MARINE METEOROLOGY AND MARITIME NAVIGATION

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Abstract

Marine meteorology as the specialized, applied part of meteorology uses general meteorology and physical oceanography data, so as to provide weather and hydrological forecasting necessary for safe maritime activities (shipping and maritime transport, ocean fishing, maritime industry, marine sports and leisure).

Keywords: marine meteorology; marine environmental conditions; maritime navigation

Introduction

Marine environmental conditions have a particular impact on navigation, life and daily activities on board ships. A navigator would not show so much interest in meteorology or oceanography, if they were to navigate only on calm seas and nice weather.

But the sea would never forgive an incompetent sailor. Therefore, throughout the history of navigation, sailors were interested in knowing both the sea and the surrounding natural phenomena, be them hospitable or hostile. On rough sea, or in difficult areas, the life of the crew can be very tough and the ship and her cargo may be endangered.

Winds, waves, fog, rain, storms have all been observed and recorded, becoming the objects of study for marine meteorology and oceanography. They have been introduced into the curriculum of marine education worldwide.

Today there are worldwide precise rules on Marine Meteorological Services, which operate on the basis of four principles²:

1. marine weather services are provided in order to meet the information requirements established by national practice and international conventions, about environmental conditions and meteorological phenomena;
2. marine weather services contribute to the safety, efficiency and economy of marine environmental activities;
3. marine weather services include the guidance on the interpretation of meteorological and oceanographic information;
4. marine weather services assist the users in obtaining high standard information.

Now, following the example of maritime navigation, defined in the recent past as both art and science, marine meteorology has shifted from the stage of art to that of independent science, with laws, principles and specific methods, using modern tools and equipment, along with specialized computer programs capable of providing the navigator with knowledge about the evolution of weather at sea, at high accuracy and for fairly long periods of time, for ensuring the ship’s safe voyage.

At sea, ships are subjected to the action of meteo-oceanographical factors, which can generate different dangerous phenomena that make navigation difficult, worsen the storage conditions of goods on board, increase the voyage execution time, increase fuel consumption and ship’s wear, or affect her stability, thus creating stressful living conditions for the crew members, to say nothing about the threats upon navigation and ship’s safety.

In bad weather conditions, loading and unloading port and fishing operations are stopped, vessels go to shelter in the inner or exterior roadsteads, sail in high seas or lie ahull.

Given that any vessel, regardless of her robustness and propulsion, is not guaranteed against loss or damage caused by severe weather phenomena, it is necessary to have thorough knowledge of the influence of meteorological parameters on navigation.

The analysis of a vessel’s cargo and crew safety is closely related to the economic factor, to the profitability of the voyage. It is necessary to choose the safest route, the one that fulfills the best economic performance criteria, so as to be able to prepare the ship and crew for navigation in bad weather.

Applied Meteorology includes meteorology those components with immediate application in practice, i.e. agriculture, forestry, land, sea and air transport, medicine, tourism etc. Marine Meteorology is a scientific and technical applied discipline that uses data from general meteorology and physical oceanography, with the purpose of producing meteorological and hydrological forecasts, which are necessary and useful for conducting maritime activities: navigation and shipping, ocean fishing, maritime industry, marine sports and leisure etc.

Marine Meteorology provides specific and accurate information about the status and evolution of weather in some areas, in time and space, further used to increase the safety of passengers and crew, of ship and her cargo.

**Brief history of marine meteorology**

The first international meteorological conference took place in August 1853, in Brussels. It was attended by major maritime countries. Here, the American lieutenant Matthew Maury, who was already known for his studies on ocean winds and currents, coordinated the works of the conference, exchanging multiannual meteorological information with the other participants. Therefore, he is considered the founder of marine meteorology and operational oceanography. He initiated the international cooperation, which further led to the establishment of the World Meteorological Organization and of the Intergovernmental Oceanographic Commission, belonging to UNESCO (Intergovernmental Oceanographic Commission-IOC).

During this conference, a few directions regarding the watch of world weather were set, i.e. the standardization, the instructions for completing the meteorological journals, and also the measured and calculated parameters (atmospheric pressure, humidity, wind, cloudiness, clouds, sea surface temperature, water temperature and depth). All the above were considered as a beginning for the current World Weather Watch.

Beginning with 1855, as a result of losses of ships and human lives in the Crimean War, during the storm in the night of November 14, 1854, action was taken to organize a system for collecting, interpreting and transmitting meteorological information to ships.

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3 Ibidem
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In 1905, the International Meteorological Organization is formally created. Since 1907, when the Technical Commission for Maritime Meteorology was created, it became compulsory for all ships to be equipped with a telegraph, by which meteorological information could be transmitted to shore.

Starting with the 30s, with the development of overseas aviation and navigation, and also with the events and circumstances generated by the Second World War, there emerged a network of meteorological ships which provided meteo-oceanographic information necessary for the safety of navigation, and which lasted until the early 80s.

In 1952 the World Meteorological Organization (WMO) was founded. Under its auspices the members of the Commission for Maritime Meteorology (later called the Commission for Marine Meteorology – CMM) meet. This commission had regular meetings for 45 years, having been entrusted with the mission of regulating the activity of meteorology for the benefit of seafarers.

