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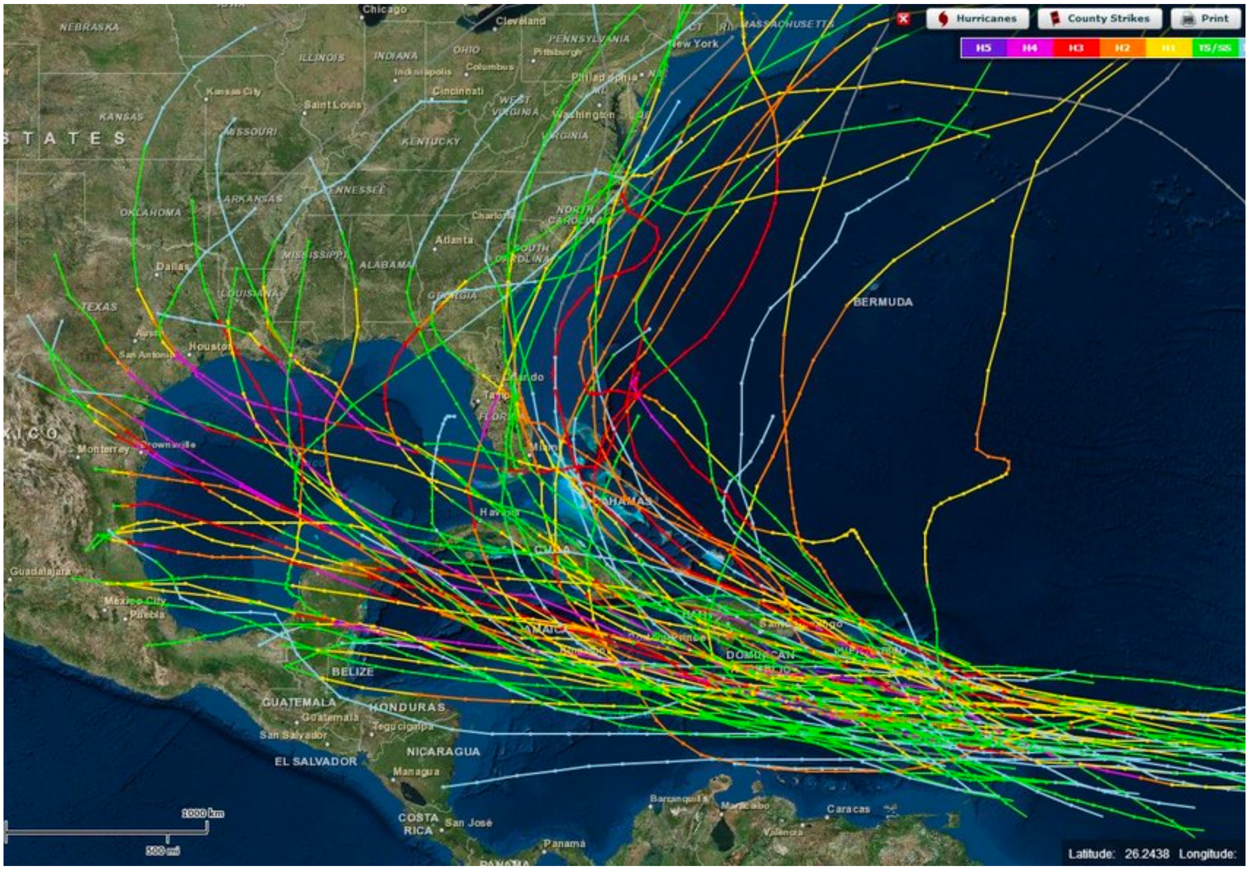

Power in Preparedness:

Determining the Most Vulnerable Communities in Hurricane Zones

HSR.health

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Power in Preparedness: Determining the Most Vulnerable Communities in Hurricane Zones

The HSR.*health* Hurricane Health Risk Index proactively addresses health and medical needs due to hurricanes, aiding emergency response efforts, resource allocation, and policy decisions.

