# Comparisons of MOPITT $X_{CO}$ with TCCON

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MOPITT

TCCON total carbon column observing network

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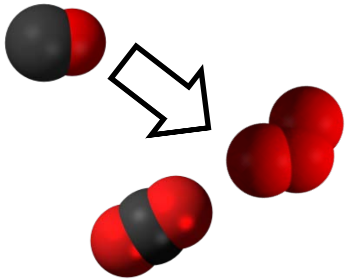
# Motivation/background – Carbon Monoxide

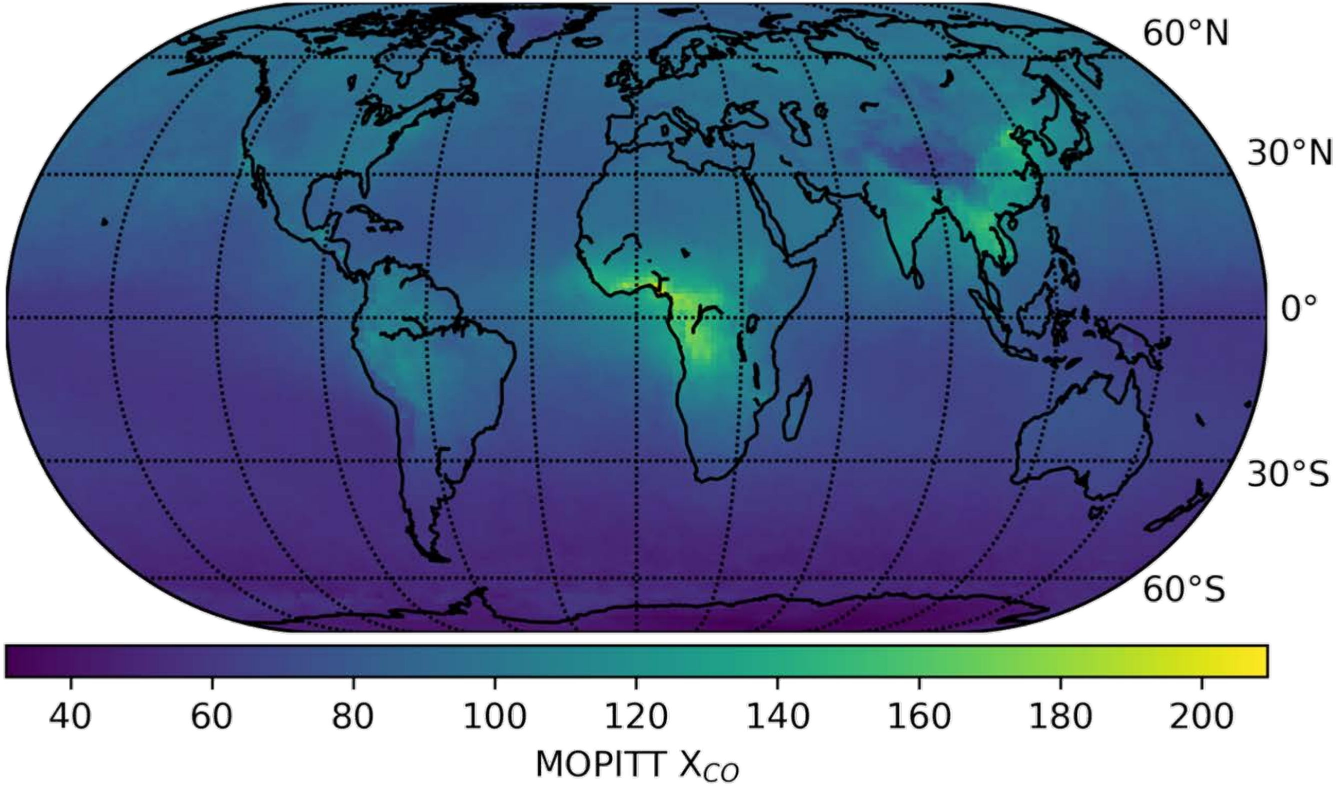
- Secondary GHG
- Constraint on OH
- Tracer of transport and pollution (lifetime ~2 months)
- Global average ~80 ppb

- Previous validation work has focused on aircraft, and NDACC-IRWG (mid-IR) comparisons
- TCCON (near-IR) uncertainty (2σ) 4 ppb (Wunch et al., 2010 doi:10.5194/amt-3-1351-2010)

**VOCs**



# MOPITT $X_{CO}$ (2016 average)

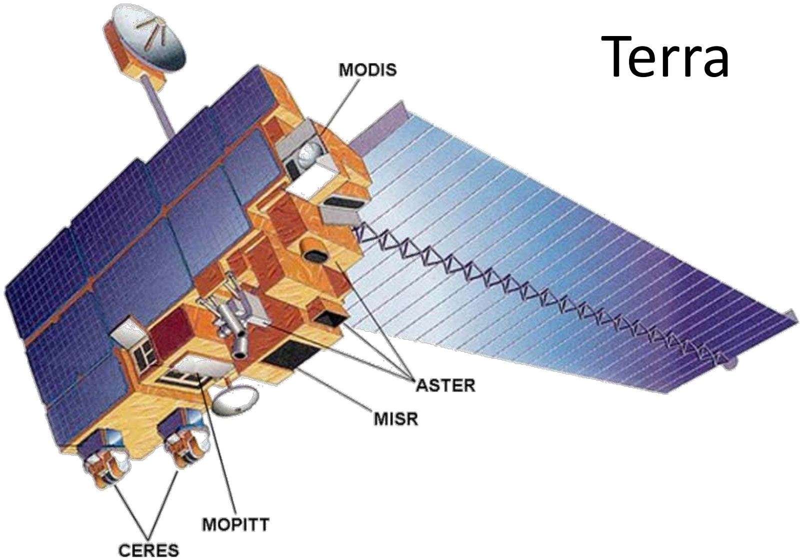


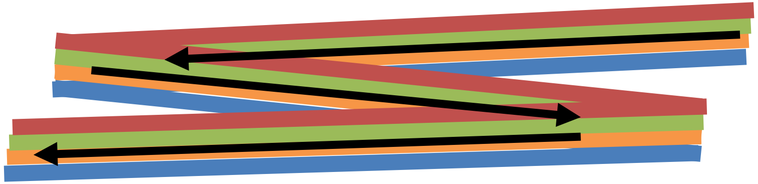
# MOPITT (**M**easurements **O**f **P**ollutants **I**n **T**he **T**roposphere)

- Launched December 1999
- ~22×22 $km^2$ soundings
- ~$10^5$ soundings/day
- TIR & NIR channels (V7J)
- "Sweep-broom" 4 footprints/pixels

- 10 level profile retrieval
- $\log_{10}$ retrieval

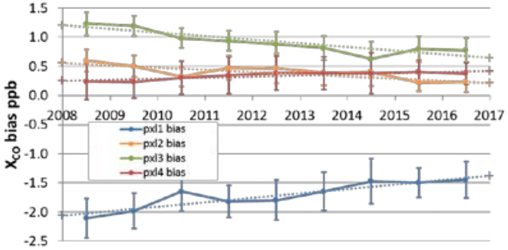
Terra



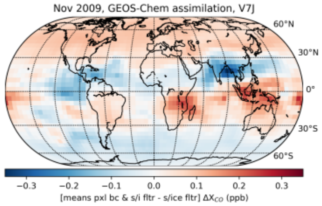



# Overview

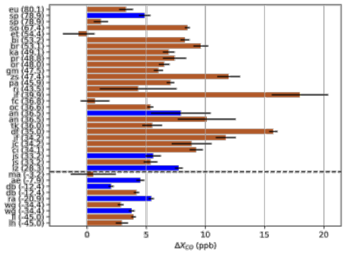
- Developing daytime QC filters
- Maximum pixel-to-pixel bias of ~2-3 ppb, with a trend




- Removing pixel bias makes a small difference (<0.35 ppb) in GEOS-Chem state assimilation



