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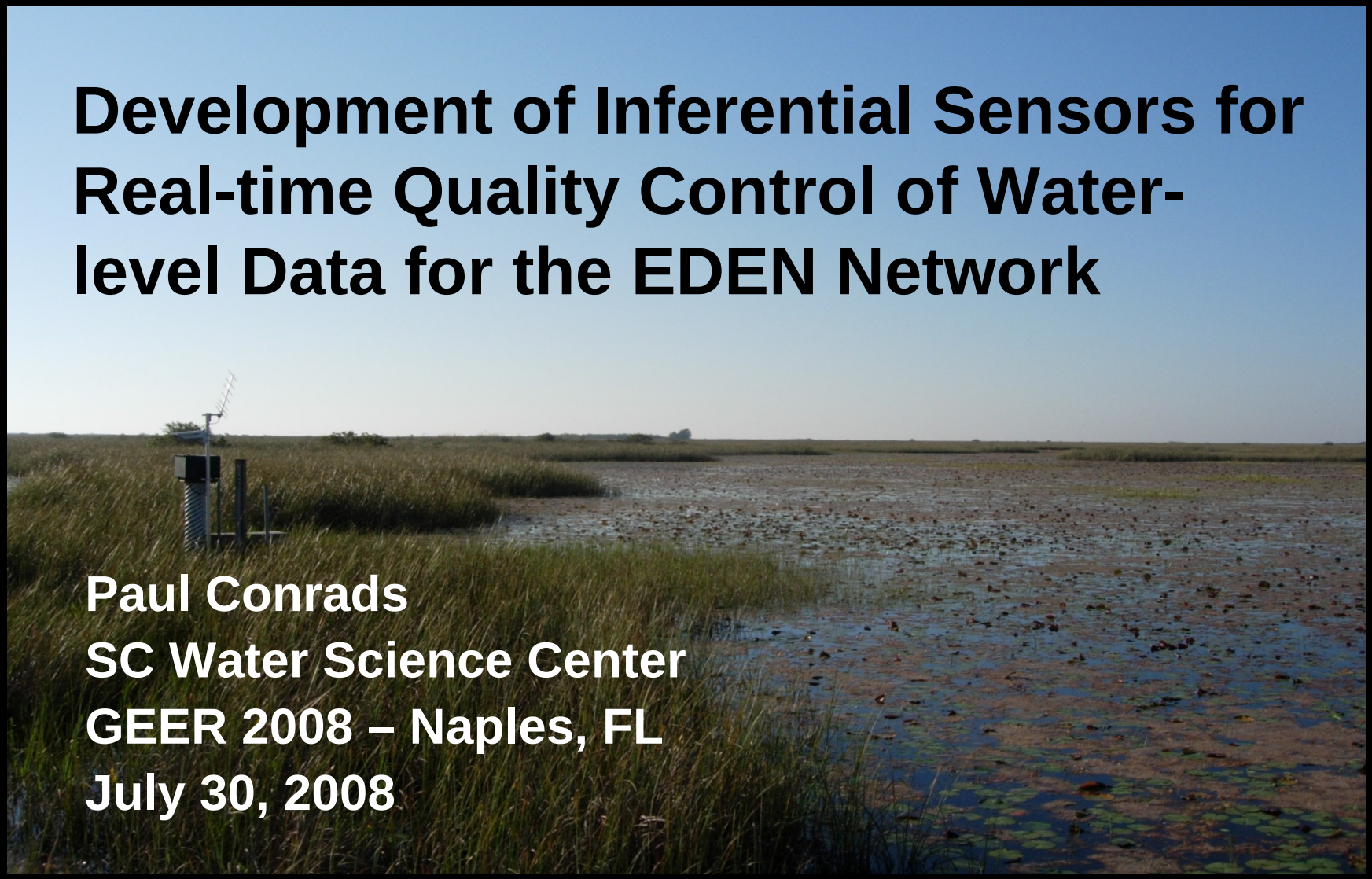
# Development of Inferential Sensors for Real-time Quality Control of Water-level Data for the EDEN Network



