INSTITUTO DE CIENCIAS DE LA ATMÓSFERA Y CAMBIO CLIMÁTICO

Carbon monoxide in central Mexico: Ground and space born measurements:

urban climatology of CO

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Mexico City Carbon monoxide measurements: consistency and intercomparison

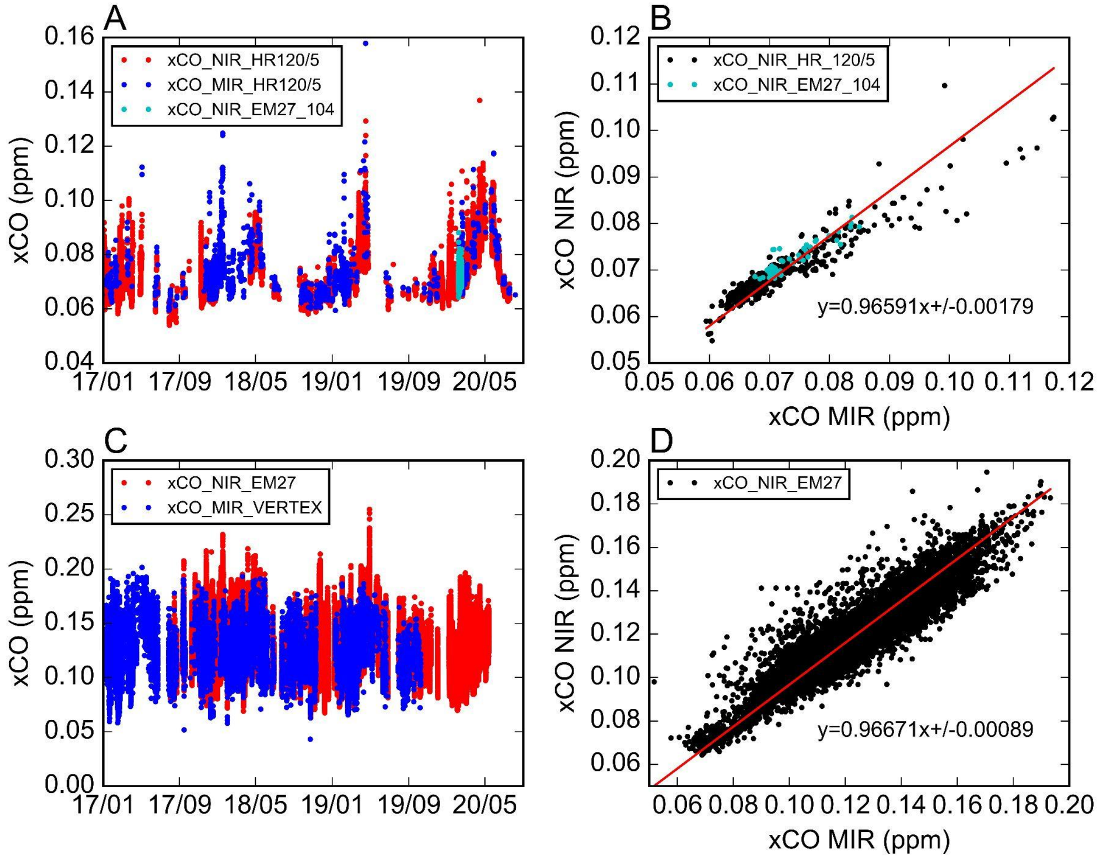
Ground based solar absorption: 10 FTIRs of
NDACC,TCCON COCCON
ALtzomoni, Vertex-UNAM Campus (CCA), Vallejo
Merci-CO2: BOXO, AMEC, TECA, Vallejo, Cautitlan

Insitu: Picarros: UNAM, Vallejo (MERCI)
RAMA: 33 sites (Government)

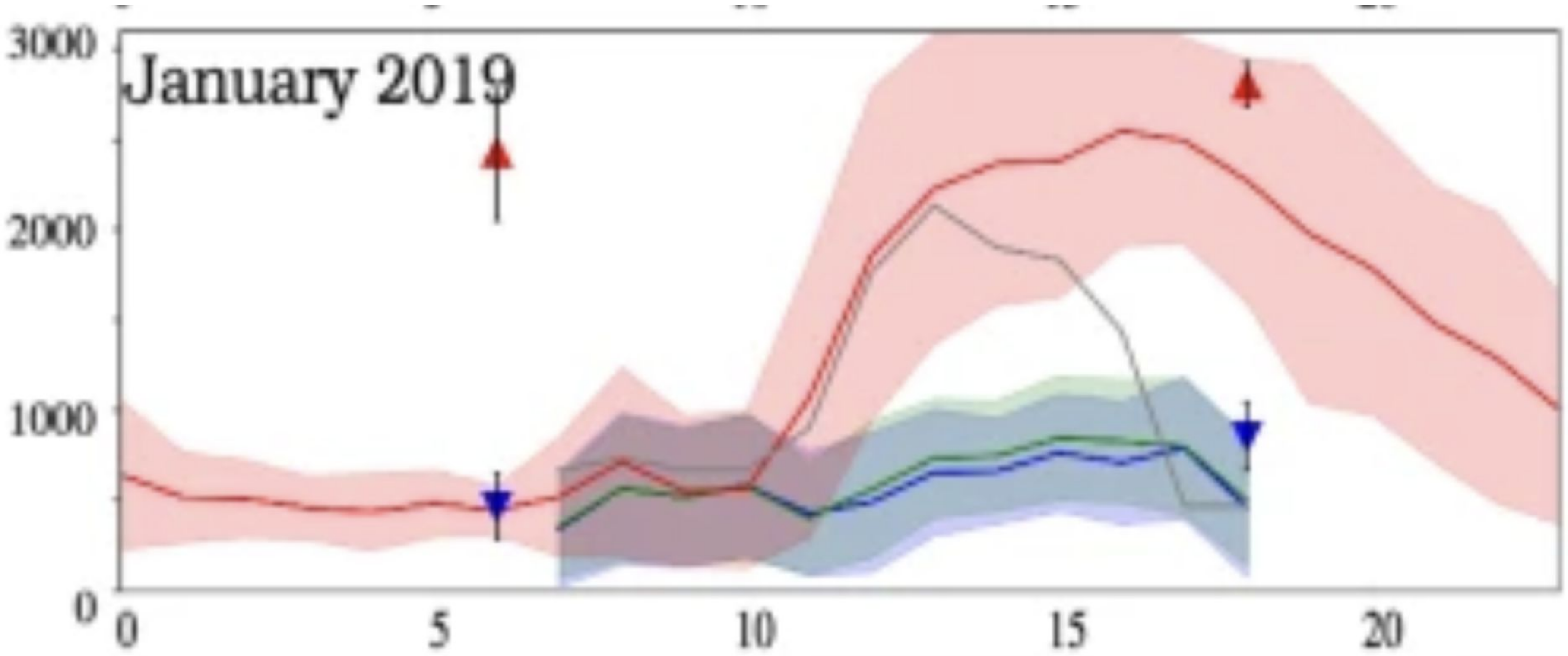
Space based measurements: 3
IASI, MOPIIT, TROPOMI

=>lots of measurements but view vertical profile measurements

Consistency is not the topic of my talk, but one slide out of supplement of Taquet et al in process:



Boundary layer CO in Mexico: LIDAR

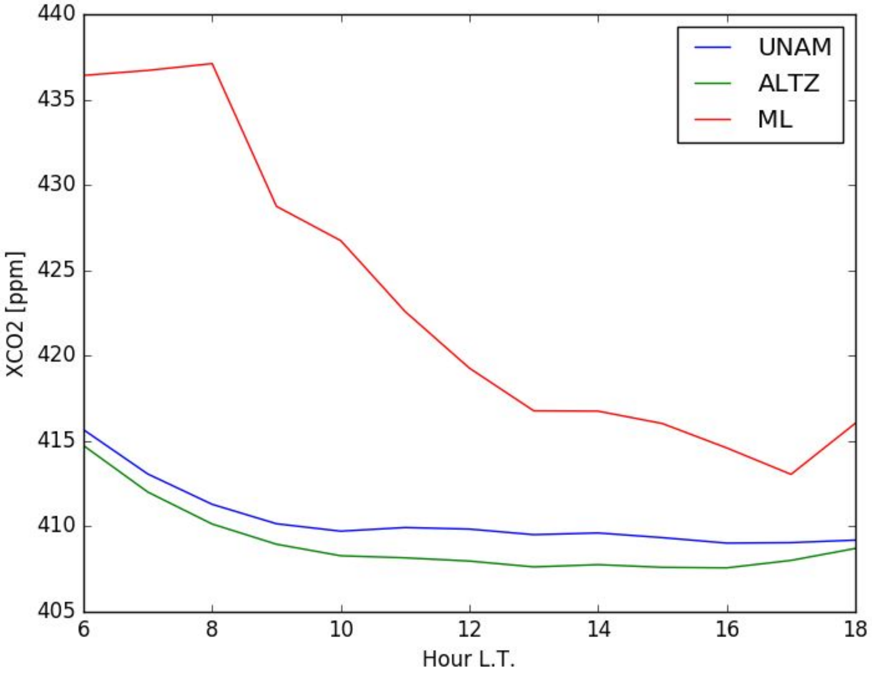


Burgos-Cuevas, A., Magaldi, A., Adams, D.K. *et al.* Boundary Layer Height Characteristics in Mexico City from Two Remote Sensing Techniques. *Boundary-Layer Meteorol* 186, 287–304 (2023)

