"The longest atmospheric record, radiative forcing and emissions for perfluorocarbons"

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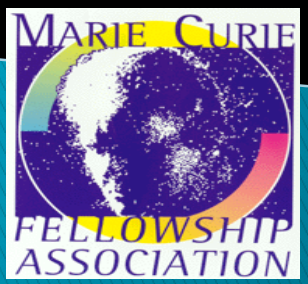
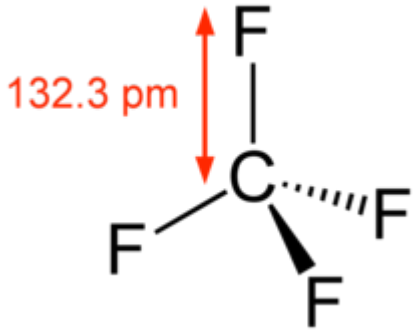
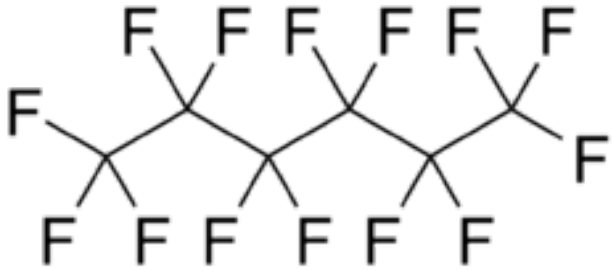


Introduction: Perfluorocarbons

- Atmospheric perfluorocarbons are compounds consisting of carbon and fluorine atoms.





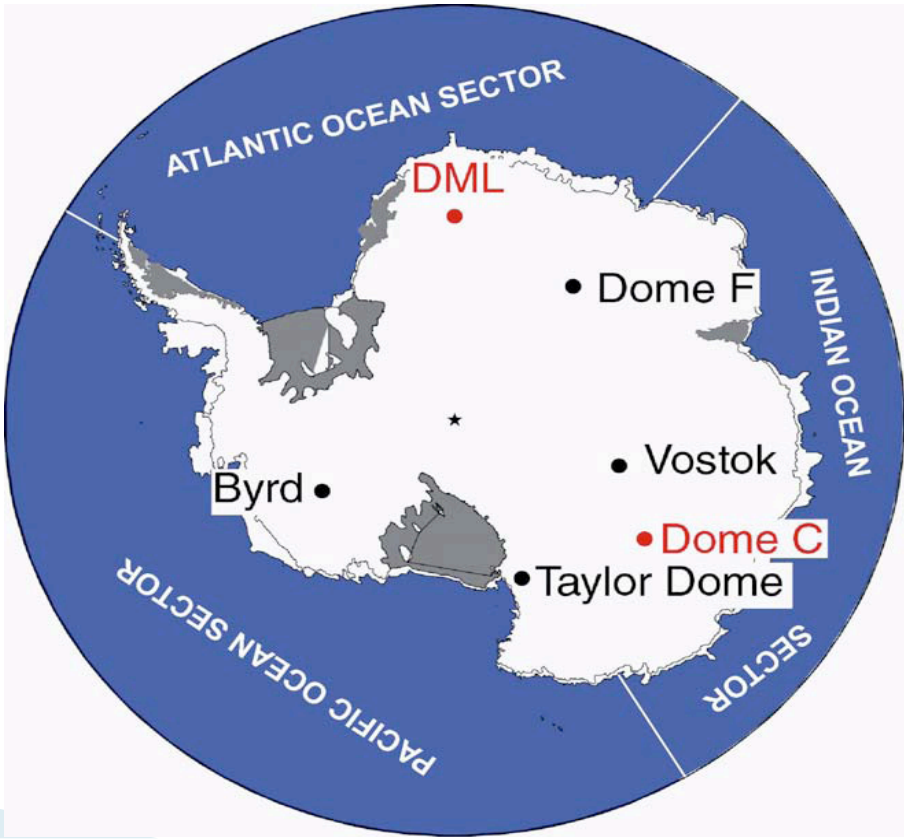
- Perfluorocarbons are strong greenhouse gases and are included in the Kyoto Protocol

