USING SAS/GRAPH® MAPPING FEATURES TO DISPLAY METEOROLOGICAL DATA FOR GEOGRAPHIC INTERPRETATION AND ANALYSIS

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INTRODUCTION

The Joint Agricultural Weather Facility (JAWF) is a cooperative effort between the National Weather Service’s Climate Analysis Center (NWS/CAC) and the Department of Agriculture’s World Agricultural Outlook Board (USDNWAOB). One of the JAWF’s main objectives is to identify anomalous weather and determine its impact on crop growth and development in domestic and foreign areas. Meteorological surface data (over 6000 reporting stations), as provided through the World Meteorological Organization (WMO) global synoptic surface network, serve as the backbone for the continuous monitoring of global weather conditions. Storing and processing these data to tailor them for geographic areas of interest is an ongoing endeavor, requiring the use of mainframe computers, personal computers (PC’s), as well as various types of software.

The Federal Crop Insurance Corporation (FCIC) of USDA provides insurance to U.S. farmers for a variety of crops. Producers can insure against the risk of crop losses. If the farmer produces less than his guaranteed production, he receives an indemnity payment. Since anomalous weather (drought, excess moisture, frost, etc.) accounts for a majority of crop losses, it is an important factor in determining the insurance rates and monitoring expected losses. Weather data, provided by the NWS/CAC and the JAWF, is used to review certain cases involving fraudulent or an excessive number of claims turned in by farmers.

This paper illustrates some SAS/GRAPH mapping features, focusing on their use at the JAWF as well as the FCIC. Examples of all types of maps (choropleth, surface, block, and prism) are shown. The ability of SAS/GRAPH mapping features to summarize and convey large amounts of information on regional differences, extremes, and trends of data makes it a potentially powerful tool in meteorological applications. The uniqueness of SAS/GRAPH to produce 3 dimensional (3d) graphics provides an attractive visual display.

MAP DATA SETS

United States

Map data sets contain points that are used to draw the maps. A map data set for climate divisions in the United States was needed to display meteorological data on a division level. Since climate divisions in most states in the central U.S. follow county boundaries, a customized map data set was created. The states which comprise this customized data set are highlighted in Figure 1 (Prism map), with the use of the PRISM statement. To create the state climate divisions, the COUNTIES map data set, as supplied with SAS/GRAPH software, was used. First, counties were assigned into their corresponding climate divisions with an IF-THEN statement. Then, PROC GREMOVE (SAS Institute, 1988) was used to remove the internal county borders, combining them into larger unit areas, containing the borders for the state climate divisions. In Figure 2, the locations of the state climate divisions are shown (unshaded area) for the central U.S. on a choropleth map. The remaining boundaries for the continental U.S. (shaded areas) are provided in this example as a point of reference and will not appear in future map examples. The second map data set (US data set), was chosen from the SAS/GRAPH software.

Figure 1

Figure 2

Soviet Union

A customized map data set was created for internal political boundaries within the western portion of the Soviet Union. The data set was created by digitizing a prior base map on a Hewlett-
Packard 7475A pen plotter. The digitized values from the base map were converted into coordinates of latitude and longitude, and then converted into radians (Slaughter, 1990). As a result, a map data set containing a COUNTRY CODE, ID, SEGMENT, and X and Y coordinates was created. The final map is shown in Figure 3 (choropleth map). The ANNOTATE facility was used to place the region names on the map.

