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Role Of Mathematics In Studying Problems Of Atmosphere

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Abstract: The main aim of science is to make reliable predictions. All such predictions are based on mathematical analysis. Mathematics plays important role in weather forecast. In the present paper, I have discussed the problems of atmosphere and role of mathematics in solving those problems.

Key Words: Thermo-elastic forecasting, Astronomy, Prediction, Meteorology

Introduction: Meteorology is branch of physics and mathematics is essential for deep physical understanding of weather. Numerical weather prediction is based upon the approximate equations of mathematics. The equation describing atmospheric processes were developed long before the invention of computer. With the development of computer, it became easy to find out the solutions of those equations easily. The set of chaotic nonlinear differential equation is initialized using observational data then numerically integrated on super computer to generate forecast. Mathematics, like music and poetry, is creation of the mind; its reality is not that of the physical world, and the primary task of the mathematician, like that of any other artist, is to extend man's mental horizon by representation and interpretation. It is true that in the minds of the most mathematicians there is a real distinction between the two kinds of mathematics but difference is never absolute. This paper is concerned solely with mathematics in physical science or, in more homely terms with 'applied', as distinct from 'pure', mathematics. In this paper I have discussed following points in which mathematics is used to study for weather forecasting.

The Problems of the Atmosphere

Main aims of science are to make reliable pre-dictions. Some of these are now accepted without question; for example, publishes the times of sunrise and sunset, or announces a forthcoming eclipse, with complete confidence. Predictions of the times of high and low water and the height of the tides at various ports are only slightly less accurate. All such predictions are quantitative and based on mathematical analysis. The prediction about the weather forecast is couched in less precise language and makes no high accuracy. Firstly it seems to be no good reason for this, because mathematics is as essential in meteorology as it is in astronomy or tidal theory. The National Almanac has described, as a miracle of forecasting.

To solve the problem into focus, first we discuss those parts of science where mathematics has succeeded beyond question. First two well-defined groups are discussed (i) those concerned with controlled processes from which many events have been largely or wholly eliminated by careful design, and (ii) those dealing with uncontrolled natural phenomena of a highly stable kind. Physical measurements in a laboratory and all operations with machines and instruments fall into the first class and second group deals with dynamical astronomy and tidal theory. The

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solar system exhibits the most stable motion known to man, and a failure of an eclipse to occur precisely at the predicted time would indicate a catastrophic change in the system.

Meteorology falls into neither of these classes. It is concerned with uncontrolled natural processes on a large scale like astronomy, but the comparison fails in other respects. Now we think about the problem objectively. As we know air, a mixture of about a dozen different gases, one of which, water vapour, is able to pass very easily into the liquid and solid states, liberating or taking up large amounts of heat. Into this mixture the sun pours energy in the form of radiation of short wavelength. When radiation passes through the atmosphere to warm the land or sea, some part is absorbed by the air and much is reflected back to space from vegetation, water and by clouds. The heated earth, gives out radiation of long wavelength known as infra-red, some of which is absorbed by water vapour and clouds and some is lost to space. The balance sheet of radiant energy shows changes with the time of day, season and locality, with the composition of the atmosphere and with the distribution of land and water over the globe. The unequal heating sets up currents in the atmosphere which circulate quantities of air from one location to another, in the course of which water is evaporated or condensed in vast amounts. Almost every element of the system reacts significantly with every other. It is concluded that the atmosphere is an incredibly complicated steam engine, with the sun as furnace, located on a spinning globe of highly irregular surface. The intricate nature of the meteorological problem is perhaps better realized by a comparison, not with astronomy but with economics. Both subjects deal fundamentally with problems of energy transformations and distributions-in economics, labour produces goods and other forms of wealth and meteorology traces the distribution of energy from the sun. Both systems are affected by complicated external influences. Economics has to reckon with man in his infinite variety, meteorology with effects arising from the irregular character of the surface of the earth and the uneven distribution of water vapour in the atmosphere. To bring the weather within the scope of exact mathematical analysis demands the formation of something mathematical a universal theory of atmospheric motions. It is seen that many universal theories appear even in highly developed subjects like physics and research, for the most part, is directed towards the exploration of limited fields.

.Routine Weather Forecasting

In order to form a reasonable estimate of the possibilities of mathematical forecasts we should know the methods which are used by 'official' forecasters to-day. The basic information and facts about present weather comes from a network of meteorological stations scattered throughout the settled areas of the world, and from ships on the high seas. At the present time it is better to say that the meteorologist has all the information that he can usefully digest for surface conditions and rather less than he needs for the upper air. The forecaster plots these observations on large maps covering Western Europe and the adjoining seas, and his first step is usually to draw lines of equal pressure for the surface. In addition, he transfers the results of soundings by radio-sondes and aircraft to thermo-dynamic diagrams. The information is displayed in selected two-dimensional ‘snapshots' of the atmosphere, together with a few vertical views. In drawing the isobars the forecaster is influenced, not only by maps for the previous period, but also by what is called 'air-mass analysis', a procedure based on the fact that streams of air of different origin tend to preserve certain properties as they move. The junctions of such air masses usually appear as lines of discontinuity, called 'fronts', in the pressure field.

