Weather forecasts

The weather forecasts

The capacity of making weather forecasts has always been one of Man's requirements, in order to be able to manage and plan all his activities, from his leisure time to sports, to agricultural activities and industrial activities in the open air.
Nowadays our knowledge about the weather and meteorological phenomena has greatly improved, even though we are far from totally comprehending them, and consequently, weather forecasts are increasingly reliable.
In Italy the official body in charge of formulating the weather forecasts is Servizio Meteorologico dell'Aeronautica Militare, the Meteorology Service of the Military Aeronautic Service, in collaboration with the European and World Meteorological Organization.
The Meteorology service publishes the official Meteorology Bulletin daily, making use of the data collected in the stations on ground (positioned in all the airports and integrated by other stations scattered around the national territory). Some of these are equipped with instruments for radar monitoring and for launching probe balloons. The data are then integrated with the recordings carried out by the world network of meteorology satellites, in particular by the European METEOSAT satellites. For short term forecasts, with indications that are valid up to 12-24 hours, ground level and high altitude synoptic weather charts are used. For this type of forecasts, the experience and personal capacity of the meteorologist are still fundamental. Therefore these are very subjective forecasts, and their reliability depends greatly on the meteorologist's ability.
For mid-term forecasts, valid up to a maximum of 3-5 days, mathematical-numerical methods are prevalently used. In this case the forecasts are based on a mathematical model of the atmosphere, that represents a state of the weather with a series of equations in which the unknown values are the temperature, pressure, air density and wind-speed. These methods require the use of very powerful and rapid calculators because simulation requires an enormous number of calculations. The evolution of high power computers for civil purposes has taken place, as a result of the research to satisfy the need to carry out calculations in the meteorological field.
For long term forecasts, that are valid from a week to a month, instead, statistical analyses are used, based on series of meteorological data over a period of time. In practice the mean conditions of the weather in the past are studied in order to foresee the possible behaviour of the weather in analogous meteorological conditions. This type of study is more suited to study the climate than to solve the problems of weather forecasts.

Global network

On ground level, meteorological observations are carried out by a network of over 10,000 stations distributed all over the Earth's surface, to which we must also add the numerous mobile stations on ships and aircraft that are equipped for the purpose.
The main observations are pressure, temperature, air humidity, direction and speed of the wind, precipitation, clouds. The more important stations also measure insolation, the sun's radiation, evaporation and ground temperature. The data that are collected enable the reconstruction of the weather charts on ground. In Italy, the stations are managed by the meteorology service of the Military Aeronautics, and are connected to the international network, coordinated by the World Meteorological Organization. All observations and transmission of data are carried out according to a precise international code.
The ground stations' data are integrated with the data recorded by the satellites, that are connected to each other through the worldwide network of meteorological satellites.
The World Meteorological Organization carries out the task of collecting the data, coordinating and codifying the exchange of information of various Countries, so that it is possible to work at the problems connected with the weather and climate on a global scale.
At present, thanks to the Internet network, it is possible to access numerous sites that are concerned with meteorology, including the national services, where it is possible to consult weather charts and have access to forecasts and satellite images.

What is a weather chart?

Weather charts are the fundamental basis for weather analysis and forecasts. They are based on the data collected by weather stations on the ground and on the data recorded at high altitudes by probes and satellites. Most modern instruments are able to guarantee a continuous recording of atmospheric data, but the weather charts are created using the data recorded at preset conventional timings, so that they may be comparable with one another in different locations around the world. The timings set by the World Meteorological Organization are called synoptic hours and are at 00:00-06:00-12:00-18:00 hrs. The related charts are known as synoptic weather charts.

All the world stations are connected by networks managed by the World Meteorological Organization and for Europe, by The International Network of European Meteorological Services and the charts are created using standard criteria and symbols, so that they can be compared with each other.

A weather chart includes an isobar chart and the representation, with opportune symbols, of the principal atmospheric parameters, such as wind direction and speed, types of clouds and extension of the cloud formations, the position of warm, cold and occluded fronts and the high and low pressure centres.