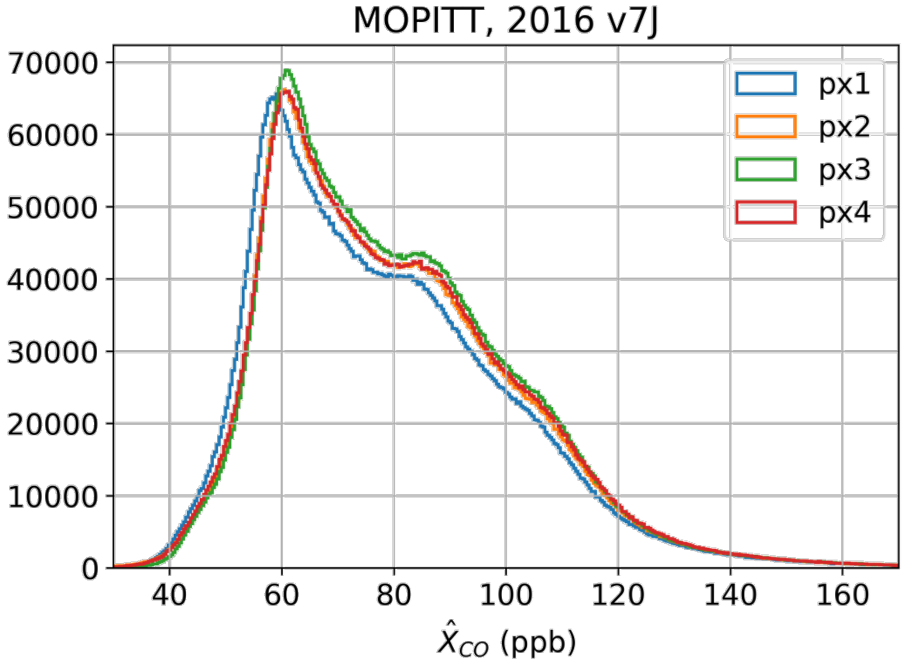

- MOPITT-TCCON is high (~4 ppb), with about ±3 ppb of scatter

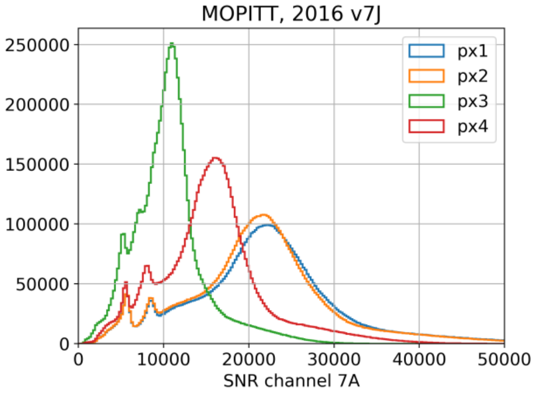


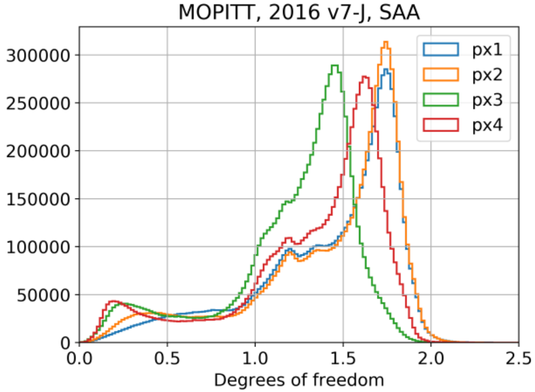

Contact: Jacob.hedelius@utoronto.ca

# Pixel bias

- Pixels/footprints are biased (esp. #1) relative to each other

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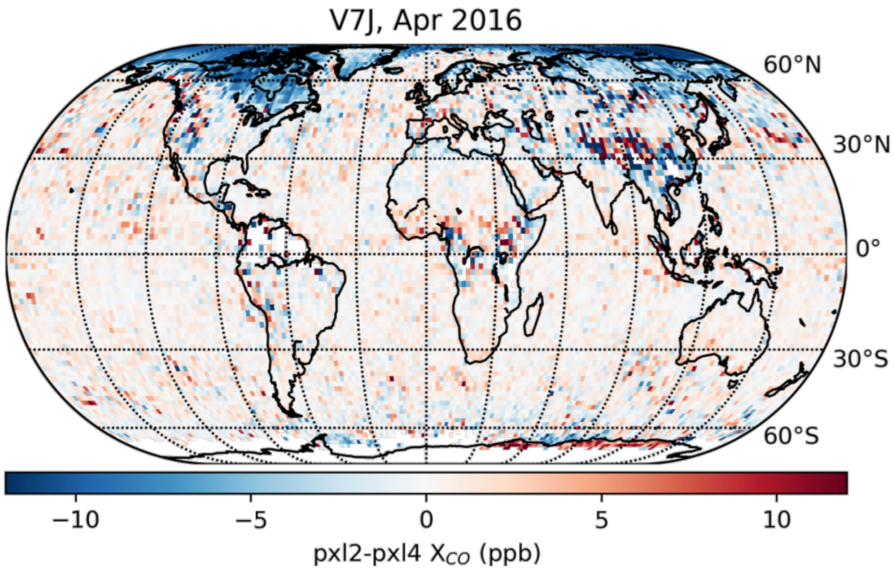
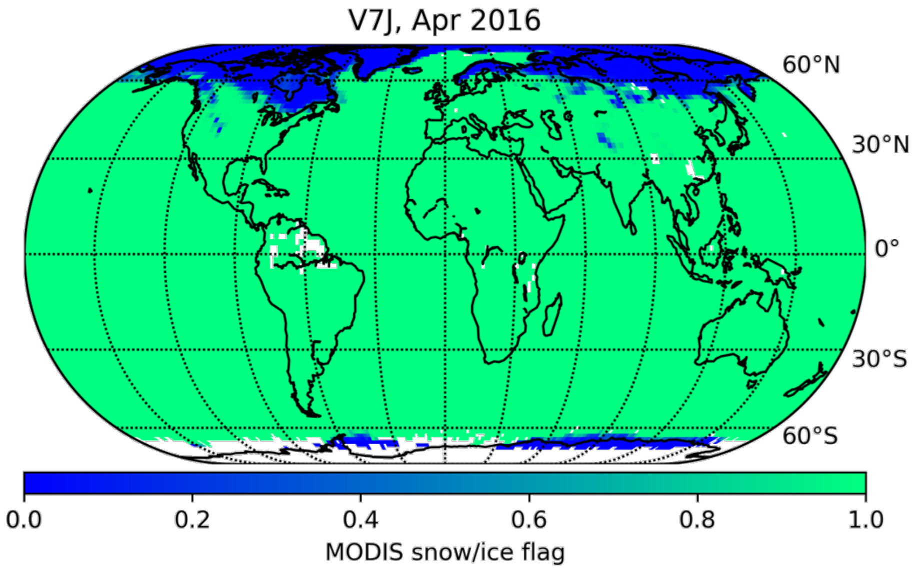
# Measurements Of Polar Ice Through pixel contrasT

- Pixel to pixel bias (left) correlates with snow/ice extent (right)

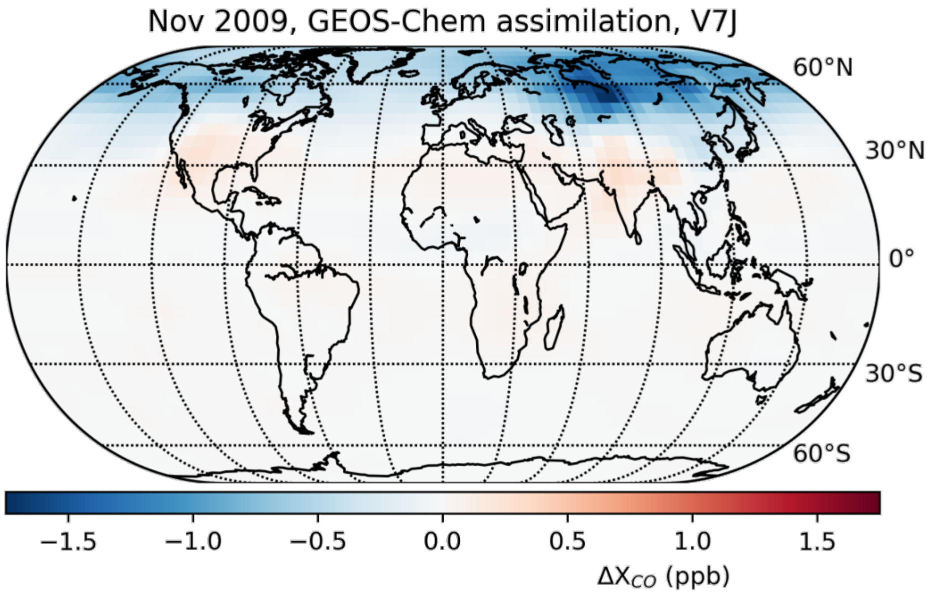


# GEOS-Chem state assimilation (4°×5°)

- Model state differences from assimilation with no filters and after removing snow/ice scenes

