Model Calibration Update
December 2020

Stephen Hundt

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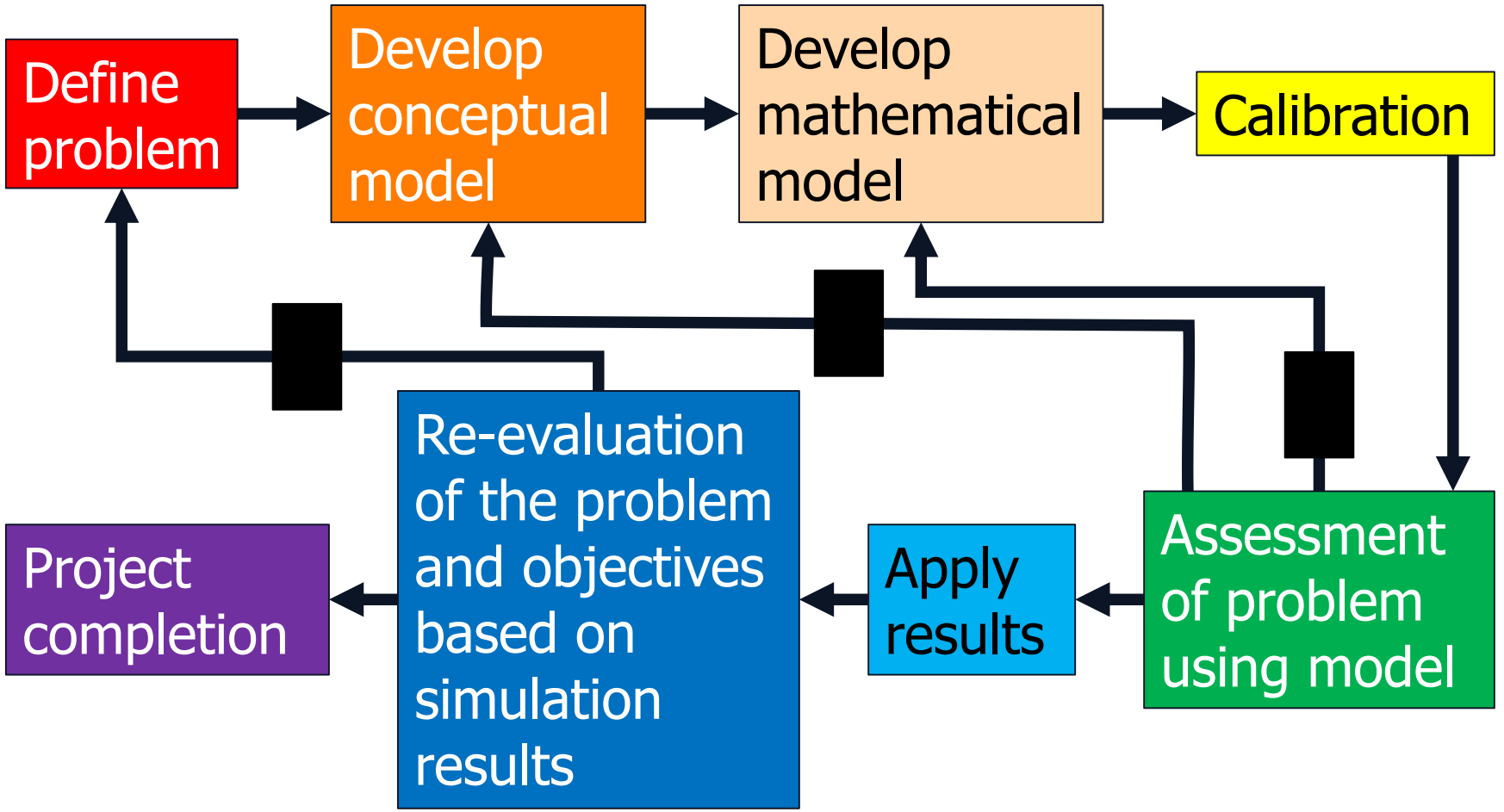
Overview

The modeling process



After Reilly (2001) TWRI 3,B8

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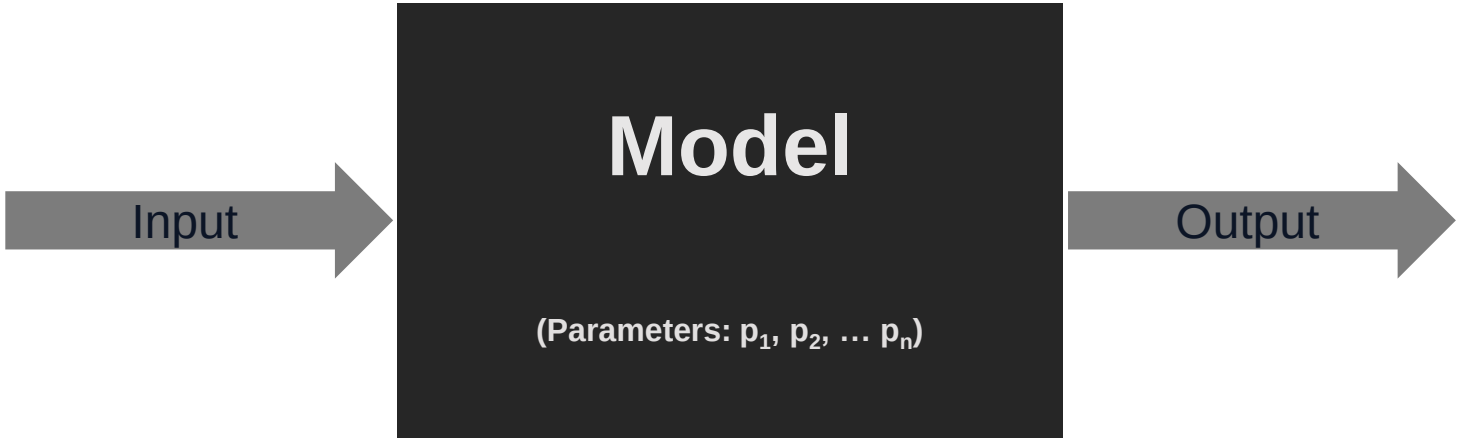
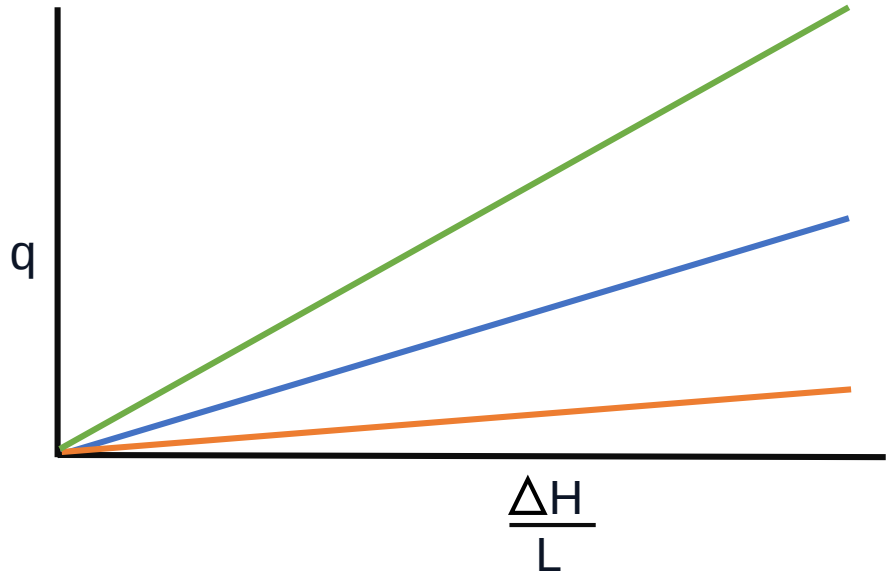
Our Parameters

Parameters: Introduction



$$q = K\frac{\Delta H}{L}$$



Model Parameters

Hydraulic Parameters (~material properties)

Lumped Hydraulic(ish) Parameters (~material properties & geometry)

Irrigation System Parameters: Leakage and infiltration estimation

Parameter	Spatial Scale	# Parameters	
		initial	expandable
Hydraulic Conductivity – horizontal	Grid: 1 every 5-10 cells * # layers	~50	easily to 400+
Hydraulic Conductivity – vertical	Grid: 1 every 5-10 cells * # layers	~50	easily to 400+
Storage Coefficient	Grid: 1 every 5-10 cells * # layers	~50	easily to 400+
River conductance	Gaged river reaches	2	to gaged reaches
Drain conductance	Gaged drain --	~5	18
Lowell conductance	Lake	1	-
NY Canal conductance	Canal	1	-
NY Canal leakage factor	Canal	1	-
Canal leakage factor	Irrigation entity	1	70
Canal leakage distribution factor	Irrigation entity	1	70
Irrigated lands infiltration factor	Irrigation entity	1	70
Semi-irrigated infiltration factor	Irrigation entity	1	70
Tributary underflow multiplier	3 values	3	
ET multiplier	1 value	1	-

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River Conductance

Parameter that alters head-dependent flux boundary

↓

Alters flux into and out of model

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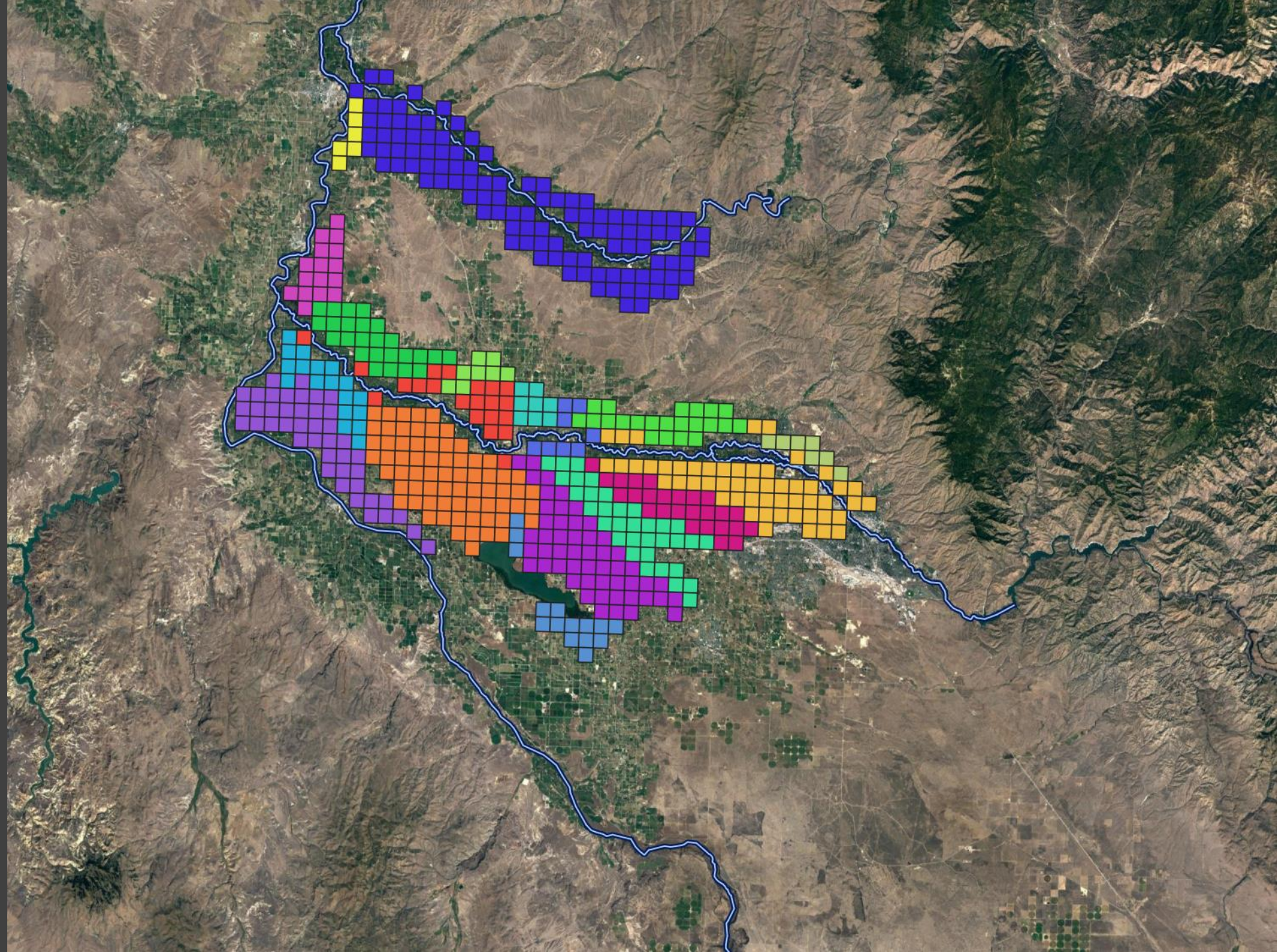
Drain Conductance

Parameter that alters head-dependent flux boundary

Alters flux out of model



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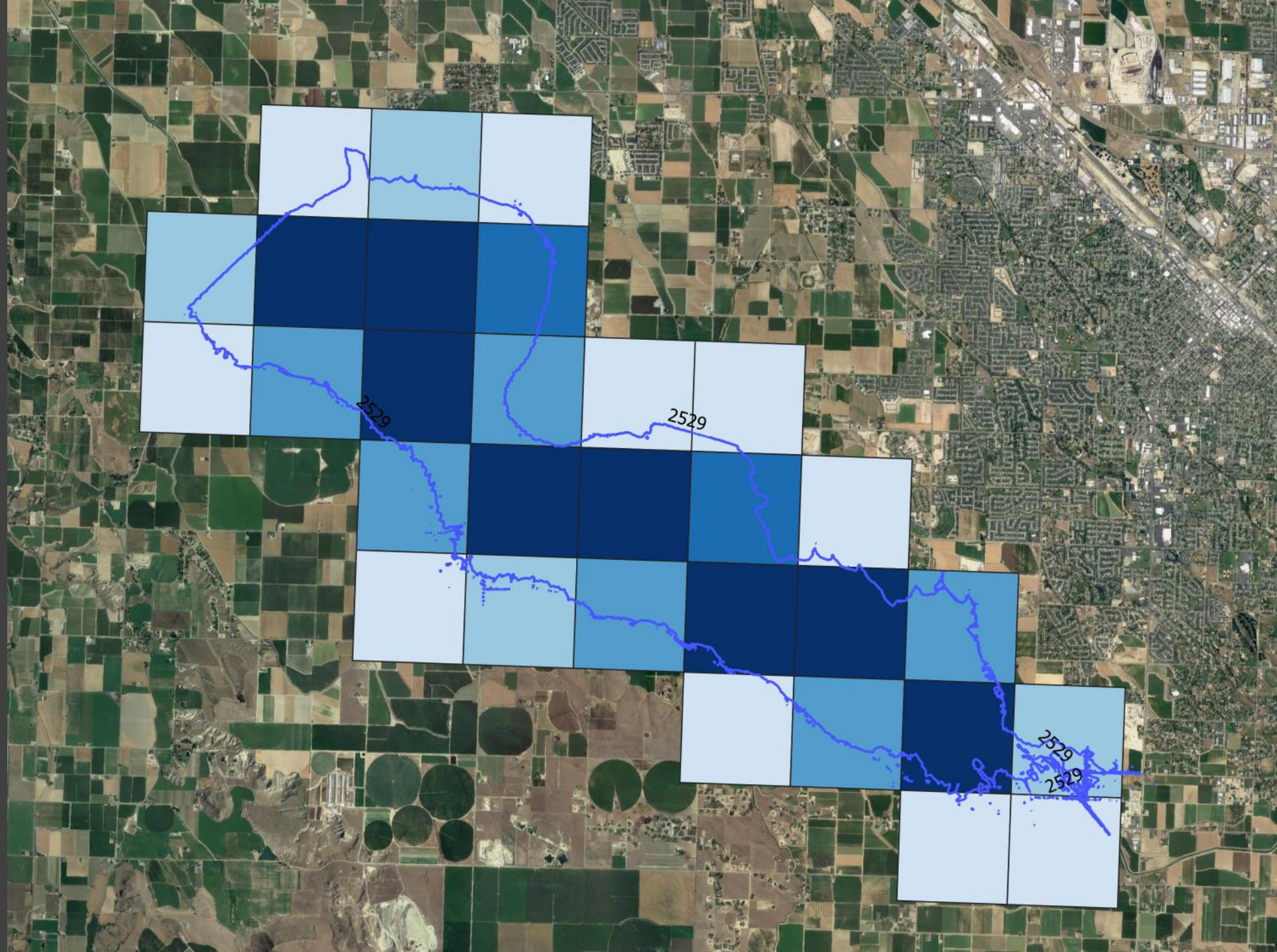
Lake Conductance

Parameter that alters head-dependent flux boundary

↓

Alters flux into and out of model



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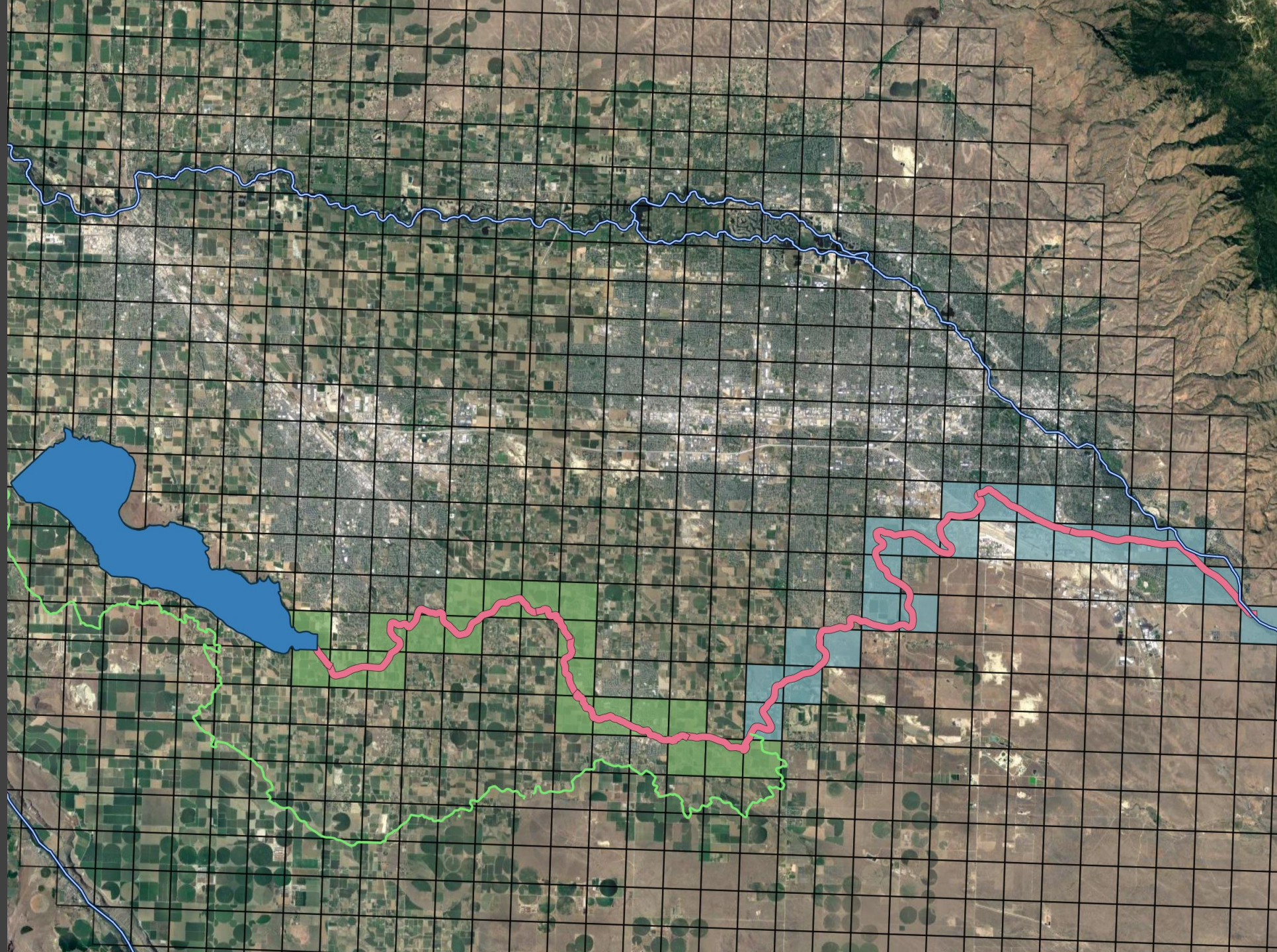
Lower NY Canal Conductance

Parameter that alters head-dependent flux boundary

↓

Alters flux into and out of model



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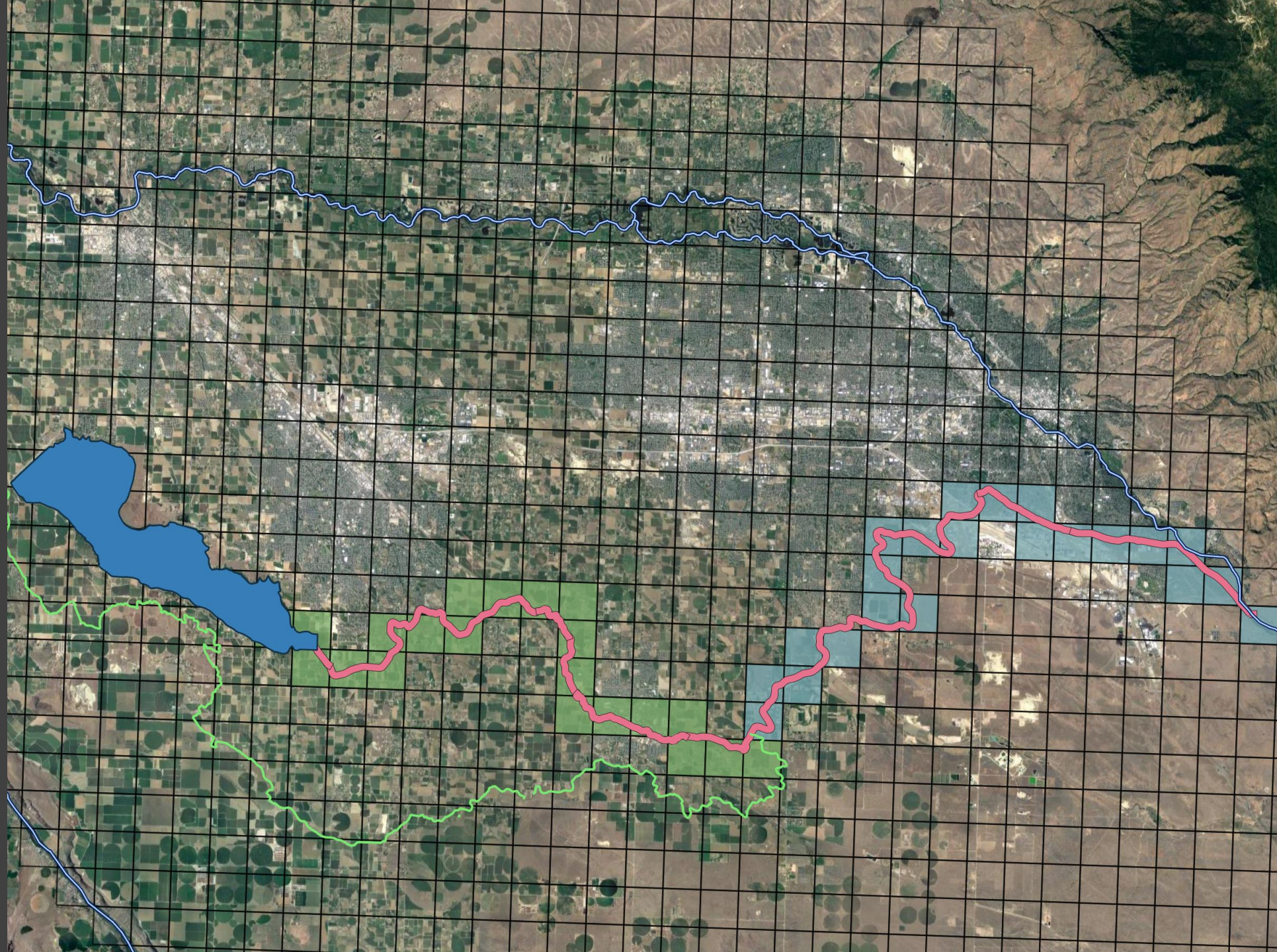
Upper NY Canal Leakage Factor

Alters specified flux into model



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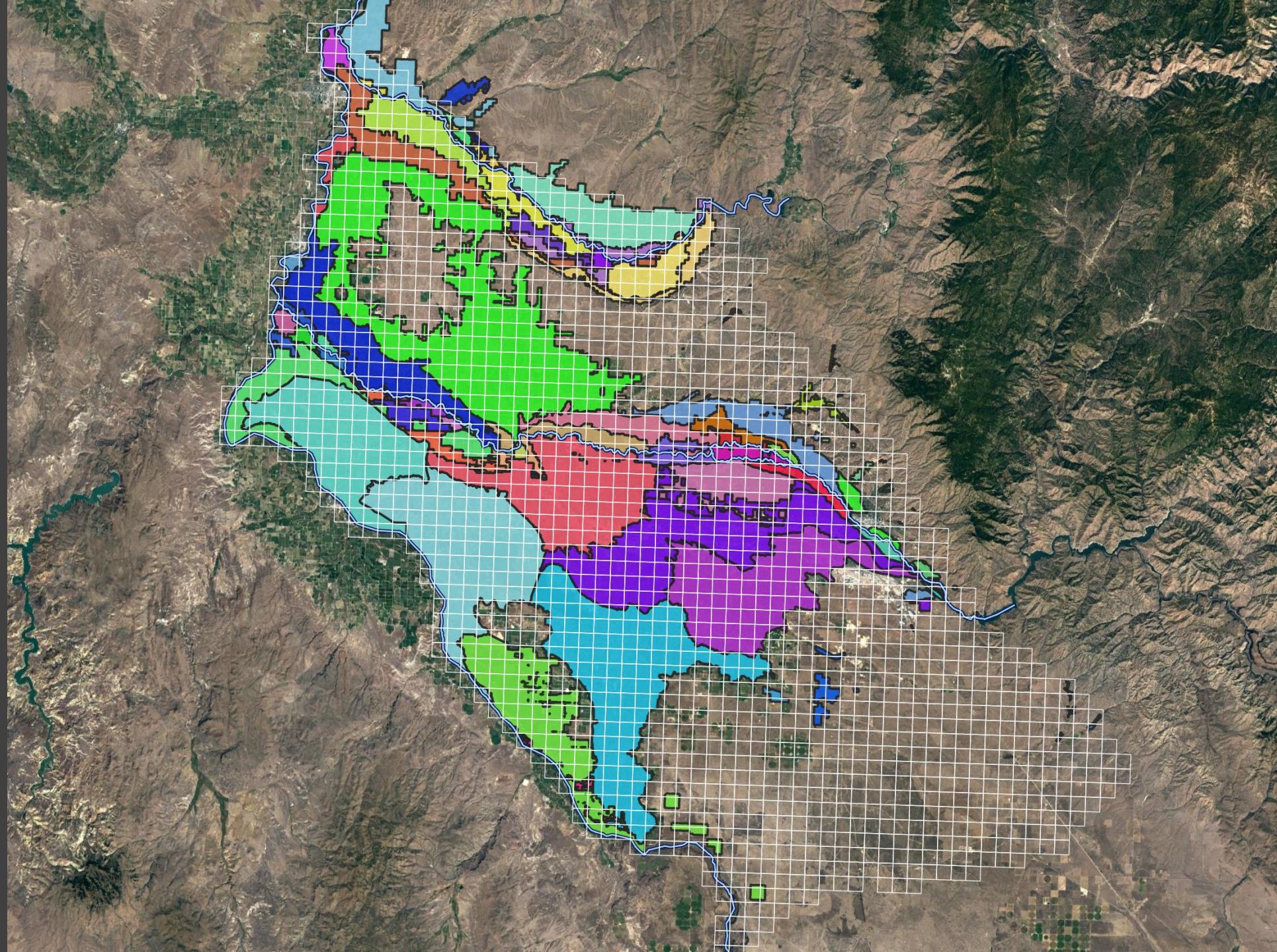
Irrigation Demand and Supply Parameters

Alters specified flux into and out of model



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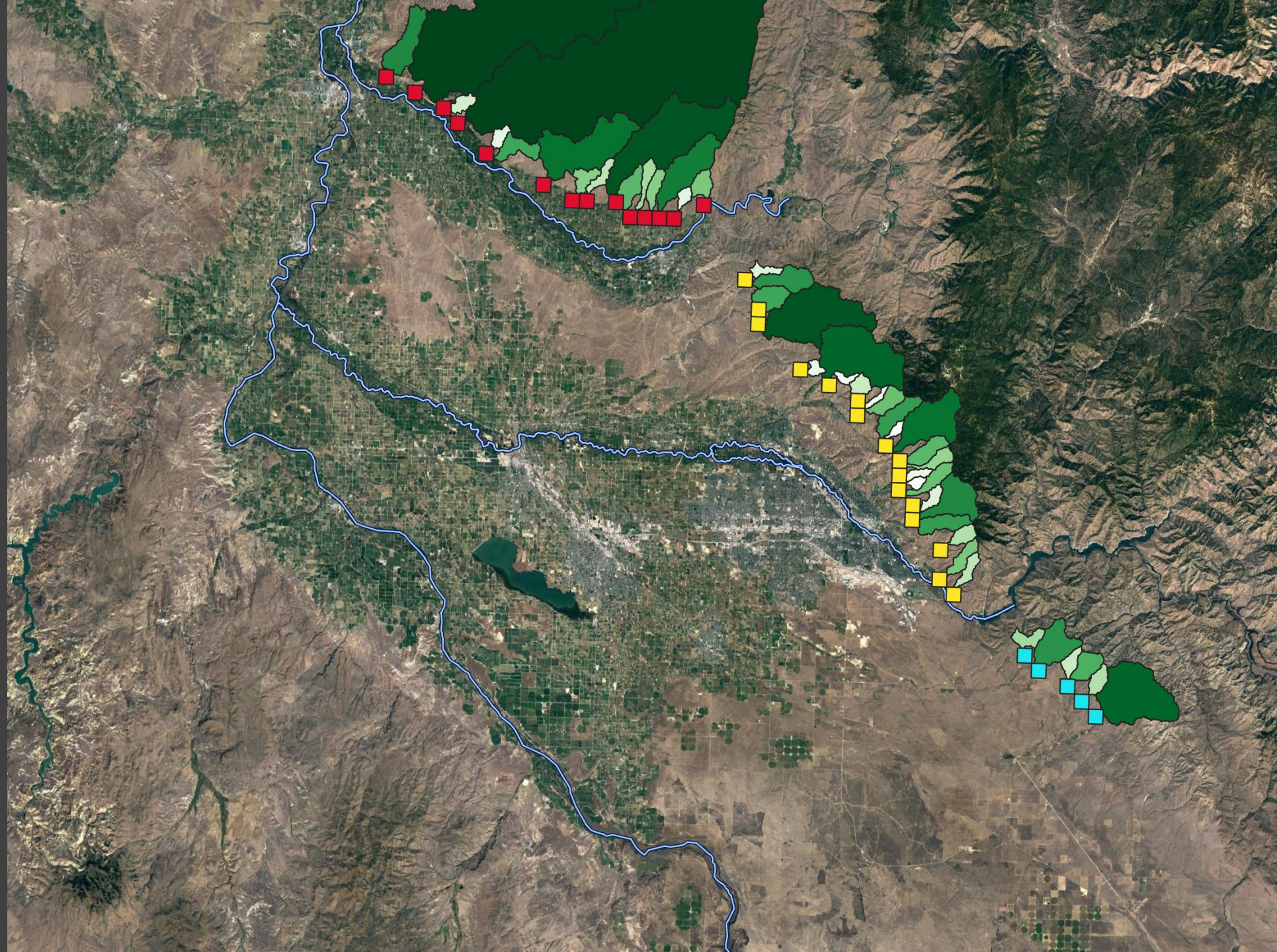
Tributary Underflow Factors

Alters specified flux into model



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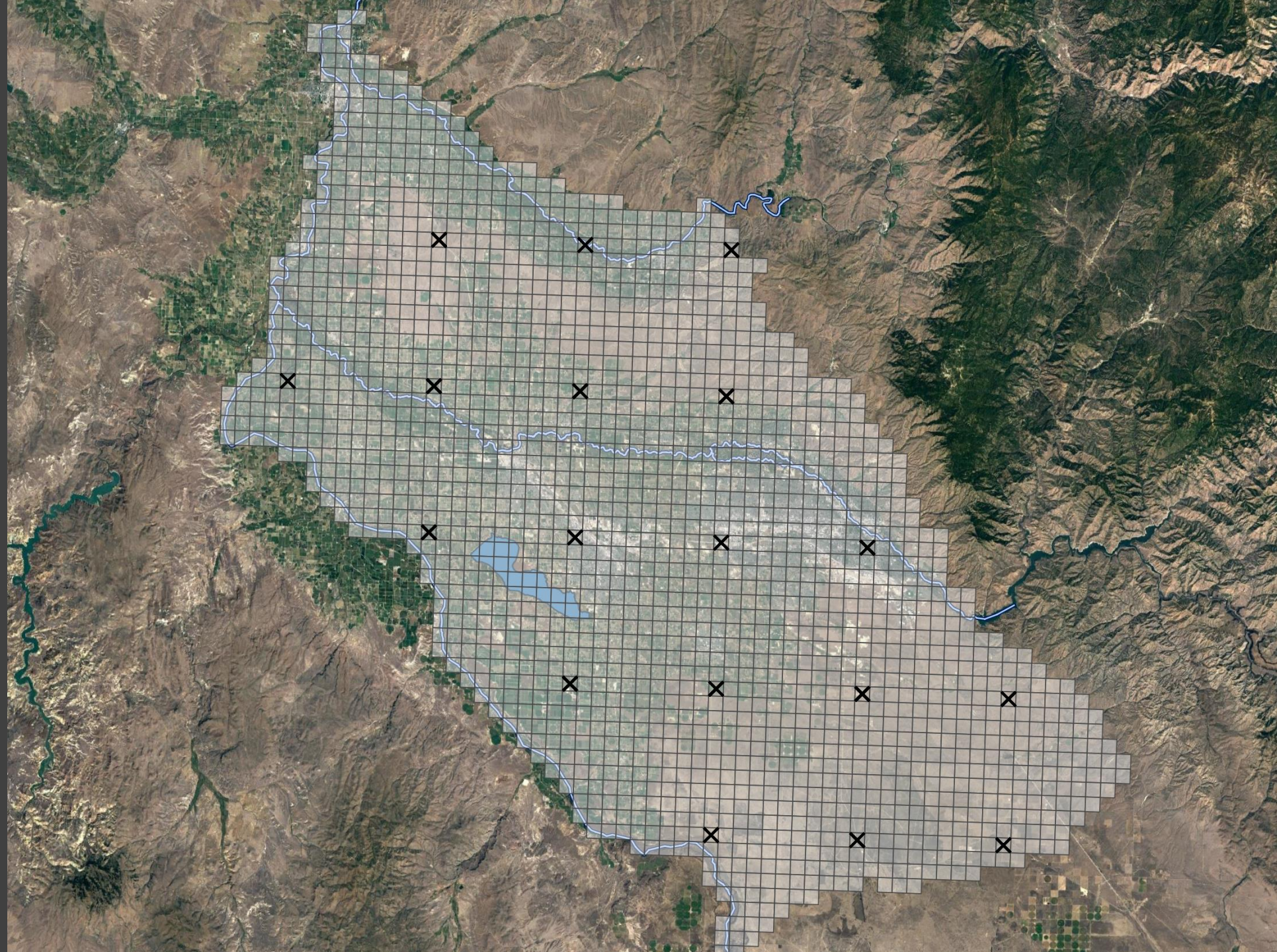
Hydraulic Parameters

Pilot Points

- Continuous variation in parameter values
- Limited # of adjustable parameters
- Geostatistical interpolation between adjustable ‘pilot-point’ parameters



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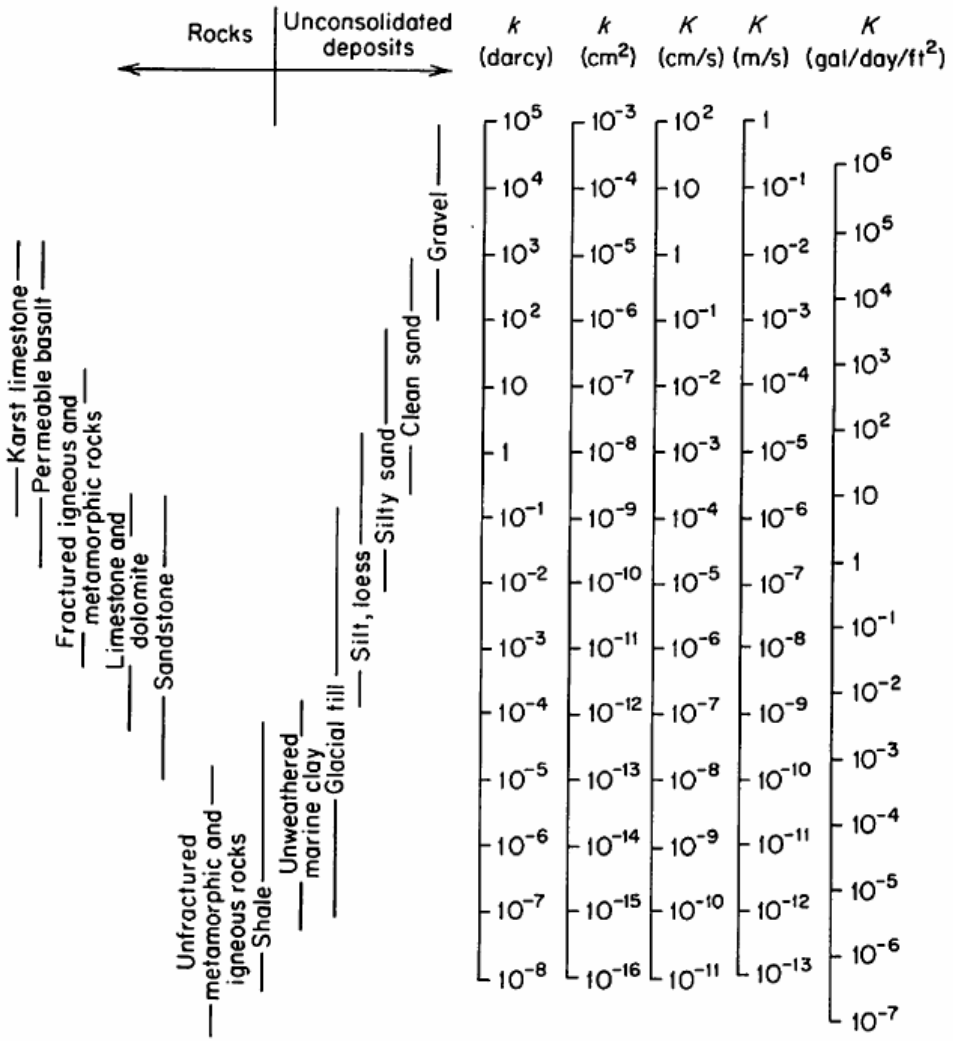
Calibration Review: Why?

