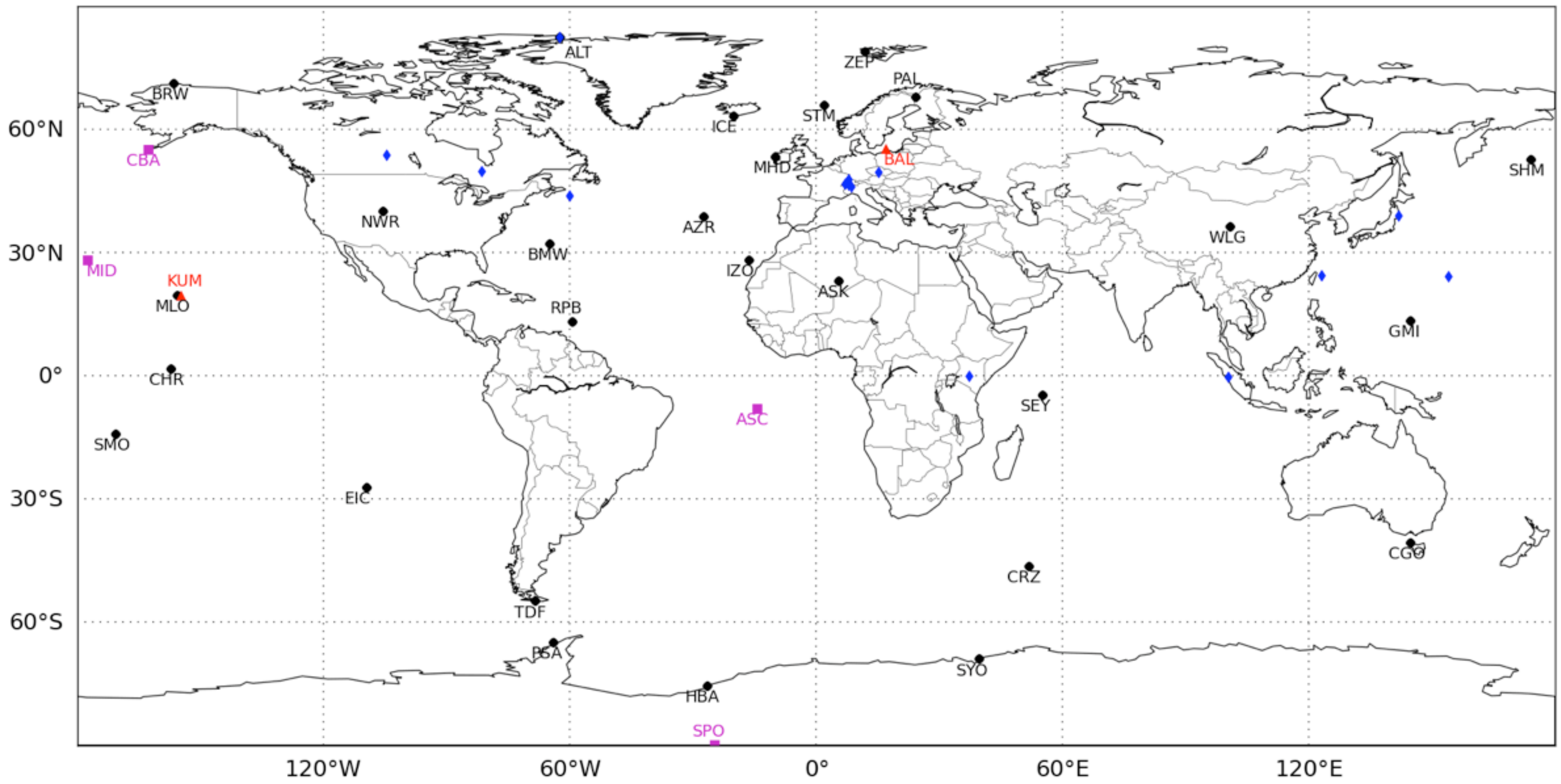
Optimizing CO emissions using the NOAA surface network stations in a 4D-VAR framework



