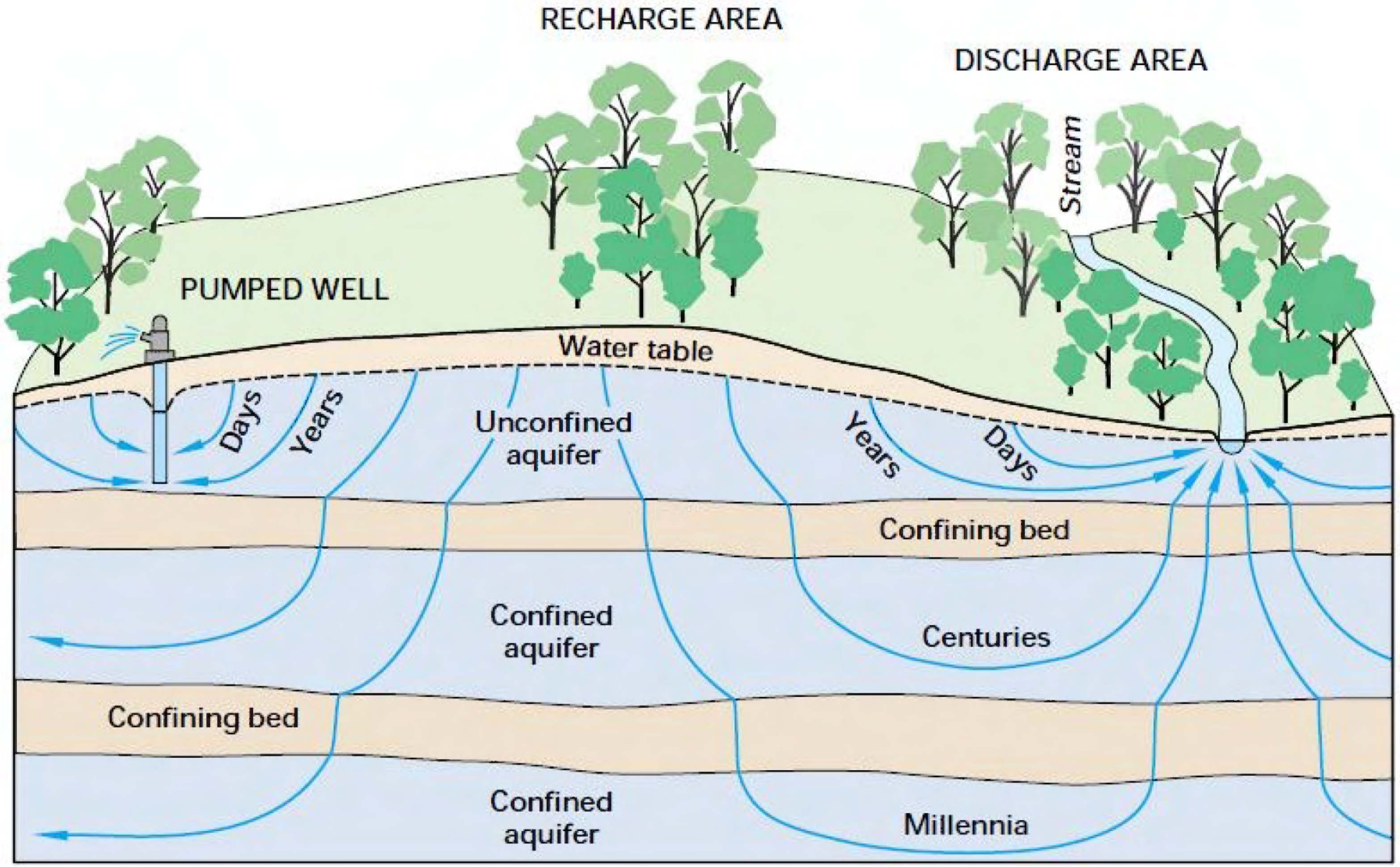
Recharge Lag Analysis

Treasure Valley MTAC, 6 December 2018

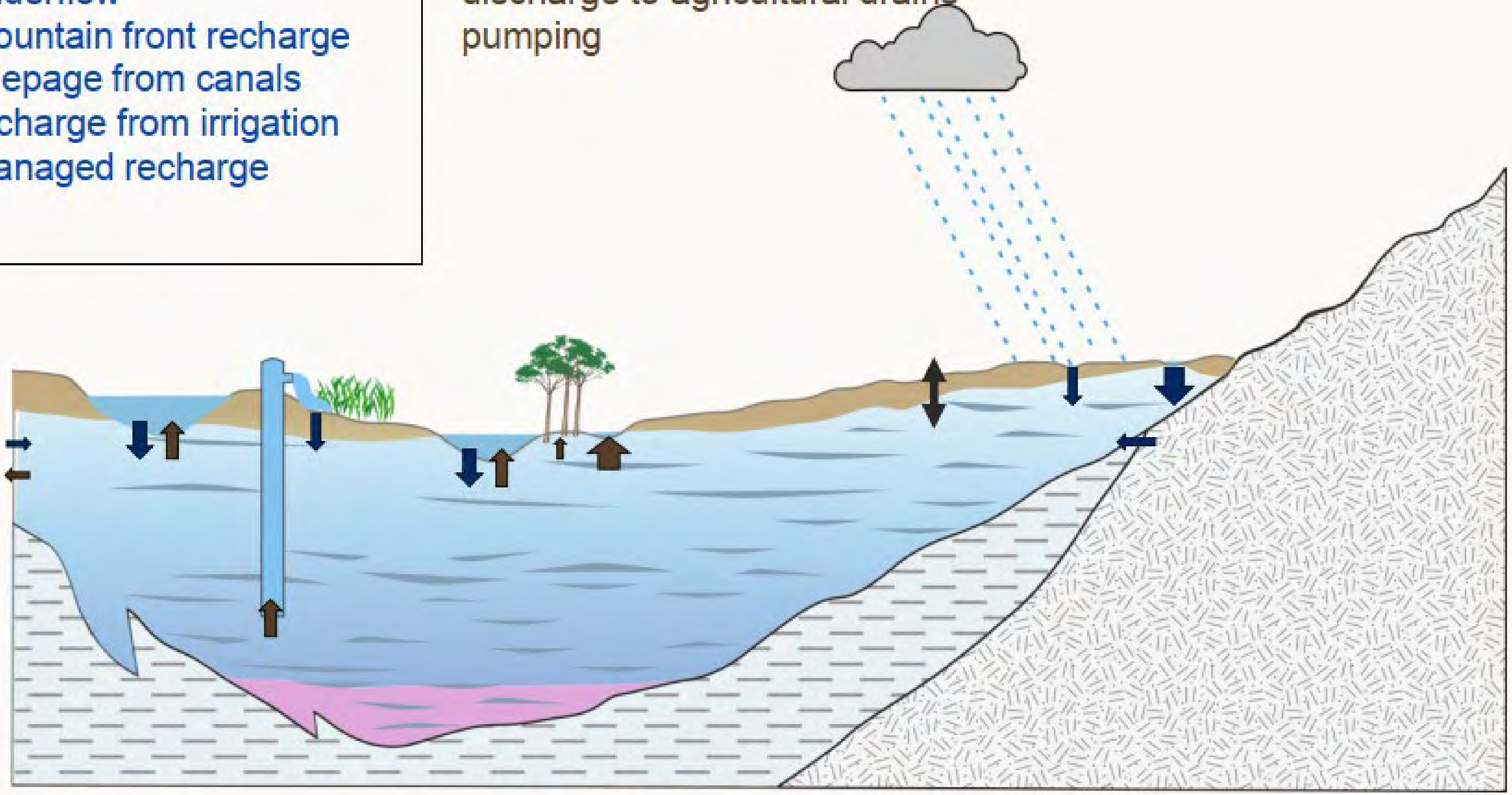


Indiana Geological Survey

In – Out = ±ΔStorage

In	Out
recharge from precipitation	discharge to streams & springs
seepage from streams	transpiration from phreatophytes
seepage from lakes	discharge to lakes & wetlands
underflow	discharge to agricultural drains
mountain front recharge	pumping
seepage from canals	
recharge from irrigation	
managed recharge	

Incidental Recharge



(modified from Faunt, 2009)

USGS science for a changing world

Aquifer System

From Hundt's TV MTAC Presentation, 3/1/2018

- Recharge lag time for infiltration of precipitation and irrigation is proportional to the thickness of the vadose zone.
  - Thicker vadose zone yields longer recharge lags.
- How much does the vadose (unsaturated) zone influence recharge rates.
  - Do we need to have a delay for recharge?
  - Does the delay vary spatially?
  - Are delays for incidental recharge and precip the same?
  - Are recharge signals attenuated?
- Do we see a need to include vadose zone influence in the model?
  - Scenarios (artificial recharge…)
  - monthly stress periods

Previous Approaches

1. Lindgren, 1982 (SE Boise)
   - 5% annual precip in non-irrigated areas
   - 100% in irrigated areas
   - No delays
2. TVHP
   - No delays
   - Spatially variable
3. USBR Transient Model
   - Shifted forward two months
     - Chosen by visual inspection of hydrograph and recharge parameter
     - Applied uniformly
   - Accounts for inter-bedding and confining layers

