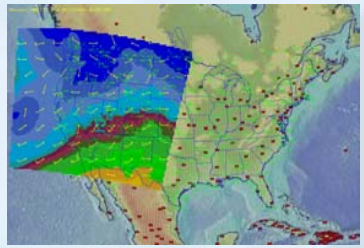
GIS Initiative: Developing an atmospheric data model for GIS






Olga Wilhelmi (ESIG), Jennifer Boehnert (RAP/ESIG) and Terri Betancourt (RAP)

Unidata seminar August 30, 2004

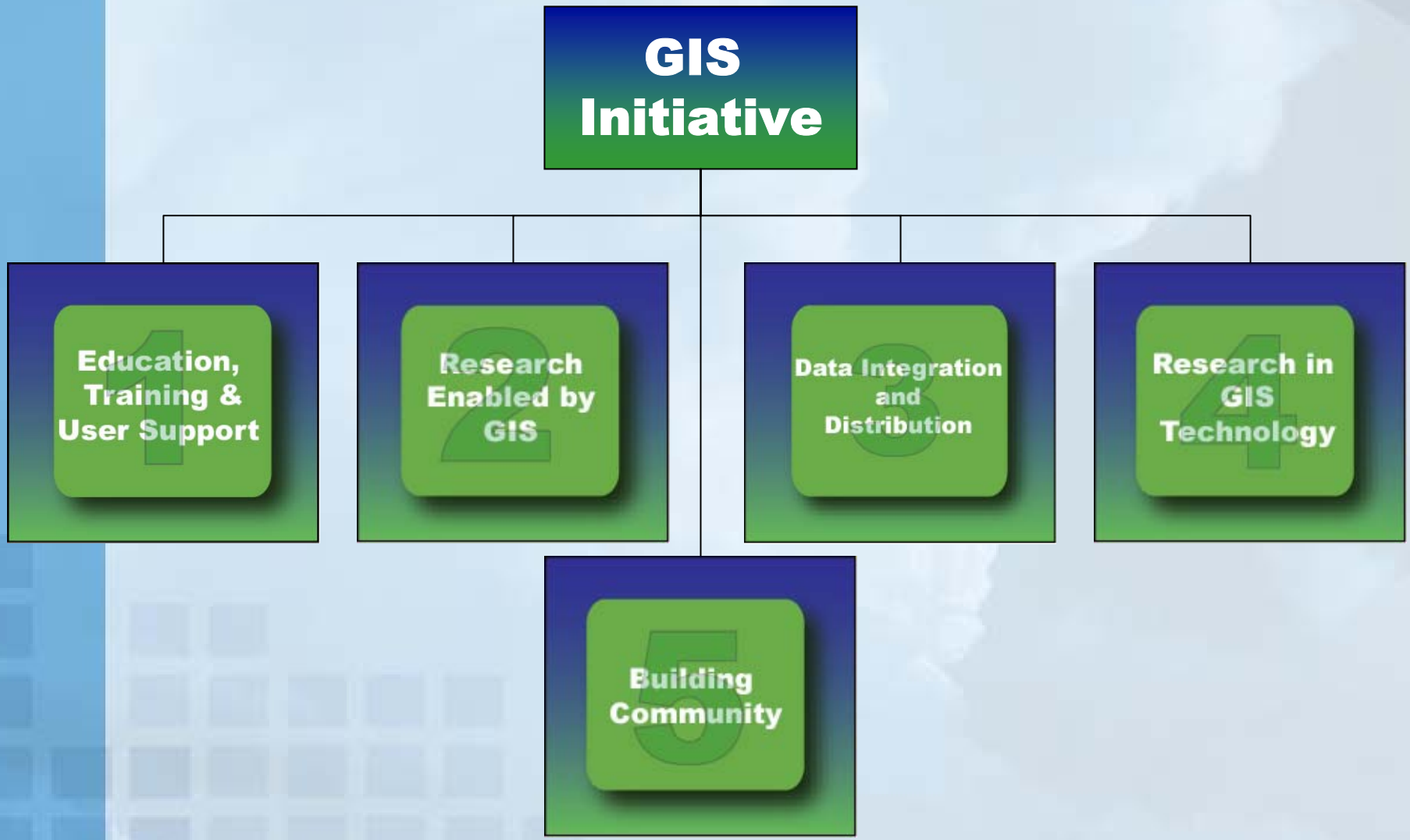
Presentation Outline

- **Overview of the GIS Initiative activities and program elements**
- **GIS Data Modeling: two approaches**
  - Framework approach
  - ESRI approach
    - Development of an atmospheric data model
- **Summary**

