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Workshop on Migration of Agriculture as One Path to Sustainability

Sara J. Graves

Director, Information Technology and Systems Center

UA System Board of Trustees University Professor

Professor, Computer Science Department

256-824-6064

sgraves@itsc.uah.edu

Boulder, CO

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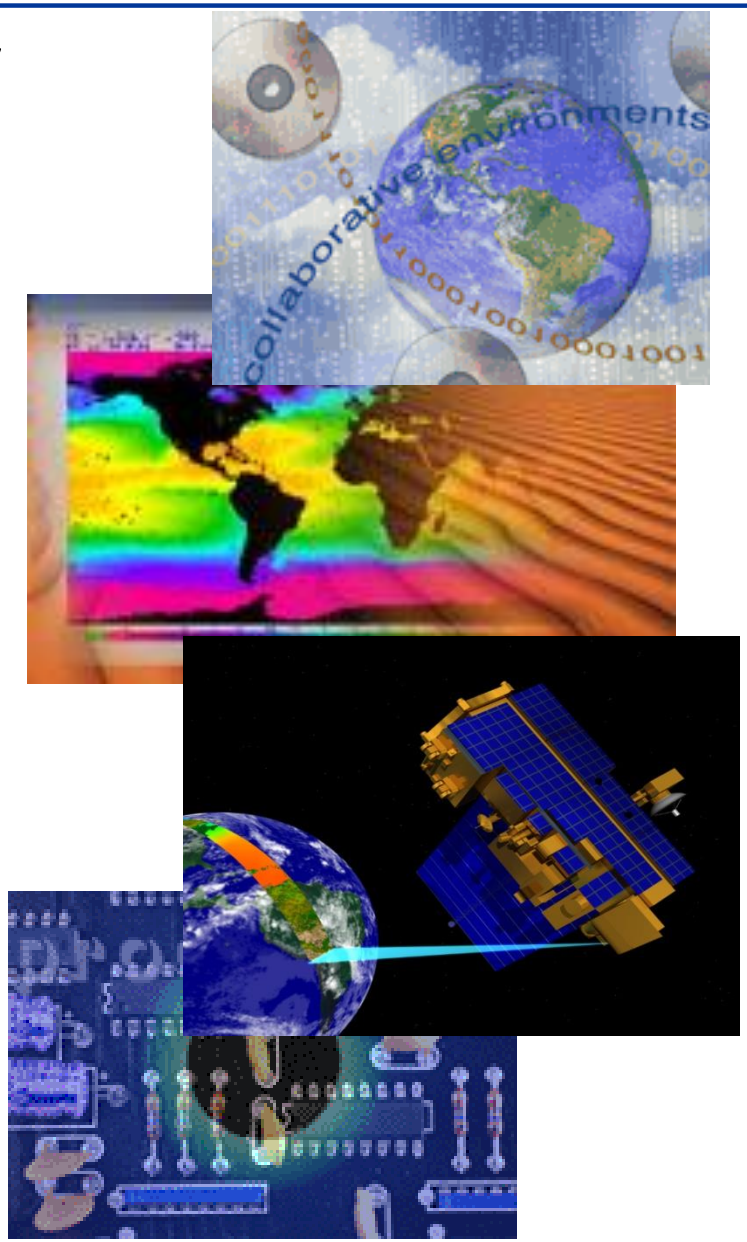
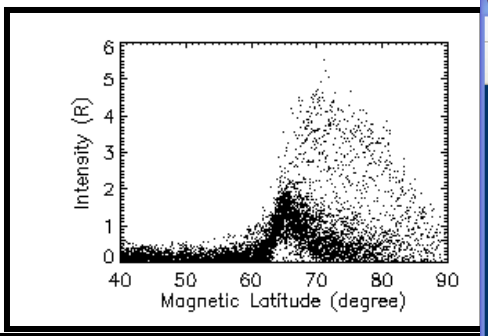
Primary Research Focus Areas

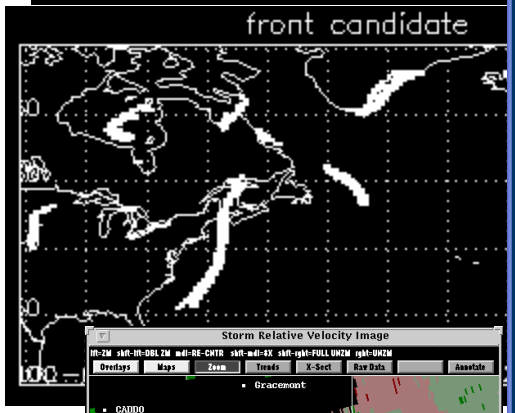
- Data Mining and Knowledge Discovery
- Visual Analytics
- Geoinformatics
- Modeling and Simulation
- Systems Interoperability
- Knowledge Engineering and Semantic Web
- Information Management and Technologies for Big Data
- Asynchronous Collaboration Technologies / Web 2.0
- Decision Support Frameworks
- Cybersecurity/Information Assurance
- Real-time Processing
- Event-driven / On-demand Processing
- Geospatial Technologies
- Sensor Networking Analysis

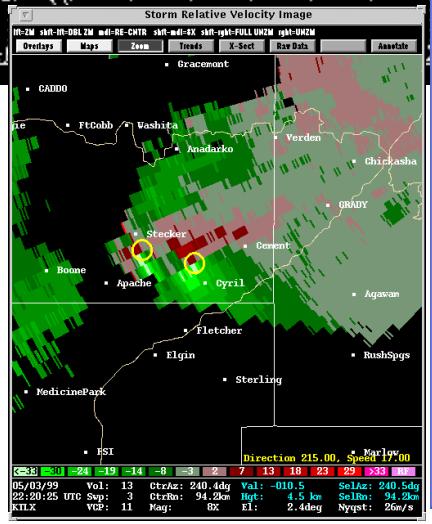


Data Mining: Algorithm Development and Mining (ADaM)

- UAHuntsville has been at the forefront of mining sensor data for over 15 years
- ADaM – UAHuntsville developed toolkit with 100+ algorithms, used worldwide
- Automated discovery of patterns, signatures, anomalies
- Derived knowledge for decision making and response
- Allows learning and training for adaptation
- Most cited article in Elsevier *Computers and Geosciences*, 2005-2010







