Hydrologic Predictability in Mountainous Terrain

Lauren Hay USGS, Denver CO
Makiko Umemoto, USGS, Denver CO
Roland Viger, USGS, Denver CO
Martyn Clark CIRES U. of CO, Boulder CO
George Leavesley, USGS, Denver CO

HEPEX Workshop, July 2005

lhay@usgs.gov

Background

- Hydrologic predictability in the US

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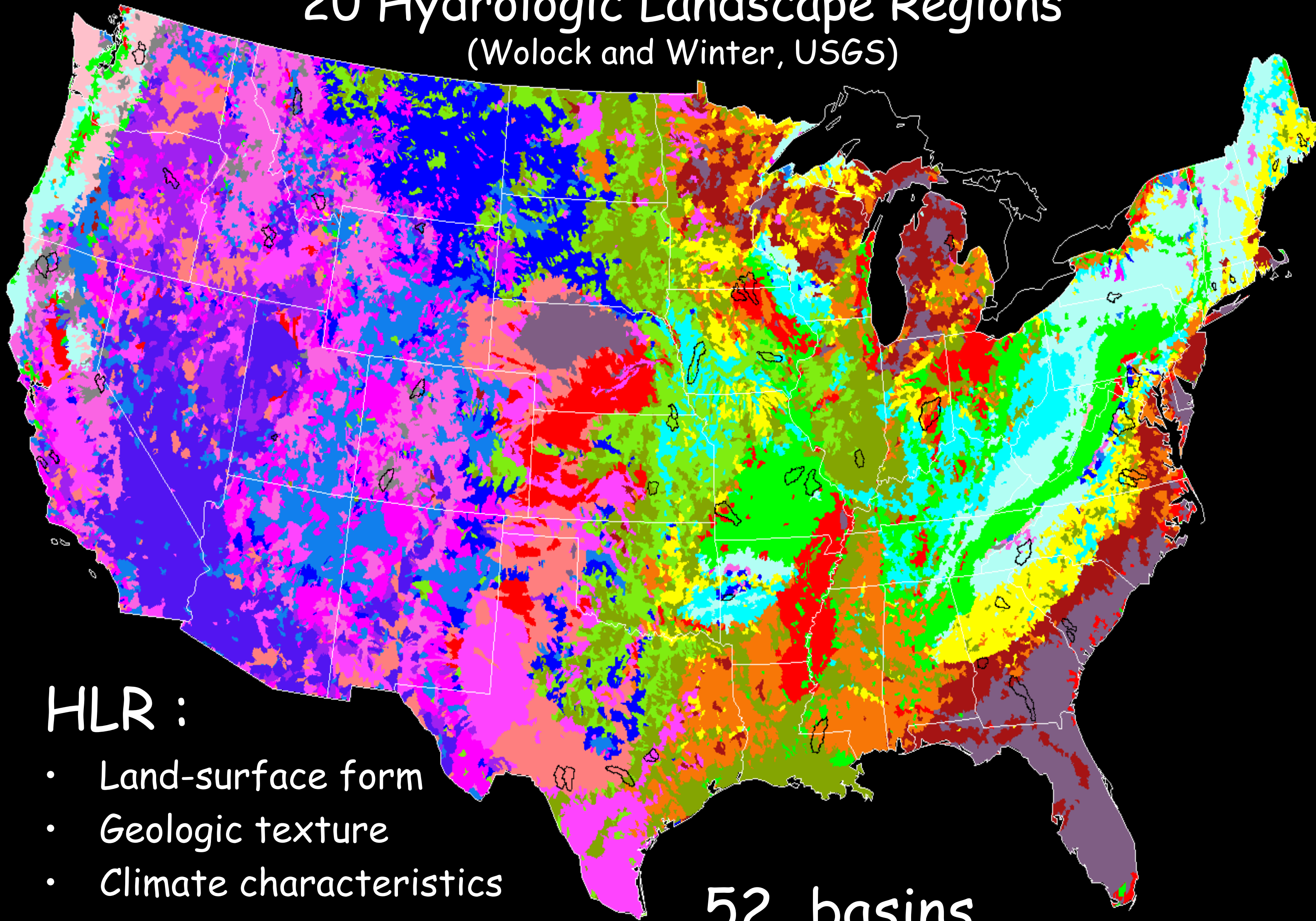
20 Hydrologic Landscape Regions

(Wolock and Winter, USGS)



HLR :

- Land-surface form
- Geologic texture
- Climate characteristics

52 basins

Background

- Hydrologic predictability in the US
- Needed to be able to apply a physically-based fully distributed hydrologic models for large number of basins in a timely and efficient manner
  - Automation in basin setup and parameter estimation

lhay@usgs.gov

Hydrologic Model Calibration

- Traditional approaches compared observed and simulated runoff at the outlet of the basin.
- Runoff is not sufficient by itself in the evaluation of a hydrologic model.
- While incorporation of spatial data into the calibration and evaluation process is ideal, research in this area has occurred mainly in heavily instrumented research basins.
- In general, the data available for calibration/evaluation of hydrologic models are limited.

lhay@usgs.gov

Background

- Used **hierarchal approach** to estimate parameters and configure hydrologic model for 52 basins in the US

Precipitation Runoff Modeling System (PRMS)

[distributed –parameter, physically-based watershed model]

Implemented in:

Modular Modeling System (MMS)

[A set of modeling tools to enable a user to selectively couple the most appropriate algorithms]

lhay@usgs.gov

Hierarchal Approach to Estimate Parameters

- 4-step model calibration procedure using **S**huffled **C**omplex **E**volution (SCE developed by Qingyun Duan):

- For each step calculate objective function(s) using "observed" and simulated:

1. Solar Radiation
2. PET
3. Water balance components
4. Daily runoff components

lhay@usgs.gov

Spatial Variability of Hydrologic Model Performance

- Look at relation of model performance (Nash-Sutcliffe -- NS) versus basin characteristics
- Annual solar radiation, gage elevation, percent groundwater can be used to predict NS
- Use MLR equation to predict NS at 1300 HCDN (Hydro-Climatic Data Network) sites

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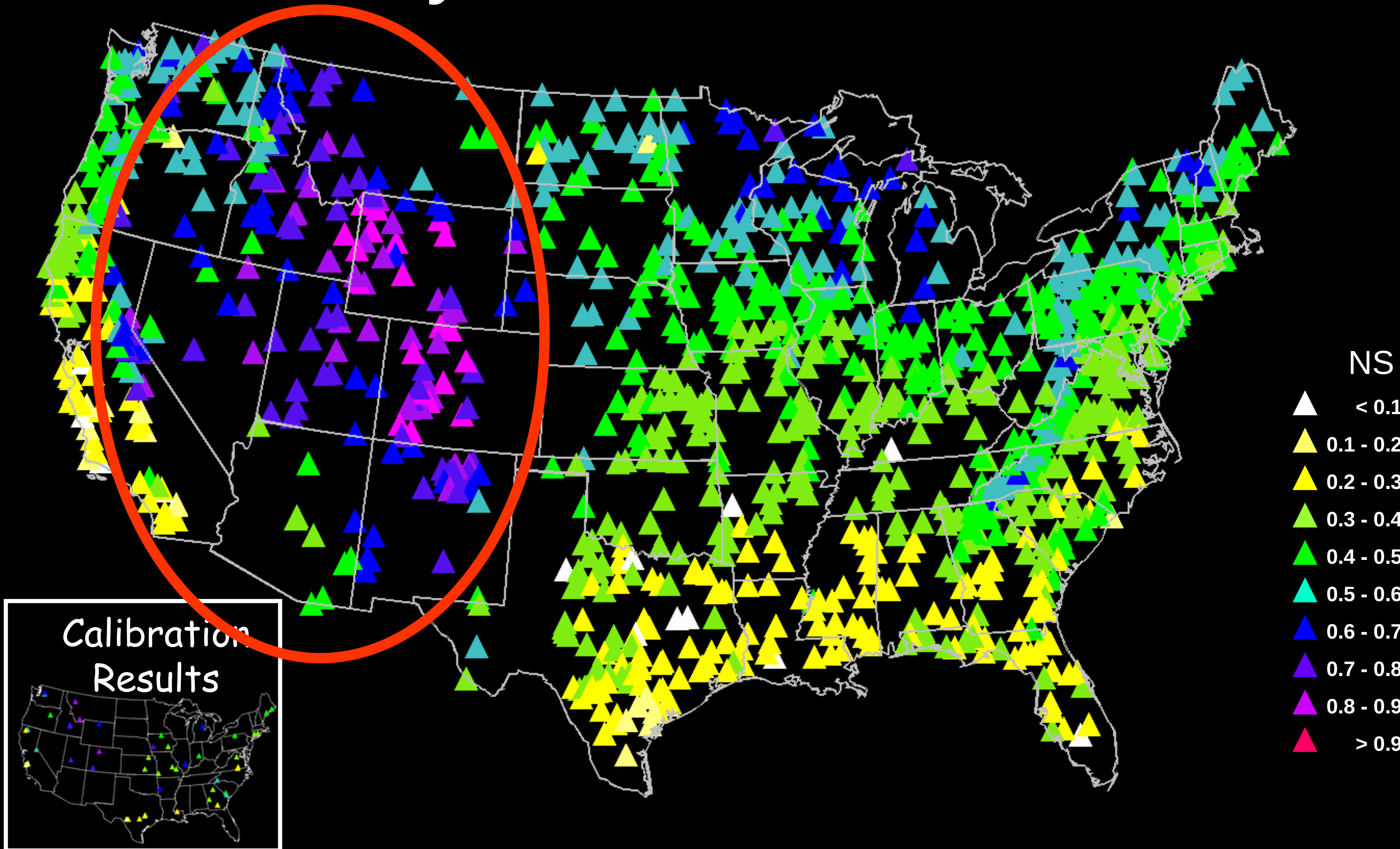
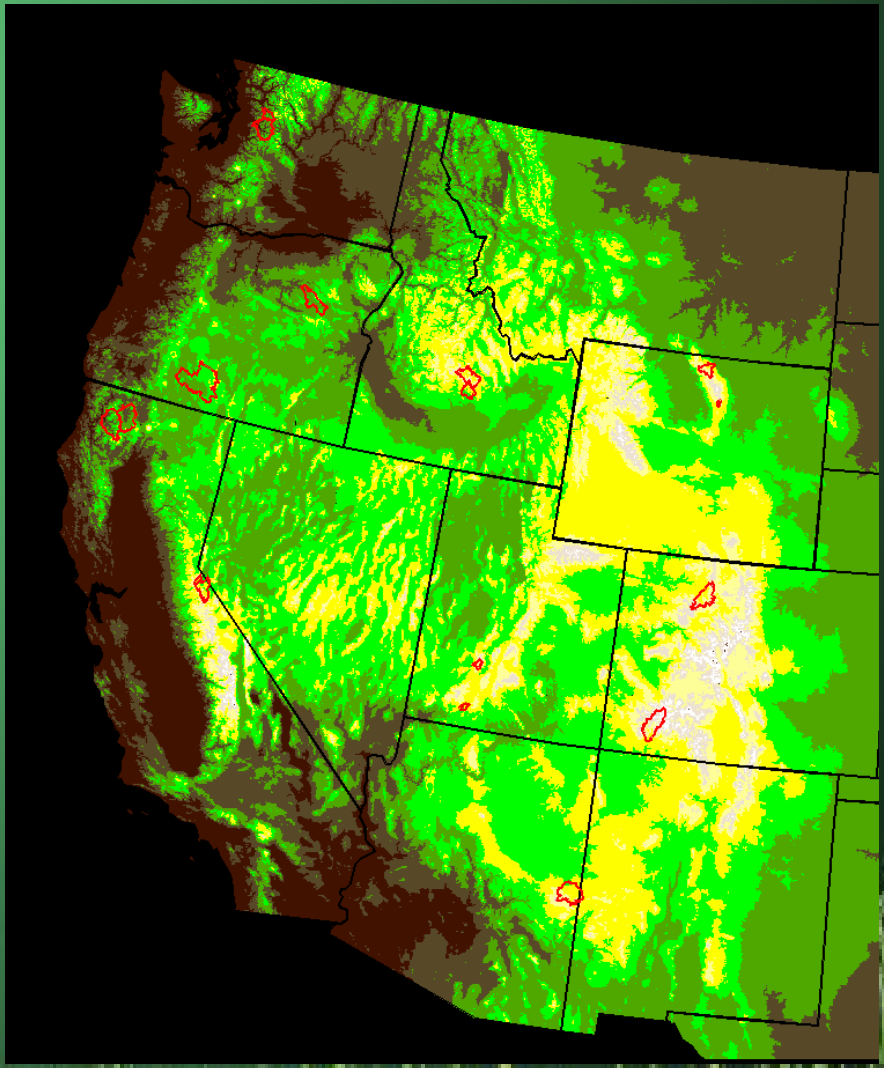
Estimated Nash-Sutcliffe Coefficient of Efficiency statistic at HCDN sites



