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High quality monitoring of water systems using in situ automatic measurement stations

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March 7, 2013

Presented by..... John B. Copp, Ph.D.



*Monitoring the Future:
Advancing Water Monitoring Network Design*

Overview

- Brief Introduction to Primodal
- Primodal Monitoring Stations/Networks
- Real-Time Data Quality Evaluation
- Discussion for the Future



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Introducing Primodal

➤ Primodal Inc.

- Based in Hamilton, ON.
- Dedicated WWTP modelling firm
- Primary consulting firm
- Projects around the world including:
 - Locally as well as US, UK, Greece, Hungary, Israel

➤ Primodal Systems Inc.

- Based in Hamilton, ON.
- Technology firm
- Monitoring equipment developer & manufacturer



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Introducing Primodal

➤ Expertise

- Process Engineering, Design, Control, Modelling or Monitoring
 - COMMON THEME → Data Evaluation
 - the need for accurate and representative data



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Process Understanding & Modelling

➤ The Potential

- User-friendly software
- Limitless applications
- Whole-system modelling



➤ The Pitfalls

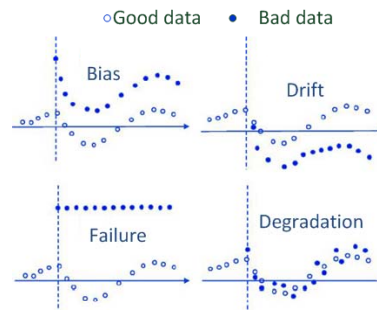
- Model Prediction Accuracy
- Communication
- Expertise
- Model Maintenance
- Data Quality

Primodal Systems Data Acquisition

Identified Needs In Water Monitoring

➤ Continuous Monitoring:

- Information-rich data sets
- Huge/complex data sets
- Challenging conditions
- Faulty sensors



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Identified Needs In Water Monitoring

➤ Continuous Monitoring:

- Information-rich data sets
- Huge/complex data sets
- Challenging conditions
- Faulty sensors



Data evaluation/validation is crucial

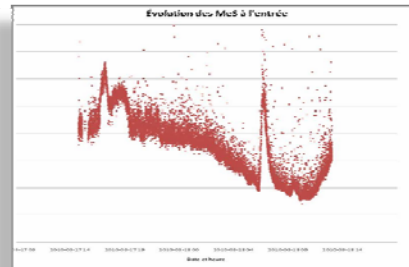


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Identified Needs In Water Monitoring

➤ Identified Issues:

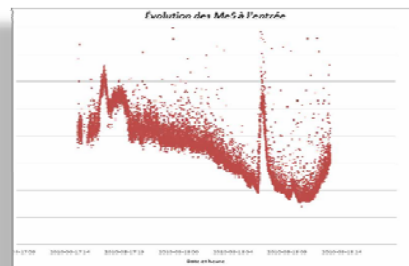
- volume of data
- creation of data graveyards
- post-processing effort
- maintenance scheduling



Identified Needs In Water Monitoring

➤ Moving Forward (more than a data logger):

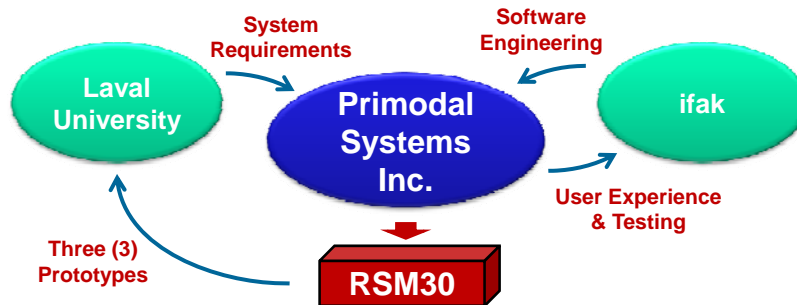
- Information available to field technician at water's edge
- Advancements with digital sensor technology
- Portability of system
- Advanced water-side real time signal processing
- Signal and sensor fault detection