Pim Hooghiemstra & Maarten Krol

Introduction

Goals and Relevance

CH4
750-940 Tg CO/year

NMVOC
200-800 Tg CO/year

CO_2 ← OH — CO

350-700 Tg CO/year
Biomass burning

600-900 Tg CO/year
Anthropogenic

Introduction

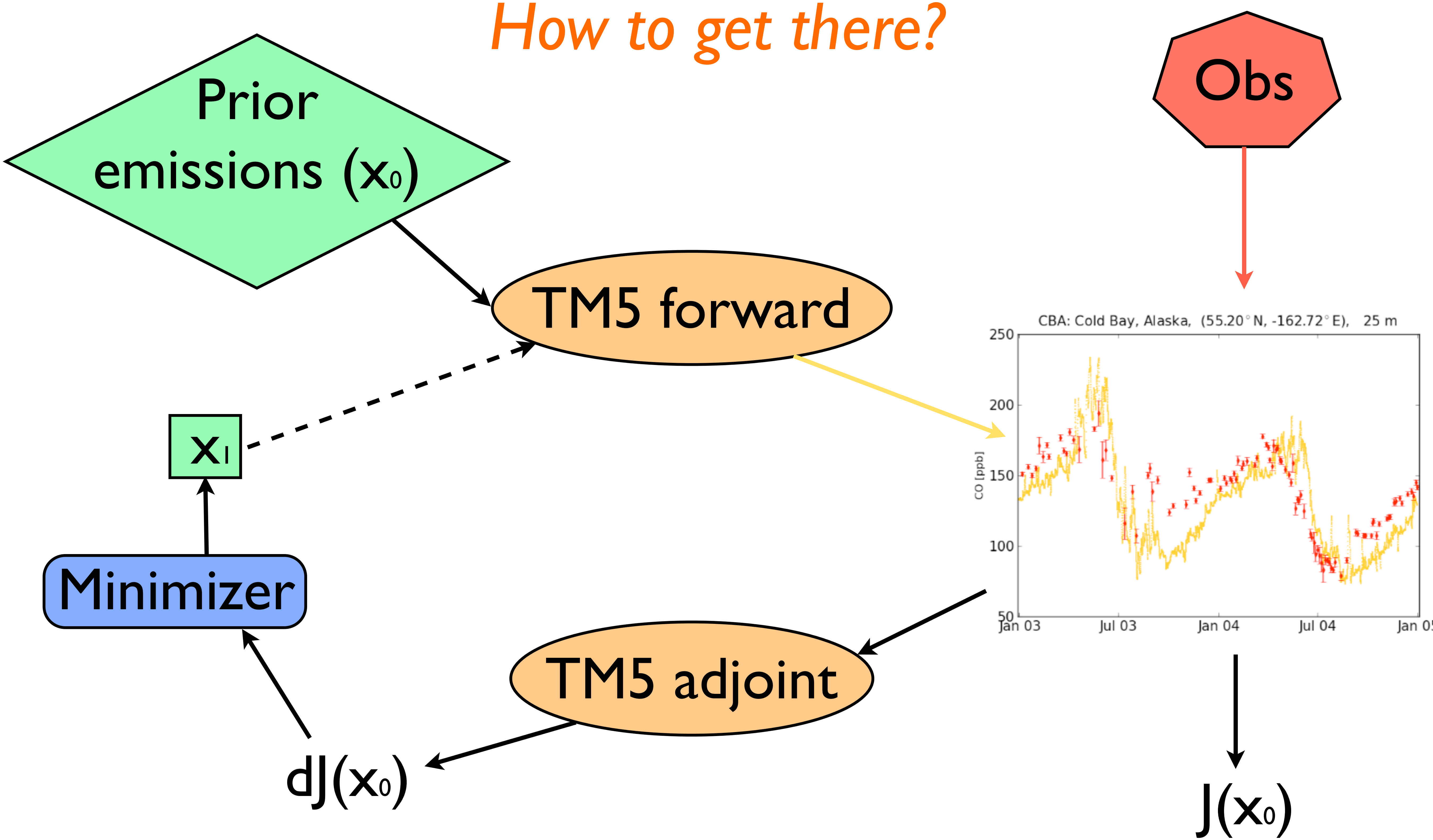
Goals and Relevance

Biomass burning emission range: 350-700 Tg CO/year

Focus on biomass burning emissions: Study the ***magnitude****, trend and variability.*

Introduction

How to get there?



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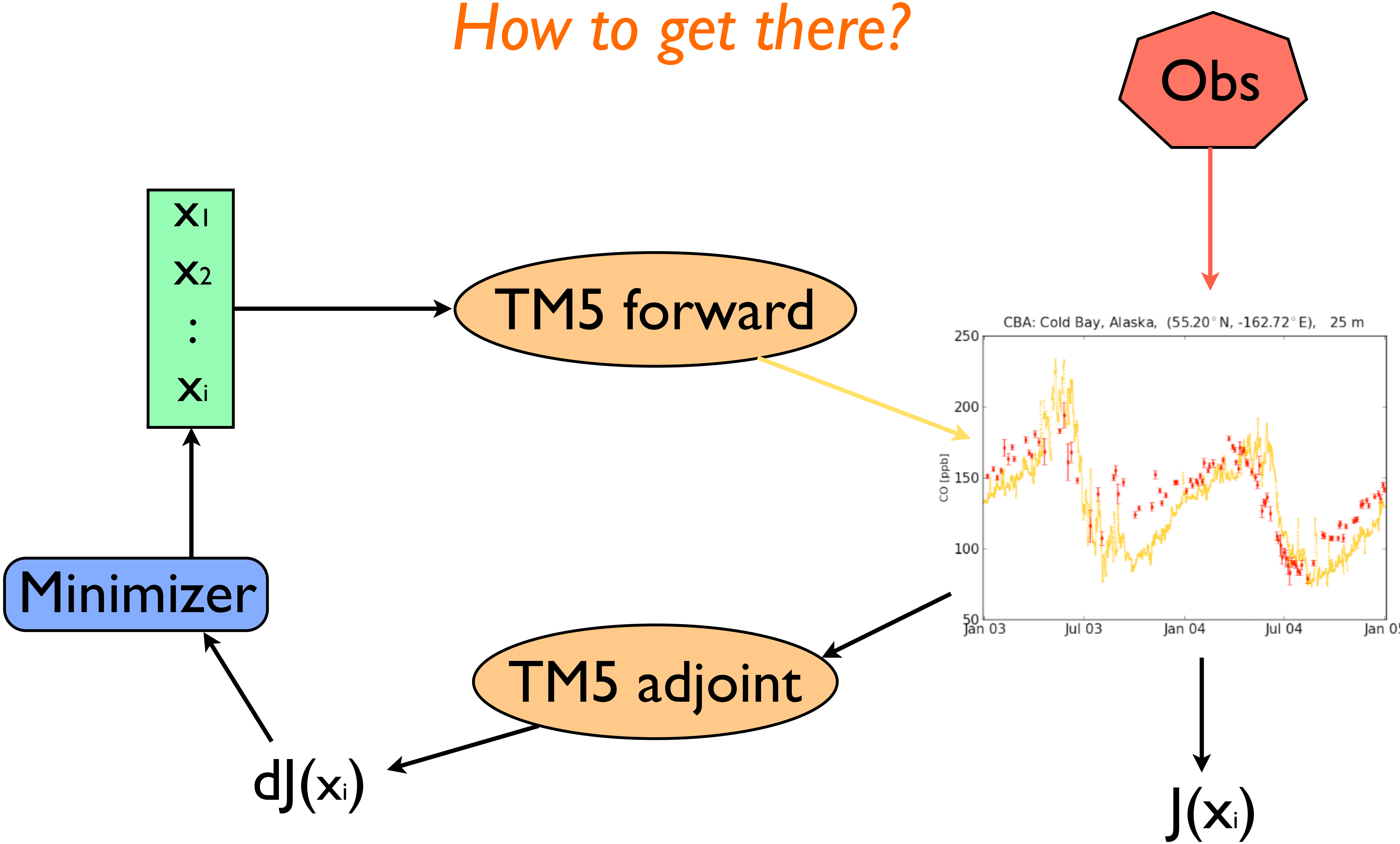