Weather charts can describe the weather conditions on ground, or at high altitudes, and are the basis for the creation of weather forecast maps.

Interaction with the oceans

The atmosphere, with its movements and the phenomena that take place, is not an isolated and independent system but it is affected by the interaction and exchange of energy with the hydrosphere, the lithosphere and the biosphere. In particular it is not possible to understand the mechanisms governing the behaviour of the atmosphere without studying its relation with the oceans.

The oceans with their enormous volumes of water, form an immense “heat container” that stores very large quantities of thermal energy absorbed from solar radiation. Unlike the ground that returns most of the energy it receives immediately, water has a great thermal inertia, therefore it is able to store large quantities of heat that are then released slowly and returned to the atmosphere.

Through the sea and ocean currents, thermal energy is redistributed from the Equatorial zones where there is an excess of heat, to the Polar regions where , on the contrary, there is a “deficit” of energy. Ocean circulation therefore has a very large influence on the distribution of atmospheric circulation cells on a planetary scale, besides, naturally, on the exchanges on a local level. The position of the high and low pressure cells also depends on the large ocean currents system. The transfer of thermal energy carried out by these, in fact, can modify the climate of entire regions. An example is the already mentioned case of the Gulf Current on the climate in Northern Europe, or the contrary case of the cold Humboldt current that touches the coasts of Ecuador and Peru.

Observing the circuits of the principal ocean currents and the atmospheric circulation cells, it can be noted that there is a certain similitude, as if the first mirrors the second or vice versa.

The role of oceans is also important in the carbon dioxide cycle, of which oceans are a large “depot”, that subtract it from the atmosphere.

Cities and local climate

Anyone who lives in suburban areas and works in the city has surely experienced the differences in the climate of large urban conglomerations compared to the climate in zones that are far from the city. Cities are generally much warmer than the surrounding areas, besides being more polluted, and in the winter months the conditions for thermal inversion are often present. In other words, large cities seem to modify local climatic conditions. What is this phenomenon due to?

The progressive replacement of land and vegetation by tar, asphalt and cement is the first cause. These materials absorb large quantities of heat, that they then release slowly, behaving as “heat wells”. In this manner, the temperatures in the cities are sensibly higher than in the surrounding areas. Secondly the fact that the buildings that are grouped together, close to one another, hinders air circulation, which also favours the heating process. The progressive increase of cement surfaces prevents infiltration of water in the ground, therefore the land that is built up with cement and covered with

asphalt is less humid than natural soil. The air in the cities, therefore is generally dryer. Since the evaporation of atmospheric humidity contributes to cooling the air itself, in this case this characteristic favours heating of the air and also a slower cooling after sunset. For this reason the inhabitants in the cities do not experience the night's cooling effect on warm summer nights.
In summer, most of the heat released by the large cities favours convectional phenomena and the formation of storms. Apparently the presence of very high buildings seems to favour the formation of cumulonimbus clouds. Also the greater emission of polluting substances in the form of gases and dusts, that are typical of industrialized areas with a high population density, contribute to modifying the characteristics of the atmosphere, in particular the capacity to absorb and radiate heat. Statistical studies show that the increase in the temperatures in the cities is proportional to the density of the population.

