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MARINE FUEL FACTS

1

BACKGROUND INFORMATION

1 Background on Shipping

Summary

- Around 80% of global trade by volume is carried by sea
- Marine Fuel demand: 6.1% of global world oil demand (2012)
- Residual Marine Fuel demand: 49.5% of total global residual demand

«Shipping: indispensable to the world»

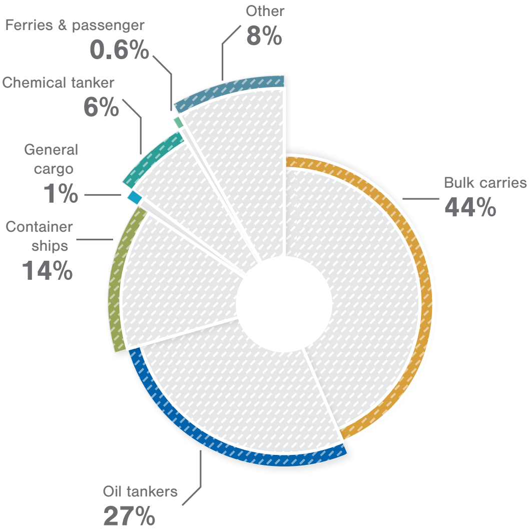
- Around 80% of global trade by volume and over 70% by value is carried by sea and is handled by ports worldwide
- More than 50,000 merchant ships are trading internationally
- The world fleet is registered in over 150 nations

Main Flags of Registration – share of world total (% dwt)

Panama	20.13%
Liberia	11.65%
Marshall Islands	10.02%
Hong Kong (China)	8.62%
Singapore	6.58%
Malta	4.69%
Greece	4.50%
Bahamas	4.33%
China	4.33%
Cyprus	1.92%

Source: UNCTAD, Review of Maritime Transport 2015, October 2015

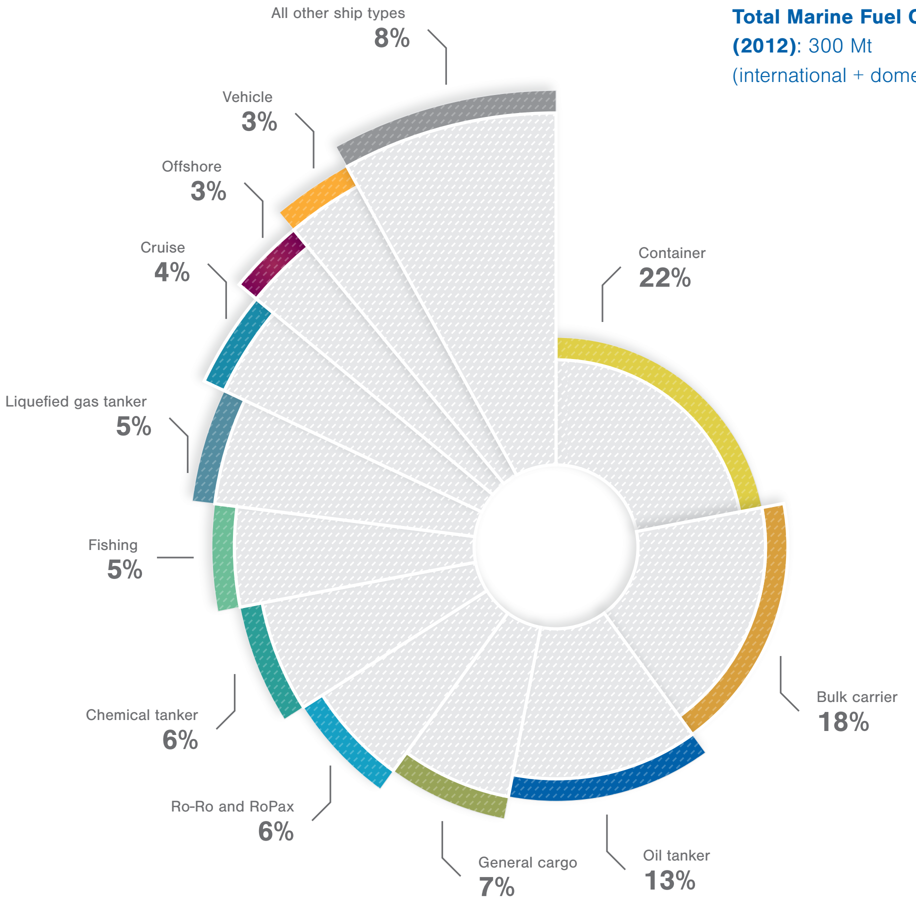
World Fleet by Type (% dwt)



Source: IMO 3rd GHG study, MEPC 67/INF.3, July 2014
Note: Due to the rounding, figures may not add up to 100%

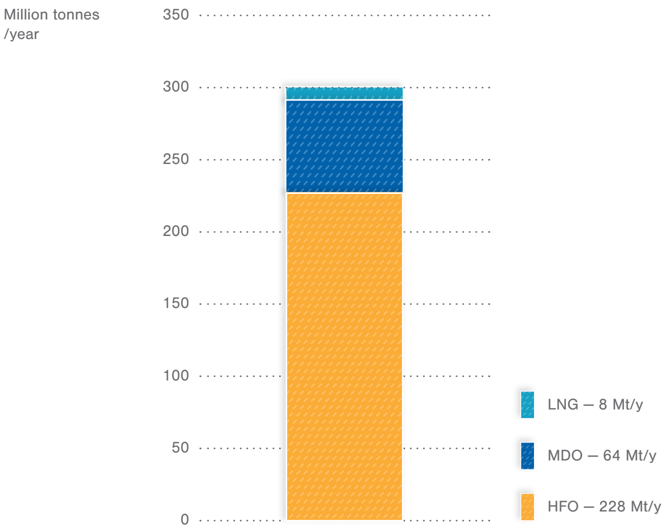
Fuel Consumption by Ship Type (2012)

Total Marine Fuel Consumption (2012): 300 Mt
(international + domestic)



Sources: IMO 3rd GHG study and BP Statistical Review of World Energy, June 2015

Marine Fuel Consumption 2012 (Mt/y)



Marine Fuel demand:
6.1% of global world oil demand (2012)

