# A Look Under the Hood

## How the JPL Tropical Cyclone Information System Uses Database Technologies to Present Big Data to Users

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# The JPL Tropical Cyclone Information System

- The TCIS brings together different types of data related to hurricanes:
  - Satellite Observation Data
  - Airborne Campaign Observation Data
  - Model Forecast Data
  - Simulated Instrument Data from Model Forecasts

- Our goal is to collect data to give users a full picture of what happens before, during, and after a tropical cyclone
  - Ultimately, to aid in future model improvements

# TCIS Data Portals

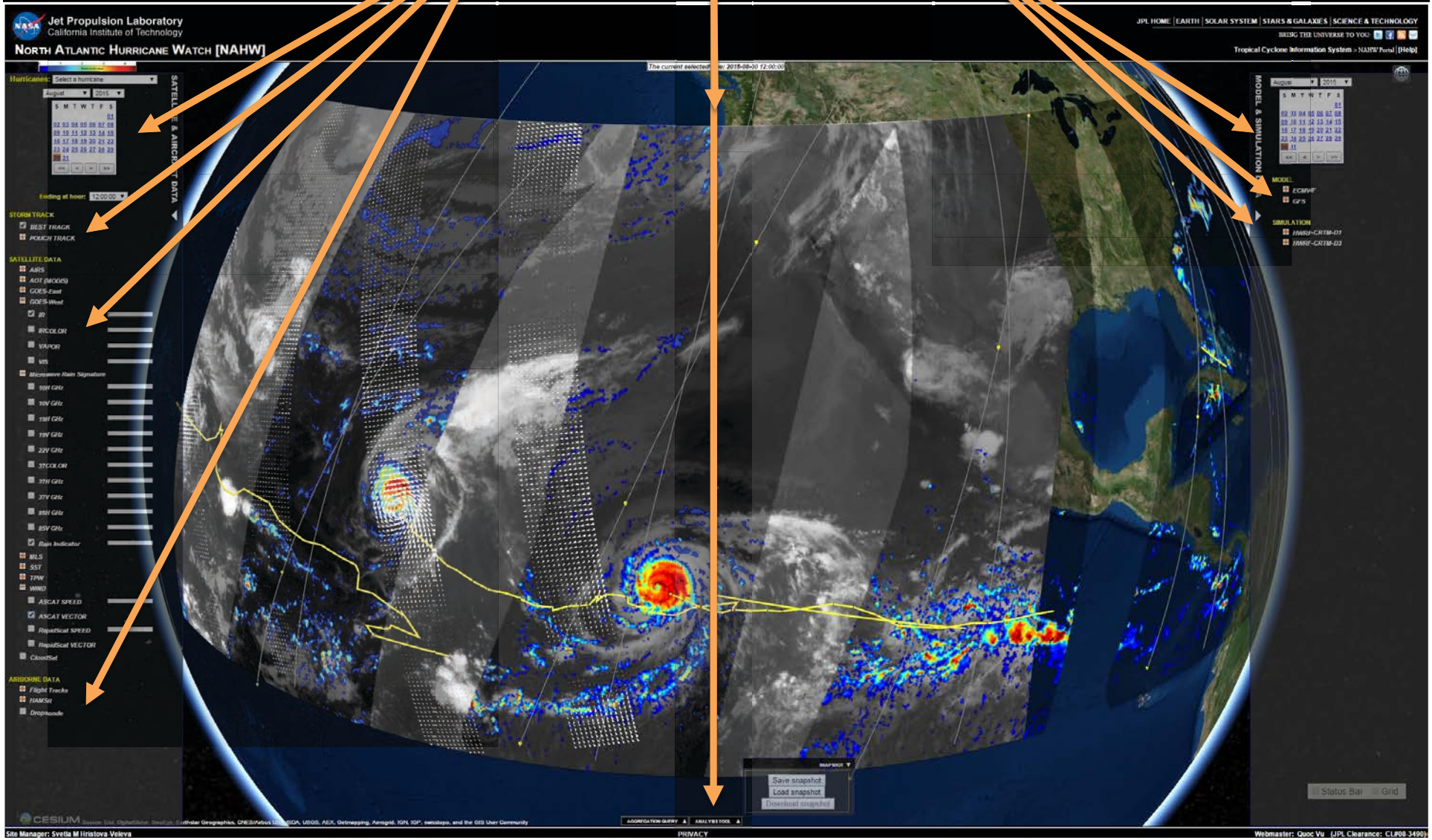
**The TCIS supports different types of data portals:**

