

## A Planetary Boundary threat: Trifluoroacetic acid (TFA) from F-gases

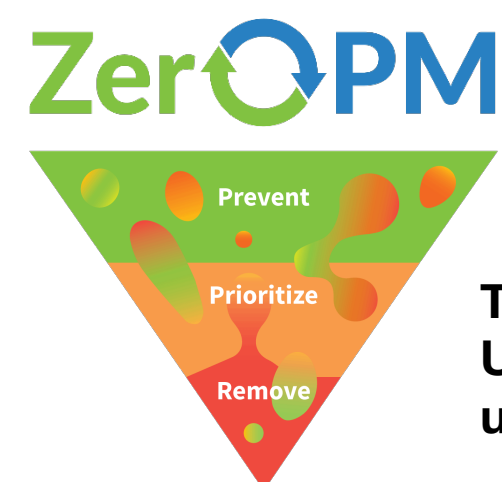
**Hans Peter H. Arp**

Norwegian Geotechnical Institute (NGI)

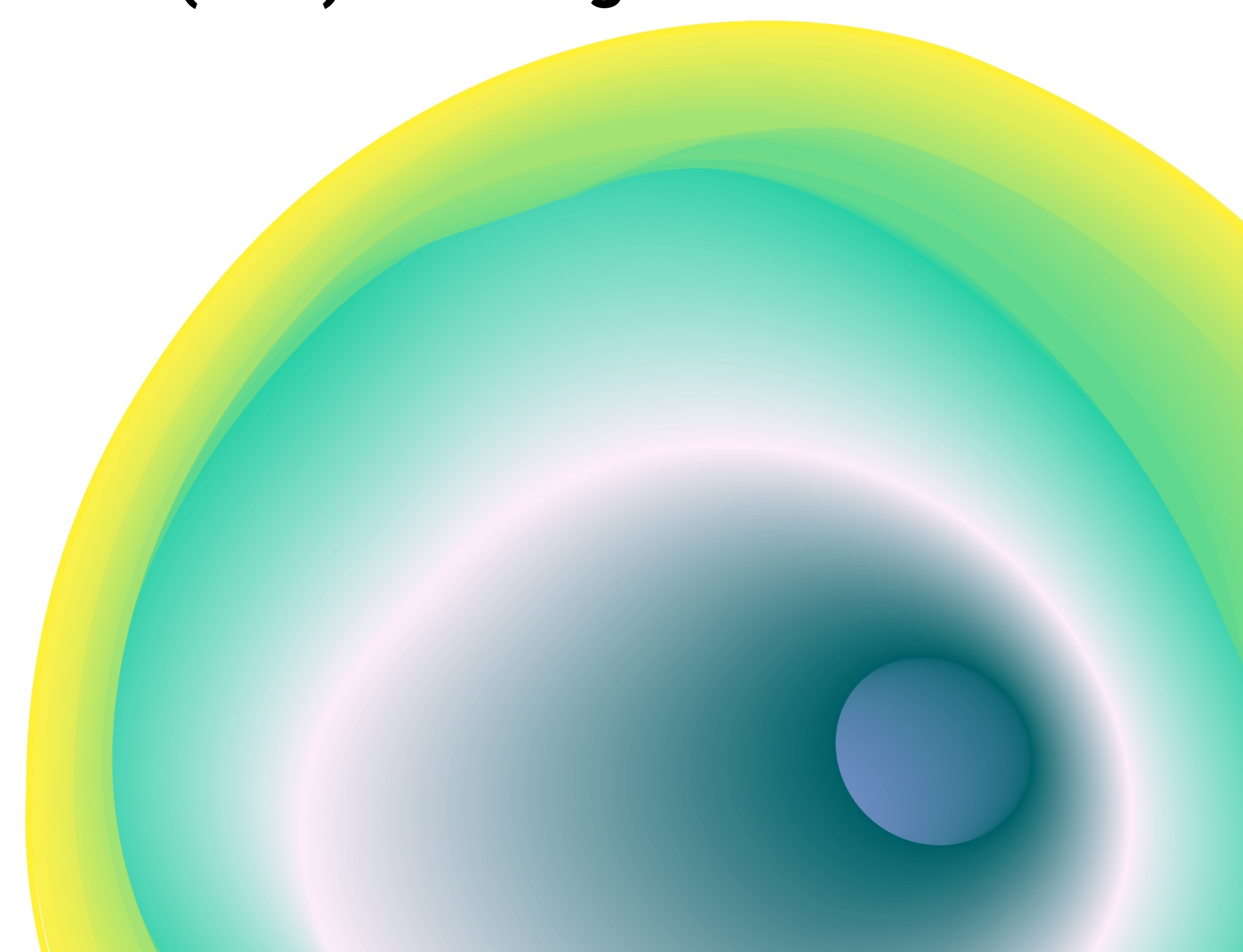
Norwegian University of Science and Technology (NTNU)

Contact:

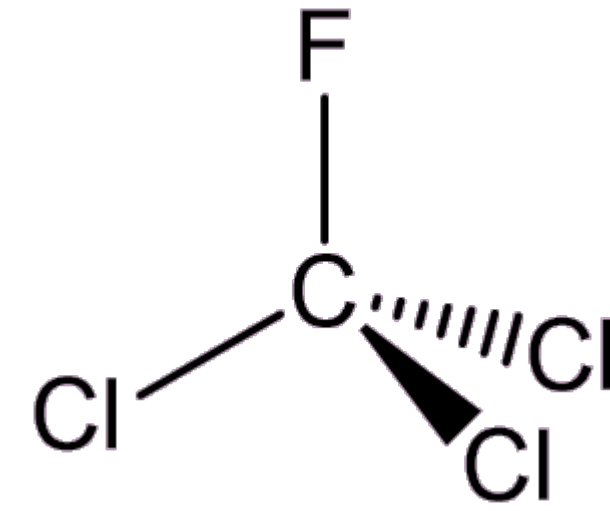
[hans.peter.arp@ngi.no](mailto:hans.peter.arp@ngi.no)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036756



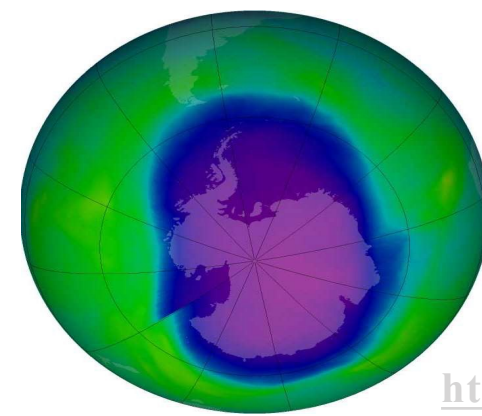
## James Lovelock (1919 – 2022)



- Invented the Electron Capture Detector (ECD)
- First to detect chlorofluorocarbons (CFCs) in the atmosphere
- Formulated the “Gaia hypothesis”

- CFCs pose “no conceivable hazard”