Boundary layer: Here for CO2

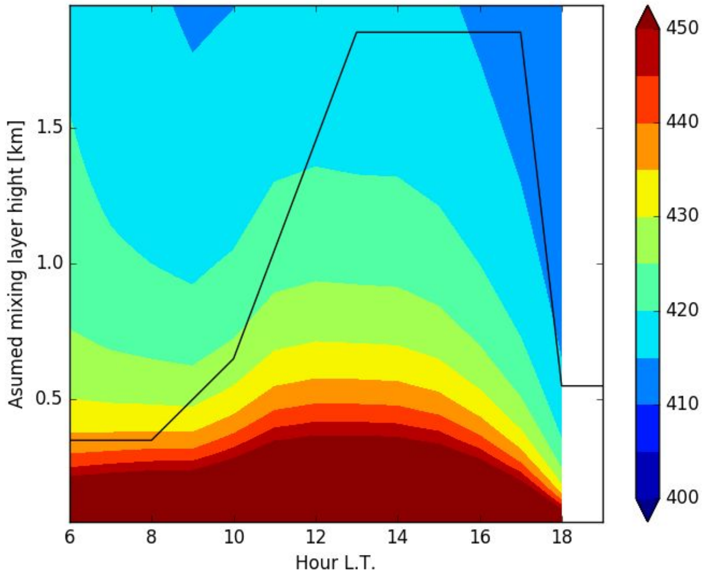
$Col_{UNAM} = Col_{ALtzomoni} + col_{ML}$

$P_{surf}\ XCO2_{UNAM} = P_{Altz}\ XCO2_{ALtzomoni} + dP\ CO2_{ML}$

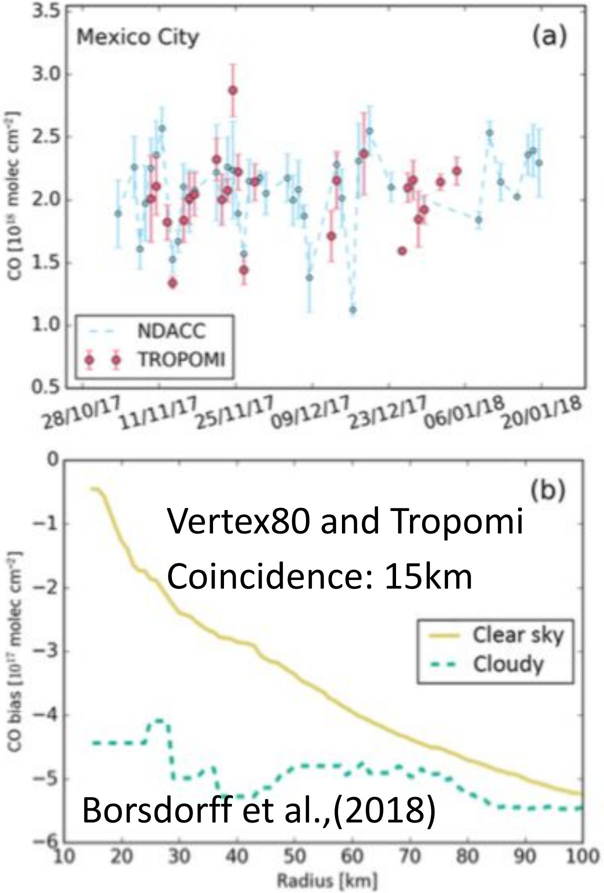


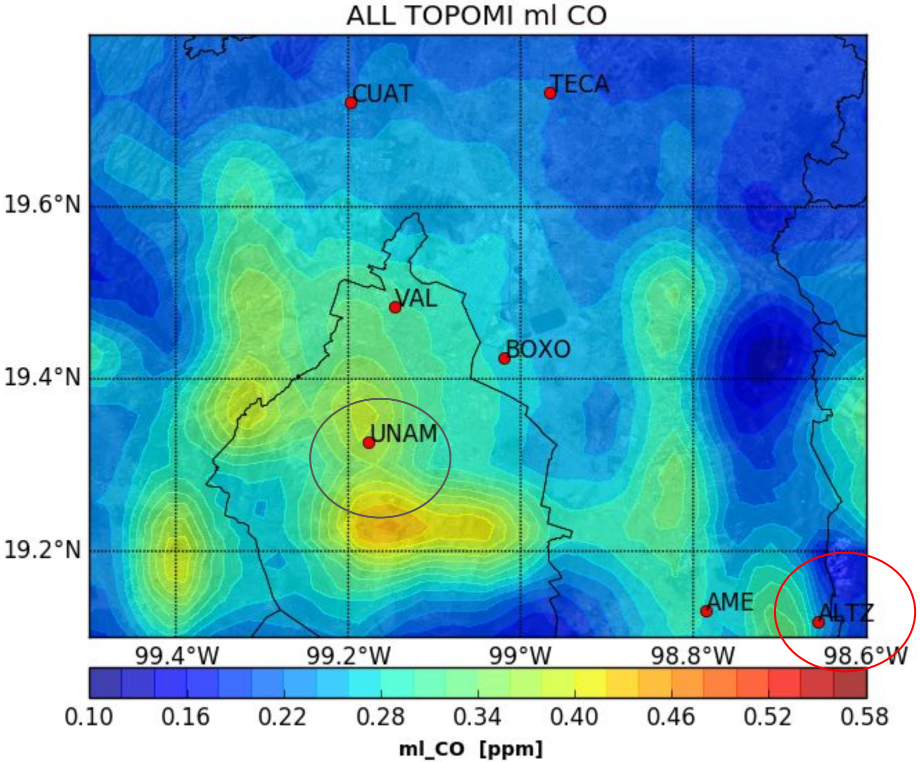
mixing layer concentration concentration is dependent on the pressure difference in the mixing layer

Taquet et al. in process



CO Validaidation and spatial and temporal coincidence in Mexico City:



