Constraints on OH in a global 3-D model inversion of OH

Stijn Naus, S. Montzka, S. Basu, M. Krol

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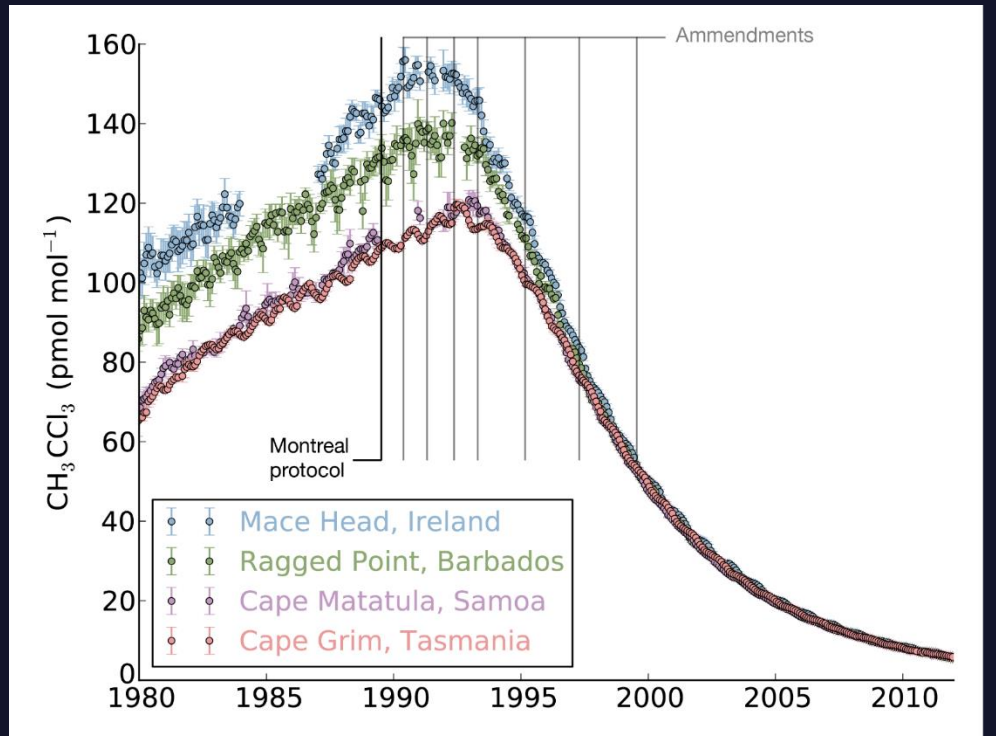
Ideal tracer: Methyl chloroform (MCF)



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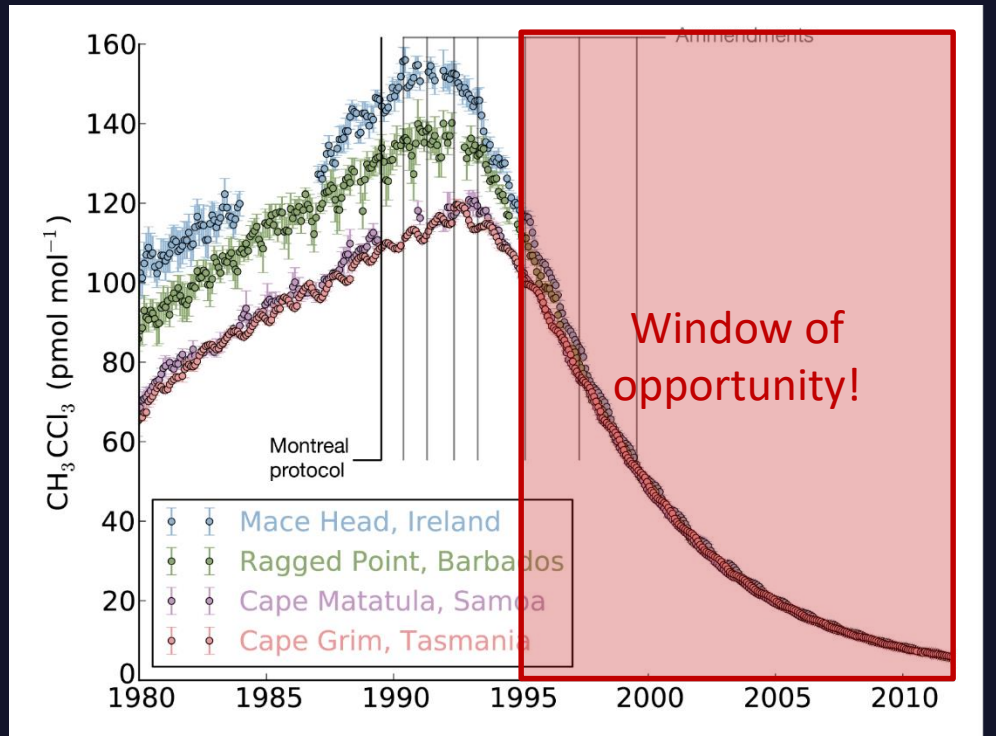
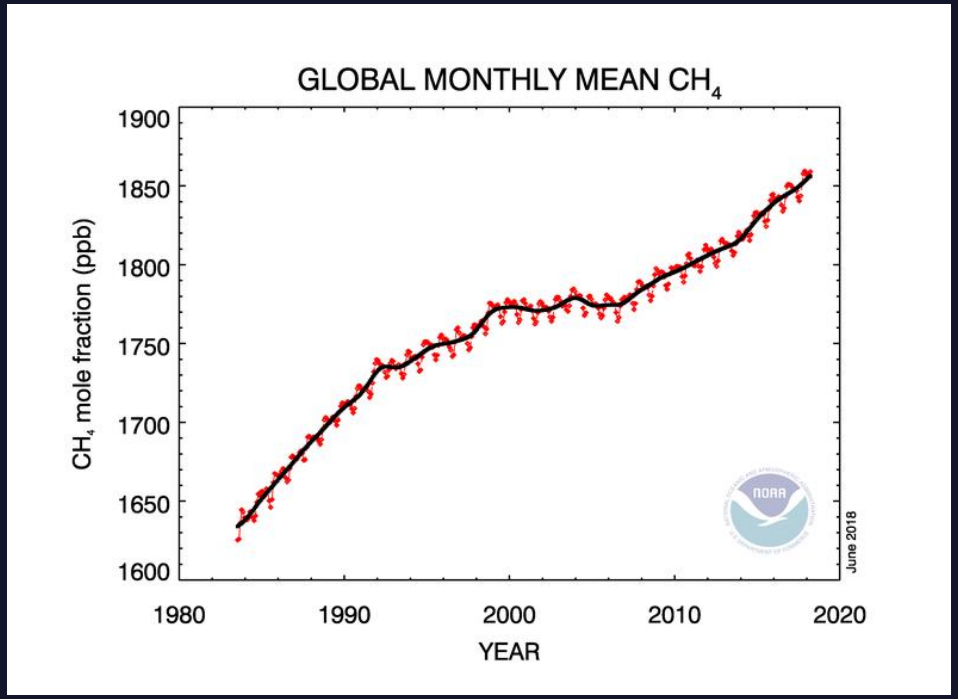


Simple box model studies

(Turner et al. (2017), Rigby et al. (2017))

Key message:

We don’t know OH well enough, so we don’t know CH_4 emissions either.

