SOCIO-ECONOMIC BENEFITS OF MET-OCEAN

INFORMATION AND SERVICES

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John W Zillman

It is too little understood, especially in quarters where it most should be, how well the world has been served by the century and a half-long partnership between the science and practice of meteorology and oceanography that is today so effectively symbolised and institutionalised in the work of the WMO (World Meteorological Organization) – IOC (Intergovernmental Oceanographic Commission) JCOMM (Joint Technical Commission for Oceanography and Marine Meteorology).

In large measure, the 19th Century met-ocean partnership shaped the view of the natural world that historians now describe approvingly as Humboldtian science in recognition of the influence of the remarkable German geographer, naturalist, expeditioner, writer, scientific communicator, administrator, and social critic Alexander von Humboldt (1769-1859) who promoted an anti-Kantian concept of knowledge of the universe based on precise measurements rather than on metaphysics and who was the first to use such things as isotherms and isobars to map the average climatic conditions over the surface of the earth (Heilbron, 2003).

It also spawned the unique WMO framework for nations to work peacefully together for the common good which emerged in the second half of the initially war-torn 20th Century and which now stands as probably the finest truly global system of international cooperation in the history of the world (Zillman, 2008).

And I suspect that it was the growing recognition of the inherent unity of atmosphere and ocean which inspired the early careers of many of the present generation of earth system scientists and which now brings the international meteorological and oceanographic communities together in this third session of JCOMM.

One of the first things I bought with my second or third pay packet when I began my own meteorological/oceanographic career more than 50 years ago was the wonderfully titled ‘Meteorology for Mariners’ from her Majesty’s Stationary Office in London (Meteorological Office, 1957); and I was almost ecstatic when, a decade later, I walked into a bookshop in Melbourne and found the second edition called ‘Meteorology for Mariners with a Section on Oceanography’. I treasure it still.

This talk (Slide 1 - and I hope you will allow me to regard it as a talk rather than a genuine scientific lecture) is about some aspects of the met-ocean partnership with which I have become a little familiar over the past 50 years. I will touch, in particular, on (Slide 2):

- the origins of international cooperation in meteorology and oceanography;
- the concept of a met-ocean service system;
- the nature of met-ocean services;
- the users and applications of met-ocean services;
- the benefits of met-ocean services;
- quantifying the value of met-ocean services;
- an economic model for service provision;
- enhancing the benefits of met-ocean services; and
- some thoughts on what JCOMM can do.

Of course, I cannot do justice to any of these individually and many members of the JCOMM community are more familiar with most aspects of them than I am. So I will pass lightly and selectively across them, and, in the process, I hope, help remind us all of how important are the challenges and how exciting the opportunities facing the Members of JCOMM in delivering their national communities with the vast social, economic and environmental benefits that are potentially available from meteorological and oceanographic information and services in the 21st Century.

The origins of international cooperation in meteorology and oceanography (Slide 3)

I would like to look forward to the role that JCOMM can play in enhancing the benefits of met-ocean information and services over the coming decades but, if we are to hope for insightful guidance for the future, we must first try to understand the past.

So let me say just a few words about the origins of international cooperation in meteorology and oceanography in the Humboldtian tradition (Slide 4) through the work of Matthew Fontaine Maury (1806-73), Georg Balthaser von Neumeyer (1826-1909), Robert Fitzroy (1805-65) and the other outstanding figures of mid-nineteenth century science such as C H D Buys Ballot (1817-1890), H Wild (1833-1902) and E Mascart (1837-1908) whose commitment to international cooperation led to the establishment, in 1873, of the International Meteorological Organization (IMO), the non-governmental predecessor of the WMO.

