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Aviation GHG emissions

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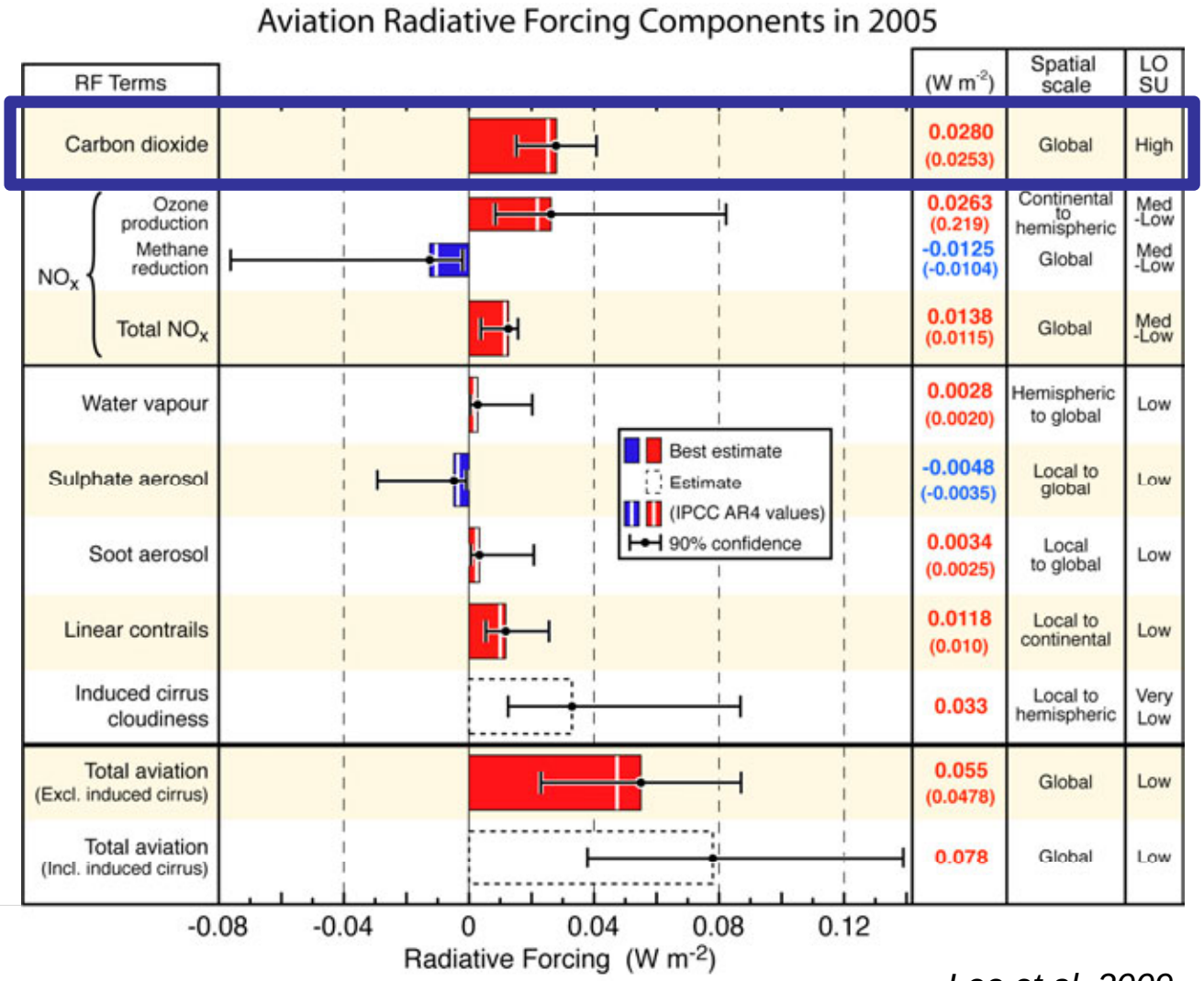
Outline

- Aviation emissions and radiative forcing
- Which emissions really matter?
- Historical aviation emissions
- Future aviation emissions
- Accumulation of CO_2
- Conclusions

Aviation is more than CO_2

(see following talks by Schumann, Waitz, Sausen)



