Inferring methane emissions and OH concentrations by combining AIRS + GOSAT satellite observations of methane

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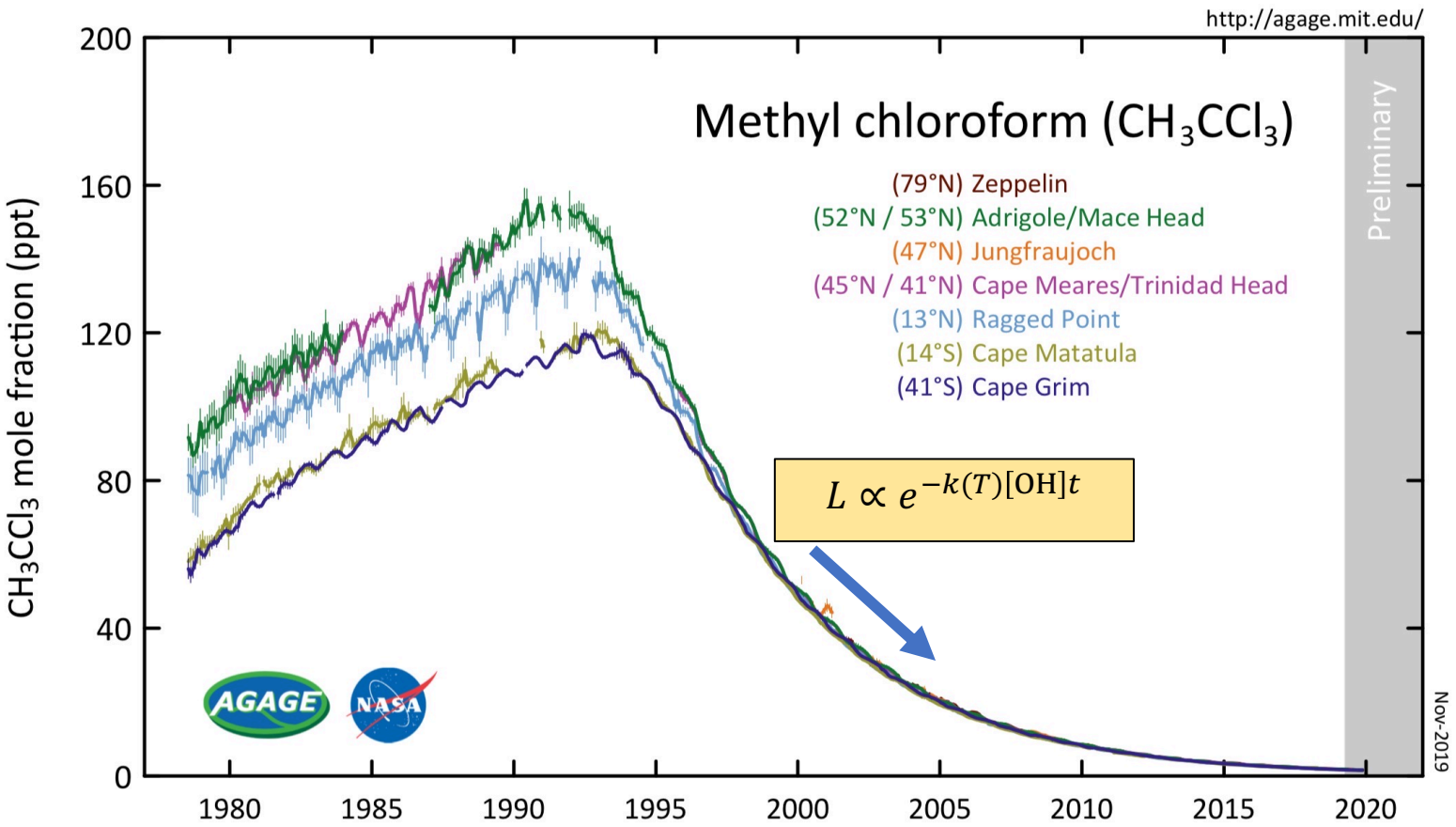
with Daniel Jacob, John Worden, Yuzhong Zhang, Hannah Nesser, Melissa Sulprizio, Zhen Qu, Zichong Chen, Daniel Varon, Xiao Lu

