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AOGS第六届学术年会气象学研究报告综述

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摘要:简要综述了第六届亚洲大洋洲地球科学学会 (AOGS)学术年会有关天气和气候的可预报性、协同亚洲季风试验、季风变化及其模拟与预测、气候变化与热带气候灾害、中层大气研究、中尺度气象学与台风研究以及卫星资料应用等方面的报告内容。在全球气候变化的大背景下,季风的年代际变化特征,可能成因及其对天气气候的影响是目前研究的热点问题之一。对亚洲季风系统形成机制的探讨及其与气候系统关系的研究有助于提高数值模式对季风系统的模拟能力,从而能够更好地预测季风系统及其演变。集合预报,特别是多模式超级集合预报方法引起了人们广泛的兴趣。研究报告指出,多个积云对流参数化方案的集成、集合卡曼滤波、条件非线性最优扰动法以及滑动训练期超级集合预报技术对数值天气预报的准确率都有明显改善。"可预报性障碍"在数值模式对大气环流的预报中同样存在。"可预报性障碍"本质上反映了系统的季节变化对预报结果的影响。研究还表明,热带气旋频率和强度的变化取决于在其形成的海域是动力因子还是热力因子起主导作用,如热力因子起主导作用则气候变暖会使该区域的热带气旋活动频率和强度增加。一些研究指出,中高纬度阻塞形势持续异常及南海的热源异常可能是造成 2008年初中国南方低温、雨雪和冰冻灾害的主要原因。Formosat-2和 Formosat-3等卫星观测资料的广泛应用将极大地提高数值天气预报、气候监测和空间天气预报水平。

关键词:可预报性;气候变化;季风;中层大气;卫星资料
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A Review of the Meteorological Research at the AOGS 6th Annual Meeting

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Abstract: This paper reviews the meteorological research reported at the sixth annual meeting of Asia Oceania Geosciences Society (AOGS) including the predictability of weather and climate, a coordinated Asian monsoon experiment, the monsoon variability and modeling, climate change and tropical climatic hazards in Asia and Oceania, Middle atmosphere science, mesoscale meteorology and typhoon, and applications of satellite data etc. On the background of global climate change, the interdecadal variability of the Asian monsoon, its possible mechanism and its impact on the weather and climate are hot research topics in atmospheric sciences. Discussions on the formation mechanism of the Asian monsoon system and its relation to the climatic system may improve the capability of the numerical models in the simulation of the monsoon system, and predict the monsoon system and its variability more accurately. Ensemble forecast, in particular the multimodel superensemble forecast technique has aroused considerable interest of scientists

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The results of presentations at the meeting show that the unified multi-cumulus convective ensemble scheme, the ensemble Kalman filter(EnKF), the conditional nonlinear optimal perturbation as well as the multimodel superensemble with the running training period are able to improve the accuracy of the numerical weather prediction significantly. The "predictability barrier" also appears in the prediction of the atmospheric circulation system in the AGCM. The main origin of the "predictability barrier" in physical essence is the seasonal variability characteristic of the climate systems. Further study shows that more tropical cyclones(TCs) or more intense TCs depend on which factors, thermodynamic or dynamic factors, play a key role in the TCs formation and development in the ocean basins where the TCs form. As global warming is likely contributing to more favorable thermodynamic conditions for the formation and development of TCs, more TCs or more intense TCs are expected in the ocean basins where thermodynamic factors are important and significant. Some results show that the persistent anomalies of blockings in middle and high latitudes as well as the heating anomalies over South China Sea may be the main causes of the extreme weather of low temperature, icy rain and snow in southern China in early 2008. In addition, the satellite observations using Formosat-2 and Formosat-3 may significantly improve the operational numerical weather prediction, climate monitoring, and space weather forecasting.

Key words: predictability; climate change; monsoon; middle atmosphere; satellite data

0 引言

2009年 8月 11—15日,亚洲大洋洲地球科学学会第六届学术年会(Asia Oceania Geosciences Society 6th Annual Meeting 2009)在新加坡新达城国际会展中心举行。来自亚洲、大洋洲、北美和欧洲共52个国家和地区的1 148名地球科学专家和学者就地球科学的最新研究成果进行了广泛的交流和深入的探讨。年会按照学科分为大气科学、水文学、海洋学、行星科学、日地科学、固体地球科学以及跨学科工作组。大气科学工作组主要就风成尘,雷暴与闪电物理学,天气与气候的可预报性,气候变化及亚洲大洋洲热带气候灾害,大气环境与污染,季风和中纬度遥相关,季风变化及其模拟与预测,协同亚洲季风试验,极地地区卫星观测的观测方法和科学发现,中尺度气象学与台风,中层大气科学,区域环境评价体系,卫星资料在亚洲降水研究中的应用,极端气候和气候变化的区域气候模拟,激光雷达技术在大气遥感和空气质量监测中的应用,东亚近海和邻近太平洋地区对海洋生物地球化学的大气强迫等方面的研究进行交流与讨论。下面对年会的气象学报告内容及研究新进展作一综述。

