SCIENTIFIC AUTOMATED WEATHER ANALYSIS

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ABSTRACT: *Synoptic Meteorology is the concerned with weather and its phenomena. The meteorologists observe the atmosphere - its temperature, pressure, winds, humidity, cloudiness, precipitation and other characteristics. The changing atmospheric conditions which affect the environment constitute weather. Large number of observers are scattered evenly over a large area, each making observation of weather elements simultaneously and at regular intervals. Observations are collected simultaneously in order to obtain comprehensive and nearly instantaneous picture of the state of the atmosphere. Such simultaneous or synchronous observations of weather elements collected over a large network of station is known as synoptic observation. These observations are used to analyze and forecast weather. But the process of analysis is so slow and time consuming that it requires nearly a day to calculate the report for each station. Scientific automated weather analysis provides a framework that will avail the user to get the instantaneous result based on current weather conditions. Thus, the prediction would be converted to accuracy and will be helpful in future applications.*

KEYWORDS: Synoptic, Meteorologists, Synchronous Observations.

1. INTRODUCTION

Synoptic Meteorology is the weather processes through a representation of atmospheric states determined by simultaneous observations over a large area at a given time. **Synoptic** means "view simultaneously" is derived from the Greek words ***syn*** meaning the same or together and "***optic***" meaning visible [1]; hence, seen together. It is the science for studying weather elements. It is the scientific discipline studying macro scale atmospheric processes with the aim of weather forecasting. Synoptic weather analysis requires the simultaneous observation of the weather at many widely located sites using standardized instruments and techniques. By international agreement all meteorological observations are taken at the same time according to **Universal Coordinated Time (UCT)**. Observations are collected simultaneously in order to obtain a comprehensive and nearly instantaneous picture of the state of the atmosphere. Such simultaneous or synchronous observations of weather elements collected over a large network of stations are known as **synoptic observations.**

The objective of synoptic meteorology is to forecast weather. By international agreement the data taken from earth's surface and aloft at certain international hours of observations are inserted in the weather charts with international symbols and codes according to fixed rules. These crude representations are then analyzed and critically evaluated in accordance with the knowledge of existing structure models in the atmosphere, in order to ascertain the best approximation to a three dimensional image of the true atmospheric states at the hour of observation. By observing the evolution of the weather elements from a series of such representation from map time to map time, the experience meteorologist can formulate prognostic positions for the key weather features with the help of empirical knowledge of their behavior and by application of theoretical results of Dynamic Meteorology [2].

2. SYNOPTIC METEOROLOGY

The synoptic method of weather forecasting is based on the simultaneous observation of the weather elements, their rapid transmission to the central forecasting office and plotting the information at the location of the several observations on a geographical map, commonly known as weather map with international symbols and codes according to fixed rules. These crude representations are then analyzed and critically evaluated in accordance with the knowledge of existing structure models in the atmosphere, in order to ascertain the best approximation to a three dimensional image of the true atmospheric states at the hour of observation. By observing the evolution of the weather elements from a series of such representation from map time to map time, the experience meteorologist can formulate prognostic positions for the key weather features with the help of empirical knowledge of their behavior and by application of theoretical results of dynamic meteorology. Many kinds of weather maps are used, depending on the weather elements of immediate interest and their elevation above the ground. Among the more common of these is the surface or the sea level map and upper air maps at fixed elevations above sea level on constant pressure surfaces.

Although the synoptic method originated in the eighteenth century, it became possible to transmit the data and issue the forecast with required speed only after the development of the electrical telegraph. By the middle of nineteenth century basic technology has been developed, but the establishment of organized weather services was not immediate [3]. During most of the nineteenth century synoptic meteorology was confined to the use of surface based observations only. It was known from early mountain observations and from the observation of cloud motion that the atmosphere was not homogenous. Yet, without routine detailed information of the vertical structure of the atmosphere, forecasters had to rely heavily upon the idealized models connecting the weather to surface pressure patterns. Since this was the only workable systems, it can be greatly in error. It is in the context of the need for better atmospheric models that the development of upper air observation systems made a great impact on weather forecasting.

