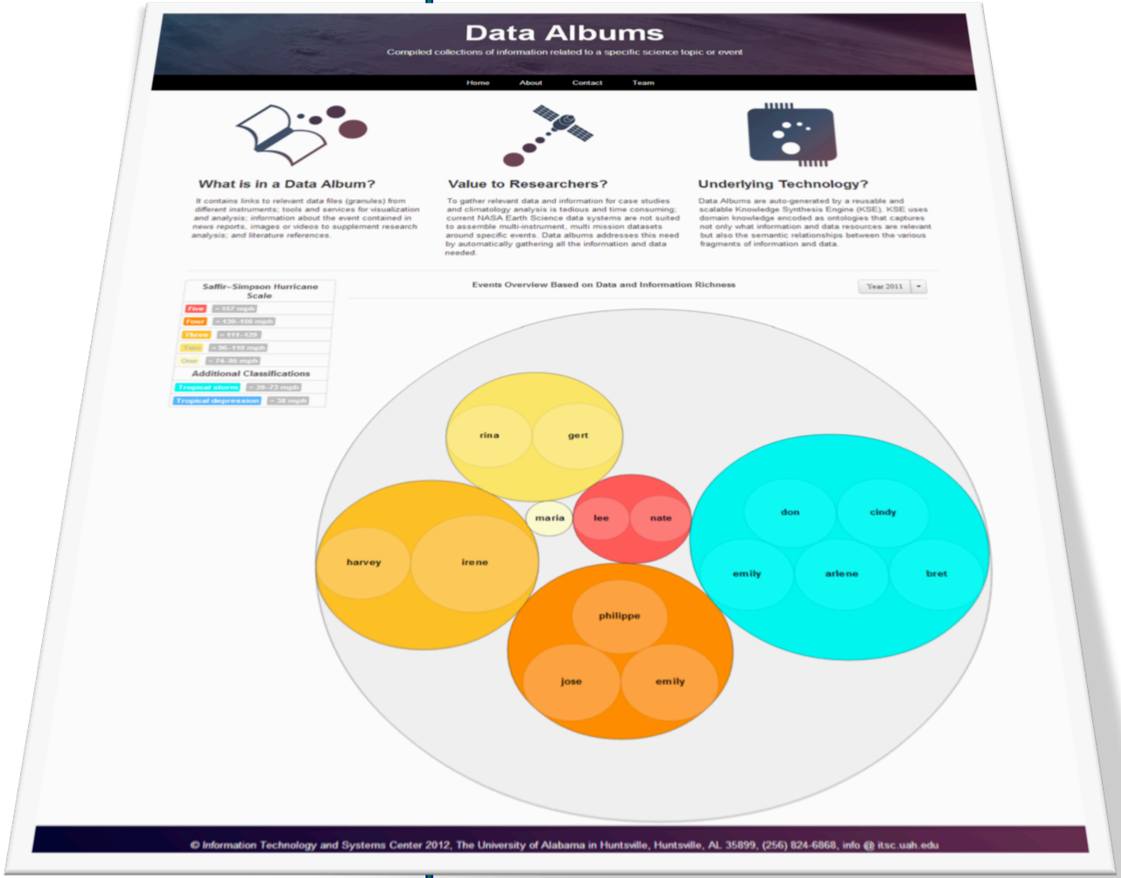
A tool for constructing data albums for significant weather events



Data Albums

Compiled collections of information related to a specific science topic or event

Home About Contact Team

What is in a Data Album?

It contains links to relevant data files (granules) from different instruments; tools and services for visualization and analysis; information about the event contained in news reports, images or videos to supplement research analysis; and literature references.

Value to Researchers?

To gather relevant data and information for case studies and climatology analysis is tedious and time consuming; current NASA Earth Science data systems are not suited to assemble multi-instrument, multi mission datasets around specific events. Data albums addresses this need by automatically gathering all the information and data needed.

Underlying Technology?

Data Albums are auto-generated by a reusable and scalable Knowledge Synthesis Engine (KSE). KSE uses domain knowledge encoded as ontologies that captures not only what information and data resources are relevant but also the semantic relationships between the various fragments of information and data.

Saffir–Simpson Hurricane Scale	
Five	157 mph
Four	130–156 mph
Three	111–129
Two	96–110 mph
One	74–95 mph
Additional Classifications	
Tropical storm	39–73 mph
Tropical depression	38 mph

Events Overview Based on Data and Information Richness

Year 2011

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itsc

UAHuntsville

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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  - Roshan Sainju (Graduated)
  - Manil Maskey (Fixer)
- Testing/Validation/ Documentation
  - Xiang Li
  - Shannon Flynn (Undergrad)

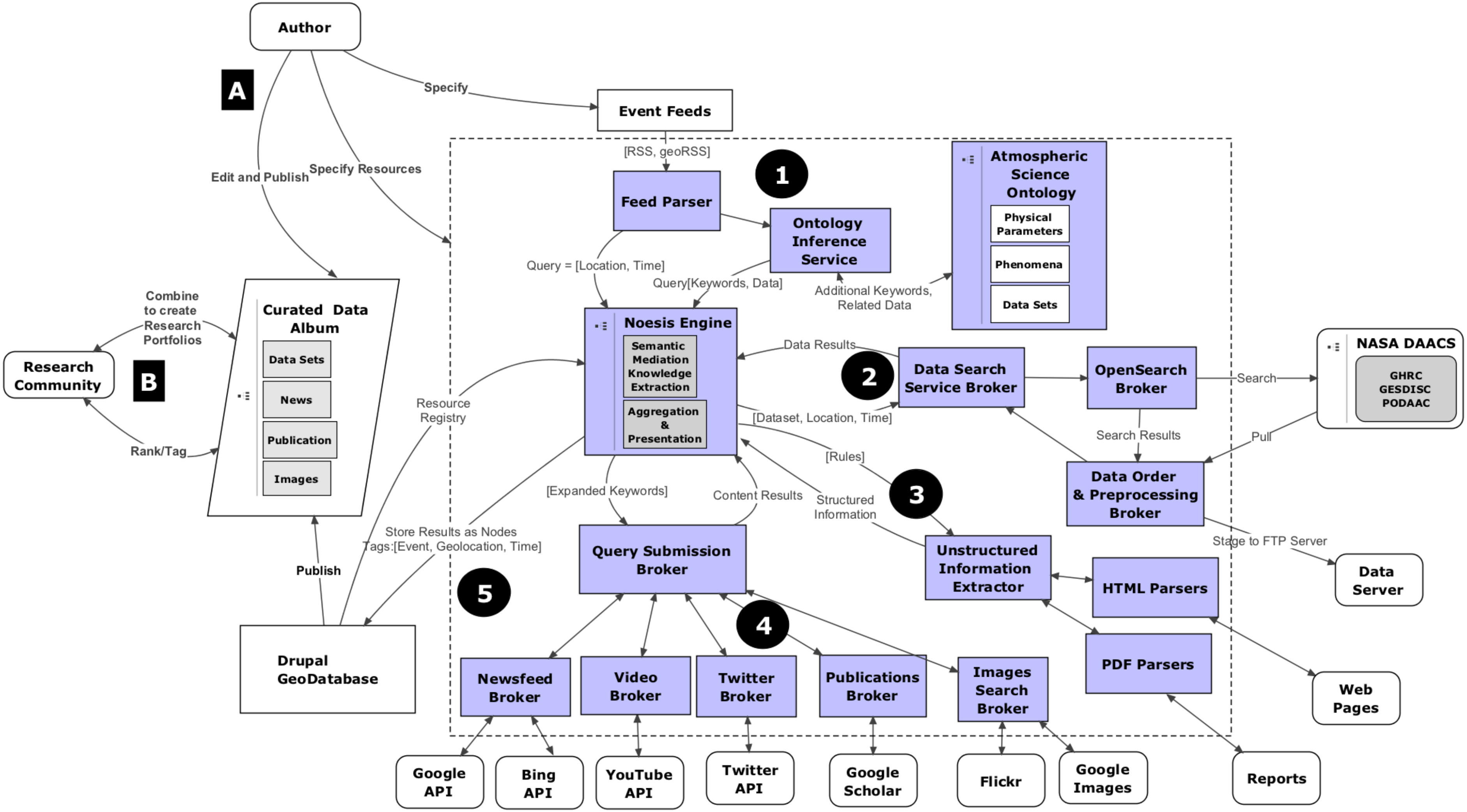
Curated Data Albums

- *Data Albums* are *compiled* collections of information related to a specific science topic or event with links to relevant data files (granules) from different instruments. Additional information include:
  - Tools and services for visualization and analysis
  - News reports, images or videos to supplement research analysis
- *Curation* provides the author of a Data Album the means to select the aggregated information

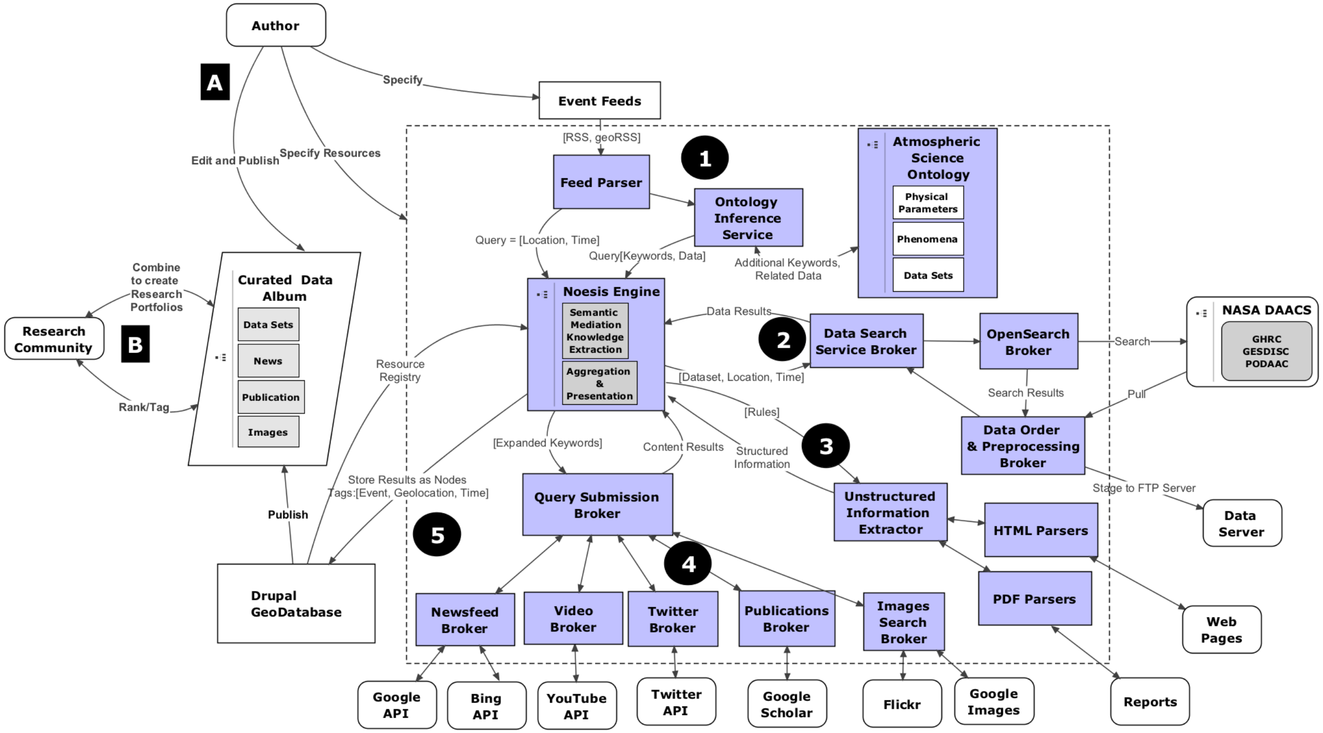
Motivation

- Case study analysis and climatology studies commonly used in Atmospheric Science research are instances where researchers studying a significant *event*:
  - Require data should be organized around the event rather than observing instruments
  - May need to discover new datasets that they would not have considered before
- Gathering relevant data and information for case studies and climatology analysis is ***tedious*** and ***time consuming***.
- Design of current Earth Science data systems assumes researchers access data primarily by instrument or geophysical parameter.
- *Need exists for tools to filter* through large volumes of online content and gather relevant information based on user's science needs.

