How to compare

climate impacts of transport

J. Fuglestvedt

Thanks to

Marianne Lund, Jens Borken-Kleefeld, Keith Shine, and Terje Berntsen

Transport Emissions: The Climate Challenge

Results from IP QUANTIFY and SSA ATTICA

Brussels, 24 June 2010

Typical questions:

”How large is the climate impact of transport?”

”Should I go by car, bus, plane, ship…..?”

”… what is best for climate”?

Difficult questions to answer

- What does these questions really mean?
- Need to specify several things

Comparing climate impacts of transportation

Challenges:

Broad mix of substances and physical / chemical processes

Warming and **cooling** effects

Large **span in lifetimes** (from < hours to centuries)

➔ Effects depend on location of emissions.

➔ Contributions to climate change differ strongly after the time of emissions.

"measures… should be cost-effective" and

"…*cover all relevant sources*, sinks and reservoirs…"

Kyoto Protocol: made this operational by its *multi-gas approach*

Often called "basket approach"

CO_2, CH_4, N_2O, HFCs, PFCs, SF_6

Transportation goes beyond the Kyoto basket

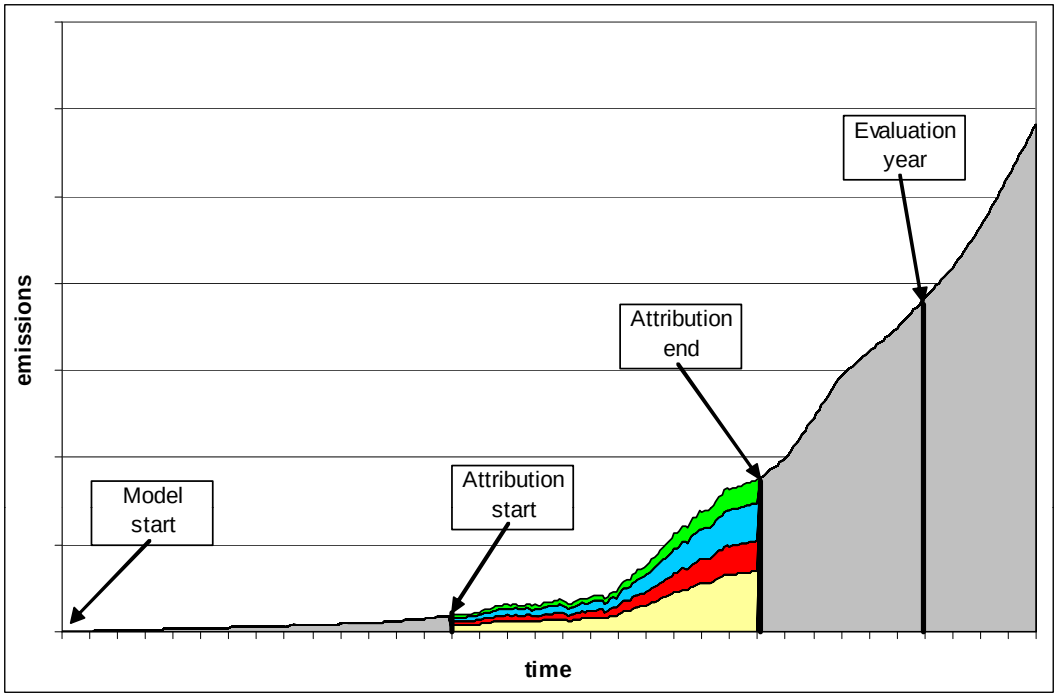
NOx, SO_2, CO, VOC, H_2O, contrails, cirrus

Design of analysis of climate impacts of transport

- **Time frames**
  - emissions
  - responses

- **Spatial dimension**

  Geographical dependence
  - emissions
  - responses



- **Boundaries of the analysis**
  - e.g. well-to-wheel vs tank-to-wheel
  - related activities

- Which **components** should be included?

- **Impact parameter**

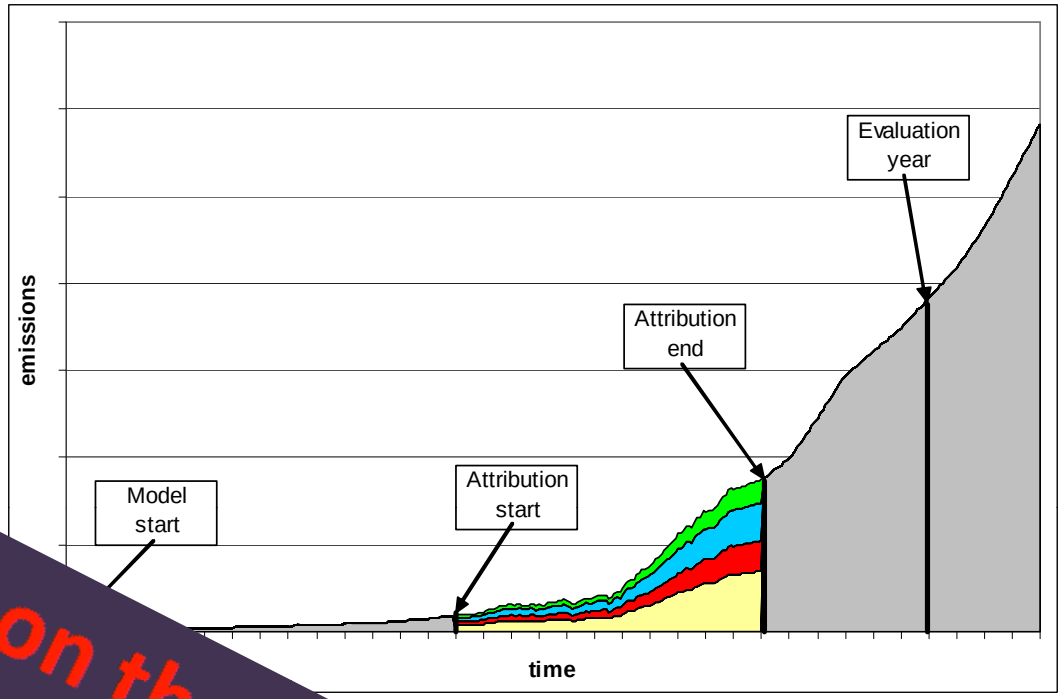
  - Radiative forcing
  - temperature
  - sea level rise

- **Normalization by transport work**

  (passenger-km or tonn-km)

Design of analysis of climate impacts of transport

- **Time frames**
  - emissions
  - responses
  - **sion**
  - lence
  - e
  - respo
- **Boundaries of the**
  - e.g. well-to-wheel vs tan
  - related activities
- Which **components** should be includ