1 天气气候的可预报性

数值天气预报经过近一个世纪的发展,取得了巨大的进步,预报准确率有了很大提高,并且由传统的单一确定性预报向集合数值预报方向发展[1]。目前集合预报产品已在许多国家的气象部门得到了广泛应用。1999年 Krishnamurti等[2]提出了一种多模式集成预报方法即超级集合预报,有效地减小了季节气候预测和天气预报的误差,预报效果远优于单个模式和多模式集合平均[2-5]。Zhi等[6]和智协飞等[7]利用 TIGGE资料对北半球及中纬度地区地面气温进行多模式超级集合预报试验,发现超级集合预报方法能有效地改进中短期预报的预报技巧,其预报准确率高于单个模式预报和多模式集合平均的预报准确率。Lee等[8]讨论了多个积云对流方案集成在东亚夏季风降水模拟中的作用,指出集合方案能很好地模拟出东亚副热带雨带及其季节演变特征。An[9]指出 ENSO对 PDO(Pacific Decadal Oscillation)的预报具有重要的作用。Zheng等[10]利用一个概率集合预报系统研究了近 120aENSO年际变化的集合可预报性。Jiang等[11]给出了条件非线性最优扰动在集合预报中的应用。Koyama等[12]指出集合卡曼滤波方法能够降低由于模式缺陷造成的预报误差。Tang等[13]利用多模式集合预报方法对 500 hPa位势高度场进行季节预报研究,发现多模式集合预报的潜在可预报性并不一定高于单个模式的潜在可预报性。热带地区实际可预报性接近其潜在可预报性,而中高纬度地区实际可预报性远低于其潜在可预报性,表明中高纬度地区季节气候预测还有很大的改进空间。Zhi等[14]讨论了北半球地面气温的多模式超级集合预报,在传统的固定训练期超级集合预报方法基础上,提出了滑动训练期超级集合

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预报思想,发现滑动训练期超级集合预报技巧明显高于传统的固定训练期超级集合预报技巧。

早在 20世纪 90年代中期,“可预报性障碍”就作为一个重要的科学问题引起了人们的重视,但到目前为止其物理本质还没有得到清楚的解释。Li[15]指出“可预报性障碍”在数值模式对大气环流系统的预报中同样存在,且不同的环流系统“可预报性障碍”出现在不同的季节。东亚大槽的“可预报性障碍”出现在夏季,中纬度环流系统的“可预报性障碍”出现在夏季和秋季,南亚季风系统和南海季风系统的“可预报性障碍”出现在冬季,并进一步指出“可预报性障碍”反映了系统的季节变化对预报结果的影响。Duan等[16]给出了条件非线性最优扰动方法(CNOP)在 ENSO事件“春季可预报性障碍”研究中的应用。

2 亚洲季风系统研究

亚洲季风是全球气候系统中的重要成员,其季节、年际和年代际变化特征显著,且与区域天气气候有密切联系。Jhun[17]讨论了东亚夏季风的长期变化特征,指出 20世纪 90年代中期东亚副热带急流附近 200 hPa纬向风速度有明显减弱的现象,而中国东南部降水明显增加。Huang等[18]也指出南海季风系统在 20世纪 90年代中期存在明显的年代际变化,1993年以前南海季风爆发相对较晚,1994年以后南海季风爆发较早,并且进一步指出这一变化可能与大气环流背景、季节内振荡和西北太平洋上空的热带气旋活动有关。Xiao等[19]指出东亚夏季风系统的年代际变化特征与太阳活动有紧密的联系。Ha等[20]分析了东亚夏季风季节内振荡的年代际变化特征与 ENSO的关系。Wu等[21]分析了中国冬季风系统的年际和年代际变化特征,指出南半球环状模对中国冬季风系统具有重要的影响。Park等[22]还给出了对应亚洲夏季风系统不同年代际变化特征,西北太平洋副热带高压的两种空间分布特征。此外,Mohankumar[23]还分析了亚洲夏季风的准两年振荡。Babu等[24]分析了冬季风盛行季节海洋大陆降水的季节内变化。

