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SmartSearch, scalable data search and aggregation in the Cloud for CCS and beyond

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U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY | MATRIC

Multi-Cloud (...really means Multi-Environment)

- "Cloud" is where you're ***not*** at
  - Cloud Service Providers
  - On-Prem Compute
  - Edge computing (sensors, cell phone, etc.)
- Leverage APIs for service-to-service communications
- Networking:
  - peered networks
  - commodity networks
  - dedicated/shared interconnects
  - consider egress fees (leverage compute where data lives)
- Utilize cloud-native concepts

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Multi-Environment

"Cloud" is compute resources where you're *not*...

Navigating on-prem to cloud (and local dev)

- One of the biggest challenges: migrating from an "on-prem" development / deployment environment to cloud – HOW???
- Utilize "cloud native" concepts
  - Containerization
  - Microservices
  - Scalability
- Leverage enabling tools:
  - Deployment:
    - Kubernetes
    - Helm
    - Terraform
  - Development:
    - VS Code
    - Containerized environments

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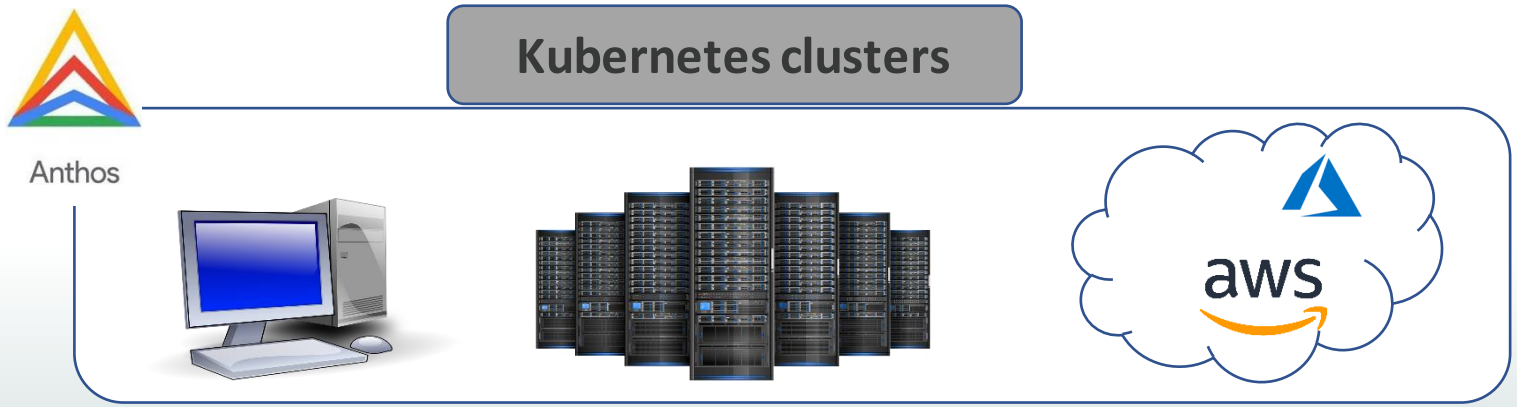
Kubernetes

- Supported by all major cloud providers
- Configurable autoscaling based on load thresholds (CPU, RAM usage)
  - Services
  - Nodes
- Managed service deployments via Helm
- Seamless local, on-prem, cloud deployments via kubectl
- Manage multi-environment clusters via GCP Anthos
- Kubeflow