Lee et al. 2009

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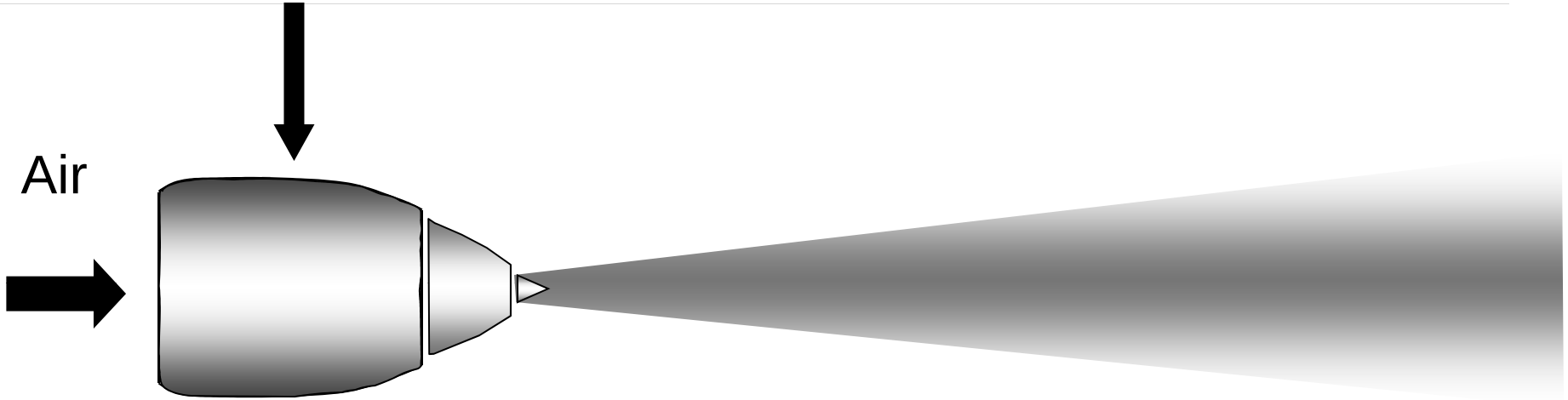
Fuel C_nH_m (+S)

