HCHO enhancements during ACCLIP and comparisons to DCOTSS 2022

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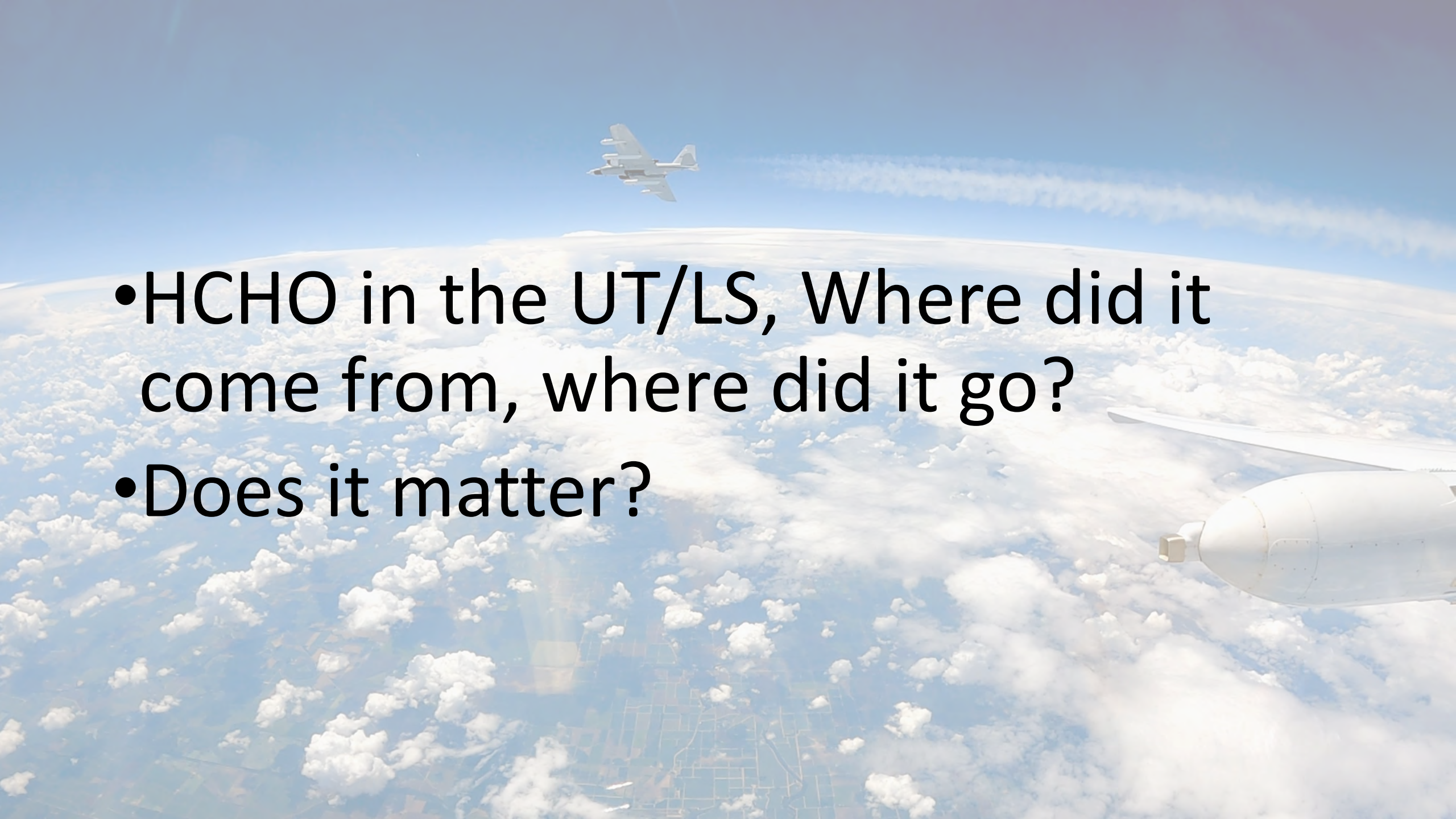
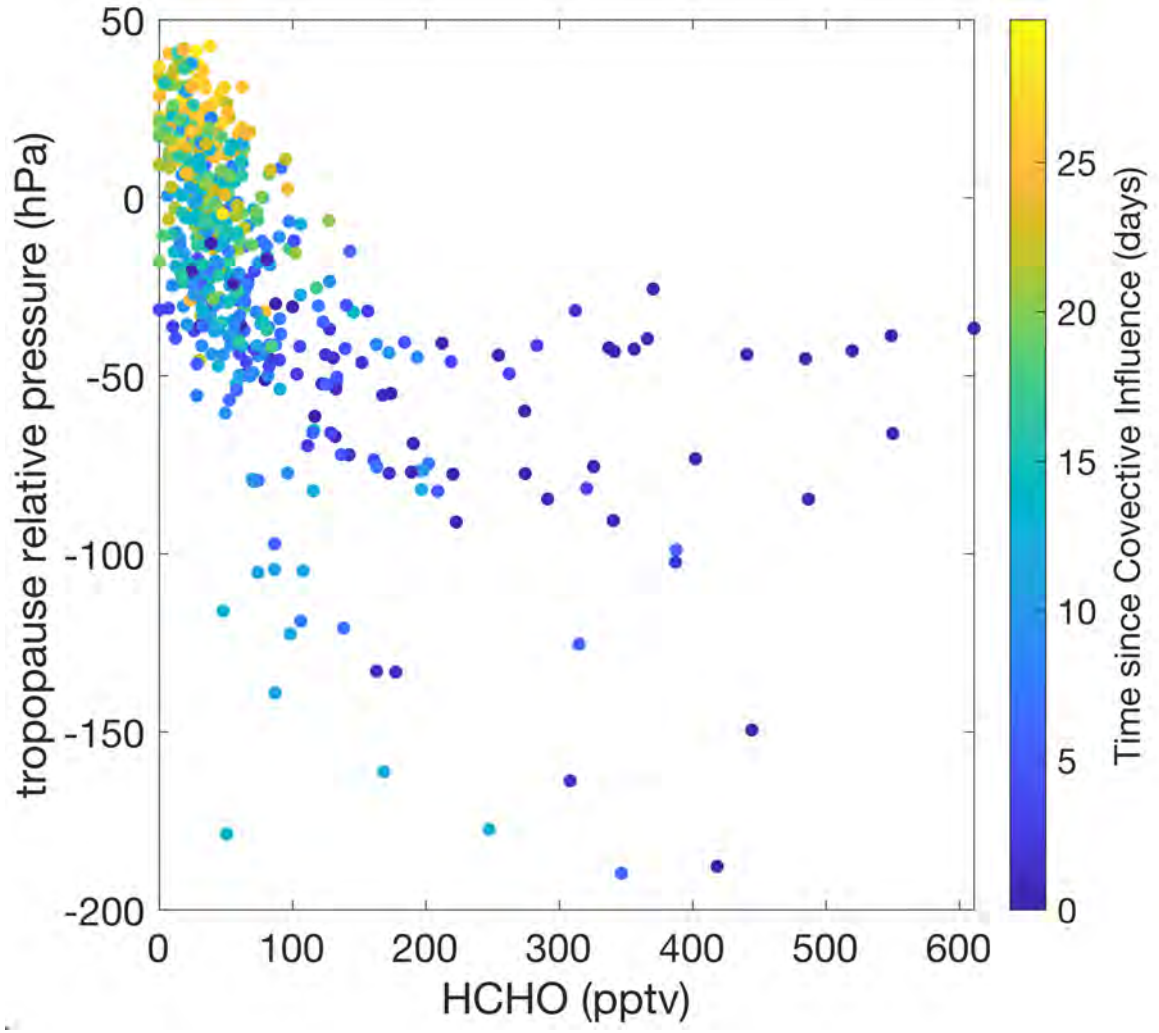
WAS, AWAS, TOGA, LIF NO/NOx/NOy, teams

NASA Earth Venture Suborbital 3
Dynamics and Chemistry of the Summer Stratosphere



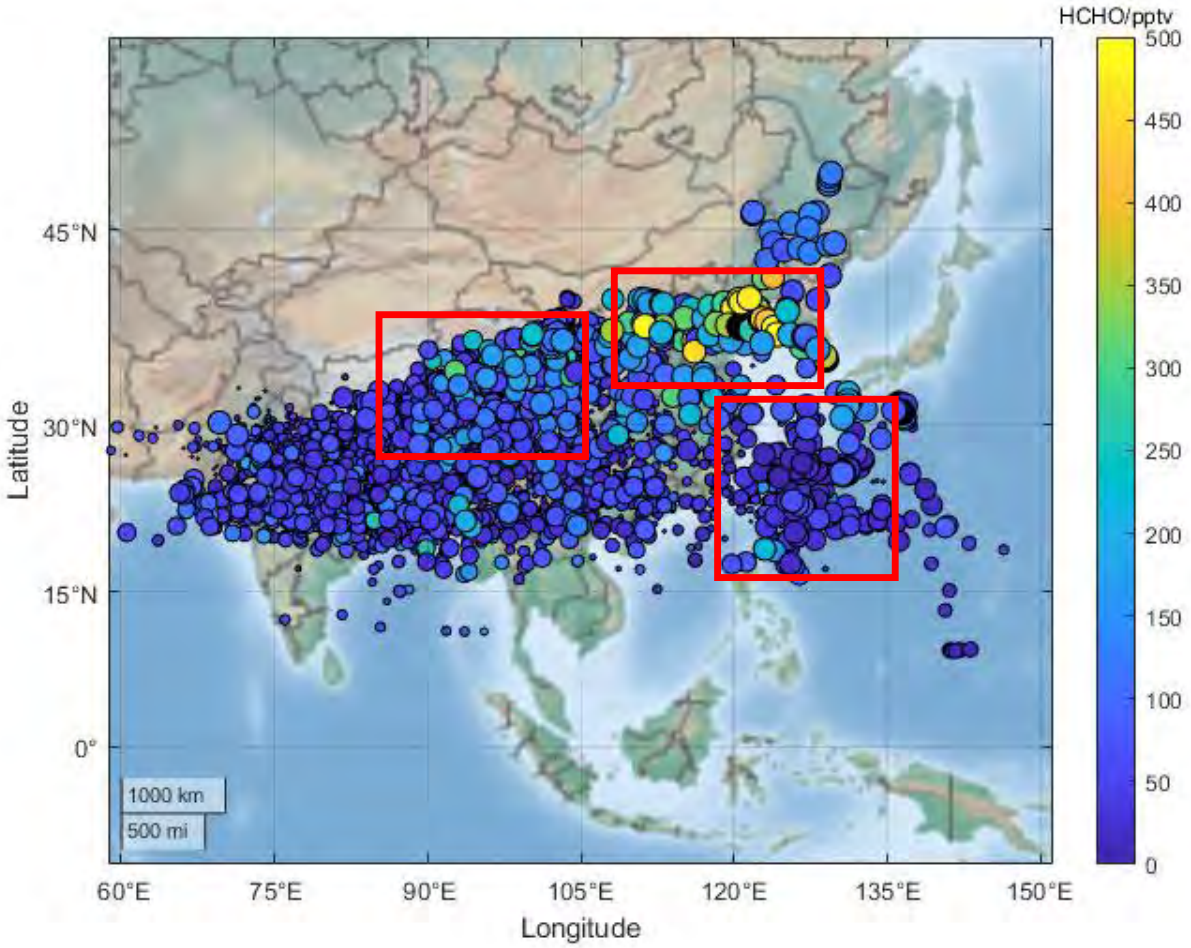
- HCHO in the UT/LS, Where did it come from, where did it go?
- Does it matter?

Where did it come from?: location of origin

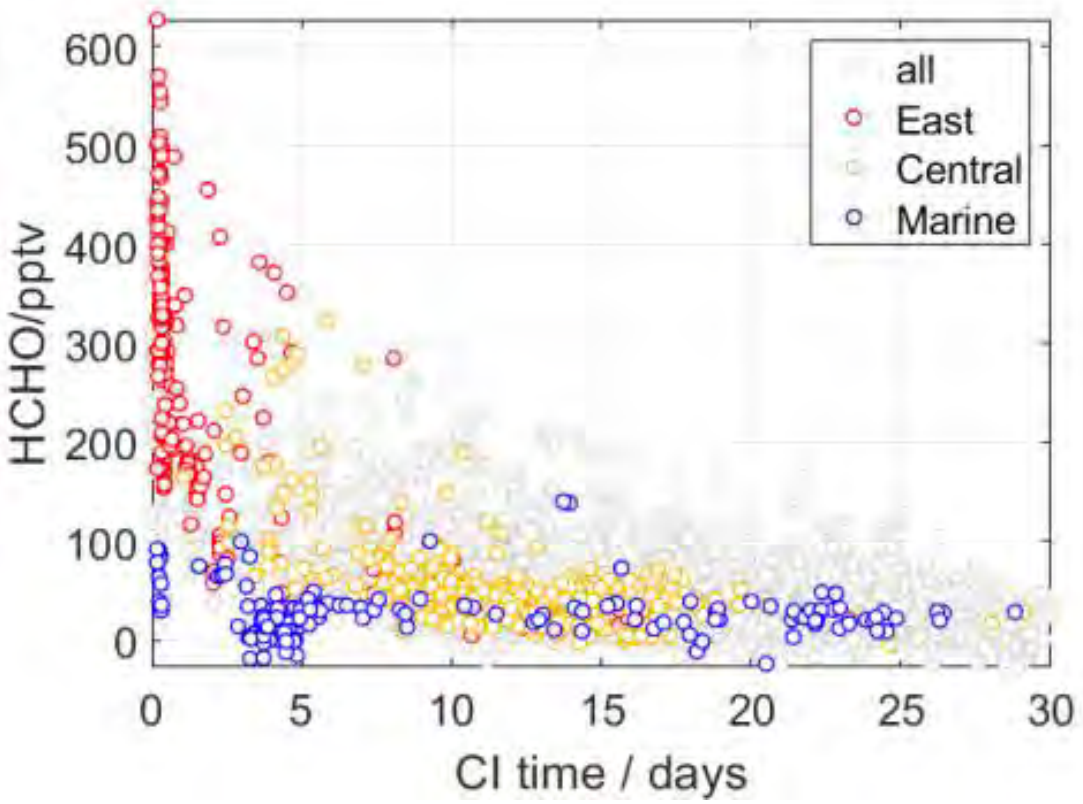


- HCHO enhancements from recent convection below the tropopause (GEOS)
- High altitude measurements tend to be from older air parcels