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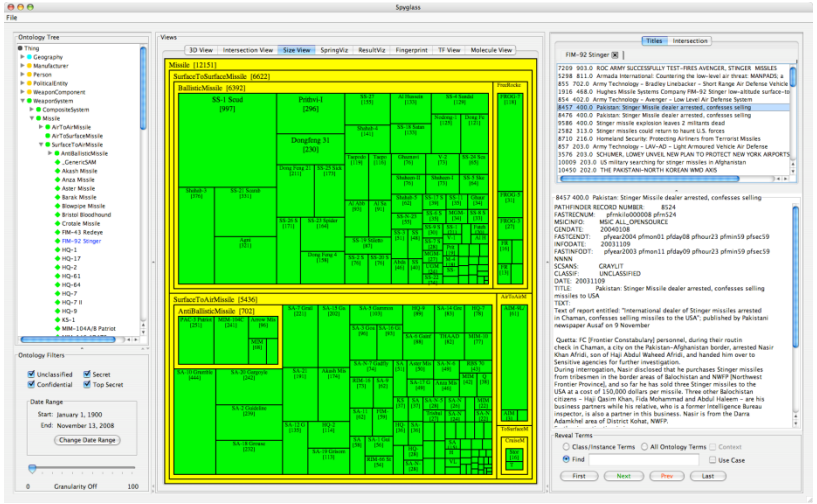
Spyglass Ontological Text Mining

analyze and search large text sources (databases, on-line resources, etc.)

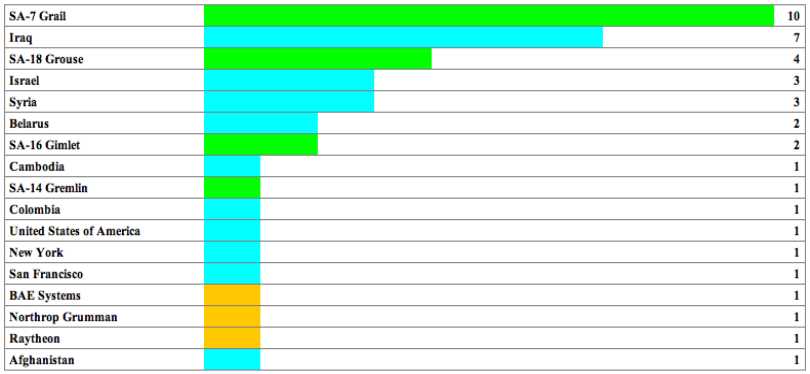
Multiple Visualization Approaches

- Show distribution of documents across categories
- Show relationships between documents / categories

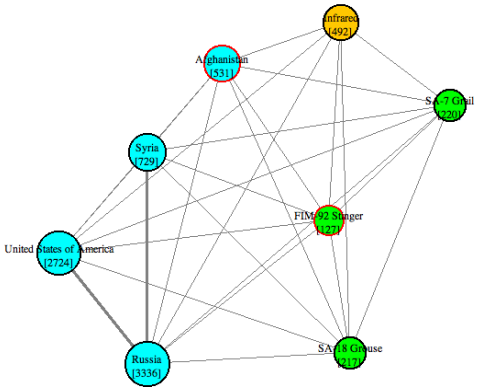


Size View

- Captures ***semantic information*** and ***contextual knowledge*** of analysts
- Ontology describes ***entities, concepts and relationships*** in a domain
- ***Constructs document index*** for each term, listing all documents where term occurs
- ***Fast indexing and retrieval***, with high precision and recall
- ***Scores documents*** by number of relevant terms
- ***More powerful*** than simple keyword queries
- ***Possible to reason*** over ontological structures



Document Fingerprint View



Molecule View of Concept Associations

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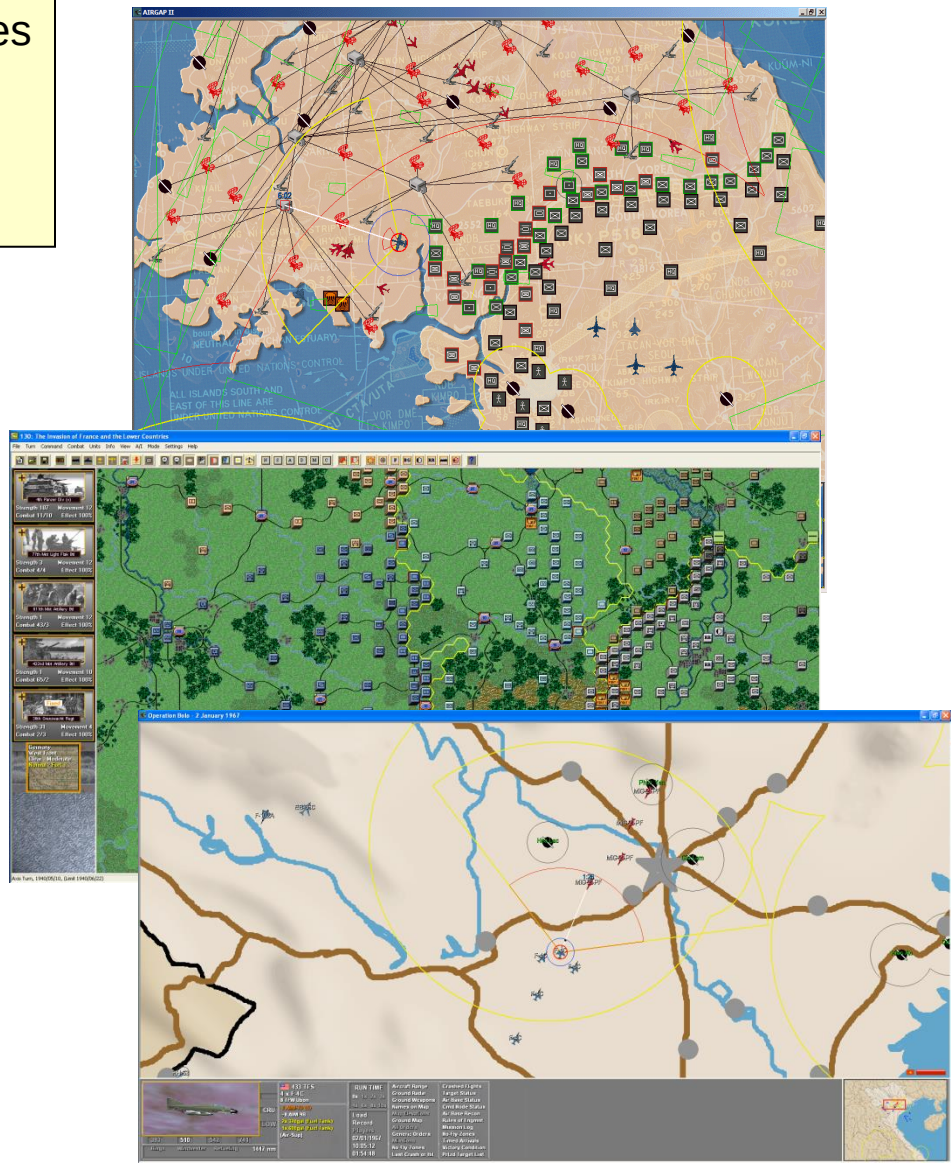
Wargaming