PFCs have very long atmospheric lifetimes and very large GWPs

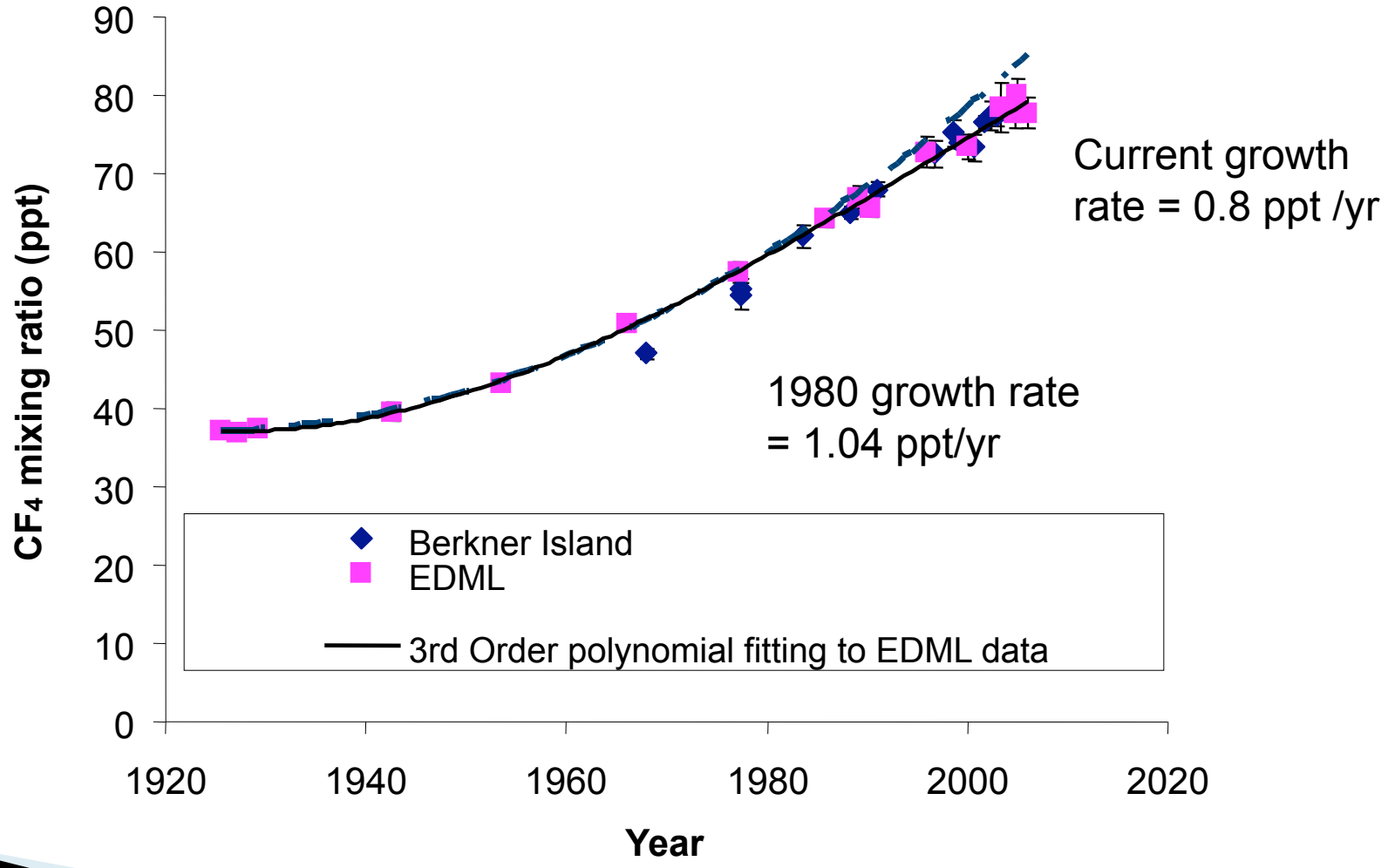
Gas	Atmospheric Lifetimes(yr)	100 y – GWP
CF_4	50000	7390
C_2F_6	10000	12200
C_3F_8	2600	8830
$c\text{-}C_4F_8$	3200	10300
C_4F_{10}	2600	8850
C_5F_{12}	4100	9150

