Using ModEx to Integrate Model Development with Emerging Data Streams

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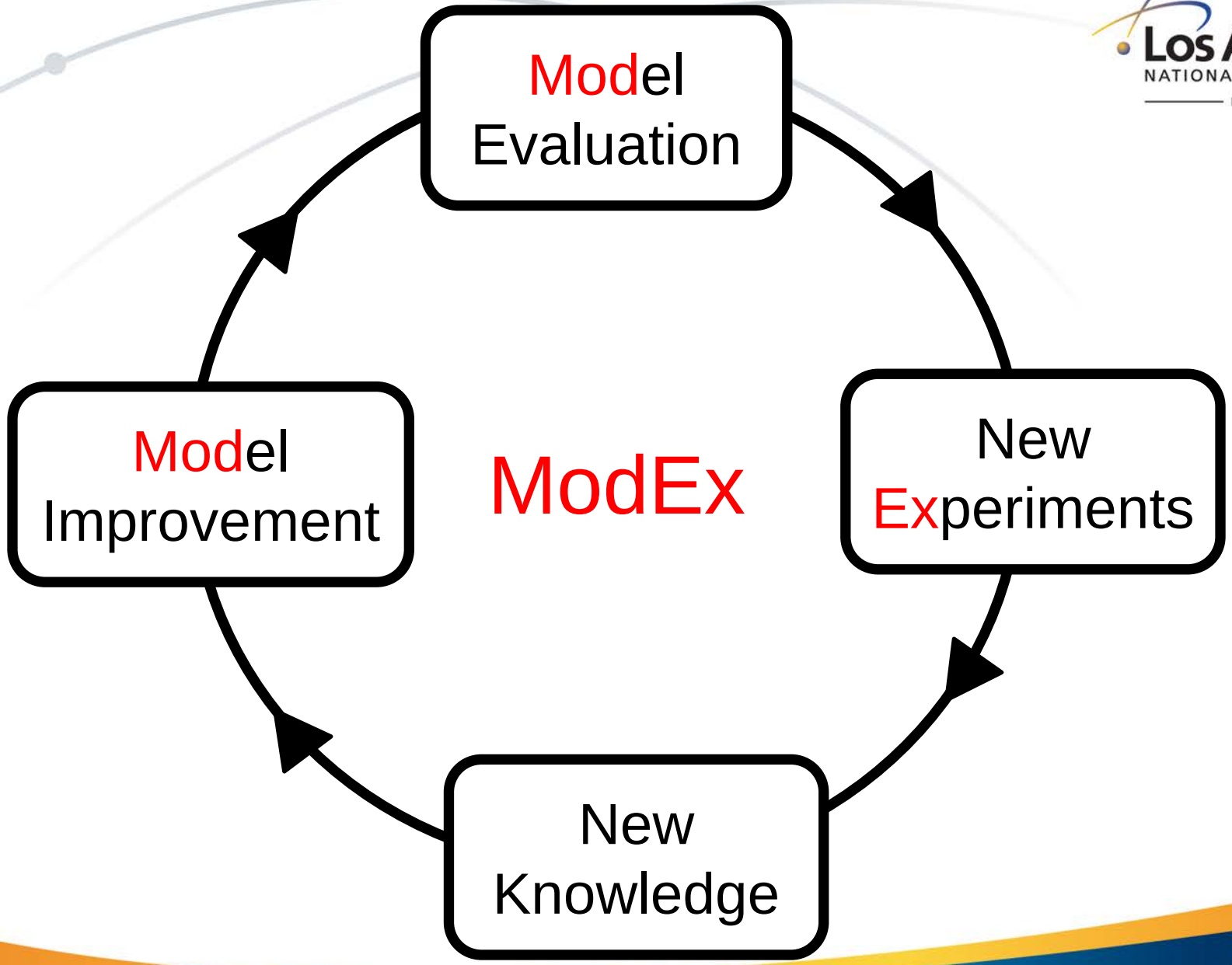
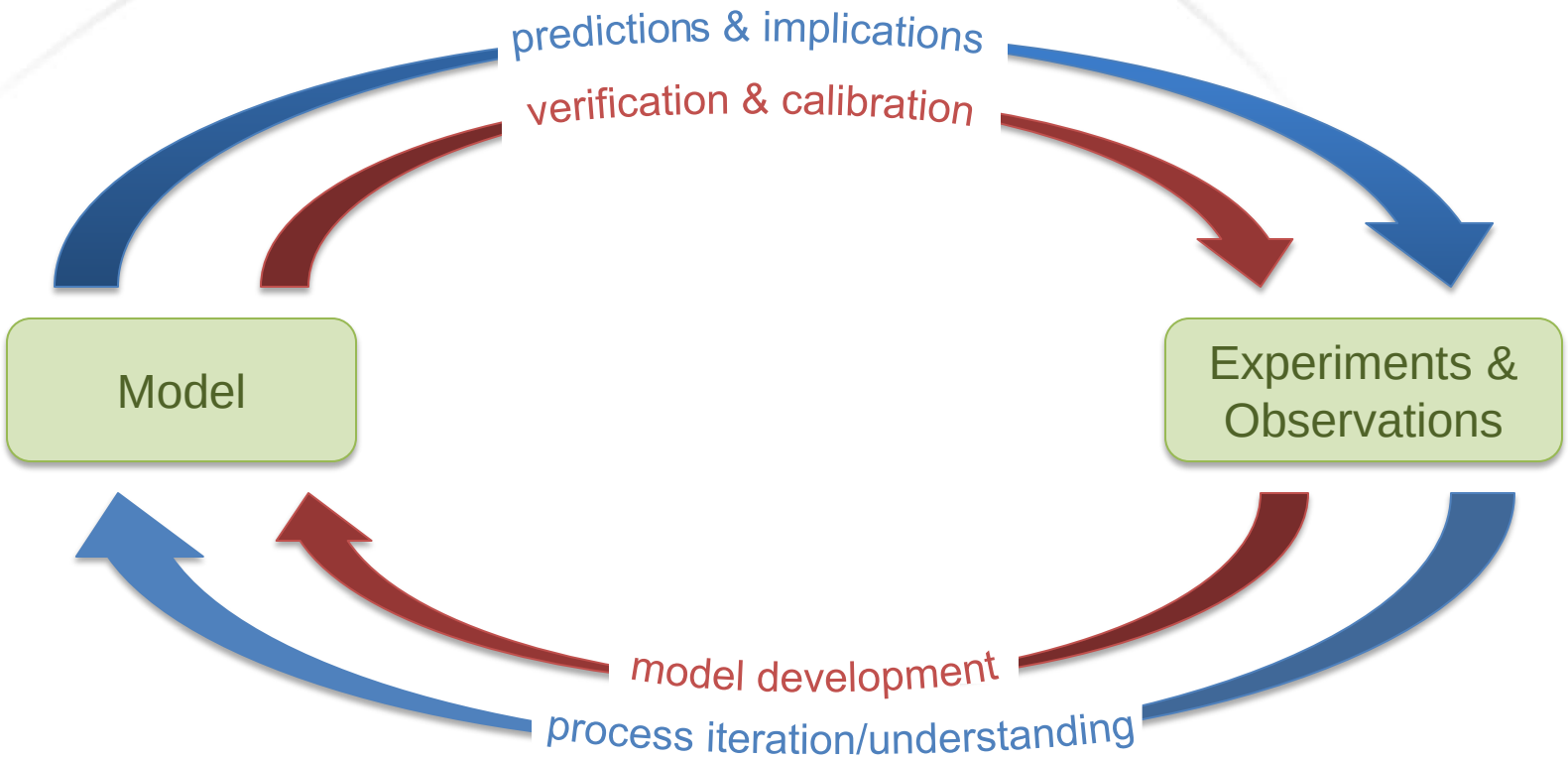
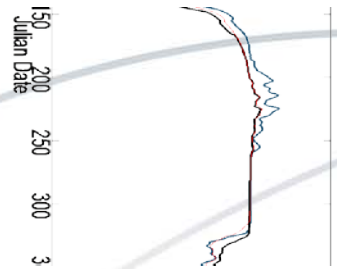
NGEE All-Hands