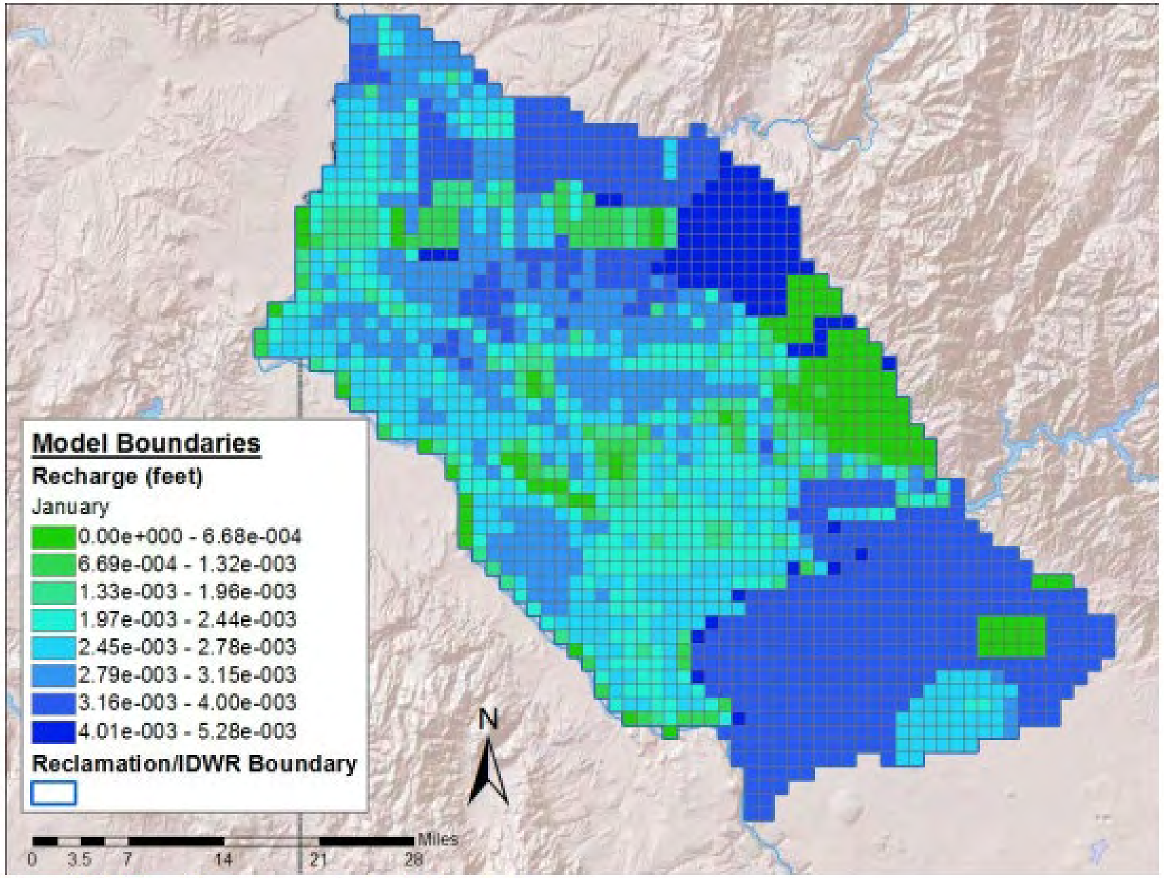
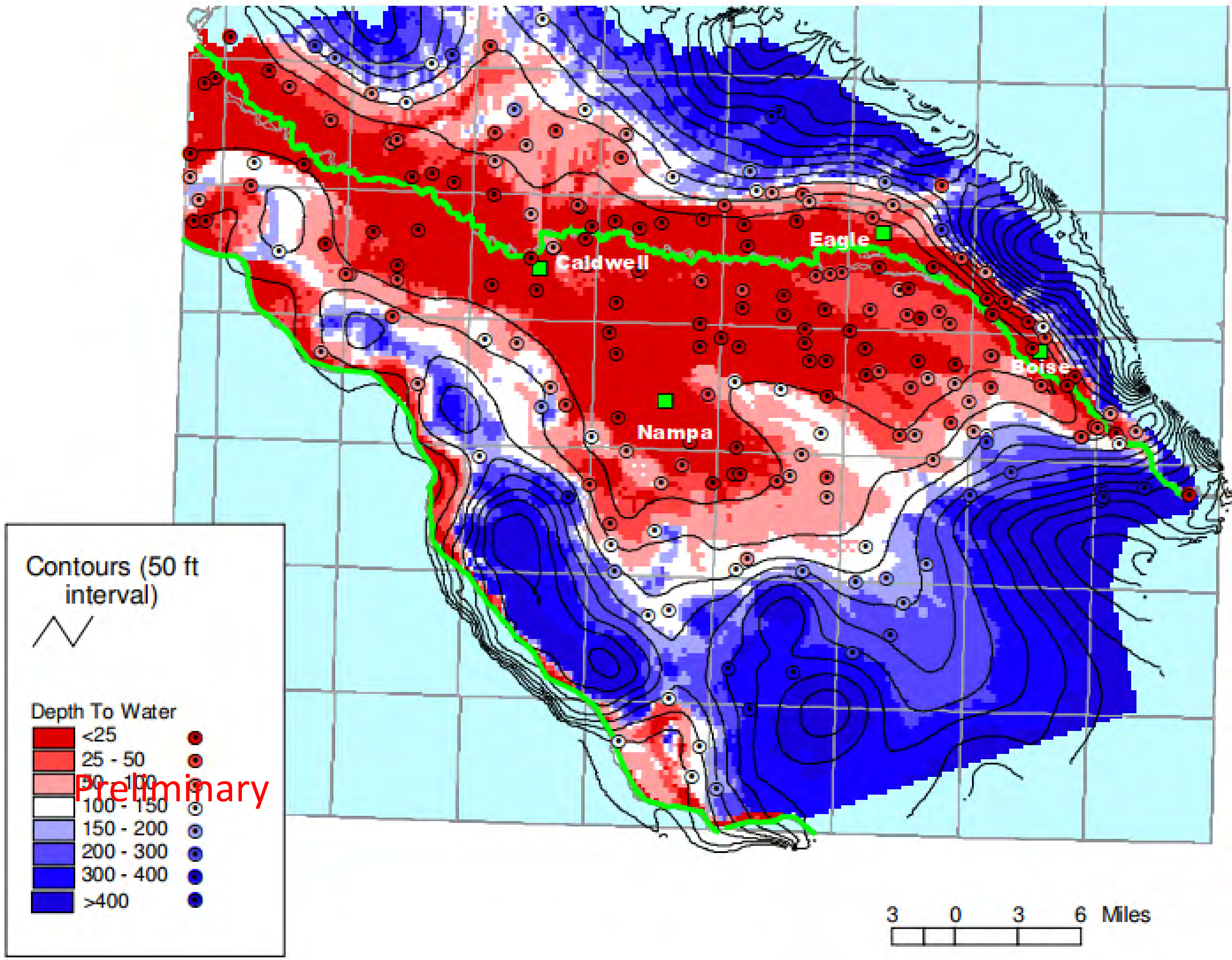


Figure 2-8: Map of average recharge for January.

Johnson, 2013, Development of Transient GW Model of Treasure Valley, USBR

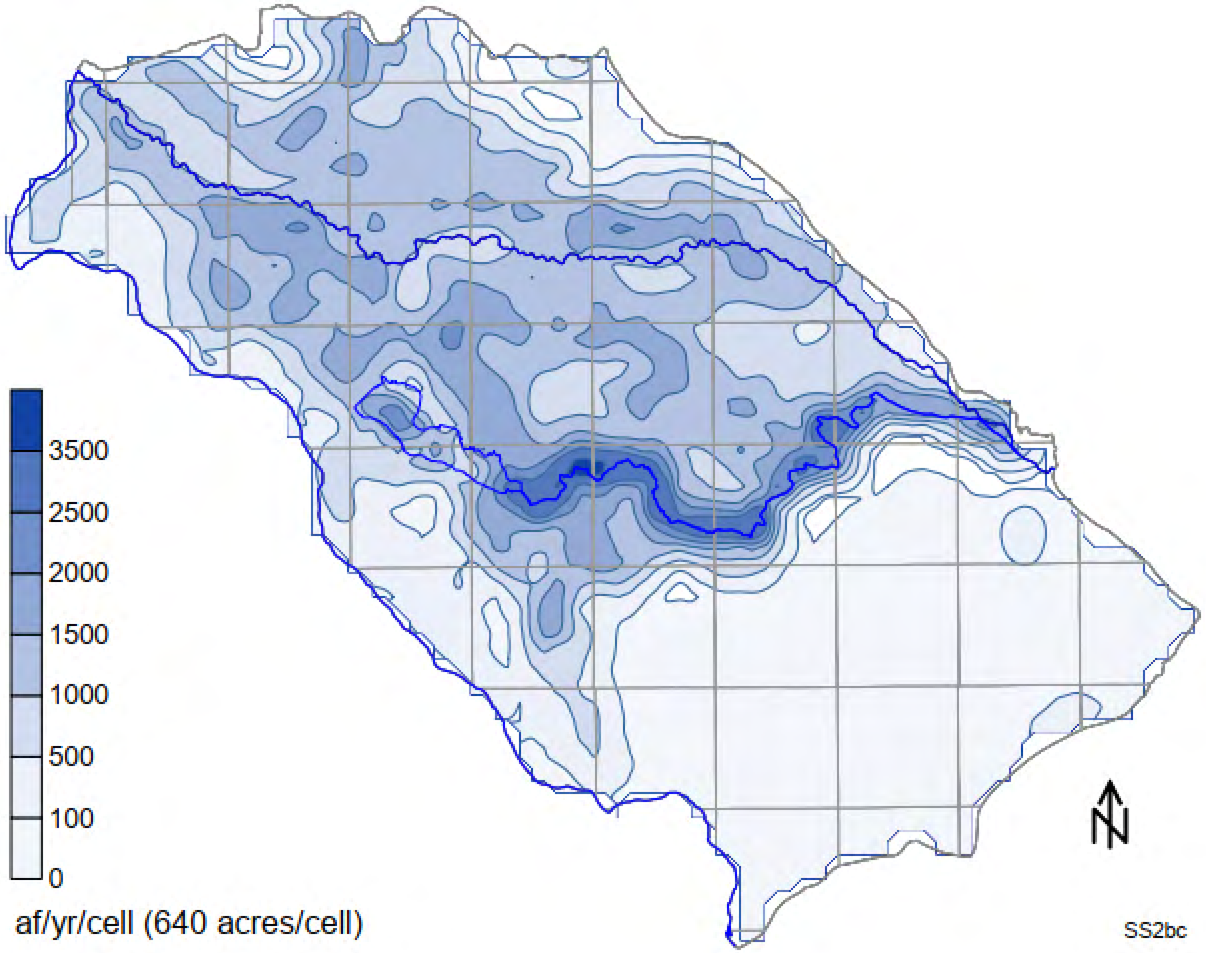
Vadose zone thickness

Depth to water/ thickness of vadose zone varies across the Treasure Valley



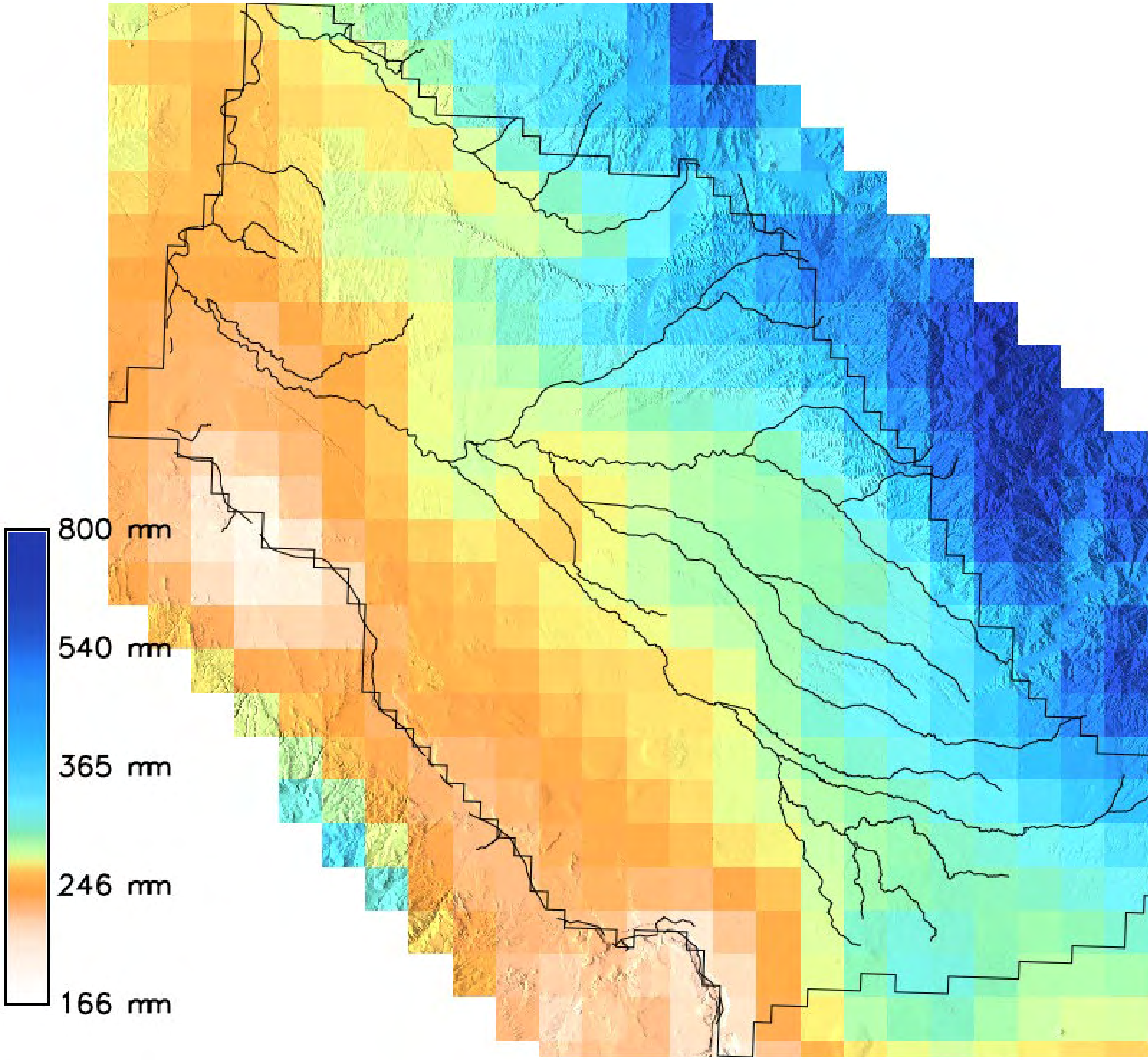
Where does recharge occur?