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**SC Water Science Center**
**GEER 2008 – Naples, FL**
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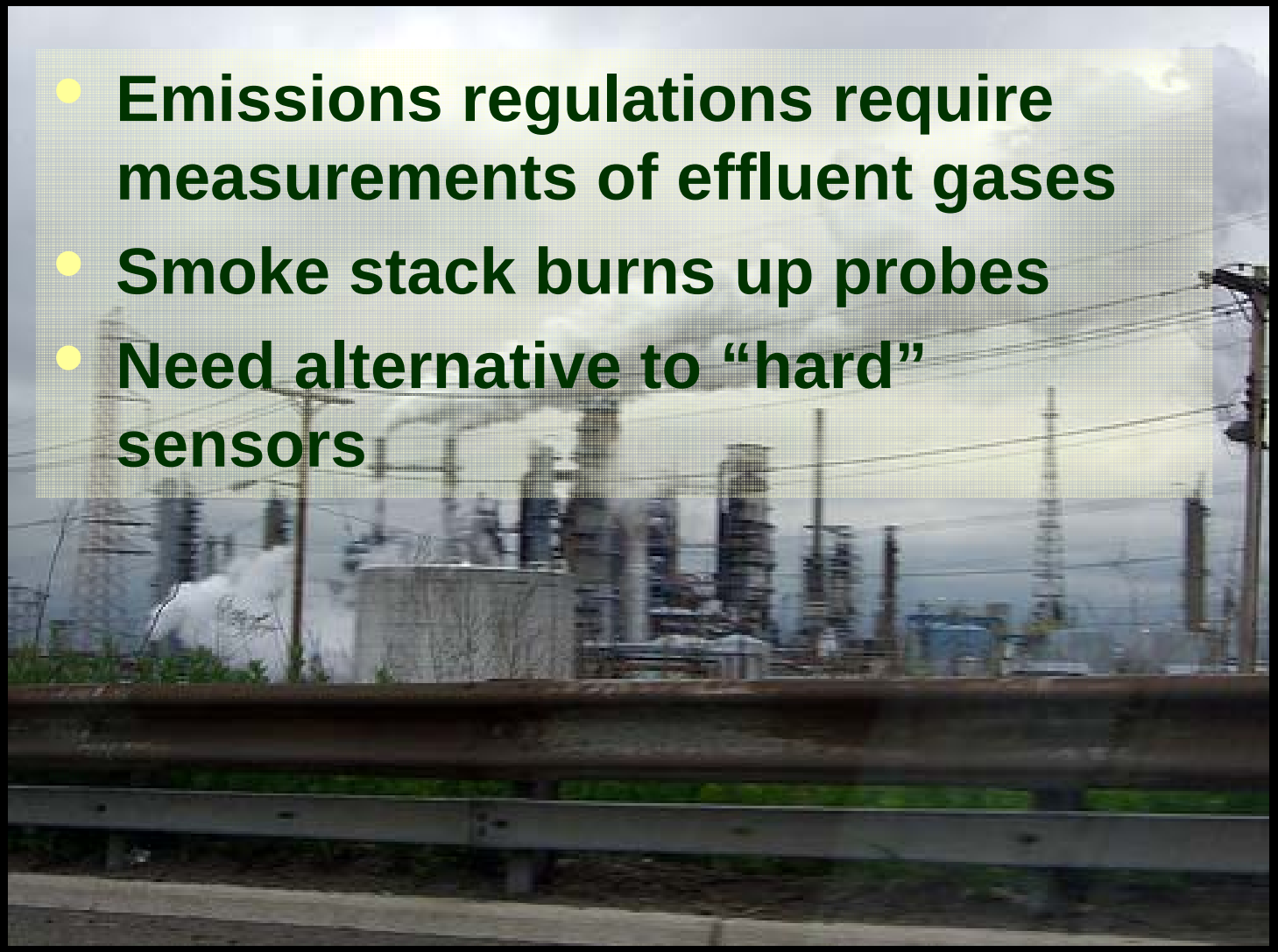
# Presentation Outline

- What is a “Inferential Sensor”?
- Background
  - Industrial application
  - Homeland security
- EDEN Network
- Water-level Inferential Sensor
- Challenges

# Tough Environment to Monitor

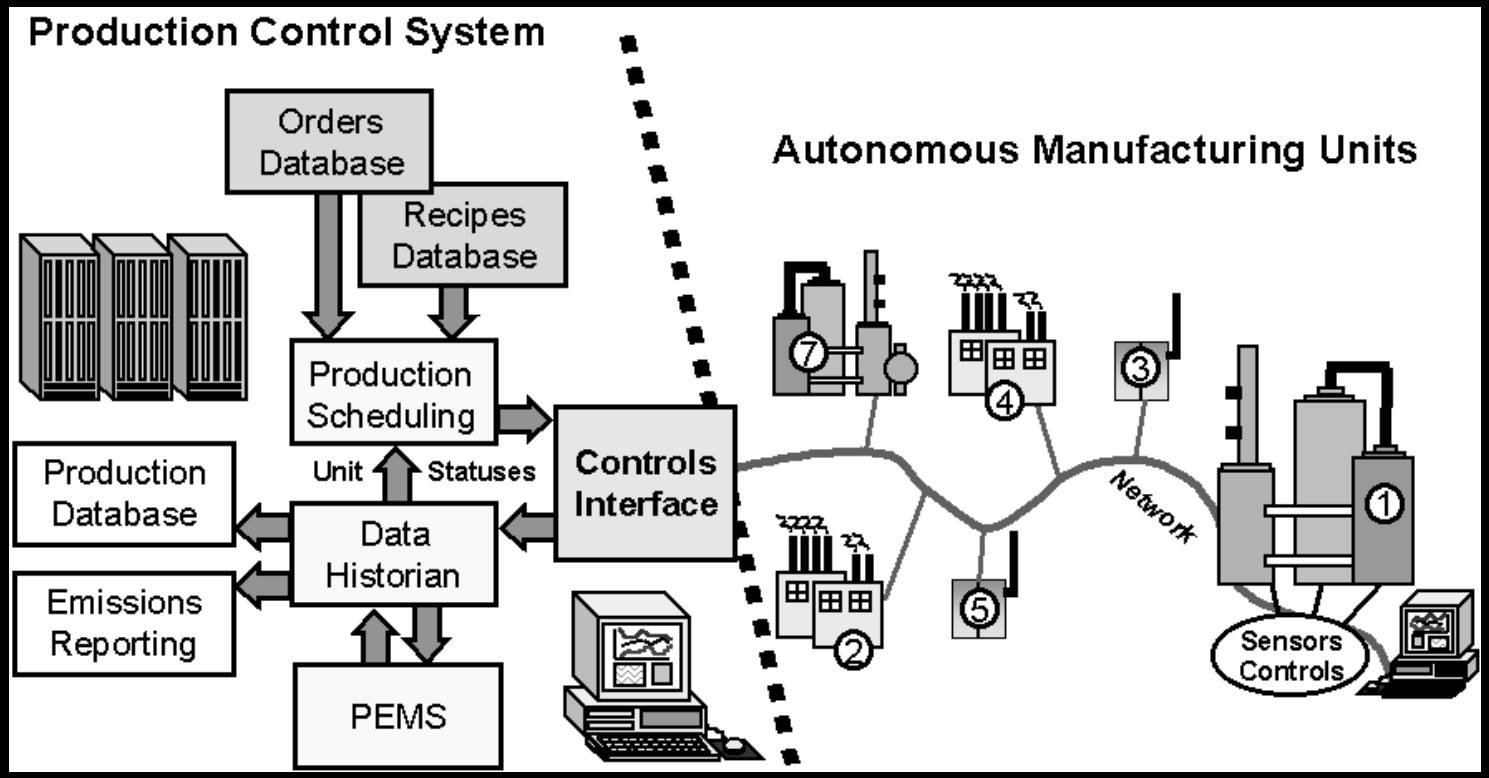


- Emissions regulations require measurements of effluent gases
- Smoke stack burns up probes
- Need alternative to “hard” sensors

