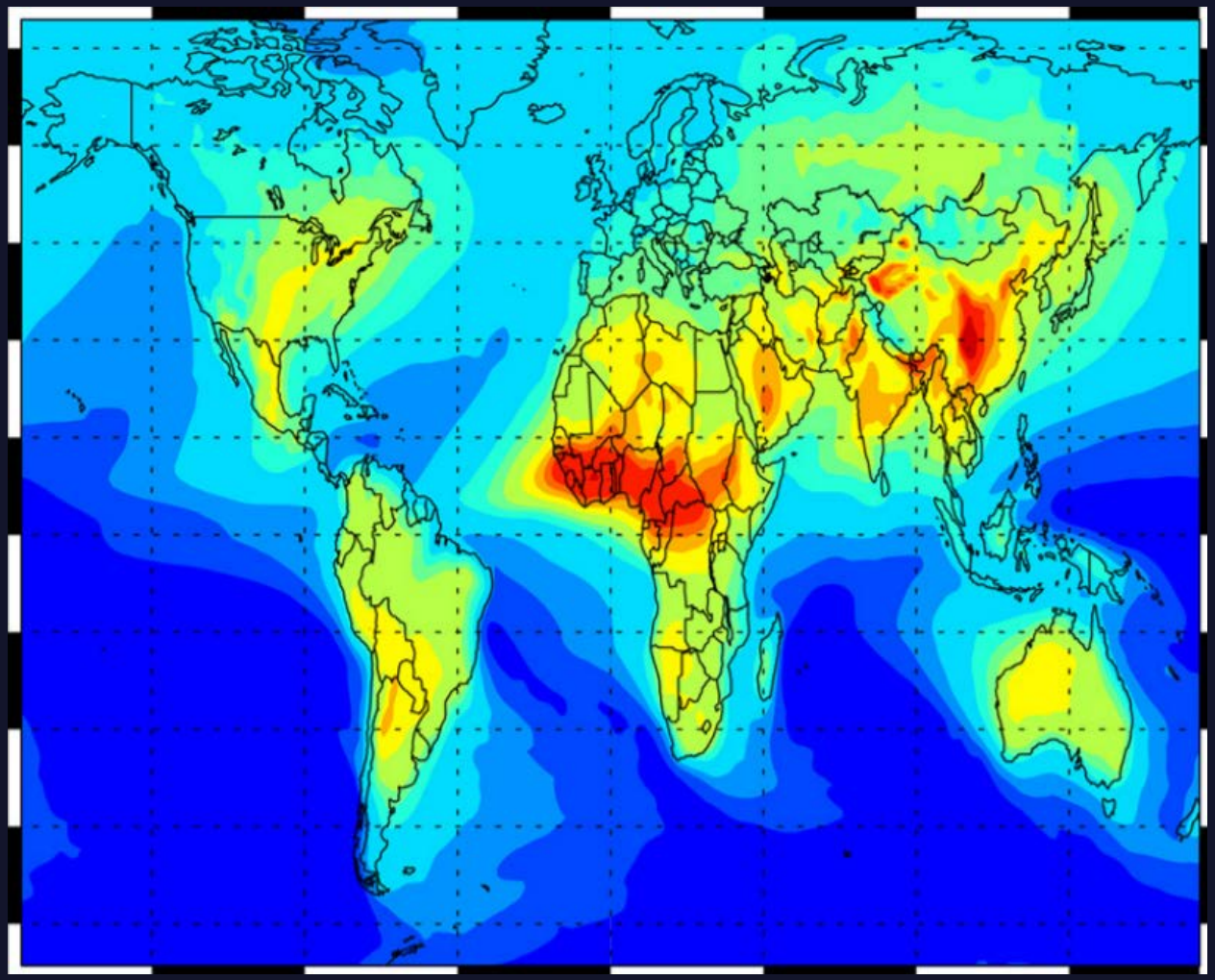
A two box perspective on TM5

Stijn Naus, S.A. Montzka, S. Basu, S. Pandey, E.J. Dlugogencky & M.C. Krol



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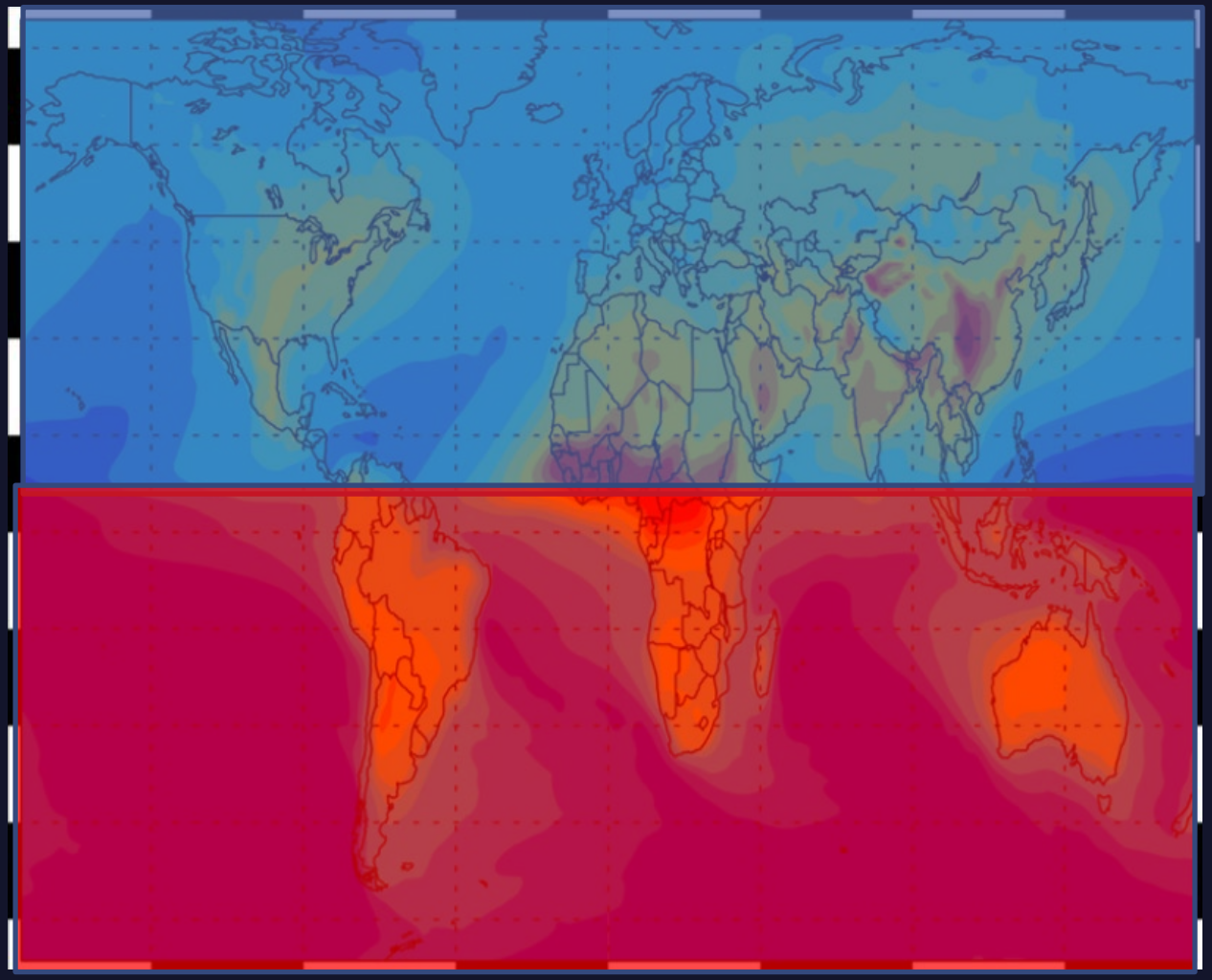

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Two recent two-box model studies

Rigby et al. (2017) & *Turner et al. (2017)*

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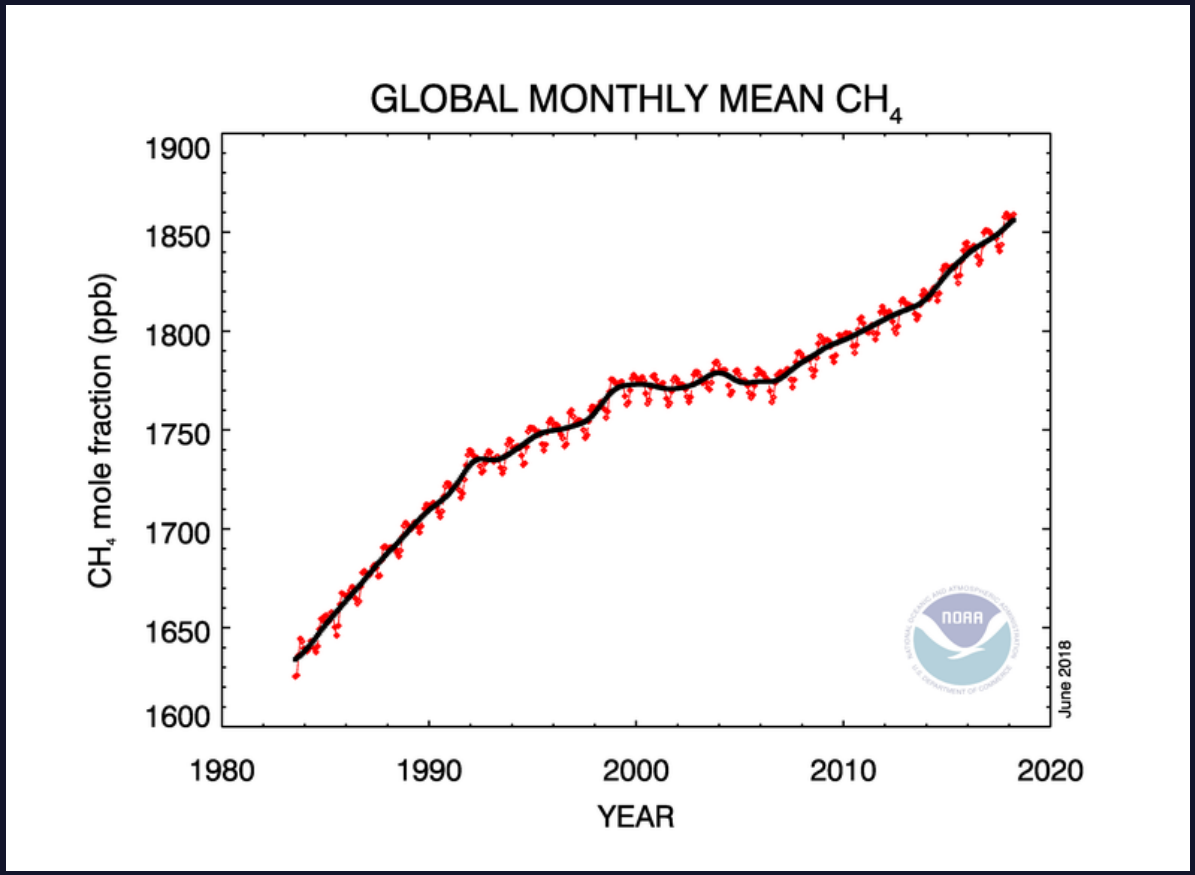
Coupled inversion of MCF-CH_4-OH

MCF → OH → CH_4

Key message:

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

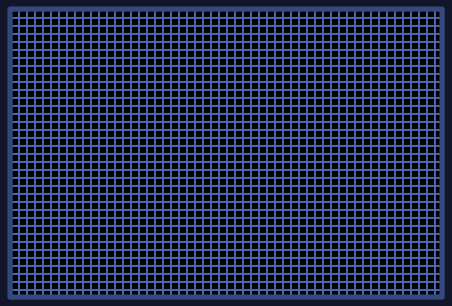


Can you capture complex problems
in a simple two-box model?