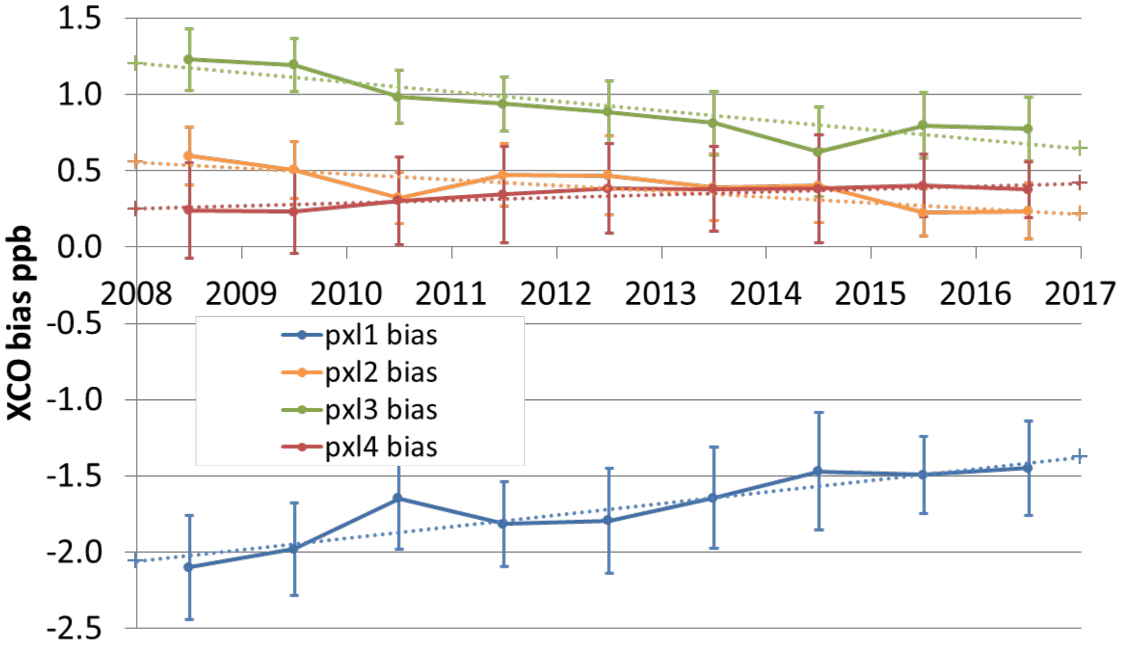
Model run by Tailong He




- (Future work – derive quality control filters based on small area analysis)

# Pixel bias trend

- MOPITT pixels have individual global bias that change with time

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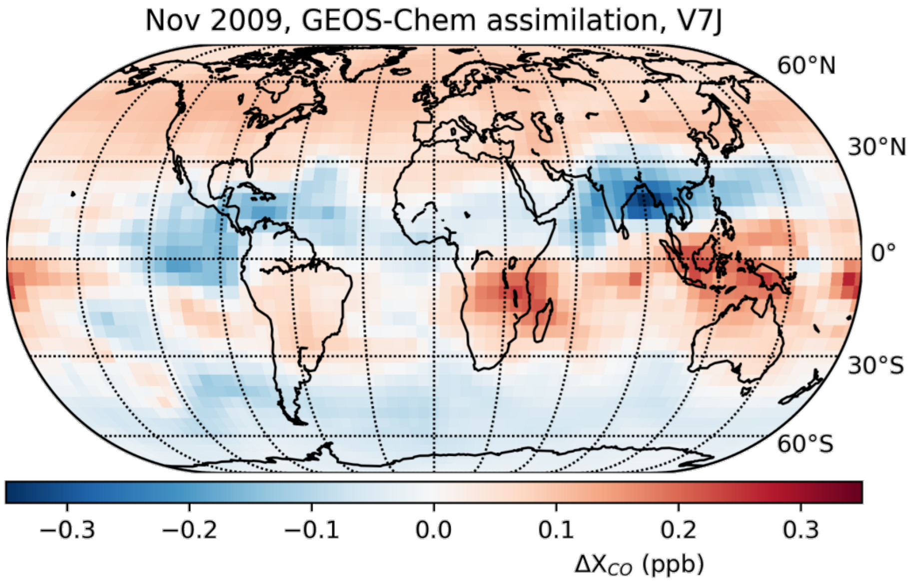
# GEOS-Chem state assimilation (4°×5°), part II

- Small differences between model with and without pixel bias correction to weighted mean

Model run by Tailong He

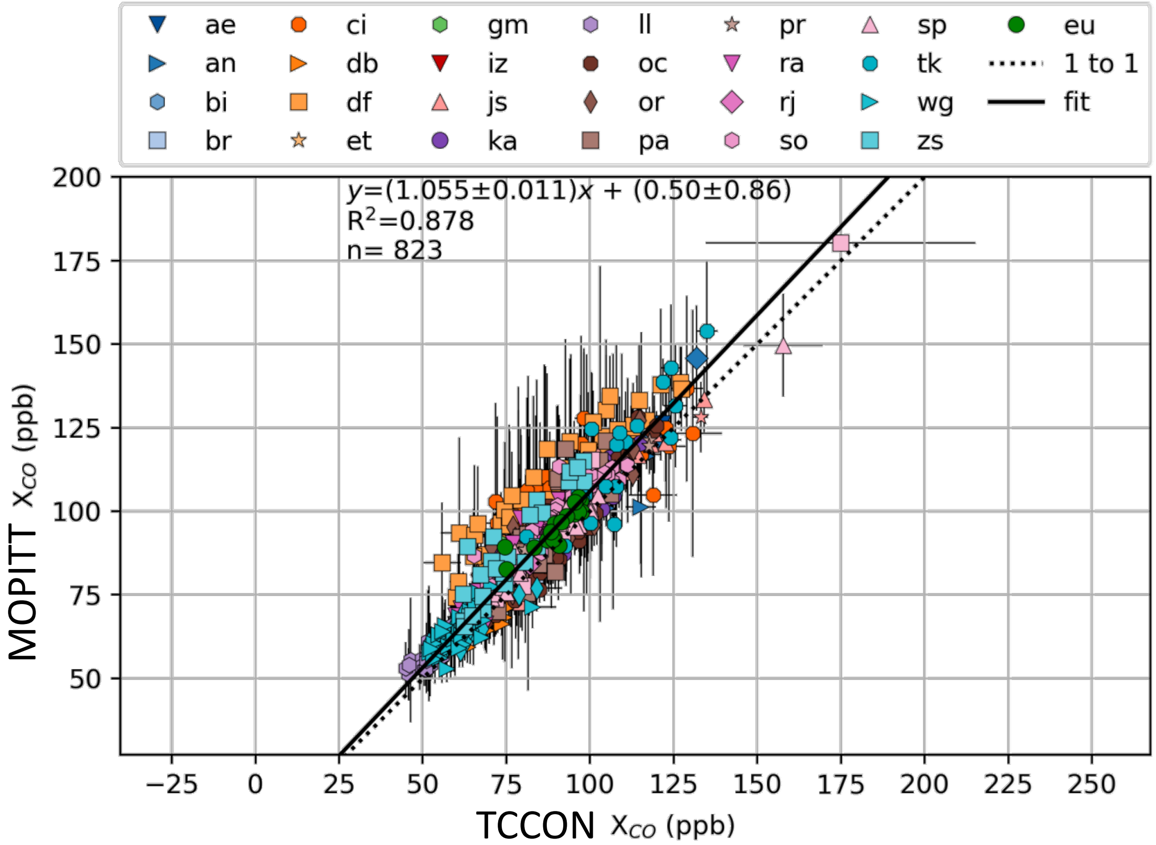


# TCCON Comparison

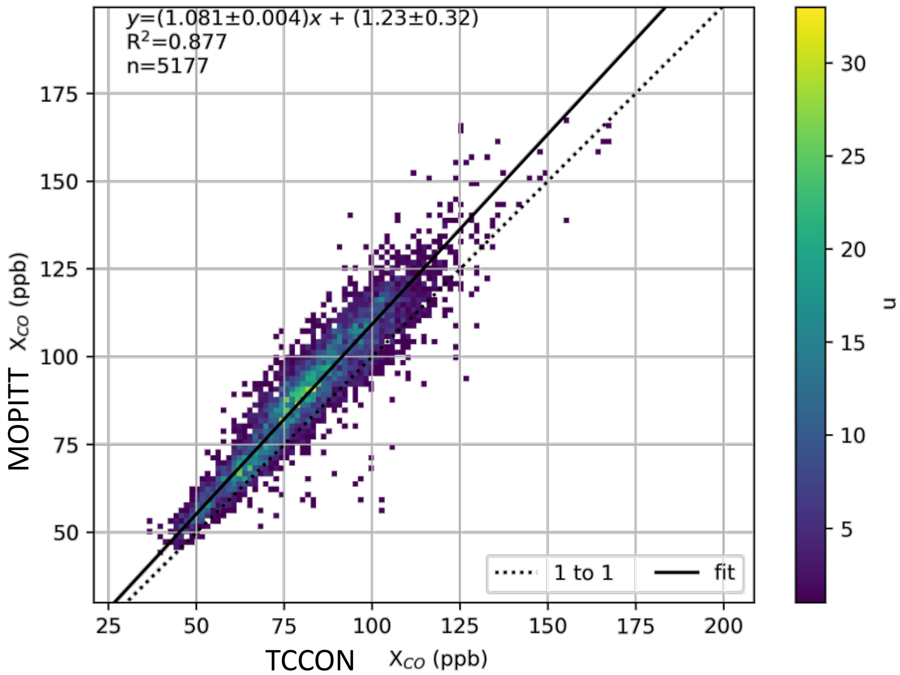
- Nominal coincidence criterion 2°×4°
- Following methods of Wunch et al. (2011) doi: 10.5194/acp-11-12317-2011
  - Using TCCON prior as comparison ensemble ($\mathbf{x}_c = \mathbf{x}_{Ta}$)
  - Applying MOPITT averaging kernels to TCCON $\hat{\mathbf{x}} = \gamma \mathbf{x}_{Ta}$

