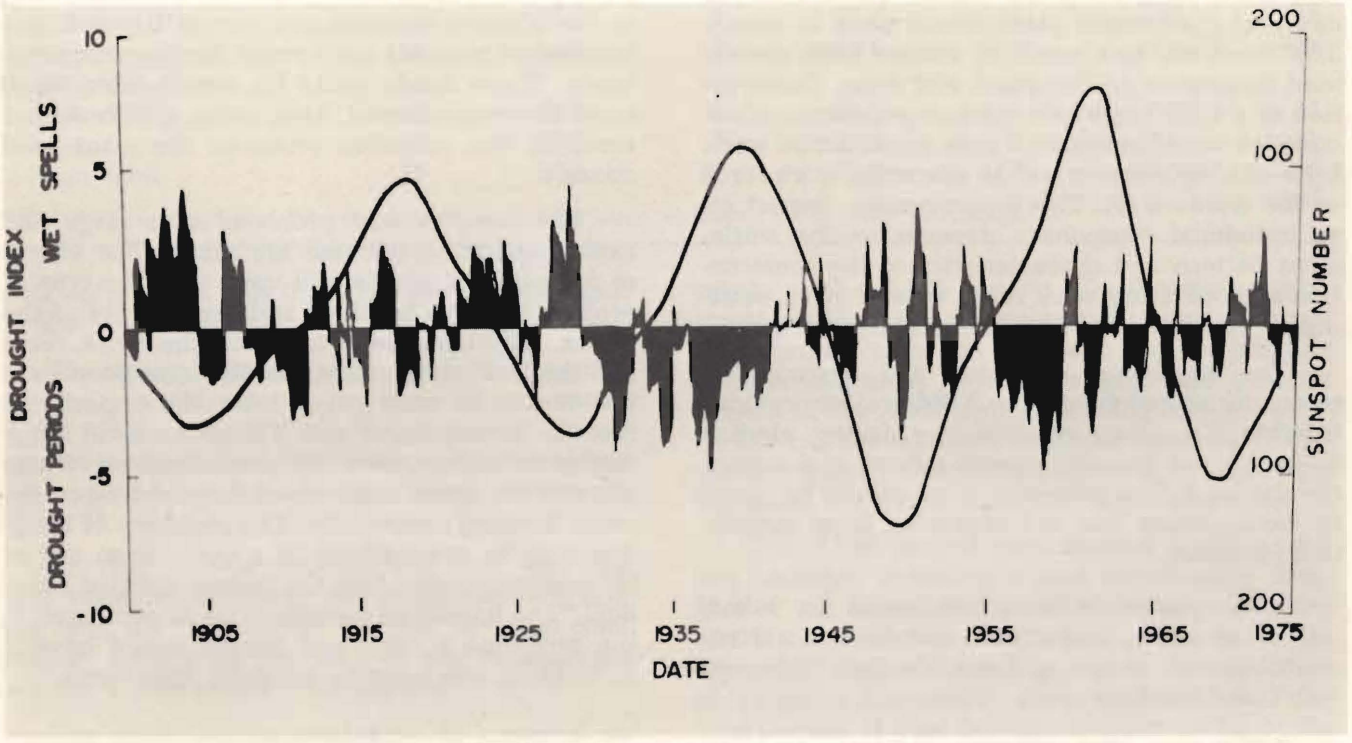

Sunspot Activity and Drought (North Dakota)

Drought in the 1970's?

. . . A CLIMATOLOGIST'S POINT OF VIEW

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The problem of adequate food production for a world where population is still increasing is, and will continue to be, the overriding public issue in the next few decades. With famine in the drought-stricken regions south of the African Sahara and the increasing concern over adequate grain reserves in the United States for us, plus possible increased responsibility to help feed the rest of the world, the perilous dependence and susceptibility of crop production to farm technology, soils and climate becomes more and more critical.

