**Gulf of México Transportation & Infrastructure**

*Evaluating the Potential of CYGNSS Wind Data to Assess Tropical Storm Impacts on Energy Infrastructure in the Gulf of México*

**VPS Title:** Tropical Impacts: A Look Through the Clouds for Energy Security

**Project Team**

***Project Team*:**

Shelby Ingram, singram2@alumni.unca.edu

Jada Blankenship

Michelle De Luna

Essence Raphael

***Advisors & Mentors*:**

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Dr. Robert Griffin (University of Alabama in Huntsville)

Dr. John Mecikalski (University of Alabama in Huntsville)

Dr. Xuanli Li (University of Alabama in Huntsville)

Maggi Klug (University of Alabama in Huntsville)

Leigh Sinclair (University of Alabama in Huntsville, Information Technology and Systems Center)

**Project Overview**

***Project Synopsis*:** This project assessed the impact of tropical storm systems on energy infrastructure within the Gulf of México (GoM). The project uses wind and wave data from the Cyclone Global Navigation Satellite System and the National Oceanic and Atmospheric Administration’s WaveWatch III, respectively, to map and identify areas of increased susceptibility to storm damage on the Outer Continental Shelf of the GoM. The final products are valuable tools that assist the Bureau of Ocean Energy Management with assessing and monitoring the environmental safety of mineral extraction infrastructure in the GoM.

***Abstract*:**

In recent years, the Gulf of México (GoM) has gained national attention for its significant contributions to the country’s overall oil supply – the area today accounts for 17% of all US oil production. The production and availability of such oil resources is threatened when tropical storm systems enter the GoM. Oil and natural gas rigs, transportation pipelines, processing plants, and other energy infrastructure in the expected path of a tropical storm are often shut down, effectively halting production. In an effort to assess and mitigate the impact of tropical storms on such infrastructure, the fall 2018 NASA DEVELOP Gulf of México Transportation and Infrastructure team partnered with the Bureau of Ocean Energy Management (BOEM) to analyze the dynamics of wind and wave-intensity during tropical storm events. The team created maps of wind and wave conditions using data collected by the Cyclone Global Navigation Satellite System (CYGNSS) constellation and the National Oceanic and Atmospheric Administration’s (NOAA) WaveWatch III (WW3). The project compared and validated CYGNSS measurements using Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) and NOAA’s National Data Buoy Center (NDBC) wind data. The team found that CYGNSS wind speeds have an average error of 2.3247ms-1 for randomized days of March through August 2018 when compared to buoy data. This information can assist BOEM in identifying possible impacts to energy infrastructure during tropical storm events and provide guidance for future infrastructure placement sites.

**Keywords:**

WaveWatch III, MERRA-2, oil, oil rigs, tropical cyclone, tropical storm, Outer Continental Shelf

***National Application Areas Addressed:*** Transportation & Infrastructure, Energy

***Study Location:*** The Gulf of México bordered by: AL, FL, LA, MS, & TX

***Study Period:*** March 2018 – September 2018

***Community Concern:***

* The GoM is one of the major energy source regions for the US; according to the US Energy Information Administration, federal offshore oil production in the GoM accounts for 17% of US crude oil production.
* Between 2% to 4% of offshore oil and gas structures exposed to hurricane force winds in the GoM experienced catastrophic failure and destruction while 3% to 6% experience extensive damage.
* The damage and disruption in energy production caused by tropical storm systems can have impacts on the environment and economy.
* During Hurricane Michael (2018), 670,831 barrels of oil per day were shut-in and 726 million cubic feet per day of gas were shut-in.
* Following Hurricane Nate (Oct. 2017), 19.6% of the oil production and 12.4% of the natural gas production in federal areas of the GoM were shut-in or producing less than capable.
* Following Hurricanes Katrina and Rita (2005) hazardous materials were released from oil and gas production facilities offshore into the GoM.

