# TOGA: Trace Organic Gas Analyzer

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# **TOGA** (Trace Organic Gas Analyzer)

- 2 min continuous analysis of >50 VOCs
- samples processed in flight using fast online GC/MS
- wide dynamic range, with detection limits at low pptv to sub-pptv range
- Semi-autonomous operation up to 50,000 ft

**VOC tracers from several sources/types:**

- Biogenic VOCs and oxidation products
- Anthropogenic VOCs
- Oil and Gas Tracers
- Long-lived Halogenated VOCs
- Short-lived Halogenated VOCs
- OVOCs, including HCHO
- DMS, OCS
- Alkyl Nitrates
- Biomass burning tracers (HCN, $CH_3CN$)






**Specific chemical compounds and groups of compounds are useful for isolating and understanding different physical and chemical processes**

Long vs. short lived compounds

Compounds specific to different sources: emissions/ratios

Compound oxidation products

Soluble and insoluble compounds

# Measured Compounds

| NMHCs: | LOD; pptv |
|---|---|
| 1-butene/isobutene | 1 |
| propane | 10 |
| isobutane | 1 |
| *n*-butane | 1 |
| isopentane | 1 |
| *n*-pentane | 1 |
| 2-methylpentane | 0.5 |
| 3-methylpentane | 0.5 |
| *n*-hexane | 0.5 |
| *n*-heptane | 3 |
| benzene | 1 |
| toluene | 0.5 |
| ethylbenzene/p-/m-xylene | 0.3 |
| o-xylene | 0.2 |
| 1,2,3-trimethylbenzene | 1 |
| 1,2,4-trimethylbenzene | 1 |

| Alkyl Nitrates: | LOD; pptv |
|---|---|
| methyl nitrate | 5 |
| ethyl nitrate | 0.5 |
| isopropyl nitrate | 0.5 |
| butyl nitrates | 1 |

| OVOCs: | LOD; pptv |
|---|---|
| formaldehyde (HCHO) | 20 |
| acetaldehyde ($CH_3CHO$) | 5 |
| propanal | 5 |
| butanal | 1 |
| acetone ($CH_3COCH_3$) | 20 |
| MEK (butanone) | 1 |
| methanol ($CH_3OH$) | 20 |
| ethanol ($C_2H_5OH$) | 10 |
| 2-propanol | 5 |
| acrolein ($CH_2CHCHO$) | 1 |
| MTBE (methyl tert-butyl ether) | 0.5 |

| Biogenic VOCs: | LOD; pptv |
|---|---|
| isoprene | 0.5 |
| MBO (2-methyl-3-buten-2-ol) | 0.5 |
| MVK | 1 |
| methacrolein | 1 |
| 3-methylfuran | 1 |
| $\alpha$-pinene | 0.2 |
| $\beta$-pinene | 0.5 |
| camphene | 0.5 |
| limonene/3-carene | 0.5 |

| Halogenated VOCs: | LOD; pptv |
|---|---|
| CFC-11 ($CCl_3F$) | 5 |
| CFC-113 ($CCl_2FCClF_2$) | 1 |
| $CH_3Cl$ (methyl chloride) | 1 |
| $CH_2Cl_2$ (dichloromethane) | 1 |
| $CHCl_3$ (chloroform) | 1 |
| $CCl_4$ (tetrachloromethane) | 1 |
| $C_2Cl_4$ (tetrachloroethene) | 0.3 |
| $C_6H_5Cl$ (chlorobenzene) | 0.1 |
| $CH_3Br$ (methyl bromide) | 1 |
| $CH_2Br_2$ (dibromomethane) | 0.03 |
| $CHBr_3$ (bromoform) | 0.2 |
| $CH_3I$ (methyl iodide) | 0.03 |
| $CH_2I_2$ (diiodomethane) | 0.05 |
| $C_2H_5I$ (ethyl iodide) | 0.5 |
| $CH_2ICl$ (chloroiodomethane) | 0.07 |
| $CHBrCl_2$ (bromodichloromethane) | 0.05 |
| $CHBr_2Cl$ (dibromochloromethane) | 0.03 |

| Others: | LOD; pptv |
|---|---|
| DMS (dimethyl sulfide) | 0.5 |
| HCN (hydrogen cyanide) | 10 |
| Acetonitrile ($CH_3CN$) | 1 |

