

Past and Future Transport Emissions

QUANTIFY EU 6th Research Framework Programme
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QUANTIFY

- Quantification of the impact of air, sea and land traffic on the global climate
- Improved, past, present and future gridded emission inventories for transport
- Acknowledgement:
 - Land transport: Jens Borken, Heike Steller, Tamas Meretei, Griet de Ceuster and Filip Vanhove (DLR Berlin, KTI Budapest, TML Leuven)
 - Shipping: Øyvind Endresen, Hanna Lee Behrens, Erik Sørgård, P.O. Brett and Ivar Isaksen (DNV, UIO, Norway)
 - Aviation: David S. Lee, Bethan Owen and Ling Lim (MMU, Manchester)
 - Non-transport: John van Ardenne (JRC)
 - Indirect, consistency and gap filling/historical: Kristin Rypdal (CICERO)
- *Part of the data presented are preliminary – in particular future - and some points are complemented with data and information from other studies*



Why focus on transport emissions?

- Constitute a large share of global anthropogenic emissions: In y2000 (EDGAR)
 - 37 % NO_x
 - 20 % CO₂
 - 17 % CO
 - 9 % SO₂
- Historical growth in emissions has been large
 - Fuel/CO₂ doubled from 1970 to 2000
- Large future growth in fuel consumption if unconstrained
 - Transportation energy use can be 80 % higher in 2030 (EIA, IEA)
 - Larger than for non-transport sources
 - Particularly large **growth rate** in Asian developing countries, large **absolute increases** from OECD countries
- Technical mitigation options
 - Technology (global market) - fuel switch
 - International and regional regulations of exhaust emissions

