WeatherOps® Climate Toolkit Toolbar

Automating Quantitative Sub-seasonal Forecasts in ArcGIS

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WHO IS WDT?

WEATHER DECISION TECHNOLOGIES, INC. IS THE INDUSTRY LEADER, PROVIDING ORGANIZATIONS WITH WEATHER DECISION SUPPORT ON A GLOBAL SCALE.

- Data provider
- Value added products
- Expert services
- Innovative products
- Cutting-edge weather information on a global scale
- Servicing clients in energy, utilities, aviation, insurance, media, and live events
- Industry experience

WHAT IS THE WXOPS CLIMATE TOOLKIT?

OVERVIEW

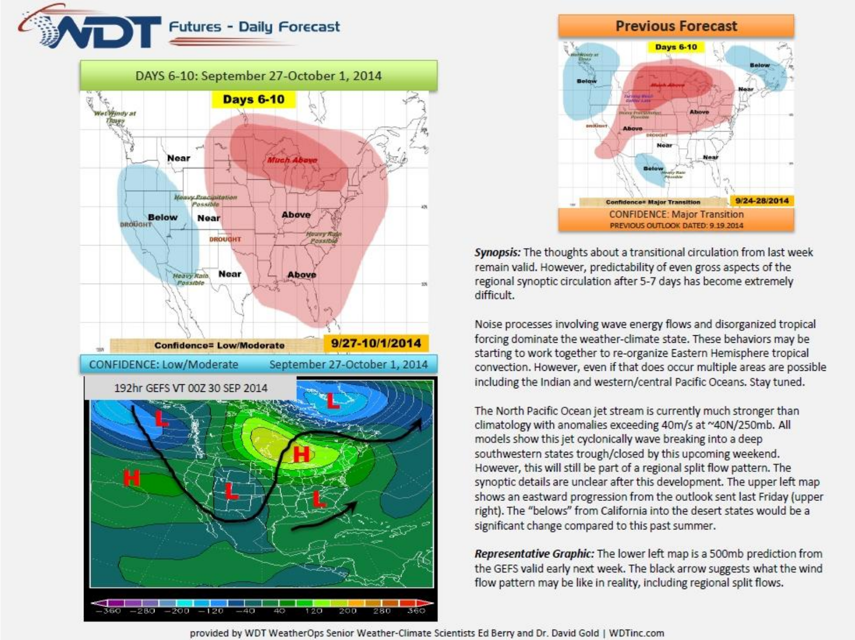
- A custom toolbar was created using the Python Add-In Wizard by ESRI.
- The WxOps Climate Toolkit was designed to automate and standardize the process of creating quantitative sub-seasonal long range forecasts in ArcGIS.
- The functionality of this toolbar includes creating a polygon feature class from a template, generating a gridded and point forecast, and exporting the resulting map to a .png image file.
- Based on a 30 year climatology built from ASOS station observations interpolated onto 100km raster grids for use in advanced calculations.
- Advanced raster calculations

WHO USES THE CLIMATE TOOLKIT?

METEOROLOGISTS – NOT GIS PROFESSIONALS

Dr. David Gold and Ed Berry - Senior Scientists & Forecasters - WDT Houston Office

- The derived products are provided to clients to aid in advanced planning for high impact events and risk mitigation.
- Energy and Agriculture companies use these products for asset optimization and commodities trading.
- Maps are sent out daily as part of WDT Futures Daily Forecast product.



Futures - Daily Forecast

DAYS 6-10: September 27-October 1, 2014

CONFIDENCE: Low/Moderate September 27-October 1, 2014

192hr GEFS VT 00Z 30 SEP 2014

Previous Forecast

CONFIDENCE: Major Transition

PREVIOUS OUTLOOK DATED: 9.19.2014

Synopsis: The thoughts about a transitional circulation from last week remain valid. However, predictability of even gross aspects of the regional synoptic circulation after 5-7 days has become extremely difficult.

Noise processes involving wave energy flows and disorganized tropical forcing dominate the weather-climate state. These behaviors may be starting to work together to re-organize Eastern Hemisphere tropical convection. However, even if that does occur multiple areas are possible including the Indian and western/central Pacific Oceans. Stay tuned.