Residual Marine Fuel demand:
49.5% of total global residual demand

Sources: IMO 3rd GHG study and BP Statistical Review of World Energy, June 2015

2 Sources of Atmospheric Sulphur Emissions

Summary

- Shipping contributes to around 10% of current global man-made SO_2 emissions
- Projected growth in shipping SO_2 emissions is now significantly lower than what was expected in 2008 when the current regulation was adopted
- There are also significant natural sources of Sulphur emissions (volcanoes, plankton): three to six times more sulphate is generated above the oceans from dimethyl sulphide released by plankton than from SO_2 emissions from shipping*

- Sulphur is a naturally occurring element, essential for life

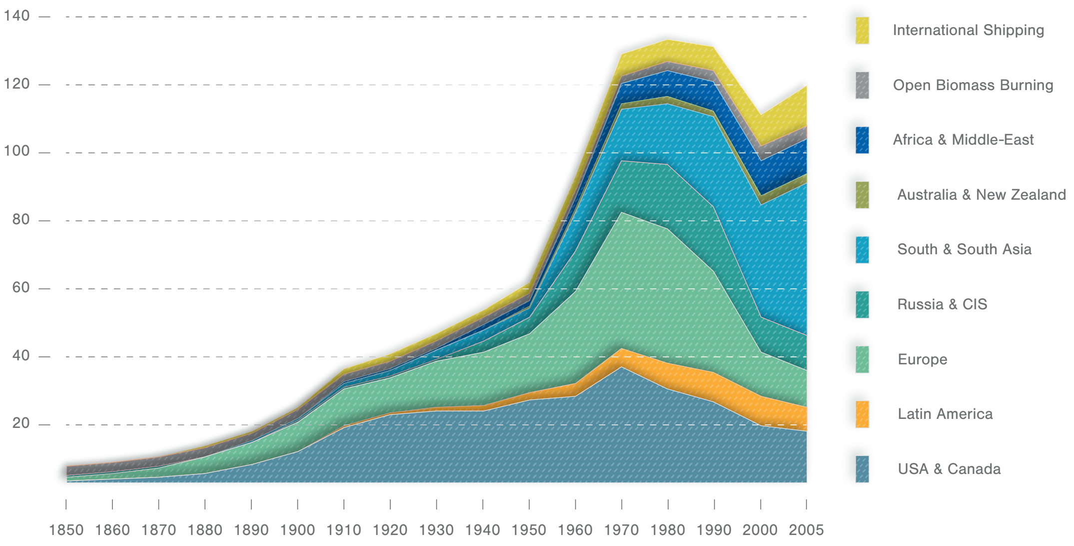
- Largest man-made sources of global SO_2 emissions are land-based:
  - In 2005, SO_2 emissions from international shipping amounted to 10% of global anthropogenic emissions
  - Land-based emissions projected to decrease substantially in coming decades (see Global SO_2 Emissions graph)

- Natural sources of Sulphur emissions are also significant:
  - Volcanic emissions
  - Biogenic emissions, primarily dimethyl sulfide (DMS) generated by plankton in the oceans
  - Both SO_2 and DMS are oxidized to form sulphate aerosols through atmospheric chemistry processes (see maps in additional information)

- Projected shipping emissions are now significantly lower than when the revision of MARPOL Annex VI was adopted in 2008:
  - Improved emission inventory lowered expected growth

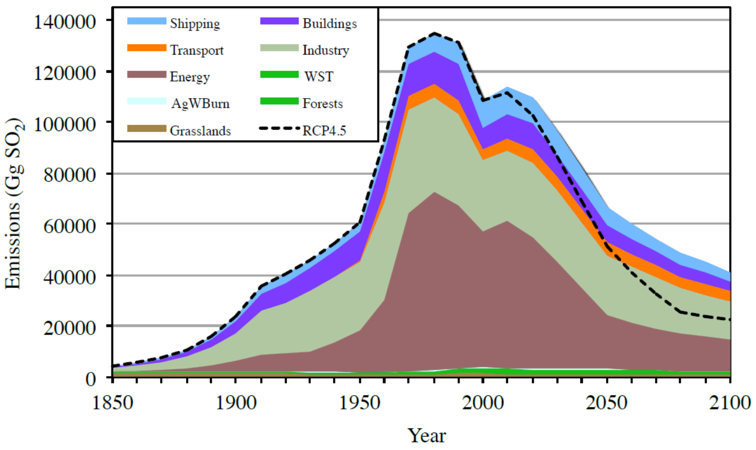
** based on data from the 3rd IPCC Assessment Report*

Anthropogenic SO_2 Emissions (Mt/y)



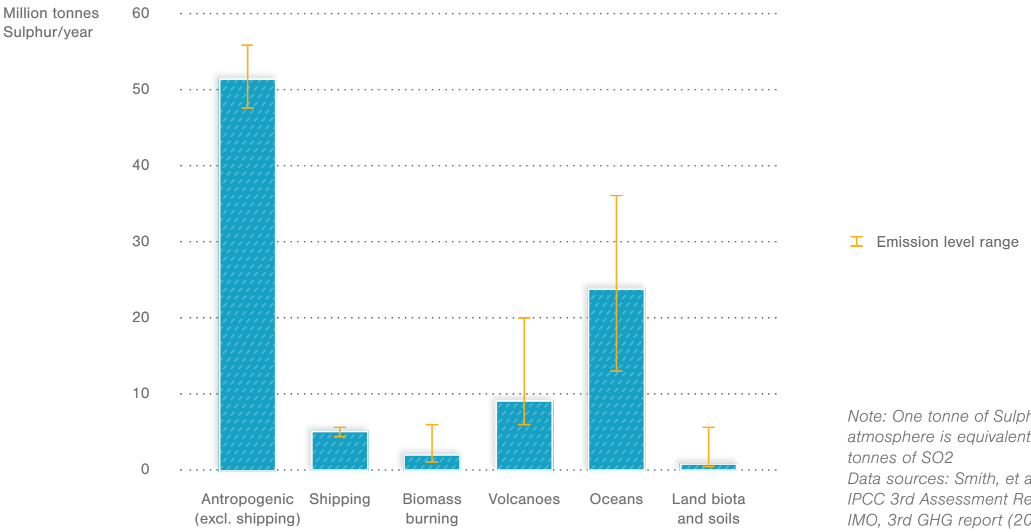
Data sources: Smith, Steven J., J. van Aardenne, Z. Klimont, R. J. Andres, A. Volke, and S. Delgado Arias. (2011). Anthropogenic Sulfur Dioxide Emissions: 1850–2005, Atmospheric Chemistry and Physics, 11:1101–1116 S. J. Smith and T. C. Bond, Two hundred fifty years of aerosols and climate: the end of the age of aerosols, Atmos.Chem. Phys., 14, 537–549, 2014