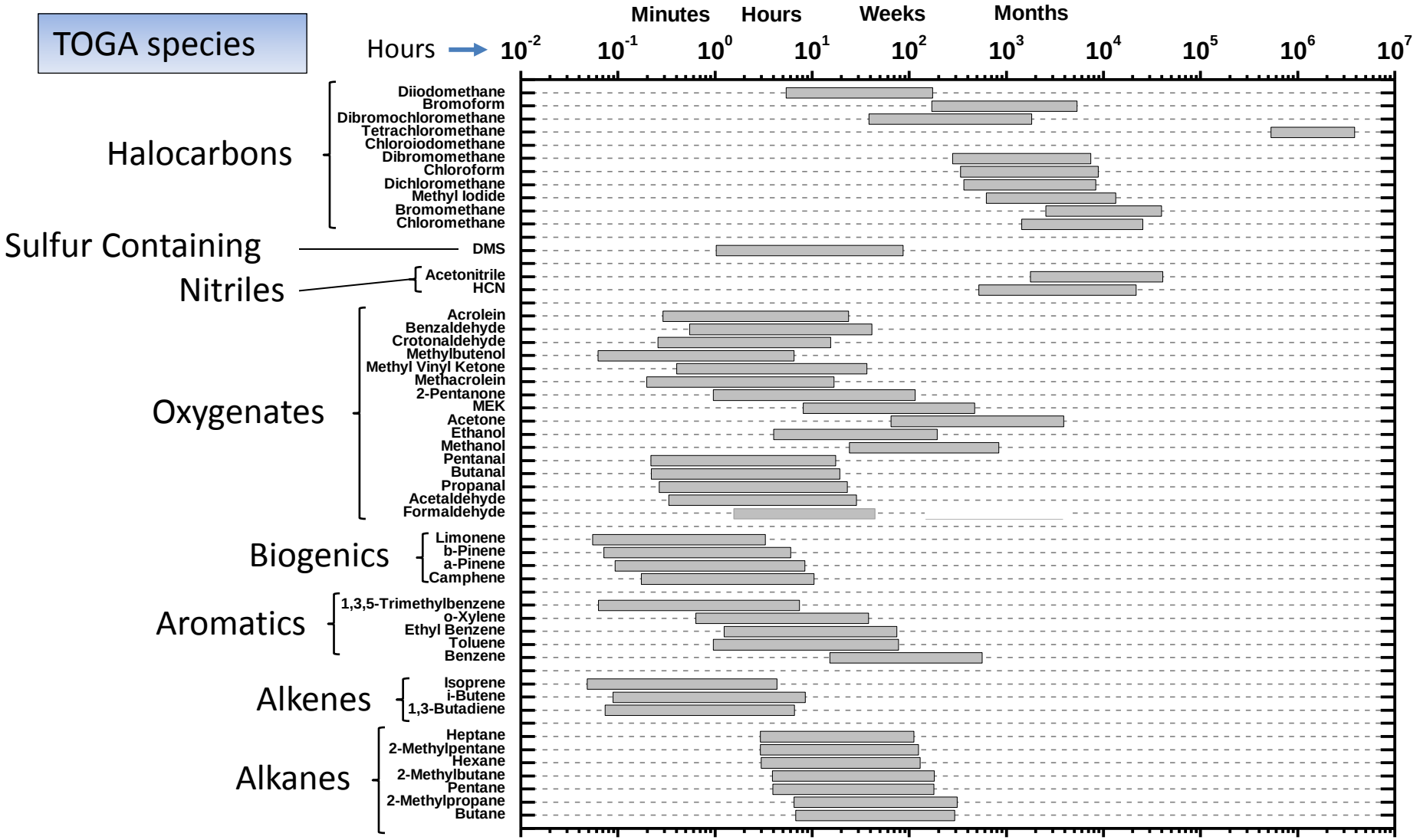
Targeted VOCs can be modified and tailored to best suit objectives of experiment.

…but have to know up front!