1. Global data archive of storm-centric observations *for the creation of robust statistics*

2. Mission/Campaign specific interactive portals *for near real-time conditions and for post-campaign analyses*

# TCIS Near F ive Portals

Simulation Data Selection

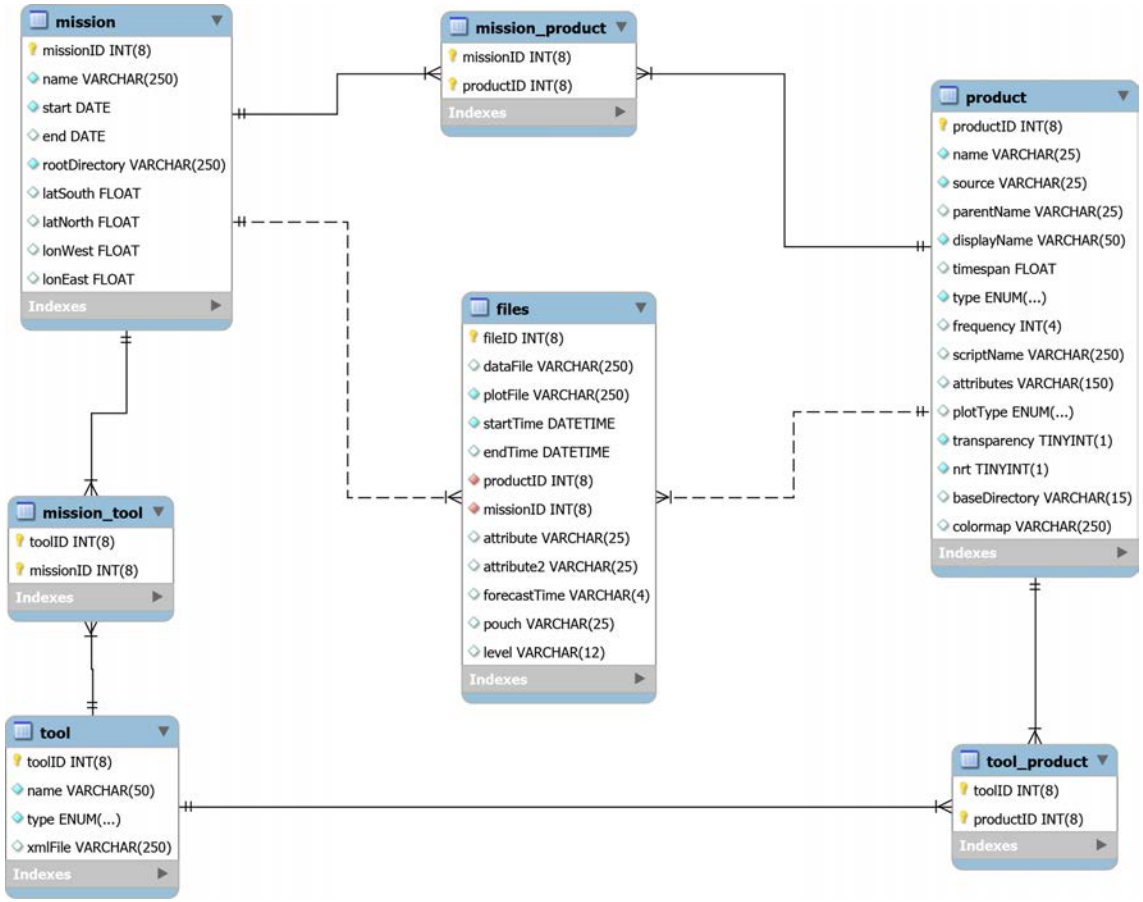



# Data File Retrieval & Database Ingestion

- Data is retrieved from data providers (e.g. a NASA DAAC) in hourly, daily, etc. intervals
- Data is subsetted and plotted to the geographical and temporal domains configured by the portal
  - Only the subsetted data and plots are stored (saves on storage)
  - Data does not have to be plotted on-the-fly (saves on user access time)
- Subsetted files and plots are ingested into the database and associated with each other
  - One plot matches with one data file
  - The MySQL database stores the metadata about the files

# NRT Portal Database Configuration

- TCIS NRT portals rely on the `campaigns` MySQL database
- The front end queries the database for all the information required to build the portal and display the plots






