In the beginning

According to the Book of Genesis, the third day of the creation process saw the separation of land and sea. This clearly provided a medium for transportation over long distances for the humans still to be created and at the same time laid the groundwork for the new science and profession of marine meteorology. Since that time, humanity has been simultaneously fascinated and awed by the powers of the air and sea, as well as anxious to understand and exploit the processes observed. However, lacking anything beyond a basic empirical knowledge, the early seafarers remained at the mercy of wind, waves and currents and whatever was driving them:

Then Jove raised the North wind against us till it blew a hurricane, so that land and sky were hidden in thick clouds, and night sprung forth out of the heavens. We let the ships run before the gale, but the force of the wind tore our sails to tatters, so we took them down for fear of shipwreck, and rowed our hardest towards the land. [1]

Homer attributed Odysseus’s maritime problems largely to the machinations of Poseidon, which was as good an explanation as any at the time (Figure 1).

Perhaps the first serious attempt to provide scientific and logical explanations for the atmosphere, the ocean and the various phenomena they engender was made by Aristotle in his Meteorologica [2]. While the book is remarkable in its lucidity and level of understanding, sadly it does not provide much in the way of forecast guidance to the marine meteorologist. Equally sadly, human scientific understanding of our natural environment largely stood still, or regressed, for centuries after that, with more reliance being placed on myth than scientific evidence and logic (Figure 2).

Fortunately, mariners, to survive and prosper, have to be intensely practical people. In extending their trading and exploration voyages over wider and wider sea areas, and to more and more distant lands, they accumulated a formidable body of empirical knowledge of the atmospheric and oceanic environment in which they lived and worked. This knowledge would

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2 Ocean Services Section, Australian Bureau of Meteorology, Melbourne, and member of the JCOMM Services Coordination Group
eventually provide a sound basis for advances in scientific understanding and the development of predictive capabilities. Notable examples of the application of such collective knowledge in the provision of aids to navigation include Benjamin Franklin’s chart of the Gulf Stream (Figure 3) and the creation in 1805 by Sir Francis Beaufort of the Beaufort wind force scale (Figure 4). Variations on the latter are still in practical use to this day. From the middle of the 17th century onwards, the invention and gradual refinement of scientific instruments to measure atmospheric and oceanic variables, together with the establishment, notably in Europe, of a network of weather stations, led to the gradual development of the scientific basis of meteorology, and its application in the service of the maritime community. However, it was from the middle of the 19th century, with the first use of the newly invented electric telegraph to transmit weather observations in 1849 in Britain and the USA, followed by the Brussels Maritime Conference of 1853, that really rapid development took place.

Brussels 1853, establishment of National Meteorological Services, IMO and maritime meteorology

Events leading to, surrounding, and as a consequence of, the Brussels Maritime Conference of 1853 have been well described in other publications, notably the WMO Bulletin articles by Michel Hontarrede [3] and Bob Shearman [4] and in the proceedings of the international seminar to celebrate the 150th anniversary of the conference [5]. The following paragraphs therefore provide a brief summary only.

The driving force behind the convening of the Brussels conference was Lt Matthew Fontaine Maury of the US Navy, already well known and respected for his work on ocean currents and winds. Although European scientists had been exchanging information for some time, the conference represented the first truly international gathering to address cooperation and standardization in meteorology. It brought together some 12 experts from 10 European countries and the USA, and agreed notably on a standard format for ships logbooks, together with a set of standard instructions for making and recording weather and ocean observations. The international cooperation that was set in train by the Brussels conference led directly to the First International Meteorological Congress in Vienna in 1873, and ultimately to the formal establishment of the International Meteorological Organization (IMO), the (non-governmental) predecessor of WMO, in 1905.

