EMERGING GLOBAL ISSUES THAT IMPACT THE FUTURE OF NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES

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John W Zillman

(Presentation at NWS (National Weather Service) International Session on "Emerging Issues and New Technologies Impacting National Meteorological and Hydrological Services", Westin Hotel, Long Beach, California, February 6-7, 2003)

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SUMMARY

The forces of weather and climate have shaped the development of civilisation and determined the patterns of habitation, shelter, safety, travel and food and water supply since humans first walked the earth. Meteorological and hydrological service provision is as fundamental a requirement of modern society as the basic laws and norms of society itself. The world has been well served by the progress of meteorological and related science and its application over the past hundred years and especially by the institutional structures that have been put in place for international cooperation in atmospheric, oceanographic and hydrological data collection, research and service provision. The science and practice of meteorology can legitimately claim to be one of the great success stories of the twentieth century. But, over the past few decades, the world has been going through a period of questioning or outright rejection of many of its established values and practices and the World Meteorological Organization (WMO) has been focusing a major effort on exploring the implications, for meteorological and related service provision, of the profound scientific, technological, social, economic and political changes taking place in the wider world; and attempting to assist its Member countries and their National Meteorological and Hydrological Services to chart a course through the current turbulence and provide a sound and robust framework for essential environmental science service provision in the early decades of the twenty-first century. This has brought the WMO community face to face with such difficult geopolitical issues as economic globalisation, foreign and homeland security, global poverty eradication and international trade in services; and such complex social and public policy considerations as trust, equity and blame; as well as into much deeper involvement with such legal and administrative matters as competition law, intellectual property protection, quality certification and performance management and reward. This presentation attempts to draw together some of the key results of recent work on these issues and to outline the essential elements of a robust strategy for the future development of National Meteorological and Hydrological Services and their relationship with the academic, media and meteorological and hydrological private sectors within the framework of the WMO.

1 INTRODUCTION

The human fascination with weather and climate and the demand for more and more reliable meteorological and related environmental information as a basis for planning and management of almost every aspect of daily life have continued to expand in the closing decades of the twentieth century and show no signs of waning in the twenty first. Indeed, the demands on meteorology and on meteorological institutions for more, and more accurate and useful, data, scientific understanding and service provision are continuing to increase rapidly at global, regional, national and local levels (Zillman, 2001a). But, while the science and technology needed to satisfy the demand and meet the ever-increasing community expectations for more individually focussed information have continued to advance rapidly and in many potentially rewarding new directions, the past few decades have also brought a

period of profound dislocation of the public policy basis of meteorological and related service provision in many countries. I believe it is fair to say that some of the developments of the closing decades of the twentieth century have dampened our earlier optimism on the prospects of delivering the full potential of scientific and technological progress in the advanced countries and of quickly bridging the historical gap to the standard of meteorological service provision possible in the developing world.

This disappointing and distressing situation is largely the product of a series of global economic policy shifts and the emergence, in both developed and developing countries, of a public policy environment which is far less supportive of the highly successful model of international cooperation in national meteorological service provision that brought such widespread benefits to the global community through most of the twentieth century. The foundation of that success was the concept of the professional, government-funded, National Meteorological Service working within an international framework of cooperation, mutual support and free exchange to provide the essential basic national meteorological infrastructure and public information, forecast and warning services to its national community; as well as to provide the essential foundation for the work of the research community in pushing forward the frontiers of knowledge; and for the commercial meteorological sector in producing a wide range of special services for weather and climate sensitive industries, businesses and individuals.

These developments have shaken the basic architecture of international meteorology to its foundations. Even the basic building blocks of international meteorological cooperation and national service provision have been called into question and, in some countries, have suffered serious damage. Many NMSs have, quite literally, been stopped in their tracks on their earlier highly promising road to progress.

Over the past decade or so, the World Meteorological Organization has focussed a major effort on its study of the implications of these emerging issues and on helping countries, individually and collectively, to steer a steady course through the current period of turbulence in national and international meteorological service provision; and on establishing a more secure and robust intellectual, economic and public policy framework for meteorological, hydrological and oceanographic service provision in the decades ahead.

The purpose of this paper is to attempt to provide some new insights into the major forces and influences that have brought us to where we are, to summarise the current situation of National Meteorological and Hydrological Services (NMHSs) around the world and to assess the implications of some of the major emerging issues that seem likely to impact on the future role and operation of NMHSs and their academic and private sector partners over the next decade. Finally, I will set down some personal views on the best strategy for the way ahead.

2 THE BUILDING BLOCKS

The established framework for meteorological service provision around the world was based on the concept of government-funded and operated National Meteorological Services (NMSs) working within a structured and coordinated system of international cooperation under the auspices of the intergovernmental World Meteorological Organization (WMO) to maintain the essential basic meteorological infrastructure over the territory of its Member countries as well as over the extra-territorial oceans and Antarctica; and to provide both the basic meteorological services required by national communities and those required for the safety and efficiency of international shipping and civil aviation.

It is useful to briefly examine the essential features of the building blocks of this framework as a point of departure for an analysis of the impact of the changing world on the international system of cooperation and on the national systems of service delivery in the individual countries.

The concept of the NMS

The National Meteorological (or Hydrometeorological) Service (NMS), operating under a range of titles from 'Weather Bureau' to 'Hydrometeorological Institute' and with either a service or a research focus, or both, has long been an established component of the basic infrastructure of developed countries and one of the key scientific institutions put in place by colonising countries and retained by the governments of newly independent states. Although the essential features of the NMS role go back to the nineteenth century and the IMO (International Meteorological Organization) era of collaboration through non-governmental mechanisms, the NMS concept became more clearly defined during the first thirty-five years of the WMO period of intergovernmental cooperation from 1950 to 1985.

Interestingly, however, despite the large amount of shared experience among countries and the resulting high level of commonality in the structure and concept of operation of NMSs around the world, there is relatively little literature on the basic role and operation of the typical NMS (Zillman, 1999). A simple overview of the place of the NMS in national and international meteorology, including an analysis of both the traditional model and some alternative approaches to service delivery, was issued by the WMO Executive Council in April 1999 (WMO, 1999a). In recent years, the series of WMO Technical Conferences on the Management of Meteorological and Hydrological Services have focussed on issues such as the mission, legal basis, structure, funding and staffing of NMSs.

One of the more remarkable features of the history of the development of the NMS and its place in the work of the WMO is that nowhere in the Convention of the World Meteorological Organization, or in the Regulations (WMO, 1999b), is there any explicit description of the role of the NMS at the national level. Historically, this was seen as very much a matter of national prerogative and beyond the legitimate concerns of WMO as an international organisation. However, by the time of the Thirteenth World Meteorological Congress in 1999, sufficient concern was felt about the pressures that NMSs were coming under in most countries that the Congress chose to issue the 'Geneva Declaration' to underscore the importance of the NMS role in the following words (WMO, 1999c): "We *REAFFIRM* the vital importance of the mission of the national Meteorological and Hydrometeorological Services in observing and understanding weather and climate and in providing meteorological and related services in support of national needs".

This led on to a Congress request to the incoming Executive Council for a range of follow up activities related to the role and operation of National Meteorological and Hydrological Services (NMHSs) leading, in turn, to the establishment of an Executive Council 'Advisory Group on the Role and Operation of National Meteorological and Hydrological Services which has taken the lead role within WMO over the past three and a half years. Two particularly important initiatives of the Advisory Group have been the development of a draft Executive Council Statement on the Role and Operation of National Meteorological Services (WMO, 2003) and the development of a consolidated set of Guidelines on the Role and Operation of National Meteorological Services (now in preparation).

The concept of the NHS

Unlike the NMS, which is a well accepted component of the national infrastructure of almost every country, the concept of a National Hydrological Service (NHS) is far less well developed and the operation of an NHS as a single national institution is limited to a significantly smaller group of countries. Although the recent work of the Executive Council Advisory Group and of the WMO Commission for Hydrology has tended to bring out many parallels between NMSs and NHSs, river monitoring, modelling, prediction and warning is usually a much more decentralised function, is often the responsibility of local or regional rather than national government, and is often coupled with the actual management of the water resource. The NHS must thus be expected to face many policy and operational issues of a different kind from those which confront the typical NMS.