# Species measured and lifetimes

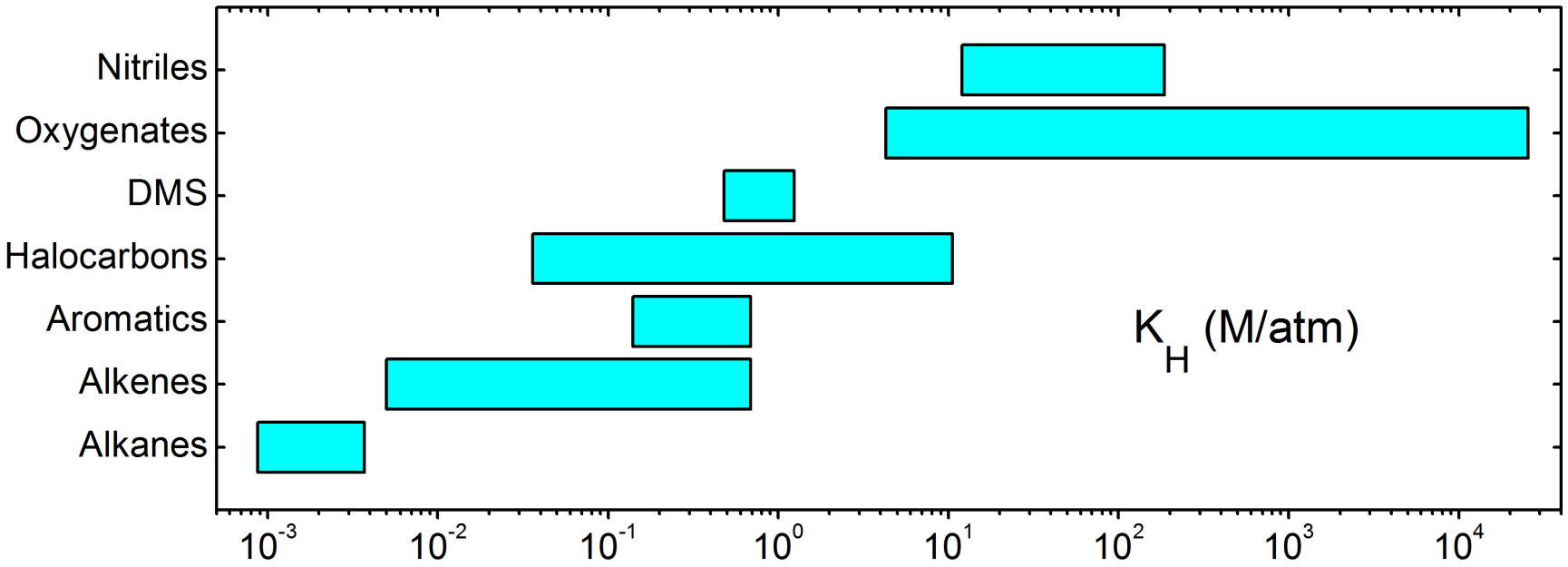
Reactivity with OH

$10^5$ OH (low), $10^7$ OH (high), 210K, 310K

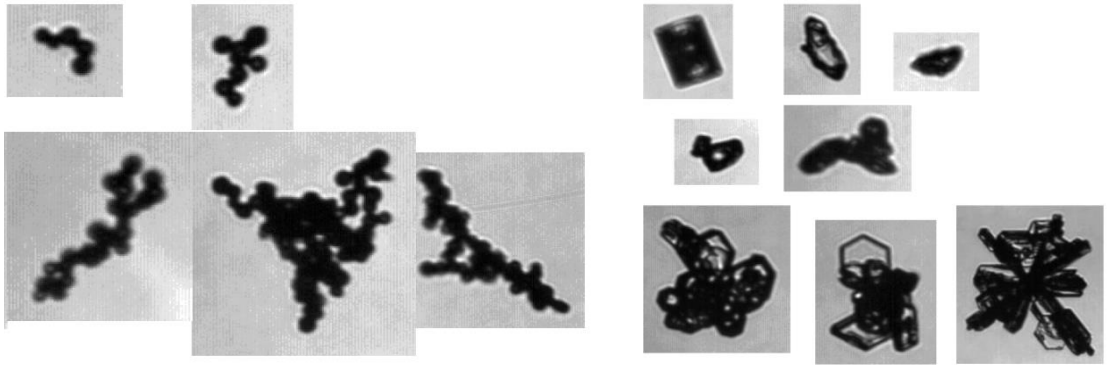


# Solubility and ice interactions

## Aqueous phase interactions

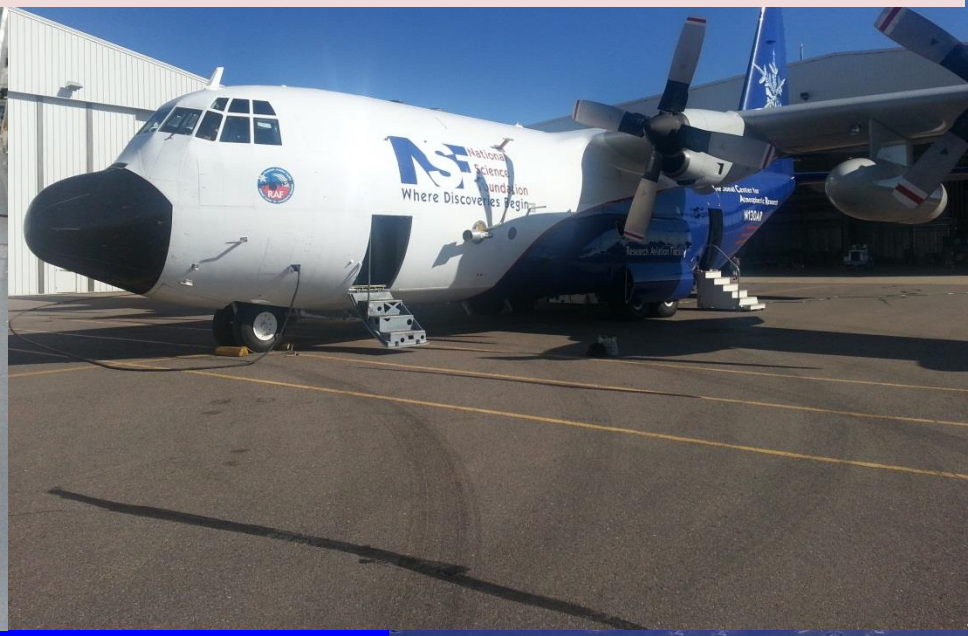