In parallel with these international developments, most of what were, at that time, the great powers were in the process of establishing their
own national meteorological agencies during the years 1850 to 1870. As in so much of early meteorology, this was stimulated by the needs of the maritime community and, in the case of France, specifically by two major maritime disasters: the loss in November 1854 of 38 French, English and Turkish ships engaged in the Crimean War and, in February 1855, the wreck of a French warship between Corsica and Sardinia, with heavy loss of life. The person charged with setting up the French meteorological service, Le Verrier, at the same time pioneered the use of the new electric telegraph as a key element of a national meteorological observation network. All the new meteorological services made observations and in many cases, attempted, with varying degrees of success, to forecast the weather.

A seminal event of the period for maritime meteorology was the invention of wireless telegraphy at the dawn of the 20th century, which opened the possibility of two-way communications with ships at sea. In 1905, the radiotelegraph was first used to relay weather reports from ships at sea to coastal radio stations. Shortly after, in 1907, the International Meteorological Organization moved to oblige all ships to be fitted with radiotelegraphy equipment, and to transmit observations to shore, while it also created a new Technical Commission on Maritime Meteorology. Thus began the modern era of meteorological service interaction with and support for the maritime community.

Safety of life at sea

While the transition from sail to steam totally changed the nature of maritime transport during the second half of the 19th century, it did not mean that shipping and the maritime community in general became immediately any less vulnerable to extreme weather and related oceanic manifestations (Figure 6). The sinking of the Titanic in 1911 with the loss of some 1,500 lives, albeit avoidable, did lead to two major developments relating to maritime safety: the establishment of the International Ice Patrol in the North Atlantic and, in 1914, the adoption of the first International Convention for the Safety of Life at Sea (SOLAS), covering a wide range of measures designed to improve the safety of shipping. It included measures relating to meteorology and the safety of navigation. In particular, SOLAS called for coverage of all shipping lanes and fishing grounds with weather forecasts broadcast by radio. This led to the evolution of an international system for the collection of meteorological observations from the oceans, the analysis of these observations and the subsequent preparation and broadcast of meteorological bulletins to shipping. Over the years, The International Meteorological Organization, its successor WMO, and maritime organizations, developed a coordinated system of marine forecast and warning services covering both coastal waters and the high seas.

There have been four versions of SOLAS agreed since 1914, the most recent that of 1974, which came into force in 1980. Since then, the convention has been supplemented, revised and updated through the addition of a Protocol of 1978 and a series of amendments, all developed, reviewed and adopted by the International Maritime Organization (IMO). From the establishment of WMO
as an intergovernmental organization in 1950, its Commission on Maritime Meteorology (later Commission for Marine Meteorology (CMM), now the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM)) has worked closely with IMO (and its predecessor the International Maritime Consultative Organization). It ensures that the components of SOLAS relating to meteorological observations and the provision of meteorological services conform to the latest scientific and technical developments in meteorology and communications and, at the same time, responds to the needs and concerns of the maritime community in regard to maritime safety. SOLAS now contains [6] a number of key regulations relating to meteorological services, which put certain obligations on contracting Governments, in particular to:

- ... warn ships of gales, storms and tropical storms..
- ... issue twice daily, by radio, weather bulletins suitable for shipping..
- ... arrange for selected ships to be equipped with tested instruments...and to take meteorological observations ...
- ... arrange for the reception and transmission ... of weather messages from and to ships ...
- ... conform to the technical regulations and recommendations made by the World Meteorological Organization ...

These regulations are a concrete manifestation of the ongoing interdependence of meteorology and the maritime community, as well as a strong commitment on the part of National Meteorological Services in maritime countries to contribute to the extent possible to the safety of life and property at sea.

Global Maritime Distress and Safety System and modern marine meteorological services

The establishment in 1982 by IMO of the International Maritime Satellite System (INMARSAT) ushered in a new era in maritime telecommunications, making use of the ongoing revolution in telecommunications worldwide. This led in turn to the development by IMO of a whole new system for maritime safety, incorporated into SOLAS as the 1988 Amendments for the Global Maritime Distress and Safety System (GMDSS), which came into force in 1992, with full implementation to occur by 1 February 1999. With the international adoption of GMDSS, marine communications have been updated to reflect the advances in satellite and other communications technology and Morse-code qualified radio officers are fast disappearing from ships.

