



THE CHALLENGE TO REDUCE EMISSIONS DURING A PERIOD OF GROWTH

SEMICON Europa

Chris Jones

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Outline



Simple F-GHG releases – and their importance.



The contribution of our industry, and some others.



Moving forward – the challenge of growth.

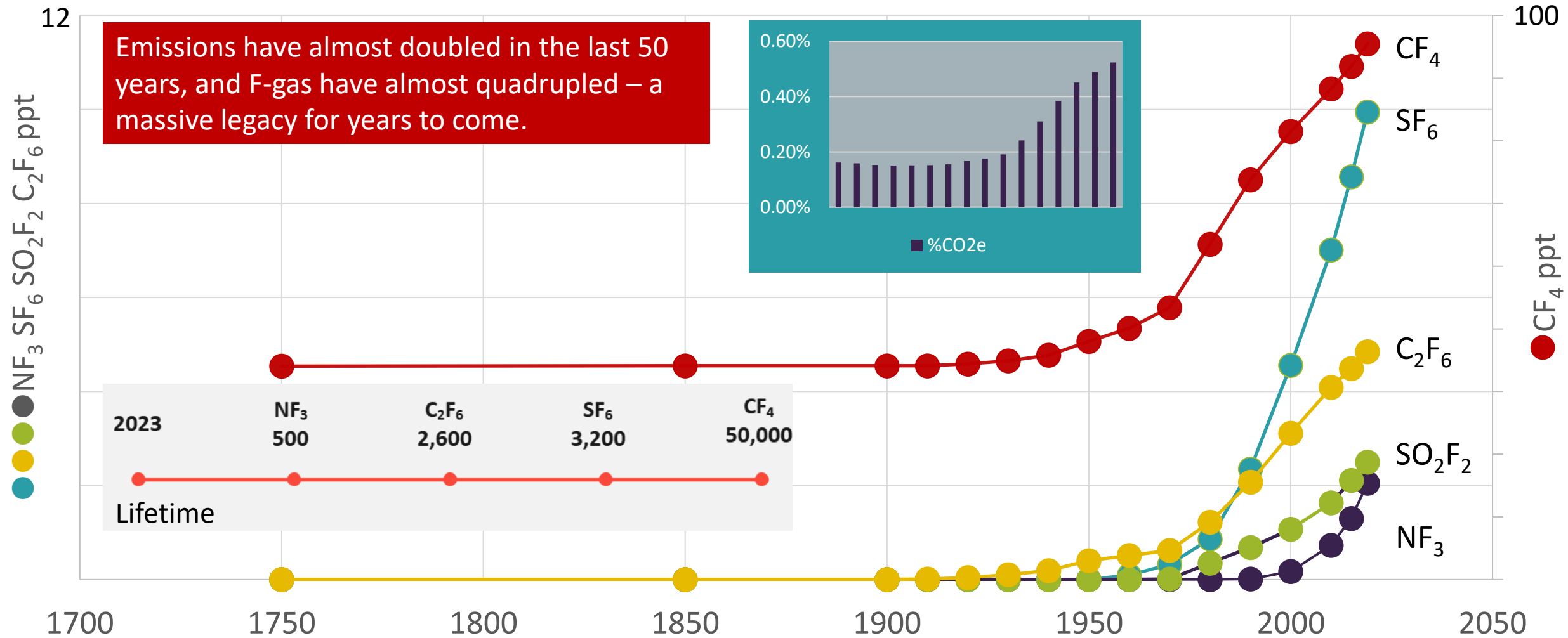


Ambient air sampling
- reinforces the message.
- the need to respond.



Summary.

Historical GHG Atmospheric Abundances.



Industry contributions



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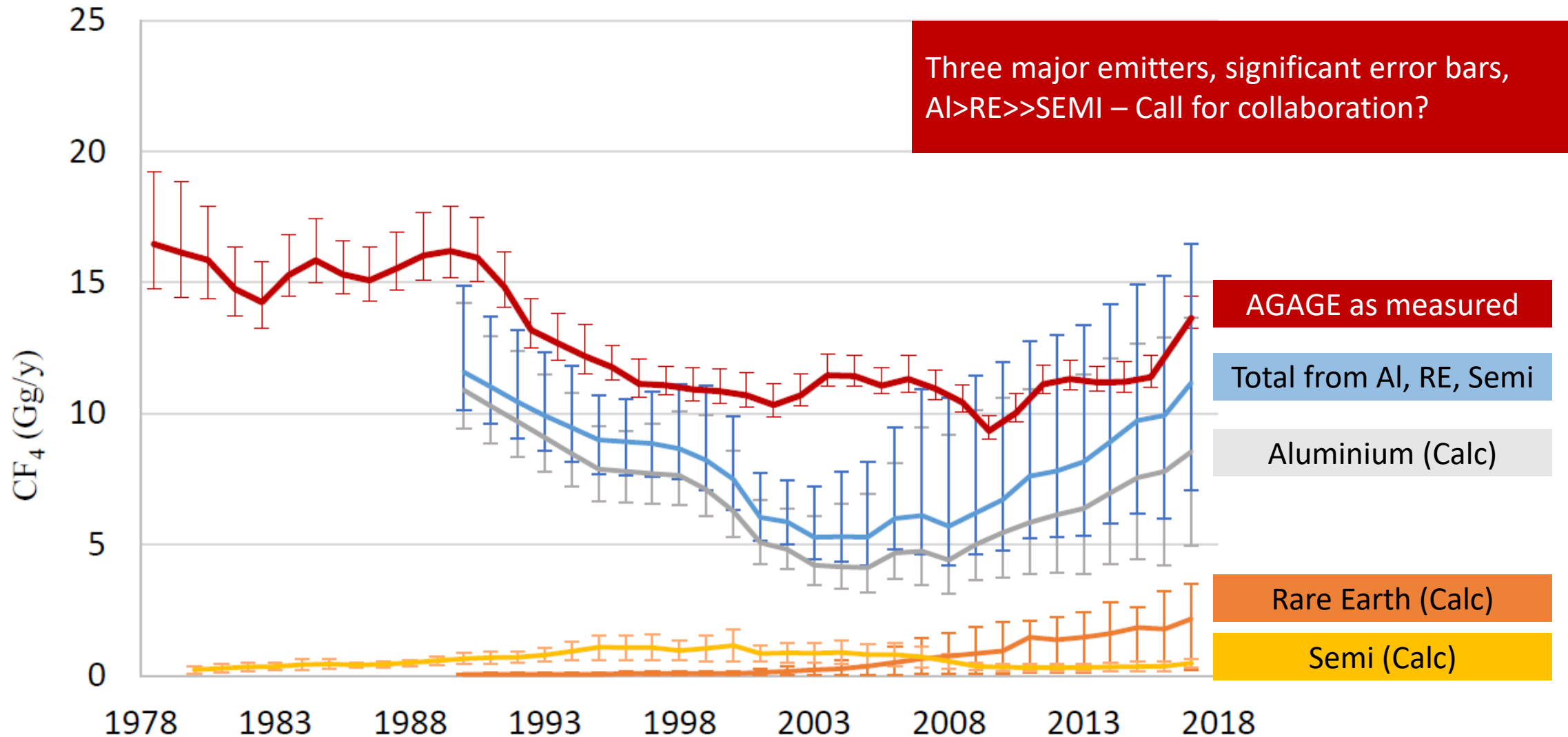


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Summary.

CF₄ – Top down from measurement in red. Bottom up from emissions factors.



Growth



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Summary.

Simple estimate of semiconductor releases from public records.

CSR and CDP Data GHG Releases By Type (detailed list PFCs/HFCs not provided).
(17 Companies 60-64% Global 200mmEq WS capacity).
Data used for 2019-2022 and then extrapolated to 2030*.

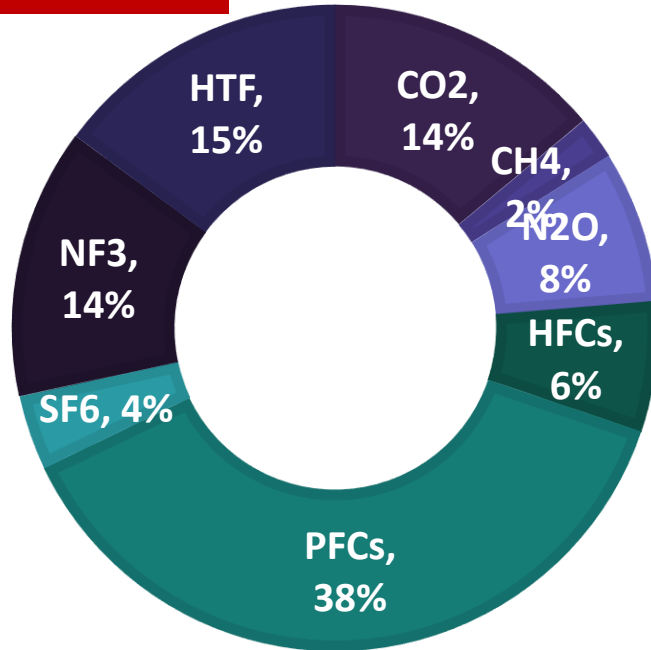
USA GHG reports which can provide 0% DRE Data - three major companies used to estimate releases pre-abatement*.

