

January 27<sup>th</sup> 2015.

**PAME I-2015 –Agenda Item 4.8(b)**  
**AMSA Recommendation II(H)**  
**Reducing air emissions – submission by Norway**

**Background**

AMSA recommendation II(H)

RoD from PAME II 2014, point 7.

*“PAME invites member governments to submit to the Secretariat information on studies and assessments, both existing and ongoing, on ship air emissions (in particular black carbon) in the Arctic, methodologies for measuring emissions, and the effect of such emissions on the Arctic marine environment. PAME invites its Secretariat to compile submissions received into a bibliography that among others is to be shared with AMAP.”*

**LIST OF REFERENCES:**

- Alley, R. B., Marotzke, J., Nordhaus, W. D., Overpeck, J. T., Peteet, D. M., Pielke Jr., R. A., Pierrehumbert, R. T., Rhines, P. B., Stocker, T. F., Talley, L. D., Wallace, J. M. (2003). Abrupt climate change. *Science* 299: 2005-2010, DOI: 10.1126/science.1081056
- Anderson, K. and Bows, A. (2008). Reframing the climate change challenge in light of post-2000 emission trends. *Philos. T. R. Soc. A* 366: 3863-3882, DOI: 10.1098/rsta.2008.0138
- Anderson, K. and Bows, A. (2011). Beyond 'dangerous' climate change: emission scenarios for a new world. *Philos. T. R. Soc. A* 369: 20-44, DOI: 10.1098/rsta.2010.0290
- Andreae, M. O., Gelencser, A. (2006). Black carbon or brown carbon? The nature of light-absorbing carbonaceous aerosols. *Atmos. Chem. Phys.* 6: 3131–3148, DOI: 10.5194/acp-6-3131-2006
- Arnott, W. P., Moosmuller, H., Sheridan, P. J., Ogren, J. A., Raspert, R., Slaton, W. V., Hand, J. L., Kreidenweis, S. M., Collett, J. L. J. (2003). Photoacoustic and filter-based ambient aerosol light absorption measurements: Instrument comparisons and the role of relative humidity. *J. Geophys. Res.* 108:4034, DOI: 10.1029/2002JD002165
- Baltensperger, U., Barrie, L., Frohlich, C., Gras, J., Jager, H., Jennings, S. G., Li, S.-M., Ogren, J. A., Wiedensohler, A., Wehrli, C., and Wilson, J. (2003). *WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations*. WMO/GAW No. 153, 67 pp.

Baron, P. A. and Willeke, K. (2001). *Aerosol Measurement: Principles, Techniques and Applications* (2nd ed.). John Wiley & Sons Inc.

Berube, K. A., Jones, T. P., Williamson, B. J., Winters, C., Morgan, A. J., Richards, R. J. (1999). Physicochemical characterization of diesel exhaust particles: factors for assessing biological activity. *Atmos. Environ.* **22**: 1599-1614, DOI: 10.1016/S1352-2310(98)00384-7

Betts, R. A., Collins, M., Hemming, D. L., Jones, C. D., Lowe, J. A., Sanderson, M. G. (2011). When could global warming reach 4°C? *Philos. T. R. Soc. A* 369: 67-84, DOI: 10.1098/rsta.2010.0292

Boé, J., Hall, A., Qu, X. (2009). September sea-ice cover in the Arctic Ocean projected to vanish by 2100. *Nat. Geosci.* 2: 341-343, DOI: 10.1038/ngeo467

Bond J. (2013). *Current Issues and Challenges of Arctic Engineering*. SNAME Annual meeting 2013 Bellevue, Seattle, USA.

Bond, T. C., Doherty, S. J., Fahey, D. W., Forster, P. M., Berntsen, T., DeAngelo, B. J., Flanner, M. G., Ghan, S., Kärcher, G., Koch, D., Kinne, S., Kondo, Y., Quinn, P. K., Sarofim, M. C., Schultz, M. G., Schultz, M., Venkataraman, C., Zhang, H., Zhang, S., Bellouin, N., Guttikunda, S. K., Hopke, P. K., Jacobson, M. J., Kaiser, J. W., Klimont, Z., Lohmann, U., Schwarz, J. P., Shindell, D., Storelvmo, T., Warren, S. G., Zender, C. S. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. *J. Geophys. Res.-Atmos.* 118(11): 5380–5552, DOI: 10.1002/jgrd.50171

Buffaloe, G. M., Lack, D.A., Williams, E.J., Coffman, D., Hayden, K.L., Lerner, B.M., Li, S-M., Nuaaman, I., Massoli, P., Onasch, T.B., Quinn, P.K, Cappa, C. D. (2014). Black carbon emissions from in-use ships: a California regional assessment. *Atmos. Chem. Phys.* 14: 1881–1896, DOI: 10.5194/acp-14-1881-2014.