- Recharge amounts vary across the valley
- Combined effects of all inputs



Where does recharge occur?

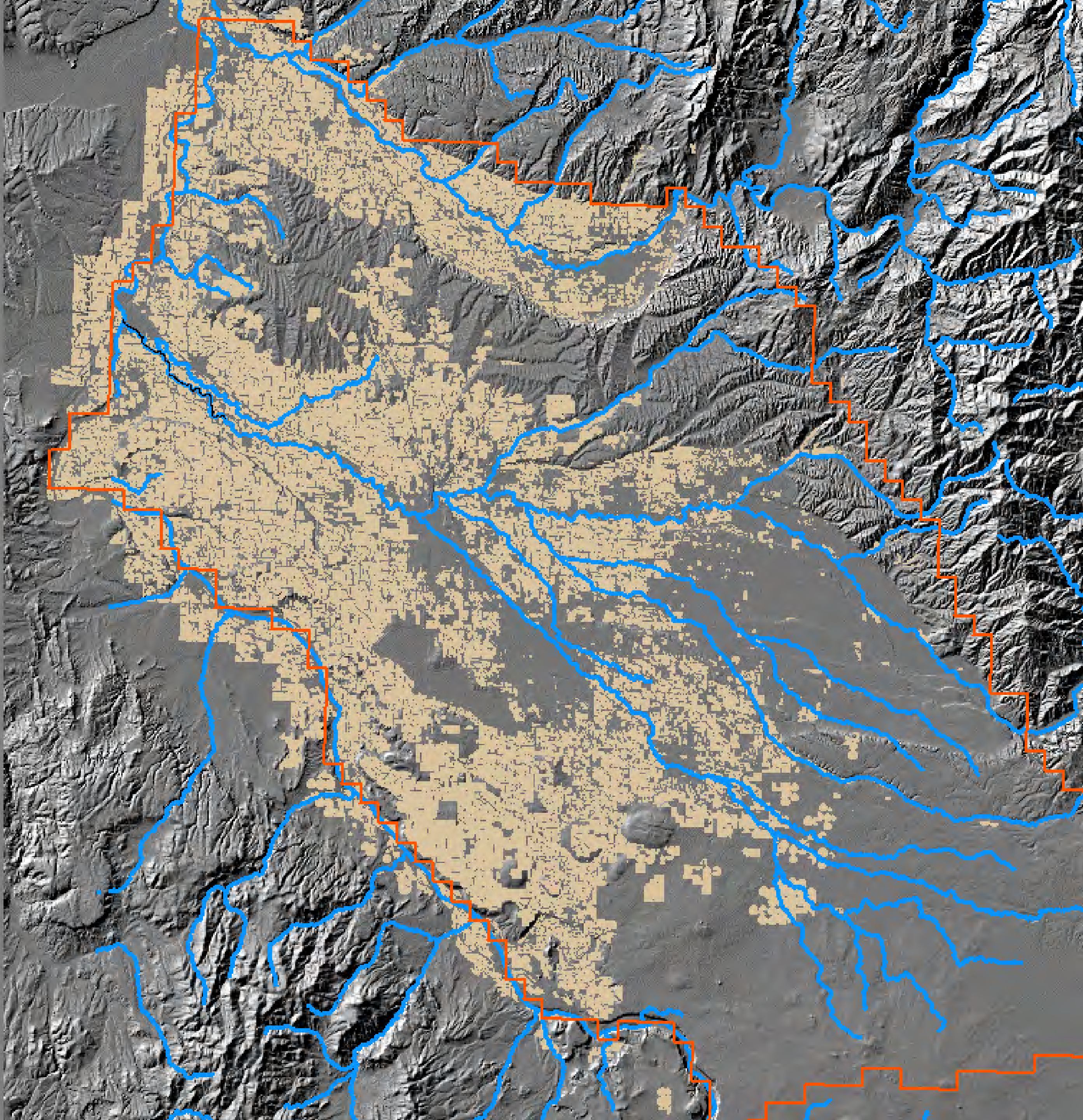
- Precipitation is higher in the mountains, lower in the SW portion of the valley



Precip 30-year normals

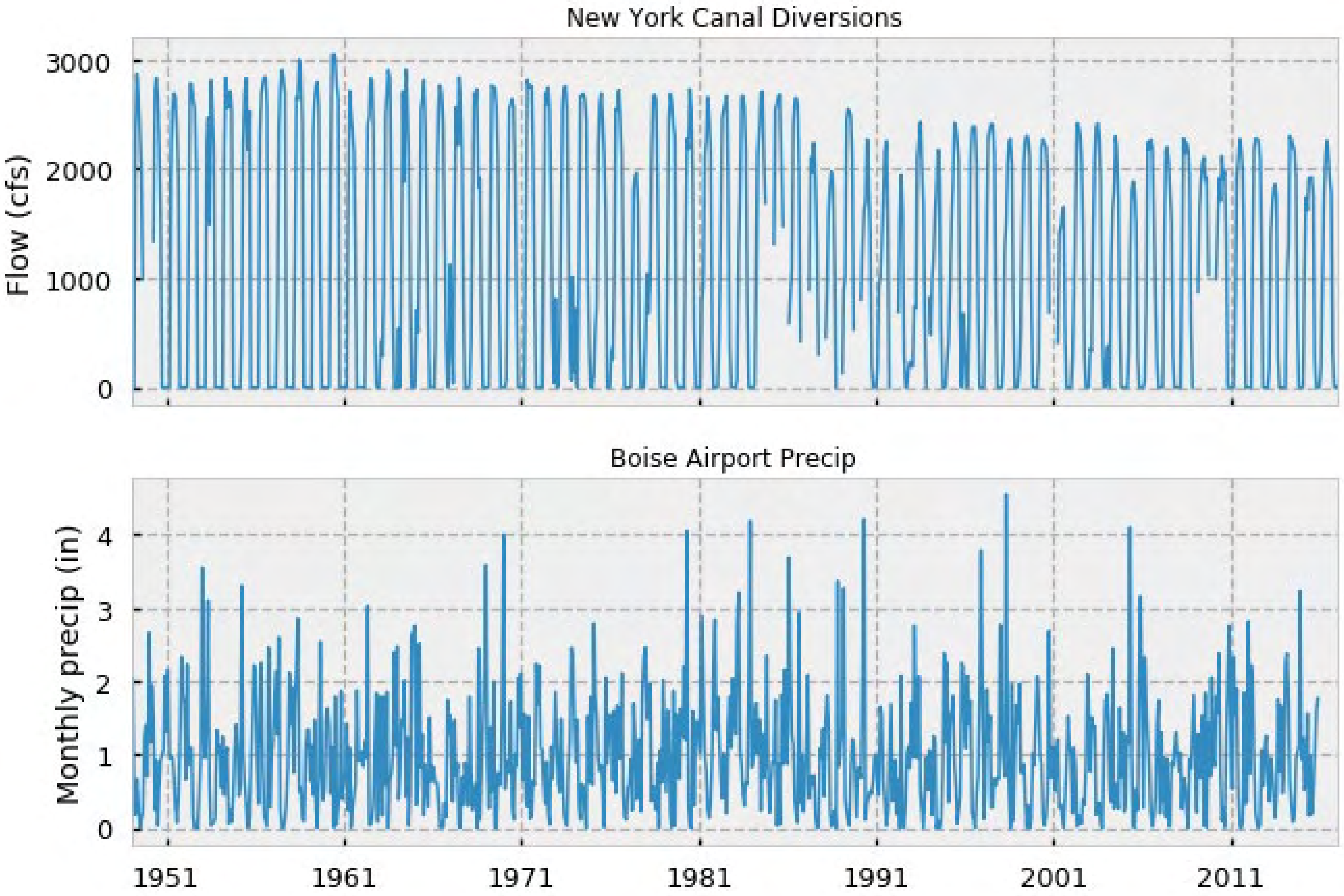
Where does recharge occur?