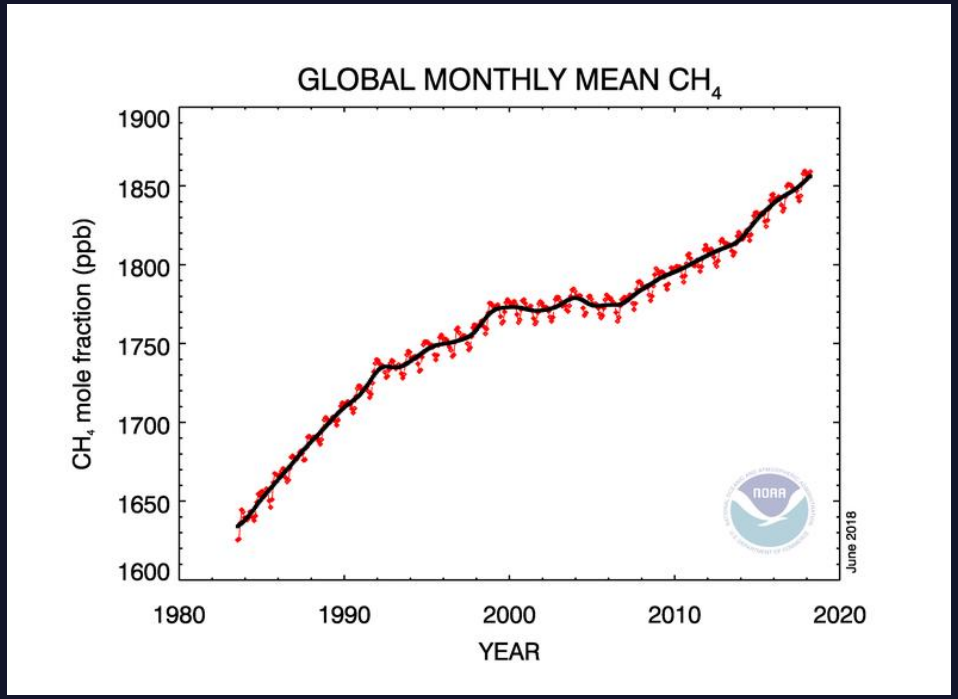


Simple box model studies

(Naus et al. (2019))

Key message:

We don't know OH well enough, so we don't know CH_4 emissions either,
but "neglecting" transport in a simple model can result in avoidable biases.



Why redo this in TM5?

1. Explicitly include transport transport

2. Simulate individual sites: site-to-site gradients carry more information than hemispheric means

3. Because it is difficult to predict what will come out

Designing the 3D model inversion

TM5 setup

- 6 x 4 degrees horizontal resolution
- 1998 – 2018

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Standard prior:

1. TransCom emissions before 2008, after 2008 emissions optimized in a one box model
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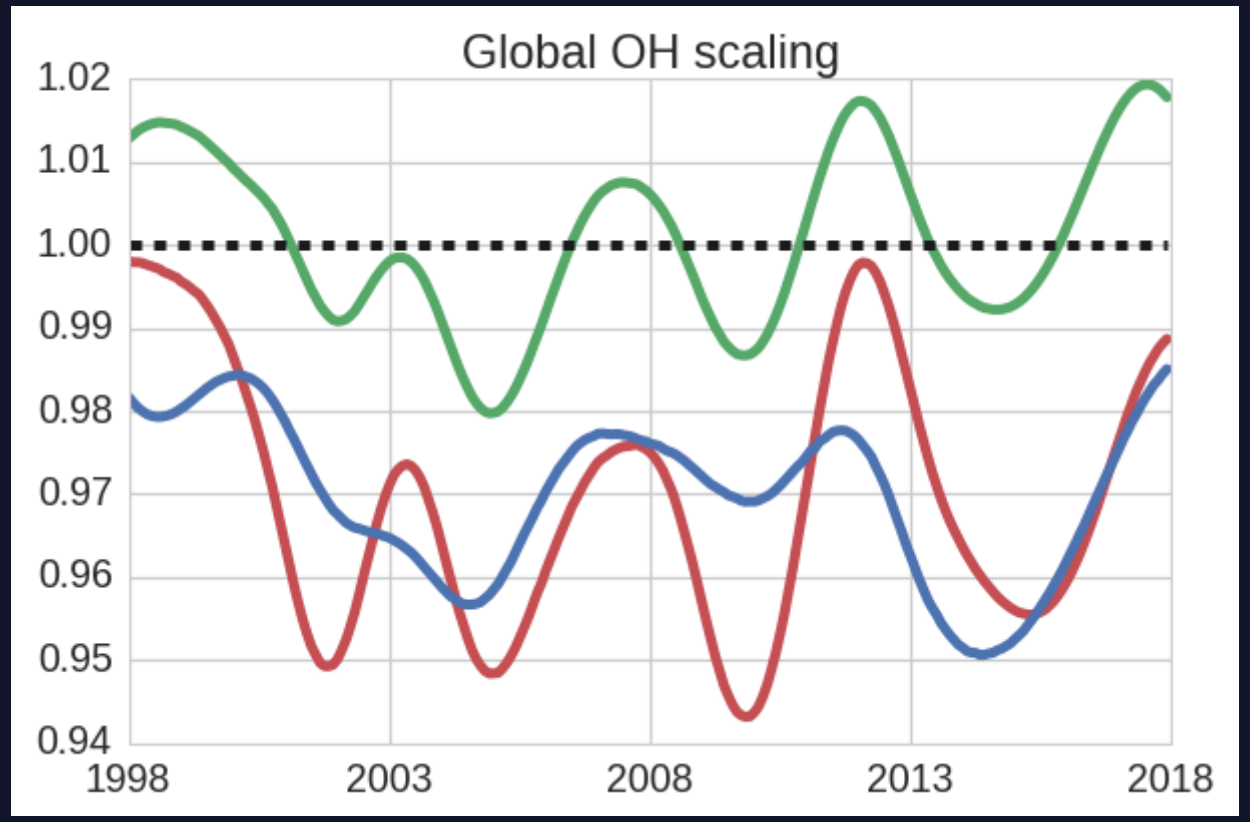
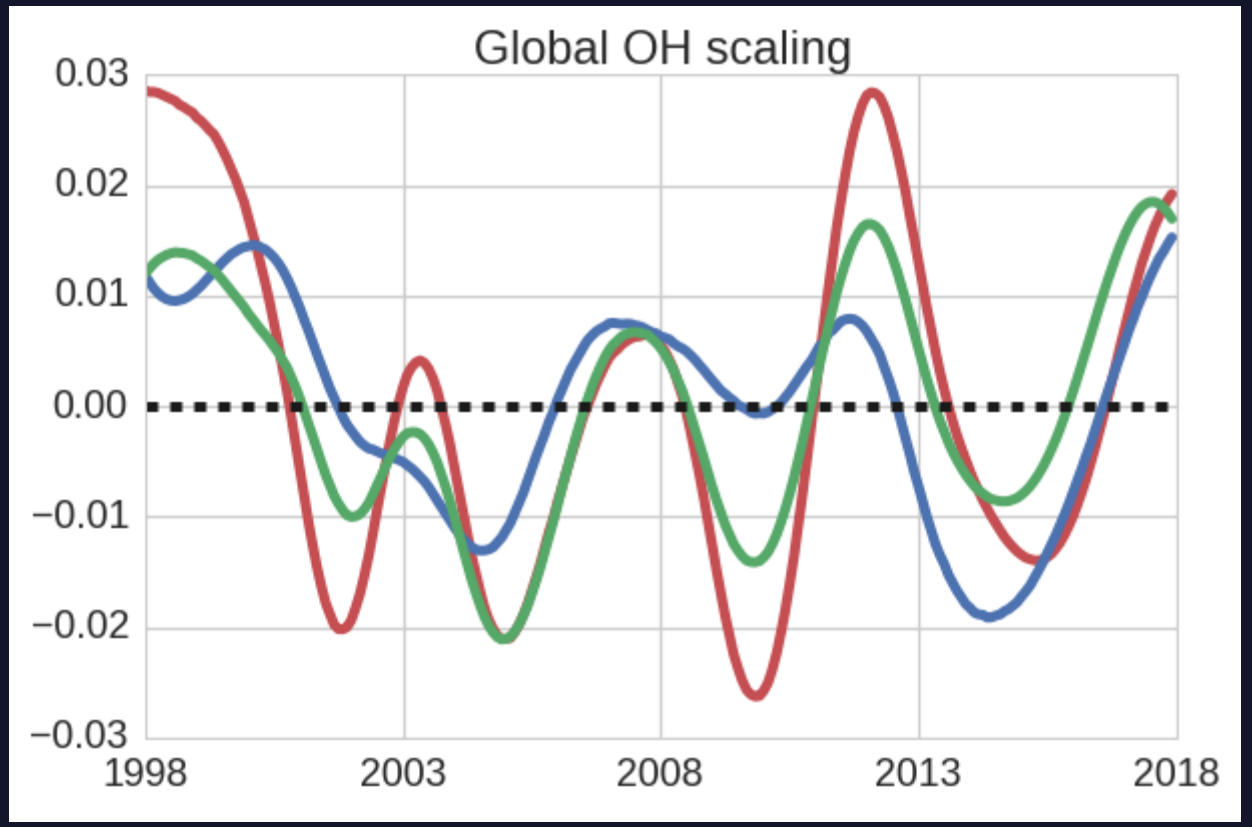
Inversion:

1. Optimize MCF emissions with large correlation lengths
2. Optimize OH 45 highly correlated zones

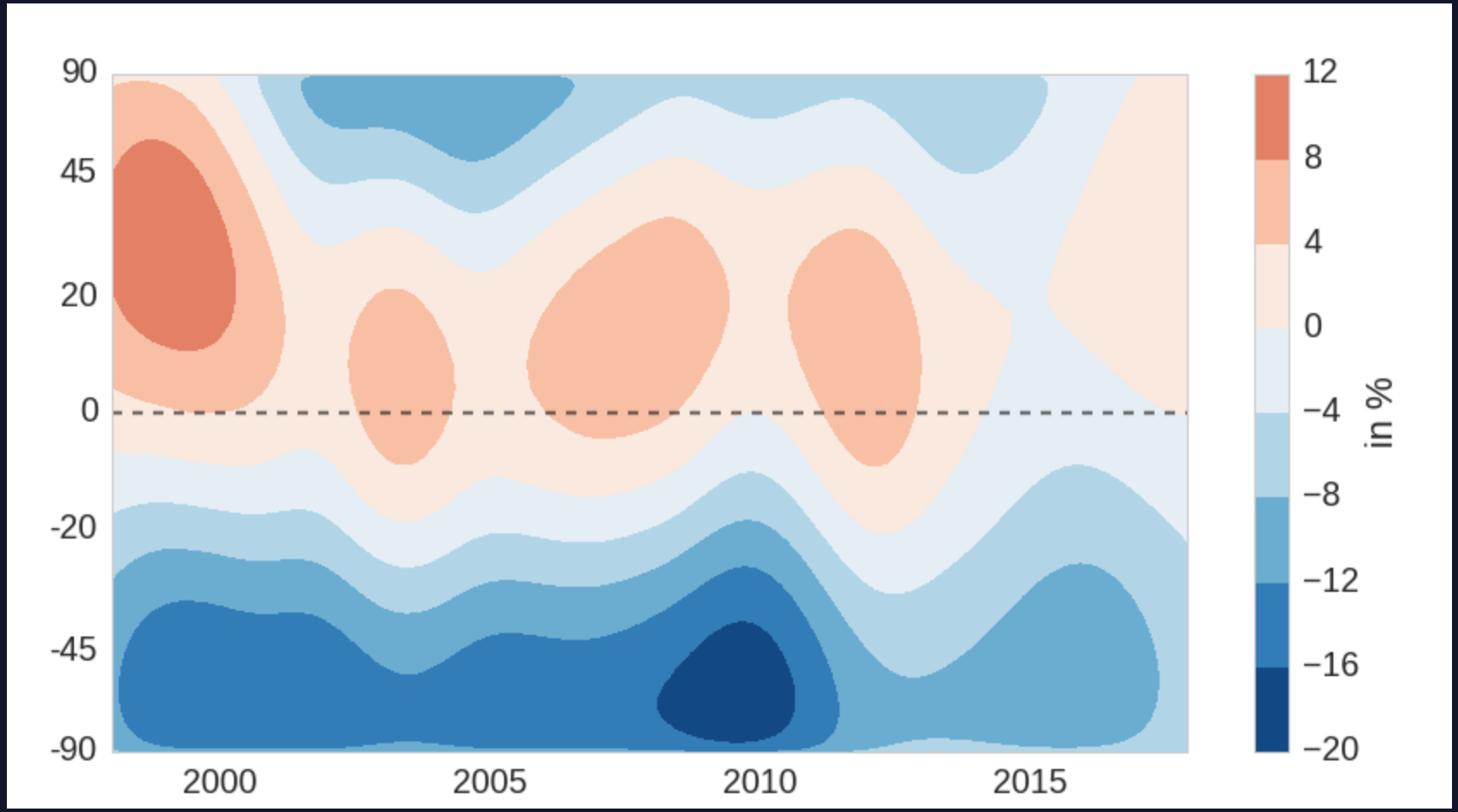
OH variations



OH variations (minus mean)



