TRANSPORT

Shipping emissions in East Asia

Large growth in East Asia's sea-borne trade has increased premature deaths and atmospheric warming in the region. New legislation could reduce these impacts in areas around China, but joint efforts are needed for region-wide benefits.

James Corbett

All sorts of goods are made in East Asia. Most of these are carried to markets by ship, as the region is connected to nearly 40% of global sea-borne trade[1]. Emissions from international shipping — both greenhouse gases (GHGs) and other pollutants — can have significant regional health and climatic impacts. These are only beginning to be quantified in detail.

In *Nature Climate Change,* Liu and colleagues[1] at Tsinghua University, China, and Duke University, USA, assess how coastal and over-the-horizon ship traffic impacts human health and regional climate forcing. They show that ship traffic in this region has more than doubled since 2005, and now accounts for more than one-sixth of global shipping activity and emissions, which are currently uncontrolled.

The authors use ship position data integrated into an activity-based ship emissions model to conclude that "60% of total emissions in the studied East Asian Region happen within 20 nautical miles (nm) of shore" and 80% of emissions in the Yangtze River Delta region occur within 60 nm of coastal communities. They find that air pollution from unregulated shipping emissions in 2013 contributed to tens of thousands of premature deaths annually. They also estimate the atmospheric warming (radiative forcing) effects, and find near-term negative forcing transitioning to longer-term positive forcing within a decade.

The authors' state-of-the-art methods and high-quality integration of satellite and terrestrial observations of ship activity represent an important contribution to recent global approaches[2], improving previous shipping health risk assessments in similar ways to European regional studies[3–6]. The authors apply direct and induced aerosol forcing calculations that improve the climate assessment of GHGs and short-lived climate pollutants by considering the near- and long-term effects of sulfates, nitrates, black and organic carbon, dust and sea-salt aerosols, cloud albedo and ozone. The analysis highlights the need for better understanding of comprehensive impacts of multiple pollutants from shipping in terms of climate effects, health impacts and policy action.

Some policies to reduce ship emissions are being implemented, with legislation in China to reduce shipping pollution aiming to take effect from 2019. This will require ship traffic in 'marine emission control areas' to cap the sulfur content of marine fuel[7]. International standards, slated to apply a similar sulfur cap globally in 2020, could be delayed to 2025[8]. The findings by Liu and colleagues raise the question whether regional control areas provide enough health benefits or reduce enough climate forcing impacts.

As shown in Fig. 1a, China's regional policy — requiring some 80% reductions in sulfur emissions through cleaner ship fuels — may provide health benefits for a fraction of East Asia's most highly populated coastal communities. Shipping traffic intensities are shown in Fig. 1b, and by using the areas defined by Liu and colleagues, we can see that sulfur (and particulate matter) emissions will be reduced in 100% of the Bohai Sea area, 10–20% of the Yellow Sea area (emission control area extended from Bohai Sea), 5–10% of the East China Sea area and perhaps 1–3% of the South China