WESTERN USSR

Figure 3

RESPONSE DATA SETS

Response data sets contain the meteorological data to be displayed on the maps. A total of 6 response data sets were created for the United States. The first four data sets contained meteorological information for each of the 200 climate divisions in the central U.S. Monthly precipitation and temperature data were combined into seasons and then ranked over the time period 1931-1990, using PROC RANK (SAS Institute, 1985). The PERCENT option was used to obtain percentile rankings of precipitation and temperature for each season. Since the summer season determines the main growing period for crops in the northern hemisphere, summer (June-August) precipitation and temperature rankings for the years 1988 and 1990 were selected for the first four response data sets. The precipitation rankings were used to display the moisture status of each climate division based on historical comparisons. The moisture status was determined by categorizing the rankings into the percentiles of extremely dry (0-10), dry (10.1-30) near normal (30.1-69.9), wet (70.0-89.9), and extremely wet (90-100). A program example for displaying the 1990 precipitation ranking categories on a choropleth map of the central U.S. is shown below.

```
data one;
  infile ranks;
  input state division $4. year summerpk summertk;
  label summerpk = 'MOISTURE STATUS';
  run;
proc sort;
  by state division;
  run;
data category(drop:::summertk);
  set one;
  if year=1990;
  proc format;
    value status
      1188 0-10.0 = 'EXTREMELY DRY'
      10.1-30.0 = 'DRY'
      30.1-69.9 = 'NEAR NORMAL'
      70.0-89.9 = 'WET'
      90.0-100.0 = 'EXTREMELY WET';
  proc gmap data=category
    map=maps.centrus all;
    id state division;
    choro summerpk / empty=black outline=black discrete;
    format summerpk status.
    pattern1 c=black v=me;
    pattern2 c=black v=m6560;
    pattern3 c=black v=5x45;
    pattern5 c=black v=s;
    title 'CENTRAL UNITED STATES';
    title2 'MOISTURE STATUS BY CLIMATE DIVISION ';
    title3 'SUMMER 1990 (JUNE-AUGUST)
    footnote1 f.simplex ,. BASED ON PRECIPITATION RANKINGS
1931-1990';
  run;
```

Similarly, the temperature status was determined by categorizing the temperature rankings into percentiles of cold (0-30), near normal (30.1-69.9), and hot (70-100). The 5th response data set contained weekly total precipitation data for selected stations throughout the continental U.S. for the period July 15-21, 1990. The 6th data set contained snowfall extremes for each state during the first snowstorm of the 1991 winter season (December 4-5, 1990).

For the Western USSR, two response data sets were created. The first data set contained total monthly precipitation data for September 1990 for each region. Regional precipitation amounts were categorized into light (0-25mm), moderate (26-75mm), and wet (more than 75mm). The second data set contained the total number of days in September with reported precipitation for each region. These were placed into 3 categories (less than 10, 10-19 days, and 20 or more).

MAPS

Choropleth

The large number of divisions in the central U.S. map data set (200 climate divisions), made the data as represented by 3d graphics difficult to interpret. As a result, a two dimensional choropleth map was chosen to display the precipitation and temperature rankings for the central U.S. For the summer of 1988, most climate divisions received precipitation which was ranked in the dry to extremely dry category. Driest areas include divisions in Montana, Wyoming, North Dakota, South Dakota, Iowa, southern Minnesota, Wisconsin, western Michigan, Illinois, Indiana, Kansas, northern Missouri, Tennessee, Alabama, and Georgia (Figure 4). The geographical extent and severity of the dry conditions in these areas created highly unfavorable growing conditions for crops (USDA-NASS, 1988), and an unusually high number of insurance claims from crop losses due to drought. In addition, climate divisions over the northern portion of the region were ranked in the hot category (Figure 5), exacerbating the dry conditions.

Distinct regional differences in both the moisture and temperature status can be seen from the maps in figures 6 and 7. Most climate divisions in the Corn Belt states of Nebraska, Minnesota, Iowa, Wisconsin, Missouri, Illinois, Indiana, Michigan, and Ohio, experienced near normal to extremely wet and cold conditions.
The cool weather and abundant moisture conditions provided overall favorable growing conditions for corn. However, wet weather in some divisions did contribute to fertilizer leaching and insect problems, while the cool weather slowed crop development (WWCB, 1990). In contrast, dry to extremely dry conditions in the southeast states of Arkansas, Louisiana, Tennessee, Mississippi, Alabama, and Georgia, were accompanied by widespread hot weather, creating unfavorable conditions for crops. The potential for insurance claims from flood or insect damage exists for locations in the Corn Belt States, while the potential for drought claims exists in the southeast.

