

Earth Information System Concept

- Global Perspective
- End-to-end Science needs an
End-to-end Information System

- Scientific discovery
 - Accessing and Visualizing diverse massive data sets
 - Exploring Correlations among diverse data sets
 - Making accurate and useful Predictions
- Public education and awareness
- Policy validation

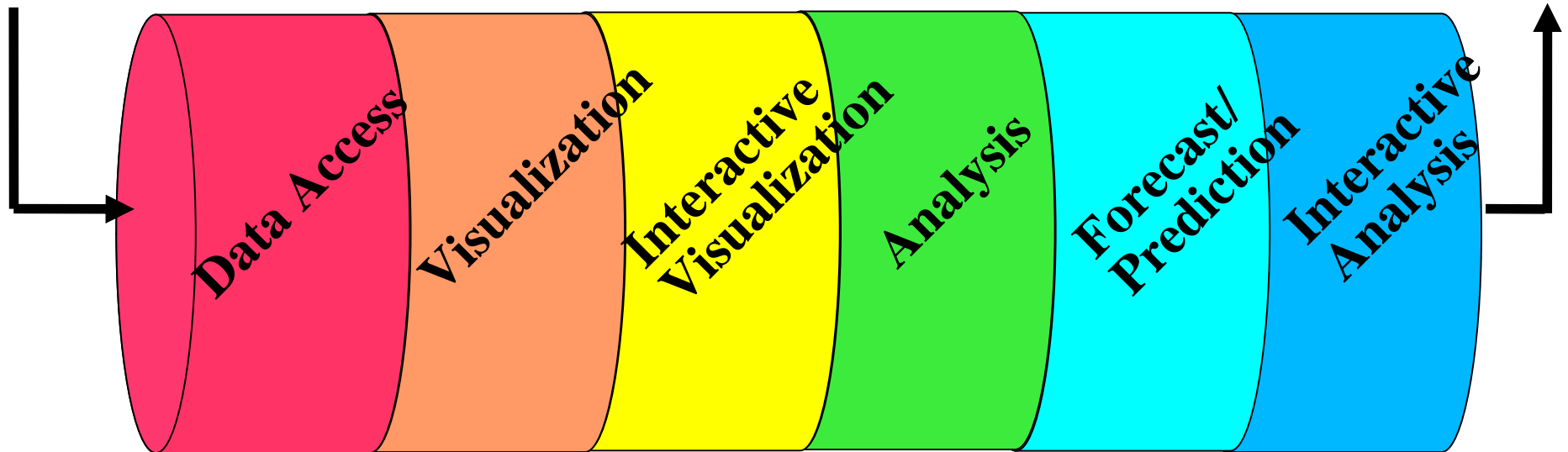
Earth Information System Framework

- New technologies emerging:
 - Service-oriented architecture, OpenDAP, HDF5, Google Earth, GIS, GEOSS
- Framework Approach
 - Applications can “plug-in” and extend functionality
 - Can support a broad set of applications with relatively concise software

Earth Information System

Observations,
Models,
Policies

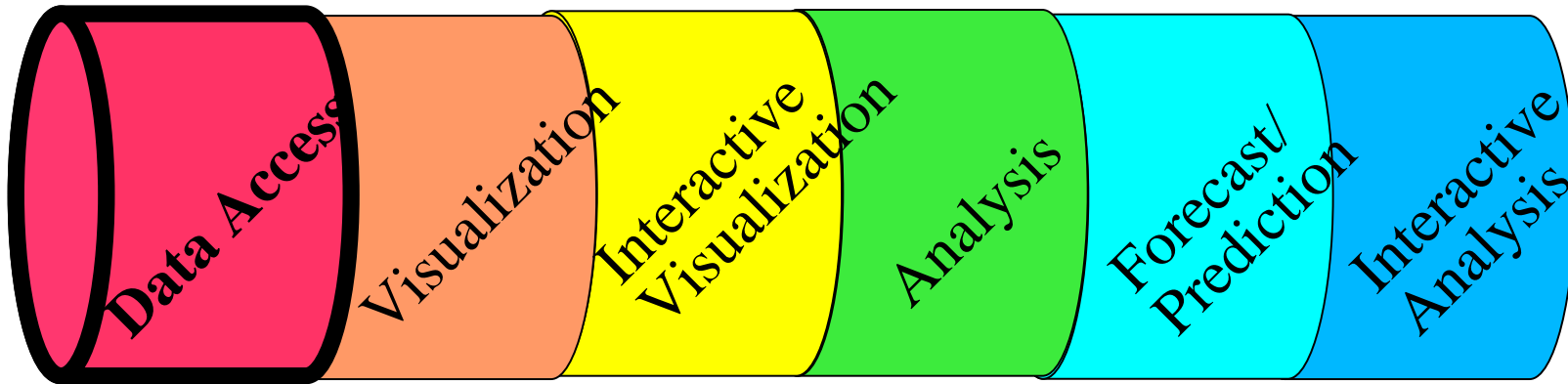
Predictions,
Improved Models,
Improved Policies