Reconstructing atmospheric histories

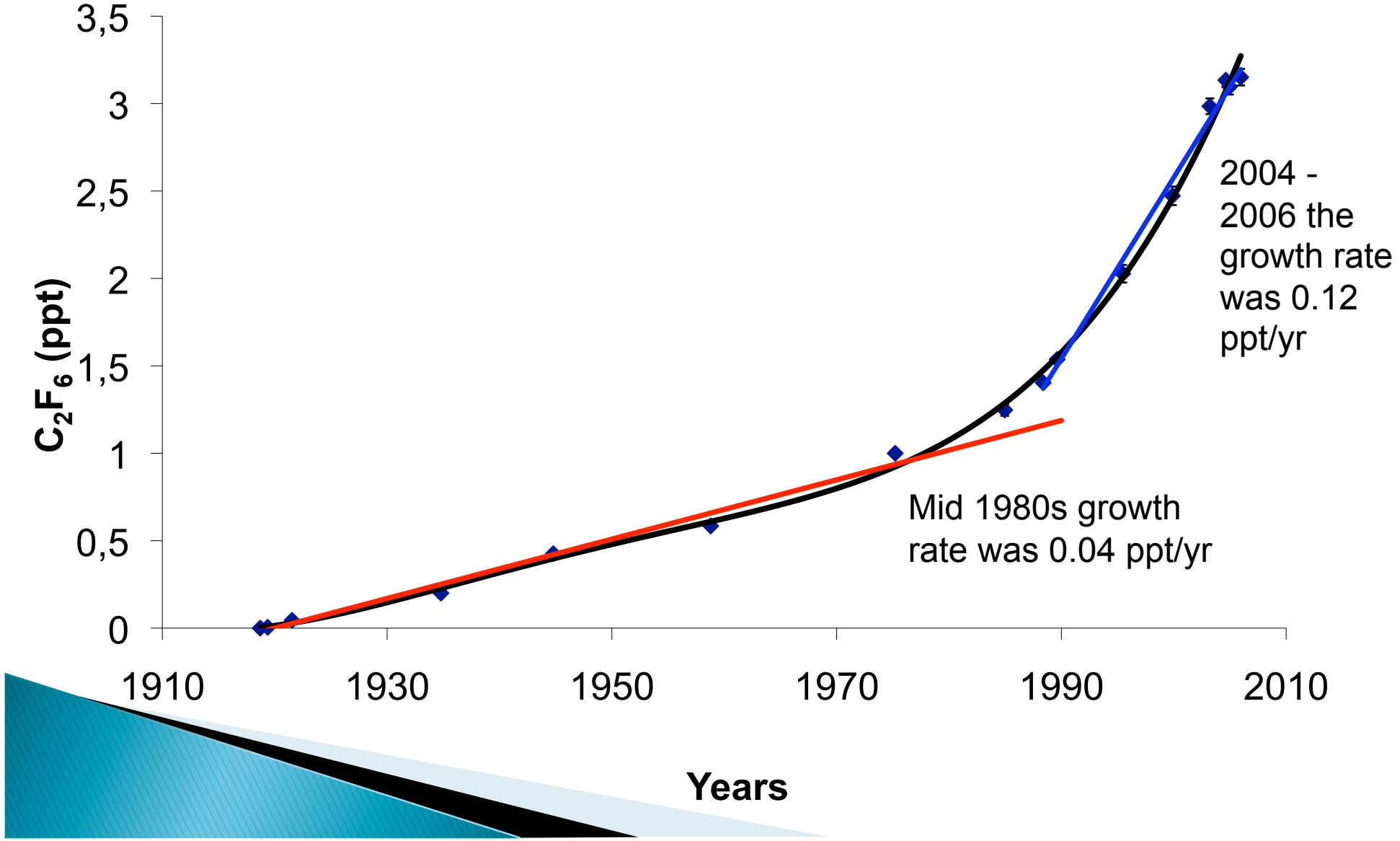
- Firn air is an archive for “old” air and when collected and analysed allows for reconstruction of past atmospheric histories of trace gases.
- Firn air samples were collected from the EDML site
- Air samples were analysed on GC-MS
- Air samples were assigned with dates with a firn diffusion model