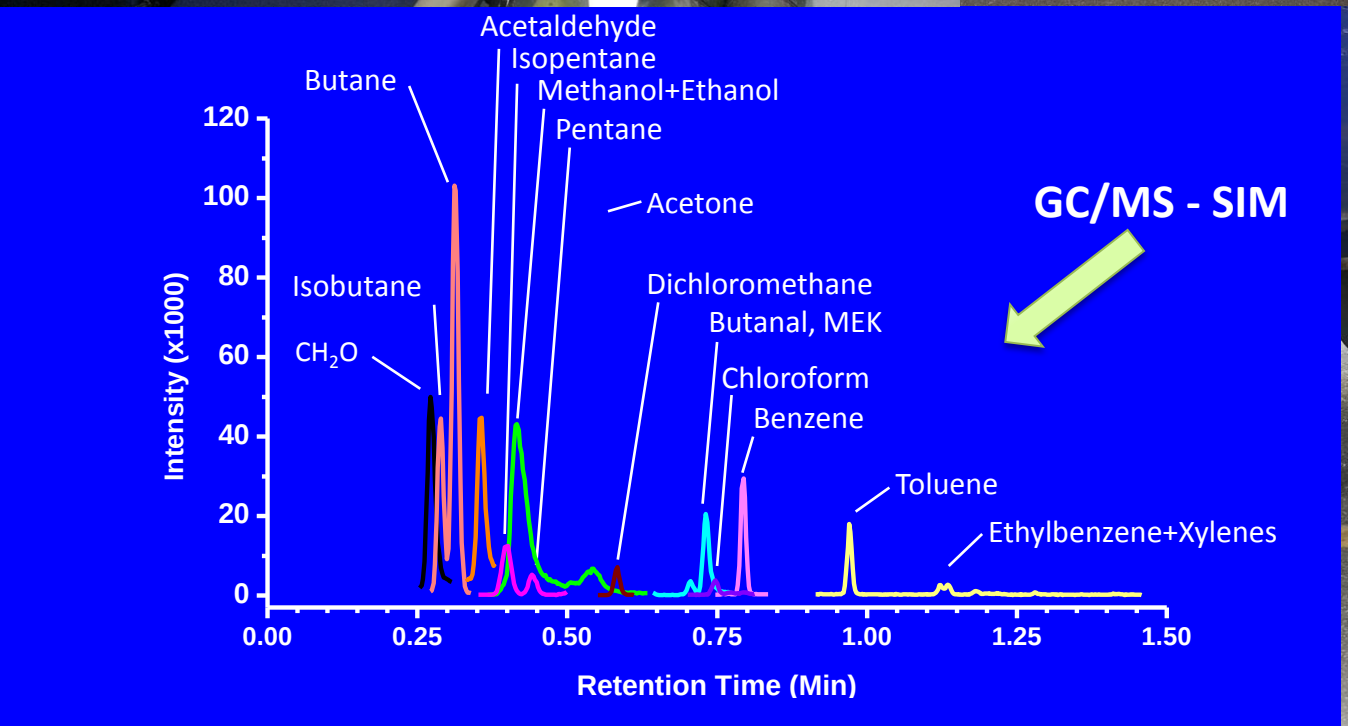

## Ice interactions



Stith - NCAR

# C130 - Atmospheric sampling from < 1 km – 8 km



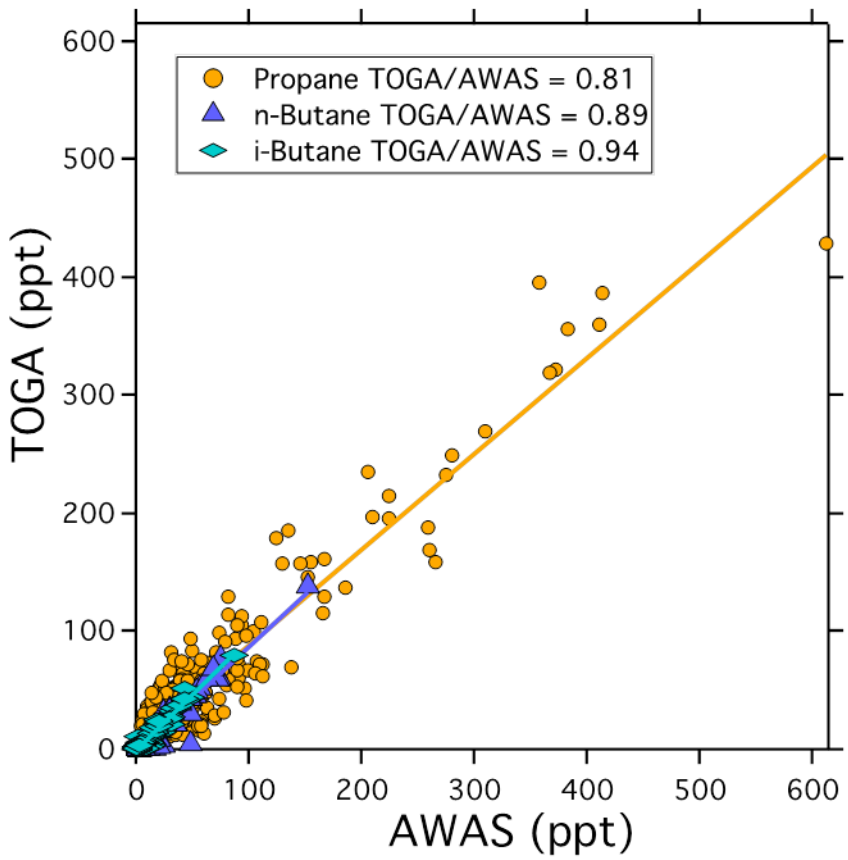



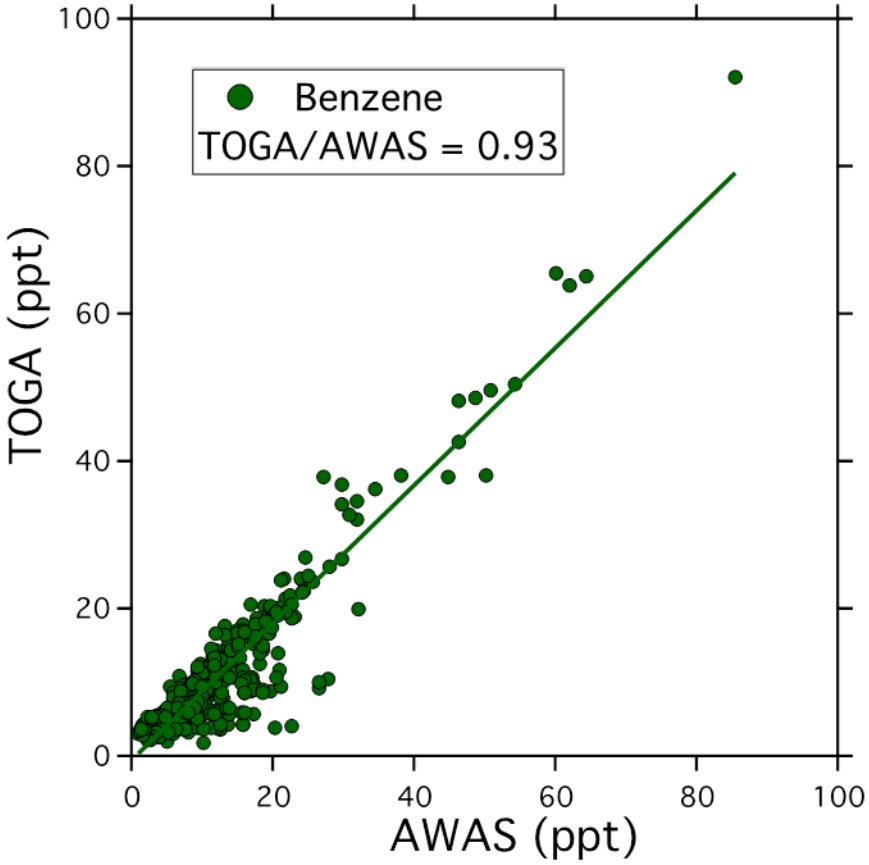