*Lovelock J (1988). The Ages of Gaia: A Biography of Our Living Earth*

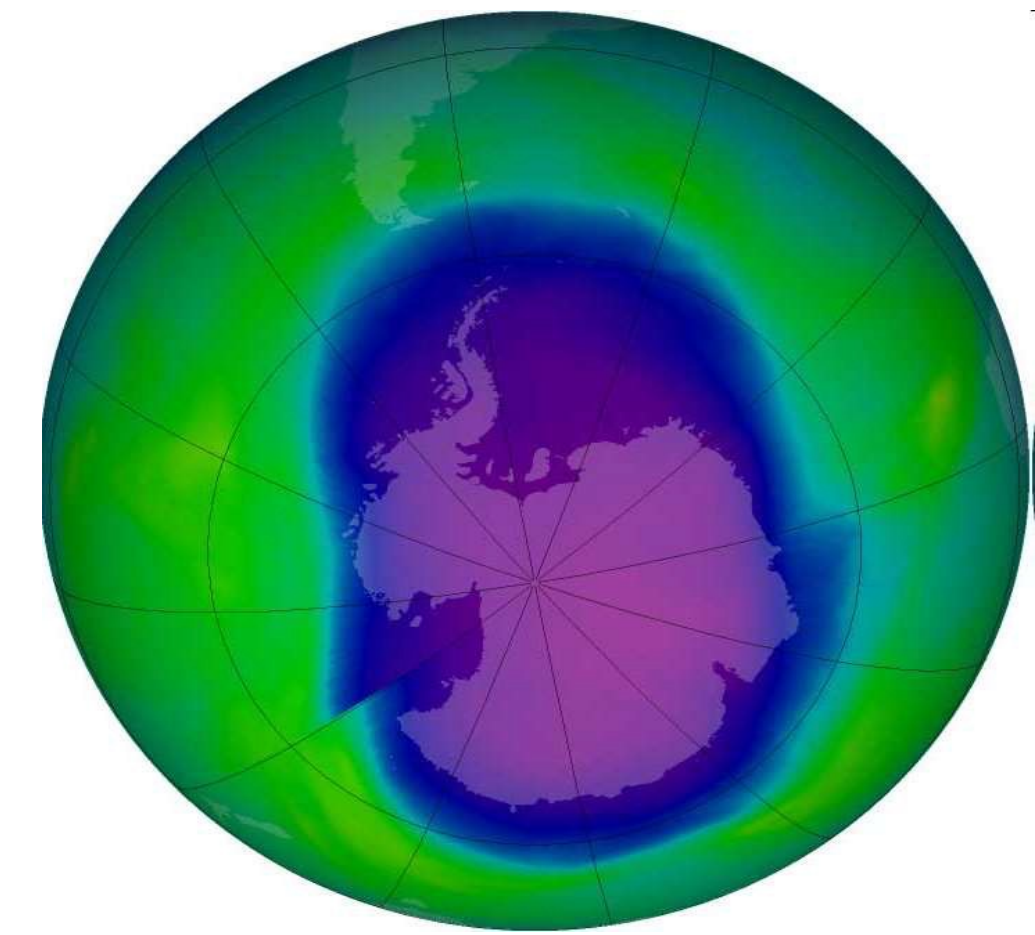
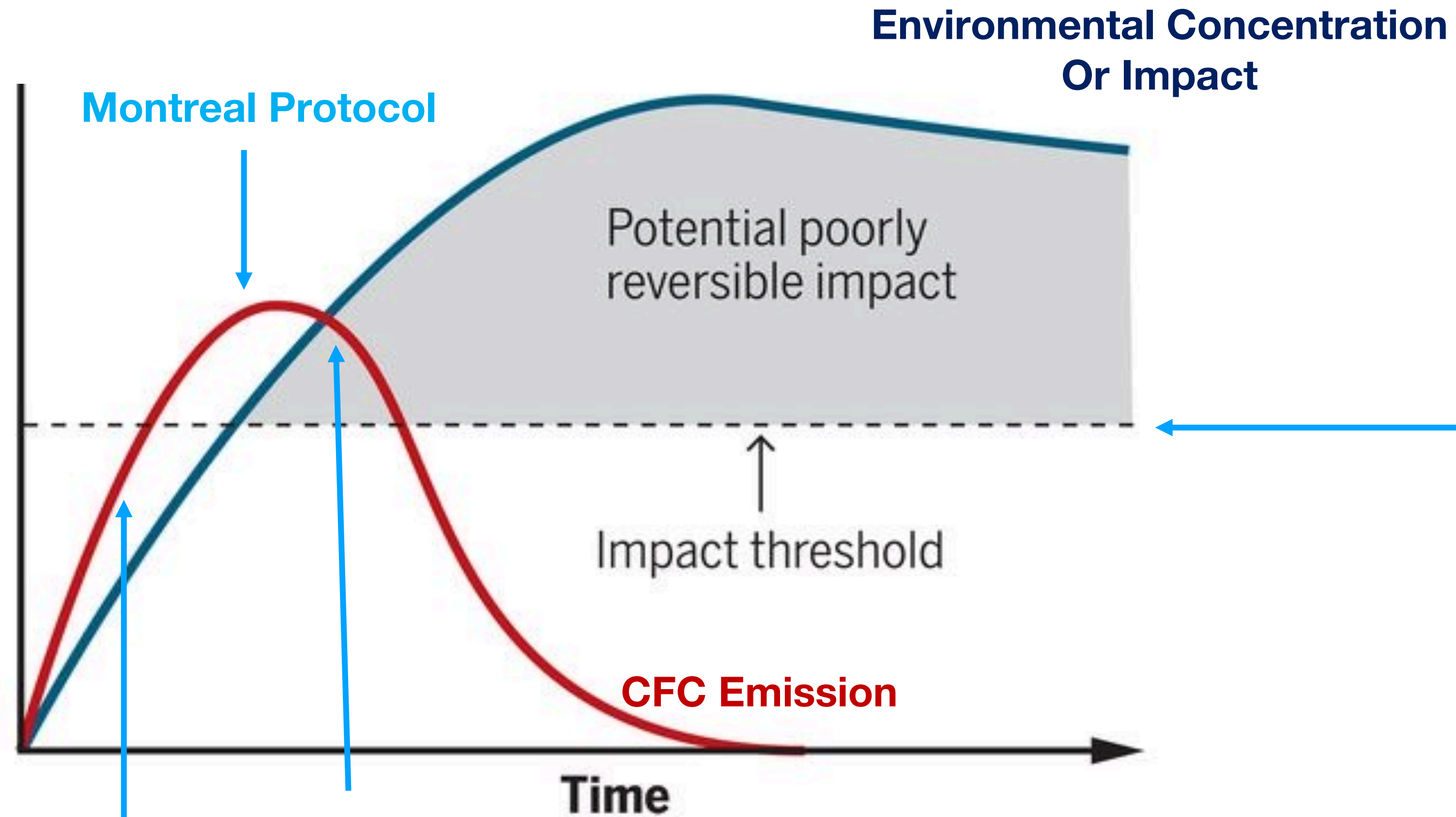


[http://www.nasa.gov/vision/earth/environment/ozone\\_resource\\_page.html](http://www.nasa.gov/vision/earth/environment/ozone_resource_page.html)

- CFCs pose “no conceivable **toxic** hazard”

*Lovelock J (2000). Homage to Gaia: The Life of an Independent Scientist*





CFCs pose “no conceivable hazard”

CFCs pose “no conceivable **toxic** hazard”

## ***Now we are detecting a new substance increasing in water and blood***

### Nyt stof fundet i grundvandet

27-01-2021

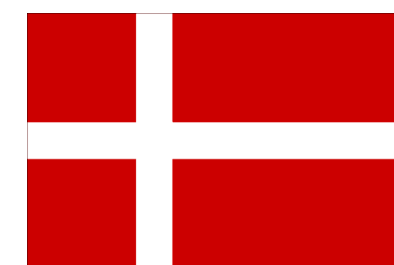
Vandmiljø Vand i hverdagen Kemikalier NOVANA

Kølemidler fra klimaanlæg og drivmidler fra spraydåser kan være kilder til stoffet TFA, som i ny undersøgelse er fundet vidt udbredt i grundvandsprøver. Intet tyder på, at der er en sundhedsrisiko.



