The Effect of Hurricanes on Annual Precipitation in Maryland and the Connection to Global Climate Change

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Precipitation contributed by hurricanes does affect Maryland's precipitation, however, the connection to global climate change is not very clear.

I. Introduction

- Precipitation is a vital aspect of our lives
- Droughts, floods and other related disasters that involve precipitation can cause costly damage in the economic system and general society
- Purpose of this project is to determine what, if any effect do hurricanes have on annual precipitation in Maryland
- Research will be conducted on Maryland's terrain, climatology, annual precipitation, and precipitation contributed from hurricanes
- Possible connections to climate change

II. Data and Processes

A) Data, Collection Methods and Tools

•Precipitation datasets: TRMM Multi-satellite Precipitation Analysis (TMPA) 3B43 monthly data and 3B42 daily data (gauge adjustments for both).
•NASA **G**eospatial **I**nteractive **O**nline **V**isualization **AN**d a**N**alysis **I**nfrastructure (GIOVANNI) **T**RMM **O**nline **V**isualization and **A**nalysis **S**ystem (TOVAS) provides access to precipitation data.

Hurricane Data from UNISYS Weather
Online database that collects hurricane tracking information such as charts and data on latitude and longitude, maximum sustained winds in knots, and central pressure in millibar.

B) Procedure

1) **Terrain Map:** Using Google Maps' terrain setting, plot Maryland area
2) **Climatology Map:** Using 3B43 in NASA GIOVANNI TOVAS to create a climatology map. Identify specific points from this map that correspond to the different regions in Maryland.
3) **Time Series:** Plot a time series of the annual precipitation from the years 1998-2014. Plot a time series for each individual point in the precipitation climatology map with Microsoft Excel. Sum up the monthly data for annual precipitation.
4) **Hurricane Analysis:** Using the UNISYS Hurricane/Tropical data to identify the dates when hurricanes passed through Maryland or the vicinity of the Maryland region. Use these dates in GIOVANNI TOVAS to record accumulated rainfall from the 3B42 daily precipitation dataset. Compare the data against the annual precipitation collected from the time series.

