Issues of prescribed OH in CO inversions

34th international TM5 meeting, October 2023

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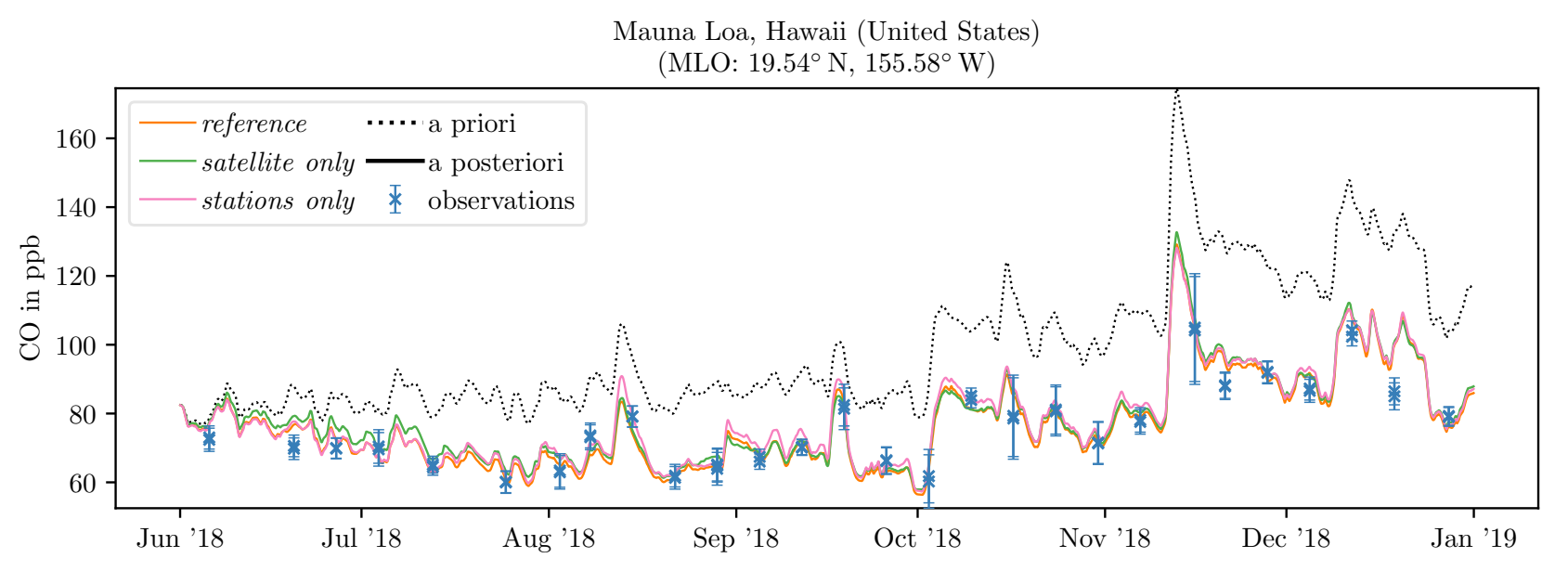
Objective

- Target: Meaningful regional and global absolute carbon monoxide (CO) source strengths
- Problem: Inversion only corrects parts of the prior that are in the state, e.g. the emissions. Prescribed OH has large impact, but low confidence and is not optimized $\rightarrow$ aliasing
- Approach: Investigate quality of prior
- Solution: ???

Outline

Previously: Posterior fits good in most places



Quantify overall mismatch as $\frac{\sum\left[\frac{(\text{obs}-\text{model})^2}{\text{error}^2}\right]}{\text{number\_of\_obs}}$

	reference	*satellite only*	*station only*
prior	21.91	21.91	21.91
posterior	3.61	**9.12**	3.26

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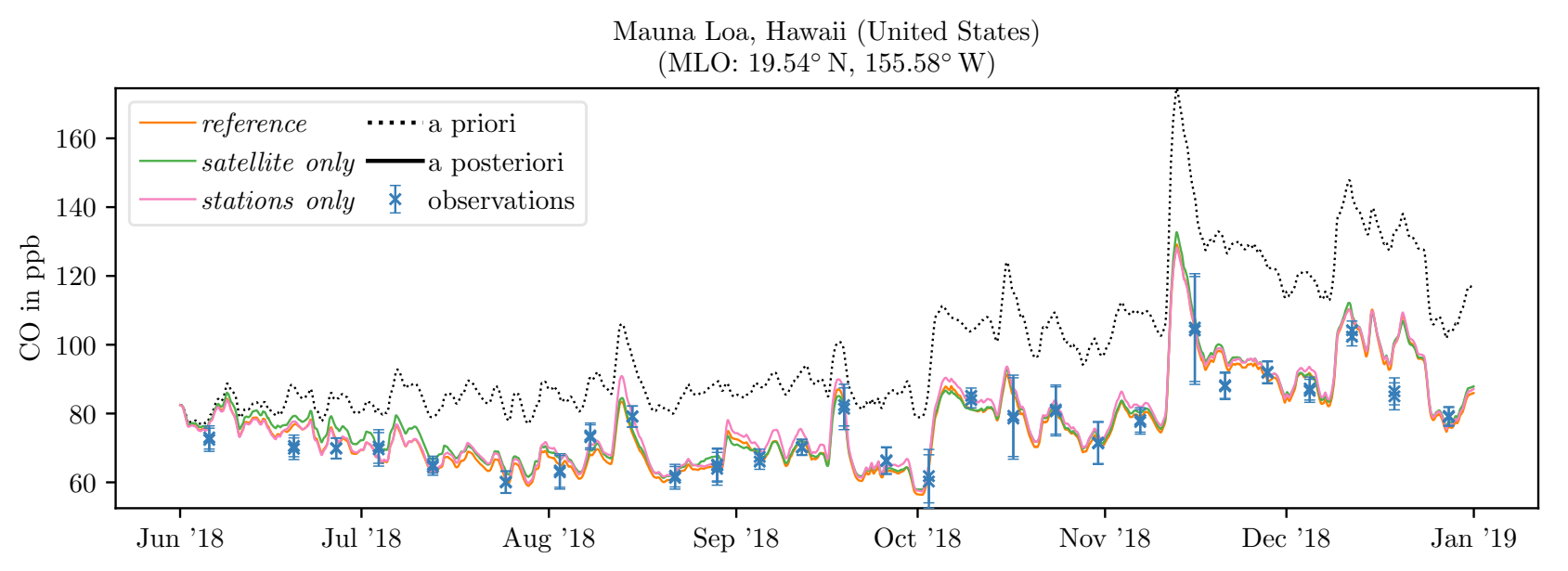