Our present scientific expertise as a global nation has come a long way to where it is now getting a good handle on farm technology and soil management. But climate-control still remains a dream, and the world's food supply is now dangerously at the mercy of weather condi-

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tions and the seemingly unpredictable amalgam of weather fluctuations we call climate.

Climate is the sum-total of weather. The climate of an area, or of the globe, though already a summary of variations, is not a fixed entity with time. The repeated return of the great ice ages is perhaps the most striking evidence of climate changes in the past. But the ice ages were thousands of years apart. For practical agricultural implications, shorter-duration climate cycles must be significant within a decade or two. Written weather records and other evidences from tree-ring analyses, pollen remains, fluctuations of lake and ocean levels, and others are reliable indications of shorter period shifts in climate.

Climatologists point to evidence that, compared to the norm of either the historical or geological past, the earth's climate of the last 50 years has been unusually warm and benign. Some other evidence suggests that parts of Greenland were once green and fertile, and that England was once more favorably warm and sunny than in the last few decades. More recent evidence suggests that since 1945 the trend in the Northern Hemisphere seems to be toward cooler temperatures. Some climatologists, reasoning from the past to the future, have warned that a significant global shift in climate may be under way that could be the forerunner of a new ice age (5).

Although short-term climatic fluctuations are irregular with time, they are still amenable to statistical analyses; and, while weather itself wildly oscillates, statistical analyses show weather to possess a fair amount of stability. For example, long-time records show "very little" and "very slow" pendulation of the year-after-year values of annual temperatures and precipitation. But within the last two years, the public has been made aware of the results of several scientific studies of the available evidence or, at least, the significant possibility of probable major climatic shifts. One reports the observed cooling-off of the Northern Hemisphere (6). Another cites the apparent shift in monsoons — those major determinants of climate in most parts of Asia (1,5).

An interesting statement in a report dated December 14, 1973 to the Administrator of the National Oceanic and Atmospheric Administration (NOAA) relative to recent yields of corn, wheat and soybeans in the United States, says, "In recent years, there has been a remarkable run of near-normal weather—or even that relatively unusual weather that produces even higher yields. The reliability of the grain yields in recent years is due to an extra-ordinary sequence of favorable seasons. This cannot be expected to continue." Please note that the above statement was made and reported before the 1974 growing season. It is also within the last years that reports and statements on apparent 20 to 22-year drought cycles have again flourished (2,3,7,8). Interest in cyclic weather patterns tends to heighten and fade with about the same periodicity as major droughts. But even during the favorable growing season of 1973, concerned individuals were already talking "drought".

Sunspots and Climatic Cycles

There are several possible causes for long-term climatic changes: the earth's motions, lunar tides, planetary tidal effects, variations in solar energy and lately, man's inadvertent alteration of the atmosphere through air pollution. But among all these, the regularity of solar activity, called sunspots, has attracted more attention among investigators. Since the development of the telescope by Galileo in 1610, it has been continuously observed that these spots on the surface of the sun spectacularly increase about every nine to 13 years, or an average of 11 years. This "storminess" is seen from the earth as "spots" on the sun and invariably causes radio and TV reception breakdowns.

It is indeed very tempting to surmise that such variations in solar activity may be related to climatic cycles. This is especially so when one notes the occurrences of serious droughts in Kansas around 1854, 1874, 1894, 1913 and 1934, and the recorded drought peaks in St. Louis in 1838, 1845, 1854, 1872, 1895, 1914, 1931 and 1955. Superimposing the observed sunspot cycles in this chronology, one cannot help but be amazed by the correspondence of a double 10 to 11-year sunspot cycle with the observed climatic changes in the past.

The two 10 to 11-year sunspot cycles within a double cycle are different in terms of contrasting polarities of magnetic fields, and in their apparent influence on climatic change. The first 11-year cycle (minor) has a less pronounced effect than the second one (major) which seems to produce more extreme shifts in climate (3).