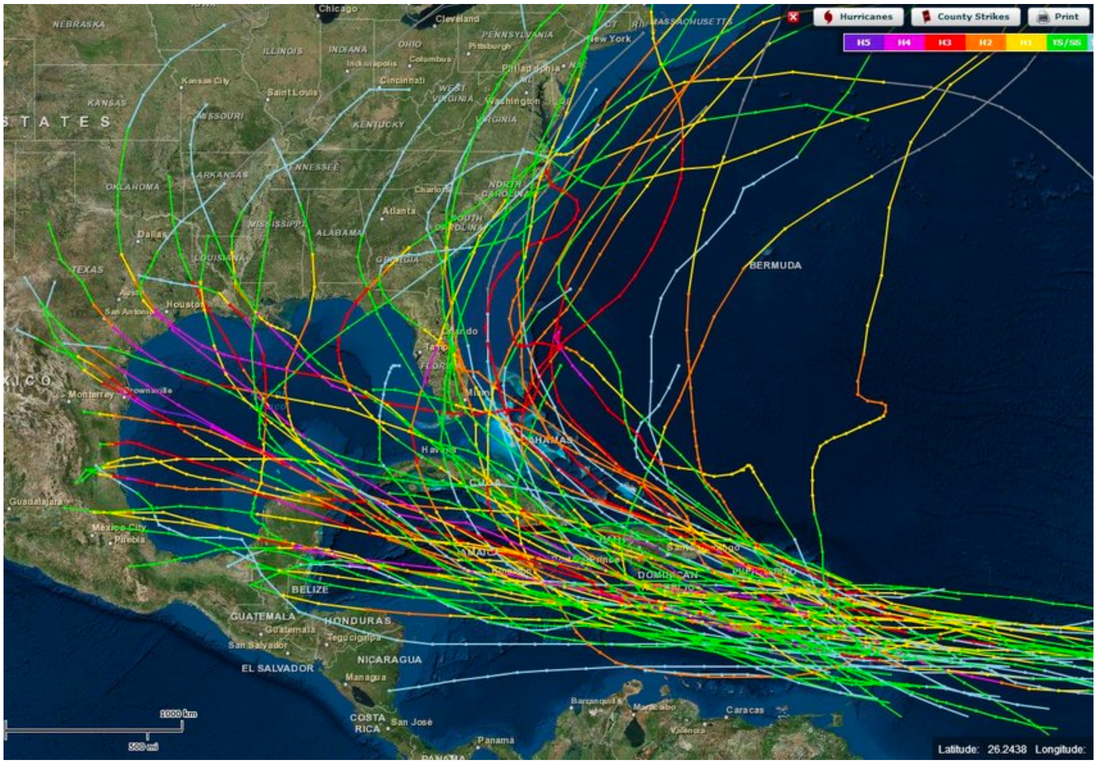

Figure 1: Historic track records of major hurricanes in the Western Atlantic Americas (NOAA, 2017).

Introduction

Despite the Caribbean's miniscule greenhouse gas emissions that contribute to climate change, the United Nations considers the Island Nations to be "ground zero" for the global climate emergency. The Caribbean islands are among the most vulnerable to the effects of climate change due to their geographical nature - they are low lying islands surrounded by water - and are more vulnerable to dramatic increases in sea-level, increased frequency of extreme weather events such as hurricanes, increased rainfall and flooding, dangerous high temperatures, coastal erosion, stormwater surges, saltwater intrusion, longer dry seasons, and shorter wet seasons. There is some concern that these effects could combine to eventually make the islands inhabitable.[1]

In particular, the effects of climate change have led to an increase in the number and severity of hurricanes and tropical storms in the Caribbean region. This risk is exacerbated as over half of the population lives within a mile of the coast. With the effects of climate change on the rise, the region is even more vulnerable to hurricanes and is experiencing a continuous increase in disastrous weather events.[2] Between 2016 and 2020, a total of nine tropical cyclones struck 21 Caribbean countries and territories, affecting 13.5 million people and causing almost $90 billion USD in economic damages.[3]

Figure 2: Hurricane Maria: Dominica 'in daze' after storm leaves island cut off from world | Dominica | The Guardian

Case Study: Three Island Nations in the Caribbean

This Hurricane Health Risk Index was piloted in three islands within the Caribbean as part of a pilot funded by the UK Hydrography Office (UKHO) and managed by the Open Geospatial Consortium (OGC), a standards setting body for the geospatial community. The pilot was a component of the Federated Marine Spatial Data Infrastructure (FMSDI) series of pilots with a goal of developing broad, cross-industry use cases for land and marine environments.