The normal process of short-range weather forecasting for periods of six, twelve or twenty-four hours ahead consists an attempt to foresee changes in the pressure field by a combination of past

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experience and physical reasoning. The actual weather is deduced as a consequence of the movements of the field. Experience has shown that more often than not definite kinds of weather accompany certain familiar patterns of isobars, the stormy, unsettled weather of a depression and the fine warm weather of a summer anticyclone. As the connection between the pressure distribution and the weather is far from unique, and the above relations are only statistically true. This is the reason why sometimes a barometers marked with weather legends declare that their instruments are ‘inaccurate.

At the present time, weather prediction is more of an art than science.. In the mathematical sense, there are very few quantitative rules, and calculations are used. It is seen that no two forecasters follow precisely the same method, but the broad basis of short-range forecasting is much the same everywhere. The drawing of isobaric charts and, especially the insertion of fronts are to some extent subjective, there are certain outstanding features of all pressure patterns. The forecast studied these results and argues future developments by process which resembles extrapolation in mathematics. Many attempts are made to produce a systematic classification of pressure systems. Because of the many variables and enormous range of possibilities no two weather maps are exactly alike. Forecasts which simply repeat the exact sequence of weather observed in the past in like systems have not been very successful. The extrapolation is based on the recognition of certain tendencies which are expected to control the development of the system during the next six, twelve and perhaps twenty-four hours. The sequence of weather predicted for the ensuing period is that which the experience of the forecaster leads him to associate with the passage of a region of low pressure over these islands. The value of this method depends on the range of the forecast. For six hours ahead such predictions are generally reliable, but the degree of success falls rapidly as the period lengthens. In general, straightforward extrapolation is of little or no use for periods of the order of a week except on occasions when the pressure field is very stable.

The requirements for success in forecasting by this method are a liking for the job and experience. Short-period fore-casting is highly subjective, and knowledge of the deeper aspects of meteorological research is no guarantee of success in this difficult art. 'The quality which is shared by all good forecasters is an intense interest in the weather which leads them, in time, to develop a 'nose' for coming changes.

The aim of meteorological research is to provide aids which will reduce the subjective element in forecasting to acceptably small proportions. As there are many doubts but we can be sure that the need for individual skill in forecasting will never disappear. There are many reasons for believing that the exact sequence of weather at any given locality can never be calculated for long periods ahead.

Mathematics and Forecasting

We examine the possibilities of improving weather prediction by mathematics; we must inquire into the meaning. Many branches of physical science the agreement between theory and observation is tested, by comparisons between numbers. This is not so for weather prediction, because forecasts tend to be qualitative rather than quantitative. The predictions of temperature, which are usually numerical, cannot always be checked.

The aim of the mathematical theorists is to find a basis for the calculation of future pressure or motion fields from existing fields. The success or failure of such schemes can be decided only by comparison of the forecast and actual maps on a visual basis.

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The attempts to bring mathematics into large-scale atmospheric processes were by means of what we call mechanical' models. The typical depression, with air moving around a centre of low pressure, resembles the classical vortex and thus it was natural to consider first the dynamics of a revolving horizontal disc of incompressible fluid when fluid is withdrawn from the centre by some unspecified process. The resulting motion is equivalent to that found by combining a simple line vortex with a solid rotation. Such a model exhibits many features found in tropical cyclones, but it is very simple to represent adequately the depressions of our latitudes. Another possible model is the so-called 'cartwheel depression', a disc of fluid spinning about a vertical axis and drifting horizontally.

The modern approach begins with the so-called wave theory of cyclones, and in many branches of applied mathematics results of great value have been obtained which is called perturbation theory. In this, a simple basic motion is postulated and effects to be studied, compared with the system as a whole, are regarded as disturbances which are 'small' in the mathematical sense. To make hydrodynamic equations linear, squares and products of the additional velocities, when considered on the scale of the whole motion, can be neglected. This concept gave forecasting its greatest impetus, by introducing the ideas of 'air masses' and 'fronts', but in the subsequent development of the theory in the forecaster's hands the mathematical aspects have tended to be ignored. To-day, the theory has become so involved that the original impetus may be considered to have spent itself. It is the familiar story of an over-simplified scheme, for relatively few disturbances conforms exactly to the polar-front scheme, but the perturbation equations remain as a subject for serious study.

Modern forecasting techniques concentrate attention on undulations in surfaces of equal pressure, rather than on variations of pressure on surfaces of equal height, and this lead is followed in the mathematical approach. Consider, for example, the 1000-mb and 500-mb surfaces. The former is roughly at sea-level and the latter lies about 18,000 feet higher (in latitude 45°, approximately mid-way between sea-level and the tropopause). As the weather changes with the passage of depressions and anticyclones, the heights of these surfaces above a fixed datum alter from point to point. Such variations may be specified in two ways: by contour-height above mean sea-level and by thickness, or the distance between two isobaric surfaces. Contour-height thus expresses the absolute topography of an isobaric surface and thickness, the relative topography of any two surfaces.

Discussion: The name meteorologist comes from a very old Greek word which means studies things that are high in the air. They use three main things to help them decide what weather is on the way: whether observations, computer weather models and their own experience. They need a lot of measurements of things like air pressure, temperature and rain wall, not on the ground but also high in the sky. For these measurements they rely on weather balloons, satellites, radars and aeroplanes. Meteorologists use methods and theories of mathematics to study the weather forecasting.

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