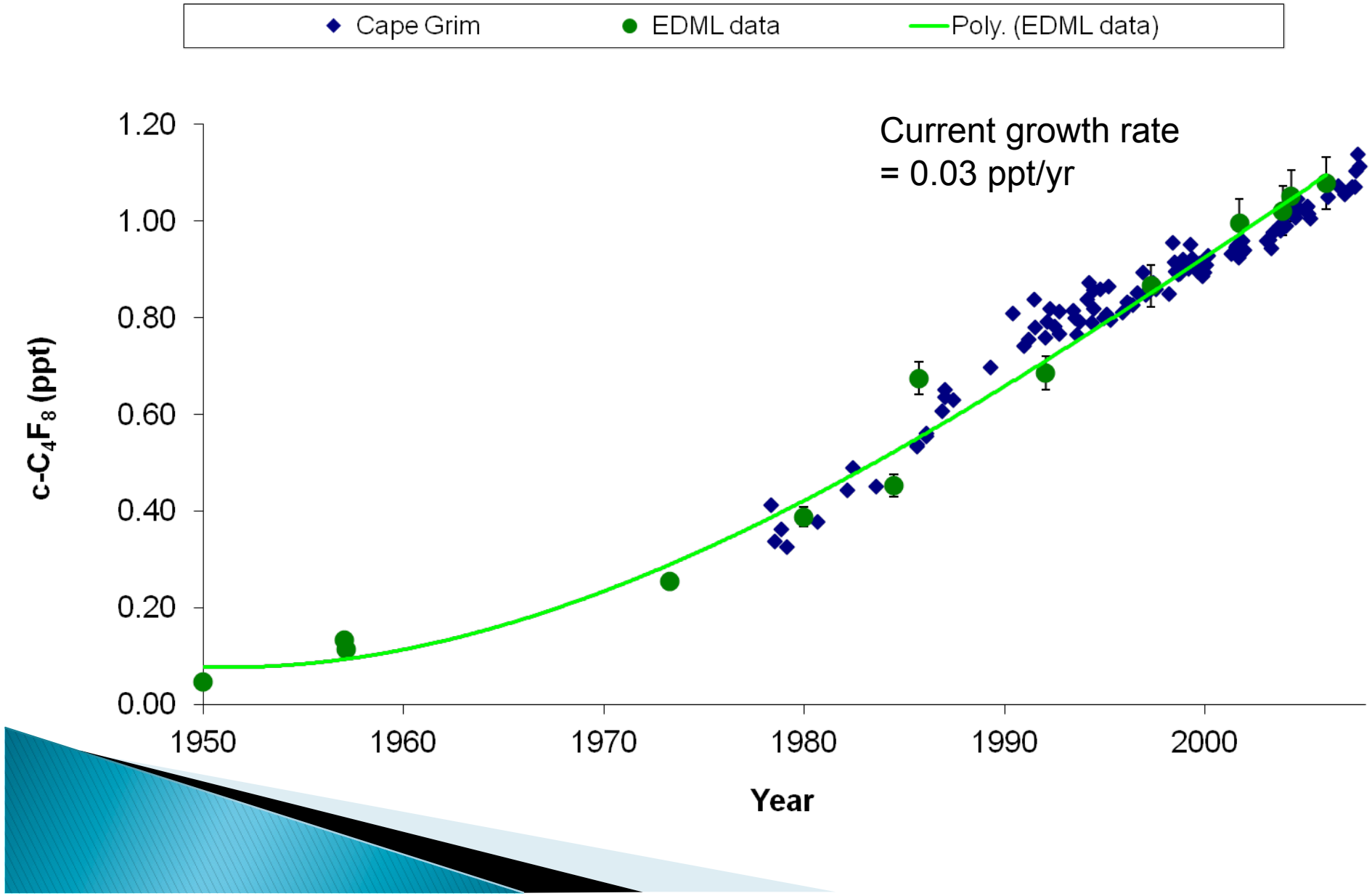
Results: CF_4


90
80
70
60
50
40
30
20
10
0
CF4 mixing ratio (ppt)
1920
1940
1960
1980
2000
2020
Year
Current growth
rate = 0.8 ppt /yr
1980 growth rate
= 1.04 ppt/yr
Berkner Island
EDML
3rd Order polynomial fitting to EDML data

