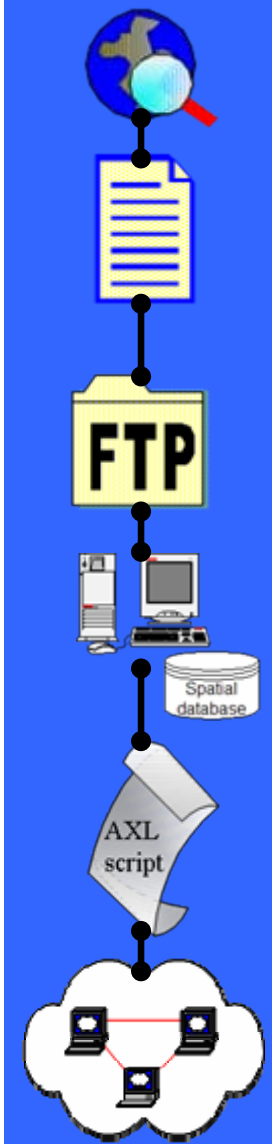


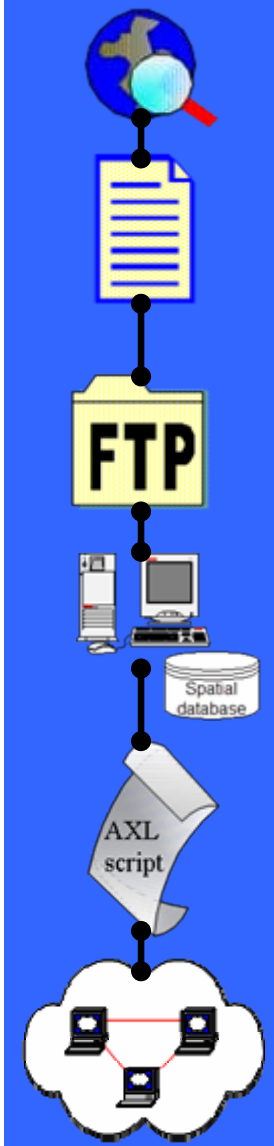
Bringing NOAA's Weather Data to your Desktop: Penn State's Internet Map Services

• **Bernd J. Haupt**, *Earth & Environmental Systems Institute*

In collaboration with

• Maurie Caitlin Kelly, *PS Institutes of Energy & the Environment*
• Ryan E. Baxter, *PS Institutes of Energy & the Environment*
• James F. Spayd, *PS Institutes of Energy & the Environment*
• Jack Settelmaier, *NOAA/NWS*
• Ken Waters, *NOAA/NWS*

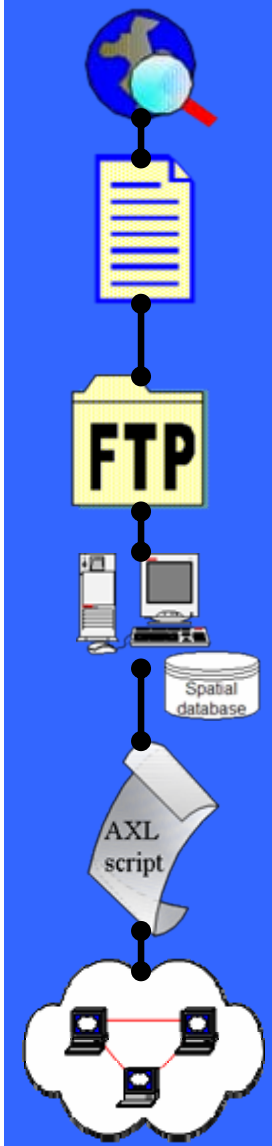
ESSC – Meteo 597E seminar, October 24, 2007



Introduction

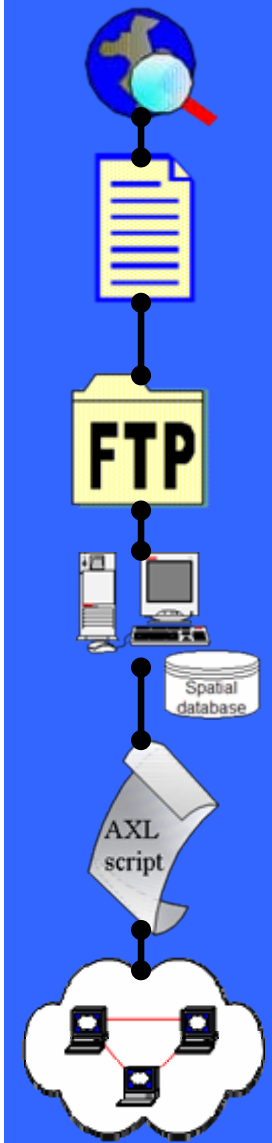
I will talk about …

- who we are,
- why we need it #1 (*background information*)
- the element in-between,
- why we need it #2 (*framework for pilot project*),
- what NOAA/NWS says,
- *6 process steps* (an example showing how our service works and how it is accessible),
- conclusions,
- what other data can be fed into our system,
- what is coming in the near future



… who we are …

- PSIEE & EESI faculty collaborate on several GIS related projects.
- Project team works with Federal agencies such as the US Geological Survey (USGS); state agencies such as the PA Office of Information Technology, and non profit organizations such as the American Fisheries Society.
- Currently, project team members manage spatial databases that house approximately 8 terabytes of data and imagery.
- Project team members manage the *Pennsylvania Geospatial Data Clearinghouse, PASDA*, http://www.pasda.psu.edu, the geospatial component of the *Mid-Atlantic Information Node, MAIN* of the *National Biological Information Infrastructure, NBII*, http://main.nbii.org, *Fisheries and Aquatic Resources (FAR) Node* of the *NBII*, and *NoiseQuest*, a noise modeling and mitigation site for the *Federal Aviation Administration*.
- Initial funding was provided from the *Penn State University GIS Council* to develop proof of concept for climate and weather data.



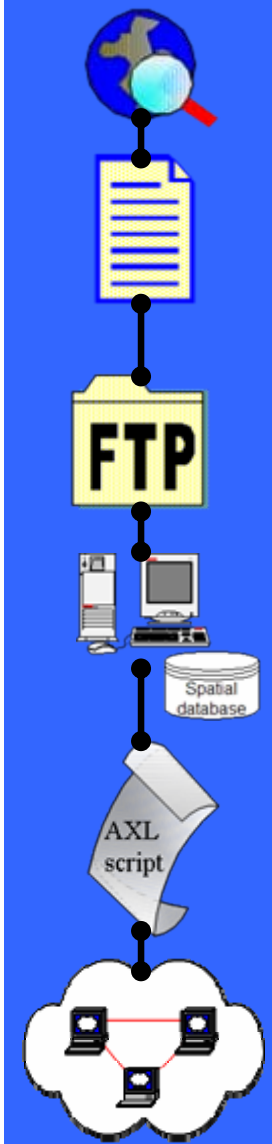
… why we need #1 (*background information*) …

Looking at the list of extreme situations that are influenced by extreme weather events and conclusions of the Intergovernmental Panel on Climate Change (IPCC; 4th IPCC report) saying that:

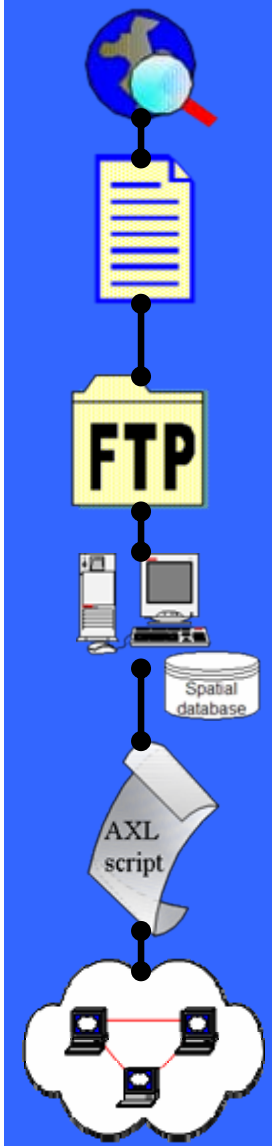
- "Global climate change is very likely to have been human-induced"
- "It is very likely that human activities are causing global warming"
- "Probable temperature rise by the end of the century will be between 1.8 and 4°C (3.2-7.2°F)"
- "Sea levels are likely to rise by 28-43 cm"
- "It is very likely that parts of the world will see an increase in the number of heat waves"
- "Climate change is likely to lead to increased intensity of tropical storms"

The IPCC is very confident about their conclusions as the IPCC report definitions of probability of occurrence are defined as follows: 'very likely' – more than 90 percent and 'likely – more than 60%.

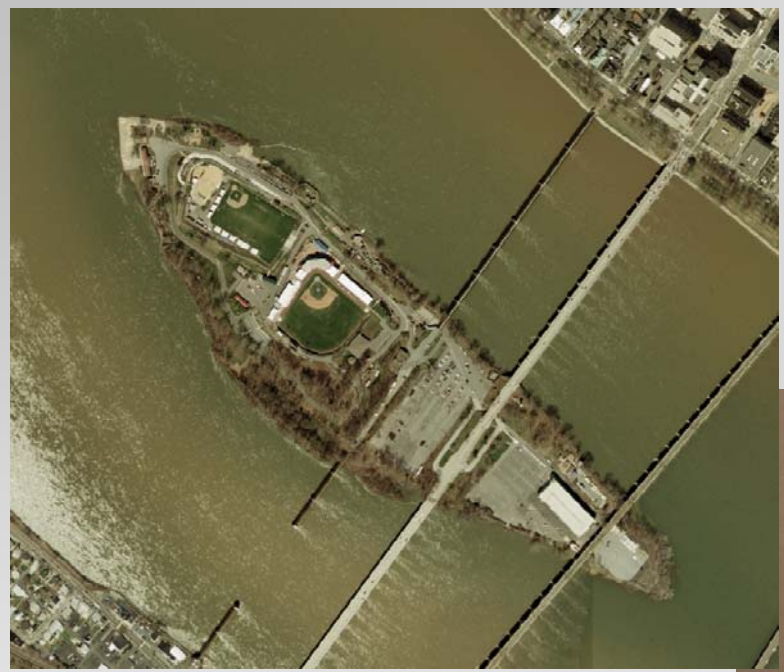
It seems only natural that extreme weather events of all kinds will strongly influence our future way of life, positively as well as negatively.



… why we need it #1 (*background information*) …

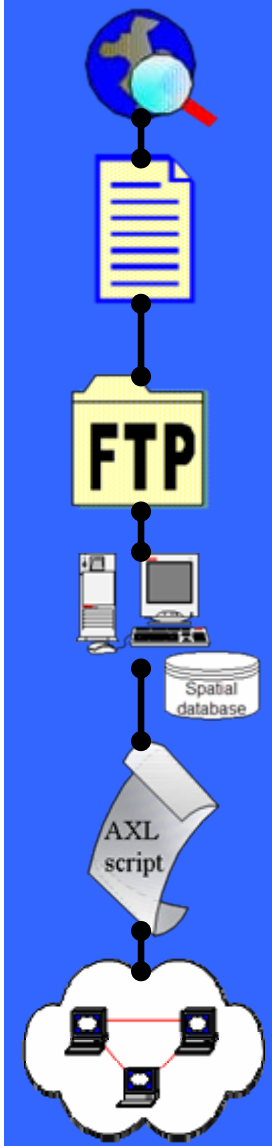


… why we need it #1 (*background information*) …



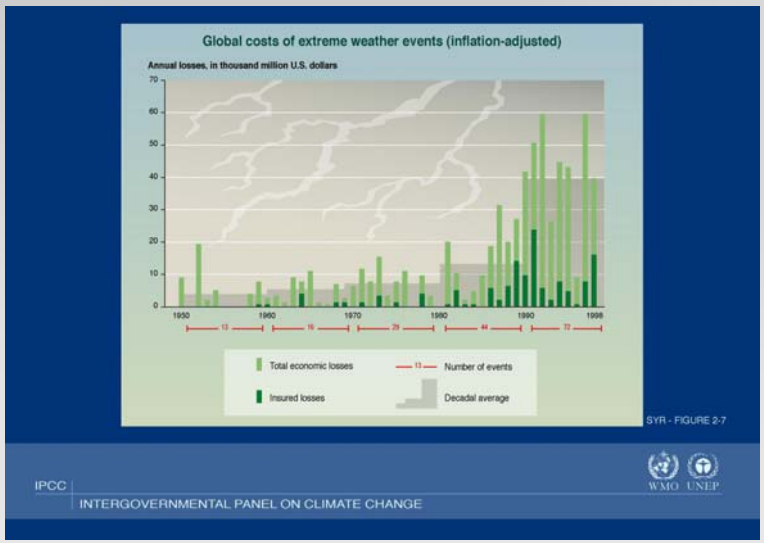
The aerial photographs show City Island, a park located within the Susquehanna River near Harrisburg, Pennsylvania. Both images were captured from a traditional WEB GIS application.

The upper left image was captured in 2003, and the other one was captured in September, 2004 during the flood caused by Tropical Depression Ivan.



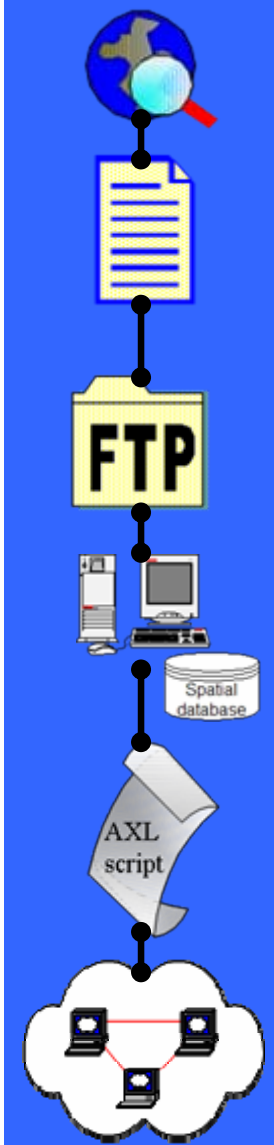
… why we need #1 (*background information*) …

- The list of natural and man-made disasters can be continued indefinitely.
- There is a whole variety of disasters that range from environmental threats and problems to health issues to local, national and international crises.
- It is important to note that disasters strike our society with increasing frequency.



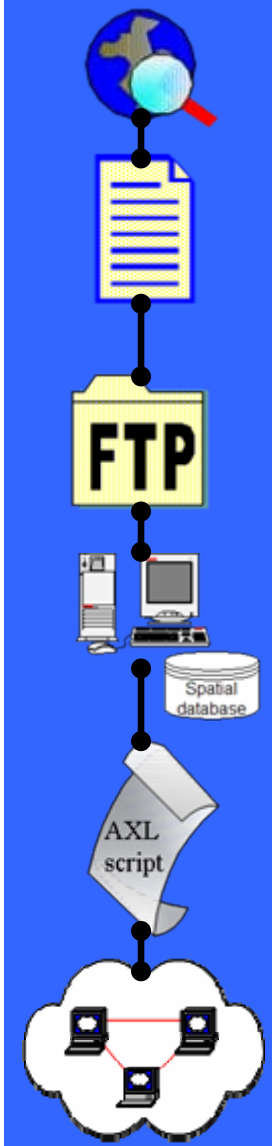
IPCC: Global cost of extreme weather events from 1950-1998.

