OH in the TWP: An In-Depth Comparison of CONTRAST and CAM-Chem OH Precursors and Implications for the Oxidative Capacity of the Troposphere

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22 July 2015

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Outline

- Box modeling method for estimating OH during CONTRAST campaign
- Comparison of OH modeled by CAM-Chem and OH inferred from GV aircraft measurements
- Campaign-wide conclusions for OH levels in TWP
- Evaluation of CH_2Br_2 lifetime
- Effect of High O_3/Low H_2O (HOLW) filaments on OH concentrations

Box Model

DSMACC: Dynamically Simple Model for Atmospheric Chemical Complexity

-Emmerson and Evans, ACP, 2009

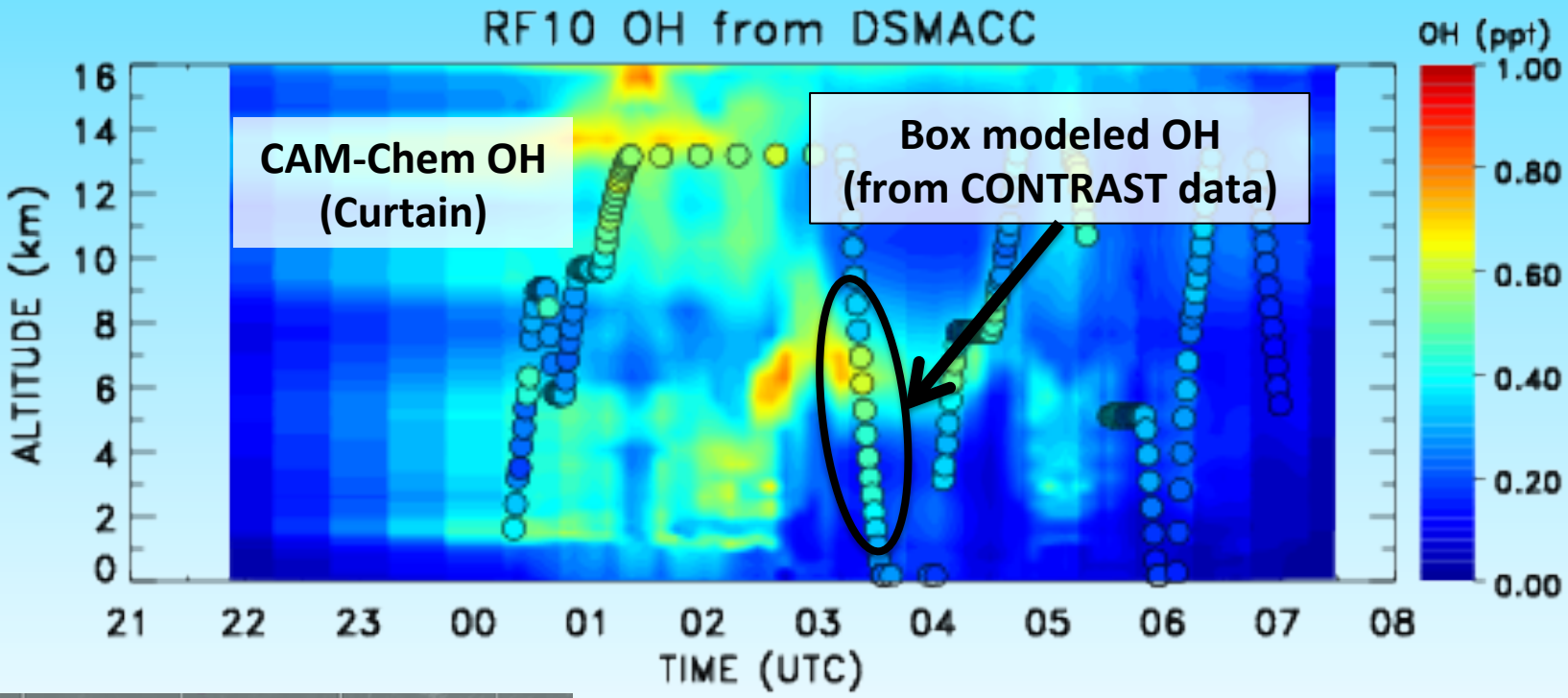
Makes use of the:

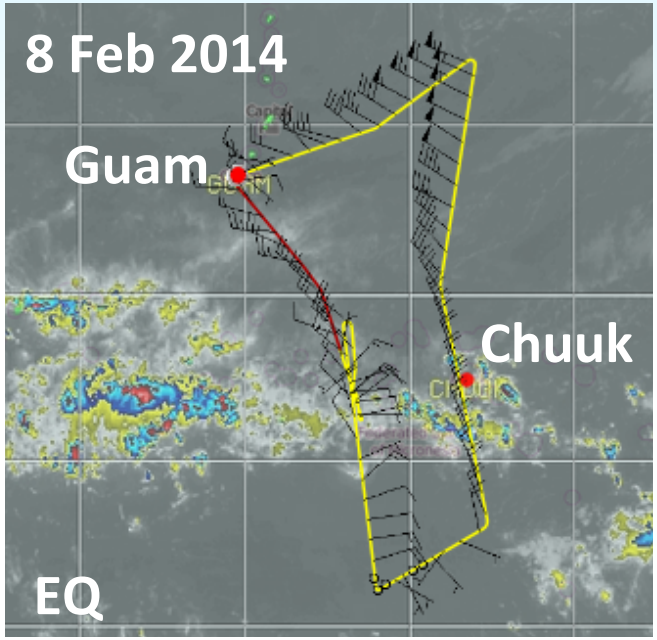
KPP (Kinetics PreProcessor)
Damian et al., Computers and Chemical Engineering, 2002.

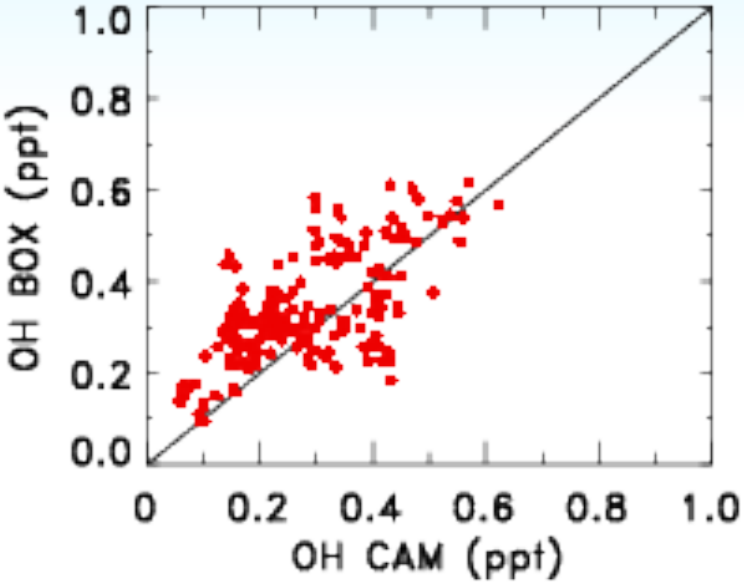
Leeds Master Chemical Mechanism
Jenkin et al., Atmos. Environ., 1997; Saunders et al., ACP, 2003

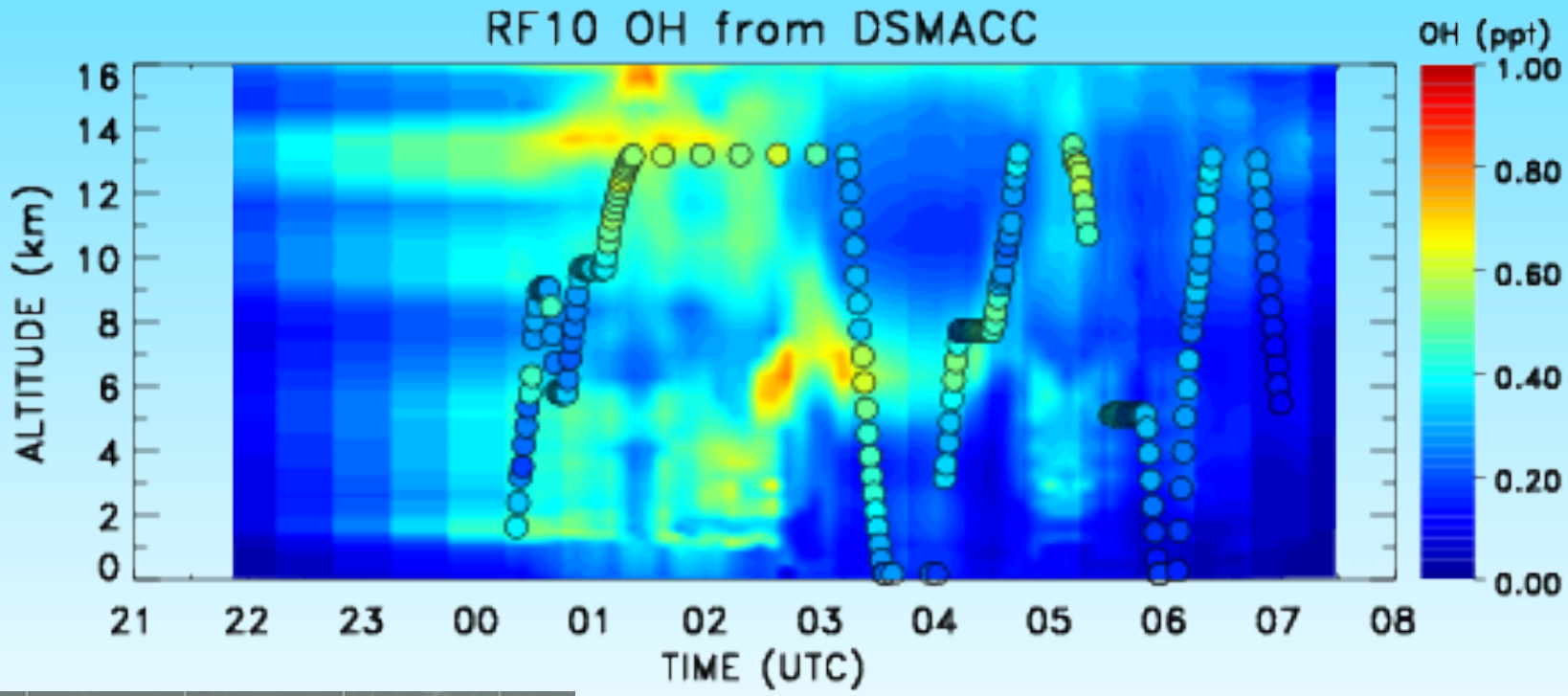
Box model can be run with inputs from observations, from a global model, or a combination of both

