1988～1998 年北半球积雪时空变化特征分析*

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摘　要　利用 NOAA 提供的北半球近 10 年（1988～1998）逐周雪盖观测资料，通过引入年或季节累积雪盖周数作为对雪量累积情况的定量衡量，对北半球雪盖变化时空特征进行了分析。结果表明：近 10 年来，北半球积雪年际变化的关键区位于青藏高原、蒙古高原、欧洲阿尔卑斯山脉及北美中西部，其中青藏高原是北半球积雪异常变化最强烈的区域。青藏高原和欧亚大陆其他地区积雪变化的关联表现为两种不同的时空变化型，第一种型表现为青藏高原地区和其他地区（如欧洲、俄罗斯远东地区）积雪的同位相趋势性增多；第二种型表现为青藏高原地区和中亚地区积雪变化同位相，而和蒙古高原—我国东北地区积雪变化反位相的年际振荡。

关键词：积雪；北半球；青藏高原

1　引言

冰雪圈是气候系统中较为活跃的成员，对区域乃至全球气候的形成及异常的维持与发展起着重要作用。冰雪覆盖分为冰盖和雪盖，其中雪盖对气候的影响表现为两方面[1]：一是反照率效应，二是积雪-水分效应。研究表明[2]，春季在低纬地区尤其是青藏高原，反照率的影响是主要的；相对而言，夏季中高纬度地区积雪-水分效应是主要的。由于雪盖对大气总是起冷却作用，因此它可以延缓季节的转换。

已有一些研究分析了北半球雪盖变化的时空特征，例如，Maston 等[3,4]分析了 1967～1981 年间北半球冬季雪盖面积的年际变化特点；李培基[5]分析了 1951～1980 年我国雪量的变化特征；Groisman 等[6]利用 1972～1992 年雪盖资料分析指出，北半球积雪范围有全球性的向高纬撤退的趋势；翟盘茂和周琴芳[7]使用类似的资料分析指出，20 世纪 70 年代雪盖范围明显扩张，而 20 世纪 80 年代雪盖范围正逐步收缩。

上述研究大多使用的是 20 世纪 80 年代及其以前的资料，对近 10 年来积雪变化的分析还很少。但从全球气候变化特征来看，近 10 年来气候变化具有新的特点，例如，全球背景增暖显著，El Niño 事件频繁发生等。另外，过去对积雪的研究主要集中在高纬区域，对位于较低纬度的青藏高原雪盖及其和高纬度大范围雪盖之间的关系没有足够的重视。本文分析将特别考虑包括青藏高原在内的北半球雪盖变化的时空分布，并使用

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近10年来的观测资料。相对于前人研究使用的数据，本文数据具有年代独立性，从而使得本文结果具有与以前年代结果的可比较性。同时，本文将引入"累积雪盖周数"的概念来描述雪盖的累积效应。

2 资料和累积雪盖周数

本文使用的北半球积雪数据资料由美国NOAA的国家环境卫星数据及信息服务（NESDIS）和国家环境预报中心（NCEP）提供，它是近11年（1988～1998）北半球$2^{\circ}\times2^{\circ}$经纬网格点上的逐周积雪资料，数值以1和0标记（网格点有雪的值为1，无雪则为0）。其中，除1992年为53周、1998年为50周外，其余年份皆为52周。

雪盖是瞬时天气出现降雪后形成的，但其对大气的影响却是缓慢的，雪面一反照率正反馈机制使得雪盖一般不会快速融化，而雪盖缓慢融化增湿土壤的水分效应又具有明显的持续性，因此，雪盖的气候效应与降雪的累积情况有很大关系。

为了定量衡量雪盖的累积情况，在每一个格点上定义了两种指数，即年累积雪盖周数和季节累积雪盖周数。年（或季节）累积雪盖周数是指一个积雪年（或季节）内有雪盖的总周数。一个积雪年并不是通常的日历年，而是一个包括降雪、积雪、融雪阶段的自然年。在北半球，降雪一般始于秋冬季，而大范围融雪一般在冬春季。因此，一个积雪年被定义为从一个日历年的第27周开始，到次年的第26周结束。为了计算季节累积雪盖周数，又将一个积雪年分为三个季节：（1）秋季（一个日历年的第27周到第48周，共计22周）；（2）冬季（该年的第49周到下一年的第9周，共计12周）；（3）春季（下一年的第10周到第26周，共计17周）。在上述定义的一个积雪年（或季节）内，在每个格点上对有雪的周数进行累加，即可计算出每个格点的年（或季节）累积雪盖周数。