In actual atmosphere all these scales are interaction with each other and have important feedback effects. Particularly for the tropical weather dynamics these feedback have been recognized as very important and crucial. Analysis of the weather chart is taken up keeping in view the scale of the weather system to be investigated, for example, a synoptic meteorologist is mainly interested in delineating the synoptic scale systems more effectively and may ignore the meso or small scales in his analysis. Depending upon the purpose the analysis of weather charts can be classified into the following categories.

(a)Climatological Analysis: This highlights the position and intensity in the planetary scale of the main centers of action and follows the variations in these from one specified period to another.

(b)Synoptic Analysis: Which highlights the intensity and movement of major synoptic scale systems viz., lows, depressions, cyclonic storms etc.

(c)Meso-scale Analysis: This highlights the features on this scale such as squall lines.

(d)Small scale Analysis: Which highlights the stability conditions over a station and follows it in time sequence of short duration e.g. thunderstorm, dust storm.

Weather Maps: A large mass of data for various atmospheric elements from surface and aloft obtained from a large network of stations are depicted in pictorial and coded form on the weather maps comprising of a large area and analyzed by drawing isopleths i.e. lines joining places with equal numerical value of the weather element. Such a map gives an organized picture of the location and structure of the various weather systems and, when several such successive maps are available, they highlight the motion and development of the weather systems.

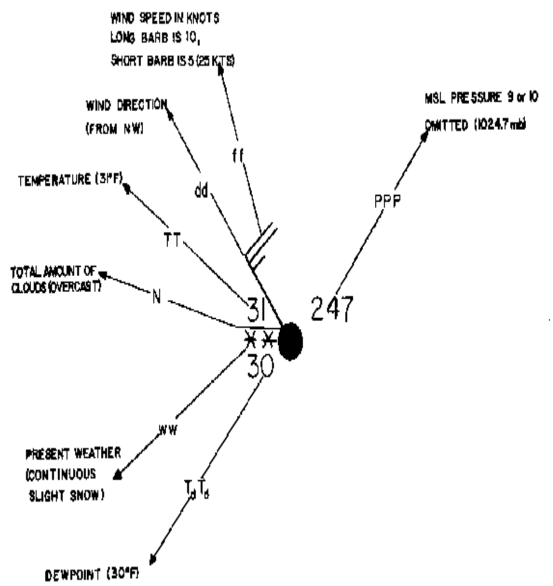

Fig: Representation of weather elements

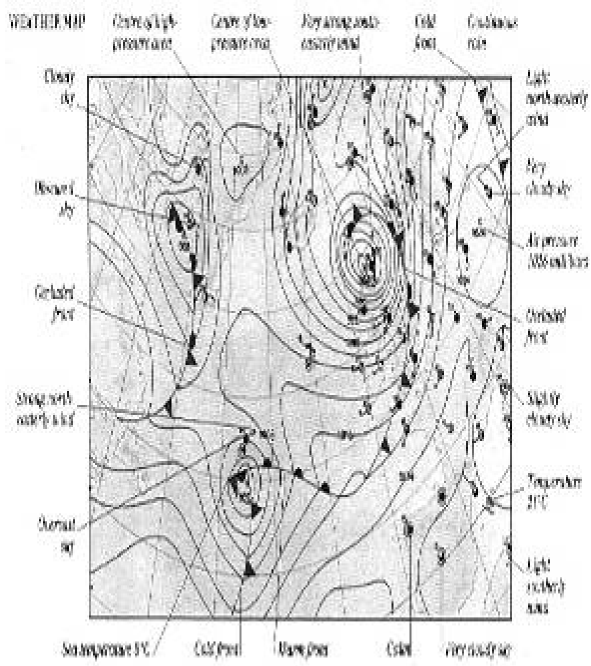

Fig: Representation of weather map

3.MEASUREMENTS OF WEATHER ELEMENTS

Atmospheric Pressure

The atmospheric pressure at any level is measured by the weight of a column of air standing on unit area at that level and extending vertically up to the upper limit of the atmosphere. Pressure is thus defined as force per unit area and so its unit is dynes per square centimetre.

