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The World is Not Enough: Base SAS® Visualizations and Geolocations

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ABSTRACT

Geographic processing in SAS® has recently undergone some major changes: as of Version 9.4 Maintenance Release M5 many procedures formerly a part of SAS/Graph are now available in BASE SAS. At the same time, SAS Graphics have added some new procedures such as PROC SGMAP that build on the functionality of SAS/GRAPH's PROC GMAP and incorporate ODS graphics techniques including attribute maps and image annotation. This paper and poster will replicate a map of the world created by the author with SAS/GRAPH and PROC GMAP with the annotate facility using PROC SGMAP to map three different metrics on a map of the world. New SAS mapping and SG procedure techniques will be demonstrated, following Agent 007's adventures across the globe.

INTRODUCTION

The focus of this paper is procedures, tools and techniques that create geographic visualizations in SAS, emphasizing opportunities for customization. Mapping in SAS was once accomplished with SAS/Graph (and prior to that, SAS/GIS); more recently, ODS graphics, in particular the SGPLOT and SGMAP procedures and templates available in BASE SAS are being utilized. Enhancing output from SAS/GRAPH has been the subject of many SAS papers over the years, including my own, and many excellent techniques have been explored and developed, and will continue to be. Maps created from ODS graphics are often "camera-ready" without any user intervention, but on occasion there is a need for additional customization, and ODS graphics has many tools available for just that purpose. This paper and e-poster undertakes to demonstrate the similarities and differences by demonstrating the recreation of a world map portraying population density that was pioneered decades ago with the newer ODS Graphics techniques, and then retools the code to follow 007's exploits across the globe. The original image created was called "World at Night", modified from a sample provided by Robert Allison. (Hadden, 2018). Techniques for enhancing visualizations such as ATTR (attribute) assignments including ATTRMAPS and annotation will be demonstrated in the process. This paper and e-poster are suitable for all levels of expertise.

BASIC REQUIREMENTS FOR MAPPING

The essential ingredients for a SAS-produced map include a map data set with geographic IDs, latitude, and longitude; and a response data set which includes geographic IDs and the information to be portrayed on a map. Annotation data sets, attribute settings, and graphic option sets can enhance maps created with SAS in both SAS/GRAPH and ODS GRAPHICS.

MAP DATA SET

SAS/Graph currently provides access to GFK marketing maps as part of the SAS/Graph license. These maps are high-quality, commercially licensed geographic boundary maps which are significantly more detailed and current than the free, sometimes user-produced, data sets that came with older SAS releases. (Hadden, 2017). GFK maps are digital boundary files that represent administrative, postal, and statistical regions across the world. They have more up-to-date boundaries and cover more countries than the original. Moreover, they have a consistent coding convention, and each boundary file comes with a matching attribute file containing shape names, etc. ODS Graphics users may or may not have a SAS/Graph license; there are many "free" shape files of different geopolitical areas available on the internet, and a BASE SAS procedure to import ESRI shape files, PROC MAPIMPORT. (Hadden, 2016.) GFK map files are also typically "pre-projected" with latitude and longitude. ODS Graphics users without access to GFK map files may need to project their map data sets, and those who are using annotate data bases will need to project their map data sets along with their response data to ensure a match. This can be done using the BASE SAS procedure PROC GPROJECT.

RESPONSE DATA SET

A response data set is a SAS data set with geographic IDs that match the map file, with information to be visualized on the map. This data set can be completely external, or, in the case of GFK maps, can be the ATTR map, or, in the case of maps created by using PROC MAPIMPORT (ESRI SHP files), in the accompanying DBF. Files should have x and y coordinates, and/or latitude and longitude; or should match via the geographic ID (for example, a state code for a statistic collected at the state level.)

ANNOTATE DATA SETS

An annotate data set contains instructions to add custom graphics elements, such as text labels, shapes, lines, or symbols, to maps or plots, allowing for detailed, user-defined annotations. An annotate data set is linked to graphical output via ANNOTATE= in SAS/GRAPH, and via SGANNOTATE= in ODS Graphics.

