River Assessment for Forecasting Temperature (RAFT) Temperature Decision Support Tool (DST)

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Outline

Decision Support Tool (DST)

- Transparency and accessibility

River

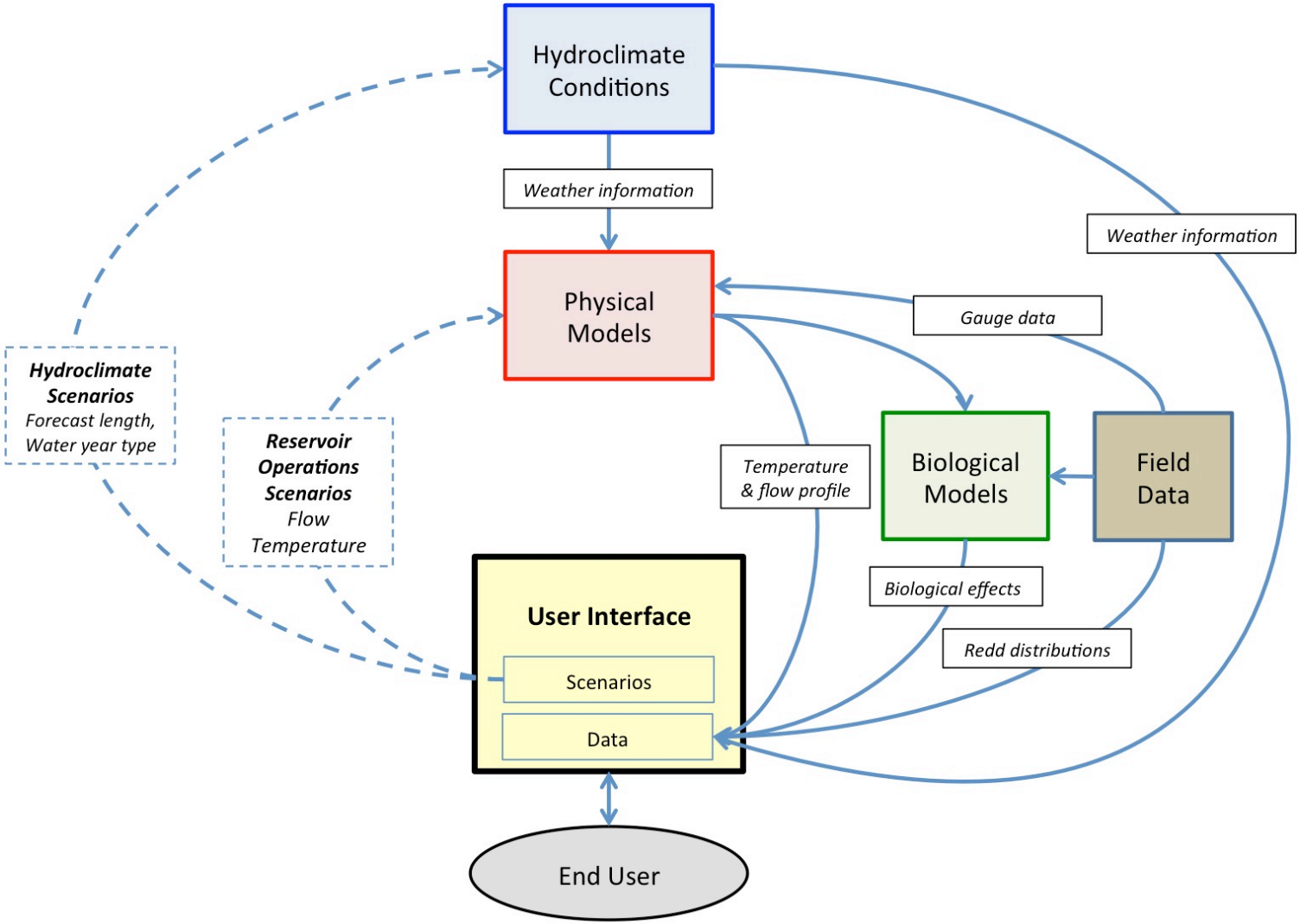
- RAFT model
- Temperature landscape

Reservoir

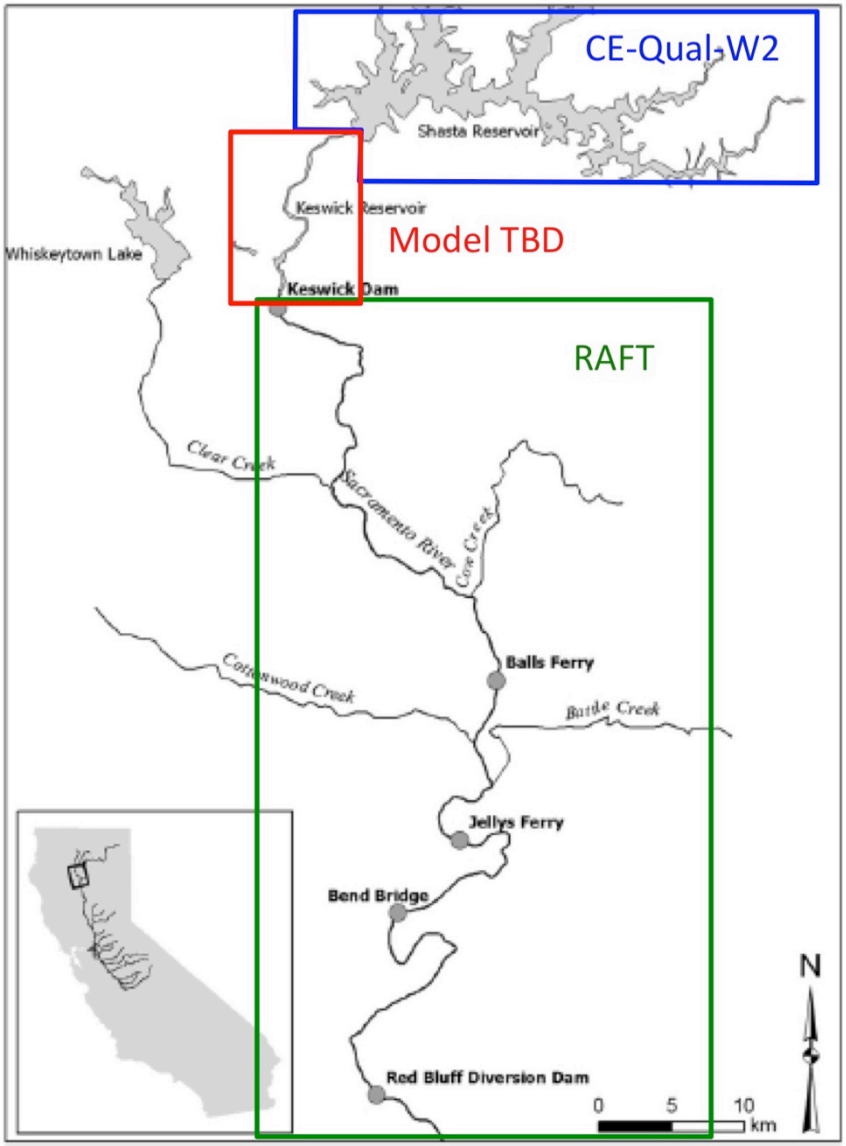
- CE-Qual-W2

DST improvements in 2016

Decision Support Tool



Coupled Physical Models



1. What additional calibration and validation is recommended for the RAFT model?

2. Keswick "river-reservoir" model. Recommendations on extending the RAFT model upstream or the CE-Qual-W2 model downstream?

3. What addition information or capabilities should be added to the DST to improve its usefulness to management?

RAFT

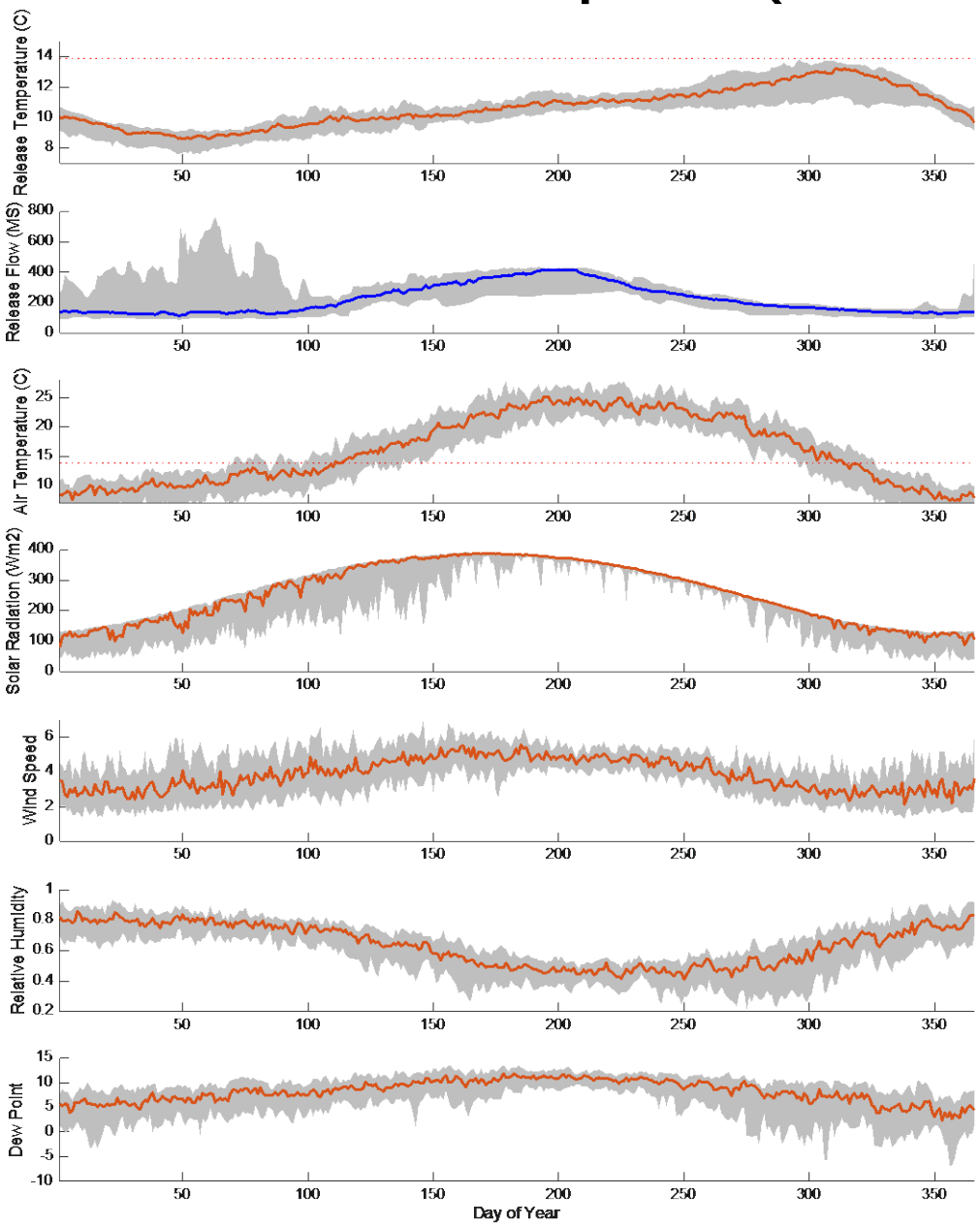
Boundary Conditions:
Discharge temperature and flow from Keswick Dam
Meteorological conditions
Tributary inputs and withdrawals

Heat Fluxes:
Heat exchange at the air-water interface and at the streambed-water interface
Heat inputs from lateral inflows (tributaries), and heat losses from water withdrawals

Scale:
1km reaches at 15 minutes time-step
Keswick Dam to City of Sacramento

Applications:
7 day forecasts - National Digital Forecast Database (NDFD)
25 years retrospective - North American Regional Reanalysis (NARR)

RAFT Model Inputs (1990-2014)



Release Temperature

Release Flow

Air Temperature

Solar Radiation

Wind Speed

Relative Humidity

Dew Point

RAFT – Model Components

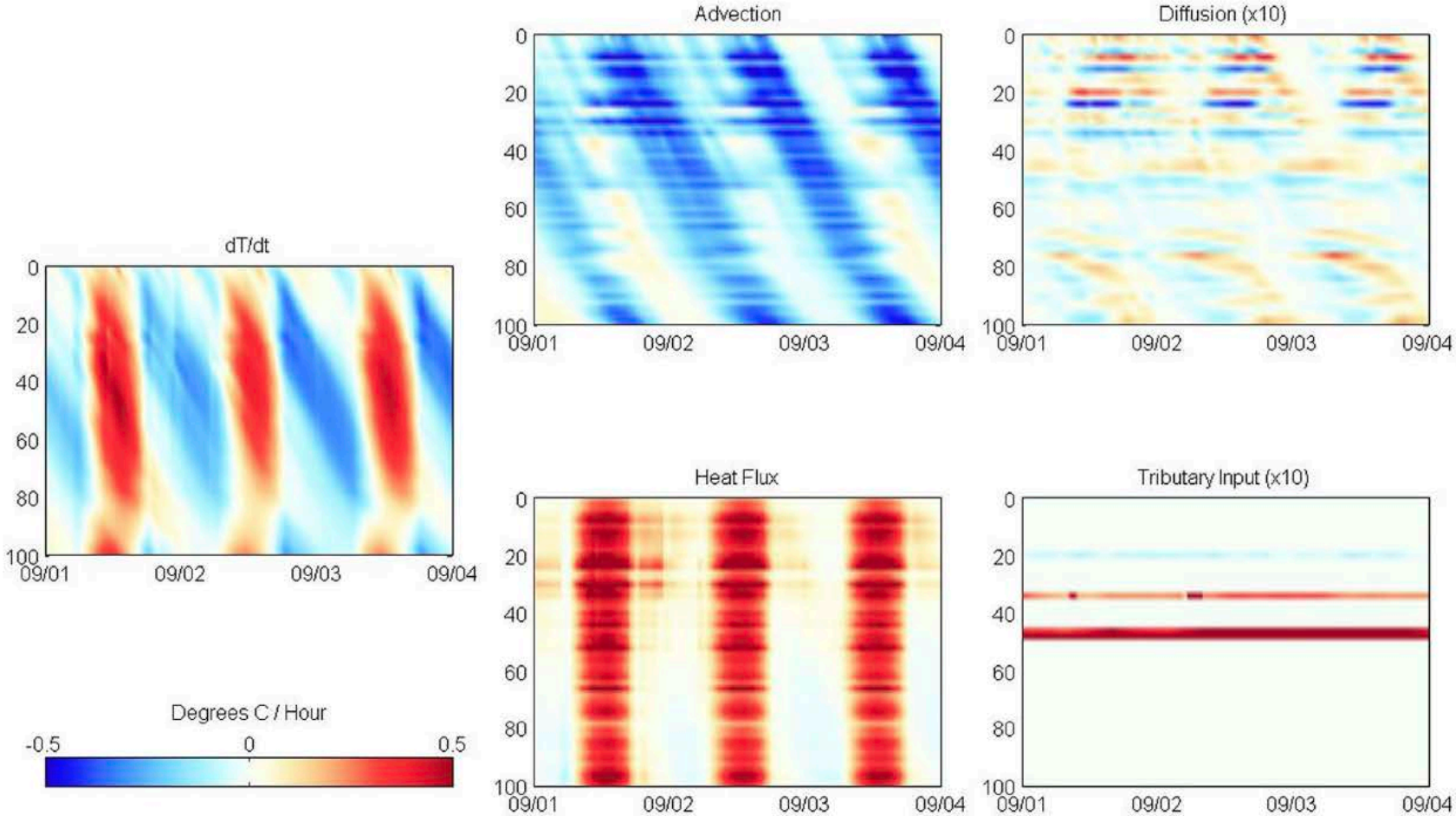
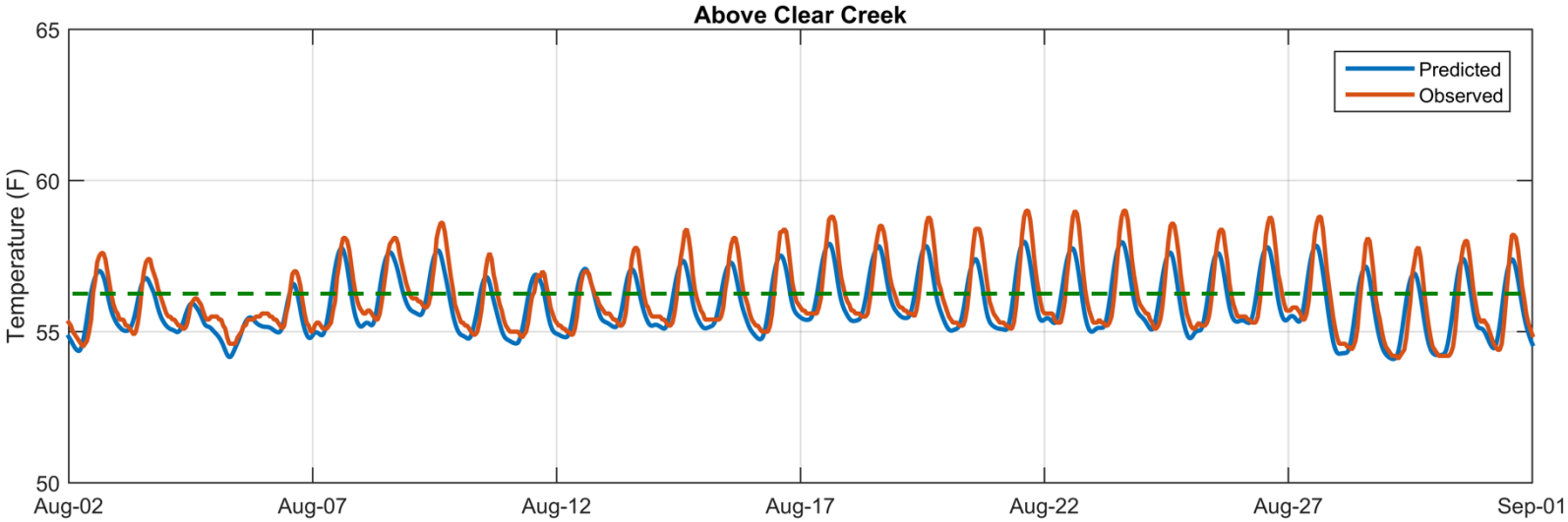
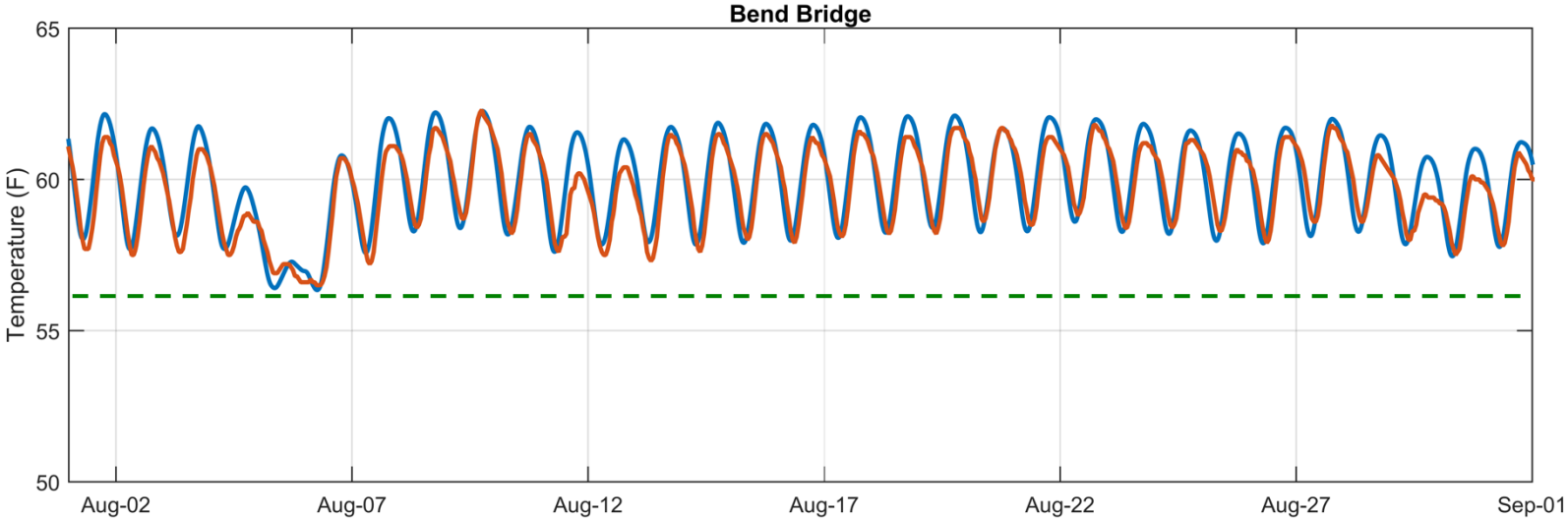


Figure 5. Model components in space and in time. The net change in temperature with respect to time (dT/dt) is the sum of advective, diffusive, atmospheric/streambed, and tributary heat fluxes. Diffusion and tributary heat fluxes have been scaled by a factor of 10 for visualization purposes.