Conceptual Information Architecture

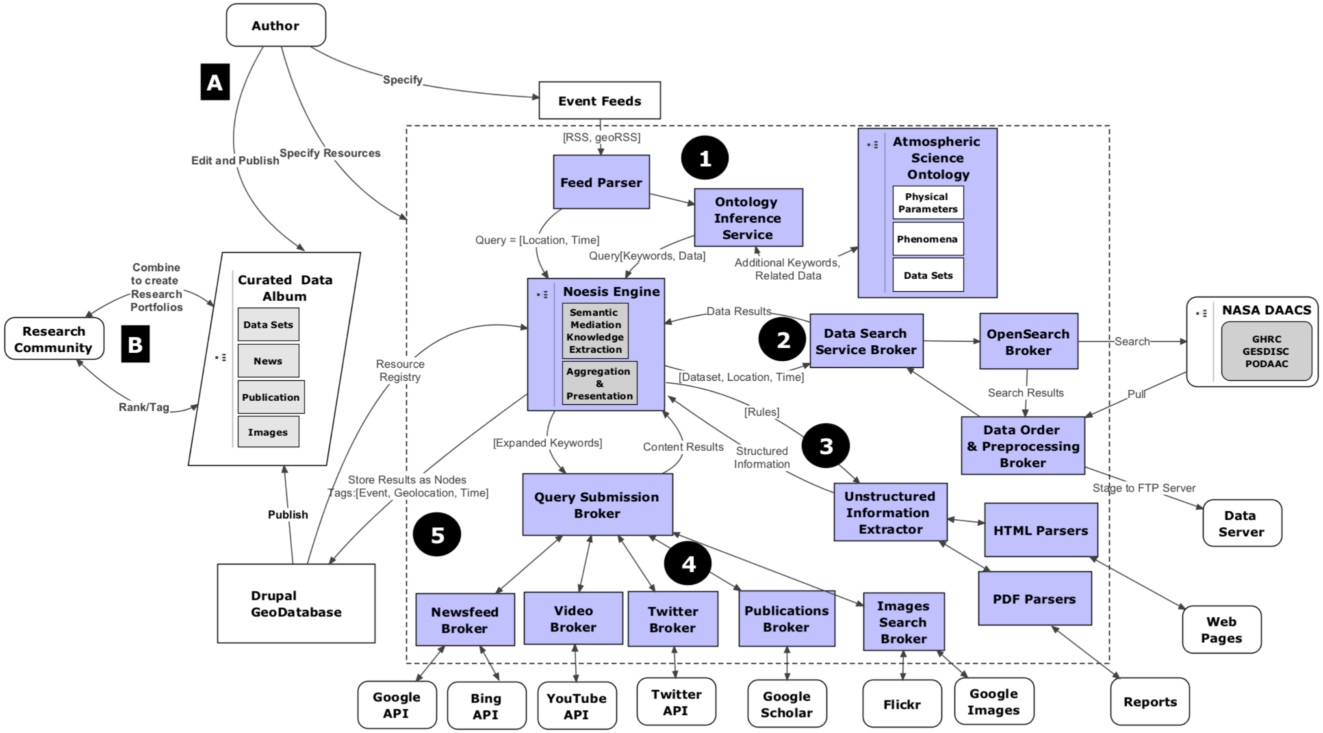


Component Interaction - 1



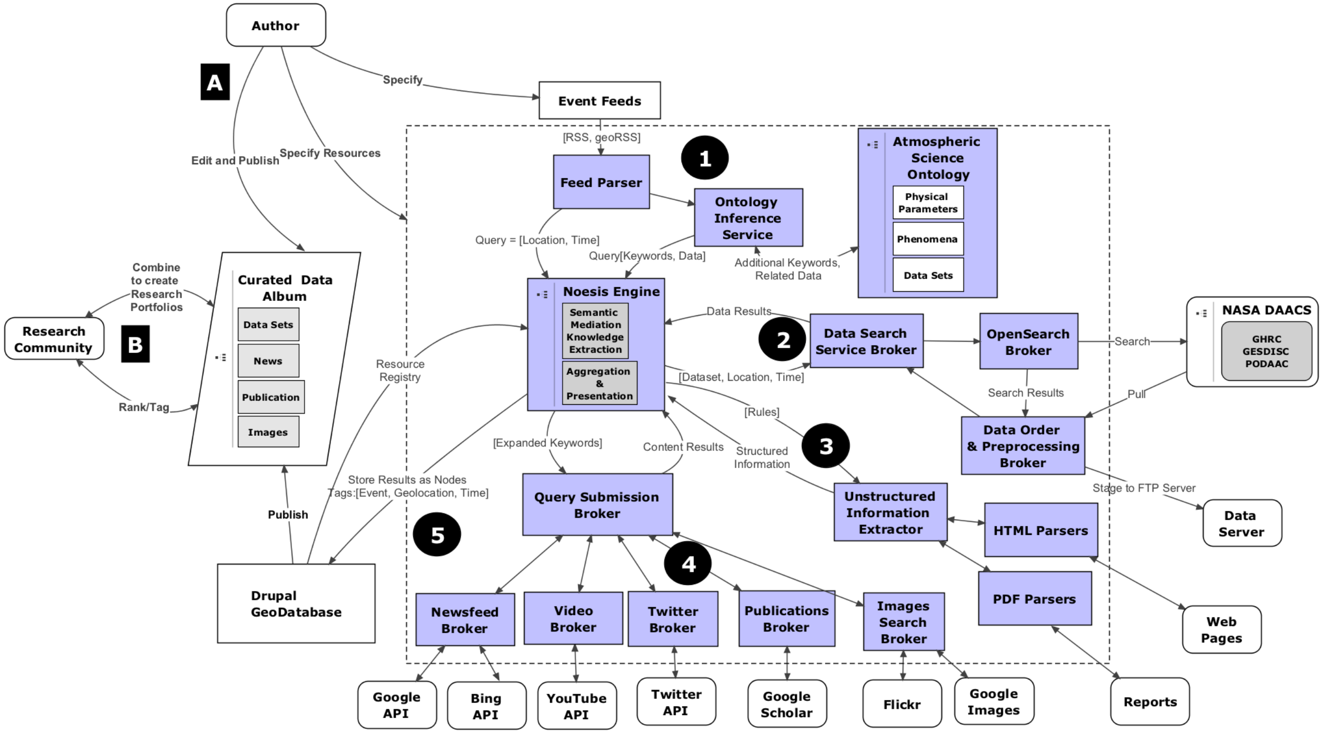
- Tool can be driven by an event feed. The feed parser will extract keywords, geolocation and time information. Keywords is fed to the OIS (Ontology Inference Service). The OIS provides additional contextual keywords including a list of relevant datasets to help refine the final query. These additional keywords, datasets, geolocation and temporal parameters are then fed to the Noesis Engine.

Component Interaction - 2



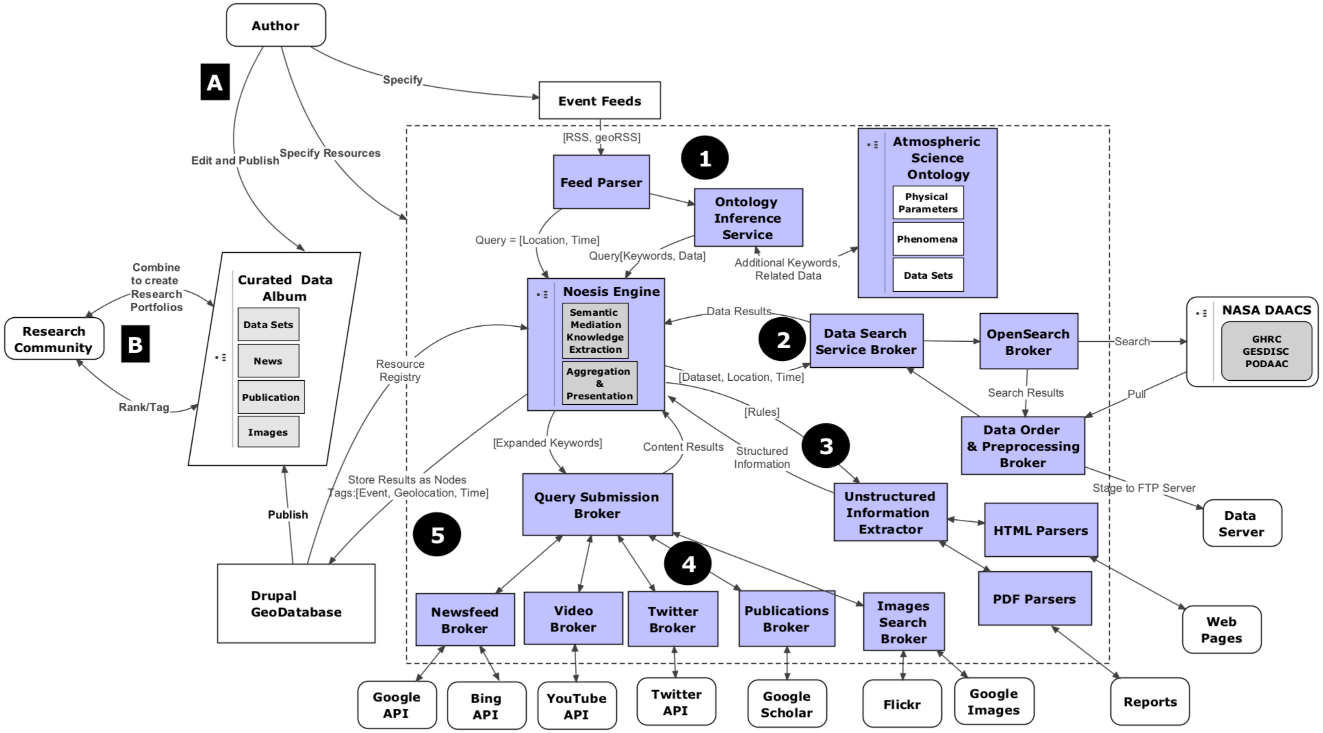
- Noesis Engine, responsible for framing the query for appropriate brokers, delegates the data search to the Data Search broker by providing dataset, keywords, location and time information. The Data Search broker then tasks an OpenSearch broker to obtain collection level metadata from the EOS Clearinghouse (ECHO) and NASA data centers, and return dataset descriptions.

Component Interaction - 3



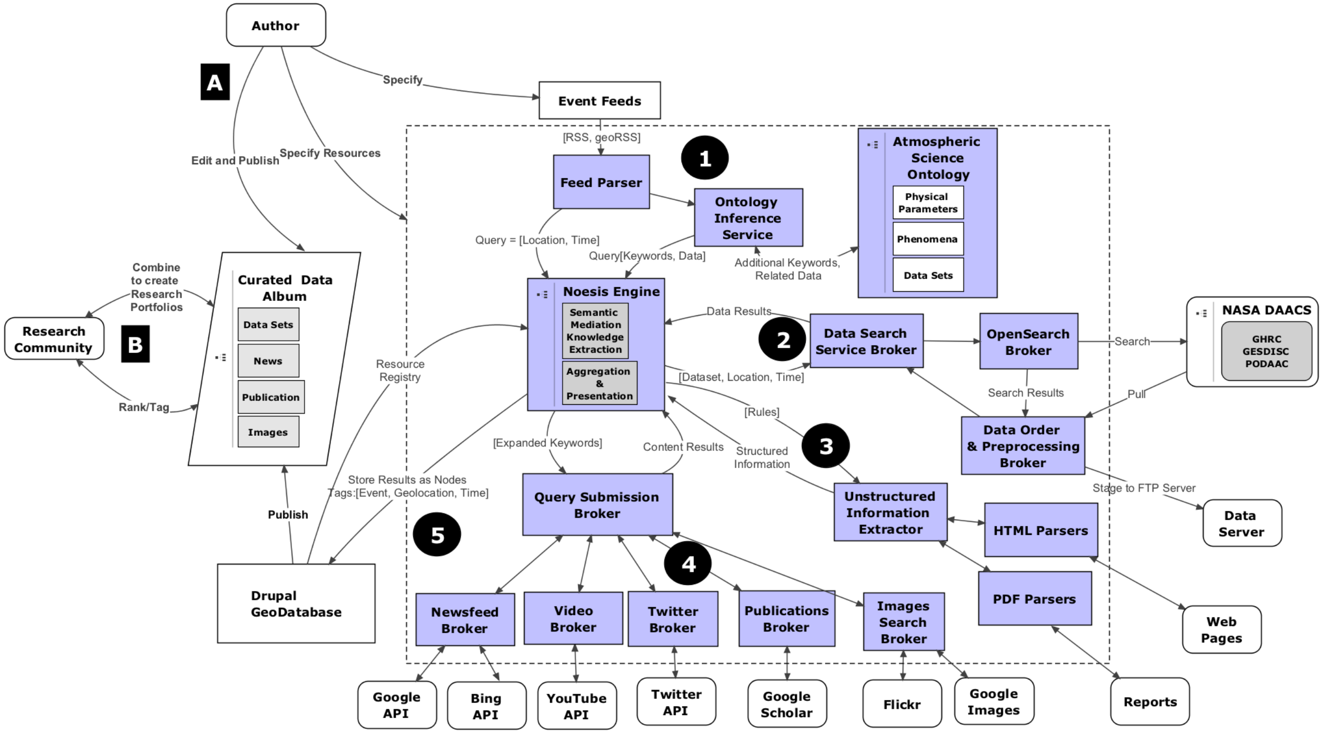
- Noesis Engine is also responsible for extracting information/ knowledge from unstructured resources such as storm reports described in web pages and pdf documents. Noesis encodes “extraction rules” that are used to parse these documents to extract structured information and assemble these individual fragments into usable information

Component Interaction - 4



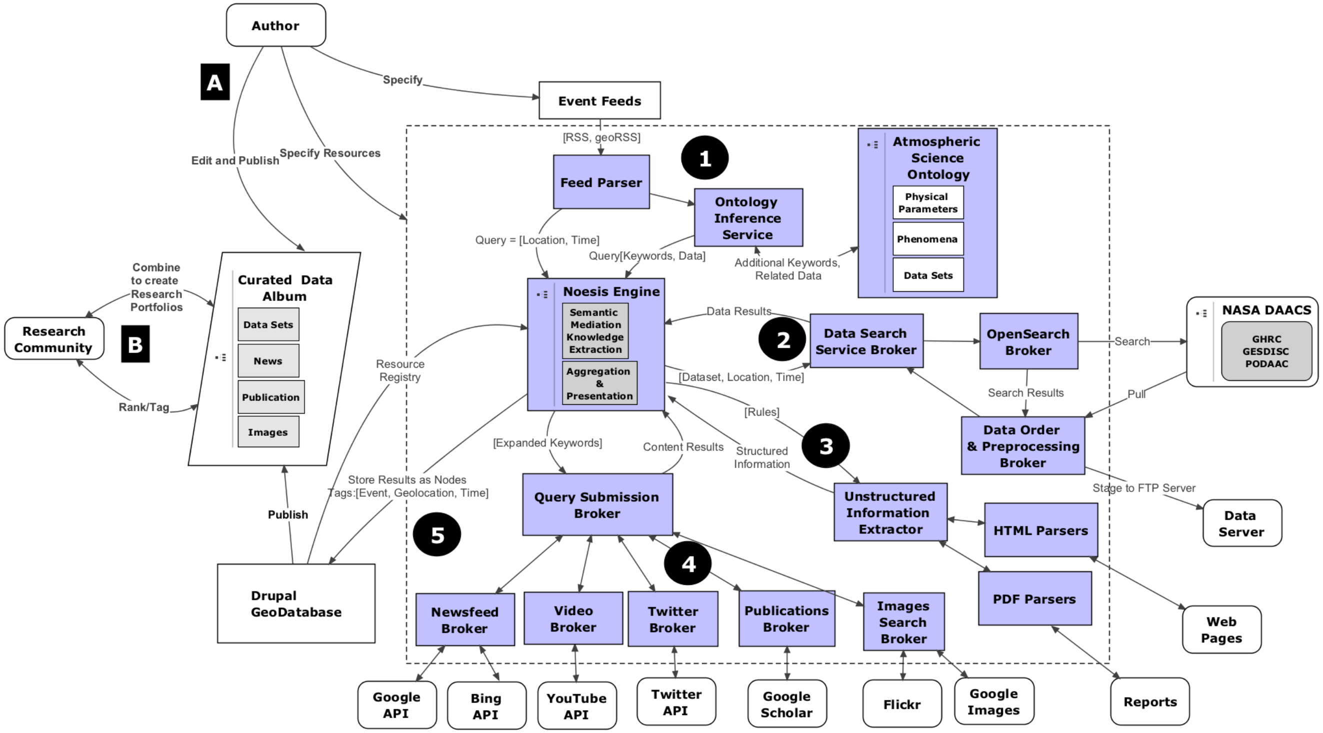
- Noesis Engine also feeds the expanded keywords to the Query Submission Broker to search for supplementary information potentially useful for research. The Query Submission Broker tasks individual brokers for different online content repositories, including Google API for news, YouTube for videos, Google scholar for any relevant published articles, Twitter and Flickr and Google Images for interesting photos.

