Innovative method to monitor groundwater and surface water interactions

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Introduction

- The frequency and magnitude of hydrological extreme events are likely to increase under climate change[1]. Groundwater and surface water interactions occur in a short time period after such events, which can be difficult to predict and capture.
- In remote areas, manual data collection and equipment maintenance can be particularly difficult.
- Critical time-sensitive information is often missed in these situations. Incomplete data can lead to inappropriate conclusions and decisions in water management and environmental assessment.

Therefore, an innovative method to collect timely data to monitor extreme meteorological event and different aspects of the transient water cycle is needed.

Objectives

- Develop a smart data logging system that supports communication between the home station and sensors and can respond to hydrological events.
- Identify key hydraulic parameters that are related to groundwater and surface water interactions under extreme events and determine thresholds for these parameters.
- Design a series of algorithms to recognize both hydrological and meteorological events that trigger specific data collection.

Study Area

Alder creek, a subwatershed of Grand River in southern Ontario. It is well instrumented and monitored by UW and Region of Waterloo.

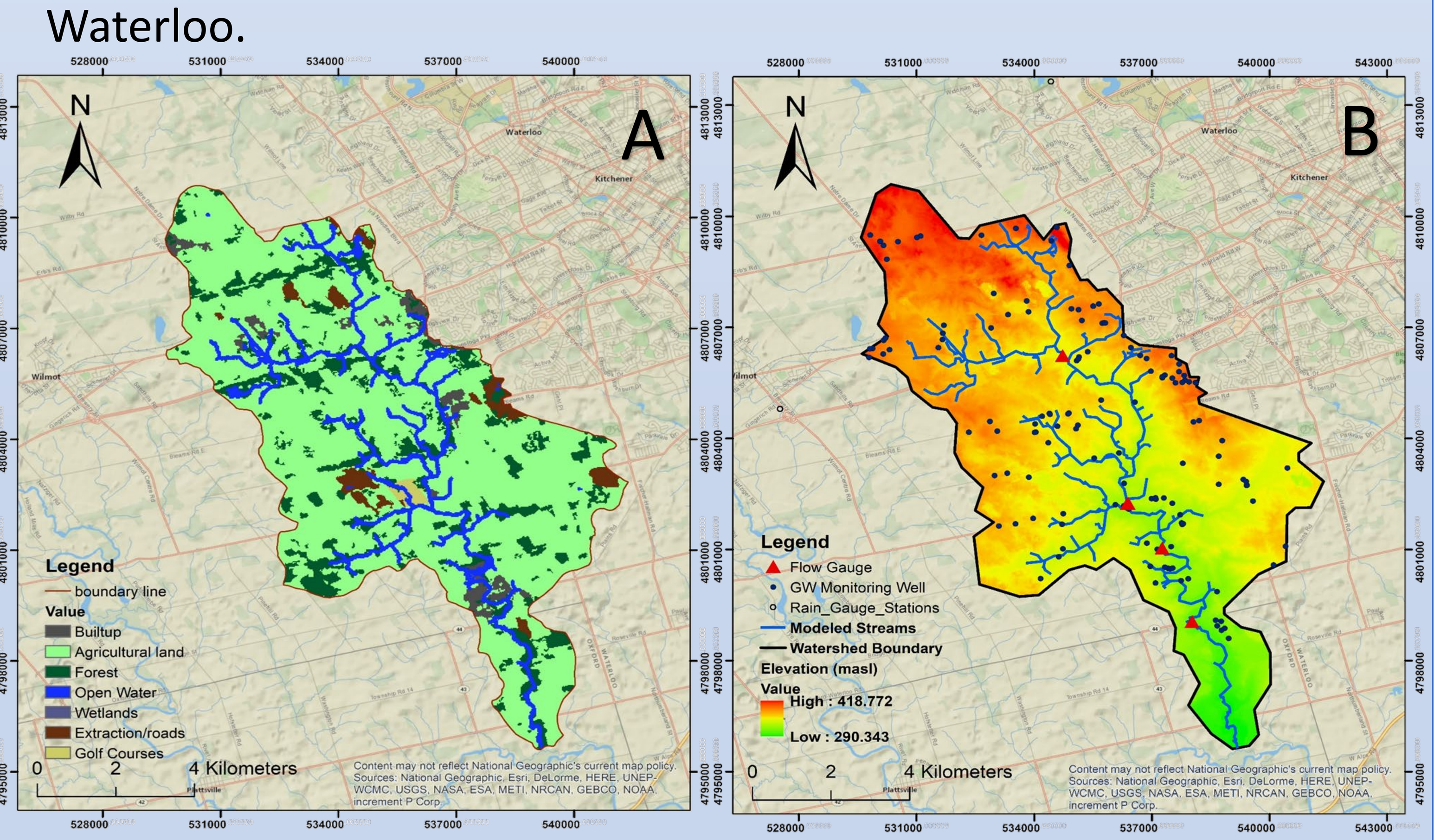

