CESM-coupled Emission Inventory of Oceanic Br-VSLS

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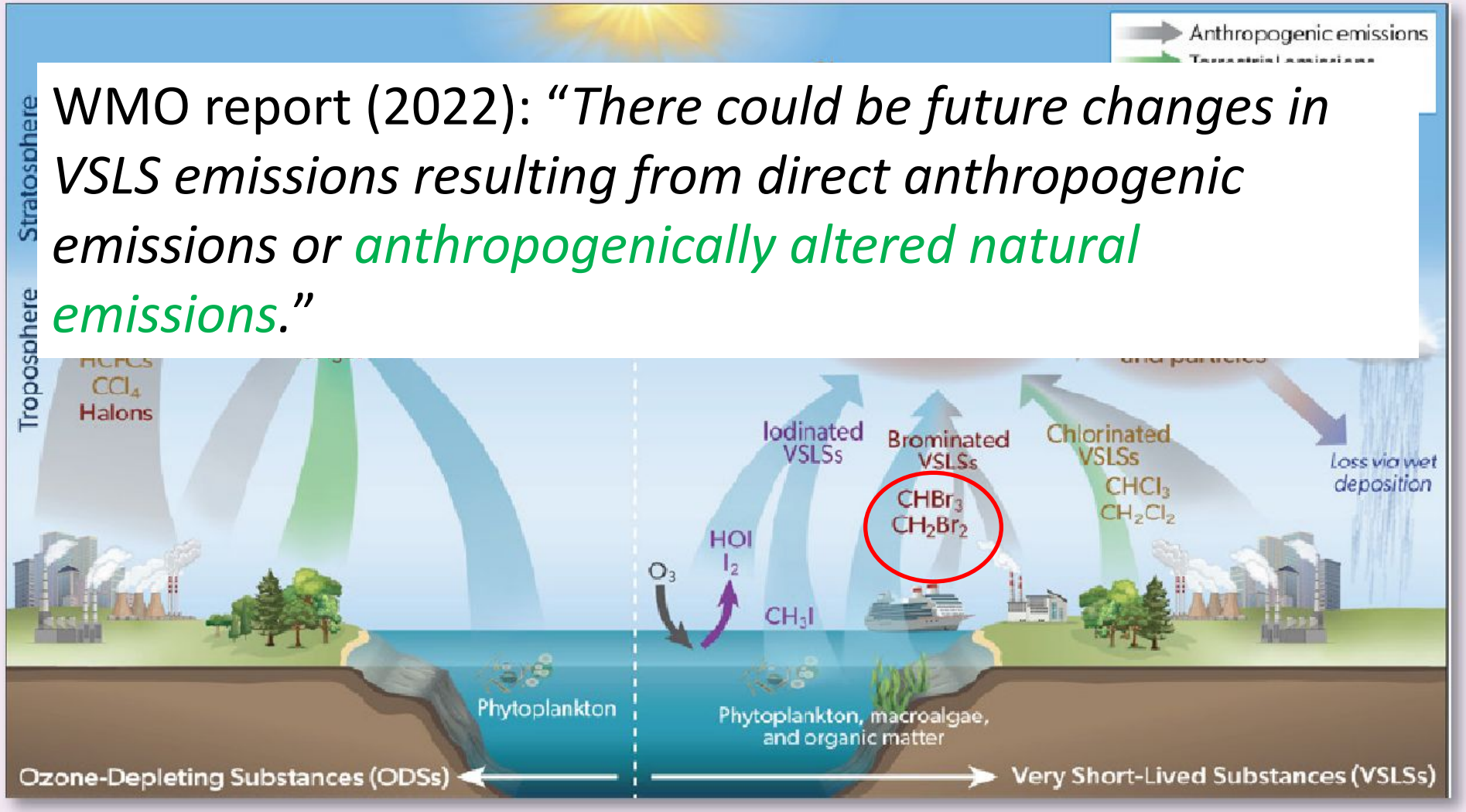
We need to know the sea surface concentrations to estimate the emission flux of oceanic VSLS in the present and future.

