Validation of RAQMS Chemical Analyses and Cloud Predictions using airborne insitu and satellite data during TORERO

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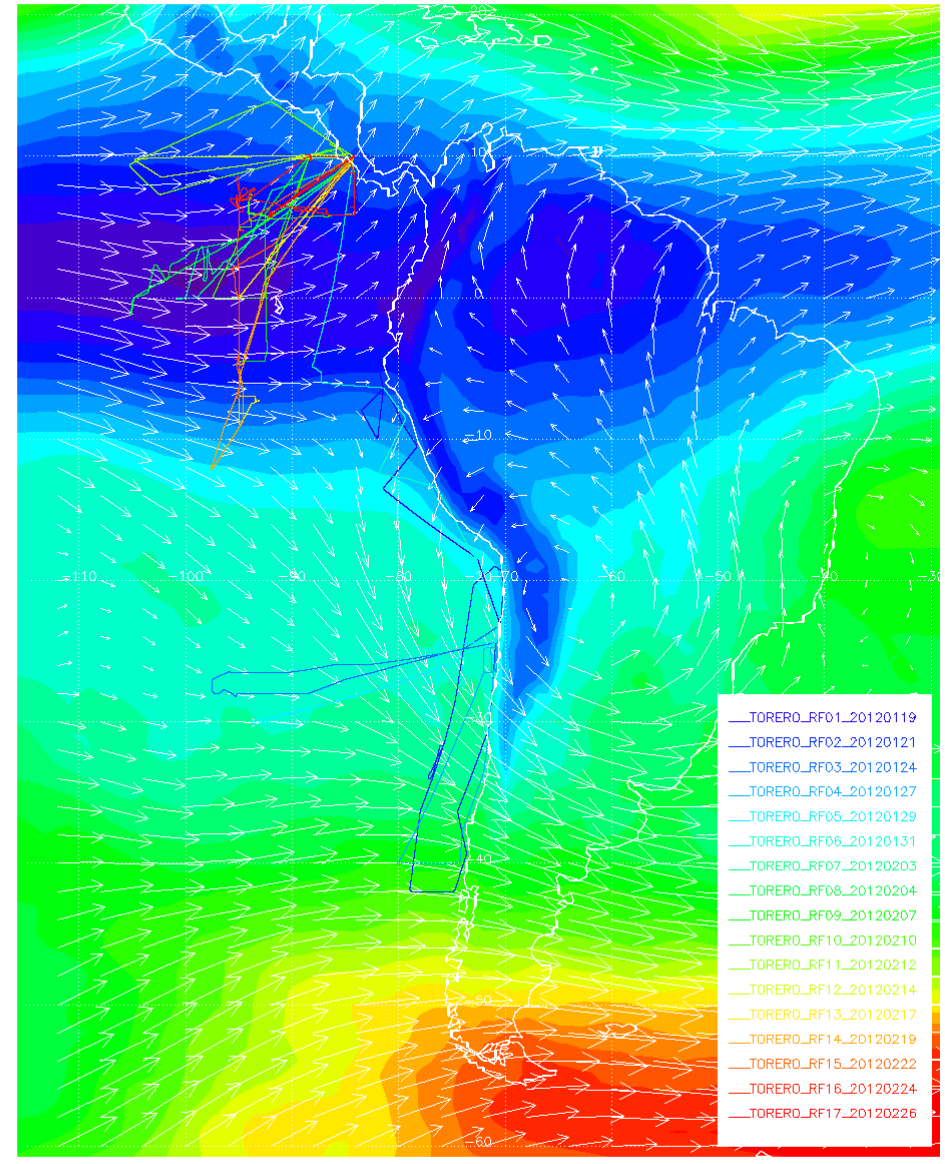
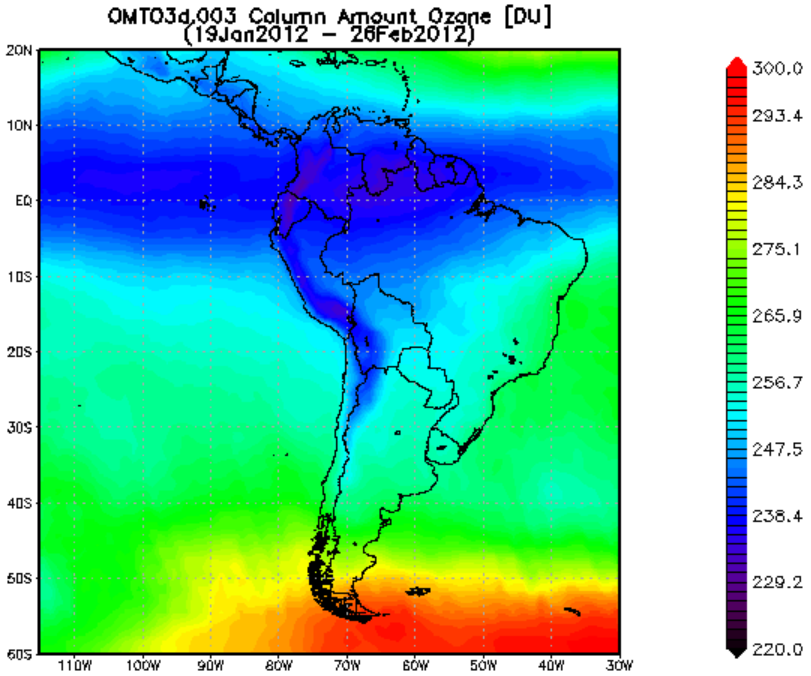
In the first part of this presentation we present comparisons between Realtime Air Quality Modeling System (RAQMS) chemical analyses with airborne insitu and remote satellite measurements during TORERO.

These comparisons are used to identify errors in predicted distributions of ozone, water vapor, and carbon monoxide in the tropical upper troposphere due to convective transport.

In the second part of this presentation we utilize cloud top height measurements from AVHRR Pathfinder Atmospheres-Extended (PATMOS-X) cloud top height retrievals based on GOES-12 measurements to validate RAQMS Cloud distributions and understand errors in RAQMS convective cloud predictions.

RAQMS Mean O3 Column Jan 19-Feb 26, 2012

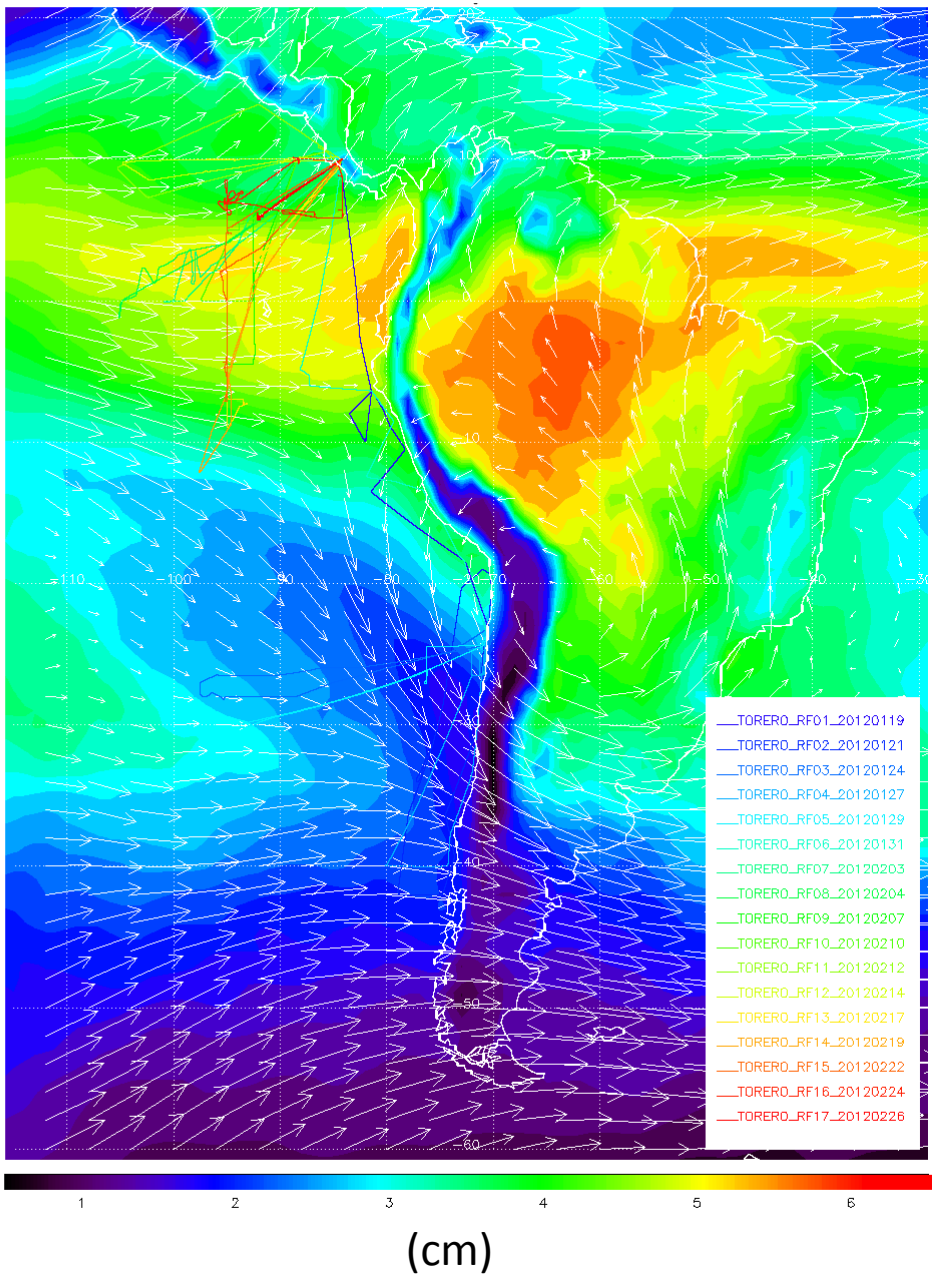


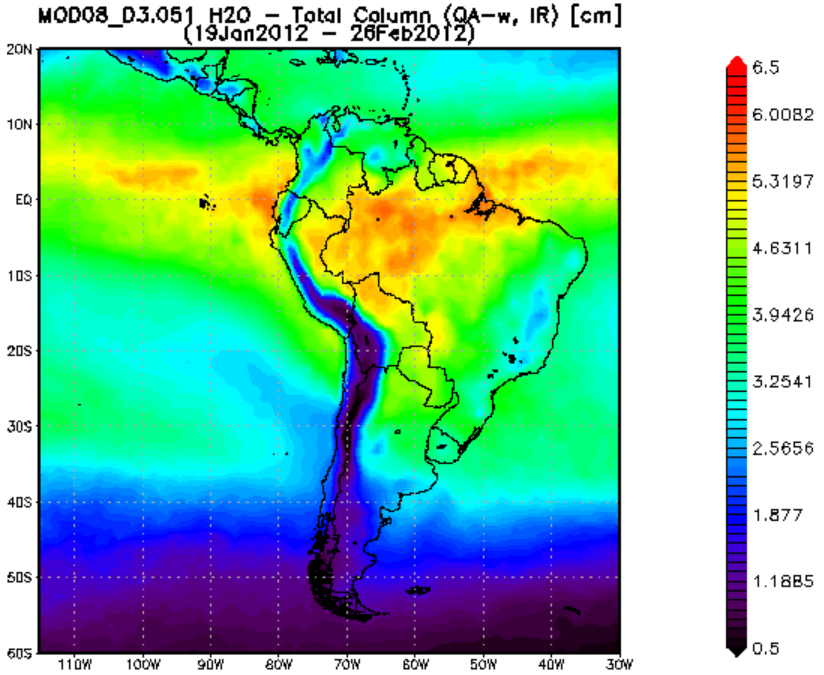


OMI Mean O3 Column Jan 19-Feb 26, 2012

Comparisons between RAQMS O3 column and Aura Ozone Monitoring Instrument (OMI) observations is generally very good although RAQMS shows lower O3 column in Equatorial Pacific

RAQMS Mean Water Vapor Column Jan 19-Feb 26, 2012

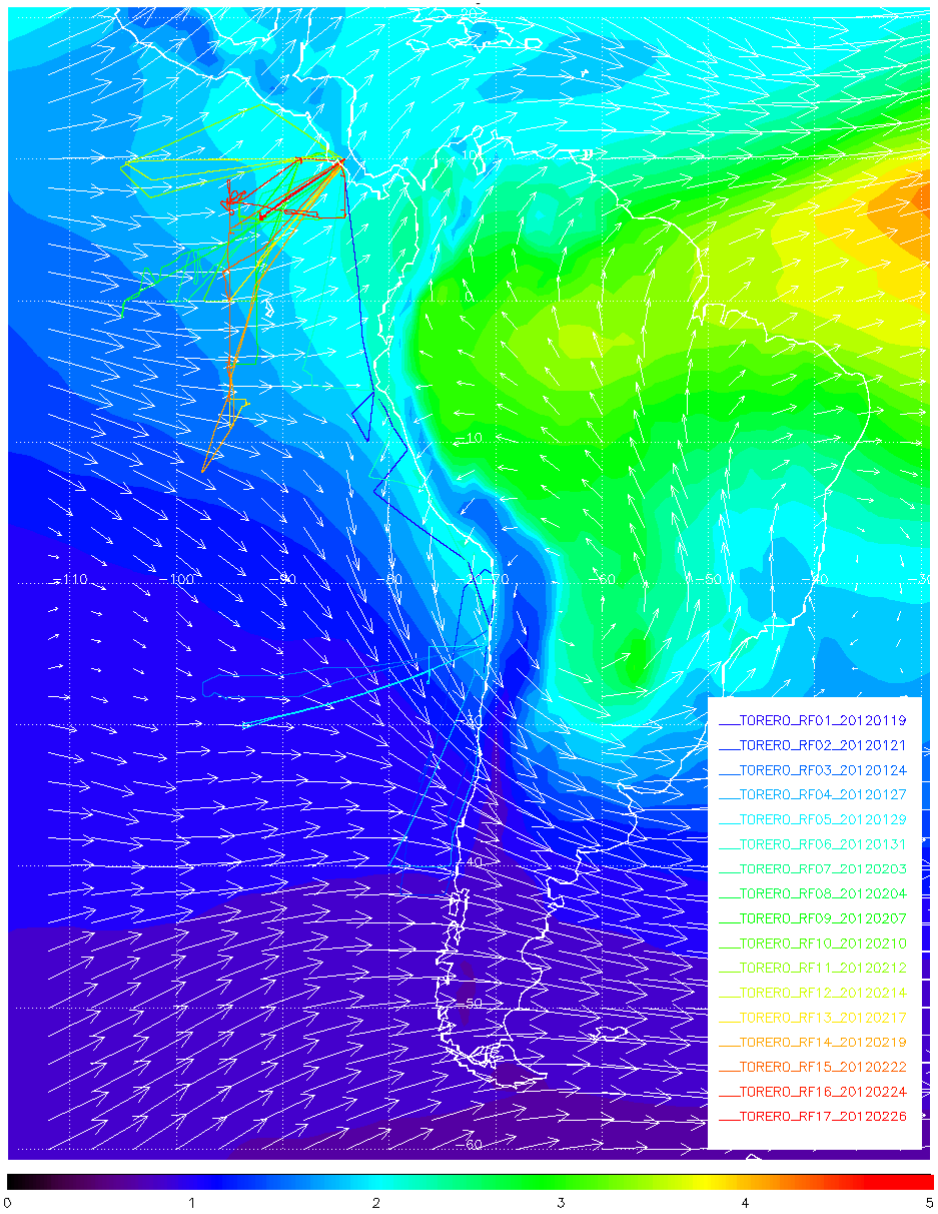




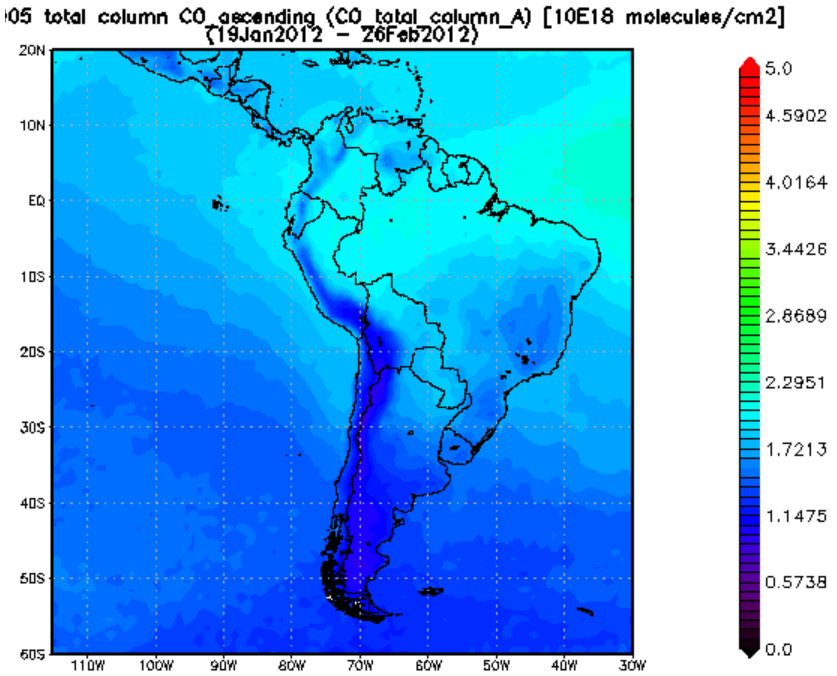
MODIS Mean WV Column Jan 19-Feb 26, 2012

Comparisons between RAQMS WV column and MODIS observations is generally very good although RAQMS shows lower WV column off the coast of Chile

RAQMS Mean CO Column Jan 19-Feb 26, 2012



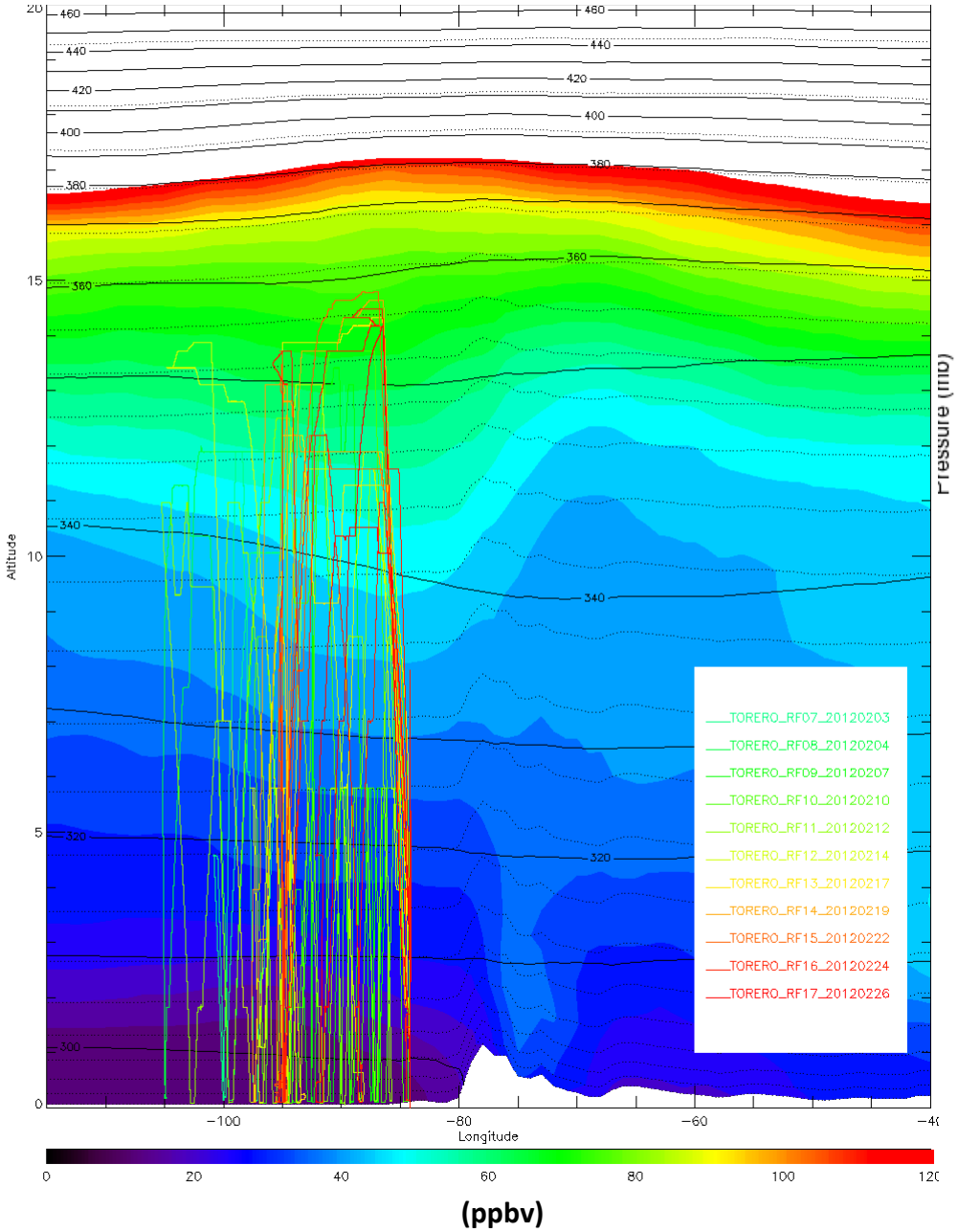
(10^{18} mol/cm^2)

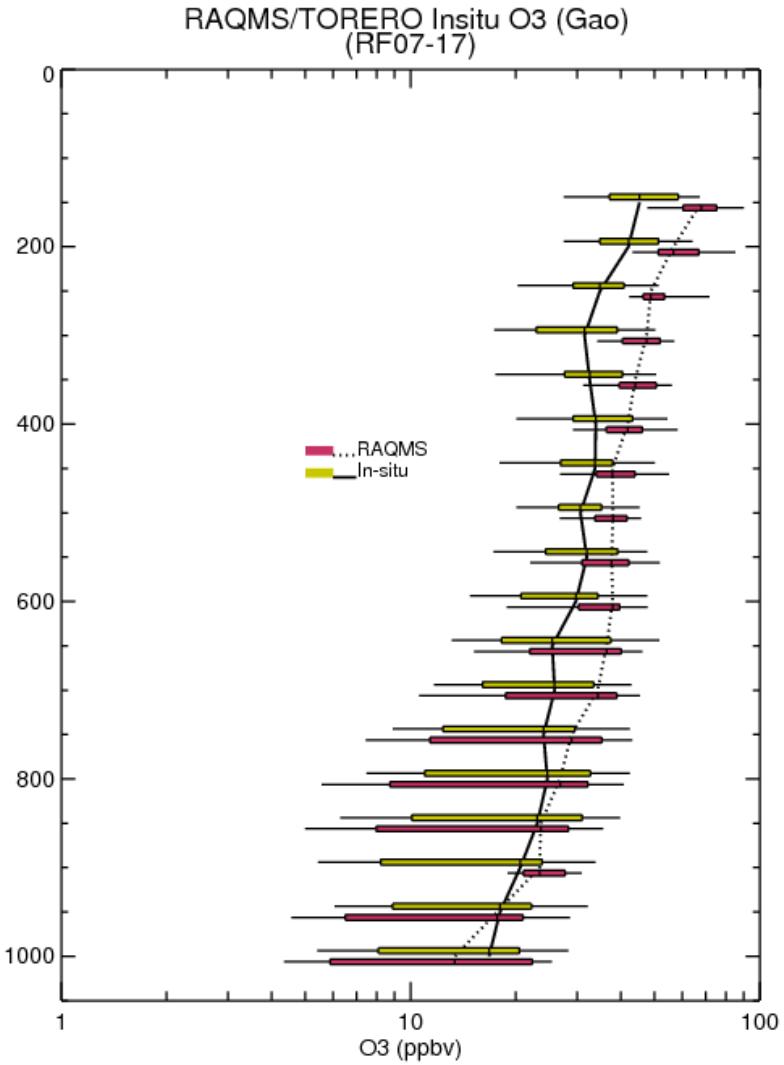


AIRS Mean CO Column Jan 19-Feb 26, 2012

Comparisons between RAQMS CO column and AIRS observations show that RAQMS overestimates continental CO over Brazil and underestimates maritime CO in the Southern Hemisphere. However, AIRS vertical sensitivity is not accounted for in these comparisons

