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Spatial and temporal variation of correlation between the Arctic total ozone and atmospheric temperature

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Daily total ozone and atmospheric temperature profile data in 2015 from the AIRS are used to investigate the spatial and temporal variation of the correlation between the Arctic atmospheric ozone and temperature. In the study, 11 lays atmospheric temperature profiles from the troposphere to the stratosphere are investigated. These layer heights are 20, 50, 70, 100, 200, 250, 300, 400, 500, 600 and 700 hPa respectively. The results show that a significant seasonal split exists in the correlation between the Arctic ozone and atmospheric temperature. Figure 1 shows the spatial and temporal variation of the coefficient between the atmospheric ozone and temperature at 50hPa.

It can be seen from the figure that an obvious spatiotemporal difference exists in the correlation between the Arctic total ozone and atmospheric temperature in the lower stratosphere. First, the seasonal difference is very remarkable, which is shown as a significant positive correlation in most regions during winter and summer, while no correlation in the majority of regions occurs during spring and autumn, with a weak positive or negative correlation in a small number regions. Second, the spatial differences are also very obvious. The summer maximum correlation coefficient occurs in the Barents Sea and other locations at 0.8 and above, while the winter maximum occurs in the Baffin Bay area at 0.6 to 0.8. However, in a small number of regions, such as the land to the west of the Bering Strait in winter and the Arctic Ocean core area in summer, the correlation coefficients were unable to pass the significance test to show no correlation. At the same time, in spring and autumn, a positive correlation only occurs over a few low-latitude land areas, while over other Arctic areas, weak negative correlation exists. The differences in horizontal position are clearly related to the land-sea distribution, underlying surface characteristics, glacial melting, and other factors.

In the troposphere, the ozone and temperature have a strong negative correlation in spring and autumn, while presenting a weak negative correlation or no correlation in winter and summer. Figure 2 shows the spatial and temporal variation of the correlation coefficient between the atmospheric ozone and temperature at 500hPa.

From figure 2, it can be seen that in the Arctic troposphere, the atmospheric ozone and tropospheric temperature mainly have a negative correlation. In winter and summer, a weak negative correlation is shown overall, but more than a third of the regions show no correlation. In spring, the negative correlation is the strongest between the ozone and temperature. Especially in Greenland - Queen Elizabeth Islands and southern New Siberian Islands, the correlation is the highest, with a correlation coefficient of -0.9 and above, followed by a negative correlation in autumn. Except for a small number of low-latitude scattered regions with weak correlation, the correlation coefficients of most regions are ranged between -0.5 and -0.7.

At 300 hPa near the tropopause, the horizontal distribution and seasonal change of the correlation between the Arctic total ozone and atmospheric temperature are as shown in Fig. 3.At the height near the Arctic tropopause, the atmospheric ozone mainly has no correlation to temperature, especially in winter and summer, when no correlation exists in the majority of regions, while weak positive or negative correlation occurs in a small number of areas. In the majority of regions during spring, a weak negative correlation is shown, while no correlation appears in Western Greenland - Queen Elizabeth Islands. In autumn, most regions show no correlation, while weak negative correlation is presented in Eastern Greenland, Norwegian Sea - Barents Sea, and other locations.

From figure 1-3, we can see a significant difference exists from the common law of positive correlation in the lower stratosphere and negative correlation in the troposphere at mid-low latitudes. The Arctic atmospheric ozone has a relation with temperature, showing significant spatial and temporal variation characteristics. In the stratosphere, winter and summer atmospheric temperatures mainly have a positive correlation to ozone. The summer maximum occurs in the Barents Sea to achieve 0.8 and above, while the winter maximum is 0.6 to 0.8 in the Baffin Bay area. In the troposphere, the autumn and spring atmospheric temperatures mainly have a negative correlation to the ozone. The spring correlation coefficient in Greenland to the Queen Elizabeth Islands reaches

up to -0.9 and above, while the autumn value is -0.5 to -0.7. At about 300 hPa, the tropopause value is reduced to 0, and further decreased in the troposphere, to show a strong negative correlation. Based on the comprehensive analysis of various influence factors, the possible action mechanism of the spatiotemporal variation pattern of the correlation between the Arctic atmospheric ozone and temperature is discussed based on the seasonal differences of various influence factors.

The spatial and temporal variation characteristics of the correlation between the Arctic atmospheric ozone and temperature are determined by the seasonal variation of various influencing factors of the Arctic atmospheric ozone and temperature. These factors include the atmospheric heating effect from the ozone matching with the Arctic sunshine conditions, the influence of dynamic delivery on the ozone and heat, the impact of underlying-surface glacial melting on atmospheric radiation and heat budget, and so on. At different heights in each season, the different effects from all kinds of factors on the ozone and temperature determine the spatiotemporal variation of the correlation between the ozone and temperature.