Uses Framework for

- Access
- Viewing
- Manipulation

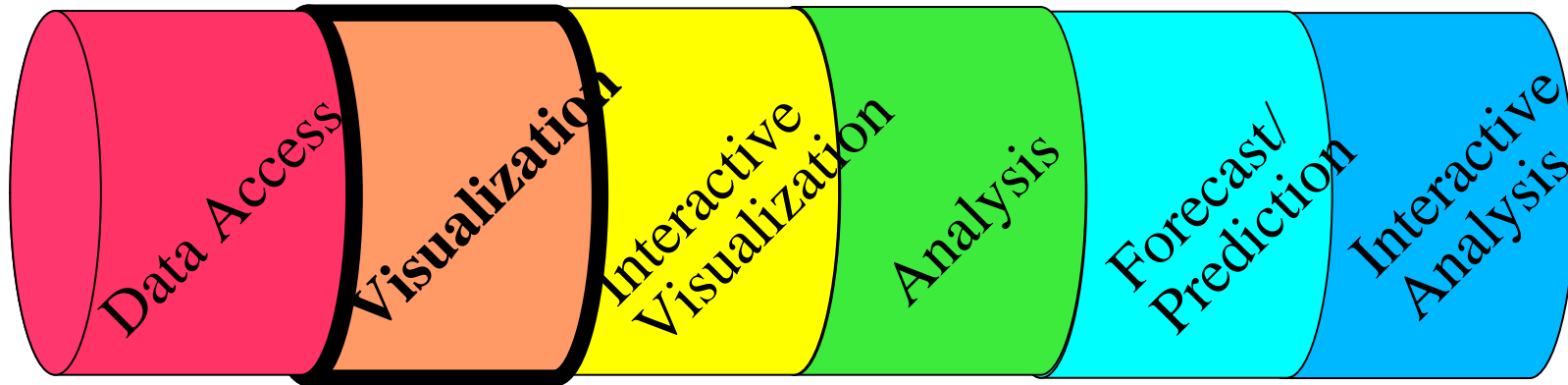
EIS – Data Access



- Access to diverse data sets – points, polygons, grids
- Using standard formats (OpeNDAP, netCDF, HDF5...)
- Distributed Data Sharing
- Meteorological, Oceanographic, Geologic, Vegetation, Population (human, animal)...

Can I access population density along with a hurricane path prediction?