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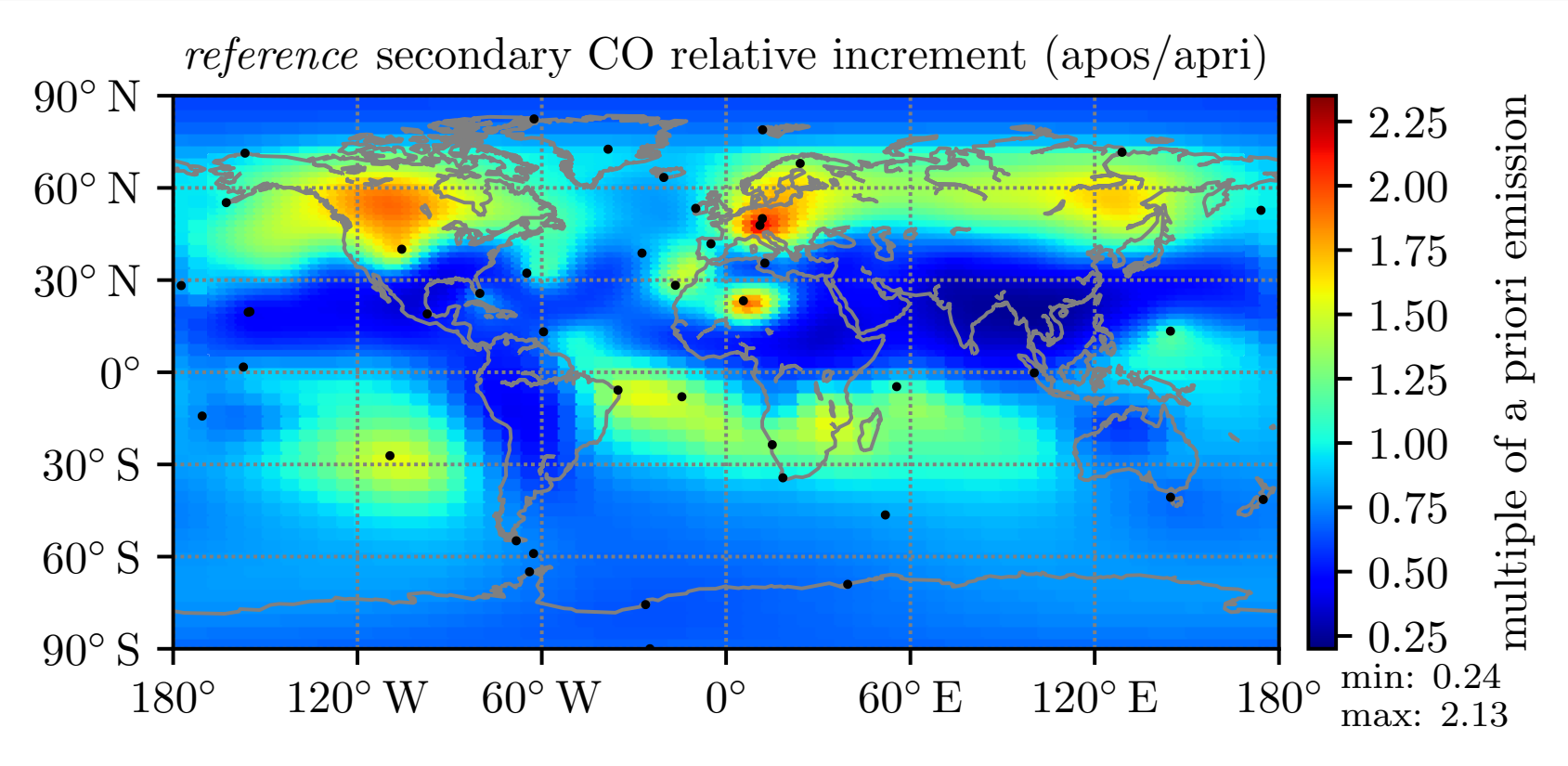
→ Prior mismatch large due to 'accumulation' of CO caused by imbalanced budget

Previously: Relative emission increments



- Unrealistically large decrements and zonal-band structure
- E.g. Asia reduced by up to 75 %

→ Priors for secondary CO production or OH likely wrong

1 Background

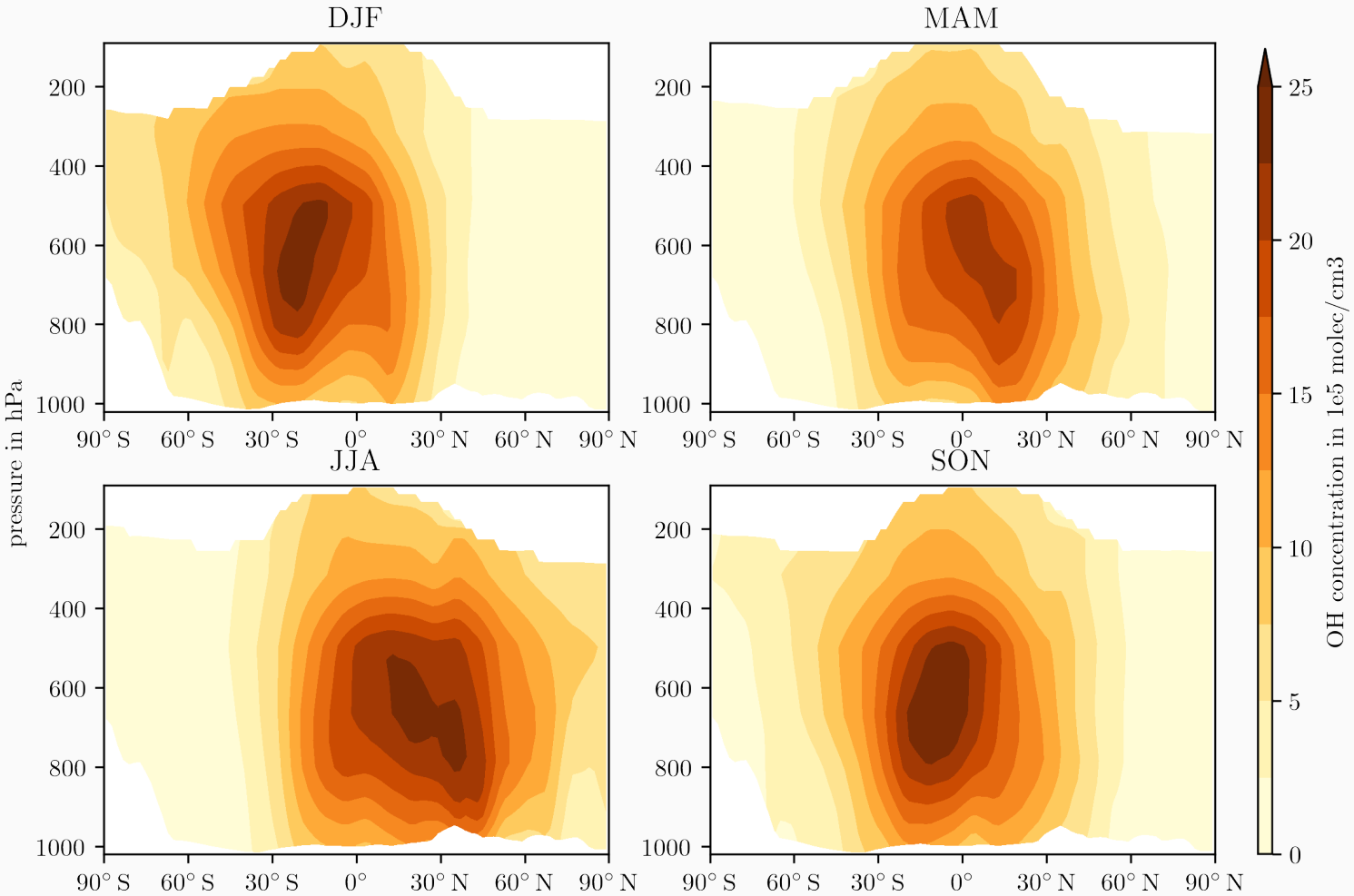
- Recall to 32nd TM meeting
- Modeled vs. climatological OH

