



University of
BRISTOL



Monitoring emissions of very short-lived ozone depleting substances in the Asian Monsoon region

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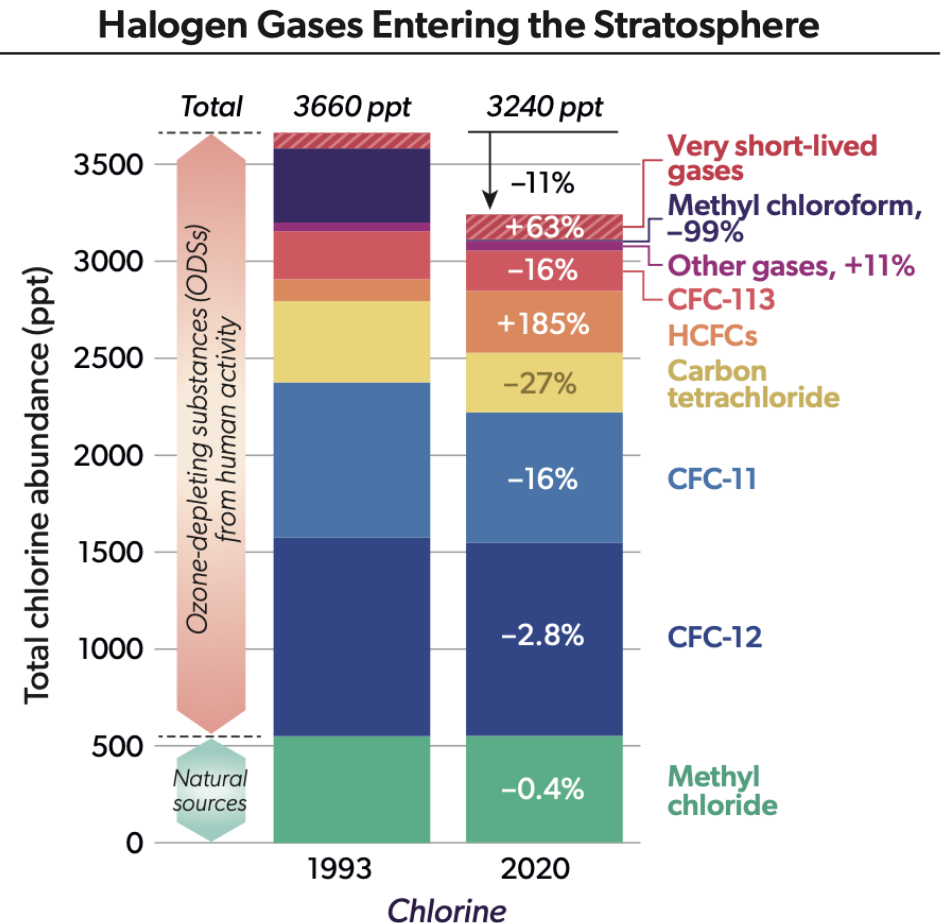
⁶ MOC/CMA

ACAM workshop
Dhaka, June 2023

And collaborators at Peking University, University of Dhaka, University of Bristol, NOAA, AGAGE

Very short-lived ozone-depleting substances

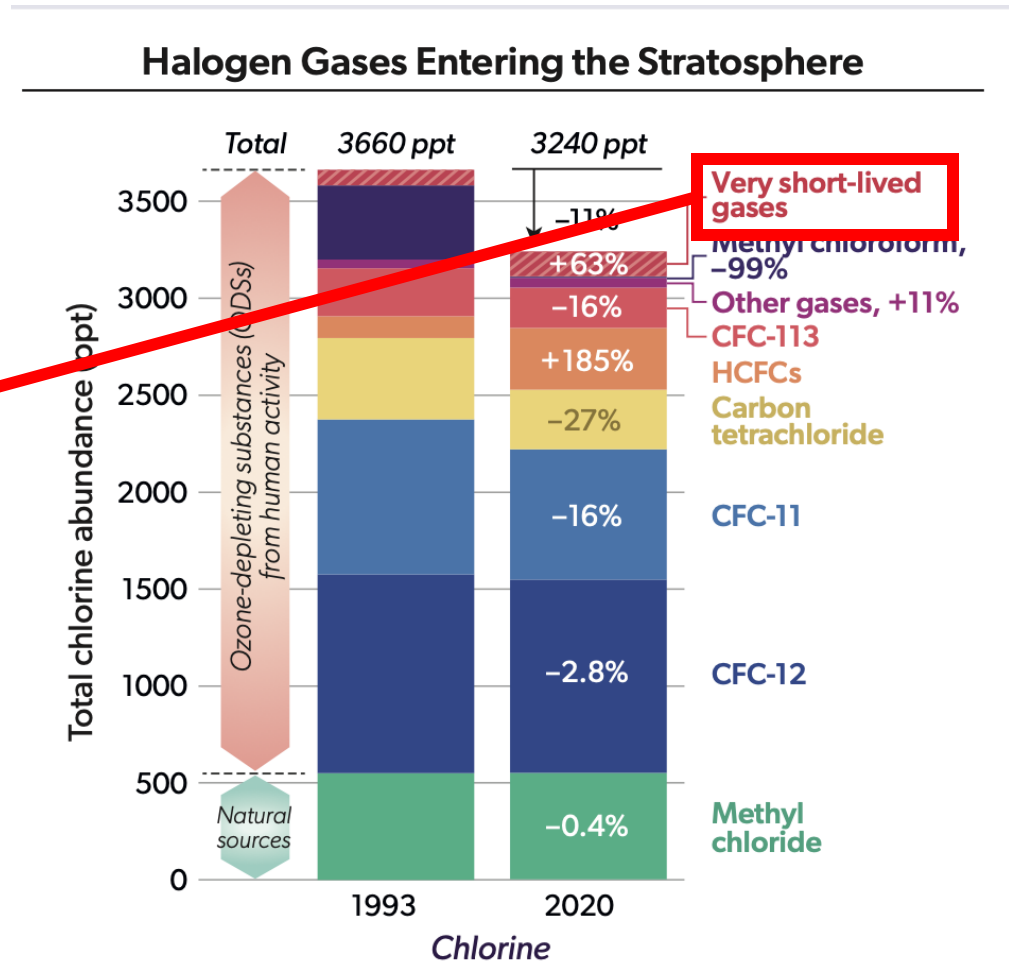
- Production of most long-lived (5+ years) ozone depleting substances is being phased out under the Montreal Protocol
- Antarctic ozone hole recovery is set to recover by around 2060
- VSLS have a total atmospheric lifetime of <6 months
- VSLS production is not controlled under the Montreal Protocol



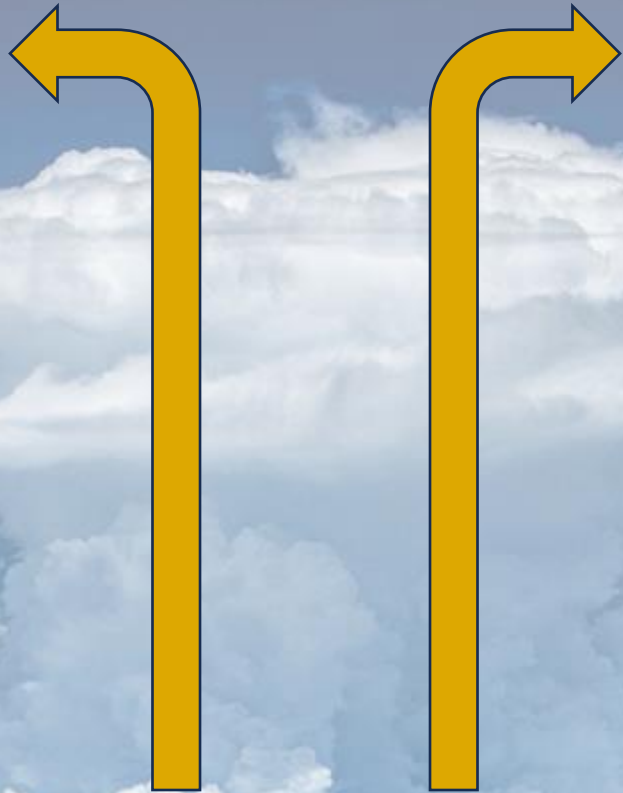
Very short-lived ozone-depleting substances

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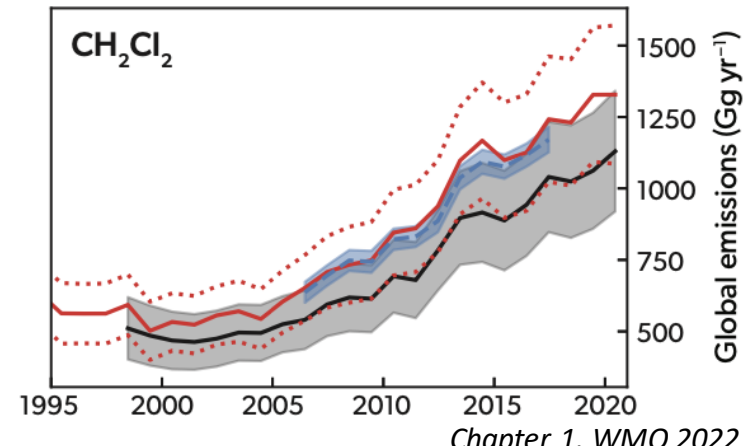
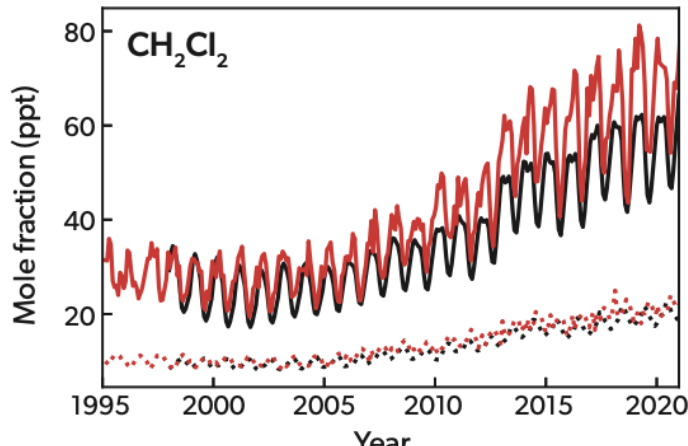
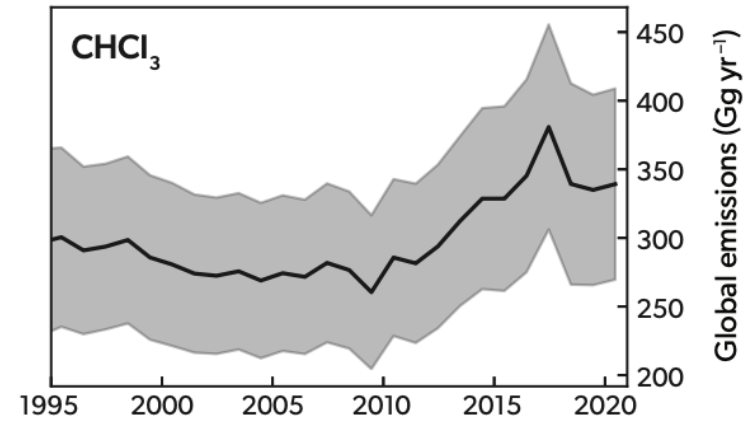
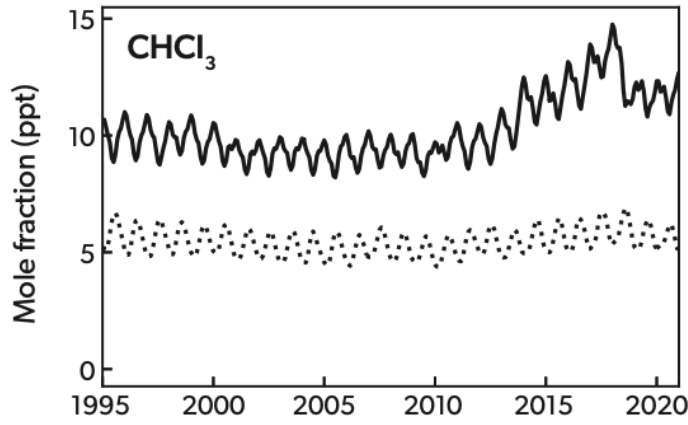
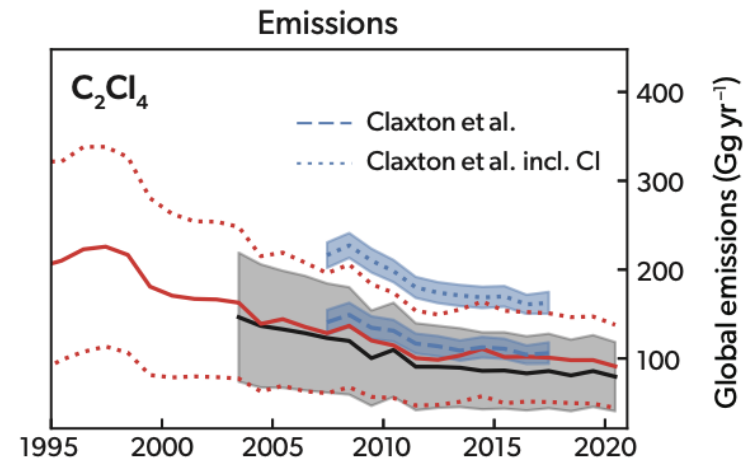
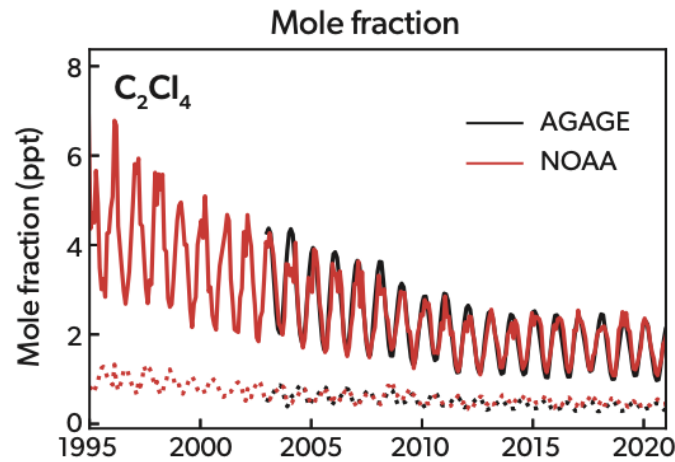
The amount of chlorine entering the stratosphere due to VSLs have increased rapidly over the past 20 years



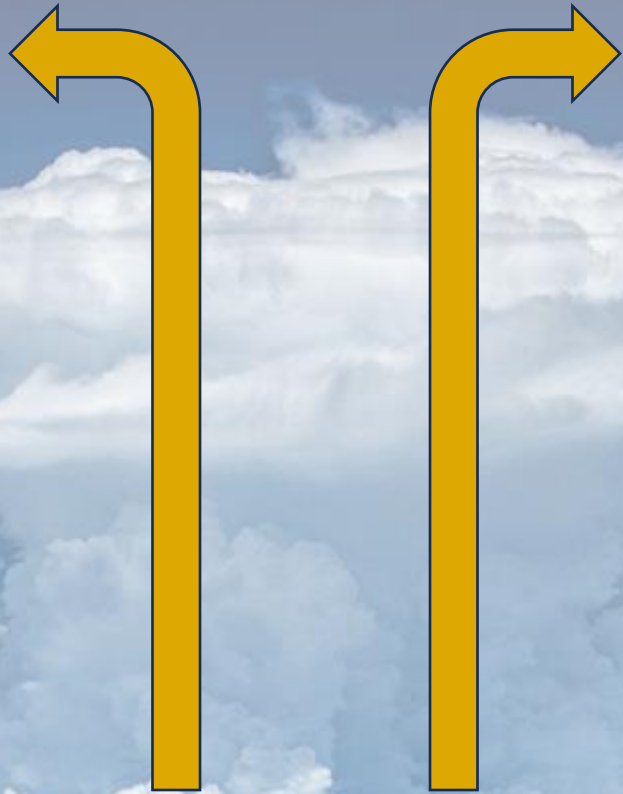
VSLs can be rapidly transported into UTLS in convective regions



Usually destroyed in lower atmosphere



VSLs can be rapidly transported into UTLS in convective regions



Usually destroyed in lower atmosphere

Article

Very short-lived halogens amplify ozone depletion trends in the tropical lower stratosphere