# Calibration and standards

TOGA – Calibrations – in-house – NIST – NOAA standards

Compares well with established measurements – even at low mixing ratios

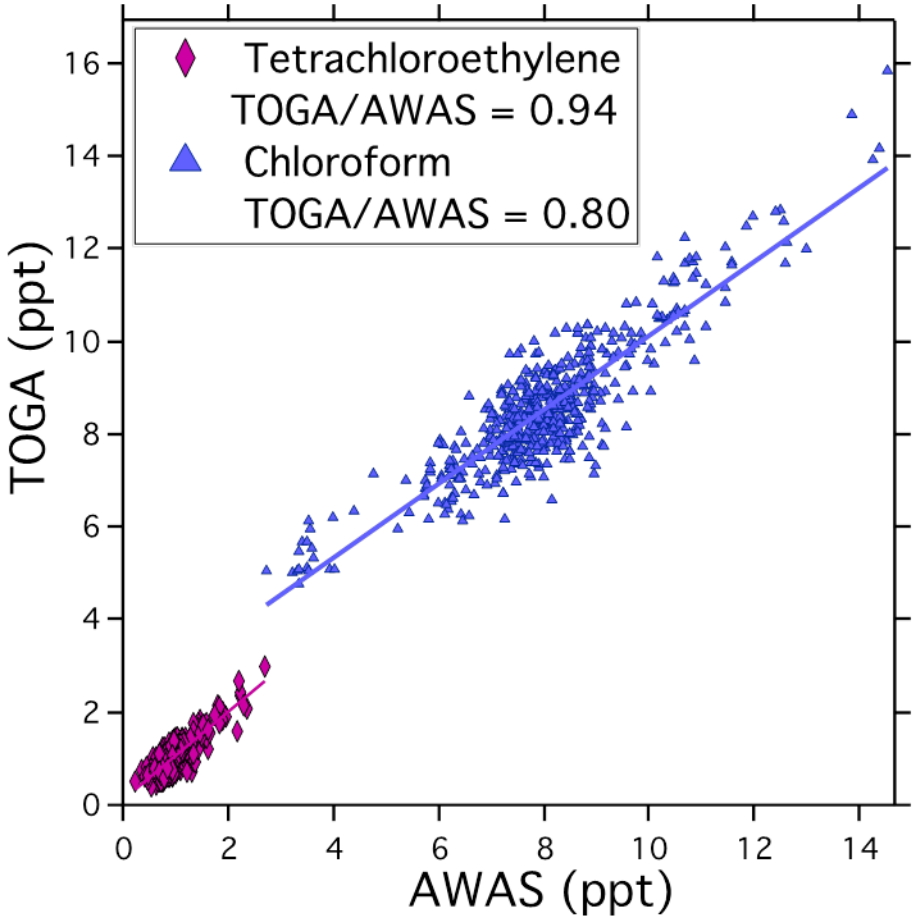
NMHC examples (CONTRAST comparison with AWAS – Atlas)



