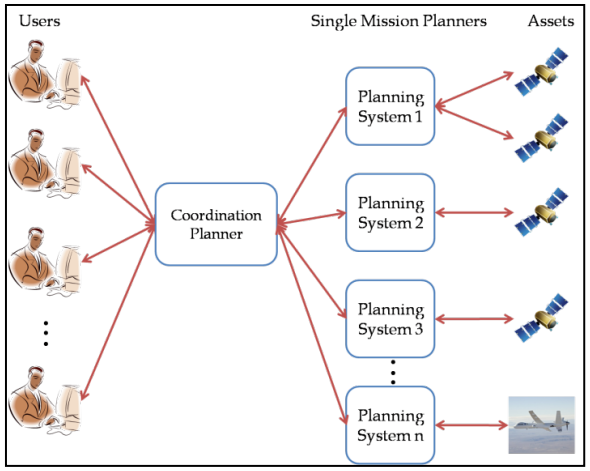
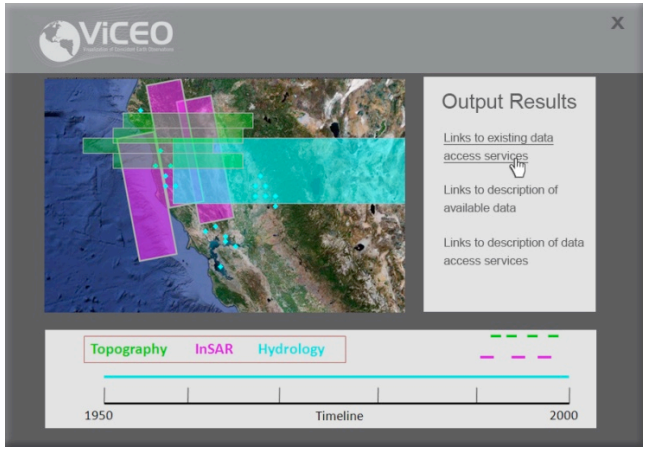
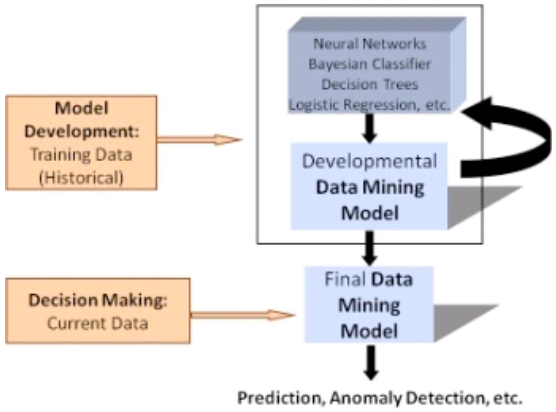
Exploitation of Coincident Earth Observations







Catherine Slesnick

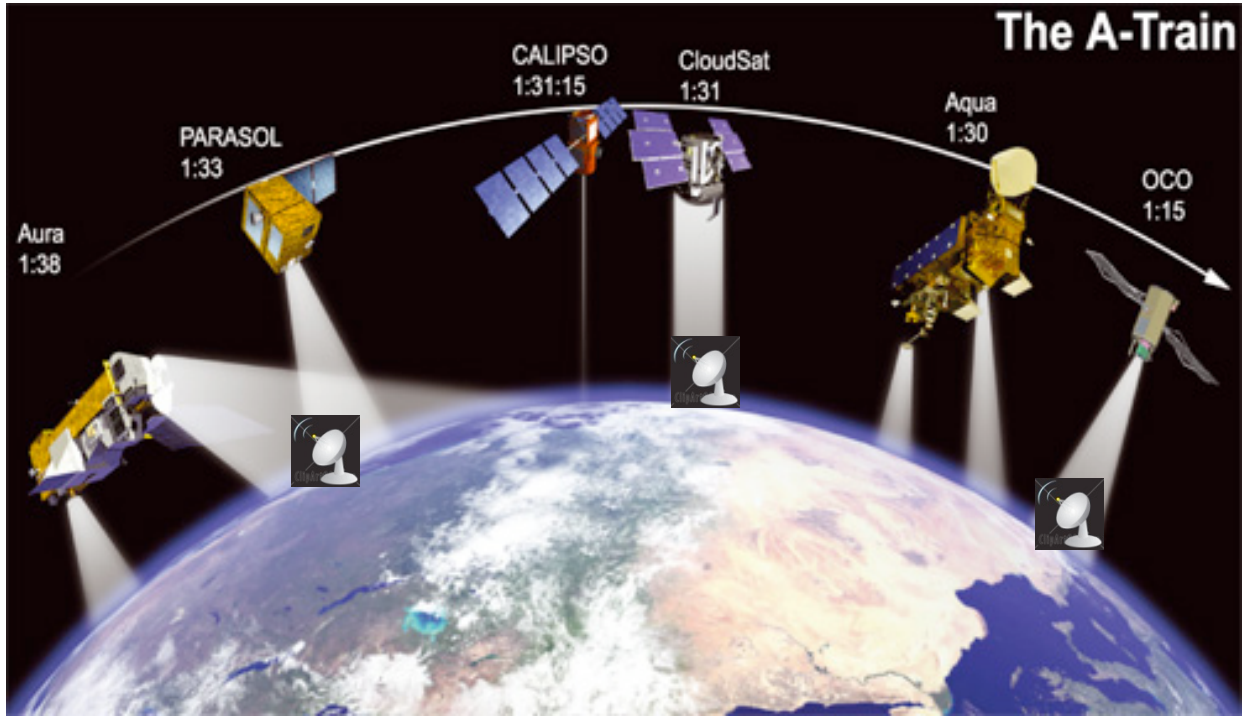
Stephan Kolitz, Shawn Murphy, Natasha Markuzon,

Mark Abramson, Tommy Herold

Draper Laboratory

Coincident Observations are Important for Understanding Earth Phenomena

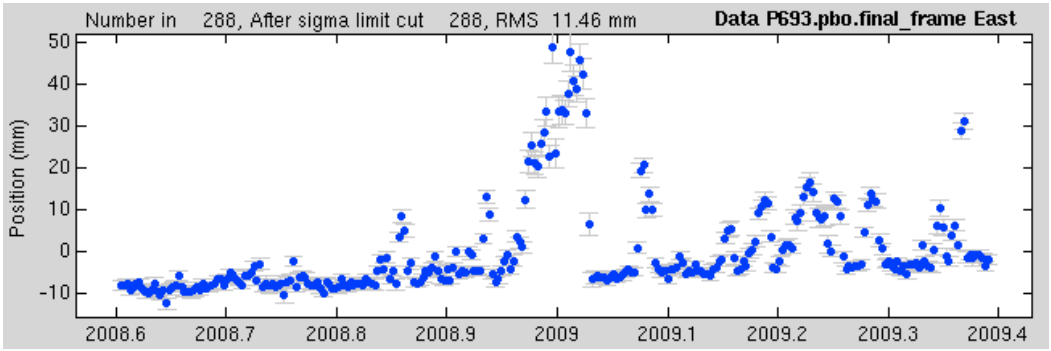
Coincident observations occur when multiple sensors take measurements of the same place on Earth at the same time (or near same time)



