Geo-statistical approach to compare radar estimated precipitation data and conventional surface rain gauge measurements - A case study for Humber Watershed

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Introduction

Today, there is a considerable interest in real time precipitation information derived from radar over the conventional rainfall gauges in operational forecasting. Even though the operational implementation is relatively slow, radar produces real time, spatially and temporally continuous data over a large area that enhance the operational flood forecasting (Wilson and Brandes, 1979). Conventional gauge methods require dense rain gauges which is not practical due to installation and operational cost. Moreover, widely used spatial interpolation techniques induce errors. Radar-precipitation is calculated based on the both scattering and attenuation of microwave by precipitation targets. Even though the radar estimated precipitation data have been used for nearly 30 years in model simulations, use of radar data as an input for hydrologic models is still controversial mainly due to the errors incorporated by,

- Variability of drop size distribution
- Attenuation
- Ground clutter
- Radar miscalibration
- Radome wetting
- Partial beam blocking
- Beam filling etc.

Even though several studies directly compare the precipitation data estimated from radar and rain gauges along with model simulations, ultimate conclusions are controversial (Bedient et al., 2000; Kalin and Hantush, 2006; Knebl et al., 2005; Neary et al., 2004). Therefore it is vital to compare radar estimated precipitation and rain gauge measurements to provide optimal precipitation data for hydrological models.

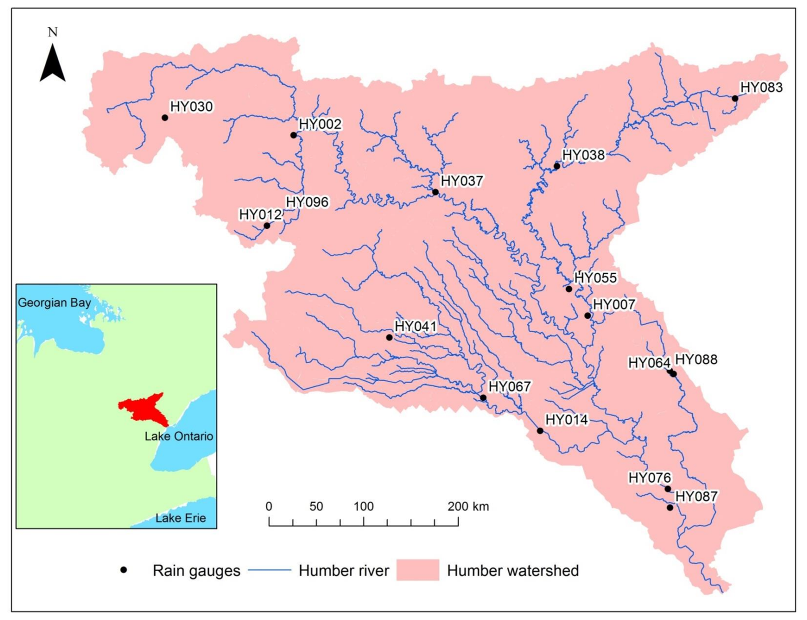
Objective

Geo-statistical comparison of radar estimated precipitation vs. gauge measured precipitation and model simulations using both radar and gauge measurements

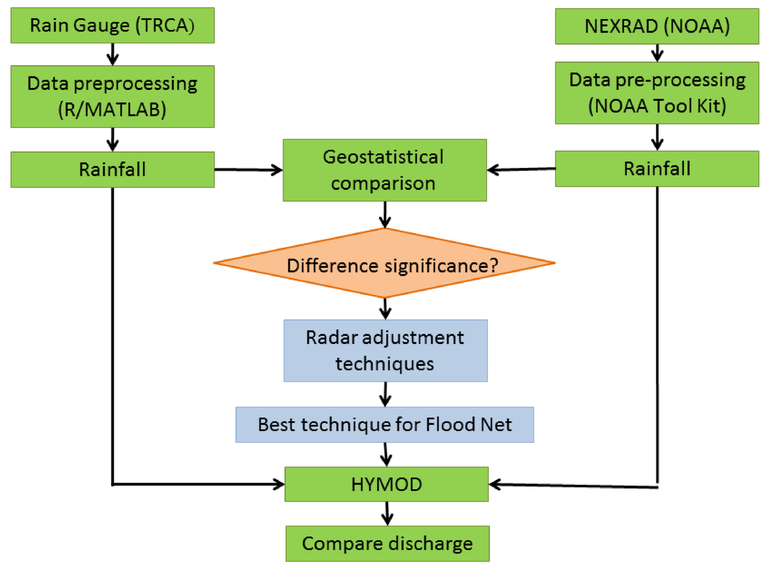
Data

- Rain gauge data - Toronto and Region Conservation (TRCA) (2009-2012)
- NEXRAD data - NOAA (National Centers for Environmental Information)
- Discharge – Environment Canada

