Intruduction

Meteorology is an highly interdisciplinary science, that use the laws of physics, mathematics and chemistry to aid in our understanding of Earth's atmosphere, its processes and its structure. It is a study that dates to ancient times, when ancient civilizations made observations and kept records of weather conditions, both for agricultural purposes and out of a general curiosity about the world around them.

Over the centuries, the atmosphere has been studied for a variety of reasons: agriculture, military defense and planning, weather watch and early warnings for severe weather systems like tornadoes and hurricanes. Technological developments, such as the advancement of scientific computing and an increase in the total number of meteorological observations daily performed across the globe, have allowed for better forecasts and a much better overall understanding of our atmosphere.

Nowaday more than one bilion of people come in contact with meteorology by means of the uncountable smartphone apps, that give them the possibility to know, one week in advance, the weather forecast over every place of the World. Other hundreds of thousands use on land, on board of ships or flying on a plane, other more comprehensive and sophisticated products that are weather maps. With few exceptions, every man is more or less directly come in contact throughout his life with a weather map. The major television networks, broadcast hours and hours of news programs on meteorology or better on weather forecast, showing this on simple weather maps, able to transmit the information, in an easy and immediate way, to an audience not always sufficiently literate. In the USA there is even a television channel (The Weather Channel) devoted entirely to weather forecasts on which 24 hours a day are alternated valid weather forecast for every corner of the World to documentaries on meteorology and of course hundreds of commercials that feed business. This enormous pervasiveness of weather forecasting and its applications in the life of most of the inhabitants of the planet, is opposed to a poor understanding of weather phenomena and the laws that govern the Atmospheric Sciences by generic users. In this paper, we want to raise awareness of the various types of meteorological data that are used to produce weather maps, the manner in which the observations are done, how the centralization and dissemination systems works and finally as you get to plot the meteorological fields that daily we watch on different weather maps.

1. A little history

1.1 Galileo and the court of Ferdinand II

In a cultural political environment dominated by forms of absolutism, European science of the seventeenth century it opened with the extraordinary figure of Galileo Galilei. Astronomer, mathematician and physicist of recognized standing, the great scientist was able to oppose, to the conception of science, until then based on rigor of abstract deductions and blind obedience to the authority of the philosophers, most notably Aristotle, a methodology based on observation concrete of natural phenomena and the consequent verification by means of suitably programmed experiments, assumptions born from the observation itself. It is the emergence of the experimental method and the final overcoming of that boundary line between the ancient science and modern science. In the field of meteorology, the first major fruit of the new Galileo quantitative science was undoubtedly the invention, refinement, and the subsequent use of the main measuring instruments such as thermometer, barometer, hygrometer and rain gauge. At the school of Galileo, born in Florence in the seventeenth century under the patronage of the Medici, then comes the instrumental meteorology, science that is designed to elevate from merely qualitative to quantitative the study of atmospheric phenomena. The interest of the Duke of Tuscany, Ferdinand II for instrumental meteorology, laid the foundation for the subsequent quantitative and systematic study of atmospheric phenomena. The building, by the master glassmaker Moriani, of a series of thermometers each other identical, known universally as "small Florentine thermometers" and their subsequent distribution to Italian and foreign observers, gave a further impetus to the establishment of a service of synchronous meteorological observations at international scale (Fig.1). What was asked to observers at this early stage were observations and measurements of some general air condition and temperature taken several times a day, but always at the same time. No coincidence that at this stage you chose the religious, used to a very methodical way of life. Early observers arose in Florence, Vallombrosa, Cutignano, Bologna, Parma, Milan, Paris, Innsbruck, Osnabruck and Warsaw and also in Florence the first historical data were recorded: two very short, one from 26 November 1657 to 8 May 1658, the other from February 12 to April 7, 1658; a third, much longer covers the period from December 15, 1654 to 31 March 1670 and is known as the Convent of St. Mary of the Angels series. After two years of the start of the temperature and state of the atmosphere measurements, to the observers were also delivered barometers, hygrometers and anemoscopes. The survey operations were coordinated from Florence, from the court chaplain, Luigi Antinori. In addition to measuring instruments, Antinori forwarded to the observers the operating instructions to follow and the forms on which to record the observations. Many of these forms with an indication of the month and the year to which the report were done, are still conserved in the Galilean Manuscripts of the National Library of Florence. We can consider that the introduction of systematic objective observations instead of discontinuous subjective estimates in use until now, has represented for meteorology the key moment, the final break from all his previous methodological approach and the consequent recognition of the discipline as a real science.

Fig. 1 Thermometers designed by the Grand Duke Ferdinando II de 'Medici, the cinquantigradi thermometers were generally used to learn about the mutations of warm and cold air both outdoors and in closed rooms. The academics made wide use of this type of thermometers, which had the advantage of being comparable between them, especially for systematic meteorological observations.

1.2 Meteorology in 1800

Becoming from this century, the atmosphere begins to be investigated from a strictly physical point of view, according to the laws of mechanics and thermodynamics rising.
One of the first physicists to contribute, was the Frenchman Gaspard Gustave de Coriolis (1792-1843). In formulating the acceleration theorem of relative motion for mechanical systems in rotation, he introduced the concept of complementary acceleration and the corresponding force "apparent" that bears his name, force that is acting perpendicular to the motion, resulting in deviant effect on motion itself. Despite such composed force plays a fundamental role in the dynamics of the atmosphere, it should be pointed out that its author is not paid particular attention to the possibility of applying it in such a fluid. Will the American researcher William Ferrel to do so, thus justifying the curvature of the air currents around the centers of high and low pressure, and thanks to his studies on the general circulation of the atmosphere, meteorology entered fully into the domain of fluid dynamics. The period that saw an especially intense theoretical development was the decade 1880-1890, thanks to the physical and mathematical studies of German Hermann von Helmholtz. Starting from Euler form of the general equations of hydrodynamics, the scientist undertook an analytical study of the equilibrium conditions of the surface of separation between air masses. To explain the origin of the fronts and depressions he called into question the concept of hydrodynamic instability that will find its application in the theory of the polar front of the Norwegian Meteorological School. Will always be von Helmholtz to formalize the first law of thermodynamics in 1847, with the publication of a study on this. The discovery of the possibility of transforming the work into heat and vice versa, opened a new field of research: the study of the thermodynamic properties of the atmosphere. In parallel with developments of atmospheric physics, the nineteenth century saw significant progress in the statistical study of the major climatic factors, primarily temperature and pressure, which was followed by studies in the fields of storms and cyclones. Will be the American engineer William Redfield to develop first the theory of nature swirling and the direction of rotation of the winds in cyclones, counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. The Redfield theory of cyclonic storms, was opposed by one based on the convection and the centripetal motion formulated by compatriot James Pollard Espy. Unlike Redfield who had preferred not to speculate explanations about the genesis of the cyclones, he hypothesized a strong upward motion at their center, at the minimum pressure, which consequently draws air from all directions. He, of course, entirely ignorant of the effect of deflective force due to Earth's rotation, and had fully understood the role of water vapor in atmospheric thermodynamics. This theory will be a basis for the theories formulated in convective cyclones followed, and for a long period prevalent in America and in Europe. The study on the development of cyclones was deepened by the German meteorologist Heinrich Wilhelm Dove, and by the English Admiral Robert Fitzroy. They came to the conclusion that the cyclones are developed at the border between the cold currents of polar origin, cold and dry, and the hot and humid currents of tropical origin, and are organized into families. Poor appear instead studies on anticyclones, perhaps related to the fact that they are normally accompanied by beautiful and stable weather. It will still be the Englishman Francis Galton in 1863 to discover the particular characteristics of the anticyclone and the predominance of light winds at the center, their clockwise rotation and the subsiding movement of the air column. Other than these two main types of pressure systems, the English meteorologist Ralph Abercromby will add another 5 secondary, namely:
- *Ridge*: high pressure area that, with isobars generally rounded or at an acute angle, and protruding from an anticyclone towards a low pressure zone;

- *Trough*: low pressure corridor with isobars at an acute angle juts out from low pressure area;
- *Secondary cyclone:* low pressure secondary center;
- *Saddle*: the relative low pressure area between two depressions and two anticyclones
- *Slope*: area characterized by pressure regularly decreasing and bounded by isobars almost straight and parallel.

Introduced by the author in his book of informative nature "Weather", published in 1888, this classification is, not only of historical interest, but it is still universally adopted (Fig.2).

