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14. Abstract/Notes *It was 1975. Several reports, all around the world had already been written, or were on the writing on food related problems; e.g., Population and Food (NAS, 1975a), World Hunger (NAS, 1975c), Resolution by the World Food Conference (FAO, 1974a), a Hungry World (U. Cal., 1974b), and World Food and Nutrition study (NRC, 1975c). If we could summarize the worries of that time (almost a decade ago), by quoting one of the reports (NRC 1975c); "the immediate challenge for this nation - - and indeed the world - - is to optimize agricultural and other renewable resource productivity per unit of land area; per increment of water; per unit of energy, pesticide, and fertilizer input; and per unit of time", one could conclude:*

(i) is it not still a challenge for the world of today the problem of food production and supply?

(ii) have we taken full control of the problem? (or at least full awareness of the problem, not even of the solutions)?

(iii) have we dreamt up some workable solutions to what one may call the "Food Shortage Epidemic"?

(iv) have we really recognized on a worldwide scale, the real influence and widespread consequences of weather and climate, on food production?

(v) or are we still in 1975 or earlier?

15. Remarks *Presented at the Climate Conference for Latin America and the Caribbean, Paipa (Boyaca), Colombia - 28 Nov. - 3 Dec. 1983, sponsored by the World Meteorological Organization.*

3121

THE MANAGEMENT OF ATMOSPHERIC RESOURCES
IN FOOD PRODUCTION

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I - BACKGROUND

It was 1975. Several reports, all around the world had already been written, or were on the writing on food related problems; e. g., Population and Food (NAS, 1975a), World Hunger (NAS, 1975c), Resolutions by the World Food Conference (FAO, 1974a), a Hungry World (U. Cal., 1974b), an World Food and Nutrition Study (NRC, 1975c). If we could summarize the worries of that time (almost a decade ago), by quoting one of the reports (NCR 1975c); "the immediate challenge for this nation - - and indeed the world - - is to optimize agricultural and other renewable resource productivity per unit of land area; per increment of water; per unit of energy, pesticide, and fertilizer input; and per unit of time", one could conclude:

(i) is it not still a challenge for the world of today the problem of food production and supply?;

(ii) Have we taken full control of the problem? (or at least full awareness of the problem, not even of the solutions)?;

(iii) Have we dreamt up some workable solutions to what one may call the "Food shortage epidemic"?;

(iv) Have we really recognized on a worldwide scale, the real influence and widespread consequences of weather and climate, on food production?

II - INTRODUCTION

Today, besides the scientific community as a whole, several segments of the society, already realize the limitations of the world in which we live in.

There is a growing awareness of the need of learning how to cope with this extremely important reality and therefore to develop the ways and means to survive, without, on the long run, to destroy life as we understand it today by destroying the environment which serves as our habitat.

There is a need to develop our knowledge both qualitatively and quantitatively about interactions between each and every human activity and the natural resources involved in it.

Atmospheric resources is just one of the many natural resources we have grown accustomed to use and abuse, instead of intelligently and resourcefully managing it.

We would like to introduce here the concept of Atmospheric Resources Management as we understand it.

We will then try to apply the concept, to some food production related problems.

III - CONCEPTS

The concept of atmospheric resources management consists in the consideration of the meteorological factors in the optimization of the operation and decision making processes in areas of man activities which are atmospheric dependent.

Therefore it pressuposes an already somewhat efficiently run system as far as other dependences than atmospheric.

In other words, by sistematically investigating the mechanism of interaction between the atmosphere and a given productive system, we should be able to develop models and techniques which will allow us to intelligently manage the resources (Atmosphere) envolved in the productive system (for example - food production).

We are all aware of the influences of temperature and precipitation on the yield of a given crop. We also know that a very effective farm operation, can be jeopardized by atmospheric (natural) disasters such as frost, hail, drought and so on.

Better prediction models are needed. Specially for the more agriculture related variables of precipitation and temperature. Climate studies indicating long term trends will also allow measures to be taken as far as relocation, or crop adaptability studies.

Here we will focus on just two atmospheric resources management applications, e. g. crop yield and frost, as they both affect food production.

