ACE-FTS observations of short-lived reactive species in the UTLS

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[1]ACOM/NCAR and [2]ACE-FTS Science Team

Workshop on Dynamics, Transport and Chemistry of the UTLS Asian Monsoon
March 7-10, 2016, NCAR Foothills Laboratory

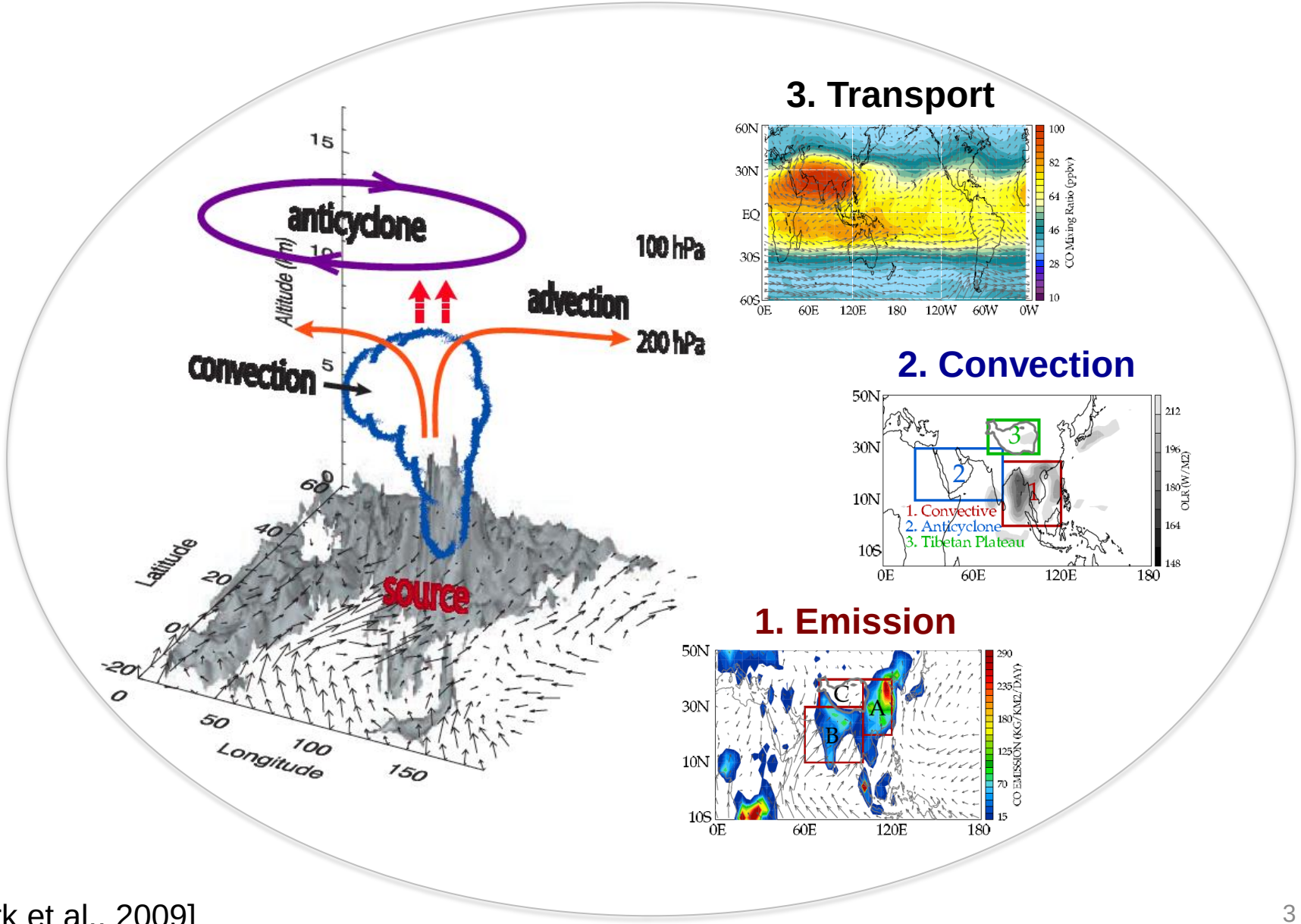
Key Questions

1. **Behavior of short-lived species in the UTLS region measured by ACE-FTS.**

   - Influence of sources, convection and transport
   - Asian *vs*. North American monsoons

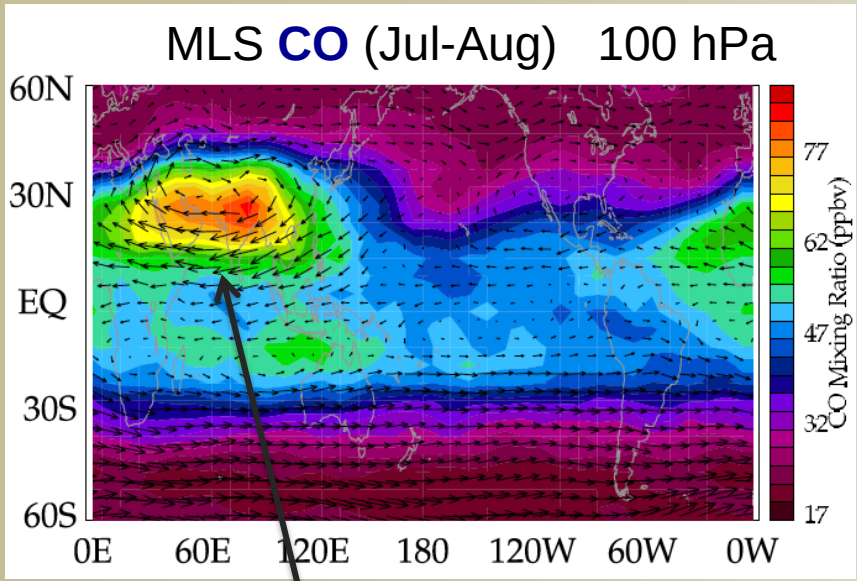
2. **Comparison of ACE-FTS measurements with *in-situ* measurements and global model outputs. How much can we believe ACE-FTS?**

Asian summer monsoon



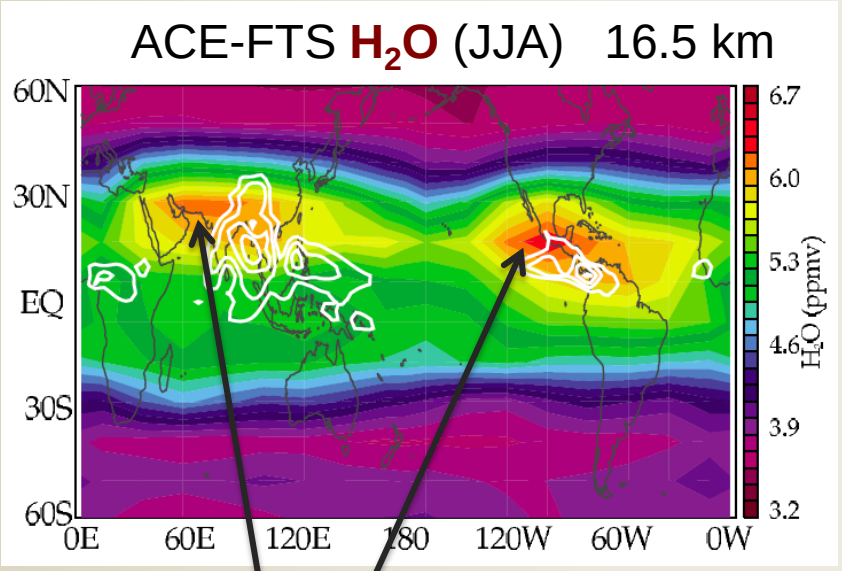
[Park et al., 2009]

Asian *vs.* N. American monsoons



[Park et al., 2007]

Asia **CO max**

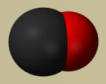
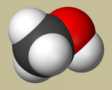
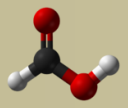


[Randel et al., 2012]

Asia **H_2O max** N. America

(white contours – convection)

OVOCs (Oxygenated VOCs)

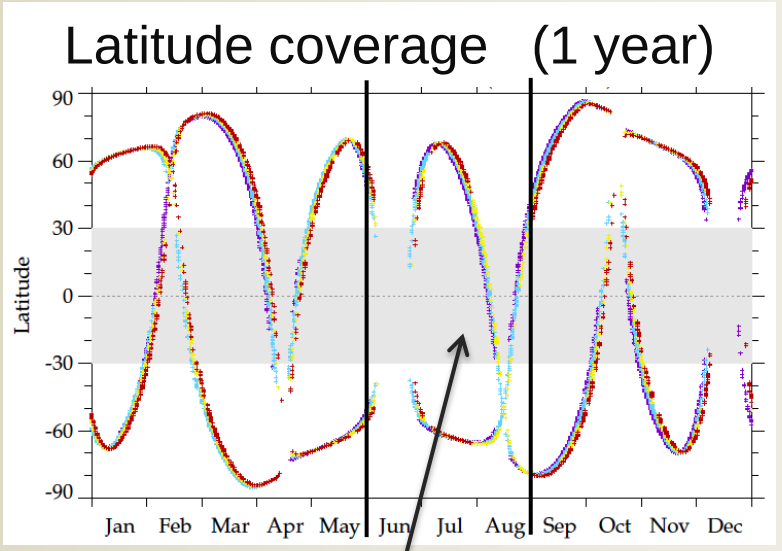
species	sources	sinks	lifetimes
 CO	BB, NMHCs	OH	2 months
 CH_3OH^*	BB, **Biogenic**	OH, dry/wet deposition	5-10 days
 HCOOH	BB, Biog, NMHCs		3-4 days
 H_2CO	BB, NMHCs	OH	< 2 days

CH_3OH (methanol)

- the most abundant non-methane VOC
- source of CO and H_2CO
- precursor of tropospheric O_3

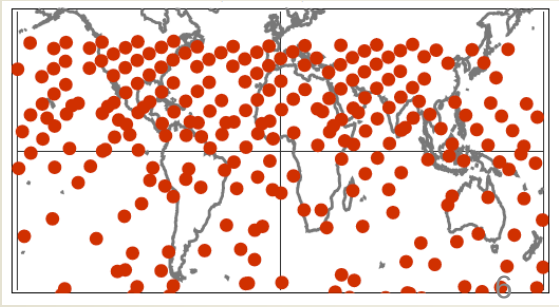
ACE-FTSv3.5 (2004-2013)

- Atmospheric Chemistry Experiment Fourier Transform Spectrometer (**ACE-FTS**) is a high spectral resolution infrared Fourier transform spectrometer on **SCISAT-1**
- **ACE-FTS** measures atmospheric absorption spectra (750-4400 cm^{-1}) using **solar occultation** technique
- CO, HCN, C_2H_6, C_2H_2, CH_3OH, HCOOH, H_2O_2, H_2CO, …



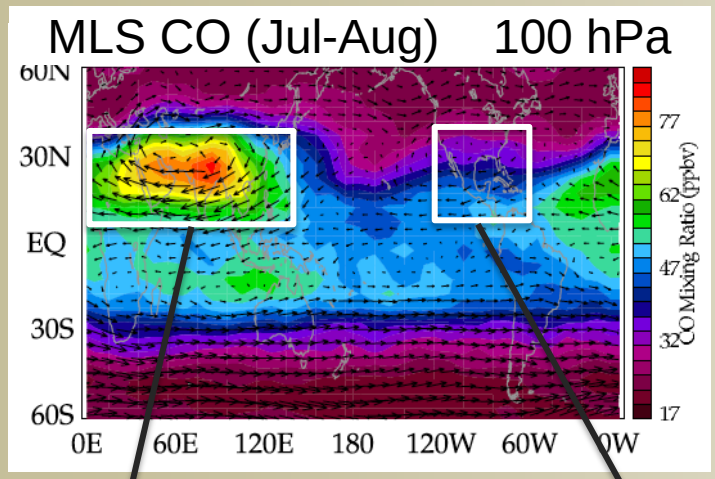
Tropical sampling during NH summer ~ Aug