There are many fascinating histories (eg Ashford, 1973; Daniel, 1973; Davies, 1990; Home, 1991; Hontarrede, 1998; Gribbin and Gribbin, 2003) of the individual and joint contributions of these 19th Century pioneers of international cooperation in meteorology and oceanography (Slide 5) but one man emerges beyond all others as the driving force for the standardised collection and international exchange of marine observations and the practical application of meteorological and oceanographic information for the benefit of mariners and all those on land and sea whose safety and welfare depend on the weather and climate. That man was US Navy Lieutenant Matthew Fontaine Maury (Slide 6) whose work through the 1840’s in assembling wind and current charts for the oceans (Slide 7) had already shortened sailing times to the point where, by 1850, he was credited with saving international commerce an estimated $50 million annually (Daniel, 1973).

The defining event of the period was Maury’s convening of the 1853 Brussels Conference of naval officers and scientists from 10 maritime nations, to put in place an international system for the taking, recording, collection and exchange of observations from ships at sea (Slide 8). In his own words (Maury, 1855):

> “This conference….. recommended a plan of observations which should be followed on board the vessels of all friendly nations….”
>
> “In peace and in war these observations are to be carried on and, in case any of the vessels on board of which they are conducted may be captured, the abstract log….. is to be held sacred”
>
> “This plan contemplates the cooperation of all states of Christendom, at least so far as the form, method, subject of observations, time of making them and the interchange of results are concerned. I hope that my fellow citizens will not fail to second and cooperate in such a humane, wise and noble scheme.”

As seems so often to have happened in the history of our field, nature soon conspired to reinforce the importance of the task Maury had set in train. In November 1854, devastating storms during the siege of Sebastapol in the Crimean War (Slide 9) caused the loss of 38 French, English and Turkish ships (Dexter and Parker, 2009) and triggered action to establish observation networks with data collection by the new Morse Code as a basis for storm warning services such as were soon pioneered by Robert Fitzroy (‘Darwin’s Captain’), the head of the newly established Meteorological Department of the UK Board of Trade, the predecessor of the Met Office (Gribbin and Gribbin, 2003).

Meanwhile, in the Antipodes, over the period 1857-63, the remarkable young German naval officer and scientist Georg Neumeyer (Slide 10)was busy, following the Maury exhortation, establishing observational networks across Victoria, collecting and analysing ships logs and developing techniques for using wind and current information to greatly reduce the sailing time from England to Australia (Zillman, 2009).

But tensions soon emerged between the science and practice of marine meteorology as a result, among other things, of the Royal Society’s very public assertions that Fitzroy’s storm warning services for shipping were ‘unscientific’. The services were withdrawn on the direction of the UK Government and, in disillusionment, Fitzroy subsequently took his own life. But the scientific leaders of the day persisted in their belief in the essentiality of international cooperation on data collection and exchange with the heads of the Russian, German and Austrian meteorological institutes moving to convene a conference in Leipzig in August 1872 in the following terms (Slide 11):

> “At the present time, the increasing interest in meteorological research shown by all civilized countries has led to a demand for far-reaching coordination and standardisation of the methods and procedures in use in different countries. Such suggestions have been put forward and discussed so frequently”…… “that the undersigned consider it both feasible and timely to propose the convening of a meteorological conference…..”

The Leipzig Conference was clear that the time had come for the establishment of some permanent form of international cooperation in meteorology and led to the convening of the First International Meteorological Congress in Vienna in September 1873 (Slide 12). This was attended by 32 delegates from 20 countries and focussed on the standardisation of instruments, hours of observation and the principle of mutual exchange of observations by telegraph. The Conference called for a permanent international meteorological organization and established a ‘Permanent Committee’ to carry this forward.

And so was born the IMO (International Meteorological Organization) which convened again in plenary at the Second International Meteorological Congress in Rome in 1879 (Slide 13). For the next 70 years, the non-governmental IMO provided essential international coordination of meteorological activities, especially through the work of its comprehensive system of technical commissions (including its Commission on Maritime Meteorology) put in place in 1929, until the establishment of the fully intergovernmental WMO in 1950. WMO and its, by then, Commission for Marine Meteorology were joined, a decade later, by the establishment, within UNESCO, of the IOC as the intergovernmental mechanism for coordination of ocean research working in partnership with the ICSU SCOR (Special Committee on Ocean Research) and a number of other governmental and non-governmental ocean science organisations.