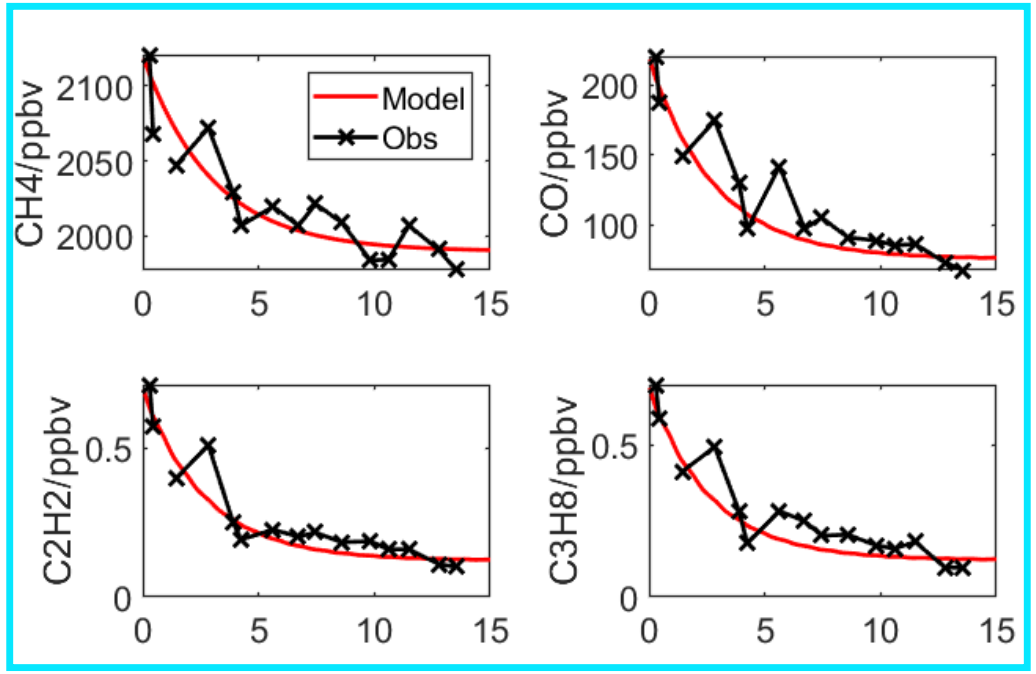
Where did it come from?: location of origin



- Largest HCHO enhancements from recent (<1 day) convection close to Beijing in Eastern China

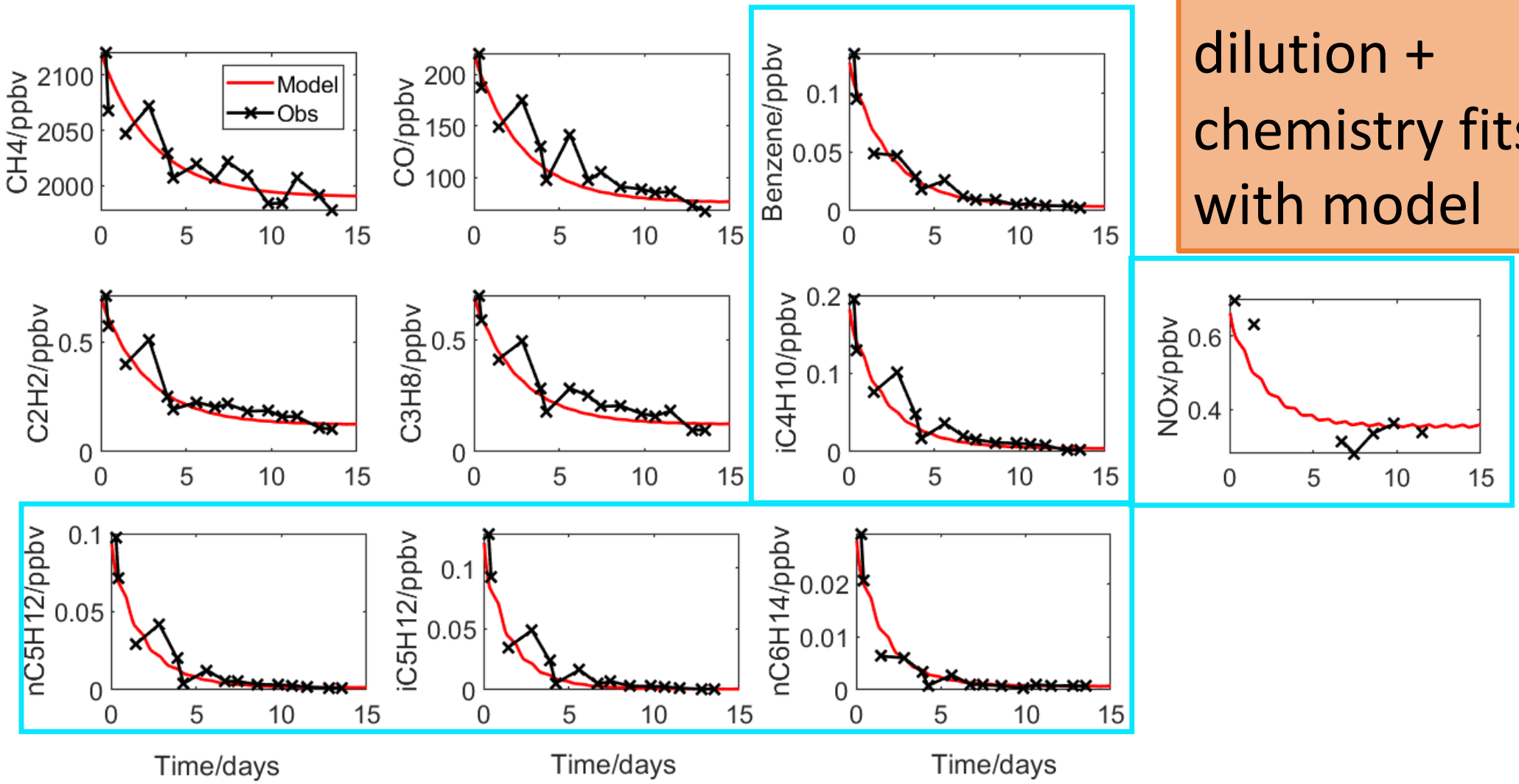


F0AM Box Model Lagrangian ACCLIP monsoon outflow



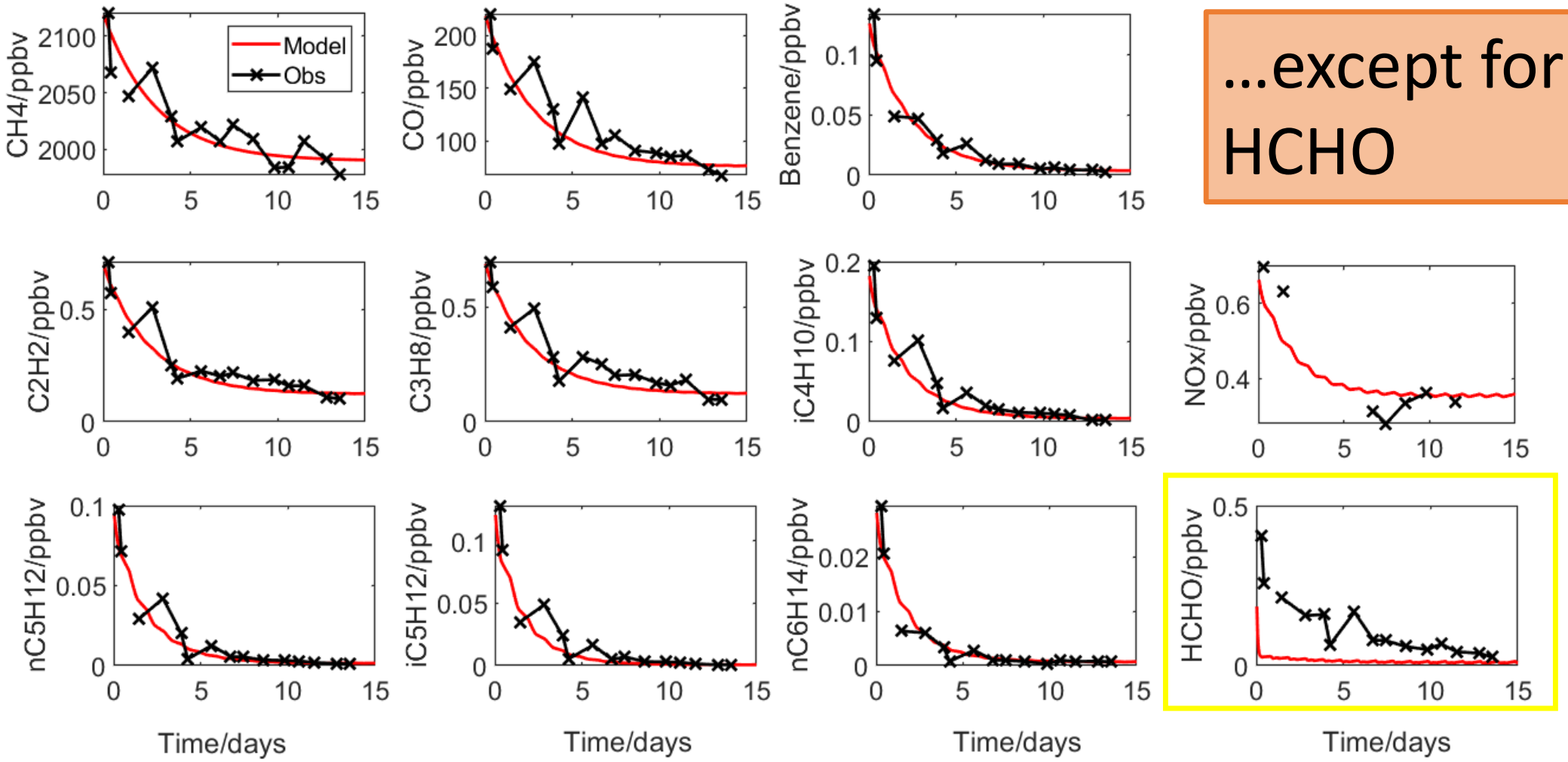
Longer lived species to constrain dilution