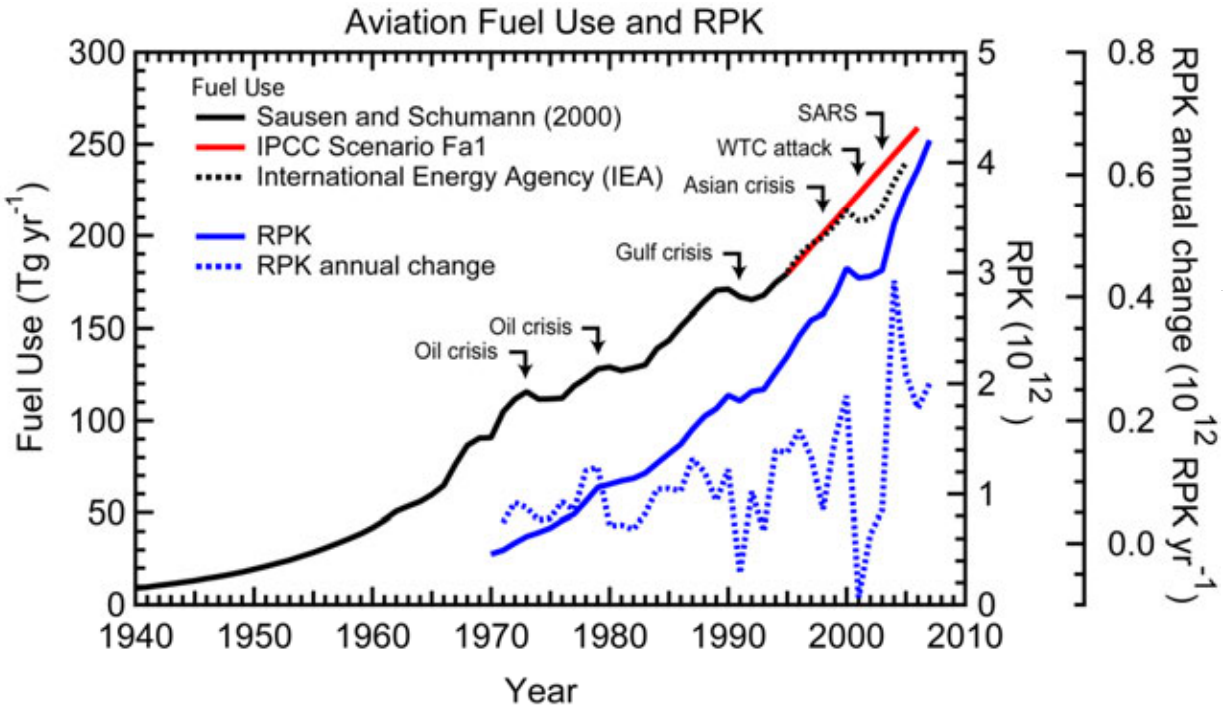


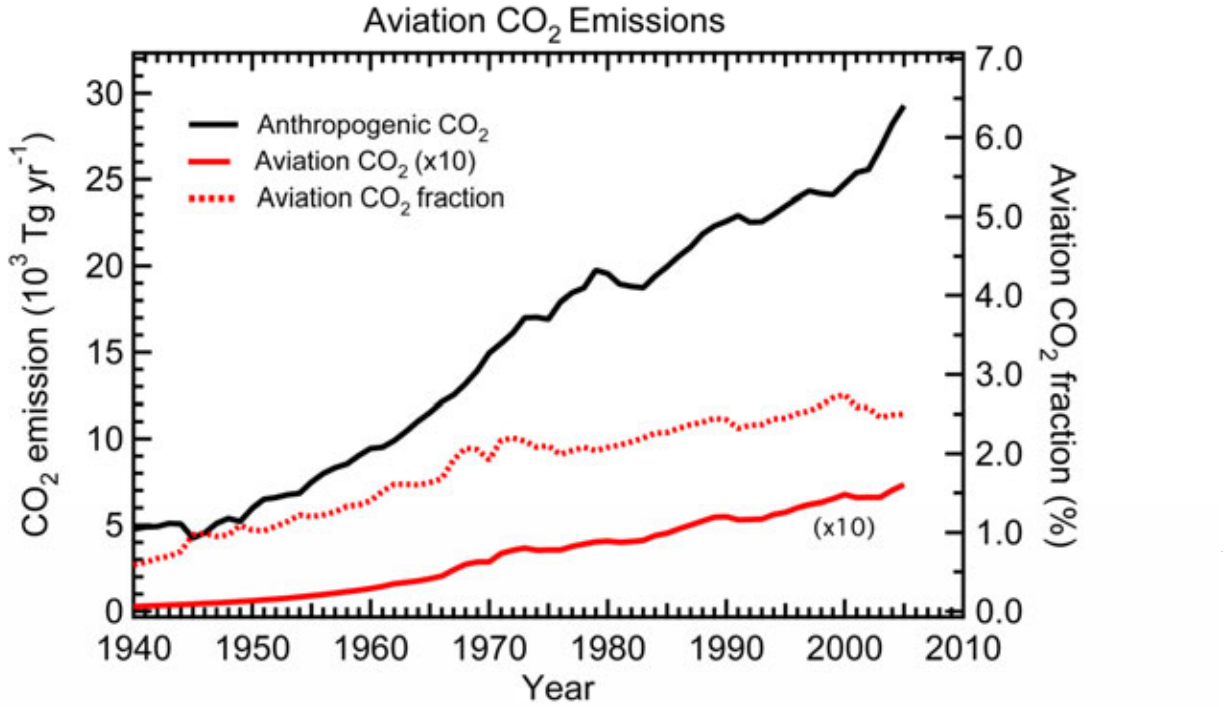
CO_2 + H_2O + N_2 + O_2 + NO_x + UHC + CO + C_{soot} + SO_x

\+ \+ O_3 CH_4 \+ \- \+ \-

Aviation CO_2

- CO_2 is the only significant long-lived GHG emission from aviation
- Other aviation non-CO_2 effects are much shorter-lived but remain as important as CO_2 whilst emissions continue (Schumann, Waitz, Sausen talks)
- However, CO_2, once emitted, is "banked" in the atmosphere and its effects persist for many thousands of years





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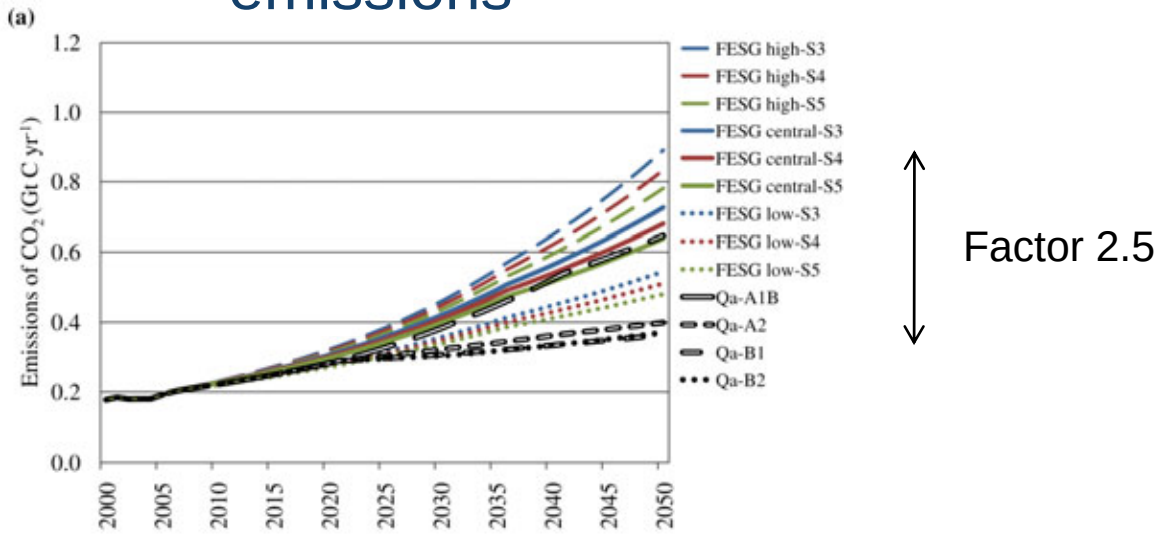
Historical aviation emissions