Our goal for this effort is to demonstrate our predictive health-focused geospatial decision support application that fits into the disaster response workflow and ecosystem. In addition, we extended the Hurricane Health Risk Index to include the impact of storm surges, as they are a common component of ocean storms and especially harmful for island nations and low-lying coastal areas.

Island Nations Included within Case Study Area

The island nations included within this pilot include Anguilla, the Commonwealth of Dominica and the Bahamas.

Anguilla

Anguilla is a small, 35-square mile island nation home to nearly 16,200 people.[4] Hurricanes Maria and Irma in 2017 severely impacted housing and infrastructure with 90% of housing and 42% of structures sustaining damage along with prolonged power outages due to fallen electric poles. The damages resulted in an estimated $290 million USD.[5]

Figure 3: The World Atlas

The Commonwealth of Dominica

Commonwealth of Dominica Consulate

The Commonwealth of Dominica is a small island nation covering 750 square kilometers, characterized by dense rainforests and an uneven, rugged, volcanic terrain.[7] Hurricane Maria in 2017 caused widespread devastation, impacting over 80% of the population and damaging over 90% of roofs. The island incurred around $931 million USD in losses, equivalent to 224% of its 2016 GDP.[8] Six years later, many residents still have unrepaired homes, as recovery remains incomplete.[9]

Figure 4: The World Atlas

The Commonwealth of The Bahamas

The Commonwealth of The Bahamas, known simply as the Bahamas, is composed of more than 700 low-lying islands and cays and its location (north of Cuba and Haiti and east of Florida) makes the island more vulnerable to hurricanes than any other island in the Caribbean.[6] Over the past years, the Bahamas has suffered from severe hurricanes, notably hurricane Dorian in 2019. It resulted in $2.5 billion USD worth of damage, devastating critical infrastructure including hospitals, schools, and fisheries, and rendering nearly 3000 homes unlivable.[2]

Figure 5: The Bahamas

The Hurricane Health Risk Index

We have created a Hurricane Health Risk Index to identify a priori the health and medical needs of the population impacted by a hurricane. In this Case Study, we have extended this index to include storm surge conditions. The Hurricane Health Risk Index provides emergency response managers and first responders the necessary decision support guidance to aid response, resource allocation, and evacuation efforts.

This aids in effective resource allocation, emergency team deployment, speeds medical response to populations at need – especially the most vulnerable. In addition, this information can inform policy, economic development, city/urban planning, and land use decisions for hurricane impacted areas - especially including areas at high risk and vulnerability to hurricane-strength storm conditions.

Data Curation

The Hurricane Health Risk Index is based on social and environmental determinants of health, population demographics, as well as the underlying health conditions of the population. Data was curated from authoritative government and intergovernmental sources, such as census departments, global public health organizations, as well as several marine data repositories housing information on the Caribbean. These data sources were analyzed to identify how the included data fields can inform emergency response to natural disasters as well as more general public health use cases.

Hurricane Health Risk Index Visualization

The risk index appears as a thematic map (as shown in Figures 6-10 below) on a geospatial layer identifying the risk level from Very Low Risk to Extreme Risk. The risk scale can be adapted to meet user needs.

This layer can be access from our patented GeoMD Platform through either the Esri AcrGIS Server environment or the GeoNode/GeoServer open source stack.

