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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effects of ship wakes on ocean brightness and radiative forcing over ocean" *by* C. K. Gatebe et al.

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This commentary addresses concerns raised by Anonymous Referee #1 that our radiative forcing estimate should rely on a more complete model computations.

This study quantifies the effect of ship wakes on the global radiation balance and for the first time illustrates the importance and influence of ship wakes on global climate. However, compared to whitecaps forcing (0.03 Wmˆ-2, see Frouin et al., 2001: Geophysical Research letters, 28, 1523-1526), the effect due to ship wake is an order of magnitude smaller (0.003 Wmˆ-2). Though small, this global value is not negligible compared with the forcing due to aircraft contrail, which is anticipated in the IPCC 2007 assessment. Thus, in addition to effects from ship emissions, ship wakes could influence global climates and deserves further attention.

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Interactive Discussion

Discussion Paper

Analysis of the spectral reflectance of ship wake reflectance data from CAR reveals a) that the spectral reflectance of the wake is distinct from that of background (both in and out of the sun-glint region), and b) that the degree of the differences in reflectance to the background increases with wavelength. The turbulent wake is composed of bubbles produced as the ship disturbs the water and air is entrained, which then enhance ocean reflectance [see e.g. Zhang et al – Optical influence of ship wakes, Applied Optics, 43, 3122-3132, 20040]. This effect should not be confused with cases of turbulent waters or whitecaps that are produced by wind and make the ocean look white. It has been observed that the ocean is most reflective in the visible, decrease with increasing wavelength, and which is consistent with the propensity of water to strongly scatter blue light while almost totally absorbing light at infrared wavelengths.

In an attempt to gain preliminary insights into how the presence of ships impact the energy balance of the ocean surface on the basis of the wake they produce, we adopted simple approaches used in other studies, e.g. Charlson et al. [Science 255, 423, 1992] for sulfate aerosols, Penner et al. [Science 256, 1432, 1992] for biomass burning aerosols and Frouin et al. (2001) for ocean whitecaps. We used a fairly realistic approach, which was constrained with observational data and a description of fractional cloud cover (0.6) adapted from Frouin et al. and based on monthly International Satellite Cloud Climatology (ISCCP) C2 data (ISCCP, 1992.)

It is conceivable that radiative forcing estimates of ship wakes can be refined by including bubble concentrations within the surface ocean model and to use radiative transfer numerical model that describes optical properties of the sea water (e.g., the absorption and scattering coefficients and the scattering phase function). But the ocean optical model depends on environmental parameters (e.g. the sky radiance distribution and sea state). Although surface marine data can found from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) gridded for 2° latitude x 2° longitude boxes back to 1800 and 1°x1° boxes since 1960, such data are too coarse for simulating more localized ship wakes effects. There are other competing effects and feedbacks that may be involved and are too difficult to quantify.

Our results does not imply that the present climate is changing due to ship wake, but it does elevate the importance of ship wakes in global climate and should serve as a call for further assessments.

We will address suggested revisions in our final response.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 21683, 2010.