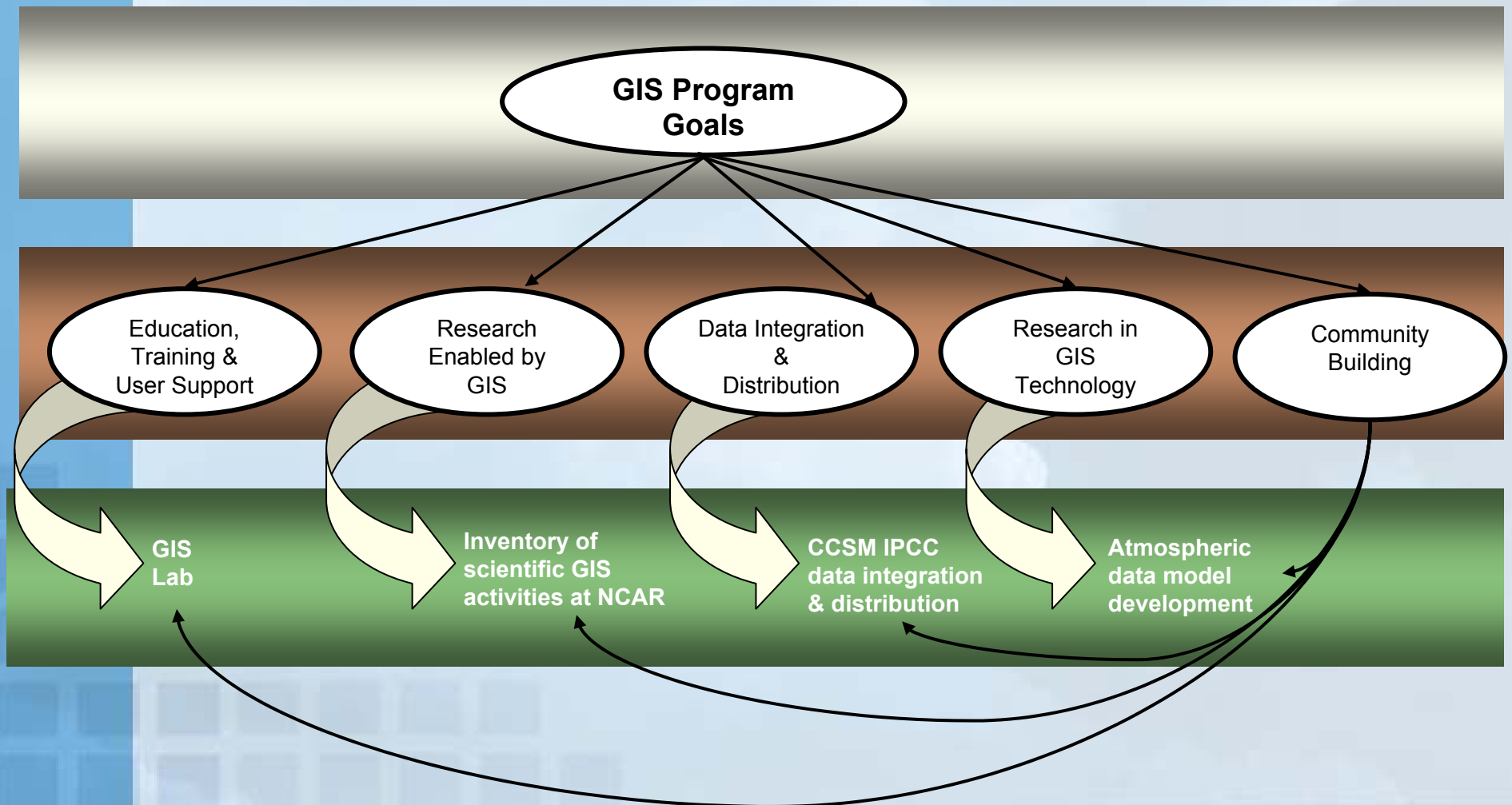
Initiative Goals

- To promote and support the use of GIS as both an analysis and an infrastructure tool in atmospheric research
- To address broader issues of data management and geoinformatics within atmospheric and related geo- and social sciences
- To integrate geospatial knowledge across disciplines

Program Elements



This Year Priorities




Education,
Training &
User Support

Focus on Service

- **Educational Elements**
  - Lecture series
    - Recent focus on ESRI GIS technology
    - Future lectures will include more diverse topics in GIS technology
  - Seminar series
  - Library manuals
  - ESRI Virtual Campus Courses
- **GIS Initiative web site: *http://www.gis.ucar.edu***

GIS Lab

- Distributed GIS service center has been in effect since December 2002
- July 2004 GIS lab officially opened as a resource for all UCAR employees.

GIS Lab – Hardware/Software

- 1 Windows public access terminal with ESRI GIS software
- 1 Linux machine dedicated to OpenGIS activities
- 1 Linux ArcIMS server
- GIS user manuals and GIS books
- Digitizer and light table
- UCAR-wide ESRI site license
- ERDAS Imagine 5 seat license
  - Remote Sensing Software
- Feature Analyst for ArcGIS

GIS Lab - Data

- **6 CD's of data and imagery through our site license with ESRI.**
- **All data available on a server accessible to all at UCAR**
  - Street data
  - Satellite imagery
  - World Demographic data
- **Relational Database and ArcSDE**

//GISserver.rap.ucar.edu

GIS Lab - Support

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GISsupport@ucar.edu

- **Assistance with GIS related questions and software installation queries**
  - Acquiring data
  - Transforming, projecting data
  - Writing scripts to automate processes
  - Performing spatial analysis in a GIS environment
  - Making maps
- **Central email for people outside UCAR to ask questions about the GIS initiative**

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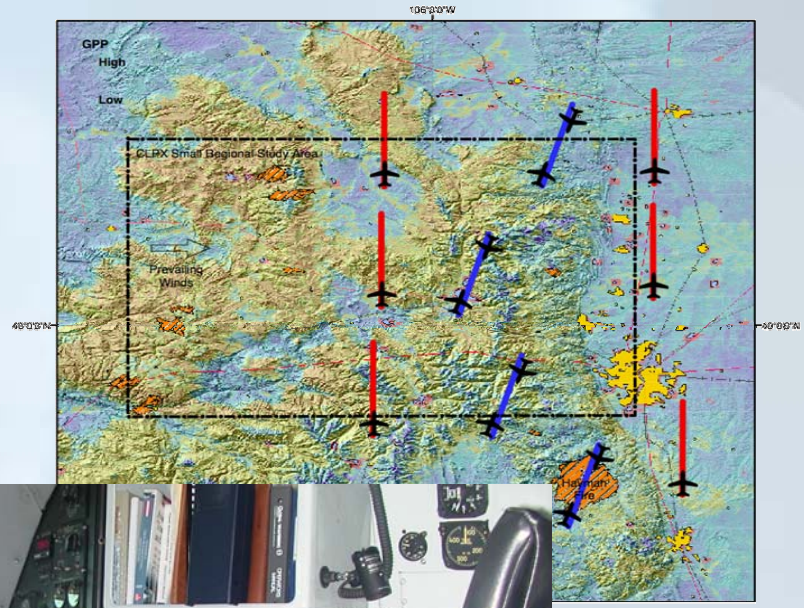
GIS Initiative Role

- **Direct collaboration with NCAR divisions, UCAR programs and other strategic initiatives**
- **Guidance and technical support**
  - From proposal to implementation
  - Ad-hoc technical help
- **Software and hardware resources**

Carbon in the Mountains Experiment



Direct link between GIS and the Biogeosciences Strategic Initiatives

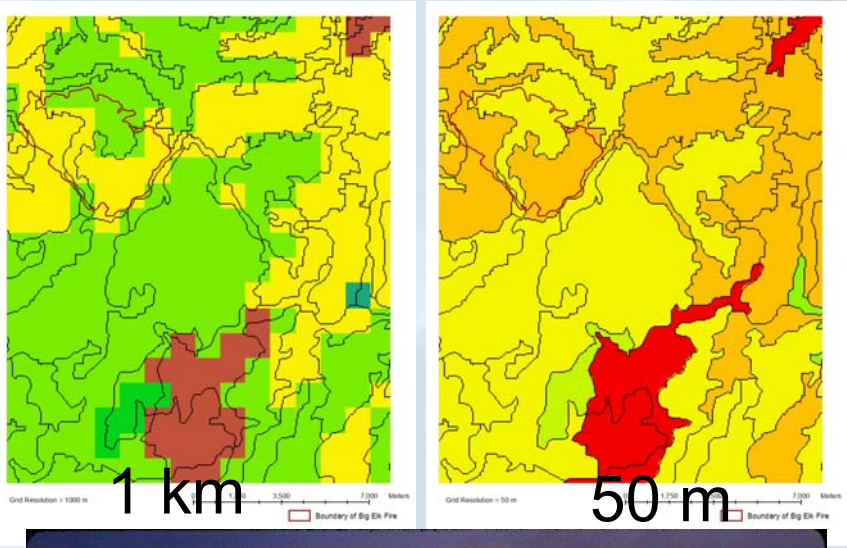
Ground-based and airborne techniques for quantifying carbon fluxes over large mountainous areas

GIS is used for planning field campaign, data integration and analysis

(Schimel, et al.)