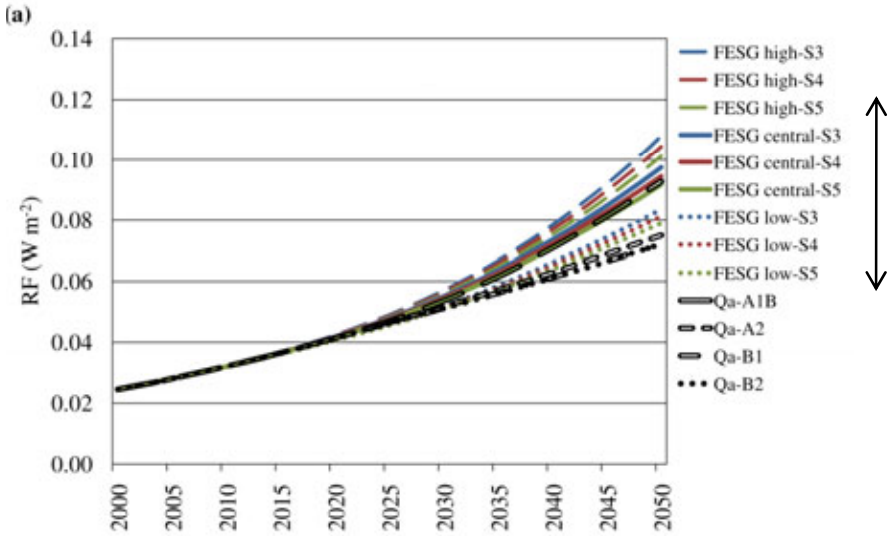
Source: Lee et al., 2009

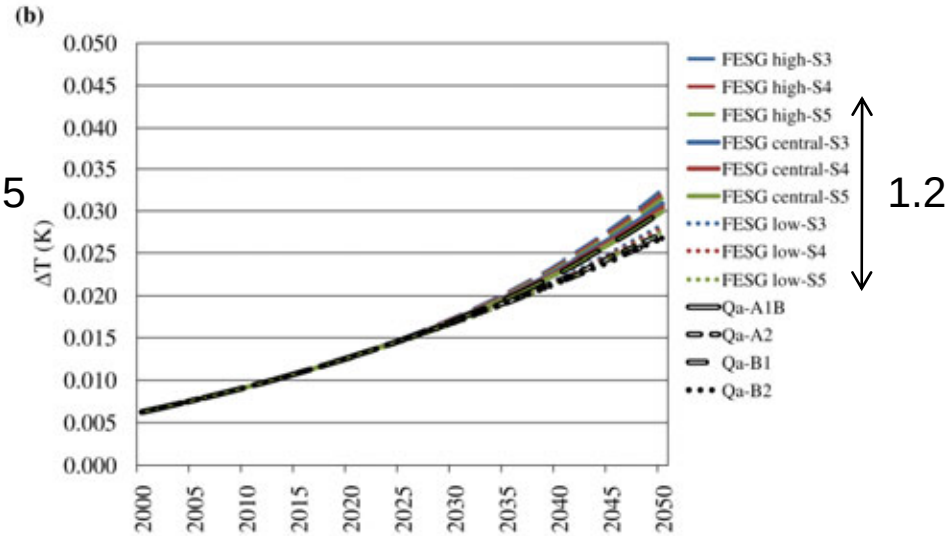
Future emissions

- Range of scenarios to 2050
- European EU Quantify project (Owen et al., 2009)
- CAEP/8-FESG emission projections for GIACC

