DIS/CE/10

Urban Flash Flood Monitoring System –

Prototype Development

FY 2005 Proposal to the NOAA HPCC Program

September 13, 2004

| Title Page | Proposed Project | Budget Page |

Principal Investigator: **Kenneth Howard**

Line Organization: NSSL
Routing Code: OAR
Address:

National Severe Storms Laboratory
1313 Halley Circle

Norman, OK 73069

Phone: (405) 366-0500
Fax: (405) 366-0513
E-mail Address: Kenneth.howard@noaa.gov

Mary Mullusky
National Weather Service

Mary.Mullusky@noaa.gov

Paul Biron
Federal Aviation Administration

Paul.biron@faa.gov

Jian Zhang
CIMMS, University of Oklahoma

Jian.Zhang@ou.edu

Proposal Theme: **Disaster Planning, Mitigation, Response and Recovery**

Funding Summary:

______________________	______________________	*Signature 3 (optional)*
Kenneth Howard	James Kimpel	Authorizing Official 2
Research Meteorologist	Director	Title
NSSL	NSSL	Organization

<u>Urban Flash Flood Monitoring System – Prototype Development</u>

Proposal for FY 2005 HPCC Funding

Prepared by: Kenneth Howard

Executive Summary:

The economic and social impact of heavy precipitation resulting in flash floods is increasing amongst US major metropolitan areas as evidenced by the recent hurricane events of 2004. The complex nature of the cityscape and its hydrologic characteristics (streets, bridges, diversion canals, impenetrable surfaces, etc) is problematic to flash flood identification and prediction. Flash flood monitoring over large cities requires improved metrological surveillance on small time and space scales as well as integrated coupling with high resolution GIS representation of the city landscape.

This multi-Line Office, university and private sector collaboration proposes to develop and bring to first prototype an Urban Flash Flood Monitoring System (UFFMS). The UFFMS will integrate high resolution Terminal Doppler Weather Radar (TDWR) data with advance precipitation estimation applications, coupled with high resolution GIS information, to produce accurate identification of flash flood potential within an urban landscape. We propose to create, deploy, and evaluate the UFFMS as an aid to NWS forecasters for flash flood warnings in three major cities. The UFFMS prototype, if successful, could serve as the basis for an operational system within 26 of the largest US cities (those that have TDWR radars) to reduce the potential for loss of life and property damage in urban catchments.

This proposal is national in scope and leverages previously funded HPCC projects, including the CRAFT proposal that helped provide free access to the national network of WSR-88D radar data in real time. The UFFMS prototype will utilize the Abilene Internet2 network data distribution for accessing the high-resolution radar data.

Problem Statement:

Major cities and associated urban corridors are subject to an increased risk of flash flooding. The amount of rainfall necessary to induce a flash flood is much less over city a landscape in comparison to a surrounding region. The complex hydrologic characteristics of major metropolitan areas increase the difficulty to produce useful flash flood predictions in terms of timing, and the spatial and temporal distribution of the runoff. Further, the current WSR-88Ds systems do not provide the adequate resolution required for monitoring rainfall over major cities. The WSR-88D operates at nominal resolution of 250 m by 1 deg beam widthwith an update of 5-6 minutes. Due to a conical beam shape, rainfall accuracy varies depending on the distance between the radar and the city. The effective resolution of the WSR-88D is insufficient at typical ranges to urban areas to provide the point rainfall accuracy required for urban drainage models. Given the land surface characteristics associated with a major city and the hydrologic nature and response to precipitation, especially intense rainfall, high resolution rainfall estimates coupled with detailed GIS information are required to adequately determine which portion of the city is at highest risk for flooding. An effective system for emergency personal to monitor flash floods conditions specifically requires an integrated approach of coupling high-resolution radar observations with GIS information.

This proposal directly addresses the HPCC theme for disaster planning, mitigation, response and recovery through the development of new tools and applications for assisting emergency management officials and agencies in anticipating and mitigating the impact of severe weather such as flash floods. The proposed urban flash flood system is focused on issues associated with heavy rainfall within a highly-populated urban landscape where damage and deaths can occur in a multitude of ways. For example, the proposed system can assist with determining which low lying areas should be evacuated as well as what roads should be closed and/or the emergency activation of systems for effective storm drainage operations. The proposed system addresses the emergency decision requirements for flash flood warnings by coupling accurate rainfall estimation with high resolution GIS information that reflects the hydrologic response characteristics of major metropolitan areas.