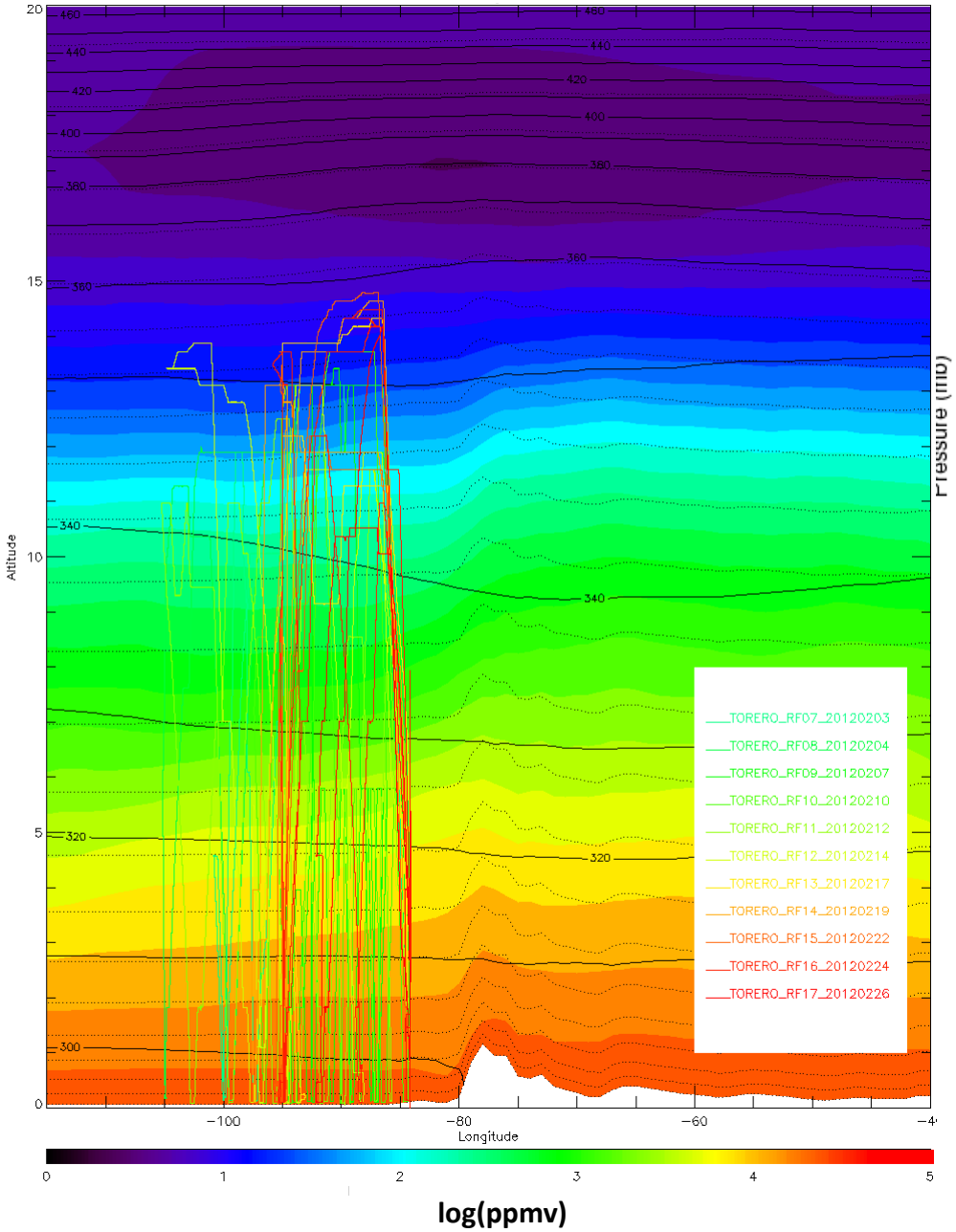
RAQMS Mean O3 10N-10S Cross Section Jan 19-Feb 26, 2012

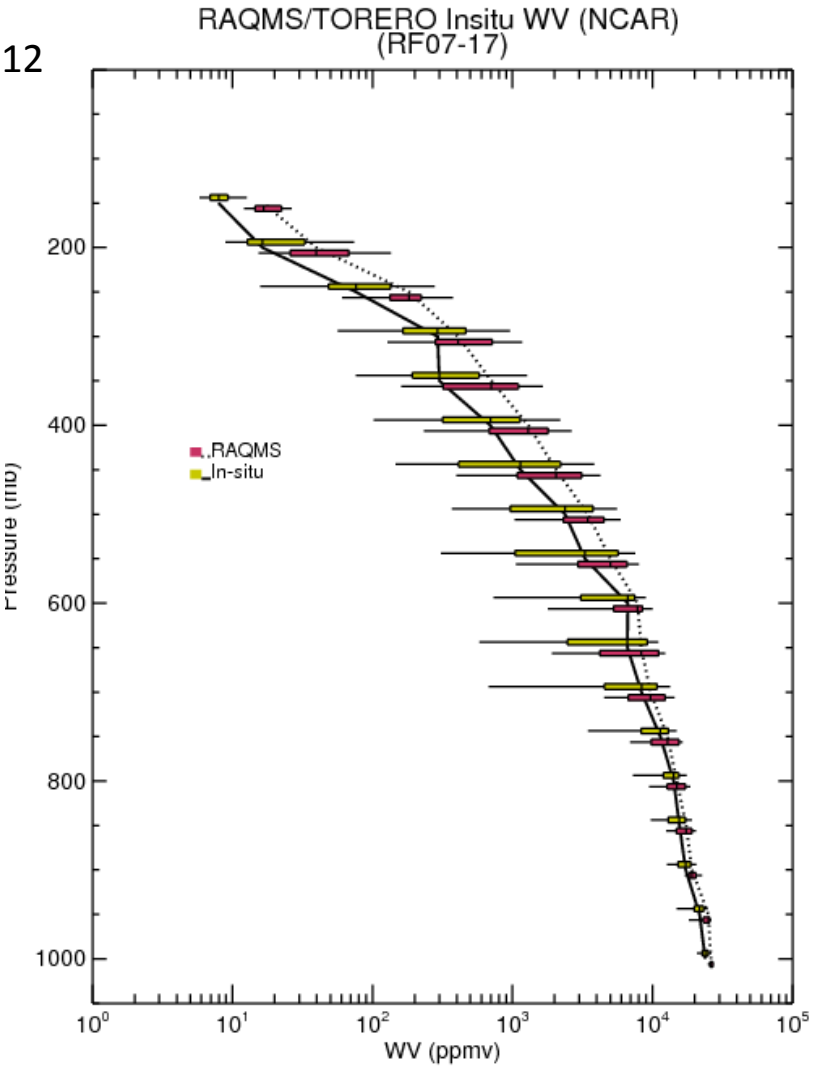




Comparison with insitu O3 shows that RAQMS overestimates median O3 above 800mb

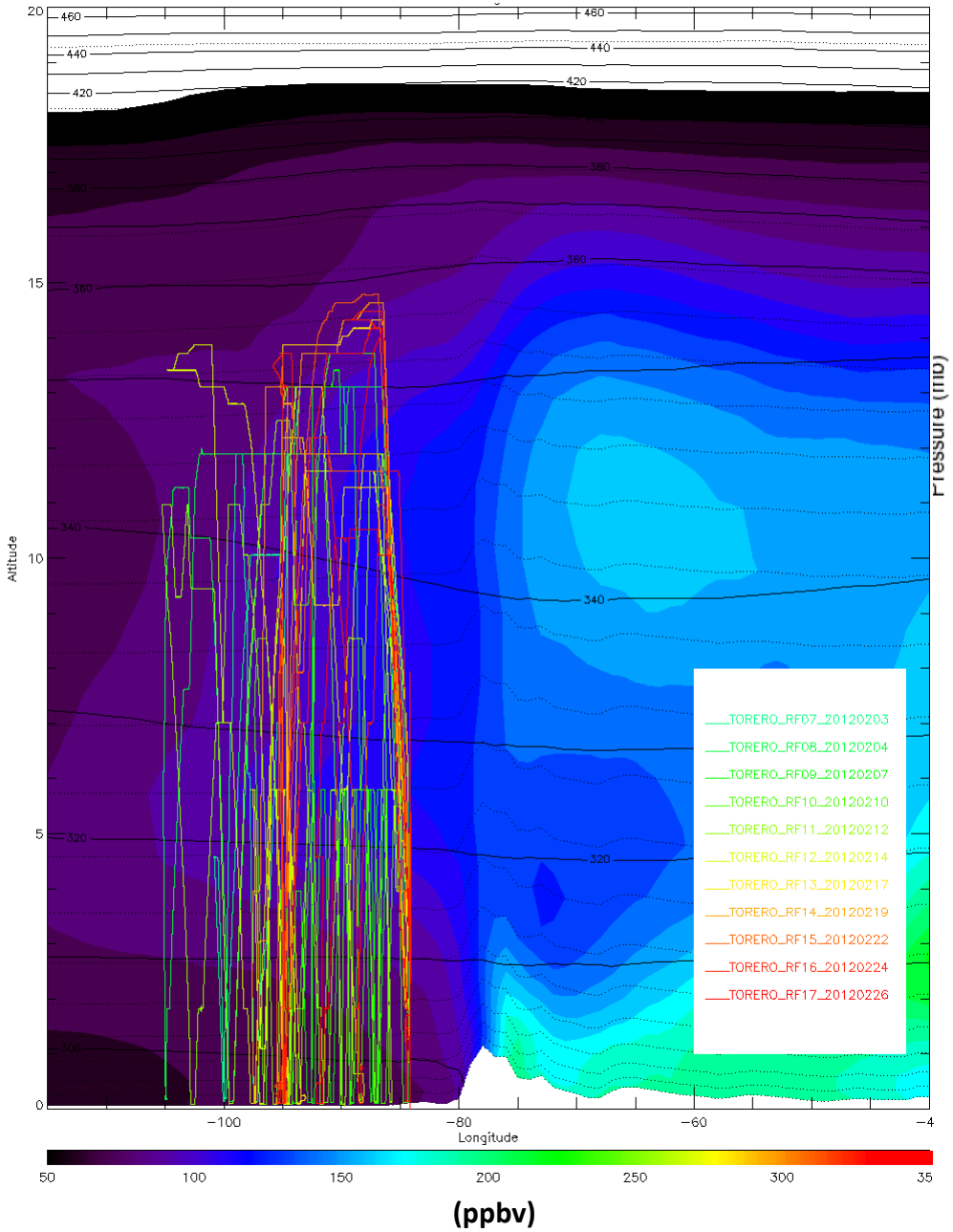
RAQMS Mean WV Cross Section 10N-10S Jan 19-Feb 26, 2012

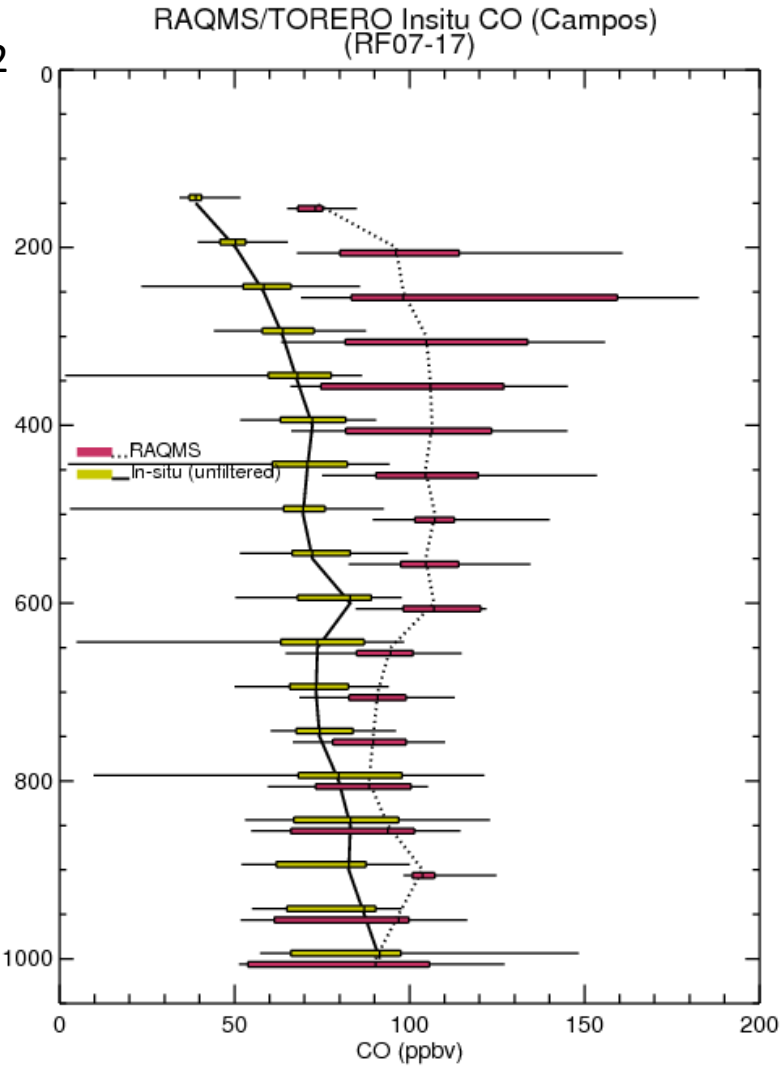




Comparison with insitu WV shows that RAQMS also overestimates median WV

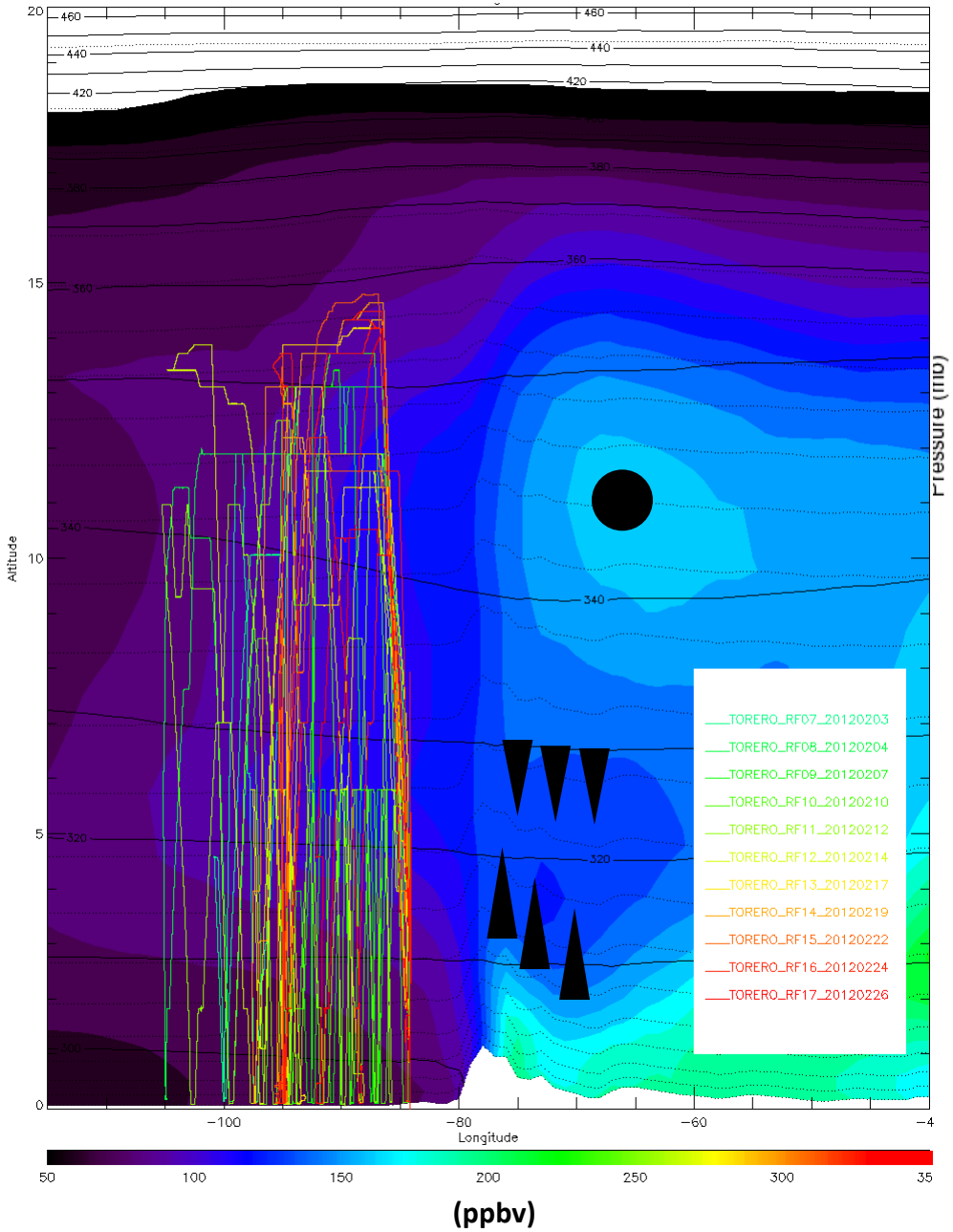
RAQMS Mean CO Cross Section 10N-10S Jan 19-Feb 26, 2012

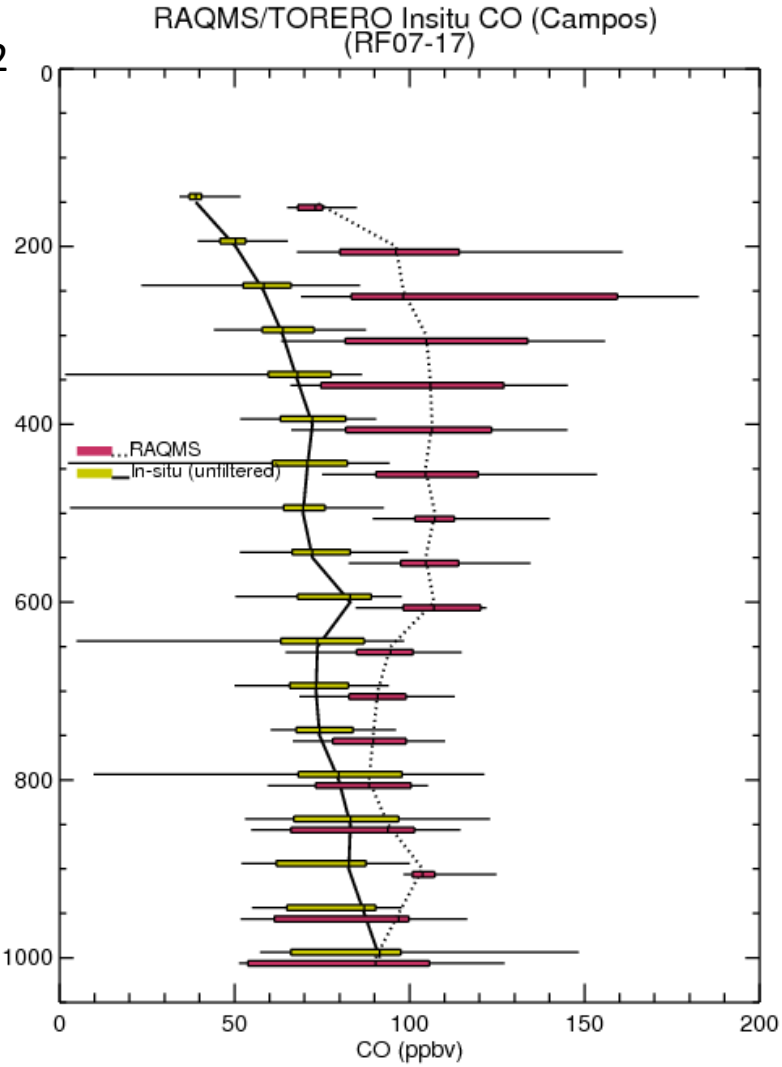




Comparison with insitu CO shows that RAQMS significantly overestimates median CO

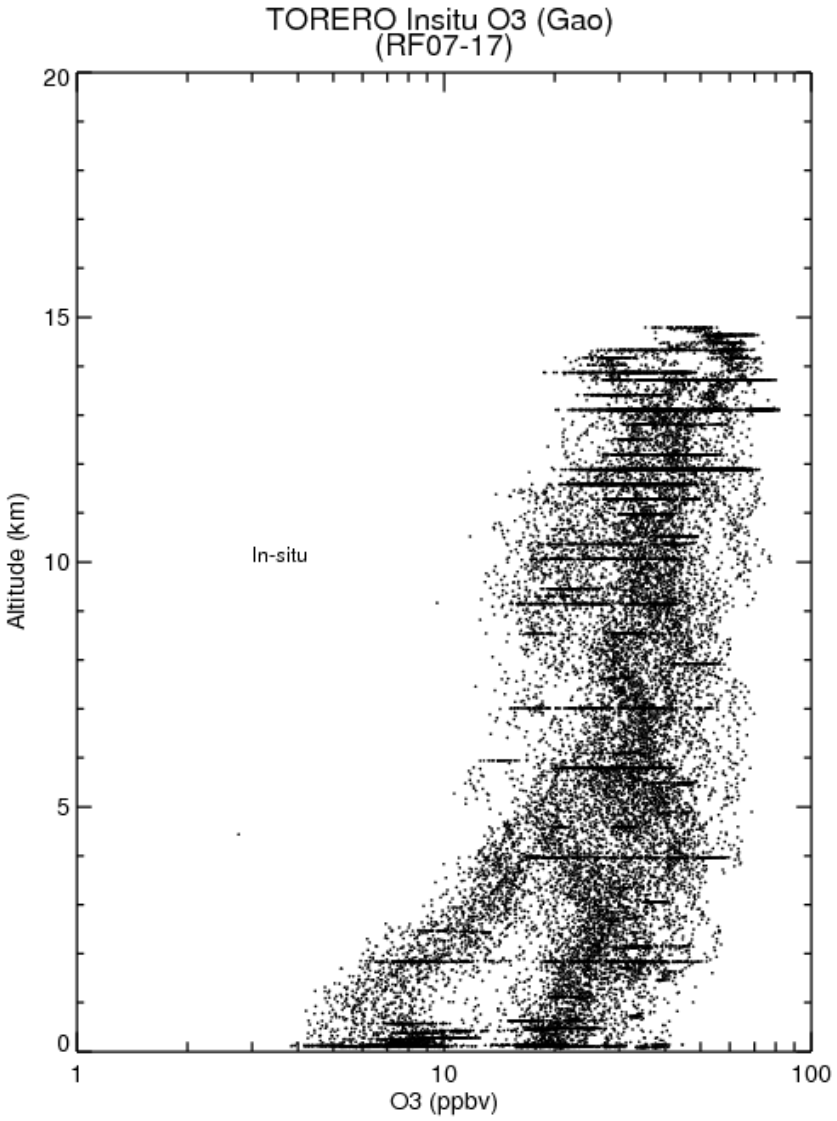
RAQMS Mean CO Cross Section 10N-10S Jan 19-Feb 26, 2012