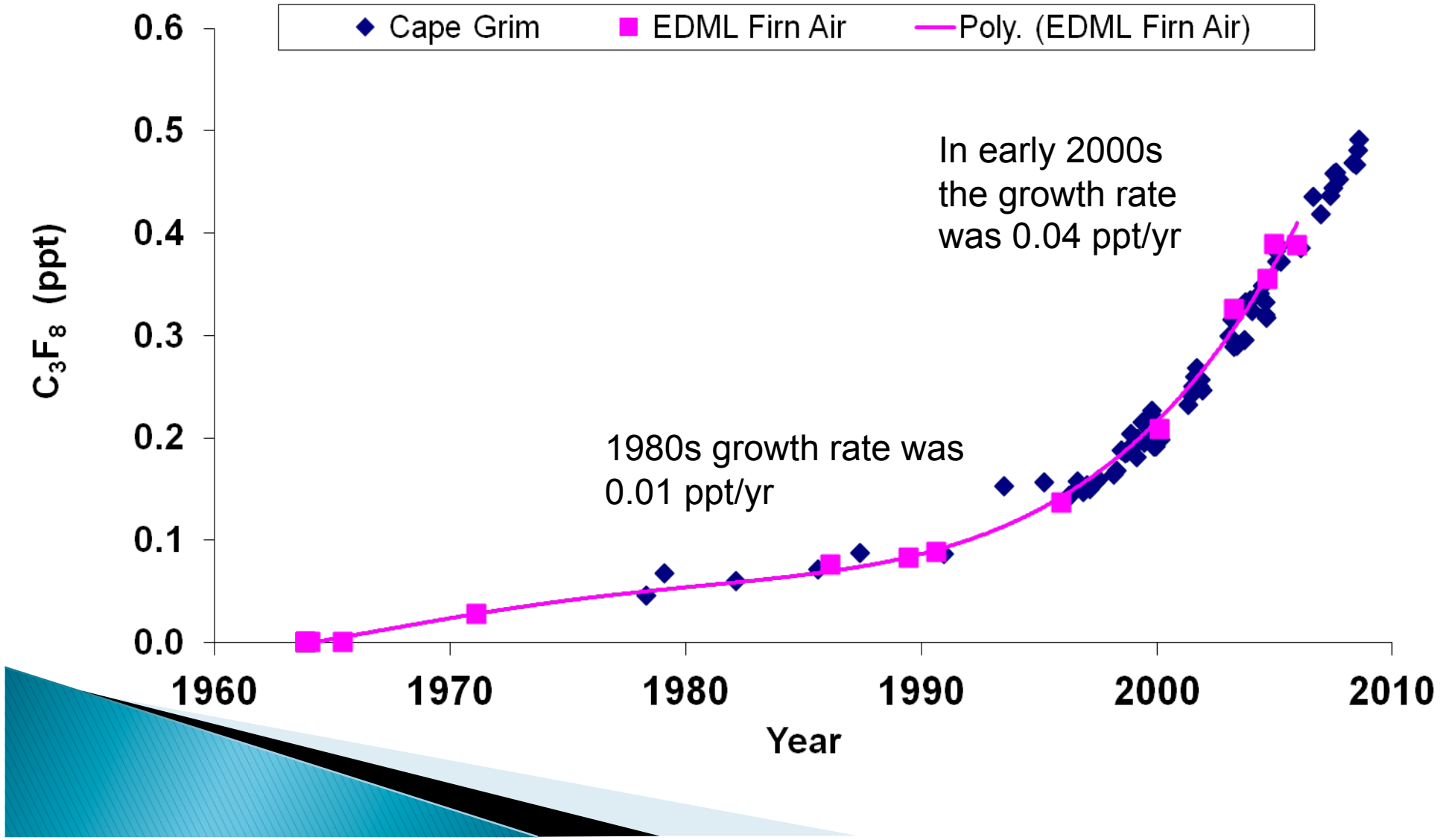
C_2F_6


3,5
3
2,5
2
1,5
1
0,5
0
C_2F_6 (ppt)
1910
1930
1950
1970
1990
2010
Years
2004 - 2006 the growth rate was 0.12 ppt/yr
Mid 1980s growth rate was 0.04 ppt/yr