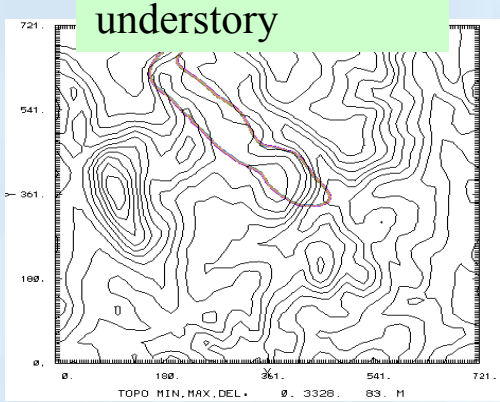
Fuel Characterization for Wildfire Modeling

- Direct link between GIS and Wildfire Strategic Initiative
- Using GIS to process vegetation data
- Assigning fuel models based on vegetation data parameters for input into fire model
- Test sensitivity of fire model to spatial resolution of input fuel data

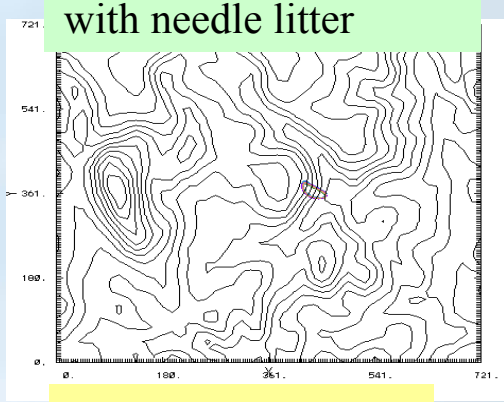


Fire Model Sensitivity

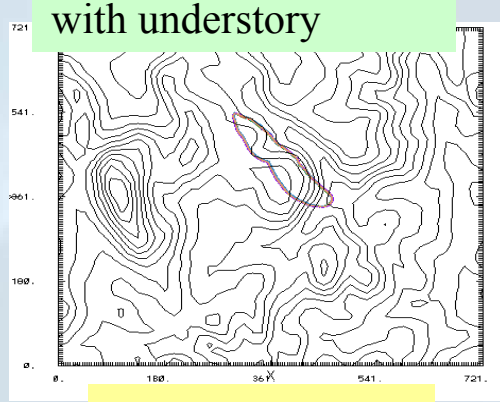
FM 2 Grass with understory



FM 8 Closed timber with needle litter



FM 10 Timber litter with understory

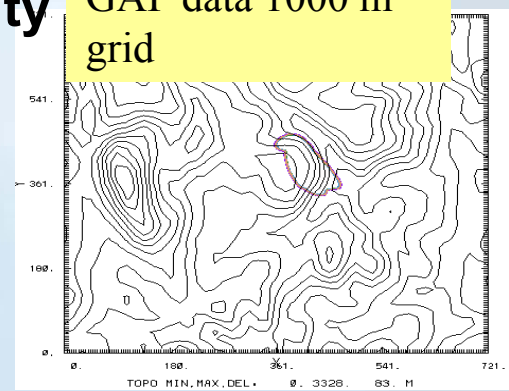


Model shows great sensitivity to classification of fuels.

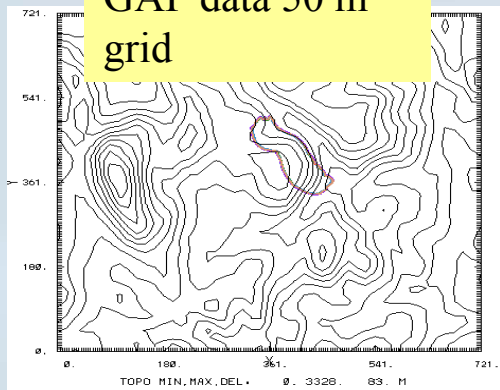
Spatial heterogeneity is important - GAP data captures much of this

Resolution of the spatially varying data (50 m vs. 1 km) affects results too

GAP data 1000 m grid



GAP data 50 m grid




3
Data Integration
and
Distribution

Data Integration:

- GIS Demonstration Project

  (NSF-funded research)

  Project Report website:

  http://www.gis.ucar.edu/FinalReport.pdf

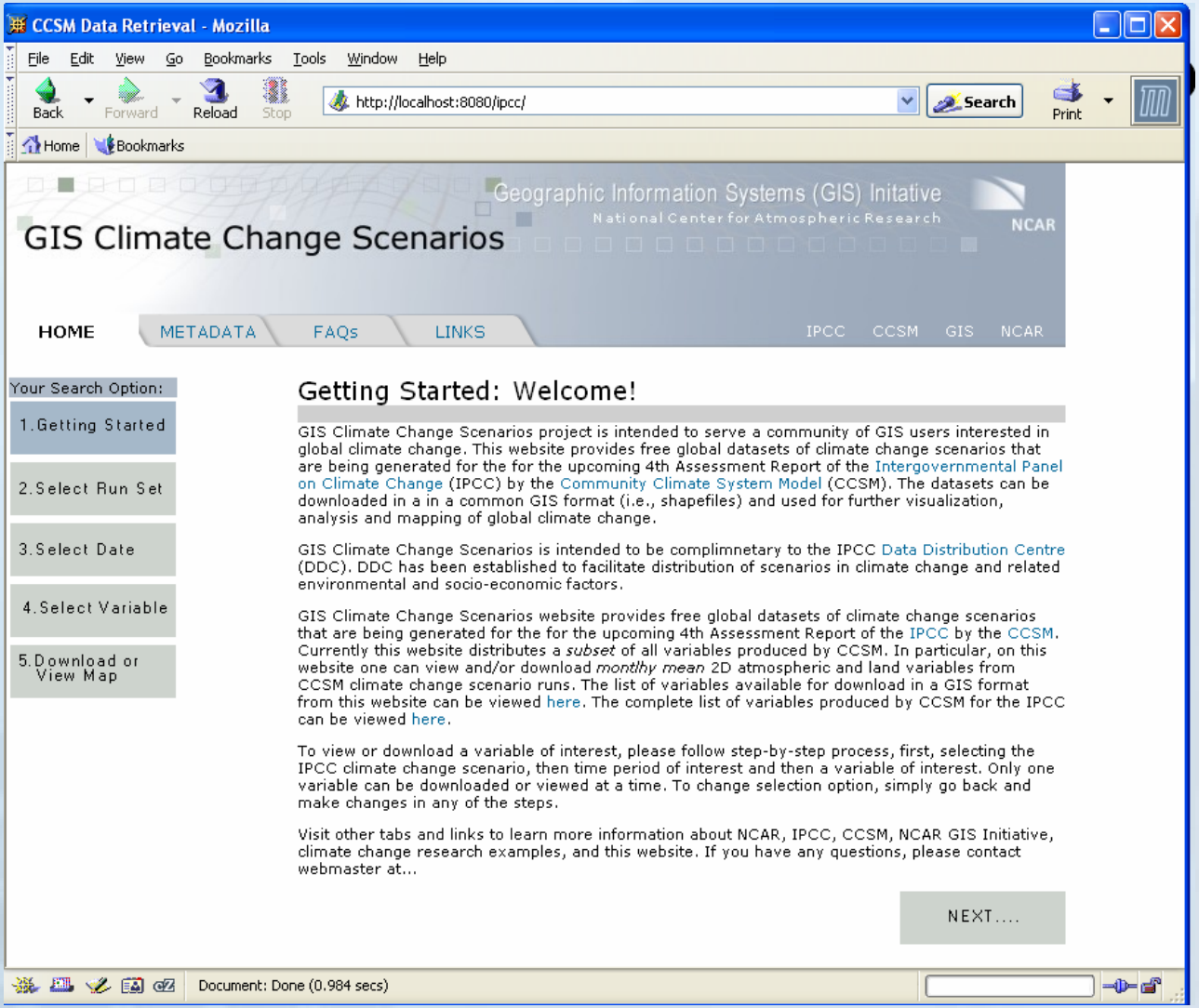
Data Distribution:

- IPCC Project

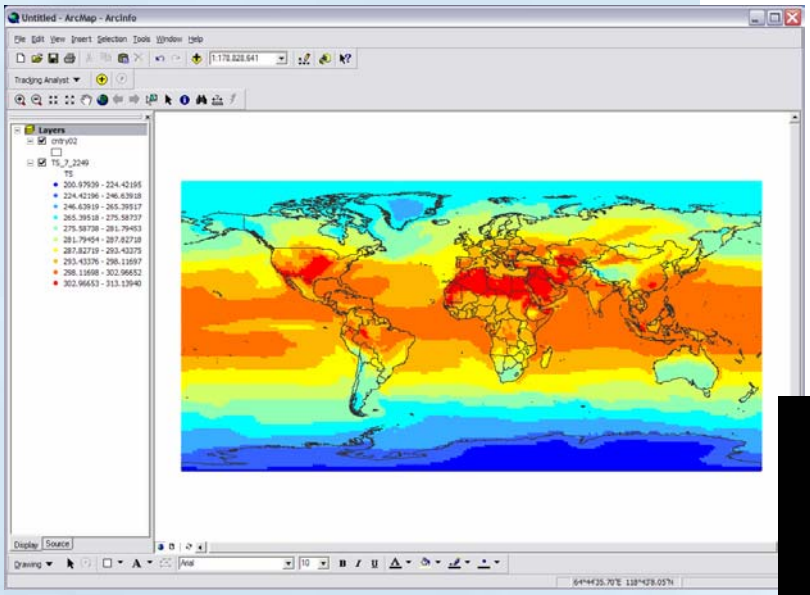
IPCC/GIS Project

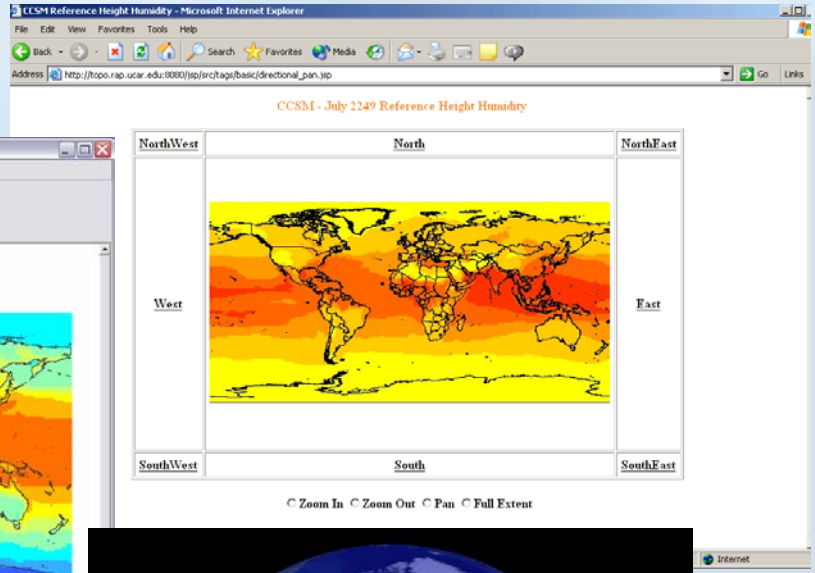
- **Intergovernmental Panel on Climate Change**
  - Fourth Assessment Report
- **Community Climate System Model (CCSM) climate change scenarios**
- **GIS Data Distribution**
  - Web-based, on-the-fly data conversion
  - NetCDF → GIS-compatible formats
  - Complement to IPCC Data Distribution Center

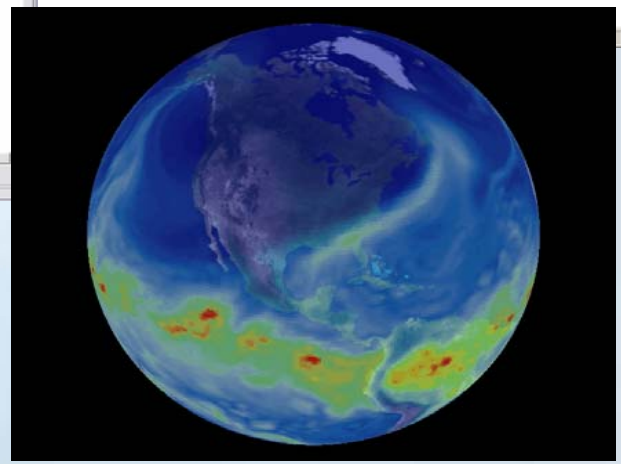
Climate Change Data Distribution



IPCC-GIS Interoperability







IPCC-GIS Timeline

- **CCSM model runs:** on-going through November 2004
- **Web site implementation:** full functionality by end of September, 2004
- **Data publication:** December 2004

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Research in Temporal GIS

- Traditionally, GIS has been 2D; atmospheric phenomena is 4D
- Development in temporal GIS research and handling temporal information in relational databases during the last decade
- Research examples show progress in representing histories or location-based change, not dynamically evolving phenomena
- Collaboration with Dr. May Yuan (University of Oklahoma) and Joe Breman (ESRI)
- Development of an atmospheric data model and proposal on temporal GIS for climate change research

