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Climate change & carbon budgets: the contribution of international transport

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University of Cambridge Seminar, October 2009

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Summary

- What is ‘dangerous’ climate change
- Cumulative emissions
- Global emission pathways
- International aviation & shipping
- Comparison with global trajectories
- Policy implications
- Conclusions

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What is ‘dangerous climate change’?

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UK and EU define this as exceeding 2ºC

- Destruction of the vast majority of coral reefs
- Hundreds of millions of people exposed to increased water stress
- 30% of species at increasing risk of extinction
- Land moves to become a carbon source
- Cereal productivity to starts to cease in low latitudes
- Millions more people experience coastal flooding
- Tipping points?

(IPCC Fourth Assessment Report, 2008. 'Impacts, adaptation & vulnerability')

Related policy targets

UK, EU & Global - long term reduction targets

- UK's 80% reduction in CO_2e by 2050
- EU 60%-80% reduction in CO_2e by 2050
- Bali 50% global reduction in CO_2e by 2050

But CO_2 stays in atmosphere for 100+ years

Today's emissions add to yesterdays & will be added to by tomorrow's

…so, the focus on long-term targets is very misleading

Cumulative emissions

The final % reduction in carbon has little relevance to avoiding dangerous climate change *(e.g. 2°C)*

What is important are the **cumulative** emissions of carbon & other greenhouse gases (*i.e. the carbon budget*)

Devising pathways

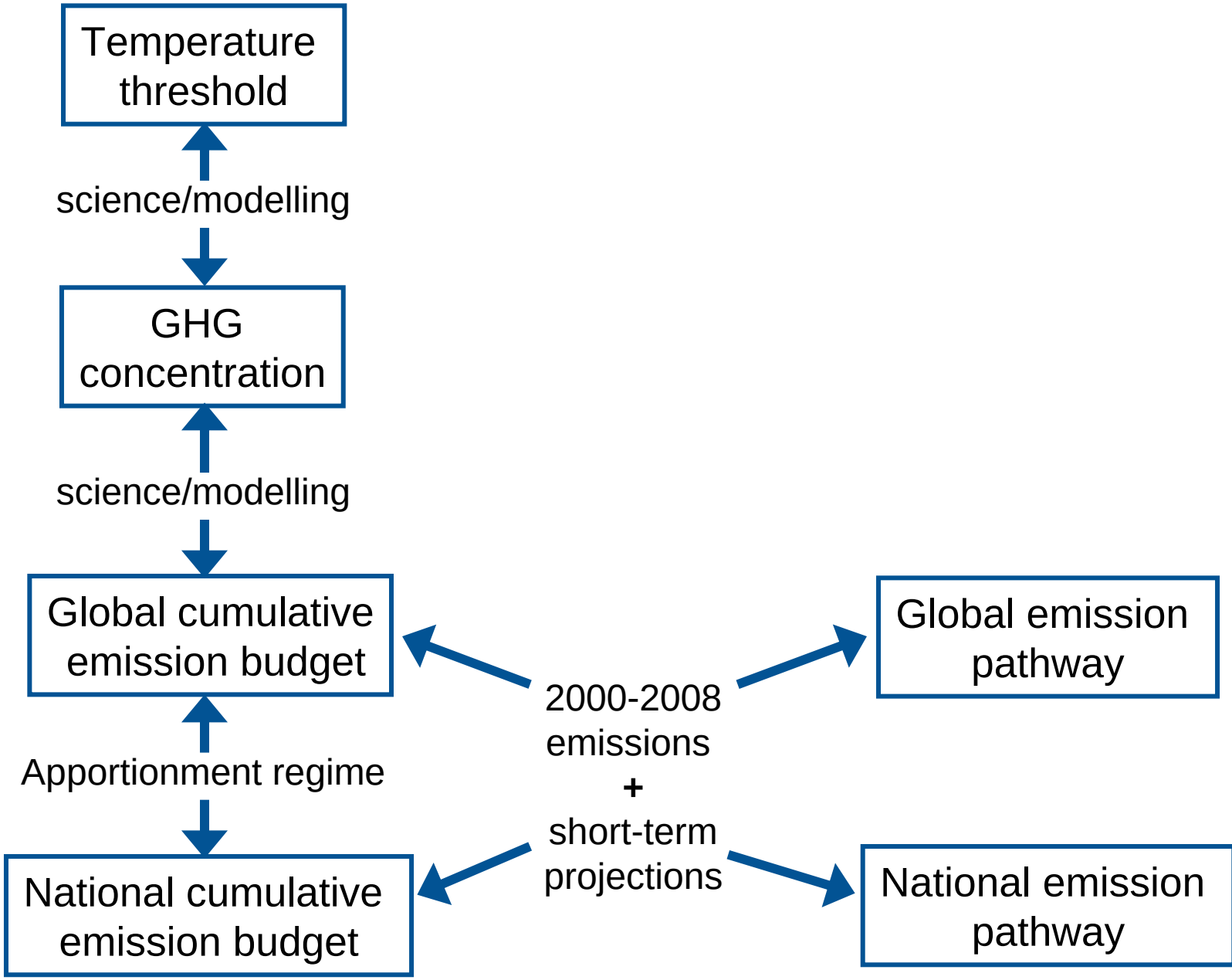
How do global **temperatures**

link to

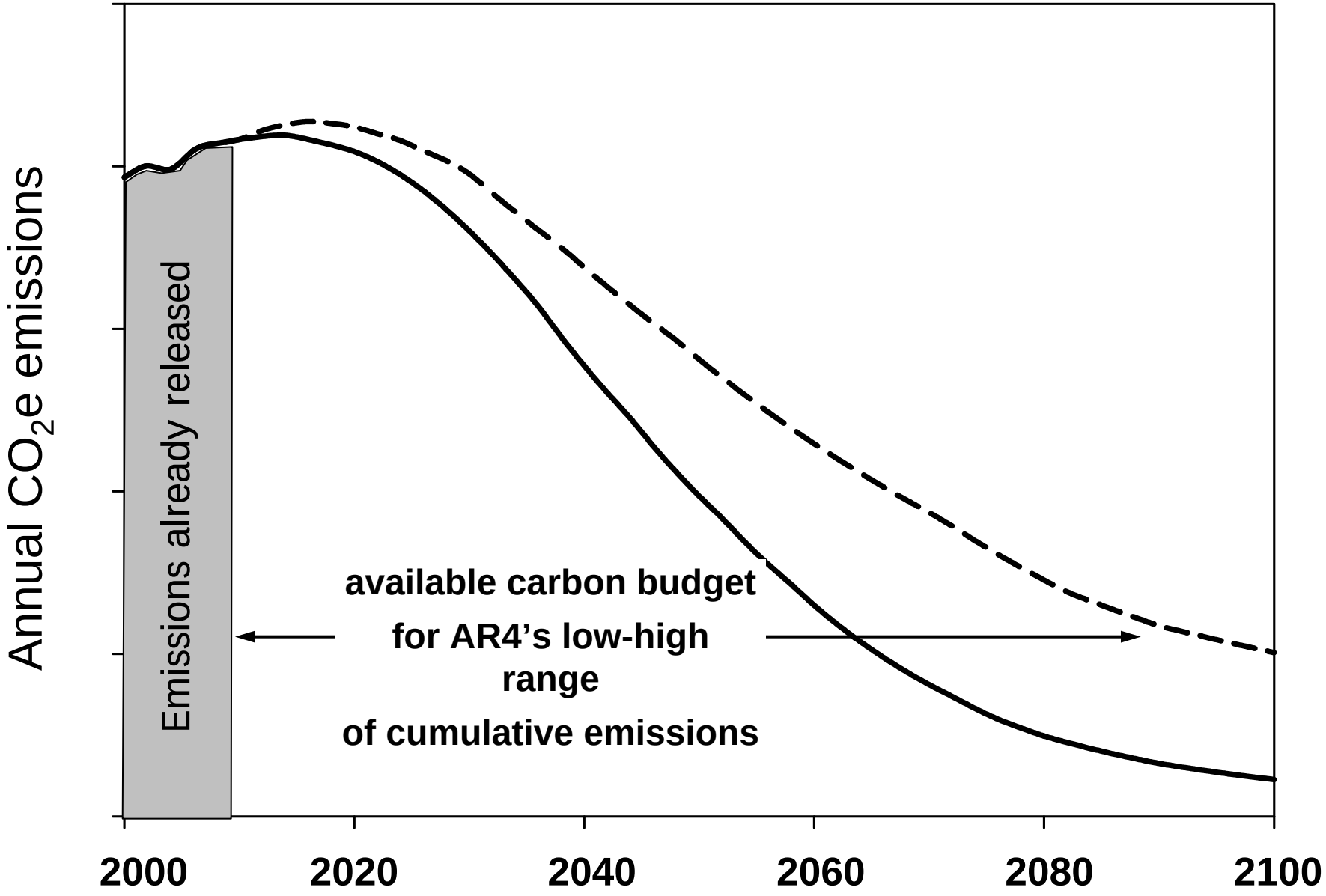
global and national **carbon budgets**

& from there to

emission-reduction **pathways**?


Temperature threshold
science/modelling
GHG concentration
science/modelling
Global cumulative emission budget
Apportionment regime
National cumulative emission budget
2000-2008 emissions
+
short-term projections
Global emission pathway
National emission pathway

Illustrative pathway for a CO_2e budget



How does this framework alter the challenge we face at the ***global*** level & in relation to individual sectors?

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Global emission trends

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Tyndall global emission scenarios

What are the latest CO_2 emission trends?

What are implications of factoring in:

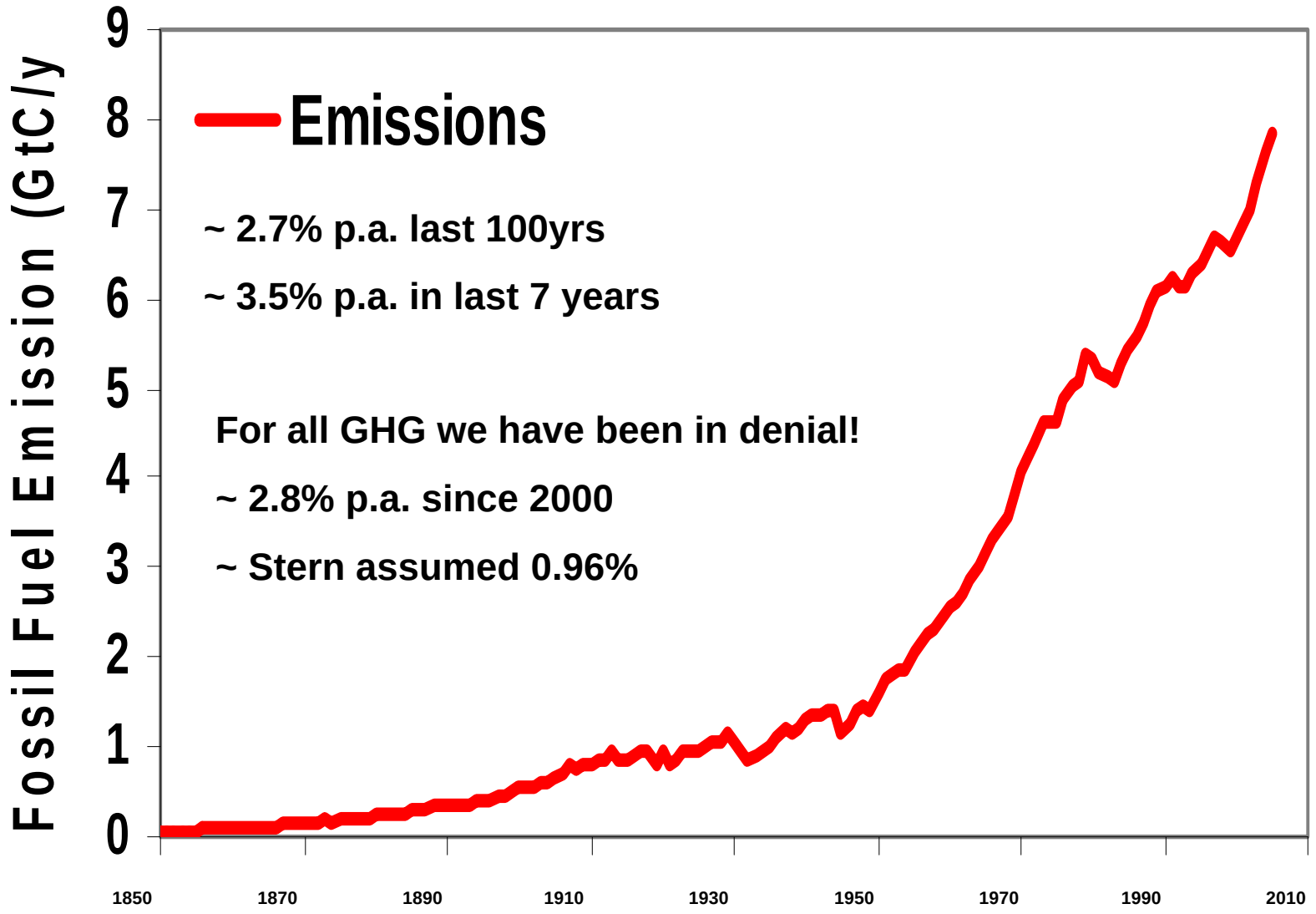
- land-use & forestry?