Global SO_2 Emissions (100 Gg = 1 Mt)



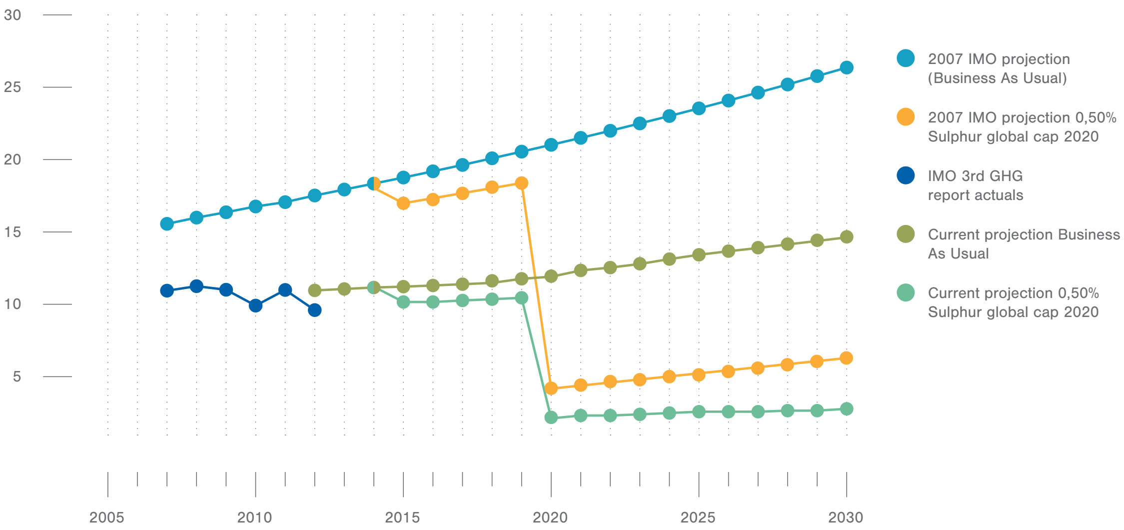
Source: S. J. Smith and T. C. Bond, Two hundred fifty years of aerosols and climate: the end of the age of aerosols, Atmos. Chem. Phys., 14, 537–549, 2014

Global Sulphur Emissions to Atmosphere



Note: One tonne of Sulphur to atmosphere is equivalent to two tonnes of SO2
Data sources: Smith, et al. (2011)
IPCC 3rd Assessment Report (2001)
IMO, 3rd GHG report (2014)

Projected Global Shipping SO_2 Emissions (Mt/y)



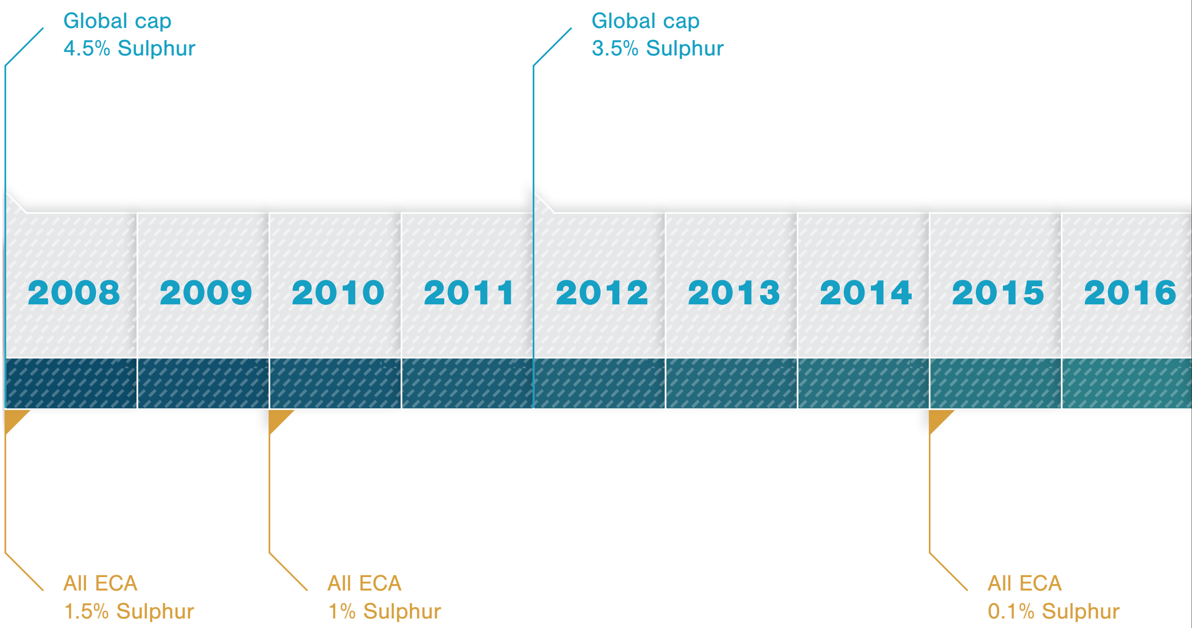
Data sources: IMO Scientific Group of Experts Report, BLG 12/6/1, 2007
IMO 3rd GHG report (2014), Marine and Energy Consulting Ltd, Outlook for Marine Bunker & Fuel Oil to 2035, May 2014
Concawe inter- and extrapollations

3 Marine Fuel Regulations

Summary

- Bunker Fuel Sulphur is regulated under Annex VI of the MARPOL Convention
- The Convention is administered by the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO)
- The Convention foresees reducing the global fuel Sulphur cap from 3.5% to 0.5% as of 2020, however subject to a review on fuel availability
- IMO has initiated the Fuel Availability Review in 2015 and is expected to review the results at the October 2016 MEPC meeting
- Europe has decided unilaterally to implement 0.5% in its Exclusive Economic Zones (up to 200 nm from the coast) regardless of the forthcoming IMO decision

MARPOL Annex VI Marine Fuel Sulphur Regulation



- International shipping is governed by Conventions administered by the International Maritime Organization (IMO), a UN body based in London