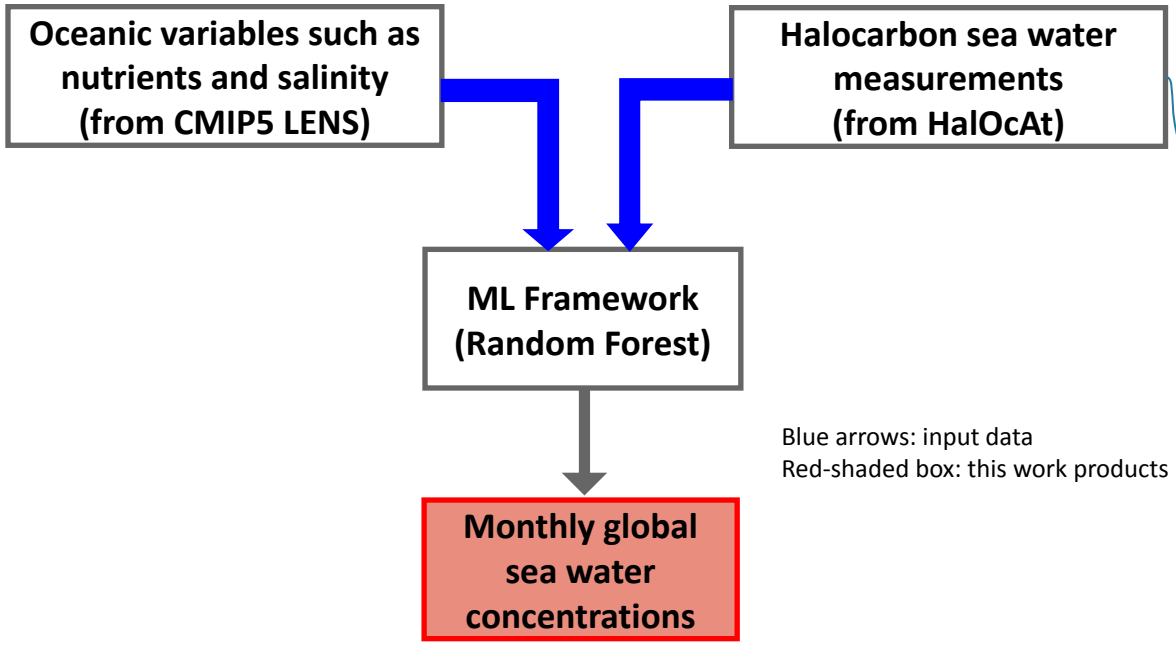
WMO report (2022): "*There could be future changes in VSLS emissions resulting from direct anthropogenic emissions or anthropogenically altered natural emissions.*"



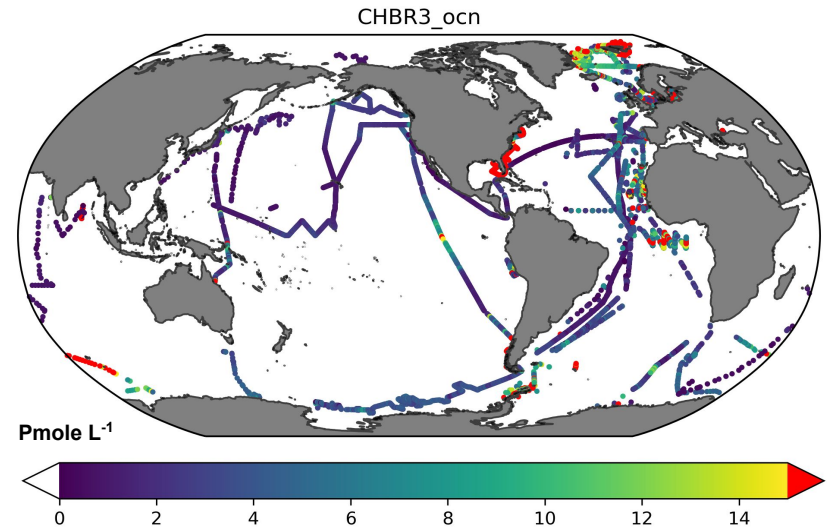
Box 1-3 Figure 1. Schematic of long-lived ozone-depleting substances (ODSs) and halogenated very short-lived substances (VSLSs).

Figure from: WMO Scientific Assessment of Ozone Depletion report, 2022

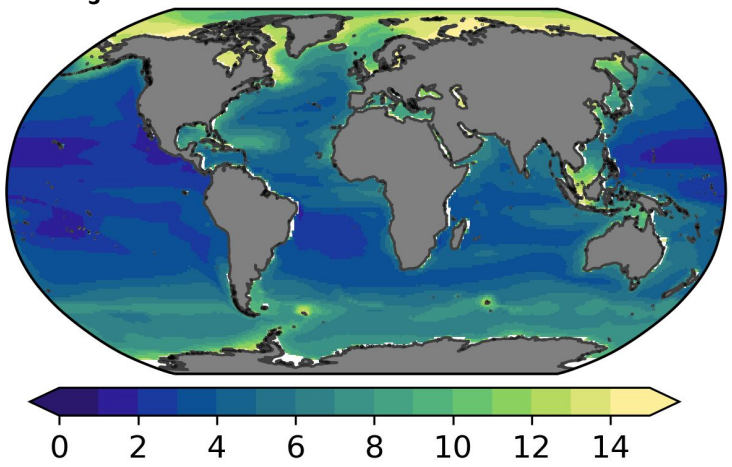
A machine learning framework is developed to estimate monthly sea surface concentrations!