Figure 1: A. Landuse map of Alder Creek watershed. B. Topography map of Alder Creek watershed showing Region of Waterloo monitoring well locations and flow gauges (Data from Grand River Conservation Authority, Ontario Ministry of Natural Resources and Forestry, Grand River Conservation Authority.)

Study Approach

A smart datalogging platform - Integrated Watershed Telemetry System (iWT) is developed and tested in cooperation with Solinst Ltd.

- Two-way communication between sensors and the home station datalogging system.
- Update monitoring protocols in response to trigger events
- Real-time data transmission through cell or satellite systems

Highlighted functions:

- Report sensor status in real-time.
- Capture critical and temporal events.
- Provides decision makers with immediate information in order to support near real-time decisions.

Hypothesized trigger events and system reactions:

Precipitation Rainfall intensity, Snow depth, cumulative precipitation…	**Temperature** Ground Temp., Diurnal temperature range (DTR)
Visual Recognition Visual Recognition Technology with on-site camera	**GW Temp. and Level** 'Lagging' Triggers

Triggers →

- Change in data collection frequency
- Trigger sampling
- Real time warning
- …

Trigger/Threshold Establishment:

An example case study is set up near Mannheim, ON, within Alder creak watershed. Key hydrological and meteorological data were collected over years and analyzed to determine triggers and thresholds.

Figure 2: Map of Mannheim site. Modified by A. Wiebe and K. Qin[2]. Picture credit to A. Wiebe.