- Annex VI of the International Convention for the Prevention of Pollution from Ships MARPOL 73/78 covers fuel Sulphur levels

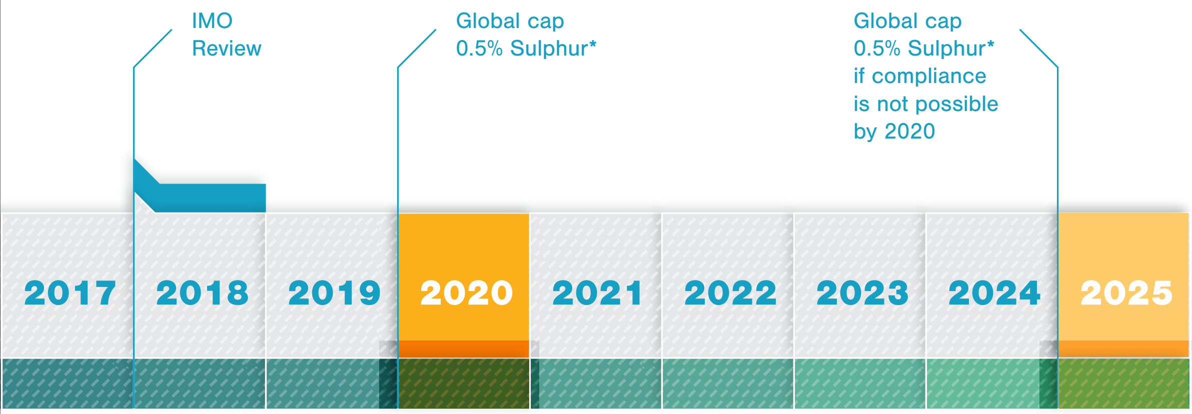
- As of March 8, 2016, 86 states have ratified Annex VI, representing 95.34% of the world's tonnage

- IMO's MEPC maintains MARPOL Annex VI

- Global Sulphur Cap
  - Mandatory review by 2018 to determine 0.5% Sulphur fuel availability
  - IMO's MEPC to decide whether it will be possible to comply in 2020

- IMO has initiated the Fuel Availability Review in 2015
  - Steering Committee appointed
  - Contractor appointed to perform study (CE Delft)
  - Results to be available for discussion at October 2016 MEPC meeting

- Supplemental study co-sponsored by several industry bodies



*Pending October 2016 MFPC meeting review

Emission Control Areas (ECAs)

Source: Exhaust Gas Cleaning Systems Association, www.egcsa.com

Regional regulations

- EU Sulphur in Liquid Fuels Directive
  - 0.1% Sulphur at berth since 2010
  - 0.5% Sulphur in EU waters effective 2020 (regardless of IMO decision)
- California rules – being aligned with IMO
- Hong Kong/China: local initiatives

2

CURRENT SITUATION, ALTERNATIVES AND POSSIBLE OUTCOMES

1 Refining Impact - Fuel Availability Concerns

Summary

- Estimated fuel switch volumes in the range of 2 Mb/d to more than 3 Mb/d (depending on total demand projection and scrubber/LNG penetration)
- Represents an unprecedented step change compared to:
  - Annual trend line growth rate for distillate demand: 500 kbd
  - Annual trend line decline in residual demand: 150 kbd
  - Experience with introduction of 0.1% Sulphur fuel in 2015: ~400 kbd
- Sound, realistic assessment of fuel availability is key:
  - Distillate production, capacity to process residual fuel oil no longer needed
  - Impacts on other products

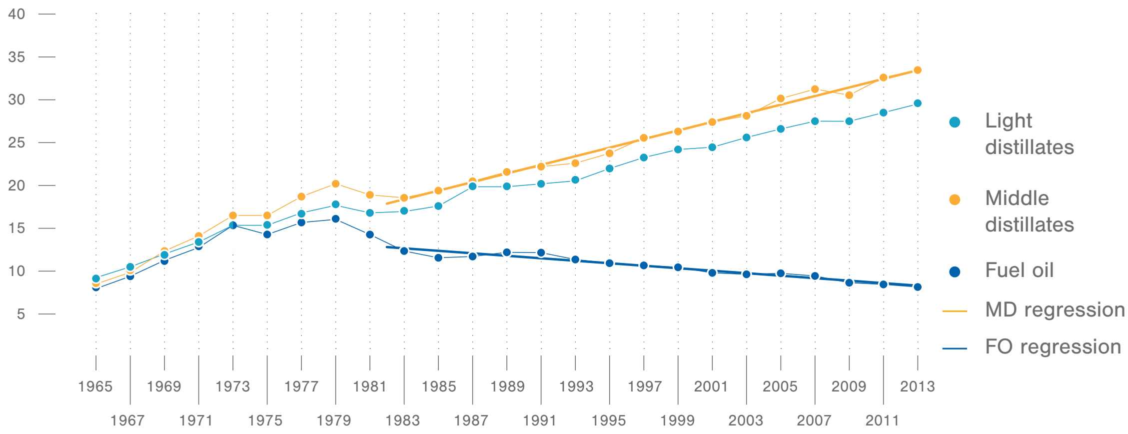
- Unprecedented impact of global cap on the refining industry

- IEA's Mid-Term Oil Market Report 2015 expects that 2 Mb/d of fuel oil would need to be switched to distillate type of fuels, while other sources show even higher switch volume estimates

- Very high switch volume compared long-term distillate growth and fuel oil decline trends:
  - Distillate: + 500 kbd/yr
  - Fuel oil: - 150 kbd/yr

