Stratospheric Ozone-induced Indirect Radiative Effects on Antarctic Sea Ice

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Recent studies demonstrated that the Antarctic Ozone Hole has important influences on Antarctic sea ice. While all these have focused on stratospheric ozone-induced dynamic effects on sea ice, here we show results that ozone-induced indirect radiative effects have important impacts on Antarctic sea ice. Our simulations demonstrate that the recovery of the Antarctic Ozone Hole leads to decreases of downward infrared radiation on the surface and solar radiation absorbed by the surface. Both cause surface cooling of the Southern Ocean and sea ice expansion around the Antarctic. The decrease in surface radiation energy is not due to the direct radiative forcing by ozone recovery. Instead, it is because of indirect radiative effect associated with equatorward shift of the westerly jet stream. The jet shift leads to equatorward cloud-band shift, which causes cloud decrease at Southern-Hemisphere high latitudes and cloud increase at middle latitudes. As a result, downward infrared radiation is reduced over the Southern Ocean, and increased solar radiation due to cloud decrease is largely offset by increasing surface reflection of sea ice. Our simulations also demonstrate increasing snow rate near the sea ice edge, which partly contributes to Antarctic sea-ice expansion. Such ozone-induced cloud radiative effect would mitigate Antarctic sea-ice melting due to greenhouse warming in the 21st century.

Key words: Antarctic sea ice, ozone recovery, infrared radiation, solar radiation, climate change