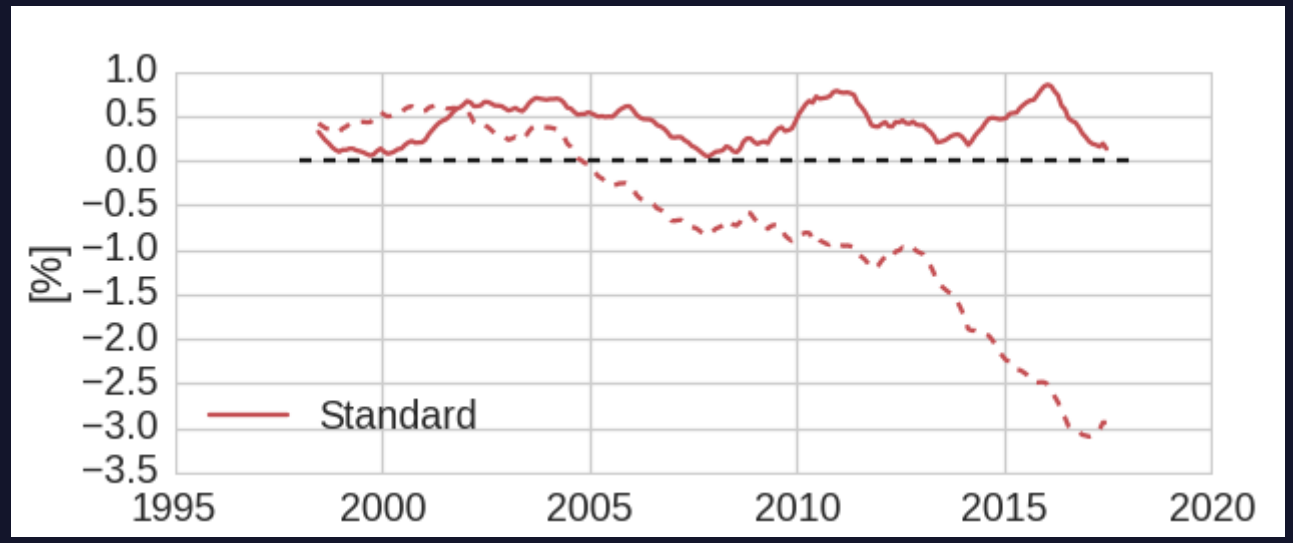
Hövemoller of OH variations



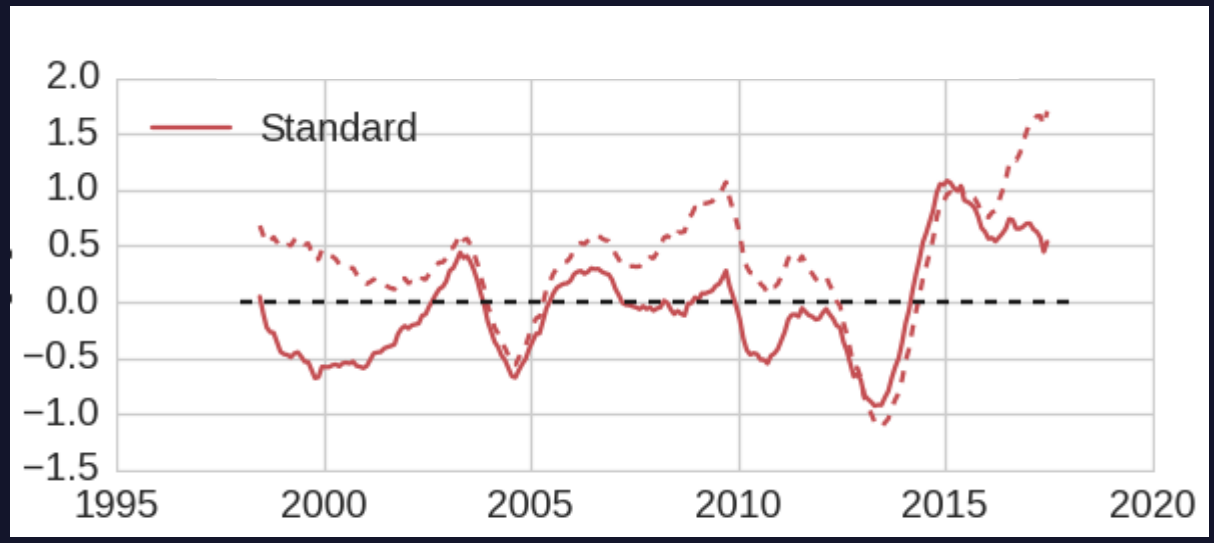
Observations

Large-scale results MCF

1. Global mean mismatch with NOAA



2. Interhemispheric gradient mismatch with NOAA



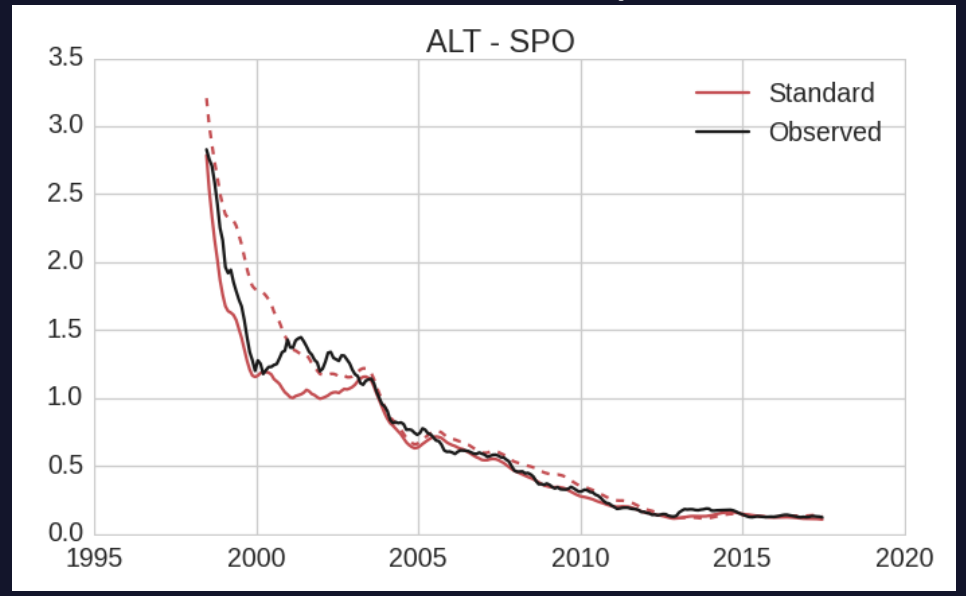
- Improvement over prior
- Still some (small) multi-annual variability is not captured

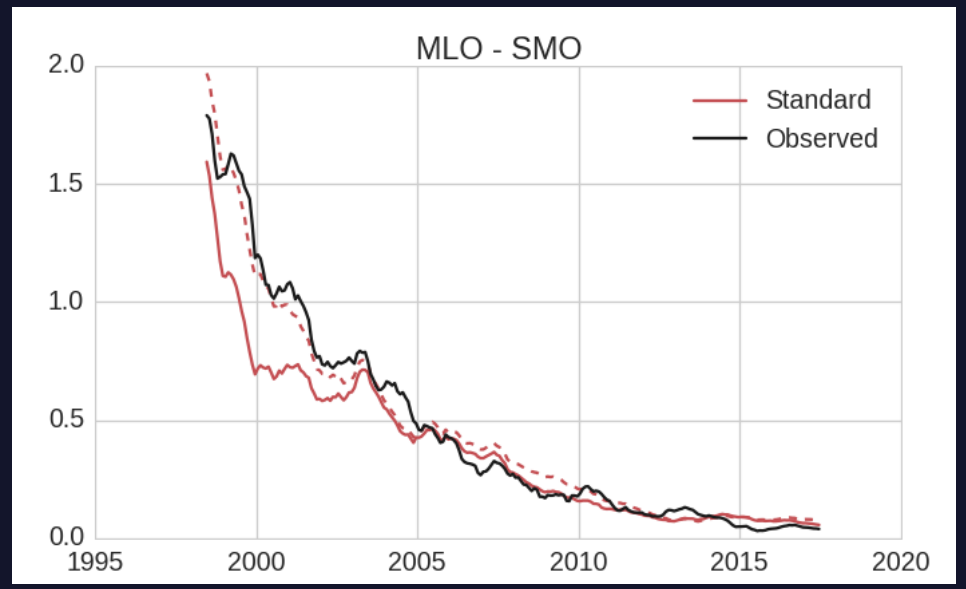
Mismatch per site (1998-2018 average)