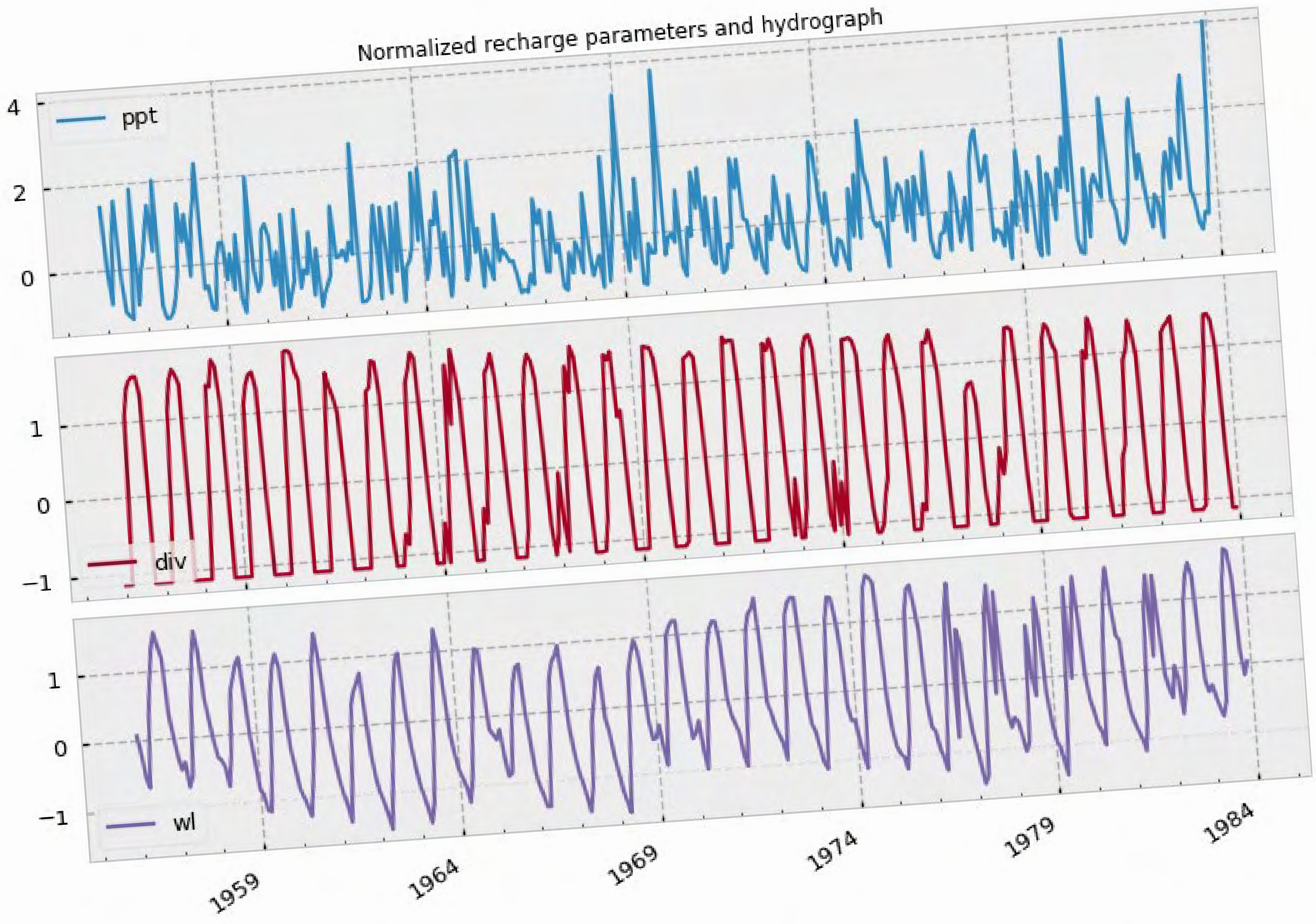
- Irrigated lands, 2015



Dataset

- Recharge inputs
  - New York Canal diversions
    - USBR
  - Boise Airport Precip
    - ETIdaho
- Response variable
  - Groundwater hydrographs
    - IDWR
    - N = 244
  - Detrended
  - Has at least 12 months of overlapping consecutive monthly values with inputs
  - Use water level change
    - Correlates peak recharge to largest increase in water level

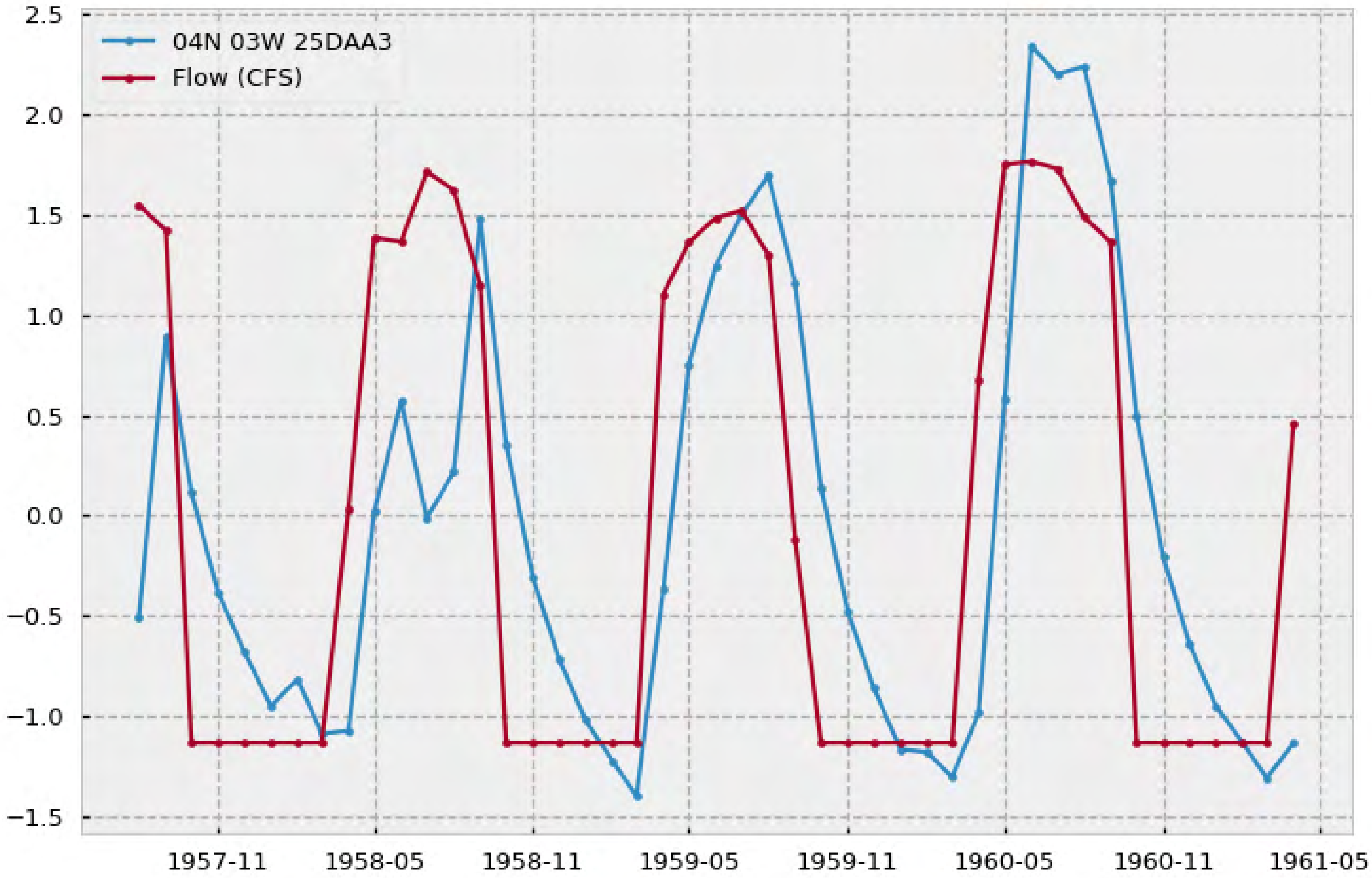




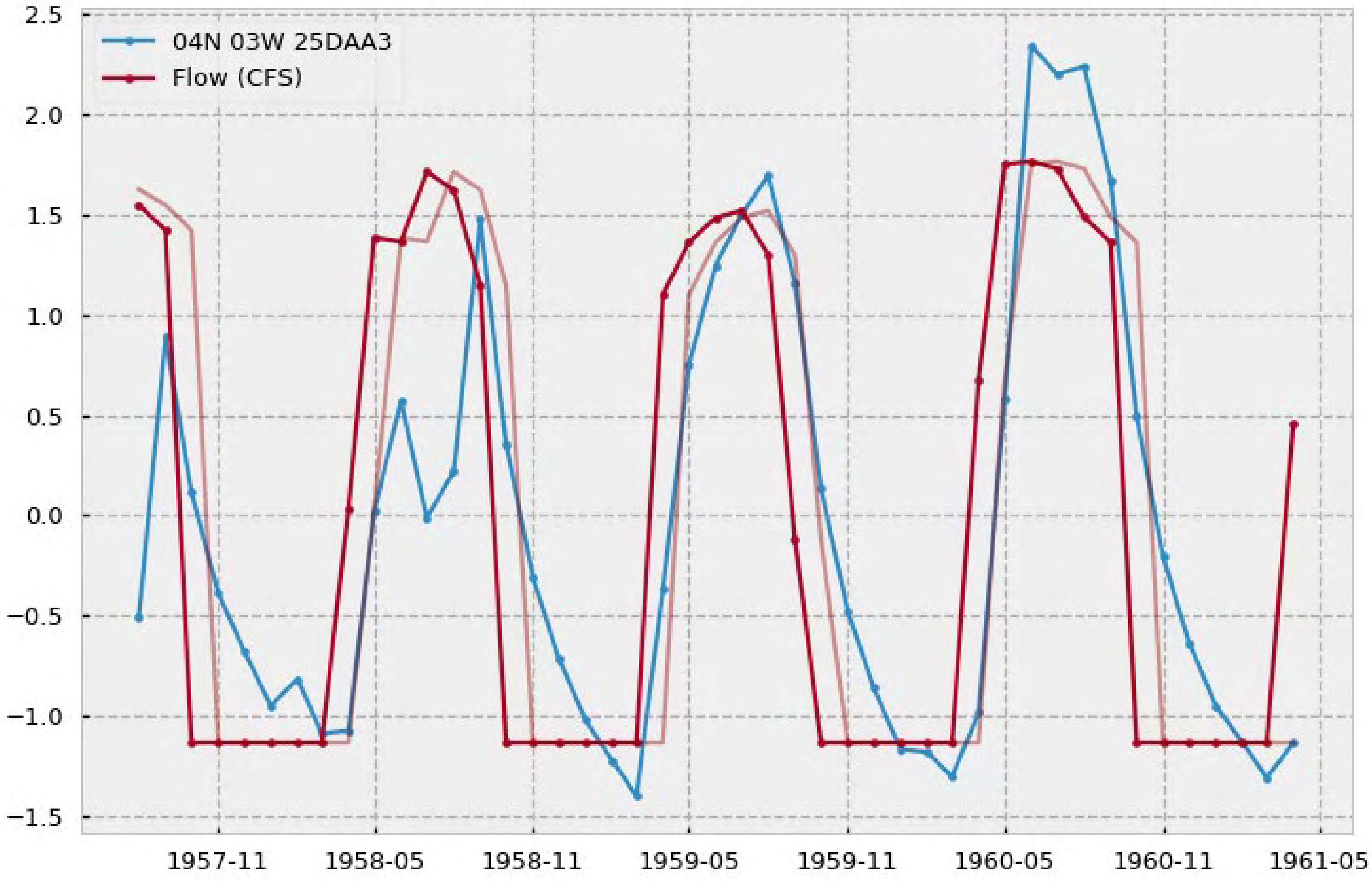
Normalized recharge parameters and hydrograph
ppt
div
wl
4
2
0
1
0
−1
1
0
−1
1959
1964
1969
1974
1979
1984