The best recent survey of the role and operation of national hydrological services is that prepared by Mosley (2001) on behalf of the WMO Commission for Hydrology and based, to some extent, on the parallel work for NMSs carried out under the guidance of the Executive Council Advisory Group.

The WMO framework of cooperation

Although the unique features of global cooperation in meteorology, that set it apart from almost every other field of international relations, go back to the 1800s and took shape in the non-governmental IMO era from 1873 to 1950, they did not achieve intergovernmental status until the coming into force of the Convention of the World Meteorological Organization (WMO) which was established "…with a view to coordinating, standardizing and improving world meteorological and related activities, and to encouraging an efficient exchange of meteorological and related information between countries in the aid of human activities" (WMO, 1999b).

The essential features of the WMO framework of cooperation which held together strongly through the Cold War period and survived a host of challenges over the past fifty years have been: the professional commitment of the WMO community to the application of meteorology for the good of humanity, largely free of influence from the political interests of individual nations; the involvement of both the governmental and nongovernmental meteorological communities of Member nations in the work of the Organization; the governance device of ensuring that the Officers and members of the Executive Council of WMO represent the interests of the Organization as a whole rather than those of the individual countries from which they come; and, most importantly of all, the recognition that all countries and all citizens stand to gain the greatest benefit from a system of cooperation in which every country contributes voluntarily to the common pool of data and knowledge, primarily on the basis of what it has to do for strictly national purposes, with it and every other nation then free to draw from the common pool.

More than fifty years after the coming into force of the WMO Convention and despite many challenges along the way, the basic features of the WMO system of international cooperation remain valid, effective and robust.

The convention of free exchange

Though it was never explicitly written down because, some believe, the founding fathers of WMO considered it was self-evident, the most fundamental principle of WMO cooperation is that of free and unrestricted exchange of meteorological and related data and products between

Members, and especially between their NMSs, to enable the best possible weather and climate services to be provided, at minimal cost, in every country.

The feature of this convention that enabled it to work so well for so long, was the understanding that every NMS receiving data and products from another NMS would use them only for the purpose of discharging its own obligations to its national community or for carrying out agreed international responsibilities on behalf of all countries. It was always accepted as critically important to the stability of this system of cooperation that no NMS would use the information received from another country to, in any way, impair the work of the originating NMS in the discharge of its national responsibilities within its own territory.

The pressures to which this fundamental principle of WMO have been subject over recent decades and the developments which hold promise of its more robust incorporation into international law and, importantly, its extension to essential data and products from meteorology's sister sciences of hydrology and oceanography, will be explored, in a little more detail, a little later.

The economic framework for service provision

It may be useful, at this point, to attempt to identify the most fundamental common features of the established system of meteorological and related service provision around the world. In both a national and international context, it is important to distinguish between three essential components of a total national meteorological service system as follows (Figure 1):

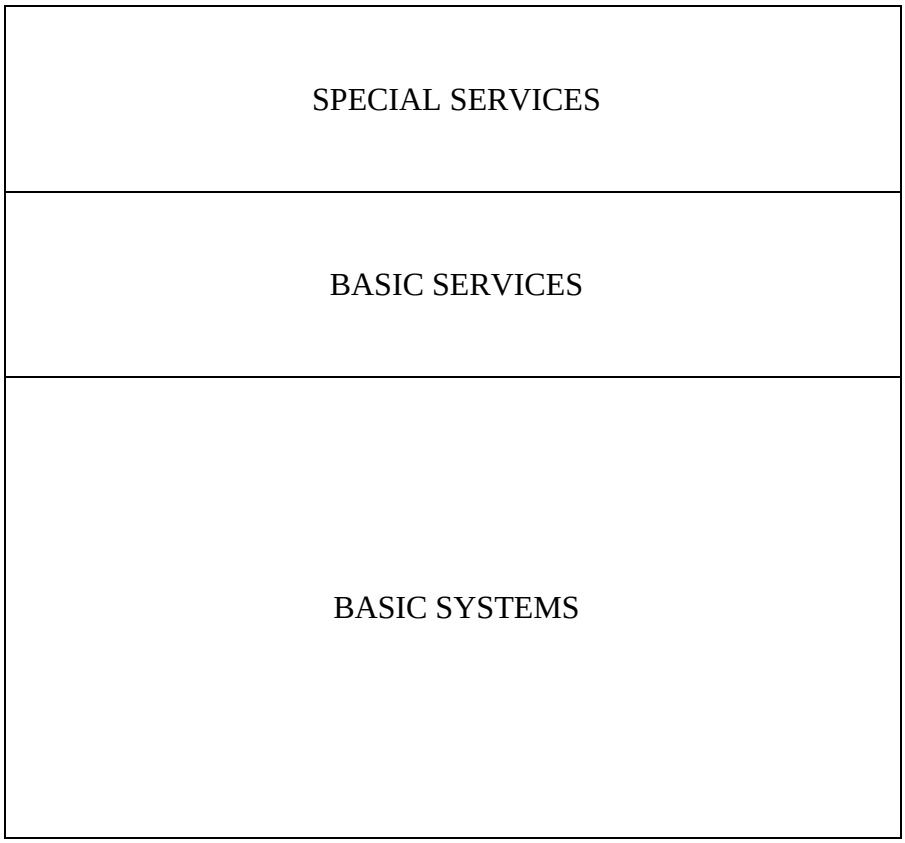

Figure 1 A schematic representation of the three essential components of a total national meteorological service system. The basic systems (observation networks; data collection and dissemination systems; and analysis, modelling and forecasting infrastructure) underpin the provision of both the basic services provided to the community at large and the special (value-added) services to individual users and customers.

- Basic Systems: the basic national data collection and processing infrastructure of an NMS which underpins the full range of services provided at the national level and which may itself be a basic service to present and future generations;
- Basic Services: those services provided by an NMS in discharging its government's sovereign responsibility to protect the life and property of its citizens, to contribute to their general welfare and the quality of their environment, and to meet its international obligations under the Convention of the World Meteorological Organization and other relevant international treaties and agreements; and
- Special Services: those services, beyond the basic services, which are provided to meet the special needs of individual users or user groups, and which may include the provision of special data and products, their interpretation, distribution and dissemination, along with special purpose investigations and consultative advice.

When account is taking of the part that each of these play in the ultimate delivery of services to the general community of users of the basic services and the (usually paying) customers of the special services, it is helpful to conceptualise the operation of the total national meteorological service system (consisting of both the NMS and the private and/or public sector suppliers of special services) and its relationship with the consolidated international infrastructure of the WMO World Weather Watch in the slightly more detailed form shown in Figure 2.

The fundamental issue in meteorological service provision at the national level is who should provide the underpinning infrastructure and the various types of service, how should they be funded and who should pay. Historically, there has been fairly general acceptance that government would fund the basic infrastructure and essential public services and the provision of special services would be done by the NMS (taking advantage of economies of scope and scale) or by the international or national private sector or by both (or through some other arrangement such as a government-owned company). In some countries, where there was essentially only one user/customer sector (eg the aviation industry) and appropriate cost recovery arrangements could be put in place, both the infrastructure and the special (ie aviation) services have been funded from air navigation charges and any basic (public) services that were provided were seen as a free spin-off to the community. But the situation in each individual country has been, at least until the 1980s, essentially a legacy of its origin and historical development.

Recent attempts to provide a more rigorous and generally applicable economic framework for considering issues related to the provision, funding, and charging for meteorological services (Zillman and Freebairn, 2001; Freebairn and Zillman, 2002 a,b; WMO, 2002a) have drawn on the economic theory of public goods (Cornes and Sandler, 1996; Stiglitz, 2000a) and, in particular, in the context of international cooperation in meteorological data collection, research and service provision, global public goods (Kaul et al, 2000; Gunasekera and Zillman, 2003).

