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Improved Design Tools for Surface Water and Standing Column Well Heat Pump Systems

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Ground Source Heat Pumps > Data Gathering and Analysis

Mandatory Overview Slide

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- Timeline
  - Start: February 2010
  - End February 2012
- 5% complete
- Budget
  - Total project funding $312,250
  - DOE: $250,000; Awardee: $62,250; FY10: $118, 439

Relevance/Impact of Research

- Improve the capability of engineers to design heat pump systems that utilize surface water or standing column wells (SCW) as their heat sources and sinks.
  - Provide improved sizing tools;
  - Provide an improved EnergyPlus model for the surface water heat pump system (with stratification, surface freezing, ice-on-coil);
  - Provide an EnergyPlus model for the standing column well system.
- Without design tools, it is difficult to size, evaluate, and select these systems.
- The design tools and EnergyPlus models are key enabling technologies.

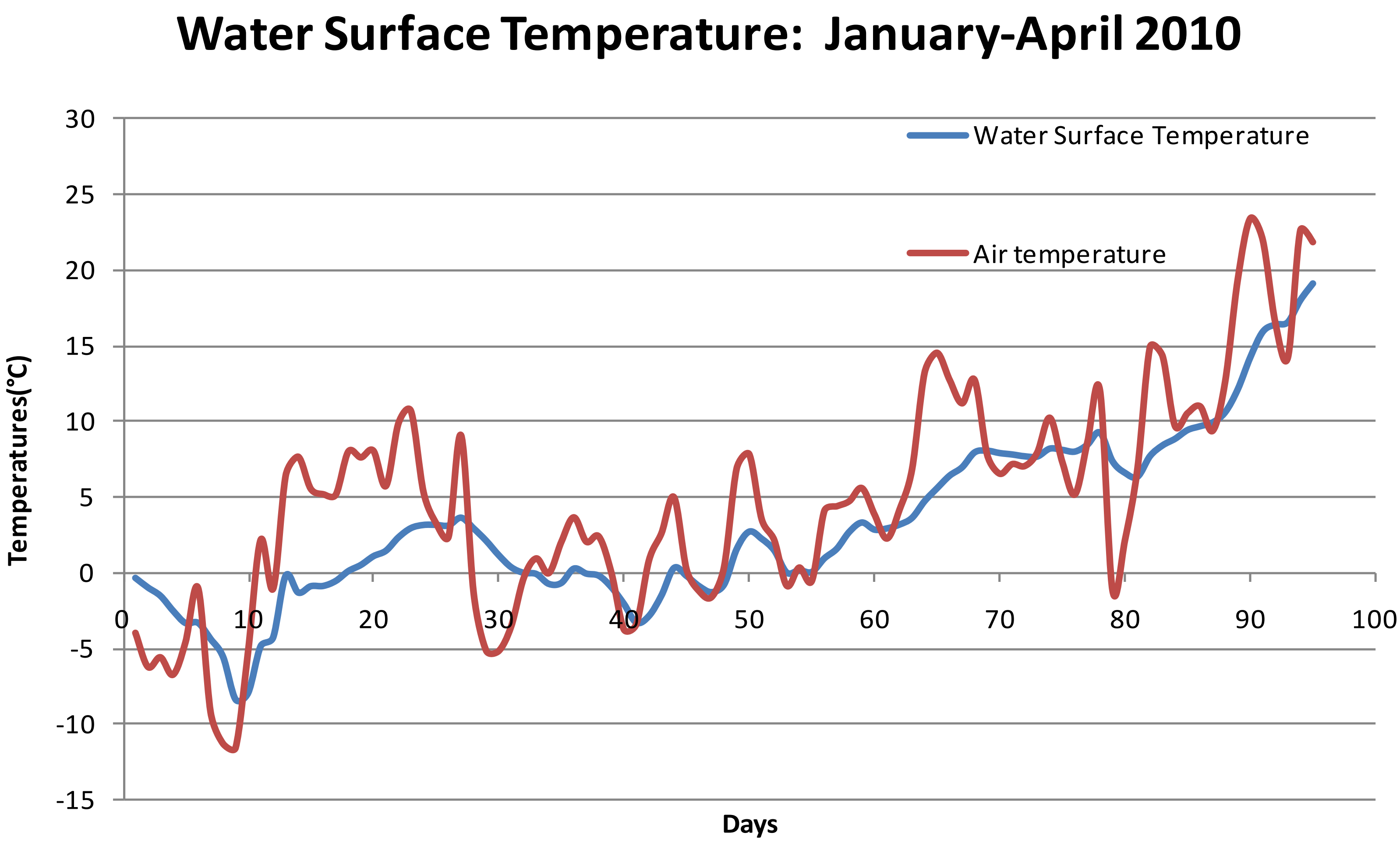
Scientific/Technical Approach

- Both aspects of the project rely on experimentally-validated computer simulation to provide design tools and EnergyPlus models.
- FY 2010 Milestones – reports on:
  - Development and validation of SCW model with separate bleed control
  - Testing of SCW model with various bleed control strategies
  - Modeling of lake stratification
  - Modeling of ice-on-coil
  - Modeling of ice-on-surface
- Progress to date – modeling of lake stratification is underway; some key features still to be modeled along with experimental validation.