- non-CO_2 greenhouse gas emissions?

When will global CO_2e emissions peak?

How much 'CO_2 space' left for energy & process emissions?

Latest global CO_2 trend



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Data Source: G. Marland, T.A. Boden, R.J. Andres, and J. Gregg at CDIAC

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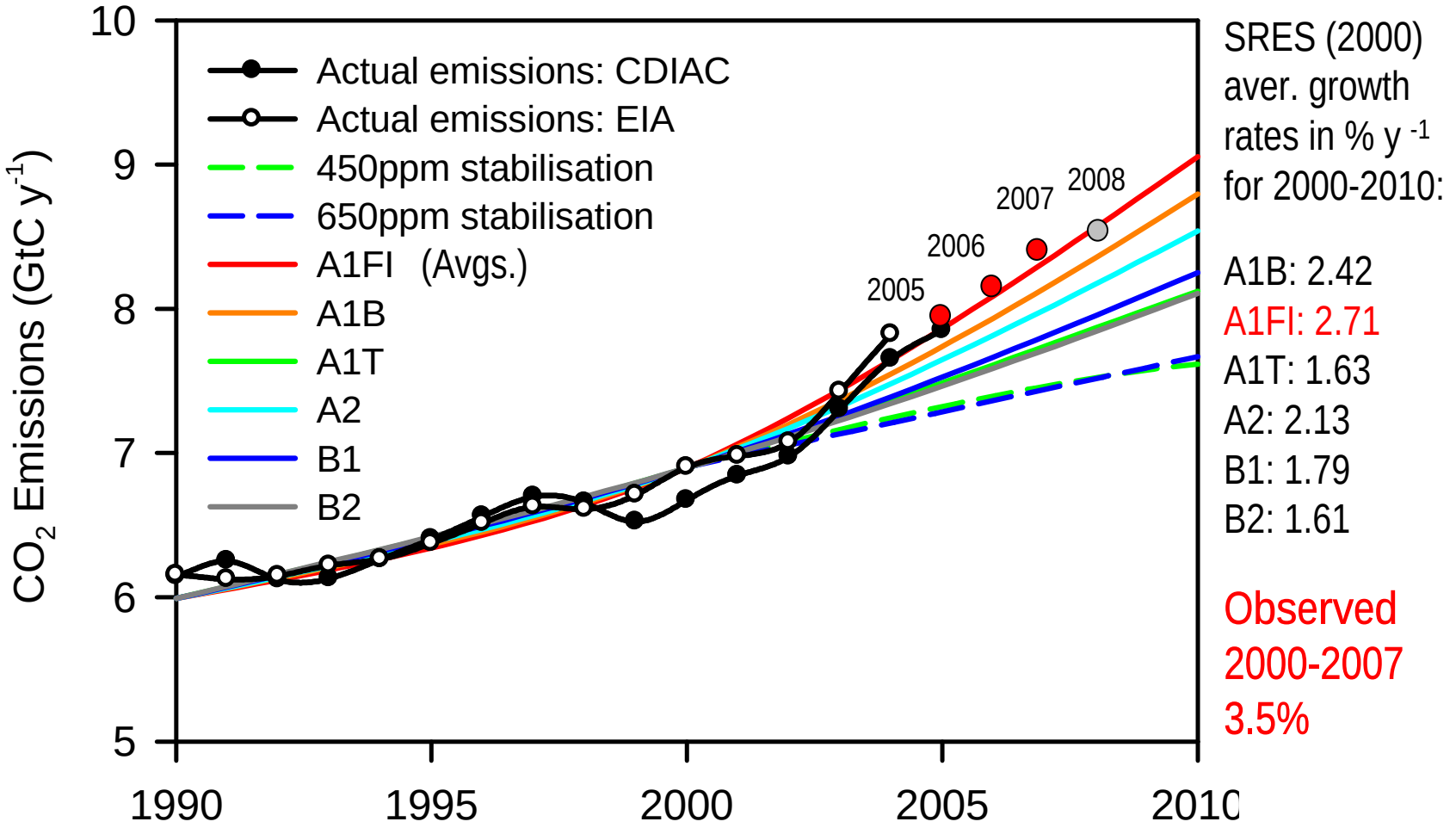
Global emission trends



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Raupach et al 2007, PNAS; Global Carbon Project 2009

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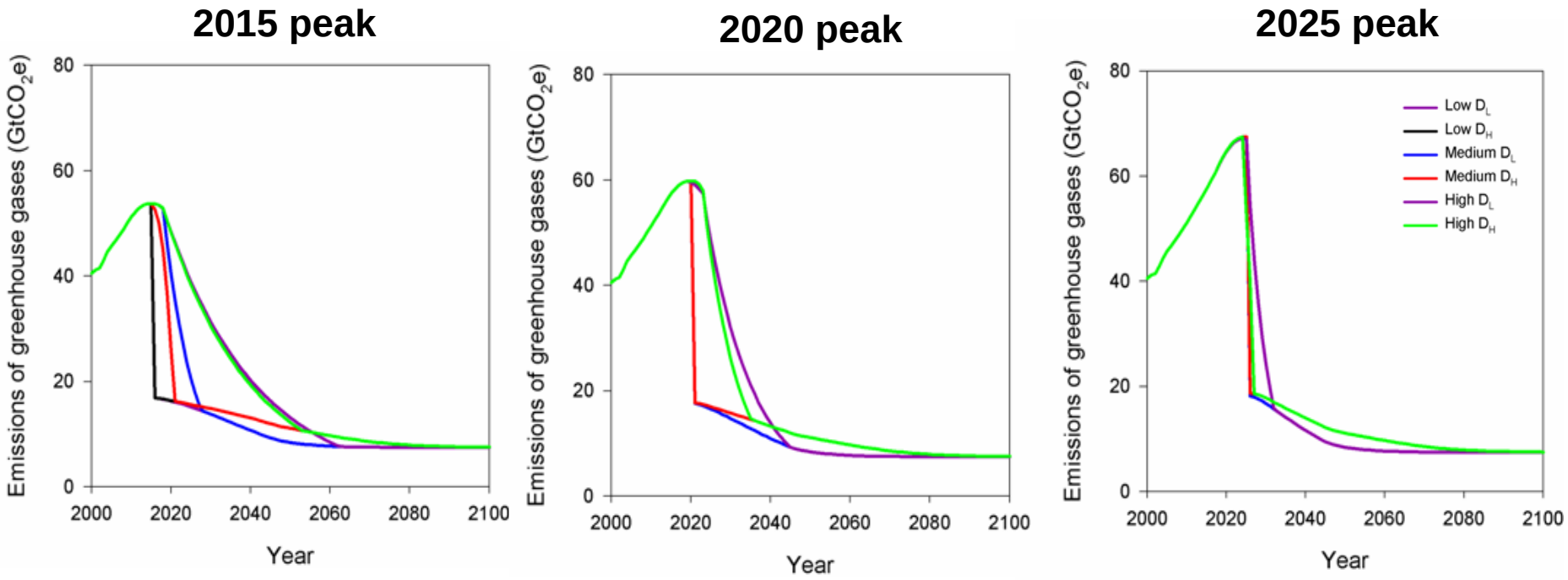
What does the future hold?

Scenarios developed to explore future 2ºC mitigation (450ppmv CO_2e):

- Assume deforestation rapidly declines
- Assume non-CO_2 greenhouse gases dramatically reduced (but not to zero due to food consumption)
- Assume emissions of greenhouse gases peak in 2015, 2020 or 2025

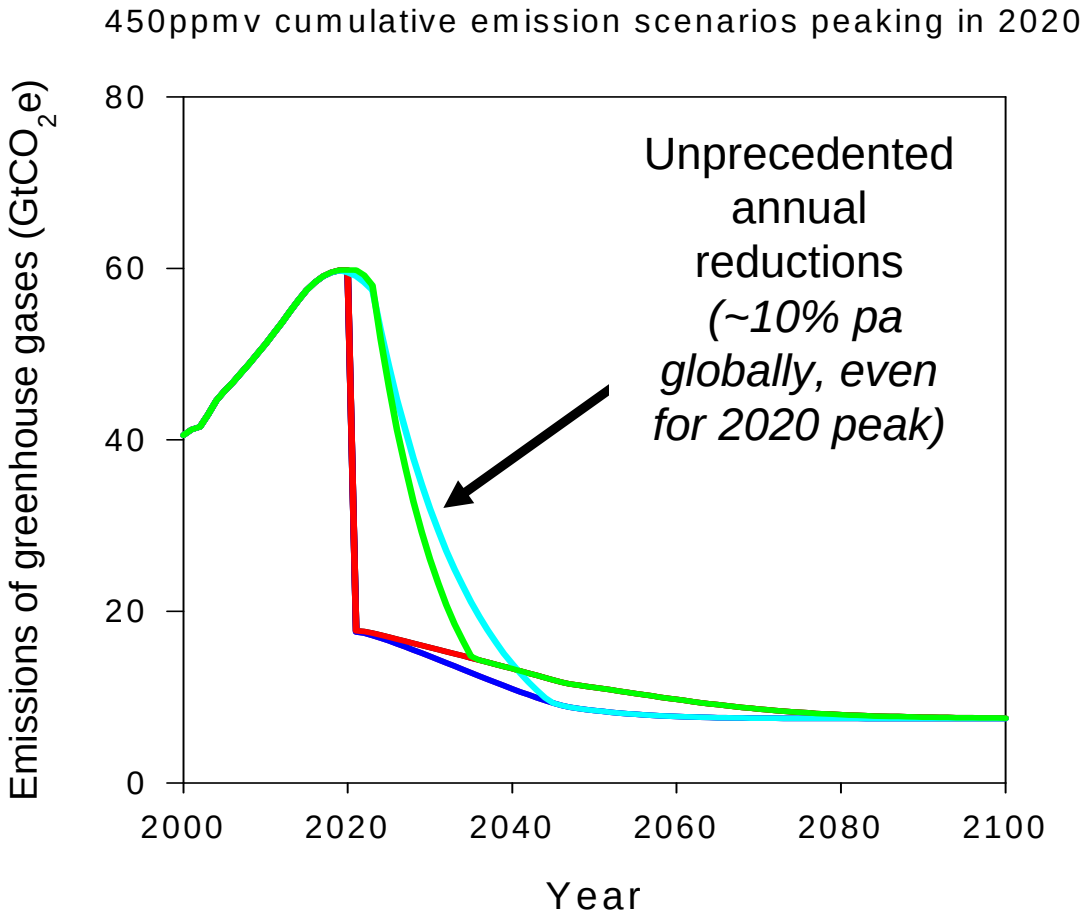
(Stern assumes 2015, Committee on Climate Change 2016, Bush 2025, Wang/Watson assume China will peak post-2025)