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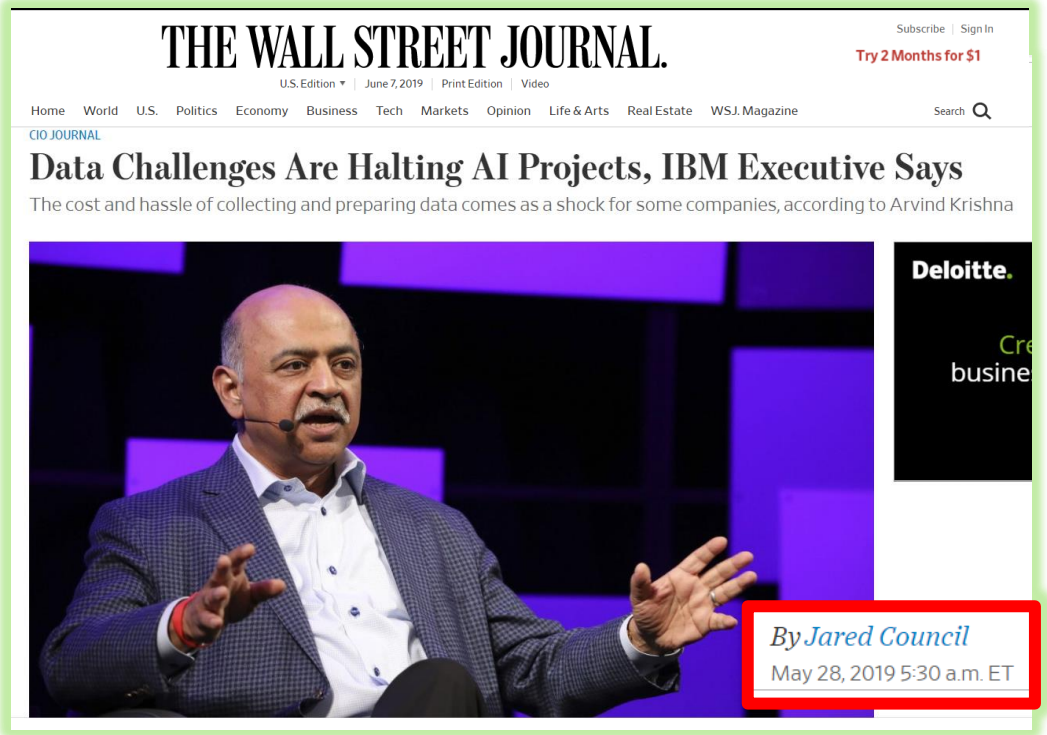
Everyone wants to jump to the top of the pyramid…

But… scientists still spend nearly 80% of their time *acquiring*, *cleaning*, and *organizing* data

The steps at the *bottom* must come first

They require leadership & support to ensure a solid data foundation for future R&D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CIO JOURNAL

Data Challenges Are Halting AI Projects, IBM Executive Says

The cost and hassle of collecting and preparing data comes as a shock for some companies, according to Arvind Krishna

Deloitte.

By Jared Council

May 28, 2019 5:30 a.m. ET

"Invest 5% of research funds in ensuring data are reusable. Funders hold the stick: they should disburse no further funding without a data stewardship plan."

- *Nature*, February 2020

nature

International weekly journal of science

Data are the energy for AI and analysis

SmartSearch©: Conquering the Data Avalanche

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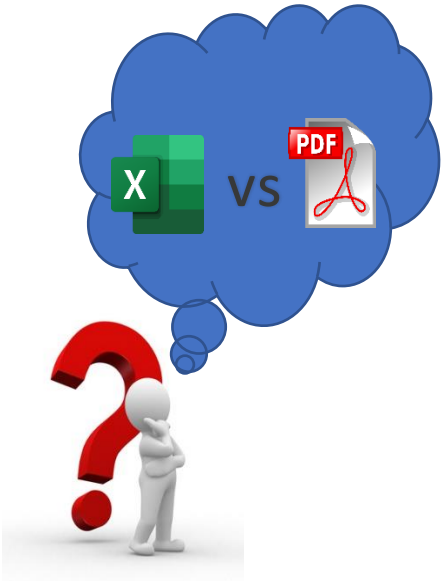
- **How do you currently search?**
  - Type in a few keywords
  - Skim the top few results
  - Type in more keywords and try again



- **How do you find and connect to something relevant?**
  - Open a file / web page
  - Read it (skim it)
  - Decide if it's relevant

What is SmartSearch©?

Problem:

You like these files.