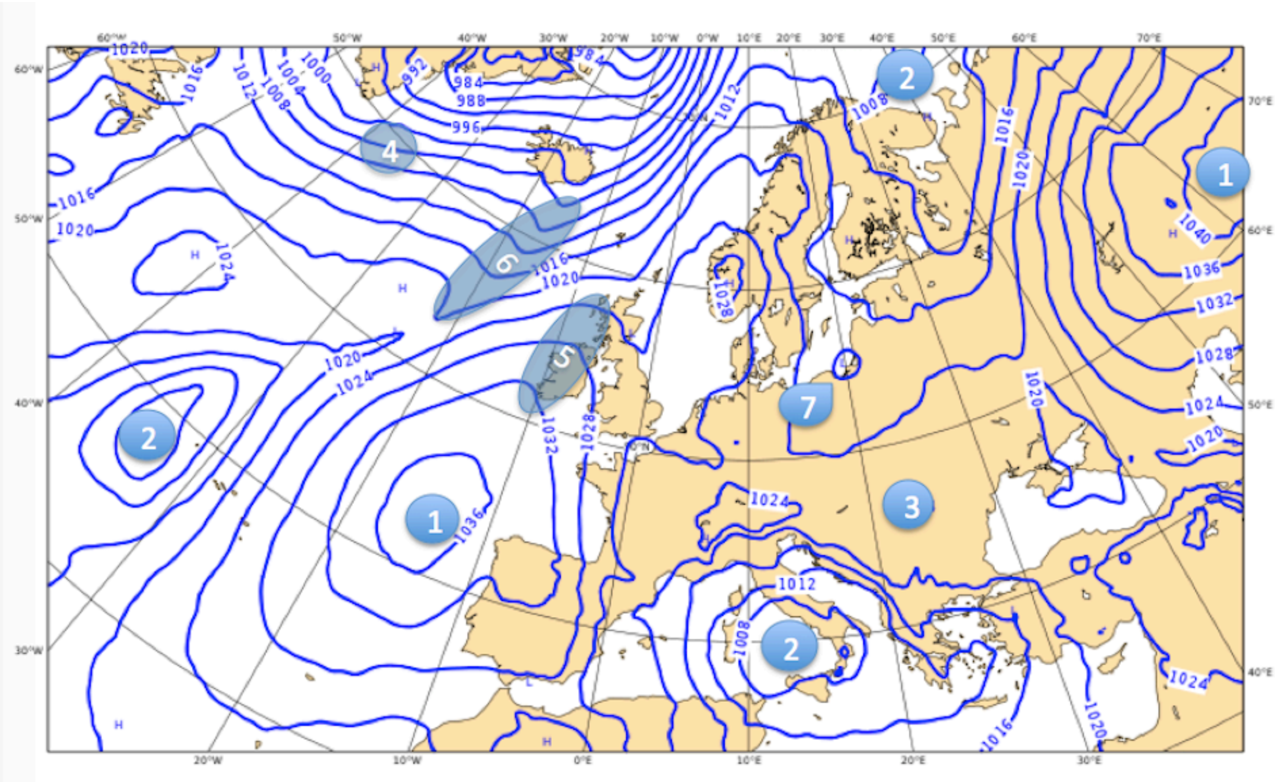


Fig. 2 Pressure configurations: 1 Anticyclone; 2 Cyclone; 3 Saddle; 4 Slope; 5 Ridge; 6 Trough; 7 Secondary low.

1.3 Developments in Synoptic Meteorology

Is due to the father of modern chemistry, Antoine-Laurent de Lavoisier, the concept of being able to represent the meteorological data, in particular the pressure, temperature, wind speed and direction observed synchronously and with great precision, on a geographical map, in order to predict, with advance of 24-48 hours, the likely evolution. He thus laid the basis to the scientific development of a new meteorology: the Synoptic meteorology. In October of 1790 he spells out rules foresee weather changes as a function of barometric change, published in "Literary Magazine". The scientist worked also to promote a campaign for the creation of a worldwide network of weather stations, barometric first, connected to each other and operating in a strictly synchronous way. However, we have to wait at least another 50 years to see the Lavoiser project realized. They were prompted by the global spread of the electric telegraph, a tool that allowed to quickly transmit the meteorological data collected from observation stations and spread the same way security alerts that it could have been derived. Is in the US that telegraphy was concretely applied to meteorology, thanks to physicist Joseph Henry, who proposed to the telegraphist of the Smithsonian Institution to replace the usual "okay" which opened daily communications, with a report of weather: "clear", "rainy", "windy" etc .. In 1843, the first weather maps are produced (Fig.3).

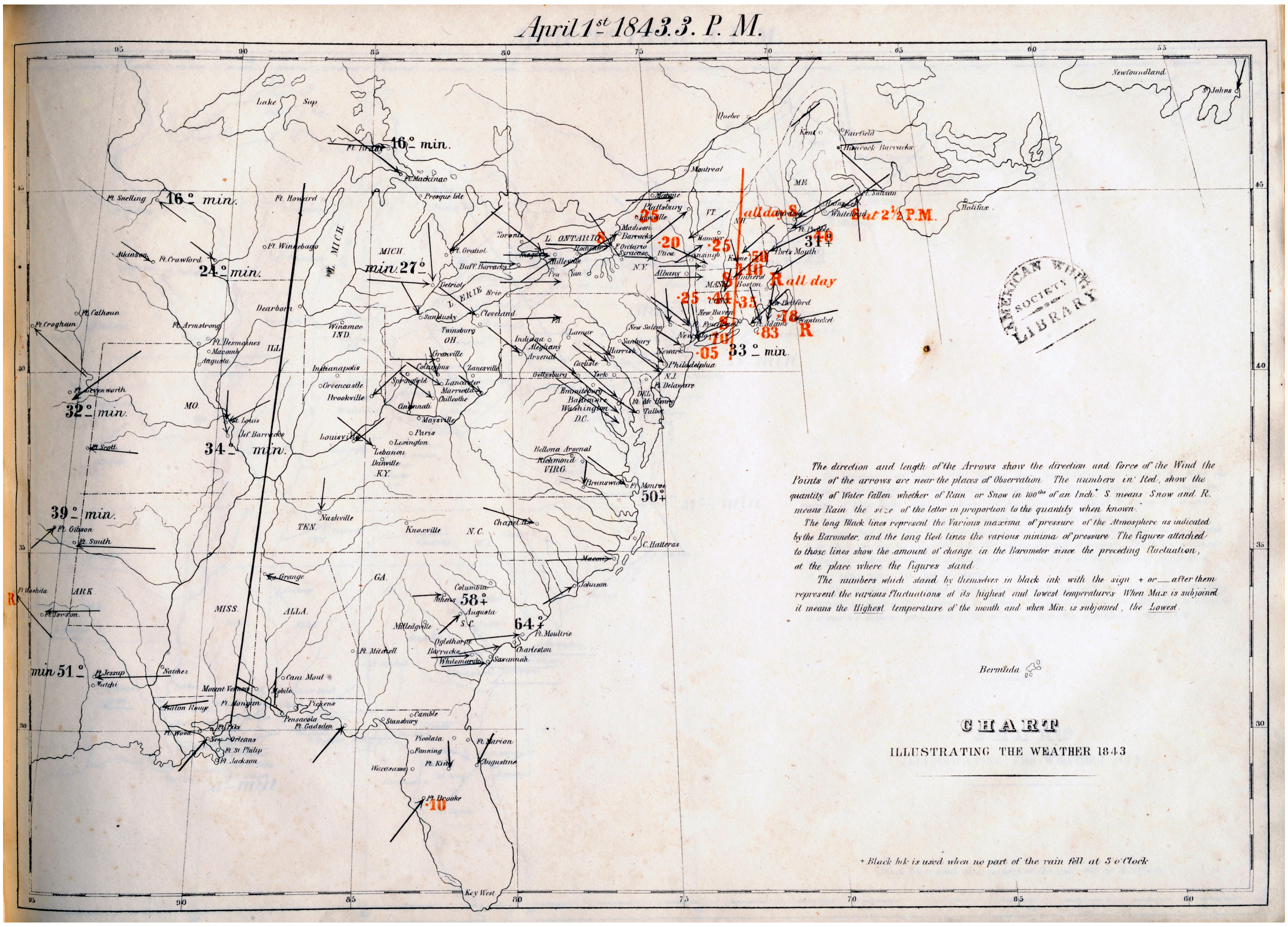


Fig. 3 One of the first synoptic map produced in 1843

A further impulse to the development of modern meteorology, occurred as a result of the intense storm that affected on 14 November 1854 the Black Sea waters, which caused extensive damage to the Brithish and French fleets intervened in support of the Turks in the war between Russia and the Ottoman Empire (Crimean War). The storm caused the death of about four hundred sailors because of the sinking of 38 between vessels and ships including the “Henry IV”, the most prestigious of the British fleet. Less than a year after the storm, the French, thanks to the efforts of the famous astronomer Jean Joseph Le Verrier, made the first meteorological network in the modern sense, composed of twenty-four stations, thirteen of which connected by telegraph, with the Astronomical Observatory of Paris. Le Verrier, studying the dynamics of the storm in the light of atmospheric circulation known laws at the time, he was able to extrapolate the future evolution in a logical and rational way, providing the first truly scientific approach to the complex issue of weather prediction. In 1873, during the Congress of Wien, participating nations agree to set up an international organization in order to facilitate the exchange of weather information across national borders. Thus it was born the International Meteorological Organization (I.M.O).