emissions







radiative forcing

temperature response

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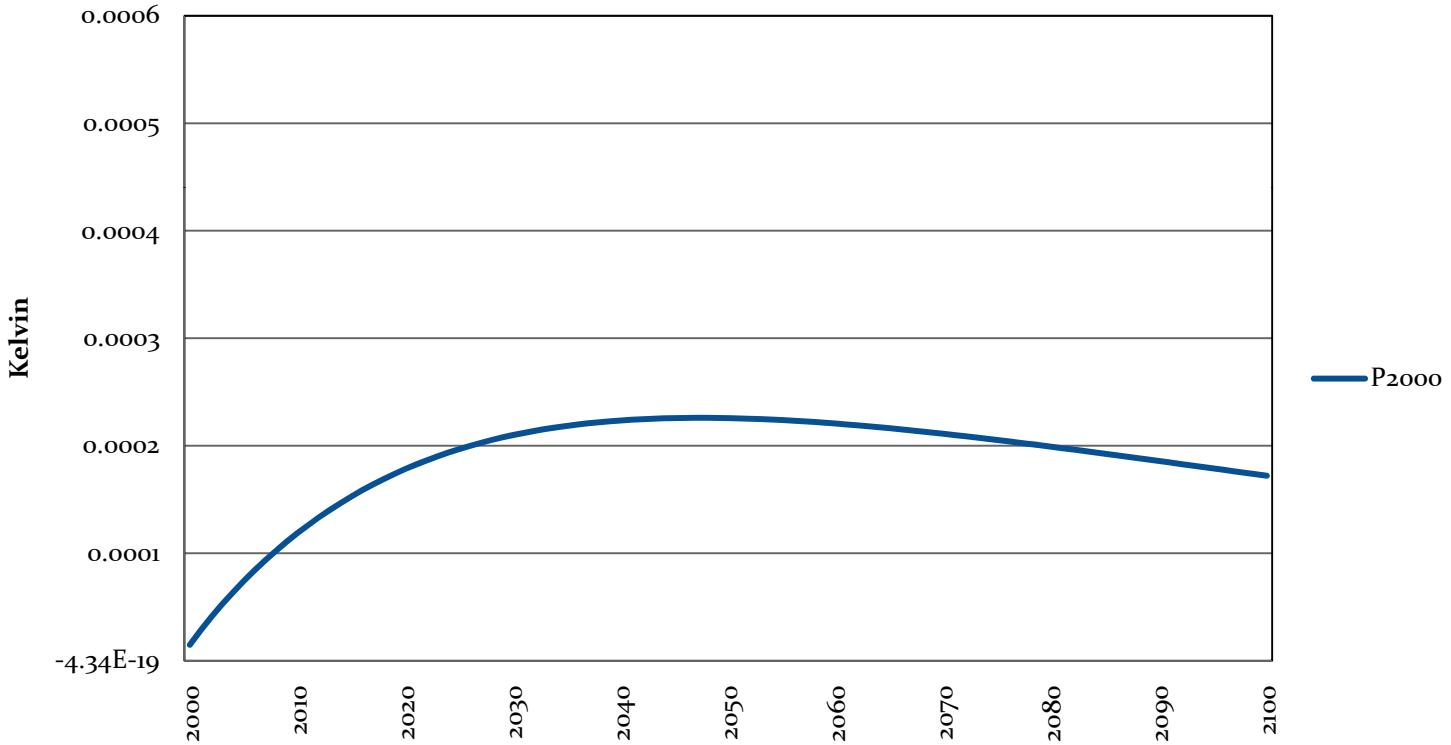
Single CO_2 pulse