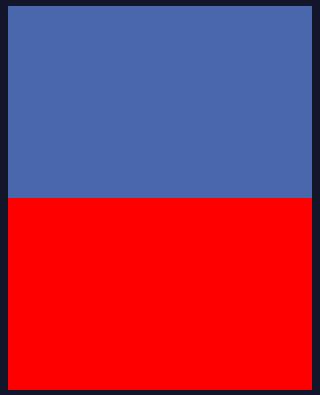
Two aspects:

- Loss of information
- Imperfect information

TM5 forward



Two-box inversion

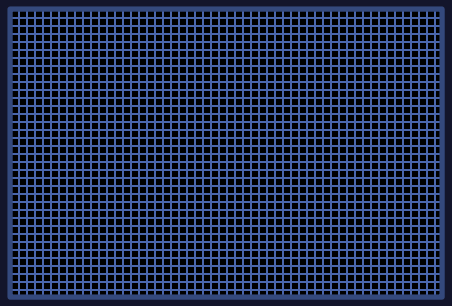


Results

OH

CH_4 emissions

TM5

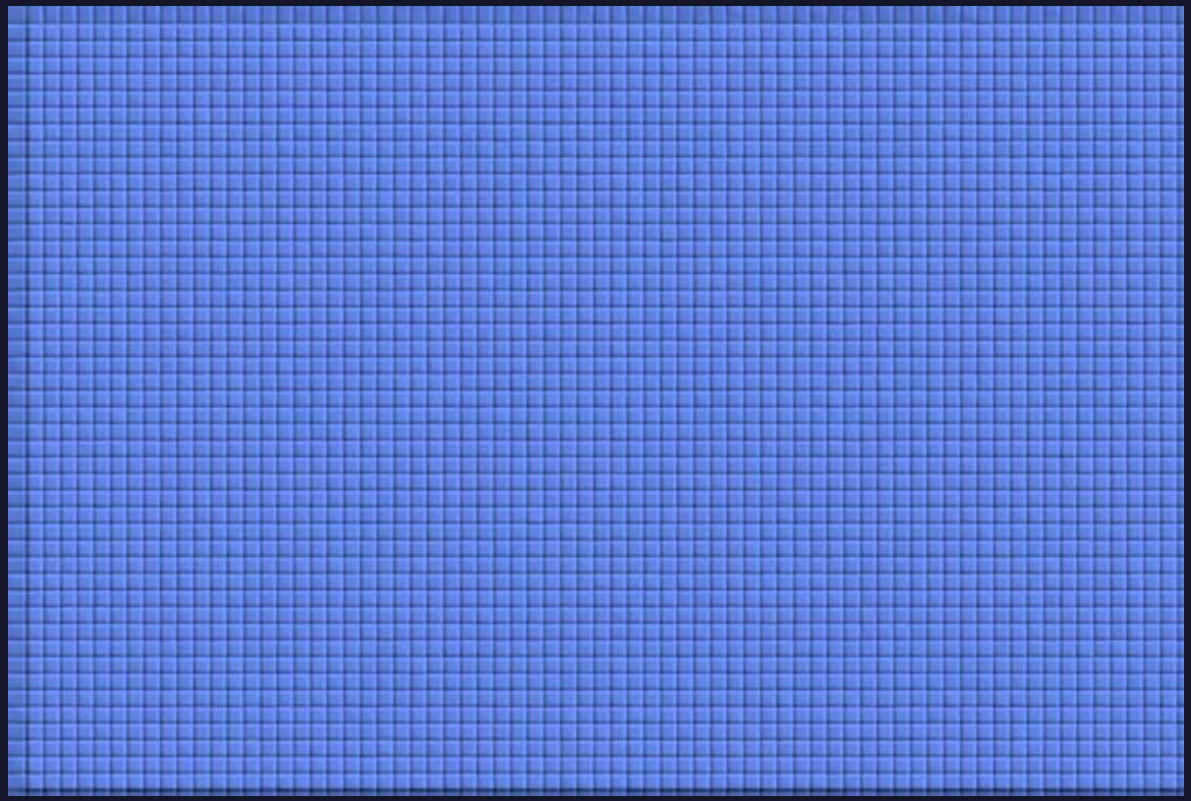


Two-box

Results

OH
CH4 emissions

From 3D to two-box



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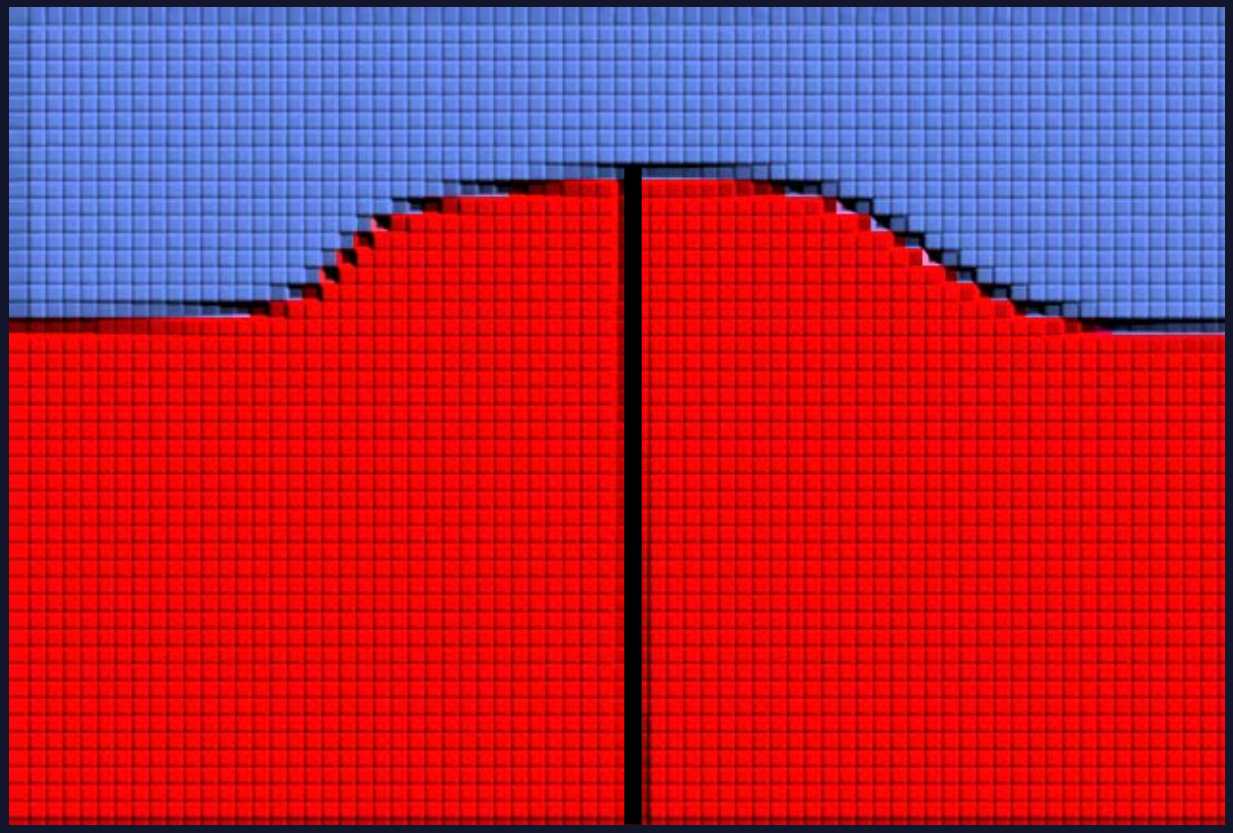

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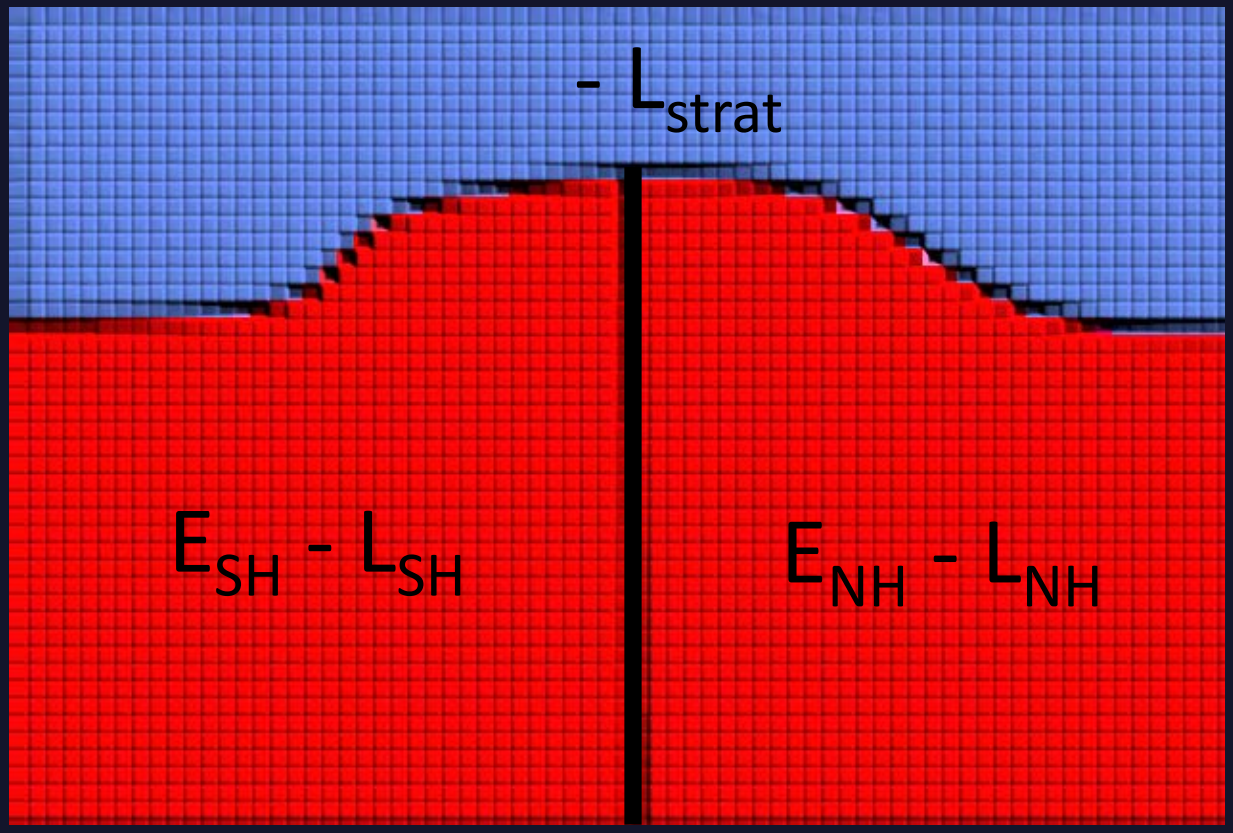