- Tropics too high, extra-tropics too low

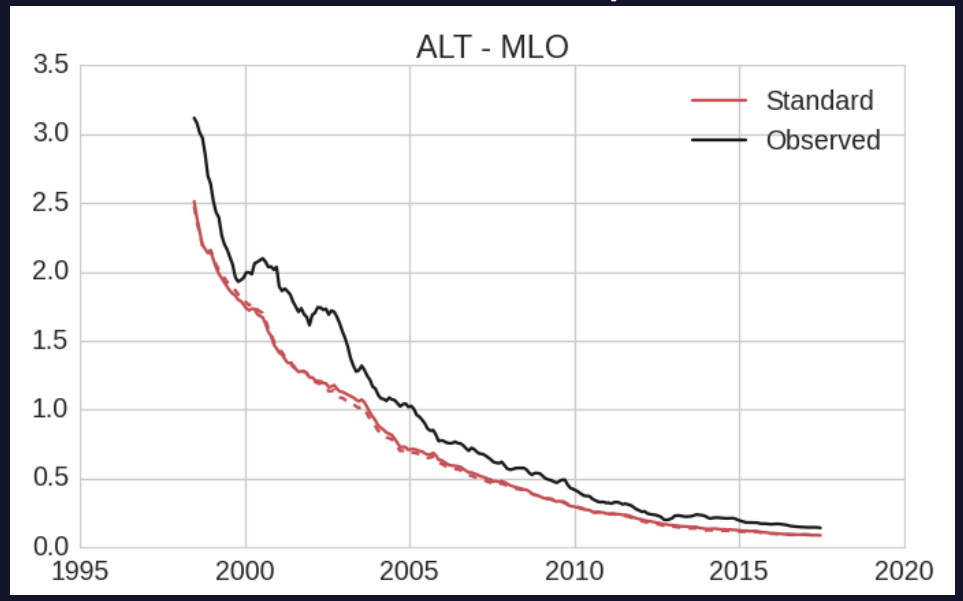
Gradients between sites

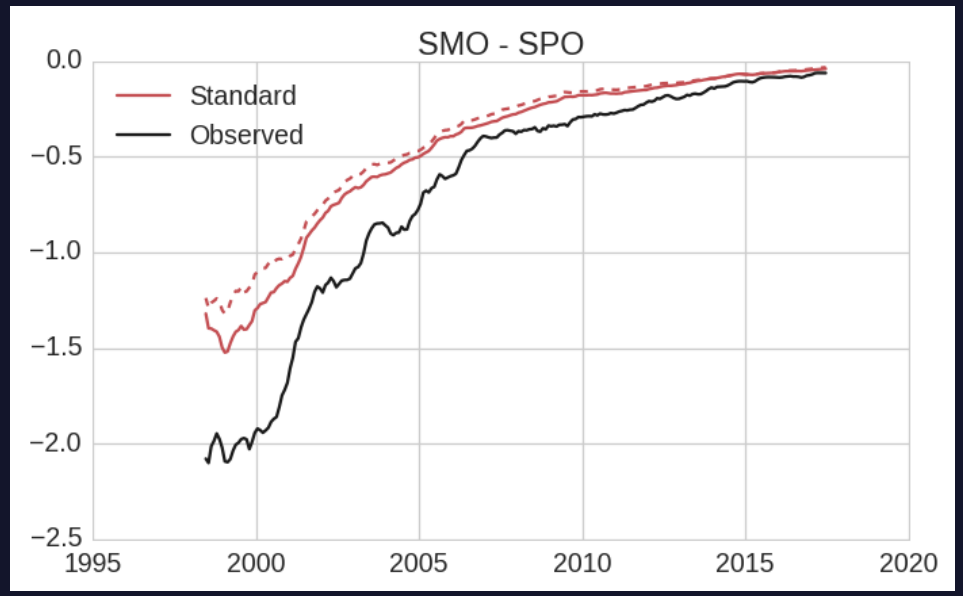
Gradients across the equator: Good!



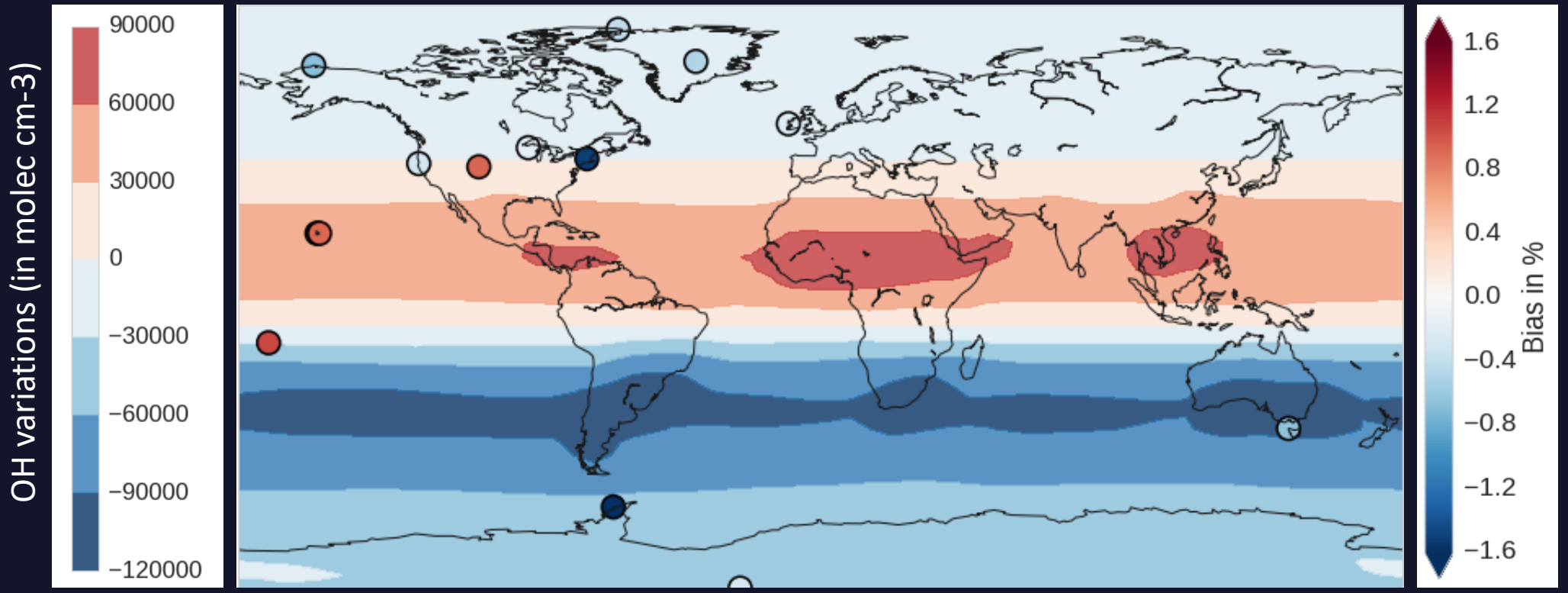


Gradients within hemispheres: Too low





Mismatch per site + OH variations (1998-2018 average)



OH adjustments seem in line with biases

Which is true?

1. These biases are unresolvable within the inversion framework
2. The biases are resolvable, but the inversion hasn’t found this solution (yet)

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Note: Removal of biases only reduces the cost function by 15%,
so scatter around bias is also important!

Conclusions

1. A 20 year 3D inversion of MCF is able to improve on the prior (so we have “optimized” Spivakovsky available)

2. But extra-tropics to tropics gradients remain underestimated

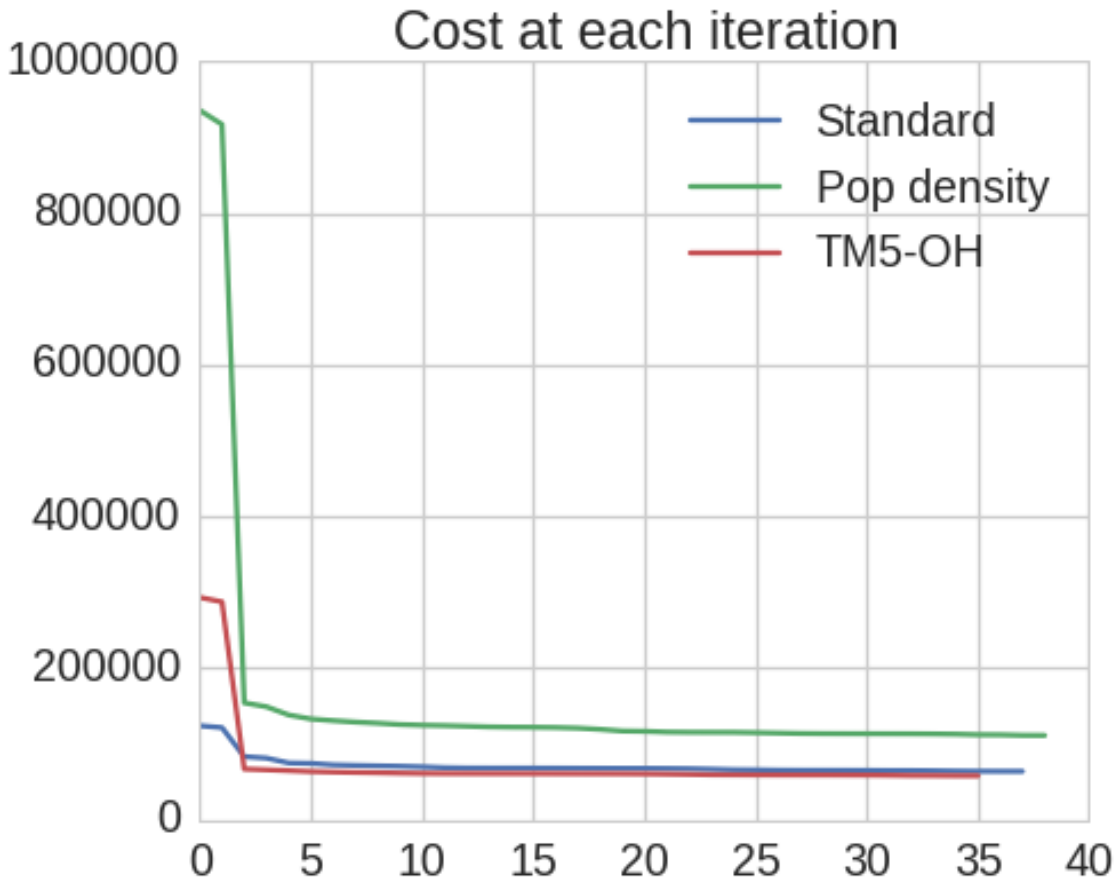
3. These remaining biases seem difficult to resolve by using realistic scenarios