Future emission scenarios - Tyndall



(Anderson & Bows, 2008, *Philosophical Transactions of the Royal Society A*, **366**, pp.3863-3882)

Future emission scenarios - Tyndall

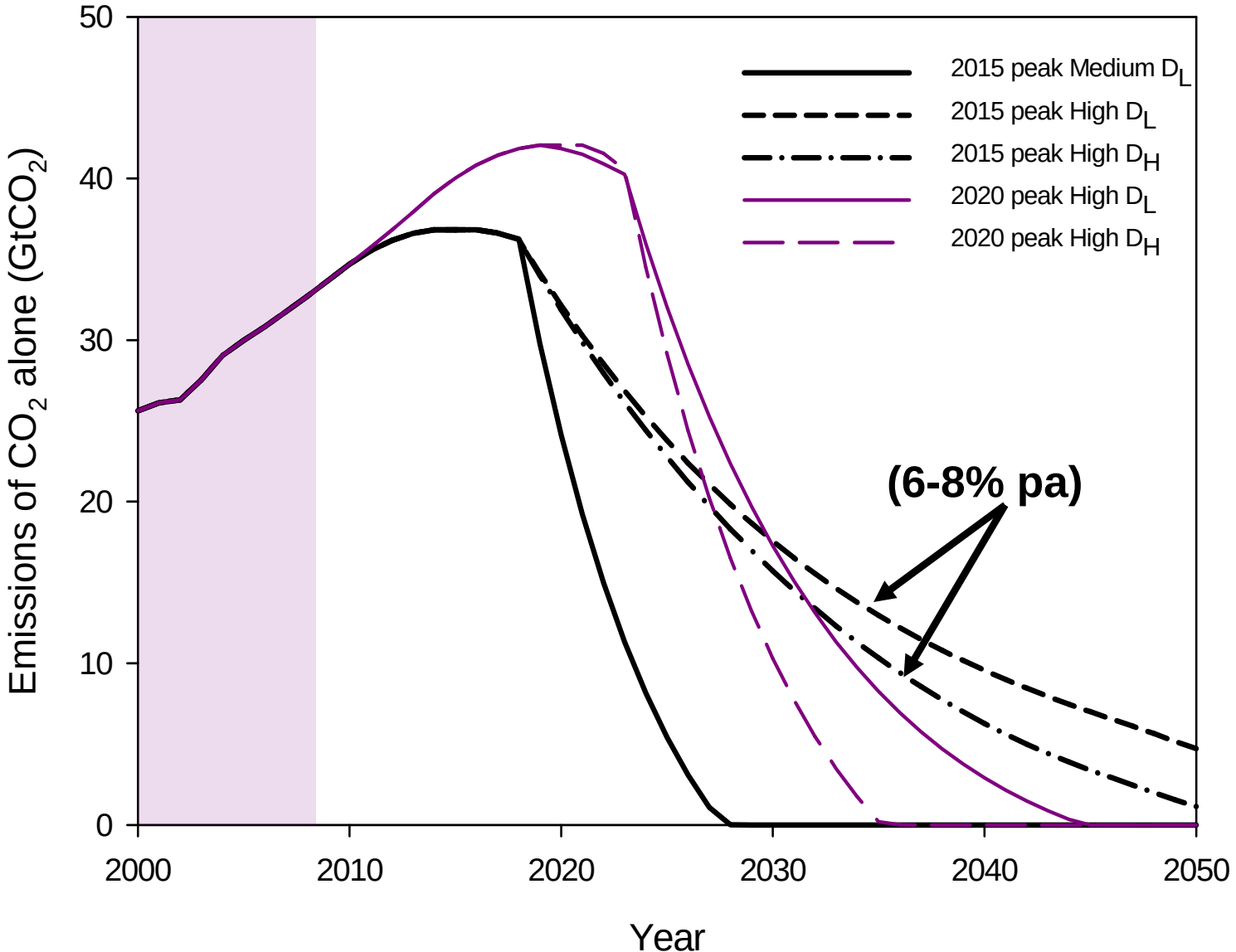


(Anderson & Bows, 2008, *Philosophical Transactions of the Royal Society A*, **366**, pp.3863-3882)

Future emission scenarios – energy/industry CO_2

5 out of 18 possible scenarios 'possible'

Of remaining 5, only 2 have annual % reductions <8%



Future 2ºC (450ppmv) emission scenarios - Tyndall

Only possible with IPCC upper cumulative emission estimate

70-80% of current forestry carbon stock remains

Halve carbon intensity of food production by 2050

- *Peak 2015: 4% p.a. reduction in CO_2e & **7% in CO_2 from energy***
- *Peak 2020: 10% p.a. in CO_2e & **over 12% in CO_2 from energy***

Future emission scenarios - Tyndall

Annual reductions of greater than 1% p.a. have only

"been associated with economic recession or upheaval"

Stern 2006

- *UK gas & French 40x nuclear ~1% p.a. reductions*

  (ex. aviation & shipping)

- *Collapse Soviet Union economy ~5% p.a. reductions*

Future emission scenarios - Tyndall

Even assuming:

… an unprecedented step change in mitigating emissions

… stabilising at **650ppmv CO_2e** appears increasingly to be the best we can expect

*i.e. human-induced climate change of **~4°C*** or more

Need to reframe climate change drivers

– For mitigation

2°C should remain the driver of policy

– For adaptation

4°C should become the driver of policy

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International transport

Barriers and potential for mitigation

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Omission of key sectors

Any target based on global temperatures or CO_2 concentrations is credible only if applied to an aggregate of all sectors

… and therefore must include

International aviation
International shipping

… the two fastest growing sectors of the OECD economies in both activity and carbon emissions.

Policy context

Kyoto Protocol:

"*The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organisation and the International Maritime Organisation respectively*".

Policy context

- International Civil Aviation Organisation (ICAO) & International Maritime Organisation (IMO) both currently exploring including their sectors within (ideally global) emissions trading schemes.

  …but, failure to take any action to mitigate to date within the EU has led to criticism by the EU…

Policy context

EU Commission 2007:

"Regrettably, it has become clear to us…that, ten years after having been requested by the UNFCCC to take action to limit or reduce emissions, it has not been possible for ICAO to agree on essential elements of this comprehensive approach. In particular, the programme put forward for agreement at this Assembly is unambitious, piecemeal and lacking in credibility on market-based measures (both greenhouse gas emissions charges and emissions trading)."

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Aviation

Barriers and potential for mitigation

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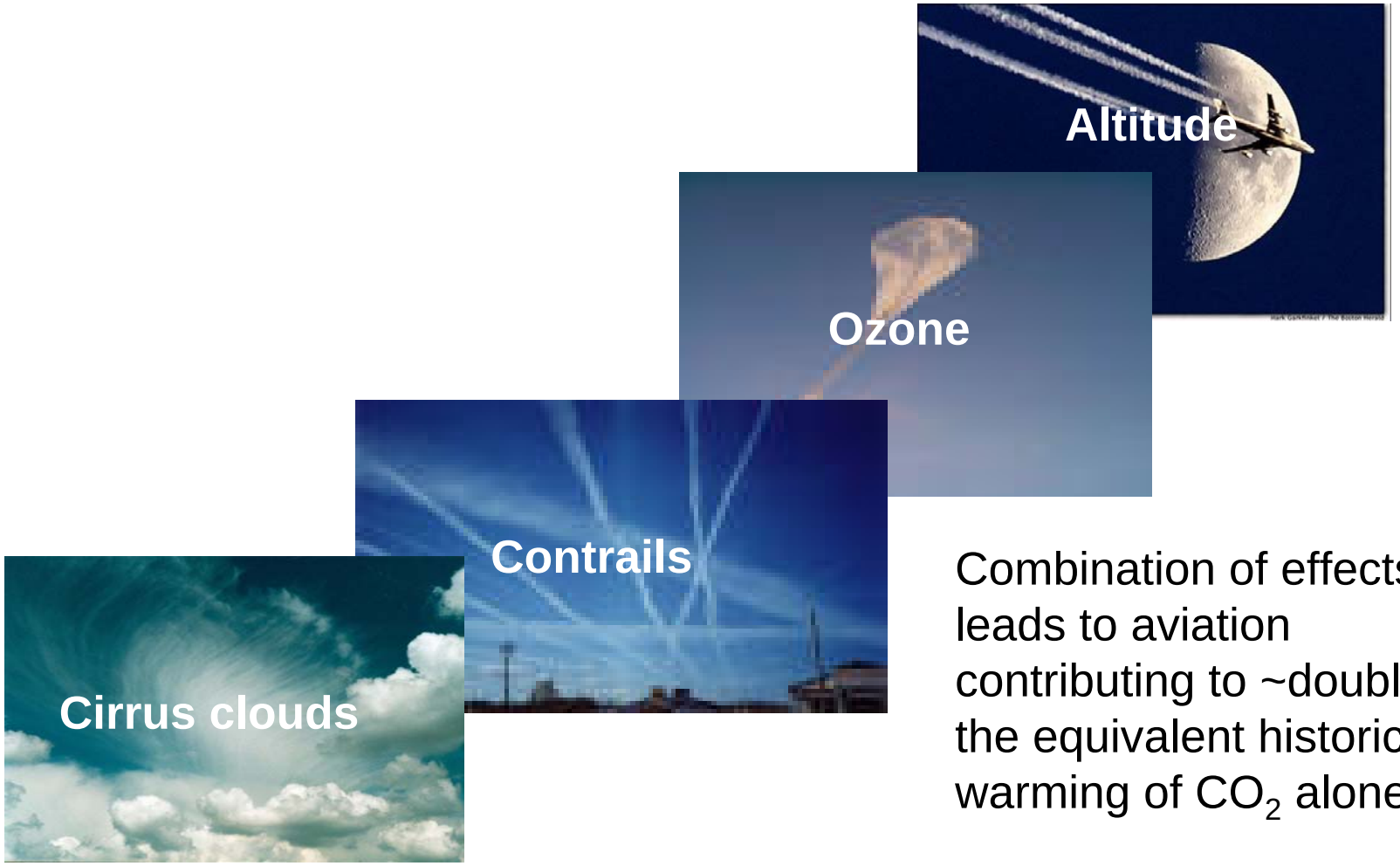
Aviation

Anderson et al. (2005) Tyndall Decarbonisation Scenarios concluded that all other sectors have opportunities to significantly reduce emissions in real terms in short-medium term. Aviation is constrained by a number of barriers…