NSF ITR proposal

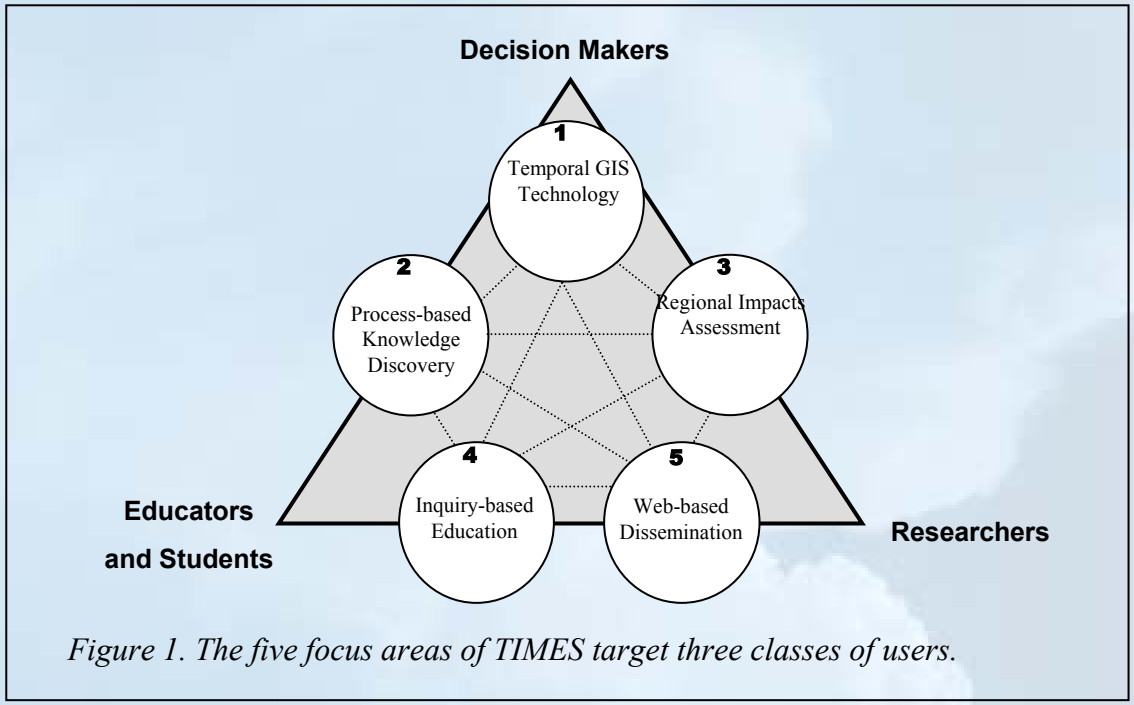


Figure 1. The five focus areas of TIMES target three classes of users.

Developing a Temporal GIS for Climate Change Research and Education


5
Building
Community

Internal Community

- **Crosswalks between NCAR divisions, UCAR programs and strategic initiatives**
- **Support**
- **Joint Research and Development**
- **Data distribution**
  - Community Data Portal
  - GIS Data Server

External Community

- **Universities**
  - Joint proposals
  - Workshops
  - Students
- **Government agencies and research centers**
  - Data modeling activities
  - Joint publications
- **Industry**
  - Partnerships with ESRI, OGC
- **International Initiatives**
  - COST-719

Data Modeling

- Introduction
- Framework approach
- ESRI data modeling approach

Data modeling

- Helps organize thinking about data and its practical application
- First step to database design
- Specifies relational schema (i.e. table definitions, required for RDBMS implementation)
- Facilitates communication, understanding, and data interoperability in non-relational environments as well
- Iterative process: conceptual design → physical design → database implementation

Framework Approach

- **Lead by Federal Geographic Data Committee - FGDC**
- **Collaborative effort to create a widely available source of basic geographic data**
- **Most common data themes that geographic users need**
- **Key aspect**
  - Seven themes of digital data
  - Procedures and guidelines that provide for integration and sharing
  - Institutional relationships and business practices that encourage the maintenance and use of data
- **Data you can trust – data for an area, described according to common standards**

http://www.fgdc.gov/framework/overview.html

http://www.fgdc.gov/framework/framdev.html

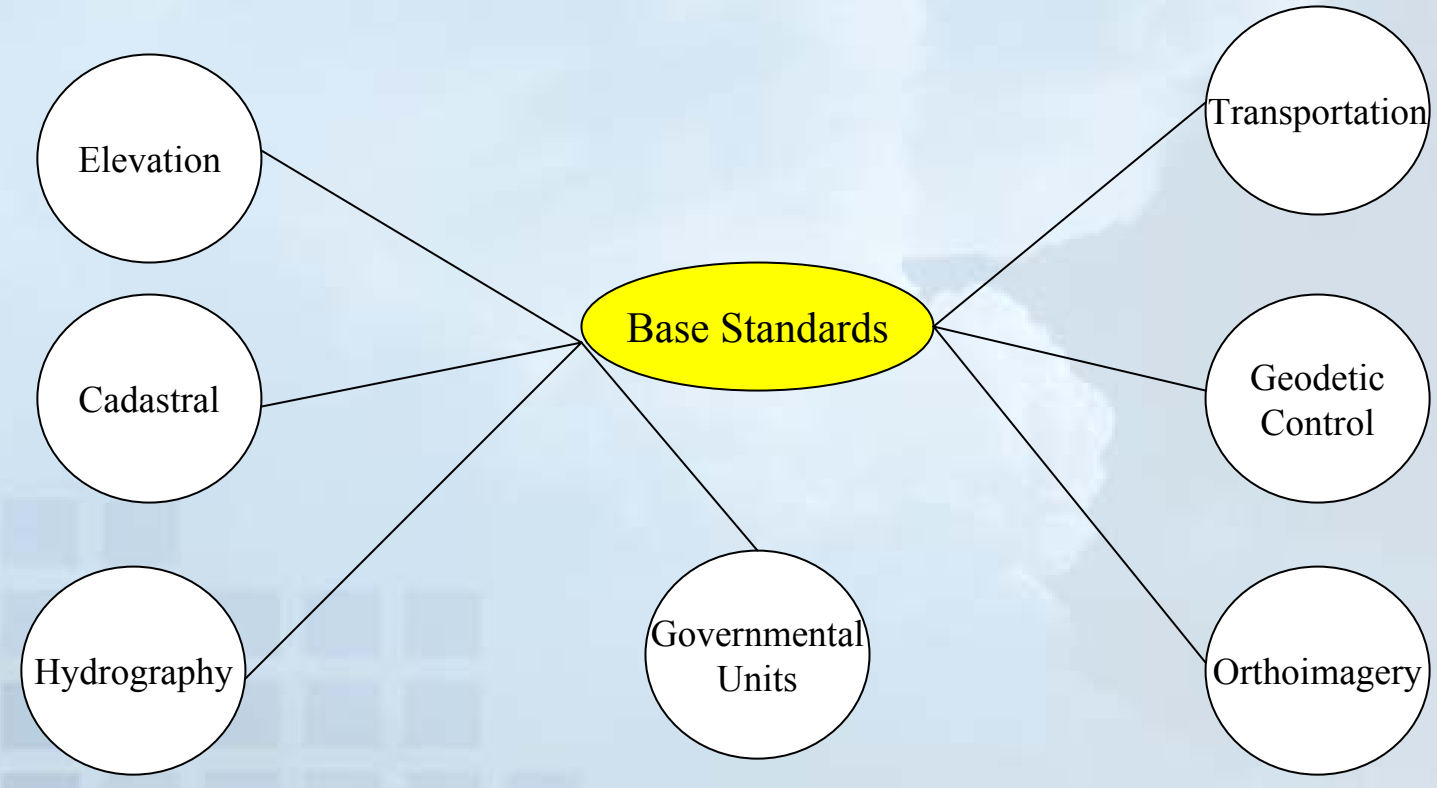
Framework – Data Standards

- **Support consistent data collection and exchange**
- **Meeting common goal**
  - National Spatial Data Infrastructure (NSDI) objectives – common geographic data sets
  - ANSI/INCITS-L1 project – update Spatial Data Transfer Standard (SDTS)
- **Specifies a minimum level of data content that data producers and consumers are expected to use for interchange**
- **Each framework includes an informative annex that describes implementation using the GML version 3.0**