# TCCON Comparison (2016 only)

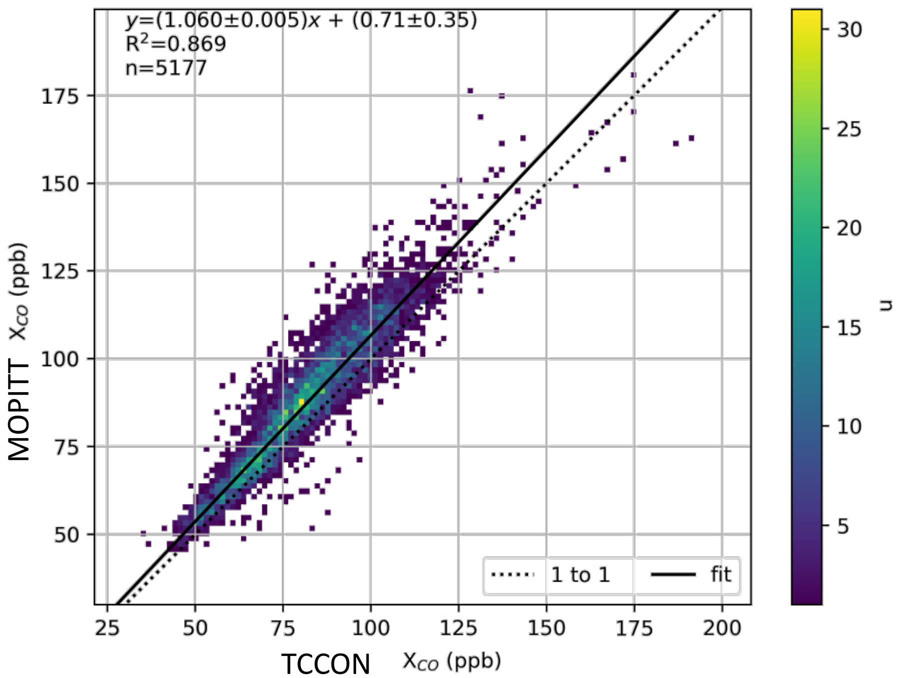
- 2016 bias on order of 5-6%



## No accounting for different AKs & priors



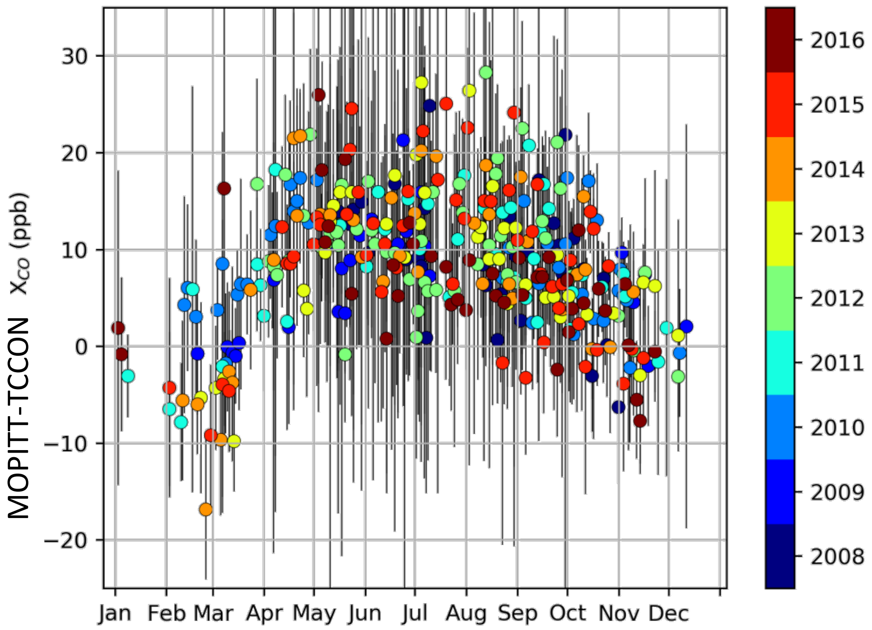

## TCCON prior as comparison ensemble, applying MOPITT AKs to "$\hat{\mathbf{x}}_T$"



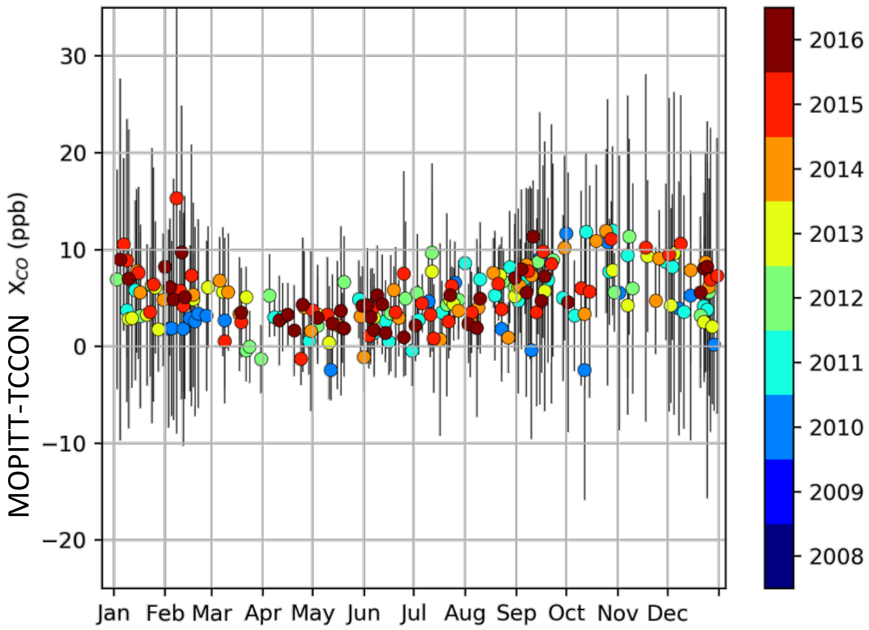

- Accounting for different AKs & priors makes about a 2% difference
- MOPITT is ~6% high compared to TCCON