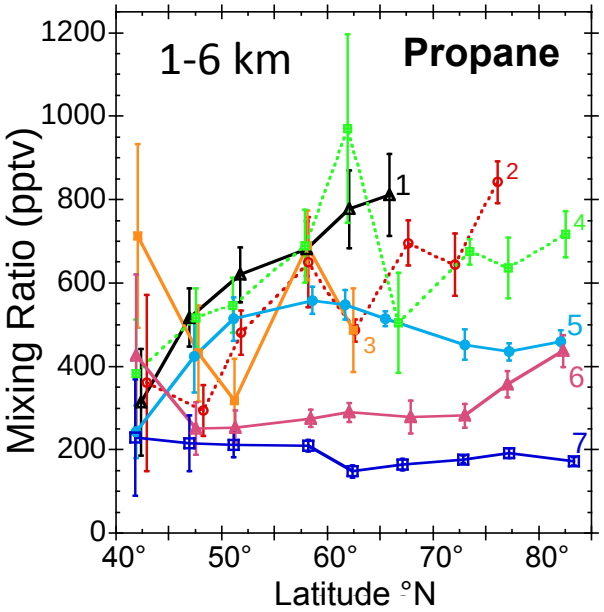



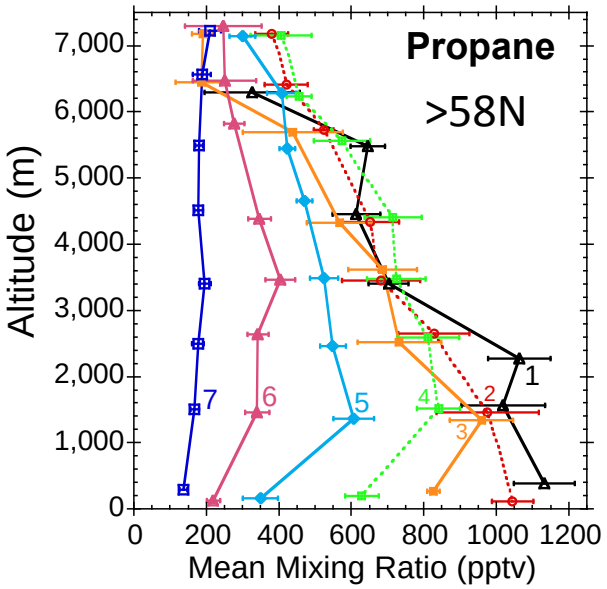
# Calibration and standards

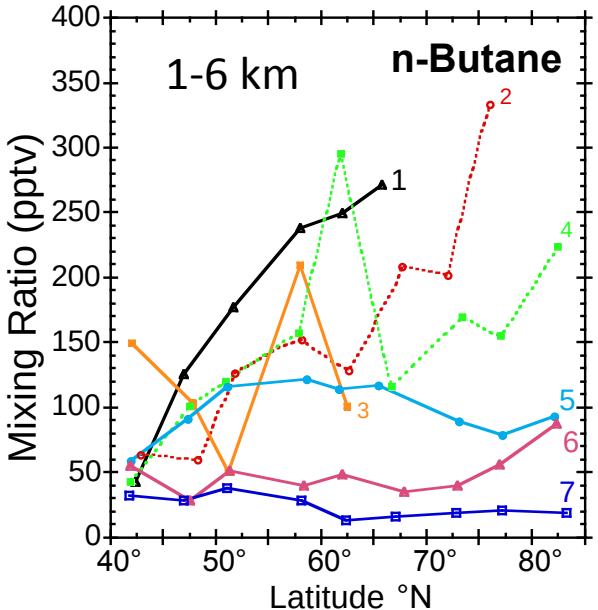
Halogenated species examples

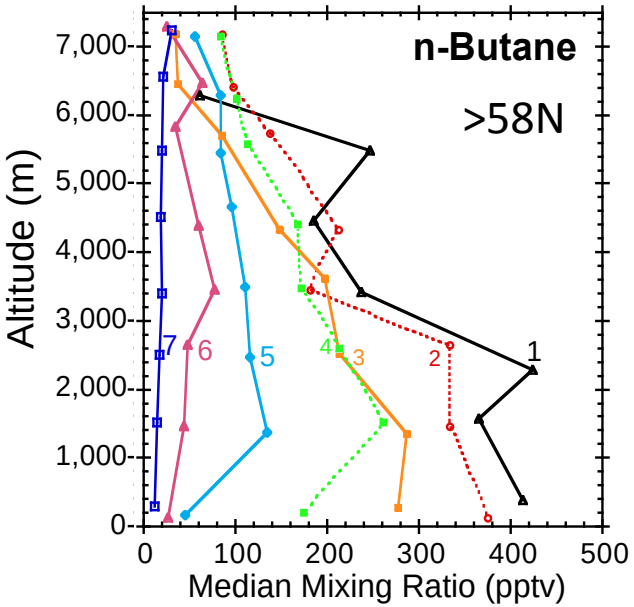


# TOPSE - Winter 2000



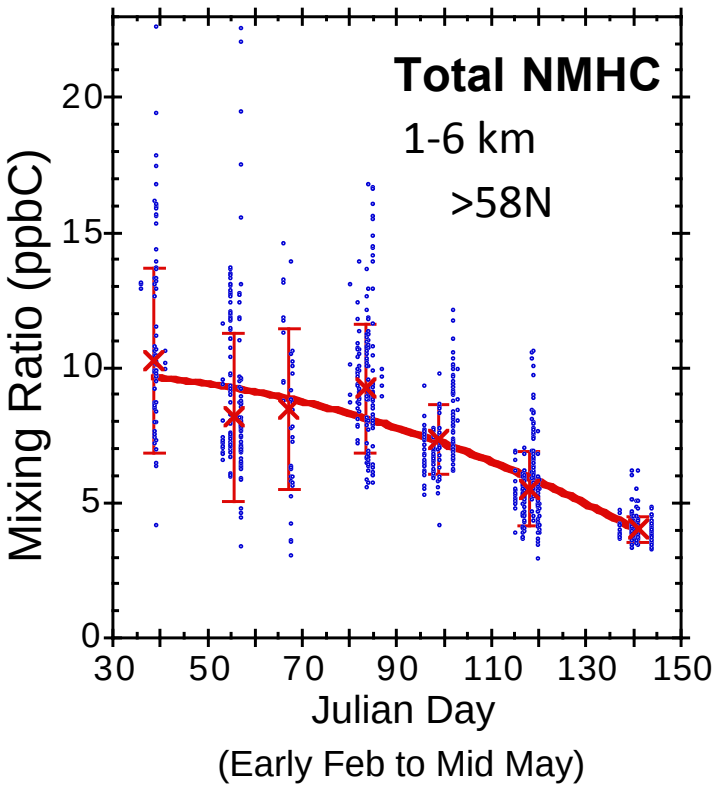

