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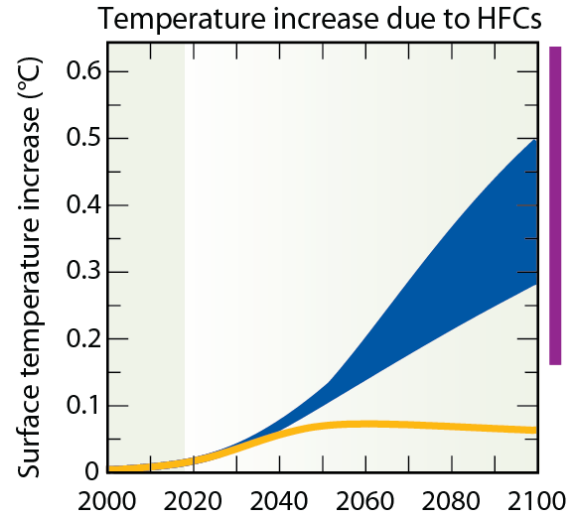
Trends in HFC emissions and updated projections

Guus Velders (RIVM, Utrecht Univ.)

John Daniel, Stephen Montzka, Isaac Vimont (NOAA),
Matthew Rigby (Univ. Bristol), AGAGE-team

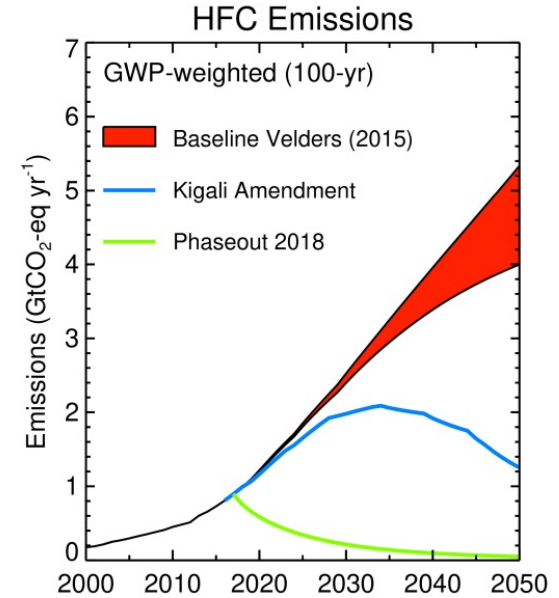
Previous HFC projections: WMO assessment 2018

- Large projected increase HFC emissions in absence of regulations
- 2050 emissions: 4.0-5.3 GtCO₂-eq/yr



HFC contribution to surface warming: 0.3-0.5 °C in 2100

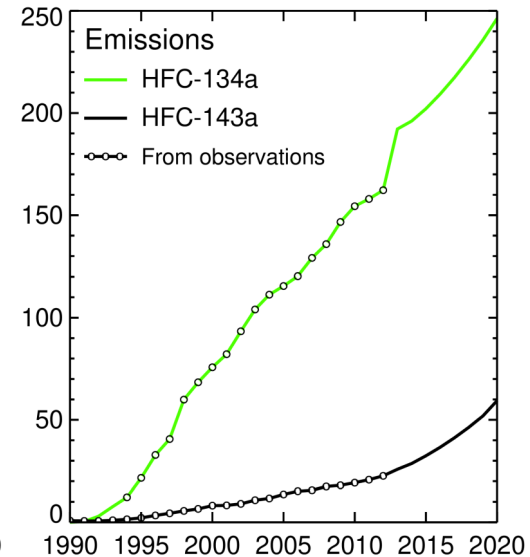
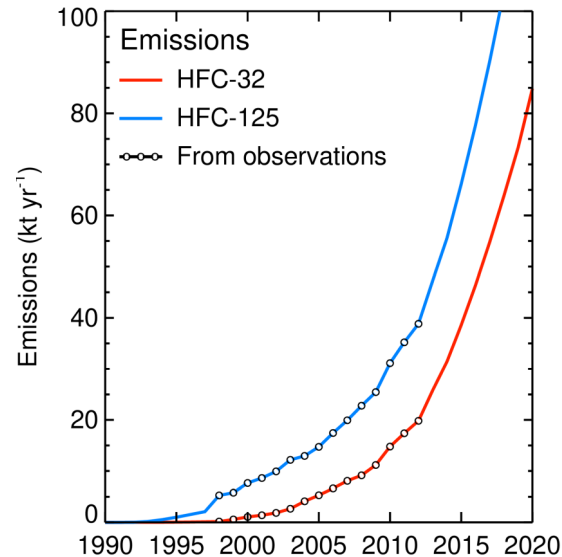
UNEP/WMO (2018)