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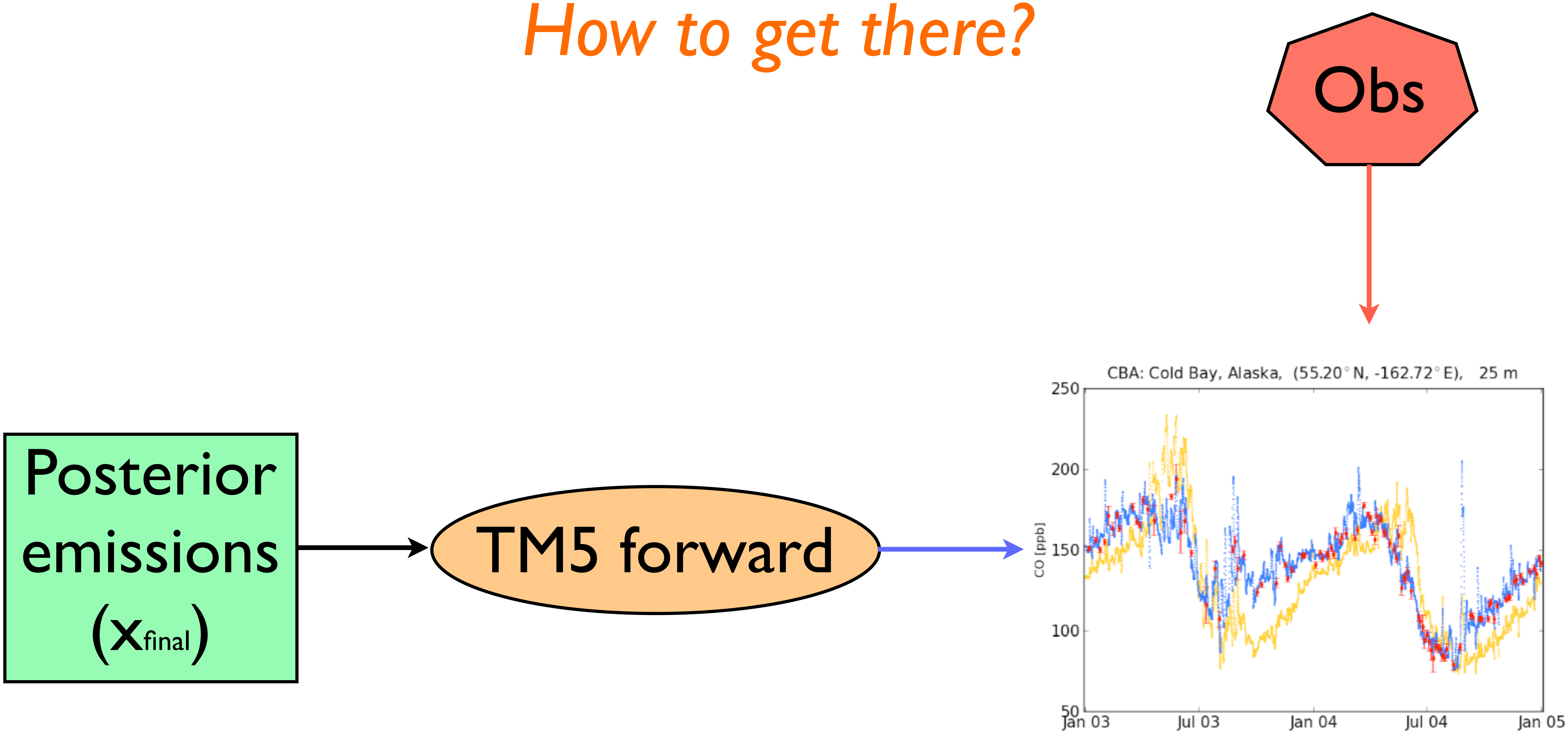
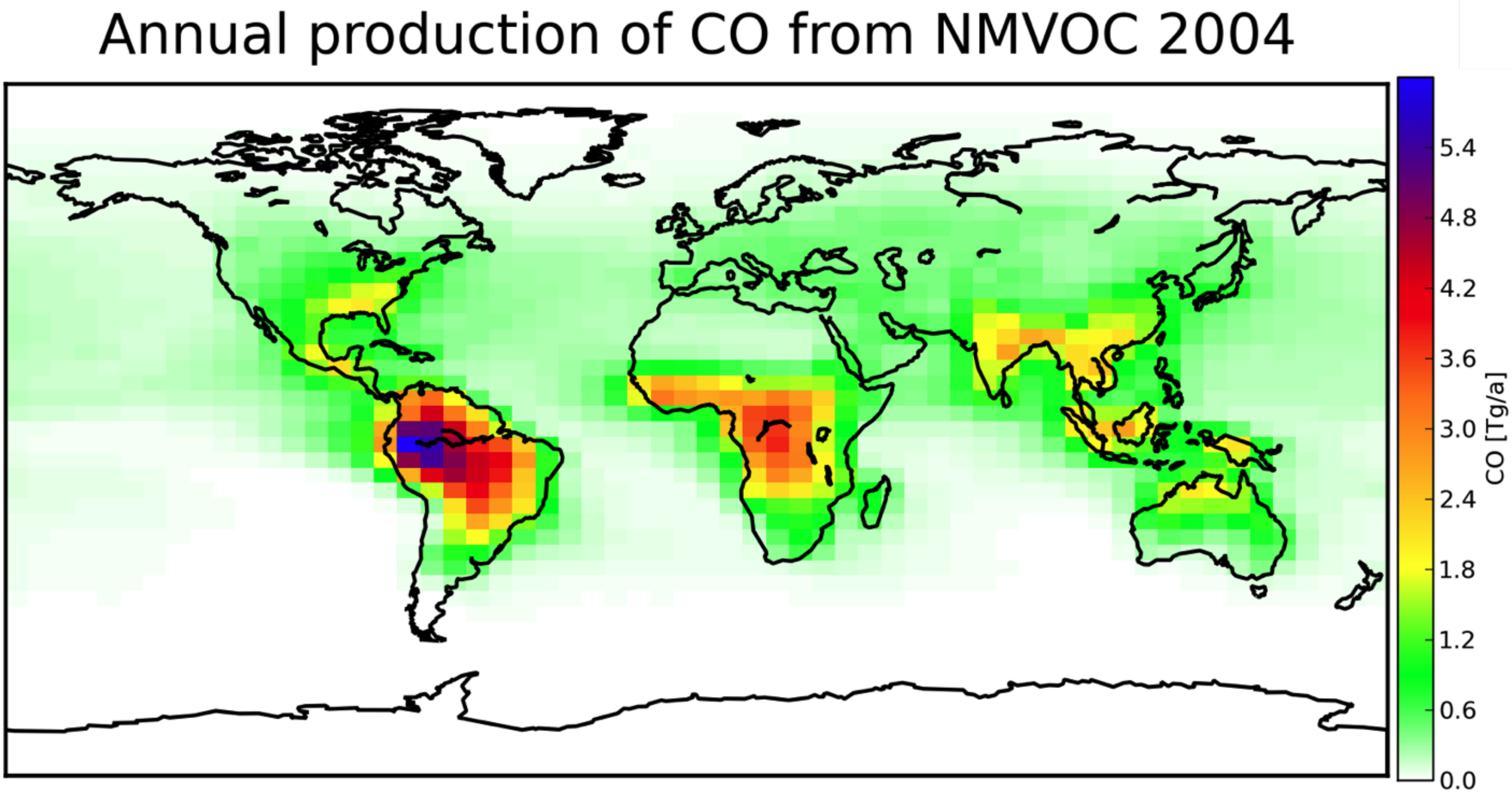