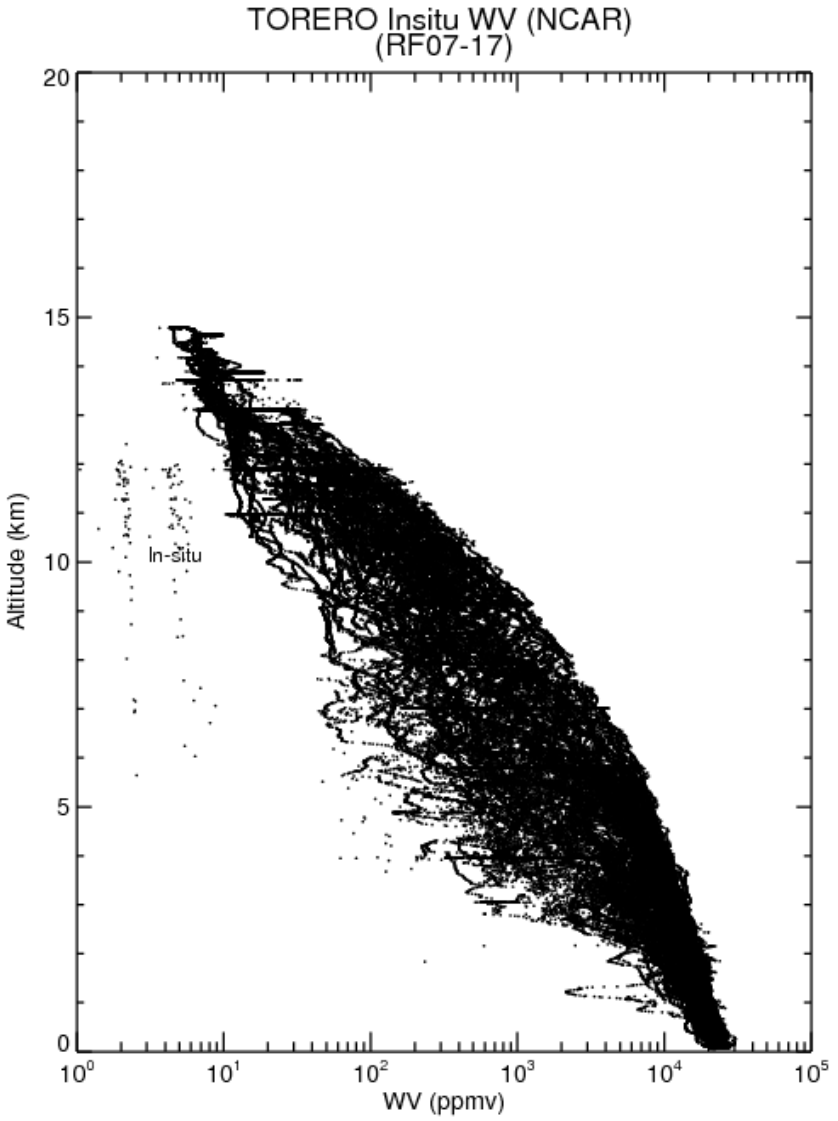




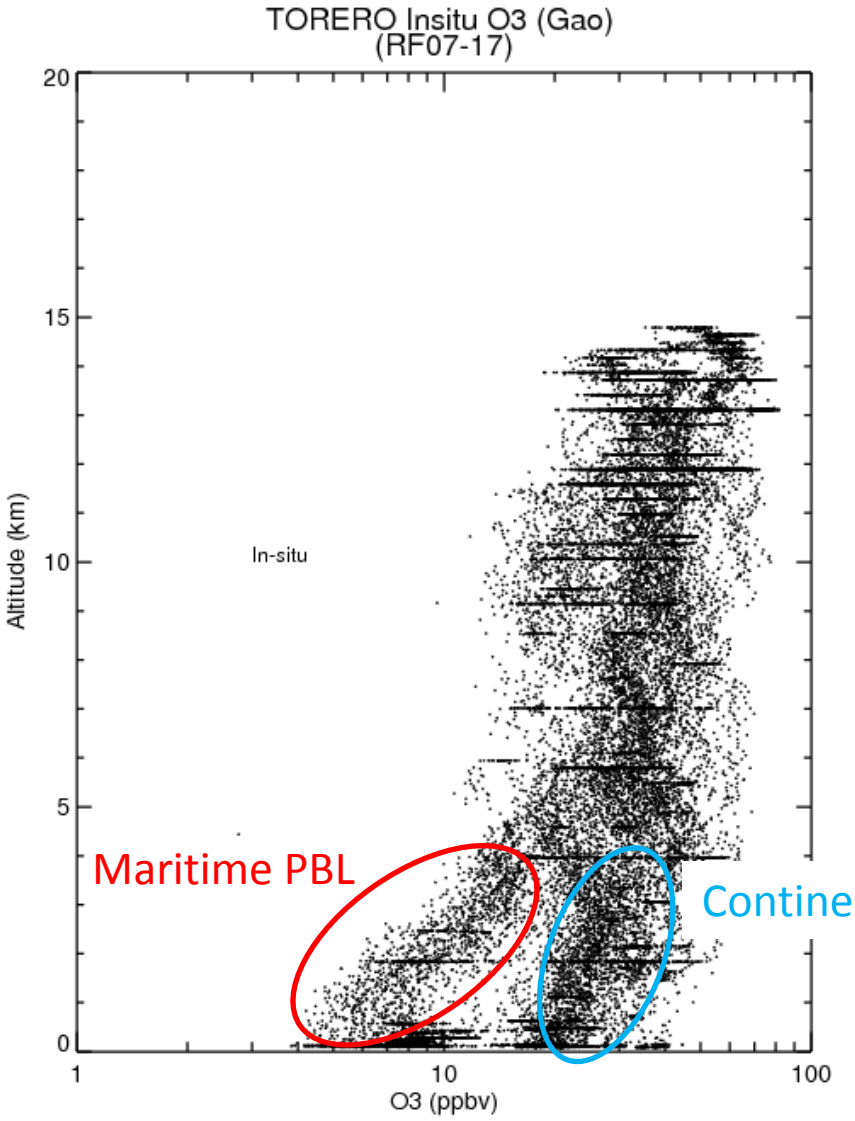
RAQMS continental profile is consistent with convective outflow of polluted air at 12km

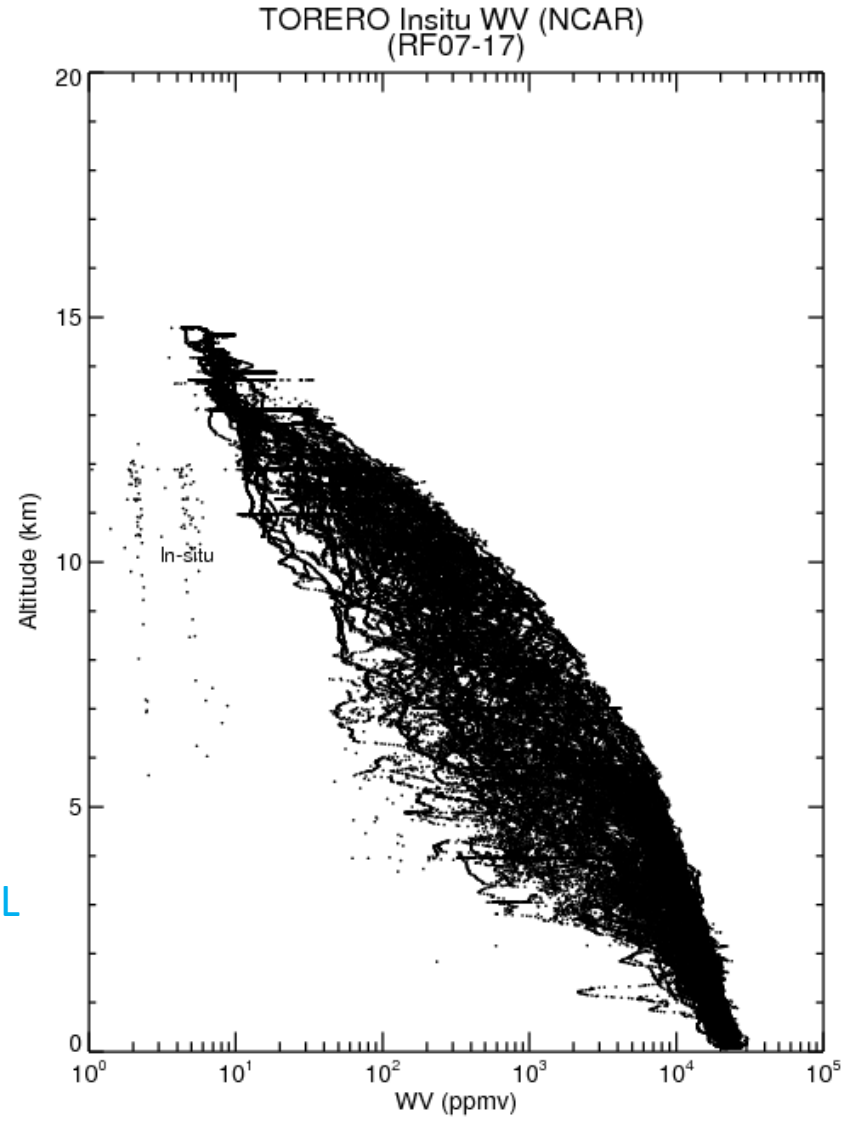
Insitu O3 (Gao) and WV (NCAR) vertical Profiles for RF07-17



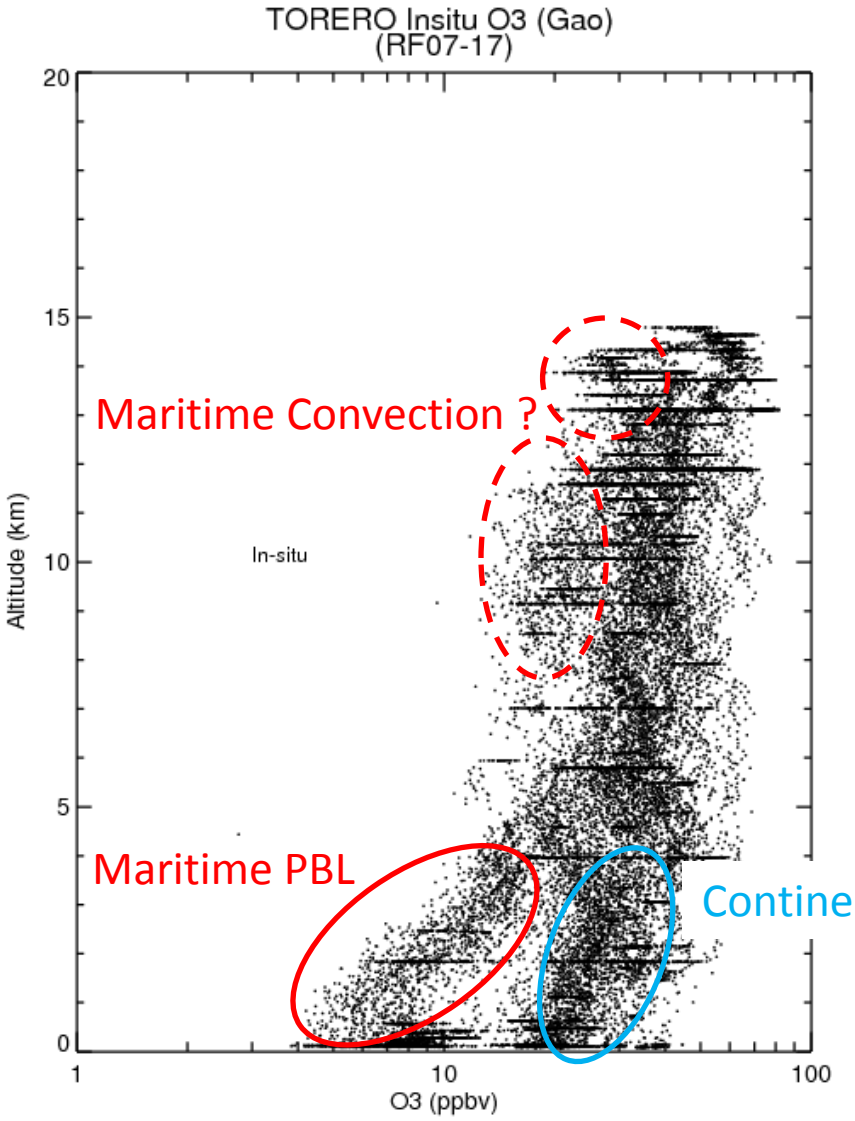


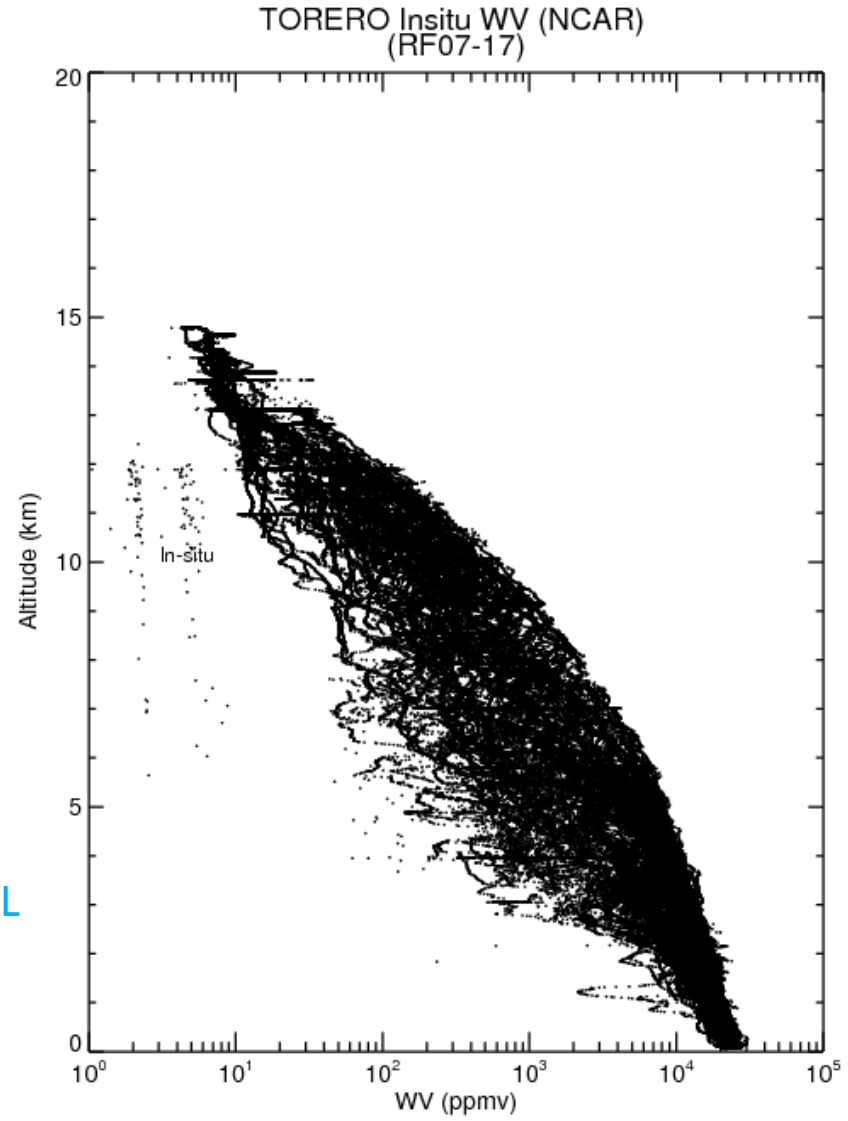
Insitu O3 (Gao) and WV (NCAR) vertical Profiles for RF07-17



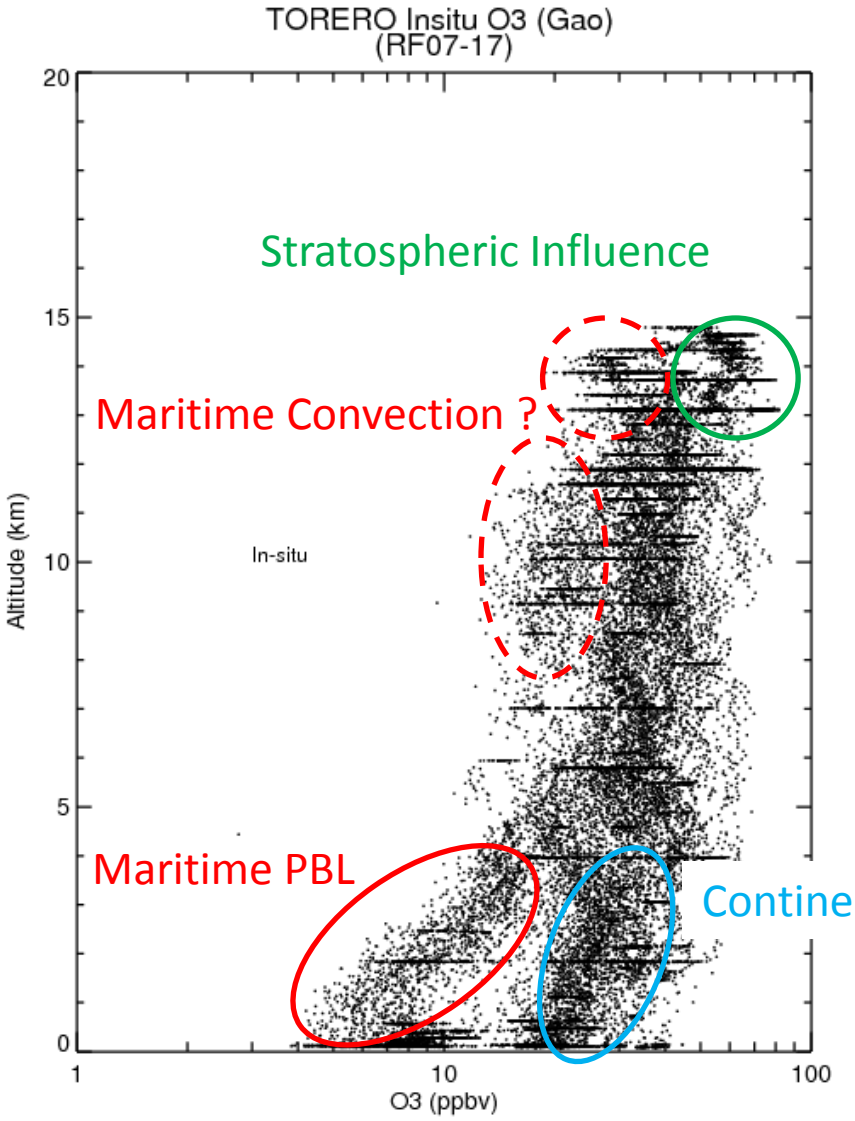


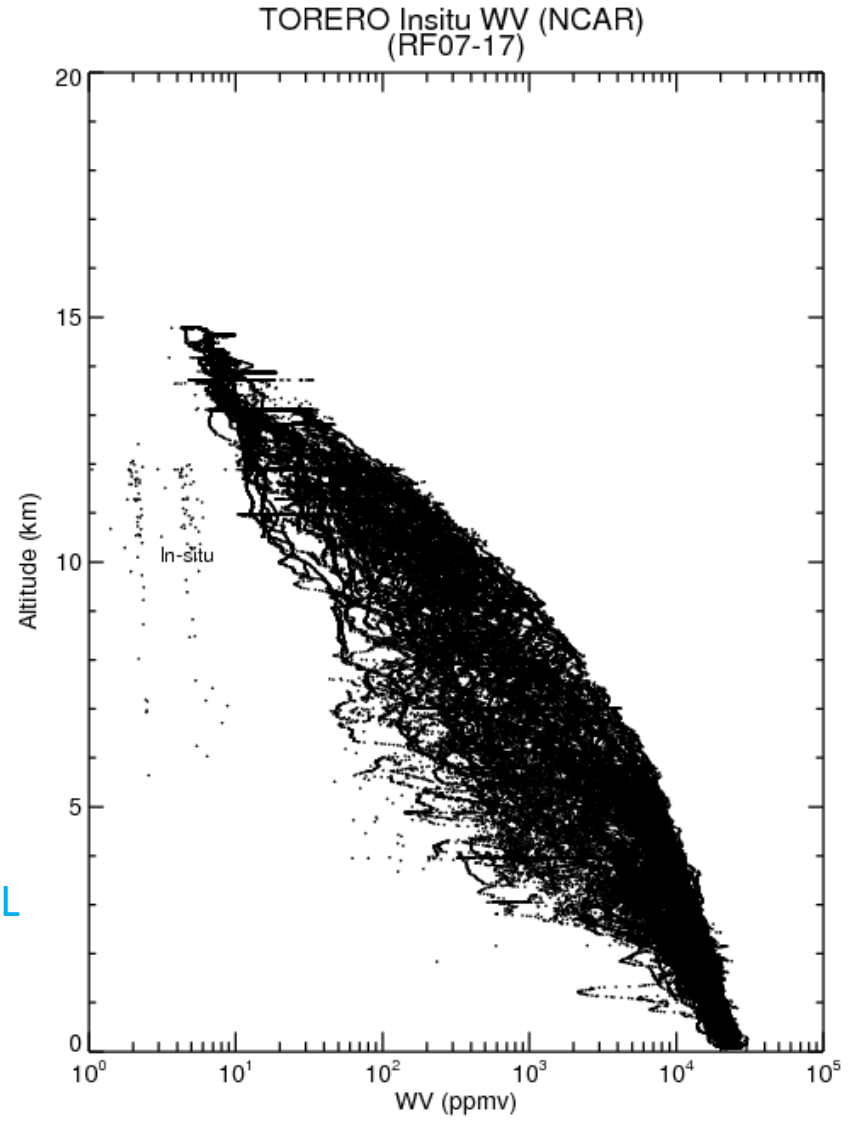
Insitu O3 (Gao) and WV (NCAR) vertical Profiles for RF07-17



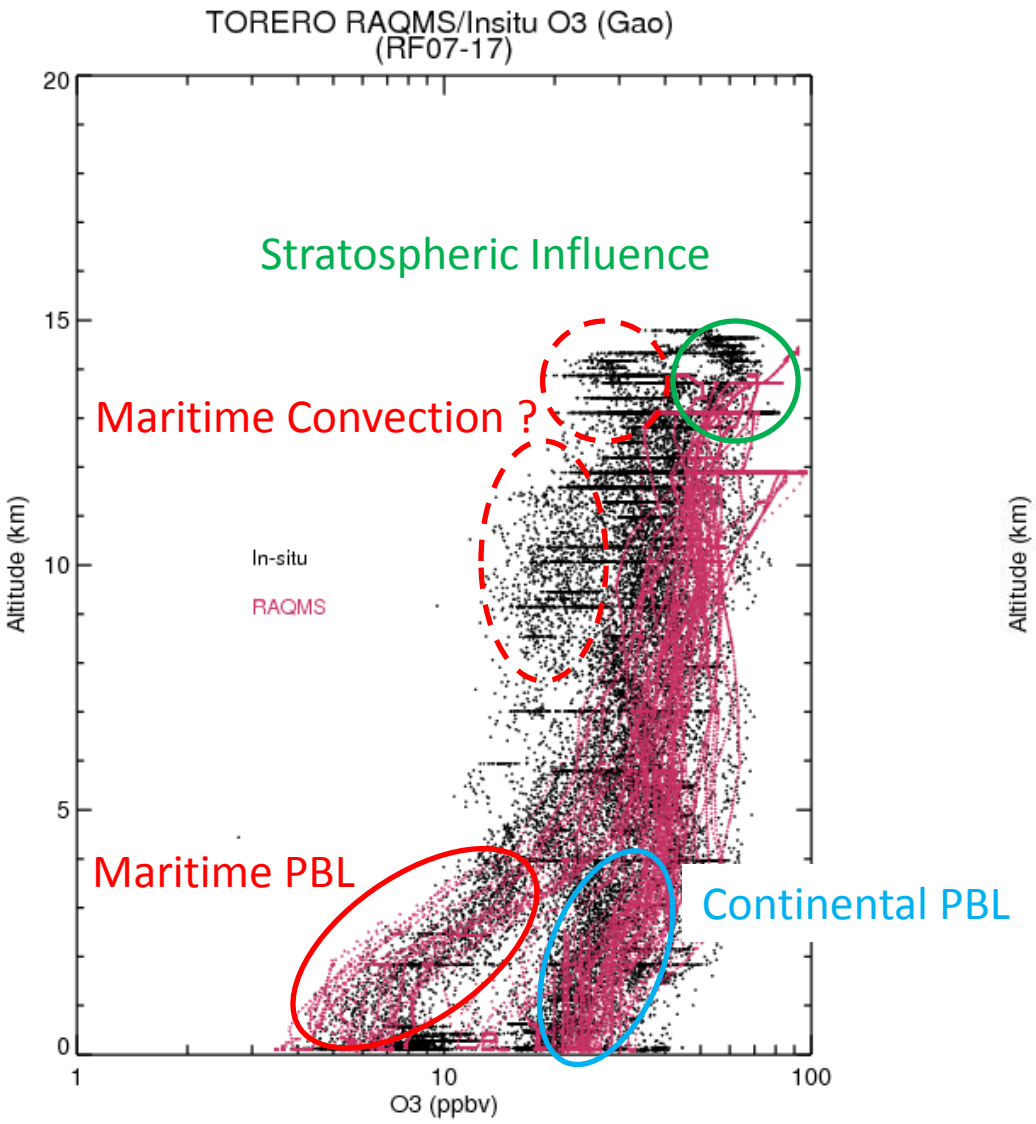


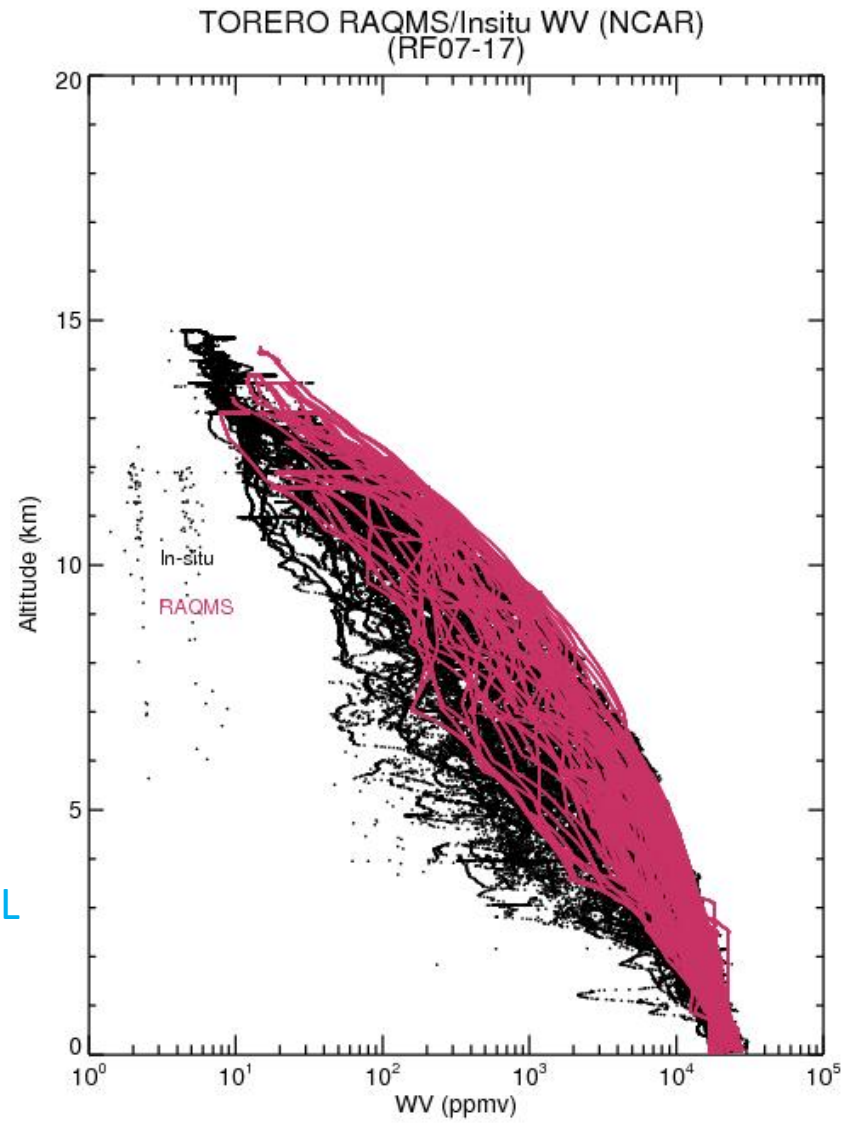
Insitu O3 (Gao) and WV (NCAR) vertical Profiles for RF07-17



