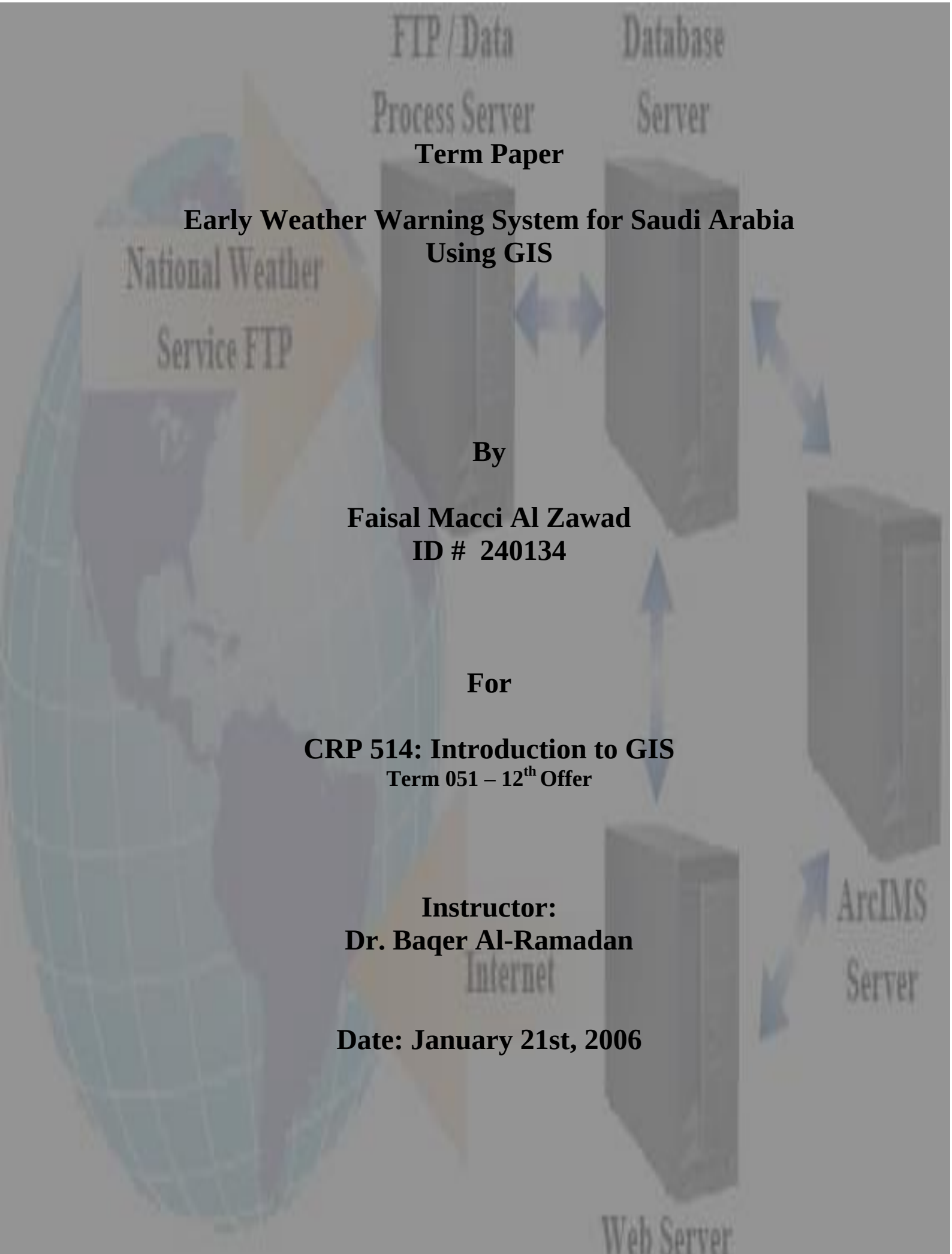

Term Paper

Early Weather Warning System for Saudi Arabia Using GIS

By

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For

CRP 514: Introduction to GIS
Term 051 – 12th Offer

Instructor:
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Date: January 21st, 2006