F0AM Box Model Lagrangian ACCLIP monsoon outflow



Shorter lived dilution + chemistry fits well with model

F0AM Box Model Lagrangian ACCLIP monsoon outflow

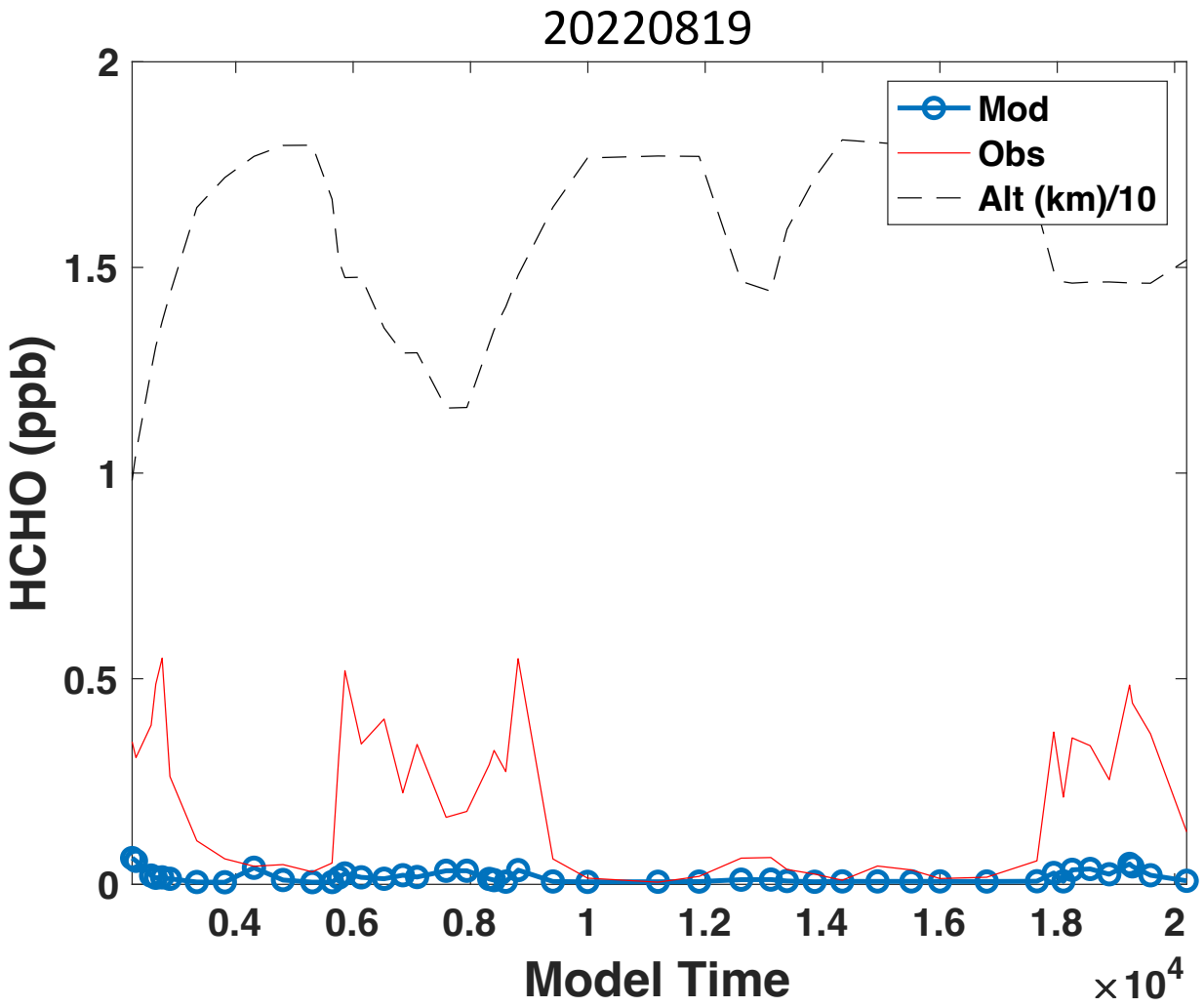


…except for HCHO

Where did it come from?: Try F0AM SS

20220819

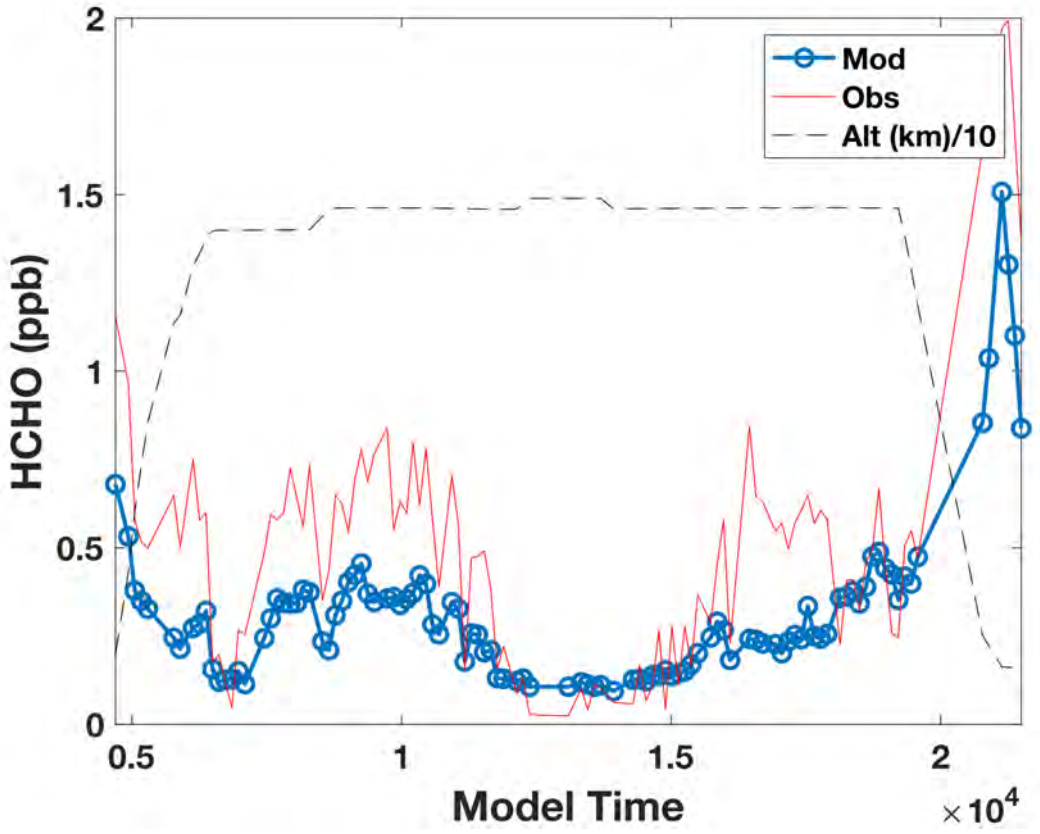
Where did it come from?: Try F0AM SS

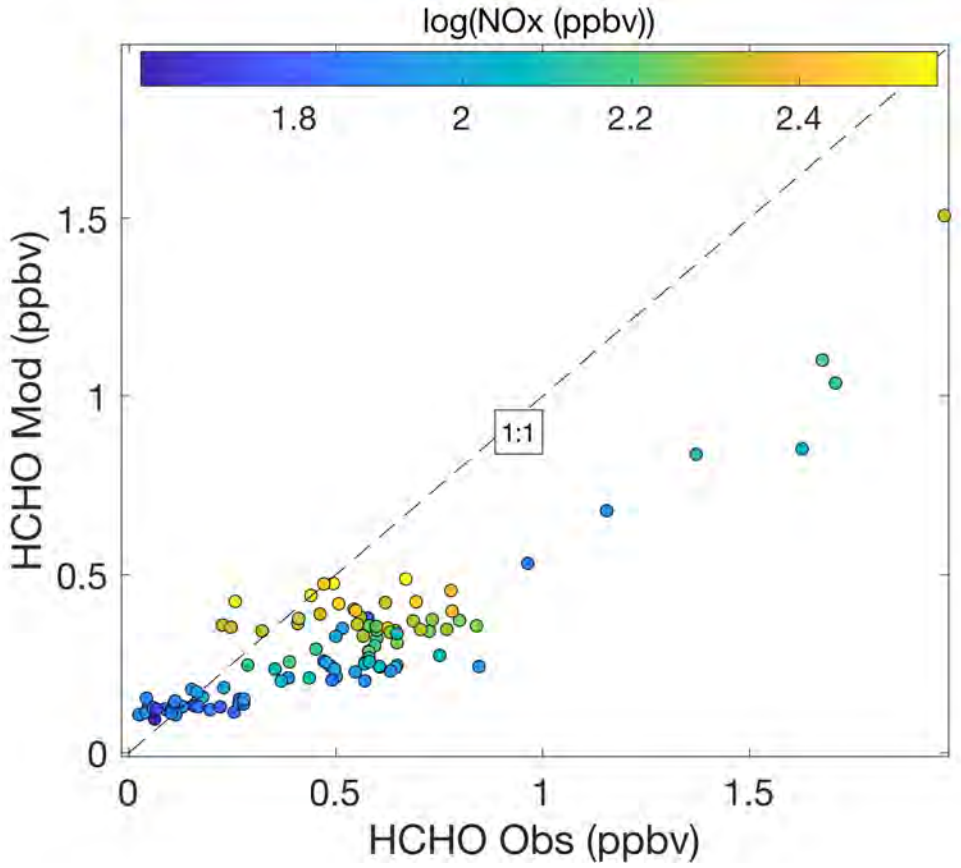


…NOPE

Where did it come from?: What can we learn from TOGA GV?

20220819





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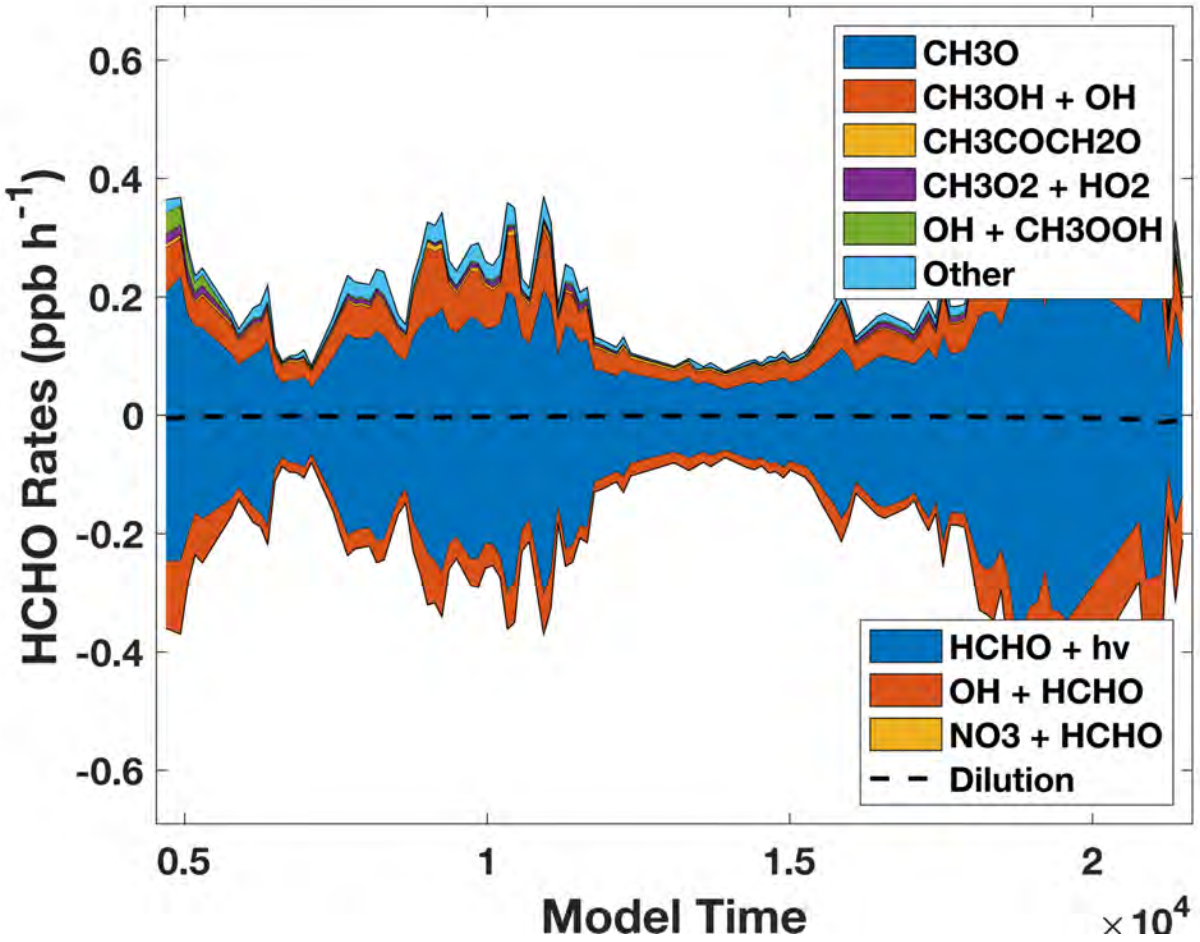

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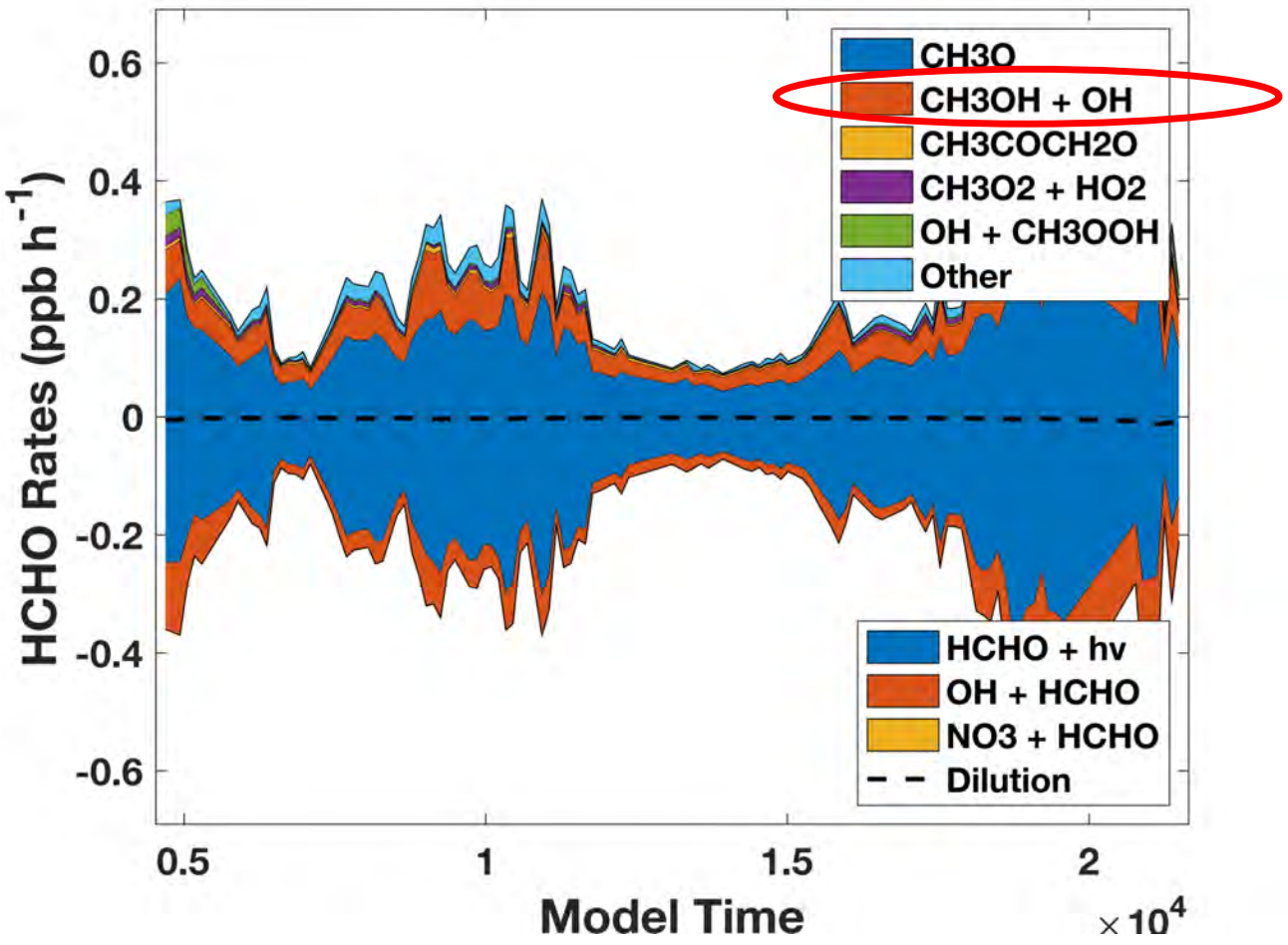

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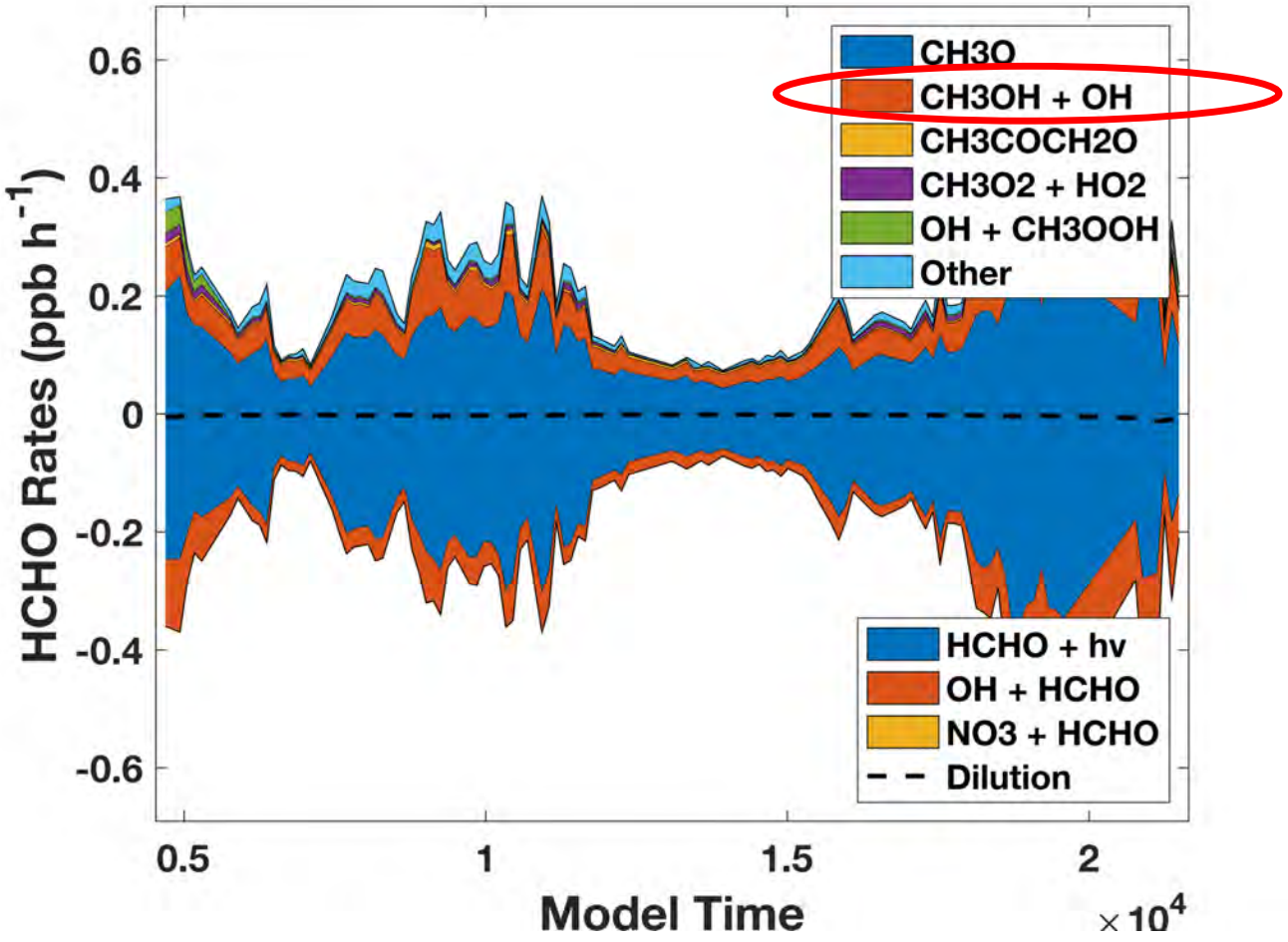