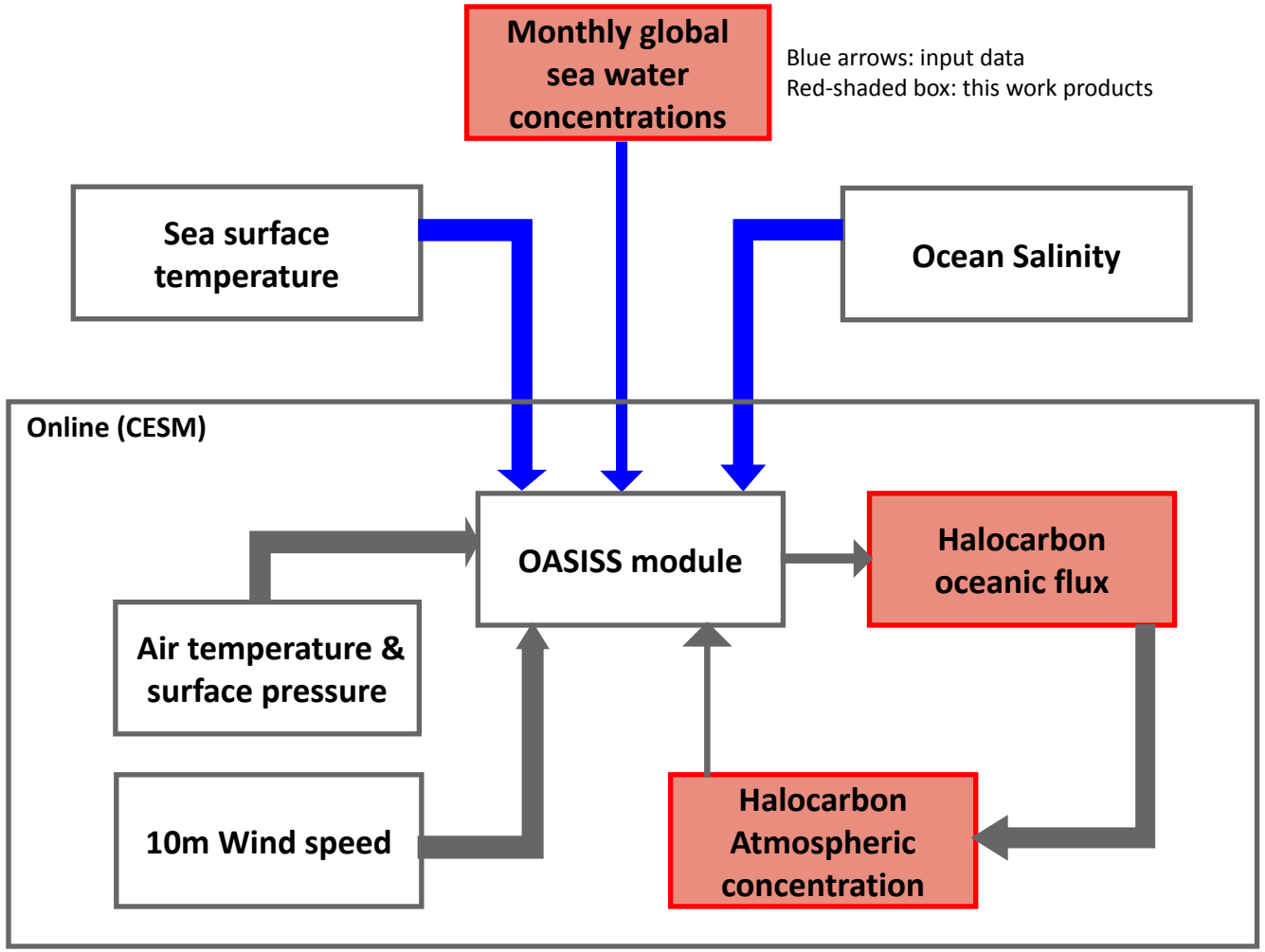
Blue arrows: input data
Red-shaded box: this work products



$CHBr_3$ sea surface concentrations (pmole/L)



The Online Air-Sea Interface for Soluble Species (OASISS) module calculates bi-directional oceanic flux of trace gases.

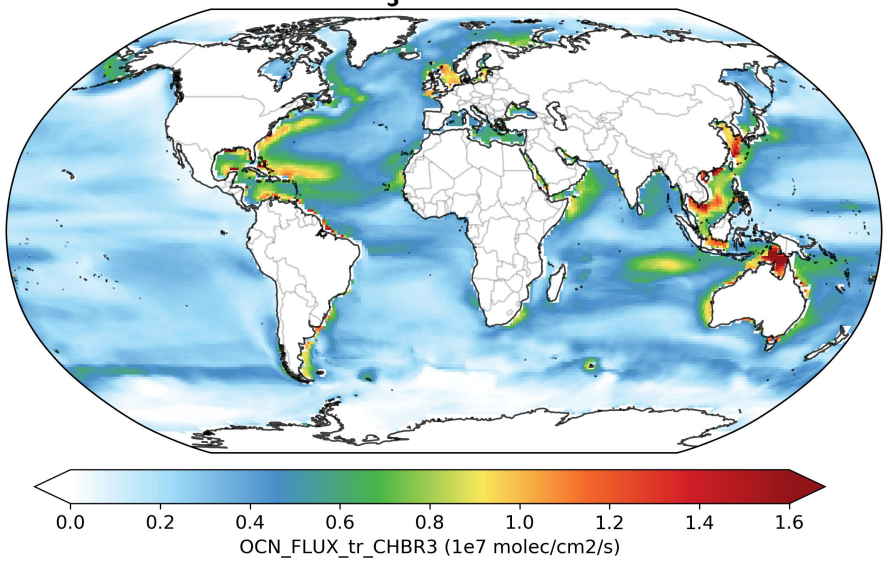


OASISS principal equation:

$$Flux = k * (C_w - \frac{C_a}{H})$$

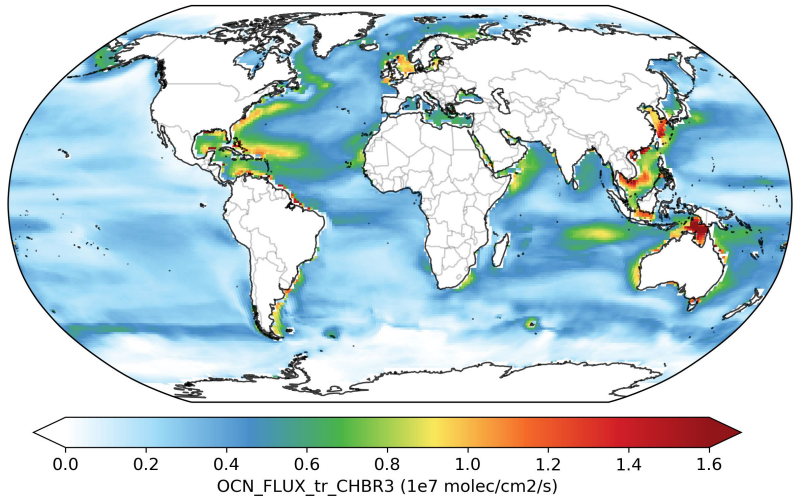
- k: Transfer Velocity
- C_w: Concentration in the liquid phase
- C_a: Concentration in the gas phase
- H: Equilibrium ratio of concentrations in the gas and liquid phase

$CHBr_3$ emission

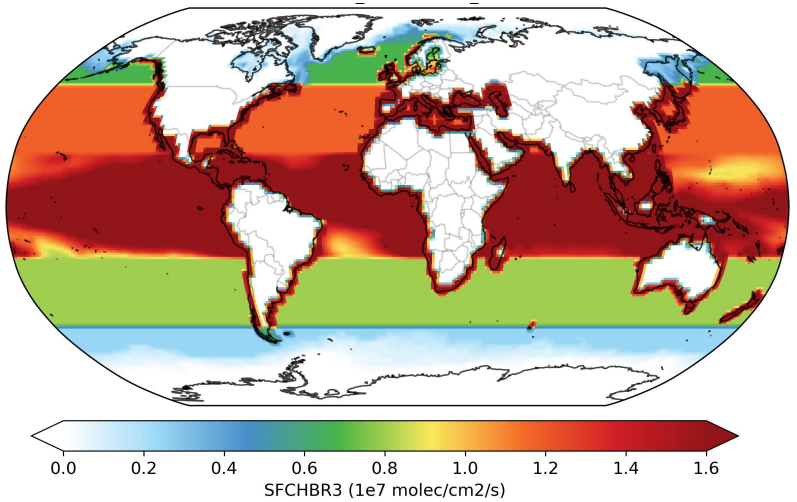


There is a large uncertainty in the emission inventories' estimates! Our results are on the lower end of the ranges.

$CHBr_3$ emission (133 Gg Br)



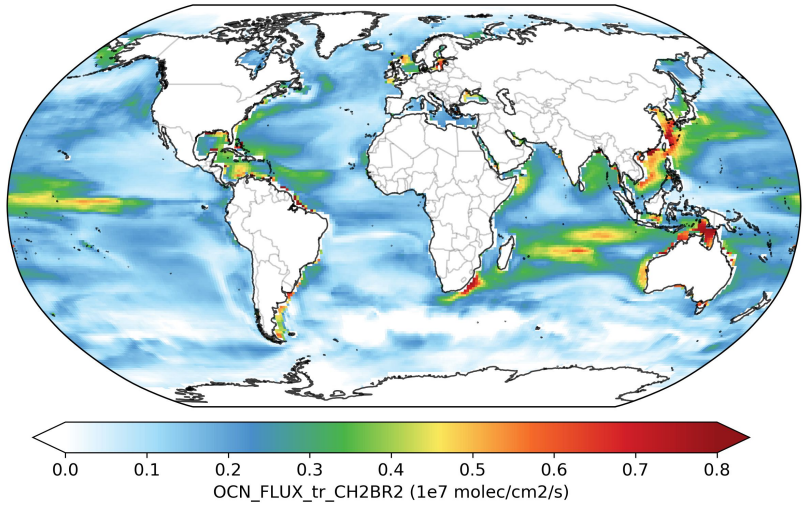
Ordonez et al., (2012) $CHBr_3$ emission (581 Gg Br)