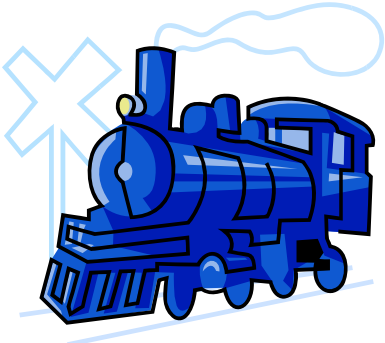


Individual emission inventories for transport

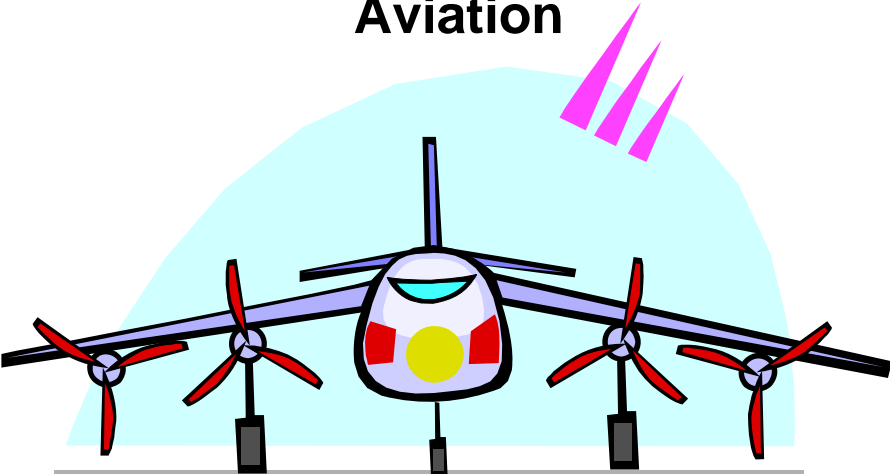
Road



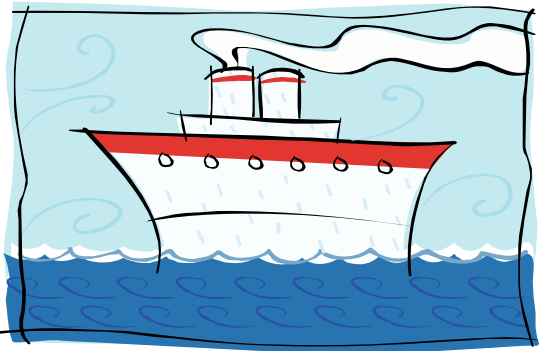
Rail



Aviation



Shipping



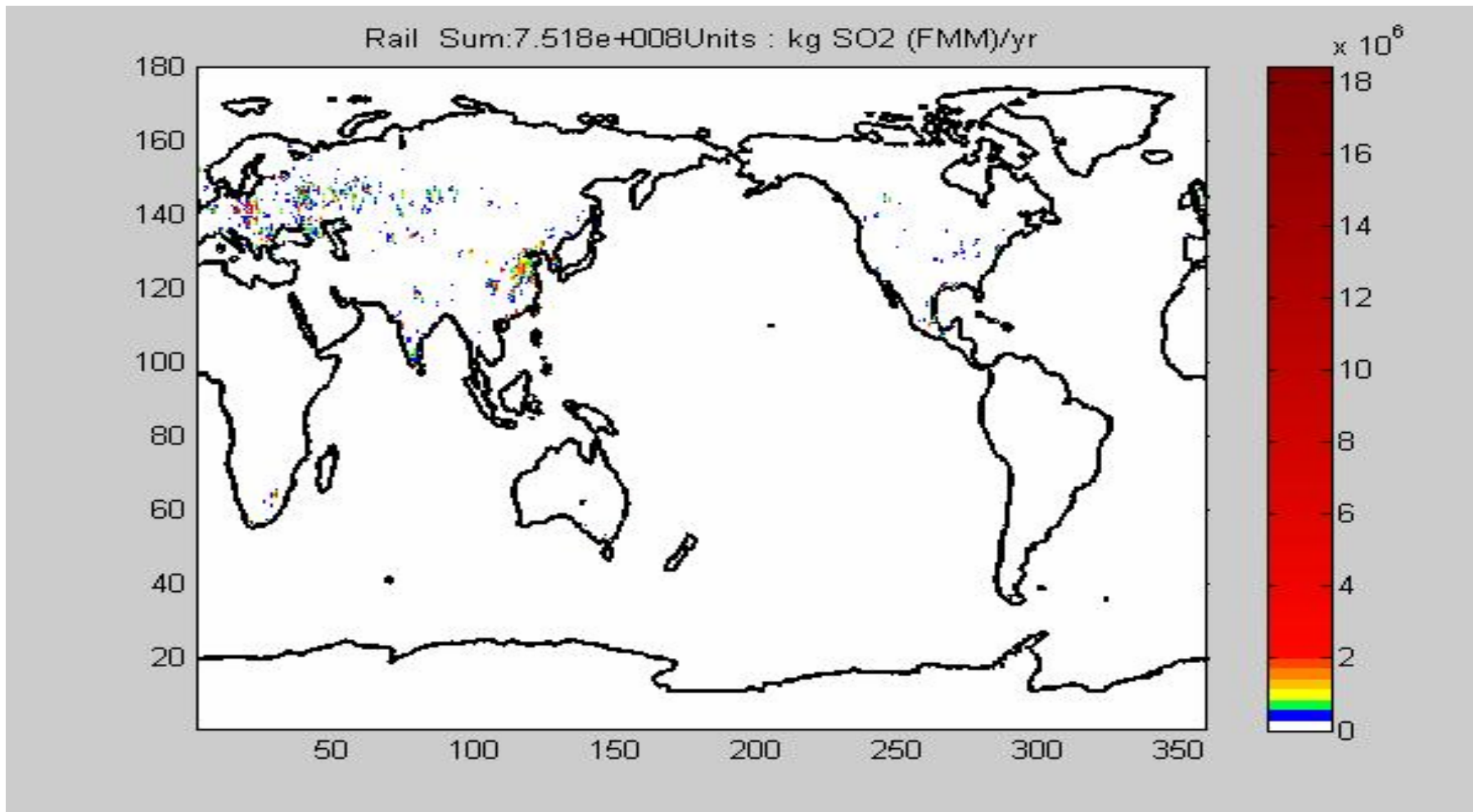
Climate vs. Air quality focus

- QUANTIFY considers the impact of all climate forcing agents, including
 - Ozone precursors: NO_x, NMVOC, CO
 - Aerosols and aerosol precursors: BC, OC and SO₂
- Overlaps with air quality problems
- Time frame 1900-2100
- Gridded data for 2000, 2025 and 2050