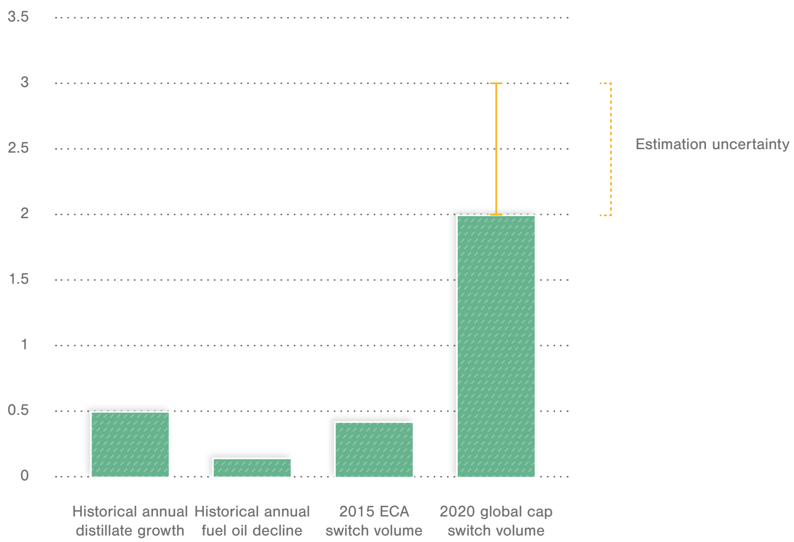
- Critical elements of IMO Fuel Availability Study:
  - Realistic forecast of 2020 fuel demand with appropriate high and low cases
  - Realistic assessment of scrubber and LNG penetration ahead of 2020
  - Solid assessment of general refining and conversion capacities that will be online by the end of 2019
  - Solid global modelling:
    - Crude outlook and low Sulphur crude opportunities
    - Proven fuels
    - No discontinuity in supply to other petroleum product markets
    - Surplus fuel oil used as feedstock for conversion units
    - Interregional trade
    - Avoidance of over-optimisation in aggregated LP model

Product Demand Trendline (Mb/d)



Data source: BP Statistical Review of World Energy, June 2015

Petroleum Product Demand Changes (Mb/d)



Data sources: BP Statistical Review of World Energy, June 2015
Marine and Energy Consulting Ltd, Outlook for Marine Bunker & Fuel Oil to 2035, May 2014
IEA Mid-Term oil Market report, February 2016
OPEC World Oil Outlook 2015

2 Scrubbers and Other Alternatives

Summary

- Production of compliant fuels will involve switching a significant volume of residual fuel to lower Sulphur distillate type fuels; contribution of LNG expected to be small by 2020
- The Convention allows use of exhaust gas scrubbers as an alternative compliance method
  - Proven technology, economically viable (new and retrofit, though retrofit not possible on all ships)
  - Several types available: open loop, closed loop, hybrid
  - Some local restrictions apply to scrubber effluent and some on-going discussion in EU on the acceptability of scrubber wash water discharges
  - Scrubbers offer overall GHG benefit – net CO_2 reduction of 9 Mt/y compared to removing Sulphur in European refineries

- MARPOL Annex VI requires ships to use fuels with a maximum Sulphur content
  - Equivalent compliance methods can be used when approved by Administrations

- Exhaust Gas Cleaning Systems (EGCS, also called “scrubbers”) are being used as equivalent method
  - Initial interest in scrubbers from ship owners was limited
    - ▸ See results December 2014 survey European Chamber of Shipping Association (ECSA)
  - EnSys/Navigistics estimated that as of the first half of 2016 some 350 ships had installed or ordered scrubbers

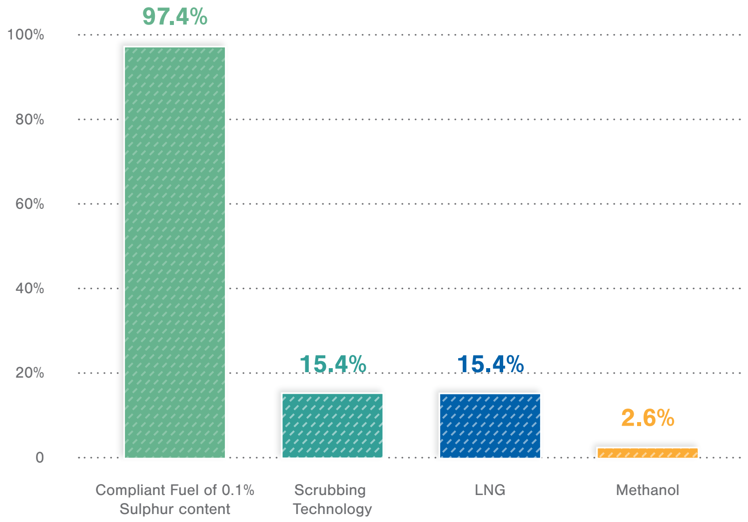
- Several commercially proven scrubber designs:
  - Sea Water Scrubber (open loop)
  - Fresh Water Scrubber with alkaline reactant (closed loop)
    - ▸ Can operate with zero discharge for a limited time
  - Hybridscrubbers can alternate between open and closedloopmodes

- Overall energy benefits:
  - Considerable CO_2 emission savings can be achieved by scrubbing
    - ▸ The scrubber case would avoid a 17 Mt/y increase in refinery CO_2 emissions
    - ▸ Partially offset by 8 Mt/y increase CO_2 emissions from scrubber energy need
    - ▸ Net saving of 9 Mt/y (source Concawe Report 1/13R)

- Acceptability and technology choice considerations:
  - For retrofitting a ship: available space, loss of cargo space, age, stability
  - Effluent impact on environment

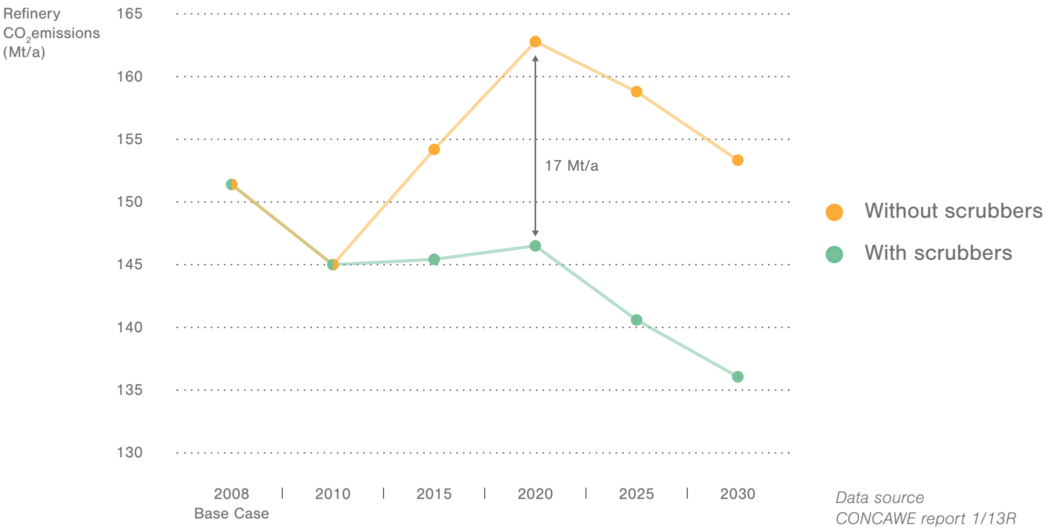
- On-going discussion in EU on the acceptability of scrubber wash water discharges (in particular when operating in coastal waters and harbours) and on the status of effluents under the Water Framework Directive
- Several measurement campaigns are underway on ships operated with scrubbers in EU and North America waters