Udtagning af vandprøver fra grundvandet. Arkivfoto: Miljøstyrelsen.

**«New substance found in groundwater»**



**Found in 219 of 247 groundwater wells  
Up to 2.4 µg/L**

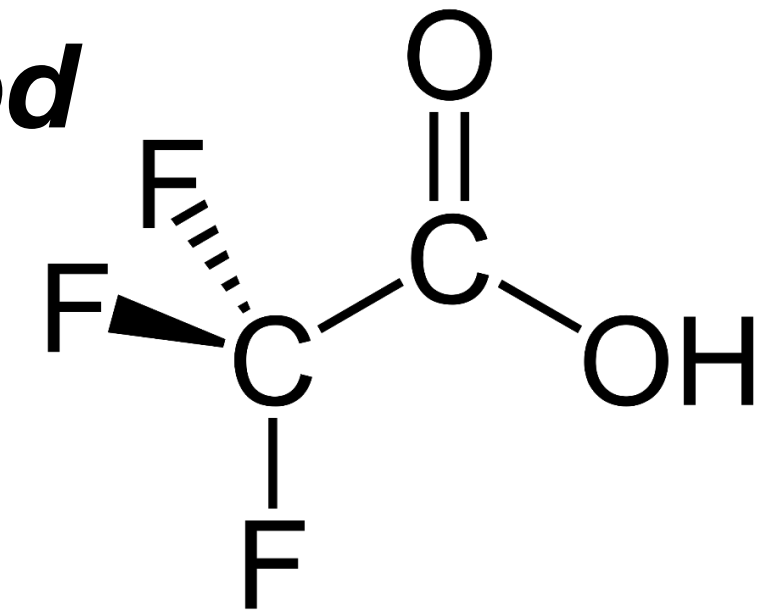


**Tap water up to 20 µg/L  
River water up to 120 µg/L**



**Chinese blood 97% detection  
Median 8.5 µg/L**

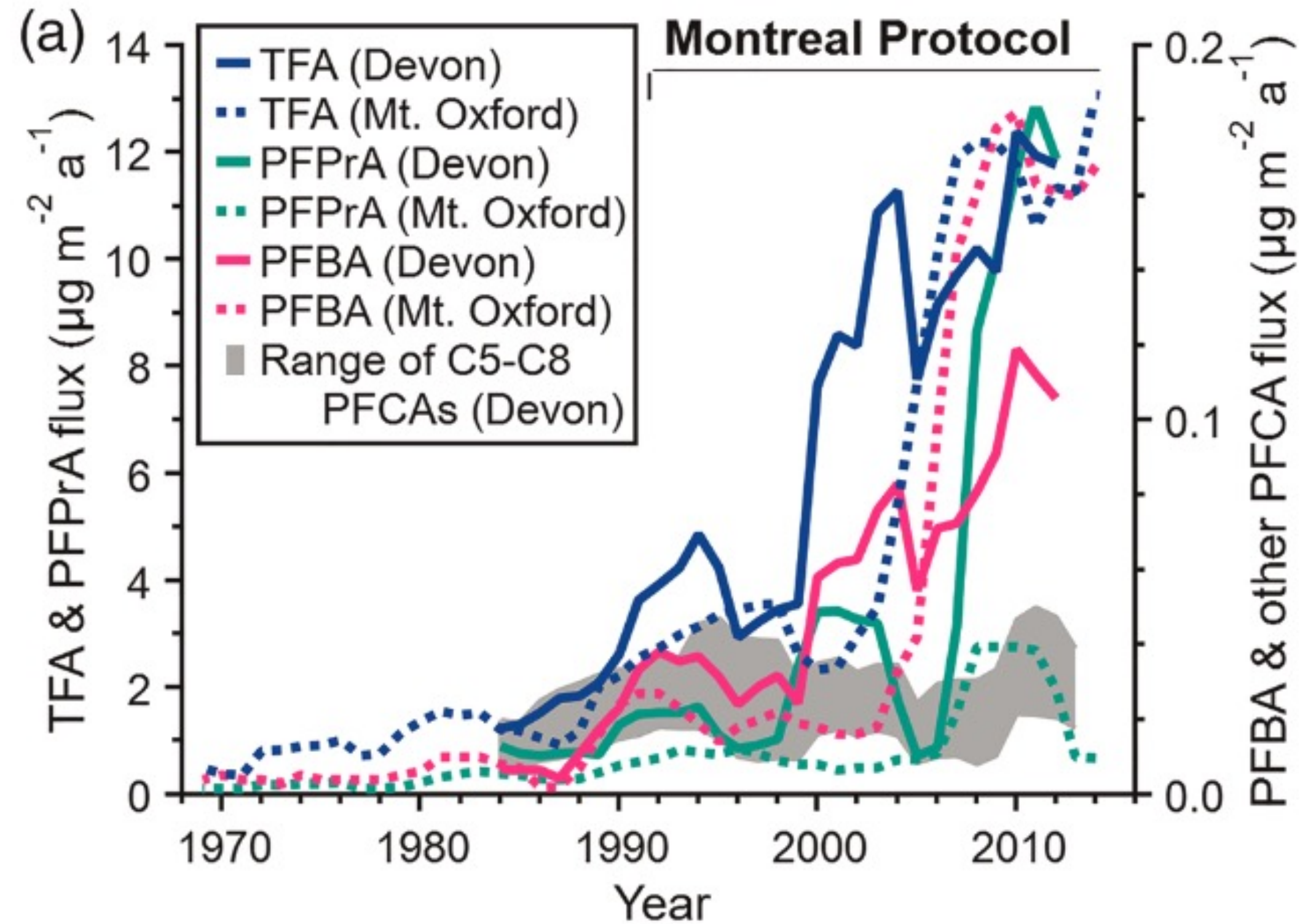
Hale et al. Environ Sci Eur 34, 22 (2022)  
Duan et al. (2020) Environ Int 134:105295.



