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对流层-平流层之间过渡层中臭氧含量及其加热率的变化研究

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摘要 利用1958~2001年共44年的ECMWF资料及参数化方法，计算了对流层顶上、下3 km气层间的臭氧含量及其吸收太阳辐射加热率的时空分布.结果表明: (1) 臭氧分布的空间梯度从赤道指向两极，而加热率则是分别由高纬和低纬指向副热带，这样的经向梯度可能是驱动对流层顶结构变化的一种重要因素；两者空间分布的季节变化显著，但其对应关系并不完全一致，1月和4月的空间结构与7月和10月的相反，随季节调整具有突变现象；东亚及青藏高原是季节变化相对稳定的区域.(2) 在热带对流层顶控制区加热率与臭氧含量呈正相关，而极地对流层顶控制区各季节有所不同，还与太阳赤纬变化相关联；各纬度间加热率季节变化的位相和变率都存在差异，但南半球相对较为一致，最大距平为$\pm 2\times 10^{-4}$ K·d^{-1}，北半球则较复杂，最大正距平为4×1010^{-4} K·d^{-1}；两半球的季节周期位相趋于相反.(3) 除赤道外，臭氧距平的季节变化位相超前于加热率距平2~3月，并且发生在季节变化的调整期；最大距平出现在南极的8月大于0.4 DU，3~4月则小于-0.2 DU，而北极为±0.2 DU.(4) 臭氧含量和加热率的年际与年代际演变关系对应一致，并具有多尺度的结构特征；但两半球及赤道的时空演变差异明显，30° S~30° N间副热带控制区的加热率变幅剧烈，最大距平为$\pm 2.5\times 10^{-4}$ K·d^{-1}，高纬和两极的变幅在不同演变期各不相同；臭氧的变幅结构与之相反，北极的最大距平分别大于0.25 DU和小于-0.35 DU.(5) 20世纪70年代以前及70年代中期，两半球的正负距平具有相反的演变结构，而90年代是负距平演变最剧烈的时期.

关键词 对流层顶 上对流层下平流层 臭氧 太阳辐射通量吸收率 加热率
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A study of ozone amount in the transition layer between troposphere and stratosphere and its heating rate

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Abstract Ozone amount in the 6-km layer near the tropopause and the spatial-temporal distribution of heating rate are calculated, using the 44-yr(1958~2001) data set provided by ECMWF and parameterization. The results show that: (1) the spatial gradient of ozone content distribution is from equatorial to polar areas, while the spatial gradient of the heating rate distribution is from the high-latitude and low-latitude to the subtropical areas. It is likely that such meridional gradient is an important factor which drives the tropopause structure variations. The seasonal variation about the spatial distributions of ozone amount and heating rate is obvious, while they are not fully consistent with each other. The spatial structure in January and April is reverse with that in July and October and abrupt change exists along with season varying. The seasonal change is relatively unobvious in East Asia and Tibetan plateau. (2) The heating rate and ozone amount shows positive correlation in the areas controlled by tropopause in tropics, and this relationship varies with seasons in the areas controlled by polar tropopause. Also this relationship has something to do with the declination; the phase and amplitude of seasonal heating rate variation differ among different latitude areas, while it is more consistent in Southern Hemisphere, and the seasonal variation is also more even, the largest anomaly is $\pm 2\times 10^{-4}$ K·d^{-1}. And the largest anomaly is $\pm 4\times 10^{-4}$ K·d^{-1} in the Northern Hemisphere. The seasonal phases are generally reverse in two Hemispheres. (3) The seasonal variation of ozone amount anomaly exceeds that of heating rate anomaly 2~3 months in the period of season adjustment, except in the tropical areas; The largest anomaly is greater than 0.4DU in August in Antarctic, it is smaller than -0.2DU in March and April; and it is ±0.2 DU in Arctic. (4) The interannual and interdecadal change of ozone amount and heating rate are correspondent, both show multi-scale characteristics. The differences of variation between two Hemispheres and equatorial areas are obvious. The amplitude of heating rate in the areas between 30° S~30° N is rather large, and the largest anomaly is $\pm 2.5\times10^{-4}$ $K\cdot d^{-1}$, the amplitude in higher and polar latitude is different in different periods; while the amplitude of ozone amount shows reverse characteristics. The largest anomaly is greater than 0.25 or smaller than -0.35 in Arctic areas. (5)There are opposite anomaly structures in two Hemispheres before 70′ s and mid-70′ s in 20th century, while the most remarkable period of the minus anomaly is in 90′ s.

Key words Tropopause; Upper-troposphere and lower-stratosphere; Ozone; Absorption of solar flux; Heating rate

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