Pike et al. 2013

Modeled vs. Observed Temperatures 2014





RAFT - Error Variance

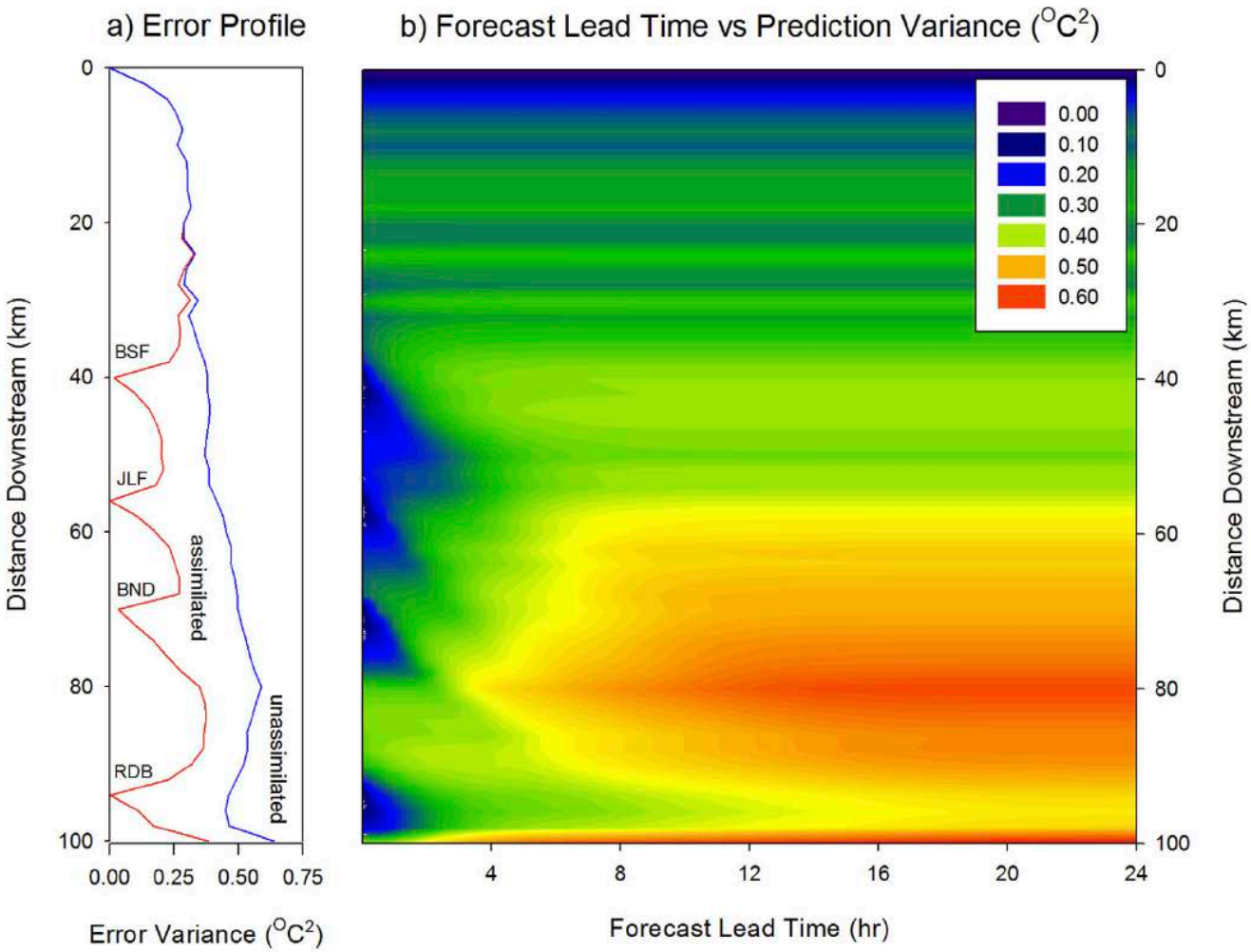
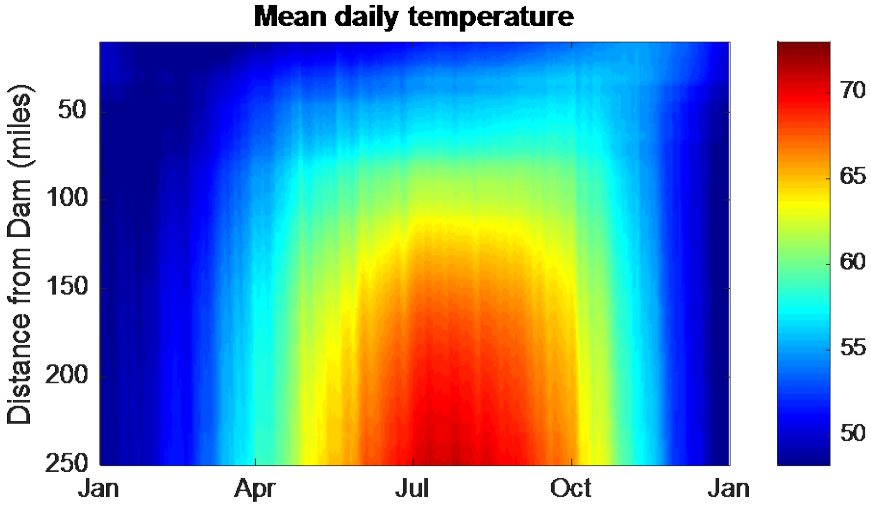
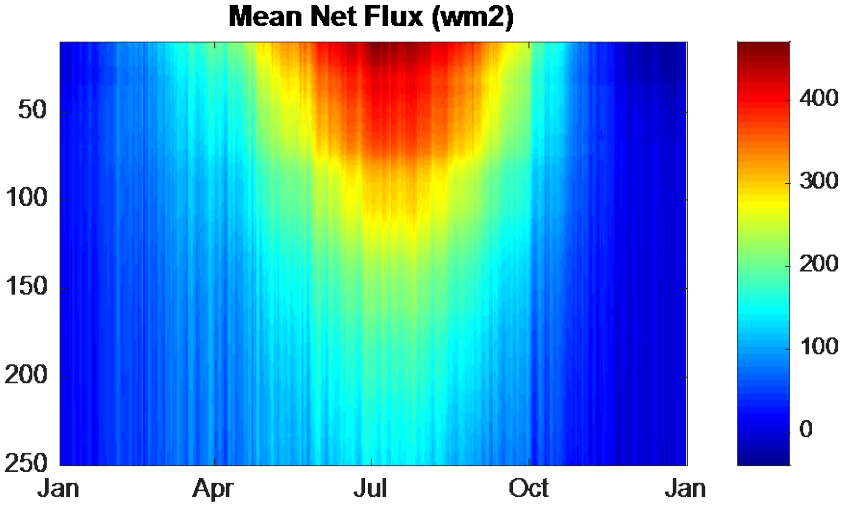


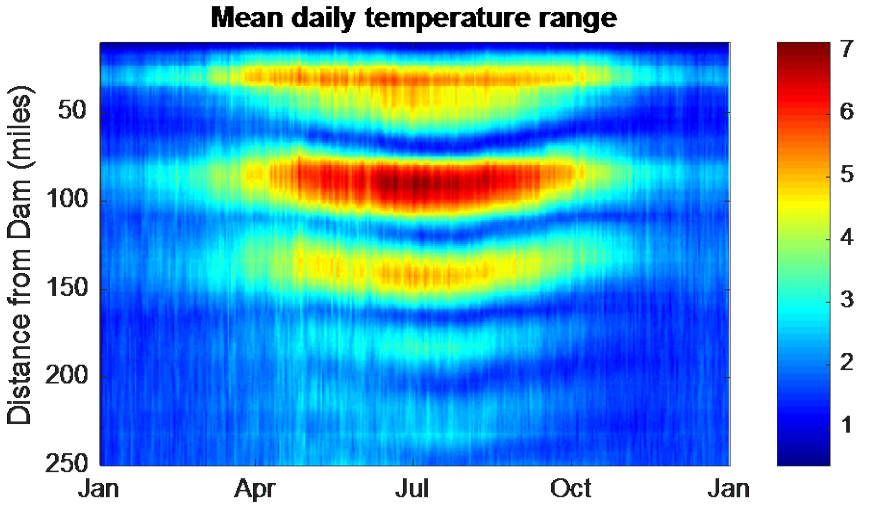
Figure 4. (a) Forecast error variance as a function of position and lead time. (b) Longitudinal profile of posterior error variance once data have been assimilated (red), and profile of error variance after 24 h/ nonassimilated.

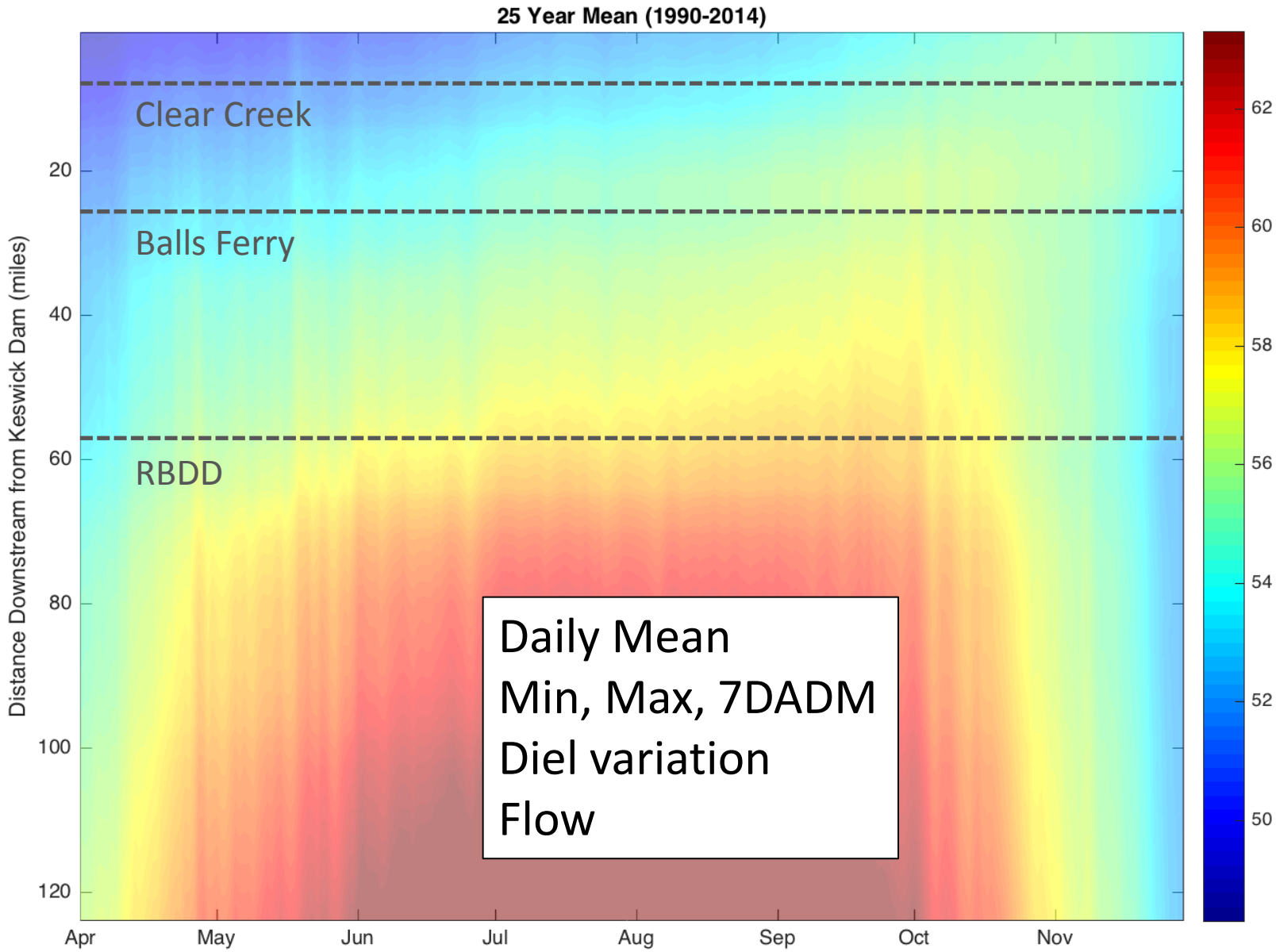
Pike et al. 2013

Temperature Landscape (1990-2014)