Comparisons are made between CDP, CSR, and US EPA to identify the key gases such as CF₄, NF₃, C₂F₆, CHF₃, and SF₆.

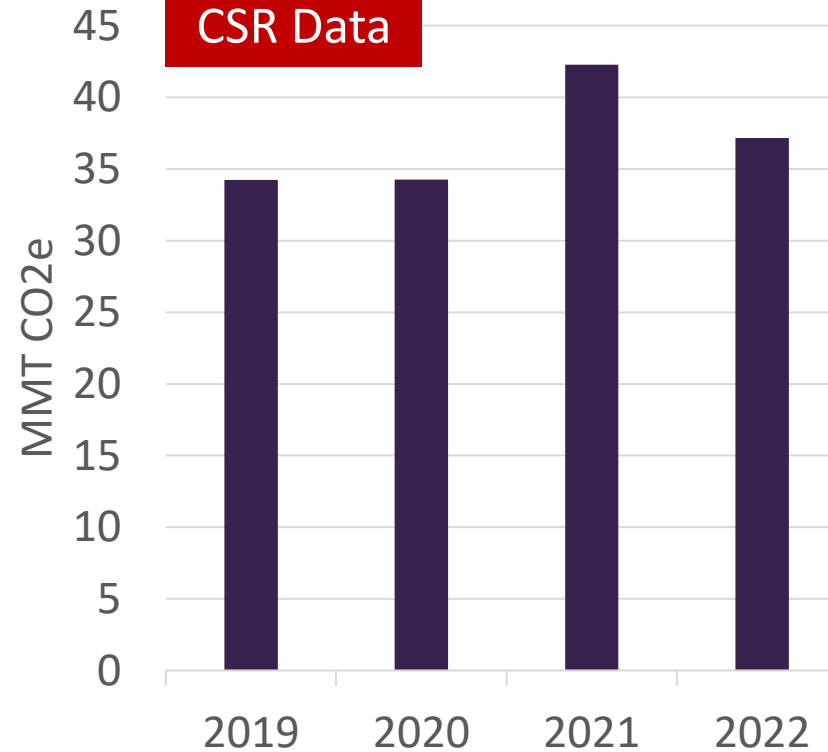
*Means that there are assumptions that may impact accuracy.

Publicly Available - CDP and CSR Data.

CDP Data



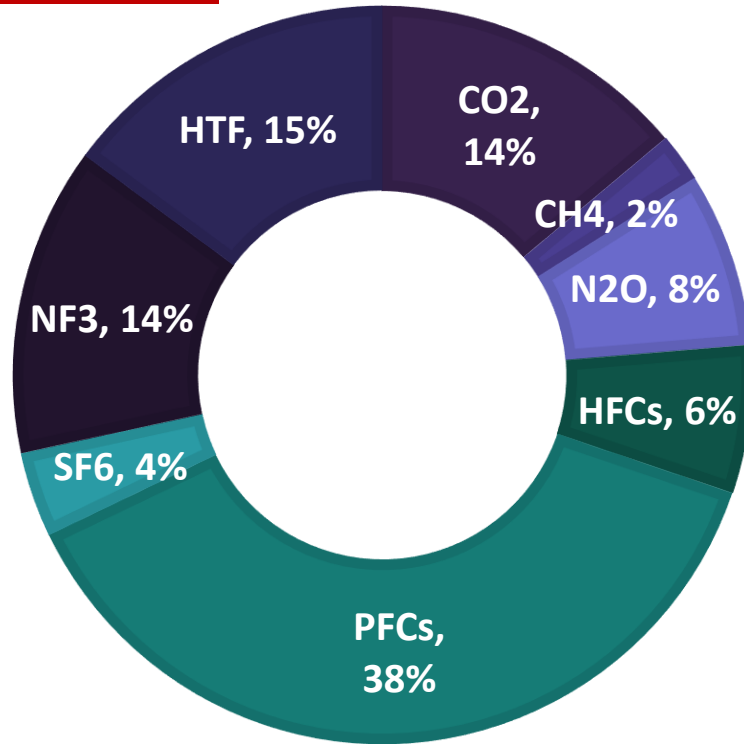
CSR Data



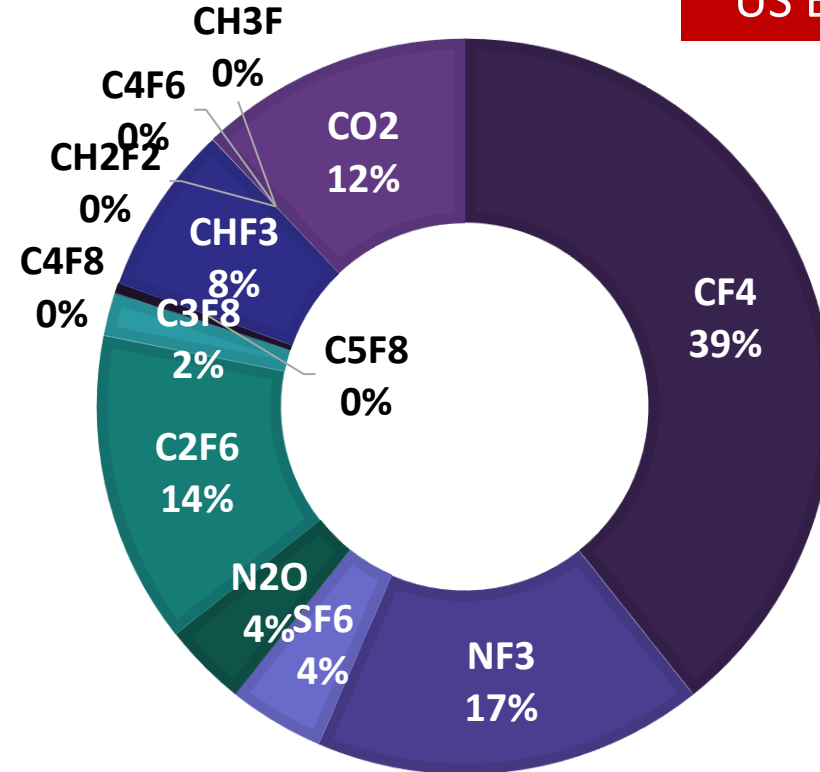
- Scope 1 emissions estimates are still developing. (Annex 1 vs Annex 2, IPCC 2006 vs 2019, AR4 vs AR5 vs AR6, ISO14064 2013 or 2018 or 2019, including HTFs or not).
- For example, CDP data is 3.3MMT greater than the equivalent CSR information 2022.
- Many rapidly expanding Chinese Manufacturers either don't release data or use CO₂ from combustion alone. The actual situation will be larger than this simple analysis estimates – but it's about baselines, budgets, and trends when considering 1.5°C pathways. The activities of the SEMI Emissions Reporting Protocol WG will be important.

Publicly Available - CDP and CSR Data.