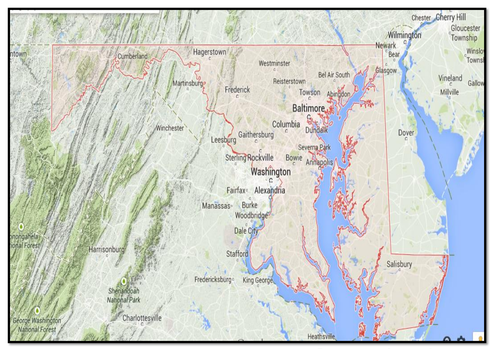

Figure 1: Terrain map of Maryland

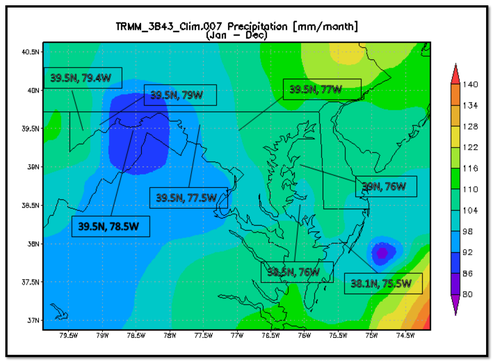

Figure 2: Precipitation climatology map of Maryland and selected points

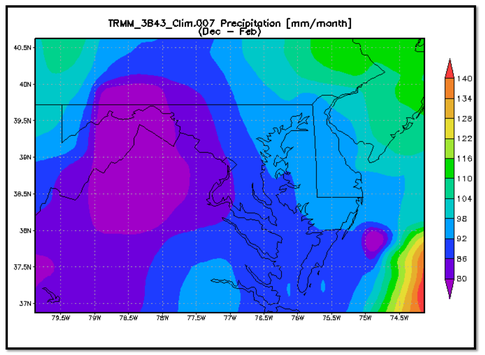

Figure 3: Precipitation climatology map of Maryland during the winter

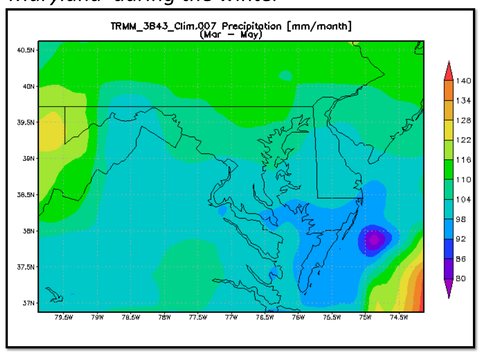

Figure 4: Precipitation climatology map of Maryland during the spring

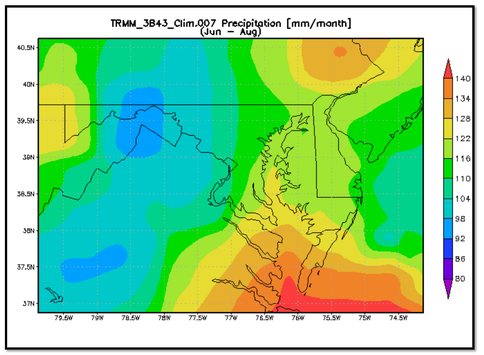

Figure 5: Precipitation climatology map of Maryland during the summer

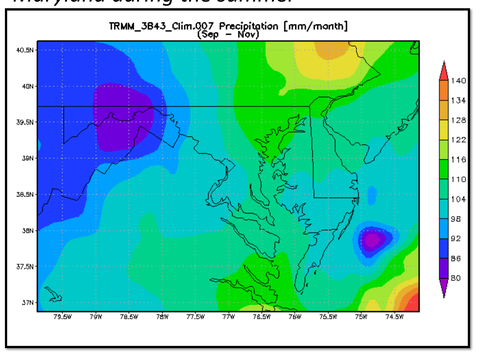

Figure 6: Precipitation climatology map of Maryland during the fall

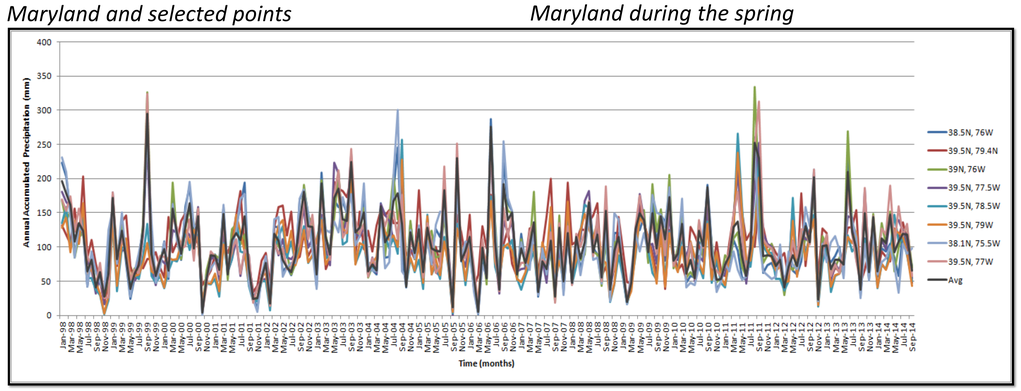

Figure 7: Time series of monthly precipitation (mm) for the selected points (Fig. 2) in Maryland from 1998-2014

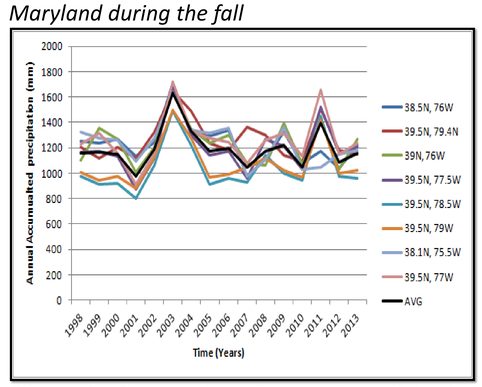

Figure 8: Time series of annual precipitation (mm) for the selected points (Fig. 2) in Maryland

III. Results

In each part of the procedure previously stated, different results and visuals were provided. Figure 1, the Terrain Map, shows the attributes of the state of Maryland that could possibly contribute to changes in precipitation. Those characteristics include: the Appalachian Mountains running through the panhandle (can obstruct cold fronts) and also the fact that Maryland is partially coastal (exposes area to coastal weather systems). Next, using GIOVANNI TOVAS, Maryland was then visualized into a precipitation climatology map (Figure 2). Results from this map show that Maryland experiences high amount of precipitation in its more northeastern part due to the Gulf Stream influence in Summer and low amount of precipitation in the panhandle due to the Appalachians causing a rain shadow in Winter. This annual climatology map was then broken down into the respective seasons. (Figures 3-6). The results of these 4 different climatology maps show that precipitation drastically changes throughout the seasons. Furthermore, it can be seen that the summer season experiences relatively higher amount of precipitation in comparison due to the effect of the Gulf Stream systems. In the winter, it can be seen that the areas around the Appalachian Mountains experience relatively low amount of precipitation due to the effect of the rain shadow.