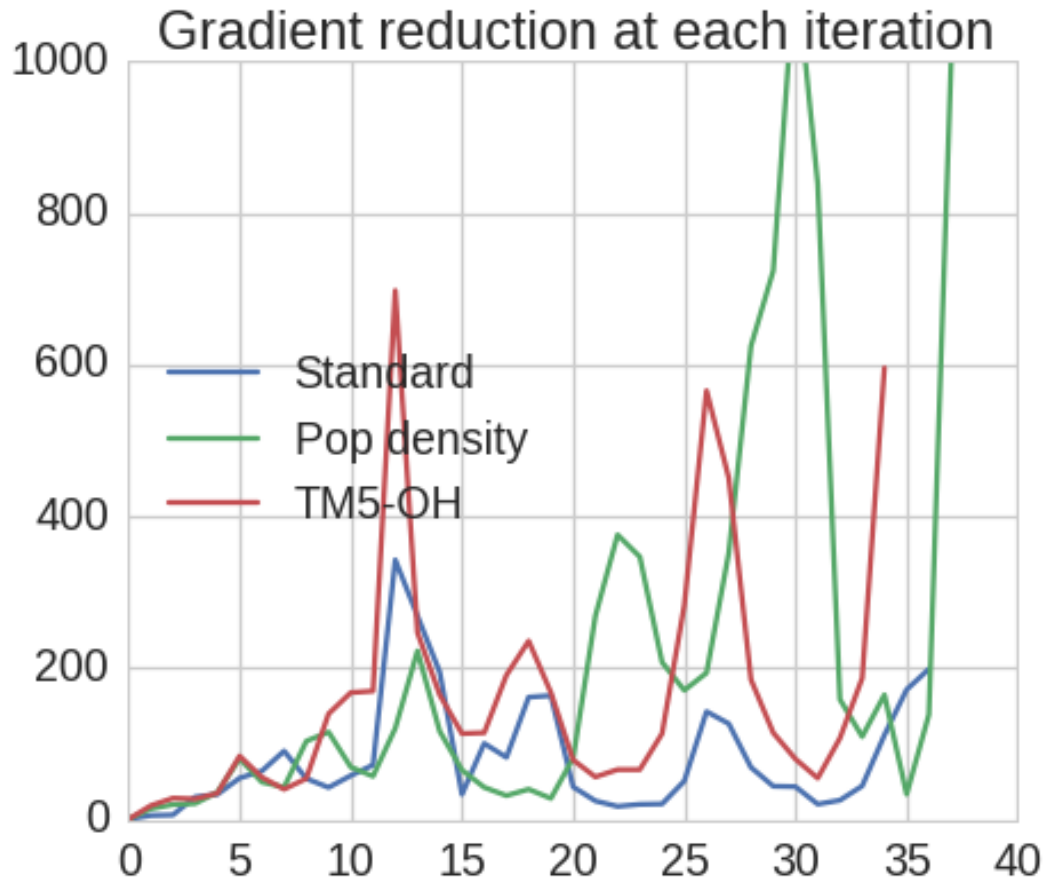
4. The uniqueness of the solution and the convergence of the inversion are difficult to diagnose

Outlook

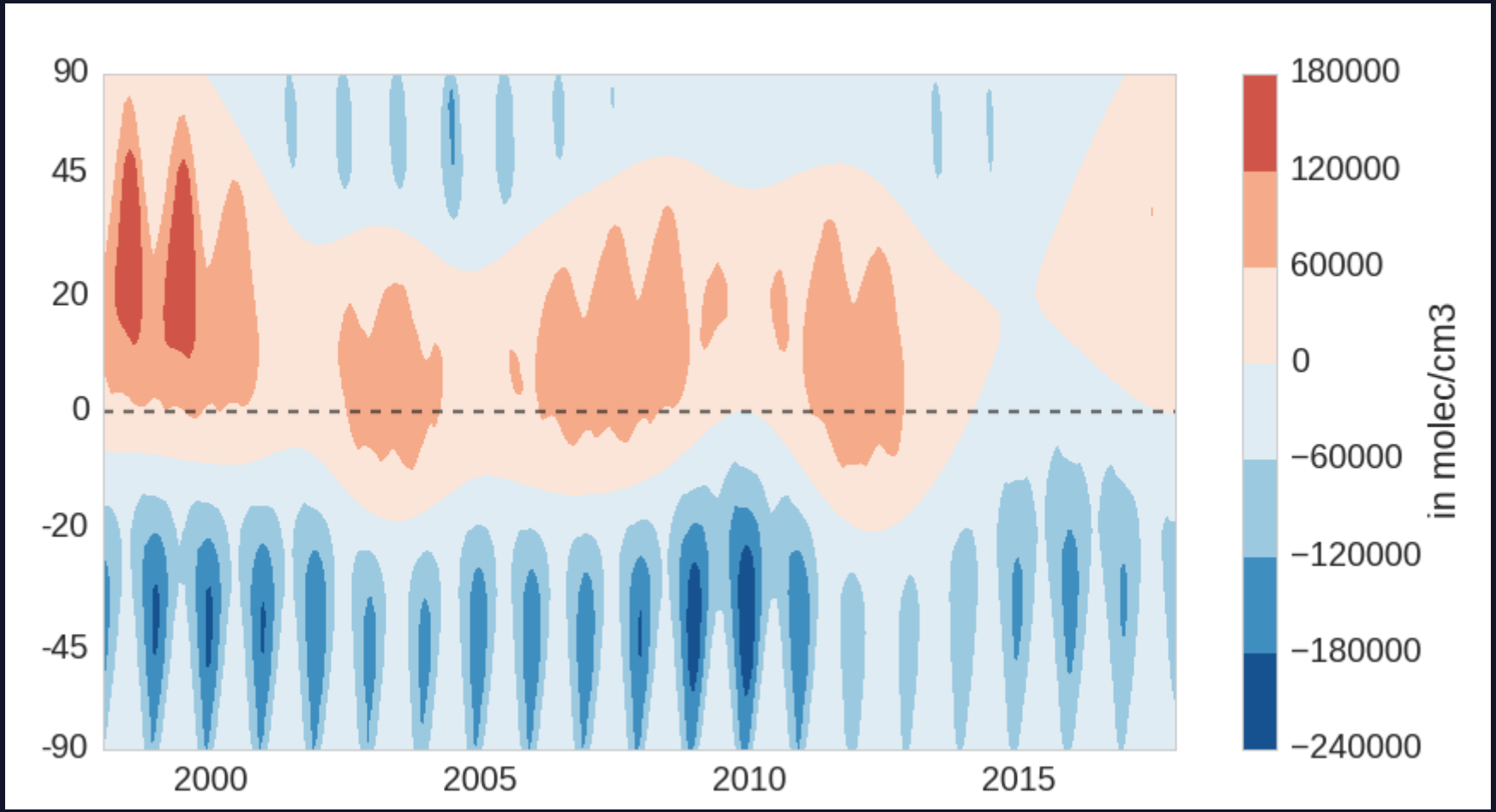
1. Couple transport model to a “simple ” inversion system
   -> Possibly using adjoint sensitivities
2. Shorter inversion windows
3. High(er) resolution forward run
4. Comparison with Patra’s MIROC4-ACTM

