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AgRISTARS

E81-10164

7. { EW-U1-04074 CR-160985
{ JSC-17130

APR 2 2 1981

A Joint Program for
Agriculture and
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Surveys Through
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6. March 1981

LARGE AREA APPLICATION OF A CORN HAZARD MODEL

NASA CR-160985

3. Pat Ashburn and T. W. Taylor
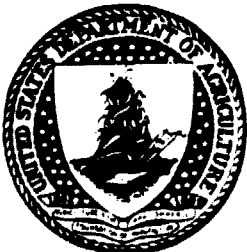U.S. Department of Agriculture
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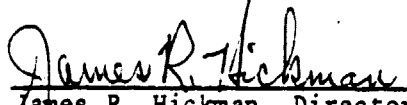
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LARGE AREA APPLICATION OF A CORN HAZARD MODEL

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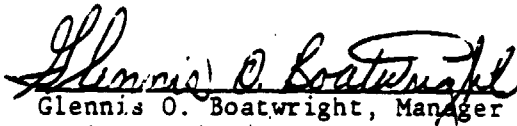NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

Houston, Texas
March 1981

A large area operational application of the Corn Hazard Model using
real time data and evaluation of results.

1. REASON FOR ISSUANCE

    Documents the first large area application of a Corn Hazard Model
    developed by T. W. Taylor and Francis W. Ravet, Early Warning and
    Crop Condition Assessment component of AgRISTARS. Large area
    application was conducted by CCAD with the support of EW/CCA
    AgRISTARS.

2. COVERAGE

    This Technical Memorandum evaluates the operational application of
    the Corn Hazard Model, by CCAD, over the major corn for grain
    producing regions of the USSR during the 1980 growing season.

3. ACKNOWLEDGMENTS

    Dr. T. W. Taylor and Francis W. Ravet, EW/CCA AgRISTARS for
    developing and documenting the model.

4. PREPARED BY·

    _____   March 1981
         Pat Ashburn, FAS, CP, CCAD   Date

    _____   March 1981
    Dr. T. W. Taylor, SEA EW/CCA AgRISTARS   Date

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PART 1.0
INTRODUCTION

1.1   SUMMARY AND CONCLUSIONS

In an effort to improve crop condition analysis capabilities used by the
Crop Condition Assessment Division (CCAD) of the Foreign Agricultural
Service (FAS), new and/or improved agricultural models are continuously
assessed and tested over large operational areas for possible future
integration into the operational system of CCAD. The Corn Hazard Model
(CHM) developed and tested by the Early Warning/Crop Condition
Assessment (EW/CCA) component of AgRISTARS is such a model. This hazard
model which also estimates a corr crop calendar was run using opera-
tional data over the corn-for-grain producing regions of the Soviet
Union. The model uses primary World Meteorological Organization (WMO)
meteorological data elements, such as temperature and precipitation.
Soils data interacts with the model through the use of soil moisture
calculations. The model provides reports on geographic areas that are
analyzed by the country analyst; thereby reducing the comprehensive
analysis of many primary data elements.

An application test of the crop calendar portion of this hazard model
was performed over the corn-for-grain producing regions of the Soviet
Union during the 1980 crop year using real data. Success of the model
was measured in terms of efficiency, accuracy, objectivity, repeatabil-
ity, and continuity, with efficiency and accuracy receiving the highest
considerations. Only the crop calendar portion was evaluated. Add-
itional analysis of the hazard indicators will follow as time permits.

The general performance of the model as operated over the test area was
very favorable. Efficiency gains in meteorological data analysis time
were 85 t, 90 percent.

Model results combined with Landsat data analysis were used to estimate
the area and condition of the corn-for-grain in the Soviet Union for
1980. The results were in line with the recent area estimates and
conditions provided by the U.S. Agricultural Counselor in the Soviet
Union and with Soviet newspaper and radio accounts.

The Crop Condition Assessment Division (CCAD) will continue to use the
Corn Hazard Model in the USSR and further evaluate its performance. We
will also provide feedback to the Early Warning component of AgRISTARS
on the results of our use of the model.

