Marine Meteorology

Data and tools available for Sailors

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These last three or four decades, knowledge in climatology and meteorology increase very rapidly and especially data provided by all the major weather institutions are growing exponentially.

The purpose of this article is by no means a course on meteorology, a course on weather routing or guide to interpret weather data, even not a tool to help in the decision of choosing the best route to take.

It simply tries to do a description of the available data and relevant tools of good quality and accessible to everyone both technically and financially.

Introduction

What tempted me and what always tempt me is the ocean, is the pleasure to admire the landscape far from land that changes every second, shape and color, as well as animals that may appear any time anywhere.

So as soon as one starts a passage of several days with our little “Flot18 (27 feet sailing boat and a draught around 1.20 meter - so a lot of drift) the average speed was low and there was no need to go far for a trip that took time.

Therefore, meteorology was very important. We were curious and wanted to know how we were going to be eaten.

It was difficult, because the quality of weather forecasts were not as good as they are today; reliability was very different according to the region as the data collected by the weather services were variable both quantitatively and qualitatively. A reliable forecast for the next 48 hours was exceptional.

Reception of weather reports were challenging. Even near the coast and in certain navigation areas, we do not always get what could help us think. Offshore, we could use long wave radio to catch the offshore forecast for the North Atlantic broadcast twice daily by a public radio; one could hope get information from other sources, but it was not easy to find them (without internet …); for instance, the frequencies of different radio stations broadcasting weather forecast, but they varied according to boat positions and times of the day, not to mention the "noise" that made more often than the desired reception inaudible.

After getting a weather report, the work of routing was starting to try not to be in the wrong place at the wrong time. This meant drawing the position of systems, strength position and wind direction in the different sectors (which implied to know the position of the areas used

by different issuers). With several sources that further complicated the task, because areas did not overlap and the probability that the situation and the forecast was different was clearly non-zero; it would be here too long to explain the reasons for these differences.

There was of course the "Pilots Charts" that provided valuable information, but in fact probabilistic, which meant that it was impossible to infer that would the actual situation at the time and in this place . It was not uncommon to have a wind 180° away from the "most frequent one" and a force also different of the most "probable one".

The observation of the sky was (and still is) absolutely essential to get an idea of the local situation. My favourite book for the observation of clouds was the International atlas of clouds[1,2]

Our "bible"[3] to help us in our work of interpretation has been for years the remarkable work of René Mayençon, marine meteorology published in 1982 and reissued in 1992[4].

Then Jean-Yves Bernot successively published 2 books[5] which are still the references in marine meteorology. Despite having taken the time to improve my knowledge between 1982 and 2004 by reading all the books, articles and other documents concerning marine meteorology, I had to hold on to their reading.

More I sailed, more I realized that the weather helped me to choose the best possible route[6]. The data were the same, the analysis led to the same result of evolution of weather; the choice of the course was largely dependent on the navigation program (cruises or regattas to stay in a general categorization).

In recent years, the number and quality of data has exploded. The sources have also increased: terrestrial data, marine data, data on the ground, in the air data, satellite data ... are shared and used daily by forecasters worldwide.

With the increase in computing power, weather numerical models have become more and more important, allowing significantly to increase the number of parameters used, to use models more sophisticated considering the morphology of the terrain and get results much faster (from several weeks to a few hours now).

For a long time reserved for the military and commercial shipping, access to technology for receiving digital data spread "small boats". First, it is almost exclusively the racing boats that are equipped, I followed the evolution of this equipment used by competitors of major

1 https://cloudatlas.wmo.int/docs/wmo_407_en-v2.pdf
2 For his story: https://cloudatlas.wmo.int/history-of-the-ICA.html and https://fr.wikipedia.org/wiki/Atlas_international_des_nuages
3 Term also used by Jean-Yves Bernot, author of "bibles" current; for references, see note 5.
4 See this review: http://documents.irevues.inist.fr/bitstream/handle/2042/53562/meteo_1993_2_100.pdf.
5 Jean-Yves Bernot : Météo et stratégie : Croisière et course au large, Paris, Voiles Gallimard, 2004 (2e édition 2010), 624 p.
Jean-Yves Bernot : Météo locale : Croisière et régate, Paris, Voiles Gallimard, 2007, 592 p.
6 I'm not the only one. I invite you to read the text of Frederic Allest about this: Choisir sa route au large en fonction de la météo (http://artimon1.free.fr/Choisir his way off according to the meteo.htm)

offshore races. In recent years, access to digital data becomes "easy" aboard a yacht, not only in terms of technology but also in terms of price.