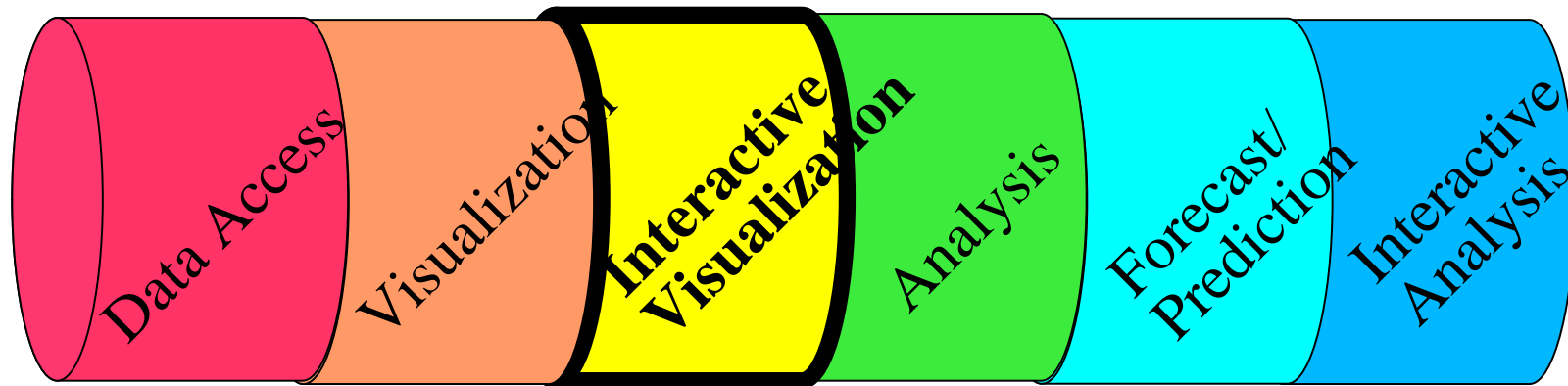
EIS - Visualization



- Viewing diverse multi-dimensional data sets (zoom, progressive disclosure, user-defined defaults for location, settings)
- Image, graphics, text
- Combined/Overlaid data sets
- Google Earth
- Actual data not necessarily accessible

Can I overlay population density along with the predicted hurricane path?

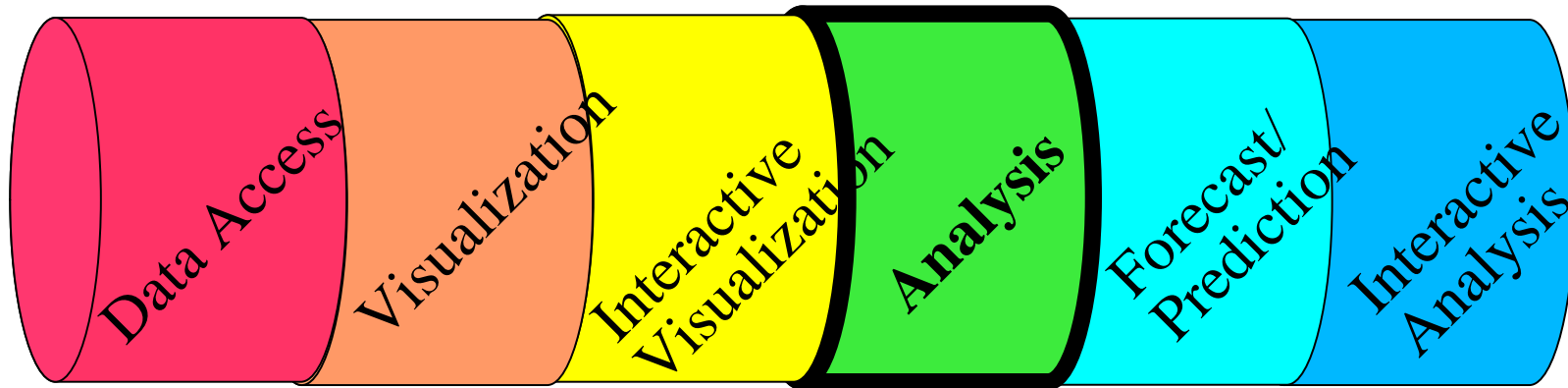
EIS – Interactive Visualization



- Sampling data values
- Deriving new visualizations based on existing data sets (time-height cross section...)
- D2D, ALPS, FxNet, others
- Need actual data; No new data sets

Can I sample the population density and wind speed at a point along the hurricane path prediction?