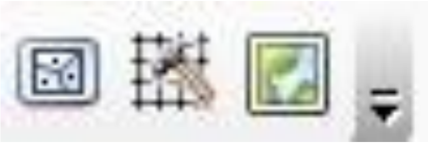
The North Pacific Ocean jet stream is currently much stronger than climatology with anomalies exceeding 40m/s at ~40N/250mb. All models show this jet cyclonically wave breaking into a deep southwestern states trough/closed by this upcoming weekend. However, this will still be part of a regional split flow pattern. The synoptic details are unclear after this development. The upper left map shows an eastward progression from the outlook sent last Friday (upper right). The "belows" from California into the desert states would be a significant change compared to this past summer.

Representative Graphic: The lower left map is a 500mb prediction from the GEFS valid early next week. The black arrow suggests what the wind flow pattern may be like in reality, including regional split flows.

provided by WDT WeatherOps Senior Weather-Climate Scientists Ed Berry and Dr. David Gold | WDTinc.com

WXOPS CLIMATE TOOLKIT TOOLBAR

THAT’S ALL FOLKS!

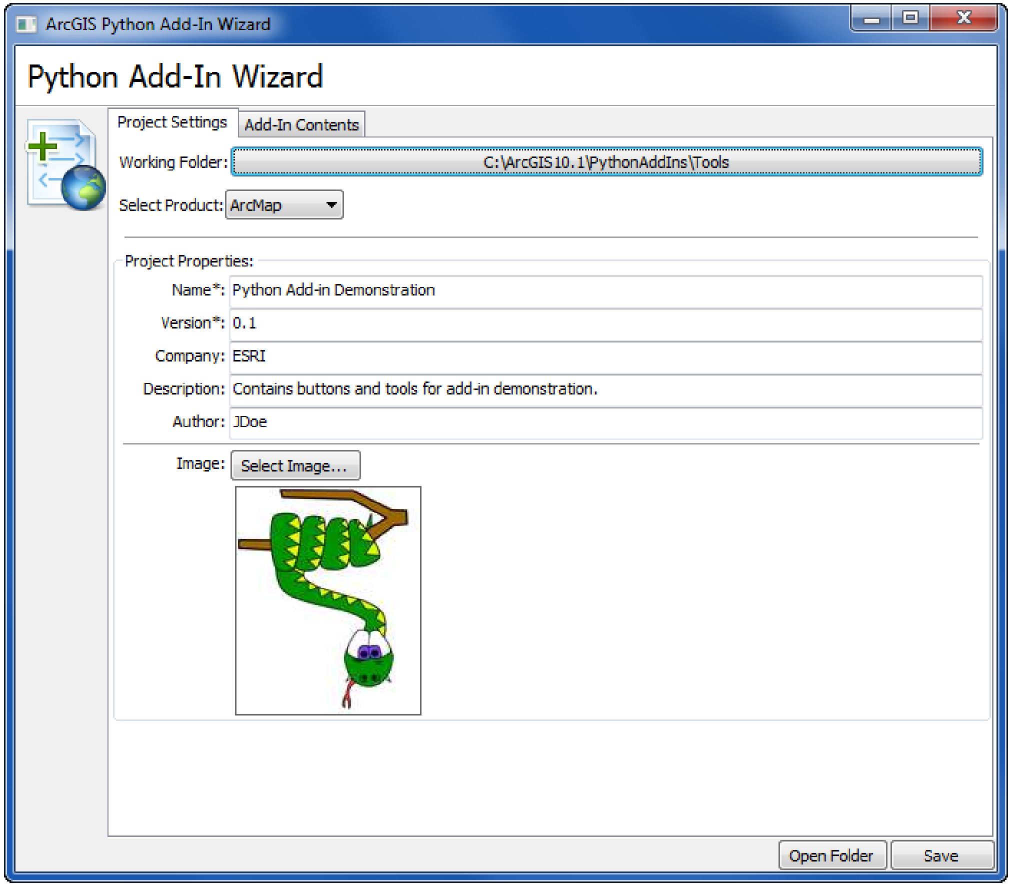


- Copy Features
- Generate Forecast
- Generate Map Image

LIVE DEMO

PYTHON ADD-IN WIZARD

AN ADD-IN IS A CUSTOMIZATION, SUCH AS A COLLECTION OF TOOLS ON A TOOLBAR, THAT PLUGS INTO AN ARCGIS FOR DESKTOP APPLICATION TO PROVIDE SUPPLEMENTAL FUNCTIONALITY FOR ACCOMPLISHING CUSTOM TASKS.*



ArcGIS Python Add-In Wizard

Python Add-In Wizard

Working Folder: C:\ArcGIS10.1\PythonAddIns\Tools

Select Product: ArcMap

Project Properties:

Name*: Python Add-in Demonstration

Version*: 0.1

Company: ESRI

Description: Contains buttons and tools for add-in demonstration.