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1. Abstract

This paper describes a proposal for a new Early Warning system to replace the current system that was installed in the year 2000 and based at Presidency of Meteorology and the Environment (PME) headquarters at Jeddah. Adapting Geographic Information System will improve the quality and capability of the warning system to save lives, and properties. Weather – enabled GIS is proven to be essential to emergency managers. GIS allows the manger to learn about the weather threatened area, and know the total number of people affected, the affected schools or governmental buildings, and other significant information. ArcInfo can be used as a Weather Processing System.

2. Introduction

2.1 Current State of PME Early Warning:

Presidency of Meteorology and Environment issues short-term (few hours) warning through its official web site (www.pme.gov.sa). The warning consists of three different levels of its severity and closeness to occur. Those level are given three different colors: (1) green: for weather watch only, (2) blue: to be cautious of a threatening weather, (3) red: for warning. The warning is handled manually then published on the internet. A designated forecaster will draw on a map of Saudi Arabia to highlight the affected area and link it to the proper color. When there is a warning over any region in Saudi Arabia, a blinking icon with an appropriate color will indicate the stage of the particular warning. Clicking on the blinking icon will show a map or maps that show affected areas (figure2).

Beside this task the Early Warning System provides current and expected weather charts, and radar images that show cloud's reflectivity.

Analysis of temperature, sea level pressure, wind speed and direction, dew points, and other weather elements and phenomena can be adopted easily by GIS with more capability of bringing clear and sound products.

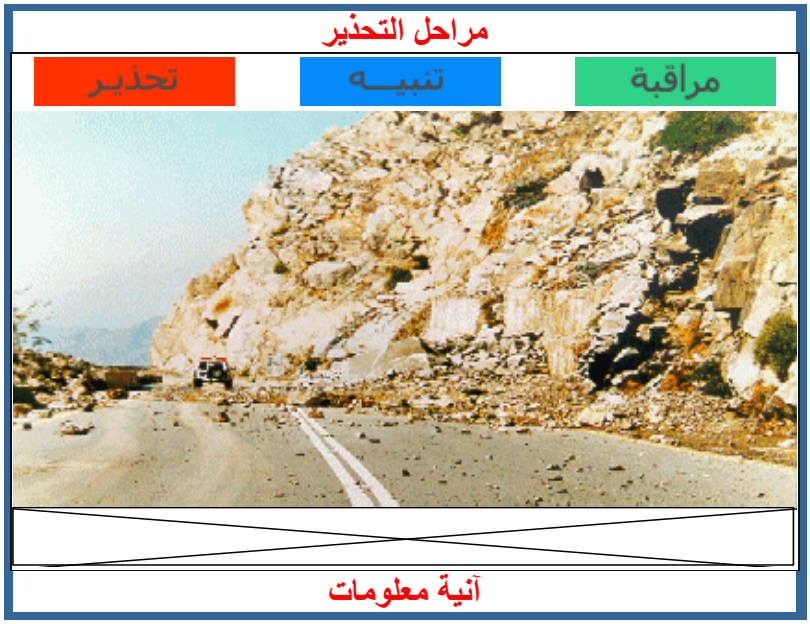

figure1: shows the PME Early Warning System, initiated on the year 2000, as it appears on official PME web site (www.pme.gov.sa).

figure2: A page linked to the green icon of the current Early Weather System on January 07, 2006. The two maps represent the affected areas by the issued Thunderstorm warning. The proposed new Early Warning System will use GIS capability to produce more informative maps.