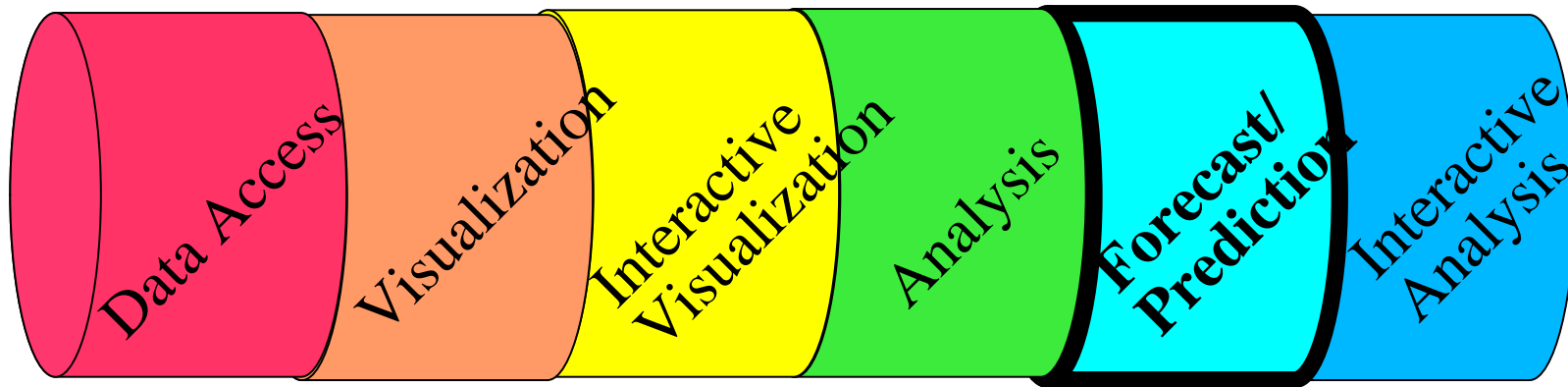
EIS Analysis / Discovery



- Exploring correlations and relationships between diverse data sets
- May create new data sets in accessible formats
- May not modify data points within a data set
- Verification tools, GIS, ifpInit

Can I create a dataset of the highest risk areas given population density and wind speed along the hurricane path prediction?

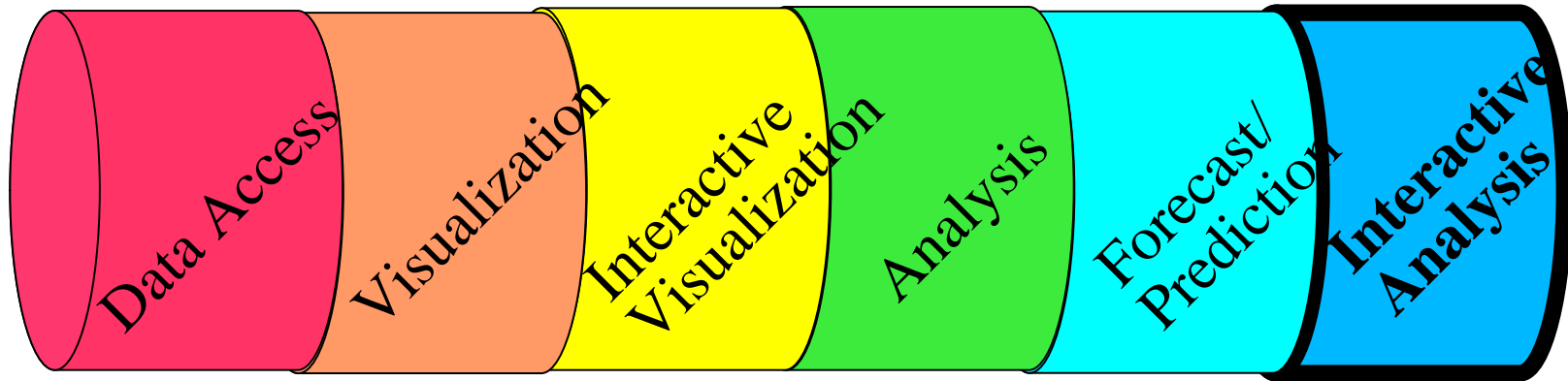
EIS Forecast / Prediction



- Incorporating interactive human input
- Framework for Tools that incorporate science
- Event-driven Tools
- Operate on single scenario
- GFE: Smart Tools, D2D: WarnGen

If the size of the hurricane increases, how many more people will be affected?