- **All disasters and crises have one common element: They need to be managed and mastered; in other words, they require *Emergency Management Planning (EMP)*.**



… the element in-between …

Weather

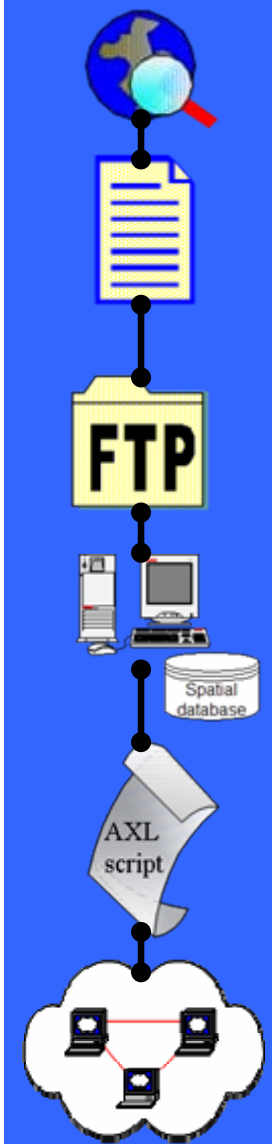


… why we need it #2 (*framework for pilot project*) …

The NDFD (National Digital Forecast Database) Pilot project was developed by PSIEE and EESI faculty for the following reasons:

- Most users are unfamiliar with the NDFD, NDGD (GMOS), MOS, RTMA data or the types of data formats (e.g., NetCDF, Grib2) that climate and weather data come in.
- Most users do not have the processing capabilities or knowledge to acquire and convert and store this data for their own use.
- *We have developed a way for users to incorporate this data into their desktop GIS with a click of a button. This eliminates the need for them to process this data themselves.*
- Emergency managers and response support agencies need this vital information to cope with potential emergency situations. *They are heavy GIS users* but are often unfamiliar with technical details.

- NDGD = Natl. Digital Guidance Database
- MOS = Model Output Statistics
- GMOS = Gridded Model Output Statistics
- NetCDF = Network Common Data Format
- Grib2 = 2nd vers. of gridded WMO data output
- RTMA = Real Time Mesoscale Analysis



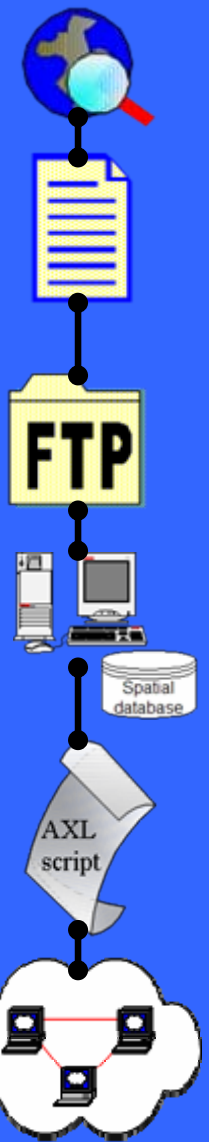
… what NOAA/NWS says …

What Can't the NWS do with GIS?

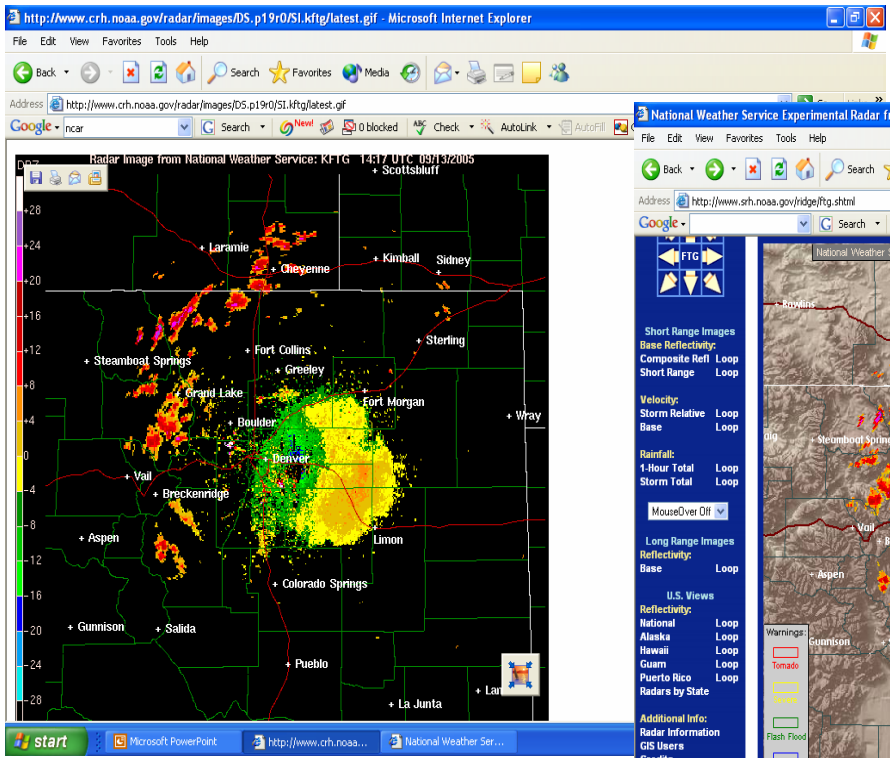
SERVE IT!

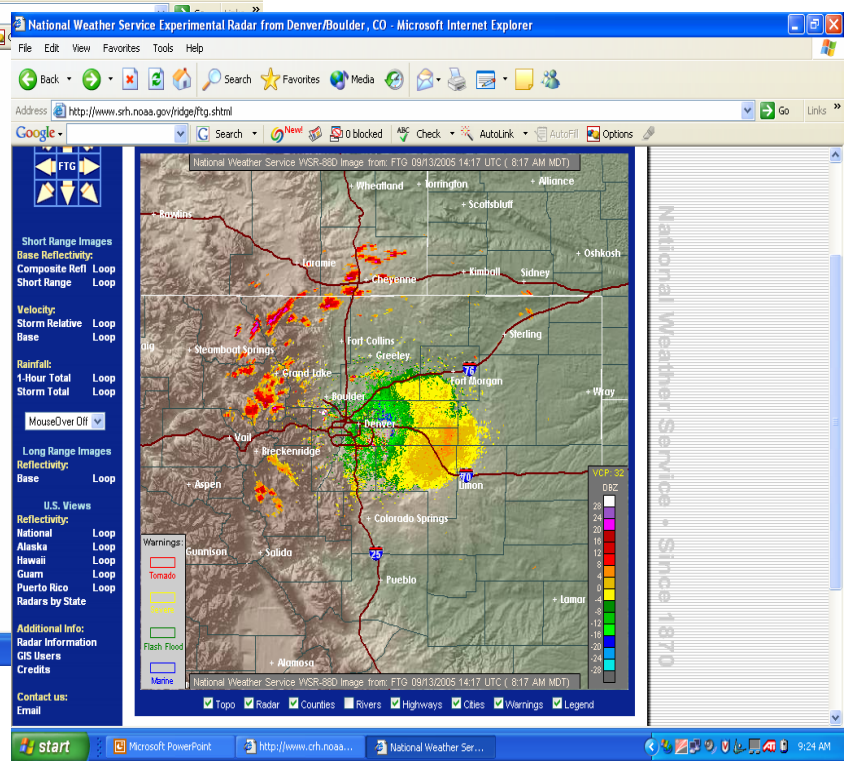
What can PSU (and others?) do with weather data in GIS?

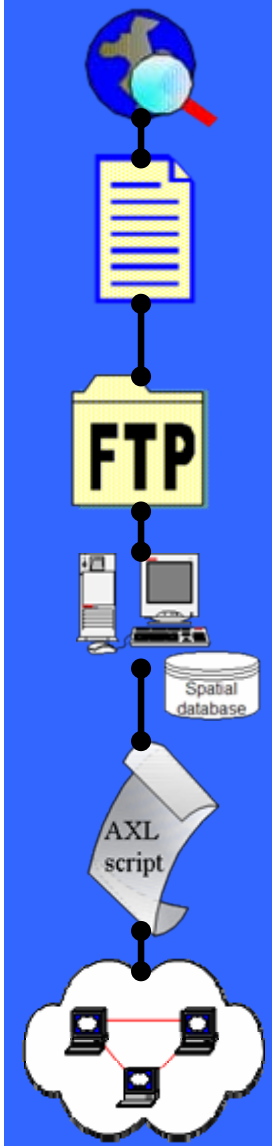
Segue to PSU portion on Serving NDFD via IMS



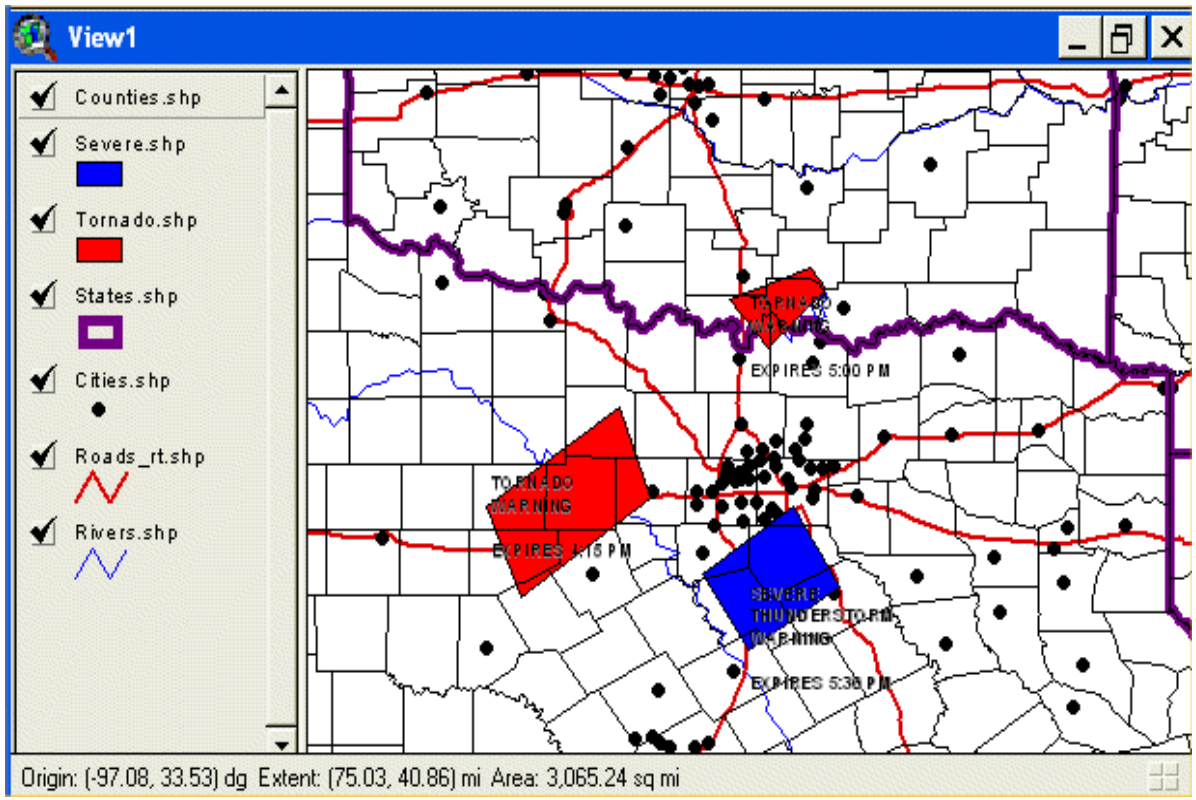
- Old and new radar imagery from the NWS offered in a viewer

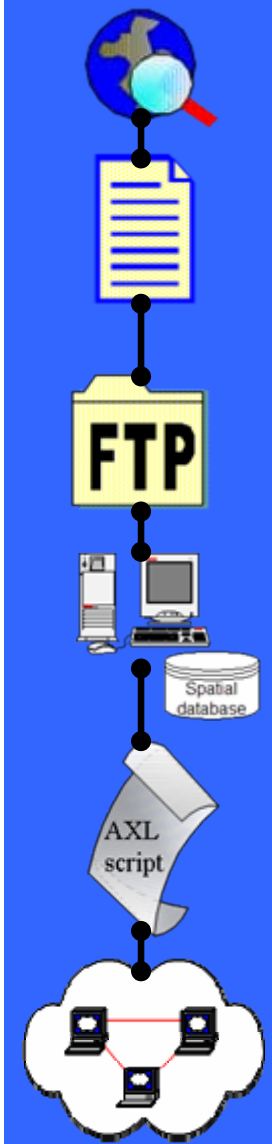






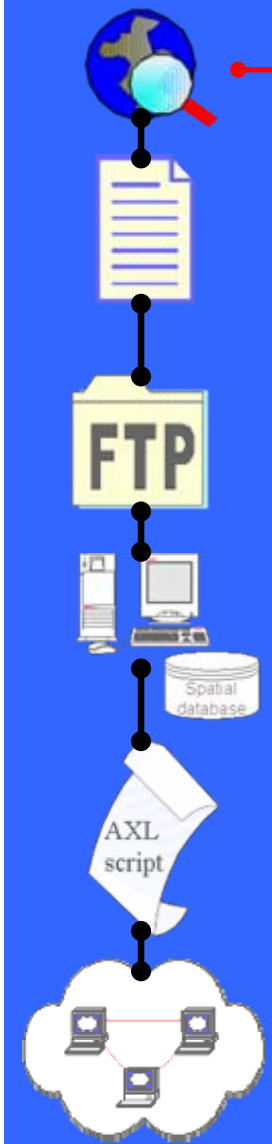
- Regional live IMS offered from the NWS for severe weather season 2004 (geared towards emergency managers)





Process Steps… (6 in total) Overview

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
- QA/QC data for completeness; convert to GIS format; create metadata; load into ArcSDE (spatial data engine).
- Create ArcIMS Image and Feature Services which are updated when data is updated in database (new AXL files with new datasets).
- Users can bring Image and Feature services directly into their desktop GIS software.



Process Steps… (step 1)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
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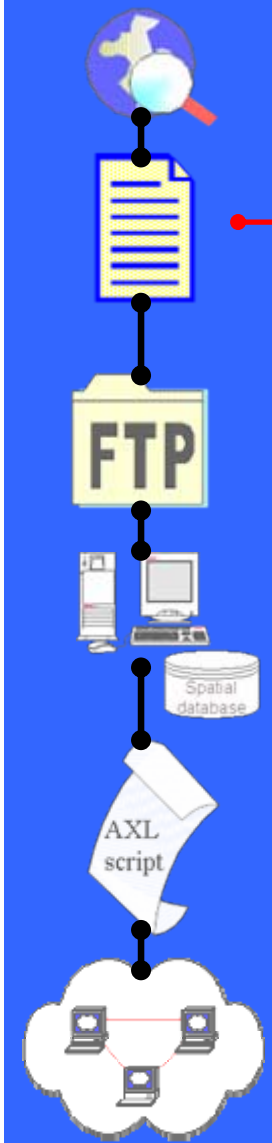

Process Steps… (step 2)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
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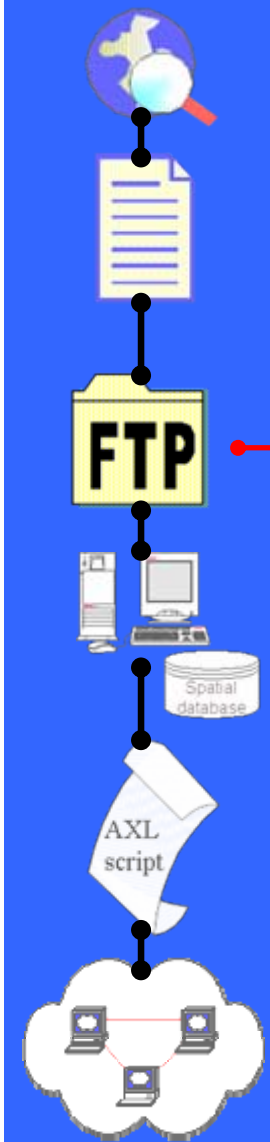

Process Steps… (step 3)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
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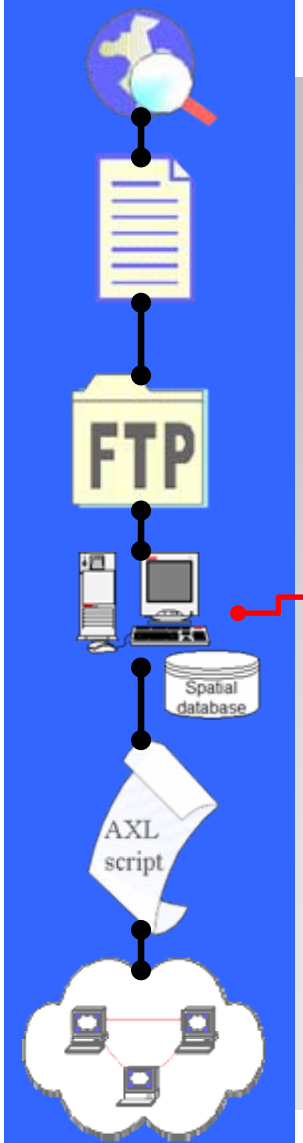