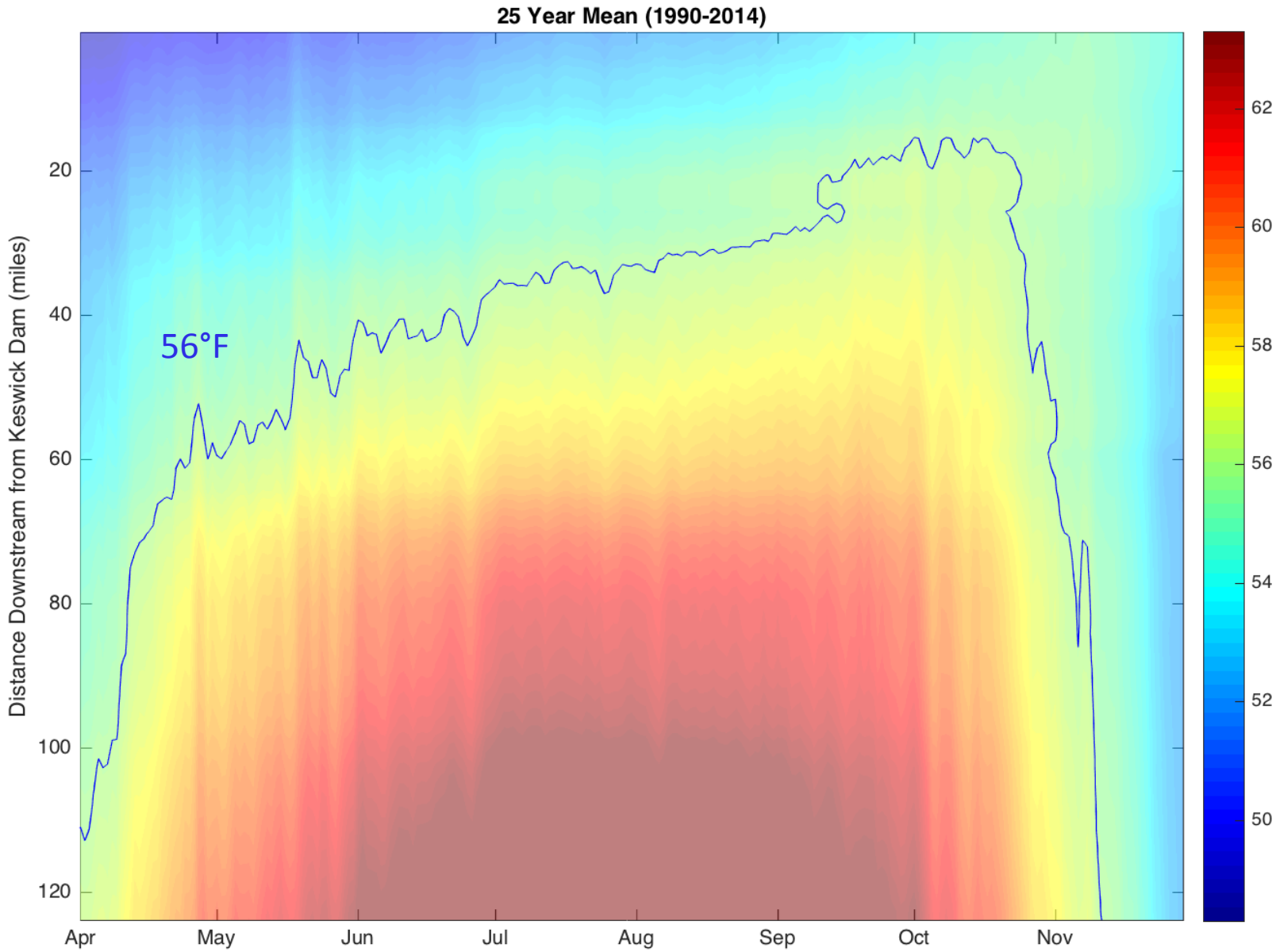








Daily Mean
Min, Max, 7DADM
Diel variation
Flow


25 Year Mean (1990-2014)
Distance Downstream from Keswick Dam (miles)
20
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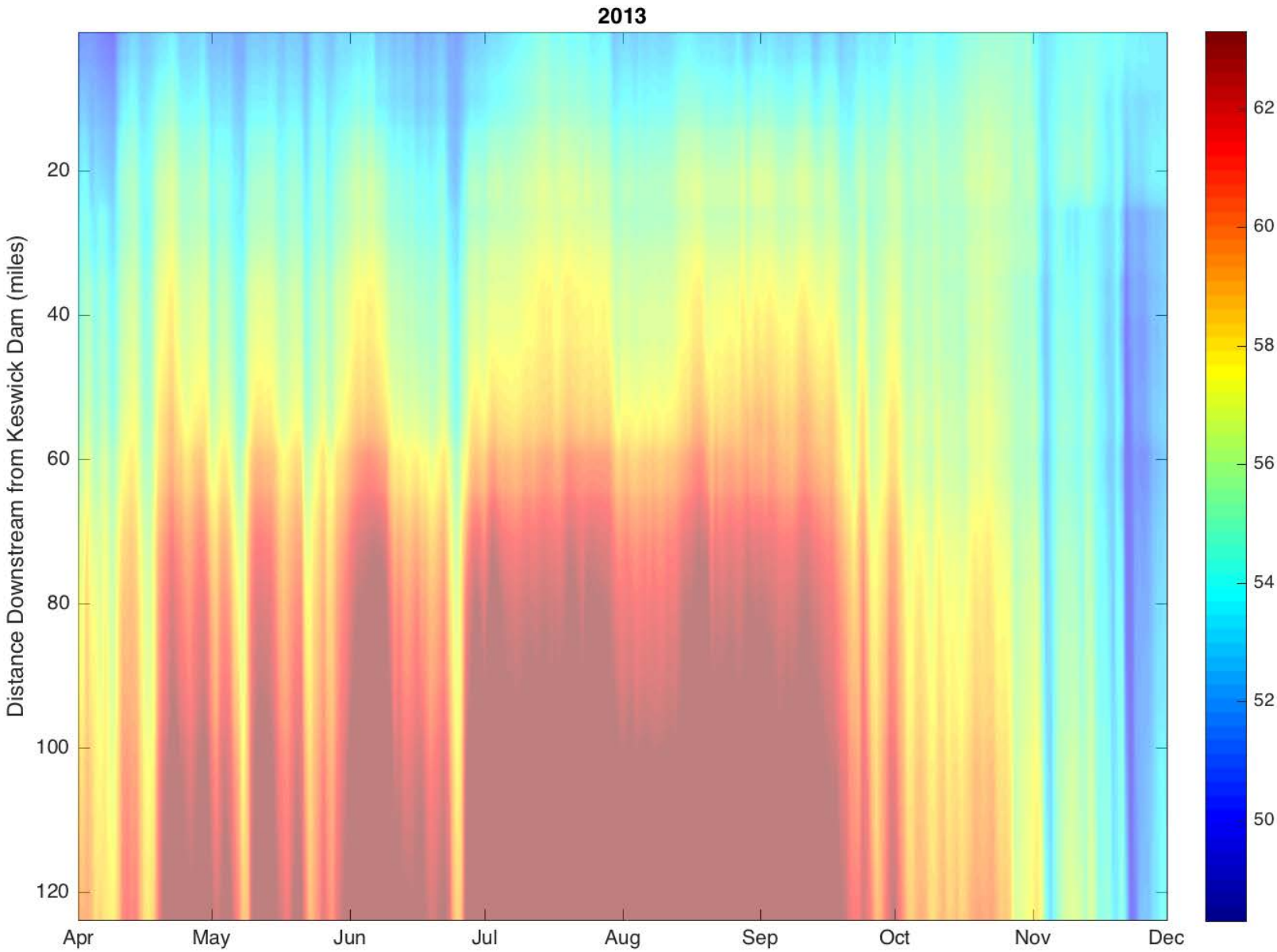
2013
Distance Downstream from Keswick Dam (miles)
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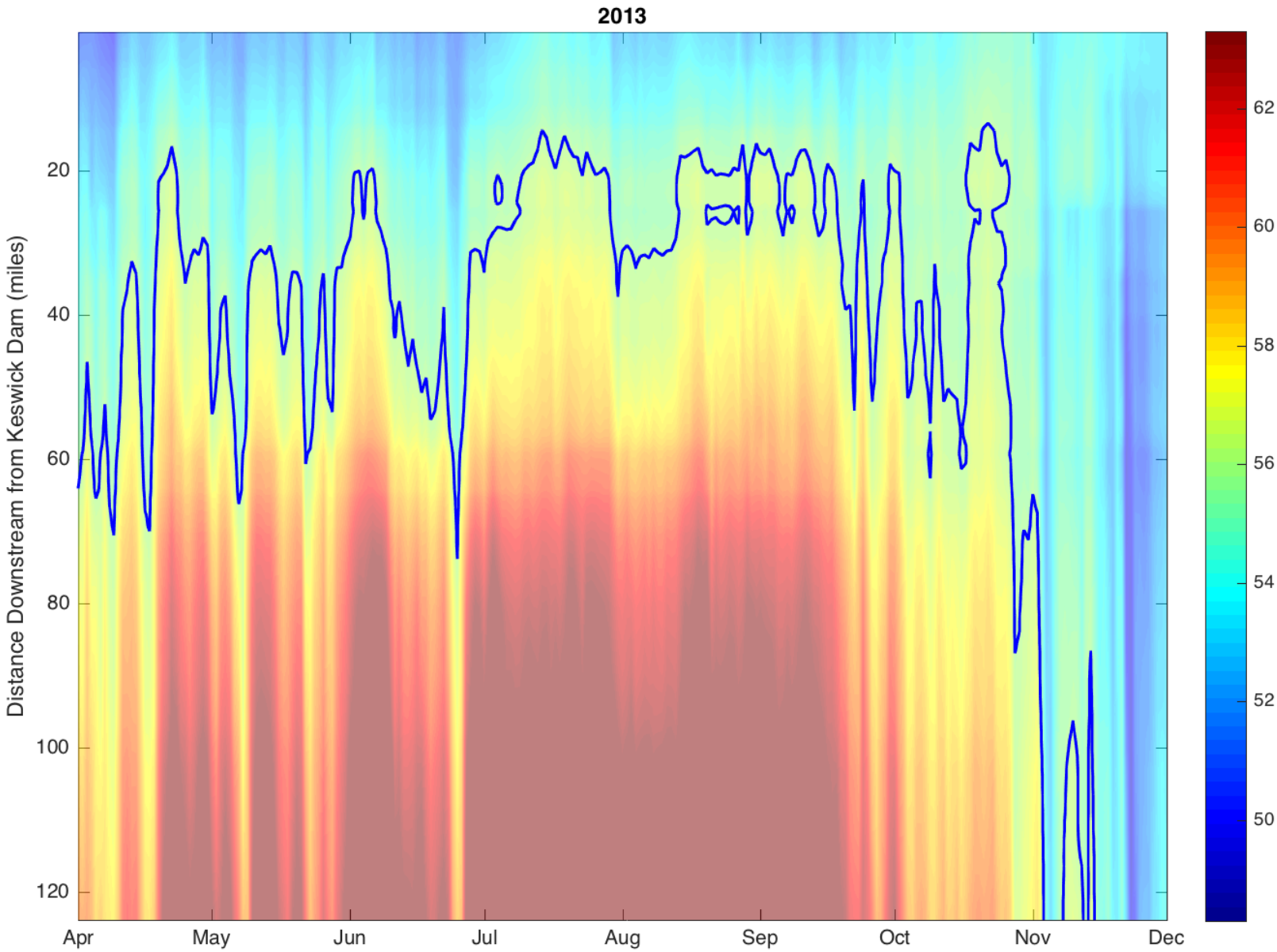
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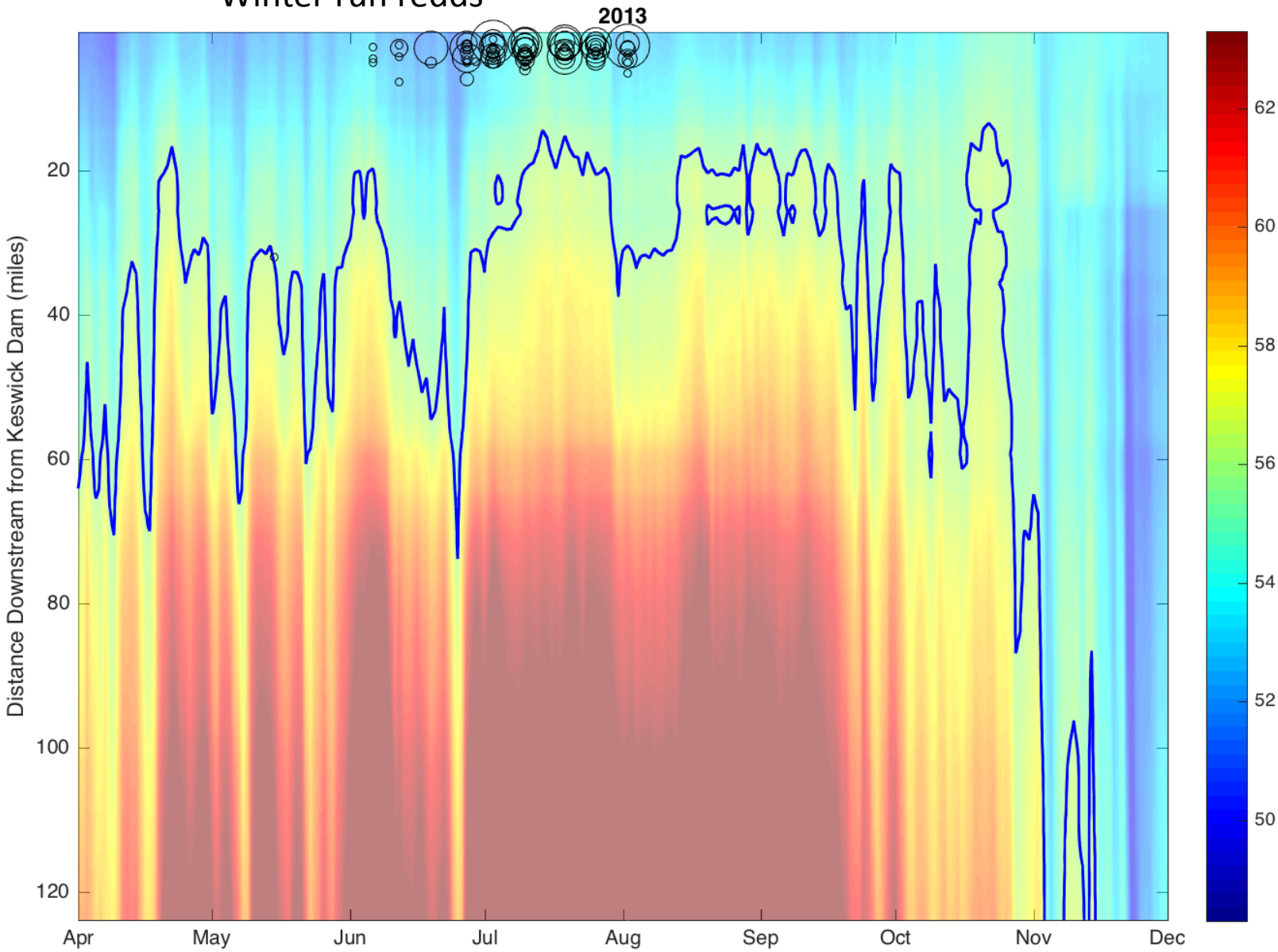
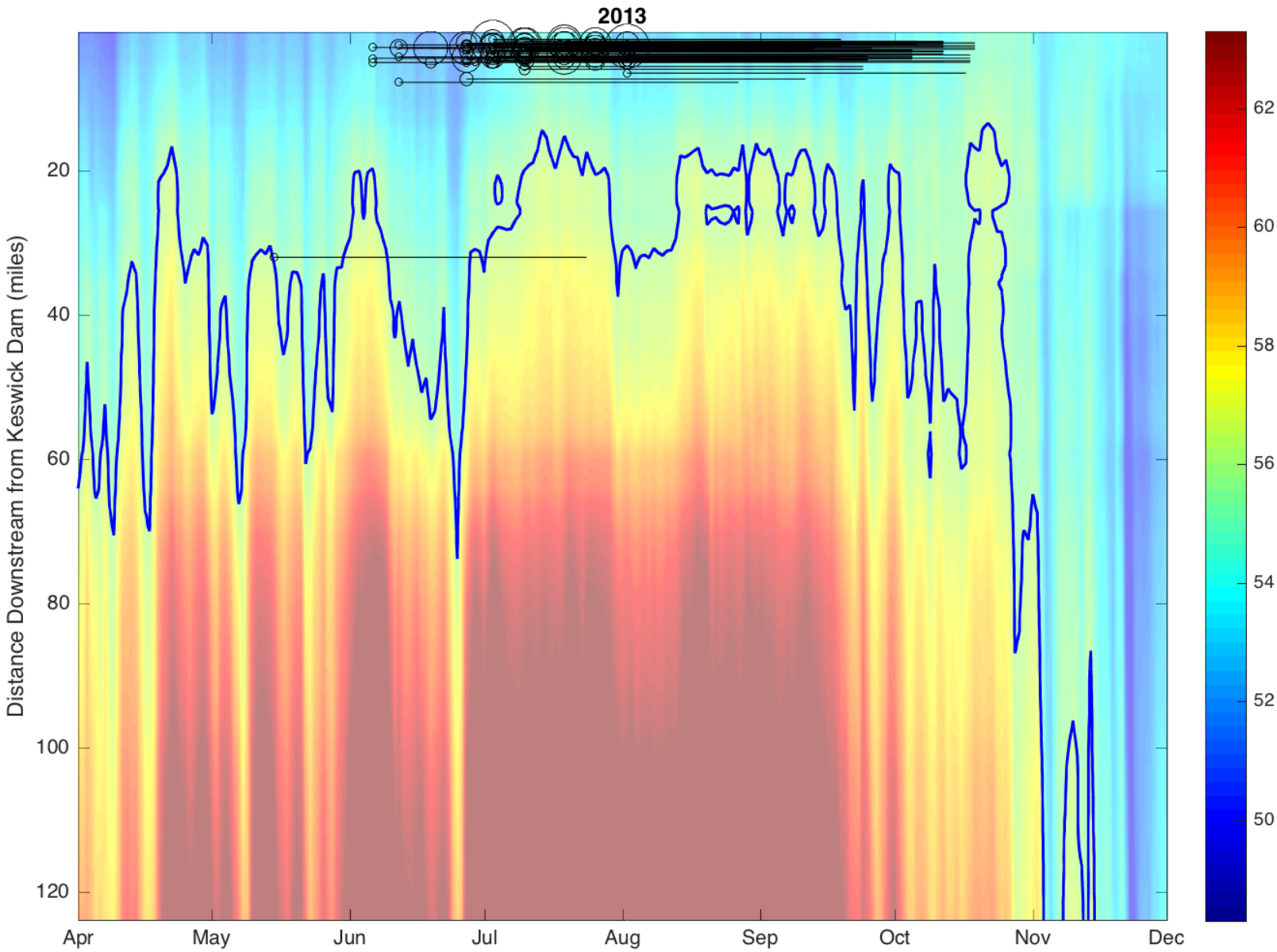
Winter run redds

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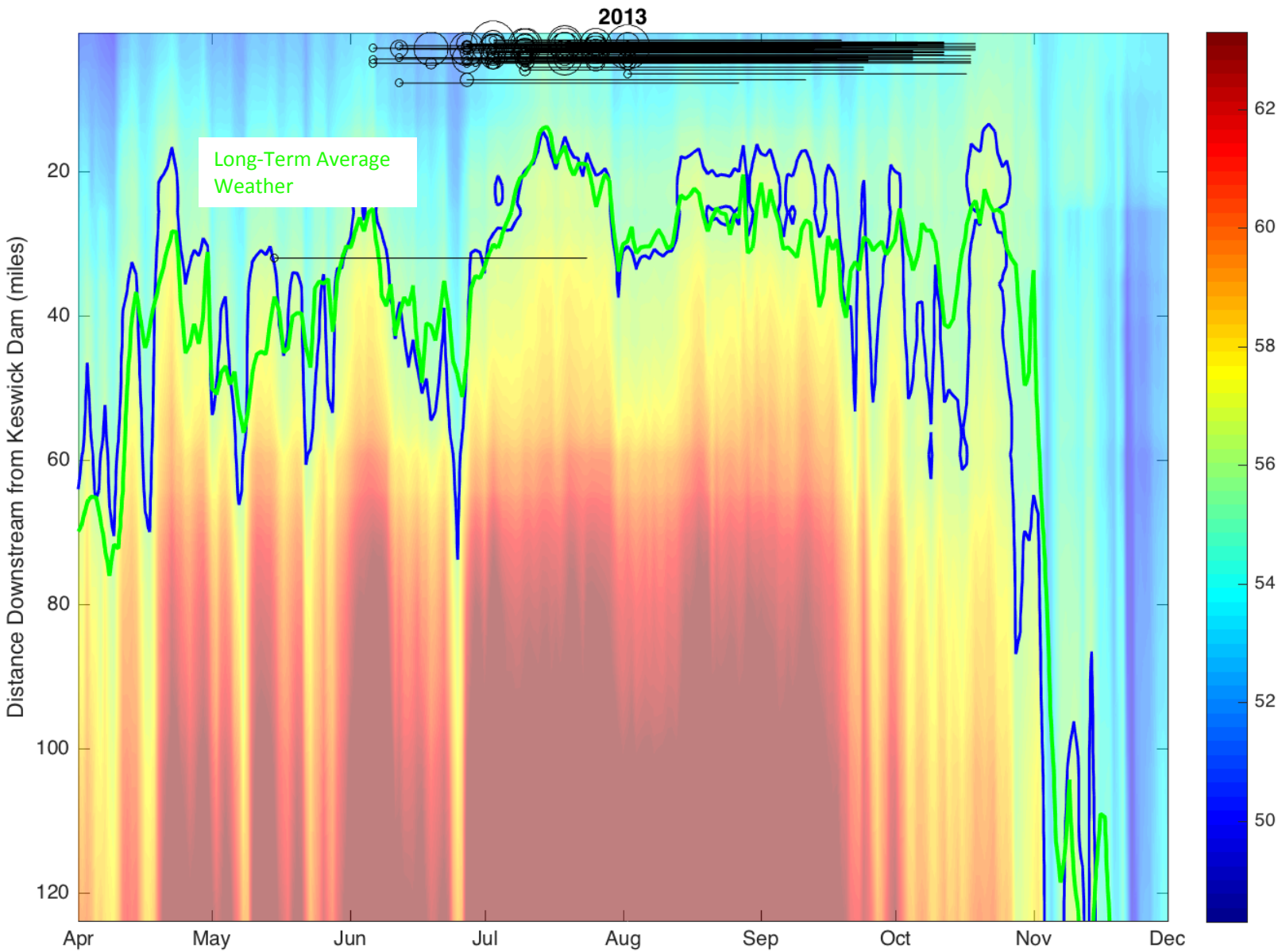
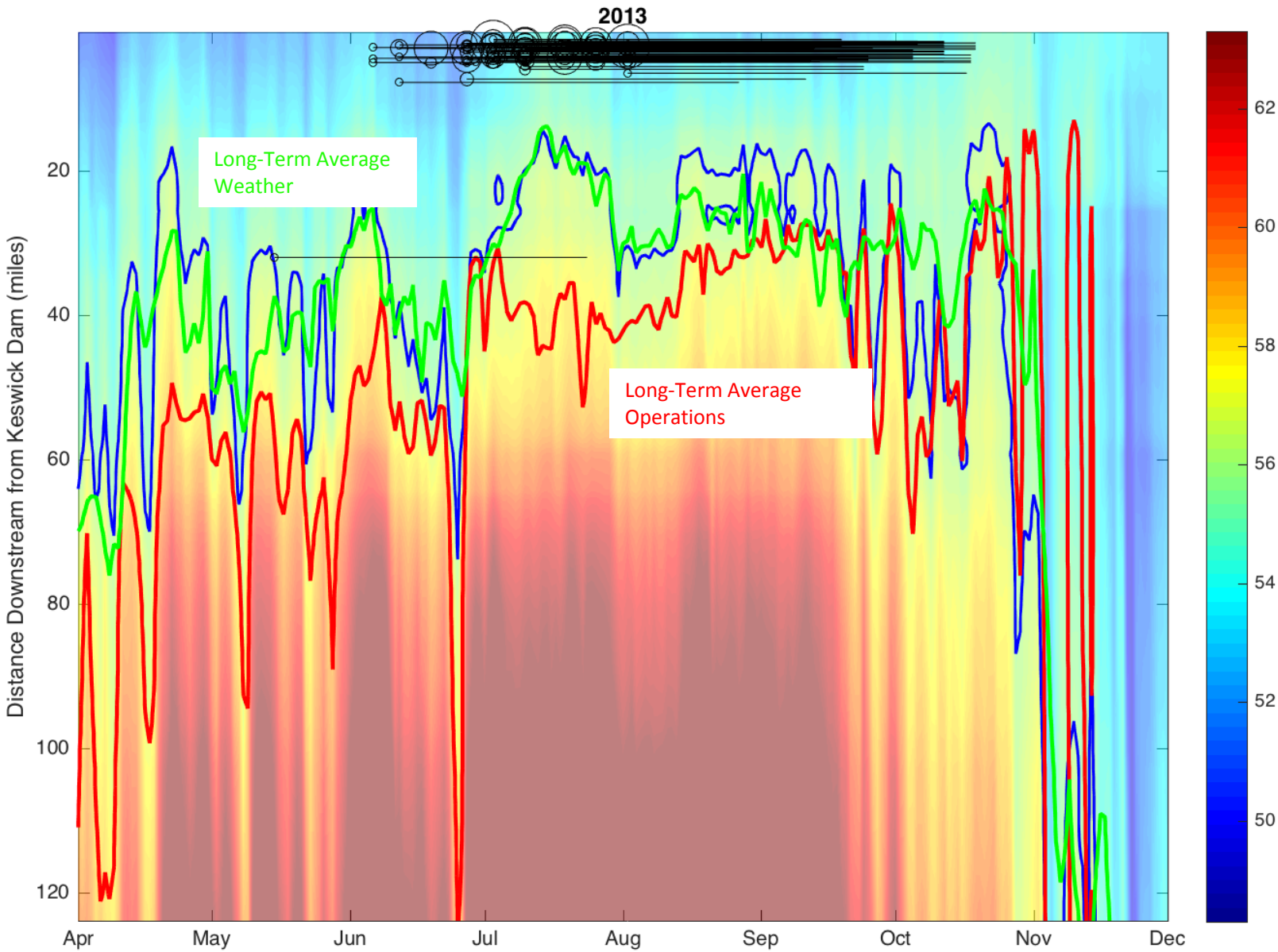


Long-Term Average Weather with 2013 Operations (Temperature and Flow)