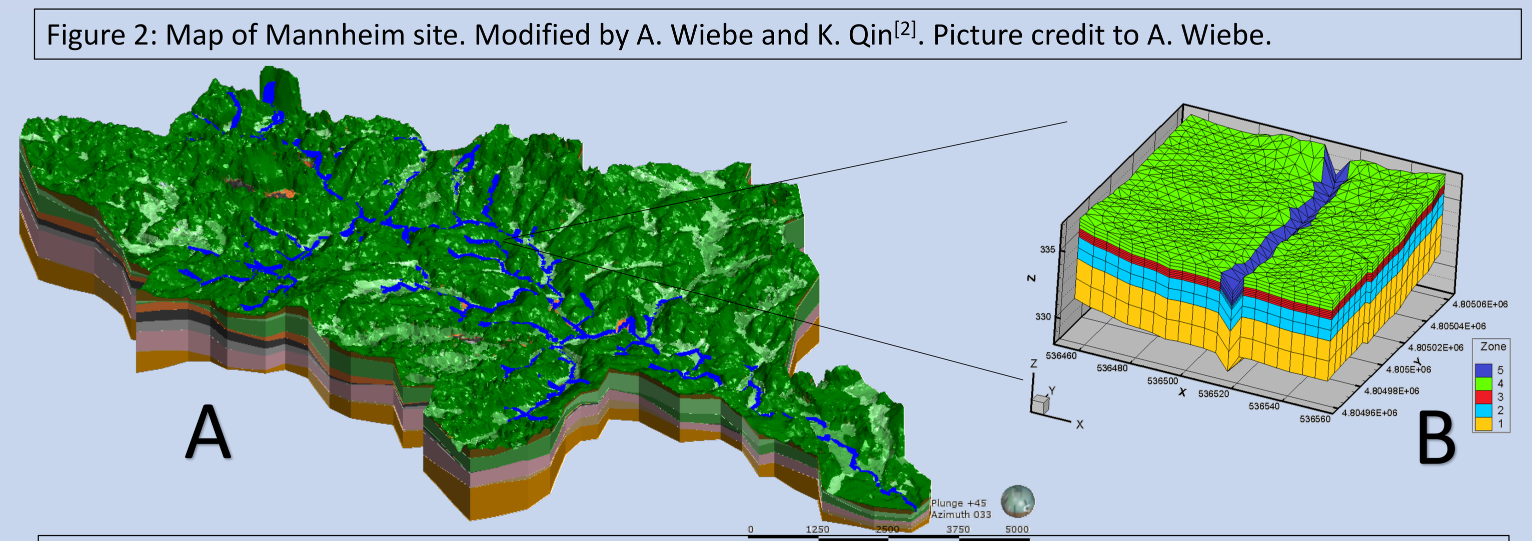

Figure 3: A. Rendered model screen shot using Leapfrog showing topography, surface water and stratigraphy of Alder Creek watershed. B. 200m by 200m grid of Mannheim site built in HGS(credit: A. Wiebe).

Results

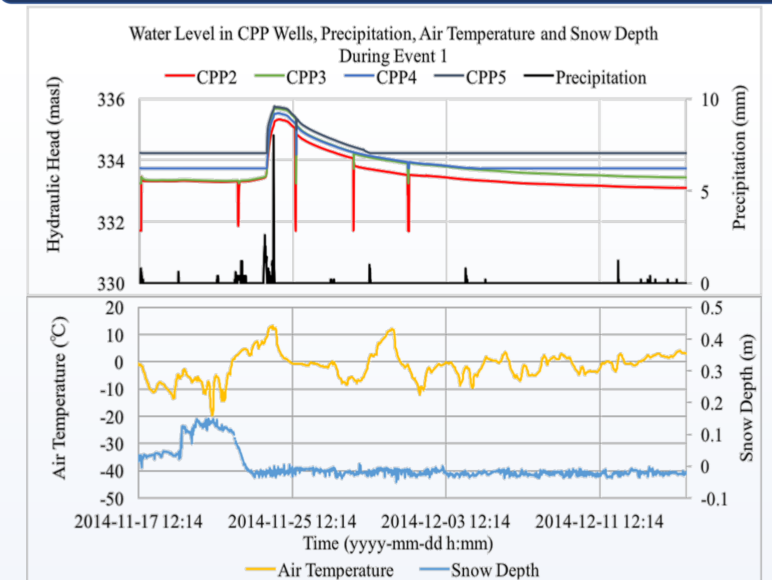

Figure 4: Water level in CPP wells, precipitation, air temperature, and snow depth during Event 1.

Identified triggers and thresholds:

Trigger Events	Threshold
Precipitation	>1.2 mm/15 min OR >3.4 mm/2 h
Snow Melting	Snow Depth Decrease>18 mm/4 h AND Air Temperature>0℃ for>4 h AND Air Temperature >4.3℃
Groundwater Level Increase	>0.45 mm/2 h
Groundwater Temperature Decrease	>0.0625℃/4 h

Trigger events that are beneath the threshold is excluded as noise. Remaining are identified as 'significant' events. The effectiveness is examined by overlaying them with observed GW recharge events.