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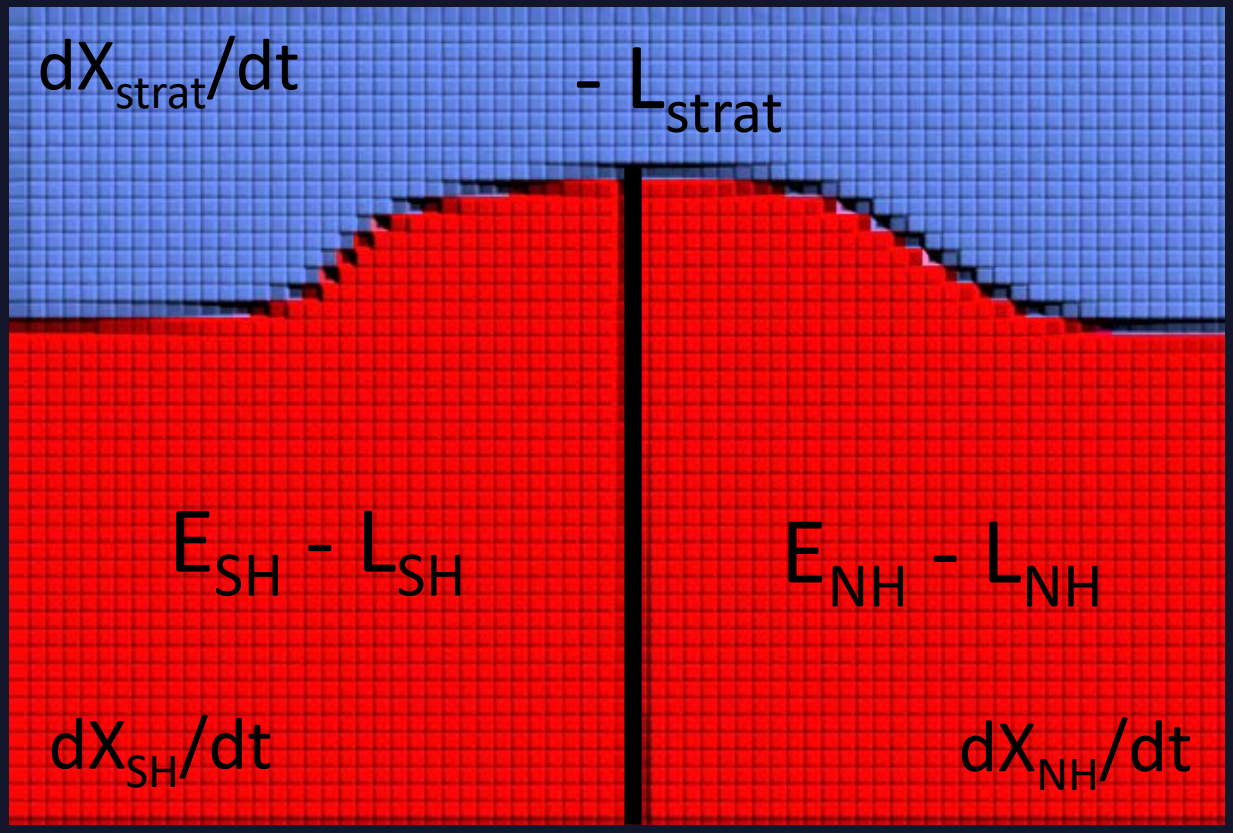

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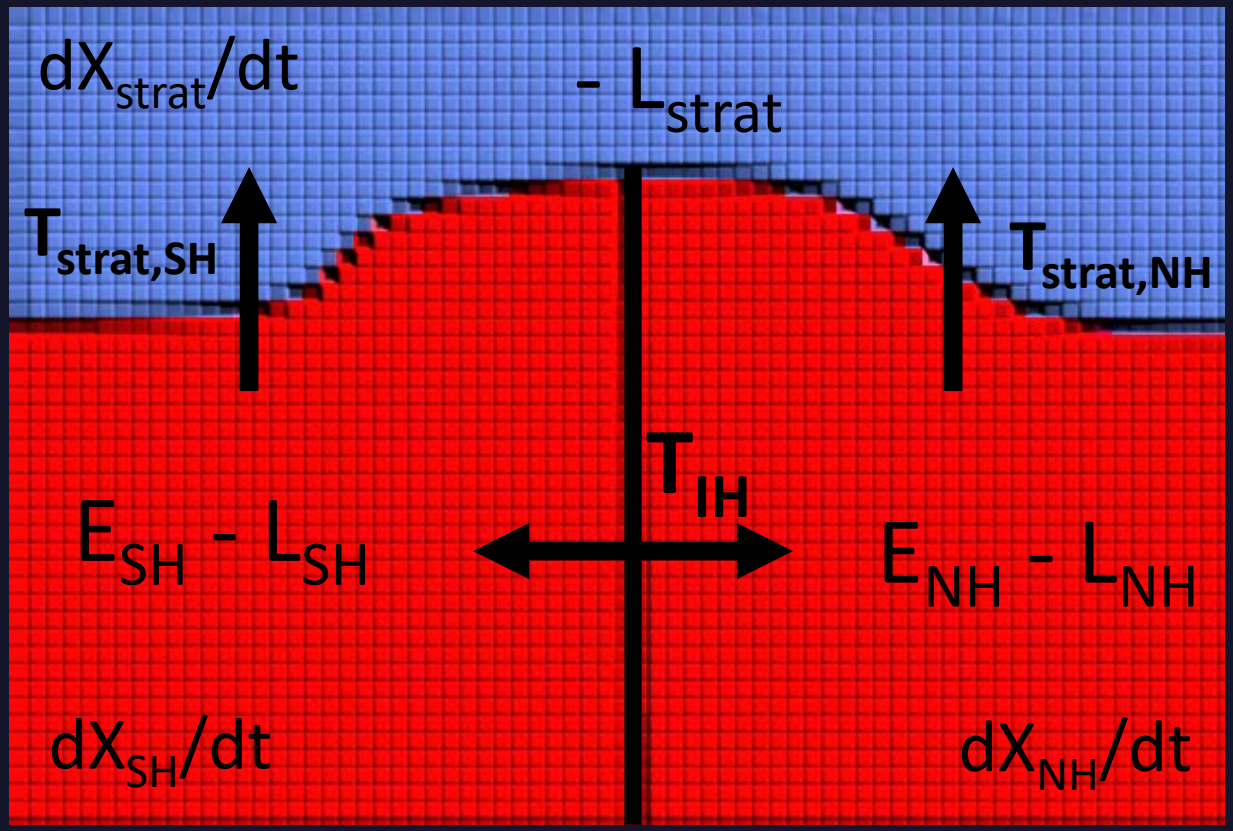