亚洲季风系统非常复杂,系统内的许多机制还不清楚。亚洲季风系统的模拟目前还存在许多问题,模式的模拟能力不成熟,其预报能力就不可能改善,因此对亚洲季风系统机理及其与气候系统之间的关系探讨仍将是一个重要研究课题。对季风系统模拟能力的提高有助于了解季风系统的变化特征及其影响机制,并能提高季风系统的预测能力。Kusunoki等[25]利用高分辨率大气环流模式对东亚夏季风系统进行模拟和预测,指出 2075—2099年黄海、日本海至日本东南部降水将会增加,东海海域降水将要减少。Fu等[26]讨论了初始场对于季风系统预报的作用,指出模式初始场中季风季节内振荡振幅提高,模式对季风系统的可预报性将增加,预报时效将延长。Tam等[27]讨论了对流参数化方案和海气耦合模式在东亚夏季风变化模拟中的作用。

季风与环流系统、海洋以及陆地有紧密联系。He等[28]分析了 4—5月期间南亚高压的再建立过程及其可能机制,指出亚洲大陆南部非绝热加热的变化是造成南亚高压 4—5月再建立的主要原因。他们还发现,孟加拉湾—印度支那半岛夏季风及南海季风对南亚高压的再建立过程起着重要作用。Yim等[29]分析了厄尔尼诺东太平洋和中太平洋型对亚洲—西北太平洋季风的作用,指出夏季中太平洋厄尔尼诺与东亚季风存在很强的相关性。Pattanaik等[30]分析了植被和土壤湿度对印度季风模拟的影响,指出在模式中加入高质量的植被和土壤湿度分布有利于更好地模拟印度季风。季风降水与 ENSO亦存在紧密联系。Wang等[31]分析了东亚降水异常与 ENSO之间的关系,指出准确预报 ENSO的演变对于预报与 ENSO密切相关的初夏和盛夏东亚降水的异常非常重要。

3 气候变化及亚洲大洋洲热带气候灾害

近年来国际社会高度重视全球气候变化及其对社会经济的影响。IPCC第四次评估报告指出,1906—2005年全球平均地面气温的 100 a线性趋势达到 0.74 ℃,预估到 2100年全球平均地面气温将升高 1.1～6.4 ℃[32]。平均温度上升的同时将伴随着极端天气气候事件频率和强度的显著变化[33]。Chan[34]分析了全球气候变暖对热带气旋活动的影响,指出热带气旋变化取决于在其形成的海域内是动力因子还是热力因子起主导作用,如热力因子起主导作用则气候变暖会使得该区域的热带气旋活动频率和强度增加。Sugi[35]简述了对热带气旋模拟的改进工程,指出要提高热带气旋的模拟能力必须对其形成机制作进一步研究,对模式进行改进,尤其是对积云对流参数化方案进行改进。Feng等[36]研究指出 1951年以来西北太平洋台风的产生具有显著的年际和年代际变化特征。近些年来,极端天气

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气候事件频发,对极端事件的研究也日益增加。Kim等[37]对 1994年夏季东亚热浪的天气特征进行了分析讨论。Zhou等[38]和 Zhang等[39]分别对 2008年初中国南方低温、雨雪和冰冻灾害的特征进行了分析,指出中高纬度阻塞形势持续异常及南海的热源异常可能是造成此次冰冻灾害的主要原因。在对极端天气气候事件的研究中,使用准确详细的高分辨率资料非常关键。美国国家气候数据中心的 Diamond等[40]介绍了国际最优气候管理路径档案(B-TrACS),这是一个更加全面、可靠的资料集,对热带气旋的研究非常重要。

4　中层大气与气候的关系

20世纪以来大气科学界逐渐认识到平流层和对流层是相互耦合、相互作用的完整的系统。Charney等[41]对行星波的垂直传播条件进行了深入研究,指出只要纬向平均气流为西风并且小于某一临界值(Rossby临界速度),对流层的行星波就能垂直传播到平流层中。Scaife等[42]讨论了平流层对地面气候的作用,指出在季节尺度上,欧洲区域对流层天气变化落后于平流层爆发性增温。在年际尺度上,平流层对厄尔尼诺、准两年振荡和热带地区的火山爆发都具有遥响应。Chen等[43]讨论了平流层变化对中国地面气温的影响,指出前期平流层中高纬度环流场对中国冬季地面气温影响十分显著。Li等[44]指出平流层环流异常通过北极涛动对东亚夏季风期间的梅雨产生影响。Inoue等[45]讨论了平流层准两年振荡与亚洲秋季对流层环流的关系。Mbatha等[46]分析了平流层爆发性增温对中间层、热成层低层区域的耦合作用,指出中间层、热成层低层的平均纬向风转向超前平流层爆发性增温 7d左右。Bar等[47]和 Kahya等[48]分别对安卡拉地区臭氧的变化特征进行了分析,指出臭氧存在显著的年际和季节变化特征。平流层大气环流异常对对流层具有显著的影响,并且平流层大气的异常对天气气候的影响具有显著的超前性,对异常天气气候的预报有重要的指示意义。从目前的研究结果看,平流层大气异常对于对流层异常的作用已经受到学者们的高度关注,但研究大都集中在平流层大气异常对地面天气气候异常影响的特征,而对其影响机制的讨论还不够全面、清楚。