Long-Term Average Operations (Temperature and Flow) with 2015 Weather



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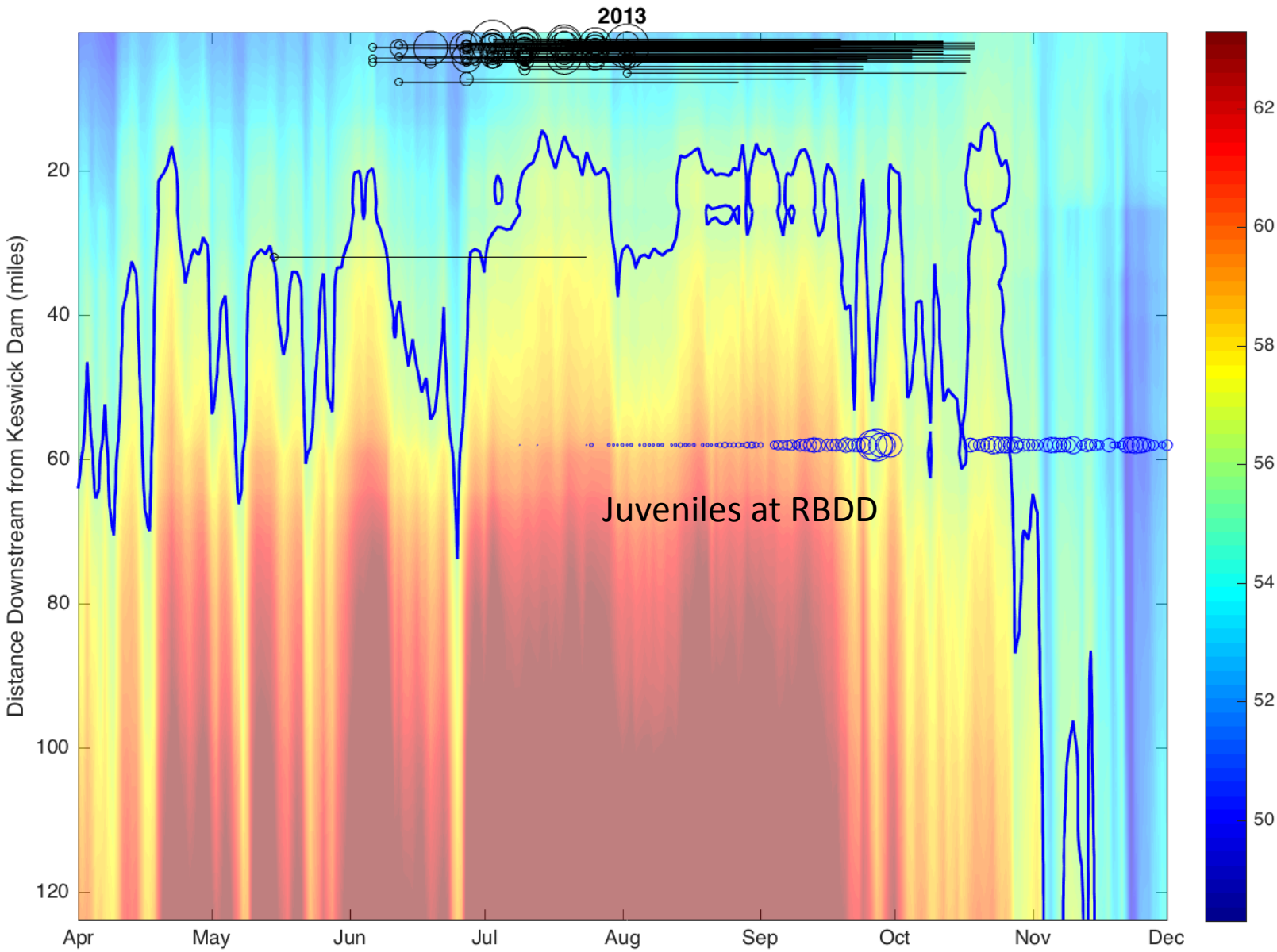
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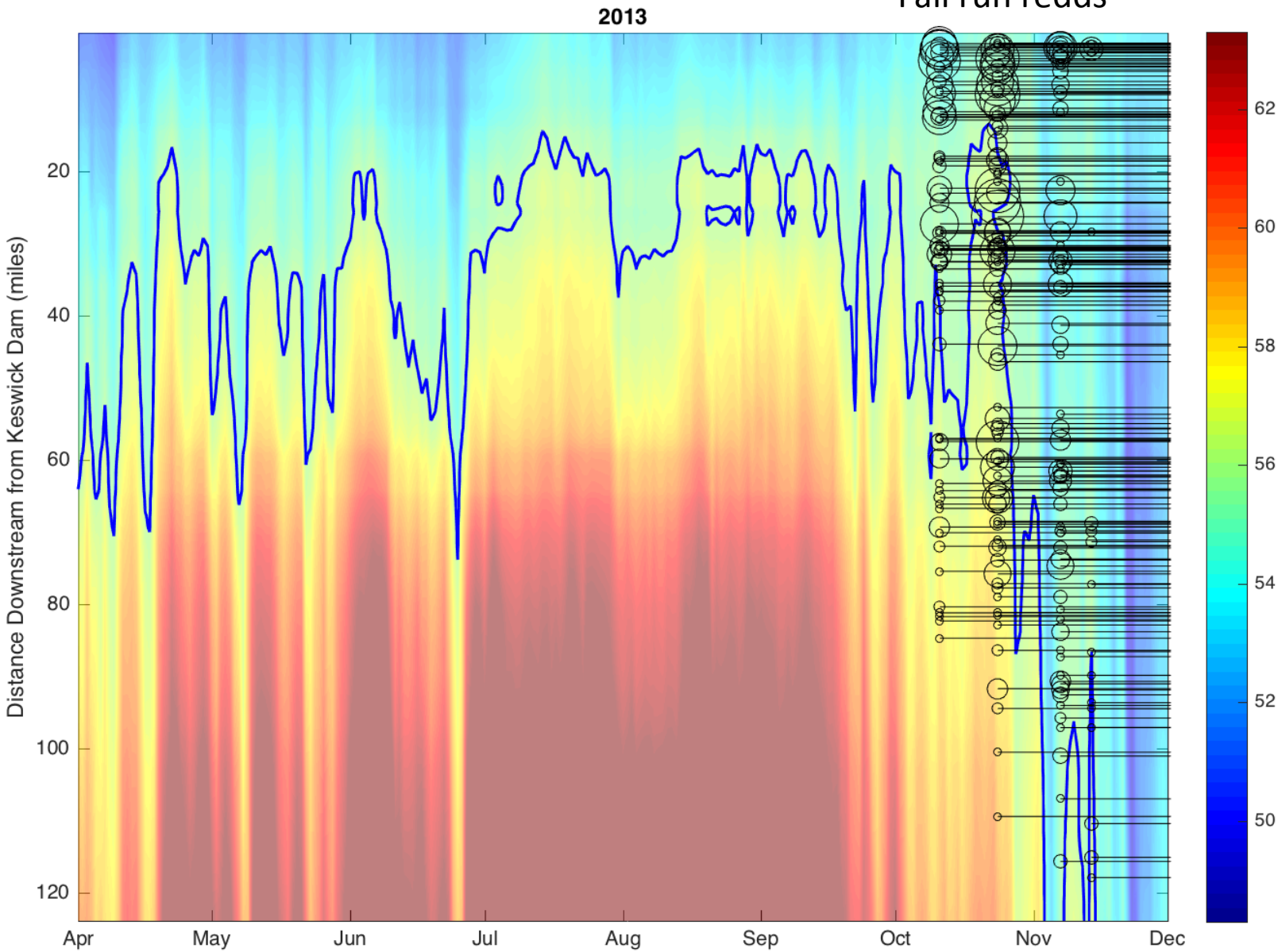
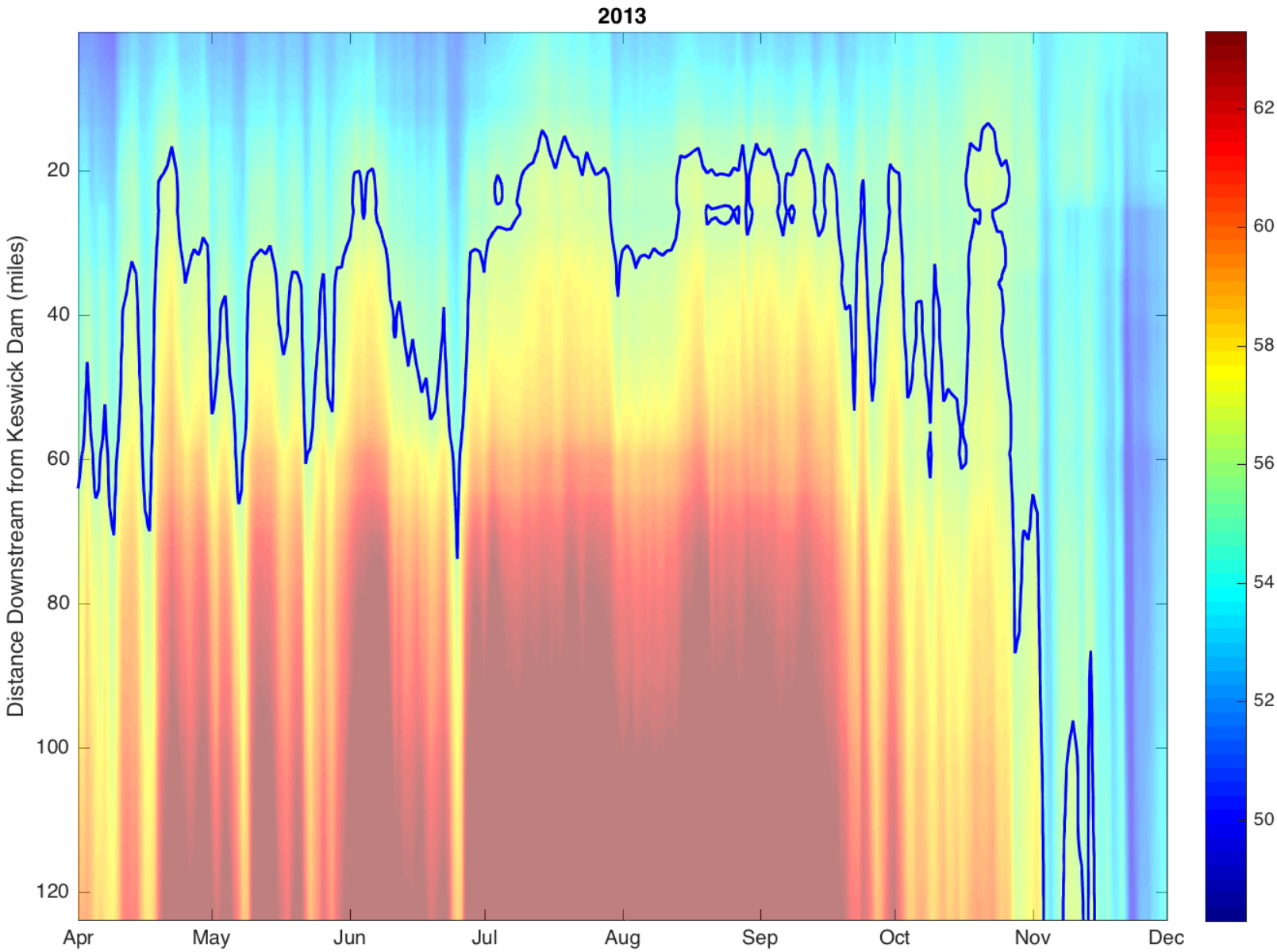
Juveniles at RBDD

Fall run redds

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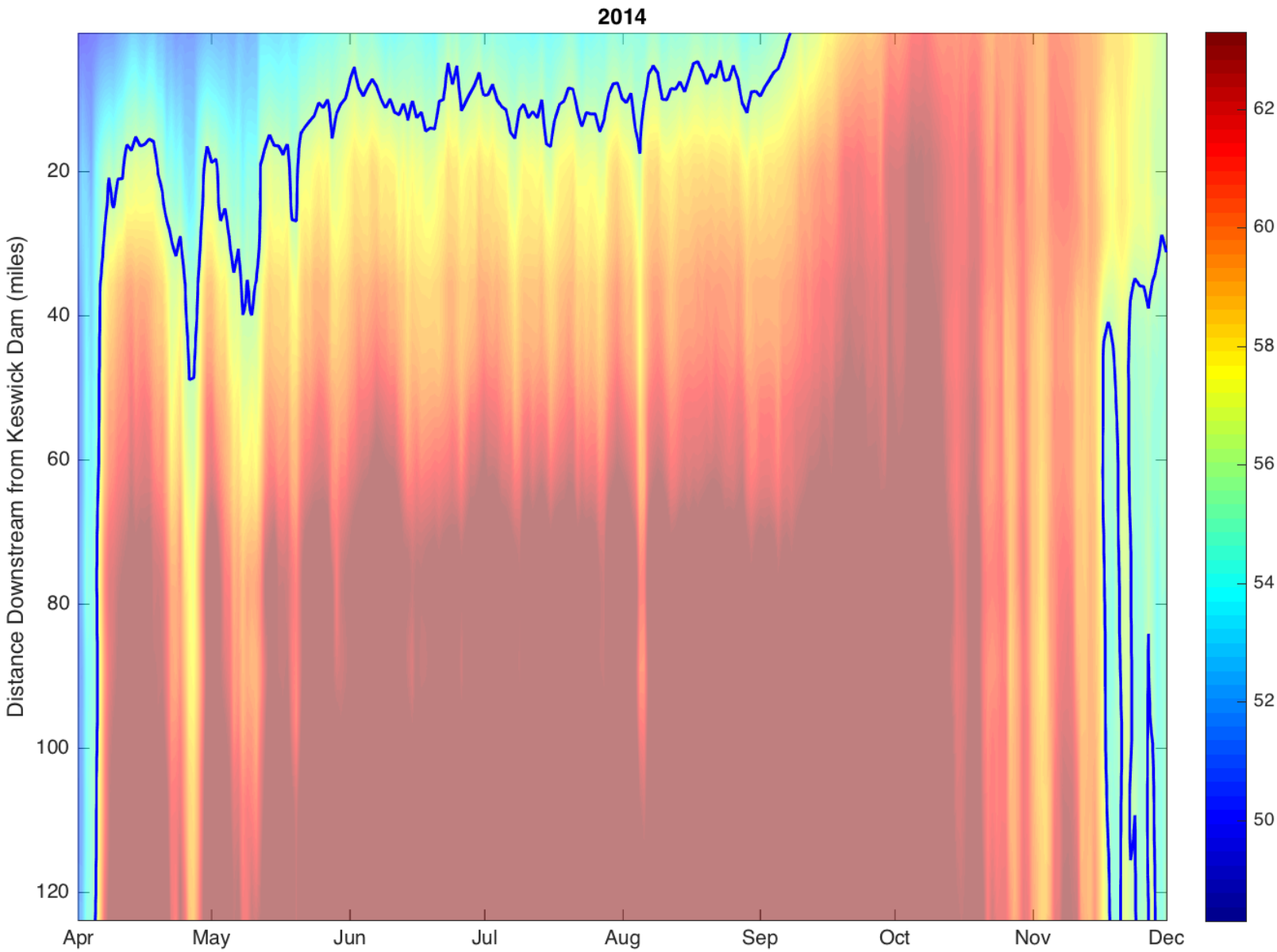
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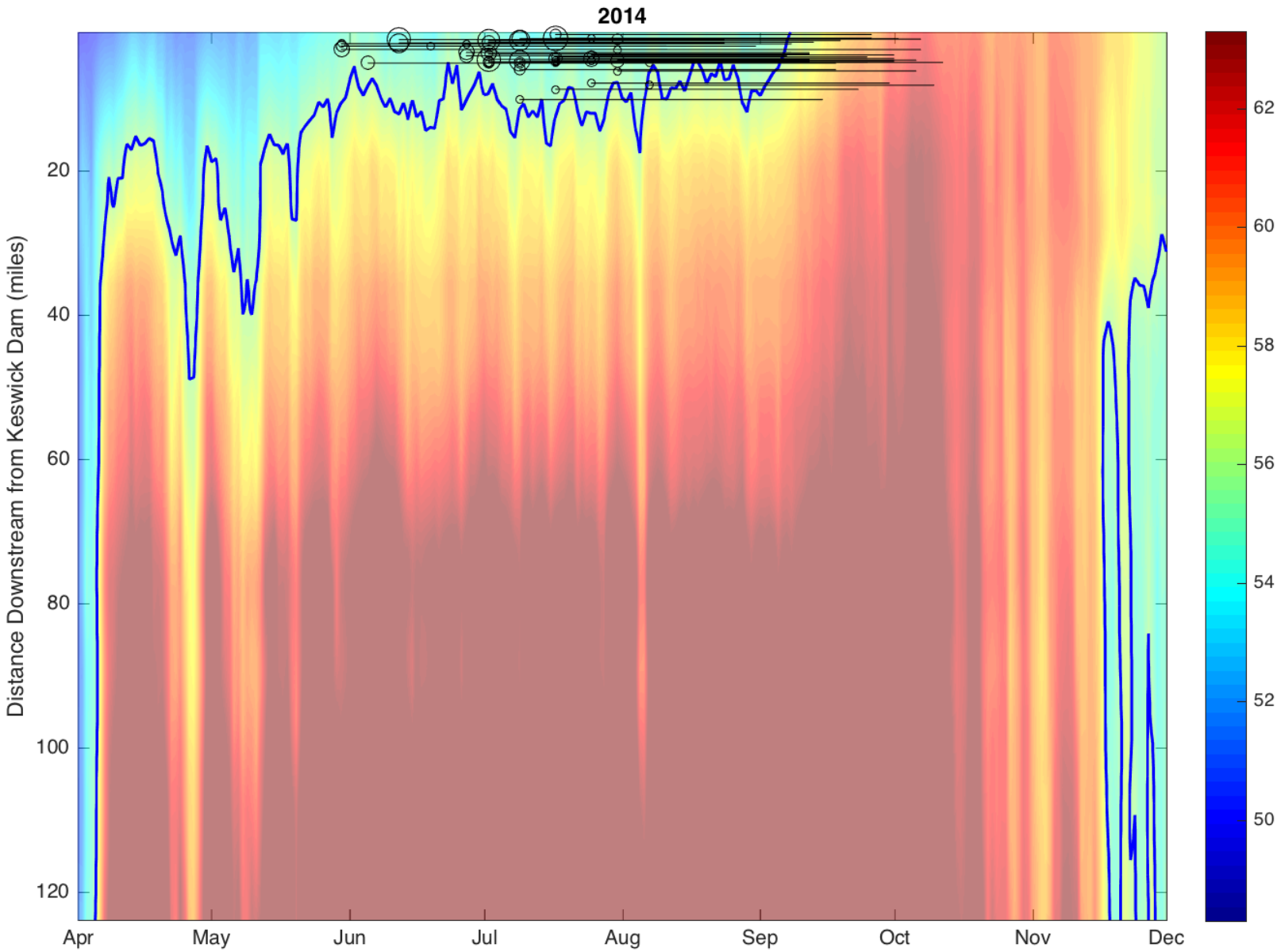
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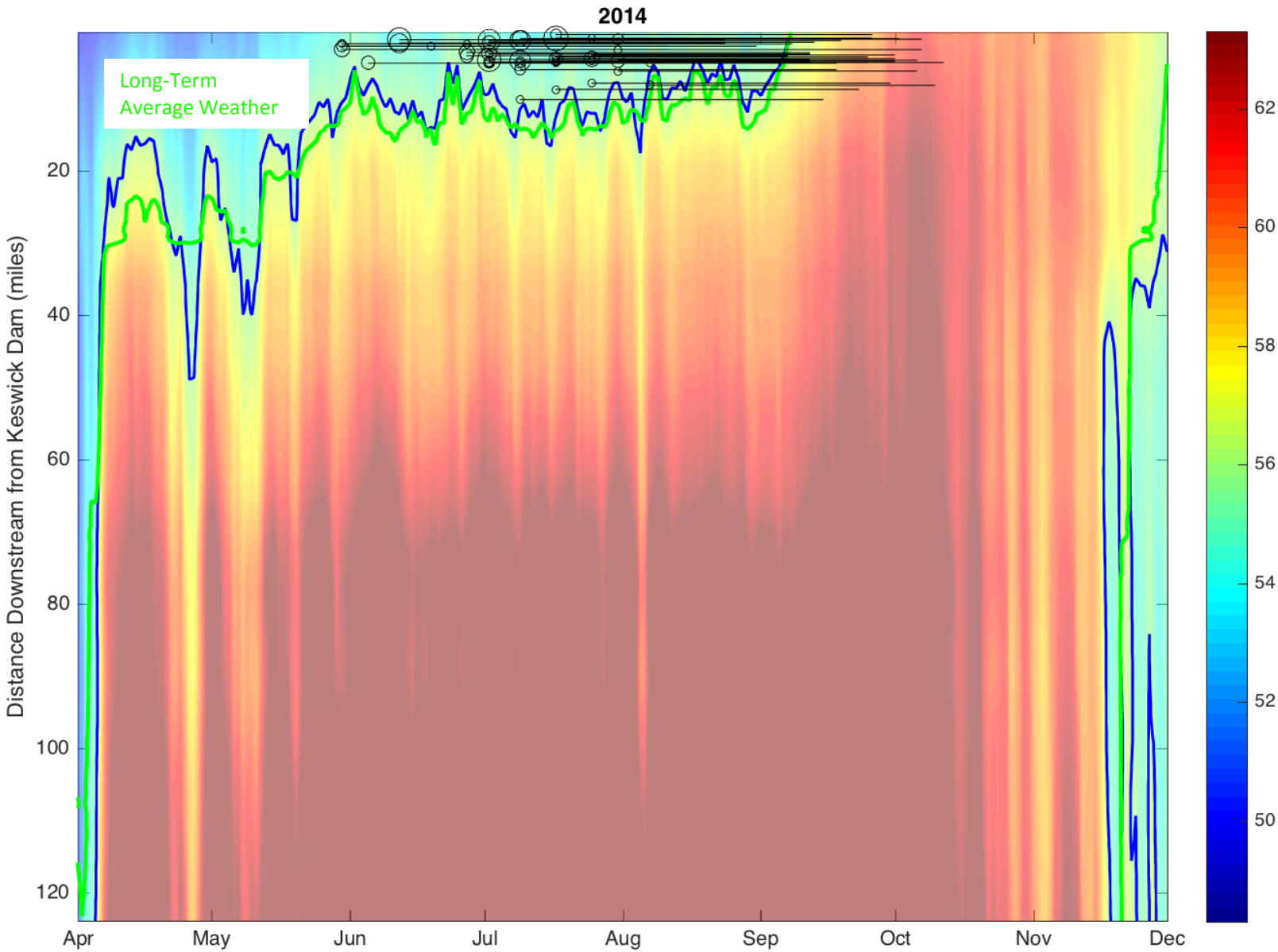