A typical SAS/Graph annotate data set comprises a list of drawing commands, with each row specifying what to draw, where, and how. Core variables are function (e.g., label, move, draw, etc.), X & Y coordinates, text, color, size, style, position, and HSYS, XSYS, and YSYS. You can add labels, draw custom lines or arrows, highlight circles or shapes, add legends or callouts, and overlay symbols or logos. Annotate data sets require precise control over coordinates and drawing order and only work with SAS/GRAPH procedures.

SGAnnotate uses a data driven approach to add graphical elements directly to SG procedure output. Like SAS/Graph annotate, you create a SAS data set with annotation instructions. It works with SG procedures including SGMAP. Annotations alight with plot axes unless using wall-percentage coordinates. Like SAS/GRAPH annotate, it supports layering. It uses ODS styles. The basis structure of an SGAnnotate data set includes an ID, DATATRANSPARENCY, coordinates for lines and/or text, coordinate system (DATAVALUE, etc.), text, width, height, colors, line attributes, and text font and styling. Some benefits of SGAnnotate is that it is style-based and aligns with ODS, and allows a rich variety of style control including transparency, fonts, etc.

GRAPHIC OPTIONS AND ATTRIBUTE SETTINGS

As with annotate data sets, both SAS/GRAPH and ODS Graphics use graphic options and attributes. SAS/GRAPH uses GOPTIONS, and in the context of maps, you can use pattern assignments to specify fill color, and other in line options to assign line width and color, etc. ODS Graphics uses an ODS graphics statement, in which you can set global graph size and appearance, set a graph style, and work with templates. Within the SG procedure, one can control the control line, marker, and fill attributes (via STYLEATTRS) and set axis or title font sizes and styles (LABELATTRS, VALUEATTRS, TEXTATTRS). Conveniently, the ATTRS statements are consistent within the ODS graphics system.

MAPPING THE WORLD WITH SAS/GRAPH PROC GMAP

Below follows code snippets for creating the SAS/GRAPH version of a stylized World Population map. This map relies on an annotate data set with points for each city. This creates an effect resembling an aerial view of the world at night.

```
/* Create the annotate data base */
/* Obtain latitude and longitude from the MAPSGFK.WORLD_CITIES data set */
/* creates the dot_anno data set, which provides a dot for the centroid of each city */
/* dither the dots for some areas of Asia to make less dense */

data dot_anno;
      set mapsgfk.world_cities;
      anno_flag=1;

      if idname='China' then
            do;
                  foo=ranuni(123);

                  if foo>.95 then
                        output;
            end;
```

```
      else if idname='Taiwan, Province of China' then
            do;
                  foo=ranuni(123);

                  if foo>.99 then
                        output;
            end;
      else if idname='South Korea' then
            do;
                  foo=ranuni(123);

                  if foo>.97 then
                        output;
            end;
      else if idname='Philippines' then
            do;
                  foo=ranuni(123);

                  if foo>.97 then
                        output;
            end;
      else
            do;
                  output;
            end;
run;

/* Get the world map dataset mymap, and remove Antartica from the display */
      set mapsgfk.world (where=((density<=1) and (idname^='Antarctica'))
      drop = resolution);
run;

/* PROJECT THE MAP AND ANNOTATE DATA BASES TOGETHER */

/* project the map and the dots */
data combined;
      set mymap dot_anno;
run;

proc gproject data=combined out=combined latlong eastlong degrees dupok project=robinson;
      id id;
run;

/* SPLIT OUT THE TWO DATA BASES AFTER PROJECTION */

data mymap dot_anno;
      set combined;

      if anno_flag=1 then
            output dot_anno;
      else output mymap;
run;

/* Add additional details to the projected annotate data base */
/* Do this after the gproject, or the character variables will slow down gproject */

data dot_anno;
      set dot_anno;
      xsys='2';
      ysys='2';
      hsys='3';
      when='a';
      function='point';
      color='cornsilk';
      position='5';
run;
```

```
/* Set GOPTIONS */

goptions device=png;
goptions xpixels=1700 ypixels=800;
goptions cback=darkblue;

/* Open HTML file */

ODS LISTING CLOSE;
ODS HTML path=odsout body="&name..html"
      (title="SAS/Graph night sky simulation")
      nogtitle style=minimal;
title1 f="albany amt/bold" h=14pt "2024 World Population Density";
title2 f="albany amt" h=12pt "Using SAS' GFK maps and world cities data";

/* Set fill pattern and color */
pattern1 v=msolid c=black;

/* add labels for hmtl hover */

data mymap_data;
      set mapsgfk.world_attr;
      length my_html $300;
      my_html='title='||quote(trim(left(idname)));
      colorvar=1;
run;

/* create map */

proc gmap map=mymap data=mymap_data anno=dot_anno;
      id id;
      choro colorvar / levels=1 nolegend
             coutline=gray
             html=my_html
             des='' name="&name";
run;

quit;

ODS HTML CLOSE;
ODS LISTING;
```