***Project Objectives:***

* Assess the wind and wave environment in the GoM during tropical storm systems
* Predict trends in wave height and wind speed through a potential storm intensity analysis
* Calculate the correlation between wind speed categorized by the Beaufort wind force scale and wave height categorized by the Douglas Sea Scale
* Compare the wind measurements from CYGNSS, MERRA-2, and the NOAA buoy network to assess the accuracy of CYGNSS wind data
* Assess the risk posed to energy infrastructure in the Gulf of México by wind and waves

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Bureau of Ocean Energy Management, Gulf of México Outer Continental Shelf Region, Office of Environment** | Greg Kozlowski, Deputy Regional Supervisor | End User | No |

***Decision Making Practices & Policies***:

The BOEM, Gulf of México Outer Continental Shelf Region, Office of Environment is responsible for monitoring, assessing, and reporting on the environmental impacts of mineral extraction in the GoM. BOEM’s Office of Environment also plans new energy development areas and monitors conditions after leases are given. The Office of Environment ensures that federal policies are continually followed in its leasing areas. BOEM studies rely primarily on *in situ* measurements and in-person assessments. In the past, the organization used remote sensing techniques to analyze natural seeps in the GoM.

***Project Benefit to End User***:

This project has the potential to assist BOEM in conducting their National Environmental Policy Act (NEPA) analyses. These analyses assess the potential for environmental impacts due to the risks posed by tropical systems to offshore energy production and coastal infrastructure in the GoM. A survey of wind speeds and wave heights produced by tropical storms in the region will support the development of models for future storm impacts and improved storm surge analysis.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **CYGNSS** | Wind speed | The wind speed product derived from CYGNSS was combined with altimetry and ancillary datasets to illustrate risk to energy infrastructure. |

***Ancillary Datasets:***

BOEM Geographic Mapping Data – locations of energy infrastructure in the Gulf

U.S. Energy Information Administration – view energy infrastructure impacts

NOAA National Data Buoy Center Observation Data – GoM weather data measured from buoys to compare to CYGNSS and MERRA-2 wind speed data

NASA Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) Atmospheric Reanalysis 2 – compare to wind speed from CYGNSS

NOAA WaveWatch III – significant wave height

***Software & Scripting:***

MATLAB – statistical analysis

Esri ArcMap – raster manipulation and analysis, imagery processing, and map production

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Potential Storm Intensity Analysis**  | CYGNSS | This product provides insight into severe weather trends in the GoM so BOEM can better prepare for storms. This assists in identifying areas of low risk for placement of new infrastructure. | N/A |
| **CYGNSS and MERRA-2 Wind Speed Comparison**  | CYGNSS | This product helps the partner decide which data product type could be useful in research of severe weather that may result in damage to infrastructure.  | N/A |
| **Potential Infrastructure Risk Maps** | CYGNSS | This product provides BOEM with another tool for assessing the risk to energy infrastructure within the GoM due to severe weather and the type of infrastructure damage that may impact the environment.  | N/A |
| **CYGNSS Tutorial** | CYGNSS | This product provides the partner with a step-by-step guide to subsetting, downloading, and processing wind speed data collected by the CYGNSS constellation. | N/A |
| **MERRA-2 Tutorial** | N/A | This product describes the steps BOEM would need to complete in order to download and process MERRA-2 wind speed data using the northward and eastward wind speed components. | N/A |

**Project Handoff Package**

**Transition Plan:**

At the end of the term, end products and results were disseminated to the project partner through Google Drive. Additionally, a web conference was conducted. During this meeting, the team gave a presentation of the results and answered any questions that the partner had. This was followed by a tutorial explaining how to use the end products.

**Team POC:** Shelby Ingram, singram2@alumni.unca.edu

**Partner POC**: Greg Kozlowski, greg.kozlowski@boem.gov

**Handoff Package:**

* Project Video
* Technical Paper
* Potential Storm Intensity Analysis displaying combinations of wave heights and wind speeds
* Potential Infrastructure Risk Maps by case study and by wave height and wind speed
* Table of case study wind speed values for CYGNSS, MERRA-2 and NOAA buoy data
* A tutorial on how to access and visualize CYGNSS data
* A tutorial on how to access and calculate MERRA-2 data
* Specialized video of ArcMap steps with CYGNSS

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