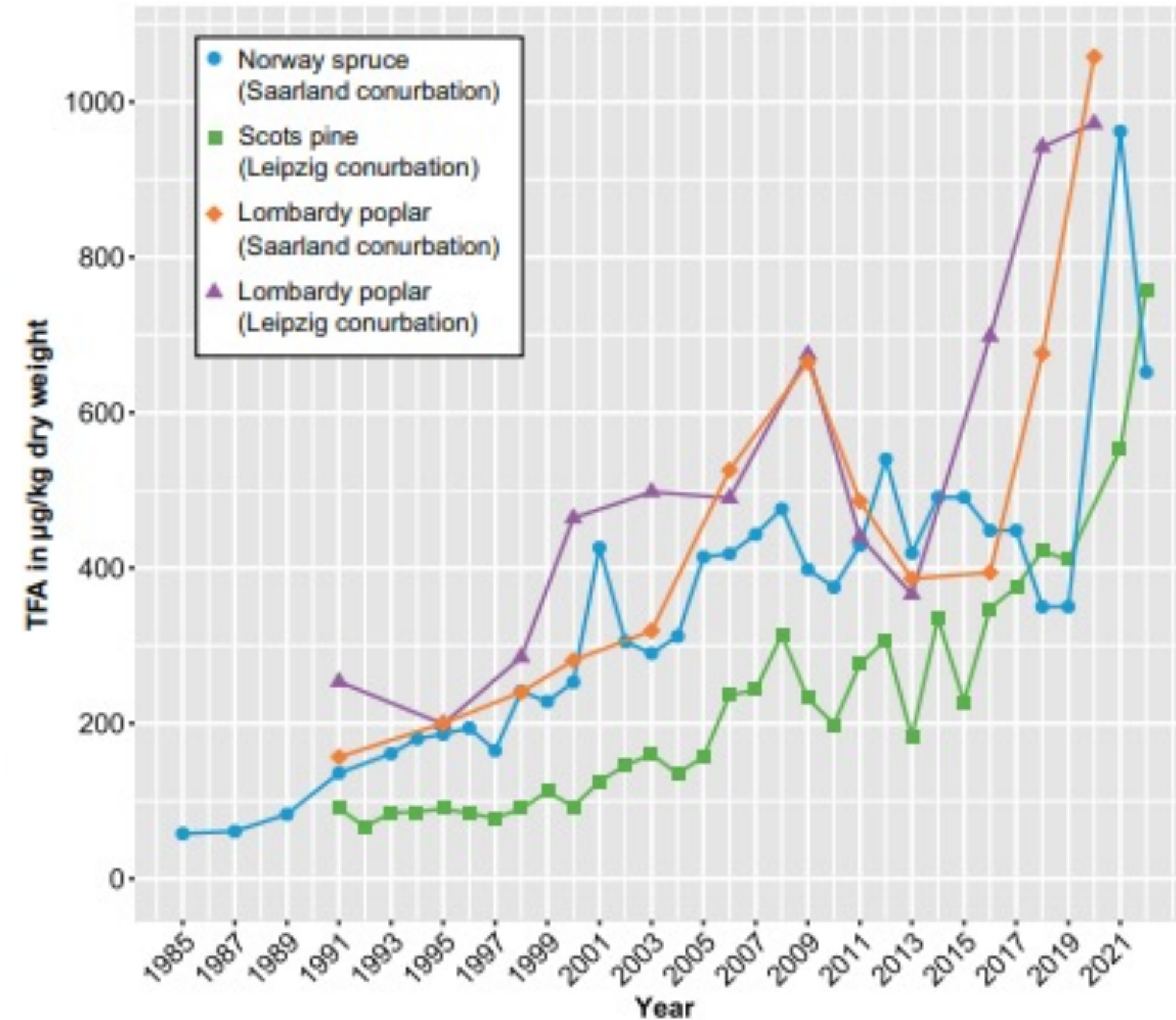
### **Trifluoroacetic acid (TFA)**

- one of the smallest PFAS
- strong acid
- very persistent
- very mobile in water and blood

## TFA accumulating in arctic ice cores



## and in trees

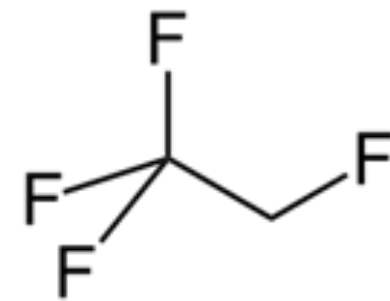


TFA increasing in ice cores since the Montreal Protocol

TFA increasing in tree leaves since the Montreal Protocol

# Could the Kigali Ammendment vastly accelerate irreversible TFA accumulation?

Less of saturated HFCs

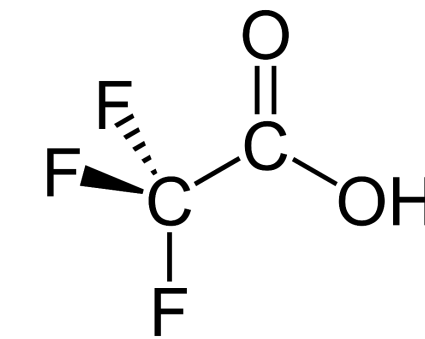


1,1,1,2-Tetrafluoroethane (HFC-134a, Norflurane)

$h \cdot \nu$

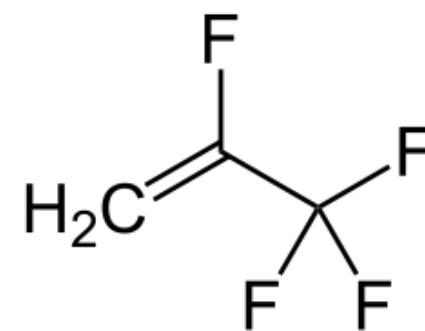


High global warming potential  
Phase down



Yield = between 7- 23%

More of unsaturated u-HFCs

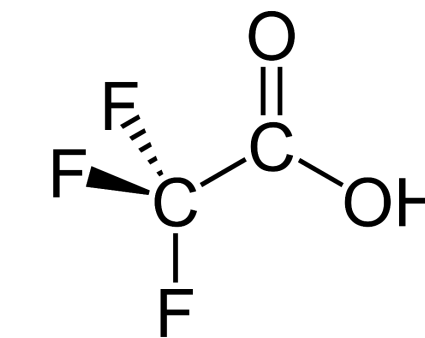


2,3,3,3-Tetrafluoropropene ( $\mu$ HFC-1234yf)