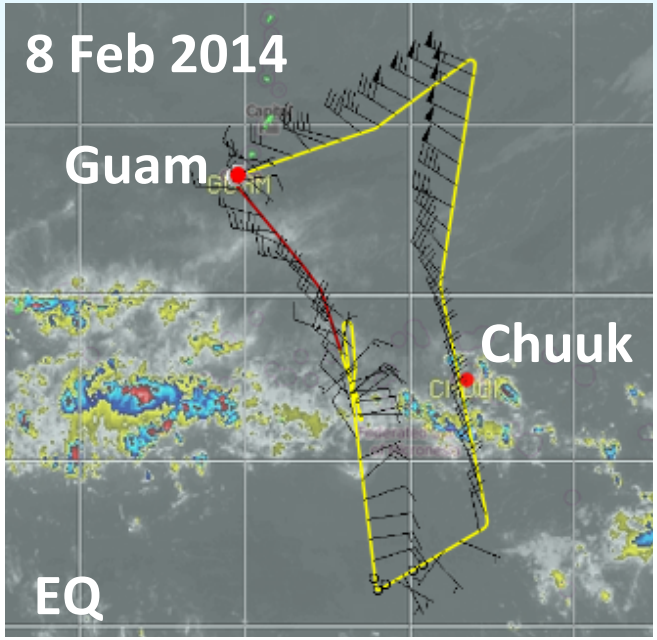
Box model inputs: all measured on GV	
p	**HCHO**
T	**CH_4**
H_2O	**Acetone**
O_3	**C_3H_8**
CO	**Isoprene**
CO_2	**MVK**
NO	**MACR**
NO_2	**CH_3OH**
$J(O^1D)$	**CH_3CHO**
$J(NO_2)$	


RF10 OH from DSMACC
CAM-Chem OH
(Curtain)
Box modeled OH
(from CONTRAST data)
ALTITUDE (km)
TIME (UTC)
OH (ppt)
16
14
12
10
8
6
4
2
0
21
22
23
00
01
02
03
04
05
06
07
08
1.00
0.80
0.60
0.40
0.20
0.00


