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OceanWorks:
Ocean Science Data Analytics using Apache Science Data Analytics Platform

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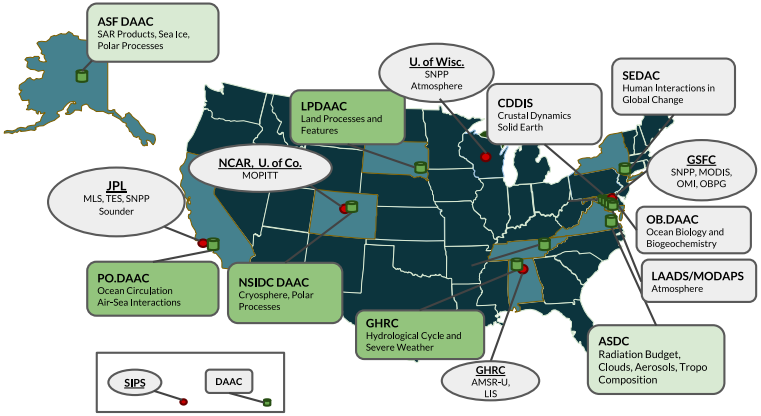
NASA's Physical Oceanography Data Center

- The **NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC)** at Jet Propulsion Laboratory is an element of the **Earth Observing System Data and Information System (EOSDIS)**. The EOSDIS provides science data to a wide communities of user for NASA's Science Mission Directorate.
- Archives and distributes data relevant to the physical state of the ocean
- **The mission of the PO.DAAC is to preserve NASA's ocean and climate data and make these universally accessible and meaningful.**



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Data Centers

- **Mainly focus on** archives and distributions
- **With additional services**
  - Better searches – faceted, spatial, keyword, ranking, etc.
  - Data subsetting – home grown, OPeNDAP, Webification, etc.
  - Visualization – visual discovery, PO.DAAC's SOTO, NASA Worldview, etc.
- **Limitations**
  - Little to no interoperability between tools and services: metadata standard, keyword, spatial coverage (0-360 or -180..180), temporal representation, etc.
  - Making sure the most relevant measurements return first
  - Visualization is nice, but it doesn't provide enough information about the event/phenomenon captured in the image.
  - With large amount of observational data, data centers need to do more than just storing bits
    - "Is the red blob in the middle of Pacific normal this time of the year?"
    - "Any relevant news and publications relate to what I am looking at?"
    - "What other measurements, phenomena, news, publications relate to the period and location I am looking at?"
    - "I can see the observation from satellite, are there any relevant in situ data I can look at?"

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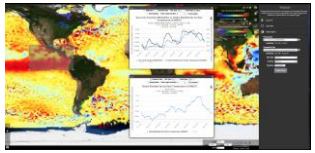
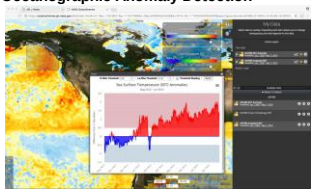
Enabling Next Generation of Ocean Science Tools and Services

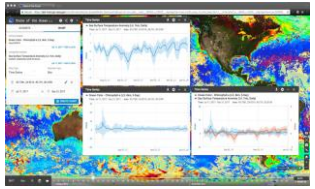
NASA Sea Level Change Portal



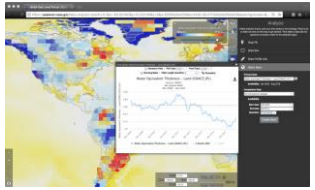
Oceanographic Anomaly Detection



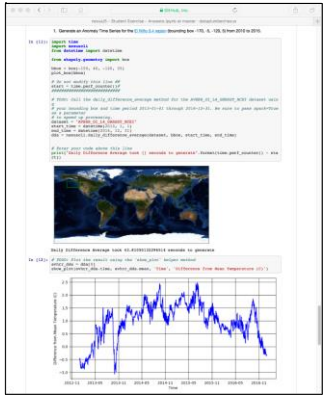
PO.DAAC State Of The Ocean



Hydrological Basin Analysis

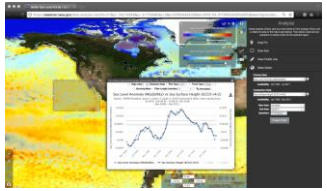


Jupyter Notebook - Interactive Workbench

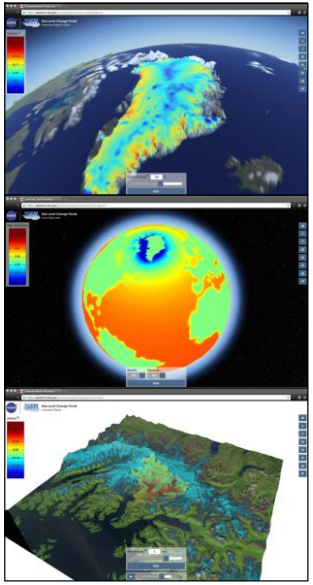


Mobile Analysis

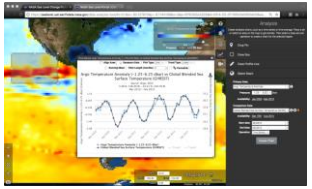
In Situ Data Analysis



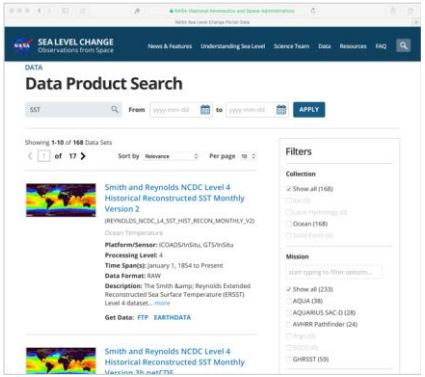
Model Simulations



Model - Observation Comparison



Integrated Search and Discovery



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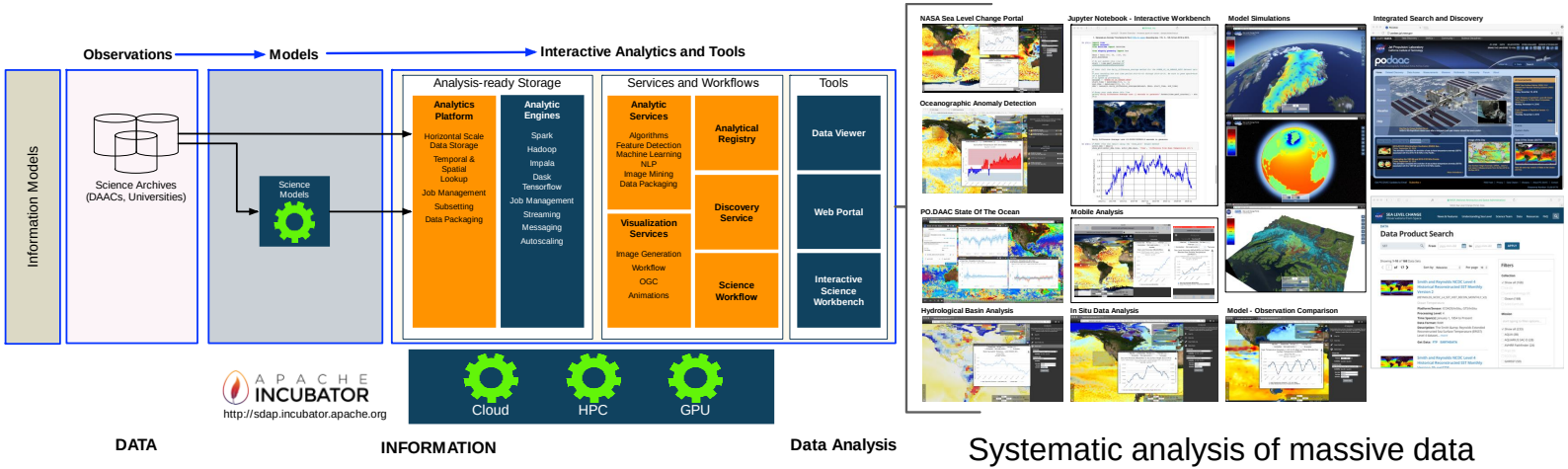
Integrated Ocean Science Data Analytics Platform



Systematic analysis of massive data

- An **Integrated Ocean Science Data Analytics Platform**: an environment for conducting a Ocean Science investigation
  - Confluence of resources for that investigation
  - Tailored to the individual study area (physical ocean, sea level, etc.)
- Harmonizes data, tools and computational resources to permit the ocean research community to focus on the investigation
- Scale computational and data infrastructures
- Shift towards integrated data analytics
- Algorithms for identifying and extracting interesting features and patterns

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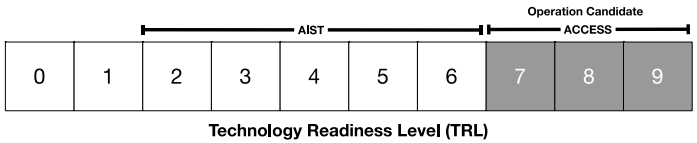
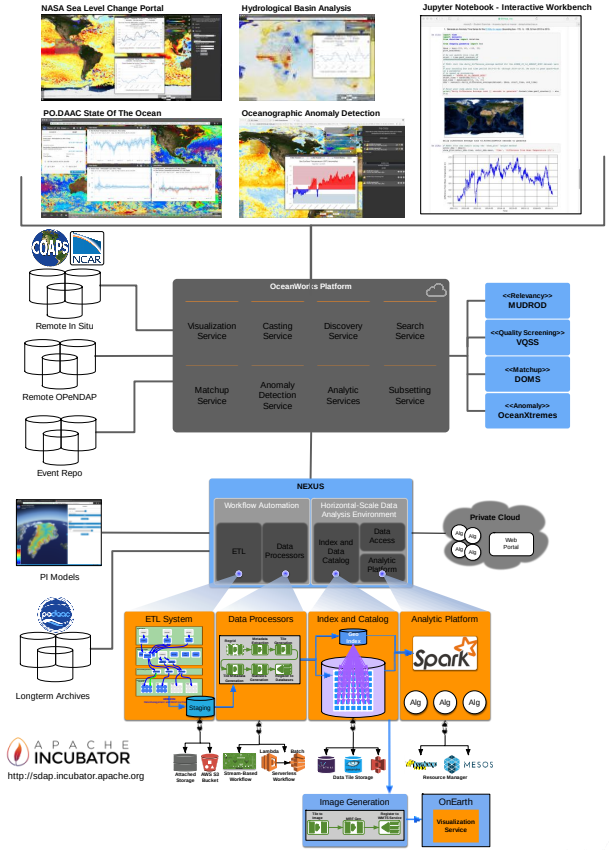
NASA AIST OceanWorks