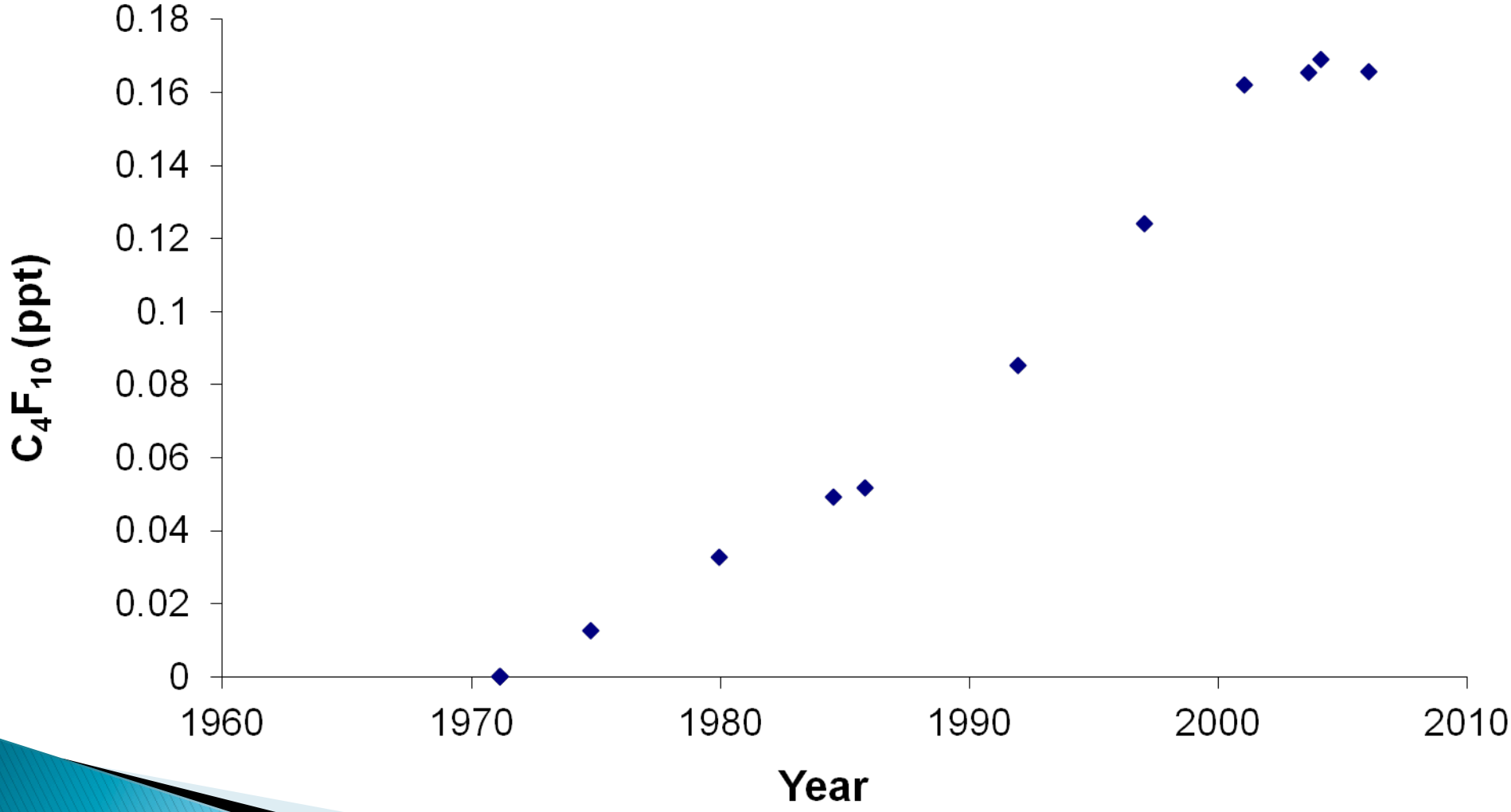
$c\text{-}C_4F_8$


Cape Grim
EDML data
Poly. (EDML data)
Current growth rate
= 0.03 ppt/yr
c-C4F8 (ppt)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1950
1960
1970
1980
1990
2000
Year