1.2   BACKGROUND

The Crop Condition Assessment Division (CCAD) of the Foreign
Agricultural Service (FAS) is responsible for verifying and assessing

1.4'   DATA SET

The primary corn-for-grain producing area of the USSR was selected as
the test area for evaluation of the CHM. Temperature and precipitation
data were extracted from World Meteorolgogical Organization (WMO)
station data. Planting dates were extracted from radio and newspaper
reports from the USSR. Soil moisture was derived from a soil moisture
model that was run using WMO data and soil type for each WMO station for
each day of data. In total 15 stations were used to evaluate the model.

Verification data were limited to FAS Agricultural Attache reports,
official USSR reports, Soviet radio and newspaper accounts, and Landsat
data.

PART 2.0
PERFORMANCE EVALUATION

2.1 EFFICIENCY

The general performance of the CHM operated over the USSR during 1980
was favorable. Efficiency gains in meteorological data analysis time
were significant. Estimates of savings in time were on a magnitude of
85 to 90 percent.

The model evaluated a larger number of stations; thus, it significantly
improved the analysis of the corn condition.

2.2 ACCURACY

Evaluating the accuracy of the CHM results were difficult due to a lack
of confirmed ground observations. Accuracy evaluation was assessed
using U.S. Agricultural Attache reports sent from the Soviet Union,
Soviet newspaper and radio reports, and analysis of Landsat data.

Nine separate WMO stations (Figure 1) were selected across the grain
producing areas. These stations are located to provide a full range of
weather conditions experienced during 1980. They are also located to
provide the full range of geographic conditions experienced in the major
grain producing regions in the USSR. The CHM was given planting dates
provided by CCAD analyst. These dates were provided by reports from the
USSR. Where no planting dates were available, they were spread from
other reporting stations.

A significant number of stations reported growth stages in a 10 day
range. This is due to the type of reports from which the information
was taken. These are decade reports published for each 10 day period.
The CHM was considered successful when the growth stage was no more than
3 days outside of this range.

Grain is harvested in the USSR sometime after the beginning of the dent
stage. The harvest is related more to weather conditions, lateness of
the season, or a need to clear the field. Consequently, accurate growth
stage reporting is clouded during the end of the year.

The hazard output of the CHM is difficult to evaluate due to a lack of
good ground truth data. Without this, the results must be checked over
a long period of time - probably more than one year. The hazard portion
of the model is presently considered successful if it alarms an area
when other information sources are indicating an alarm should be
announced. For the 1980 data, the model seems to be setting flags where
they should be set. However, additional information and time are
required to adequately evaluate the hazard portion of the model.

The crop calendar portion of the CHM was highly successful in the USSR for 1980. The results shown in Table 1 were very encouraging. These indicated the model accurately operated over a very wide geographic area and over a wide range of very different weather conditions.

2.3   SUMMARY

The crop calendar component of a corn stress indicator model was evaluated using 1980 real time data for the corn-for-grain producing regions of the Soviet Union. Model success was measured in terms of efficiency, accuracy, repeatability and continuity. Verification data were FAS Agricultural Attache reports, official USSR reports, Soviet radio and newspaper accounts, and Landsat imagery. Use of the model resulted in a time saving for meteorological data analysis of 85 to 90 percent. A description of the model logic and components is included.

TABLE 1. ESTIMATED AND REPORTED CORN GROWTH STAGE IN THE USSR, 1980

WORLD METEOROLOGICAL ORGANIZATION STATION NUMBER

STAGE GROWTH	34300 E	34300 R	33345 E	33345 R	33711 E	33711 R	33815 E	33815 R	34929 E	34929 R	33837 E	33837 R	34731 E	34731 R	33429 E	33429 R	34401 E	34401 R
Planted	6/5	4/15		4/10	6/1	4/10		4/10		4/10		4/10		4/10				4/10
2 Leaves		6/10				6/10	5/28	5/20-31	5/21	5/20-30	5/28	5/20-30	5/24	5/20-31			5/28	5/20-31
6 Leaves							6/11	6/1-10	6/4	6/10	6/11	6/10	6/7	6/10			6/11	6/1-10
8 Leaves									6/11	6/15			6/14	6/14				
10 Leaves	7/14	7/1-10			7/9	7/1-10												
12 Leaves																		
16 Leaves																		
Silk-Tassel	7/27	8/1-10	8/5	8/1-10			7/13	7/1-10	7/4	7/5	7/10	7/1-10	7/6	7/5	7/25	8/1-10	7/11	7/1-10
Blister Kernel					8/11	8/1-10	7/22	7/11-20	7/13	7/11-20	7/23	7/11-20	7/16	7/11-20	8/22	8/20-30	7/21	7/11-20
Dough Stage	8/24	8/20-30	8/20-30	8/20-30	9/23	8/20-30	8/12	8/1-10	7/31	8/1-10	8/13	8/1-10	9/3	8/1-10			8/9	8/1-10
Begin Dent	9/8	9/1-10	9/16	9/16	9/22	8/20-30	8/26	8/20-31		8/20-30	8/24	8/20-31					8/23	8/20-31
Full Dent	9/27		9/14	9/14	9/22	9/1-10	9/7	9/16	8/21	8/20-30	9/6	9/14	8/24	8/20-30	10/11	10/10	9/6	9/6
Physio Mature		10/10	10/4	10/4	10/29	10/10	9/20	10/2	9/1	8/30	9/18	10/2	9/5	8/31			9/19	10/6