Proposed Solution:

The integration and coupling of both dynamic and static observations is required to facilitate high resolution weather surveillance over major metropolitan areas for flash flood monitoring and prediction. Our proposed solution is to couple the Federal Aviation Administration's Terminal Doppler Radars (TDWR) and NWS's WSR-88D radars on a horizontal grid with a resolution of 250-meters. The high-resolution grid serves as the basis for creating highly accurate estimates of precipitation calibrated with dense gage networks. The precipitation estimates will then be coupled with a high-resolution GIS database specific to individual cities' topography and resulting hydrologic characteristics. Based on the topography, rainfall intensity and drainage network efficiency, the system will identify regions prone to flooding with information being routed to emergency officials directly responsible for evacuation, traffic management and storm sewer routing.

The Federal Aviation Administration terminal Doppler radars (TDWR) were deployed to provide warning capability to major airports for wind shear conditions. The TDWRs are located near 26 of the nation's largest airports, which are collocated with the nations 26 largest cities, and corresponding population centers. Like the WSR-88D, the TDWR data samples are 250 m. Unlike the WSR-88D, the TDWR beam width is 1/2 that of the WSR-88D resulting in higher resolution. The TDWR typically scans near the surface, almost 3 times as often. Most importantly, because the TDWRs are much closer to the urban areas and the lowest elevation angles of the TDWR are typically lower, the TDWR scans much closer to the ground, sometimes as much as ten times closer By using reflectivity data close to the ground, errors in estimates of instantaneous precipitation rates (used in flash flood warnings) are minimized.

The NSSL has been involved in the creation of highly accurate advanced precipitation estimation techniques, which utilize a multi-sensor approach (radar combined with satellite, model and surface observations). All major cities encompass a dense rain gage network of ALERT gages, as well as additional gage networks operated by various city agencies. NSSL will modify current precipitation estimation techniques to ingest ALERT and other gage data sets to produce accurate real time adaptive gage corrected rainfall estimates. The advanced precipitation estimates will be produced at the 250 meter resolution with a 2-3 minute update cycle. By working with city officials, NSSL will then calibrate the precipitation estimates with the landscape characteristic to ascertain thresholds for flash flood identification similar to NWS flash flood guidance values but more deterministic to the characteristics of the city and related hydrologics.

Analysis:

The various components describe in the previous section will be combined into an end-to-end UFFMS prototype run in a quasi-operational mode. The UFFMS will be configured for the cities of Oklahoma City, Phoenix, and Houston. Each of these cities represents different climatic regimes, varying city hydrologic characteristics and encompasses major populations that are within the surveillance umbrella of both a TDWR and WSR-88D. The systems will be executed on a Linux OS cluster located at NSSL. Communications, product dissemination and display protocols will be established with appropriate city agencies for evaluation by each individual cities emergency management agency. The base level radar connections and data feeds will be facilitated through the Abilene Internet2 NWS CRAFT infrastructure. This will minimize the costs associated with communications, hardware and maintenance associated with setting up a prototype system at each city. Communications with the emergency management agency of each city will occur through an internet web interface. The products will be also sent to forecast offices responsible for the city using the AWIPS system (this won't happen).

Performance Measures:

The UFFMS products will be coupled with a real time verification system already developed at NSSL, which will generate skill scores on the precipitation estimates, as well as comparisons to other operational precipitation estimation techniques (PPS, FFMP, MPE, Hydroestimator, etc). Post analysis will be done for three cases for each city that will include details analysis of flash flood occurrences with the accuracy and utilization of products by emergency personal including the city managers and other officials.

Milestones

> **April 2005 –** Establish connection to, and ingest of, TDWRs. NSSL has worked with the FAA to established two base data distribution systems (BDDS) connections for the Phoenix and Oklahoma City TDWRS. We will work with the FAA TDWR Program Support Facility to install a BDDS on the Houston TDWR run UNIDATA LDM

software. Base level data would then be transmitted over the Internet 2 and ingested by NSSL's Linux cluster from all three TDWRS.

Configure and create reflectivity grids combining WSR-88D and TDWR data, including the creation of hybrid scans and other reference data sets used in the quality control of radar and rainfall gage data.

May 2005 – Interface NSSL precipitation estimation applications to high-resolution grid, including creation and testing of run time scripts and ingesting of gage data.   Create products using historical data sets. Establish initial GIS reference data sets and web-based display capabilities.

June 2005 – Disseminate real time products and web-based products to emergency management officials.

October 2005 – Complete case analysis and final report.

Deliverables

List of the final products from this project include

- Deliverable 1 - Full system configuration including software (source code) and run time scripts for the generation of precipitation estimates using a combination of TDWR and WSR-88D reflectivity data (transmitted via Abilene/Internet2) as well dense rain gage network.
- Deliverable 2 - Documentation on system performance, including network performance and case studies performance
- Deliverable 3 – Articulation of recommendations and configurations needed for operational implementation within the NWS networking and computing architecture.