Model Improvements



Global annual total NMVOC-PCO: 800 Tg CO

Results

- *NOAA surface stations: prior/posterior simulation*
- *Emission estimates & Uncertainty reduction on continental scales*
- *Validation with CO total columns derived from MOPITT*

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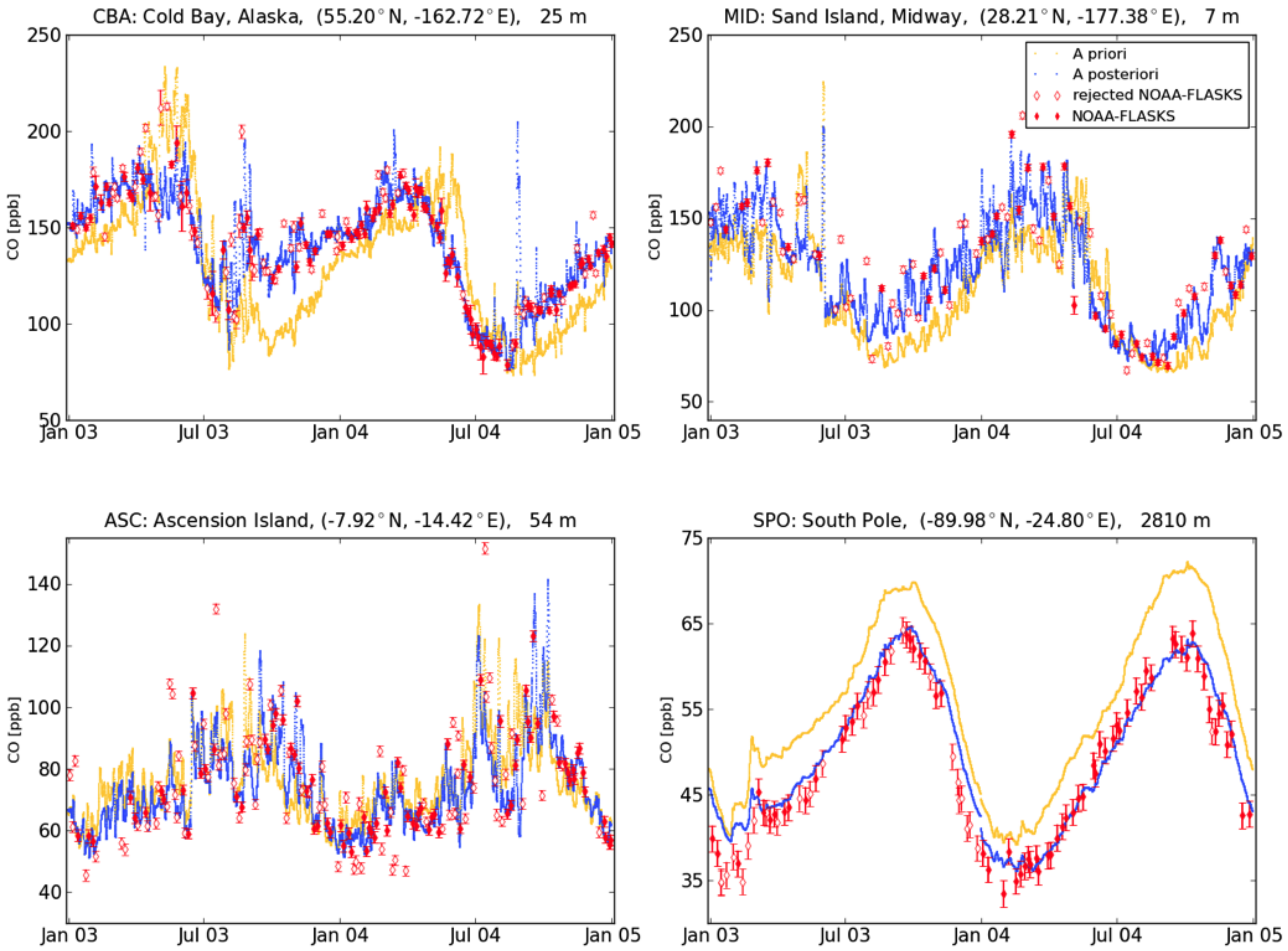
CBA: Cold Bay, Alaska, (55.20° N, -162.72° E), 25 m
MID: Sand Island, Midway, (28.21° N, -177.38° E), 7 m
ASC: Ascension Island, (-7.92° N, -14.42° E), 54 m
SPO: South Pole, (-89.98° N, -24.80° E), 2810 m
CO [ppb]
Jan 03
Jul 03
Jan 04
Jul 04
Jan 05
A priori
A posteriori
rejected NOAA-FLASKS
NOAA-FLASKS