- **OceanWorks** is to establish an **Integrated Data Analytics Center** at the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) for Big Ocean Science
- Focuses on technology integration, advancement and maturity
- Collaboration between JPL, Center for Atmospheric Prediction Studies (COAPS) at Florida State University (FSU), National Center for Atmospheric Research (NCAR), and George Mason University (GMU)
- Bringing together PO.DAAC-related big data technologies
  - Big data analytic platform
  - Anomaly detection and ocean science
  - Distributed in situ to satellite matchup
  - Dynamic datasets ranking and recommendations
  - Sub-second data search solution and metadata translation and services aggregation
  - Quality-screened data subsetting





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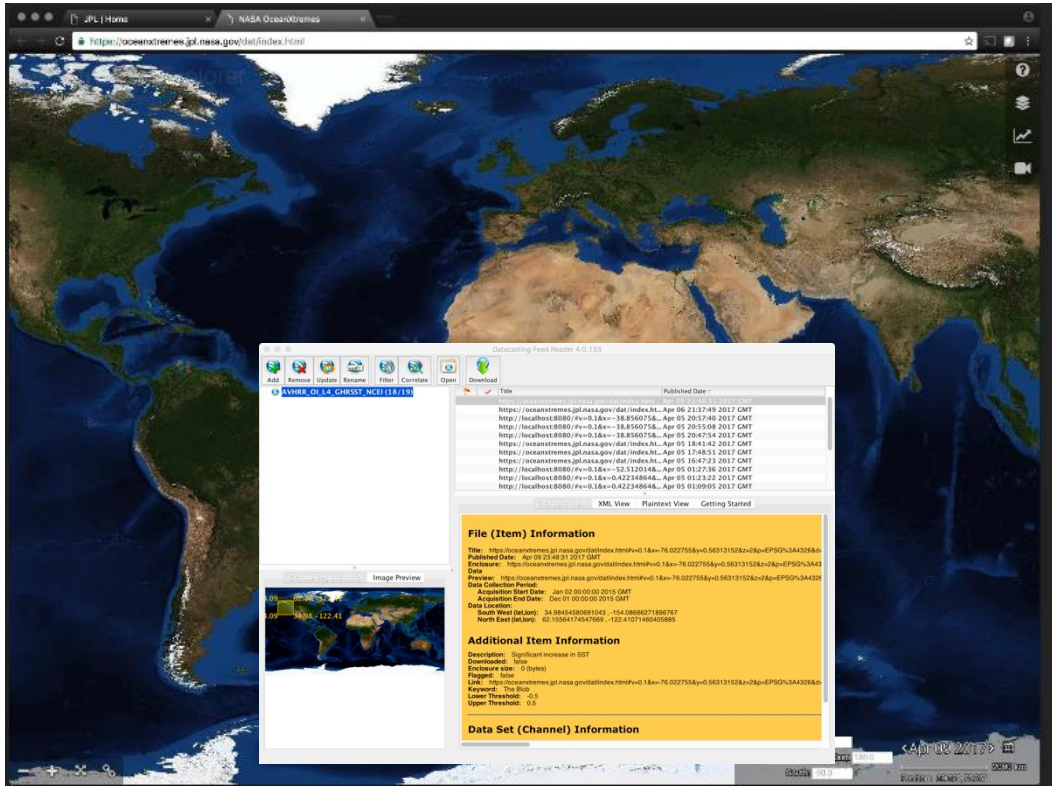
Interactive Ocean Science Analysis

Interactive Anomaly Detection



Sea Level Analysis

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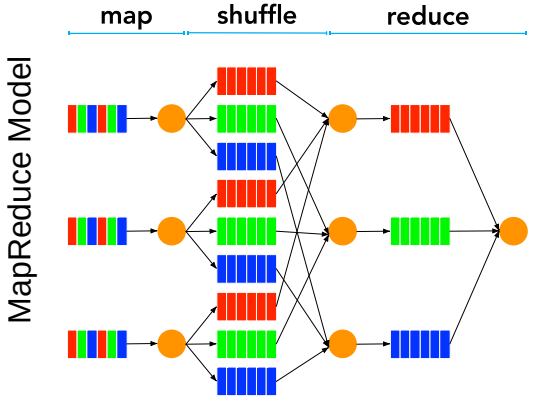
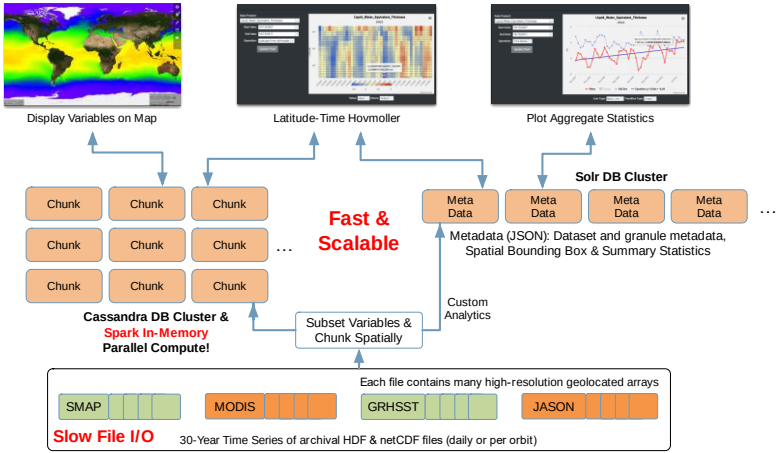
NEXUS: Scalable Data Analytic Solution

- **MapReduce**: A programming model for expressing distributed computations on massive amount of data and an execution framework for large-scale data processing on clusters of commodity servers. - J. Lin and C. Dyer, "*Data-Intensive Text Processing with MapReduce*"
  - **Map**: splits processing across cluster of machines in parallel, each is responsible for a record of data
  - **Reduce**: combines the results from Map processes
- **NEXUS** is a data-intensive analysis solution using a new approach for handling science data to enable large-scale data analysis
  - Streaming architecture for horizontal scale data ingestion
  - Scales horizontally to handle massive amount of data in parallel
  - Provides high-performance geospatial and indexed search solution
  - Provides tiled data storage architecture to eliminate file I/O overhead
  - A growing collection of science analysis webservices





NEXUS' Two-Database Architecture

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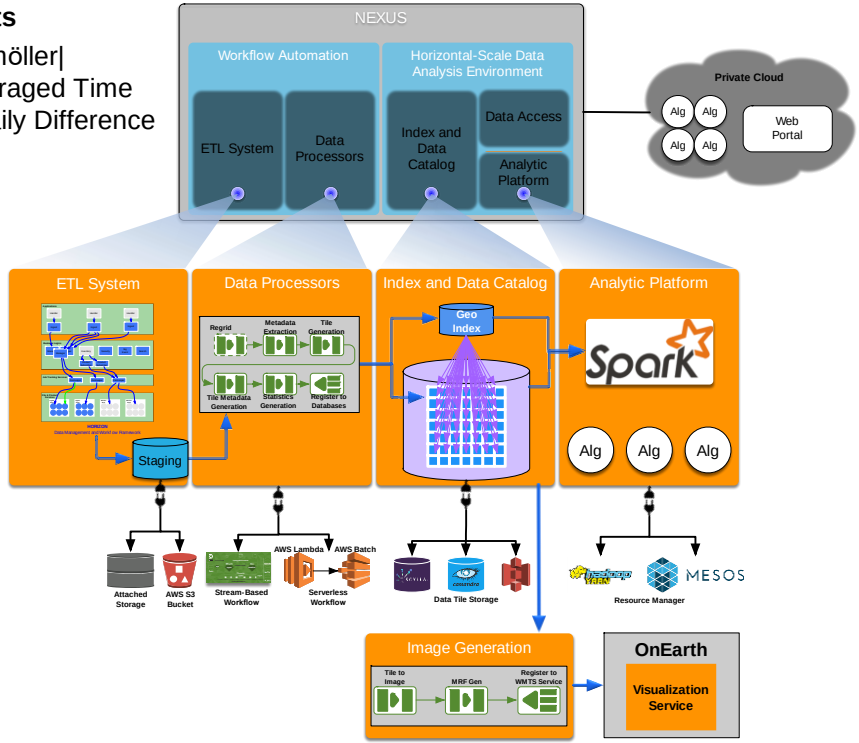
NEXUS' Pluggable Architecture for different Operation Needs

- **NEXUS supports public/private Cloud and local cluster deployments**
- **It has a growing set of algorithms –** Time Series | Latitude/Time Hovmöller| Longitude/Time Hovmöller| Latitude/Longitude Time Average | Area Averaged Time Series | Time Averaged Map | Climatological Map | Correlation Map | Daily Difference Average
- **It offers several container-based deployment options**
  - Local on-premise cluster
  - Private Cloud
  - Amazon Web Service
- **Automate Data Ingestion with Image Generation**
  - Cluster based
  - Serverless (Amazon Lambda and Batch)
- **Data Store Options**
  - Apache Cassandra
  - ScyllaDB
  - Amazon Simple Storage Service (S3)
- **Resource Management Options**
  - Apache YARN
  - Apache MESOS
- **Analytic Engine Options**
  - Custom Apache Spark Cluster
  - Amazon Elastic MapReduce (EMR)
  - Amazon Athena (work-in-progress)