http://www.fgdc.gov/framework/framework.html

Seven Framework

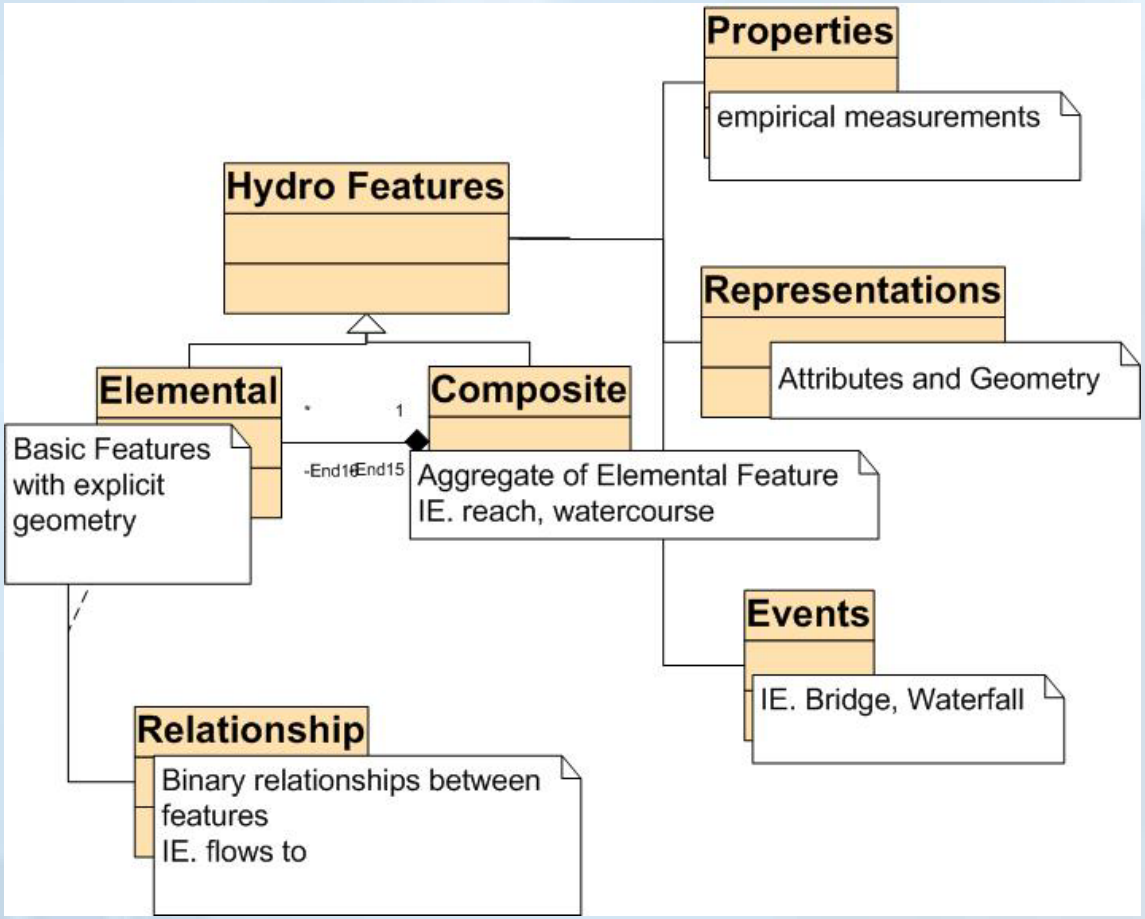
- **Develop a common geographic base data for 7 data themes – FRAMEWORKS**



Example: Hydrography Framework

- **Support the exchange of surface water information**
- **Common baseline for semantic content of hydrographic datasets**
- **Contributing agencies –**
  - National Hydrography Dataset (NHD)
  - Pacific Northwest Framework (PHW)
  - ArcHydro data model
  - Geographic Names Information System (GNIS)

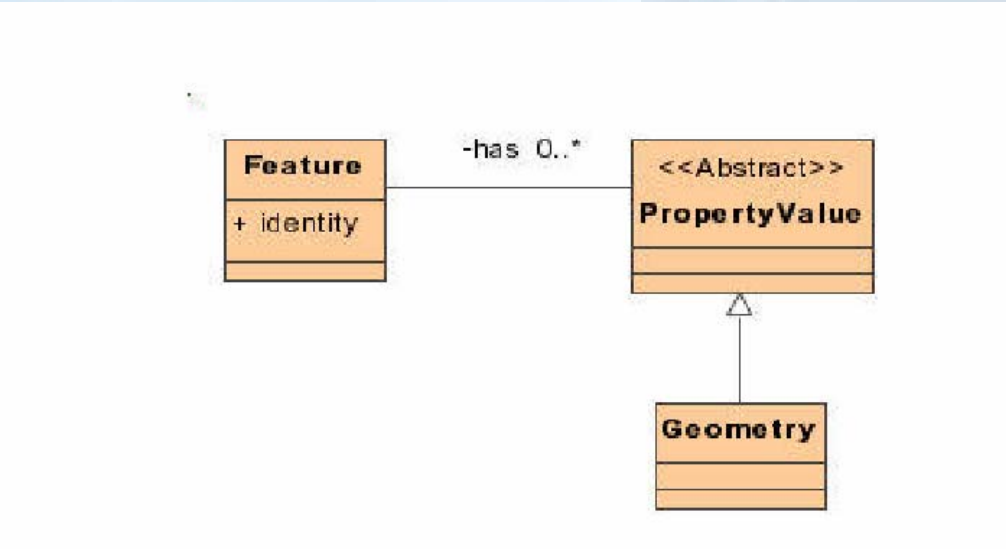
Hydrography Information Model



- http://www.geo-one-stop.gov/Standards/Hydrography

OGC Feature Model

- An instance of a phenomenon that has attributes and, geometry
- Feature Model is a simple yet extensible object
- All features in the Hydrography Framework exist through associations to Features