E = Estimated by Model
R = Reported

FIGURE 1

USSR CORN FOR GRAIN AREA
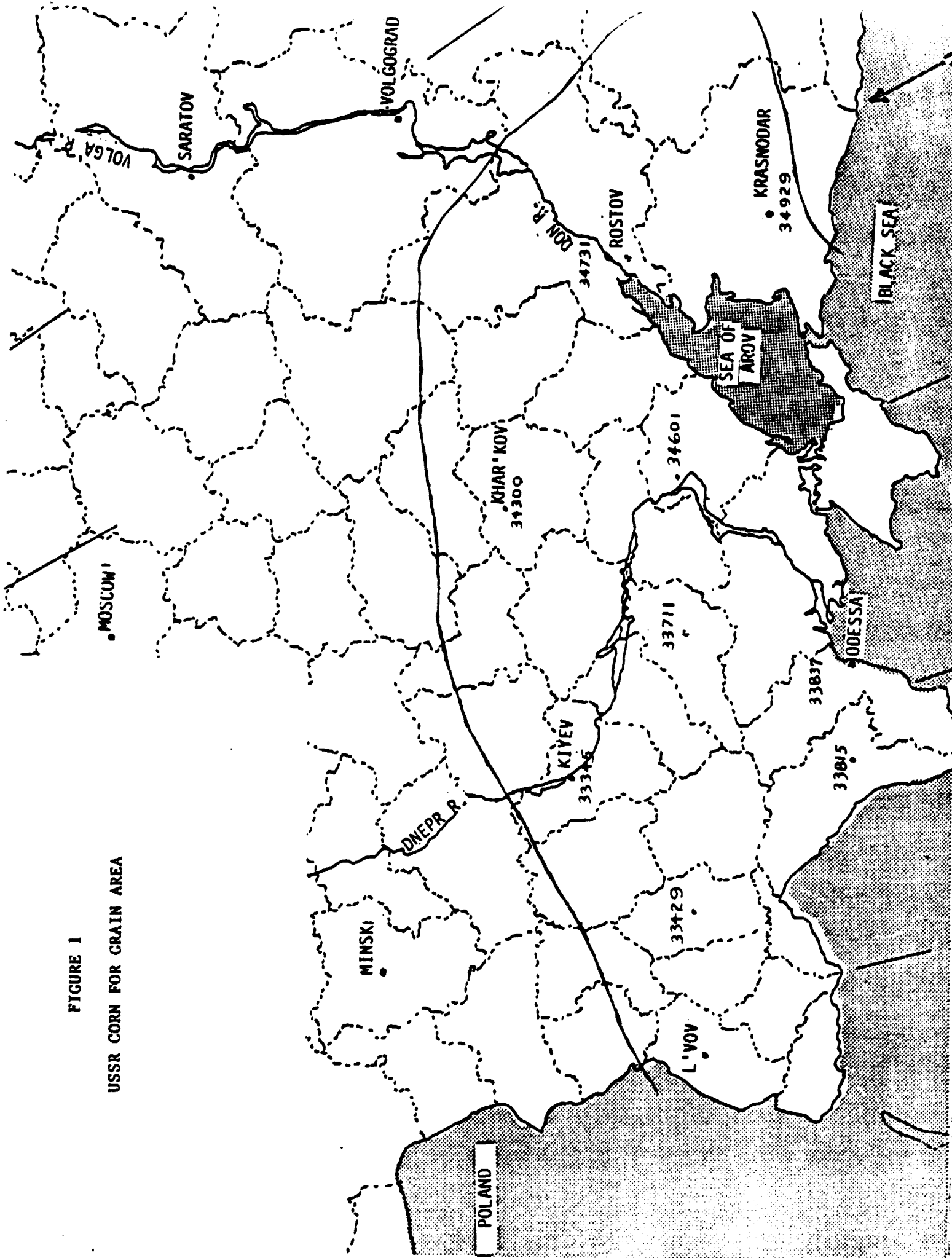
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APPENDIX A