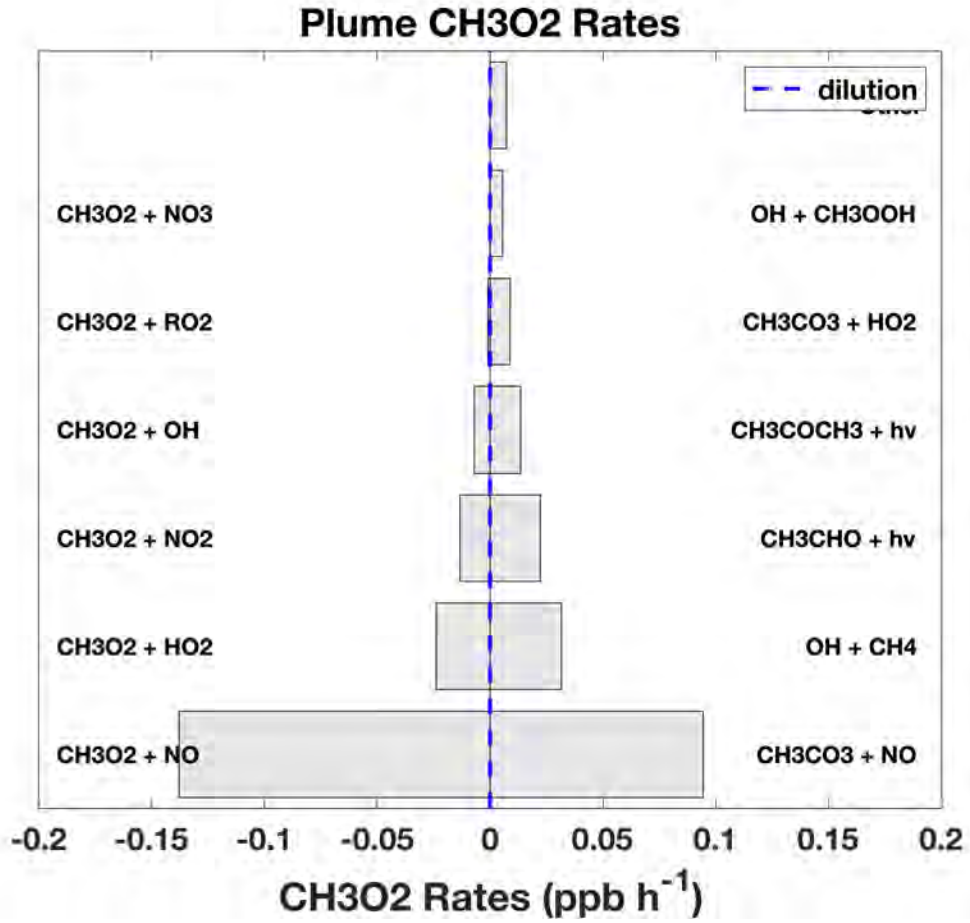

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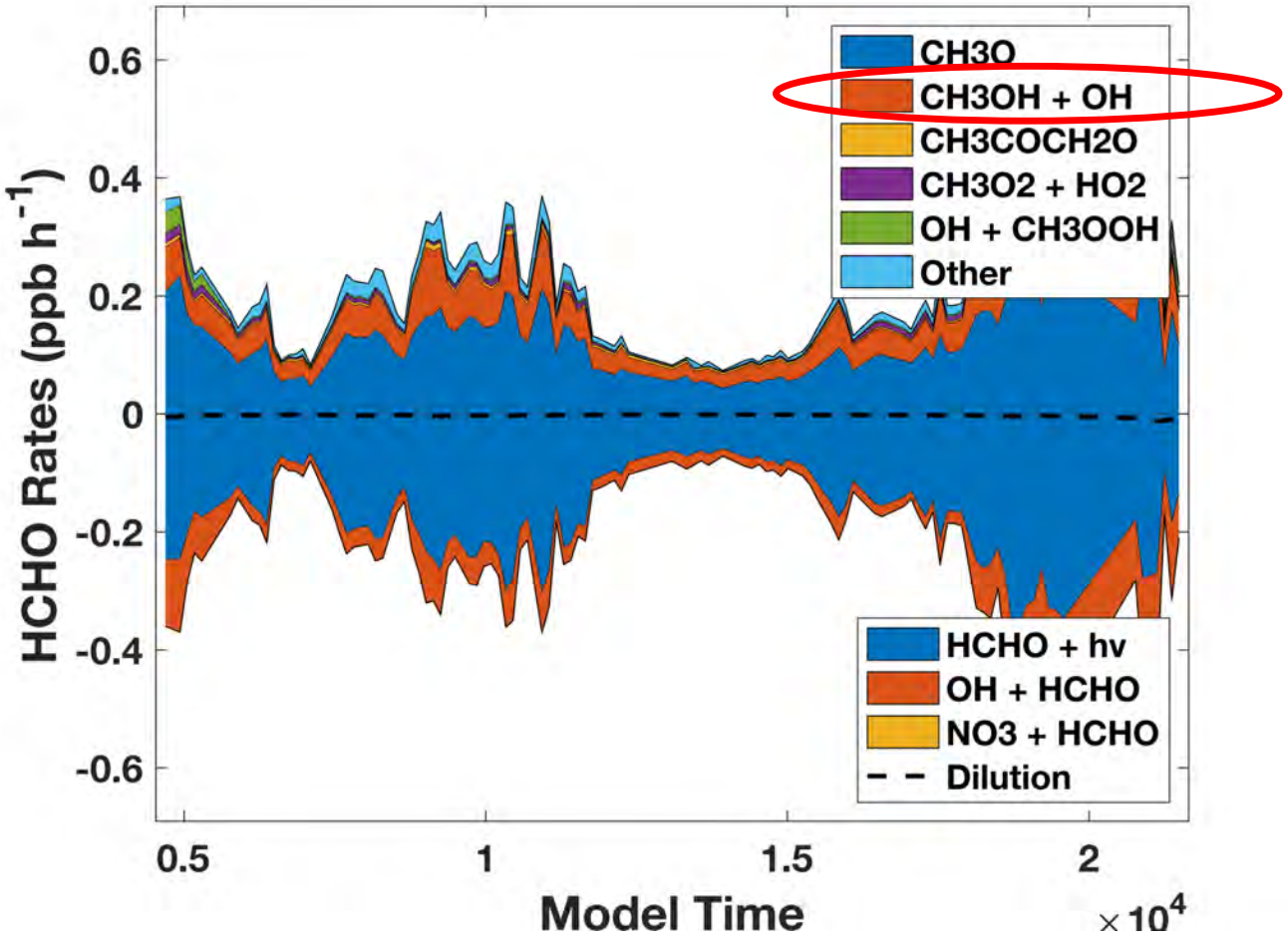
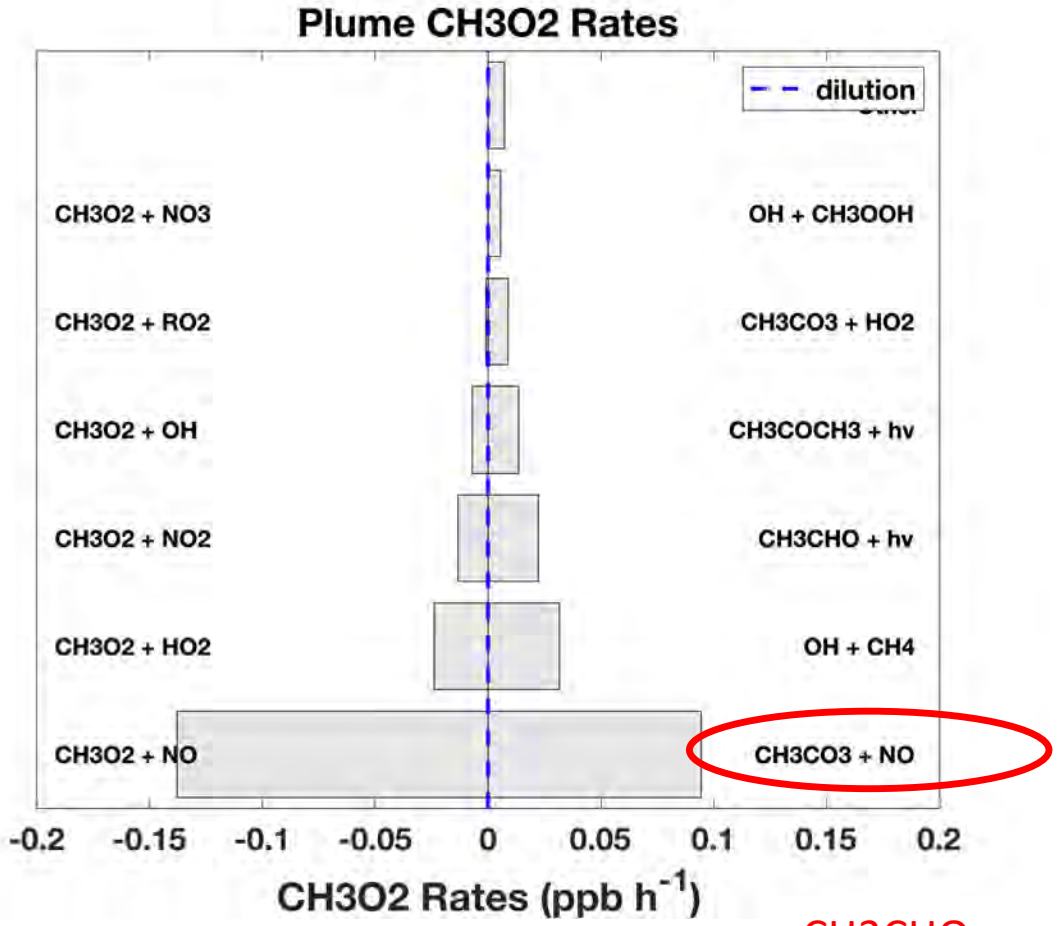
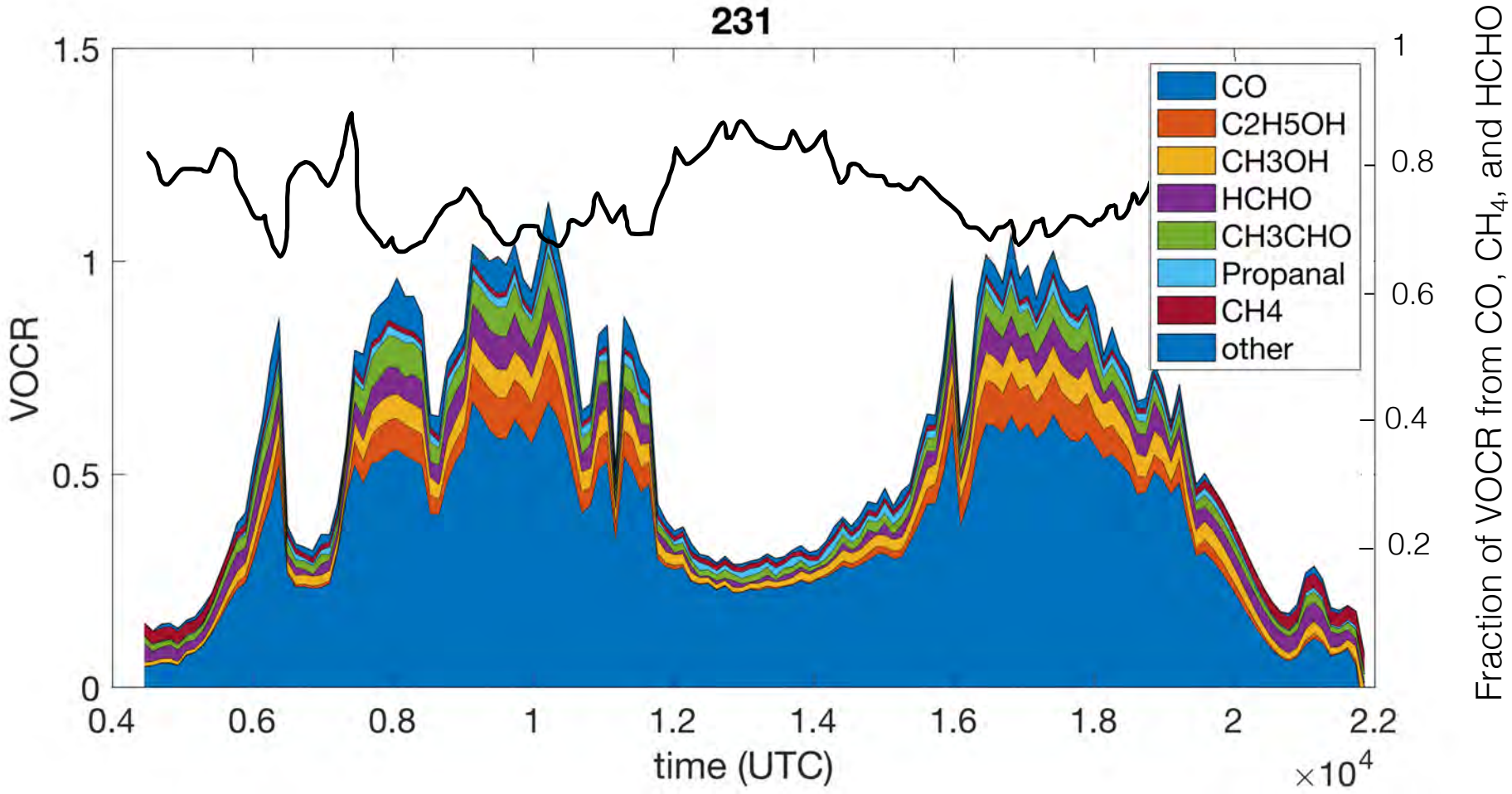




CH3CHO

Where did it come from?: What can we learn from TOGA GV?



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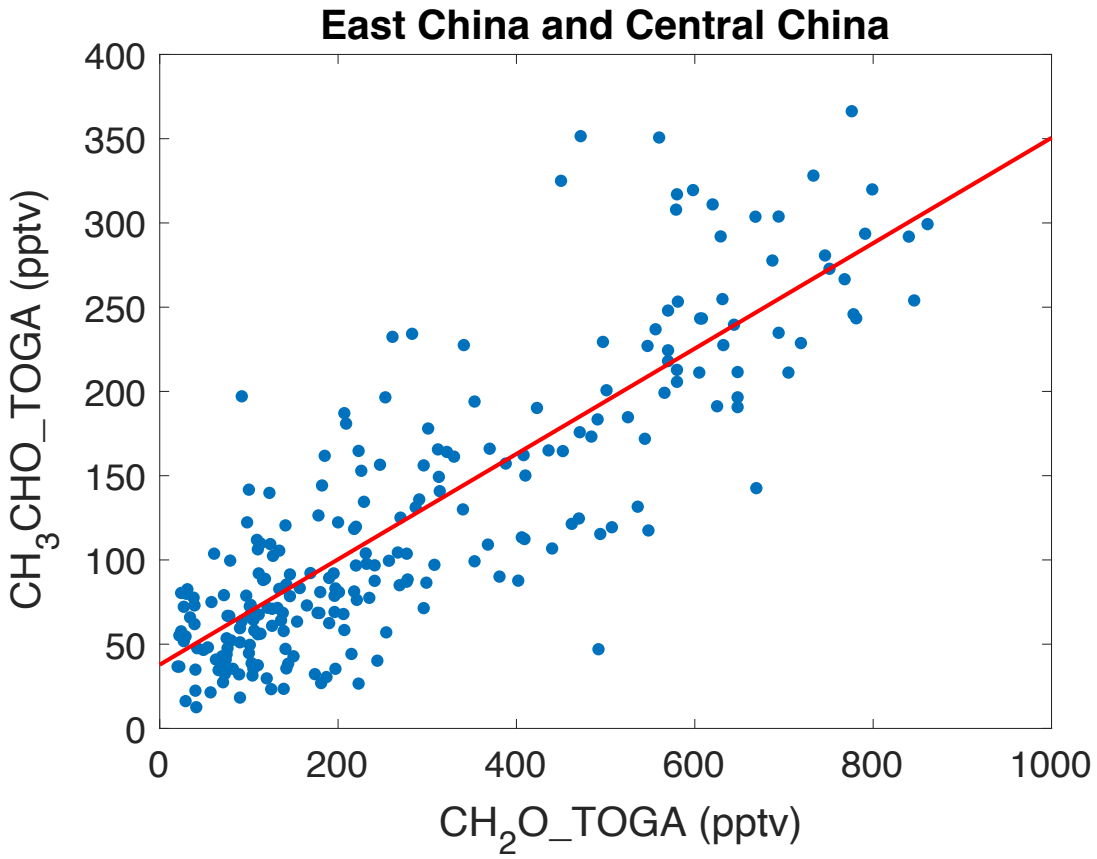