Looking back over the past 40 years of climatic records in the mid-latitudes, the exceptionally severe droughts of the 30's are associated with a minor sunspot cycle when sunspots were decreasing from 1932 to 1936, and a major cycle from 1937 through 1939 when solar activity was on the rise again. A similar pattern in solar storminess occurred from 1953 through 1959, which marked the end of the latest completed 22-year sunspot cycle. Indeed, we had prolonged although relatively mild dry spells (compared to that of the 30's) in the 50's.

Using the wealth of climatic records from se-

lected weather stations in North Dakota and applying a water balance model developed earlier in the Department of Soils through a support grant by the North Dakota Water Commission, the history of drought and wet spells has been described (4). The observed sunspot numbers in North America were superimposed on this history and are shown in Figure 1. Based on these background materials, I have stated what many other colleagues have expressed earlier: "If the cyclical patterns of sunspot numbers continue as they have in the past 250 years, and if the correspondence of drought severities to the past cycles of solar activity continues, and noting that the last minor cycle (first 11-year cycle of 22-year cycle) peaked in 1969, then we probably could expect a series of dry spells in the mid-seventies, probably around 1974 through 1977."

Climatologists readily admit their inability to offer any concrete scientific explanation for the dynamic relationships between the observed solar storminess and weather patterns. Nonetheless, many were willing to make the statement mainly because of the significance that it offers to the "price of bread". The droughts of the 30's came at a time when the U. S. had ample surpluses. Droughts of the '50's were less severe and grain carryover was sufficient to prevent any food crisis. But the U. S. is exporting more grain now than it ever did before.

Because of expressed export commitments and the increasing dependence of European countries and Japan on the surplus production of the U. S., Dr. Louis Thompson of Iowa State University (7) warned that a drought in this decade could be devastating. But if indeed the observed cooling of the Northern Hemisphere is an inherent part of cyclic weather, it must be recognized that small grain yields benefit from lower mean temperatures during latter growth stages. Thus, minor shortages in precipitation may possibly be compensated for by beneficial effects of lower mean temperatures.

One important point must be established. Grain reserve and export commitments are mostly based on the agricultural economists' projections of future production levels. The analyses made to derive these projections have continued to treat weather as a random variable. However, when the critical adequacy or inadequacy of grain reserves is at stake, the likelihood that weather patterns may be cyclical and not altogether random should be considered in making crop yield forecasts .

It does appear now that mere logic or visual correlation will not be the only bases for supporting the hypotheses of probable relationships between solar activity and meteorological phenomena. On November 7 and 8, 1973, 200 scientists gathered at the Goddard Space Flight Center (GSFC) in Maryland to discuss these relationships (2). The symposium was co-sponsored by the National Aeronautics and Space Administration (NASA), the University Corporation for Atmospheric Research (UCAR), which is an organization of Universities doing atmospheric science research, and the American Meteorological Society (AMS). It is most interesting to learn that the invited participants included meteorologists, aeronomers, solar-, plasma-, and astro-physicists. The participating scientists came from England, Australia, the Netherlands, Germany, the Soviet Union and the United States.

In this symposium and workshop, sunspot cycles were reported to be related to the lengths of growing season in England. A scientist from the Embassy of Australia correlated the cycles of solar activity across Australia. Dr. Walter Orr Roberts, past director of the National Center for Atmospheric Research, indicated that droughts appear to present some of the most convincing correlations with solar activity. Towards the end of his presentation, Dr. Roberts even suggested a possible mechanism by which the two phenomena may be physically related.

The 1974 Growing Season

The year 1974 was equally interesting and far more revealing. The unusally wet spring of the year in the midwest delayed seeding schedules; then the unusually dry summer caused damage to grain yields. To cap it all, general early frost wasted some of the crop as it was approaching maturation.