Buhaug, Ø., Corbett, J. J., Endresen, Ø., Eyring, V., Faber, J., Hanayama, S., Lee, D. S., Lee, D., Lindstad, H., Markowska, A. Z., Mjelde, A., Nelissen, D., Nilsen, J., Pålsson, C., Winebrake, J. J., Wu, W.-Q., Yoshida, K. (2009). *Second IMO GHG study 2009*. IMO - International Maritime Organization, London.

Burtscher, H. (2005). Physical characterization of particulate emissions from diesel engines: a review. *J. Aerosol Sci.* 36: 896-932

Buseck, P. R., Adachi, K., Gelencser, A., Tompa, E., Posfai, M. (2012). Are black carbon and soot the same? *Atmos. Chem. Phys. Discuss.* 12: 24821–24846, DOI: 10.5194/acpd-12-24821-2012

Chang, R. Y.-W., Leck, C., Graus, M., Müller, M., Paatero, J., Burkhart, J. F., Stohl, A., Orr, L. H., Hayden, K., Li, S.-M., Hansel, A., Tjernström, M., Leaitch, W. R., Abbatt, J. P. D. (2011). Aerosol composition and sources in the Central Arctic Ocean during ASCOS. *Atmos. Chem. Phys. Discuss.* 11: 14837-14881, DOI: 10.5194/acpd-11-14837-2011

Chow, J. C., Yu, J. Z., Watson, J. G., Ho, S. S. H., Bohannon, T. L., Hays, M. D., Fung, K. K. (2007). The application of thermal methods for determining chemical composition of carbonaceous aerosols: A review. *J. Environ. Sci. Health A Tox. Hazard Subst. Environ. Eng.* 42: 1521-1541, DOI: 10.1080/10934520701513365

- Claes, M., Gysels, K., van Grieken, R., Harrison, R. M. (1998). Inorganic composition of atmospheric particles, in: Harrison, R. M., van Grieken, R. E. (Eds.) *Atmospheric Particles. IUPAC Series in analytical and physical chemistry of environmental systems*. John Wiley & Sons Ltd., 95-146 pp.
- Corbet, J. J., Wang, H., Winebrake, J. J. (2009). The effectiveness and cost of speed reductions on emissions from international shipping. *Transport. Res. D-Tr. E* 14: 593-598, DOI: 10.1016/j.trd.2009.08.005.
- Corbett, J. J., Lack, D. A., Winebrake, J. J., Harder, S., Silberman, J. A., Gold, M. (2010). Arctic shipping emissions inventories and future scenarios. *Atmos. Chem. Phys.* 10: 9689-9704, DOI: 10.5194/acp-10-9689-2010.
- Corbett, J. J., Winebrake, J. J., Green, E. H. (2010). An assessment of technologies for reducing regional short-lived climate forcers emitted by ships with implications for Arctic shipping. *Carbon Management* 1(2), DOI: 10.4155/cmt.10.27
- Corbett, J. J., Winebrake, J. J., Green, E. H., Kasibhatla, P., Eyring, V., Lauer, A. (2007). Mortality from Ship Emissions: A Global Assessment. *Environ. Sci. Technol.* 41: 8512-8518.
- Cross, E. S., Onasch, T. B., Ahern, A., Wrobel, W., Slowik, J. G., Olfert, J., Lack, D. A., Massoli, P., Cappa, C. D., Schwarz, J. P., Spackman, J. R., Fahey, D. W., Sedlacek, A., Trimborn, A., Jayne, J. T., Freedman, A., Williams, L. R., Ng, N. L., Mazzoleni, C., Dubey, M., Brem, B., Kok, G., Subramanian, R., Freitag, S., Clarke, A., Thornhill, D., Marr, L. C., Kolb, C. E., Worsnop, D. R., and Davidovits, P. (2010). Soot Particle Studies - Instrument InterComparison - Project Overview. *Aerosol Sci. Technol.* 44: 592–611
- Dalsøren, S. B., Endresen, Ø., Isaksen, I. S. A., Gravir, G., Sørgård, E. (2007). Environmental impacts of the expected increase in sea transportation, with a particular focus on oil and gas scenarios for Norway and northwest Russia. *J. Geophys. Res.* 112, D02310, DOI: 10.1029/2005JD006927
- De Armas, M., Vanko, M. (2008). Mitigating black carbon as a mechanism to protect the Arctic and prevent abrupt climate change. *Sustainable Dev. L. & Pol'y* 41
- Eckhardt, S., Hermansen, O., Grythe, H., Fiebig, M., Stebel, K., Cassiani, M., Baecklund, A., Stohl, A. (2013). The influence of cruise ship emissions on air pollution in Svalbard – a harbinger of a more polluted Arctic? *Atmos. Chem. Phys.* 13: 8401-8409, DOI: 10.5194/acp-13-8401-2013
- Eide, M. S., Dalsøren, S. B., Endresen, Ø., Samset, B., Myhre, G., Fuglestvedt, J., Berntsen, T. (2013). Reducing CO<sub>2</sub> from shipping – do non-CO<sub>2</sub> effects matter. *Atmos. Chem. Phys.* 13: 4183-4201, DOI: 10.5194/acp-13-4183-2013.
- Eyring, V., Isaksen, I. S. A., Berntsen, T., Collins, W. J., Corbett, J. J., Endresen, Ø., Grainger, R. G., Moldanova, J., Schlager, H., Stevenson, D. S. (2010). Transport impacts on atmosphere and climate: Shipping. *Atmos. Environ.* 44(37): 1-37, DOI: 10.1016/j.atmosenv.2009.04.059
- Eyring, V., Köhler, H. W., van Aardenne, J., Lauer, A. (2005). Emissions from international shipping: 1. The last 50 years. *J. Geophys. Res.* 110, D17305, DOI: 10.1029/2004JD005619
- Fisher, J. A., Jacob, D. J., Wang, Q., Bahreini, R., Carouge, C. C., Cubison, M. J., Dibb, J. E., Diehl, T., Jimenez, J. L., Leibensperger, E. M., Lu, Z., Meinders, M. B. J., Pye, H. O. T., Quinn,