CDP Data

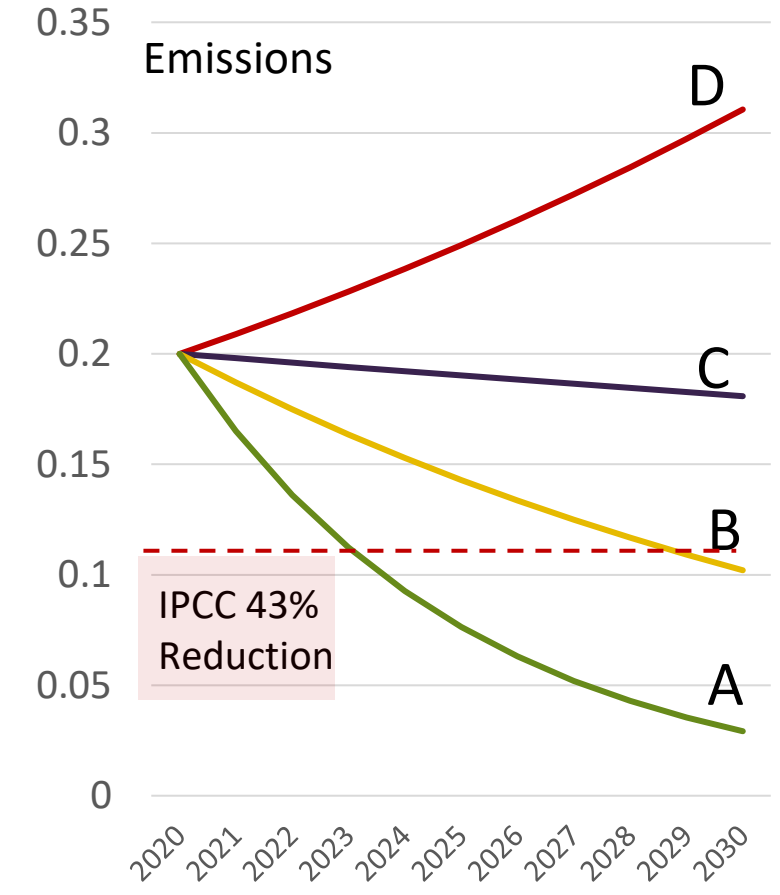
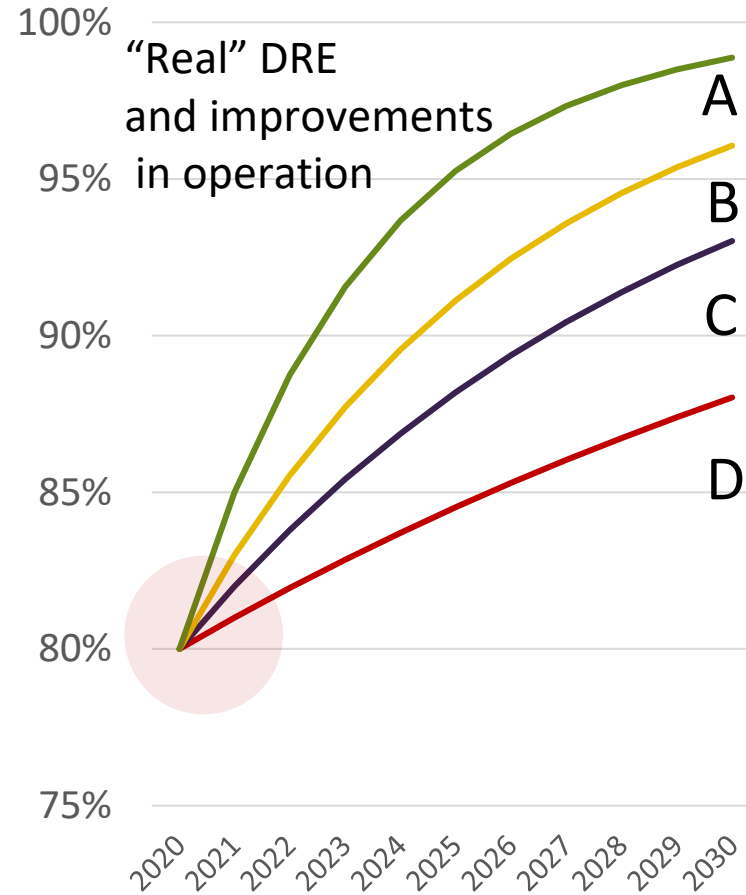
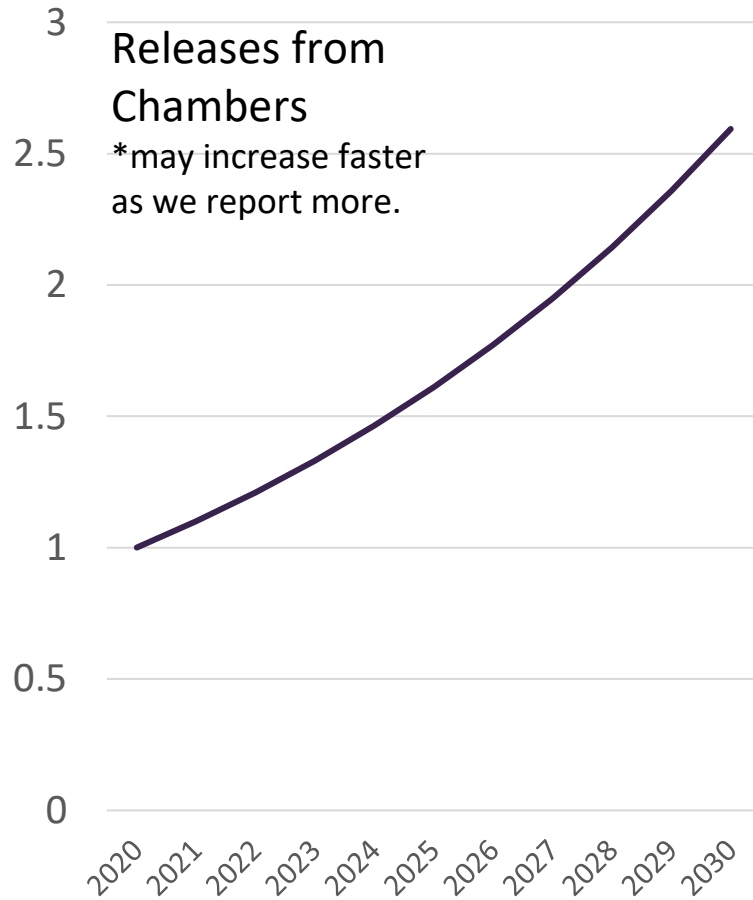


US EPA



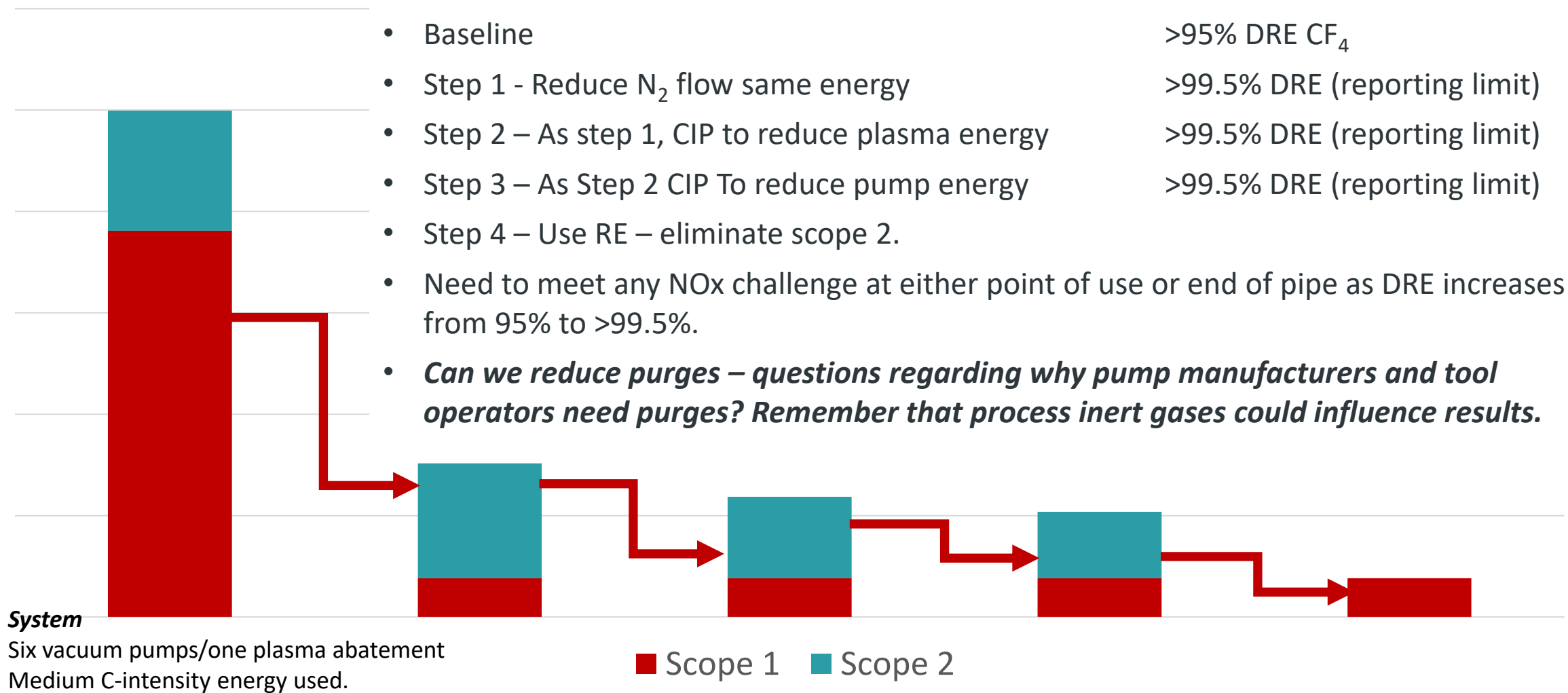
- Important to note that only three company's data are used for our 2021 US estimate (awaiting 2022 data).
- Even so, the trends are very similar. The major contributors are likely CF₄, NF₃, C₂F₆, CHF₃, and SF₆.
- These mainly require high-energy abatement. How best to target abatement?

Simple illustration of chamber releases growth – DRE starting point and improvements



- **Improvements depend on the starting point – use, performance, operation, and maintenance, AI and PdM is available to enhance performance (A-D different DRE improvement strategies)..**
- Current estimates that scope 1 emissions are ~50% of scope 2 and scope 3 is much higher still.
- Emissions reduction strategies will concentrate on large emitters throughout the value chain, and some may find it easier to reduce scope 1 than scope 2 – others the reverse situation.

Plasma abatement and vacuum system starts at 95% CF₄ DRE. Flow is important.



- ***Other options under consideration – shared pumping, absorbers, catalysis – are all under investigation.***

Air sampling.



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Summary.