Emissions from observations vs projections

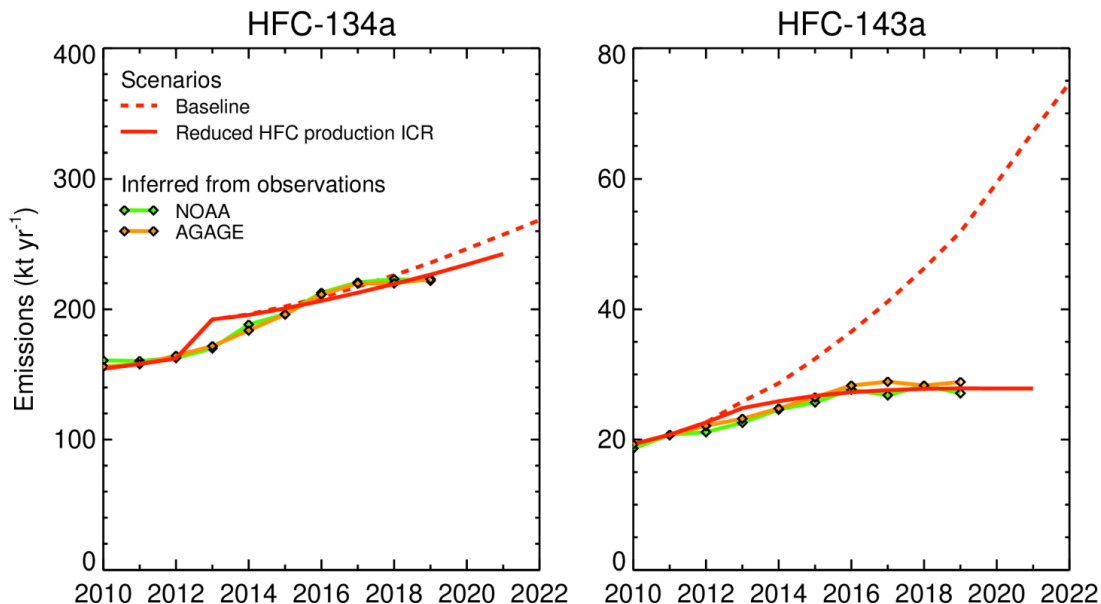
Are recent HFC observations in agreement with projections?

- Emissions inferred from observed global average mixing ratios from NOAA and AGAGE
- Baseline HFC projection from Velders et al. (2015) and WMO(2018)
 - Business-as-usual



Velders et al. (2015)

Inferred emissions HFC-143a much lower



Velders et al. (ACP, 2022)

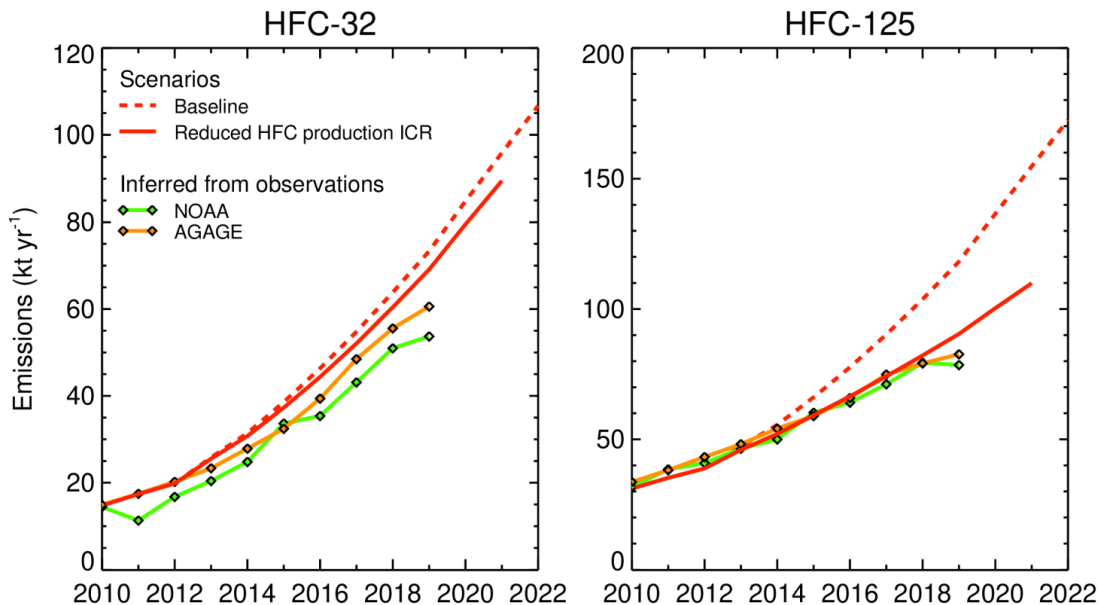
- HFC-143a
 - Refrigeration (industrial & commercial)
 - 50% below projected level
- HFC-134a
 - Various uses
 - Good agreement with projection

