Development of Weather Processing System by Integrating Weather Data into GIS.

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ABSTRACT:

City decision-makers need the ability to integrate timely, accurate weather data into GIS analysis systems. First, one must understand the important relationship of GIS and Weather. GIS allows the user to electronically map and “geo-locate” layers of critical infrastructure such as streets, schools, hospitals, fire and police stations, Government offices, even moving EMS vehicles (fleet management). Other mapped layers could include population demographics, industrial facilities, utilities, etc. Weather events such as severe thunderstorms and high winds can be mapped to show and analyze its impact on infrastructure and incidents. One has to search the tool that provides the facility to place real-time weather observations into a GIS format.

One of these powerful new technologies is GIS, Geographical Information System. GIS combines interactive mapping and spatially related information databases, including real time, continually updating severe weather information. Weather-enabled GIS is critical to homeland security and emergency managers because by combining and sharing this information, analysis and graphic representation speeds understanding of an event and improves the decision making process at all levels of response. For instance by overlaying a projected tornado path onto multiple map layers showing locations of hazardous materials storage sites, streets, schools, hospitals and fire stations, the user can more readily and accurately make decisions such as when and where to deploy emergency teams, what streets to blockade, which streets to assign for evacuation routes, which schools and neighborhoods to evacuate, which hospitals to assign potential casualties. Because he has detailed attributes of the storm’s intensity, speed and direction, he can better assess the potential damages and casualties that might occur. Armed with this information, the user has the tools to be proactive in mitigating the effects of severe weather, resulting in significantly reducing the human, material and financial loss to his city.

1 INTRODUCTIION:

1.1 Introduction:

Nowadays there are many sources of weather data, maps, and tables. This study will briefly describe methods to combine these sources to assist one in understanding current and future weather patterns for any location in the world using desktop mapping systems. There are wildest weather conditions prevailing in almost every corner of the world. The normal conditions will show swings in temperature from 120 degrees F heat, -30 degrees F cold, tropical humidity, dryness of the desert, and the destructiveness of tornadoes, hurricanes, snowfall, and hail storms. These weather conditions are very important and have a continued effect on every individual in the world. Weather plays a significant factor in the operations of many businesses and/or industries in the world.

When it comes to protecting people, property and businesses, managers in our largest metro areas face challenges and threats more complex than ever. More often than not, weather is at the heart of any given emergency, and government officials need the best information possible to prepare for the impact of a severe weather event and to support future and long-term city planning issues, e.g. the insurance industry uses weather data for storm damage to support claim adjustment and planning. The electric power industry uses climate and severe weather analysis to support planning and repair of power grids and production capacity. Agribusiness uses past, present and forecast weather variables to estimate crop production

The transportation industry, whether it is road, rail, or air, has specific weather requirements. The integration of real-time weather information into a GIS-based transportation management system is now not only possible but also much easier and more practical to implement. Many applications are possible. For example, very accurate and immediate determinations of what sections of pavement are being affected by specific weather features can allow more accurate traffic metering, rerouting options, and fuel and safety management.

Agriculture professionals, so often dependent upon the weather, can, with access to GIS-ready weather, not only display but also objectively analyze the potential effects weather will have on their crops. The emerging field of precision agriculture can greatly benefit from having georegistered weather information that can, within a GIS, accurately map and calculate cropland section by section in conjunction with weather parameters. For example, the mapping of past precipitation derived from radar over a section of cropland, within a GIS, can easily be accomplished. Whereas individual rain gauges only measure precipitation at their point, radar derived precipitation estimates converted into GIS formats afford the agricultural community, for the first time ever, the ability to easily and quantitatively evaluate the spatial and temporal variations of rainfall.

With the right weather information delivered at the right time, many business leaders could make more profitable decisions. Here are just a few examples:

A railroad dispatcher sees a heavy storm with damaging winds headed in the direction of a moving freight train. He orders the train to stop, and avoids a catastrophic derailment.
A pilot gets weather update just before take-off. Seeing a nasty thunderstorm headed through his flight plan, he alters the plan? Saving thousands in fuel costs, and keeping his crew and cargo safe.
A golf course superintendent fertilizes the course, only to have a sudden shower wash away thousands of dollars worth of fertilizer. Accurate, up-to-the minute weather data would have prevented that loss.