Compliance Method(s) for ECA 0.1% Sulphur Requirements



Data source ECSA

Effect of On-Board Scrubbers on EU Refinery CO_2 Emissions



Data source CONCAWE report 1/13R

3 Timelines and Possible Outcomes

Summary

- Earliest possible decision point will be at October 2016 MEPC meeting
- MECP will review the results of the IMO Fuel Availability Study and any comments submitted by IMO Member States and/or Observer Organisations
- Regulation 14.10 of Annex VI only foresees two possible outcomes:
  - Implementation of the 0.5% Sulphur requirement in 2020 (base case)
  - Postponement of the implementation date until 2025

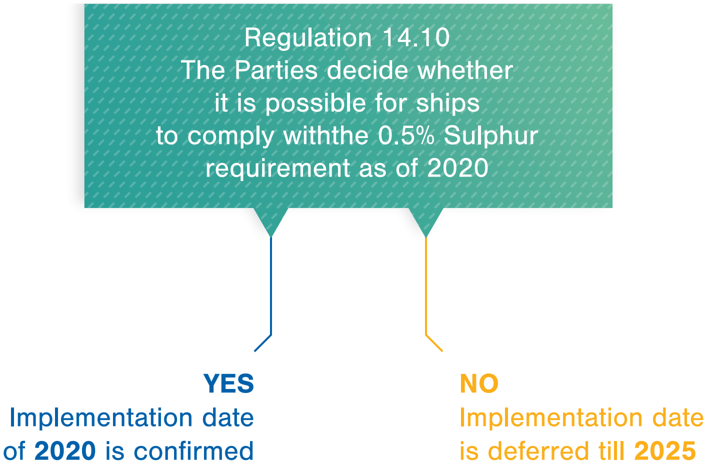
May 2016	Draft Report CE Delft available
June 2016	Steering Committee comments
July 2016	Final Report CE Delft available
August 2016	Steering Committee Report to MEPC
October 2016	MEPC Review of Fuel Availability Study Possible decision on implementation date
Mid-2017	Next meeting: Further discussion and decision making in case no decision was made in October 2016 meeting

- April 2016 MEPC meeting agreed "in principle" to take the decision at the October 2016 MEPC meeting

- MEPC will review the results of the IMO Fuel Availability Study and any comments submitted by IMO Member States and/or Observer Organisations

- Regulation 14.10 of Annex VI only foresees two possible outcomes:
  - Implementation of the 0.5% Sulphur requirement in 2020 (base case)
  - Postponement of the implementation date until 2025

- Decision will be made by the IMO Member States that have ratified MARPOL Annex VI



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ENVIRONMENTAL AND CLIMATIC IMPACT

1 Environmental Impact of SO_2 Emissions

Summary

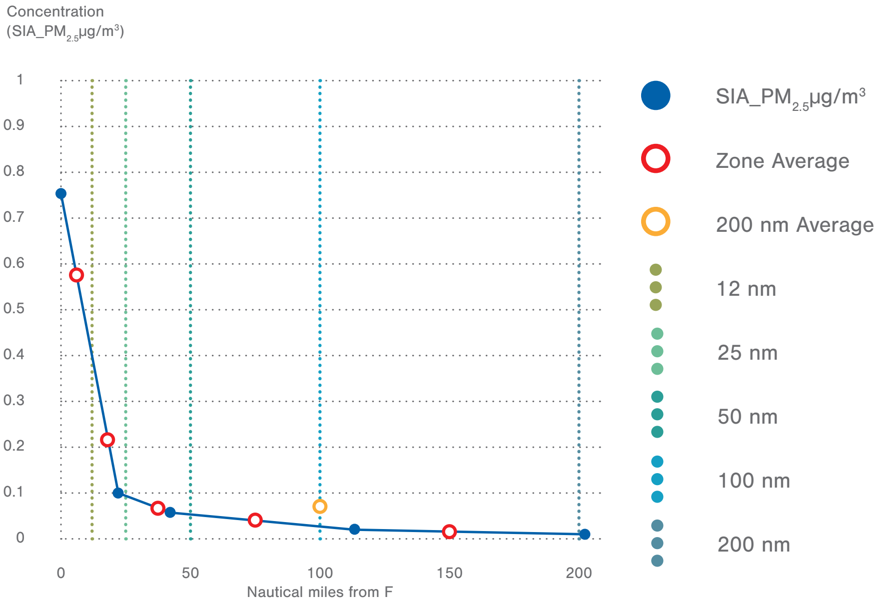
- Contribution to air quality on shore decreases rapidly as ships move away from shore
- Concentration of sulphate aerosol that reaches land from a ship 25 nm away from shore is only about 1/10th of concentration from a ship in the harbor
- Cost-effectiveness analysis on basis of benefits' analysis as used for EU air policy shows that only emission reductions close to shore (<12 nm or <25 nm depending on the sea area) would be potentially cost-effective compared to land-based measures

- Rapid decrease in impact on air quality as ships move away from shore
  - Example: calculations for a ship sailing west out of Lisbon
  - At 25 nm from shore, concentrations that reach land are about 1/10th of concentrations when the ship leaves port

- Population weighted environmental impact analysis of three European sea areas:
  - Emissions >25 nm away from shore have <20% of impact of emissions within the territorial seas (<12 nm)