Barometric correction

For a given pressure, the length if the mercury column of a barometer is not constant but depends upon the density (and therefore on the temperature) of the mercury, the value of the acceleration due to gravity (g) at the place of observation and the height above sea level. g = 980.665 cm/sec^2, temperature 0°C, and density of mercury 13.5951 gm/cc

Thus in order to obtain correct pressure (under standard conditions of temperature and gravity) at the station level the following corrections is to be applied:

- Index correction
- Temperature correction
- Gravity correction
- Bar convention correction

Reduction to Mean Sea Level

It is often necessary to deduce the horizontal gradient of pressure between two places at different levels. This cannot be done by the direct comparison of the readings of pressure at the station concerned because of the change in pressure and height. So it is necessary both the readings to a common datum level (standard level), which is the mean sea level for stations whose elevations are below 800m. In case of stations with higher elevation the nearest standard level (850hPa, 700hPa, 500hPa etc.) is considered.

The reduction to mean sea level consists in adding to the observed pressure, the pressure due to the weight of a hypothetical vertical column of air equal in length to the height of the barometer cistern above mean sea level. The pressure due a column of air depends on its temperature, the amount of water vapour in it, the value of gravity and the pressure at the top of the column i.e. pressure at the station level. In the hypothetical case the first three may be assumed constant or may be assumed to vary along the column. The temperature of the air column is taken to be equal to the temperature of the outside air at the level of the station. With the constant value of g, it may be shown that if the temperature of the air column is T°A, z the height of the column, P_0 the pressure at the mean sea level and p the observed pressure at the top of the column corrected for index, temperature and gravity, then the station level spressure p can be deduced to P_0 from the following relationship, which can be obtained by integrating the hydrostatic equation, $\partial p = pg\partial z$, where p is the density of air and is equal to RT/p.

In $(P_0/p) = gz/RT$ or $= P_{0\,=}\, pc^{gz/RT}$

where R is the gas constant for dry air.

Temperature

The value of the air temperature at fixed hours is read from an ordinary thermometer known as the dry bulb thermometer. The wet bulb thermometer is also an ordinary thermometer, but with its bulb covered with a muslin cloth, which is kept continuously moistened by means of a wick of cotton strands, the ends of which dips into distilled water (or clear rain water) contained in a suitable small vessel. The wet bulb thermometer indicates the temperature to which the air can be cooled by evaporating water into it till saturation and is known as wet bulb temperature. Its action depends on the fact that evaporation taken place from the wet bulb as long as the air in contact with it is not saturated with water vapour. In normal circumstances the wet bulb temperature is lower than the air temperature i.e. the dry bulb temperature. That means, in a saturated atmosphere both thermometers should read the same. From the dry bulb and wet bulb readings the dew point can be obtained by reference to hydrometric tables or by the use of humidity slide-rules.

The maximum and minimum thermometer are two self-registering thermometer. The maximum thermometer us designed to indicate the highest temperature reached since the instrument was last set. The minimum indicates the lowest temperature reached during the corresponding interval.

Humidity

The atmosphere contains a variable amount of water vapour. A measure of the amount of water vapour present in the air is known as humidity. The humidity parameters expressing the moisture of the air the dew point temperature, the vapour pressure, humidity mixing ratio, the specific humidity, absolute humidity, the relative humidity and precipitable water etc. Any of the above humidity parameters can be derived from the air temperature and the wet bulb temperature. These humidity parameters are defined as;

Dew point Temperature: If air, that is not saturated is sufficiently cooled, its capacity to hold moisture us reduced, and a temperature us eventually reached at which the mass of air becomes completely saturated. This critical temperature at which saturation is reached is called the dew point temperature. If air is cooled further below the dew point temperature, condensation takes place and the excess of water vapour, over and above what the air can contain at that temperature, is given off in the form of minute particles of water, known as dew. With further cooling of air below its freezing point the minute particle of liquid water freezes to ice crystal forming frost.