<https://doi.org/10.1038/s41558-023-01671-y>

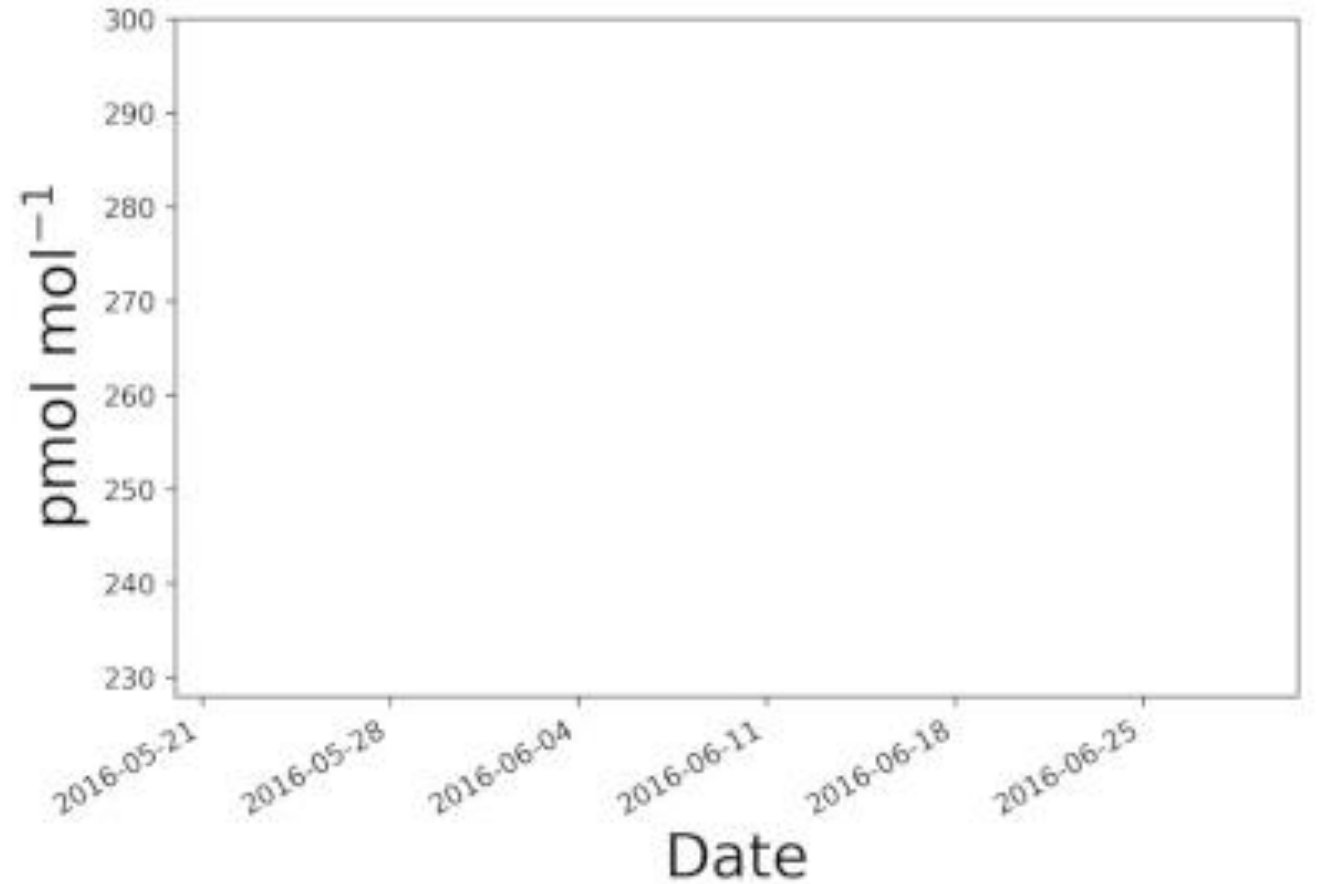
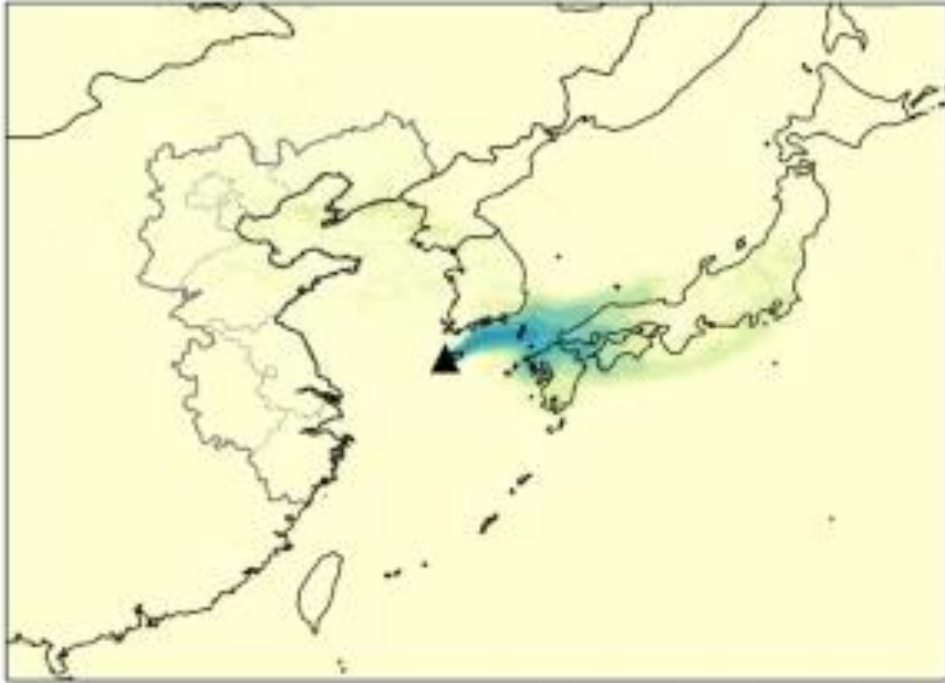
The location of the emission source is important for the impact of VSLs on ozone depletion

Focus on two
chlorinated
VSLs with
increasing
emissions

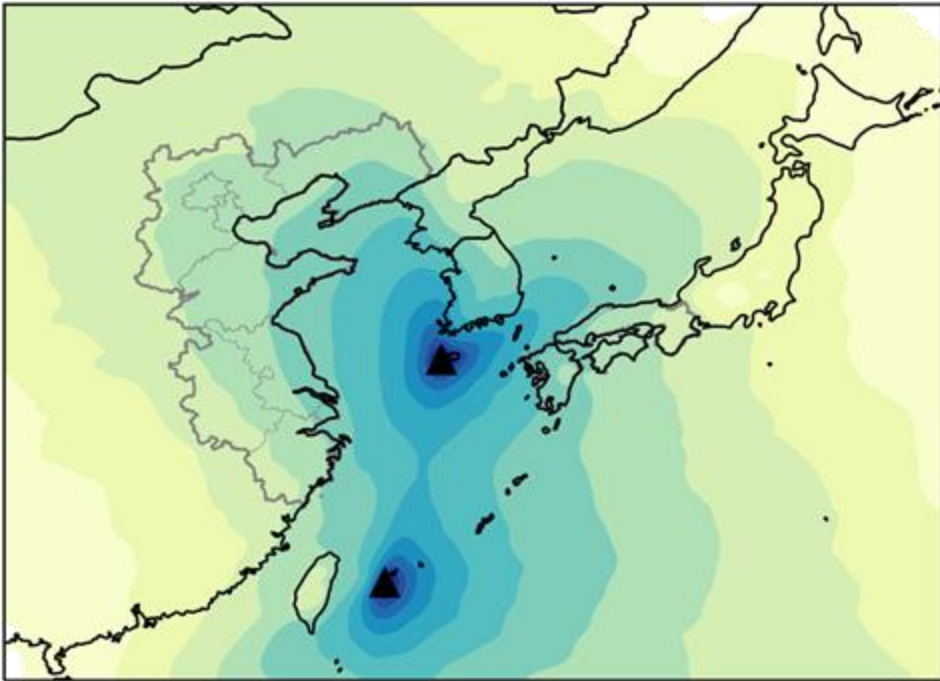
**Dichloromethane
and chloroform**



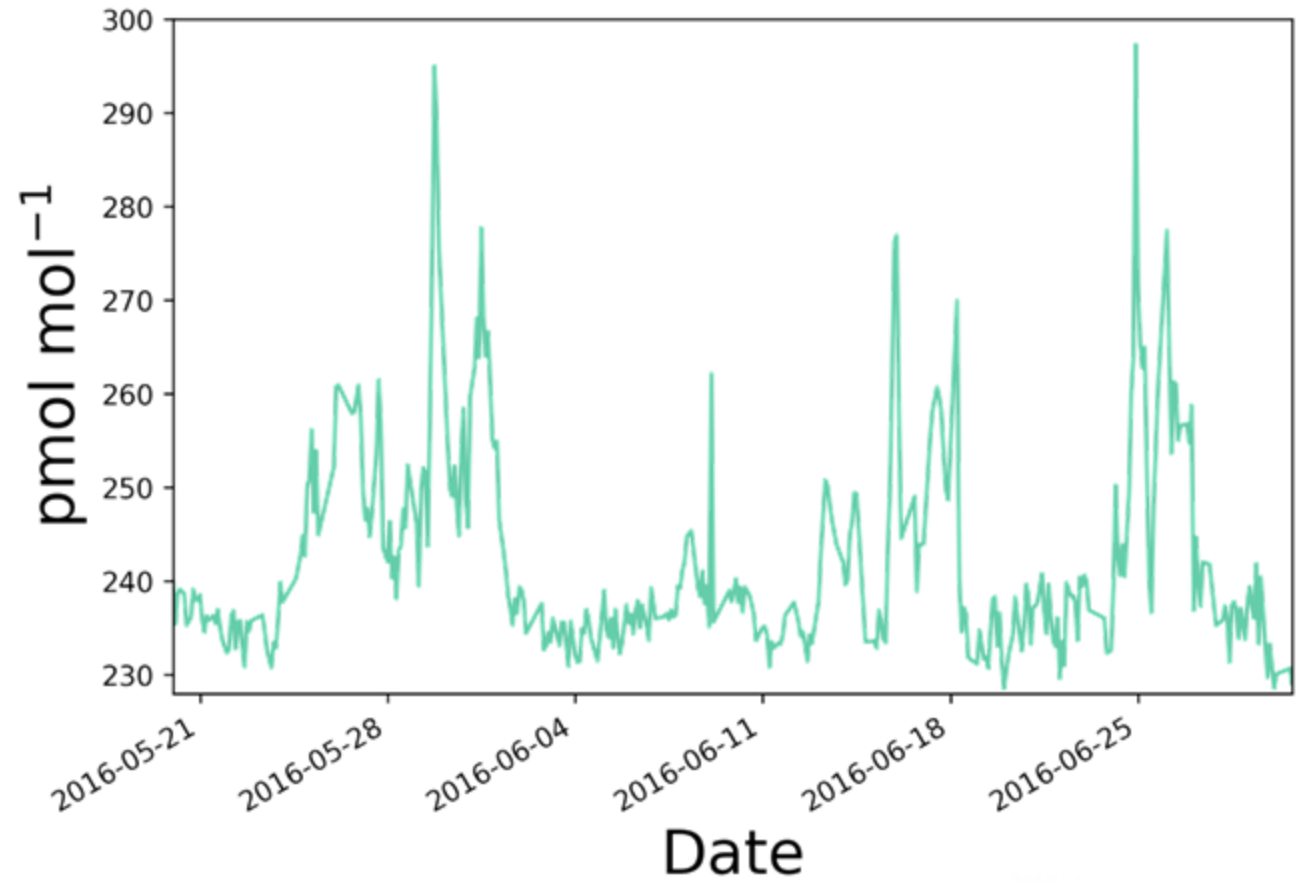
Use of regional inverse methods to quantify emissions



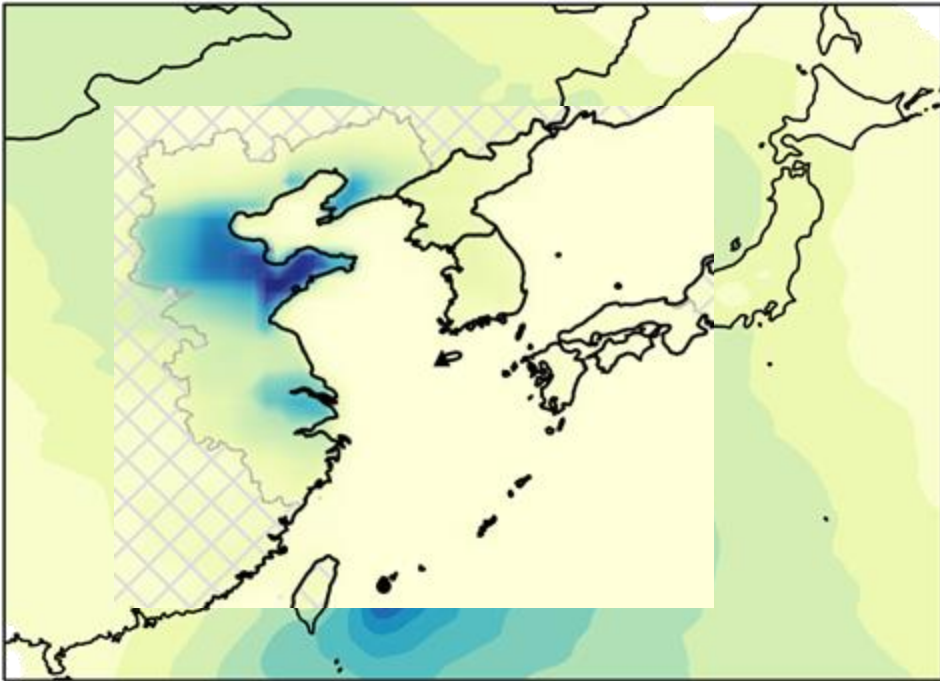
Use of regional inverse methods to quantify emissions