$$T_{IH} = k_{IH}(X_{NH} - X_{SH})$$

$$T_{strat,NH} = l_{strat} X_{NH}$$

TM5 set-up

- Resolution 6^ox4^o
- MCF, CH_4 and SF_6

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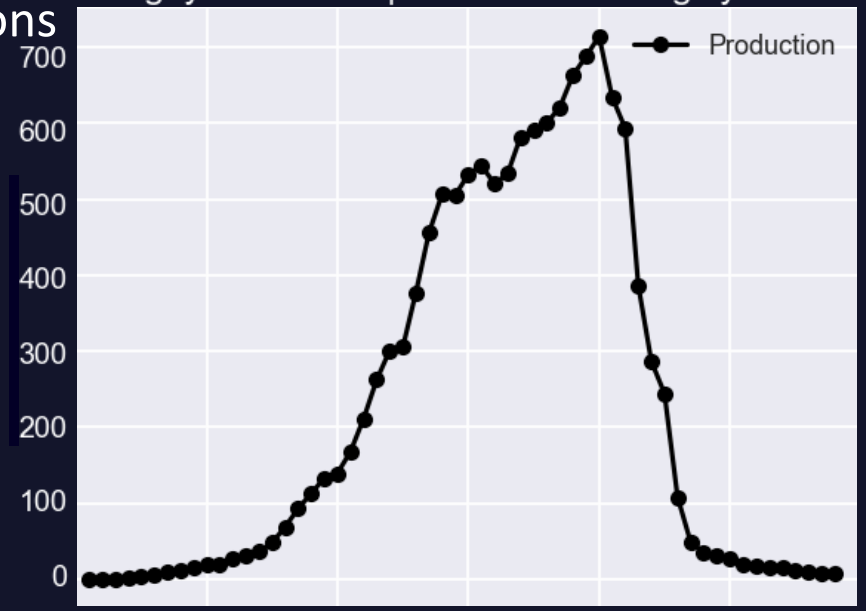
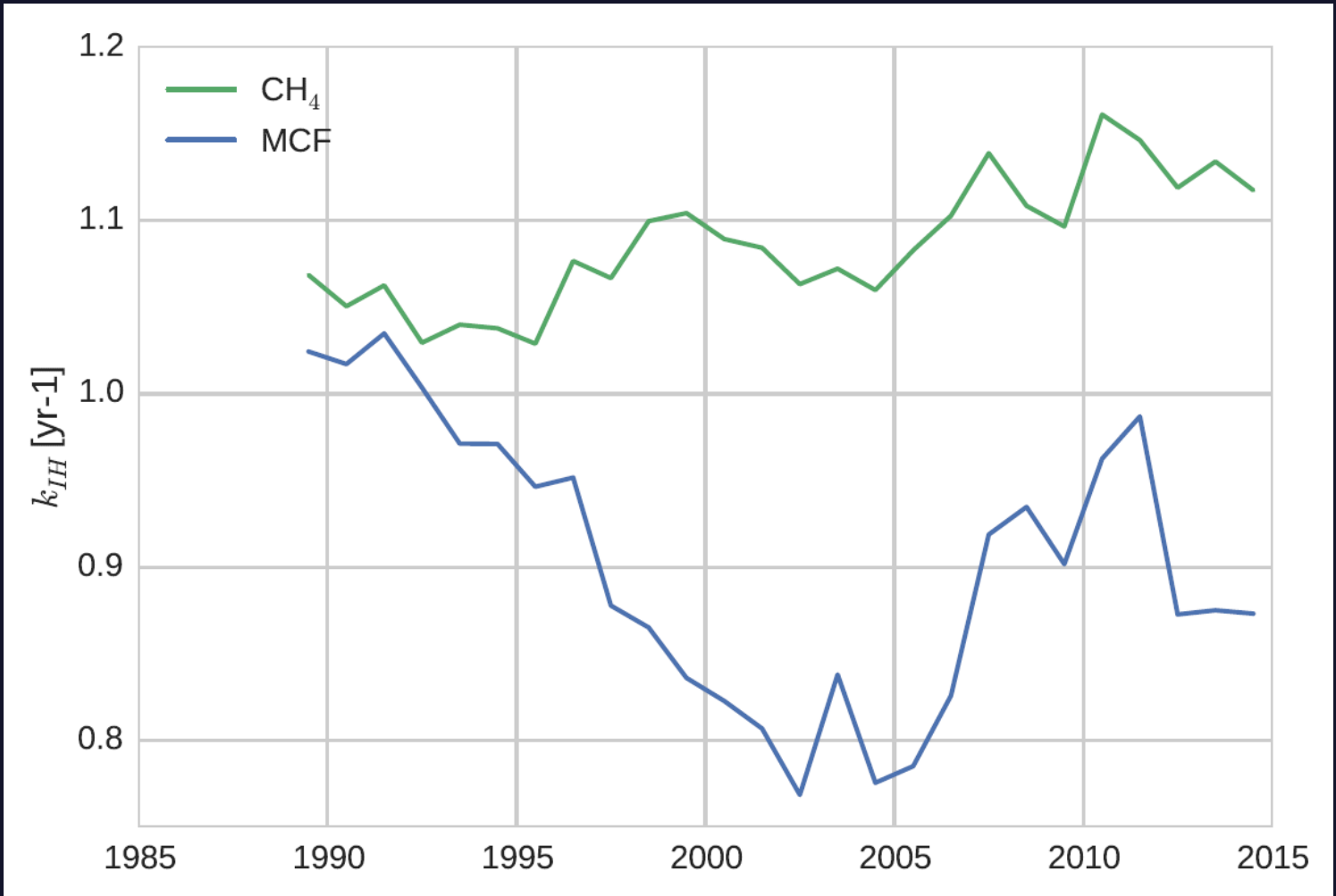
MCF production

Rigby et al. 2008 | McCulloch & Midgley 2001



Interhemispheric transport



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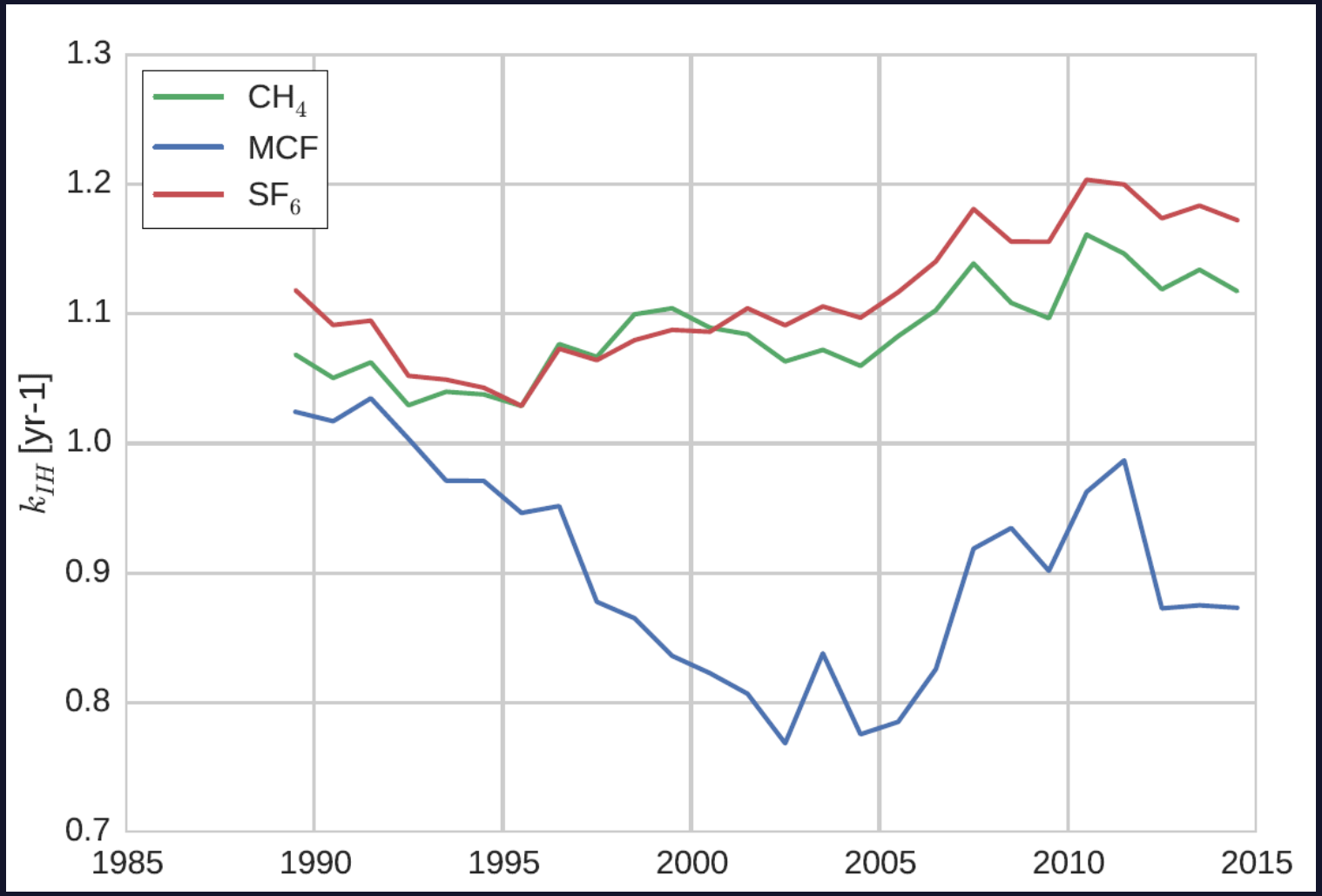
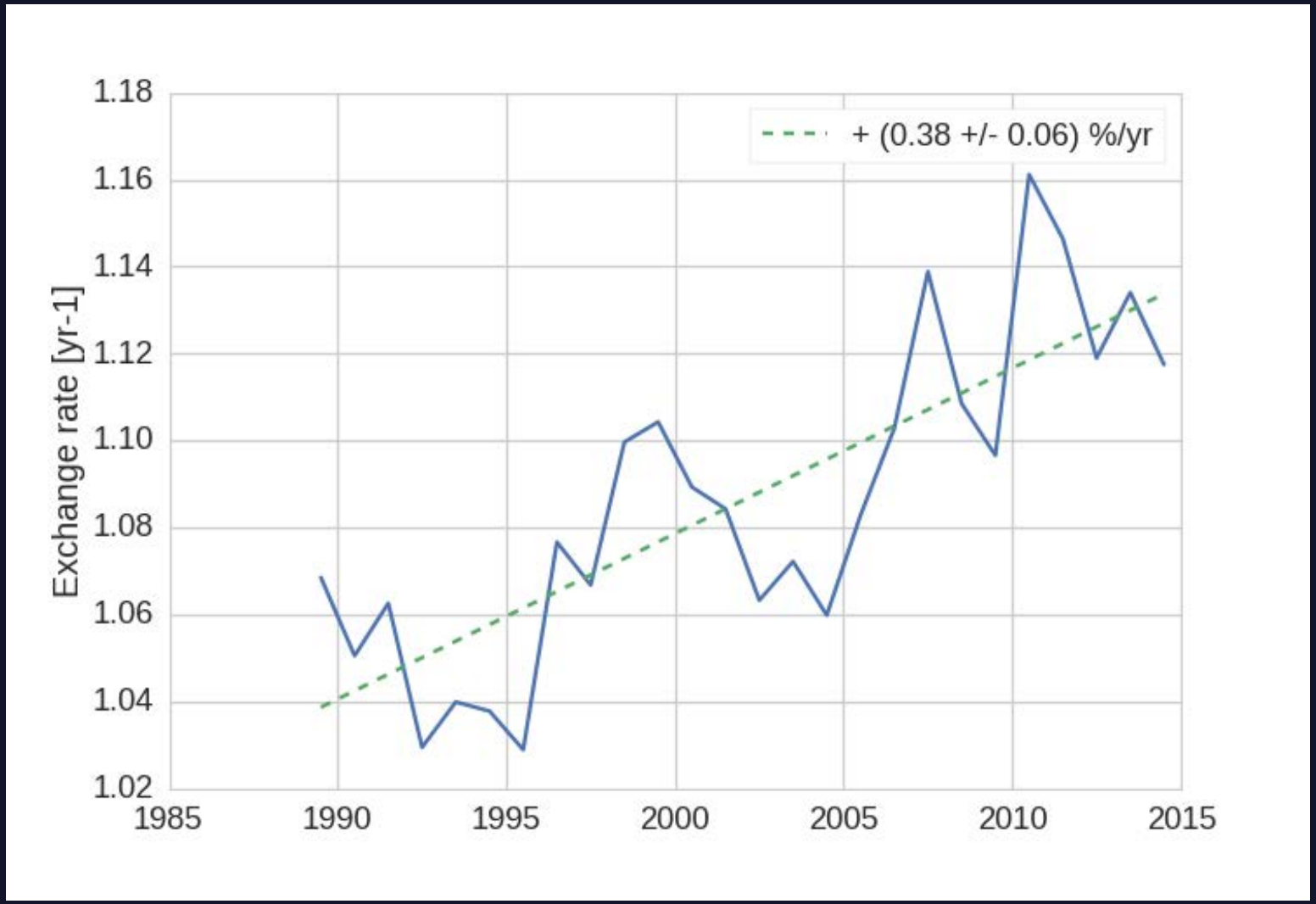
Interhemispheric transport