Aug 2012

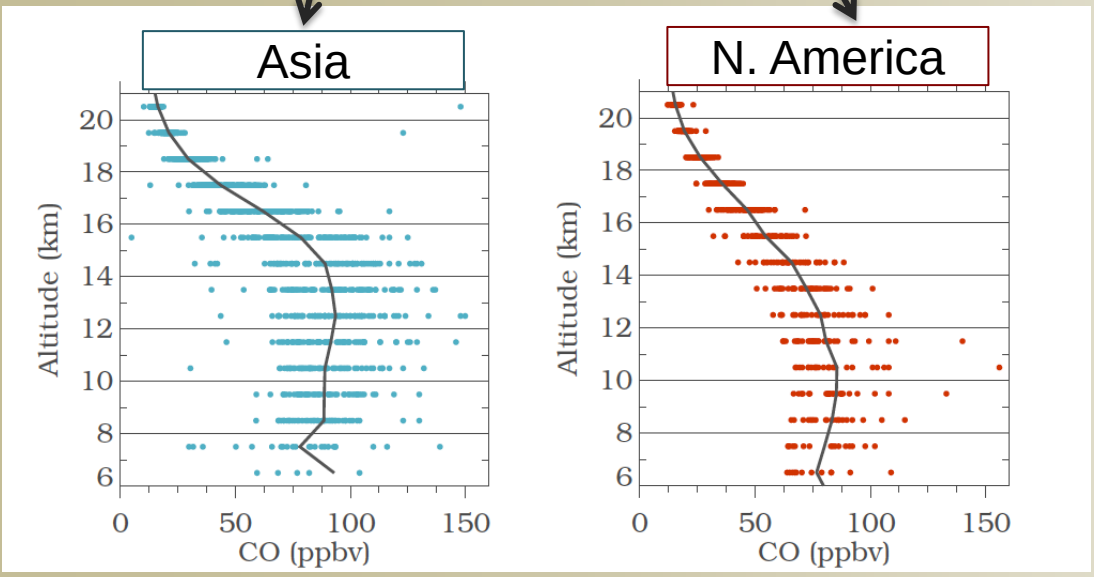


CO - Vertical Structures

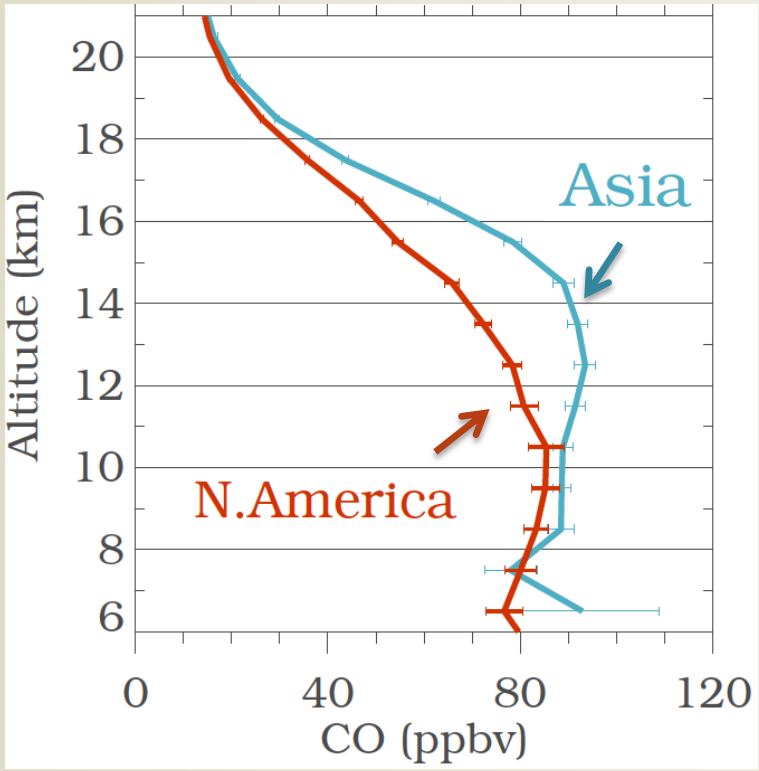
ACE-FTS CO averaged over Asia *vs*. N. America



(Park et al., 2007)

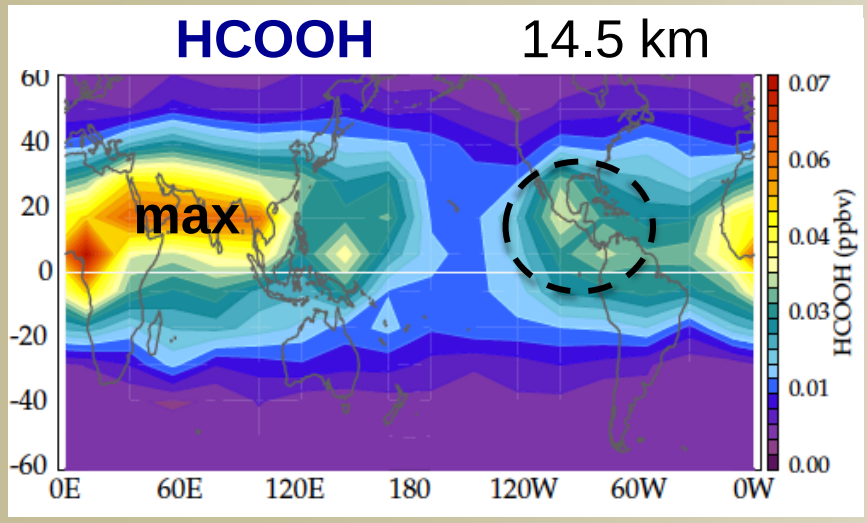


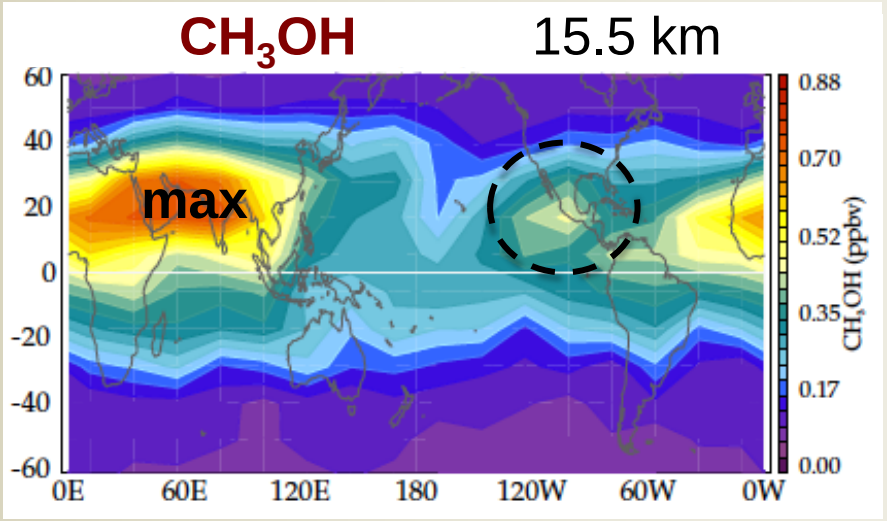
CO enhancement : **12-17 km**
(Asian monsoon)

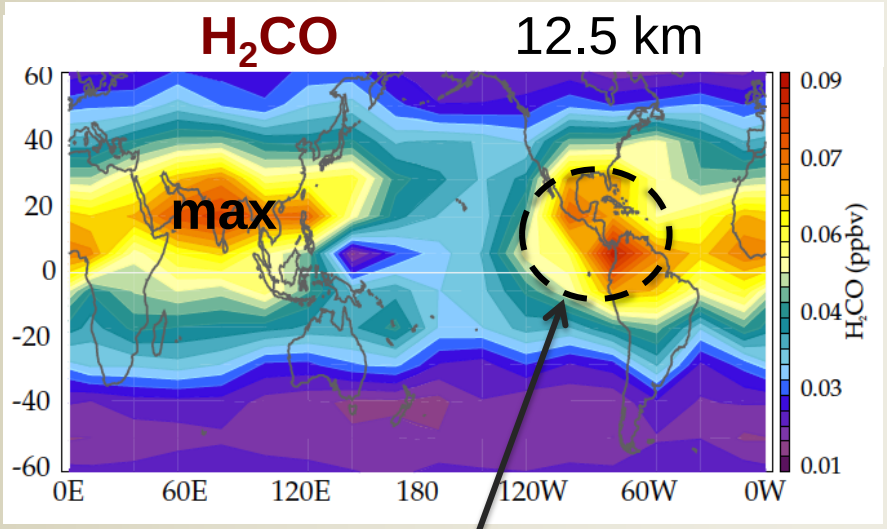


ACE-FTS – Lon *vs.* Lat (JJA)

