# Atmospheric Composition and Radiative forcing changes due to UN International Ship Emissions regulations

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Ship exhausts are a significant source of sulfur(S)-containing aerosols to the marine atmosphere and some global models suggest the emissions cause a large negative radiative forcing by modifying cloud properties. International Maritime Organisation (IMO, an agency of the UN) regulations require that ships in international waters reduce their S emissions from a maximum of 3.5% to 0.5% from January 2020. The ACRUISE project, taking advantage of this unique large-scale aerosol perturbation, addresses the impacts of the IMO's 2020 sulfur regulations on atmospheric chemistry and climate in the North Atlantic and globally.

Here I summarise our findings so far from analyses of satellite cloud properties, in situ observations, and global model simulations. Satellite cloud images clearly show reduced cloud effective radius and enhanced cloud albedo within ship tracks (i.e. long, bright, quasi-linear cloud features) compared to adjacent areas. Lagrangian airmass trajectory modelling and machine learning of ship track detection are used to improve the statistical characterizations of pollution-affected clouds. Our aircraft campaign in 2019 suggests that ship emissions of particulate sulfate, aerosol number concentration, and cloud condensation nuclei may decrease by up to an order of magnitude as a result of the 2020 sulfur regulation. To assess the climatic effect of this, global model simulations are run with pre- and post-2020 ship emission scenarios. The sulfur regulation is modelled to reduce the shortwave radiative forcing by ~0.16 W/m2 and increase the temperature by ~0.05 °C globally, with larger effects in the North Atlantic. Further aircraft campaign in 2021 and ongoing long-term surface observations will tell us the degree of compliance by the international shipping fleet and the actual changes in sulfur and aerosols. These insights will be used to improve the model estimates of the impact of ship emissions.