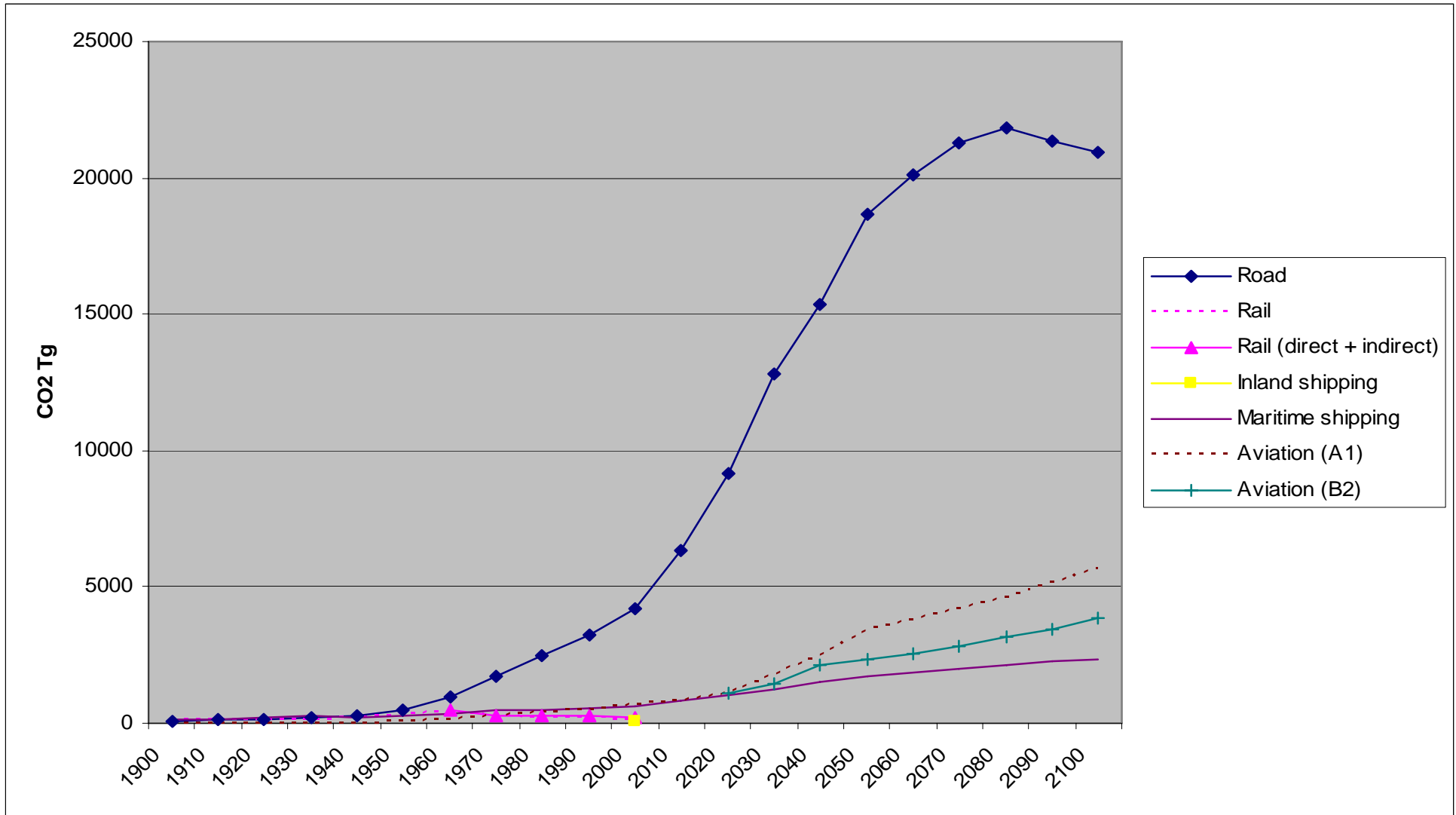


Indirect emissions

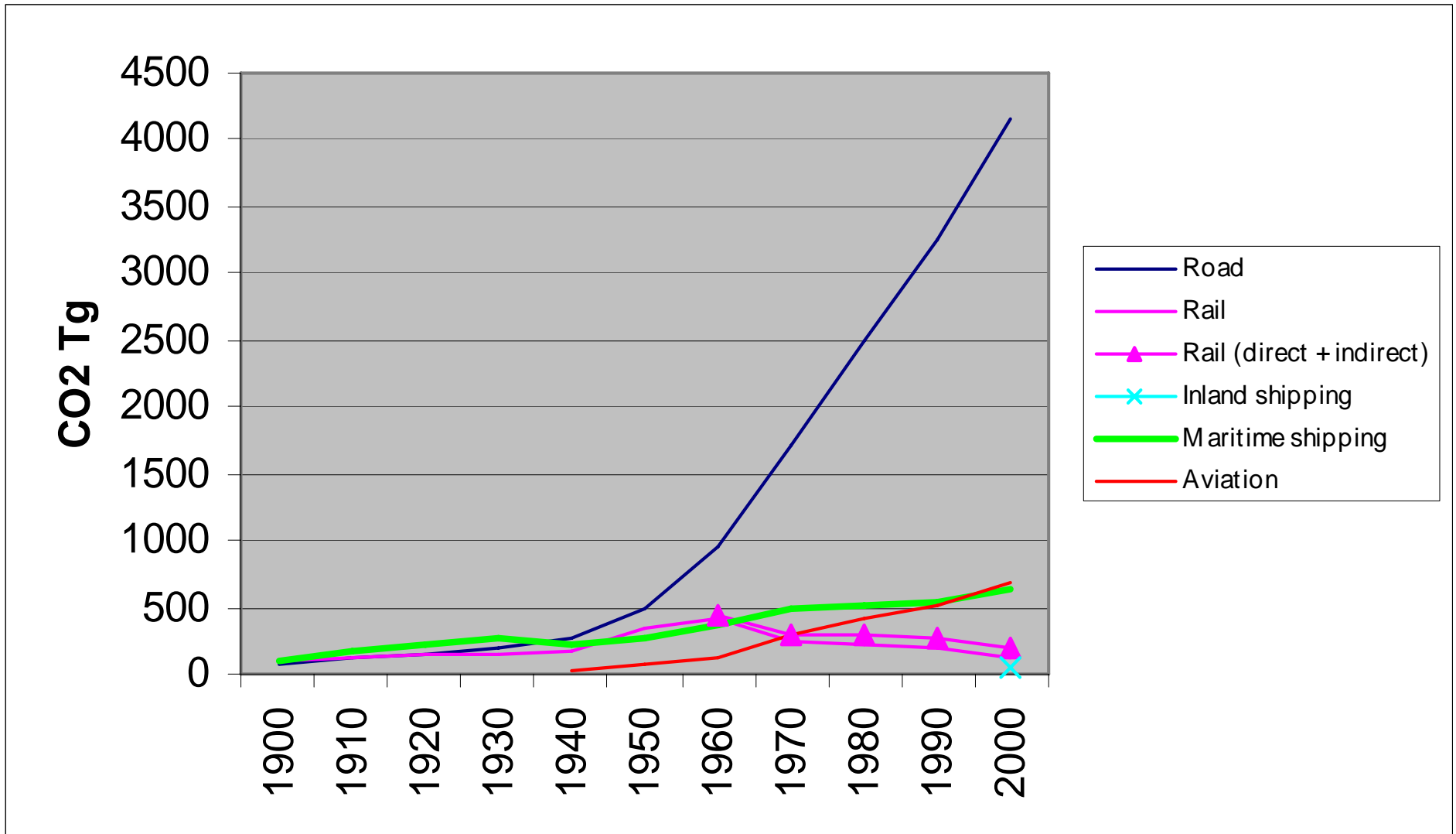
- New transport fuels may shift emissions from the consumption stage to the production stage
- Quantify includes datasets for emissions from provision of transport fuels