- P. K., Sharma, S., Streets, D. G., van Donkelaar, A., Yantosca, R. M. (2011). Sources, distribution, and acidity of sulfate-ammonium aerosol in the Arctic in winter-spring. *Atmospheric Environment* 45(39): 7301-7318
- Flanner, M. G. (2013). Arctic climate sensitivity to local black carbon, *J. Geophys. Res. - Atmos.* 118: 1840-1851, DOI: 10.1002/jgrd.50176.
- Flanner, M. G., Zender, C. S., Randerson, J. T., Rasch, P. J. (2007). Present-day climate forcing and response from black carbon in snow. *J. Geophys. Res.* 112, D11202, DOI: 10.1029/2006JD008003
- Forsberg, B., Hansson, H.-C., Johansson, C., Areskoug, H., Persson, K., Järholm B. (2005). Comparative health impact assessment of local and regional particulate air pollutants in Scandinavia. *Ambio* 34: 11
- Fridell, E., Steen, E., Petersen, K. (2008). Primary particles in ship emissions. *Atmos. Environ.* 42: 160-169
- Fuglestedt, J. S., Dalsøren, S. B., Samset, B. H., Berntsen, T., Myhre, G., Hodnebrog, Ø., Eide, M. S., Bergh, T. F. (2014). Climate Penalty for Shifting Shipping to the Arctic. *Environ. Sci. Technol.* 48(22): 13273-13279
- Goldberg E. D. (1985). *Black Carbon in the Environment - Properties and Distribution*. John Wiley & Sons Inc., New York, 216 pp.
- Goo, J. H. and Kim, C. S. (2003). Theoretical analysis of particle deposition in human lungs considering stochastic variations of airway morphology. *J. Aerosol Sci.* 34: 585-602
- Granier, C., Niemeier, U., Jungclaus, J. H., Emmons, L., Hess, P. G., Lamarque, J.-F., Walters, S., Brasseur, G. P. (2006). Ozone pollution from future ship traffic in the Arctic northern passages. *Geophys. Res. Lett.* 33, L13807, DOI: 10.1029/2006GL026180
- Hansen, J., Nazarenko, L. (2004). Soot climate forcing via snow and ice albedos. *P. Natl. Acad. Sci. USA* 101(2): 423-428, DOI:10.1073/pnas.2237157100.
- Hinds W. C. (1999). *Aerosol Technology: Properties, Behaviour and Measurement of Airborne Particles*. John Wiley & Sons, Inc., New York, 483 pp.
- Hirdman, D., Burkhardt, J. F., Sodemann, H., Eckhardt, S., Jefferson, A., Quinn, P. K., Sharma, S., Ström, J., Stohl, A. (2010). Long-term trends of black carbon and sulphate aerosol in the Arctic: changes in atmospheric transport and source region emissions. *Atmos. Chem. Phys.* 10: 9351-9368, DOI: 10.5194/acp-10-9351-2010
- Houghton, J. T., Jenkins, G. J., Ephraums, J. J. (eds.) (1990). *Climate Change. The IPCC Scientific Assessment*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 364 pp.
- IMO (1998). International Maritime Organisation (IMO). *1998 Annex VI of MARPOL 73/78 Regulations for the Prevention of Air Pollution from Ships*. MPG Books Ltd., UK
- IPCC (2007). *Fourth assessment report of the intergovernmental panel on climate change*, www.ipcc.ch
- IPCC (2013). *Fifth assessment report of the intergovernmental panel on climate change*, www.ipcc.ch