The important message that I hope you will gather from this brief foray into history is that it was the partnership between practitioners of the sciences of the atmosphere and the ocean undertaken to deliver specific benefits (safety) to a specific community (mariners), which inspired the development of an entire global system of cooperation in meteorological and oceanographic observation, data exchange and service provision which now delivers a wide range of benefits to all the nations of the world.

The concept of a met-ocean service system (Slide 14)

Let me now change tack and introduce a few basic concepts that are essential to any consideration of the socio-economic benefits of met-ocean services.

The first, and most basic, is the concept of an ‘end-to-end’ service system for the atmosphere or for the atmosphere and the ocean (Slide 15). The most fundamental components of any such system are the underpinning observational networks that support both research and operational models which, in turn, provide the analysed information and predictions on the various time and space scales that are required to produce the full range of services in support of user needs. And it is through the users’ application of this information in decision-making that better outcomes (greater safety, reduced damage, increased profits, a cleaner environment) are achieved than would otherwise have been the case and increased benefits are delivered to society.

In the case of the atmosphere, the system on the right represents the essential architecture of the traditional National Meteorological Service (NMS) delivering weather and climate information, forecast and warning services to its national community. It is the global network of NMSs of the 188 Member States of WMO that has so successfully implemented the World Weather Watch and the various WMO applications and services programs that are built on it and which are estimated to deliver some $US 25 to 50 Billion in benefits annually to the global community.

Surprisingly and disappointingly, there are, so far, relatively few similarly self-contained and well integrated end-to-end National Ocean Services (NOSs) around the world with the large majority of ocean observation and research programs generally implemented on a project basis with specific research objectives and limited lifetimes. For the most part, routine operational oceanographic services, where they exist, are provided as extensions of the national role of the NMSs making use of the essential overlap, interdependence and synergy between the observational, research, modelling and service provision elements of meteorological and oceanographic service provision.

I will not elaborate here on issues relating to the funding and operation of the underpinning observational, research and modelling infrastructure of NMSs and NOSs, whether integrated or stand-alone, except to note that, in order to provide the services which deliver such huge benefits to society, it is essential for the basic infrastructure to be supported and maintained for the long term. I will return in a little while to the question of how, from an economic efficiency perspective, the costs of this basic infrastructure should be met.

The nature of met-ocean services (Slide 16)

So let us look now in a little more detail at the nature and scope of the services represented schematically in the upper part of the previous slide.

Partly in response to their obligations under the International Convention for Safety of Life at Sea (SOLAS) and partly for purely domestic reasons, the NMSs of most maritime nations nowadays provide a comprehensive suite of marine meteorological and oceanographic services (Shearman, 2003; Dexter, 2005; Dexter, Guddal and Clark, 2007).

There are, of course, many different ways of describing and categorising the various types of meteorological and oceanographic services and what a particular service actually consists of will ultimately depend on an interactive process between the potential providers and users to achieve a match between what is scientifically and technically possible and what the users need or can beneficially apply.

It is, however, for some purposes, useful to categorise the various meteorological and oceanographic services under such broad headings as (Slide 17):

- Type of service (basic data, analysis, forecast, warning, advice, investigation);
- Time frame (instantaneous or period average conditions for various times in the past, present or future);
- Space scale (point information, local, regional or global spatial patterns; coastal waters or high seas);
- Atmospheric variable (pressure, wind, temperature, cloud, humidity, precipitation, fog etc)
- Ocean variable (sea level, currents, temperature (surface and sub-surface) , salinity (surface and sub-surface), waves, dissolved gases, plankton, chlorophyll, dissolved organic matter, sediments etc);
- Type of marine phenomenon (hurricanes, cyclones, storms, squalls, ice, tsunamis, surges etc).

These are all very familiar to this community and most of them are already provided through the various local, national and international marine service systems (eg Slide 18) operated by NMSs and other national governmental and private sector service provider agencies under the auspices of WMO, IOC and other service and applications programs.