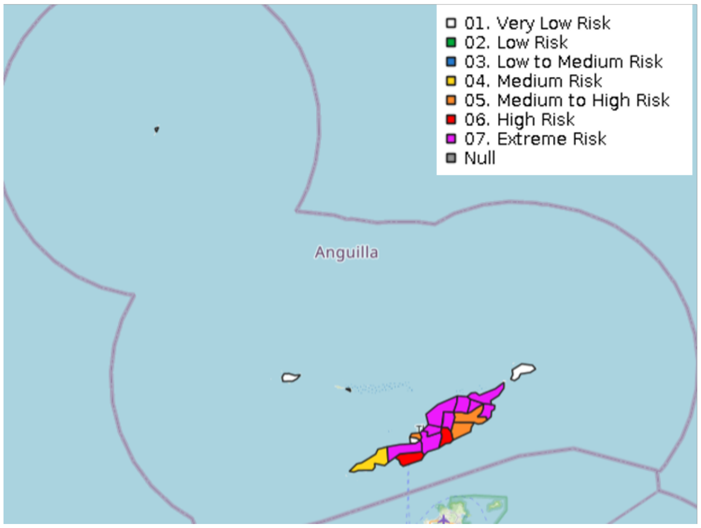

Figure 6: Hurricane Health Risk Index for Angiulla.

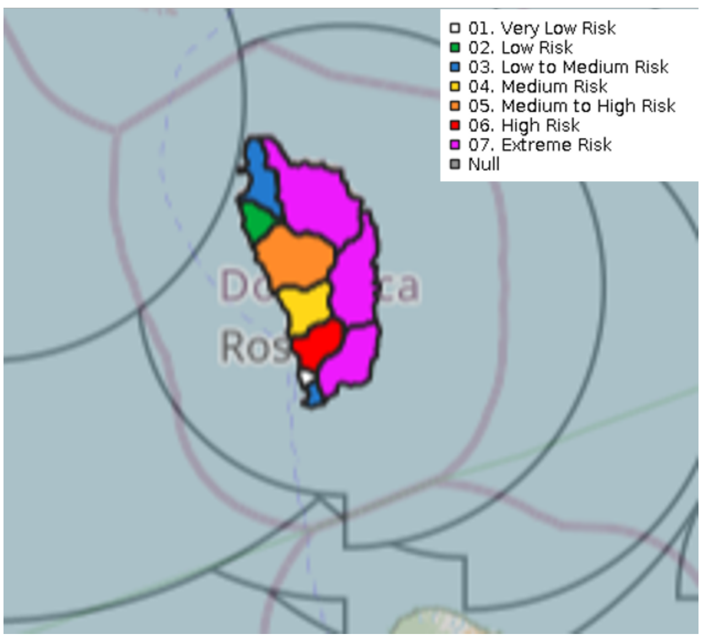

Figure 7: Hurricane Health Risk Index for the Commonwealth of the Dominica.

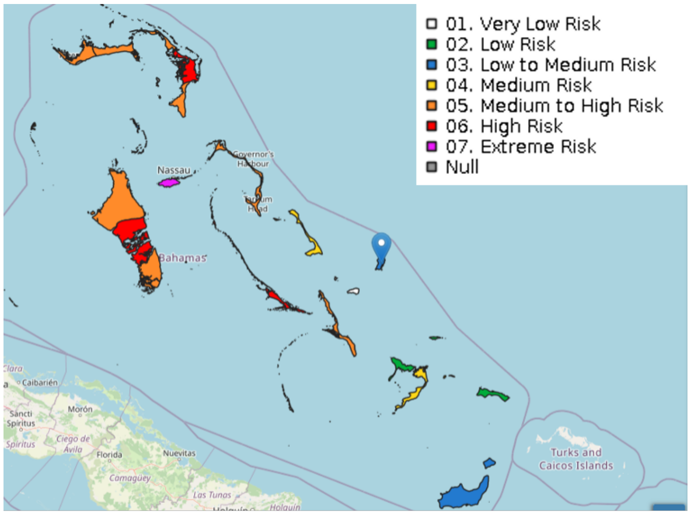

Figure 8: Hurricane Health Risk Index for the Bahamas.

The Risk Index identifies the underlying factors that inform the risk level, as shown for the selected location for the Bahamas in Figure 9 below. These factors can also be identified in natural language.