Coincident Observations are Important for Understanding Earth Phenomena

Often multiple types of observations are needed to get full understanding of

- anomalous activity



Example 1 — Volcano Monitoring

- GPS
- Snow/Ice data
- Atmospheric information
- Hydrological information

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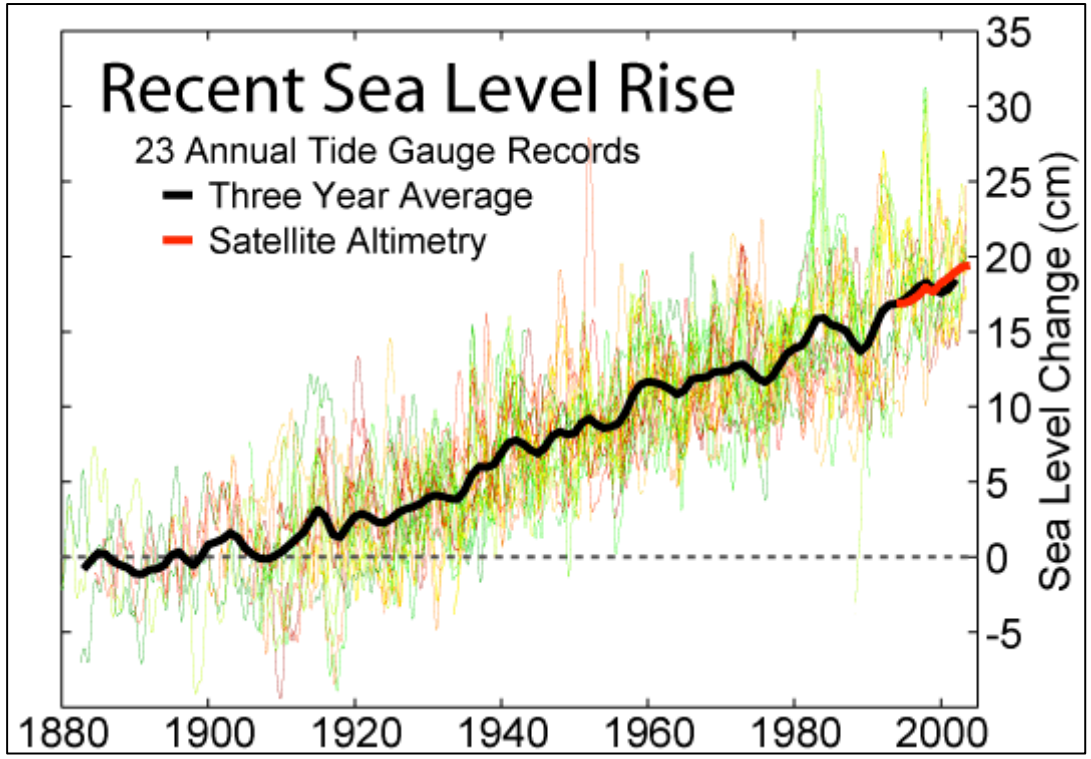
Coincident Observations are Important for Understanding Earth Phenomena



Often multiple types of observations are needed to get full understanding of

- long-term trends

Example 2 — Sea Level Rise

- Gravity measurements
- Thermal measurements
- Altimetry

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Coincident Observations are Important for Understanding Earth Phenomena

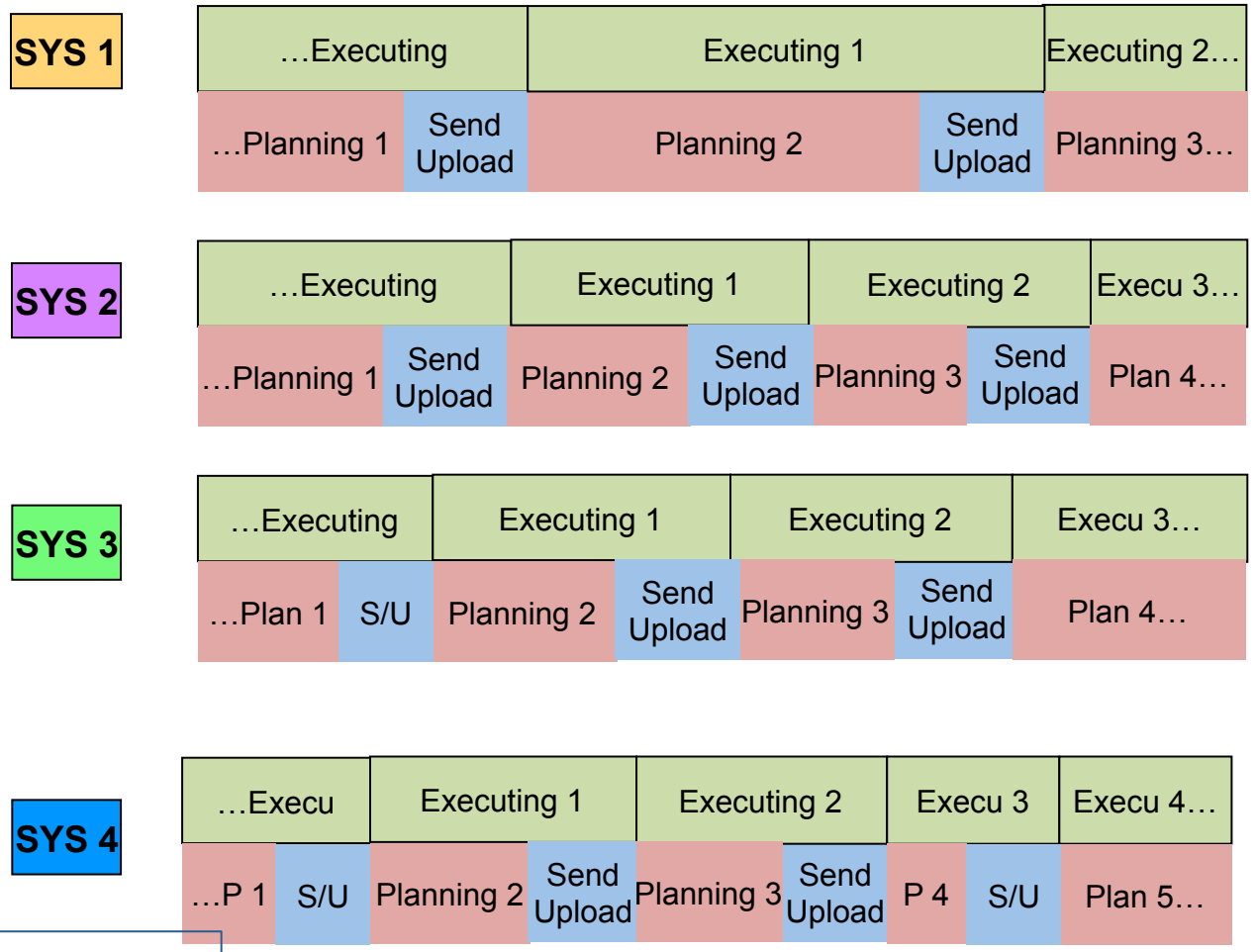
1. Coincident Observation Planning
   - Earth Phenomena Observing System
     - Coordinated planning system for coincident observations
2. Coincident Observation Data Retrieval
   - Visualization of Coincident Earth Observations
     - Software architecture for open-source web service that allows for discovery of coincident observations
3. Coincident Observation Data Analysis
   - Data-driven modeling
     - Understanding relationships between variables in large sets of coincident observations

Coincident Observation Planning

Current Observation Planning is Done in a Stove-piped Manner

Inefficient use of resources

- Known resources may be inappropriate or unavailable
- Duplicate requests
- Poor ability to respond to transient events
- Poor data quality due to clouds, etc.