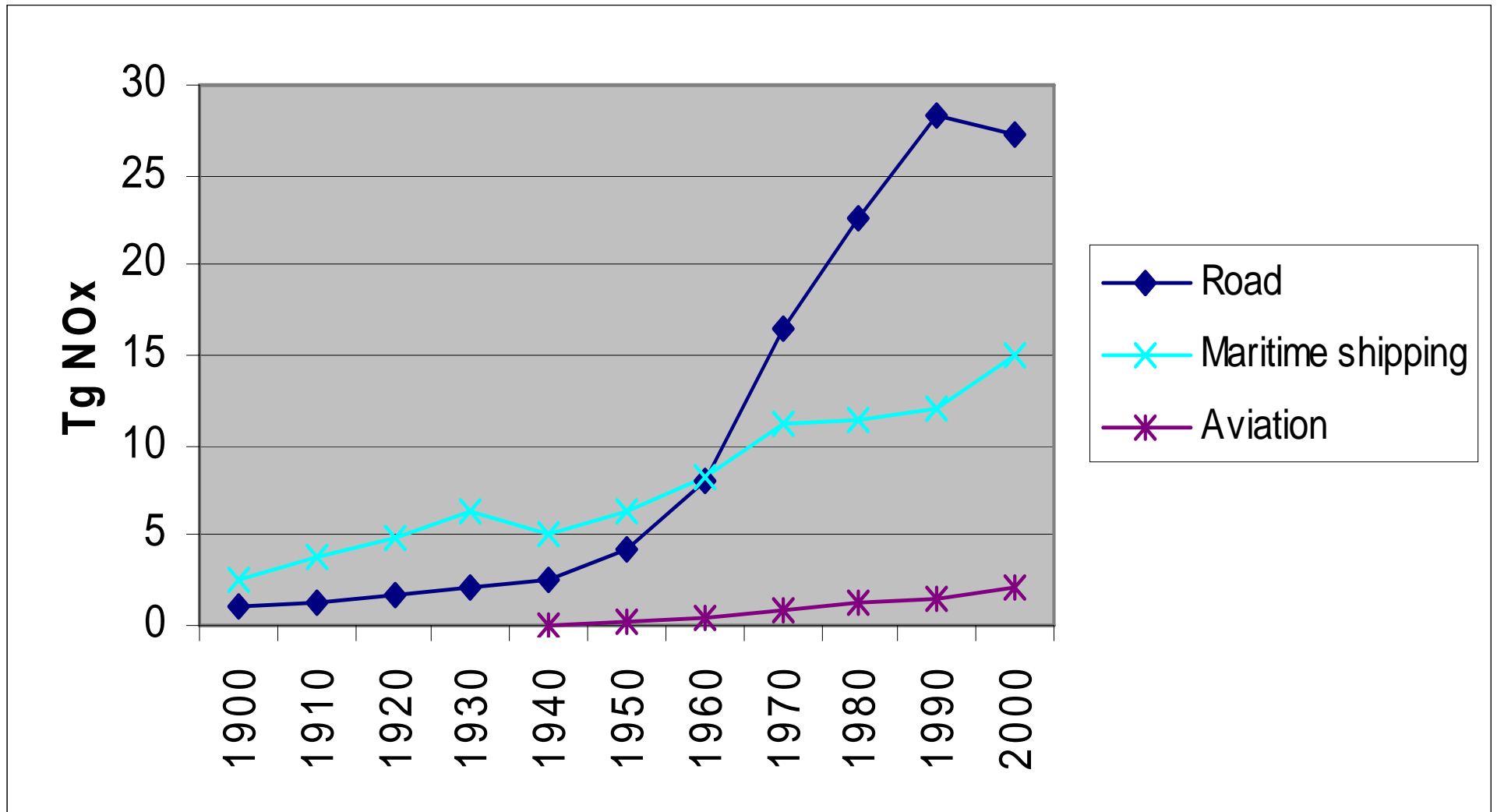
Overview CO₂ (fuel) 1900-2100



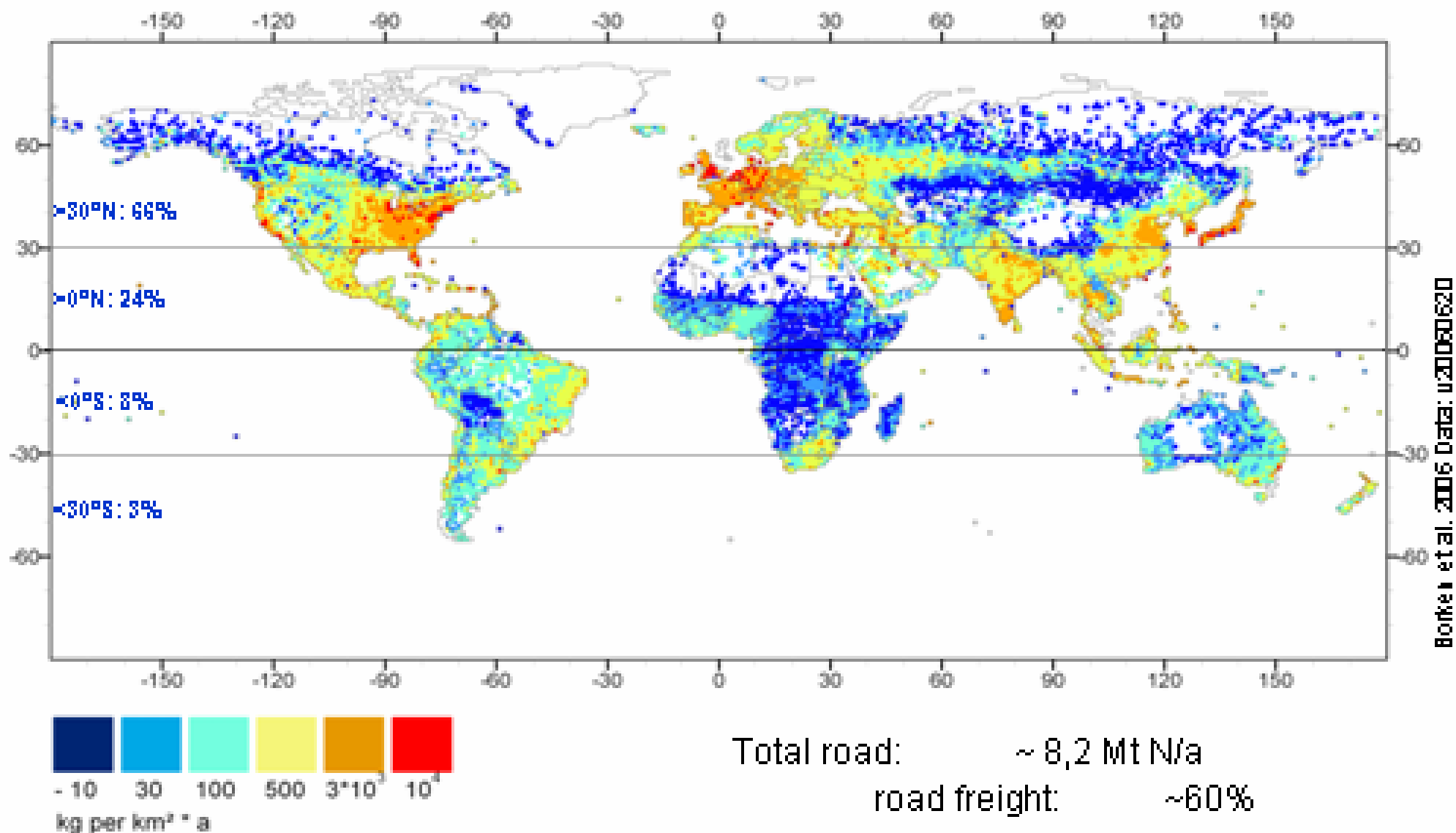
Past CO₂



Past NOx



Road transport NO₂ emissions in 2000



Botter et al. 2006 Data: v20060620



Road: Future CO₂ emissions (fuel use)

- Many explaining factors, including
 - Wealth ~ growth in distances traveled for both passenger and freight transport,
 - Shift to car and truck transport (from cycle, bus, rail, ...),
 - Engine fuel efficiency traded against more power, weight, comfort, safety features,
 - Fuel prices

- How will higher vehicle fuel efficiency balance the growth in transport volumes?
 - *Increase fuel efficiency* of current internal combustion engines (+10-30% efficiency),
 - Consider *switch* from gasoline to diesel fuel (+15% efficiency),
 - De-carbonise fuel e.g. by addition of bio-fuels (-5-100% less CO₂),
 - Reduce *vehicle weight and power* (+5-10% efficiency),
 - Intelligent energy management e.g. hybrid power-train (+5-10% efficiency),

- Major policy levers: **Decouple**
 - GDP growth from transport growth,
 - transport growth from road transport growth,
 - transport growth from transport energy growth,
 - transport energy consumption from CO₂ emissions