Monitoring Station Development (RSM30)

➤ RSM30 / PrecisionNow development

- private company / university collaborative effort
- custom software development
- sensor manufacturer independent

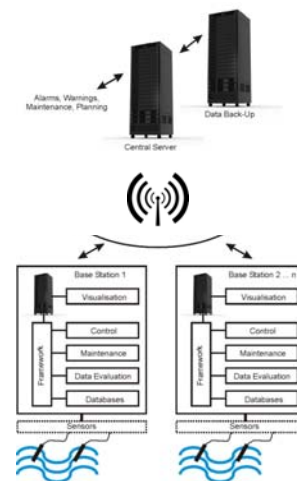


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Primodal Monitoring Networks

➤ Network Features

- Central Server
 - Connection to multiple stations
 - Supervisory control
- Remote communication
 - TCP/IP – based
 - Wireless, ethernet, GSM,...
- BaseStation
 - Water-side storage and data analysis
 - Real-time data analysis



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Primodal Monitoring Stations

➤ Installed at:

- Quebec City WWTP
- St. Charles River, QC
- Lynette WWTP, Denmark



➤ Soon

- Eindhoven WWTP, NL
- Grand River, Ontario



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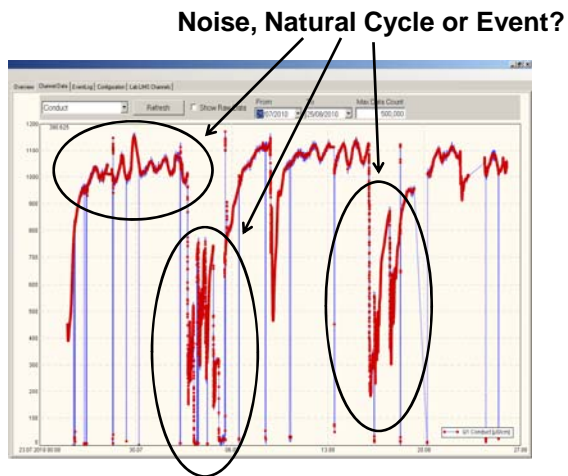
Primodal Monitoring Stations



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Primodal Real-Time Data Modules – Simple

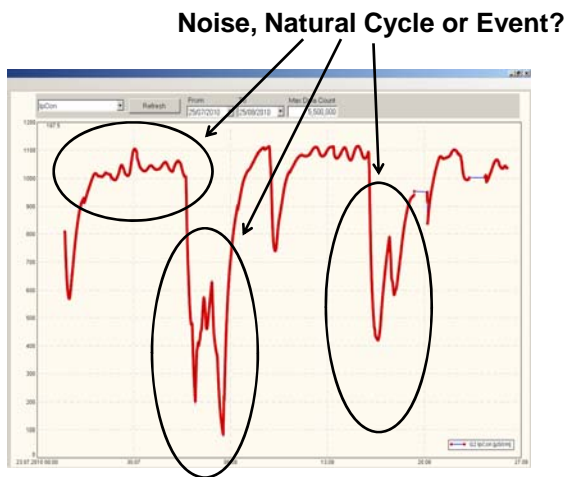
- Data from Quebec City: St Charles River
- Conductivity raw data



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Primodal Real-Time Data Modules – Simple

- Data from Quebec City: St Charles River
- Conductivity data after LowPass Filter

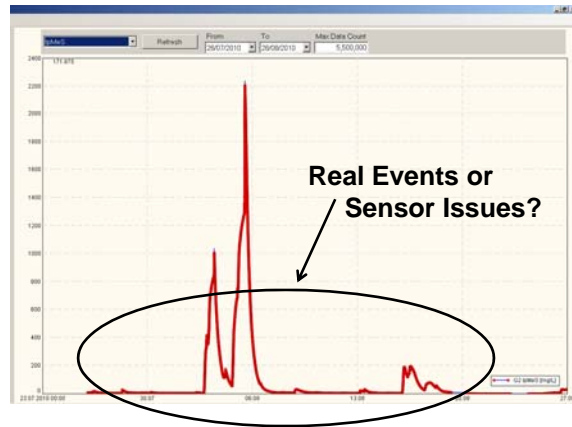


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Primodal Real-Time Data Modules – Simple