8 Feb 2014
Guam
Chuuk
EQ


OH BOX (ppt)
OH CAM (ppt)
1.0
0.8
0.6
0.4
0.2
0.0
0
0.2
0.4
0.6
0.8
1.0


RF10 OH from DSMACC
OH (ppt)
1.00
0.80
0.60
0.40
0.20
0.00
ALTITUDE (km)
16
14
12
10
8
6
4
2
0
21
22
23
00
01
02
03
04
05
06
07
08
TIME (UTC)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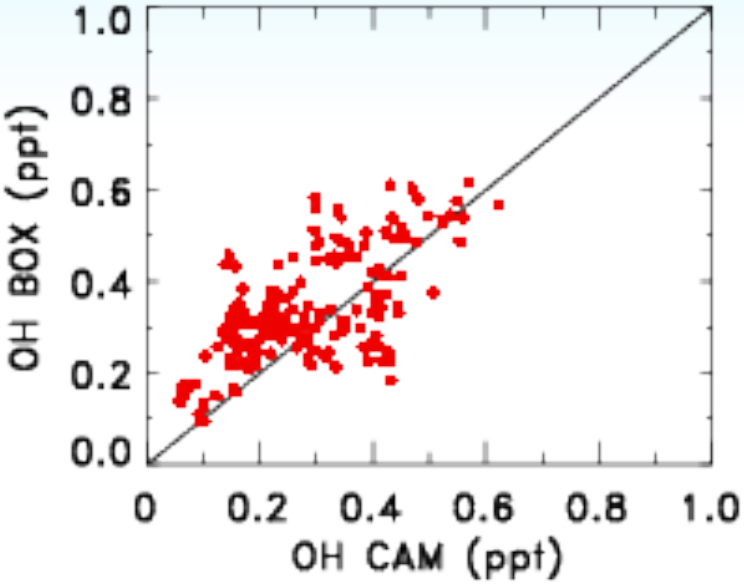
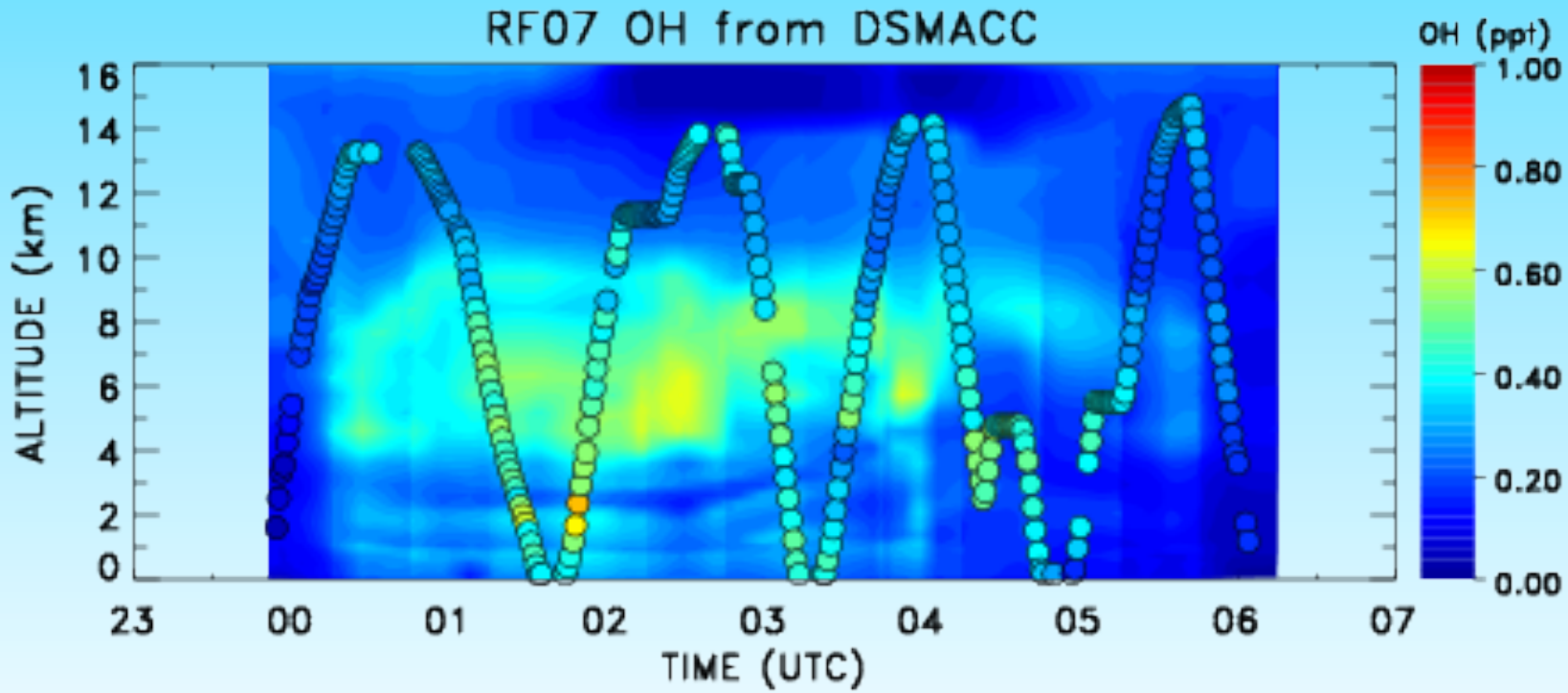
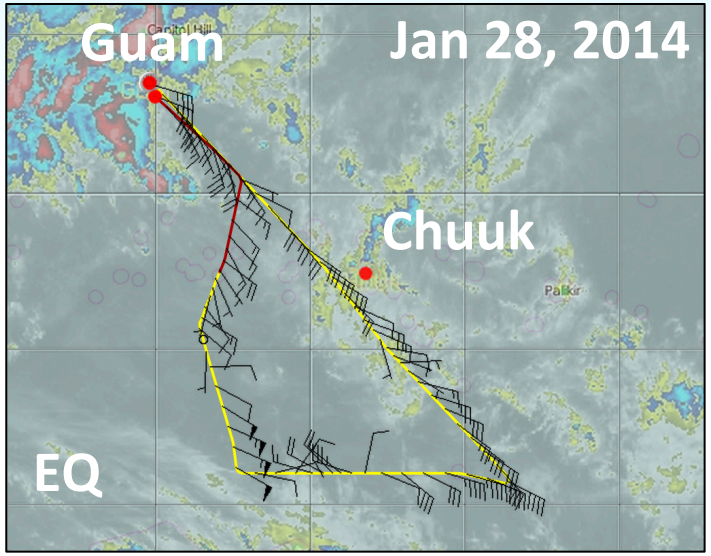
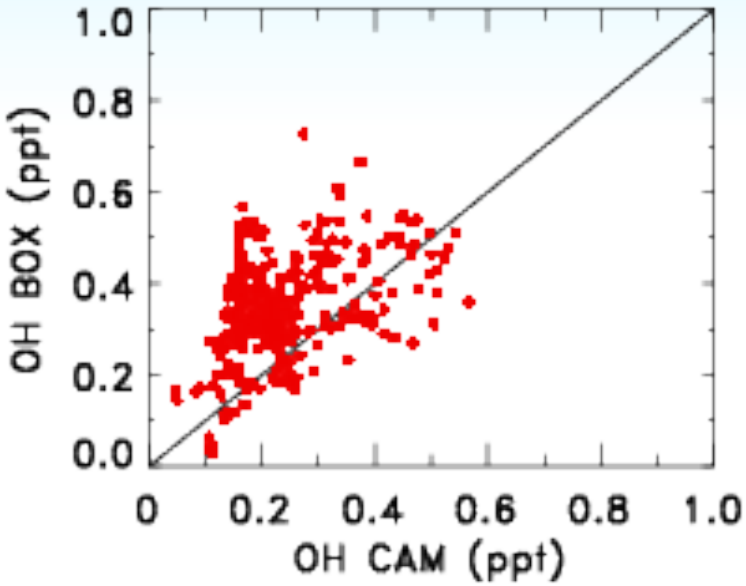
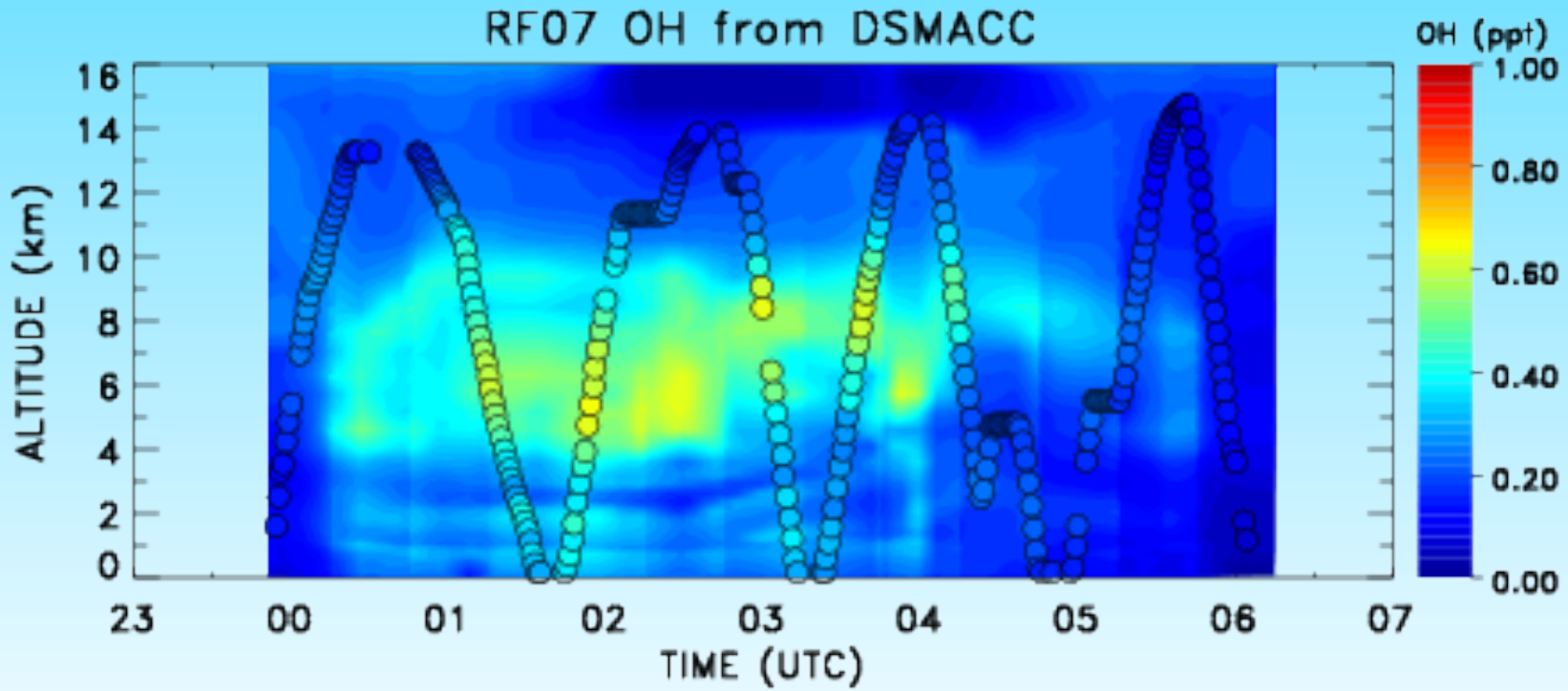
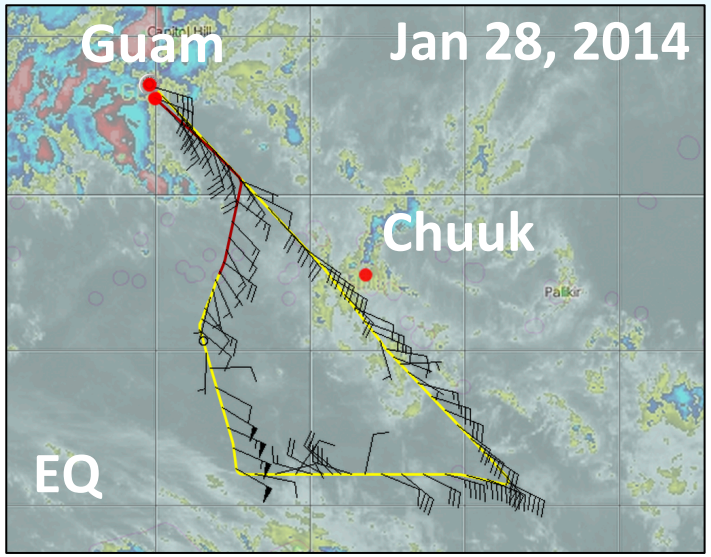

OH BOX (ppt)
1.0
0.8
0.6
0.4
0.2
0.0
0
0.2
0.4
0.6
0.8
1.0
OH CAM (ppt)


RF07 OH from DSMACC
OH (ppt)
1.00
0.80
0.60
0.40
0.20
0.00
ALTITUDE (km)
16
14
12
10
8
6
4
2
0
23
00
01
02
03
04
05
06
07
TIME (UTC)