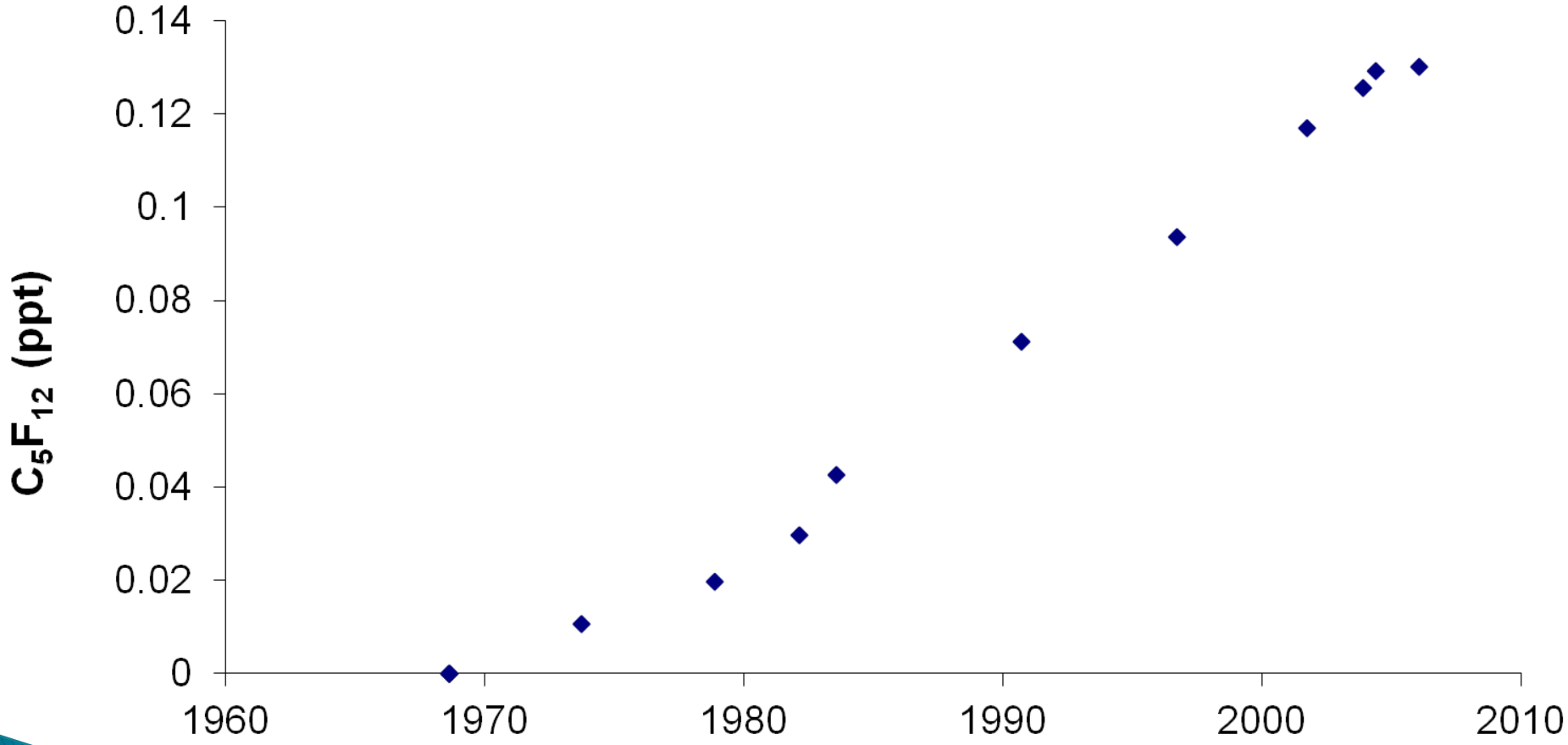
C_3F_8


Cape Grim
EDML Firn Air
Poly. (EDML Firn Air)
In early 2000s
the growth rate
was 0.04 ppt/yr
1980s growth rate was
0.01 ppt/yr
C_3F_8 (ppt)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1960
1970
1980
1990
2000
2010
Year

C_4F_{10}


0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
C4F10 (ppt)
1960
1970
1980
1990
2000
2010
Year

C_5F_{12}


0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
C_5F_{12} (ppt)
1960
1970
1980
1990
2000
2010
Year

Emission Estimates: Data from AGAGE Top-down model (Mühle et al., 2010)