Cost function

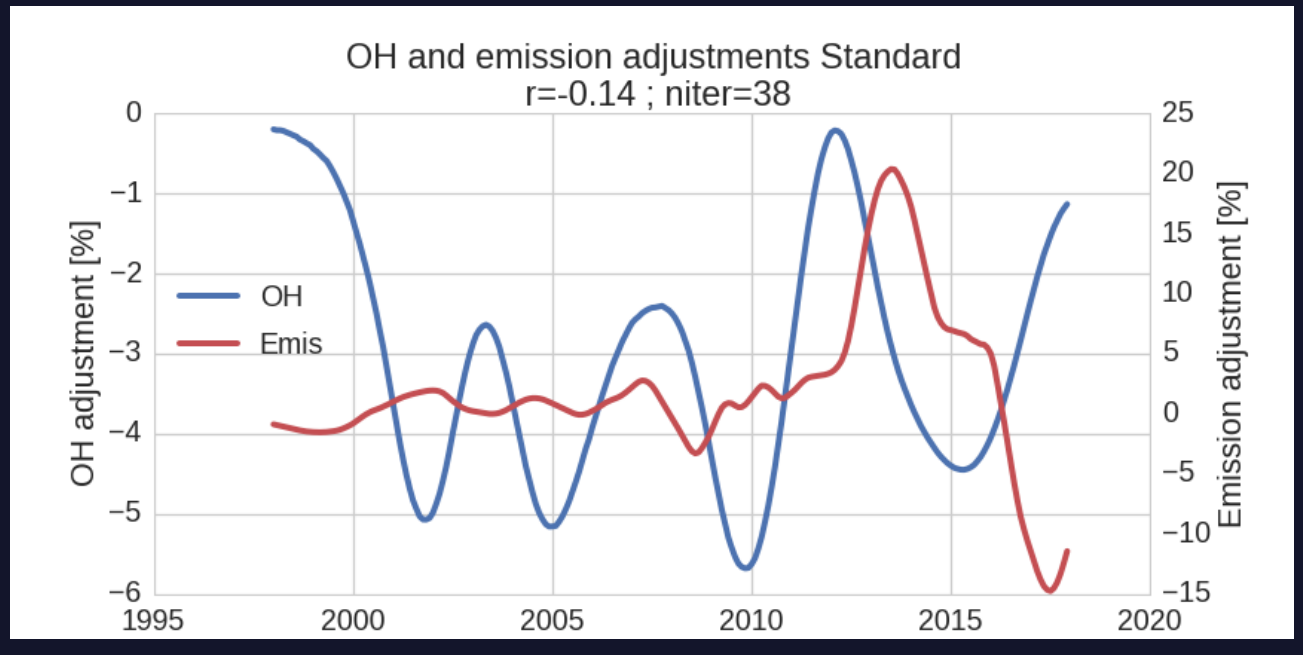


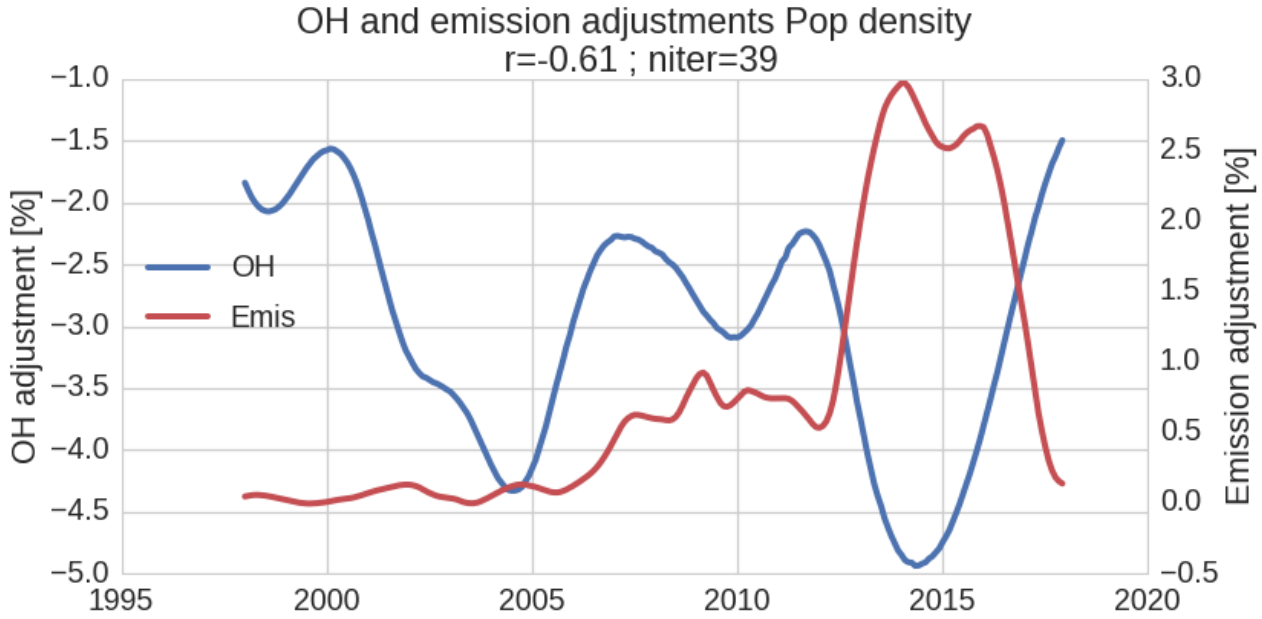


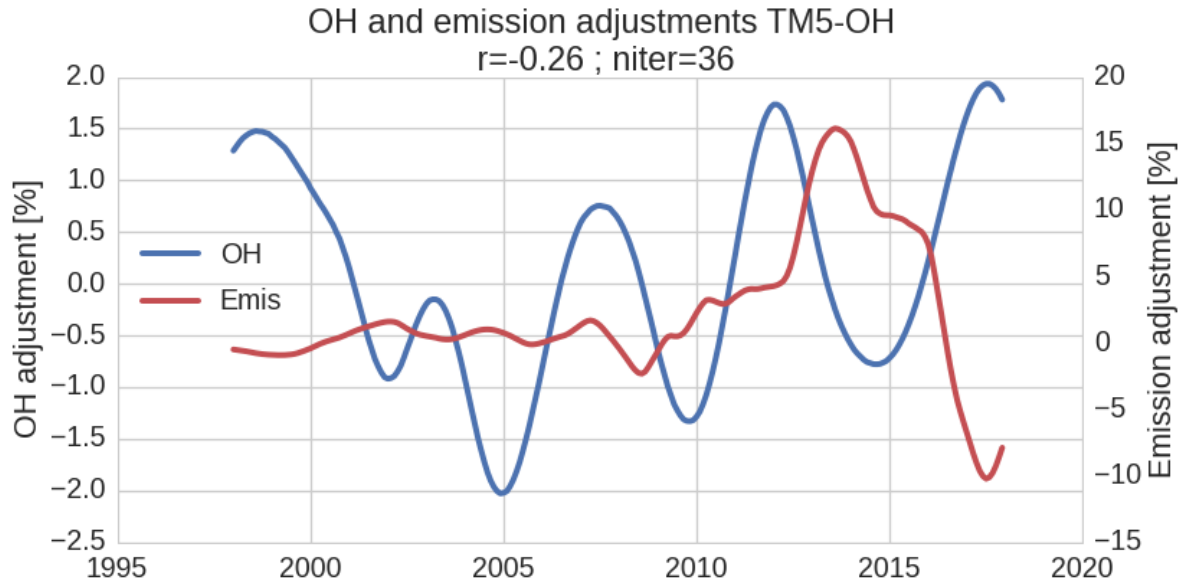
Hövemoller of OH variations (absolute)