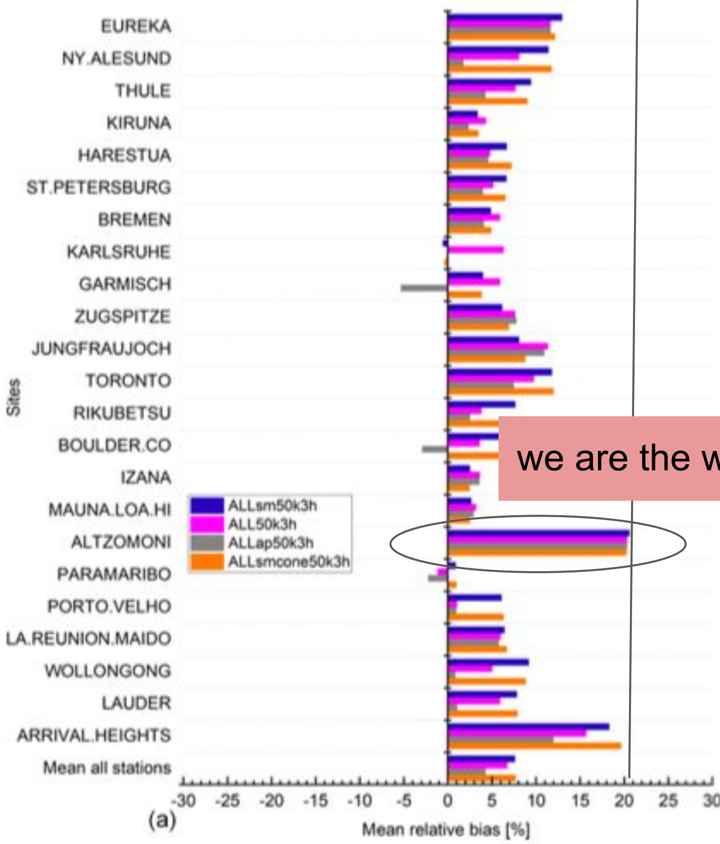


UNAM Vertex

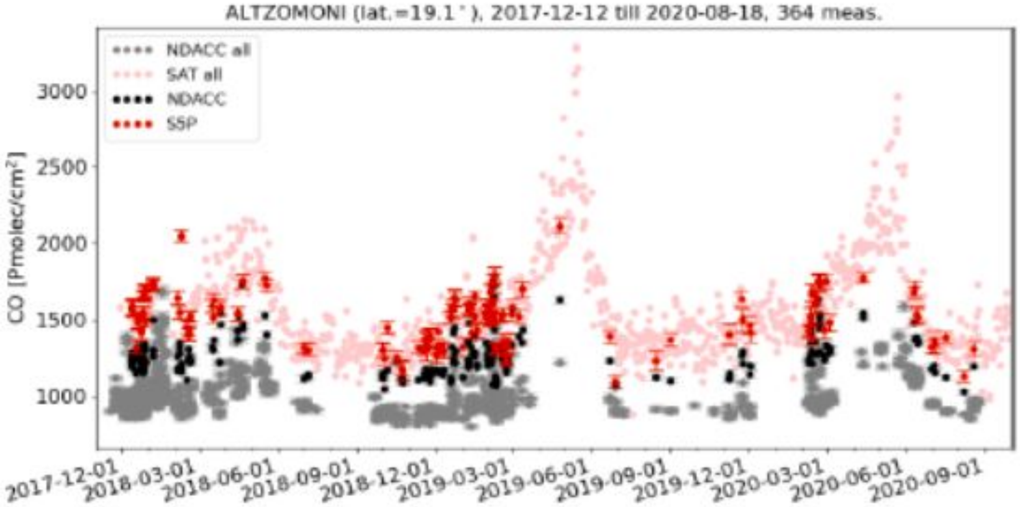
space < ground

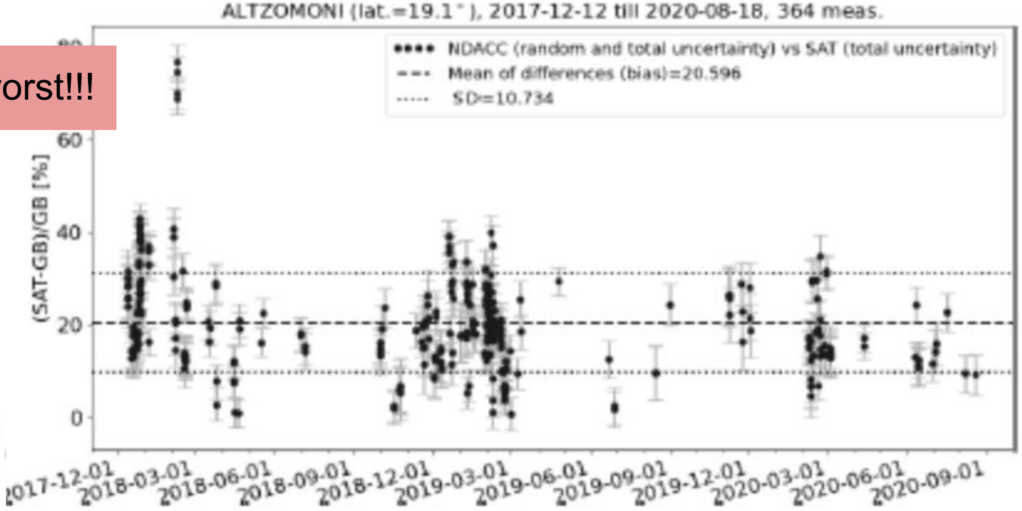
CO TOPROMI: Validation

Sha, M. K. et al. (2022)

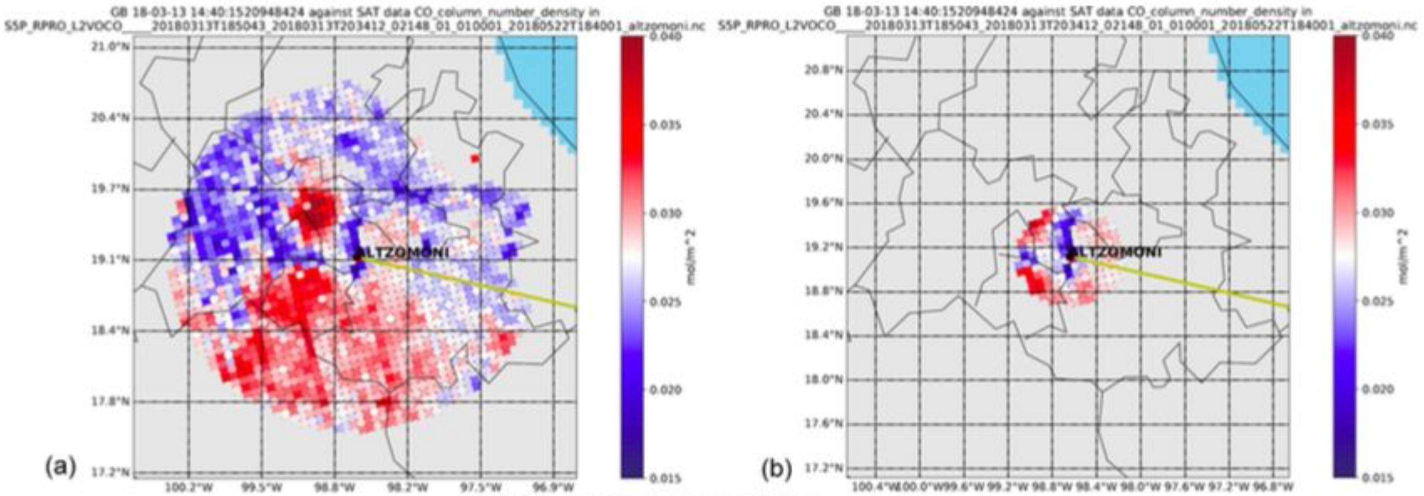


we are the worst!!!





CO Validaidation and spatial and temporal coincidence in Mexico City:Bias in Carbon monoxide: Altzomoni: FTIR > SAT: Mountain and Mexico City



Altzomoni: space > ground

Sha, M. K. et al. (2022)

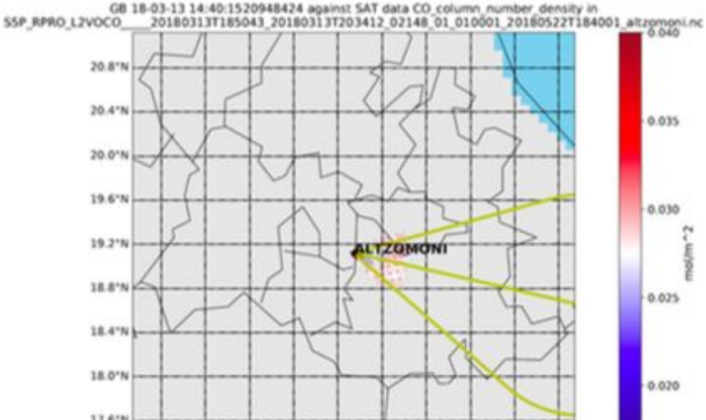
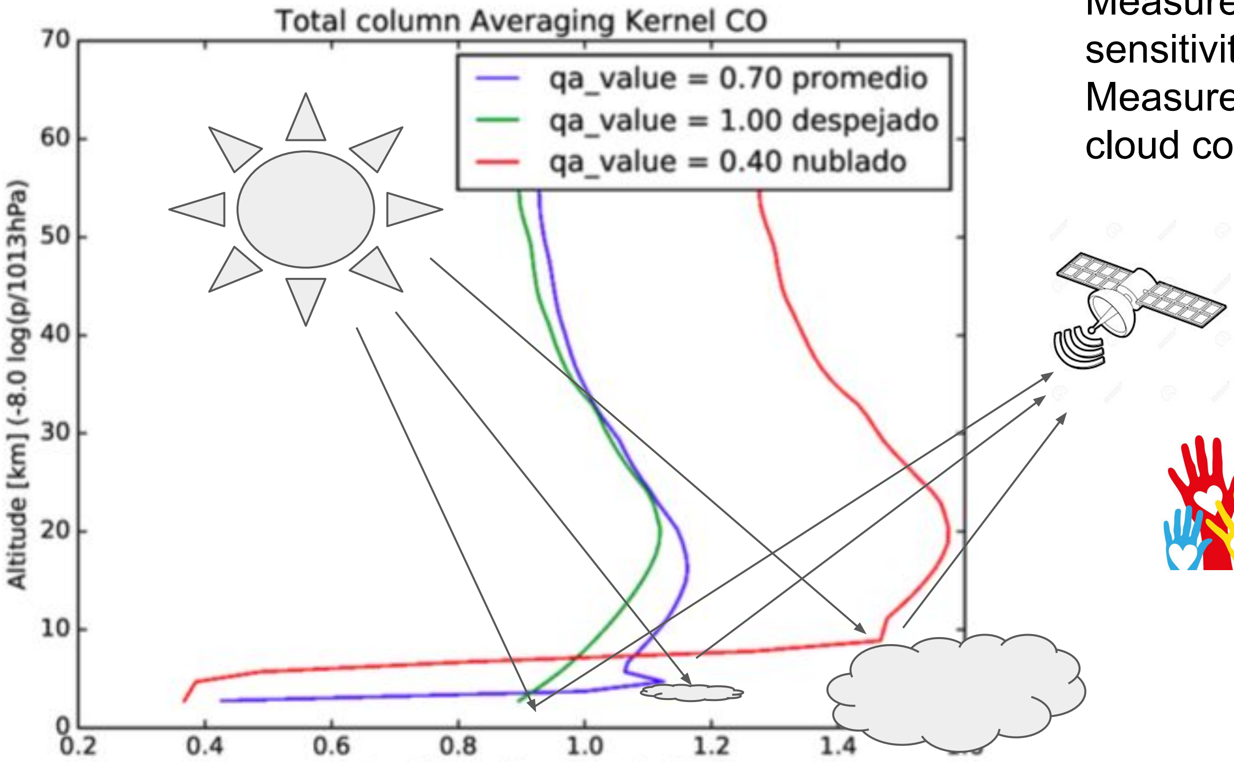


Figure 25. S5P CO column number density plotted around NDACC station at Altzomoni for one sample day. Panel (a) shows all available S5P pixels containing CO data in the overpass file. Panel (b) shows the co-located S5P pixels with 50 km radius selection criterion. Panel (c) shows the co-located S5P pixels with the cone co-location criterion with 1◦ opening angle of the cone at the highest altitude. The yellow line in the plots represents the line of sight of the ground-based FTIR at the time of the satellite

Reconstruction of monthly mean TROPOMI: Urbancimatology of CO

- all qualities
- monthly mean
- valid for around 15:00
- 24x24 gridcells in a 1°x1° area
- boundary layer: last two pressure levels
- surface concentration=> validation with 33 insitu sites
- free tropospheric monthly mean profile:
- Validation with NDACC ALTZOMONI

http://www.epr.atmosfera.unam.mx/INECC2021/informe/Informe_final_INECC_2021.pdf



Sensitivity

Measurements with different sensitivity:

Measurements with different cloud coverage:

TOPROMI: Urban climatología

Reconstruction monthly mean of carbon monoxide:

$y_{tropomi}$ all tropomi measurements in a month in the area of interest 1°x1°

K contain the total averaging kernel (level 49 layers pressure based from above until the last but one and lowest layer is located somewhere in the row.