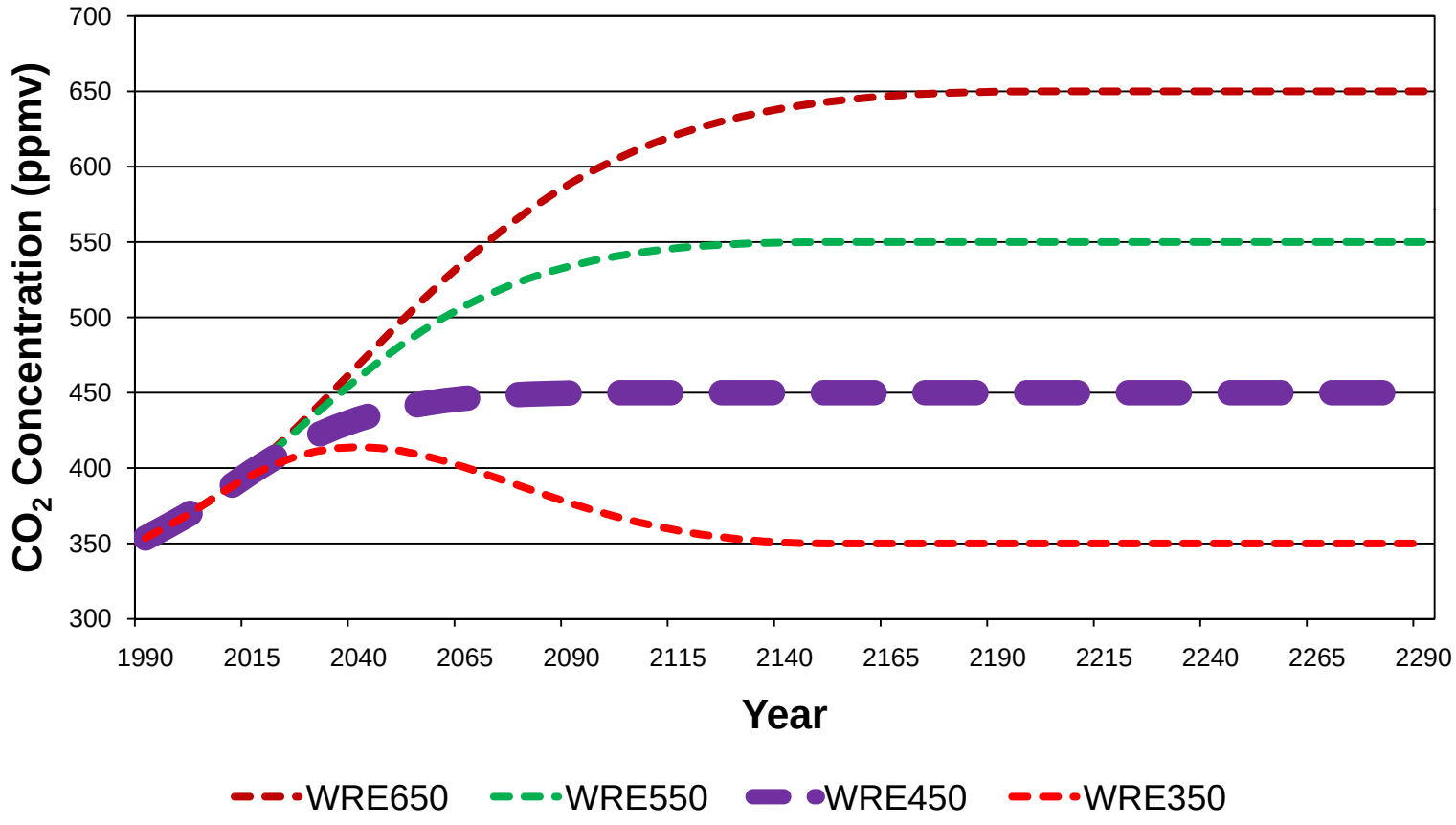
Carbon dioxide accumulates

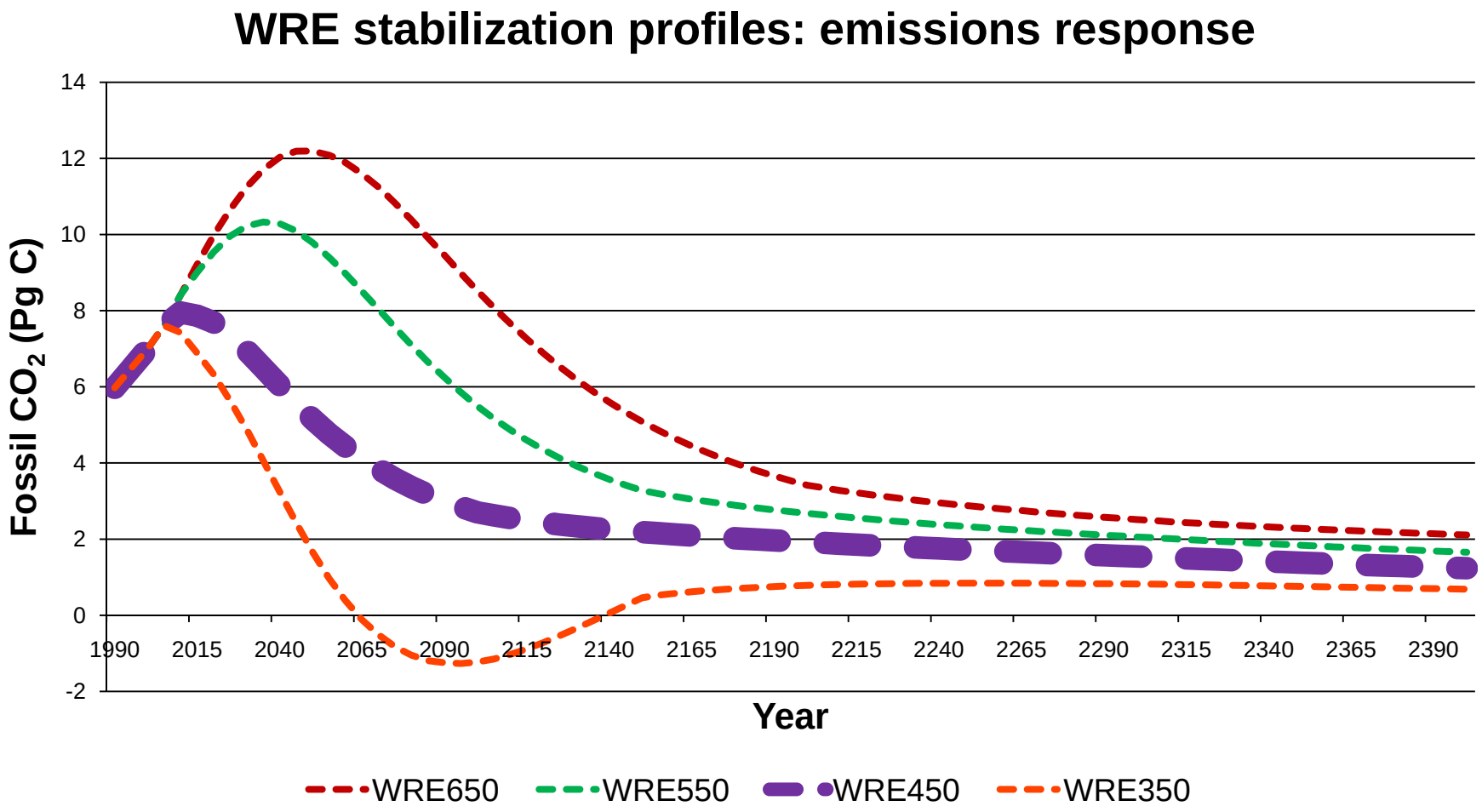
- It does not have a lifetime of “about 100–150 yrs”
- CO_2 has several timescales of removal: about 50% of an increase is removed within 30 yrs, and a further 30% within a few centuries: the remaining 20% will remain for many thousands of years (IPCC, 2007)

Aviation emission of CO_2 and stabilization at 2 degrees C increase