Current Study

Snow-melt dominated basins in the western US



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Hierarchal Approach to Estimate Parameters

4-step model calibration

1. Solar Radiation
2. PET
3. Water Balance
4. Daily runoff

GUI for Hierarchal Model Calibration

Allows users to modify the calibration procedure to their own models, data, objective functions, and calibration steps.

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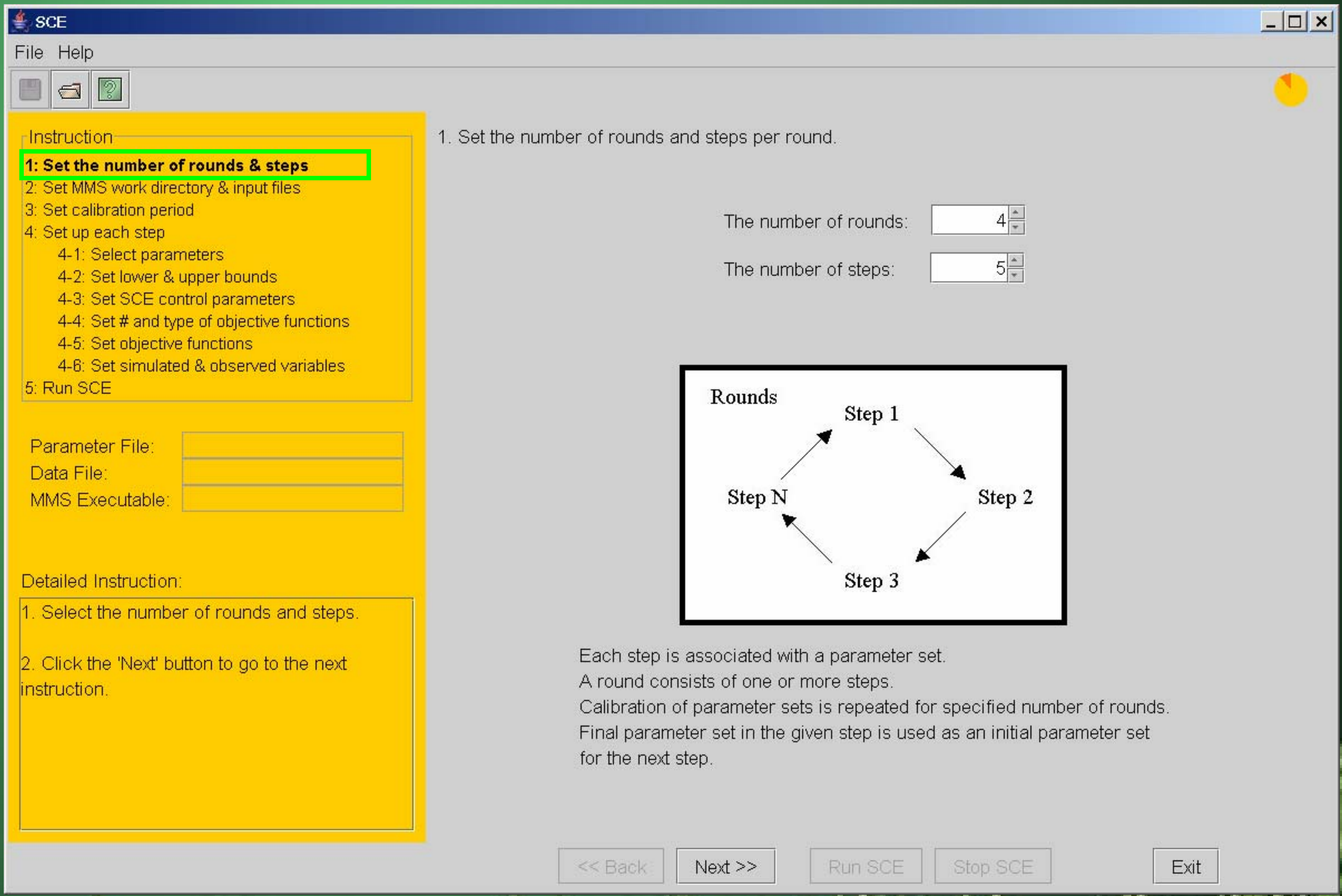

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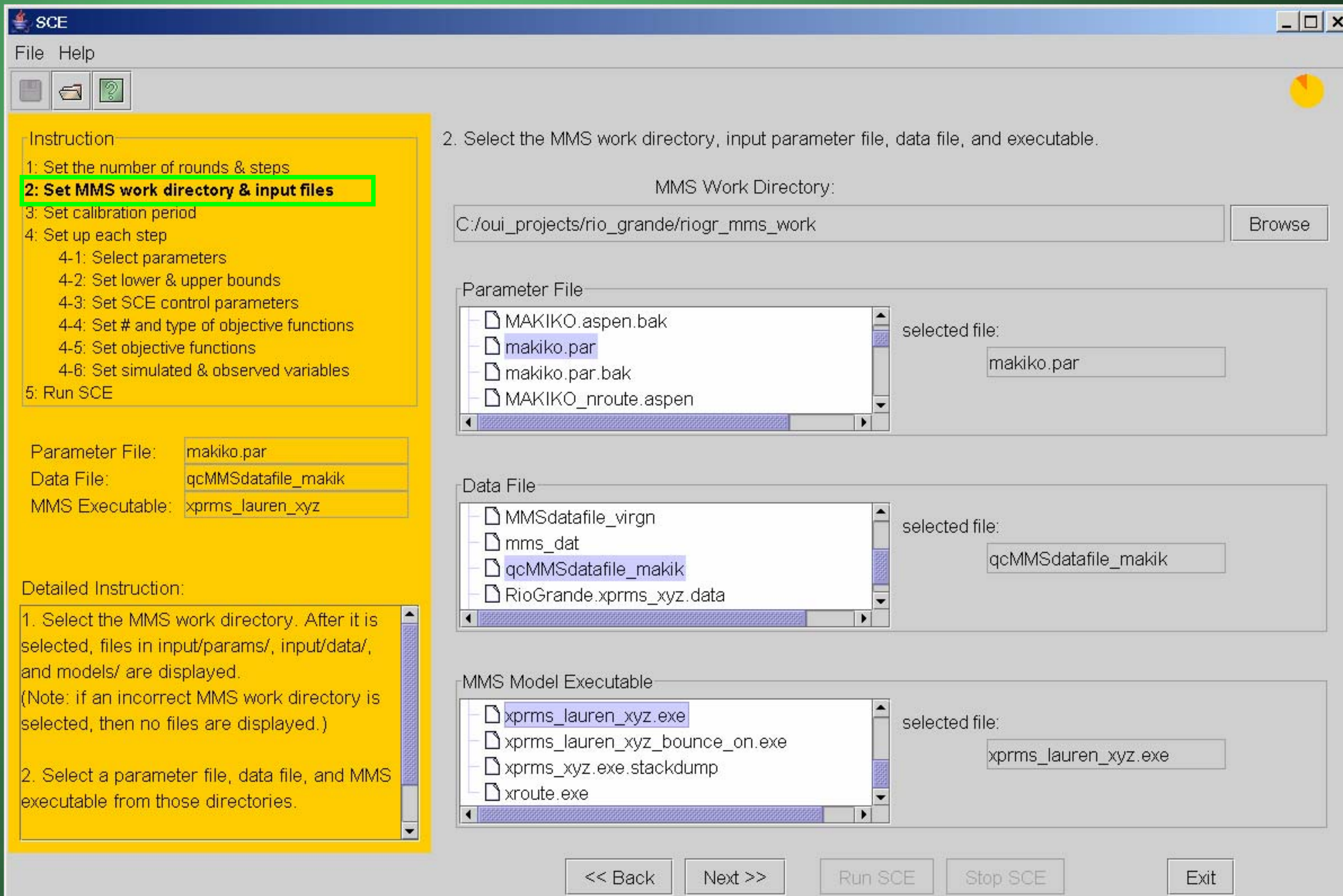