Study Area



Methods



Geo-statistical comparison

- The ratio of gauge (G) and radar (R) depth estimate
  - G/R < 1 - radar over estimate
  - G/R > 1 - radar under estimate
- Parametric deviance measures
  - Average difference
  - Average difference (storm bias removed)
  - Mean Absolute Error (MAE)
  - Root Mean Square Error (RMSE)
  - Correlation coefficient (r)
- Non parametric
  - Wilcoxon signed rank test

Dimensionless indices

- Nash-Sutcliffe Efficiency index (NS)
- Modified index of agreement (md)
- Kling-Gupta Efficiency (KGE)

Preliminary results

Gauge vs. radar comparison

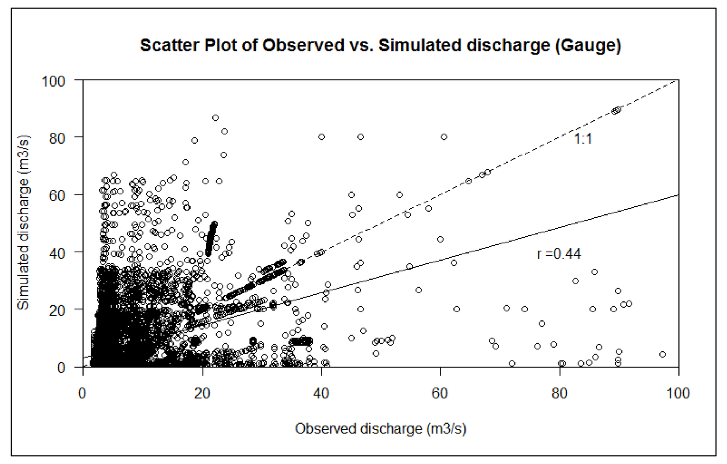
The ratio of gauge (G) and radar depth (R) varies from 0.3 to 1.7

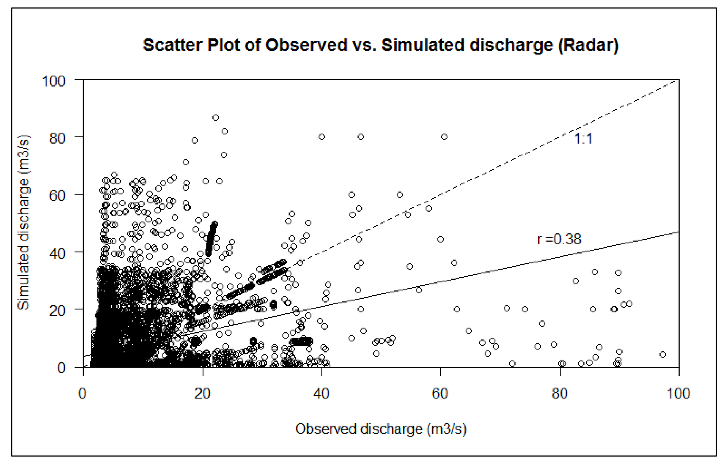
Wilcoxon rank test p-value = 0.0325

Statistical parameter	Precipitation	
	Gauge	Radar
Mean	1.7	1.5
Average difference (%)	32	
Average difference (storm bias removed) (%)	20.5	
MAE	0.4	
RMSE	1.0	

Gauge vs. radar model simulations

Visual interpretation of model simulations





Quantitative/Statistical analysis and indices of model simulation results

Statistical parameter	Radar		Gauge	
	Observed	Simulated	Observed	Simulated
Mean	7.468	6.963	7.109	6.948
MAE	6.04		5.69	
RMSE	11.38		10.38	
NS	0.15		0.25	
md	0.22		0.25	
KGE	0.26		0.37	

Conclusions

- There is a significant difference between means of gauge and radar estimated precipitations
- The correlation between observed and simulated discharge is relatively higher for gauge estimated precipitation than radar
- Radar adjustment techniques can be used to adjust the radar data to match with gauge measurements before using radar data as precipitation input for hydrological models to predict real time flash floods

Limitations

- Even though resolution is good, the time period used for the study is not sufficient
- Input radar data itself include many uncertainties
- HYMOD is a simple lumped model and spatial variability is not taken into account
- Optimized parameters for the model run were obtained using Monte Carlo simulation

Recommendations

- Radar data should be corrected using different radar adjustment techniques before using them as precipitation inputs
- More robust method such as Particle Swarm Optimization (PSO) method should be used to estimate the optimized parameter value during calibration
- Complex distributed model should be used for model simulations
- Automated techniques using different programming languages should be implemented to preprocess the radar data

References

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