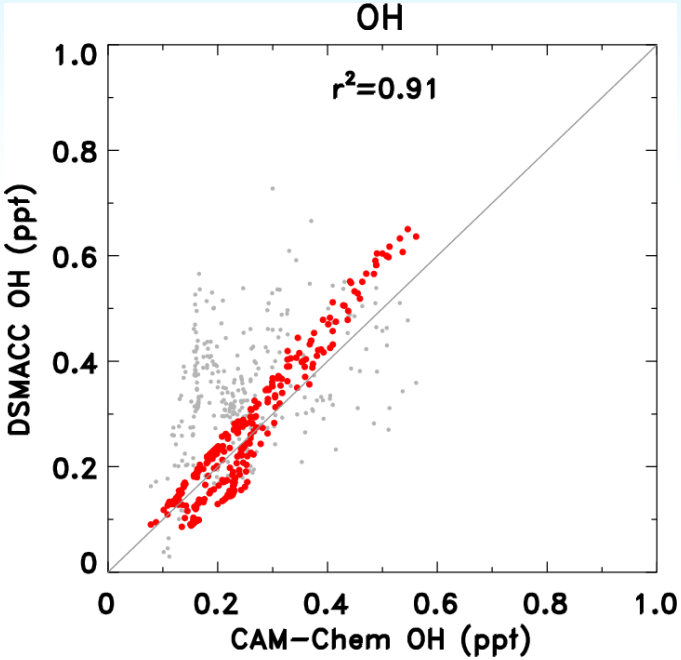

Guam
Jan 28, 2014
Chuuk
EQ

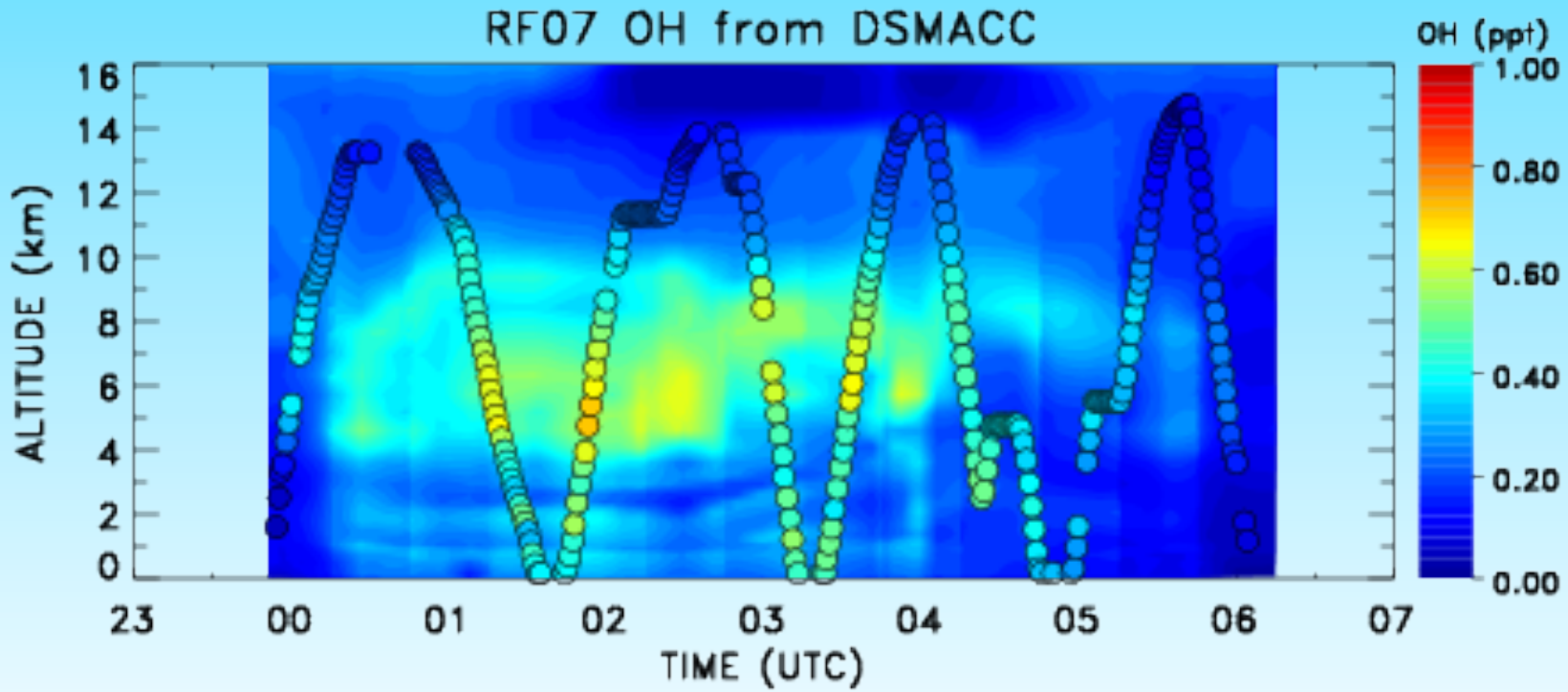

OH BOX (ppt)
1.0
0.8
0.6
0.4
0.2
0.0
0
0.2
0.4
0.6
0.8
1.0
OH CAM (ppt)