AI in Cyber Wargaming provides much needed insight into system interactions and human activities

- Simulation and Modeling of Large Systems
- Training
- Strategic and Tactical Planning

- **Cyber warfare modeling and simulation development for the Air Force Research Laboratory**
- **War Games deployed for training at the Air Force Squadron Officer College**
  - **Every officer uses the game to study strategic and tactical measures**
- **Can be used for analyzing what-if scenarios including asymmetric warfare and the use of advanced weapons systems**
- **War game Artificial Intelligence Development in conjunction with John Tiller Games**
- **Many commercial titles published**



***The First Blitzkrieg* won the Wargamer Award for Excellence**

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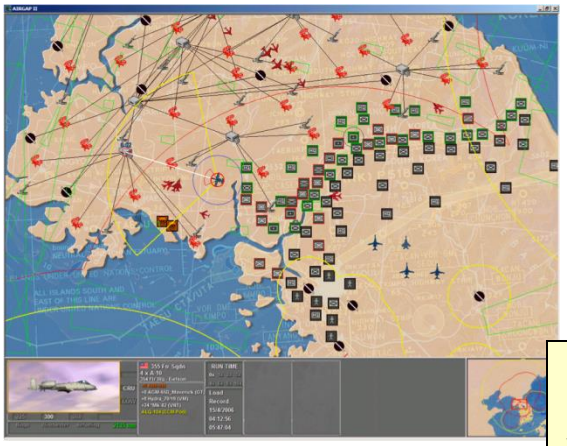
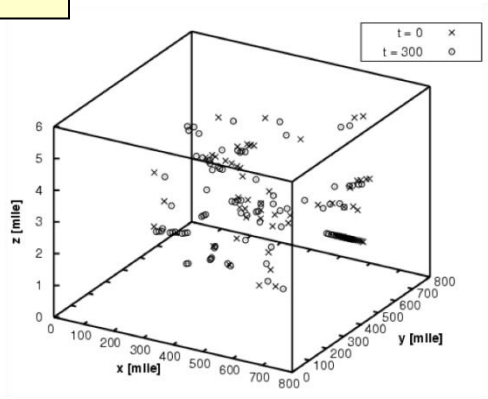
Vantage: Sensor Network Definition, Analysis and Optimization

Simulations provide a means to study new systems and the impact they will have on current and future scenarios

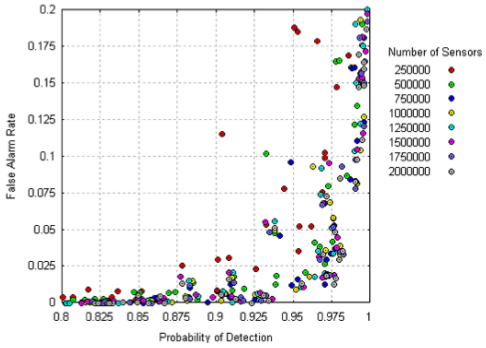


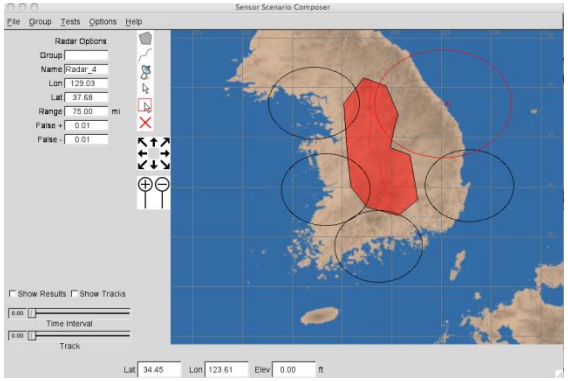
Users define scenarios using Vantage tools

Modeling



Analysis





Visualization of Results

- Model Large-scale Networks of Sensors
- Compose High-density Sensor Networks of Heterogeneous Sensors
- Analyze and/or Determine Sensor Placement and Effectiveness
- Detect and Tracks Targets Over Time (including error rates)
- Evaluate Large Passive Sensor Networks - Defense
  - For detecting hostile aircraft
  - For vectoring interceptors
  - For activating SAM sites
  - For guiding SAMs (initial stage)
- Evaluate Large Passive Sensor Networks – Offense
  - How to best vector aircraft
  - How best to select targets
  - Aircraft detection probabilities and times
- Real Time Integrated Simulation
  - Modern Air Power or other simulation on front end
  - Sensor network on Linux cluster on back end
  - Good for interactive exploration / what if's

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Data Albums

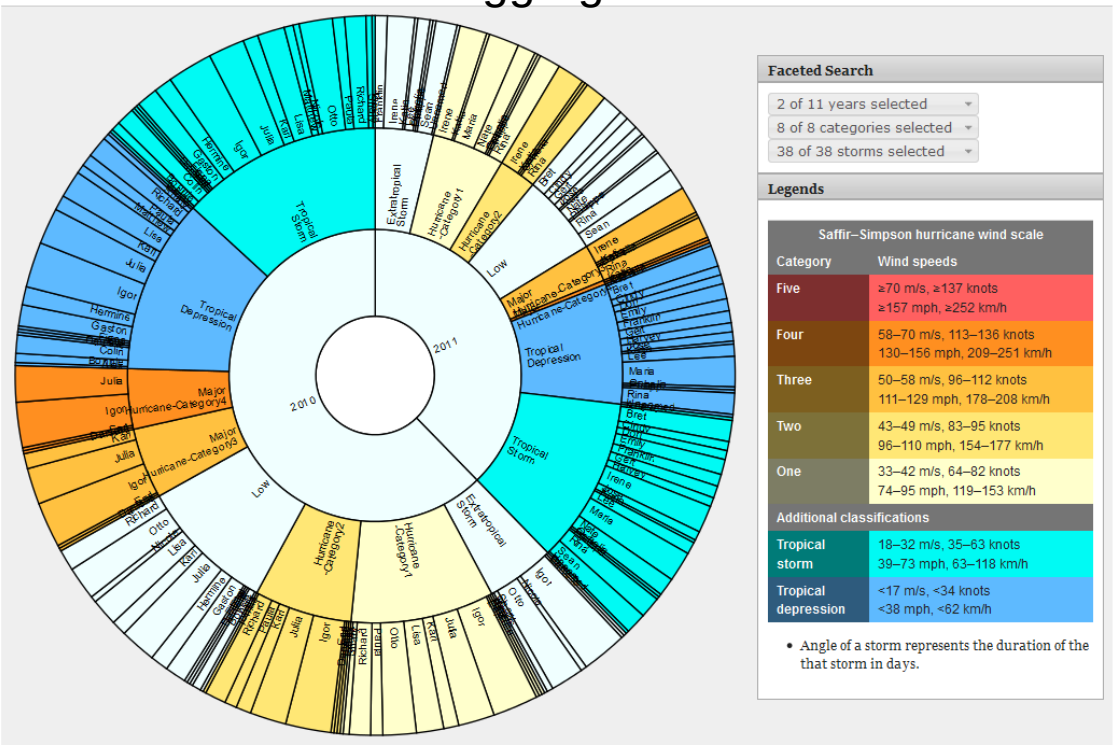
- Supports search, aggregation and access of data and online resources around events
- Automates the gathering of online resources with information filtering
- New ways of displaying search results
  - Infographics – graphic visual representation of information, data or knowledge intended to present complex information quickly and clearly
  - Results enriched with additional information
- Analytics dashboard on the gathered information for events
- Use of semantic technology for relevancy ranking