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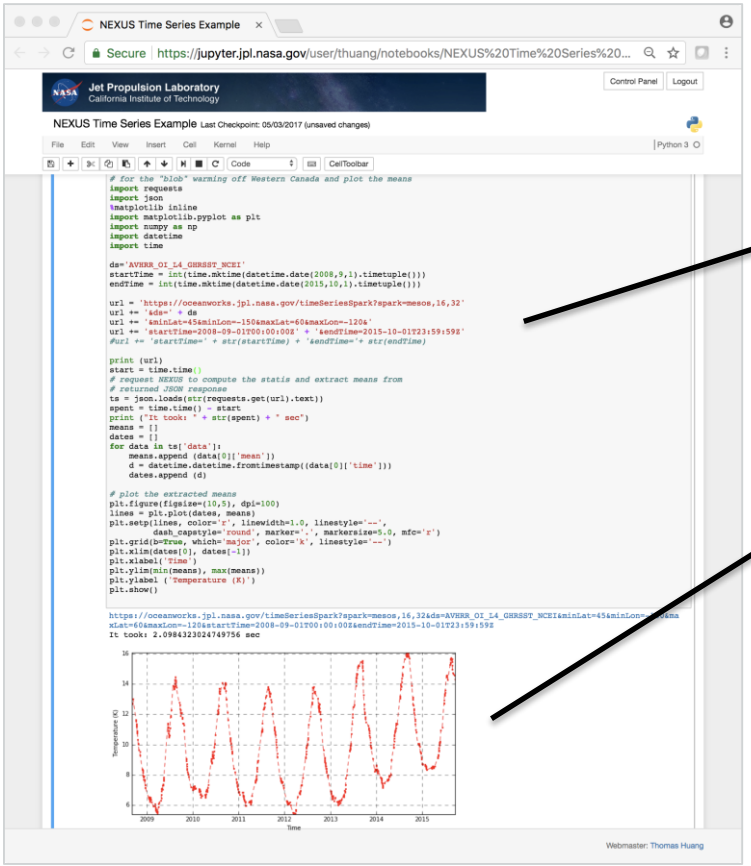
Enable Science without File Download




```
# Request NEXUS to compute SST Time Series 2008/9/1 - 2015/10/1
# for the "blob" warming off Western Canada and plot the means
…
ds='AVHRR_OI_L4_GHRSST_NCEI'

url = … # construct the webservice URL request


# make request to NEXUS using URL request
# save JSON response in local variable
ts = json.loads(str(requests.get(url).text))

# extract dates and means from the response
means = []
dates = []
for data in ts['data']:
    means.append (data[0]['mean'])
    d = datetime.datetime.fromtimestamp((data[0]['time']))
    dates.append (d)

# plot the result
…
```

https://oceanworks.jpl.nasa.gov/timeSeriesSpark?**spark**=mesos,16,32&**ds**=AVHRR_OI_L4_GHRSST_NCEI&**minLat**=45&**minLon**=-150&**maxLat**=60&**maxLon**=-120&**startTime**=2008-09-01T00:00:00Z&**endTime**=2015-10-01T23:59:59Z

It took: 2.0984323024749756 sec

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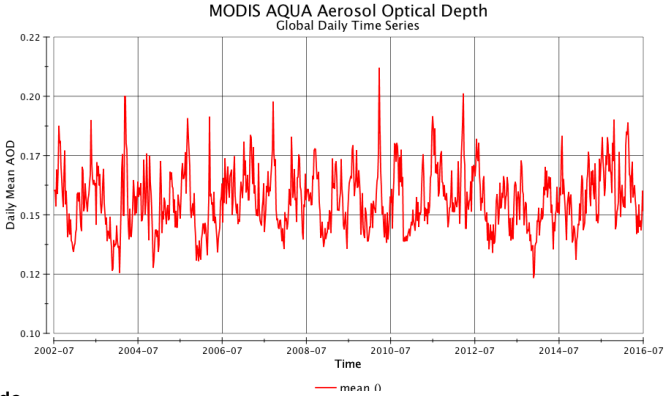
NEXUS Performance

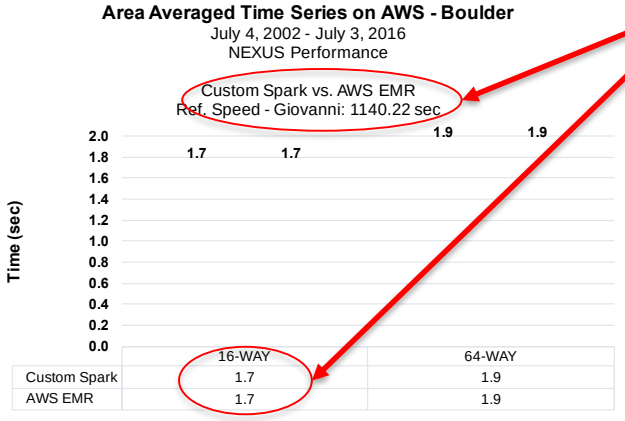
A recent benchmark comparison between **NASA GIOVANNI**, **NEXUS** with **Amazon's Elastic Map Reduce (EMR),** and NEXUS with custom Apache Spark Cluster

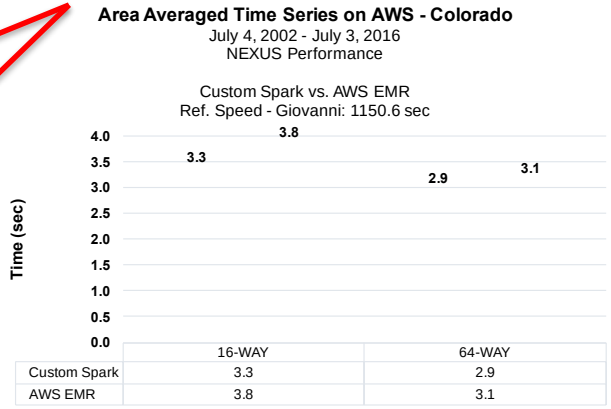
- **Giovanni**: A web-based application for visualize, analyze, and access vast amounts of Earth science remote sensing data without having to download the data.
  - Represents current state of data analysis technology, by processing one file at a time
  - Backed by the popular NCO library. Highly optimized C/C++ library
- **AWS EMR**: Amazon's provisioned MapReduce cluster

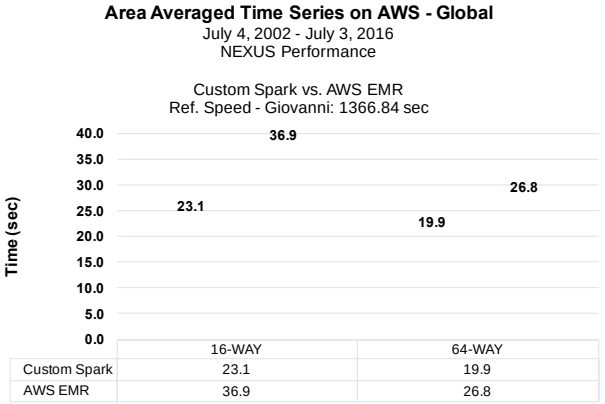
Dataset: 14-years of MODIS AQUA Daily (1 degree daily) Aerosol Optical Depth 550nm (Dark Target) (MYD08_D3v6), Level 3
File Count: 5106
Total 2.6GB



GIOVANNI: 20 min
NEXUS: 1.7 sec







Algorithm execution time. Excludes Giovanni's data scrubbing processing time

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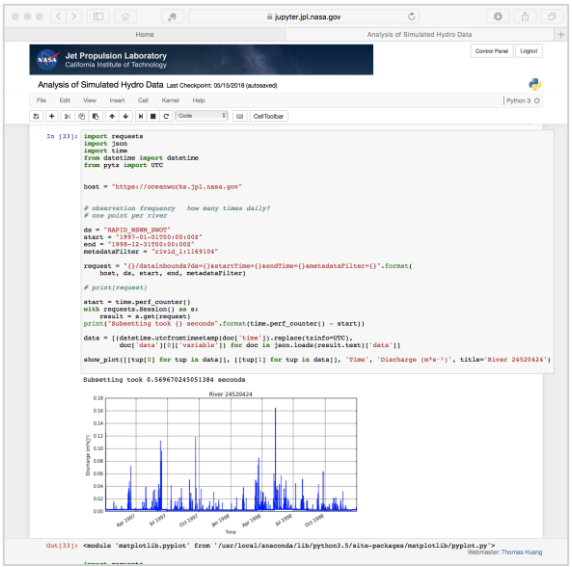
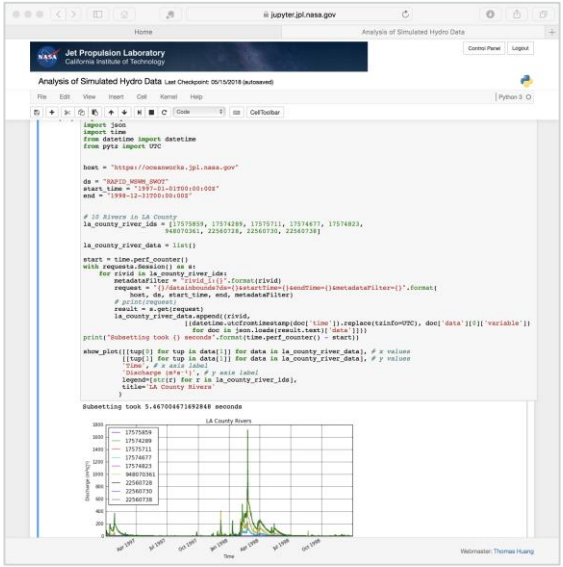
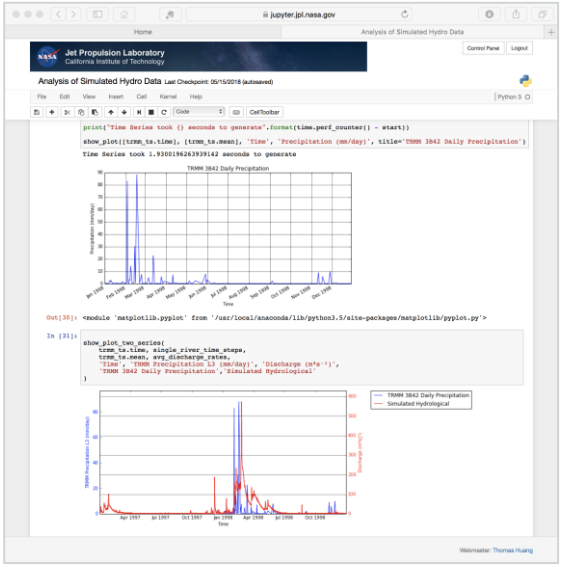
Performance example: support for hydrology



Retrieval of a single river time series



Retrieval of time series from 9 rivers



Time series coordination between TRMM and river

- Simulated hydrology data in preparation for SWOT hydrology
- **River data**: ~3.6 billion data points. 3-hour sample rate. Consists of measurements from ~600,000 rivers
- **TRMM data**: 17 years, .25deg, 1.5 billion data points
- Sub-second retrieval of river measurements
- On-the-fly computation of time series and generate coordination plot