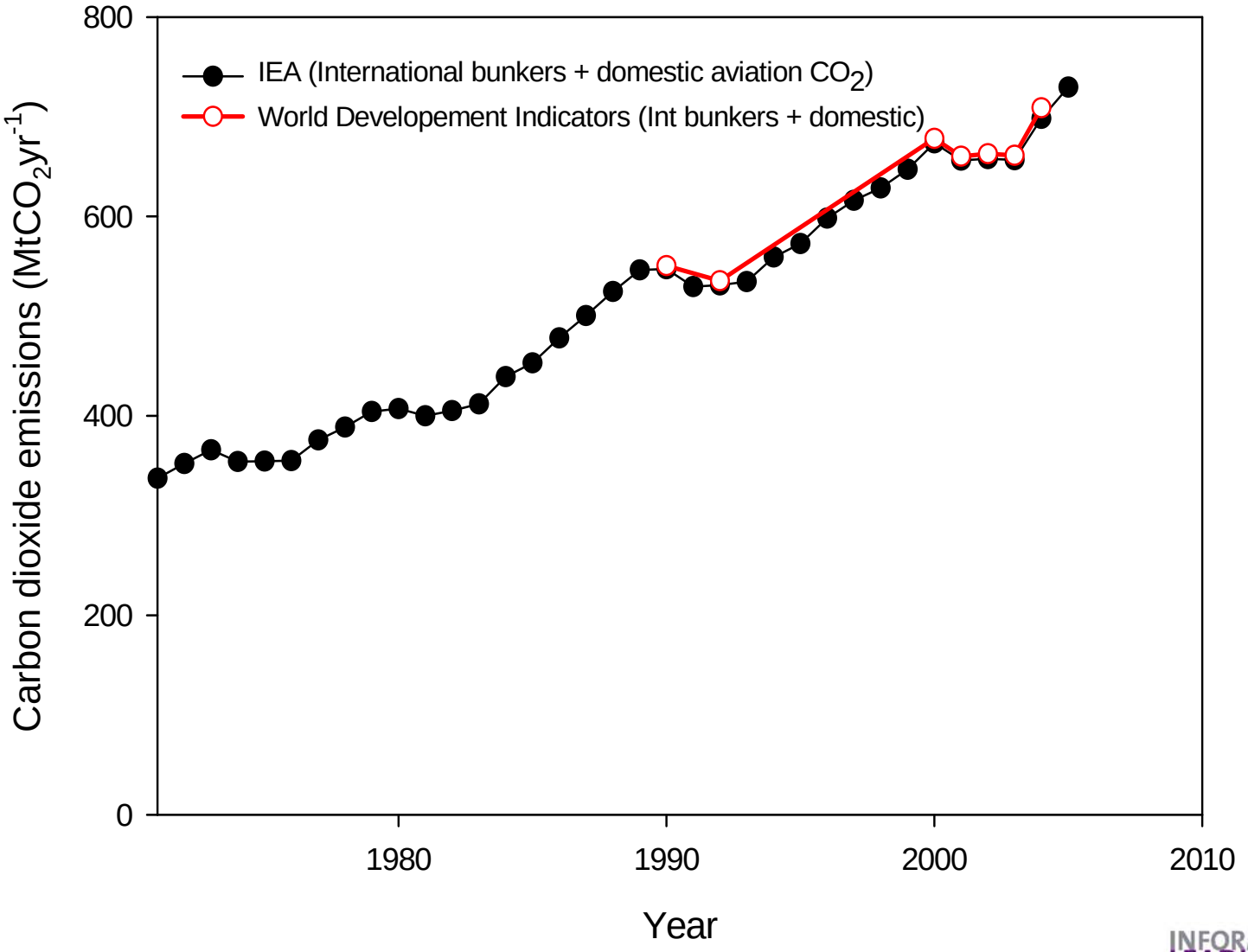
- Medium-long term reliance on kerosene
- Aircraft have long lifetimes – 60 year lock-in
- No short-term technological step-changes
- Growth is higher than in any other sector
- Most of the population currently don't fly – potential growth
- Aircraft cause additional climate warming

Aviation



Combination of effects leads to aviation contributing to ~double the equivalent historical warming of CO_2 alone

Historical aviation CO_2 emissions



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Future aviation scenarios

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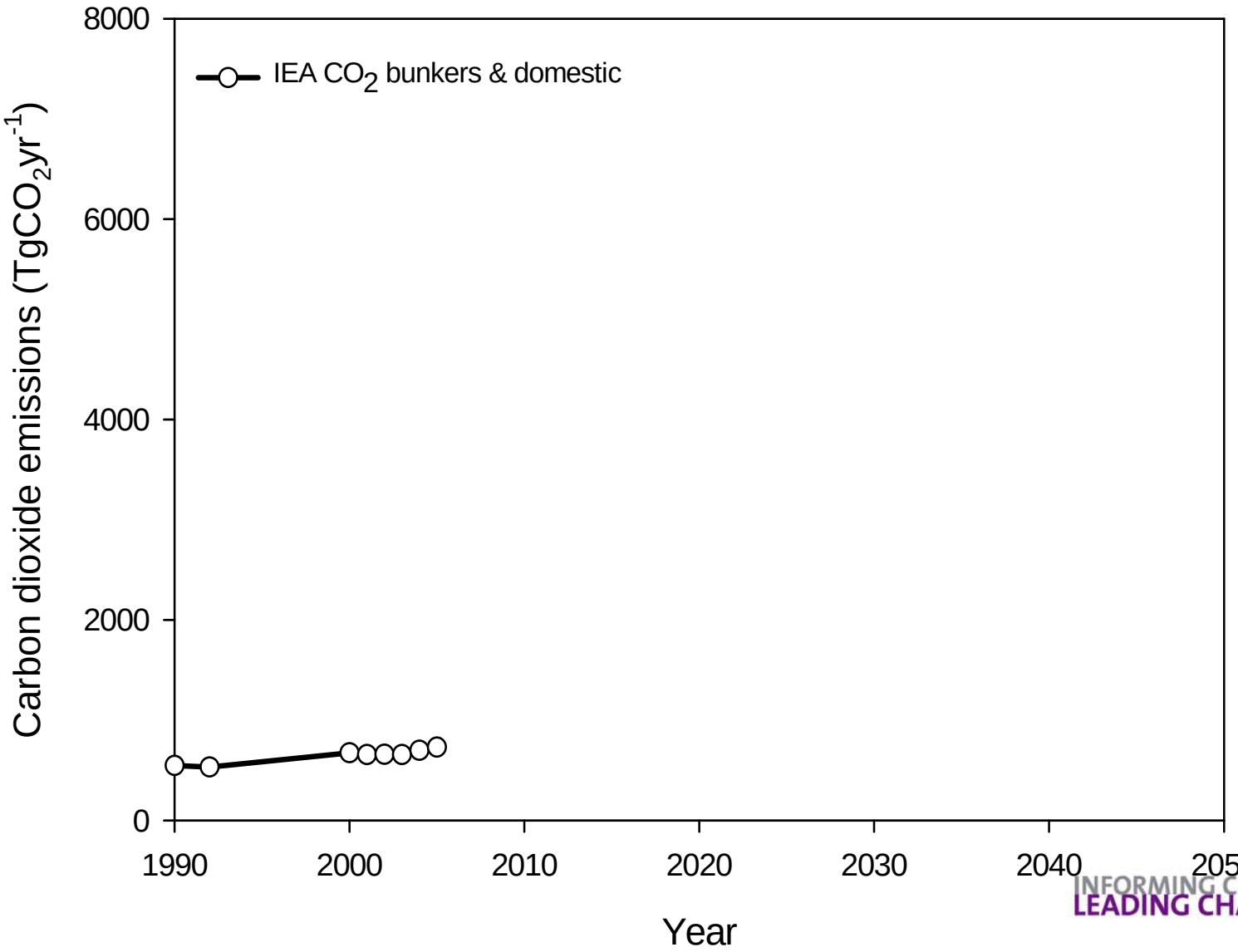
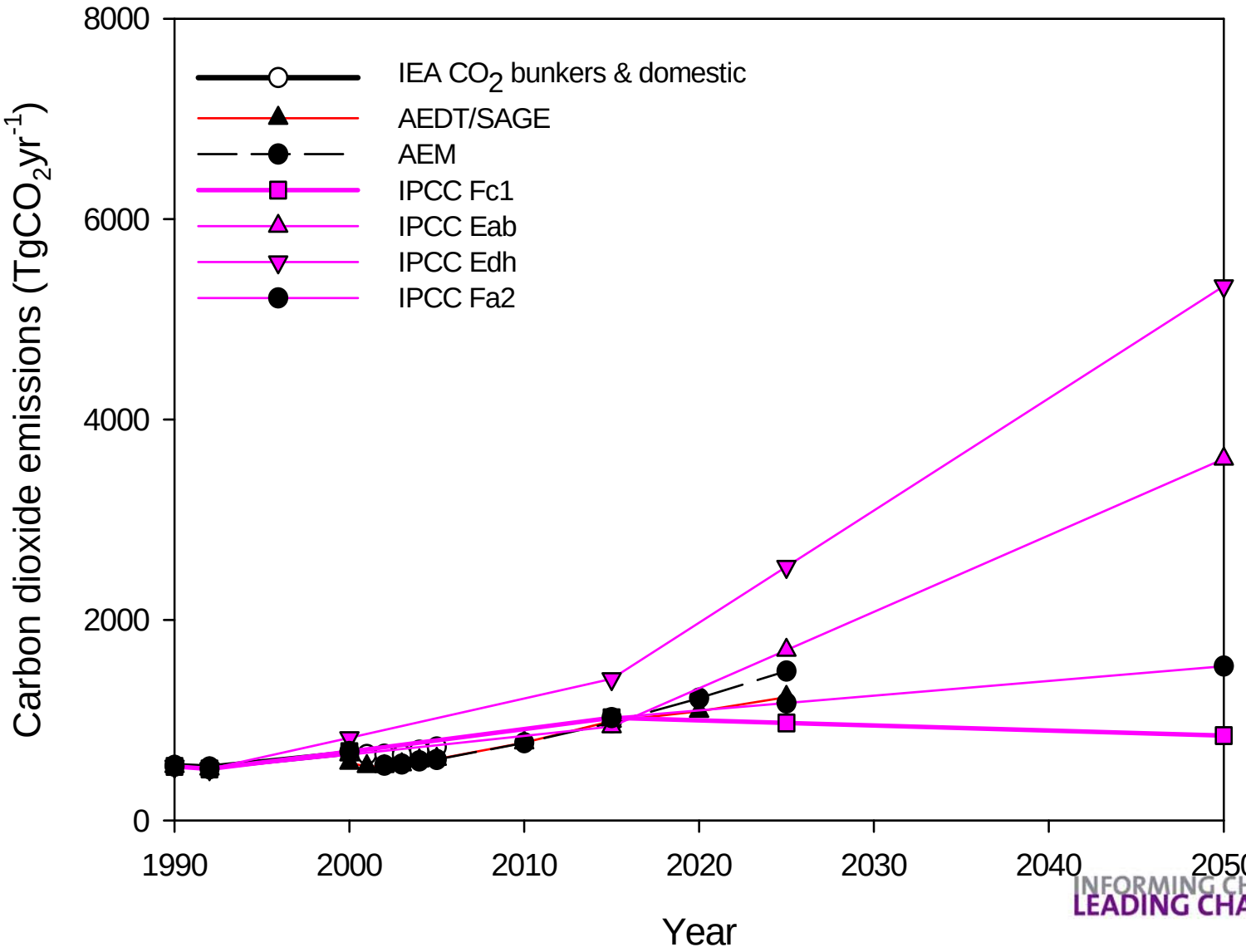
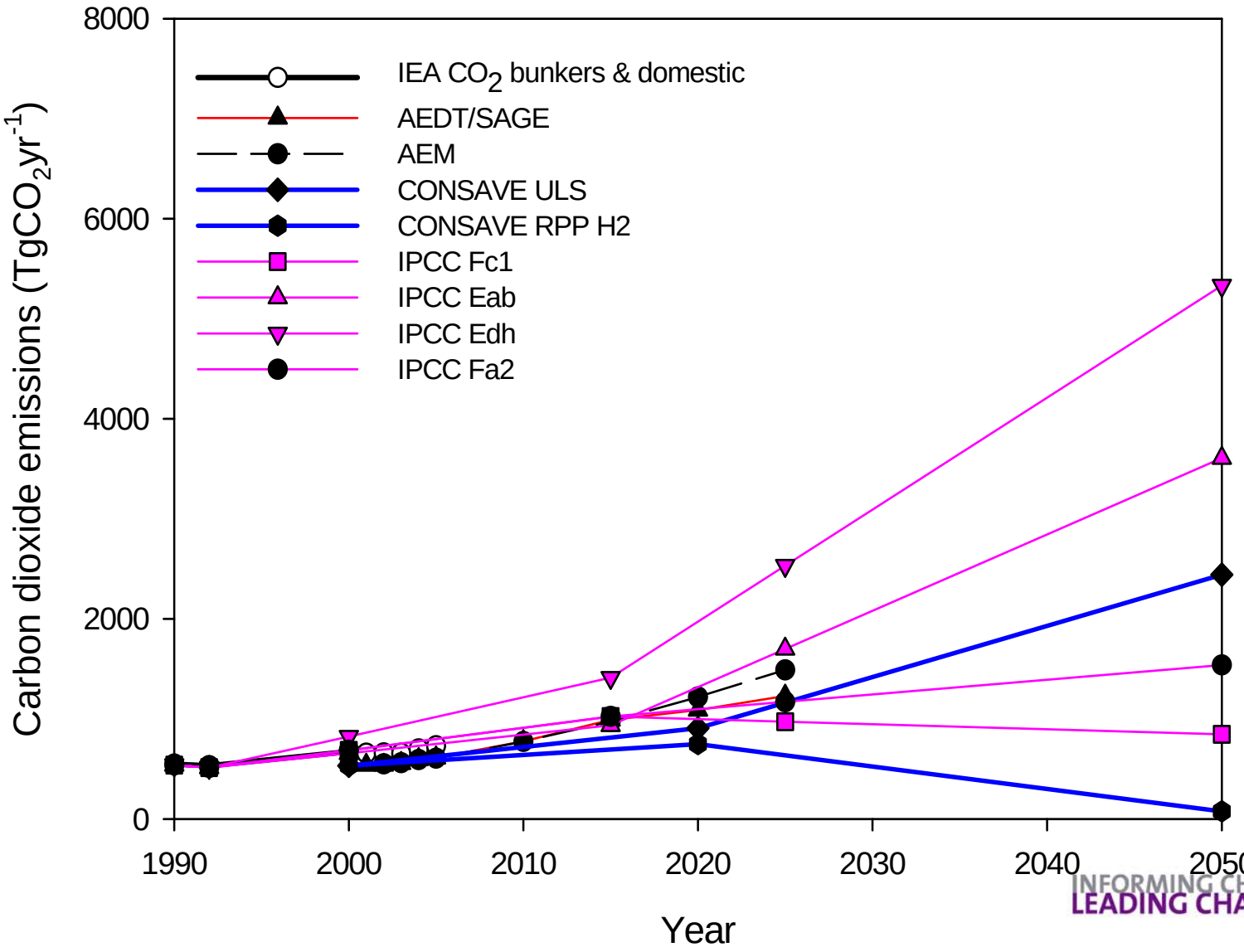
Aviation scenarios