Flask Sampling and Meteorological Data – Directional Source For PFC/HFC/ODS/HC.

The selected sampling location was Edwards Korea Co. Ltd manufacturing facility in Cheonan, S. Korea.

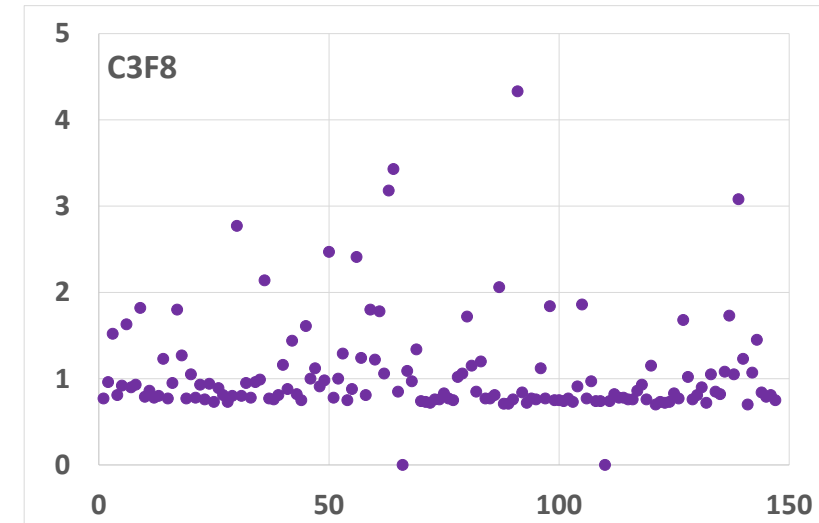
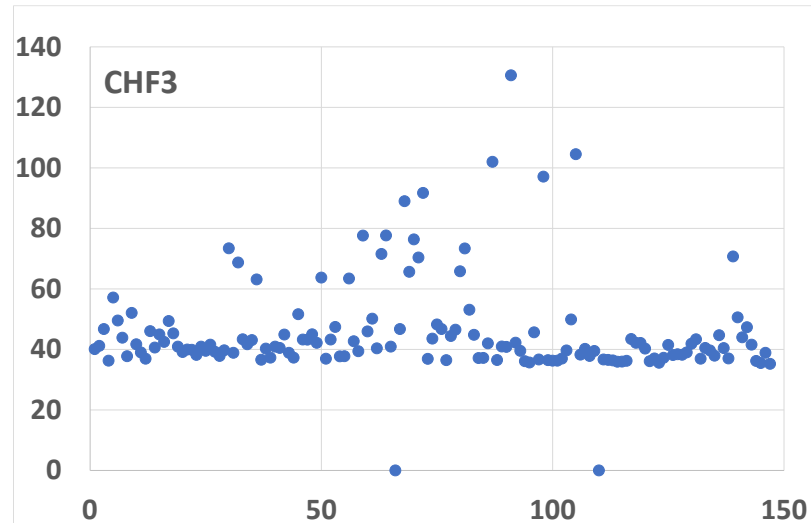
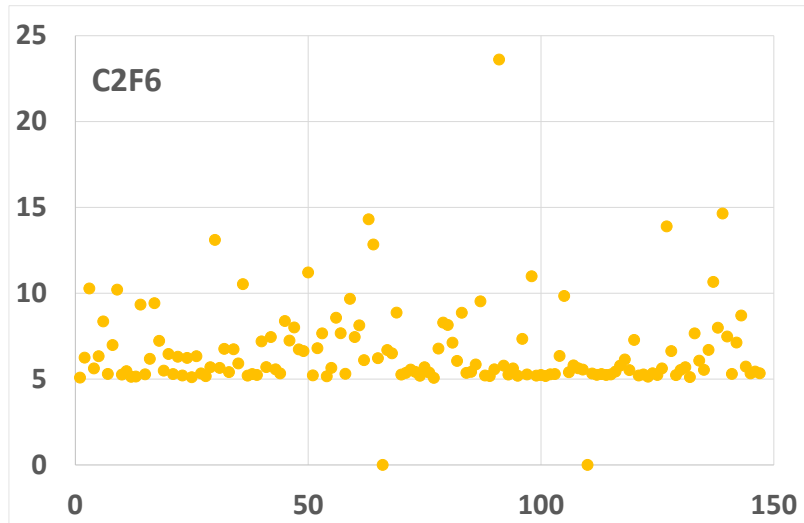
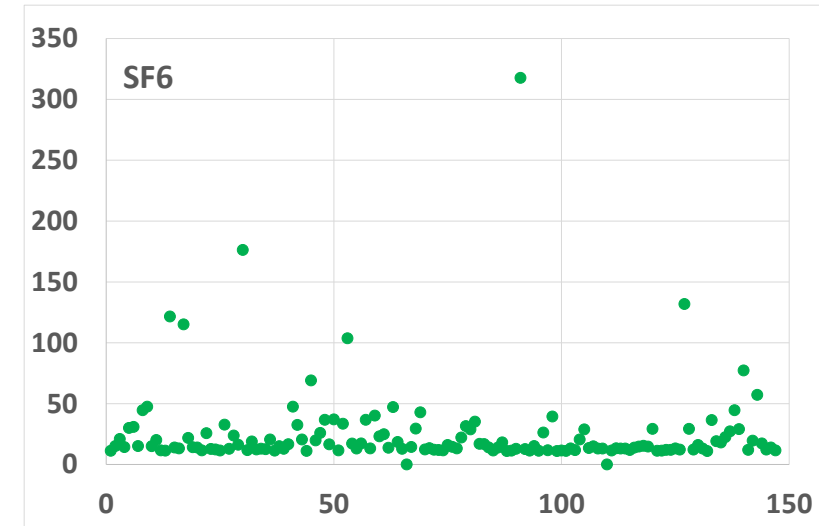
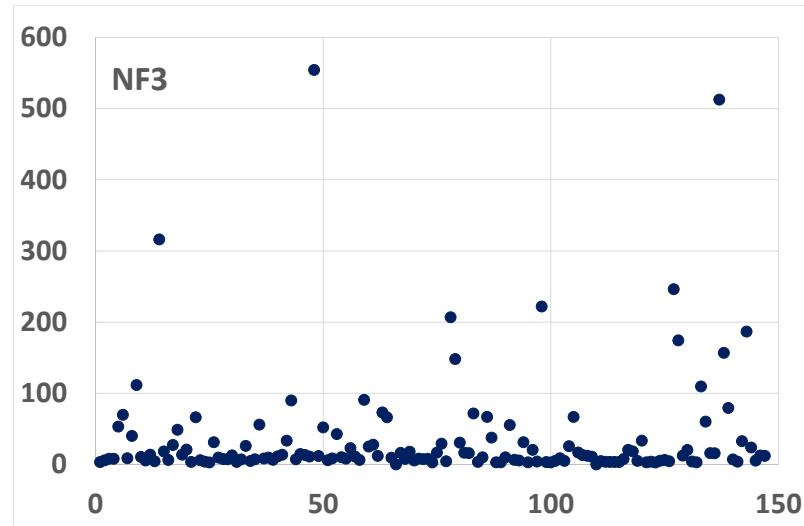
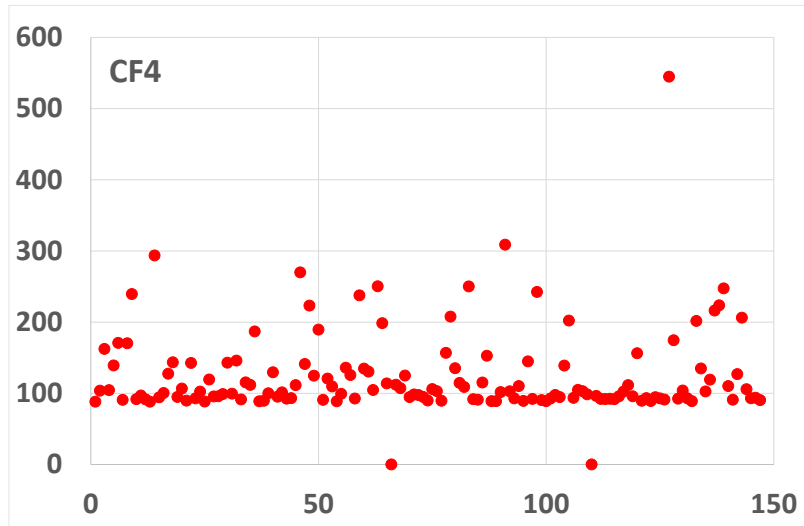
- Weather station and sample collection house in the building on the roof.
- Samples returned to Bristol University for analysis.
- Dispersion means that sources nearby can dominate.
- More distant sources can be identified using weather patterns with Gaussian plume models.



Compounds Analysed.