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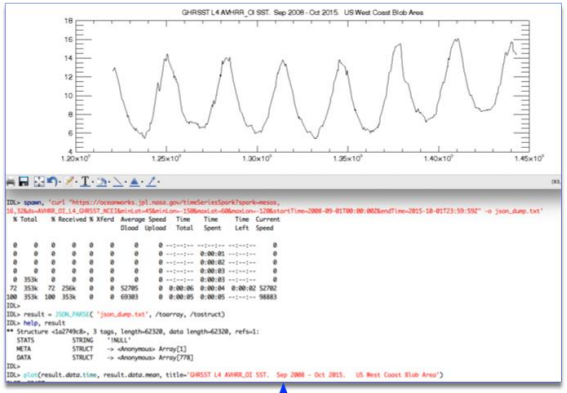
Using IDL with NEXUS

```
IDL> spawn, 'curl
"https://oceanworks.jpl.nasa.gov/timeSeriesSpark?spark=mesos,16,32&ds=AVHRR_OI_L4_
GHRSST_NCEI&minLat=45&minLon=-150&maxLat=60&maxLon=-120&startTime=2008-09-
01T00:00:00Z&endTime=2015-10-01T23:59:59Z" -o json_dump.txt'
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed

  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0
  0     0    0     0    0     0      0      0 --:--:--  0:00:01 --:--:--     0
  0     0    0     0    0     0      0      0 --:--:--  0:00:02 --:--:--     0
  0     0    0     0    0     0      0      0 --:--:--  0:00:03 --:--:--     0
  0  353k    0     0    0     0      0      0 --:--:--  0:00:03 --:--:--     0
 72  353k   72  256k    0     0  52705      0  0:00:06  0:00:04  0:00:02 52702
100  353k  100  353k    0     0  69303      0  0:00:05  0:00:05 --:--:-- 98883
IDL>
IDL> result = JSON_PARSE( 'json_dump.txt', /toarray, /tostruct)
IDL> help, result
** Structure <1a2749c8>, 3 tags, length=62320, data length=62320, refs=1:
   STATS           STRING    '!NULL'
   META            STRUCT    -> <Anonymous> Array[1]
   DATA            STRUCT    -> <Anonymous> Array[778]
IDL>
IDL> plot(result.data.time, result.data.mean, title='GHRSST L4 AVHRR_OI SST.  Sep
2008 - Oct 2015.   US West Coast Blob Area')
PLOT <29457>
```



Credit: Ed Armstrong
Jun. 05, 2018

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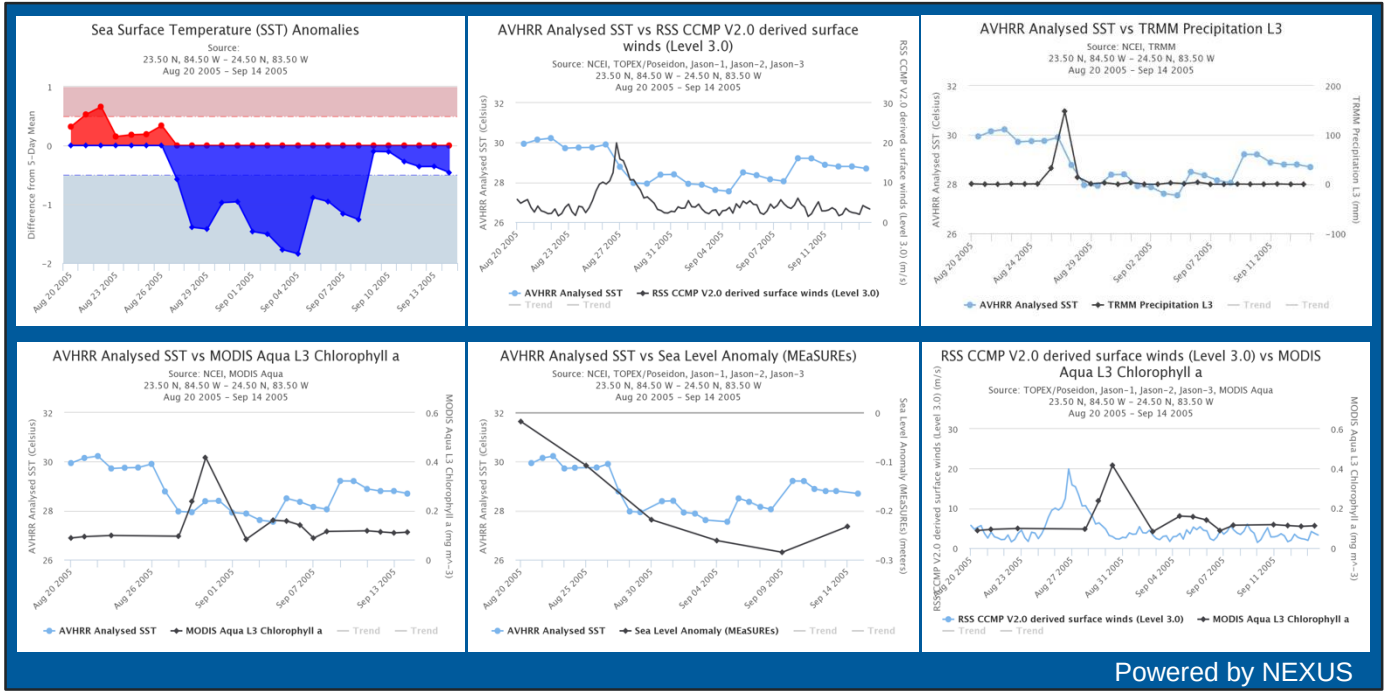
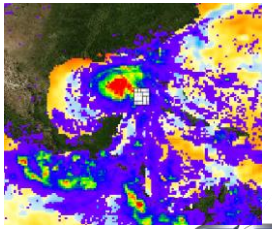
Hurricane Katrina Study



Hurricane Katrina passed to the southwest of Florida on Aug 27, 2005. The ocean response in a 1 x 1 deg region is captured by a number of satellites. The initial ocean response was an immediate cooling of the surface waters by 2 ℃ that lingers for several days. Following this was a short intense ocean chlorophyll bloom a few days later. The ocean may have been “preconditioned’ by a cool core eddy and low sea surface height.

The SST drop is correlated to both wind and precipitation data. The Chl-A data is lagged by about 3 days to the other observations like SST, wind and precipitation.



Hurricane Katrina TRMM overlay SST Anomaly

A study of a Hurricane Katrina–induced phytoplankton bloom using satellite observations and model simulations
Xiaoming Liu, Menghua Wang, and Wei Shi
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, C03023, doi:10.1029/2008JC004934, 2009

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Growing List of Datasets

- **Atmosphere**
  - MODIS Aqua Daily L3 Atmospheres, Collection 6, variable Aerosol Optical Depth 550 nm (Dark Target) (MOD08_D3v6)
  - MODIS Terra Daily L3 Atmospheres, Collection 6, variable Aerosol Optical Depth 550 nm (Dark Target) MOD08_D3v6)
  - MODIS Aqua Monthly L3 Atmospheres, Collection 6, variable Aerosol Optical Depth 550 nm (Dark Target) (MOD08_D3v6)
  - MODIS Terra Monthly L3 Atmospheres, Collection 6, variable Aerosol Optical Depth 550 nm (Dark Target) MOD08_D3v6)
- **Chlorophyll**
  - MODIS Aqua Level 3 Global Daily Mapped 4 km Chlorophyll a
- **Estimating the Circulation and Climate of the Ocean (ECCO)**
  - Monthly Mean Version 4 release 2 – Net Surface Fresh-Water Flux, Net Surface Heat Flux, Mixed-Layer Depth, Bottom Pressure, SEAICE Fractional Ice-Covered Area, Free Surface Height Anomaly, SEAICE Effective Snow Thickness, Total Heat Flux, Total Salt Flux
  - Monthly Mean Version 4 release 1 – Net Surface Fresh-Water Flux, Net Surface Heat Flux, Mixed-Layer Depth, Ocean Bottom Pressure, SEAICE Fractional Ice-Covered Area, Free Surface Height Anomaly, SEAICE Effective Snow Thickness, Actual Sublimation Freshwater Flux, Total Heat Flux, Total Salt Flux
- **Gravity**
  - Center for Space Research (CSR) GRACE RL05 Mascon Solutions
  - JPL GRACE Mascon Ocean, Ice, and Hydrology Equivalent Water Height RL05M.1 CRI filtered Version 2
- **Ocean Temperature**
  - GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (v4.1)
  - GHRSST Level 4 MUR Global Foundation Sea Surface Temperature Analysis (25km)
  - GHRSST Level 4 AVHRR_OI Global Blended Sea Surface Temperature Analysis (GDS version 2) from NCEI
  - MODIS Aqua Level 3 SST Thermal IR Daily 4km Nighttime v2014.0
  - MODIS Aqua Level 3 SST Thermal IR Daily 4km Daytime v2014.0

Growing List of Datasets (+)

- **Salinity**
  - JPL SMAP Level 2B CAP Sea Surface Salinity V2.0 Validated Dataset
  - JPL SMAP Level 3 CAP Sea Surface Salinity Standard Mapped Image Monthly V3.0 Validated Dataset
- **Sea Surface Height Anomalies (SSHA)**
  - JPL MEaSUREs Gridded Sea Surface Height Anomalies Version 1609
- **Wind**
  - Cross-Calibrated Multi-Platform Ocean Surface Wind Vector L3.0 First-Look Analyses
- **Precipitation (non-ocean data)**
  - TRMM (TMPA) Precipitation L3 1 day 0.25 degree x 0.25 degree V7 (TRMM_3B42_Daily) at GES DIS
  - TRMM (TMPA-RT) Precipitation L3 1 day 0.25 degree x 0.25 degree V7 (TRMM_3B42_RT) at GES DISC
- **In Situ**
  - Shipboard Automated Meteorological and Oceanographic System (SAMOS)
  - International Comprehensive Ocean-Atmosphere Data Set (ICOADS) Release 3, Individual Observations
  - Salinity Process in the Upper Ocean Regional Study – 1 (SPURS1)
  - Salinity Process in the Upper Ocean Regional Study – 2 (SPURS2)
  - Global gridded NetCDF Argo only dataset produced by optimal interpolation (salinity variables)
  - Global gridded NetCDF Argo only dataset produced by optimal interpolation (temperature variables)