5　卫星资料及其应用

常规测站观测方法受到观测站点的分布及观测时间的限制,许多气象信息不容易捕捉到,这就影响到对一些测站稀少地区天气气候特征的准确可靠的分析。气象卫星从外层空间观测地球表面和大气层,居高临下,观测区域广,观测频次高,可对地球进行大范围的动态观测,因此对气象卫星资料和卫星产品进行开发利用已成为气象领域的一个热点问题。Oki等[49]介绍了日本与美国合作的全球降水测量(Global Precipitation Measurement, GPM)的卫星观测工程,作为 TRMM(Tropical Rainfall Measuring Mission)的延伸工程,GPM能获得更加准确、全面的全球降水观测资料。日本太空发展署将制作并实时发布 3 h全球降水图。Shimizu等[50]讨论了 GPM产品在地面数据验证方面所用的一些计算方案,主要介绍了 DPR(Dual-frequency Precipitation Radar)算法的发展。青藏高原作为世界"第三极"对全球气候变化的作用意义重大。然而,由于高原上环境恶劣、测站稀少,缺少观测资料,这为当地区域天气气候的研究带来了许多问题。卫星资料的应用为学者们对这一地区天气气候变化的深入研究奠定了基础。Singh等[51]利用 TRMM资料对青藏高原中部地区夏季降水的日变化特征进行了分析,指出夏季青藏高原的山、谷、湖泊等地区都存在显著的降水日变化特征,山地日降水的峰值一般都出现在傍晚前后,谷地和湖泊附近的峰值则出现在深夜。

从 2007—2008第四次国际极地年(IPY)开始国际科学界更加关注极地气候变化及其与海洋、陆地、大气之间的相互作用,Formosat-2和 Formosat-3卫星遥感被用于对极地环境的探测。Liou等[52]利用 Formosat-2和 Formosat-3卫星观测极冰随时间演变的特征和测量大气廓线,并对极地地区大气重力波的气候学特征进行了讨论。Yen等[53]介绍了目前 Formosat-3/COSMIC项目的研究成果,并讨论了此项工程的一些延伸计划。

6　结语

在亚洲大洋洲地球科学学会第六届学术年会上各国气象学者报告了其最新的大气科学研究成果。气象学报告内容反映了目前国际大气科学界普遍关注的研究热点。

季风作为一个经典的研究课题仍受到广大学者的关注。季风系统与大气、海洋以及陆地之间有密切联系。在全球气候变化的大背景下,季风的年代际变化特征及其对天气气候的影响以及可能成因是目前研究的热点问题之一。对亚洲季风系统形成机

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制的探讨及其与气候系统关系的研究有助于提高数值模式对季风系统的模拟能力,从而能够更好地预测季风系统及其演变。

集合预报的研究受到各国学者的普遍重视,特别是多模式超级集合预报方法也已引起人们的广泛兴趣。多个积云对流参数化方案的集成、条件非线性最优扰动法、集合卡曼滤波以及滑动训练期超级集合预报技术对数值天气预报的准确率都有明显改善。"可预报性障碍"在数值模式对大气环流的预报中同样存在。对于不同的环流系统,其"可预报性障碍"出现的季节不同。"可预报性障碍"本质上反映了系统的季节变化对预报结果的影响。平流层大气异常对地面天气气候的变化具有明显的预示性,加强其影响机制的讨论有助于提高短期气候的预测能力。

热带气旋频率和强度的变化取决于在其形成的海域是动力因子还是热力因子起主导作用,如热力因子起主导作用则气候变暖会使得该区域的热带气旋活动频率和强度增加。研究还指出,阻塞形势的持续异常及南海的热源异常可能是造成 2008年初中国南方低温、雨雪和冰冻灾害的主要原因。

近来,美国国家气候数据中心推出了最新的热带气旋路径数据集,为热带气旋的研究提供了更加全面、真实可靠的数据。日本太空发展署的全球降水测量(GPM)卫星观测工程能提供更加准确、全面的全球降水观测资料。Formosat-2和 Formosat-3卫星被用于观测极冰随时间演变的特征和测量大气廓线。这些观测资料的使用将极大地提高数值天气预报、气候监测和空间天气预报水平。

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