2 New work: Inversions based on either OH field

- Changes in setup
- Results

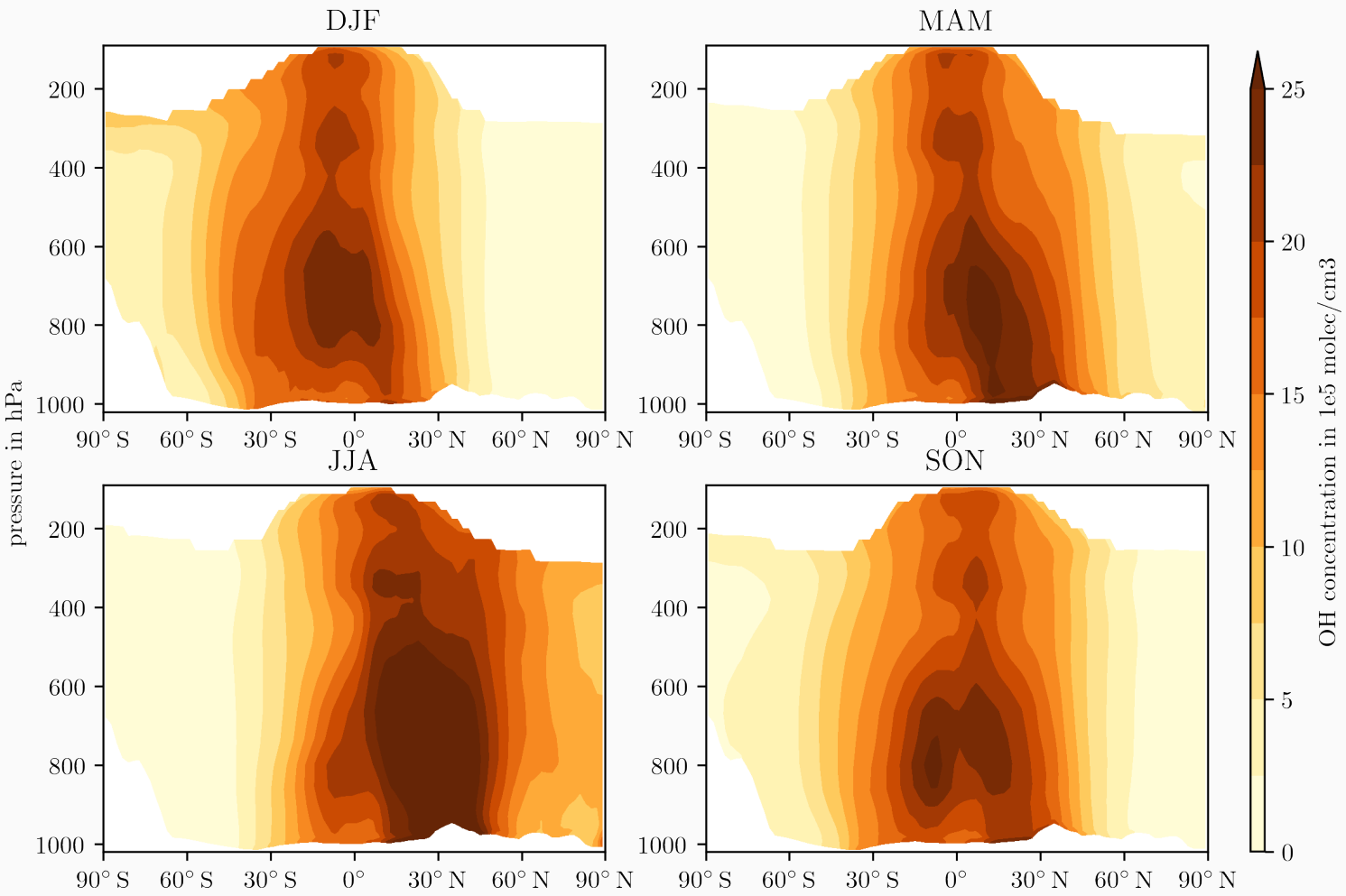
3 Discussion

Climatological OH (Spivakovsky et al. 2000)



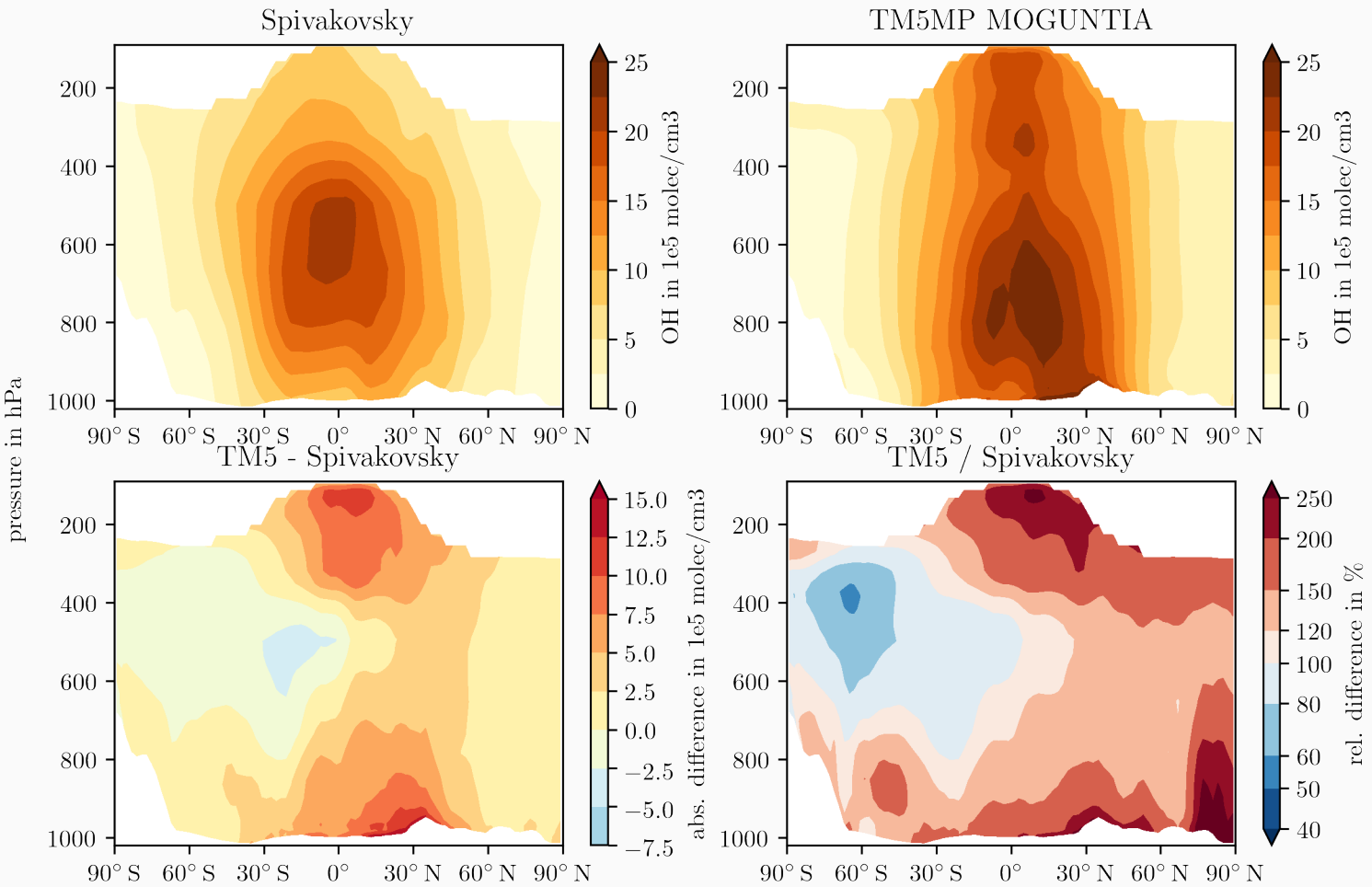
- Scaled by 92 % to match MCF (Huijnen et al. 2010)
- 'Status quo' established in various studies over past decades

Model OH (Myriokefalitakis et al. 2020)



- Monthly means from TM5-MP with MOGUNTIA chemistry
- Likely high biased, especially in Northern Hemisphere