$h \cdot \nu$



low global warming potential



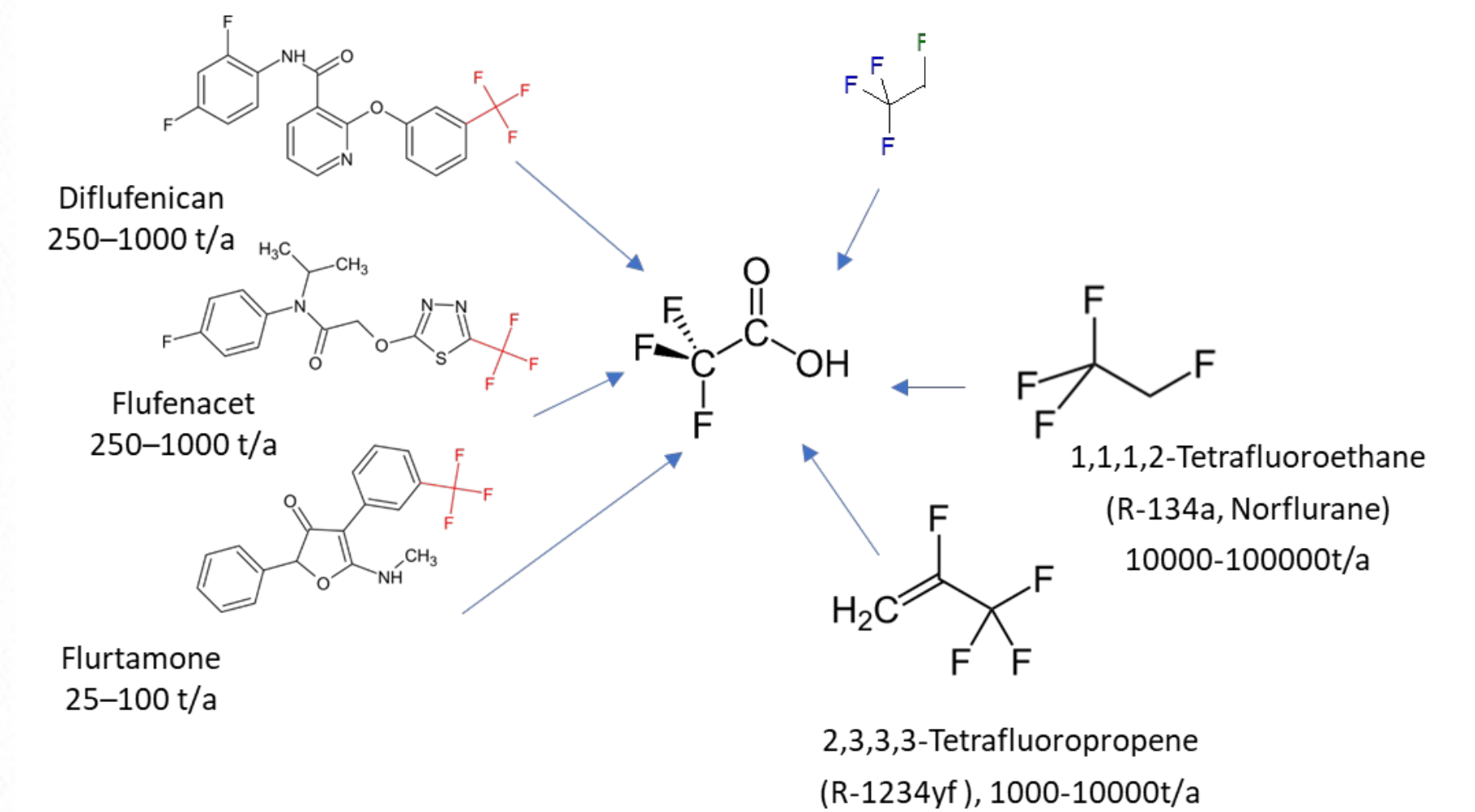
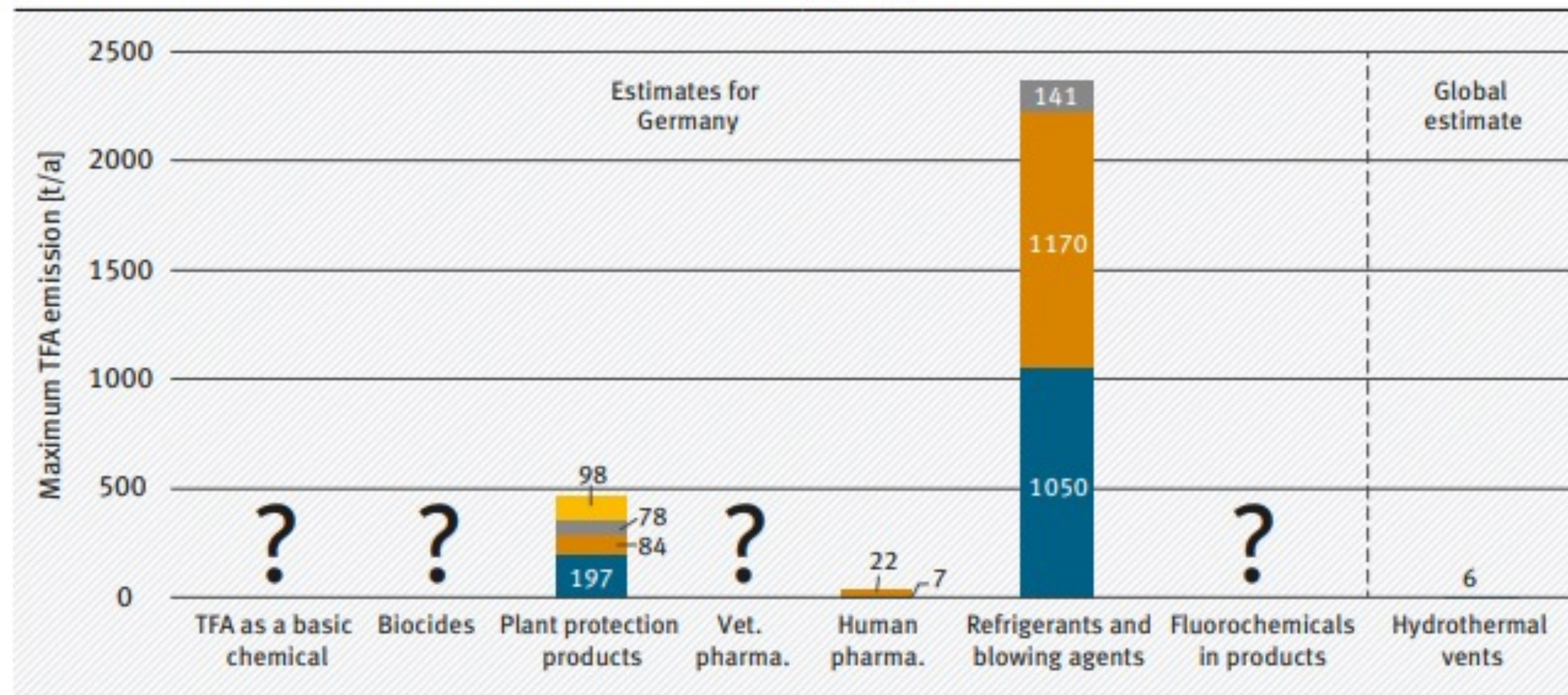
Yield = 100% !

Projection of metric tonnes emitted in EU-28

Substance	2000	2010	2020	2030	2040	2050	Total TFA sum (2000-2050)	Share of total sum
HFC-134a	3,895	7,595	6,351	1,756	1,084	836	202,781	14.7 %
u-HFC-1234yf	0	0	6,902	37,432	45,469	47,650	1,125,699	81.3 %

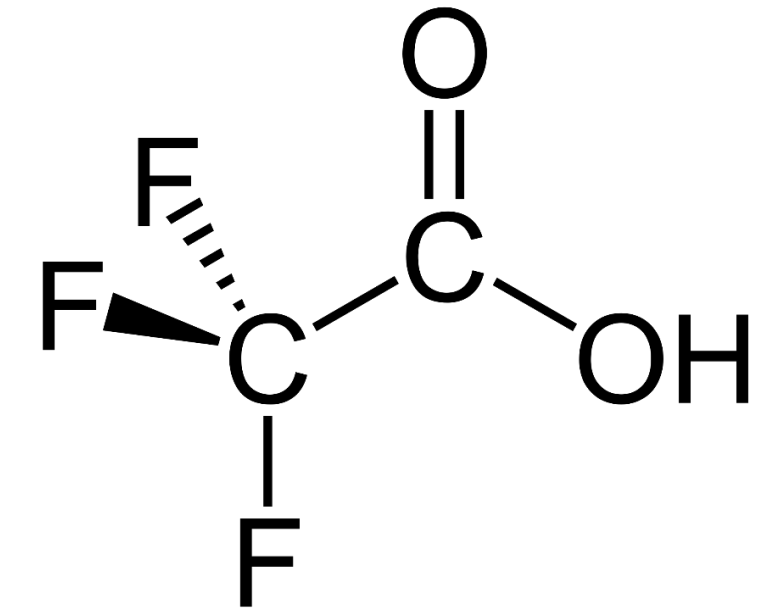
# F-gases from refrigerants and blowing agents are the greatest known source of TFA