Author: JDoe

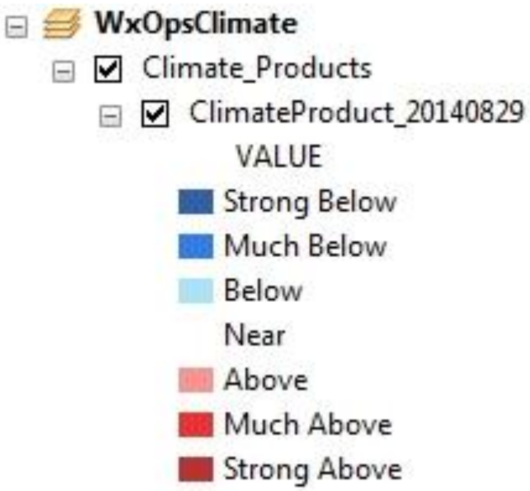
Image:

* ESRI - http://resources.arcgis.com/en/help/main/10.1/index.html#//014p00000025000000

COPY FEATURES

BUTTON 1

- Uses Arcpy & Arcpy.Mapping
- Sets up map document settings
- Copies template feature class – arcpy.CopyFeatures_management
- Renames layer to append forecast date
- Adds new layer to group layer in mxd
- Applies symbology to layer



⊟ WxOpsClimate

⊟ ☑ Climate_Products

⊟ ☑ ClimateProduct_20140829

VALUE

🟦 Strong Below

🟦 Much Below

🟦 Below

Near

🟥 Above

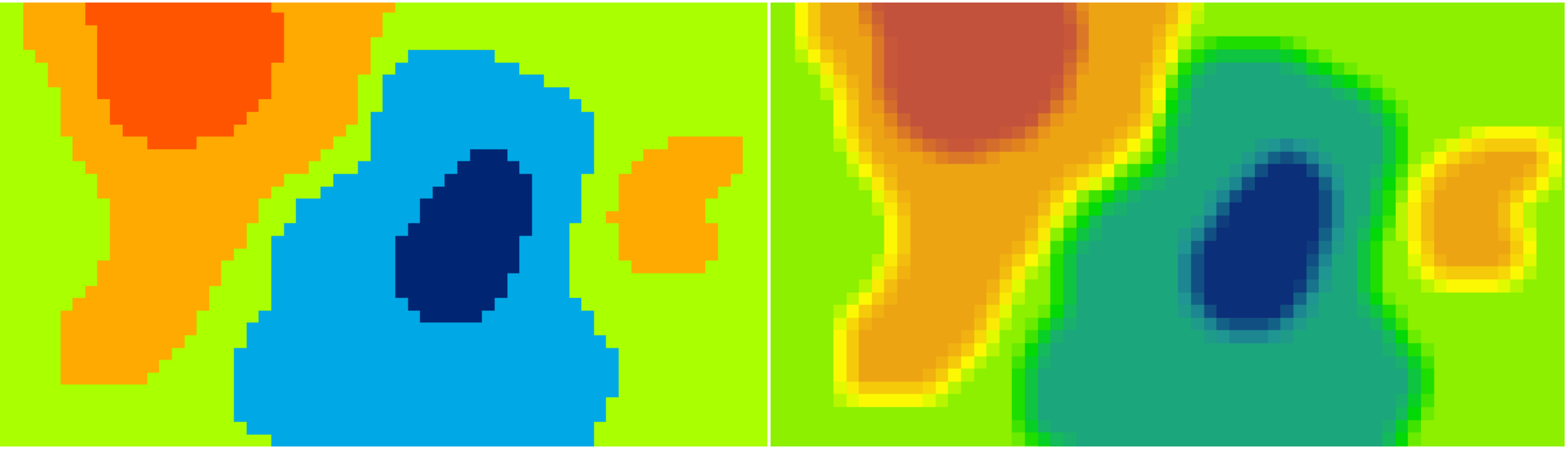
🟥 Much Above

🟥 Strong Above

GENERATE FORECAST

BUTTON 2

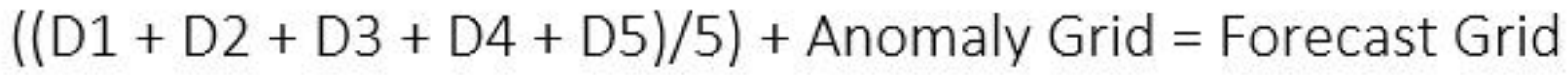
- This is where the magic happens ☺
- Gathers forecast range
- Renames anomaly feature class with forecast date and forecast range
- Converts polygon feature class to raster
- Applies smoothing filter to anomaly grid



