大气科学
CHINESE JOURNAL OF ATMOSPHERIC SCIENCES

doi: 10.3878/j.issn.1006-9895.2012.01.12

云凝结核浓度对WRF模式模拟飑线降水的影响：不同云微物理参数化方案的对比研究

Effects of Cloud Condensation Nuclei Concentration on Precipitation in Convection Permitting Simulations of a Squall Line Using WRF Model: Sensitivity to Cloud Microphysical Schemes

基金: 国家自然科学基金资助项目40875064、40921003，公益性行业 (气象) 科研专项GYHY200806020，中国气象科学研究院基本科研业务费专项基金2007R001

中文关键词: 云凝结核—降水影响 WRF模式 云微物理参数化方案 飑线

英文关键词: cloud condensation nuclei－precipitation impact WRF model cloud microphysical scheme squall line

作者中文名	作者英文名	单位
董昊	DONG Hao	南京信息工程大学，南京 210041；中国气象科学研究院灾害天气国家重点实验室，北京 100081
徐海明	XU Haiming	南京信息工程大学，南京 210041
罗亚丽	LUO Yali	中国气象科学研究院灾害天气国家重点实验室，北京 100081

引用:董昊,徐海明,罗亚丽.2012.云凝结核浓度对WRF模式模拟飑线降水的影响：不同云微物理参数化方案的对比研究[J].大气科学,36(1):145-169,doi:10.3878/j.issn.1006-9895.2012.01.12.

Citation:DONG Hao,XU Haiming and LUO Yali.2012.Effects of Cloud Condensation Nuclei Concentration on Precipitation in Convection Permitting Simulations of a Squall Line Using WRF Model: Sensitivity to Cloud Microphysical Schemes[J].Chinese Journal of Atmospheric Sciences (in Chinese),36(1):145-169,doi:10.3878/j.issn.1006-9895.2012.01.12.

中文摘要:

采用WRF模式模拟一次影响中国广东省的飑线过程， 分别选取Morrison、 Thompson07、 Thompson09和WDM6云微物理方案实施了四组试验， 每组试验包括不同云凝结核（CCN）浓度的三次模拟， 称为 “低浓度”、 “中浓度” 和 “高浓度”， 将模拟区域划分为深对流、 浅对流和层云区域， 对比分析四组试验中CCN浓度变化对模拟的总降水量、 不同区域降水率和不同区域面积的影响， 进一步分析了云微物理过程、动力环流强度等受CCN浓度变化的影响。发现： （1） 由于不同云微物理过程与CCN浓度有着直接或间接的联系、 不同云微物理过程之间存在复杂的关联、 云微物理过程与动力环流之间发生非线性耦合， 采用不同的云微物理方案导致模拟的CCN—降雨影响既有相似、 也有差异； （2）模拟的CCN—降水影响在采用Thompson09和Thompson07方案时更显著， 采用WDM6方案时最小； （3）四组模拟试验均出现CCN浓度增加延迟降水产生、 初期降水减弱的情况， 在模拟后期降水量也随着CCN浓度增加而减小， 而飑线成熟阶段CCN—降水影响更加复杂。

Abstract:

Effects of cloud condensation nuclei (CCN) concentration on explicit-deep convection simulations of precipitation associated with a squall line that developed in Guangdong Province, China are investigated using the Weather Research and Forecasting model. Four groups of simulations are conducted, each with a different bulk microphysical scheme (Morrison, Thompson09, Thompson07, and WDM6) and consisting of three members with low, median, and high CCN concentration, respectively. Changes caused by the CCN concentration variation in the surface rainfall rates within the regions of deep convection, stratiform cloud, and shallow convection, as well as in their areas, are compared among the four groups of simulations. Then the microphysical processes and strength of dynamical circulation in the simulations are examined. It is found that: (1) The CCN－precipitation impacts among the four groups of simulations exhibit both similarities and differences, due to the direct or indirect relationships between the microphysical processes and CCN concentration, the complicated linkage among various microphysical processes, and the nonlinear coupling between microphysical and dynamical processes.(2) The simulated CCN－precipitation impacts are the most significant with the Thompson09 or Thompson07 scheme and the least notable with the WDM6 scheme. (3) In these experiments, precipitation is delayed and weakened during the early stage of the simulations and rainfall amount is also decreased during the late stage, while the CCN－precipitation impacts are more complicated during the mature stage of the simulated squall line.