# Seasonal cycle in MOPITT-TCCON difference

N. Hemisphere, Park Falls, USA (46°N)

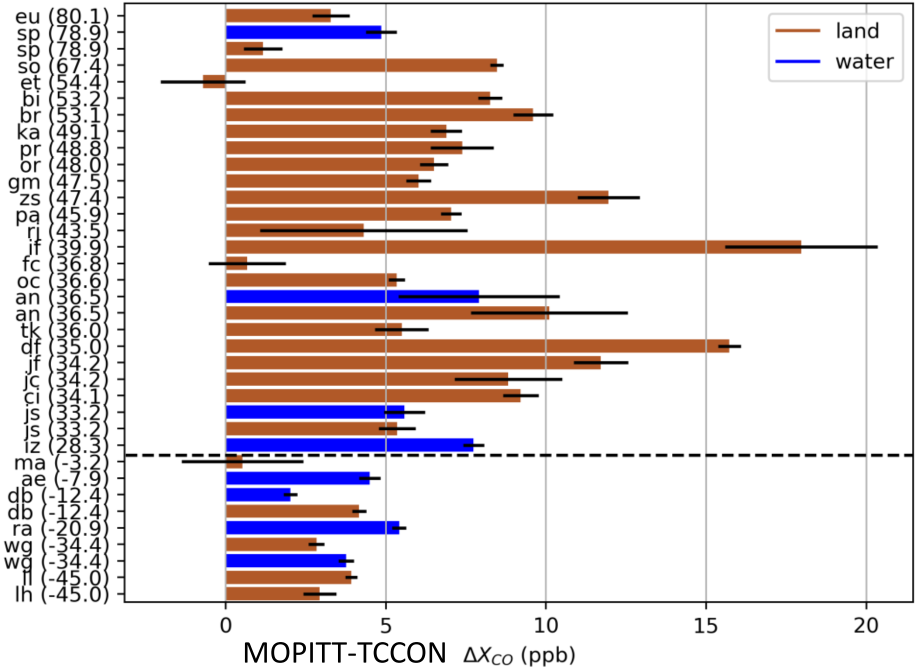


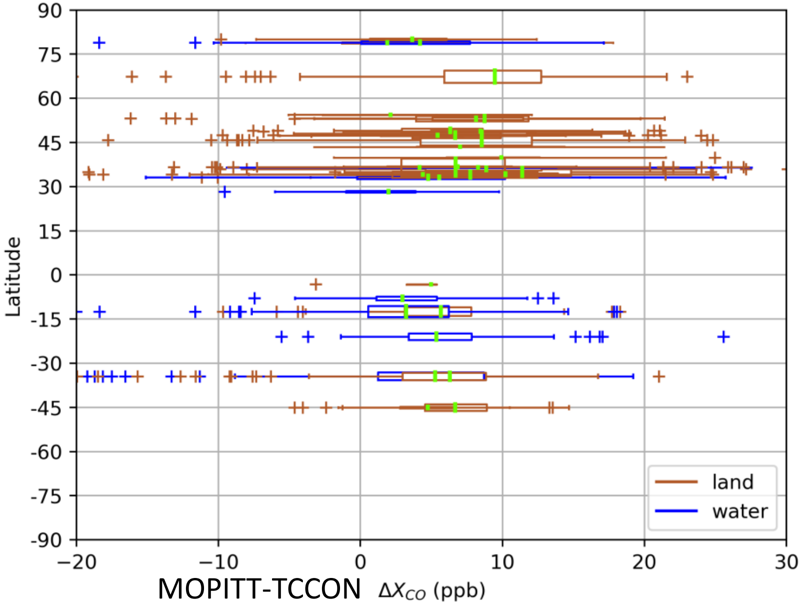

S. Hemisphere, Lauder, NZ (45°S)




- Seasonal cycle ~10 ppb in MOPITT-TCCON difference
- Working on diagnosing origin

# Site-to-site/latitude comparison




- MOPITT-TCCON difference is positive at nearly every site
- Scatter among sites about ±3 ppb

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# Overview/summary

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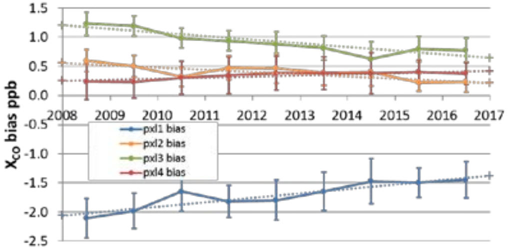
- Maximum pixel-to-pixel bias of ~2-3 ppb, with a trend

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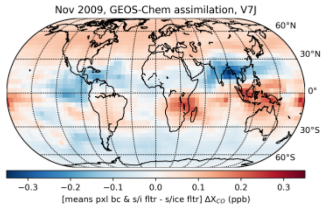


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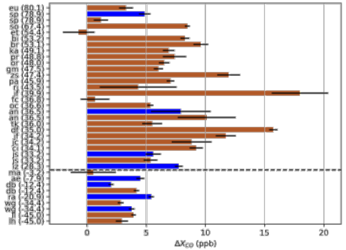


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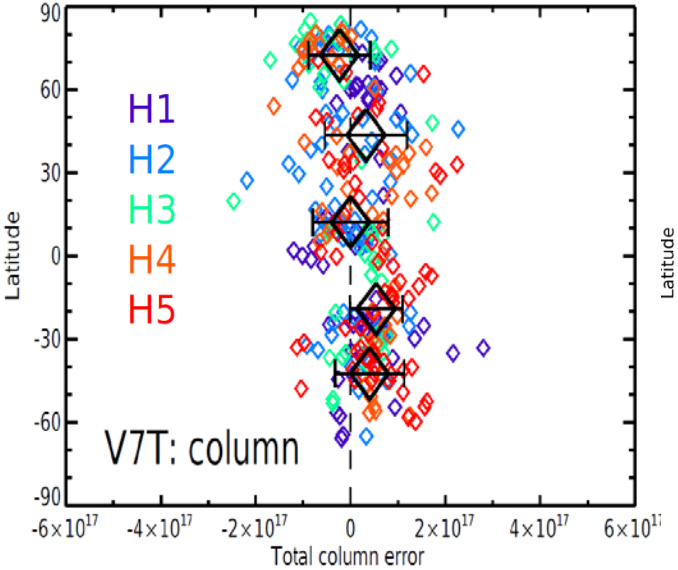
# Latitude comparison

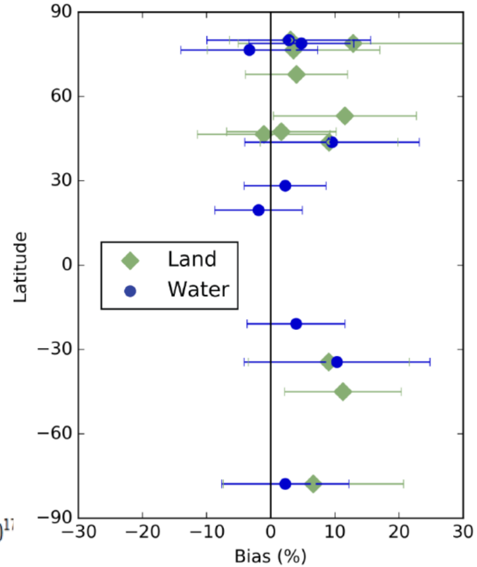
## TIR (vs. HIPPO)