→ **Use of HFCs in industrial/comm. refrigeration smaller than expected**

- In EU
- Consumption in China

→ **Scenarios with reduced HFC use in ICR**

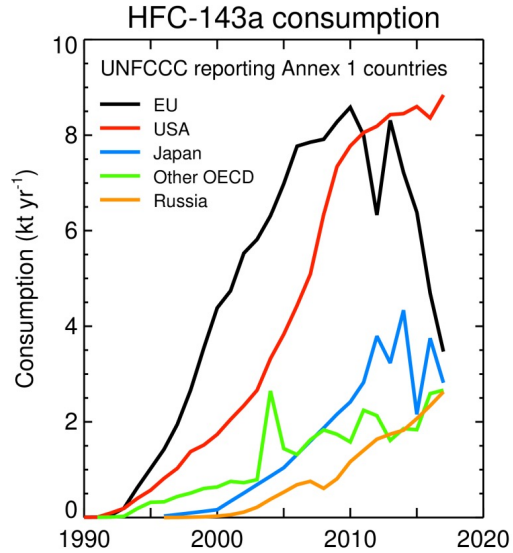
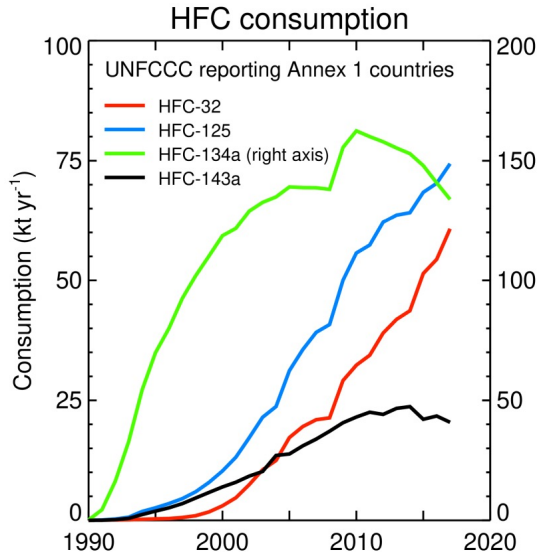
Inferred emissions HFC-32, -125 lower



Velders et al. (ACP, 2022)

- HFC-32
 - Stationary AC
 - 20-25% below projection
 - HFC-125
 - Stationary AC + Refrigeration
 - 30-40% below projection
 - Good agreement with limited use in refrigeration
- **Use of HFCs in industrial/comm. refrigeration smaller than expected**
- Smaller growth in sector
 - Conversion away from HFCs

HFC consumption nonA5 countries



- Consumption derived from UNFCCC reported data
- Reduction in HFC-134a consumption
- Consumption HFC-143a stabilized
- HFC-143a more than halved in EU
- Stabilized in USA and Japan