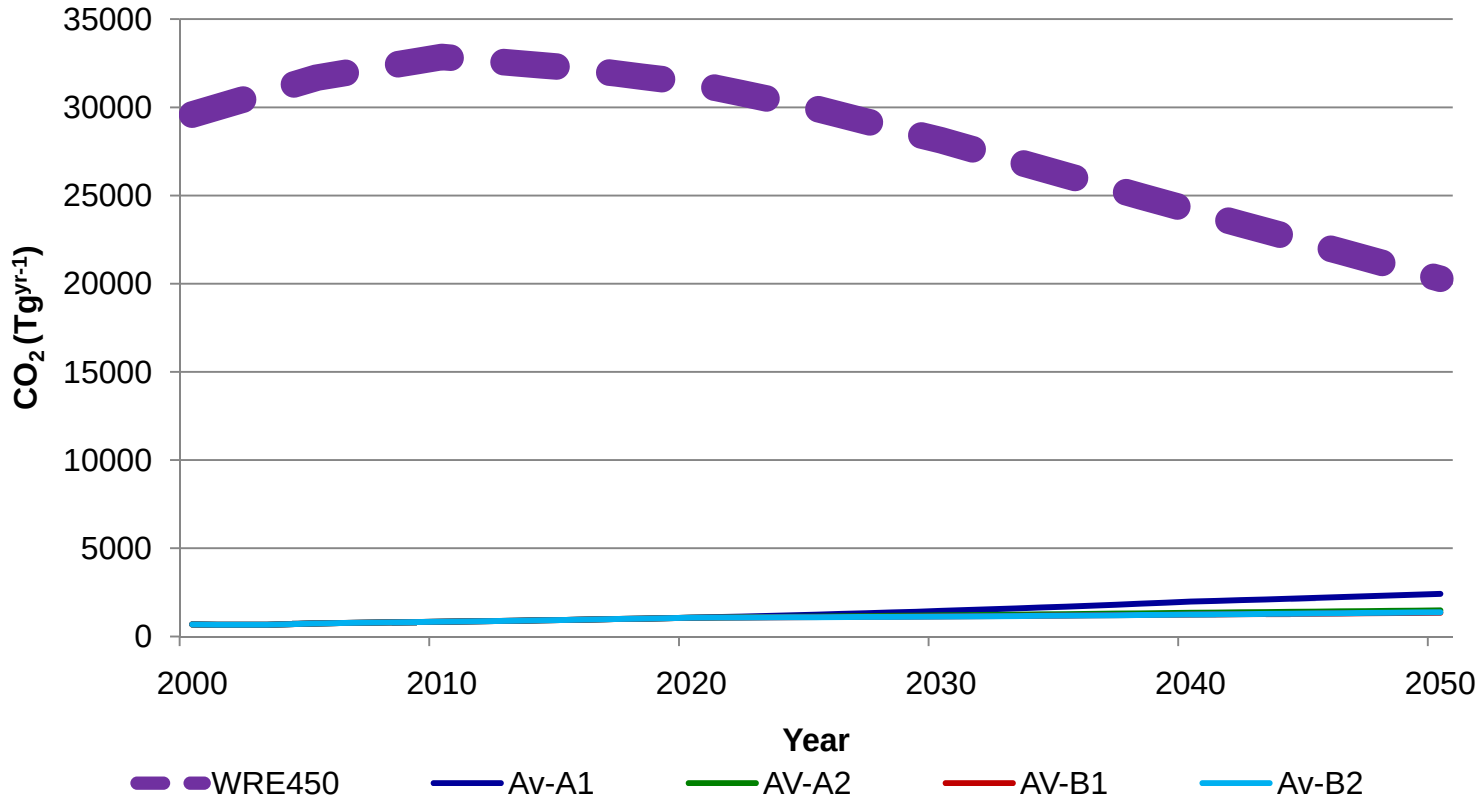
- Total accumulative CO_2 emissions, to a first order, provides guidance for a 'safe limit' of emission (*Allen et al., 2009, Nature, and other papers*)
- Emission of **1 Trillion tonnes of CO_2 (as C)**, since industrialization will put us on course for a 2 ^oC (1.3 – 3.9 ^oC) increase and we have 'spent' over half of this already