Component Interaction - 5



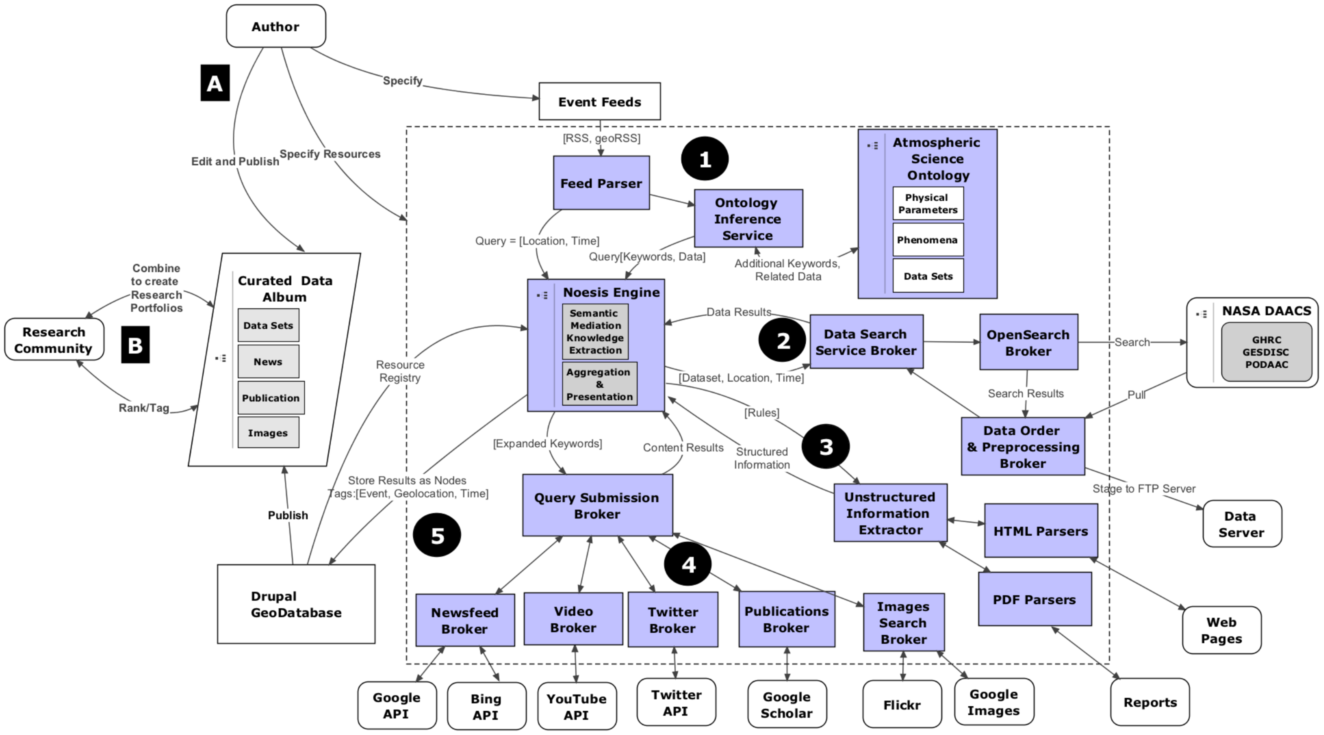
- Noesis Engine combines the aggregated data and content results and map this information into a Data Album. The Data Album is implemented as a custom Drupal node stored in the Drupal Geodatabase. The node is also annotated by all the keywords used to perform the query including expanded keywords, dataset names, geolocation and time.

Component Interaction - A



- Author with the appropriate permissions will be able to indicate a new event feed to trigger the creation of Data Albums. The author will be able to specify the different digital and data repositories to be searched, an important personalization feature to empower curation capabilities for their Data Album. The Data Album can also be shared with rest of the research community on the portal, and published as an information cast.

Component Interaction - B

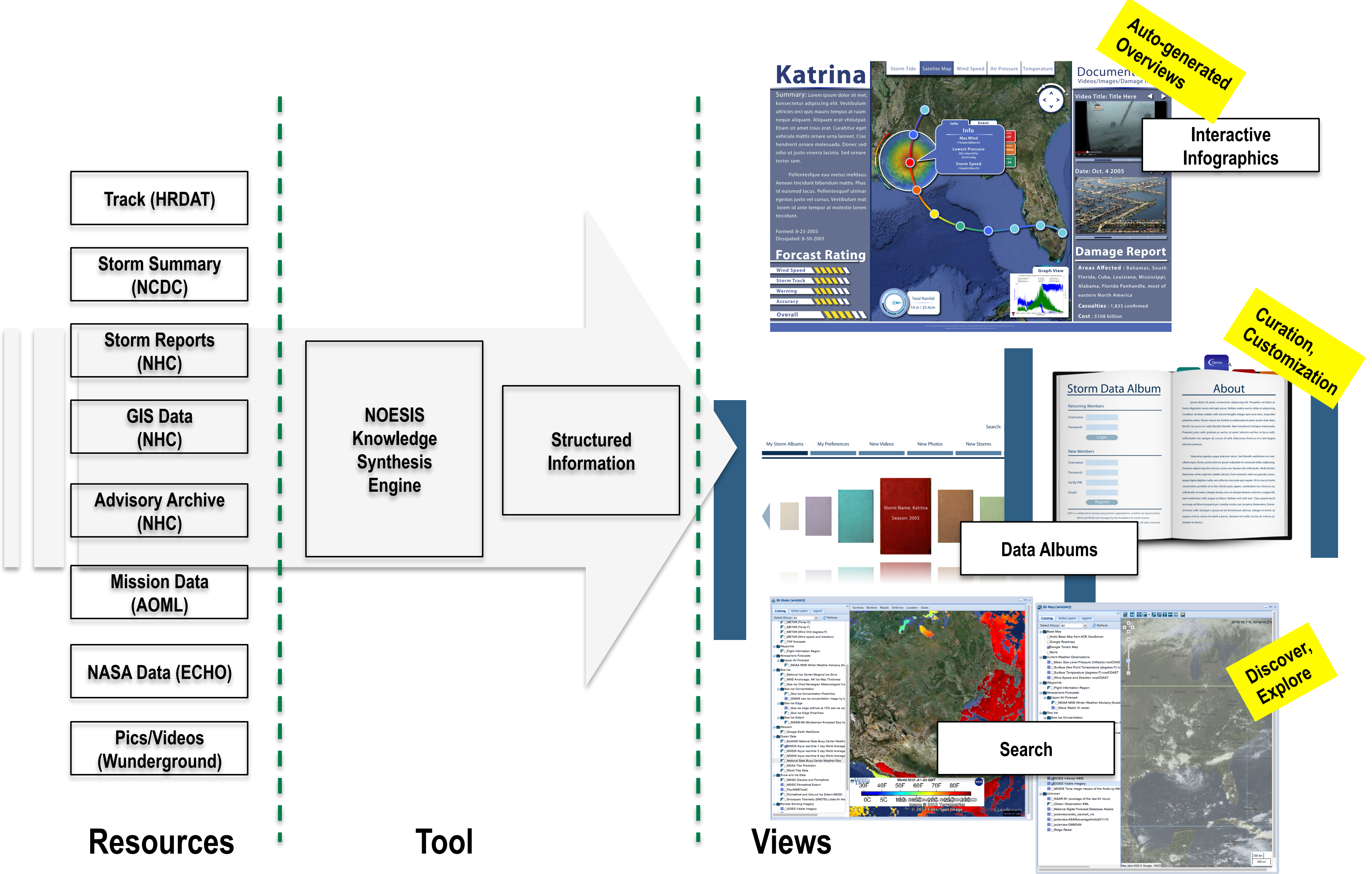


- Once users start creating and sharing Data Albums, an online research community on hurricane research will evolve. The community can use the portal to discover useful Data Albums and to rate or annotate published Data Albums with new tags. The users will be able to search for specific published Data Albums and aggregate a series of Albums to create Research Portfolios for climatology studies.

Data Album Implementations

- Catalog of Hurricane Case Studies at GHRC. Noesis 2.0 will be integrated into the GHRC to create a portal to support hurricane case study research. (*Prototype Ready*)
- Case study generator at NASA's SPoRT Center. One goal of Noesis 2.0 will be installed at SPoRT to help automate the selection of weather events and other information needed for evaluating the SPoRT's mesoscale configuration of the Weather Research and Forecasting (WRF) model for convective cases (*To be implemented*)

Catalog of Hurricanes: Conceptual Architecture



Track (HRDAT)

Storm Summary (NCDC)

Storm Reports (NHC)

GIS Data (NHC)

Advisory Archive (NHC)

Mission Data (AOML)

NASA Data (ECHO)

Pics/Videos (Wunderground)