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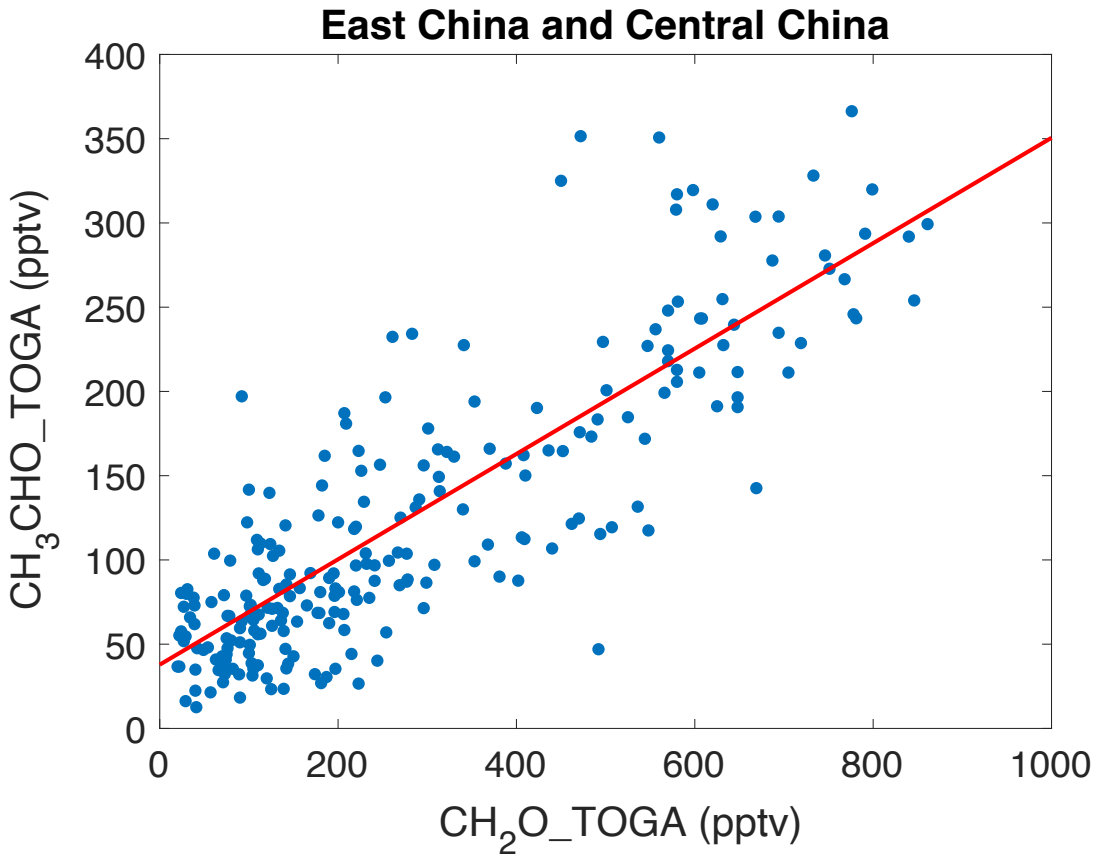
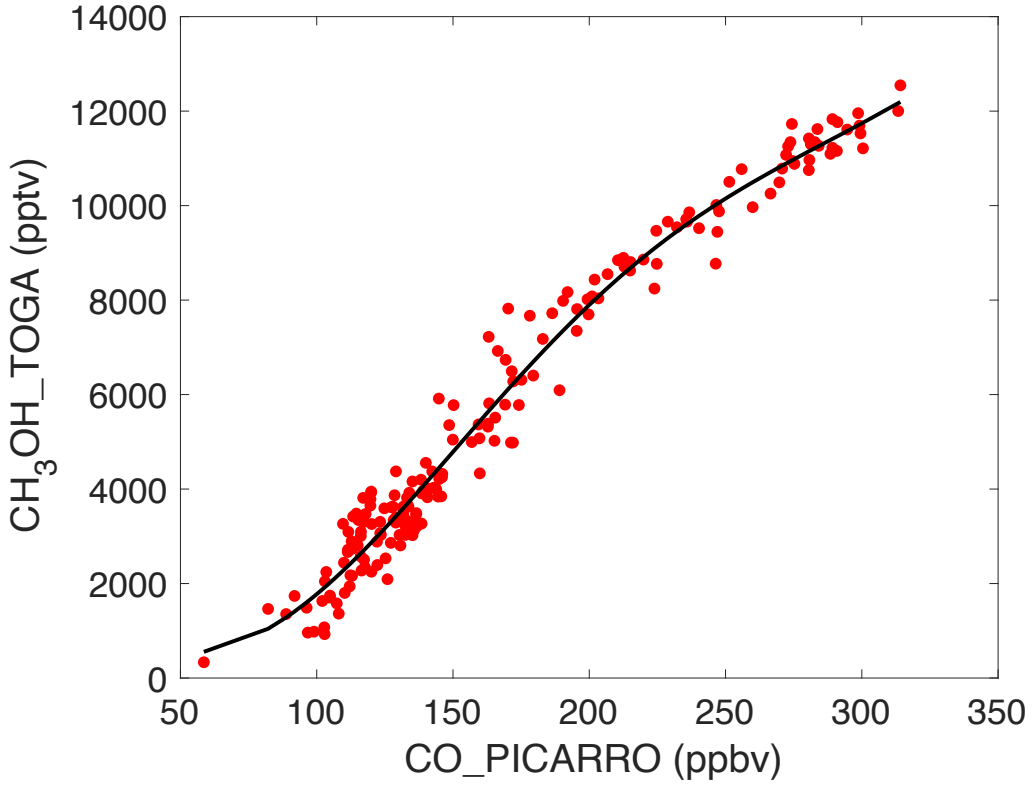
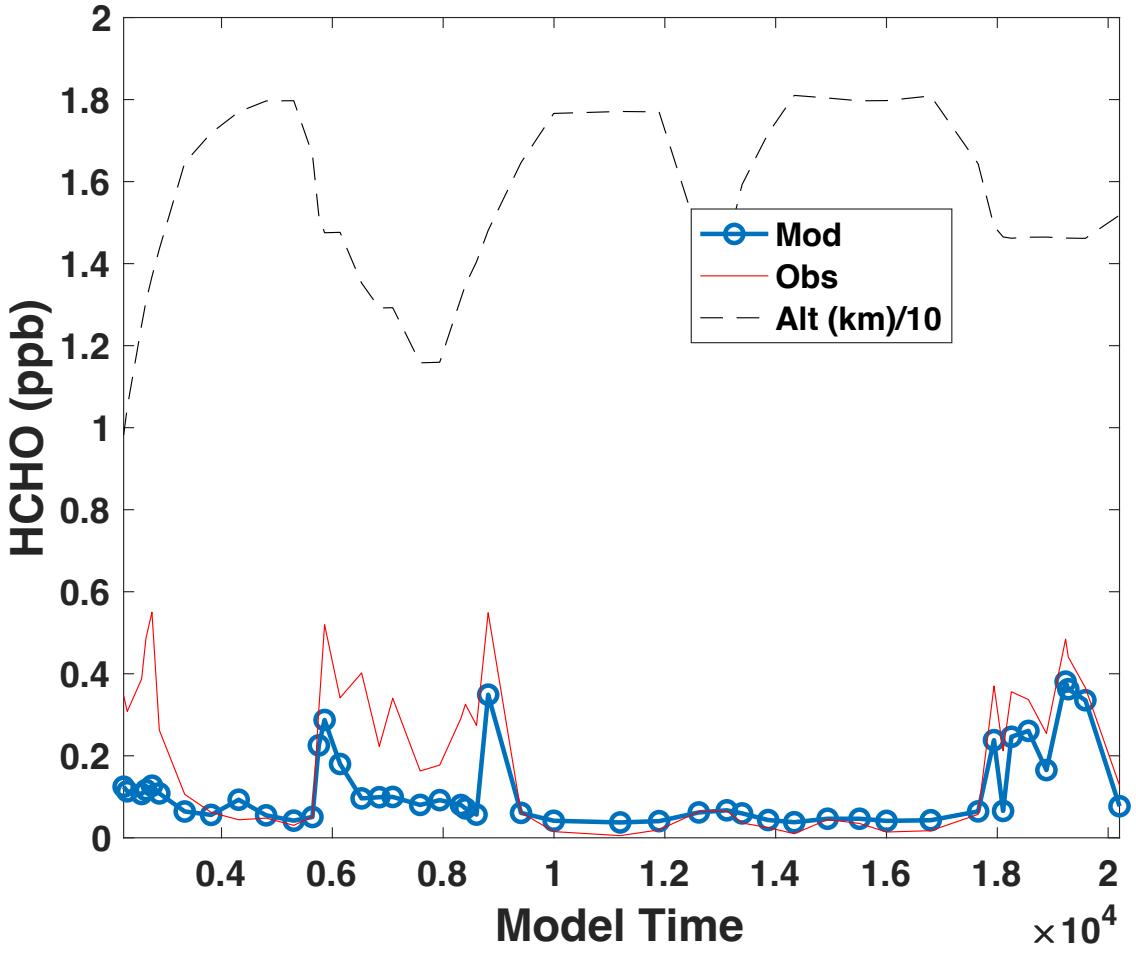
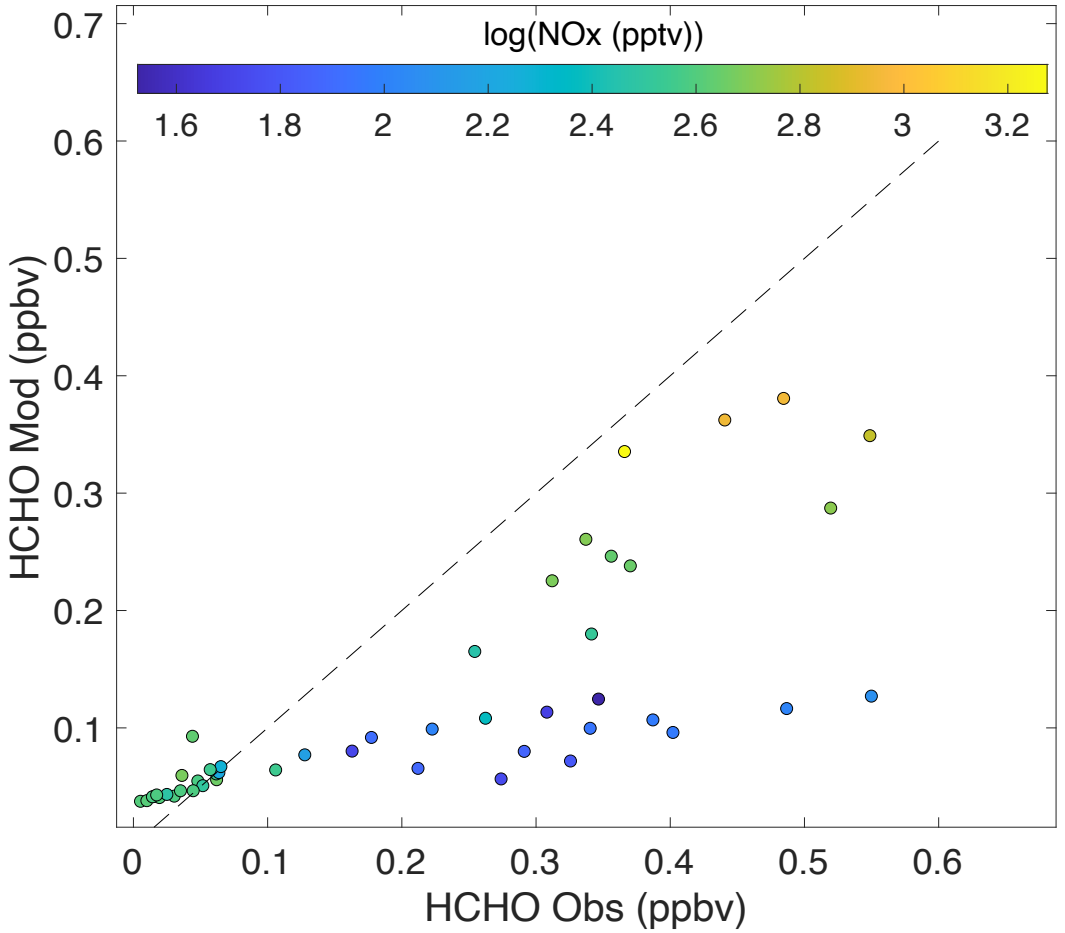