WRE[1] stabilization profiles for CO_2 concentration




WRE stabilization profiles: emissions response
Fossil CO_2 (Pg C)
14
12
10
8
6
4
2
0
-2
1990
2015
2040
2065
2090
2115
2140
2165
2190
2215
2240
2265
2290
2315
2340
2365
2390
Year
WRE650
WRE550
WRE450
WRE350

BAU aviation emissions under a climate stabilization regime



Aviation emissions of CO_2 to 2050

Scenario	2050 emissions (Gt C yr^{-1})	**Percentage of WRE450 2050 emissions**	Cumulative emissions 2006–2050 (Gt C)	**Percentage of WRE450 cumulative emissions (2006-2050)**	Scenario family or type	Source (notes)
Background						
WRE450	5.15	100	310.5	100	WRE450	Wigley *et al* 1996
Aviation						
FESG high-S3	0.89	**17.3**	21.1	**6.8**	High demand	FESG 2009
FESG high-S4	0.83	16.2	20.4	6.6	High demand	FESG 2009
FESG high-S5	0.78	15.2	19.7	6.3	High demand	FESG 2009
FESG central-S3	0.73	14.1	18.9	6.1	Central demand	FESG 2009
FESG central-S4	0.68	13.2	18.3	5.9	Central demand	FESG 2009
FESG central-S5	0.64	12.4	17.7	5.7	Central demand	FESG 2009
FESG low-S3	0.54	10.6	15.9	5.1	Low demand	FESG 2009
FESG low-S4	0.51	9.9	15.4	4.9	Low demand	FESG 2009
FESG low-S5	0.48	9.3	14.9	4.8	Low demand	FESG 2009
Qa-A1B	0.65	12.5	17.4	5.6	A1B	Owen *et al* 2009
Qa-A2	0.40	7.7	13.9	4.5	A2	Owen *et al* 2009
Qa-B1	0.36	**7.1**	13.3	**4.3**	B1	Owen *et al* 2009
Qa-B2	0.37	7.2	13.3	4.3	B2	Owen *et al* 2009

The challenge

- The challenge on CO_2 is clear
- But so is the solution – limit the global amount of CO_2 emitted to a certain cumulative amount
- Who gets how much?

Conclusions

- In the absence of policy intervention, aviation CO_2 emission rates are predicted to increase over 2005 levels of 0.2 Gt C yr^{-1} by 1.9 – 4.5 fold (0.37 – 0.89 Gt C yr^{-1}) in 2050
- Emission *rates* are less relevant to *effects* since it is *accumulated* CO_2 that matters
- Integrated (cumulative) CO_2 emissions is a better measure of climate change than an annual emission rate
- How much will aviation be 'allowed' of the remaining half a trillion tonnes of C?

Acknowledgements

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