Model Evaluation
New Experiments
New Knowledge
Model Improvement
ModEx

ModEx


predictions & implications
verification & calibration
Model
Experiments & Observations
model development
process iteration/understanding



calibrate model with observations

Validate model, parameters with observed measurements

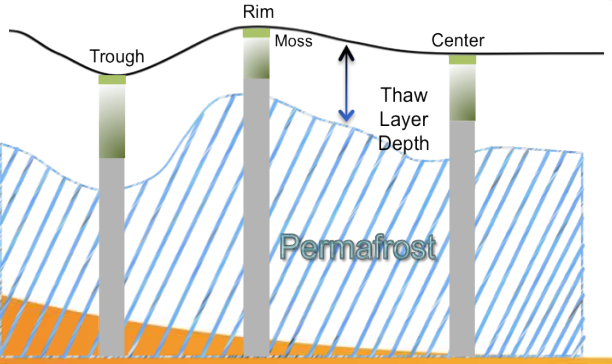
verification & calibration

implement, verify

Model

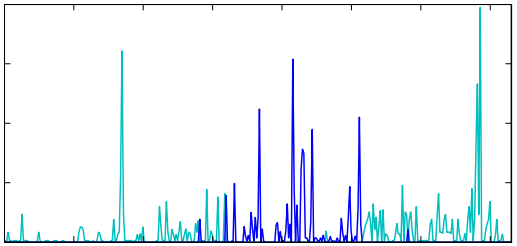
E&O

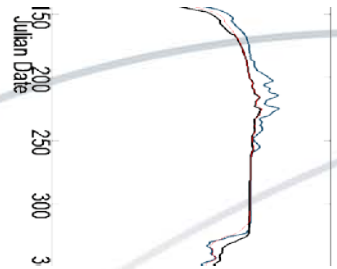
develop conceptual model



model development

gather simulation input, observational constraints





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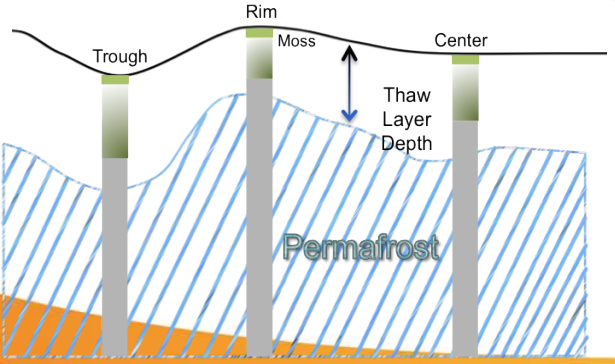

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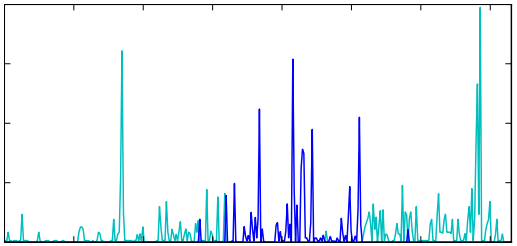

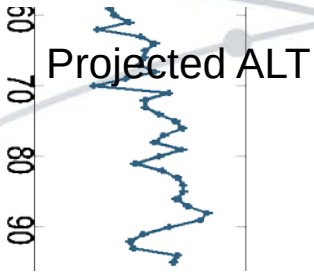

predictions & implications

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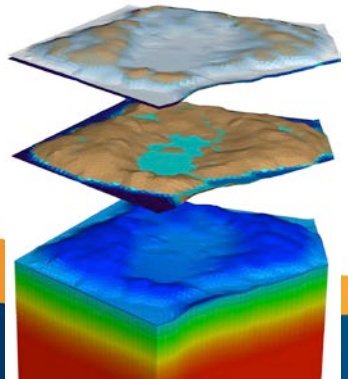
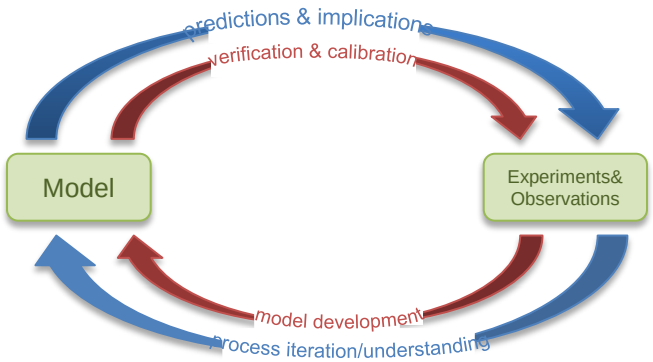
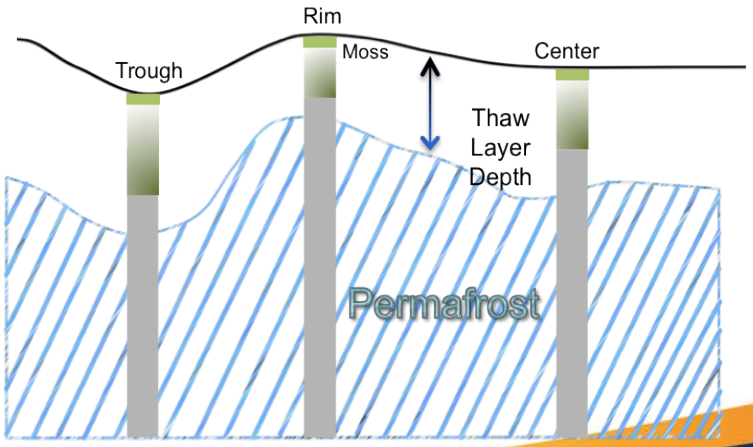