2.2 **Meteorological Data:**

There are many sources for meteorological data: surface observations, upper air data through rawinsonde measurements in which a helium gas filled balloon carries a small box containing weather elements sensors to upper atmosphere that communicate with a ground PC by digital signals, radar reflectivity and satellite imagery. The data carries information about temperature, pressure, wind, humidity and weather phenomena like thunderstorm, sand storm, rain, fog, and various weather conditions. Weather plays an important part of our lives. Knowing precise locations of weather related danger will protect lives, property, and businesses. The fact that weather is geographically located, brings GIS technology into the picture. GIS allows the user to geo-locate weather information with created layers that contain important infrastructure such as schools, streets, government offices, population. This will show needed details about the danger evolved with the emergency situation.

3. Problem Statement

The current Early Warning System will issue a warning over a province or a big region of Saudi Arabia, and this call for a need to be more precise information. A military air base is after the location of the center of a thunderstorm to avoid potential danger of transferring ammunitions. A detailed warning that specifies, besides weather information, affected roads, buildings, schools, and the number of affected population will be critical to be better prepared and protect life and property.

4. Objectives

Replacing the current PME Early Warning System by GIS-based technology. GIS can display Early Warning System and current weather information with more precise information and better resolution. This will minimize loss of life and property.

5. Methodology

GIS display of meteorological data requires managing the data as points, lines and polygons. Surface observations are examples of point data and their attribute tables will include all meteorological information received from the observation stations besides their names, locations, time of observation, and identification numbers assigned by the World Meteorological Organization of the United Nations. Paths of tornados, streets, rivers are examples of line data. Radar reflectivity, warning are examples of polygon data. A layer of surface observations will be shown on a map of Saudi Arabia and by using the identification icon of GIS tools, weather information will be revealed.

Using GIS as a Weather Processing System (WPS) requires the use of a prototype GIS/WPS developed by ESRI. Servers based on GIS/WPS prototype to handle heavy loads on the internet with easy to use Graphic User Interface are already on the market (Shipley, Graffman, Beddoe, 1996). User friendly interface is to be used to prepare weather information and link it to the internet, and also can allow interactions with other users over the internet.

The basic steps required to update the current Early Weather System are:

1. PME forecasters to get familiar with GIS User Interface and basic GIS functions.
2. Using GIS and Operating System tools to study current and future weather situation.
3. Using GIS to analyze and manipulate meteorological data including Satellite imagery, and RADAR reflectivity.
4. Using GIS tools, an appropriate polygon representing a particular weather-threatened area is drawn on a previously prepared map of Saudi Arabia.
5. Using GIS Bookmark to represent more detailed map for the affected area. Depending on availability of information, GIS will create proper layers; for example, the affected number of population and the number of affected schools or important governmental buildings can be included in addition to the occurring weather phenomenon.

6. Study Limitations

Digitized data is not available at high resolution level in Saudi Arabia. For example, information about schools, city population, streets are not available in GIS format.

7. Review of Literature

It was shown that GIS can be used as a Weather Processing System (Shipley, Graffman, Beddoe, 1996). ESRI ArcInfo version 7.0.3 and Arc View 2.0 were used to display and analyze weather data. A sample polygon representation for weather radar is shown in figure2. An interactive Graphical User Interface (GUI) toolkits are standard components in ArcInfo and Ark View. ESRI ARC Macro Language (AML) can be used as an object oriented programming.