Estimated maximum TFA emissions in t/a for the relevant groups of chemicals\*



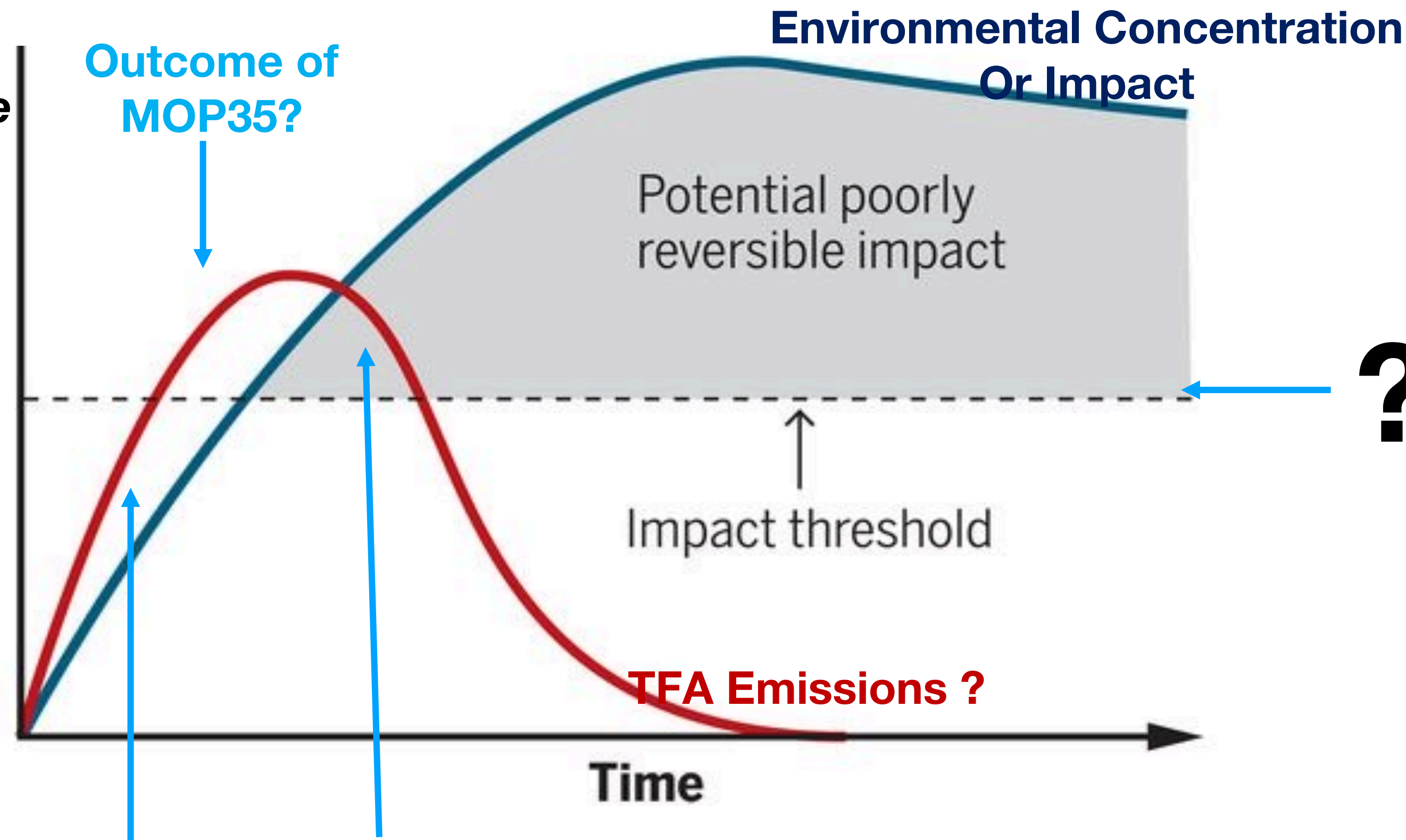
\* Calculated from the respective quantities sold or the emissions (refrigerants and blowing agents), or taken from published model-based estimates (hydrothermal vents)

Source: own diagram, German Environment Agency (data basis: see Notes on Fig. 4)

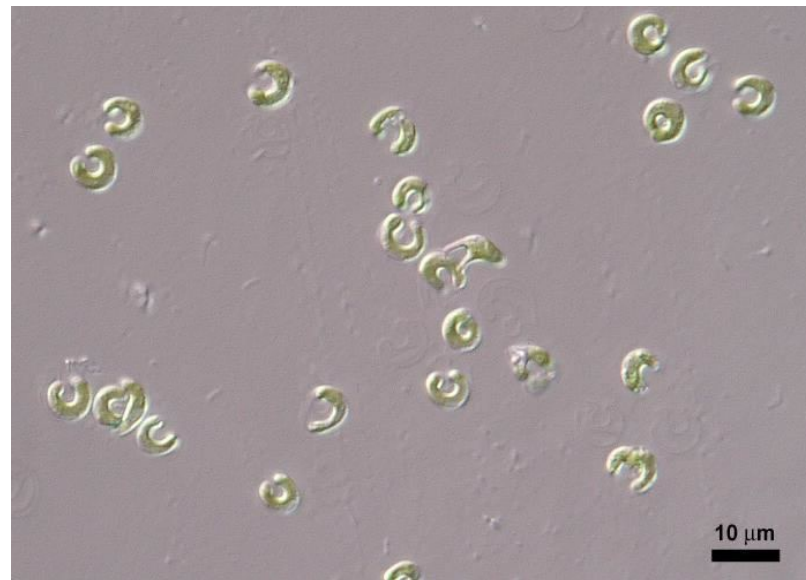


Aquatic systems?  
Atmospheric systems?  
Terrestrial systems?  
Marine systems?  
Mammals?

?



- (1) increasing exposure;
- (2) Exposure is poorly reversible
- (3) Thresholds exist, but some maybe unknown



Lowest no-observable effect concentration **so far:**  
*Raphidocelis subcapitata* (120 µg/L) PNEC of 0.12 µg/L (Xie et al. 2022)

“Environmental levels of TFA... do not pose a threat to the environment”  
(Boutonnet et al. 1999)

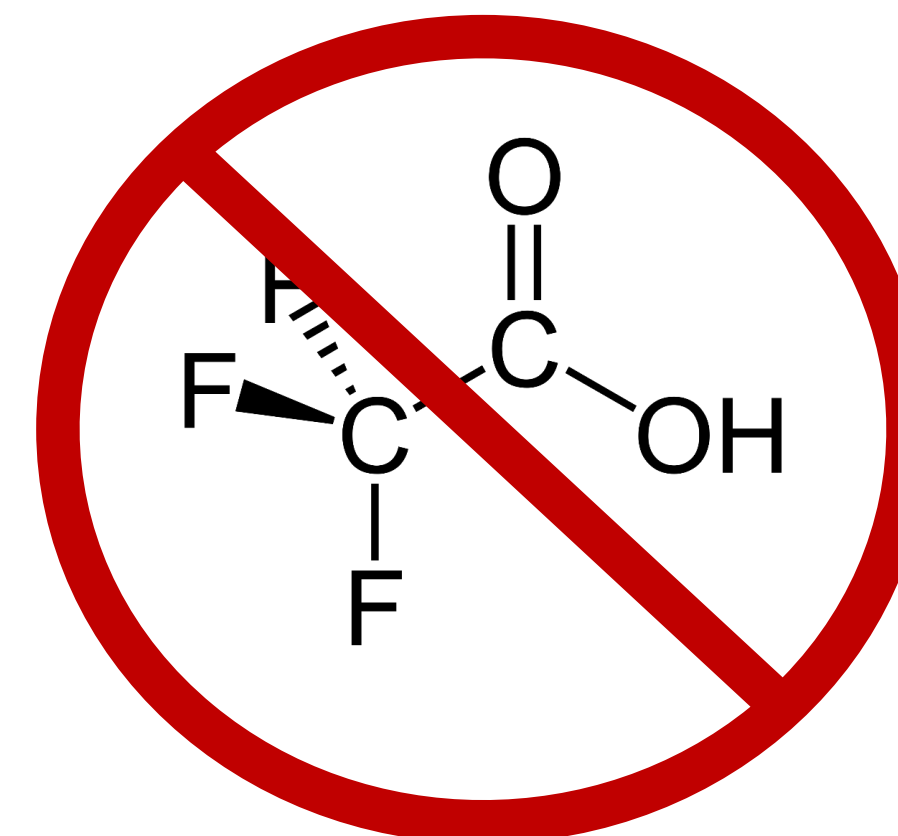
“TFA threats were not recognized in time”