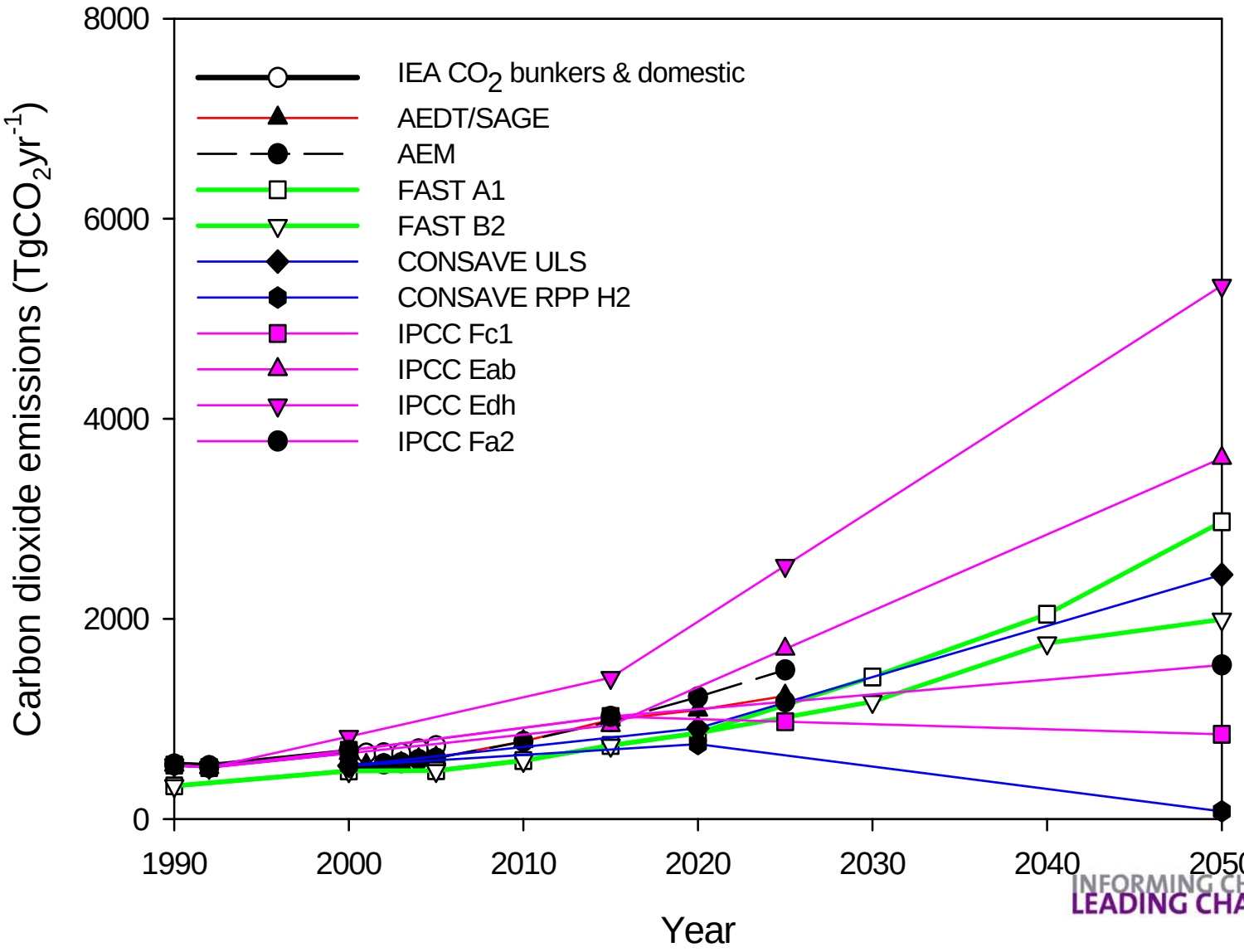
Aviation scenarios



Aviation scenarios



Aviation scenarios



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Shipping

Barriers and potential for mitigation

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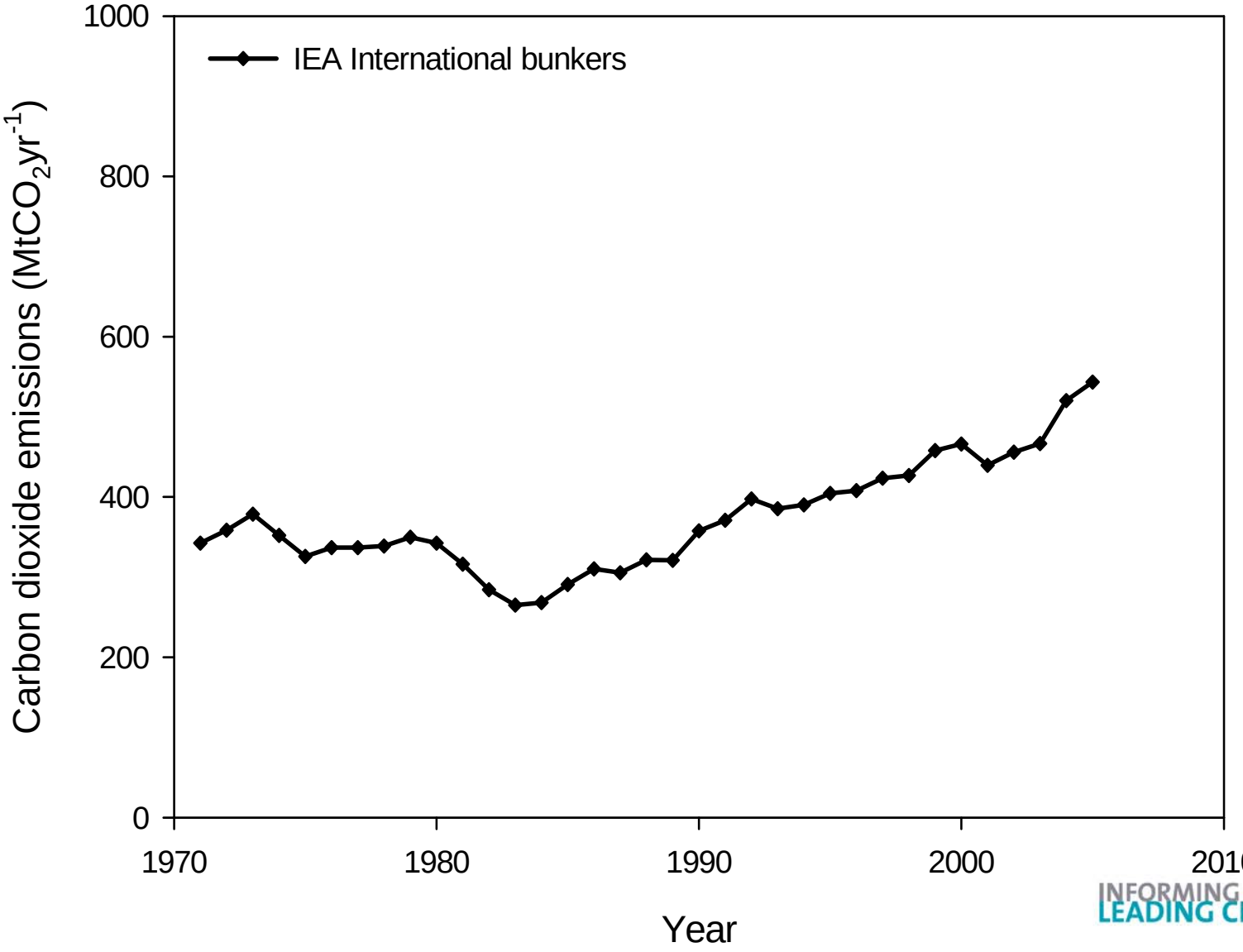
Challenges for shipping