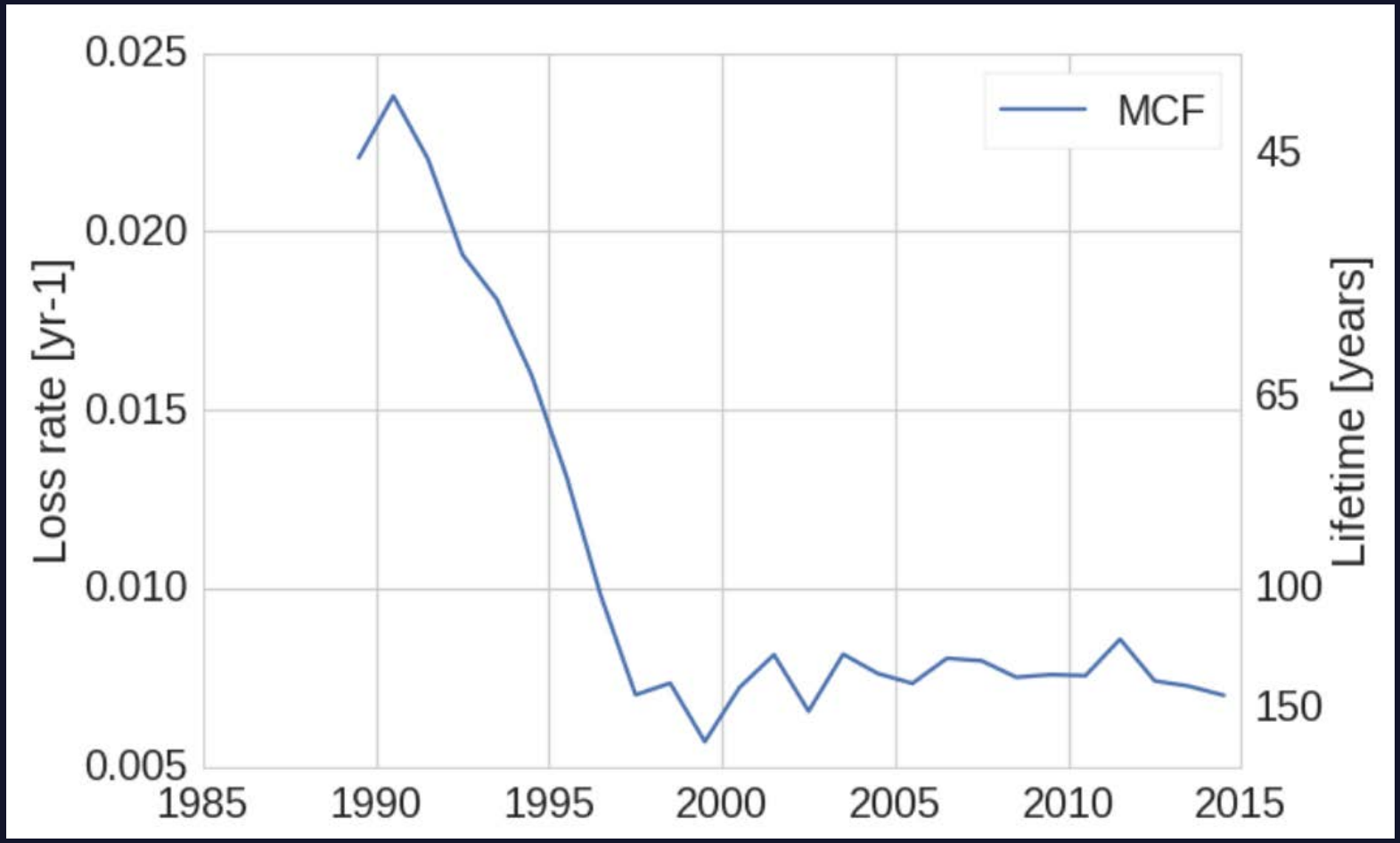
Interhemispheric transport: Trend for CH_4 ?



Stratospheric MCF loss

$$T_{strat,NH} = l_{strat} X_{NH}$$

Stratospheric MCF loss



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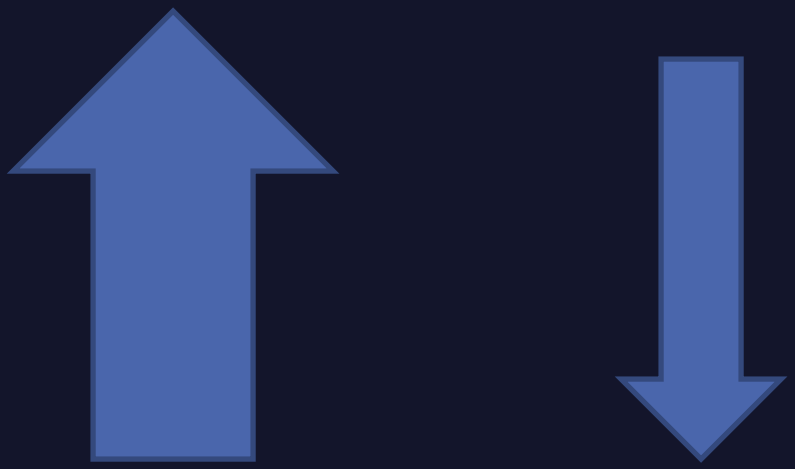

Stratospheric MCF loss

Emissions drop

Stratospheric MCF loss

Emissions continue to decrease...

Two more:

- Surface sampling bias
- Interhemispheric OH ratio

Conclusions

- Correct usage of simple box models requires complex tuning by a full 3D model
- The two-box parametrization provides an interesting perspective on TM5

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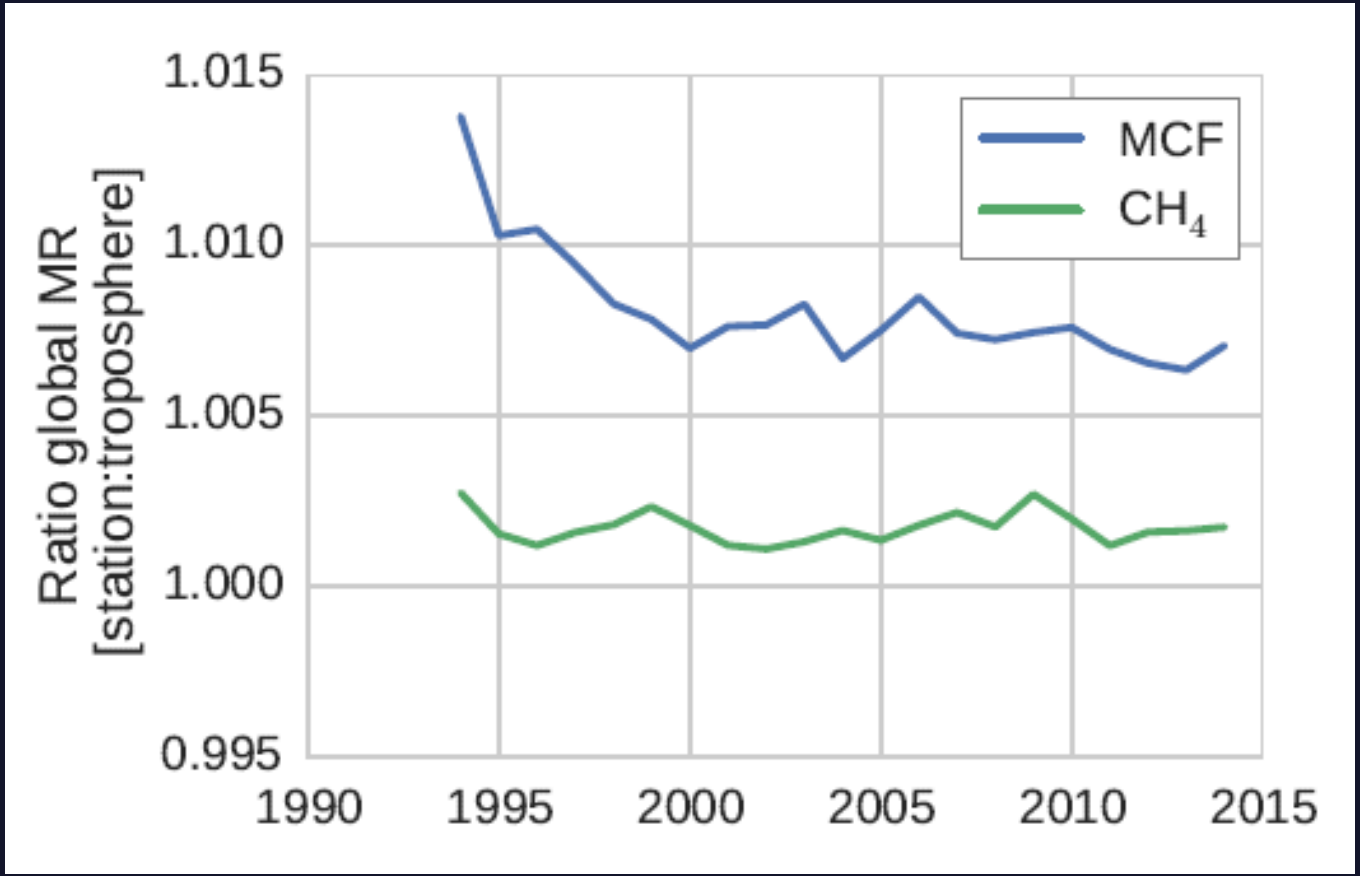
Outlook