Determining the delay

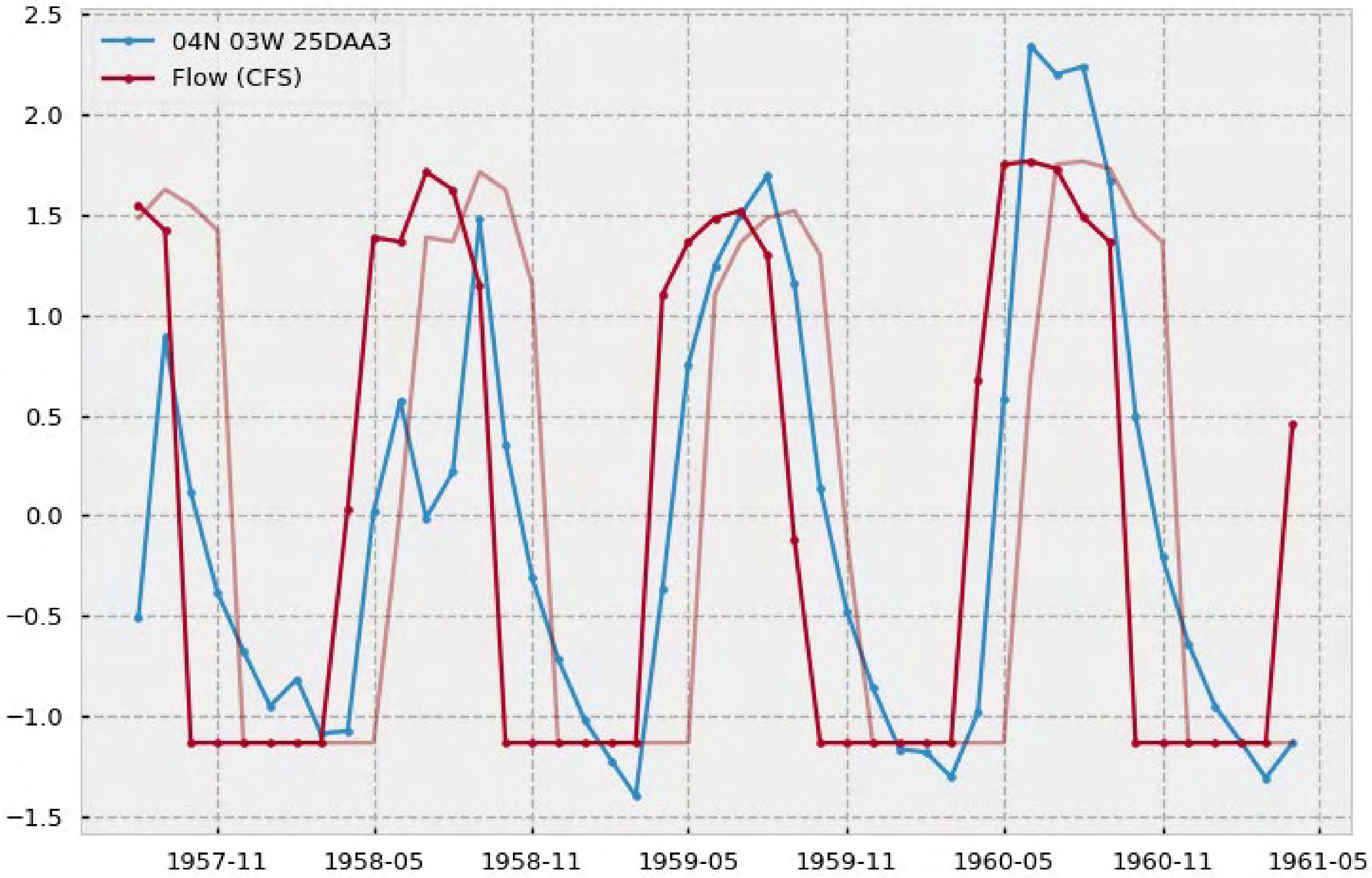
- Diversion and water level signals are offset.
- Water level appears to increase one month ahead of water level



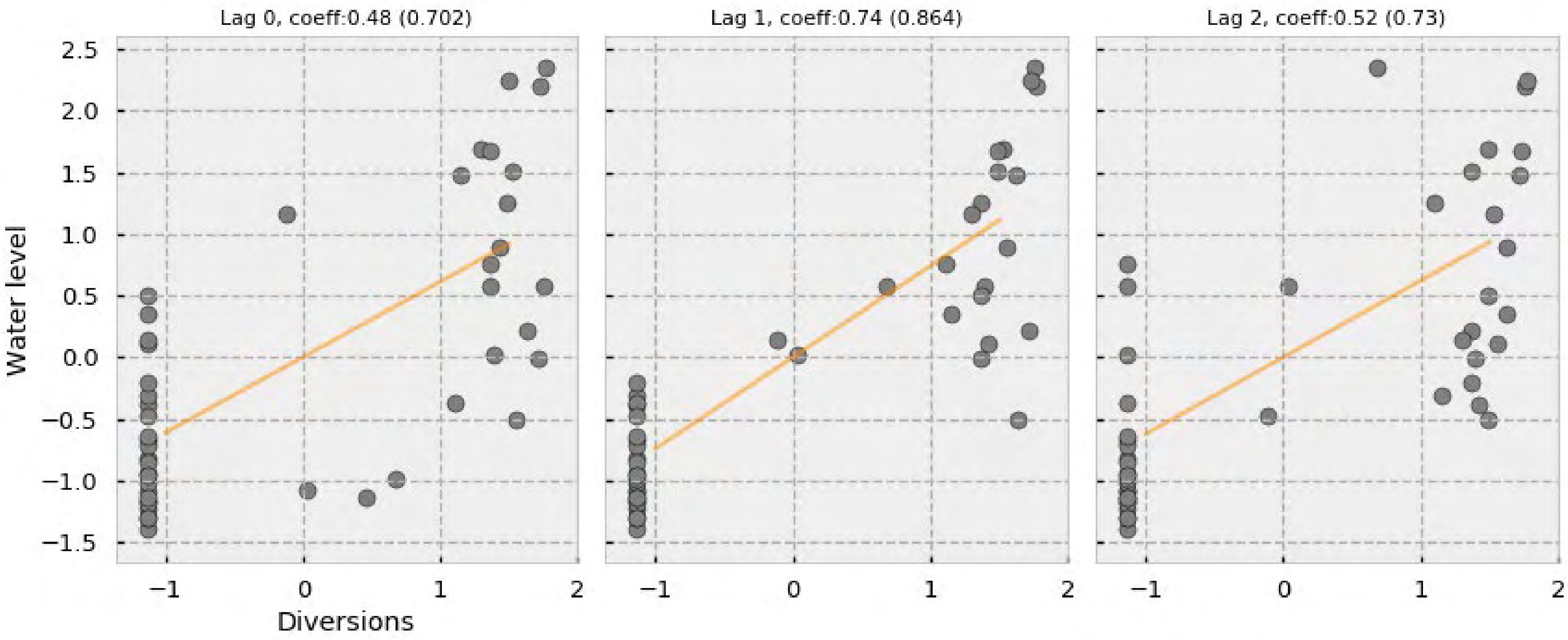
Shift by 1 month



Shift by 2 months

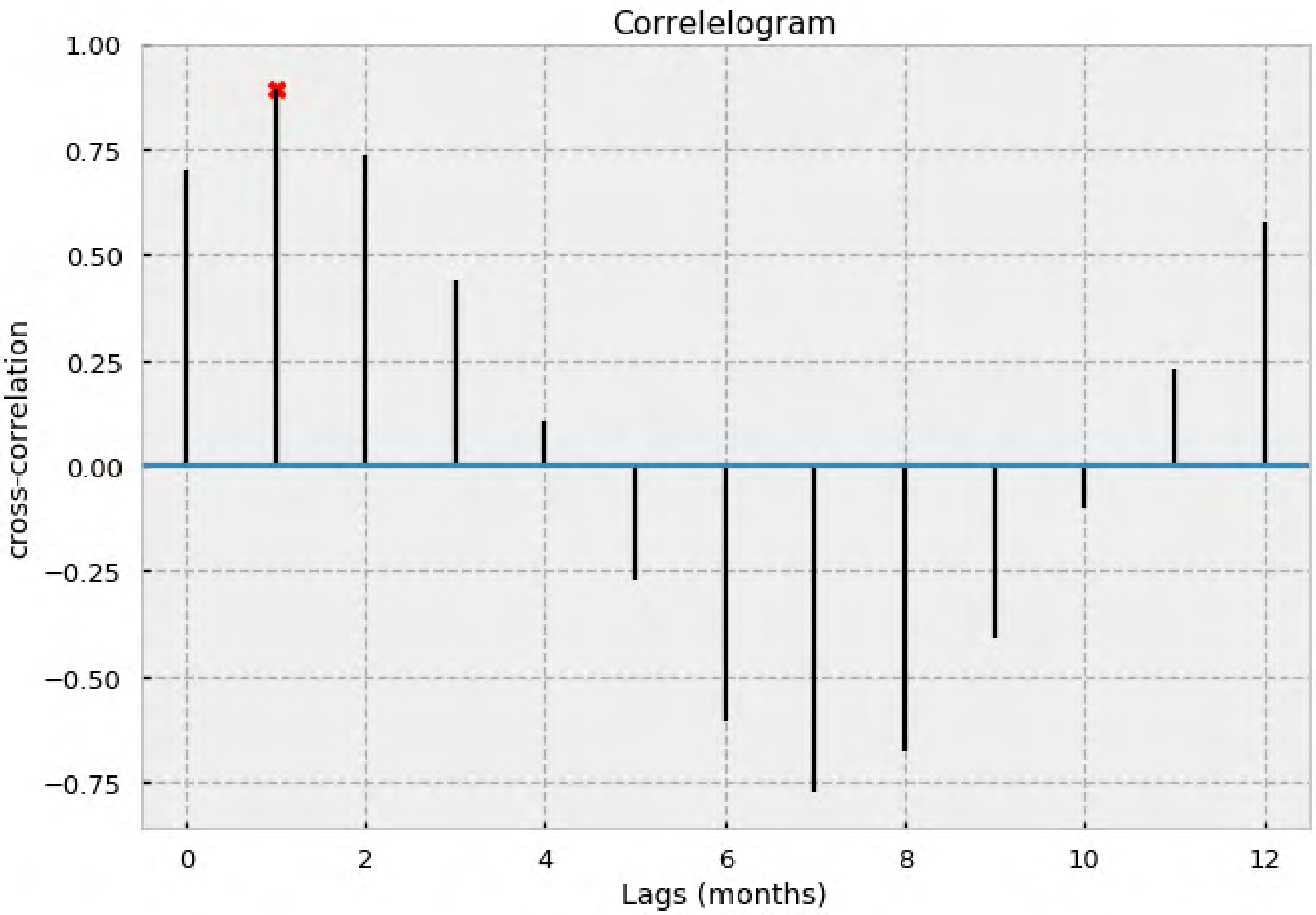


- We can define the goodness-of-fit for these lags
- Shifting diversions forward one month gives the largest correlation coefficients
  - R = .74
  - Xcorr = .864