➤ Data from Quebec City: St Charles River

– MeS probe: TSS data after LowPass Filter



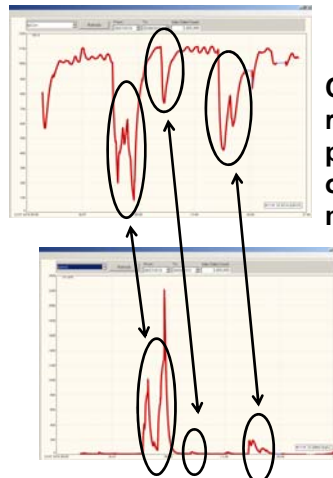
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Primodal Real-Time Data Modules – Simple

➤ Data from Quebec City: St Charles River

– Conductivity vs MeS (data after LowPass Filter)

- no alarm



Confirmation of real events as picked up by other measurements

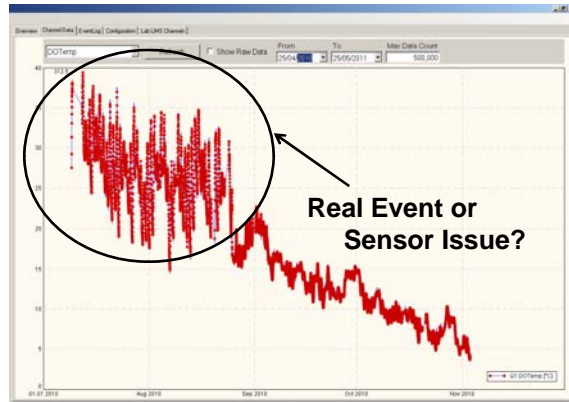


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Primodal Real-Time Data Modules – Simple

➤ Data from Quebec City: St Charles River

– DO probe: Temperature



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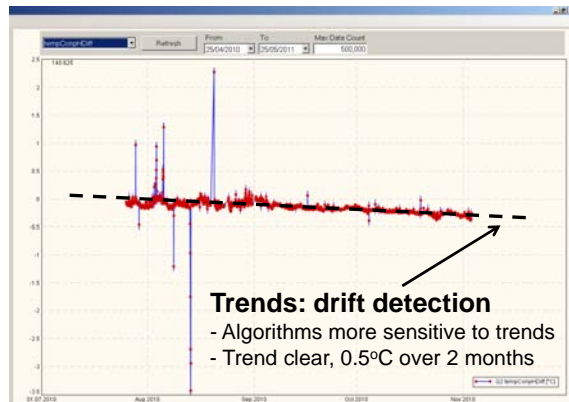
Primodal Real-Time Data Modules – Simple