Program 1. PROC GMAP version of World Population Map

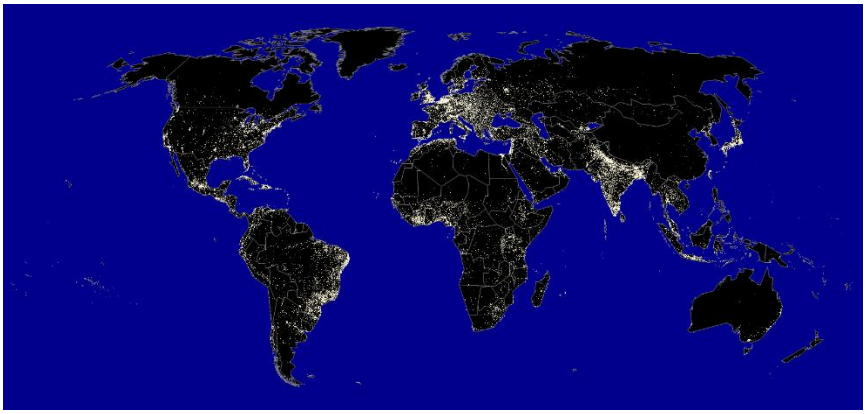


Figure 1. World Population via PROC GMAP

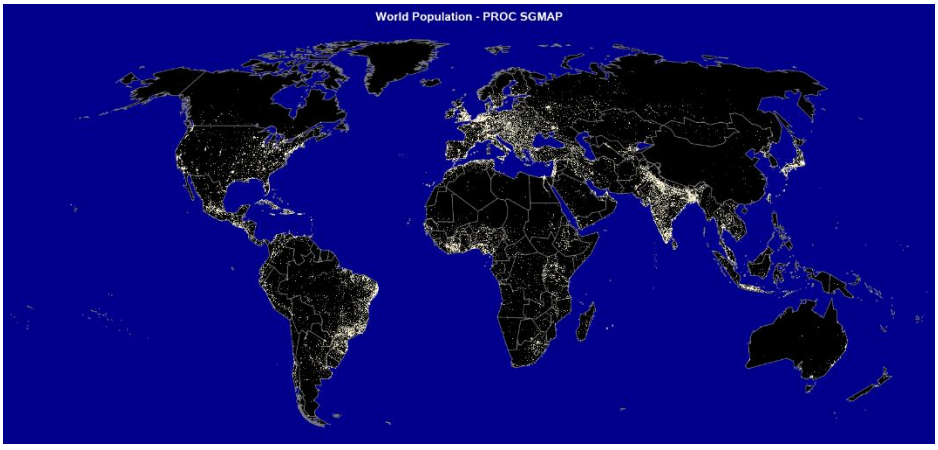
MAPPING THE WORLD WITH BASE SAS PROC SGMAP

The PROC SGMAP version of the program creates a remarkably similar map, but with quite different syntax. The code needs to be run with BASE SAS 9.4 M7 or higher.

```
/* Get the world map */

data my_map;
      set mapsgfk.world
            (where=((density<=1) and (idname^='Antarctica')) drop = resolution);
run;

/* project the map */
proc gproject data=my_map out=my_map latlong eastlong degrees dupok project=robinson
      parmout=projparm;
      id id;
run;

/* drop the unprojected lat/long, so PROC SGMAP will not use them by default */
data my_map;
      set my_map (drop=lat long);
run;

/* Create the sgannotate data base */
/* Obtain latitude and longitude from the MAPSGFK.WORLD_CITIES data set */
/* creates the dot_anno data set, which provides a dot for the centroid of each city */
/* dither the dots for some areas of Asia to make less dense */

data white_dots;
      set mapsgfk.world_cities;

      if idname='China' then
            do;
                  foo=ranuni(123);

                  if foo>.95 then
                        output;
            end;
      else if idname='Taiwan, Province of China' then
            do;
                  foo=ranuni(123);

                  if foo>.99 then
                        output;
            end;
      else if idname='South Korea' then
            do;
                  foo=ranuni(123);

                  if foo>.97 then
                        output;
            end;
      else if idname='Philippines' then
            do;
                  foo=ranuni(123);

                  if foo>.97 then
                        output;
            end;
      else
            do;
                  output;
            end;
run;
```

```
/* project the sgannotate */
proc gproject data=white_dots out=white_dots latlong eastlong degrees dupok
      parmin=projparm parmentry=my_map;
      id;
run;

data my_mapdata;