Choropleth Map with the Annotate Facility

In Figure 8, precipitation totals for selected locations for the week ending July 21, 1990 are placed in an ANNOTATE= data set and plotted on a U.S. map. The following example creates the map in Figure 8.
data precip;
infile 'a:pcp.prn';
input sta y x pcp $;
proc gproject data=precip out=proj degree east;
id sta;
data project;
set proj;
if pcp='999' then pcp='.';
if sta ne '.' then do;
xsys='2';
ysys='2';
text=pcp;
function='label';
size=.5;
position='S';
when='a';
coIor='black.';
sty~='simplex';
output
end;
else delete;
data us;
set map.us;
if state^=stfips('ak') and state^=stfips('hi');
proc gmap data=us
  map=us all;
id state;
  choro state / nolegend levels=1 annotate=proj;
  pattern c=black v=empty;
title1 'WEEKLY PRECIPITATION';
title2 'FOR THE WEEK ENDING JULY 21, 1990';
footnote1 'PRECIPITATION (1/100 in)';
run;

With this type of map, differences in precipitation amounts for locations within each state as well as regional differences in precipitation can be shown.

WEEKLY PRECIPITATION
FOR THE WEEK ENDING JULY 21, 1990

PRECIPITATION (1/100 in)

Figure 8
Surface
To visually display extremes in snowfall, a three dimensional surface map was chosen to represent the data (Figure 9). From the map, levels of magnitude of snowfall are depicted with three dimensional spikes of varying heights. The locations which received the greatest amounts of snowfall during the December 4-5 winter storm have the highest spikes, and are located in the Midwest and parts of the Northeast.

Block
A block map was chosen to represent the response variables for Western USSR because the small number of regions (12 regions) allowed for a more discernable 3 dimensional display. September 1990 rainfall for regions in Western USSR are shown with a block at the approximate center of it’s corresponding region (Figure 10). The heights of the blocks represent the ordinal scale, while the shading represents the rainfall categories (light, moderate, and wet). From the map, wettest regions include the Baltic States, Belorussia, the Central Region, and the Black Soils Region (see Figure 3 for region names). Regions with light precipitation include Moldavia (recently renamed Moldova), and Kazakhstan. The total number of days in September for which precipitation occurred are shown for each region in Figure 11. Not only did the Baltic States, Belorussia, the Northwest Region, and the Central Region receive the highest amounts of precipitation (Figure 10), but these regions experienced 20 days or more the rain. The persistence of the rain in these areas during the month along with the extremes in rainfall caused significant delays in winter grain planting and potato harvesting (SELSKAYA ZHIZN, 30 Sept 1990).

![Extreme Snowfall December 4-5, 1990](image1)

![Western USSR Precipitation by Region September 1990](image2)
CONCLUSION

SAS/GRAPH mapping procedures were found to be a powerful tool in displaying meteorological data for geographic interpretation and analyses. The geographic display features allow for rapid visual detection of areas experiencing anomalous weather such as drought, floods, or extremes in temperature. Also, regional differences in weather can be visually summarized. The type of information as well as the number of regions in a map will determine whether two dimensional or 3D graphics should be used. Although the ability to annotate information on the maps is available with the SAS/GRAPH Annotate facility, in some cases, it may be a difficult task for the novice programmer. The author's suggest that one takes advantage of the Computer Graphic Metafile (CGM) drivers available with the 6.03 release of SAS/GRAPH software to transfer graphics output to other PC software such as Lotus Freelance Plus®, Release 3.0 (CGMFL device driver), or Harvard Graphics® (CGMHG device driver) for annotation.

Future applications of SAS/GRAPH mapping procedures for agricultural applications are straightforward. The various types of maps used above could be used to map crop condition, levels of agricultural production for individual crops, or areas of insurance coverage or claims.

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REFERENCES


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