# Hard Sensor vs. Inferential Sensor

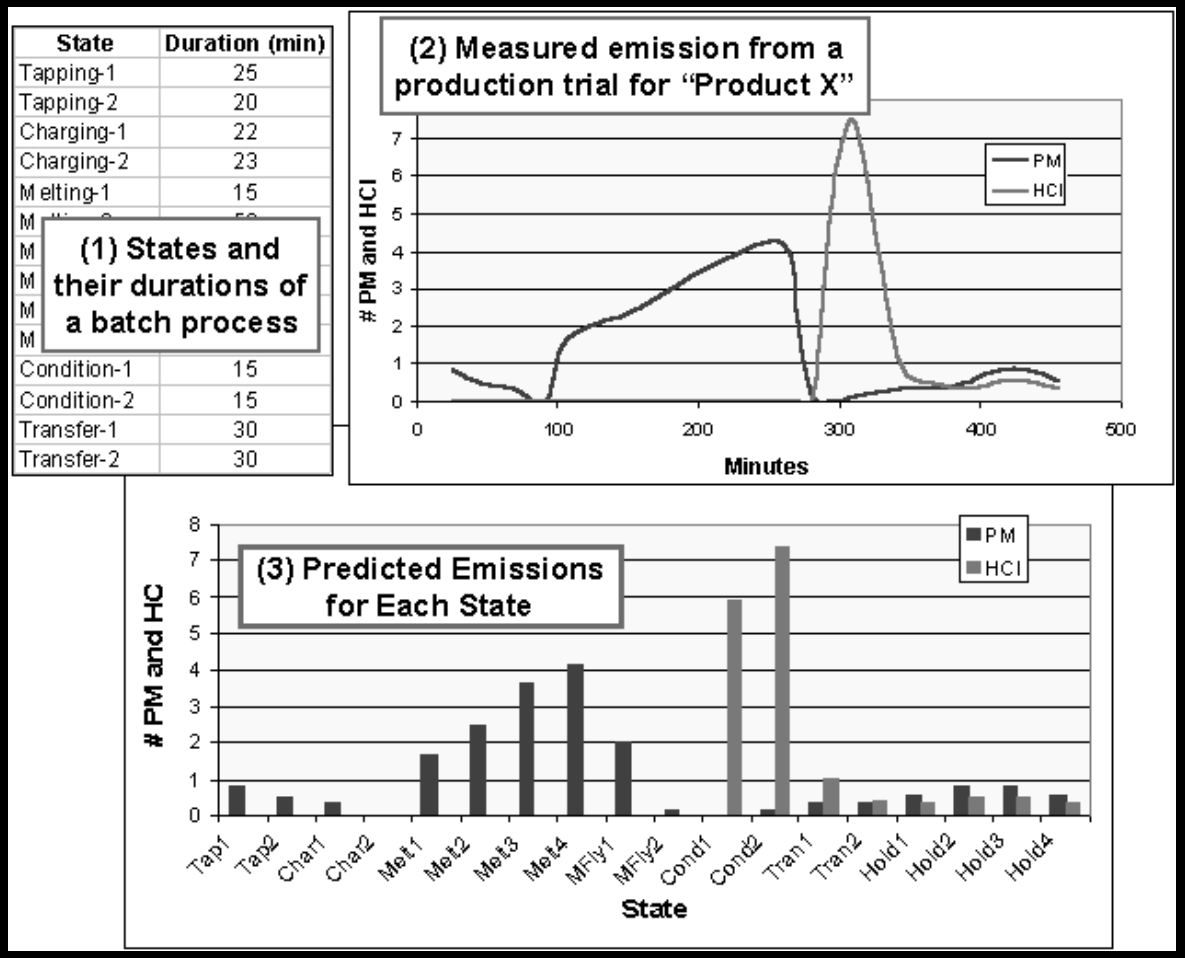
- Virtual sensor replaces actual sensor
  - Temporary gage smoke stack
  - Operate industry to cover range of emissions
  - Develop model of emissions based on operations
  - Model becomes the “Inferential Sensor”

