Investigating the drivers of interannual variability in methyl bromide atmospheric levels

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Background and motivation

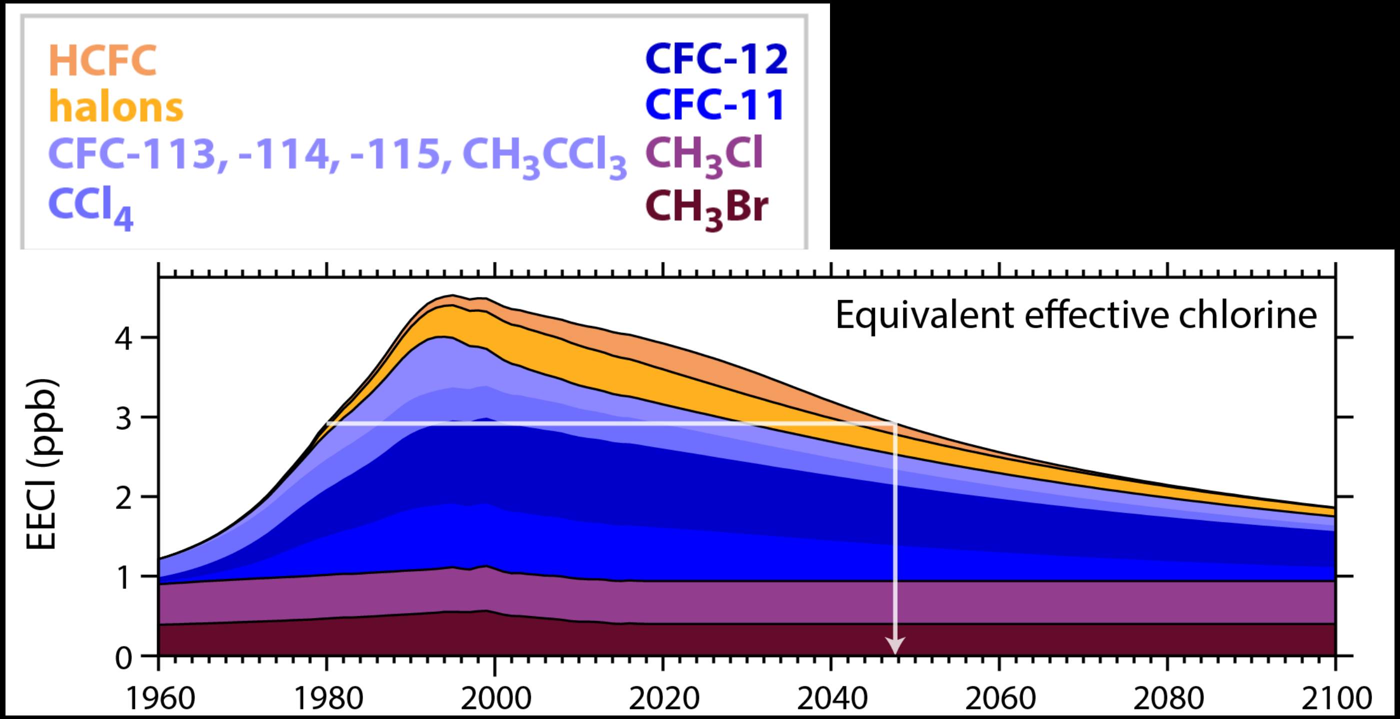


Figure from the Executive Summary of the Scientific Assessment of Ozone Depletion: 2018

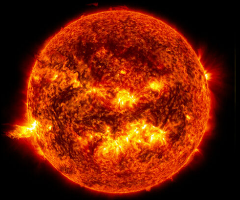
As **big players** decline, naturally emitted ODS become increasingly more important: **methyl halides**

The climate of 2050 will not be the same as that of 1980

Methyl bromide: A (mostly) naturally-emitted ozone depleting gas

SINKS

OH



44%

stratosphere

<1%

ocean

34%

soil

24%

Anthropogenic production controlled by Montreal Protocol (1995)

SOURCES

8% (non-QPS)

anthropogenic

10% (QPS)

