PROVIDING THE NWS STORM PREDICTION CENTER'S CONVECTIVE AND FIRE WEATHER OUTLOOKS IN FORMATS SUITABLE FOR TWO-DIMENSIONAL MAPS AND THREE-DIMENSIONAL EARTH BROWSERS

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1. INTRODUCTION

The National Weather Service's (NWS) Storm Prediction Center (SPC) issues Convective and Fire Weather Outlooks in text and graphical formats (NOAA/NWS/SPC, 2011). The Outlooks serve as guidance to the local NWS forecast offices and are also used by emergency managers, land management agencies, private sector meteorologists, the media, and the general public to inform them of the risks of severe weather and fire weather. This paper describes how these Outlooks are being converted into color-shaded, closed polygons in formats suitable for visualization within Internet-based two-dimensional maps, and three-dimensional Earth browsers. The color-shaded polygons allow a user to easily determine whether a portion of any particular county has been included in the area at meteorological risk.

The Categorical Convective Outlooks define areas of slight, moderate and/or high risk of severe thunderstorms for Day 1 through Day 8. The Day 1 and Day 2 Outlooks also define areas where there is at least a 10% or greater probability of general thunderstorms. The Fire Weather Outlooks define areas of significant dry thunderstorms, critical and/or extremely critical fire weather for Day 1 through Day 8. Both products include the coordinates (latitude and longitude) of a series of points that outline the area. At the NWS Shreveport, LA office, computer programs were developed to ingest the text versions of the Outlooks and convert them into Shapefiles and Keyhole Markup Language (KML) polygons. This paper describes these programs and also the processes involved in quality controlling the data, finishing line segments and/or arcs into closed polygons, and determining the layering priority of the data. The Shapefiles and KML files are available on the NWS Shreveport web site (NOAA/NWS/SHV, 2011) and the NWS's Geographic Information System (GIS) web site (NOAA/NWS/GIS Portal, 2011) for use by the various customers.

2. DATA INGEST AND FORMATTING

The Storm Prediction Center routinely issues both the Convective and Fire Weather Outlook Areal Outline products that include the geographical coordinates of the areas they are defining. These products are ingested into the NWS Advanced Weather Interactive Processing System (AWIPS) which then triggers software to process the coordinates of the various Outlooks into a different format that is used to create both the Shapefiles and KML files of the Outlooks.

The SPC formats the coordinates, which are single geographical points, into a series of eight digit blocks of numbers that are delimited by a single white space. The first four digits of the eight digit blocks represent the latitude of the point, and the last four represent the longitude. The last two digits of each four digit block represent the decimal degree section of the latitude and longitude of each point. The shape that is depicted by the series of coordinates varies from a line, to an arc, to a closed polygon. Not all of the areas are closed polygons since some terminate at the near-

shore marine zones and/or the Canadian or Mexican borders.

The SPC delineates each shape by inserting an eight digit block of all nines (99999999). The direction that coordinates are presented is significant. One rule that the SPC places on the geometry of the areas is that the affected area is to the right of any line or line segment they provide. See an example of how the SPC formats the coordinates in Figure 1.

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CATEGORICAL OUTLOOK POINTS DAY 1

... CATEGORICAL ...

HIGH   35658461 35088441 34168503 33308591 32328725 32308877
       32608944 33398961 34068927 34958797 35478608 35668534
       35658461
MDT    37028157 35338179 34308254 33388411 32778502 31948618
       31298739 31148897 31809036 33269048 34438992 35378822
       36658539 38718357 38508258 37028157
SLGT   45027267 43407291 41887411 41087468 40567504 39207596
       38857621 38447648 36747675 35317729 33747857 32368116
       31238271 30388361 29678395 99999999 29288851 29378997
       30139138 31139146 32499114 33029143 33589324 34379400
       35199403 35899352 36569120 37958821 40008495 41348294
       41938188
TSTM   25147978 25318088 25808181 26888239 27298286 27268331
       99999999 29019257 31439294 32269440 33259503 33859680
       35499780 36879687 37479489 38389026 41588593 45498247
       99999999 49179829 46409728 43629640 42719750 42369986
       43960325 45540554 47060621 49171003
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Fig. 1. *Portion of the Storm Prediction Center's Day 1 Convective Outlook from 27 April 2011, showing the format of the coordinates of each point that define the Categorical Outlook area for that day.*