➤ Data from Quebec City: St Charles River

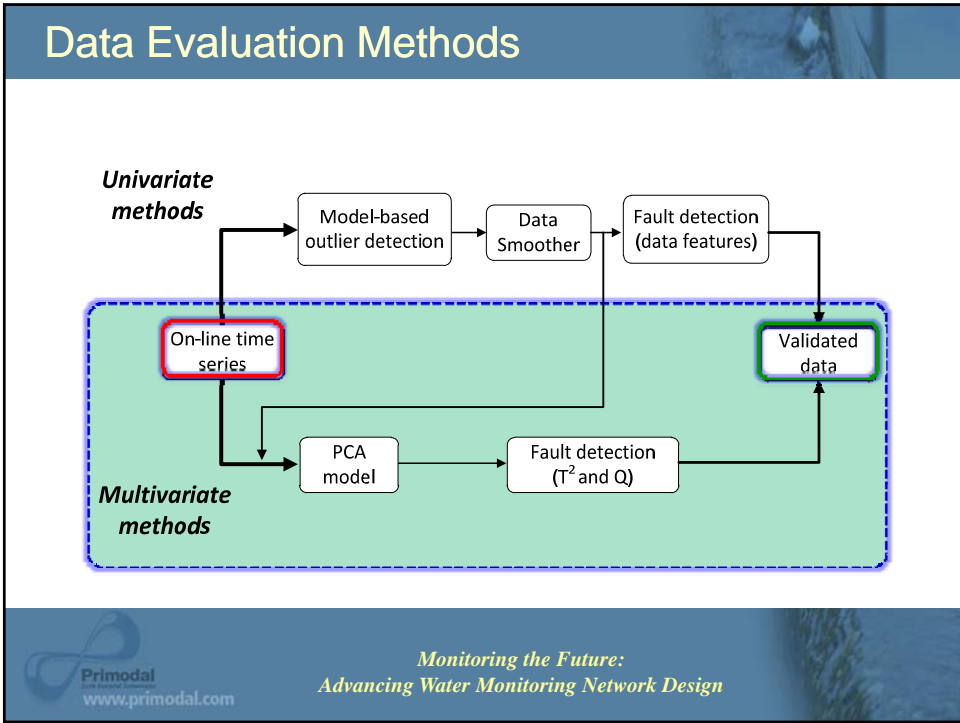
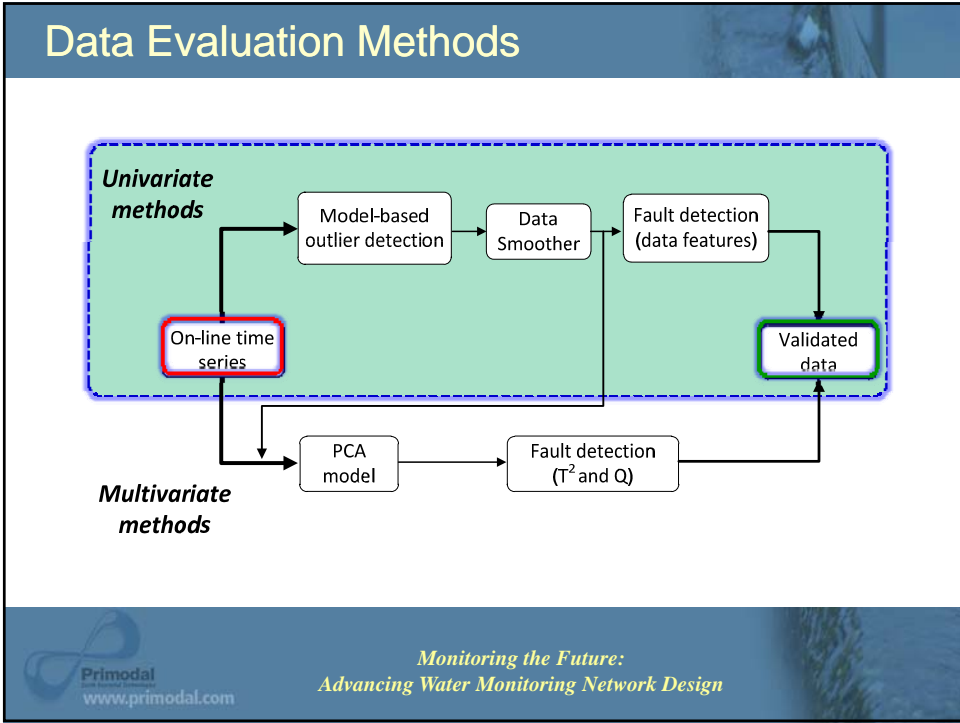
– Comparison of Temperature Signals

- Conductivity vs pH Probes

- alarm triggered



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Real-Time Data Modules – Multivariant