2. How to create a modern meteorological map.

Compared to the first synoptic maps what then has changed?
The modern system of meteorological observations, the fundamental and essential starting point for any meteorological activity, has today a multitude of systems, unknown at the time of Le Verrier, and that includes, computers, satellites, super-fast data networks, electronic meteorological instruments , radar and more (Fig.4).

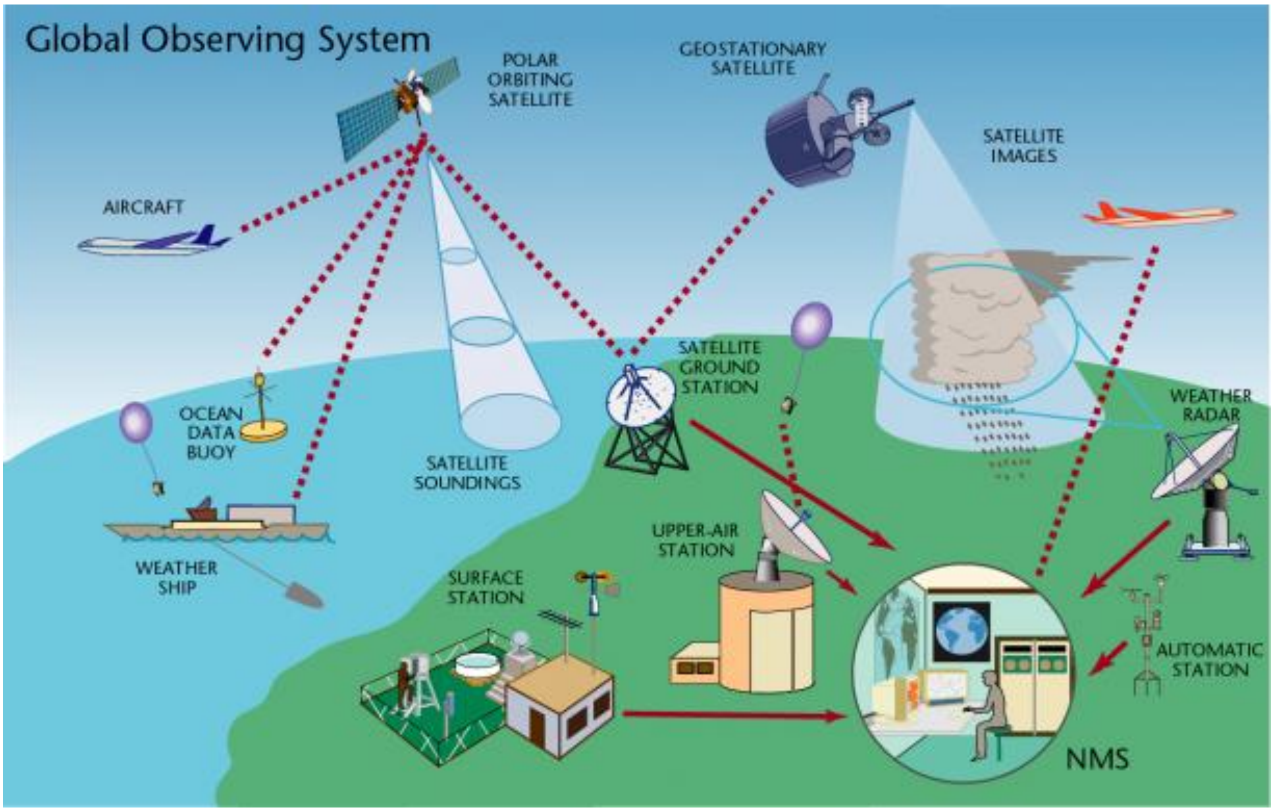


Fig. 4 The Global Observing System (source : public.wmo.int)

One thing is, however, remained almost unchanged since the days of Le Verrier: the work of the almost 11 000 observation stations, that at set times, making measurements of the main meteorological parameters such as atmospheric pressure, wind direction and speed, temperature, humidity, cloud coverage, ongoing phenomena etc ...
From their observations it extrapolates a "snapshot" picture of what is the state of the weather across the planet. This network of stations on the ground contributes significantly to the so-called Global Observing System (GOS) (Fig. 5), one of the programs of the World Meteorological Organization (WMO), the specialized agency of the United Nations, created in 1950 and that is mainly involved in international cooperation and coordination in the field of meteorology, the state and behavior of the atmosphere and its interactions with the oceans and soils and climate and weather that it produces.

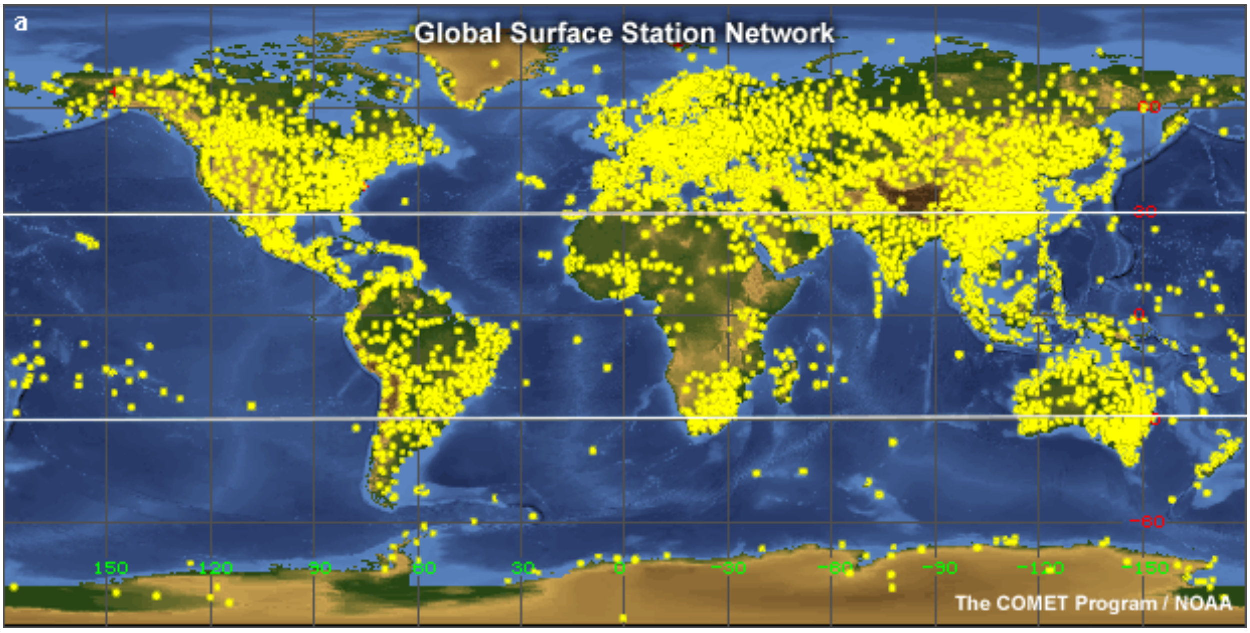


Fig.5 The Global Surface Meteorological Station Network (source www.meted.ucar.edu)

11,000 of these stations, about 4000 constitute the Regional Basic Synoptic Network and more than 3000 are part of the Regional Basic Climatological Network. Parallel to the network of surface observation stations, which deal with collecting data in the lower atmosphere, next to the ground, there is a network of high altitude observation stations, consisting of about 1300 stations, which at regular intervals of 12 hours release a balloons, to make measurement of the main atmospheric parameters till about 30 kilometers of altitude. All data collected by these networks regularly exchange data in real time. The exchange and circulation of meteorological data is done through another program of WMO, the Global Telecommunication System (GTS), defined as: "The co-ordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observations and processed information Within the framework of the World Weather Watch. "

3. Overview of weather maps and symbols: observation and messagges

Each weather station, whether fully automated or with weather observer staff, must make the meteorological measurements, translate them into a standard meteorological code or message, store them on a suitable base (paper until a few years ago) and enter this massage on G.T.S. so that all over the world it has available in real time, such information. While the automatic stations the whole process is almost instantaneous and managed entirely by electronics, stations staffed it takes place substantially without significant differences compared to a century ago.
About 10 minutes before the observation time, the operator performs the instrument readings, taking temperature, air humidity, direction and strength of the wind, pressure etc. Runs also subjective observations such as the quantification of the type, height, and the amount of clouds present in the vicinity of the point of observation, the horizontal visibility and any visible horizon phenomena.
The next step, until a few decades ago, included the completion of the so-called " station's notebook " on which were annottate all measures taken to the instruments. Today, the data are inserted on special software that also take care of the coding according to the standards in use. The meteorological code universally adopted is called "SYNOP" and contain in summary form all the data that allow any meteorologist, at any location on the planet, to know exactly

the weather observed at any locations within the meteorological station. The Synop message is a numeric code composed of groups of five numbers arranged in such a manner that each of the code group is uniquely a data type. For example,

"SMIY01 111800 16429 11462 73504 10044 20021 30009 40021 55005 60232 72196 85360 333 20040 32 /// 55005 55300 82915 83818 85356 2 ////"

is a synop message of Sigonella station of day 11 to 1800 UTC when the wind was from 350 ° 4 knots, the temperature of 4.4 ° C and so on. For further information, please refer to dedicated publications. Synop is a specific message for synoptic meteorology and is produced simultaneously from stations around the world starting at 00 UTC, at 3-hour intervals.
In order to plot on a map synoptic observations, it was at least necessary to take a number of forms, capable of translating the observed data in graphical symbols (Fig.6).