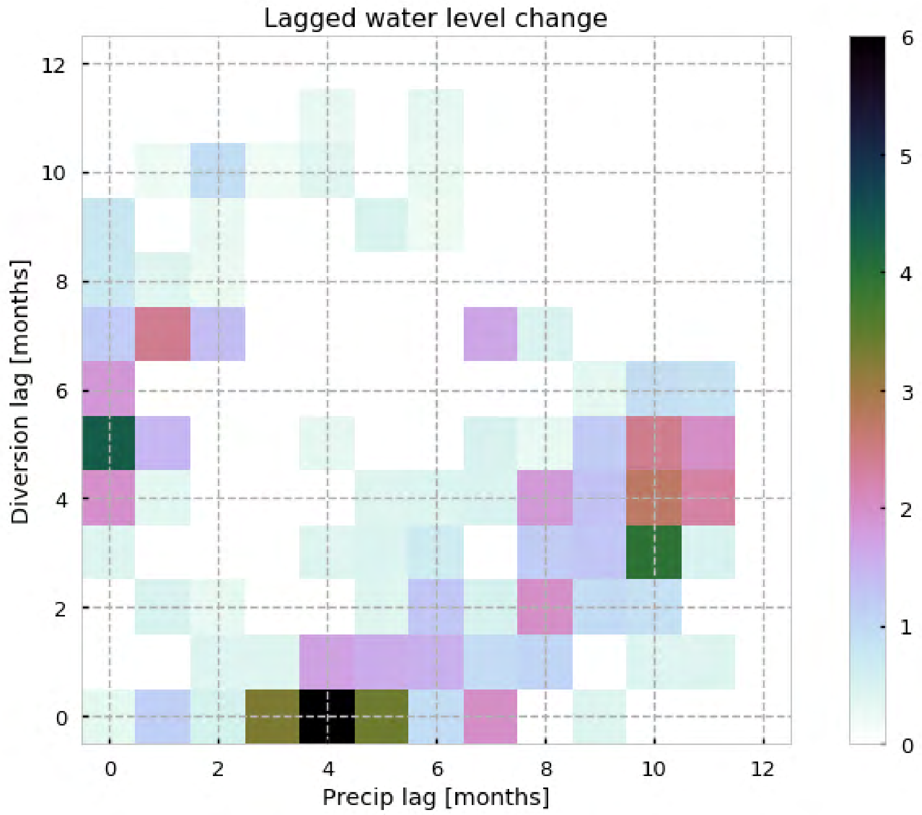


Cross-correlation

- Repeat for multiple lags
  - This is the essence of cross-correlation
  - Mathematically occurs for all number of overlapping shifts, even for 1 point
  - Physically meaningful lags in this case are just a few months



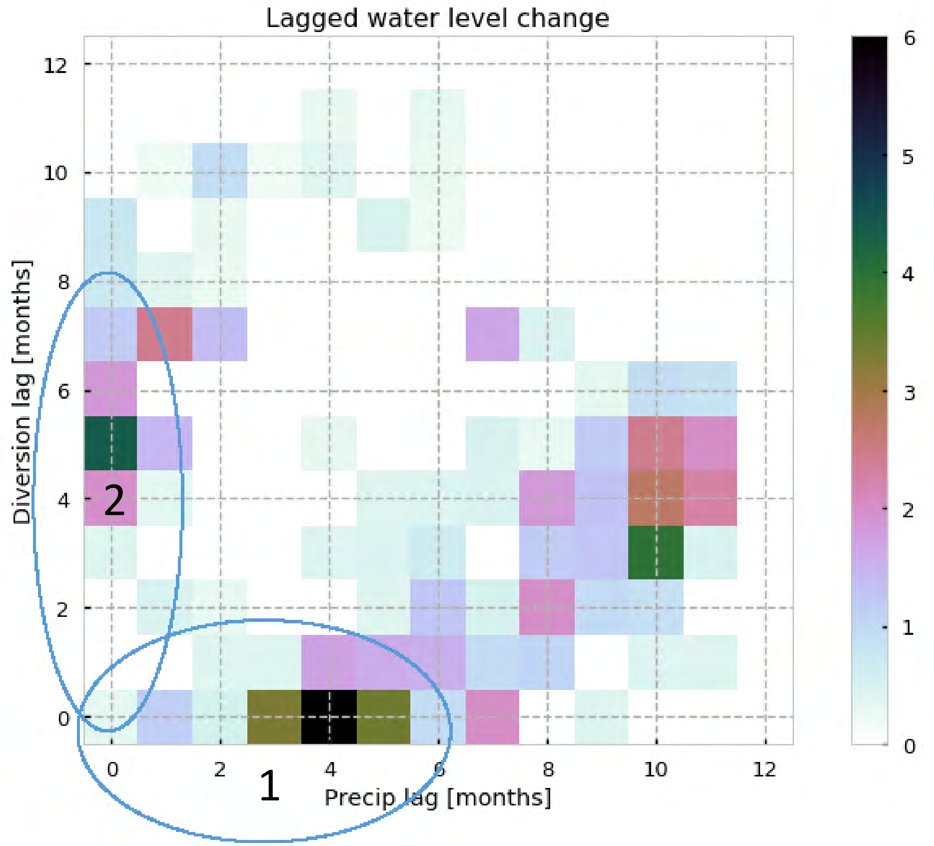
Results: Frequencies of lags in dataset



Frequency of max lags weighted by cross-correlation coefficient

- Darker colors are more frequent maximum-valued lags (most significant)