Modeling & estimating OH is a longstanding challenge

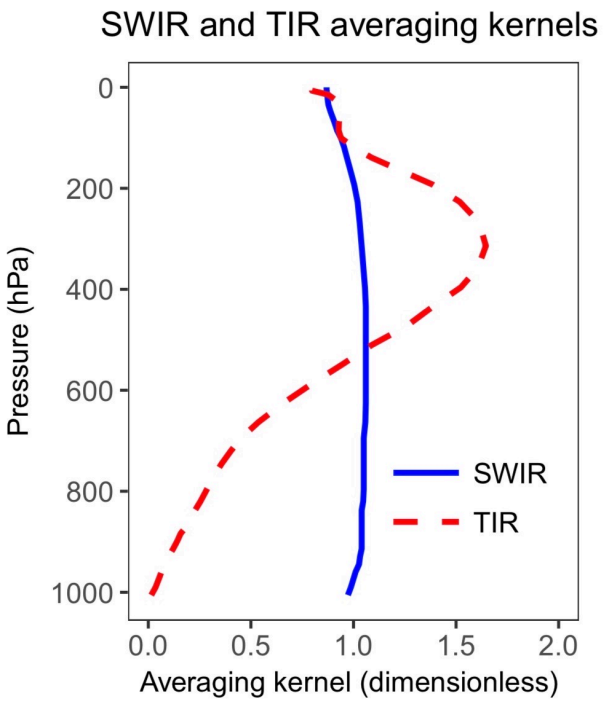
- OH is the primary sink of pollutants & greenhouse (**methane!**)
- Mean global OH is **measured indirectly** to within 10% by monitoring methyl chloroform decay.



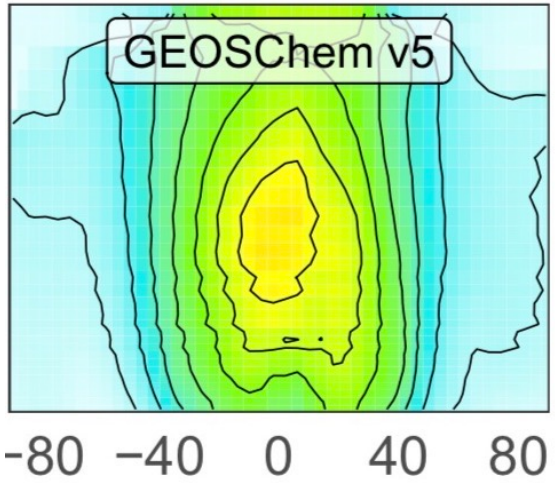
Challenges:

- Methyl chloroform is running out
- OH interhemispheric gradient
- OH interannual variability

What can satellite observations tell us about OH?



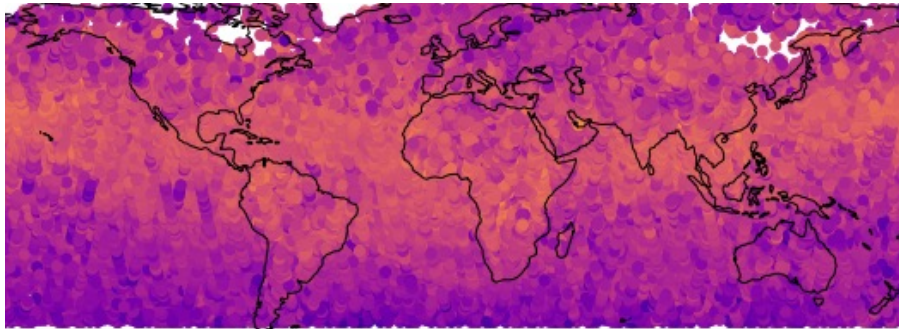
Methane loss in GEOS-Chem

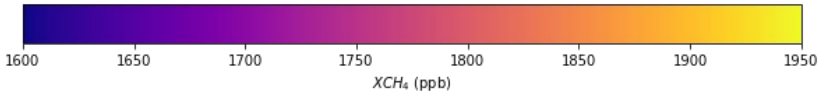


(Zhang et al. 2018)