DESCRIPTION OF CORN STRESS INDICATOR MODEL

PURPOSE

The purpose of this section is to document a corn hazard model that detects plant stress due to moisture deficiency and adverse temperatures. A brief synopsis of the climatic stress thresholds for corn (maize) at different growth stages is also given.

MAJOR VARIABLES

The degree of stress is dependent on three variables - phenological growth stage, available soil moisture and temperature.

PHENOLOGICAL GROWTH STAGE

The Hanway Growth Stage (HGS) system (Hanway, 1963) was used in the model as defined below:

HGS	PHENOLOGICAL STAGE
0.0	Emergence
1.0	4 Leaves
2.0	8 Leaves
3.0	12 Leaves
4.0	16 Leaves
5.0	Silk-tassel
6.0	Blister Kernel
7.0	Dough
8.0	Begin Dent
9.0	Full Dent
10.0	Physiological Maturity

During each stage optimum and stress conditions exist. Most of these conditions are directly related to meteorological factors. Stress was defined in this model version as those factors considered to most affect the maize growth cycle and for which input data are presently available to CCAD. Problem and optimal conditions that form the model logic are presented by growth stage in Table 1.

STRESS MODEL COMPONENTS

The stress model has 3 central components - a hazard model, a crop calendar model and a soil water budget model. These latter 2 models collectively require daily meteorological data - maximum and minimum temperature and precipitation. The phenology-based hazard routine contains the stress definitions and thresholds. The crop calendar is a fixed-increment degree-day model developed by EW/CCAD that requires an actual or estimated planting date. Degree-day summations are variety specific. A two-layer soil moisture model as modified by Ravet and Hickman (1979) is employed to track the amount of plant-available soil water.

DEGREE-DAY CALCULATION

Temperature is a regulator of maize growth and development. Most efforts to predict the timetable of maize development have used a heat-unit approach; the most common is the degree-day. The Brown method (1975) of determining degree days is based on the physiological response of plants to temperature and is determined as follows:

$$DD = (Ymax + Ymin) / 2$$

where $Ymax = (Tmax - 10^{\circ}C)*[3.33-0.084*(Tmax - 10^{\circ}C)]$ and $Ymin = 1.8 *(Tmin - 4.44^{\circ}C)$. When Tmax is less than or equal to $10^{\circ}C$ the value of Ymax is zero and when Tmin is less than or equal to $4.44^{\circ}C$ the value of Ymin is zero. When Tmax is greater than $32^{\circ}C$ the value of Tmax is $32^{\circ}C$.

The values of the accumulated degree-days for the most common Soviet Union variety are: 110 to emergence, 420 to HGS 1.0, 775 to 2.5, 1520 to 4.75, 1730 to 6.5, 2080 to 8.0 and 2565 to 10.0.

MODEL PARAMETERS AND OUTPUTS

The model identifies three environmental conditions - optimum, adequate and hazardous. Hazardous conditions include:

(a) Insufficient pre-season stored soil moisture
(b) Planting/harvest delay (tractability problems)
(c) Poor germination
(d) Poor emergence
(e) Adverse growing season soil moisture and temperature (excessive/deficient, phenology-based)

The stress indicator model determines the possibility of maize stress based on temperature and moisture conditions (see Table 1). The stress and optimal growth conditions are recorded for each growth stage as well as the time the plant remained in these stages. From this information the analyst can judge the degree of damage or stress occurring at a growth stage and then determine the overall effect on crop development. The model does not predict events nor does it attempt to assess the impact of stress; it provides information that indicates conditions occurring within a predescribed geographic area. The output from the model is a record of each day that a stress condition has occurred, the reason for the stress and the crop growth stage. At the completion of processing data for a given meteorological station, the data are summarized giving the total days for development, and the number of optimum and hazardous growth days.

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