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- **Vertical structure of recent Arctic warming**

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- **Abstract**

- Near-surface warming in the Arctic has been almost twice as large as the global average over recent decades—a phenomenon that is known as the 'Arctic amplification'. The underlying causes of this temperature amplification remain uncertain. The reduction in snow and ice cover that has occurred over recent decades may have played a role. Climate model experiments indicate that when global temperature rises, Arctic snow and ice cover retreats, causing excessive polar warming. Reduction of the snow and ice cover causes albedo changes, and increased refreezing of sea ice during the cold season and decreases in sea-ice thickness both increase heat flux from the ocean to the atmosphere. Changes in oceanic and atmospheric circulation, as well as cloud cover, have also been proposed to cause Arctic temperature amplification. Here we examine the vertical structure of temperature change in the Arctic during the late twentieth century using reanalysis data. We find evidence for temperature amplification well above the surface. Snow and ice feedbacks cannot be the main cause of the warming aloft during the greater part of the year, because these feedbacks are expected to primarily affect temperatures in the lowermost part of the atmosphere, resulting in a pattern of warming that we only observe in spring. A significant proportion of the observed temperature amplification must therefore be explained by mechanisms that induce warming above the lowermost part of the atmosphere. We regress the Arctic temperature field on the atmospheric energy transport into the Arctic and find that, in the summer half-year, a significant proportion of the vertical structure of warming can be explained by changes in this variable. We conclude that changes in atmospheric heat transport may be an important cause of the recent Arctic temperature amplification.

FIGURE 1. Averaged temperature trends around latitude circles for 1979–2001 plotted versus latitude and height for the four seasons.

- Trends are shown for winter (**a**, December–February), spring (**b**, March–May), summer (**c**, June–August) and autumn (**d**, September–November). The linear trends are estimated from monthly mean data using a least-squares fit.