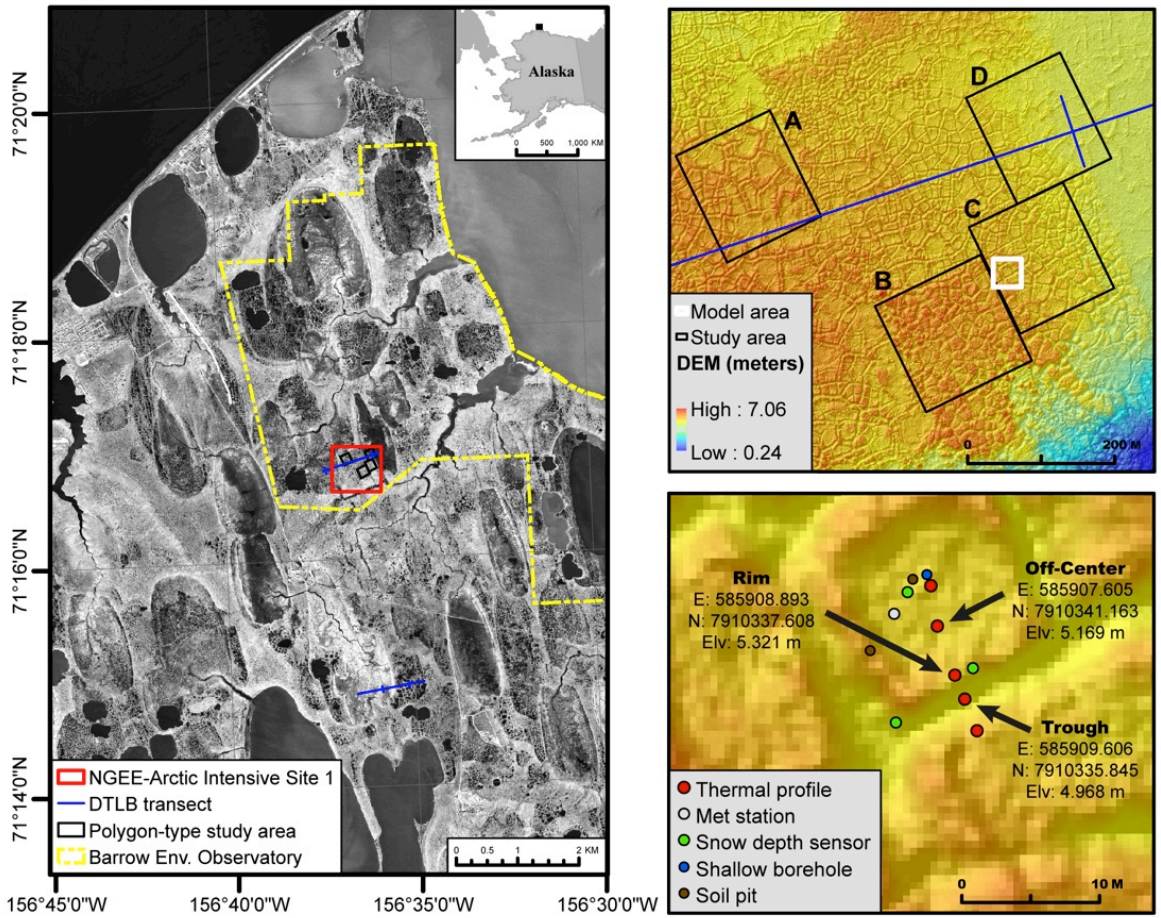
Use the ModEx Cycle to:

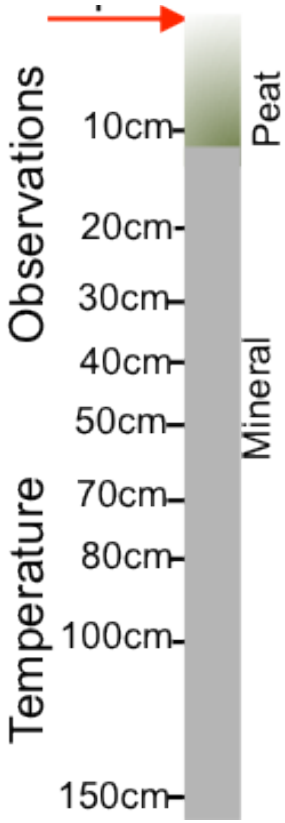
- Develop a fine-scale model of thermal-hydrology to simulate complex freeze-thaw dynamics of polygonal tundra systems.
- Provide valid characteristic parameters for use in physical thermal-hydrology models
- Provide initial model conditions for use in Active Layer Thickness projections due to climate change.





ModEx Calibration/Model Development

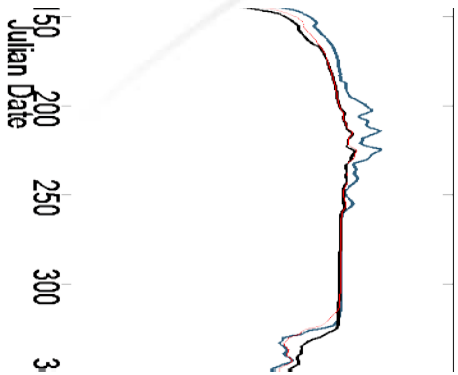




- Observed temperature time-series at 9 depths used to calibrate the model.
- Center, rim, and trough columns calibrated separately, then coupled.
- 8 calibration starts spread across parameter space.
- Calibrated both with and without the surface model