Annual zonal OH comparison



- Model OH much larger near surface, where most chemistry happens

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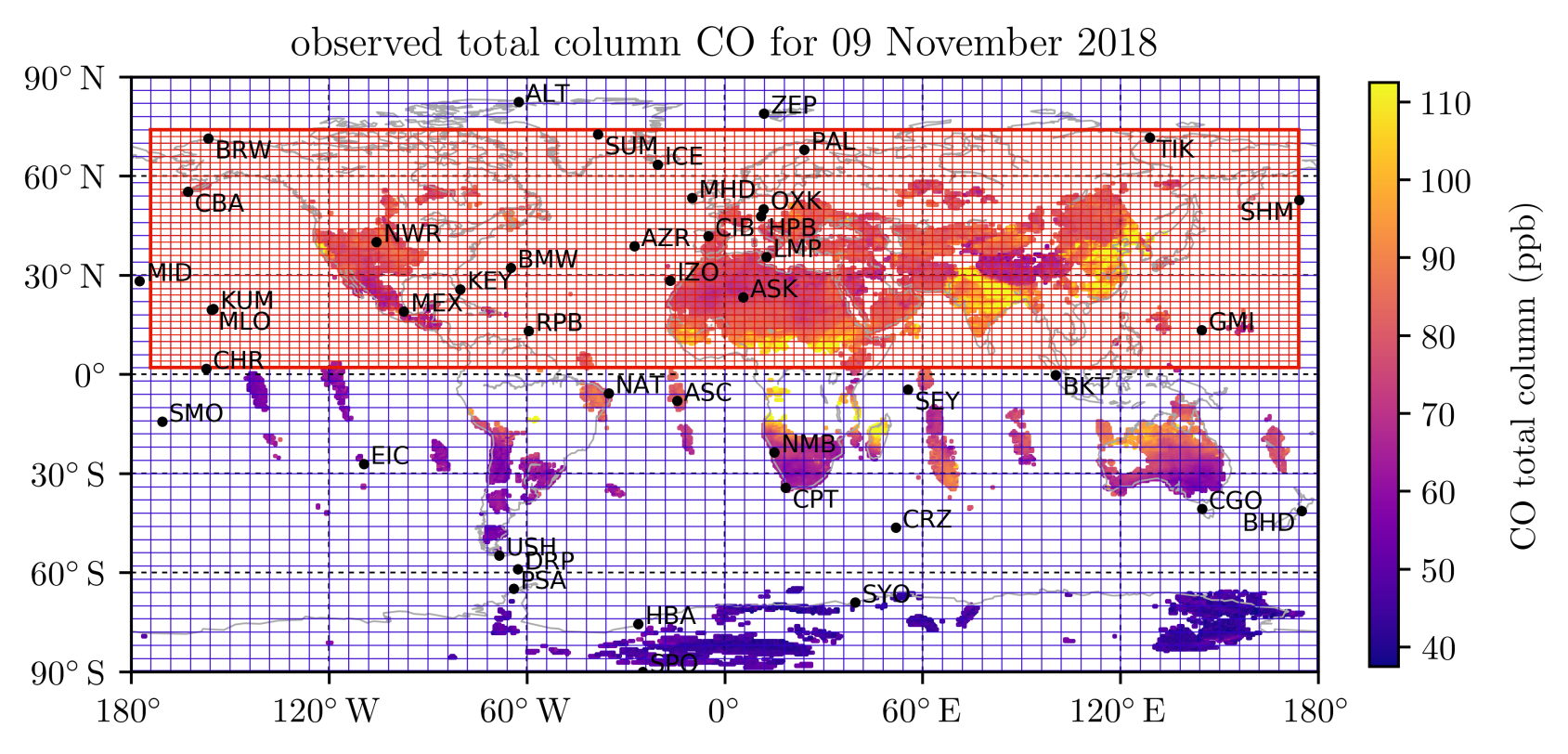
- Zoom over northern hemisphere

Zooming setup and observations



- global TROPOMI observations, gridded to $0.5° \times 0.5°$
- NOAA surface flask measurements, filtered for background stations

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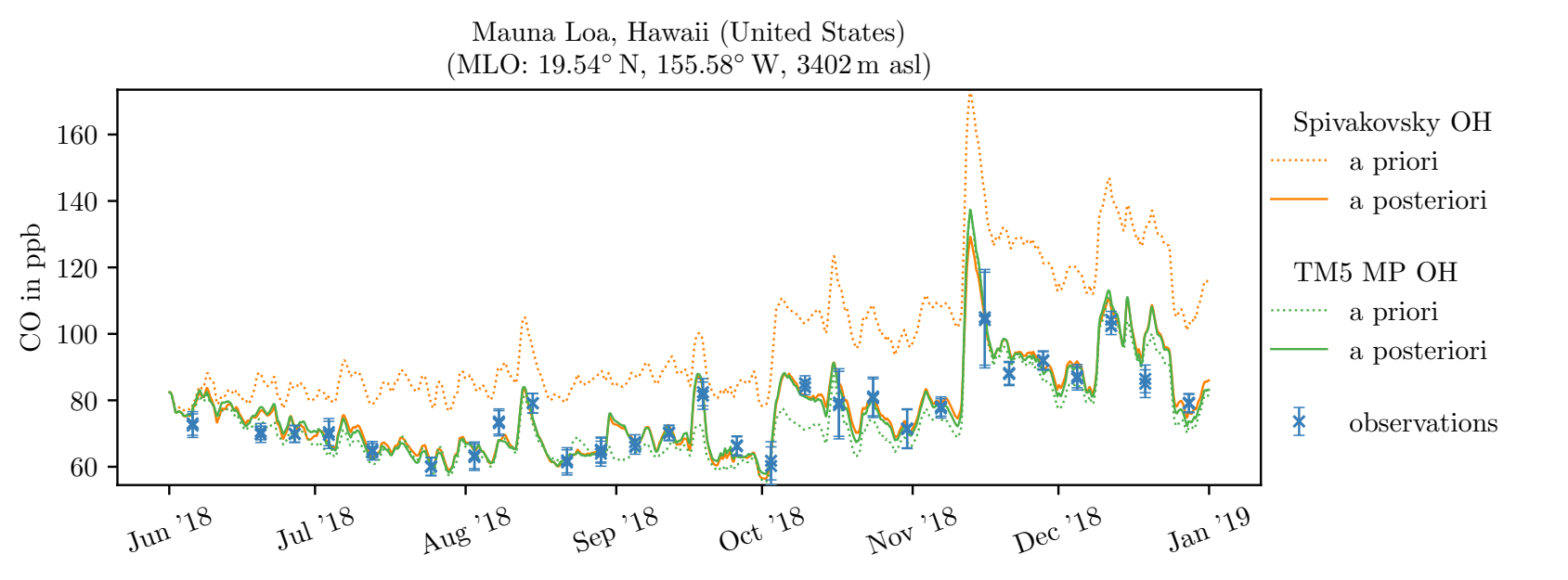

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northern Tropics (0 - 23° N)	prior	45.6	8.4
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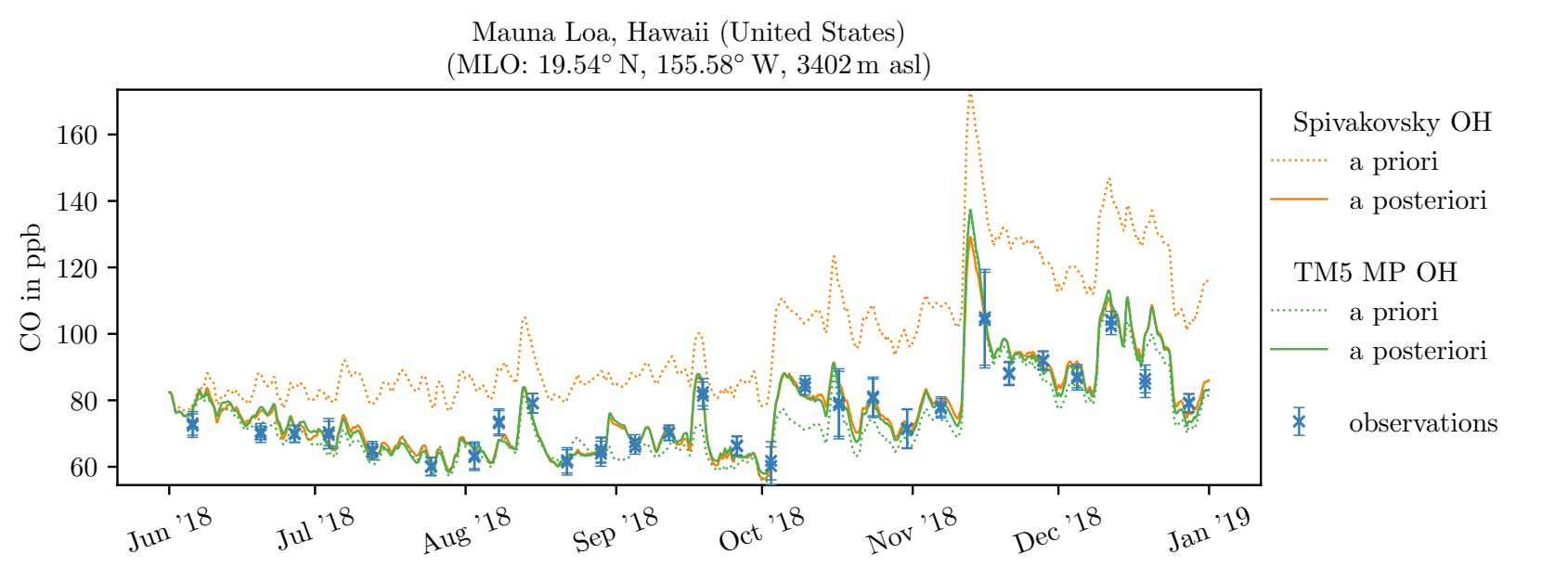