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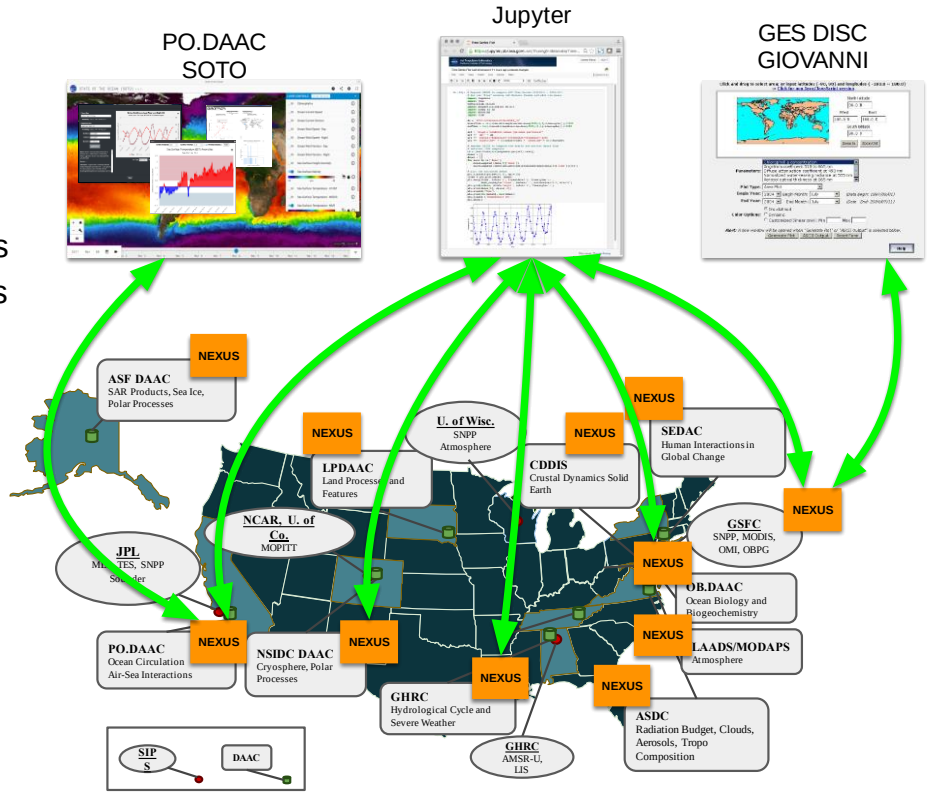
Moving Toward Multi-Variable Analysis

- Public accessible RESTful analytic APIs where computation is next to the data
- NEXUS as the analytic engine infused and managed by the data centers on the Cloud
- Researchers can perform multi-variable analysis using any web-enabled devices without having to download files
- Reduce unnecessary data movement and egress charges
- An architecture to enable next generation of scientific applications



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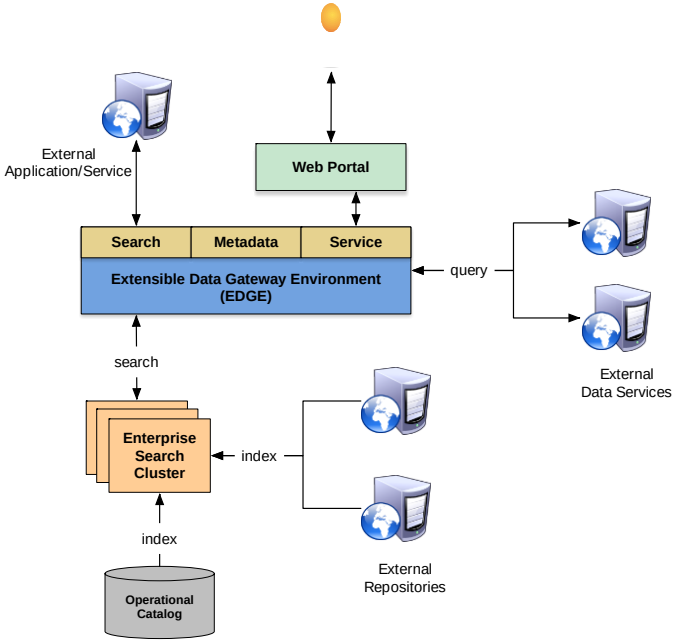
Extensible Data Gateway Environment (EDGE)

- Open Source high-performance geospatial data search and access
- Delivers sub-second search solution
- Implements the ESIP Federation's Discovery Specification (http://wiki.esipfed.org/index.php/Discovery_Cluster), which is a specialization of the OpenSearch (http://www.opensearch.org) standard (both XML and JSON)
- Platform to support multi-metadata standard specifications including ISO-19115, NASA UMM-C, NASA ECHO-10, NASA Global Change Master Directory (GCMD), Federation Geographic Data Committee (FGDC), and various domain-specific metadata standards
- Two main building blocks: data aggregation service and enterprise geospatial indexed search cluster
- Aggregation – provides a plugin approach to integrate with other external data repositories by proxying to other local/remote data services to reduce the number of interfaces a requestor has to access
- Enterprise geospatial indexed search cluster for fast lookup. Supports Apache Solr (and SolrCloud) and ElasticSearch
- Various production deployments including NASA Sea Level Change Portal, GRACE Web Portal, PO.DAAC, NASA ACCESS and AIST projects, and various Navel Research projects



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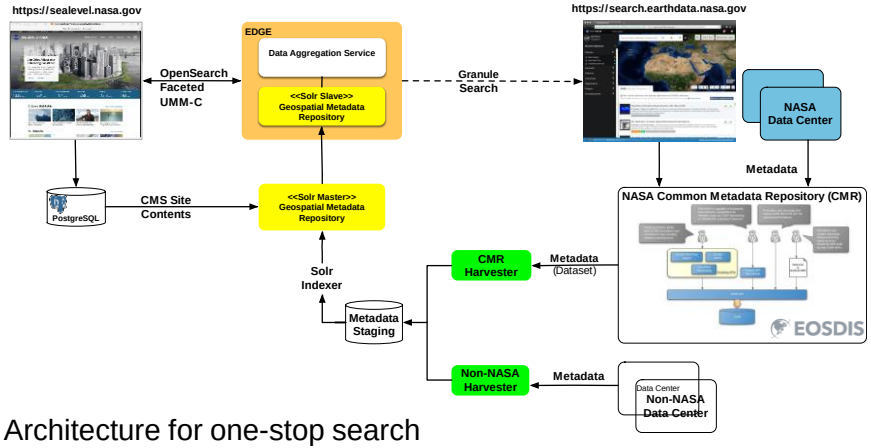
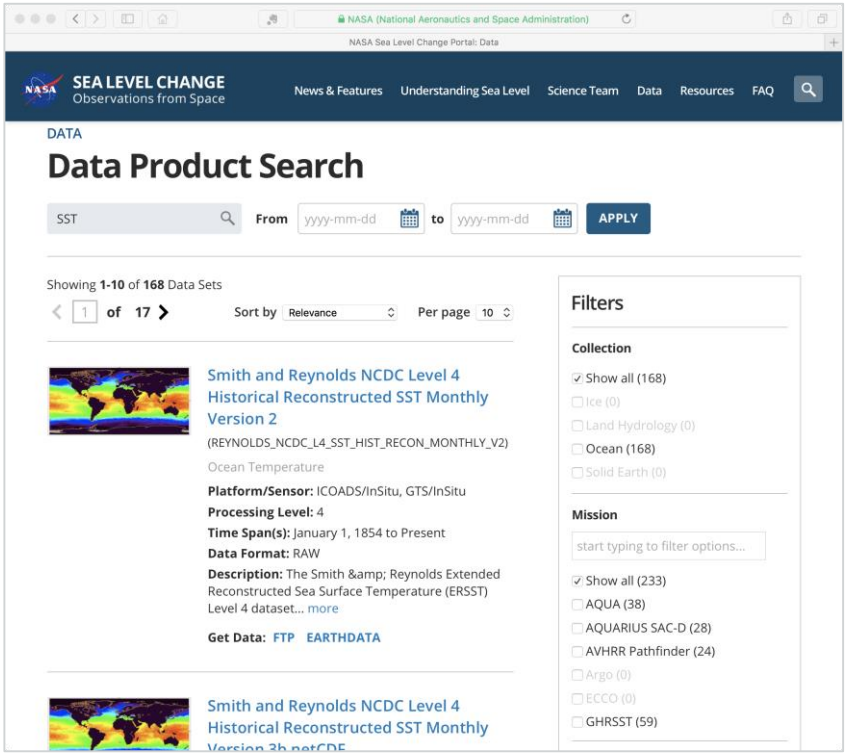
NASA Sea Level Change Portal's One-Stop Search

- Homogenize metadata acquired from different providers
- On-the-fly translation metadata and search results according to the NASA ECHO-10 and UMM-C specification
- Simplify web portal integration by providing one-stop search solution for all Sea Level artifacts – data, news, publications, and multi-media resources



Architecture for one-stop search



NASA Sea Level Change Portal's One-Stop Search

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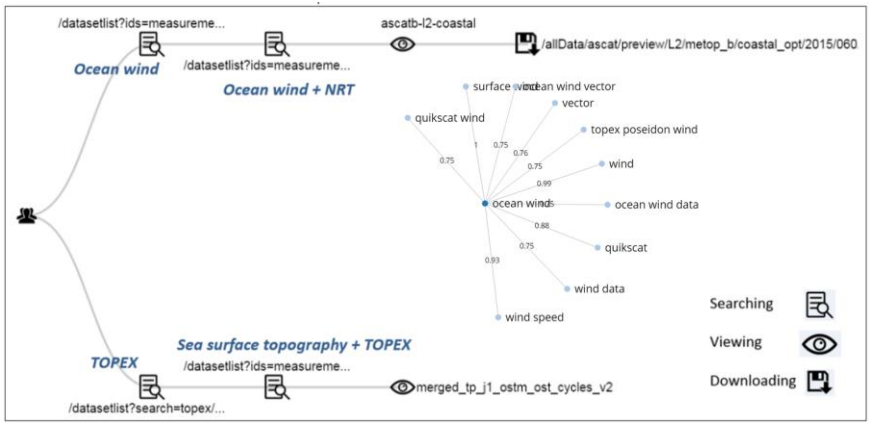
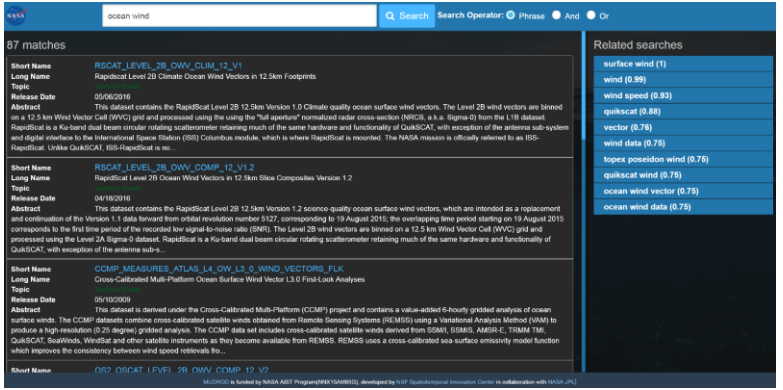
Dynamic Search Ranking