Compiled collections of information related to a specific topic or event with links to relevant data files. Additional information includes:

Tools and services for visualization and analysis

News reports, images or videos to supplement analysis

Curation provides the author of a Data Album the means to select the aggregated information



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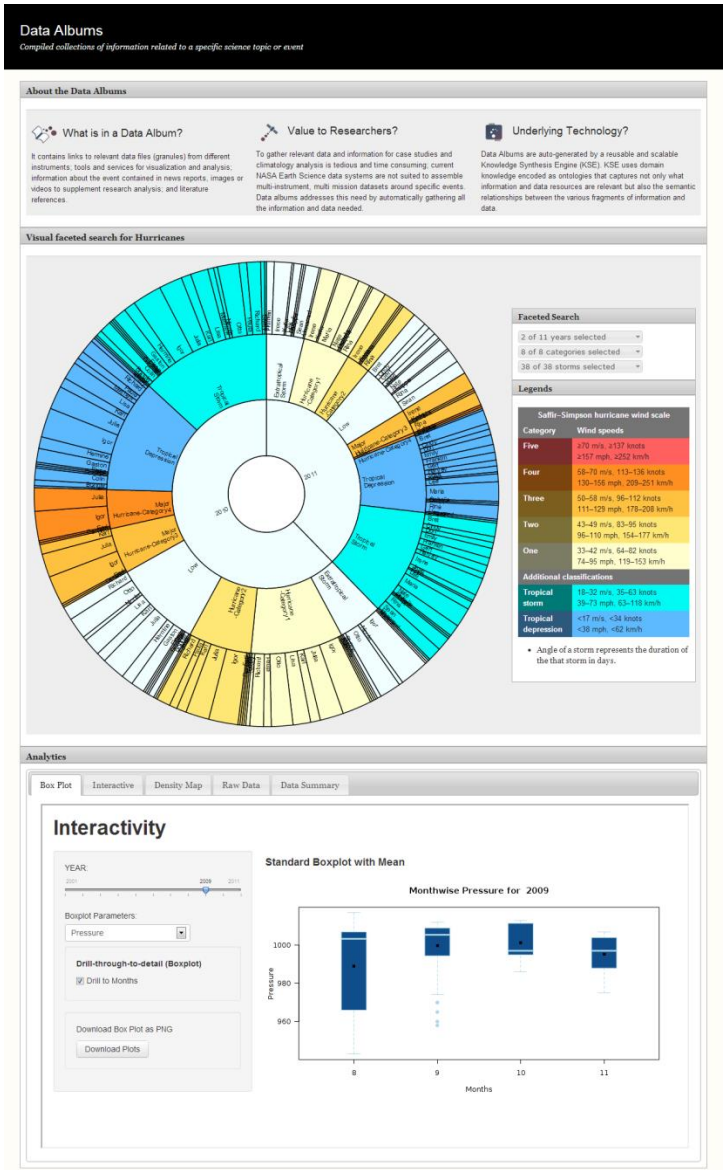
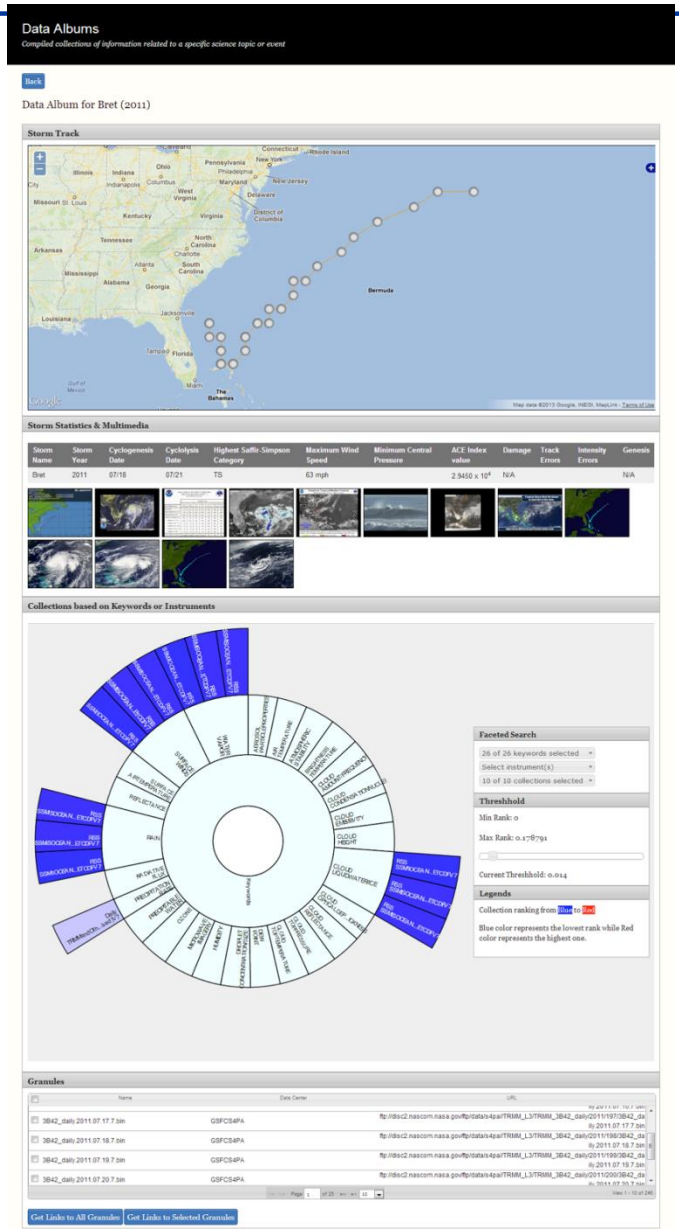
Data Album Snapshots