fumigation

12%

biofuel & biomass burning

29%

ocean

20%

terrestrial sources

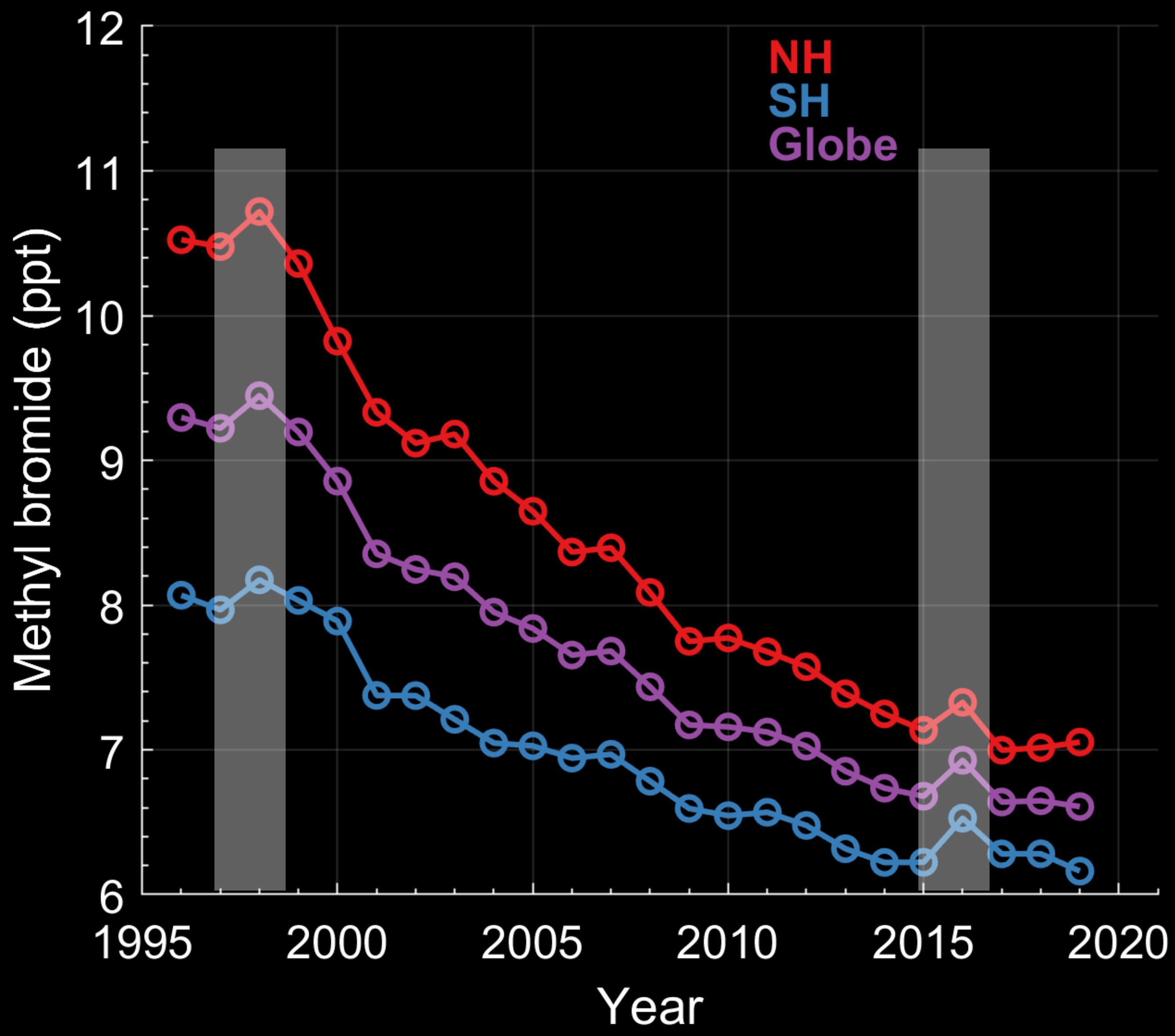
~22%

?

Missing??