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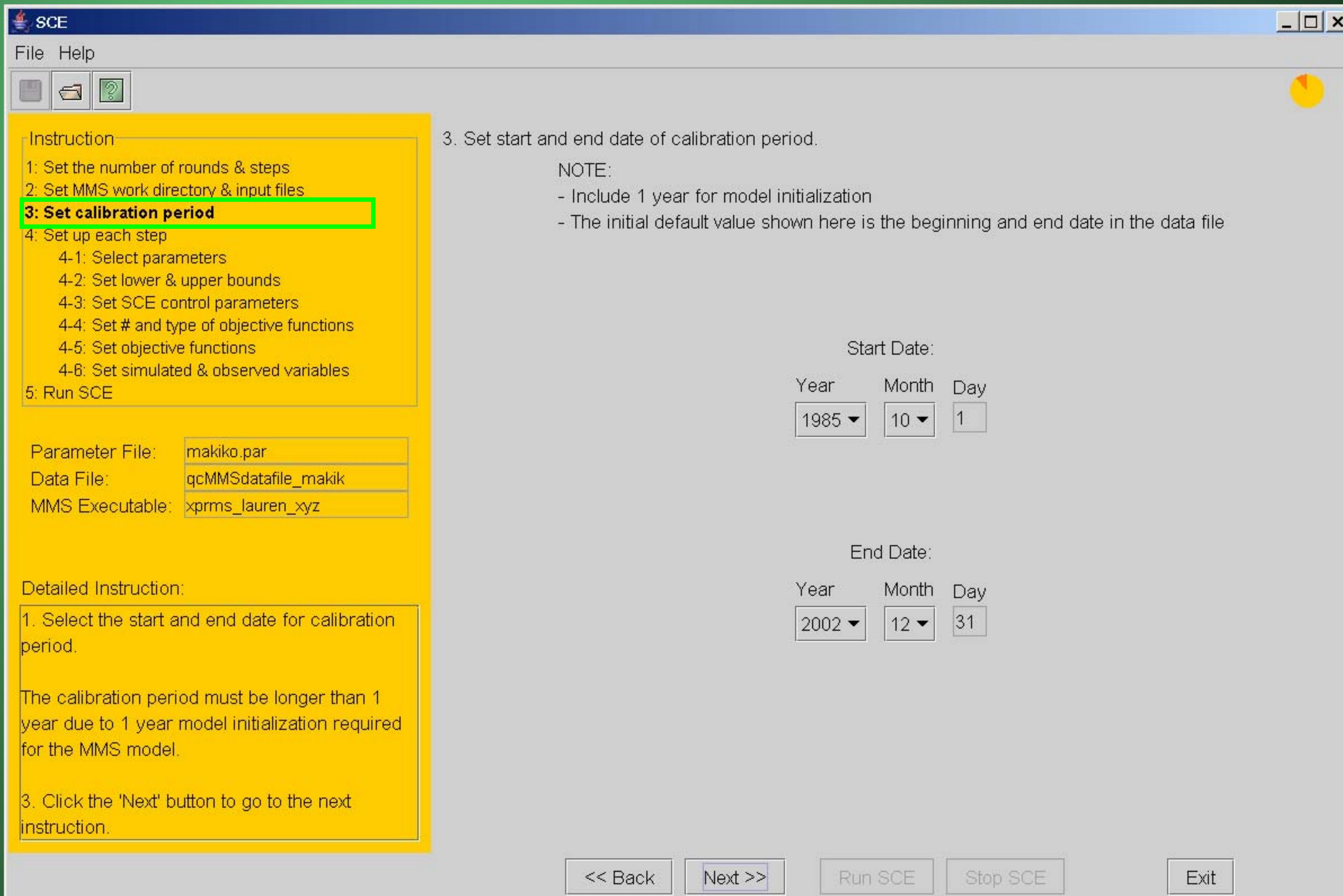

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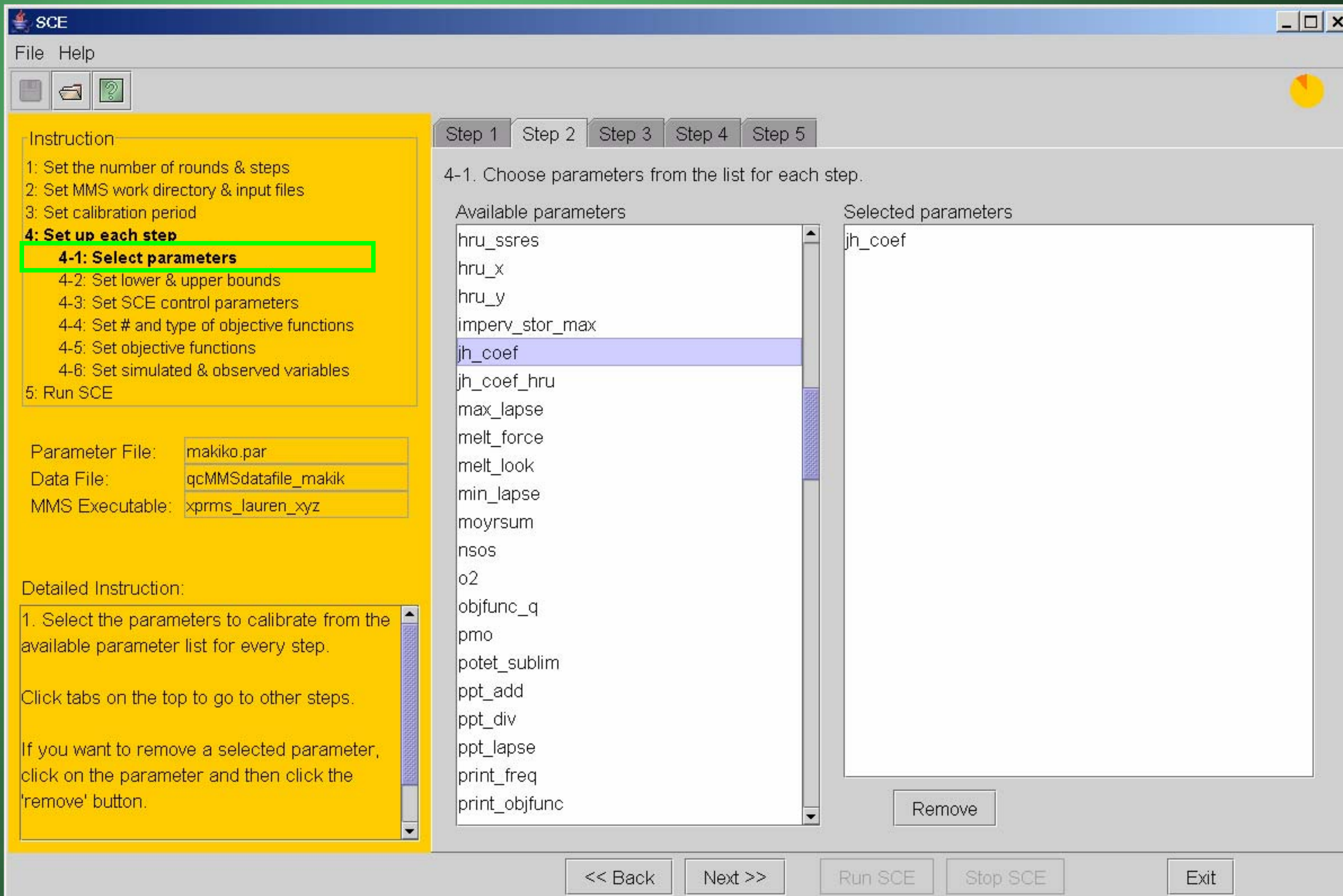

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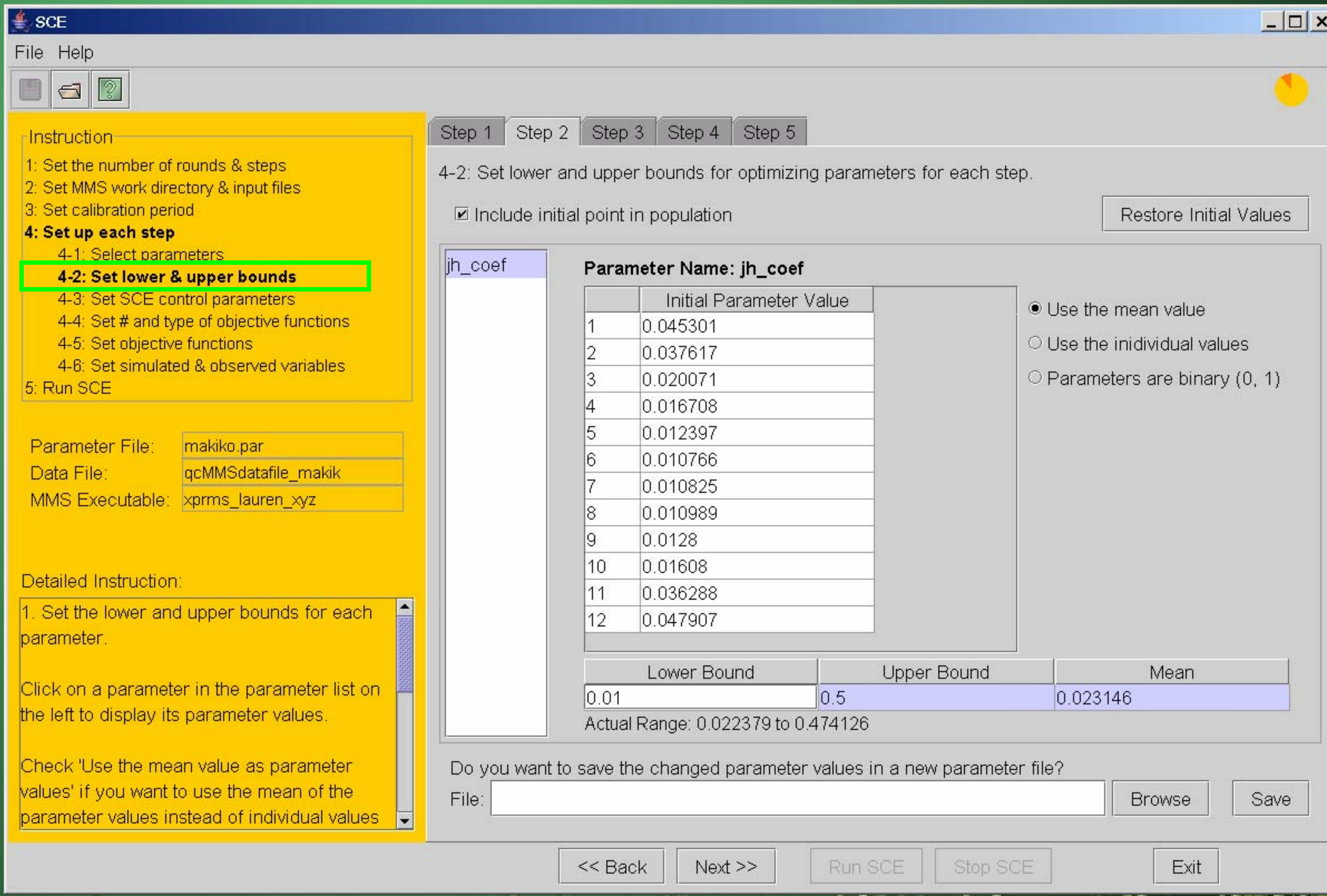