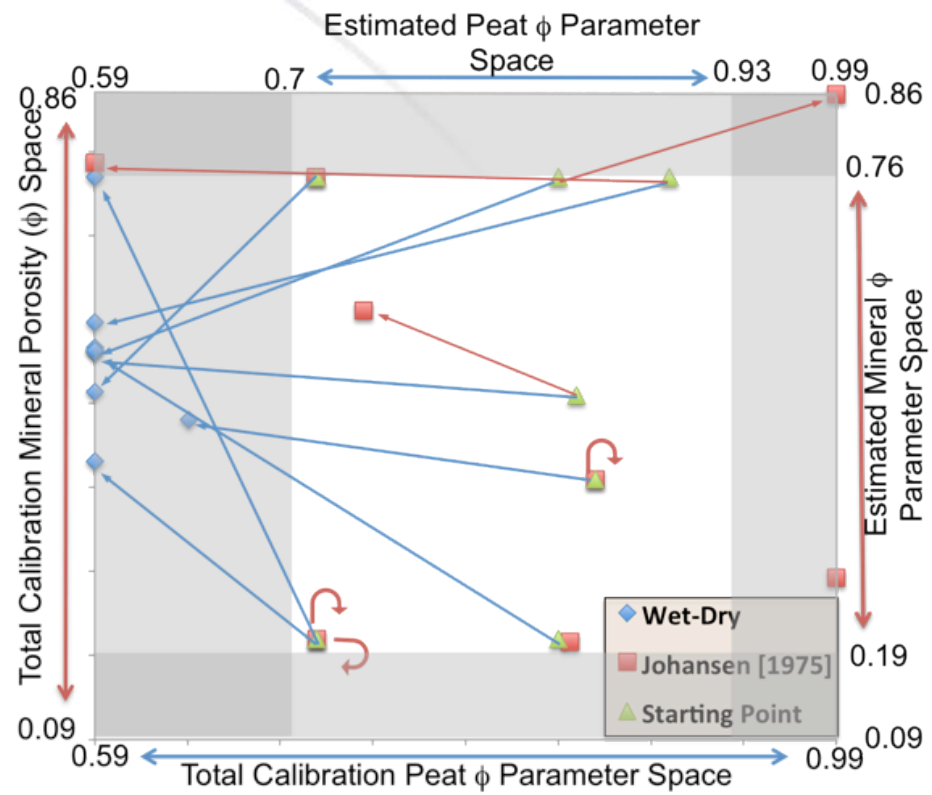
ModEx Calibration/Model Development

Pest, a gradient-based Levenberg-Marquardt algorithm is used to calibrate model parameters



Calculate root mean squared error between simulations and observations

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\hat{y}_i(\boldsymbol{\theta}) - y_i)^2}$$



Is the RMSE adequate?

Are calibrated parameters realistic?

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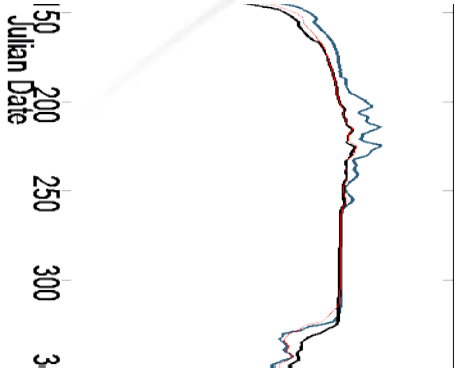

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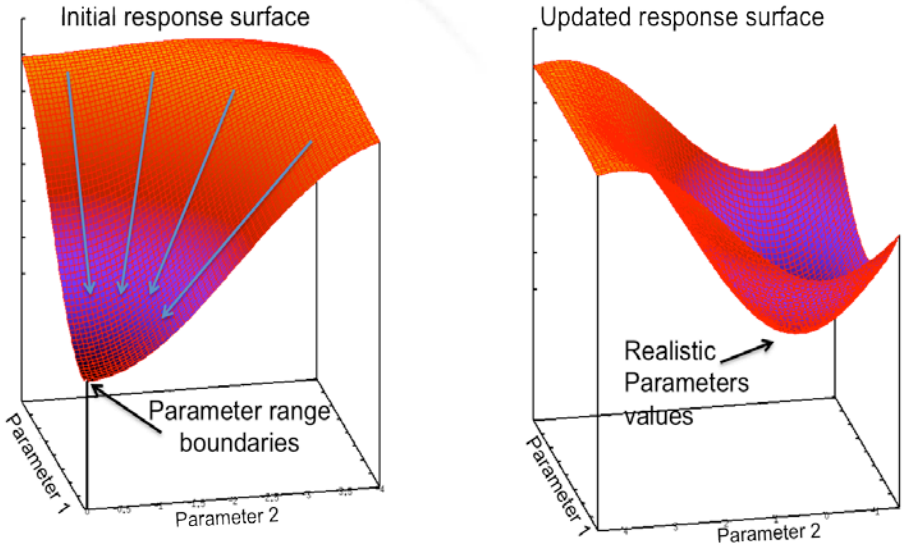