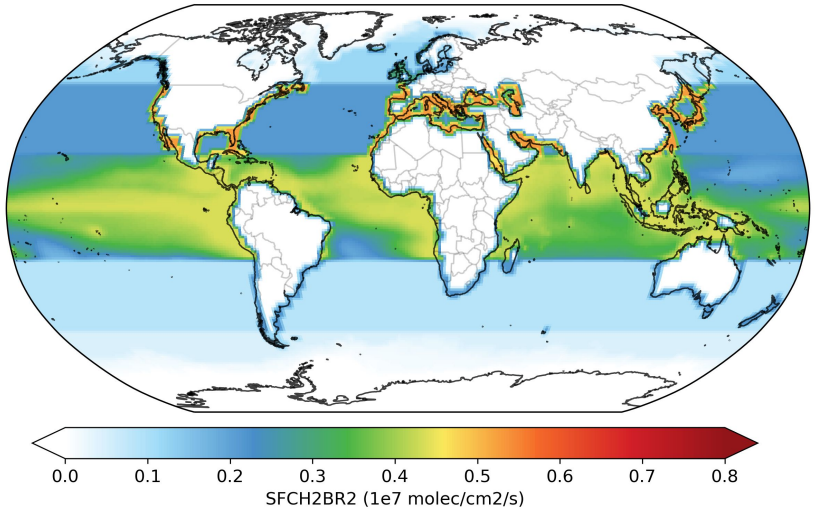
WMO report Lit. Range

150-820 Gg Br Yr^{-1}

CH_2Br_2 emission (48 Gg Br)



Ordonez et al., (2012) CH_2Br_2 emission (71 Gg Br)



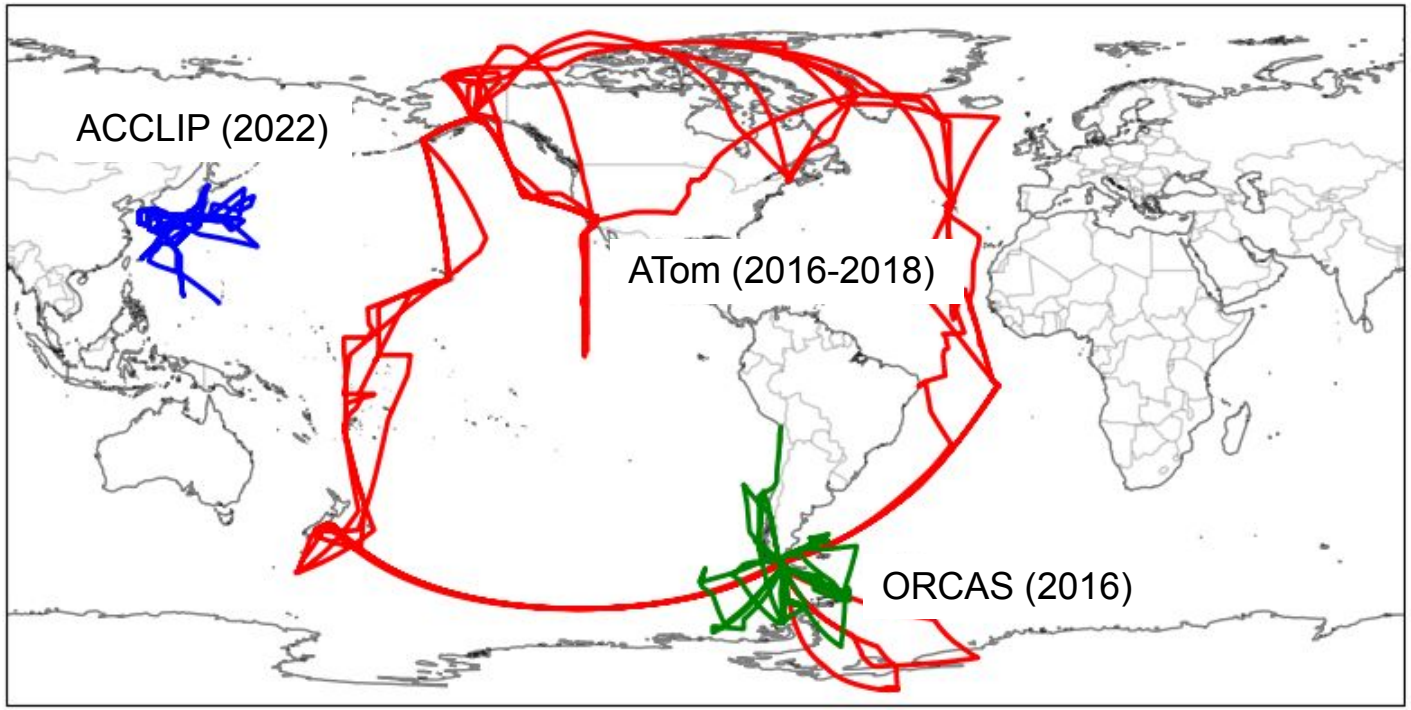
54-100 Gg Br Yr^{-1}

Maps and data are reported for 2017.

We use the NSF NCAR TOGA-TOF measurements in recent aircraft campaigns to evaluate the model.