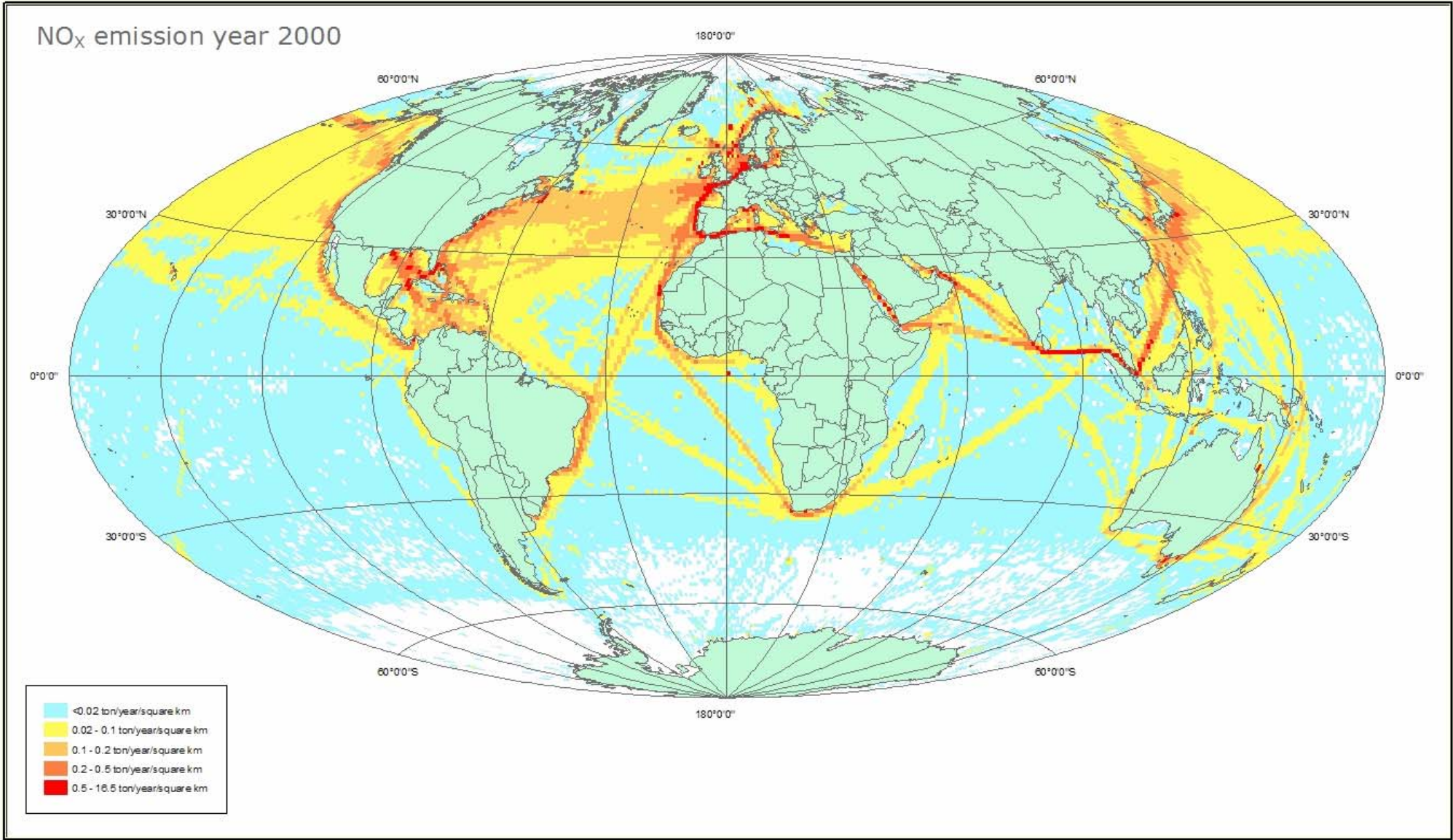
Road: Future emissions of air pollutants

- Exhaust emission control can probably outweigh growth in transport volumes
 - super-emitters (old or defunct vehicles, 2-stroke vehicles) are phased-out,
 - current exhaust emission standards enforced,
 - future exhaust emission standards tightened
 - the internal combustion engine replaced by electric drive (hybrid, fuel cell, .)