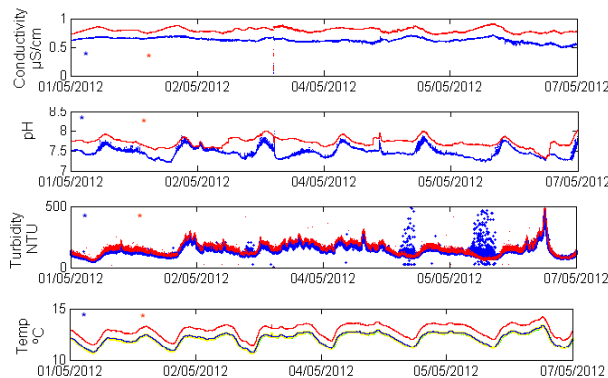
➤ Université Laval (modelEAU)

- Development of appropriate multivariant methods
- PCA-based methods
- Offline historical datasets as test data
- Knowledge transfer and implementation into PrecisionNow / RSM30 platform in coming months



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Real-Time Data Modules – PCA



- Variable 20% bias (Cond₁, Cond₂)

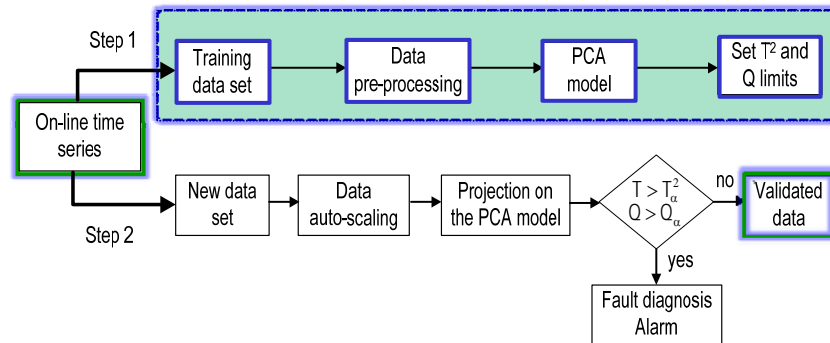
- Variable bias (pH₁, pH₂), (Turb₁, Turb₂)

- Const. 5% bias (Temp₁, Temp₂)



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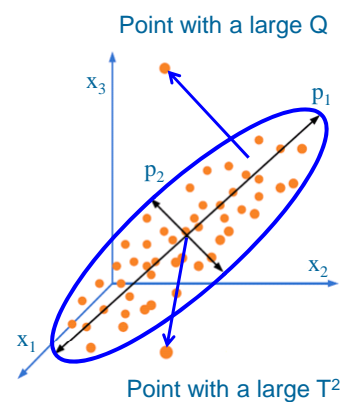
Real-Time Data Modules – PCA



Real-Time Data Modules – PCA

➤ T² and Q statistics

- Fault detection within the PCA space
 - T²: normalized sum of scores: variations within the model
 - Q: sum of squared residuals: goodness of fit of samples to the model
- Detection limits are defined on basis of “normal data”



Real-Time Data Modules – PCA

➤ Case 1 – WWTP

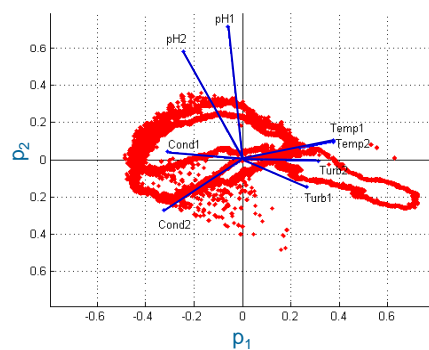
- Offline (historical data)
- Dataset with 8 variables
 - pH₁, pH₂, Cond₁, Cond₂, Turb₁, Turb₂, Temp₁, Temp₂
- First 3 principal components > 90% variability
- Training: 3-day data set to build the model



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Real-Time Data Modules – PCA

Data in the new space – 2 Components



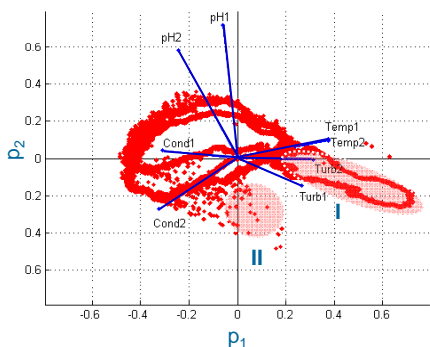
- Vectors represent variables and contributions to p_1 and p_2
- Each point corresponds to a sample in the new space
- Divergences between vectors account for bias