In very brief summary, goods and services are categorised by economists according to two important properties – rivalry in consumption and excludability (Stiglitz, 2000a):

- A good is rivalrous if one person's consumption of it means that it cannot then be used by another (eg an ice cream). It is non-rivalrous if one person's consumption of it does not detract from its availability for use by others (eg a weather forecast); and, once supplied for one person, the marginal cost of its availability for use by others is zero;

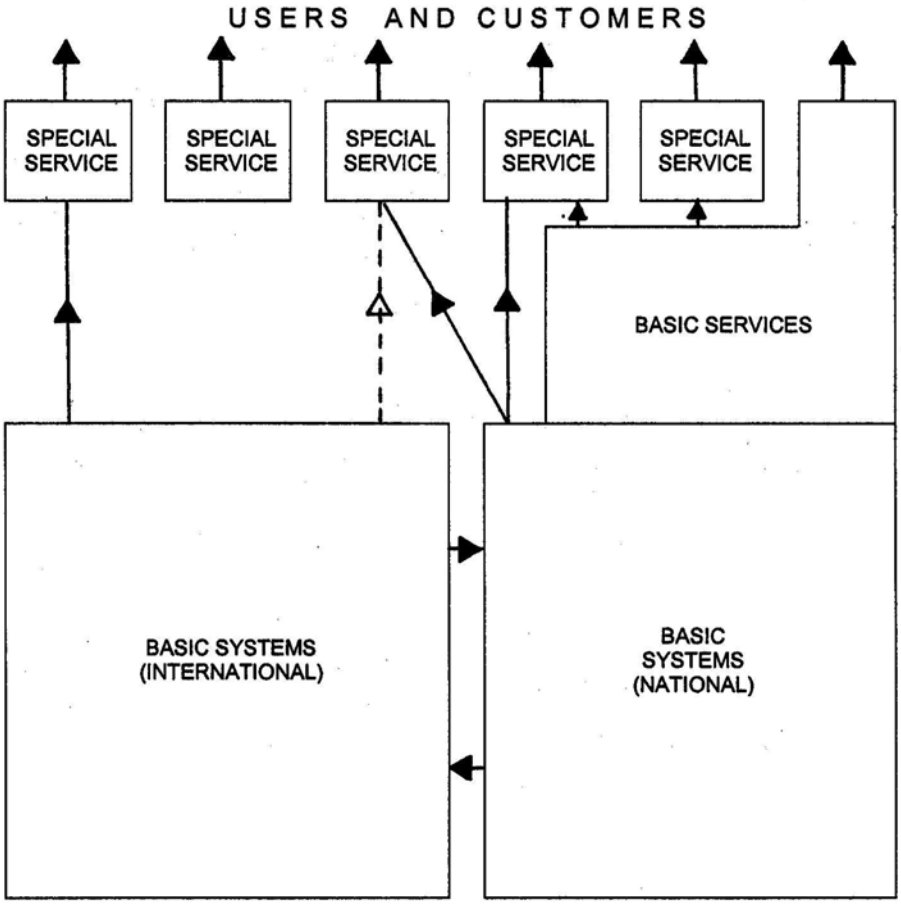

Figure 2 A more detailed representation of the total national meteorological service system highlighting the interchange of data and products between the NMS and the rest of the international meteorological data collection and service system; and the various channels through with the (public or private sector) providers of user-specific special services may draw on both the national and international data flow and the basic service itself to provide the services needed to meet client/customer needs. The provision of a special service may involve additional purpose-specific data collection and processing on top of that made available through the basic national and international data collection and processing systems of the World Weather Watch and the official national meteorological service system. The situation in which a service is provided without any recourse to basic data or products from national or international sources is also shown.

- A good is excludable if it is possible through technological, legal or other means to prevent someone from having it (eg a program on cable TV). It is non-excludable if it is impossible, or very costly, to prevent someone from accessing it (eg a weather forecast broadcast on public radio).

This system of categorisation leads to the definition of four important classes of goods and services as follows (Figure 3):

- Private goods which are both rival and excludable and which are usually efficiently provided through the operation of competitive market processes;
- Pure public goods which are both non-rival and non-excludable and which, because they cannot be withheld from non-payers, cannot be provided efficiently through market mechanisms;

- Club goods and natural monopoly goods (also referred to as impure public goods or mixed goods) which, while non-rival within a group (or club), or once provided to one, incur no additional cost in being made available to many, can relatively easily be withheld from those who will not contribute to their cost. An example of a club good is an entertainment facility. An example of a natural monopoly is a natural gas distribution system;
- Common resources (another form of impure public good or mixed good) which, while non-excludable, are rival in consumption (eg use of a freeway subject to congestion on busy days or use of public land for grazing cattle).

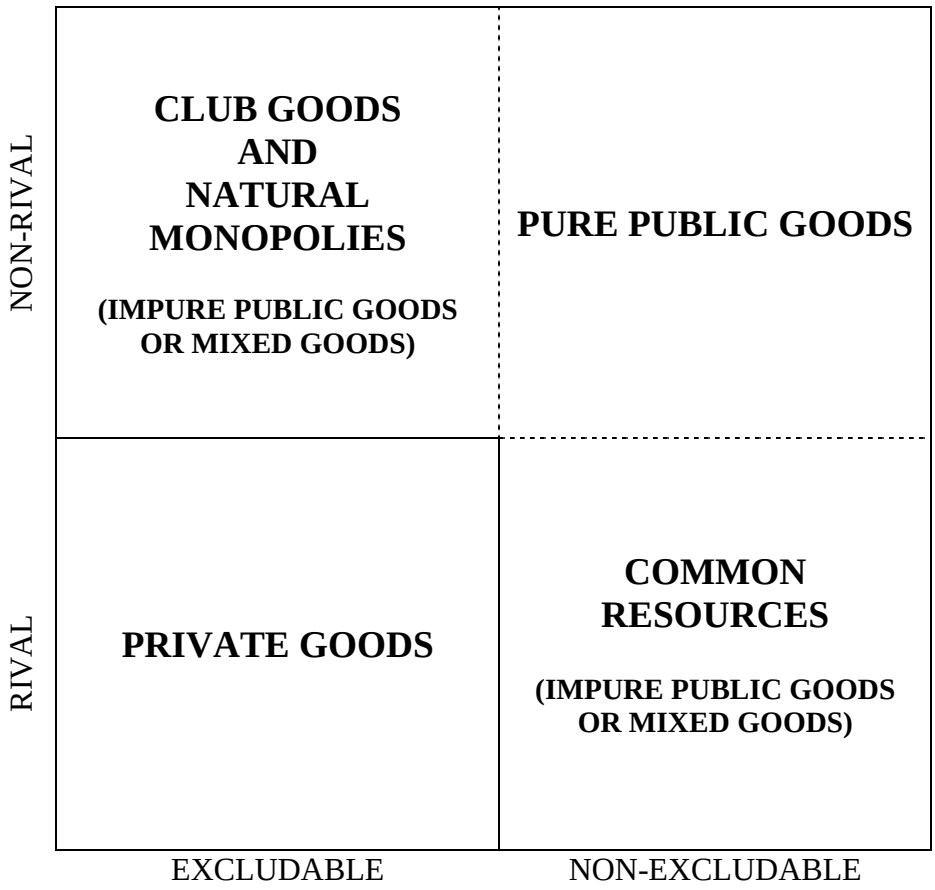

Figure 3 The rivalry-excludability matrix for the classification of goods and services.

Basic meteorological data and weather forecasts are intrinsically non-rival in consumption and, once freely exchanged or publicly broadcast, are, by definition, non-excludable and thus fall in to the category of pure public goods. They will, thus, not be provided, or at least will not be provided to socially optimal levels, by market processes. The provision of a wide range of basic meteorological systems and basic services falls in this category and hence the primary responsibility for their provision must reside with government. A feature of non-rival goods that has particular relevance in the case of meteorological services is that the total benefit to society from their availability is the sum of the individual benefits derived by all who use them.

Special services are, by definition, those that are provided to meet the needs of individuals or identifiable groups – where exclusion is usually possible (eg provision of access to a meteorological data network) although, in some cases, even though the service is rivalrous, exclusion may be difficult (eg climatological statistics for use in competitive air route design). They generally fall in the category of impure public goods or mixed goods for which some

form of cost recovery or market mechanism may be invoked to ensure efficient levels of supply.