- Major uncertainties, not least in dynamic developing countries
 - Growth in transport demand, and notably car travel,
 - Pace of technology development,
 - Penetration of technologies,
 - Vehicle maintenance and fuel quality (fuel sulfur and lead),
 - Diesel gasoline fuel switch (PM vs CO/NMVOC)



NO_x shipping 2000



Shipping present and future

- Currently ongoing discussions in the scientific literature about the current level of emissions from shipping
 - The QUANTIFY inventory is made bottom-up but is in good agreement with fuel statistics
 - Fishing included
 - Inland shipping separate

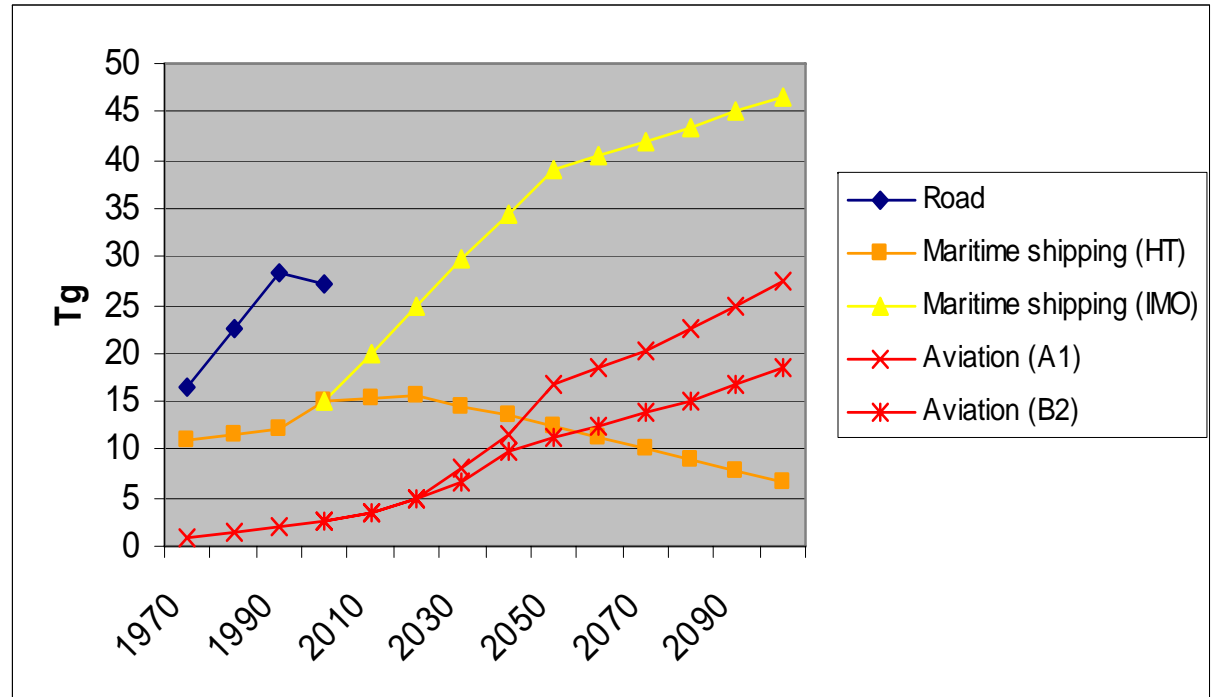
- Activity level is expected to grow until 2030 and beyond
 - Following international trade (closely related to economy/structure)
- Technology change
 - Higher energy efficiency (lower fuel) – higher NO_x
 - Slow penetration
 - ▶ Long life times of vessels > 30 years
 - ▶ High expenses in changing existing engines
 - Only operational measures can have a short term effect



Shipping future NOx

➤ Technologies are available to reduce NOx emissions

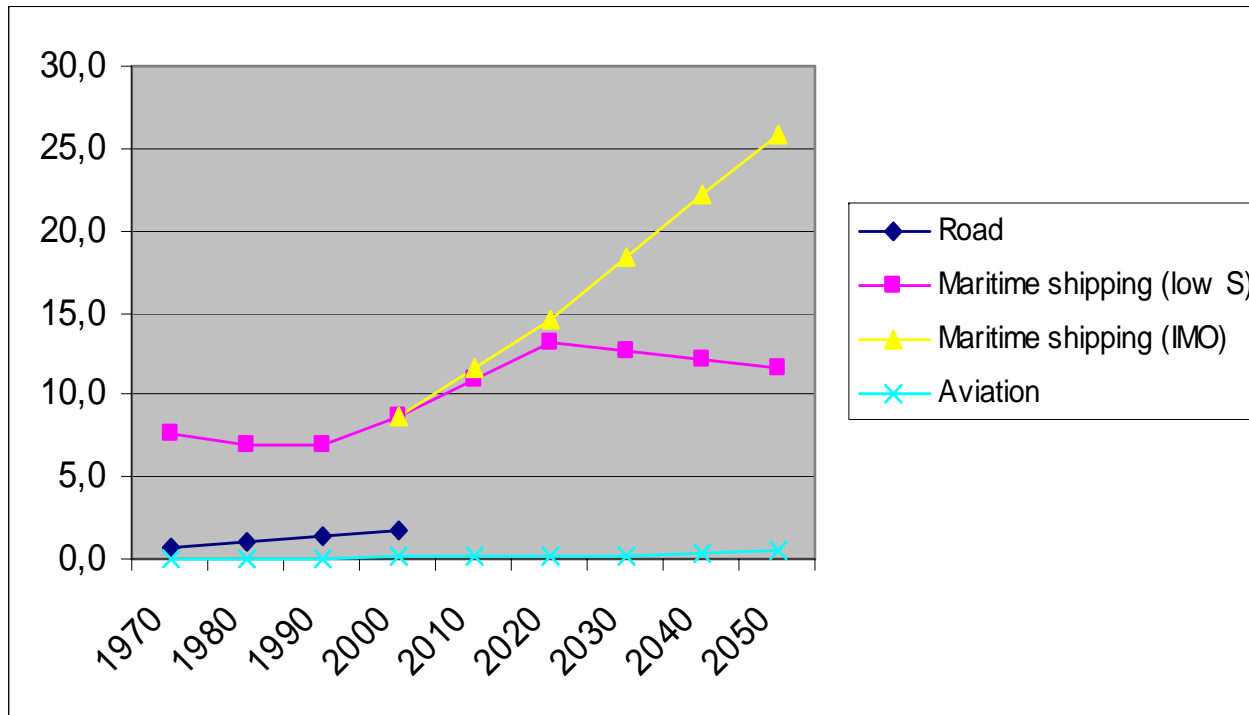
- IMO agreement on stricter standards for new engines (goal to reduce emissions by 30 %)
- Discussing stricter regulations
- Fuel economy measures (without NOx penalty)
 - ▶ E.g. shape of ships, operational
- Future from Eyring et al. (2004), J. Geophysical Research, vol 110, D17306.