Process Steps… (step 4)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
- QA/QC data for completeness; convert to GIS format; create metadata; load into ArcSDE (spatial data engine).
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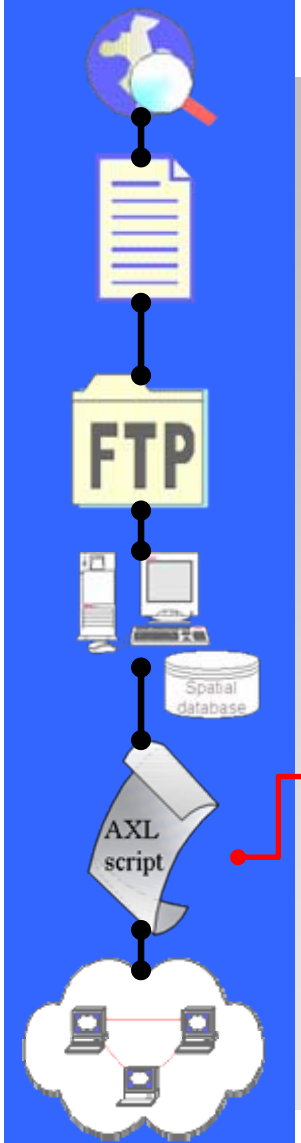

Process Steps… (step 5)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
- QA/QC data for completeness; convert to GIS format; create metadata; load into ArcSDE (spatial data engine).
- Create ArcIMS Image and Feature Services which are updated when data is updated in database (new AXL files with new datasets).
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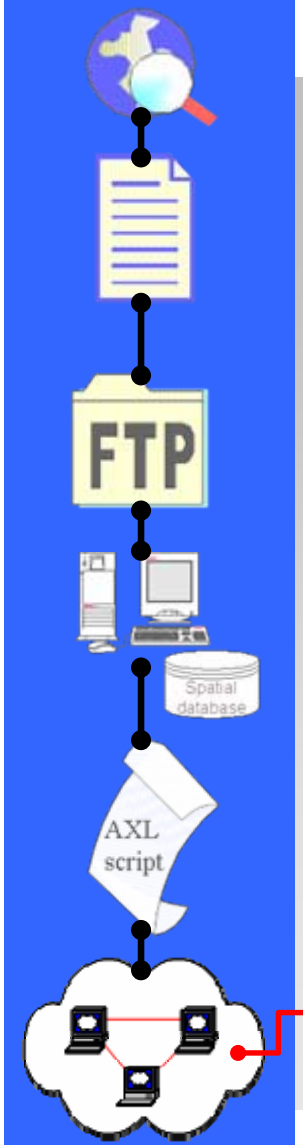

Process Steps… (step 6)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
- Develop partnership with data provider.
- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).
- QA/QC data for completeness; convert to GIS format; create metadata; load into ArcSDE (spatial data engine).
- Create ArcIMS Image and Feature Services which are updated when data is updated in database (new AXL files with new datasets).
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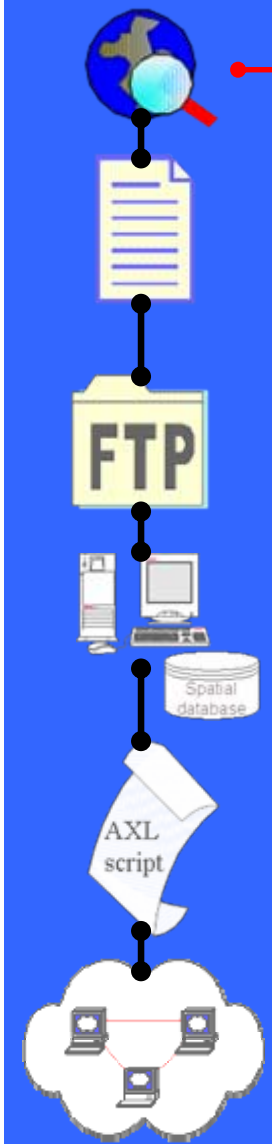


Process Steps… (step 1a)

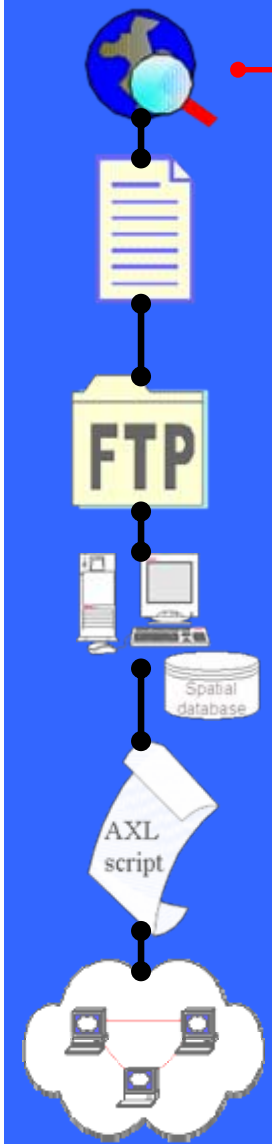
- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.

There many sources of temporal data such as:

- National Oceanic & Atmospheric Administration (NOAA)
  - ➢ National Weather Service (NOAA/NWS) ⇔ *today's example*
- US Geological Survey (USGS)
- National Biological Information Infrastructure (NBII)
- Multi-State Aquatic Resources Information System (MARIS)
- Universities
- Government
- …

- Today, we'll use NOAA/NWS NDFD/NDGD data as one possible example.

- NDFD = National Digital Forecast Database; http://www.weather.gov/ndfd
- NDGD = National Digital Guidance Database



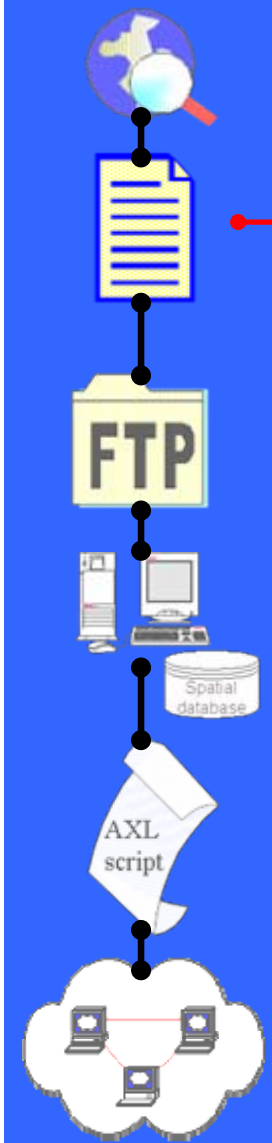
Process Steps… (step 1b)

- Identify sources of spatial and temporal data from agencies, organizations, or academic institutions.
  - The National Digital Forecast Database (NDFD) broke the CONUS (Continental United States) into sixteen geographic sub-sectors.

Available variables we are currently serving to the GIS community are:

min. & max. temp., 12-hour probability of precipitation, temp., dew point, quantitative precipitation forecast (QPF), snow amount, wind direction & speed, significant wave height, sky cover, apparent temp., rel. humidity, wind gust, ozone, smoke

More variables provided by NOAA/NWS and others are hopefully coming soon (depends on interest and time available -- non-funded enterprise)



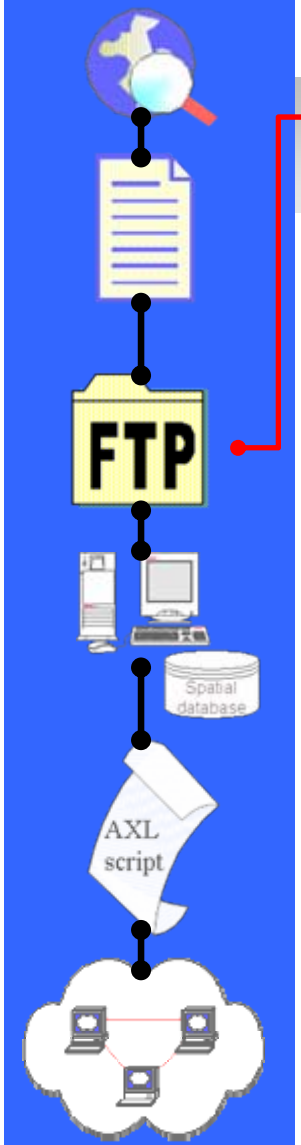
Process Steps… (step 2)

- Develop partnership with data provider.

Developing a relationship with a data provider gives the project a more sustainable base, allows data to be updated more readily, and encourages further cooperation should additional data become available.

The following step should be made once a dataset has been identified:

- The data provider should be contacted to ensure that he/she agrees to the distribution of his/her data by another institution.
- Appropriate credit should be given in the metadata to the data provider.
- Disclaimer and use constraints can also be included in the metadata where applicable.

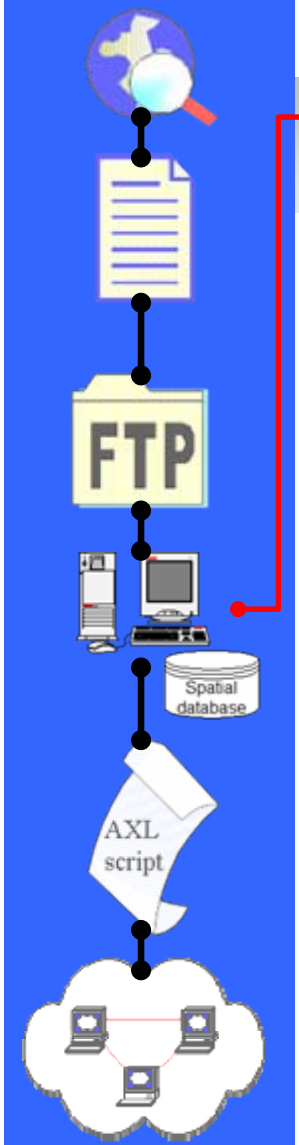


Process Steps… (step 3)

- Acquire data from provider or from public access site such as an FTP site (Automate this process where possible).

Some details that the normal user will not get to see and does not have to worry about:

- Data (e.g., NDFD/NDGD; ~100 MB -- compressed) will be downloaded from the data provider at ***predetermined time intervals (e.g., every 1-3 hours)*** via either anonymous FTP or HTTP (Unix, Linux, Cygwin).
- Parallel downloads immensely speed up data transfer (frequently datasets are split into chunks, which is preferable; note: datasets need to be concatenated to become usable).
- Avoid sequential data downloads if possible.
- If downloads require a username and password other than an anonymous login, *make sure that files are read and write protected, especially on multi-user systems*.



Process Steps… (step 4)

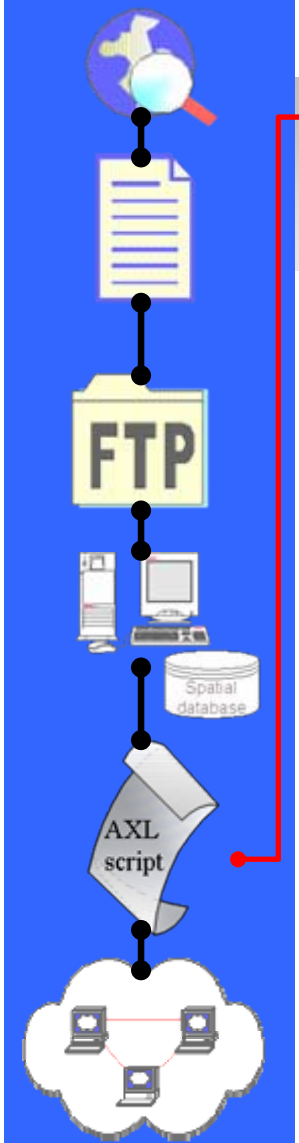
- QA/QC data for completeness; convert to GIS format; create metadata; load into ArcSDE (spatial data engine).

  - Check data for completeness

  - Data come in compressed format => “Degrib” (uncompress) data and convert to ESRI shape files (GRIB2 is the second version of the World Meteorological Organization’s (WMO) standard for distributing gridded data; initial 100 MB become several Gigabyte).

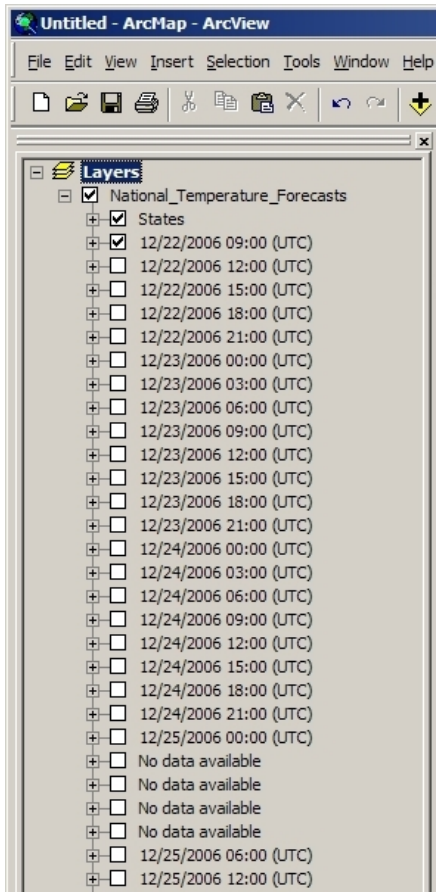
  - Upload ESRI shape files/layers into “Spatial Database”, e.g., 40 forecast layers for “temperature” (26 x every 3h = 78h; then 14 x 6h = 84h; forecast for about 1 week)

  - Repeat for all other variables (total of over 500 layers)

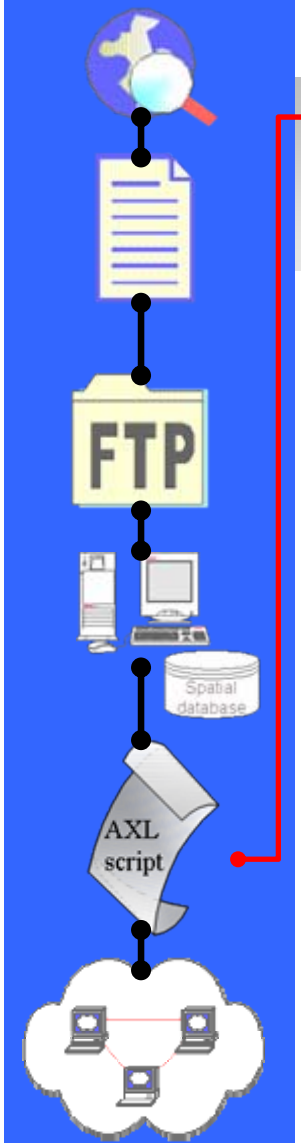


Process Steps… (step 5a)

- Create ArcIMS Image and Feature Services which are updated when data is updated in database (new AXL files with new datasets).



- *Update time stamp (BONUS; tricky; wait for next slide).*
- Usually timestamps say, e.g. 3, 6, 9, … , 150 hours from now; **ours do show real times**.
- Problem: A users saves a map and reopens it without remembering the time he saved the map ➔ *ideally the timestamp should show the forecast time.*



Process Steps… (step 5b)

- Create ArcIMS Image and Feature Services which are updated when data is updated in database (new AXL files with new datasets).