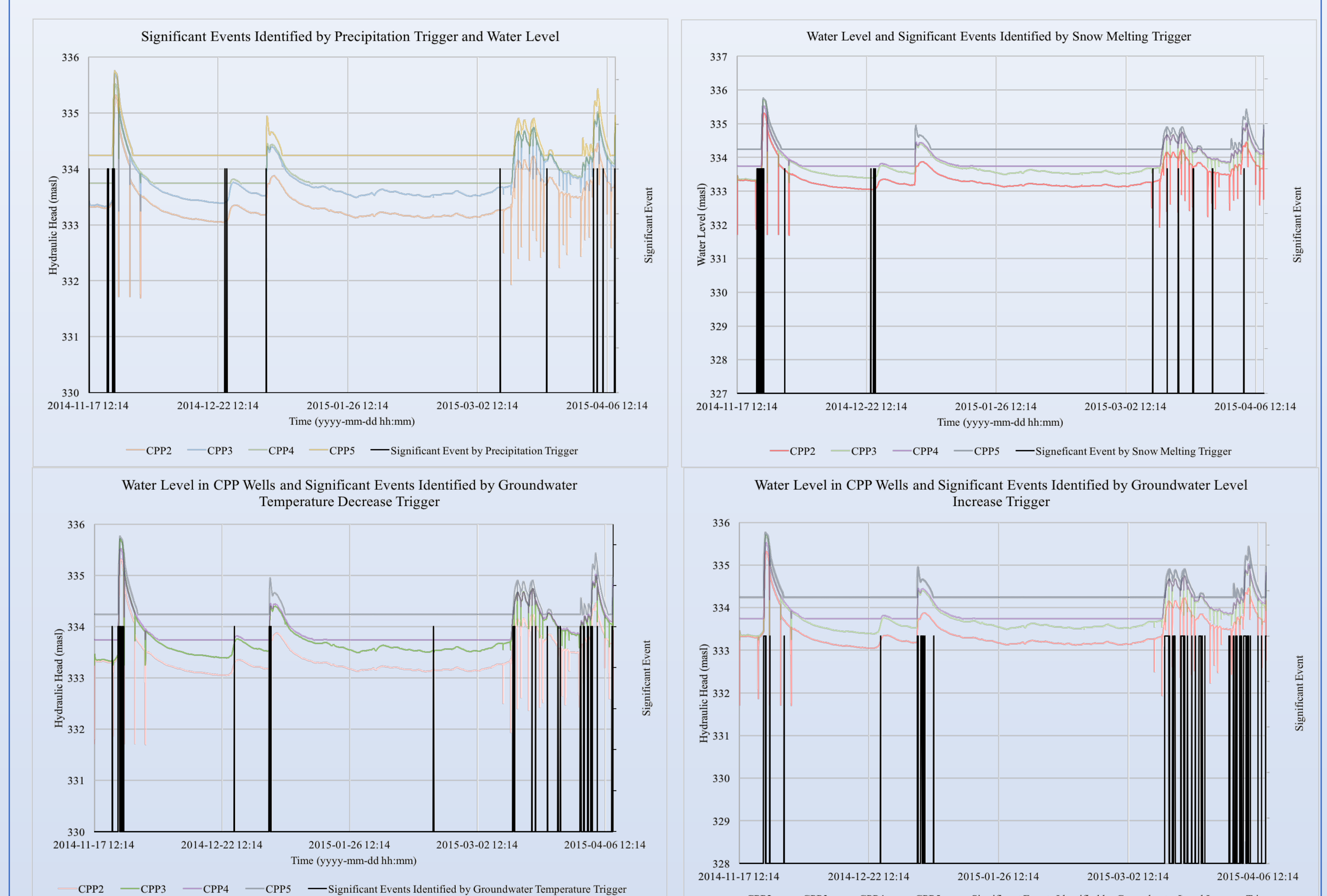

Figure 5: Effectiveness assessment for precipitation, snow melting, GW level and Temp. triggers.

Identified triggers are **very effective** in predicting GW recharge in winter and early spring in this study.

Future Directions

- Algorithms to control sensor network and data transmission will be developed and tested on the iWT system using knowledge learned from the case study.
- Fully integrated models like Hydrogeosphere can help refine triggering protocols. Synthetic data generated by models can used to train the threshold-targeted artificial narrow intelligence (ANI). The trained ANI will be able to determine the triggering algorithm quickly to help forecast and capture a hydrologic event of interest.

References and Acknowledgements

[1] K.E. Trenberth. Framing the way to relate climate extremes to climate change Clim. Change, 115 (2012), pp. 283-290
[2] Ke Qin. Analysis of groundwater recharge events in winter and early spring to establish physical triggers for a reactive monitoring system in the Mannheim site. (2019)

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