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PCSWMM REAL TIME FLOOD FORECASTING - TORONTO CANADA

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Radar has been used to estimate ground level rainfall for almost as long as radar meteorology has been in existence. Radar data has the advantage of providing enhanced spatial resolution that is useful in large scale hydrologic modeling. However there are limitations to the technology in this application and calibration to rain gage data is generally recommended [4].

Remote sensing by radar involves emitting short bursts of radio waves and recording their reflectivity (echo). Generally, the more water droplets the radio waves encounter, the greater the echo will be. By recording the direction of the beam and the time interval before reflection, a discrete spatial representation of the reflectivity can be determined. Converting this reflectivity into rainfall intensity is commonly performed by applying a Z-R relationship [2].

If rain gage data is available, a second step can be performed to adjust for uniform errors over the entire field. This involves the determination and removal of radar-rainfall bias by some means of calibrating to observed rain gage data. The resulting product is a spatial grid or polar coordinate arrangement of cells, each with a unique rainfall time series. This product can be used in spatial analysis of storm intensity, accumulative rainfall depth, storm cell speed and direction (for forecasting) and/or as input to a dynamic hydrologic/hydraulic model.

Next Generation Radar (NEXRAD) level III data available through the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) provides commonly used weather radar products. Currently there are 160 operational Next Generation Radar (NEXRAD) Doppler radar stations in the US and overseas, operated and maintained by the Weather Surveillance Radar 88 Doppler (WSR-88D) Radar Operations Center (ROC), under a consortium of US. Government agencies.

Nine WSR-88D Level III products in particular lend themselves to small time steps, spatially distributed rainfall time series generation and precipitation forecasting. These include: *Base Reflectivity*, *Digital Hybrid Scan Reflectivity*, *Digital Precipitation Array*, *Digital Precipitation Rate*, *One Hour Precipitation*, and *Storm Tracking Information* products.

Objectives of this ongoing research are to determine the radar products and bias methods that provide the most reliable and accurate rainfall estimates for the Don River watershed in Toronto, Ontario, Canada, a 360km^2 area under the jurisdiction of the Toronto and Region

Conservation Authority (TRCA). Accurate rainfall estimates are required as input to the TRCA's high resolution, deterministic, real-time flood forecasting system. Using PCSWMM Real-Time, NEXRAD radar data, US EPA SWMM5, HTML5 and Google Maps, the system forecasts near-future water surface elevations and relays the information to a single integrated web-based platform for analysis and decision making [3].

In Ontario, watersheds are managed by 36 Conservation Authorities under Ontario Conservation whose jurisdictions coincide with the natural watersheds. For the TRCA, the Buffalo, NY radar station (KBUF) provides complete coverage of their watersheds as well as the surrounding area. Located at the Buffalo International Airport in Erie County at 42°56'26"N, 78°44'08"W, KBUF is approximately 90 km SSE of the southern TRCA watershed boundary, and 154 km SSE of the northern boundary. KBUF has a ground elevation of 211m (693ft), and a tower height of 25m, for a radar dome elevation of 236m (774ft). KBUF historical NEXRAD Level III data is available through the HDSS Access System (HAS) from Feb 23, 1996 onwards (approximately 12 years of data to date).

Three bias correction methods for translating WSR-88D reflectivity rainfall have so far been examined; (a) radar rainfall method (RR), (b) rain gage moving average method (RGMA) and, (c) rain gage values method (RGV). The radar rainfall (RR) method applies the NEXRAD bias estimate obtained from the one-hour surface accumulation product. One hour precipitation (N1P) provides a one-hour rainfall accumulation estimate and is currently used to provide the WSR-88D precipitation processing subsystem (PPS) [1]. Disadvantages of this type of bias method are that the rain gage network used by NEXRAD is not necessarily in proximity to the project site, and the bias factor calculated may not be reflective of the local conditions.

For the Rain Gage Moving Average (RGMA) method, a rain gage network time series is used to calibrate the radar rainfall. This is done by comparing the accumulated rain gage rainfall depth over a user-specified time period (from 1 to 24 hours duration) to the accumulated depth over the same period computed by the radar rainfall processing [1]. From there the radar rainfall is multiplied by the difference, known as the bias, to calculate ground-truthed radar rainfall.

Similar to the RGMA method the Rain Gage Values (RGV) method uses a rain gage network time series to calibrate the radar rainfall to calculate a bias. Instead of comparing the rainfall totals over a user-specified time period, the bias is determined by comparing the average rain gage rainfall for each scan interval to the average rainfall depth computed using the radar rainfall processing [1].

Advances in technology have led to the development of detailed high resolution rainfall for use in historical analysis and flood warning systems. This paper discusses WSR-88D radar and compares three different radar processing methods: the RR method, the RGMA method and the RGV method. Using these processing methods to examine a variety of NOAA NEXRAD radar products, multiple significant events between 2008 and 2013 are evaluated for forecasting in the Don River watershed. Inflow hydrographs calculated using an existing SWMM5 model for the Don River Watershed and radar rainfall scenarios are also presented.

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