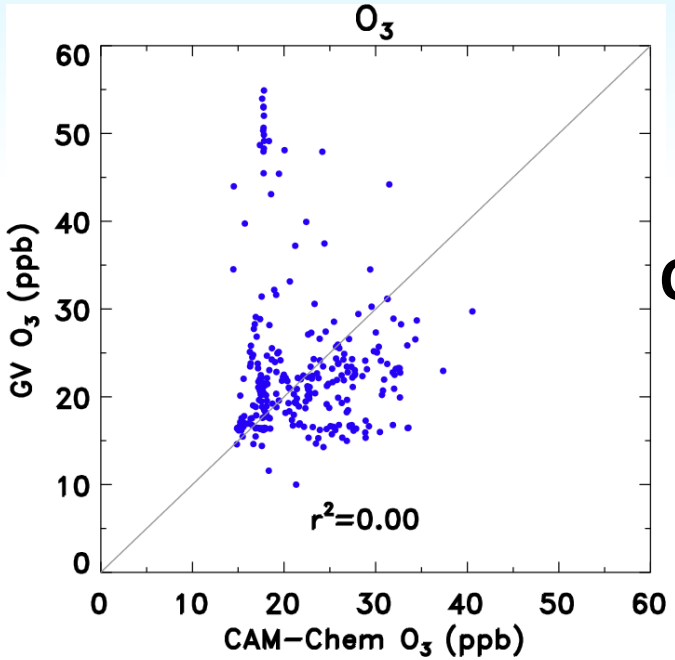




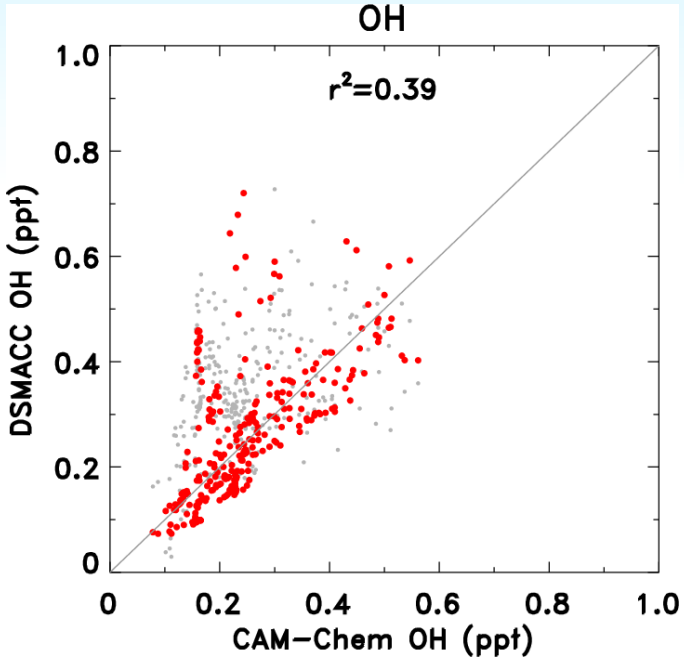
CAM Constraints

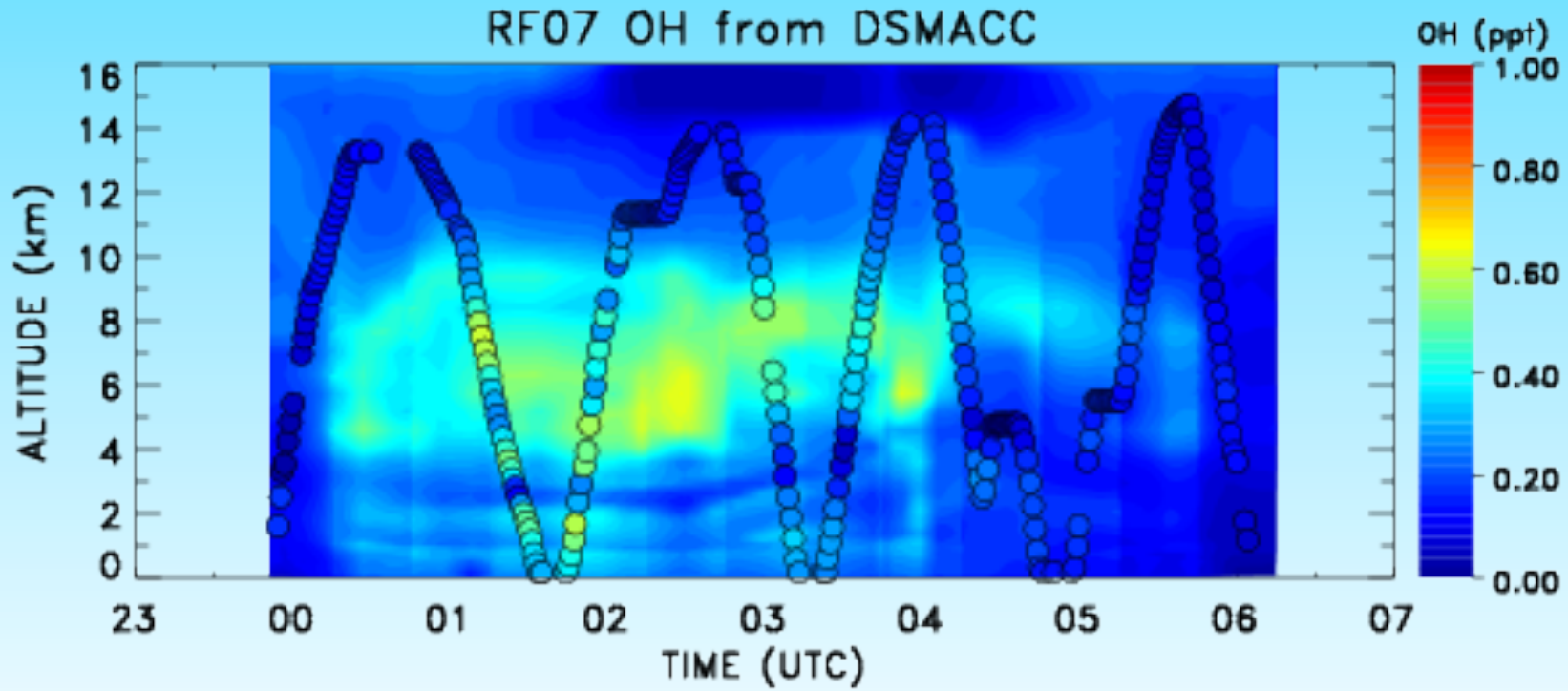


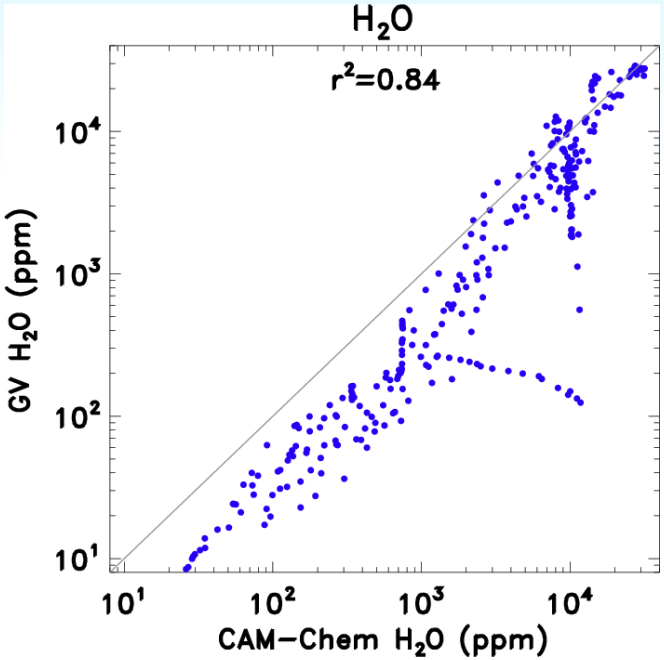




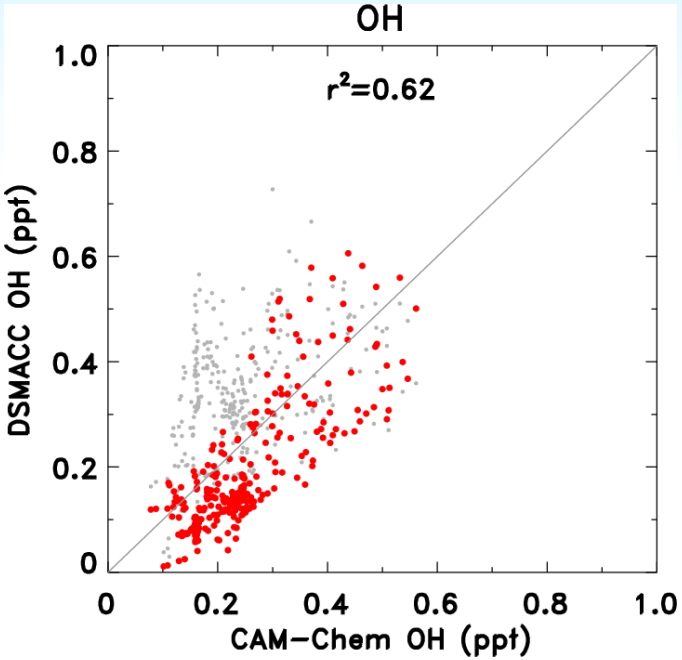
CAM Constraints + GV O_3

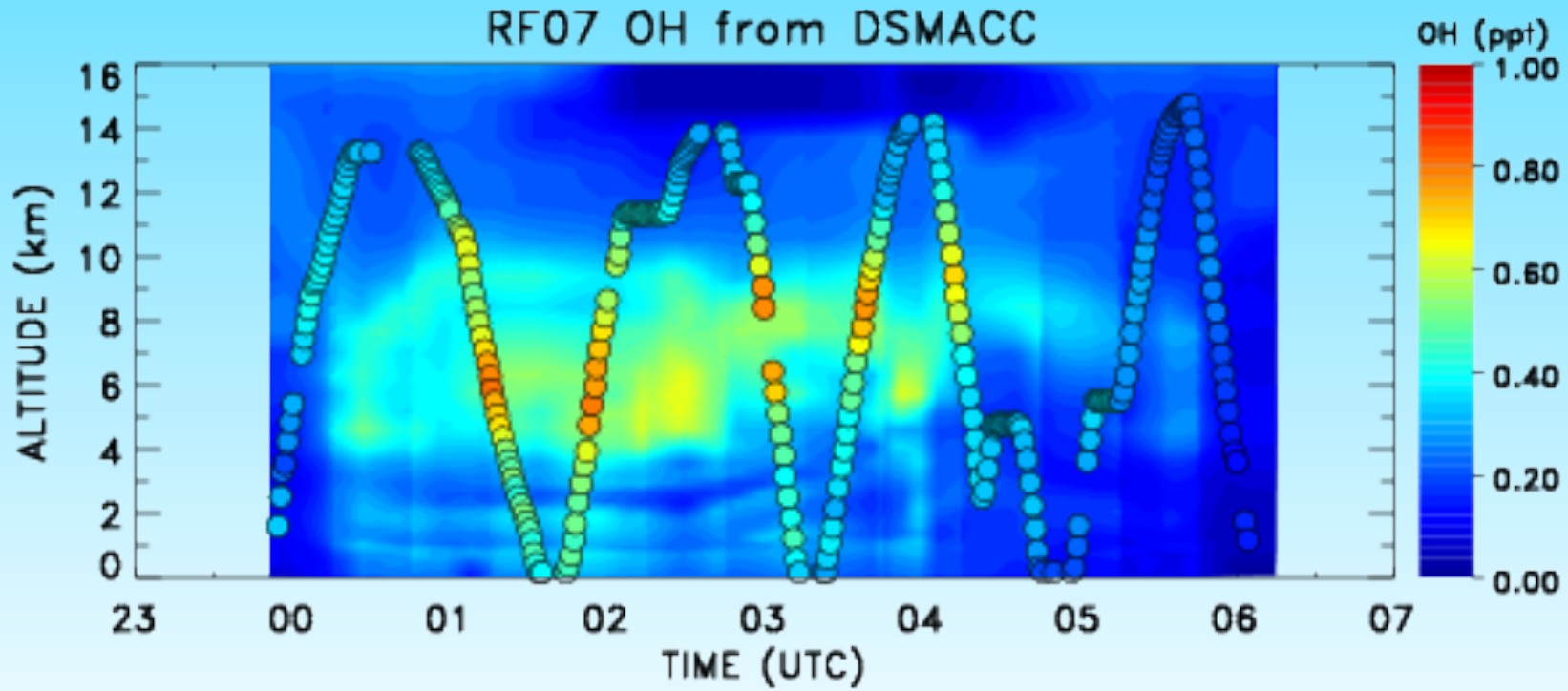


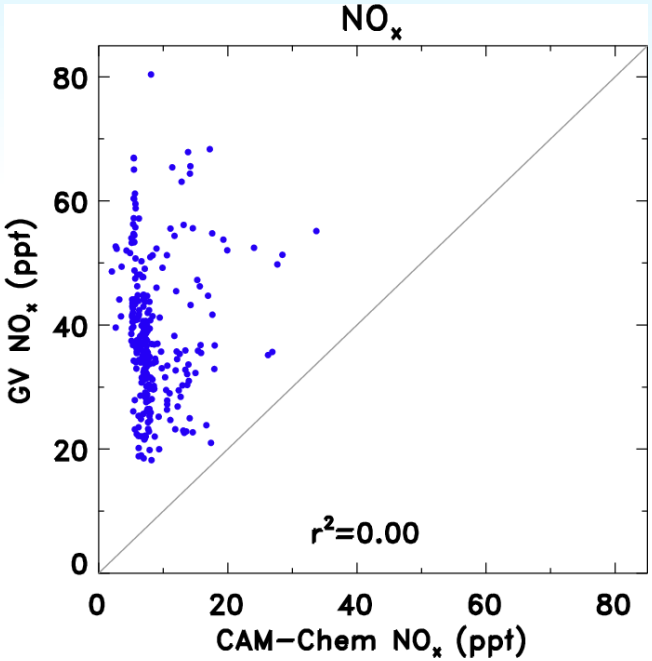