Economics provides further useful guidance in the determination of the socially optimal level of investment in national meteorological infrastructure and service provision. In summary, the economically efficient level of service provision is that level at which the total (societal) benefits most greatly exceed the total costs of provision as shown schematically in Figure 4. In terms of assessment of the appropriate levels of investment in infrastructure (basic systems) and service provision (basic and special services), this is the level at which the marginal benefits and marginal cost curves intersect. The challenge, then, in providing answers to questions as to the optimal level of investment in the operations of an NMS becomes, in principle, that of determining the total or marginal benefits and cost curves of Figure 4.

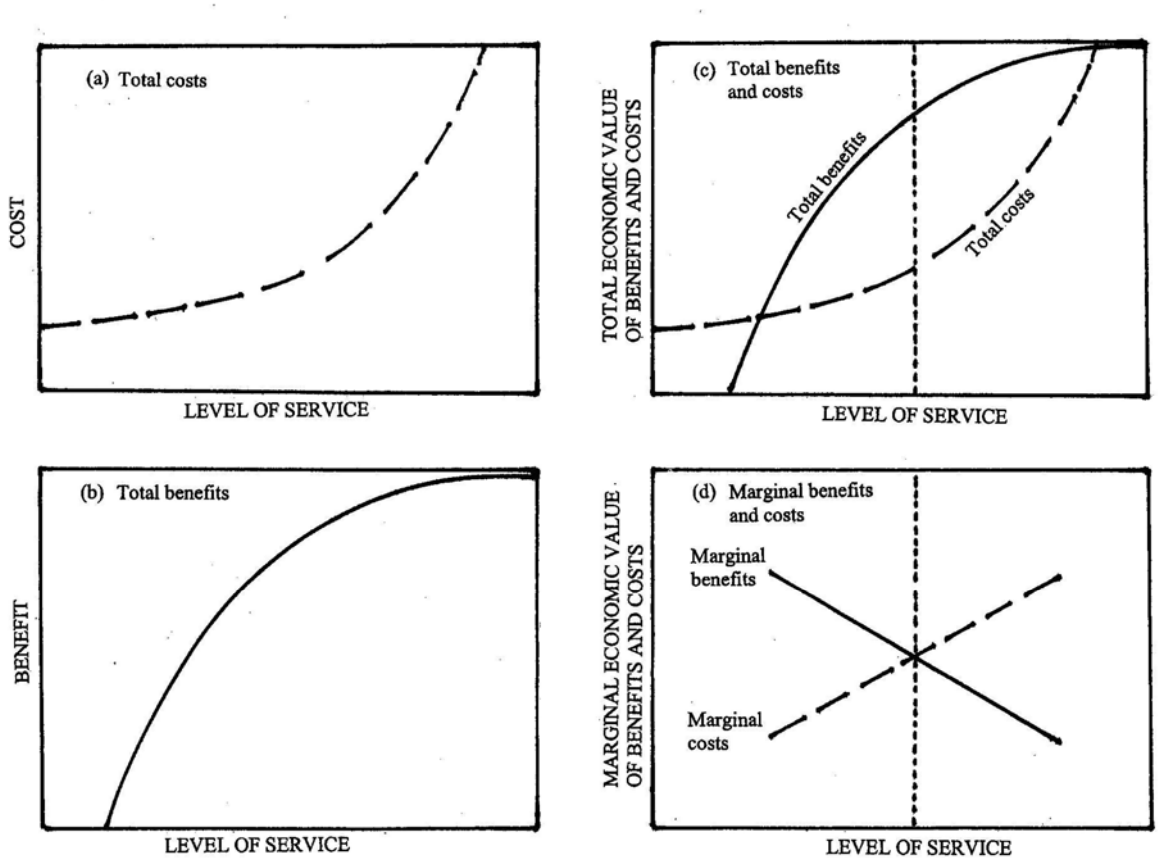

Figure 4 A conceptual approach to determination of the economically efficient level of meteorological service provision at the national level. The total cost curve (panel (a)) shows the need for a significant investment in basic infrastructure before any service can be provided and the scope for substantial increases in the level (quality and quantity) of service for little additional cost once the initial investment has been made; but at some point the cost curve becomes concave upwards as more and more resources must be invested to provide further increases in the level of service. The total benefits curve (panel (b)) shows that, once a certain level of service (quality and quantity) is available and users have developed confidence in its potential benefits for their decision making, the total benefits increase rapidly for small increase in the level of service until a point is reached where, no matter how good or extensive the service, the potential for further improvement in decision making is exhausted and the total benefits curve plateaus out. The combination of the total costs and benefits curves in panel (c) and the corresponding marginal costs and benefits curves (ie the slopes of the total costs and benefits curves) in panel (d) shows that the economically efficient level of service provision occurs at the point where the difference between the total benefits and costs is greatest and the marginal benefits and cost curves intersect.

3 THE DEVELOPMENTS OF THE 80s AND 90s

The 1980s were a very interesting period for the development of meteorological service provision at the national level in both the developed and developing countries. The decade began with the promise of major progress in both observational and forecasting capabilities in the wake of the Global Weather Experiment or First GARP Global Experiment (FGGE) of 1979 and the commitment within the WMO community to incorporate the most successful outcomes of FGGE into the routine operations of the World Weather Watch. There was also considerable optimism at the prospect of harnessing sufficient international development assistance funding to proceed with accelerated modernisation of developing country NMSs and bridge the gap between the NMSs of the developing and the developed world. Such outcomes were identified as both the goals and the confident expectations of the WMO community in its first and second ten-year Long-term Plans drafted in the early and mid 1980s.

By the mid to late 80s, however, the changing approach to the role of government in several advanced countries was beginning to call into question the traditional mode of funding of NMSs and pressures developed for the generation of alternative funding sources through 'commercialisation'. In the early stages, it was not so much a case of NMSs being singled out for commercialisation as their getting swept up in more general national programs of commercialisation, corporatisation, outsourcing and privatisation of activities traditionally carried out by the public sector (Lane and Ersson, 2002). The pressures that this generated – resulting both from the desire or the need of some NMSs to try to sell data or products that they had traditionally made freely available, and from the more proactive belief of some NMSs in the benefits of competitive business models for the provision of government services – quickly surfaced in WMO and ushered in a period of increasing tension between those Services who were committed to the commercial route and those others, especially the US, who considered the provision of commercial user-specific services to be a proper role for the private sector rather than for the NMS.

The WMO responded by establishing an Executive Council working group on 'commercialisation', thus, for the first time, requiring the Executive Council to come to grips with the international implications of different approaches to the funding of service provision at the national level. As part of its attempts to counter the deepening rift within the WMO community, the Congress reinforced its commitment, through its Third Long-term Plan, to measures to avert the feared flow-on impact of impaired international exchange of data and products and established a new Public Weather Services Programme to strengthen the shared commitment of NMSs to their core public services to the community at large.

By the early 1990s, the philosophical gulf between the public interest and commercially orientated NMSs had developed to the stage where it was widely recognised that a serious threat existed to the very foundation of international meteorological cooperation and national service provision – the free and unrestricted flow of data and products (WMO, 1995) among all the Members of WMO. The attention of the Executive Council turned from the commercialisation issue as such to the more fundamental issue of how to maintain the international flow of data and products under the World Weather Watch. By the time of the lead-up to the 1995 Twelfth World Meteorological Congress, it was far from clear that this would survive and many NMSs began to brace themselves for the implications of an international meteorological data war.

As it turned out, the 1995 Congress succeeded in unanimously adopting its 'Resolution 40' committing the WMO community to the principle and practice of free and unrestricted

international exchange of essential data and products. Every bit as important as the commitment to continuing free and unrestricted data exchange in the body of the Resolution, was a set of Annexes which represented the achievement of a fragile consensus on a wide range of compromises relating to the relations among NMSs and between NMSs and the national and international private/commercial sector. While the conditions of Resolution 40, and especially those in its Annexes, were honoured more in the breach than in the spirit or the letter in some cases, the intensity of the emotional commitment of the Twelfth Congress to the basic principle of free and unrestricted exchange was sufficiently strong that the follow-up years were largely free of explicit threats to the future of international cooperation. But the underlying threats to the future of individual NMSs in many countries continued to increase. The focus of the WMO Congress and Executive Council turned back to the basic issues associated with the role and operation of NMSs.