EIS Interactive Analysis



- Probabilistic Forecasting
- Ensembles
- Building contingencies
- Multiple Scenarios – combine, assess

What is the probability that hurricane force winds will occur at a particular location?

Climate Change

- *Data access, visualization, interactive visualization*
 - Can I access, view and interactively sample annual average temperature and temperature increase per area, current animal population, and current habitat data?
- *Analysis*
 - Can I create new datasets to determine the interrelationships between temperature, habitat, and animal population?
- *Prediction*
 - Can I express interrelationships using "event-driven" tools such that if the annual temperature increases in a particular area, I can see the effect on animal population?
- *Interactive Analysis (Probabilistic)*
 - Can I see the possible effects of temperature increase depending on whether animals will migrate, adapt, or die?

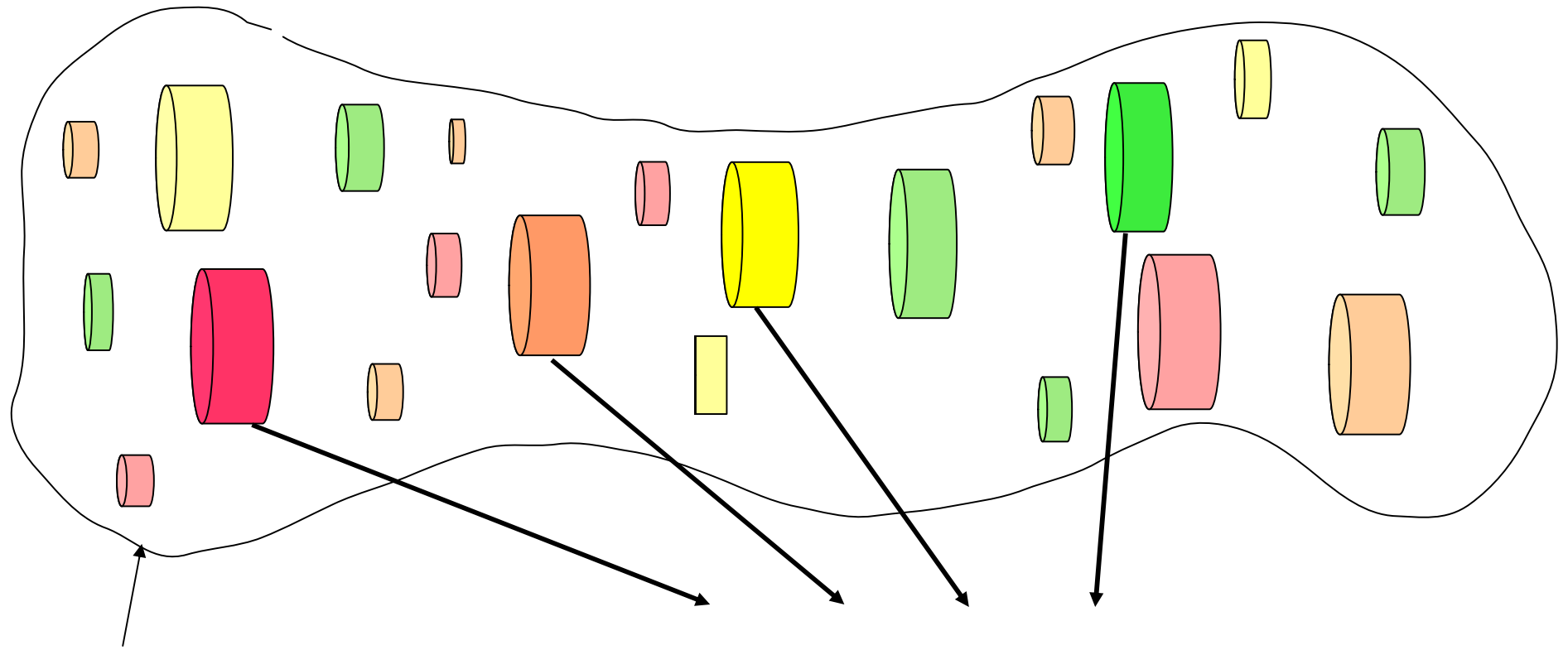
Coral Bleaching

- *Data access, visualization, interactive visualization*
 - Can I access, view, and interactively sample coral bleaching hot spots and indices along with animal population data?
- *Analysis*
 - Can I create a dataset correlating coral bleaching hot spots to variations in animal populations?
- *Prediction*
 - If a new coral bleaching hot spot appears, what will be the effect on the animal populations in the area?
- *Interactive Analysis (Probabilistic)*
 - How much coral bleaching is necessary to endanger a particular animal population?

