NEI08 estimation: **4.5** Gg C/year

Parrish et al. [2012]: **25.2±1.1** Gg C/year
HRVOCs emissions and secondary HCHO in HGB area

Understanding relative contribution of secondary play an important role in developing ozone control strategies

Secondary HCHO contribution near Houston:

- 24±17%, Rappenglück, et al., [2010]
- 36%, Guven and Olaguer [2011]
- 63%, Friedfeld et al., [2002]
- 92%, Parrish et al., [2012]

10 HRVOCs emissions from NEI08
Total=9.1 Gg C/year

- Acetaldehyde 20%
- Ethylene 18%
- Formaldehyde 24%
- Propylene 18%
- Isopropyl alcohol 2%
- n-Butanol 2%
- Diethyl Ether 2%
- Isobutylene 3%
- 1,3-Butadiene 5%
- 1-Butene 6%
Distinguish primary and secondary HCHO based on plume structure

NEI08 underestimates secondary HCHO by 3~6 times
Oversampling of OMI HCHO columns provides a new solution to the long-standing problem of detecting and quantifying anthropogenic HRVOCs emissions from space.

Top-down constraint shows reactivity-weighted HRVOCs emission in HGB is 13.7±5.2 Gg C/year, 3.0±1.2 times higher than that estimated using NEI08.

HCHO columns can go as fine as 0.02 degree (~2 km)!

2005-2008, available
2008-now, processing

Other urban areas?
VOCs point sources regions?
Gas/oil fields?
Trends?

Take home messages

AQ managers:
Are there any specific areas or periods that you would want me to look at?
Thank you!