Deeter et al. (2017), doi:10.5194/amt-10-2533-2017

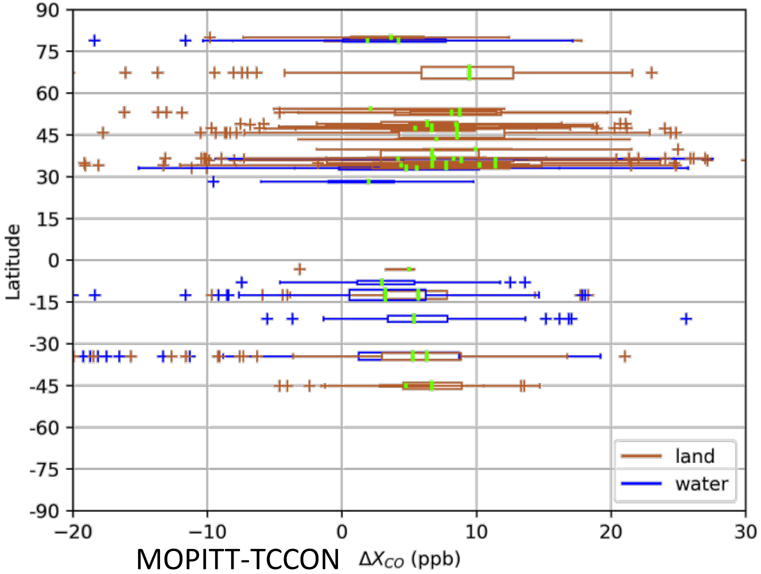



## TIR+NIR (vs. NDACC-IRWG)

Buchholz et al. (2017), doi:10.5194/amt-10-1927-2017



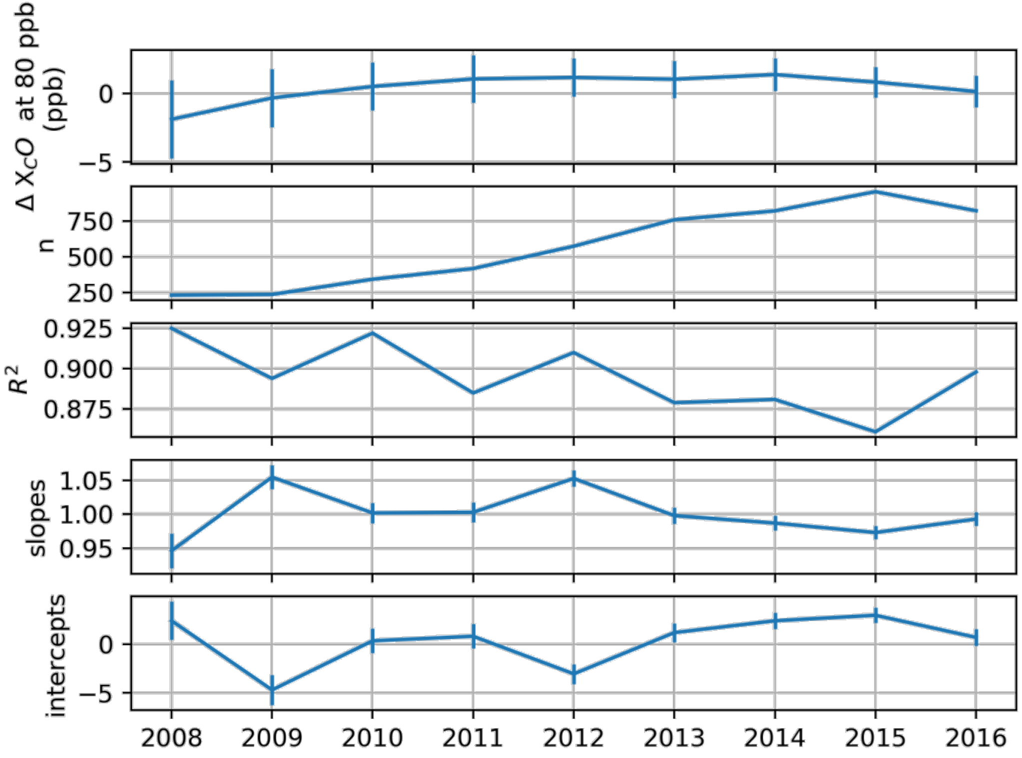

## TIR+NIR (vs. TCCON)



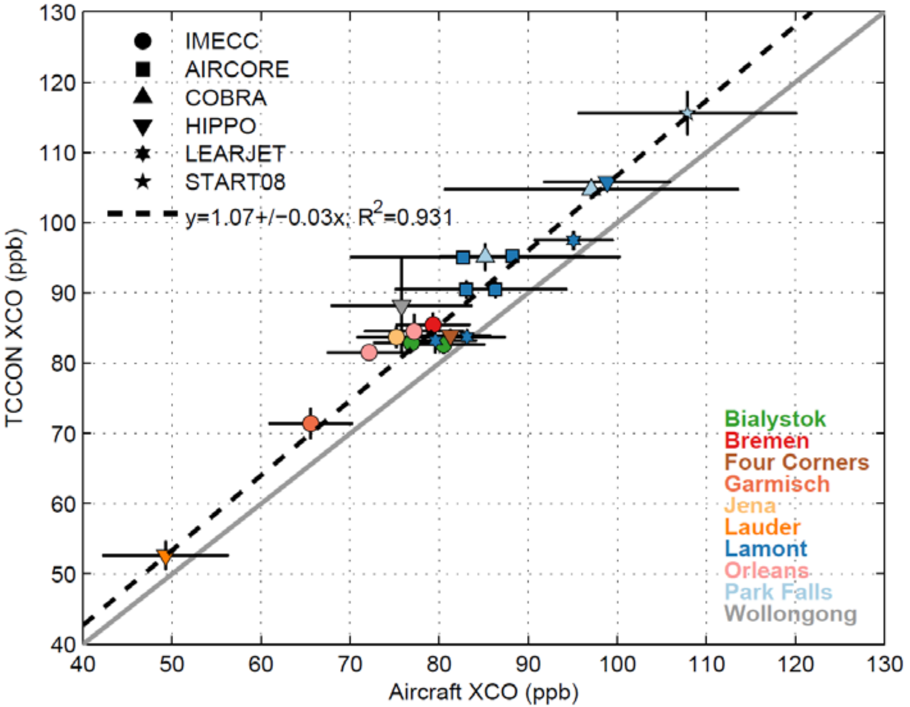

- MOPITT-TCCON difference is positive at nearly every site
- Scatter among sites about ±3 ppb
- Unclear still if there is latitude dependence