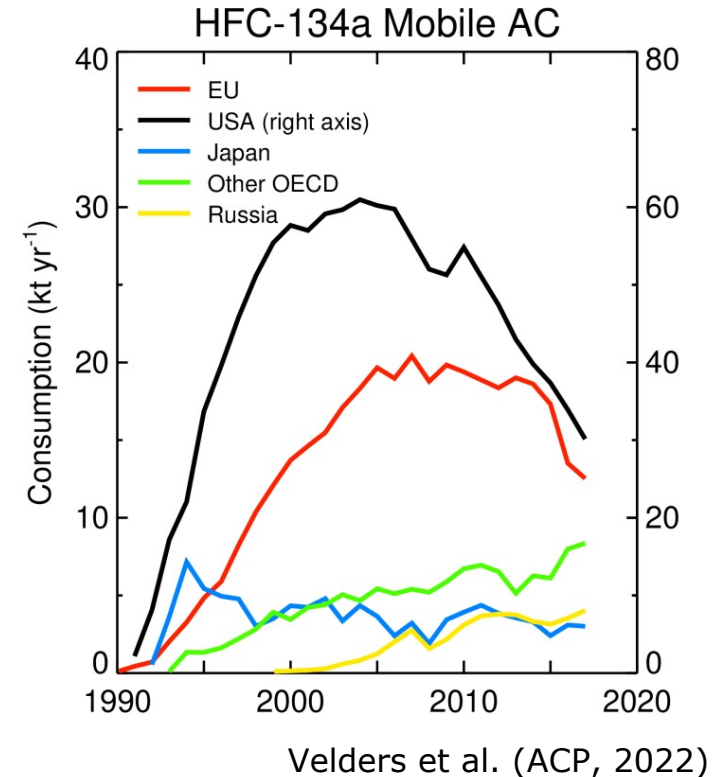
Also (not shown here)

- Lower consumption in China than before

Velders et al. (ACP, 2022)

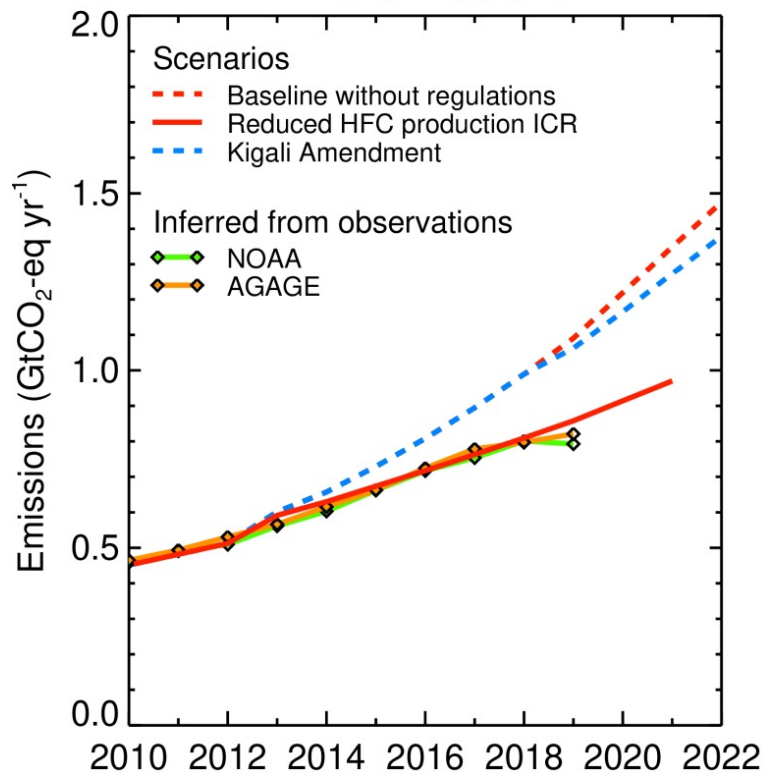
HFC-134a consumption nonA5 countries

- Large reduction in HFC-134a consumption in mobile AC use



Inferred CO₂-eq emissions below projections

HFC emissions



- Total emissions seem to level off
- Emissions 20-30% below projections
- Annex 1 reported emissions constant since ~ 2014
- Reduced HFC prod/cons in refrigeration → close agreement with inferred emissions

Velders et al. (ACP, 2022)

Updated scenarios

- NOAA and AGAGE observed mixing ratios 1990-2020
 - ➔ Inferred global emissions of 10 HFCs
- NonA5: HFC data from UNFCCC reporting
 - Statistics: Newly manufactured, Operating systems, Decommissioning
 - Emissions from various stages
 - ➔ Consumption 1990-2017 for 10 HFCs, 13 use sectors
- A5: New HFC consumption data
 - China, bottom-up data 1995-2017 from Li et al. (2019)
 - India, data for 2016 (Say et al., 2019)
- HCFC phaseout data from UNEP
- Policies in EU, USA, Japan
- Kigali amendment provisions

