



## Can increasing CO<sub>2</sub> cool Antarctica?

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CO<sub>2</sub> is the strongest anthropogenic forcing agent for climate change since pre-industrial times. Like other greenhouse gases, CO<sub>2</sub> absorbs terrestrial surface radiation and causes emission from the atmosphere to space. As the surface is generally warmer than the atmosphere, the total long-wave emission to space is commonly less than the surface emission.

However, this does not hold true for the high elevated areas of central Antarctica. Our investigations show, that for the high elevated areas of Antarctica the greenhouse effect (GHE) of CO<sub>2</sub> is commonly around zero or even negative. This is based on the quantification of GHE as the difference between long-wave surface emission and top of atmosphere emission. We demonstrate this behaviour with the help of three models: a simple two-layer model, line-by-line calculations, and an ECMWF experiment.

Additionally, in this region an increase in CO<sub>2</sub> concentration leads to an instantaneous increased long-wave energy loss to space, which is a cooling effect on the earth-atmosphere system. However, short-wave warming by the weak absorption of solar radiation by CO<sub>2</sub> are not taken into account here.

The reason for this counter-intuitive behaviour is the fact that in the interior of Antarctica the surface is often colder than the stratosphere above. Radiation from the surface in the atmospheric window emitted to space is then relatively lower compared to radiation in the main CO<sub>2</sub> band around 15 microns, which originates mostly from the stratosphere. Increasing CO<sub>2</sub> concentration leads to increasing emission from the atmosphere to space, while blocking additional portions of surface emission. If the surface is colder than the stratosphere, this leads to additional long-wave energy loss to space for increasing CO<sub>2</sub>.

Our findings for central Antarctica are in strong contrast to the generally known effect that increasing CO<sub>2</sub> has on the long-wave emission to space, and hence on the Antarctic climate.