$y_{tropomi-}y_{apriori}$= K $(x_{ret}-x_{apr})$+

G $=(K^TK+R)^{-1}K^T$

x_{ret}=G $(y_{tropomi-}y_{apriori})$ $+x_{apr}$

xret[.50]= vertical VMR profile   => validation with ALTZOMONI-NDACC

xret[50:]= VMR distribution near surface (between lowest two pressure levels (24x24 grid cells)

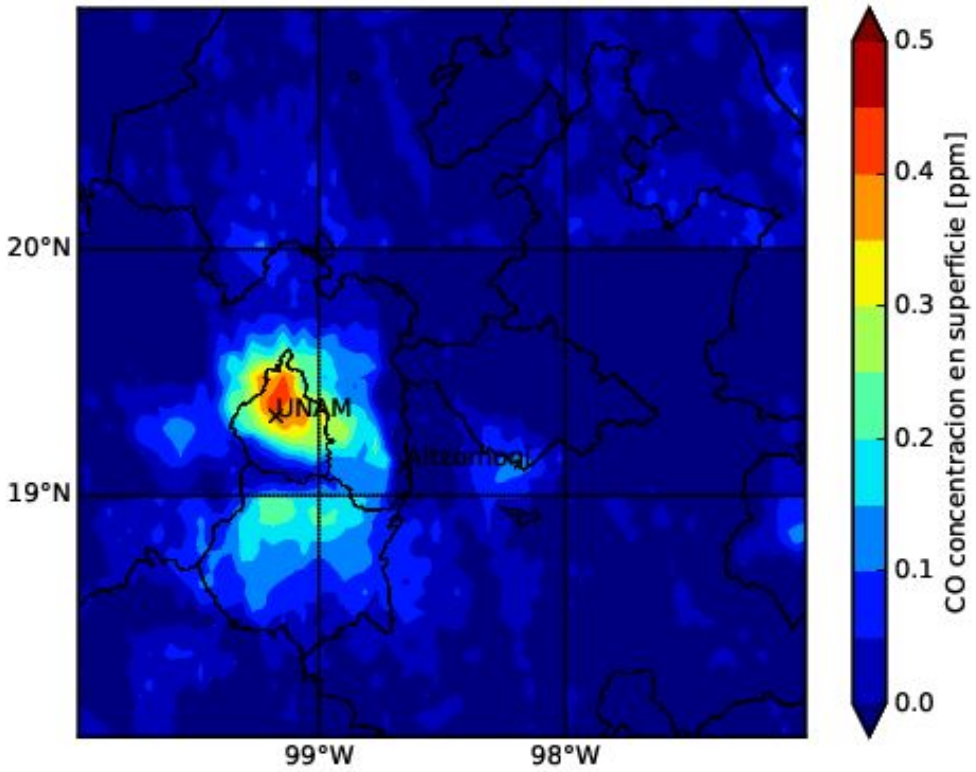
Validation with RAMA (insitu) =>

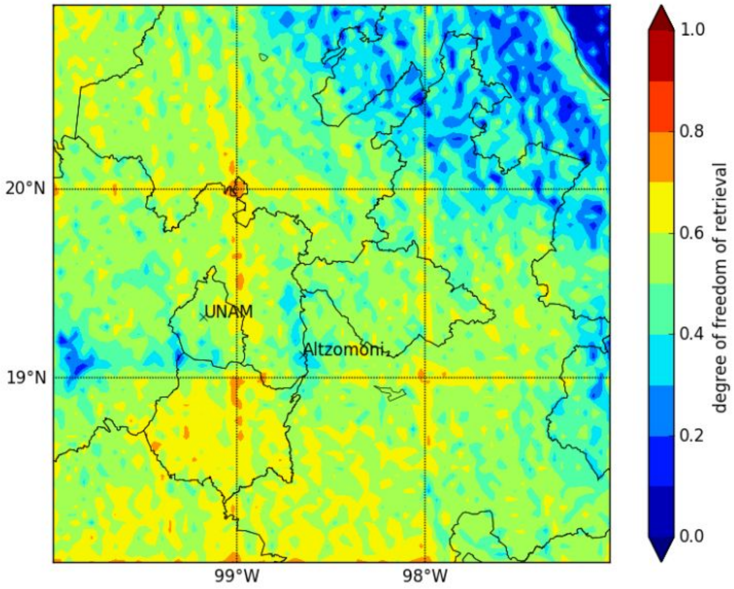
AK= G K

Monthly mean of Tropomi Reconstruction

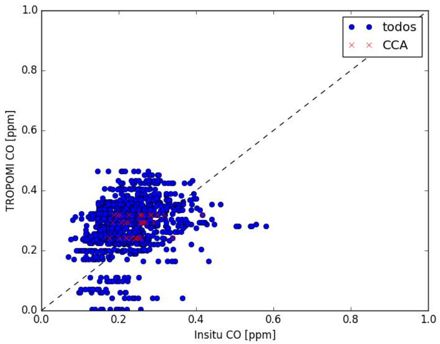
state vector x: 50 layer +24x24 grid cells

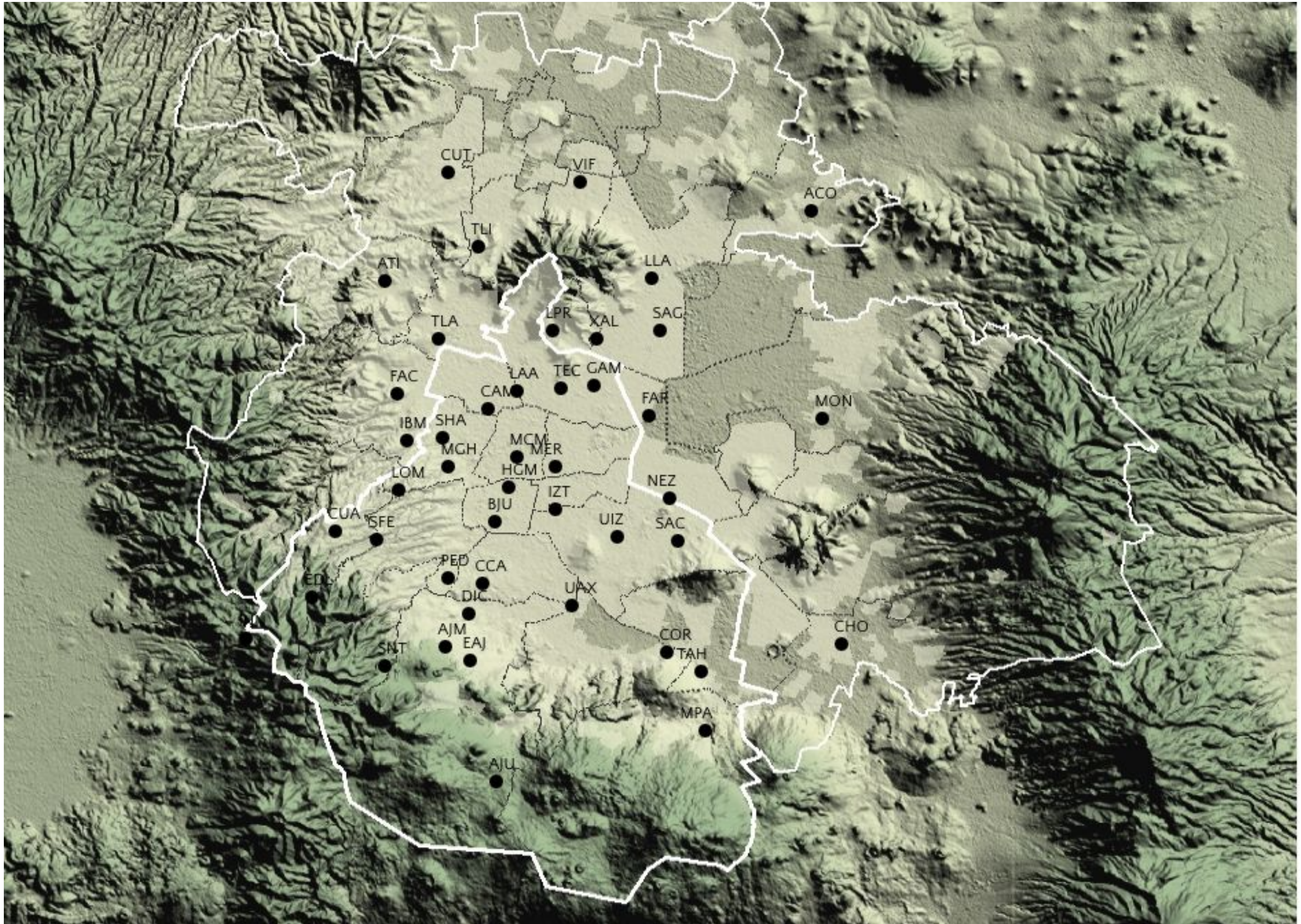
(L1-Tikhonov constraint)