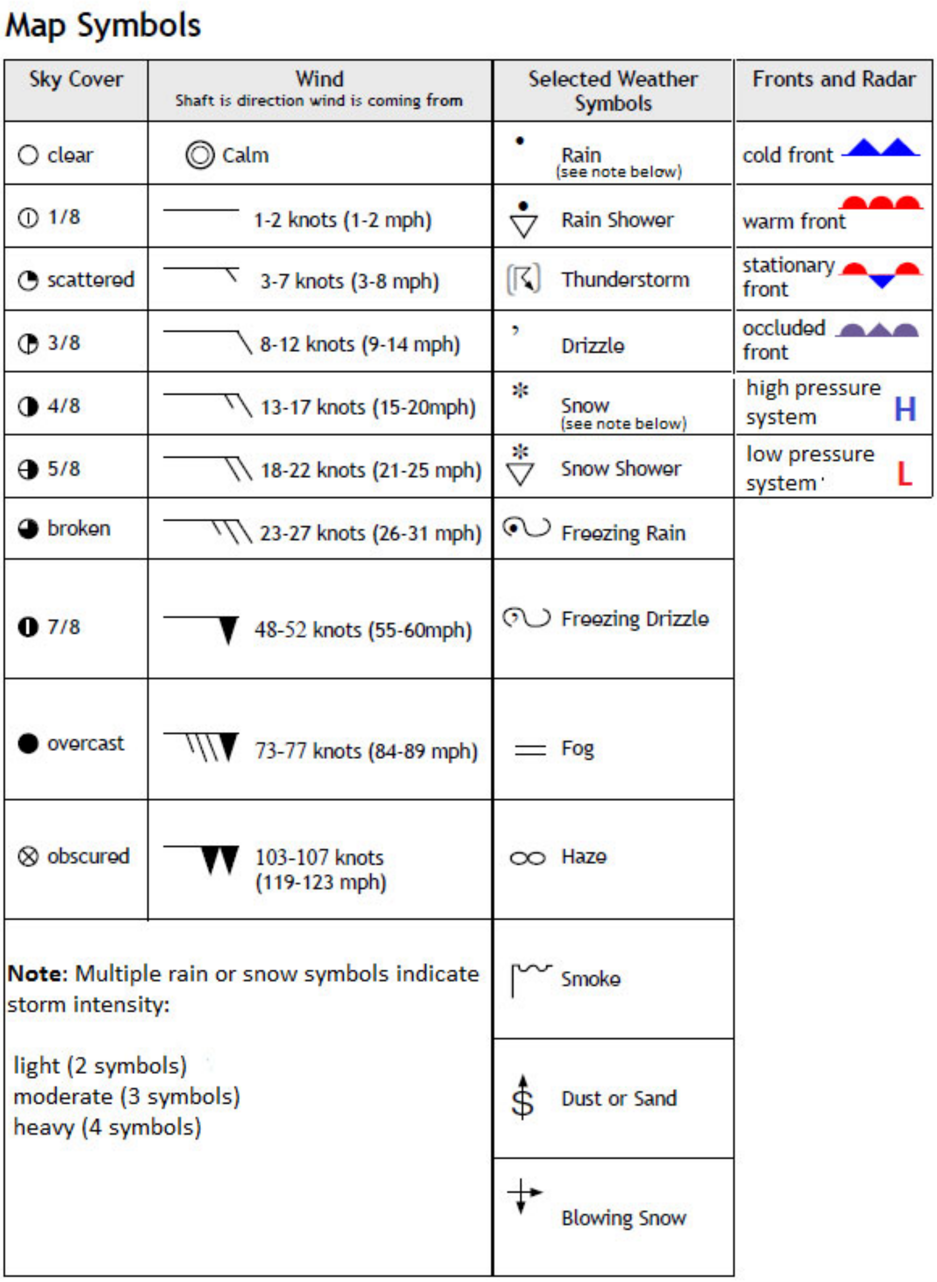


Fig.6 Meteorological Symbols worldwide used

The result of this process leads to show on a map a group of symbols and numbers that can summarize and synthesize the whole process of observation, called "station plot" (Fig.7).

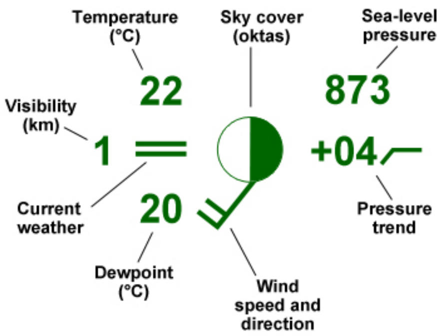
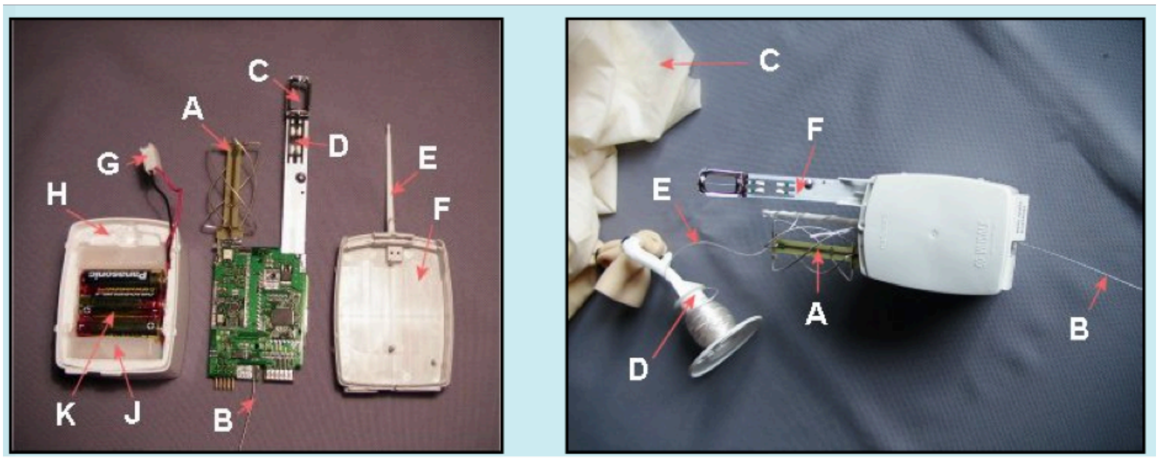


Fig. 7 Station Plot

In addition to the "Synop", which is the most widespread exchange format of weather data, there are also other types of codes, which are used especially in aviation; It is the case for example of "METAR" format, an aeronautical meteorological code used for the observation carried out at the aerodrome meteorological stations. Characteristic of the "Metar" is the speed of preparation and dissemination at the expense of accuracy. In this message, the measured data are rounded. It is also an alphanumeric code, more clear than Synop, which contains the main meteorological information useful for aircraft pilots.
"Metar LICC 182200Z 35008KT 9999 RA SCT020 BKN035 OVC090 12/10 Q1010" is for example the Metar of Catania aerodrome.



A: GPS receiver antenna
B: Transmitter antenna
C: Temperature sensor
D: Humidity sensor
E: Hooking of the cord
F: Box
G: Power connector
H: Box
J: Mass compensator
K: Battery pack

A: GPS receiver antenna
B: Transmitter antenna
C: Baloon
D: Sprocket of twine
E: Twine
F: Temperature and Humidity sensors

Fig. 8: Radiosonde

In the same way to what happens for the ground stations, the stations that take upper data, start the observational activities much before the time of observation. Indeed, they have the delicate task of preparing the necessary instruments to collect data, called radiosondes, small boxes of polystyrene, which enclose internally all the sensors for measurement of temperature, pressure and humidity in addition to the electronics for the transmission of data to the ground station (Fig.8).
Such equipments, attached to a balloon inflated with helium and released simultaneously from all stations at 00 and 12 UTC, send temperature, humidity and pressure data, in addition to the wind calculated by GPS, to the receiving station (Fig.9).
The bursting of the balloon, which normally occurs between 20 and 30 km above sea level, and in any case after one hour from the time of launch, the transmitted data are encoded in a message called "TEMP" and forwarded to the appropriate collection Center through the GTS network. The messages "TEMP", in addition to the station identification and the date-time groups, contain data of temperature, humidity and wind to the various pressure altitudes touched by the radiosonde. Such data can be plotted on maps by sybology the station plot, slightly modified, or be analyzed by the atmospheric thermodynamic diagrams, which summarize the characteristics of the air column crossed by the radiosonde (Fig.10).