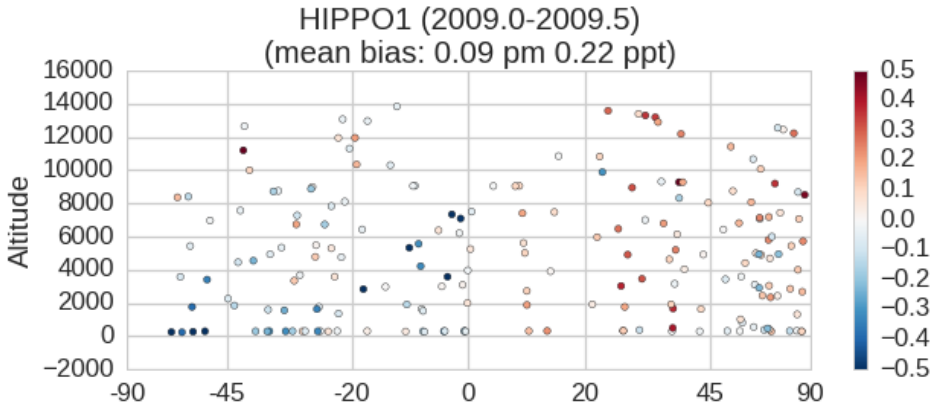
OH + emission adjustments

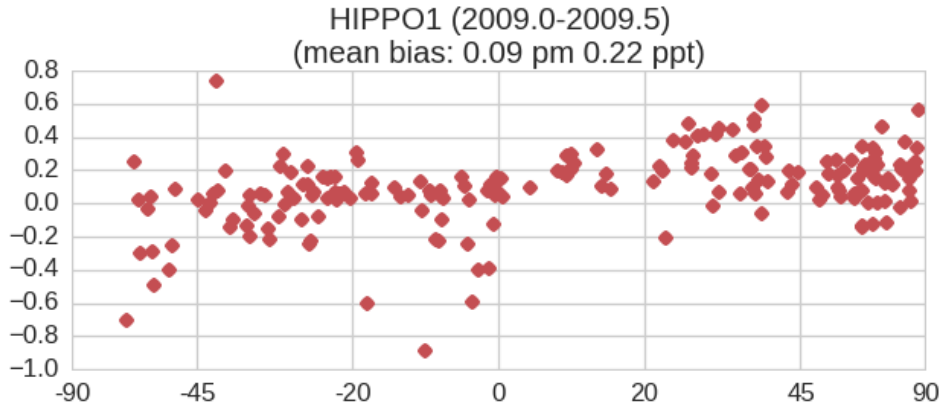


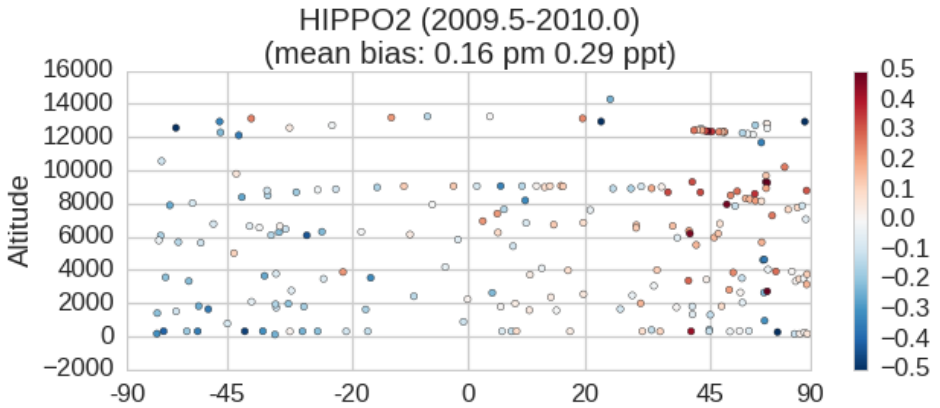


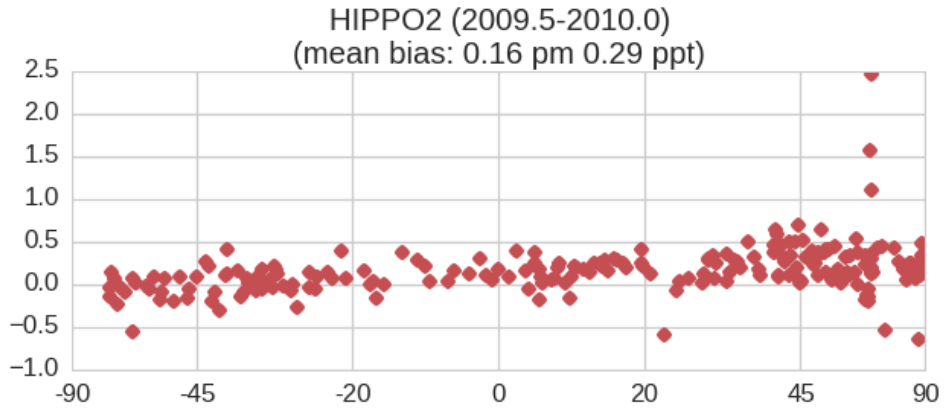


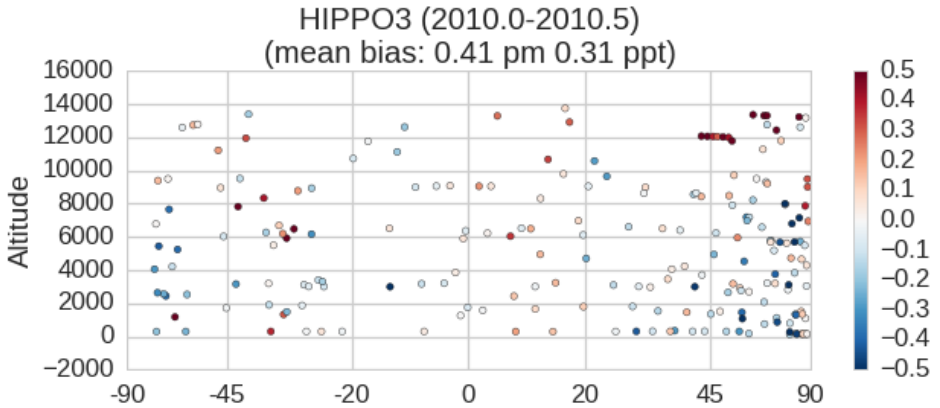
Aircraft : HIPPO

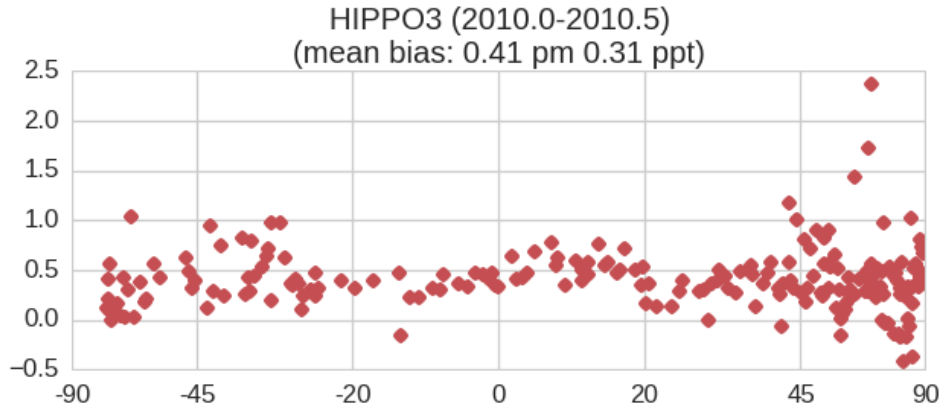












Aircraft : ATOM