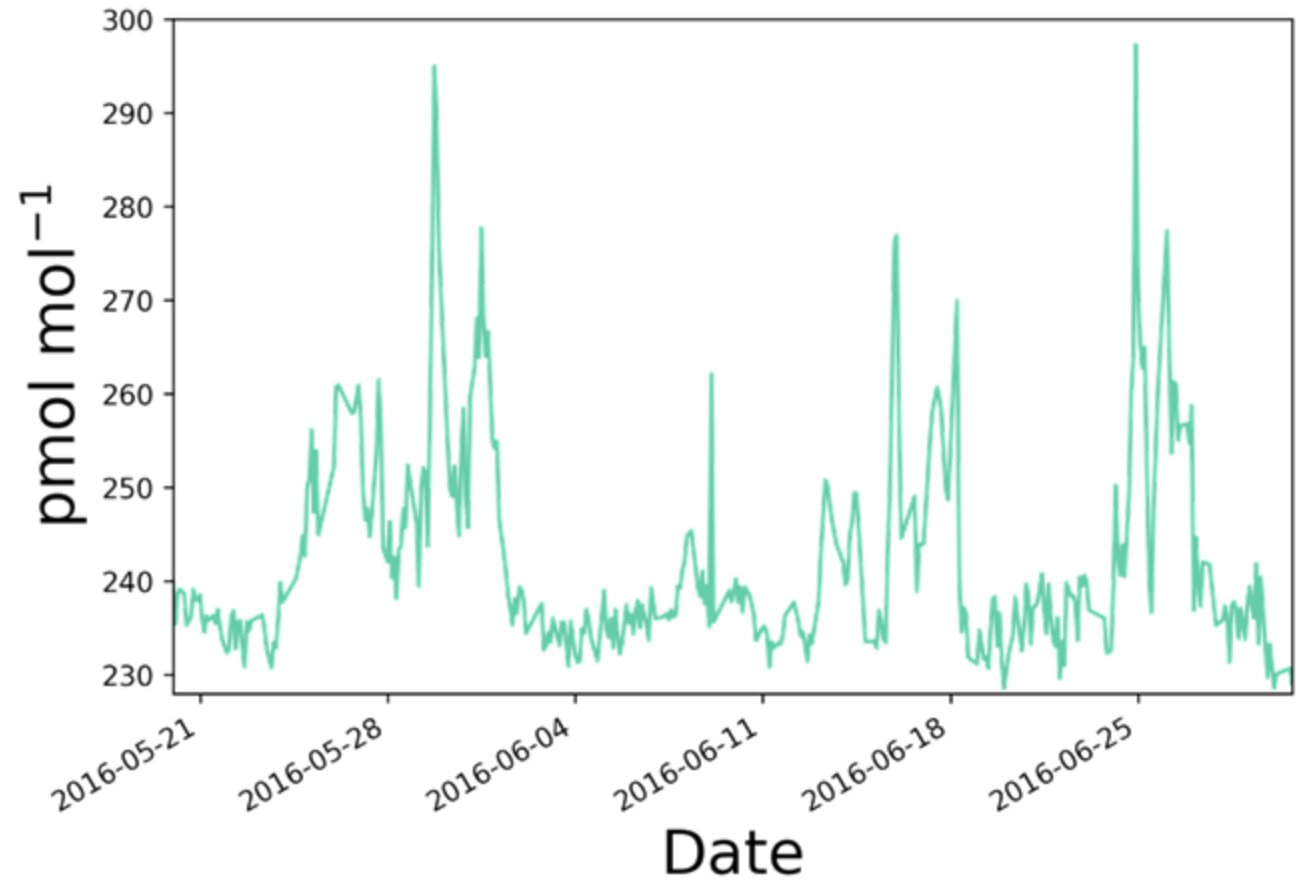
Sensitivity to measurements



Use of regional inverse methods to quantify emissions



Emissions



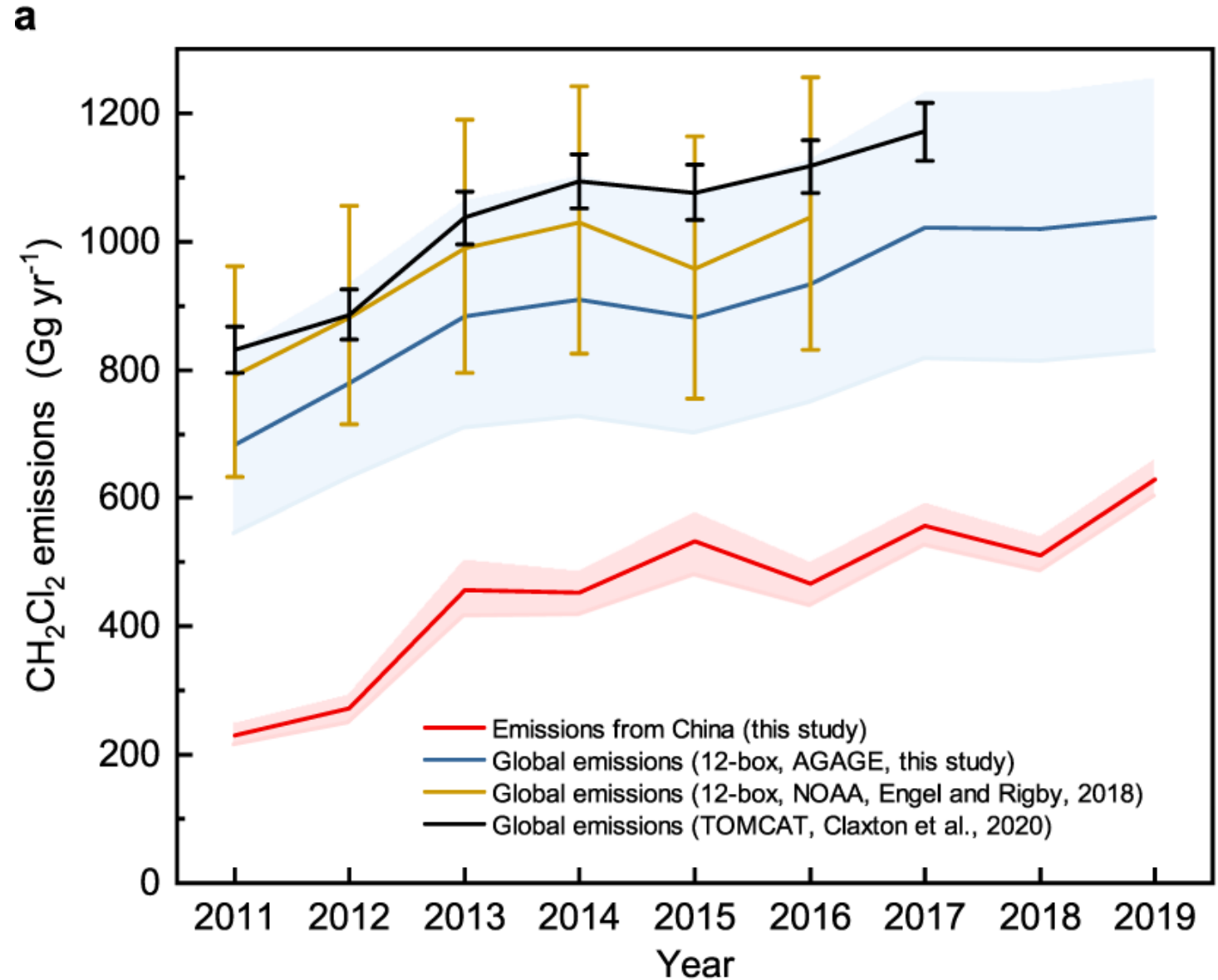
Dichloromethane

- The most abundant chlorine-containing VSLs
- Lifetime of ~6 months
- Emitted from its use as an adhesive and solvent
- Used in the production of other chemical (feedstock)
- Small natural source from seaweeds



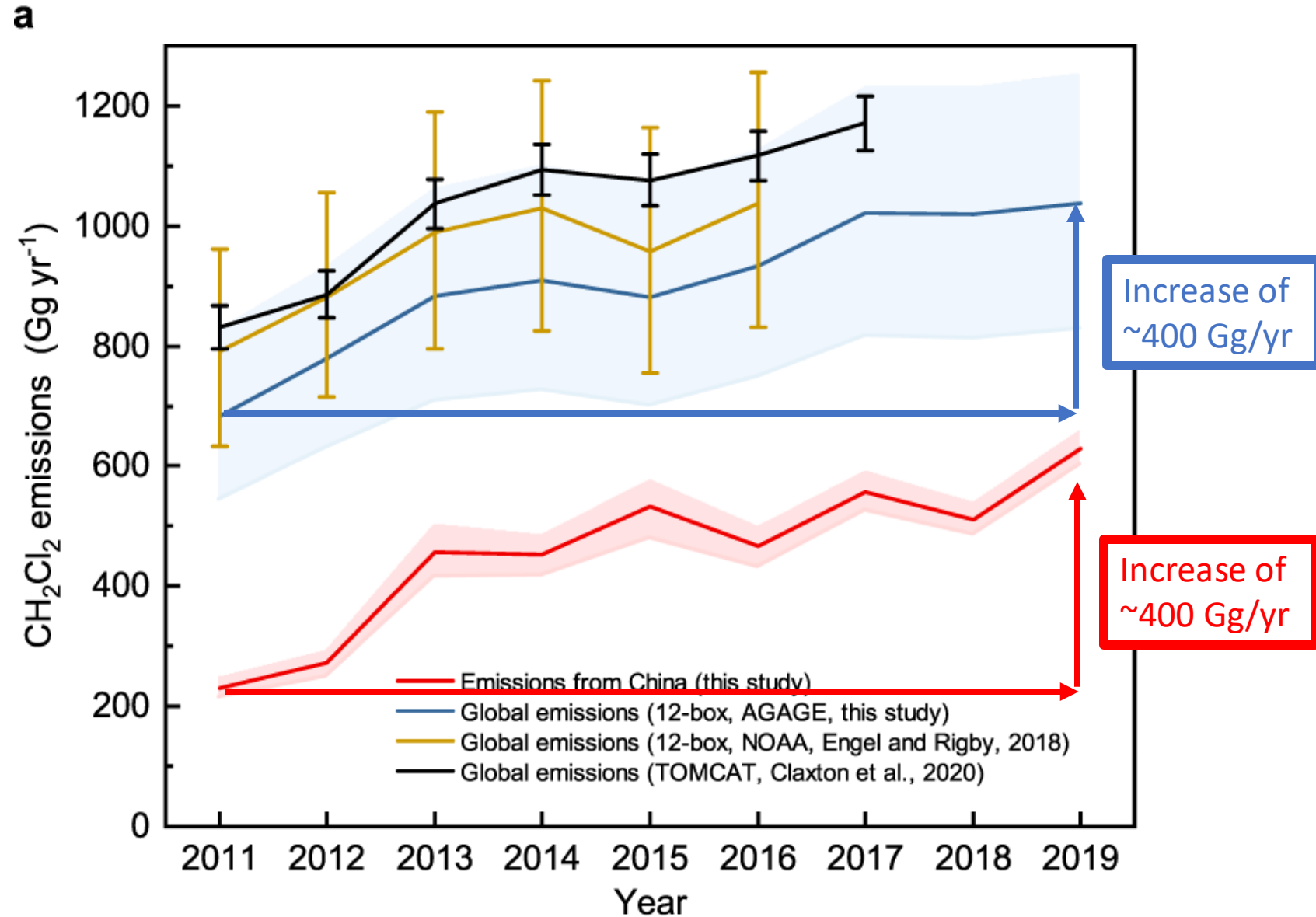
Dichloromethane

- Emissions of dichloromethane have risen rapidly in China
- The entire global rise can be explained by emissions from China



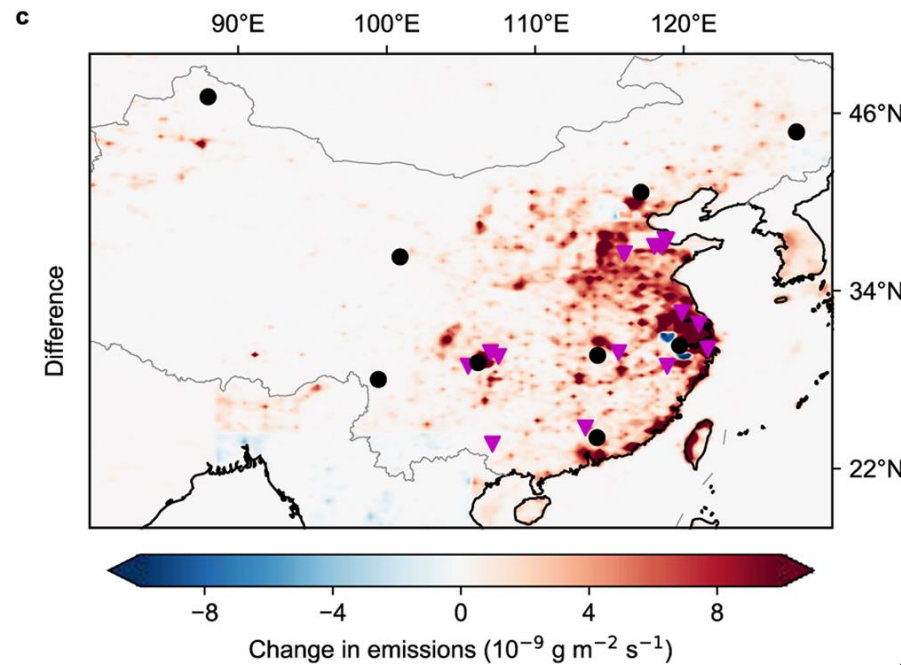
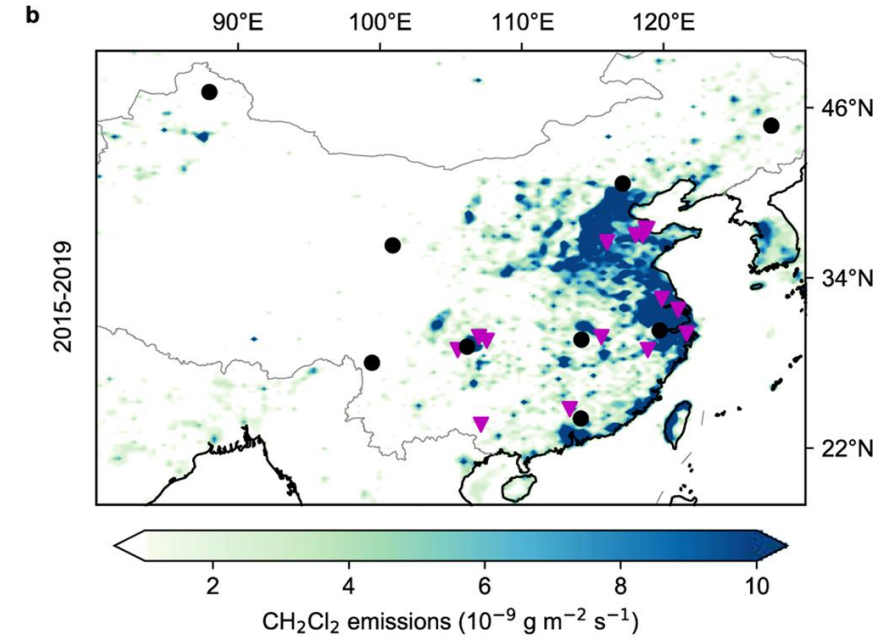
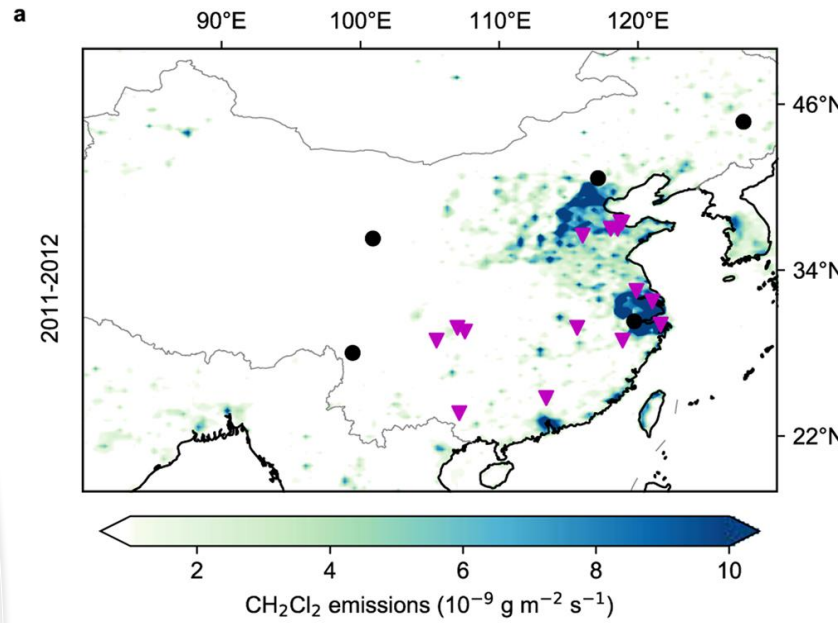
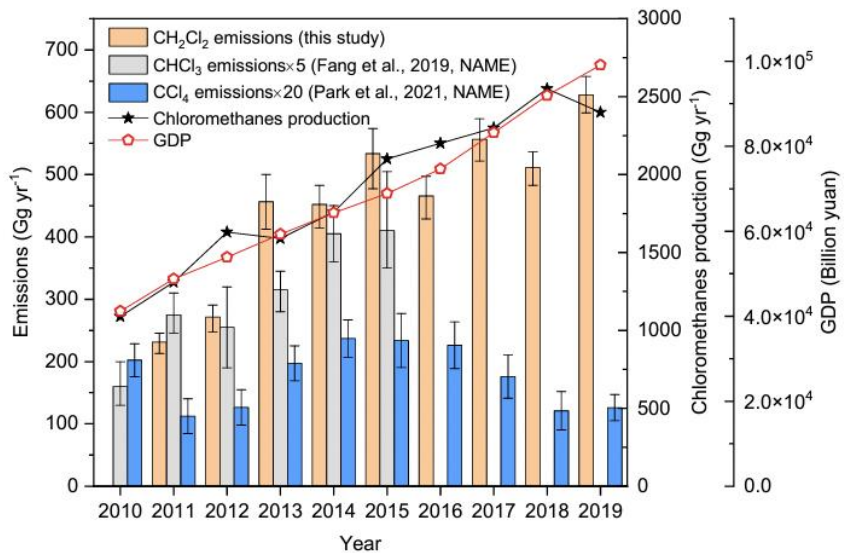
Dichloromethane

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Dichloromethane

- Increase in emissions occurs in industrialised/populated regions, likely from solvent use and production leakage