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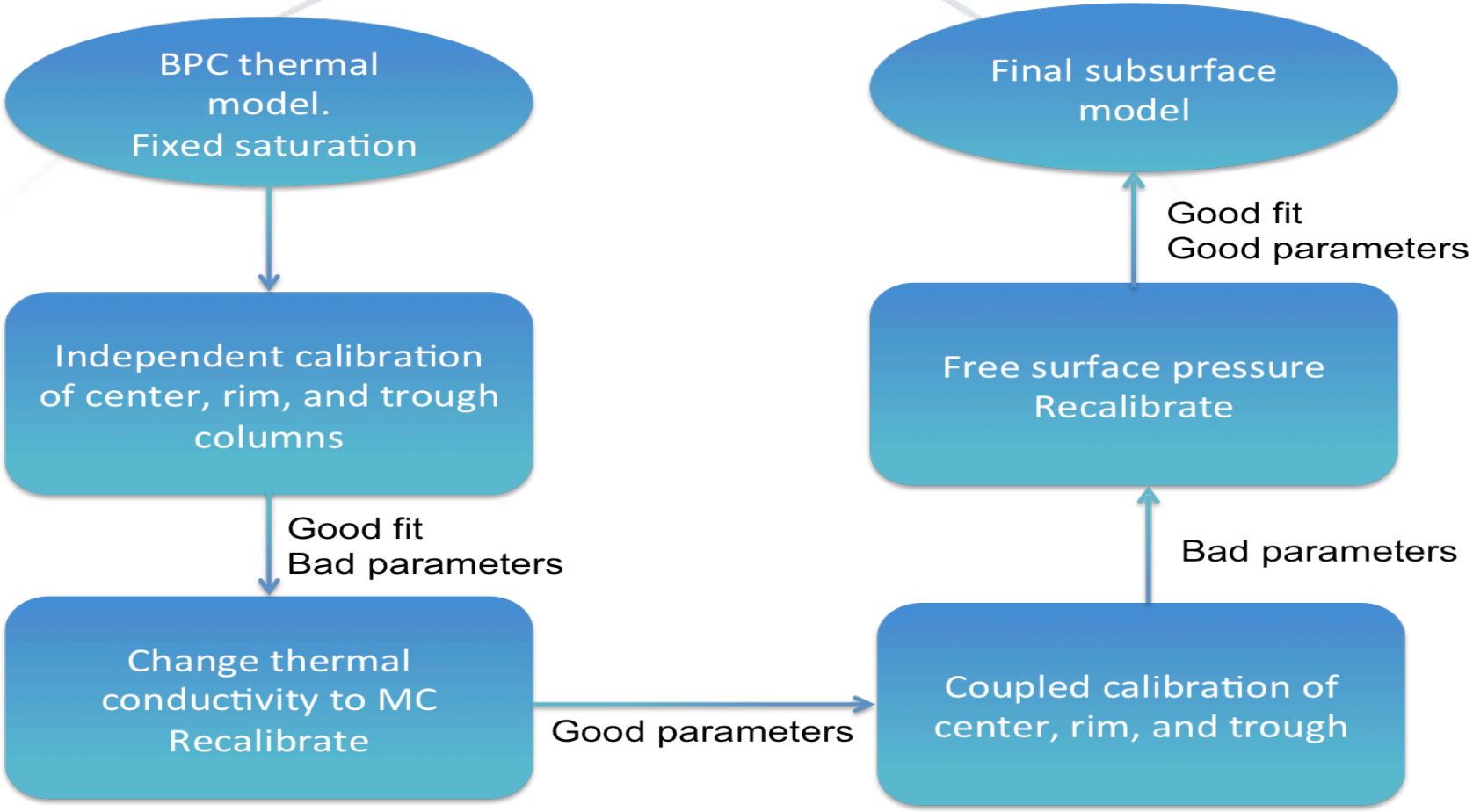