IV - CROP YIELD - THE ATMOSPHERIC DEPENDENCE

When one looks at the problem of increasing food production, one deals with two basic possibilities. We either increase acreage, or we concentrate on productivity. It is clear that a bit of both might be the sensible way on a worldwide basis, since land in some regions is very scarse, even unexistent, while in other regions land, although possibly marginal, is plentiful.

According to the U. Cal (1974b) studies, there were about 1.5 billion hectares being used for crop production worldwide. Another 3.0 billion hectares were potential grazing land.

Once a crop has been established, new genetic improvement, as well as the more efficient utilization, or simply, the utilization of fertilizer, machinery and so on, can guarantee better and higher yields. Weather variations during a season, on a year by year basis, properly taken into consideration, can give us the lead, between stable food supply or large, going unpredicted, variations which might mean either surpplus or starvation.

Therefore, it is very important that the weather component of the agricultural productive business system, be taken into account very seriously. Also, that, the manager or decision making personnel behind these operations, be aware of what it is already available today in terms of crop weather models to try to squize out of them, beneficial information.

Data is data. It will only turn, into valuable information, if one learns how to manage it and put it to good use.

What will it be the use, for the farm manager, to receive, or even collect. temperature and precipitation data, in his or hers own operation site, if he or she does not have the models (ways) and knowledge (means) to manage this data. Is it good to know that the precipitation accumulation during some crop time, was 10% lower than last year? At a given time, during a crop calendar; is it possible to estimate the yield with an economic valuable accuracy?.

These and other questions, when properly handled (looked upon in an atmospheric resources management working environment and awareness) can have answers, already today, to help a farm manager to stay ahead. Let us take for example a corn farm production. For the sake of clarify we will use a crop-weather model developed for the regional agricultural district of Campinas, in the State of São Paulo, Brazil, which uses temperature and precipitation as independent variables. If the farm manager, has this model, at his or hers disposal, at the farm site, he or she then, can really take advantage of the previously mentioned precipitation and temperature data available. He or she can run the model equation and come out with good indications on expected yield for that year. He or she might use the same model to access irrigation decisions.

Models of this type, can be derived for several different regions, indicating better variety adaptability to some climates than others.

All of these are atmospheric resources management applications.

Let us then utilize as a form of example the 'Campinas' Model, (Celaschi, 1983) i. e.,

$$Y\ (Kg/Ha) = -\ 1956.11 + 47.85\ (Year) + 20.10\ P_1 + 22.37\ P_2 + 33.26\ P_3$$

For the year 78, the variables P_1, P_2 and P_3 (indicating precipitation) were observed to be 0.3, 5.5 and 6.3 which resulted in a model yield of 2114,80 kg/Ha. This yield is calculated by about mid January, while the actual harvesting happens around March, therefore giving the farm manager a lead time of about 2 to 3 months. With respect to the official estimates, which come about at around mid year, the lead time is even greater. For the example used (year 1978) the error was within 1% of the official estimate. If one had to choose, in a water scarce region the best period for increasing the water supply, the model suggests that we should use the period defined by the P_3 variable. For this case, a 10% increase in P_3 would result in about 1% increase in yield. For the 1978 acreage observed in 'Campinas' this P_3 increase would have resulted in about one million kilograms of more harvested corn. If the increase in income is larger than the cost to put the additional water in, needed to achieve this net gain, then, this would have been a profitable operation.

Therefore, with simple tools, if the farm manager is willing to recognize the importance of weather and climate in his or hers farm operation, Atmospheric Resources Management (ARM) will be part of his or hers management system.

The model above has been used, simply as an example and not as a recomended model to be used either in 'Campinas' or elsewhere.

V - FROST - A GOOD EXAMPLE FOR ARM APPLICATION

An efficient food production and supply system, depends among other things on a farm manager aware of his or hers systems dependence on weather and climate.