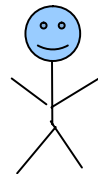
Earth Information System Framework

- Not necessary to write huge system that does “everything for everybody”
- Instead, build a Framework with Key features:
 - Distributed Data (and Code) Sharing
 - Library of “primitives” built upon conventions for each layer
 - Event-driven Tools
 - Encode intelligence, interrelationships
 - User-developed and extensible
 - “Remote” Processing for Performance

EIS Framework Approach



Distributed modules
compatible with the
framework



User interactively “plugs-in” modules to the
framework to perform desired operations

Show me the highest risk areas given population density and wind speed along the predicted hurricane path.

Earth Information System Framework

- Current Prototype
 - Uses HDF5/OpenDAP – data access
 - BaseMap -- visualization
 - Event-driven tools – analysis, prediction
 - Need to add Interactive Analysis and further develop other layers

Where do we go from here?

- Apply concepts to current projects
- Continue to develop framework and prototype
- Host Workshop to meet with diverse NOAA/Academic user community and refine framework
 - Use prototype for demonstration and discussion
- **Suggestions?**

Potential Applications

Hurricane Prediction

- *Data access, visualization, interactive visualization*
 - Can I access, view, and sample population density along with a hurricane path prediction?
- *Analysis*
 - Can I create a dataset of the highest risk areas given population density and wind speed along the hurricane path prediction?
- *Prediction*
 - If the size of the hurricane increases, how many more people will be affected?
- *Interactive Analysis (Probabilistic)*
 - What is the probability that hurricane force winds will occur at a particular location?

CONOPS

- *Data access, visualization, interactive visualization*
 - Can I access, view, and sample meteorological data from any WFO or set of WFO's?
- *Analysis*
 - Can I produce verification statistics comparing my forecast with observations?
- *Prediction*

If a front comes through with a given path, how will the winds, temperatures, and precipitation be affected?
- *Interactive Analysis (Probabilistic)*
 - Given a set of possible front paths, what is the probability that a thunderstorm will occur in a particular location?

Climate Change -- Effect of Temperature on Animal Population

- *Data access, visualization, interactive visualization*
 - Can I access, view and interactively sample annual average temperature and temperature increase per area, current animal population, and current habitat data?
- *Analysis*
 - Can I create new datasets to determine the interrelationships between temperature, habitat, and animal population?
- *Prediction*
 - Can I express interrelationships using "event-driven" tools such that if the annual temperature increases in a particular area, I can see the effect on animal population?
- *Interactive Analysis (Probabilistic)*
 - Can I see the possible effects of temperature increase depending on whether animals will migrate, adapt, or die?

Coral Bleaching

- *Data access, visualization, interactive visualization*
 - Can I access, view, and interactively sample coral bleaching hot spots and indices along with animal population data?
- *Analysis*
 - Can I create a dataset correlating coral bleaching hot spots to variations in animal populations?
- *Prediction*
 - If a new coral bleaching hot spot appears, what will be the effect on the animal populations in the area?
- *Interactive Analysis (Probabilistic)*
 - How much coral bleaching is necessary to endanger a particular animal population?

Climate Change – Affect of Temperature on Vegetation

- *Data access, visualization, interactive visualization*
 - Can I access, view and sample temperature observations along with vegetation data?
- *Analysis*
 - Can I create a dataset of the correlation between average temperature and type of vegetation?
- *Prediction*
 - If I increase the temperature over this area, how will the vegetation change?
- *Interactive Analysis (Probabilistic)*
 - What are the various scenarios for vegetation change based on possible temperature changes?