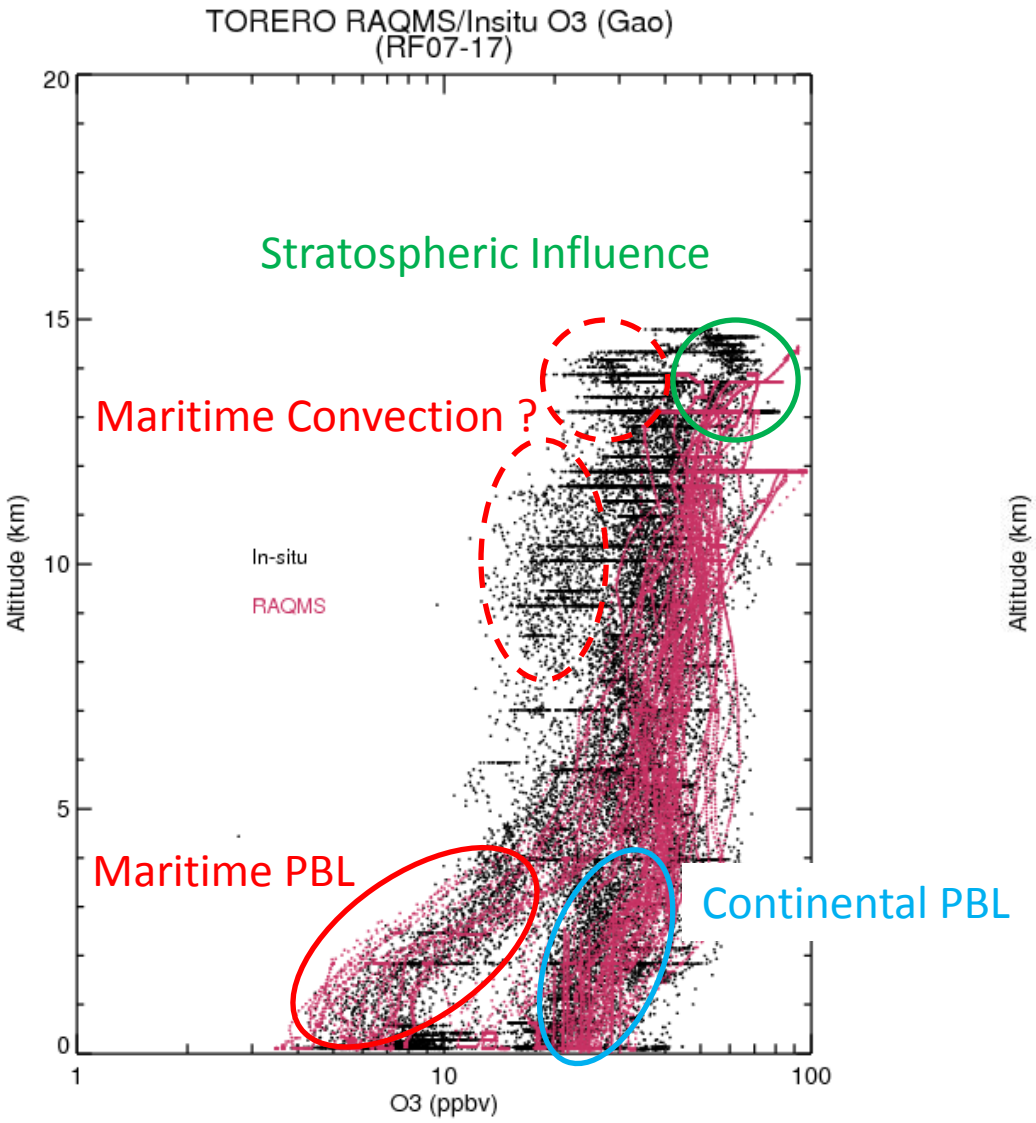


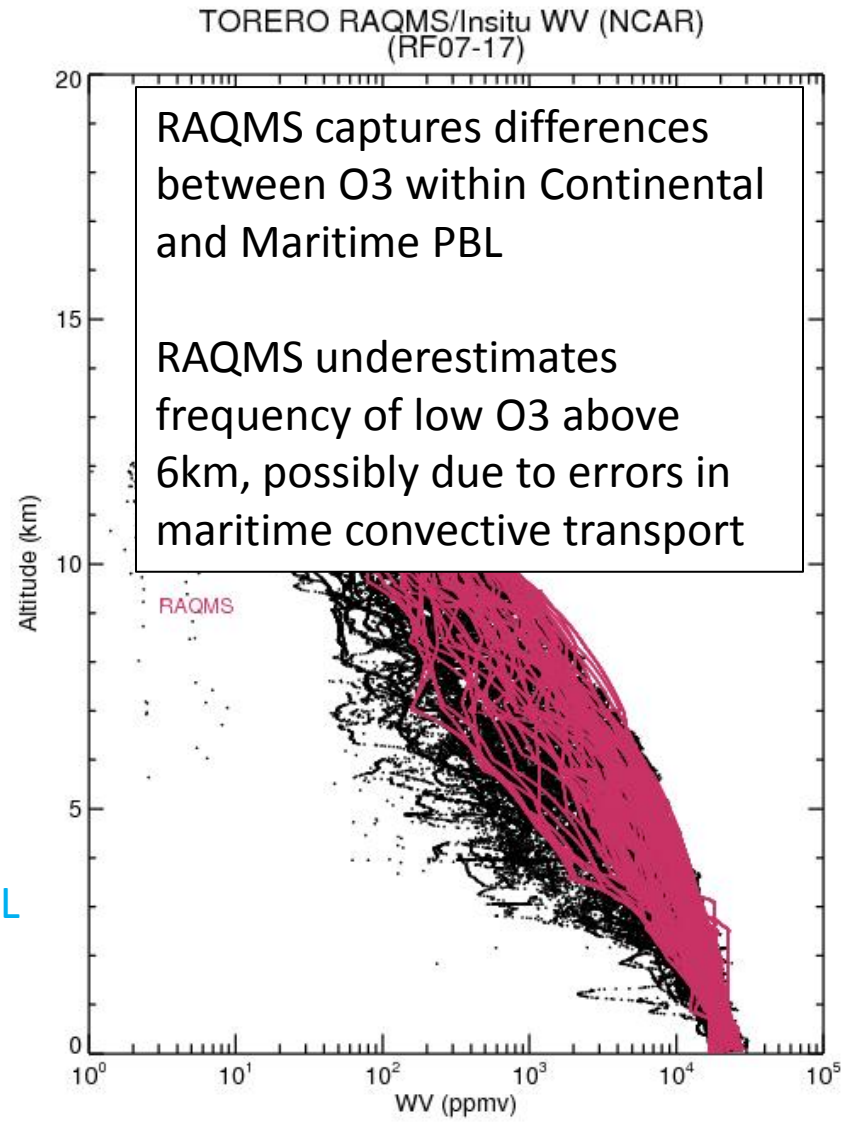
RAQMS/Insitu O3 (Gao) and WV (NCAR) vertical Profiles for RF07-17



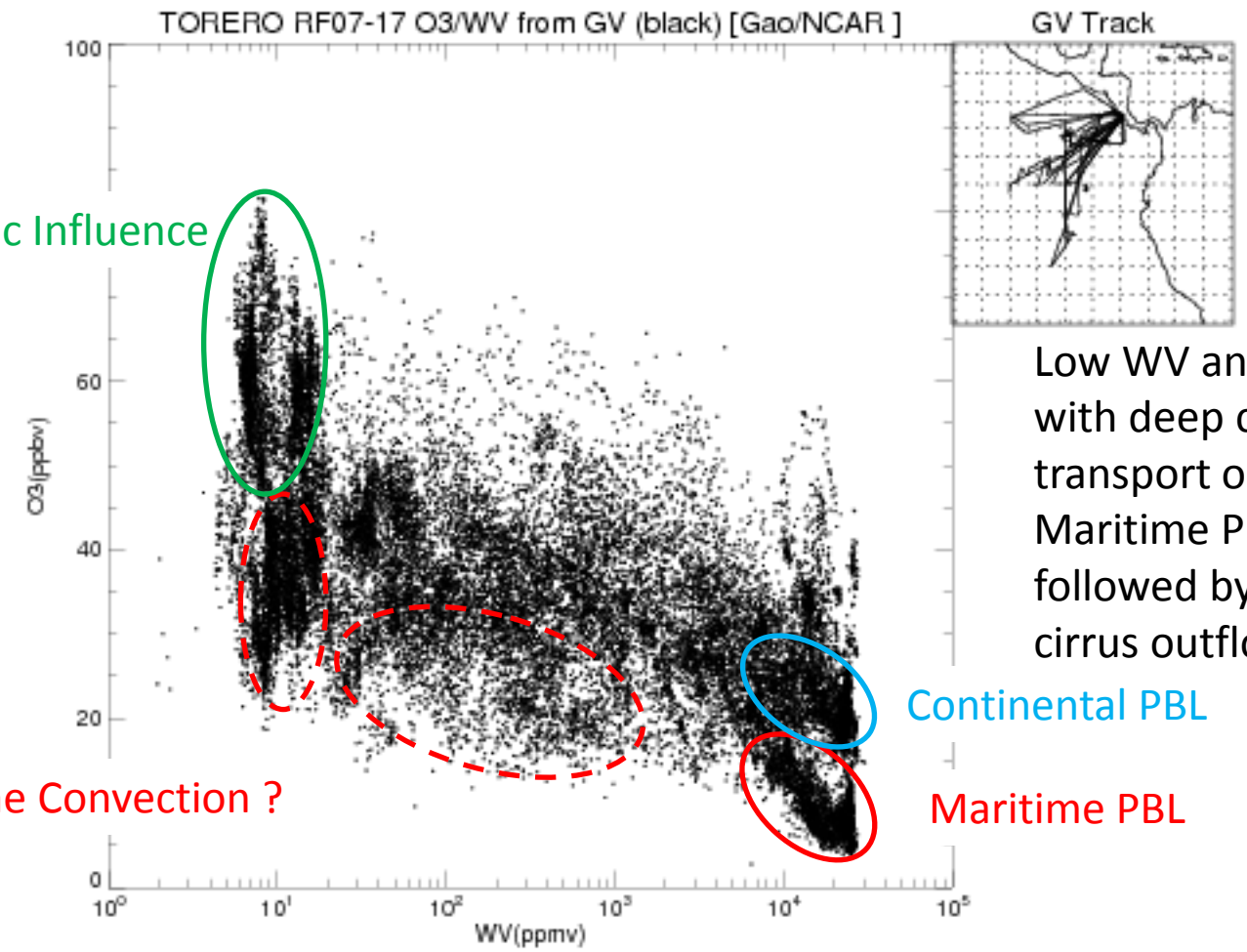


RAQMS/Insitu O3 (Gao) and WV (NCAR) vertical Profiles for RF07-17





Insitu O3 (Gao) verses WV (NCAR) Scatter Plot for RF07-17



Stratospheric Influence

Low WV and O3 consistent with deep convective transport out of the Maritime PBL (low O3) followed by dehydration in cirrus outflow (low WV)

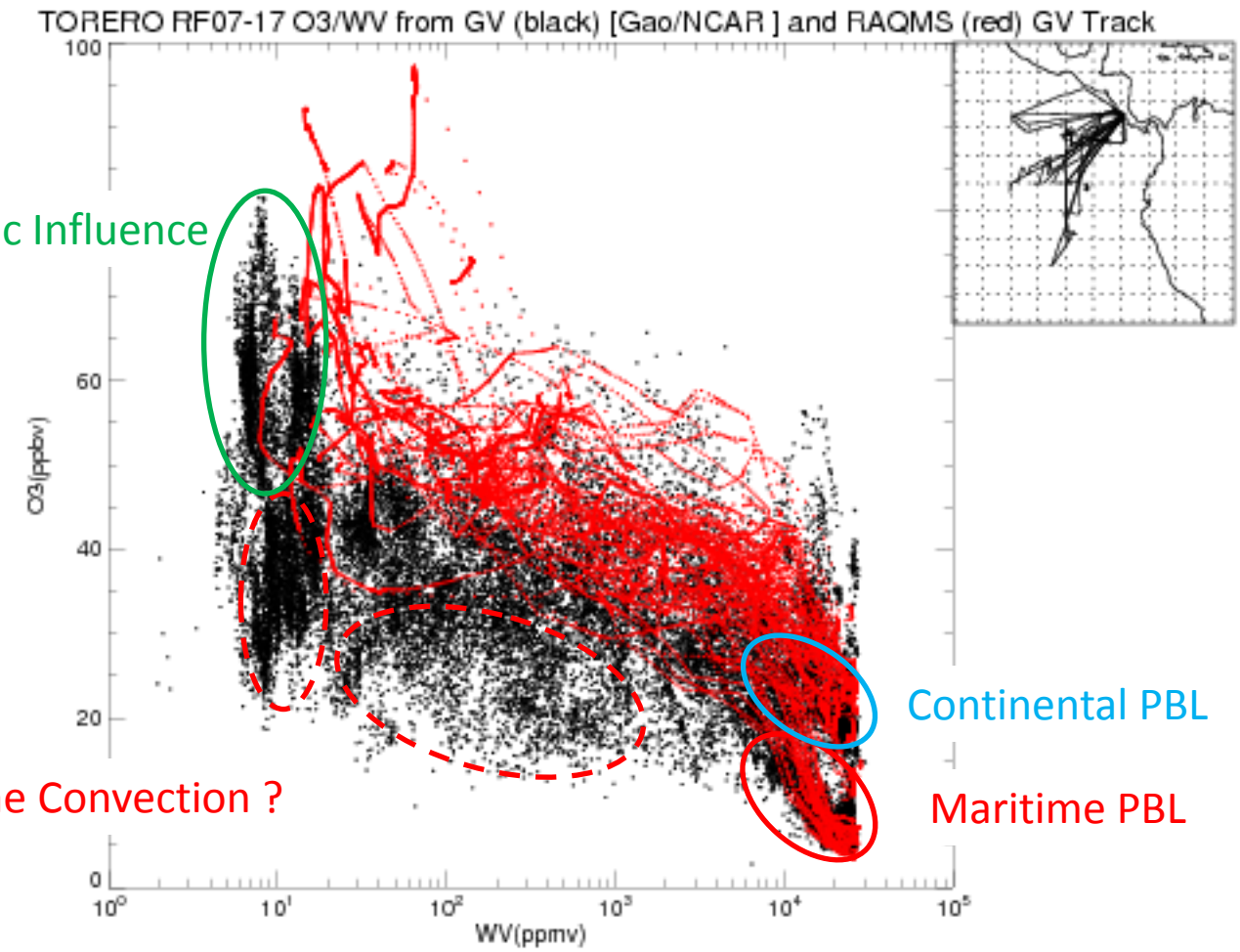
Continental PBL

Maritime Convection ?

Maritime PBL

Wed Jul 18 12:41:23 2012

RAQMS/Insitu O3 (Gao) verses WV (NCAR) Scatter Plot for RF07-17



Stratospheric Influence

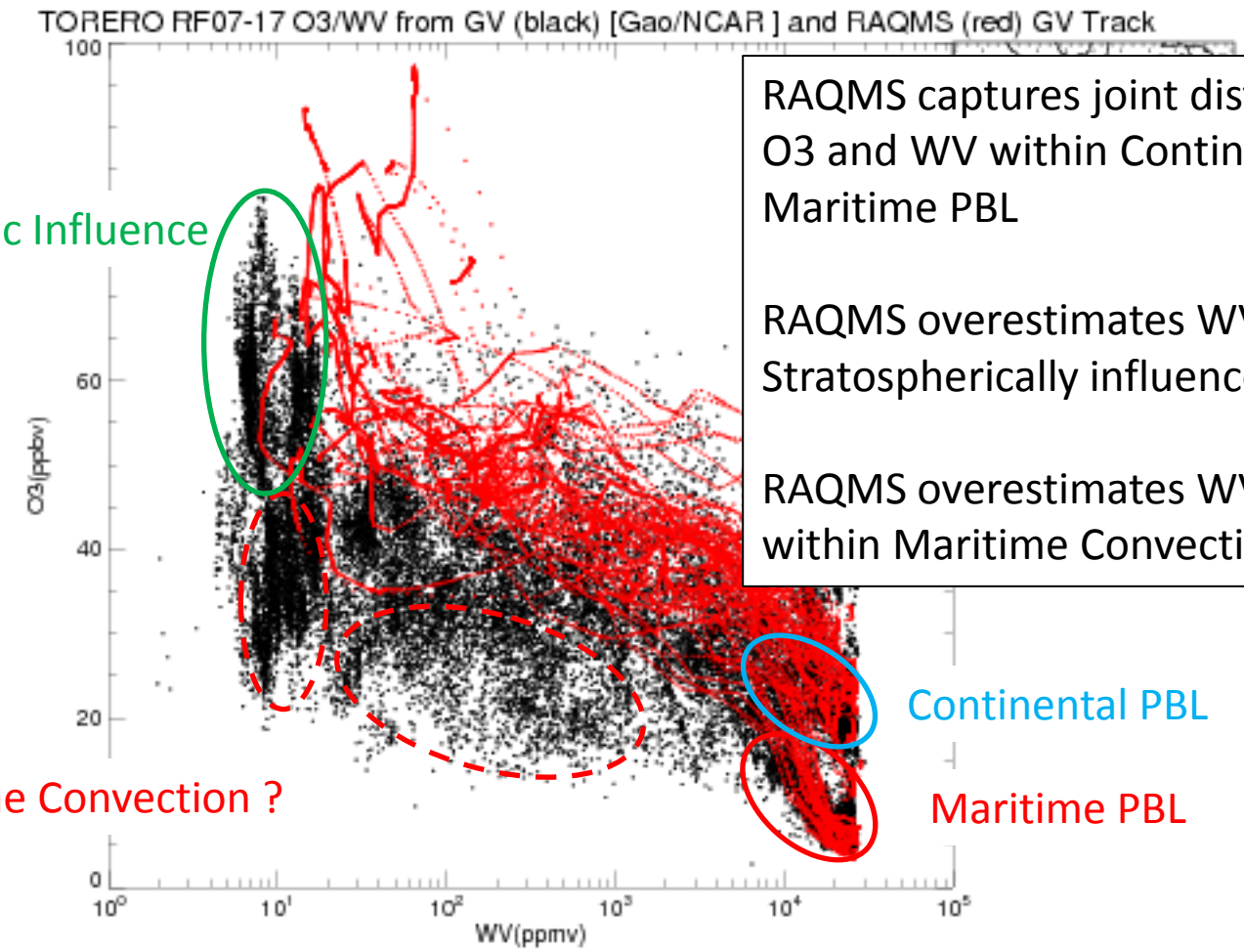
Continental PBL

Maritime Convection ?

Maritime PBL

Wed Jul 18 12:42:22 2012

RAQMS/Insitu O3 (Gao) verses WV (NCAR) vertical Profiles for RF07-17



Stratospheric Influence

Maritime Convection ?

Continental PBL

Maritime PBL

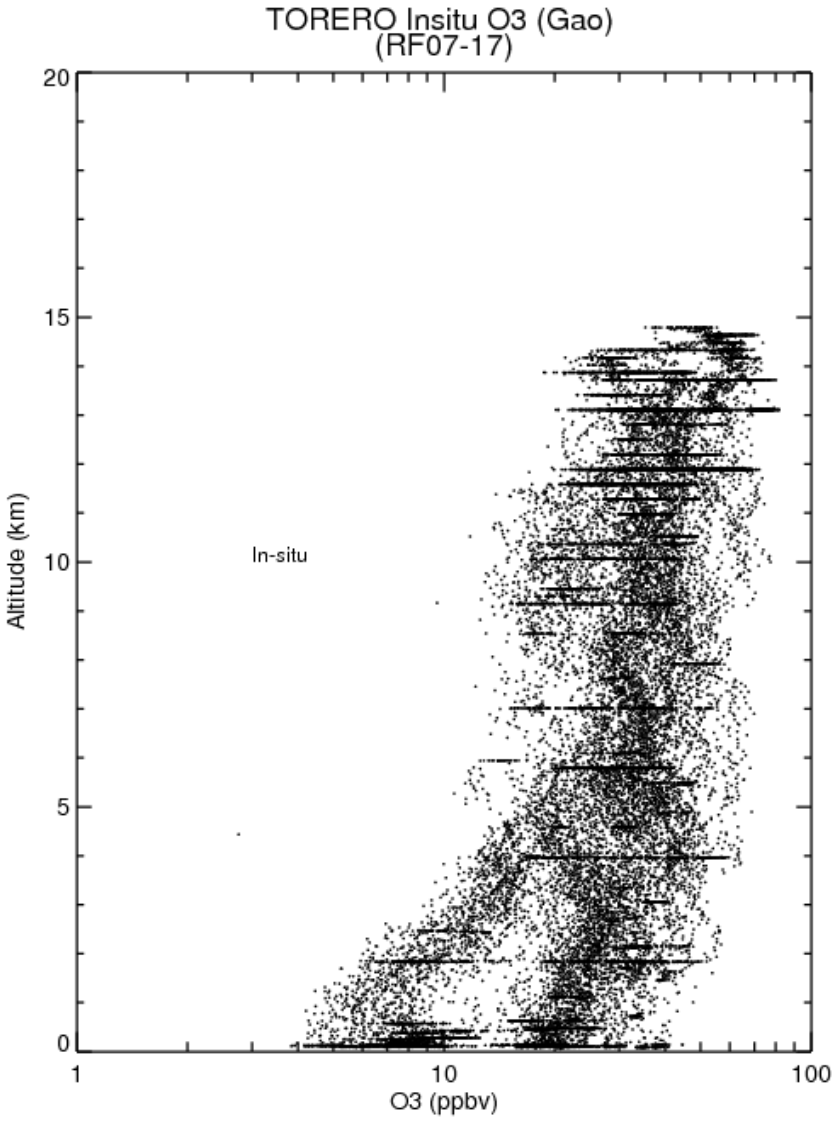
RAQMS captures joint distribution of O3 and WV within Continental and Maritime PBL

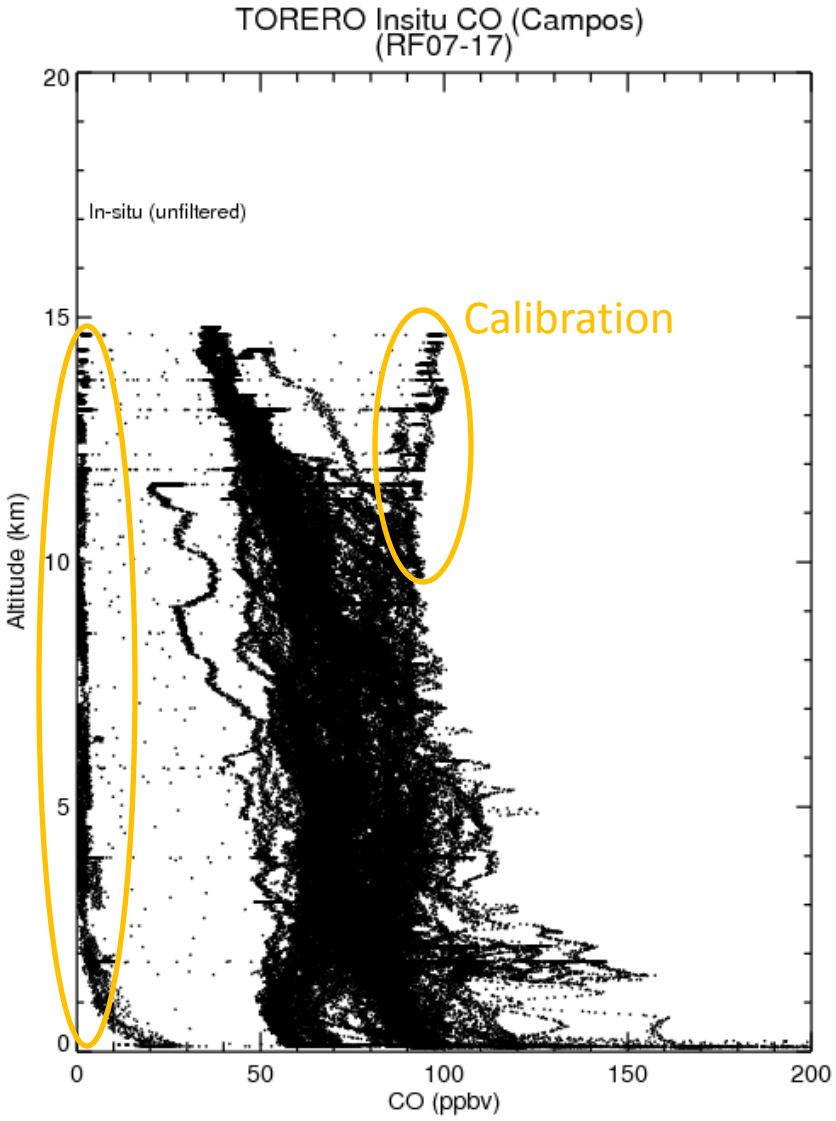
RAQMS overestimates WV within Stratospherically influence air