- Adjust search result according how user search and retrieval
- Use machine learning approach to adjust search ranking by taking a number of features into consideration – version, processing level, release date, all-time popularity, monthly-popularity, and user popularity
- Semantically mind dataset metadata to identify relationship

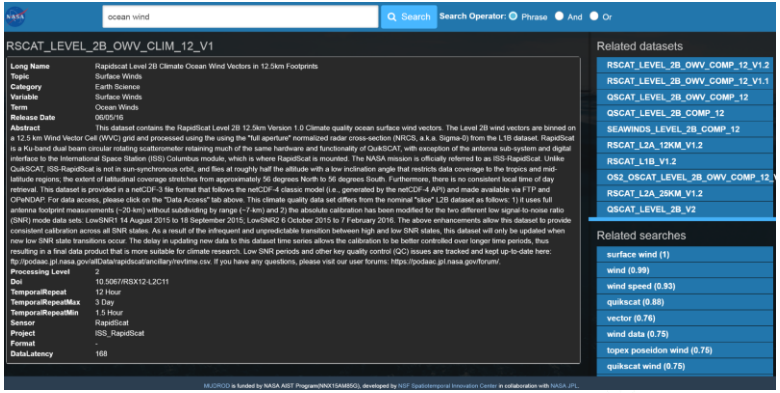


Session Reconstruction

Search Ranking



Search Recommendation



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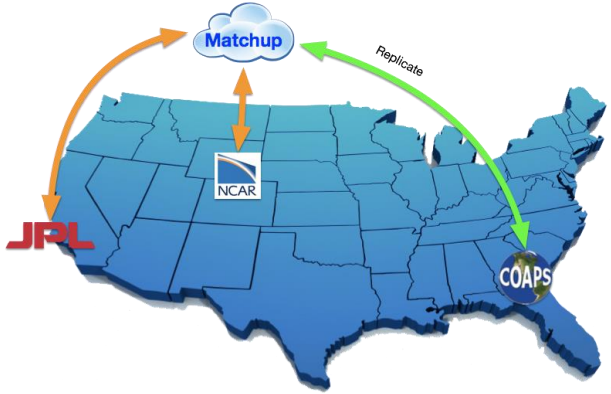
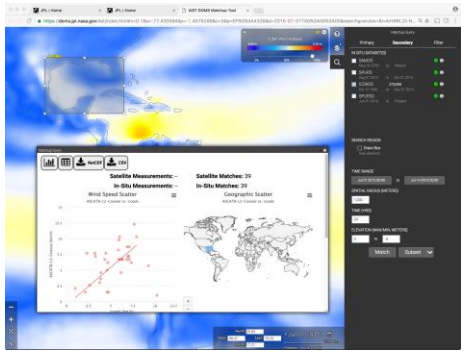
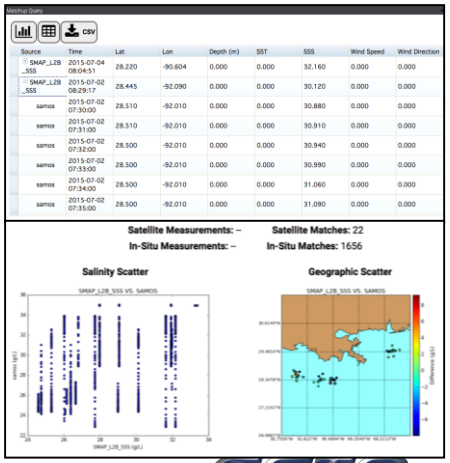
In-Situ to Satellite Matchup

- Typically data matching is done using one-off programs developed at multiple institutions
- Leverage horizontal-scale technology for fast, in-memory execution of matchup algorithm
- Common and open source architecture to reduce in duplicate development and man hours required to match satellite/in situ data
- Satellite measurements. Hosted at the PO.DAAC
  - **GHRSST JPL-L2P-MODIS_A** and **JPL-L2P-MODIS_T**
  - **SMAP L2 Sea Surface Salinity** (JPL Evaluation product) (4/1/2015 – 8/1/2016)
  - **ASCAT ASCATB-L2 Coastal** (10/29/2012 – 06/06/2016)



- In situ data nodes at SPURS/JPL, ICOADS/NCAR, and SAMOS/FSU operational.
  - **Shipboard Automated Meteorological and Oceanographic System (SAMOS)**. Hosted at FSU/COAPS
  - **International Comprehensive Ocean-Atmosphere Data Set (ICOADS).** Hosted at NCAR
  - **Salinity Processes in the Upper Ocean Regional Study: (SPURS-1)** N. Atlantic (2012-13) : salinity max region. **(SPURS-2)** Eastern Equatorial Pacific (15-16): high precipitation/low evaporation region. Hosted at JPL
- Provides data querying, subset creation, match-up services, and file delivery operational.
- Supports on-the-fly in situ to satellite matchup of SST, SSS, Wind parameters





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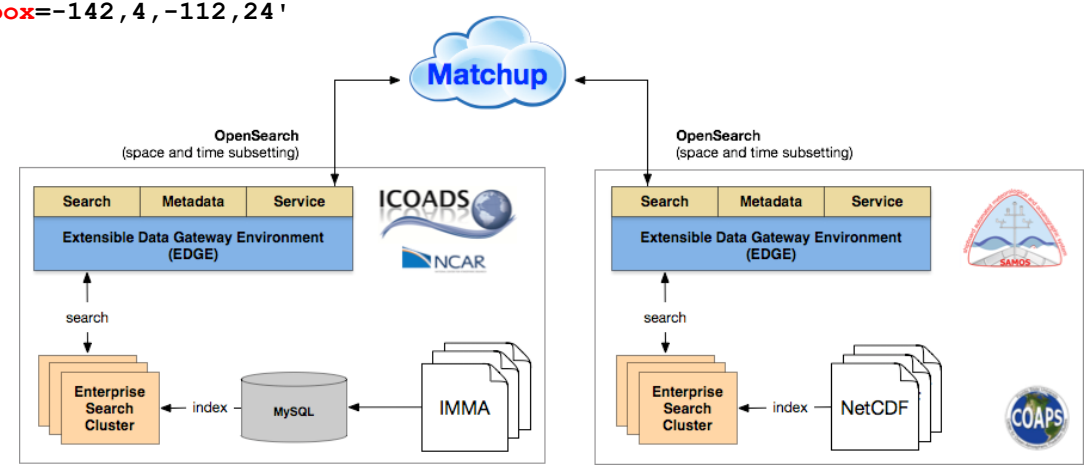
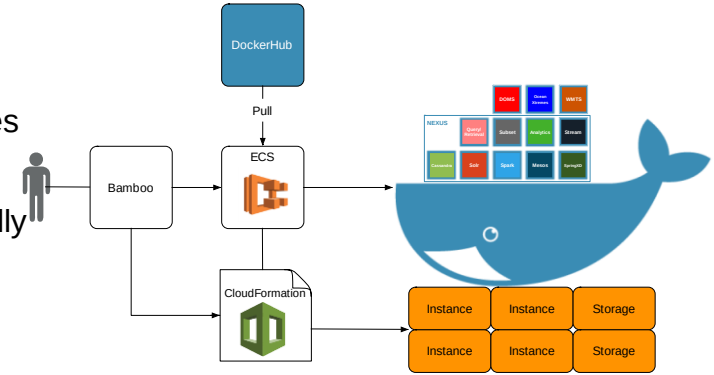
On-The-Fly Subsetting of In-Situ Measurements using OpenSearch

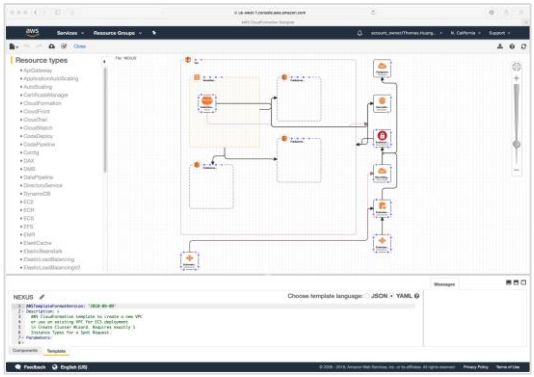
- Using OpenSearch as the standard interface to in-situ data repositories
- Enable distributed, federated search and data subsetting
- Subset in-situ data by time and space using OpenSearch
  - **ICOADS:** `'http://rda-data.ucar.edu:8890/ws/search/icoads?startTime=2012-08-01T00:00:00Z&endTime=2013-10-31T23:59:59Z&bbox=-45,15,-30,30'`
  - **SAMOS:** `'http://doms.coaps.fsu.edu/edge/samos?startTime=2012-08-01T00:00:00Z&endTime=2013-10-31T23:59:59Z&bbox=-45,15,-30,30'`
  - **SPURS-1:** `'https://doms.jpl.nasa.gov/spurs?startTime=201208-01T00:00:00Z&endTime=2013-10-31T23:59:59Z&bbox=-45,15,-30,30'`
  - **SPURS-2:** `'https://doms.jpl.nasa.gov/spurs2?startTime=2016-07-01T00:00:00Z&endTime=2016-07-31T23:59:59Z&bbox=-142,4,-112,24'`



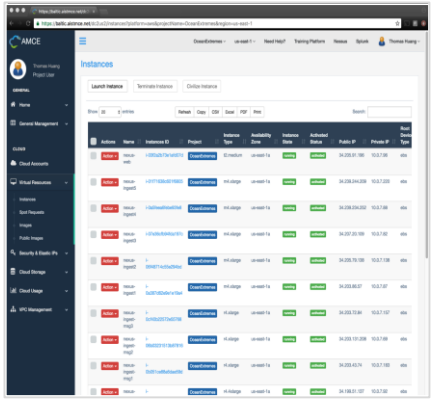
Deployment Automation

- Cloud Deployment is nontrivial
- Infrastructure Definition
  - Various machine instances
  - Storage and buckets
- Software Deployment.. manually
  - Build
  - Package
  - Install
  - Configure
  - Shell login (security issues)
- Best Practice: Deployment Automation
  - Script Infrastructure Definition (e.g. Amazon CloudFormation)
  - Container-based Deployment (e.g. Amazon ECS and DockerHub)