# Industrial Application: Production Emission Monitoring System



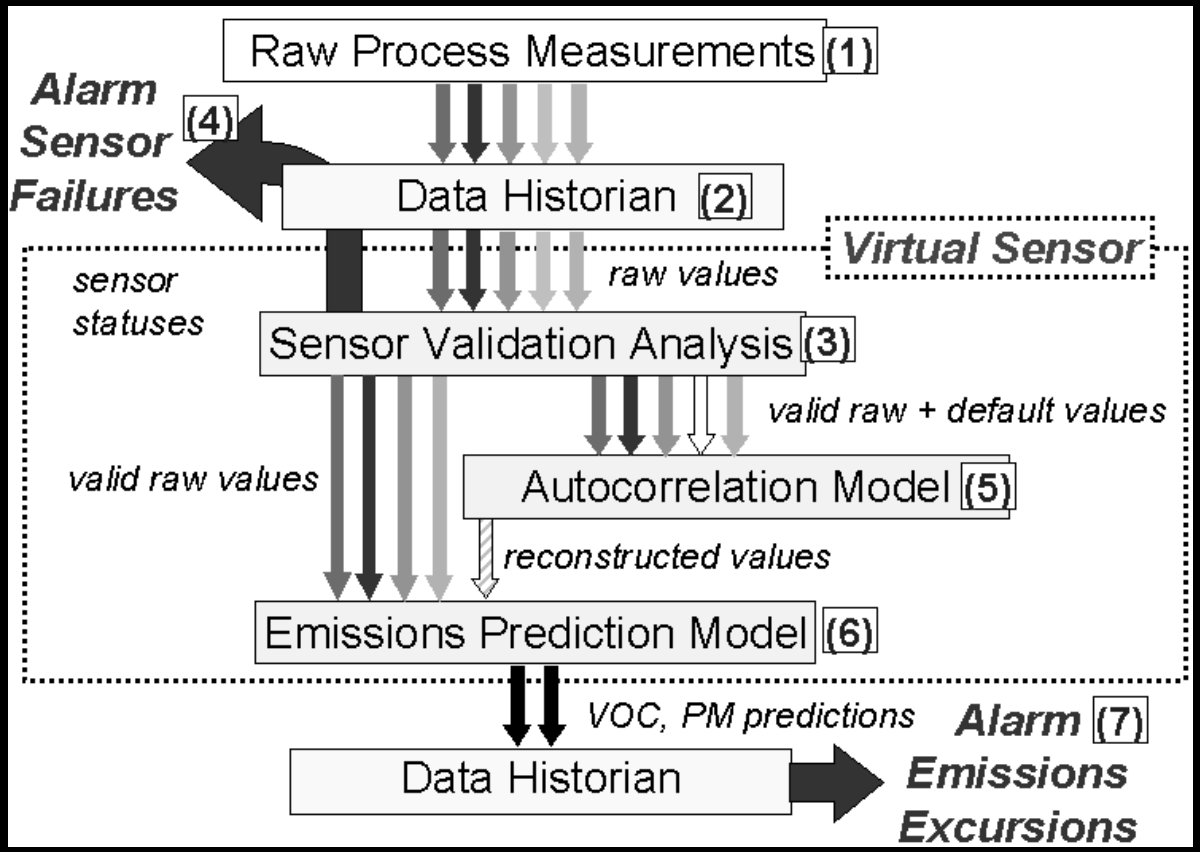

**Production Control System Components.** A Data Historian is a special database designed to hold massive amounts of process and laboratory time series data.

# Production Emission Model




**Predicted Emissions History for a Manufactured Product.**

# Inferential Sensor Architecture




**PEMS Architecture**

# Industrial Benefits

- Optimizes Manufacturing Processes
- Documents Continuous Compliance
- Lower Cost – *In some situations, a proactive intelligent system can partially or fully replace passive back end controls to reduce capital and long-term operating expenses*
- Most Advantageous Permitting – *because it actively prevents pollution*
- Works with Existing or New Production Controls

# If it is good enough for Industry...

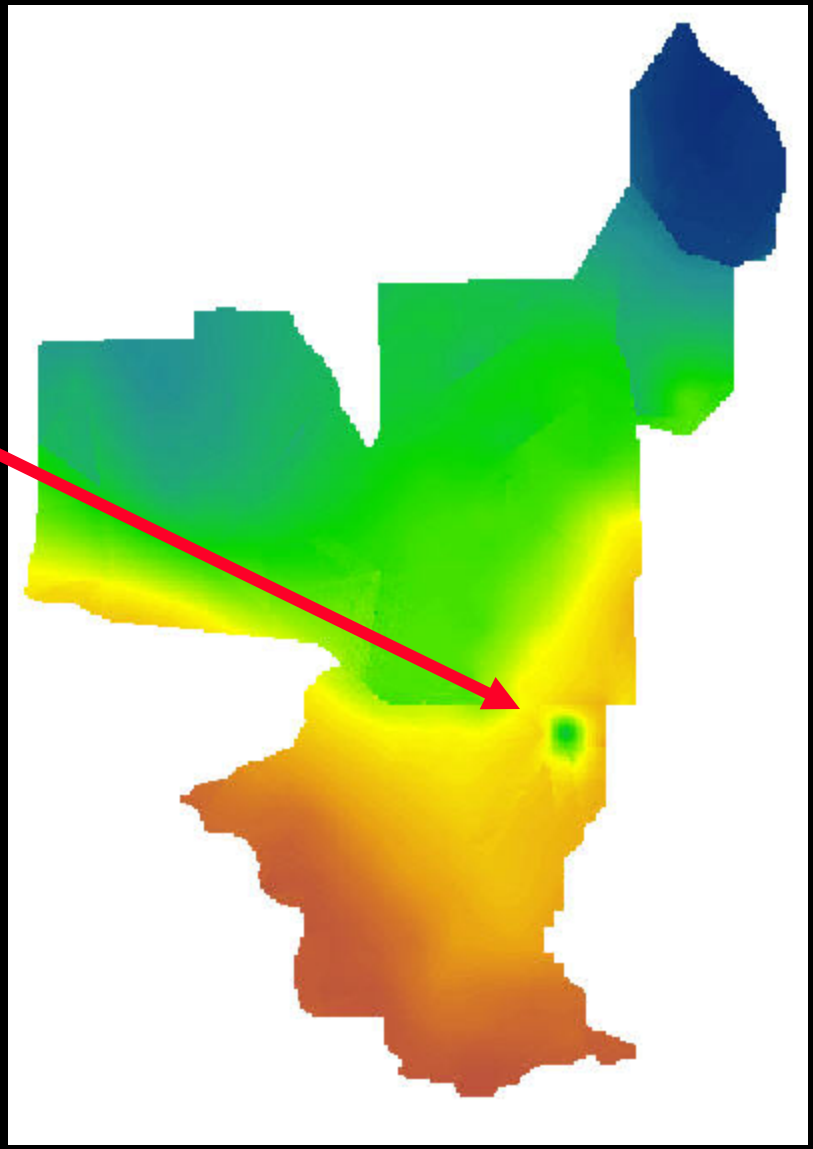
- Use similar approach for real-time data
- Develop models to predict real-time data
- Use predictions as “inferential-sensor” to:
  - QA/QC hard sensor
  - Provide accurate estimates for hard sensor
  - Provide redundant signal