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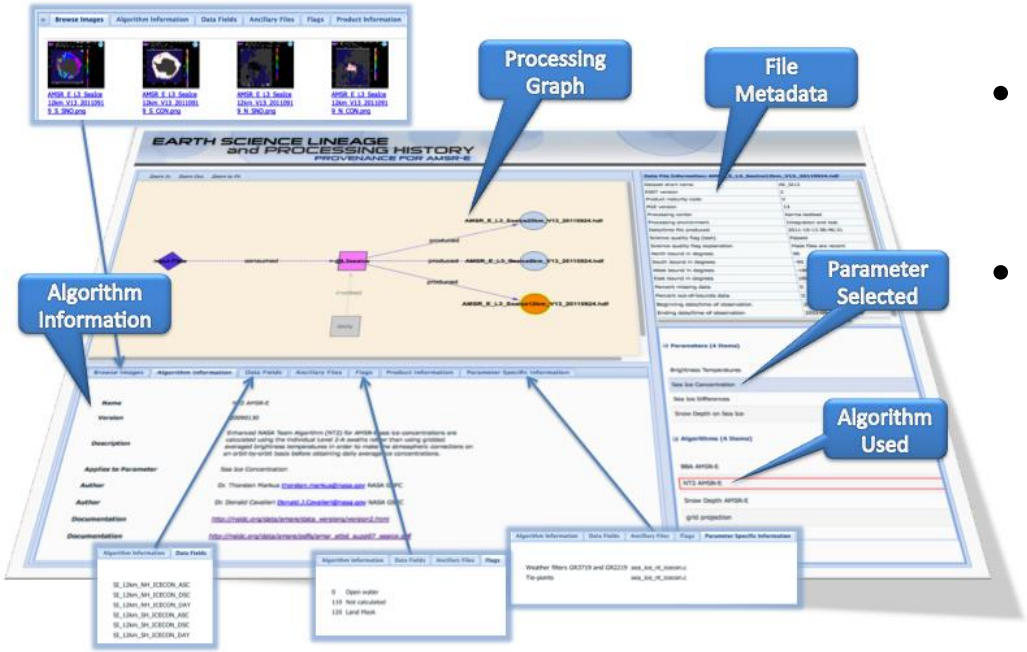
Provenance



- Provenance of hardware, software, and data
- Standards and Interoperability
  - Proposed Open Provenance Model for technology-neutral representation

- Provenance, or “chain of custody”, important to cybersecurity; used to verify trustworthiness and reliability
- Representation, management, presentation; also system engineering and legal, policy and economic issues
- Provenance and context information, such as pedigree and tracking information, may include imagery, data fields, flag values and other information, in addition to a provenance graph and metadata

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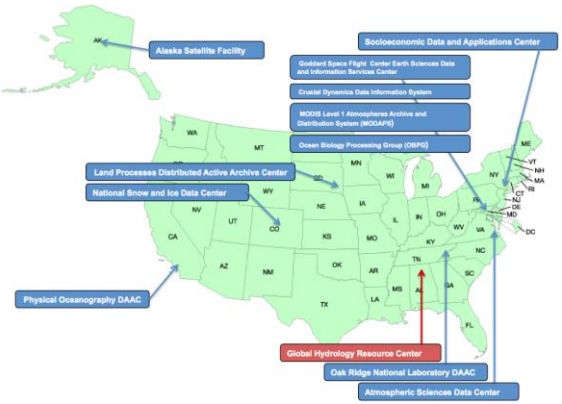
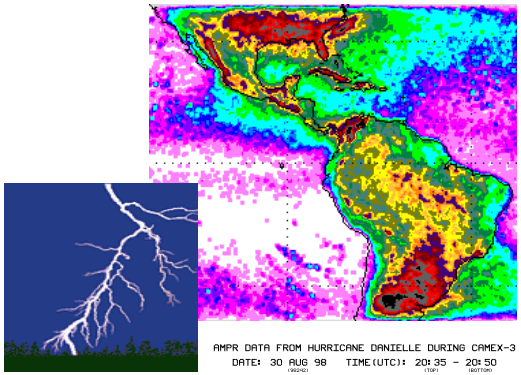
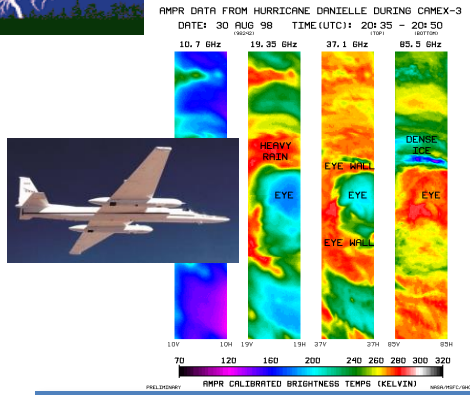
Global Hydrology Resource Center

- **Partnership** between NASA and UAHuntsville to apply **advanced information technologies** to a variety of **science data projects**, thereby enabling research and scientific discovery
- **One of twelve full service NASA data centers** providing data ingest, routine and custom processing, archive, distribution, user support, and science data services
  - *Passive Microwave Data*
    - Twenty-five year inventory of data from satellite and aircraft instruments
  - *Lightning Imaging Sensor Science Computing Facility*
    - National lightning data center for the TRMM Lightning Imaging Sensor and validation networks, satellite lightning observations back to 1973
  - *Field Campaigns*:
    - Web-based collaboration for science before, during, and after experiments. Data acquisition, integration, archive and distribution.
    - CAMEX (1998, 2001), ACES (2002), TCSP (2005), NAMMA (2006), TC4 (2007), ARCTAS (2008), GRIP (2010), MC3E (2011), GCPEX (2012), IFloodS (2013), IPHEX (2014), OLYMPEX (2015)
  - *AMSR-E Science Investigator-led Processing* System
    - Generates swath, daily, and monthly products of precipitation, sea ice, water vapor, cloud water, sea surface temps, etc.
    - Near-real-time processing and distribution capability