→ Missed science opportunities!

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Coordinating Observations between Sensors is Beneficial

Coordination Manager

SYS 1

…Executing		Executing 1		Executing 2…
…Planning 1	Send Upload	Planning 2	Send Upload	Planning 3…

SYS 2

…Executing		Executing 1		Executing 2		Execu 3…
…Planning 1	Send Upload	Planning 2	Send Upload	Planning 3	Send Upload	Plan 4…

SYS 3

…Executing		Executing 1		Executing 2		Execu 3…
…Plan 1	S/U	Planning 2	Send Upload	Planning 3	Send Upload	Plan 4…

SYS 4

…Execu		Executing 1		Executing 2		Execu 3		Execu 4…
…P 1	S/U	Planning 2	Send Upload	Planning 3	Send Upload	P 4	S/U	Plan 5…

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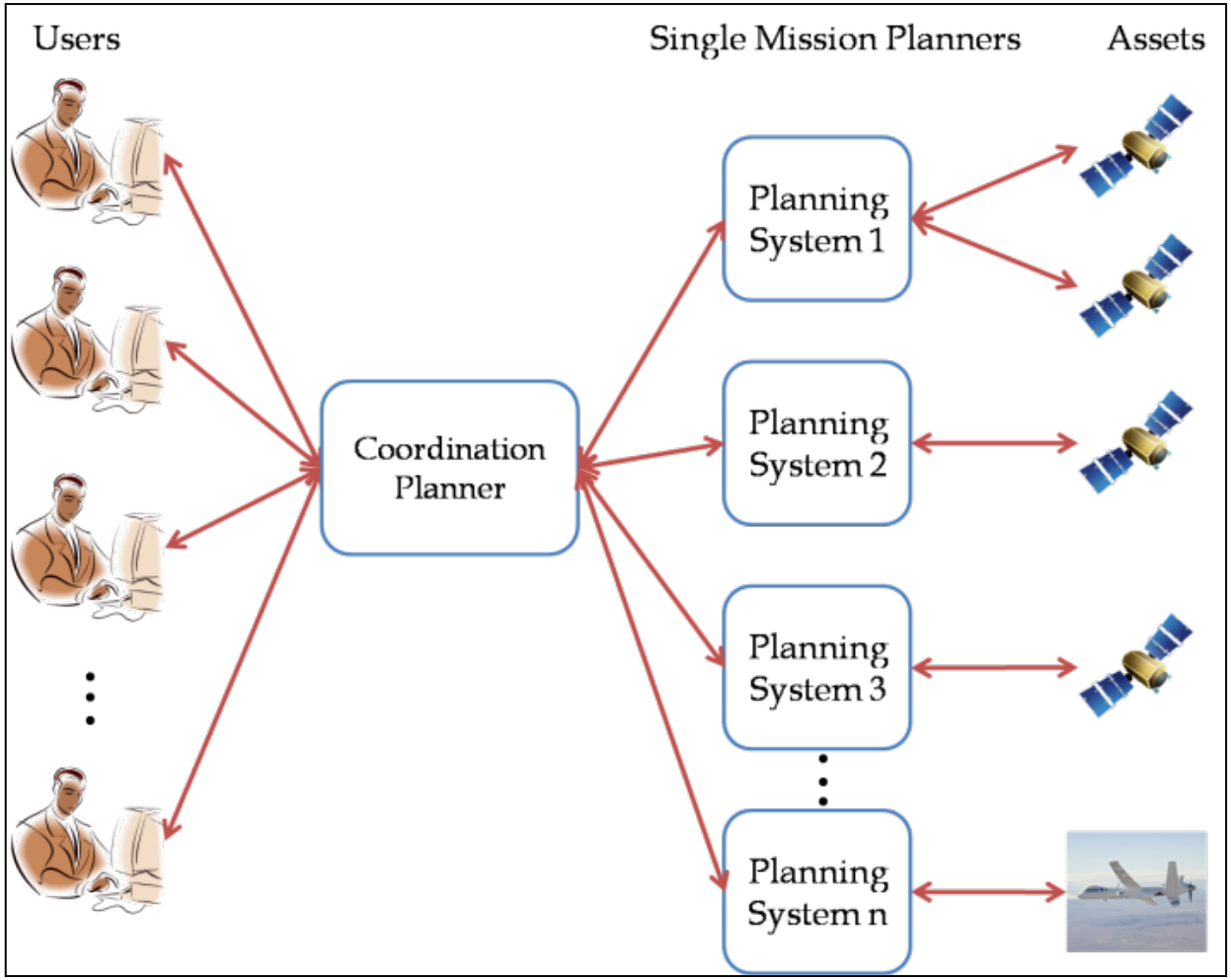
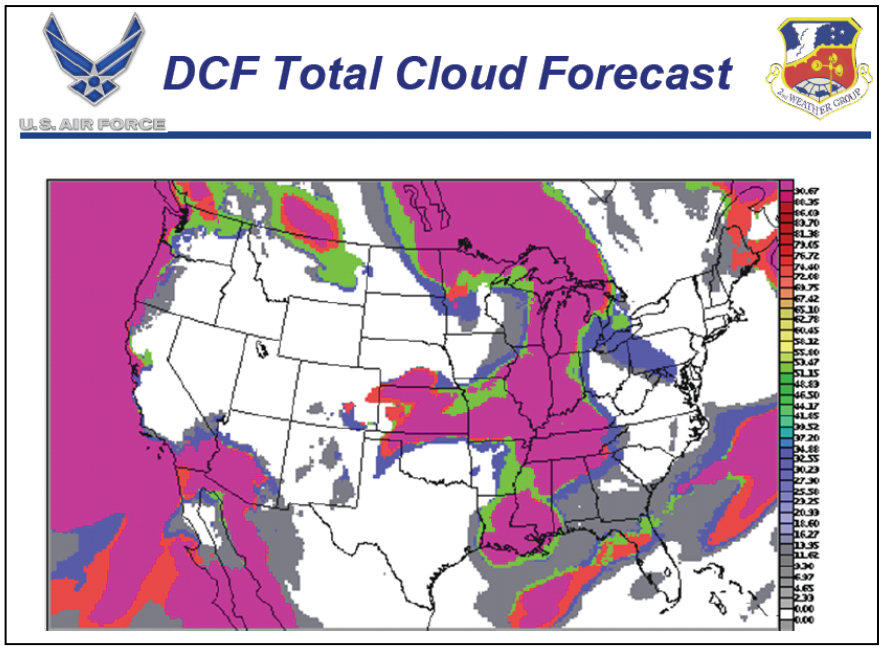
Coordination Manager has been Developed and Run in Simulation Mode