Where did it come from?: Try F0AM SS with CH3CHO and CH3OH

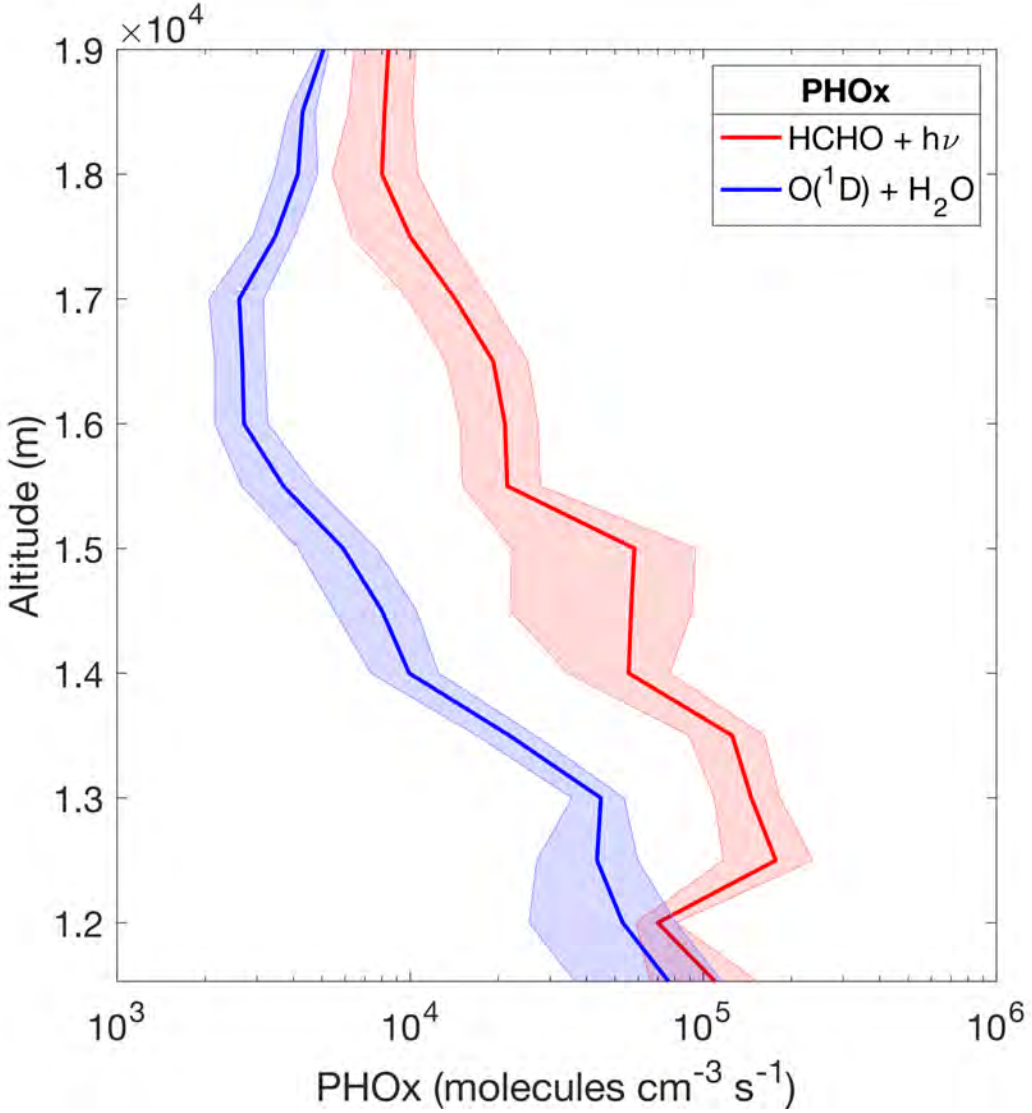




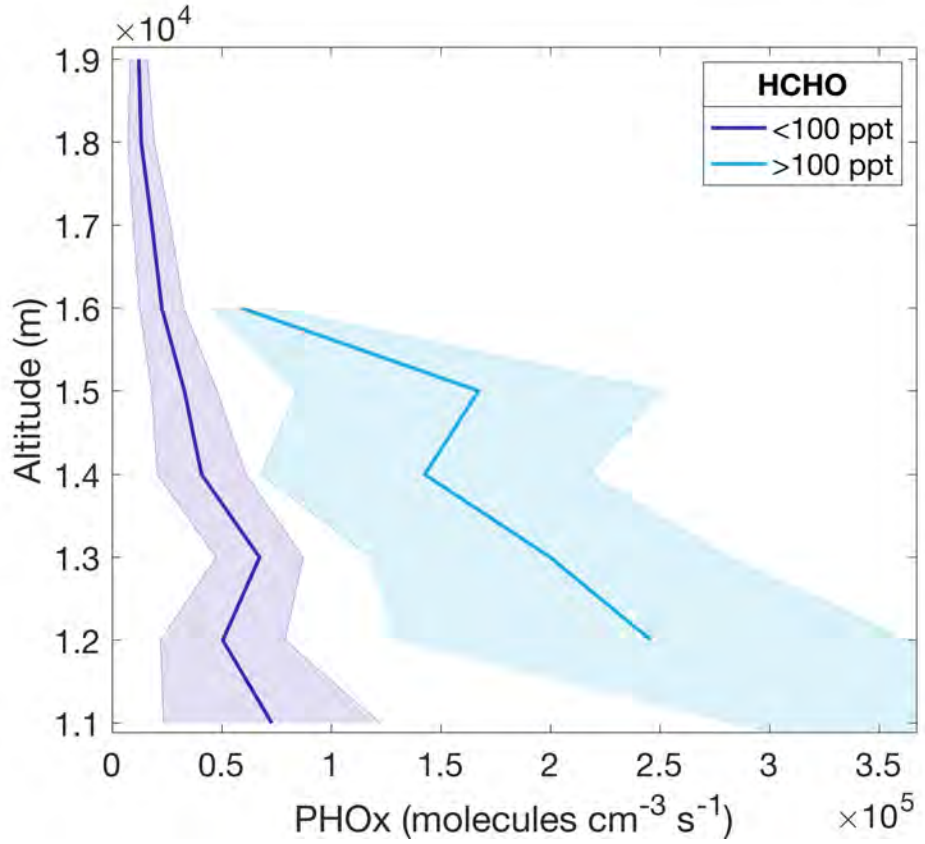
Does it matter?: PHOx

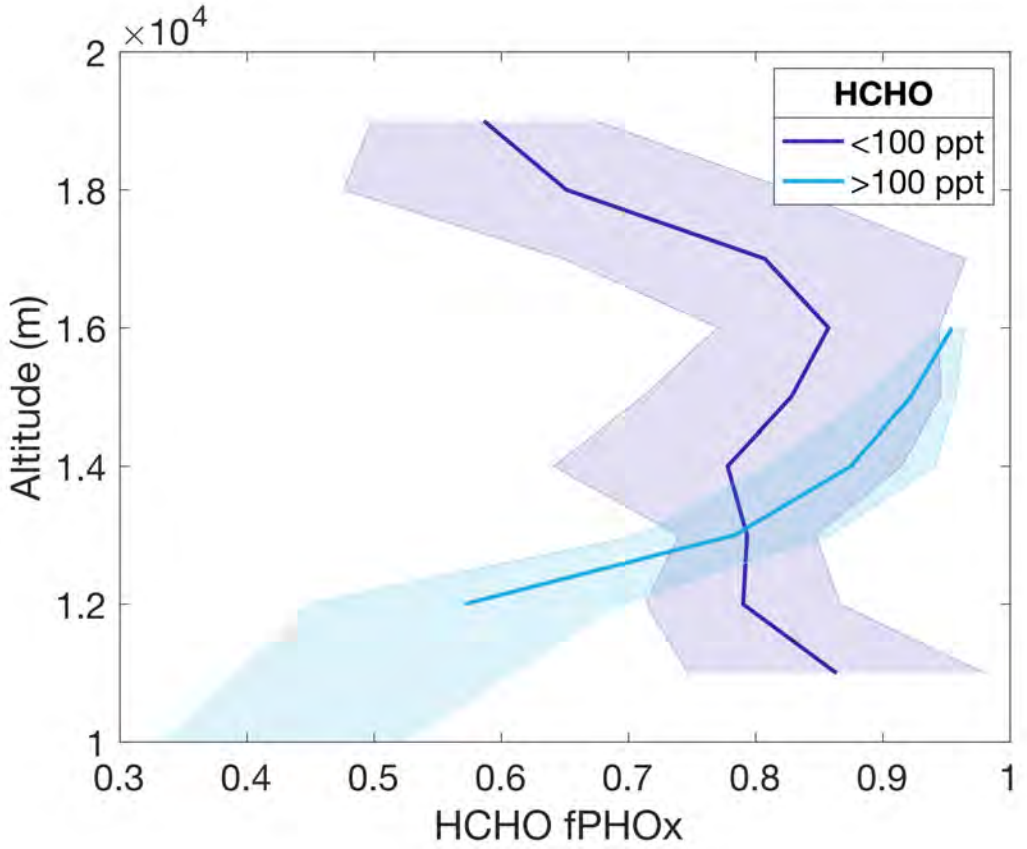
- Simple chemical box model for all observations during ACCLIP on WB57
- VOCR scaled to reflect only ~80% measured by WB57 to calculate HO_x

$$\mathrm{PHOx} = \frac{2J_{O3\rightarrow O1D}[O_3]\left(k_{O1D+H_2O}[H_2O]\right)}{k_{O1D+H_2O}[H_2O] + k_{O1D+M}[M]} + 2J_{HCHO\rightarrow H+HCO}[HCHO]$$



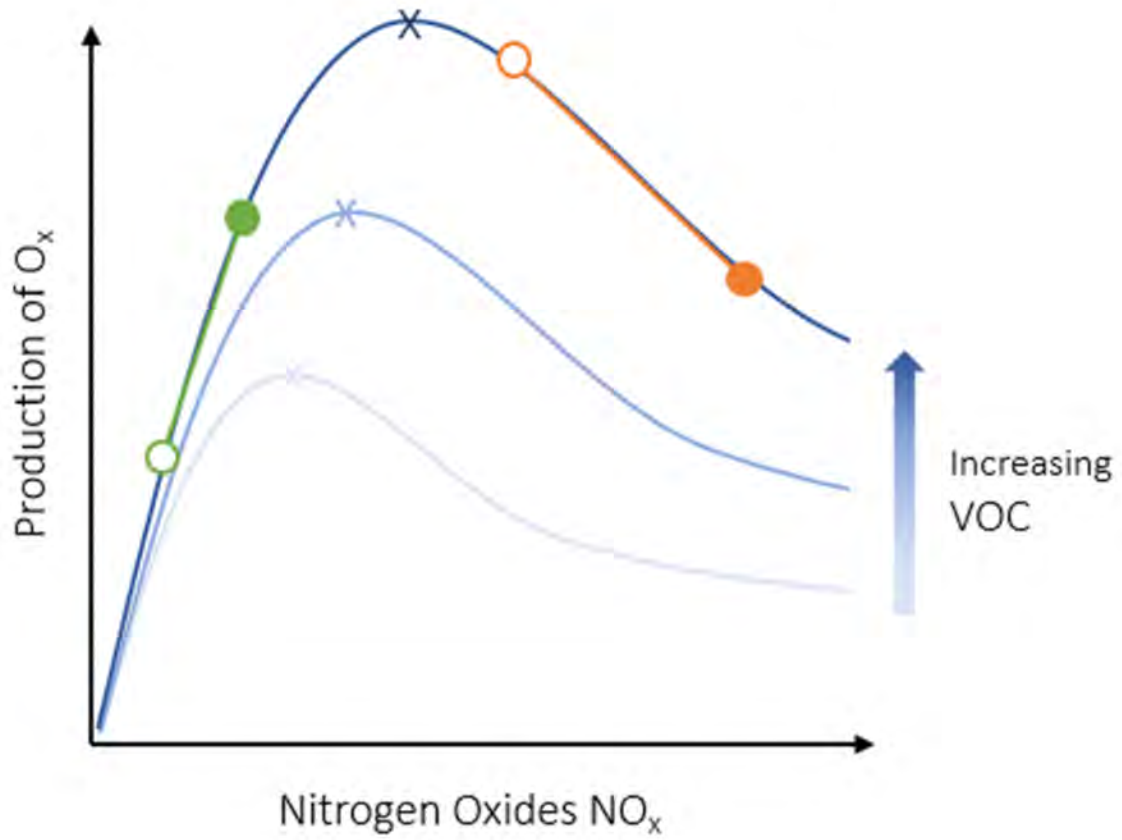
Does it matter?: PHOx





Higher PHOx and possible higher fraction of PHOx from HCHO with elevated HCHO

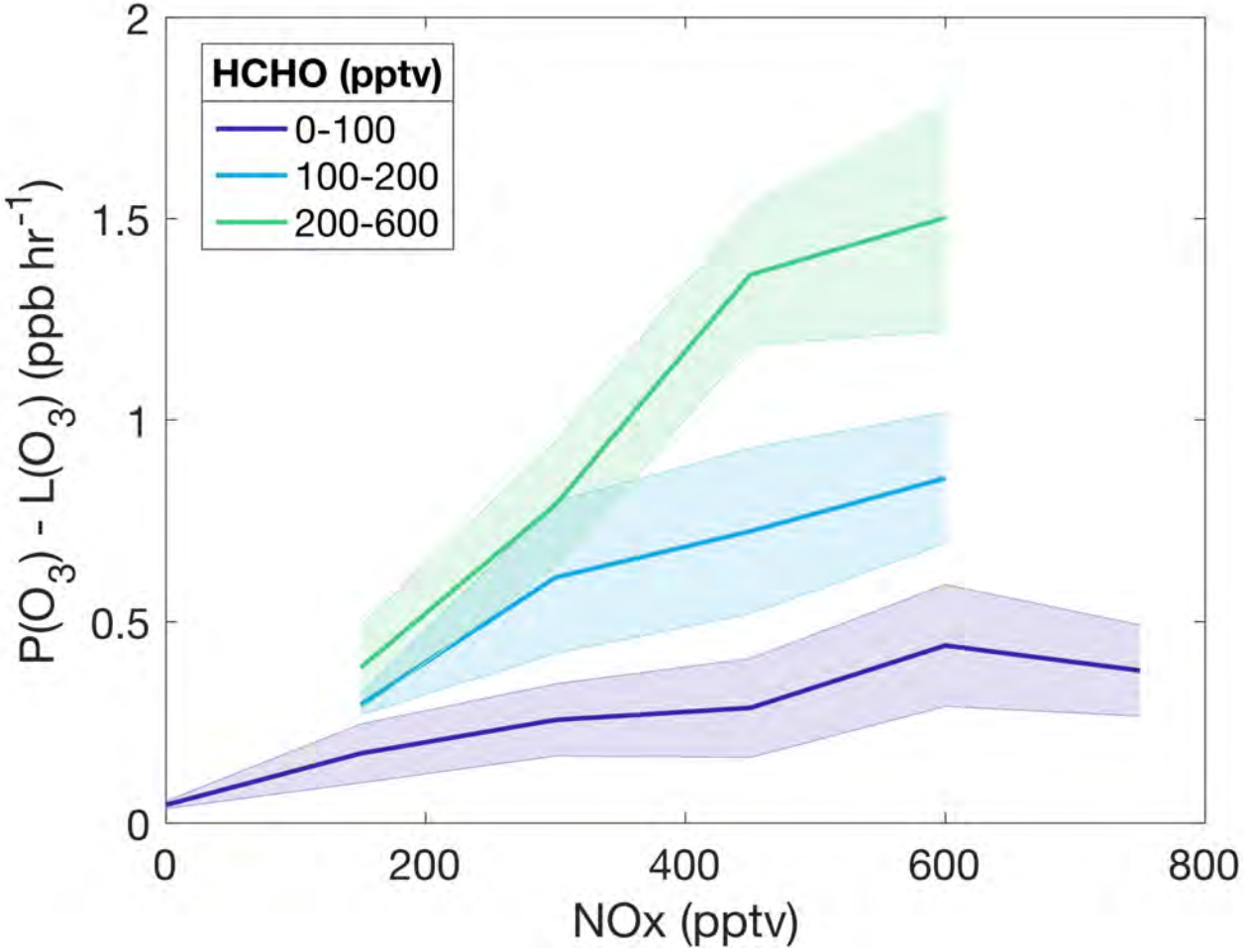
Does it matter?: PO_3



$$P(O_3) = k_{NO+HO_2} \times [HO_2] \times [NO] + k_{NO+R\ O_2} \times [R\ O_2][NO]$$

$$L(O_3) = k_{O_3+HO_2} \times [HO_2] \times [O_3] + k_{O_3+OH} \times [OH] \times [O_3] + \alpha_{O^1D} \times j\left(O^1D\right) \times [O_3]$$

Does it matter?: PO_3

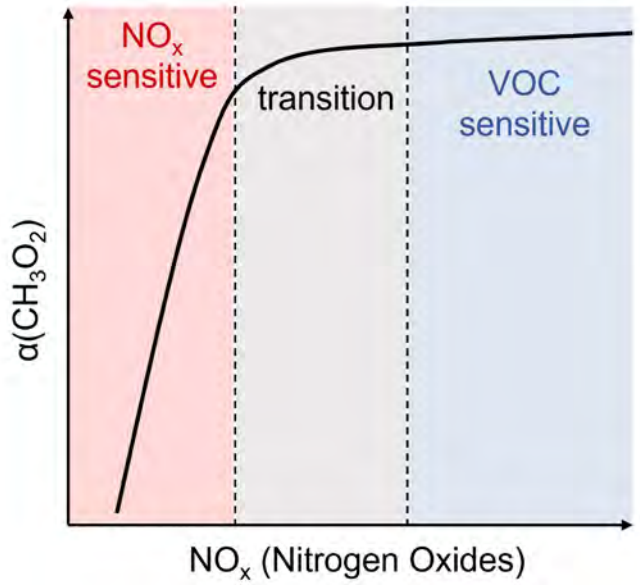


- For background HCHO concentrations, ozone production becomes NOx limited ~ 600 ppt
- Chemical regime shifts towards more NOx limited with increasing HCHO

$$P(O_3) = k_{NO+HO_2} \times [HO_2] \times [NO] \\ k_{NO+R\ O_2} \times [R\ O_2][NO]$$

$$L(O_3) = k_{O_3+HO_2} \times [HO_2] \times [O_3] \\ + k_{O_3+OH} \times [OH] \times [O_3] \\ + \alpha_{O^1D} \times j\left(O^1D\right) \times [O_3]$$

Does it matter?: $\alpha(CH_3O_2)$



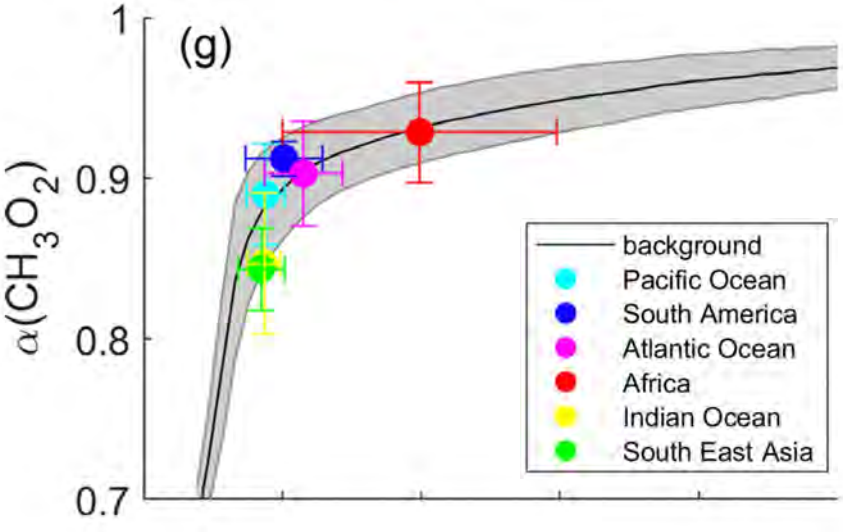
What controls ozone sensitivity in the upper tropical troposphere?