You want to find more data relevant to the content of these files

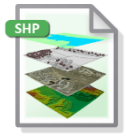
Solution:

SmartSearch automates data discovery by …

1) **Analyzing** content you like

2) **Finding** new content via www, local, enterprise data stores

3) Telling you **how relevant** the discovered data is to what you like



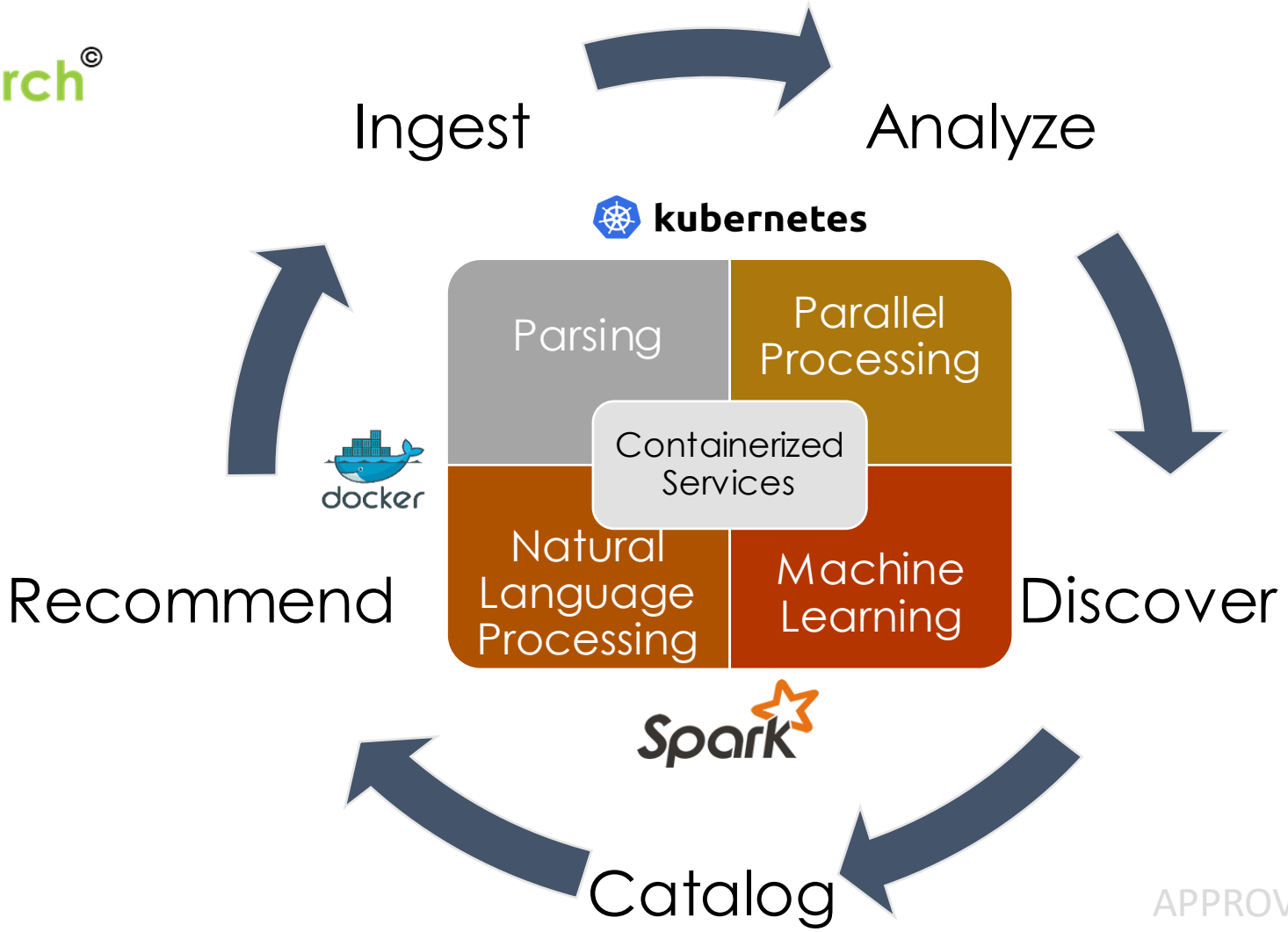
Input

72%

Discovered

APPROVED FOR PUBLIC RELEASE

How Does SmartSearch© Work?



Benefits of SmartSearch©

- **Infinitely Scalable (Automated) Data Discovery**
  - Analyze millions+ of files and generate comparison metrics
  - Generate topic models, categorization, recommendations
  - Desktop, cluster, cloud

- **Treat geospatial data like a document**
  - Automatically extract text from geospatial data (shapefiles, geodatabases)
  - Compare textual vs geospatial data to identify relevancy
- **Search for meta tags within HTML body of discovered web sites**
  - i.e., find map tags
- **Analyze archive files – even archives within archives (zips within zips, etc.)**
  - Process every file – docs, spatial, etc.