Jacob, D. J., Crawford, J. H., Maring, H., Clarke, A. D., Dibb, J. E., Emmons, L. K., Ferrare, R. A., Hostetler, C. A., Russell, P. B., Singh, H. B., Thompson, A. M., Shaw, G. E., McCauley, E., Pederson, J. R., Fisher, J. A. (2010). The Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) mission: design, execution, and first results. *Atmos. Chem. Phys.* 10: 5191-5212, DOI: 10.5194/acp-10-5191-2010

Jacobson, M. Z. (2010). Short-term effects of controlling fossil-fuel soot, biofuel soot and gases, and methane on climate, Arctic ice, and air pollution health. *J. Geophys. Res.* 115(D14209), DOI: 10.1029/2009JD013795.

Jalkanen, J.-P., Johansson, L., Kukkonen, J., Brink, A., Kalli, J., Stipa, T. (2012). Extension of an assessment model of ship traffic exhaust emissions for particulate matter and carbon monoxide. *Atmos. Chem. Phys.* 12: 2641-2659, DOI: 10.5194/acp-12-2641-2012

Janssen, N. A., Hoek, G., Simic-Lawson, M., Fischer, P., van Bree, L., ten Brink, H., Keuken, M., Atkinson, R. W., Anderson, H. R., Brunekreef, B., Cassee, F. R. (2011). *Black carbon as an additional indicator of the adverse health effects of airborne particles compared with PM10 and PM2.5.* *Environ. Health Perspect.* 119 (12): 1691-1699, DOI: 10.1289/ehp.1003369

Jennings, S. G., O'Dowd, C. D., Cooke, W. F., Sheridan, P. J., Cachier, H. (1994). Volatility of elemental carbon. *Geophys. Res. Lett.* 21: 1719–1722, DOI: 10.1029/94gl01423

Kasper A., Aufdenblatten S., Fors A., Mohr M., Burtscher H. (2007). Particulate Emissions from a Low-Speed Marine Diesel Engine. *Aerosol Sci. Tech.* 41: 24-32, DOI: 10.1080/02786820601055392.

Kennedy, I. M. (2007). The health effects of combustion-generated aerosols. *P. Comb. Inst.* 31: 2757-2770

Kittelson, D. B. (1998). Engines and nanoparticles: a review. *J. Aerosol Sci.* 29: 575-588.

Koch, D., Schulz, M., Kinne, S., McNaughton, C., Spackman, J. R., Balkanski, Y., Bauer, S., Berntsen, T., Bond, T. C., Boucher, O., Chin, M., Clarke, A., De Luca, N., Dentener, F., Diehl, T., Dubovik, O., Easter, R., Fahey, D. W., Feichter, J., Fillmore, D., Freitag, S., Ghan, S., Ginoux, P., Gong, S., Horowitz, L., Iversen, T., Kirkevåg, A., Klimont, Z., Kondo, Y., Krol, M., Liu, X., Miller, R., Montanaro, V., Moteki, N., Myhre, G., Penner, J. E., Perlwitz, J., Pitari, G., Reddy, S., Sahu, L., Sakamoto, H., Schuster, G., Schwarz, J. P., Seland, Ø., Stier, P., Takegawa, N., Takemura, T., Textor, C., van Aardenne, J. A., Zhao, Y. (2009). Evaluation of black carbon estimations in global aerosol models. *Atmos. Chem. Phys.* 9: 9001-9026, DOI: 10.5194/acp-9-9001-2009

Lack, D. A., Corbett, J. J. (2012). Black carbon from ships: a review of the effects of ship speed, fuel quality and exhaust gas scrubbing. *Atmos. Chem. Phys.* 12: 3509-3554, DOI: 10.5194/acp-12-3985-2012.