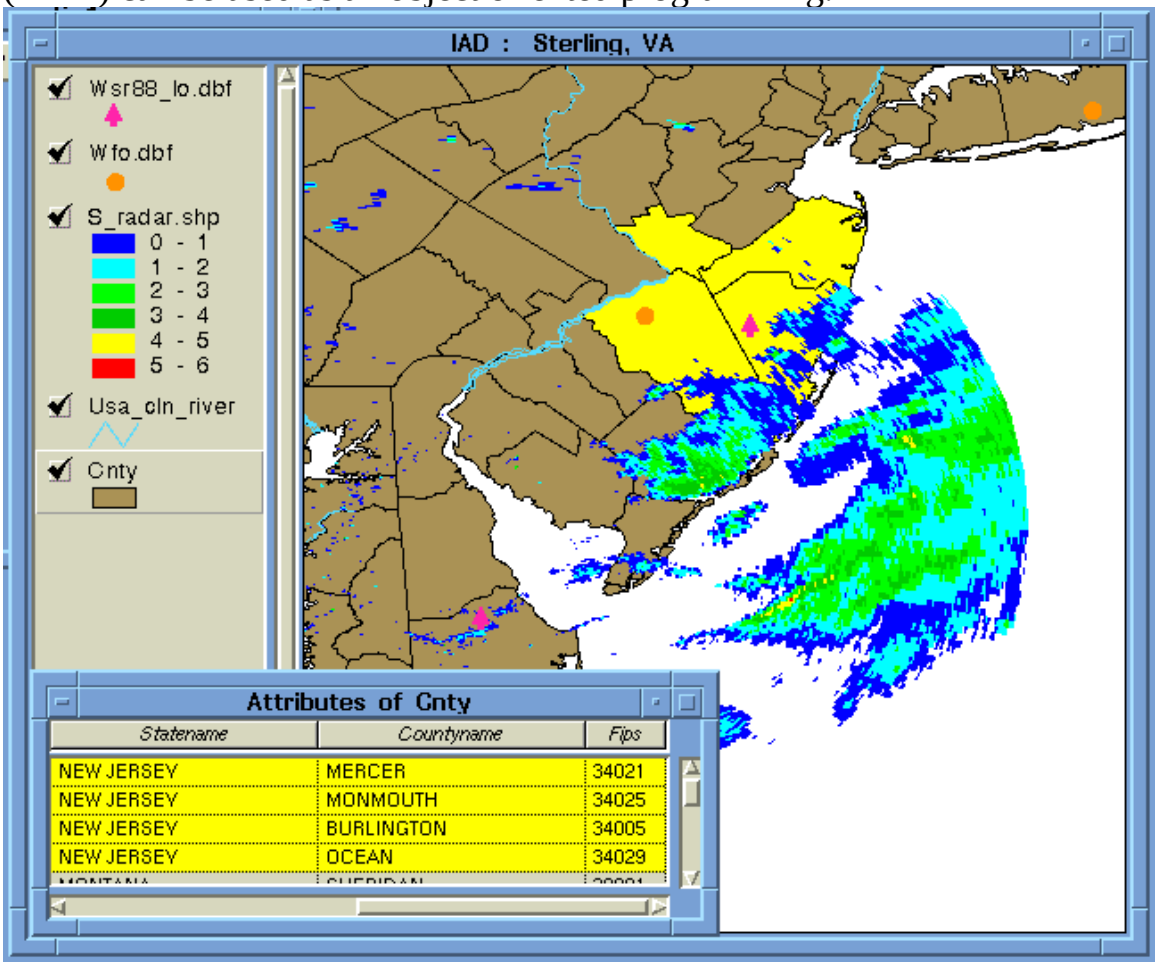

figure3: Radar reflectivity is plotted, and county records as an attributes of county is also shown.

There are several successful GIS projects and applications at many of the US National Weather Service offices across the Southern Region

(Stellman, Welch, Love, Mckee, Atwell, 2005) including the Lower Mississippi, Arkansas, and Southern River Forecast Centers. A detailed description of the graphical severe weather warning system at Dallas / Fort Worth National Weather Service office is presented in (Bunting, Bucklew, Kirkwood, Rae, 2005). Those applications are very much suitable to the offices of Saudi Arabia National Center for Meteorology and the Environment (PME Forecast offices) because it requires GIS software, a software called WARNGEN, and the use of programming languages compatible with GIS like Visual Basics and Java. The idea is to use the software WARNGEN to generate a polygon on a GIS map representing the area under severe weather threat coded by different colors. Clicking on a certain color will take you to a detailed map containing the specific location of severe weather with demographic information on the total population inside the warning polygon, the percentage of the population sex, age , marital status, type of homes affected, and other information related to the population at risk (figure4).