Unknown Material Properties



13. LITHOLOGIC LOG: (Describe repairs or abandonment) — Water

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Y	N
18"	0'	2'	brown top soil		X
18"	2'	4'	brown clay		X
18"	4'	27'	brown gravel		X
18"	27'	46'	brown clay		X
18"	46'	54'	brown sand & gravel	X	
18"	54'	61'	brown clay		X
18"	61'	89'	brown sand & gravel	X	
18"	89'	91'	brown sandy clay		X
18"	91'	98'	brown sand & gravel	X	
18"	98'	108	brown sand fine	X	
18"	108	114	brown sand & clay strips	X	
18"	114	127	brown sand fine	X	
18"	127	130	brown clay		X
18"	130	143	brown sand & clay strips	X	

RECEIVED

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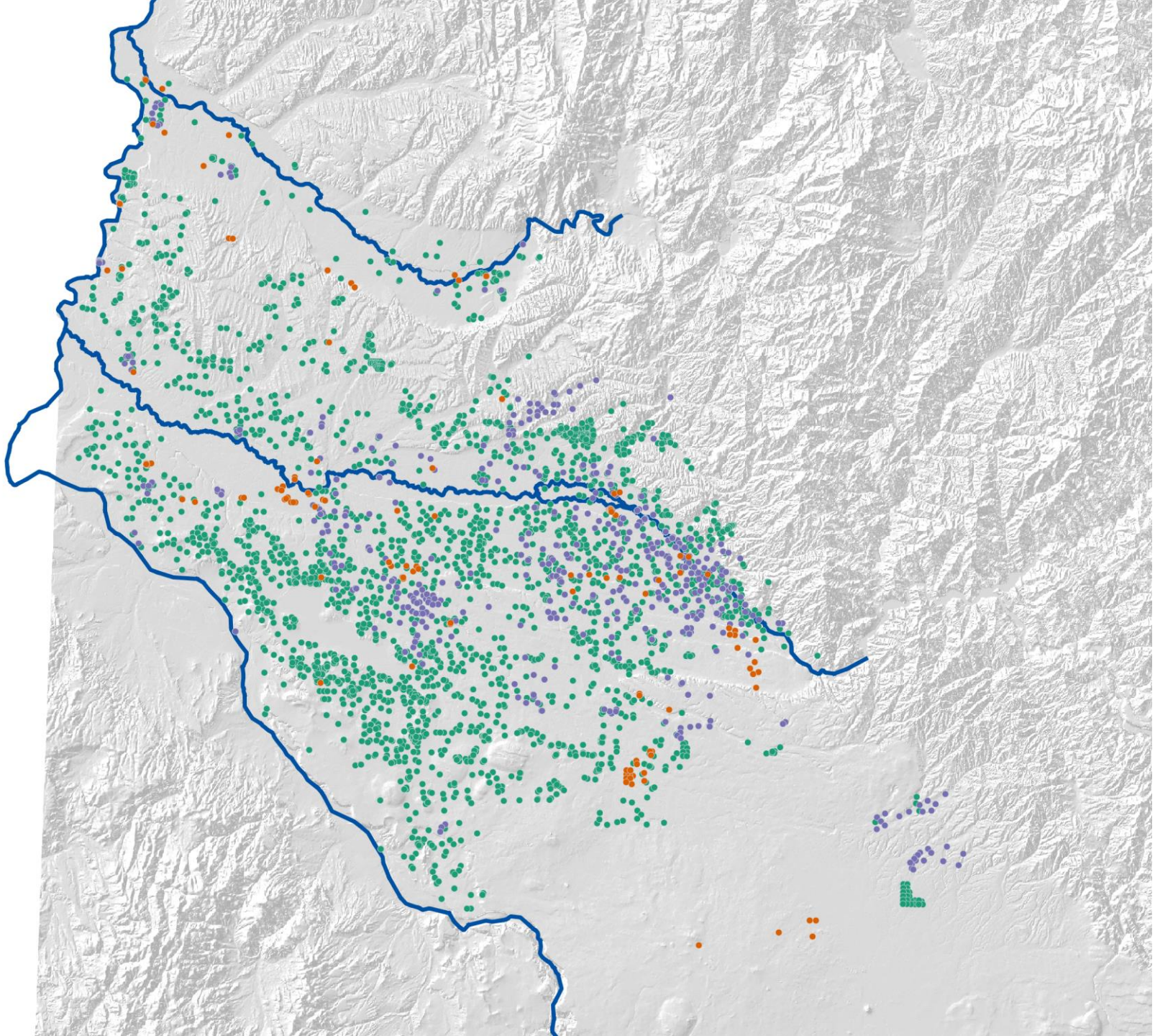
Unknown Boundary Fluxes



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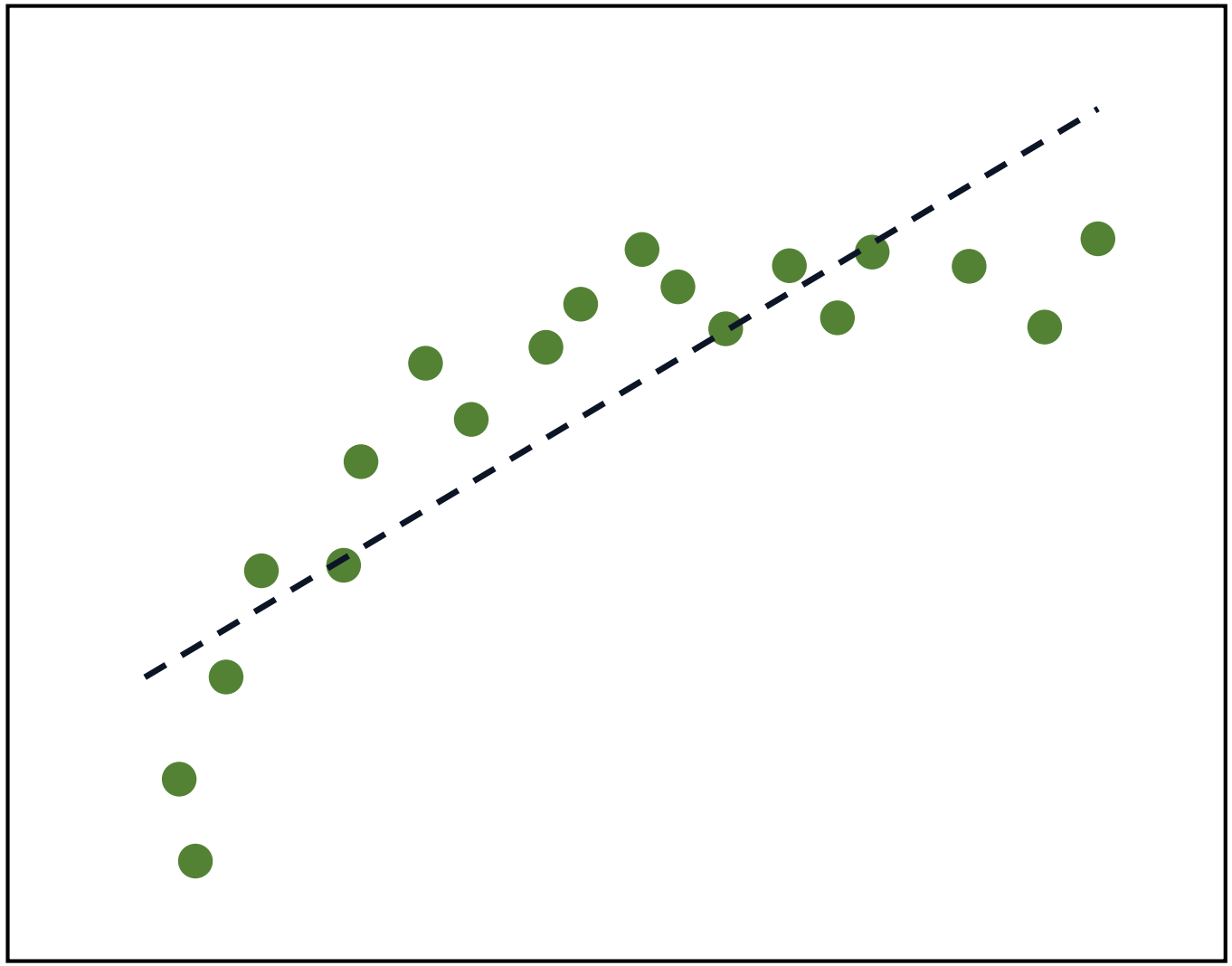
Model Structural Error

Model represents a process ‘wrong’

Too simple?

Parameter compensation of model error



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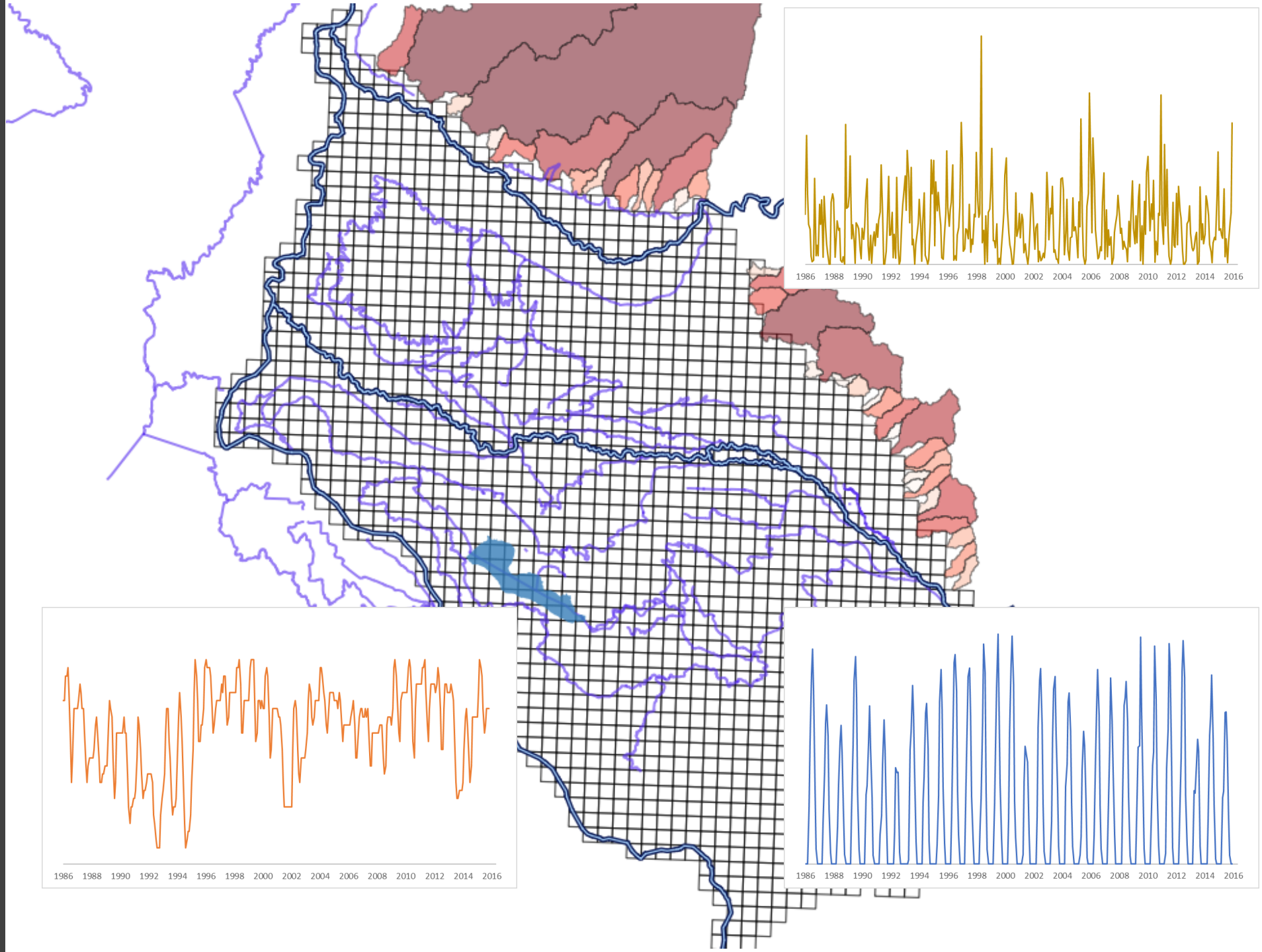
Calibration Review: How?

Construct Historic Scenario



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Field Observations

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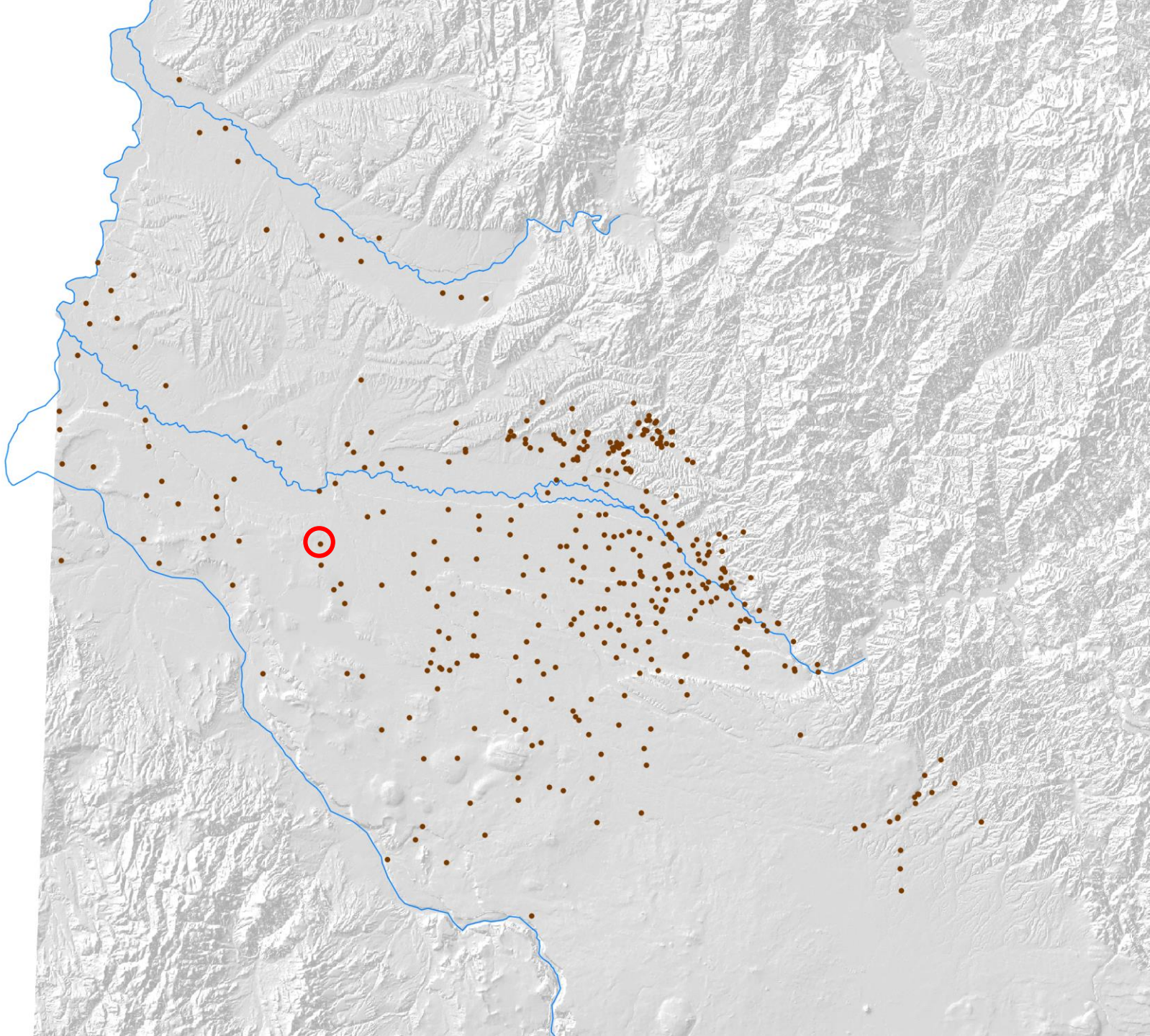
Field Observations



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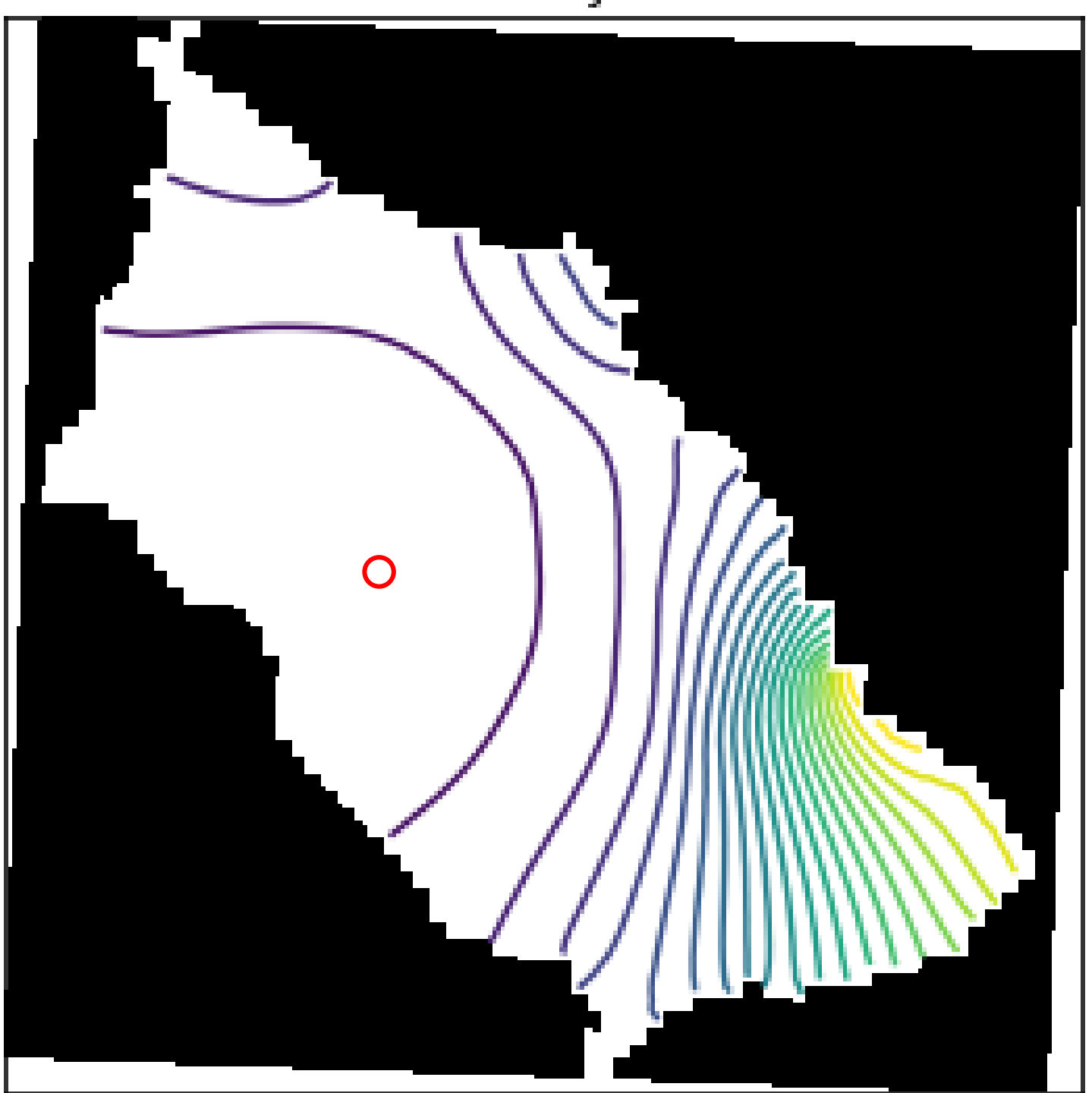
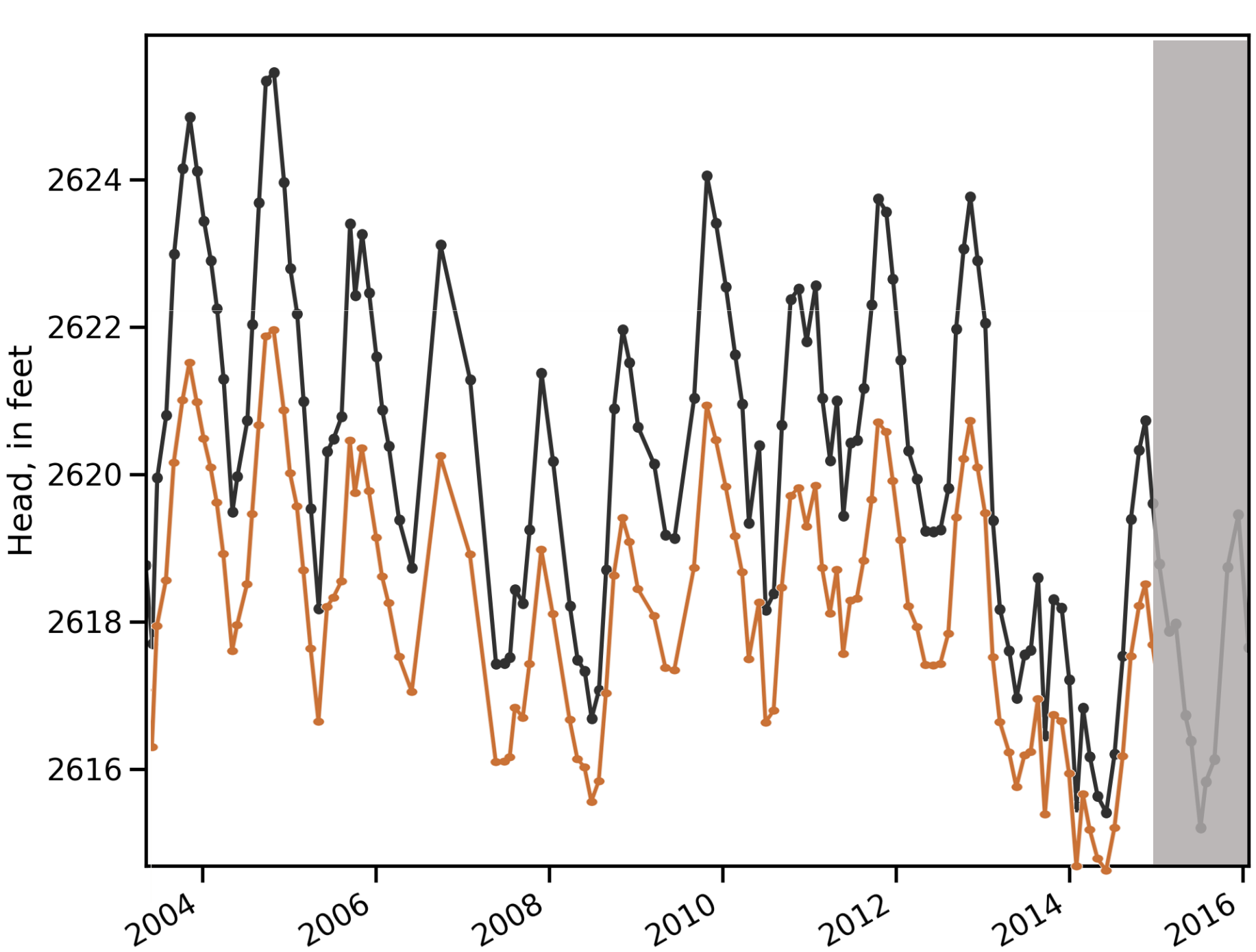
Simulated Equivalents



Observed compared to simulated



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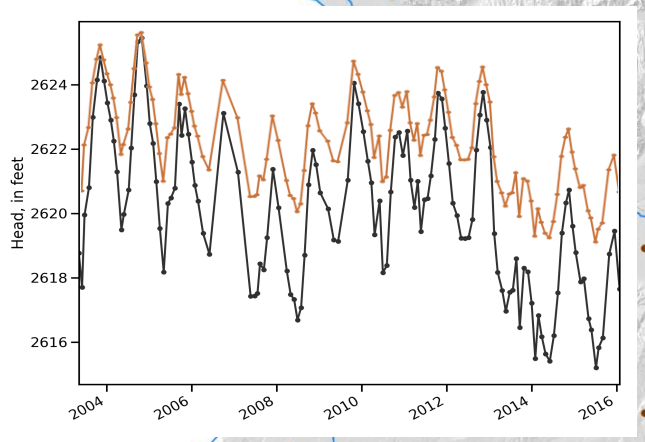
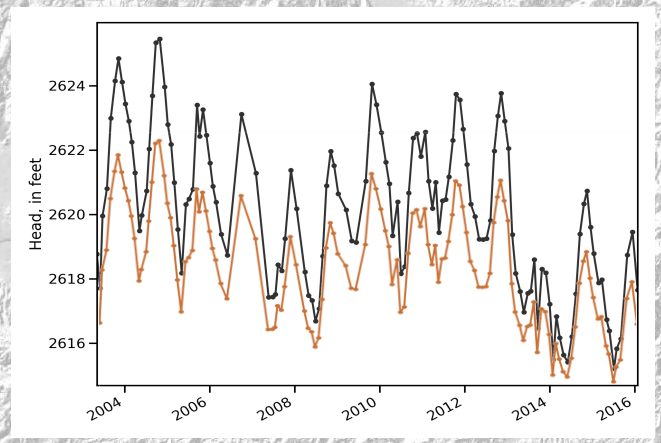
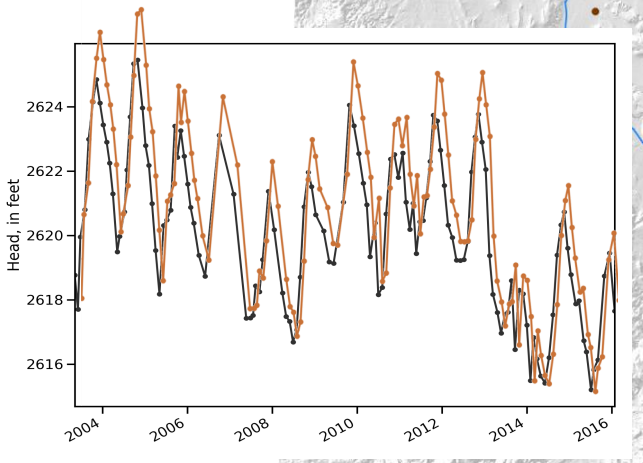
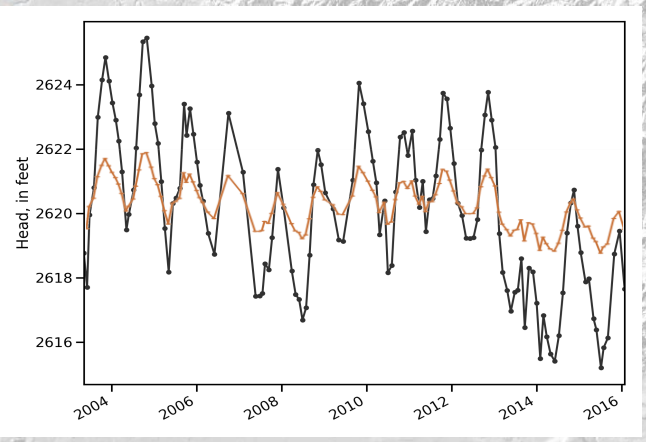
Observed compared to simulated









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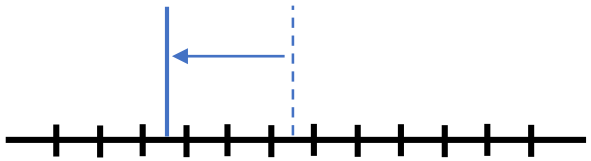
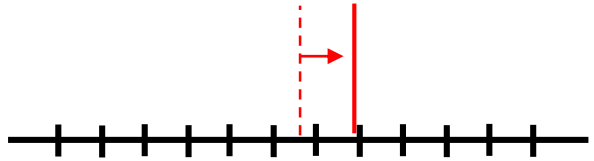
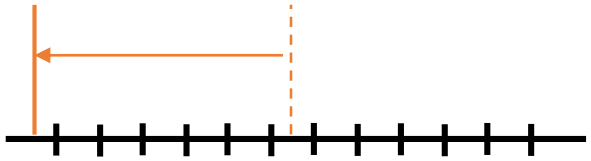
Tweak Parameter Values



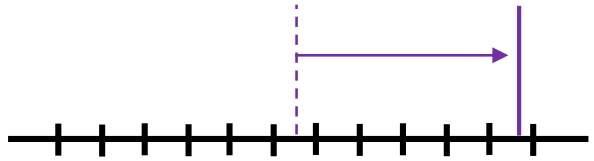
hk1



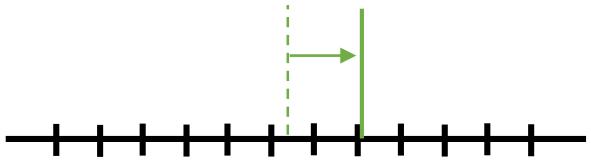
lowell_cond



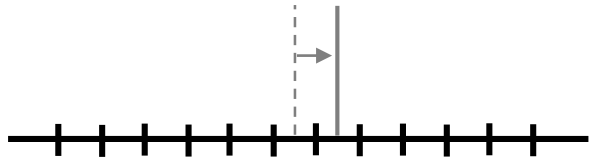
vk2



drain_cond1



ss1



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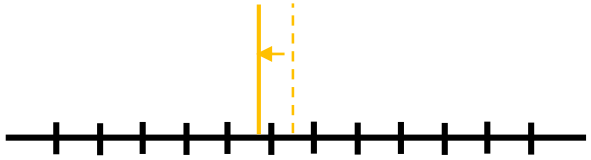
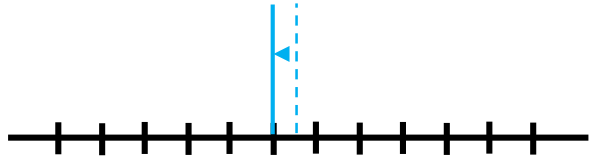


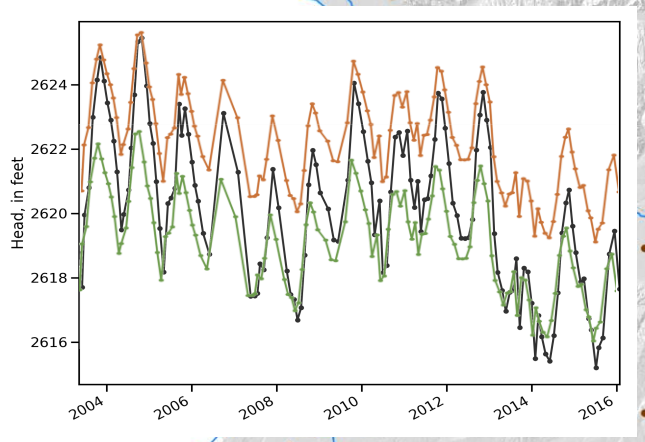
infil_fac1

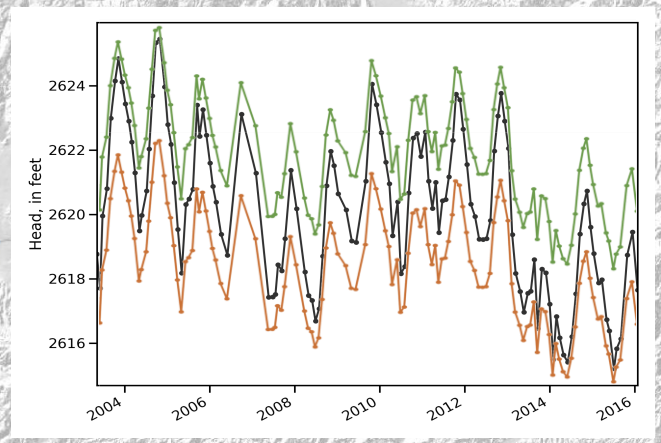


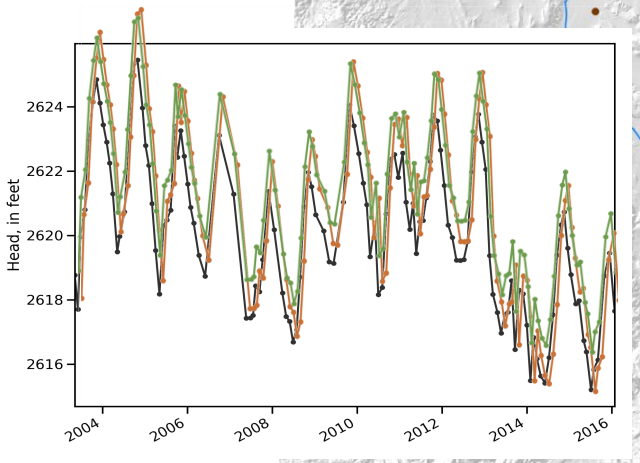
trib_mult1

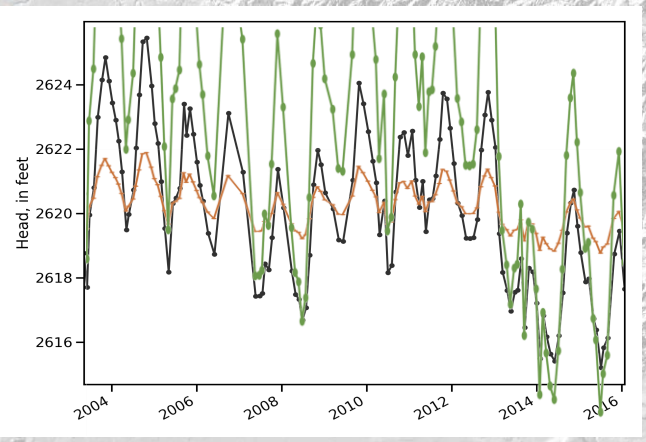
and so on…

Tweak Parameter Values









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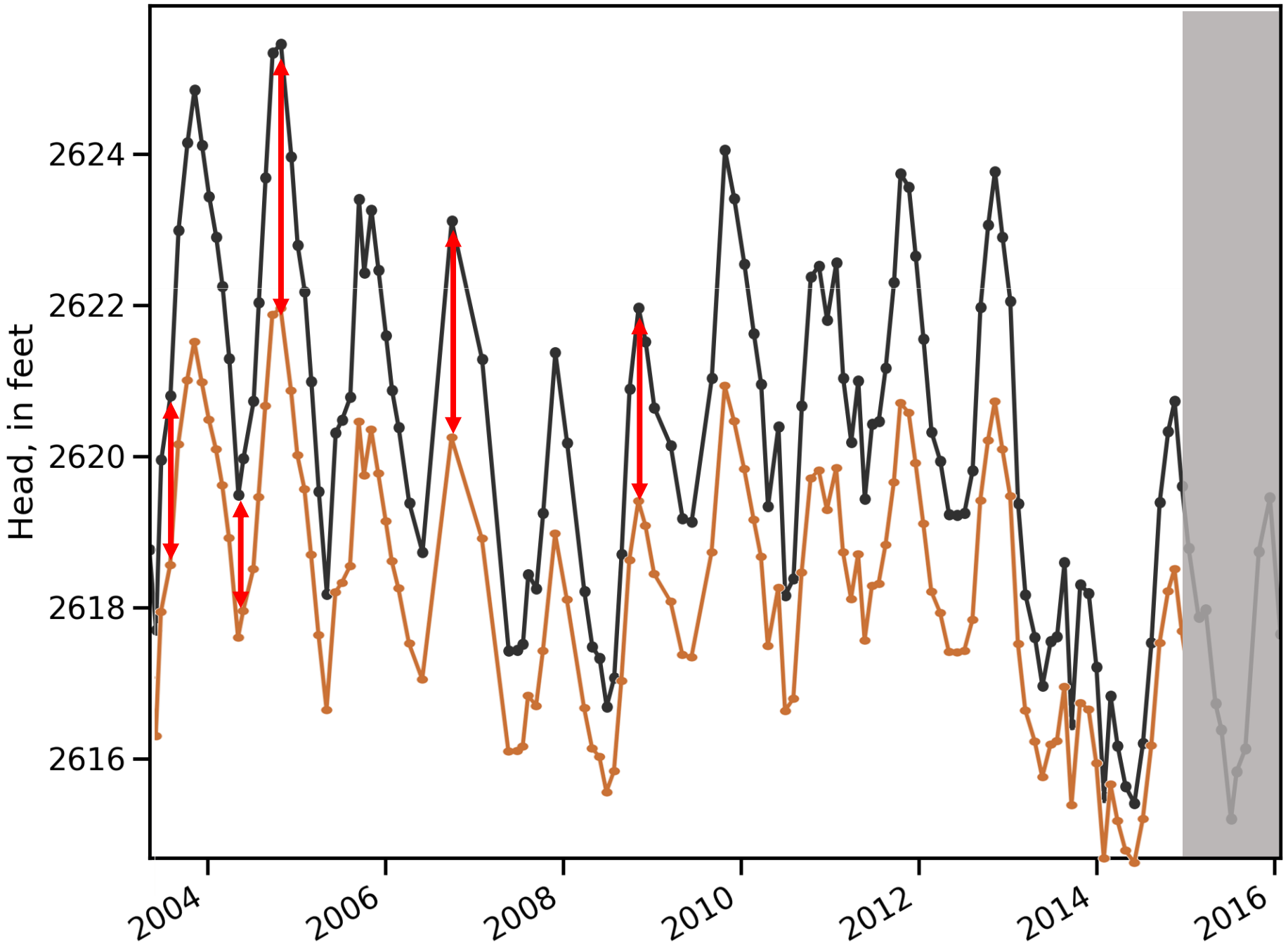
Residuals