Yvon-Lewis et al., 2009

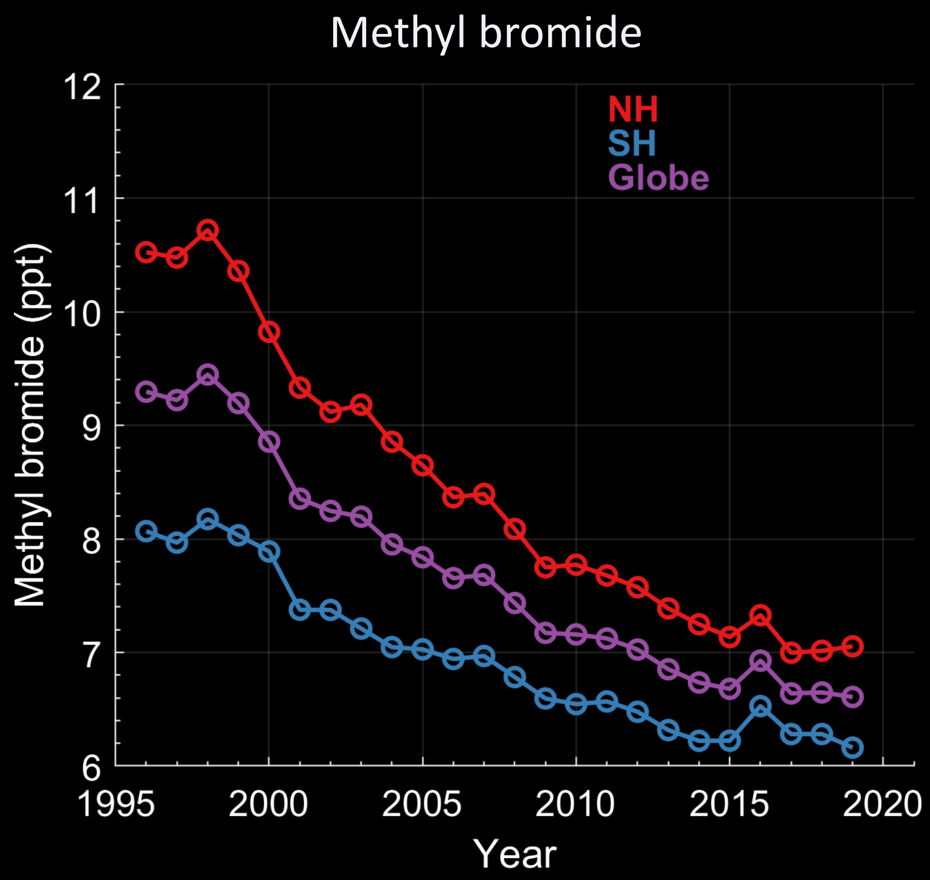
Methyl bromide: annual means

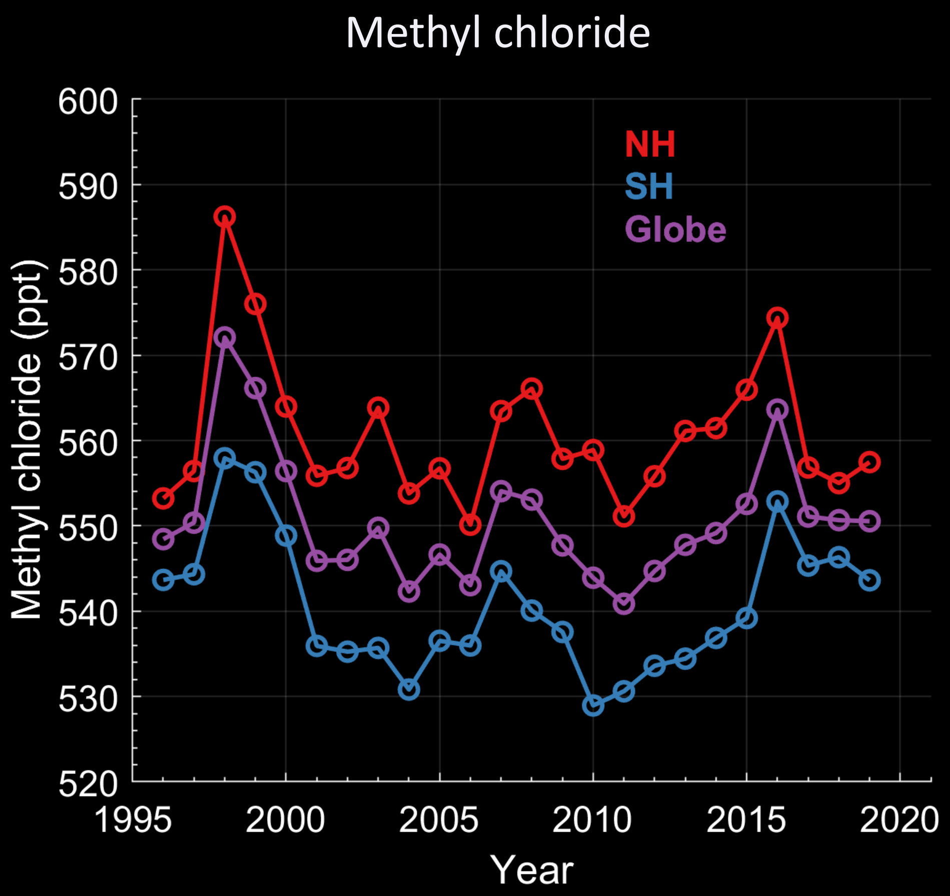


Data from HATS, NOAA GML

Driving research questions:

1. What is causing the interannual variability in the methyl bromide (chloride) levels?
2. Most likely natural, so will that process change in the future?





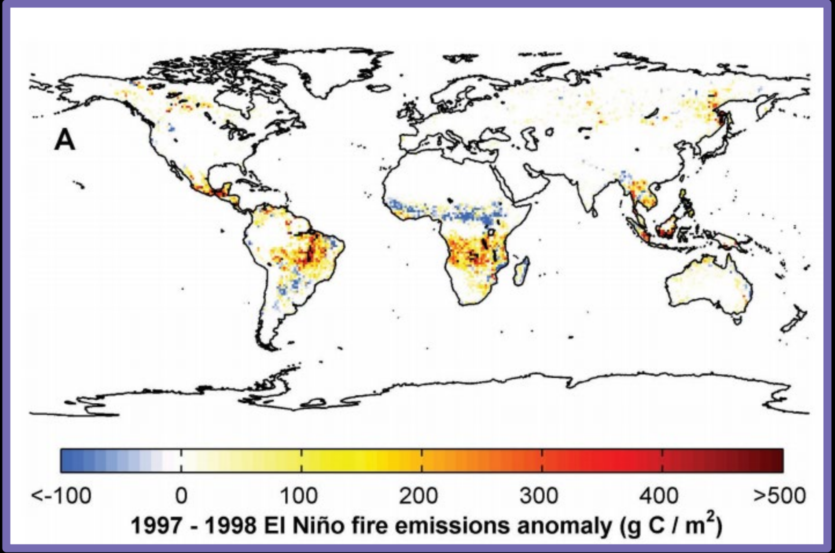
Drivers of interannual climate variability?

