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N_2O增加对大气环境影响的模拟及其与甲烷和平流层水汽影响的比较

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Simulation of influence of N_2O's increase on atmospheric environment and comparison with the influences of methane and stratospheric water vapor

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摘要

本文利用美国国家大气环境中心(NCAR)的二维化学、辐射和动力相互作用的模式(SOCRATES),模拟了大气中N_2O增加对O_3和温度的影响,并从化学、辐射和动力过程讨论了影响原因,此外还与大气甲烷和平流层水汽增加对大气环境的影响进行了对比.分析表明:大气中N_2O浓度增加以后,将通过化学过程引起30 km以上O_3损耗,30~40 km损耗较多;30 km以上降温明显,下平流层中低纬度地区以及对流层O_3增加并有微弱升温;30~40 km附近,北半球中高纬地区O_3减少以及降温幅度都大于南半球.对流层升温主要是N_2O和O_3增加所致,而平流层温度变化主要受O_3控制.北半球中高纬地区动力过程对温度变化的反馈较其它地区明显,这种反馈对平流层中高层北半球中高纬地区温度和O_3的变化都有明显影响.大气中甲烷增加引起的O_3损耗在45 km以上,45 km以下O_3增加.平流层水汽增加会引起40 km以上O_3减少,20~40 km大部分地区O_3增加.N_2O增加造成的O_3损耗正好位于臭氧层附近,其排放对未来O_3层恢复至关重要.N_2O增加引起下平流层15~25 km中低纬度地区有弱的升温,这与其它温室气体增加对该地区温度的影响不同,CO_2,CH_4和H_2O等增加后下平流层通常是降温.

关键词 温室气体, 臭氧, 平流层化学, 剩余环流, NCAR 模式

Abstract:

A sensitivity experiment, with the increasing N_2O volume mixing ratio, was carried out to study the influence of an increase of N_2O on O_3 and temperature using the 2D interactive chemical radiative dynamical (SCORATES) model of the National Center for Atmospheric Research, and the reasons for O_3 and temperature change were analyzed from chemistry, radiation and dynamical processes. Moreover, the differences in influences on the atmospheric environment of methane and water vapor increase as well as N_2O increases were compared. The results show that when N_2O concentration increases, the chemical process results in O_3 depletion over 30 km, and the high value appear between 30 and 40 km. The cooling is obvious over 30 km, the O_3 increase and slight warming appear at middle-lower latitudes in the lower stratosphere and troposphere. The extents of ozone decrease and cooling over 30~40 km are larger at middle-high latitudes in the North Hemisphere than in the South Hemisphere. The tropospheric warming is mainly caused by the increases of N_2O and O_3, while the temperature change in the stratosphere is mainly dominated by O_3. The dynamical feedback to temperature change is more distinct at middle-high latitudes in the Northern Hemisphere than in other regions and significantly affects temperature and ozone in the middle-high stratosphere at middle-high latitudes in the Northern Hemisphere. Whereas the O_3 depletion caused by methane increase appears above 45 km, and the O_3 increases below 45 km. The stratospheric water vapor increase can result in the O_3 depletion above 40 km, and the O_3 increases in the most of between 20 and 40 km. The O_3 depletion caused by N_2O increase appears right near the O_3 layer, and its emission is very important to the future O_3 layer recovery. The slight warming caused by N_2O increase appears

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from 15 to 25 km at middle and low latitudes, however the increase in CO_2, CH_4, and stratospheric water vapor can respectively lead to cooling there.

Keywords Greenhouse gas, Ozone, Stratospheric chemistry, Residual circulation, NCAR model

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