short-lived species





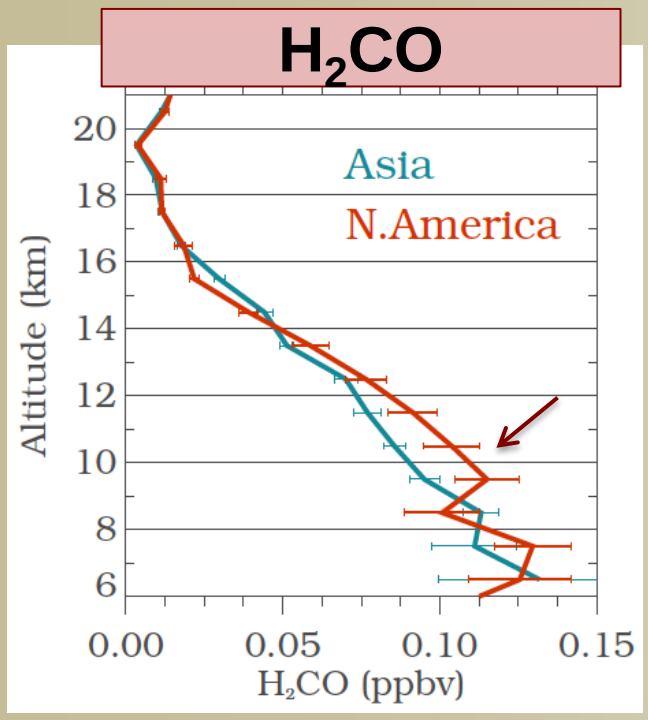


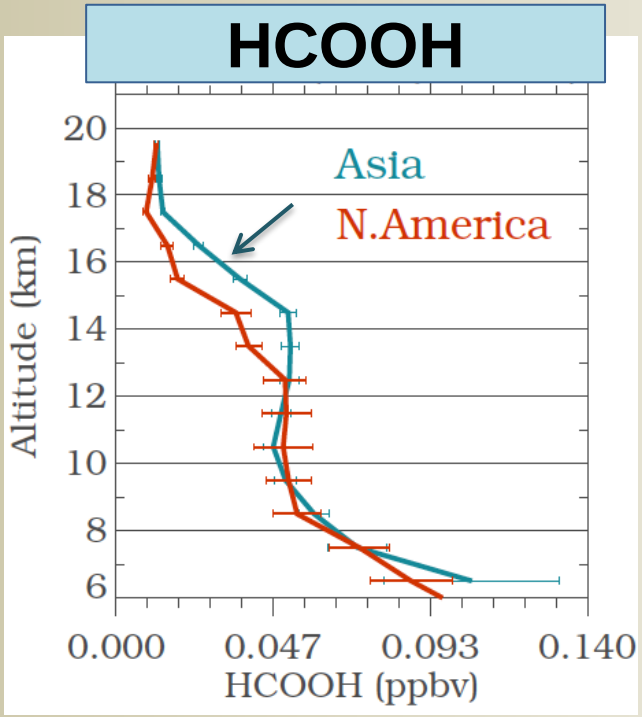
Max over **Asian** monsoon

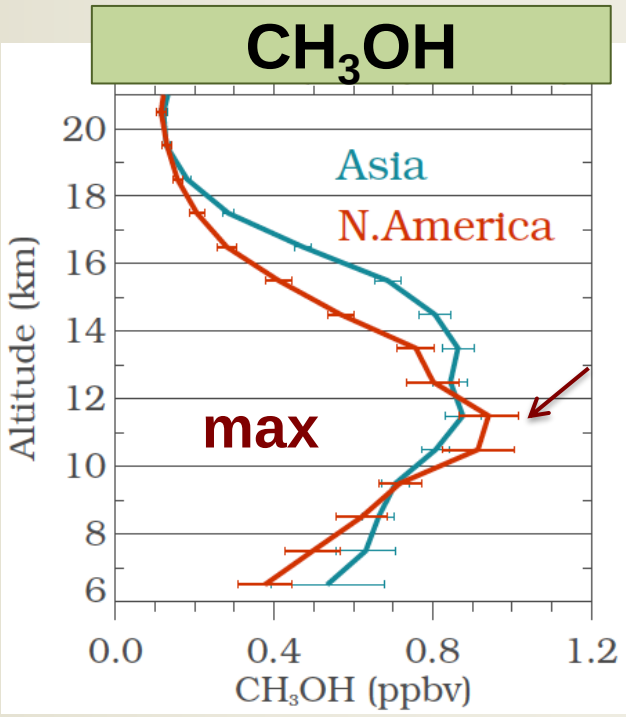
Enhancement over **N. American** monsoon

ACE-FTS - Average Profiles

Asian *vs.* N. American Monsoons







τ< 2 days

τ = 3-4 days

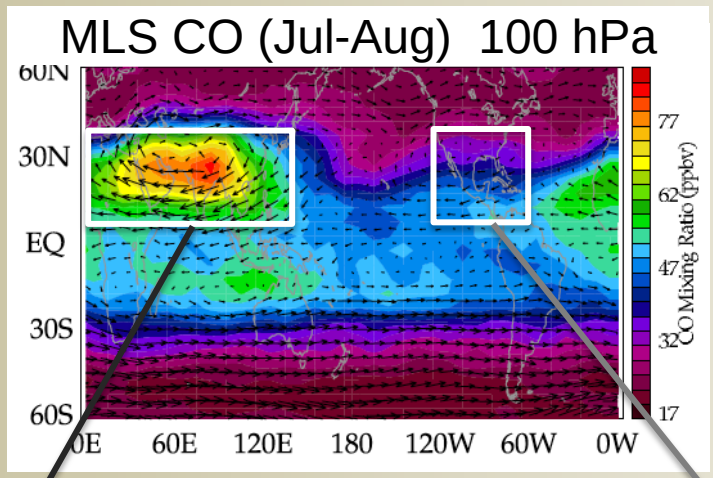
τ = 5-10 days

CH_3OH enhancement over N. America (**10-12 km**)

→ Do we understand this?

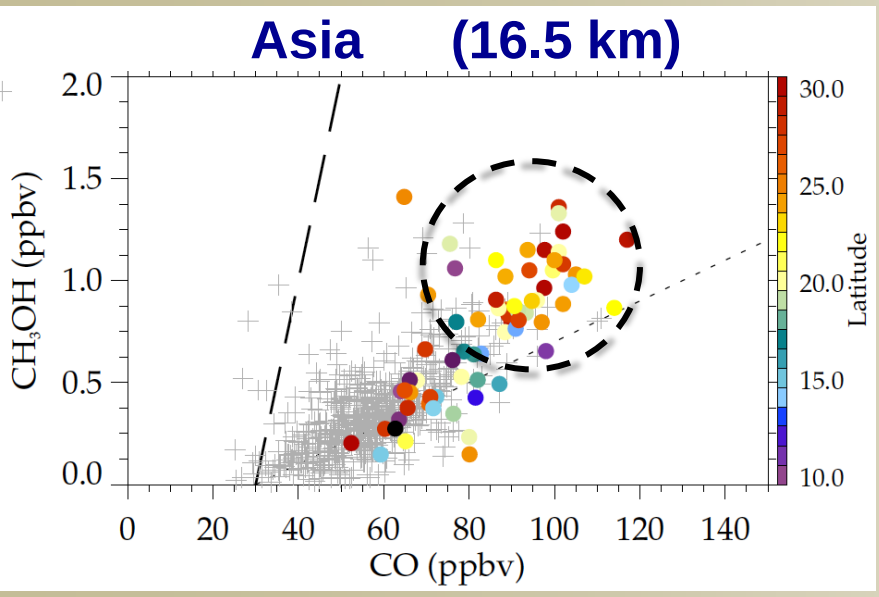
CO *vs.* CH_3OH (JJA)

Asia
- high CH_3OH
- high CO

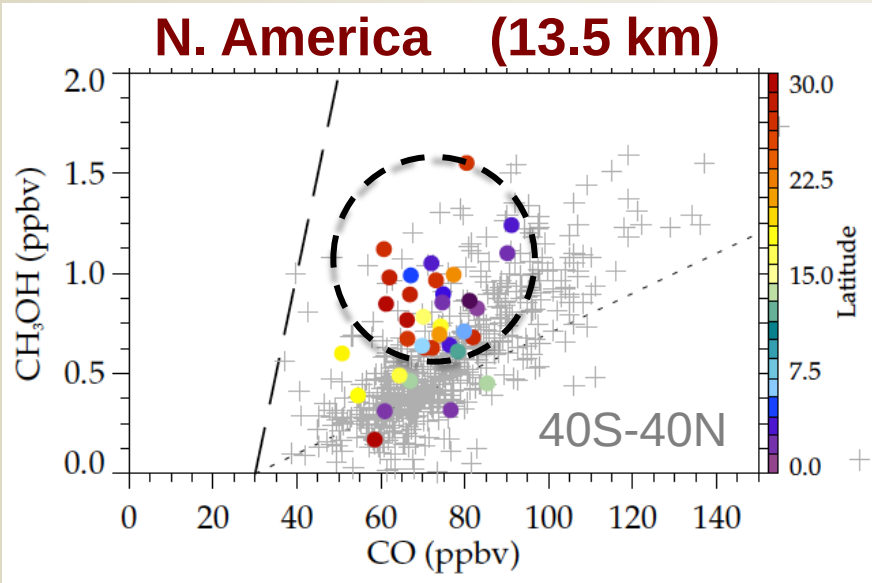


[Park et al., 2007]