All choices depend on the question being asked

Misuse is possible

mpact parameter

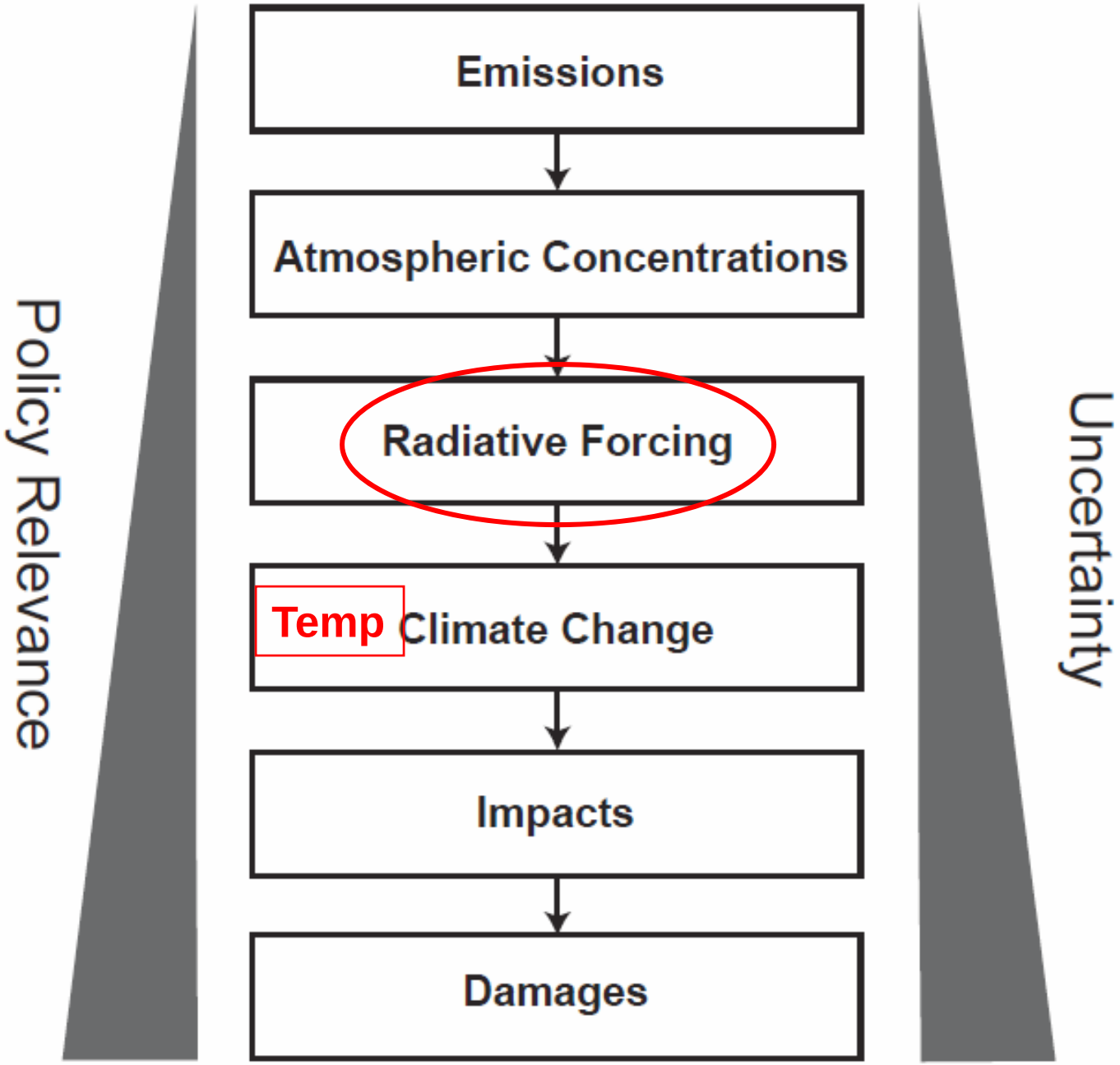
e forcing

- **Normalization by transport work**

(passenger-km or tonn-km)

QUANTIFY

Choice of climate impact



"But climate impacts of transport should be given per transport work"

Specific climate impact = Climate impact **/** transport work

What is an adequate denominator?