El Niño Southern Oscillation

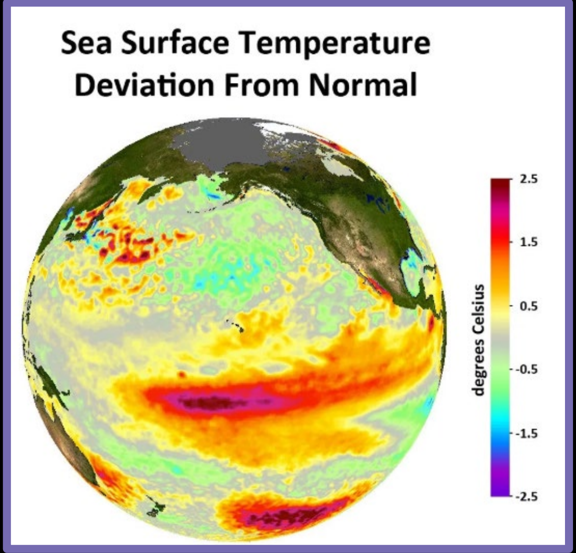
Fires
location, extent, severity

Ocean
SST, productivity

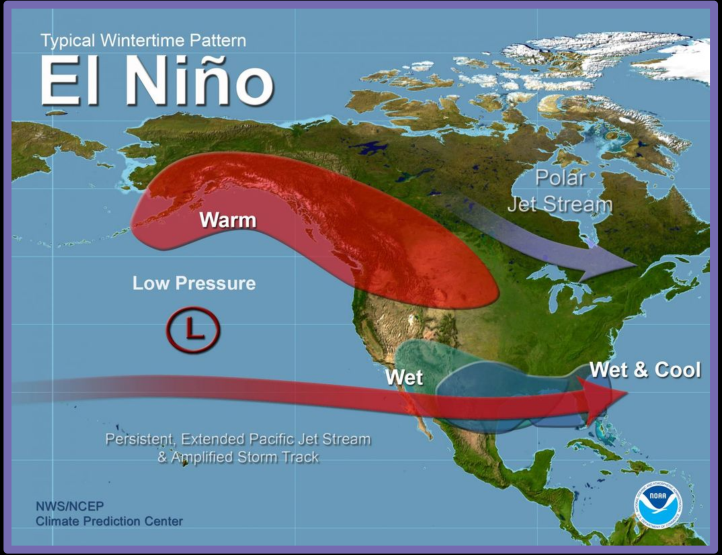
Land
temp, precip, uptake