- A full 3D inversion of MCF
- Integrating additional tracers

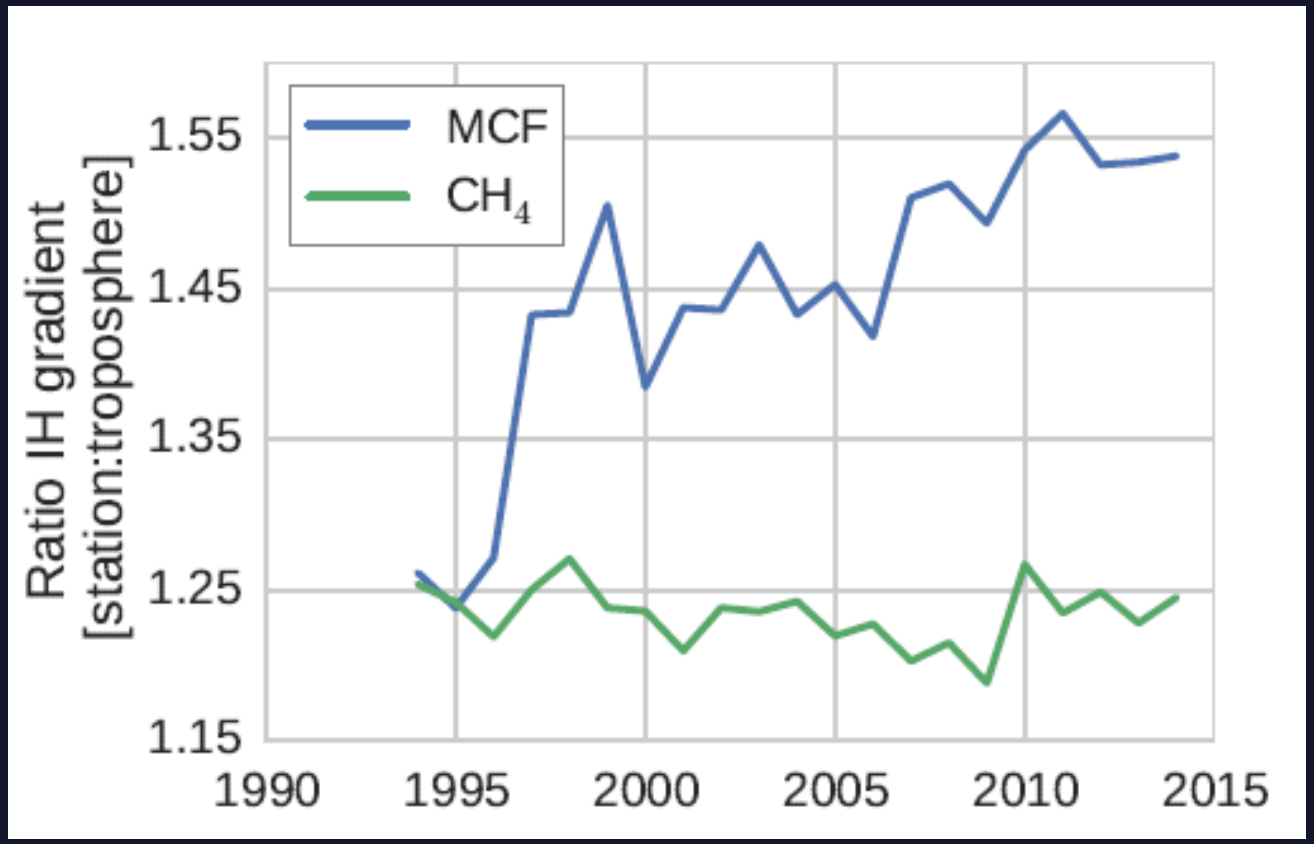
Surface sampling bias

Bias in global mean mixing ratio



Surface sampling bias

Bias in interhemispheric gradient



Sampling the atmosphere: Latitude

1995

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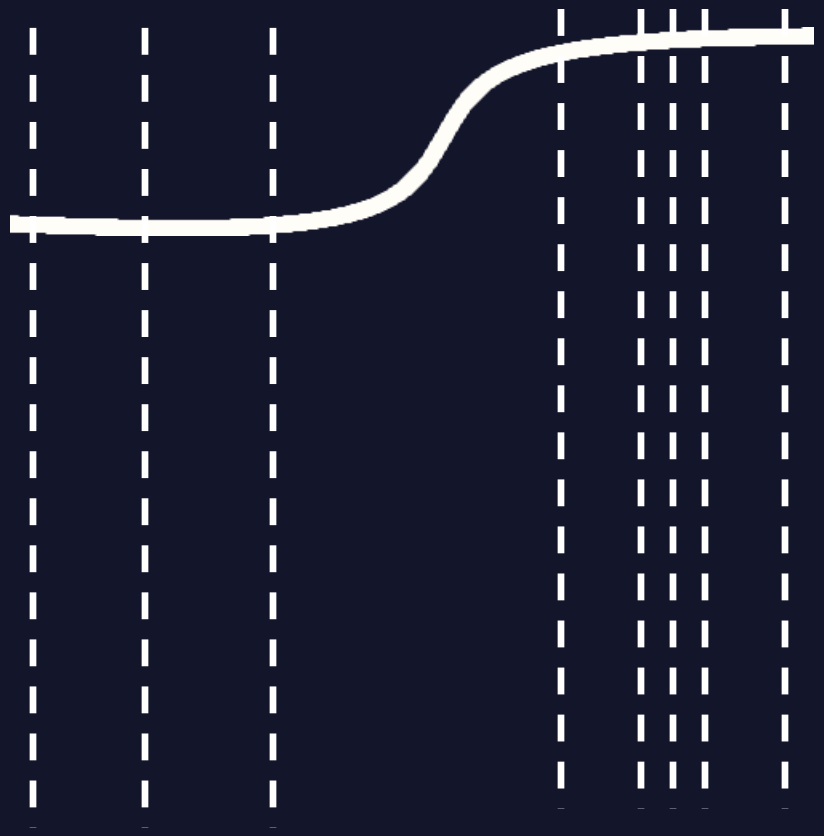
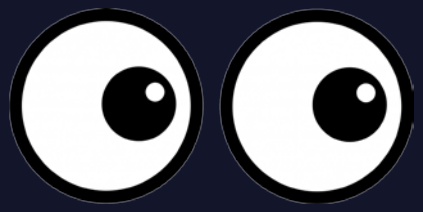


1995



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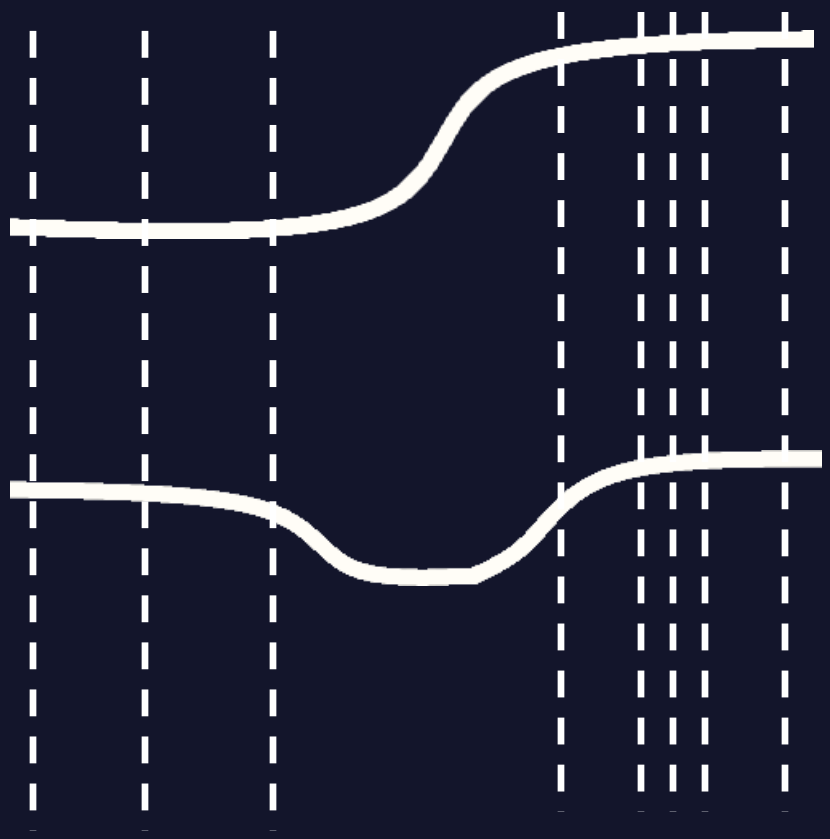
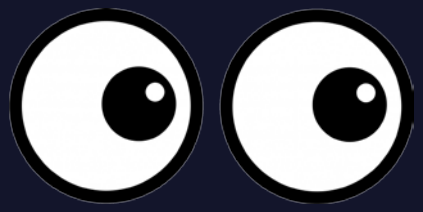
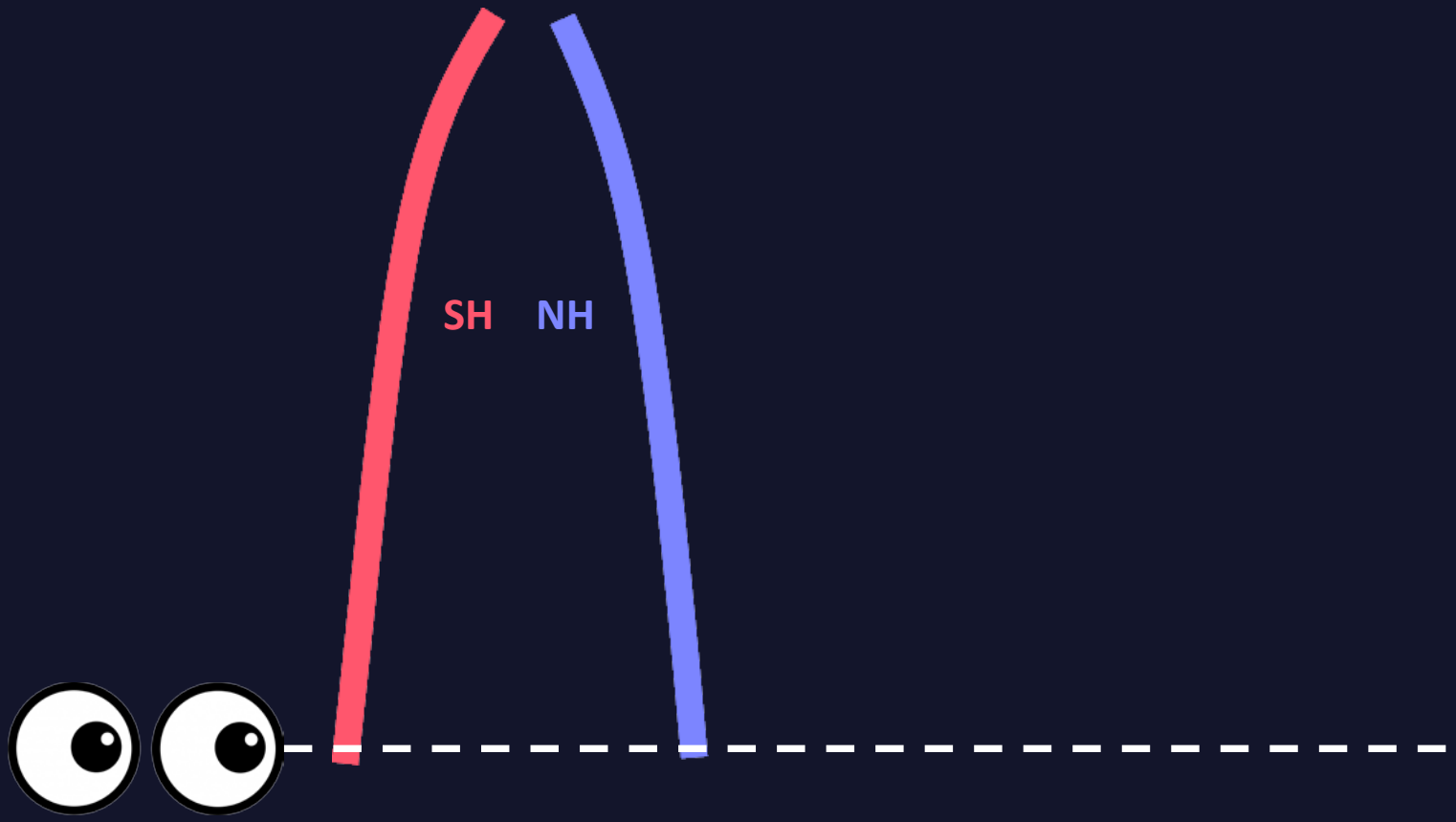