Lannefors, H., Heintzenberg, J., Hansson, H. C. (1983). A comprehensive study of physical and chemical parameters of the Arctic summer aerosol; results from the Swedish expedition *Ymer-80.* *Tellus B*, 35B: 40–54, DOI: 10.1111/j.1600-0889.1983.tb00006.x

Lauer, A., Eyring, V., Hendricks, J., Jöckel, P., Lohmann, U. (2007). Global model simulations of the impact of ocean-going ships on aerosols, clouds, and the radiation budget. *Atmos. Chem. Phys.* 7: 5061–5079, DOI: 10.5194/acp-7-5061-2007.

- Law, K. S., Stohl, A. (2007). Arctic air pollution: origins and impacts. *Science* 315: 1537-1540, DOI: 10.1126/science.1137695
- Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S., Schellnhuber, H. J. (2008). Tipping elements in the Earth's climate system. *P. Natl. Acad. Sci. USA* 105: 1786-1793, DOI: 10.1073/pnas.0705414105
- Lewis E. D. (1988). *Principles of naval architecture*, vol. II. The Society of naval architects and Marine Engineers
- Lindqvist G. (1989). *A straightforward method for calculation of ice resistance of ships*. In 10<sup>th</sup> POAC international conference on port and ocean engineering under Arctic conditions. Lulea, Sweden
- Lindstad H. (2013). *Assessment of Bulk designs Enabled by the Panama Canal expansion*. SNAME Annual meeting, Proceedings page 53 – 71, 2013. Seattle, Nov 2013. Selected for inclusion in the 2013 volume of the SNAME Annual Transactions
- Lindstad, H. Asbjørnslett, B. E., Strømman, A. H. (2011). Reductions in greenhouse gas emissions and cost by shipping at lower speed. *Energ. Policy* 39: 3456-3464, DOI: 10.1016/j.enpol.2011.03.044
- Lindstad, H. Asbjørnslett, B. E., Strømman, A. H. (2012). The Importance of economies of scale for reductions in greenhouse gas emissions from shipping. *Energ. Policy* 46: 386-398, DOI: 10.1016/j.enpol.2012.03.077
- Lindstad, H., Asbjørnslett, B. E., Jullumstrø, E. (2013). Assessment of profit, cost and emissions by varying speed as a function of sea conditions and freight market. *Transport. Res. D-Tr. E* 19: 5-12, DOI: 10.1016/j.trd.2012.11.001.
- Lindstad, H., Jullumstrø, E., Sandass, I. (2013). Reduction in cost and emissions with new bulk ships designed enabled by the Panama Canal expansion. *Energ. Policy* 59: 341-349, DOI: 10.1016/j.enpol.2013.03.046
- Lindstad, H., Mørkve, O. T. (2009). *A Methodology to assess the Energy Efficiency and the Environmental Performance of maritime logistics chains*. Conference proceedings 10<sup>th</sup> International Marine Design Conference Trondheim, May 26 – 29<sup>th</sup> 2009, IMDC09 & Tapir Academic Press, ISBN 978-82-519-2438-2
- Lindstad, H., Sandaas, I. (2014). *Emission and Fuel Reduction for Offshore Support Vessels through Hybrid Technology*. Conference Proceedings at Society of Naval Architects and Marine Engineers (SNAME) Annual Convention 20 – 25 October 2014, Houston, USA
- Lindstad, H., Steen, S., Sandass, I. (2014). Assessment of profit, cost, and emissions for slender bulk vessel designs. *Transport. Res. D-Tr. E* 29: 32-39, DOI: 10.1016/j.trd.2014.04.001
- Liousse, C., Cachier, H., Jennings, S. G. (1993). Optical and thermal measurements of black carbon aerosol content in different environments: Variation of the specific attenuation cross-section,  $\sigma$  ( $\sigma$ ). *Atmos. Environ.* 27: 1203–1211, DOI: 10.1016/0960-1686(93)90246-u
- Lund, M. T., Eyring, V., Fuglestedt, J., Hendricks, J., Lauer, A., Lee, D., Righi, M. (2012). Global-Mean Temperature Change from Shipping toward 2050: Improved Representation of the Indirect Aerosol Effect in Simple Climate Models. *Environ. Sci. Technol.* 46(16): 8868-8877