/cygdrive/d/noaa.conus/data-archive/2007010301/conus

```
$ degrib vp004-007/ds.temp.bin -I
MsgNum, Byte, GRIB-Version, elem, level, reference(UTC), valid(UTC), Proj(hr)
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2.0, 255958, 2, T="Temperature [K]", 0-SFC, 01/03/2007 06:00, 01/06/2007 12:00, 78.00
3.0, 511415, 2, T="Temperature [K]", 0-SFC, 01/03/2007 06:00, 01/06/2007 18:00, 84.00
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12.0, 2845848, 2, T="Temperature [K]", 0-SFC, 01/03/2007 06:00, 01/09/2007 00:00, 138.00
13.0, 3108526, 2, T="Temperature [K]", 0-SFC, 01/03/2007 06:00, 01/09/2007 06:00, 144.00
14.0, 3371488, 2, T="Temperature [K]", 0-SFC, 01/03/2007 06:00, 01/09/2007 12:00, 150.00
```
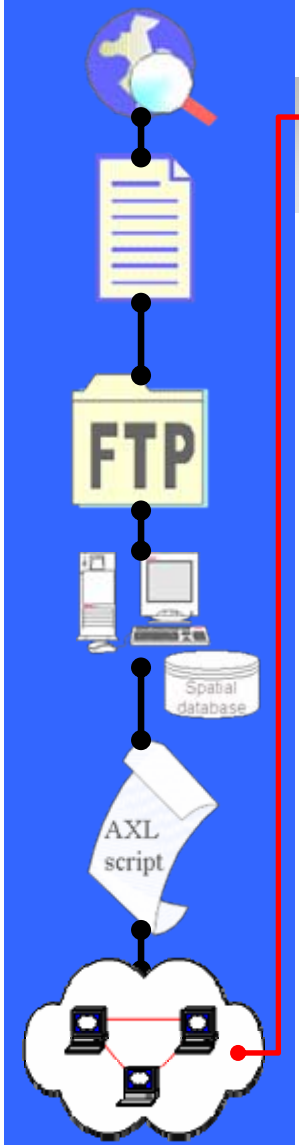
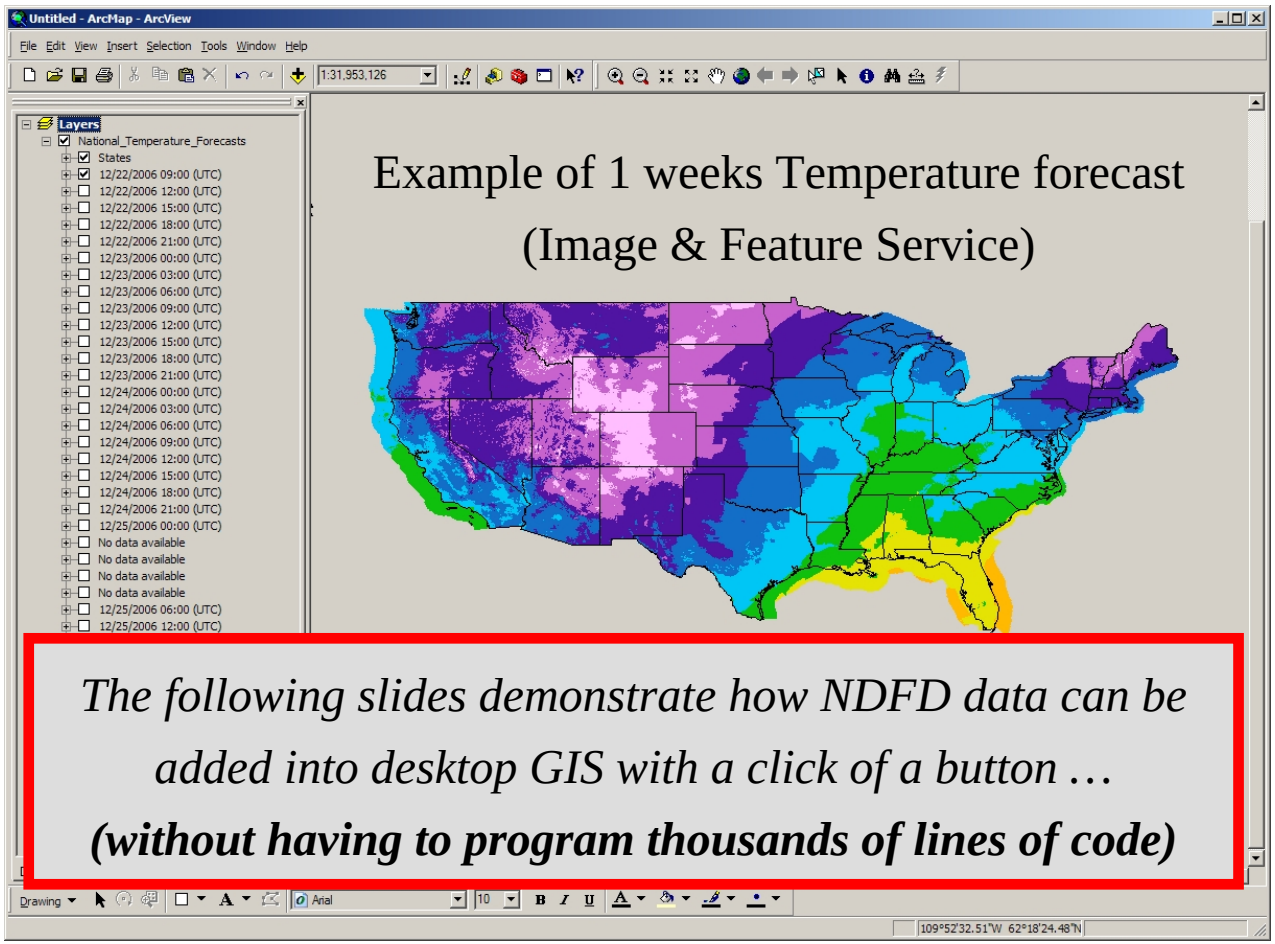

Example of metadata
- degrib ds.temp.bin -I

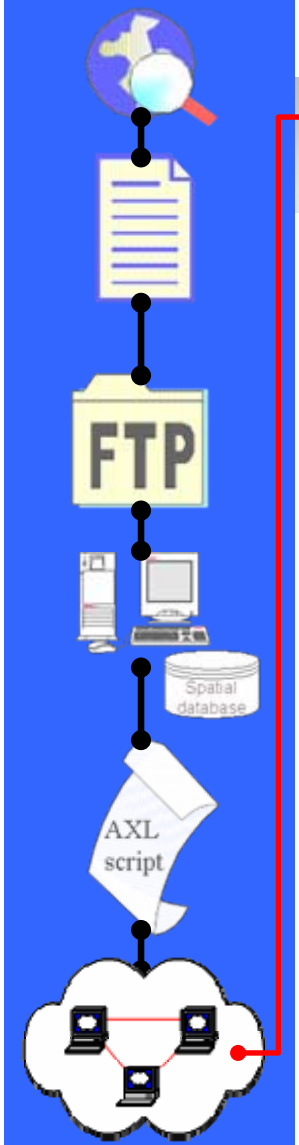
- Here is how we *update the time stamp* …
  1. Extract timestamp from data archive/metadata
  2. Update AXL file with the “real” time information
  3. Stop Feature and Image Service
  4. Replace old AXL file with new updated file
  5. Restart Feature and Image Service
  6. Repeat for all other variables
  7. DONE



Process Steps… (step 6a)

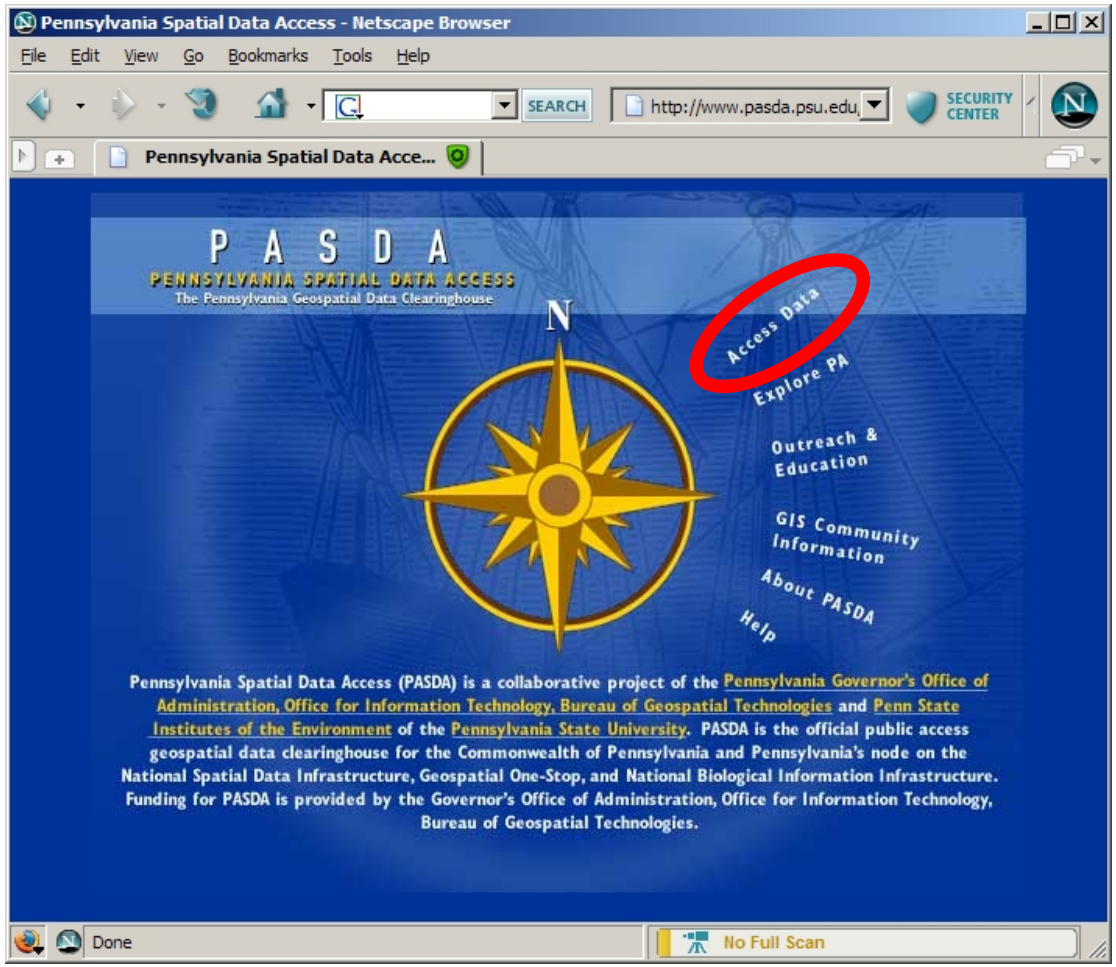
- Users can bring Image and Feature services directly into their desktop GIS software.





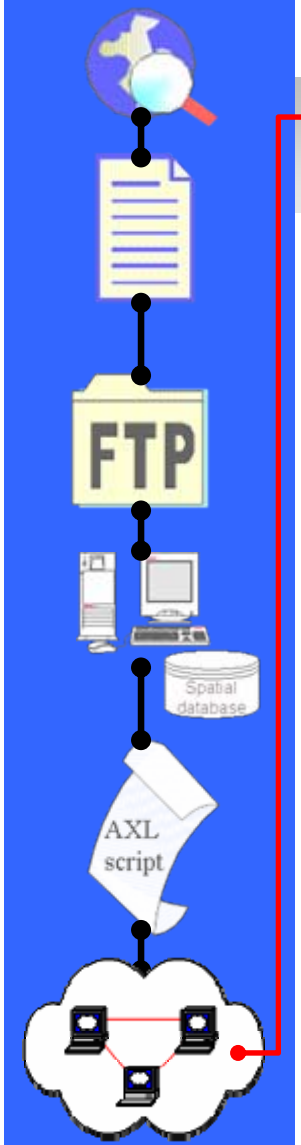
Process Steps… (step 6b)

- Users can bring Image and Feature services directly into their desktop GIS software.



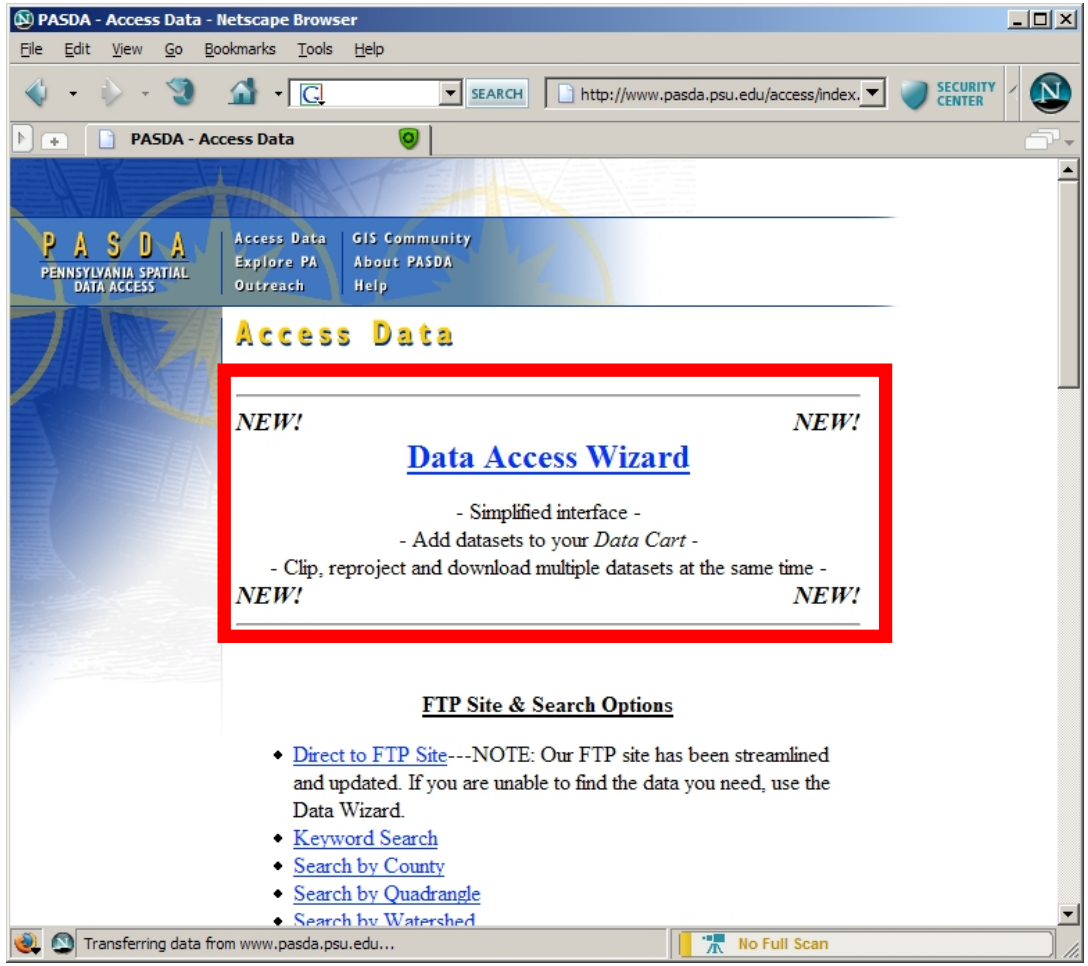
GIS weather data with a click of a button!