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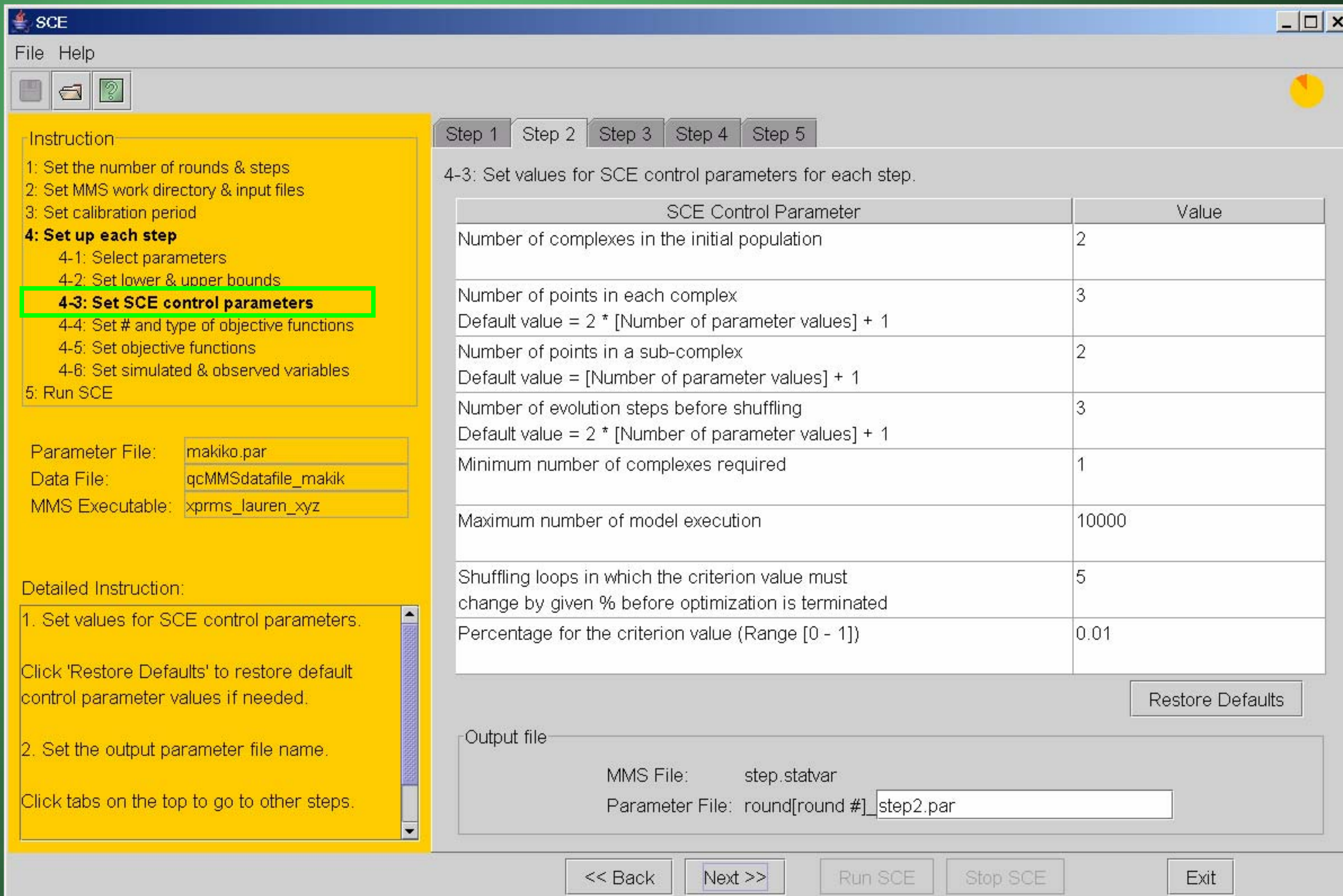

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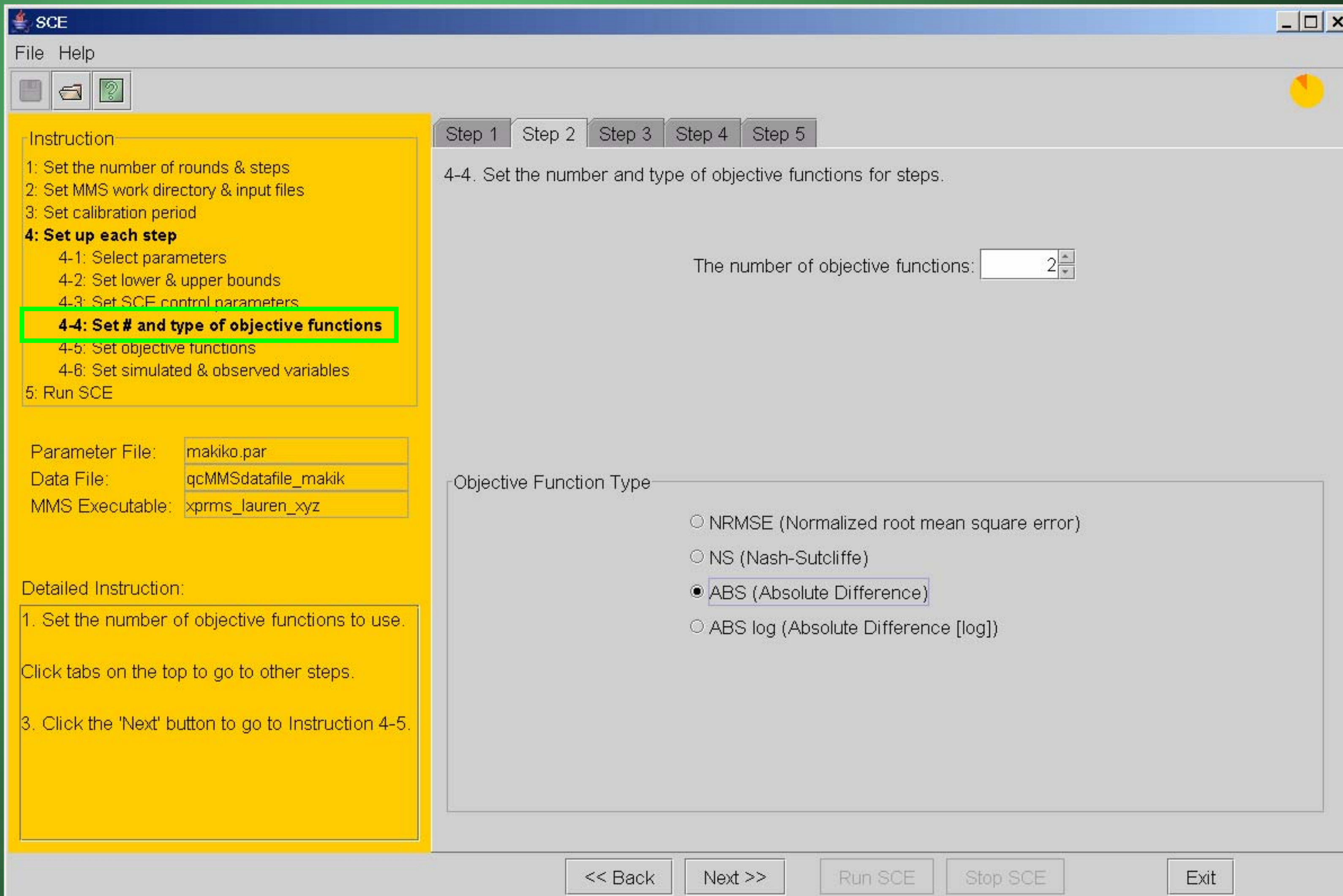

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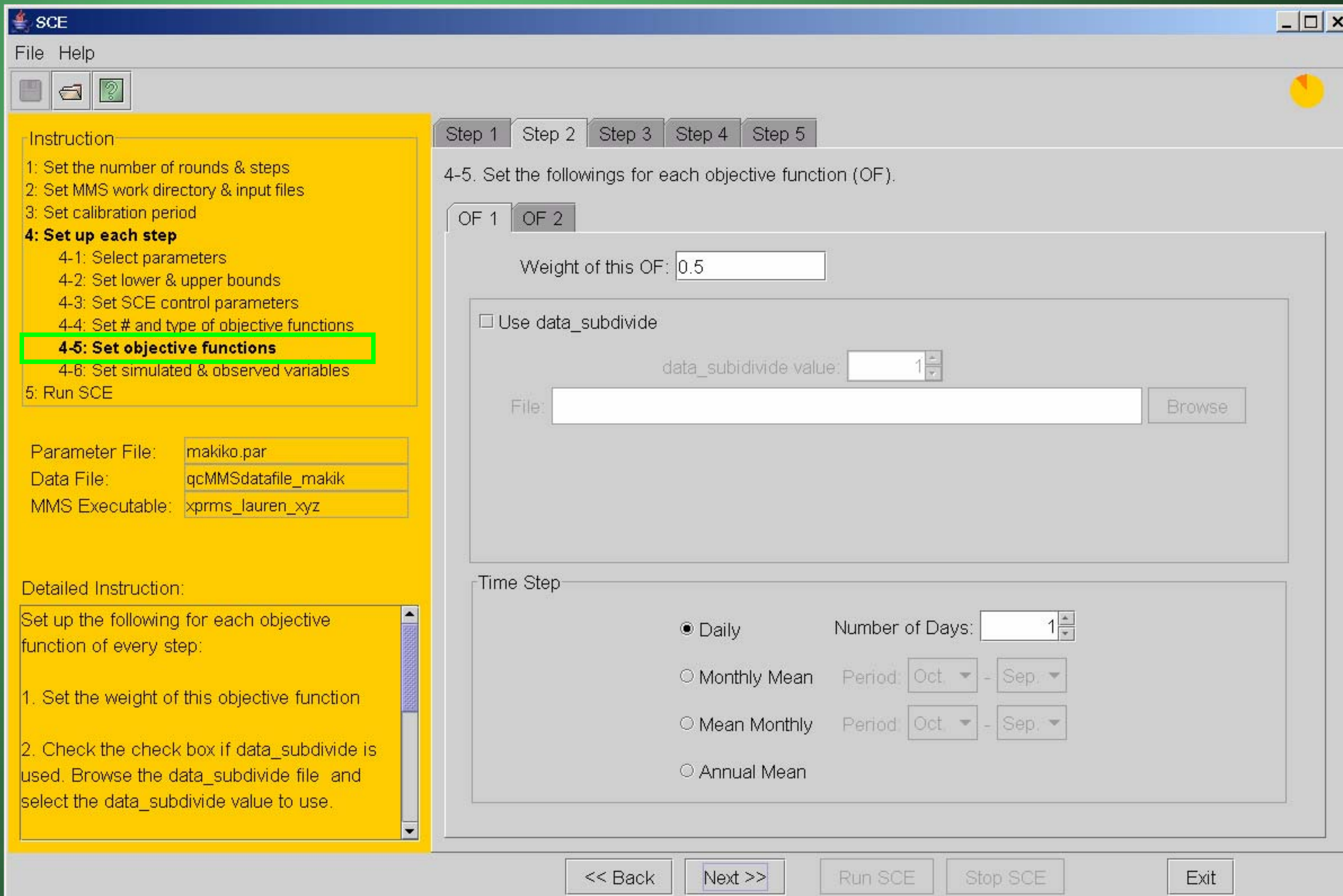