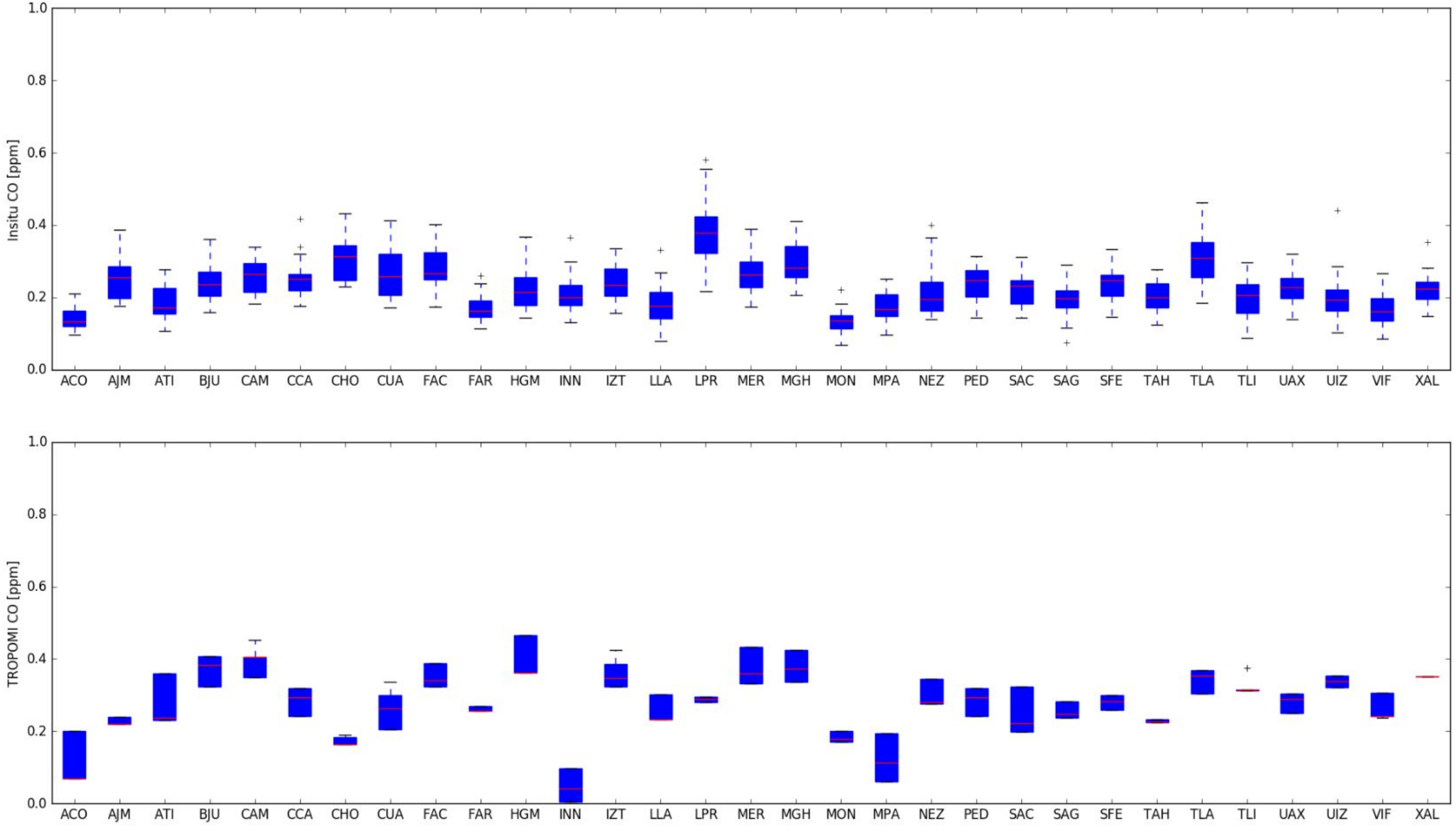




Intercomparison: TROPOMI-RAMA-insitu: monthly mean

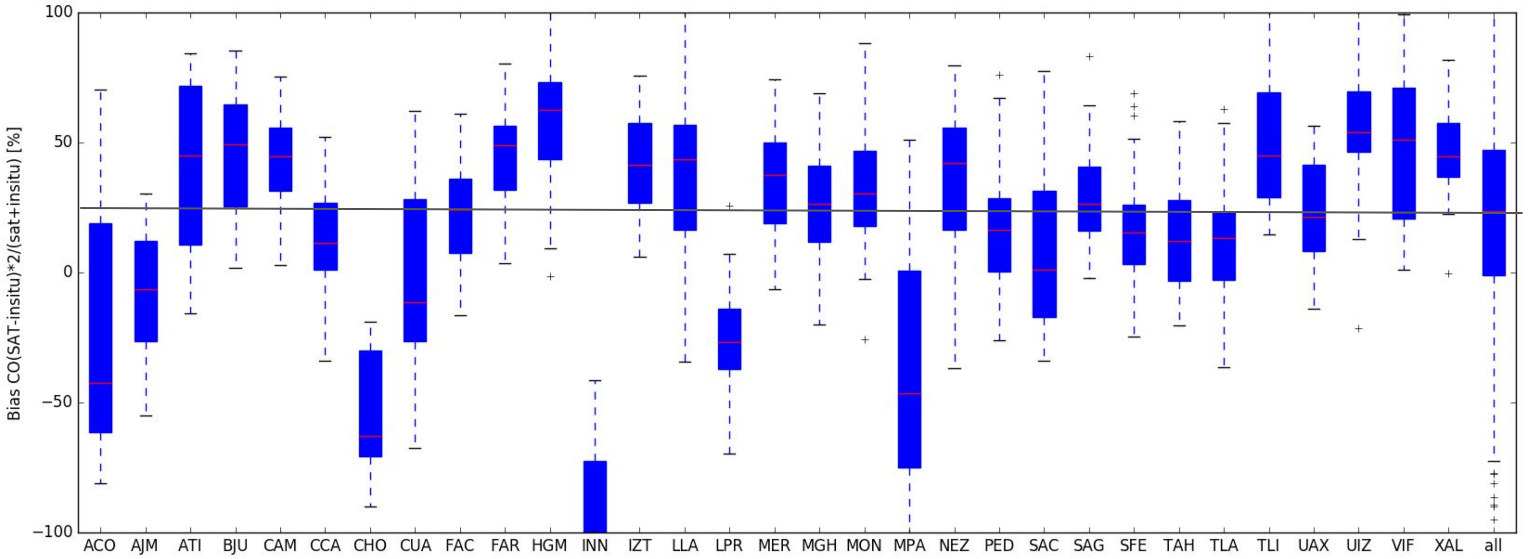






Insitu CO [ppm]
TROPOMI CO [ppm]
0.0
0.2
0.4
0.6
0.8
1.0
ACO AJM ATI BJU CAM CCA CHO CUA FAC FAR HGM INN IZT LLA LPR MER MGH MON MPA NEZ PED SAC SAG SFE TAH TLA TLI UAX UIZ VIF XAL

Bias TROPOMI insitu in Boundary layer

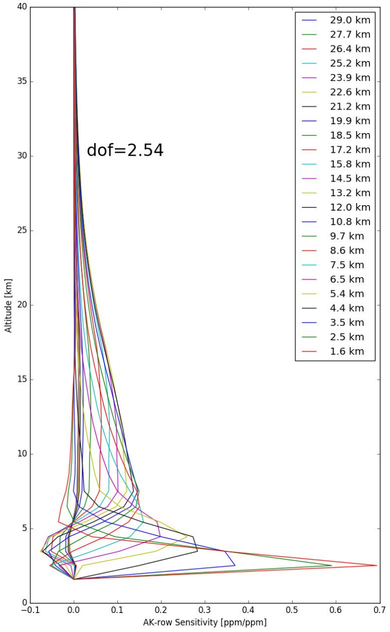


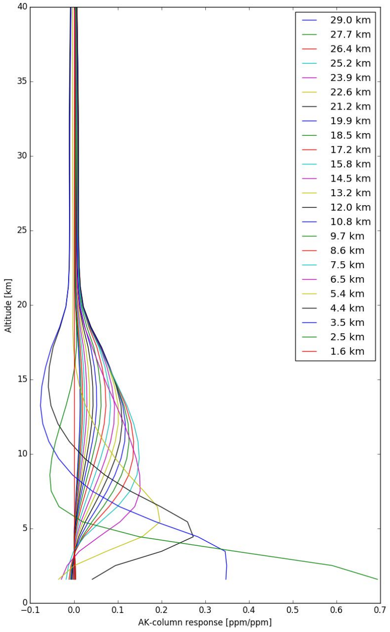
approx
20%

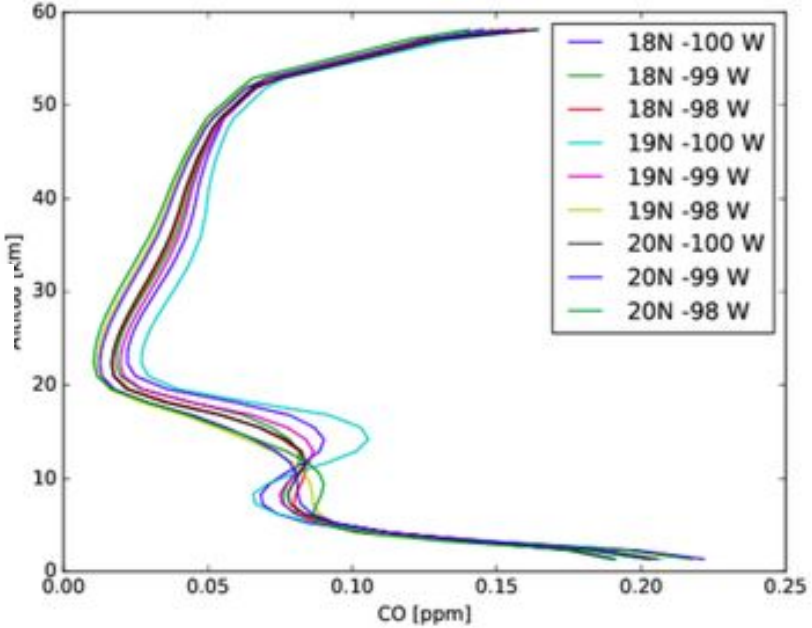
asumed pressure difference in boundary = around 100 hPa and aroud 1800m (2230m Mexican basin and 4000m at Altzomoni.)
an error in dP of around +10hPa we have to detail with an error of 10% in the mean difference.