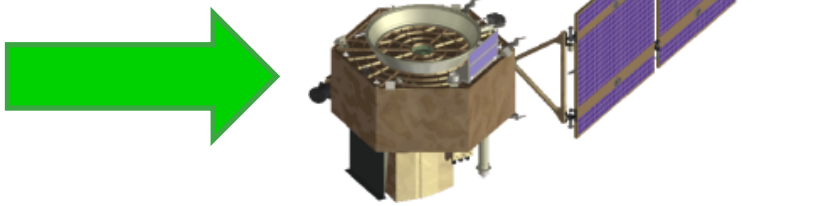
Coordination Manager provides:

- Situation awareness
- Observation opportunity finder
- Observation coordinator



Information from other Sensors Allows Better Use of Limited Observing Resources



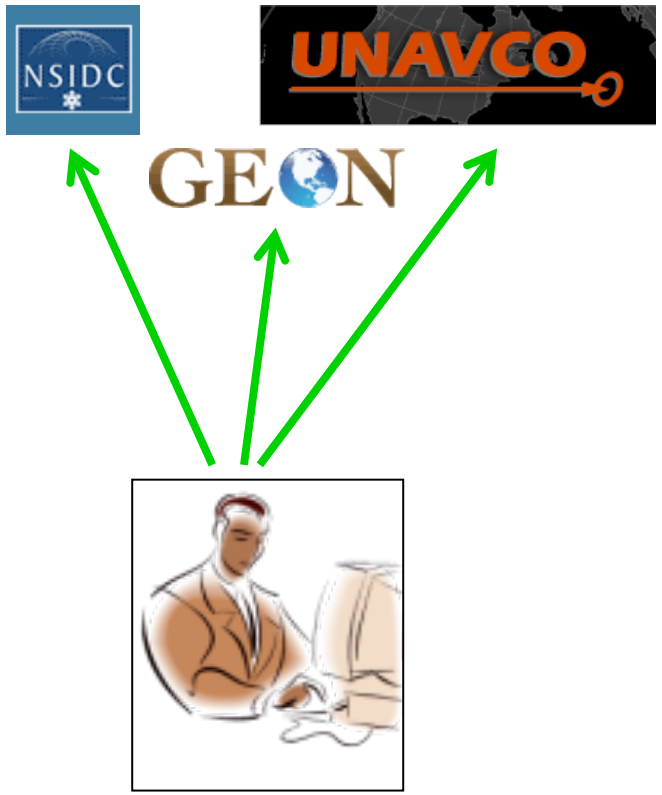


Using cloud data as input to observation planning algorithm for EO-1

Minimize number of cloudy observations

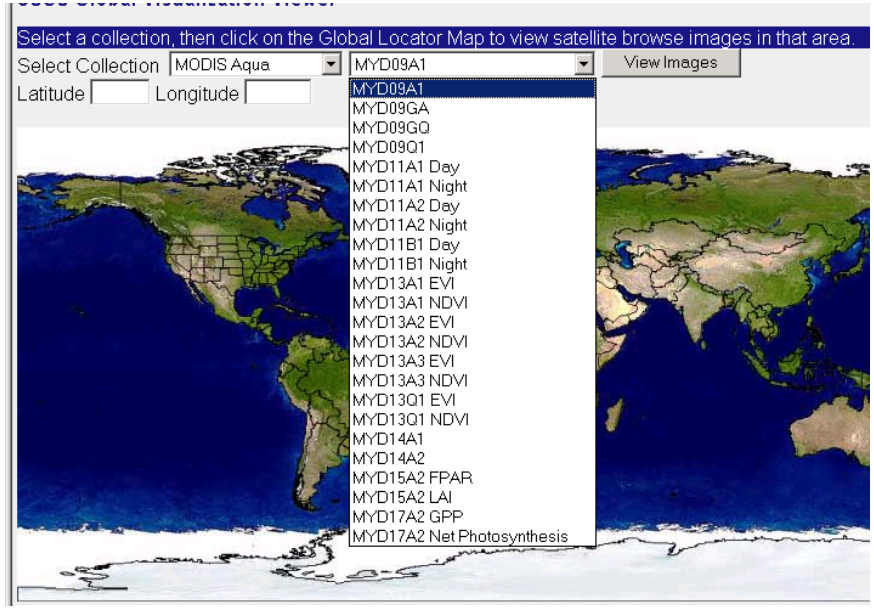
Coincident Observation Data Retrieval

Current Data Retrieval Systems do not Allow for Easy Discovery of Coincident Earth Observations



1. Require searching multiple data portals

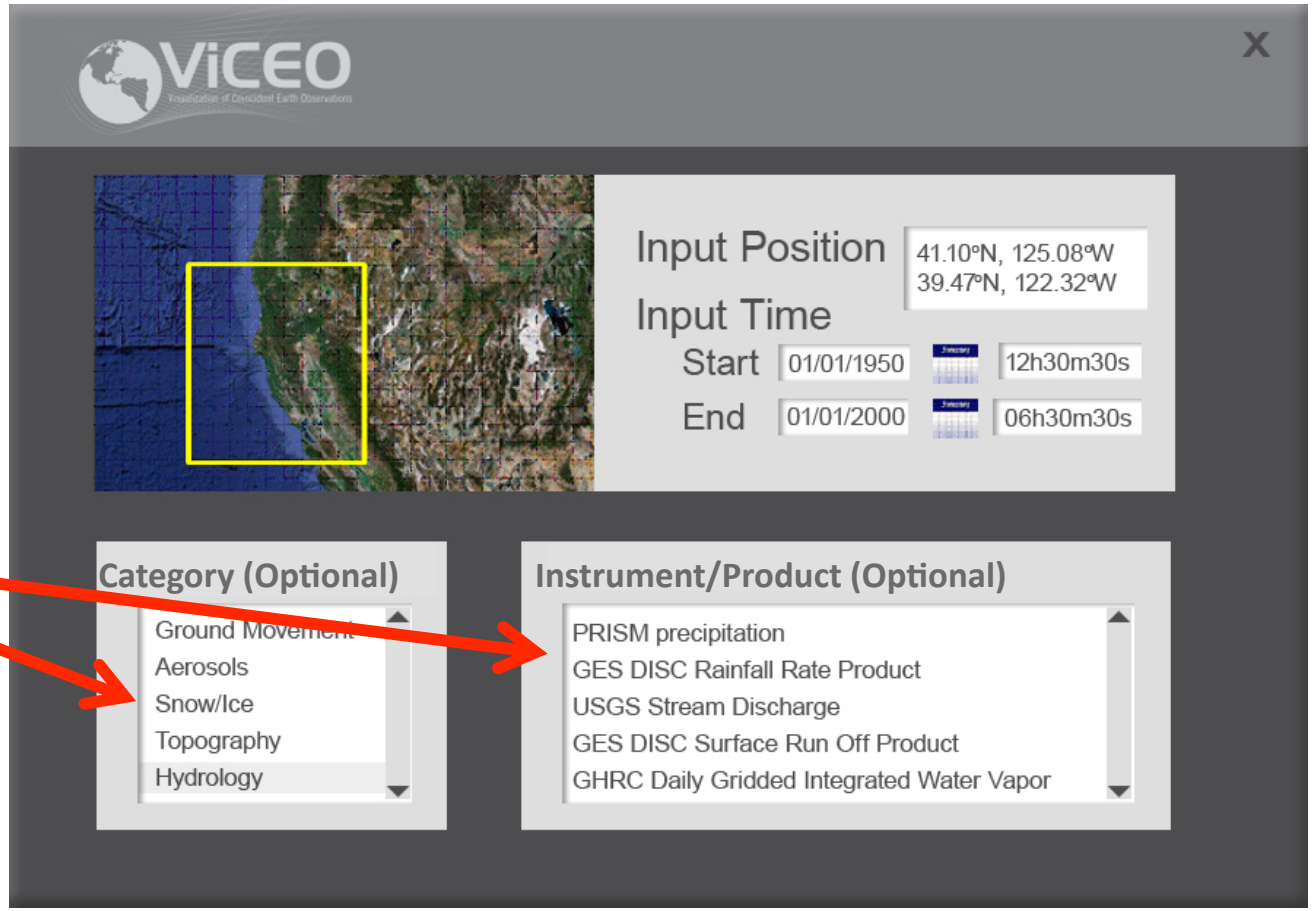
2. Require *a priori* knowledge of needed datasources