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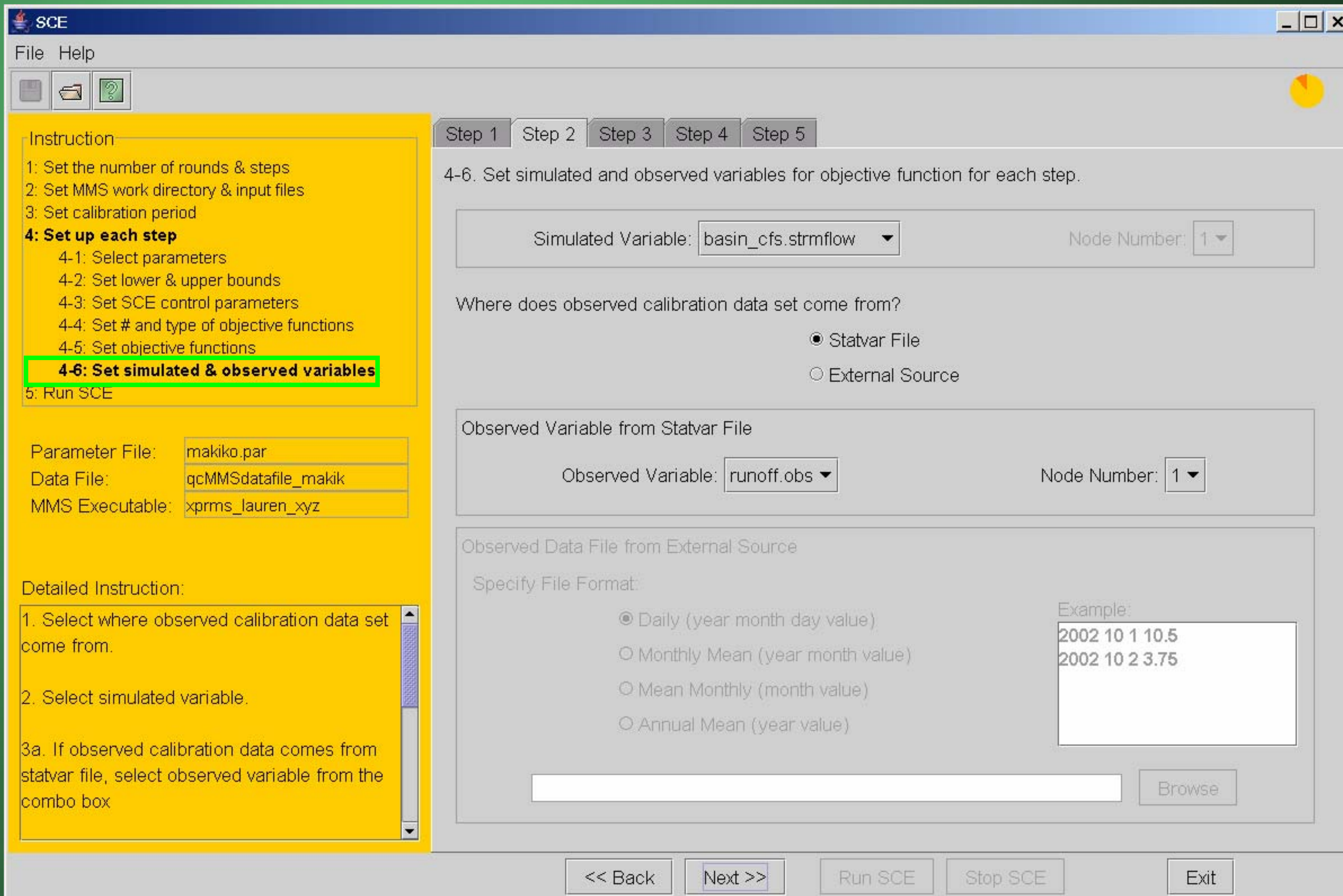
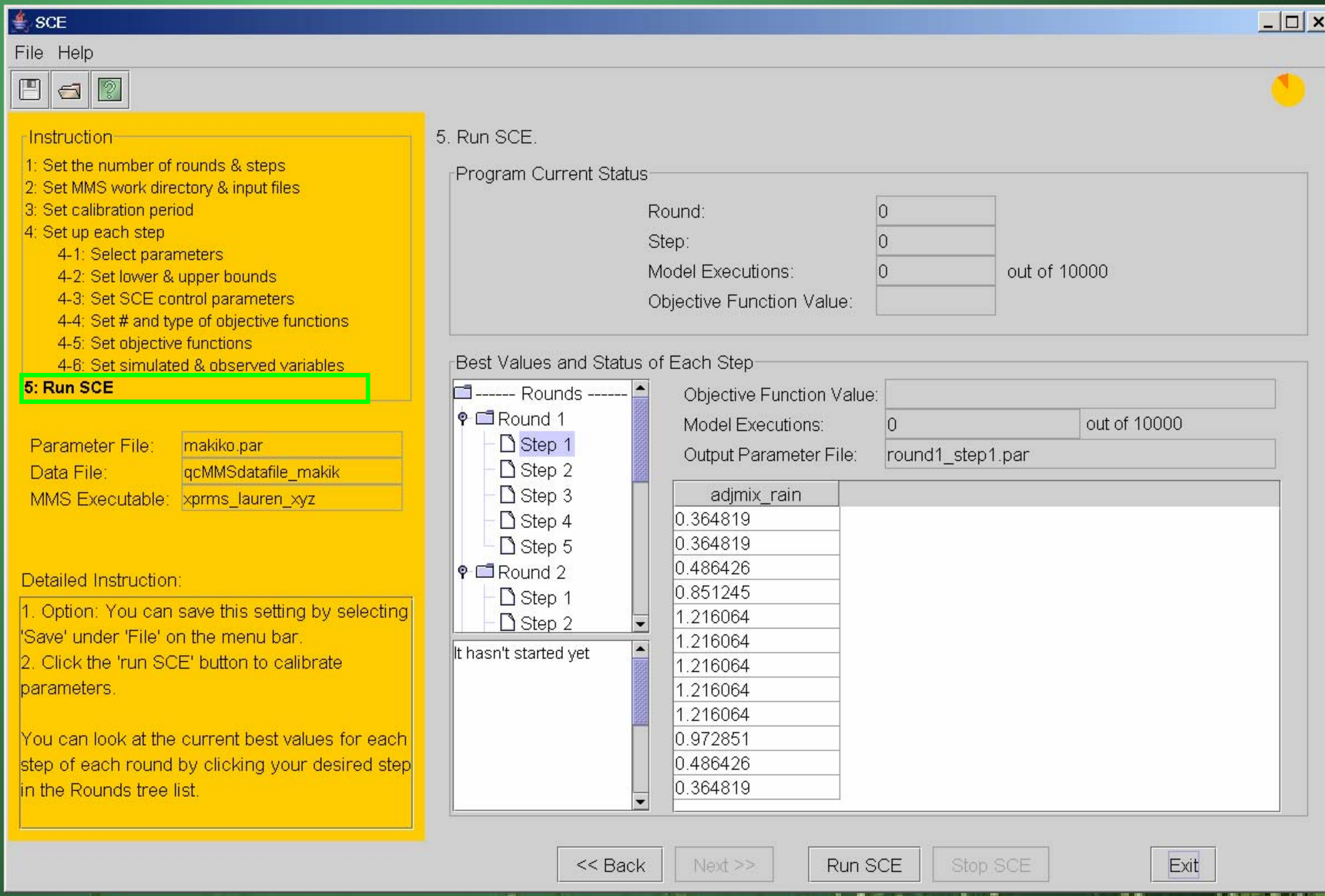

SCE
File Help
Instruction
1: Set the number of rounds & steps
2: Set MMS work directory & input files
3: Set calibration period
4: Set up each step
4-1: Select parameters
4-2: Set lower & upper bounds
4-3: Set SCE control parameters
4-4: Set # and type of objective functions
4-5: Set objective functions
4-6: Set simulated & observed variables
5: Run SCE
Parameter File: makiko.par
Data File: qcMMSdatafile_makik
MMS Executable: xprms_lauren_xyz
Detailed Instruction:
1. Select where observed calibration data set come from.
2. Select simulated variable.
3a. If observed calibration data comes from statvar file, select observed variable from the combo box
Step 1
Step 2
Step 3
Step 4
Step 5
4-6. Set simulated and observed variables for objective function for each step.
Simulated Variable: basin_cfs.strmflow
Node Number: 1
Where does observed calibration data set come from?
Statvar File
External Source
Observed Variable from Statvar File
Observed Variable: runoff.obs
Node Number: 1
Observed Data File from External Source
Specify File Format:
Daily (year month day value)
Monthly Mean (year month value)
Mean Monthly (month value)
Annual Mean (year value)
Example:
2002 10 1 10.5
2002 10 2 3.75
Browse
<< Back
Next >>
Run SCE
Stop SCE
Exit



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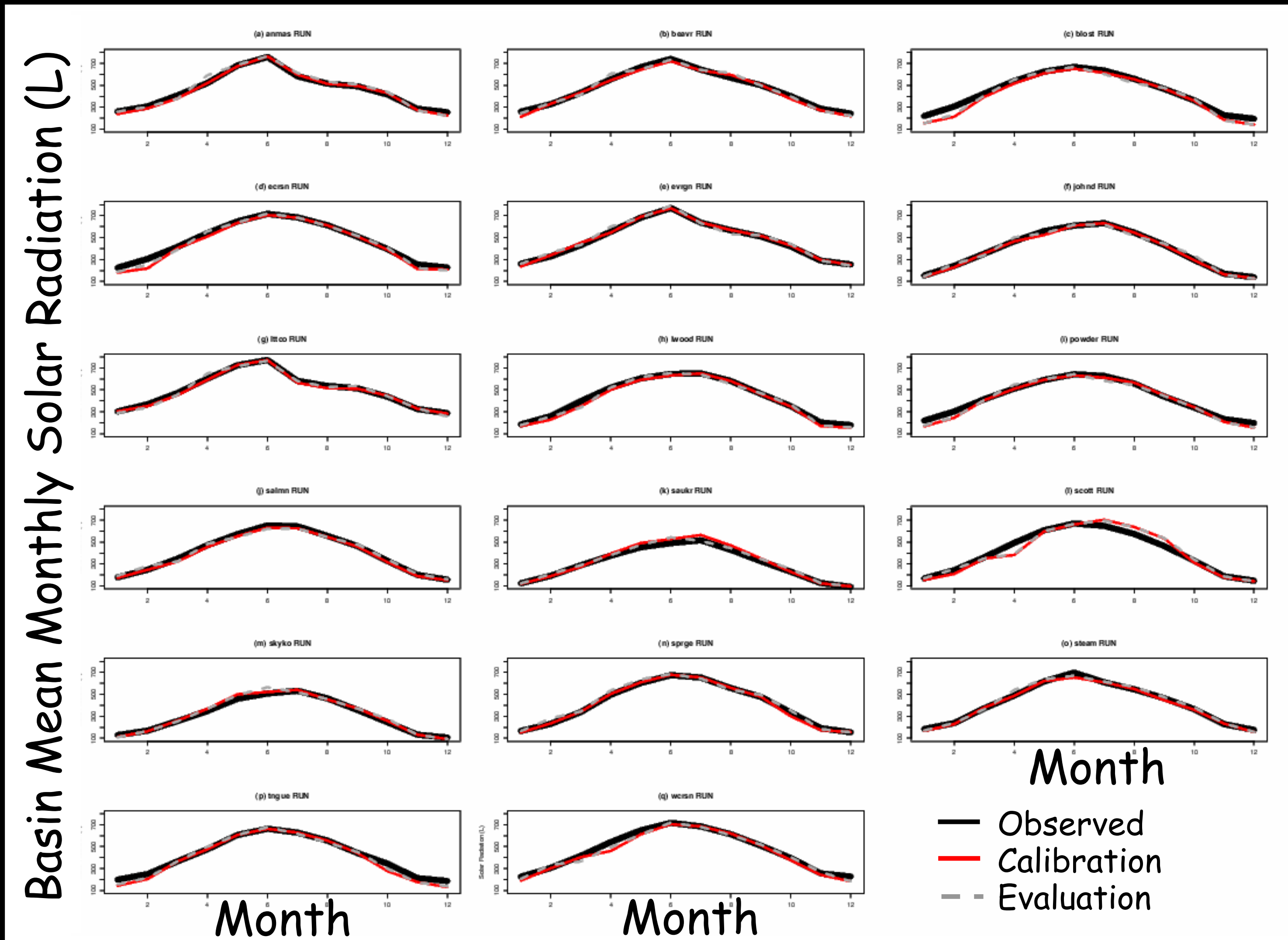
Hierarchal Approach to Estimate Parameters