- TFA is increasing in ground water, ocean water, rainwater, blood, and vegetation
- TFA is persistent and mobile. It won't degrade and is already diluted. The TFA we produce now will be on the planet for generations. It will only increase.
- Current projections indicated that TFA will increase more rapidly unless actions are taken on their F-gas precursors
- The rational response to the global threat posed by accumulating and poorly reversible TFA is to phase-out F-gases and other TFA precursors

European Chemical Agency Publishes Proposal to Restrict PFAS  
Chemicals, Including Some F-Gases and TFA

February 10, 2023 EUROPE POLICY





# ATMO Network



**Hans Peter H. Arp**

Norwegian Geotechnical Institute (NGI); Norwegian University of Science and Technology (NTNU)

Contact: [hans.peter.arp@ngi.no](mailto:hans.peter.arp@ngi.no)

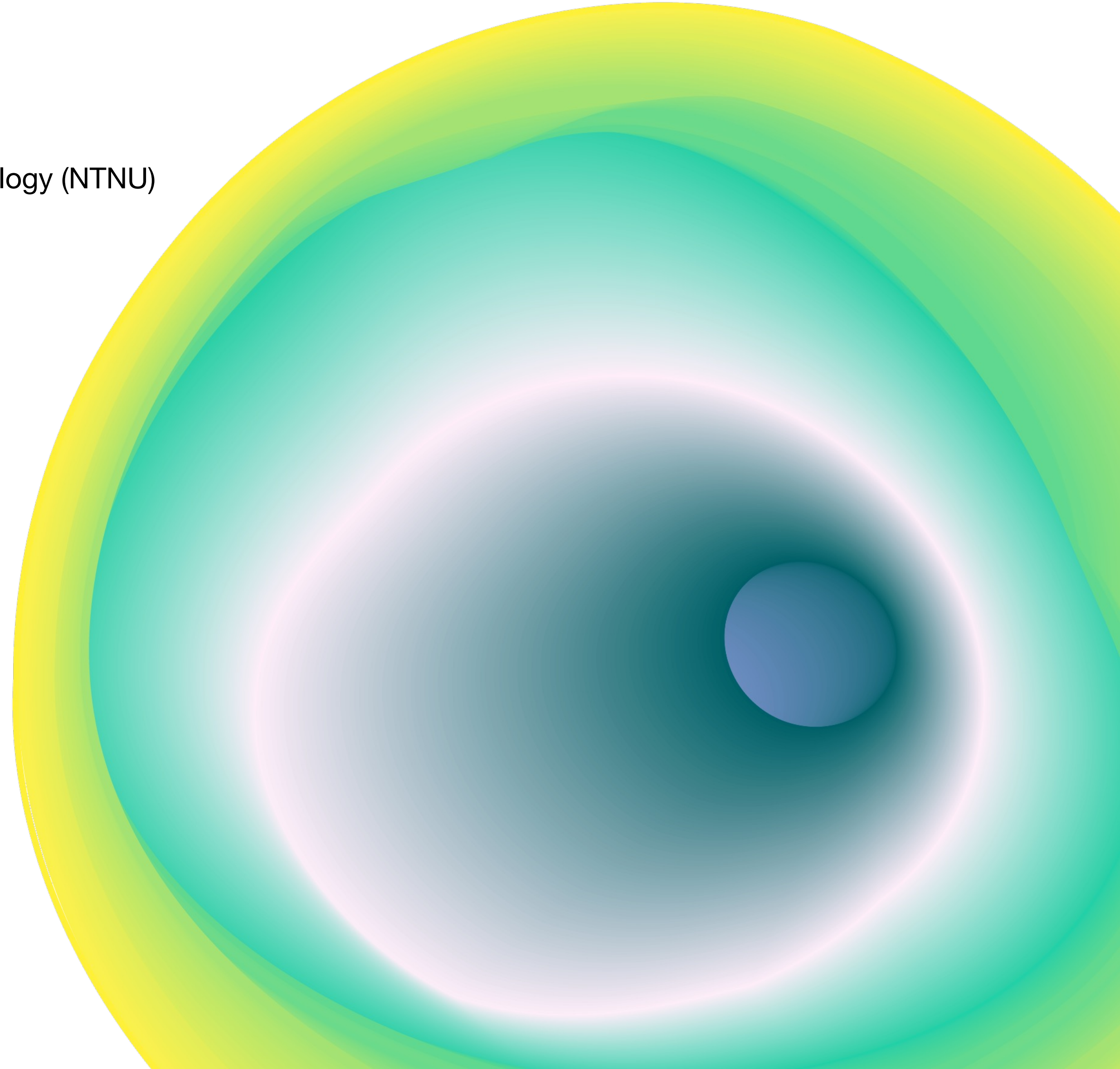
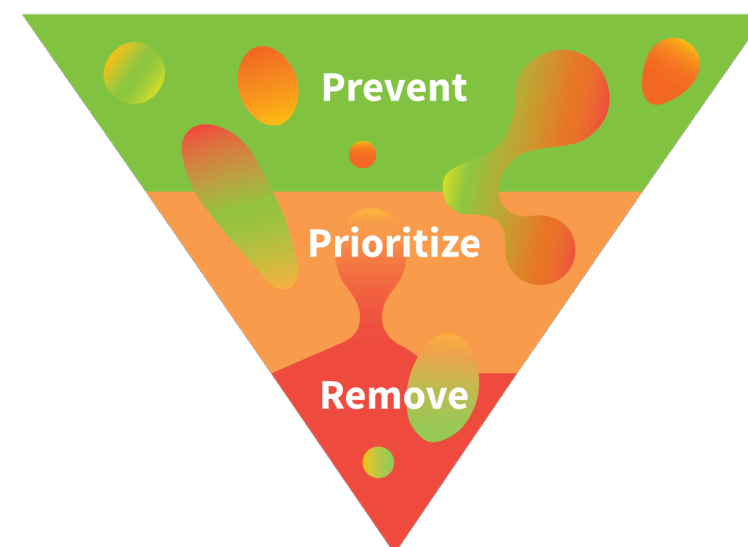