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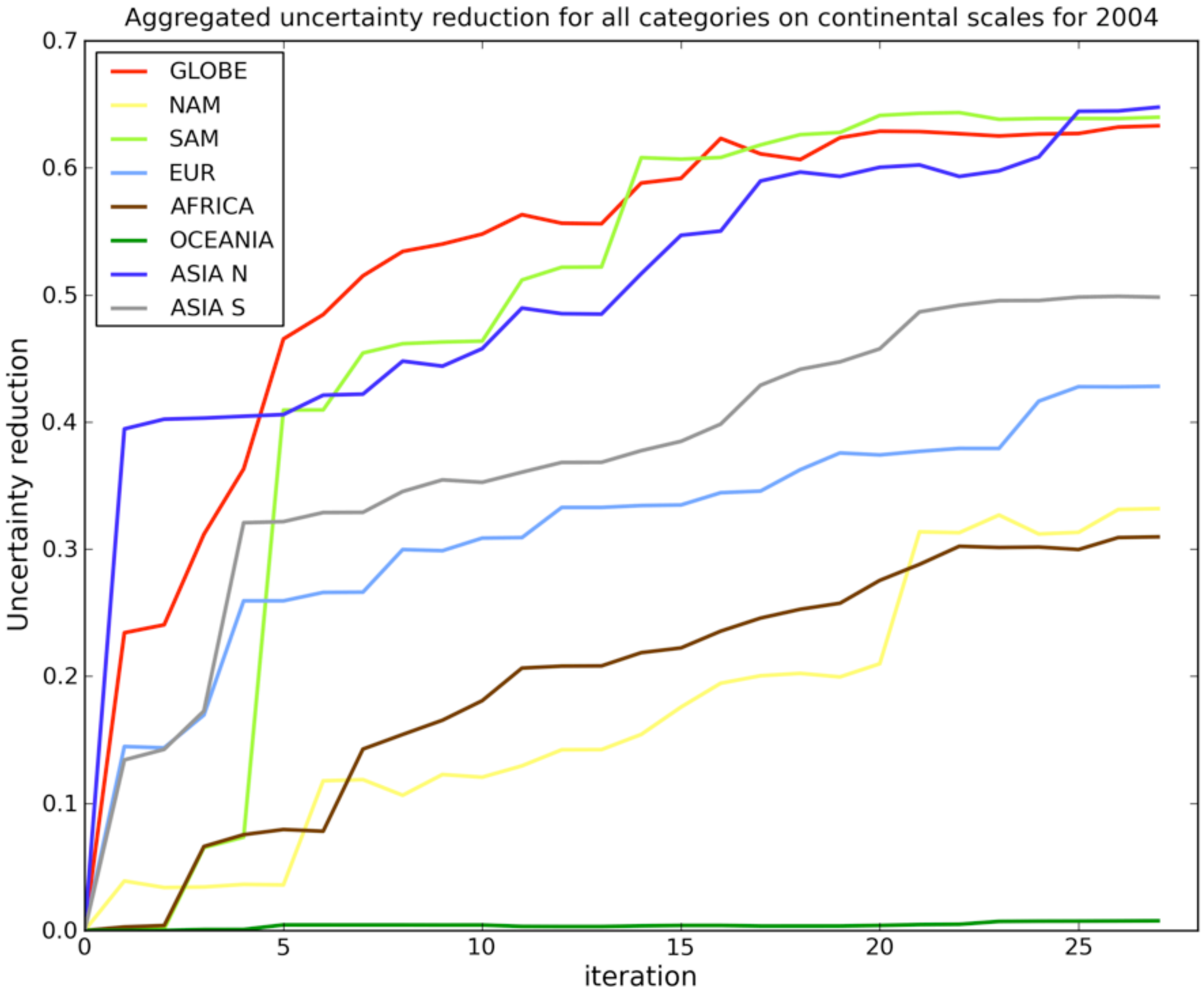