Perhaps less familiar but just as important for the purpose of understanding the benefits of met-ocean services is their categorisation according to the economic criteria of rivalry and excludability (Zillman and Freebairn, 2001; Gunasekera, 2004).

In summary (Slide 19), an economic good or service is:

- ***Rival*** if one person's consumption of it means that it is no longer available for consumption by others (eg an apple);
- ***Non-rival*** if one person's consumption of it leaves it undepleted and equally available for use by others (eg the navigational assistance provided(at least in the old days!) by the light from a light-house);
- ***Excludable*** if it is possible to make it available for a particular consumer while excluding all others from its use;
- ***Non-excludable*** if it is impossible or extremely difficult or expensive, having made it available to one person, to exclude others from having access.

This leads to an extremely important basis for categorisation of goods and services such as meteorological and oceanographic services (Slide 20). For example:

- Services such as storm warnings broadcast on radio or free to air television which, once available to one, are available to all are clearly non-rival and non-excludable and are known as ***"public goods"***; while

- Services such as a tailored forecast for competitive yacht racing provided to a client through secure channels which are both rival and excludable are known as ***"private goods"***.

I will return to this important distinction when we come to the question of quantifying the economic benefits of the various types of services and considering who should pay. But the key point to make here is that, for the socially optimum provision of public goods, they must be provided by government at tax-payer expense while, for private goods, the most economically efficient provision of services will be achieved through competitive market processes. In the case of the rival but non-excludable common resources and the non-rival but excludable natural monopoly goods, a range of individual policy and practical considerations apply.

The users and applications of met-ocean services (Slide 21)

As we all know, there is an enormously wide range of public and private, national and international, simple and sophisticated users of all the various types of meteorological and oceanographic services provided by NMSs and private sector service organisations. While some individual users may apply a particular service for a number of different purposes, in general there is a close link between the category of user, the type of application and the nature of the benefit achieved or sought.

It is not possible here to be in any way comprehensive but an indicative list some of the main users of met-ocean services and the primary purpose of their application would include the following (Slide 22):

Users	Applications
Shipping on the high seas	Safe and efficient navigation, ship routing
Port authorities	Port and harbour management
Fishing industry	Catch location, safe and effective operation
Naval operations	Navigation, submarine detection etc
Maritime safety	Marine disaster avoidance and rescue
Emergency response agencies	Oil slick tracking, environment protection
Design and construction engineers	Design/installation of coastal and offshore facilities
Offshore oil and gas facilities	Safe and efficient operation
Coastal management authorities	Coastal planning and protection
Energy and water supply agencies	Renewable energy and desalination plant design and operation
Health authorities	Reducing risks to public health
Tourism industry	Safety, planning and operation of facilities
Recreational fishers, sailors, swimmers and divers	Safe and enjoyable recreation
Research community	Research into atmospheric/ocean processes

The benefits of met-ocean services (Slide 23)

Much has been said and written over the years on the benefits that flow to individuals, households, organisations, socio-economic sectors and nations from the effective application of meteorological and related services. At the broadest level, the social, economic and environmental benefits that flow from the operation of the National Meteorological Services that exist in almost every country of the world (Zillman, 1999) can be summarised as (Slide 24):

- reduction of the impact of natural disasters;
- economic development and prosperity of primary, secondary and tertiary industry;
- safety of life and property;
- national and international security;
- preservation and enhancement of the quality of the environment;
- community health, recreation and quality of life;
- efficient planning, management and operation of government and community affairs;
- provision for the information needs of future generations; and
- advancement of knowledge and understanding of the natural systems of the planet.

Quantifying the value of met-ocean services (Slide 25)

While some of the applications we looked at a moment ago (Slide 22) can lead to clear and quantifiable benefits such as sailing times reduced, port charges avoided, clean-up costs saved and increased revenue earned through use of the service, many others relating to safety of life, environmental quality, community welfare and contribution to the overall body of knowledge of the atmosphere and ocean are of an intangible nature and it is extremely difficult to quantify their value in dollar terms.