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Southern Hemisphere	prior	8.5	3.7
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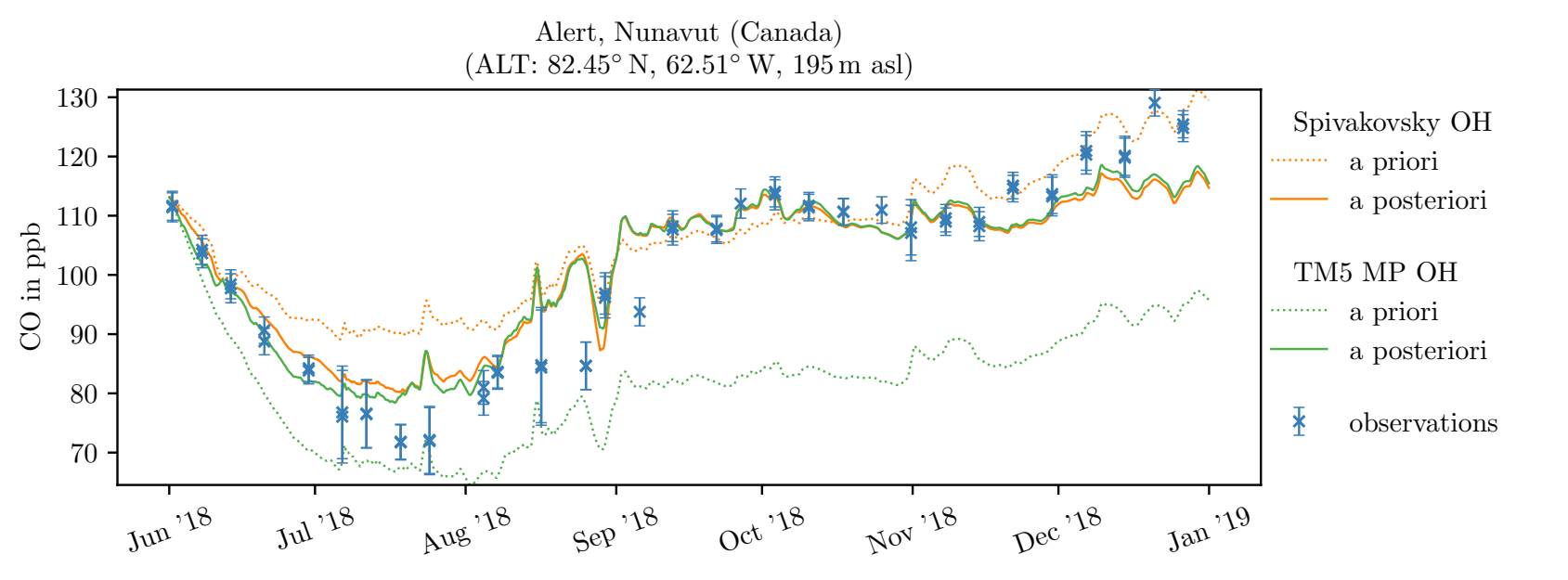
… but worse in northern extratropic



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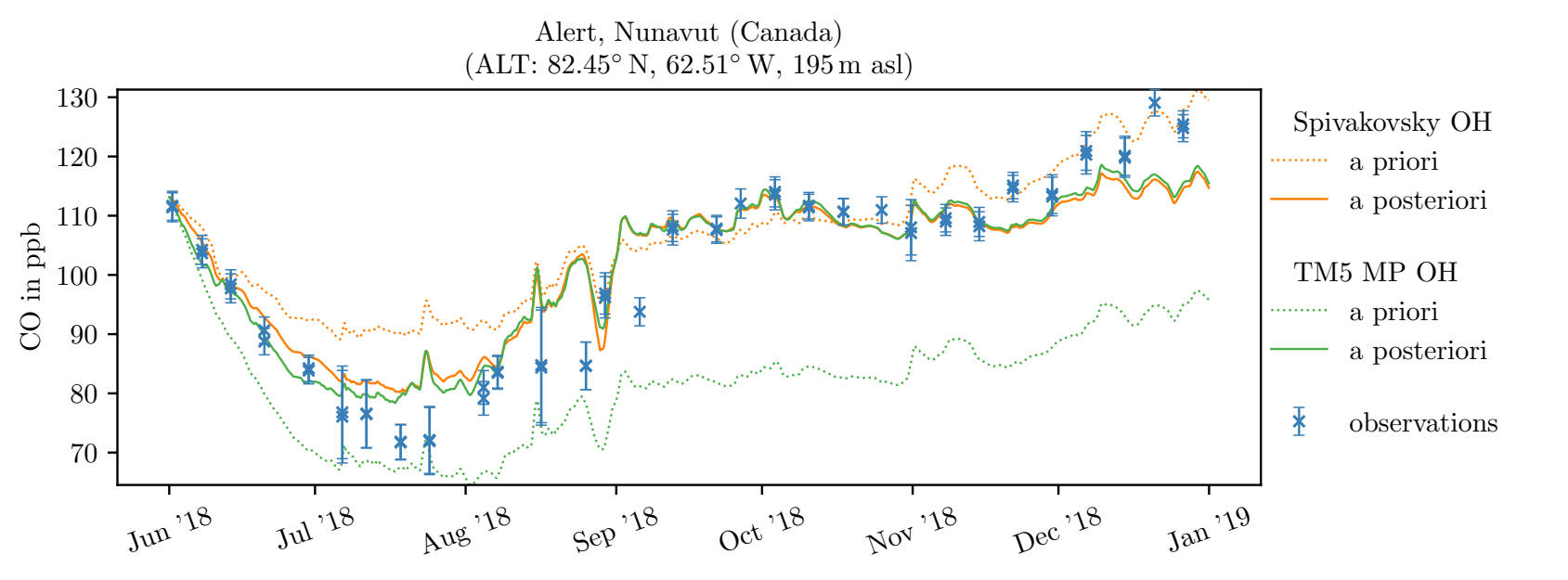

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global	prior	20.6	26.8
	posterior	3.6	3.3

$\rightarrow$ station locations biased to NH

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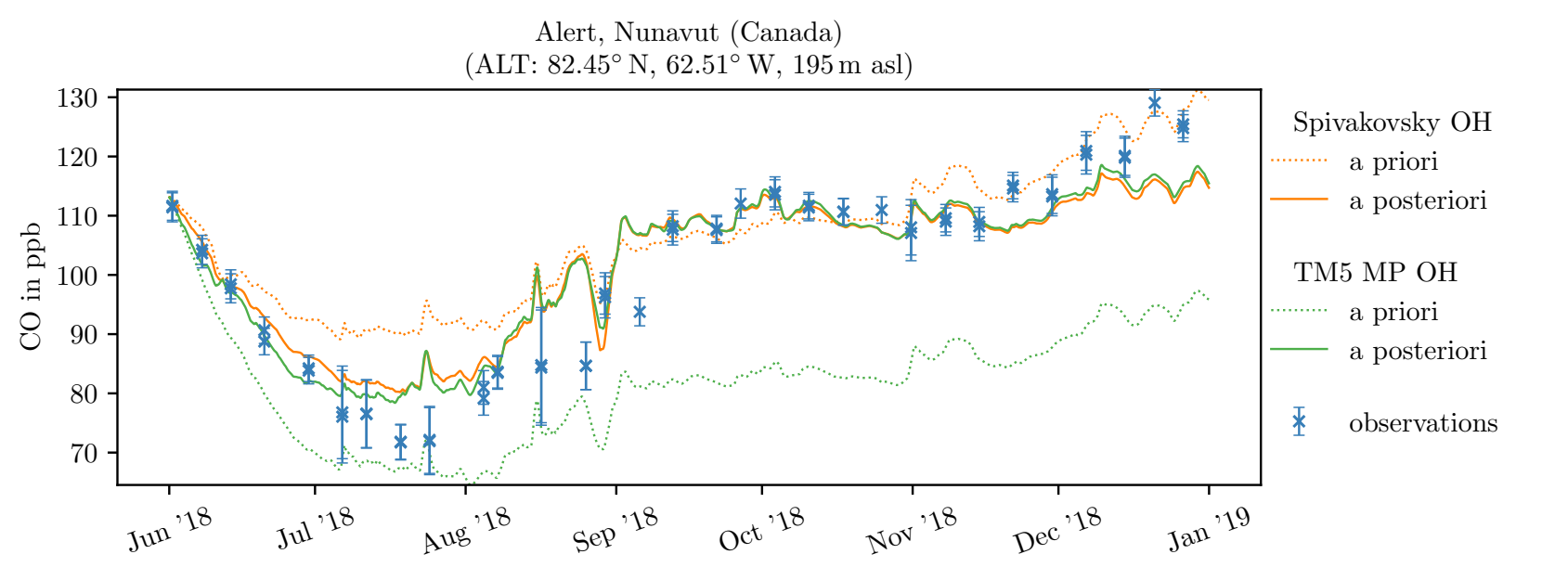