SWIR (GOSAT)

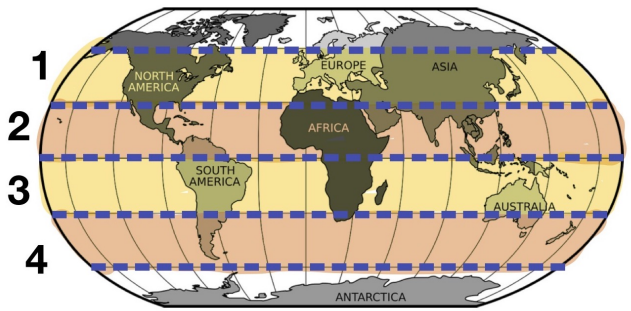
TIR (AIRS)





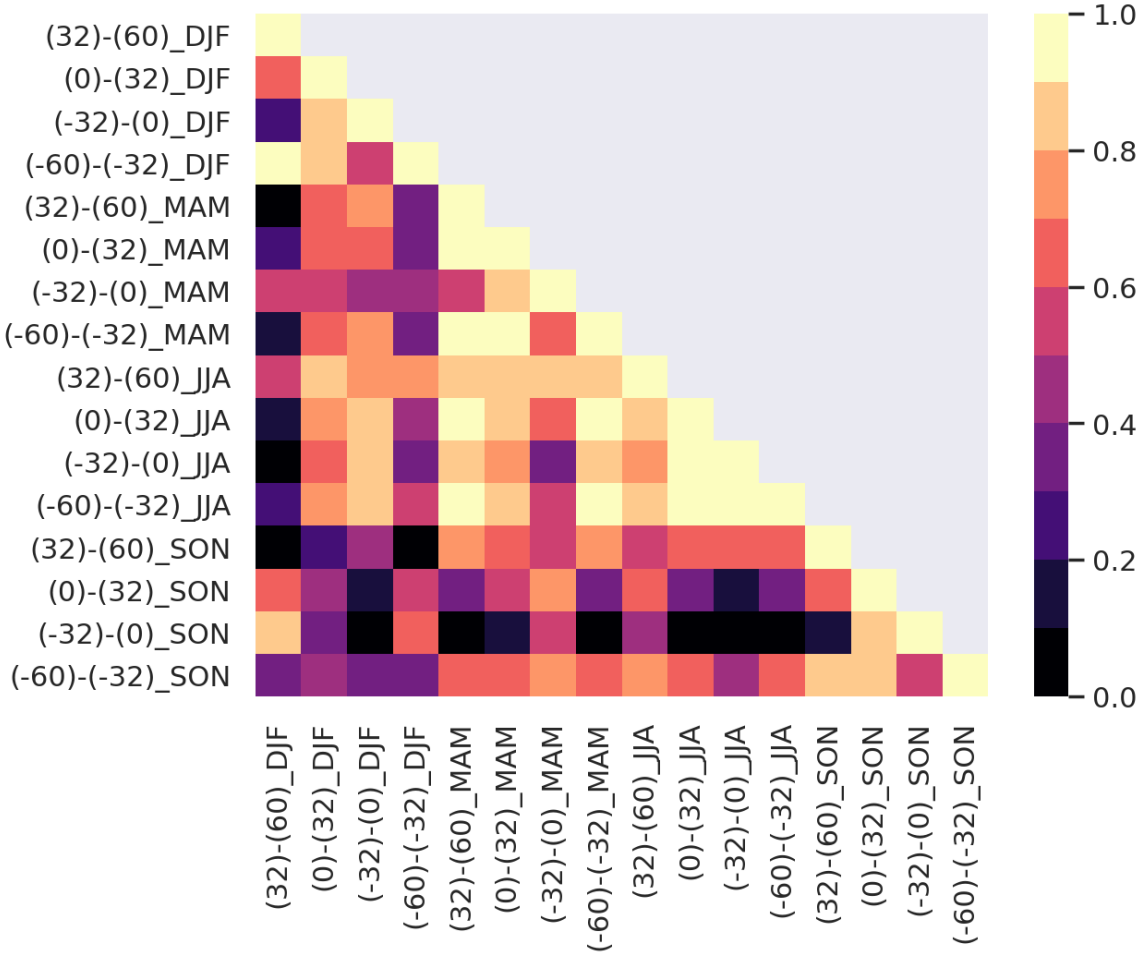
Prior errors in OH concentrations are spatially & temporally correlated