AI/ML in SmartSearch©

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NETL SmartSearch

- SmartSearch built via cloud native design principles
- Combines 'cluster of clusters', Spark, Kubernetes, and data lakes for massively scalable compute infrastructure
- Natural Language Processing via SparkNLP
  - Distributed NLP processing via the Spark framework
  - Implemented via SparkML Pipelines
  - Provides thousands of pretrained models and pipelines (Glove, Bert, Onto, etc.)
  - Custom models can be implemented and trained within same distributed framework
- Machine Learning via SparkML Pipelines
  - Distributed ML processing via the Spark framework
  - SmartSearch Recommendation Engine
  - LDA Topic Modeling
  - Named Entity Recognition (NER)
  - Question Answering
  - Summarization

SmartSearch© In-Use

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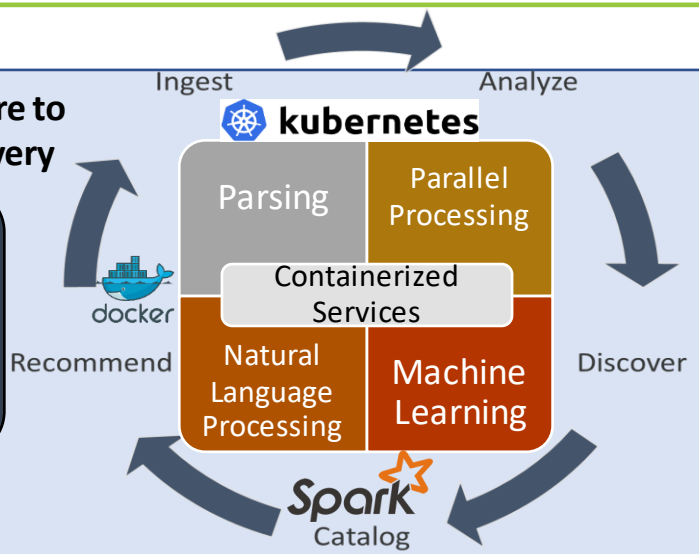
AI informed approach

Challenge: data infrastructure to AI/ML enhanced data discovery

Employing AI/ML tools to find open resources

NETL SmartSearch



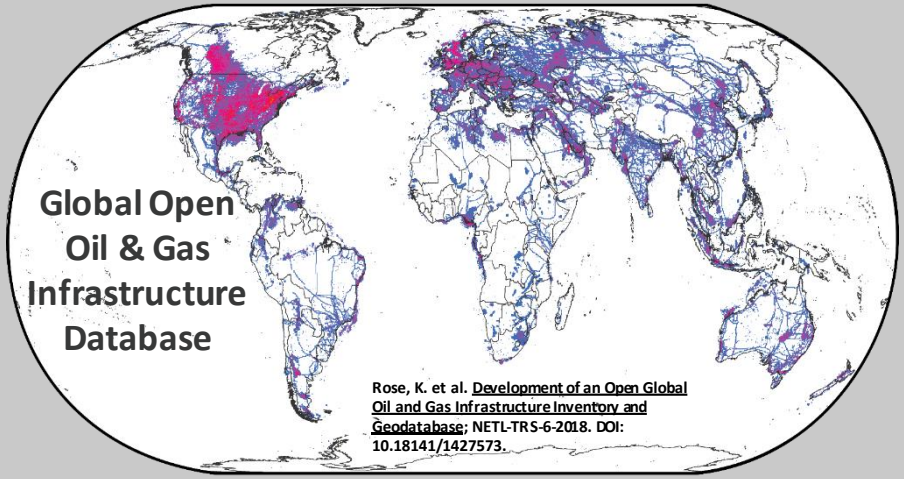
SmartSearch leverages ML+NLP to:

1) **Analyzing** content you like
2) **Finding** new content via www, local, enterprise data stores
3) Telling you **how relevant** the new data is to what you like