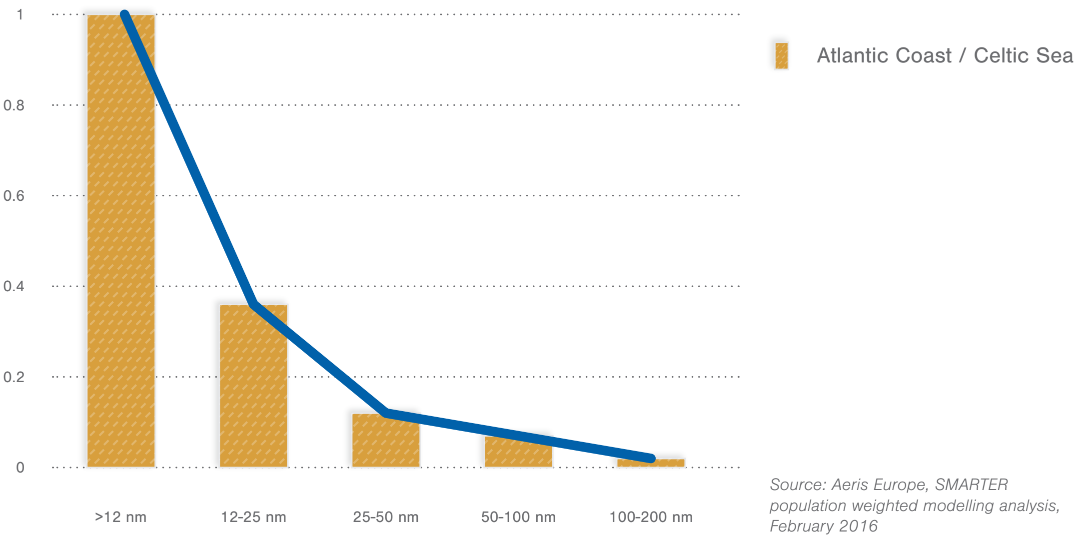
- Cost-effectiveness analysis on basis of benefits analysis as used for EU air policy shows that only emission reductions close to shore (<12 nm or <25 nm depending on the sea area) would be potentially cost-effective compared to land based measures under consideration
  - Shipping SO_2 emissions should be reduced where they contribute measurably to air quality concerns

Sulphate $PM_{2.5}$ Concentration (µg/m³ per kt SO_2) at Lisbon Centre (F) Versus Distance from Shore & Designation of Zones Within 200 nm



Source: Aeris re-analysis of Lisbon Ship trajectory study undertaken for Concawe by the Swedish Meteorological and Hydrological Institute, soon to be published.

Relative Impact of Shipping Emissions as a Function of Distance from Shore



Source: Aeris Europe, SMARTER population weighted modelling analysis, February 2016

2 Climate Impact

Summary

- Removal of Sulphur in refineries around the globe will amount to at least 30 million tonnes CO_2/ years – equivalent to 3% increase in global shipping emissions
- Sulphate has a significant climate cooling effect – this will be lost when the global cap is introduced

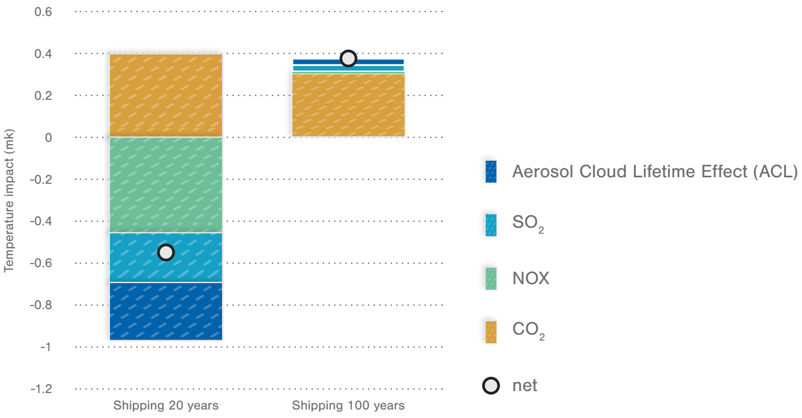
- Global shipping CO_2 emissions represented 2.6% of total CO_2 emissions (IMO 3rd GHG study, MEPC 67/INF.3, July 2014)

- Climate impact is also affected by other pollutants emitted – Short Lived Climate Forcers (SLCFs)
  - E.g. Black Carbon and methane have a warming effect
  - Sulphate aerosols have a cooling effect on the climate
  - Longer term warming effect of CO_2 will dominate

- Shipping is assessed to have an overall cooling effect when integrated over a 20 years period
  - Warming effect only when integrating over a 100 years period

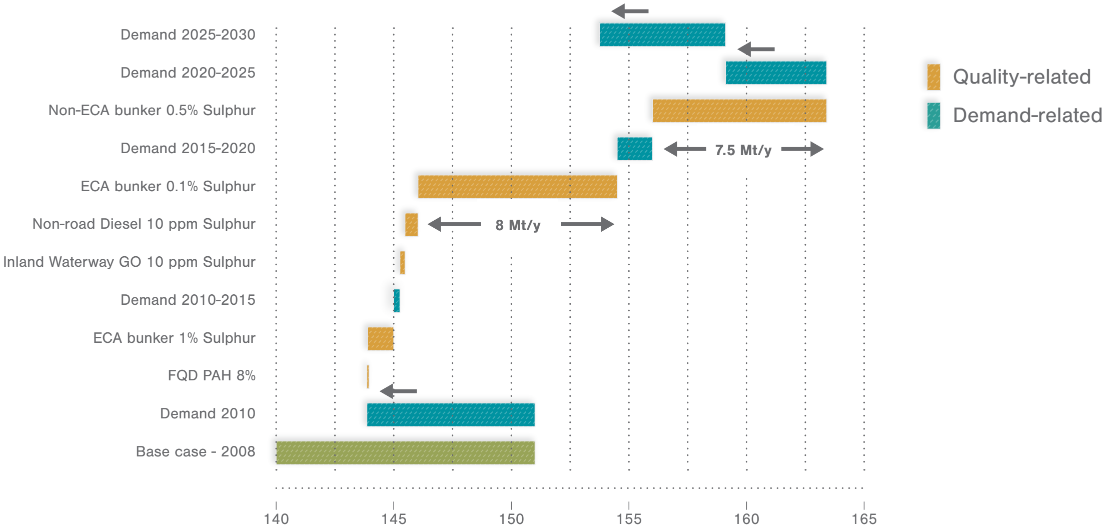
- Reducing the global Sulphur cap to 0.5% will affect climate impact in two ways:
  - Increased GHG from the global refining industry to desulphurise refinery streams and convert heavy residue to lighter fractions
    - Concawe analysis for Europe estimates increase at 7.5 Mt CO_2
    - Globally increase of ~ 30 Mt/y can be expected
    - This would be equivalent to a 3% increase in global shipping CO_2 emissions (2012 basis)
  - Short-term cooling effect will essentially be eliminated