GENERATE FORECAST

BUTTON 2 (CONTINUED)

- Creates lists of climate rasters within the forecast range
- Averages or sums the rasters in the list based on their intended purpose (arcpy.sa.CellStatistics and arcpy.Plus)
- Computes forecast by differencing the average of the grids with the anomaly grid



$$((D1 + D2 + D3 + D4 + D5)/5) + \text{Anomaly Grid} = \text{Forecast Grid}$$

- Identifies raster values onto point dataset and outputs to .csv
- Loads all forecast grid layers into current map document and unchecks them
- Spatial Analyst is an integral piece of the functionality of this tool

ARCPY.DA MODULE – SEARCH CURSOR

THE DATA ACCESS MODULE, ARCPY.DA, IS A PYTHON MODULE FOR WORKING WITH DATA.*

```
#Define Function to search the attribute table and return the values
#Gather the Climate Grids within the Specified Date Range
#Using Search Cursor http://resources.arcgis.com/en/help/main/10.2/index.html#//018w00000011000000

def get_feature_value(feature, value_field, where=None):

    """
    get_feature_value(feature, value_field, where=None):
    This function returns a single value for a given column in a specified feature class.
    This function assumes there is only ONE valid value in the given column in the feature class, as in all values in that particular
   column are the same and are being represented by that first feature returned in this function.
    Arguments: feature - feature class, value_field - name of field/column containing the value we are retrieving, where - valid SQL
     statement.
    Return: Single value for features
    """

    where=where if where else "1=1"
    with arcpy.da.SearchCursor(feature, value_field, where) as cursor:
        return cursor.next()[0]
```

Function call in main:

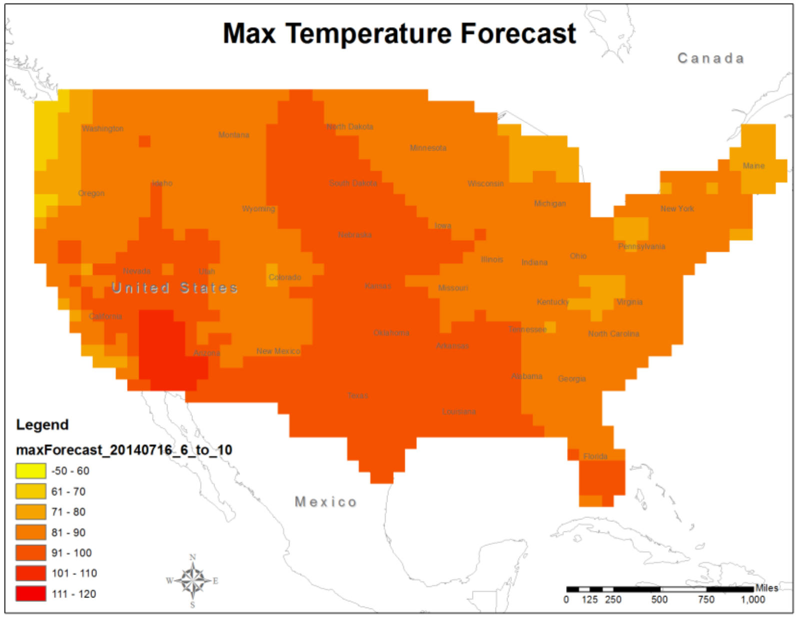
```
start_date = get_feature_value(outClimateProduct, "START_DATE" )
```