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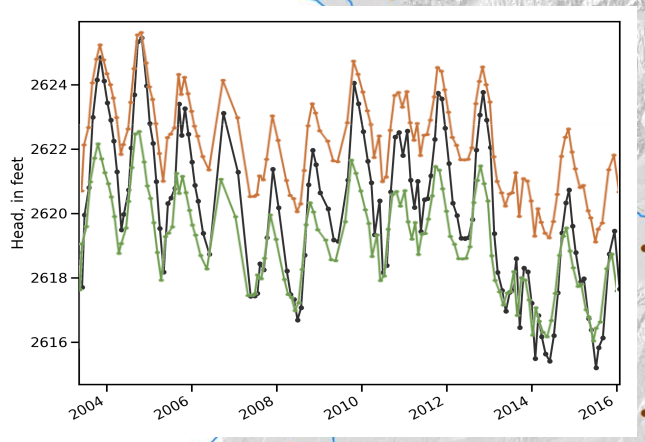
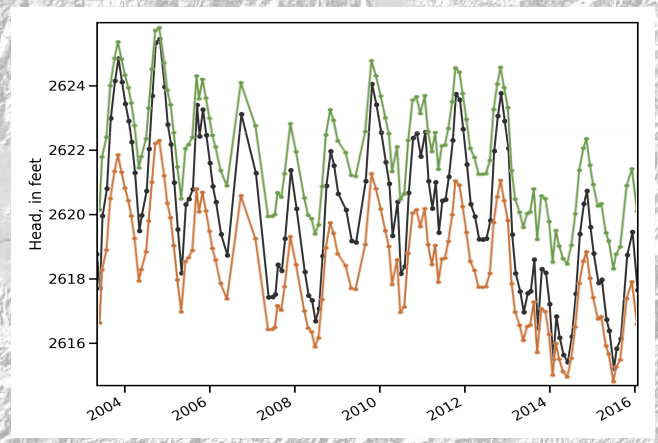
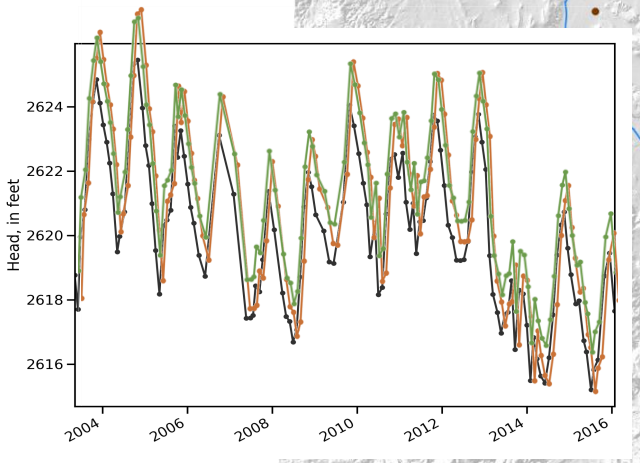
Residuals

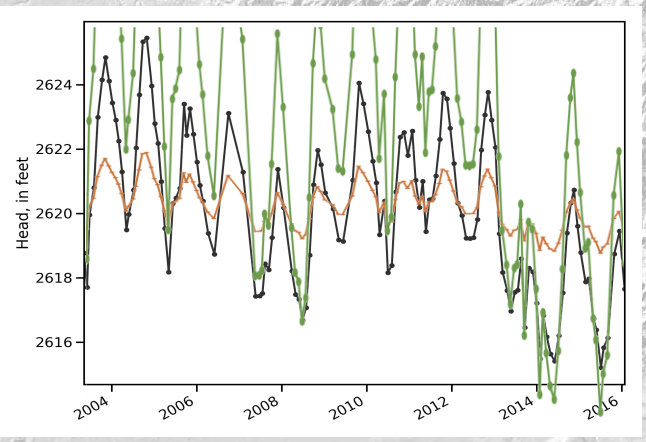
Residuals = 2, -3, 4, …

Residuals = 1, -5, 2, …









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Objective Function

$$r_i = observed_i - simulated_i$$

$$w_i = weight$$

$$objective\ function: \Phi = \sum (w_i r_i)^2$$

$$\begin{aligned}\Phi = & \sum (w_{heads} r_{heads})^2 \\ & + \sum (w_{vert_head_diff} r_{vert_head_diff})^2 \\ & + \sum (w_{temp_head_diff} r_{temp_head_diff})^2 \\ & + \sum (w_{drain_flux} r_{drain_flux})^2 \\ & + \sum (w_{lowell_seepage} r_{lowell_seepage})^2\end{aligned}$$

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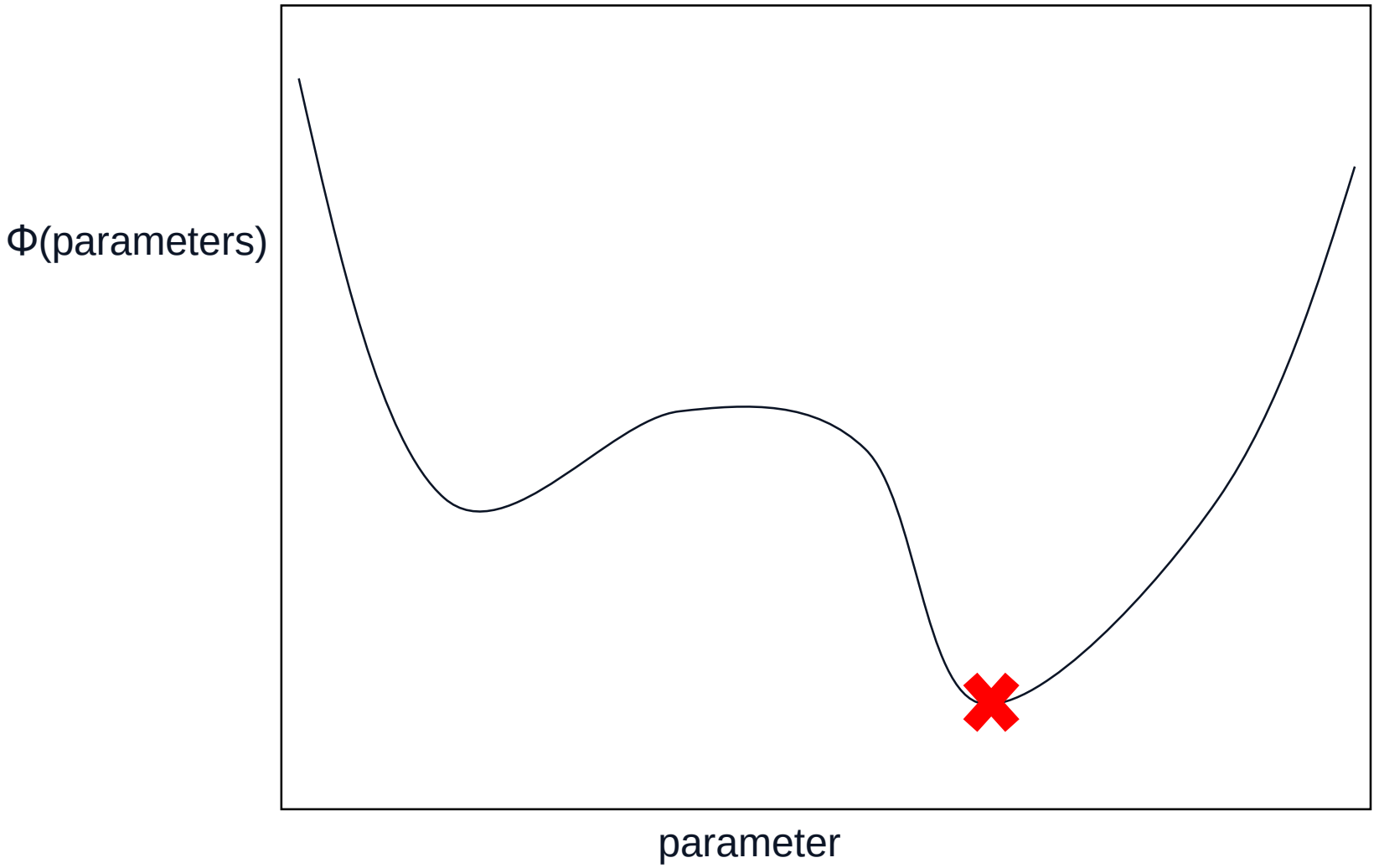
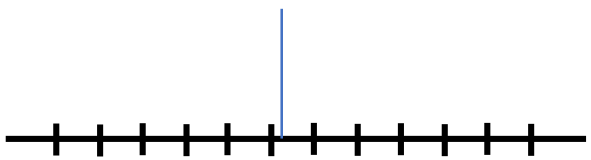
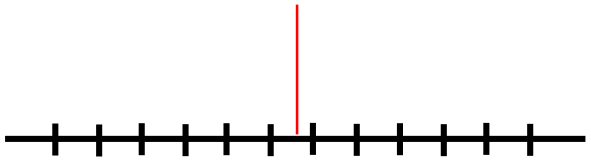
Minimizing Objective Function



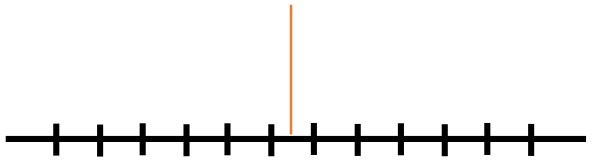
Minimizing Objective Function



hk1



lowell_cond



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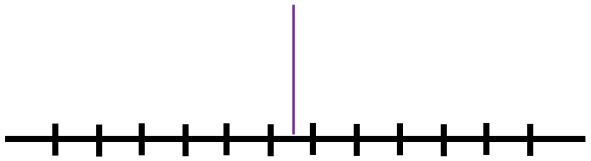
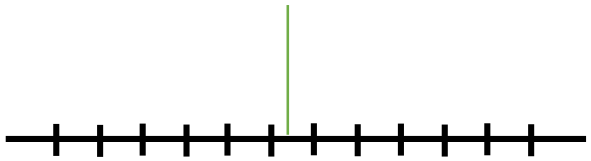
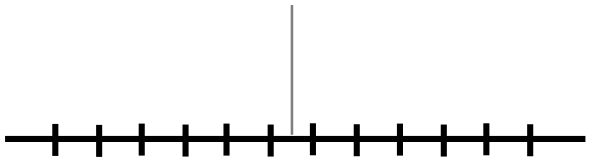


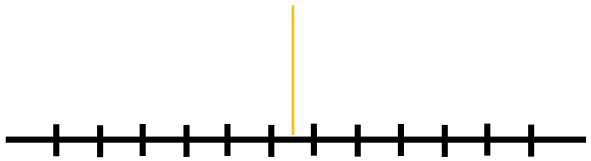
drain_cond1



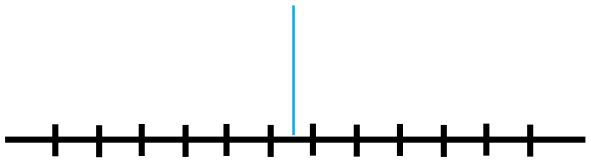
ss1



riv_cond1



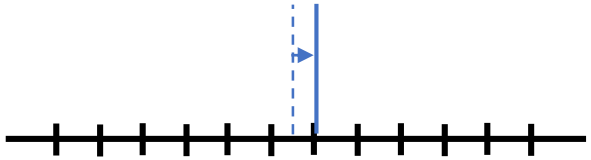
infil_fac1



trib_mult1

Φ

Minimizing Objective Function



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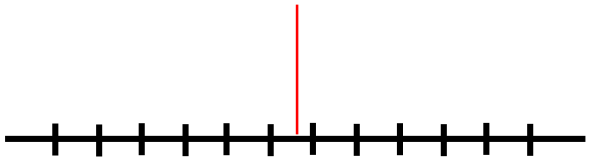

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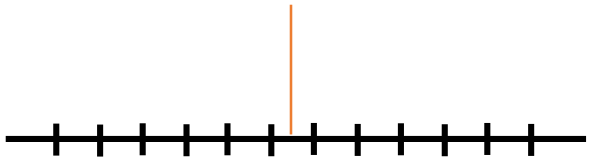

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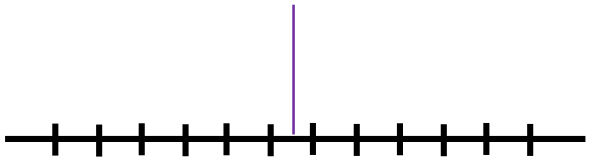

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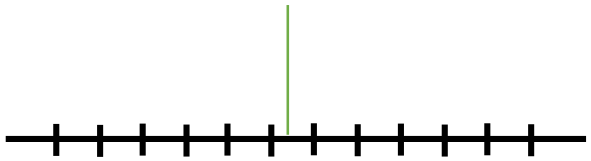

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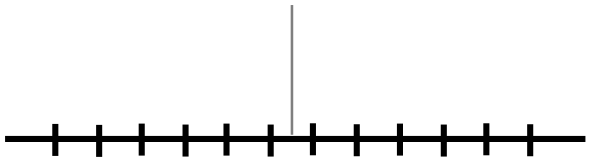

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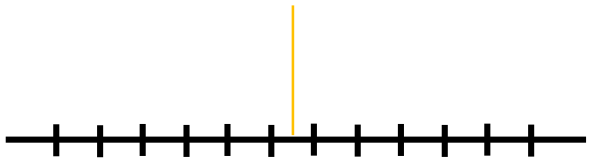
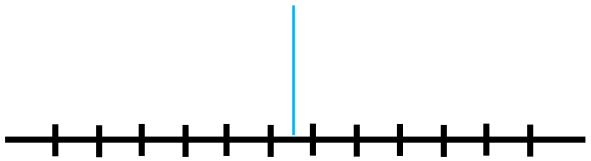


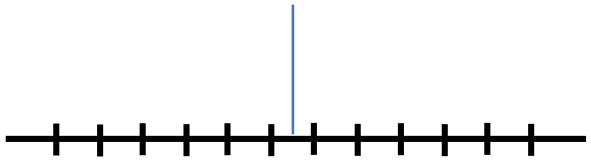
infil_fac1



trib_mult1

Φ ↑

Minimizing Objective Function



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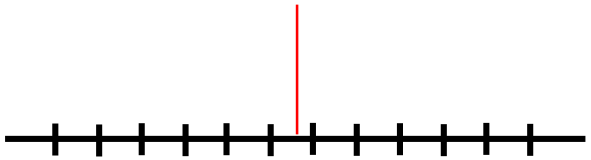

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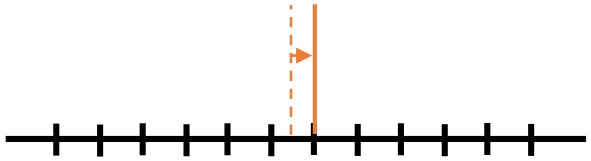

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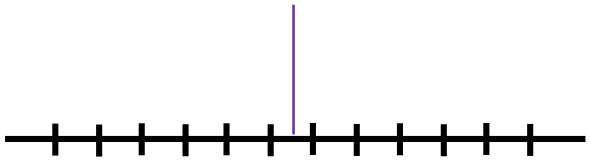

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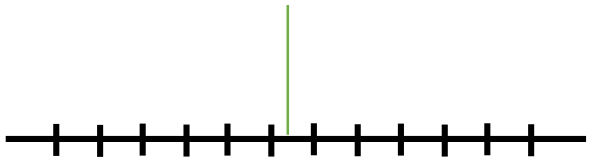

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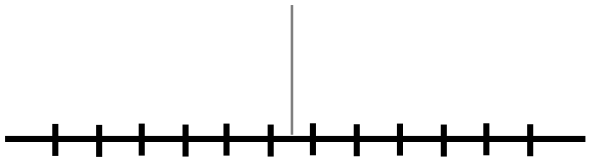

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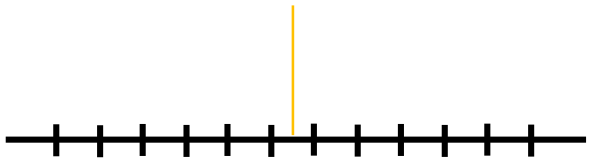
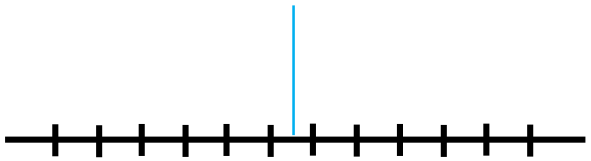


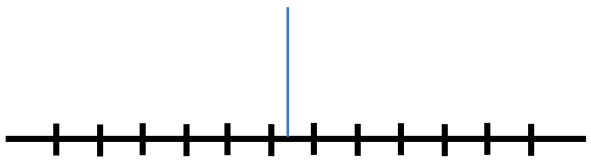
infil_fac1



trib_mult1

Φ ↑

Minimizing Objective Function



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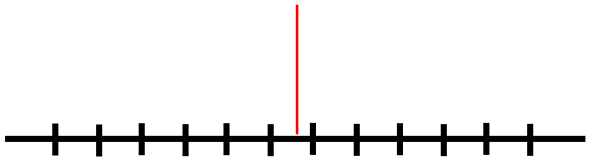

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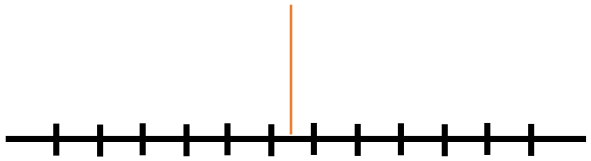

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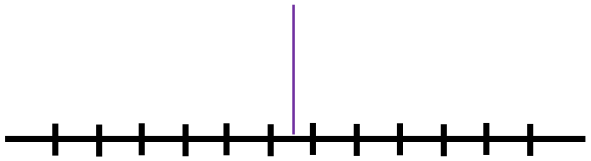
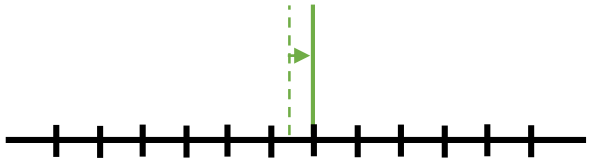


drain_cond1



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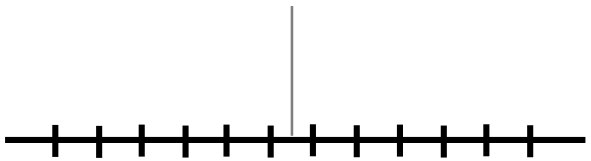

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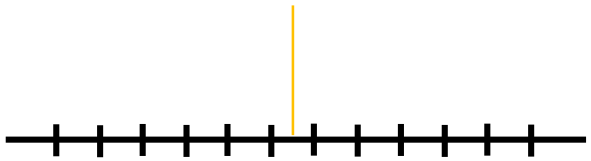
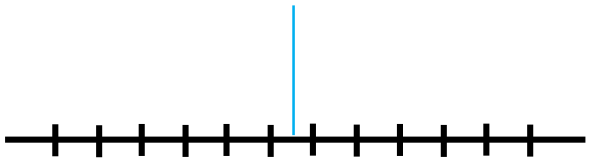


infil_fac1



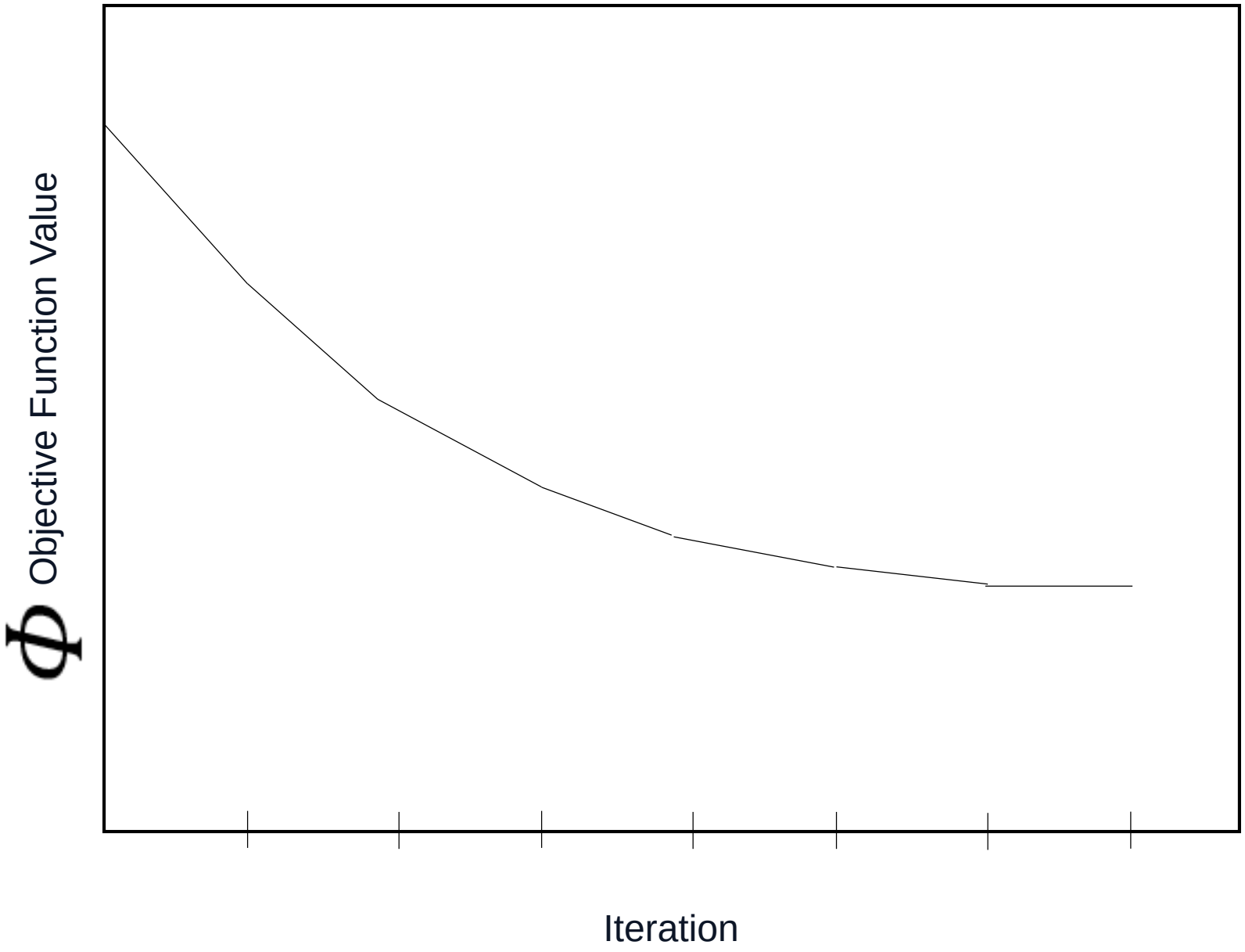
trib_mult1

$\Phi \downarrow$

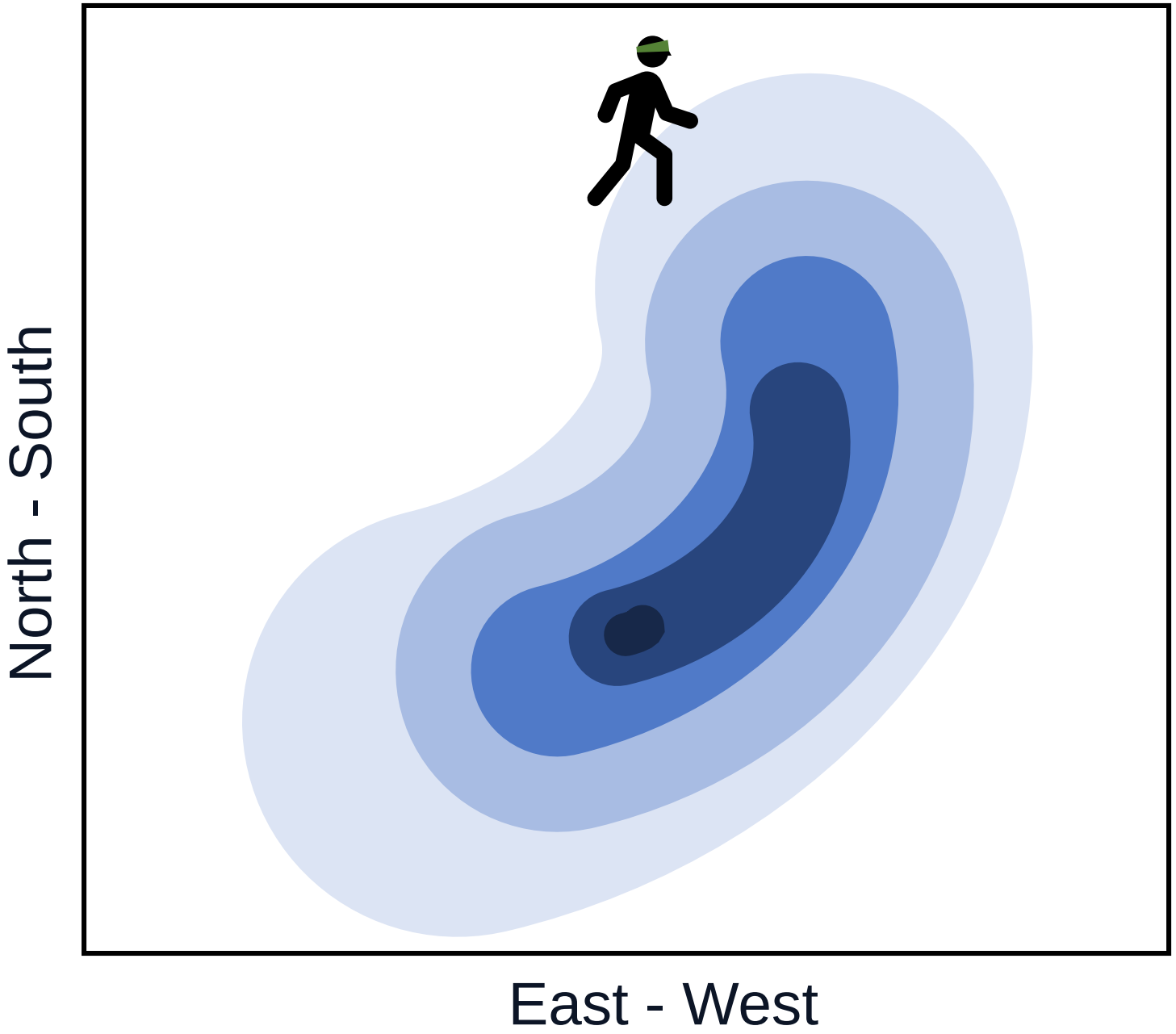
Minimizing Objective Function

	obs1	obs2	obs3	. . .	
par1	$\frac{\Delta\phi_1}{\Delta par_1}$	$\frac{\Delta\phi_2}{\Delta par_1}$	$\frac{\Delta\phi_3}{\Delta par_1}$		$\frac{\Delta\phi}{\Delta par_1}$
par2	$\frac{\Delta\phi_1}{\Delta par_2}$	$\frac{\Delta\phi_2}{\Delta par_2}$	$\frac{\Delta\phi_3}{\Delta par_2}$		$\frac{\Delta\phi}{\Delta par_2}$
par3	$\frac{\Delta\phi_1}{\Delta par_3}$	$\frac{\Delta\phi_2}{\Delta par_3}$	$\frac{\Delta\phi_3}{\Delta par_3}$	. . .	$\frac{\Delta\phi}{\Delta par_3}$
par4	$\frac{\Delta\phi_1}{\Delta par_4}$	$\frac{\Delta\phi_2}{\Delta par_4}$	$\frac{\Delta\phi_3}{\Delta par_4}$		$\frac{\Delta\phi}{\Delta par_4}$
⋮			⋮		

Minimizing Objective Function



Minimizing Objective Function



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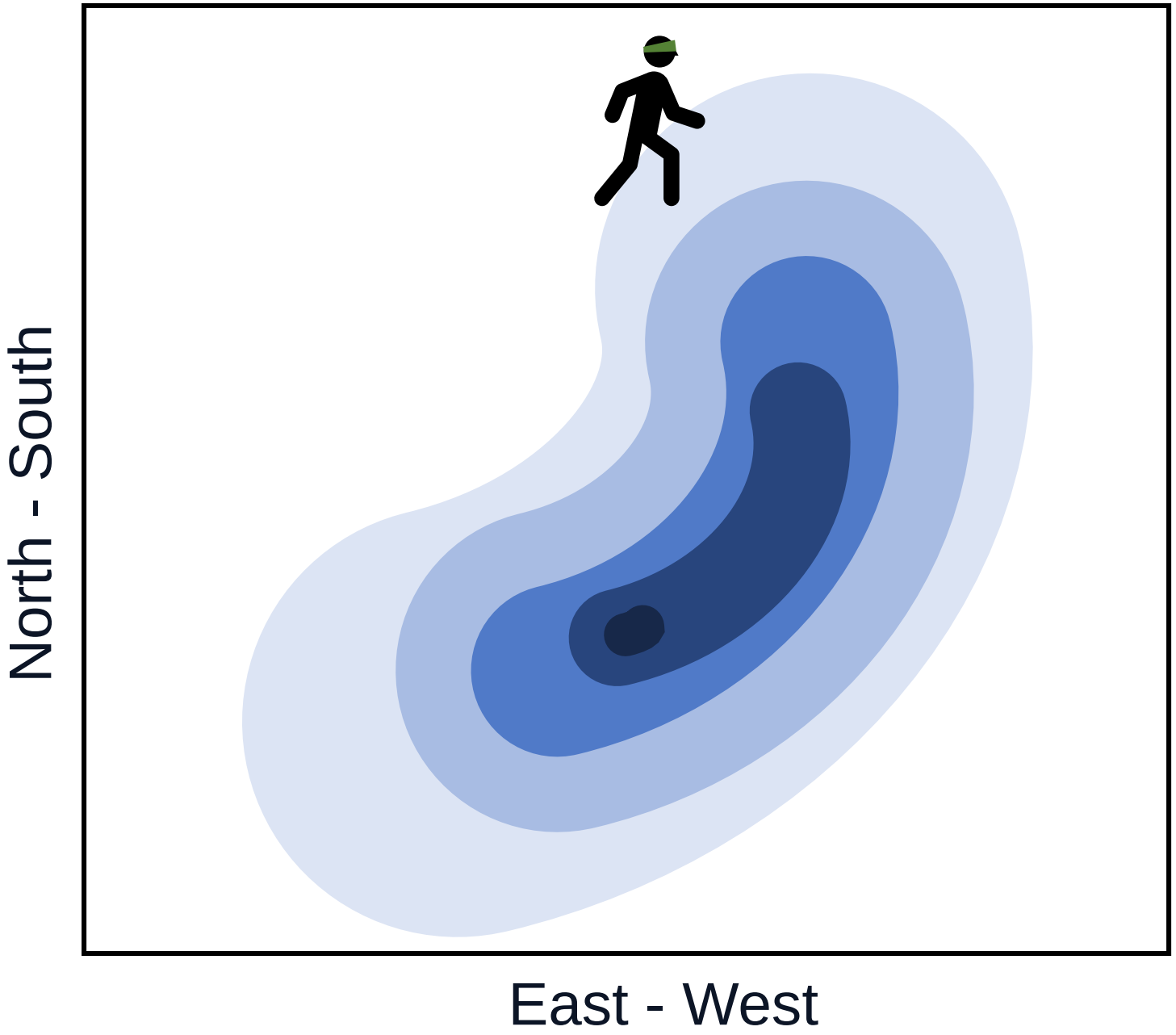

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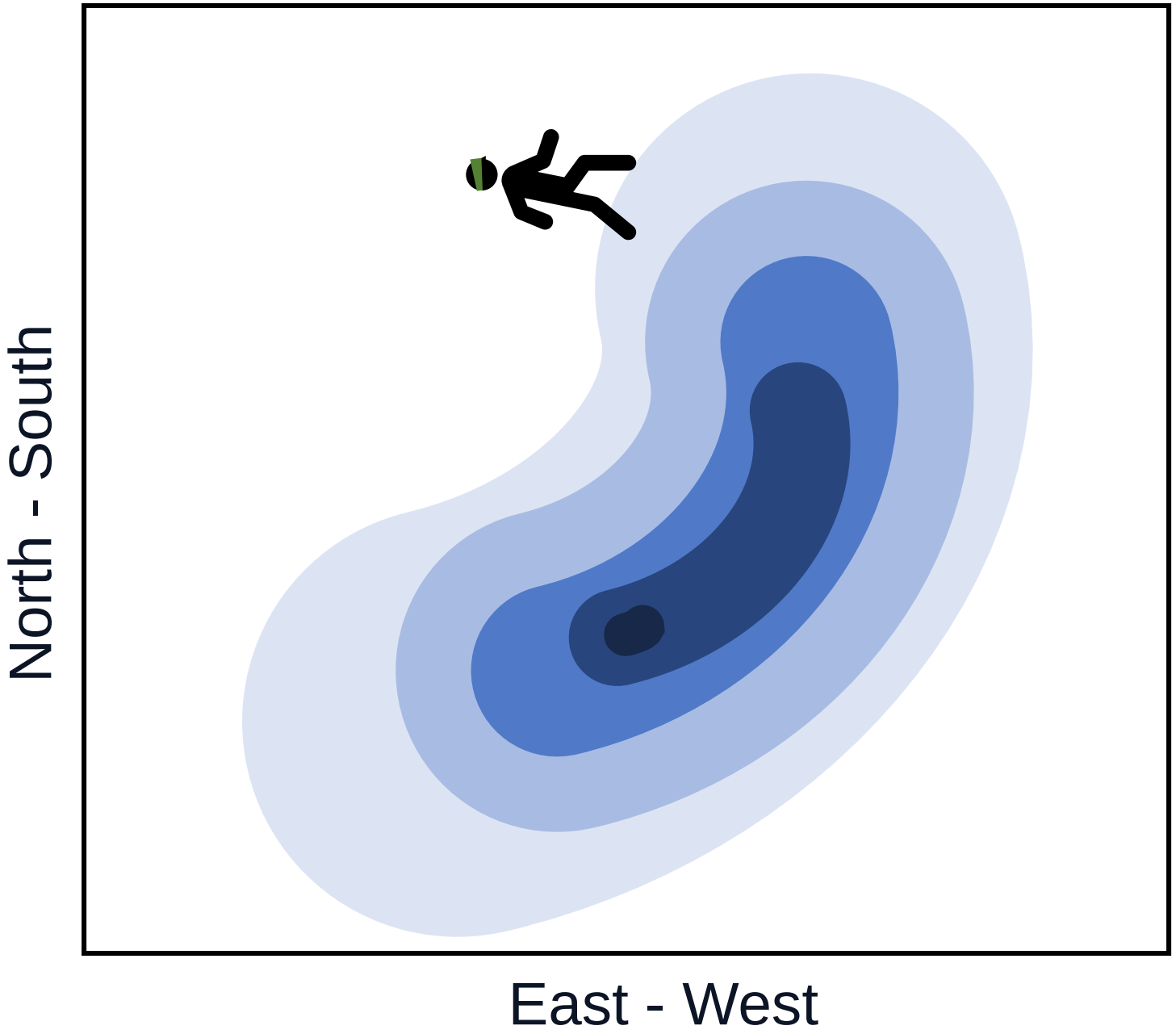