« *Le routage météorologique embarqué appliqué aux voiliers de course ou de croisière est une pratique récente liée à l'émergence de l'informatique. On l'a vu naître dans les années 1980, se développer auprès des coureurs océaniques dans les années 1990 et se généraliser pour le grand public dans les années 2000.* »[7] Let's say that in the 2000s, we were still not many to have started in the use of IT to develop our own forecast.

The decision taken by the European Union to release all the data produced by public structures to everyone (Open Data) has largely contributed to the acceleration of access to many raw data or reworked for specific objectives by different sources regularly increasing.

There is therefore no reason not to use them and largely rely on the routing of our boat to ensure the safety of the crew and the boat[8] in addition to weather forecasts issued by official or recognized institutions.

Weather data

The "weather" portal available on the Wikipedia website[9] provides extensive information and links about what the weather is. In meteorology[10], numerical weather prediction (NWP)[11] uses mathematical models of the atmosphere and oceans to predict the weather based on current weather conditions; these models are based on choice of primitive equations[12] offering a close approximation of the behaviour of the real atmosphere. In operational meteorology, NWP is further used to make predictions with raw numerical results will have various forms of post-processing to make them usable. The results will be processed by other software or interpreted by meteorologists to meet the specific needs of users, in our case, marine weather forecasting[13].

The currents, waves and waves are key parameters for navigation, because it is they who primarily determine the state of the sea[14].

As seaman, we focus primarily on the impact that will have wind[15] and sea state on our present and future navigation. And this is what will determine the choice of data that we wish to access.

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7 "The onboard weather routing applied to racing or cruising yachts is a recent practice related to the emergence of computing. It was born in the 1980s to grow with ocean racers in the 1990s and generalize to the general public in the 2000s " Jean-Yves Bernot, p 13; Les routages en course et en croisière. Paris, Voiles et voiliers, 2014, 207p.

8 On this subject « Bonnes pratiques pour assurer la sécurité météo en haute mer », a document published in 2016 by la commission « sécurité en haute mer » from the association « Sail the World » (http://stw.fr/fr/blogs/securite-haute-mer/2016-04-08-securite-meteo-haute-mer-bonnes-pratiques)

9 See https://en.wikipedia.org/wiki/Portal:Weather

10 See https://en.wikipedia.org/wiki/Meteorology

11 See https://en.wikipedia.org/wiki/Numerical_weather_prediction

12 See https://en.wikipedia.org/wiki/Primitive_equations

13 See https://en.wikipedia.org/wiki/Marine_weather_forecasting

14 See https://en.wikipedia.org/wiki/Sea_state

15 See https://en.wikipedia.org/wiki/Wind

Weather forecasts prepared by professionals provide an analytical synthesis of multiple data. Understanding the terminology is needed, but to use them does not require high skills of forecasters and to take appropriate decisions based on the objectives of the sailing programme.

All meteorological services states provide weather forecast reports and very often specialized reports for coastal and offshore navigation.

Atmospheric models

Among the different atmospheric models[16] used by meteorological services, key used for marine forecasting are:

Global level

- **GFS** Global Forecast System[17] - developed by National Oceanic and Atmospheric Administration - NOAA[18].
- **GEM** Global Environmental Multiscale Model[19] - developed by Meteorological Service of Canada[20].
- **IFS Integrated Forecast System**[21] (Known in the United States, the European model) developed by European Centre for Medium-Range Weather Forecasts - ECMWF[22].
- **UM** Unified Model[23] developed by the UK Met Office[24].
- **ICON**[25] developed by German Weather Service[26].
- **ARPEGE**[27] developed by Météo-France[28].