Indeed, historically, governments have accepted that the benefits of many services such as those related to safety of life at sea are so self evidently important that they have willingly adopted international conventions such as SOLAS (International Convention for Safety of Life at Sea) which oblige them to provide those services under international law. There are also many other services which governments believe it is in the long-term public interest for people to use. These are known as '***merit goods***' and are usually provided at public expense even though it may not be possible to quantify the benefits of the use of the services relative to the cost of their provision.

Nowadays, however, it is becoming extremely important, in order to justify the expenditure of public or private funds on the infrastructure needed to enable the various services to be provided, to find ways of putting dollar values to the services to ensure that the benefits derived will, in fact, exceed the costs.

Several such techniques have been developed and used to assess the economic value of a wide range of meteorological services (eg Freebairn, 1979; Katz and Murphy, 1997; Freebairn and Zillman, 2002; Gunasekera, 2004); with a smaller number of similar case studies for ocean infrastructure and services (eg Steedman, 2006).

While there is not time to describe the detail of these techniques or of the many case studies that have been carried out over the last couple of decades, it is important that I explain one absolutely fundamental point that bears directly on the policy issue of how such services should be funded and provided in order to maximise the benefits to the community.

To only slightly oversimplify, (Slide 26)

- For services that are of the nature of private goods, the economic value of the service is essentially the price that the highest bidder is willing to pay to get it; while

- For services that are of the nature of public goods, the economic value of the service, which has to be weighed against the cost of its provision, is the **total of all the benefits** derived by all the users of the service.

An economic model for service provision (Slide 27)

This leads to a few very basic considerations from economics which we, in the meteorological and oceanographic communities, probably never encountered in our professional education but which, as we fight for budgetary support for the basic infrastructure on which all met-ocean services depend, we now ignore at our peril.

The most important relates to the determination of the socially optimum level of service provision as the point (Slide 28) at which the marginal benefits and cost curves for increased service provision intersect.

In the top part of the figure, the total costs curve is concave upwards because an initial substantial cost must be incurred for the underpinning infrastructure before any service can be provided and because, at some point, no matter how much more is spent on the infrastructure, the level of service will not significantly increase. The marginal cost curve, in the bottom of the chart, which is just the slope of the total cost curve, therefore slopes upward to the right.

The total benefits curve, on the other hand, is concave downwards because there is initially little or no value delivered until the service reaches a certain threshold level and ultimately, no matter how extensive the service is, no more benefit can be derived and the total benefits curve will plateau. The marginal benefits curve therefore slopes downward to the right.

The economically efficient level of service provision lies at the point of intersection of the marginal benefit and marginal cost curves. Anywhere to the left of that point, an extra dollar invested in the service will produce more than an extra dollar’s worth of benefit. And everywhere to the right, an extra dollar’s investment will produce less than an extra dollar’s worth of value. For public good services (for which, as we saw earlier, the total benefit is the sum of the individual benefits derived by all who use the service) the more widely the service is used, the larger are the total benefits, the higher the benefit/cost ratio, the further the marginal benefits curve will shift upwards and to the right and hence the larger the economically optimum level of investment in the infrastructure supporting the provision of the service.

I said that I would return to the question of how the costs of the basic infrastructure and the provision of the services should be met. Economic analysis suggests that the basic infrastructure and most of the basic services provided for community (including marine community) safety and welfare have public good properties. The information is non-rival in consumption, there are many actual and potential users from many sectors of the economy and the costs of exclusion are high. In this situation, it is most economically efficient for the funding of the infrastructure and public services to be met from taxation. Additional user-specific special services that have private good properties should, on the other hand, be funded by user charges on either a cost-recovery or commercial basis.

Enhancing the benefits of met-ocean services (Slide 29)

While we have more than a century of experience in the provision of marine meteorological services and well established arrangements, such as those for the Global Maritime Distress and Safety System (GMDSS), through which they are provided, the concept of operational oceanography is relatively new, most operational ocean services are still only in the experimental and pilot phases and many of their users and prospective users are yet to fully understand their potential for delivery of both public and private benefits. There are still many untapped opportunities for major benefits for the marine community.