N. America
- high CH_3OH



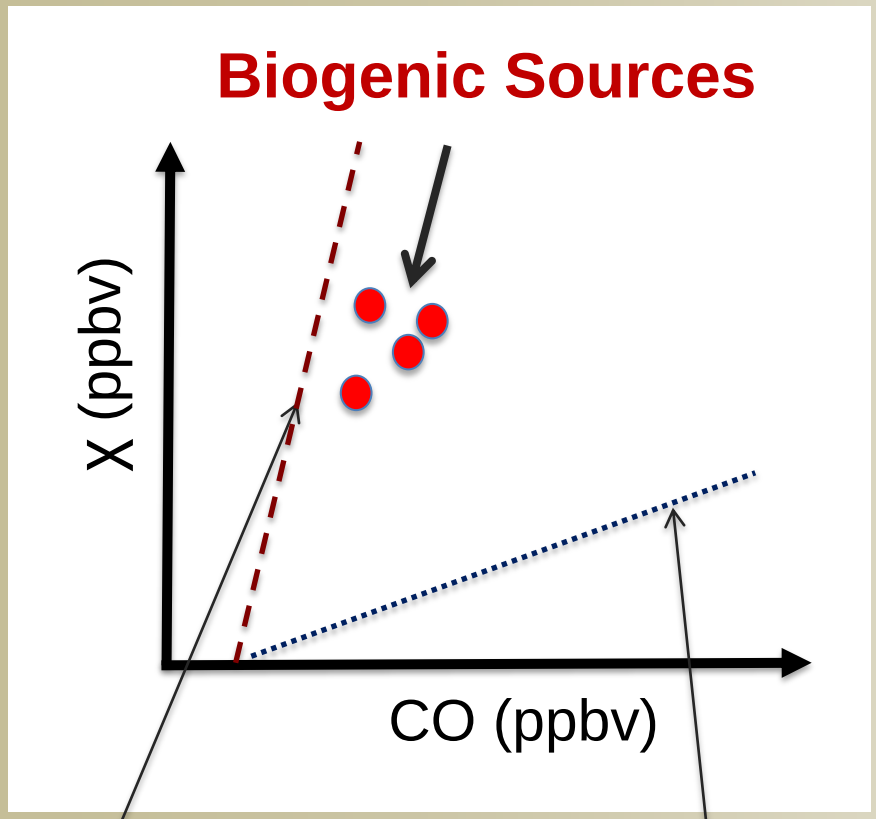
Color: latitude

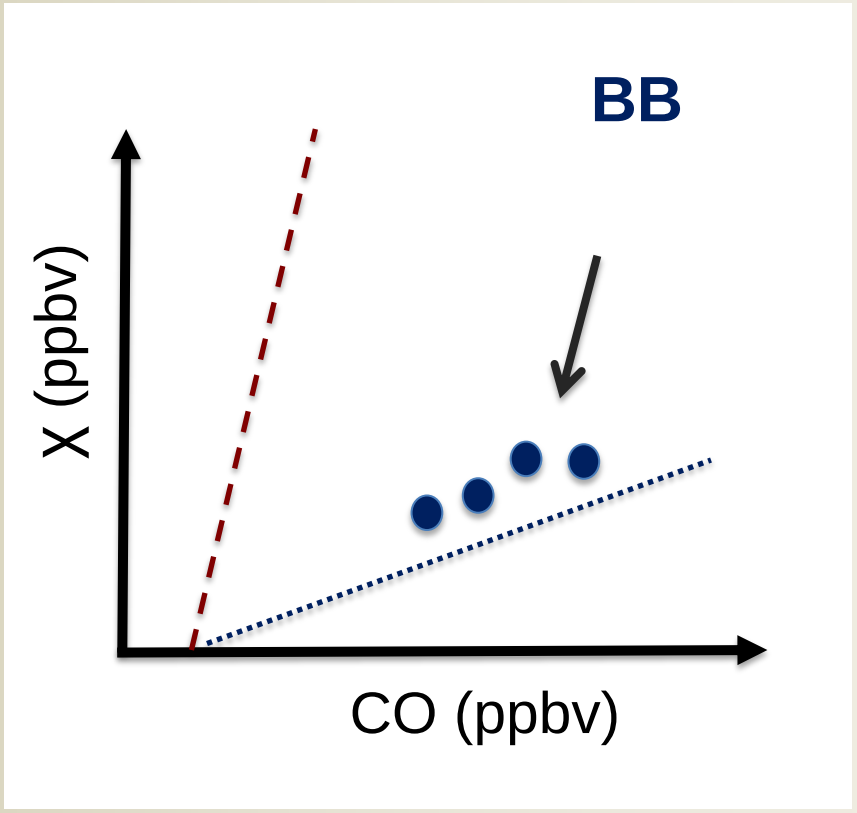


High CO/High CH_3OH

High CH_3OH

Identifying Sources





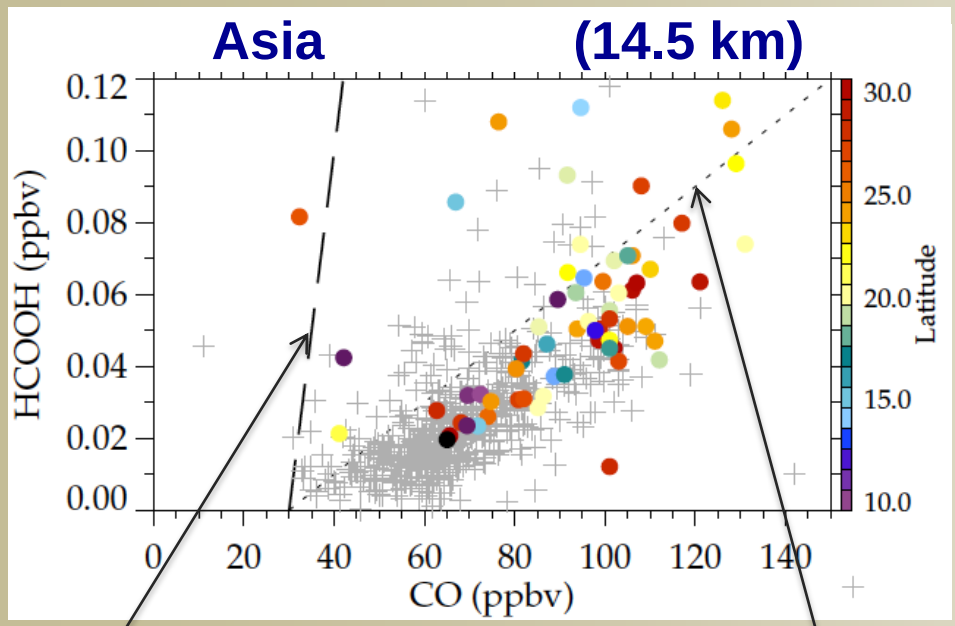
$\Delta\chi/\Delta CO = 0.1$

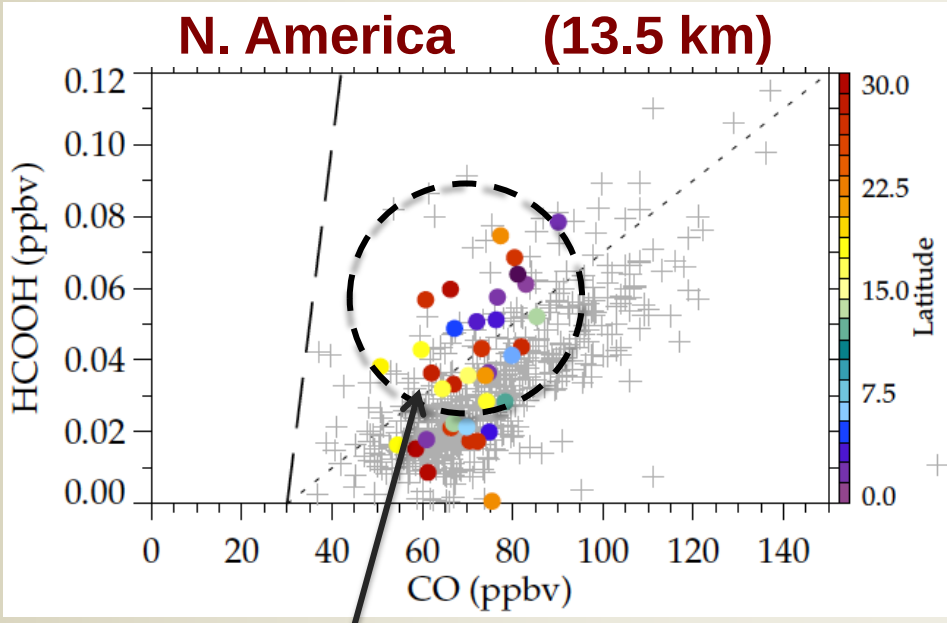
$\Delta\chi/\Delta CO = 0.001$

CO – no biogenic sources
Large increase in χ

CO – large BB sources
Linear correlation with χ
(Example – C_2H_2)

CO *vs.* HCOOH (JJA)





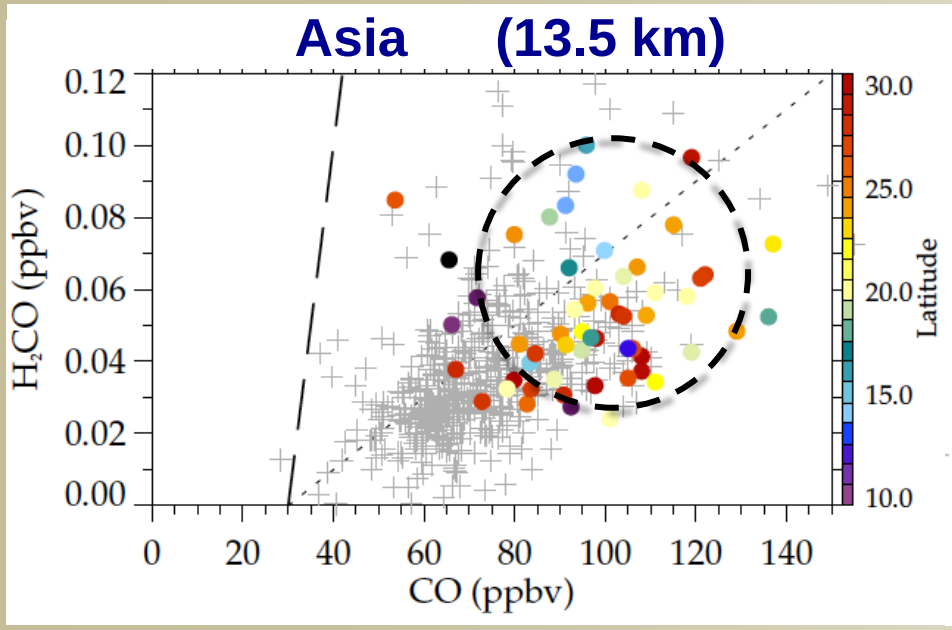
$\Delta\chi/\Delta CO = 0.1$

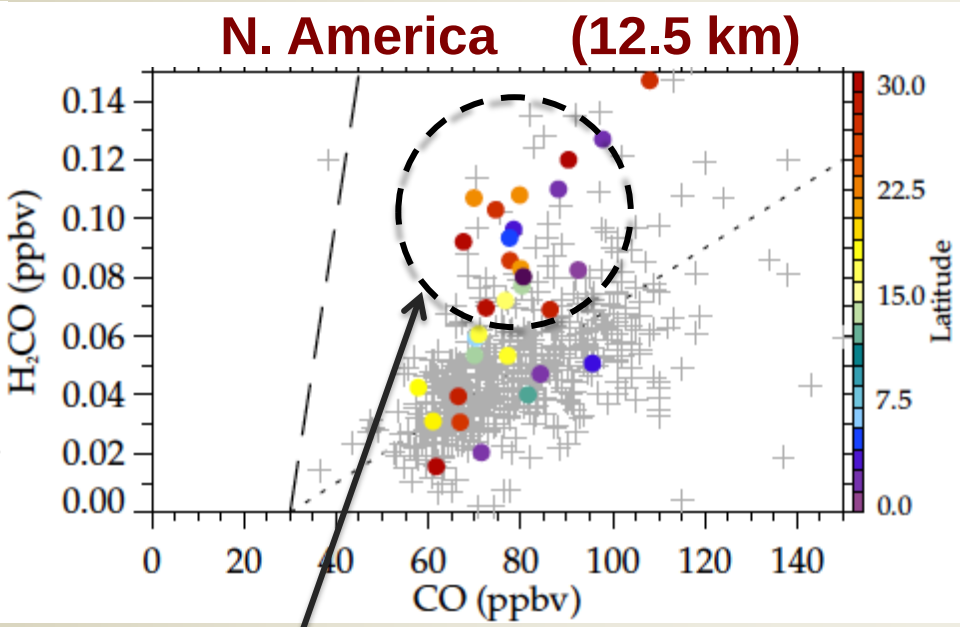
$\Delta\chi/\Delta CO = 0.001$

High **CO**/High **HCOOH**
(BB + transport)

HCOOH enhancement ~ 13.5 km
(similar to CH_3OH)

CO *vs.* H_2CO (JJA)





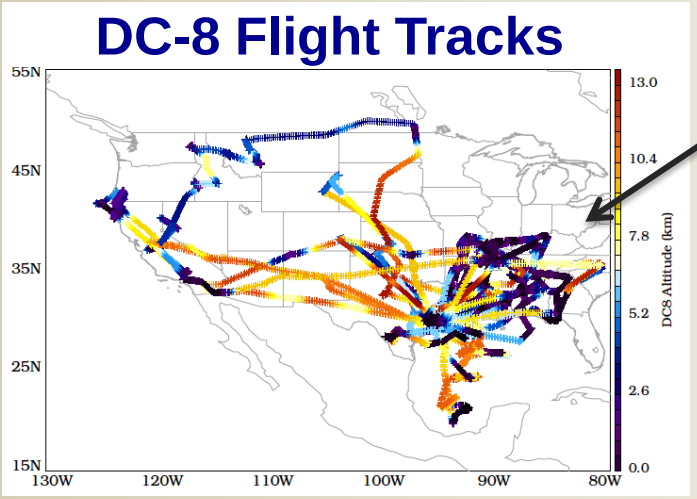
High **CO**/High **H_2CO**

H_2CO enhancement ~ 12.5 km
(similar to CH_3OH)

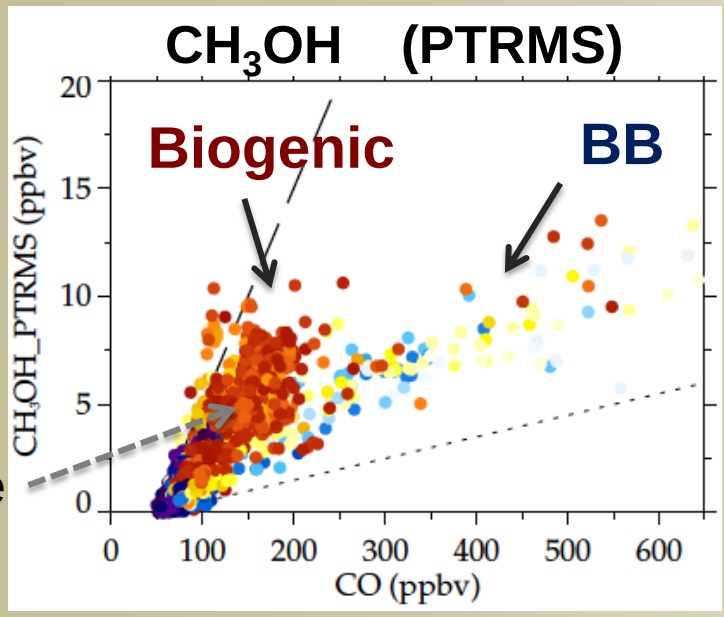
ACE-FTS *vs.* *In-situ* measurements

NASA SEAC⁴RS
(Aug-Sep 2013)