Climate impact / person-km

Climate impact / ton-km

Climate impact / passenger-hour

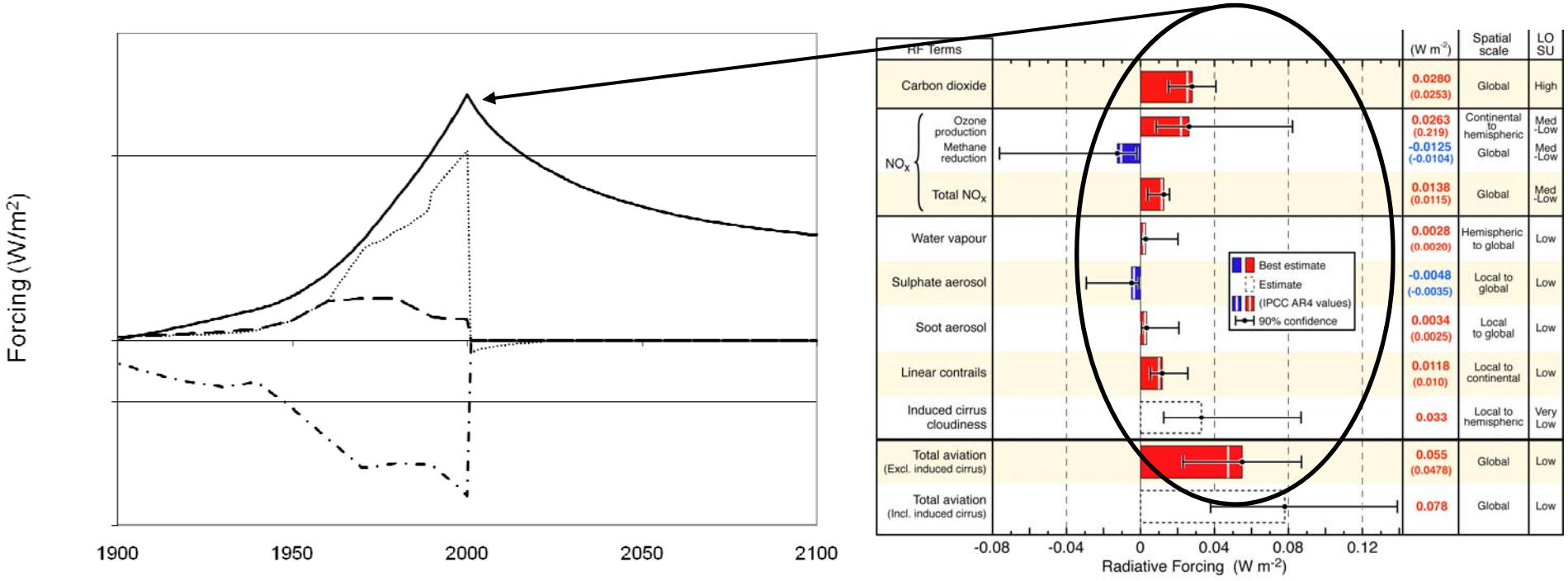
Climate impact / value-km

Climate impact / volume km

QUANTIFY

More on this in presentation by Jens Borken-Kleefeld

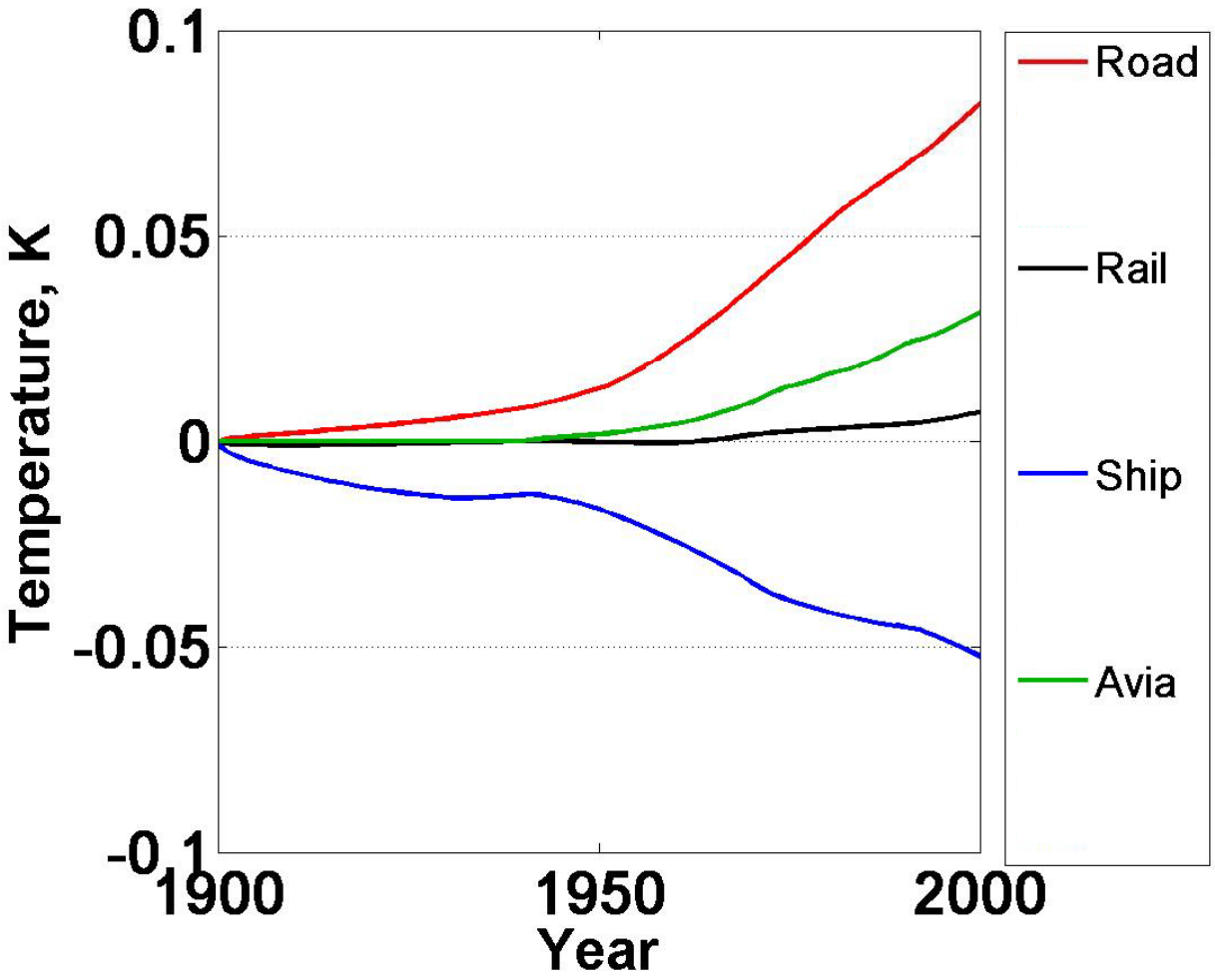
Time frames



Effects of:

- Historical emissions (as presented by Keith Shine)
- Current annual emissions
- Emissions sustained for a period (e.g. lifetime of a car)
- Future emissions (scenarios)

Timeframe: **Historical**

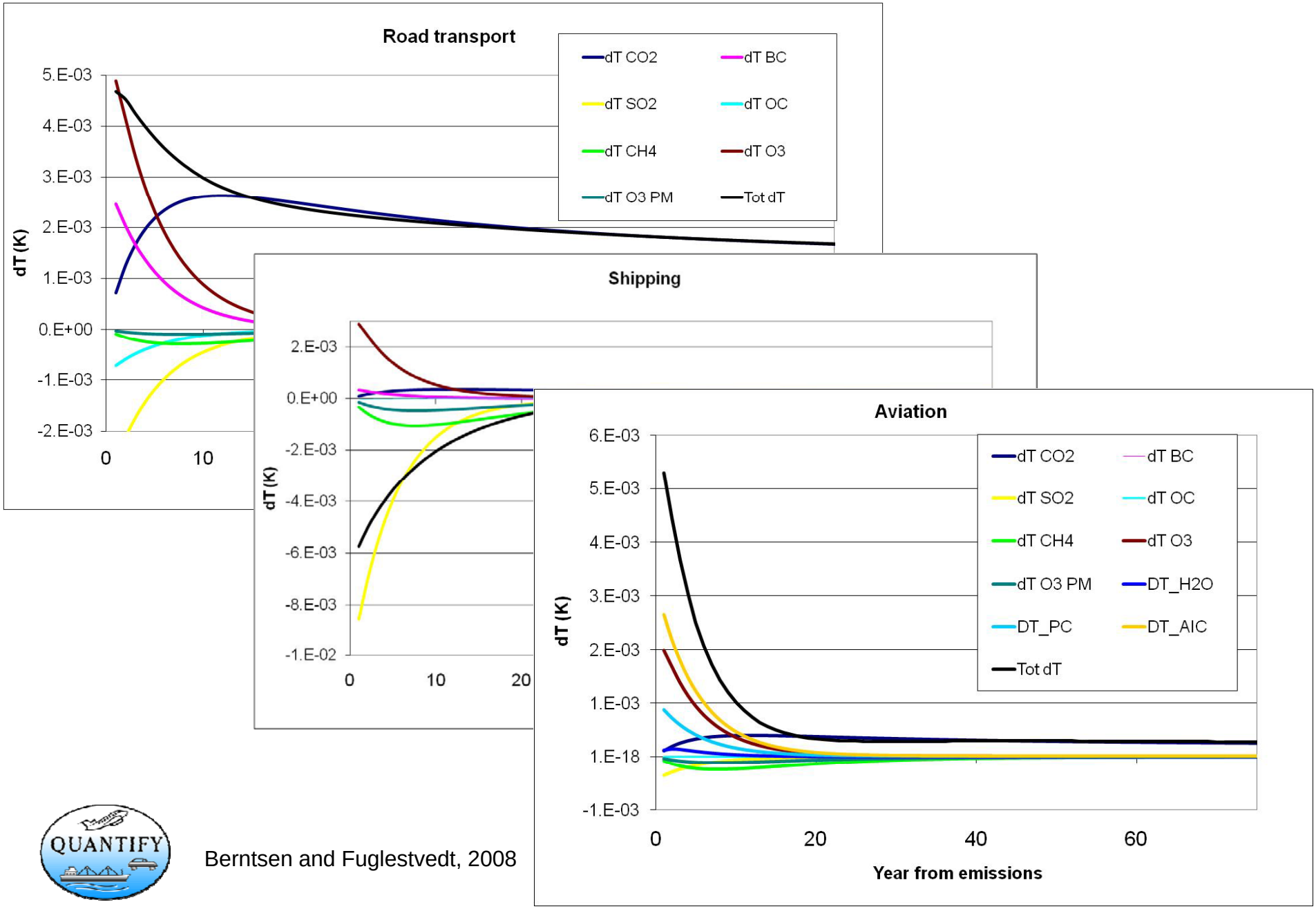


Total transport:

10% of man-made warming in 2000

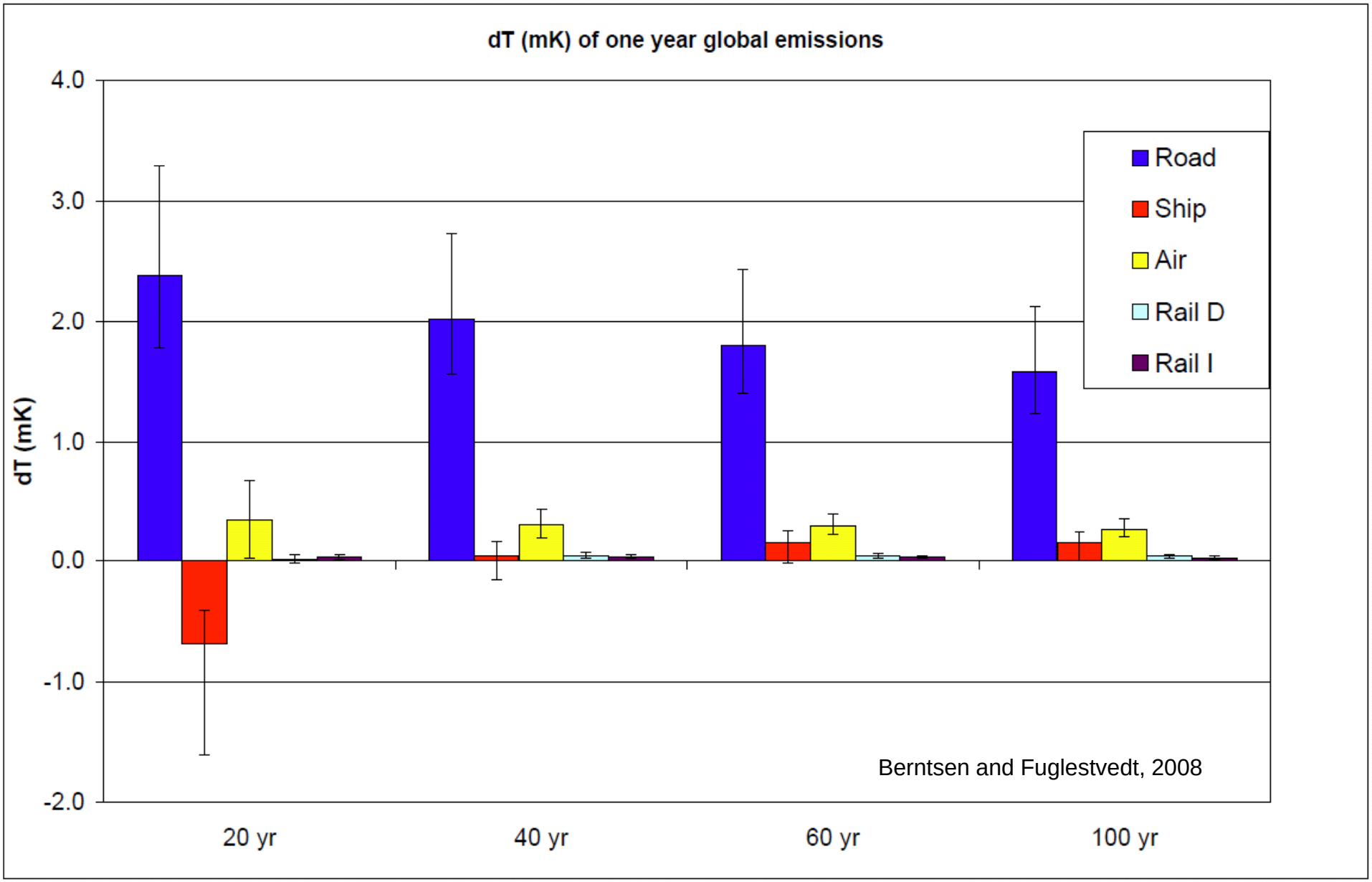
Skeie et al., 2009

Current global emissions - one year

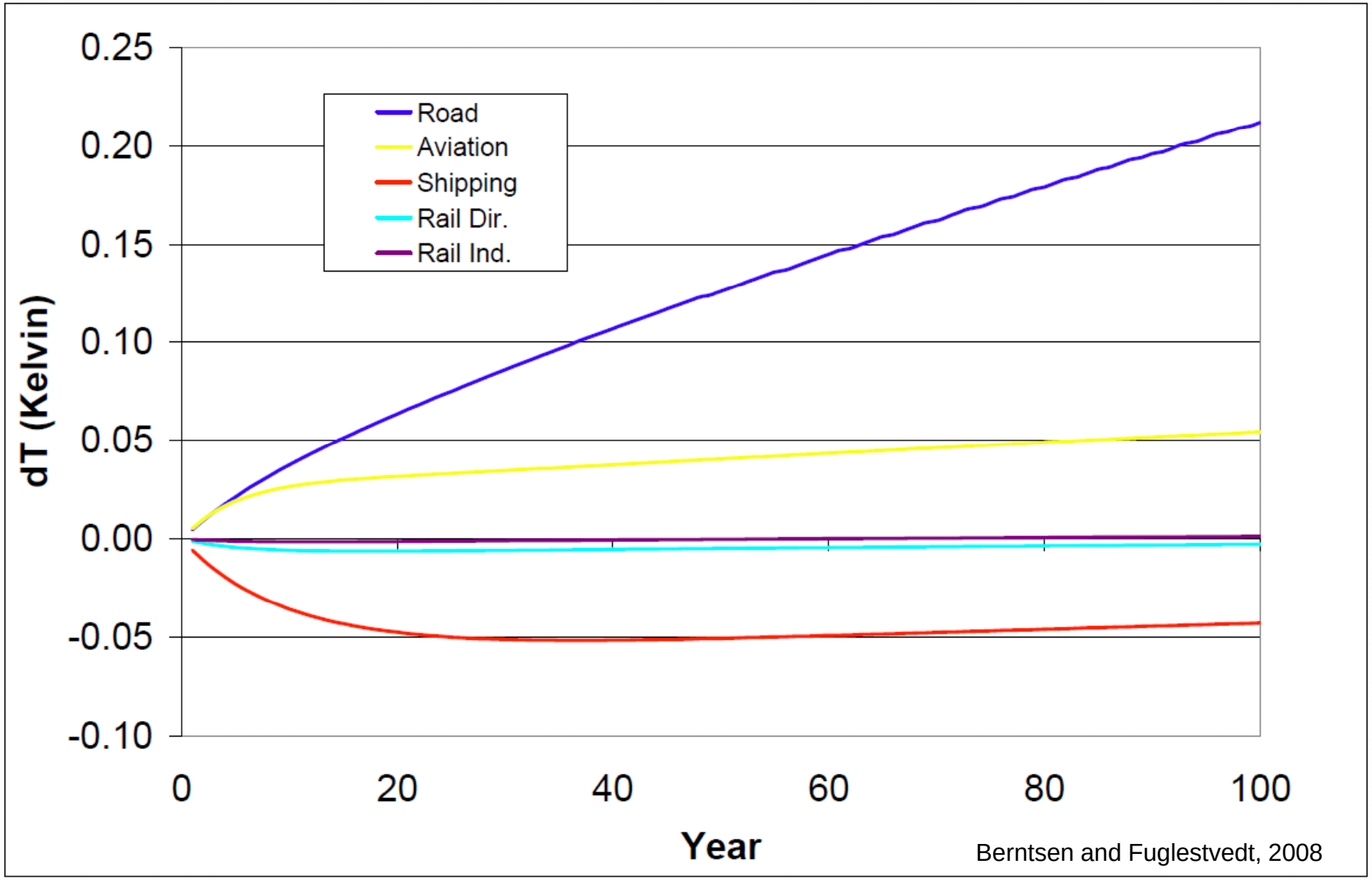


Berntsen and Fuglestvedt, 2008

Current global emissions – selected time horizons



Current emissions - kept constant