***Vapour Pressure* :** The vapour pressure (e) is that part of the atmospheric pressure which water vapour contributes to the total atmospheric pressure. This is expressed in the same units as total air pressure i.e., in hectoPascal (hPa). The saturated vapour pressure (e_s) is the partial pressure which water vapour would contributes to the total atmospheric pressure if the air were saturated.

Mixing Ratio **:** In a sample of moist air, the mixing ration (r) is the ration of the mass of water vapour (M_v) to the mass of dry air (M_d) and is expressed in grams of water vapour contained in a kilogram of dry air.If ρ is the pressure of the moist air, e the partial pressure exerted by the water vapour, then ρ-e us the pressure of the dry air and ρ-e is the pressure of the dry air, then from equation of state we find,

$e = \rho_v R_v T$ for water vapour and

$\rho - e = \rho_d R_d T$ for dry air

where R_v and R_d are the gas constants for water vapour and dry air ,the mixing ratio r can be expressed in terms of vapour pressure as,

$$q=\rho_v/\rho_d+\rho_v$$

where $R_d = 0.287$ joul gm $^{-1}$°K^{-1},

$R_v = 0.461$ joul gm $^{-1}$°K^{-1} and $R_d/R_v = 0.622$

The saturation mixing ratio (r_s) is the mixing ratio a sample of air would have if saturated.

Specific humidity **:** Specific humidity (q) is the amount of water vapour (M_v) in grams in a kilogram of moist air ($M_d + M_v$) and is expressed in grams per kilogram.

$$q = M_v / (M_d / M_v)$$

Applying equation (1) and (2) the specific humidity can be expressed as

The saturation Specific humidity (q_s) is the Specific humidity of air would have if saturate.

Absolute humidity : Absolute humidity is the amount of water vapour present in unit volume of moist air and is usually expressed in grams per cubic meter. It is same as the density of water vapour.

Relative humidity : Relative humidity is the ratio of the amount of water vapour actually present in the air to the amount of water vapour necessary to saturate it at that temperature expressed as a percentage. The relative humidity can be computed from the mixing ratio (r) and the saturation mixing ratio (r_s) by the following equation.

$$RH = (r / r_s) \times 100$$

Precipitable Water : The precipitable Water (w) is define as the mass of water vapour contained in a vertical column of air of unit cross section between any two levels (e.g. from the earth's surface (p_o) to the top of the atmosphere (Pr) and is expressed by

$$w = \rho_{v\,\delta} z = - (\rho_v / \rho g)\,_\delta p = - (1 / g)\, q_\delta p$$

Rainfall

Rainfall during any period is expressed by the height of water collected in an open impermeable space by direct precipitation provided there is no loss of water due to run off, evaporation, absorption or any other cause. The simplest method of measuring rainfall is by setting up raingauges with a horizontal circular aperture of known area and collection and measuring at regular intervals the precipitation collected in them.

4. IMPLEMENTATION

Due to much inefficiency in the current system, new model is depicted to improve the inadequateness of weather conditions. The goal behind to introduce scientific automated weather analysis is to:

- Provides a framework that enables them to make synoptic analysis of weather fast with good accuracy.
- Estimates are made within a limited time frame till the end.
- It will update regularly as the technology progresses.
- Adaptive to work at any platform and any operating environment.
- In addition, estimates define best analysis of humidity, rainfall, gravity and user friendly.

