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Impact of ship emissions on the microphysical, optical and radiative properties of marine stratus: a case study

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Abstract. Modifications of existing clouds by the exhaust of ships are well-known but inadequately quantified impacts, which could contribute to climate change. The perturbation of a cloud layer by ship-generated aerosol changes the cloud reflectivity and is identified by long curves in satellite images, known as ship tracks. As ship tracks indicate a pollution of a very clean marine environment and also affect the radiation budget below and above the cloud, it is important to investigate their radiative and climatic effects. Satellite-data from MODIS on Terra are used to examine a scene from 10 February 2003 where ship tracks were detected close to the North American West-Coast. The cloud optical and microphysical properties are derived using a semi-analytical retrieval technique combined with a look-up-table approach. An algorithm is presented to distinguish ship-track-pixels from the unperturbed cloud pixels in the scene and from this the optical properties of the former are compared to those of the latter. Within the ship tracks a significant change in the droplet number concentration, the effective radius and the optical thickness are found compared to the unaffected cloud. The resulting cloud properties are used to calculate the radiation budget below and above the cloud. Assuming a mean solar zenith angle of 63° for the selected scene, the mean solar surface radiation below the ship track is decreased by 43.2 Wm^{-2} and the mean reflectance at top of atmosphere (TOA) is increased by 40.8 Wm^{-2}. For the entire analyzed scene the ship emission decreases the solar radiation at the surface by 2.1 Wm^{-2} and increases the backscattered solar radiation at TOA by 2.0 Wm^{-2}, whereas no significant effect on thermal radiation was detected.

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