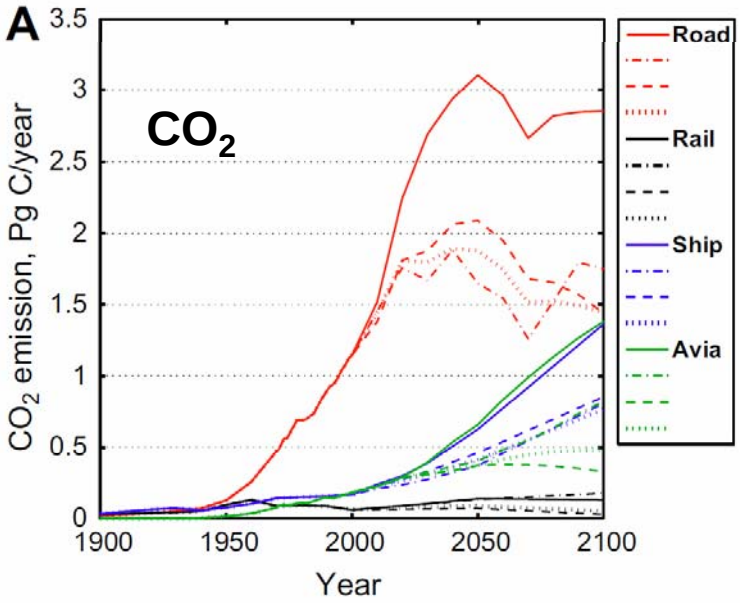


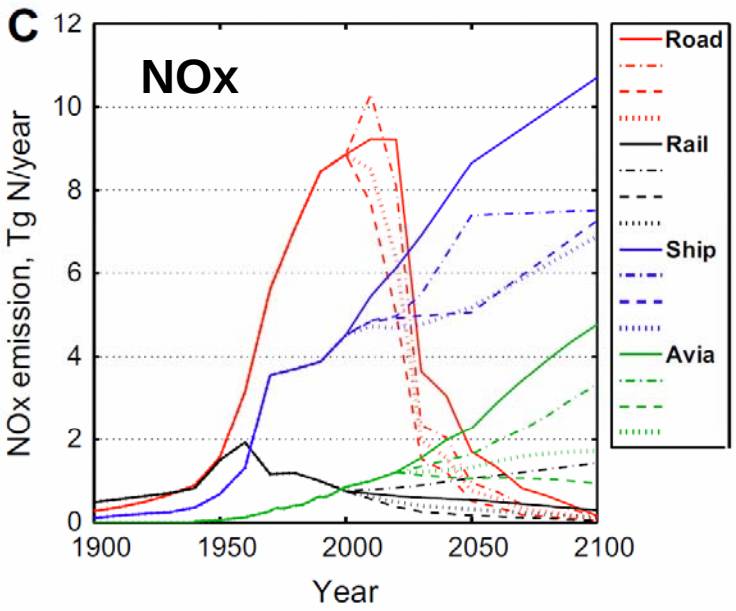
Berntsen and Fuglestvedt, 2008

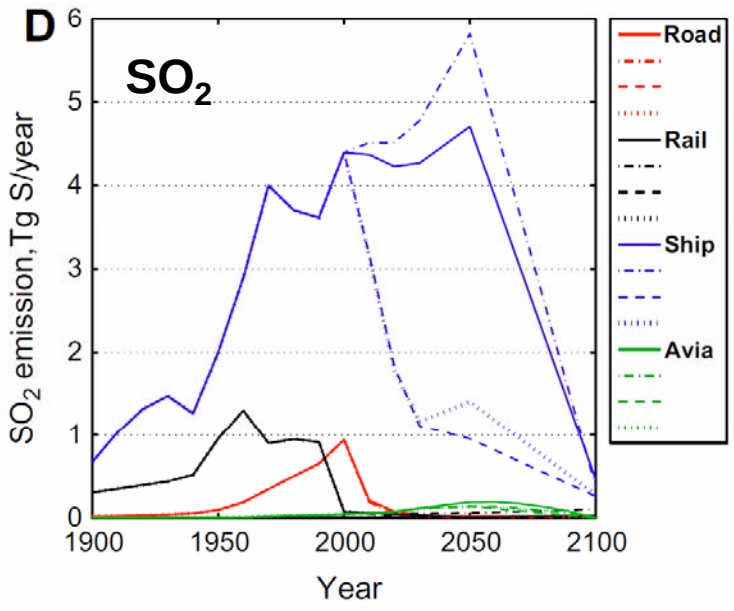
Future scenarios

- IPCC SRES storylines
- New technology
- Fuel mix
- Emission factors
- Regional developments

