APPLIED AGRO METEOROLOGY, APPLIED AGRO BIOLOGY AND THE HYPOTHETICO-DEDUCTIVE PRINCIPLE

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Abstract

The general scientific method called the hypothetico-deductive principle is presented and interpreted, and the scope of this principle in the agro meteorological and agro biological context of man's advanced crop growing systems, is shortly discussed.

The presentation of this method is based on a rather thorough discussion and interpretation of two important concepts, the parameterization of physical and biological phenomena, and the testing procedures of the systems.

The scope of this method is discussed especially as used in modelling, biological and biological-meteorological interrelated phenomena.

The views and discussion are also extended toward the society, the producing and distribution systems of crops and fruit products in advanced industrialized countries.

Introduction

Agro meteorology is applied science, using elements from meteorology, physics, plant physiology, crop science, soil physics etc. In this science some of the physical processes connected to the atmosphere near the ground are our concern, as well as some processes connected to the vegetation and the upper layers of the soil. It is used in an operational context, in decision making in crop growing and horticultural production. Agro meteorology is more operational in the advanced developed industrialised countries.

The production systems of crops and orchards are rather deeply influencing physical and biological environments of man, both on short and long time scale. The methods used for getting necessary information to make strategic and tactical decisions in many plant production systems, and the methods used for analysing the consequences of this decision making, are to a very great extent dependent on the scientific method.
called the hypothetico-deductive principle. Agro meteorology is used in many strategic as well as tactical ways in crop production.

In the following an interpretation of the general scientific method called the hypothetico-deductive principle is given, and the means for discussing the scope of this principle in an agro meteorological and agro biological context are presented. In the conclusion of the paper the views and discussions are extended toward the society as a whole, relations in the society and the scientific questions in this context worth to focus on.

**Discussing the scope of the hypothetico – deductive principle**

The hypothetico-deductive principle as it is used in meteorology and agro meteorology may be summed up in the scheme given in the figure below inspired by an elementary textbook in statistics, Godske (1966), and extended in several ways.

The aim is to find out if some sort of systematic documentation system could and should be constructed to say something about the scope of the models used in agro meteorology and agro biology. The starting point is the observer looking at the world and noting the appearance of different phenomena. The observer picks out a
phenomenon that is given a name. This phenomenon is his entity, or class according to object oriented terminology.

The next step consists of induction, abstraction and systematisation. The observer is living in a society, and he knows how to count and measure and connect numbers to different physical objects or sets of physical objects in the world. The observer now picks out several attributes of the entity observed. These attributes are his parameters. The values of the parameters are numbers. One must have a prescribed system for measuring each of the attributes, and the parameters each have a definition.

Through time certain preliminary hypotheses connecting parameters have been constructed. These hypotheses are often called ‘physical laws’ like the conservation of mass, the conservation of energy (containing the first law of thermodynamics), the conservation of momentum, and the second law of thermodynamics that prescribes the direction of certain processes.

Hypotheses derived from these ‘laws of physics’ are constructed, consisting of mathematical equations of the parameters, and initial measured values of the parameters are put into these mathematical equations. One of the parameters used is usually the time, and by using logical and mathematical deduction (analytically or numerically), the values of the attributes are predicted at a later time, or the values of the attributes are predicted at another place in space.

The last step is the test or comparison between the predicted values of the attributes of the phenomenon considered and the observed attributes of the phenomenon according to some sort of independent system for measurement.

The remaining problem is then to analyse the results of the testing and decide whether the system constructed, hypothesis, theory, parameters and measuring system are sound and what the scope of the whole system is. Usually the hypothetico-deductive principle is interpreted more restrictively. The test is only considered a test of the hypotheses considered, if the hypotheses should be rejected or confirmed in the actual situation, or generally.

The often rather complicated models used in micro meteorology, dynamic meteorology, crop research, plant pathology etc., are as a rule combinations of scientific hypotheses containing parameters of different spatial and temporal scales. A discussion of a model as a set of hypotheses possible to test, or as an extended hypothesis is found in Addiscott (1993) or in Sivertsen et. al. (1999) and Sivertsen (2000).

The validity and scope of the models are documented only through testing and actual use of the models. No hypothesis or extended hypothesis has much value outside the
temporal and spatial reality where the hypothesis may be tested and operationally used.

Only the phenomena defined by the parameters, the quantification of the niche of the world considered, can give us quantified prognostic knowledge of the future. A prognostic model does say something quantitatively meaningful in space and time about the parameters in the system considered. Such a system can say nothing or very little about the other physical, chemical and biological phenomena occurring in this system, or about phenomena crossing the spatial borders and not being included in the boundary conditions.