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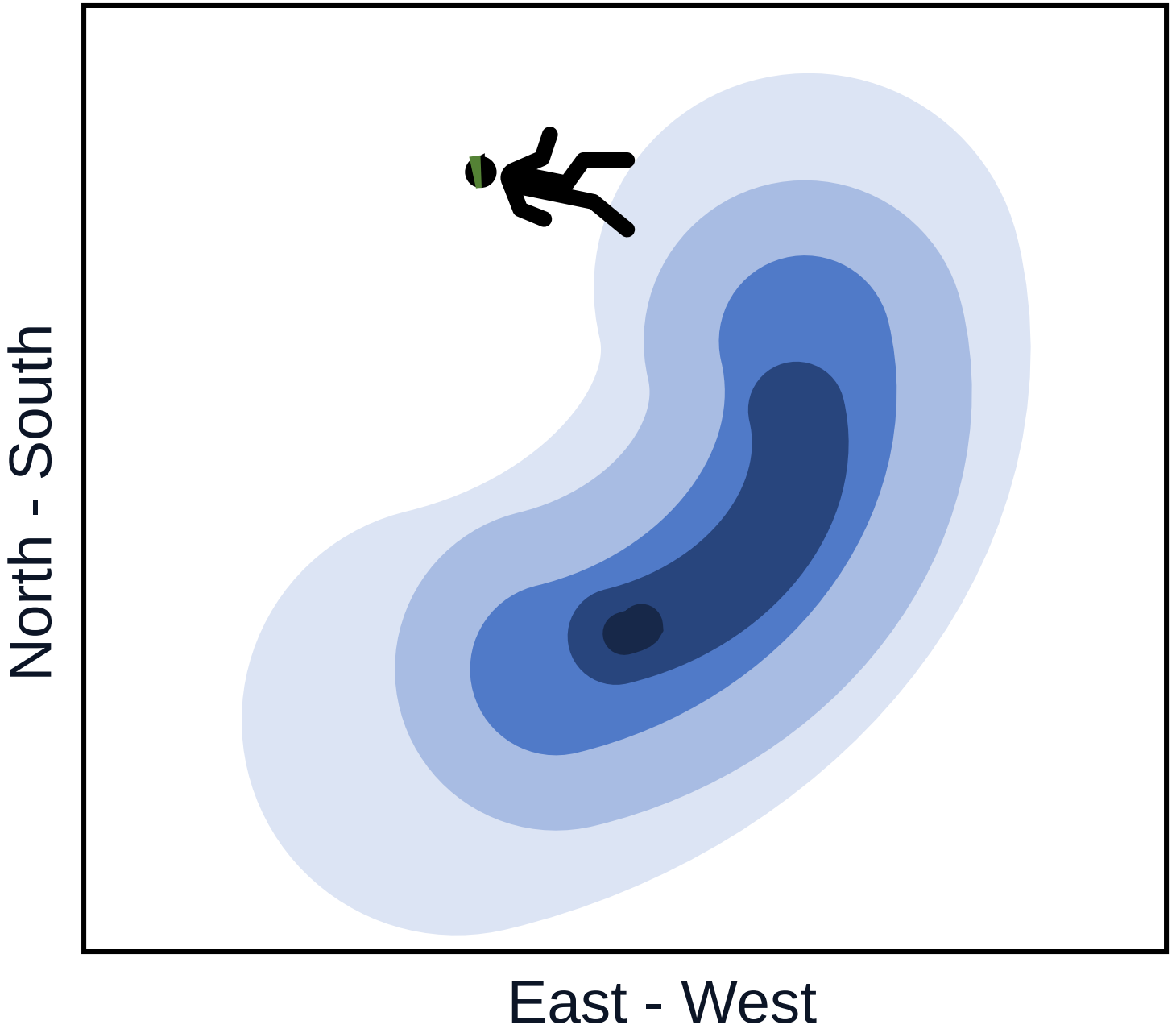

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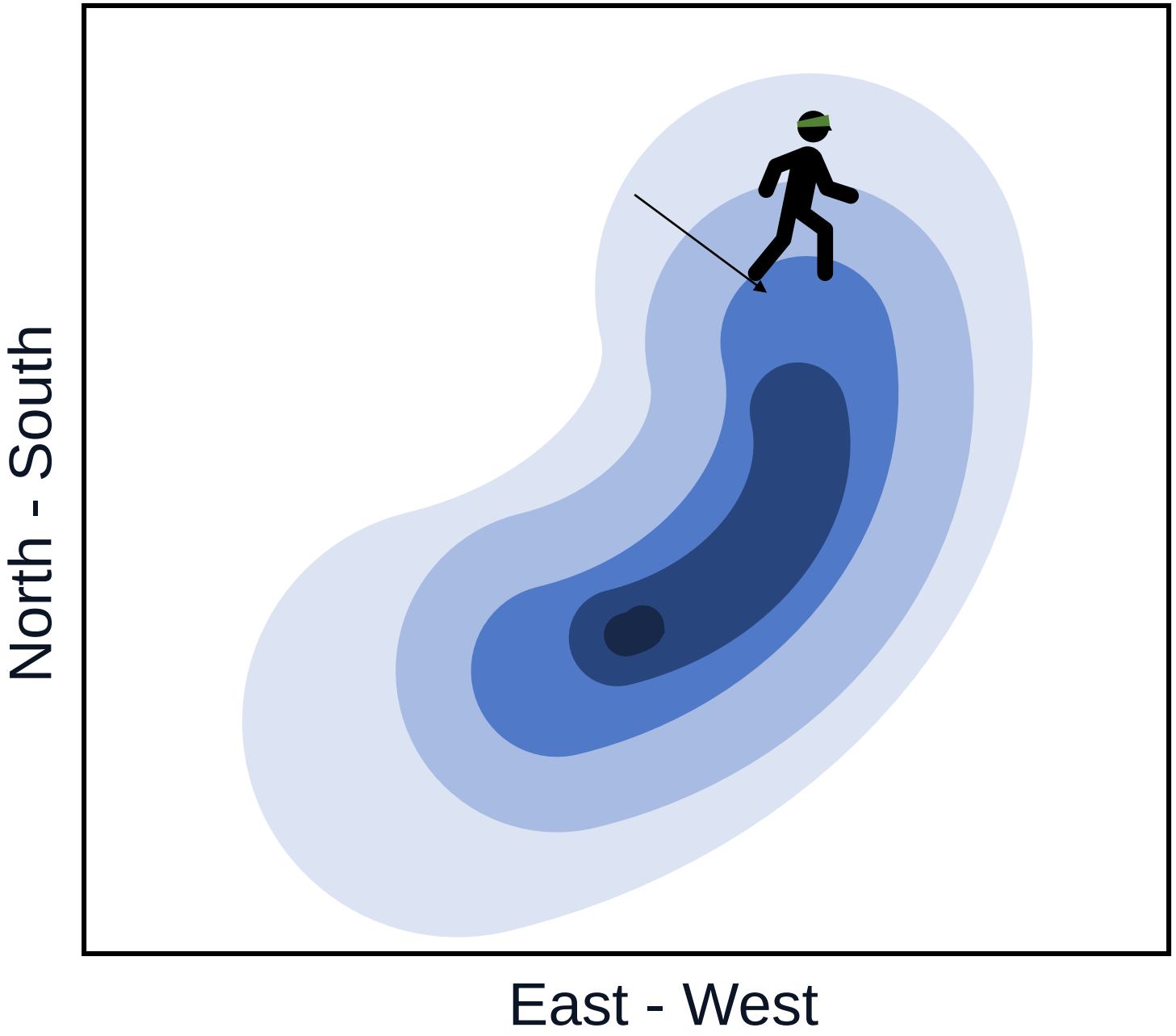
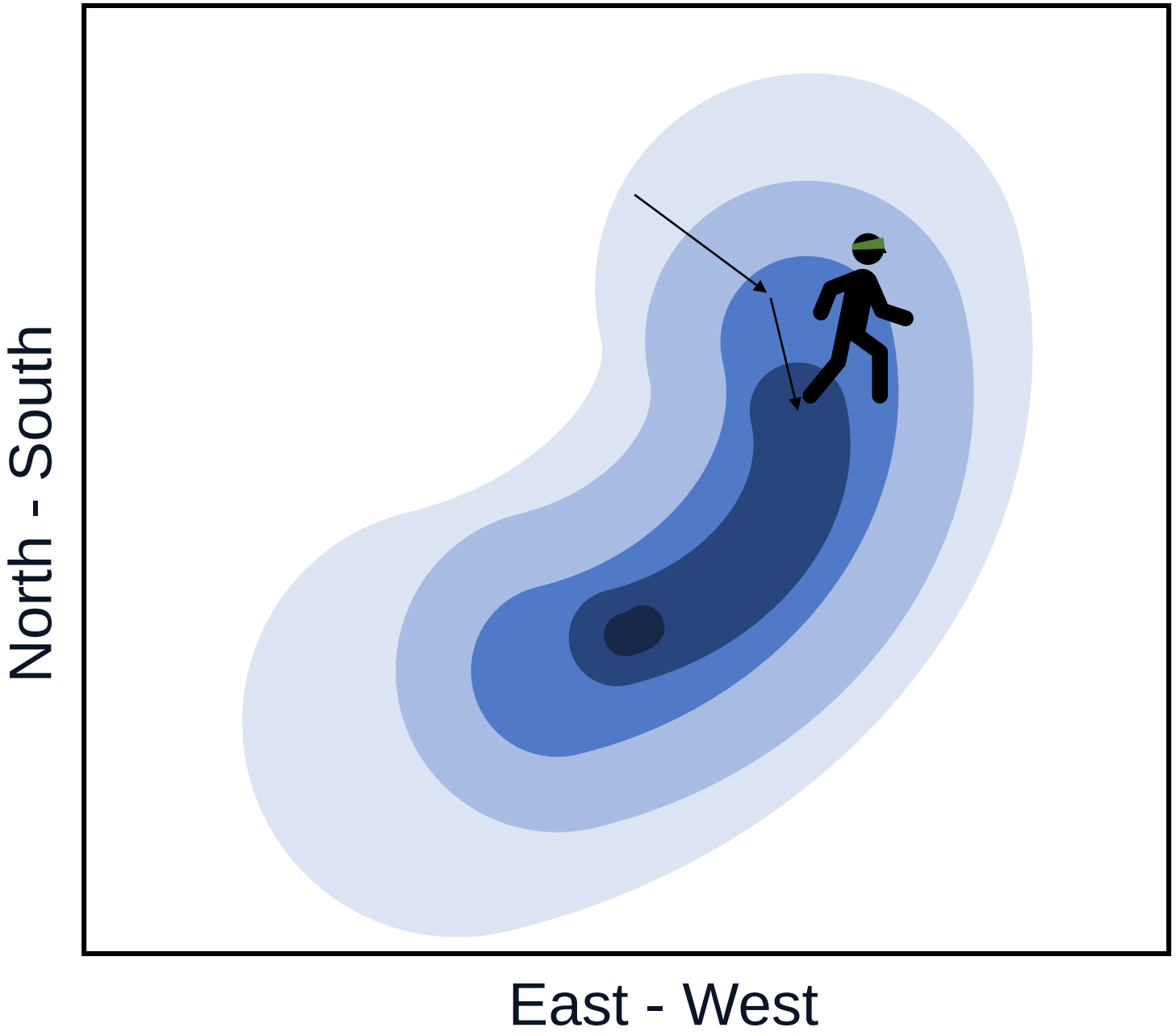
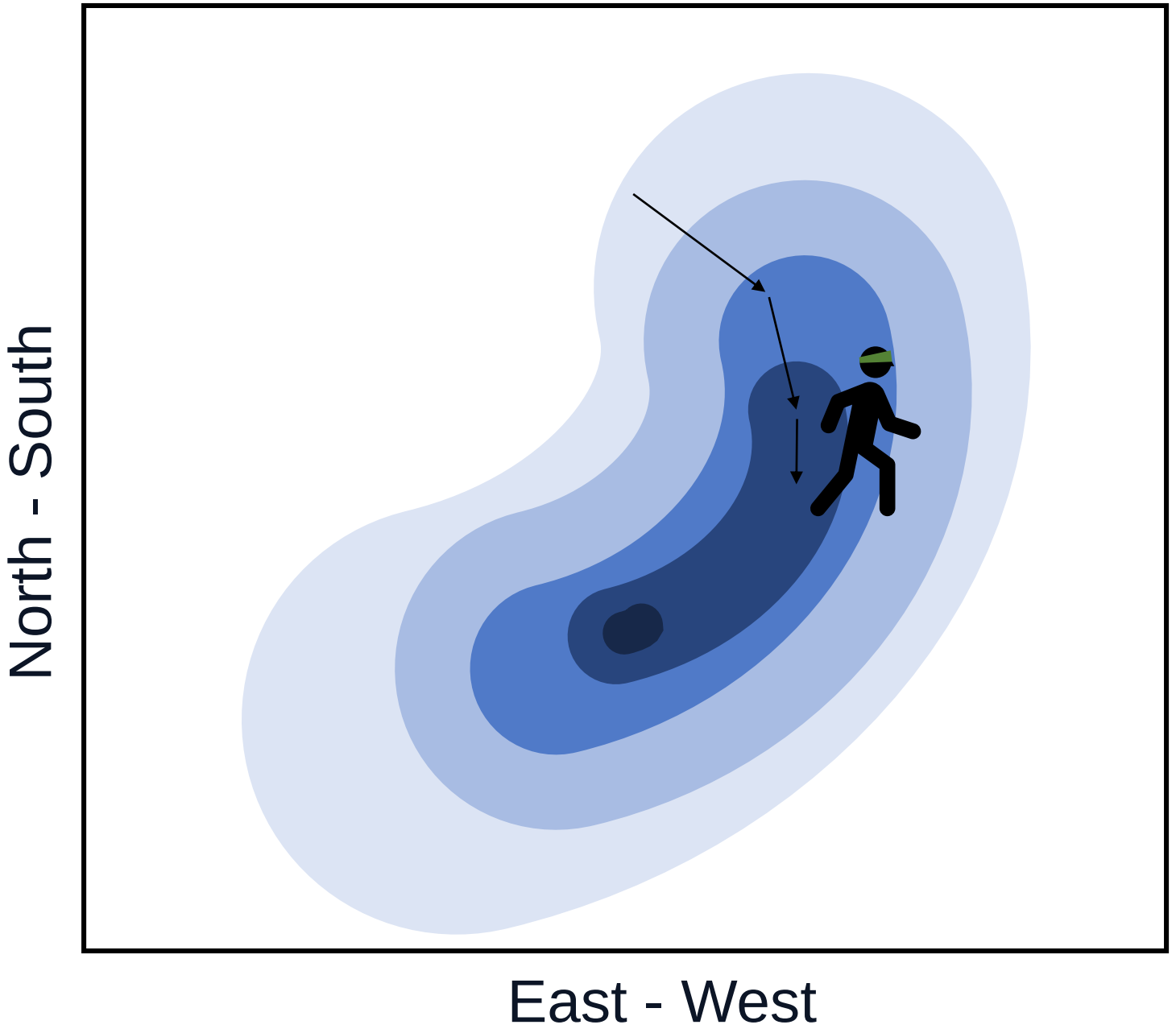
Minimizing Objective Function



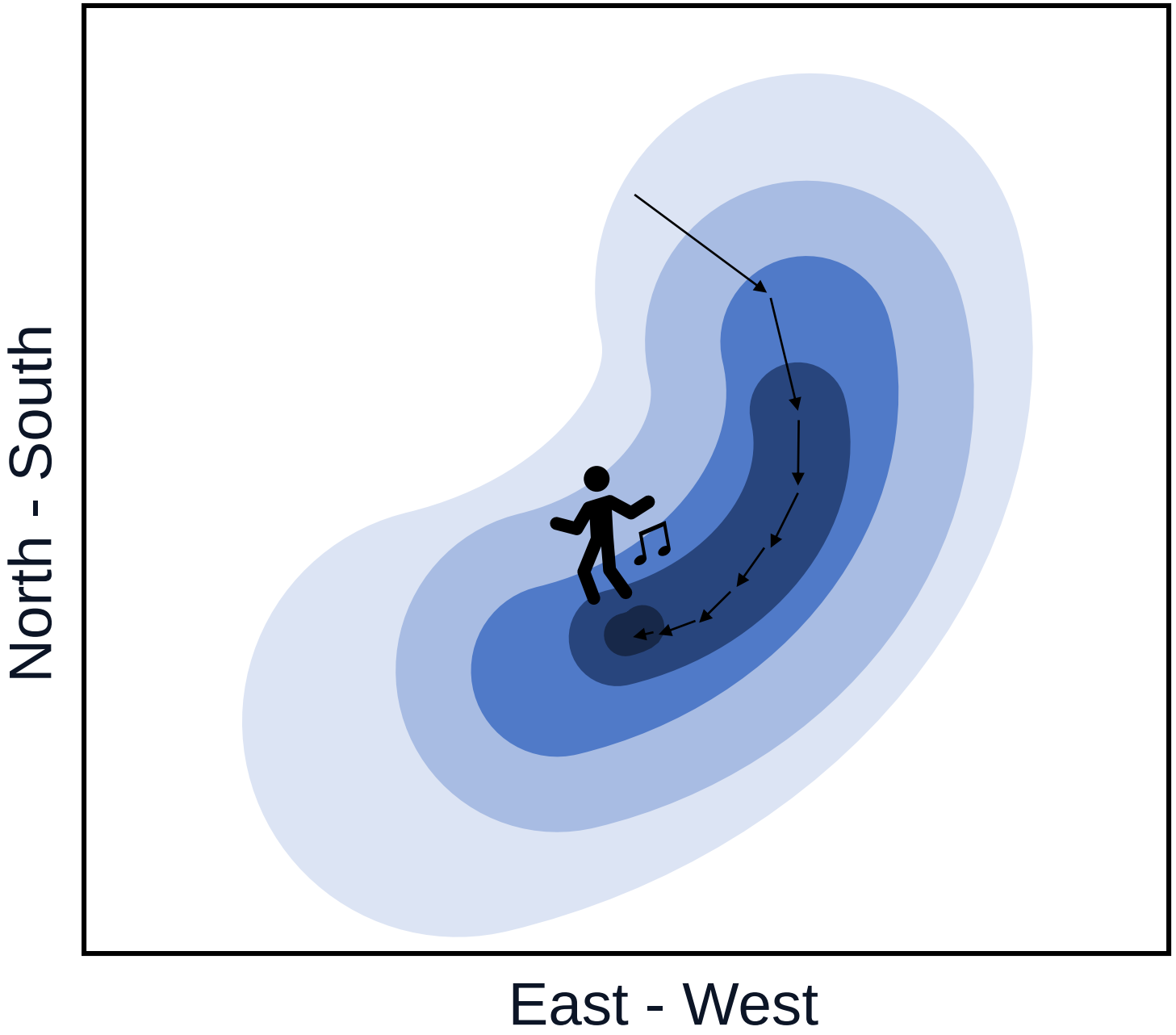
Minimizing Objective Function



Minimizing Objective Function



Minimizing Objective Function



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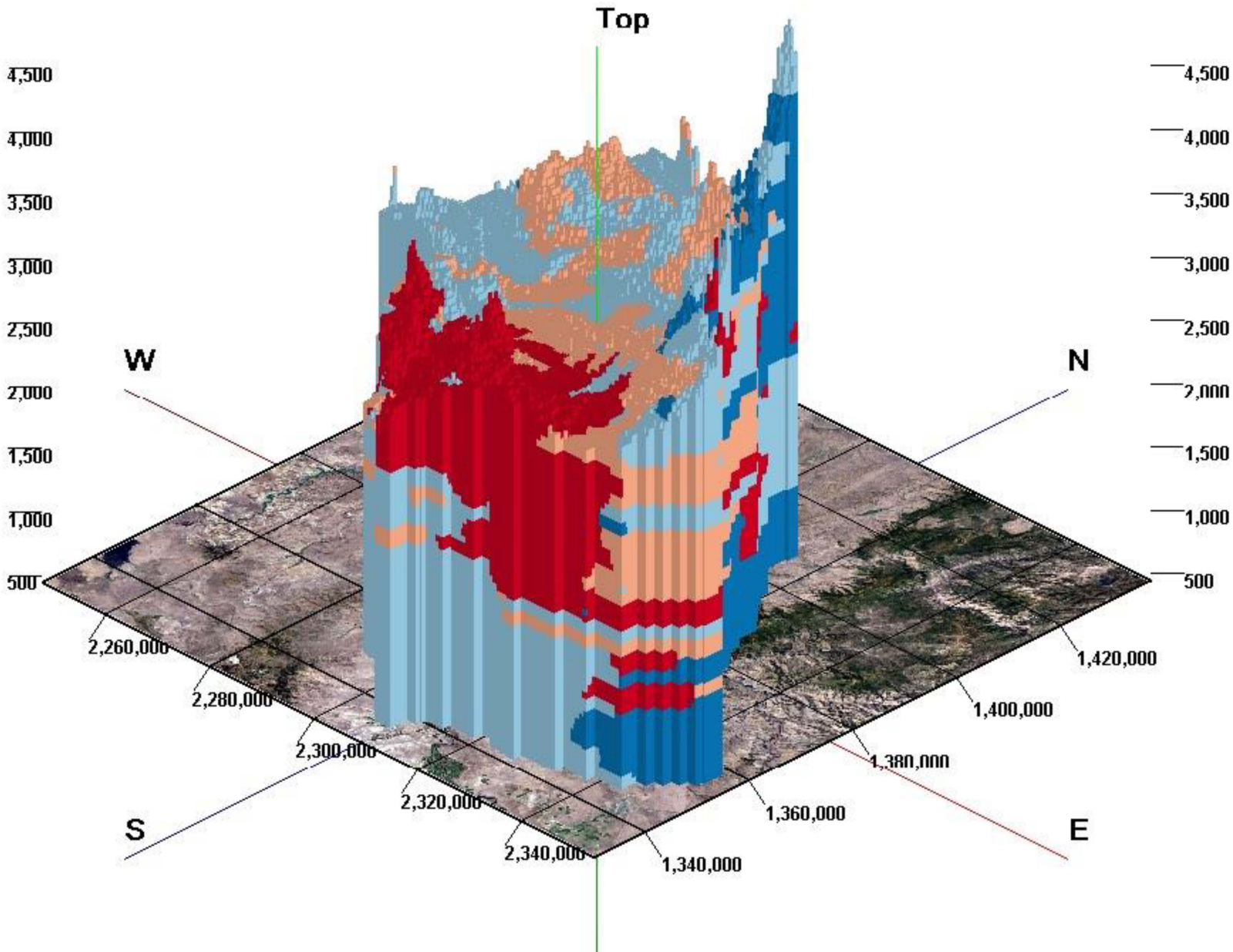
Parameter Values: ‘Soft’ Knowledge

Hydrogeologic Framework of the Treasure Valley and Surrounding Area, Idaho and Oregon

J.R. Bartolino, USGS, Idaho Water Science Center



Hydrogeologic unit

- BAS: Basalt, undifferentiated: includes Pliocene-Pleistocene and Miocene basalts
- CGF: Coarse-grained fluvial and alluvial deposits
- FGL: Fine-grained lacustrine deposits
- GRB: Granitic and rhyolitic bedrock

20X vertical exageration

Vertical scale is feet above datum

Horizontal scale is Idaho UTM meters

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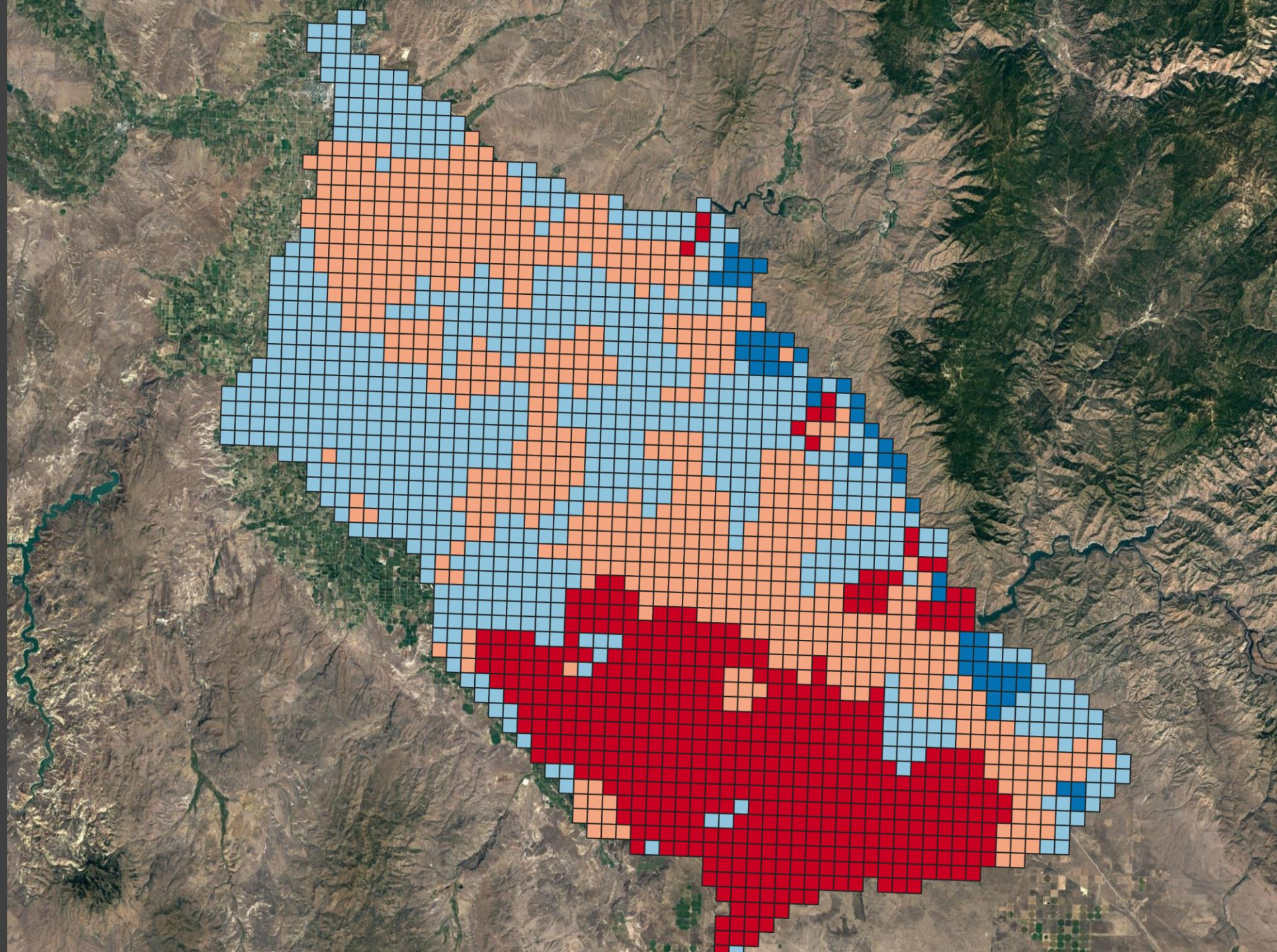
Lithology Mapped to Grid: Layer 1



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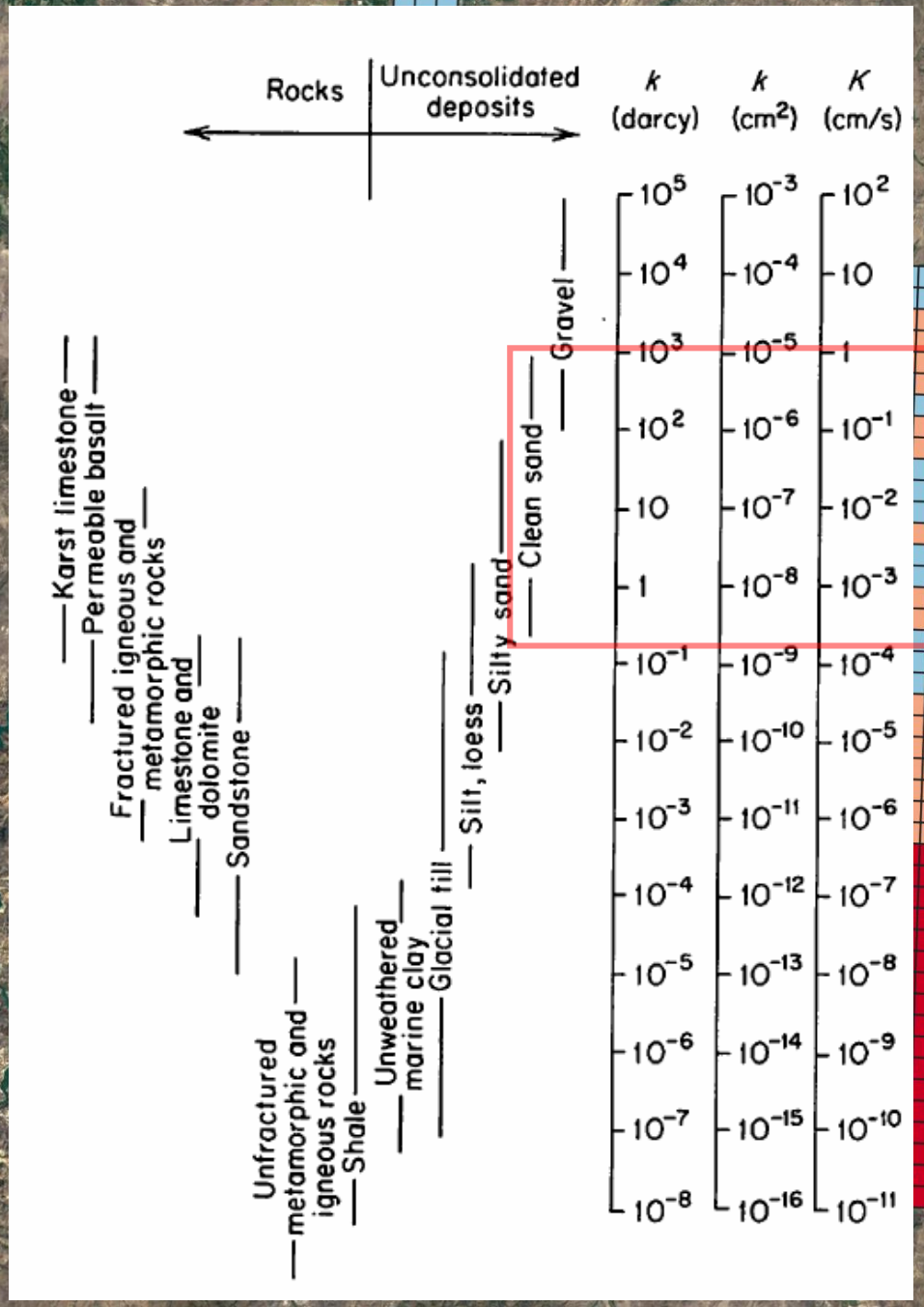
Parameters & Material Properties



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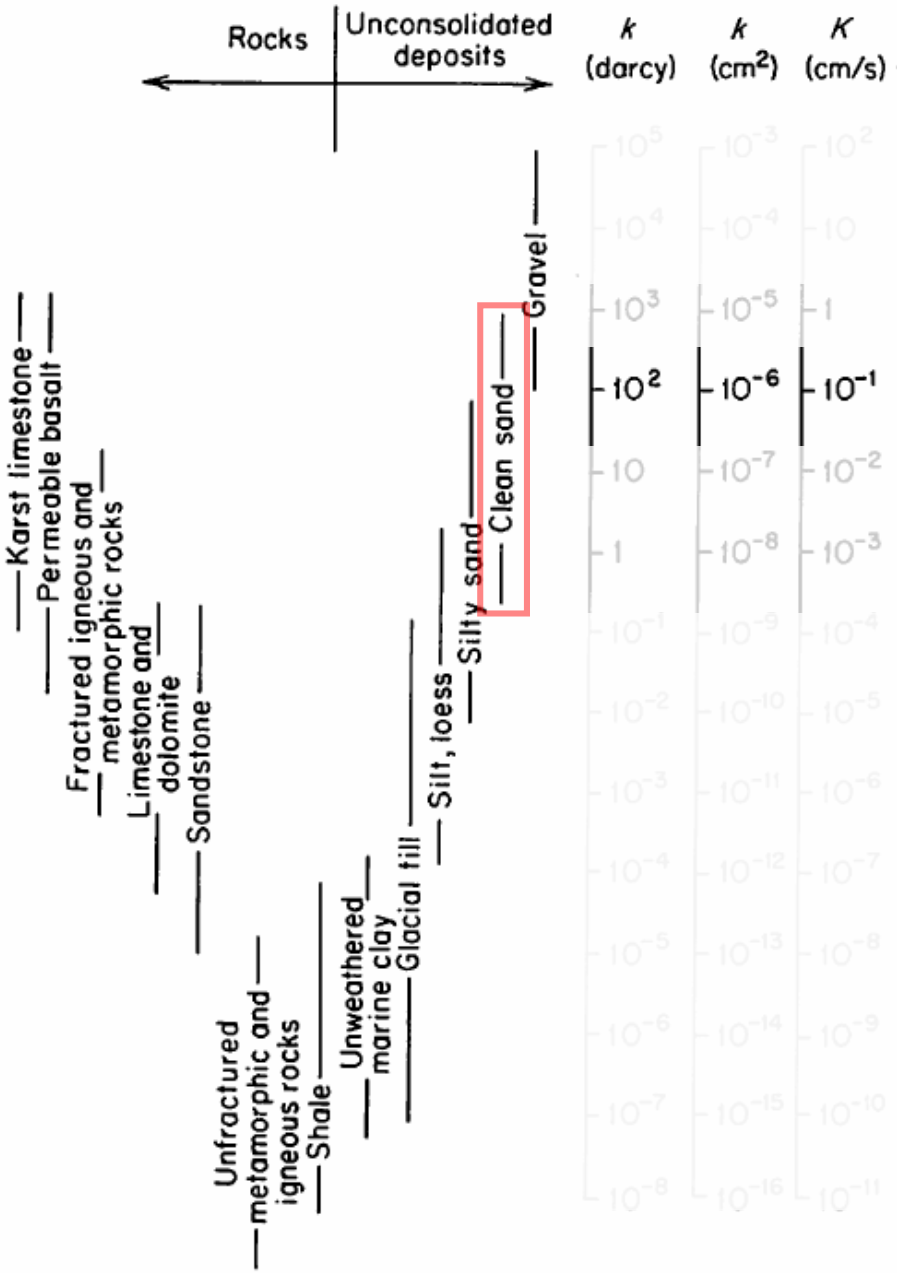
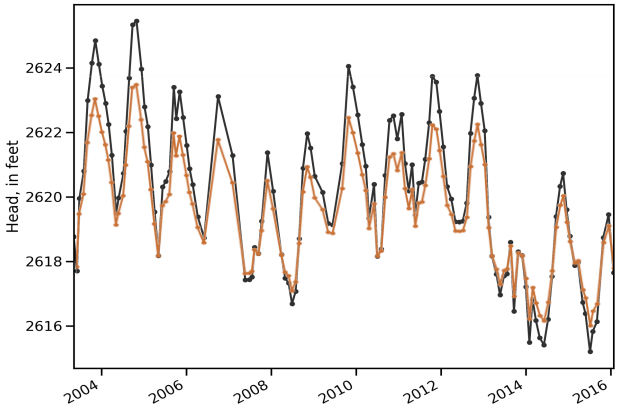
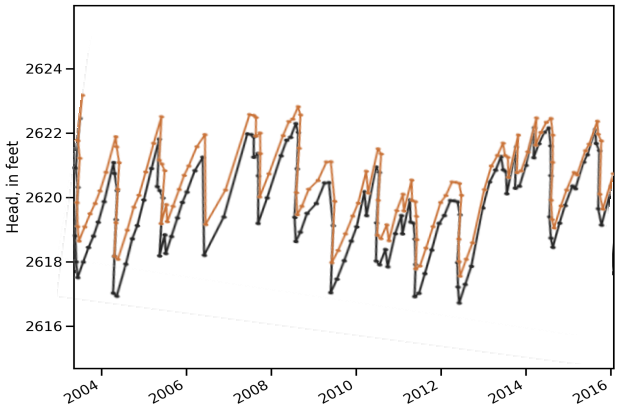
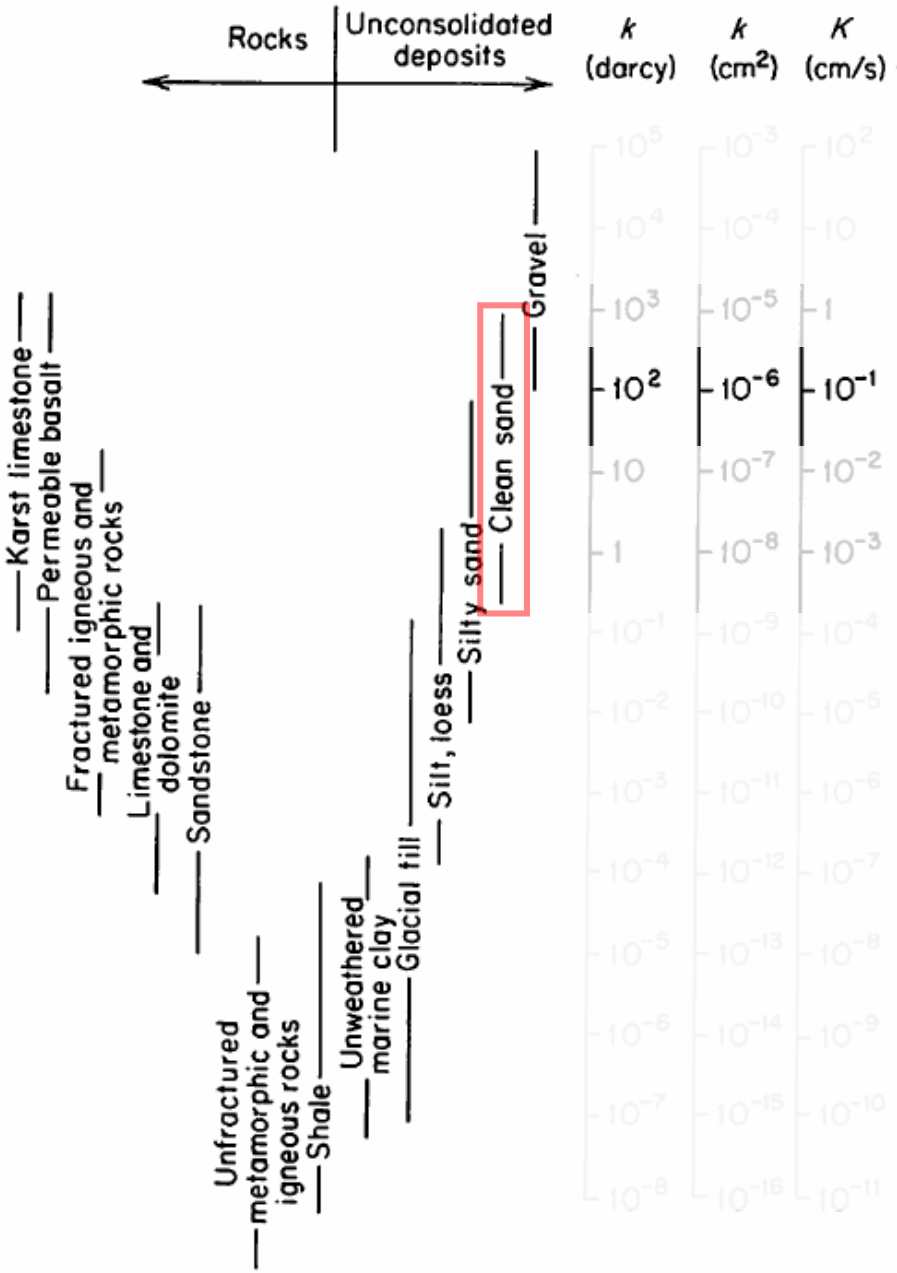
Parameters & Material Properties