Most deployments CO to Thule Greenland via Churchill (58°N)

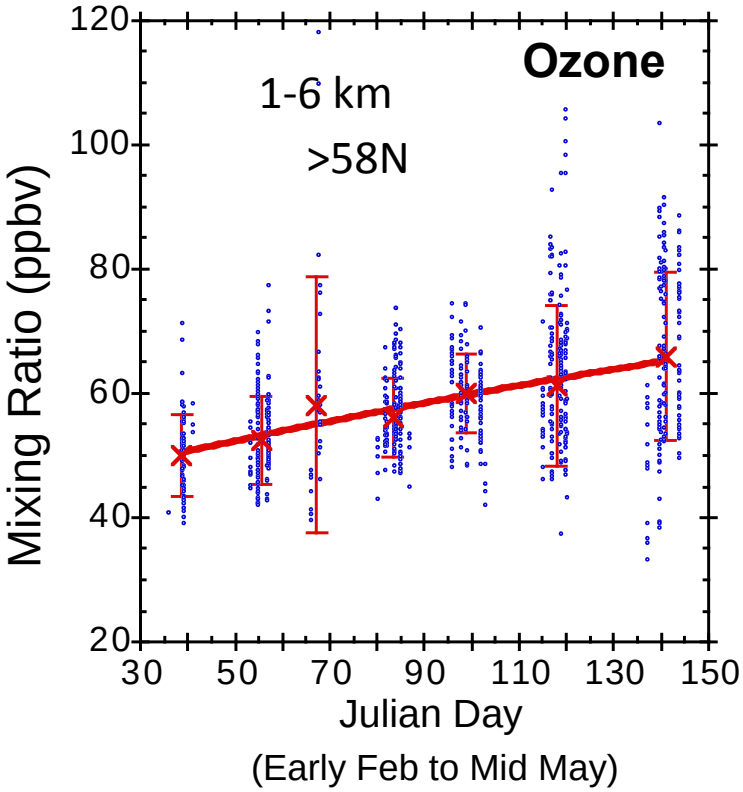
1 - early Feb
2 – late Feb
3 - Early Mar
4- late Mar
5 – early April
6 – late April
7 – midMay

Strong latitude and vertical gradients – WINTER will likely see much higher MRs if we get to the cold side of the polar jet

