Precipitation Nowcasting

NCAR

Auto-Nowcaster storm initiation nowcast field showing the likelihood for new storm development within the next hour over the United States. Orange colors are highly likely.

State-of-the-Art
The skill of precipitation nowcasting decreases very rapidly in the first hour using basic storm extrapolation techniques. In addition, NWP techniques have insufficient skill to provide suitable, accurate warnings of heavy precipitation on the scale needed for flash flood forecasting. Thus, a heuristic nowcast system called Trident, that blends observations with numerical model analyses, is used to improve upon simple precipitation extrapolation techniques. This is a unique state-of-the-art real-time system that provides explicit prediction of precipitation and warnings of heavy rainfall.

The Trident system automatically assesses the instability of the atmosphere using numerical model analyses and combines this information with observational data sets (radar, satellite, surface stations, soundings, and high-resolution 4-D boundary layer winds) to predict the location and timing of new storm initiation, storm growth and dissipation. This system provides 0-60 min precipitation nowcasts and warning products, updated every minute, with a spatial resolution of 1 km.

Background
The Trident system is a new, revised version of the Auto-Nowcaster system that has been tested and run in selected operational weather services offices over the past 15 years and is currently being tested by the NWS over the CONUS (see figure above). This system was initially developed for the Federal Aviation Administration as a completely automated system. The Auto-Nowcaster system is based on 25 years of research conducted around the world on storm initiation and evolution and has been run during the Sydney and Beijing Olympics. The Trident system has been recently configured to blend synoptic, mesoscale and storm scale information together in a physically meaningful way, to provide high resolution, timely, quantitative prediction of heavy rainfall and warning guidance products for the potential for flash floods. The Trident system has been installed at Taiwan’s Central Weather Bureau for prediction of heavy rainfall over their mountainous terrain and will be a component of the hydrometeorology system being tested along the Colorado Front Range in July-August 2014.

Thunderstorm and Heavy Rainfall Applications
COLORADO FRONT RANGE TESTBED
NCAR is in the process of establishing a testbed along the Front Range of the Colorado Rocky Mountains. This testbed is designed for developing and testing new technologies for inclusion in an end-to-end system for predicting streamflow, with a strong emphasis on high impact weather phenomena such as flash floods and urban street flooding. The Trident system will be run in real-time during the summer of 2014, providing high-resolution (1 km) gridded nowcasts of thunderstorm initiation, growth and heavy rainfall, and high-resolution 4-D wind fields from the Variation Doppler Radar Analysis System (VDRAS) radar data assimilation system.

The end-to-end system will utilize state-of-the-art observations, quantitative precipitation estimation (QPE), quantitative precipitation forecasts (QPF) with radar data assimilation and quantitative precipitation nowcasts (QPN) as input to hydrologic streamflow prediction models. Trident nowcasts have been run for the extreme heavy rainfall and flooding event along the Colorado Front Range in September 2013 indicating areas where 0.5 and 1.0 inches of continued rainfall would occur in the next hour. One of the nowcasts for the Great Colorado Front Range Flood is shown below.

Two hour accumulation of precipitation during the Colorado Flood. Trident 60 min nowcast, indicating regions for an additional 0.5 inch (black contours) and 1.0 inch (blue contours) of precipitation, are overlaid.

continued on reverse side
The Auto-Nowcaster was used during the Beijing Olympics to provide weather forecasters guidance on nowcasting thunderstorm timing and intensity.

U.S. NATIONAL WEATHER SERVICE
In collaboration with the National Weather Service (NWS), the Auto-Nowcaster system has been installed at the Washington D.C./Baltimore, Ft. Worth/Dallas, Melbourne Florida, and Chicago Weather Forecast Offices to provide high-resolution, time and location-specific nowcasts of thunderstorm initiation and evolution. The system was enhanced to include: installation of forecaster-interactive tools on the NWS Advanced Weather Interactive Processing System (AWIPS) enabling the forecasters to modify the nowcasts, for dissemination to end-users, optimization of the system by using different sets of heuristic logic for different weather regimes, and near real-time, continuous statistical evaluation of performance. The NWS demonstration has shown that forecasters play an important role in nowcasting high impact weather in a future where automated forecast processes will increasingly become the norm. The NWS is currently running the Auto-Nowcaster system over the U.S.

BEIJING OLYMPICS
A Forecast Demonstration Project was conducted by the World Meteorological Organization for the 2008 Summer Olympics in Beijing China to demonstrate state-of-the-art nowcast systems. The Auto-Nowcaster was particularly successfully in providing accurate nowcast guidance information for forecasters responsible for relaying thunderstorm nowcast information to the Olympic venues. Particularly important to the success was the development of local heuristic rules that governed the evolution of thunderstorm intensity.

TAIWAN CENTRAL WEATHER BUREAU
The tropical island of Taiwan is extremely vulnerable to flash floods resulting from heavy rain produced by local thunderstorms and by a spectrum of large-scale synoptically forced weather. A particular challenge in accurately predicting the initiation, intensity and duration of rainfall in these regions is correctly accounting for the impact of terrain on storm formation and evolution. In collaboration with CWB, NCAR has installed the Trident system at the Taipei forecast office. Products available for viewing include: gridded 3-hourly precipitation accumulations, precipitation nowcasts, the township heavy precipitation nowcast (warning guidance) product, in 10 minute intervals out to 1-hour, and high-resolution four dimensional, terrain-following winds from the VDRAS.

Advantages
- Runs on one high-performance computer workstation.
- Utilizes single or dual-polarization, radar-based quantitative precipitation estimates
- Includes a 4D-Variational Doppler Radar Analysis System (VDRAS) for assimilation of radar data into a numerical model to produce high-resolution, 4-D boundary layer winds
- Runs in regions of complex terrain
- Modular software for different observational data sets.
- Includes real-time forecaster-interactive tools

Applications
- Prediction of location and intensity of thunderstorms and heavy rainfall
- Prediction of convection initiation and evolution
- Monitoring of cloud growth and cloud top properties
- Storm analysis, tracking, extrapolation and trends
- Tools for building climatology datasets for thunderstorms and heavy rain events
- Algorithm and forecaster tools for tracking gust fronts and wind shear events
- 4-D winds from VDRAS radar data assimilation system
- Tools for near real-time verification of nowcast performance

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