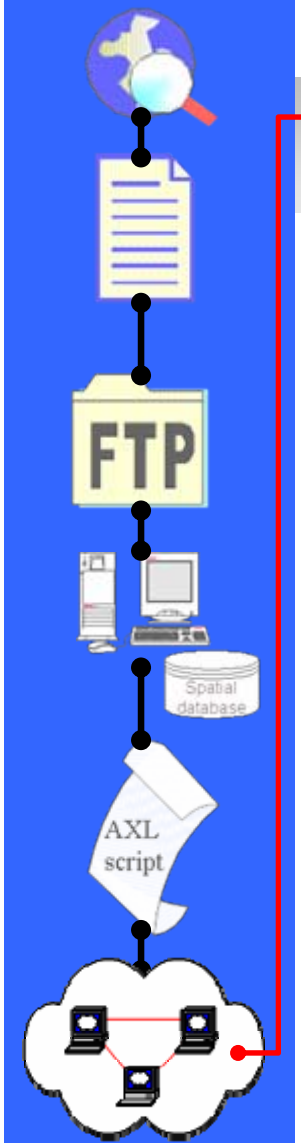
PASDA is funded by the Geospatial Technologies Office of the PA Office for Information Technology



Process Steps… (step 6c)

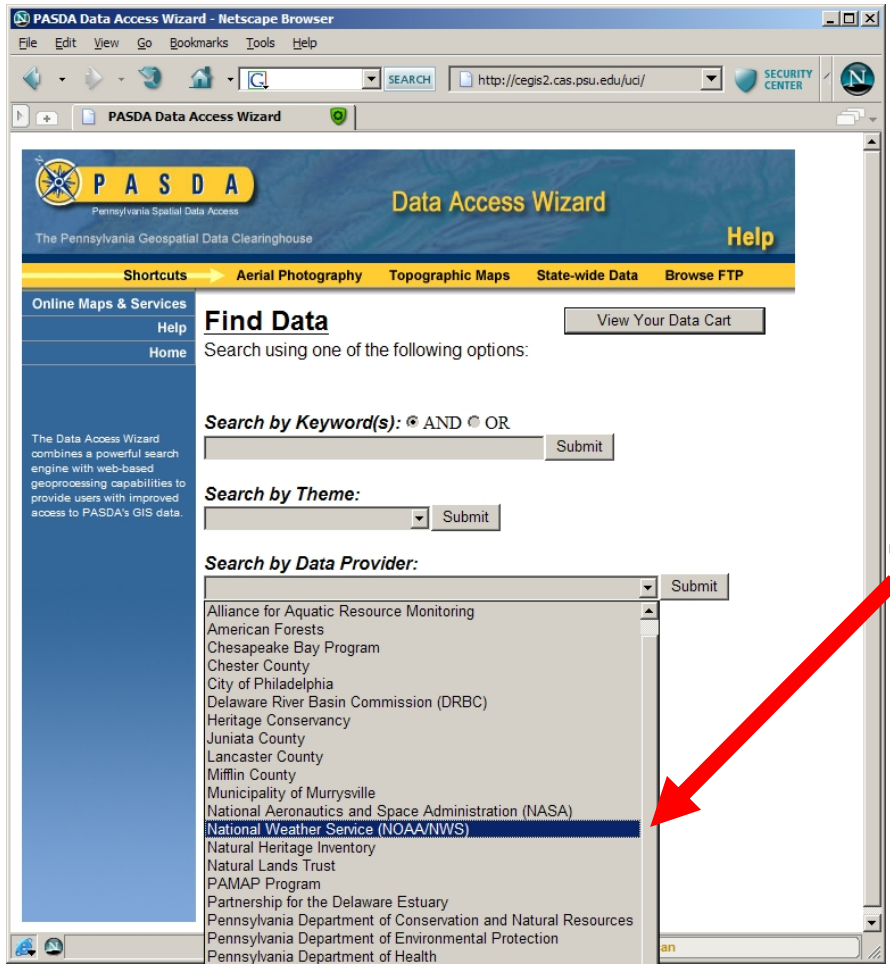
- Users can bring Image and Feature services directly into their desktop GIS software.



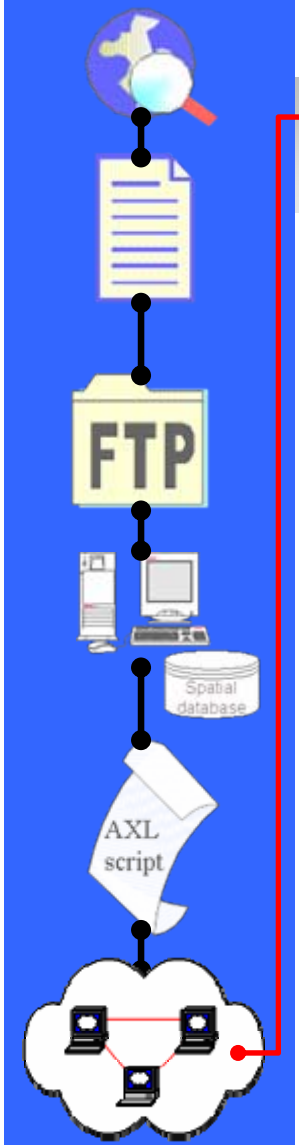


Process Steps… (step 6d)

- Users can bring Image and Feature services directly into their desktop GIS software.

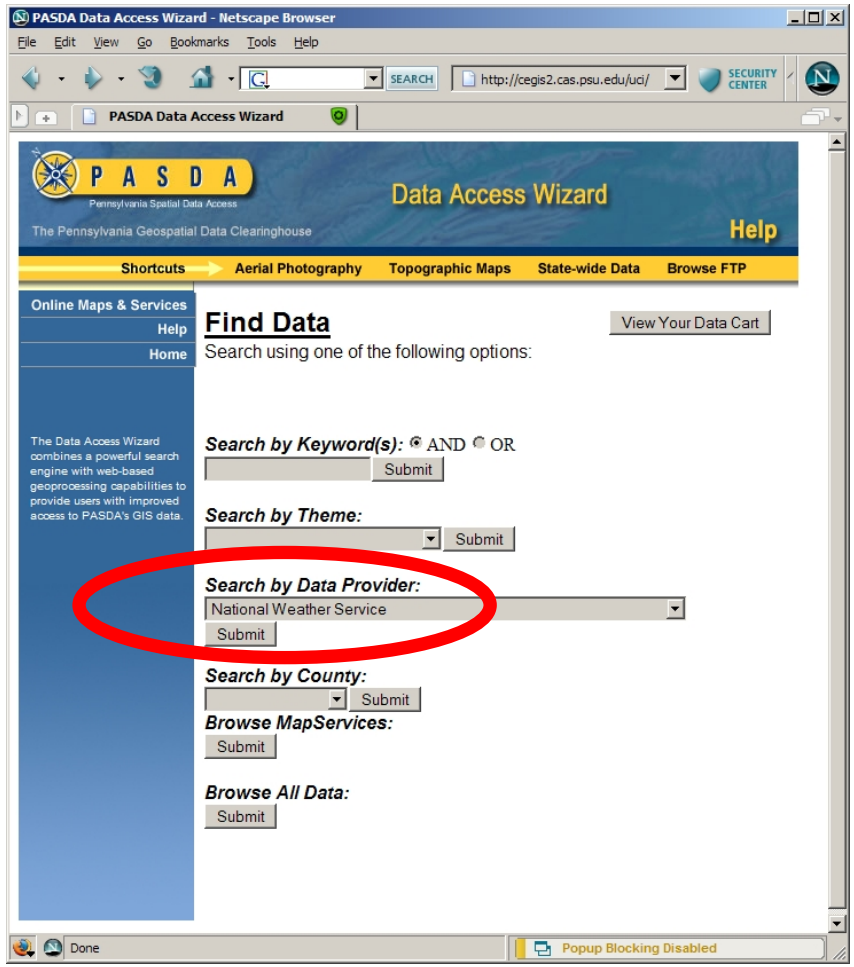


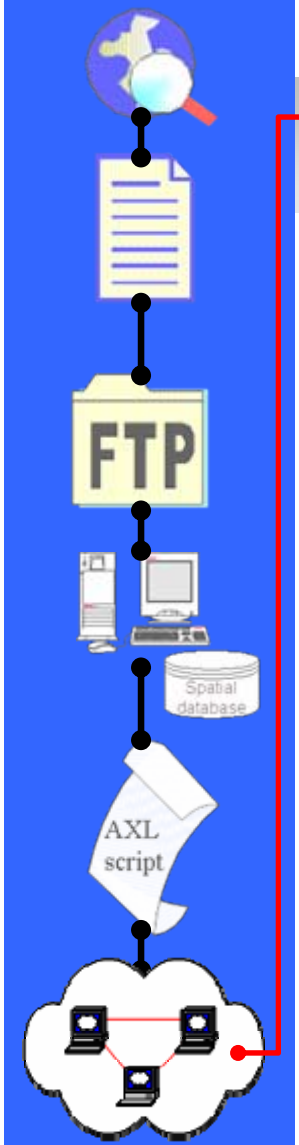
Today's example: NOAA/NWS



Process Steps… (step 6e)

- Users can bring Image and Feature services directly into their desktop GIS software.



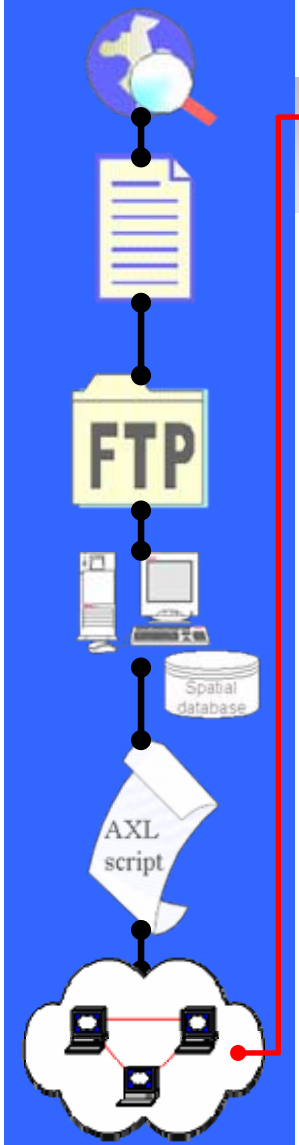


Process Steps… (step 6f)

- Users can bring Image and Feature services directly into their desktop GIS software.

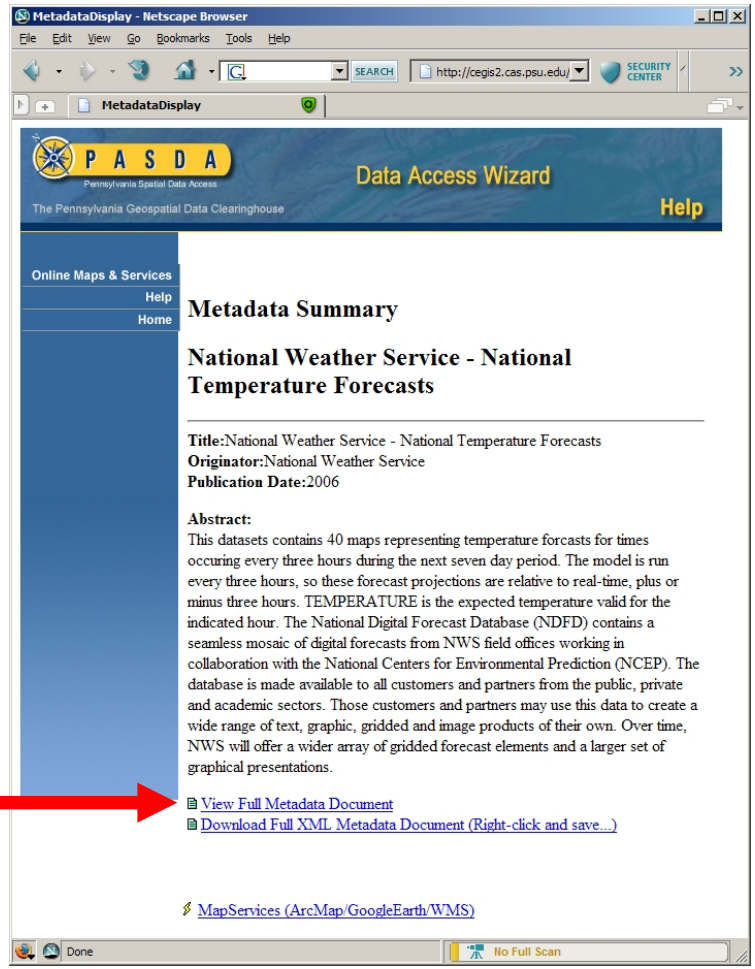
18 + 3 = 21 variables

- 3 temporal images
- 18 NDFD datasets

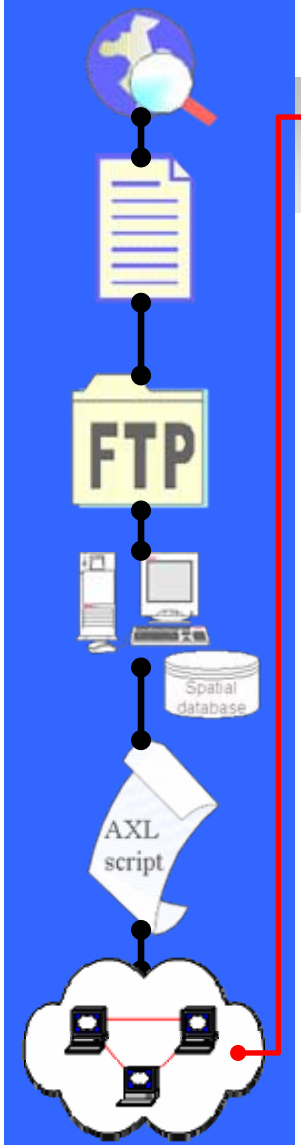


Process Steps… (step 6g)

- Users can bring Image and Feature services directly into their desktop GIS software.

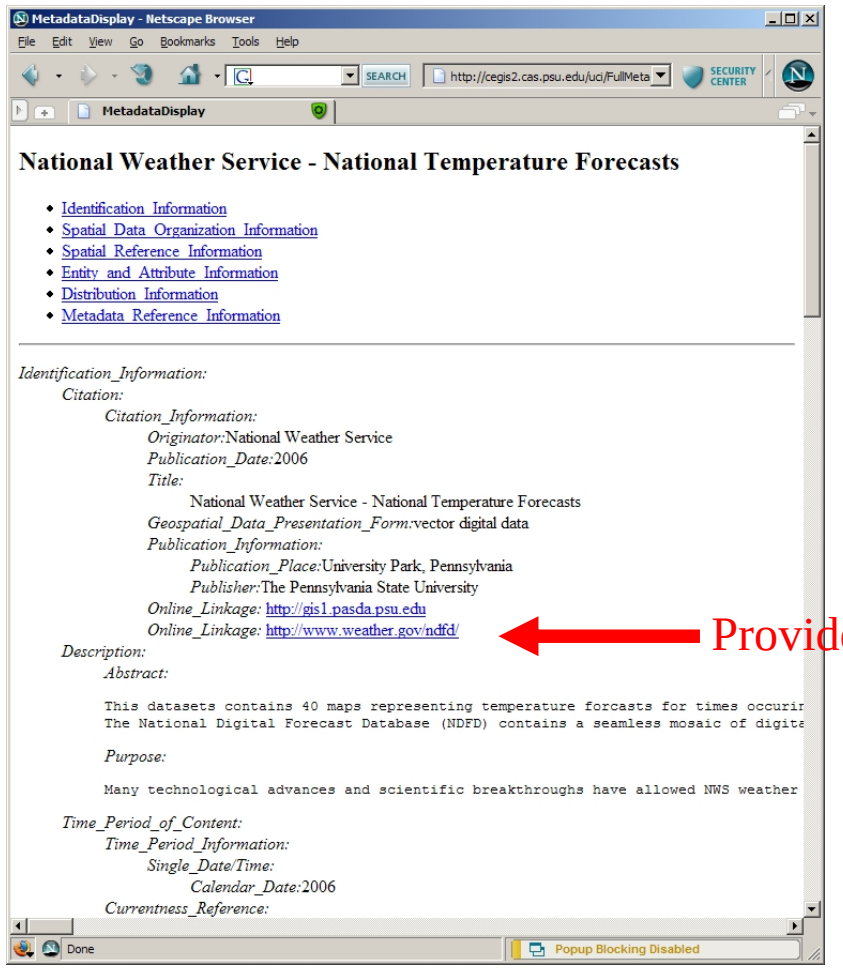


Keep slide in mind, we'll return to it.