Clara M. Nussbaumer[1], Horst Fischer[1], Jos Lelieveld[1,2], and Andrea Pozzer[1,2]

[1]Department of Atmospheric Chemistry, Max Planck Institute for Chemistry, Mainz, Germany
[2]Climate and Atmosphere Research Center, The Cyprus Institute, Nicosia, Cyprus

$$\alpha_{CH_3O_2} = \frac{k_{CH_3O_2+NO} \times [NO] + k_{CH_3O_2+OH} \times [OH]}{k_{CH_3O_2+NO} \times [NO] + k_{CH_3O_2+OH} \times [OH] + k_{CH_3O_2+HO_2} \times [HO_2]}$$

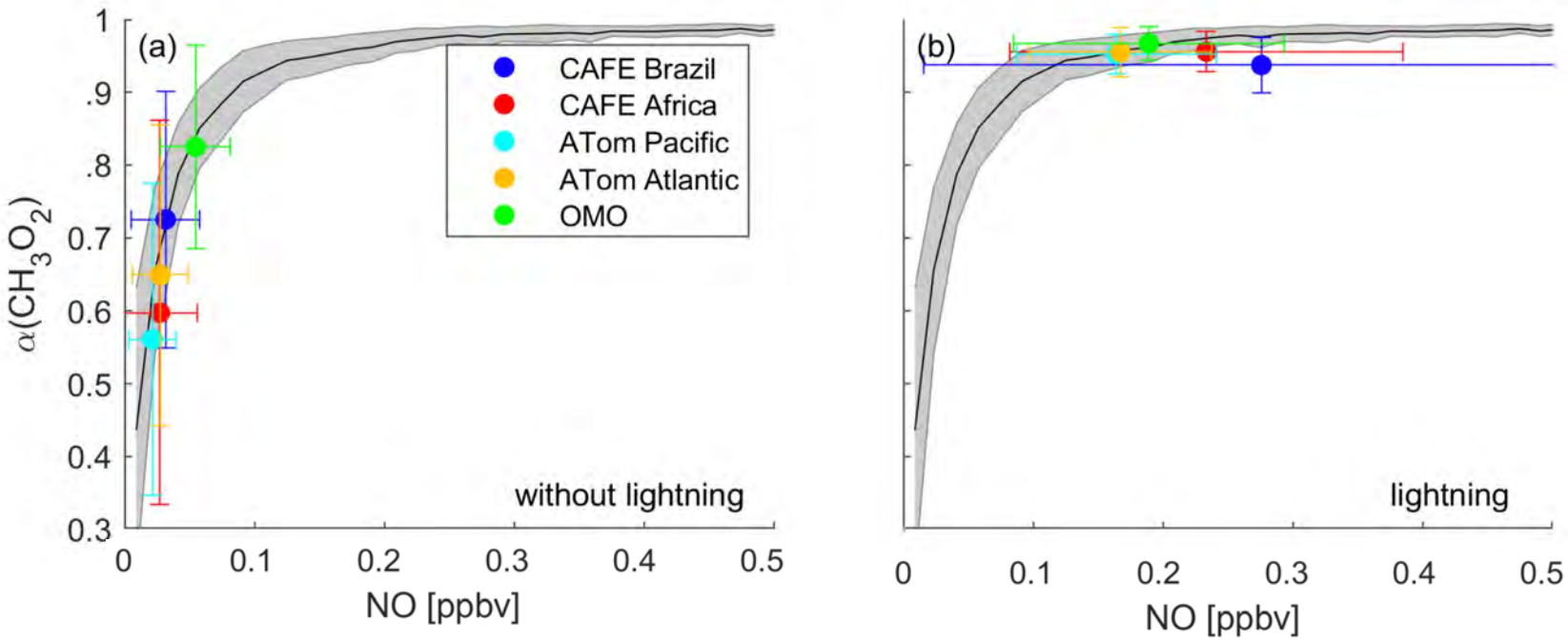
Fraction of CH_3O_2 that forms HCHO



Does it matter?: $\alpha(CH_3O_2)$

O_3 formation sensitivity to precursors and lightning in the tropical troposphere based on airborne observations

Clara M. Nussbaumer[1], Matthias Kohl[1], Andrea Pozzer[1,2], Ivan Tadic[1], Roland Rohloff[1], Daniel Marno[1], Hartwig Harder[1], Helmut Ziereis[3], Andreas Zahn[4], Florian Obersteiner[4], Andreas Hofzumahaus[5], Hendrik Fuchs[5], Christopher Künstler[5], William H. Brune[6], Tom B. Ryerson[7], Jeff Peischl[8,9], Chelsea R. Thompson[8], Ilann Bourgeois[8,9,a], Jos Lelieveld[1,2]and Horst Fischer[1]



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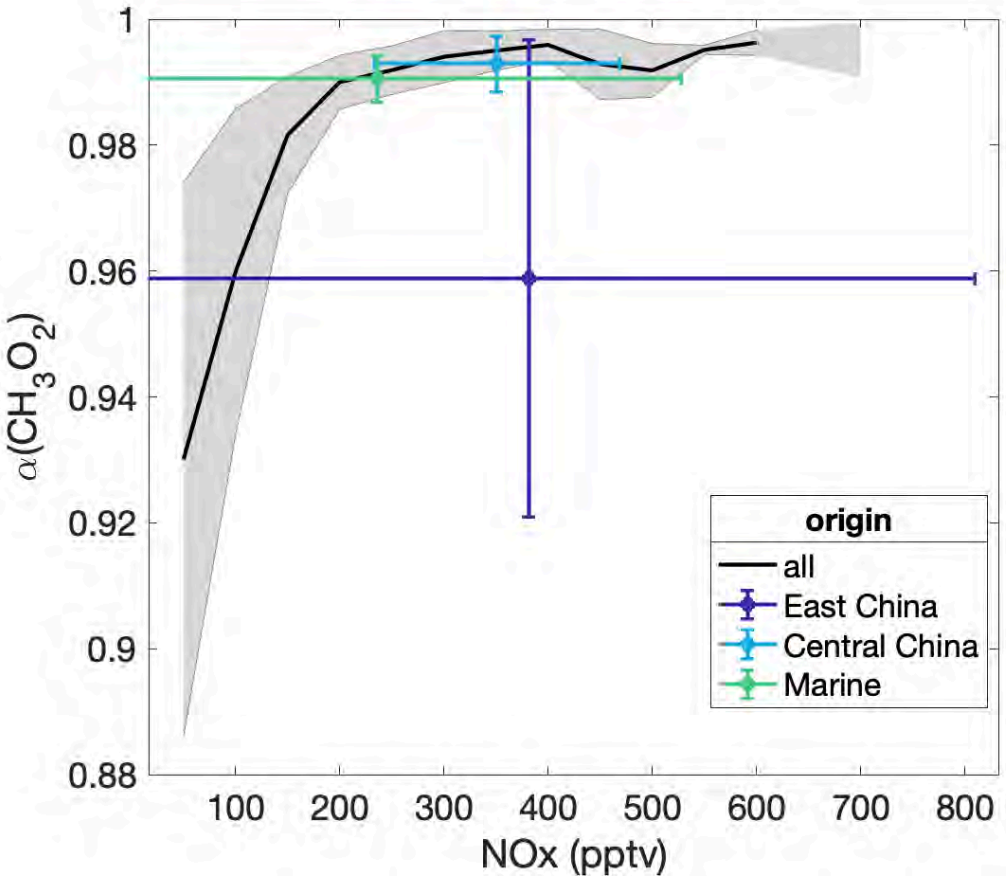
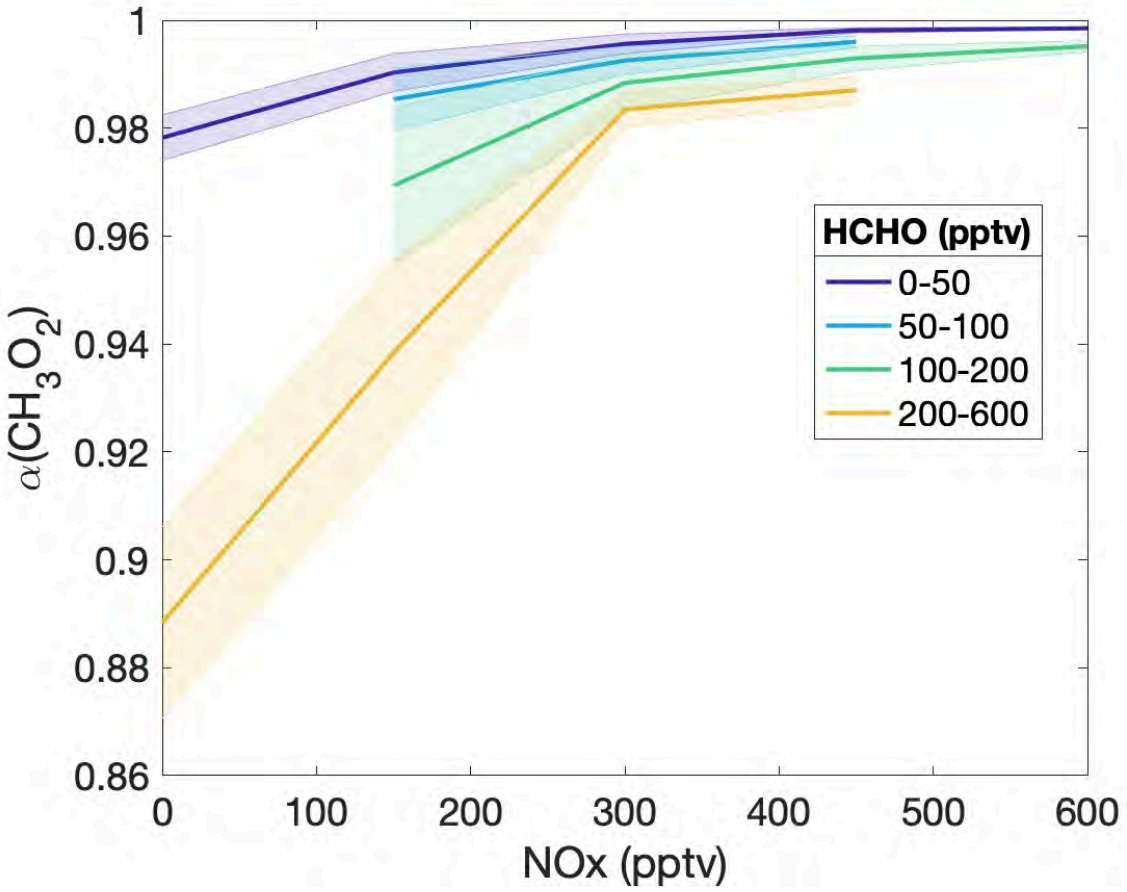
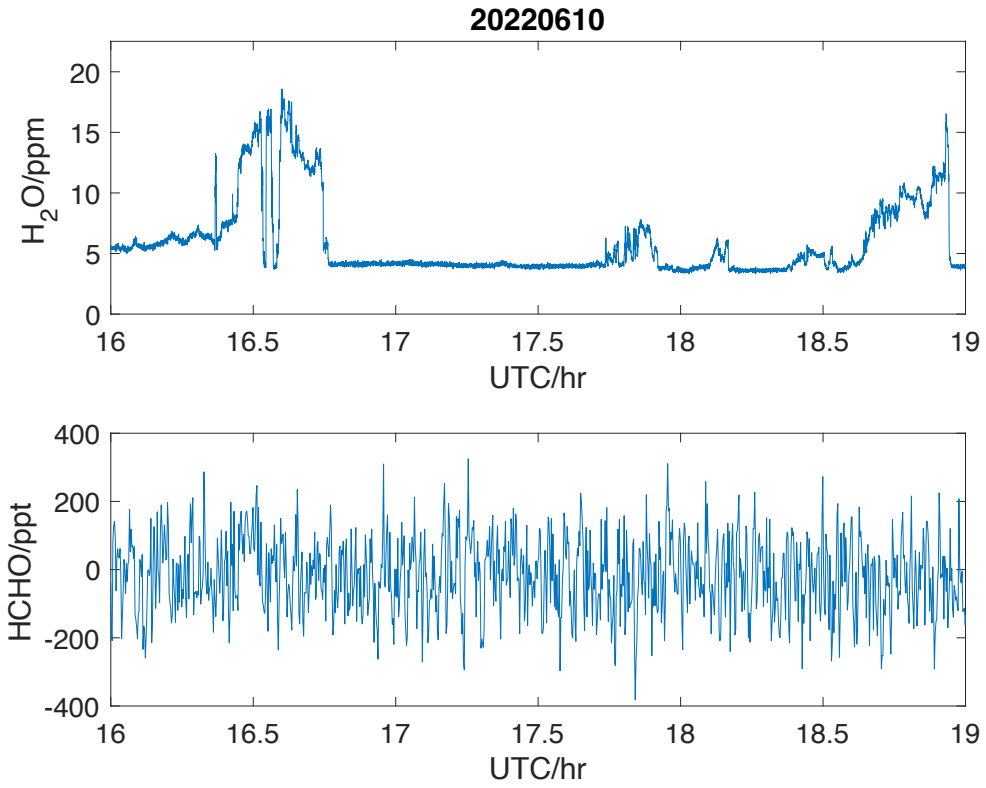




~~Conclusions~~ Questions?

- HCHO seems to be a good indicator of very recent convective influence in the UT
  - How is what was observed during ACCLIP different (or not) than other regions and observations of deep convection
  - How important is this for the chemistry of the UT?
  - Could this affect satellite retrievals of HCHO in a similar manner that lightning NOx affects NO_2 retrievals?