- Lyyräinen, J., Jokiniemi, J., Kauppinen, E.I., Joutsensaari, J. (1999). Aerosol Characterization in Medium-Speed Diesel Engines Operating with Heavy-Fuel Oils. *J. Aerosol Sci.* 30: 771-784
- McKenna, J. D., Turner, J. H., McKenna Jr., J. P. (2008). *Fine particle (2.5 microns) emissions. Regulation, measurement, and control.* John Wiley & Sons Inc., Hoboken, NJ
- Ménégoz, M., Krinner, G., Balkanski, Y., Cozic, A., Boucher, O., Ciais, P. (2013). Boreal and temperate snow cover variations induced by black carbon emissions in the middle of the 21st century. *Cryosphere* 7(2): 537-554, DOI: 10.5194/tc-7-537-2013
- Moldanova J, Fridell E, Popovicheva O, Demirdjian B, Tishkova V, Faccinnetto A and Fosca C. 2009. Characterisation of particulate matter and gaseous emissions from a large ship engine. *Atmos. Environ.* 43: 2632-2641
- Molenaar E. J. (2008). Arctic marine shipping: Overview of the international legal framework, gaps, and options. *J. Transnat'l. L. & Pol'y* 289
- Murphy, S. M., Agrawal, H., Sorooshian, A., Padró, L. T., Gates, H., Hersey, S., Welch, W. A., Jung, H., Miller, J. W., Cocker III, D. R., Nenes, A., Jonson, H. H., Flagan, R. C., Seinfeld, J. H. (2009). Comprehensive Simultaneous Shipboard and Airborne Characterization of Exhaust from a Modern Container Ship at Sea. *Environ. Sci. Technol.* 43(13): 4626-4640
- Myhre, G., Shindell, D. (2013). Chapter 8: Anthropogenic and Natural Radiative Forcing - Final Draft Underlying Scientific-Technical Assessment, in *Working group contribution to the IPCC fifth assessment report (AR5), Climate change 2013: The physical science basis.* Accessed at: [http://www.climatechange2013.org/images/uploads/WGIAR5\\_WGI-12Doc2b\\_FinalDraft\\_Chapter08.pdf](http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter08.pdf), edited, Geneva
- National Snow and Ice Data centre Boulder (2012). *Total ice extent in March 2012.* <http://nsidc.org/arcticseaicenews/>
- New, M., Liverman, D., Schroder, H., Anderson, K. (2011). Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications. *Philos T R Soc A* 369: 6-19, DOI: 10.1098/rsta.2010.0303
- Oberdörster G., Finkelstein J., Ferin J., Godleski, J., Chang, L.-Y., Gelein, R., Johnston, C., Crapo, J. D. (1996). Ultrafine particles as a potential environmental health hazard. Studies with model particles. *Chest* 109 (Suppl. 3): 68–9
- Oberdörster, G. (2000). Toxicology of ultrafine particles: in vivo studies. *Philos. T. R. Soc. A* 258: 2719–2740
- Oberdörster, G., Sharp, Z., Atudorei, V., Elder, A., Gelein, R., Kreyling, W., Cox, C. (2004). Translocation of inhaled ultrafine particles to the brain. *Inhal. Toxicol.* 16: 437-445
- Ødemark, K., Dalsøren, S. B., Samset, B. H., Berntsen, T. K., Fuglestad, J. S., Myhre, G. (2012). Short-lived climate forcers from current shipping and petroleum activities in the Arctic. *Atmos. Chem. Phys.* 12: 1979-1993
- Ogren, J. A. and Charlson, R. J. (1983). Elemental carbon in the atmosphere – cycle and lifetime. *Tellus*, 35B: 241–254.