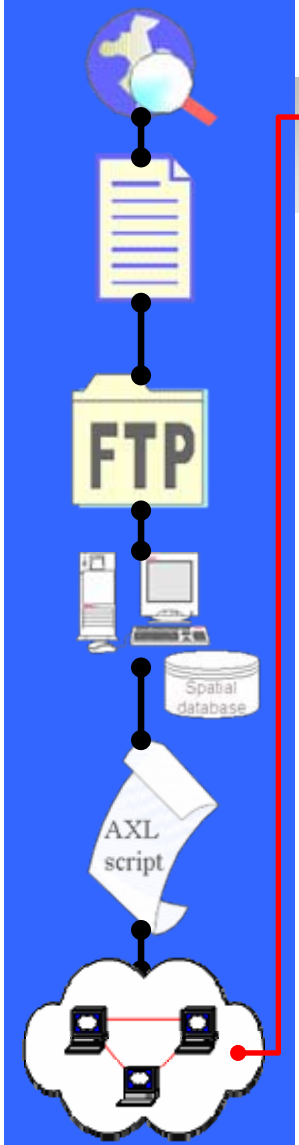


Process Steps… (step 6h)

- Users can bring Image and Feature services directly into their desktop GIS software.

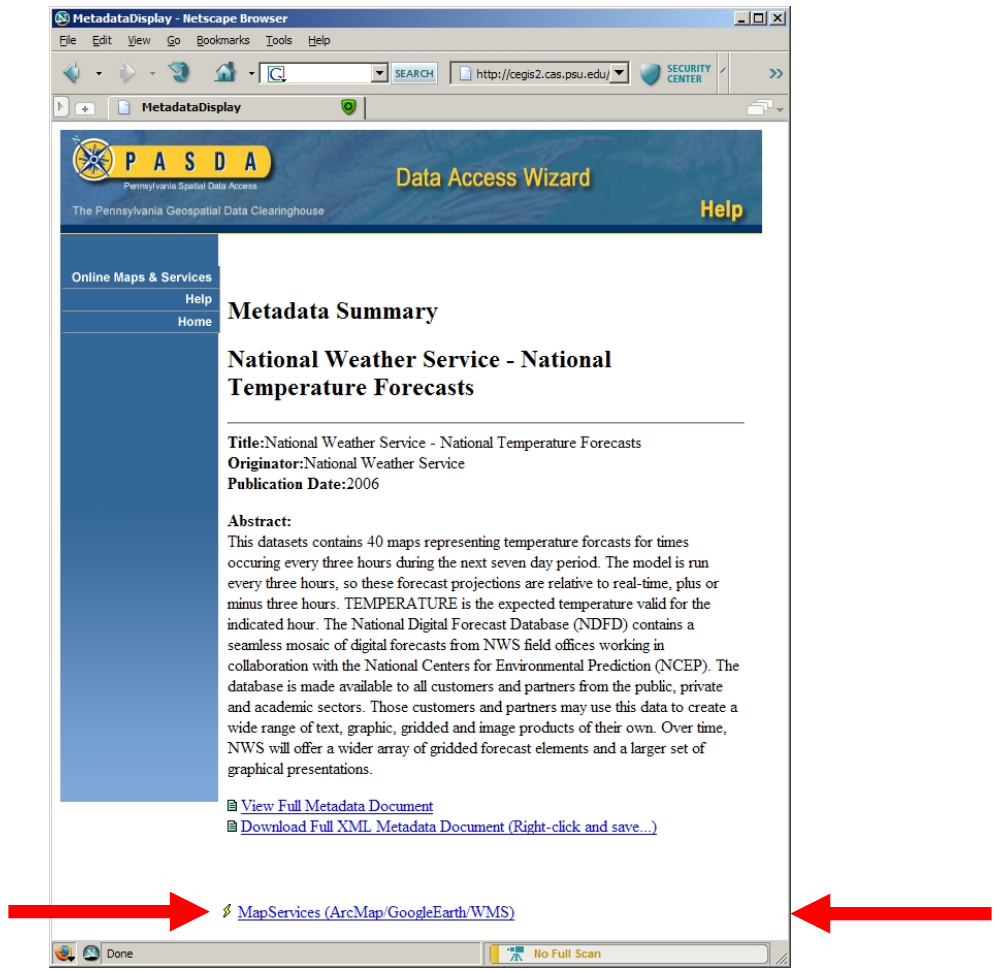


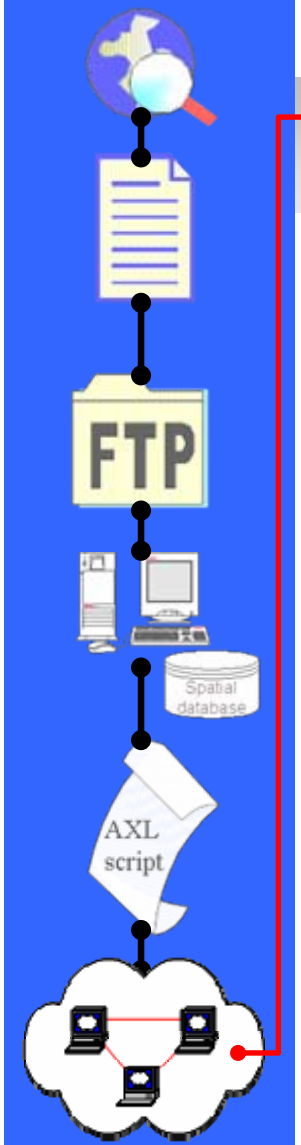
Provide appropriate credit



Process Steps… (step 6i)

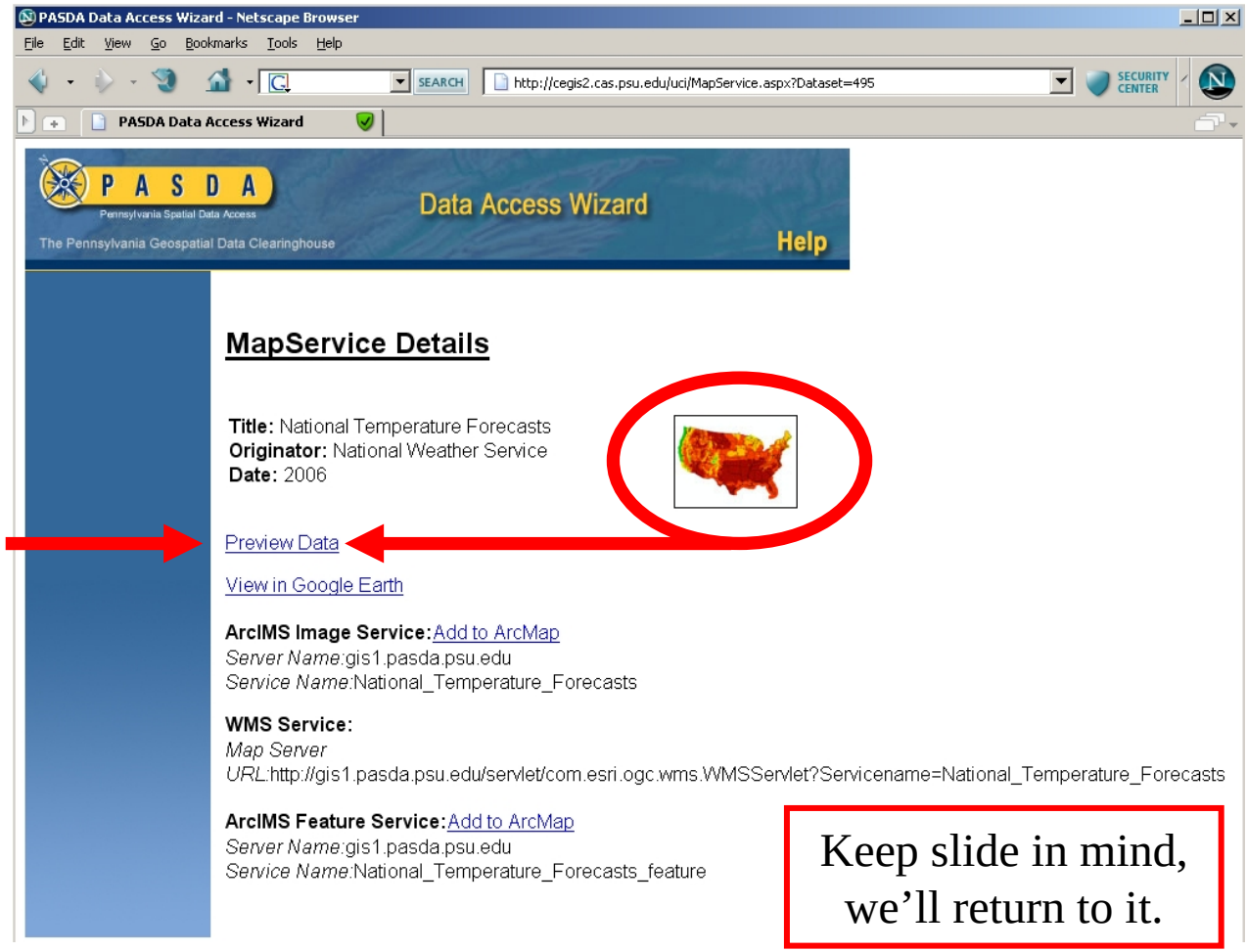
- Users can bring Image and Feature services directly into their desktop GIS software.



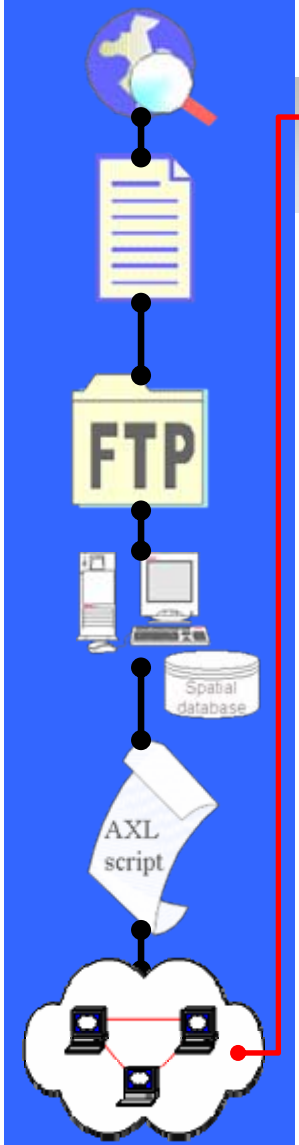


Process Steps… (step 6j)

- Users can bring Image and Feature services directly into their desktop GIS software.

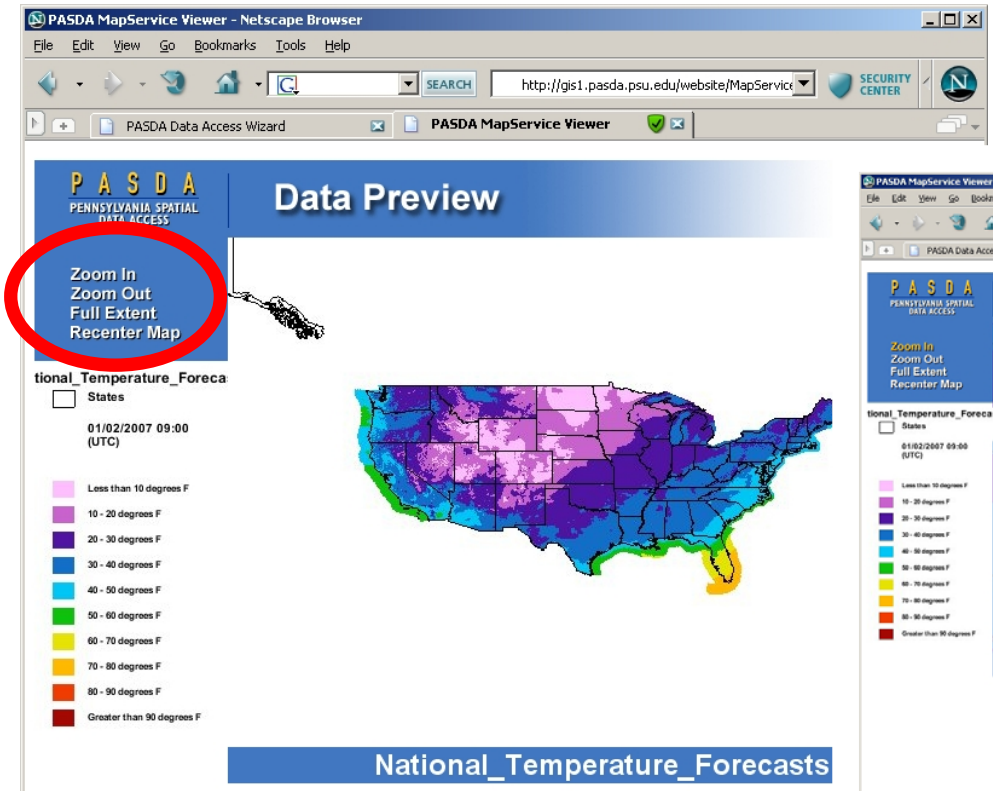


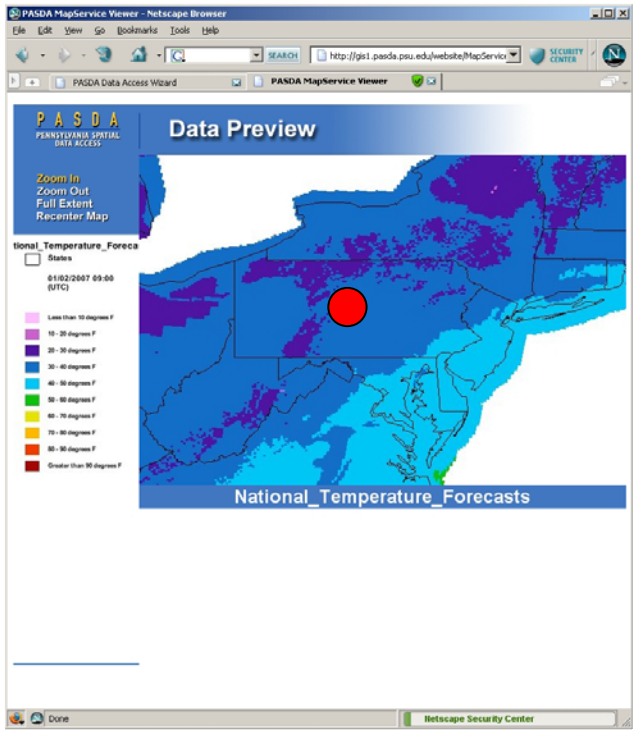
Keep slide in mind, we'll return to it.



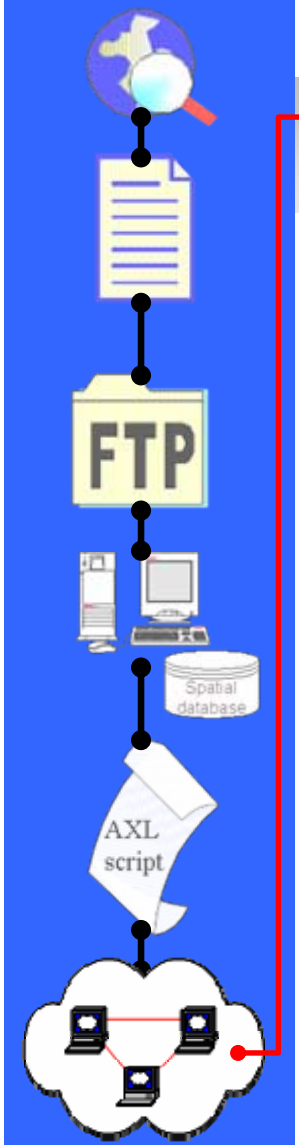
Process Steps… (step 6k)

- Users can bring Image and Feature services directly into their desktop GIS software.