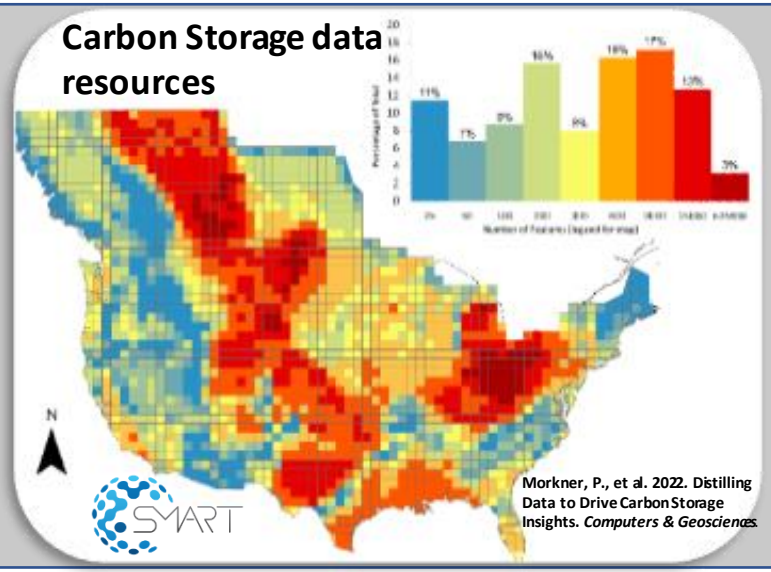
Opportunity:

Infinitely scalable to return text, graphical, tabular, image, html, spatial, etc. result

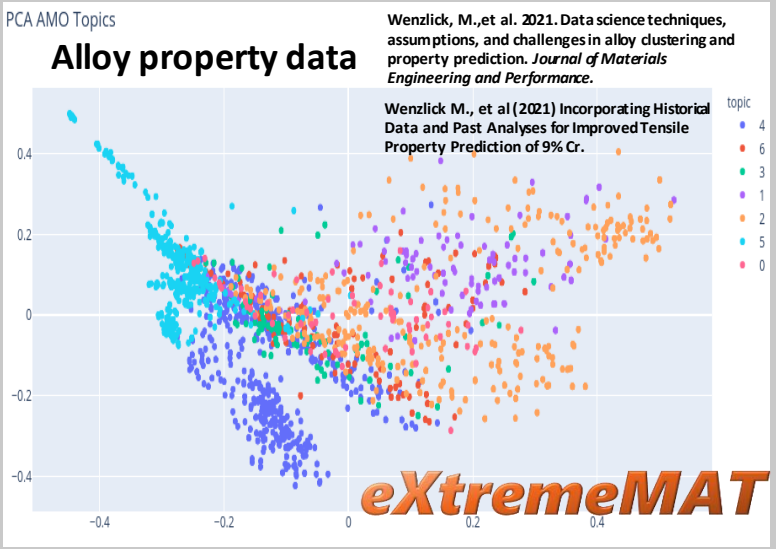
Example applications to date



Carbon Storage data resources



Alloy property data



SmartSearch© for building the Carbon Storage Open Database

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Collection of geospatial data from disparate websites (NETL SmartSearch)

↓

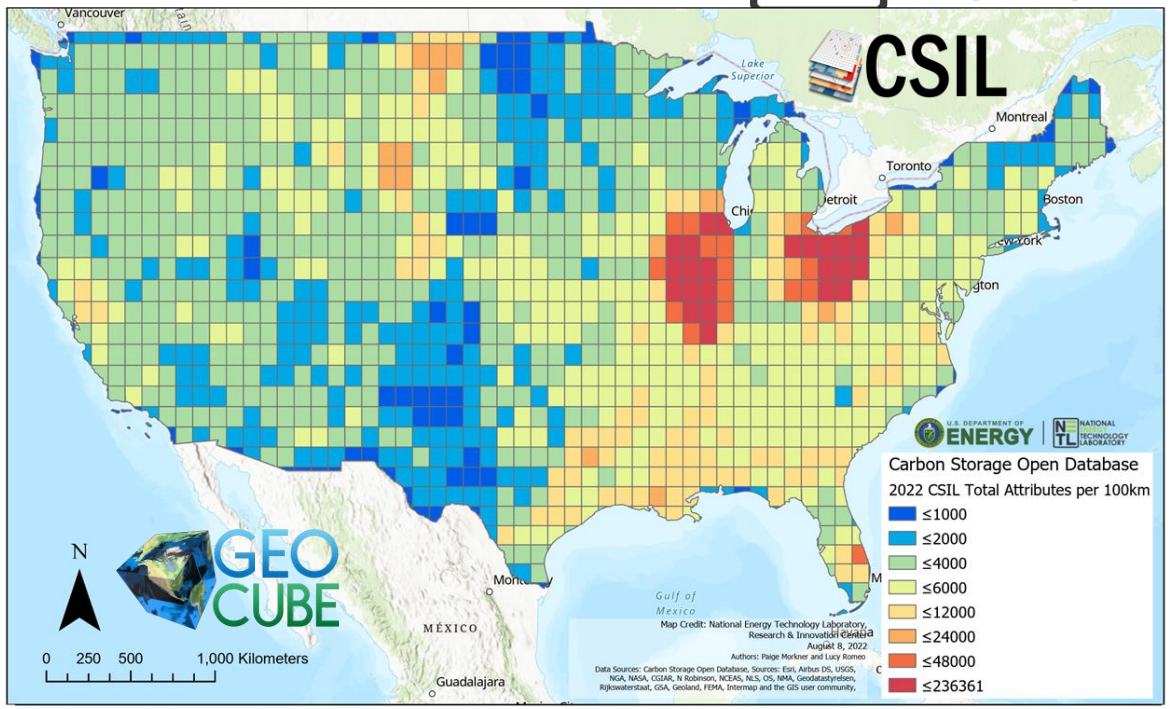
Aggregation of resources into central database