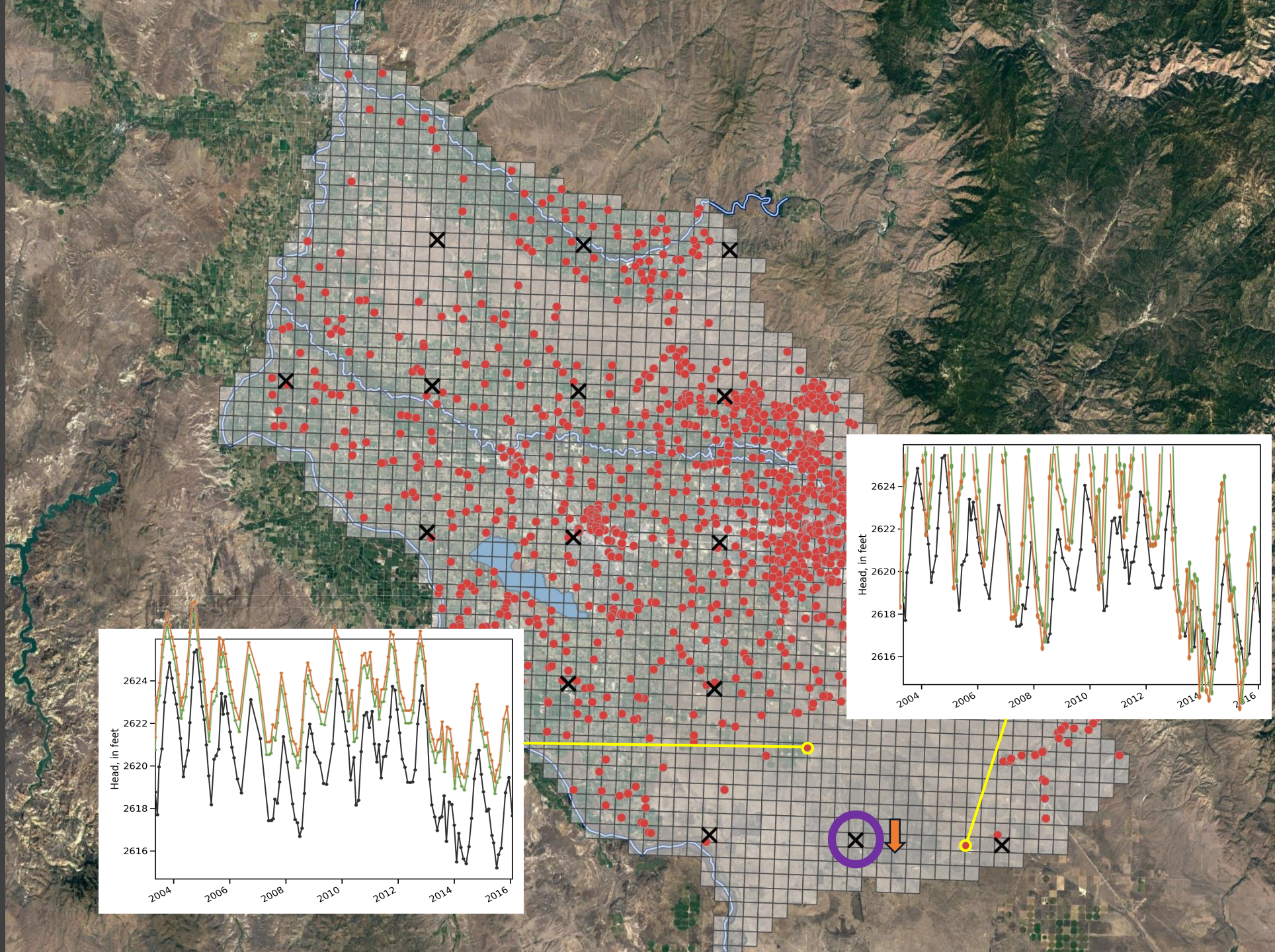


Estimating Parameters

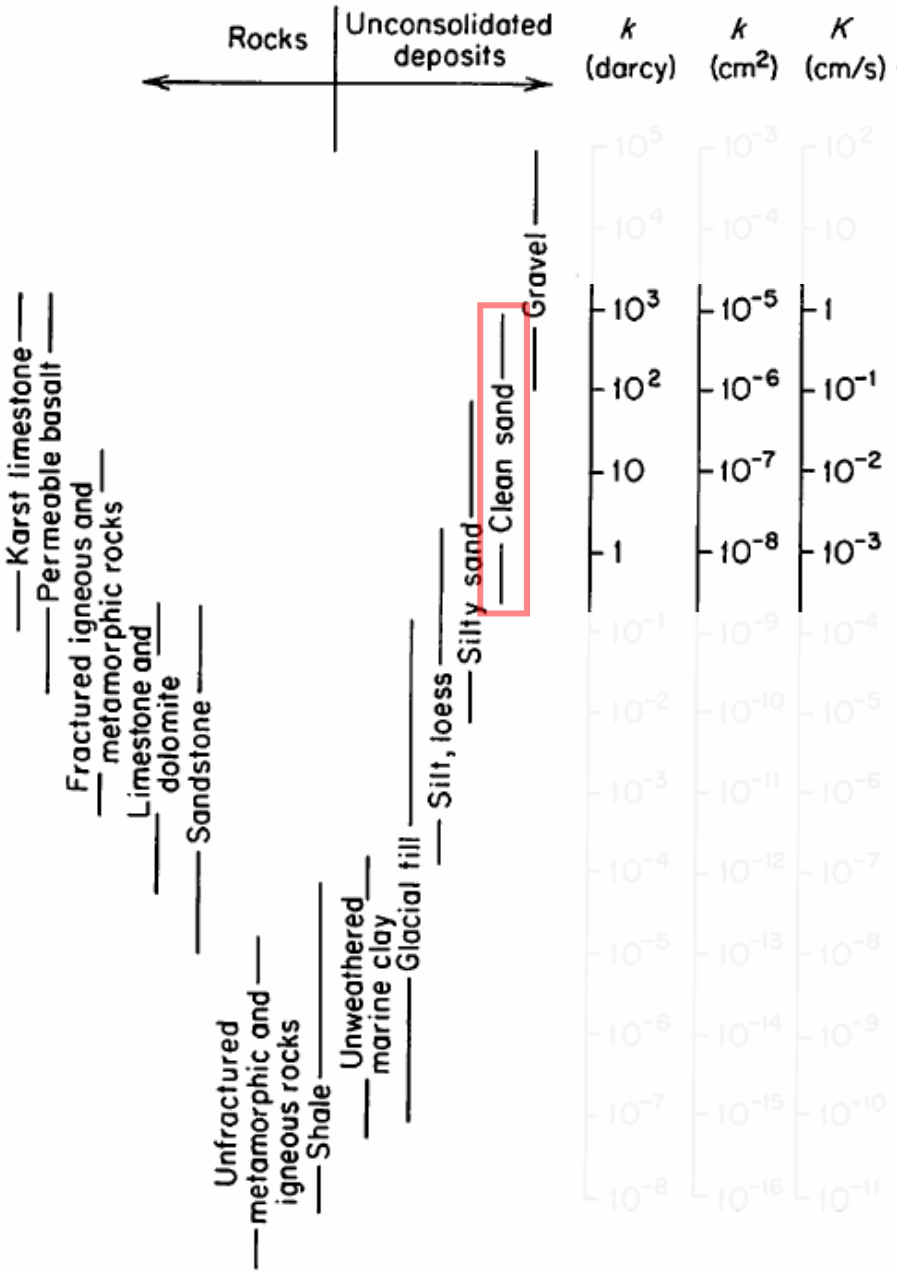


Estimating Parameters

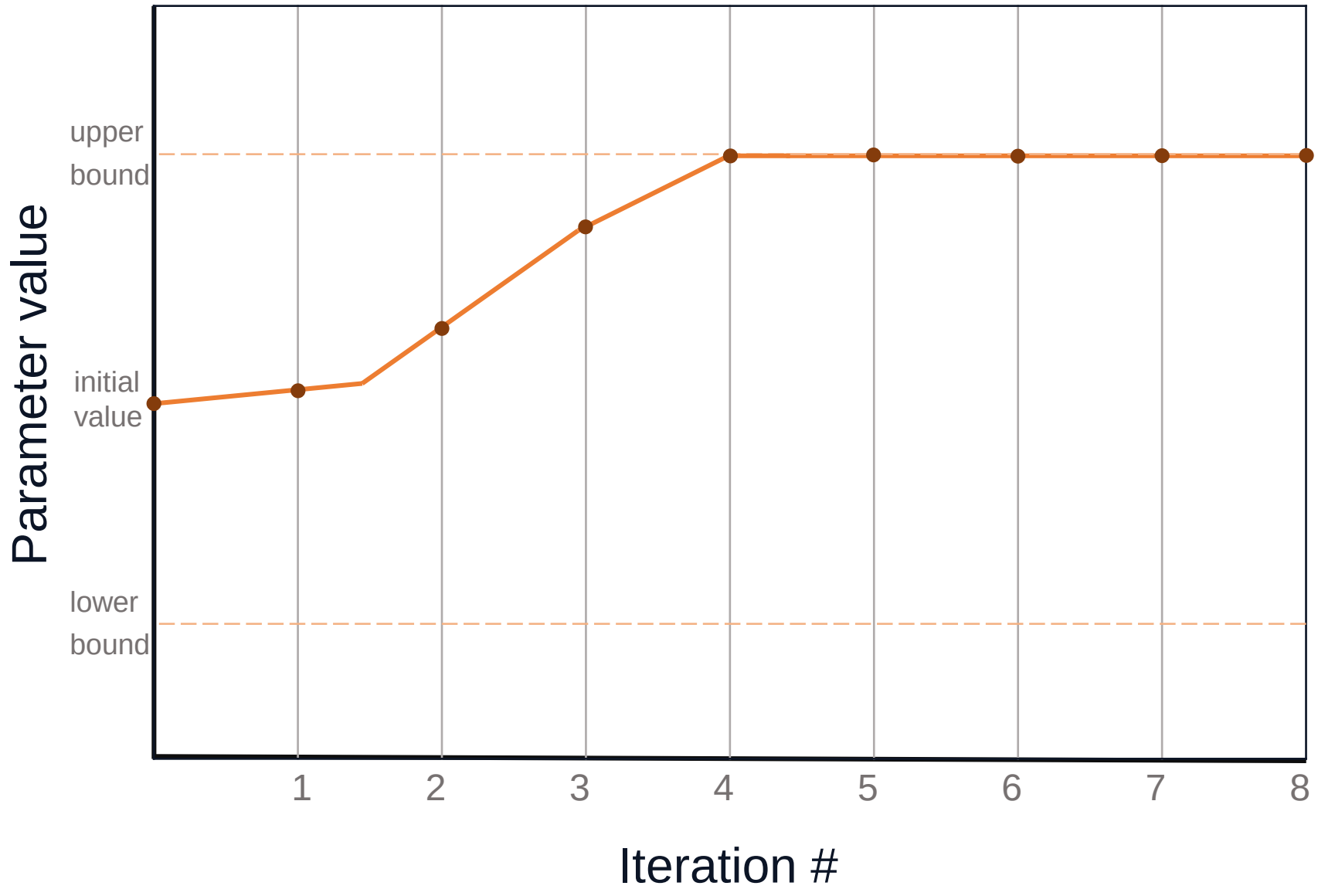
Not all parameters are equally constrained by observation data



Estimating Parameters



Parameter Limits



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Model Parameters

Parameter	Spatial Scale	# Parameters	
		initial	expandable
Hydraulic Conductivity – horizontal	Grid: 1 every 5-10 cells * # layers	~50	easily to 400+
Hydraulic Conductivity – vertical	Grid: 1 every 5-10 cells * # layers	~50	easily to 400+
Storage Coefficient	Grid: 1 every 5-10 cells * # layers	~50	easily to 400+
River conductance	Gaged river reaches	2	to gaged reaches
Drain conductance	Gaged drain --	~5	18
Lowell conductance	Lake	1	-
NY Canal conductance	Canal	1	-
NY Canal leakage factor	Canal	1	-
Canal leakage factor	Irrigation entity	1	70
Canal leakage distribution factor	Irrigation entity	1	70
Irrigated lands infiltration factor	Irrigation entity	1	70
Semi-irrigated infiltration factor	Irrigation entity	1	70
Tributary underflow multiplier	3 values	3	
ET multiplier	1 value	1	-

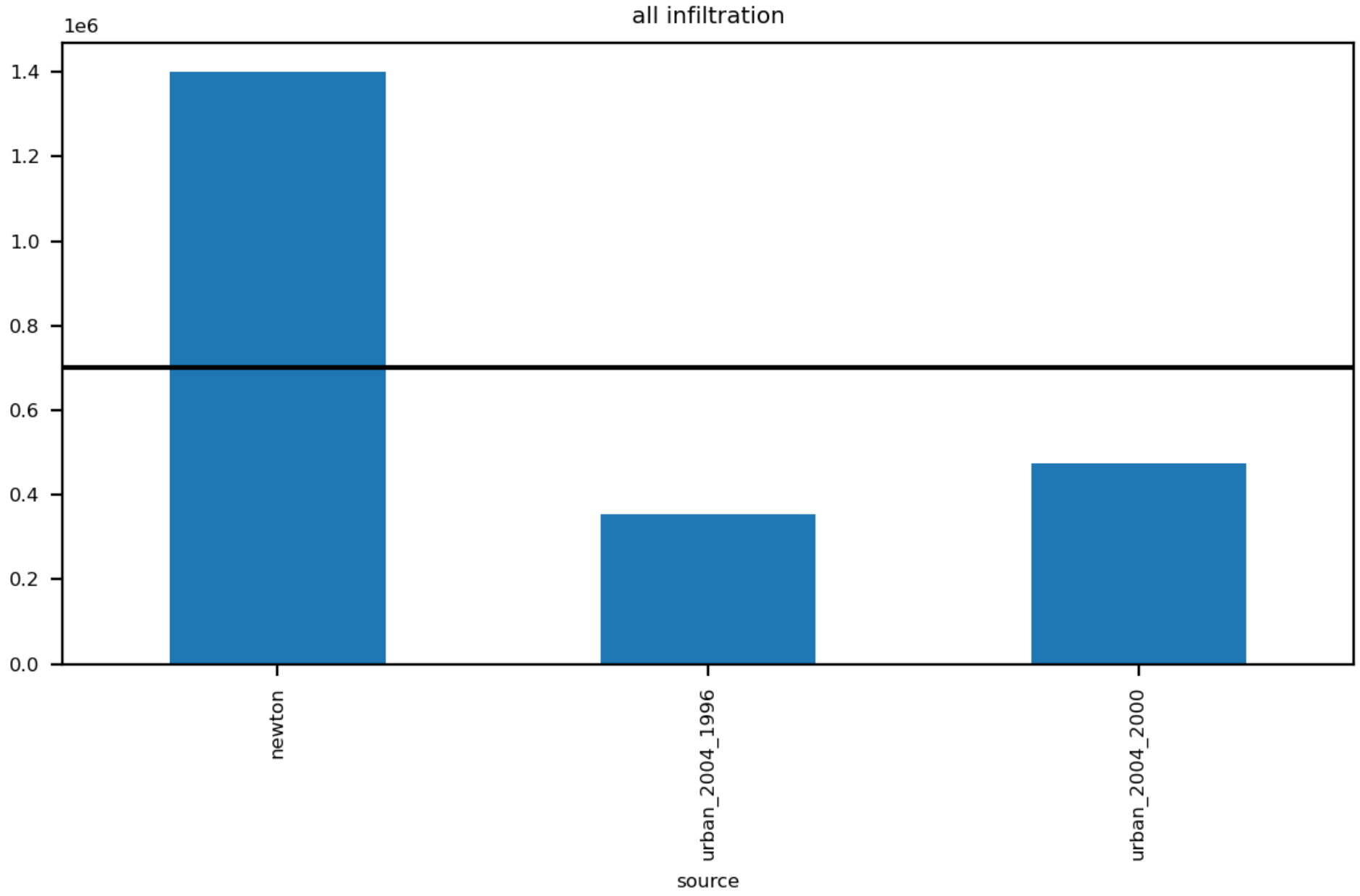
DISCLAIMER

The following are not *results*!!!

I am showing where the **unfinished** model currently stands, warts and all

Troubleshooting: Budget plots
(for 'initial guess' parameter values)

Entire Model Average Budget



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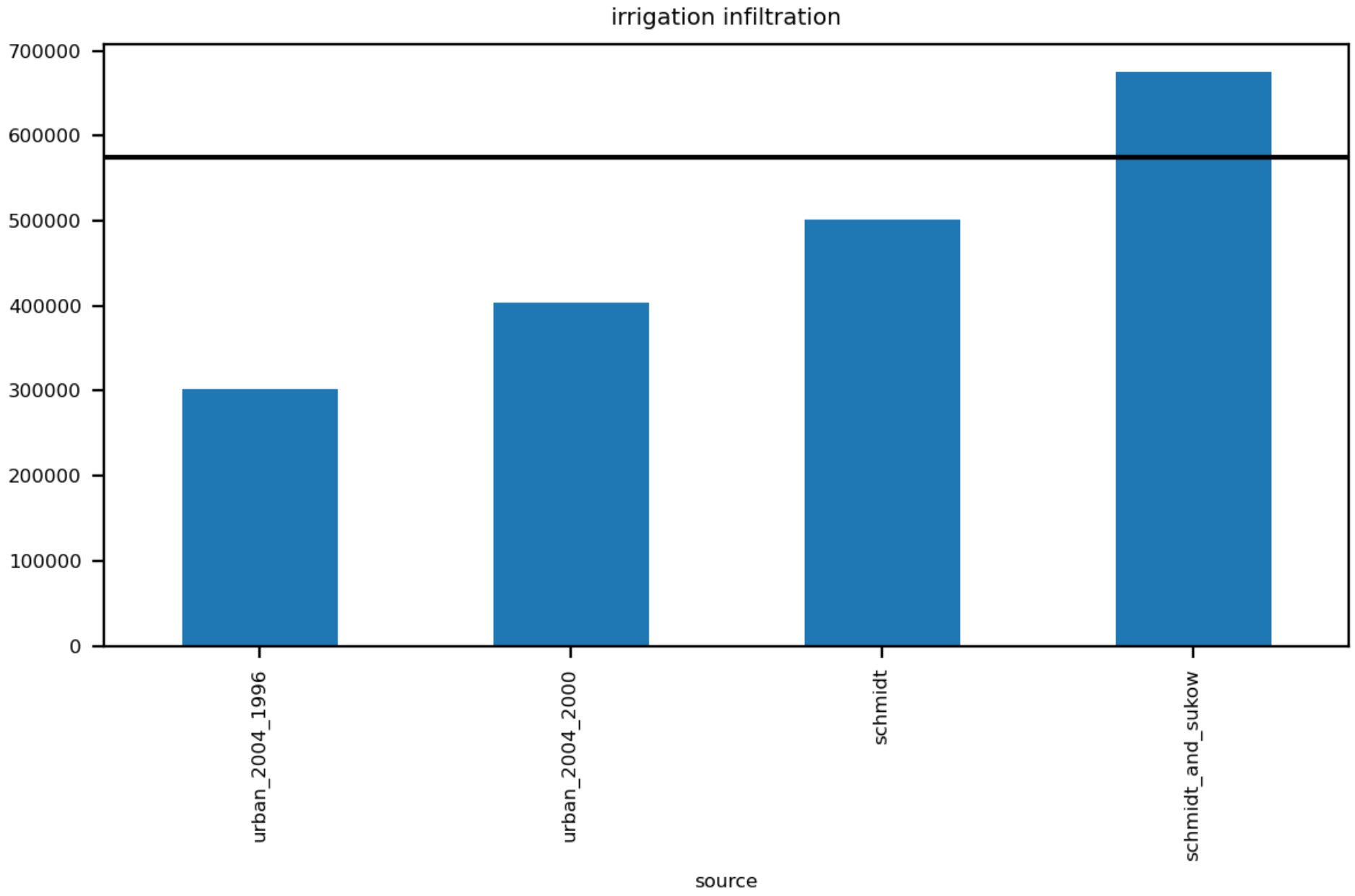
Entire Model Average Budget



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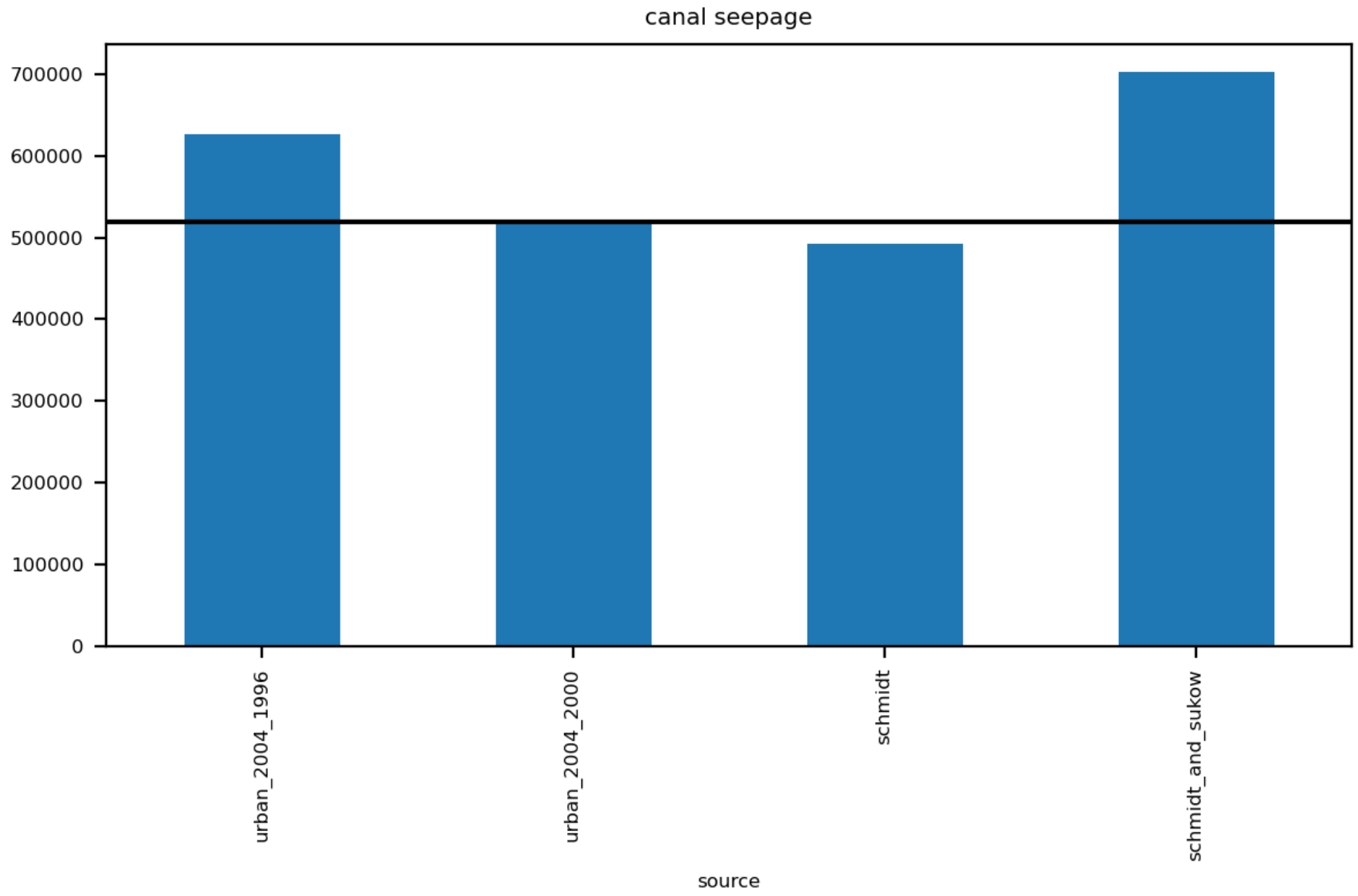
Entire Model Average Budget



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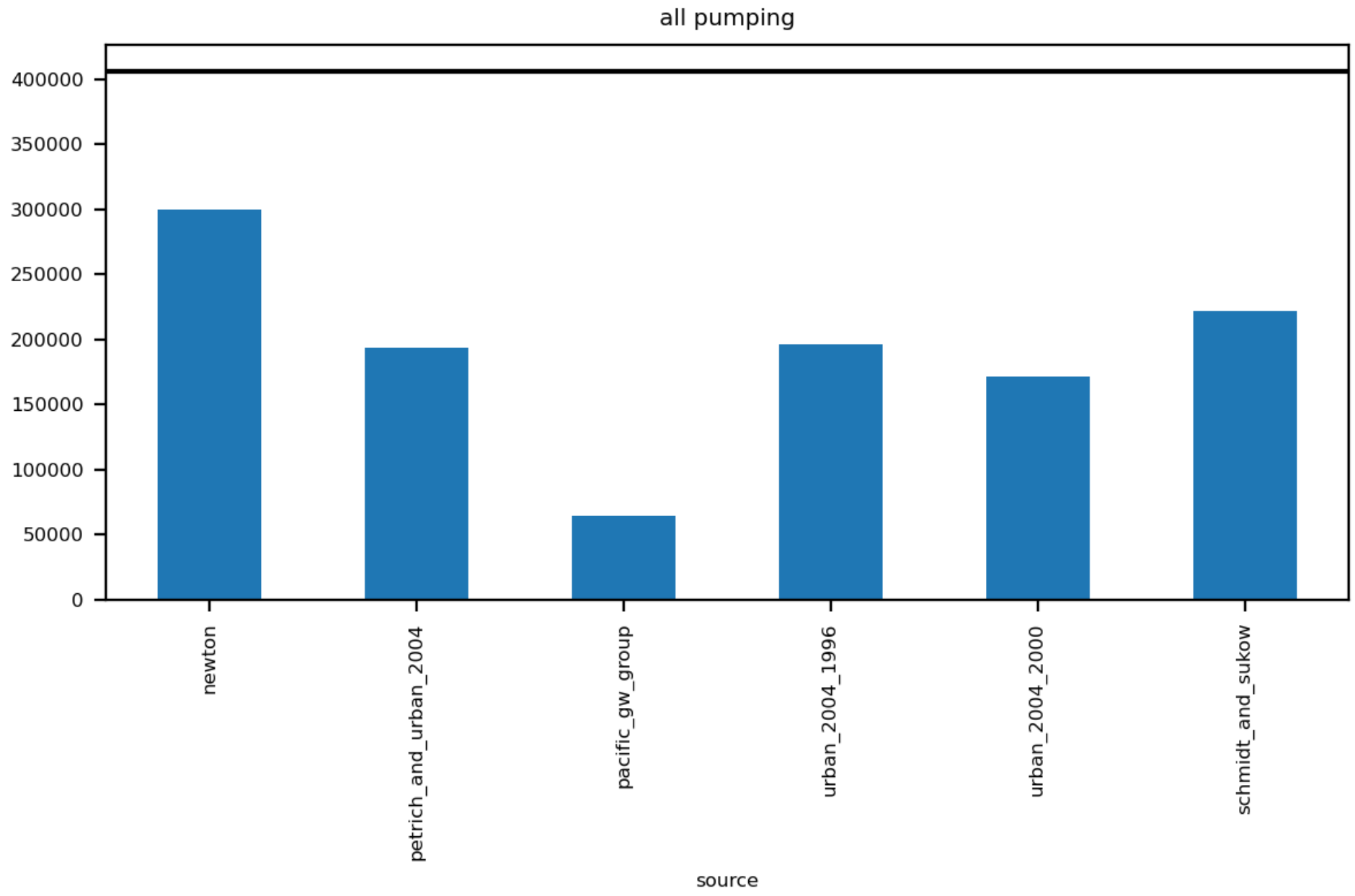
Entire Model Average Budget



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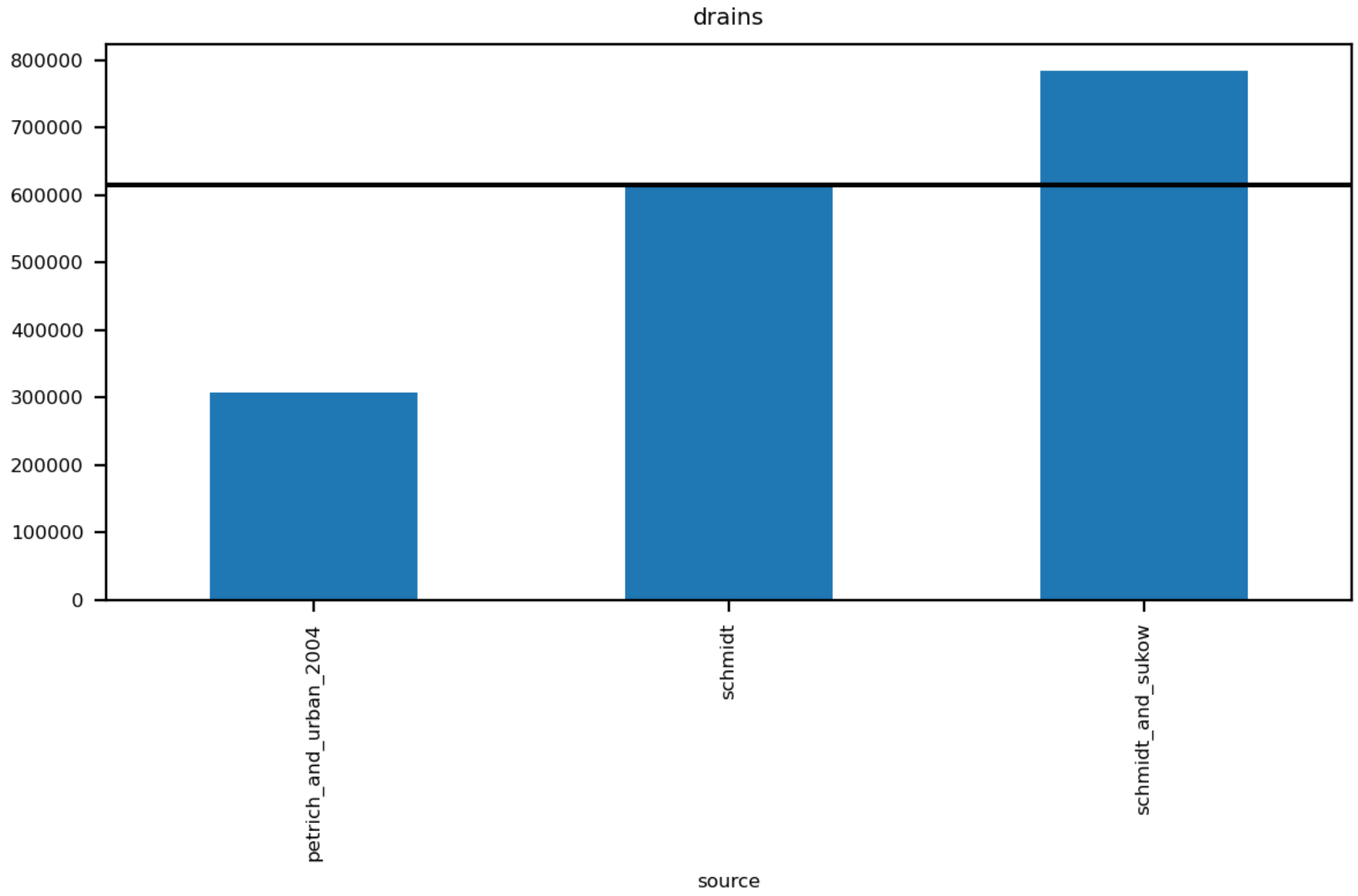
Entire Model Average Budget



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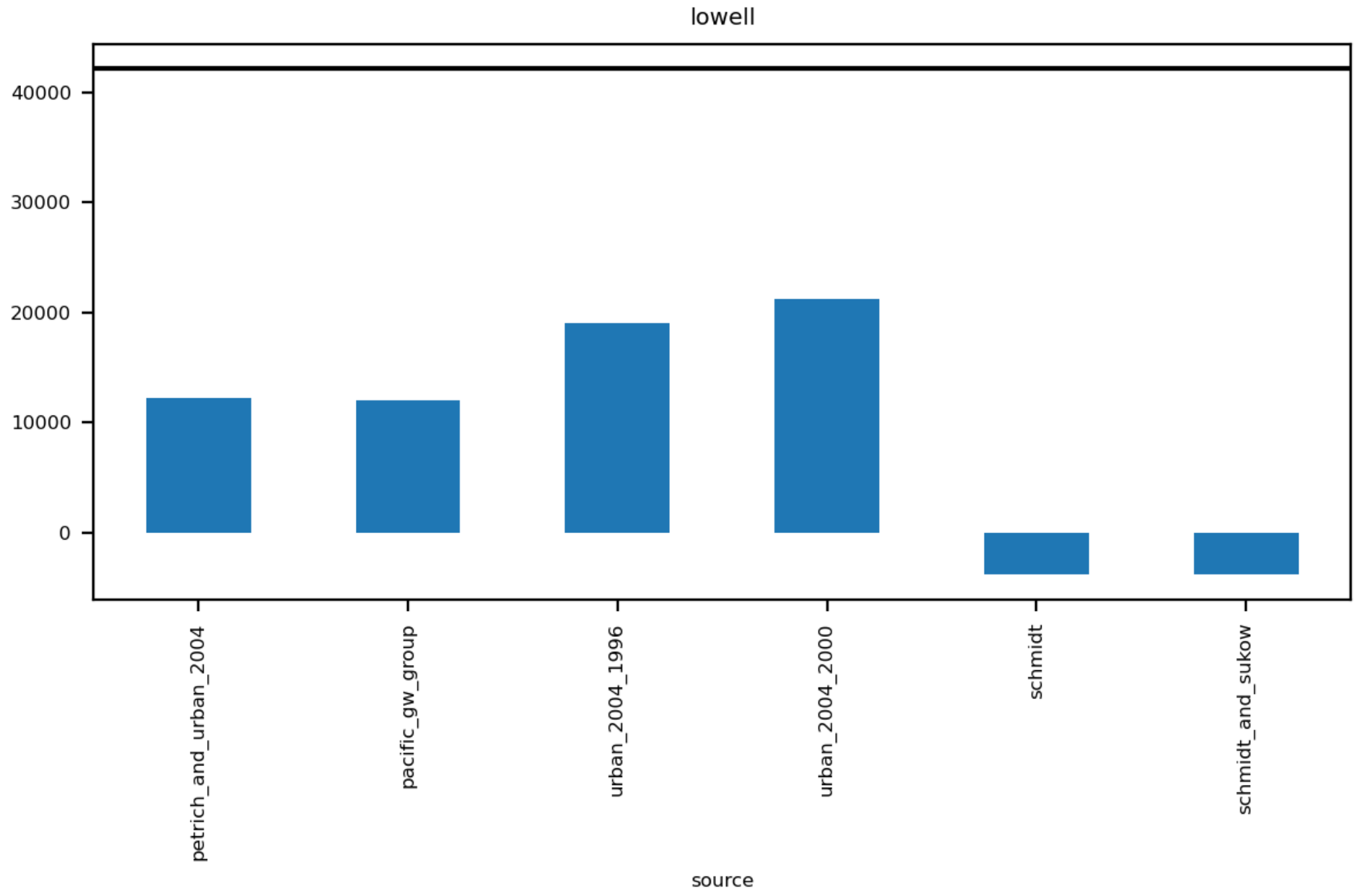
Entire Model Average Budget