Known chloromethane factories

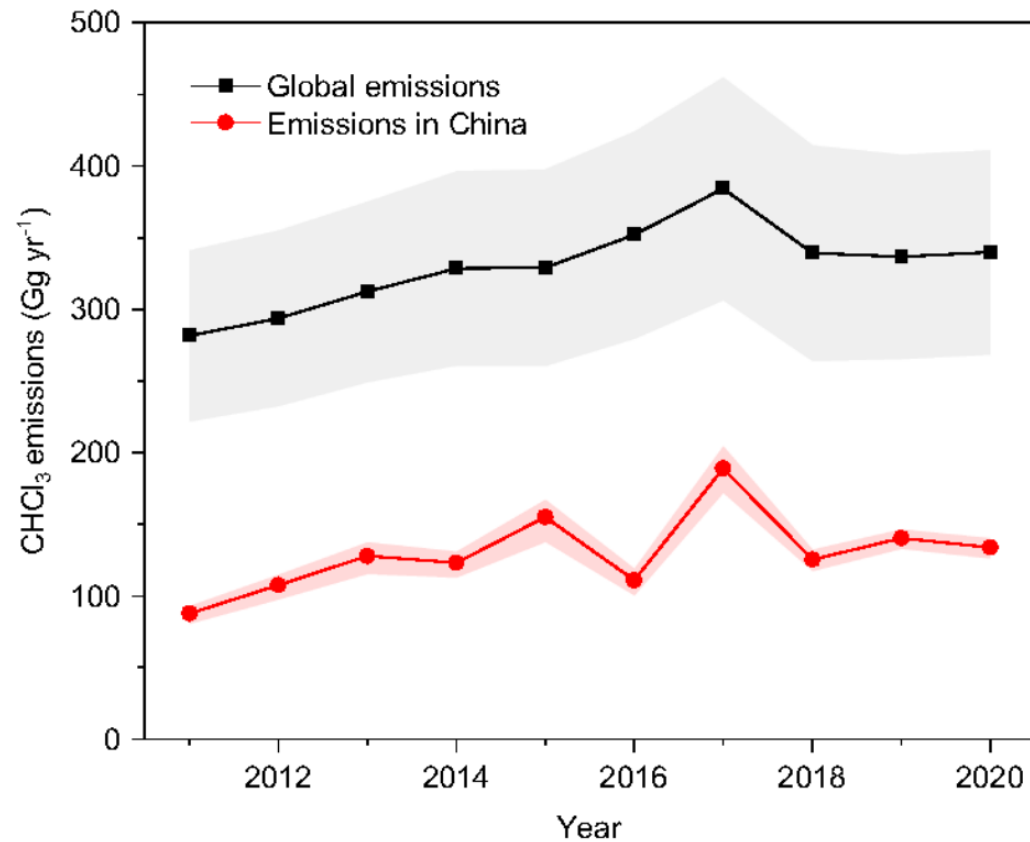
Chloroform

- The second most abundant chlorine-containing VSLs
- Less than 50% anthropogenic sources: HCFC-22 production, solvent, disinfectant/bleaching, combustion, landfill, livestock
- More than 50% natural sources: Soils, peatland, seaweed



Chloroform

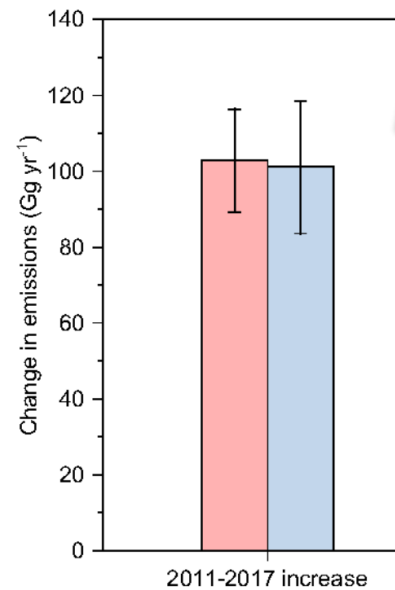
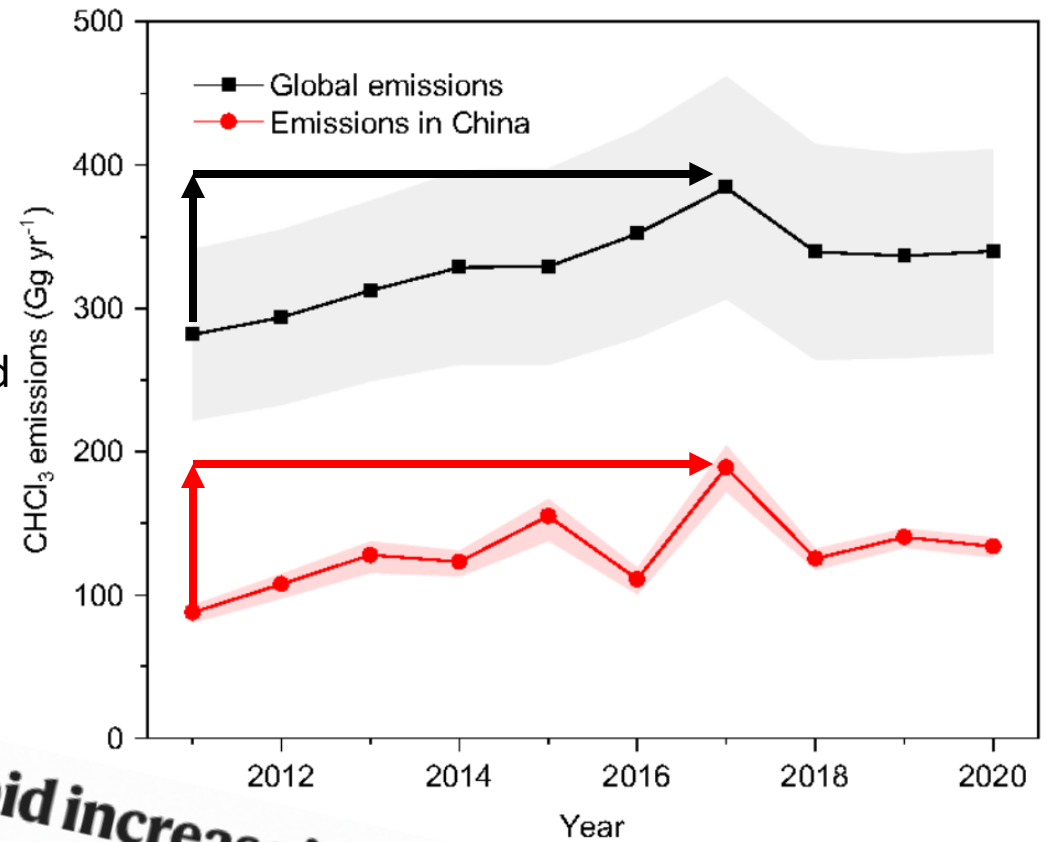
- Emissions of chloroform had risen rapidly in China until 2017



Chloroform

- Emissions of chloroform had risen rapidly in China until 2017
- The entire global rise can be explained by emissions from China

“CHCl₃ emitted from East Asia is probably more important for ozone depletion than CHCl₃ emitted from other regions of the world.”



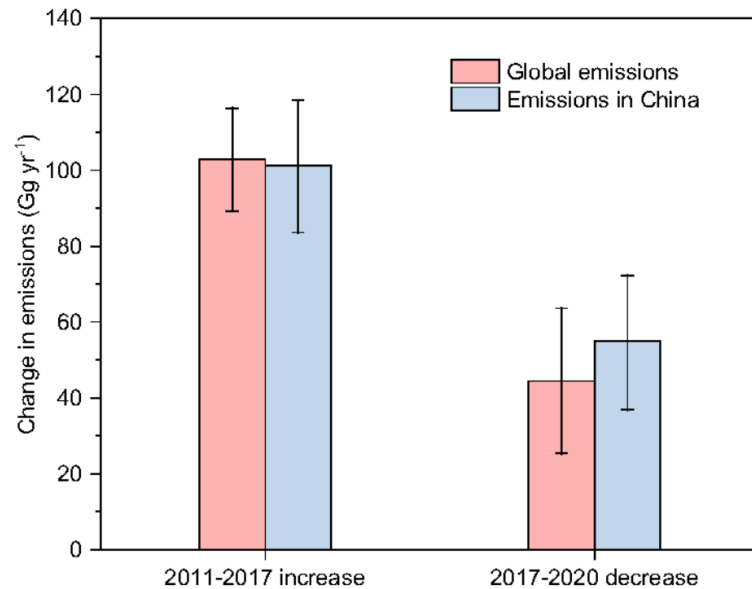
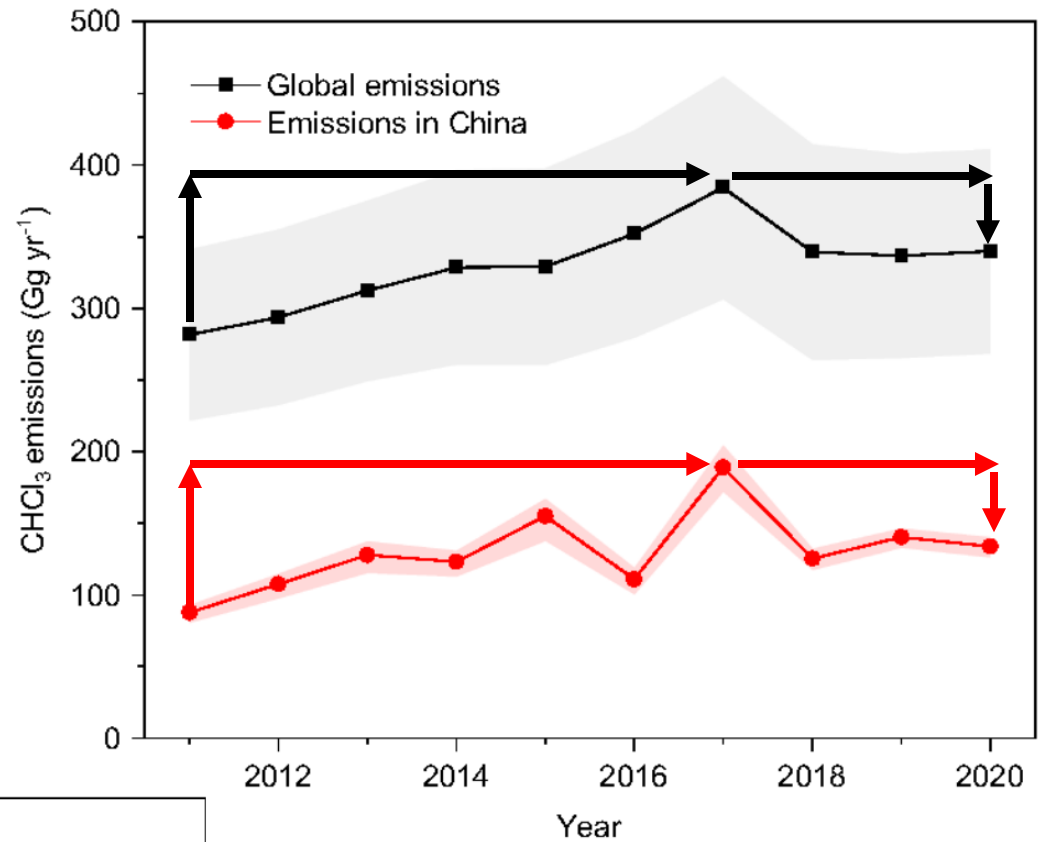
Rapid increase in ozone-depleting chloroform emissions from China
Fang et al., (2019), Nat. Geosci.

“If growth continued at the average rate observed between 2010 and 2015, the delay could be 4–8 years”

Chloroform

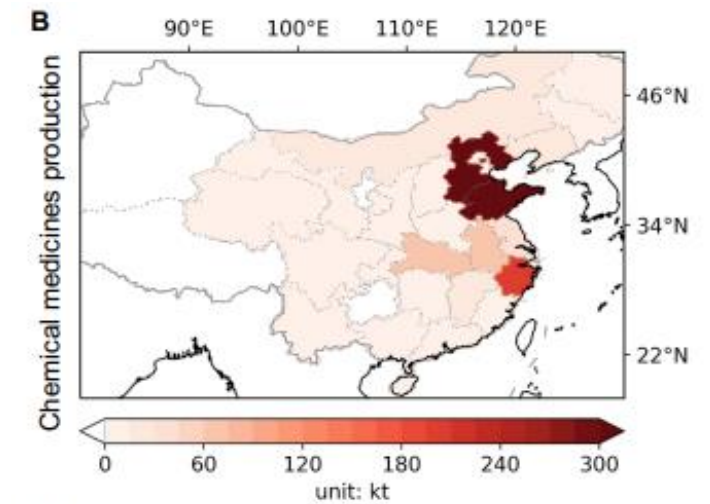
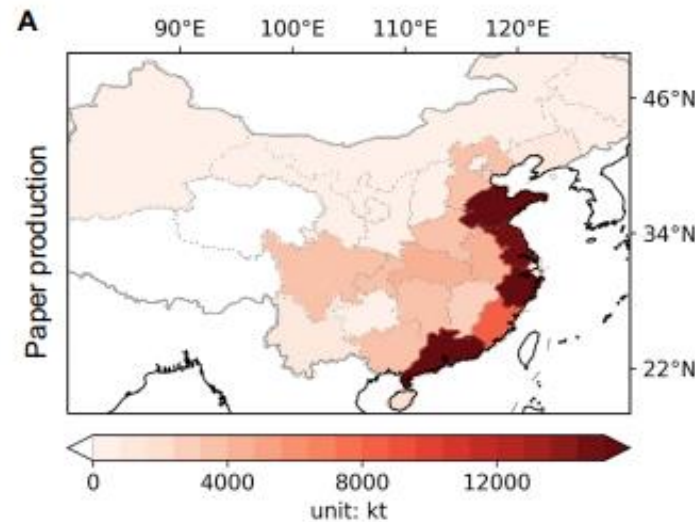
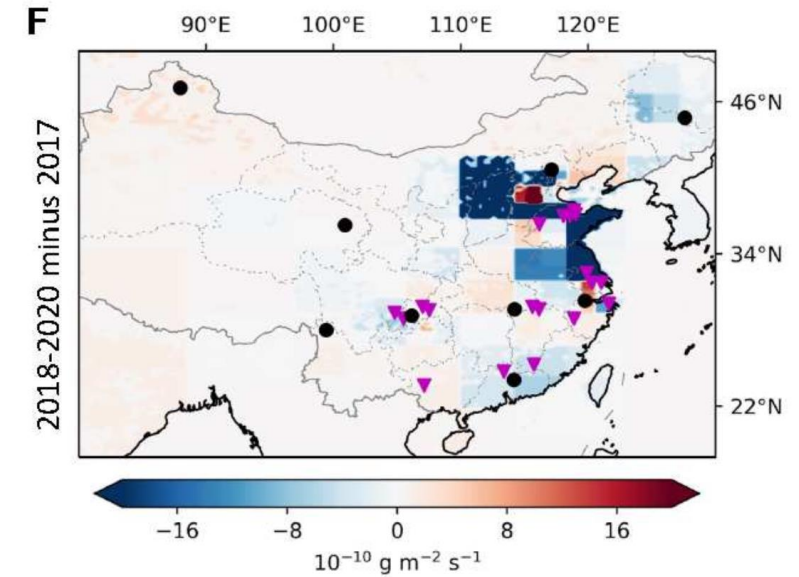
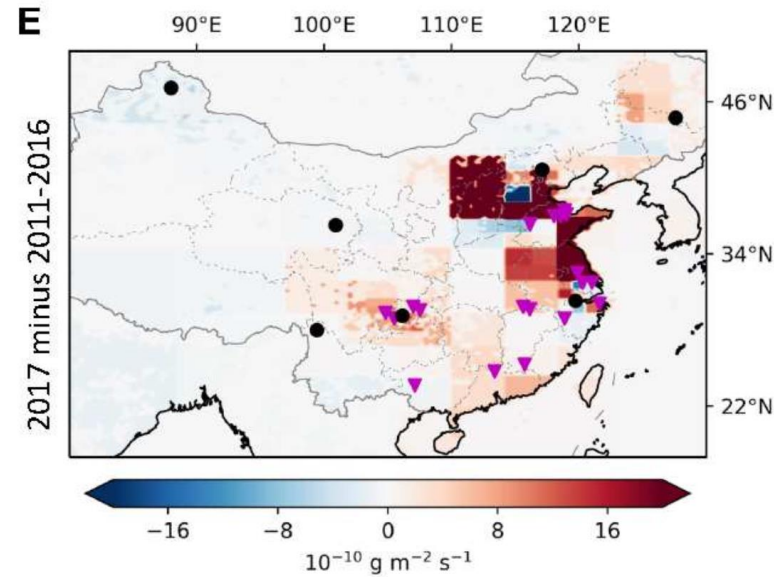
- Emissions of chloroform had risen rapidly in China until 2017
- The entire global rise can be explained by emissions from China
- Emissions have since fallen to levels seen in 2014/2015
- The entire global decrease can be explained by emissions from China

“a significant delay in the recovery of the ozone layer caused by the increasing CHCl_3 emissions could be avoided if future CHCl_3 emissions do not increase”