January 2020

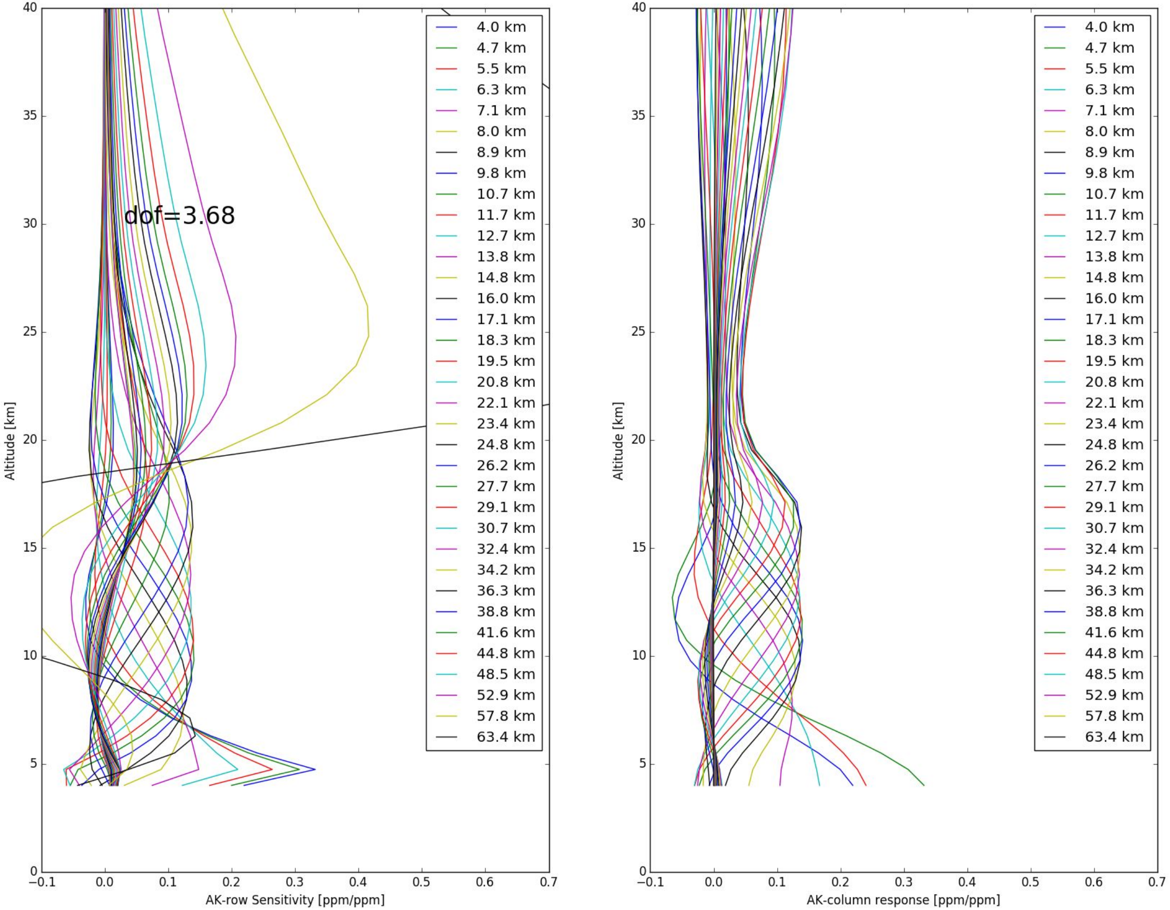
9 Vertical profiles above central Mexico



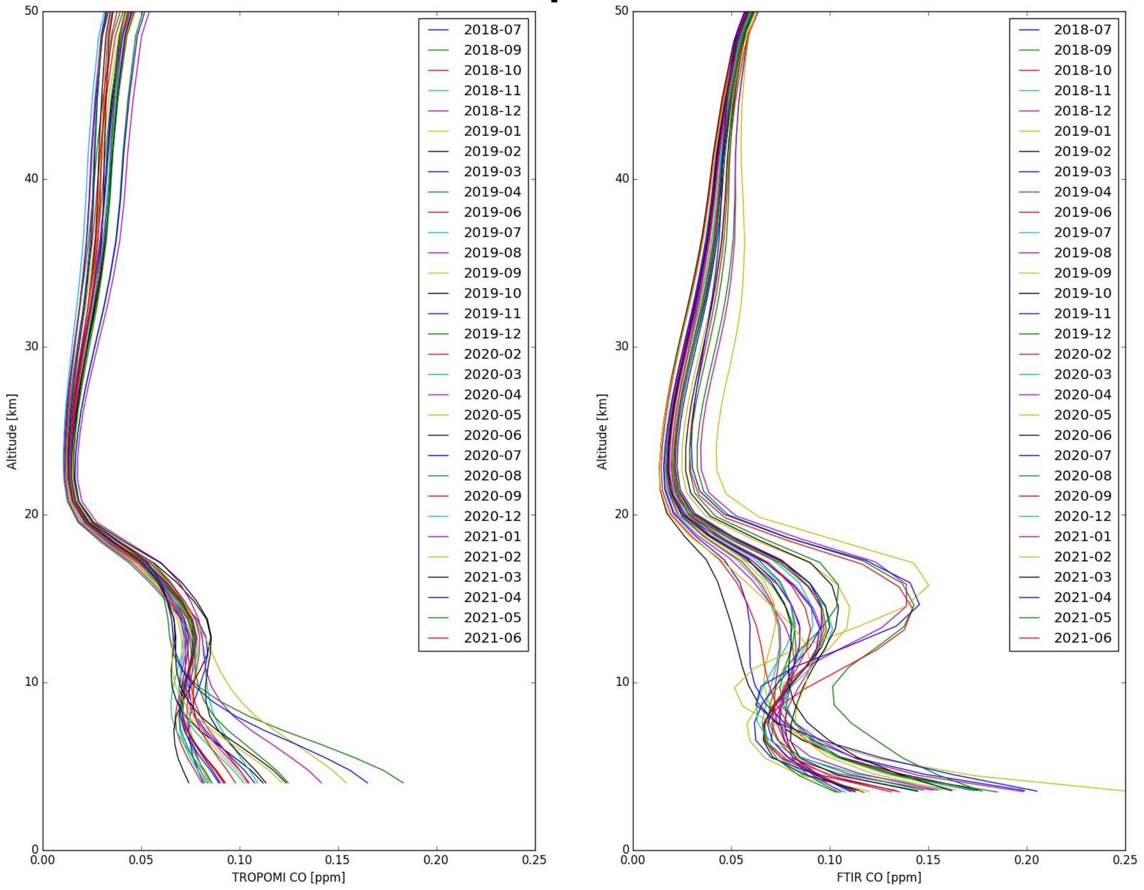




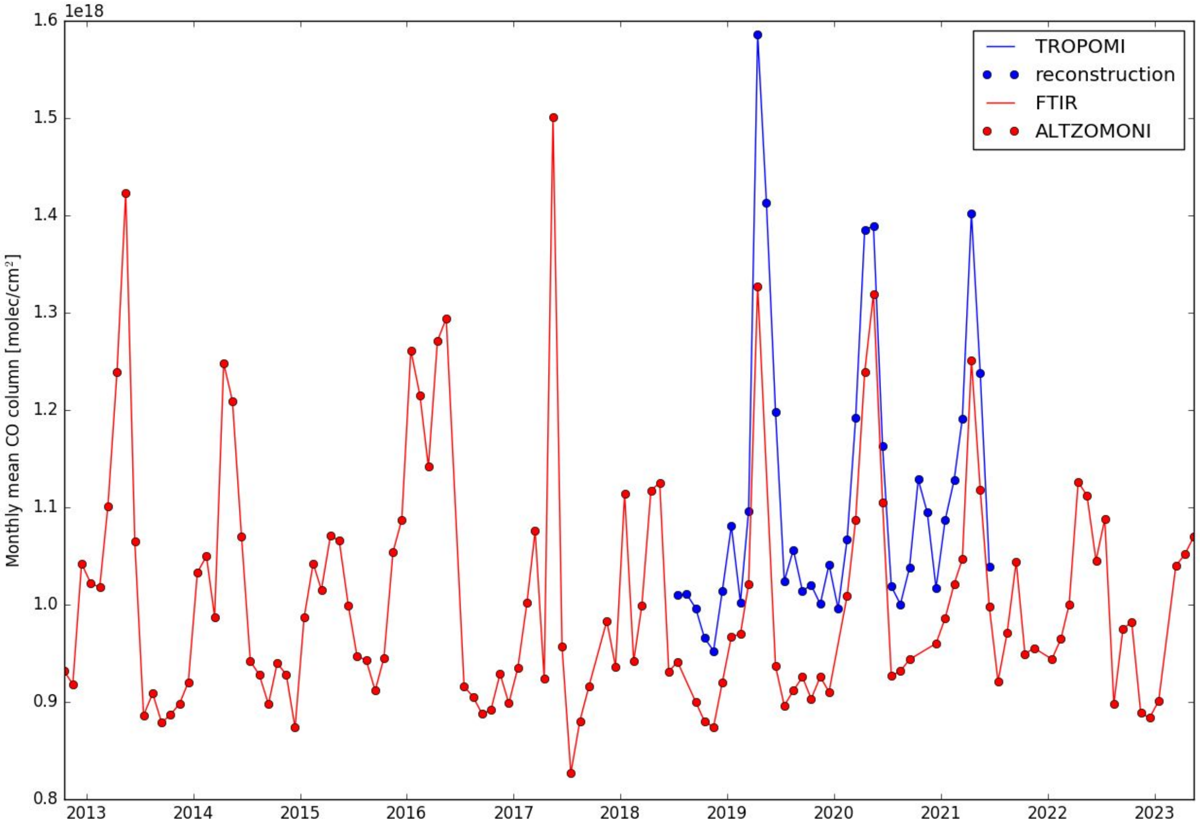
Averaging Kernel Altzomoni - NDACC standard retrieval



