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Title

Do Sensor Failures Matter

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Do Sensor Failures Matter?

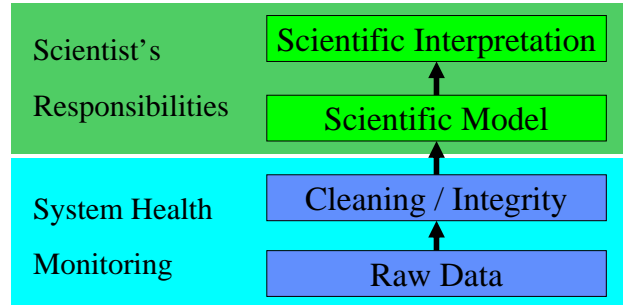**Tom Schoellhammer[1], Nithya Ramanathan[1], Mark Hansen[2], Deborah Estrin[1]**
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Sensor Failures are Inevitable!

The State of Sensor System Health Monitoring

- **System health tools ensure that data is delivered properly**
  - **Data can go "missing" due to node and sensor failure**
- **System health tools make *implicit assumptions* about the system**
  - **Networking is done using wireless ad hoc routing**
  - **System health tools see failures as all the same**
  - **System health tools do not take into account the science**
- **Currently, system health monitoring tools do not quantify the impact of missing data on the science**

Scientist's Responsibilities

Scientific Interpretation ← Scientific Model

System Health Monitoring

Cleaning / Integrity ← Raw Data

Appropriate Corrective Action Depends on the Science Application

Fixing Faults may not be Possible

- **Fixing a broken soil sensor may require perturbing the soil**
- **Fixing a broken soil sensor may require damaging roots**
- **Remote deployments may not be accessible when faults occur**

Improved System Health Monitoring

- **Understand the impact of missing data on the science application**
- **Whether missing data can be predicted accurately enough**
- **Estimate the lifetime of the prediction model**

Application-Aware Sensor System Health Monitoring

Avoid Data Stream Interruptions using Predictions

- **Correlations between sensing modalities can be used to produce reliable predictions**
- **An important component is to *assess uncertainty* in predictions when data does go missing**

Quantify the Impact of Input Uncertainty

- **Several plausible values of missing data can be generated**
- **Knowledge of the scientific model allows automatic analysis of the impact on confidence intervals**
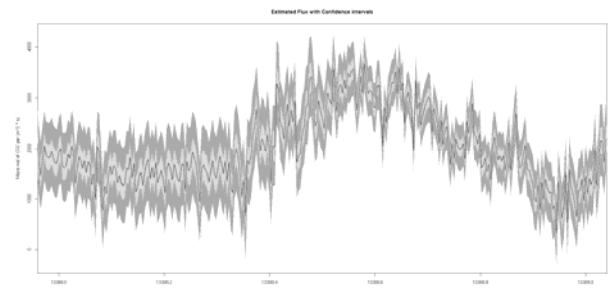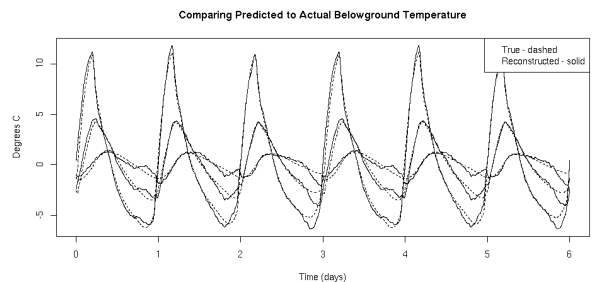
Model Expiration Estimation

- **Look at full data sets from previous years during the same time of year**
- **Build the same model on all sensors that do have complete data**
- **Project forward, and find where each model breaks**
- **The set of expiration times can be used as a distribution for expiration**
- **This can be used to help schedule maintenance conservatively**

Model Expiration Determination

- **Model quality can be judged using a *complete* data set**
- **Build the same model on neighboring sensors that do have complete data**
- **In realtime, check if neighboring models are predicting properly**
- **This provides a notification when the model begins to go astray**

Comparing Predicted to Actual Belowground Temperature

True - dashed
Reconstructed - solid

Degrees C

Time (days)

Estimated Flux with Confidence Intervals

Interpretation ← Science Model ← Cleaning ← Raw Data

Expiration Estimation ← Prediction ← Model Construction