Emissions



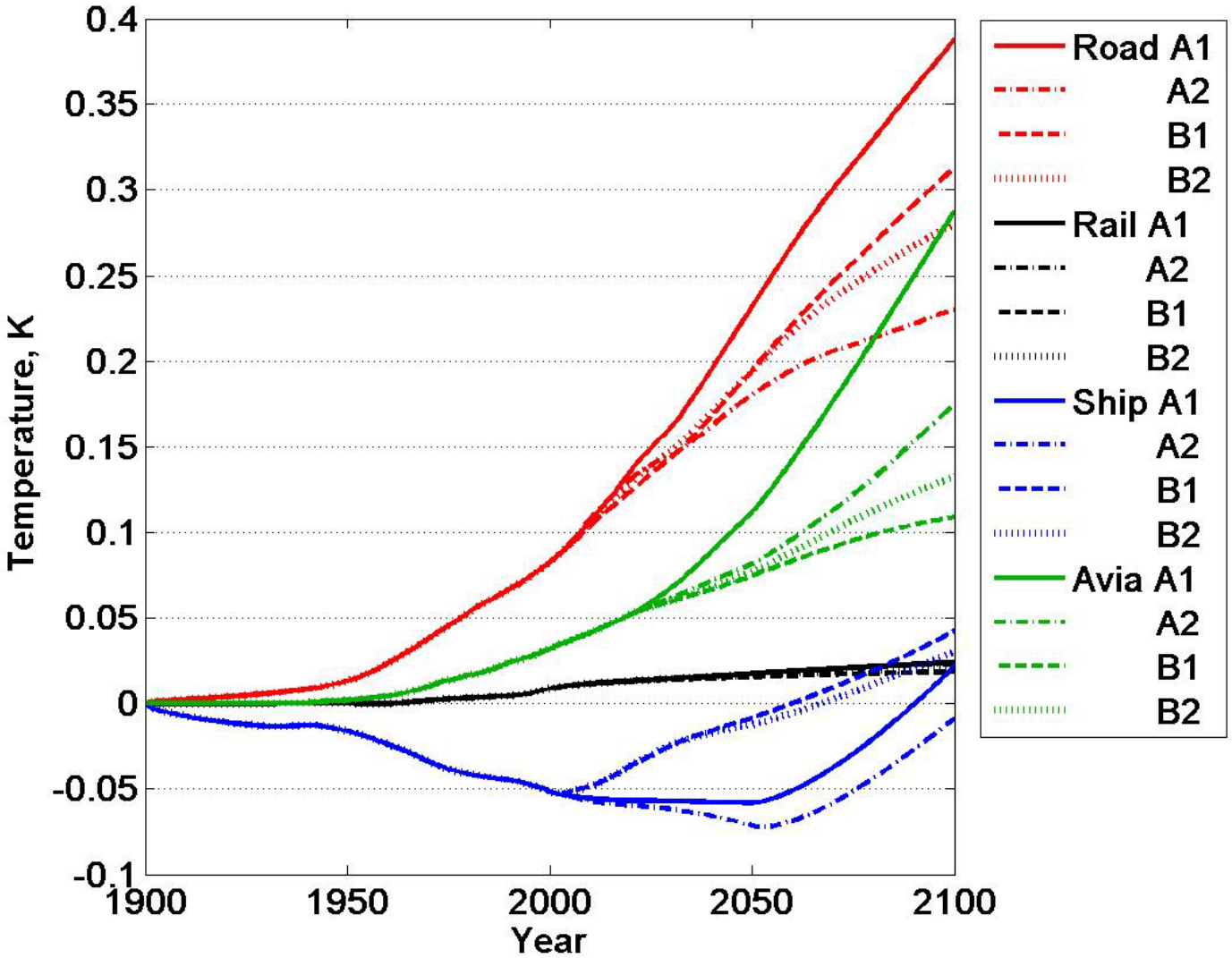




Borken et al., 2009; Uherek et al., 2009; Skeie et al., 2009

QUANTIFY

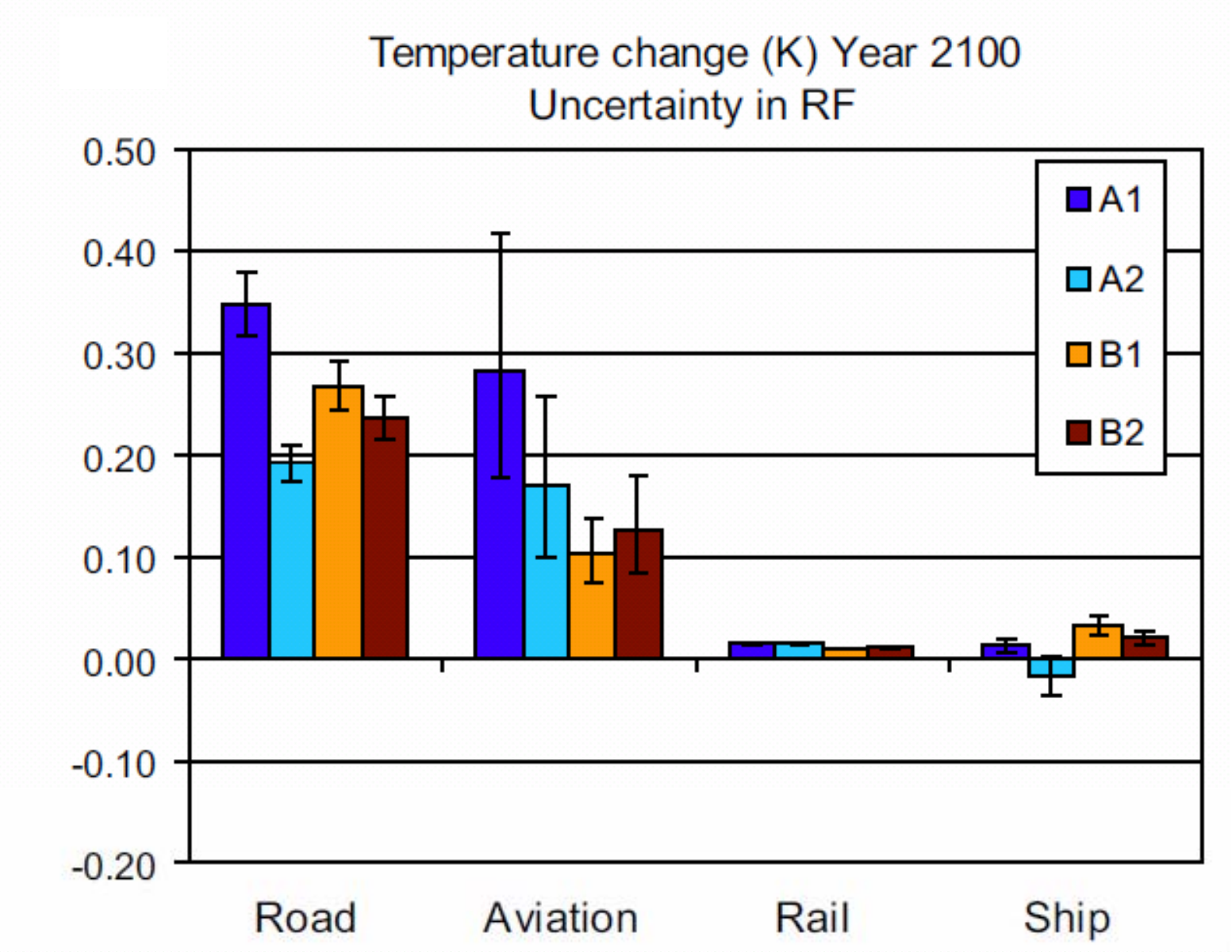
Future scenarios: Change in global mean surface temperature



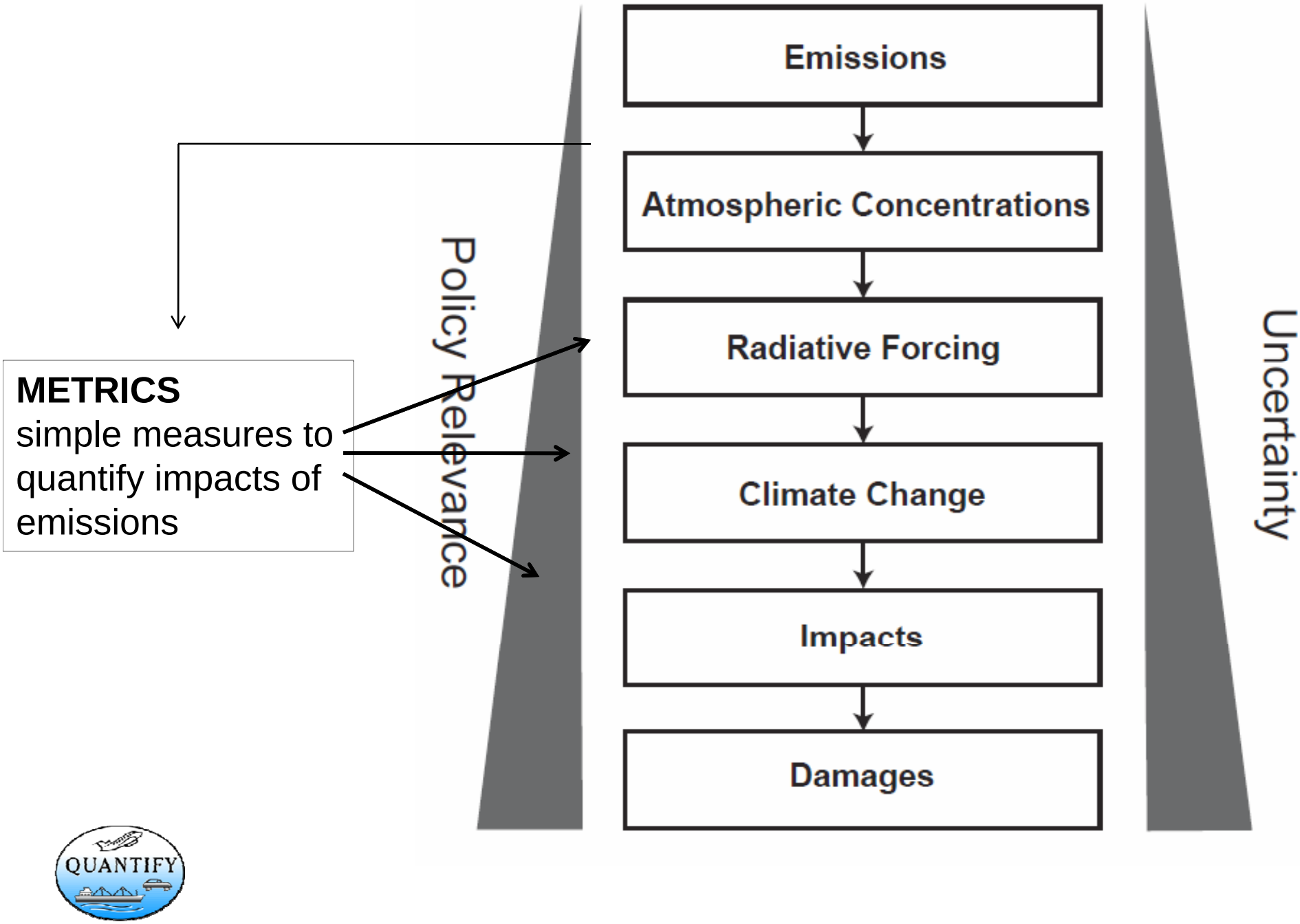
Total transport
2000: ~ 10%
2100: 10-20%