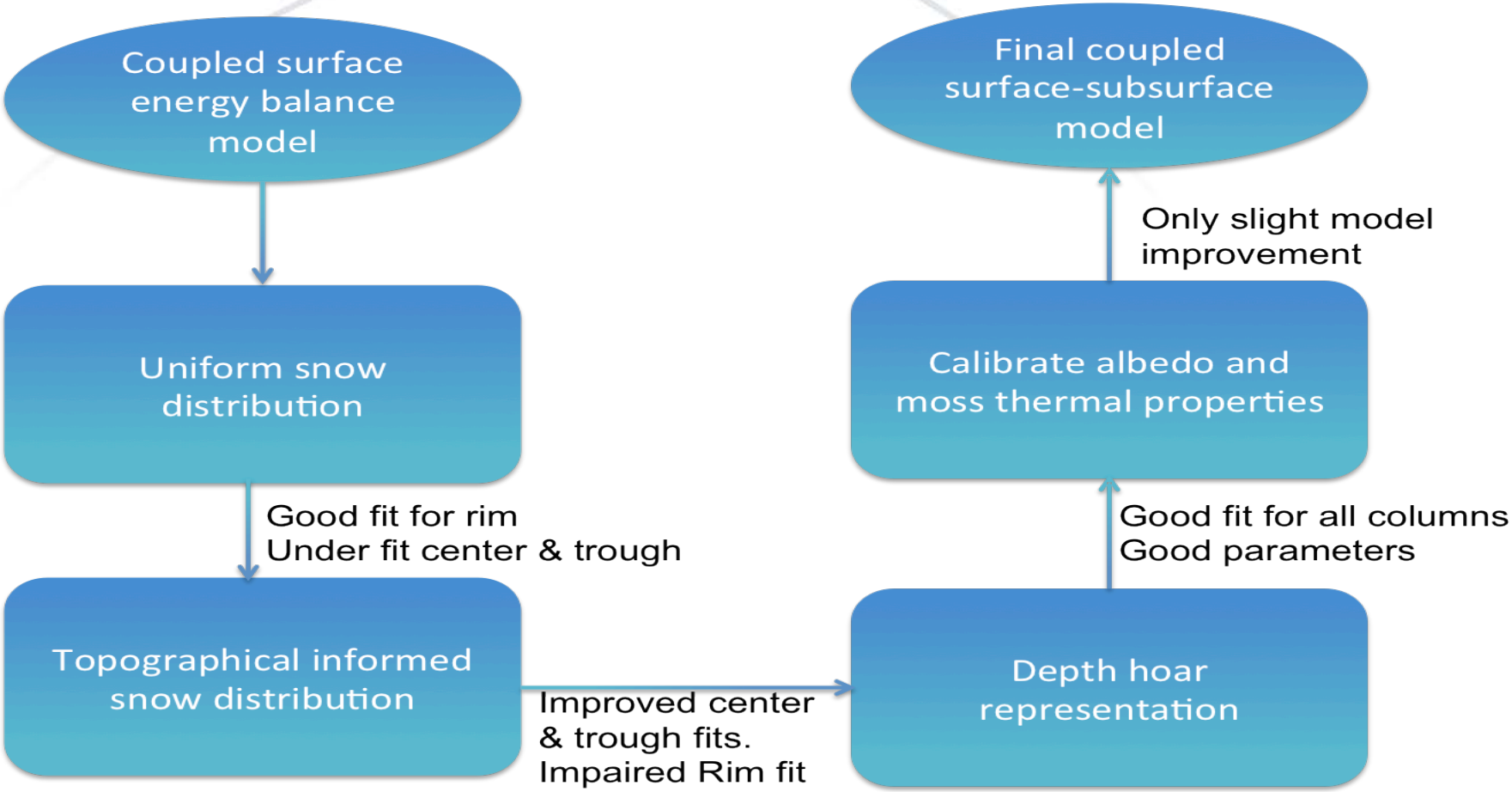
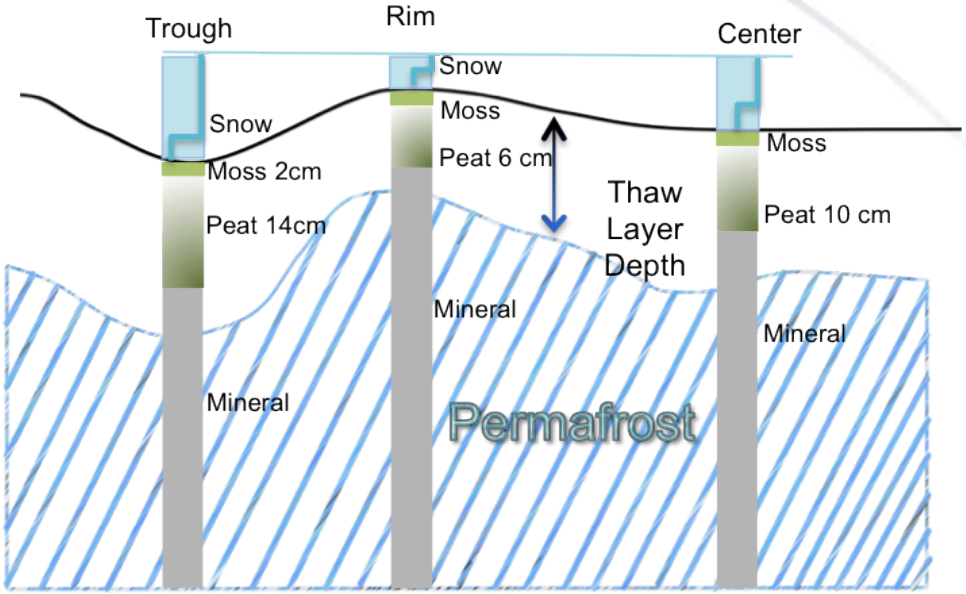
Subsurface Calibration/Model Development