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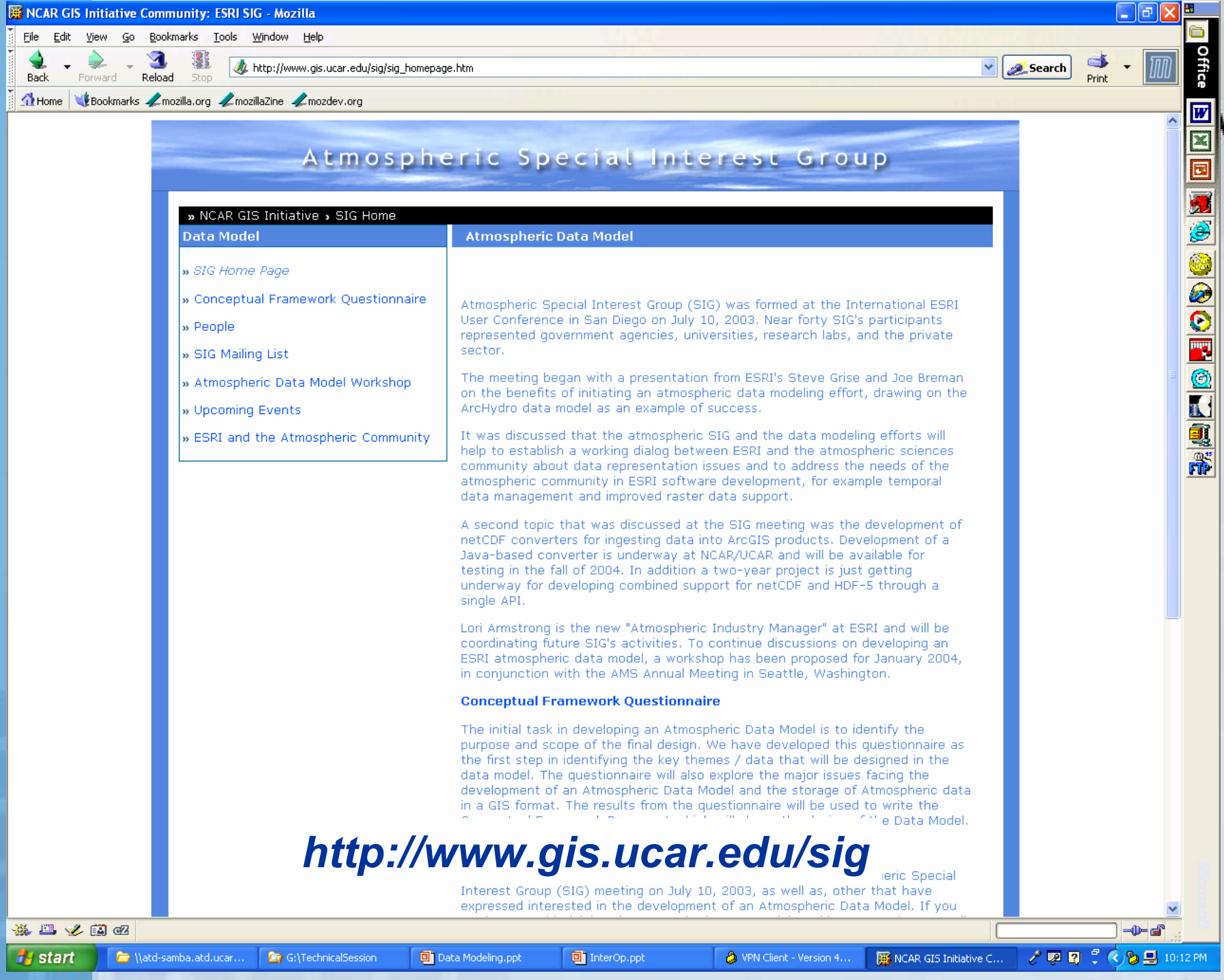
ESRI Data Modeling Approach

- Development of community data models for industries and scientific disciplines
- Build simple, multi-purpose models
- Support and encourage standards


NCAR GIS Initiative Community: ESRI SIG - Mozilla
File Edit View Go Bookmarks Tools Window Help
Back Forward Reload Stop
http://www.gis.ucar.edu/sig/sig_homepage.htm
Search
Print
Home Bookmarks mozilla.org mozillaZine mozdev.org
Atmospheric Special Interest Group
» NCAR GIS Initiative › SIG Home
Data Model
» SIG Home Page
» Conceptual Framework Questionnaire
» People
» SIG Mailing List
» Atmospheric Data Model Workshop
» Upcoming Events
» ESRI and the Atmospheric Community
Atmospheric Data Model
Atmospheric Special Interest Group (SIG) was formed at the International ESRI User Conference in San Diego on July 10, 2003. Near forty SIG's participants represented government agencies, universities, research labs, and the private sector.
The meeting began with a presentation from ESRI's Steve Grise and Joe Breman on the benefits of initiating an atmospheric data modeling effort, drawing on the ArcHydro data model as an example of success.
It was discussed that the atmospheric SIG and the data modeling efforts will help to establish a working dialog between ESRI and the atmospheric sciences community about data representation issues and to address the needs of the atmospheric community in ESRI software development, for example temporal data management and improved raster data support.
A second topic that was discussed at the SIG meeting was the development of netCDF converters for ingesting data into ArcGIS products. Development of a Java-based converter is underway at NCAR/UCAR and will be available for testing in the fall of 2004. In addition a two-year project is just getting underway for developing combined support for netCDF and HDF-5 through a single API.
Lori Armstrong is the new "Atmospheric Industry Manager" at ESRI and will be coordinating future SIG's activities. To continue discussions on developing an ESRI atmospheric data model, a workshop has been proposed for January 2004, in conjunction with the AMS Annual Meeting in Seattle, Washington.
Conceptual Framework Questionnaire
The initial task in developing an Atmospheric Data Model is to identify the purpose and scope of the final design. We have developed this questionnaire as the first step in identifying the key themes / data that will be designed in the data model. The questionnaire will also explore the major issues facing the development of an Atmospheric Data Model and the storage of Atmospheric data in a GIS format. The results from the questionnaire will be used to write the
http://www.gis.ucar.edu/sig
eric Special
Interest Group (SIG) meeting on July 10, 2003, as well as, other that have expressed interested in the development of an Atmospheric Data Model. If you
start
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G:\TechnicalSession
Data Modeling.ppt
InterOp.ppt
VPN Client - Version 4...
NCAR GIS Initiative C...
10:12 PM

Ten steps to designing geodatabases

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conceptual design

1. *Identify the information products that will be produced with your GIS.*
   Inventory map products, analytical models, database reports, Web access, data flows, and enterprise requirements.
2. *Identify the key thematic layers based on your information requirements.*
   Specify the map use, data source, spatial representation, map scale and accuracy, and symbology and annotation.
3. *Specify the scale ranges and spatial representations for each thematic layer.*
   GIS data is compiled for specific scale use; feature representation often changes between points, lines, and polygons at larger scales. Rasters are sampled to include multiresolution pyramids.
4. *Group representations into datasets.*
   Discrete features are modeled with feature datasets, feature classes, relationship classes, rules, and domains. Continuous data is modeled with raster datasets. Measurement data is modeled with survey datasets. Surface data is modeled with raster and feature datasets.

logical design

5. *Define the tabular database structure and behavior for descriptive attributes.*
   Identify attribute fields, specify valid values and ranges, apply subtypes to control behavior, and model relationships.
6. *Define the spatial properties of your datasets.*
   Use networks for connected systems of features and topologies to enforce spatial integrity and shared geometry. Set the spatial reference for the dataset.
7. *Propose a geodatabase design.*
   Make informed decisions on applying structural elements of the geodatabase and prepare a design. Study existing designs for examples.

physical design

8. *Implement, prototype, review, and refine your design.*
   From the initial design, build a geodatabase and load data. Test and refine your designs.
9. *Design work flows for building and maintaining each layer.*
   Each layer has distinct data sources, accuracy, currency, metadata, and access. Define work flows to conform to your agency's business practices.
10. *Document your design using appropriate methods.*
    Use drawings, layer diagrams, schema diagrams, and reports to communicate your data model.