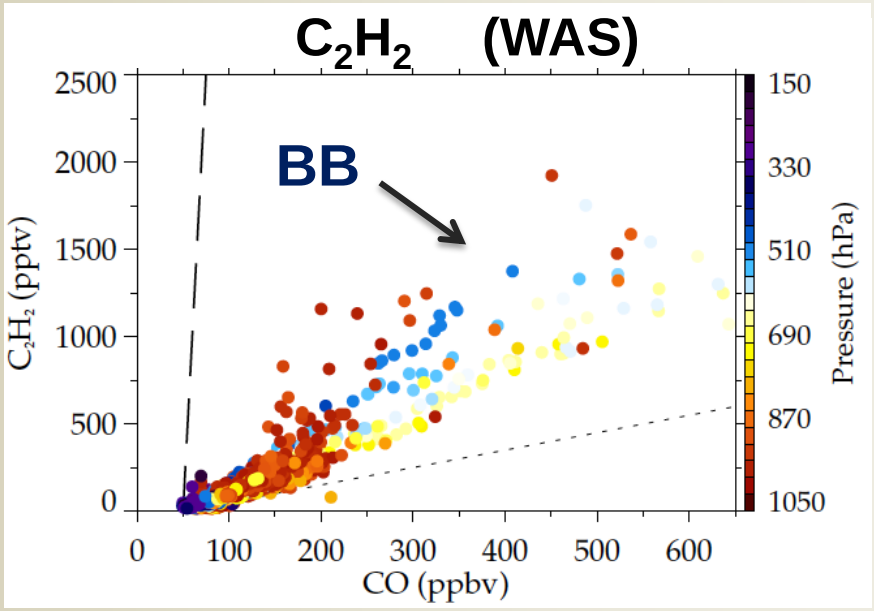
DC-8 measurements



N. America



surface



Color: pressure

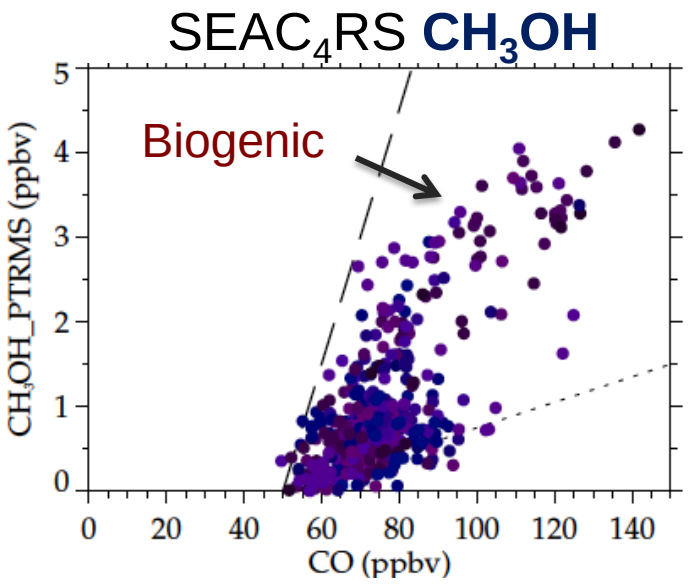
CH_3OH has a large **biogenic** sources over **N. America** in summer

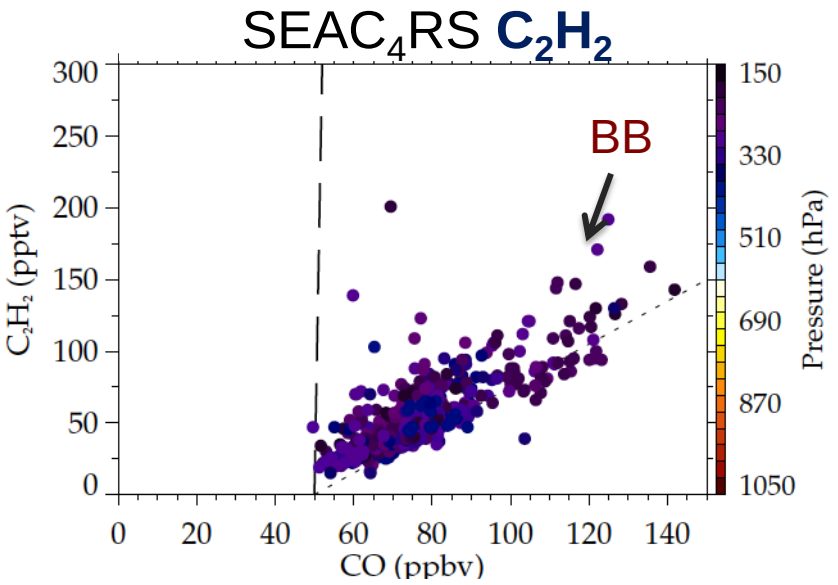
CO *vs.* CH_3OH & C_2H_2

SEAC⁴RS

Upper Trop.
(p < 400 hPa)

Aug 2013

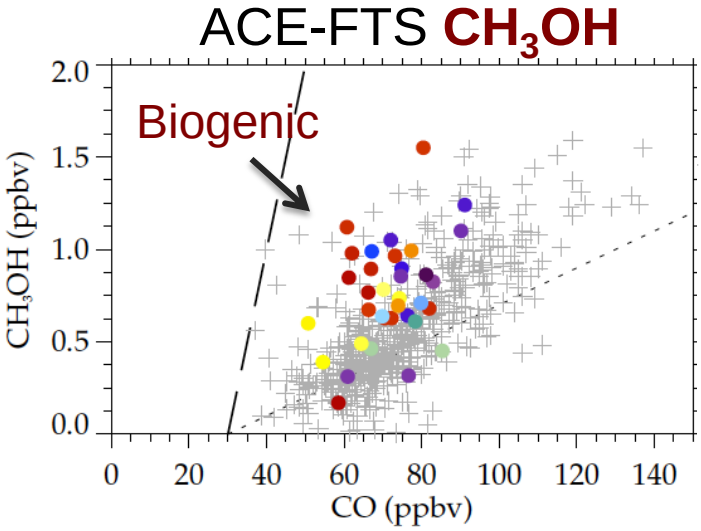


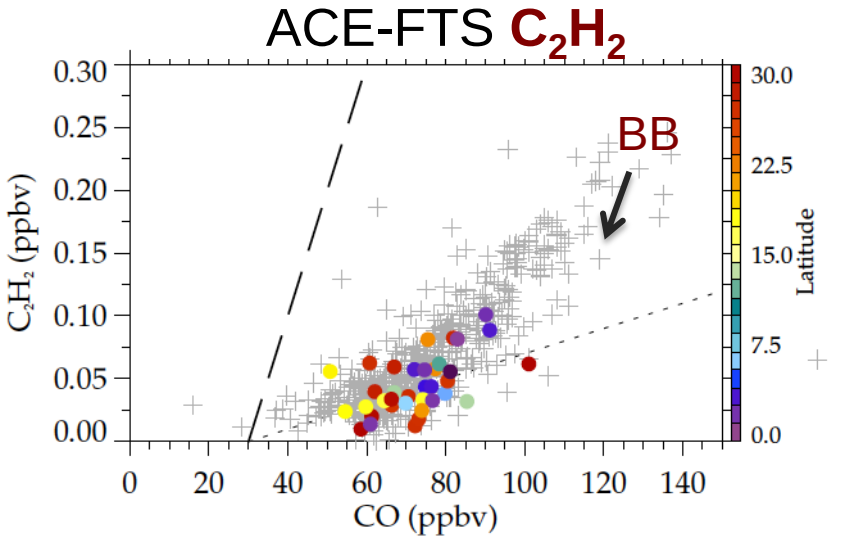


ACE-FTS

Upper Trop.
(13.5 km)

JJA (N. Am)

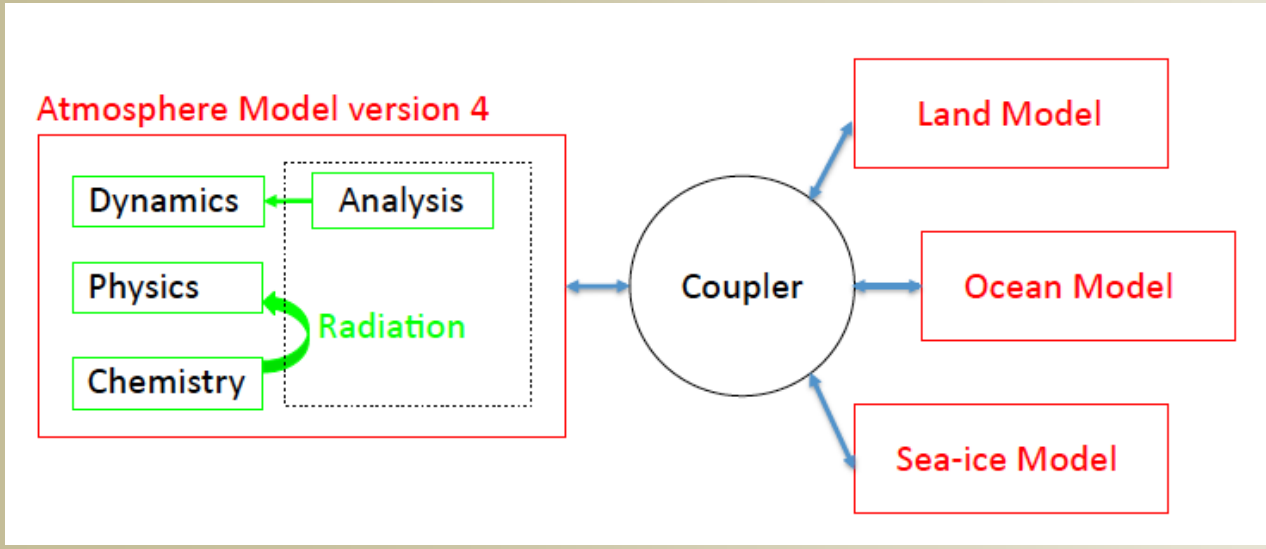




CAM-chem simulations (Aug 2013)

CAM-chem (Community Atmosphere Model with Chemistry) component of the NCAR Community Earth System Model (CESM) and is used for simulations of global tropospheric and stratospheric composition [Lamarque et al., 2012]

GEOS-5, resolution - 1.9° x 2.5°, 56 levels
FINN (v1.5) BB emission (1x1 km) [Wiedinmyer et al., 2011]
Dry deposition and biogenic emissions [CLM]



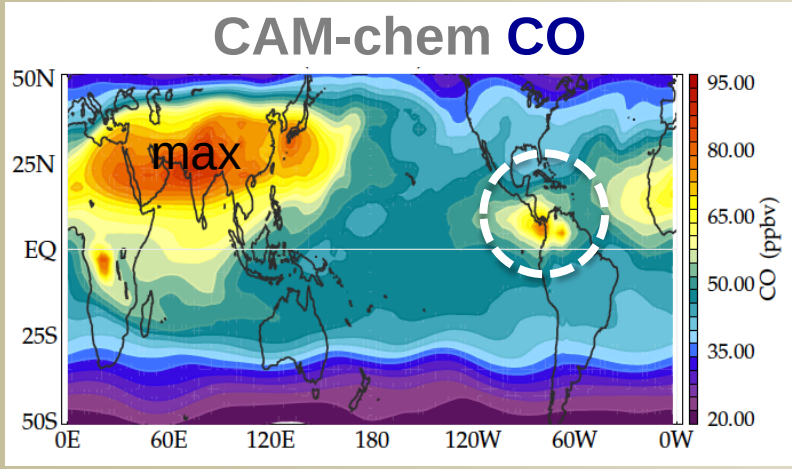
[Lamarque et al., 2012]