***Database model edited for illustrative purposes**

# Data Analysis Tools

- Some data products can be used for on-the-fly analyses

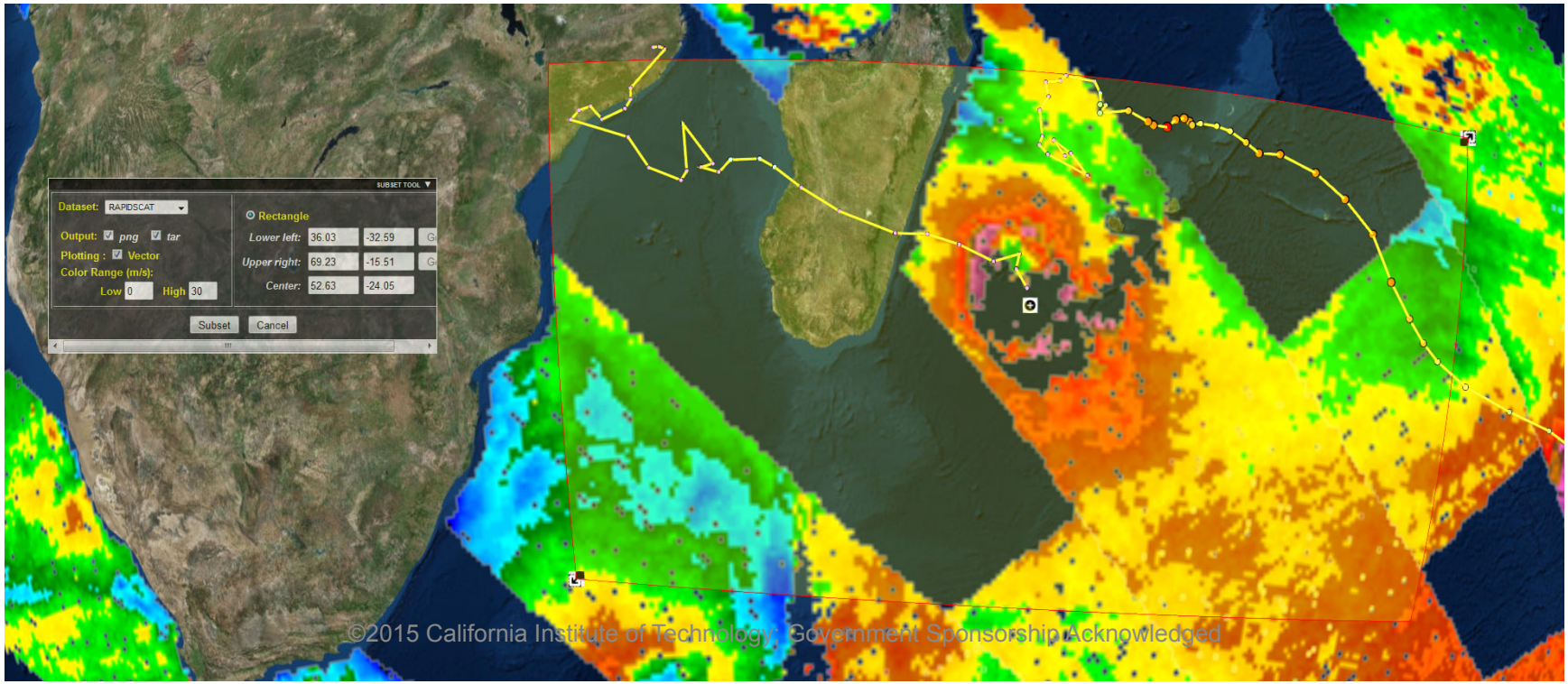
- The TCIS offers the following analysis tools:
  - Joint Probability Density Function (Joint PDF)
  - Wave Number Analysis
  - Automated Rotational Center Hurricane Eye Retrieval (ARCHER)
  - Data Cross-Section Slicer
  - Subsetting functions