Shipping Climate Impact - 20 and 100-year time horizon



Data source: G. Myhre, D. Shindell, et al., 5th IPCC Assessment - Anthropogenic and Natural Radiative Forcing, 2013

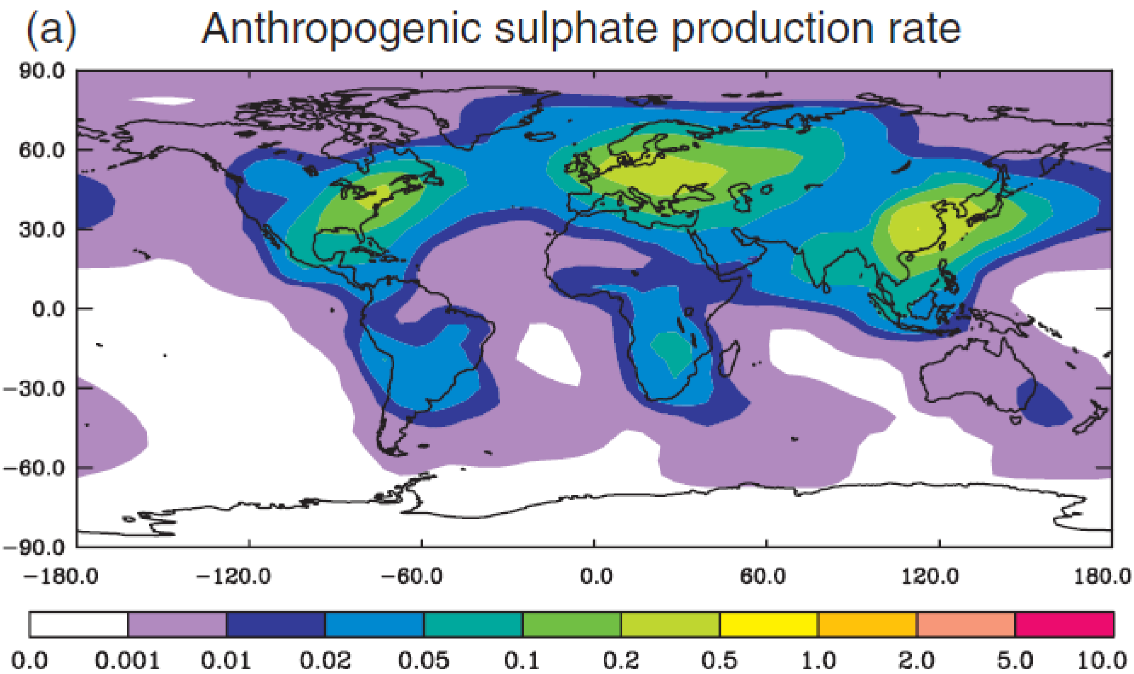
Step-Wise Evolution of Total CO_2 Emissions from EU27+2 Refineries



Source: CONCAWE report 1/13R – Oil refining in the EU in 2020, with perspectives to 2030, available at www.concawe.org

3 Additional Information: Anthropogenic and Natural Sulphate Sources

Anthropogenic Sulphate Production Rate

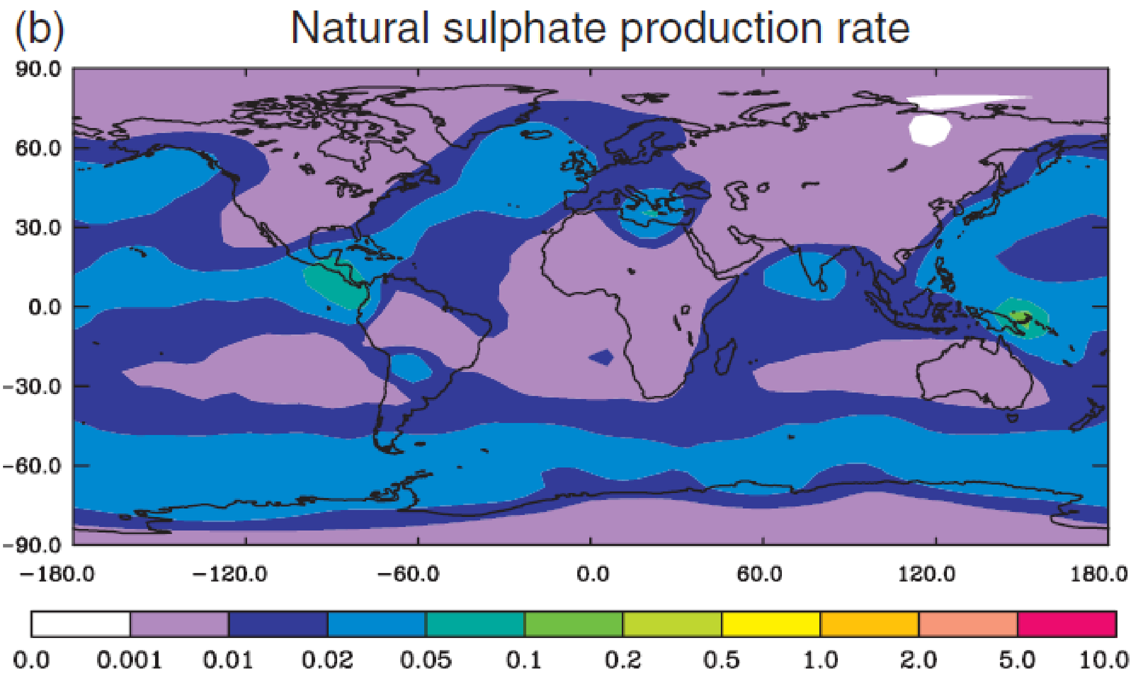


Source: Penner, J.E. et al., IPCC 3rd Assessment report, Aerosols, their Direct and Indirect Effects, 2001

Annual average source strength in kg km−2 hr−1

(a) the column average H_2SO_4 production rate from anthropogenic sources
(b) the column average H_2SO_4 production rate from natural sources
(DMS and SO_2 from volcanoes)

Natural Sulphate Production Rate



Data source: Penner, J.E. et al., IPCC 3rd Assessment report, Aerosols, their Direct and Indirect Effects, 2001 concawe

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