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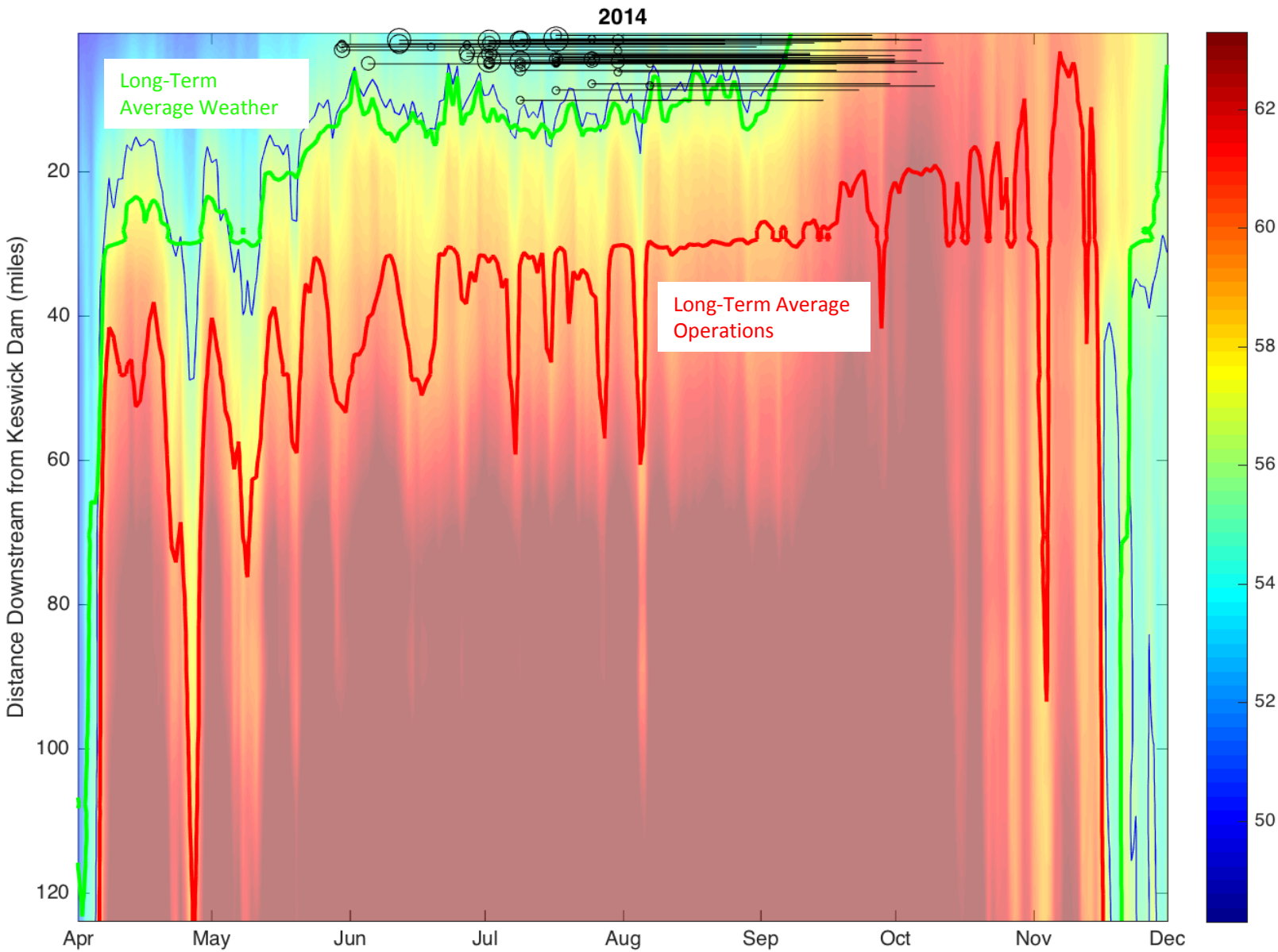

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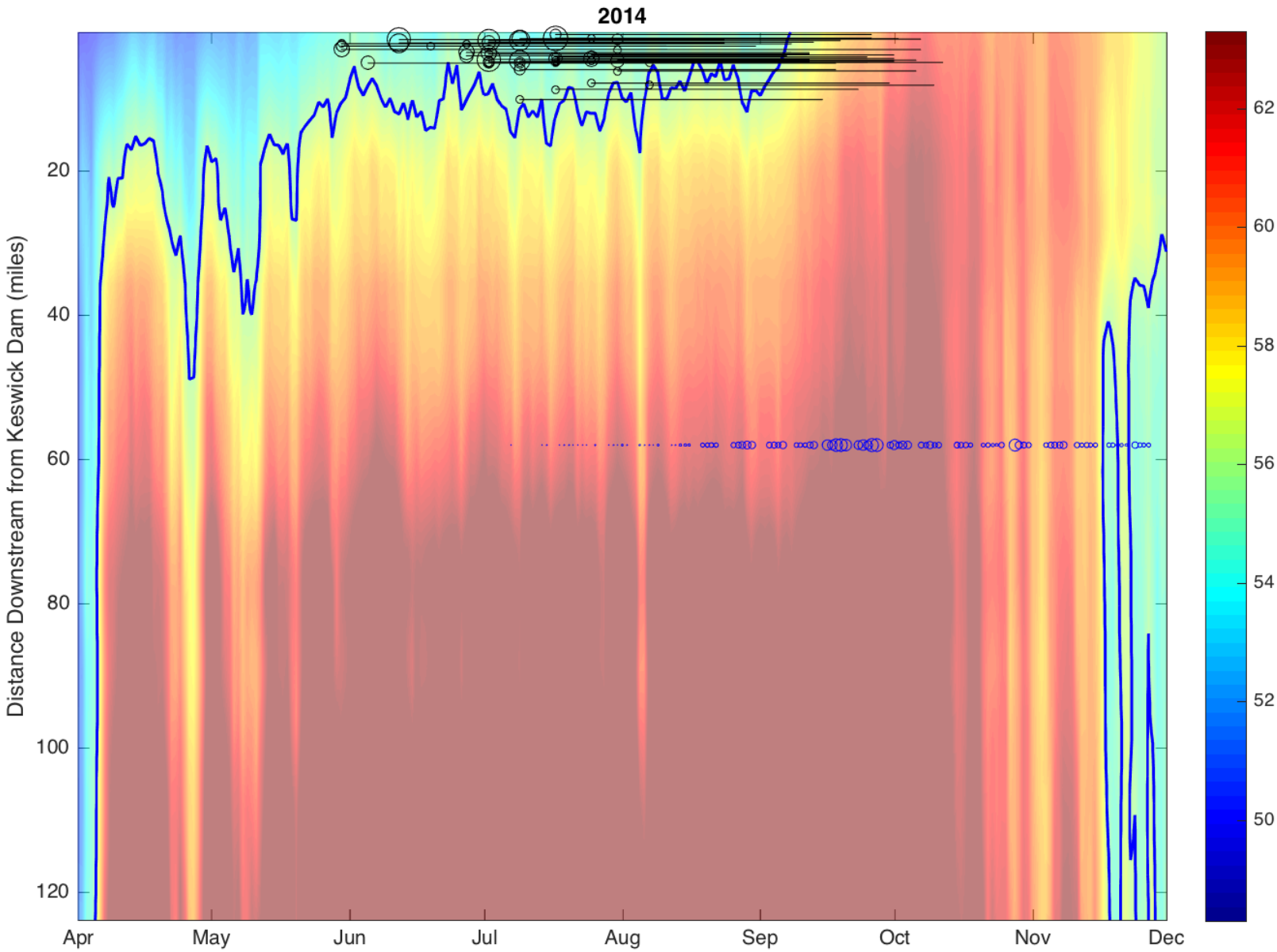
Long-Term Average Operations (Temperature and Flow) with 2015 Weather


2014
Distance Downstream from Keswick Dam (miles)
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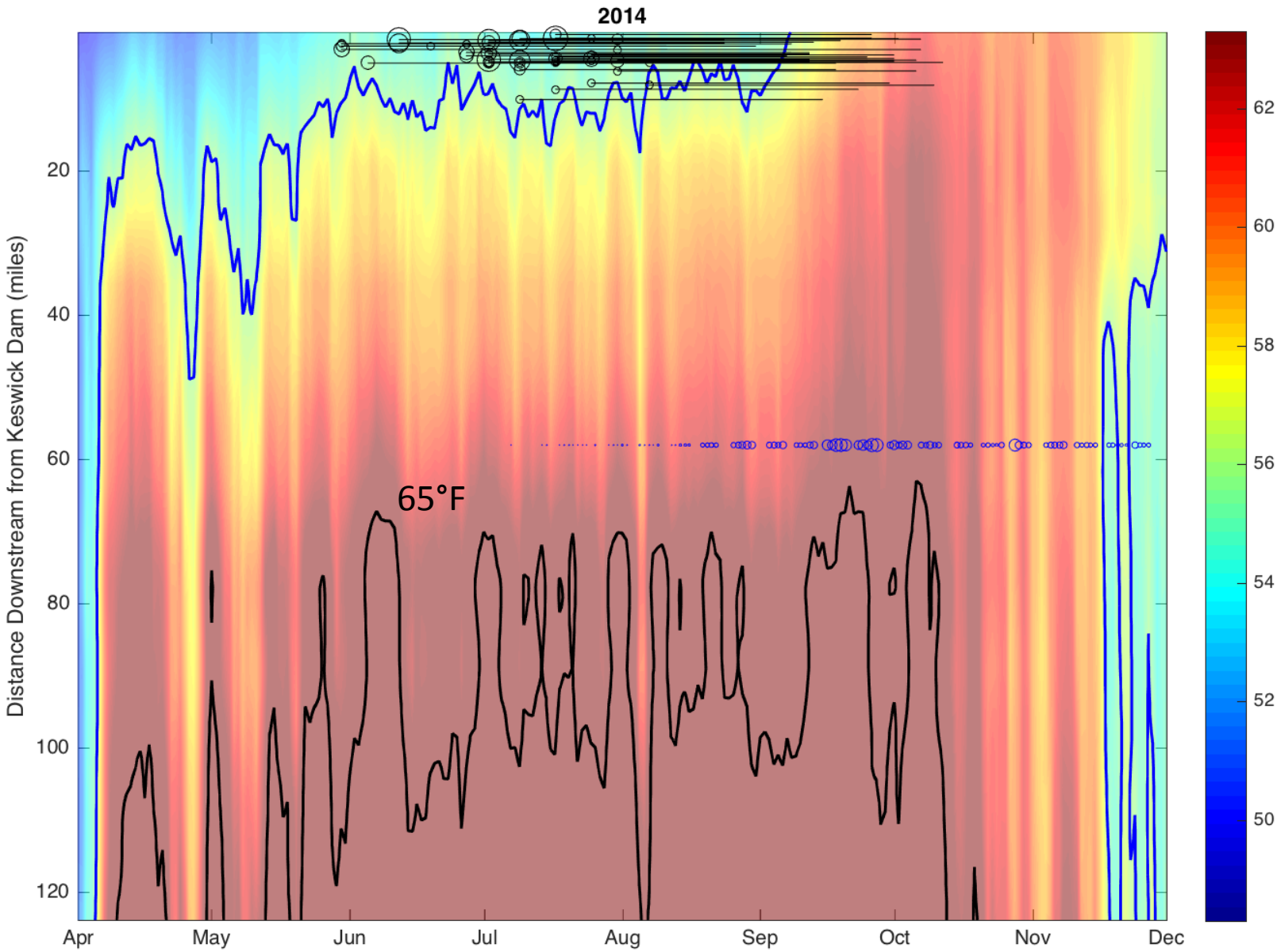
2014
Distance Downstream from Keswick Dam (miles)
20
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Nov
Dec
65°F
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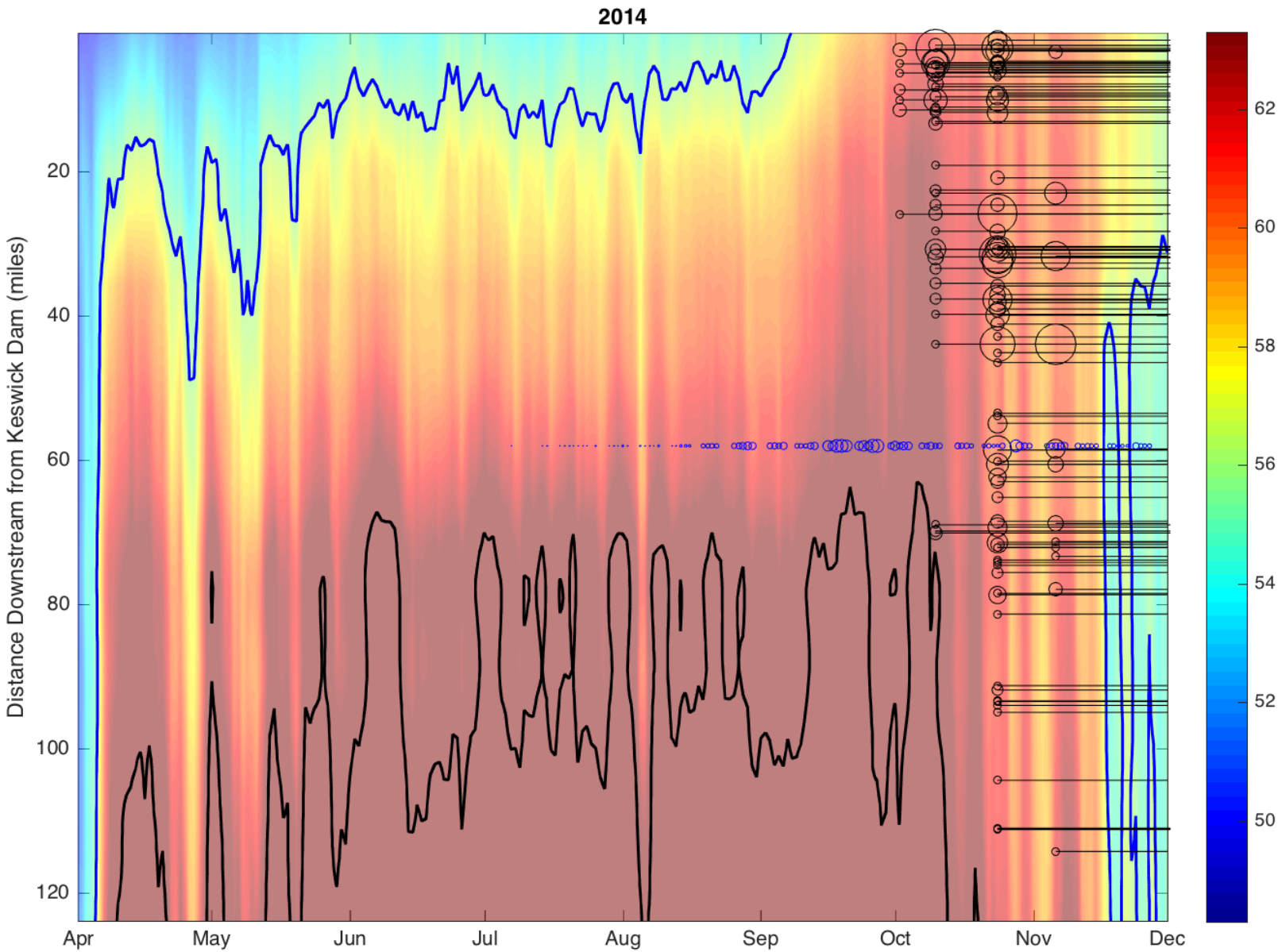
2014
Distance Downstream from Keswick Dam (miles)
20
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80
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120
Apr
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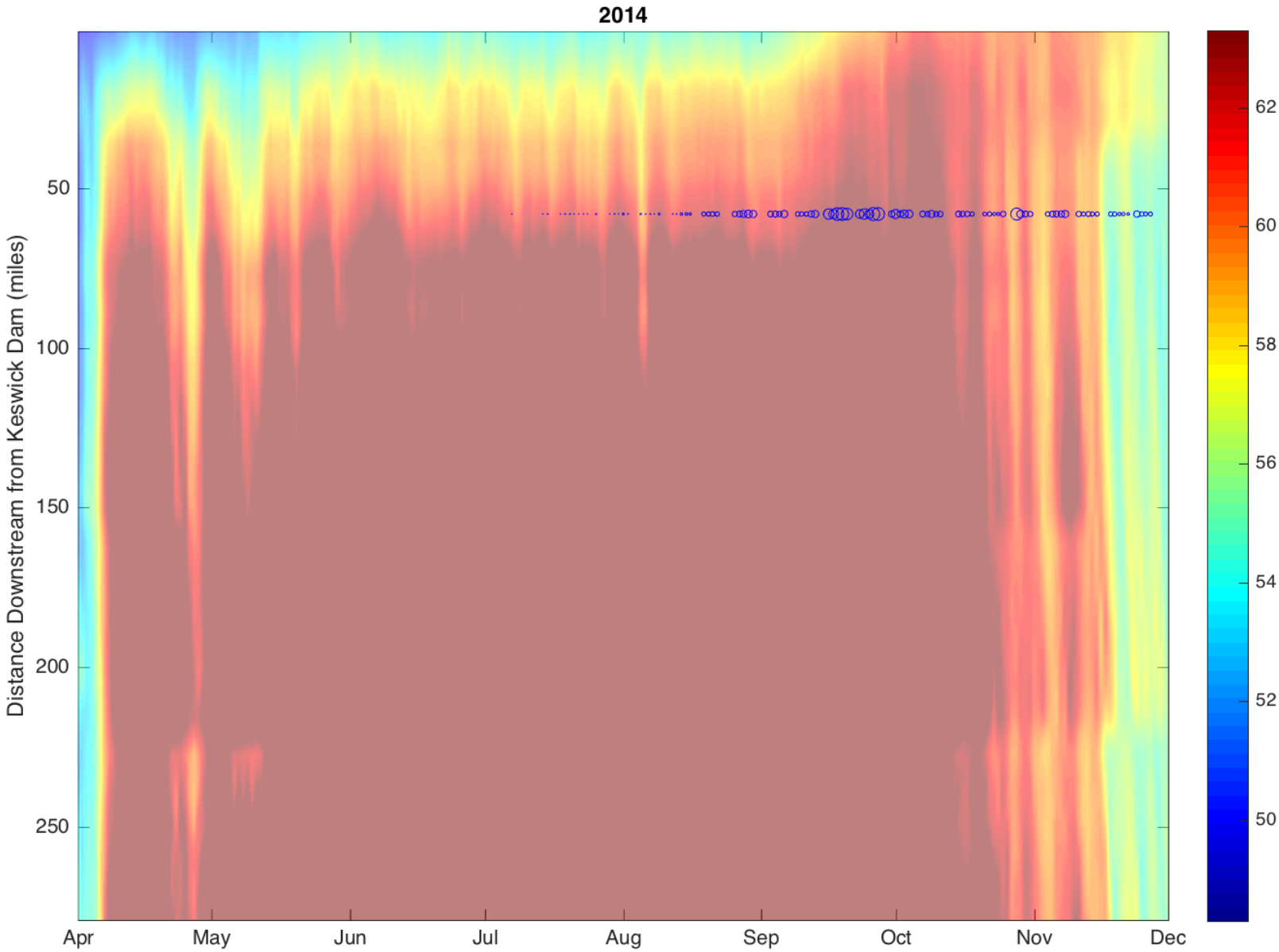
2014
Distance Downstream from Keswick Dam (miles)
50
100
150
200
250
Apr
May
Jun
Jul
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Nov
Dec
62
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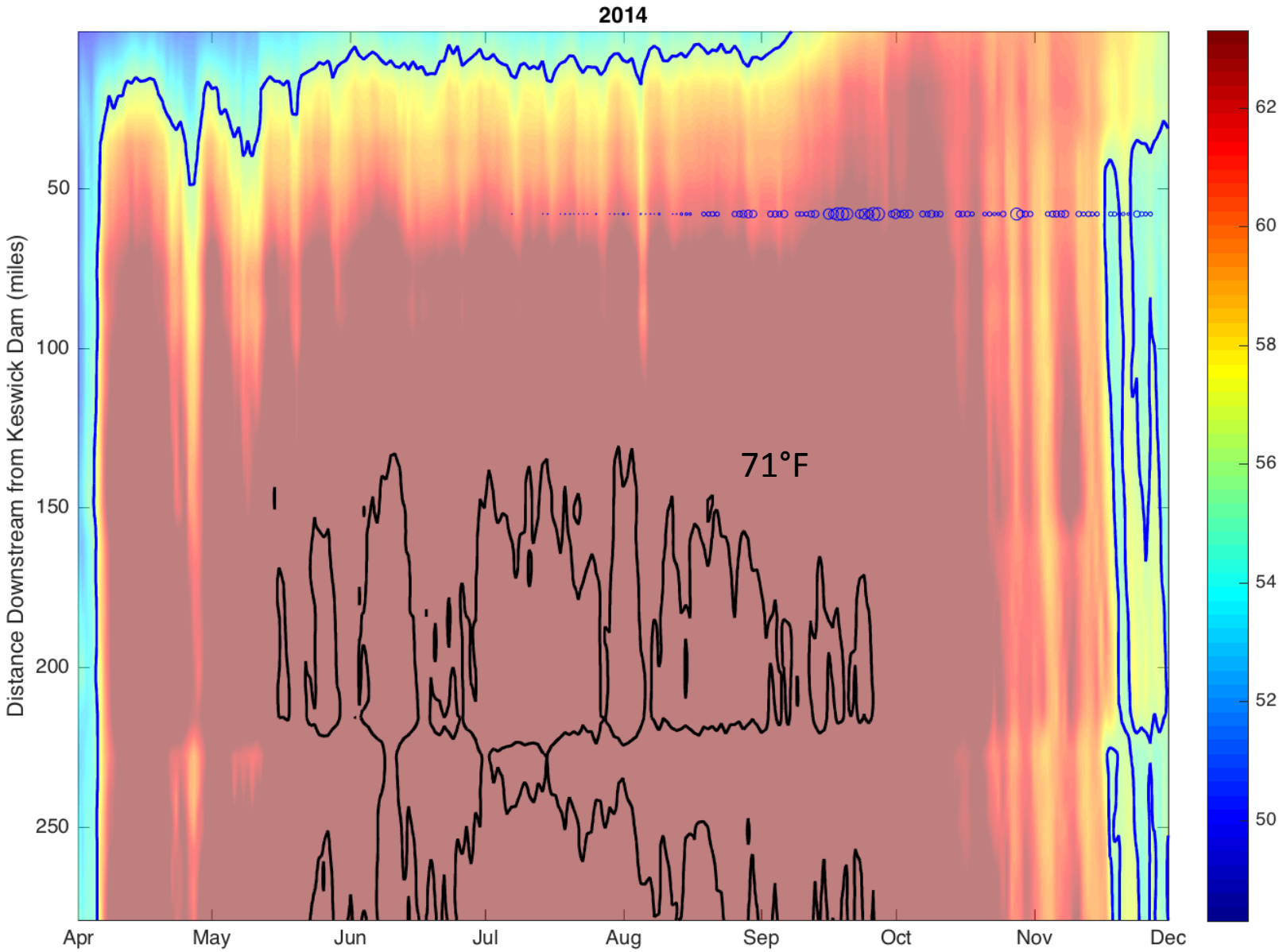
52
50