Despite being the most fuel-efficient mode of transport in relation to tonne-km moved, CO_2 emissions may already be a larger proportion of global CO_2 than aviation

- Use ‘dirtiest’ fuels – heavy fuel oil
- Truly global infrastructure
- Highly competitive ship building industry
- High growth – closely aligned with global GDP growth
- Difficult to incentivise fuel efficiency
- Emissions regulations only recently started to consider to CO_2



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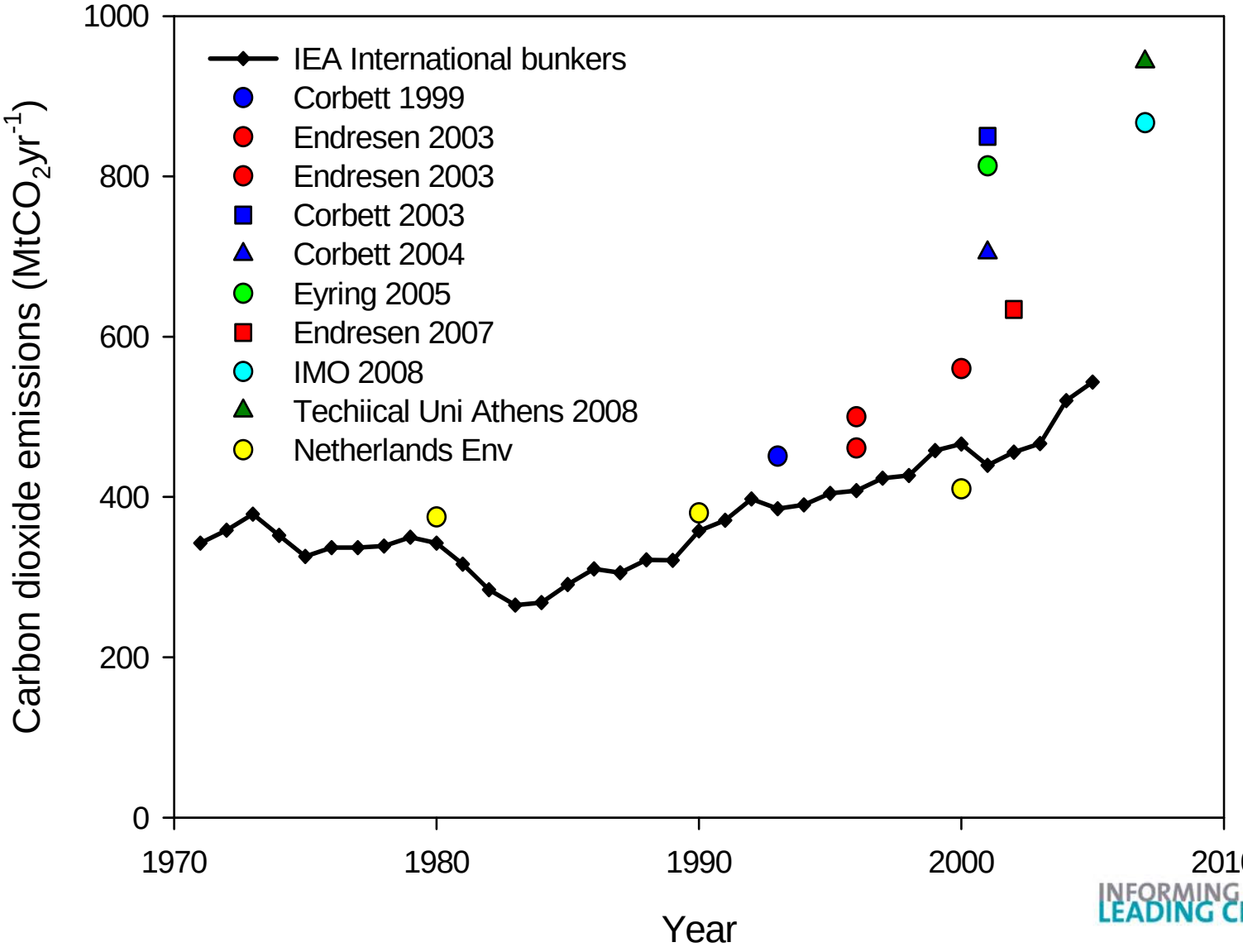

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Future shipping scenarios

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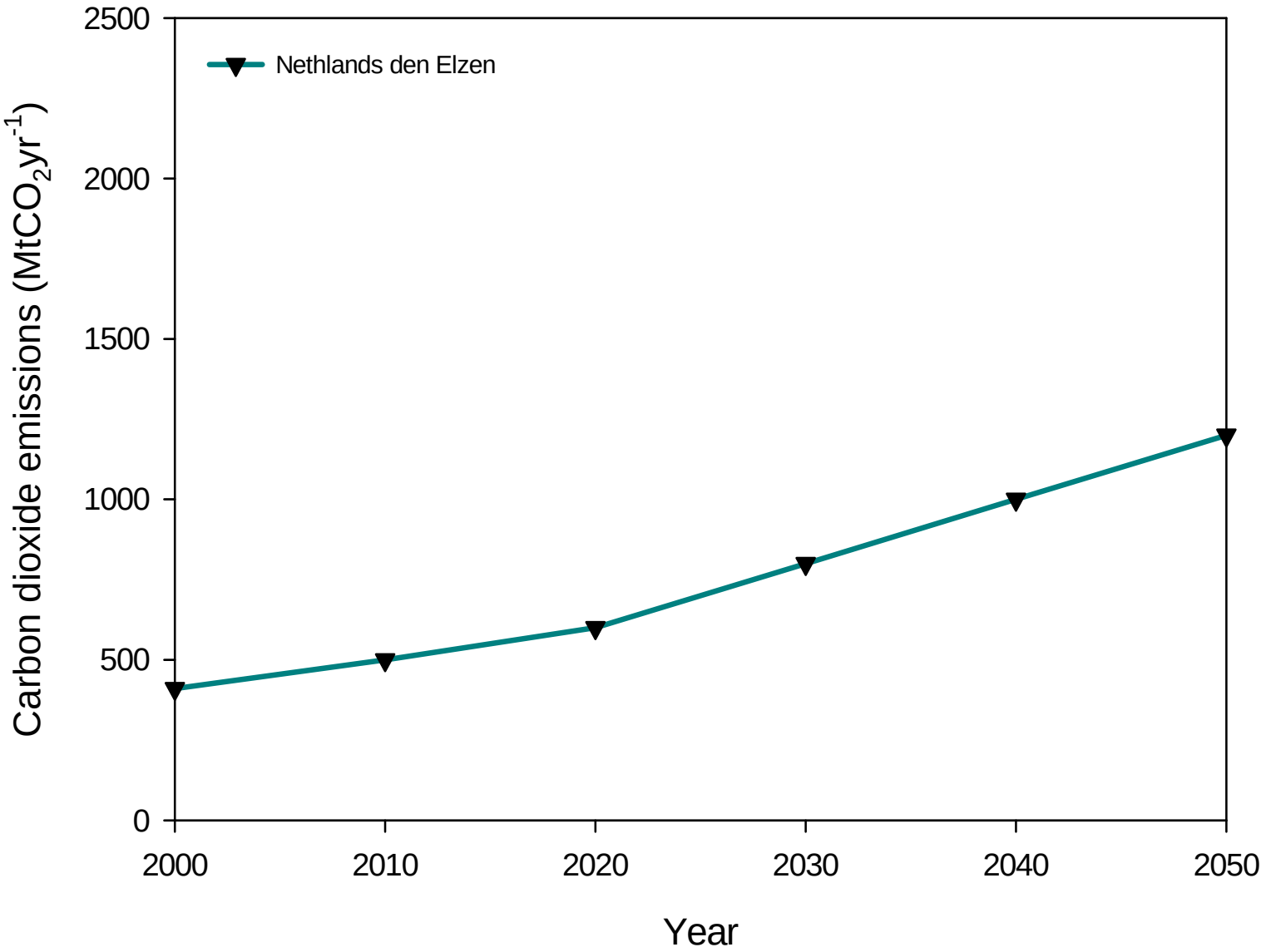
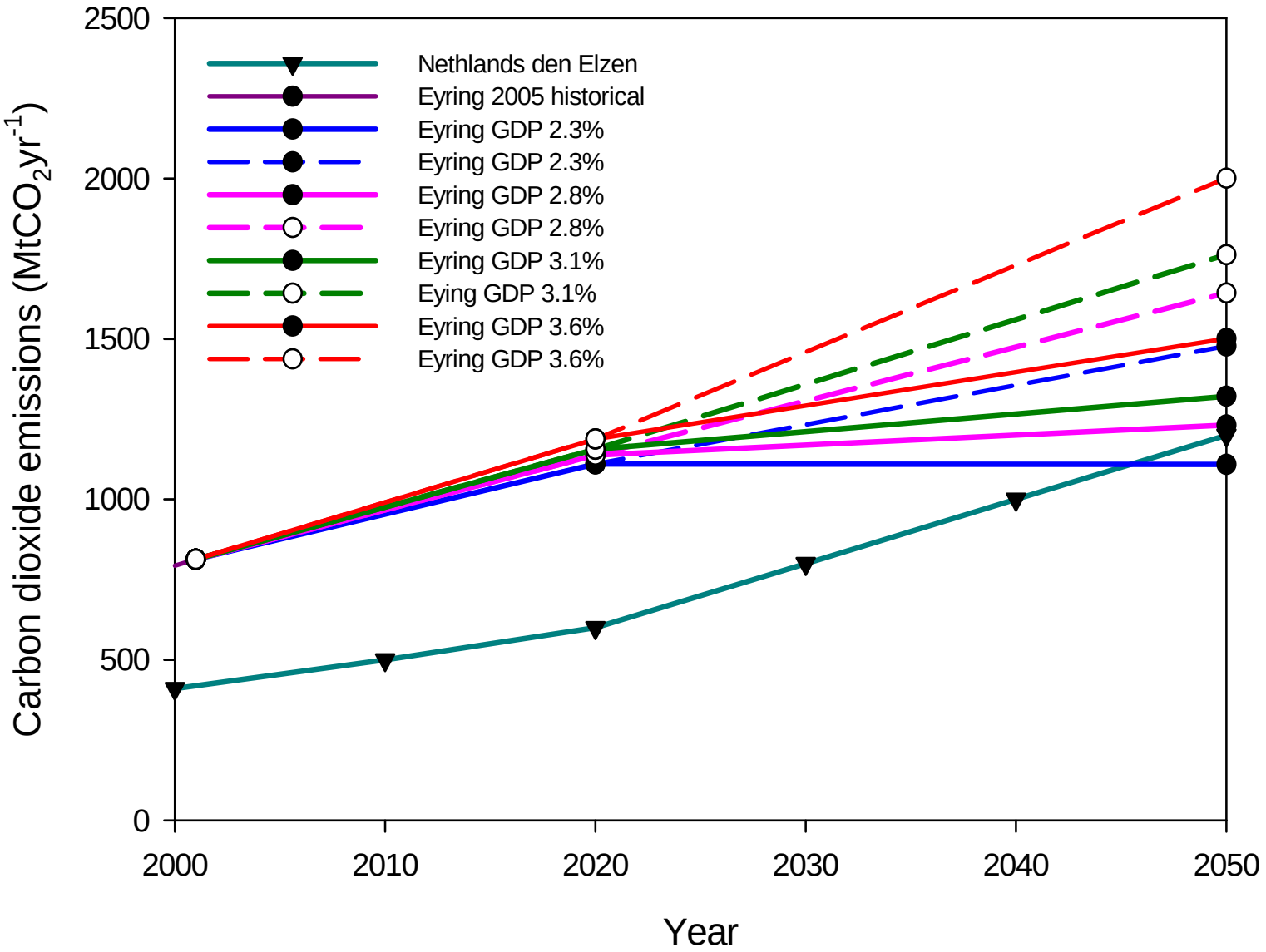
Shipping scenarios