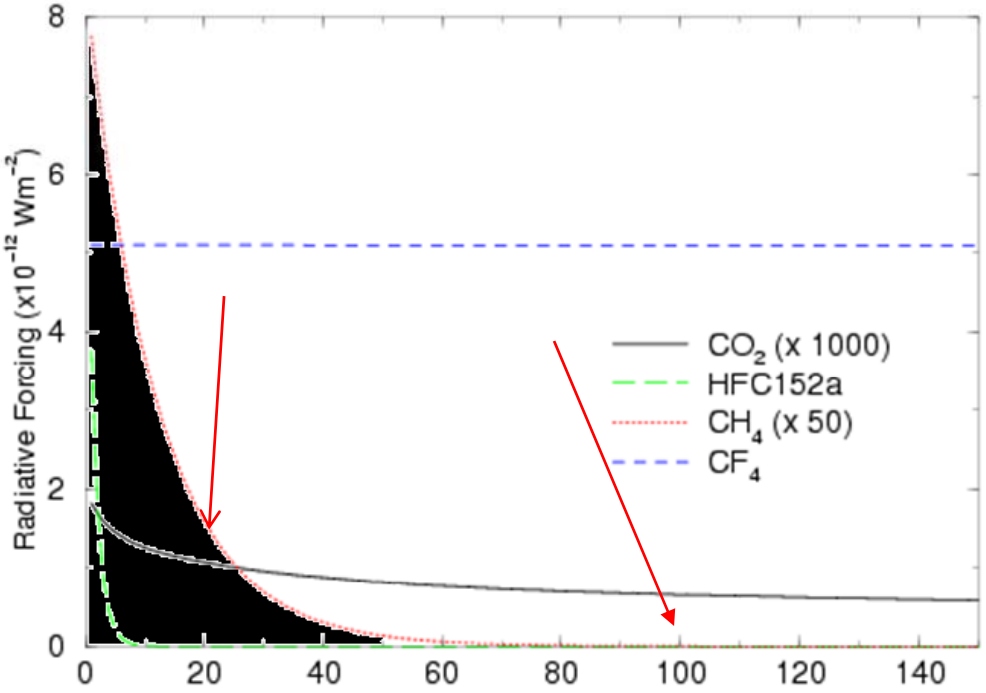
By sector in 2100
Road: 5-12%
Aviation: 4-8%

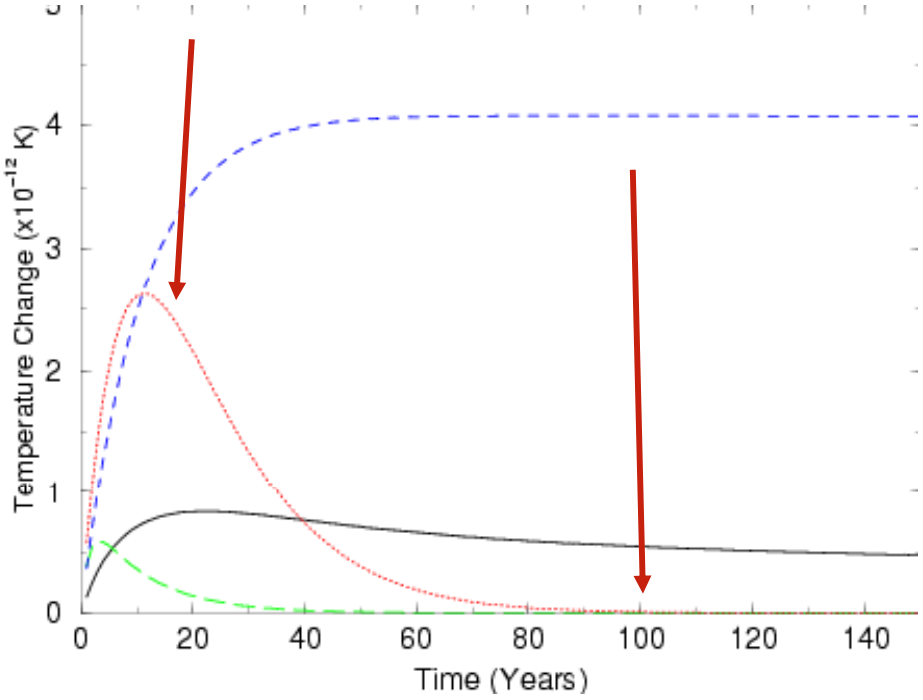
Skeie et al., 2009



Skeie et al., 2009


Emissions
Atmospheric Concentrations
Radiative Forcing
Climate Change
Impacts
Damages
Policy Relevance
Uncertainty
METRICS
simple measures to quantify impacts of emissions