↓

Cataloging and collection of metadata

↓

Integration of metadata and data into EDX++ framework and online mapping platform

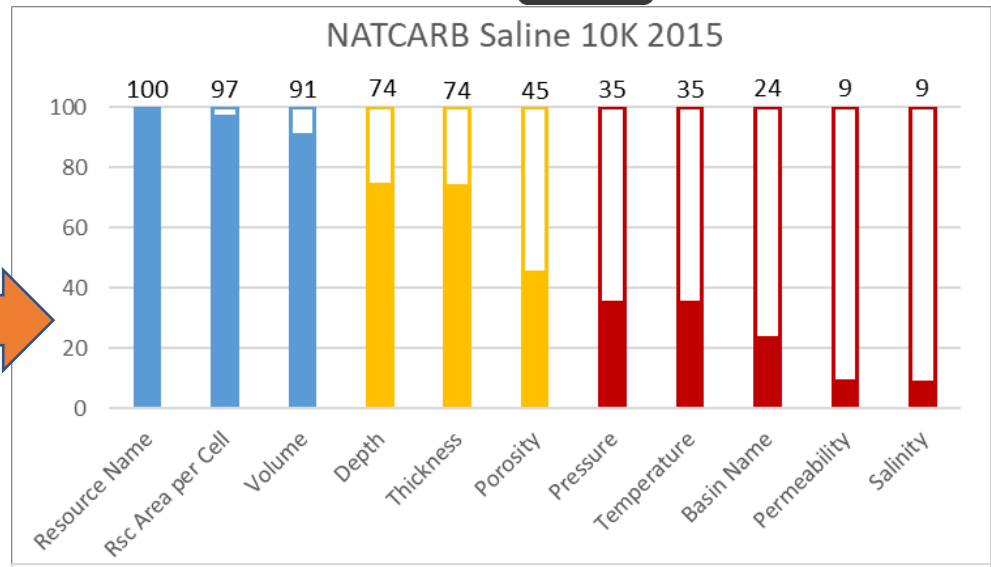


- Use of SmartSearch in finding geospatial data resources to build out collection of 892 geospatial data resources to build the Carbon Storage Open Database on GeoCube
- Morkner, P., et al. 2022. Distilling Data to Drive Carbon Storage Insights. *Computers & Geosciences*.