Supposing we have an efficient crop production system as far as technological factors dependence is concerned (seeds, machinery, fertilizer, etc). The variables weather and climate will still play a major role in defining a better or worse yield than expected. Also, to assure the supply, the managing decisions concerning harvesting, storage and distribution, are very much weather and climate dependent. Next to land and water, the basic and perhaps most fundamental determinant of agricultural production is the influence of weather and climate.

We will illustrate the concept of Atmospheric Resources Management (ARM) applied to the agricultural system, analyzing the problem of frost damage, as an atmospheric variable to be managed.

As we all know, there are ways of mitigating and sometimes even avoiding the damaging effect of low temperatures affecting a field crop, depending on intensity and duration of the frost and the crop stage.

There exists active (as pressurized sprays, burners,etc) and passive (cover, burying, etc) methods to avoid or mitigate frost damage.

The application of a given method, in a given crop, can only be evaluated as economically feaseable if we have, given all other variables are constant, the cost of application of the chosen method, versus the saving obtained by retaining the crop, undamaged, in the field.

Some methods are more labor intensive, others are more energy intensive, nevertheless, they all have a fixed cost attached to them.

If we have a good forecasting 'warning' system, and a very reliable, error defined detection and monitoring system, with a very short range (about 8 hours) 'nowcasting' capabilities, we can design, depending on the dissemination system (which has to be real time) a very powerful application of the concept of Atmospheric Resources Management. To fix ideas, let us suppose that a farm manager has at his on hers disposal a frost mitigating system (for example: a pressurized spray system), which to protect a given area A, will have to be activited one hour before the given crop critical temperature is reached. The cost to operate this system is set at C units per hour. In other words, if we have to use the frost protection system in area A for H hours, the total cost would be H. C units.

Let us also suppose that the crop being cultivated has an yield of Y kg/area, therefore resulting in a Y. A kg for the total area A. The cash value for that crop has being set at P units per kg. Therefore, in our example, the farm manager will obtain a total cash value of Y. A. P. units for his or hers crop.

Now, at a given night, he or she, is faced with the following problem: there is a probability (about 80%) that a frost will hit his or hers crop. As a good farm manager, he or she will keep up with the situation to reach a decision of turning the frost protection system <u>on</u> or not.

The criteria, using the values defined above is,

$$H < \frac{Y.A.P.}{C}$$

or, that the number of hours needed to keep the frost protection system on, has to be less than the 'equivalent hour - cash/cost'.

Let us suppose first, as one possibility that H is always less than Y.A.P/C for the maximum H possible of about 8 hours. In other words, either the frost protection system is cheap to operate or the cash price for the crop under protection is very high.

If there exists a reliable statistics about the probability of frost cases to happen during a crop calendar, (for example, N nights during the season), the farm manager, even for the first assumption of H always less than Y.A.P/C per night of frost, has now to face the problem of probability risks for an entire crop season, i.e.,

$H < \frac{Y.A.P.}{C.N}$ at a given probability level.

As it can be appreciated, the real world will be such that there is always a tight balance, between N.C.H. and Y.A.P. therefore forcing the farm manager to rely on 'educated guesses' or to look for reliable frost information system. As described above, this system has to permit the farm manager to know what to expect in a frost night and to be able to monitor the intensity and duration which the crop will experience under the frost temperature.

This same type of study could be turned other way around to demonstrate the possibility of using a contemplated frost protection system for a given local and crop. Again the importance of making, meteorological information available, within the framework of an ARM application is stressed.

Just to inform the reader, a system for detecting, monitoring and disseminating in real time, frost occurrence, based on digitally processed satellite infrared images is being tested in Brazil as the first step to achieve the atmospheric resources management application illustrated above (Almeida et al., 1982).

VI - <u>CONCLUSION</u>

If every thing which was said up to here, is asked for to be put at the disposal of the food production and supply system, this will require from the meteorological operational services a system capable - to collect, quality control, and disseminate the data needed in time to be used by the farm manager. If we keep in mind the economic returns which we can collect from intelligently using meteorological data, in a food production system, as the above examples of applying the concepts of Atmospheric Resources Management have suggested, although this might represent a burden for some, it should be strived for all. This is one of the many reasons, for us (Meteorologists) to exist and help mankind.

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