A global climatic model

Man has always tried to understand the climate and make forecasts on the weather. For agricultural activities, for travel, for transportation, weather forecasts are indispensable in order to plan human activities, but also for the realization of housing, roads, bridges that must resist against the most adverse weather conditions. It is difficult for us to understand a complex system such as the climate on a planetary scale. In fact in order to understand how the climate functions and in order to build a valid and realistic model, it is necessary to understand that the climate is a complex system, a chaotic system made up of a set of orderly sub-systems. In other words, while we are able to understand the single events that take place (a thunderstorm, a snow storm, a cyclone) and to write about the physical laws governing them, we are unable to describe the behaviour of a system, where single events can be summed, using mathematical formulas. In order to describe the climate, therefore, it is necessary to elaborate models that are as similar as possible to reality, however we must be aware that any model will only be a schematic and incomplete representation of the real climatic system.
In the current climatic model it is postulated that the atmospheric circulation, and therefore the climate on a planetary scale, depends on the differences in solar radiation due to both orbital parameters and the Earth's inclination on its axis during rotation. These parameters are responsible for the alternating seasons and the difference in energy between the Equator and at the Poles, and therefore atmospheric circulation is organized in six large high and low pressure cells that are also influenced by the interaction with the ocean currents. The present distribution of the climates on the Earth and their variability during the course of the year, derive from this model.
Until significant variations in these parameters and in the physical and chemical characteristics of the atmosphere arise, the present climatic model should theoretically remain valid without any major modifications. However many parameters that are taken into consideration in the climatic model that is currently proposed, are difficult to control and to foresee : and therefore, for example, small variations in solar radiation or small modifications in the oceanic circulation may produce big changes in the climatic model. The problem is to succeed in understanding whether the climatic variability that can be observed every year in different parts of the Earth, the "exceptions" to the current climatic model, are only natural and casual fluctuations, or if, instead, these are precursors of a possible change in the global climatic model.

Is the weather changing?

In order to understand whether the climate of our planet is really changing, it is indispensable to study what happened in the past. Man has always had an anthropocentric vision of natural events, and for this reason tends to give importance to the more recent facts that affect him directly, or the more catastrophic, "extreme" events that are often seen as a "rule" or as signals of sudden changes. For this reason, every hot summer seems to be the "hottest recorded in the past years", every cold winter, the coldest. We do not take into account that often, a great quantity of information that reaches us every day from the media can generate confusion: a particularly catastrophic event that takes place makes the attention towards analogous events rise, so that after the passing of a particularly devastating hurricane, for example, the passage of all the other hurricanes are signalled. This may make us think that the number of hurricanes has increased, but is it really so? Has the number of violent manifestations really increased, or is it only their interaction with

man that has increased, due to the increasing amount of anthropization in areas that once were uninhabited. As a result, the same data, the same succession of events are interpreted at times in a radically opposite manner by different researchers. In fact, some researchers see an increase in the concentration of greenhouse gases in the atmosphere as the cause of a global heating of the planet in the near future, while others hypothesize that on the contrary we could expect a new ice age. The only objective way to solve this doubt is to observe the series of data on the temperatures in various areas of the Earth, for a reasonably long period of time so that the normal fluctuations around the mean temperature do not influence the readings.

Apart from any personal subjective interpretation, only if we use an analysis of the objective data, then is it possible to understand if there are really some changes in the general climatic model, and what is the real trend of the various phenomena. For this type of study on the climate it is therefore indispensable to carry out an accurate analysis of the climatic and meteorological data collected over a period of time. Only by analyzing the series of historical data will we be able to state objectively if there really is a trend of an increase or a decrease in a phenomenon, or if instead it is only a matter of simple casual oscillations around the average. For this it is necessary to take data from a sufficiently long period of time. However, nature is used to changes. The geological and paleo-environmental data enable us to reconstruct climatic variations, even of a very remote past, and the history of the Earth offers numerous examples of climatic changes that were quite drastic and sudden. But, unfortunately, this is not a systematic and tidy collection, but rather a series of incomplete data that are available in a discontinuous manner in space and time. The analyzed time is the geological time, on a scale of millions and billions of years. In order to monitor the “finer” variations, instead, it is necessary to work on a period of time that is shorter than the geological time, but which however is longer than the life span of a human being, and with series of data collected with as much continuity as possible in the same region. Only this way, in fact, will it be possible to understand what are the trends and the changes taking place.

Unfortunately a systematic collection of climatic and meteorological data began only slightly over 200 years ago in Europe, and approximately 100 years ago in the United States, and in many Countries it still has not begun. This is precious information, however the observation periods are still too short to enable the construction of long term variation models. In other words, the analysis of a series of historical data still does not enable us to answer the crucial question: is the Earth’s climate really changing? Also because the data of the past cannot take into account one of the factors that is becoming increasingly important, year after year, in introducing possible modifications to the parameters that govern the climate of our planet : the influence of the constantly growing human population.