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global	prior	20.6	26.8
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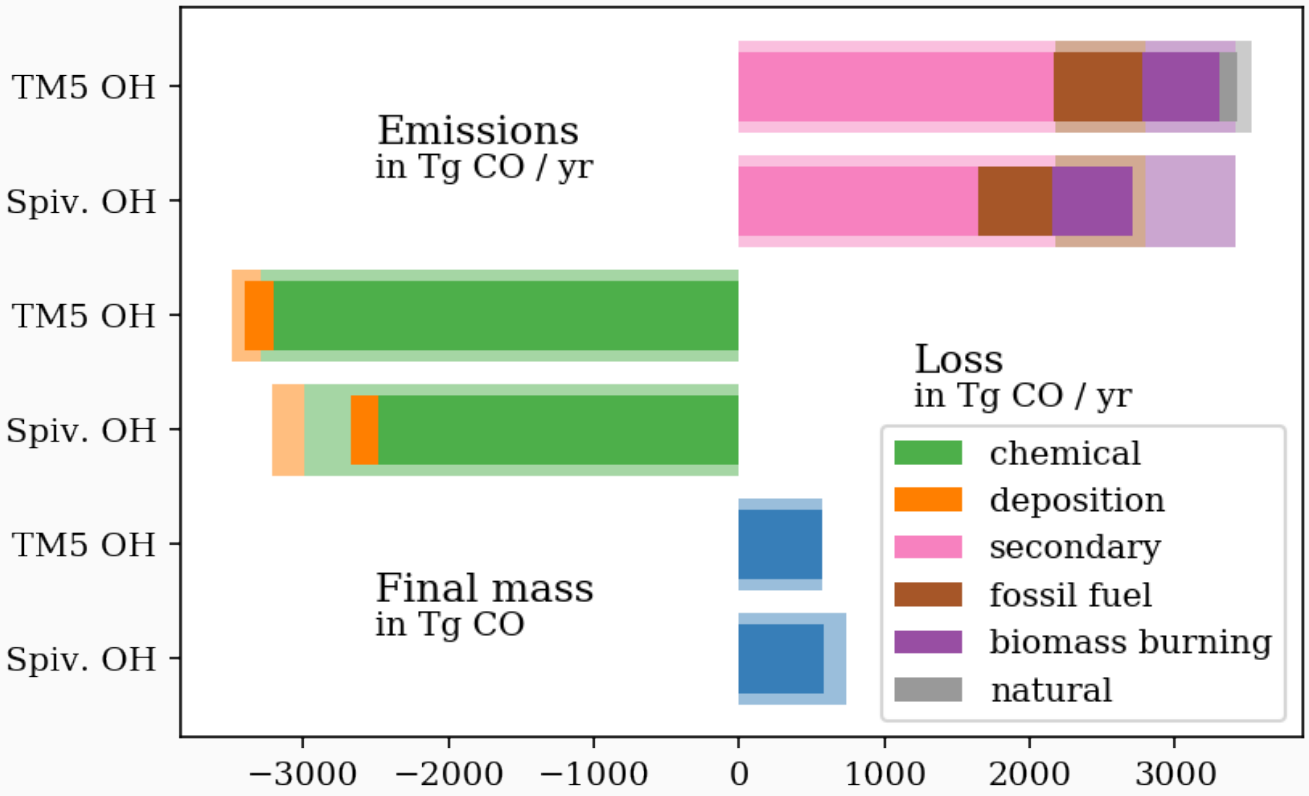
satellite	prior	10.2	3.3
	posterior	1.0	0.9

$\rightarrow$ station locations biased to NH, but satellite biased to Tropics

Budgets



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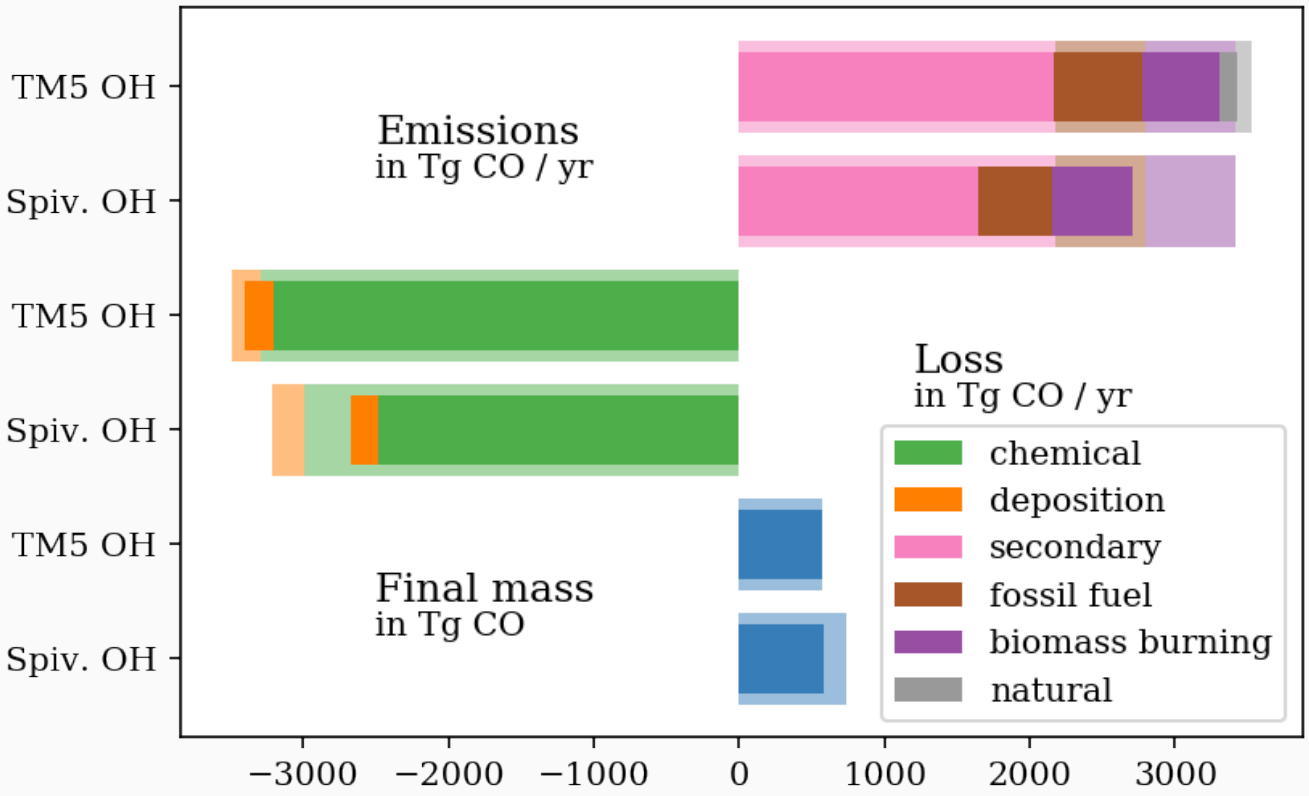