RAQMS overestimates WV and O3 within Maritime Convective outflow

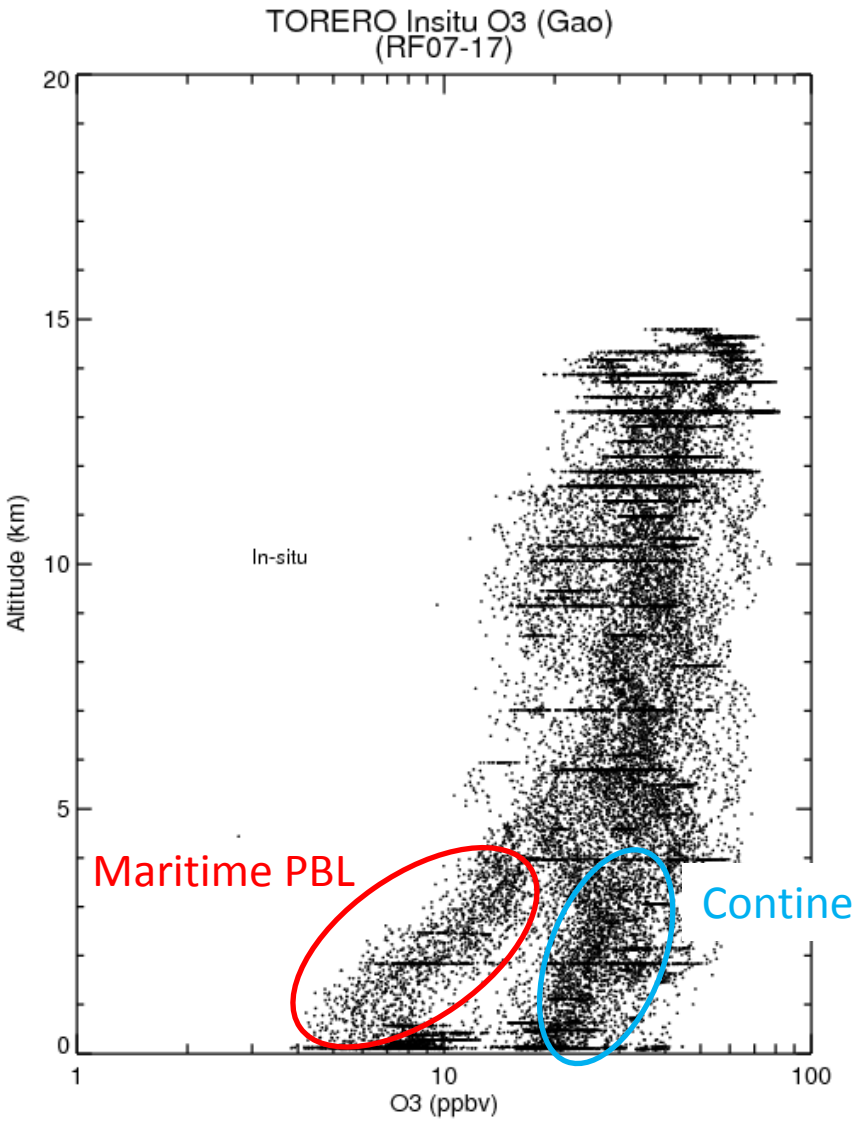
Wed Jul 18 12:42:22 2012

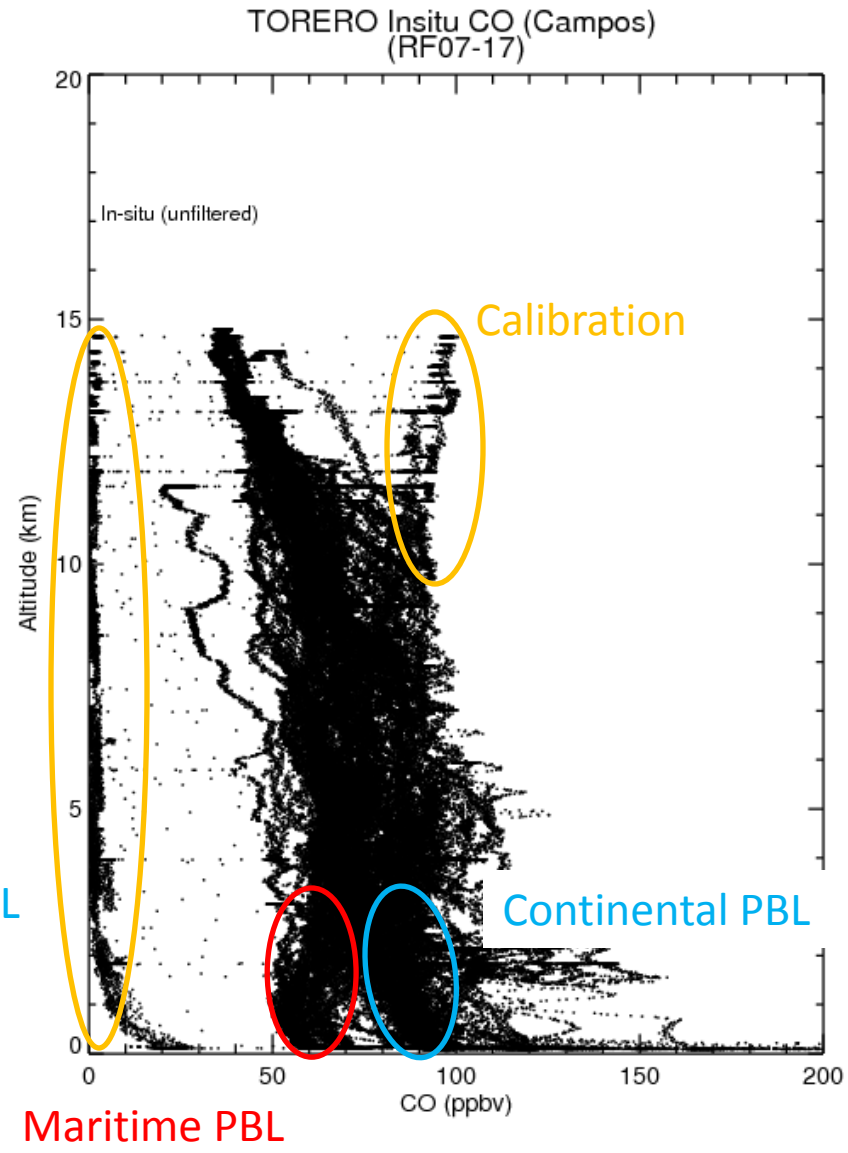
Insitu O3 (Gao) and CO (Campos) vertical Profiles for RF07-17



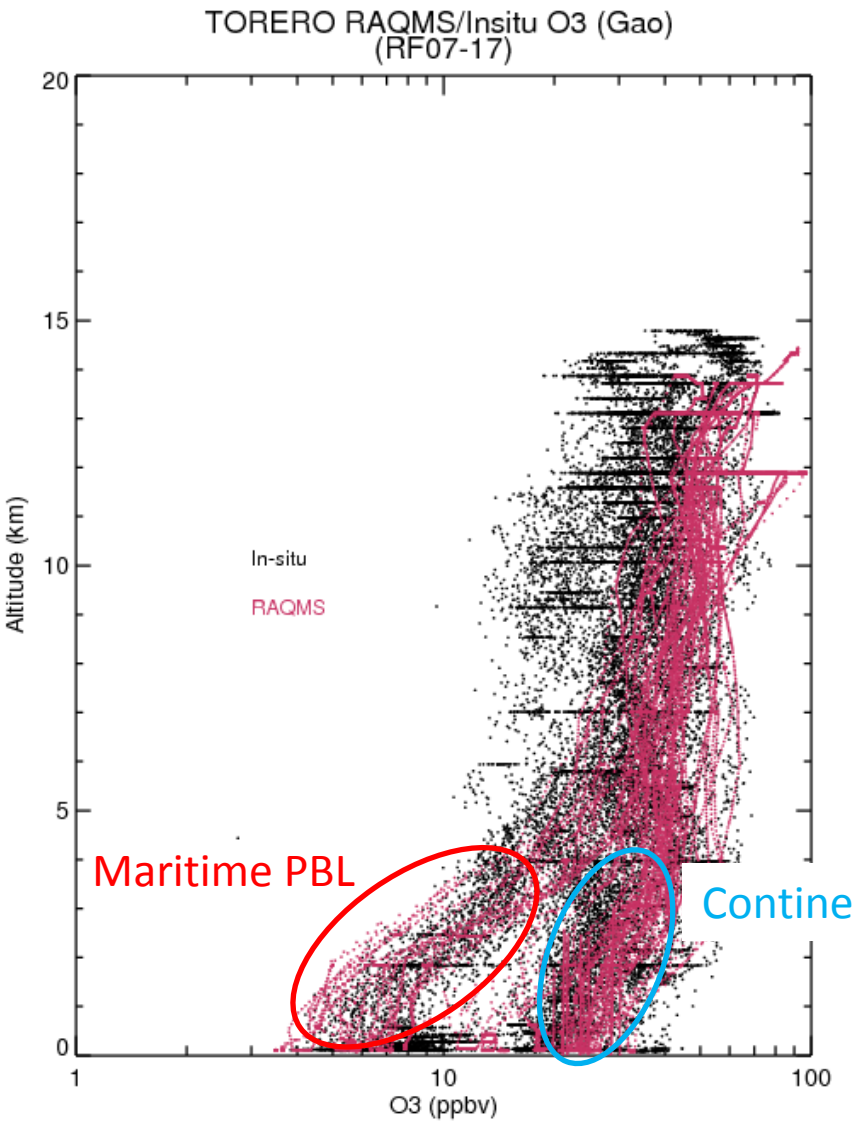


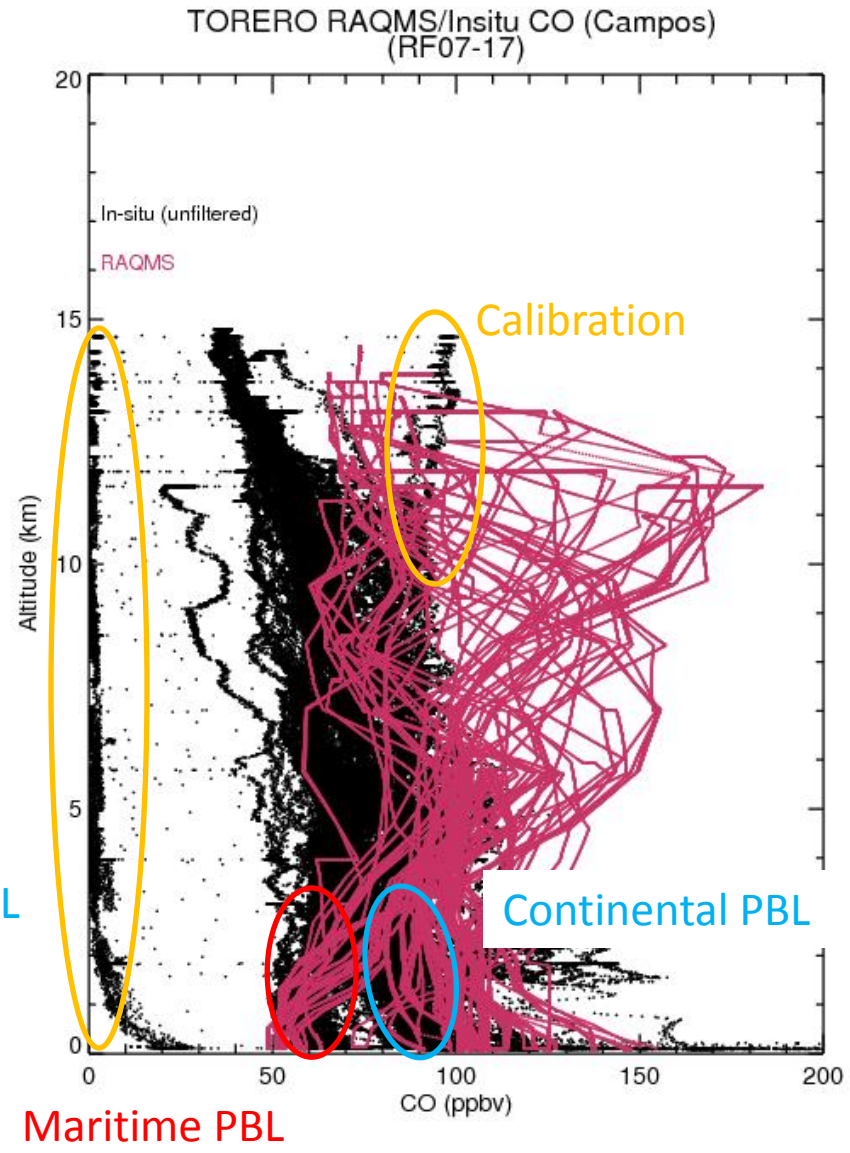
Insitu O3 (Gao) and CO (Campos) vertical Profiles for RF07-17



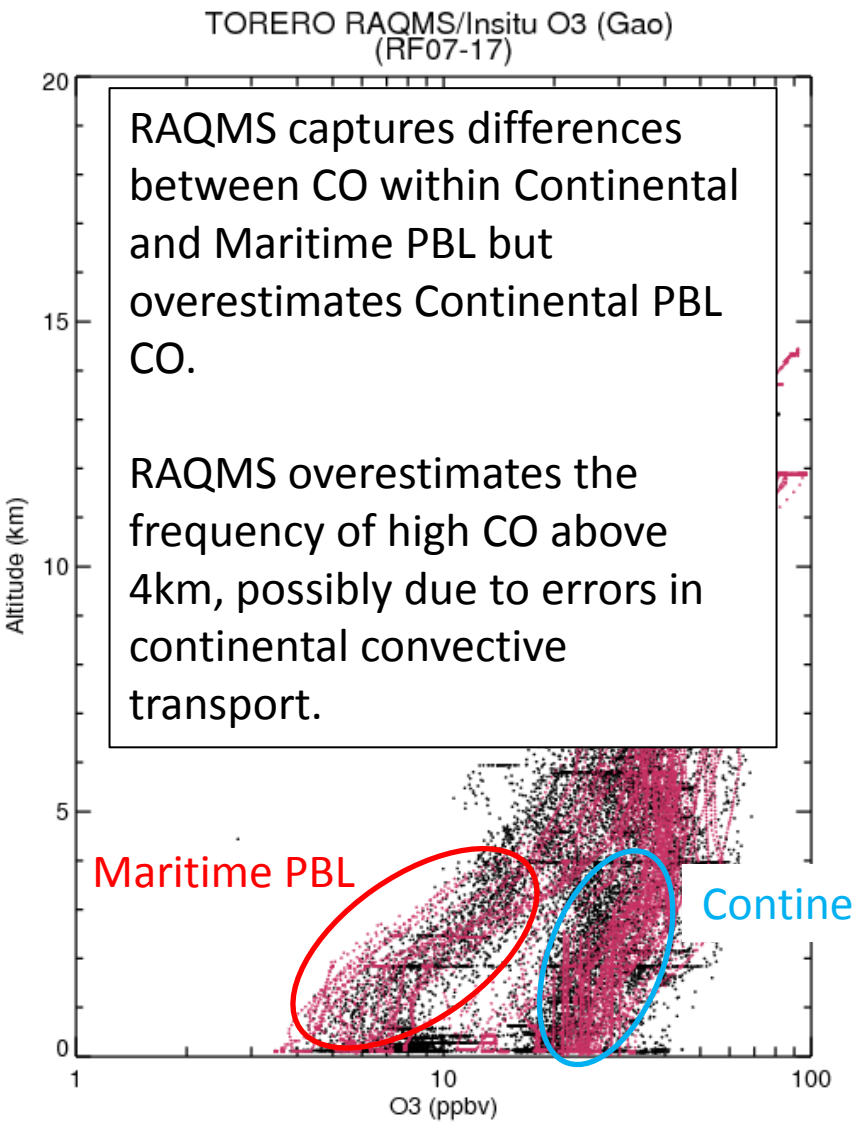


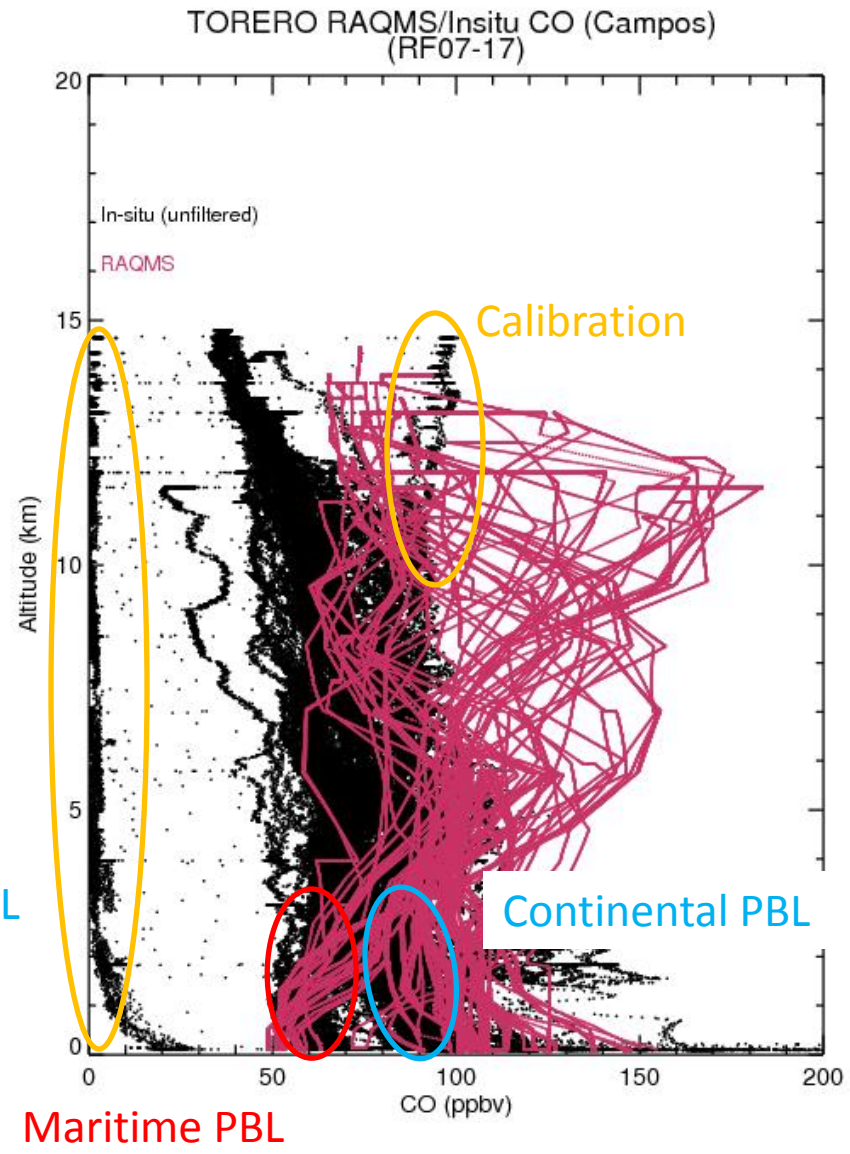
RAQMS/Insitu O3 (Gao) and CO (Campos) vertical Profiles for RF07-17



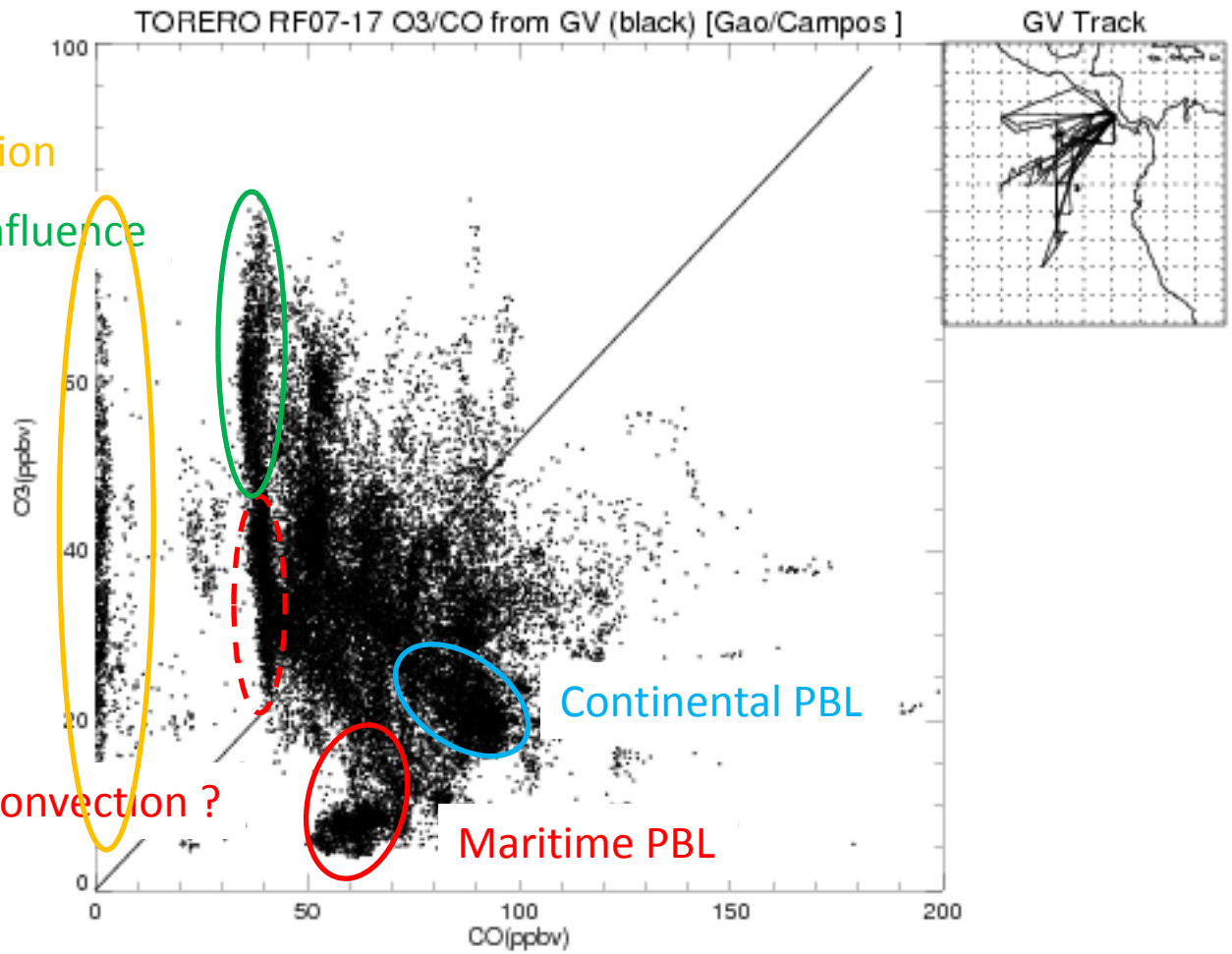


RAQMS/Insitu O3 (Gao) and CO (Campos) vertical Profiles for RF07-17



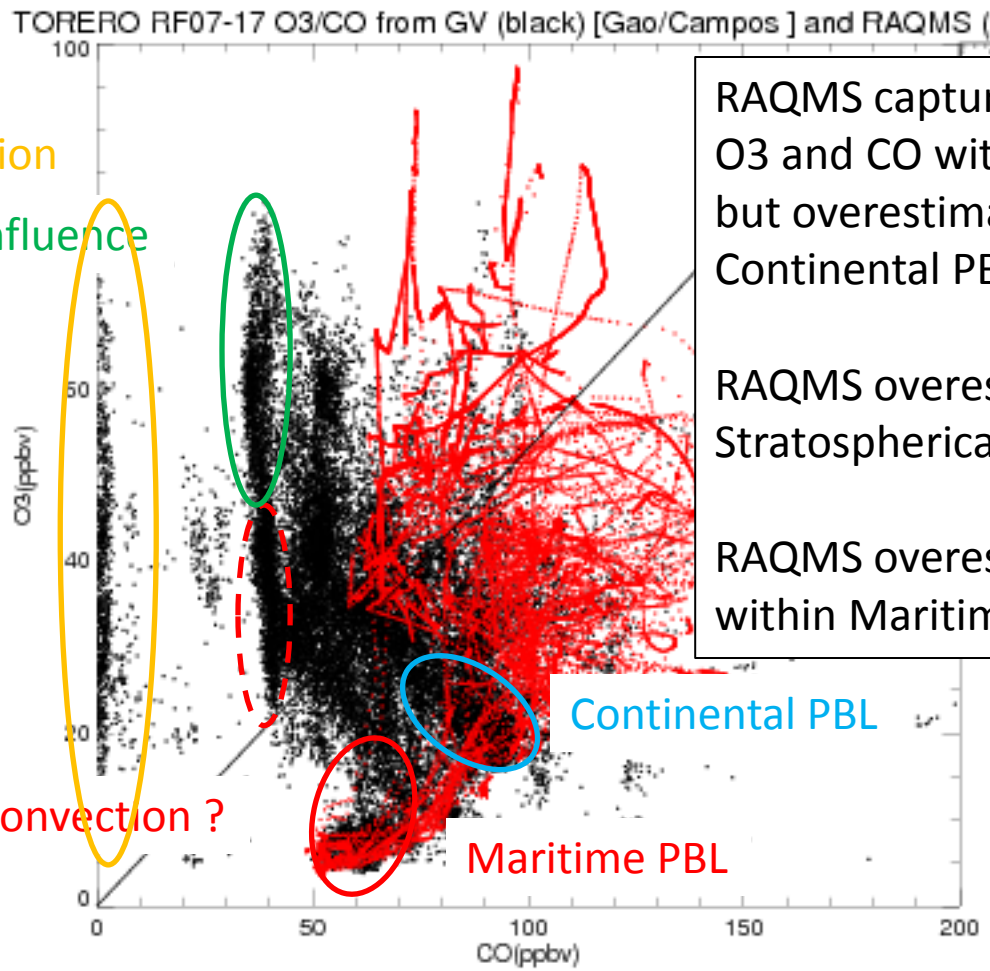


Insitu O3 (Gao) verses CO (Campos) Scatter plot for RF07-17



Wed Jul 18 12:36:34 2012

RAQMS/Insitu O3 (Gao) verses CO (Campos) Scatter plot for RF07-17



RAQMS captures joint distribution of O3 and CO within the Maritime PBL but overestimates CO within the Continental PBL