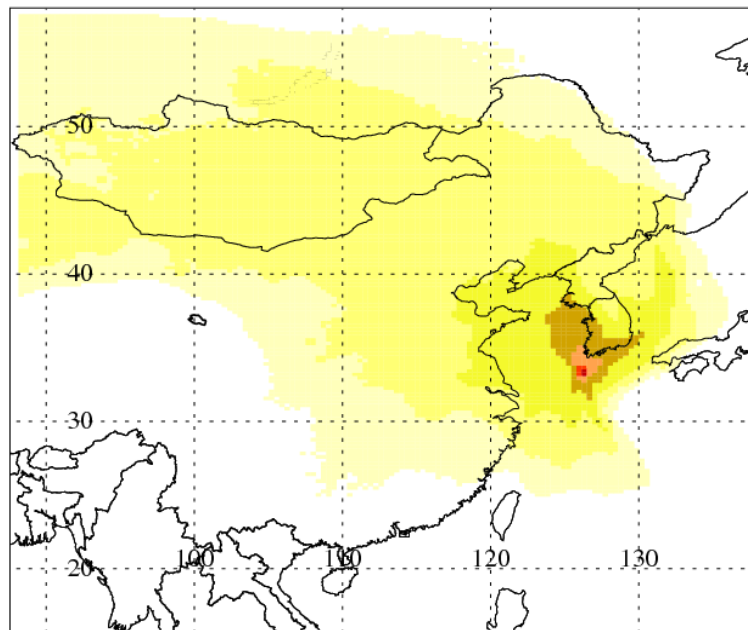
Compound List						
benzene	CFC_13	CHCl ₃	HCFC_123	hexafluoropropene	HFC_365mfc	PFC_216
c_propane	CFC_13.1	ClCH ₂ CH ₂ Cl	HCFC_124	HFC_125	HFC_41	PFC_218
C ₄ F ₁₀	CH ₂ Br ₂	COS	HCFC_132b	HFC_134	HFC_4310mee	PFC_318
C ₄ F ₈ O	CH ₂ BrCl	Desflurane	HCFC_133a	HFC_134a	HFC_4310mee_e	PFTBA
CCl ₄	CH ₂ Cl ₂	Ethane	HCFC_141b	HFC_143a	HFO_1114	Propane
CF ₄	CH ₂ I ₂	Ethene	HCFC_142b	HFC_152a	HFO_1123	Sevoflurane
CFC_11	CH ₃ Br	Ethyne	HCFC_21	HFC_161	HFO_1216	SF ₆
CFC_112	CH ₃ CCl ₃	Furane	HCFC_22	HFC_227ea	HFO_1234yf	SO2F2
CFC_113	CH ₃ Cl	H_1202	HCFC_225ca	HFC_23	HFO_1234zeE	TCE
CFC_114	CH ₃ I	H_1211	HCFC_225cb	HFC_236fa	NF ₃	toluene
CFC_115	CHBr ₃	H_1301	HCFC_31	HFC_245fa	PCE	
CFC_12	CHBrCl ₂	H_2402	HCFO_1233zdE	HFC_32	PFC_116	

Simple Sample Results (concentration in ppt vs sample number).



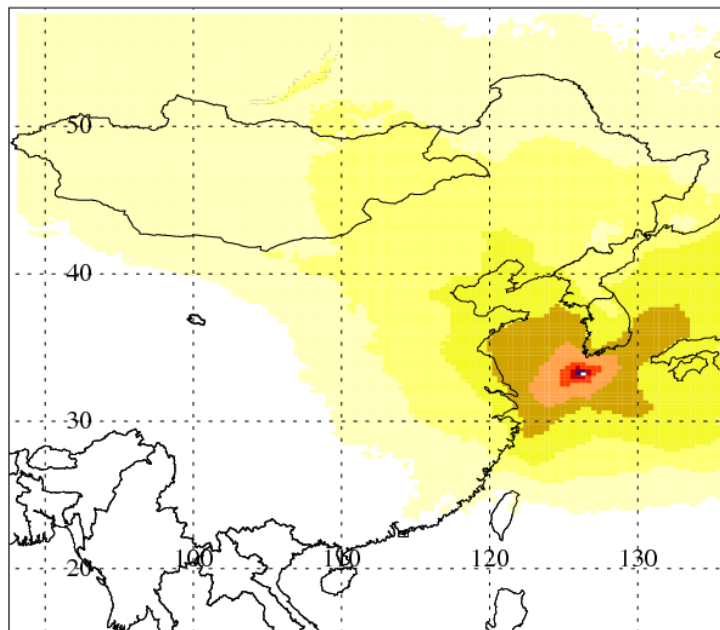
Seasonal dependence of dispersion models