1995

2005

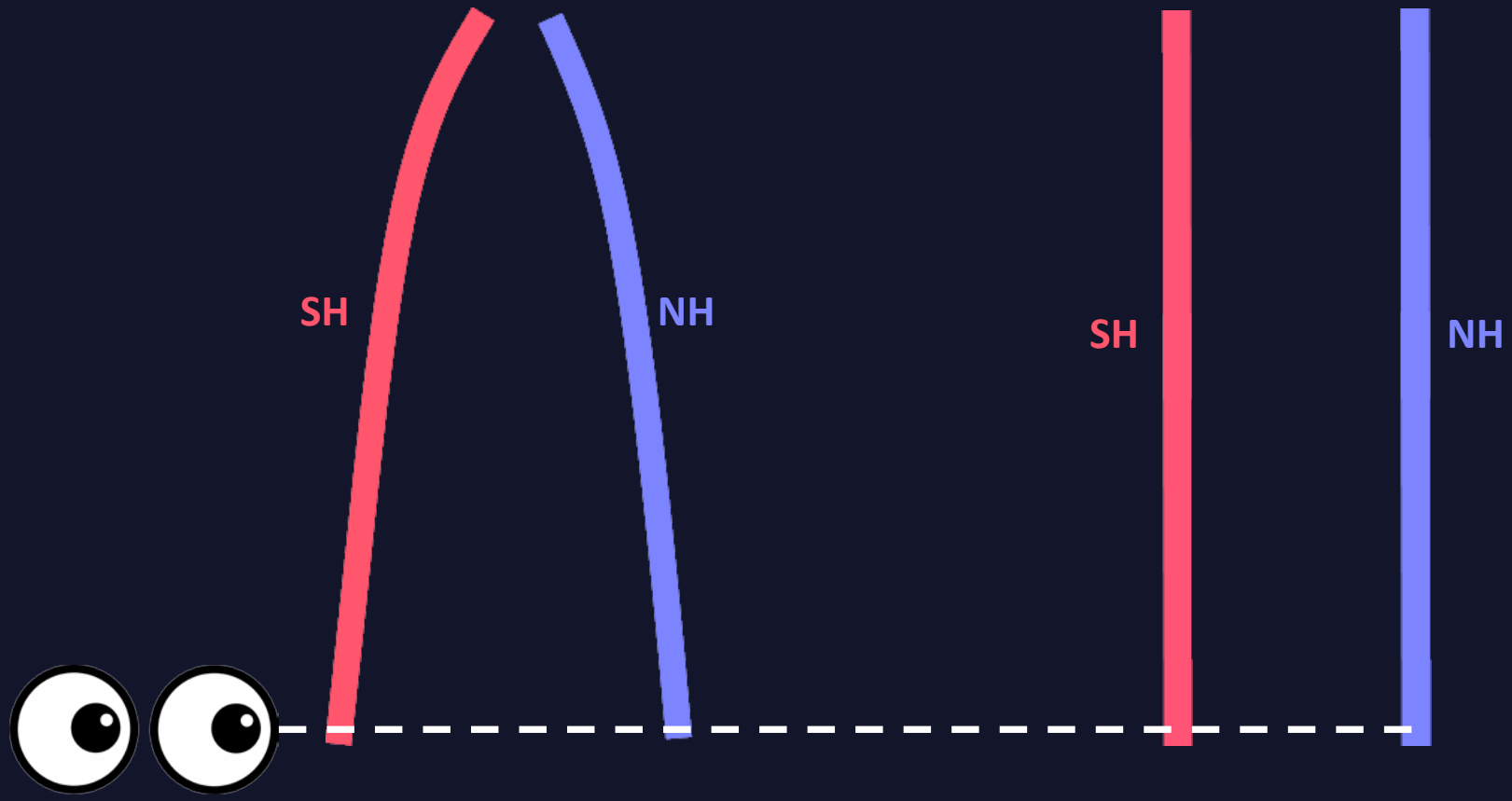


Sampling the atmosphere: Vertical

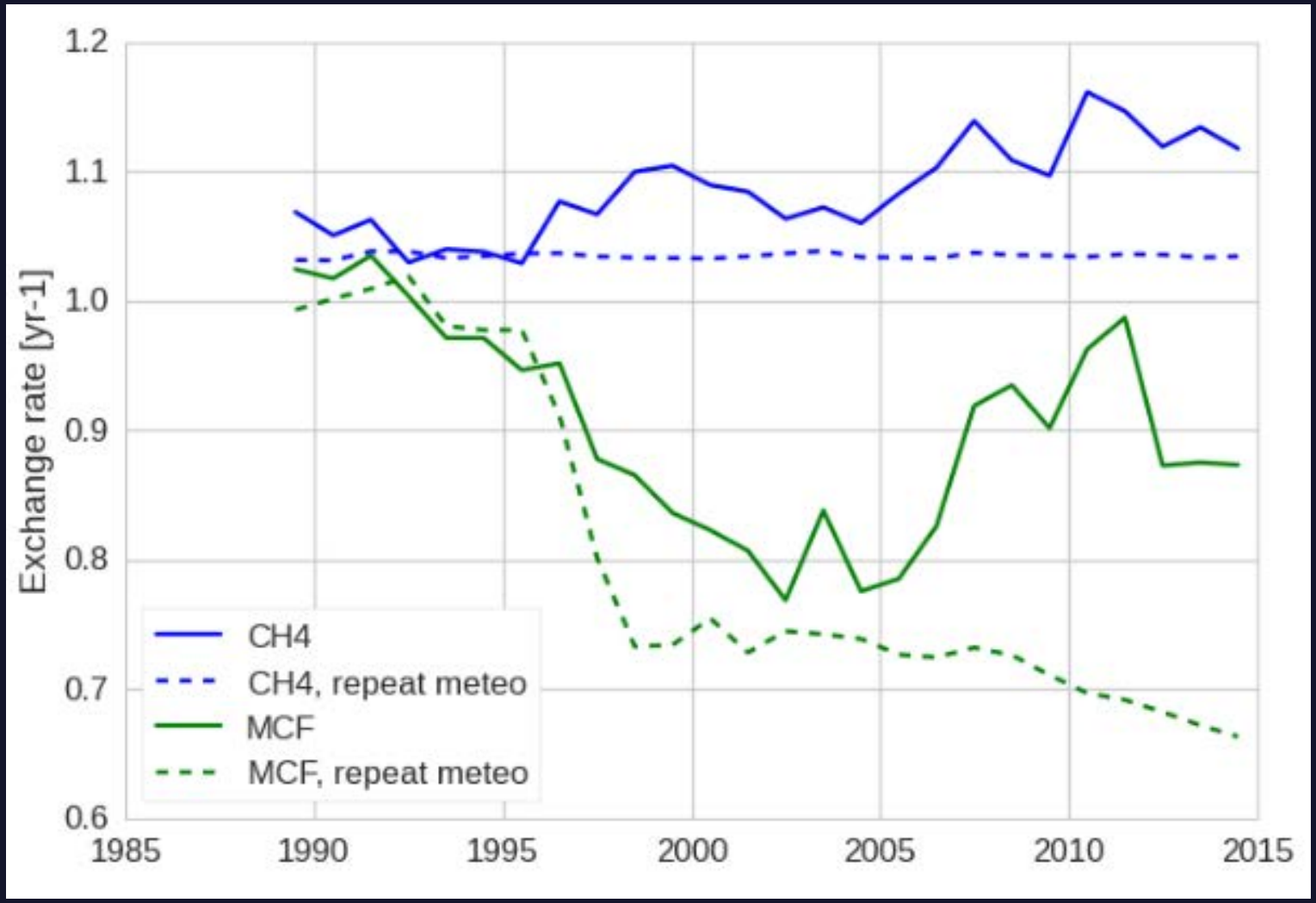


1995

Sampling the atmosphere: Vertical



IH exchange rate if repeat meteo



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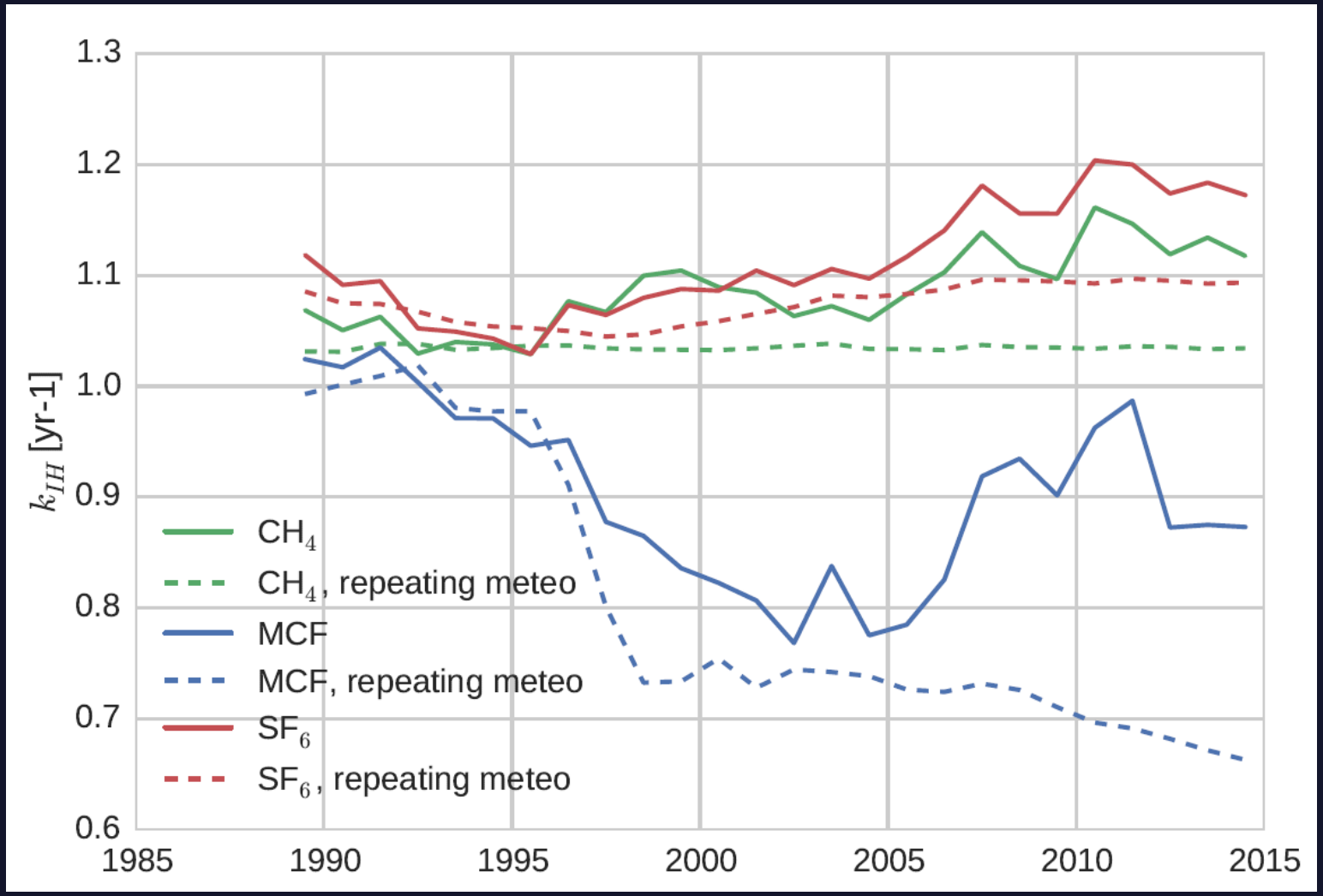
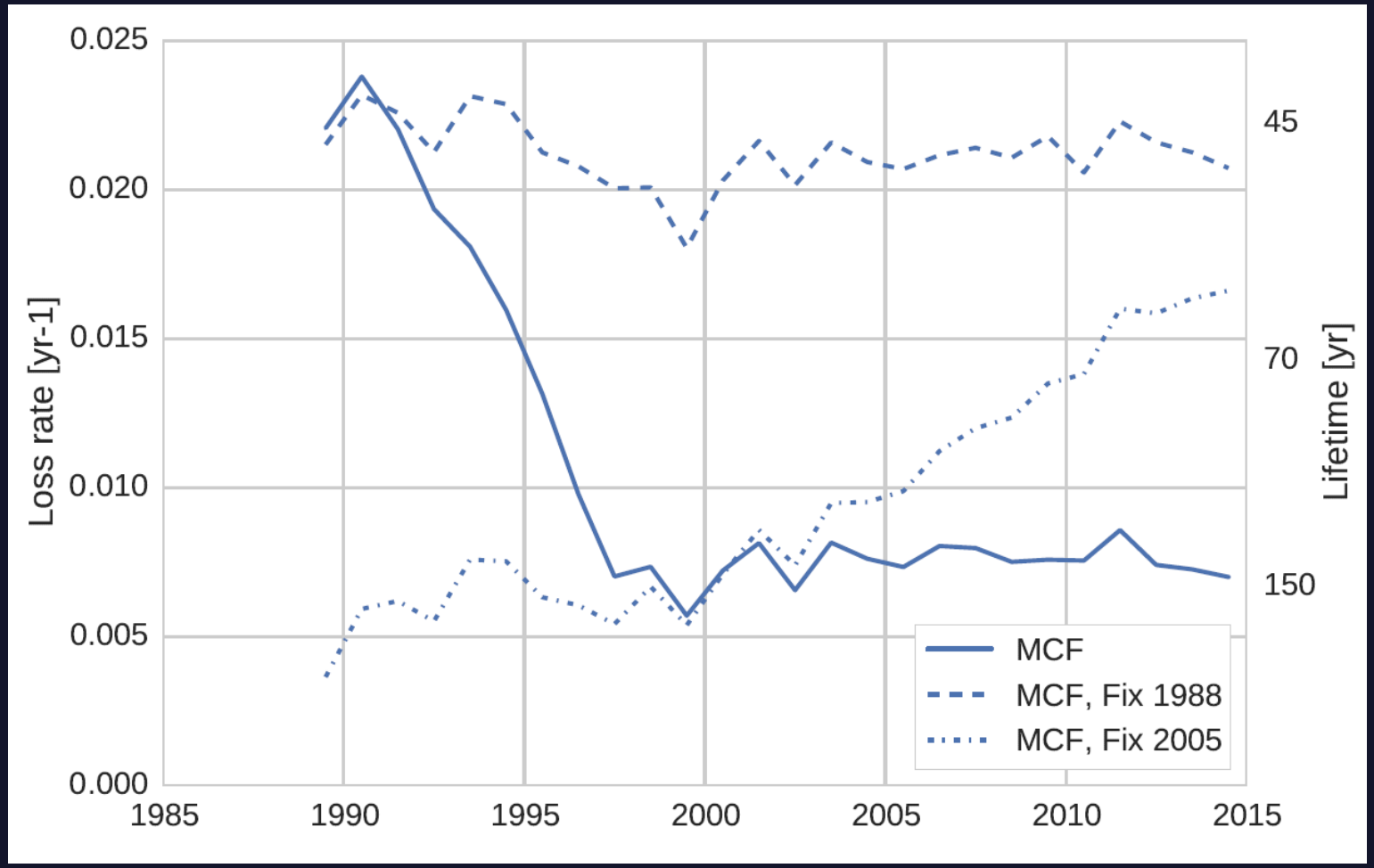


Stratospheric loss if fixed emissions