3 积雪的时空变化

3.1 10年平均分布及其季节变化

图1给出了10年平均的年累积雪盖周数和三个季节累积雪盖周数的空间分布。从10年平均的积雪年来看（见图1a），年累积雪盖周数的分布基本上是纬度的函数，并且随纬度的增加而递增，在接近北极的高纬度大片区域（如西伯利亚、加拿大北部和阿拉斯加等）年累积雪盖周数达26周（超过半年）以上，而像格陵兰岛等特殊区域则终年为雪盖（年累积雪盖周数为52周）。然而，例外的是，位于中低纬度的青藏高原地区则也是年累积雪盖周数的高值区，除极少数点为终年雪盖外，也有相当范围的累积雪盖时间超过半年。

冬季（见图1b）在西伯利亚、加拿大北部和阿拉斯加等大范围高纬地区累积积雪时间为12周，这意味着这些区域的冬季（12～2月）始终为积雪覆盖。秋、春两季为介于冬夏之间的过渡时期，其中，秋季主要为积雪的开始阶段，而春季主要为积雪的融化阶段。这两季的累积雪盖时间相对较短（见图1c和图1d），其中在秋季阶段，大范围累积积雪时间为2～8周，而在春季，则大范围累积积雪时间为2～14周。青藏高原

为两种不同的时空变化型，第一种表现为青藏高原地区和其他地区（如西欧、俄罗斯远东地区等）积雪的同位相趋势性增多．第二种表现为青藏高原地区和中亚地区积雪变化同位相、而和欧洲、蒙古高原—中国东北地区积雪变化反位相的年际振荡。这两种积雪变化型的相互叠加使得某些年积雪异常减少（如 1991／1992 年、1992／1993 年）、某些年的积雪又异常偏多（如 1997／1998 年）。

由于本文使用的雪盖资料仅为最近 10 年，对雪盖年际变化分析的结果局限于 20 世纪 90 年代，因此有必要将本文结果和以往研究作一简要比较。（1）总体而言．本文得到的最近 10 年北半球雪盖变化的关键区与前人根据以前资料分析得到的类似，但本文分析表明，最近 10 年来，青藏高原地区是北半球年际变化最强烈的区域；（2）以前的资料分析显示北半球雪盖范围自 20 世纪 70 年代到 80 年代存在一种缩小趋势，但本文分析表明，最近 10 年来，青藏高原和欧亚许多地区的年累积积雪时间表现为趋势性增长，北半球积雪变化趋势存在着年代际差异；（3）以前研究表明，高纬度的雪盖（欧亚雪盖、北美雪盖）变化基本具有同位相性，并且这种变化具有年代际时间尺度特征，但本文分析指出，除了和年代际尺度相联系的趋势性变化外、最近 10 年来、青藏高原和中亚地区积雪变化与欧洲、蒙古高原—中国东北地区积雪变化可以呈反位相变化，这种变化主要集中在年际时间尺度。

北半球雪盖趋势变化的原因是复杂的．其中既涉及人类活动引起的全球增暖过程，又与气候系统本身的自然变化有关：一些研究把自 20 世纪 70 年代末期到 80 年代的北半球大范围雪盖萎缩归因于全球增暖。但积雪变化与气候系统自然变化也有某种联系，其中，海洋大气相互作用产生的 El Niño 现象与北半球积雪之间也存在关系。Groisman 等人的研究[6]表明，El Niño 总伴随着北半球秋、冬季积雪增多。因此，本文得到的结果，即 20 世纪 90 年代以来青藏高原等北半球许多地区积雪趋势性增多，可能与近 10 年来 El Niño 频繁发生有很大关系。事实确实表明，一个世纪以来最强的 1997／1998 年的 El Niño 事件期间，青藏高原等地区积雪也极端偏多，测站资料也明确地显示了这一特征。

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An Investigation of Temporal and Spatial Variations of 1988～1998 Snow Cover over the Northern Hemisphere

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