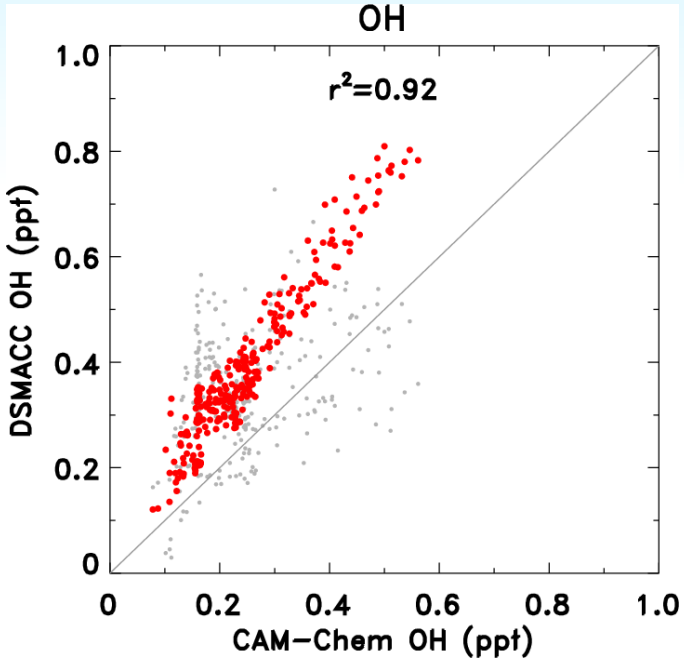
CAM Constraints + GV H_2O

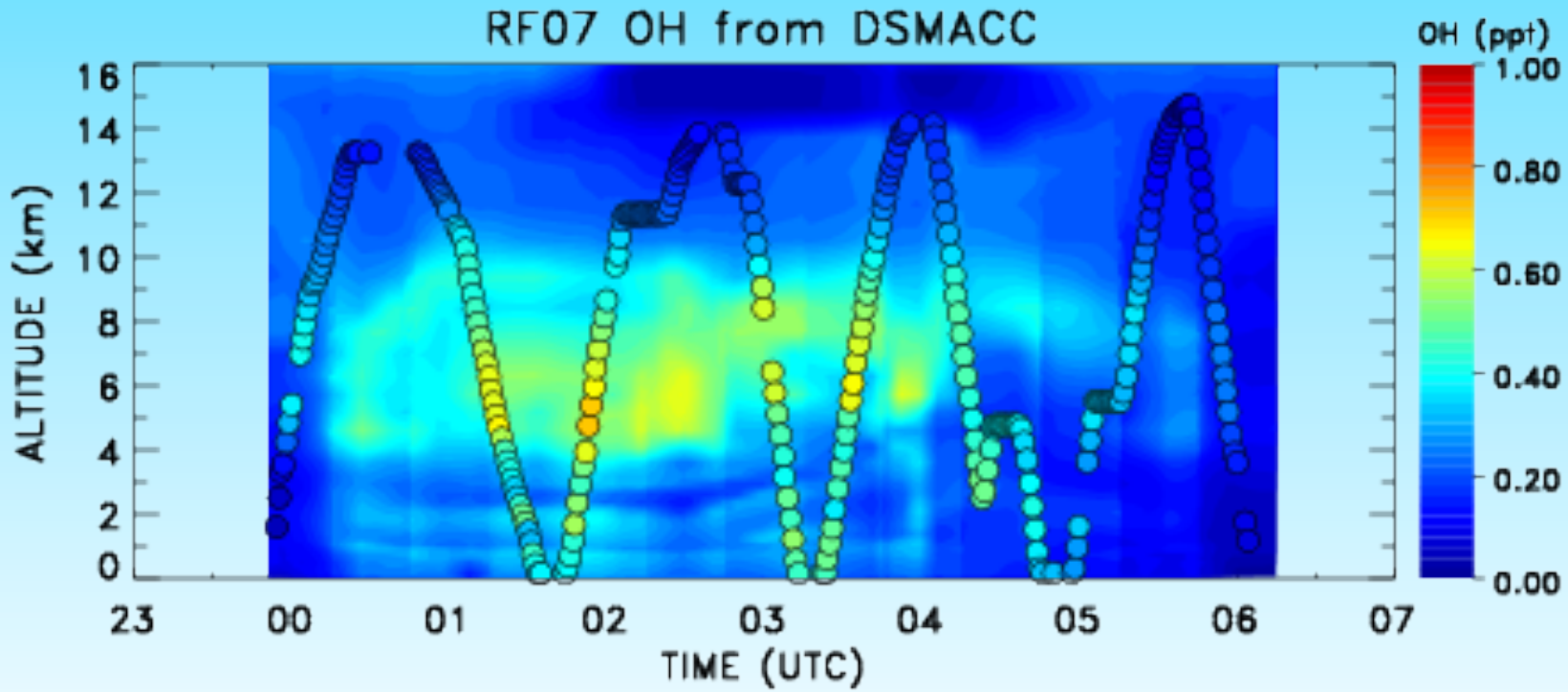


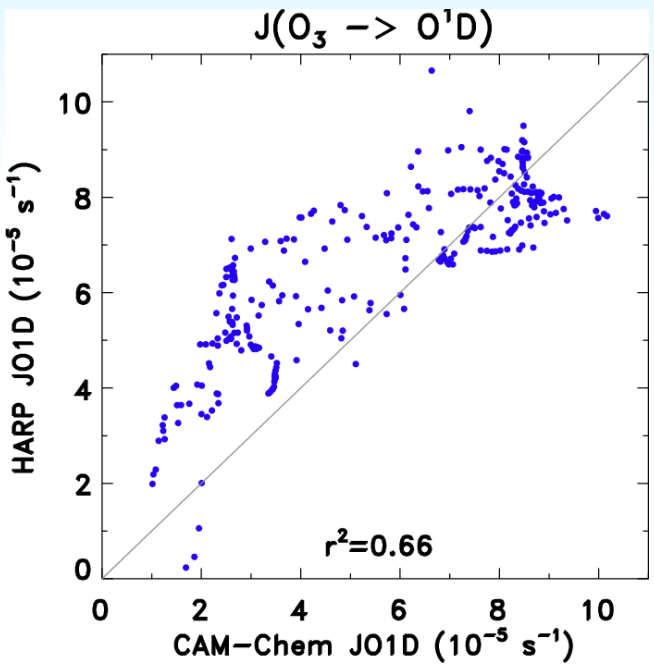




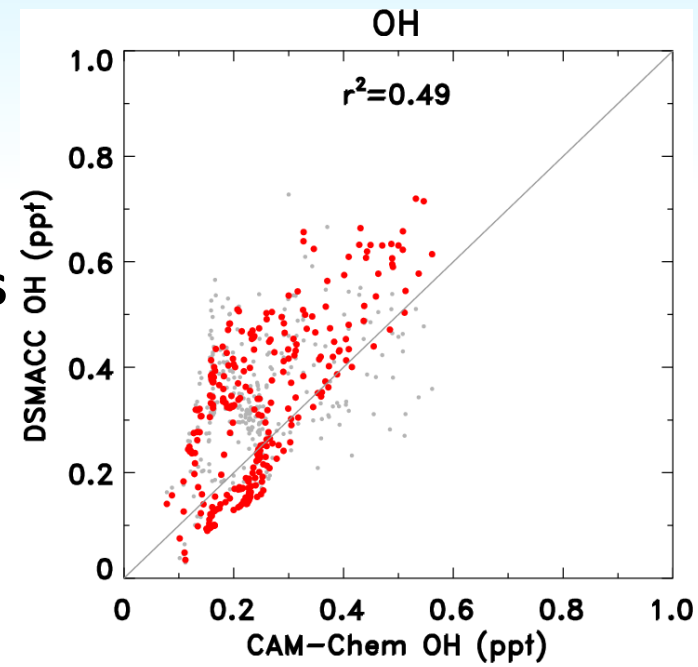
CAM Constraints + GV NO_x

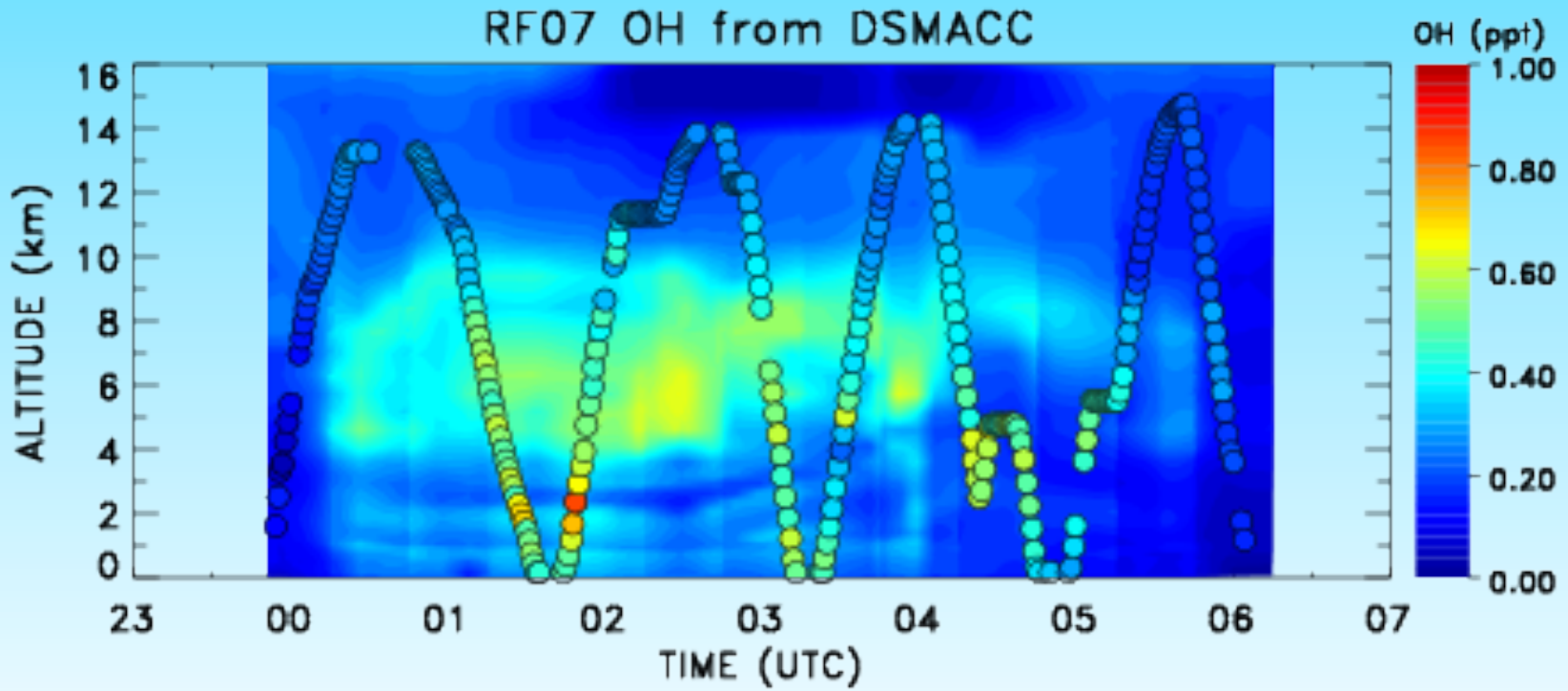






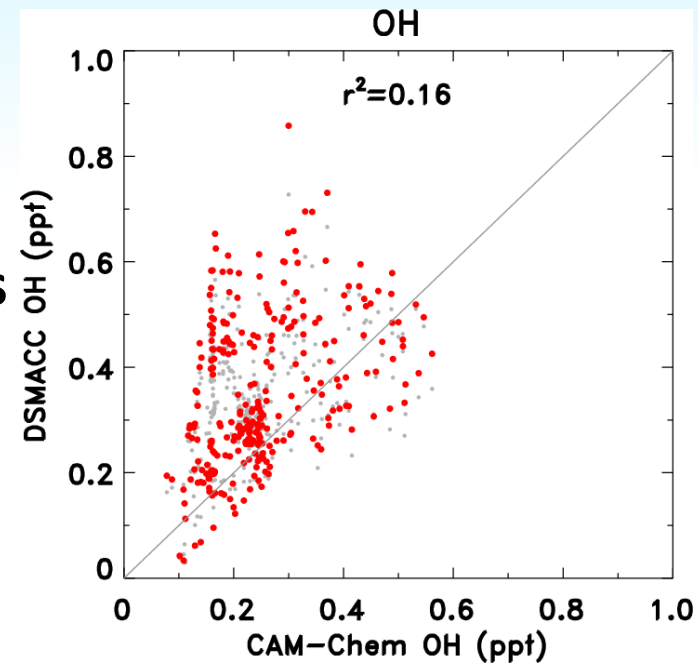
CAM Constraints + GV J(O¹D)