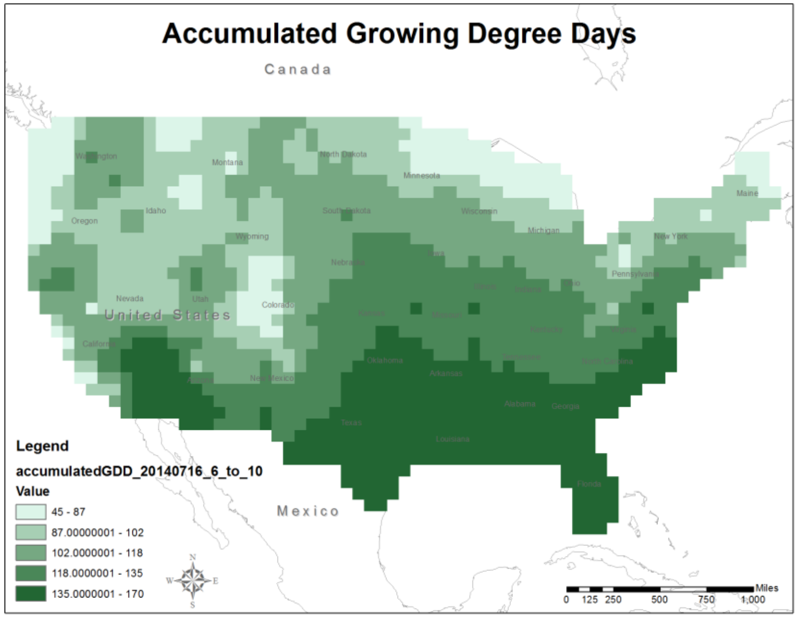
*ESRI - http://resources.arcgis.com/en/help/main/10.1/index.html#//018w00000008000000

CREATING FORECAST GRIDS

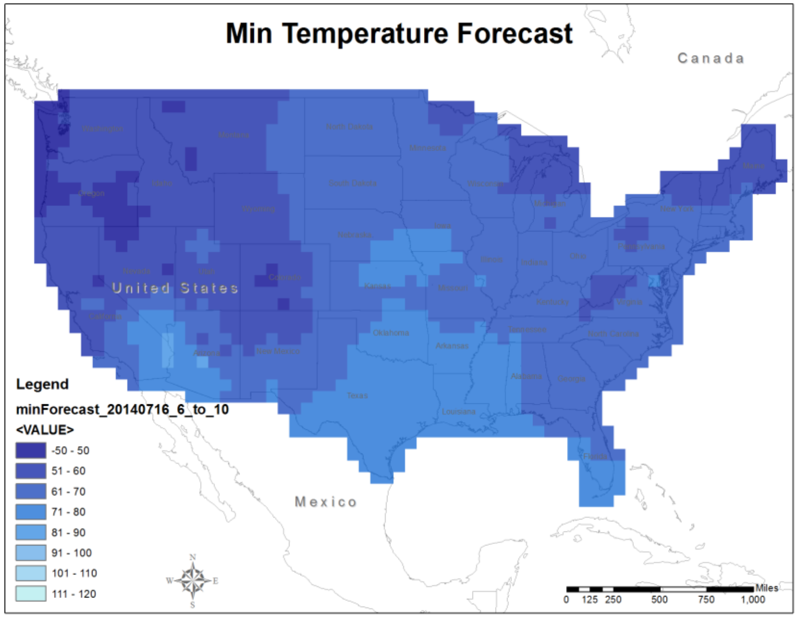
```
#Take the valid start and end dates and retrieve the climate grids that we need and return them in a list
    minTempGrids = []
    GDD_Grids = []

#Populate Lists with Rasters in Range
    while start_date <= end_date:
      minTempGrids.append('c%s_%s_MinTemp_F_CONUS' % (pad(start_date.month,2,0), pad(start_date.day, 2,0)))
      GDD_Grids.append('c%s_%s_GDD_F_CONUS' % (pad(start_date.month,2,0), pad(start_date.day, 2,0)))
      start_date += timedelta(days=DAY_STEP)

#Average all Grids in the date range   #Cell Statistics to Calculate Mean
#http://resources.arcgis.com/en/help/main/10.1/index.html#//009z0000007q000000
    avgMinTempGrid = arcpy.sa.CellStatistics(minTempGrids, "MEAN", "NODATA")

#Sum all Grids in the date range #Cell Statistics to Calculate Sum for Accumulated Values of GDD
#http://resources.arcgis.com/en/help/main/10.1/index.html#//009z0000007q000000
    accumulatedGDD = arcpy.sa.CellStatistics(GDD_Grids, "SUM", "NODATA")
    accumulatedGDD.save(basePath + "\ForecastsGDD.gdb\\accumulatedGDD" + "_" + FORECAST_DATE + forecastRange)

#Compute forecast temperature from adding the averaged grid and the smoothed anomaly grid #Sptial Analyst Math Tools - Plus
    minForecast = Plus(avgMinTempGrid , Anomaly_Grid_Full)
    minForecast.save(basePath + "\ForecastsMin.gdb\\minForecast" + "_" + FORECAST_DATE + forecastRange)

#Compute the CDD & HDD
#Formula (((min temp + max temp)/2)- 65)*(Number of Days in Range)
    minus65= basePath +"\ReferenceData.gdb\CDDHDD"
    daysInRange=len(avgTempGrids)
    CDDHDDForecast = arcpy.sa.Times(arcpy.sa.Plus(avgForecast, minus65),daysInRange)
    CDDHDDForecast.save(basePath + "\ForecastsCDDHDD.gdb\CDDHDD" + "_" + FORECAST_DATE + forecastRange)
```