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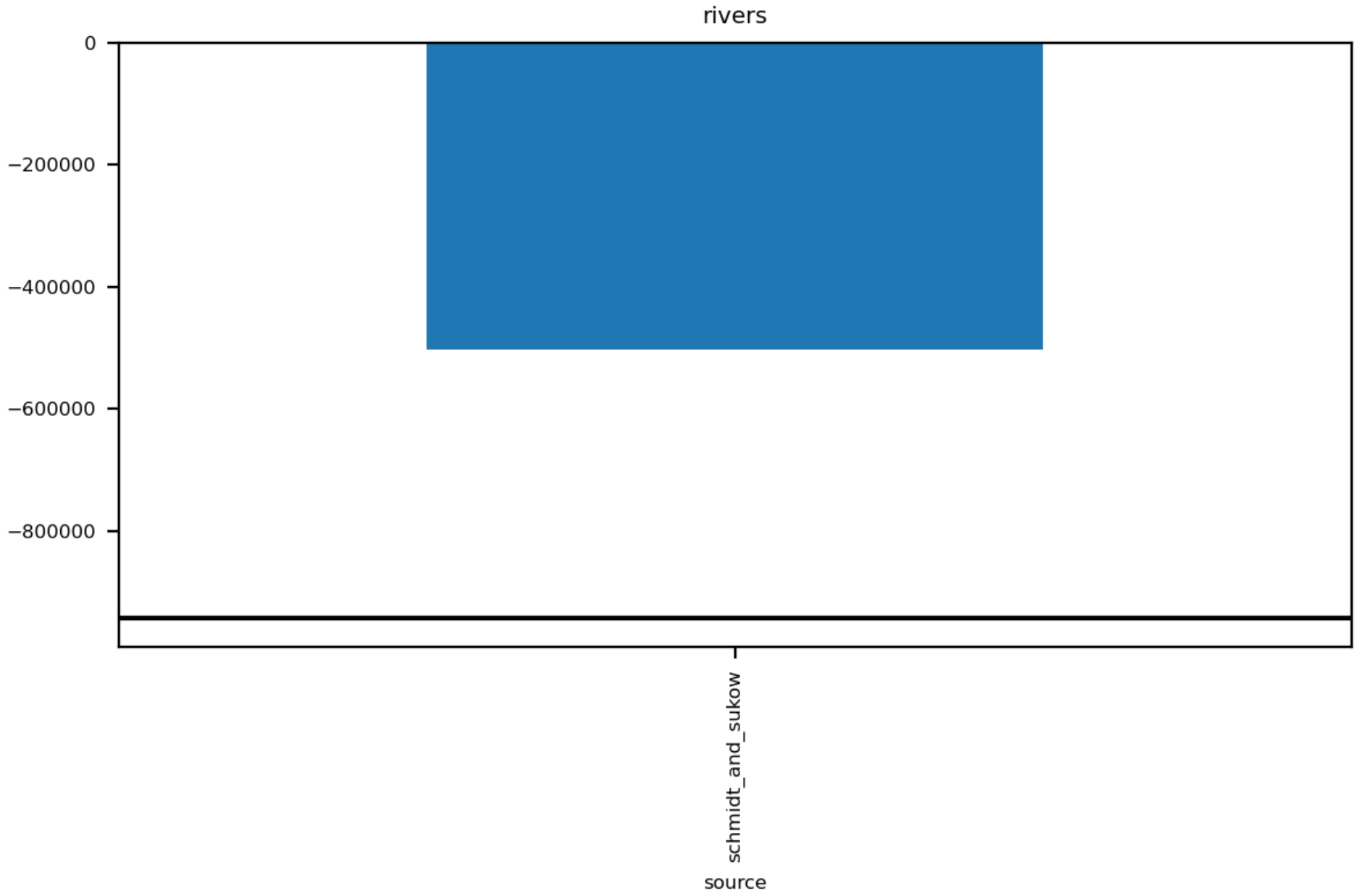
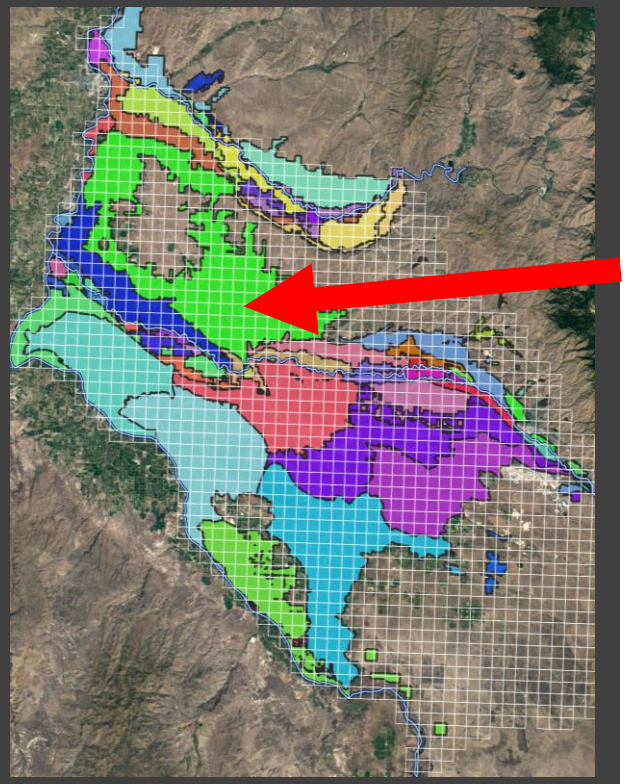
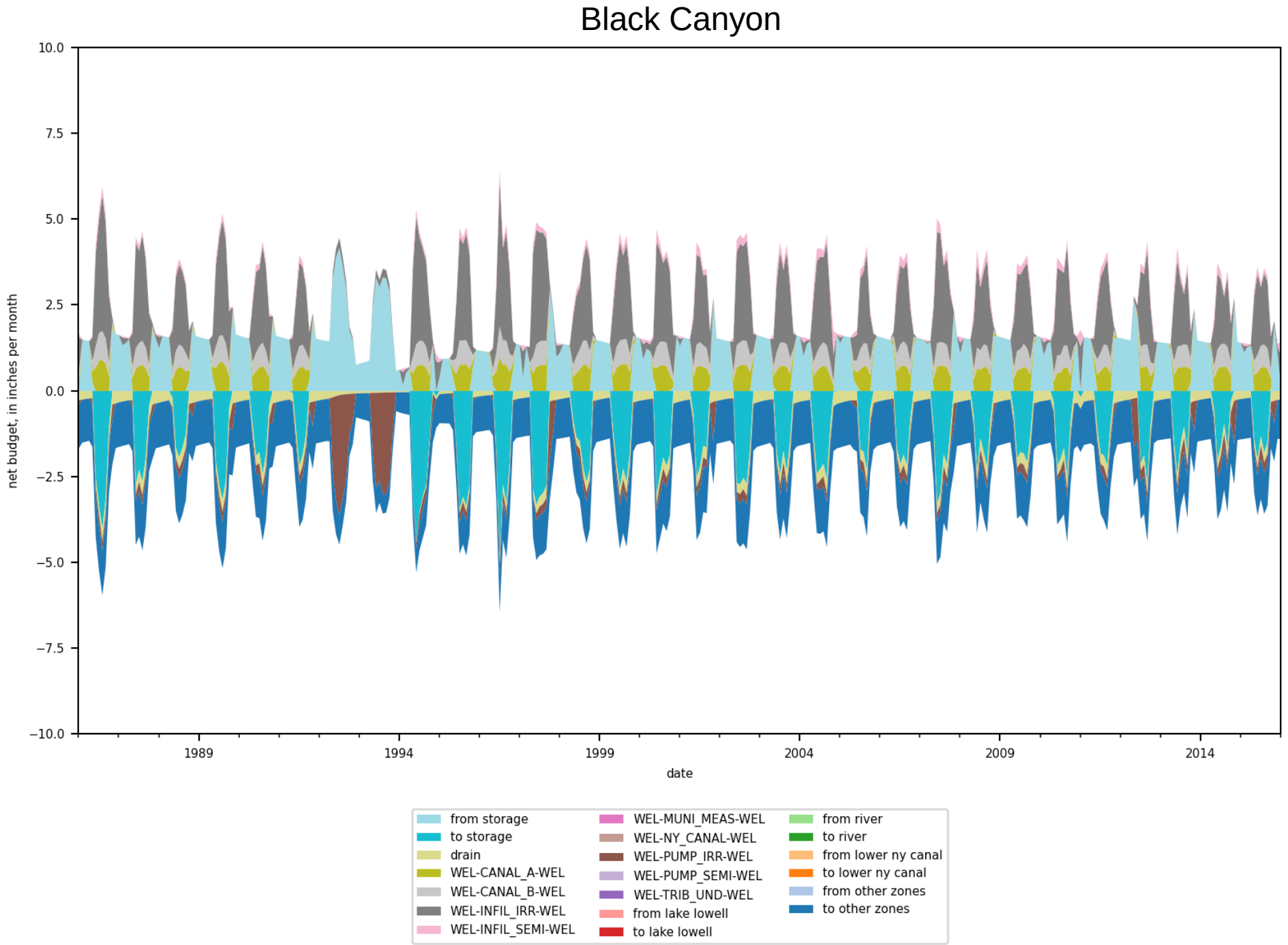
Entire Model Average Budget



Zone Budget





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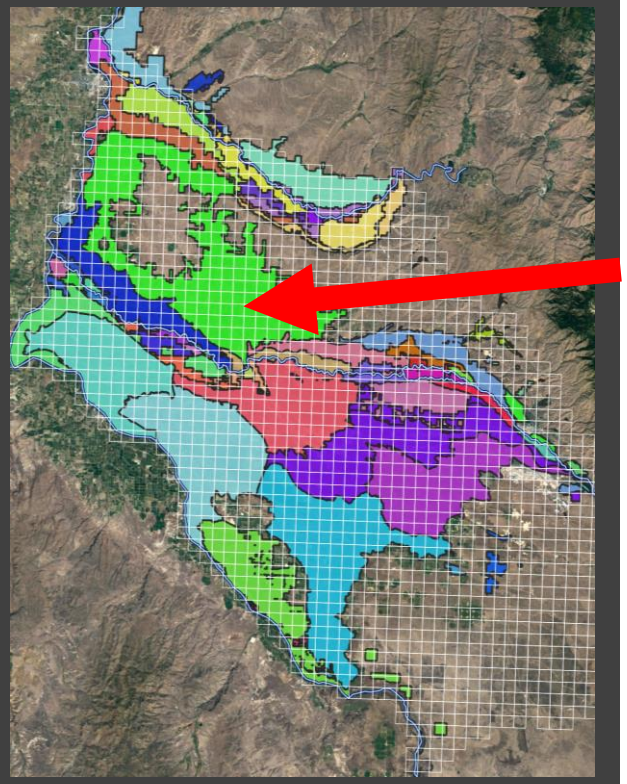
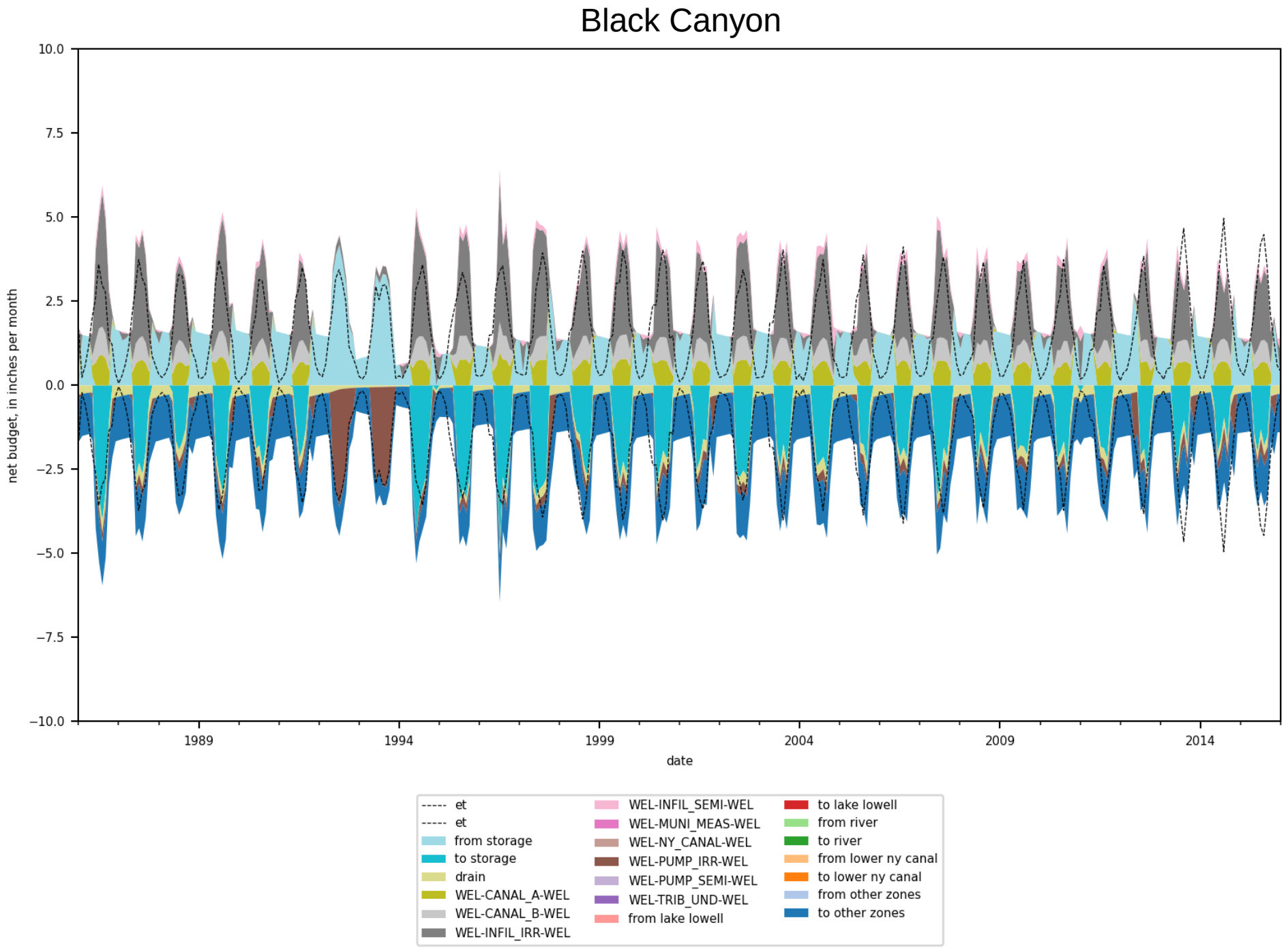
Zone Budget





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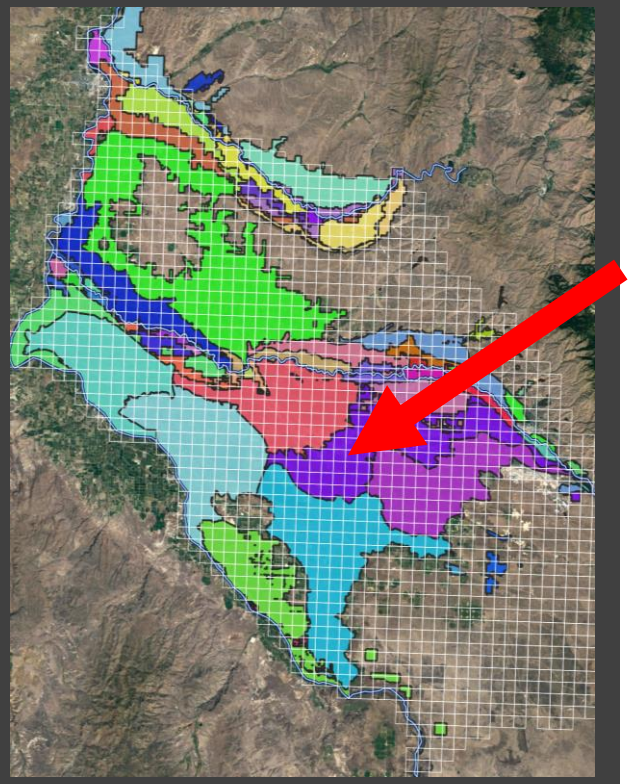
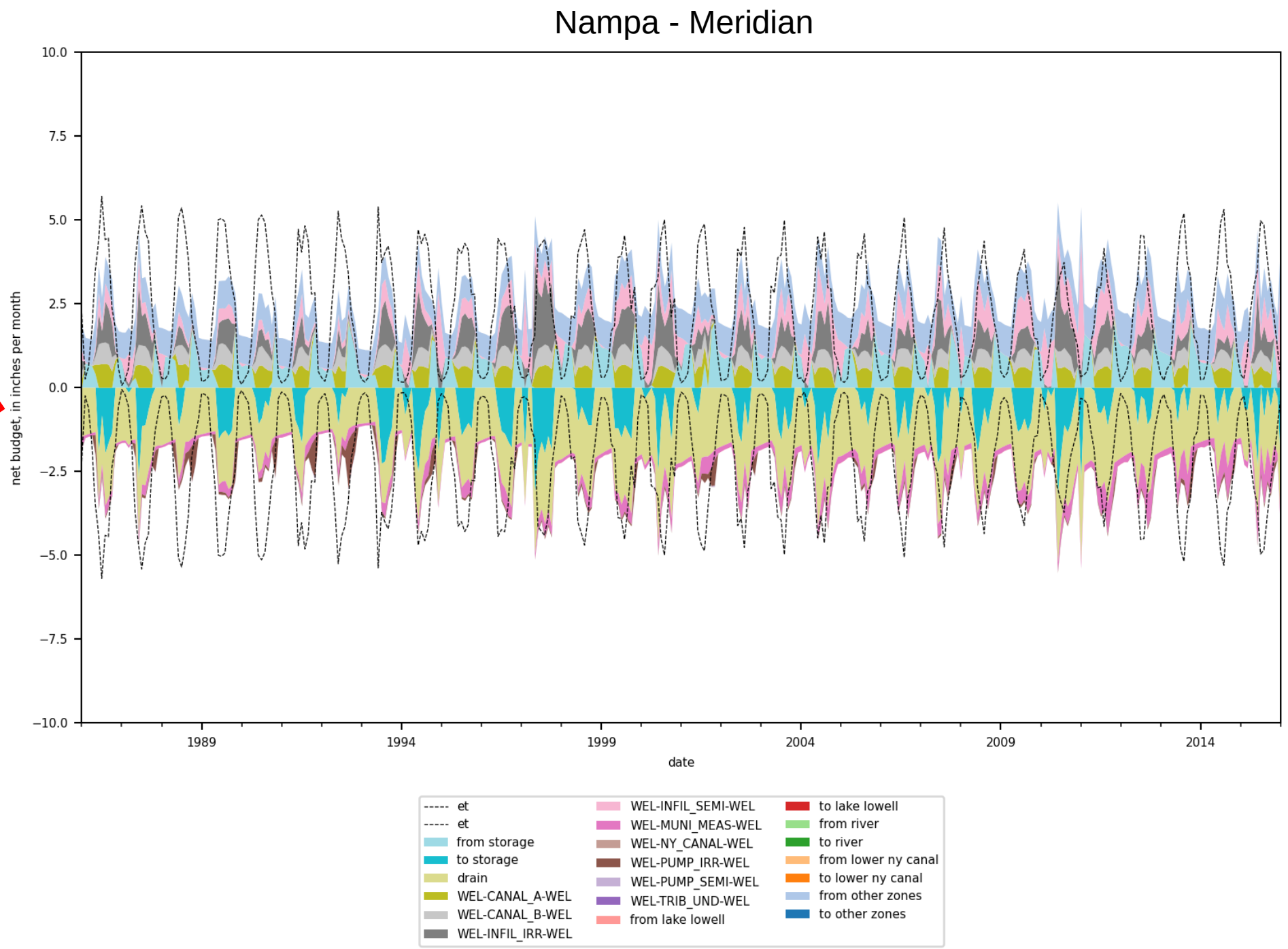
Zone Budget





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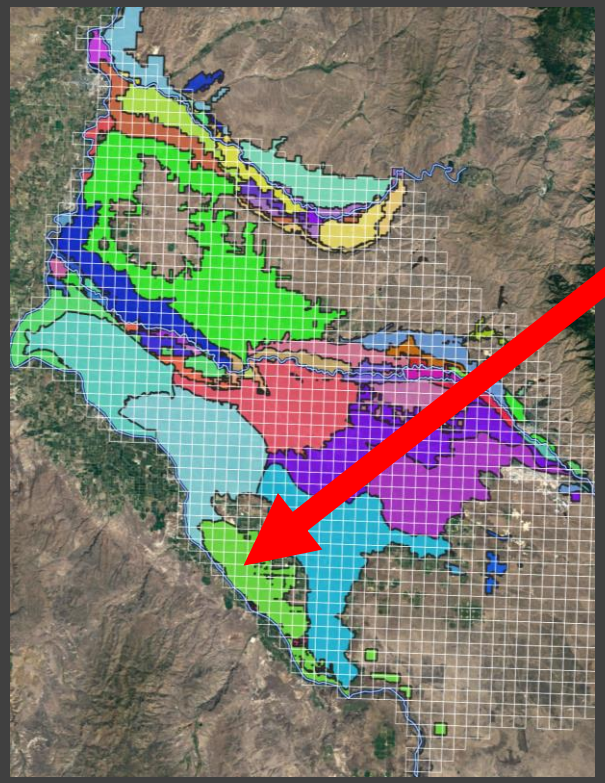
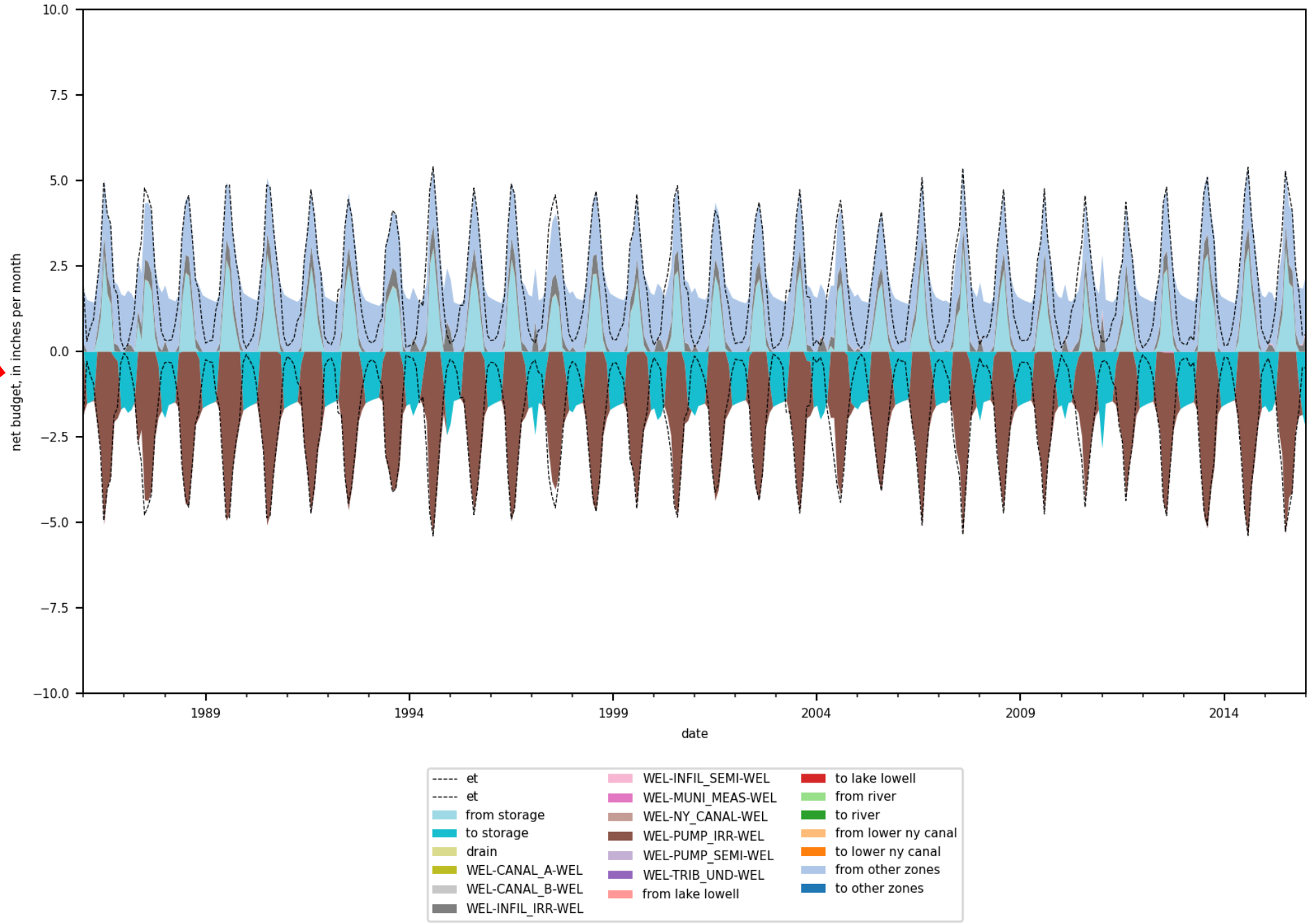
Zone Budget



Snake – Adrian to Nyssa



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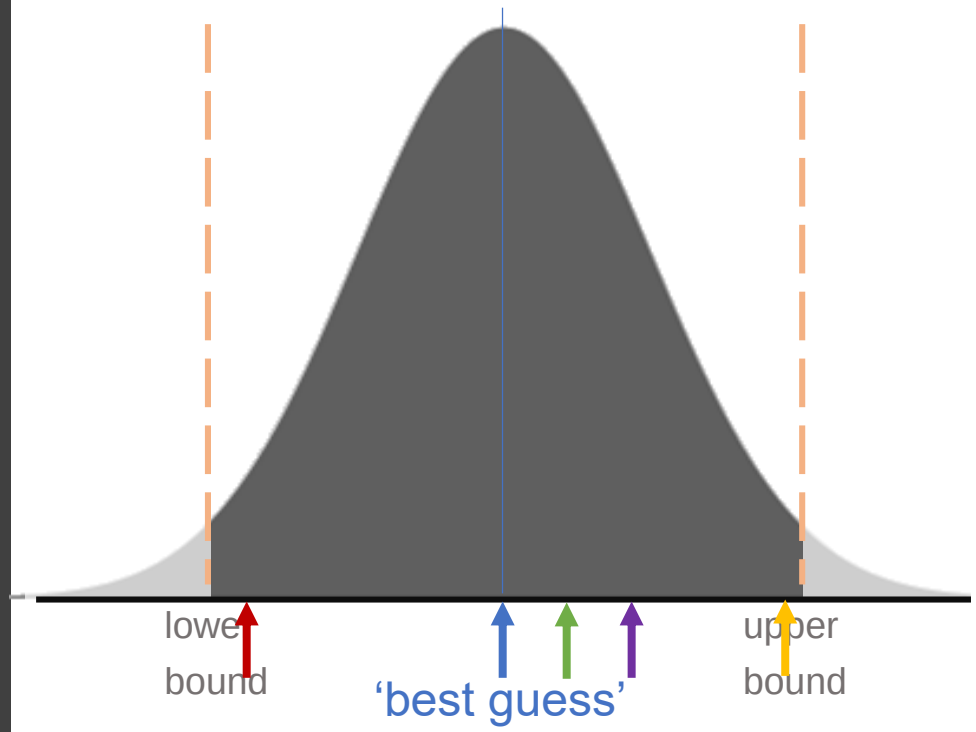
Troubleshooting: Pre-Calibration (prior) plots

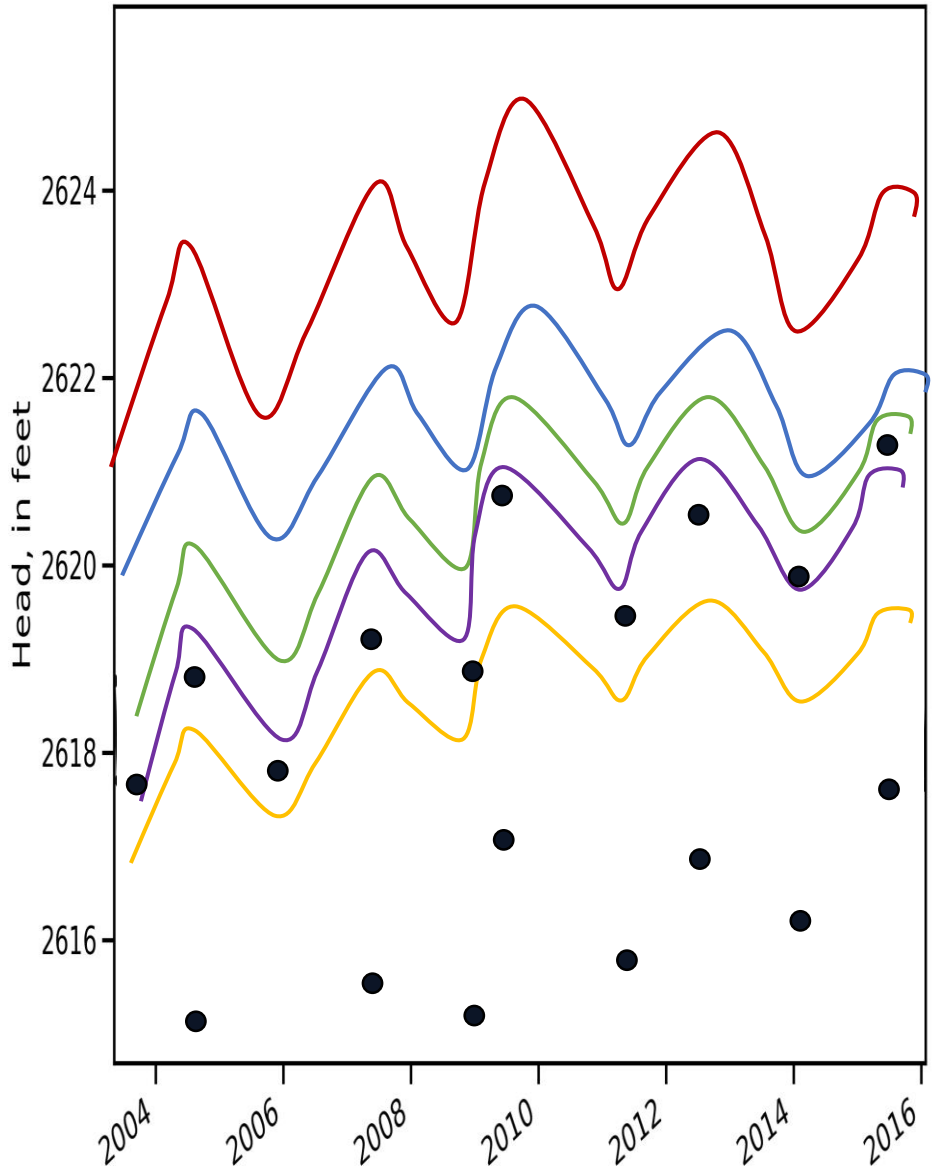
Parameter Limits

You can look at a bunch of combinations of *plausible* parameter values prior to calibration.

Can reveal where model will have trouble matching observations.

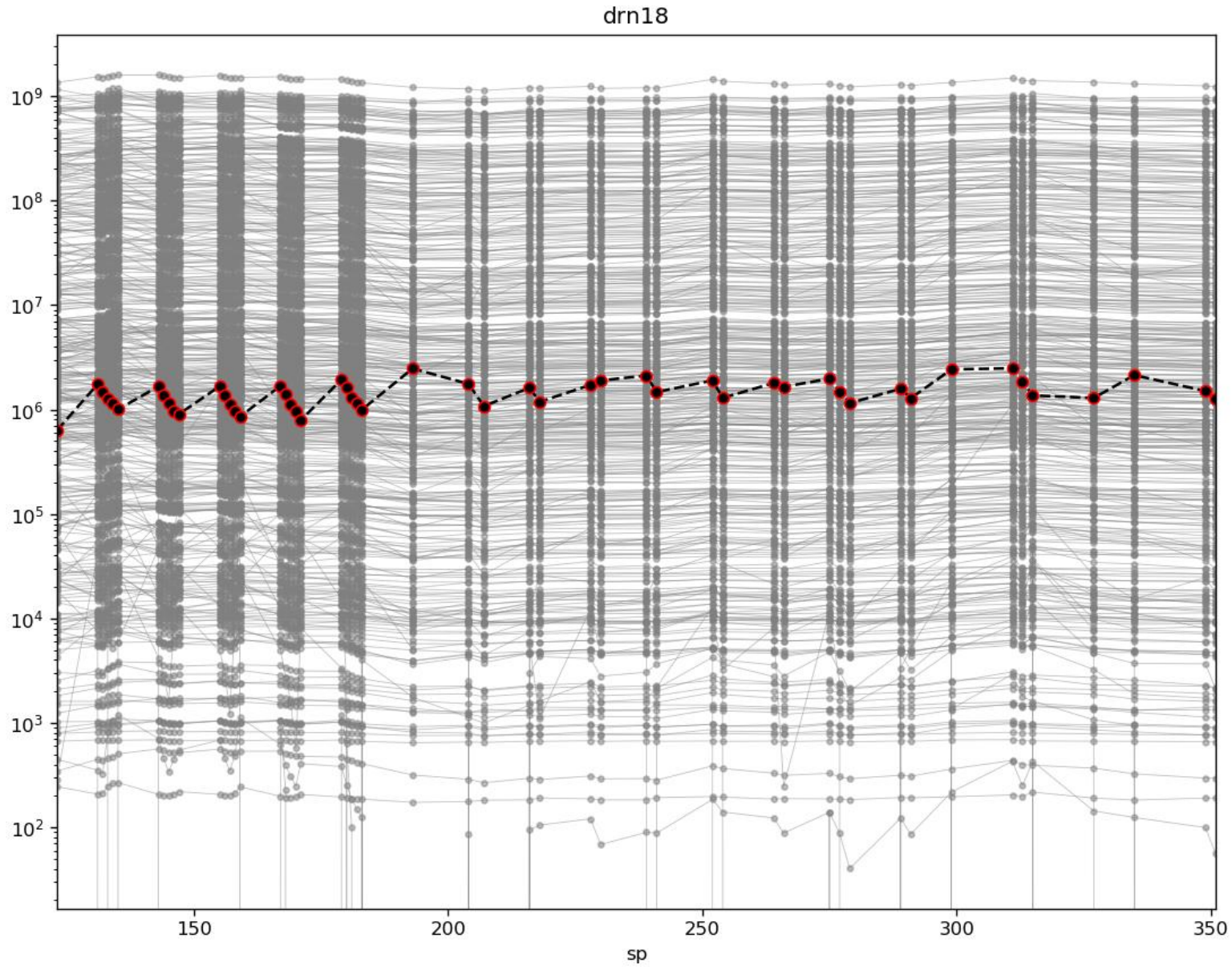
Sometimes called '**prior montecarlo**'





Diagnostic ‘Prior’ Plots

Drain Flux



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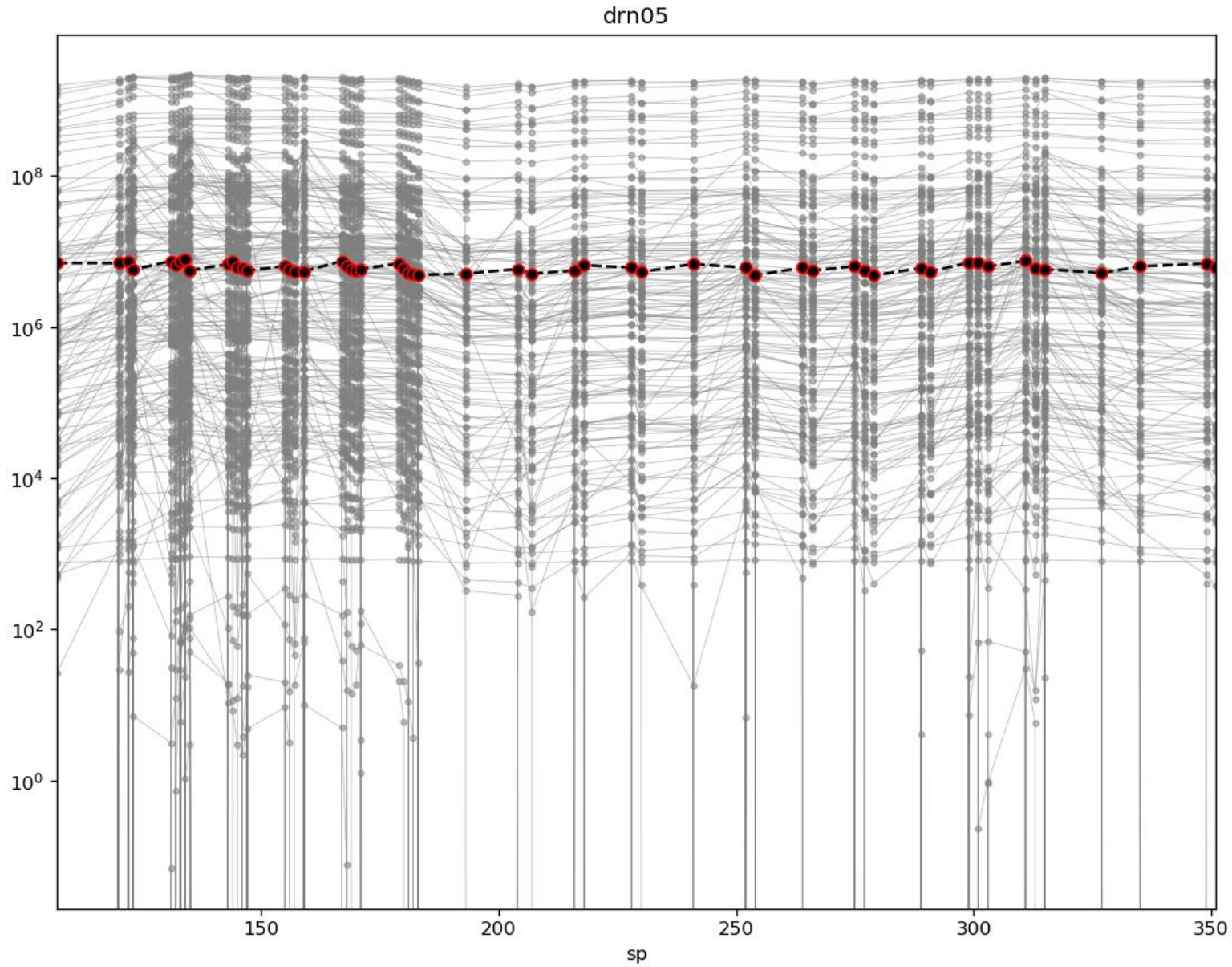
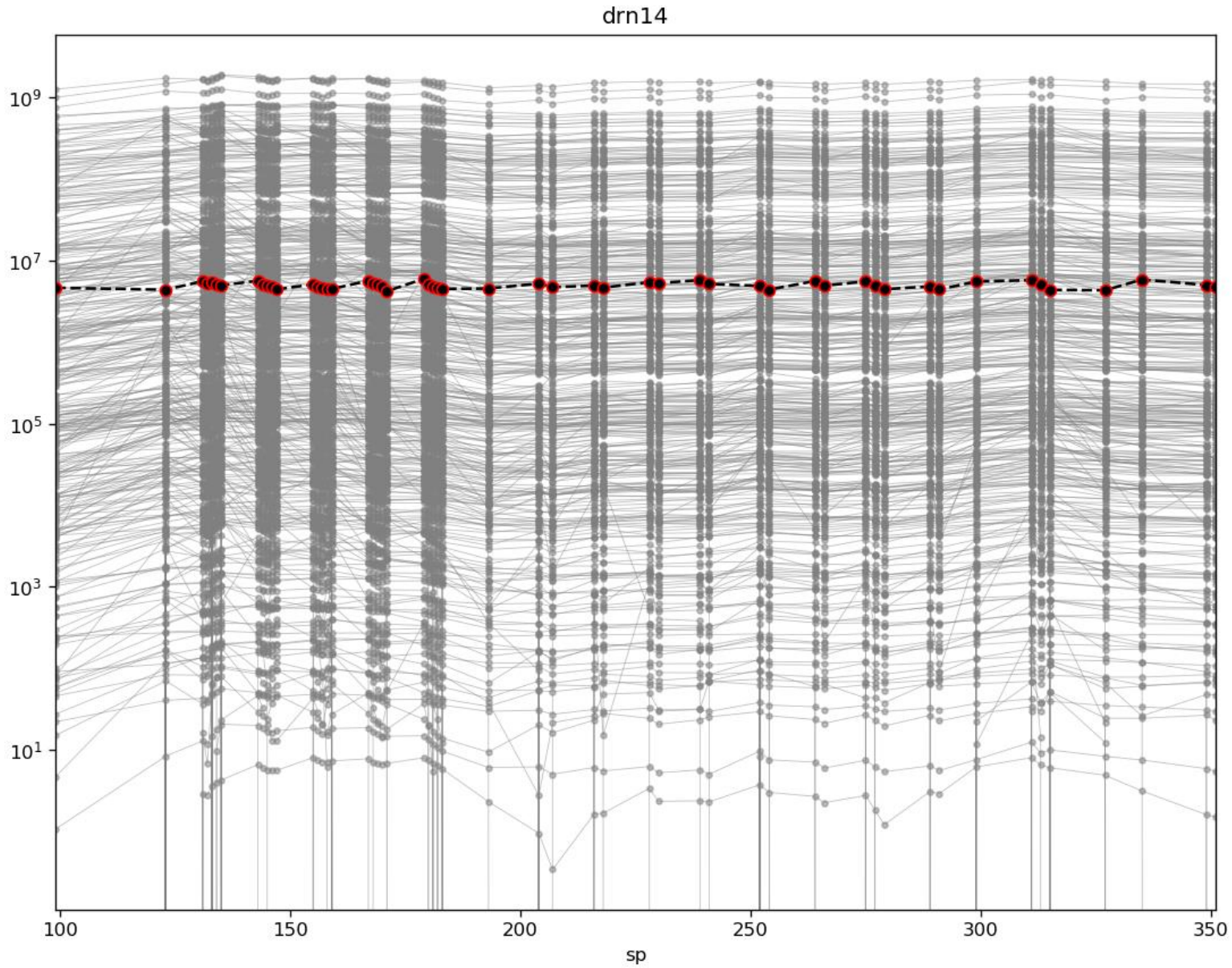
Diagnostic ‘Prior’ Plots