4-step model calibration

1. Solar Radiation
2. PET
3. Water Balance
4. Daily runoff

lhay@usgs.gov

Preliminary Results – 17 basins
Observed vs. Simulated Solar Radiation



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Hierarchal Approach to Estimate Parameters

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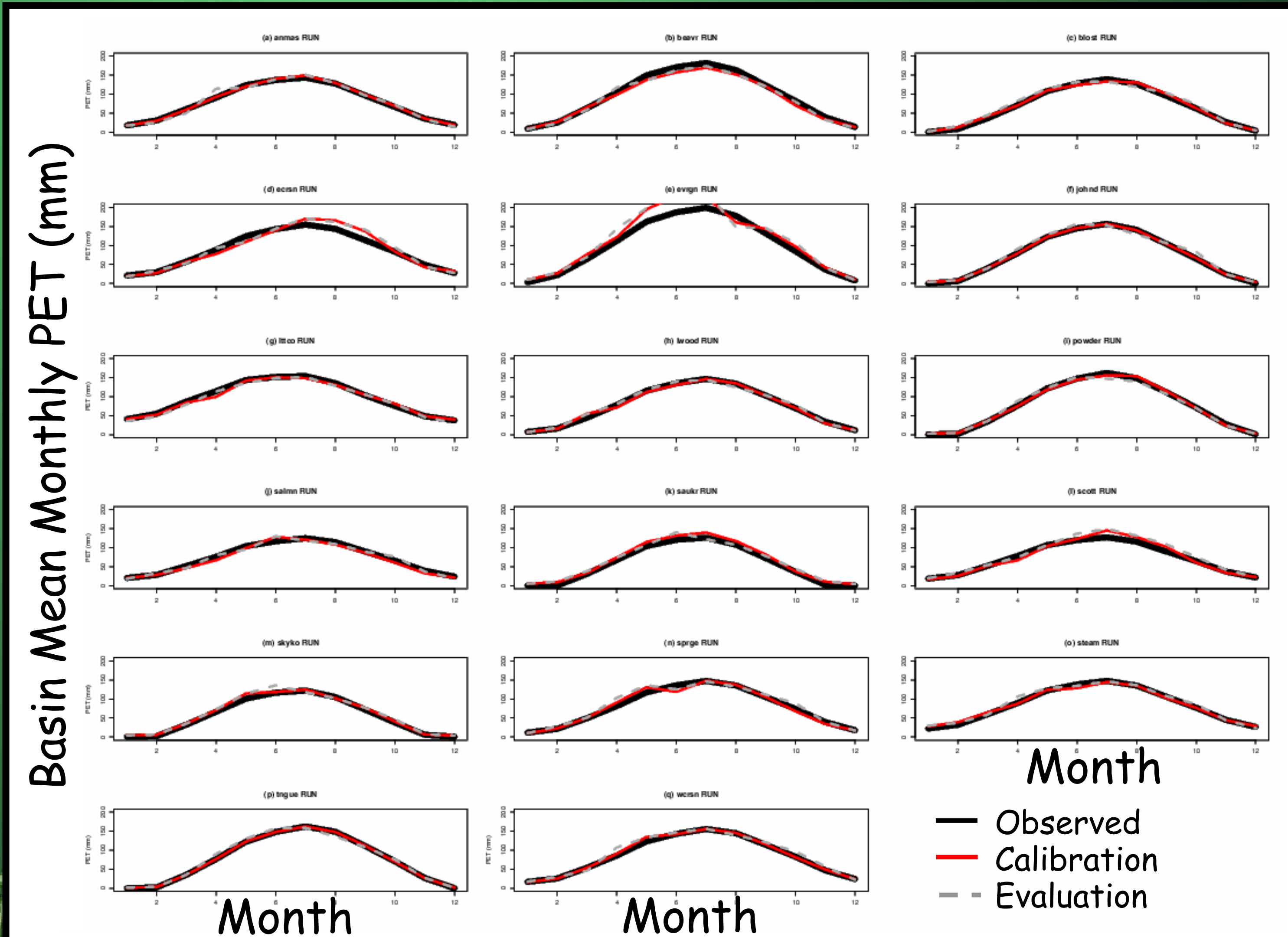
Preliminary Results – 17 basins
Observed vs. Simulated PET



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Hierarchal Approach to Estimate Parameters

4-step model calibration

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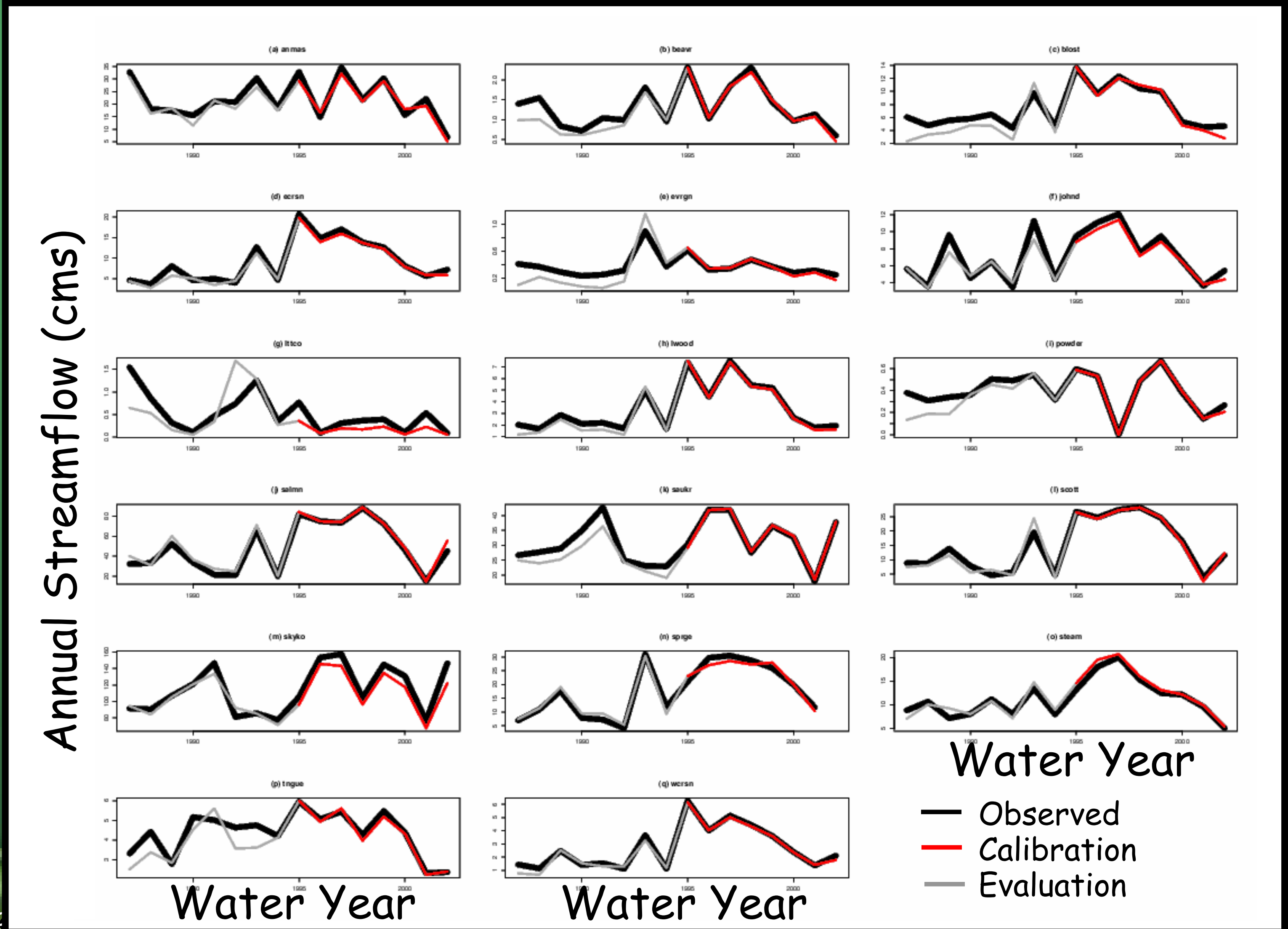
lhay@usgs.gov

Preliminary Results – 17 basins
Observed vs. Simulated Annual Streamflow



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Hierarchal Approach to Estimate Parameters

4-step model calibration

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2. PET
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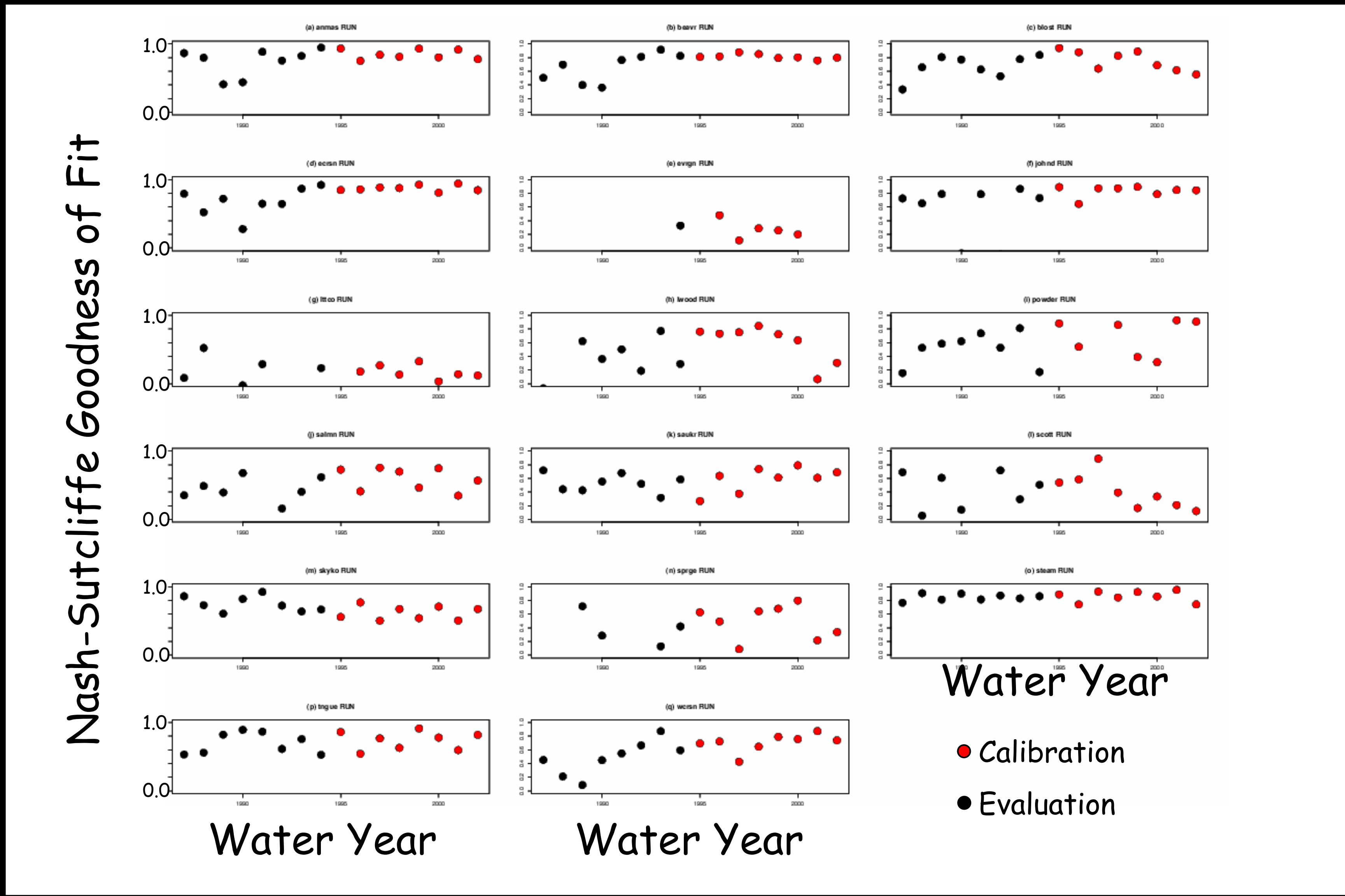
Preliminary Results – 17 basins
Nash-Sutcliffe Goodness of Fit by WY