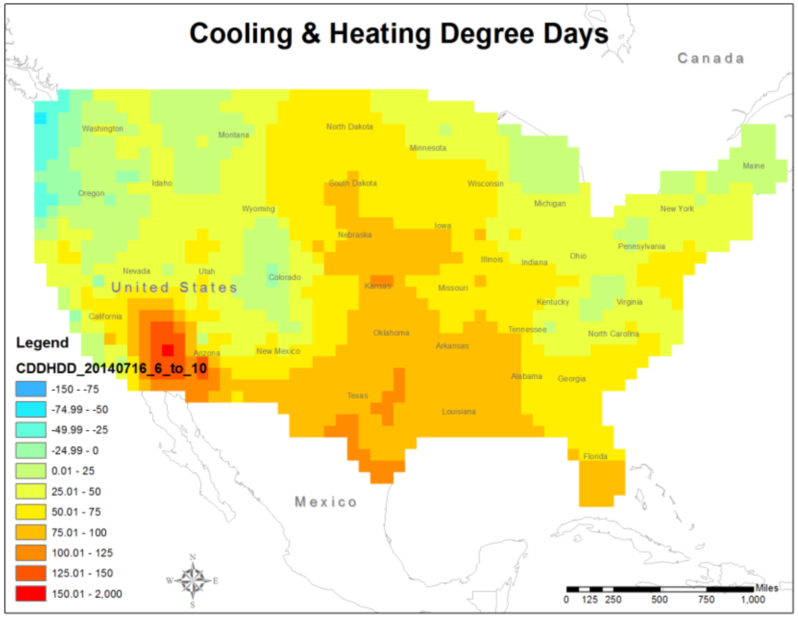
*Note: I have removed several lines of this code from each section or loop to save space, but all are similar to what is shown.





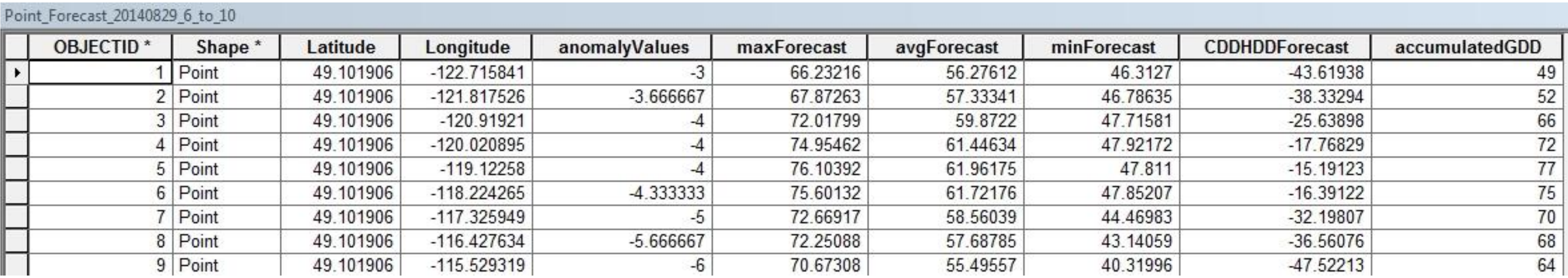
FINAL OUTPUT FORECAST GRIDS





POINT FORECASTS

```
#Extract Values from All Forecast Rasters to Point Forecast Feature Class
ExtractMultiValuesToPoints(point_forecasts, in_raster_list, "NONE")

 #Variabes for Export to CSV
in_point_file = os.path.join(basePath,"PointData.gdb","Point_Forecast_"+ FORECAST_DATE + forecastRange)
out_point_path = os.path.join(basePath,"OutputCSV")
out_csv = os.path.join(basePath,"OutputCSV","Point_Forecast_"+ FORECAST_DATE + forecastRange +'.csv')
csv_fields = ['Latitude','Longitude', 'anomalyValues','maxForecast','avgForecast','minForecast','CDDHDDForecast','accumulatedGDD']

#Export Point Forecasts to CSV
f = open(out_csv, 'wb')
writer = csv.writer(f, delimiter =',')
writer.writerow(csv_fields)
with arcpy.da.SearchCursor(in_point_file, csv_fields) as cursor:
    for row in cursor:
        row_list = []
        for value in row:
            row_list.append(float("{0:.6f}".format(value)))
            writer.writerow(row_list)
        f.close()
```



