Formation of high-ozone regions downstream of the Asian continent in winter and spring

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The anthropogenic impact on the distributions of ozone (O_3) over the western Pacific from winter to spring is investigated using a three-dimensional chemistry-transport model (GEOS-CHEM). The GEOS-CHEM results for January and April-May 2002 are first compared with data obtained from the PEACE aircraft missions flown for the same periods to validate the model results. The concentrations of O_3 and its precursors calculated by GEOS-CHEM generally agree well with those observed at 0-12 km. The O_3 distributions calculated by the GEOS-CHEM are then interpreted in terms of O_3 production rates and transport over East Asia into the western Pacific regions. The impact of the ozone precursors, especially NO_x, emitted from East Asian countries (China, Korea, and Japan) are found over the western Pacific, which can be characterized by regions of high boundary layer O_3 levels. The locations of the high-O_3 regions are controlled mainly by the geographical distribution of the sources of NO_x, dominating wind fields, and UV radiation. In January, the strong northwesterlies, combined with low OH, efficiently transport NO_x to 160^{o}E at 30^{o}N. As a result, about 5-10 parts per billion by volume (ppbv) of O_3 is produced during transport over a distance of about 3000 km within 5-6 days. This leads to a high-O_3 (˜40 ppbv) belt located at 20^o-35^{o}N, south of the Japan archipelago, extending further downstream to about 5000 km east of the Asian continent (120^o-170^{o}E). In April, southwesterly winds dominated due to the development of the anticyclone over the western Pacific. Along this flow, O_3 continues to be produced by NO_x emitted from China, Korea, and Japan during the northeastward transport over distances of about 3000 km. This results in the formation of a high-O_3 (higher than 50 ppbv) region extending over 30^o-50^{o}N within about 2000 km along the coastal areas of the three countries. The GEOS-CHEM model was also used to estimate the impacts of anthropogenic NO_x emissions from the Asian continent on O_3 in the free troposphere over the entire Pacific Ocean.