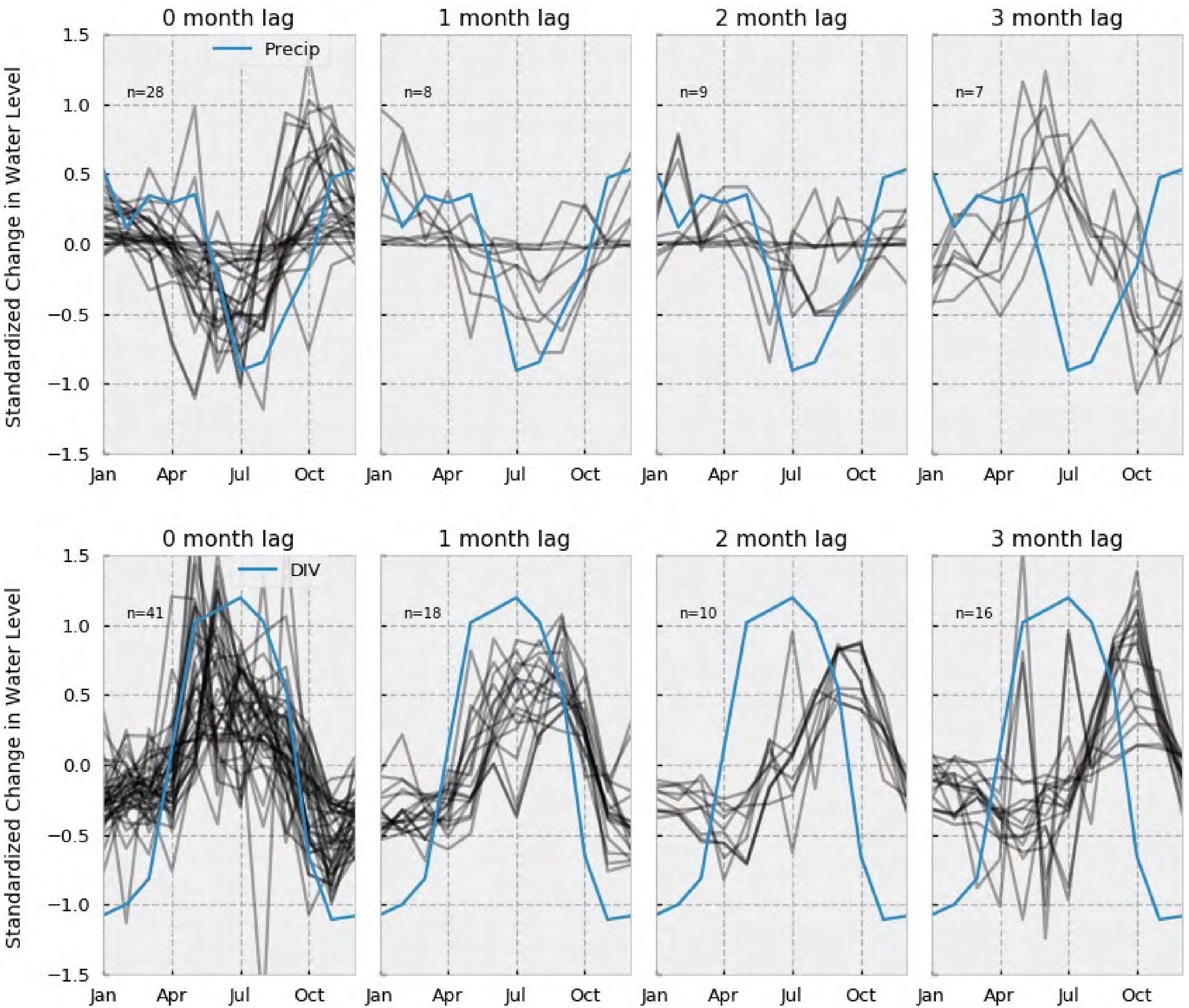
Results: Frequencies of lags in dataset

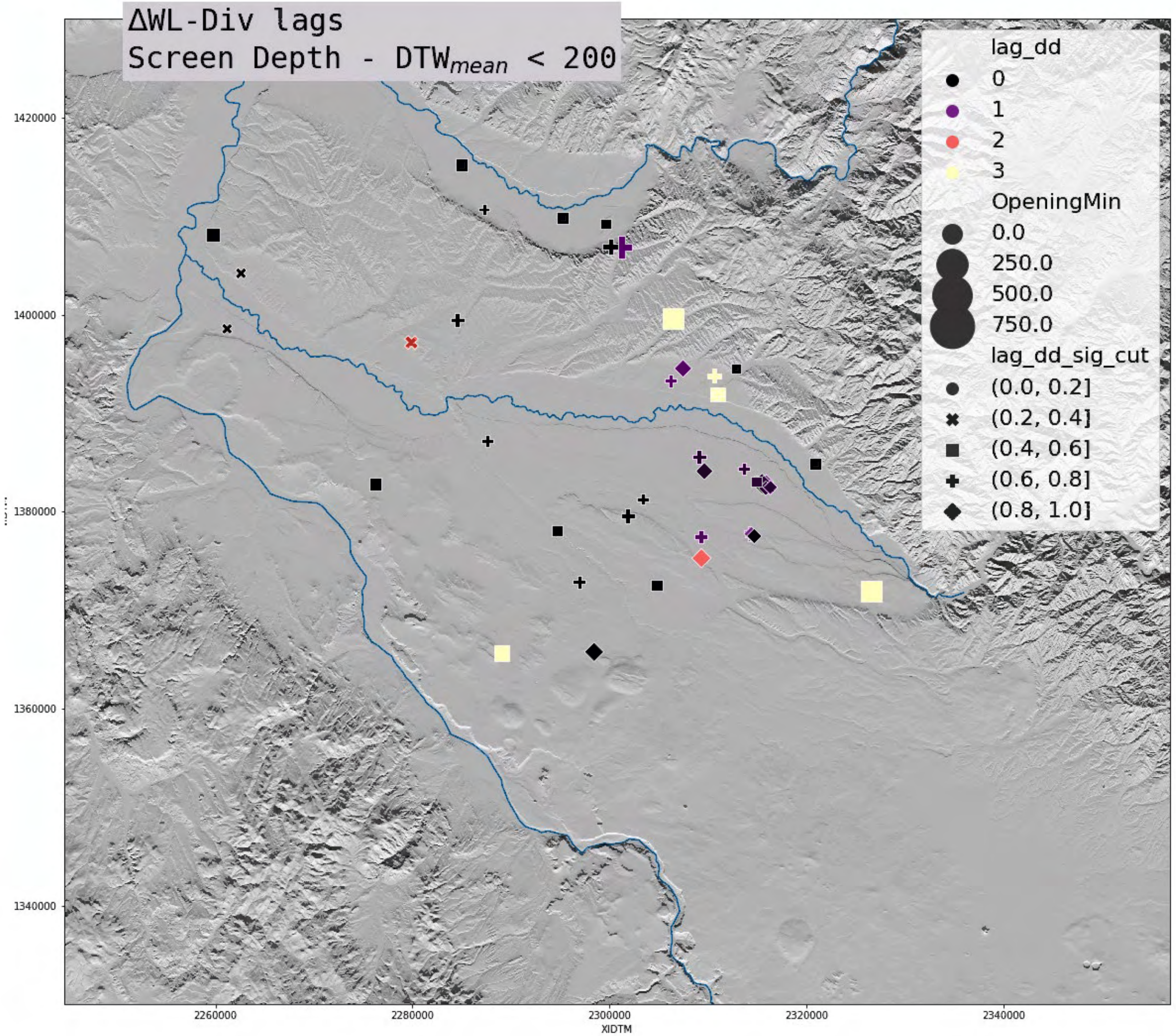


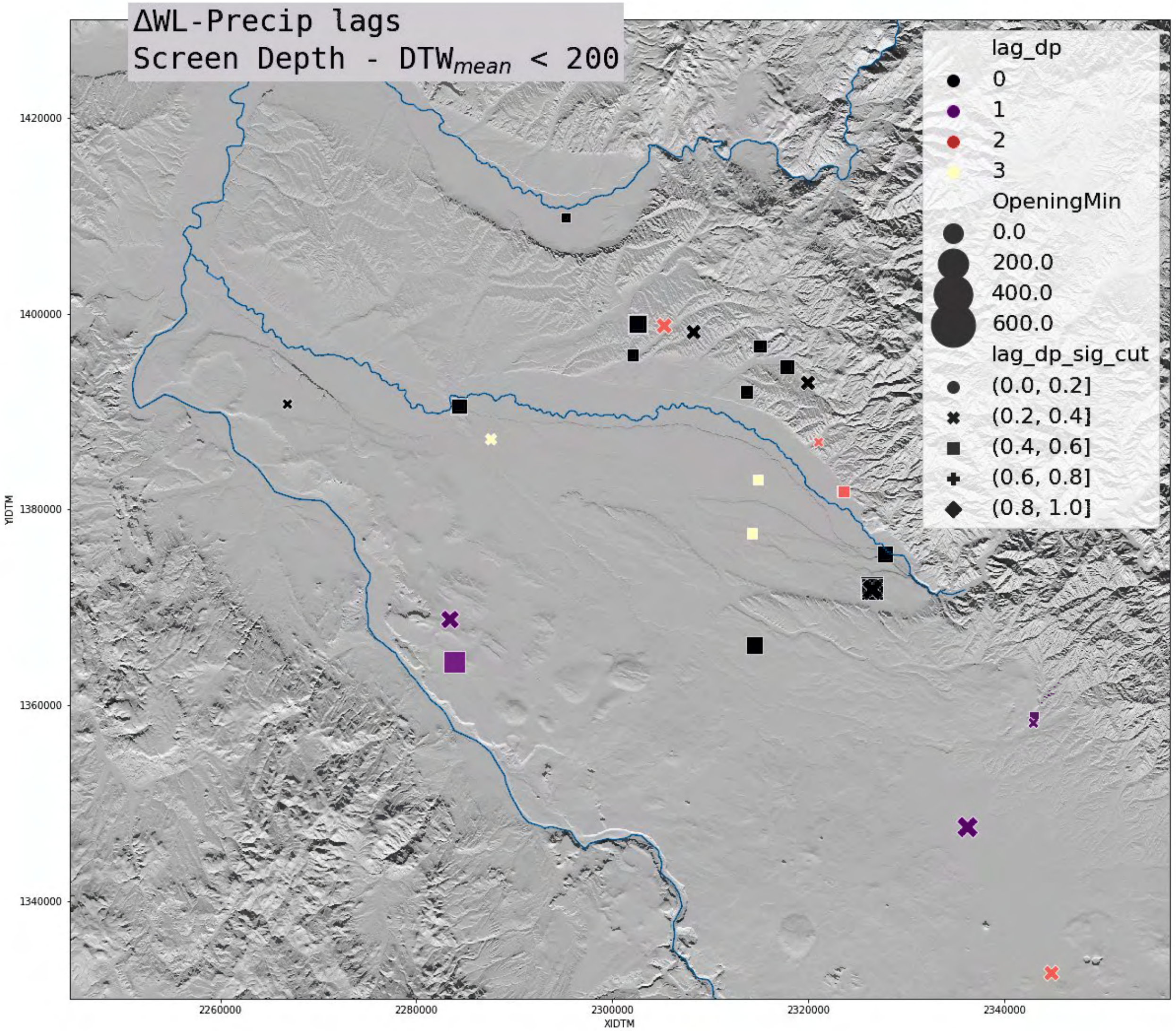
Two groups

1. Low level lags relative to diversion typically lag precip by 3-5 months
2. Wells responding to precip in the same month lag diversions by 4-6 months

Monthly mean water levels grouped by max lag

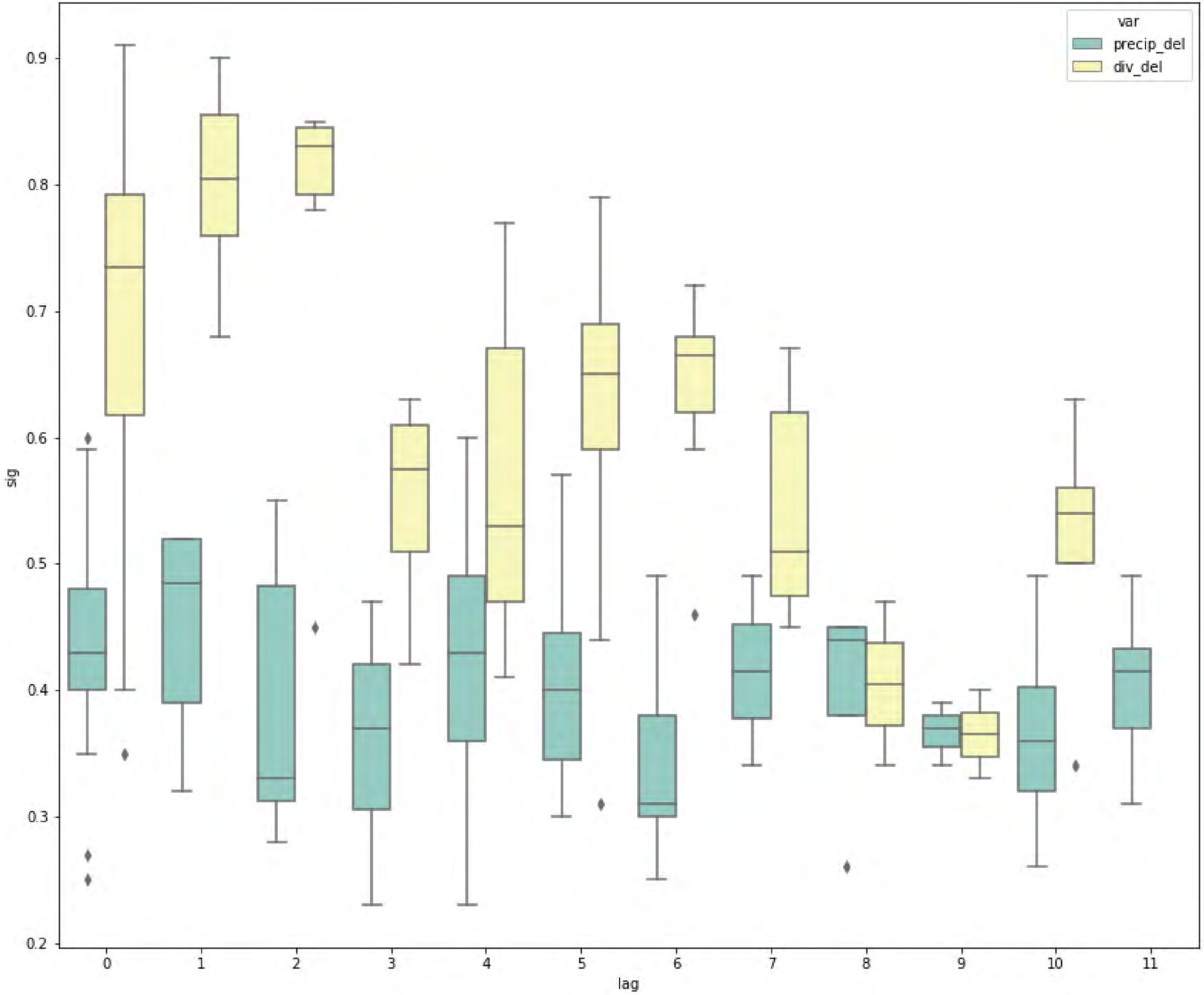



ΔWL-Div lags
Screen Depth - DTW$_{mean}$ < 200
lag_dd
0
1
2
3
OpeningMin
0.0
250.0
500.0
750.0
lag_dd_sig_cut
(0.0, 0.2]
(0.2, 0.4]
(0.4, 0.6]
(0.6, 0.8]
(0.8, 1.0]
1420000
1400000
1380000
1360000
1340000
2260000
2280000
2300000
2320000
2340000
XIDTM