TOGA-TOF suite of VOCs
~ 120 VOCs total: Complementary to WAS and PTR-TOF-MS

TOGA-TOF – Fast GC-MS
(2 min) w TOF



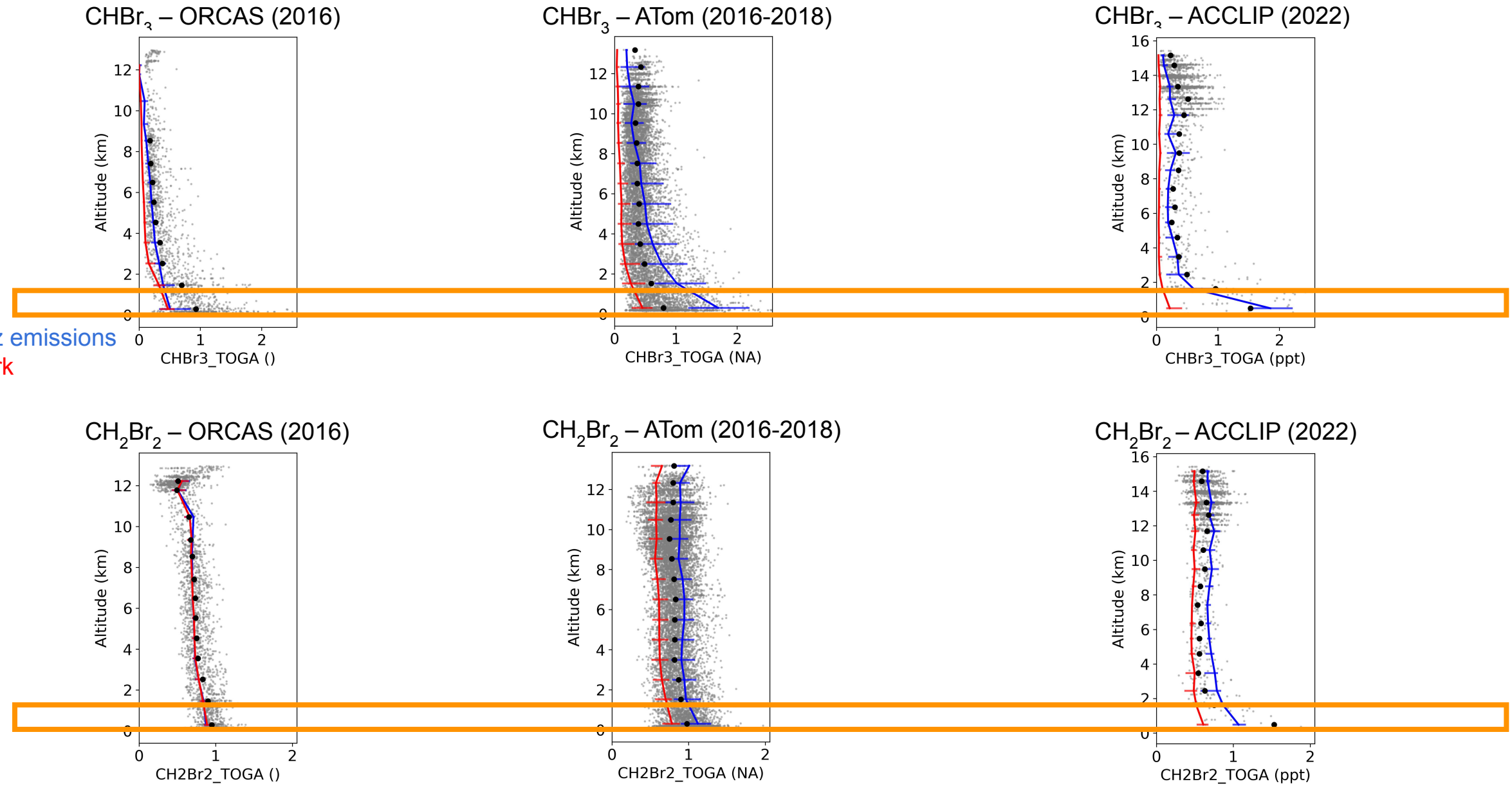
ACCLIP: NASA & NSF Asian Summer Monsoon Chemical & Climate Impact Project
ATom: NASA Atmospheric Tomography Mission
ORCAS: NSF O_2/N_2 Ratio and CO_2 Airborne Southern Ocean Study

The resulting atmospheric concentrations are biased low, sea surface concentrations should be scaled.

Obs

Ordonez emissions

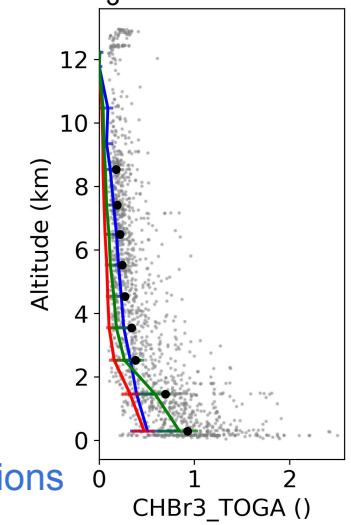
This work



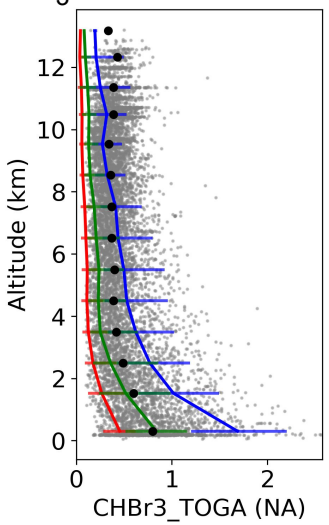
The resulting atmospheric concentrations are biased low, sea surface concentrations should be scaled.