RAQMS overestimates CO within Stratospherically influence air

RAQMS overestimates CO and O3 within Maritime Convective outflow

Wed Jul 18 12:39:00 2012

J. H. Chae et al.: The role of tropical deep convective clouds in the tropical tropopause layer

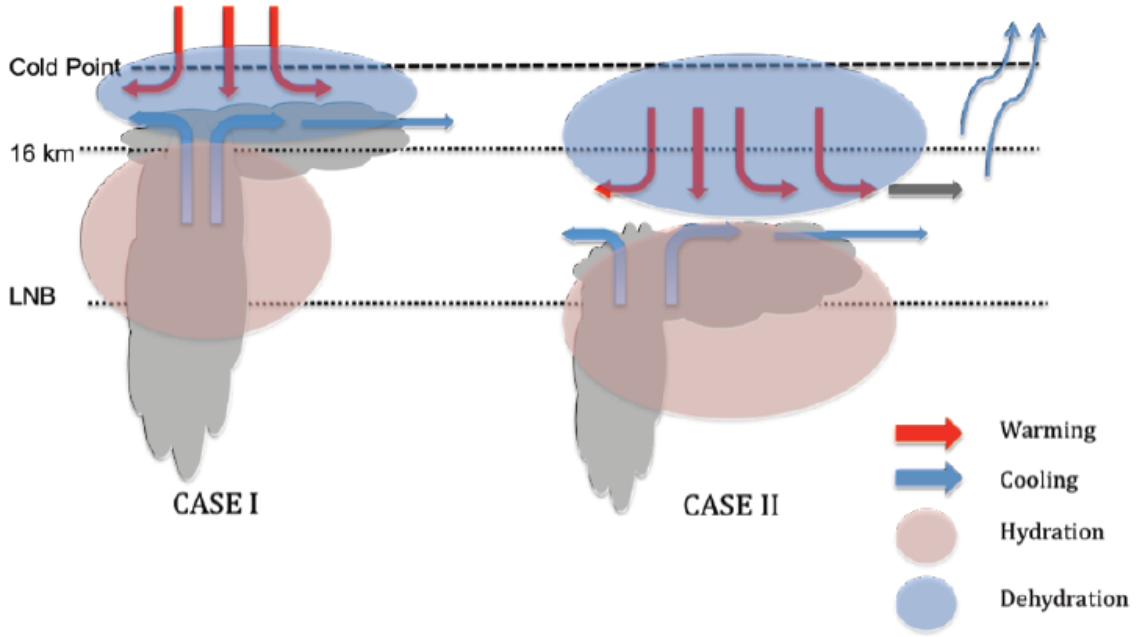


Fig. 10. A schematic of the dehydration and hydration process (including temperature variations) and water vapor transport to the stratosphere above cloud top in the TTL.

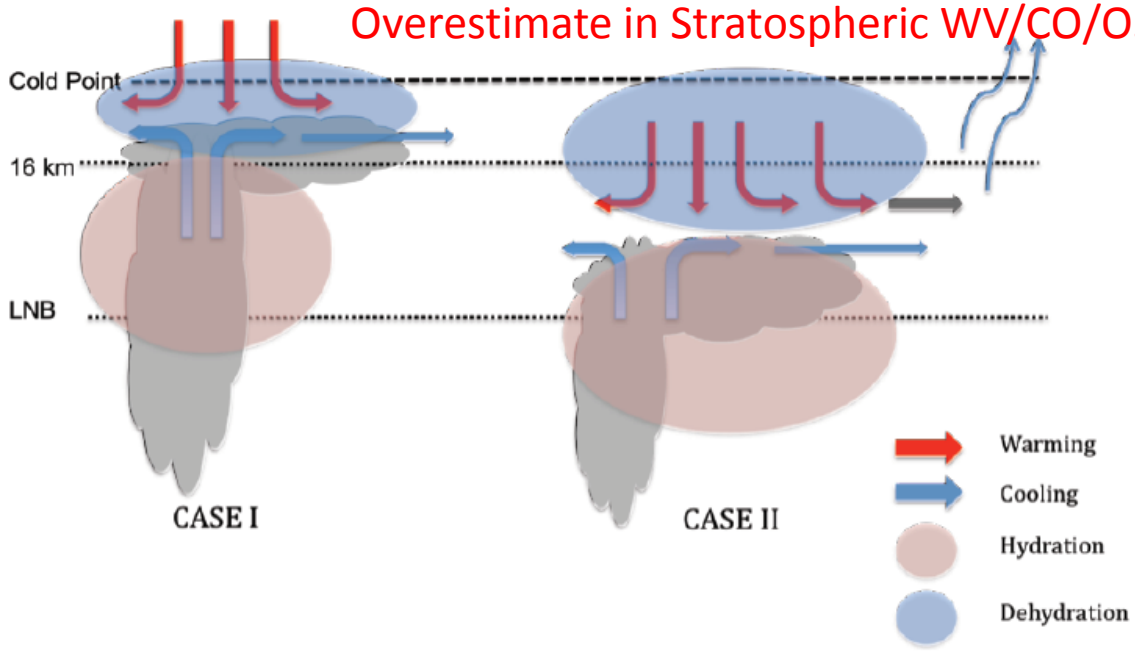
"The critical factor which divides these different water vapor variations below cloud tops is relative humidity. Clouds hydrate the environment below 16 km, where the relative humidity after mixing between cloud and environmental air does not reach saturation (case II in Fig. 10), but clouds dehydrate above 16 km because air there is supersaturated due to the bigger temperature drop and the high initial relative humidity (case I in Fig. 10)."

"In this paper, we explain cooling and reduced water vapor below cloud top by convectively generated cirrus."

Atmos. Chem. Phys., 11, 3811–3821, 2011 www.atmos-chem-phys.net/11/3811/2011/ doi:10.5194/acp-11-3811-2011

J. H. Chae et al.: The role of tropical deep convective clouds in the tropical tropopause layer

Overestimate in Stratospheric WV/CO/O3



Overestimate in Continental CO

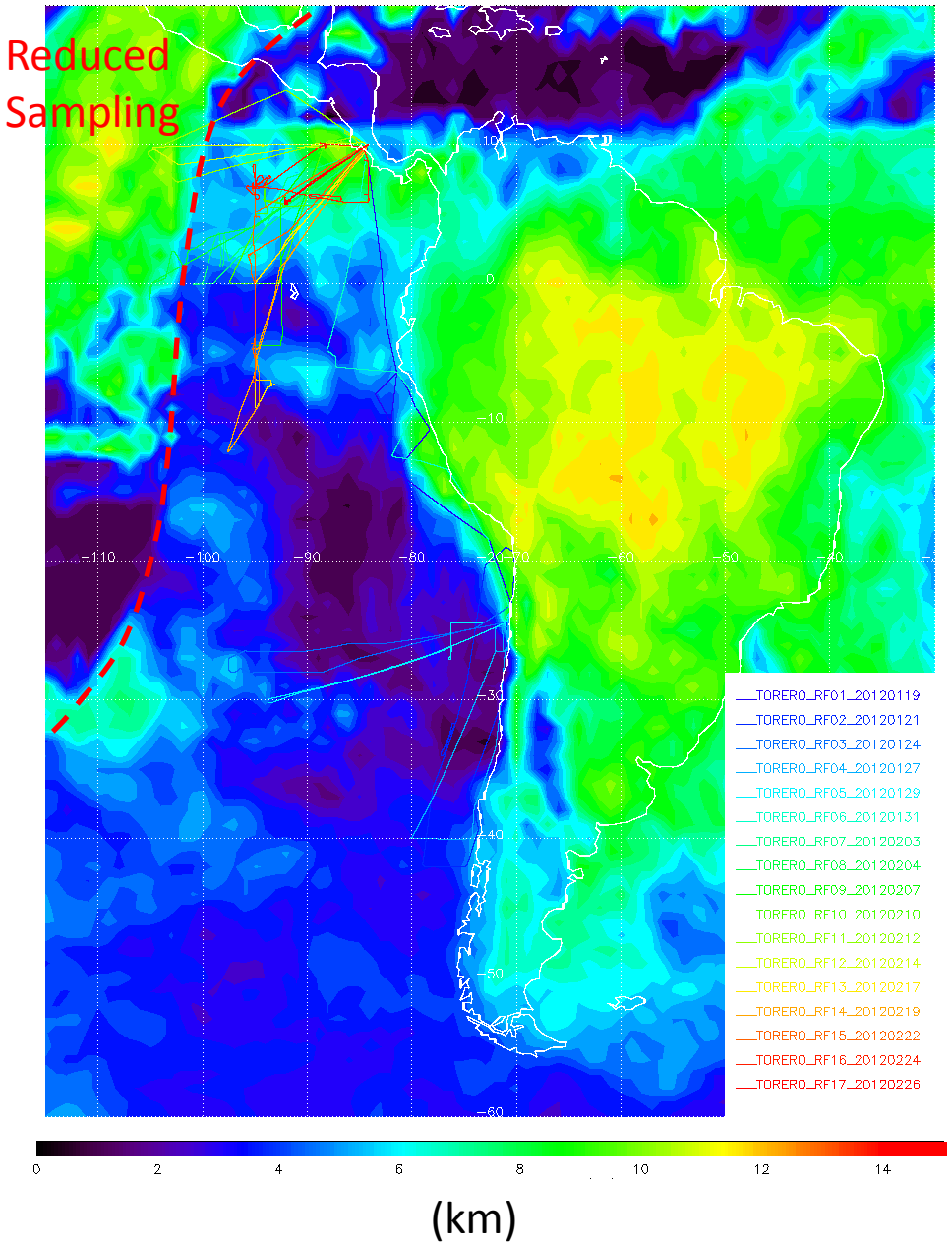
Fig. 10. A schematic of the dehydration and hydration process (including temperature variations) and water vapor transport to the stratosphere above cloud top in the TTL.

Overestimate in Stratospheric WV/CO/O3 impacts air above marine convective clouds through descent

Overestimate in continental boundary layer CO impacts air within continental convective clouds through ascent

Atmos. Chem. Phys., 11, 3811–3821, 2011 www.atmos-chem-phys.net/11/3811/2011/ doi:10.5194/acp-11-3811-2011

PATMOSX Mean Cloud Height Jan 19-Feb 21, 2012

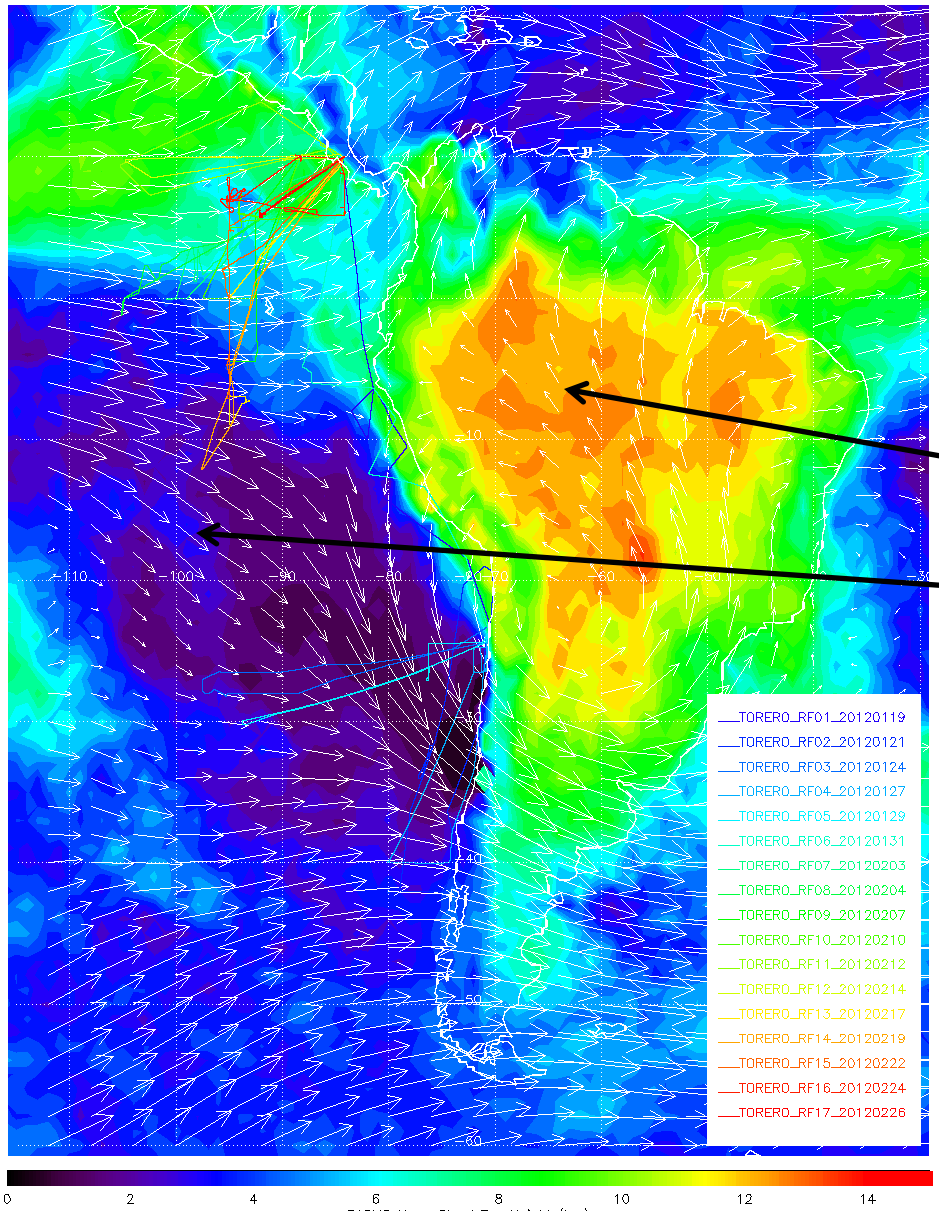


PATMOS-x is a project to derive atmospheric and surface climate records from the roughly 25 years of data from NOAA's Advanced Very High Resolution Radiometer (AVHRR) flown on the POES spacecraft.

During TORERO, PATMOSX cloud algorithms were applied to GOES12 geostationary measurements to provide realtime cloud retrievals over the TORERO field of operations every 15 minutes.

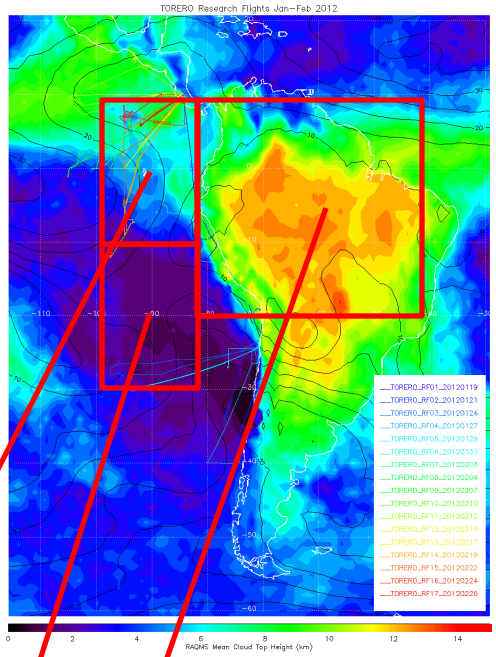
http://cimss.ssec.wisc.edu/patmosx/

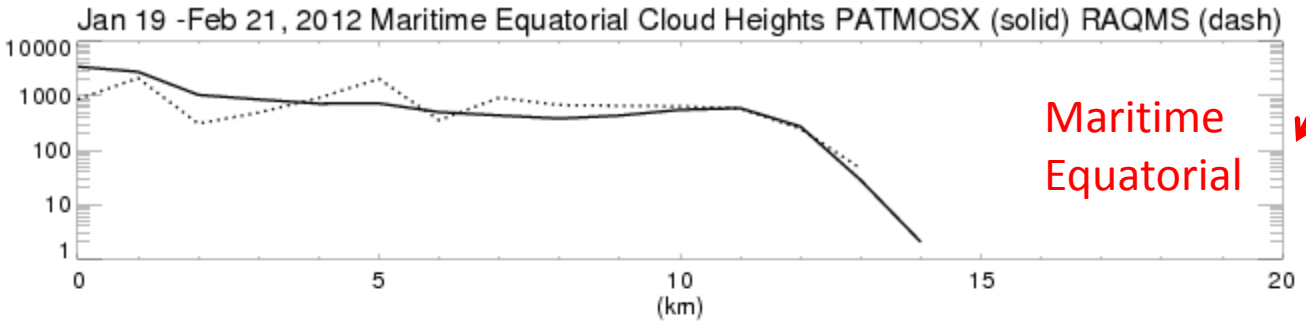
RAQMS Mean Cloud Height Jan 19-Feb 21, 2012



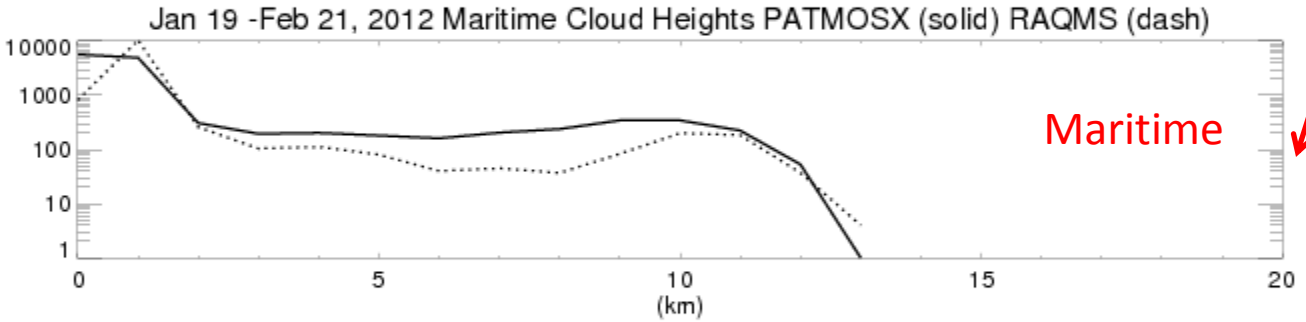
RAQMS tends to <u>overestimate</u> the height of the Continental Deep Convection and <u>underestimate</u> the height of Maritime Convection