3. Require *a priori* knowledge of when/if coincident observations were taken or a "trial and error" approach

ViCEO would Allow for Visualization of Coincident Earth Observations

Data selection categories are optional



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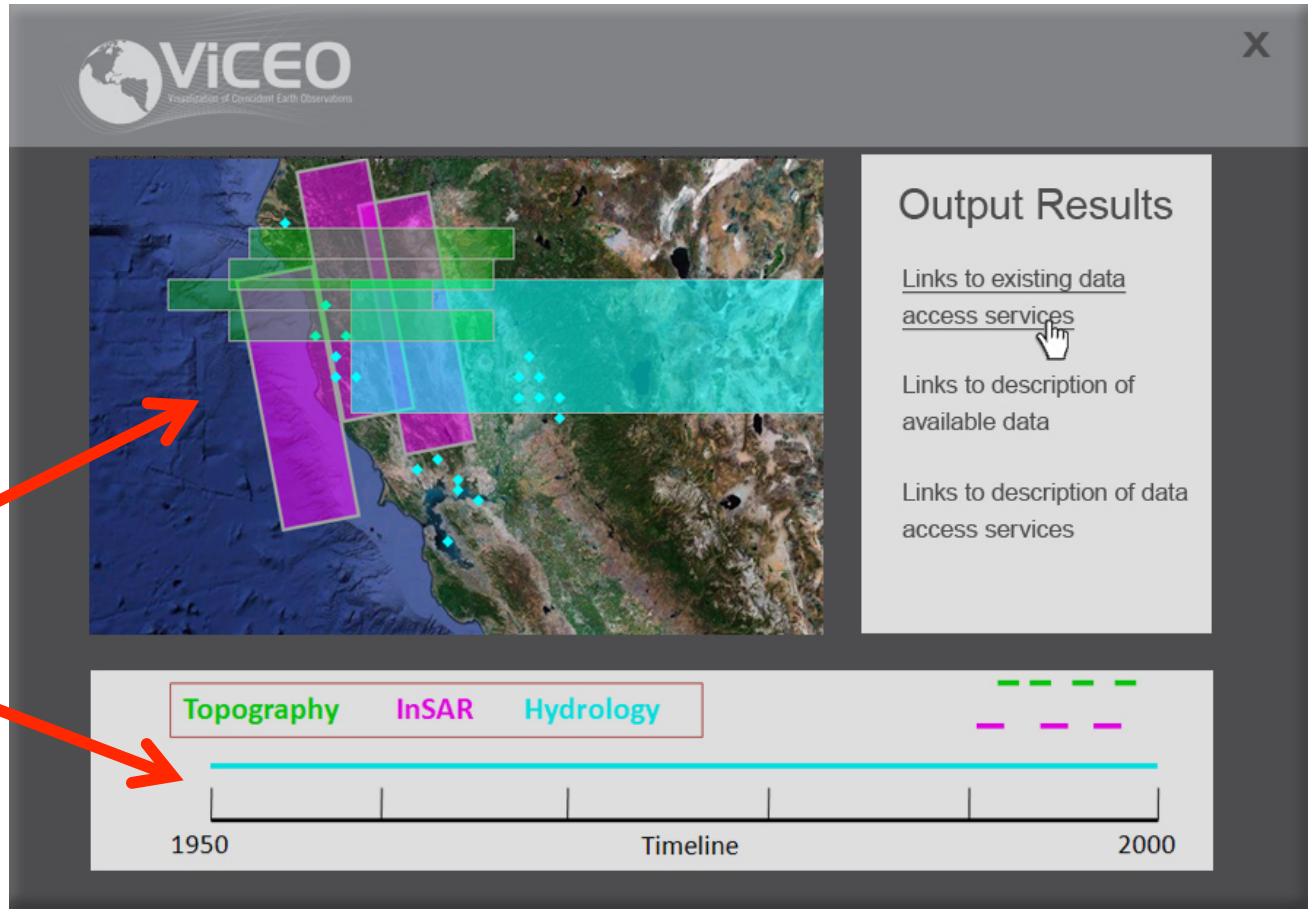
ViCEO would Allow for Visualization of Coincident Earth Observations