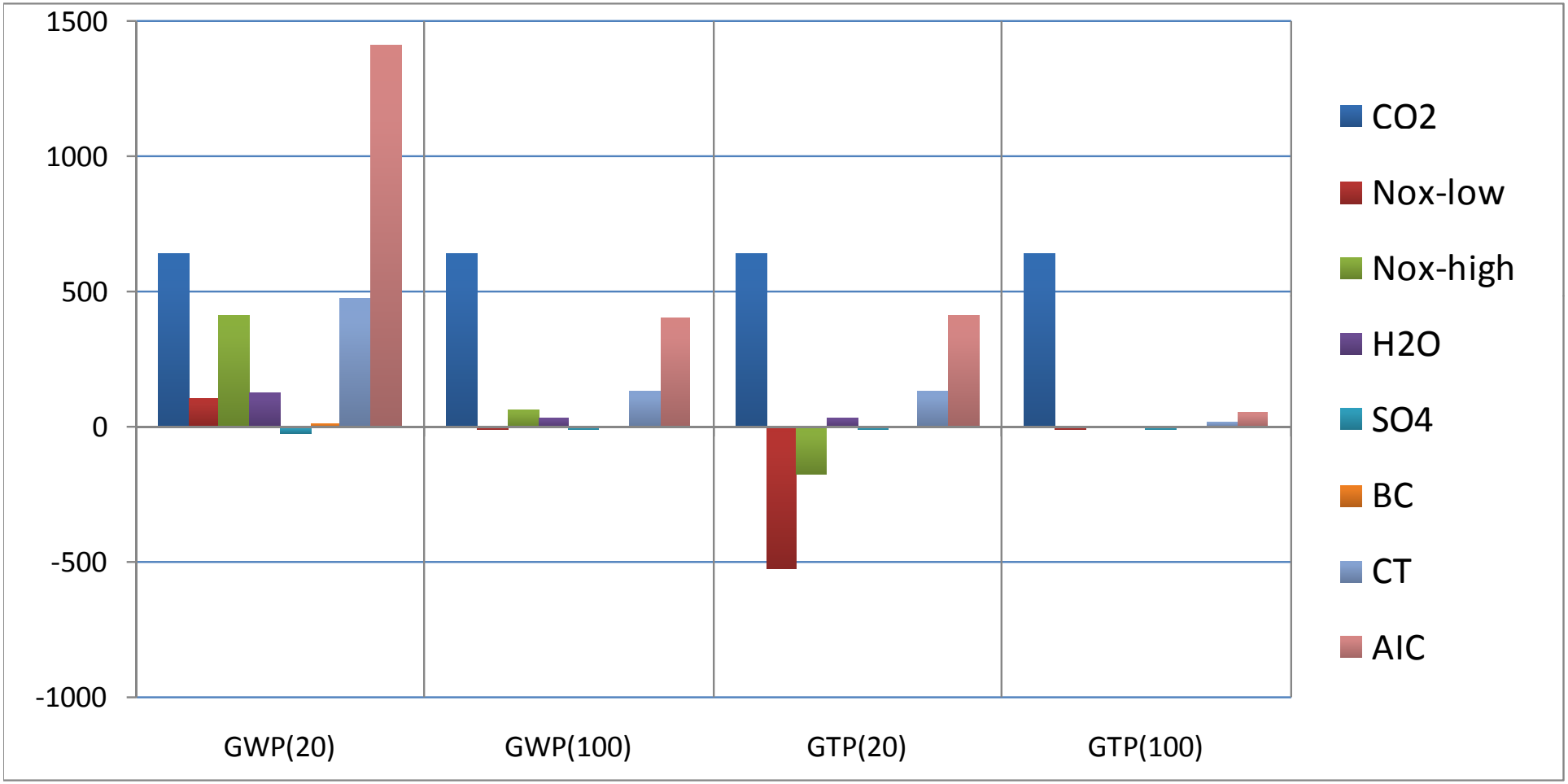
$$GWP_i(T) = \frac{\int_0^T RF_i(t)\,dt}{\int_0^T RF_{CO_2}(t)\,dt}$$

➔ strong memory
(often misunderstood; no climate response included)

$$GTP_i(t) = \frac{\Delta T_i(t)}{\Delta T_{CO_2}(t)}$$

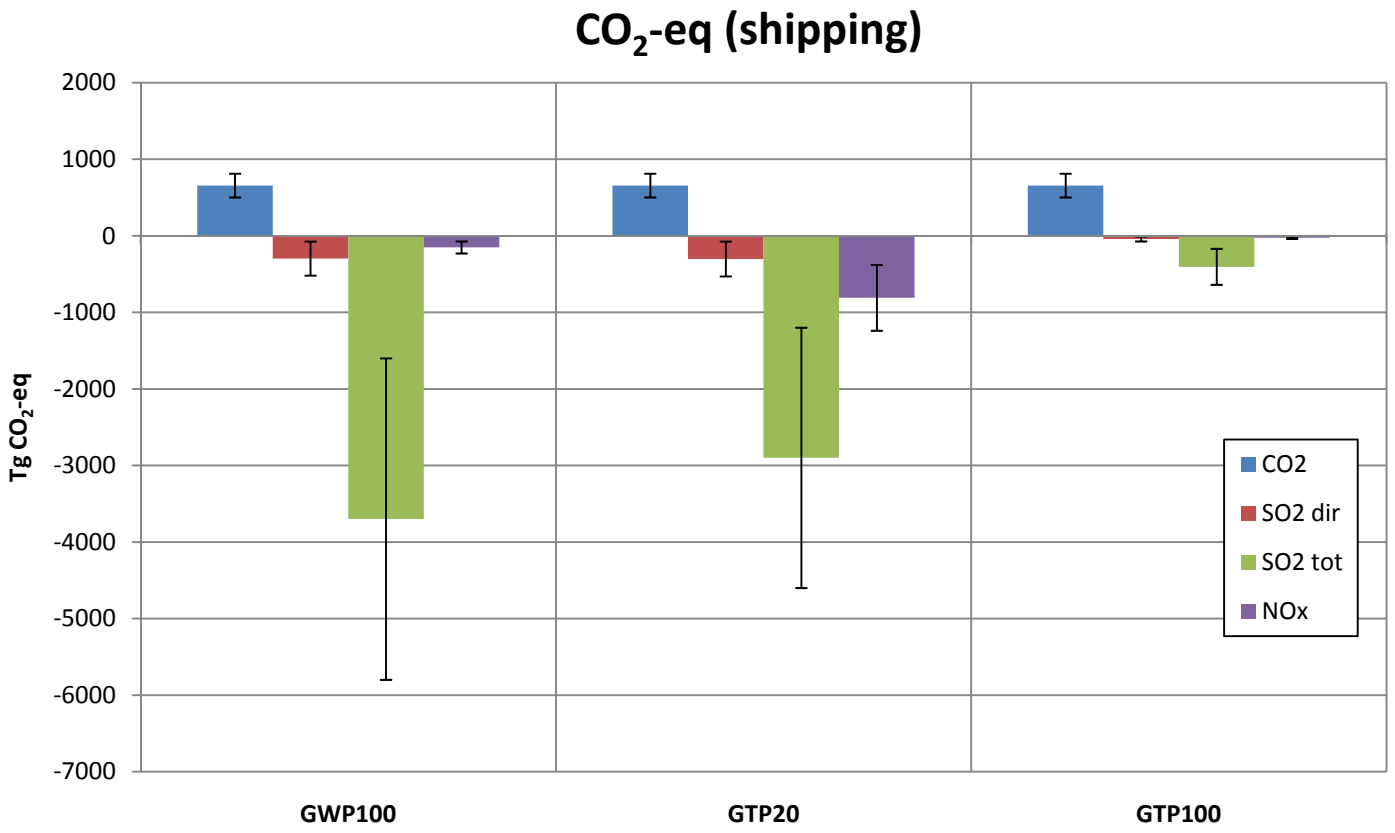
Large differences for short-lived components (CH_4, BC….)

AVIATION: Emissions x Metric = CO_2 equivalents (Tg / yr)



Based on Lee et al., 2009 (ATTICA)

Shipping: Emissions x Metric = CO_2 equivalents (Tg / yr)



Based on Eyring et al., 2009 (ATTICA)

Conclusions

Many different perspectives – need to clarify the questions

On a global scale:

Historically: Road transport > aviation >> train

Shipping: **cooling**

Future: Shipping: Switches from **cooling** to **warming**

Road transport: Dominating

Aviation: potentially strong short-lived effects, but large uncertainties

Alternative perspective: impact per transport work (next presentation)

Emission metrics are useful for:

- Climate protocols and emission trading
- Climate policy assessments, related effects and trade-offs

GTP and GWP are fundamentally different

One single time horizon gives a partial picture