http://ghrc.nsstc.nasa.gov

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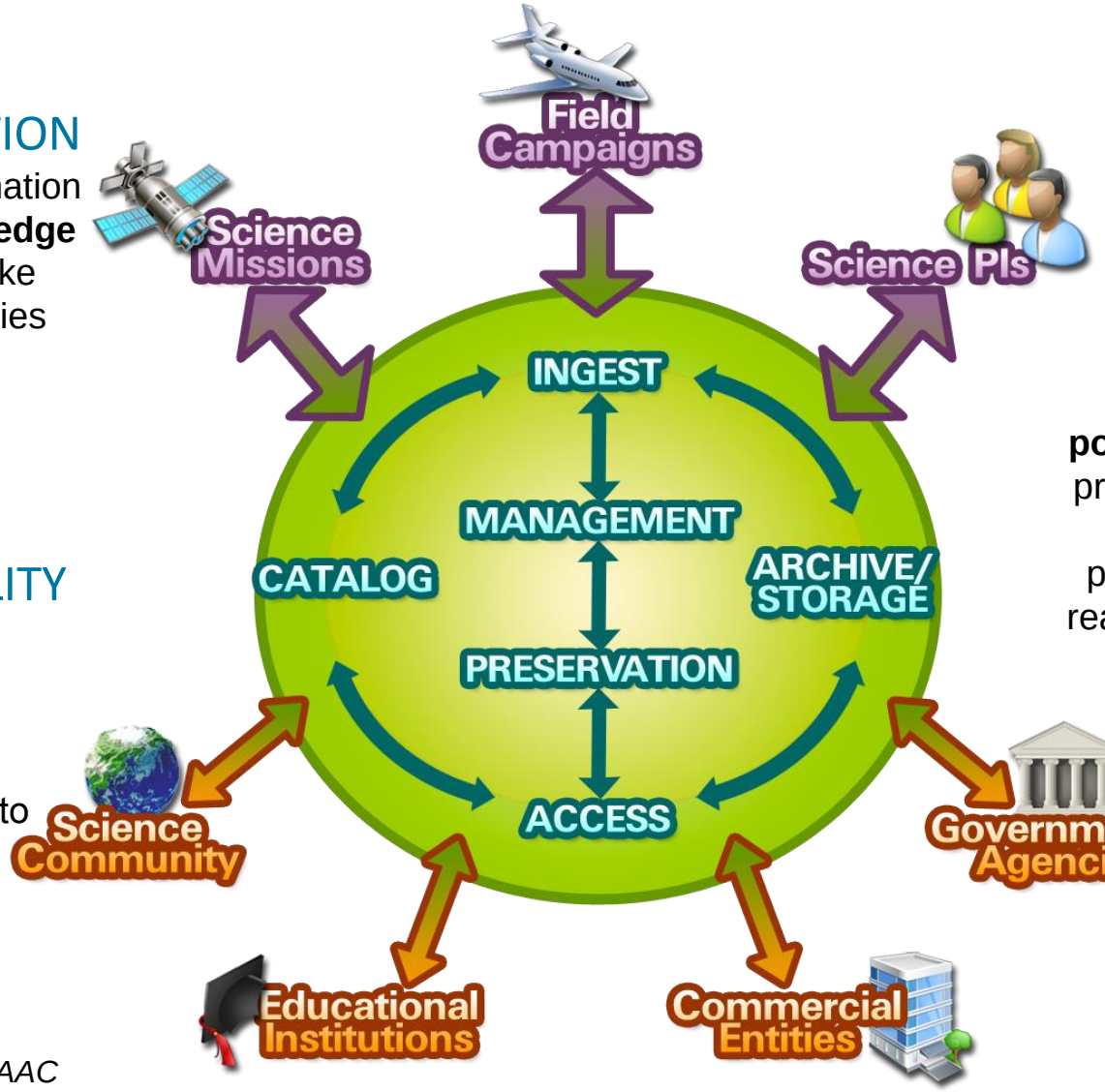
Data Stewardship

DOCUMENTATION

Capture this information to **create a knowledge base** for our stake holder communities

INTEROPERABILITY STANDARDS

Ensure that the information is "**independently understandable**" to all stakeholders without requiring experts



** Image from GHRC DAAC*

CURATION

Work with Science Teams to gather not only data but also **all relevant information**

PRESERVATION

Follow **documented policies** and **engineered** procedures at every step to insure information preservation against all reasonable contingencies

PROCESSING

include **science product generation** and reformatting, algorithm integration and test, interfaces with external providers

Data stewardship for scientific, educational, commercial and governmental communities

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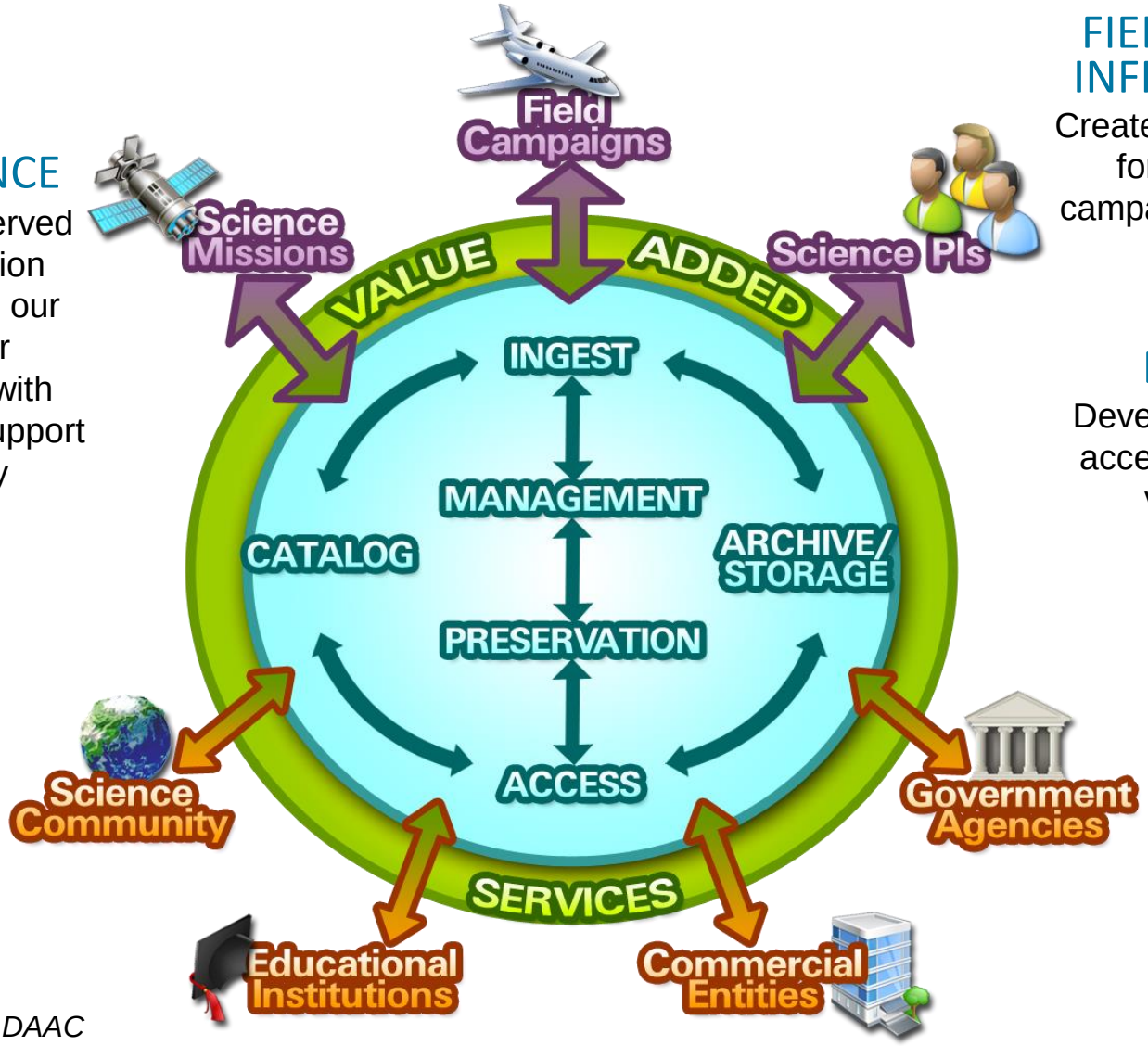
Knowledge Augmentation Services