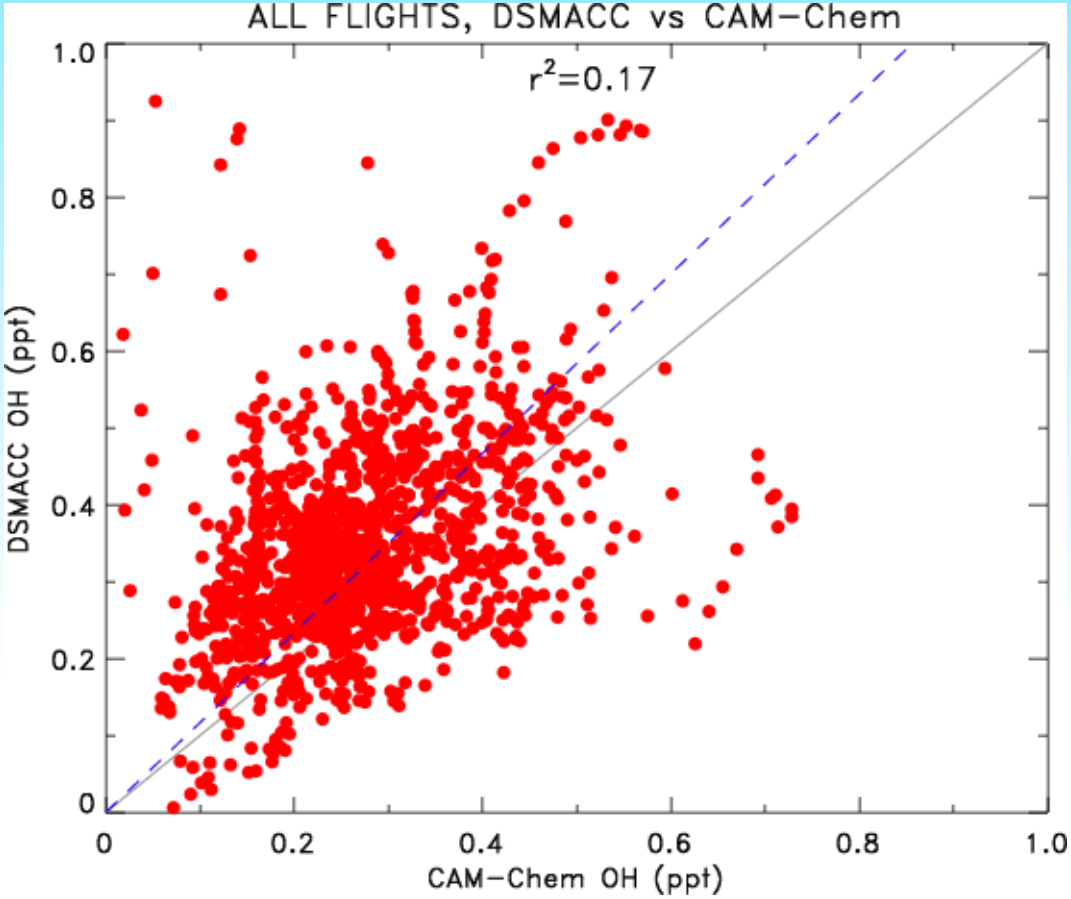
CAM-Chem OH generally agrees well with measurement-inferred OH

CAM Constraints + GV O_3, H_2O, NO_x $J(O^1D)$



CONTRAST Campaign Results
(RF04-14, filtered for SZA < 60°)

Box OH—constrained to GV data



CAM-Chem OH

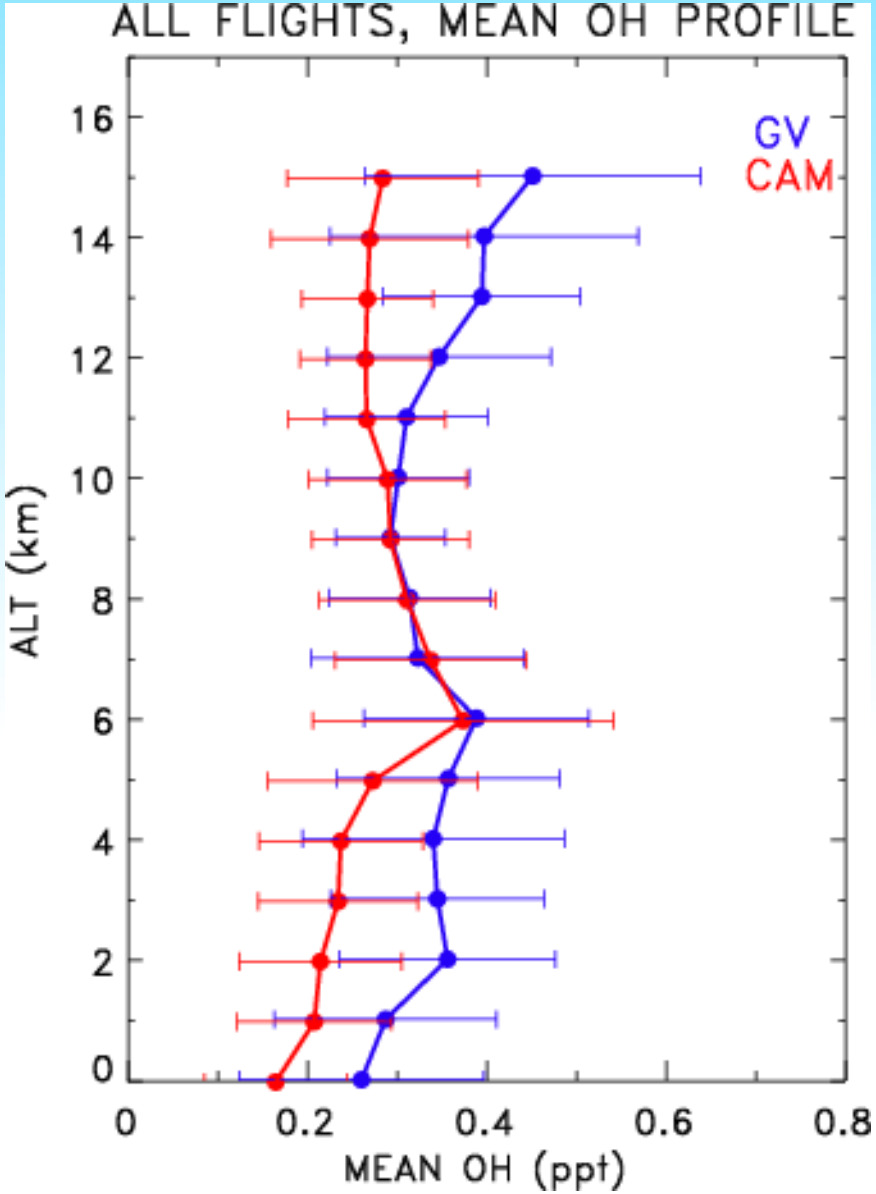
Mean ratio
GV OH/CAM OH = 1.62

CONTRAST Campaign Results
(RF04-14, filtered for SZA < 60°)