A data formatting script converts each series of coordinates for each Outlook to a format suitable to be used by Shapelib, third-party software that creates Shapefiles, and KML files. See an example of the converted coordinates in Figure 2. (NOTE: Mention or display of a trademark, proprietary product, or firm in text or figures does not constitute an endorsement by the National Weather Service, NOAA or the Department of Commerce, and does not imply approval to the exclusion of other suitable products or firms.) All longitude values for the continental United States fall within the range of 65 – 130 degrees. Longitude values between 100 - 130 degrees have the initial "1" stripped off in the Categorical Outlook data, so a digit of "1" must be prepended to the value, as well as a minus sign (-) since each longitude

value in the western hemisphere is west of the Prime Meridian. Also, a decimal point must be inserted into the coordinate values to properly encode them. The data formatting script then calls a second script that processes the formatted line segments, arcs, and polygons.

```
271300Z 271300Z 281200Z Day1_Conv_Outlook 20110427_1300Z
TORNADO_02% 1 -90.90 28.56 -91.63 29.90 -91.85 31.39 -91.64 32.26 -91.59
TORNADO_05% 1 -73.64 45.52 -73.62 44.76 -74.09 42.99 -74.69 41.06 -76.48
TORNADO_10% 1 -82.63 34.24 -83.56 33.59 -84.92 32.28 -86.14 31.39 -87.55
TORNADO_15% 1 -82.92 37.59 -82.75 36.13 -84.33 33.74 -85.13 32.71 -86.48
TORNADO_30% 1 -84.57 35.64 -84.42 35.02 -84.92 34.23 -85.72 33.42 -87.23
TORNADO_SIGNIFICANT 1 -85.38 36.70 -84.23 37.46 -82.94 37.60 -82.73 36.17
HAIL_05% 1 -90.70 28.26 -91.68 30.02 -91.89 31.35 -92.35 31.84 -94.04 32.
HAIL_15% 1 -88.75 29.30 -89.97 29.37 -91.42 30.15 -91.46 31.48 -91.13 32.
HAIL_30% 1 -87.35 31.31 -89.11 31.18 -90.47 31.89 -90.56 33.25 -89.90 34.
HAIL_45% 1 -85.76 33.33 -87.26 32.35 -88.87 32.35 -89.44 32.66 -89.54 33.
HAIL_SIGNIFICANT 1 -87.72 30.89 -89.07 30.77 -89.92 31.13 -90.46 31.52 -9
WIND_05% 1 -71.25 46.03 -70.68 44.23 -70.86 43.47 -72.39 42.47 -73.35 40.
WIND_15% 1 -88.71 29.29 -90.02 29.39 -91.42 30.15 -91.48 31.11 -91.29 31.
WIND_30% 1 -82.49 33.41 -85.09 31.77 -87.43 31.29 -89.03 31.15 -90.43 31.
WIND_45% 1 -88.55 35.19 -85.31 36.69 -83.57 38.71 -82.60 38.51 -81.60 37.
WIND_SIGNIFICANT 1 -85.11 32.71 -87.19 32.31 -88.88 32.32 -90.43 33.25 -8
CATEGORICAL_GENERAL 1 -79.78 25.14 -80.88 25.31 -81.81 25.80 -82.39 26.88
CATEGORICAL_SLIGHT 1 -72.67 45.02 -72.91 43.40 -74.11 41.88 -74.68 41.08
CATEGORICAL_MODERATE 1 -81.57 37.02 -81.79 35.33 -82.54 34.30 -84.11 33.3
CATEGORICAL_HIGH 1 -84.61 35.65 -84.41 35.08 -85.03 34.16 -85.91 33.30 -8
```

Fig. 2. *An example of the final format that each area of the SPC's Day 1 Convective Outlook must be converted into so that Shapefiles and KML files can be created.*

3. DATA PROCESSING AND QUALITY CONTROLLING

The data formatting script processes the data for each Outlook and sorts through the coordinates. If a shape begins and ends with the same geographical coordinate it is easily processed because it must be a closed polygon. For the series of coordinates that do not meet this criterion, a more complicated process is required to complete a closed polygon.

