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Large-scale industrial cloud perturbations confirm bidirectional cloud water responses to anthropogenic aerosols

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Aerosols offset poorly quantified fraction of anthropogenic greenhouse gas warming, whereas the aerosol impact on clouds is the most uncertain mechanism of anthropogenic climate forcing. In this research, we extend satellite observations of polluted cloud tracks from Toll et al. (2019, Nature, https://doi.org/10.1038/s41586-019-1423-9) with analysis of larger scale polluted cloud areas detected in MODerate-resolution Imaging Spectroradiometer satellite images. We demonstrate that large-scale anthropogenic aerosol-induced cloud perturbations exist at various major industrial aerosol source regions. The areal extent of the polluted cloud areas detected in MODIS satellite images extended to hundreds by hundreds of kilometres. Polluted clouds detected in satellite images in the global anthropogenic air pollution hot spot of Norilsk, Russia, and in other regions show close compensation between aerosol-induced cloud water increases and decreases. On average, there is relatively weak decrease in cloud water in the large areas with strong decreases in cloud droplet radii. This is in very good agreement with previous results based on small-scale polluted cloud tracks (Toll et al., 2019) and strongly disagrees with unidirectionally increased liquid water path in global climate models.