UCI WAS Data
– Blake et al., 2003

# TOPSE - Winter 2000

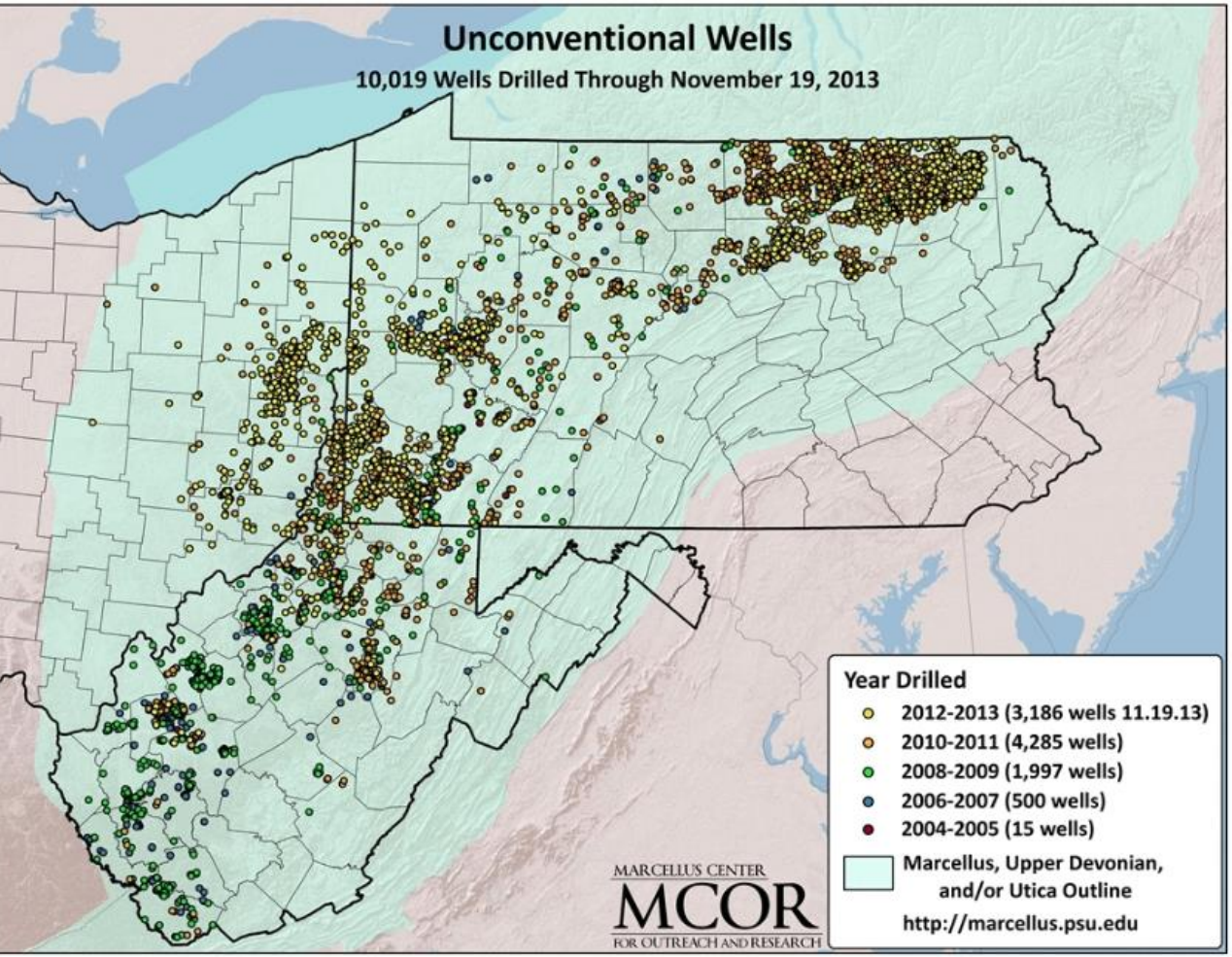


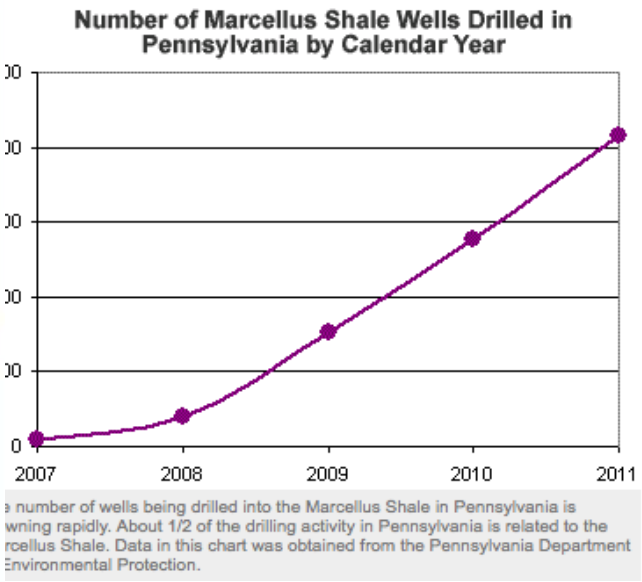




– Blake et al., 2003

**Reminder: request specific compounds for TOGA to quantify**

# Oil and Gas - Marcellus Shale?




number of wells being drilled into the Marcellus Shale in Pennsylvania is wning rapidly. About 1/2 of the drilling activity in Pennsylvania is related to the rcellus Shale. Data in this chart was obtained from the Pennsylvania Department Environmental Protection.