# Thank you for listening.

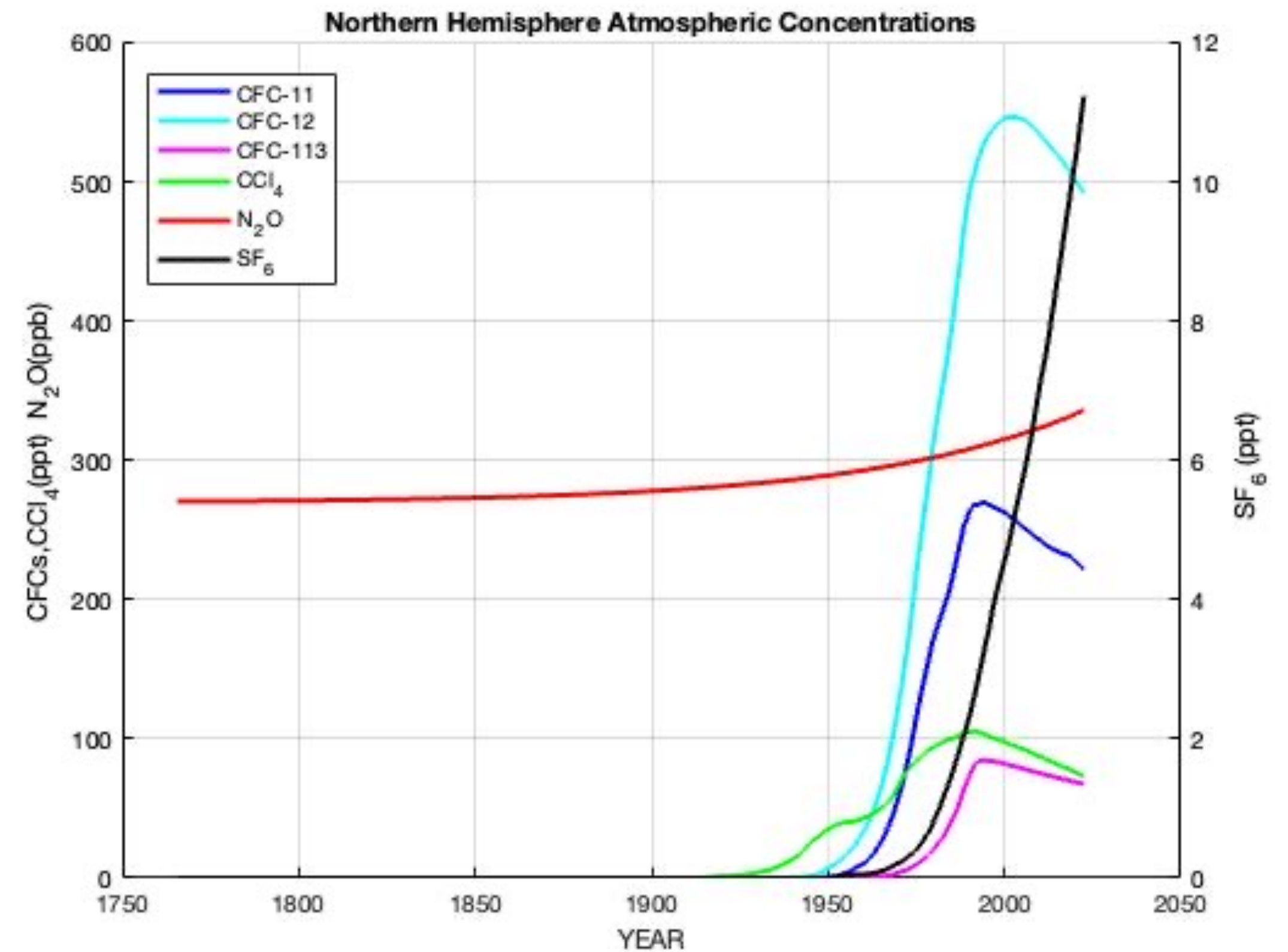
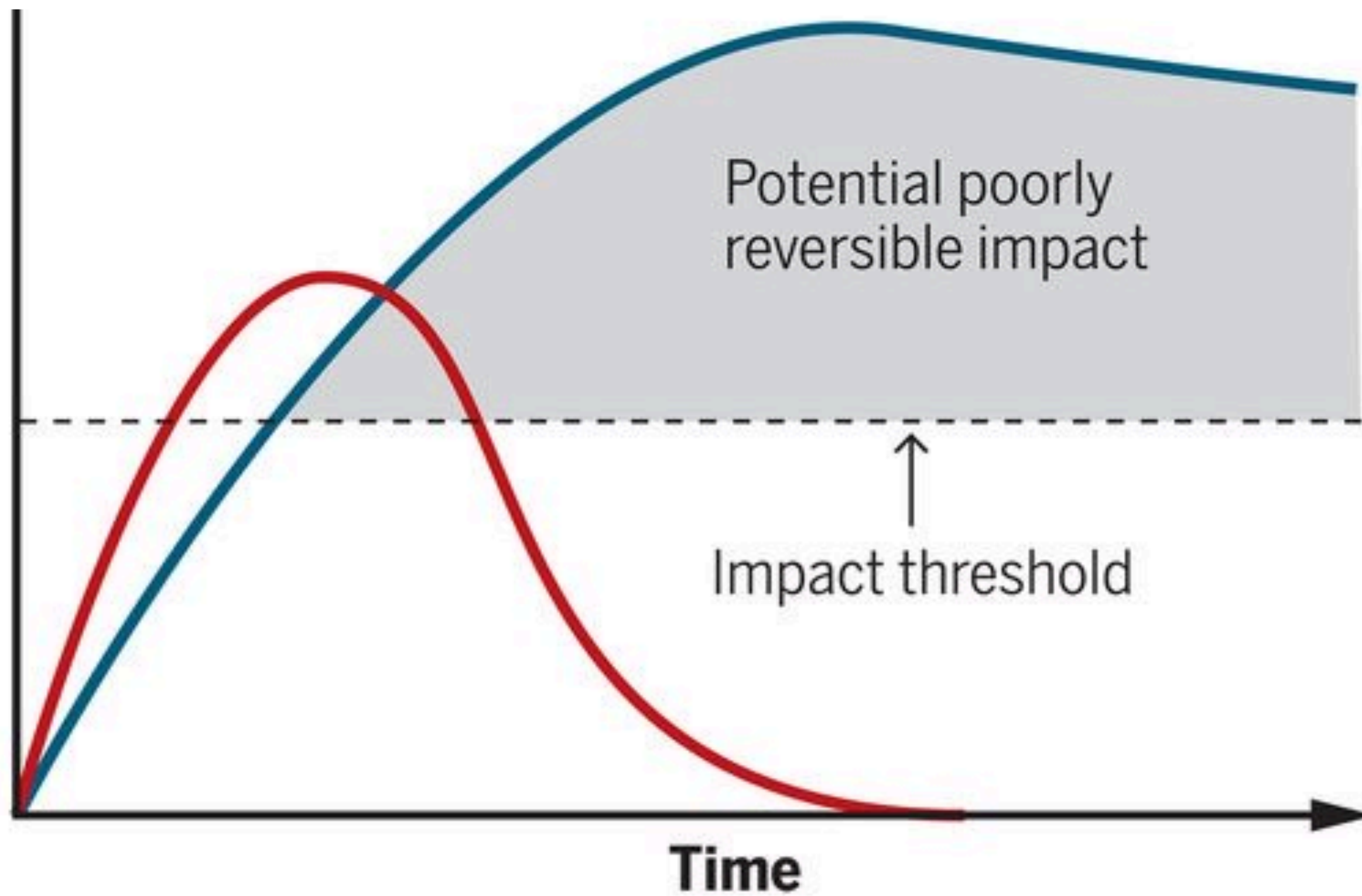


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## Zero PPM



# Annex



[https://www.ncei.noaa.gov/access/ocean-carbon-acidification-data-system/oceans/CFC\\_ATM\\_Hist2015.html](https://www.ncei.noaa.gov/access/ocean-carbon-acidification-data-system/oceans/CFC_ATM_Hist2015.html)