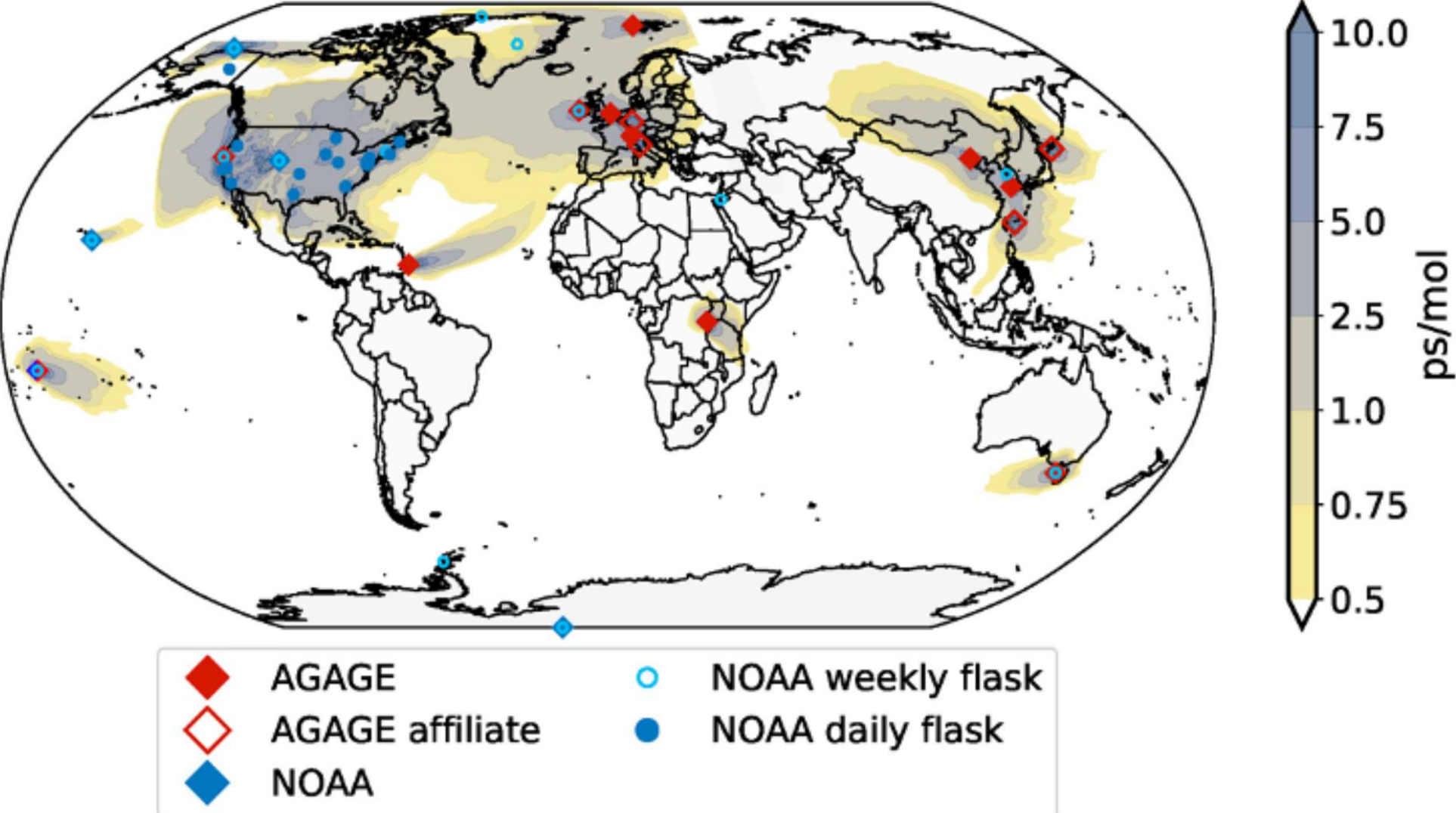


Chloroform

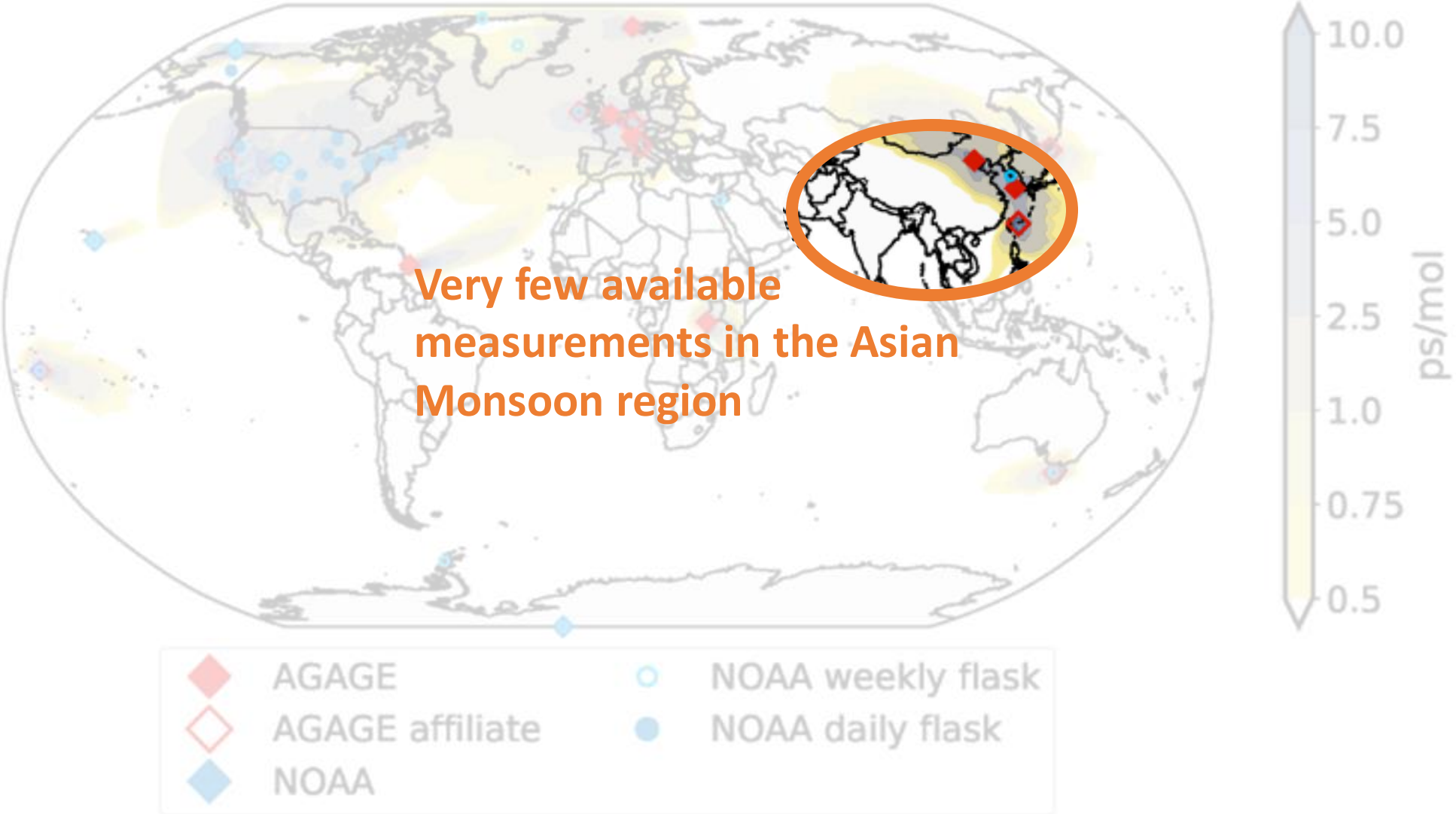
- Increase in emissions co-located with anthropogenic sources
- Largest emissions as by-product from paper and pulp industry
- Other emissions from by-product and feedstock leakage
- Natural emissions unlikely to be driver



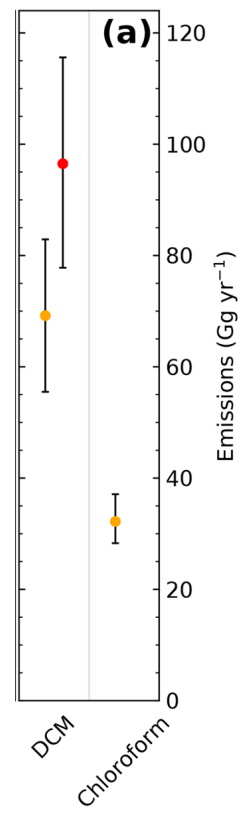
Shading shows regions where we can confidently quantify emissions using long-term publicly available data



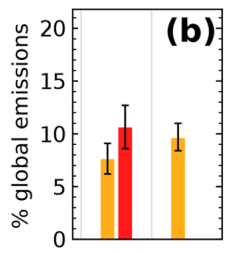
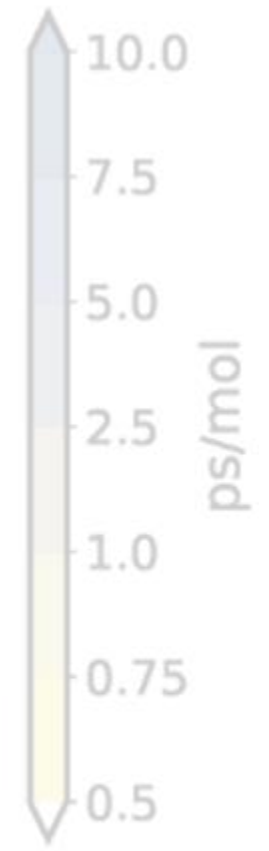
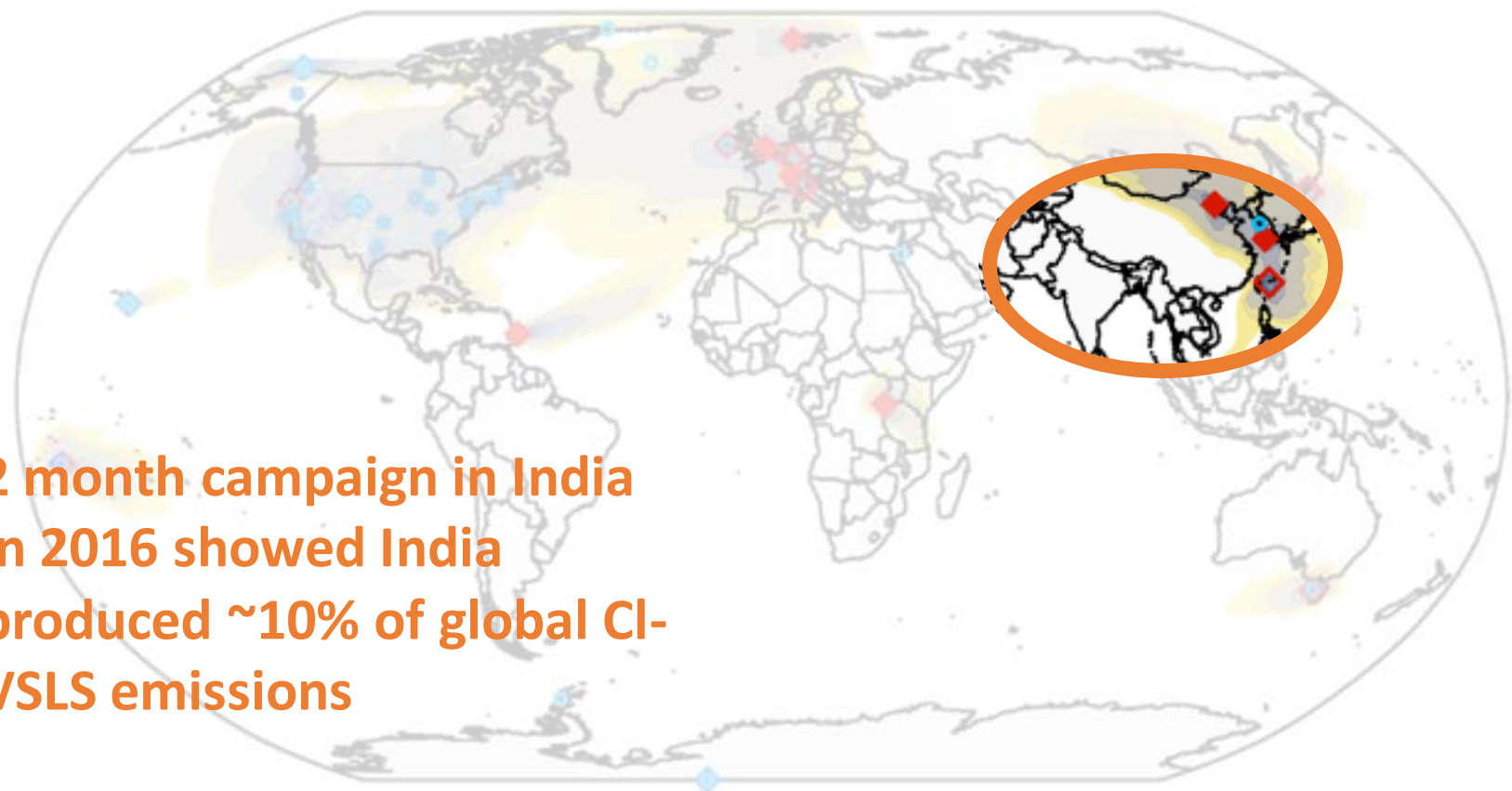
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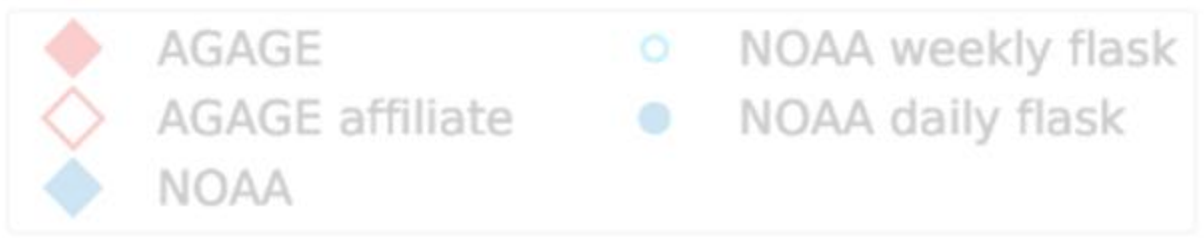
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2 month campaign in India in 2016 showed India produced ~10% of global Cl-VSLS emissions

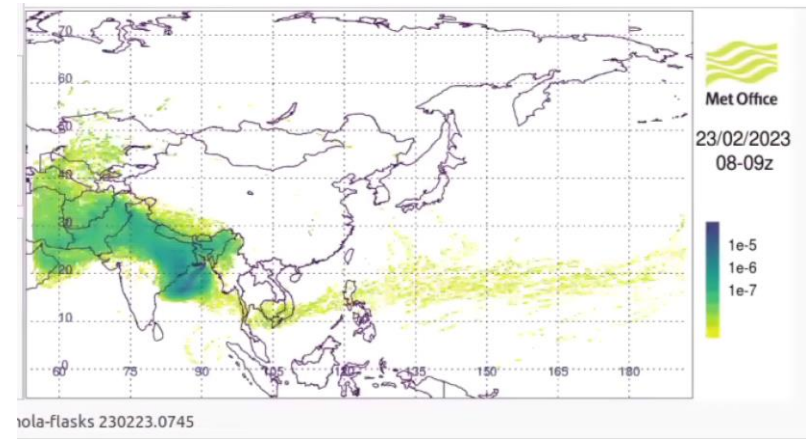
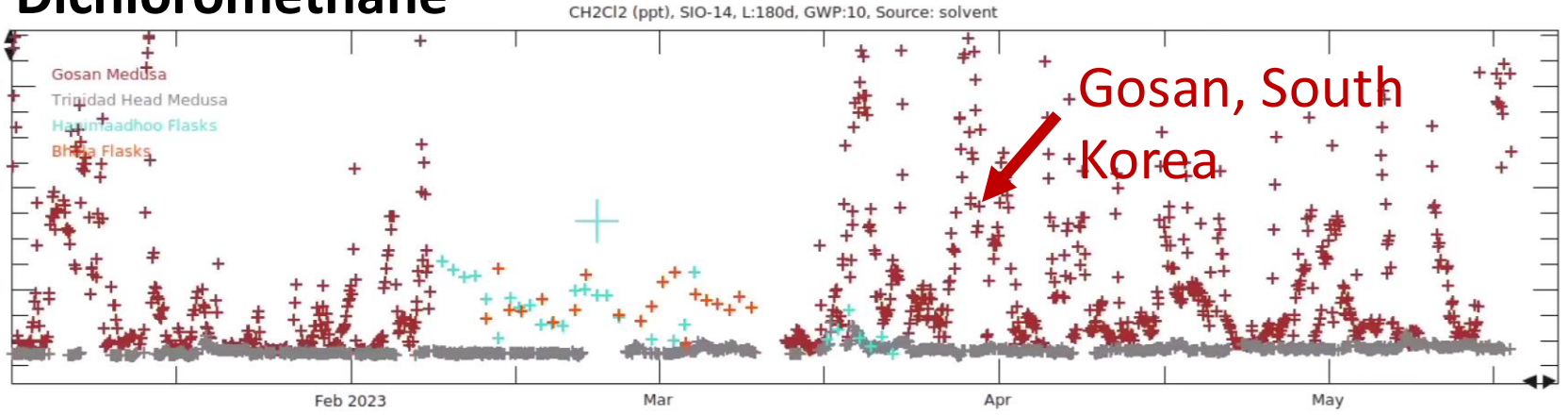