- Paxian, A., Eyring, V., Beer, W., Sausen, R., Wright, C. (2010). Present-Day and Future Global Bottom-Up Ship Emission Inventories Including Polar Routes. *Environ. Sci. Technol.* 44(4): 1333-1339
- Penner, J. E., Eddleman, H. (1993). Towards the development of a global inventory for black carbon emissions. *Atmos. Environ. A-Gen.* 27(8): 1277-1295
- Peters, A., Liu, E., Verrier, R. L., Schwartz, J., Gold, D. R., Mittleman, M., Baliff, J., Oh, J. A., Allen, G., Monahan, K., Dockery, D. W. (2000). Air pollution and incidence of cardiac arrhythmia. *Epidemiology* 11: 11–17
- Peters, G. P., Nilssen, T. B., Lindholt, L., Eide, M. S, Glomsrød, S., Eide, L. I, Fuglestvedt, J. S. (2011). Future emissions from shipping and petroleum activities in the Arctic. *Atmos. Chem. Phys.* 11: 5305–5320, DOI: 10.5194/acp-11-5305-2011
- Peterson, M. R. and Richards, M. H. (2002). Thermal-optical transmittance analysis for organic, elemental, carbonate, total carbon, and OCX2 in PM2.5 by the EPA/NIOSH method, in: *Proceedings, Symposium on Air Quality Measurement Methods and Technology – 2002*, Pittsburgh, PA, 2002, 83-81-83-19
- Petzold, A., Ogren, J. A., Fiebig, M., Laj, P., Li, S.-M., Baltensperger, U., Holzer-Popp, T., Kinne, S., Pappalardo, G., Sugimoto, N., Wehrli, C., Wiedensohler, A., Zhang, X.-Y. (2013). Recommendations for reporting "black carbon" measurements. *Atmos. Chem. Phys.* 13: 8365-8379, DOI: 10.5194/acp-13-8365-2013, 2013.
- Pietropaoli, A. P., Frampton, M. W., Hyde, R. W., Morrow, P. E., Oberdörster, G., Cox, C., Speers, D. M., Frasier, L. M., Chalupa, D. C., Huang, L. S., Utell, M. J. (2004). Pulmonary function, diffusing capacity and inflammation in healthy and asthmatic subjects exposed to ultrafine particles. *Inhal. Toxicol.* 16 (suppl. 1): 59–72
- Pio, C., Cerqueira, M., Harrison, R. M., Nunes, T., Mirante, F., Alves, C., Oliveira, C., Sanchez de la Campa, A., Artinano, B., Matos, M. (2011). OC/EC ratio observations in Europe: Re-thinking the approach for apportionment between primary and secondary organic carbon. *Atmos. Environ.* 45: 6121–6132.
- Pope III, C. A., Dockery, D. W. (2006). Health effects of fine particulate air pollution: lines that connect. *J. Air Waste Manage. Assoc.* 56: 709–742
- Pope III, C.A. (2000). Epidemiology of fine particulate air pollution and human health: Biologic mechanisms and who's at risk? *Environ. Health Perspect.* 108 (Suppl.): 713–723
- Pope, C.A. III., Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito, K., Thurston, G. D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate matter. *JAMA*, 287: 1132-1141
- Poschl U. (2003). Aerosol Particle Analysis: Challenges and Progress. *Anal. Bioanal. Chem.* 375: 30-32
- Psaraftis, H. N., Kontovas, C. A. (2010). Balancing the economic and environmental performance of maritime transport. *Transport. Res. D-Tr. E* 15(8): 458-462, DOI: 10.1016/j.trd.2010.05.001