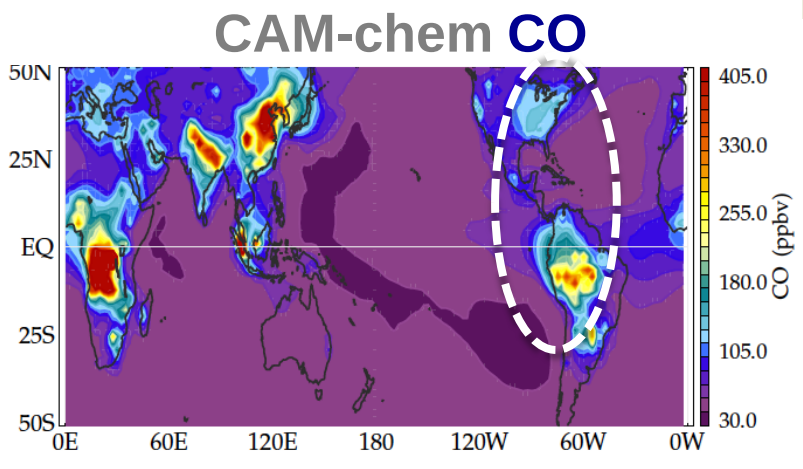
CAM-chem (Aug 2013)

150 hPa

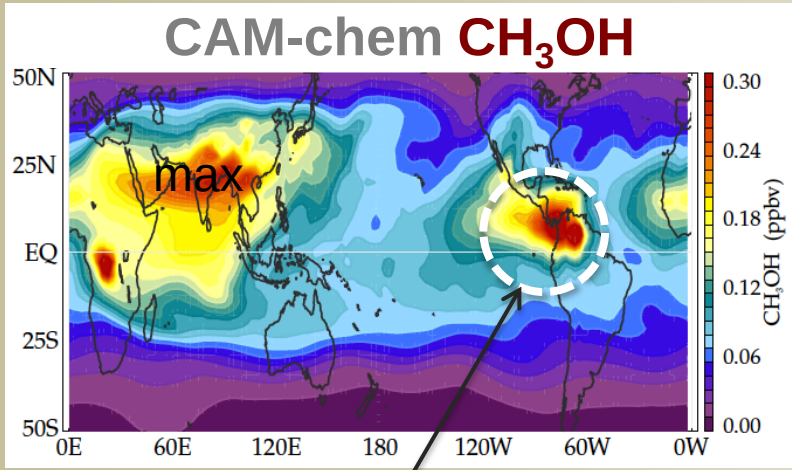
surface

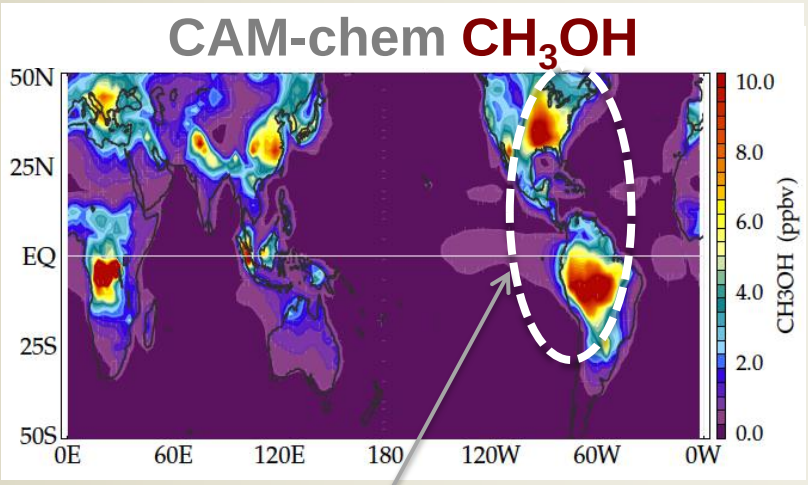
CO





CH_3OH





max

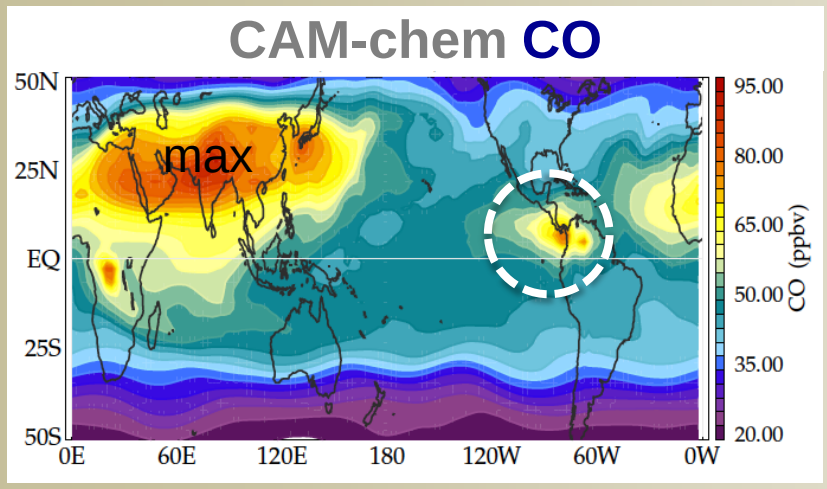
Biogenic Emissions

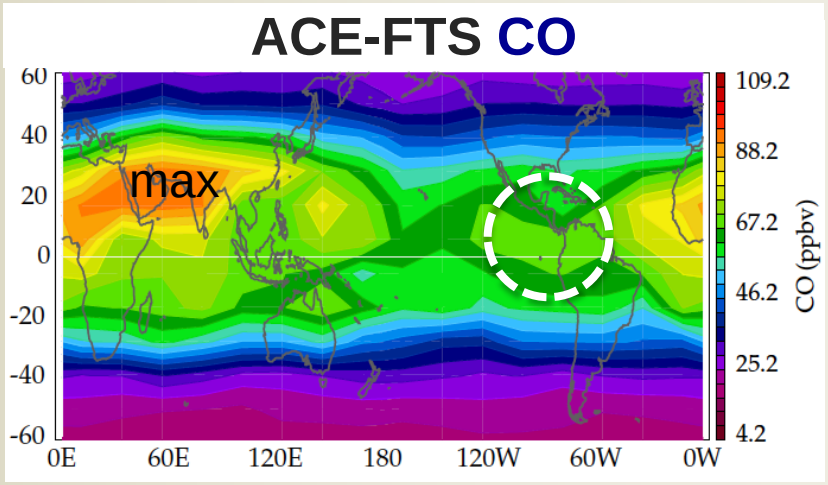
CAM-chem *vs.* ACE-FTS

150 hPa

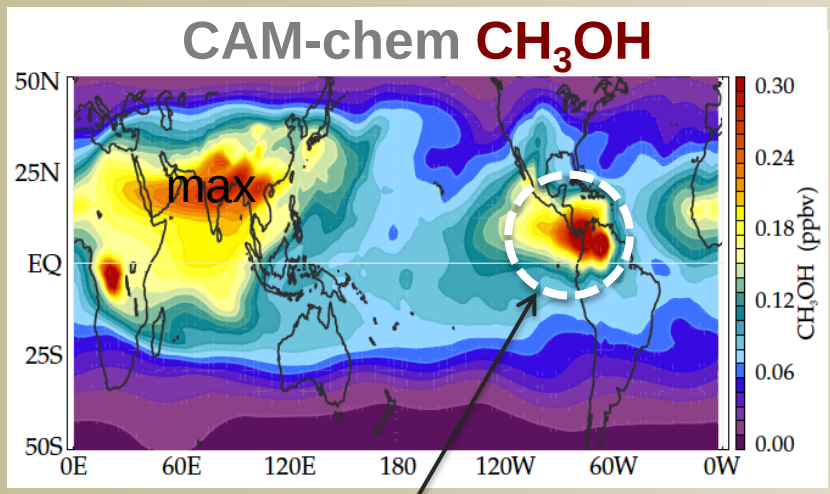
14. 5 km

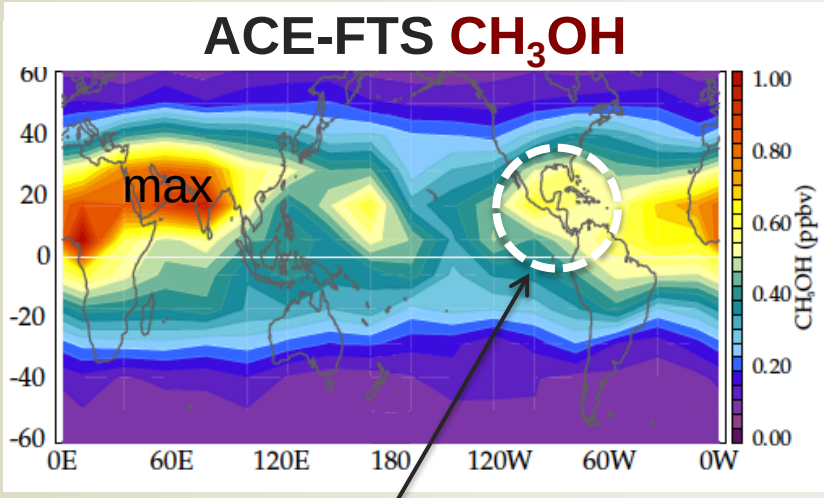
CO





CH_3OH





max

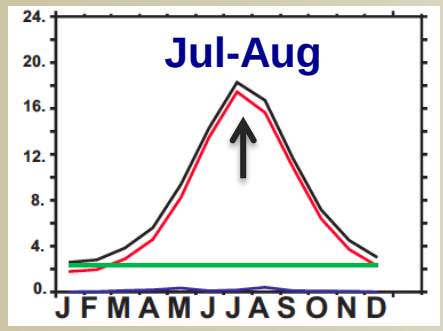
weaker max

ACE-FTS – **Zonal Mean** (JJA)

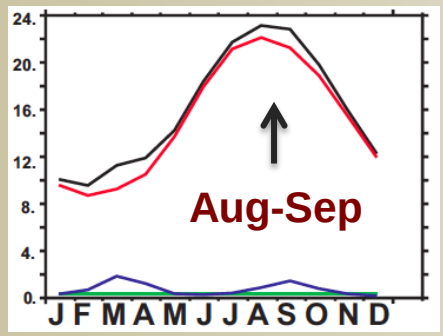
Black - all sources
Red – biogenic
Green – anthro
Blue - BB