janfeb



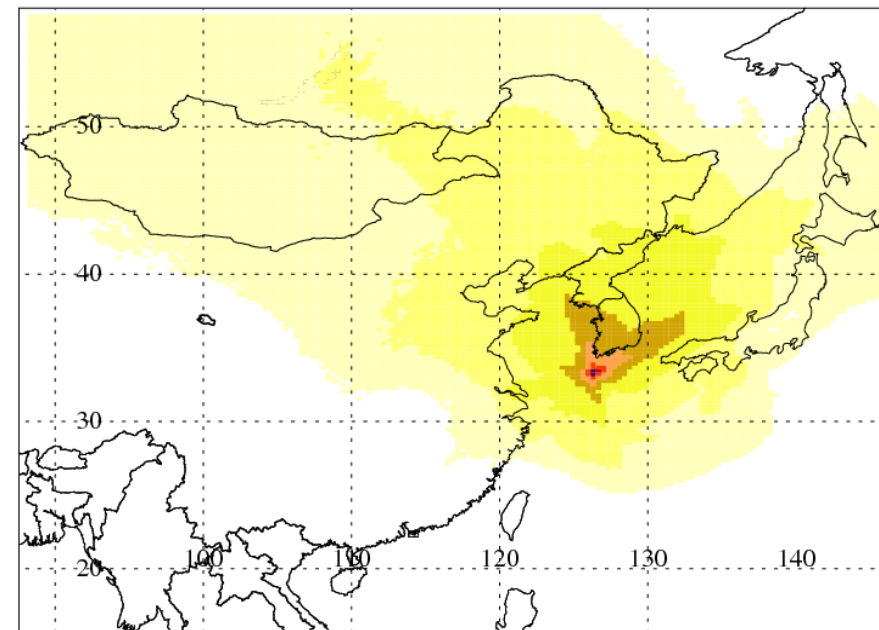
Maximum value = 3.738 s/m

mayjun

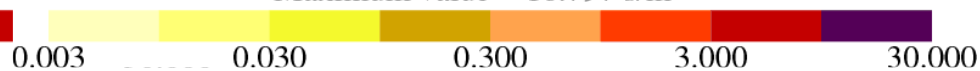


Maximum value = 31.986 s/m

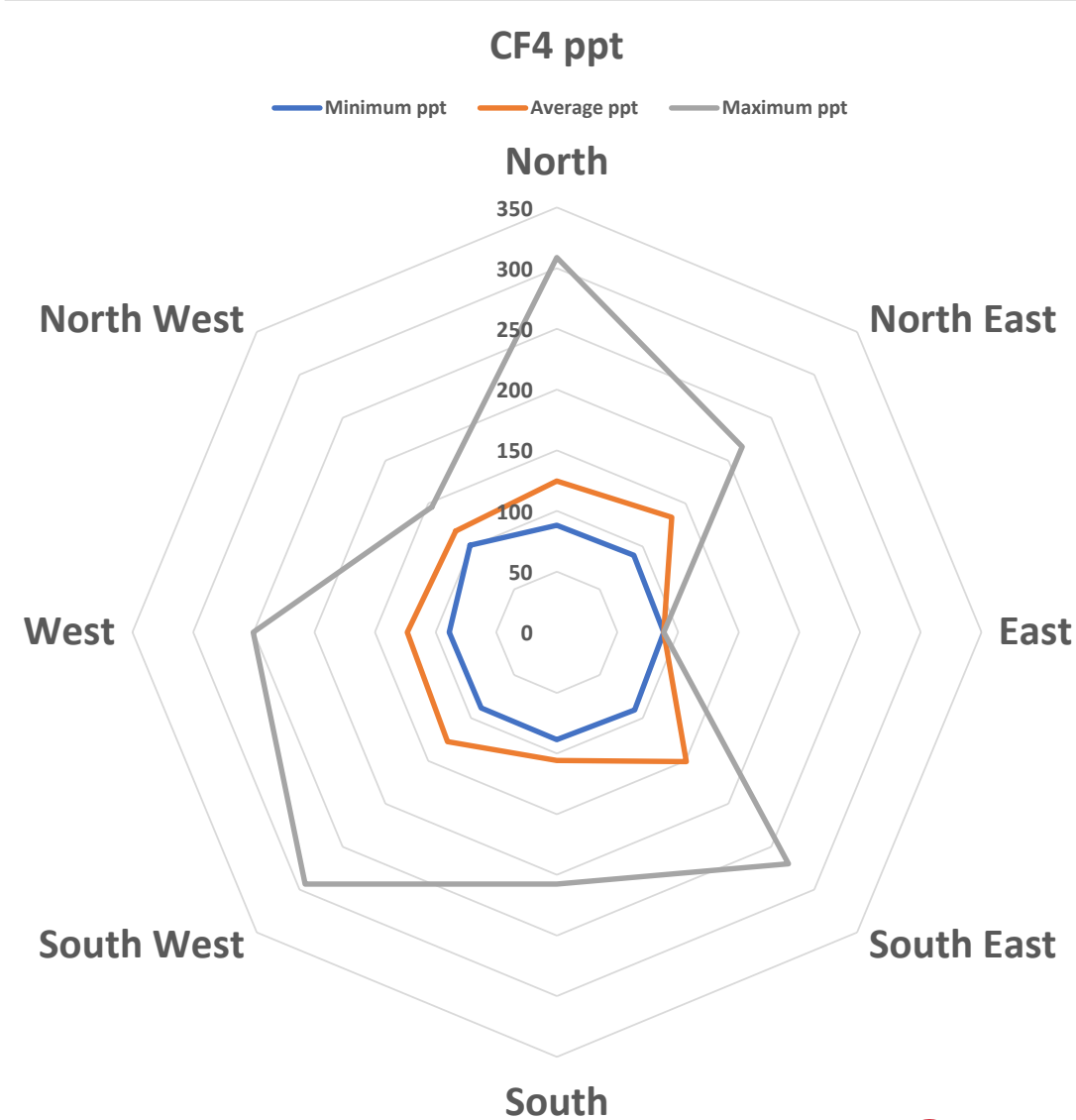
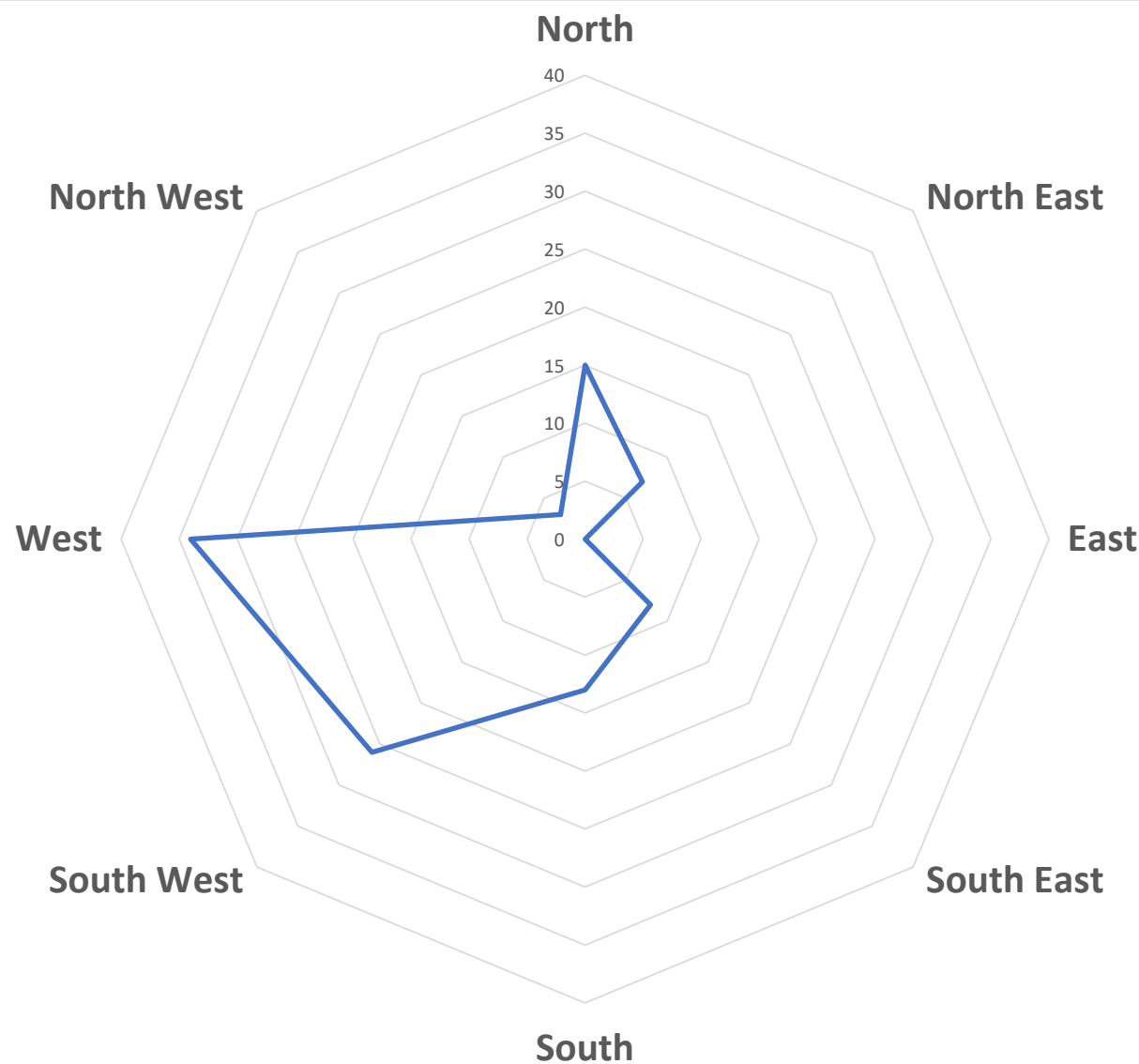
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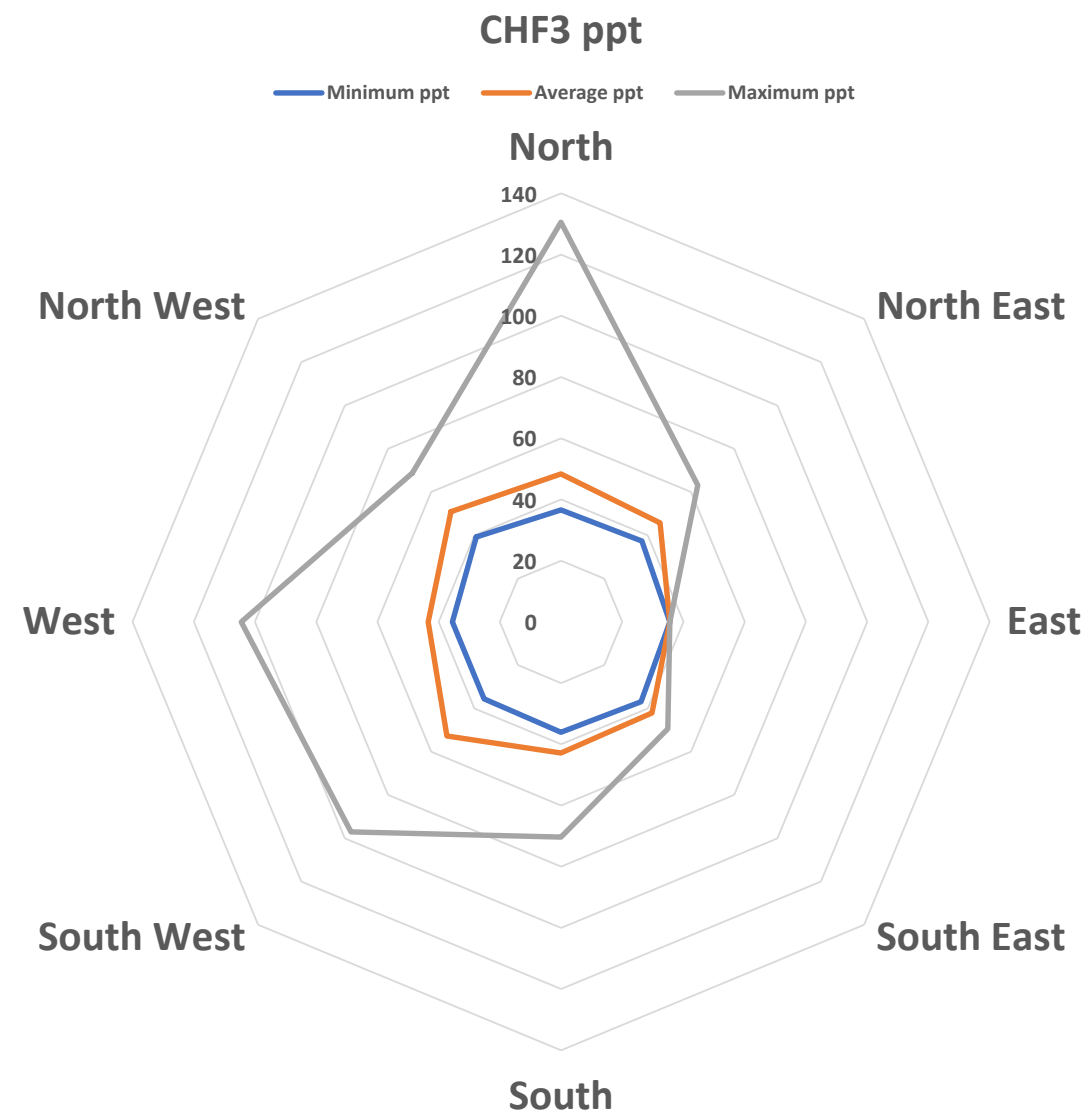
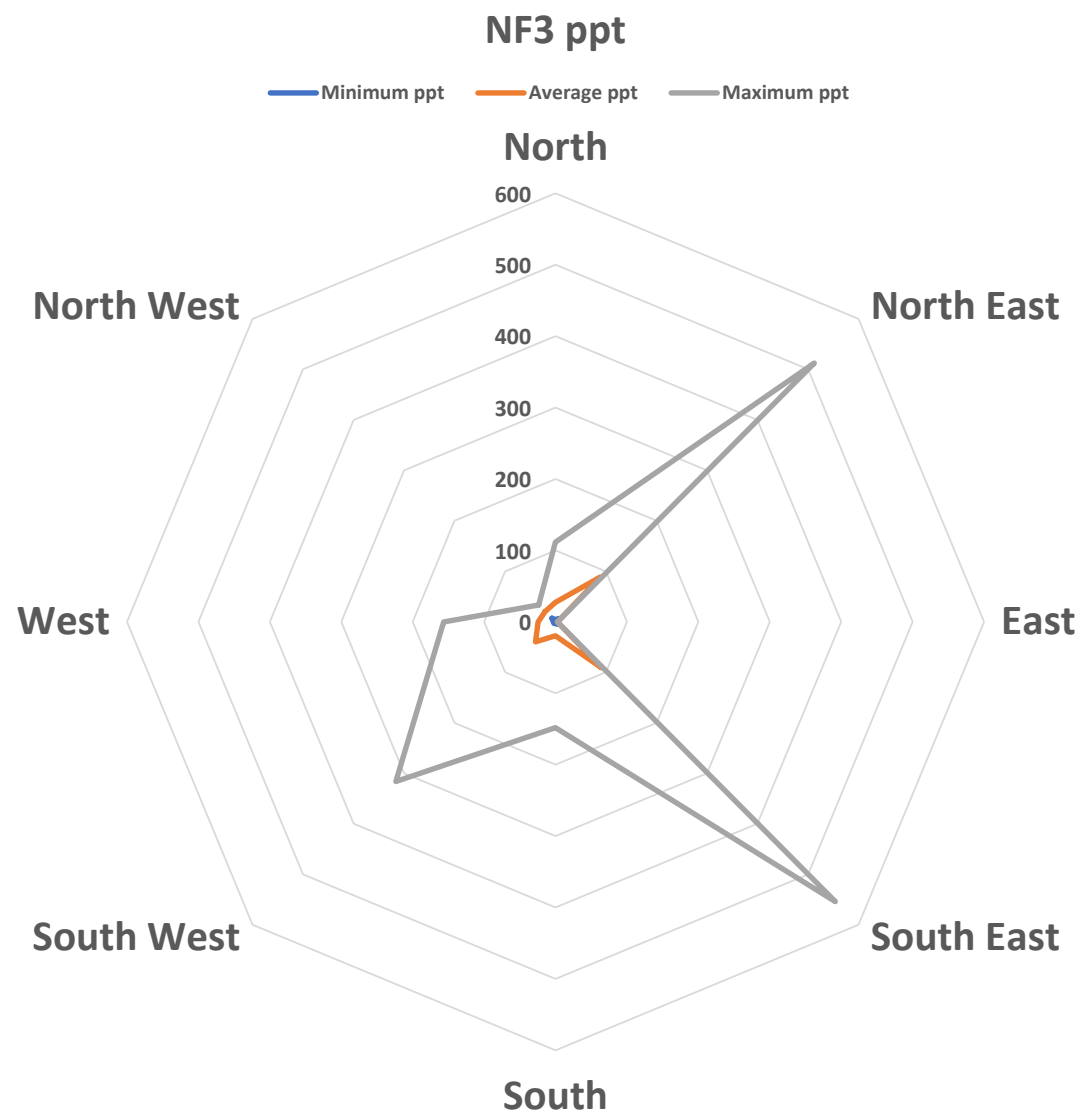
Maximum value = 16.797 s/m