Surface Calibration/Model Development



Technical Conclusions



M-1) Thermal Model: Material Component

M-2) Dominant Saturation State

M-3) Temporally Variable Saturation

O-1) Material Thermal Conductivity measurements

O-2/3) Soil Moisture time-series

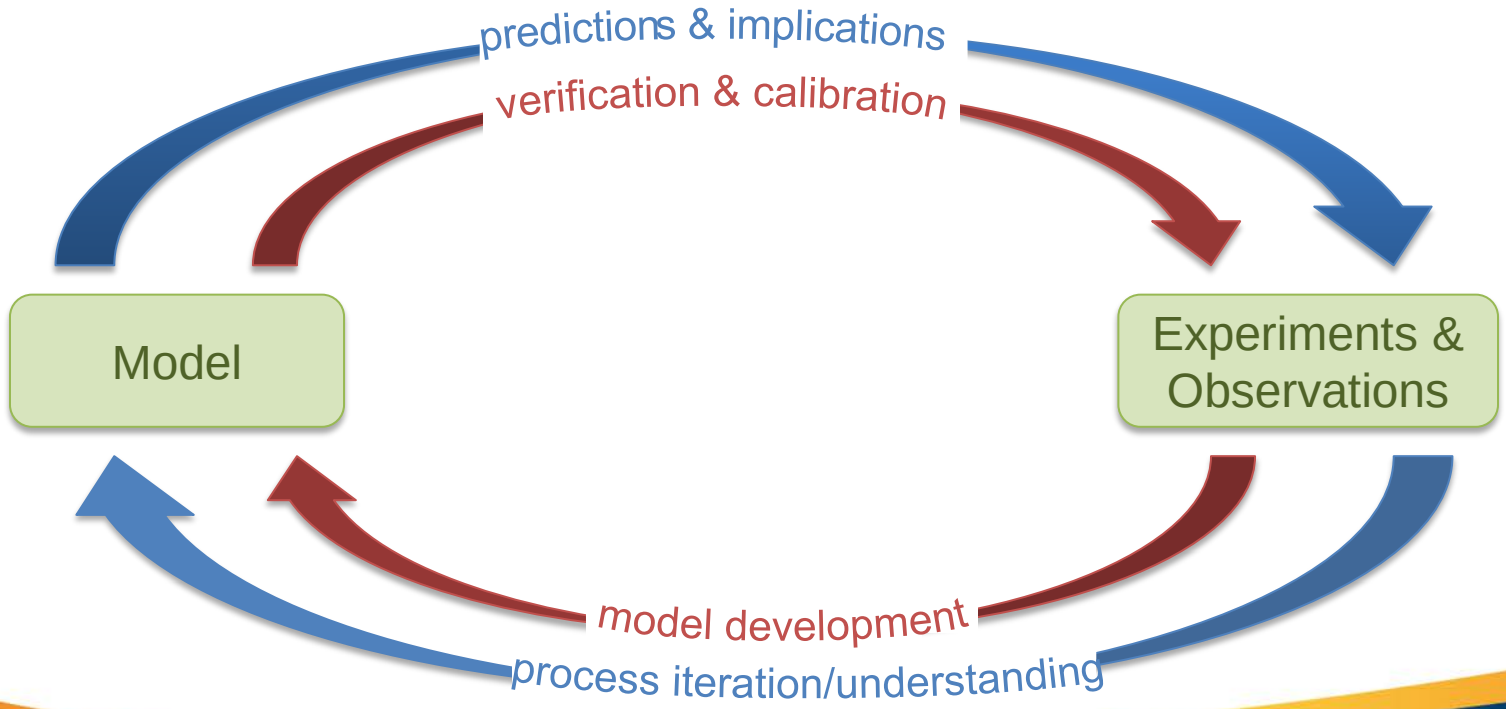
O-2/3) Monitor variable water fluxes: ET, lateral flow, snow melt

M-4) Snow Distribution & Depth Hoar Representation

O-4) Measure Snow distribution and snowpack dynamics.

M-5) Need for refined surface saturated properties, i.e. ponded albedo or local albedo?

O-5) Measure surface water flow and temperatures?

ModEx Conclusions

- ModEx is a powerful tool for both model development and process understanding.
- For each ModEx iteration of the outer cycle, many inner cycles are required, each with data needs.
- The ModEx process requires flexible model prototyping and testing.