Available data would be visualized in space and time



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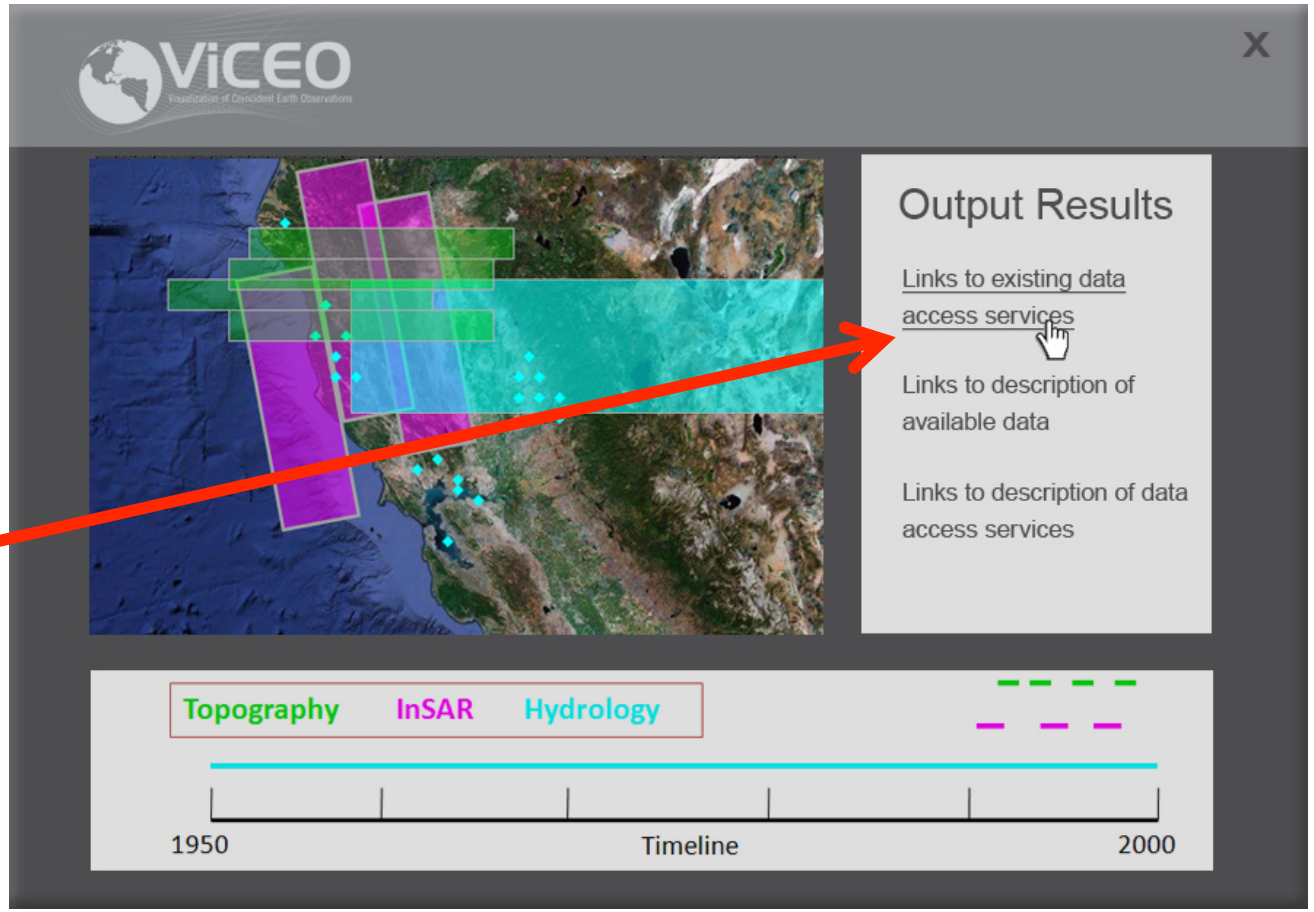
ViCEO would Allow for Visualization of Coincident Earth Observations

Desired data would be retrieved through existing portals



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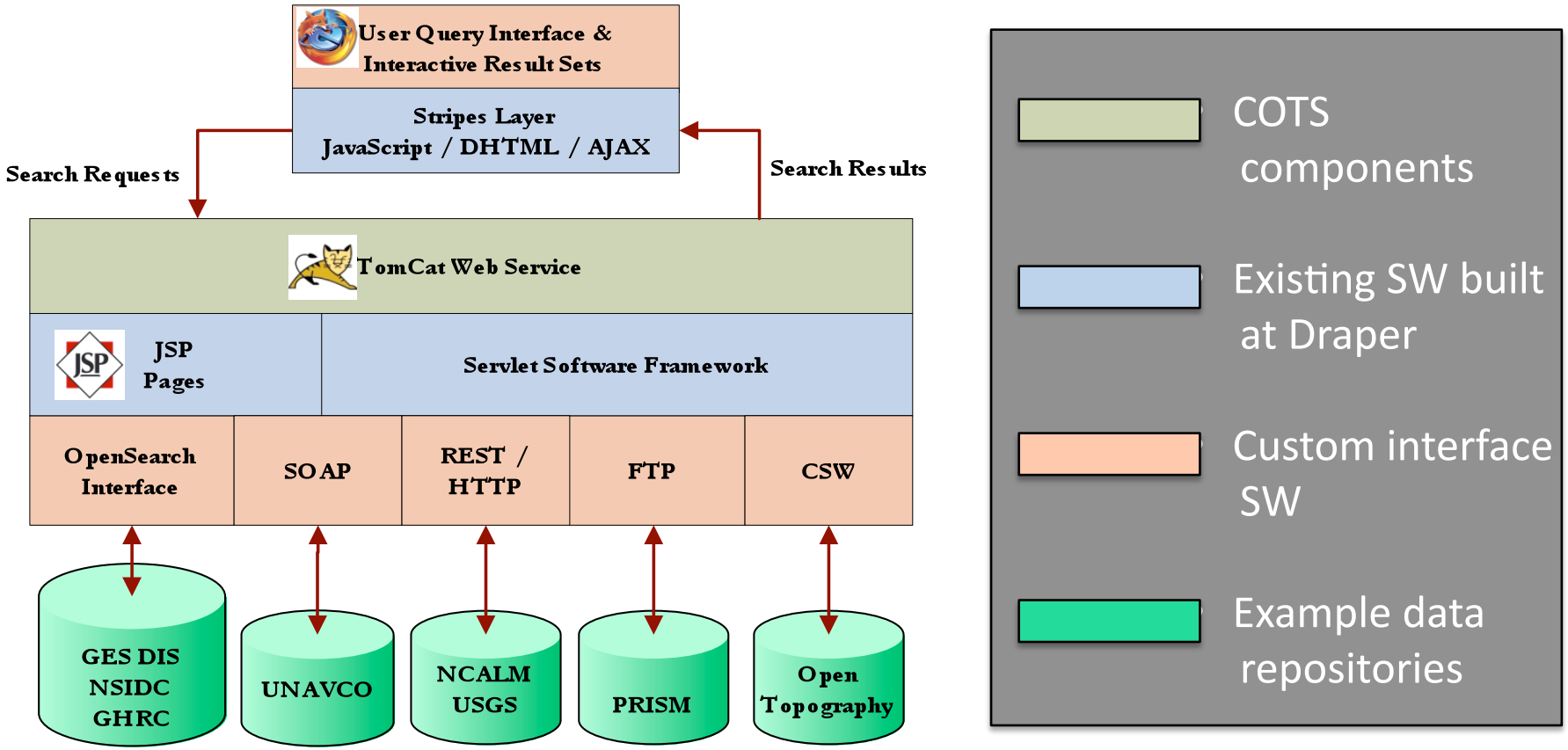
ViCEO would Allow for Visualization of Coincident Earth Observations

Advantages of ViCEO include:

- Guides investigator to most relevant data
- Provides descriptions of all available data in one place
- Retrieves bounding boxes (in time and space) of available data, not data itself
  - — Can implement sooner
  - — Can link more data sources
  - — Can link heterogeneous data sources more easily

Most of ViCEO can be Built Using Existing and COTS Components



Flexible design allows for additional data sources to be included with no necessary framework modification