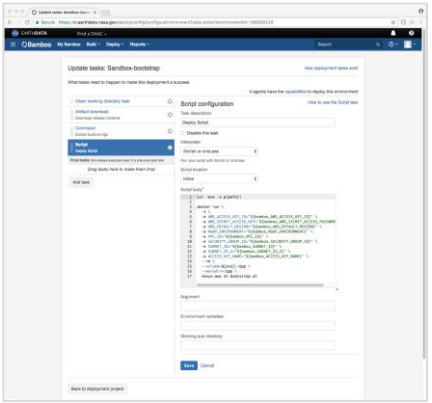




AWS CloudFormation Template Editor



AIST Managed Cloud Environment



ESDIS NGAP

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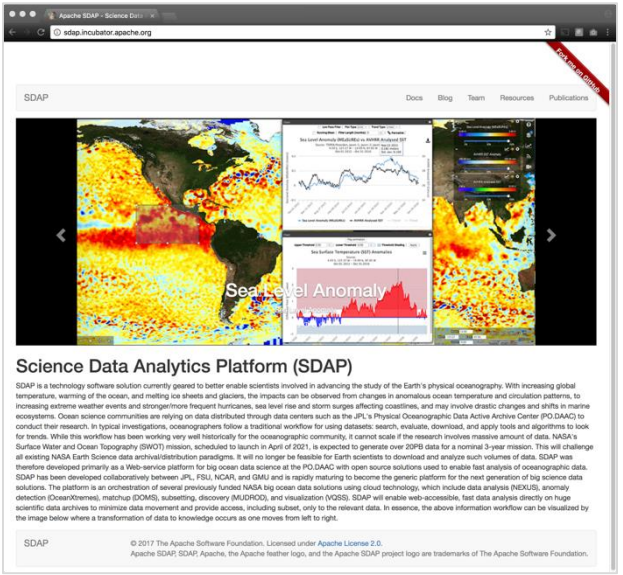
Free and Open Source Software (FOSS)

- October 2017, the OceanWorks project released all of its source code to Apache Software Foundation and established the **Science Data Analytics Platform (SDAP)** in the **Apache Incubator**
- Technology sharing through Free and Open Source Software (FOSS)
- Why? Further technology evolution that is restricted by projects / missions
- It is more than GitHub
  - Quarterly reporting
  - Reports are open for community review by over 6000 committers
  - SDAP has a group of appointed international Mentors: Jörn Rottmann, Raphael Bircher, and Suneel Marthi
- OceanWorks is now being developed in the open
  - For local cluster and cloud computing platform
  - Fully containerized using Docker (multiple containers)
  - Infrastructure orchestration using Amazon CloudFormation
  - Analyzing satellite and model data
  - In situ data analysis and colocation with satellite measurements
  - Fast data subsetting
  - Data services integration architecture
  - OpenSearch and dynamic metadata translation
  - Mining of user interactions and data to enable discovery and recommendations
  - Streamline deployment through container technology



http://sdap.incubator.apache.org

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Current Development

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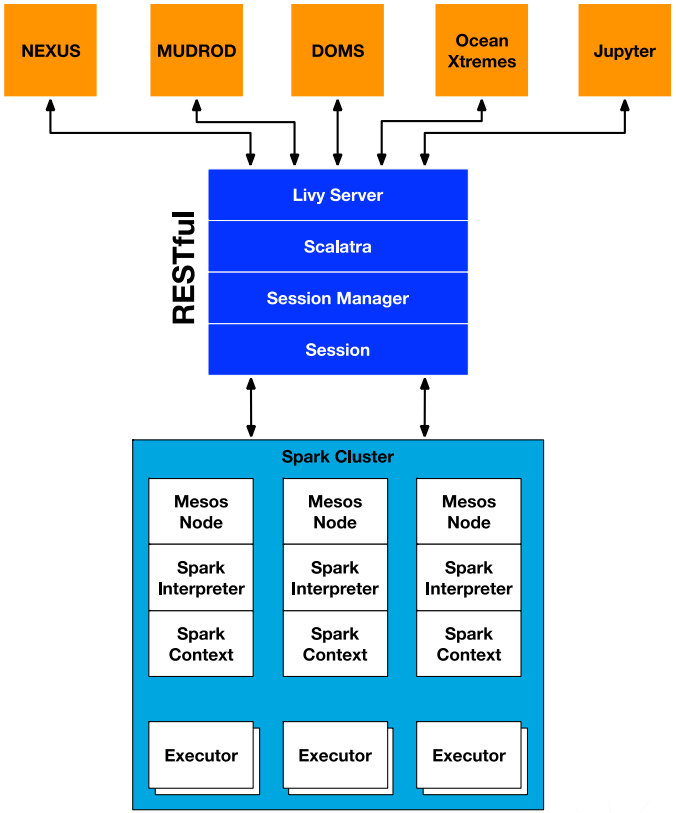
Architecture for Apache Spark Integration and Sharing

- Developed independently, all the major services in OceanWorks require Apache Spark cluster
- If OceanWorks simply deploy these services to Amazon, it will require dedicated Apache Spark cluster for each
- Too many cluster and very costly, since Apache Spark recommends high memory machine instances
- Looking at the Amazon's EMR model. It is designed to be a job execution solution, and the jobs could from different applications
- Apache Livy provides a RESTful interface to Apache Spark cluster. It is a drop-in service to enable applications to interact with Spark cluster using RESTful api.
- The Apache Livy API also allows users to submit ad hoc map and reduce logics to be handled by the Spark cluster
- Through Apache Livy, scientists could use Jupyter environment to design their analytic algorithms that will be executed in the OceanWorks' Spark Cluster



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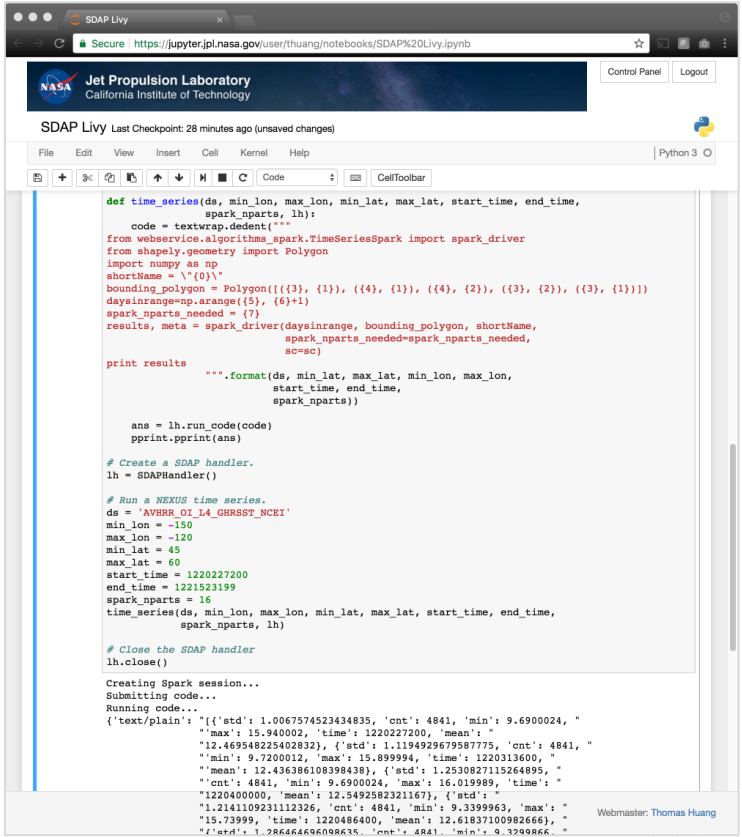
Push Python/Scala Code to Spark Cluster

- Provide scientist a platform to develop algorithms to execute in OceanWorks' Spark cluster
- A new OceanWorks' RESTful service to offer flexible environment for researchers to experiment with their algorithms and our data, without having to deal with the complexity of Cloud and job management



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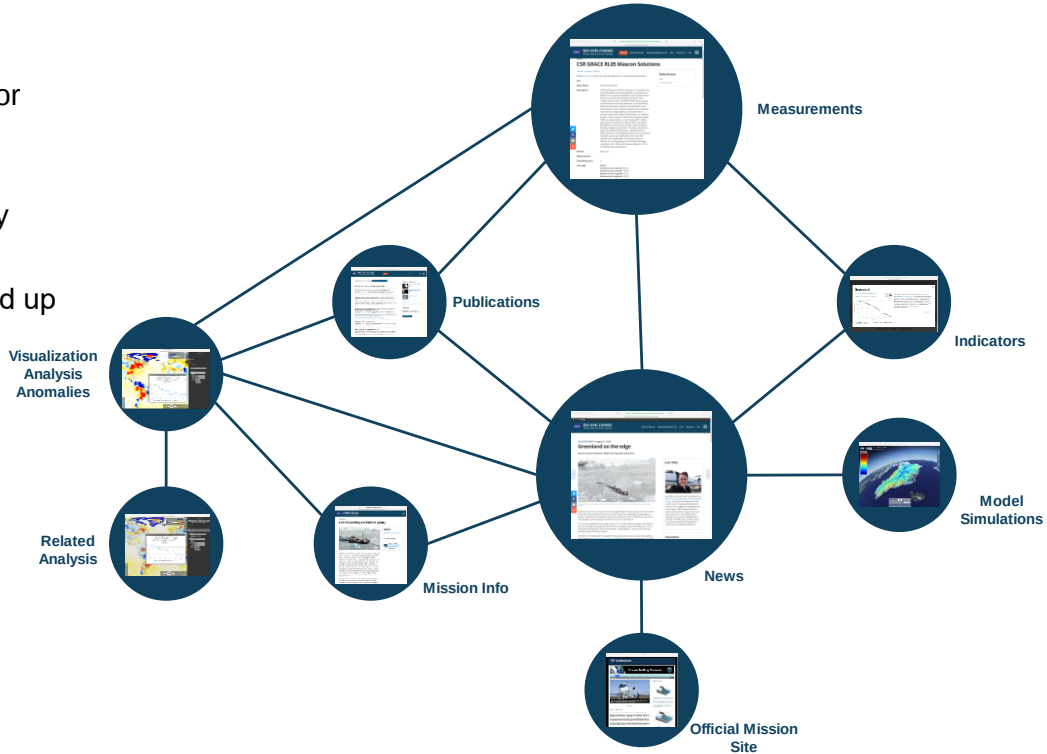
OceanWorks Tackles Information Discovery

- **Search** is looking for something you expect to exist
  - Information tagging
  - Indexed search technologies like Apache Solr or ElasticSearch
  - The solution is pretty straightforward
- **Discovery** is finding something new, or in a new way
  - This is non-trivial
  - Traditional ontological method doesn't quite add up
  - The strength of semantic web is in inference
  - Need method involves
    - Dynamic data ranking
    - Dynamic update to the ontology
    - Mining user interaction and news outlets
- **Relevancy** is
  - Domain-specific
  - Personal
  - Temporal
  - Dynamic