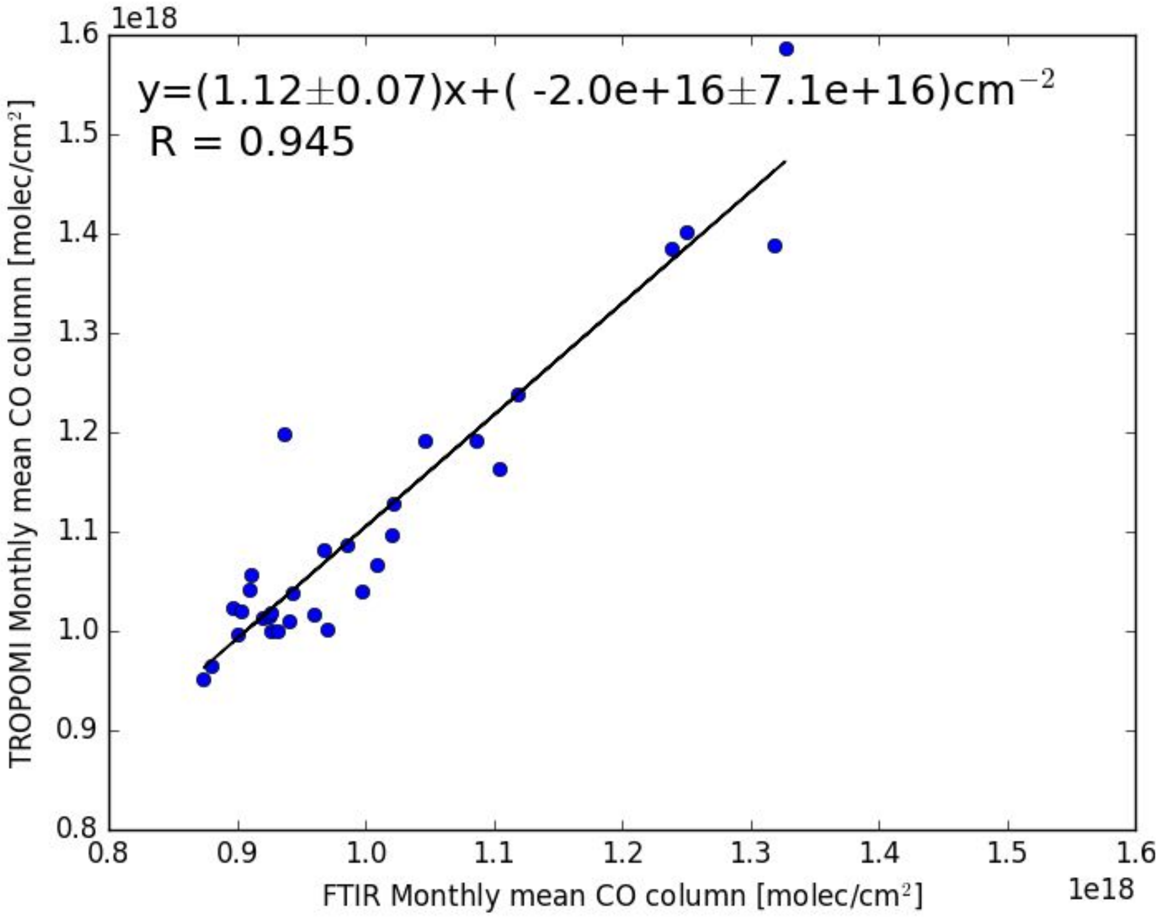
Monthly mean vertical CO profiles above Altzomoni



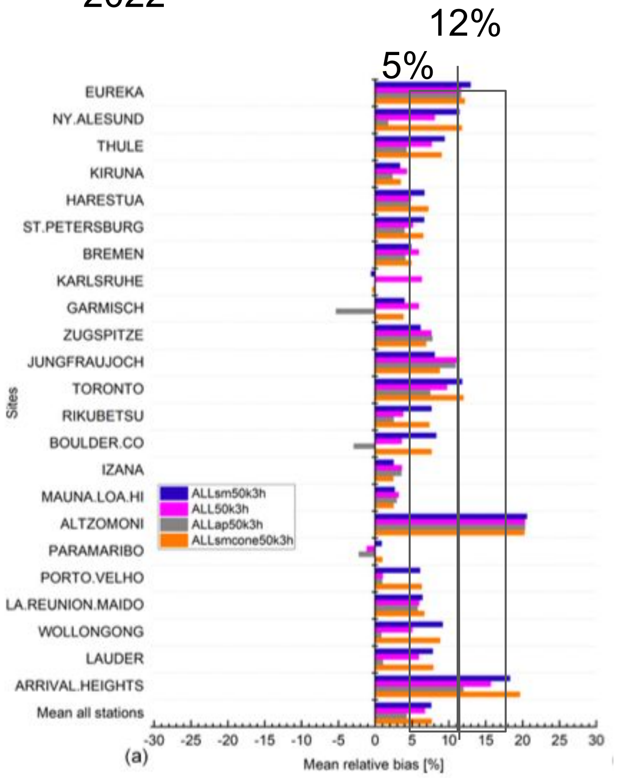
Total column intercomparison: TROPOMI-ALTZOMONI



Bias around
10 %



still a clear Bias of 12 % +/- 7%
But we are now better:
6% bias is found by Sha et al 2022



We have not yet used the averaging kernel of the FTIR of the reconstruction: Can we explain the slope by the AVKs and the variability of CO in the atmosphere?

$$dX_{ret}=A\ dX_{true}+error$$

How to compare two retrievals with a limited dof: 4 for FTIR and 2.5 for TROPOMI reconstruction:

Both use WACCOM apriori, no significant offset (-2+/- 7)E16.

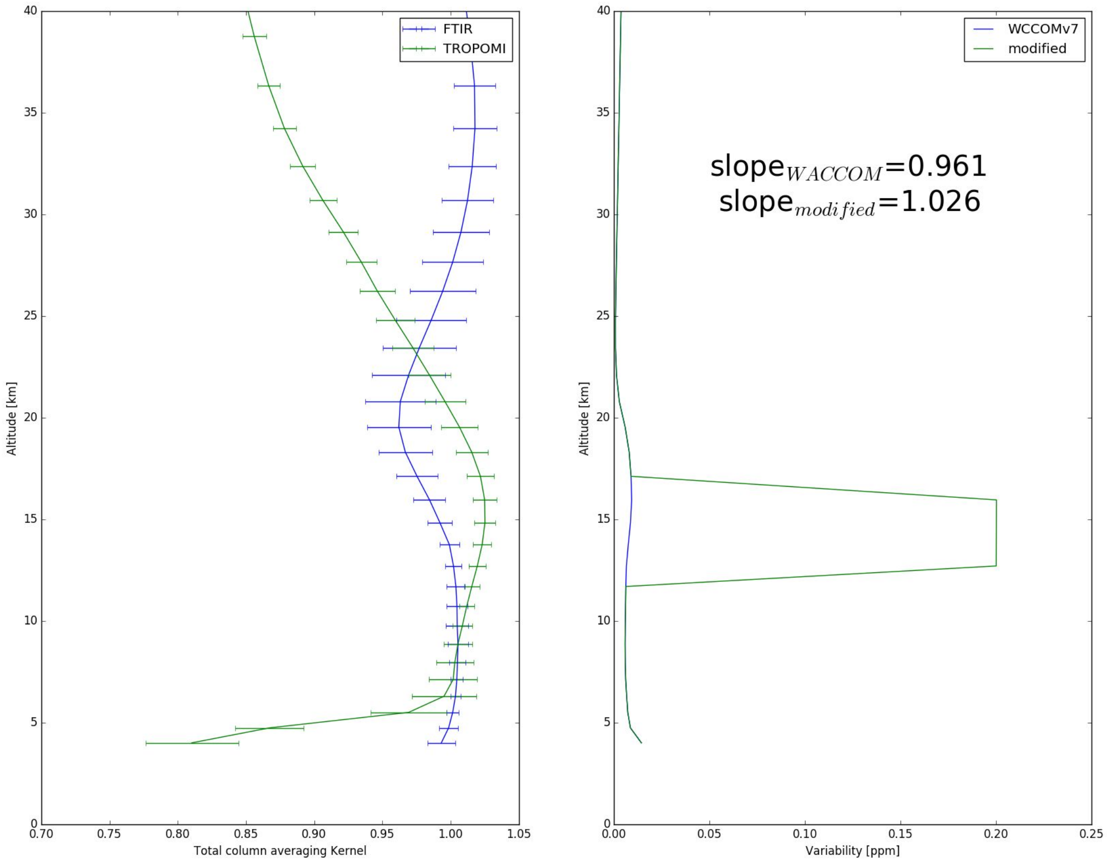
=> a slope is calculated by this quotient $<x|y>/<x|x>$.