On August 12, 1974, the United States Department of Agriculture (USDA) reported a substantial reduction in the production of feed grains and oil seeds over earlier projects for 1974 . . . "as a result of drought conditions for 1974, the worst since the 1930's over much of the corn belt and the western range country." On October 4, 1974, the White House stopped the shipment of 3.2 million tons of corn and wheat to the Soviet Union. Three days later, October 7, 1974, President Ford ordered that any big export deals in the future should receive federal approval first. A few days later, the Soviet Union grain deal was reduced to 2.2 million tons until the 1975 harvest.

On November 1, 1974, an Associated Press release cited a USDA report indicating that the world wheat reserves will be down 48.8 million metric tons by the time that new crops are ready in 1975, the lowest stockpile since global record-keeping began 15 years ago. Moreover, the total

grain supplies will be down more sharply than the previous projection dated September 24. Interestingly enough, this is despite 1974 U S. yields setting all time records, according to the North Dakota Wheat Commission. The Commission cited, however, that the 1974 increase is not because of but despite troubled harvests due to weather. The record yields are attributed by the Commission to the freeing of all U. S. acres from controls and encouraging farmers to pull-out all production stops.

Drought in the 70's? That question may have already been answered in the minds of many midwest farmers. The rainfall patterns of 1974 have been spotty, mostly inadequate and/or untimely in the U. S. corn and wheat belts. Now the question becomes — how about next year, and the year after that?

It is admittedly most difficult to establish whether an initial climatic aberration, like 1974, represents the start of a trend or whether it is merely a minor random fluctuation inherent in weather. Physical models which may be designed to accomplish this task are critically dependent upon a variety of factors such as sunlight, clouds, wind, ocean temperatures, sea ice and snow cover — all of which are dependent upon each other. These climatic models, however, have received such an encouraging amount of attention recently that they now offer better insights into the mechanisms of climatic features such as the rainfall of the Indian monsoons and the lack of it in the sub-Saharan plains (5). With the new sense of urgency created by a world food crisis, these climatic models have at least given hope of limited climatic forecasts in the coming years. Right now, however, these models offer virtually no help in making decisions today that may determine not only the price of bread tomorrow, but more important, whether there will be enough for everyone.

Will there be drought next year? Past drought history seems to suggest that the answer "yes" is more probable than "no". But is either "yes or no" really the important thing? The apparent 20 to 22-year cyclicity of major droughts may not be a precise number that can be used for a reliable prediction of future droughts, but the lessons of the 30's, the 50's, and 1974 should at least serve a warning to expect such an event in 1975 and **be prepared** for it. **That** is really most important.

The National Weather Service (NWS) offers a checklist of what-to-do's in cases of flash floods, blizzards, tornadoes, lightning storms and hurricanes. Such lists of precautions have saved hundreds of lives from the wrath of these weather hazards. We are advised on procedures to protect ourselves in the event of an enemy nuclear attack; the probability of which is probably less than the chances of another severe drought. Suppose the enemy is the latter? Are we prepared as a nation to handle a drought of the extent and severity of 1934 or 1936? I do not believe that we are, because to be prepared, answers to a number of questions are yet to be found:

1. Suppose we can determine that there will be a drought next year or the year after that, do we know exactly how much reduction in crop yields that will mean? I don't believe so.

2. What should the individual farmer, and agribusiness as a whole do to at least minimize the impact of drought?

3. Just how well can our present farm technology, the most advanced in the world, respond to the problems associated with a major drought? Have we made an attempt to find out?

4. If the cooling of the Northern Hemisphere persists, can or should the corn belt effectively shift from corn, soybeans and sorghum to small grains and forages?

5. How dependable can deliberate weather modification be in helping to minimize the hazards of a major drought?

Drought during the rest of the 70's? Indeed, a good answer to this question is important . . But it cannot be more important than knowing exactly what to do in the case of drought even if 1975, 1976 and 1977 turn out to be favorable years for crop production.

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