Regional level

- **WRF** Weather Research and Forecasting[29] developed by US National Centers for Environmental Prediction (NCEP)[30] and the US National Center for Atmospheric

16 See a list of different atmospheric models: https://en.wikipedia.org/wiki/Atmospheric_model#Domains
17 See https://en.wikipedia.org/wiki/Global_Forecast_System
18 See https://en.wikipedia.org/wiki/NOAAFor more details on the models developed, see http://www.emc.ncep.noaa.gov/home.phpThe page of the National Weather Service's National Centers For Environmental Prediction's Environmental Modeling Center
19 See https://en.wikipedia.org/wiki/Global_Environmental_Multiscale_Model
20 See https://en.wikipedia.org/wiki/Meteorological_Service_of_Canada
21 See https://en.wikipedia.org/wiki/Integrated_Forecast_System
22 See https://en.wikipedia.org/wiki/European_Centre_for_Medium-Range_Weather_Forecasts
23 See https://en.wikipedia.org/wiki/Unified_Model
24 See https://en.wikipedia.org/wiki/Met_Office
25 See https://www.dwd.de/EN/research/weatherforecasting/num_modelling/01_num_weather_prediction_models/icon_description.html
26 See https://en.wikipedia.org/wiki/German_Weather_Service
27 See http://www.umr-cnrm.fr/spip.php?article121
28 See https://fr.wikipedia.org/wiki/Météo-France
29 See https://en.wikipedia.org/wiki/Weather_Research_and_Forecasting_model
30 See https://en.wikipedia.org/wiki/National_Centers_for_Environmental_Prediction

Research (NCAR)[31] is used in multiple configurations, especially WRF-NMM Nonhydrostatic WRF Mesoscale Model[32]Used primarily for forecasting and WRF-ARW Advanced Research WRF, considered as a tool for prediction for atmospheric research.

- **HARMONIE**[33,34], Developed by the European consortium numerical models HIRLAM time[35].
- **AROME**[36] is a small-scale model developed by Météo-France and the ALADIN consortium[37].
- **COSMO**[38] is a small-scale model developed by the COSMO consortium[39].

Ocean models

The Fleet Numerical Meteorology and Oceanography Center (FNMOC)[40] develops and produces a digital wave model[41], WW3 Wavewatch III; he also worked on the WAM now part of IFS.

The consortium MyOcean[42]Bringing together a large number of institutions and supported by European Union funds, in particular pilot type of production centers (MFC Monitoring and Forecasting Centers) that correspond to 6 "basins" European plus the global ocean. They number 7:

- **MFC Global** (Mercator Ocean)
- **Arctic MFC** (NERSC)
- **Baltic MFC** (DMI)
- **North West Shelves MFC** (UK Met Office)
- **Iberian, Biscay, Ireland MFC** (Mercator Ocean)
- **Med MFC** (INGV)
- **Black Sea MFC** (MHI)

31 See https://en.wikipedia.org/wiki/National_Center_for_Atmospheric_Research
32 This model is also named NAM, WRF, or NMM
33 See http://hirlam.org/index.php/hirlam-programme-53/general-model-description/49-mesoscale-model-harmonie
34 This model is also known as HARMONIE-AROME, not to be confused with the AROME model used by Meteo France
35 See http://hirlam.org/index.php/hirlam-programme-53
36 See http://www.umr-cnrm.fr/spip.php?article120
37 See http://www.umr-cnrm.fr/aladin/spip.php?rubrique7
38 See http://cosmo-model.cscs.ch/content/model/general/default.htm
39 See http://cosmo-model.cscs.ch
40 See https://en.wikipedia.org/wiki/Fleet_Numerical_Meteorology_and_Oceanography_Center
41 See https://en.wikipedia.org/wiki/Wind_wave_model
42 See https://en.wikipedia.org/wiki/MyOcean

Where can we find its data and in what form?

Certified weather forecasts reports are available on all the national meteorological institutes websites; to list them would amount to cover all the states lying beside a sea of water (ocean and sea).

Many sites allow you to view the results of simulations of different models. Again most of the sites of national meteorological institutes publish these data in the form of animated maps.