Drain Flux



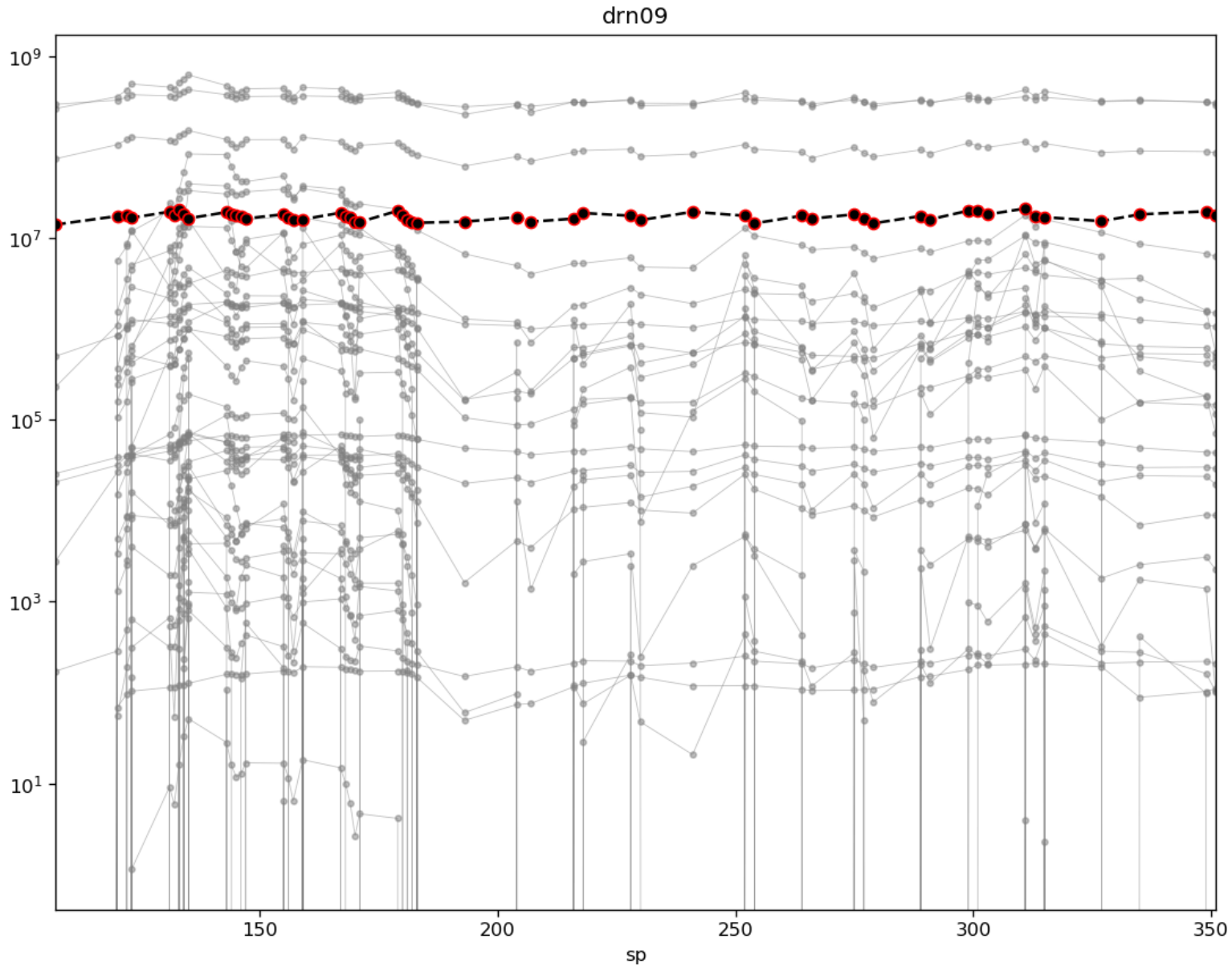
Diagnostic ‘Prior’ Plots

Drain Flux



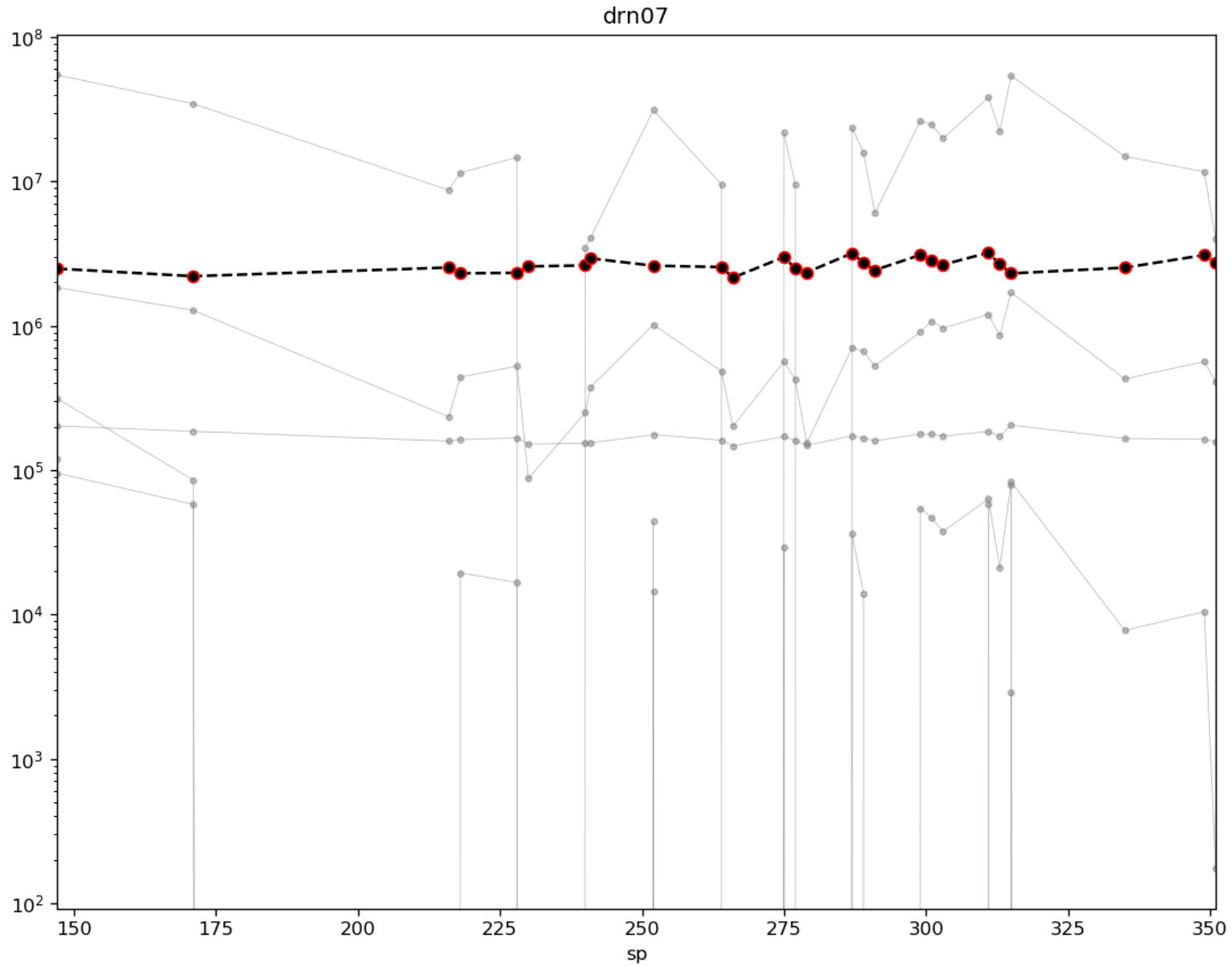
Diagnostic ‘Prior’ Plots

Drain Flux



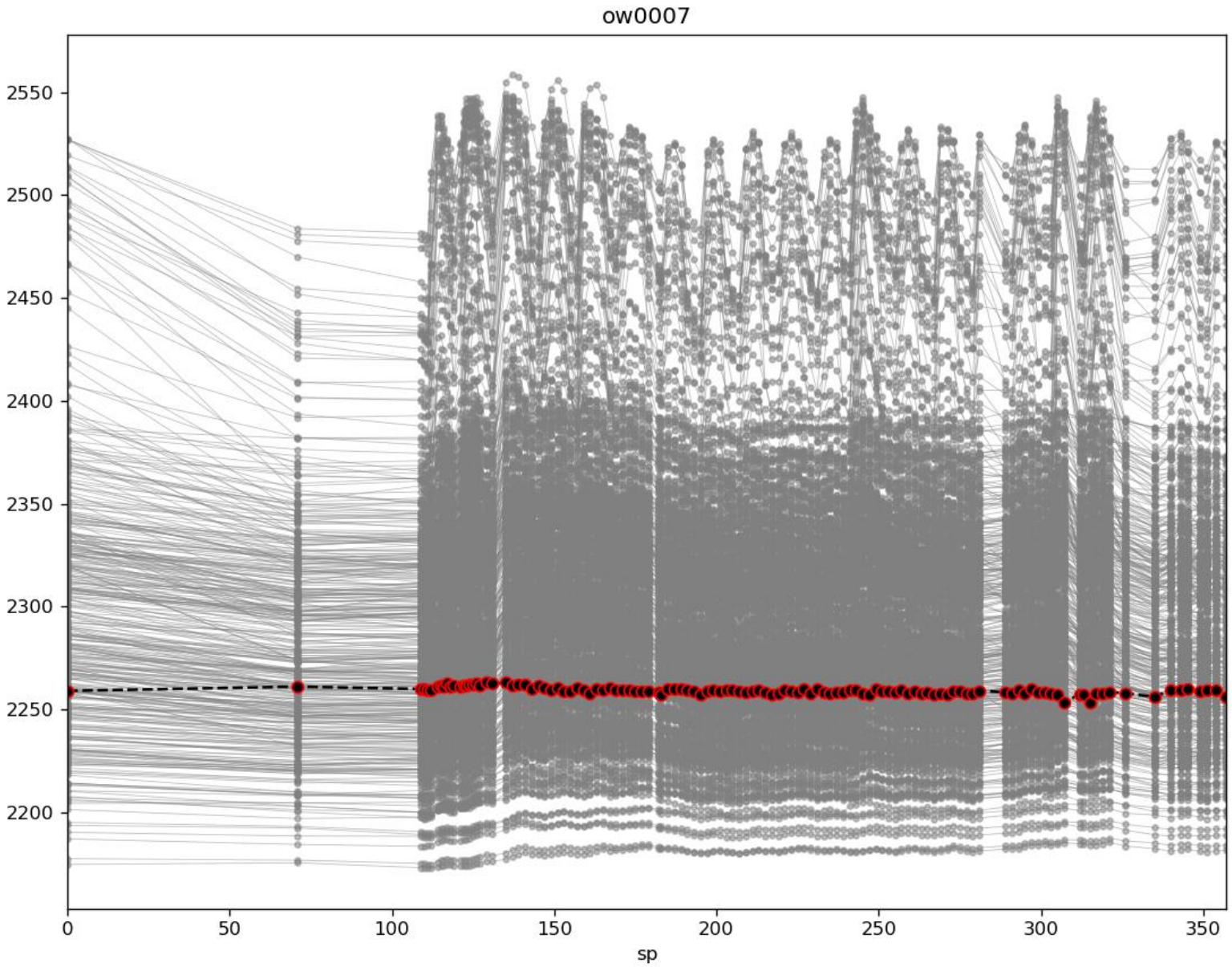
Diagnostic ‘Prior’ Plots

Drain Flux



Diagnostic ‘Prior’ Plots

Head



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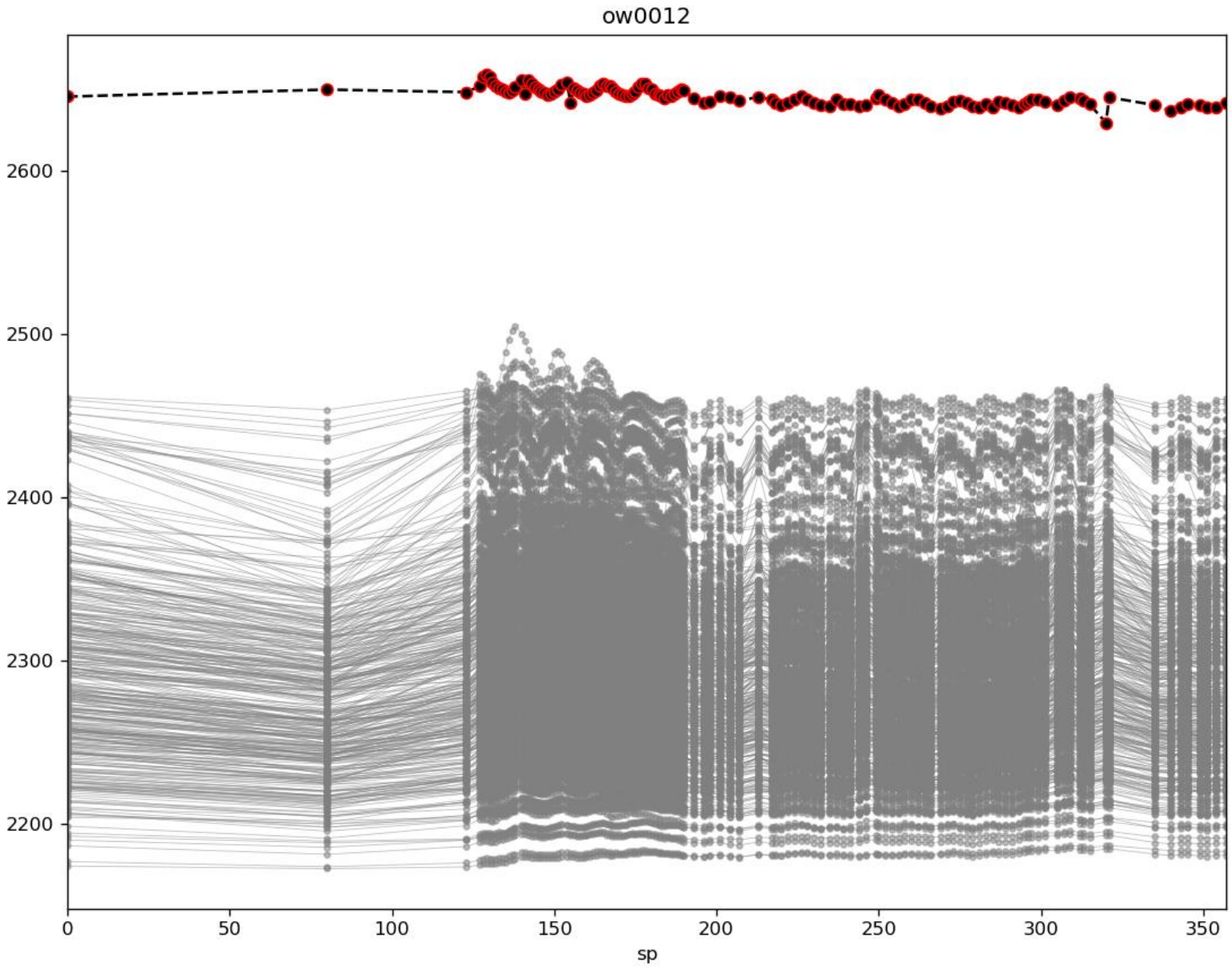
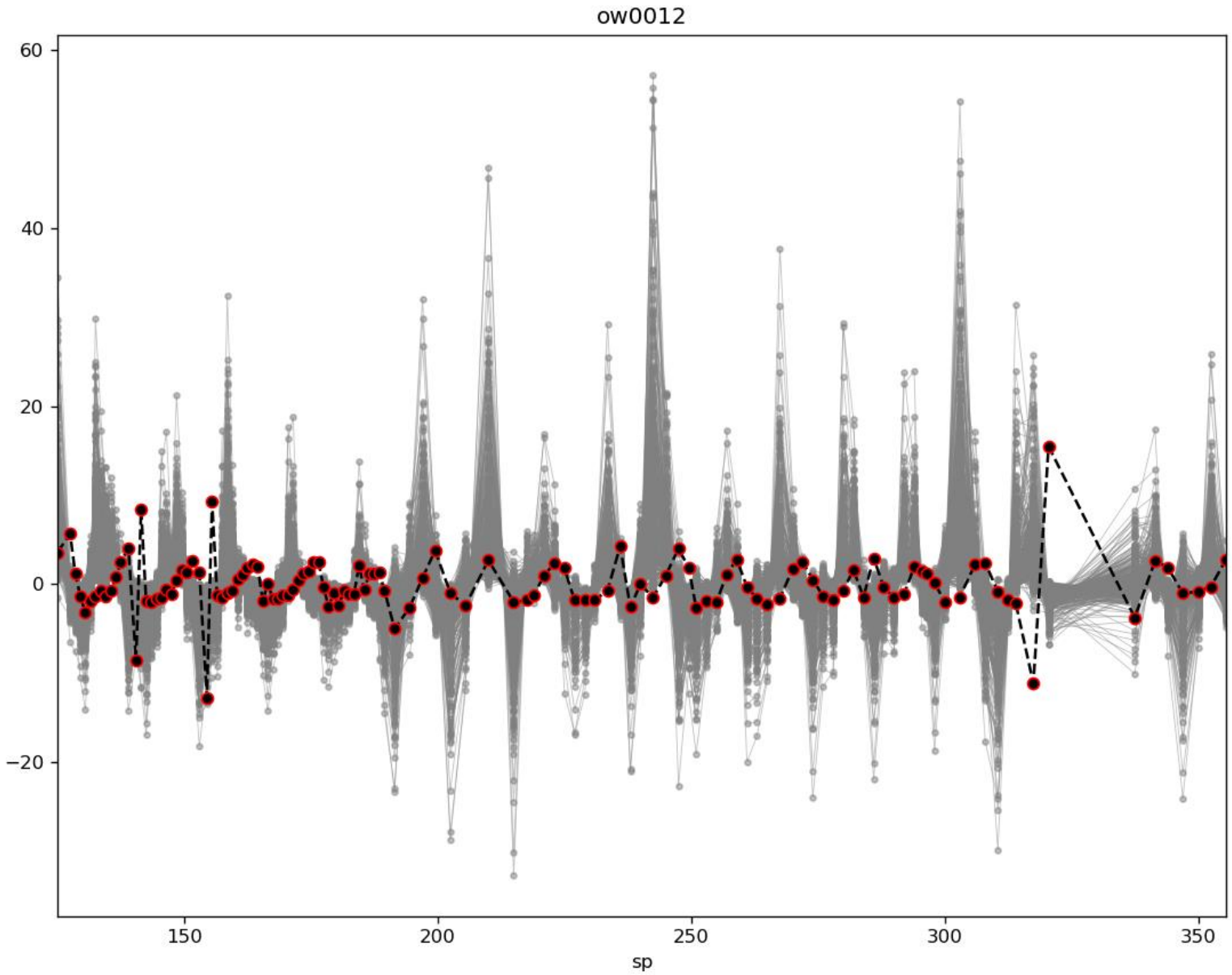
Diagnostic ‘Prior’ Plots