4 THE CURRENT STATE OF NMSs AROUND THE WORLD

It is clear from even brief visits to NMSs, from discussion with NMS staff at international meetings and examination of the annual reports now prepared and distributed by many NMSs from both developed and developing countries that, while most Services feel clear and confident about their basic mission and consider that the level of awareness of their role and operation at the national level is high, almost all are currently beset by a bewildering array of issues and problems relating to funding, staffing, management, service delivery policy, user charging and the constant challenge of how to respond to the opportunities provided by scientific and technological progress in an environment of constrained or contracting public sector funding. These and many other issues came out clearly in intervention after intervention in a special unstructured plenary meeting on 'Major issues facing Members' convened at the beginning of the Fifty-second Session of the WMO Executive Council in June 2000.

In the light of the Executive Council discussion, its Advisory Group on the Role and Operation of NMHSs developed a comprehensive questionnaire which was trialled with the members of the Executive Council and distributed to all Member States and Territories in December 2000 to obtain a comprehensive assessment of the current state of NMSs around the world. The questionnaire sought detailed information on:

(a) National circumstances (geography and economy, impact of meteorological influences, organisation of meteorological activities, perceptions of public awareness etc);
(b) Basic information on the NMS (budget, staffing, leadership etc);
(c) Organisation and management (legal status, administrative arrangements, structure, management philosophy, planning and performance measurement);
(d) National goals served by NMS operations;
(e) National economic applications sectors served by the NMS;
(f) Warning services provided by the NMS;
(g) General scope of responsibilities of the NMS at the national level;
(h) Resources (internal allocation of funds and staff, funding sources, charging policy, staff composition and training);
(i) Composition and operation of NMS basic infrastructure;
(j) NMS facilities available for use by other NMSs;
(k) Main issues currently facing the NMS;
(l) Mechanisms for interaction with users;
(m) WMO-related matters (assessment of support received, priority for enhanced support, funding source for national contribution to the WMO Regular Budget).

From 185 Member States and Territories, a total of 128 responses was received as follows:

WMO Region	Members	Responses	Percent
I	52	27	52
II	32	24	75
III	12	10	83
IV	22	16	73
V	19	11	58
VI	48	40	83
World	**185**	**128**	**69**

A comprehensive analysis of the responses to the questionnaire has been prepared by the WMO Secretariat and a full report should be published shortly. A brief summary has recently been published in the WMO Bulletin (WMO, 2002b). Some important indicators of the current state of NMSs and the issues facing them may be summarised as follows.

National goals served by NMSs

There is a remarkable level of agreement amongst countries and regions, irrespective of geography or current economic status, on the relative importance of the national goals to which the NMSs of the world contribute. The contribution of the NMS to the safety of life and property and reduction of the impact of natural disasters is of paramount importance. In summary, by region, the order of importance was as shown below:

NATIONAL GOAL	WMO REGION						
	I	II	III	IV	V	VI	World
Safety of life and property	1	1	1	1	1	1	1
Reduction of impact of natural disasters	2	2	3	2	2	2	2
National sustainable development	3	3	4	3	3	3	3
Community health, recreation and quality of life	5	6	5	4	5	6	4
National security	6	4	2	10	6	5	5
Quality of the environment	8	5	6	6	9	4	6
Meeting international requirements	4	8	7	5	4	7	7
Advancement of knowledge	7	9	8	7	7	8	8
National planning and management	9	7	9	9	10	9	9
Information needs of future generations	10	10	11	8	8	10	10
Policy setting	11	11	10	11	11	11	11

National application sectors

There is also fairly strong agreement across WMO regions in respect of the most important national applications sectors served by the NMS. In summary, the importance of the applications sectors was ranked by region as shown below.

APPLICATIONS SECTOR	WMO REGION						
	I	II	III	IV	V	VI	World
Aviation	1	1	1	1	1	1	1
Disaster management	3	3	2	2	2	2	2
Agriculture	2	2	3	3	3	4	3
Environmental protection	7	5	5	4	8	5	4
Mass media	9	4	9	7	4	3	5
Water resources planning and management	5	7	6	6	6	6	6
Construction	6	12	12	8	7	11	8
Energy generation and supply	13	6	4	9	14	10	7
Marine transport	18	9	8	10	5	8	10
Food production	4	10	11	13	18	17	12
Tourism	11	14	16	5	13	14	9
Fisheries	10	8	19	11	11	18	14

Major issues facing NMSs

NMSs were invited to assess the current significance of each of twenty one separate issues currently facing them in terms of ‘very significant, ‘significant’ and ‘not significant’. From the analysis of the responses, it appears that there is considerable variation from region to region but that, while relationships with other government agencies, academia, the private sector and other geophysical institutions are not seen as particularly significant issues at the present time, those such as the role of the NMS at the national level, the overall level of government funding, capacity building, aeronautical service provision and technological modernisation are on almost everyone’s agenda. The summary rankings by region were as follows:

ISSUE	WMO REGION						
	I	II	III	IV	V	VI	World
Modernisation	2	1	7	3	5	3	1
Provision of aeronautical services	5	9	1	11	2	1	2
Capacity building	3	2	13	6	4	5	3
Overall level of government funding	1	3	17	1	12	2	4
Role of the NMS at national level	4	4	2	2	18	6	5
Data and products exchange	8	5	3	17	1	9	6
Provision of weather services	9	8	5	8	10	4	7
Relationship with the media	12	10	4	4	6	10	8
Provision of climate services	6	7	6	7	20	7	9
Commercialisation	11	6	16	5	8	11	10
Regional cooperation	10	14	12	10	3	14	11
Relationship with other NMSs	16	15	9	20	7	12	12
Visibility	7	20	15	9	14	15	13
User interaction	15	11	14	15	9	16	14
Legal status	13	12	21	12	19	8	15
Management	14	21	10	14	11	18	16
Relationship with other government agencies	17	13	11	16	13	19	17
Relationship with academia	19	18	8	18	16	13	18
Relationship with private sector (national)	18	17	20	13	15	17	19
Relationship with private sector (international)	20	16	18	19	21	20	20
Interaction with other geophysical institutions/programmes	21	19	19	21	17	21	21

5 THE MAJOR ISSUES AND THEIR IMPLICATIONS

It is evident, from the above, that there is no shortage of issues currently impacting on NMHSs and likely to continue to do so in the years ahead. Many of them are interrelated and most are linked to still bigger issues impacting on the wider world. Some have already been analysed extensively by the various constituent bodies of WMO, including, of course, the Executive Council through its Advisory Group on the Role and Operation of NMHSs and most have been taken into account, at least in general terms, in the drafting of the WMO Sixth Long-term Plan for consideration at the forthcoming Fourteenth World Meteorological Congress.

All that I can do here is to elaborate briefly on a few of them, to bring out a few important considerations and expresses some personal points of view. As a basis for grouping of those that I have chosen for discussion, I will address them under four headings:

- The major NMS issues identified by Members;
- The specific issues facing NHSs;
- The issues for more detailed analysis later in the session on 7 February; and
- Some other emerging issues.

The major issues identified by Members

While the situation of every Member is unique in terms of its assessment of the combination of major issues currently facing its NMS, and a few of the global 'top ten' issues identified in the WMO survey (WMO, 2002b) are clearly of minor significance for individual countries and regions, it is clear that virtually all are seen as having important implications for the future of NMSs (and, with different emphasis, for NHSs) around the world. I offer a few observations on each:

- *Modernisation*. This is a major issue for both developing and developed country NMSs. Much of the technological infrastructure (observing systems, communication facilities, data archival systems …) of developing countries dates from the colonial or post-colonial technical assistance era and most Services lack the government funds for equipment replacement or the political leverage on technical assistance programs to bring in external funding from overseas or local aid sources. By the same token, even many developed country NMSs lack the asset replacement funding to renew their basic infrastructure on reasonable timescales, let alone introduce the many promising new systems and technologies emerging from the international research effort. While the various WMO and other training and technical assistance programs can help to some extent, especially in the area of technical and professional training and project management systems, the greatest barrier to progress is clearly the absence of a critical mass of expert staff and funding to plan, implement and operate state of the art equipment and systems in both the developed and developing countries.
- *Provision of aeronautical services*. The development of cut-throat competition and industry-wide preoccupation with cost-reduction in the aviation sector, coupled with limited understanding, in the aviation community, of the scientific, technological and organisational basis for provision of aviation meteorological services at both the international and national levels, has brought the arrangements for aviation service provision to the brink of crisis in many countries.