- No more accumulation with modeled OH
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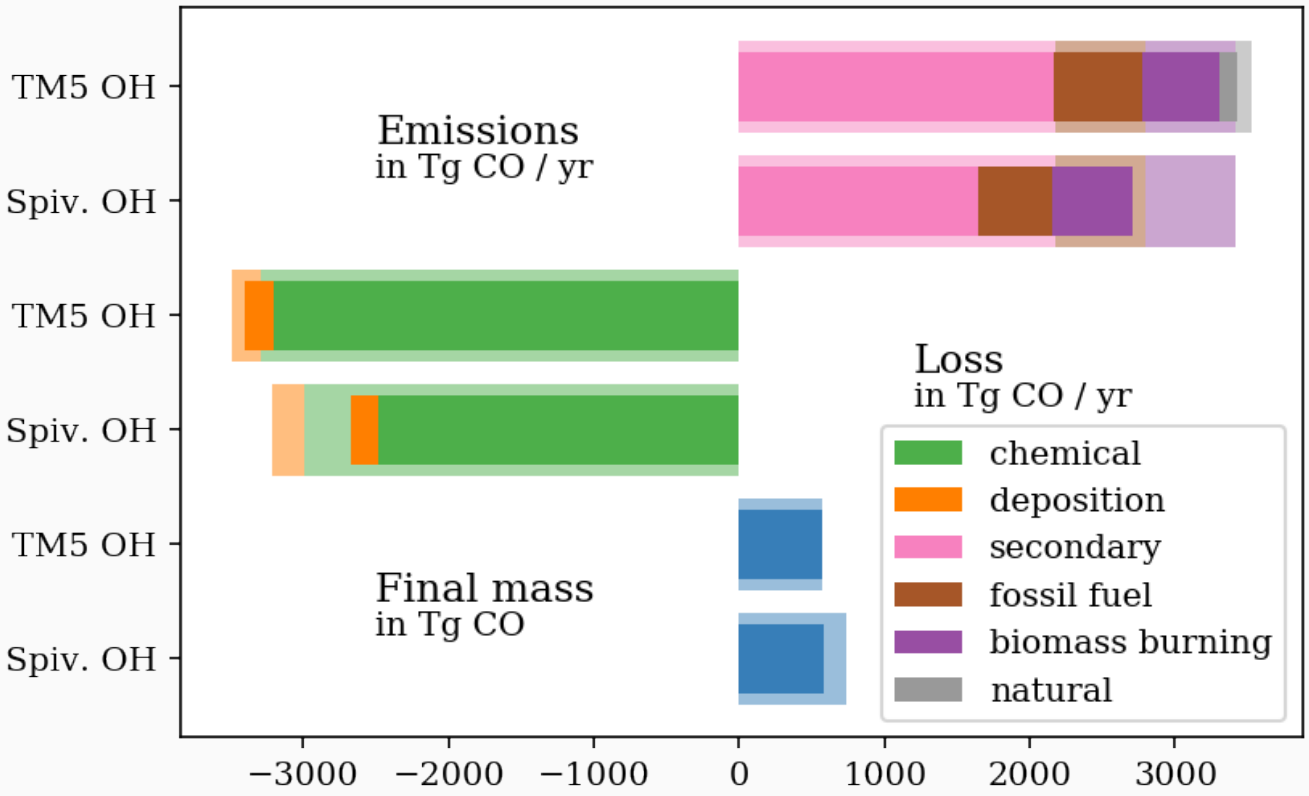

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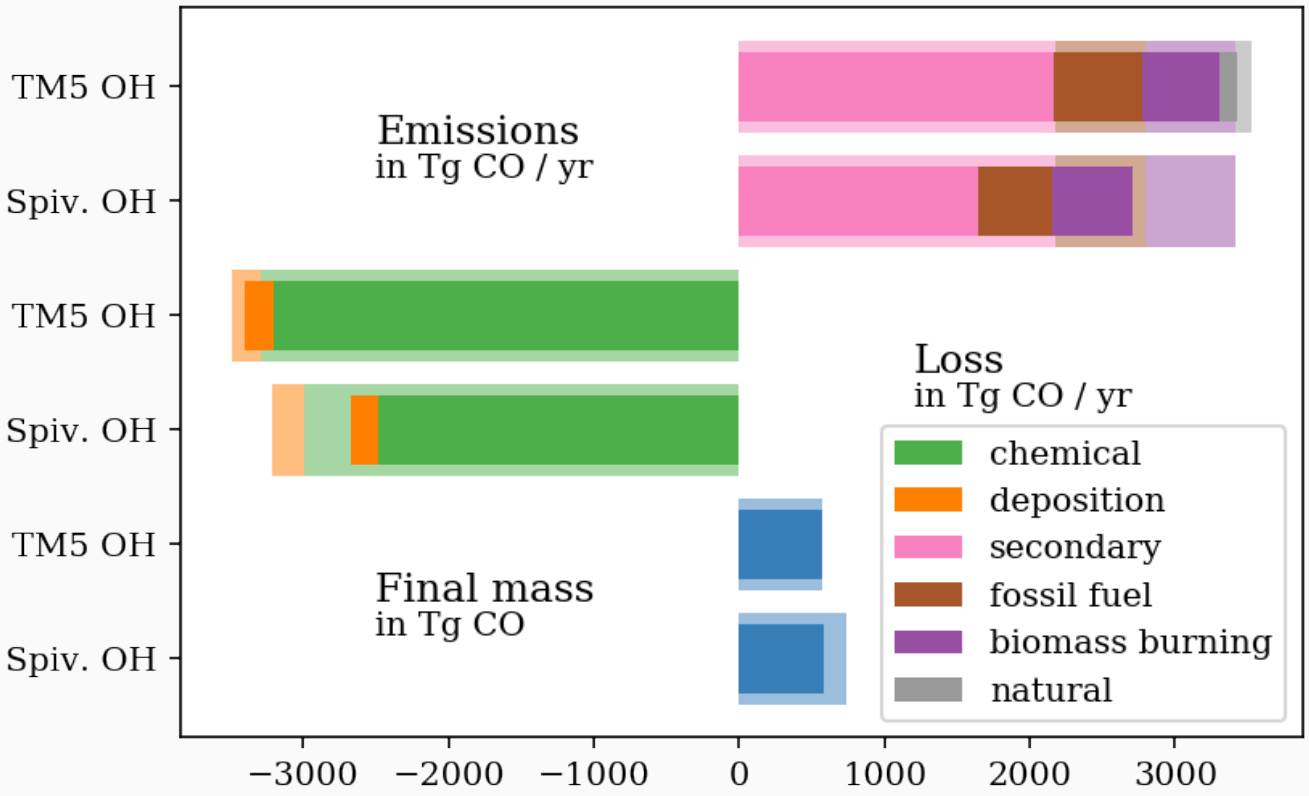

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- Much smaller emission increments required...
- ... except for (poorly captured) biomass burning
- However, chemical loss very high

Discussion

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$\rightarrow$ Probably too low close to surface in (northern) Tropics

- Modeled OH (not only in TM5MP) too high in Northern Hemisphere

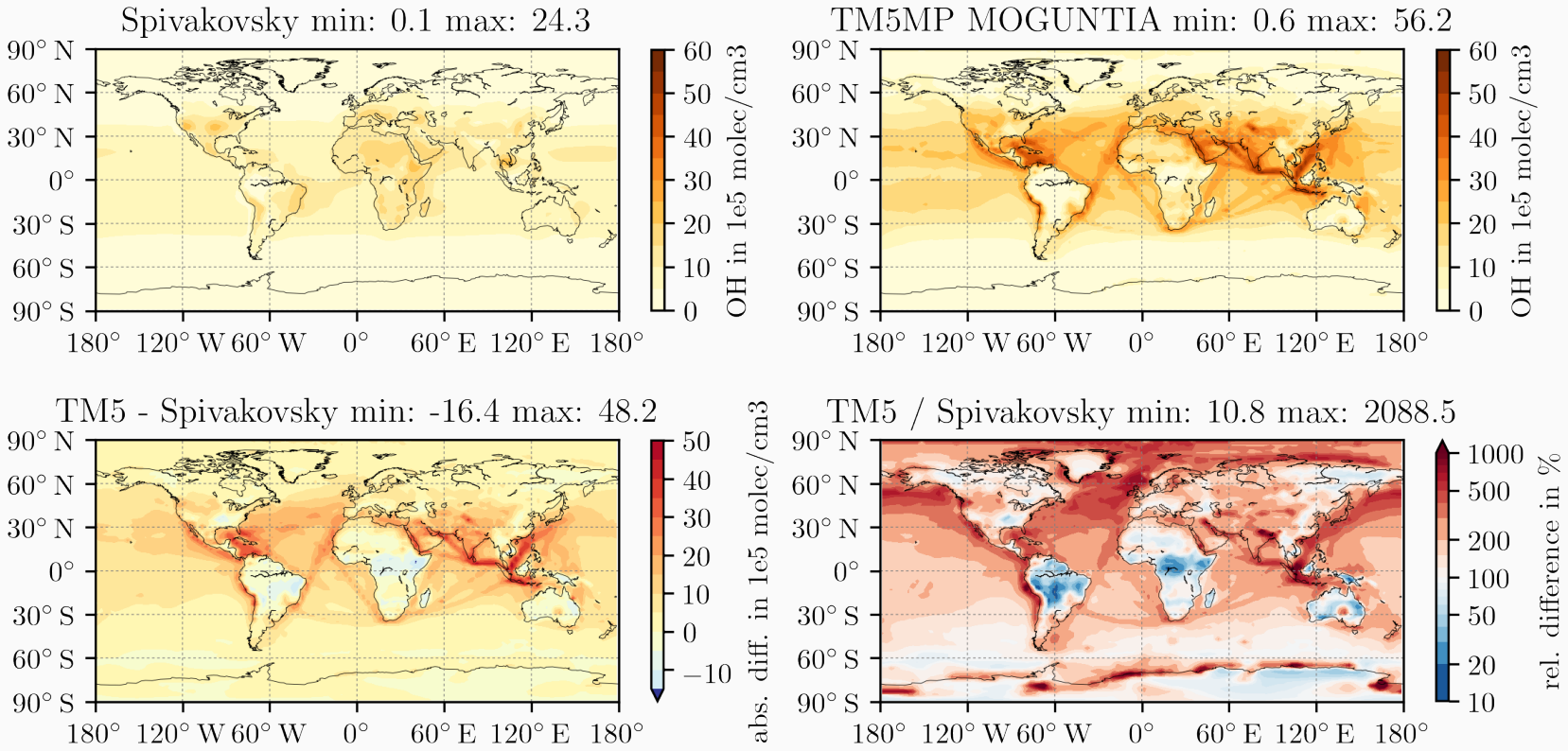
$\rightarrow$ Low confidence in resulting absolute emissions, on any scale