Head



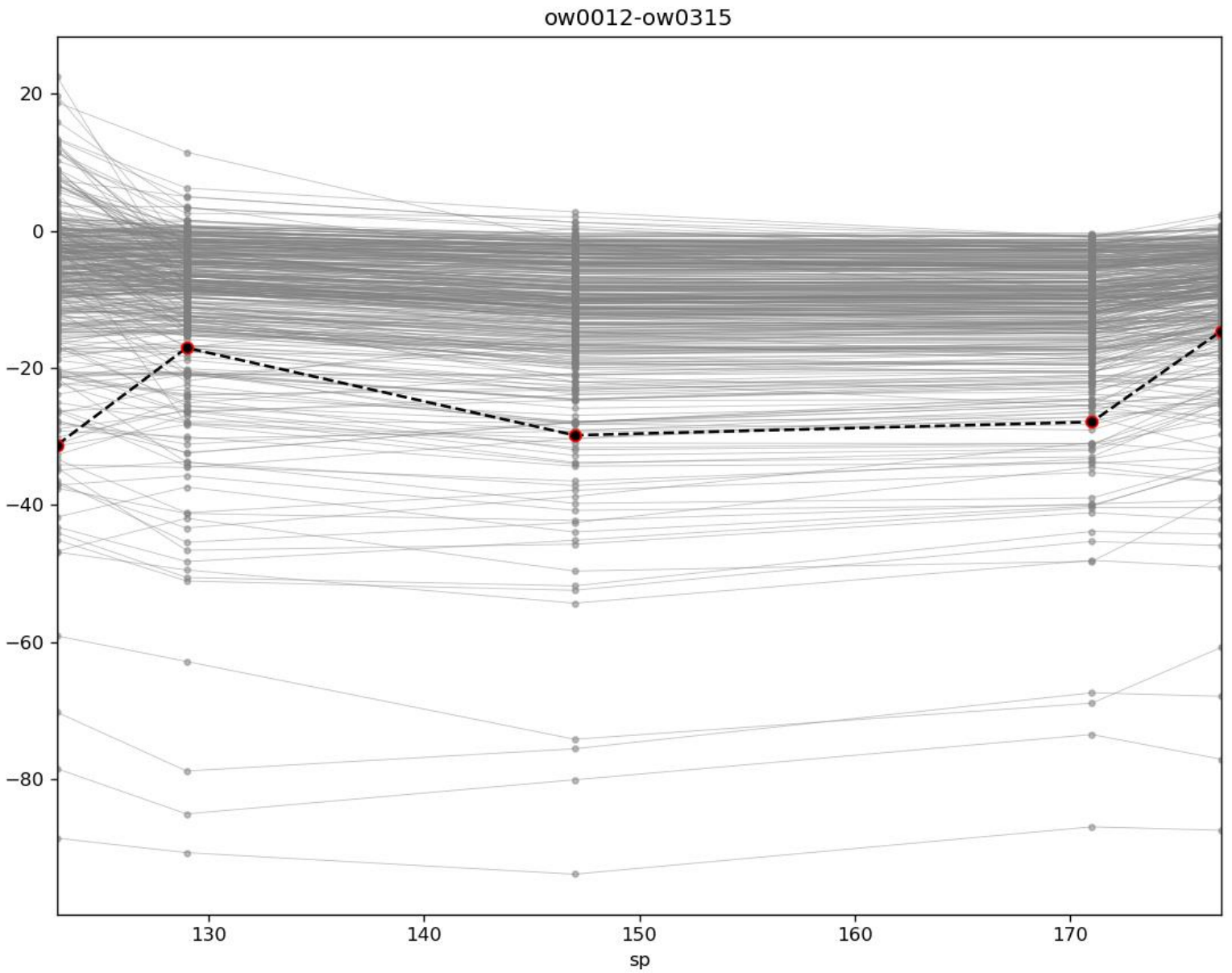
Diagnostic ‘Prior’ Plots

Temporal Head Difference



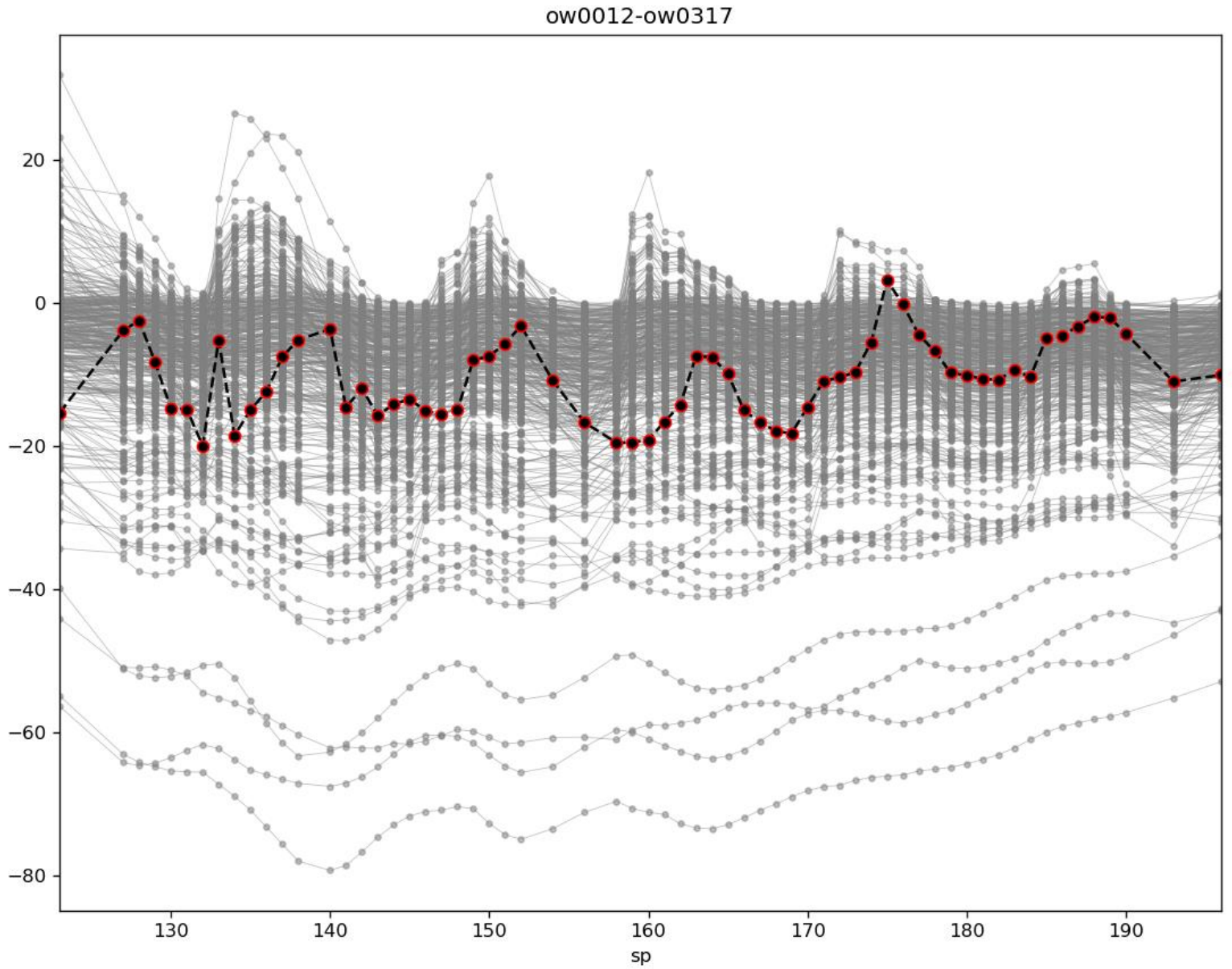
Diagnostic ‘Prior’ Plots

Vertical Head Difference



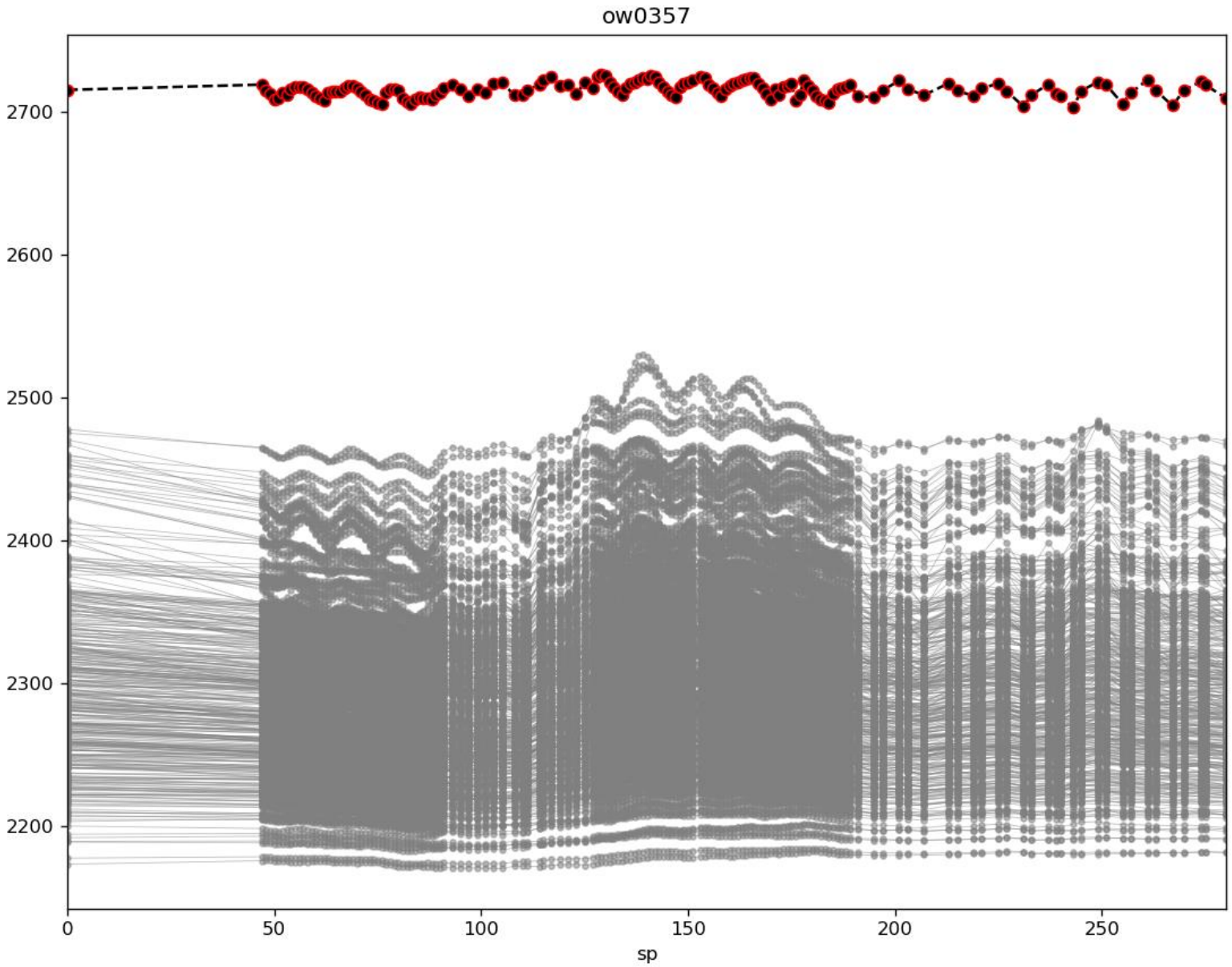
Diagnostic ‘Prior’ Plots

Vertical Head Difference



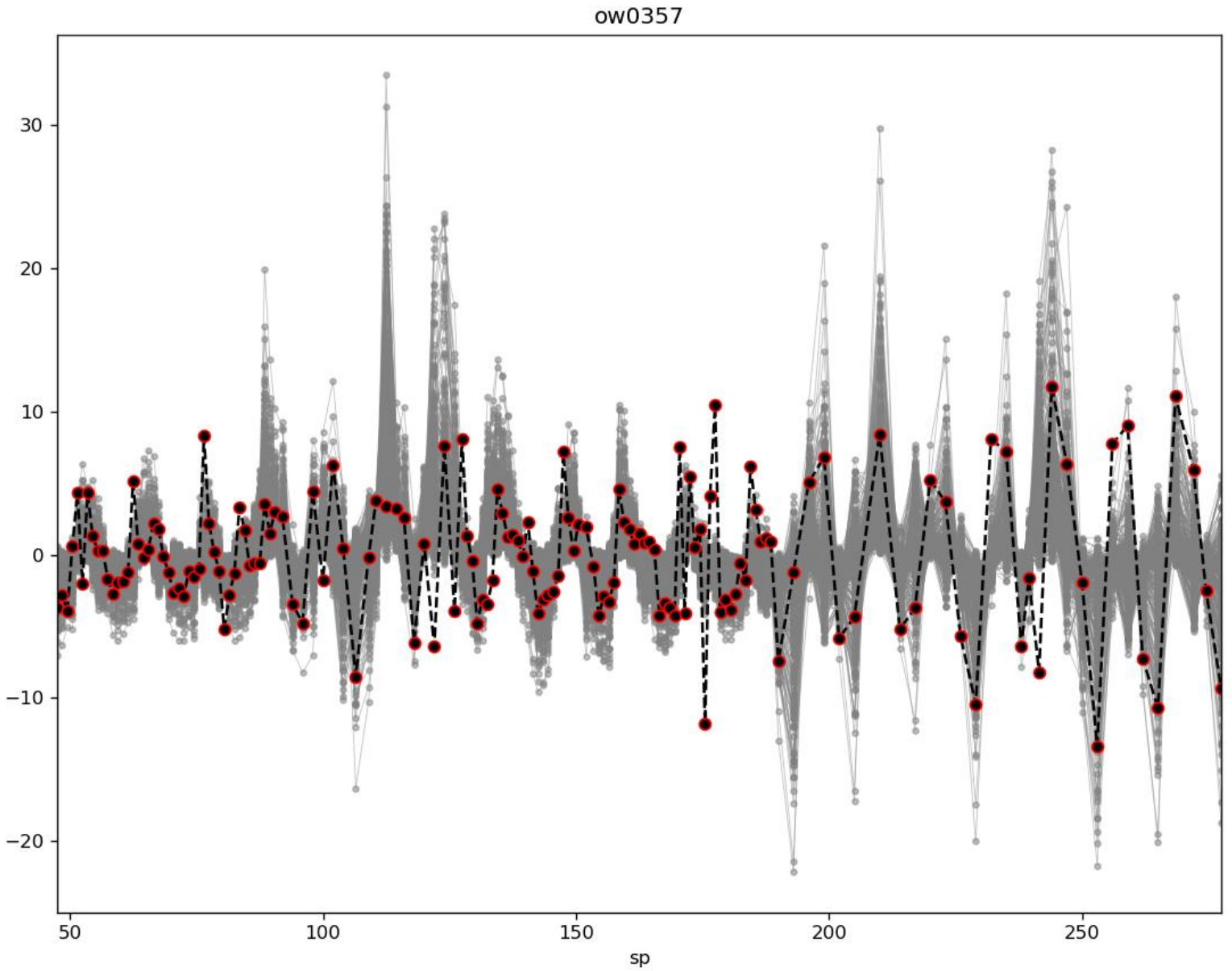
Diagnostic ‘Prior’ Plots

Head



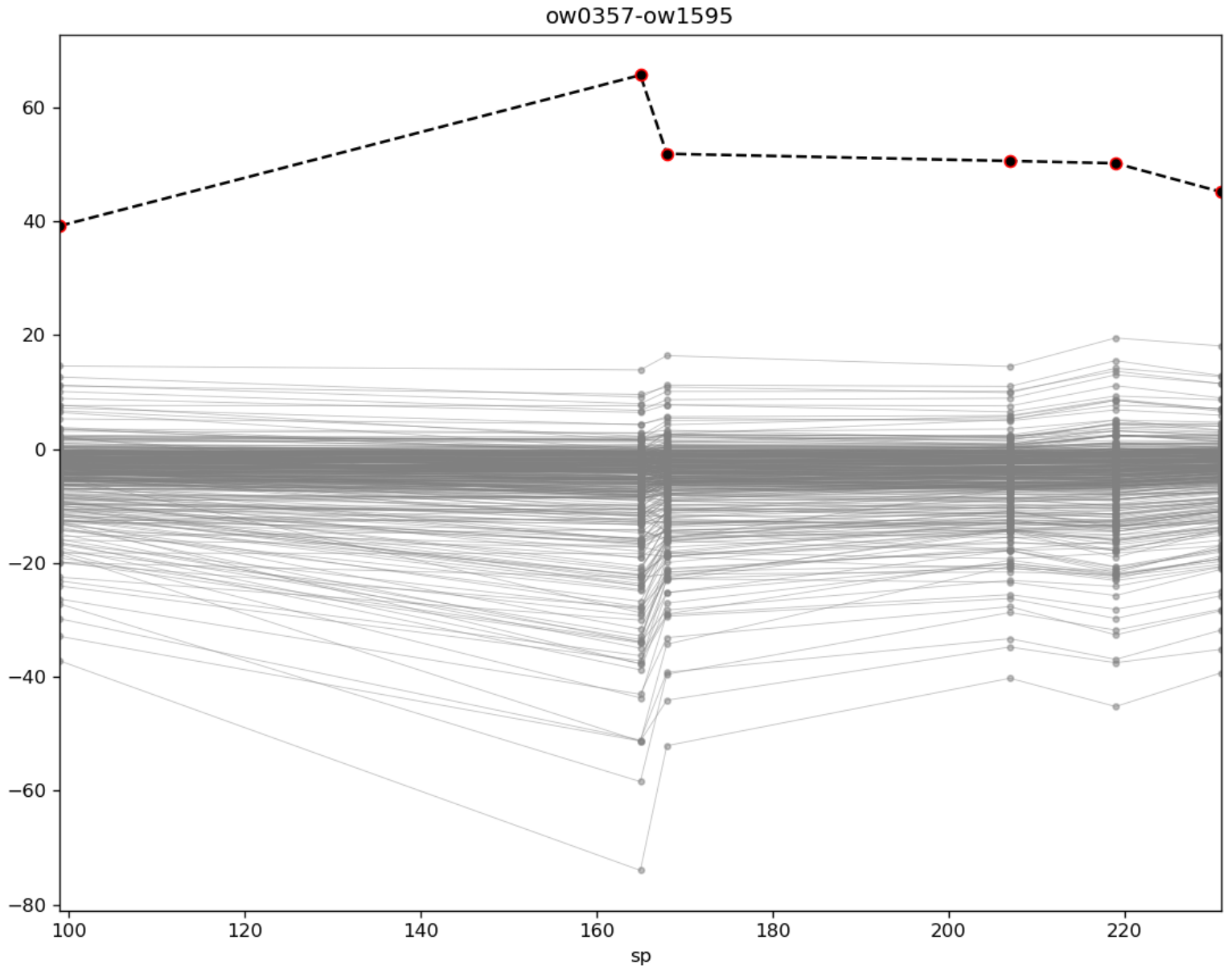
Diagnostic ‘Prior’ Plots

Temporal Head Difference



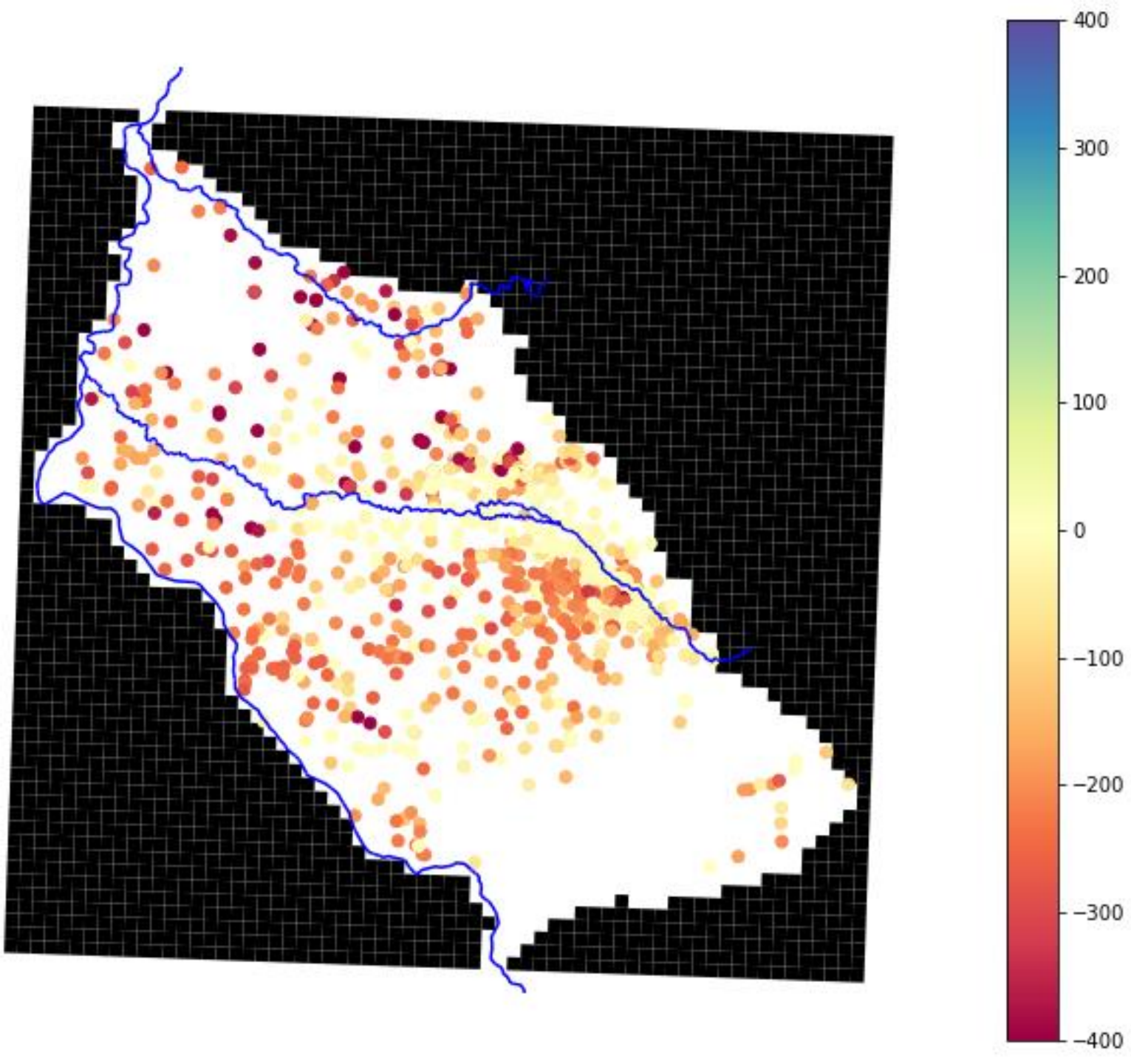
Diagnostic ‘Prior’ Plots

Vertical Head Difference



Prior Residuals

Residuals
Heads
All layers
1st percentile



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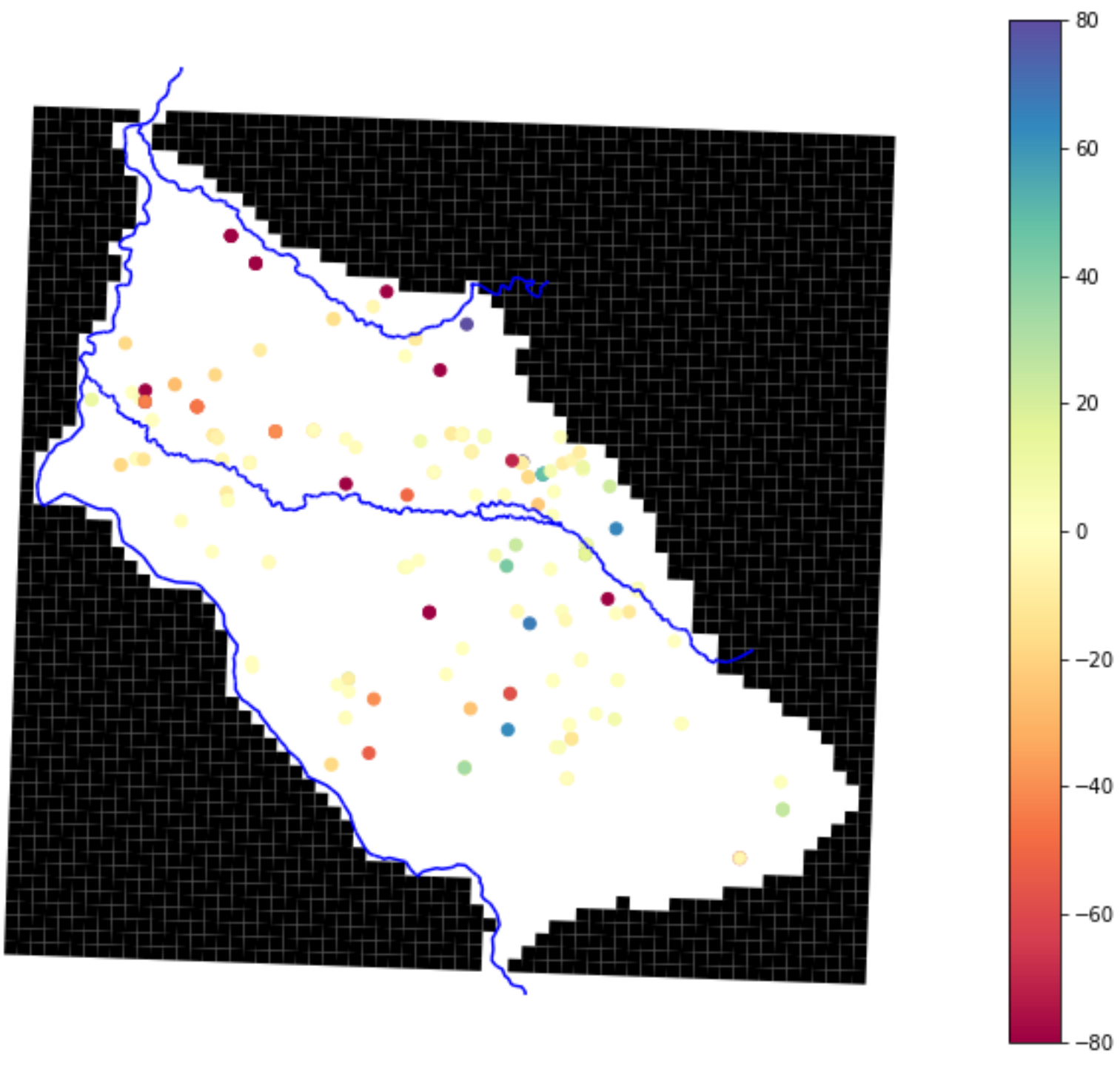
Prior Residuals

Residuals
Vertical Head Difference
All Layers
1st percentile



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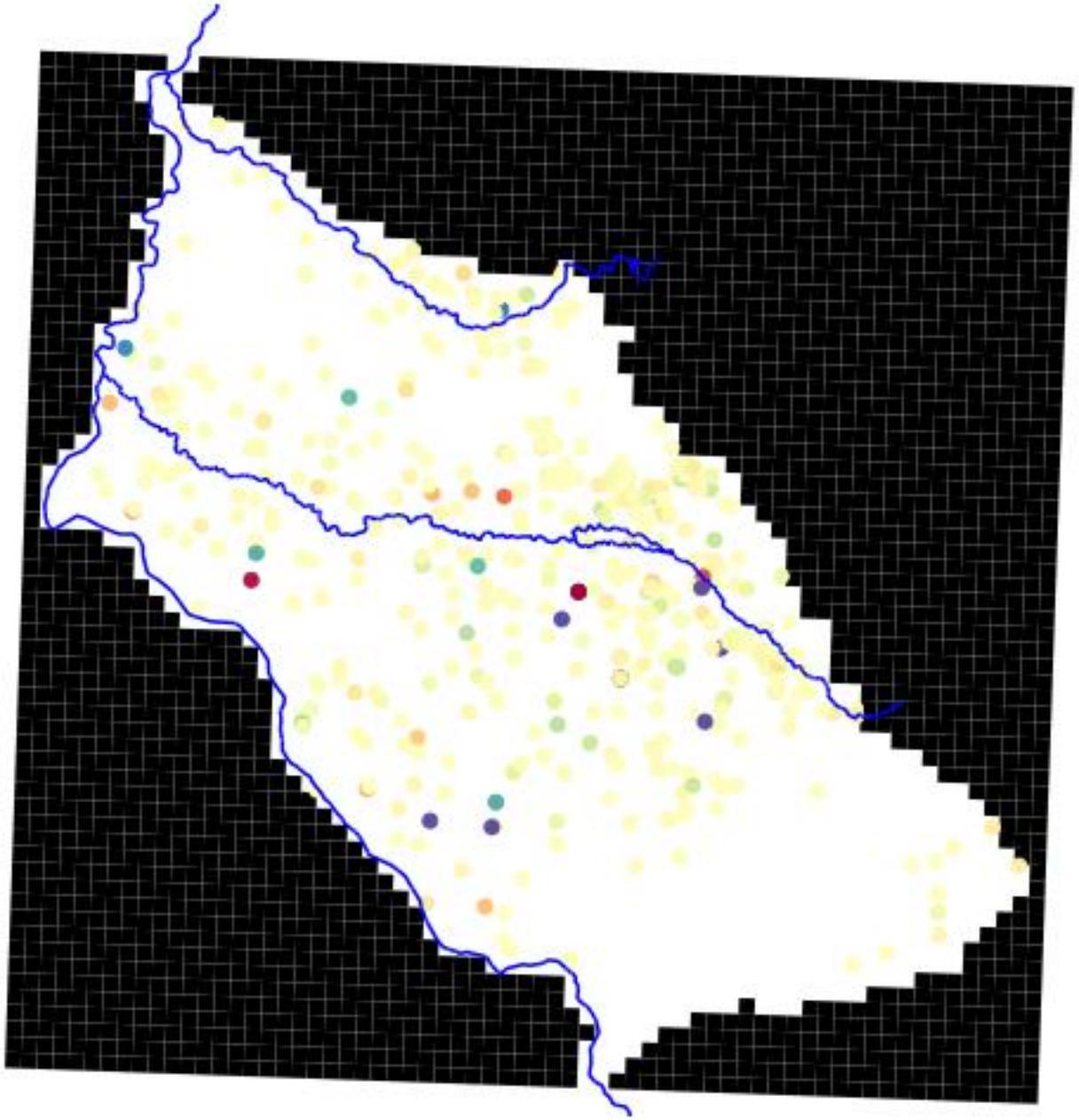
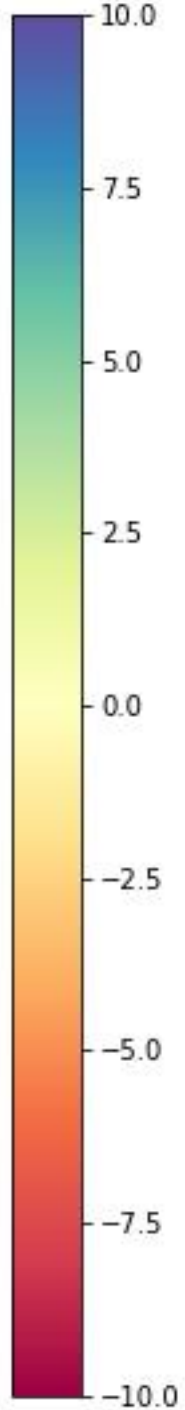
Prior Residuals

Residuals
Temporal Head Difference
All Layers
1st percentile





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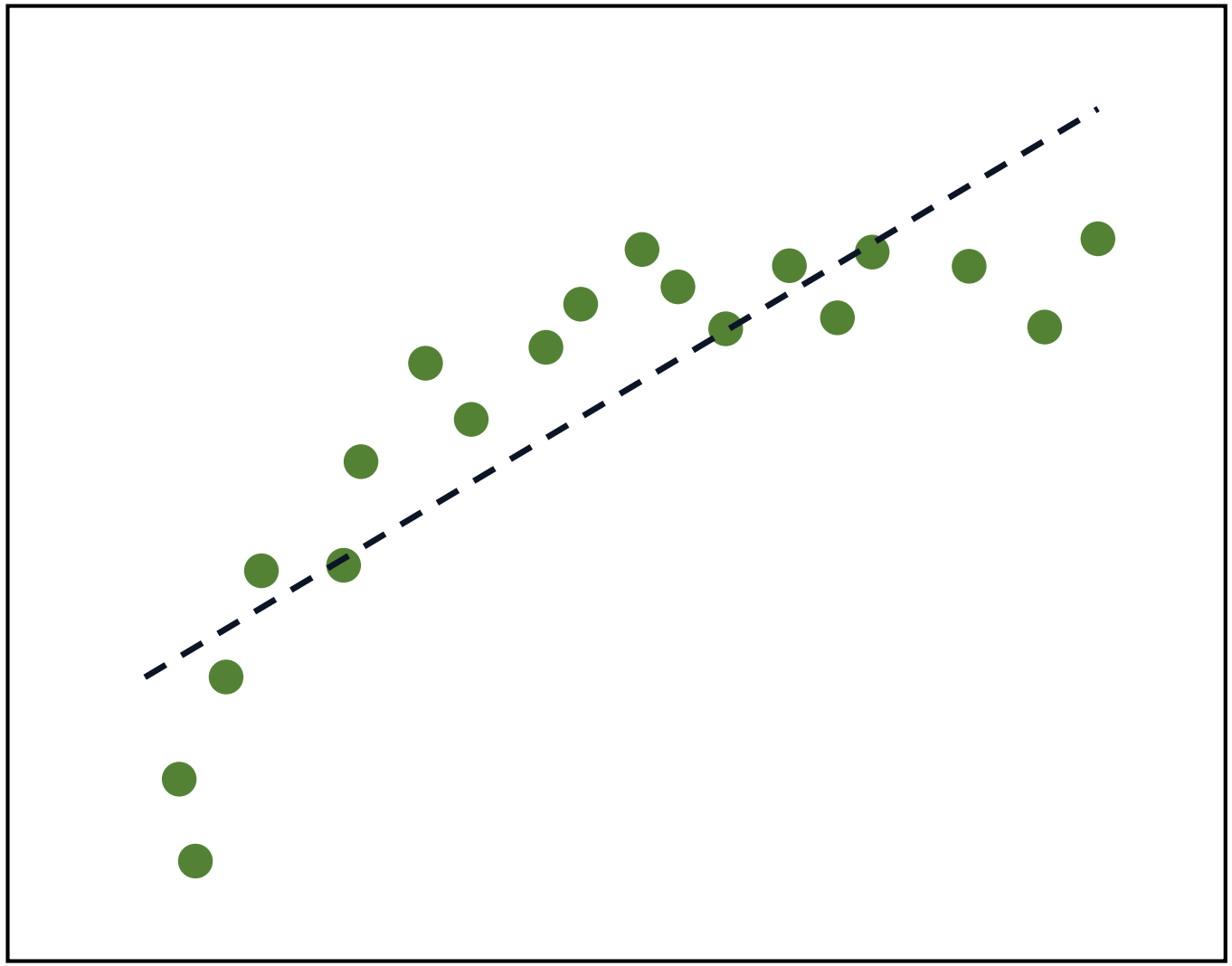
Next Steps

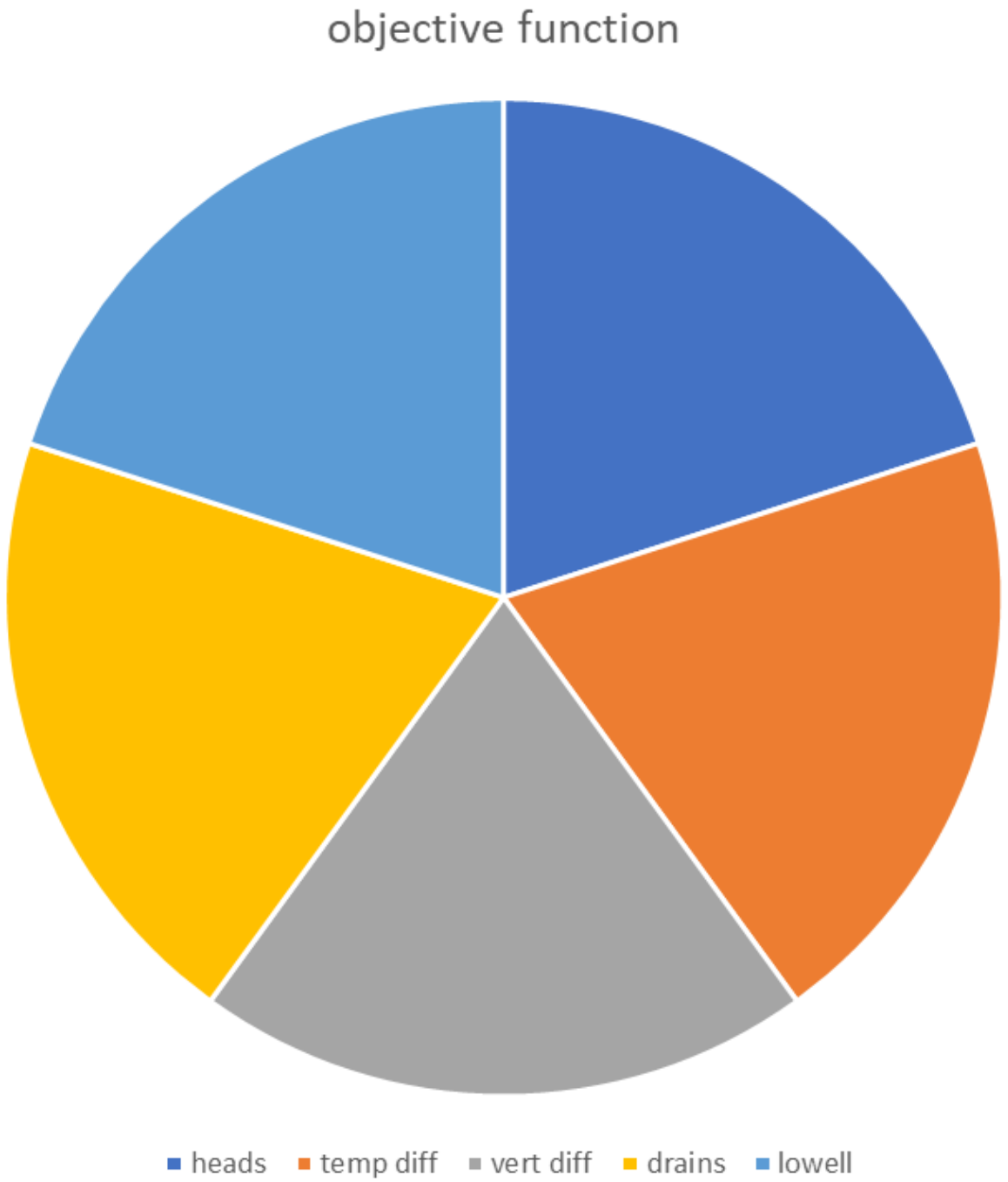
Common Challenges

FIX STRUCTURAL ERRORS !!!



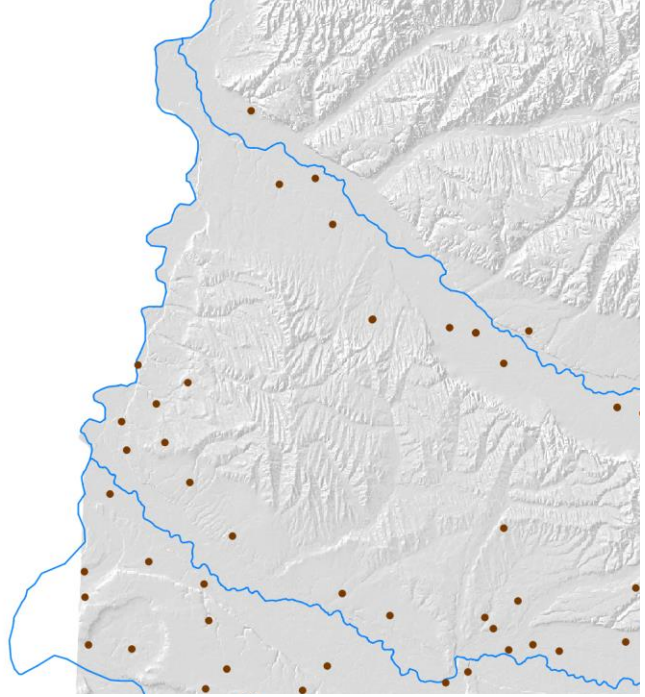
Common Challenges

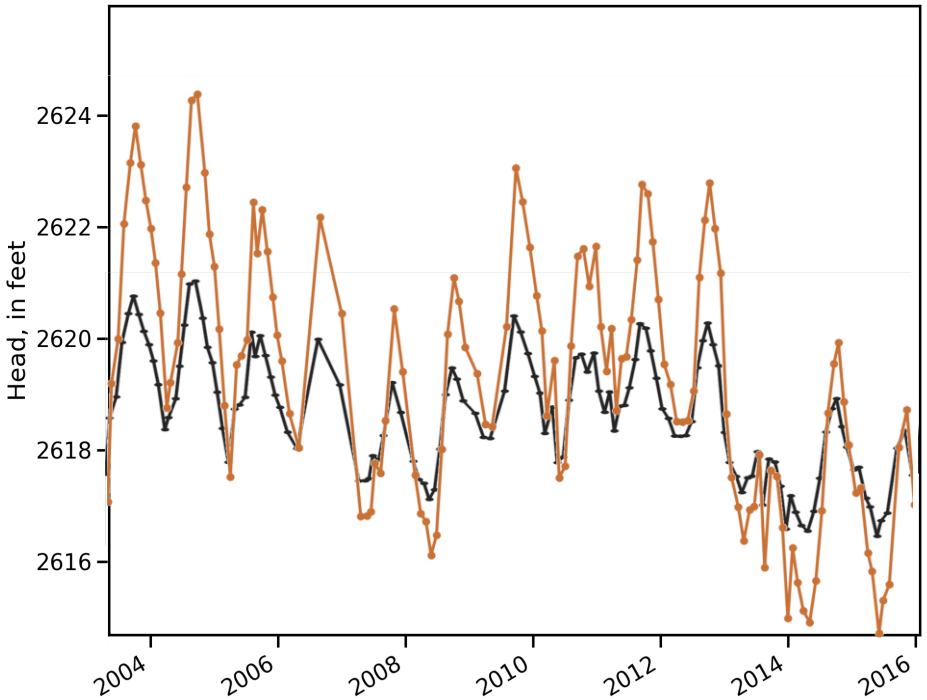
weighting

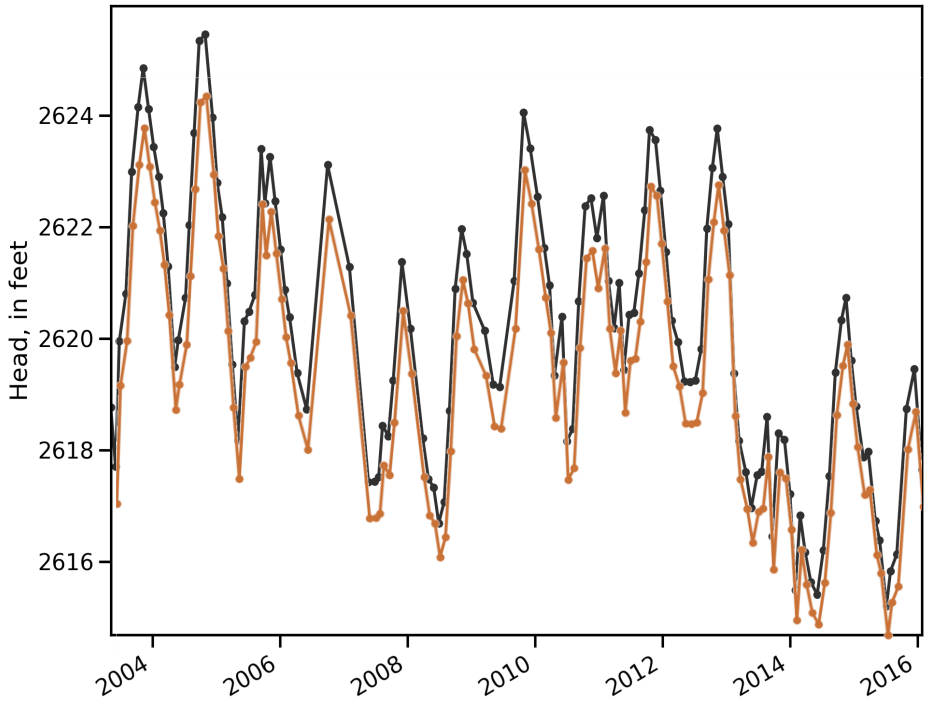


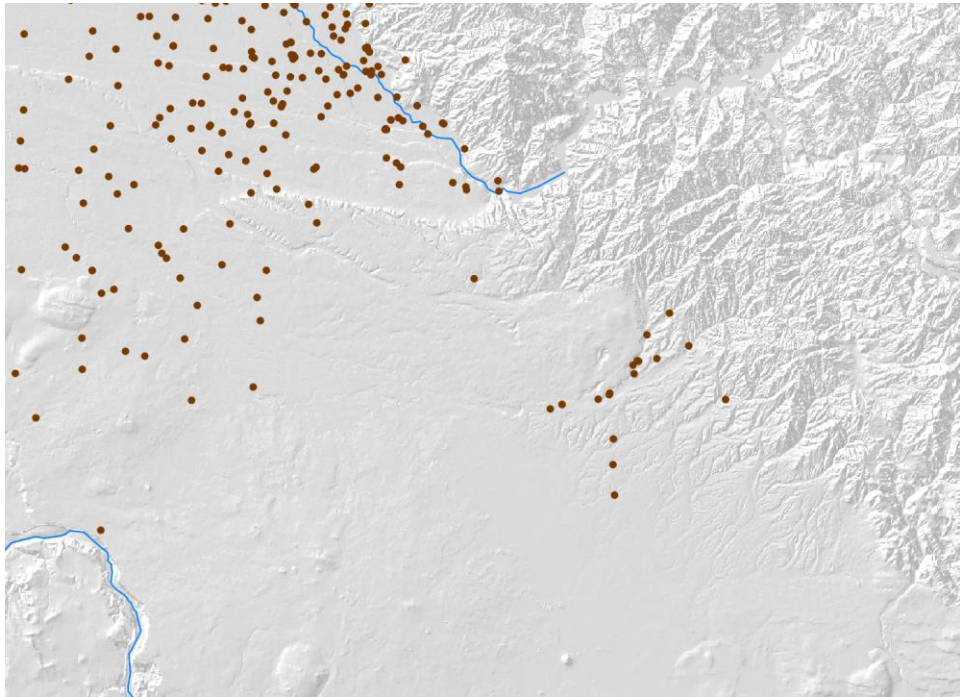
Common Challenges

systematic misfits or tradeoffs









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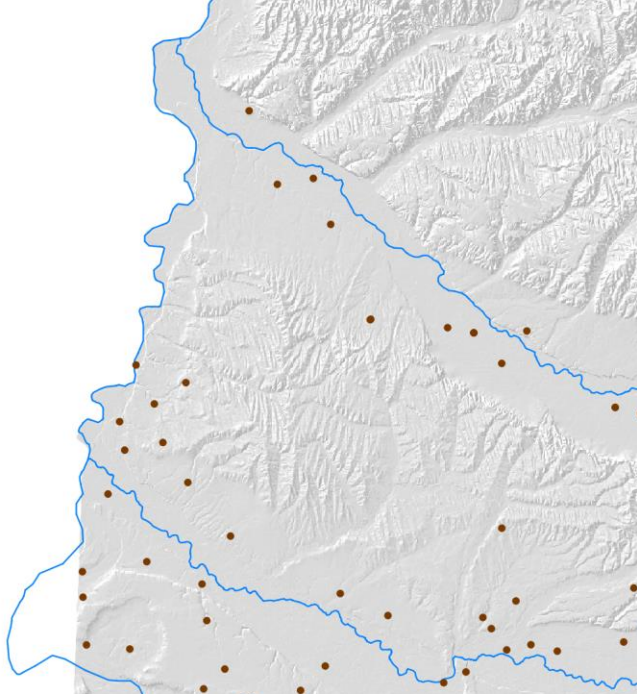
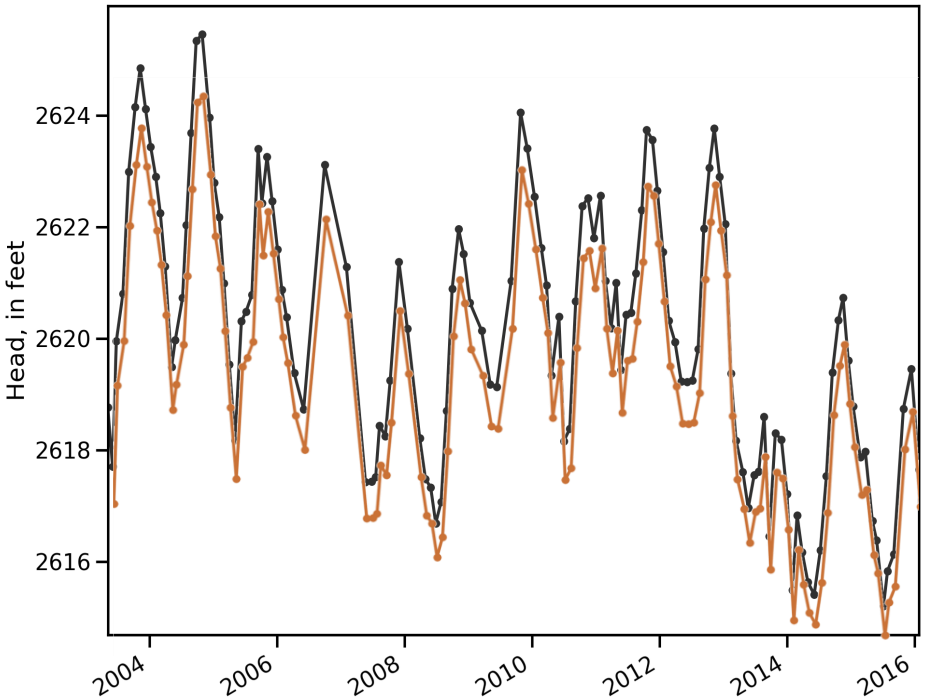
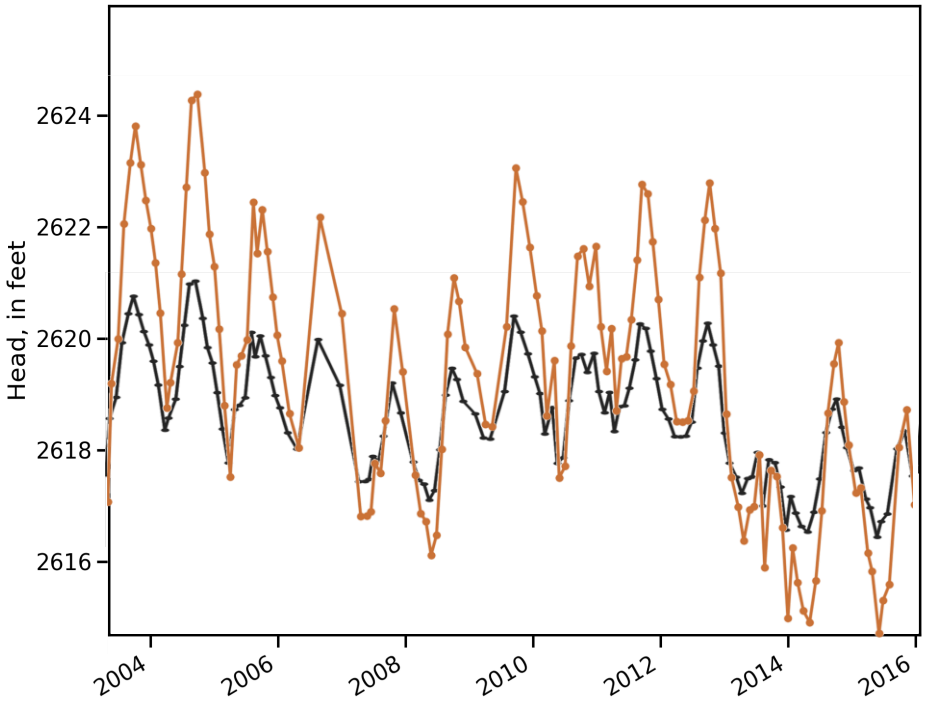
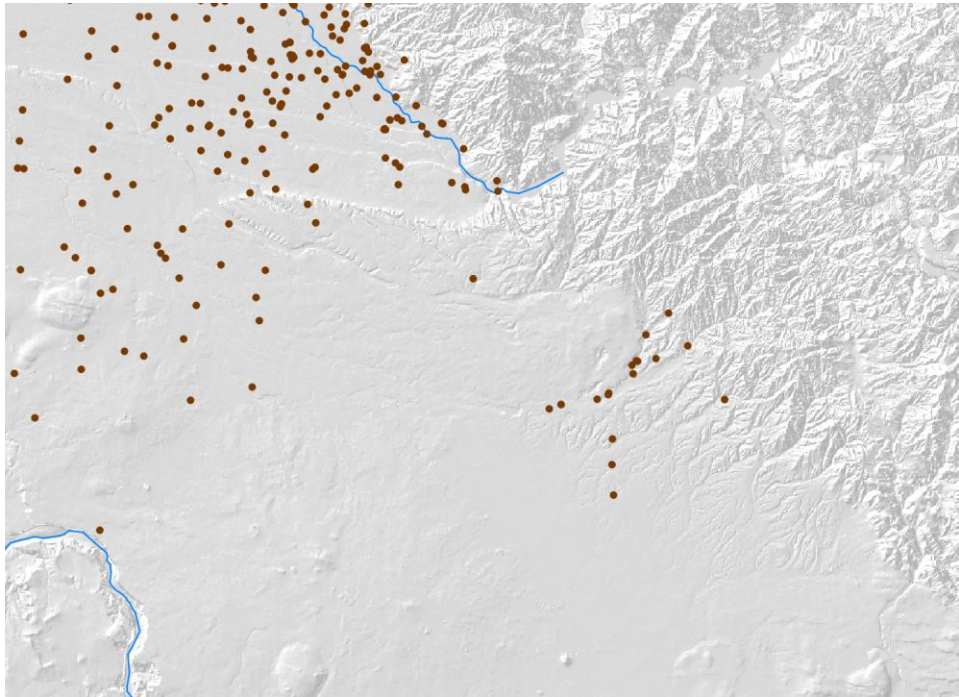
Common Challenges

systematic misfits or tradeoffs









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Thanks for listening!

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