Fig.9 : Release of baloon at midnight at Mario Zucchelli Station, the Italian Base in Antarctica.

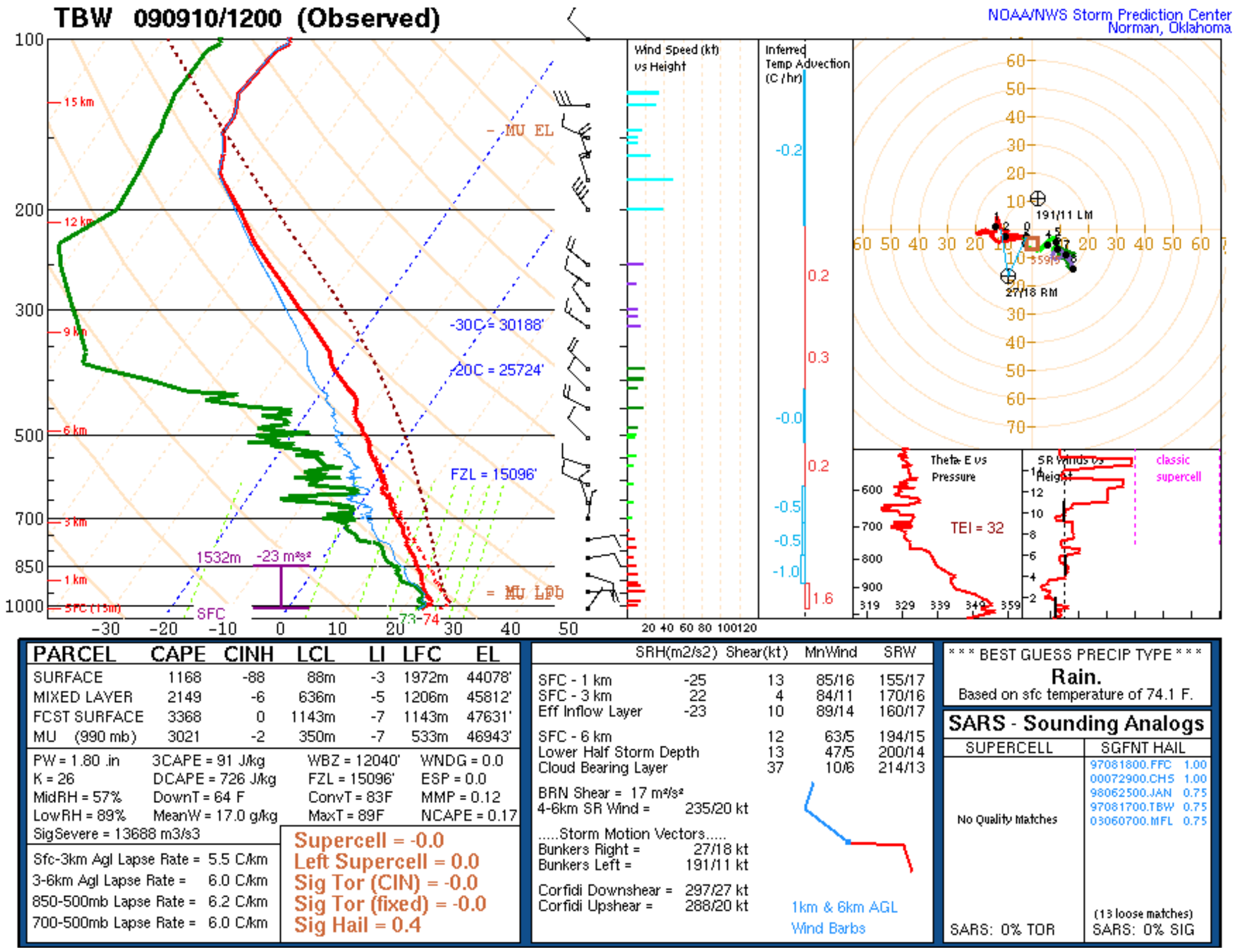


Fig.10 Thermodinamic diagram and data received from radiosonde

4. Surface and upper analysis maps

The enormous amount of data that, trough G.T.S., regularly flow into to the main Meteorological Centres around the world, are the raw material to start the production of any kind of maps. The first step, which will get to the final release of the weather map, is the plot of the graphic symbols - station plot - on a map, in correspondence with the geographical location It's clear, however, due to the excessive crowding of data, that this type of representation does not lend itself to be used for any kind of analysis. The next step will therefore be to draw the isolines, using the measured data to the stations, on a map cleaned thinning out most of stations plot and leaving only the most significant (Fig. 11).

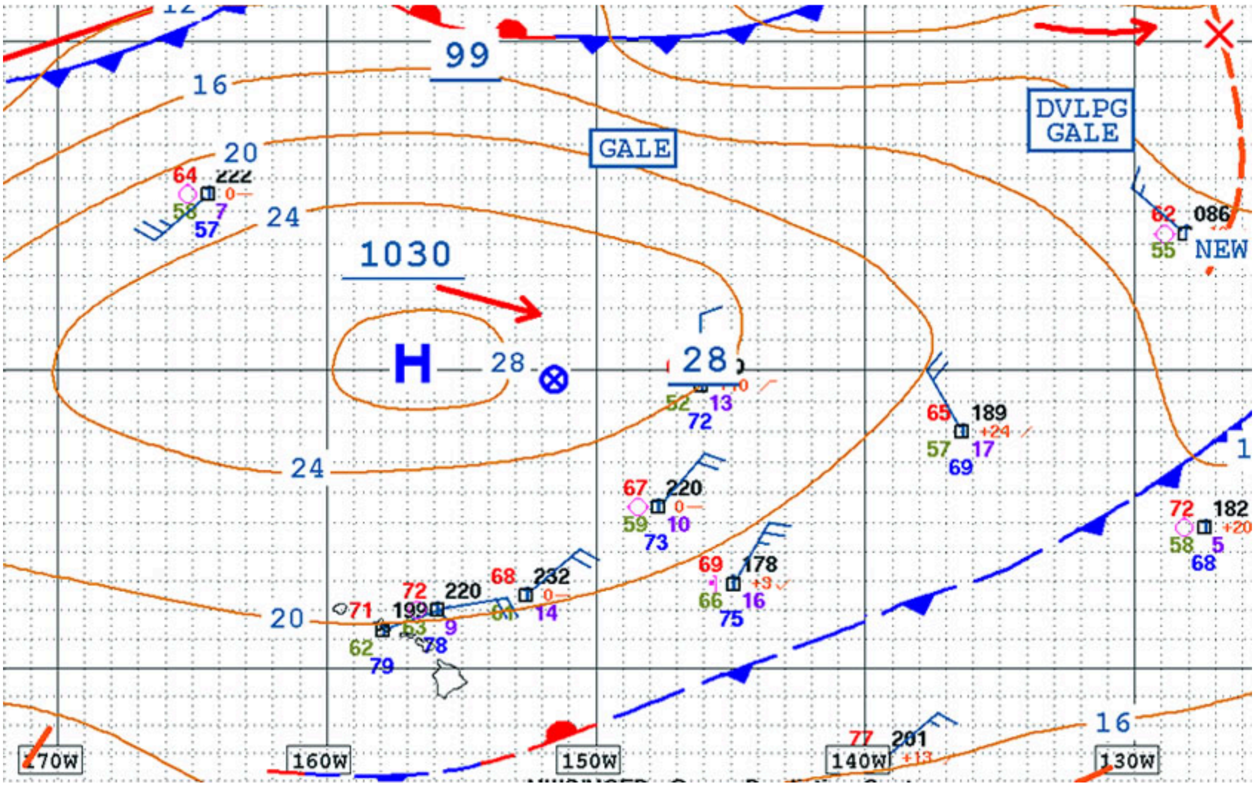


Fig.11 map of analysis containing the pressure field to the ground, represented by isobars (yellow lines), in which have been left only some station plot.

Similarly, it is possible to draw contour lines of the main data observed: isobars for pressure, isotherms for temperature and so on. The final result will be a map that contains one or more fields, represented by contour lines, easy to read and interpret (Figg. 12 and 13).