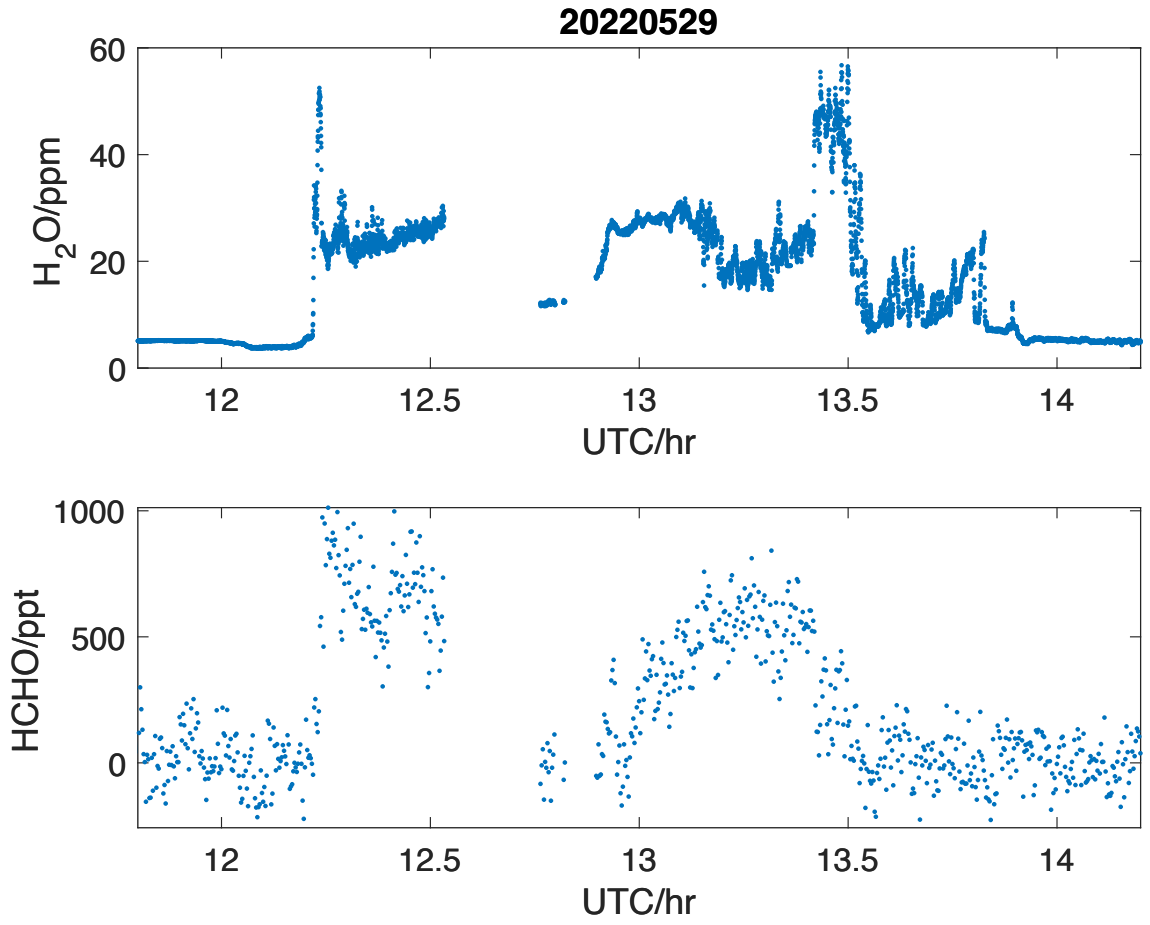
DCOTSS: elevated H_2O with no HCHO



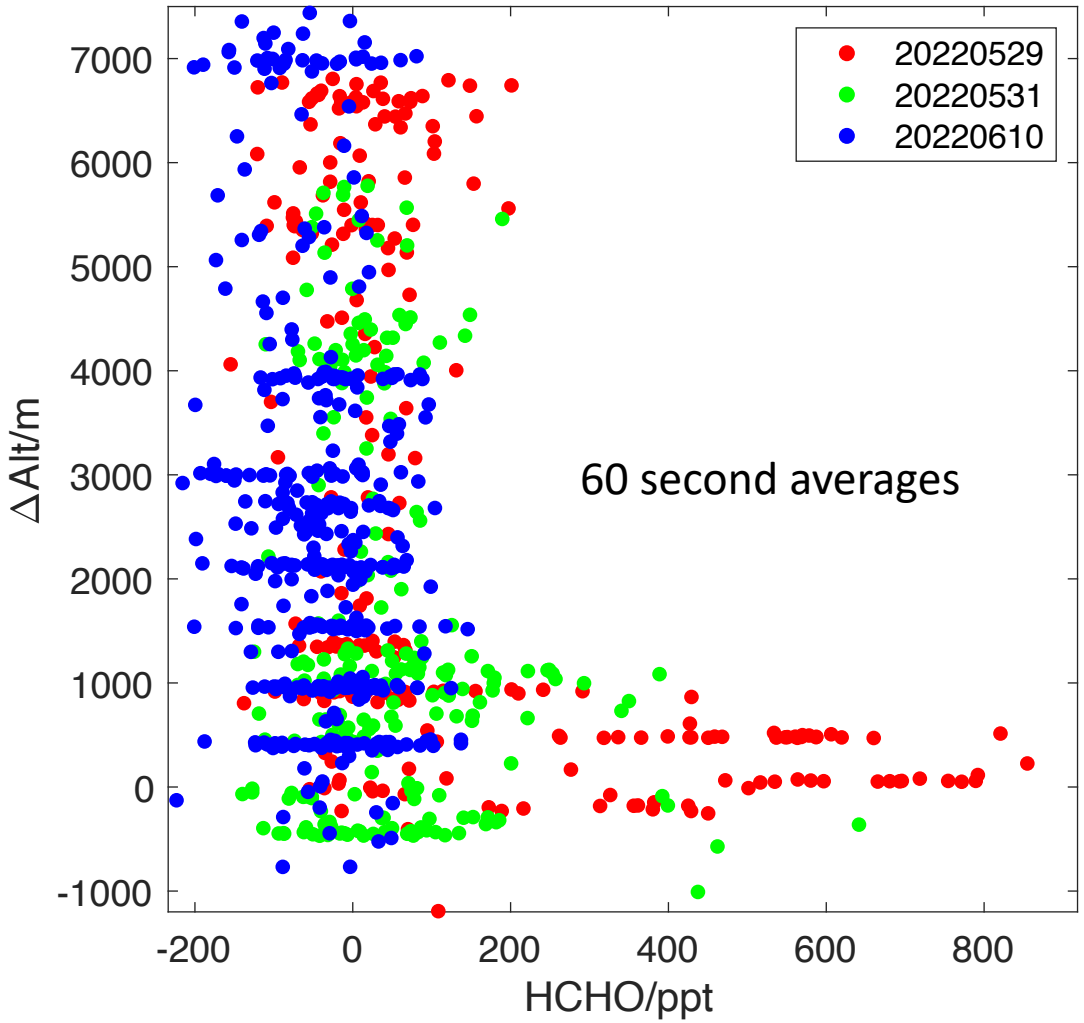
- This was the case for all of 2021 DCOTSS and most of 2022 DCOTSS
- no tropospheric tracers in old air parcels high in stratosphere
  - DCOTSS focused on overshooting tops: we saw elevated water vapor, but fewer cases of enhanced tropospheric tracers.
  - ACCLIP wasn't focused on overshooting tops, sampled more outflow.

DCOTSS: elevated H_2O with elevated HCHO

- Several cases of large HCHO enhancements during DCOTSS 2022: most notably 5/29 and 5/31
  - sampled elevated tropospheric tracers in storm outflow
  - HCHO elevation only detectable for very recent convection (several hours)



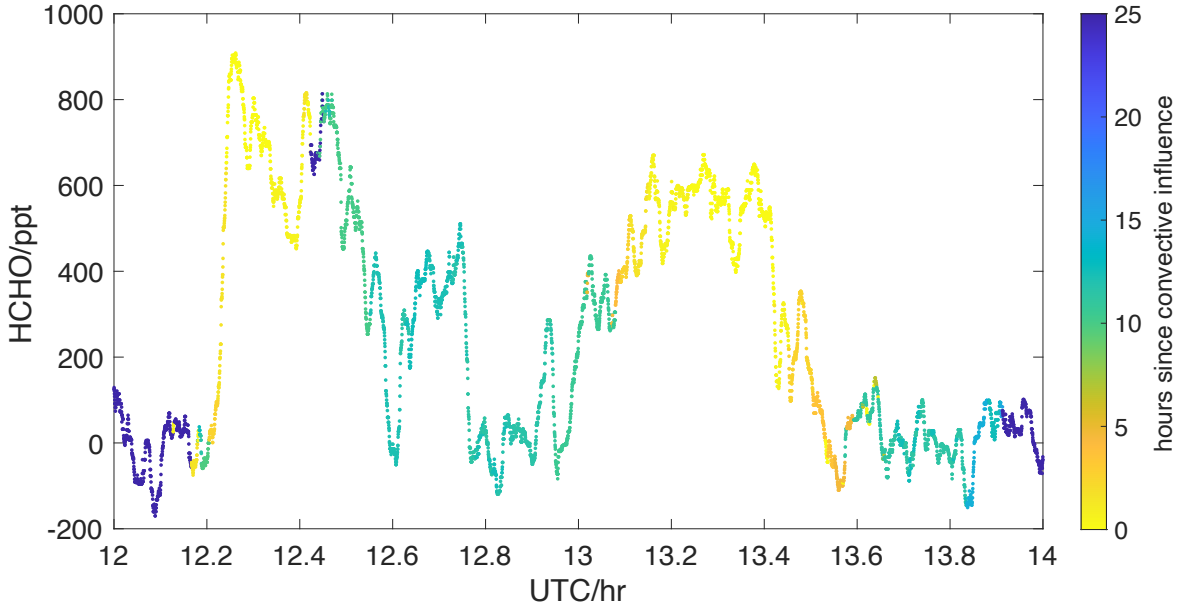
DCOTSS: elevated H_2O with elevated HCHO

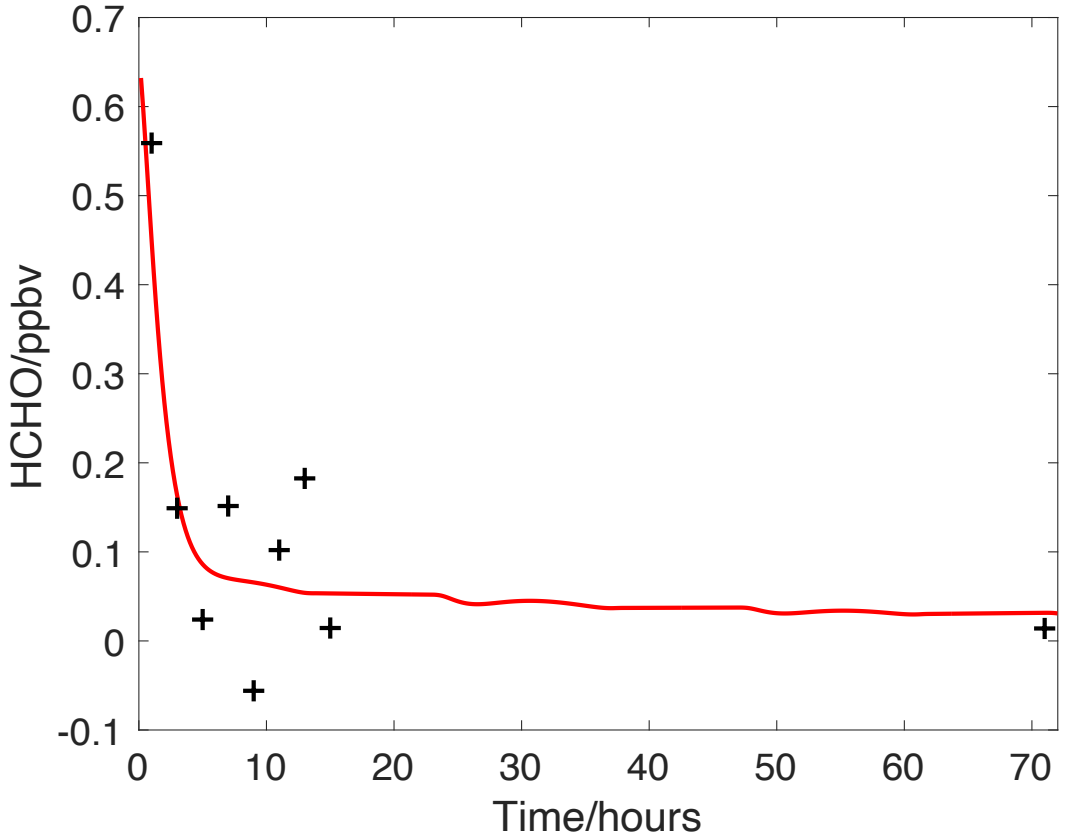


- Most flights like 6.10.22 (~0 in UT/LS)
- 5.29.22 and 5.31.22 elevated HCHO up to 1 ppb observed just at and above predicted tropopause.

Recent Convection on 20220529

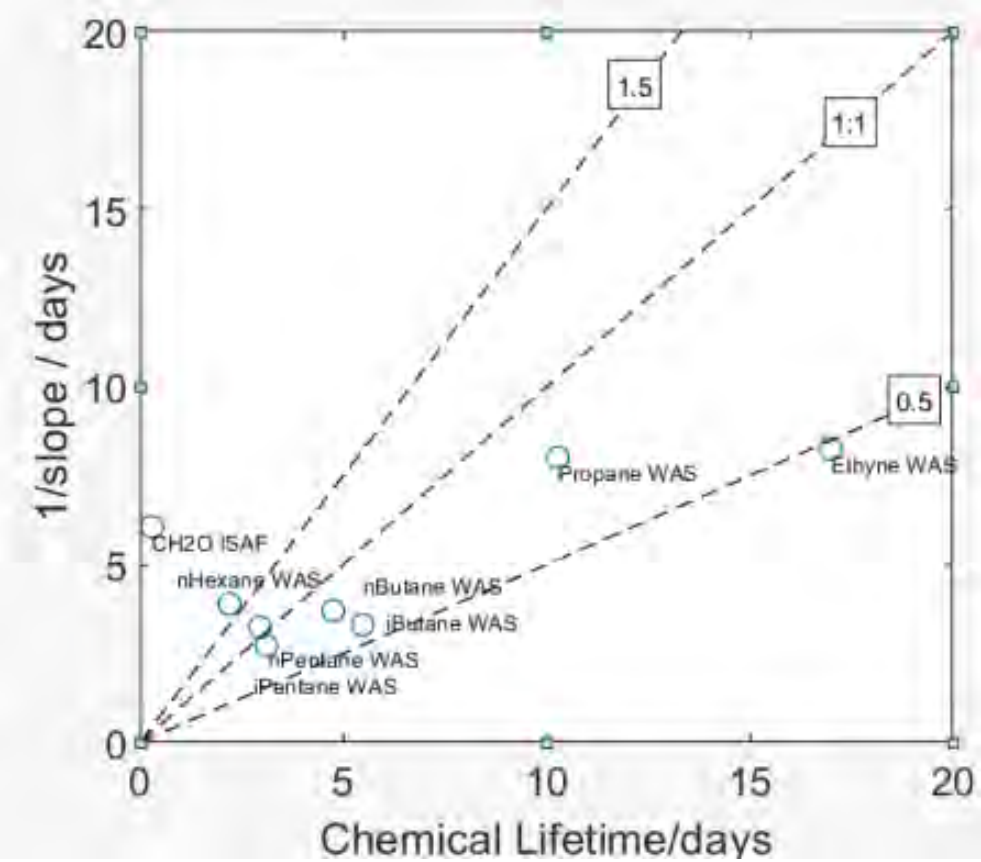
- estimate of last overshooting convective influence






Questions?

Where did it come from?: “missing” source?



L(HCHO) = (k[OH] + J)*[HCHO] = k'*[HCHO]
Assume steady state, then P = L