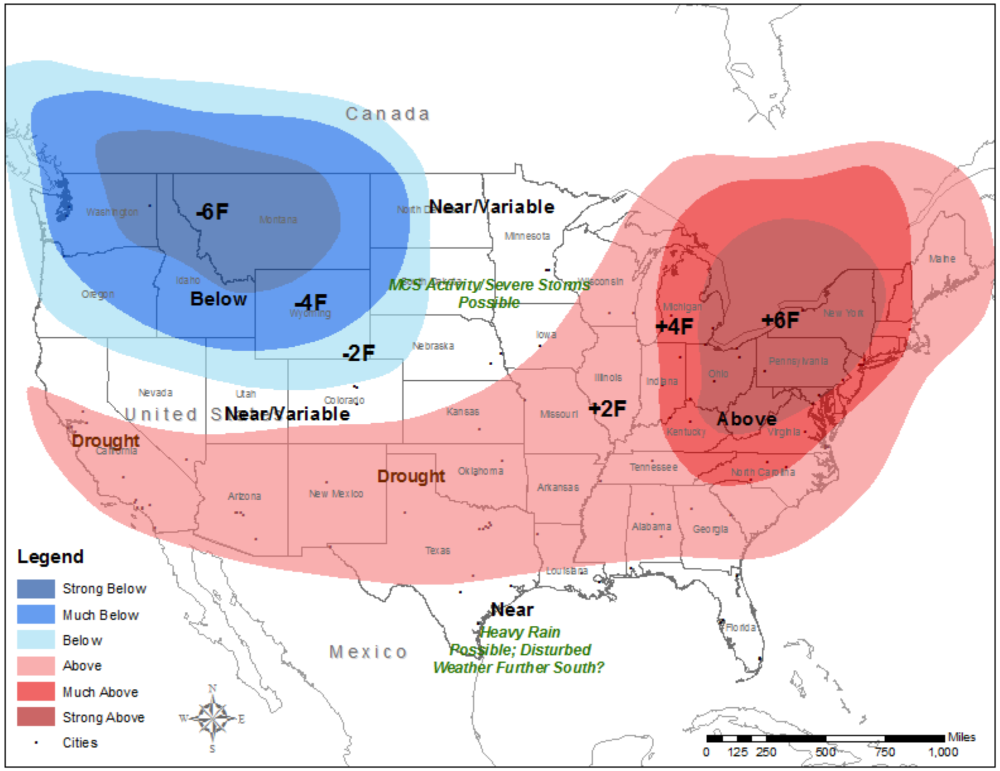
Point_Forecast_20140829_6_to_10

OBJECTID *	Shape *	Latitude	Longitude	anomalyValues	maxForecast	avgForecast	minForecast	CDDHDDForecast	accumulatedGDD
1	Point	49.101906	-122.715841	-3	66.23216	56.27612	46.3127	-43.61938	49
2	Point	49.101906	-121.817526	-3.666667	67.87263	57.33341	46.78635	-38.33294	52
3	Point	49.101906	-120.91921	-4	72.01799	59.8722	47.71581	-25.63898	66
4	Point	49.101906	-120.020895	-4	74.95462	61.44634	47.92172	-17.76829	72
5	Point	49.101906	-119.12258	-4	76.10392	61.96175	47.811	-15.19123	77
6	Point	49.101906	-118.224265	-4.333333	75.60132	61.72176	47.85207	-16.39122	75
7	Point	49.101906	-117.325949	-5	72.66917	58.56039	44.46983	-32.19807	70
8	Point	49.101906	-116.427634	-5.666667	72.25088	57.68785	43.14059	-36.56076	68
9	Point	49.101906	-115.529319	-6	70.67308	55.49557	40.31996	-47.52213	64