Emissions

N. America
lon: 180°W-40°W
lat: 20°N-80°N

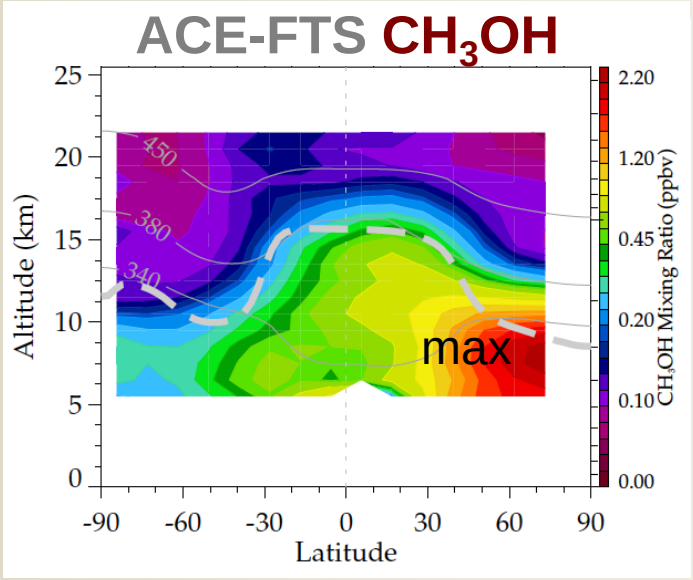


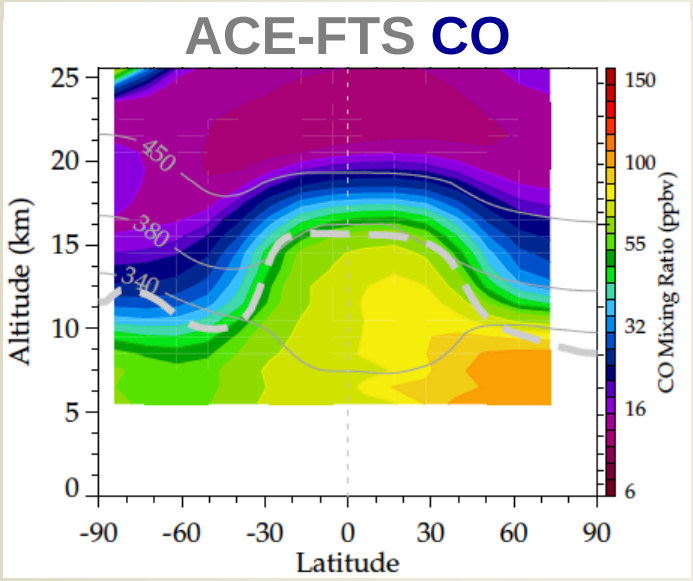
Asia
lon: 50°E-150°E
lat: 20°S-40°N



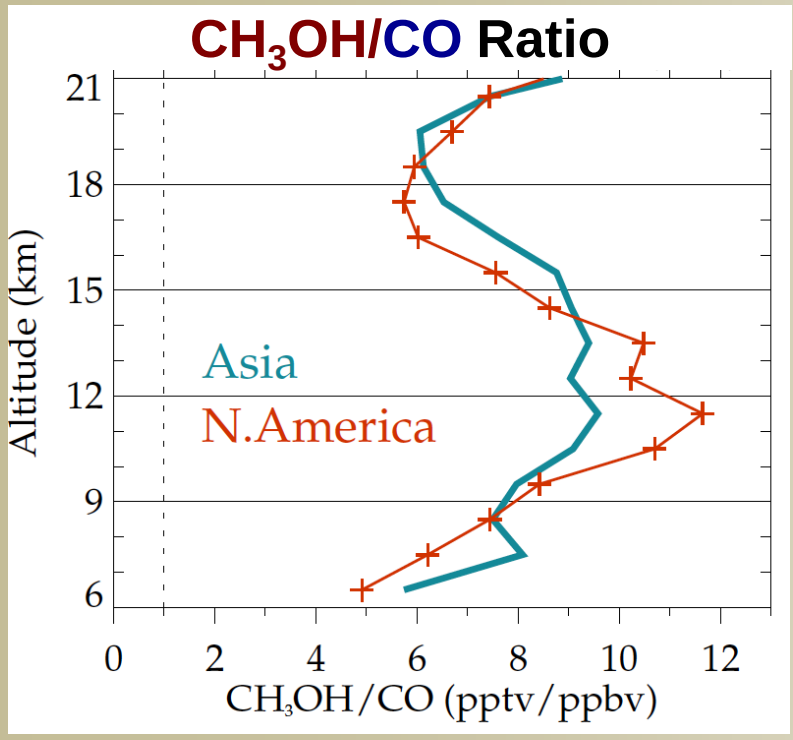
[Dufour et al., 2007]

CH_3OH – Dominant **biogenic** emissions (max – summer)

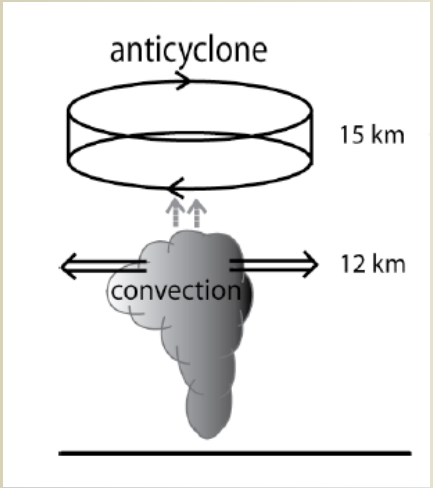




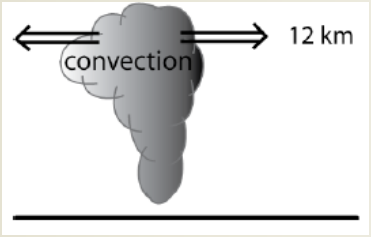
Asia vs. American Monsoons



Asian Monsoon

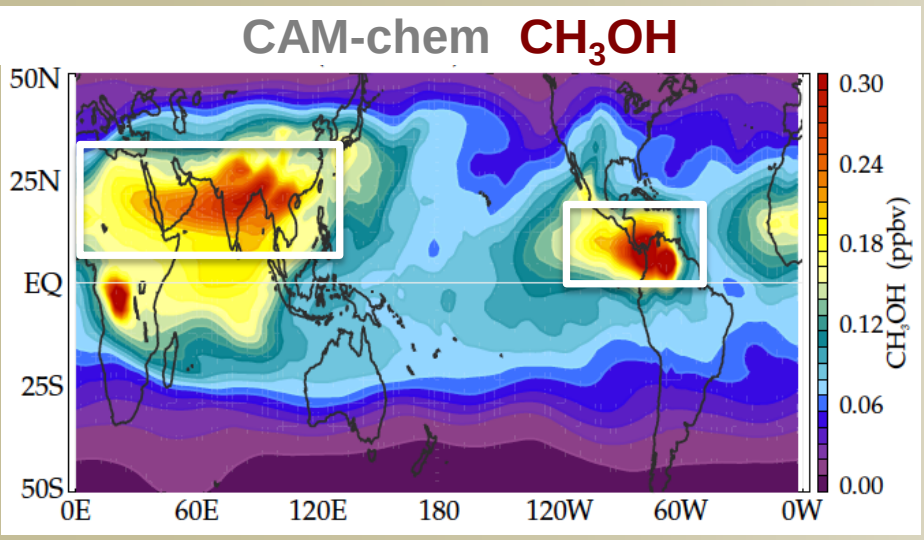


N. American Monsoon?

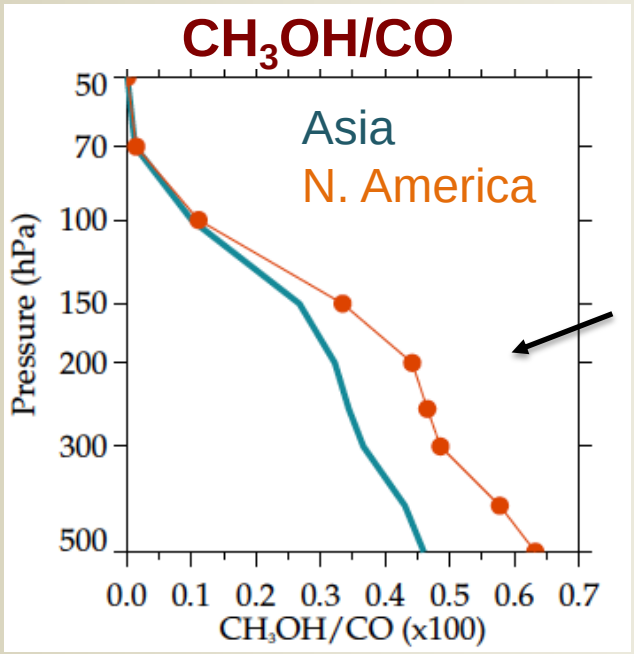


[Park et al., 2008]