NOESIS Knowledge Synthesis Engine

Structured Information

Auto-generated Overviews

Interactive Infographics

Curation, Customization

Data Albums

Discover, Explore

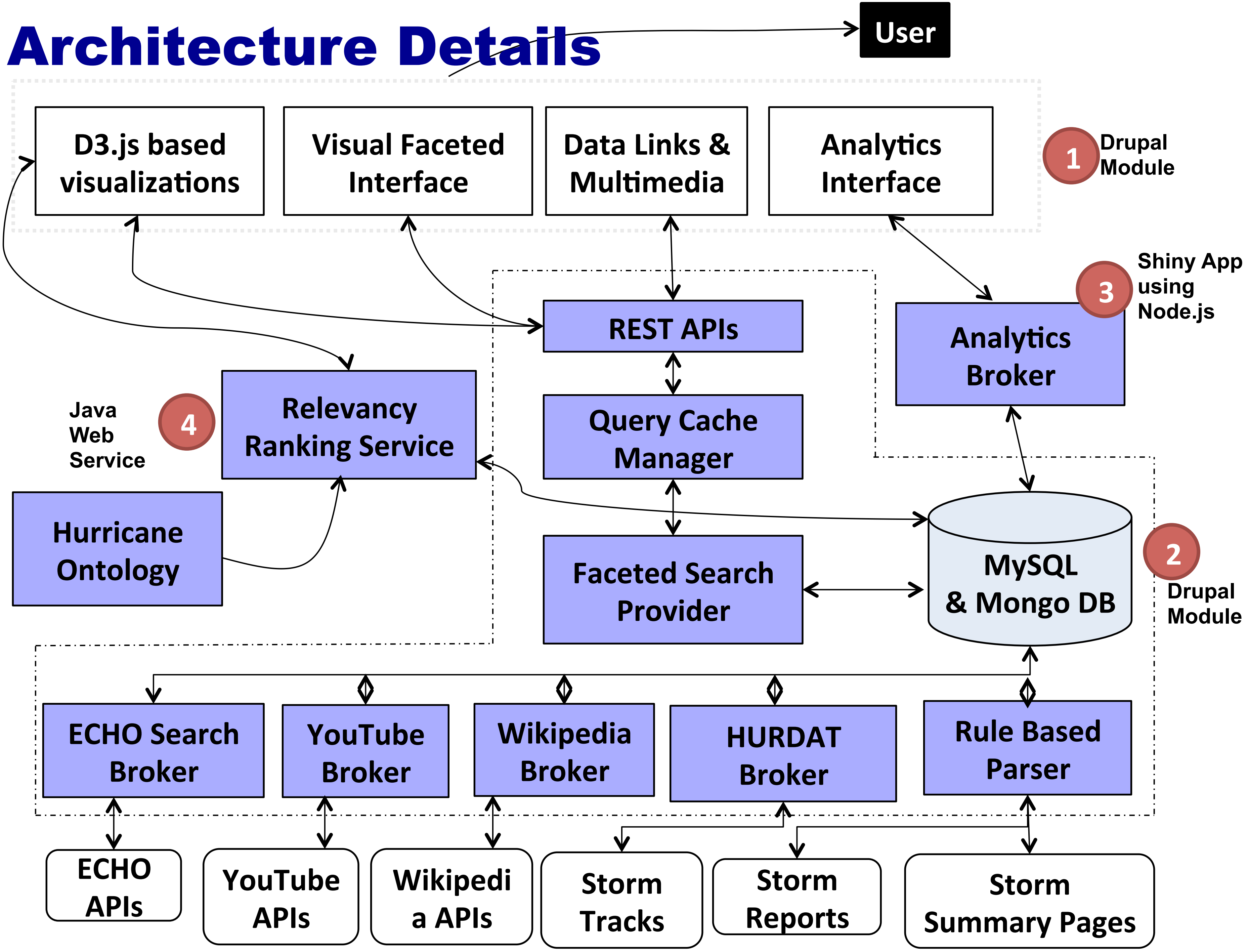
Search

Resources

Tool

Views

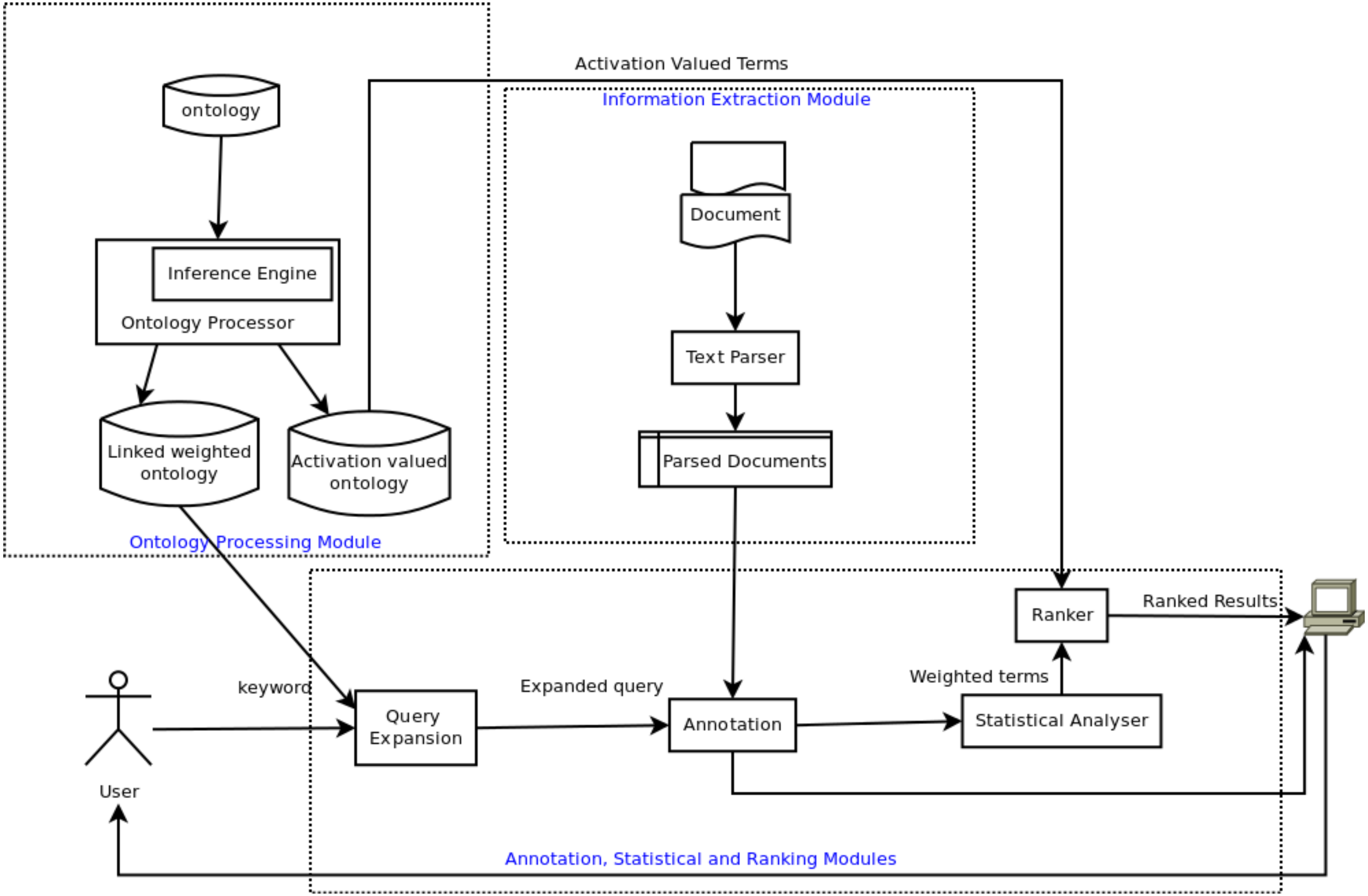
Architecture Details



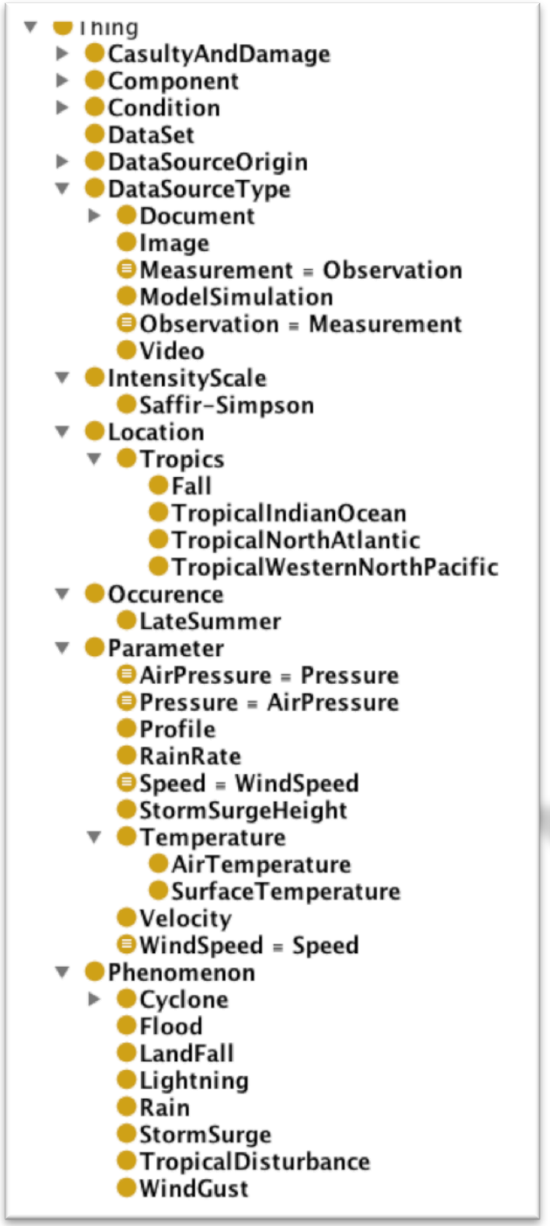
Ontology-based Relevancy Ranking Service

- General service that can be customized for specific applications
- Service needs to provide the following capability :
  - Feed application ontology to the system
  - Feed collections of documents that are need to be ranked
  - Provide search keywords
  - System provides the ranked documents.

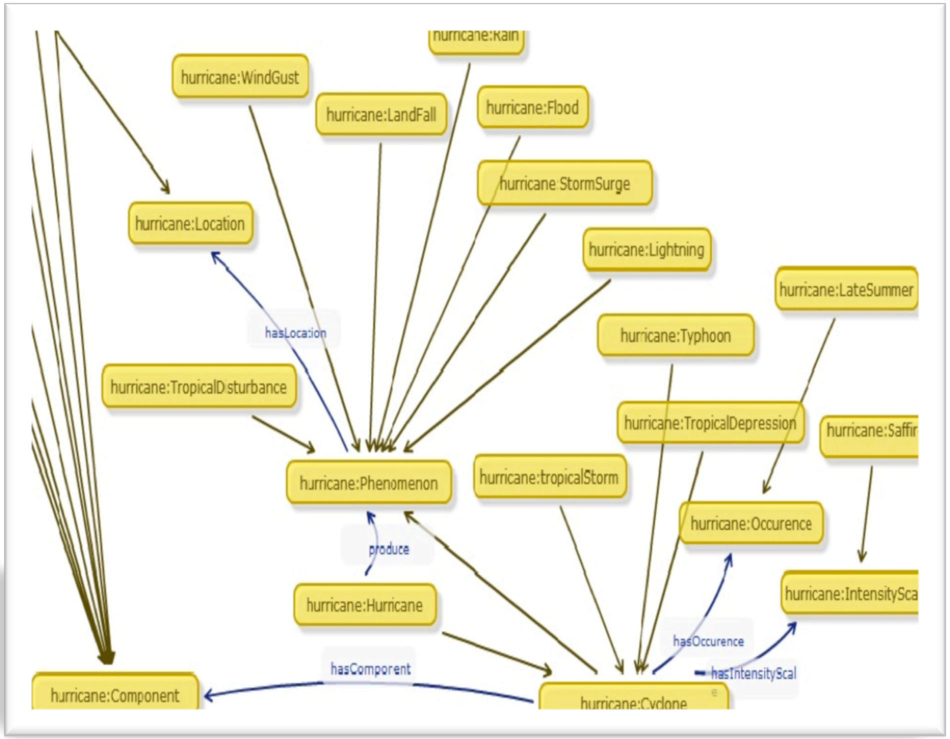
Service Architecture



Initial Hurricane Ontology



- Thing
  - CasultyAndDamage
  - Component
  - Condition
  - DataSet
  - DataSourceOrigin
  - DataSourceType
    - Document
    - Image
    - Measurement ≡ Observation
    - ModelSimulation
    - Observation ≡ Measurement
    - Video
  - IntensityScale
    - Saffir-Simpson
  - Location
    - Tropics
      - Fall
      - TropicalIndianOcean
      - TropicalNorthAtlantic
      - TropicalWesternNorthPacific
  - Occurence
    - LateSummer
  - Parameter
    - AirPressure ≡ Pressure
    - Pressure ≡ AirPressure
    - Profile
    - RainRate
    - Speed ≡ WindSpeed
    - StormSurgeHeight
    - Temperature
      - AirTemperature
      - SurfaceTemperature
    - Velocity
    - WindSpeed ≡ Speed
  - Phenomenon
    - Cyclone
    - Flood
    - LandFall
    - Lightning
    - Rain
    - StormSurge
    - TropicalDisturbance
    - WindGust



Ontology-based Ranking Algorithm

- Algorithm combines ontology based and traditional statistical score to estimate relevancy of a resource
- Algorithm based on:
- A. Bouramoul and M. Kholladi, “An ontology-based approach for semantic ranking of the web search engines results,” in *2012 International Conference on Multimedia Computing and Systems (ICMCS)*, 2012.
- M. Shamsfard, A. Nematzadeh, and S. Motiee, “ORank: An Ontology Based System for Ranking Documents,” *International Journal of Computer Science*, vol. 1, no. 3, pp. 225–231, 2006.

Ranking Algorithm: Concept Weights

The weight of links between two concepts calculated with following equations

$$W(c_j, c_k) = \frac{\sum_{i=1}^{m} n_{i,j,k}}{\sum_{i=1}^{o} n_{i,j} + \sum_{i=1}^{p} n_{i,k}}$$

$W(C_j, C_k)$ is weight between C_j and C_k

n (i,j,k) is total number of related concepts to both C_j and C_k

n (i,j) is total number of related concepts to C_j

n (i,k) is total number of related concepts to C_k

Weights are stored in database

Subject	Predicate	Object	wt
Hurricane	sibling	Typhoon	0.71
Hurricane	sibling	TropicalDepression	0.71
Hurricane	sibling	TropicalStorm	0.71
Cyclone	superClass	Phenomenon	0.44
Cyclone	subClass	Typhoon	0.33
Cyclone	subClass	Hurricane	0.33
Cyclone	subClass	TropicalDepression	0.33

Ranking Algorithm: Activation Value

- Spread Activation algorithm is used to calculate activation value for each concept in ontology.
- The concepts that are specified by user form the initial concept set. These initial concept sets are set to value 1.

$$I(c_j) = I(c_i) \times W(I(c_i), I(c_j))$$

  - $I(c_j)$ is activation value of current concept
  - $I(c_i)$ is activation value of previous concept
  - $W(I(c_i), I(c_j))$ is link weight between two concepts
- Activation values are stored in database

Concept word (c)	Val (I)
Hurricane	1.0
TropicalDepression	0.71
TropicalStorm	0.71
Typhoon	0.71
Cyclone	0.33
Flood	0.19

Ranking Algorithm: Statistical Analysis

- Term weight: TF-IDF model is used to provide weight to each concept words present in the documents.
- TF (Term Frequency): It measures the frequency of each concept word (c) in each document (d)

$$tf(c,d) = \frac{f(c,d)}{|d|}$$

Where:

– f(c, d) is frequency of concept word (c)in document (d)

– |d| is count of words in document (d)

Ranking Algorithm: Statistical Analysis

- IDF (Inverse Document Frequency): measures the importance of concept word (c) in entire document collection (D).

$$idf(c,D) = \log(\frac{|D|}{df_c})$$

  - |D| is count of the corpus (D)
  - df_c is document frequency of (c): the number of document that contain (c)
- The tf-idf for the concept word calculated as below:

$$tf.idf(c,d,D) = tf(c,d) \times idf(c,D)$$

  - tf.idf(c,d,D) is the tf.idf for (c) in (d) that is in corpus (D)
- The obtained tf.idf saved in memory to use for the ranking calculation.

Ranking Algorithm: Relevancy Score

- Score (S_d) for document (d) in collection of documents (D) is as below:

$$S_d = \sum_{i=1}^{m} I(c_i) \times tf.idf(c_i, d, D)$$

  - S_d is final score of document (d)
  - $\sum_{i=1}^{m} I(c_i) \times tf.idf(c_i, d, D)$ is sum of score of each matched concept word and is obtained by multiplying ontology-based score and the statistical score

- The obtained score is used to rank the document (D)

Algorithm Evaluation

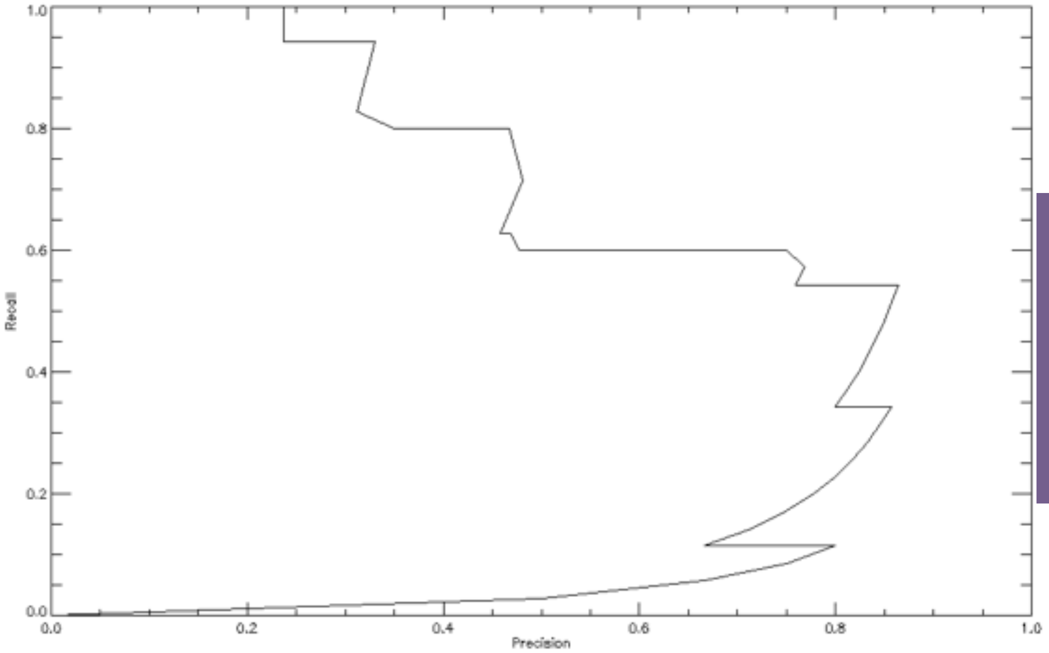
- Compared algorithm results versus “truth data”
- Truth data:
  - A total of 35 GHRC collections were manually selected
    - Considered as useful and relevant to hurricane studies
- Top 35 ranked results from the algorithm are used for performance evaluation.