The general philosophy behind making closed polygons from line segments and arcs is to complete the polygon by using a segment of points that comprise the adjacent border of the United States and/or the near-shore water zones that border the coastal sections of our country. See Figure 3 for an example of the territorial boundary of the lower forty-eight states of the United States and the near-shore water zones. See Figure 4 for a representation of how a

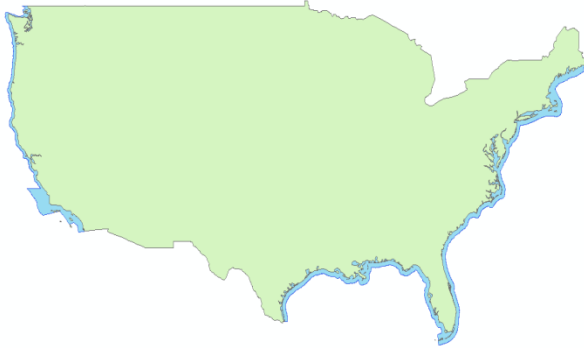series of points of the merged border and near-shore water zones are extracted.

Fig. 3. *The continental border (green) and the near-shore water zones (blue) of the lower forty-eight states of the United States. These two shapes are then merged and only the outer edge of the resulting shape is used to depict the area for which the Storm Prediction Center issues all Convective Outlooks.*
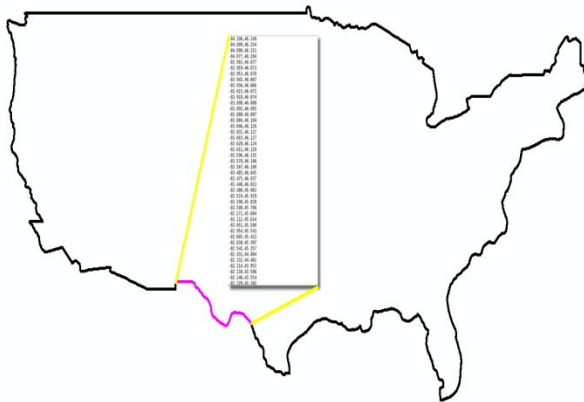

Fig. 4. *The outline of the continental border and the near-shore waters combined. Also shown is a series of coordinates of that outline that is extracted to form a closed polygon of an SPC threat area.*

There are some inherent problems in the data that the SPC provides that must be overcome through quality control efforts. The first and last point in each line segment need to be outside of the boundary of the United States while the second and second-to-last point need to be inside the boundary so that an intersection point with the boundary can be determined on both ends

of the line segment. The SPC's supplied points do not always fit this scenario perfectly, thus a subroutine was written to either extend the end of a line segment outside the boundary or progress sequentially down the line segments until an intersection is met with the known line segments of the boundary. Once the boundary intersection points are determined for each line, and/or line segment of each area outline, they must be sequentially ordered to determine which series of boundary points must be included to complete the closed polygon.

Another subroutine was written to order the intersection points along the boundary and then capture the series of boundary points between the appropriate ones to complete a closed polygon. To accomplish this complicated task, each boundary point is given an arbitrary value and progresses sequentially around the border until the beginning point is reached. The intersection points are points on the boundary, thus they have an arbitrary value and are associated with a given line segment. The SPC's supplied lines, line segments, and arcs must have alternating beginning and ending intersection points along the boundary. All of this information aids in determining which lines, line segments, and arcs are associated with a single outlook area and should be pieced together to form the appropriate closed polygon.