The quantitative attributes of the entities contained in our hypotheses, we call parameters. They can be measured, and we can give them a numerical value by using instruments. Some parameters are much more difficult to measure than others, and it is only possible to give them rather inaccurate numerical values. All parameters are given numerical values within a certain range. This means that both the measurements and the resulting calculations are inaccurate to a certain degree.

The hypothetico-deductive principle may be regarded as basically a non-authoritarian principle. There is no human authority which guarantees that a scientific hypothesis including the system of measurement and parameterisation or a set of such hypotheses is true or useful. Only the hard way, by defining and measuring the different parameters and testing the outcome of the constructed hypothesis may give us verification or non-verification of the system of parameterisation, measurement and hypothesis, and the scope of the system. This does not mean that the principle exists and ought to be discussed in isolation from a social context. But the social context could be more aware of the methods actually used and the basic character of this principle.

Two concepts that ought to be discussed in connection with models and testing of models are the concept of ‘scale’ and the concept of ‘representativeness’. One can probably regard time scale and spatial scale of meteorological and agro meteorological phenomena as special parameters to be used as attributes of entities in models or sub-models. As a rule the scale attributes will not change in time, and there should exist some definition and measuring system to define the scale in each case.

The concept of ‘representativeness’ can be defined as some property connecting the definition and measuring system of a parameter to a model. The representativeness of a measured parameter therefore may be found by using the values of this parameter in a model. This is a way of testing the representativeness connected to this model. A parameter measured in some prescribed way may be representative in one model but fail to be representative in another model, usually dependent on the spatial scale and time scale of the models.
A thorough description of the measuring systems of the different parameters is of relevance for analysing representativeness. In agro meteorology such systems may be automated meteorological station networks or synoptic station networks, manually or automated. In agro biological systems the observations of parameter values are more difficult to make in an automated way.

Certain biological phenomena are impossible or very difficult to include (statistically or otherwise) in any modelling based on the hypothetico-deductive principle on short or long time scales, such as:

(a) The consequences of stress on the biological systems on a massive scale causing natural occurrence of resistance to pesticides, fungicides and herbicides in organisms.

(b) The consequences of stress on local biological systems caused by transport of all sort of biological organisms across borders, across oceans and across continents.

This sort of reflections can help us confining the relevant use of scientific methods, and we are brought to a discussion on the relations of living organisms, and the place of man.

Looking at some relations connected to Agro Biological Systems

Man is fundamentally living in a complex relational context. The agricultural production, the distribution, and the consumption of food in modern industrialized countries are taking place in a complex relational context. This paper primarily considers general methods used in operational agro meteorology - and in some other fields connected to primary crop production in such advanced countries - to control the primary food production. This production is depending on certain principles:

(a) Optimal or maximum economical benefit for the producer, processing industry and distribution system in a dynamic situation with competition. The market always wants cheaper food or better food for the same price.

(b) Quality control and other demands on the products.

(c) Feed back from society regarding human health and environmental conditions on long and short time scales.

(d) The interests of the farmer community and the rest of society in maintaining a sustainable agriculture.

The relational context in this system is very complex to describe, and below only a few important relations will be mentioned. In the first place we have got the production system, the farmers, the agricultural extension service, the input of know how from research etc. Then we have got the food processing industry and the
distribution system to the consumers and other aspects of the society as well. We have also got all the biological organisms influenced in time and in space, and we ought also to reflect on passing sustainable and healthy systems on to later generations.

Each entity of a food product distributed to the consumers in a modern industrialized society may be characterized by many attributes. Several of these may be quantified. The edible content of such a product, regarding fats, carbohydrates, proteins and vitamins etc. are often written on the package, as well as the price and some measures of quality. But there are also sets of attributes connected to the relations of the product, such as the CO₂ output to the atmosphere from the production, processing and distribution systems, the use of renewable and non-renewable energy in the production, processing and distribution, the conditions and relations to the labour force in production, processing and distribution, the environmental and biological context of the product in production, processing and distribution etc..

One can define ethical values as the actual weight man is giving his different relations, as an individual or as an organized member of a human society. Ethical values may be regarded as rather conservative. We generally want to maintain a stable relational situation, at least if we are consciously aware of a situation at all.

Above the scope of the hypothetico-deductive principle was discussed. This is seen as an important tool used in designing controlling systems for agricultural production, in a frame given by some principles.

Is it at all satisfying mainly to base the development of the agricultural technology on the demands for cheaper food on a great market place?

It would be possible to describe many of the relations connected to the different products of food by attributes connected to these relations.

Is it of any interest to uncover such relational attributes systematically? Could this uncovering also be relevant themes of future research?

Or in short:

Clarify the scope of your methods!

Uncover the attributes of relevant commodities!

Clarify ethical values!

Then define the direction and tasks of research!
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References


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