2014
Distance Downstream from Keswick Dam (miles)
50
100
150
200
250
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
71°F
62
60
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56
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52
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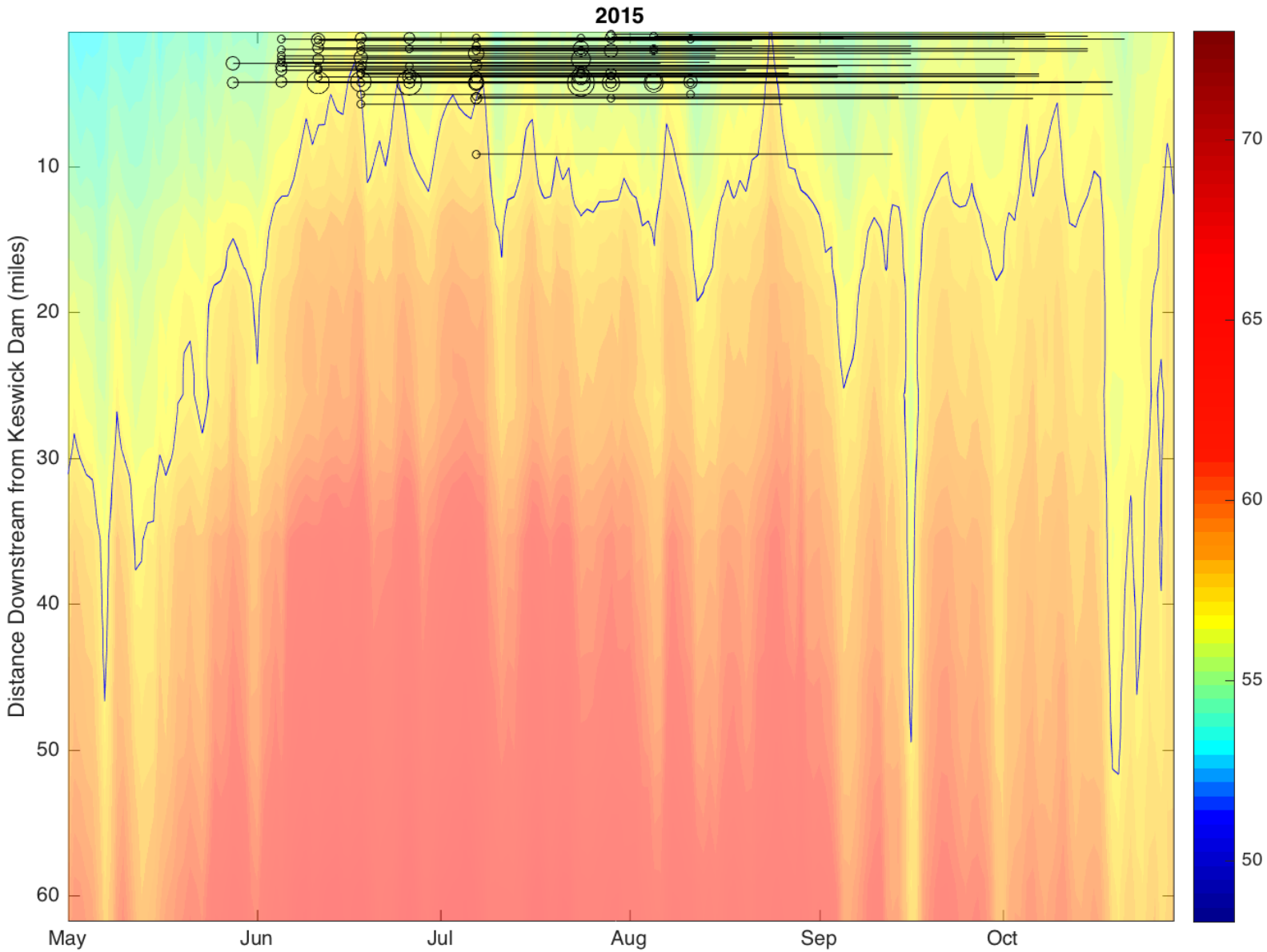
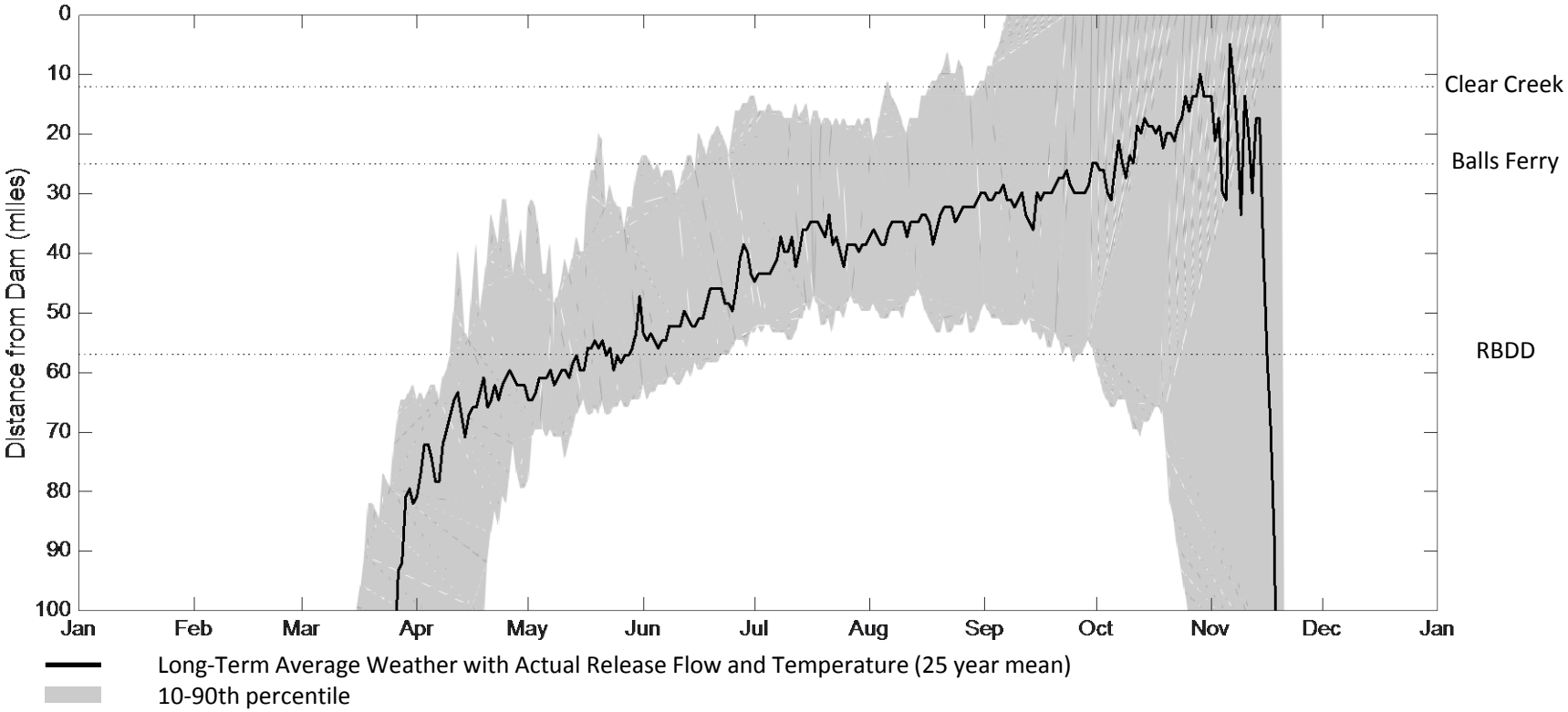

2015
Distance Downstream from Keswick Dam (miles)
10
20
30
40
50
60
May
Jun
Jul
Aug
Sep
Oct
70
65
60
55
50

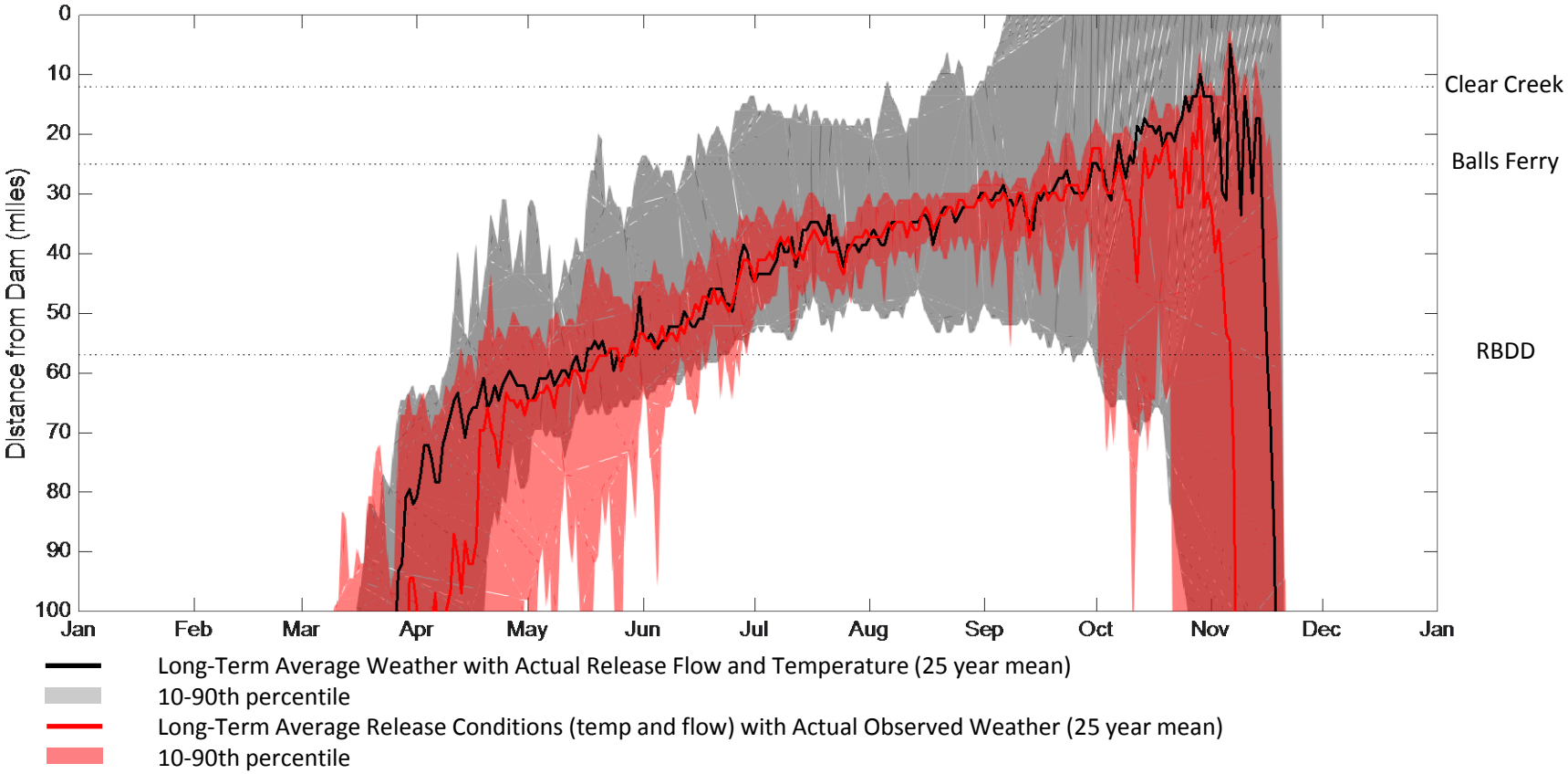
Amount of Coldwater Habitat

Distance downstream with daily mean temperatures below 56°F
(y-axis reversed)



Amount of Coldwater Habitat

Distance downstream with daily mean temperatures below 56°F
(y-axis reversed)



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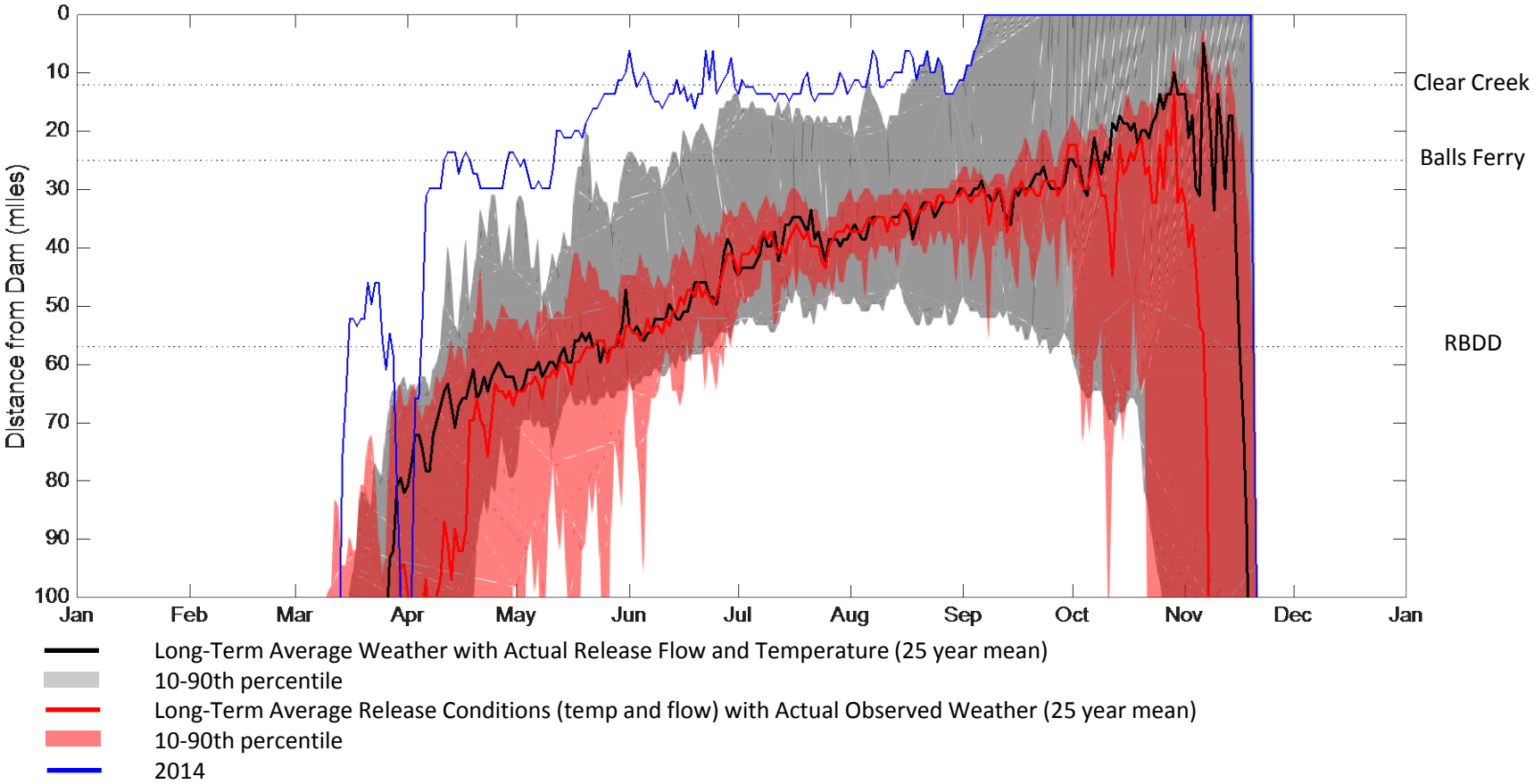
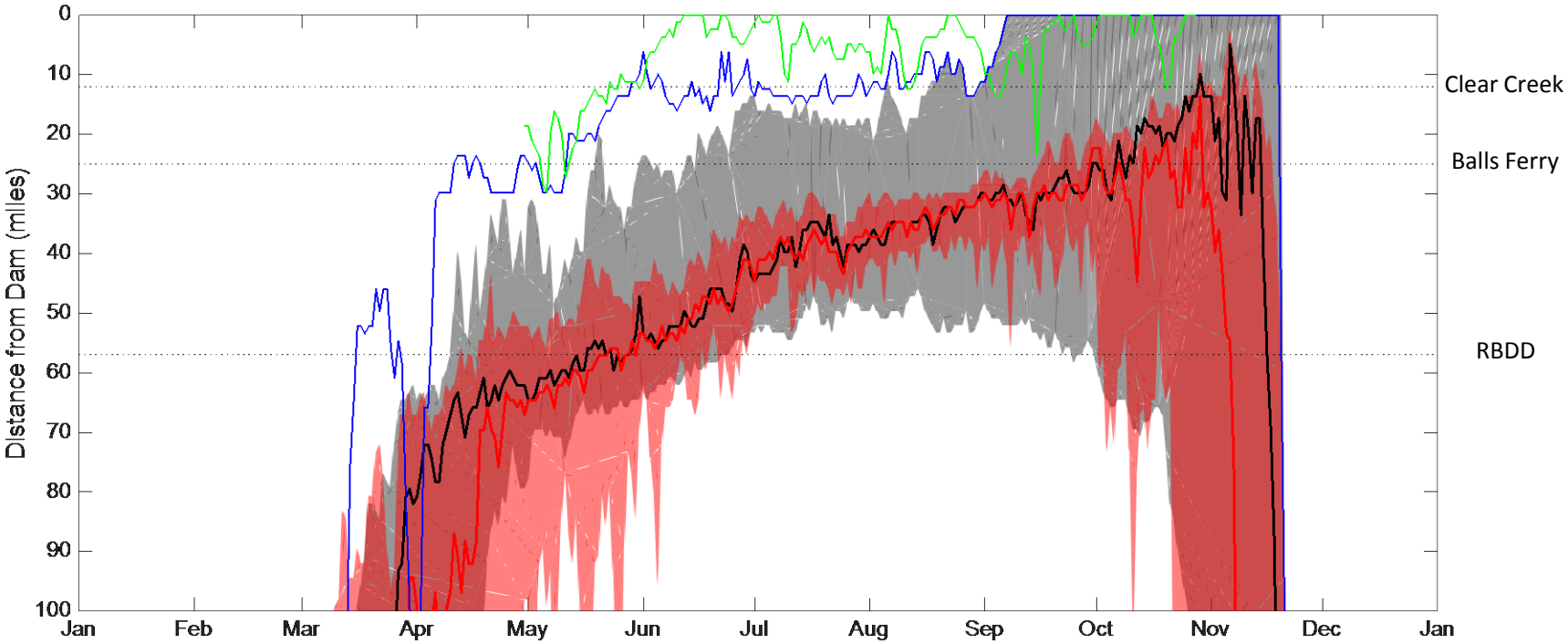