4 OH sections



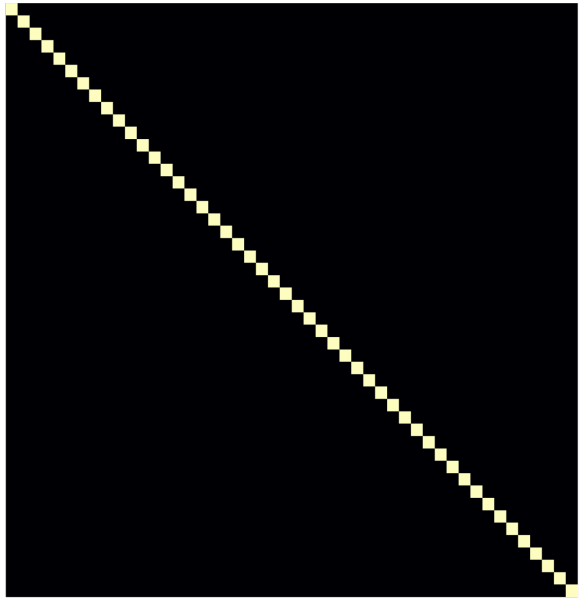
x 4 seasons x 3 years

Correlation between ACCMIP model members



ACCMIP = Atmospheric Chemistry and Climate Model Intercomparison Project

Past inversions have not accounted for spatial correlations in OH prior errors.