PATMOSX and RAQMS Cloud top Height Frequency Distributions
Jan 19-Feb 21, 2012

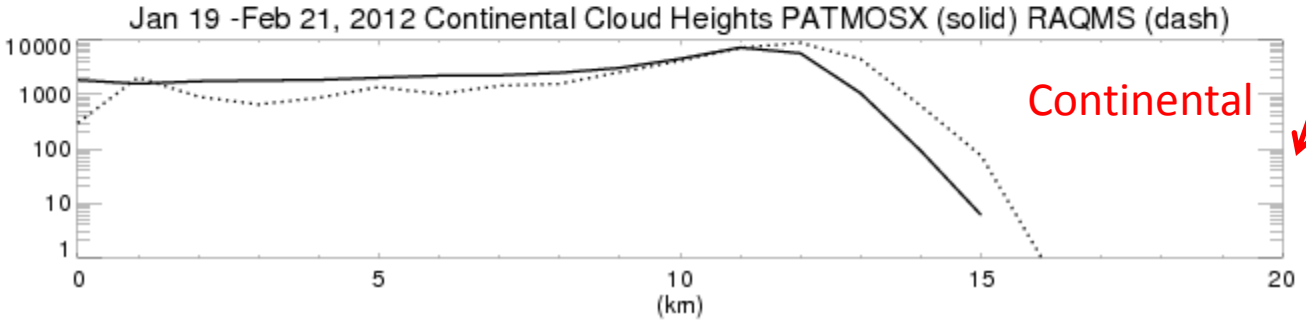




Maritime Equatorial

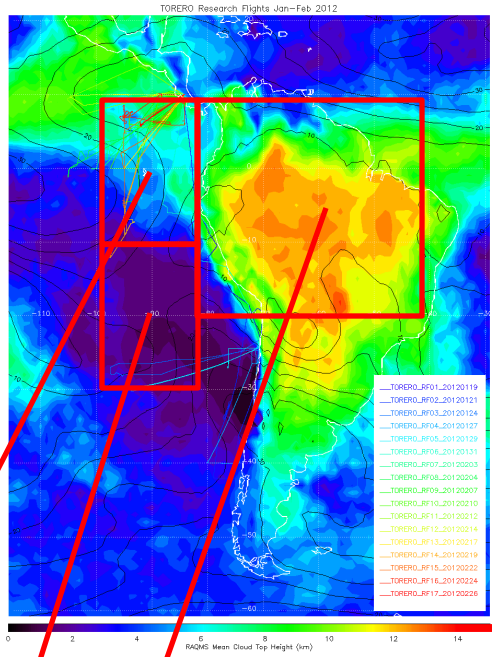


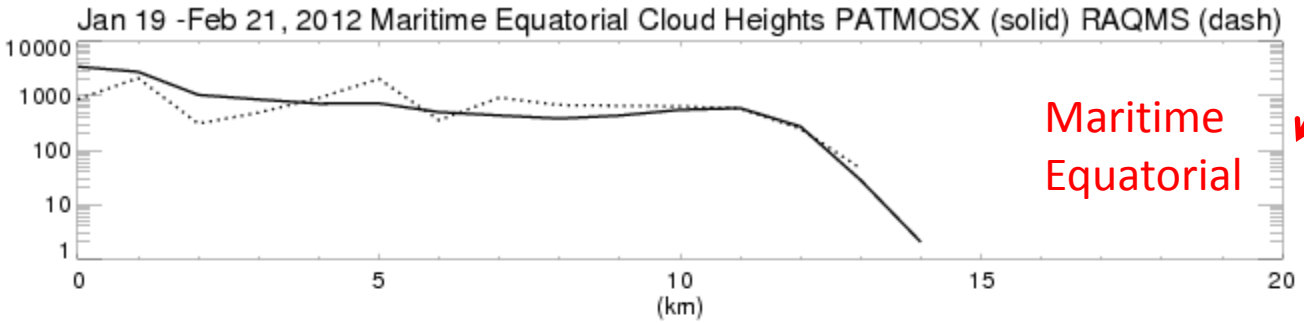
Maritime



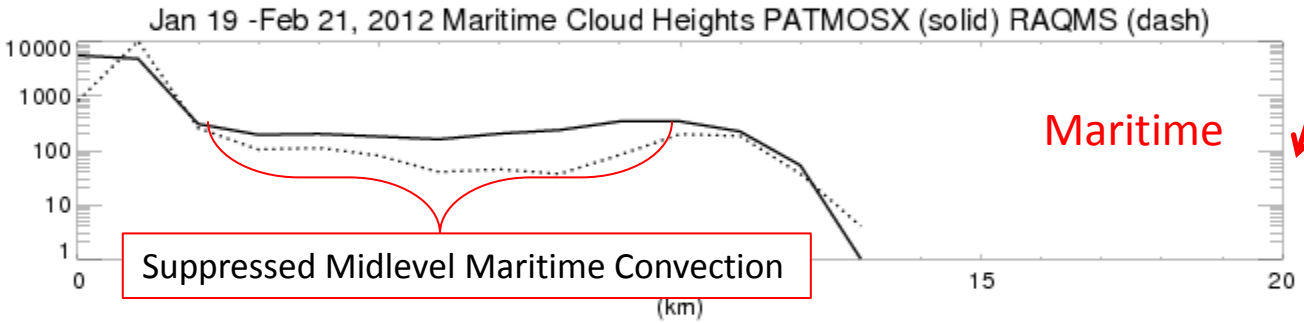
Continental

PATMOSX and RAQMS Cloud top Height Frequency Distributions
Jan 19-Feb 21, 2012



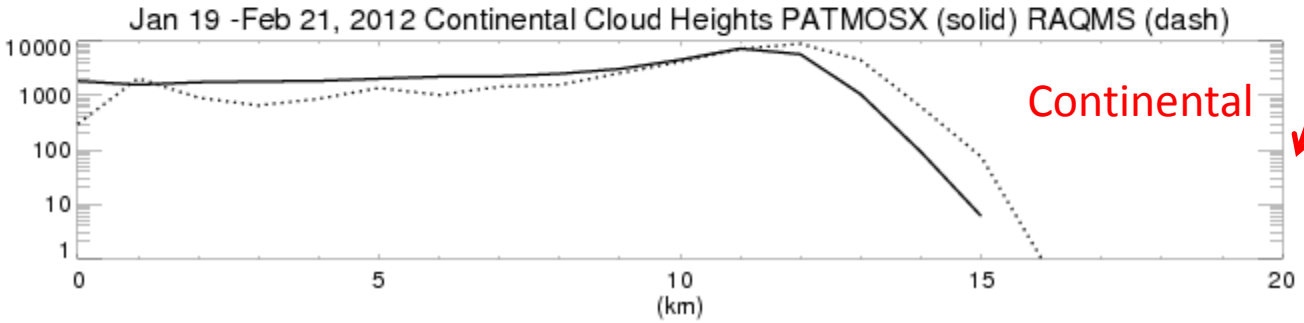


Maritime Equatorial



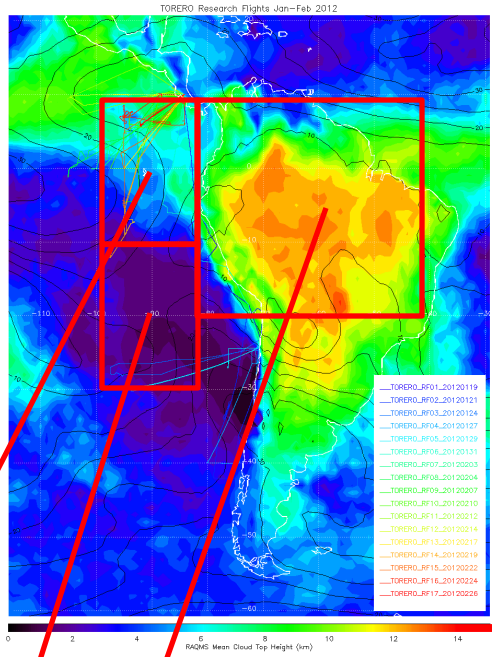
Maritime

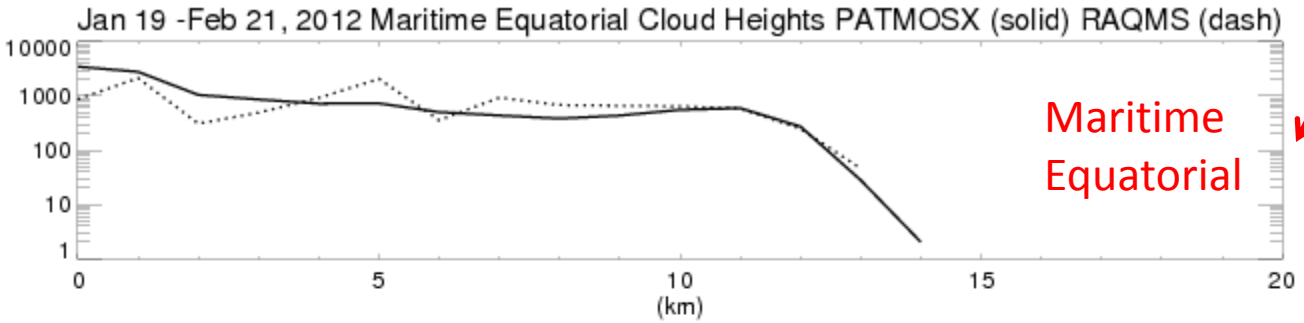
Suppressed Midlevel Maritime Convection



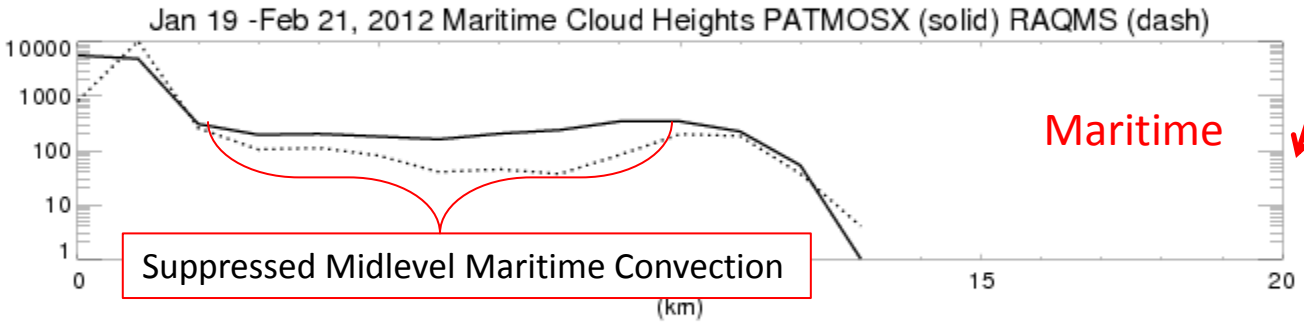
Continental

PATMOSX and RAQMS Cloud top Height Frequency Distributions
Jan 19-Feb 21, 2012



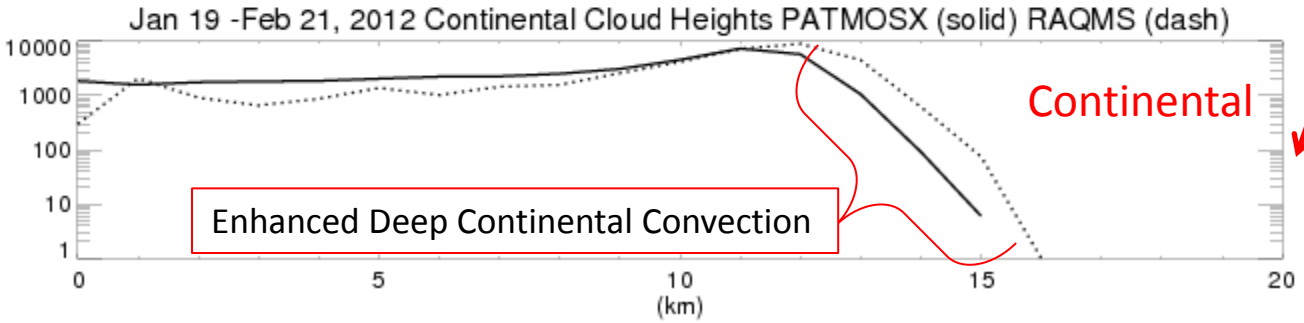


Maritime Equatorial



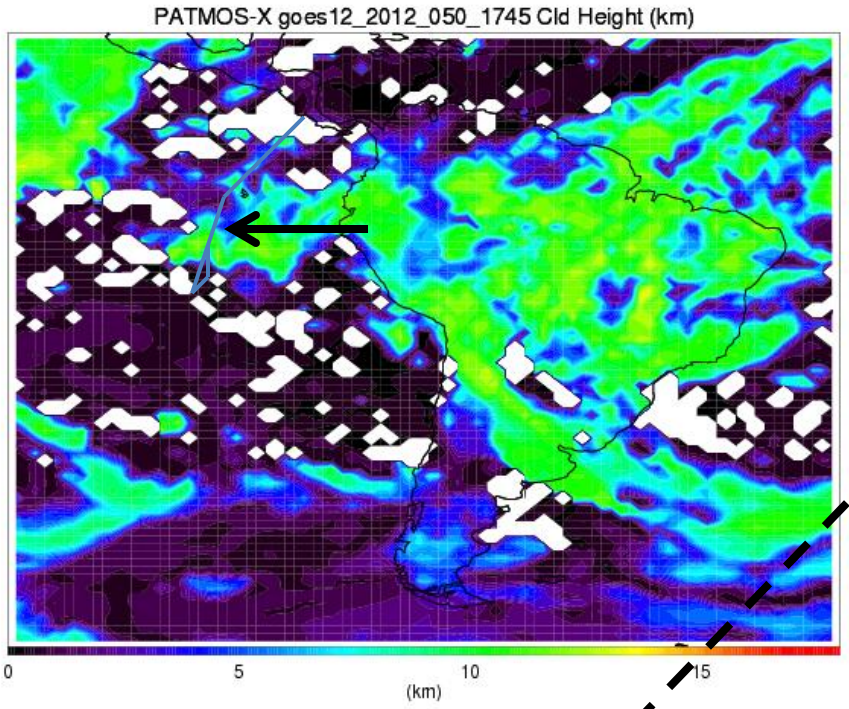
Maritime

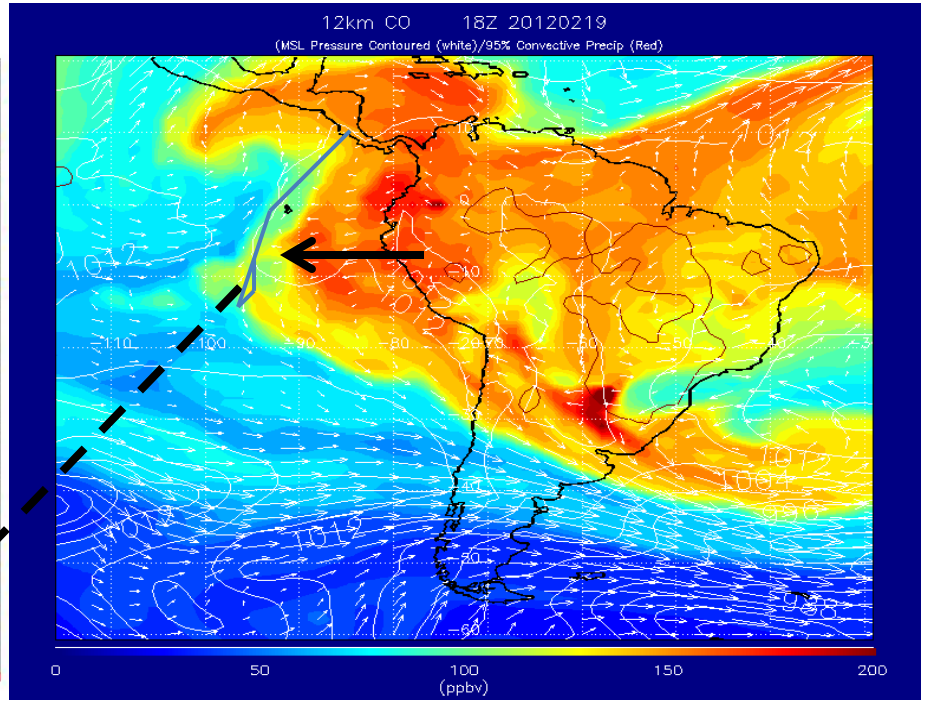
Suppressed Midlevel Maritime Convection

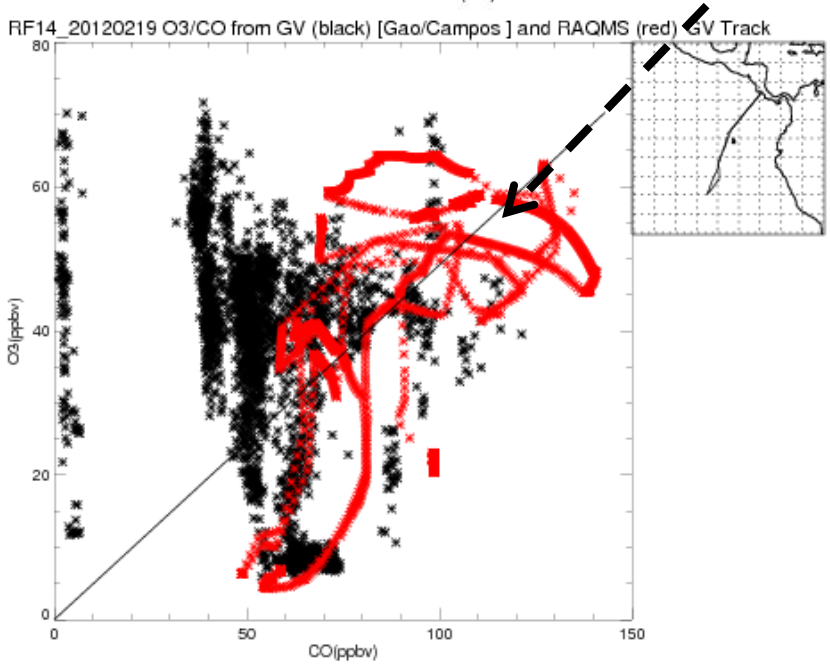


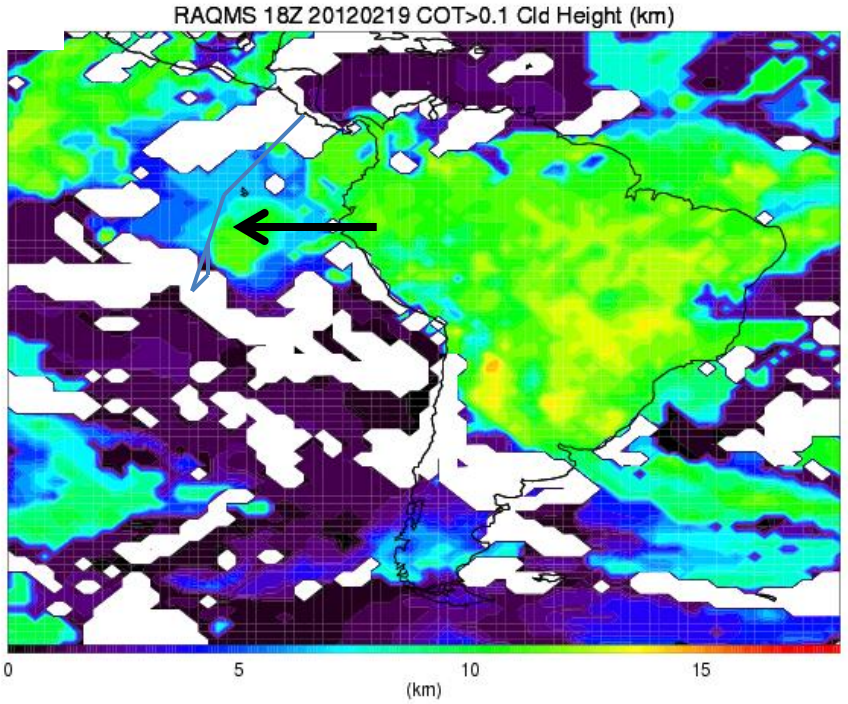
Continental

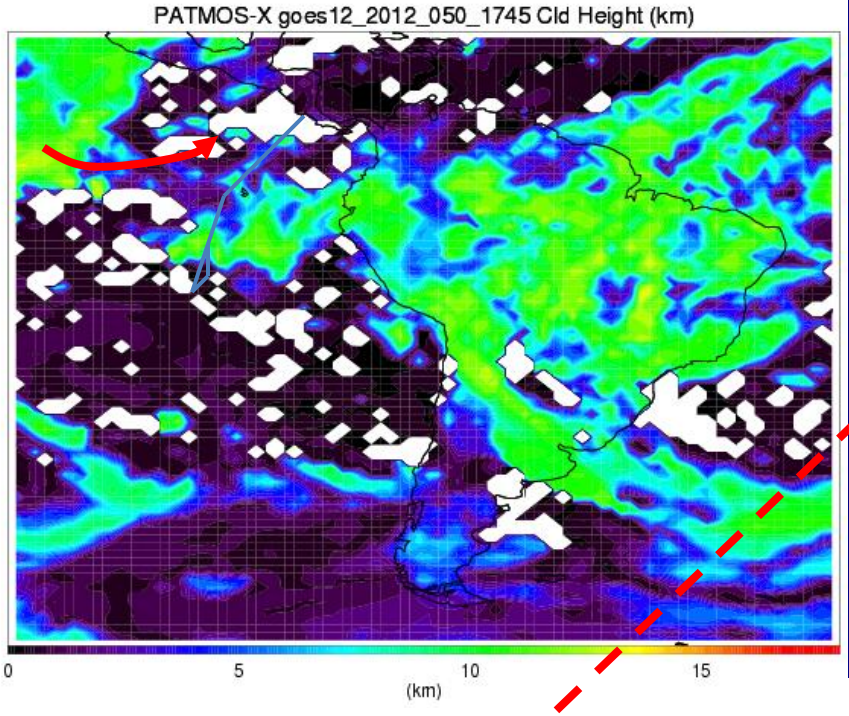
Enhanced Deep Continental Convection

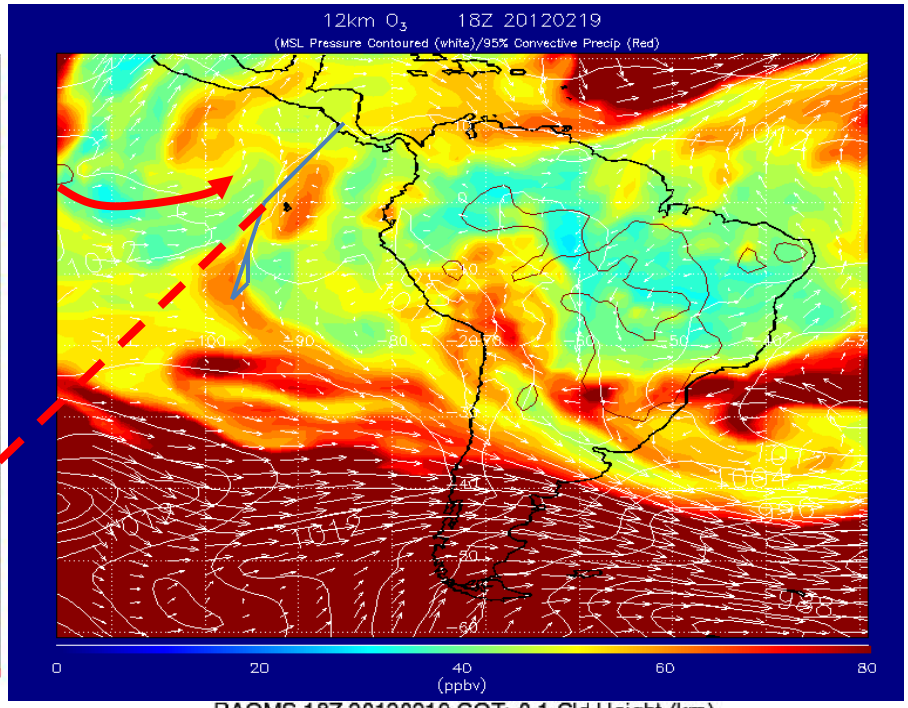

PATMOS-X goes12_2012_050_1745 Cld Height (km)
0
5
10
15
(km)

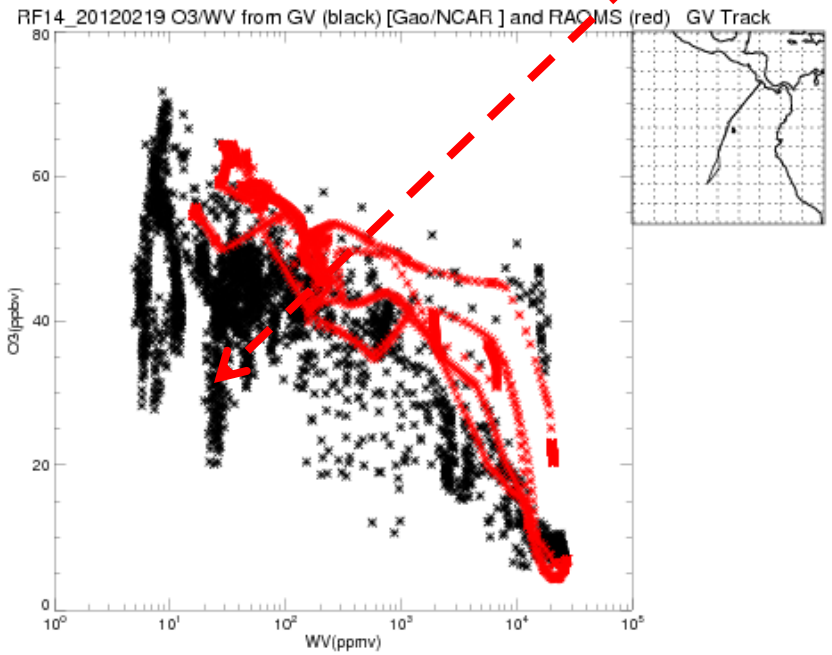

12km CO 18Z 20120219
(MSL Pressure Contoured (white)/95% Convective Precip (Red)
0
50
100
150
200
(ppbv)

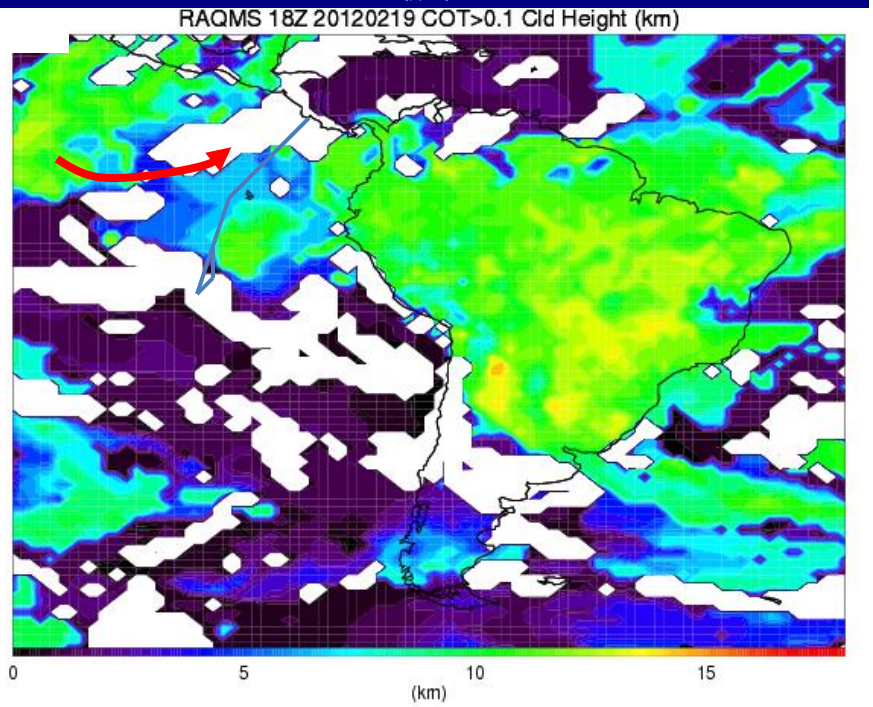

RF14_20120219 O3/CO from GV (black) [Gao/Campos] and RAQMS (red) GV Track
O3(ppbv)
CO(ppbv)
0
20
40
60
80
0
50
100
150