SO₂

➤ SO₂: Shipping the largest transport source

- Stabilisation or decline in emissions if reductions in fuel S content
 - ▶ Several regional and local regulations make a stabilisation / decline from 2025 likely
 - * IMO cap on max S content
 - ▶ (Future from Eyring et al.)



Aviation future

- Fuel consumption is expected to grow strongly (5 % per year) until 2025
 - Strong correlations with GDP historically
 - Improved fuel efficiency is expected

- No prospects for fuel switching over the next 30 years

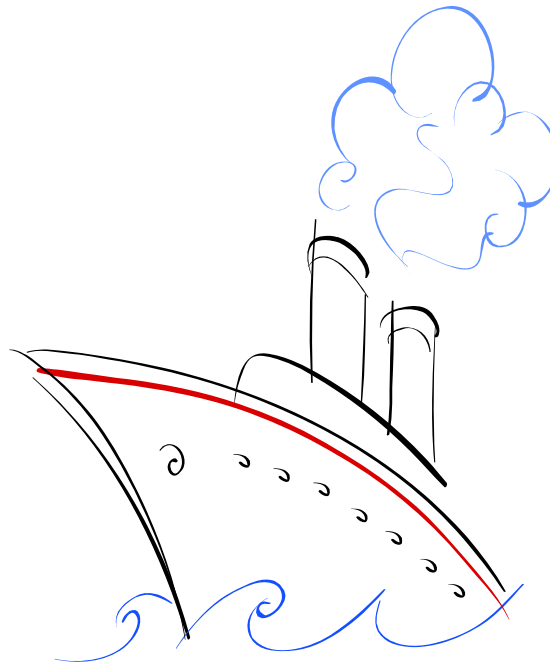
- NO_x, CO and NMVOC from aviation are regulated (ICAO certification of engines)
 - Fuel penalty in NO_x control
 - Considerations of noise and safety
 - Resistance for stricter NO_x regulations by industry
 - Slow penetration – long craft lifetime (25 years)

- NO_x emission factors are expected to grow in the future unless a change in policy
- Total emissions may be higher than shipping after 2050



Bunker fuels

- Shipping and aviation international bunker emissions are excluded from national totals in emission inventories reported to UNFCCC and EMEP
- Reported on an aggregated basis allocated to the country where the fuel was sold
- Allocation is part of ongoing policy discussions under UNFCCC
- Consequences for national policies



Future – mode shifts

- Global trend towards using faster and more energy intensive modes (car, truck, airplane)
 - Time spent on travel is more or less constant in all cultures!
 - Distance travelled makes the difference
 - High speed rail may substitute shorter air trips and longer passenger car trips
 - Passenger cars vs. public transport
 - Freight: car vs. Truck
- Major uncertainty in predicting future emissions
 - Policies and preferences



Quantify – inclusion of developing countries' experts

- The emission and projection team of Quantify will from late 2006 be strengthened with experts from China, India and Russia
- These experts will contribute to verification of the transport inventories using their national available bottom-up data
 - Tsinghua University
 - Center for Sustainable Transportation, China Academy of transport sciences
 - Indian central institute of road transport



Conclusions

- Transport activities are expected a continuous growth over the next 30 years, especially in developing countries
- Improved fuel efficiency is expected to reduce growth in fuel for all modes
- New regulatory standards will be important in reducing emissions of air pollutants for road, shipping, but likely not for aviation
- Slow penetration of new technologies for rail, shipping and aviation since these are targeting new engines
- Only road transport can drive short term reductions (2030) of air pollutants
 - tighter shipping NOx standards will likely contribute to neutralize the result of higher transport demand
 - aviation NOx emission will increase
- Developing country technology implementation, fuel standards and maintenance is an uncertain factor in determining future emissions of air pollutants from road transport



GLOBAL Road transport energy consumption and exhaust emissions A1B scenario