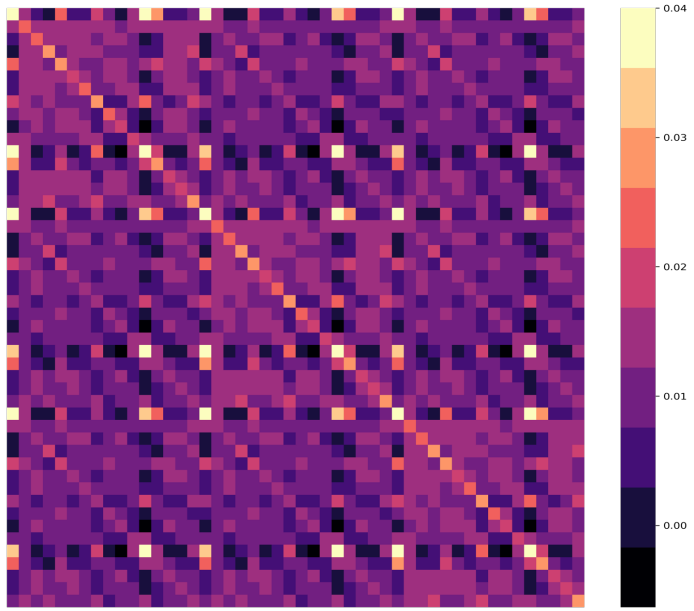


Massakkers 2019

- No systematic errors
- Latitude bands independent

Zhang et al. 2021

- Systematic errors between years
- Latitude bands independent



This study

- Systematic errors
- ACCMIP-informed correlation between latitude bands

The OH error covariance matrix has a large effect on the posterior solution

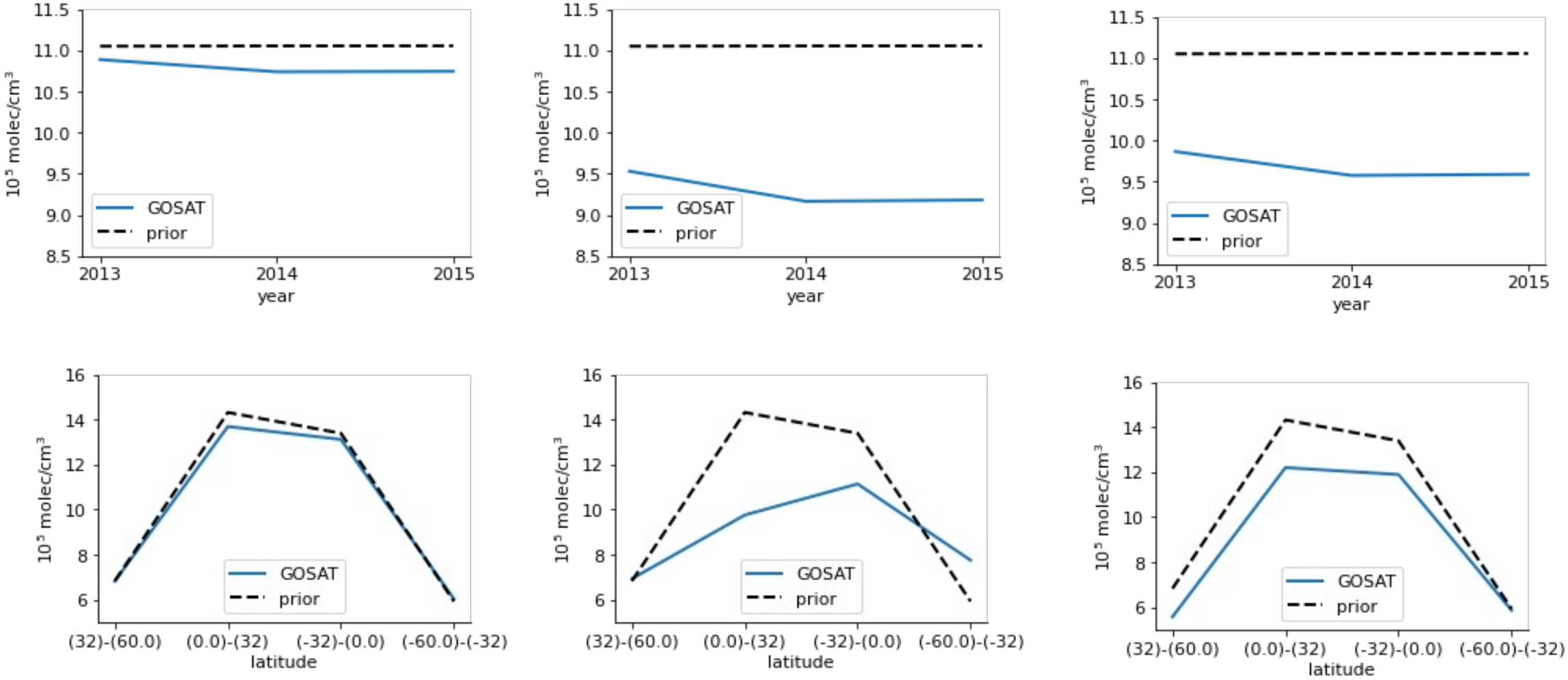
Independent 3% errors

Systematic errors between years only

Systematic errors between years, latitude bands, and seasons

Interannual variation

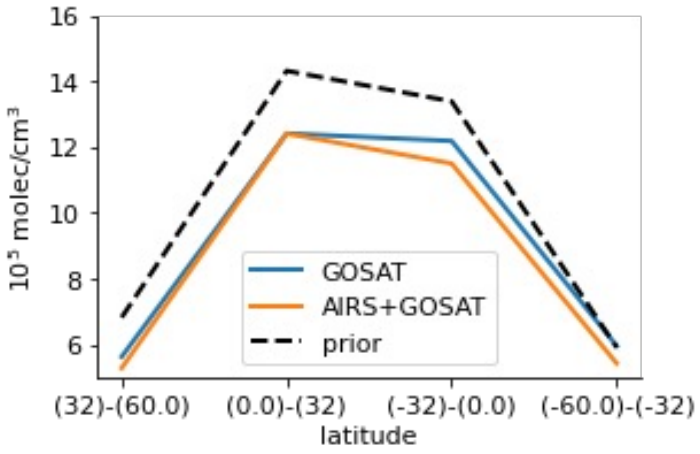
Zonal distribution



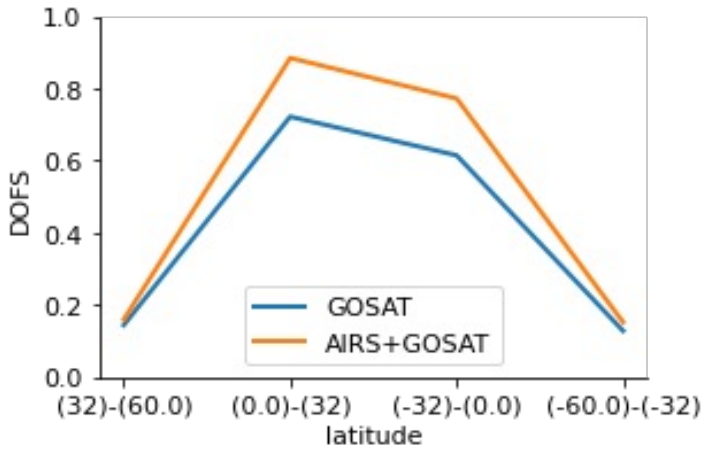