Example UNFCCC CRF data

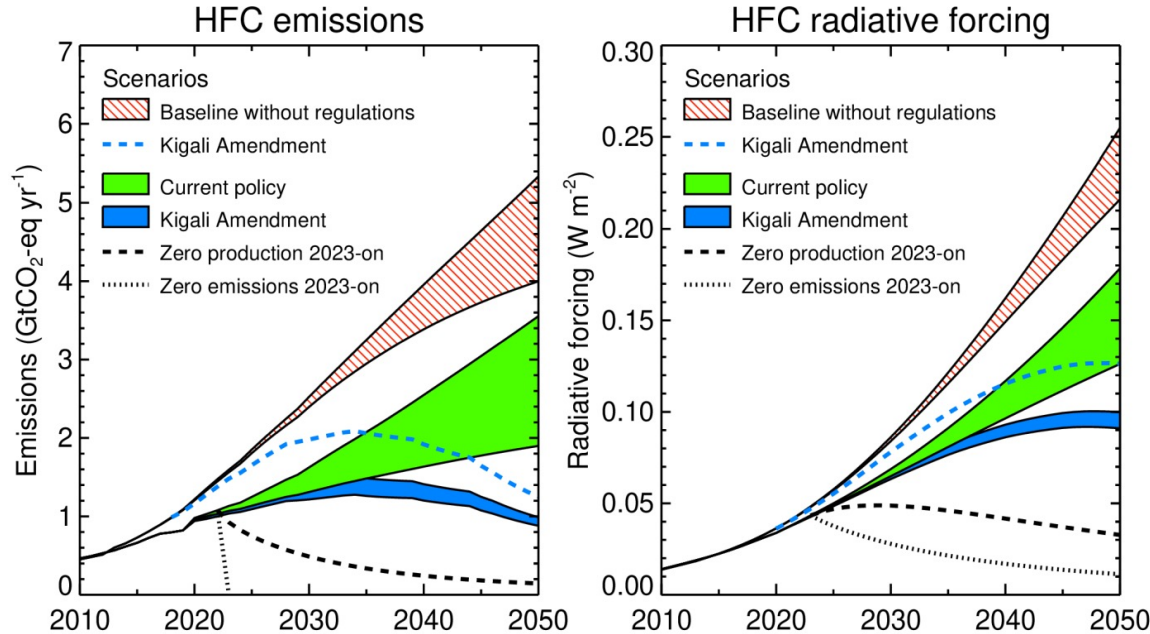
TABLE 2(D).B.H. SECTORAL BACKGROUND DATA FOR INDUSTRIAL PROCESSES AND PRODUCT USE
Sources of fluorinated substances
(Sheet 2 of 2)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Gas (please specify) One row per substance	ACTIVITY DATA		
		Amount		
		Filled into new manufactured products	In operating systems (average annual stocks)	Remaining in products at decommissioning
(0)				
F. Product uses as substitutes for ODS				
1. Refrigeration and air conditioning				
Commercial refrigeration				
	HFC-23	NA	NA	NA
	HFC-32	NO	NO	NO
	HFC-41	NA	NA	NA
	HFC-43-10ane	NA	NA	NA
	HFC-125	646.84	4015.25	1.98
	HFC-134	HFC-134a	NA	NA
	HFC-134a	HFC-134a	489.29	2669.01
	HFC-143	HFC-143a	NA	NA
	HFC-143a	HFC-143a	723.56	3724.68
	HFC-149a	HFC-149a	723.56	3724.68

Scenario, as before:

HFC demand proportional to GDP and Population from IPCC Shared-Socioeconomic Scenarios

Updated HFC projections



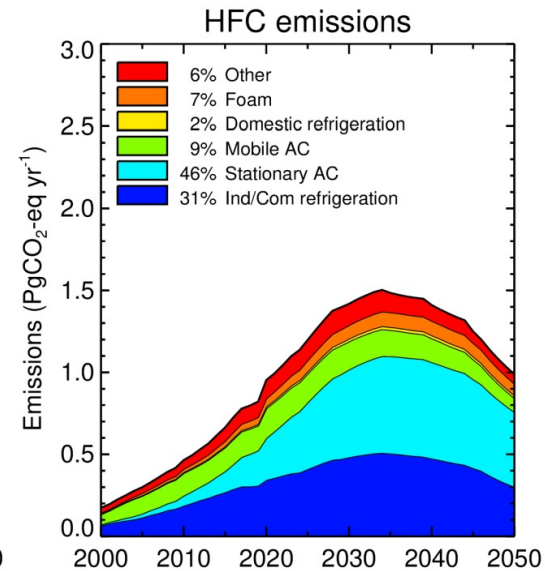
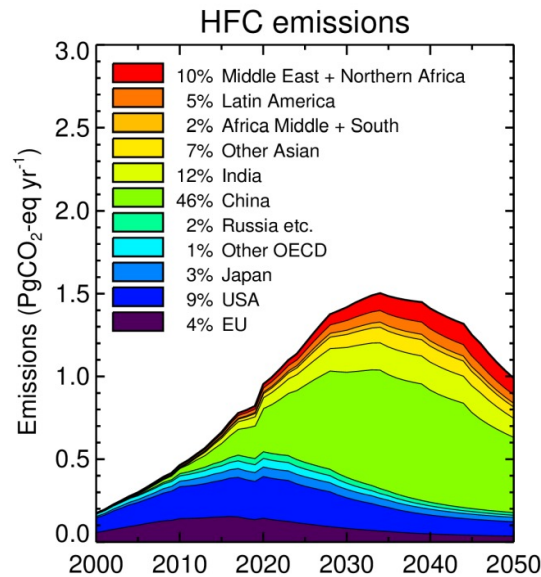
- Baseline without HFC controls
- Current policies in EU, USA, Japan
- Current trends (from obs.)
- Kigali amendment
- Hypothetical zero production and emissions scenario