Representing Atmospheric Data in a GIS Data Model

- Representing 4D data in a 2D environment
- Types of data suitable for the data model
- Data representation
  - Points
  - Lines
  - Polygons
  - Rasters

Atmospheric Data Modeling Workshop

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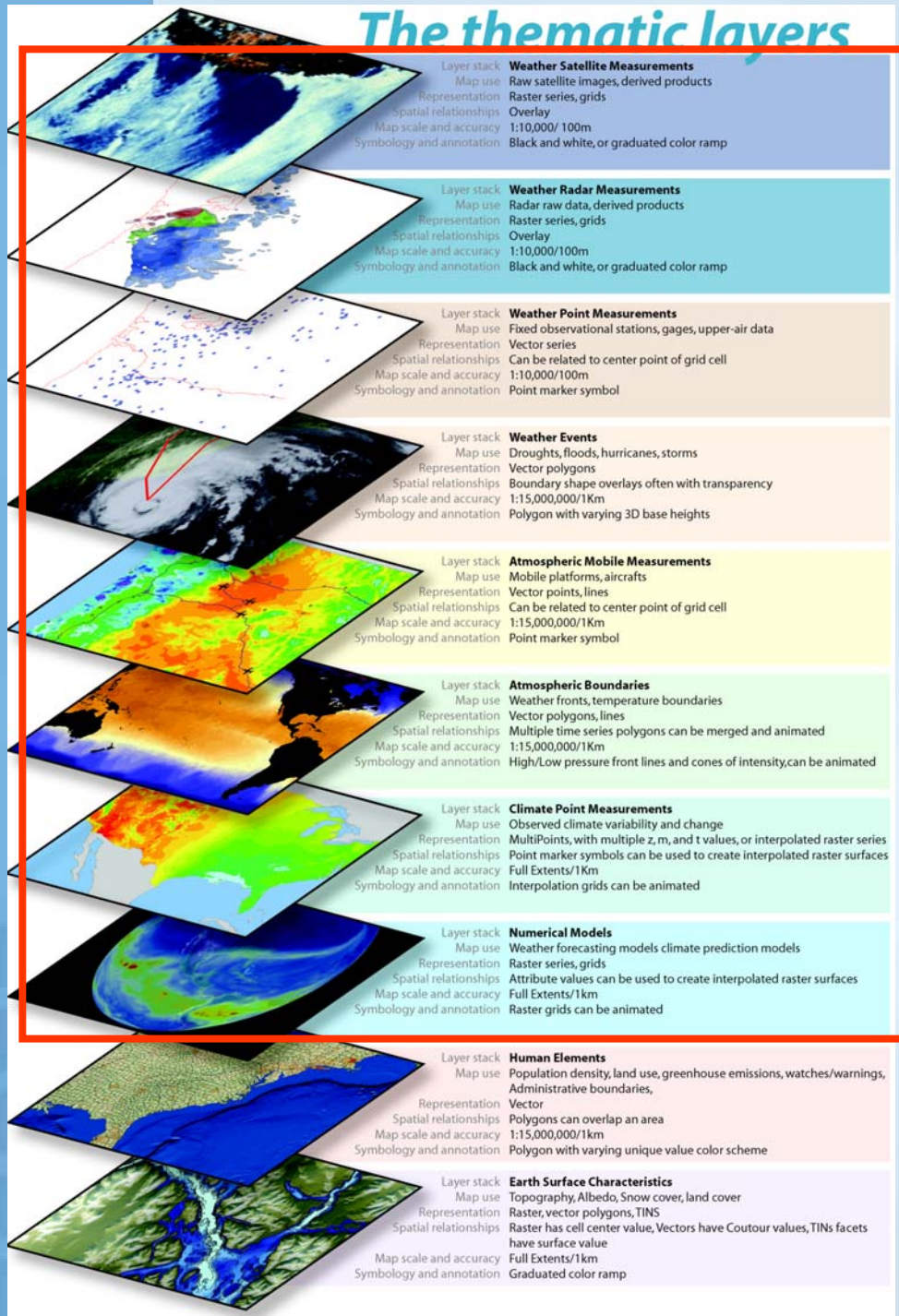
- January 16-17, 2004 in Seattle, WA
- Initial focus was on conceptual design of the atmospheric data model

Uses and Scope of Atmospheric Data Model

- **Structure around which to build GIS functions for atmospheric applications**
- **Interface to other ArcGIS community models**
  - Hydrology
  - Marine
- **Focus on the *atmosphere* and provide links to other data models**



The Thematic Layers (draft)

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Weather *Satellite* Measurements
Weather *Radar* Measurements
Weather *Point* Measurements
Weather Events
Atmospheric Mobile Measurements
Atmospheric Boundaries
Climate Point Measurements
Numerical Models
Human Elements
Earth Surface Characteristics

Challenges in Data Model Design

- Data interoperability
- Temporal dimension
- Vertical dimension
- Semantics
- Bridging the gap between discrete objects and functions
- Geoprocessing capabilities

Next Steps

- Conceptual framework design document
- Second Data Modeling Workshop – January 2005 in San Diego
- Collaborations: community data model
- Ongoing work on bringing NetCDF format into ArcGIS environment
- Ongoing work in improved temporal and raster support

Existing ArcGIS Support for Time

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- **Preliminary work has been done over the last few years as part of the Water Resources Data model and other data model projects.**
- **Tracking Analyst extension – provides support for temporal visualization of vector data.**
  - Aimed at visualizing the movement or change of features or phenomena through time, e.g. airplanes, census data, etc.

ESRI Ongoing Work with Temporal Support

- **Provide a framework and tools for building direct bridges to temporal data.**
- **Temporal Analysis**
  - Space/Time clustering
  - Space/Time interpolation and query
  - Trend analysis
  - Time integrated Temporal Modeling
- **Simulation Modeling**
  - Conditional simulation, Monte Carlo

ESRI Current Research on Data Formats

- **NetCDF as a native format**
  - Direct read as raster, point, table, or graph
  - Display like any other ArcGIS data source
  - Use directly in analysis
  - No conversion or intermediate file

    - *What profiles/flavors are most important?*
    - *CF standards, others?*
    - *How to handle projection/datum?*
  - E-mail Steve Kopp: skopp@esri.com

Summary

- **Five program elements of the GIS Initiative include:**
  - Education, Training, User Support
  - Research enabled by GIS
  - Data integration and distribution
  - Research in GIS technology
  - Community building
- **Data modeling**
- **GIS website: *http://www.gis.ucar.edu***
- **Questions: *GISsupport@ucar.edu***

Data Download Websites

- http://www.geographynetwork.com
- http://data.geocomm.com
- http://www.geo-one-stop.gov
- http://seamless.usgs.gov – imagery and Shuttle Radar Topography mission data