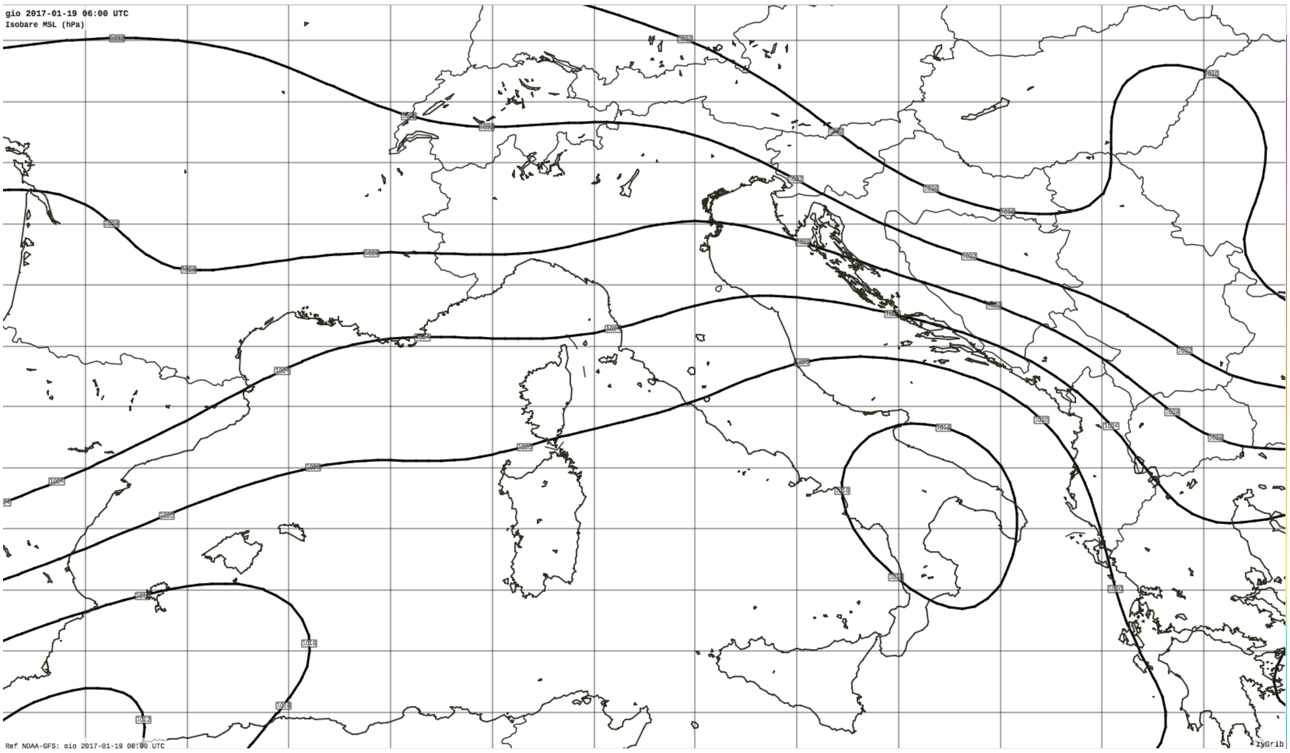


Fig. 12 Plot of surface pressure field (ZyGrib freeware)

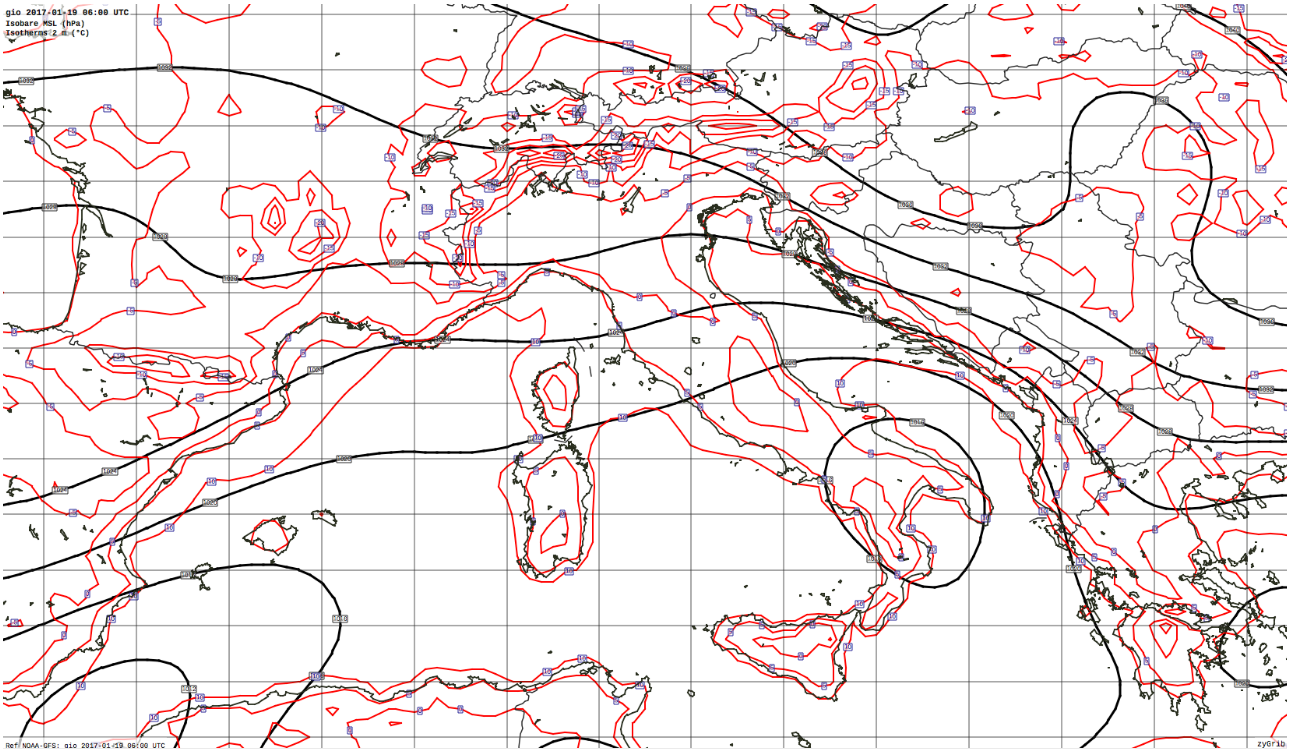


Fig. 13 Plot of surface temperature and pressure fields (ZyGrib freeware)

The process of production of maps at high altitude, does not differ much from the one to the ground. However it should be specified that in them, in place of the pressure, the heights of the isobaric surfaces are represented. For this reason, the upper maps are also called absolute topographies and altitudes are expressed in geopotential heights, a term that is obtained from the relationship between geopotential, the work necessary to overcome the force of gravity and move upwards, to a certain height, a unit mass of air, and gravity at sea level (Fig.14).

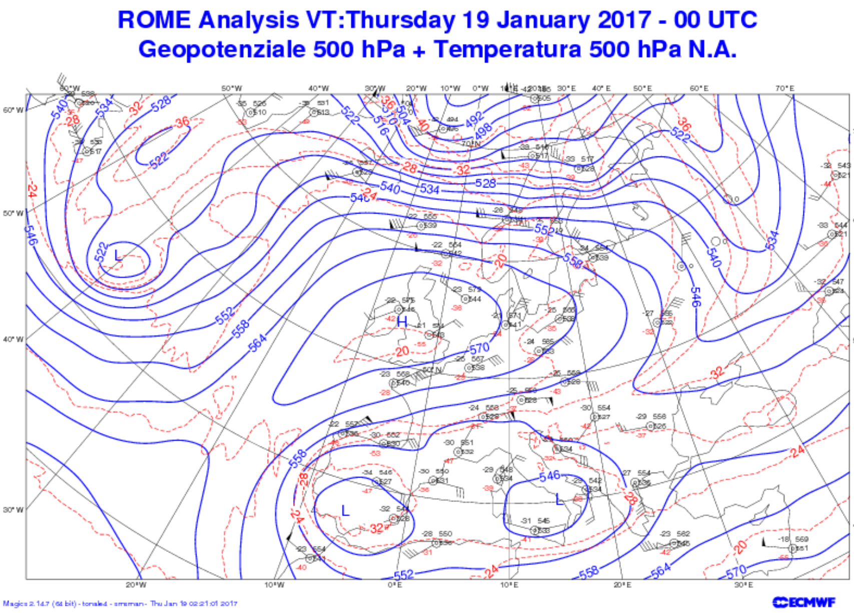


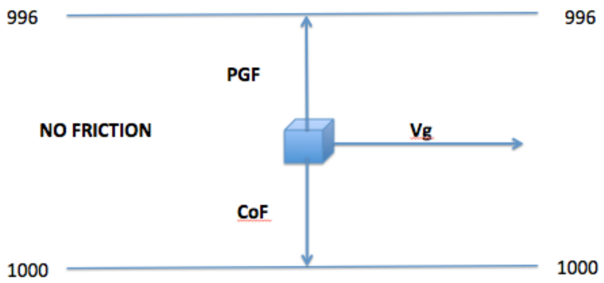
Fig. 14 Plot of geopotential height (blue lines) and temperature (dotted red lines) at 500 hPa