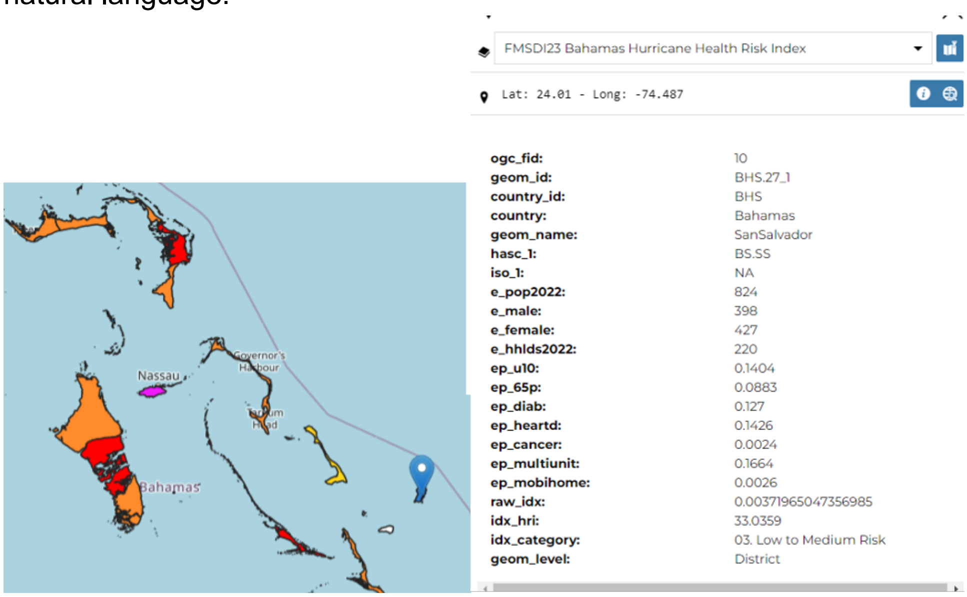

Figure 9: Risk factors for Hurricane Risk Index for a selected location within the Bahamas.

Emergency response managers can superimpose the cone of uncertainty or expected storm path of a hurricane to identify the communities at the greatest risk from that particular storm, as shown in Figure 10.

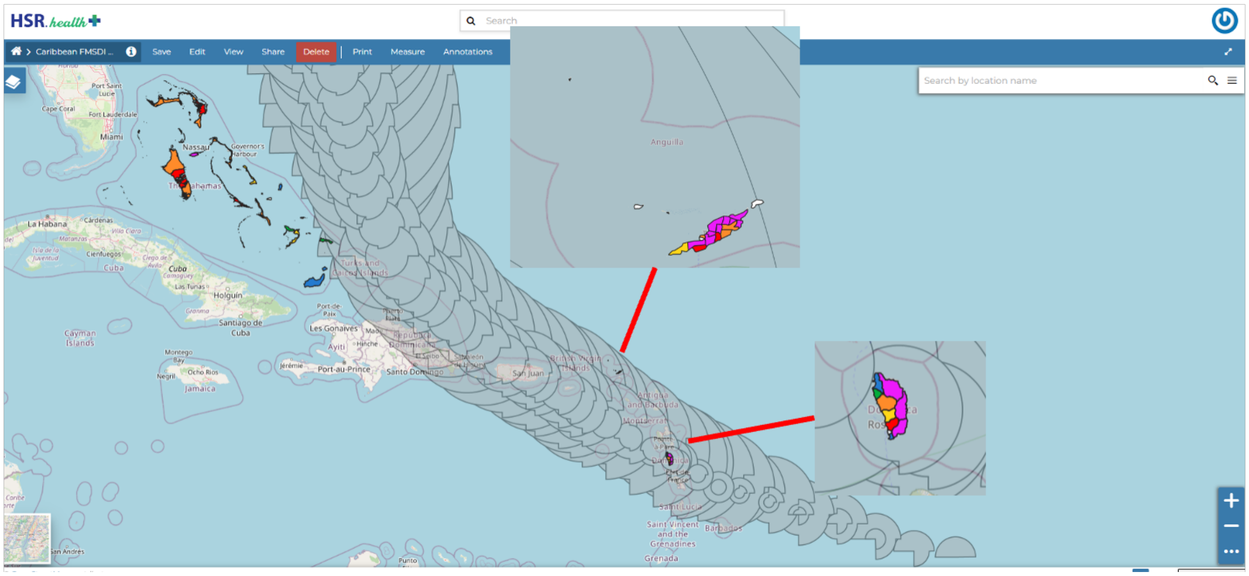

Figure 10: Hurricane Maria storm path layered on top of Hurricane Health Risk Index for the island nations included in the case study.