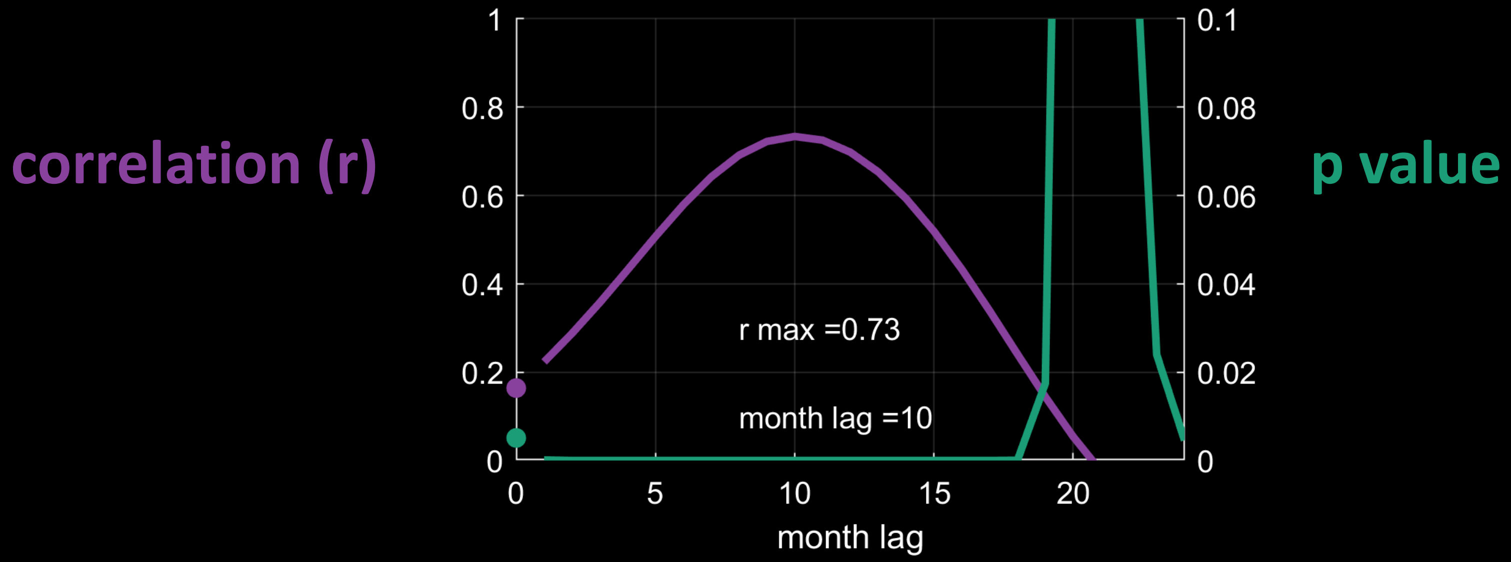
van der Werf et al., 2004 Science

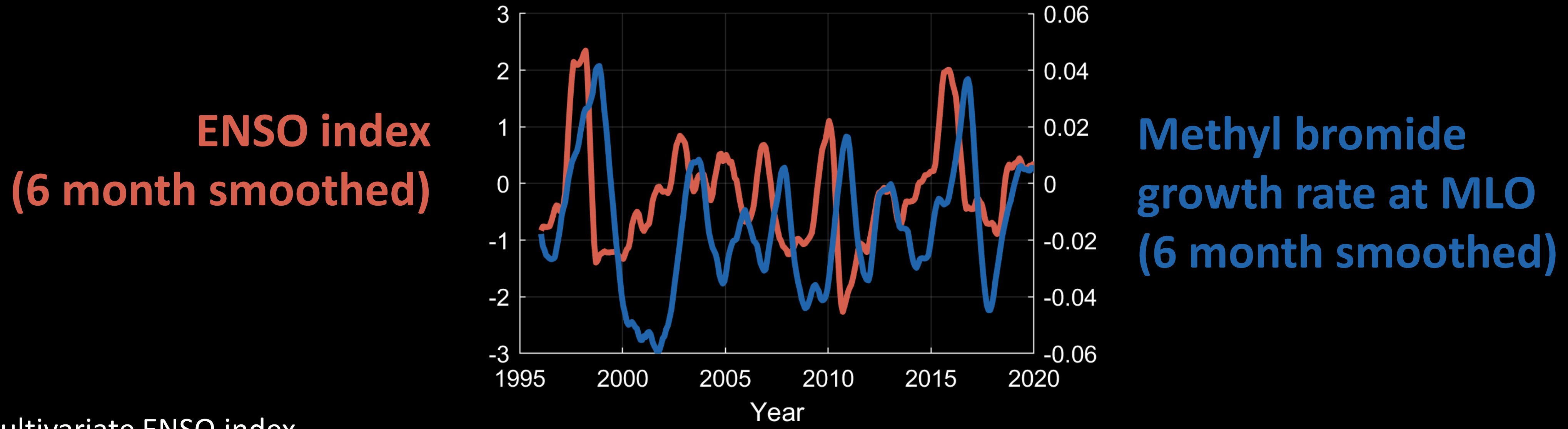


NASA/JPL-NOAA



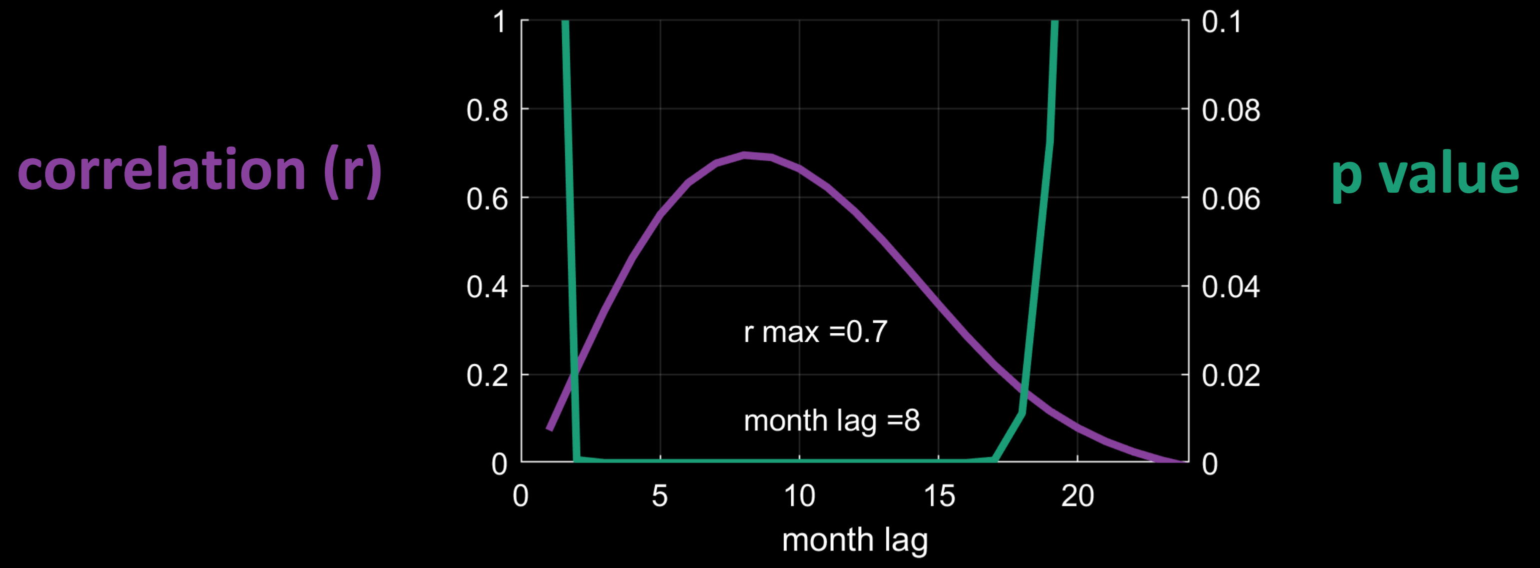
Multivariate ENSO Index versus MLO growth rate