# Selecting Data for Analysis

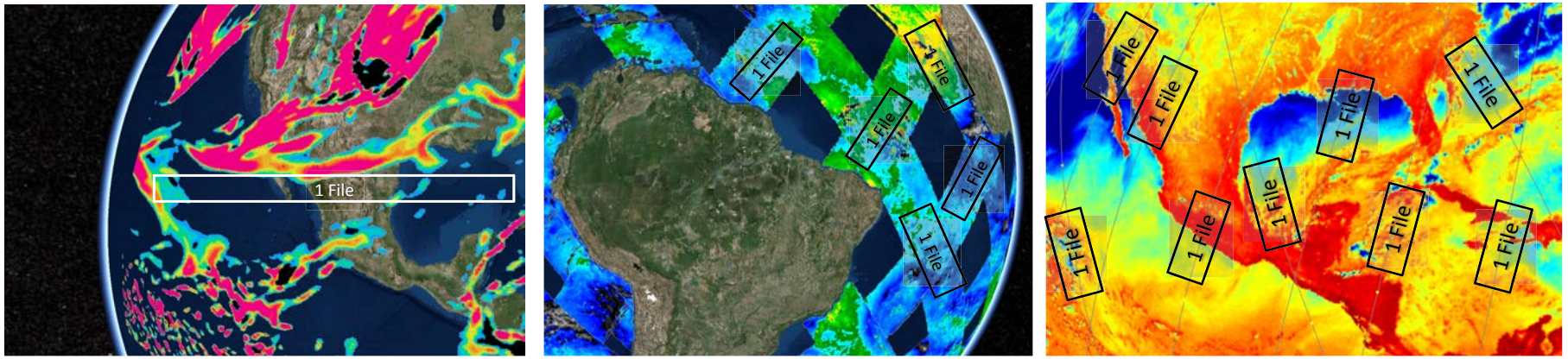
Users select portions of the plots they see on their screens

***-then-***

The analysis tool queries the database for the data files that created the selected area, finds them, runs the analysis, and return results



# Swath Data Challenge




Some data arrives to us as one daily file

***1 plot = 1 data file***

Other data comes to us in multiple (swath) files throughout the day and are made into composite images

***1 plot = X data files***


# Geospatial Search Implementation

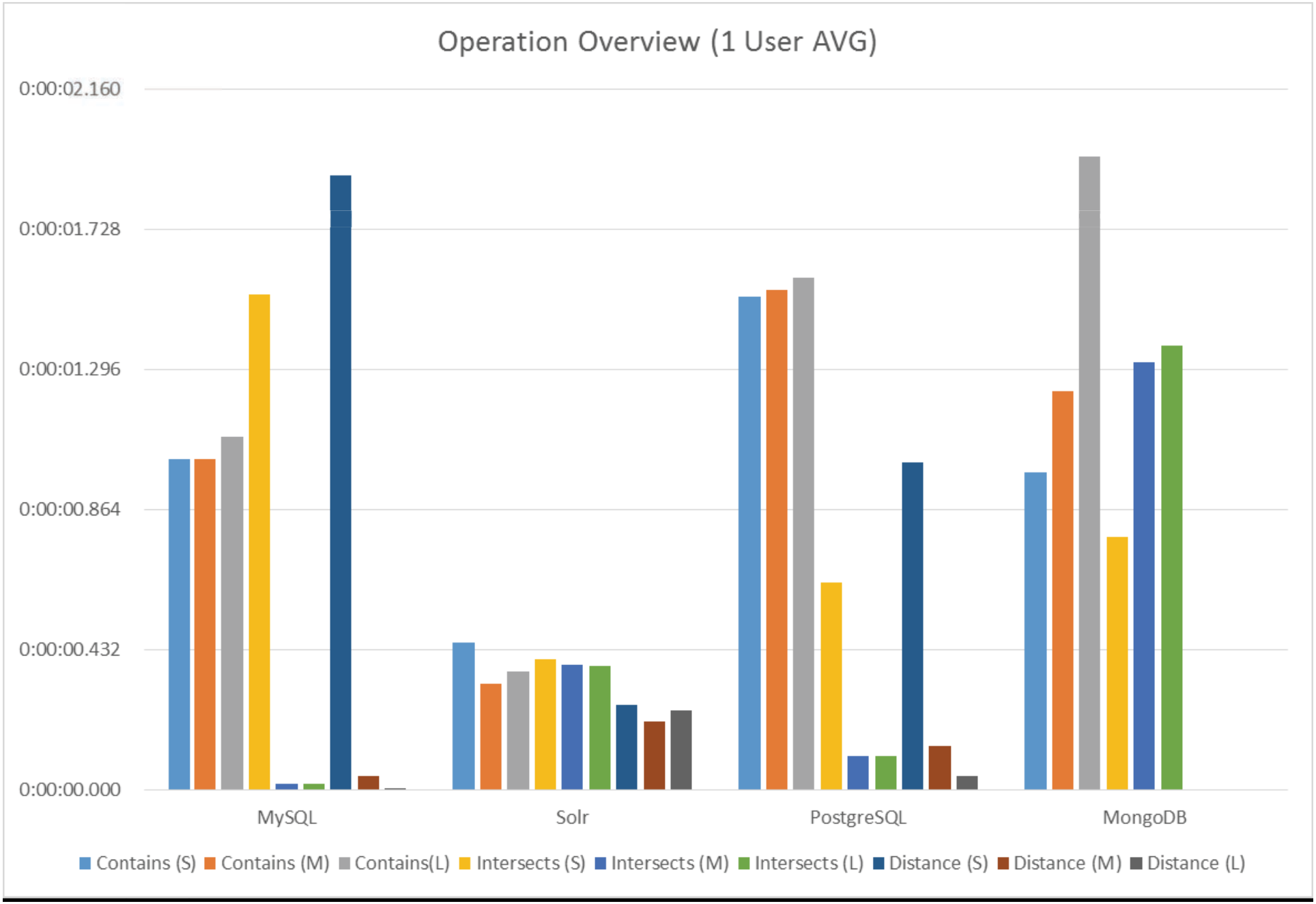
- Decided to store swath footprints in the database to make them searchable
  - Goal was to have a system that is both FAST and ACCURATE
- Developed a custom Python script to extract footprints from satellite swaths, and ingested them into the database as polygon objects
- Created a table in MySQL with geospatial keys on the footprint field so that we could have an index of them
- We noticed some issues with query inaccuracies:
  - Python footprint extractor did not always include enough points
  - MySQL v5.5 used the Minimum Bounding Rectangle (MBR) method for searches