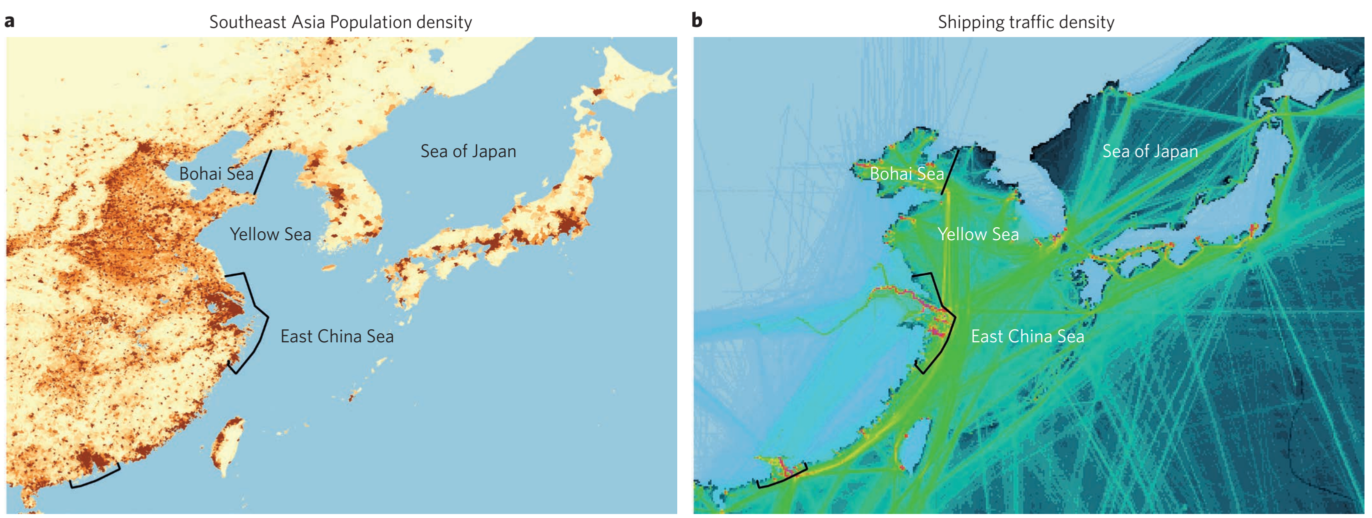

Figure 1 | Map of planned emissions reduction areas (black lines) for shipping based on Chinese legislation, detailed by Edward Carr. Population densities in 2015 with data from SEDAC[9] (**a**) and shipping traffic densities in 2015 from AIS (**b**; calculated by Lasse Johnson, used with permission from Jukka-Pekka Jalkanen).

Sea area. Chinese control zones represent only 1–2% of the area defined in Liu and colleagues' study. However, given that 60% or more of ship emissions occur close to shore, the control zones suggest non-trivial benefits to major Chinese trading regions.

Without broader policy, emissions will remain unabated in substantial parts of the East Asian coastline studied, such as highly populated communities in South Korea, Japan and parts of China outside control areas (see ref. 1, Fig. 3). Eight of the top ten global container ports are included in Liu and colleagues' study area: based on recent ship position data, emissions from 10 of the top 30 shipping emissions 'hotspots' fall within the Chinese emission control areas. Additional advanced integrated research is needed to help illustrate health and climate risks of expanded shipping activity globally. Such studies must be used to inform policy and to ensure proposed actions are sufficient to address these impacts. ❐

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References

1. Liu, H. *et al. Nature Clim. Change* **6,** 1037–1041 (2016).
2. Smith, T. W. P. *et al. Third IMO GHG Study 2014* (International Maritime Organization, 2014).
3. Corbett, J. J. *et al. Environ. Sci. Technol.* **41,** 8512–8518 (2007).
4. Winebrake, J. J., Corbett, J. J., Green, E. H., Lauer, A. & Eyring, V. *Environ. Sci. Technol.* **43,** 4776–4782 (2009).
5. Jonson, J. E., Jalkanen, J. P., Johansson, L., Gauss, M. & van der Gon, H. A. C. D. *Atmos. Chem. Phys.* **15,** 783–798 (2015).
6. Andersson, C., Bergström, R. & Johansson, C. *Atmos. Environ.* **43,** 3614–3620 (2009).
7. *Ministry of Transport on the Issuance of the Pearl River Delta, Yangtze River Delta, Bohai (Beijing, Tianjin) Waters Ships Emission Control Area Embodiments* [in Chinese] (Ministry of Transport of the People's Republic of China, 2015); http://go.nature.com/29jNiJR
8. *Index of MEPC Resolutions and Guidelines related to MARPOL Annex VI* (International Maritime Organization, 2008); http://go.nature.com/29r21jW
9. *Gridded Population of the World (GPW), v3* (Socioeconomic Data and Applications Center, 2005); http://go.nature.com/29lMRjp