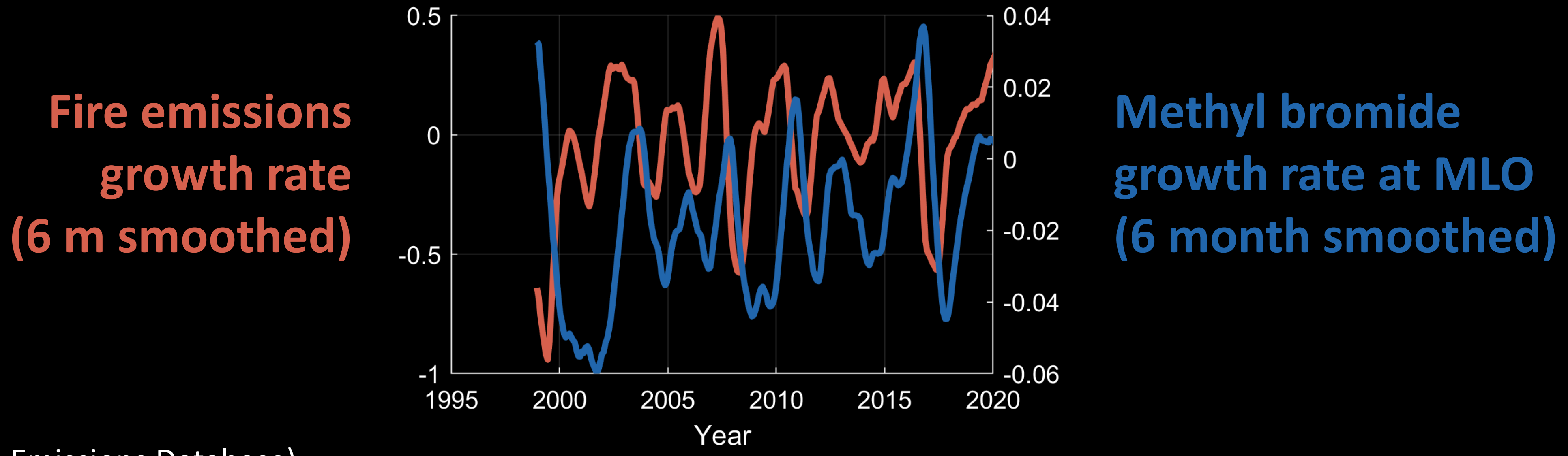




NOAA PSL multivariate ENSO index

Global fire emissions versus MLO growth rate





GFED4 (Global Fire Emissions Database)

Coupled atmospheric & oceanic box model

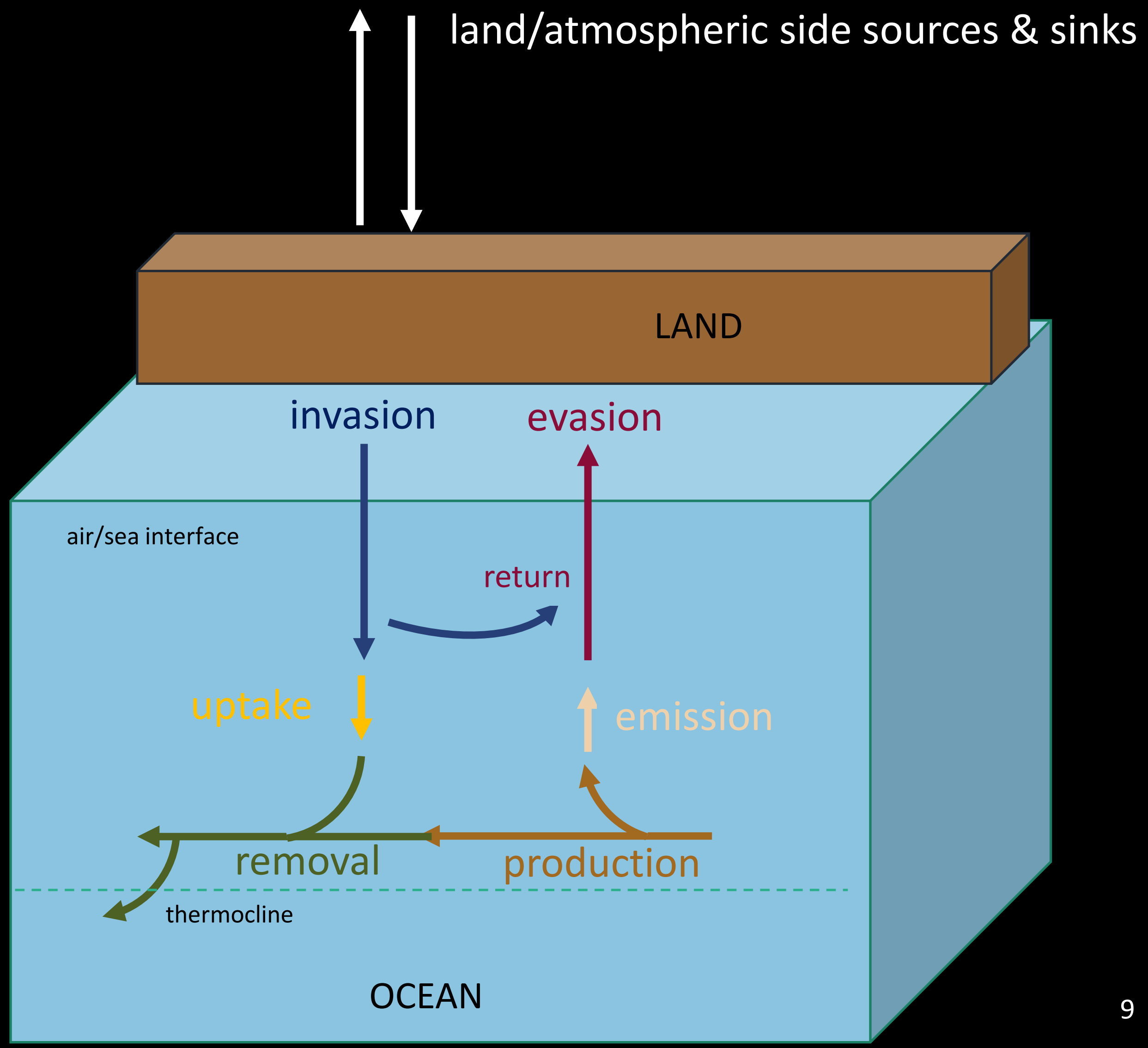
What is the relative importance of the difference sources/sinks? Fires may dominate.