Notwithstanding the efforts of WMO and ICAO Secretariat staff to promulgate and reinforce the basic concepts of partnership and cost recovery built into the WMO-ICAO agreement (and counterpart agreements at the national level), many individual country NMSs have been forced, and a few have chosen, to move their aviation service provision from a cooperative partnership to a competitive basis of supply without full awareness of the downstream implications for the entire system of weather service provision for aviation and the community at large. It is fairly clear, in particular, that few in the aviation industry have yet recognised the implications of the course on which they are headed. I believe that this is the most serious policy issue currently facing NMSs in many countries and that the future of the entire international system of aviation meteorological service provision is in the balance.

- *Capacity building*. This is, by definition, more an issue for the developing and transitional economy countries than for the NMSs of the developed countries. With many traditional sources of Official Development Assistance (ODA) drying up, and sharply reduced government funding for the NMSs of developing countries subject to IMF (International Monetary Fund) and other economic restructuring programs, the scope for capacity building through international staff exchange, in-country development experience and the like is severely limited. By far the most important opportunities for capacity building still available are those through the training workshop and fellowship components of the various scientific and technical programs of WMO and the bilateral capacity-building initiatives still being carried out by a number of developed country NMSs and aid agencies.
- *Overall level of government funding*. The level of government funding has become a critical issue for all but a few developed country NMSs and some of the historically strong NMSs have, in recent years, found themselves subject to cumulative budget cuts of a severity that makes it virtually impossible for them to maintain the historical scope, scale and quality of their operations and services. While this is variously a product of changing government attitudes to the funding of public sector agencies, the impact of economic globalisation on governments' ability to raise sufficient levels of tax revenue, the dramatically increased competition for funding from the available public purse and the imposition of externally-driven (eg IMF) economic restructuring programs, the impacts are already severe in most countries and the solution is far from obvious. The most promising medium term strategy appears to be through a systematic program to establish a more secure economic and public policy framework for NMS operations and clear demonstration of the national economic and public welfare benefits of an upgraded level of services.
- *Role of the NMS at the national level*. This has become an issue for NMSs in both developed and developing countries. Several different influences are at work. In some countries, the traditional position of the NMS as the official national source of weather and climate information has been eroded by the private sector, the university research community and global television with most members of the user community essentially oblivious to the fact that all of these depend ultimately on the basic infrastructure operated by the NMS. In other countries, the situation of the NMS has become confused by the growth of competitive mechanisms for provision of government services in lieu of the historical functional allocation of government responsibilities among agencies, especially since the advent of climate change as a potential source of funds for agencies seeking to take advantage of the political profile of the climate issue in ways that effectively divert funds away from the basic national meteorological (ie integrated weather and climate) networks of the NMS. In still other countries, legitimate questions are being asked about the most appropriate organisational grouping of public

sector responsibilities, including possible arrangements that would lead to a separation of functions in ways that would impact seriously on the integrity of the established NMS concept of operation. By the same token, some Members are looking at the scope for better integration of meteorological, hydrological, oceanographic and other geophysical functions at the national level.

- *Data and products exchange*. Though much of the surface heat has gone out of the data exchange issue in the WMO community since 1995, the original basis for concern and the tensions which led the WMO community to the brink of a data war are all still there below the surface. The complex set of issues related to the relative roles of the NMS and the private sector remain unresolved in many countries and the pressures on NMSs to supplement their operating budgets through sale of data and products are, in some countries, even greater than before. One of the more promising developments appears to be the greater awareness of governments of the overall benefits of international cooperation and free exchange and of the essential conditions for maintaining the stability of the data exchange regime of Resolution 40.
- *Provision of weather services*. Most NMSs are seen by their national communities as primarily the providers of public weather services, albeit, in many tropical developing countries, the public weather function has historically come a distant second to a primarily aviation weather role. At present, many NMSs in both developed and developing countries are, however, struggling to assert their public weather role in the face of an entrepreneurial media sector, a range of amateur and other (including international) web sites and, in a few cases, other NMSs seeking to create or enter a market for weather services within the national borders of other countries. There are many difficult issues currently on the agenda, one of the most complex relating to delineation of the boundary between freely available basic services and those appropriate for cost recoverable or commercial provision. Others relate to the level of acceptance of the NMS as the single official voice in respect of warning services at the national level.
- *Relationship with the media*. Working relations with the mass media has always been a key issue for any NMS concerned with ensuring the effective communication of its information to the community at large. Questions such as the responsibility of the media to convey the NMS information, especially warnings, promptly and accurately, and the right of the media to draw on sources other than the NMS, present particular difficulties from time to time. In recent years, the development of the WMO Public Weather Services Programme has focussed on media relations and especially on the concept of public weather service provision as a public interest partnership between the NMS and its national mass media. In some countries, however, the media assert a right to operate independently of the NMS and to draw on international service providers or employ their own data sources and forecasters. In others, the media are required, or agree, to deliver the NMS services to the community exactly as provided and are willing to pay the NMS for the information. Relations between the NMS and the media seem likely to continue to be an area of continuing experimentation and debate.
- *Provision of climate services*. Many developing country NMSs and a few in the developed world have historically operated essentially as 'weather' services, playing only a small role in climate data archival and supply and essentially none in the provision of broader climate services to the general public or specialised users. Those NMSs which have been precluded by a narrow 'weather service' mission or who have chosen to build up a strong focus on weather, leaving climate to others, are presently having to come to grips with the burgeoning community interest in climate, particularly its seasonal to interannual and decadal

variability and the prospect of long-term greenhouse-induced change. The issues associated with effective NMS climate service provision are significantly different from those for weather services, not least because of the increased scope for international differences of opinion on the former and the greater perishability of the latter. New issues relate to the optimum role of the NMS, versus that of regional or global centres, as the originating authority for climate forecasts.

- *Commercialisation*. In all its forms, 'commercialisation' continues as a major issue for many NMSs. Though a few have chosen a commercial model of operation for policy or ideological reasons, the vast majority of the NMSs that have adopted a commercial approach have done so in response to government pressures to supplement their tax-payer funding with user charges from external sources. One of the major issues dealt with in the Annexes to Resolution 40 related to the relationship between the NMS and the commercial/private sector. A great deal of work remains to be done on the commercialisation issue.

Specific issues facing NHSs

While many of the problems facing NMSs as identified in the WMO questionnaire have close analogues in hydrology, it is also relevant to note some of the specific issues facing NHSs as identified by Mosley (2001). Mosley listed the key issues facing the global community of hydrological services as:

- Growing pressure on water resources in many countries, with resultant competition for water among the different sectors of the economy;
- Increasing recognition of the need to sustain freshwater ecosystems while meeting the demands of human users;
- Increasing adoption of Integrated Water Resources Management as the framework for water management;
- The adoption of new management models developed in other parts of the economy, and the development of models that are specific to water management – especially those based on the river basin as the basic unit of management;
- Technological advances in data and information management, which provide greatly enhanced service opportunities but at greatly increased capital cost;
- The tendency for national/provincial governments to reduce expenditure and taxation, and to withdraw from functional areas in which they have no comparative advantage, relative to the private sector;
- Widespread acceptance of the four Principles of the International Conference on Water and the Environment (Dublin, 1992), and rapidly evolving thinking on water-related issues in such fora as the UN Conference on Environment and Development (Rio de Janeiro, 1992), the UN Commission for Sustainable Development, and the international development banks.