# Everglades

**Differences of 1 ft can change vegetation communities**

# EDEN Water-Surface Map

**Bad values creates erroneous areas on maps**

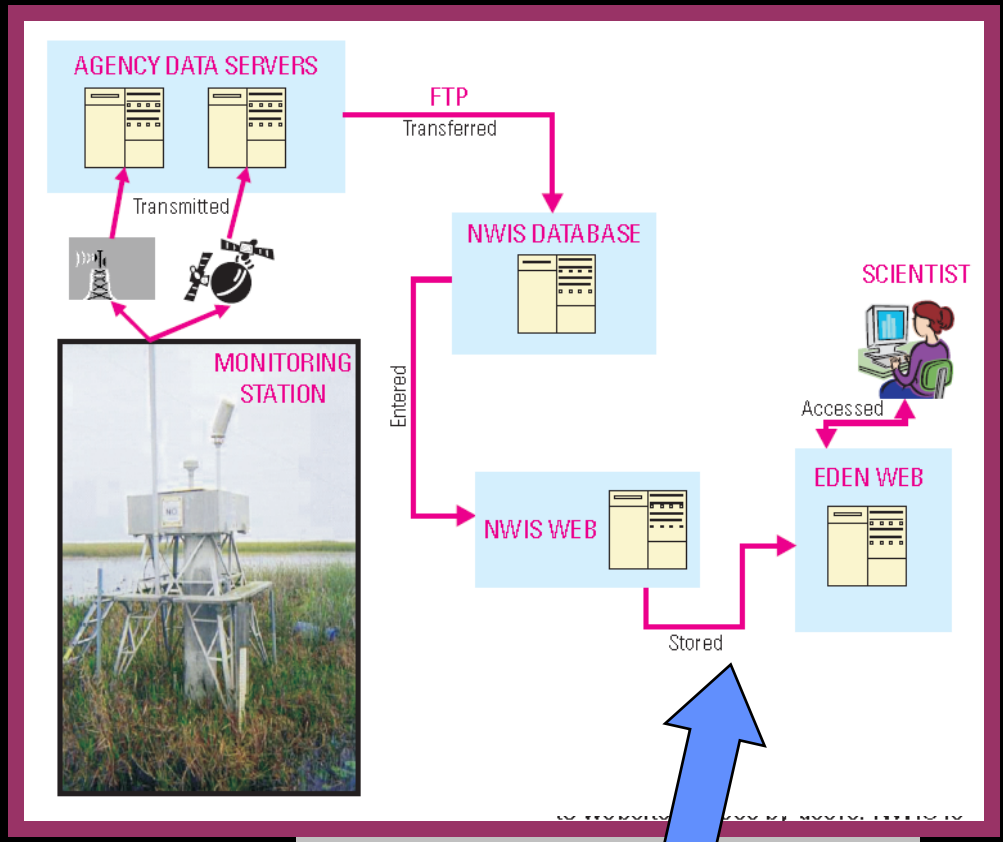


## Problem

Need to minimize missing and erroneous data

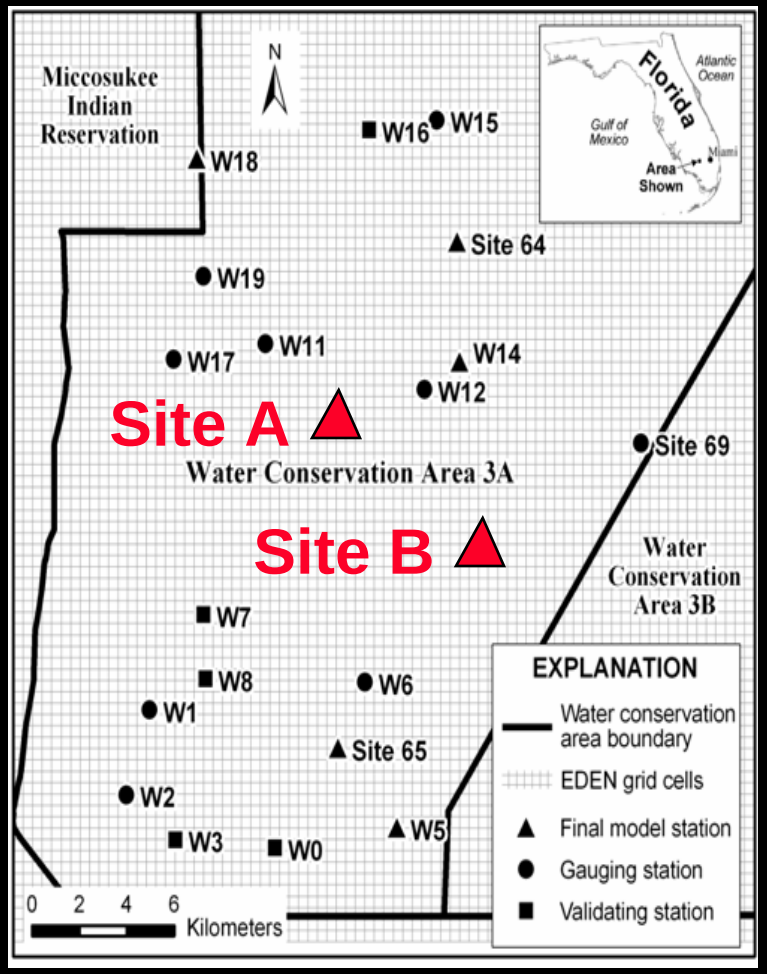
## Approach

Develop “inferential” sensors for redundant signal




*Inferential Sensor application*

# Hypothetical Case

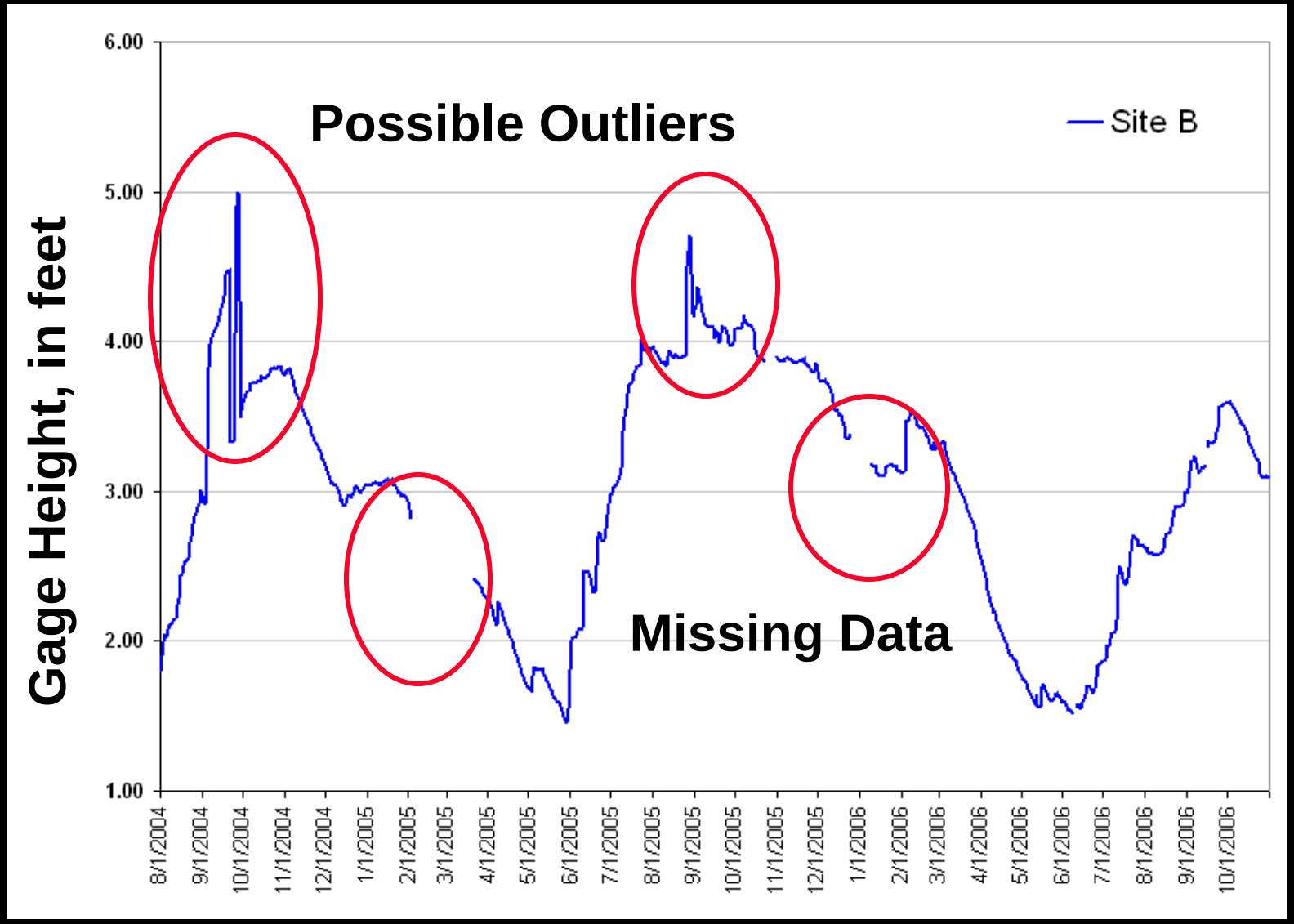



**Create model (Inferential Sensor) for Site B using Site A as an input**

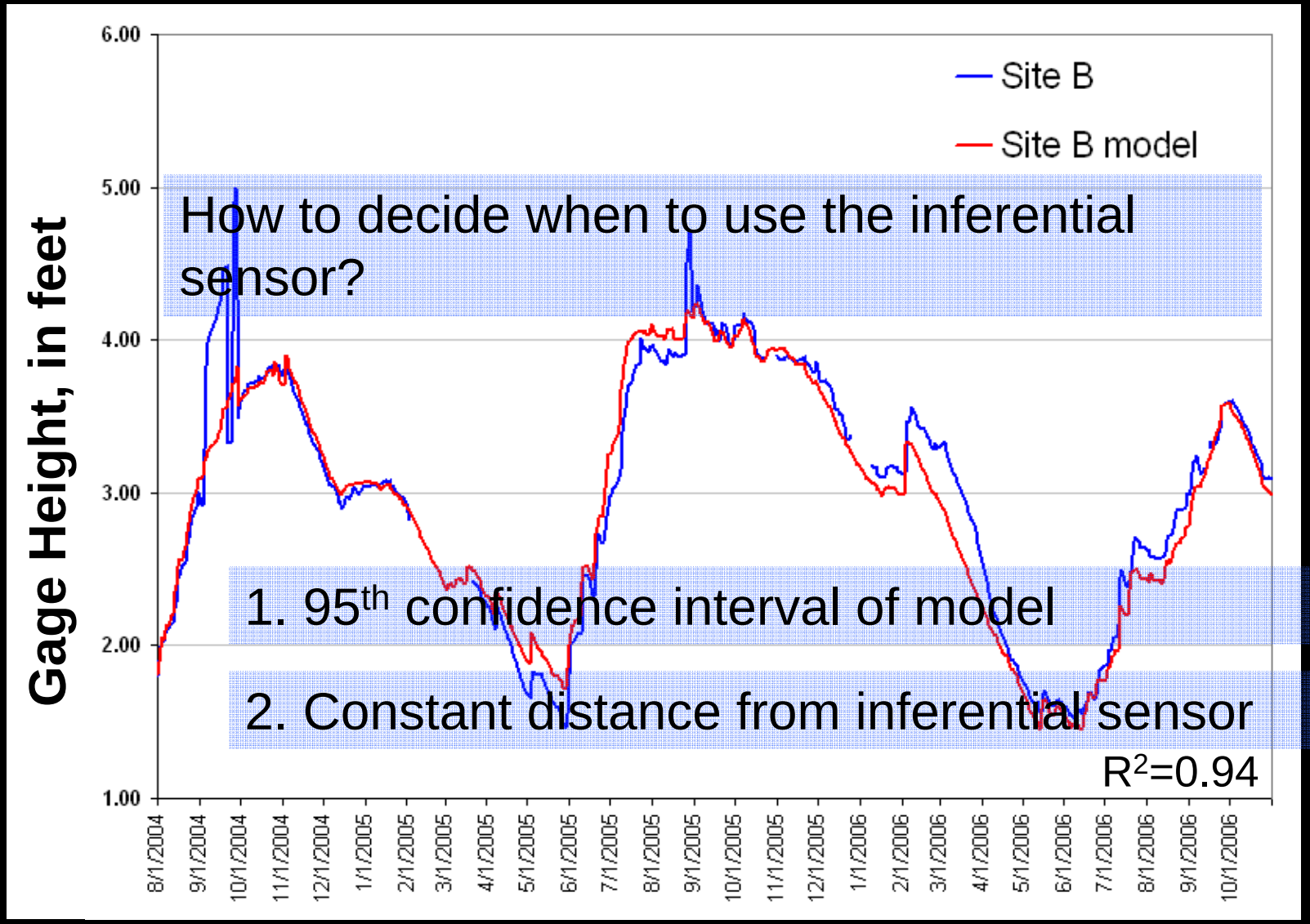
**Decide when to use Inferential Sensor instead of gage data**

***Actual application would be for 253 stations***

# Hypothetical Case: Gage Data



# Hypothetical Case: Inferential Sensor



# When to use Inferential Sensor?
# 95th confidence interval of model

# When to use Inferential Sensor?

## Constant distance from inferential sensor

# Hypothetical Case - comments

- Issue of model accuracy
- Immediate benefit for missing data
- Made the assumption that Site A was correct
- Example used daily data
  - Use inferential sensor on hourly data
  - Compare daily medians (used for EDEN maps)
- What if data for Site A is missing?
- *Issues are magnified when dealing with a network of 253 gages*

# Initial Approach: Data Evaluation

- Need to know what data is good
- Set of filters to evaluate data quality
- Robust series of thresholds
  - Differences with other gages
    - Time delays and moving window averages
  - Time derivatives
    - Rate of change over various time intervals
- Create subset of good data