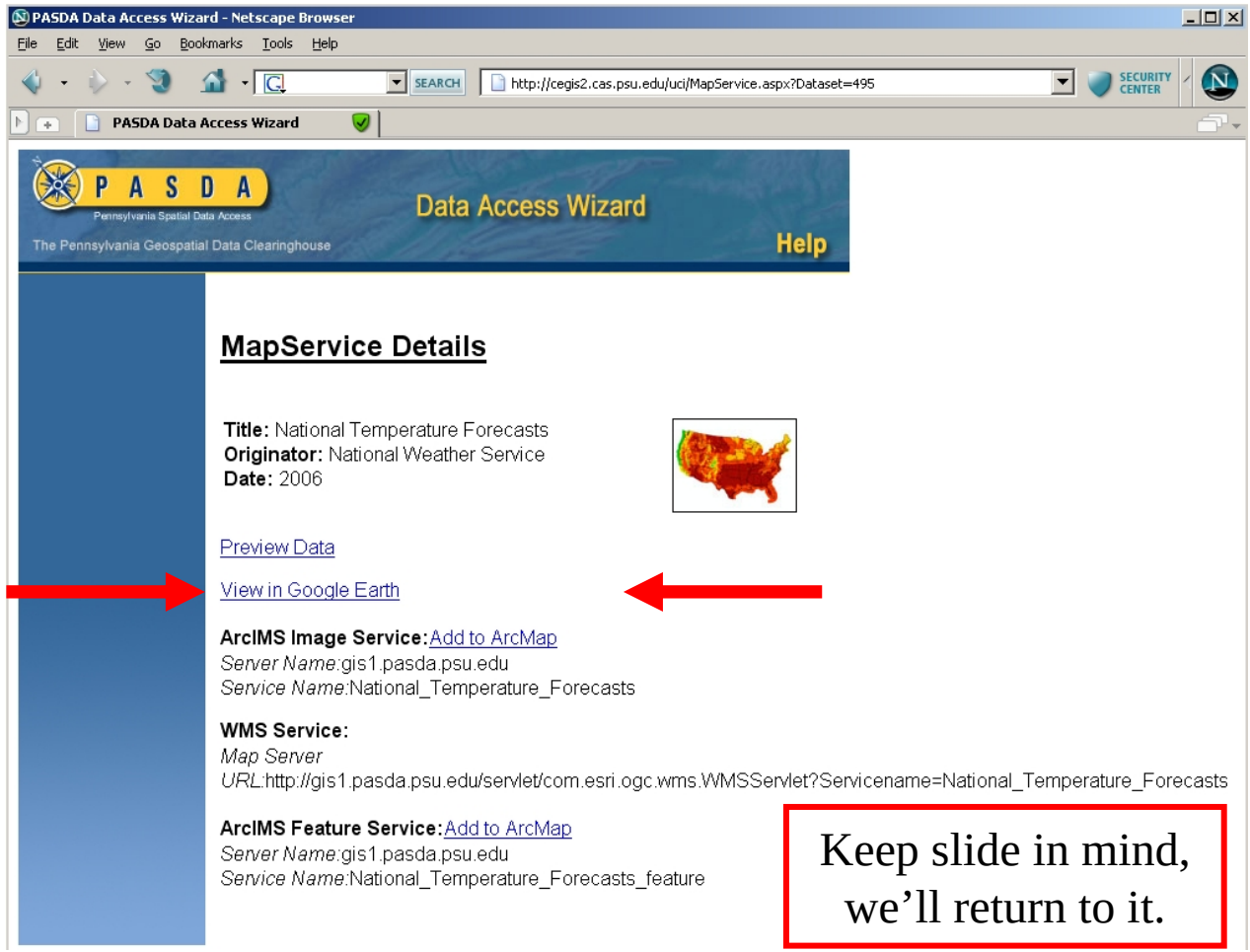


Does not require GIS software!

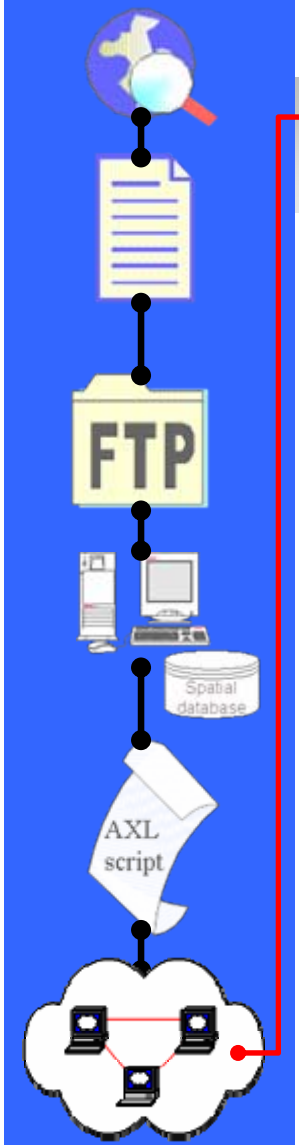


Process Steps… (step 6l)

- Users can bring Image and Feature services directly into their desktop GIS software.



Keep slide in mind, we'll return to it.

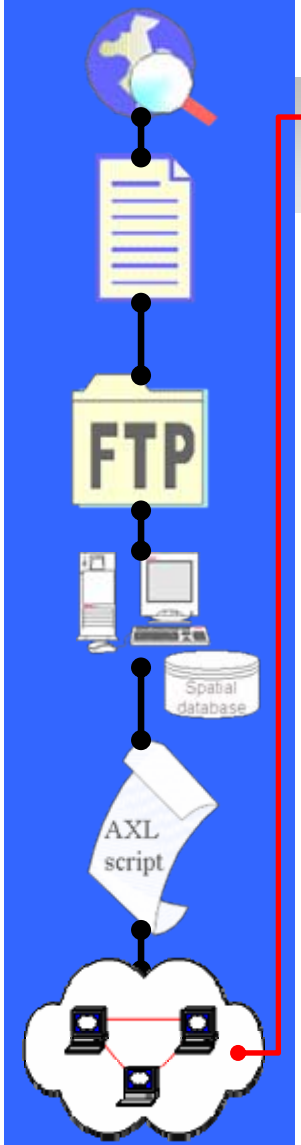


Process Steps… (step 6m)

- Users can bring Image and Feature services directly into their desktop GIS software.

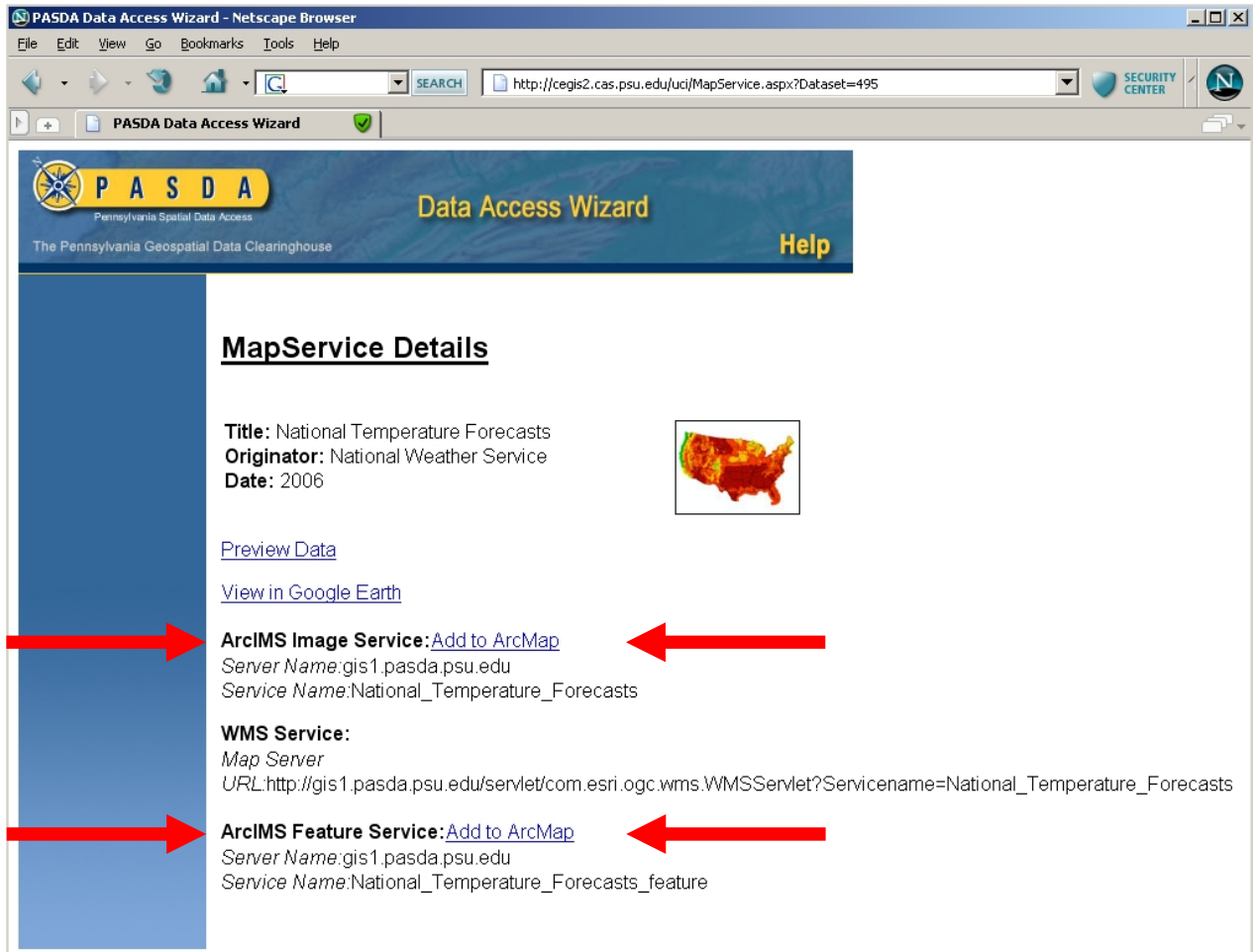
Does not require GIS software!

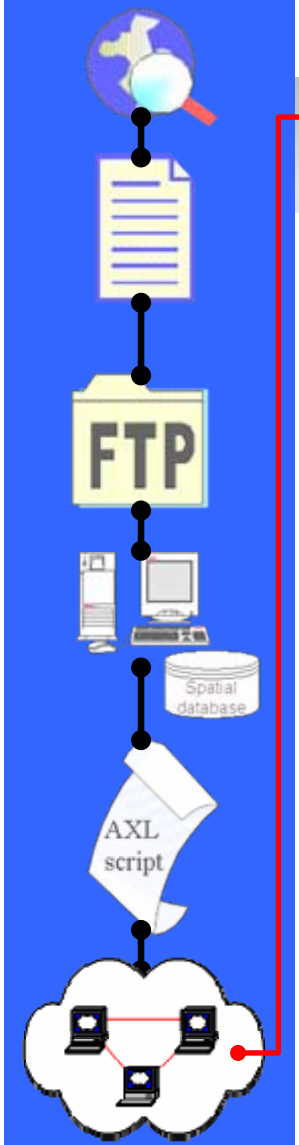
Three NDFD/NDGD forecast layers are available for each variable at 3h, 1d, & 2d



Process Steps… (step 6n)

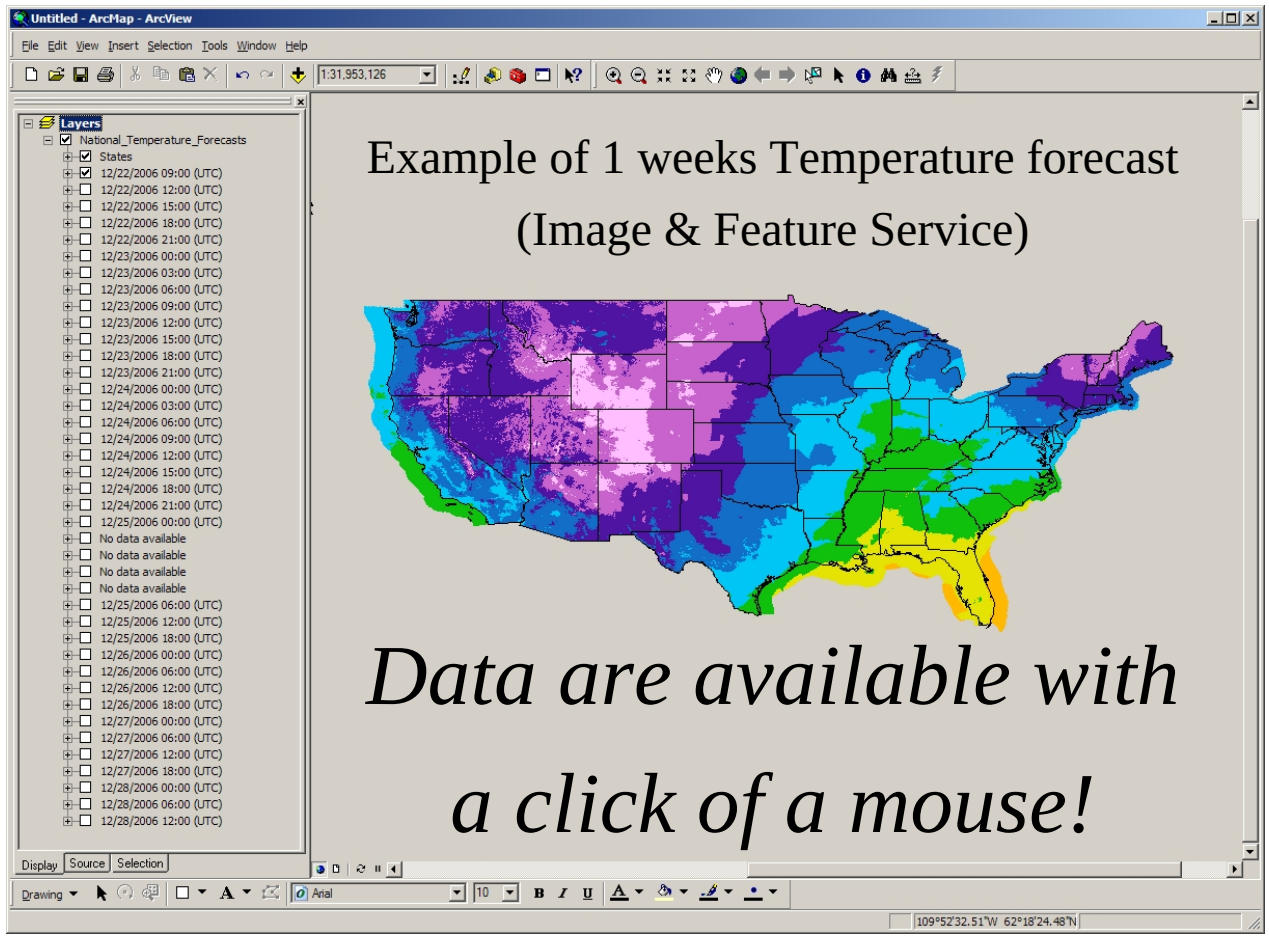
- Users can bring Image and Feature services directly into their desktop GIS software.

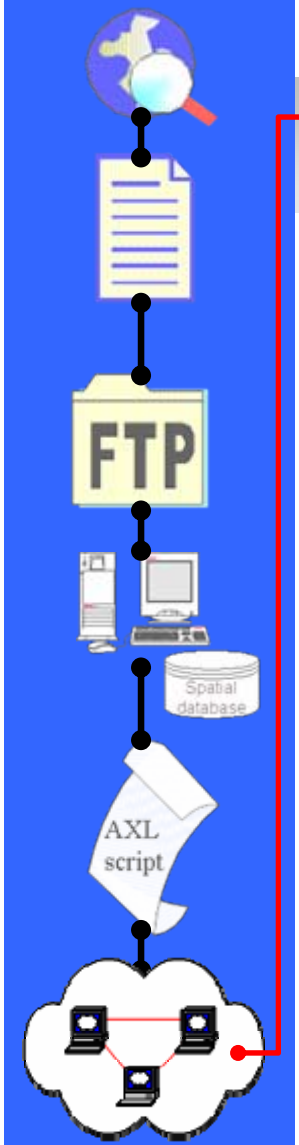




Process Steps… (step 6o)

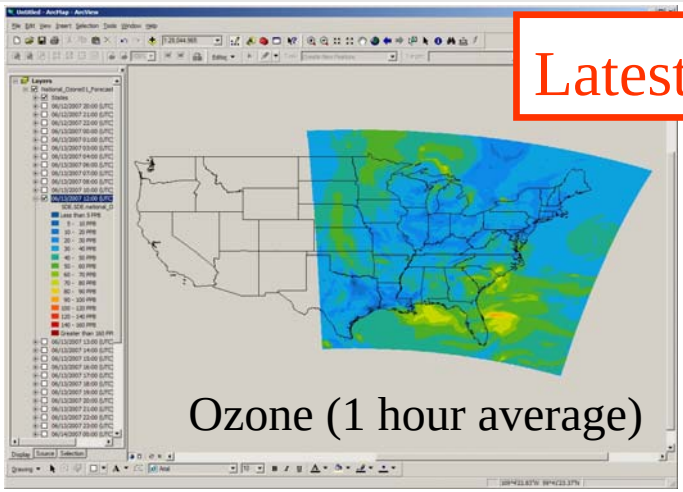
- Users can bring Image and Feature services directly into their desktop GIS software.