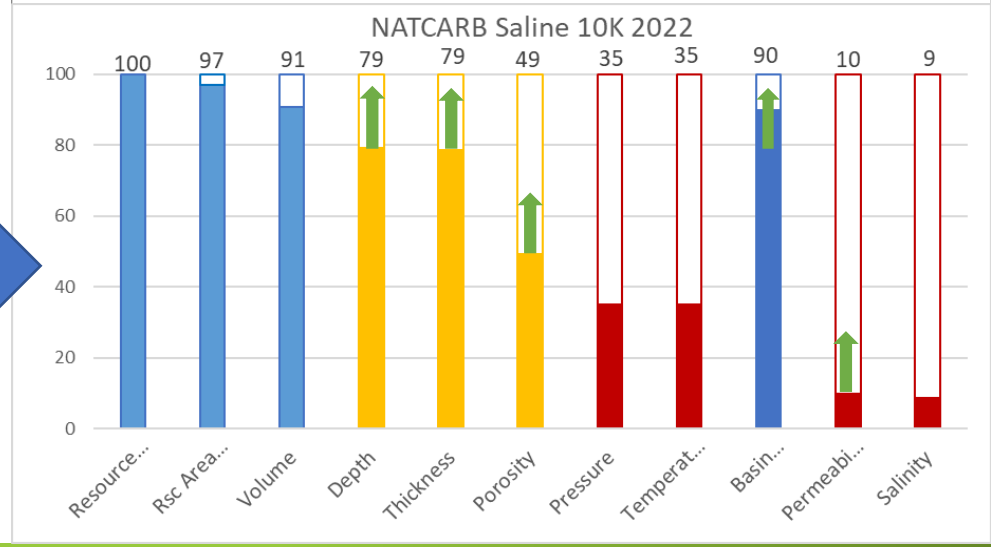
SmartSearch© for addressing data gaps in CS data

- SmartSearch was leveraged to find data to meet data gaps in the NATCARB database during EY21
- NATCARB's 2015 Saline 10km layer was used as seed data
- 1000s of results returned above 10% similarity
- Result text bodies were integrated into a postgreSQL database where keywords were used to query relevant results
- Researchers integrated thousands of new data results improving data available for:
  - Depth, thickness, porosity, basin name, and permeability

Original NATCARB Saline 10km

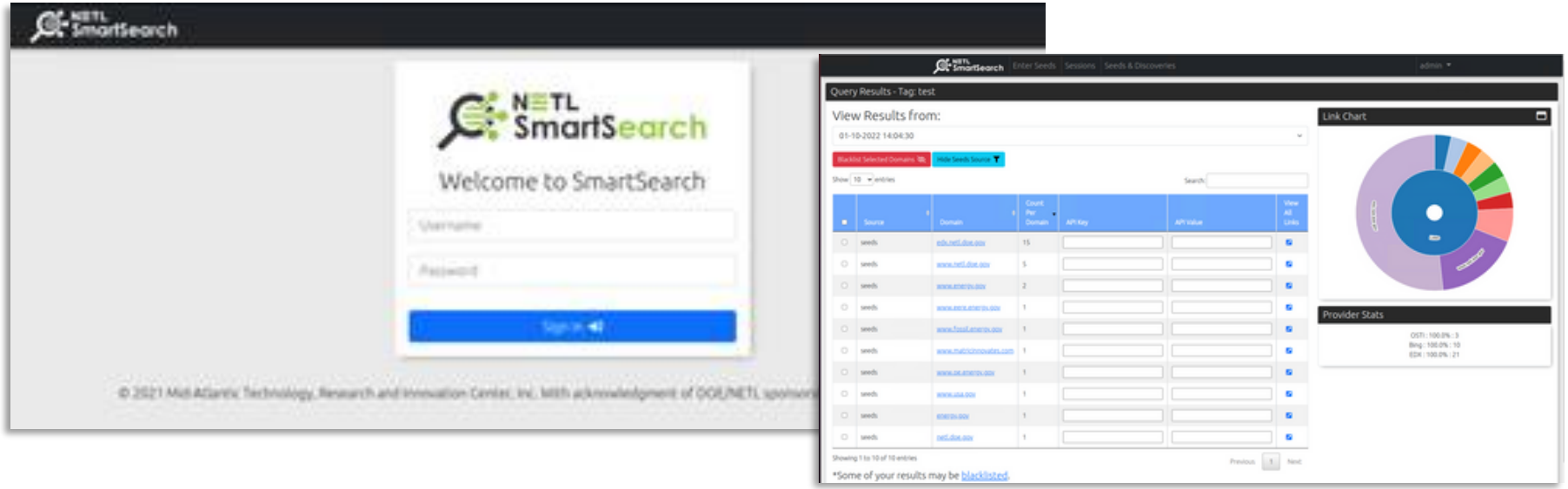


With additional data added



Summary

- SmartSearch© automates the data discovery process by using a scalable compute environment coupled with NLP and ML
- Will be integrated within EDX++
- SmartSearch supports ongoing research projects
- SmartSearch used to evaluate cloud providers (GCP, AWS, Azure)



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Thank you!