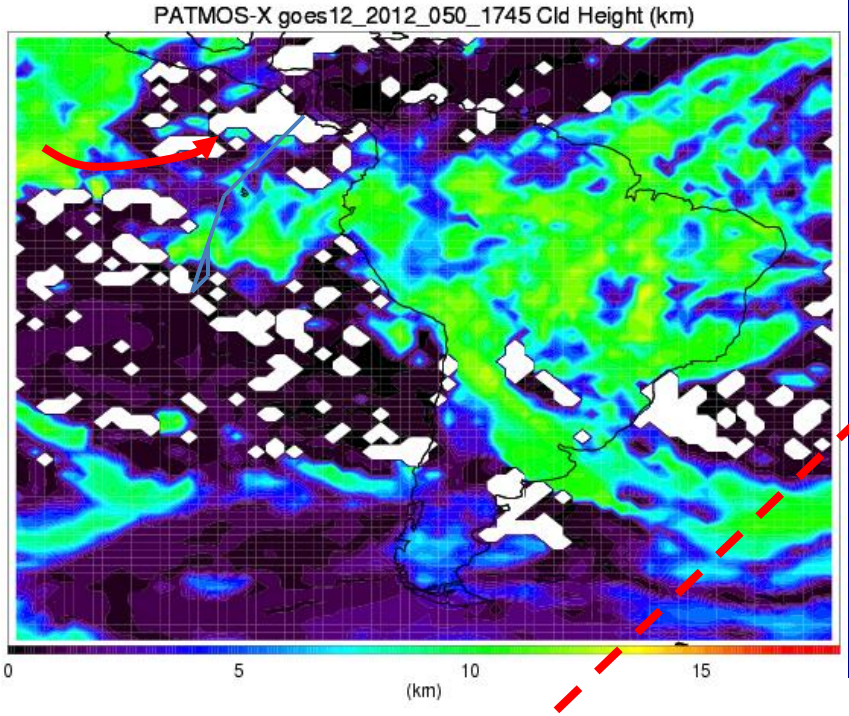

RAQMS 18Z 20120219 COT>0.1 Cld Height (km)
0
5
10
15
(km)

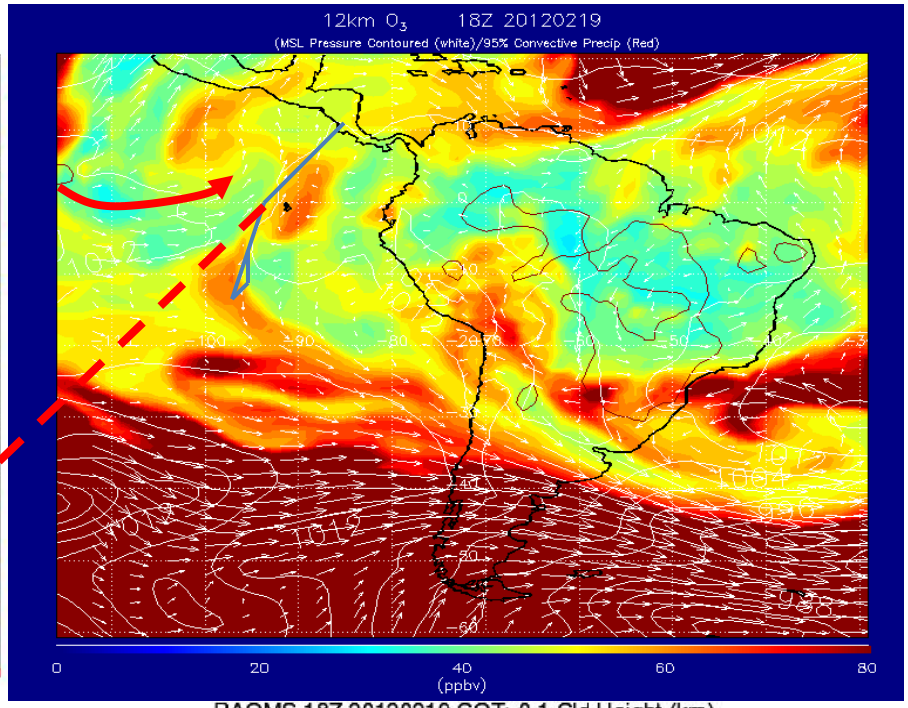

PATMOS-X goes12_2012_050_1745 Cld Height (km)
0
5
10
15
(km)

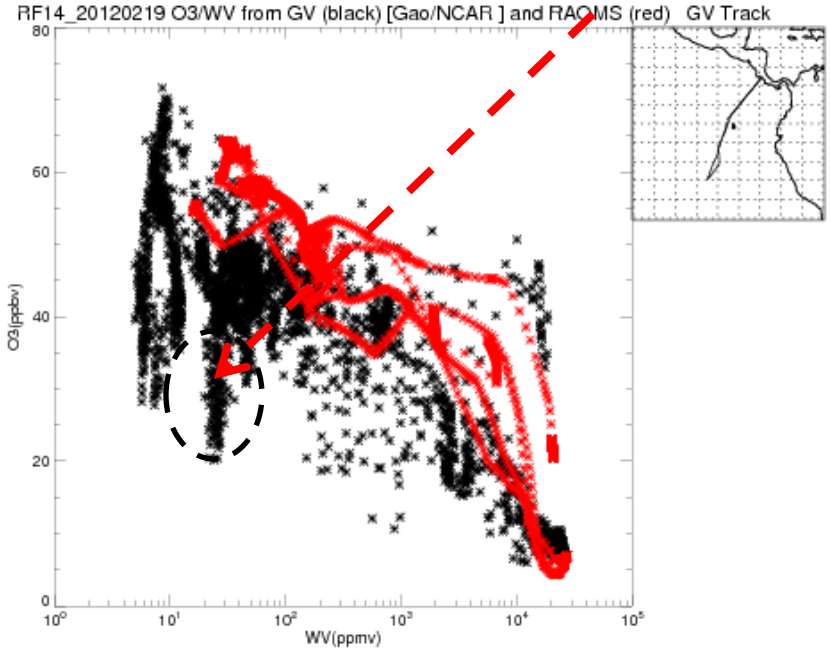

12km O3 18Z 20120219
(MSL Pressure Contoured (white)/95% Convective Precip (Red)
0
20
40
60
80
(ppbv)

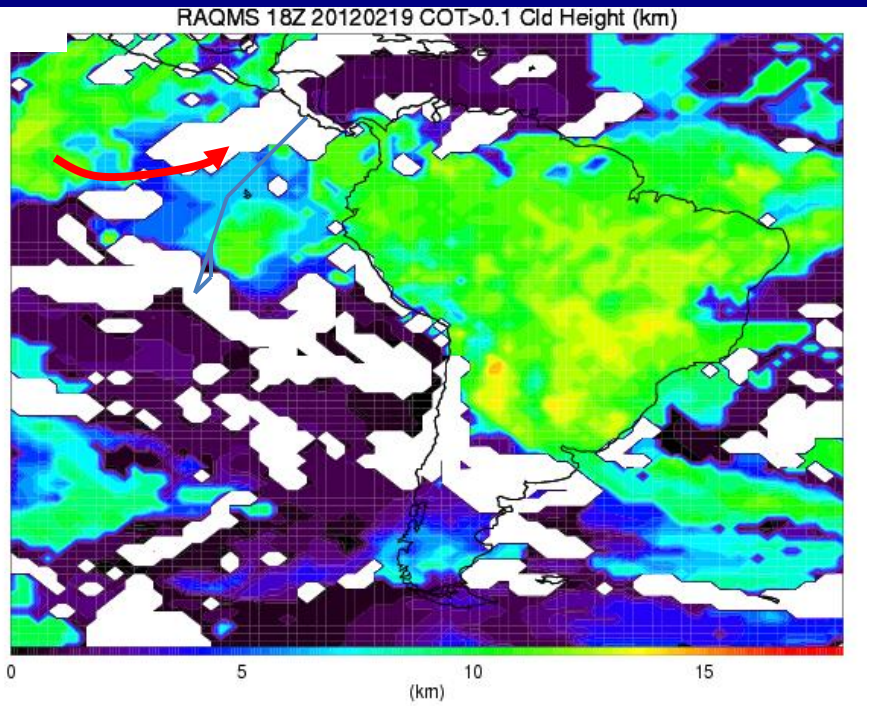

RF14_20120219 O3/WV from GV (black) [Gao/NCAR] and RAQMS (red) GV Track
O3(ppbv)
WV(ppmv)

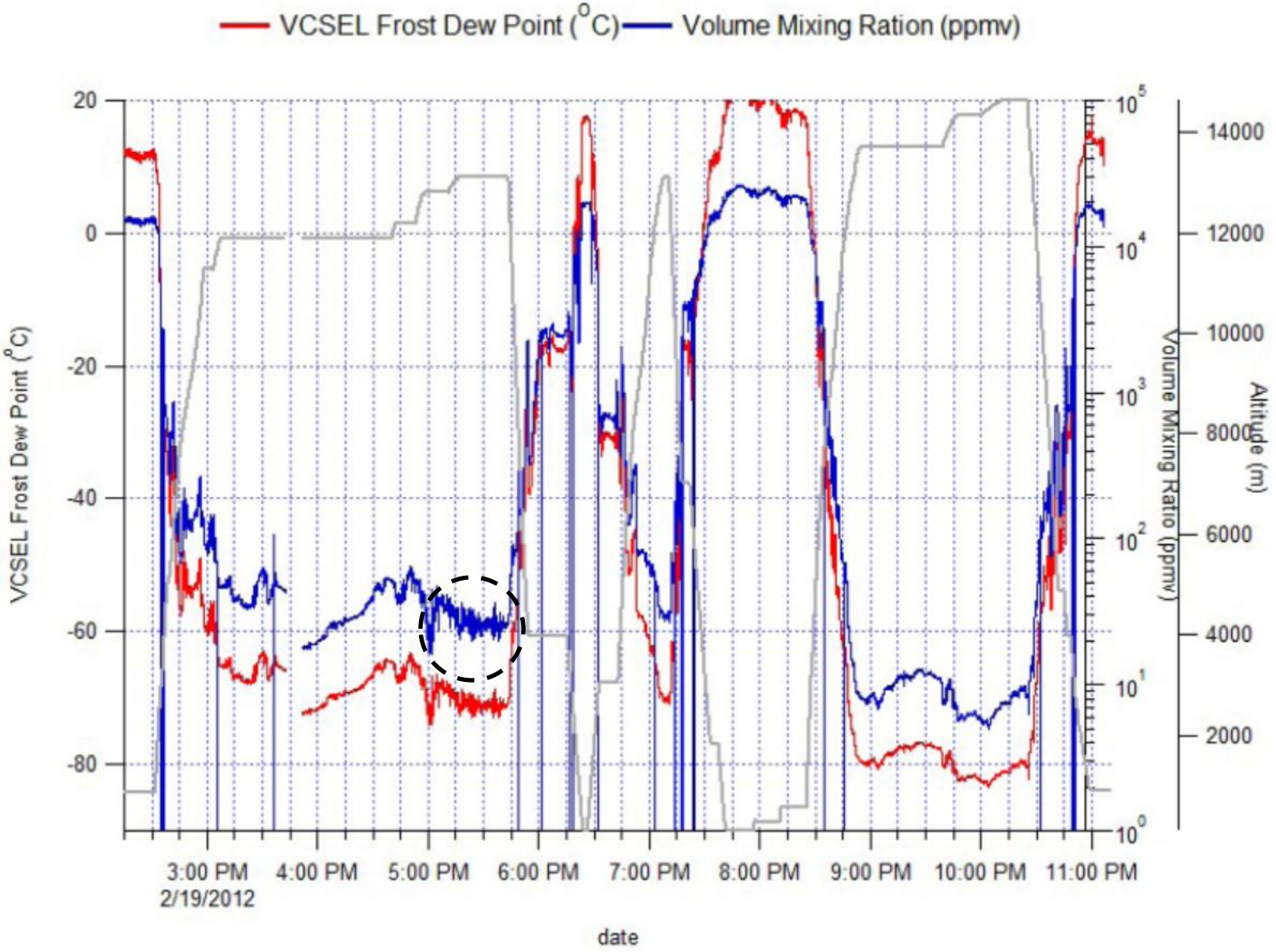

RAQMS 18Z 20120219 COT>0.1 Cld Height (km)
0
5
10
15
(km)


PATMOS-X goes12_2012_050_1745 Cld Height (km)
0
5
10
15
(km)

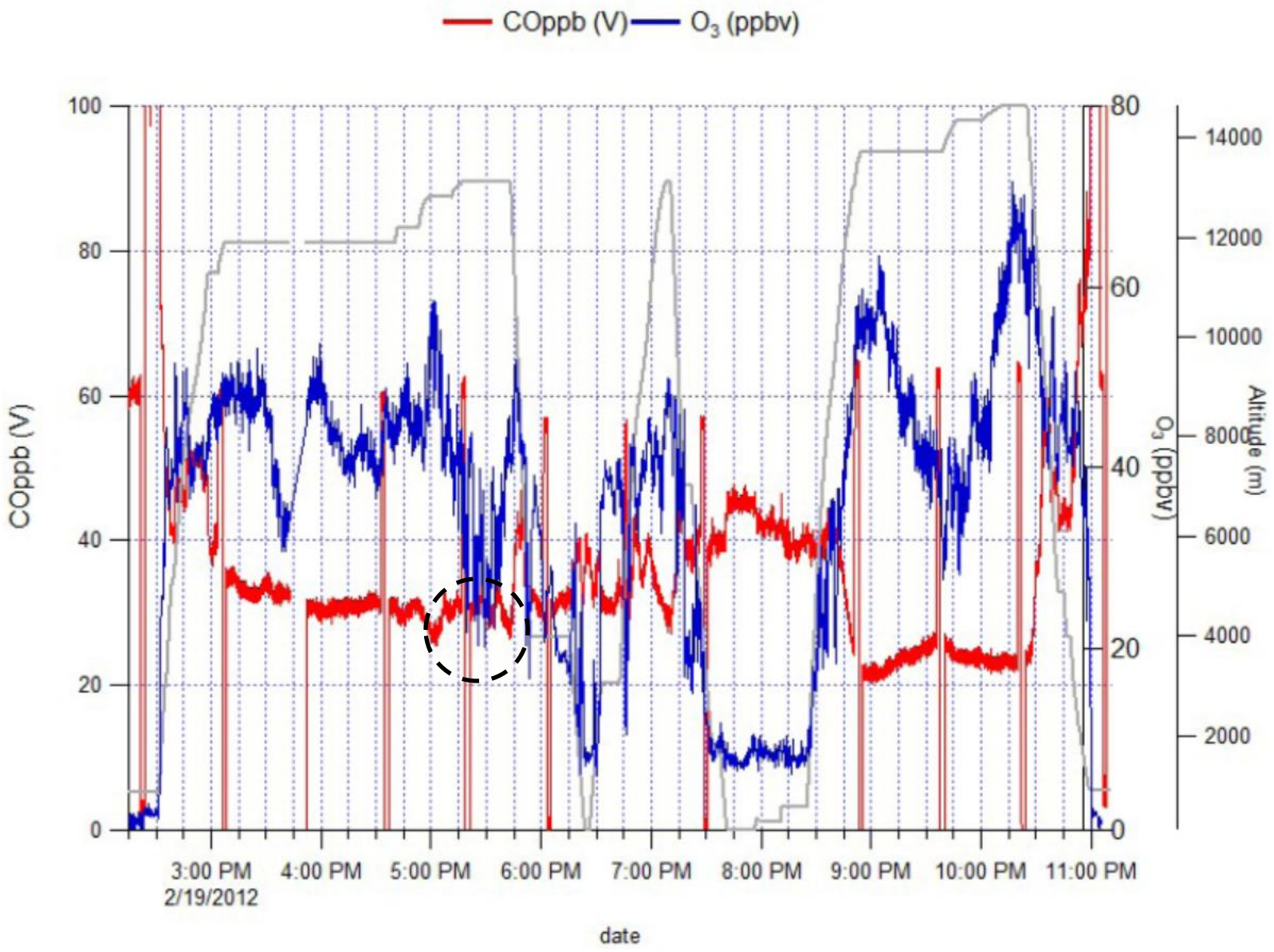

12km O3 18Z 20120219
(MSL Pressure Contoured (white)/95% Convective Precip (Red)
0
20
40
60
80
(ppbv)


RF14_20120219 O3/WV from GV (black) [Gao/NCAR] and RAQMS (red) GV Track
O3(ppbv)
WV(ppmv)

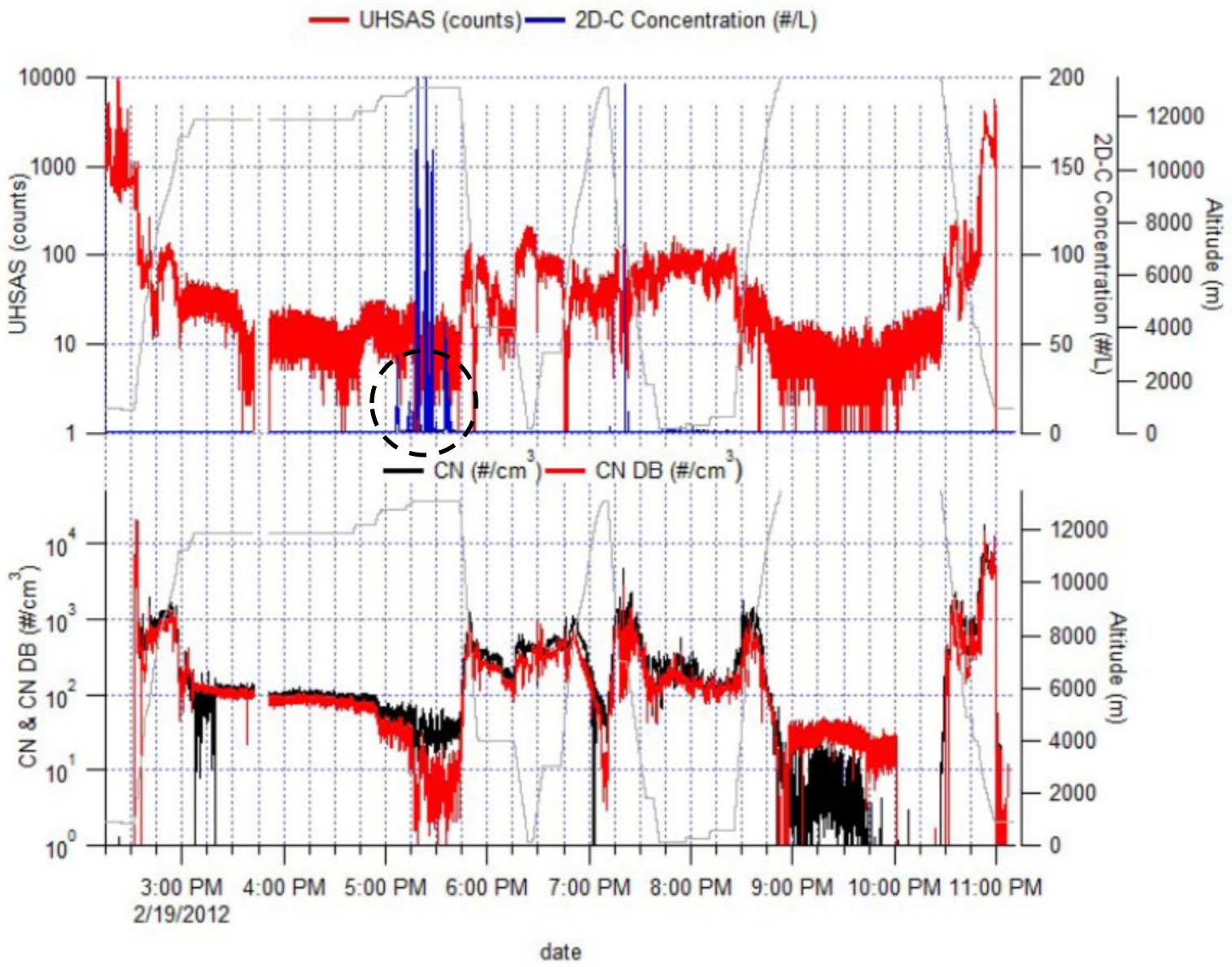

RAQMS 18Z 20120219 COT>0.1 Cld Height (km)
0
5
10
15
(km)



VCSEL WV/Dew Point (Zondlo/Beaton)

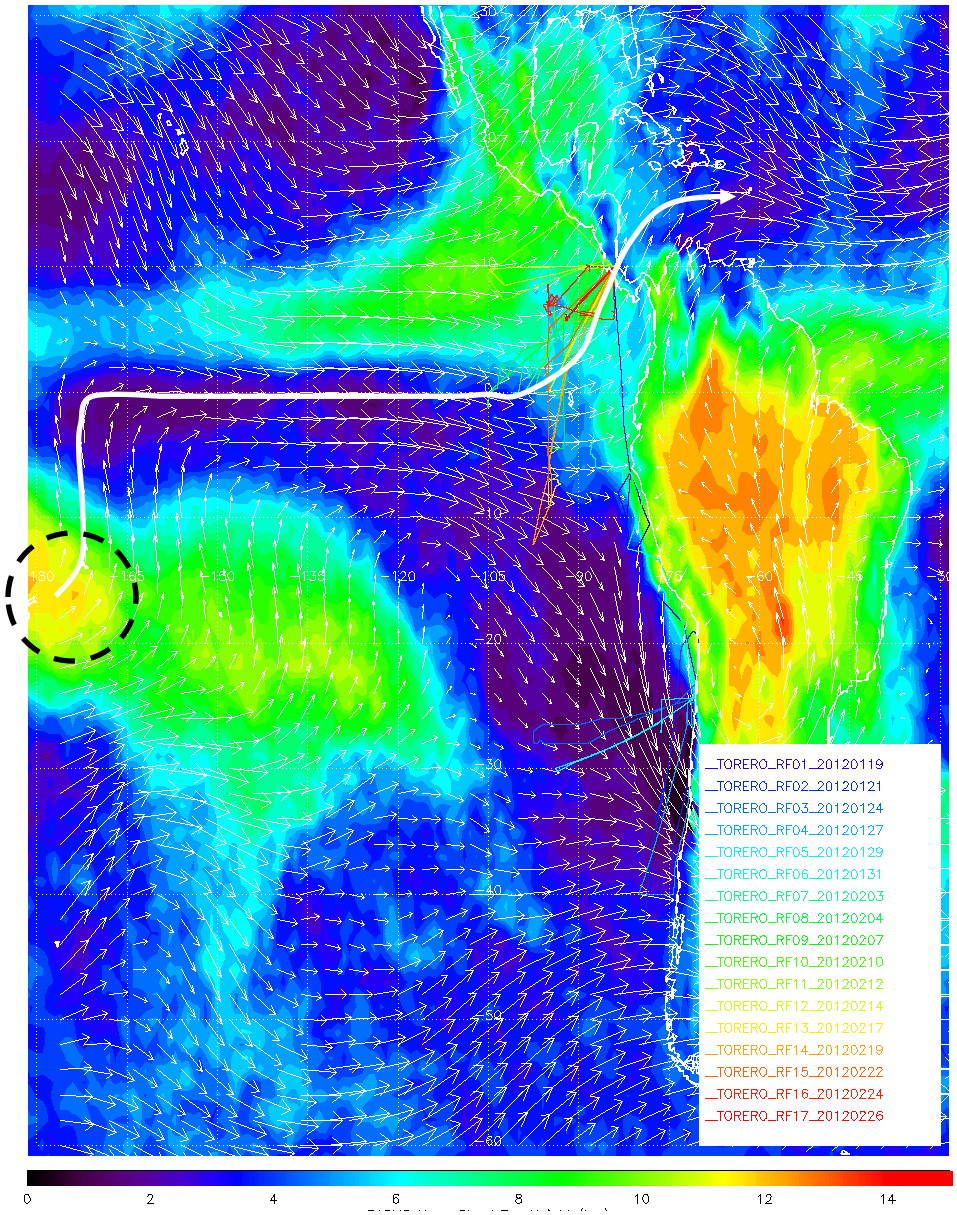


CO/O3 (Campos/Gao)



PMS 2D cloud probe (NCAR/RAF)

RAQMS Mean Cloud Height Jan 19-Feb 21, 2012



Region of upwind deep (12km) maritime convective clouds is near 180W/10-20S

Possible source dehydrated air with maritime PBL ozone signature sampled by GV during TORERO

Summary:

- Continental outflow from deep convection over Brazil is likely to have influenced the upper tropospheric TORERO measurements during the later half of the mission although RAQMS clearly overestimated the CO signature associated with this outflow.

- Signatures of both maritime deep convection (low O3/low H2O/low CO) and Strat/Trop Exchange (higher O3/low H2O/low CO) are evident in the TORERO insitu measurements although RAQMS shows predominately STE signatures.

- The O3 transport and cirrus dehydration associated with maritime deep convection most likely occurred upstream from the TORERO field of operations since RAQMS deep convective clouds are in relatively good agreement with satellite (PATMOSX) retrievals.

- The EqPOS balloon profiles of O3, H2O, and CO should be examined for signatures of maritime deep convection and cirrus dehydration