With the launch of the first INMARSAT satellite, the development of GMDSS by IMO, and the expected eventual disappearance of the traditional coastal (HF) radio stations, it was quickly recognized by WMO and the National Meteorological Services providing maritime safety services that they would need to adapt to, and take advantage of, the new regulations and communications facilities.

During the 1980s, WMO, through CMM, and working closely with IMO, the International Hydrographic Organization (IHO), responsible for the Worldwide Navigational Warning Service) and representatives of international shipping through the International Chamber of Shipping, developed a new WMO marine broadcast system for the GMDSS. This system was adopted on a provisional basis in 1989 and in final form in 1993. It now forms an integral part of the WMO Technical Regulations [7].

Under this broadcast system, the world’s oceans are divided into a network of Metareas (Figure 7, identical to the Navareas of IHO), for each of which a specified National Meteorological Service is obligated to ensure the broadcast, via INMARSAT, of meteorological warnings and forecasts for shipping, according to a published broadcast schedule. In 2003, a new Website was implemented by the French Meteorological Service, Météo France, which displays, in real-time, the forecasts and warnings for all the 16 original Metareas [8]. Recently, IMO and WMO agreed to implement five new Metareas covering Arctic waters, recognizing the growing importance of these waters for maritime transport.

![Figure 7 — Metareas for the Global Maritime Distress and Safety System](image-url)
Dissemination of meteorological warnings and forecasts to shipping is now an integral part of the GMDSS system and GMDSS communications permit automatic shipboard receipt of weather and navigation information by INMARSAT satellite communications, radiotelephony and radio-telex (NAVTEX). Regularly scheduled weather, sea-state and ice forecasts, along with warnings of tropical cyclones, gales, storms and other hazards, are now routed to ships at sea by INMARSAT and NAVTEX broadcasts.

At present, meteorological warning and forecast information is normally presented to ships officers in text format via a computer screen or printout. However, technological advances in the electronic chart display system, developed originally under IHO to display navigational hazards on board ships in electronic chart form, will allow ephemeral information such as meteorological warnings and sea-ice information also to be displayed in this format. This approach will also facilitate the replacement of the traditional meteorological chart transmission by HF radio facsimile broadcast, much valued by mariners but gradually being phased out because of cost pressures, by new forms of digital graphical broadcast and display.

The new maritime communications systems also provide a very efficient, accurate and reliable means for the collection of real-time meteorological and oceanographic reports from ships at sea. It should never be forgotten that such reports remain essential for meteorological analysis and forecasting, and to the delivery of the accurate meteorological forecasts and warnings now expected as routine by the public and many different specialized users. They also remain critical to the provision of accurate maritime safety services. In addition, such data contribute substantially to our knowledge and understanding of global climate, climate variability and climate change.

Other national services

Formally, although the GMDSS provides communications carriage requirements for all sea areas (VHF for near-shore, NAVTEX essentially for EEZs (to 200 nm) and INMARSAT for the high seas), it represents an obligation only for vessels over 300 tonnes, registered in countries which are signatories to SOLAS. There are inevitably some gaps. For many countries, providing full coastal coverage by VHF and NAVTEX facilities is simply not cost-effective, which means that other facilities have to be implemented to reach vessels in these areas. A whole range of more or less seaworthy vessels (and their crews!) are anyway not subject to GMDSS regulations, ranging from the local fisherman’s “tinnie”** through coastal ferries and small freighters to cruising yachts and deep-sea fishing vessels (Figure 6). At the same time, these account for the largest segment of users of marine weather services overall. Often, the smaller vessels, and those operating in the coastal zone, are the most weather-sensitive and thereby vulnerable to rapidly changing or deteriorating weather and ocean conditions.