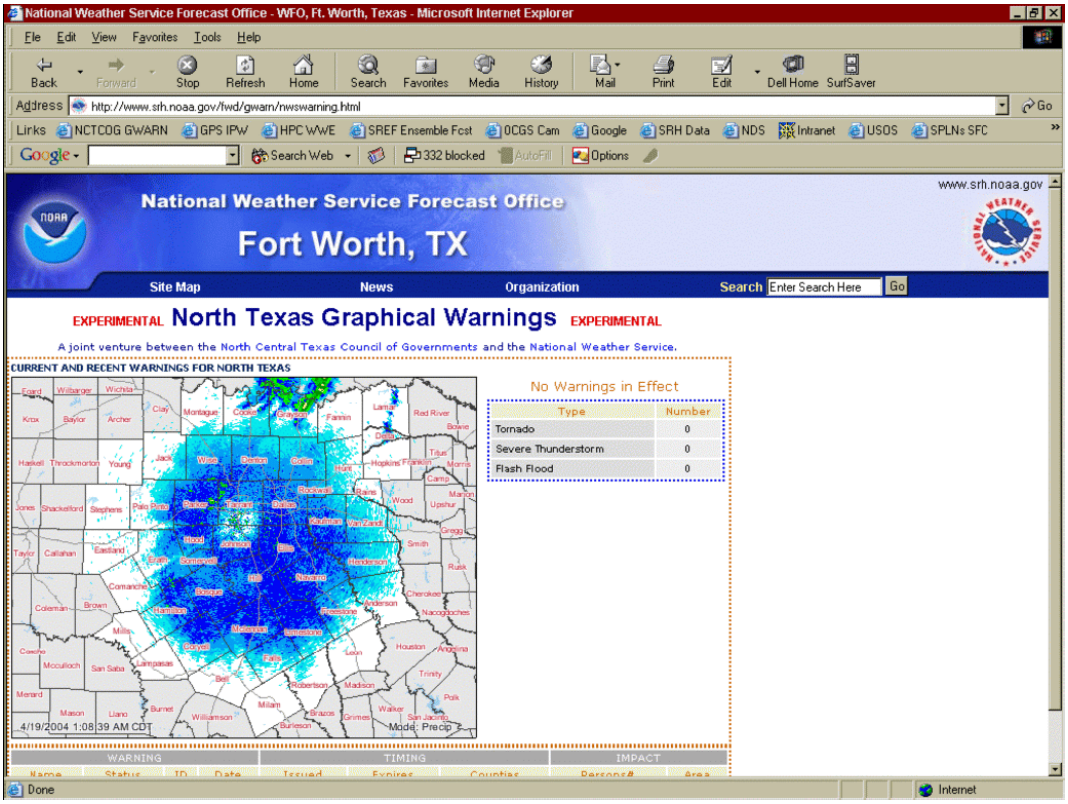

figure4: Graphical Severe Weather Warning overview page showing current radar reflectivity data.

An example of a tornado warning for Palo Pinto and Parker Counties in North Texas is presented in figure4. Notice the detailed information about the population at risk: their total number, percentage of type of homes the live in, the percentage of their spoken languages, the percentage of urban or rural areas affected, and the percentage of population not living in Texas in 1995.