Samples collection direction and CF₄ results (peak, average, minimum).



NF₃ and CHF₃ results (peak, average, minimum).



SF₆ and C₂F₆ results (peak, average, minimum).

SF₆ ppt

— Minimum ppt — Average ppt — Maximum ppt

North

350

300

250

200

150

100

50

0

North West

North East

West

East

South West

South East

South

C₂F₆ ppt

— Minimum ppt — Average ppt — Maximum ppt

North

25

20

15

10

5

0

North West

North East

West

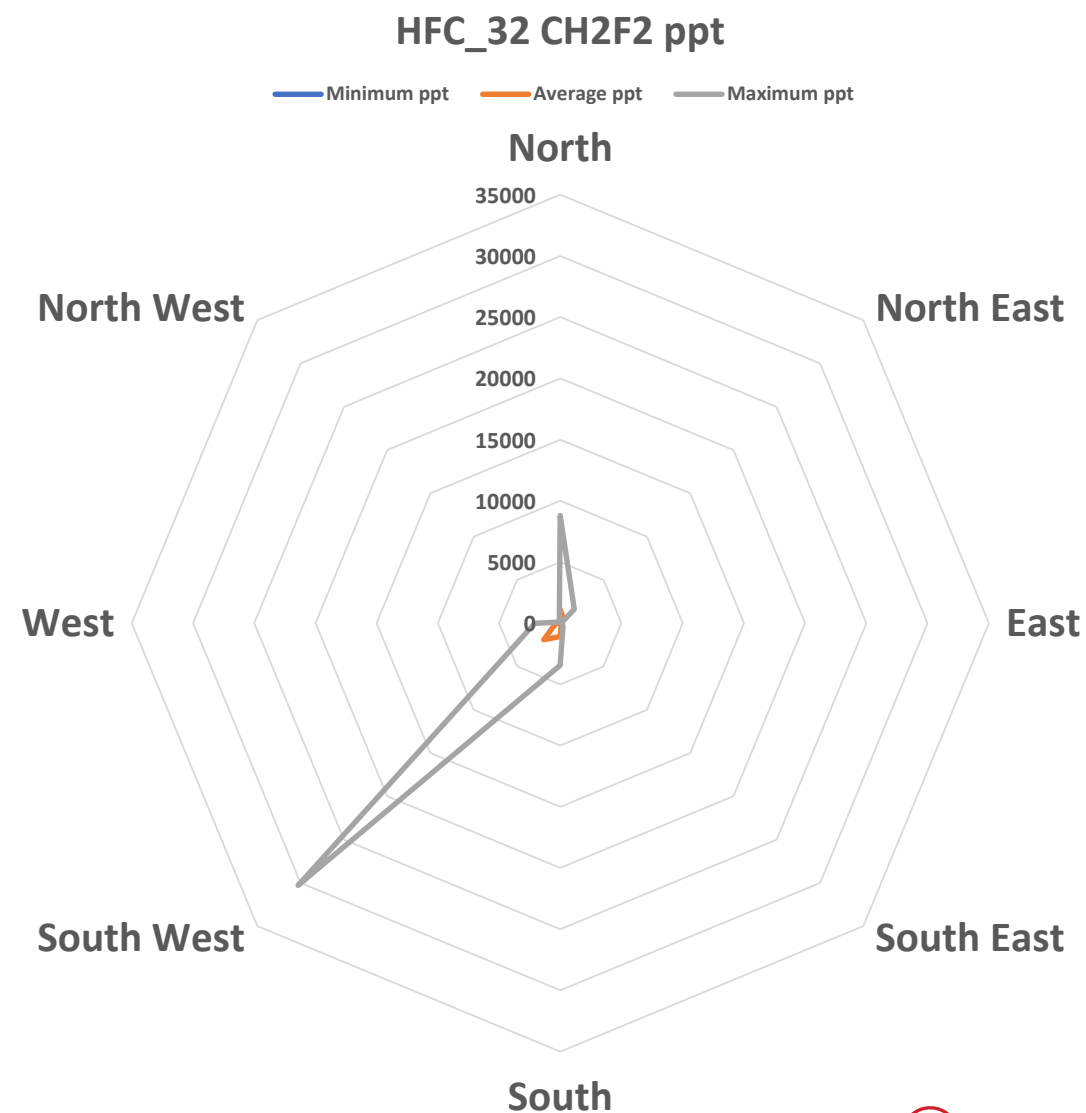
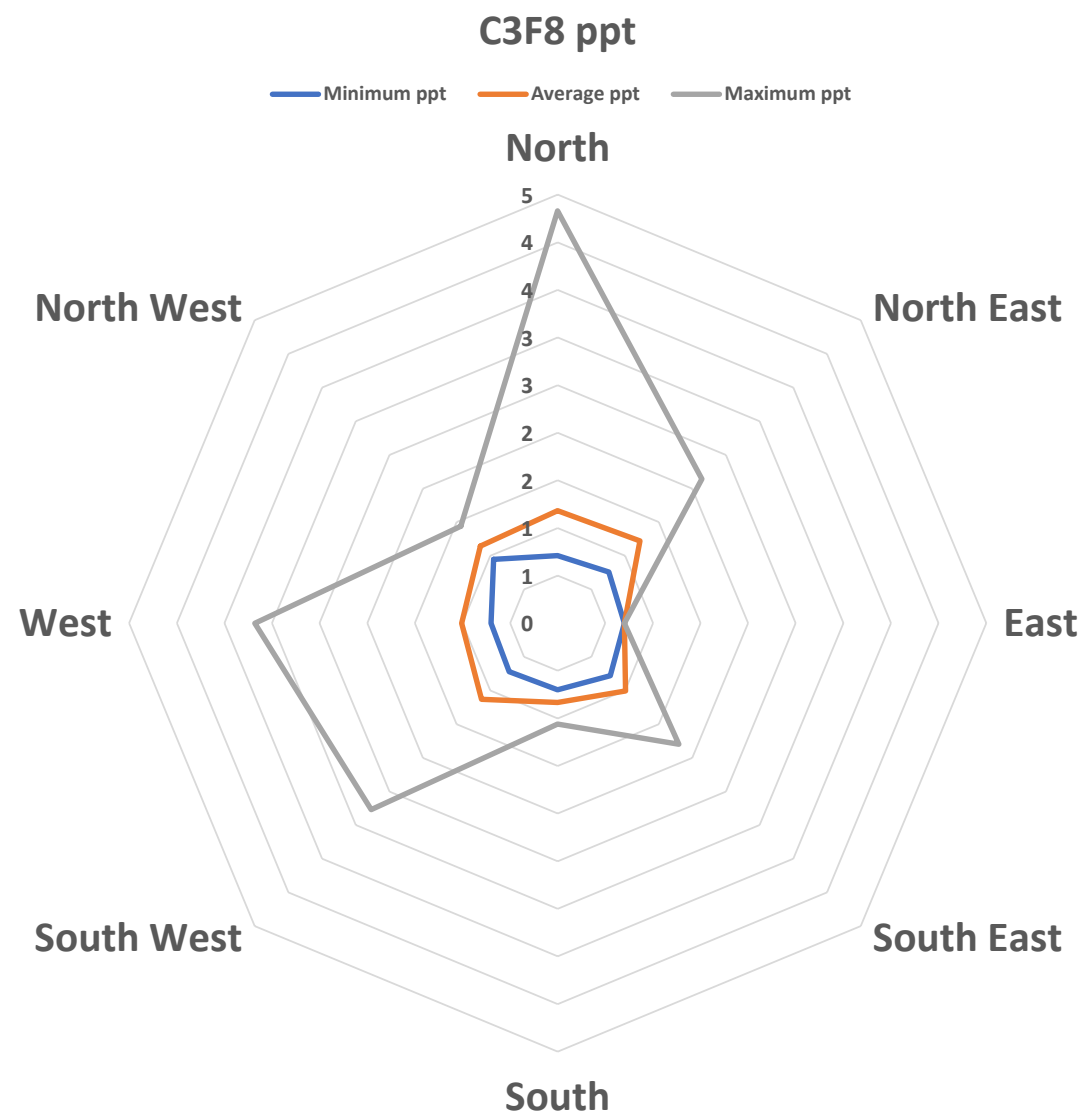
East