5. From Analysis to Weather Forecast

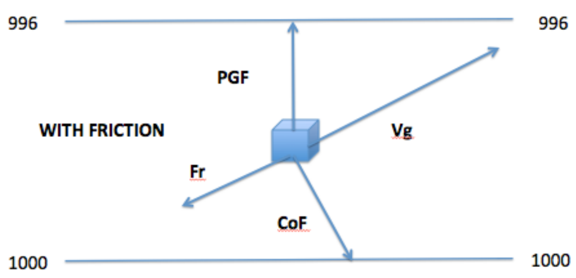
Looking at a surface pressure analysis map, it is possible to infer an amount of usefull information that can help us to better understand the meteorological phenomena.
Let's analyze for example the surface map of Fig. 12. The first operation that can accomplish is to locate and mark the high and low pressure centers indicating them with H (high) and L (Low) and highlight the isobar that separates the two areas. In the map we now identified two areas whose pressure values are respectively lower and higher of highlighted isobar. On the maps of the main World Meteorological Centres, the isobars are normally spaced at 4 hPa.
Let’s make a few comments on the area of low pressure present on Southern Italy. The air will begin to move toward the low pressure (just as a soccer ball to be free to roll on a slope), subject to the force of gradient PGF given by the ratio between the pressure difference AP and the distance between two points Δ X:

$$PGF=\frac{\Delta P}{\Delta X}$$

This means that, where the isobars are close together (maximum gradient) we will have the maximum wind speed, and where the isobars are widely spaced we will have light winds or absent. In the figure these two situations are respectively present between Bosnia and the Adriatic coast (maximum gradient) and to the south of Sardinia (minimum gradient).
However, as understood by Coriolis over two centuries ago, the moving masses on the earth's surface, are subject to the homonymous strength CoF and are thus diverted, in their initial momentum, to the right in our hemisphere and to the left in the southern hemisphere.
Therefore, in the hypothetical case of straight and parallel isobars and ignoring for the moment all forms of friction, the wind resulting from the balance between the Coriolis force and pressure-gradient force, will give rise to what we call geostrophic wind Vg:



The geostrophic wind will therefore be parallel to the isobars. However an air mass moving on a surface such as that of the Earth, will be subject to the resistances of friction F_r that depend upon the roughness of the surface and which act in the opposite direction to the motion. Introducing this force the new equilibrium will be as follows:



The resultant of this new balance will be a wind (ageostrophic) which will tend to cut the isobars pointing toward the low pressure, with an angle that will be greater the greater the friction. On the sea or over a very smooth land surfaces this angle is between 10 and 30 degrees, while on rough land or mountain areas you can get to even exceed 60-70 degrees.
These considerations help us to understand that the surface wind forecast will follow the isobars, converging, with an angle comprised between 10 and 70 or more degrees, towards the low pressure. Furthermore, the same considerations allow us to establish that in the case of closed circulations of high or low pressure, winds will assume a counterclockwise rotation (or cyclonic) around the low-pressure centers, and clockwise (or anti-cyclonic) around high-pressure centers. For the considerations made on the friction they will tend to diverge from the high pressures and to converge toward the low.
The convergence that occurs around low-pressure centers, is one of the mechanisms which produces the lifting of the air masses.
When the mass of moist air that converges around low-pressure centers begin the lifting process, it expands and cools, condensing the water vapor that contains and giving rise to the typical cloudiness of the low pressure zones. Conversely, the divergence produced by the high pressure center that draws air from the top down dimension is compressed and heated, favoring the dissipation of any present clouds (Fig.15) .

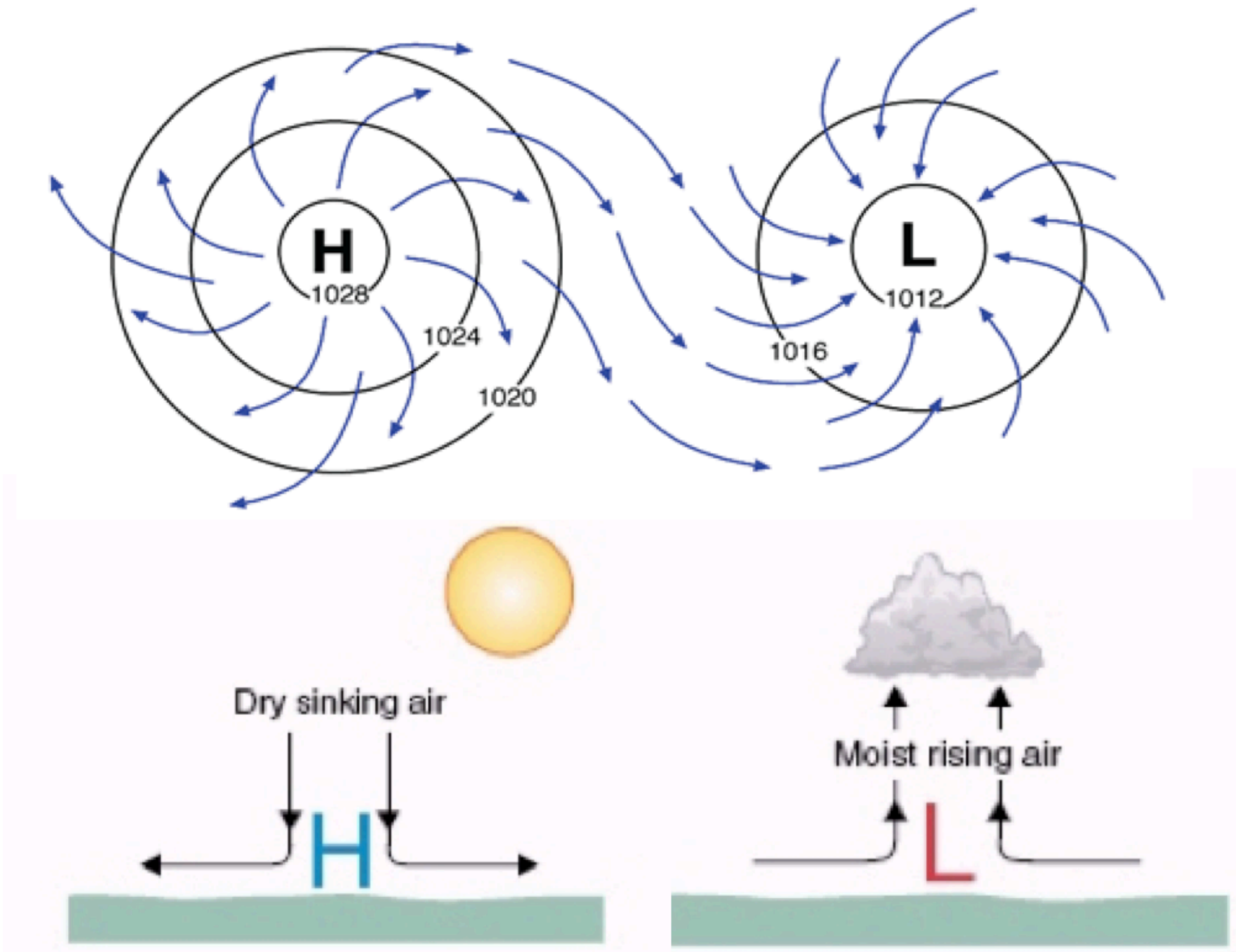


Fig.15 Motion of air around a High and a Low pressure in Northern hemispere

From Synoptic Meteorology to climate analysis

The huge amount of data, continuously observed and archived from weather stations around the world, was one of the most important resources for the development of new branches of meteorology such as the statistical meteorology and climatology. After the invention of the first measuring instruments, one of the key issues was what to do and how to use the data sets collected. The first analyzes carried out using meteorological data, were of simple descriptive statistics, or the study of the variability of a phenomenon since the data collected. This led to the first attempts to classify climates of different places, depending on the temperature and average rainfall occurring during the year.
In 1817 **Alexander von Humboldt** drew annual-mean temperatures on a world map. **Wladimir Koeppen** (1846-1940) refined this map and plotted seasonal temperature range in 1884, leading to his climate classification. This classification followed that of plants realized by Linnaeus in 1735, being likewise hierarchical, with major categories subdivided, and then subcategories divided again, and so on. In fact Koeppen had initially studied botany at St Petersburg, later completing a Ph.D. at Heidelberg on the effect of temperature on plant growth. At the highest level his system is based on five sets of temperature limits. These were developed from his categorisation in 1884 of thermal zones suited to various kinds of vegetation (Fig.16).