Lake Stratification – Work to date

- The one dimensional advection-diffusion equation is solved with a finite difference approach to predict water temperatures as a function of depth in the lake or pond.
- Cell size (depth) of 0.25 m and a time step of one day.
- Full surface energy balance: solar radiation, long-wave radiation, evaporation and convection.
- Solar radiation is transmitted and absorbed below the surface. Turbidity is treated as an input parameter.
- The eddy diffusivity coefficients for the epilimnion (well-mixed region near the surface) are computed based on wind speed. The epilimnion depth is computed by balancing the potential energy due to temperature difference and the kinetic energy due to wind shear. The eddy diffusivity coefficients for the lower layers are currently fixed.
- The bottom boundary condition is currently adiabatic.

Sample Preliminary Results



Sample Preliminary Results

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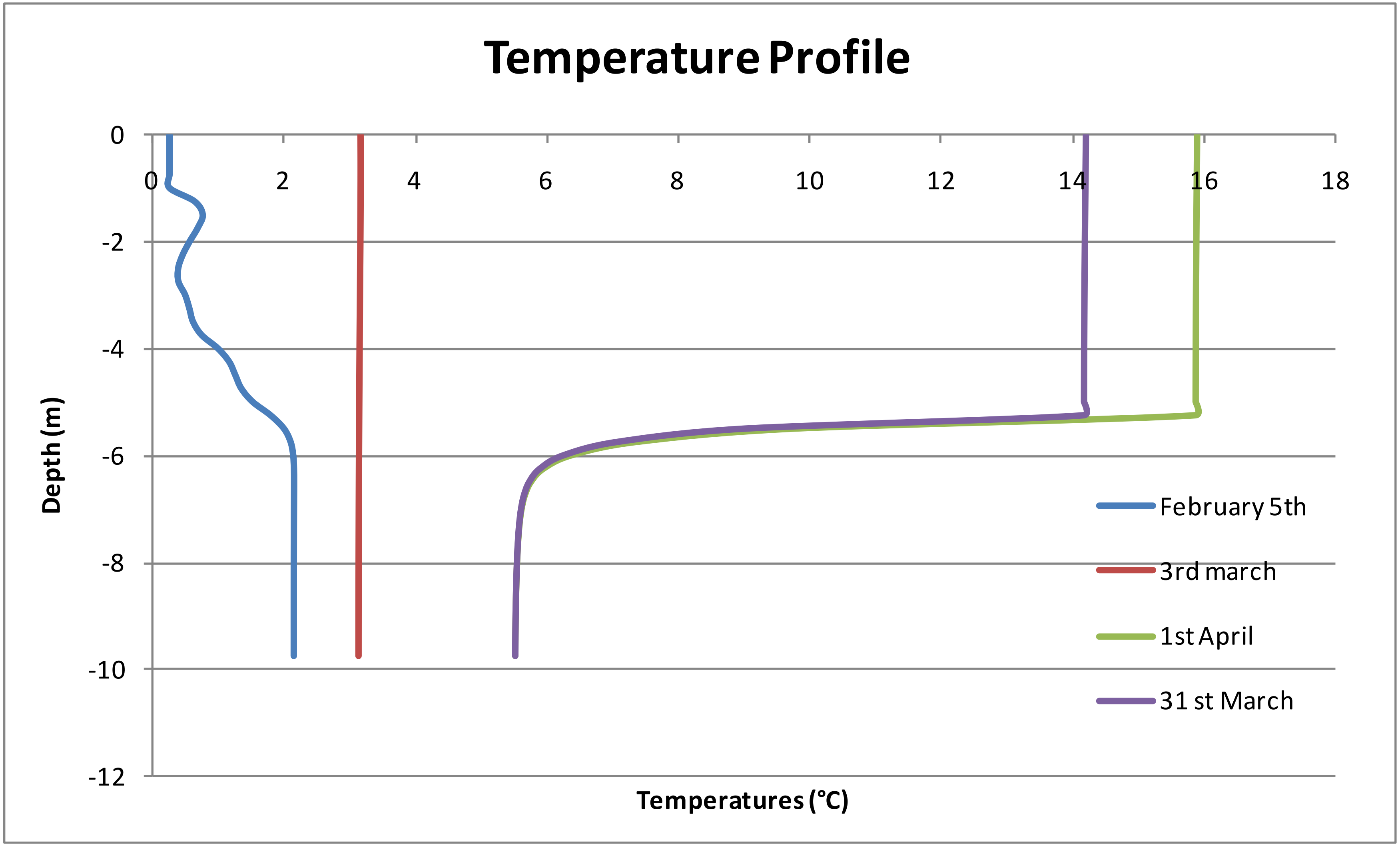

Accomplishments, Expected Outcomes and Progress

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Progress to Date

- Lake stratification model running

Next Steps

- The lake bottom will be modeled with a quasi 1-d conduction model coupled by convection to the water.
- Modeling seasonal lake turnover requires an algorithm to detect the transition.
- Addition of a pond heat exchanger model.
- Addition of freezing and thawing on the surfaces of the pond heat exchanger.
- Freezing and thawing at the lake surface, as well as snow accumulation.

Standing Column Wells

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- Existing HVACSIM+ model, previously developed by project team
- Next steps
  - Incorporate separate bleed control
  - Improved buoyancy-driven convection correlations
  - Test bleed control strategies

Project Management/Coordination

- The PI, Prof. Spitler directly supervises the two graduate students and is responsible for ensuring the quality of the work and satisfying the reporting requirements.

Future Directions

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- Deployment Strategy
  - Implementation in distributed version of EnergyPlus
  - Implementation in commercially available ground heat exchanger design tool, distributed by International Ground Source Heat Pump Association
- Expected Outcomes
  - Increased capabilities for design engineers

Summary Slide

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- Project is still in very early stages.
  - Initial work on stratification in lakes appears promising but is yet to be validated.
  - Work is ongoing.