Figure 7 shows monthly precipitation data collected for the state of Maryland. When compared with hurricanes that had passed through the state, results show that high peaks in precipitation correspond with major hurricanes (e.g. Hurricane Floyd, Charley, Ernesto, and Irene). Furthermore, Figure 8 shows the monthly data compounded annually. Results from this graph show that Maryland experienced relatively high amount of precipitation in years 2003 and 2011 and relatively low amount precipitation in the year 2001. In addition, further calculations show the average annual precipitation in Maryland is about 1200 mm. Figure 9 shows how much precipitation hurricanes have contributed to annual precipitation. The highest contribution of precipitation (35%) occurred in 2011, possibly due to major hurricanes passing through Maryland such as Hurricane Irene. Additionally, in 2001 when Maryland was experiencing a drought, no hurricanes passed through the state. The average contribution of precipitation by hurricanes to annual precipitation is about 15%. The next figure (Figures 10) shows the average annual precipitation compared against each year's precipitation with and without precipitation contributed by hurricanes. Results show that when precipitation contributed by hurricanes is removed, most annual precipitations fall below the average. Some exceptions occur such as in year 2003, where Maryland was receiving relatively high monthly precipitation in general. Conclusions from this study show that Maryland's precipitation is affected by a number of factors. In addition, hurricanes contribute about 15% to annual precipitation. This result was later shown to affect annual precipitation so much so that if removed, annual precipitation in Maryland would fall below the average. As a result, one could conclude that precipitation contributed by hurricanes does affect Maryland's precipitation.

Hurricane rainfall can be affected by track and intensity as well as other factors (i.e. terrain, interaction with mid-latitude synoptic systems, etc.). It is not clear about the connection between climate change and hurricane or tropical cyclone activity, especially in Maryland. Few studies have shown that the intensity and track of hurricanes may be affected by global climate change, such as a rise in surface and atmospheric temperatures correlates to a rise in hurricane intensity. Though these studies do show some sort of evidence to this, the correlation is rather loose and other papers on this topic are very limited and inconclusive. Nonetheless, further studies are needed to track how much precipitation hurricanes contribute over time on a global scale as well as to better understand hurricane activity associated with climate change.

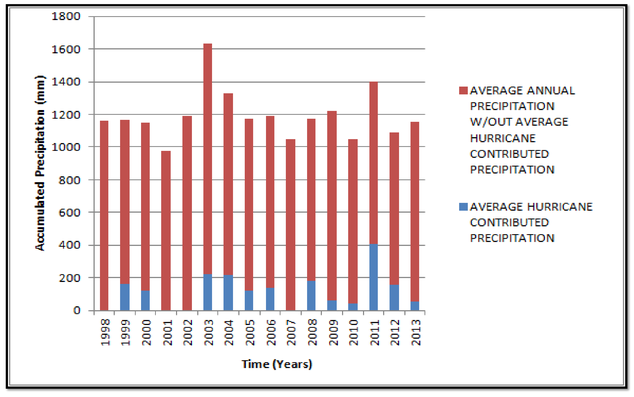

Figure 9 Time series of average annual precipitation with average hurricane contributed precipitation highlighted

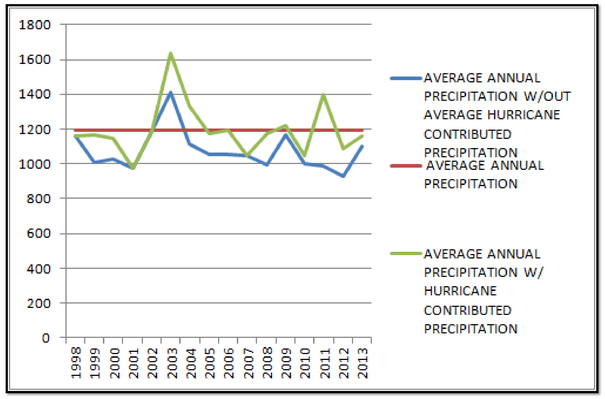

Figure 10: Average annual precipitation compared against annual precipitation with and without hurricane contributed precipitation

Acknowledgements: The NASA GES DISC Giovanni online visualization and analysis tool (http://giovanni.gsfc.nasa.gov) and NASA TRMM multi-satellite precipitation products archived and distributed by the GES DISC (http://disc.gsfc.nasa.gov).