Since 1980, the Commission for Marine Meteorology has known two main directions of development: the oceanographic meteorology and the coastal meteorology, the two, equally serving both navigation and maritime coastal industry. Towards the end of the twentieth century the necessity of cooperation between marine meteorologists and oceanographers becomes almost mandatory, so that, in 1999 the WMO Congress and the IOC Assembly decided to create the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology - JCOMM, whose first session was held in 2001. On this occasion, the development and action directions were settled.

The World Meteorological Organization (WMO), http://www.wmo.int, is the United Nations specialized agency for conducting, coordinating, harmonizing and improving the world meteorological activities and for achieving the specialized collaboration among states.

Beginning with 2007 the WMO has developed an integrated concept on meteorological observations, i.e. WMO Integrated Global Observing Systems – WIGOS, that ensures a complex network of meteorological observations, in space, on land and at sea. Today, this network consists of over 10,000 classical and automated weather stations on land, more than 1,000 stations in the atmosphere, over 7000 stations on maritime vessels, over 3000 meteorological stations on board civil aircraft, over 100 anchored meteo-buoys, over 1,000 drifting meteo-buoys, hundreds of weather radars, weather satellites etc.

Currently there are meteorological observation systems, such as global observation system (Global Observing System - GOS) of the World Weather Watch - WWW), the Global Ocean Observing system - GOOS), the Global Hydrological Networks – WHYCOS, operating at national and regional level, the Global Atmosphere Watch - GAW which provides information for scientific research, and also warning regarding changes in the chemical composition of the atmosphere, or in the atmospheric physics with serious consequences on the environment.

**Marine meteorology in Romania**

In Romania the marine meteorological activity is related to the foundation, in 1926, of the Maritime Hydrographic Service. Beginning with 1955, the Maritime Hydrographic Direction has provided the hydrographic and hydrometeorological information for the Romanian Navy. Through Law 395, of 2004, the Maritime Hydrographic Direction – DHM has become the national authority in the field of marine hydrography. The Marine
Meteorology Department of DHM has a permanent role in weather watch and weather forecasting in areas of responsibility and interest of the Romanian Navy, for safe navigation.

Also, this unit functions as a forecasting center within the Integrated Meteorological System of Romania-SIMIN. The Marine Meteorology Department operates, maintains and develops the National Integrated Meteorological System of the Navy (SIMIN-FN) and the Navy Meteorological Maritime Surveillance Network (RSMM-FN), composed of coastal and marine automatic weather stations.

Romania is a founding member of the World Meteorological Organization (WMO) and has a total number of 170 meteorological stations, of which five are located on the Romanian Black Sea coast, i.e. Sulina, St. George, Gura Portiţei, Constanţa and Mangalia (Figure 1).

Among the outstanding Romanian authors who have contributed to the development of the Romanian marine meteorology, through their significant activity and important papers in the domain, the following are worth mentioning: Constantin Bondar, PhD - Black Sea-hydrological monograph, 1971; sea captain Liviu Neguţ - Maritime Meteorology-1981; assistant professor Octavian Mircea Selariu, PhD, with numerous studies and marine meteorology; assistant professor Brânduşa Chiotoroiu, PhD – River Hydrometeorology, 2001; Cornelia Pescaru, PhD - Marine Meteorology, 2005; assistant professor Romeo Boşneagu, PhD - Marine Meteorology. Meteorological Navigation, 2014.

**Meteomarine information**

The main meteorological parameters which are used in the maritime activities are: solar radiation; sunshine duration; temperature; water temperature; salinity; air moisture; atmospheric pressure; nebulosity; rainfall; the wind, and weather phenomena.

For the vessel voyage planning and for the preparation of a maritime technological activity in a sea area or ocean basin it is necessary to thoroughly study the meteorological and oceanographic documentation, both from the hydrographic point of view (bathymetry, bottom

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7 www.dhmfn.ro
nature, dangerous depths) and also in terms of marine meteorology and hydrology (medium waves, variation limits, physical processes and dangerous phenomena).

The meteo-oceanographic information for the navy can be twofold: direct meteo-information, and encoded meteo-oceanographic information.

The direct meteo-information refers to transmitting and receiving weather bulletins and gale warning on board vessels. Such messages inform on the meteorological situation in the area of navigation, or in the surrounding areas, being used for more accurate interpretation of synoptic charts.

They contain the following information:

1. presence or absence of storm in the area;
2. the general meteo-synoptic context: the presence and development of maximum pressure centers, and of low pressure disturbances, and also some information on the weather conditions when crossing the atmospheric fronts related to extratropical depressions;
3. meteorological forecast for a certain period of time (degree of cloudiness, visibility, dangerous phenomena at sea, sea state). The weather bulletins/notices are received by radio or NAVTEX.

The encoded information is done by using multiple specialized codes among which the most important are SYNOP and SHIP codes. These encoded messages contain meteorological and hydrological information organized in a logical order, so as to be easily decoded and understood. These data are contained in the basics of meteo and hydrosynoptic charts, while a part of it used in support of meteorological and oceanographic maritime navigation.