6-box atmospheric model

- seasonality, location, magnitude of emissions
- 30° zonal latitude bands

2°x2° gridded ocean

- Gas transfer velocity (??)
- SST (w/ sea ice), mixed layer depth, salinity, bathymetry
- Solubility, biological & chemical degradation, production



Model schematic adapted from:
Yvon-Lewis & Butler, 2002

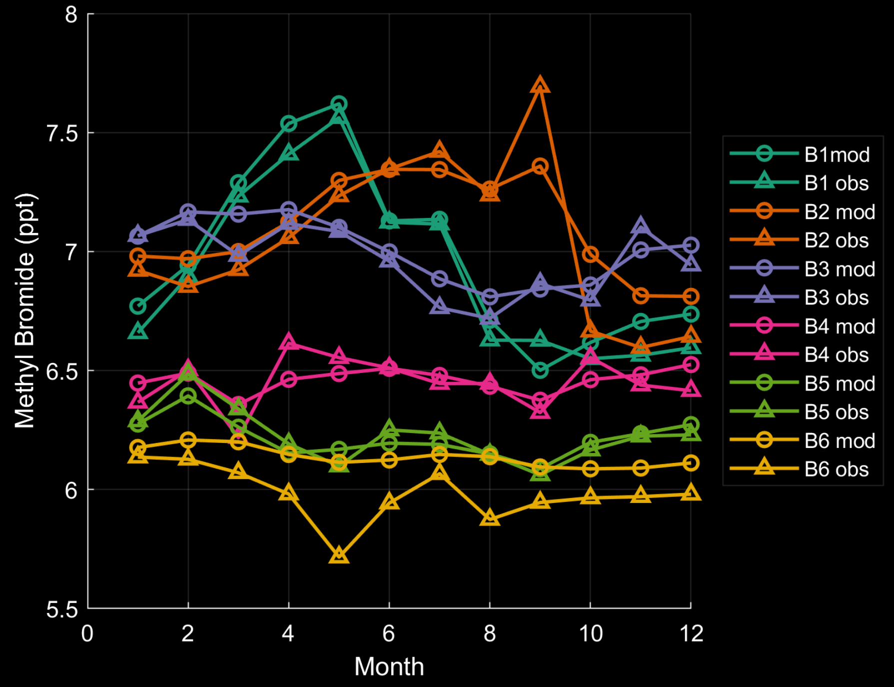
Model adapted from: Yvon-Lewis et al., 2009;
Saltzman et al., 2004; Butler, 1999