Storm Surge

In addition to identifying risks from hurricanes, the integration with a storm surge indicator, as shown in Figure 11, provides a more comprehensive view of the potential risk to ocean storms overall. The storm surge indicator was produced by partner [Global Geo-Intelligence Solutions, Ltd](#).

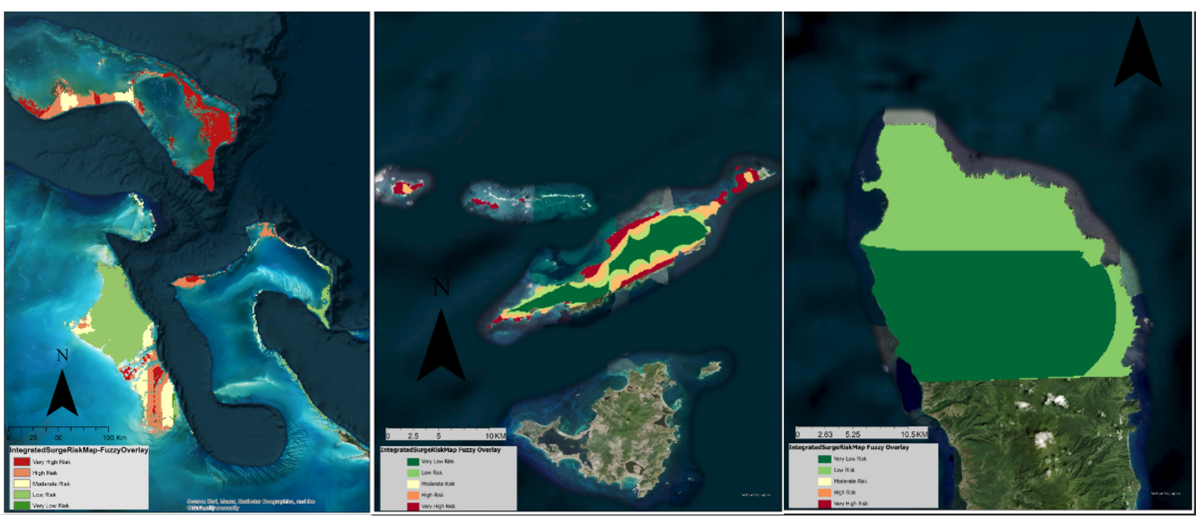

Figure 11: Storm surge indicator for the Bahamas (left), Anguilla (center), and the Commonwealth of Dominica (right).

Future Work

This pilot effort is completed and a [video demonstration](#) of this case study has been produced, and the results will be presented at the [Meso American & Caribbean Sea Hydrographic Council](#)

24 (MACHC24) conference in Paramaribo, Suriname of December 14th. Plans for potential future work include the following.

Generative AI

We are adding a generative AI-based conversational front end to the Hurricane Health Risk Index to make the insights available more broadly and without the need for coding or data analysis skills.

Figure 12 shows the high-risk regions within Camden County, Georgia for Hurricane Dorian. A past hurricane is used in this example, however, for a current storm, the system will download the latest data from the appropriate authorities, perform the calculation of the risk index and provide the result – which can be on a map, text-based, graphical, or in any user defined format.