Amount of Coldwater Habitat

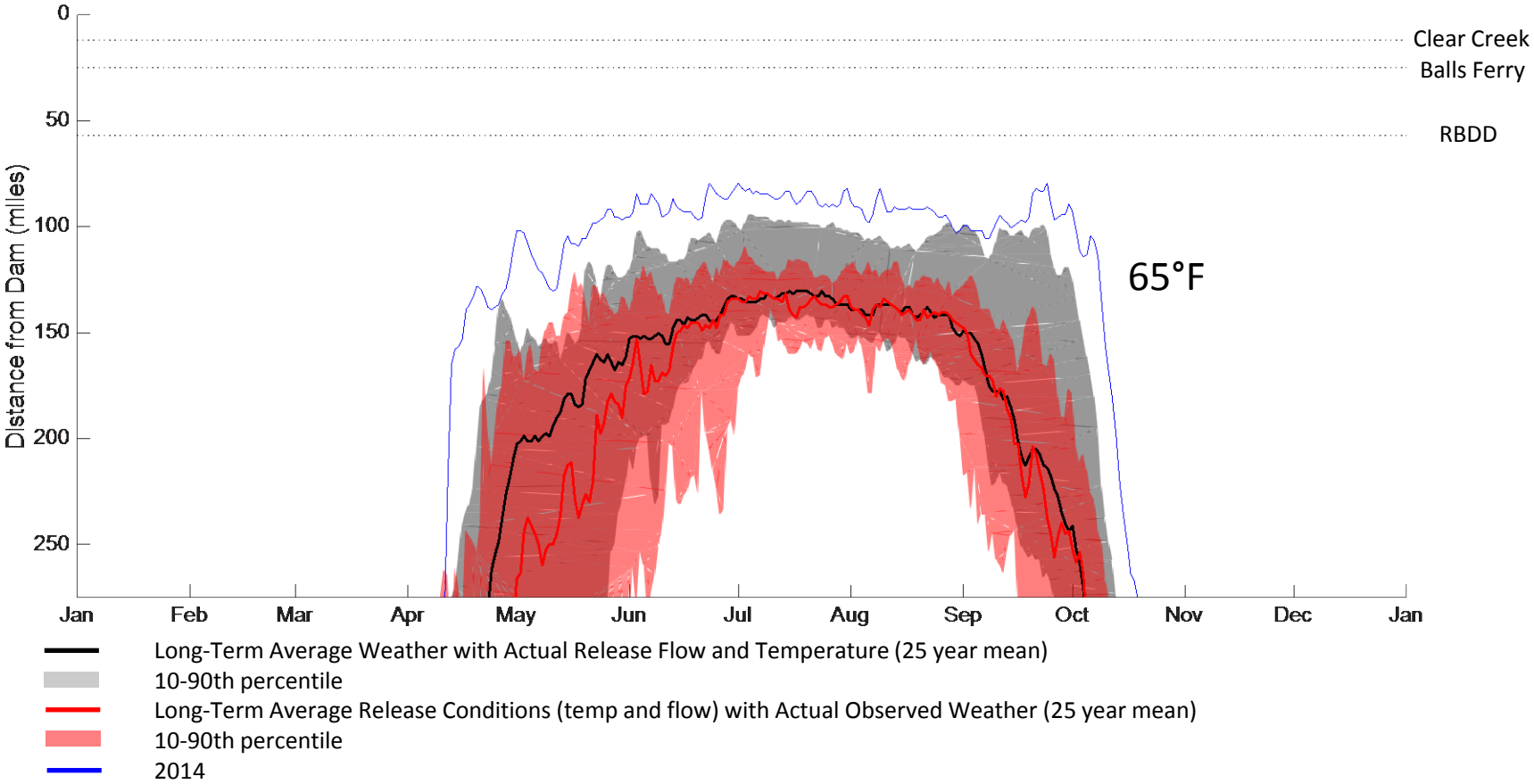
Distance downstream with daily mean temperatures below 56°F
(y-axis reversed)



- Long-Term Average Weather with Actual Release Flow and Temperature (25 year mean)
- 10-90th percentile
- Long-Term Average Release Conditions (temp and flow) with Actual Observed Weather (25 year mean)
- 10-90th percentile
- 2014
- 2015

Amount of Coldwater Habitat

Distance downstream with daily mean temperatures below 65°F
(y-axis reversed)



Linking RAFT to CE-Qual-W2

Tributary Inflow and Water Temperatures
- Sacramento River
- Pit River
- McCloud River
- Squaw Creek

Gridded Meteorological Data
- Air Temperature (°C)
- Dewpoint Temperature (°C)
- Wind Direction (phi radians)
- Wind Speed (m/s)
- Cloud Cover (0-10 = clear to cloudy)
- Solar Radiation (W/m2)

Reservoir Operations Data
- Outflow
- TCD operations

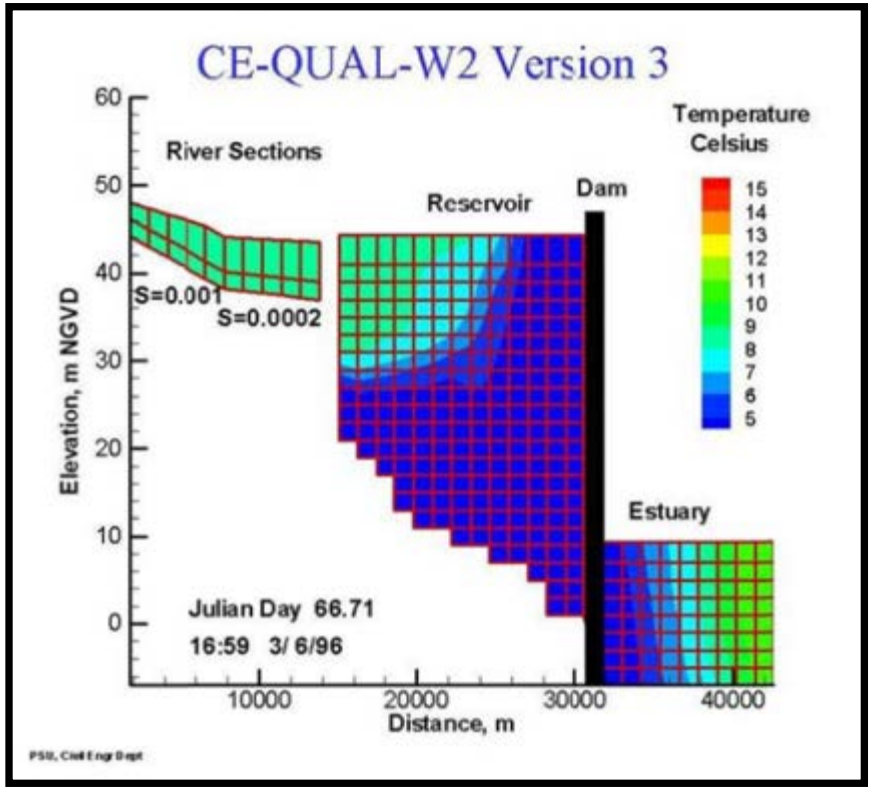
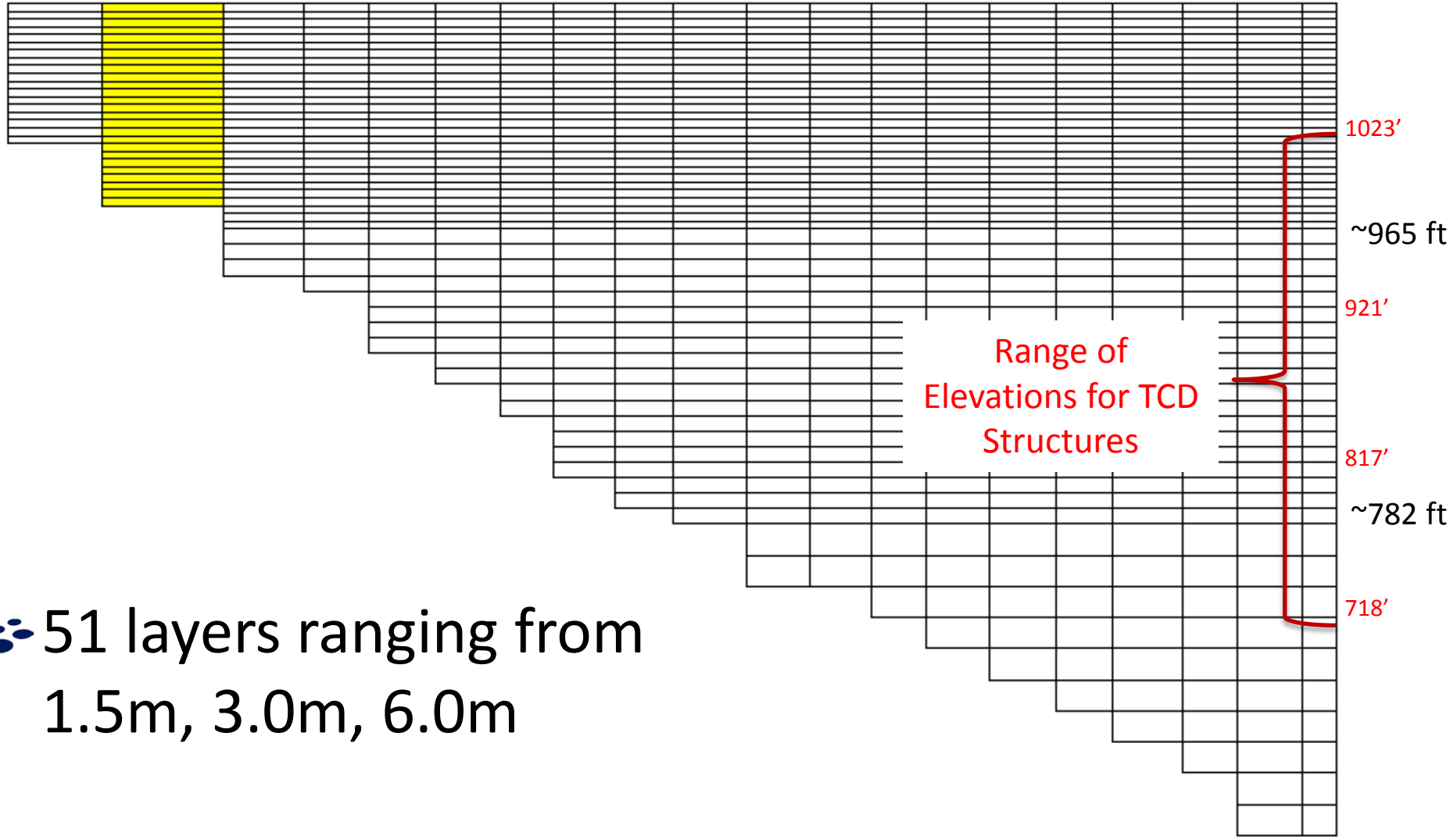


Figure 1. Sample two-dimensional CE-QUAL-W2 representation showing grid with in the vertical and horizontal directions. Conditions are assumed constant across the width of each cell.

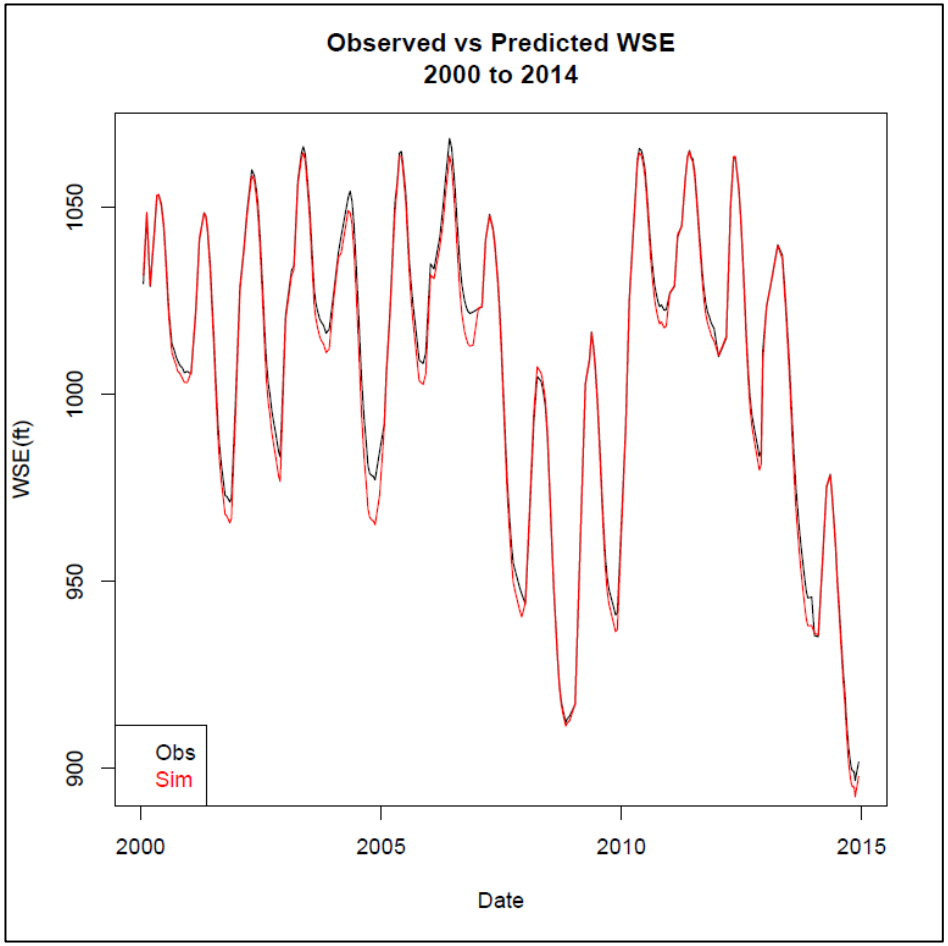
CE-Qual-W2

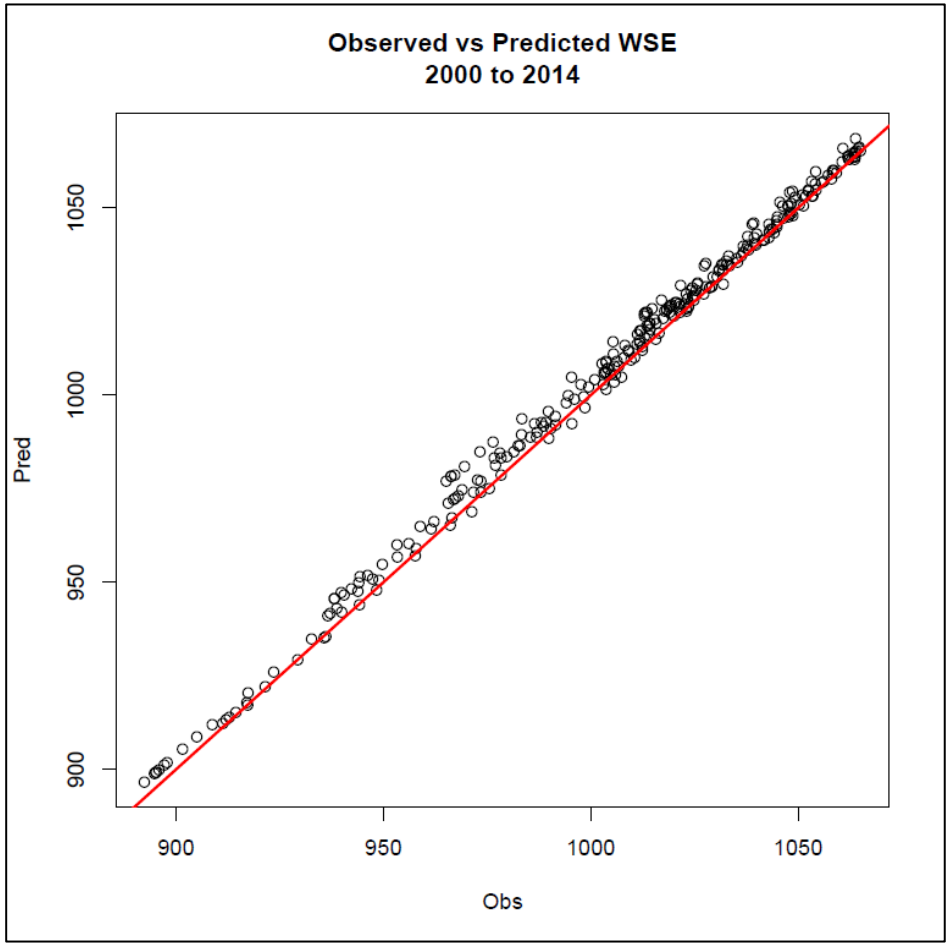


- 51 layers ranging from 1.5m, 3.0m, 6.0m

Model Water Surface Elevation Calculations

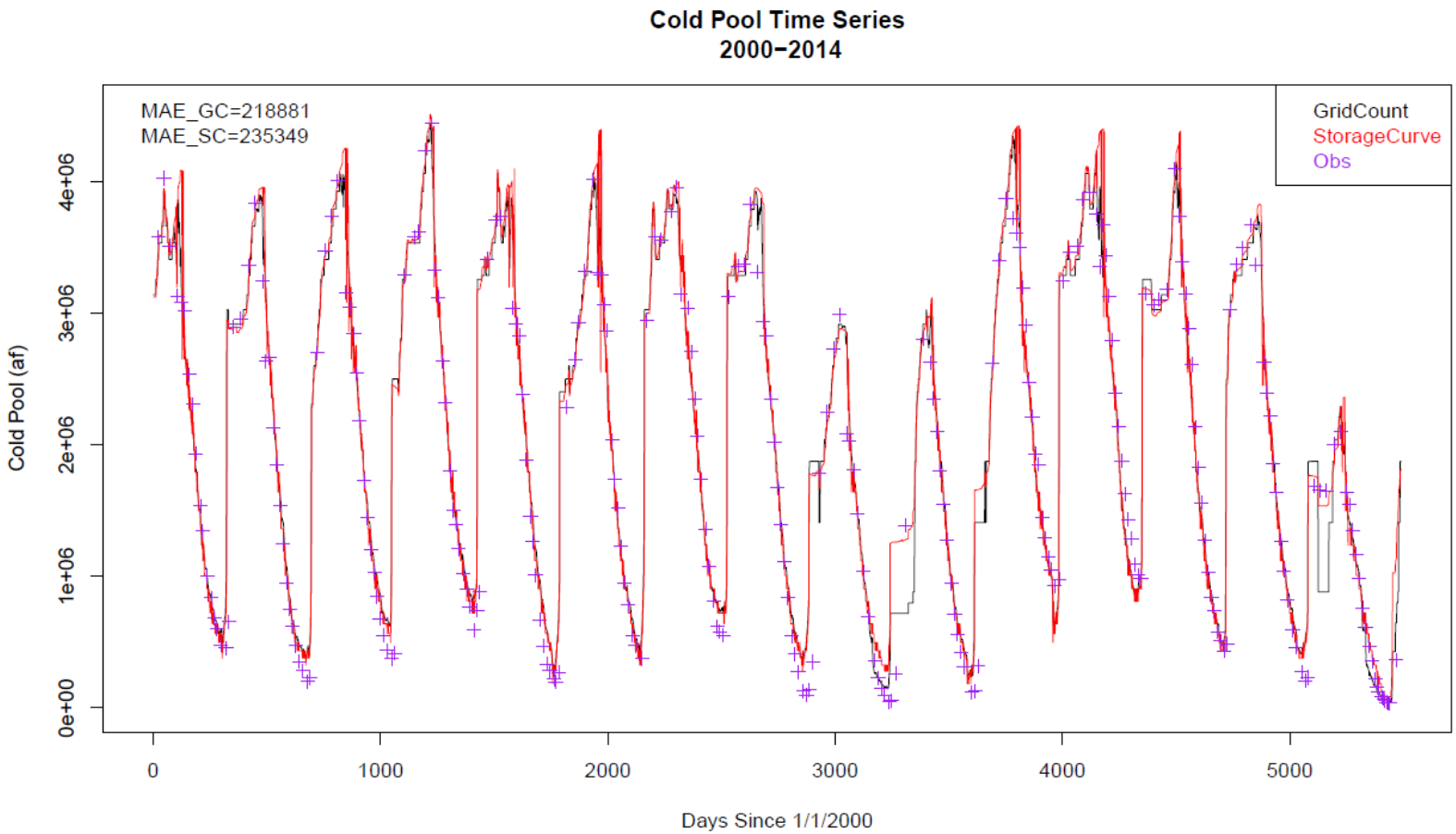
Mean Absolute Error = 3.2 feet (0.97 m)

