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Sensitivity of mid-latitude westerly flow in the troposphere to human induced global change

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Since 1989 nearly all winter- and spring seasons in the Netherlands have been significantly warmer than "normal". This is partly due to the increase of the frequency of westerly winds, bringing relatively mild air from the Atlantic Ocean. It is hypothesized that this increase of the westerlies near the Earth's surface is connected to an increase in the amplitude of the positive potential vorticity anomaly in the stratosphere which, in turn, can partially be explained by the stratospheric "cooling" which has taken place over the past few decades due to ozone loss, especially at the end of the winter and early spring. An additional important effect that may contribute to explaining the increase of the intensity of the westerlies in midlatitudes is the decrease of the area of ice-cover in the Arctic, leading to a decrease of the effective radius of the negative temperature anomaly at the Earth's surface. A negative temperature anomaly at the Earth's surface induces an anticyclonic wind anomaly in the atmosphere. With a smaller area of ice-cover, the cyclonic wind anomaly induced by the positive potential vorticity anomaly in the stratosphere will therefore penetrate more strongly into the troposphere. The relative contributions of these different effects to the change in the westerly wind in midlatitudes is investigated with the help of a program that solves the invertibility principle for potential vorticity in isentropic coordinates numerically with realistic boundary conditions for a domain spanning the atmosphere approximately up to the mesopause over the northern hemisphere. We assume axisymmetry around the pole. We show that the mid-latitude zonal wind at the Earth's surface is more sensitive to typical large scale potential vorticity perturbations associated with with the radiative-dynamical response to human induced changes in trace gas concentrations in the stratosphere, than to realistic temperature changes at the Earth's surface in the Arctic.