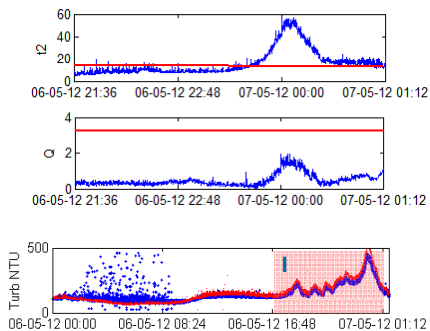
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Real-Time Data Modules – PCA

Data in the new space – 2 Components



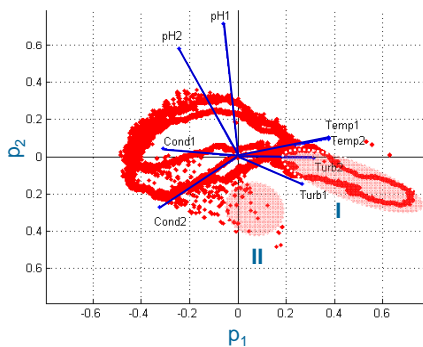
Statistics period I



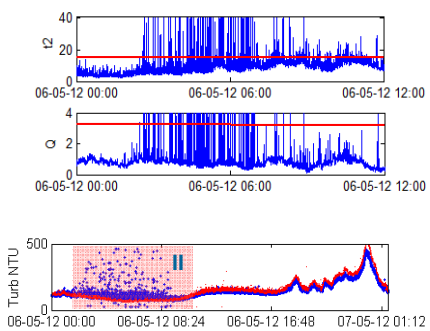
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Real-Time Data Modules – PCA

Data in the new space – 2 Components



Statistics period II



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Real-Time Data Modules – PCA

➤ Case 2 – River

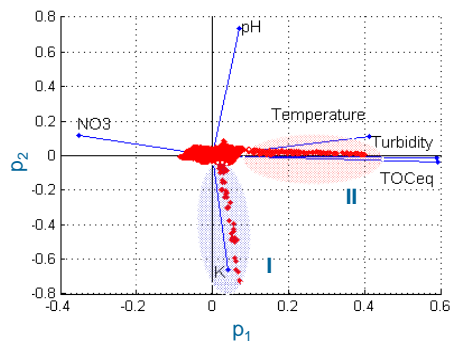
- Offline (historical data)
- Dataset with 6 variables
- NO_3 , Turb, TOC_{eq} , pH, Temp, K^+
- First 3 components > 85% variability
- Training: 1 day data set to build the model



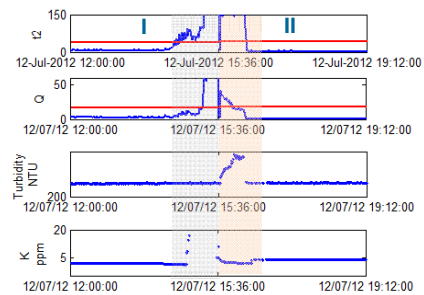
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Real-Time Data Modules – PCA

Data in the new space – 2 Components



Statistics period I and II



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Conclusions

- Dealing with faulty sensors represents a challenge for effective WQ monitoring
- Multivariate methods allow dimension reduction and detection of multiple faults
- Abnormal conditions and faulty data can be detected by monitoring statistical metrics
- Next step: On-line implementation



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Moving Forward

- **Moving Forward**
 - More field deployments
 - More data analysis / testing
 - More method development / tuning
 - More data module development
 - → more advanced time-series analysis
 - → multivariant method implementation



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Acknowledgements



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**UNIVERSITÉ
LAVAL**



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Canada Foundation for Innovation



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www.primodal.com

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Thank-you !



Primodal
Earth Essential Technologies

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