The met-ocean service provider and user communities thus face the considerable challenge of working together to implement more integrated and more user-focussed met-ocean service arrangements at both national and international levels and especially to design the algorithms and build the operational capacity to make better use of ocean information and services for decision-making in all the potential application areas.

Several recent international conferences and initiatives have provided a strong foundation for national and international action to enhance the value of met-ocean services. These have included:

- The March 2007 '*International Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services*' (WMO, 2009) which, through its Madrid Action Plan ,set out a comprehensive five-year strategy for major enhancement in the value of, and benefits from, a wide range of meteorological and related services;

- The *Third World Climate Conference* in Geneva in August-September 2009 which decided to establish a new 'Global Framework for Climate Services' with five specific recommendations on ocean and coastal climate issues bearing on the provision of improved climate services.

- The *OceanObs'09 Conference* in Venice in September 2009 which reviewed the enormous progress achieved in ocean observation since 1999 and its impact on a range of ocean applications and services. It pointed to the benefits potentially available from enhanced services over the coming decade.

Quite a number of specific actions emerge, from these and other service improvement initiaties, which, if implemented, could go a long way towards realising the full potential benefits of met-ocean services over the next few decades. These include (Slide 30):

- Establish user-oriented National Ocean Services (NOSs) in many more maritime countries than presently operate them (as earlier recommended by the International Council of Academies of Engineering and Technological Sciences (CAETS, 2007));

- Strengthen the Global Ocean Observing System (GOOS) and ensure that it is maintained on a long-term sustained basis to support the full range of operational oceanographic services;

- Develop improved ocean prediction models and improved decision-support models and algorithms for application by key user communities;

- Establish much greater interaction and dialogue between the providers and potential users of met-ocean services.

- Initiate a range of pilot projects aimed at demonstrating the value and benefits of met-ocean services in various application sectors; and

- Put a major effort into building capacity, in both the provider and user communities, for joint initiatives to enhance the quality, utility and value of the various services.

A particular challenge for all maritime countries will be to take advantage of the rapidly increasing information content and service provision capabilities from comprehensive ocean models (such as the Australian 'Blue Link', the Russian ESIMO and the European 'My Ocean') in collaboration with the broader weather, climate and hydrological service communities to gradually develop the technical capability and integrated institutional arrangements for provision of seamless ocean, weather, climate, and water and other environmental services to national communities (Slide 31).

Some thoughts on what JCOMM can do (Slide 32)

Both by its charter and its composition, JCOMM is pre-eminently positioned to guide the international effort to deliver greatly increased national and international benefits from met-ocean services to the marine community.

Some particular initiatives that JCOMM might usefully undertake would include (Slide 33):

- Promote the initiation of a range of case studies of the economic benefits of different categories of met-ocean services in line with the Madrid Action Plan and as a contribution to greater government and user community awareness of the value of the services;

- Re-emphasise the importance of national contributions to the international ocean observing and data processing infrastructure as a global public good;

- Advocate Members' establishment of government-funded operational National Ocean Services (NOSs) providing a range of core public good ocean services;

- Foster coordination and economies of scope and scale between the service roles of NMSs and those NOSs and ocean research agencies that are engaged in the provision of services; and

- Offer to assume responsibility, in collaboration with the WMO Commission for Climatology, for advancing the development of ocean climate services as part of the proposed new Global Framework for Climate Services (GFCS).

JCOMM and its WMO and IOC predecessor bodies have a proud history of guiding the development and application of meteorological and oceanographic services for the good of all nations. By bringing together, for the work of the Commission, representatives of both the main meteorological and ocean communities of Member countries, it provides a particularly powerful mechanism for fostering coordinated national effort on the development and further enhancement of the benefits from met-ocean services in all maritime countries.

I would like to thank the JCOMM Co-Presidents for their invitation to speak about enhancing the socio-economic benefits of met-ocean services and I wish the Commission every success in this important task. Thank you for your attention (Slide 34)