Say et al., (2019), ACP

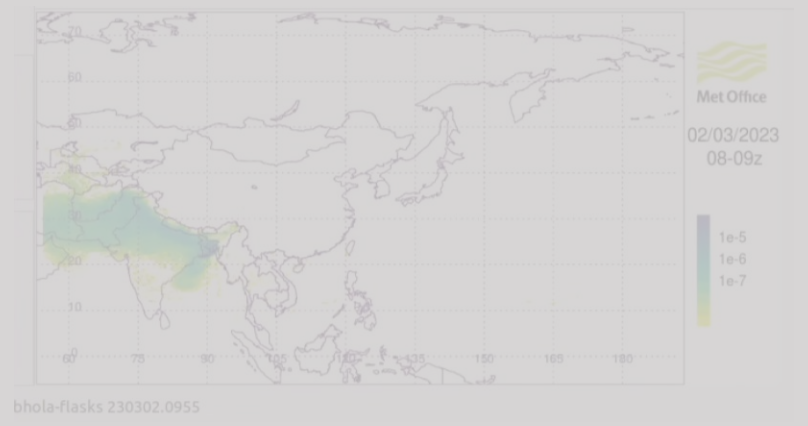
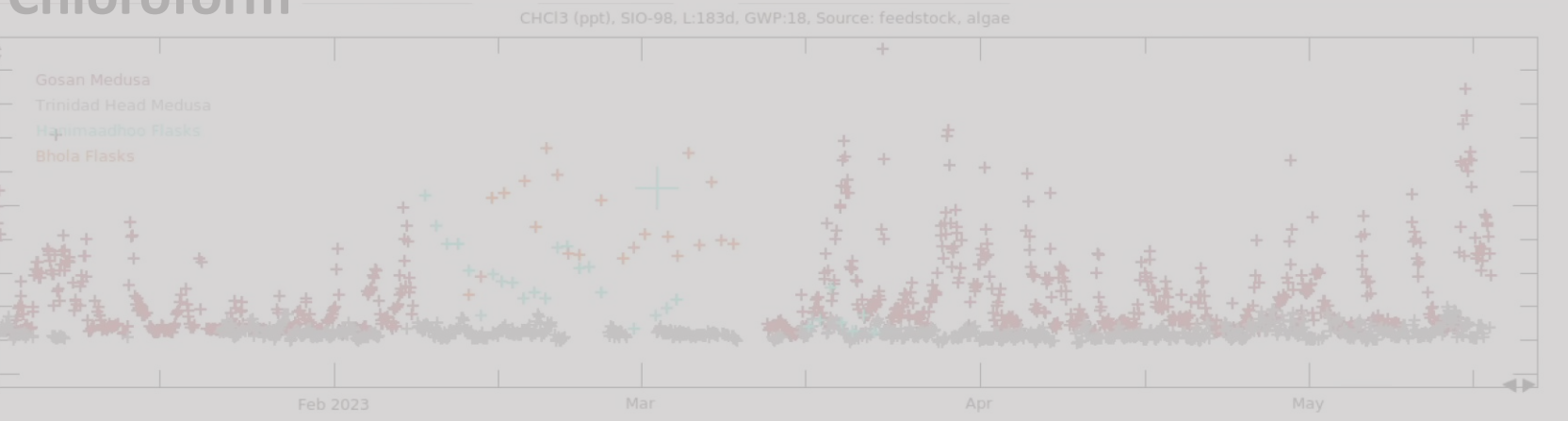


New measurements at Bhola in Bangladesh

Dichloromethane

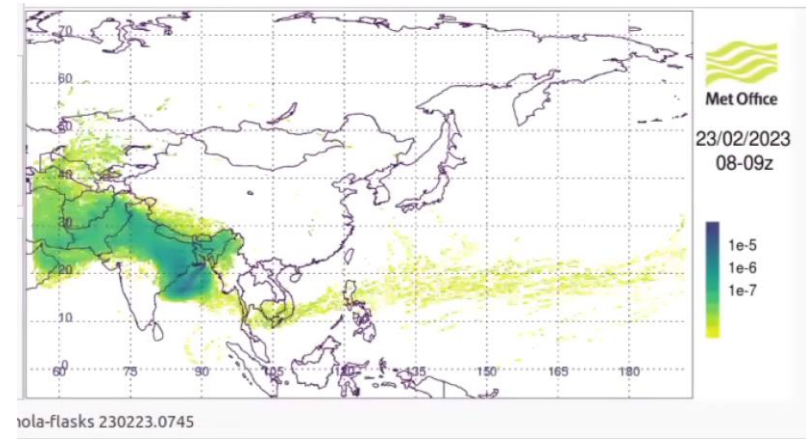
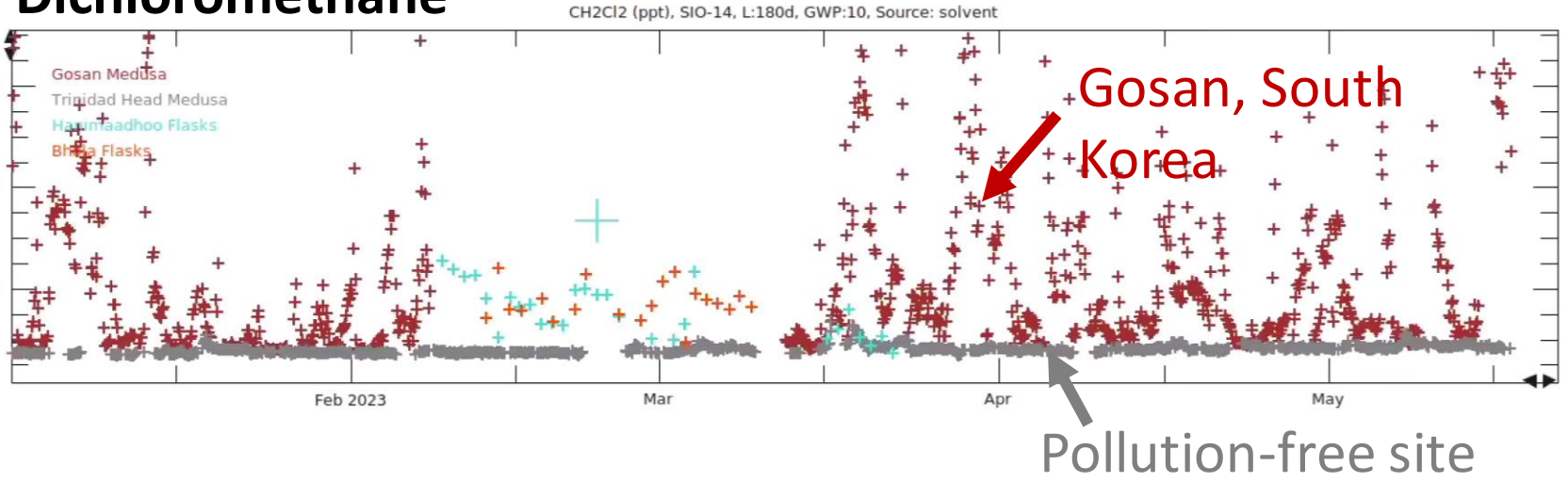


Chloroform

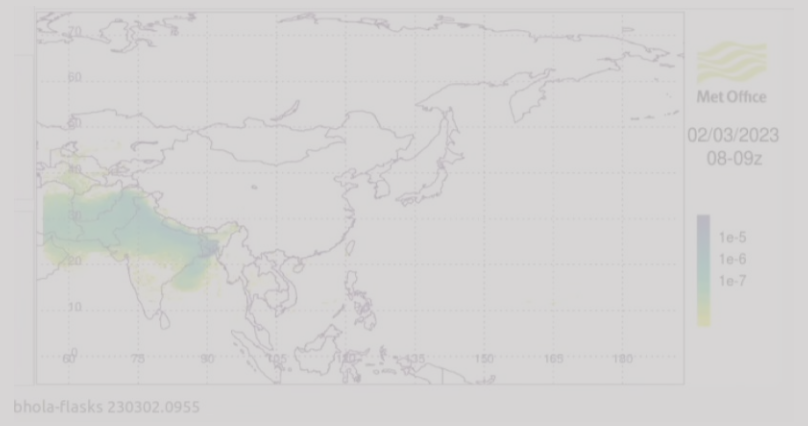
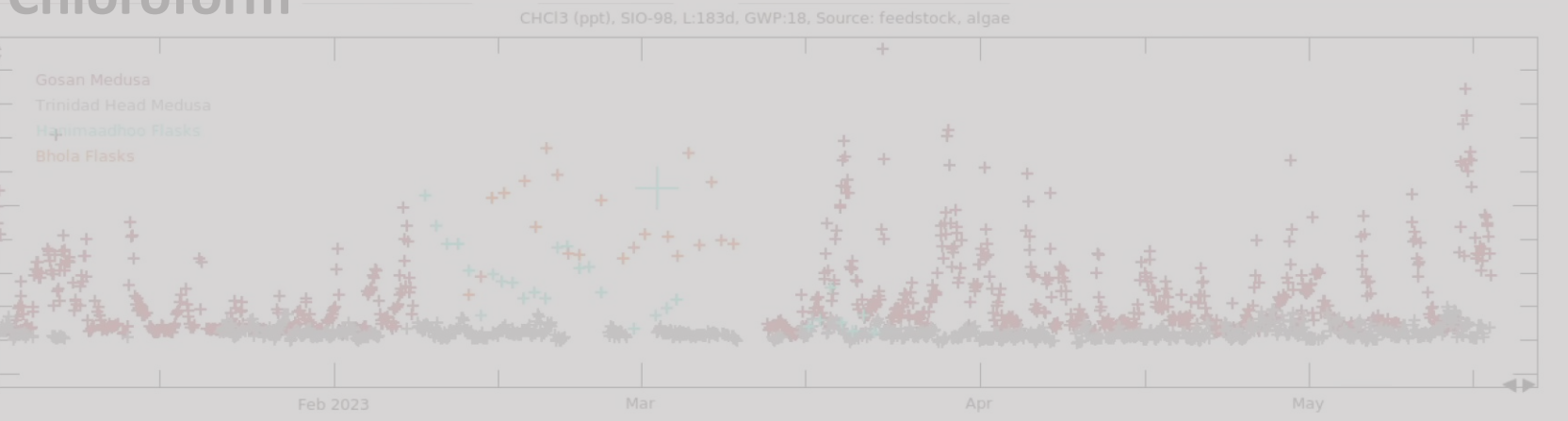