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- Wenzlick, M.,et al. 2021. Data science techniques, assumptions, and challenges in alloy clustering and property prediction. *Journal of Materials Engineering and Performance.*
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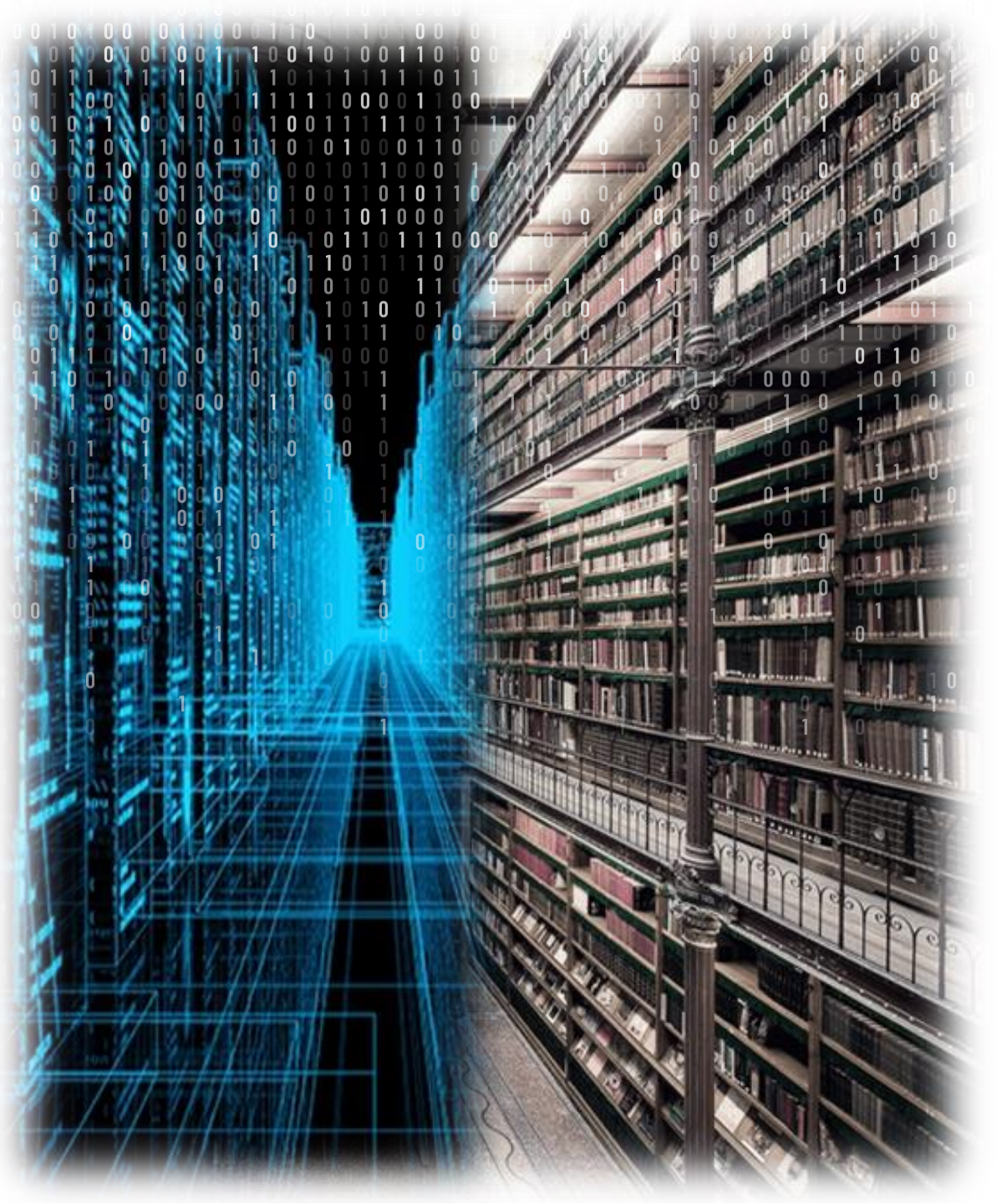

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