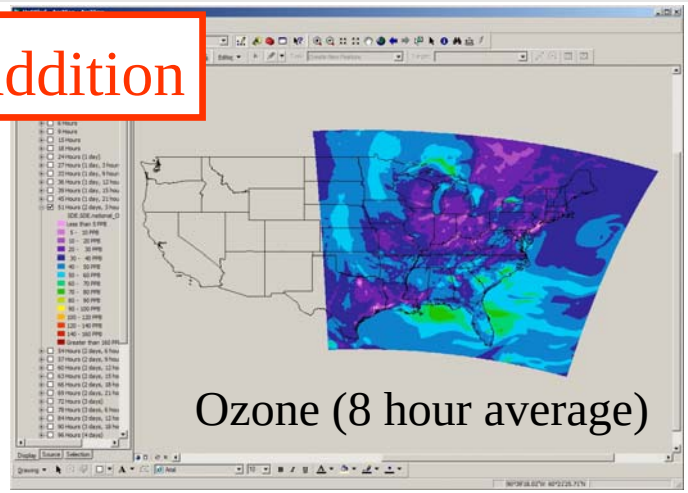
Process Steps… (step 6p)

- Users can bring Image and Feature services directly into their desktop GIS software.

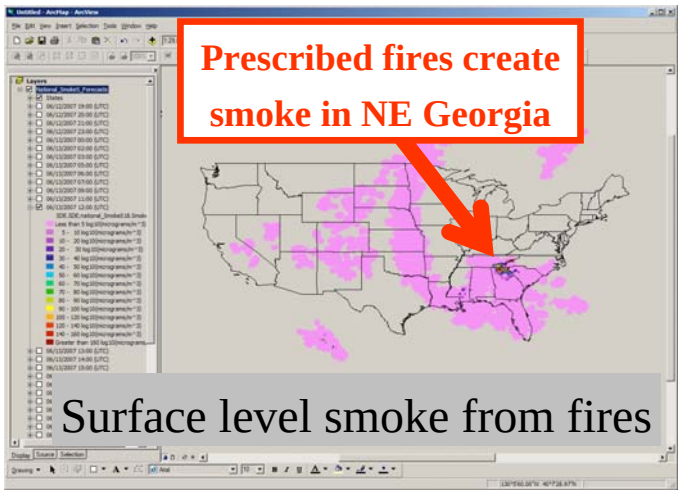


Latest addition

Ozone (1 hour average)

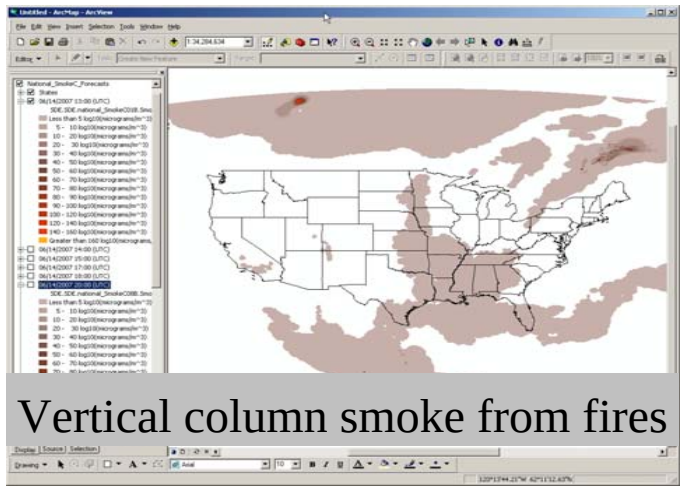


Ozone (8 hour average)

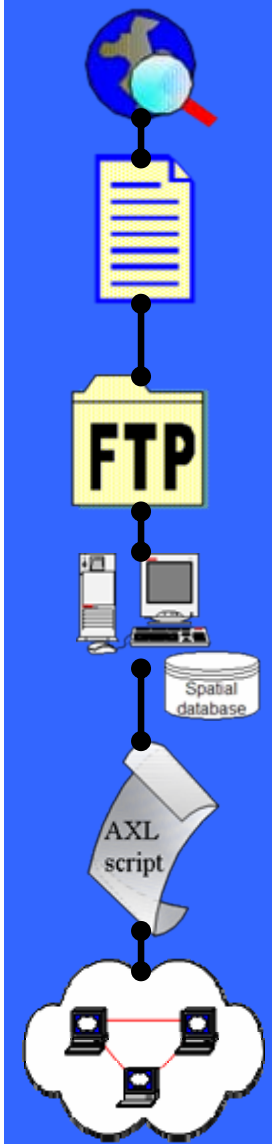


Prescribed fires create smoke in NE Georgia

Surface level smoke from fires

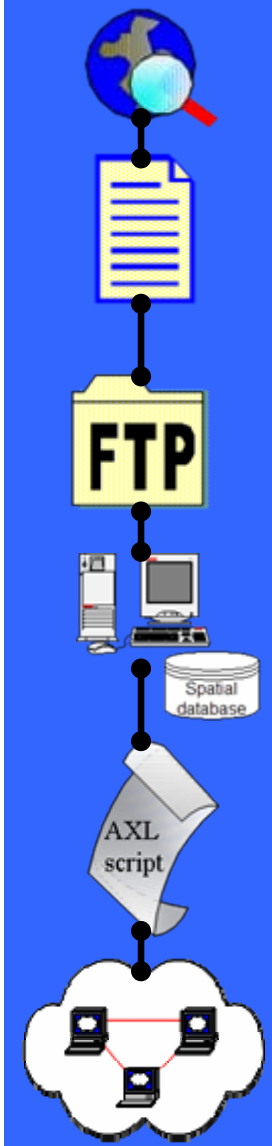


Vertical column smoke from fires



Conclusions

- PSIEE & EESI (PSU) team communicates and collaborates with NOAA/NWS on GIS projects.
- Together, we, PSIEE, EESI, and NOAA/NWS can grow together for a greater benefit to anyone tapping in ➔
- We provide continuously updated NOAA/NWS weather data *in GIS format* to emergency managers and response support agencies as well as the general public (includes scientists, farmers, utility companies, and other).
- *With a click of a mouse users can bring our Image and Feature services directly into their desktop GIS software.*



Conclusions II

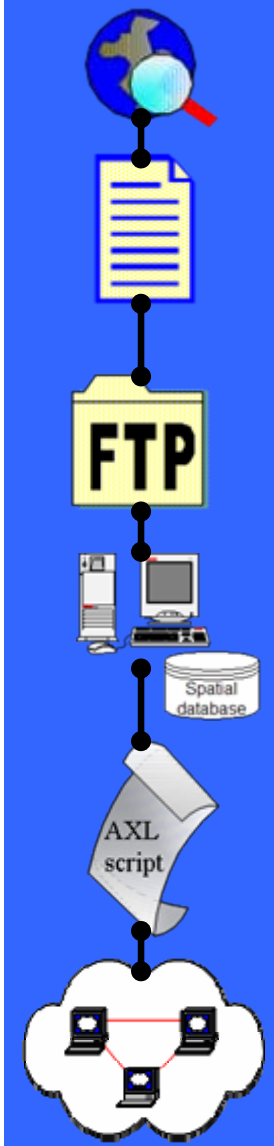
(this slide was added by NOAA/NWS collaborators)

- **Collaboration works!!**

(according to NOAA/NWS collaborators)

- **Further exploration/resources needed**

- http://www.weather.gov/gis
- http://www.pasda.psu.edu
- http://www.nbii.gov



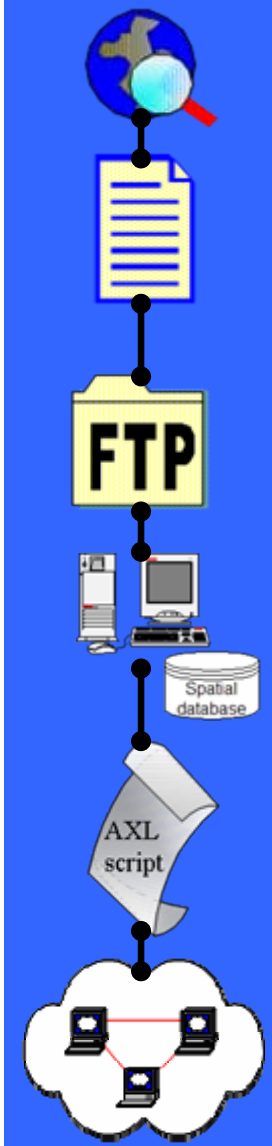
… what other data can be fed into our system …

Any kind of temporal gridded data starting from:

- observed data (e.g., satellite data, climate data, soil data, biological data, power grid data, health data, etc.)

to

- data from numerical models (e.g., climate models, hydrological models)



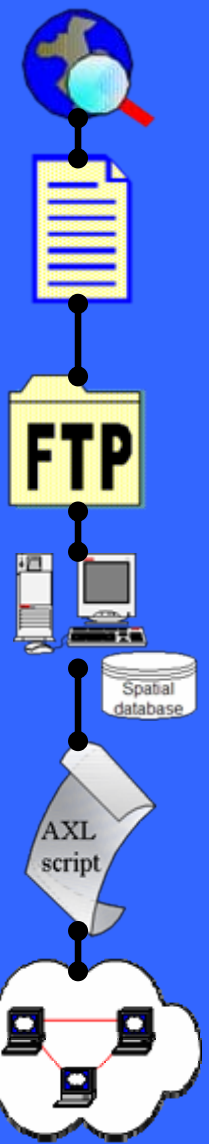
… what is coming in the near future …

More data from:

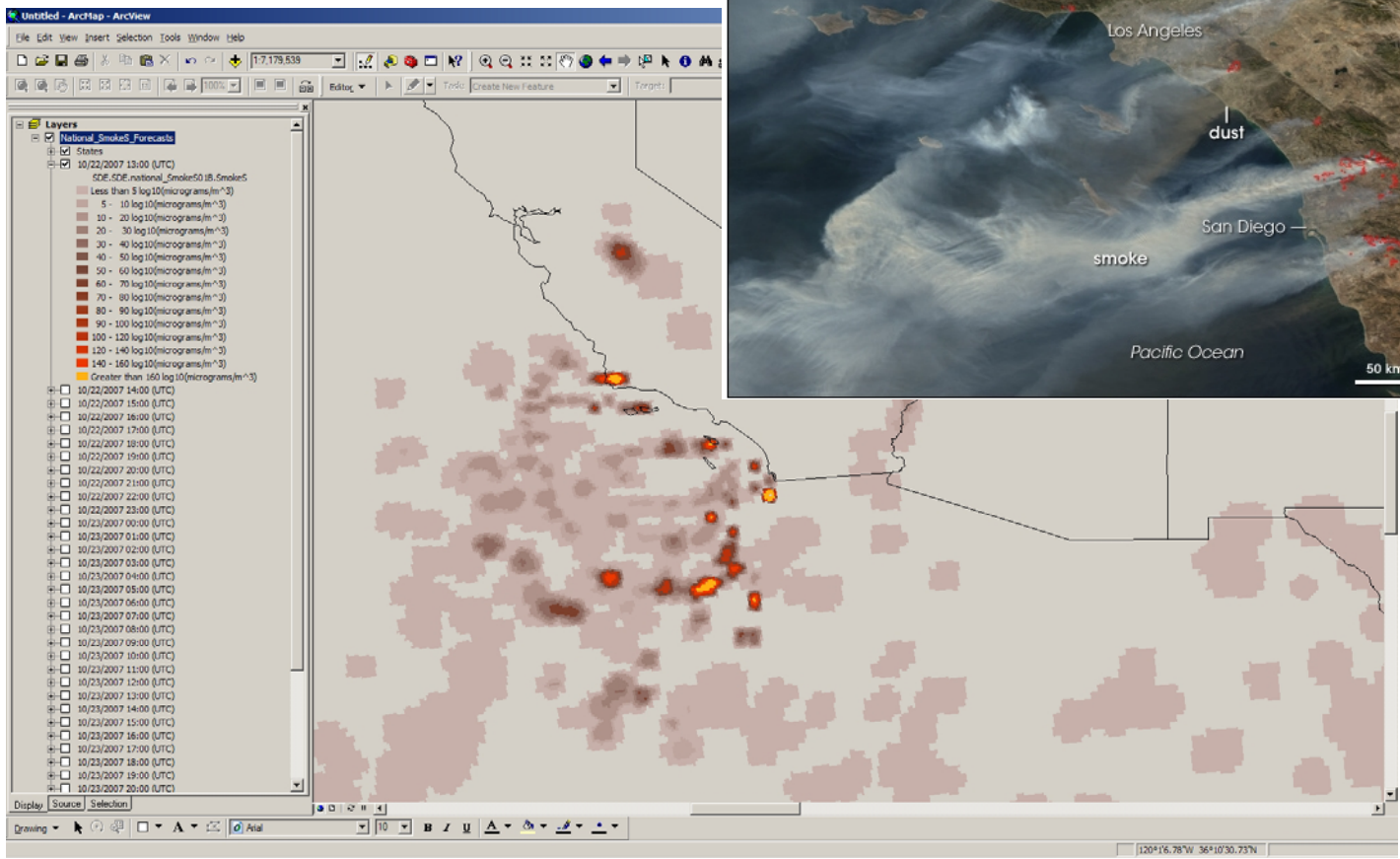
- NWS/NOAA
  - NDFD (National Digital Forecast Database) – new fields
  - NDGD (National digital Guidance Database), e.g., lightning strikes and wind gusts
- National Hurricane Center (NHC) in Miami:
  - Tropical cyclone wind speed probs, tornado, hail, damaging thunderstorm wind probs
  - Extreme tornado, hail, damaging wind probs, total severe, and extreme severe thunderstorm probs
- River gauge data (if made available as one dataset)
- Bedford Institute of Oceanography (BIO) & Dalhousie University
  - Buoy data

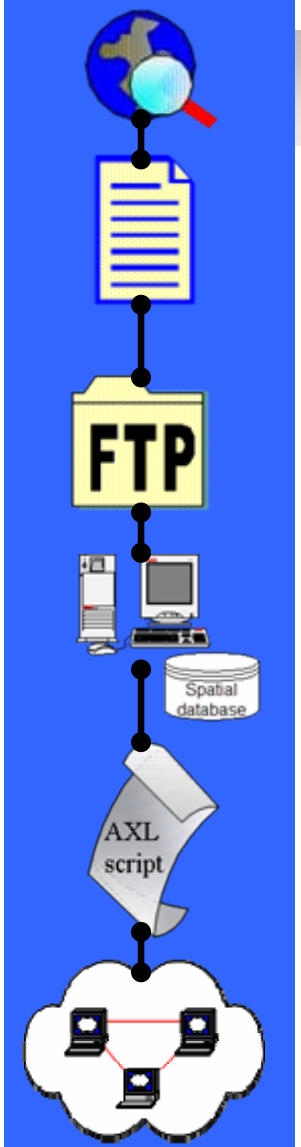
And:

- NOAA/NWS might use us an official GIS data outlet



… questions and comments …





… questions and comments …