- Quincey P. (2007). A relationship between Black Smoke Index and Black Carbon concentration. *Atmos. Environ.* 41(36): 7964-7968, DOI: 10.1016/j.atmosenv.2007.09.033
- Quinn, P. K., Bates, T. S., Baum, E., Doubleday, N., Fiore, A. M., Flanner, M., Fridlind, A., Garrett, T. J., Koch, D., Menon, S., Shindell, D., Stohl, A., Warren, S. G. (2008). Short-lived pollutants in the Arctic: their climate impact and possible mitigation strategies. *Atmos. Chem. Phys.* 8: 1723-1735, DOI: 10.5194/acp-8-1723-2008
- Ramanathan, V. and Carmichael, G. (2008). Global and regional climate changes due to black carbon. *Nat. Geosci.* 1: 221–227, DOI: 10.1038/ngeo156
- Reisinger, P., Wonaschutz, A., Hitzenberger, R., Petzold, A., Bauer, H., Jankowski, N., Puxbaum, H., Chi, X., and Maenhaut, W.: Intercomparison of measurement techniques for black or elemental carbon under urban background conditions in wintertime: Influence of biomass combustion. *Environ. Sci. Technol.* 42: 884–889, DOI: 10.1021/es0715041
- Ristimäki, J., Hellen, G., Lappi, M. (2010). *Chemical and physical characterization of exhaust particulate matter from a Marine medium speed diesel engine*. Conference proceedings of CIMAC Congress 2010, Bergen, Norway
- Rodrigue, J. P., Comtois, C., Slack, B. (2013). *The Geography of transport systems*. Routledge. ISBN 978-0-415-82253
- Sand, M., Berntsen, T. K., Seland, Ø., Kristjå, J. K. (2013). Arctic surface temperature change to emissions of black carbon within Arctic or middle altitudes. *J. Geophys. Res.-Atmos.* 118: 7788-7798.
- Sarvi, A., Fogelholm, C.-J., Zevenhoven, R. (2011). Emissions from large-scale medium-speed diesel engines: 1. Influence of engine operation mode and turbocharger. *Fuel Process Technol.* 89: 510-519
- Sarvi, A., Fogelholm, C.-J., Zevenhoven, R. (2011). Emissions from large-scale medium-speed diesel engines: 2. Influence of fuel type and operating mode. *Fuel Process Technol.* 92: 520-527
- Sarvi, A., Lyyräinen, J., Jokiniemi, J., Zevenhoven, R. (2011). Particulate emissions from large-scale medium-speed diesel engines: 1. Particle size distribution. *Fuel Process Technol.* 92: 1855-1861
- Sarvi, A., Lyyräinen, J., Jokiniemi, J., Zevenhoven, R. (2011). Particulate emissions from large-scale medium-speed diesel engines: 2. Chemical composition. *Fuel Process Technol.* 92: 2116-2122
- Sea at Risk and CE Delft (2010). *Sea at Risk and CE Delft 2010*, <http://www.seas-at-risk.org/>
- Seaton, A., MacNee, W., Donaldson, K., Godden, D. (1995). Particulate air pollution and acute health effects. *Lancet* 345: 176–178
- Shine K. (2009). The global warming potential-the need for an interdisciplinary retrieval. *Climatic Change* 96(4): 467-472, DOI: 10.1007/s10584-009-9647-6
- Slowik, J. G., Cross, E. S., Han, J. H., Davidovits, P., Onasch, T. B., Jayne, J. T., Williams, L. R., Canagaratna, M. R., Worsnop, D. R., Chakrabarty, R. K., Moosmuller, H., Arnott, W. P., Schwarz, J. P., Gao, R. S., Fahey, D. W., Kok, G. L., Petzold, A. (2007). An inter-comparison

of instruments measuring black carbon content of soot particles. *Aerosol Sci. Technol.* 41: 295–314, DOI: 10.1080/02786820701197078

Stenersen, D., Nielsen, J. (2010). *Emission factors for CH<sub>4</sub>, NO<sub>x</sub>, particulates and black carbon for domestic shipping in Norway*. Norwegian Marine Technology Research Institute. [www.nho.no/nox](http://www.nho.no/nox)

Stohl, A., Klimont, Z., Eckhardt, S., Kupiainen, K., Shevchenko, V. P., Kopeikin, V. M., Novigatsky, A. N. (2013). Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions. *Atmos. Chem. Phys.* 13: 8833-8855, DOI: 10.5194/acp-13-8833-2013

Stott, P., Wright, P. (2011). *Opportunities for improved efficiency and reduced CO<sub>2</sub> emissions in dry bulk shipping stemming from the relaxation of the Panamax beam constraint*. Trans RINA, Vol. 153. Part A4, Intl J Maritime Eng

Tree, D. R., Svensson, K. I. (2007). Soot processes in compression ignition engines. *Prog. Energ. Combust.* 33: 272-309

Tumolva, L., Park, J. Y., Kim, J. S., Miller, A. L., Chow, J. C., Watson, J. G., Park, K. (2010). Morphological and elemental classification of freshly emitted soot particles and atmospheric ultrafine particles using the TEM/EDS. *Aerosol Sci. Technol.* 44: 202–215, DOI:10.1080/02786820903518907

Ushakov, S., Valland, H., Nielsen, J. B., Hennie, E. (2012). *Particulate emission characteristics from medium-speed marine diesel engines*. Proceedings of PACIFIC 2012 International Maritime Conference. 31 January – 2 February 2012, Sydney, Australia

Vignati, E., Karl, M., Krol, M., Wilson, J., Stier, P., Cavalli, F. (2010). Sources of uncertainties in modelling black carbon at the global scale. *Atmos. Chem. Phys.* 10: 2595–2611

Warren, J. (2003). *Health Effects of Diesel Exhaust: An HEI Perspective*. Health Effect Institute (HEI), <http://www.healtheffects.org>

Watson, J. G., Chow, J. C., Chen, L.-W. A. (2005). Summary of organic and elemental carbon/black carbon analysis. Methods and intercomparisons. *Aerosol Air Qual. Res.* 5(1): 65-102

Zender, C. S. (2012). Snowfall brightens Antarctic future. *Nature Climate Change* 2(11): 770-771, DOI: 10.1038/nclimate1730