* Australian slang for a small recreational dinghy, often made of aluminium and propelled by oars or an outboard motor.
Coastal conditions are often more rapidly changeable, reflecting the complex interaction of the nearby land with ocean and weather systems. Consequently, coastal mariners require a significantly higher level of detail about conditions likely to be experienced. At the same time, in many parts of the world, the smaller users do not have ready access to the communications technology required to access the services provided via the contemporary systems that are used by the more sophisticated and better resourced operators that ply the high seas.

National Meteorological Services provide a range of forecast and information services for the many types of operators in coastal areas, in keeping with the identified needs of this sector. Radio still provides a backbone for disseminating forecasts and bulletins of information in coastal areas, while really near-shore users are also taking advantage of new mobile phone technologies to access a range of dial-up weather services. VHF radio broadcasts of weather information are provided in many coastal areas around the world and are an indispensable element of maritime safety for fishing, passenger transport, recreational craft and coastal traders.

The nature of the forecasts and related information provided for coastal zones reflects the characteristics of the weather and oceans in different regions. For example, sea fog and attendant low visibility are a significant hazard to navigation in some coastal regions but are quite rare in others. Lee and funnelling effects may be common in areas where mountain ranges run alongside coastal areas. Complex coastal geography, especially coastlines and disposition of island groupings, add further complexity to the description of the meteorology and the amount of detail required to convey it to mariners.

As mentioned earlier, NAVTEX services provided as part of GMDSS are designed for coastal and other users out to around 200 nm, but global coverage (of all coastlines) remains unlikely. To cover gaps in NAVTEX and VHF coverage in some countries, such as Australia, coastal forecasts are also broadcast as part of the GMDSS service via INMARSAT.

Where next?

The transition from sail to steam at the end of the 19th century and the consequent belief that the safety of maritime transport might gradually become less critically dependent on meteorological information, together with the advent of aviation as the primary focus for meteorological services in the first half of the 20th century, resulted in some loosening of the traditional close ties between meteorology and the mariner.

Recent years, however, have seen a reversal of this trend, with a number of factors each playing a part: the recognition that a large majority of maritime safety incidents (up to 70 per cent) remain weather-related (Figure 9); the new communications technologies described above, which allow the reliable delivery of an enhanced range of maritime safety information to ships at sea; the development of much more specialized shipping, requiring a balance among safety, minimizing the potential for cargo damage, reducing voyage times and fuel costs and managing increasingly busy ports and seaways; and the opening up of new sea routes, especially in polar waters. All these factors are contributing to a new recognition of, and reliance on, the delivery of high-quality meteorological and oceanographic information to ships at sea.

Yet another factor is now coming into play. Mankind retains a fascination with the age of sail, and modern tall ships are an increasingly popular choice for deep ocean pleasure cruising (Figure 10). The priority with this type of ocean travel is to maximize safety for the passengers, while providing them with an authentic experience under sail, which requires accurate and timely information on future wind and sea conditions. At the same time, the current costs of fuel for powered maritime transport, major concerns with carbon emissions from fossil fuels and a likely increasing shortage of such fuels in the decades to come, are leading marine engineers and ship designers to look once more at harnessing the wind as a means of at least partially powering large marine transport vessels. While several different approaches are being considered here, they all rely to a greater or lesser extent on wind
propulsion. With such vessels, the concerns will be to maximize wind usage, while delivering the most efficient and cost-effective route and again preserving maritime safety.

The new age of sail, together with all the other developments in maritime transport, indicates that the old symbiotic relationship between meteorology and the mariner is returning: meteorology continues to depend critically on the observational data provide by the mariner at sea, while the safety and efficiency of global shipping remains no less dependent on accurate and timely meteorological and oceanographic information than it was more than 150 years ago, at the time of Maury and the dawn of meteorological services for the mariner.

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