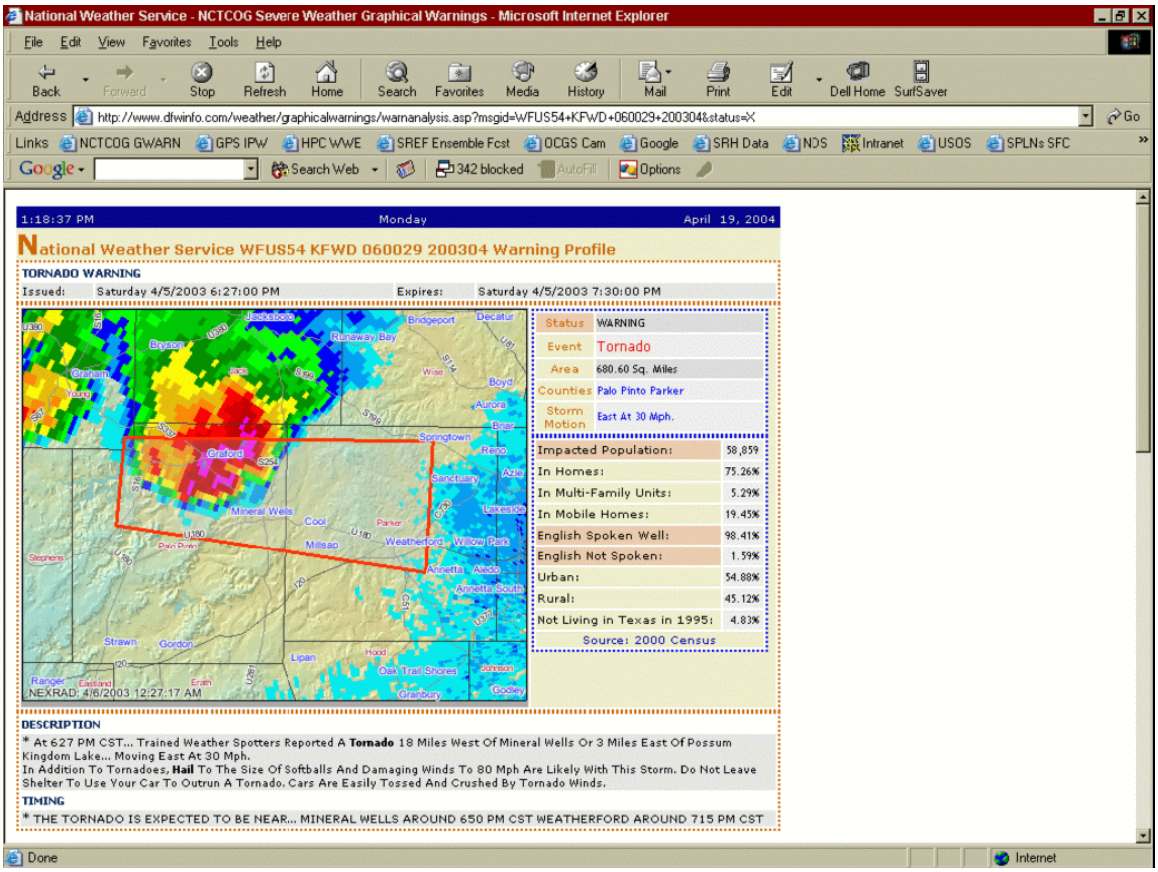

figure5: Graphical Severe Weather Warning for a tornado warning for Palo Pinto and Parker Counties in North Texas.

There is a special course taught every year since 1991 at George Mason University, Fairfax, VA, Department of Geography, about applying GIS into meteorology (Shipley, 2005). The course is titled "GEOG 309, Climate & Meteorology" and is maintained online at http://geog.gmu.edu/classes/geog309/g309.htm. It helps undergraduate students get familiar with various GIS applications in meteorology; from examining weather data using GIS and Operating System tools to importing raw (not GIS-Ready) weather data into GIS (figure6).

figure6: The GEOG 309 class of 2005, Spring Semester, at George Mason University. Equipments used are 27 XP workstations, preloaded with ESRI and other GIS software, each connected to a local network and the Internet. The AV Control Panel supports 28th XP workstation, VHS, DVD, and a document projection system besides the instructor's laptop.