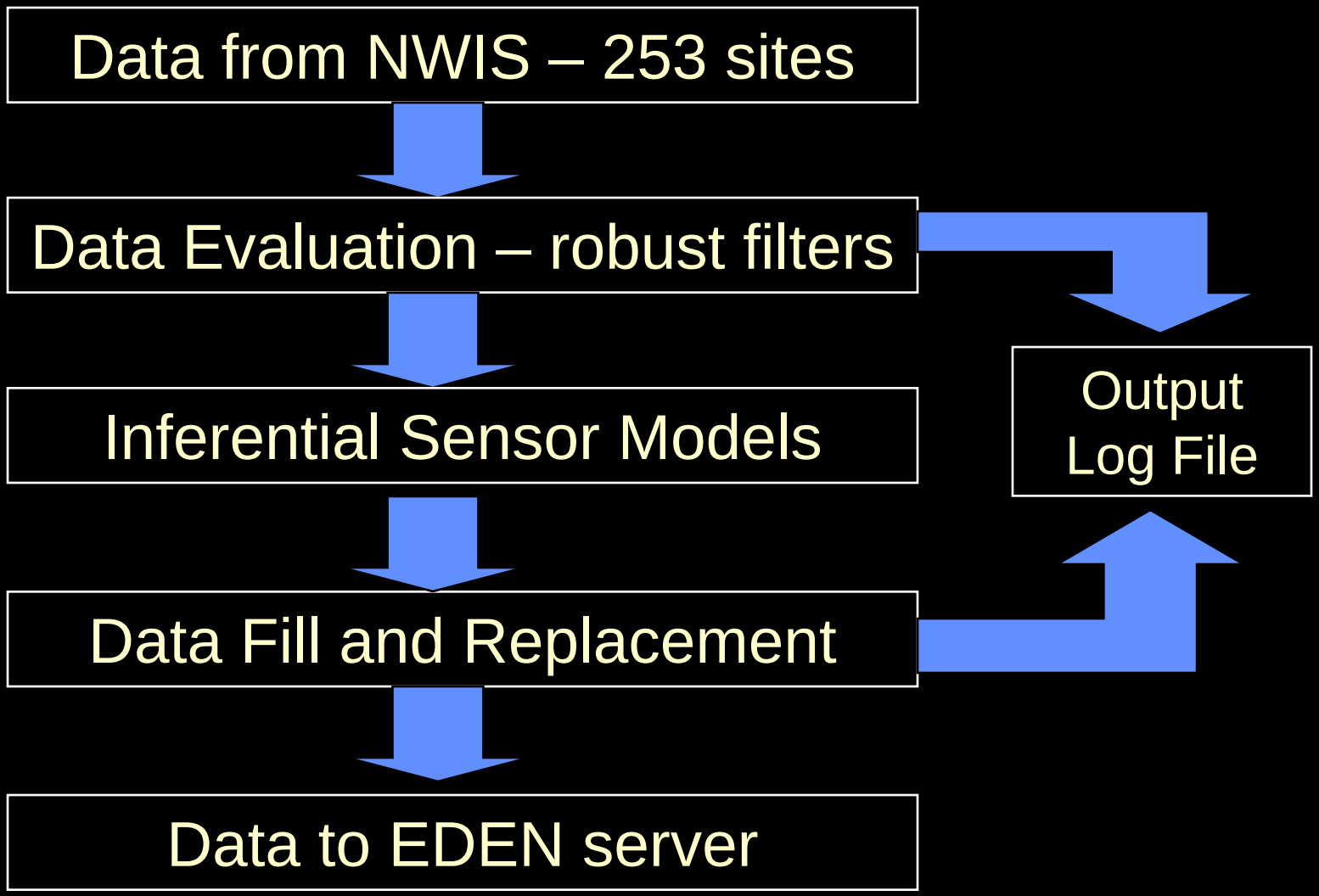
# Initial Approach: Model Development

- One Approach – Canned Models
  - Create multiple models for a gage
  - Set priority for model to use depending on available data
  - Large number of models
  - Not all combinations of gages would be addressed

# Initial Approach: Model Development

- **Second Approach – Model on the Fly**
  - **Subset of good data, determine input data with the highest correlation**
  - **Develop models based on available data**
  - **Issue of evaluation of models**
  - **More complex programming than first approach**

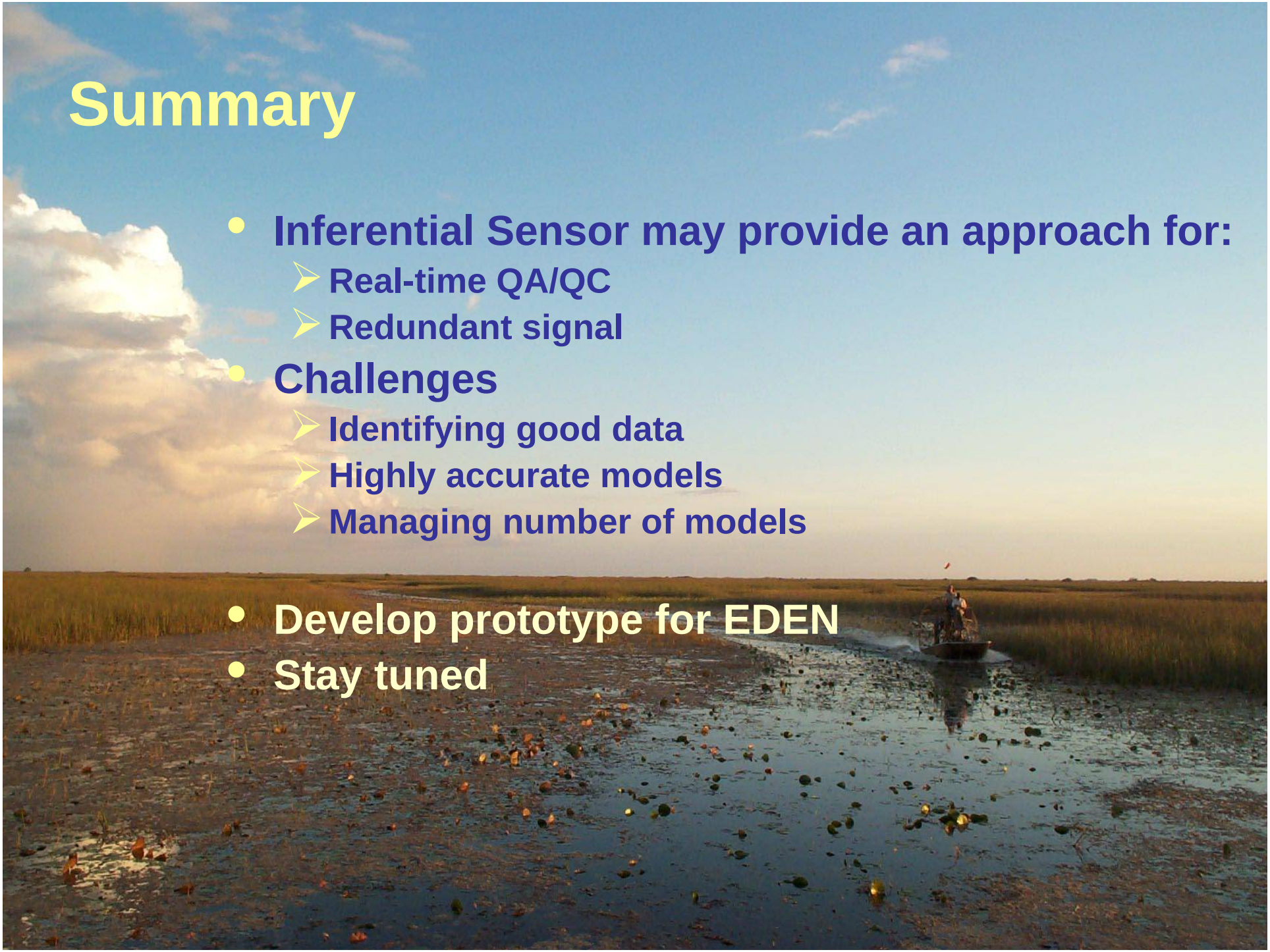
# EDEN Inferential Sensor Architecture



# Summary

- Inferential Sensor may provide an approach for:
  - Real-time QA/QC
  - Redundant signal
- Challenges
  - Identifying good data
  - Highly accurate models
  - Managing number of models

- Develop prototype for EDEN
- Stay tuned




Questions?