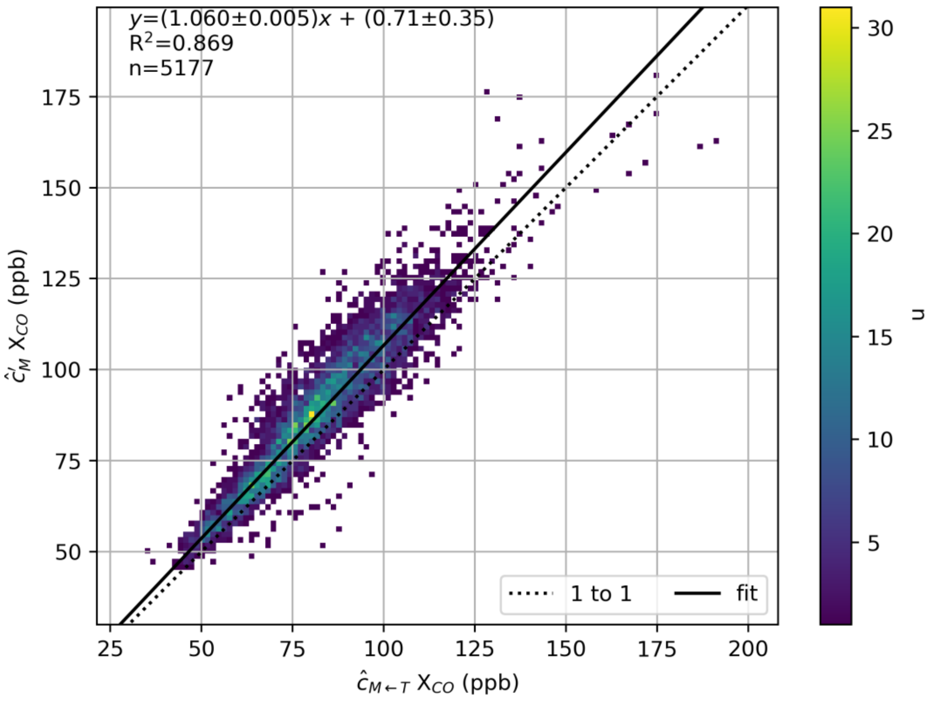
# TCCON comparison w/time

No empirical TCCON correction



# TCCON Comparison

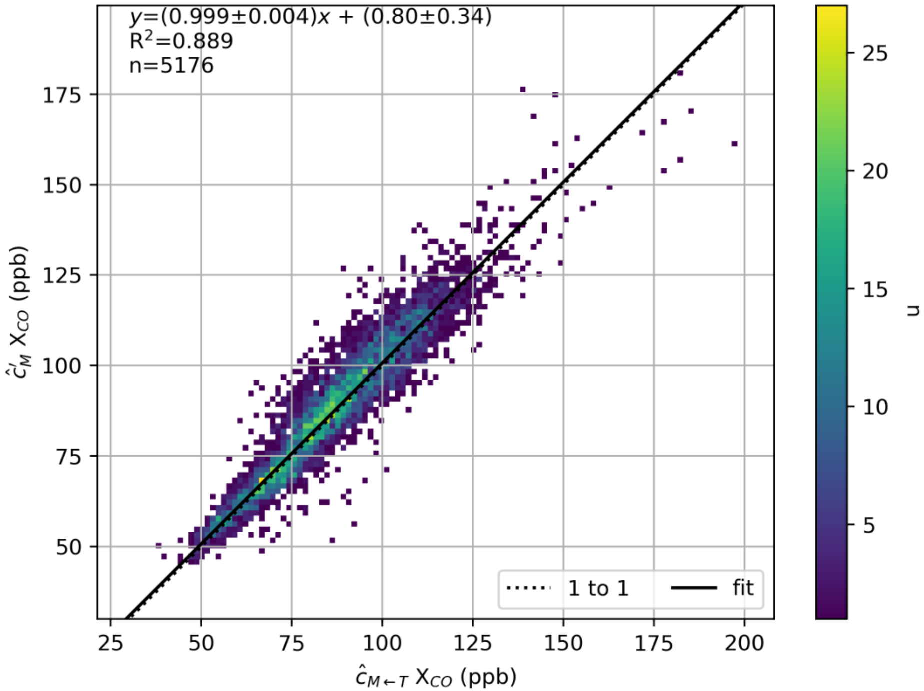


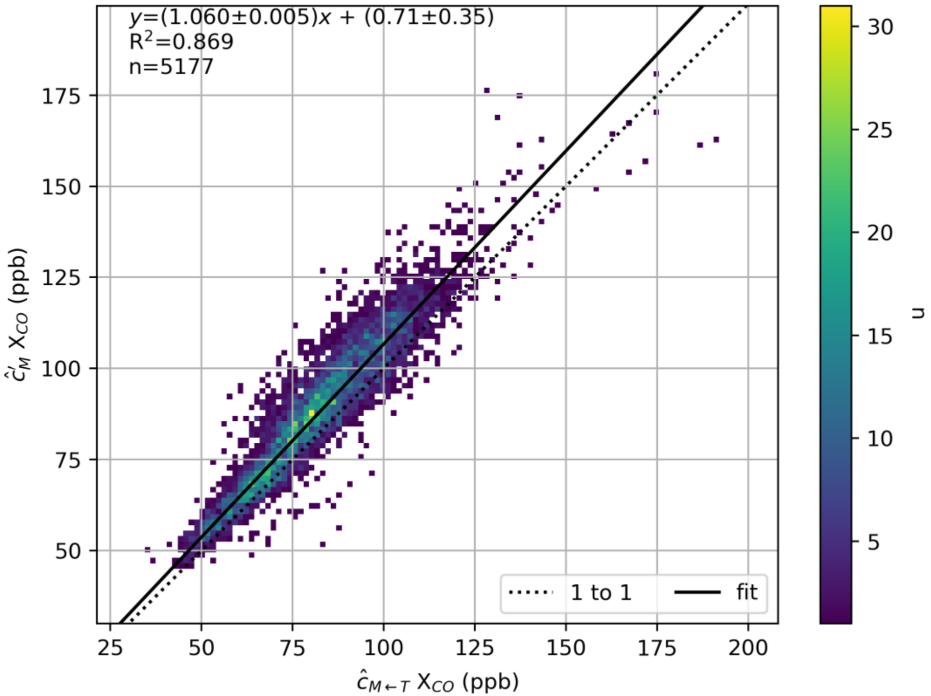




Wunch et al. (2015),
doi:10.14291/tccon.ggg2014.documentation.R0/1221662

# TCCON Comparison

## No empirical TCCON correction



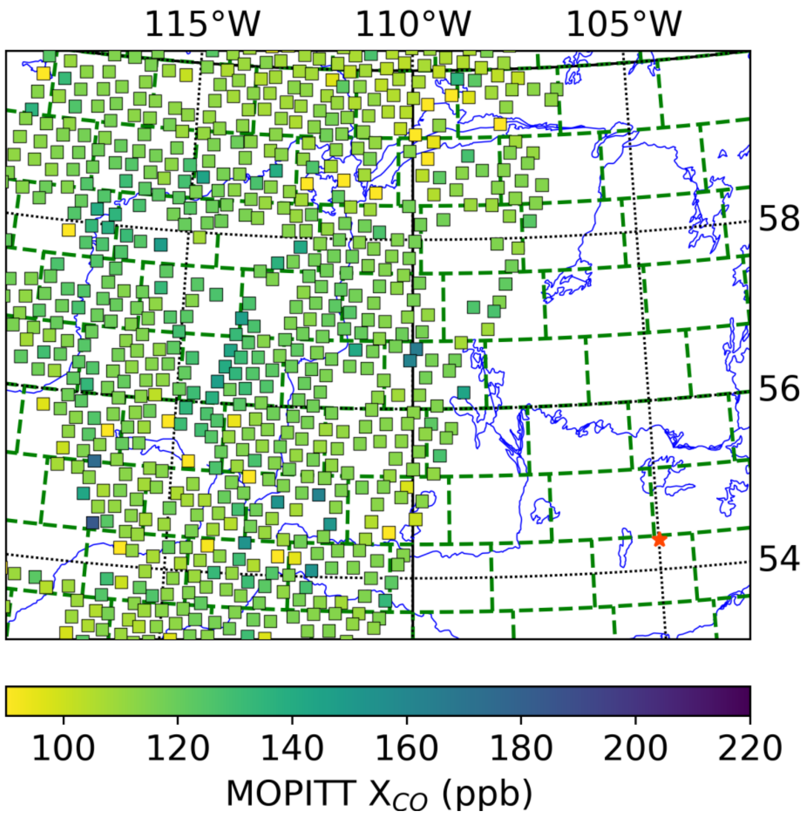
| M | $x_c$ | $x_t$ (assumed) | Comp 1 | Comp 2 |
|---|---|---|---|---|
| II | $\boldsymbol{x}_{T,a}$ | $\widehat{\boldsymbol{x}}_T = \gamma \boldsymbol{x}_{Ta}$ | $\hat{c}'_M = \hat{c}_M + c_{T,a} - c_{M,a} + \sum_j^{10} a_{M,j}\left(\log_{10}(x_{Ma}) - \log_{10}(x_{Ta})\right)_j$ | $\hat{c}_{M \leftarrow T} = c_{T,a} + \sum_j^{10} a_{M,j}\left(\log_{10}(\hat{x}_T) - \log_{10}(x_{Ta})\right)_j$ |

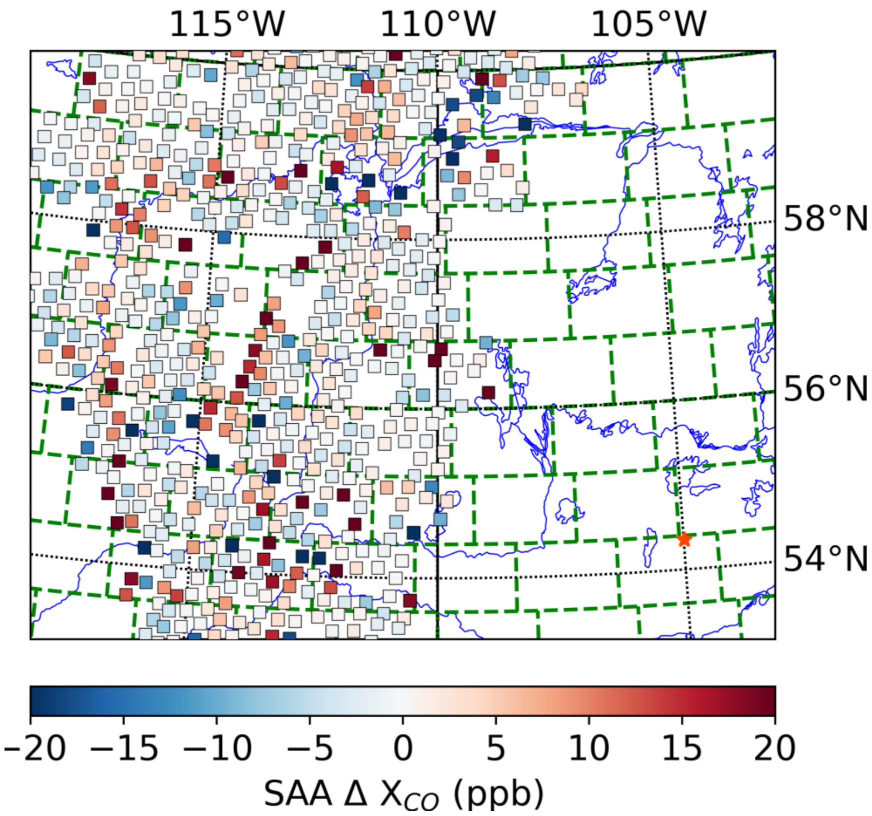
Analogous to method in Wunch et al (2011), doi: 10.5194/acp-11-12317-2011