Obs
Ordonez emissions
This work
This work - scaled

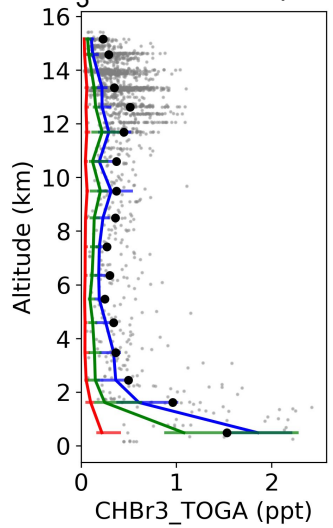
$CHBr_3$ – ORCAS (2016)



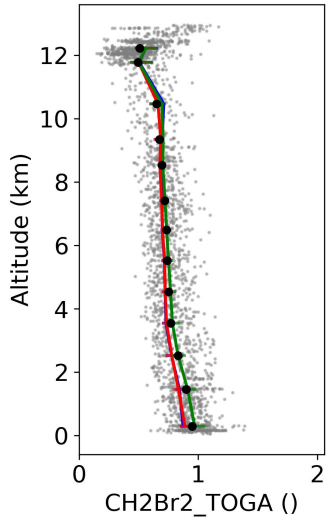
$CHBr_3$ – ATom (2016-2018)



$CHBr_3$ – ACCLIP (2022)



CH_2Br_2 – ORCAS (2016)



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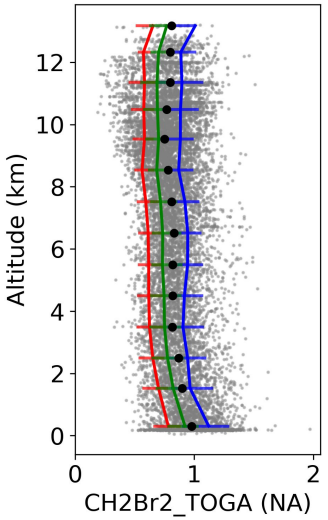