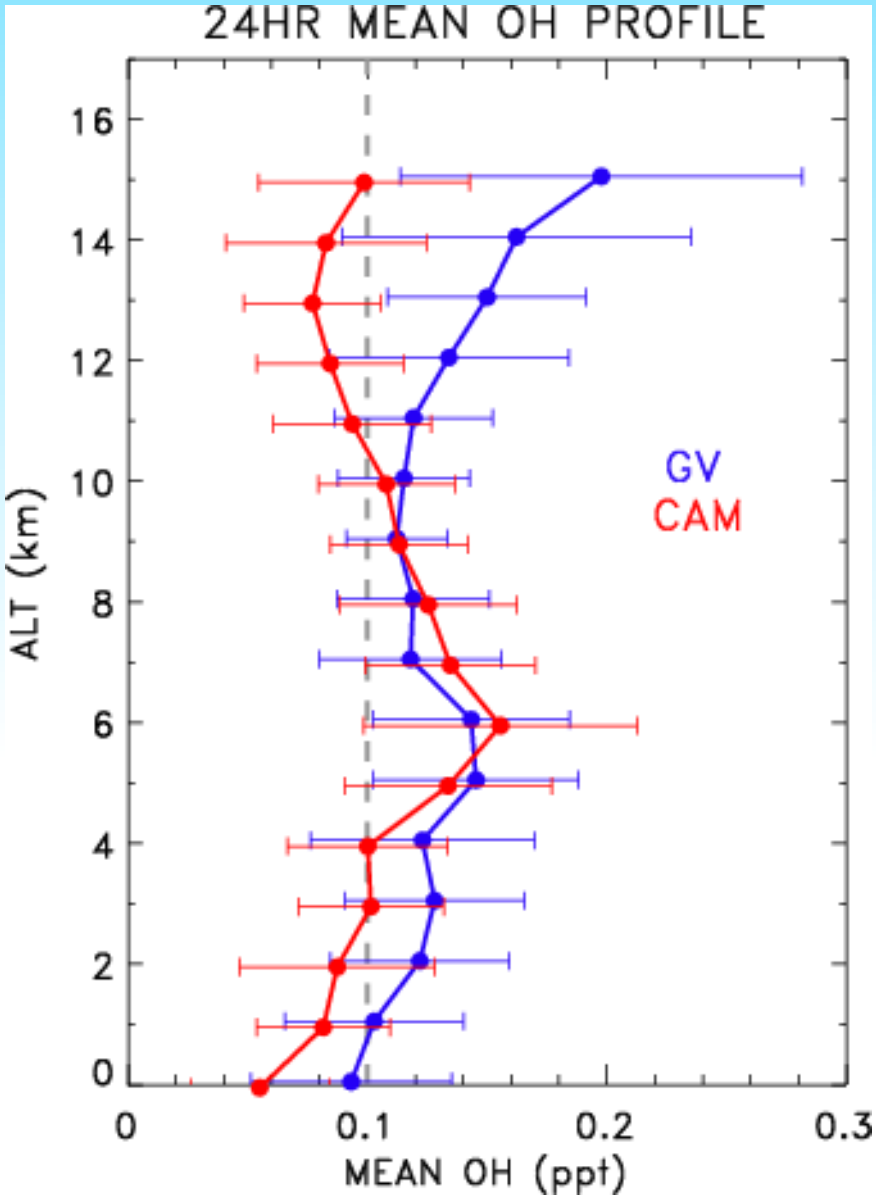
Instantaneous OH mean profile

(OH at the time the airplane sampled)

Box model constrained to measurements



CONTRAST Campaign Results
(RF04-14, filtered for SZA < 60°)

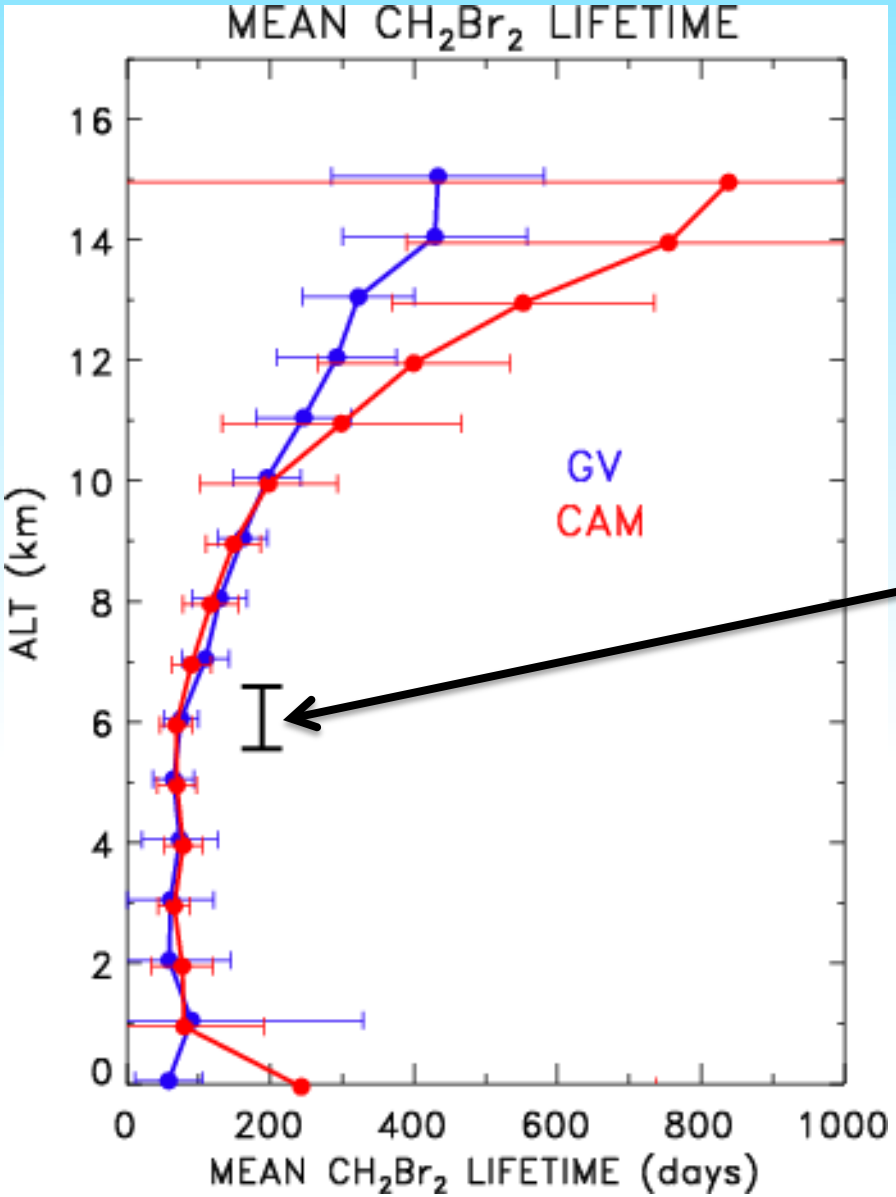


24 hour average mean OH profile

(obtained from box model at steady state)

-This is most relevant for determining lifetimes

CONTRAST Campaign Results
(RF04-14, filtered for SZA < 60°)



CH_2Br_2 lifetime with respect to OH

Rex et al. (2014) estimated CH_2Br_2 lifetime as 188 days due to OH minimum in Oct. at 500 hPa

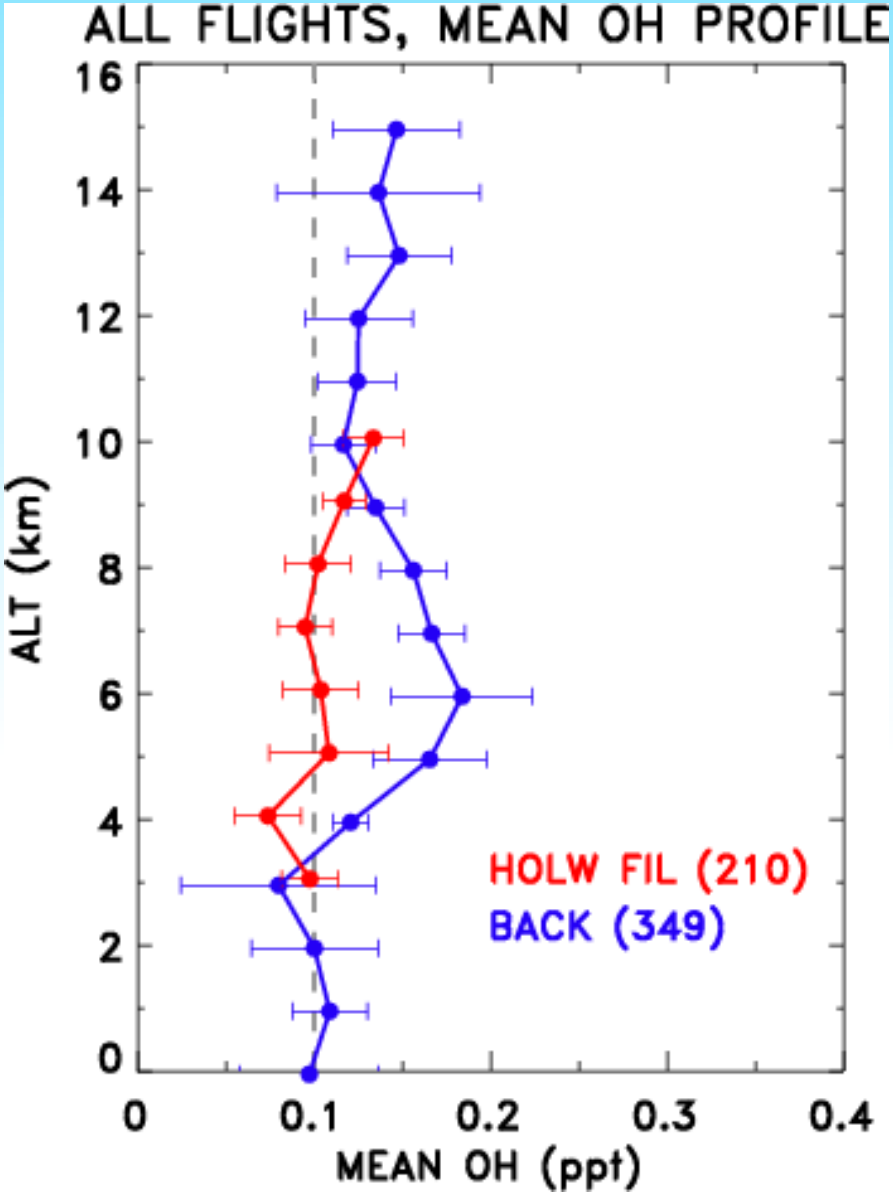
CONTRAST data suggest lifetime closer to 75 days for Jan/Feb

CONTRAST Campaign Results
(RF04-14, filtered for SZA < 60°)

High O_3 / Low H_2O filaments have competing effects on OH primary production

OH separated by:
Background: O_3 < 25 ppb,
RH > 70%
Filament: O_3 > 40 ppb,
RH < 20%

OH significantly depressed in HOLW filaments



Conclusions

- OH derived from box model constrained to CONTRAST measurements agrees well ***<u>on average</u>*** with CAM-Chem OH
- HOLW filaments cause OH to decrease, because low H_2O trumps high O_3
- CH_2Br_2 lifetime from mean OH profile is 75 days at 6 km, increasing to 200+ days above 10 km
- Increase of lifetime above base of TTL means convectively lofted VSLS lost primarily by OH will easily make it into stratosphere