GENERATE MAP IMAGE

BUTTON 3

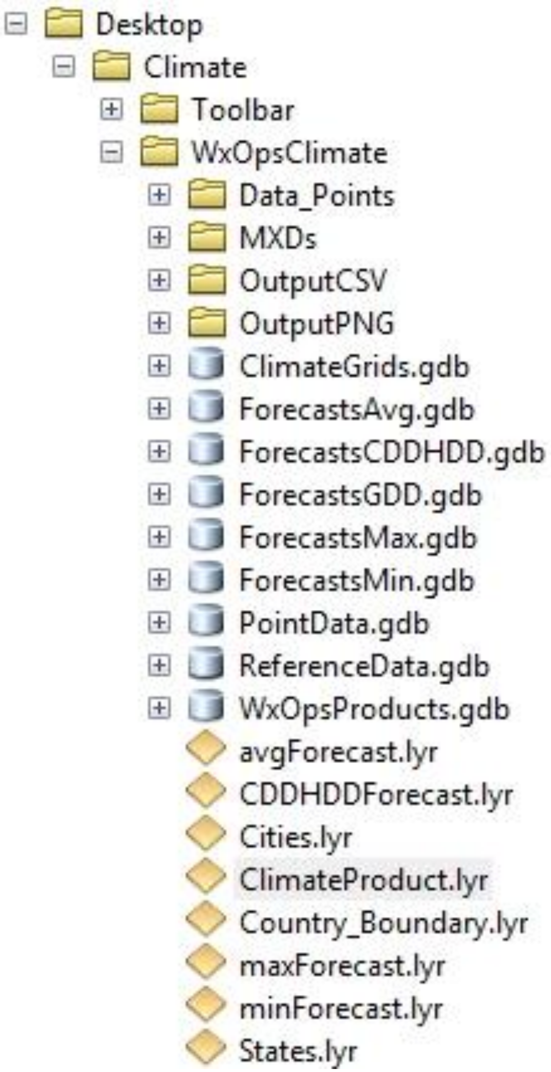
```
#Export Maps
extentLayer = arcpy.mapping.Layer(basePath +"\ReferenceData.gdb\ExtentPolygon")
ext = extentLayer.getExtent()
df.extent = ext

outPng = basePath + "\\OutputPNG\\ClimateProduct_"+ FORECAST_DATE + forecastRange + ".png"
arcpy.mapping.ExportToPNG (mxd, outPng, df_export_width =792, df_export_height=612, resolution = 72)
mxd.save()
```



ESRI - http://resources.arcgis.com/en/help/main/10.2/index.html#/ExportToPNG/00s300000002s000000/

DATA STRUCTURE

- Each output product has it’s own directory or geodatabase
- Each product has it’s own symbology layer file within the main directory
- The toolbar folder contains the add-in files and script
- All base files and template feature classes are within the ReferenceData geodatabase



- ⊟ Desktop
  - ⊟ Climate
    - ⊞ Toolbar
    - ⊟ WxOpsClimate
      - ⊞ Data_Points
      - ⊞ MXDs
      - ⊞ OutputCSV
      - ⊞ OutputPNG
      - ⊞ ClimateGrids.gdb
      - ⊞ ForecastsAvg.gdb
      - ⊞ ForecastsCDDHDD.gdb
      - ⊞ ForecastsGDD.gdb
      - ⊞ ForecastsMax.gdb
      - ⊞ ForecastsMin.gdb
      - ⊞ PointData.gdb
      - ⊞ ReferenceData.gdb
      - ⊞ WxOpsProducts.gdb
      - avgForecast.lyr
      - CDDHDDForecast.lyr
      - Cities.lyr
      - ClimateProduct.lyr
      - Country_Boundary.lyr
      - maxForecast.lyr
      - minForecast.lyr
      - States.lyr

CURRENT LIMITATIONS & FUTURE SCOPE

WHAT CAN'T WE DO AND WHERE WE ARE GOING

- Limitations
  - Immobile
  - Only covers CONUS
  - Applies same value for all areas within an anomaly
- Future Scope
  - Expand climatology grids to all of North America (Short Term)
  - Expand climatology grids globally (Long Term)
  - Revamp anomaly calculations to station based
  - Ingest model output for baseline first guess field
  - Possibility to expand to a full web based application

QUESTIONS??

Contact Info:

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http://wdtinc.com/

For more info about WDT and our GIS Services feel free to attend the Vendor Promotion session talk by Matt Gaffner at 1:25pm in room 210