In Mosely's judgement, however, the most fundamental issue facing hydrological service provision is the tendency to redefine the role of the State in providing or funding water-related services like piped water supply, and the extent to which they could be provided more efficiently or effectively by the private sector or the services' users and beneficiaries themselves. Almost inevitably, in his view, the question will be raised as to what the role of the State should be in supply the information required to design and operate such services.

Issues for more detailed analysis

Several of the issues scheduled for elaboration in later presentations to the session overlap with those identified by Members, including the WMO 'top ten', and the specific hydrological issues touched on briefly above. I therefore offer only brief comments here by way of general introduction and overall scene setting for the in-depth presentations to follow:

- *Weather and climate prediction*. The two great challenges facing the NMS community are how to continue to improve the accuracy and time range of weather and climate forecasting and how best to communicate the information to the potential user community. An ancillary issue, already being faced by some NMSs, relates to the management of unrealistic expectations including the associated risk of litigation when users are disadvantaged by reliance on an erroneous forecast. There seems little doubt that weather and climate prediction will continue to improve, at least in the most advanced countries, through the contribution of new and better data and models and increased computer power. International research programs promise to contribute most strongly to improvement in the area of very short-term forecasting of severe weather phenomena and seasonal to interannual prediction of climate. The major challenge for most NMSs will be that of finding more effective ways of conveying forecast information to users in forms that are more suitable for decision making.
- *Partnerships with the private sector and the media*. The partnership model has always held much attraction for the meteorological community, albeit the tendency over the past few decades for NMSs to enter into commercial service provision in potential competition with the private sector has put the public-private partnership (PPP) model under considerable stress (Saarikivi et al, 2000). While there is immense scope for other countries to develop more robust public-private partnerships in service provision, somewhat along the lines of the US model (White, 2001), the growing trend for use of PPP terminology as a euphemism for privatisation suggests the NMS community may be well advised to proceed cautiously in adoption of the language, if not of the spirit, of public-private partnership. The NMS partnership with the mass media is, and seems certain to remain, central to the effectiveness of the NMS and to its value to the user community.
- *Partnerships with academia*. NMSs, in general, have always had a special relationship with the tertiary education sector based on their heavy dependence on the universities for their intake of professional (usually science) graduates and for research. In many respects, the international partnership in global research initiatives such as GARP (Global Atmospheric Research Programme) between the WMO and ICSU (International Council for Science) communities has been especially helpful in fostering counterpart partnerships at the national level. The research partnership between the NMS and academia is becoming increasingly important in attracting the best young minds into meteorology and helping ensure the efficient transfer of research results into practical application.
- *Climate change*. The impact of the climate change issue on NMSs over the past decade has varied markedly from country to country. The impacts on developing country NMSs fall into two sharply different categories. For those countries where the government assigned national lead responsibility for IPCC (Intergovernmental Panel on Climate Change) and FCCC (Framework Convention on Climate Change) policy matters to the NMS, the involvement in

the various international fora has dramatically enhanced the expertise of NMS staff on climate science and policy issues and lifted the profile of the NMS in government policy circles at the national level. For those where the NMS has been bypassed and the lead responsibility for climate change matters passed to other (usually environmental) agencies, the NMS has not only found itself left out of the action but, to varying extent, has had to face the loss of parts of its mission as well as the resources that might otherwise have been available for basic NMS climate purposes. One of the most serious impacts is the conceptual split between weather and climate and the weakening of the commitment to common networks, models and service delivery mechanisms. The impacts of the climate change issue on developed country NMSs have been similar in kind to those in the developing countries although the extremes, for the most part, have not been as great. Relatively few developed country NMSs have been assigned lead responsibility for climate change policy matters at the national level. The emerging challenge for NMSs everywhere will be how to build towards a more integrated approach to environmental monitoring, prediction and service provision, bridging across weather, climate and water and their impacts on society and the environment.

- *The global water crisis*. The impacts of the growing national and international concern with the availability of adequate supplies of fresh water in the decades ahead will be felt most directly by NHSs and those NMSs that also include substantial national hydrological responsibilities. Certainly the requirement for improved monitoring of the various components of the hydrological cycle (rainfall, evaporation, run off …) and more reliable assessment of surface and underground resources in connection with agricultural planning, drought management and the like is going to place greatly increased demands on the density, accuracy and reliability of hydrological networks and the incorporation of improved representation of the hydrology of different regions in climate models. It would seem likely that the role of NHSs will be strengthened in many countries and closer links developed between the NMS and NHS functions.

Some other emerging issues

While it is clearly impossible to foresee all the emerging issues that will impact on the future role and operation of NMHSs, even on the short term, there have been several recent attempts to identify the main external forces for change that seem likely to impact on NMSs over the coming decades (eg Zillman, 2001 a,b; WMO, 2003). It is appropriate, here, to canvass just a few that, at this stage, seem certain to appear on WMO and NMS agendas for the next few years.

- *The impacts of economic globalisation*. The debate on almost every aspect of globalisation has been going on for more than a decade (eg Shipman, 2002; Soros, 2002; Stiglitz, 2002) and its implications for meteorology and the role of NMSs have been the subject of analysis in a range of WMO fora. In some respects, meteorology can be seen as a pioneer and principal beneficiary of globalisation. On the other hand, the pressures that the free flow of information and finance across national borders have brought to bear on governments' ability to raise the tax revenue to fund the full range of traditional public services has been a major factor in the declining capacity of countries to continue to properly maintain the basic infrastructure of their NMSs in both developed and developing countries. In those developing countries where economic restructuring programs imposed as a condition of IMF (International Monetary Fund) or other rescue packages from economic crises brought on by globalisation have involved massive across-the-

board cuts to the country's public sectors, the NMSs have suffered badly, along with the rest. There are clearly potential benefits, too, for NMSs, from some of the hoped-for gains from globalisation but the overall picture is far from clear and the way ahead is difficult to define in any general sense. It will, however, be important for NMSs and NHSs to keep abreast of the evolving debate on the benefits and costs of globalisation.

- *Intellectual property, TRIPS, GATS, WIPO and data exchange*. One particular manifestation of globalisation that has, so far, had a profound impact on international meteorology and the role of NMSs has been the widespread move towards stronger intellectual property regimes as part of the global free trade agenda of the World Trade Organization (WTO). The implementation of TRIPS (Trade Related Intellectual Property Rights) and the parallel pressures for development of a sui generis regime for assertion of intellectual property in data bases (effectively already in place in Europe under the 1996 'European Directive') was already one of the major influences that precipitated the meteorological data exchange crisis of the mid 1990s by essentially turning what had once been generally accepted as international public property (basic meteorological data contributed voluntarily by NMSs to the global pool) into the intellectual property of the originating NMS with a view to their commercialisation through market processes. Potentially even more significant for the future role and operation of NMSs will be the WTO's GATS (General Agreement on Trade in Services) regime. The key issue here is that countries will be expected to decide, on public policy grounds, which meteorological services they wish to have provided as an official, authoritative service of government in support of the general safety and welfare of the community at large and which services they are happy to see left to the markets for provision on a competitive basis without regard to the location, professional standing or national origin of the provider. Only those services which are provided in the exercise of government authority will be excluded from the internationally competitive regime of GATS. The challenge for NMSs, individually and collectively, will be to ensure that those within their governments who are responsible for overall coordination of GATS implementation properly understand the implications of the various possible choices of boundary of the services to be excluded from coverage by GATS.
- *The international trust and security situation*. The detailed implications for the long-standing WMO regime of international trust and cooperation among Member country NMSs of the greatly increased emphasis on security flowing from the events of September 11, 2001 and the US 'war on terrorism' are difficult to determine but it would seem inevitable that it will become more difficult to maintain the informality and mutual trust of the meteorological world in a political world that is increasingly focussed on issues of security, counter-terrorism and military conflict. A particular issue will be the extent to which the increased concern with the security implications of information will impact on the free flow of meteorological data and remote sensing and communication technologies among NMSs.
- *The culture of blame-seeking and litigation*. Until now, users of the services provided by NMSs have largely accepted the information provided, especially forecast and warning information, as the best professional judgement of experts in a complex field of science where nothing can ever be certain but where, on average, the best professional judgement will be significantly better than chance. This acceptance has been reinforced by the perception of conformance with international professional standards of training and service delivery provided by the WMO framework within which the NMS is seen to be operating; as well as by the insistence of most NMSs on providing only those products and services where