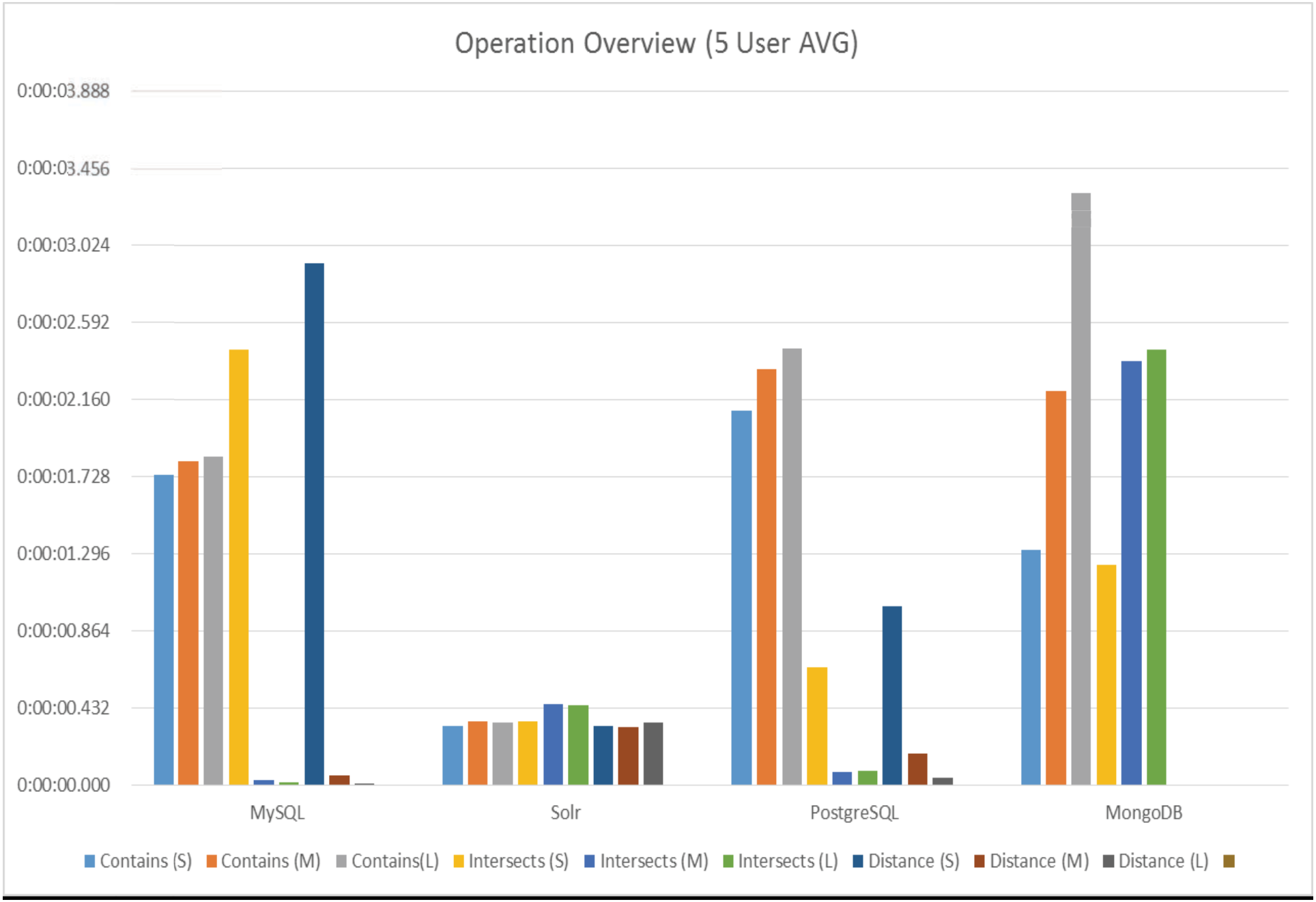
***Needed to update our database to improve query speed and accuracy***