CF_4

Year	Emission (Gg/yr)
1975	15
1980	18
2000	11

C_2F_6

Year	Emission (Gg/yr)
1975	1.5
Mid 1990s	2.2
Early 2000s	3.0
2008	2.3

Emissions cont'd

C_3F_8

Year	Emission Gg/yr
1975	0.1
1992	0.3
Mid 2000s	1.1
2008	0.6

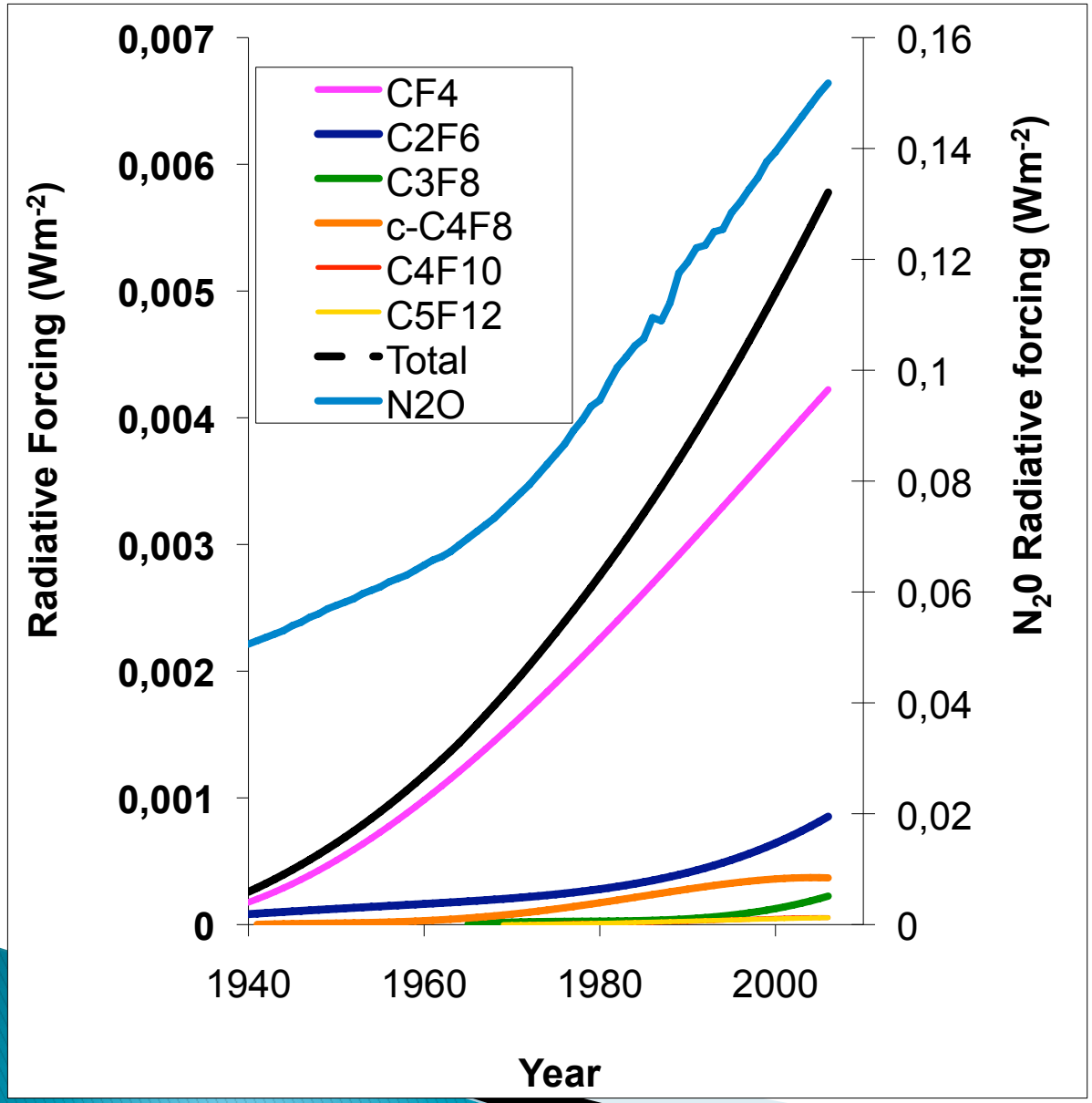
c-C_4F_8

Year	Emission (Gg/yr)
1978	0.9
Mid 1980s	1.7
Mid 1990s	0.4 (0.002)*
2008	1.0 (0.02)*

* EDGAR emission database

(Source for c-C_4F_8: Dave *et al.*, 2011)

Radiative forcing



The total radiative forcing from PFC is ~ 0.006 Wm^{-2}, which is only ~ 4% of N_2O radiative forcing.

Since 1995 the total RF of PFCs changed by +25% whereas for N_2O the RF changed by +15%

Due to long atmospheric lifetimes, PFCs can permanently alter the radiative budget of the atmosphere

Conclusion

- Although the atmospheric abundance of PFCs and its contribution to radiative budget are small but if emissions are left uncontrolled and not monitored than it can seriously add to the anthropogenic forcings of climate change.
- The cumulative emission of c-C_4F_8 up to 2007 was 38.1 Gg/yr which is equivalent to 0.39 billion tonnes of CO_2. To put this in context, it is similar to the annual anthropogenic CO_2 emission for UK (0.47 billion tonnes in 2009)

Conclusions cont'd

- More work is required to identify sources and quantify emissions for the new PFCs identified in the atmosphere. Consequently mitigation options could be implemented.

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THANK YOU