=> Pearson’s R is calculated with this expression: $<x|y>/sqrt(<x|x><y|y>)$

for our retrievals we get: $<x|y>= < a_{ftir}| Sa_{waccom}|a_{tropomi}>$ and $<x|x>= < a_{ftir}| Sa_{waccom}|a_{ftir}>$

slope= $< a_{ftir}| Sa_{waccom}|a_{tropomi}>/ < a_{ftir}| Sa_{waccom}|a_{ftir}>$

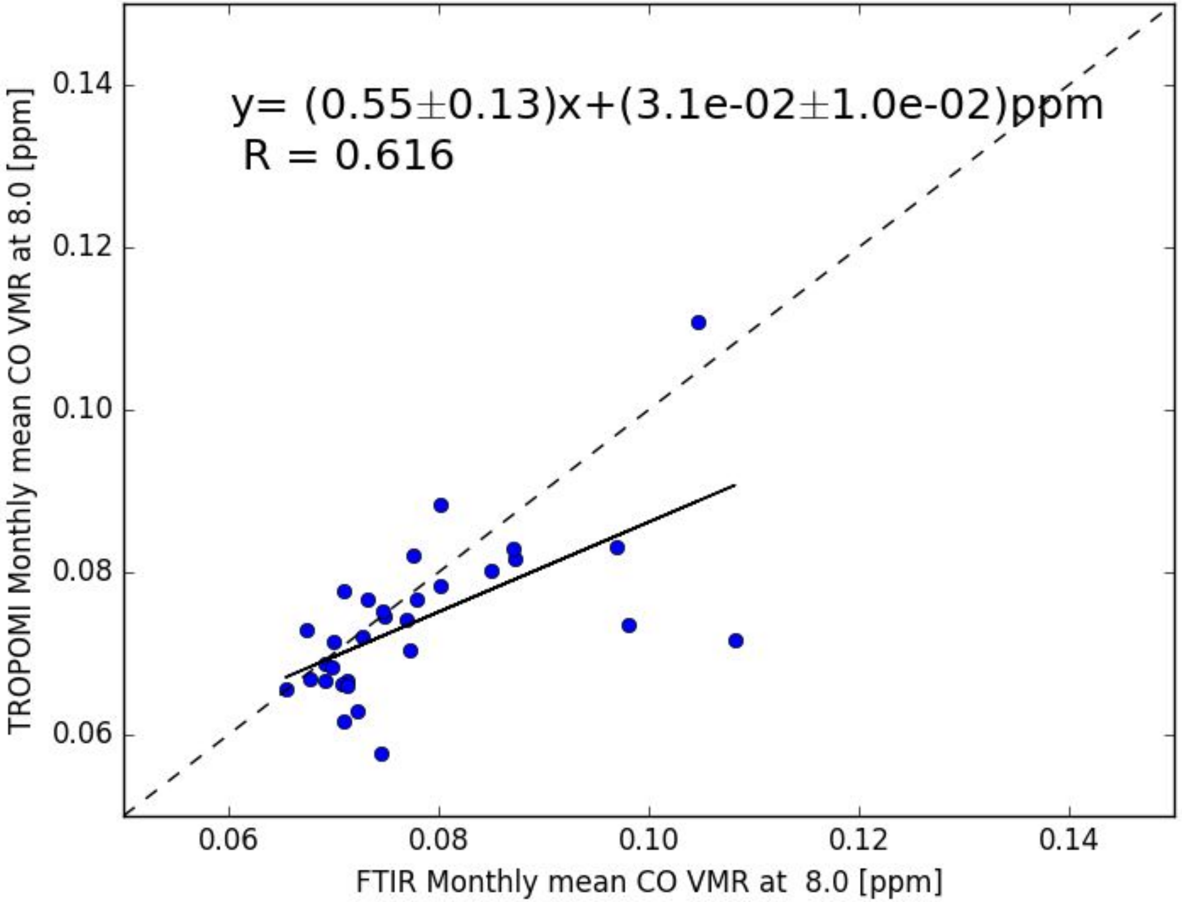
$$slope = < a_{ftir} | Sa_{waccom} | a_{tropomi} > / < a_{ftir} | Sa_{waccom} | a_{ftir} >$$



even trying hard, it is not easy to explain the 12% bias in the total column with the sensitivities and the averaging kernel.

Actually a negative bias about -4% would be expected assuming the variability of the WACCOM model run v7

But that tht there is a bias, we know from Sha et al. 2022



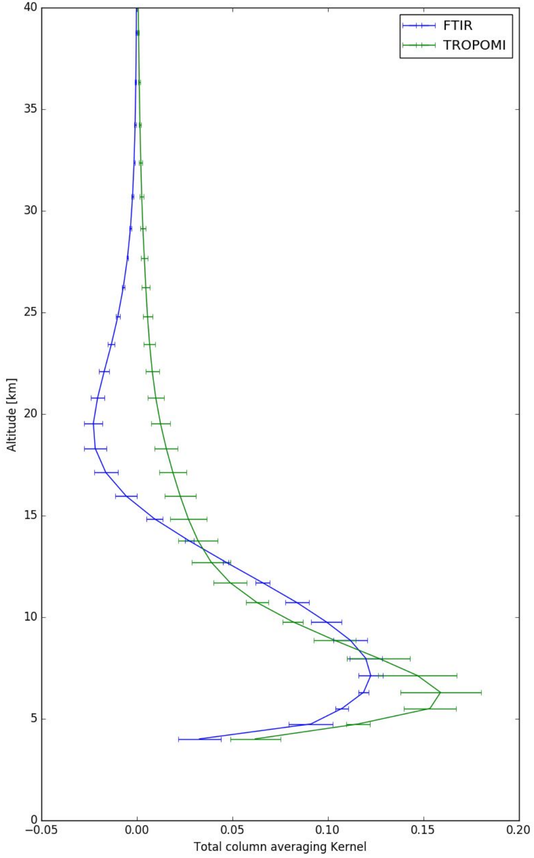
profile retrievals:

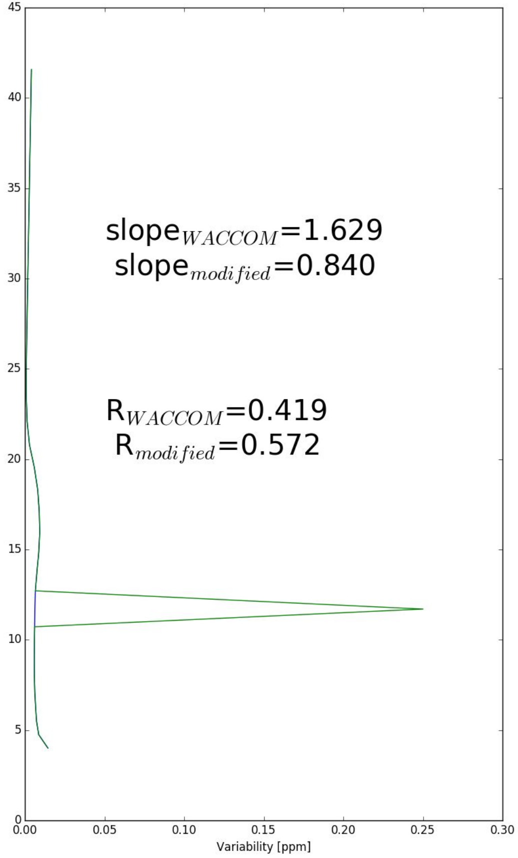
we can compare the VMR in different altitudes

8 km => more or less

maybe remove some point would be improve correlation

and slope





Waccom SA suggest the correlation should not be to nice,

but maybe the slope should be higher

modified Sa might result in better slope and R.
We can optimize our Sa to explain slope and R.

Summary:

There is a lot of different measurements and products of Carbon monoxide in Mexico

One more is the monthly mean CO profiles reconstructed from the heterogen TROPOMI CO dataset: Combination from cloudy and no cloudy measurements give the vertical resolution.

The column of the reconstructed TROPOMI profile above Altzomoni is slightly higher than the NDACC-FTIR columns. That's is consistent with Sha et al. 2022.

Reconstructed TROPOMI the boundary layer is about 20% higher than RAMA => probably the boundary layer is probably a bit thicker than the lowest to pressure levels.

The averaging kernel and Sa covariance matrix can be used to check, if the difference, which might originate from the sensitivities, are consistent.

An example for the totalcolumn and the lowest layer was shown the forecast of a good and a bad correlation.

Maybe that might an alternative way for validation: Not to worry about bad correlation and bias, when the variability and different sensitivities explain it.

Thank you

Acknowledgements: PAPIIT IN115121,. I….