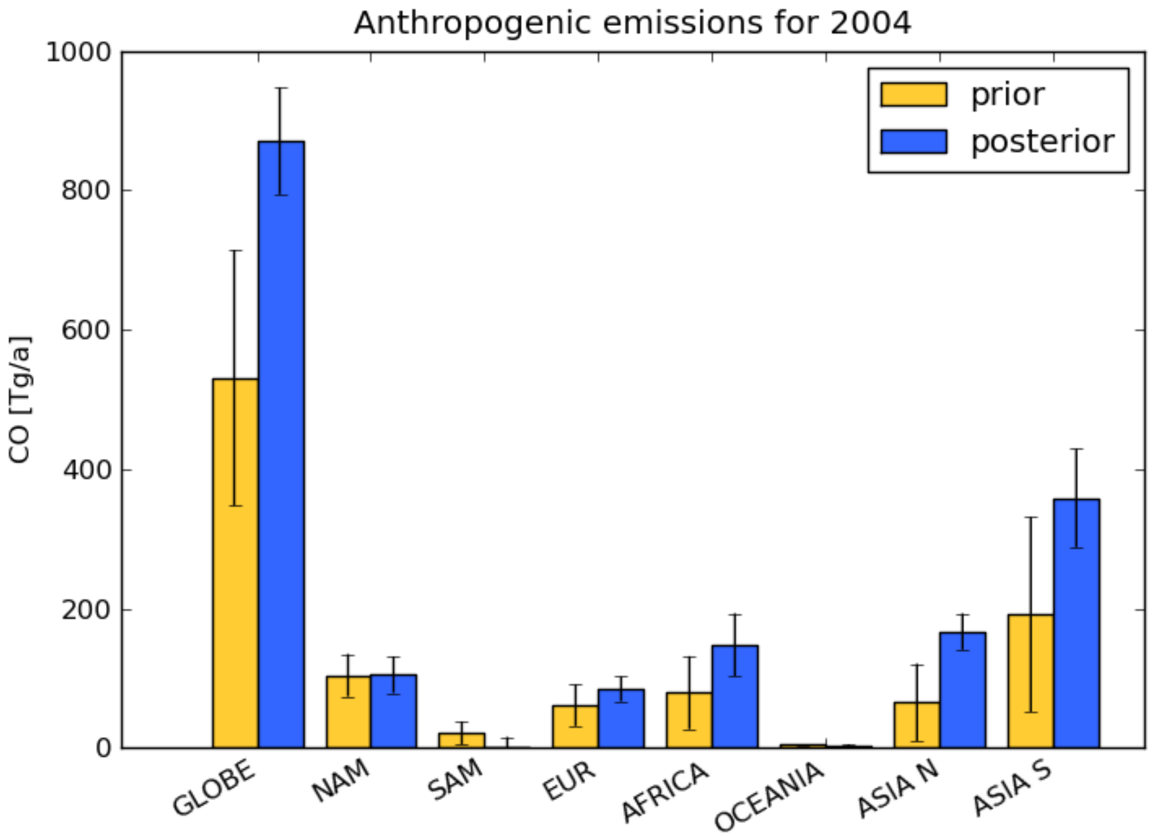
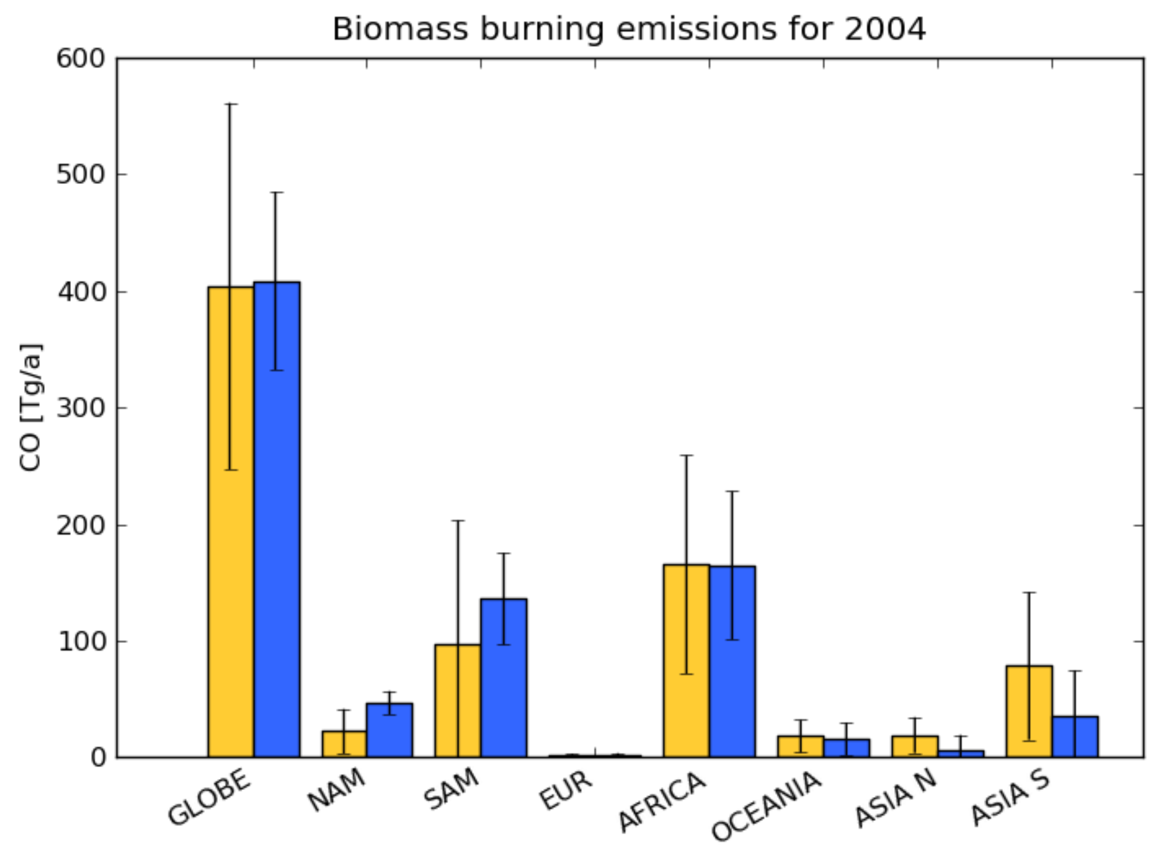
Uncertainty Reduction:

$$1 - \frac{\sigma_a}{\sigma_b}$$







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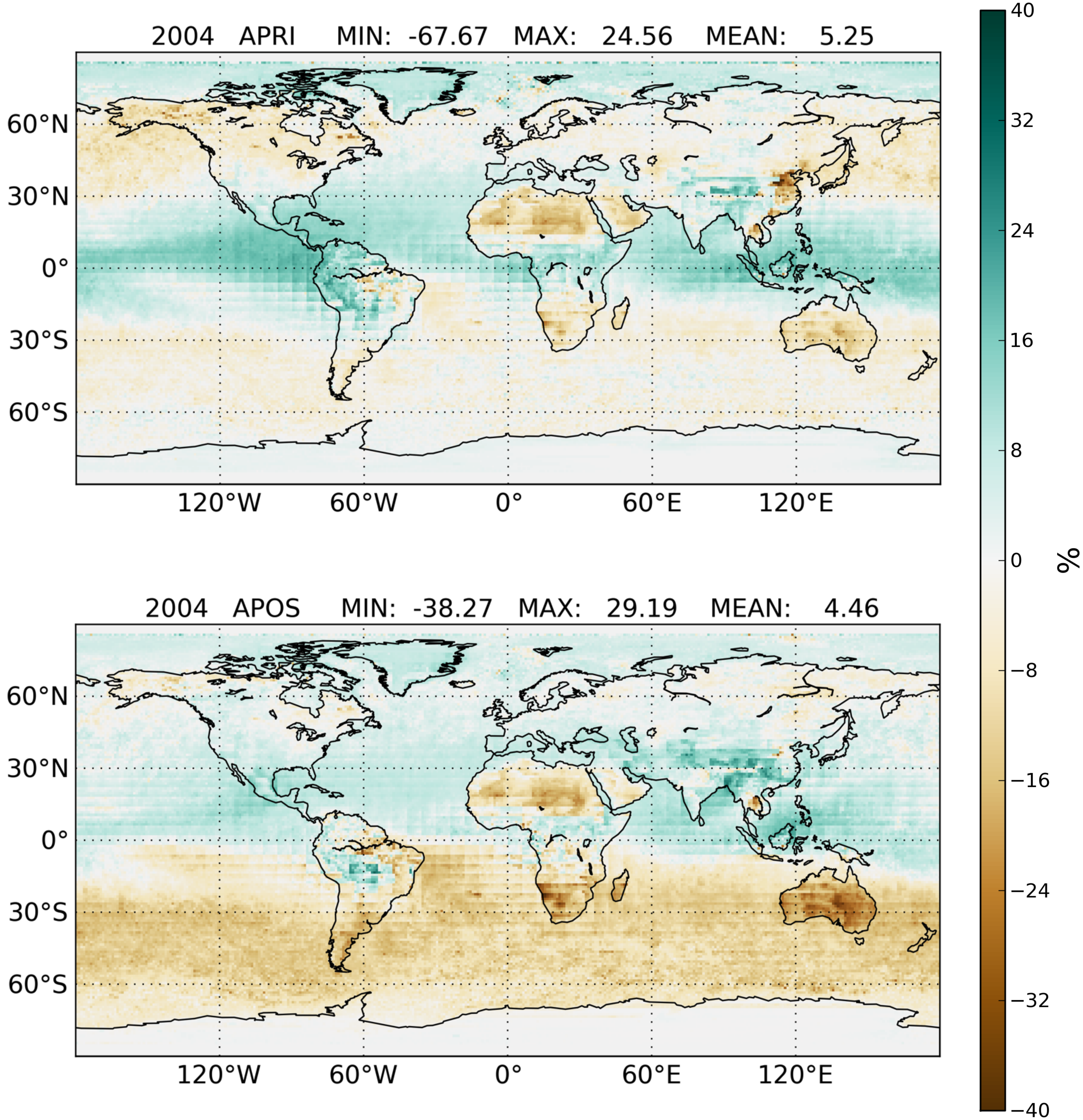
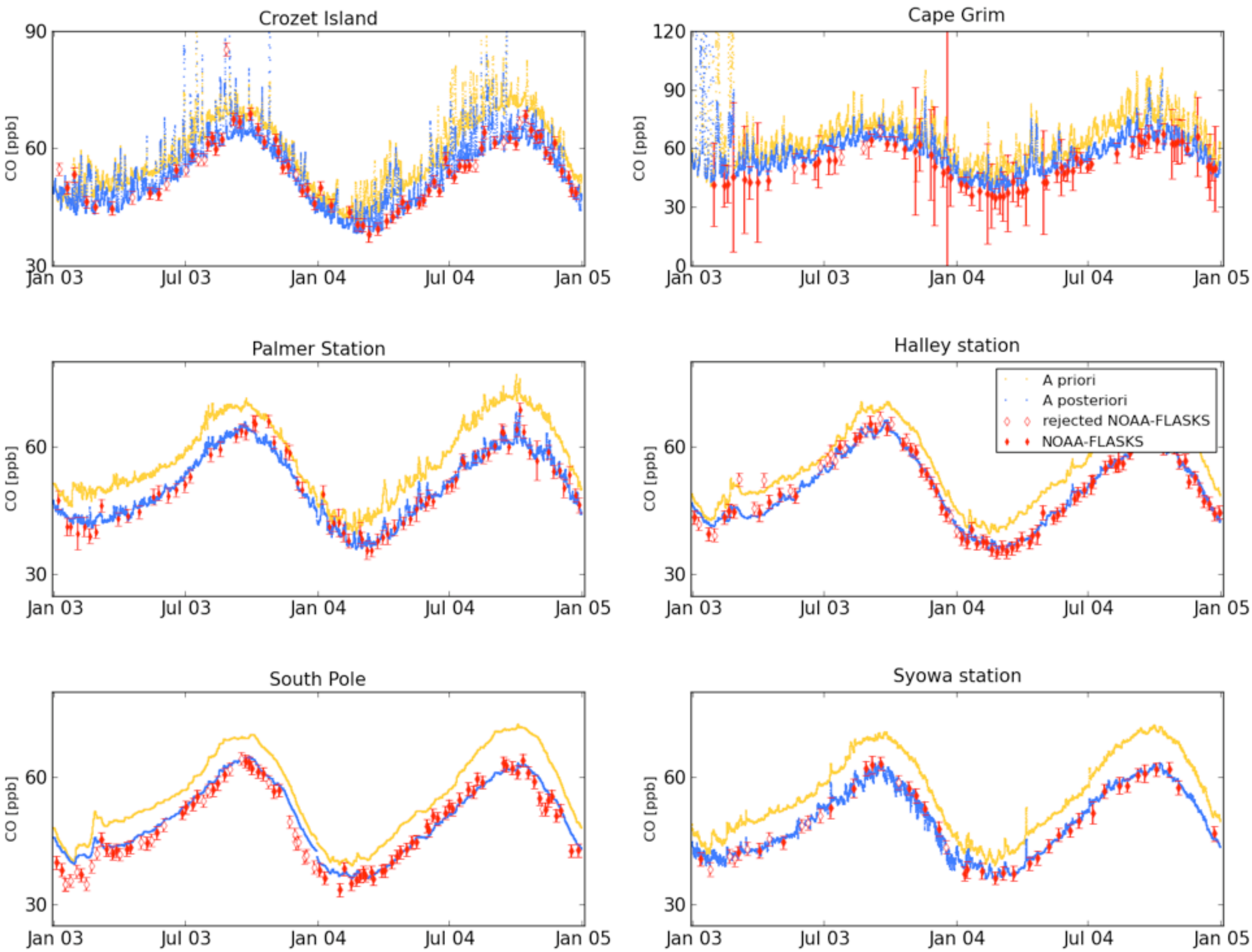


Comparison TM5/MOPITT for posterior simulation:

- NH (increased Asian ant)
- tropical band (decrease NMVOC)
- SH => trouble


Crozet Island
Cape Grim
Palmer Station
Halley station
South Pole
Syowa station
CO [ppb]
Jan 03
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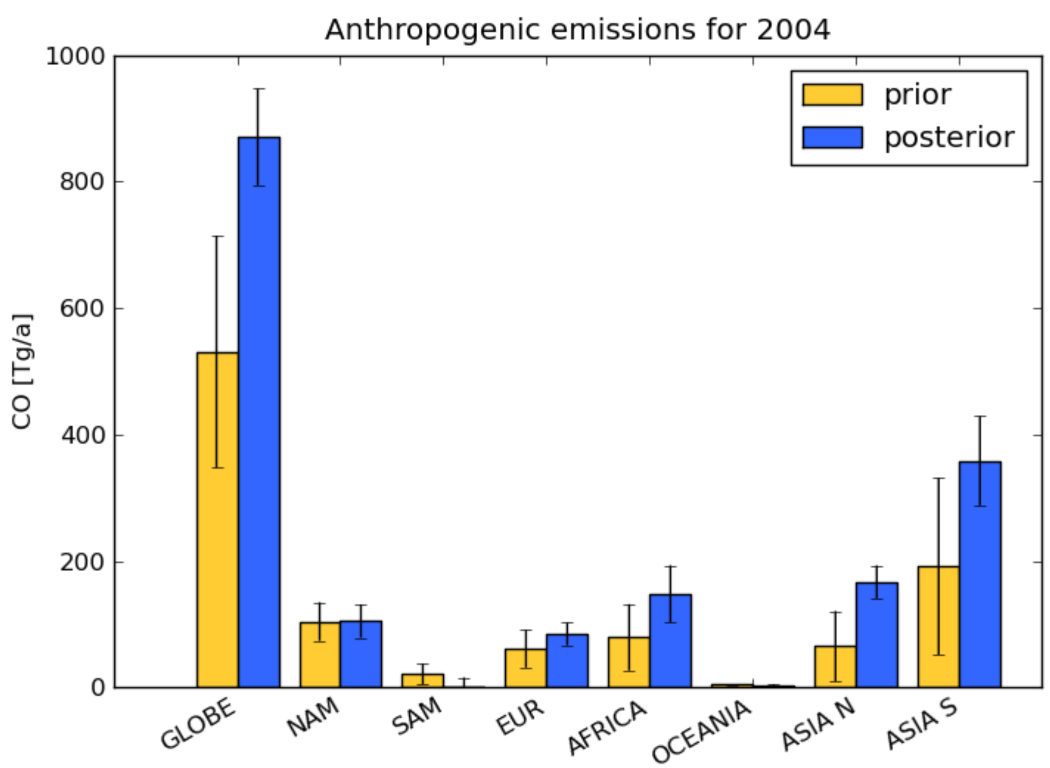
A priori
A posteriori
rejected NOAA-FLASKS
NOAA-FLASKS

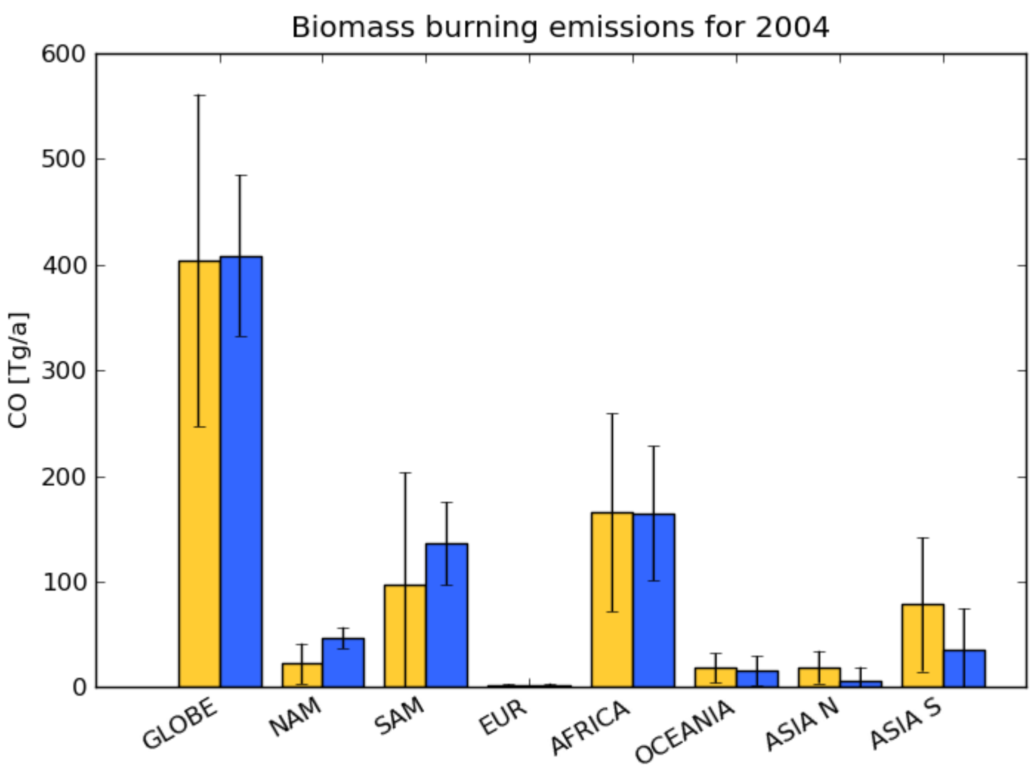
Discussion

Data sparsity: Differentiation of emissions

- We have seen the posterior emissions and their uncertainties relative to the prior emission estimates.
- Since there are some regions not well covered by the surface sites (e.g. tropics and remote SH), uncertainty reduction is NOT expected there. Moreover, changes in the emission estimate (from prior => posterior) in these regions are attributed to a compensation mechanism:

Emissions can change to compensate for large changes in another source. In this case, we call the change *unrealistic*.





Discussion

Data sparsity: Dependence on prior

- Due to the compensation mechanism, the combination of prior error for the anthropogenic source and the NMVOC-PCO source largely influence the inversion results.

	ANT		BB		NMVOC-PCO			
	APRI	APOS	APRI	APOS	APRI	APOS	Corr(ANT,BB)	Corr(ANT,NMVOC)
Base	531 ± 183	871 ± 77	404 ± 157	409 ± 76	$812 \pm 8\%$	410	-0.44	-0.23
S1	531 ± 364	491 ± 107	404 ± 314	417 ± 129	$812 \pm 8\%$	763	-0.62	-0.23
S2	531 ± 94	879 ± 40	404 ± 79	455 ± 48	$812 \pm 8\%$	362	-0.27	-0.41
S3	531 ± 183	935 ± 78	404 ± 157	477 ± 89	$812 \pm 16\%$	293	-0.28	-0.36
S4	531 ± 183	518 ± 66	404 ± 157	442 ± 71	$812 \pm 4\%$	785	-0.63	-0.18
B1	531 ± 183	904 ± 73	301 ± 107	374 ± 66	$812 \pm 8\%$	428	-0.40	-0.23

Future work

Assimilate satellite observations

- Regions that are not well constrained by the data (Africa, South America, Indonesia..) can be constrained better by assimilating satellite data.
- Currently starting to set this up. When implementation done, we'll do an inversion with pseudo satellite data only to test.
- Later on we will do realistic inversions using observations from both surface sites and satellite data. However, from the current study it seems important to do a *bias correction.*

Conclusions

- CO 4D-VAR: source description complete.
- 4D-VAR works: posterior fit better than prior.
- Compensation mechanism.
- Satellite observations required.