Box model utilization

Inversion

Solves for emissions to match observations

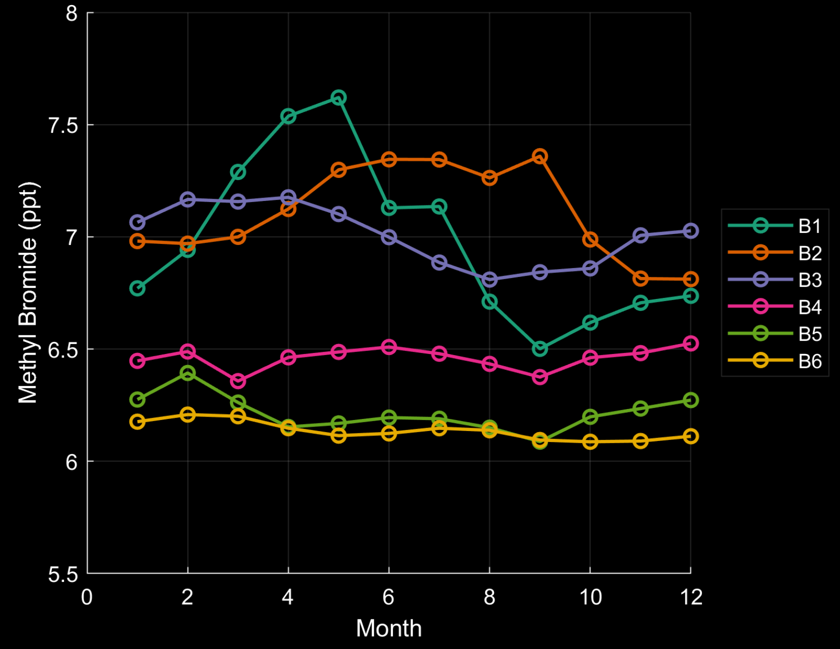
*Computationally expensive



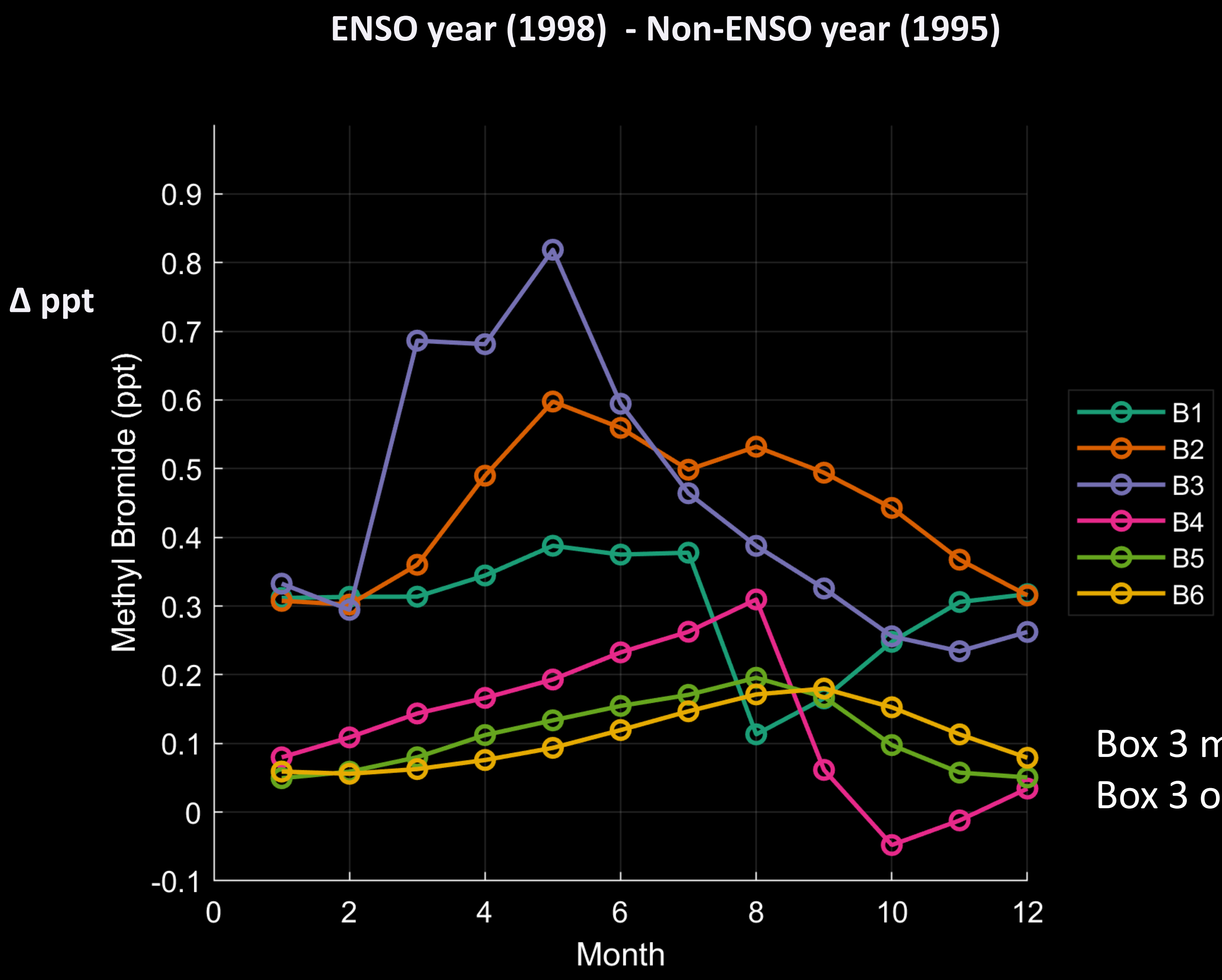
Forward time-dependent

Uses emissions to calculate mixing ratios

*Need to know emissions and their locations well



Preliminary sensitivity tests



Box 3 modeled: 0.44 ppt
Box 3 observed: 0.43 ppt

Hopeful outcomes

1. Quantify the sensitivities to changes in sources (fires, SST)
2. Re-evaluate the global budget of methyl bromide w/o major anthropogenic emissions (2018 vs 2008)
3. Was there a true missing source or just an underestimation of known sources?
4. Evaluate possible changes to the methyl bromide budget due to future climate change? (SST will change, increased ENSO frequency, soil sink)
5. Impacts for stratospheric ozone in the future

nature climate change
LETTERS
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Increasing frequency of extreme El Niño events due to greenhouse warming

Wenju Cai[1,2]★, Simon Borlace[1], Matthieu Lengaigne[3], Peter van Rensch[1], Mat Collins[4], Gabriel Vecchi[5], Axel Timmermann[6], Agus Santoso[7], Michael J. McPhaden[8], Lixin Wu[2], Matthew H. England[7], Guojian Wang[1,2], Eric Guilyardi[3,9] and Fei-Fei Jin[10]

Historical change of El Niño properties sheds light on future changes of extreme El Niño

Bin Wang[a,b,1], Xiao Luo[a], Young-Min Yang[a,b], Weiyi Sun[c,d,e], Mark A. Cane[f], Wenju Cai[g,h], Sang-Wook Yeh[i], and Jian Liu[c,d,e]

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