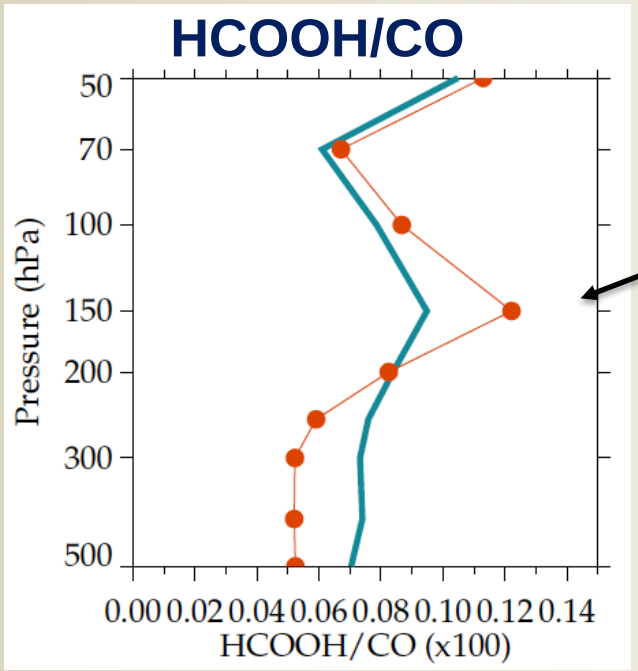
CAM-chem - Asia vs. American



CAM-chem **HCOOH** show **max** near ~ 150 hPa



weak max

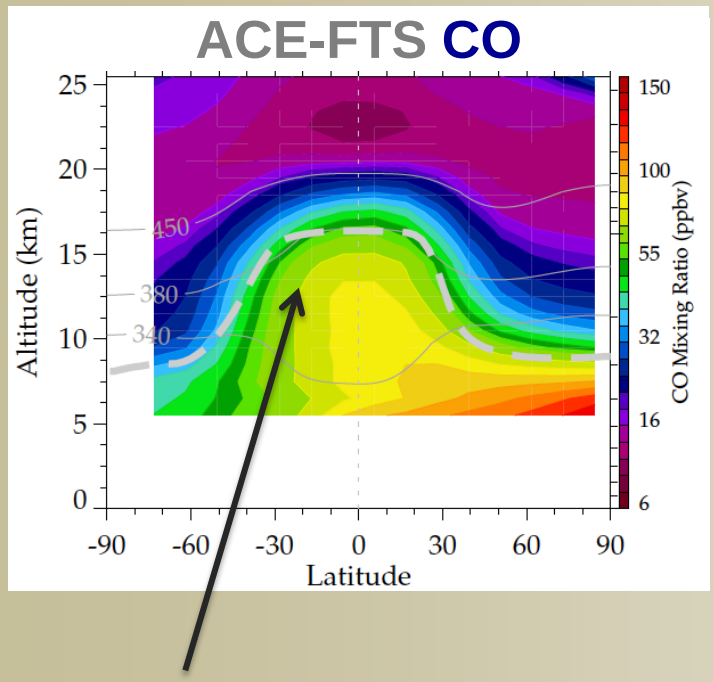


max

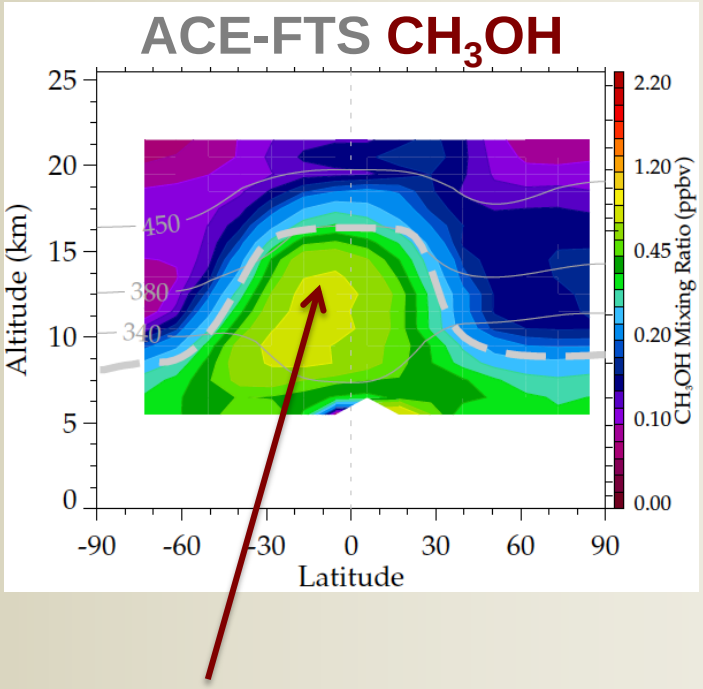
~ 150 hPa

Convective Signal in NH Winter?

ACE-FTS climatology (**DJF**)

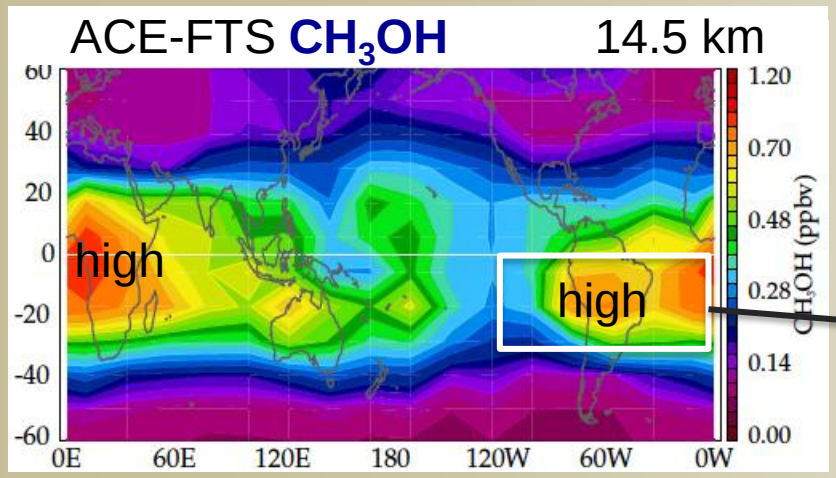


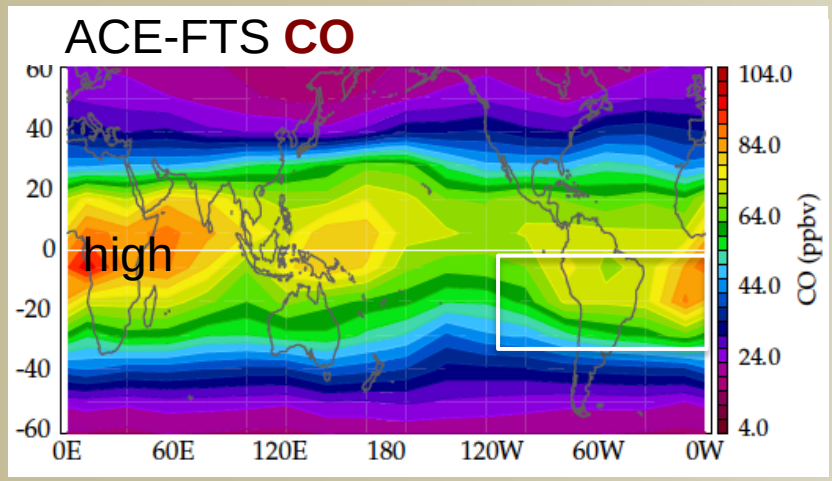
Lack of max (SH)

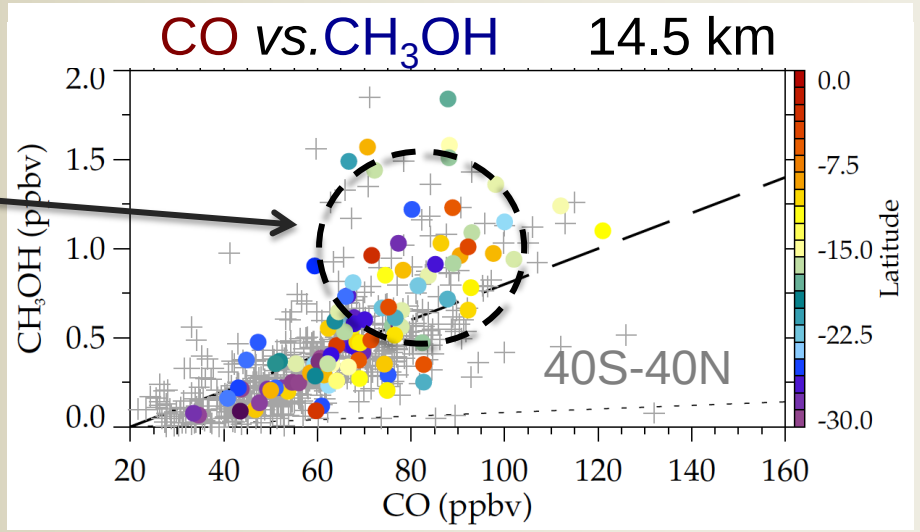


Max (biogenic sources + convection over Australia)

Convection over S. America – CH_3OH





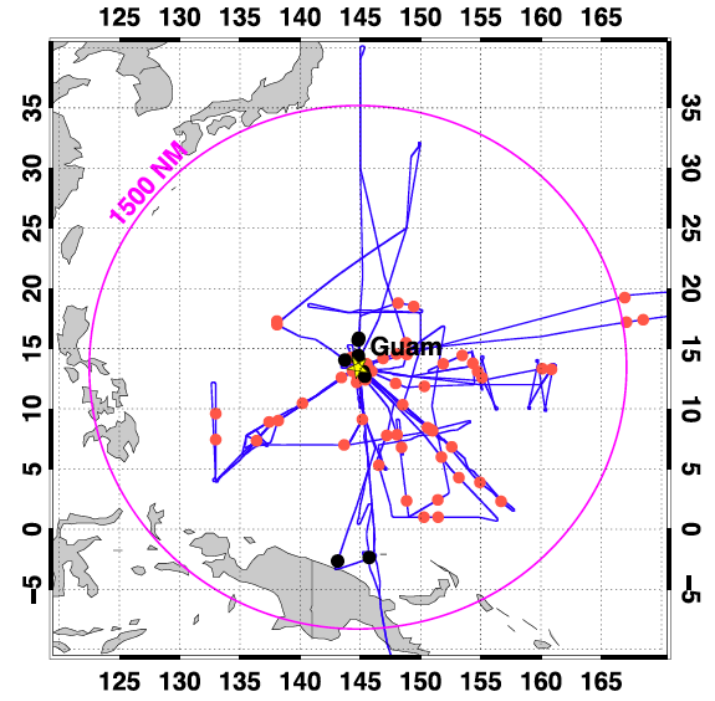


color: -30<lat<0, 240<lon<360

CH_3OH high over S. America (convection + sources)

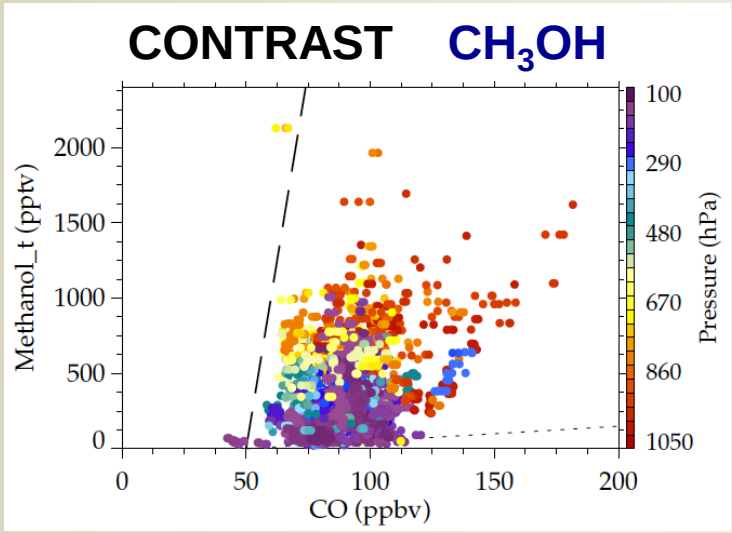
CO *vs.* CH_3OH (Pacific, NH Winter)

CONTRAST (Jan-Feb, 2014)

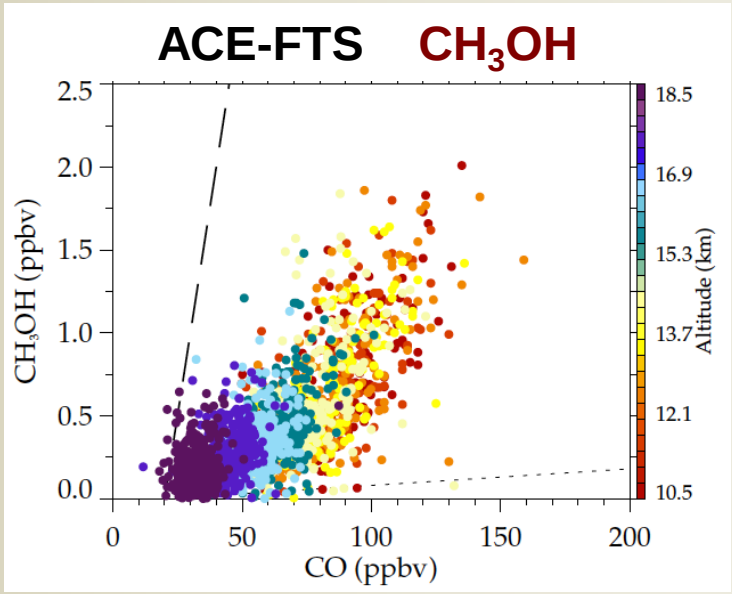


[Pan et al., 2015]

ACE-FTS shows general agreement with **CONTRAST**



Color: pressure



Color: altitude

(20S-20N, 10.5-18.5 km)

Summary

1. Short-lived species (**HCOOH, H_2O, CH_3OH**) measured by **ACE-FTS** show similar behavior with **CO** over the **Asian** monsoon region.

2. However, those species show relative enhancement over the **N. American** monsoon region, which is different from CO.

3. Different sources (*e.g.*, **biogenic**) may contribute enhancement in **CH_3OH** over N. America with possible link to local convection.

4. Comparison of **ACE-FTS** with *in-situ* measurements and **CAM-chem** simulations suggests positive outlook.