These are real, everyday situations, and they are typical of the many ways Weather system brings bottom-line value to business. In this scenario Weather Processing System plays an important role as Decision Support System (DSS) for any individual or Organization.

1.2 Scope And Objectives Of The Study:

The theme of the study is to integrate weather data into Geographic Information System by converting weather data into GIS negotiable formats to develop a sophisticated Weather Processing System (WPS).
This helps cities better communicate, plan and respond to both natural and technological disasters that we are facing today. The following are the advantages by having such a sophisticated WPS:

- Reducing disaster costs.
- Minimizing the loss of life, limb, property and critical infrastructure
- Enhancing and coordinating hazard mitigation activities.
- Implementing disaster information management and decision support systems.
- Improving local preparedness efforts.
- Maintaining a constant high level of preparedness and response capability.

The detailed objectives under the above said theme are:

- Integration of weather data into Geographic Information System
- Transformation of all weather data to "GIS negotiable" formats

?? Acquisition of satellite images in standard projections
?? Web enabled GIS
?? Publish the data on the web that is accessible to the managers, decision makers readily available and around the clock.
?? Dynamic linking
?? Dynamic linking of weather data to see real time scenarios and predict the destructiveness of natural disasters.

2 METHODOLOGY, DATA USED, RESULTS AND DISCUSSIONS:

2.1 Study Area:

The study area exists between Latitude 8?00’ to 36?00’ and Longitude 68?00' to 96?00' covers all the states in India.

Limitations: Data is not available at micro level*.

Another technology that can be added to this mix is the county/city-wide deployment of a network of locally based weather data collection stations. This helps to dynamically link weather data into GIS. Similar to the weather stations commonly seen along highways and on bridges, these automated devices measure wind direction, speed, temperature, humidity, barometric pressure, and even soil moisture and temperature, water level and flow. An advanced GIS-based decision support system can now integrate interactive maps with layers of projected storm paths, as well as real-time, “streaming” weather data giving wind direction and speed.

2.2 MATERIALS AND METHODS

2.2.1 Data Used:

Weather data in GIS negotiable formats that should contain the following layers:

?? Surface winds
?? Surface temperature
?? Rainfall data
?? IMD Warnings
?? Local Radar Network data
?? Dynamic Imagery provided by METSAT

Non-weather layers (ESRI GIS format)

?? States
?? Cities
?? Streets
?? Hospitals (in case of major only)
?? Schools (in case of major only)

2.2.2 Software Used:

?? Arc View and Extensions:
  - Spatial Analyst
  - Tracking Analyst

Figure 1: Weather data ingest, display and product processing flow.

?? ESRI Map objects to develop user friendly GUI.
?? Web enabled GIS (ArcIMS) to publish the weather data on the web.
?? Convert weather data to "GIS negotiable" formats as points, lines, polygons, images and grids.

2.2.3 Methodology:

The following five elements must be demonstrated to develop sophisticated WPS: (Refer to Figure 1)

Display of meteorological data *- Convert weather data to "GIS negotiable" formats as points, lines, polygons, images and grids.*
Customize GIS functionality *- Support conventional weather functionality such as overlay (superposition), contouring, cross sections, and information at cursor.*
Integrate other sources of information *- Provide access to analysis and prediction algorithms,* real-time *interaction with models, and calls to external programs for special functions.*
User friendly interface *- Customization, User Development Toolkit, support for conventional "look and feel", and meteorological character sets. Theme classification can be altered for custom subsetting.*
Dynamic linking and animation - *Intrinsic functions for animation are emerging (3D-Analyst), but can be supplied as call to an external program.*

Display of meteorological data:

The first goal in GIS Meteorology is to convert meteorological data and information to "GIS negotiable" formats. The following table summarizes the relationships of weather data to GIS formats (or shape), but is not intended to be exhaustive. Several examples are provided (some from previous papers). The most notable is that images must be provided in standard projections, and sufficient registration information must be provided in order to construct a World File for each image. Many systems also assume that the satellite image is *the "natural" projection, and maps are transformed to match the greater data volume. Another change relates to data formats and customary business practices within the weather services. There are many formats extant for weather data and products, and weather systems must develop a decoder/encoder pair for each. However, we have found that these products reduce to a few formats, usually defined by geographic coverage, and a message(s) or datum (data array). The data/product format field can be simplified, and the formats could also be simplified.*