Conclusions

Now, the influence of weather conditions on maritime navigation can be quantified by:

**Navigation and visibility**

For maritime navigation it is important to define and know some specific situations related to visibility, such as: good visibility; poor visibility; no visibility.

Good visibility is manifested in nice weather and ensures the observation of the various ships, boats, objects etc., at sea at long and very long distances.

Poor visibility generally is generated by covered skies, and is usually accompanied by moderate weather events. Observation in poor visibility is done on short distances, which directly affects the safety of ship and navigation. Additional watching measures are required.

No visibility or "zero visibility" is generated by dense fog and rainfall. Special measures should be taken in such cases, both during watches and during ship maneuvering so as to minimize the occurrence of navigation accidents.

Reduced visibility at sea may also be caused by a number of meteorological phenomena such as fog, snow, heavy rains etc. In compliance with the international regulations regarding safety of navigation in poor visibility, a vessel’s speed must be reduced to a value that would allow avoidance of any hazards.

At the first signs of low visibility the navigator must determine the fix, and also record the ship’s course and speed. The officer on watch (OOW) and all members of the crew should engage both visual and auditory senses so as to prevent or avoid accidents. Fog signals are issued, and also particular attention is given to the radar information and to the data existing on the navigation charts (depths, navigational hazards etc.).

Also, the navigator needs to take into account that sound is deflected both horizontally and vertically, in the air, thus making it difficult to determine the position of the source of noise (ship, aids to navigation, be it afloat, or on land).
At sea visibility is paramount. Low visibility, even in the current technical conditions, is still a great danger to navigation. Visibility depends on a number of factors: atmospheric transparency, brightness and colors of objects, land-marks or background, etc. The main cause for poor visibility is the existence of water vapor in the air, which, under certain environmental conditions, merges into liquid or solid form. Fog could decrease visibility to zero, at sea.

Most often, the fog occurs due to the advection of warm and moist air on the relatively cool surface of seawater (advection fog). This is characterized by large vertical thickness, extension on large areas, duration and mobility. The intensity of advection fog depends on the difference in temperature between the mass of air and sea water (the greater the difference, the greater the intensity and density of fog). Due to the aforementioned characteristics, the advection fog may occur unexpectedly.

The advection fog’s density decreases when hot air comes over, or when the wind changes its direction, in which case it is possible that it bring cooler and less humid air.

In winter, the evaporation fog occurs over maritime areas due to the access of cold air masses over warmer waters. The evaporation fog occurs at low air temperatures, and high water temperatures (higher than at least 100°C).

In winter, worsening visibility warm front occurs before a slow-moving or while driving an occluded front after a warm one. It is caused by the evaporation of warmer droplets of rain or frost in cold air. In winter fog can appear after a cold front, if it rains in the area with cold air, or evaporation comes over from a surface which is warmer than the air. Frontal type fog can formed both within the cold front, and outside it, in the narrow coastal areas, due to the mixing of warm and humid air with cold air. As a practical conclusion, in winter the crossing should be done by taking a perpendicular course.

**Influence of air temperature on navigation**

Air temperature has a great influence on navigation, ship, cargo and crew. The optimum temperature for work on board ships is 180 to 250°C. Temperatures higher than these, accompanied by excessive humidity, or low temperatures create a specific discomfort (for lower temperature variation), or influence the activity of the crew in a negative way.

Excessive dampness or moisture can deteriorate the cargo stored on deck or in cargo holds. Deposits of ice on the deck and superstructure could be dangerous for the ship and crew. Moving ice drifting at mid-latitudes hinder navigation and become extremely dangerous.

**The influence of air humidity on maritime navigation**

The amount of atmospheric moisture has a great influence on people, on physiological processes, especially on thermoregulation processes. The thermal comfort index has a special influence on those who work on deck.

**Weather associated with cloud types**

The stratus clouds do not have a special significance for the weather condition analysis. If the stratus clouds are very low they may affect visibility. They indicate a stable air mass if the convection is low. They may produce drizzle.

The nimbostratus clouds are rain clouds. Generally, these clouds announce bad weather, possibly with rain. In some cases rain does not reach the ground.
The stratocumulus clouds have special significance for weather analysis. Overall, they are not bad weather clouds. They indicate stable weather. Sometimes they are accompanied by light rain or drizzle.

The small Cumulus clouds generally indicate good weather. The big Cumulus clouds indicate instability with possible showers caused by the strong convection phenomenon. They may indicate rain when they are spread by the wind.

The Altocumulus does not have a special significance for weather analysis. Overall they are not bad weather clouds. They indicate rain when they are spread by wind.

The Altostratus clouds announce the advance of a baric depression if they derive from Cirrostratus clouds and the atmospheric pressure is dropping.

The Cirrus clouds in development generally indicate the proximity of bad weather with rain.

The Cirrocumulus clouds are associated with fair weather with light wind.

The Cirrostratus clouds indicate proximity of rain. If Cirrus follows, chances are for a tropical storm to approach.

Bibliography