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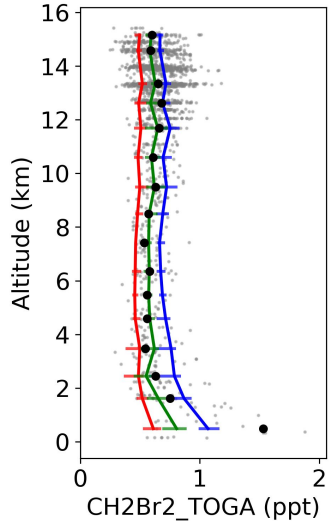
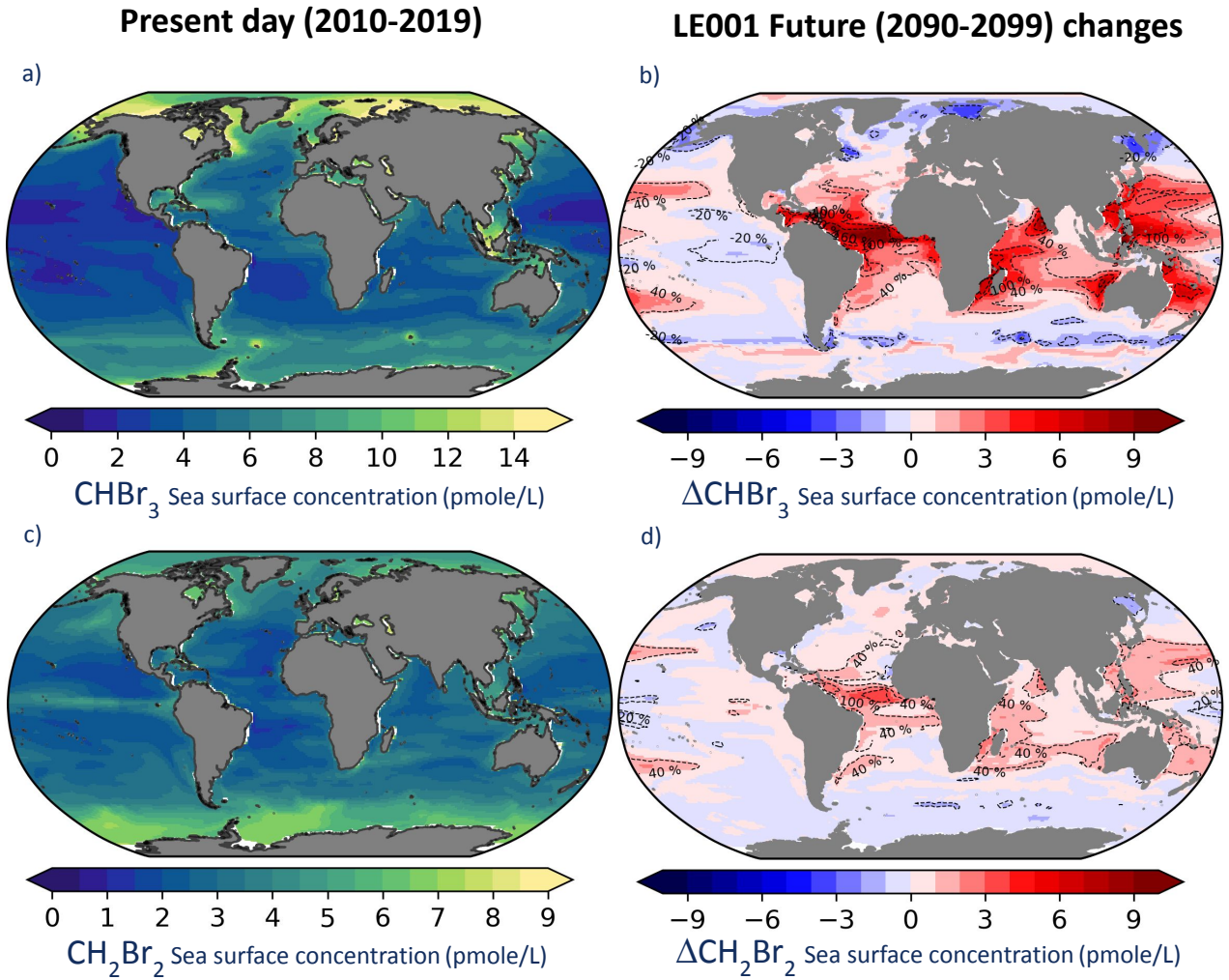
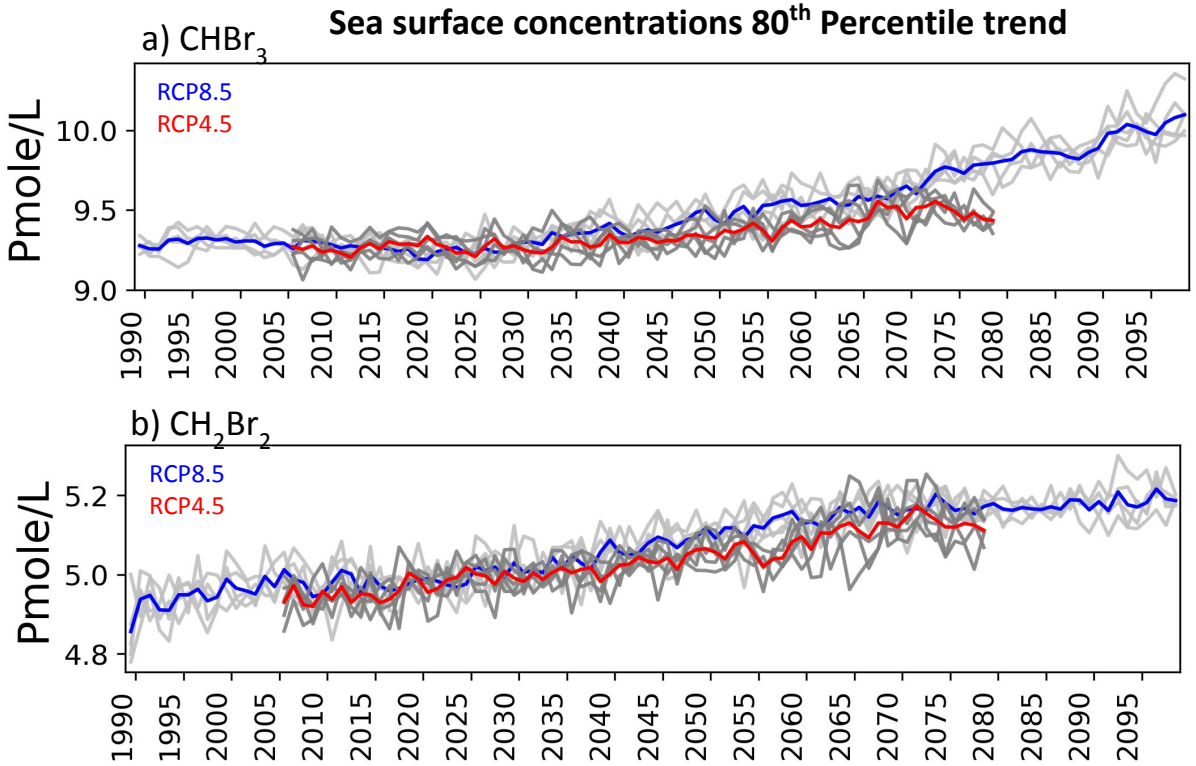


Now we can answer the WMO's question – as next step:

What are the future changes in Br-VSLS emissions resulting from anthropogenically altered natural emissions.

Changes in sea surface concentration based on RCP8.5





Summary

A dataset for long-term monthly Br-VSLS oceanic concentrations (and emissions – in progress) are produced.

We use the modeled atmospheric concentrations to adjust the oceanic concentrations.

We estimate significant increases in sea surface concentrations in the western tropical pacific ocean – which could transport more Br-VSLS to the UTLS region based on deep convection pathways (i.e., Asian Summer Monsoon).