	Yes (Algorithm)	No (Algorithm)
Yes (Manual)	21	14
No (Manual)	14	111

- *Accuracy = (21+111)/160 = 82.5%*
- *Precision = 21/35 = 0.60*
- *Recall = 21/35 = 0.60*

Algorithm Application

- Precision vs Recall Graph



Relevancy Score Threshold : 0.0140
Identified number of collections: 60.0
Matched number of collection: 28.0
Precision: 0.466667
Recall: 0.800000

- Ideally you want high precision, high recall
- For data search, we want higher recall:
  - Gets everything that is important
  - Gets non-relevant data (users can filter out)

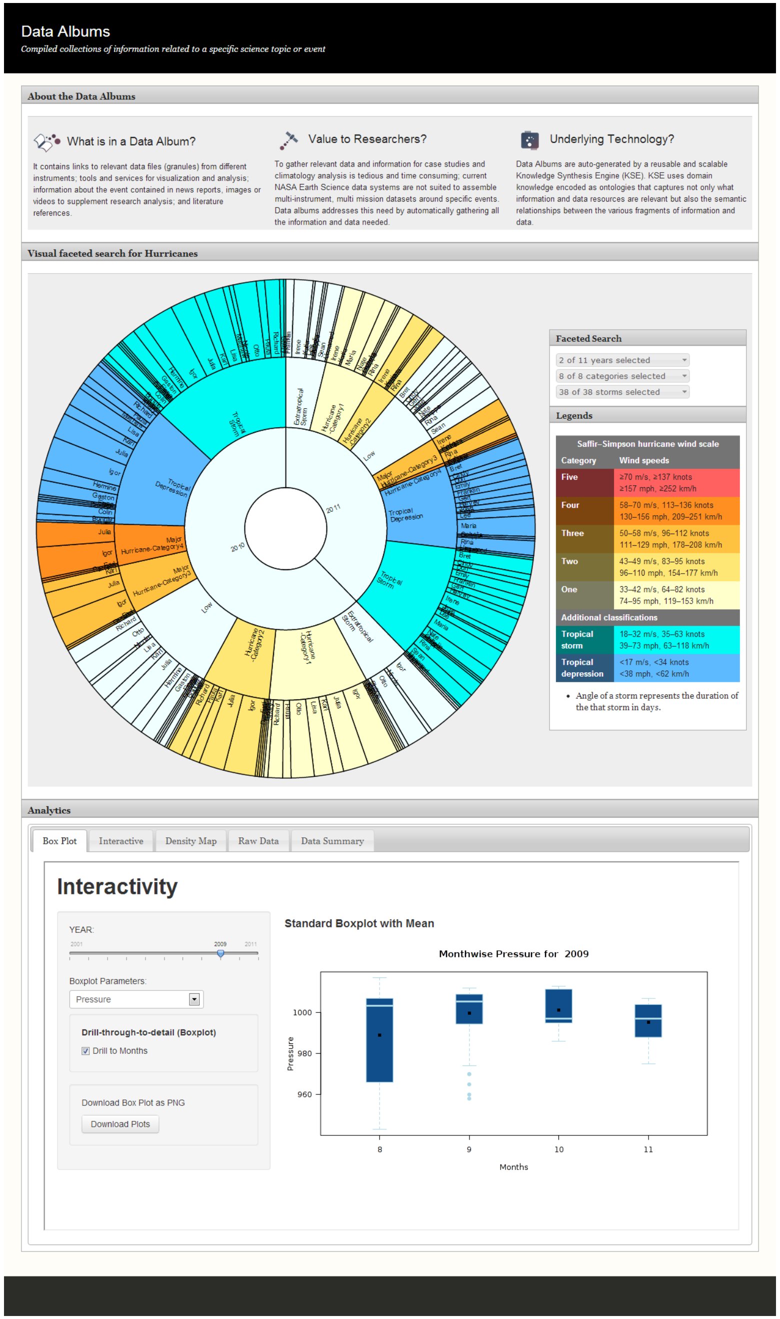
Algorithm Improvements

- Improving the ontology richness
- Utilizing semantic relationships to improve weight calculations
- Utilizing concept word “location” to improve weight calculations.
  - Example: Keywords vs Description

Key Features

- Autogenerates infographic view of Hurricanes
- Visual faceted search interface for Hurricanes
  - Results ordered alphabetically
  - Storms color coded by category
- Visual faceted search interface data for a given Hurricane
  - Data collection color coded by relevancy
  - Relevancy thresholds can be adjusted by the user
- Analytics
  - Summary statistics for events such as box plots, density map
  - Interactive plots that allow user to configure and display six parameters within a scatter plot
- Download scripts to facilitate access to the data files

Version 2 Snapshots



Data Albums

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Visual faceted search for Hurricanes

Faceted Search

2 of 11 years selected ▾
8 of 8 categories selected ▾
38 of 38 storms selected ▾

Legends

Saffir–Simpson hurricane wind scale	
Category	**Wind speeds**
Five	≥70 m/s, ≥137 knots ≥157 mph, ≥252 km/h
Four	58–70 m/s, 113–136 knots 130–156 mph, 209–251 km/h
Three	50–58 m/s, 96–112 knots 111–129 mph, 178–208 km/h
Two	43–49 m/s, 83–95 knots 96–110 mph, 154–177 km/h
One	33–42 m/s, 64–82 knots 74–95 mph, 119–153 km/h
Additional classifications	
Tropical storm	18–32 m/s, 35–63 knots 39–73 mph, 63–118 km/h
Tropical depression	<17 m/s, <34 knots <38 mph, <62 km/h

- Angle of a storm represents the duration of the that storm in days.

Analytics

Interactivity

YEAR: 2009

Boxplot Parameters: Pressure

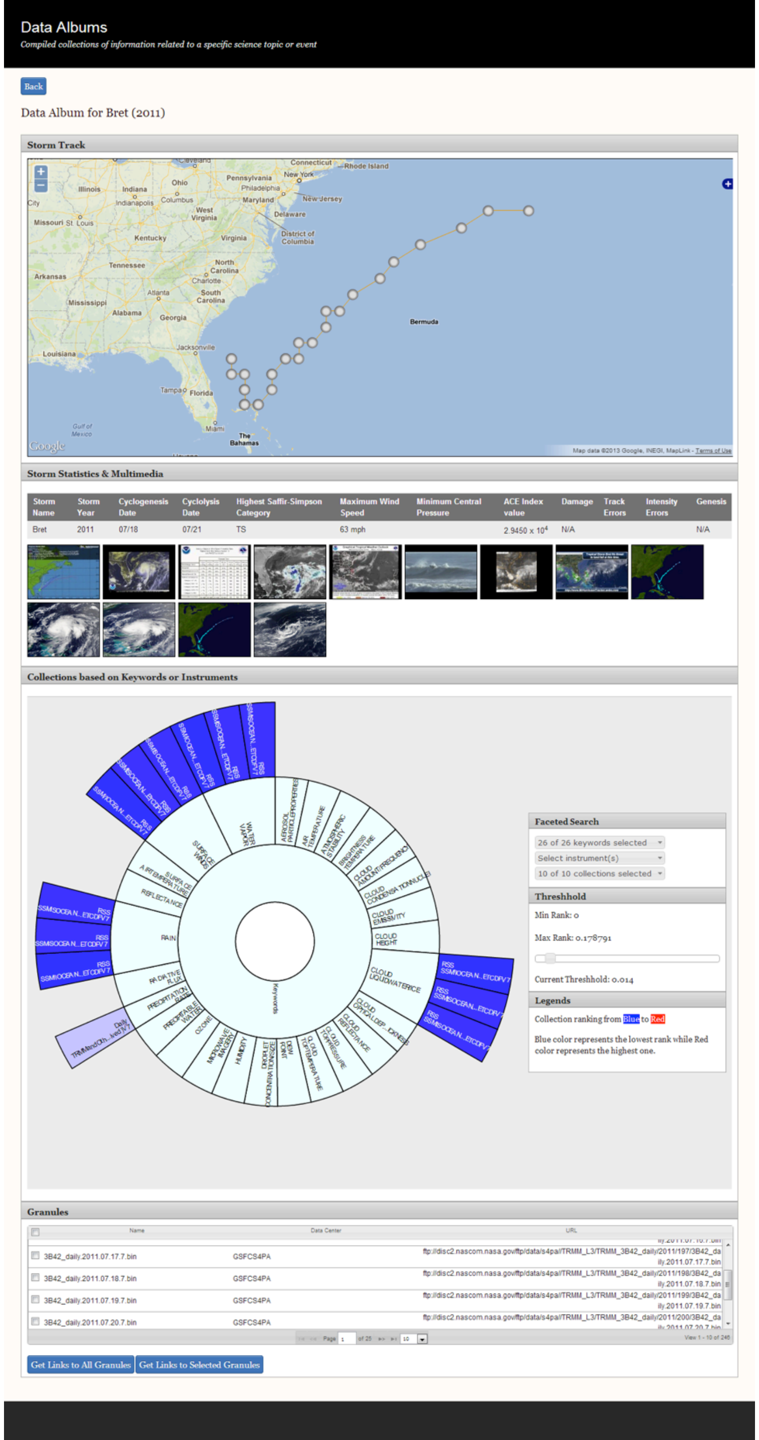
Drill-through-to-detail (Boxplot)

☑ Drill to Months

Download Box Plot as PNG

Download Plots

Standard Boxplot with Mean



Data Albums

Compiled collections of information related to a specific science topic or event

Back

Data Album for Bret (2011)

Storm Track

Storm Statistics & Multimedia

Storm Name	Storm Year	Cyclogenesis Date	Cyclolysis Date	Highest Saffir-Simpson Category	Maximum Wind Speed	Minimum Central Pressure	ACE Index value	Damage	Track Errors	Intensity Errors	Genesis
Bret	2011	07/18	07/21	TS	63 mph		2.9450×10^4	N/A			N/A

Collections based on Keywords or Instruments

Faceted Search

26 of 26 keywords selected ▾
Select instrument(s) ▾
10 of 10 collections selected ▾

Threshhold

Min Rank: 0

Max Rank: 0.178791

Current Threshhold: 0.014

Legends

Collection ranking from Blue to Red

Blue color represents the lowest rank while Red color represents the highest one.

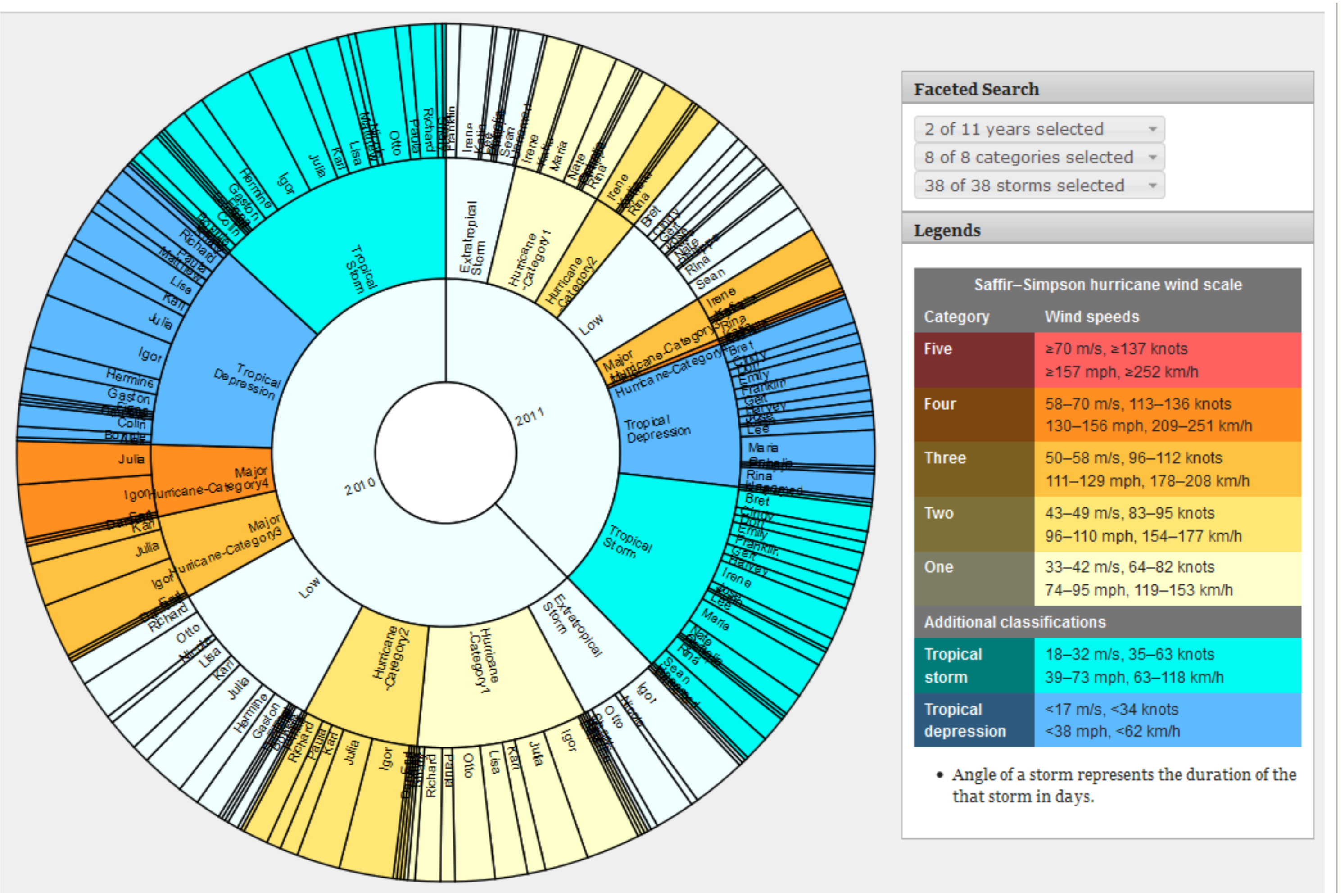
Granules

☐	Name	Data Center	URL
☐	3B42_daily.2011.07.17.7.bin	GSFCS4PA	ftp://disc2.nascom.nasa.gov/ftp/data/s4pa//TRMM_L3/TRMM_3B42_daily/2011/197/3B42_daily.2011.07.17.7.bin
☐	3B42_daily.2011.07.18.7.bin	GSFCS4PA	ftp://disc2.nascom.nasa.gov/ftp/data/s4pa//TRMM_L3/TRMM_3B42_daily/2011/198/3B42_daily.2011.07.18.7.bin
☐	3B42_daily.2011.07.19.7.bin	GSFCS4PA	ftp://disc2.nascom.nasa.gov/ftp/data/s4pa//TRMM_L3/TRMM_3B42_daily/2011/199/3B42_daily.2011.07.19.7.bin
☐	3B42_daily.2011.07.20.7.bin	GSFCS4PA	ftp://disc2.nascom.nasa.gov/ftp/data/s4pa//TRMM_L3/TRMM_3B42_daily/2011/200/3B42_daily.2011.07.20.7.bin