      set mapsgfk.world_attr;
      colorvar='1';
run;

/* Open HTML file */

ODS LISTING CLOSE;
ODS HTML path=odsout body="&name..htm"
      (title="World Population")
      style=htmlblue;

/* Set ODS Graphics */
ods graphics /
      noscale /* if you do not use this option, the text will be resized */
imagemap TIPMAX=31066
imagefmt=png imagename="&name"
antialias=off subpixel=off
width=1700px height=800px noborder;
title1 c=white h=16pt "World Population - PROC SGMAP ";

/* Create map */

proc sgmap maprespdata=my_mapdata mapdata=my_map noautolegend plotdata=white_dots;
      styleattrs datacolors=(black) backcolor=darkblue;
      choromap colorvar / mapid=idname lineattrs=(thickness=1 color=gray)
      tip=(idname) tiplabel=('Country');
      scatter x=x y=y / transparency=0 markerattrs=(size=1px color=cornsilk
symbol=squarefilled)
            tip=none;
run;

quit;

ODS HTML CLOSE;
ODS LISTING;
```

Program 2. PROC SGMAP version of World Population Map



THE WORLD OF JAMES BOND, AGENT 007

One of my guilty pleasures are James Bond books and movies. I used to take my babysitting money and buy secondhand copies of Ian Fleming books as a tween, and as an adult, I enjoy the crazy poetic license of the movies and join in the debate about my favorite Bond actor. I particularly enjoy the Q character, who appeals to my nerdiness. Unfortunately, Q's exploits were static, and did not lend themselves to mapping. The map of 007's exploit locations, and two additional metrics, shown in the e-Poster, and based on the SGMAP sample, will have to do.

CONCLUSION

SAS has always been at the forefront of data visualization, from the days of SAS/GRAPH to the SG procedures, SAS Visual Analytics, and SAS Viya. The use of annotation and attributes can greatly enhance both SAS/GRAPH and ODS GRAPHICS output and allow a high degree of customization. I hope you will look at the newish PROC SGMAP procedure for following your data (or guilty pleasures) and have an increased understanding of how these similar, but different, procedures work.

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