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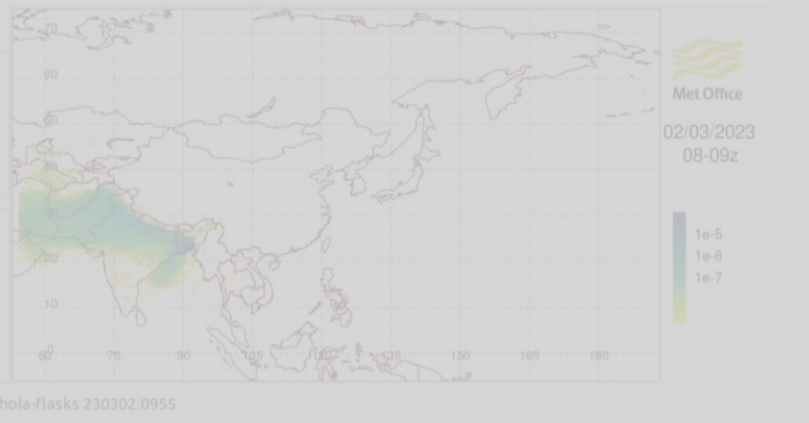
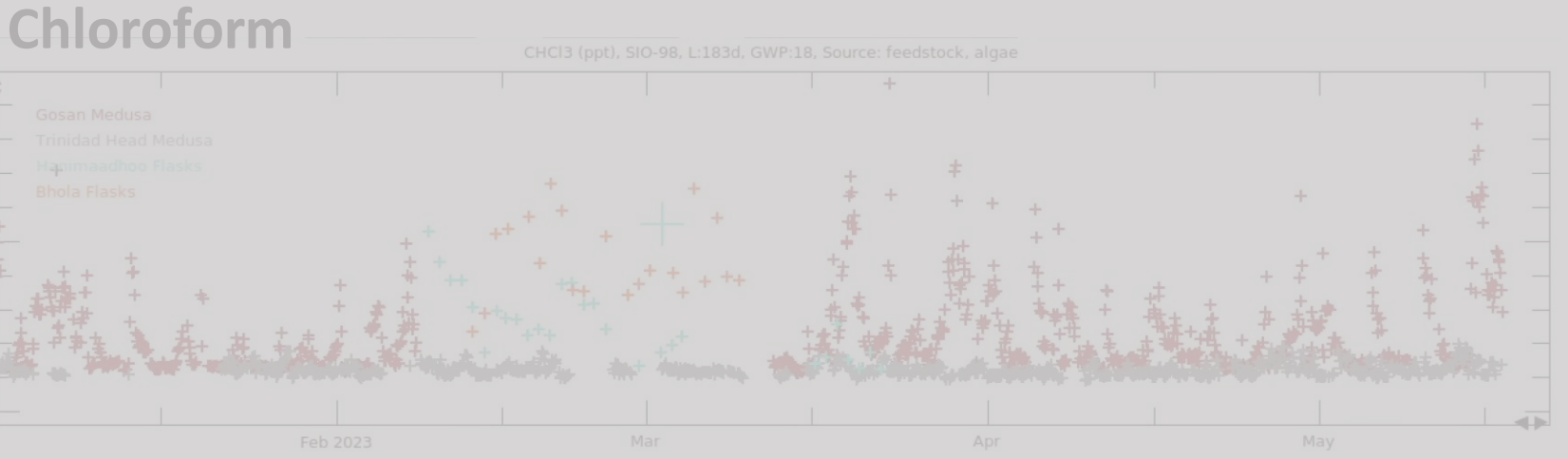
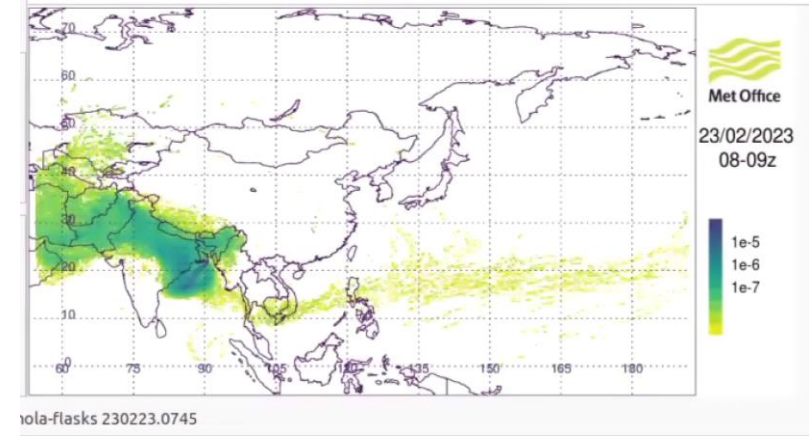
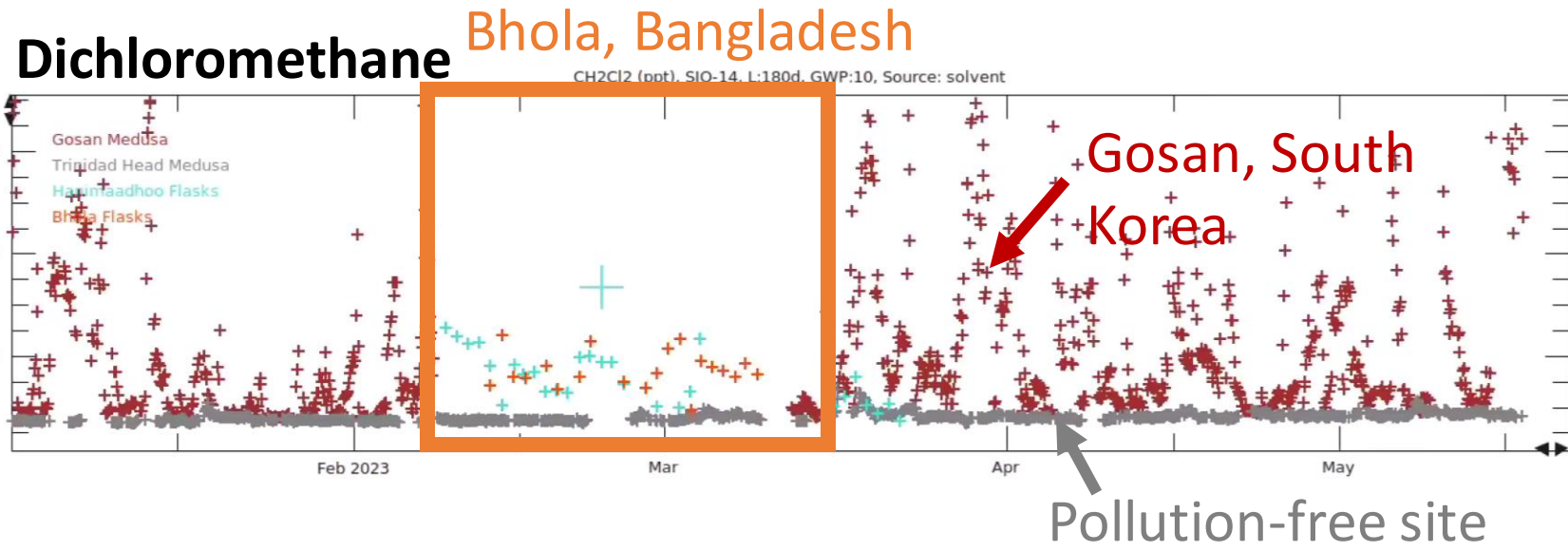
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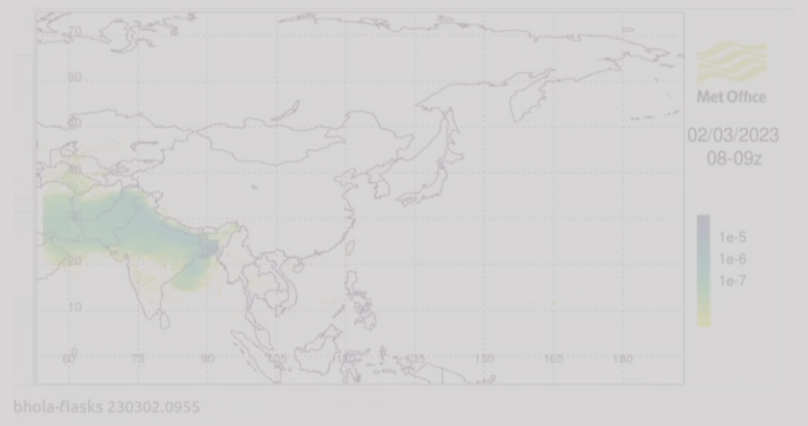
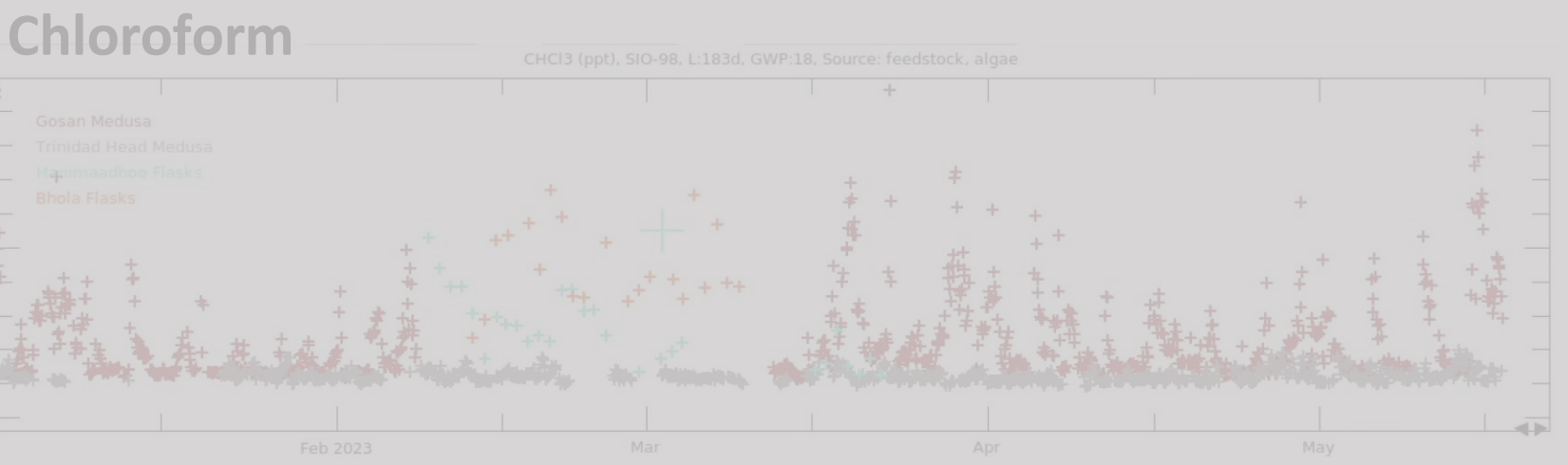
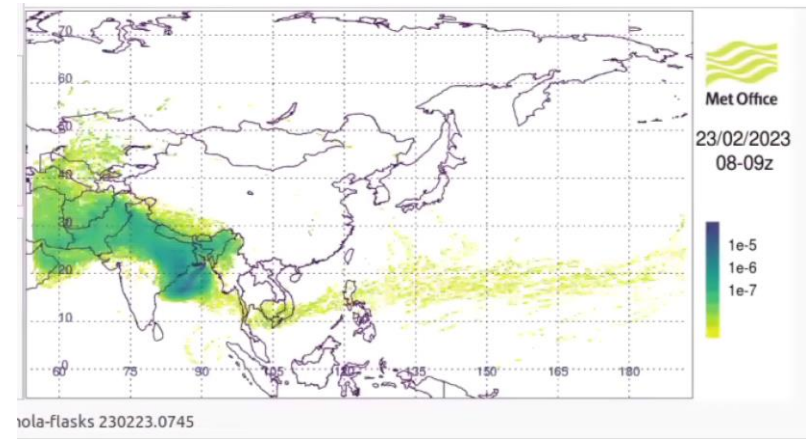
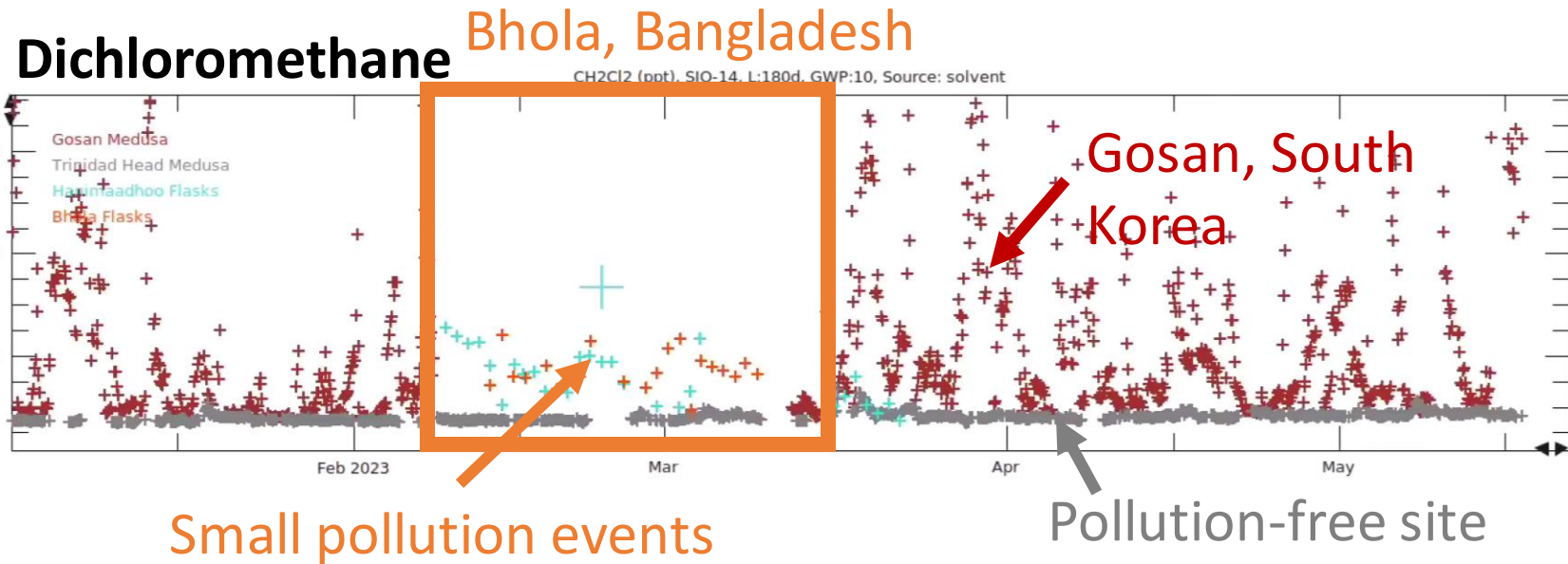
Chloroform



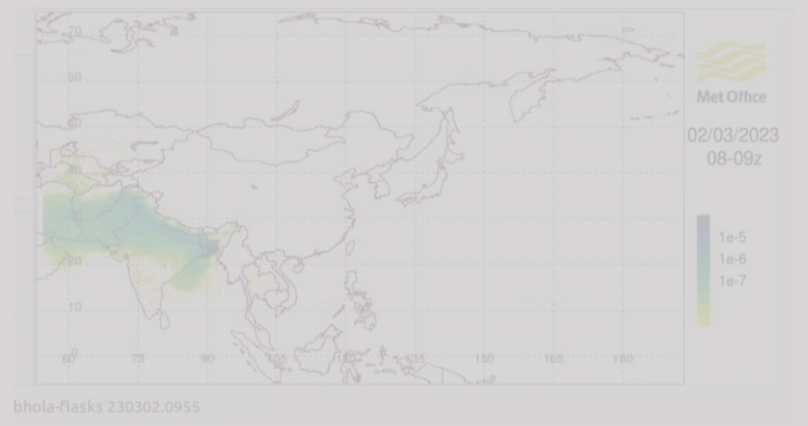
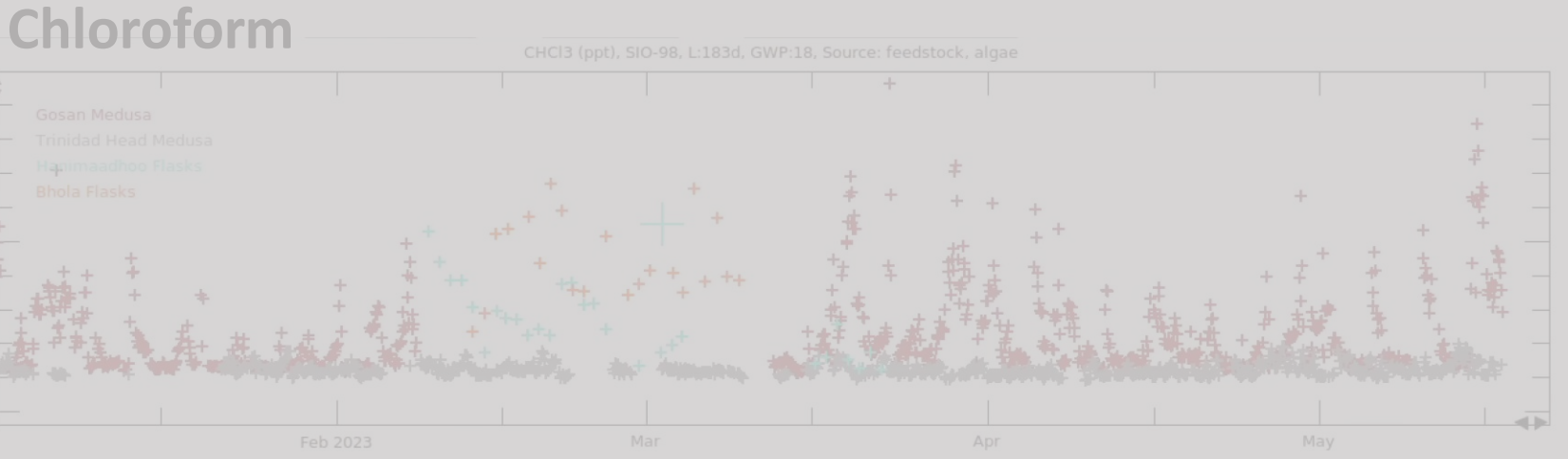
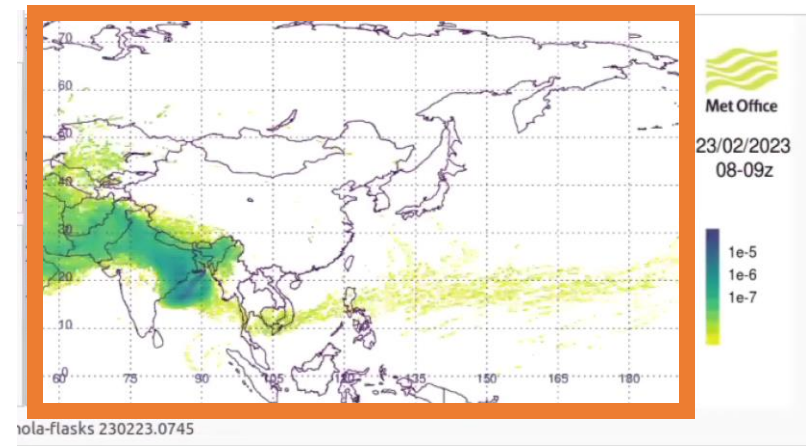
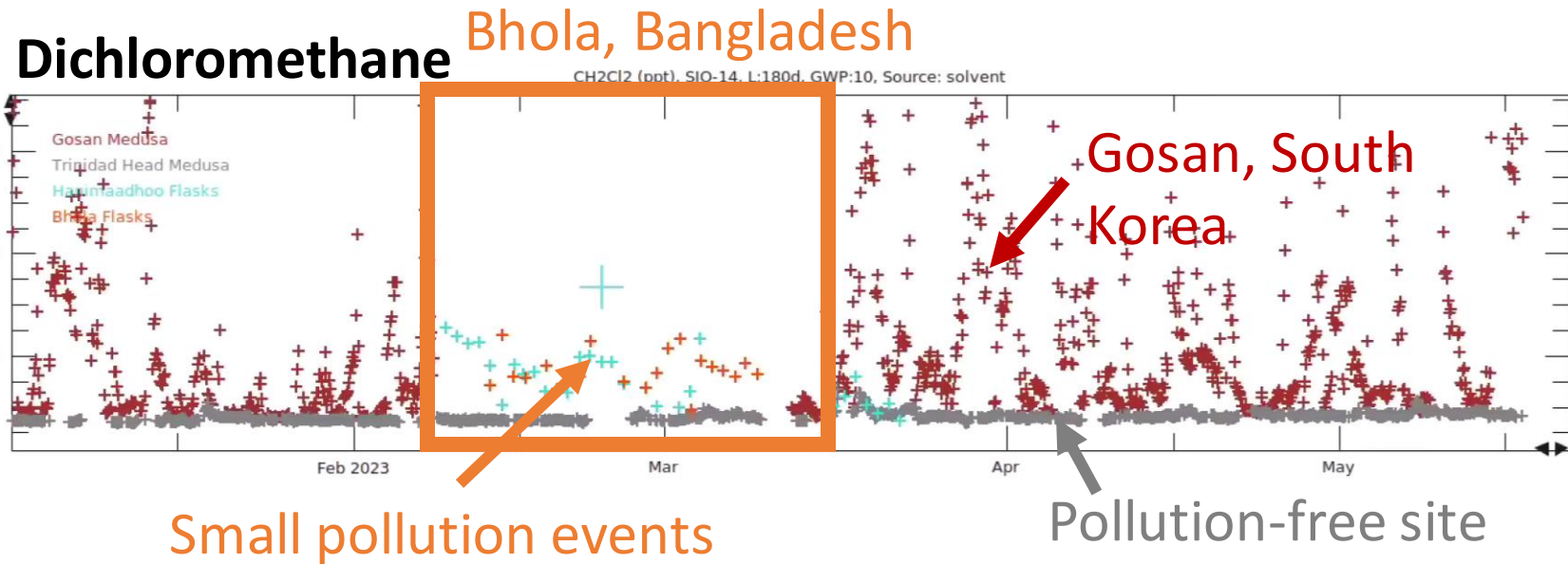
New measurements at Bhola in Bangladesh