Published online: 18 July 2016

EPIDEMIOLOGY

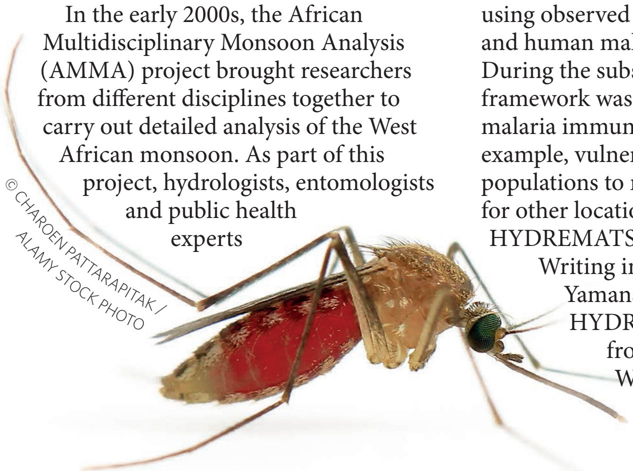
Malaria in a warmer West Africa

Malaria risk in West Africa is expected to fall (western region) or remain the same (eastern region) in response to climate change over the twenty-first century. This is primarily due to extreme temperature conditions projected under a high greenhouse gas emissions scenario.

C. Caminade and A. E. Jones

Malaria is a major vector-borne disease transmitted to humans by the bites of infectious *Anopheles* mosquitoes. It particularly impacts vulnerable people — such as children, pregnant women, and the elderly — and is highly prevalent in sub-Saharan Africa. Following the pioneering work of Ronald Ross and George MacDonald, different mathematical models, with varying degrees of complexity, have been developed and refined over the past 70 years to model the risk of malaria in space and time[1].

In the early 2000s, the African Multidisciplinary Monsoon Analysis (AMMA) project brought researchers from different disciplines together to carry out detailed analysis of the West African monsoon. As part of this project, hydrologists, entomologists and public health experts worked together to develop a malaria model at high spatial and temporal resolutions for the village of Banizoumbou in Niger. Malaria is a climate sensitive disease: rainfall is a necessary condition for mosquito breeding sites, and temperature impacts the development and mortality of the vector and the incubation period of the malaria parasite in the mosquito. Pond levels and other environmental parameters were monitored in real time over Banizoumbou and used to drive the malaria model. The model simulations were then extensively validated using observed mosquito abundance and human malaria prevalence data[2,3]. During the subsequent years, the model framework was further refined to include malaria immunology parameters (for example, vulnerability estimates of exposed populations to malaria) and was validated for other locations in West Africa[4]. The HYDREMATS malaria model was born.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Writing in *Nature Climate Change*, Yamana *et al.*[5] extrapolate the HYDREMATS malaria model from village scale to the whole West African region, and from the present to the warmer world of the future.

This is the first time that a dynamical model, developed and validated at the village scale, has been employed to carry out climate change risk assessment over West Africa. First, the authors sub-selected climate model simulations that showed the best agreement with historical climate observations over the region. The HYDREMATS model was then driven by this sub-ensemble of climate models under the extreme RCP8.5 emission scenario to assess potential changes in future malaria risk. The results suggest that malaria risk is not significantly affected by climate change over the eastern part of West Africa, whereas the risk decreases over the western part due to extreme temperature conditions.

These results are consistent with analogues from past observations. Following the severe drought that occurred during the 1970s and the 1980s over the Sahel, *An. funestus,* an important malaria vector, almost disappeared in northern Niger and northern Mali, leading to a significant decrease in observed malaria prevalence[6]. Other recent multi-model risk assessments show similar trends for the future, with a decreased risk generally simulated over West Africa under the most extreme emission scenario at the end of the twenty-first century, whereas malaria