# Database Benchmarking

- Decided to test the geospatial functions of four different DBMSes in the TCIS environment
- Worked with the NASA PO.DAAC team to integrate their L2 Footprint Generator tool to improve footprint accuracy
  - Uses WKT format
  - Easy to configure for different types of data
  - Easy to adjust number of points you need in the footprint
- Created a test data set of 2.1 million polygon object entries to run queries against in each DBMS

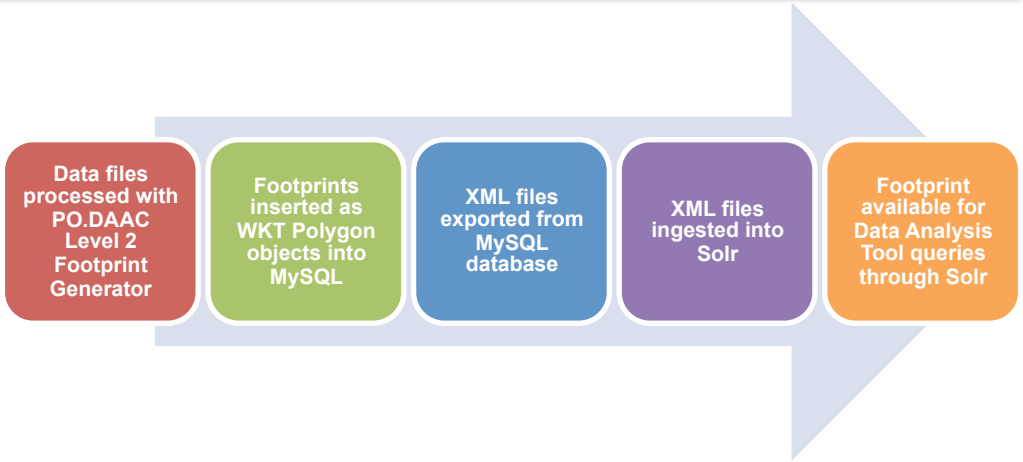
| | Entries | Disk Space (GB) | Memory (GB) | Data Length (GB) | Index Length (GB) |
|---|---|---|---|---|---|
| MySQL | 2108505 | 1.40 | 0.00 | 1.11 | 0.29 |
| Solr | 2108505 | 2.10 | 1.20 | 2.1 | N/A |
| PostgreSQL | 2108505 | 2.50 | 0.00 | 1.27 | 1.10 |
| MongoDB | 2106886 | 78.00 | 78.00 | 2.93 | 77.59 |





# Database Architecture Update

- Benchmarking tests showed that Solr was consistently the fastest tool for the data in our environment




- Moved to implement a MySQL + Solr architecture

- Needed fine tuning to make sure we were accurately storing and indexing footprints. This included:
  - Finding an optimal number of footprints points for each data set
  - Finding the optimal distance error percentage in the Solr RPT field that stored the footprints

# Future Portal Expansions

- Currently, we have three NRT portals:
  - **GRIP** Field Campaign Portal
  - **HS3** Field Campaign Portal
  - **RapidScat** Mission Portal

- Could be used for upcoming field campaigns

- Could expand portals for other campaigns and missions outside of "hurricane science"


## Website

http://tropicalcyclone.jpl.nasa.gov

## Contact

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