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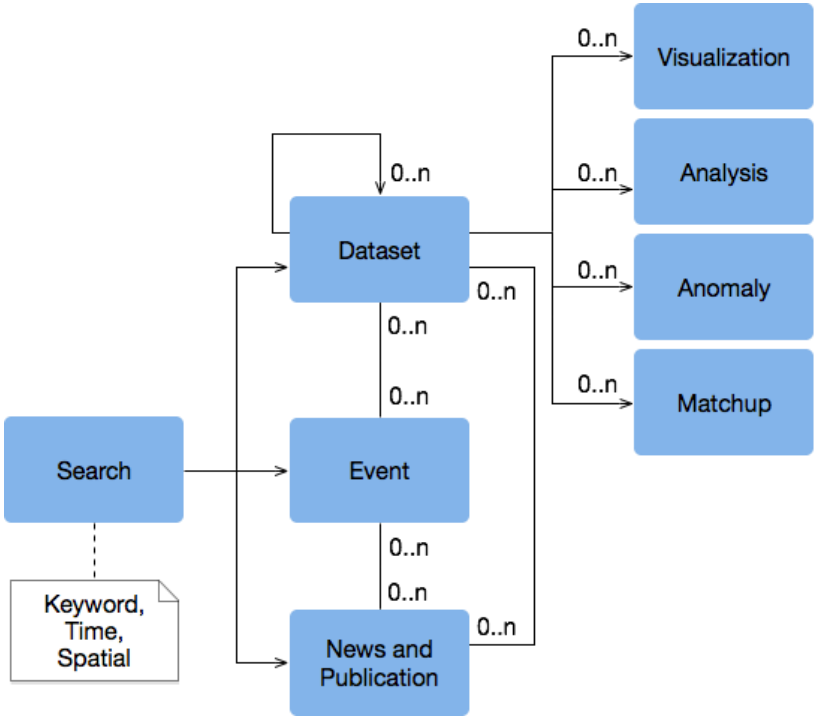
OceanWorks Tackles Information Discovery

- Support for oceanographic events
  - Continuous harvesting active events from Earth Observatory Natural Event Tracker (EONET)
  - Adding ability to register custom events
  - Mapping datasets to events by time and space
- Connecting artifacts
  - Linking datasets with analysis and matchup for recommendation
  - Linking news and publications with events and datasets
- Dynamic ranking of datasets to improve relevancy



Information Model for Data Discovery

Notable Public Engagements

- Hosted hands-on cloud analytics workshops using Amazon Web Services (AWS) at 2017 Earth Science Information Partners (ESIP) summer meeting
- Invited to speak at the **Space Studies Board of The National Academy of Sciences**
- Invited to present to the **NASA Advisory Council's Ad-Hoc Big Data Task Force (BDTF)**
- Invited to present to the **JPL Deputy Lab Director and Chief Technologist**
- Invited to present to **CNES Chief Technologist and Delegations**

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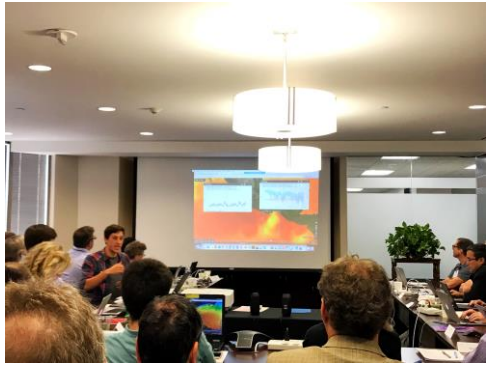
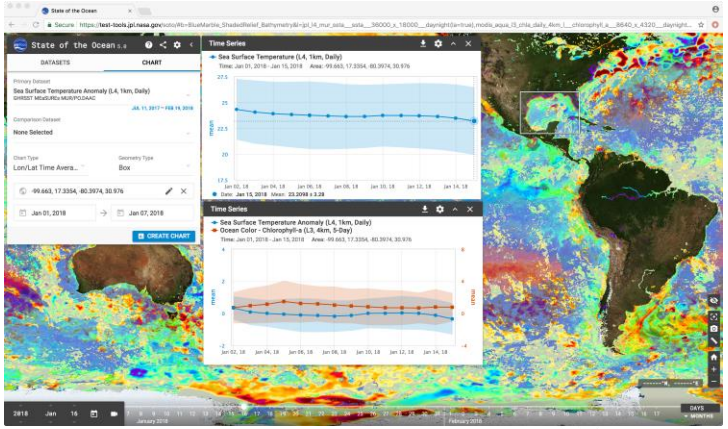
PO.DAAC UWG 2018

- Demonstrated initial PO.DAAC SOTO integration with OceanWorks' analysis platform on Amazon Web Service
- UWG request immediate access to the new SOTO analytic features
- User Acceptance Testing (UAT) planed in August 2018
- Presented the current state of the OceanWorks' project and map to UWG 2017 recommendations
  - 2017-11.3 Several different projects were coordinated into OceanWorks (i.e. OceanXtremes, NEXUS, DOMS, MUDROD, VQSS)
  - 2016-15 Advanced search capabilities
  - 2016-27 Cloud Computing
  - 2016-36 In situ faceted search



PO.DAAC State of the Ocean (SOTO)
Coming to User Acceptance Testing 2018



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In Summary

- Traditional method for scientific research (search, download, local number crunching) is unable to keep up
- Let's think beyond archive and file downloads
- Connected information enables discovery
- Community developed solution through open sourcing
- Investment in data and computational sciences
- Data Centers might want to be in the business of Enabling Science!
- OceanWorks infusion 2018 – 2019
  - Turnkey AMCE deployment
  - Solution for large job management
  - Integration with Amazon Athena
  - Integration with Pangeo
  - Watch for changes to the NASA's Sea Level Change Portal
    - Even faster analysis capabilities
    - More variety of measurements – satellites, in situ, and models
    - Event more relevant recommendations
  - NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC)
    - More than just pretty pictures. SOTO will have new analytic capabilities.
- Coming Soon: 2018 Wiley Book on **Big Earth Data Analytics in Earth, Atmospheric and Ocean Sciences**

Current OceanWorks Portfolio

- NASA Sea Level Change Portal - https://sealevel.nasa.gov (Production)
- JPL GRACE Website – https://grace.jpl.nasa.gov (Production - June 2018)
- NASA PO.DAAC SOTO (UAT – August 2018)
- CEOS Ocean Variables Enabling Research and Application for GEOS (COVERAGE) (Workshop – Sept. 2018)
- Being review by
  - NASA LARC
  - NOAA
  - Australian Government Bureau of Meteorology (BOM)
  - IFREMER (Institut français de recherche pour l'exploitation de la mer)
  - EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites)

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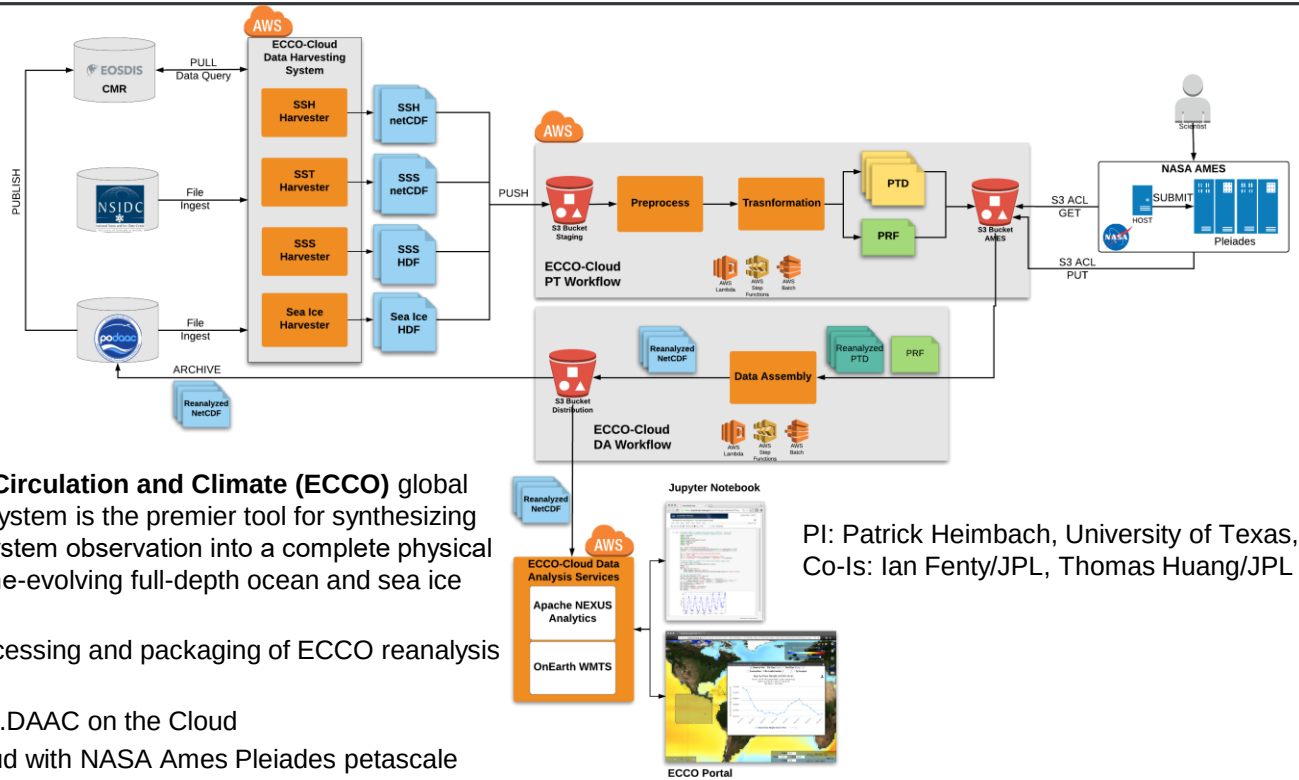
NASA ACCESS 2017: ECCO-Cloud (just announced)



- **Estimating the Ocean Circulation and Climate (ECCO)** global ocean state estimation system is the premier tool for synthesizing NASA's diverse Earth system observation into a complete physical description of Earth's time-evolving full-depth ocean and sea ice system.
- Automate ingestion, processing and packaging of ECCO reanalysis products
- Automate delivery to PO.DAAC on the Cloud
- Integrating Amazon Cloud with NASA Ames Pleiades petascale supercomputer
- Establish ECCO Data Analysis Services and web portal for interactive visualization and analysis, and distribution using Apache SDAP

PI: Patrick Heimbach, University of Texas, Austin
Co-Is: Ian Fenty/JPL, Thomas Huang/JPL

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THANK YOU

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