A recent study (Chape, Richardson, Lambert, Welsh, 2005) shows that the estimating of rain rates over roadways using GIS and the weather Doppler radar WSR-88D level-2 is promising. This means that forecasters will be able to make more specific and accurate weather warning with GIS aid (figure7). GIS is helping to build a real-time automated driver safety system with the use of doppler radars that are already available in some regions in Saudi Arabia and PME is in the process of completing a national Doppler radar system that will cover all Saudi Arabia. This is a big advantage to the proposed new Early Weather System as it can includes rainfall monitoring system that will warn drivers of heavy rainfalls on certain highway segments. What a plus sign this will be for the driving safety in Saudi Arabia.

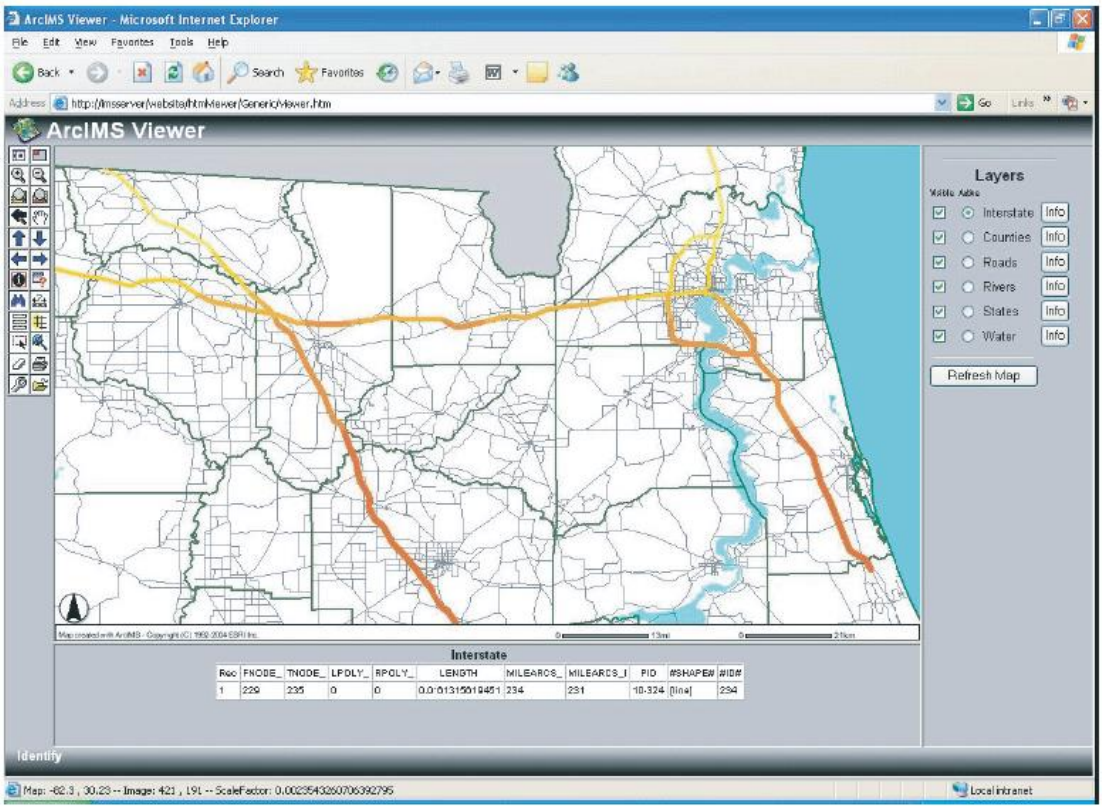

figure7: A prototype of ArcIMS application was developed for display of near real time precipitation volume.

8. Conclusions & Recommendations

PME is responsible in getting the best information about weather and represent it to the public and decision makers in the country. Also, during Al Haj a detailed weather forecast is urgently needed as more than two millions moslims from all around the world gather at Mecca. PME has an Early Warning System on the internet that is available to the public. Integrating GIS to the current Early Warning System will enhance its benefits and will be fruitfall to emergency managers, public officials, newspapers and television, and general public.

9. References & Appendices

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