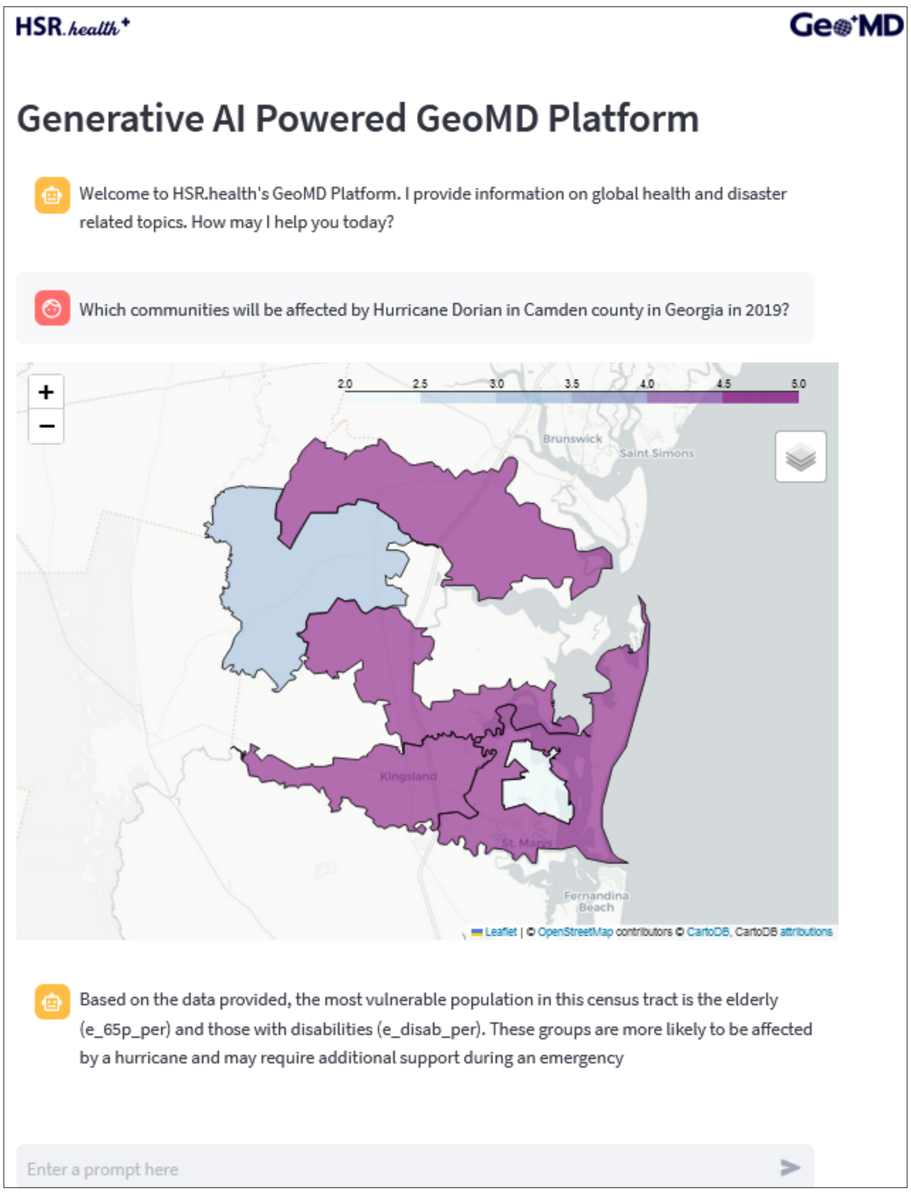

Figure 12: Generative AI front end for the Hurricane Health Risk Index.

Expand of Spatial Scope

We look forward to work with the UKHO as well as governments throughout the Caribbean to expand this case study to deploy the Hurricane Health Risk Index to all island nations as well as all nations with low lying coastal areas that lie along the paths of hurricanes and ocean storms.

Increase Data Granularity

One issue encountered was the lack of availability of granular data regarding certain social determinants of health. For these specific indicators, we used national level data. The granularity of the data influences the granularity of the ultimate risk index.

Conclusion

We thank the UKHO and the OGC for conducting this pilot and the opportunity it provided to further the development of our Hurricane Health Risk Index as well as to extend the index to include storm surge considerations.

The combined and improved risk index can provide great value to nations in pre-disaster planning, speeding response efforts through actionable guidance, as well as aid post-disaster recovery efforts.

The additional of a generative AI-based front end that allows a conversational series of queries will broaden the audience for the risk index as well as make it easier to ingest its insights. We look forward to demonstrating this component in future pilots.

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