AIRS may add additional information about OH interannual variability.

Information content

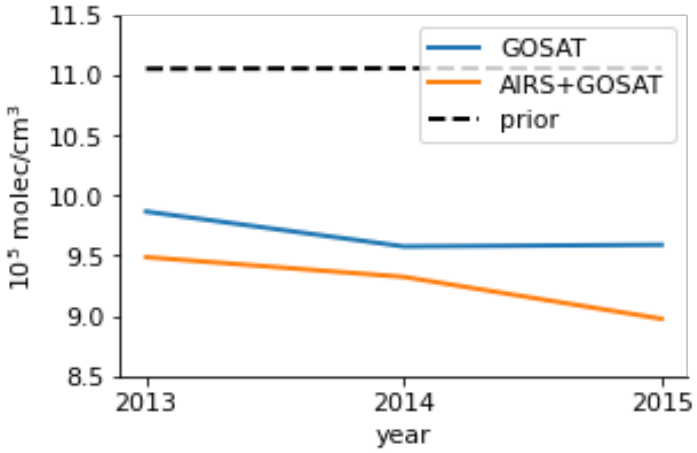
Zonal distribution (2013)



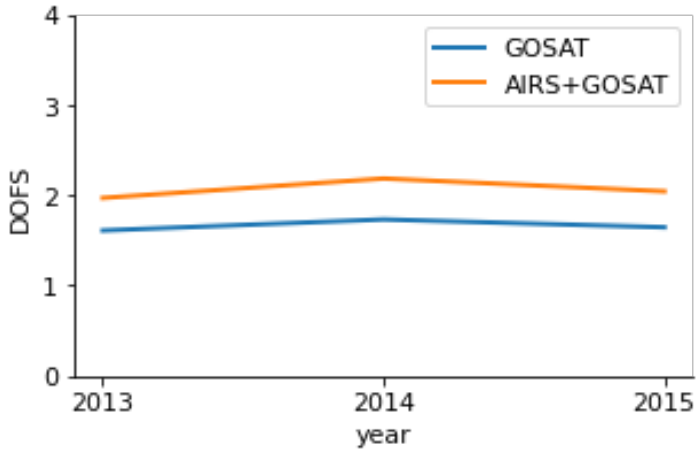
AIRS adds information content over the tropics



Interannual variation



SWIR+TIR result suggests a different OH interannual variation.



Conclusions

- Errors in OH mixing ratio in different hemispheres/seasons are highly correlated.
- Estimates from satellite inversions of methane are sensitive to the choice of prior OH errors.
- TIR instruments may add some information on OH, but are not sufficient on their own.