they have been able to objectively demonstrate integrity and skill. When a forecast failure has had very serious consequences, it has been usual practice to undertake careful objective assessment of the causes to help ensure that no similar future service failure occurs through factors whose better understanding on the basis of the previous experience could have made it avoidable. But we are moving into a much more blame-seeking and litigious world and, to some extent, NMSs are becoming victims of their own success. Because weather forecasts nowadays are almost always right, and often spectacularly right, the public expectation is that they should always be right and that, if they are not, someone has been negligent or incompetent, the blame must be sheeted home and retribution sought. While this has been an inevitable general trend in a more market-orientated and contract–driven society, it has particularly serious implications in meteorology for the future willingness of professional forecasters to give their best and most useful judgement rather than the safest judgement. The increased tendency, nowadays, for NMSs to have to cover their own legal costs rather than have them absorbed by 'the government', coupled with the perception, on the part of potential litigants, that government agencies have deep pockets, is currently exacerbating the situation. I believe this is going to emerge as a very serious issue for NMSs in many countries.

- *The pressures for quality certification*. The increasing adoption of a wide range of quality management and quality certification systems in the business world over recent decades has undoubtedly contributed to the quality, reliability and economy of many of the goods and services made available through the marketplace and consumed by society. Quality management and quality certification systems represent an important source of information for consumers about the products they are purchasing and they have played an important role in establishing and enhancing the competitiveness of individual firms in the market place. Most professional public services, such as meteorological services, have historically relied on the totally different mechanism of ensuring adherence to prescribed standards of education and training of the service providers and the professional culture of the providing organisation. With the marketisation of meteorological services in some parts of the world, and the expectation of potential customers that services provided through the market will be subject to the disciplines of the market, significant pressure has developed for NMSs to adopt the quality certification schemes of the business world. Hence, from the aviation industry has come the pressure for ISO 9000 certification of the providers of aviation meteorological services. While some, especially the more competitively orientated, NMSs have welcomed these developments, others see serious risks in surrendering the universality of the WMO badge of quality to a non-meteorological organisation and submitting the public good functions of government to market processes in ways that seem likely to encourage competition rather than cooperation between NMSs; and, most seriously, raise the spectre of the emergence of two classes of NMSs, those, primarily in developed countries, with the resources to implement ISO or related certification schemes and those, primarily in the developing countries, who can not. This will almost certainly develop into a major issue for WMO and the NMS community over the next few years.
- *The role and influence of WMO*. For the past fifty years, the role and operation of the individual NMSs of its Member countries has been strongly guided by the programs and systems developed and implemented on a cooperative basis through the various constituent bodies of WMO. Over the past twenty years, the WMO Long-term Plan has played an important guiding role in informing NMSs of the global sweep of influences and in shaping NMS strategy at the national level.

Over the last decade, many NMSs, particularly those from the developing countries, have turned increasingly to WMO for advice and guidance on addressing policy, organisational and funding issues besetting them within their own countries. For some, this has proved to be one of the most important roles now played by the WMO and to others it has seemed close to inappropriate WMO interference in the domestic affairs of sovereign states. The recent role of the Executive Council in focussing much of its effort on the development of policy statements and guidelines on the role and operation of NMSs is of central importance in the present context. Indeed the surfacing, in recent years, of proposals to amend the WMO Convention to explicitly mandate the role of the NMS at the national level, although at this stage seeming unlikely to proceed at the Fourteenth Congress, reflects a continuation of this trend. A major issue for the NMS community at the coming Congress will be the extent to which they wish the WMO, as an organisation, and in particular its Executive Council, to continue down this path.

- *The free rider problem in international meteorology*. Though it is, in many respects, a manifestation of a number of the other issues already discussed such as globalisation, commercialisation and data exchange, one of the emerging issues for WMO and the NMS community seems likely to be the development of a free rider problem in international meteorology. The traditional culture of international cooperation is powerful but fragile. Individual countries and NMSs have always been prepared to do their best to play their part in the total international effort on the understanding that every one else will do the same. But as the forces of competition, relentless pressures on national budgets and the focus on individual, rather than the greater global, benefit take hold in many countries, the pressures to withdraw from contributing something that it is hoped others will continue to provide are increasing. Given that, the WMO Regular Budget aside, there are no global funding mechanisms for the provision of international meteorological information and services, we thus potentially face the classic free rider problem in international meteorology. The extent to which it will emerge as a major issue over the next few years is hard to say at this stage.
- *Pressures on the radio spectrum*. Commercial pressure, from mobile phone and other sectors, for access to parts of the radio spectrum that have historically been reserved for meteorological use (radiosonde frequencies and meteorological satellite frequencies in particular) have been increasing rapidly in recent years and appear to constitute a very serious threat to the integrity of meteorological data flow and NMS operations in the years ahead. The strategic challenge for NMSs collectively is to achieve sufficient leverage on the positions of their national delegations to the relevant intergovernmental negotiation fora on radiofrequency allocation to ensure that the frequency bands that are essential for the continued discharge of the public good functions of NMHSs are retained for meteorology and not made available for auction.
- *A more holistic view of earth science*. This issue also has many dimensions and is beginning to impact on NMHSs in many ways. The increasing scientific awareness of the interdependence of the various components of the earth system, recognition of the scope for more efficient monitoring and modelling of the total earth system and community expectations for more integrated access to essential environmental science services are increasing the pressures on NMSs and NHSs to develop common standards, employ common systems and work more closely together and more closely with other traditionally separate research and information providing sectors to deliver the benefits of a more holistic view of earth science. At both the national and international levels, this seems likely to be a major issue on the agendas of NMHSs for the years ahead.

6 SOME THOUGHTS ON THE WAY AHEAD

The development of a consensus on the optimum strategy for addressing the many difficult issues currently impacting on NMHSs is probably the largest single challenge facing the forthcoming Fourteenth World Meteorological Congress. It is implicit in much of the draft Sixth Long-term Plan and it is explicit in the proposals that will be submitted to Congress for follow up on the work of the Executive Council Advisory Group on the Role and Operation of NMHSs and the parallel work of the Commission for Hydrology for the specific situation of NHSs. Without seeking to duplicate any of this, I would like here to offer a few personal views on how the WMO community might best proceed to get the role and operation of NMHSs onto a more secure basis and heading in the right direction for the decades ahead.

- First, I believe the NMS and NHS communities must put a major effort into the development of consensus on an economically rigorous public policy framework for meteorology and related science services based on the theory of public goods and formalised and promulgated through WMO in consultation with UNESCO, WTO, WIPO, ICAO and IMO;
- Second, I suggest that every effort be made to build the principle of free and unrestricted international exchange of meteorological and related data and products into the WMO Convention at the Fifteenth World Meteorological Congress in 2007;
- Third, I think that, at both the national and international levels through WMO and its gradually emerging non-government counterparts in the media, academic and private sectors, it is time to foster formal partnership structures that clearly recognise the role of each in the overall meteorological and related science service enterprise and as clearly as possible demarcate the boundary between cooperative and competitive regimes;
- Fourth, I urge a WMO-led international effort to develop the methodology, and to foster case studies, for assessing the economic and social benefits of both public and private good products and services and especially of the operation of the national meteorological infrastructure;
- Fifth, I urge a new commitment to both multilateral (WMO) and bilateral programs for education and training and other forms of capacity building for the young staff of developing country NMHSs, including especially international attachments and the development of regional partnerships among NMHSs;
- Sixth, I believe it is time for new approaches to partnership and consolidation at the national level between the ‘weather’ and ‘climate’ communities, where they have grown apart, and new interdisciplinary partnerships in observing, monitoring, modelling and service provision between the meteorological, hydrological and oceanographic communities more generally.

These are all, of course, much easier said than done. The challenge we all face is to elaborate and elucidate the many interconnected issues we are facing in the various individual NMHSs and regions and move carefully towards international consensus on how they are best addressed.

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