Shape	***Weather data type***
point	*Surface obs, rain gage, river gage, pilot reports, model grid point data, lightning,*

	Tropical Cyclone position
line	*Contours, fronts, rivers and river stage, rawinsonde profiles, roads and road conditions, air parcel trajectories*
Polygon	*Radar, watch/warning boxes, area/zone forecasts, plumes (air parcels)*
image	*Satellite images, charts*
grid object	*Intermediate objects for all data on a surface. Surfaces include constant height (e.g. MSL), constant pressure (isobaric), and constant potential temperature (isentropic).*

Customize GIS functionality

The arrival of ESRI Spatial Analyst opened the way for serious meteorological analysis, substantially reducing our need to call external functions. Various conventional meteorological procedures were prototyped. Remote Sensing plays an important role in data acquisition and processing. Procedures demonstrated include:

Cloud Data *- Infrared image raster data are converted to a grid, calibrated for radiance, and then transformed to cloud top temperature. Independent information on atmospheric temperature variation with height allows conversion of brightness temperature to geopotential height (meters above MSL). The resulting grid is essentially a "DTM" of cloud tops. This capability is relevant to the analysis of Tropical Cyclone character.*
Surface Analysis *- Atmospheric soundings from rawinsondes (plus satellite and aircraft observations) are used to estimate the Montgomery Stream Function (MSF) on a surface of constant potential temperature. Note that ArcView is well suited to calculating the actual geographic locations of the balloons (they move during ascent to 100 mb and above). Contours of MSF on this surface can be used to calculate isentropic air parcel trajectories.*
Satellite Data *- Selected multi-spectral images from Polar and Geostationary satellites can be arithmetically combined to estimate "soundings" of meteorological parameters (e.g. Temperature) and trace species (e.g. water vapor). The trick is knowing which coefficients are best in the (usually linear) combination of brightness temperatures.*
Integrate other sources of information
It became obvious to us that the typical GIS-based systems architecture should be redesigned to account for the streamlining gained through our prototyping with external interfaces (DDEs and RPCs). This modification demonstrates the similarity of external algorithms, models, and other support functions. The closed loop from data ingest (1), to user interaction (2), to analysis and simulation/modeling (3), is commonly known as the "data assimilation cycle" (4).

User friendly interface

We have an informal list of terms which are commonly used by meteorolgists, but which are known by a different name to those more familiar with GIS. For example, an ArcView "theme" is known as an "overlay" to IMD field personnel familiar with WPS (s weather processing system). Classification of a theme in ArcView is close to "enhancement" of an image by meteorologists, but there is little corollary for older weather systems. Most of our GIS effort supporting the IMD Modernization concerns the development of map databases. Such databases include IMD forecast zones, marine zones, time zones, political boundaries, etc. We have to select ESRI Shapefile ™ to provide map "backgrounds", which are considered to be "static" and fundamentally different from the "dynamic" hydromet data which are so important to all of us.

Dynamic linking and animation

Animation is a key function for weather display and analysis systems. It is clear that ESRI could support animation using frame sequencing, but such a capability would be unique to each hardware platform. Commercial frame animation software is also available, but there remains the issue of coupling the ArcView View object with the animation page or frame.

3.0 RESULTS AND DISCUSSIONS:

3.1 Results:

A sophisticated WPS that will protect people, property and businesses, managers in our largest metro areas face challenges and threats more complex than ever. More often than not, weather is at the heart of any given emergency, and government officials need the best information possible to prepare for the impact of a severe weather event and to support future and long-term city planning issues

3.2 Summary:

By integrating real-time weather information into a GIS-based decision support system, and utilizing advanced software tools for storm tracking, hazard prediction and consequence assessment, today's decision makers or managers are technologically prepared to make better and faster decisions which can reduce disaster costs, minimize loss of life, and improve preparedness against natural and technological disasters.

3.3.Future considerations:

In the future, it is possible to envisage a suite of tools that could support MEAs such as Kyoto. The Remote Sensing component would include a constellation of optical,LIDAR and radar instruments, flying roughly in formation that would collect data simultaneously over the same land areas. These would need to be operational, with a commitment to long-term data provision. These would be linked, in turn, with in situ observations (for ground-truthing), improved estimates of biomass stocks, and to models that would integrate the Remote Sensing data and provide some predictive capacity regarding future land-use changes and their relationship to emissions and concentrations of GHGs.

4.0 References

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