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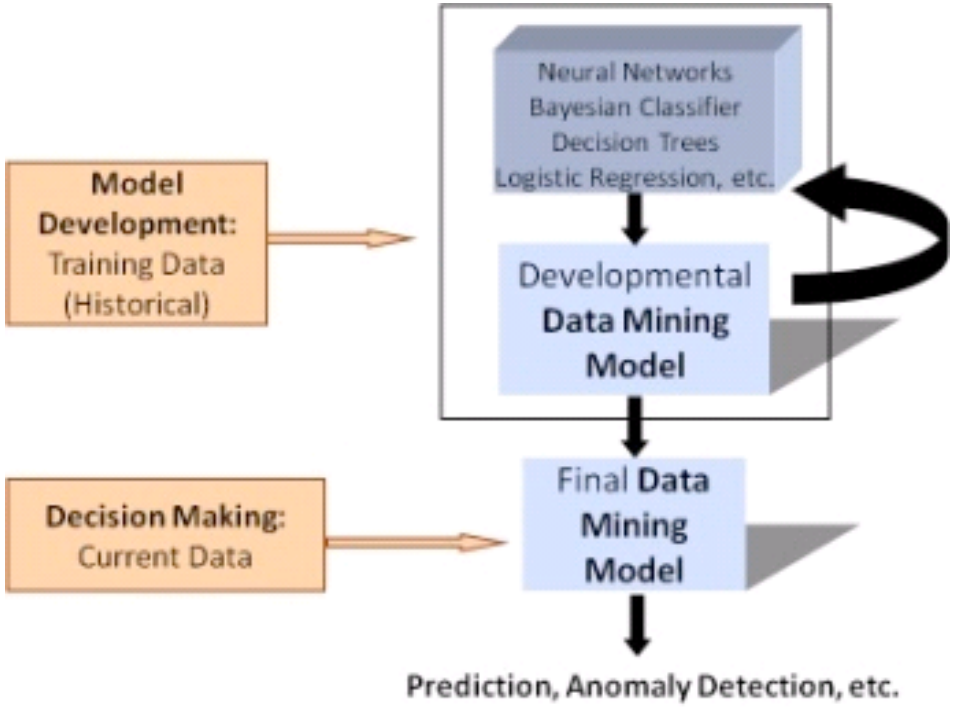
Coincident Observation Data Analysis

Data-driven Modeling Will Help Us to Better Understand Coincident Earth Observations



Technique to model systems where no physical relationship (hypothesis) between variables is known

- Proven technique
- Widely used today in finance, marketing and biomedical fields

We are just beginning to explore the use of data mining to help us understand climate change

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Data-driven Modeling Will Help Us to Better Understand Coincident Earth Observations

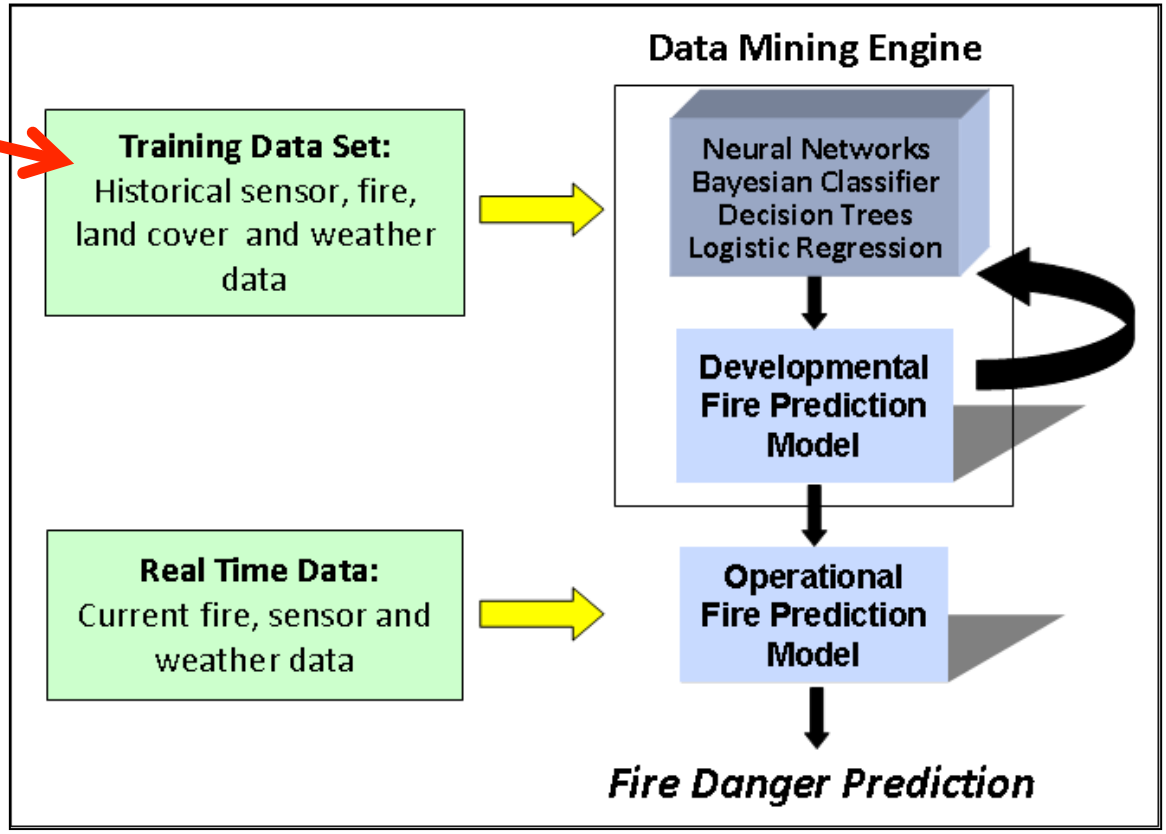
- Analytic models can assess only a limited number of variables at a time
- Analytic models aimed at proving/disproving a specific hypothesis
- Data-driven modeling (data mining) can complement analytic models
  - fuse large amounts of heterogeneous into a single model
  - model spatial and temporal components in concert
  - flexible enough to discover previously un-hypothesized non-linear relationships between Earth System variables
  - identify which variables are most affected by model changes
  - can combine with analytical models to determine why variable relationships exist

Data-driven Modeling Will Help Us to Better Understand Coincident Earth Observations

Ex 1 —Data-Driven Approach to Estimating Fire Danger

Combined:

1. MODIS Thermal observations
2. NOAA Weather Data
3. NLCD Land Cover Information



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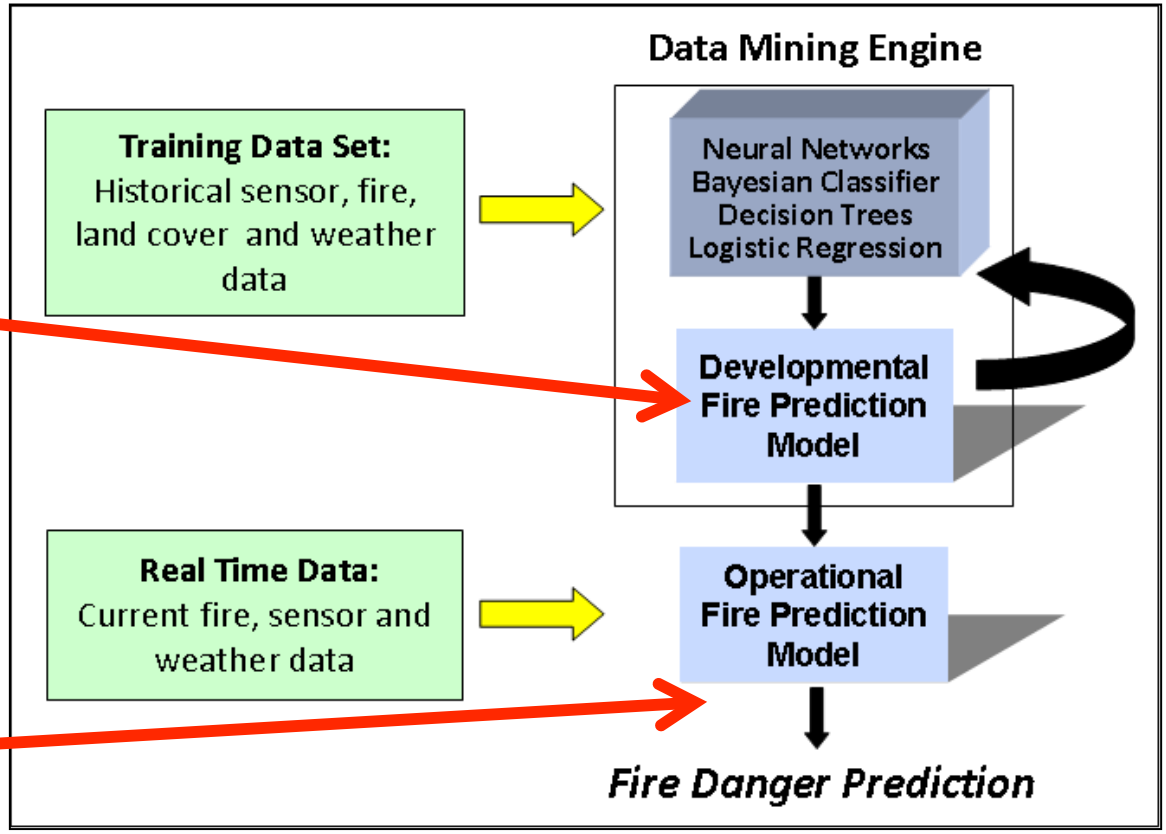
Data-driven Modeling Will Help Us to Better Understand Coincident Earth Observations

Ex 1 —Data-Driven Approach to Estimating Fire Danger

- Can we predict which fires will become large within the next two days?
- Model able to improve prediction performance by a factor of 4-6



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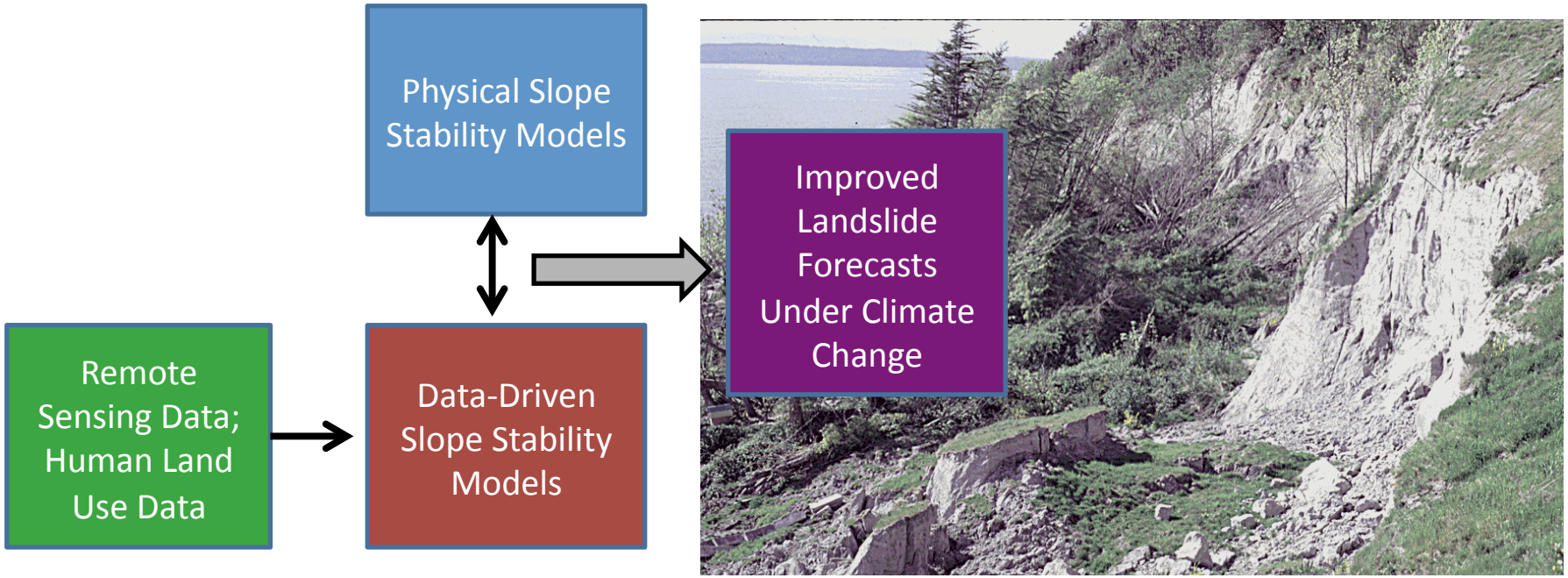
Data-driven Modeling Will Help Us to Better Understand Coincident Earth Observations

Ex 2 — Using Data-Driven Models to Improve Physical Slope Stability Models

Climate Change → Precipitation Extremes → Landslide Risk



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Future Work

1. Coincident Observation Planning
   - Expand operational support beyond EO-1
   - Link Coordination Manager with Decadal Missions **before** they fly

2. Coincident Observation Data Retrieval
   - Implement SW architecture with 4-5 portals around a specific science goal
   - Expand to include more data sources

3. Coincident Observation Data Analysis
   - Continue work on landslide models
   - Begin work modeling spread of infectious diseases under the influence of climate change

Coordination Manager has been Developed and Run in Simulation Mode

- More efficient use of resources
  - Knows about subsystem platforms and sensors
  - Can balance timeliness, quality, and availability
- Enterprise-wide value is a factor in collection decisions
  - Global optimization criteria (quality, benefit, timeliness, cost) considered in selecting what enterprise resources to request
- Highly dynamically responsive
  - Earliest available and feasible resource can be requested using knowledge of planning phases and subsystem capabilities
- Increased opportunities for enhanced science value through joint observation collection
  - Using knowledge of planning phases and subsystem capabilities

Coordinating Observations between Sensors is Beneficial