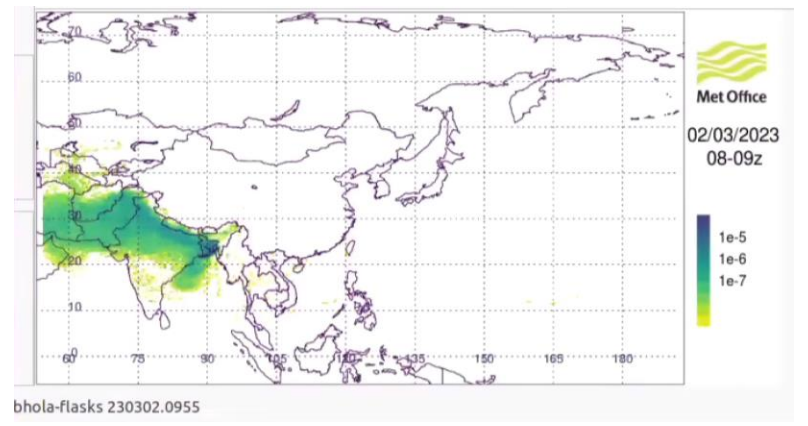
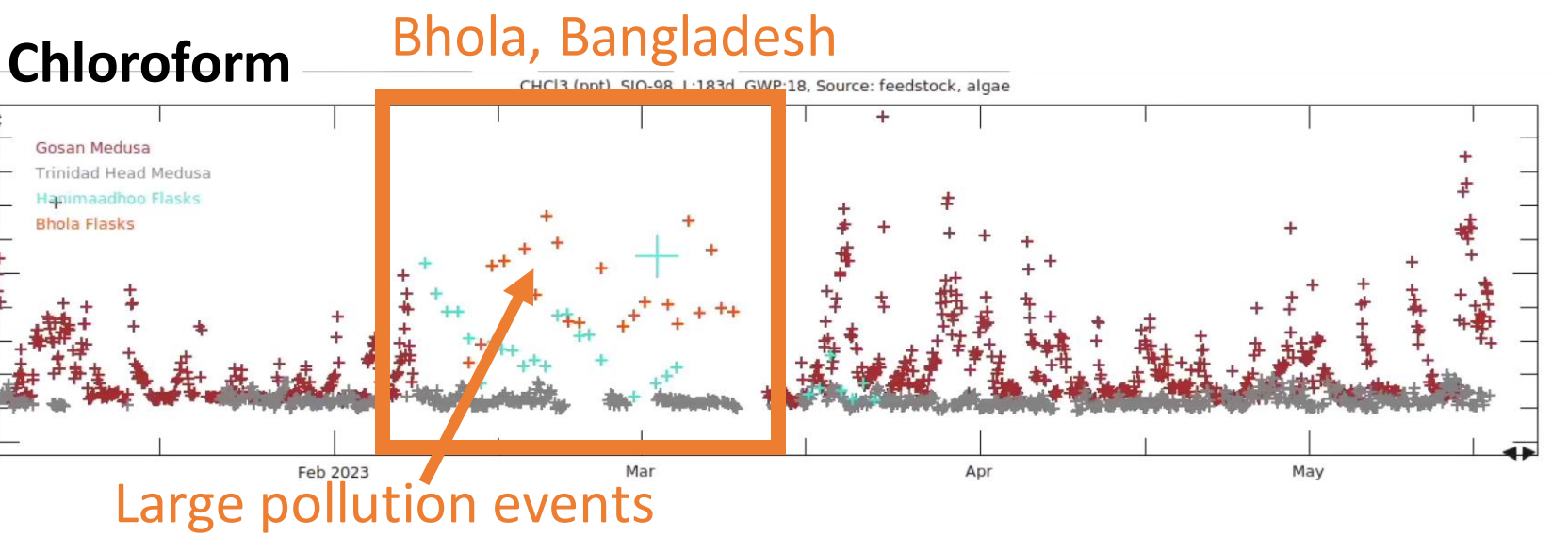
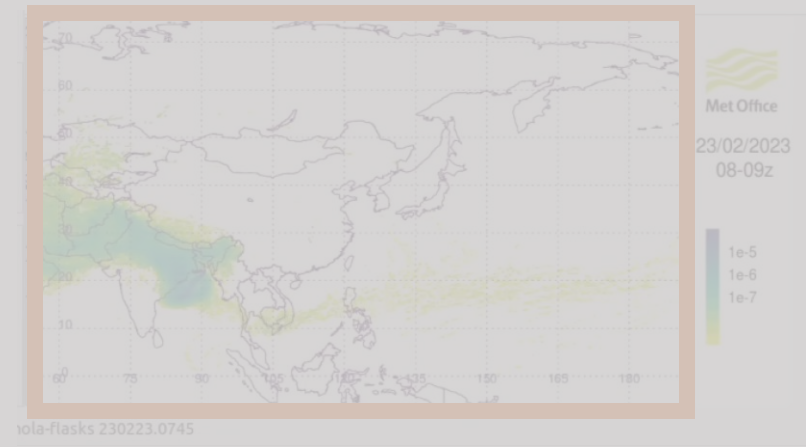
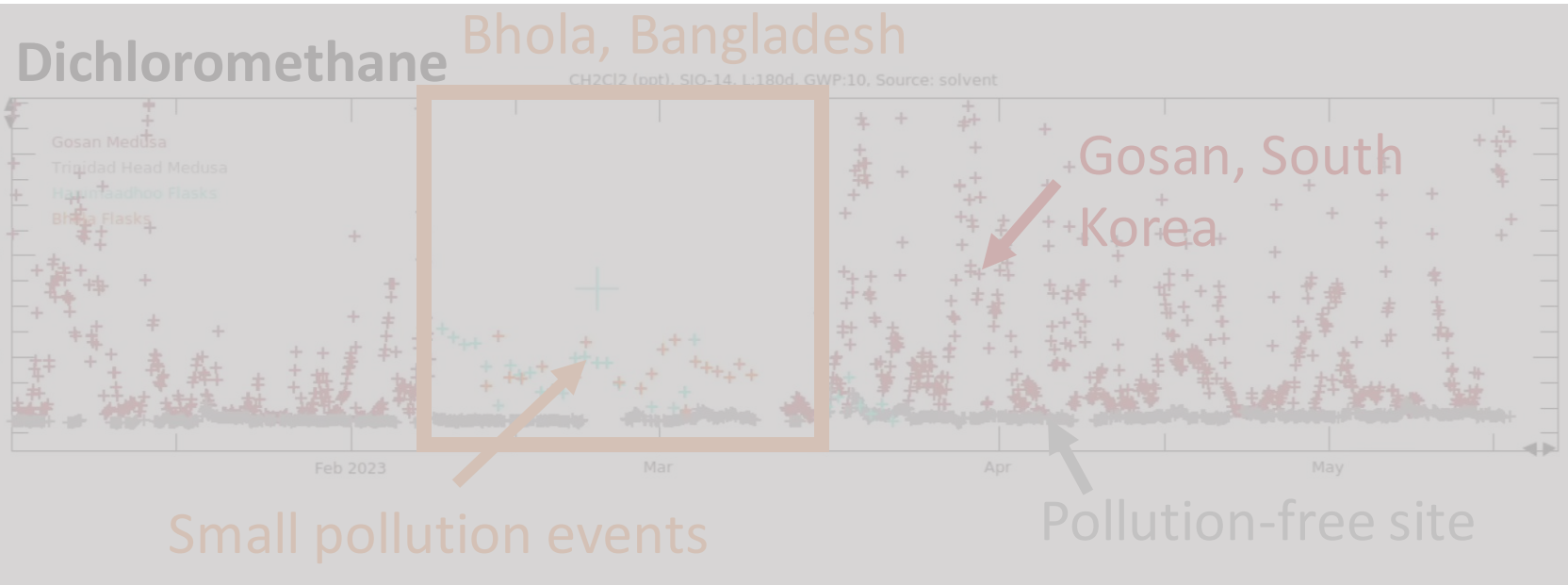
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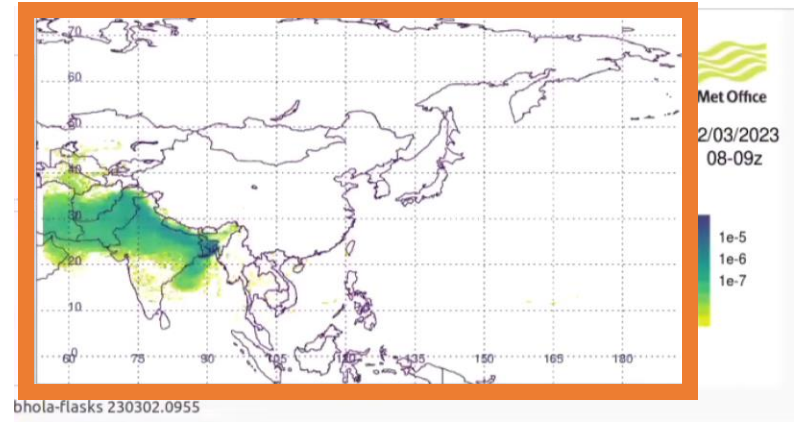
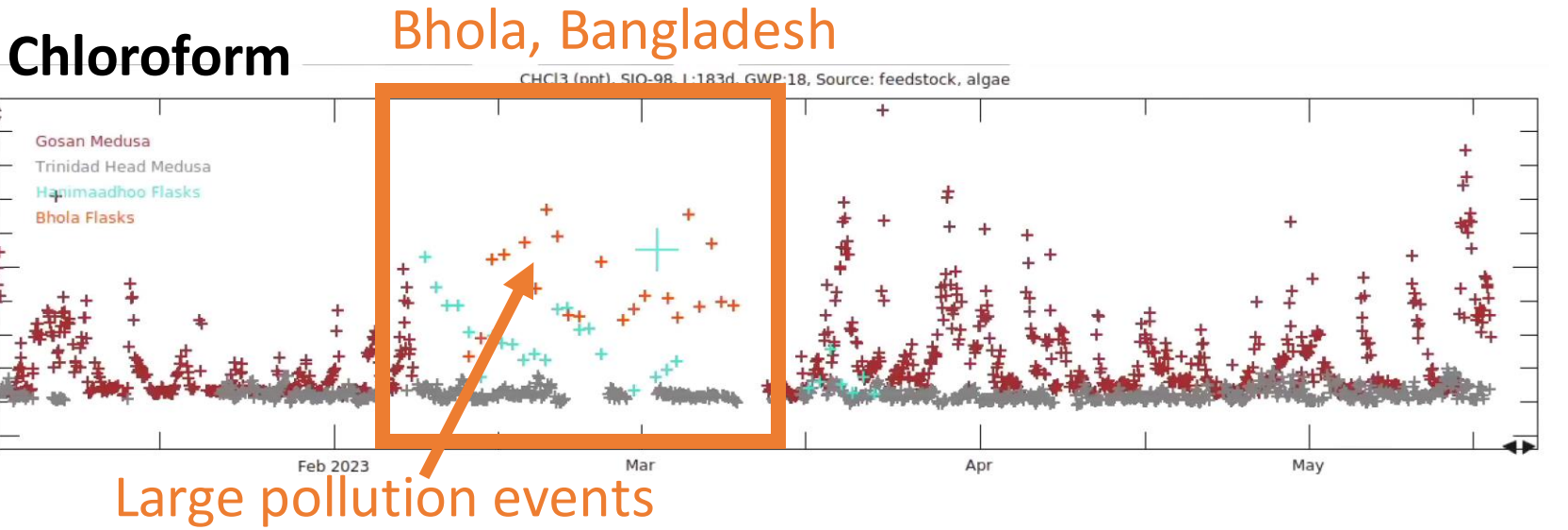
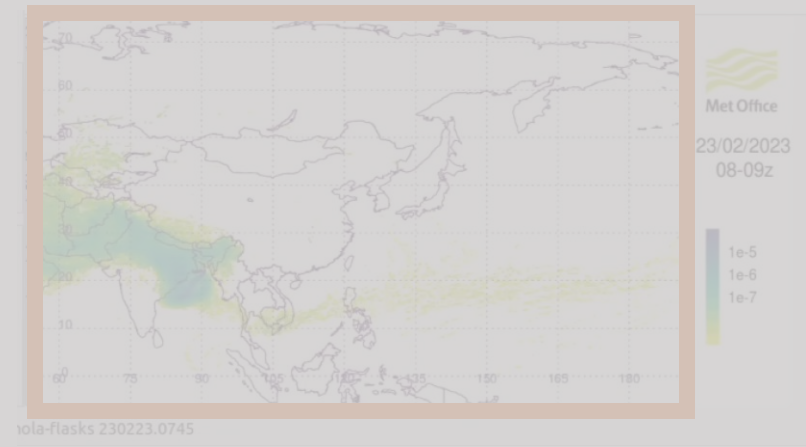
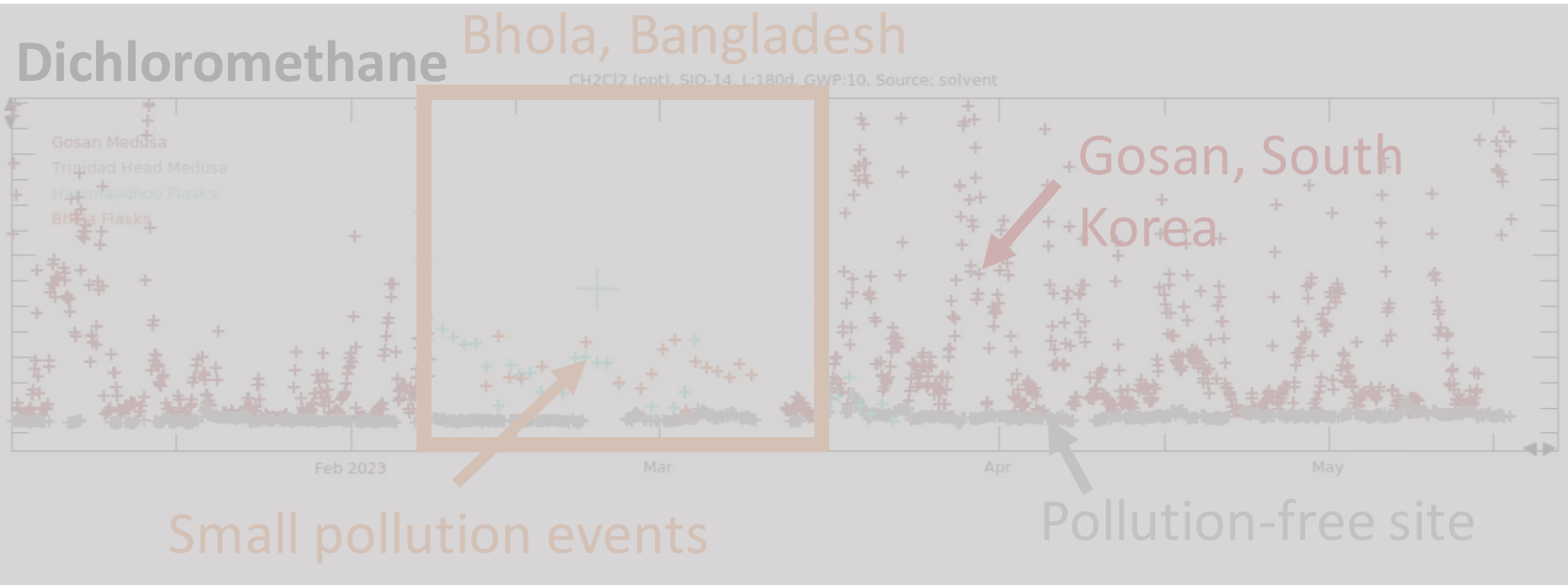
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New measurements at Bhola in Bangladesh



New measurements at Bhola in Bangladesh



Conclusions

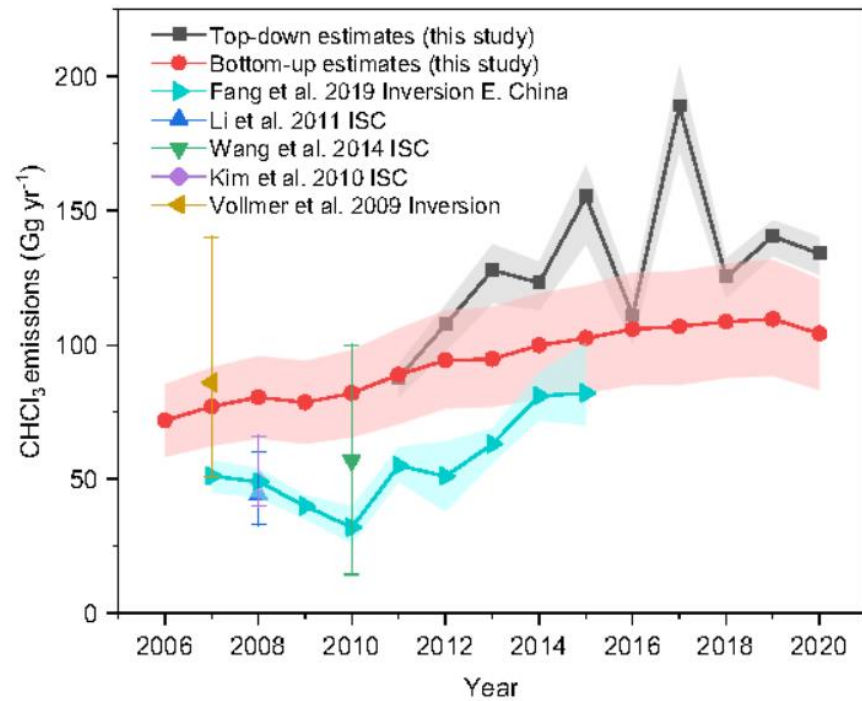
Emissions of VSLS in the Asian Monsoon Region are particularly important for ozone depletion due to their rapid transport into the upper troposphere-lower stratosphere

This region is responsible for a large (perhaps majority) of global anthropogenic VSLS emissions



Extra slide

A



B