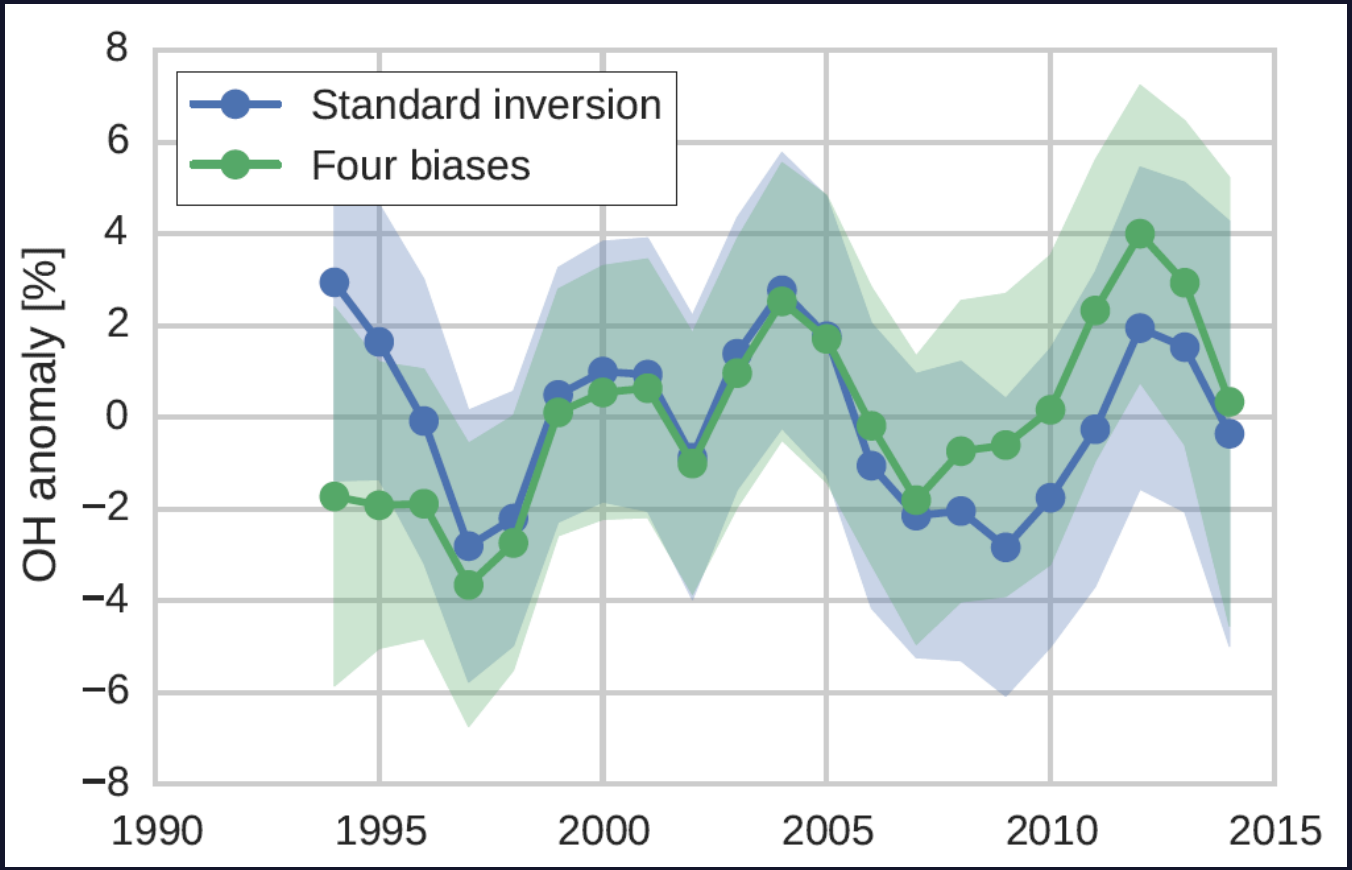
In equations

$$\frac{dX_{SH}}{dt} = E - k_{OH} OH_{SH} X_{SH} + k_{IH}(X_{NH} - X_{SH}) - l_{strat} X_{SH}$$

$$\frac{dX_{NH}}{dt} = E - k_{OH} OH_{NH} X_{NH} - k_{IH}(X_{NH} - X_{SH}) - l_{strat} X_{NH}$$

$$\frac{dX_{strat}}{dt} = -L + l_{strat} X_{SH} + l_{strat} X_{NH}$$

OH anomalies from two-box model



CH_4 emission anomalies from two-box model