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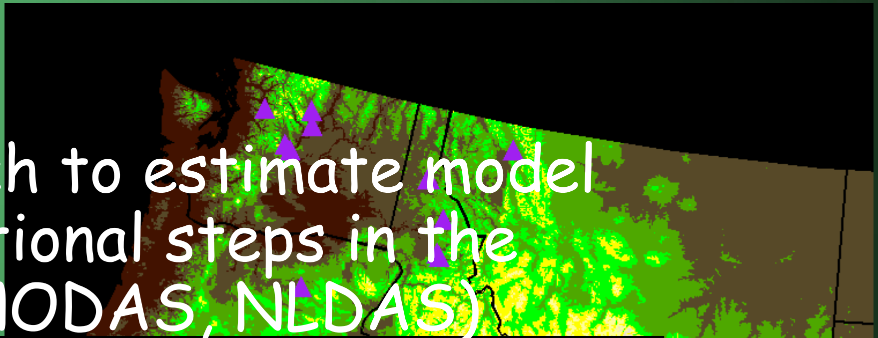
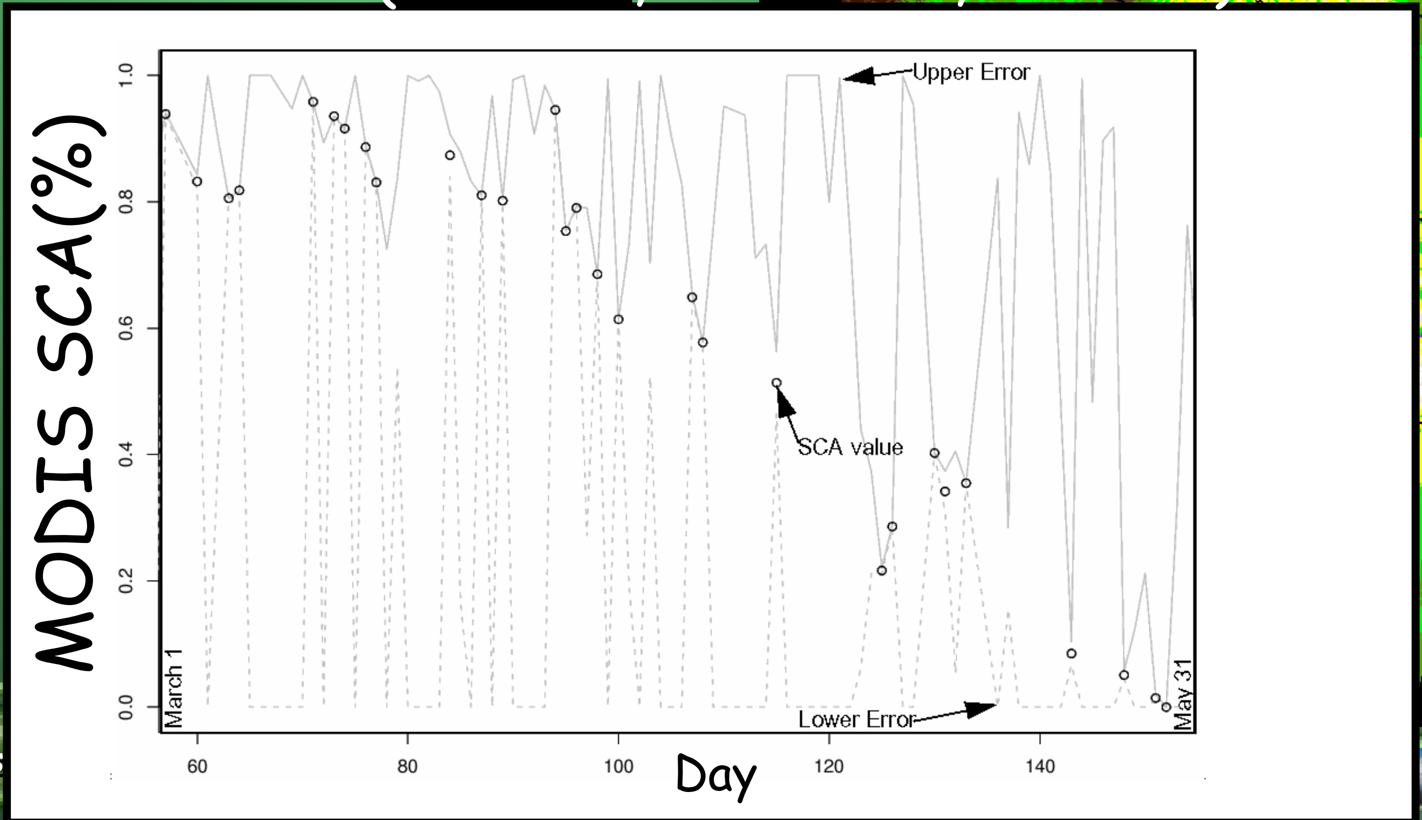
Current Study

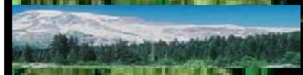
- Additional snowmelt-dominated basins added (60 total).

Methodlogy

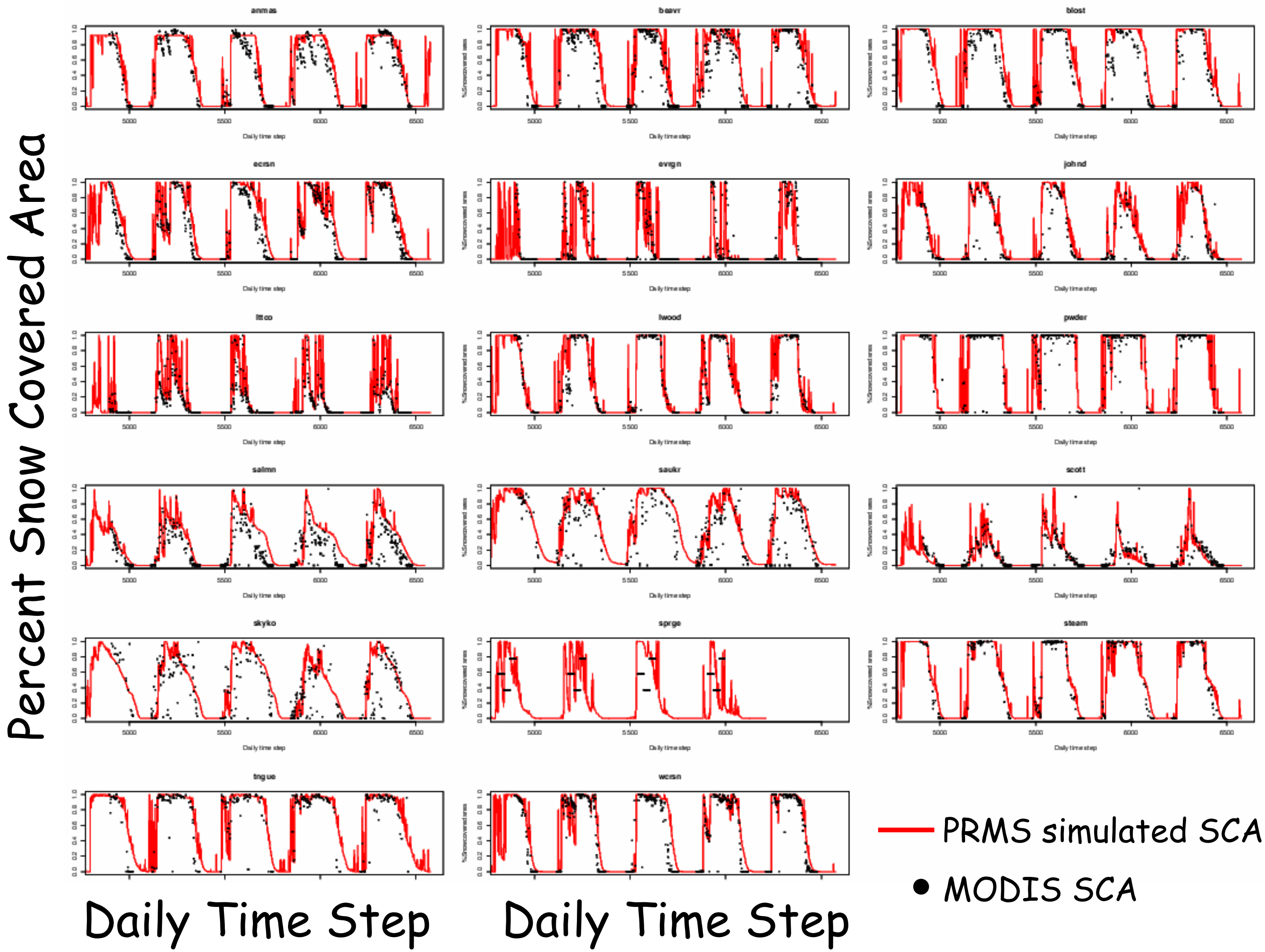
- Apply hierarchal approach to estimate model parameters, adding additional steps in the calibration (MODIS, SNODAS, NLDAS)