Acknowledgments

The computations were performed on the HPC cluster Aether at the University of Bremen, financed by DFG in the scope of the Excellence Initiative.

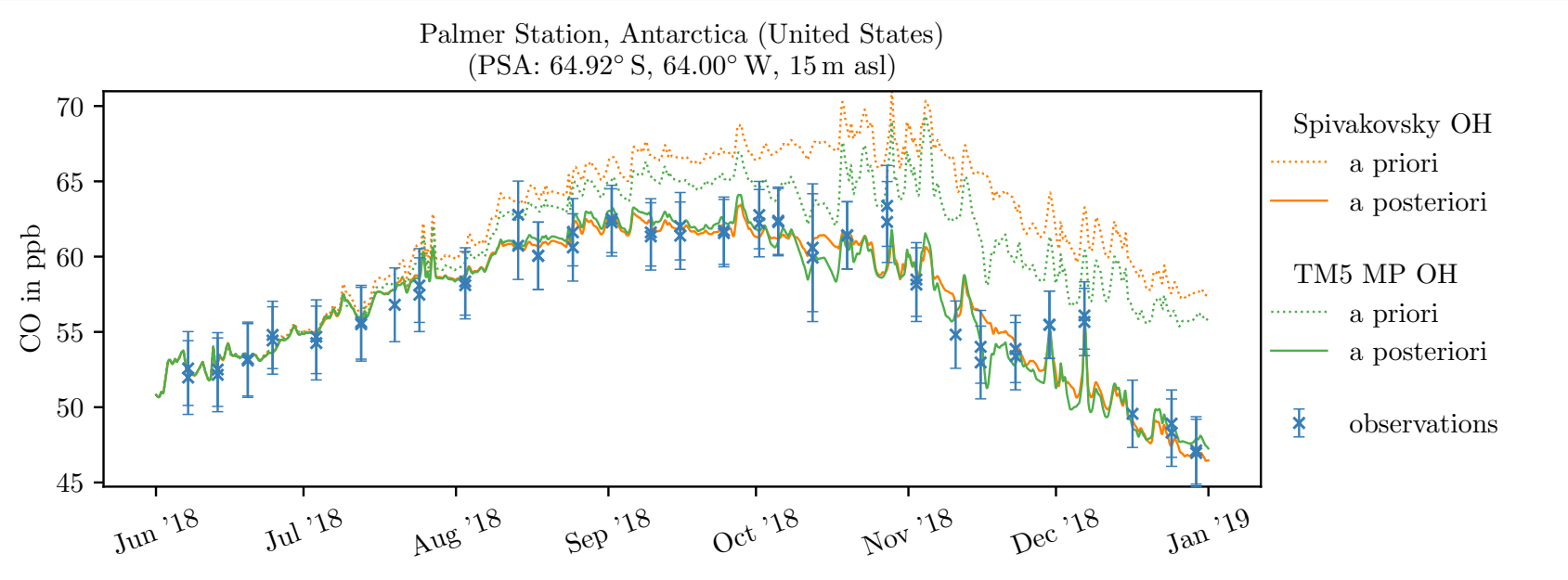
Thank You for your attention :)

Annual lateral OH comparison at ground layer



- Model OH more 'detailed' and larger over oceans and Asia
- Climatological OH larger over land in Southern Hemisphere, but concentrations there are small

... and in the Southern Hemisphere...



Mismatches to stations in Southern Hemisphere:

	Spivakovsky OH	TM5 MP OH
prior	8.48	3.73
posterior	1.46	1.38

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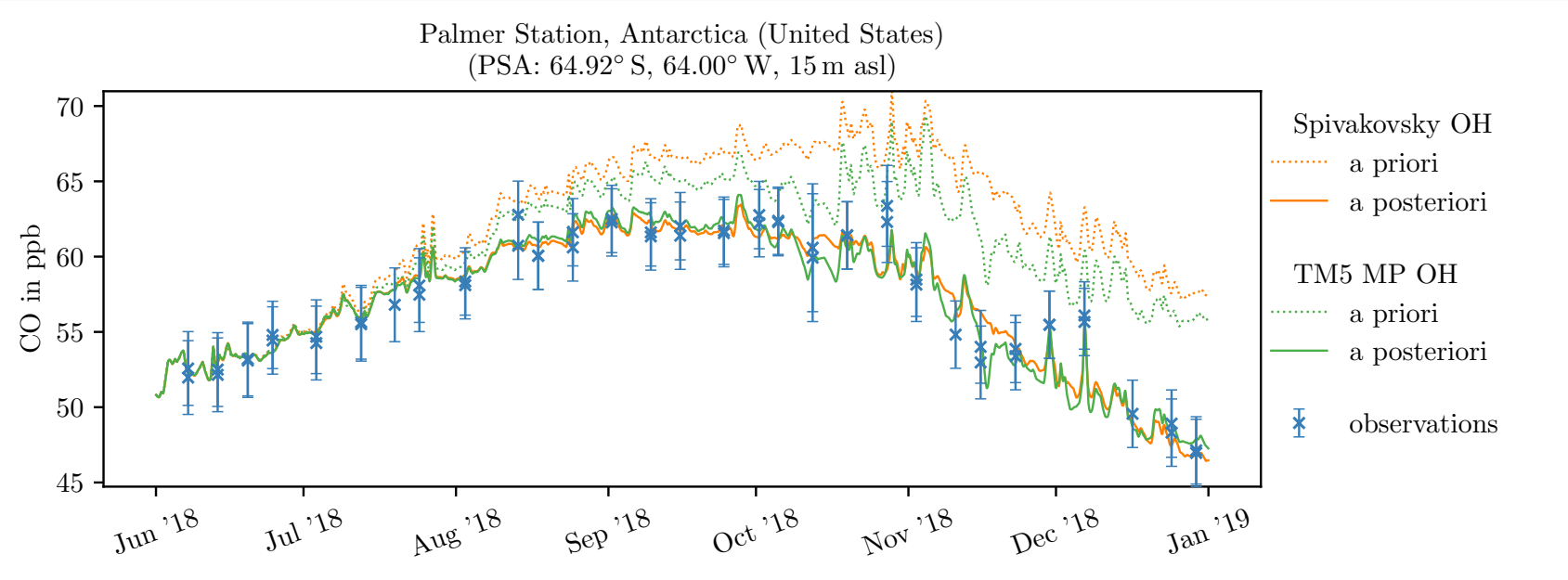

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→ Still some 'accumulation' close to South Pole