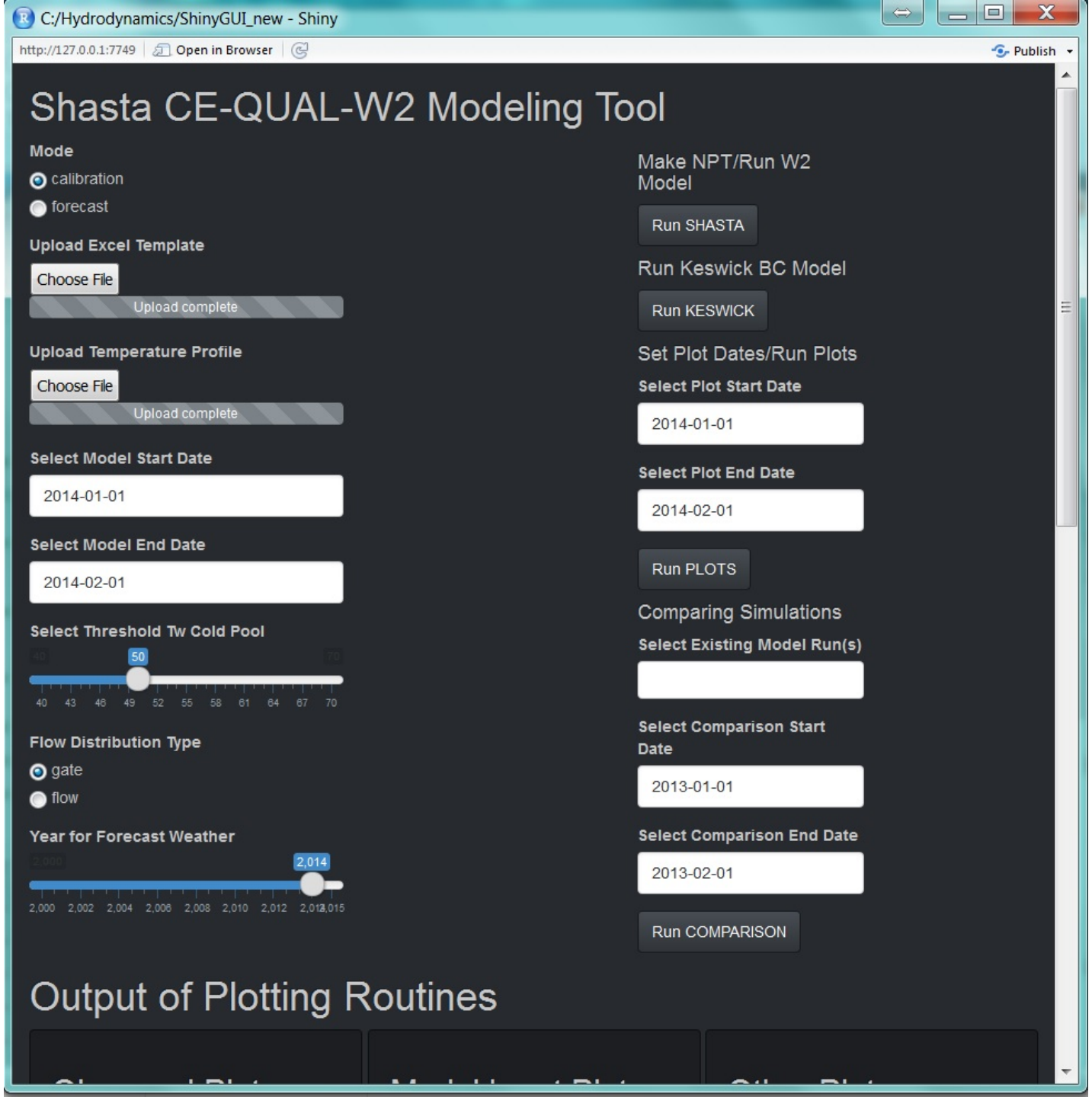




Model Cold Pool Calculations

Observed values calculated from thermal profiles and elevation-storage curve → similar results to modeled values throughout the period 2000-2014




C:/Hydrodynamics/ShinyGUI_new - Shiny
http://127.0.0.1:7749
Open in Browser
Publish
Shasta CE-QUAL-W2 Modeling Tool
Mode
calibration
forecast
Upload Excel Template
Choose File
Upload complete
Upload Temperature Profile
Choose File
Upload complete
Select Model Start Date
2014-01-01
Select Model End Date
2014-02-01
Select Threshold Tw Cold Pool
50
40 43 46 49 52 55 58 61 64 67 70
Flow Distribution Type
gate
flow
Year for Forecast Weather
2,014
2,000 2,002 2,004 2,006 2,008 2,010 2,012 2,014 2,015
Make NPT/Run W2 Model
Run SHASTA
Run Keswick BC Model
Run KESWICK
Set Plot Dates/Run Plots
Select Plot Start Date
2014-01-01
Select Plot End Date
2014-02-01
Run PLOTS
Comparing Simulations
Select Existing Model Run(s)
Select Comparison Start Date
2013-01-01
Select Comparison End Date
2013-02-01
Run COMPARISON
Output of Plotting Routines

C:/Hydrodynamics/ShinyGUI_new - Shiny

http://127.0.0.1:7749 | Open in Browser | Publish

Output of Plotting Routines

Observed Plots

- TCD Side
- TCD Low
- TCD Mid
- TCD Upp
- SHS Inflow
- SHS Outflow
- SHS Storage
- SHS WSE
- Pit Tw
- McCloud Tw
- Sacramento Tw
- USGS Flow Pit
- USGS Flow McCloud
- USGS Flow Sacramento

Compare Sim Plots

- ColdPoolElev
- ColdPoolVol
- SHS Tot Out
- SHS AvgTw Out
- SHS Storage
- SHS WSE
- Thresh Tw
- KES Q
- KES Tw

Model Input Plots

- TCD Side Frac
- TCD Low Frac
- TCD Mid Frac
- TCD Upp Frac
- Pit Inflow
- Squaw Inflow
- McCloud Inflow
- Sacramento Inflow
- Pit Inflow Tw
- Squaw Inflow Tw
- McCloud Inflow Tw
- Sacramento Inflow Tw
- Hourly Tair
- Hourly Tdew
- Hourly Wind Speed
- Hourly Wind Dir
- Hourly Cloud Cover
- Hourly Side Flow
- Hourly Low Flow
- Hourly Mid Flow
- Hourly Upp Flow

Other Plots

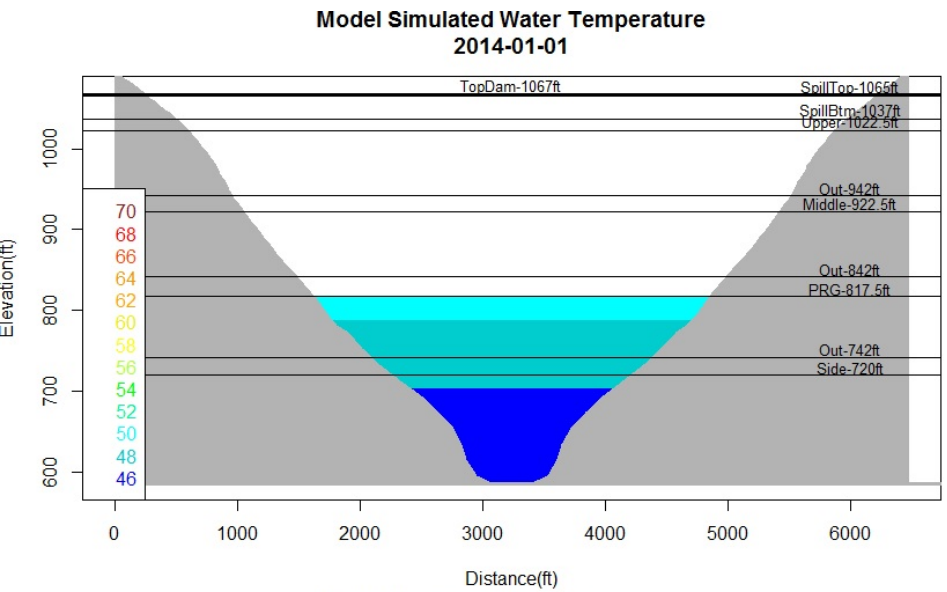
- Cold Pool Volume TS
- Cold Pool Elevation TS
- 2-Panel Plot
- Cross Section Movie
- Keswick BC CSV

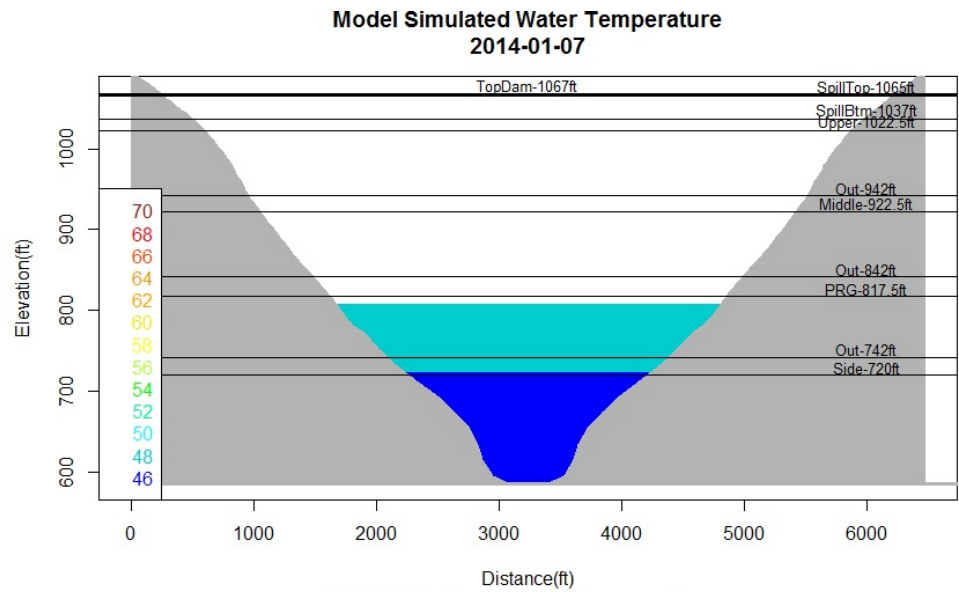
Calibration Plots

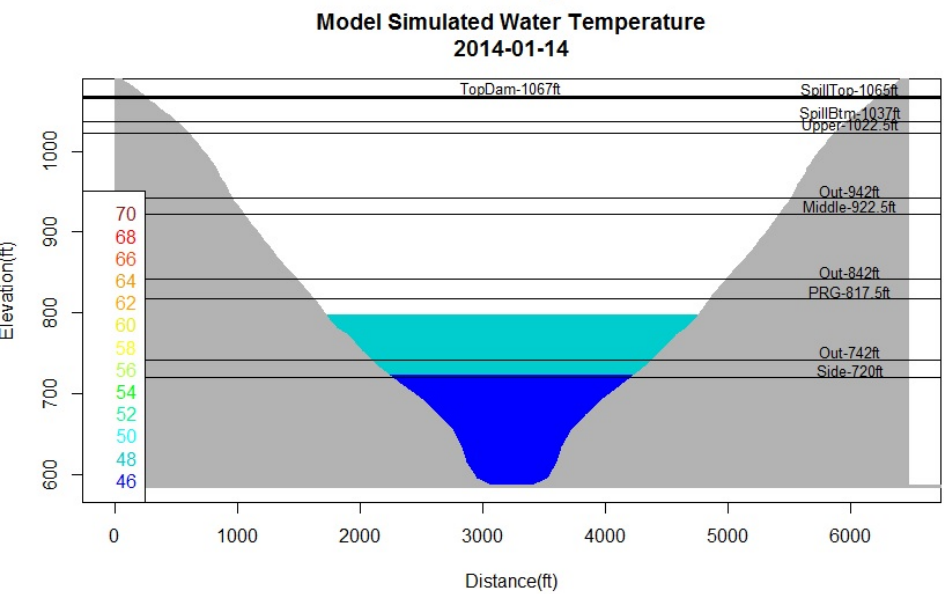
- Obs-Pred Tw by Elev
- Obs-Pred WSE (Scatter)
- Obs-Pred WSE (TimeSeries)
- Obs-Pred Keswick Q
- Obs-Pred Keswick Tw

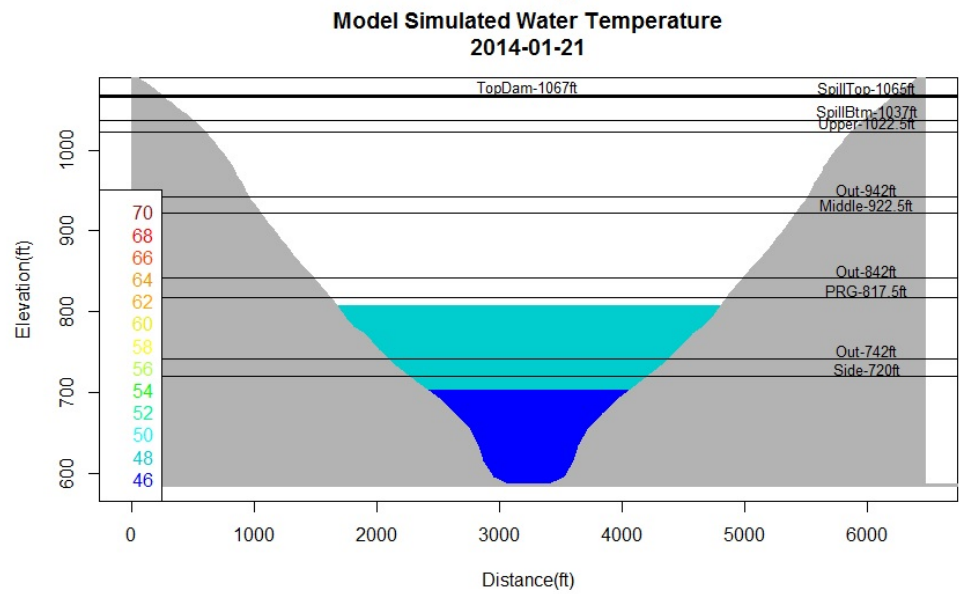
Orig 2000-2014 Calib Plots

- Seasonality Errors (Tw)
- Seasonality Errors (Flow)
- Obs-Pred Keswick Q
- Obs-Pred Keswick Tw
- ARIMA Model vs Obs
- Obs-Pred WSE (Time Series)
- Obs-Pred WSE (Scatterplot)
- Compare Tw by Elevation
- Default Gate Operations
- Compare Model-Obsv Cold Pool at 56F

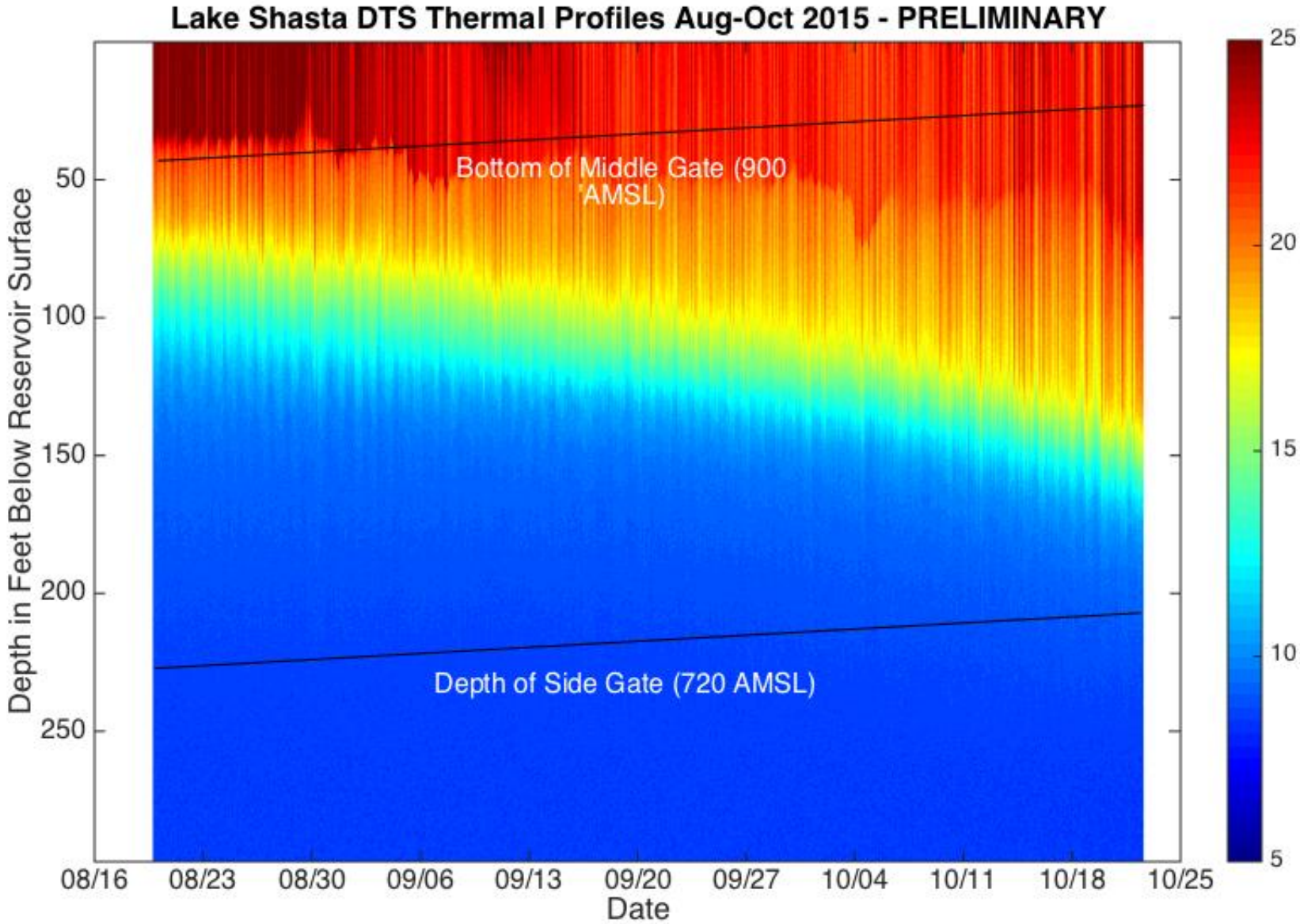

Model Simulated Water Temperature
2014-01-01
TopDam-1067ft
SpillTop-1065ft
SpillBtm-1037ft
Upper-1022.5ft
Out-942ft
Middle-922.5ft
Out-842ft
PRG-817.5ft
Out-742ft
Side-720ft
70
68
66
64
62
60
58
56
54
52
50
48
46
Elevation(ft)
600
700
800
900
1000
0
1000
2000
3000
4000
5000
6000
Distance(ft)


Model Simulated Water Temperature
2014-01-07
TopDam-1067ft
SpillTop-1065ft
SpillBtm-1037ft
Upper-1022.5ft
Out-942ft
Middle-922.5ft
Out-842ft
PRG-817.5ft
Out-742ft
Side-720ft
70
68
66
64
62
60
58
56
54
52
50
48
46
Elevation(ft)
600
700
800
900
1000
0
1000
2000
3000
4000
5000
6000
Distance(ft)


Model Simulated Water Temperature
2014-01-14
TopDam-1067ft
SpillTop-1065ft
SpillBtm-1037ft
Upper-1022.5ft
Out-942ft
Middle-922.5ft
Out-842ft
PRG-817.5ft
Out-742ft
Side-720ft
70
68
66
64
62
60
58
56
54
52
50
48
46
Elevation(ft)
600
700
800
900
1000
0
1000
2000
3000
4000
5000
6000
Distance(ft)


Model Simulated Water Temperature
2014-01-21
TopDam-1067ft
SpillTop-1065ft
SpillBtm-1037ft
Upper-1022.5ft
Out-942ft
Middle-922.5ft
Out-842ft
PRG-817.5ft
Out-742ft
Side-720ft
70
68
66
64
62
60
58
56
54
52
50
48
46
Elevation(ft)
600
700
800
900
1000
0
1000
2000
3000
4000
5000
6000
Distance(ft)

Distributed Temperature System (DTS)


Lake Shasta DTS Thermal Profiles Aug-Oct 2015 - PRELIMINARY
Bottom of Middle Gate (900 AMSL)
Depth of Side Gate (720 AMSL)
Depth in Feet Below Reservoir Surface
50
100
150
200
250
08/16
08/23
08/30
09/06
09/13
09/20
09/27
10/04
10/11
10/18
10/25
Date
25
20
15
10
5

Biological Models

1. Central Valley Chinook Live Cycle Model
2. Dynamic Energy Budget models
3. Egg mortality models

Summary

RAFT model is accurate, comprehensive, and flexible

Operations (release temperature and flow) have the greatest impact on downstream temperatures

Coupled river-reservoir model is critical

Future river temperatures will depend on proper management of reservoir temperature profiles

Questions for Panel

1. What additional calibration and validation is recommended for the RAFT model?

2. Coupling of the reservoir model with the river model requires modeling the intermediate 17km of the Keswick “river-reservoir”. Does the panel recommend extension of the RAFT model upstream or the CE-Qual-W2 model downstream?

3. What addition information or capabilities should be added to the DST to improve its usefulness to management?

Thank you

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