Page 1 of 25 — 10 — View 1 - 10 of 246

Get Links to All Granules | Get Links to Selected Granules

Visual Faceted Discovery Interface



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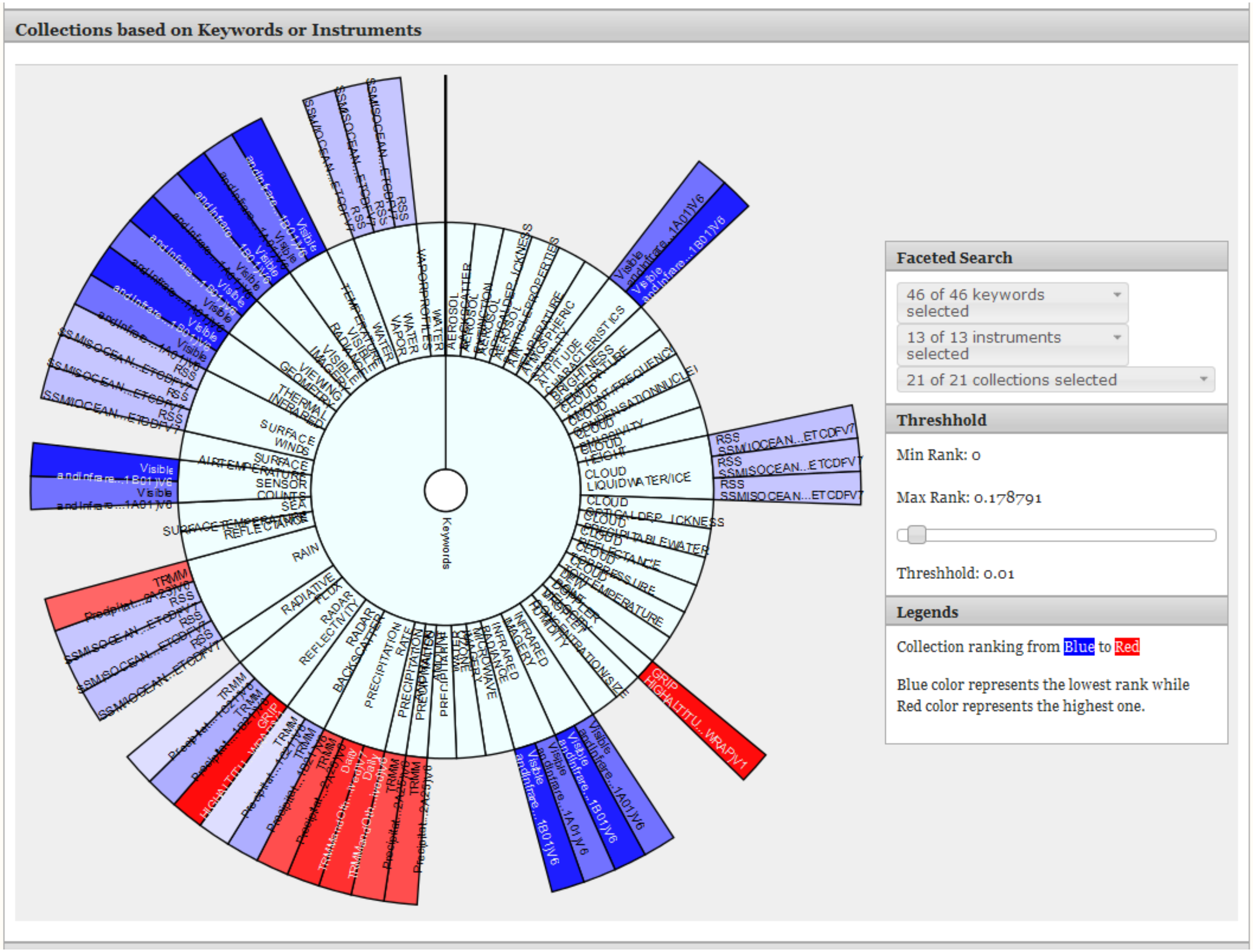
- Angle of a storm represents the duration of the that storm in days.

Storm View – Data Collections



Collections based on Keywords or Instruments

Faceted Search

46 of 46 keywords selected ▾

13 of 13 instruments selected ▾

21 of 21 collections selected ▾

Threshhold

Min Rank: 0

Max Rank: 0.178791

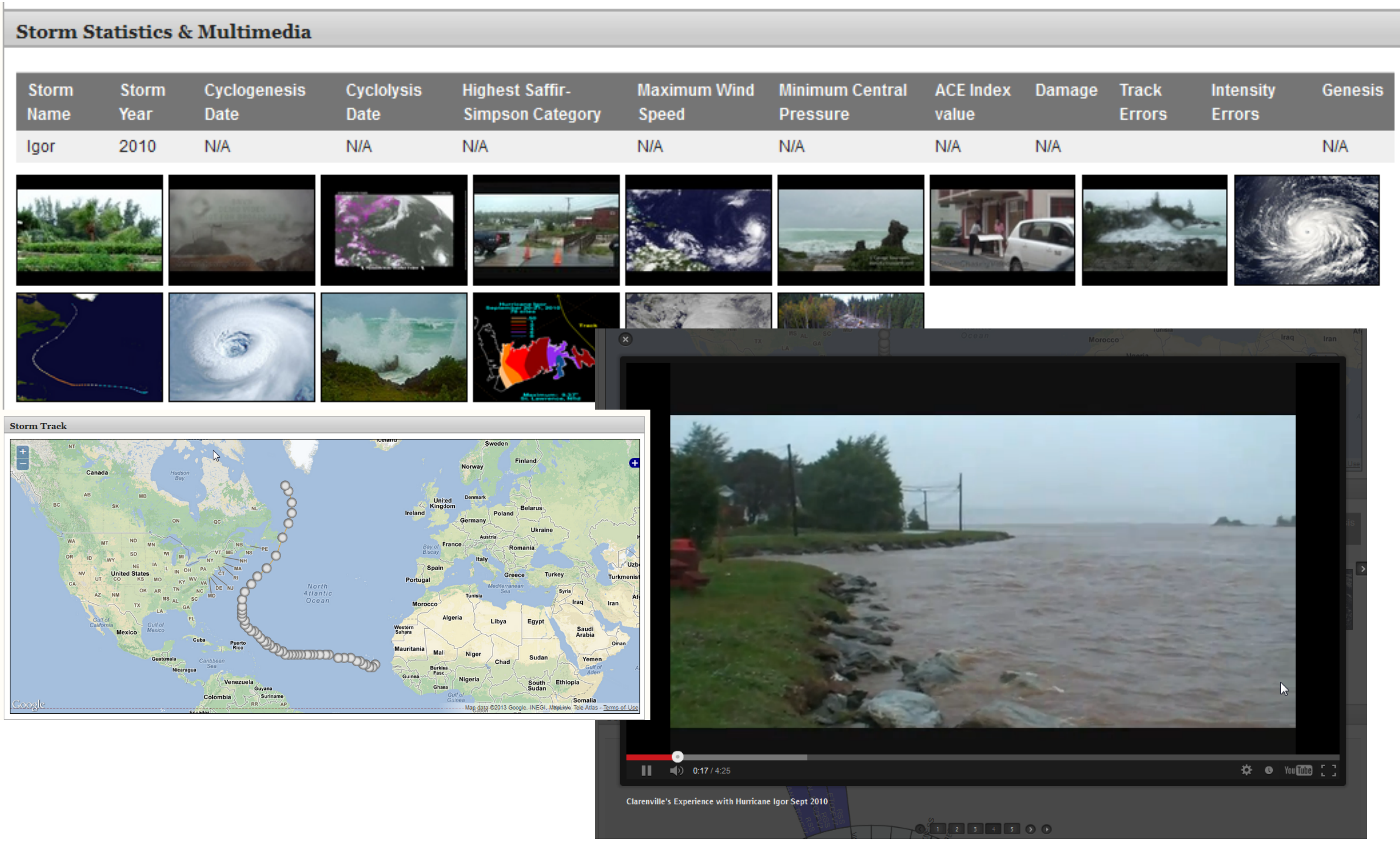
Threshhold: 0.01

Legends

Collection ranking from Blue to Red

Blue color represents the lowest rank while Red color represents the highest one.

Other Aggregated Information



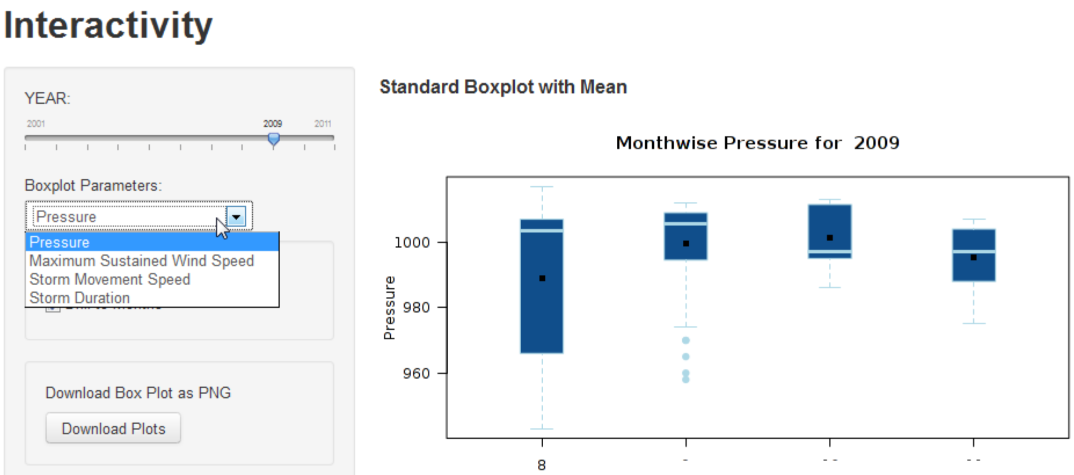
Storm Statistics & Multimedia

Storm Name	Storm Year	Cyclogenesis Date	Cyclolysis Date	Highest Saffir-Simpson Category	Maximum Wind Speed	Minimum Central Pressure	ACE Index value	Damage	Track Errors	Intensity Errors	Genesis
Igor	2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N/A