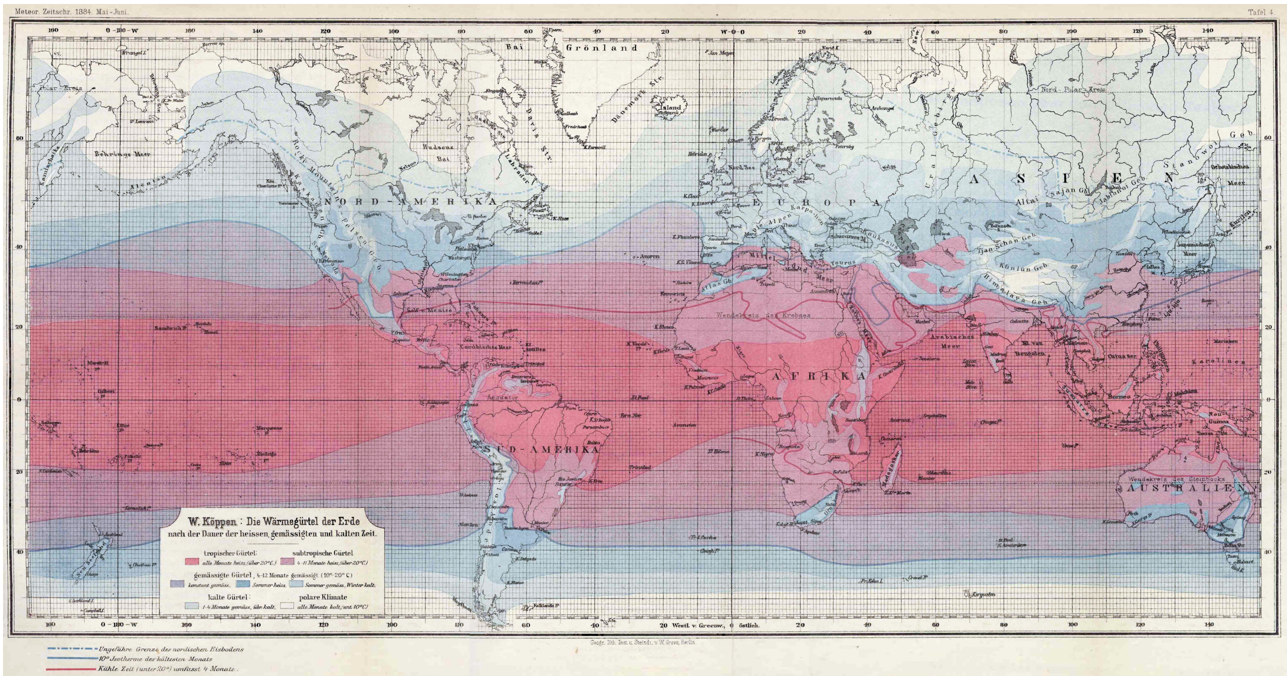


Fig.16 the first Koeppen Climate classification map

In 1924 Koeppen became associated at Gradz University with **Rudolf Geiger** (1894-1981) and collaborated with him in producing the 1936 system of climate classification. Geiger established the discipline of microclimatology as he collected a wealth of observations to understand 'the climate near the ground' (to quote the title of his book, translated into English in 1960), and its variations due to topography and land use.
In the USA, **Warren Thornthwaite** (1892-1963) developed a hierarchical classification in 1931, essentially in terms of the annual pattern of soil-moisture conditions. These were

regarded as depending in a complicated manner on the monthly input as rain, and implicitly on the output as evaporation, indicated by temperature.
In parallel to these study of climate descriptions based primarily on statistical considerations, new techniques of analysis of the time series were developed. The Fourier analysis applied to a time series α (t) is a technique that allows the study of the signal α in the frequency domain, due to the decomposition of the temporal function itself in an infinite number of harmonics (fundamental waves), in which the 'amplitude of each harmonic represents the weight that it has in the original signal. The decomposition into harmonics is expressed by the inverse Fourier function, defined as

$$\alpha(t) = \frac{1}{2}\int_{-\infty}^{+\infty} A(\omega)e^{i\omega t}d\omega$$

where the inverse relationship, the Fourier transform, it is defined as

$$A(\omega) = \frac{1}{\pi}\int_{-\infty}^{+\infty} \alpha(t)e^{-i\omega t}dt$$

whit *i* imaginary unit, *ω* angular frequency of the harmonic (rad / s), given $\omega = 2\pi / T$ and *T* period of harmonica in seconds. The analysis in the frequency domain is conducted to highlight certain properties not immediately recognizable in the time representation of a signal. The spectral analysis of climate data is now a widely used technique in the world, and through it many dark sides and little known of the Earth's climate system, were revealed. Thanks to analysis on paleoclimatic data was possible, for example, reconstruct and correlate the duration of the astronomical cycles with terrestrial glaciations. Further developments which benefited Meteorology and Climatology came undoubtedly from the use of wavelet analysis. The Wavelet analysis is a powerful mathematical tool capable of providing a representation time-frequency of any signal analyzed in the time domain. They can be used to analyze time series that contain nonstationary power at many different frequencies. In the case of meteorological and climatological series this type of analysis is particularly appreciated being able to extract valuable information from the signal. Compared for example to the simple Fourier transform, wavelets allow to find not only in the value of certain frequencies present in a non-stationary series, but also to identify the time interval in which these frequencies have been present and predominant. These sophisticated tools have been used in several studies of climatology and the scientific literature is rich of many examples. (Baliunas et al. 1997 Torrence and Compo 1998 Park and Mann 2000 etc). The continuous wavelet transform of a discrete sequence x_n with a scaled and translated version of $\psi_0(\eta)$:

$$W_n(s) = \sum_{n'=0}^{N-1} x_{n'}\psi * \left[\frac{(n'-n)\delta t}{s}\right]$$

where the (*) indicates the complex conjugate. By varying the wavelet scale s and translating along the localized time index *n*, one can construct a picture showing both the amplitude of any features versus the scale and how this amplitude varies with time (Torrence and Compo 1997) (Fig.17).

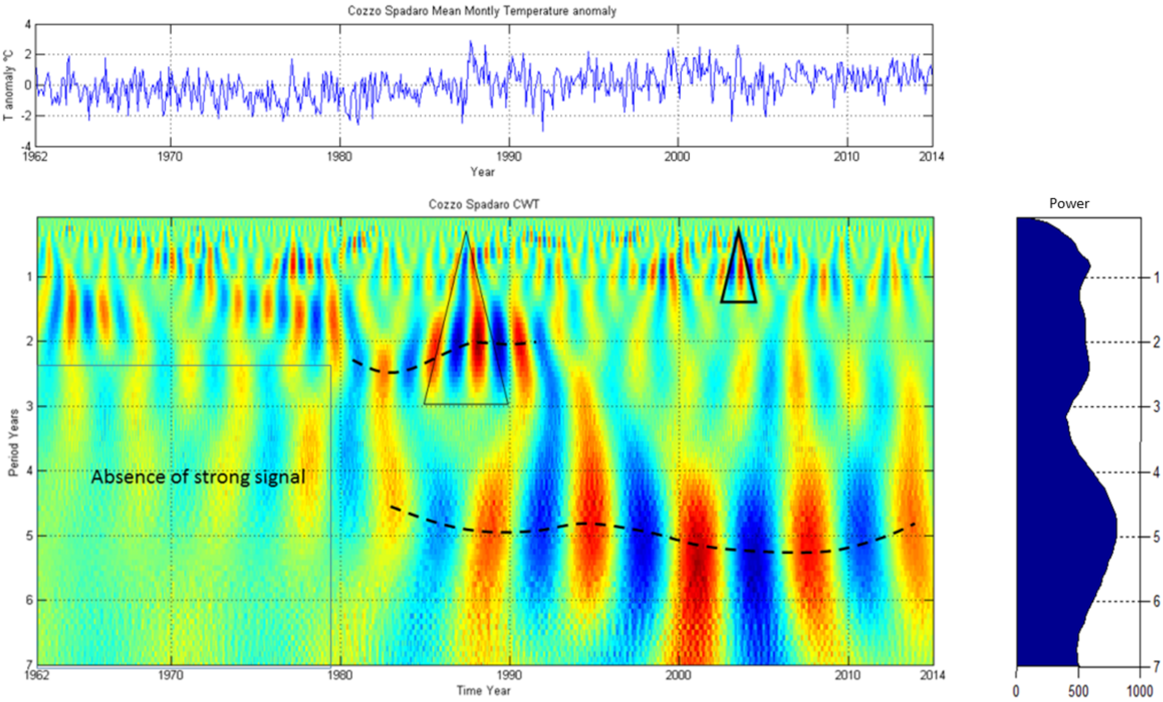


Fig.17 Exemple of wavelet analisys on a temperature time serie

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