Shipping scenarios



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Comparison with global scenarios

Aviation & Shipping

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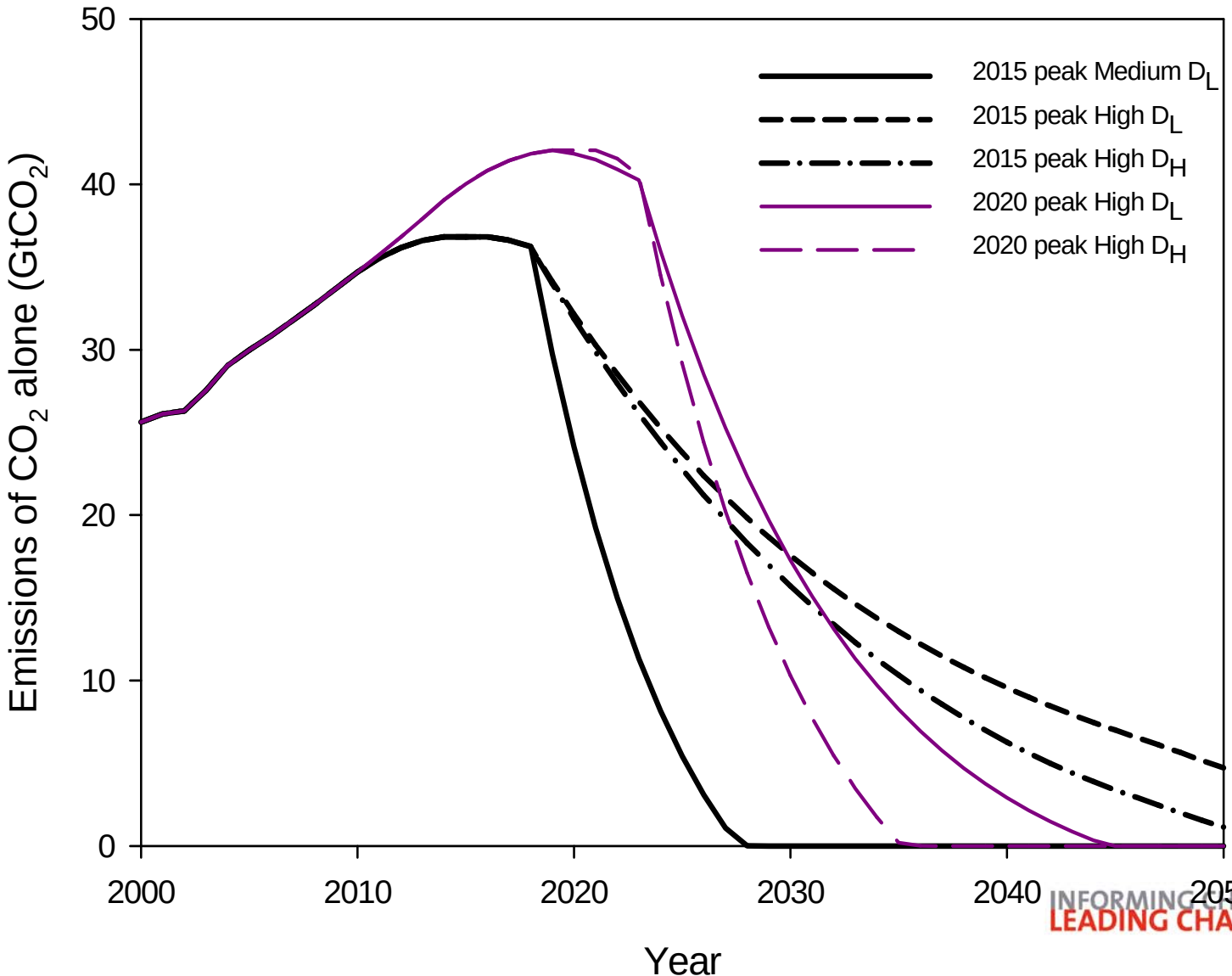
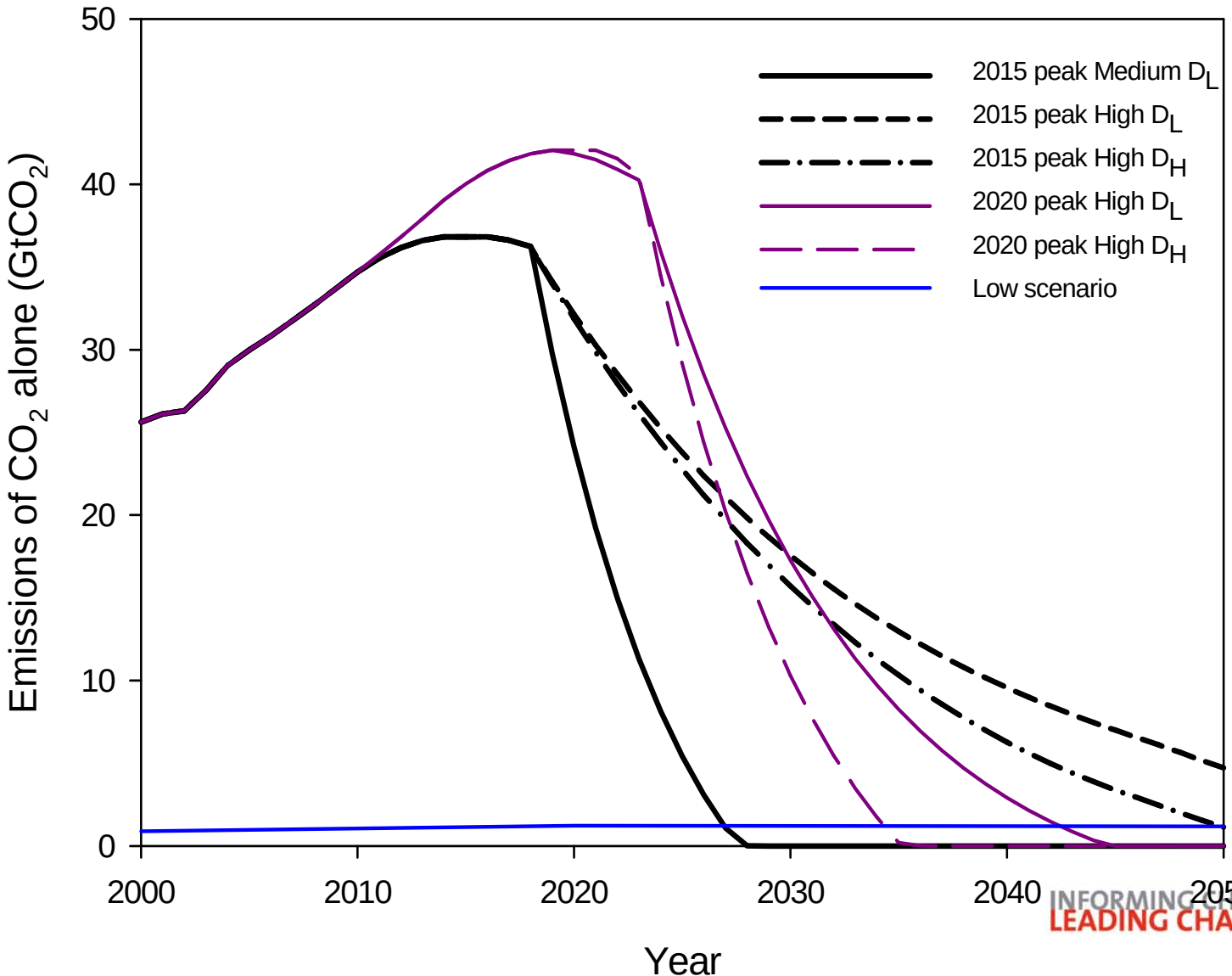
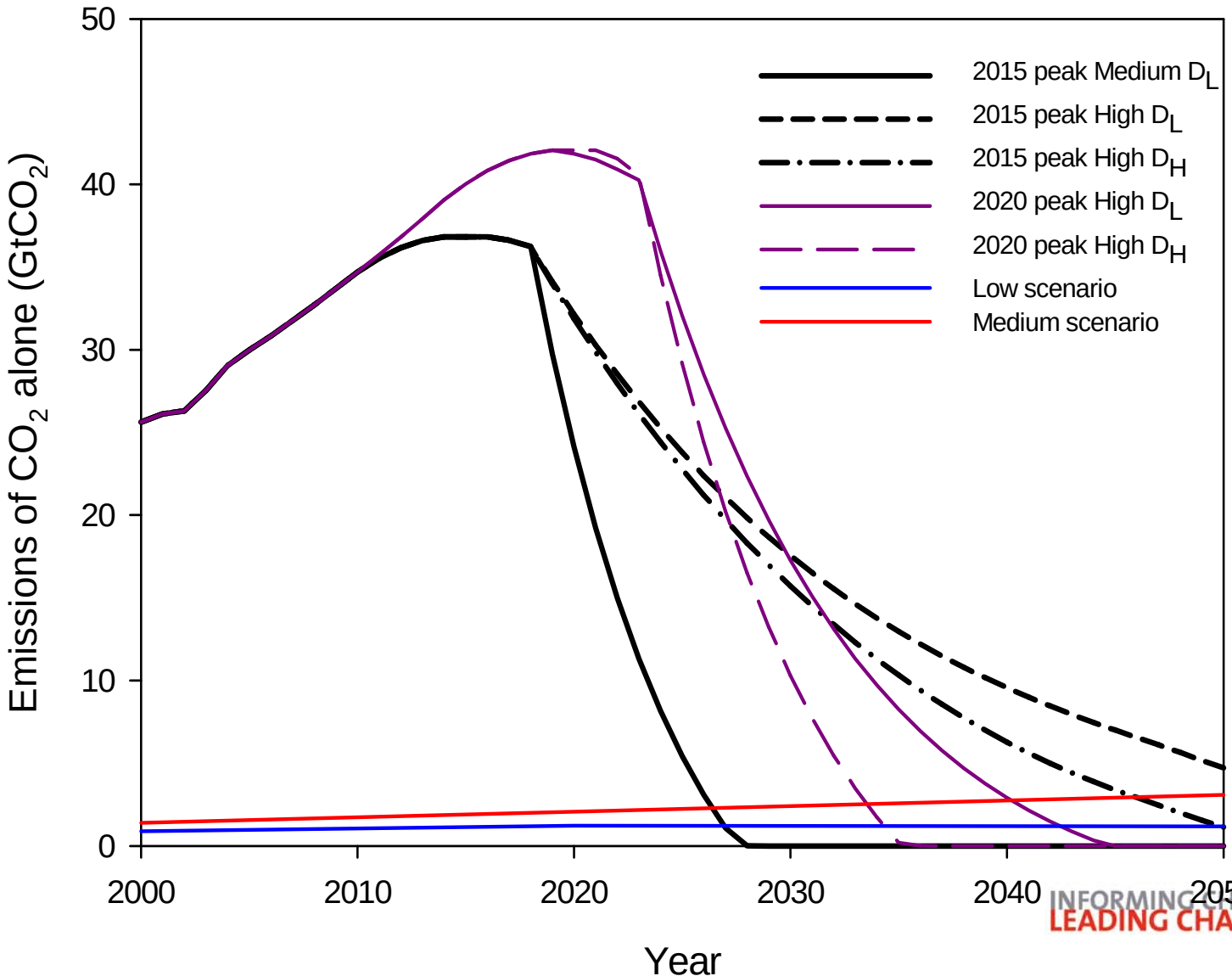
Comparison with global scenarios