Storm Track

Clarenville's Experience with Hurricane Igor Sept 2010

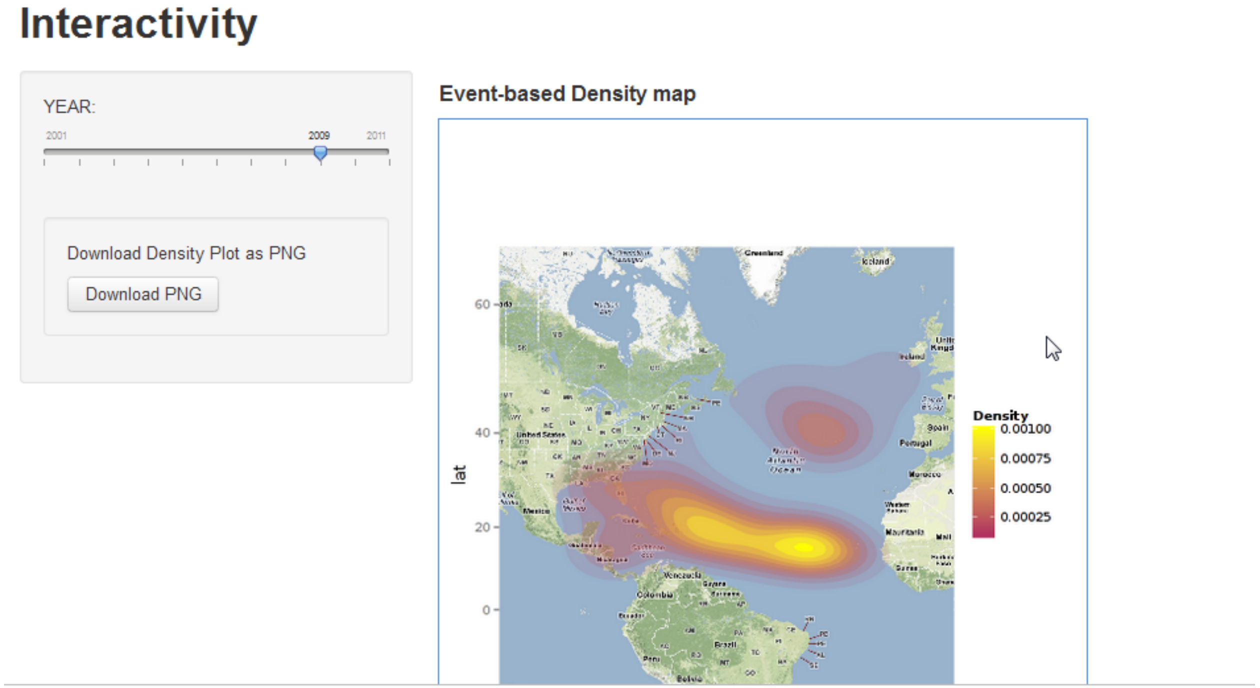
Summary Analytics



Interactivity

YEAR: 2009

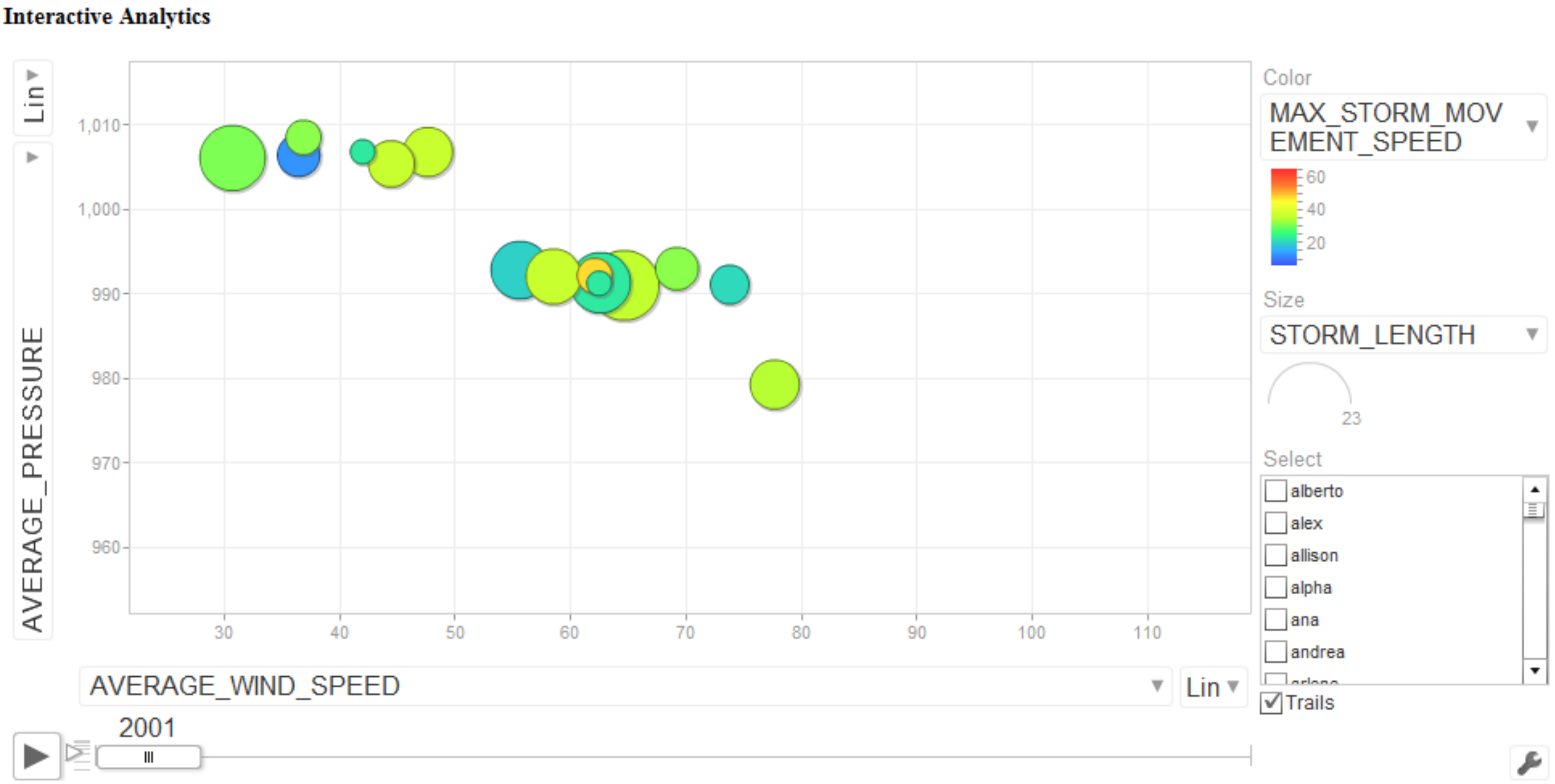
Boxplot Parameters: Pressure



Interactivity

YEAR: 2009

Interactive Analytics



Interactive Analytics

Color: MAX_STORM_MOVEMENT_SPEED

Size: STORM_LENGTH

AVERAGE_WIND_SPEED Lin

AVERAGE_PRESSURE Lin

2001

☑ Trails

Innovations Enabled

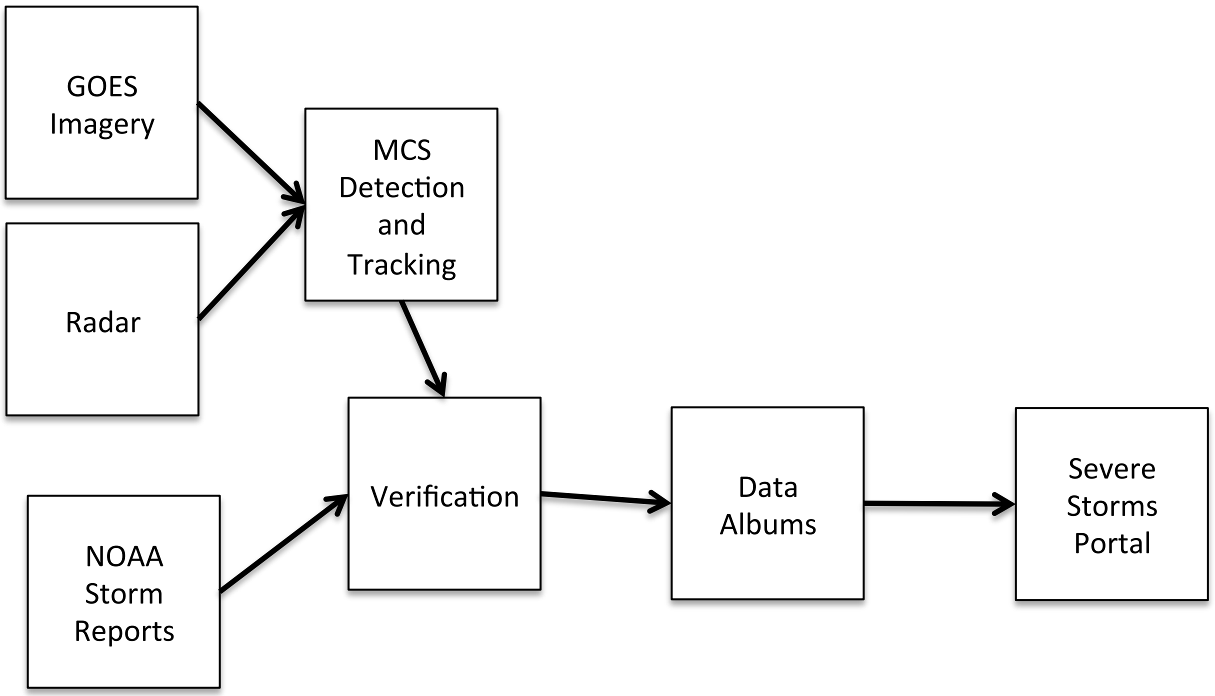
- Generalized tool designed to support “search, aggregation and access” of data and other online resources around events and *can be easily configured for other uses (disasters)*
- Automates the gathering of online resources with information filtering
- New ways of displaying search results
  - Infographics – graphic visual representation of information, data or knowledge intended to present complex information quickly and clearly
  - Results enriched with additional information (rel. score, storm cat)
- Analytics dashboard on the gathered information for events
- Use of semantic technology for relevancy ranking

Remaining Tasks

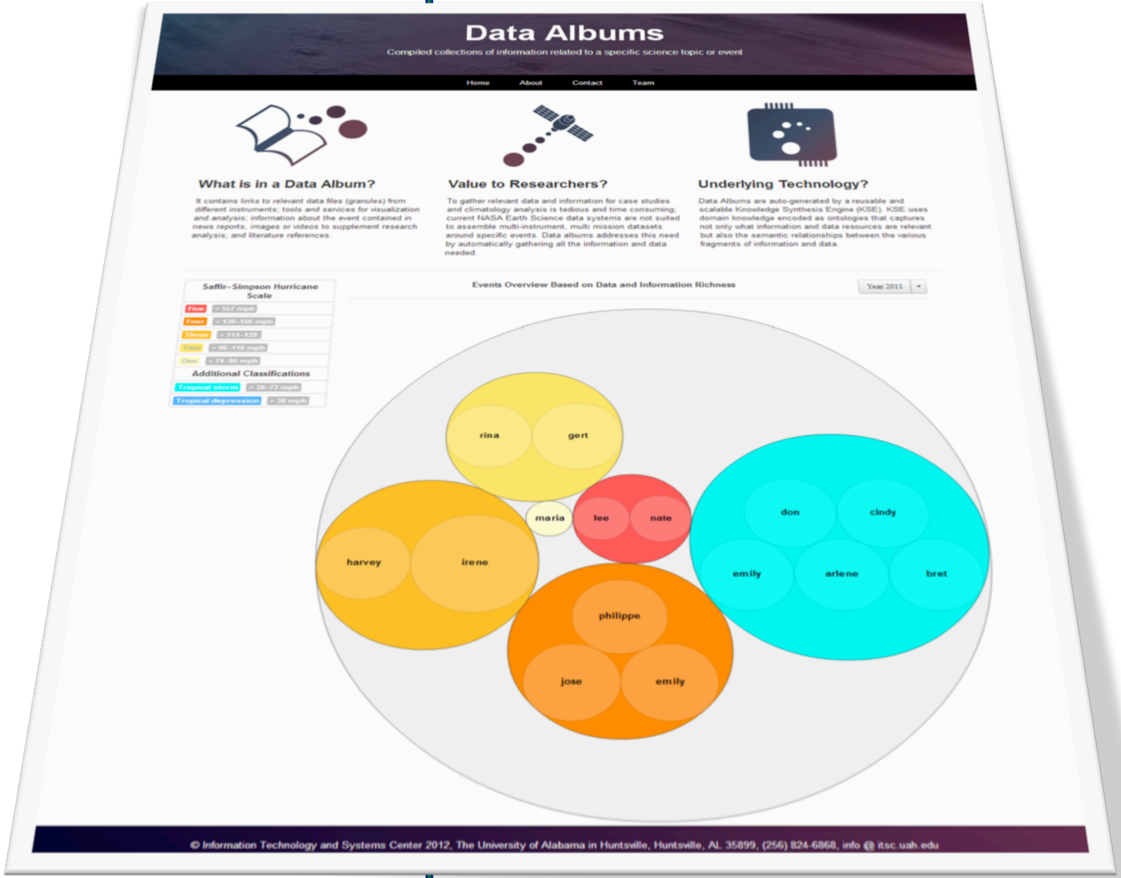
- Feature freeze and Hurricane Portal Release
  - Migrating to Dev Server, internal testing
  - Science Team Evaluation
  - Pushing to production server
- Additional Features to be added in the near feature
  - Calendar View to see which data collection are available for which days
  - Displaying browse images
  - Additional data parameters for analytics (# of death, ACE index, forecast evaluations)
- SPoRT Severe storm scenario application for Year 2

Data Albums for Severe Storms

- Focus on extreme events
  - Tornadoes, Flooding, Wind Gusts, Hail Events



Birds Eye View of Other Projects



Data Albums

Compiled collections of information related to a specific science topic or event

What is in a Data Album?

It contains links to relevant data files (granules) from different instruments; tools and services for visualization and analysis; information about the event contained in news reports, images or videos to supplement research analysis; and literature references.

Value to Researchers?

To gather relevant data and information for case studies and climatology analysis is tedious and time consuming; current NASA Earth Science data systems are not suited to assemble multi-instrument, multi mission datasets around specific events. Data albums addresses this need by automatically gathering all the information and data needed.

Underlying Technology?

Data Albums are auto-generated by a reusable and scalable Knowledge Synthesis Engine (KSE). KSE uses domain knowledge encoded as ontologies that captures not only what information and data resources are relevant but also the semantic relationships between the various fragments of information and data.

Saffir–Simpson Hurricane Scale

Five	- 157 mph
Four	- 130–156 mph
Three	- 111–129
Two	- 96–110 mph
One	- 74–95 mph

Additional Classifications

Tropical storm	- 39–73 mph
Tropical depression	- 38 mph

Events Overview Based on Data and Information Richness

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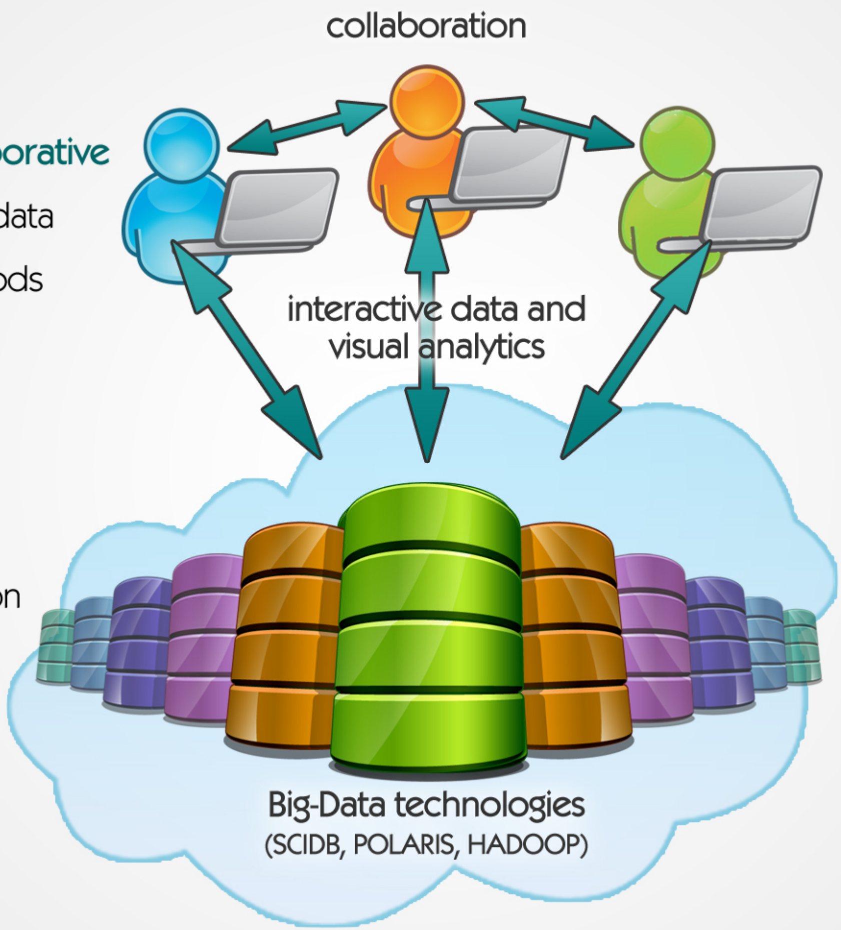
Automated Event Services

Utilize **Big-Data** technologies to…

- Enable **interactive** and **collaborative** scientific data analysis on big data
- Share data and analysis methods seamlessly,

…in order to…

- Relieve scientists from data management,
- Empower scientists to focus on science, and
- Boost science productivity.