PROVENANCE

Make the preserved data/information available to all our stakeholder communities with traceability to support authenticity

DATA DISCOVERY

Develop new tools for data discovery, curation and aggregation



** Image from GHRC DAAC*

FIELD CAMPAIGN INFRASTRUCTURE

Create specialized portals for managing field campaigns and collecting data

DATA USE

Develop new tools for access, analysis and visualization

INFUSING CUTTING EDGE INFORMATICS

Research new approaches and technologies and infuse them into operational processes

Knowledge augmentation services encompass tools, infrastructure, user support, and expertise

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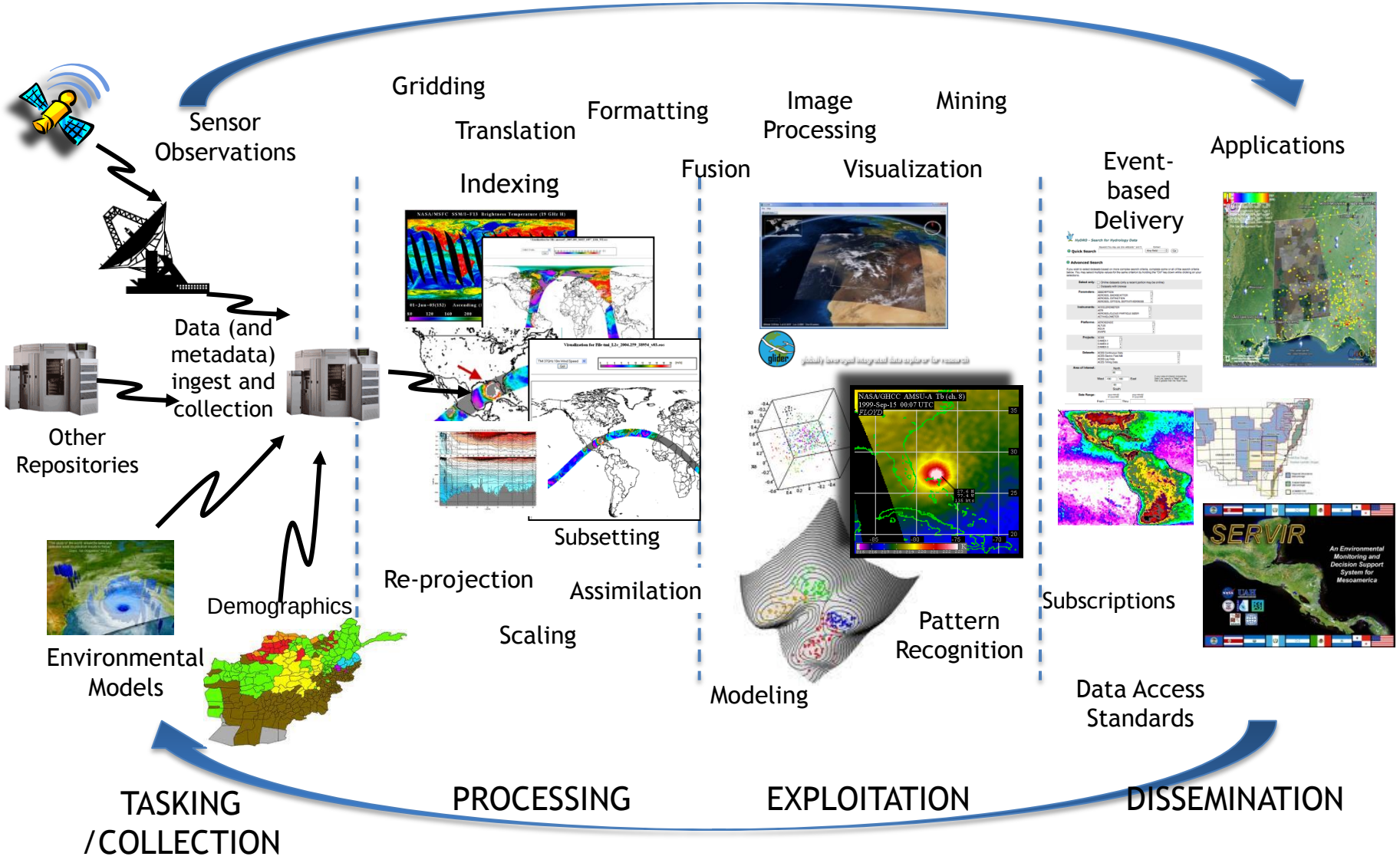
Conceptual Framework for Multi-source, Multi-function Analysis