Climate Change – Affect of Population on Temperature

- *Data access, visualization, interactive visualization*
 - Can I access, view and sample temperature trend data along with population density?
- *Analysis*
 - Can I create a dataset of the correlation between population density and increasing temperature trends?
- *Prediction*
 - If the population density increases, how will this affect the temperature?
- *Interactive Analysis (Probabilistic)*
 - If the population density increases, what are the possible effects on temperature?

Lead Poisoning

- *Data access, visualization, interactive visualization*
 - Can I access, view, and interactively sample tax parcel data (year built, rented or owned, residents and ages, income level) along with lead poisoning sample statistics?
- *Analysis*
 - Can I create a new data set (using a regression equation calculated from the data) for the risk of lead poisoning for each tax parcel? Can I identify neighborhoods where the problem is most severe?
- *Prediction*
 - If I employ a "re-paint" policy for tax parcels in a certain income bracket, how effective will it be?
- *Interactive Analysis (Probabilistic)*
 - If I employ a "re-paint" policy for tax parcels in a certain income bracket, what are the possible effects?

Malaria Prevention

- *Data access, visualization, interactive visualization*
 - Can I access, view, and interactively sample annual rainfall, land cover (agriculture, forest, developed), mosquito density, biting rate (bites/female/week), and bite infection rate along with population density, income level, and malaria statistics (such as population distribution of occurrences)?
- *Analysis*
 - Can I create a new data set from these data sets to determine the interrelationships and risk factors?
- *Prediction*
 - Can I express this information in "event-driven" tools such that if I introduce a policy such as issuing bed nets for all pregnant women and children, I can see the effect on malaria statistics? on income level? on population density?
- *Interactive Analysis (Probabilistic)*
 - Can I see the possible effects of a particular policy? Can I explore other policies such as using insecticides to control the mosquitoes? Can I find the optimum policy or set of policies in terms of the above variables?

Medicine

- *Data access, visualization, interactive visualization*
 - Can I access, view, and interactively sample physical symptoms? (Possibly displayed on a human body)
- *Analysis*
 - Can I create a dataset correlating symptoms to causes?
- *Prediction*
 - If I introduce a treatment, what is the expected outcome?
- *Interactive Analysis (Probabilistic)*
 - If I introduce a treatment, what are the probable outcomes? Which of a set of treatments gives me the optimum solution?

More Details

Earth Information System

- Diverse User Base:
 - Tool for scientists/modellers
 - NOAA decision makers
 - Emergency Managers
 - Education – SOS, Universities
 - Public

Earth Information System

- Diverse Data Sets to capture **Interrelationships** -->
- Distributed data sharing and event-driven tools make the system **Adaptable** to improve predictions.

Earth Information System

- Climate Change example
 - If the annual average temperature rises in Iowa, the corn farmer will adapt, perhaps by growing another crop, perhaps by migrating to another location. This type of interaction needs to be captured in models.
- Marine Reserve example
 - Creating a marine reserve to reduce the impact on a species of fish will also affect the fishing habits outside the marine reserve area. The system must be able to account for this interaction.

Suggested Applications of Vision

- Apply to current projects
 - Incorporate the vision when developing current projects by:
 - Designing with the “bigger picture” in mind
 - Building components that might fit into an EIS framework
 - Benefits
 - Will increase success of current projects
 - Can re-use or extend to build future systems
 - Identify the features of current systems both inside and outside our organization

Suggested Applications of Vision

- Organize around one Earth Information project:
 - Build Framework on which specific applications can be built
 - Build selected applications
 - NWS Conops
 - MADIS users
 - ESRL/Duke Climate Change Research
 - Funding – Base funding / PPBES?

Earth Information System Framework

- Development Steps
 - Identify potential users
 - Create initial set of requirements
 - Build a prototype
 - Iterate, extend functionality

Suggested Application of Vision

- **Benefits**

- Common vision
- Reposition us as leaders in Information System Technology
- Better communication and sharing of concepts, experience, lessons learned, even code
- Potential for future projects to build on current ones, expanding their functionality and/or extending them to new users.