Whenever we talk about weather very huge amount of data and analysis are required. The meteorologists have to rely heavily upon the weather forecasting. Weather forecasting being static does not provide the accurate analysis to present weather conditions. The meteorologists have to calculate the reports on their own manually. The work being hectic doesn't provide correctness to the analysis. It is practically impossible to enumerate those calculations again. Domain expert is required to understand the terms and follow the rules. Due to such requirements they need to provide the complex training to the user. Still there is no surety of the accuracy.

Thus, scientific automated weather analysis provides a paradigm to eradicate the inaccuracy. With the use of this model we would be able to get:

- Computerized model to calculate all weather components.
- Complexities are not shown at the user interface.
- No complex training is required to handle the model or to understand the terminologies of weather.
- Large paper work as well as much time consumption can be avoided.

The following fig(c) shows the architecture of Scientific Automated Weather Analysis. This fig shows the implementation of SAWA.

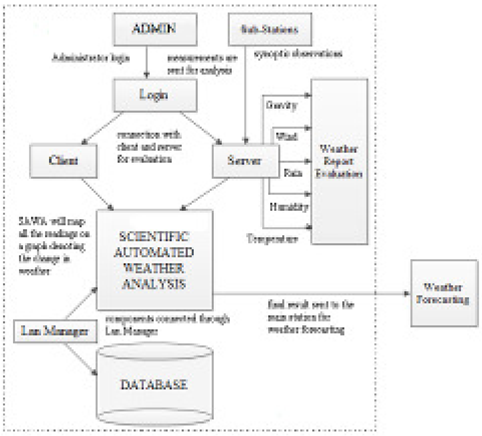

Fig: Graphical Representation of SAWA

The user i.e. **Admin** will log onto the system and connect to the server. The server will fetch the reports from all the sub- stations in Microsoft Excel Sheet. The basic purpose of main stations is only to observe the climatic conditions and note the corresponding measurements and send it for analysis. Those observations which are carried out are called as **Synoptic Observations.** Then server will generate the notifications for each weather element and saved to the database. Thus as the measurements would be input to the system it will calculate the reports automatically. Thus the time will be saved. With the less time consumption the updated report will be sent for broadcasting and thus many disastrous calamities can be detected easily. With the implementation of such system we can have many advantages in the favor of environment:

- With the help of updated report it will notify the calamities occurred (if any).
- Alerts the people and save human lose.
- It can be used in favor of agriculture and shipping.

With the use of such system the accuracy provided would be 95%. Thus, synoptic meteorology would get a new direction in the evolution of new technologies. The future scope of this system is it can be implemented in geostationary satellites and GPS systems which may enhance the functioning of SAWA.

5. CONCLUSION

In "Data Organisation and Analysis System for Meteorology Purpose" we have studied different elements of weather, their unit and measurement and studied also data organized by geostationary satellite and chart analysis for upper air analysis and surface level analysis. All these analysis are useful for plotting chart for meteorological purpose. In meteorological system we observed the condition of element which indicate present weather conditions and provide the information about rainfall, precipitation, storm, cyclone etc. Similarly collecting of data and after observing it's sent to forecasting centre which forecast these weather conditions through media like TV channels, news, radio station etc. and people to alert from the future natural disaster or misfortune.

Studying this" scientific automated weather analysis" will allow to manipulate without difficulties with basic notions and terms they will use while learning the main course of synoptic meteorology and other meteorological disciplines such as long-term weather forecasting, now casting, tropical meteorology, etc. Having been well acquainted with the bases of synoptic meteorology, we will easily understand regularities of the atmospheric process development and weather variations caused by the synoptic processes. On this ground and using recent statistical and hydrodynamic achievements, they will be able to work out some new methods and techniques for short-range weather prediction.

Knowledge of Synoptic Meteorology will facilitate to get ideas on basic directions and methods of research activity in the field of weather forming processes, and, hence, to be prepared for further sophistication of existing weather forecasting methods thereby providing a robust system for effective weather analysis.

6. REFERENCES

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