	<u>Baseline</u>	<u>Policies</u>	<u>Kigali</u>
2050 Emissions	4.0-5.3 →	1.9-3.6 →	0.9-1.0 GtCO ₂ -eq/yr
Rad. forcing	from 0.22-0.25 →	0.13-0.18 →	0.9-1.0 W/m ²

Velders et al. (ACP, 2022)

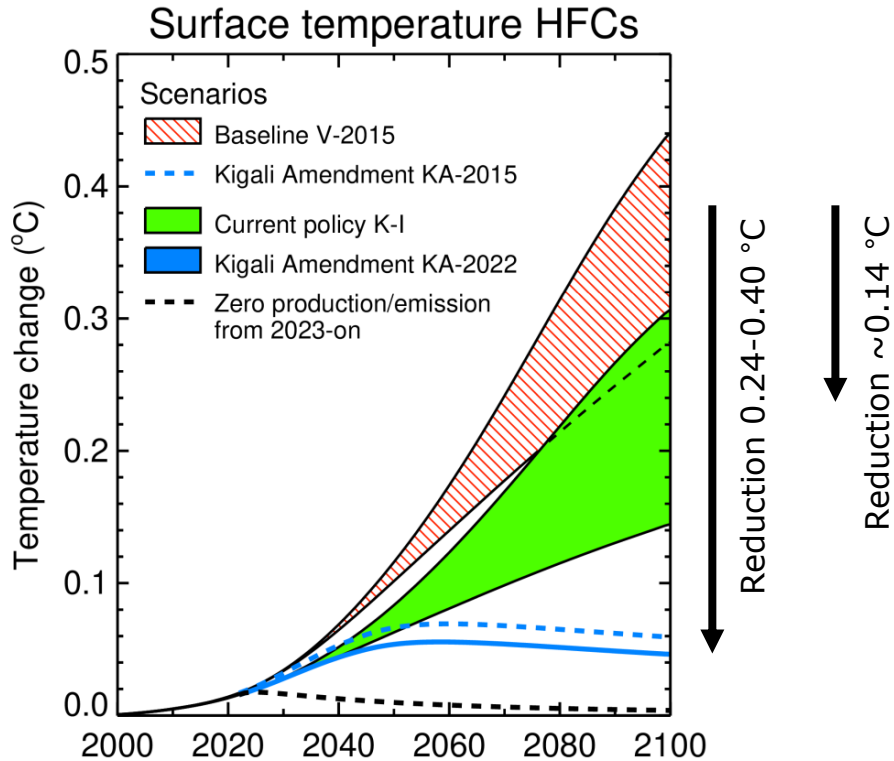
Sectoral and regional contributions

- Implementation of Kigali Amend.
- Assumed here: uniform reduction over all sectors



Velders et al. (ACP, 2022)

Figure 7: Temperature



- Temperature contribution HFCs in 2100:
 - From baseline: 0.28-0.44 °C
 - To current policy: 0.14-0.31 °C
 - To Kigali Am.: ~ 0.04 °C
- Zero production in 2023: <0.01 °C

Velders et al. (ACP, 2022)

Conclusions

HFC emissions inferred from observations less than business-as-usual projections

→ Smaller HFC use for industrial/comm. refrigeration smaller than projected previously

Updated projections lower than before

Effect of Kigali Amendment similar as before

→ Surface temperature reduction of 0.2-0.4 °C



Remember!!!