South West

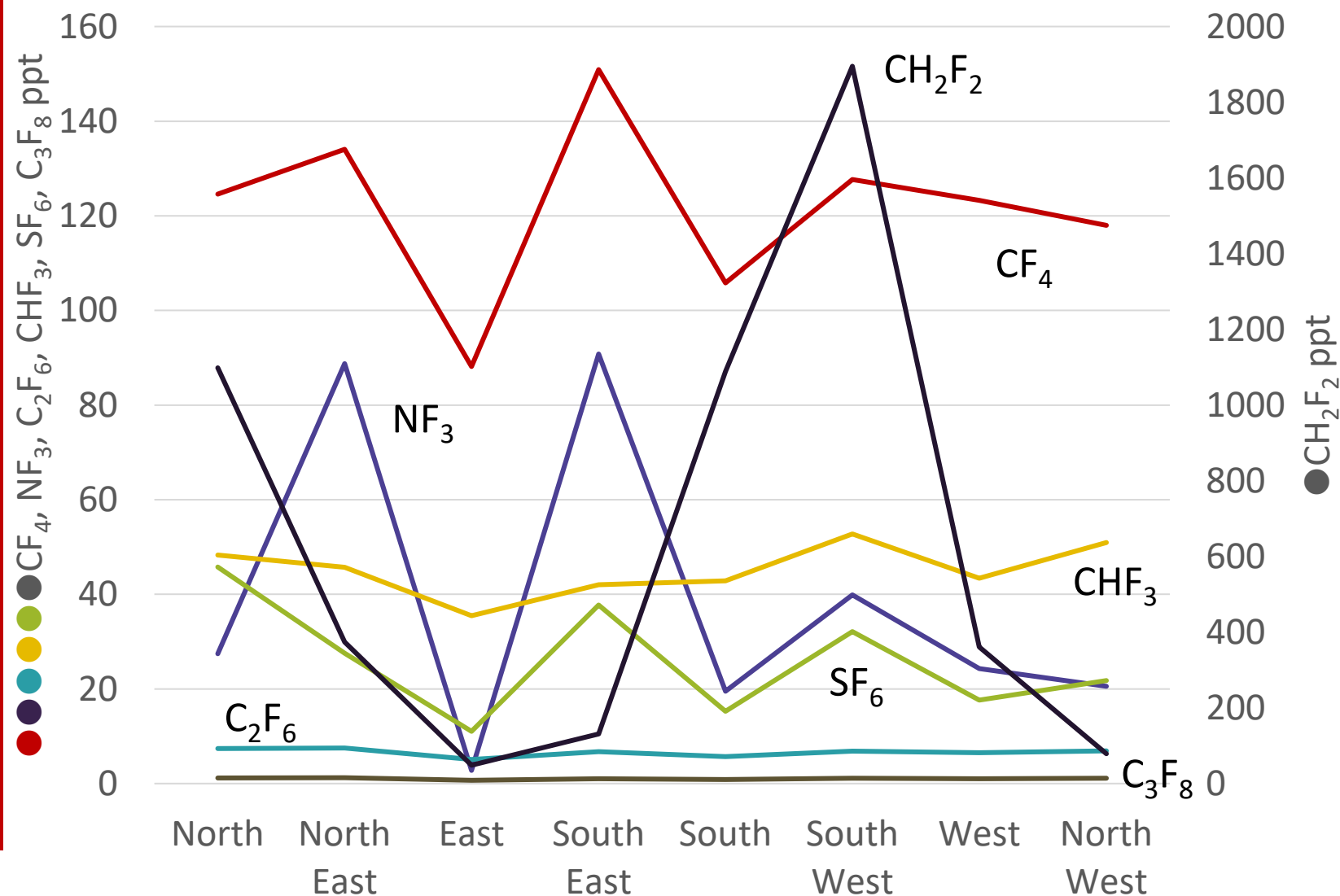
South East

South

C₃F₈ and CH₂F₃ results (peak, average, minimum).



Average data – some correlation between gases (east uses minimum since no samples).



Average Data

- Average data shows some correlation between the gas releases.
- Semiconductor in some form is the likely source of NF_3 , it is interesting to note the peak correlations north east, south east, south west.
- This does not rule out non-semi sources in the same direction.
- These releases are very important to understand and limit.
- More testing, with two collection points, and better use of weather data is required.

Conclusion.



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Summary.

Conclusions

- There is a gap between emissions and recorded.
 - Better modelling.
 - More complete data sets.
 - Cross-industry collaboration.
 - Need more consistent reporting.
- Declared emissions will rise if no action is taken.
 - As the industry grows and if we continue to take the same approach.
 - They will rise as more species are included.
- The industry is improving its use of abatement to manage releases better.
 - Systems analysis and collaboration can take us a long way.
 - We will then need technology changes – the gases are long-lived and will leave a legacy.
- Must never forget that it combines scope 1, scope 2, and scope 3 across the value chain.



edwardsvacuum.com

Abstract

Establishing the Semiconductor Climate Consortium underscores the semiconductor industry's unwavering dedication to confronting its unique and shared challenges concerning greenhouse gas emissions as the industry grows.

Given the longevity of many of these gases in our atmosphere, their management is crucial and will also gain heightened significance over time. We will examine such releases from our industry using both top-down and bottom-up approaches and some monitoring that we have performed in Korea. We will juxtapose the information from our industry with that from other sectors.

Central to our discussion will be emissions management strategies that resonate with the Consortium's emphasis on holistic collaboration across the value chain, bolstered by the active involvement of myriad external stakeholders.

Speaker details

With a Ph.D. in chemistry and nearly four decades of dedication to Research and Development and Environmental Protection, Chris has been at the forefront of creating solutions for industries ranging from semiconductor and nuclear to military and pharmaceutical. He's crafted methods to keep our air and water clean and is currently Edwards' Environmental Solutions Business Development Manager. Always eager to share his knowledge, Chris is passionate about helping fab owners grasp their operations' local and global environmental impacts. He's genuinely committed to a greener future!