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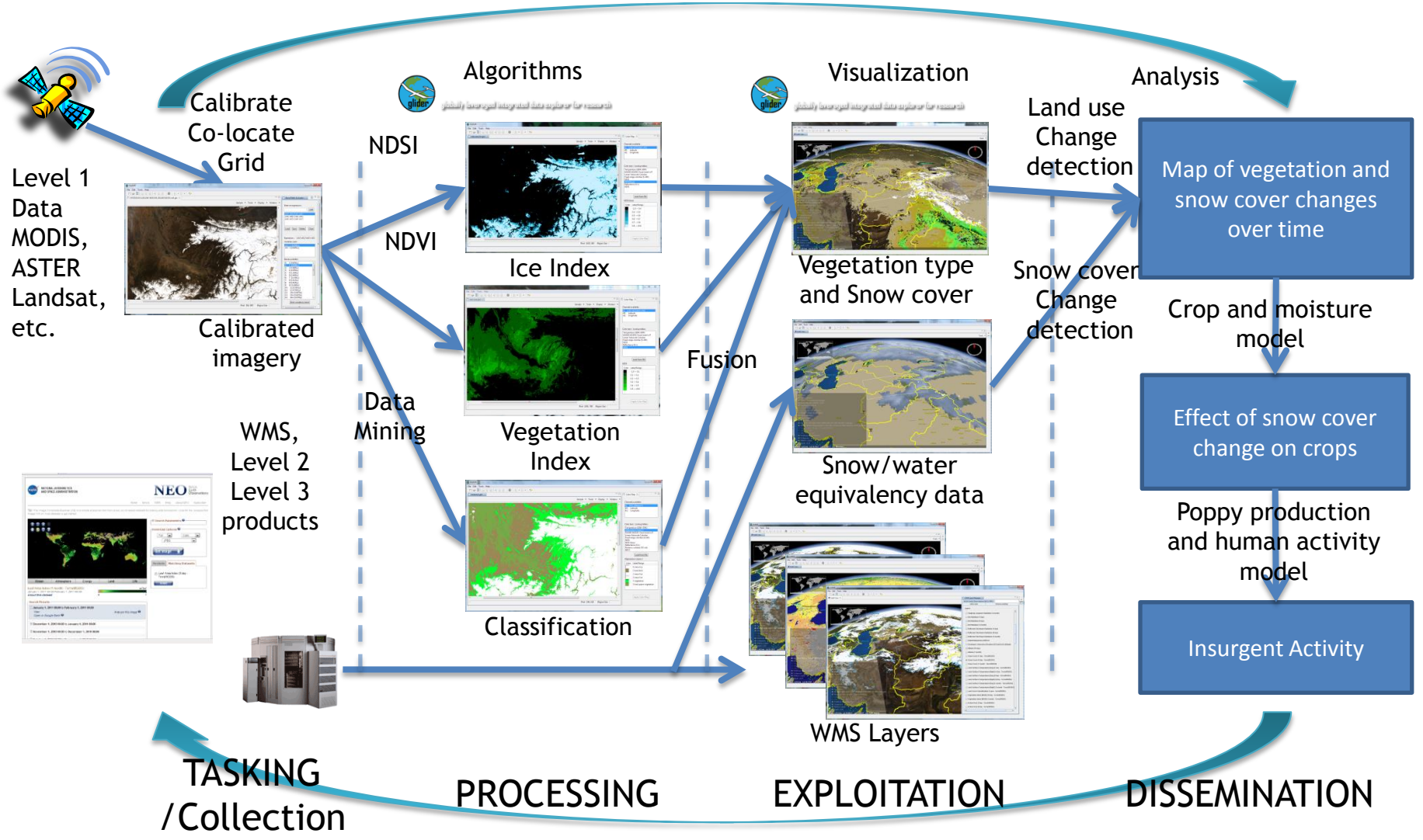
Conceptual methodology for examining the linkages between snow cover and insurgent activity in Afghanistan



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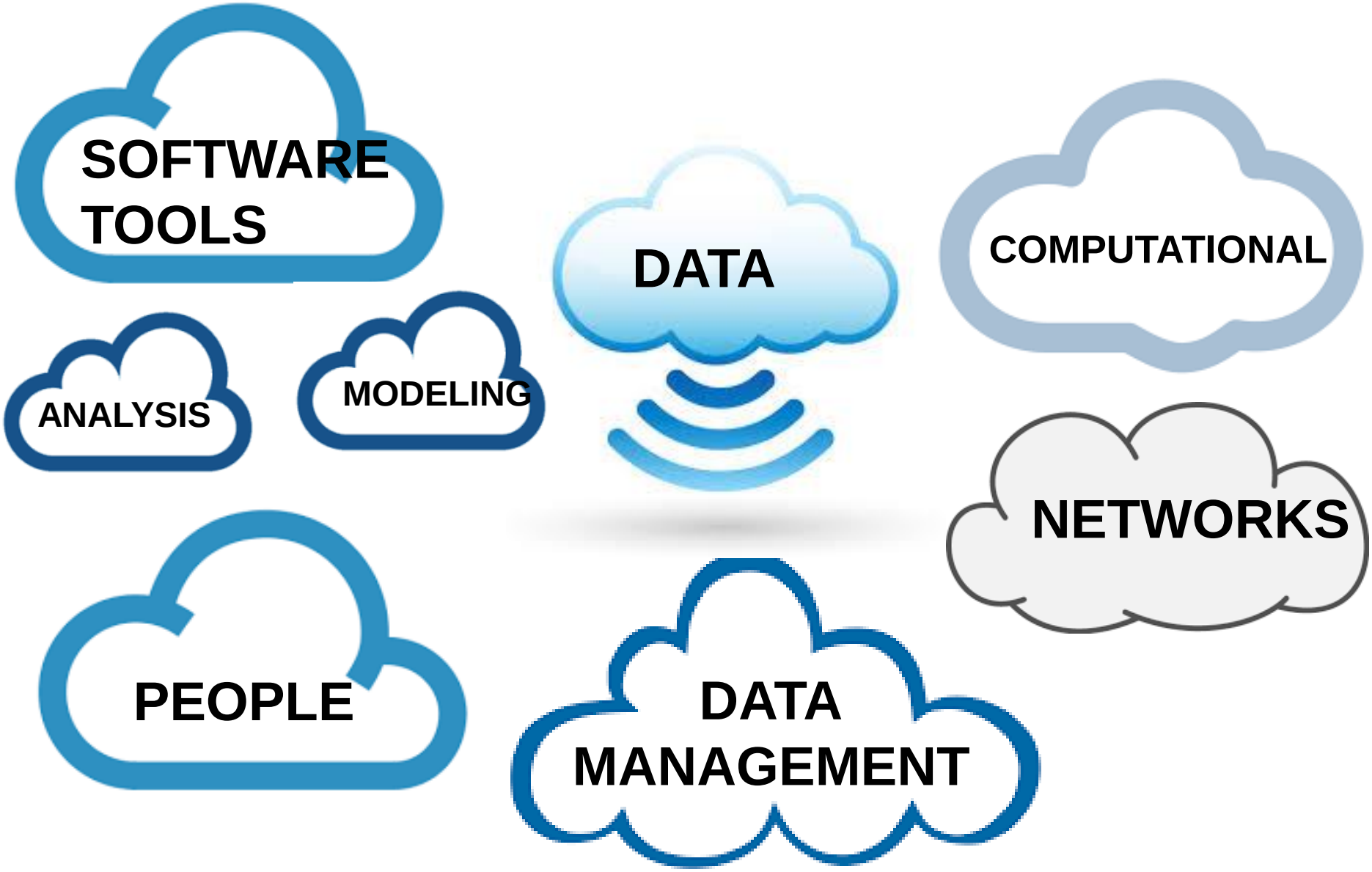
Cyberinfrastructure Components