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Hemispheric differences in the return of midlatitude stratospheric ozone to historical levels

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The return of stratospheric ozone to 1980 levels is projected to occur earlier in northern midlatitudes than in southern mid-latitudes. The future evolution of ozone will be affected both by decreases in ozone depleting substance concentrations and increases in greenhouse gas concentrations. In addition to cooling the stratosphere, and thereby affecting chemical reaction rates, increases in greenhouse gas levels also change bundances of substances important for ozone chemistry (e.g. nitrogen oxides NOx). Changes in the temperature structure of the atmosphere also change the transport of ozone. Hemispheric differences in such changes in transport are thought to be the cause of projected hemispheric differences in ozone return dates. In this study we revisit the hemispheric differences in ozone evolution from 1960 to 2100 with a specific focus on the importance of changes in ozone transport on the trends in mid-latitude ozone. Transient and time-slice simulations from two chemistry-climate models (E39CA and NIWASocol) are used. A method is applied that quantifies the influence of transport and chemistry on ozone trends, and then further separates the chemical changes into different production and destruction cycles. Using this method, it is shown that the annual mean stratospheric ozone trends are primarily determined by changes in chemistry. While transport of ozone is important for the annual cycle and inter-annual variability, the long-term changes in transport are small in the annual mean. Furthermore, the hemispheric differences in projected midlatitude ozone trends cannot be explained by differences in transport changes both in the past and in the future. In contrast to current understanding of the causes of hemispheric differences in the evolution of ozone through the 21st century, this result implies that differences in in-situ chemistry are responsible for the observed differences in mid-latitude ozone return dates. Indications are presented that the hemispheric differences are due to different trends in ozone destruction by the NOx cycle, likely resulting from hemispheric differences in NOx. These deviations might arise from differences in the evolution of the circulation, and thus transport of NOx.