Basin SCA: MODIS vs PRMS



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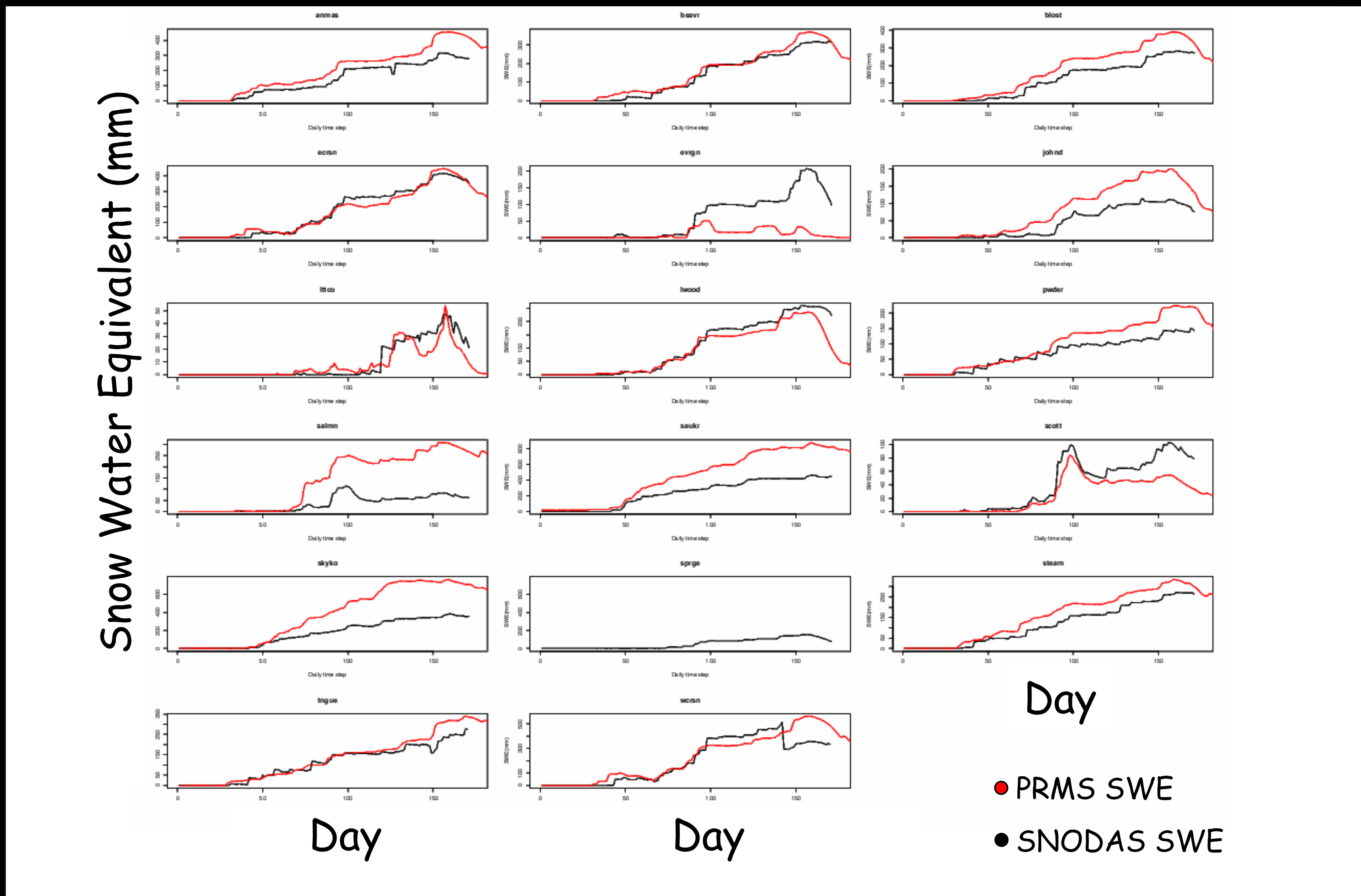
lhay@usgs.gov

Basin Snow Water Equivalent



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Current Study

- Additional snowmelt-dominated basins added (60 total).

Methodlogy

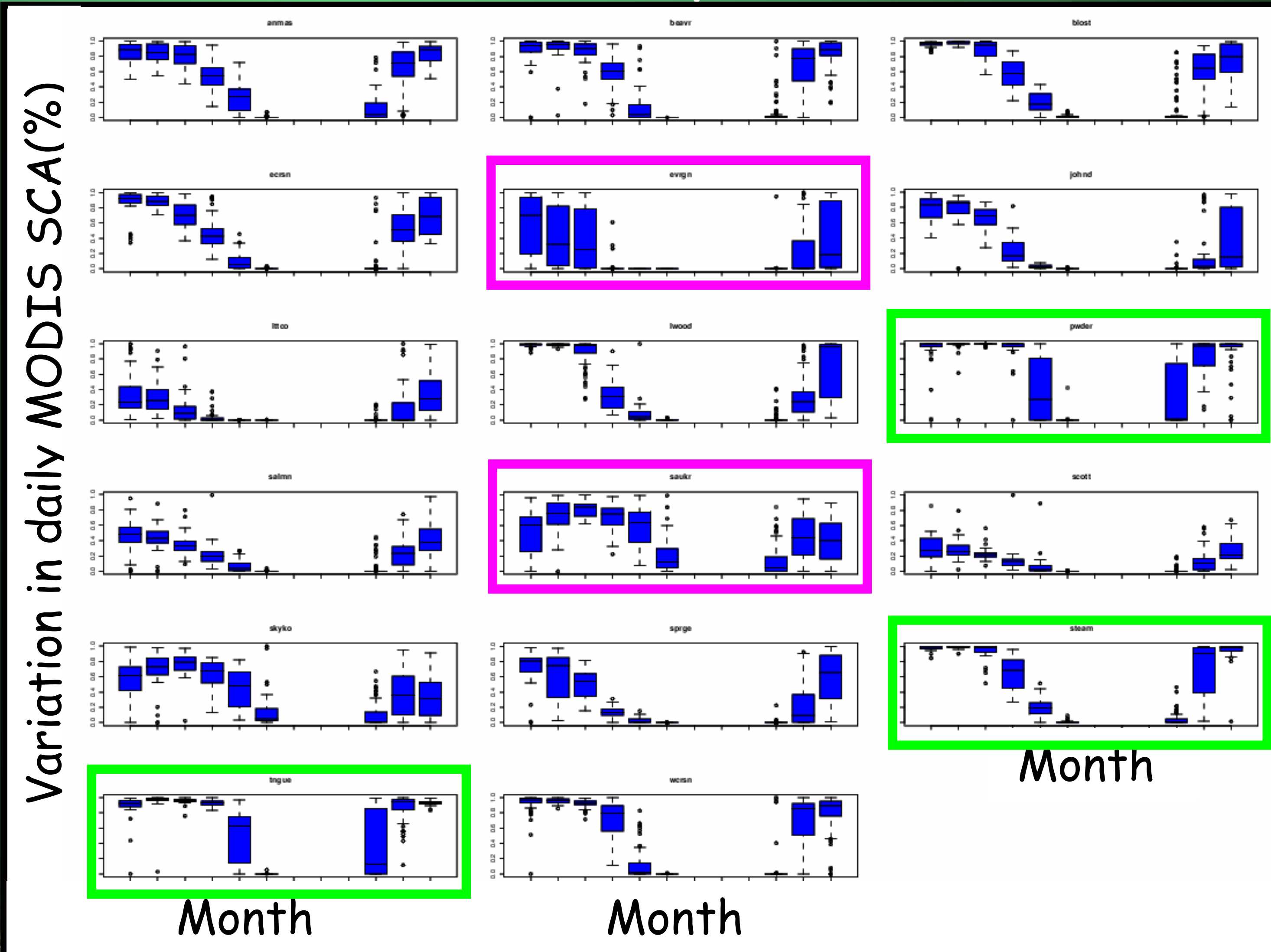
- Apply hierarchal approach to estimate model parameters, adding additional steps in the calibration (MODIS, SNODAS, NLDAS)

- Evaluate accuracy to identify basins where streamflow simulations are poor. (Preliminary results show relation to streamflow characteristics, variation in SCA, climate)

lhay@usgs.gov

Preliminary Results – 17 basins

Variation in MODIS Daily Snow Covered Area



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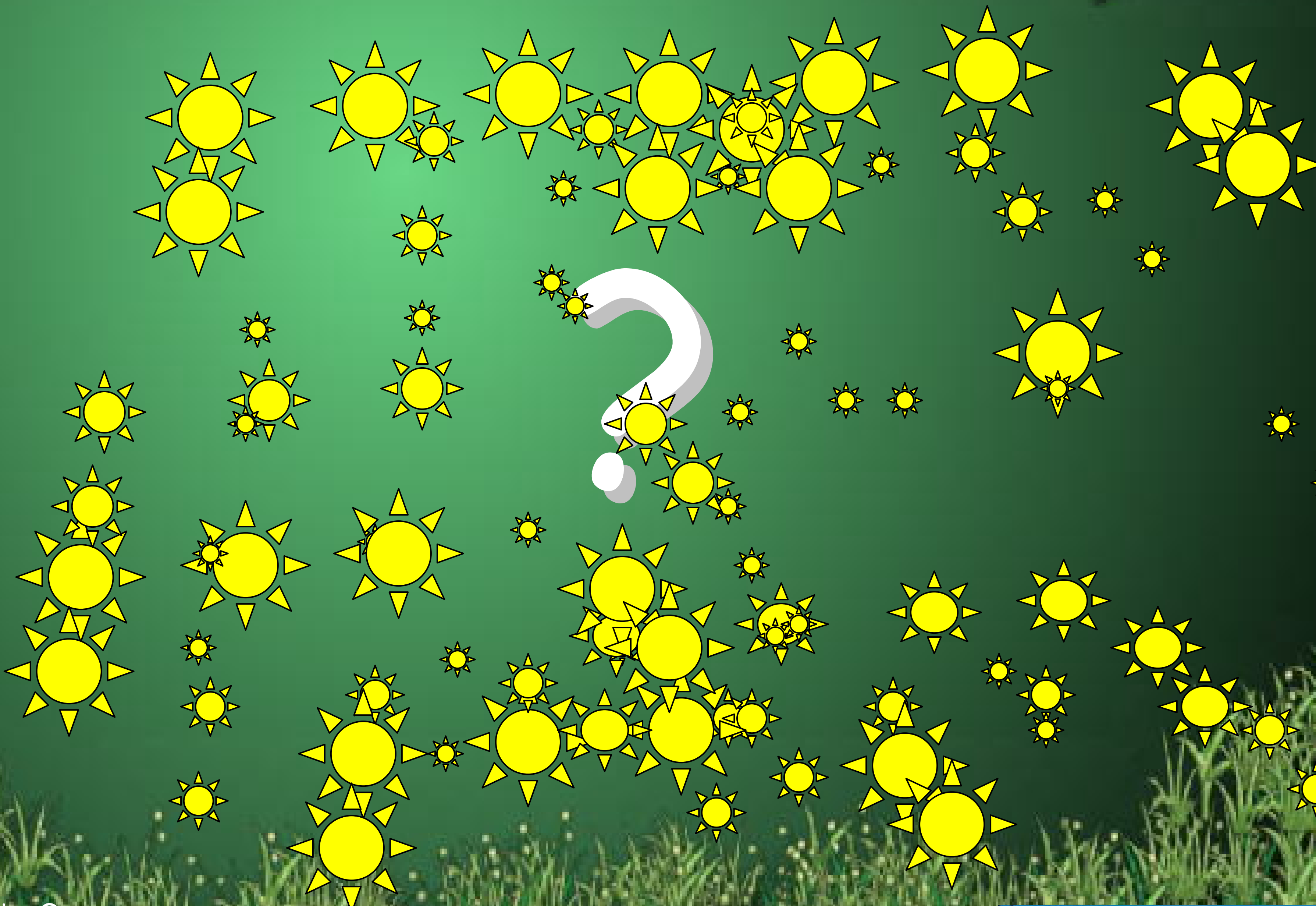
Methodlogy

- Apply hierarchal approach to estimate model parameters, adding additional steps in the calibration (MODIS, SNODAS, NLDAS)
- Evaluate accuracy to identify basins where streamflow simulations are poor. (Preliminary results show relation to streamflow characteristics, variation in SCA, climate)
- Implement additional modules , addressing issue of model complexity
- Produce improved streamflow forecasts for snowmelt-dominated basins using seamless suite of forecasting tools in an ensemble mode
- Incorporate into CHPS

lhay@usgs.gov



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