1 Identify occurrences (events) of phenomena
   - Entities in the 4D spatiotemporal space

2 Associate additional relevant data with events.

3 Characterize phenomena with defining features extracted from data.

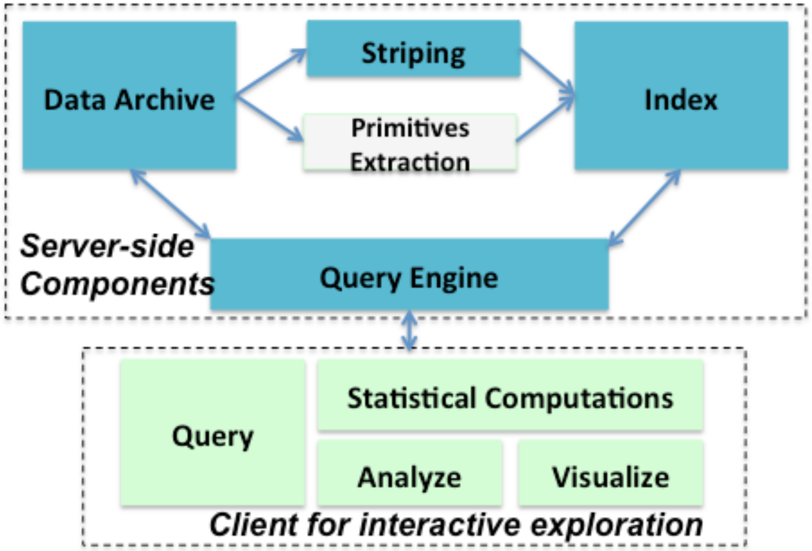
4 Correlate defining features of various phenomena in both space and time.

5 Improve predictions of future events using correlations among phenomena for **better decision making**.

Big-Data Vision → Technology Infrastructure → Science Enablement

Polaris: Discovery Engine

- All Special Sensor Microwave / Imager (/ Sounder; SSM/I and SSMIS) gridded data files of 1440x720 pixels staged on the cluster
- Data sets – Rain Rate, Surface Wind Speed, Atmospheric Water Vapor, Cloud Liquid Water
- Total volume is less than 1 Tb
- Cluster with 70 compute nodes consisting of two single core processors each used
- Data was preprocessed by striping it across the available compute nodes


Data Archive

Striping

Primitives Extraction

Index

Server-side Components

Query Engine

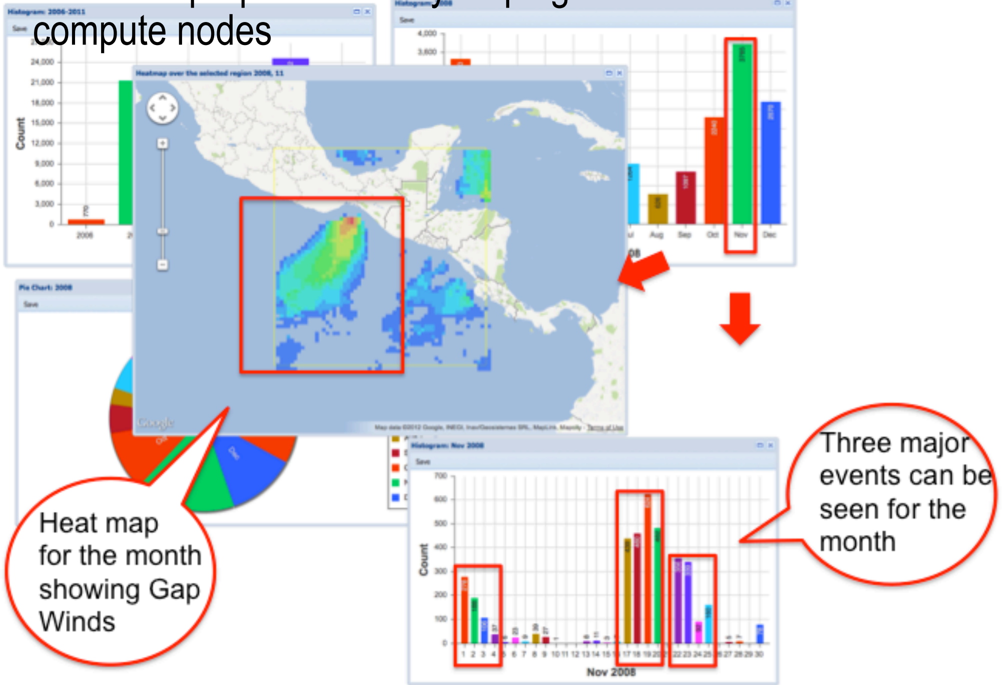
Query

Statistical Computations

Analyze

Visualize

Client for interactive exploration



Heat map for the month showing Gap Winds

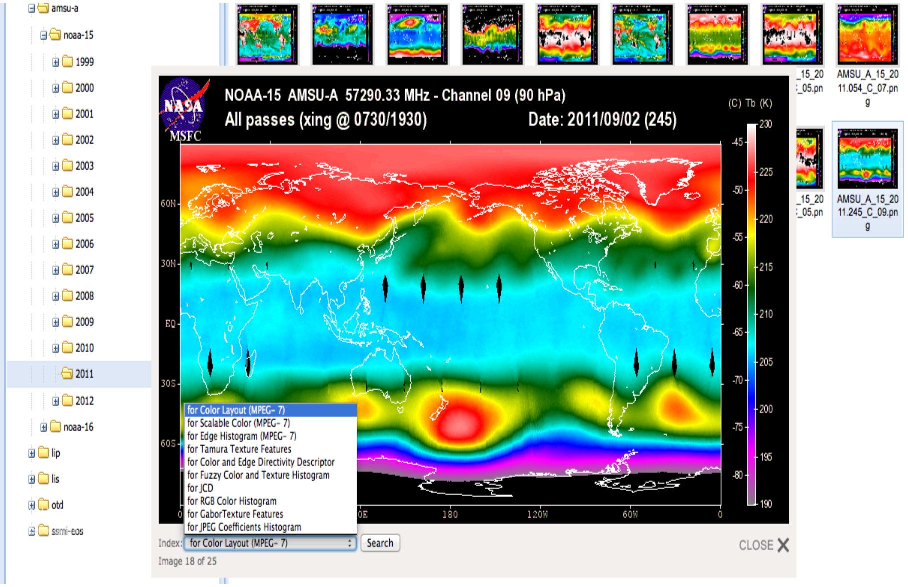
Three major events can be seen for the month

- Initial evaluations by researchers has clearly demonstrated the value of such a tool
- Polaris has been adopted by a joint project with NASA GSFC National Center for Climate Simulations
- Exploring opportunities to make the tool operational at NASA DAACs and NASA’s Earth Exchange (NEX).

NASA Science on Drupal

Content Based Image Retrieval Module

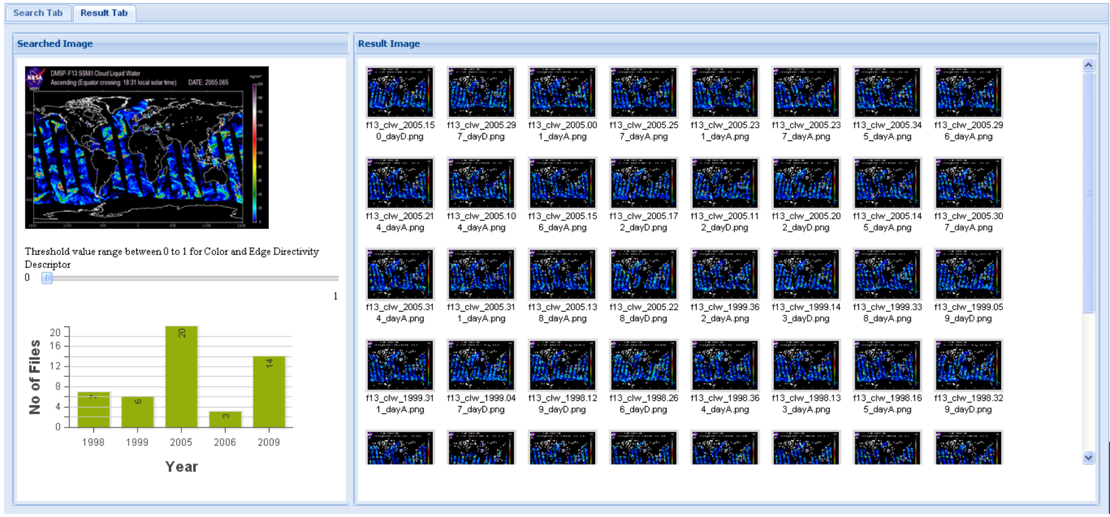
- Allows users to interactively query a large database of browse images based on image contents.
- Search service provides confidence scores for the matching images and filters the images based on the scores
- Provides basic analytics on the results is available via histogram on the count of number of matching results for years, months, and days.



NOAA-15 AMSU-A 57290.33 MHz - Channel 09 (90 hPa)
All passes (xing @ 0730/1930) Date: 2011/09/02 (245)

Index: for Color Layout (MPEG- 7)

Image 18 of 25


Search Tab
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DMSP-F13 SSM/I Cloud Liquid Water
Ascending (Equator crossing: 18:31 local solar time) DATE: 2005.065
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1
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2005
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2009
Year
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f13_clw_1998.133_dayA.png
f13_clw_1998.165_dayA.png
f13_clw_1998.329_dayD.png

Threshold value range between 0 to 1 for Color and Edge Directivity Descriptor

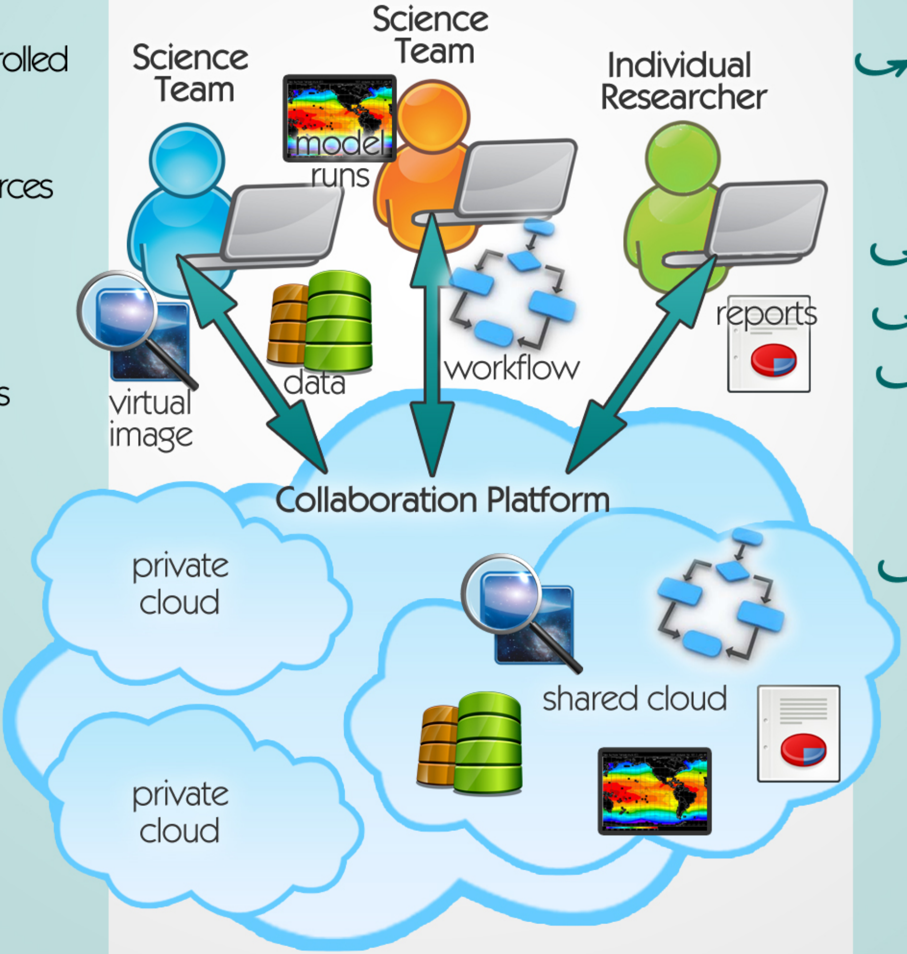
Collaborative Workbench (CWB)

to Accelerate Science Algorithm Development

Sharing Knowledge is at the heart of science, yet it is challenging for researchers to effectively share information and tools

Goals

- An architecture for scalable, controlled collaboration
- Selective sharing of science resources
  - among individuals
  - within science teams
  - with the entire science community.
- Software that fits how researchers currently do scientific analysis to promote adoption



Benefits

- **Accelerate science algorithm development** by distributed science teams
- **Reduce redundancy**
- **Improve productivity**
- Securely share all science artifacts (data, information, workflow, virtual machines)
- Generalizable to support collaborative science algorithm development for other mission and model enterprises

Questions?

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