There are however some sites[43] that provide numerous and detailed data for comprehensive coverage (global) or regional:

- **Wetterzentale**[44] which put under Creative Commons licence[[[License: Creative Commons Attribution-NonCommercial 4.0 International License.->https://creativecommons.org/licenses/by-nc/4.0/]]] detailled charts for all part of the globe with NWP daily used by meteorological services.
- **Meteoblue**[45] provides the comparison for a given location of these models and several variant of these models in the form of graphs, the example proposed[46] highlights the differences for localisation north of Cowes in the Solent.
- **Windy**[47] allows to visualize many data from several models: for meteorology at the global level, GFS-22km and IFS-9km (mentioned as ECMWF on the map), at European level and NEMS-4km ICON-7km[48] and at USA level NAM Hawaï-3km, NAM Alaska-6km and NAM CONUS-5km and for ocean WW3 model and model MyOcean (designated as ECMWF WAM on the map).
- **Yr**[49] allows viewing of the HIRLAM model data for North of Europe and GFS for the global level.
- **OpenSkiron**[50] allows users to view data openWRF model for the Mediterranean.

Finally with the help of tools (see next section for a description of these tools), it is possible to work without a high-speed Internet connection and for reasonable costs; This is the case when sailing out of reach of internet transmitters (cable, wifi, GSM).

To avoid to have a rapidly outdated list, I invite the reader to refer to the list available on **OpenGribs**[51].

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43 The list is far from being exhaustive ; the sites mentioned are the ones I use regularly.
44 See http://www.wetterzentrale.de/en/default.php
45 See https://meteoblue.ch. This site offers a wide variety of quality data. Part of the offer is not free.
46 See https://www.meteoblue.com/fr/meteo/prevision/multimodel/50.781N-1.291E
47 See https://windy.com
48 Concerning models and sources see models https://community.windy.com/topic/12/what-source-of-weather-data-windy-use and on models and structures (framework) modeling view http://www.nomads.ncep.noaa.gov/txt_descriptions/NEMS_NMM_doc.shtml
49 See https://www.yr.no/kart/?spr=eng
50 See http://openskiron.org/en/charts
51 See https://opengribs.org/fr/gribs-fr

The tools

They fall into two categories, the tools of visualization and routing tools.

There are few tools developed strictly under a free license such as the GNU GPL; some tools are available for free as "restrained" and on some platforms only; their cost is generally modest, which is why I mention what I think still be useful in some circumstances.

Visualization Tools

- **XyGrib**[52] ***opensource*** (OS Windows, OS Mac, Linux OS), a clone of zyGrib, started in April 2018 by the OpenGribs team to develop several improvements required by users zyGrib; will, among other access on the fly to multiple data sources based on different models; new data will be included and the application will be available on Android OS and iPAD.
- **zyGrib**[53] ***opensource*** (OS Windows, OS Mac, Linux OS) started around 2002, has not changed since 2016 viewing application on the fly many data GFS and WW3 models.
- **SailGrib**[54] *free "restrained" / pay* (Android OS) visualization application to the data stolen from several sources for the free version and many sources for the paid version.
- **UGRIB**[55] *free* (Windows OS) historical, viewing application of some data from the GFS model.

Weather Routing Tools

- **OpenCPN**[56] ***opensource*** (OS Windows, Mac OS, Linux OS, Android OS, Raspberry Pi) navigation application with weather data visualization extension and weather routing extension.
- **qtVlm**[57] *free "restrained" / pay on smartphones and tablets* (Windows OS, Mac OS, Linux OS, Android OS, iPad) weather routing and navigation application.
- **SailGrib WR**[58] *free "restrained" / pay* (Android OS) weather routing application, integrating navigation, over 400 polar available.

Conclusion

Changes in meteorological and oceanic areas and improving weather forecasting will continue in coming years. My feeling is that it will go much faster than we imagine.

52 See https://opengribs.org
53 See http://zygrib.org
54 See http://www.sailgrib.com
55 See http://62.148.188.51
56 See http://opencpn.org
57 See https://www.meltemus.com
58 See http://www.sailgrib.com

This paper will likely become quickly outdated. So do not hesitate to produce new versions.

In the meantime, if you have any suggestions, corrections, supplements, do not hesitate to let me know by email to ycg (at) increase (dot) ch.