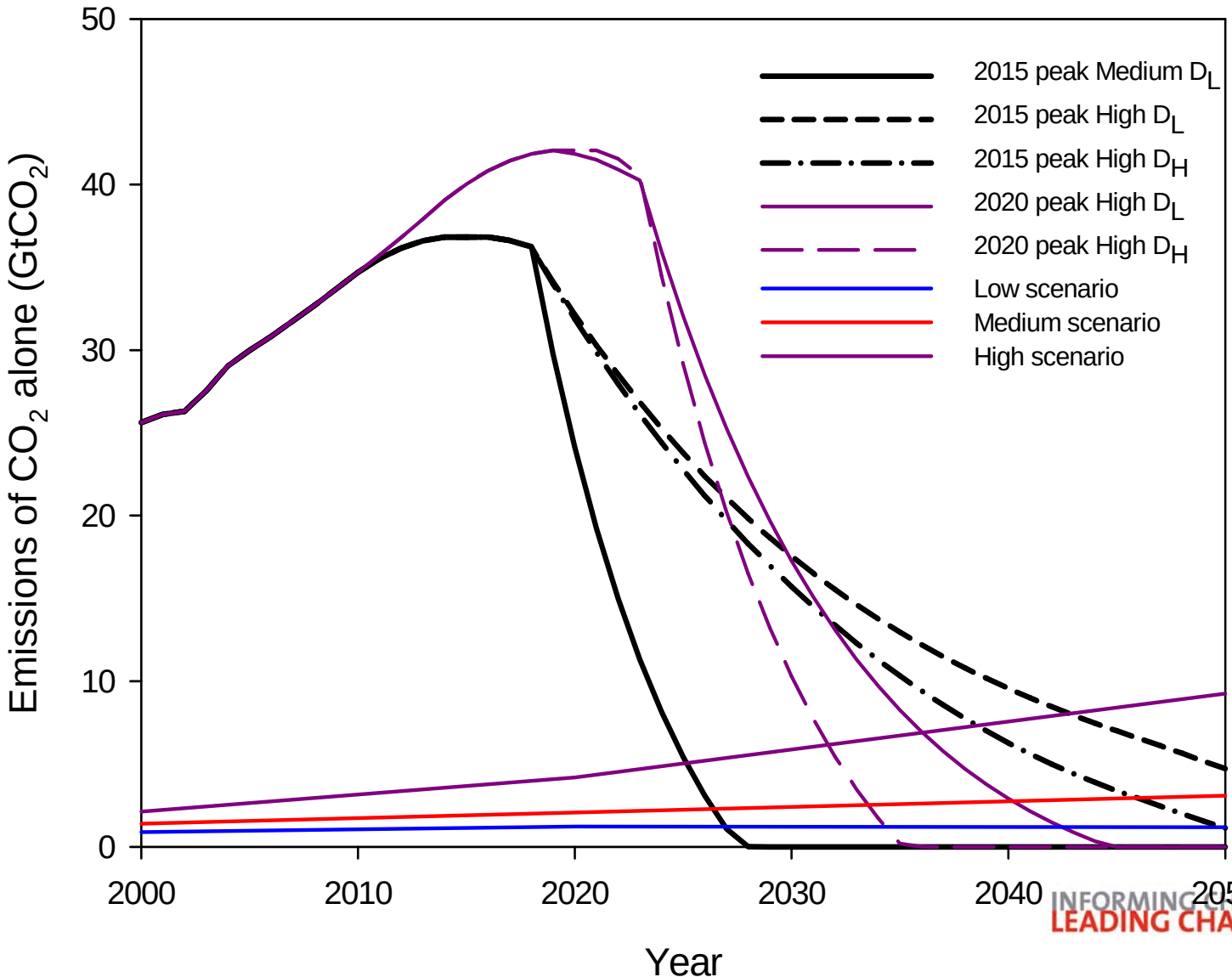
Comparison with global scenarios



Comparison with global scenarios



Comparison with global scenarios



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Policy implications

Policy implications

- Aviation and shipping must be included in policies to mitigate emissions
- Although aviation is within the EU's emissions trading scheme, complimentary policies within nations are required given the cumulative emissions framework – ie the earlier reductions are made the better – EU scheme not fast enough
- Zero emission requirements for aviation and shipping not currently seen as viable by those industries but emissions trading post zero-decarbonisation not an option
- UK Committee on Climate Change will include aviation within its 2050 target & future budgets – to deliver reductions sub-national polices may be needed (ie via RDAs)
- EU may include shipping within its EU emissions trading scheme
- UK wishes to understand the 'apportioned' emissions from shipping for the nation
- Apportioning shipping emissions controversial given its truly international nature

Apportionment of emissions

- Aviation currently apportioned on the basis of bunker fuel sales
- This approximates to 50% of emissions as flights generally A to B
- If shipping emissions apportioned on the basis of bunker fuel sales, UK has one eighth of the emissions allocated to the Netherlands because of the port of Rotterdam
- Alternative regimes subject to debate: by flag, by location of emissions, by tonnes loaded etc.
- Some argue for shipping to be treated as a 'nation' or a global bunker fuel trading scheme
- We currently assume shipping emissions for the UK apportioned on the basis of GDP
- Difficultly of top-down apportionment is the reliance on global bunker fuel estimates which, as illustrated, vary widely (550-900MtCO_2 per year)
- For UK, this would give between 18MtCO_2 and 30MtCO_2 for 2004 depending on global figure chosen (compared with around 32MtCO_2 for international aviation)

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Conclusions

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Headline messages

- All scenarios either exceed or consume significant portions of CO_2 energy budget by 2050
- High scenario not compatible with 2ºC future – even with trading
- No scenario compatible with 2020 emission peak
- 'Low' & 'Medium' scenarios compatible but only if total global emissions peak by 2015
- Continued emission growth to post-2060 for any economic sector is not compatible with 2ºC future – even with emissions trading
- Many technological opportunities for aviation & shipping but they must all be exploited if temperatures of >2ºC are to be avoided
- But, technology solutions won't reduce emissions in the short/medium-term due to growth
- Not currently enough drivers for aviation or shipping to significantly mitigate
- Issues of apportionment require further exploration, particularly if UK is to include aviation and shipping within its mitigation policies and monitor their progress

Conclusions

- CO_2 emission pathways commensurate with the 2ºC temperature threshold are at best extremely challenging and at worst impossible
- Without tackling the aggregate of all sectors with stringent policies that deliver within the decade, adaptation for 4ºC is increasingly necessary
- Large range of scenarios associated with international transport but only the most radical will avoid consuming considerable portions of budget by 2050
- Technological solutions to improve fuel efficiency will not be adequate to mitigate CO_2 in the medium to long-term without alternative fuels and energy demand management in short-term

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Thank you

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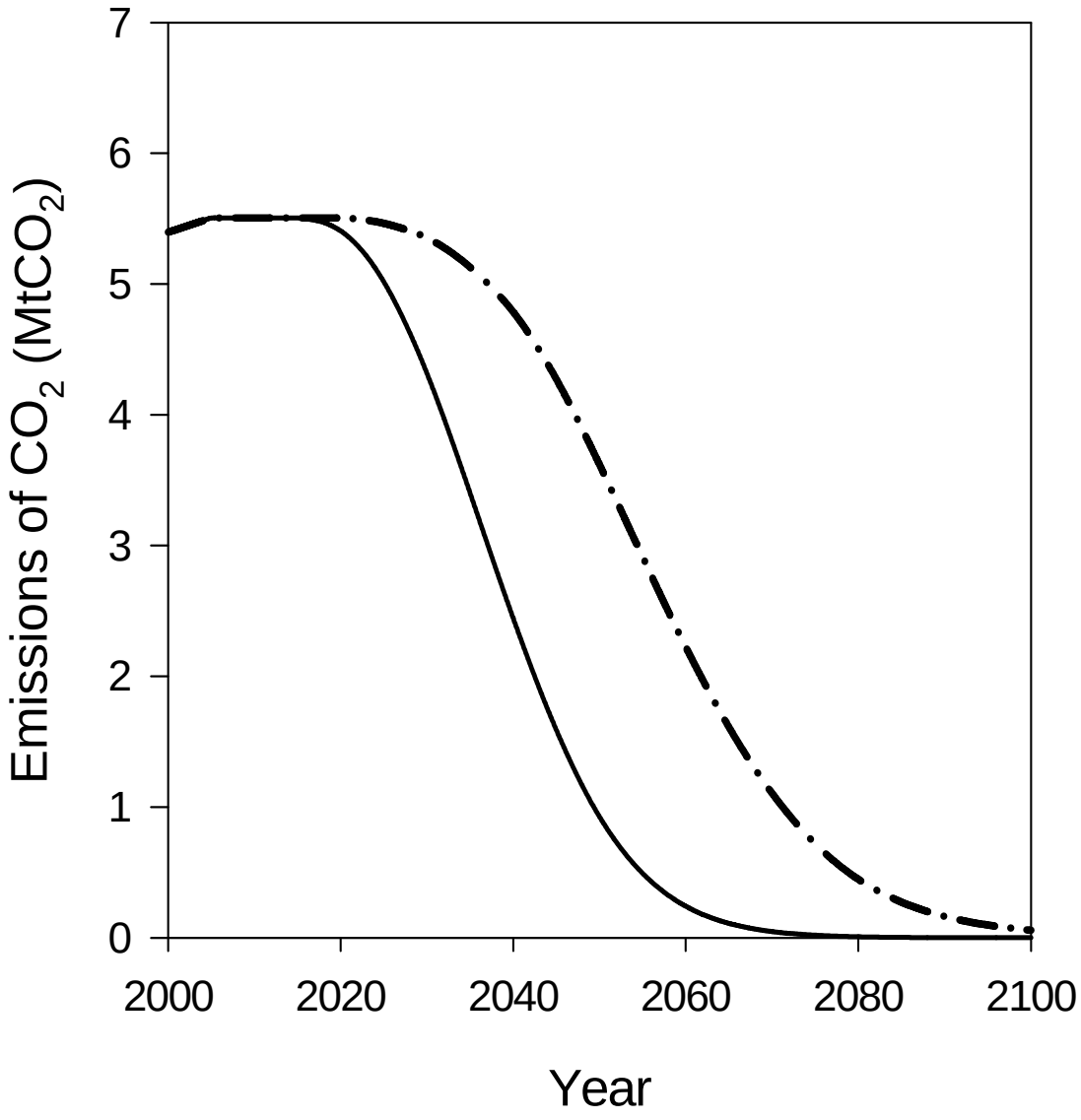
Future emission scenarios - deforestation

- Characterised by high uncertainty *(principally driven by deforestation)*
- Represents 12%-25% of total global greenhouse gas emissions in 2000
- Two Tyndall scenarios with different carbon-stock levels remaining: *70% & 80%*
- Optimistic compared with Forest Resource Assessment



Future emission scenarios – non-CO_2 ghg

- Short-term EPA estimates
- Characterised by considerable tail due to emissions associated with food production
- Represents ~20-23% of total global greenhouse gas emissions in 2000
- Three scenarios with different peak dates