Additional quality control is needed for each line segment to determine how many intersections occur with the United States border/boundary. Each line segment is tested for an intersection with the United States boundary both in a clockwise and counter-clockwise direction. When the intersection points from each direction test differ, the section of the United States boundary clipped is solely determined by the given line segment and is not combined with any other supplied line segment to form a closed polygon.

Polygons that are formed outright also need to be checked to determine in which

direction the points that compose it are being assembled. A subroutine was written to determine if the closed polygon was turning clockwise or counter-clockwise. A clockwise turning closed polygon means that the area *inside* is included in the Outlook while a counter-clockwise turning polygon's area is not included. The direction of turning is stored for each polygon that is already formed because it will be needed later when layering each polygon within the Shapefiles and KML files.

Identification for each category within each Outlook is assigned to every polygon that is pieced together or formed outright. This identification allows for ease of combining many polygons that define each category of an Outlook into one file that is named for that Outlook.

4. POLYGON COMBINING AND FILE CREATION

All polygons are layered by area within the Shapefiles and KML files from largest to smallest. The polygons are run through the Shapelib software to create Shapefiles of each category. See Figure 5 for an example of a Shapefile created through this process. Layer files are then included into each main Outlook Shapefile to color-code all similar polygons and delineate one category from another. The KML files are formed in a similar manner by layering each polygon by area. See Figure 6 for an example of a KML file created through this process. The difference with the KML files is that all layering and color-coding of the polygons are done manually and not through separate software.

5. SHAPEFILE AND KML FILE AVAILABILITY AND DOWNLOAD

The Outlook Shapefiles and KML files are available for download from on the Shreveport NWS web site approximately five minutes after issuance by the Storm

Prediction Center (NOAA/NWS/SHV, 2011). National Weather Service Headquarters copies the files to their servers and makes them available on the NWS GIS web page (NOAA/NWS/GIS Portal, 2011).
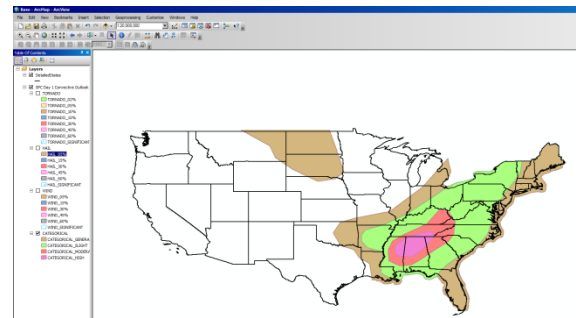

Fig. 5. *The Shapefiles created from the SPC's Day1 Convective Outlook for 27 April 2011, within the Environmental Systems Research Institute's (ESRI) ArcMap two-dimensional map viewer.*
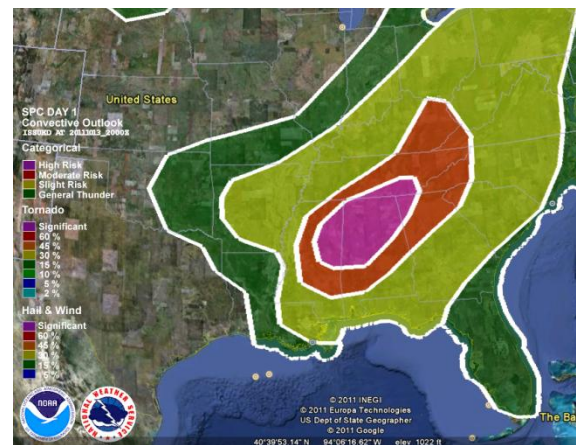

Fig. 6. *The KML file created from the SPC's Day1 Convective Outlook for 27 April 2011, within the Google Earth three-dimensional Earth Browser.*6. CONCLUSION

The National Weather Service's Storm Prediction Center provides Convective (Severe Storm) and Fire Weather Outlooks in graphical formats. A project was undertaken to take the SPC's graphical Outlooks and convert them into color-shaded, closed polygons in formats suitable for visualization using Internet-based two-dimensional maps, and three-dimensional

Earth browsers. The color-shaded polygons allow a user to easily determine whether any geographical region is included in the area at meteorological risk.

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8. REFERENCES

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