$$a_{T,j} = \frac{\partial \hat{c}_T}{\partial x_j}\frac{1}{h_j}$$

$$a_{M,j} = \frac{\partial \hat{c}_M}{\partial \log_{10} x_j}$$

# Small Area Analysis



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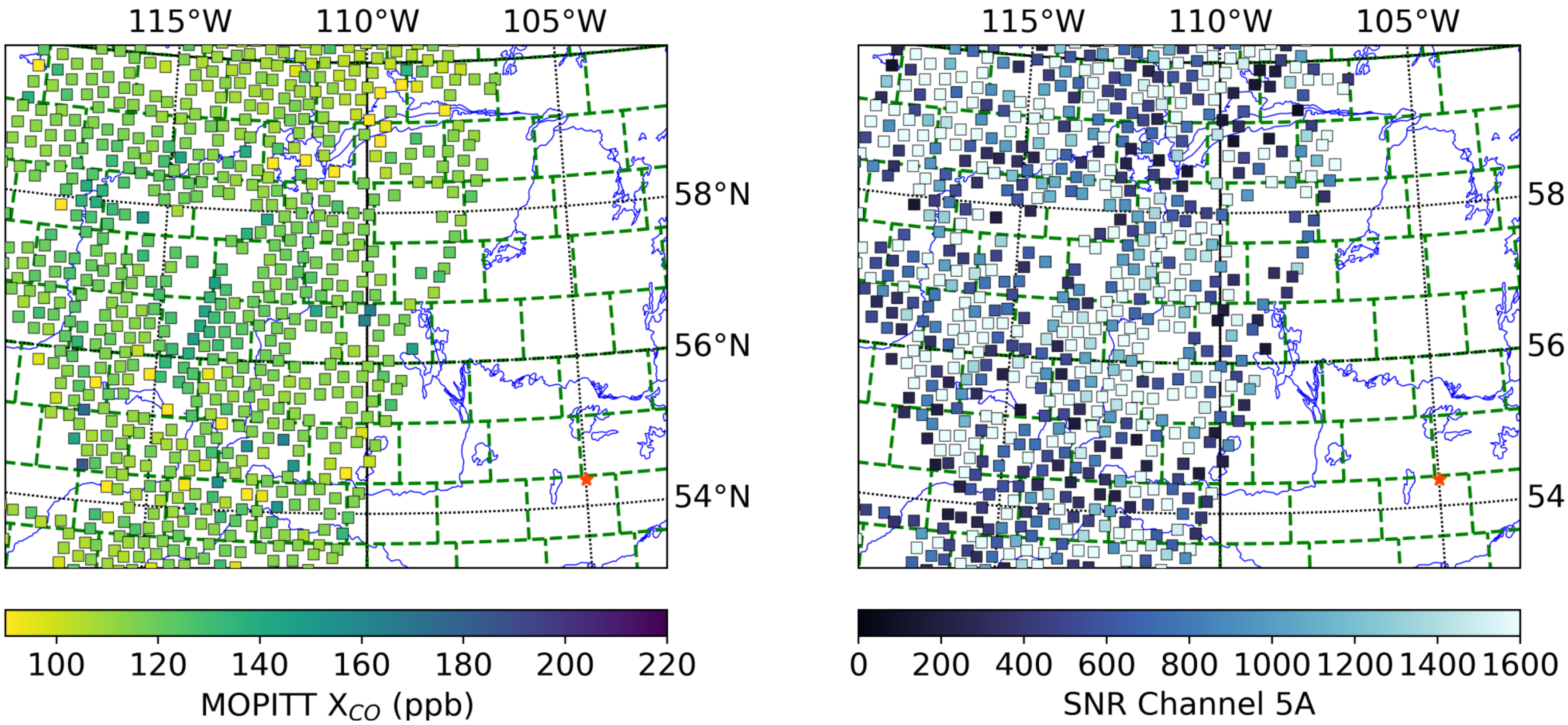
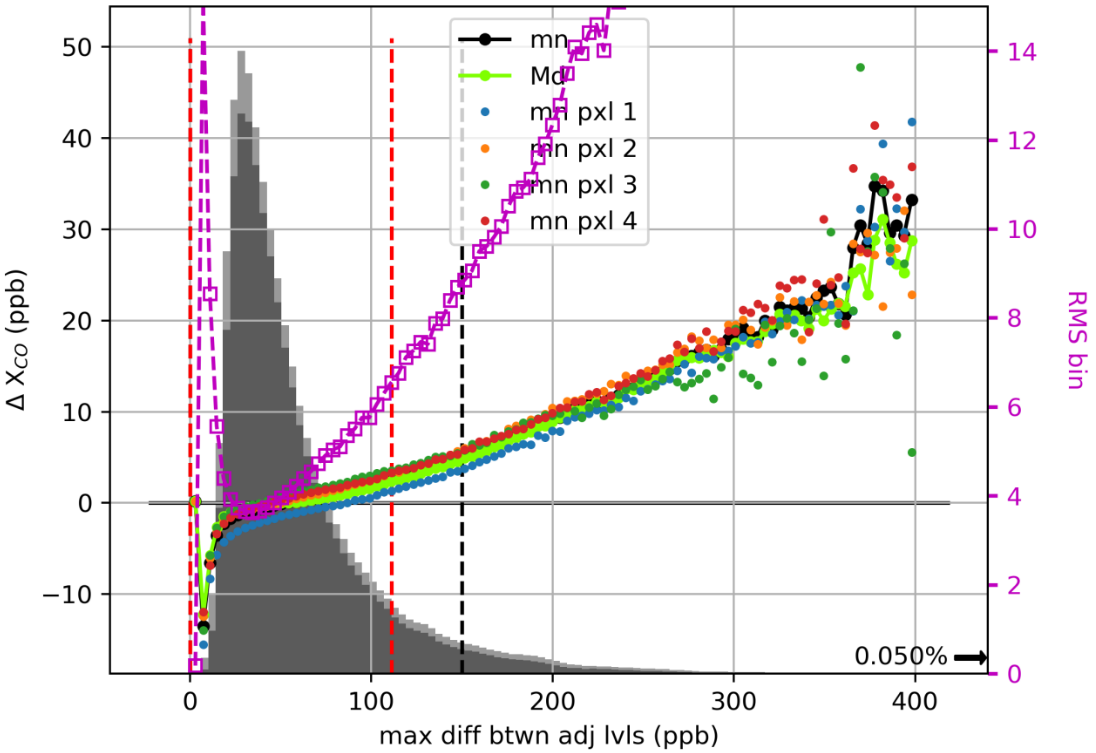


# Small area analysis for QC

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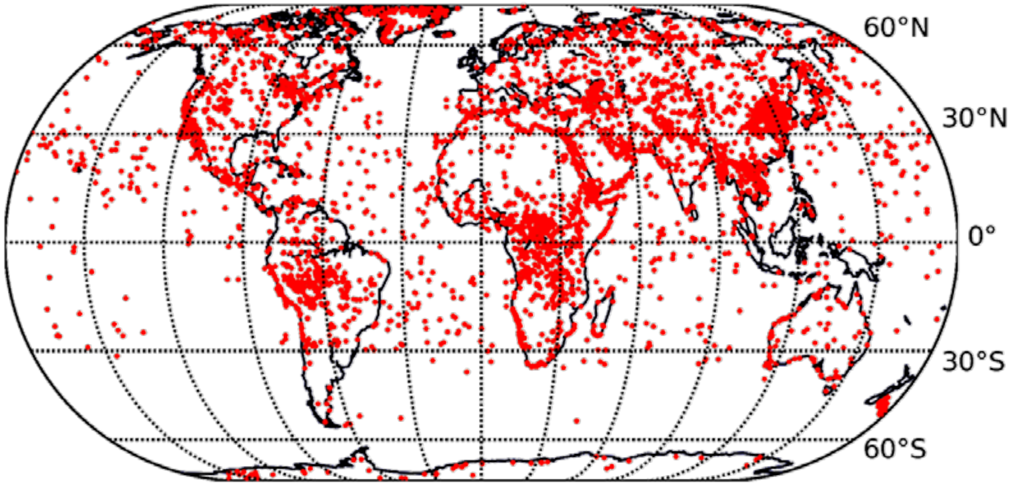
# 10000 largest maximum differences between adjacent levels

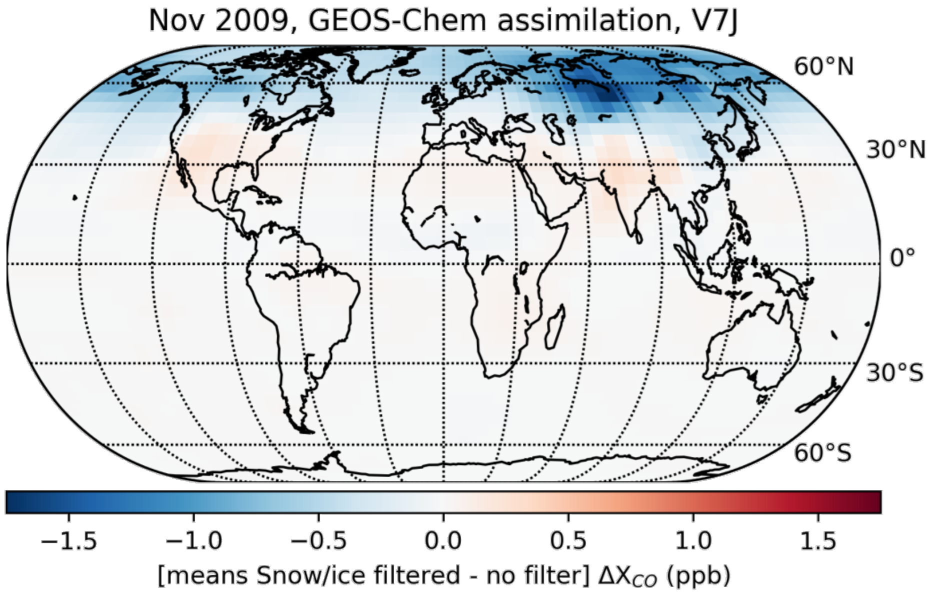


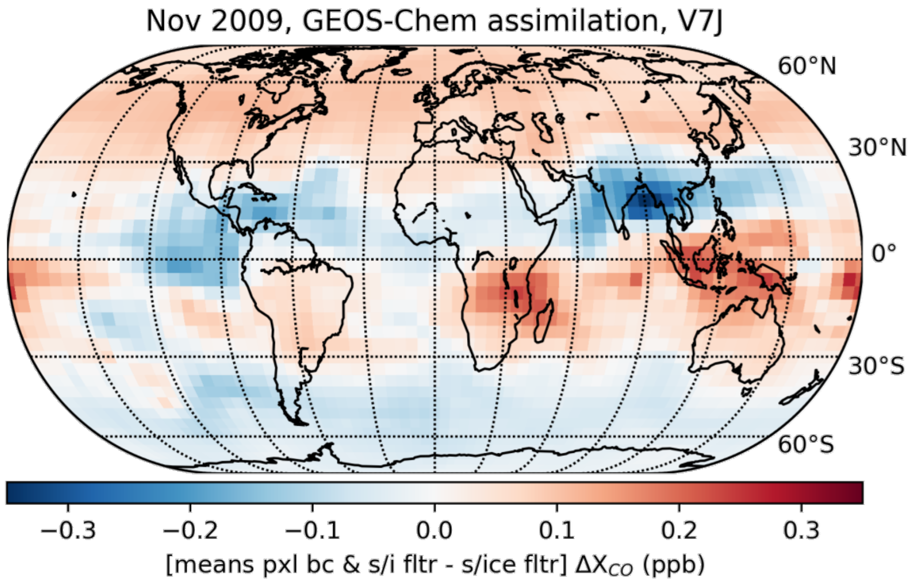
# GEOS-Chem state assimilation (4°×5°)

Left: Model state differences from assimilation with no filters and after removing snow/ice scenes

Right: Model state differences after correcting for pixel biases

Model run by Tailong He

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