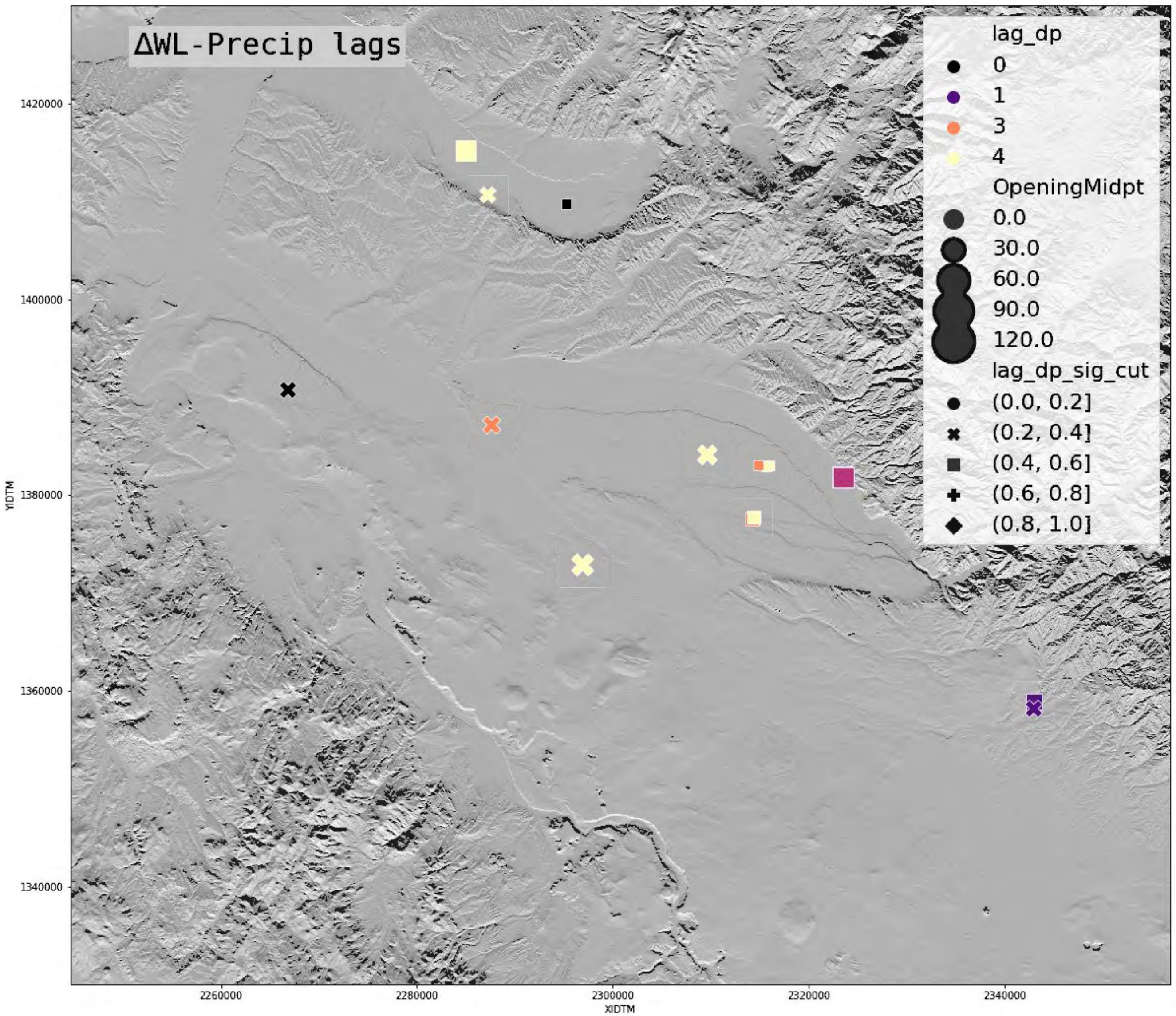

ΔWL-Precip lags
Screen Depth - DTW$_{mean}$ < 200
lag_dp
0
1
2
3
OpeningMin
0.0
200.0
400.0
600.0
lag_dp_sig_cut
(0.0, 0.2]
(0.2, 0.4]
(0.4, 0.6]
(0.6, 0.8]
(0.8, 1.0]
1420000
1400000
1380000
1360000
1340000
YIDTM
2260000
2280000
2300000
2320000
2340000
XIDTM

Diversion signals are stronger

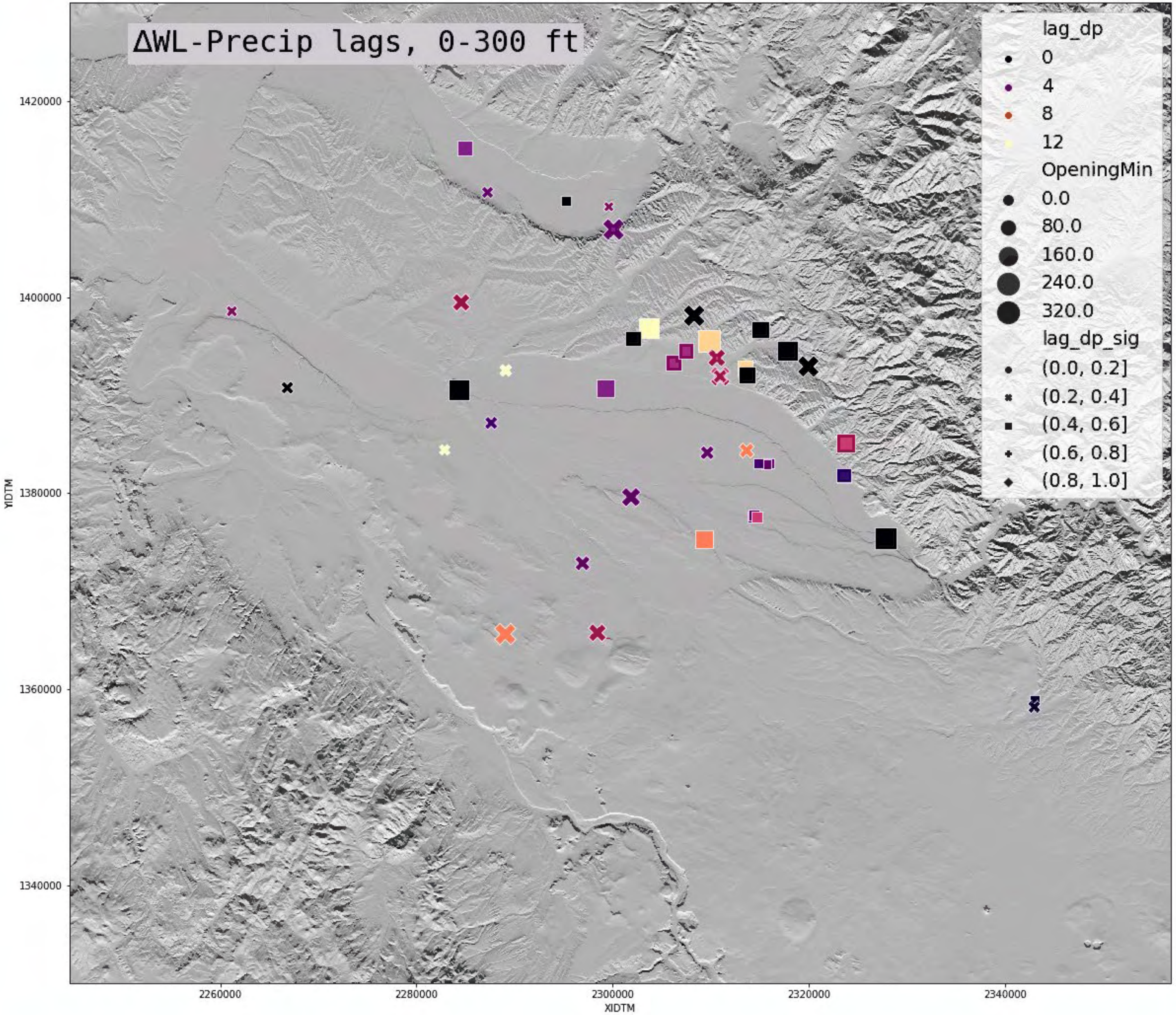
- At lags of 0-3 months, recharge from diversion correlates better with water levels

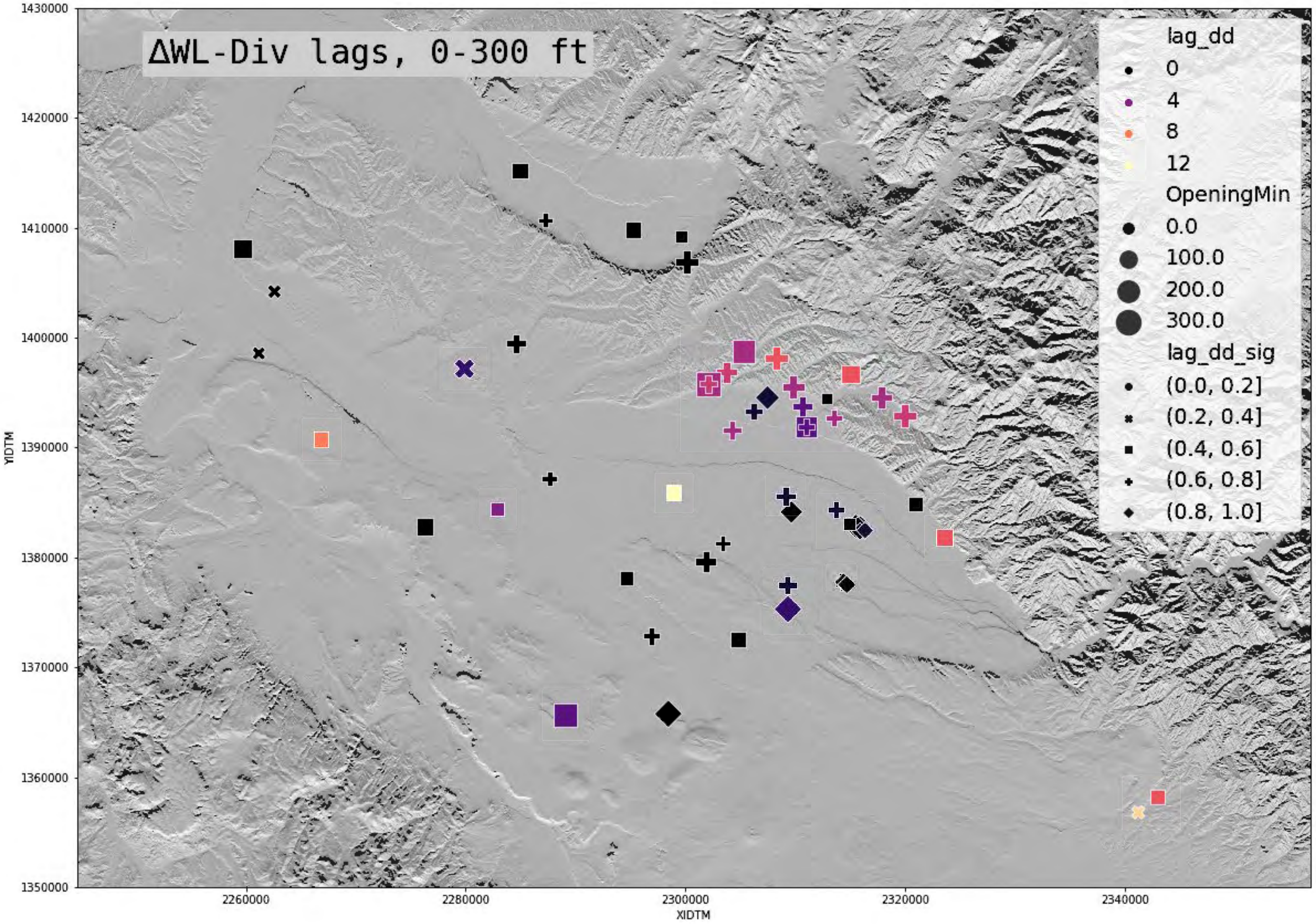


- Shallow wells in areas with irrigation are typically responding during the same month with a few that lag by a few months
- Spread of significant lags across valley is sparse
- Response to irrigation/canal seepage is stronger than responses to precip.
- A majority of diversion lags in irrigated lands are 0.
- Where there are diversion lags > 0 in irrigated areas, there is not enough data to support applying the lags to other wells.
- Caveats
  - New York canal is only a proxy for when irrigation occurs across the valley
  - Precipitation varies widely around the valley

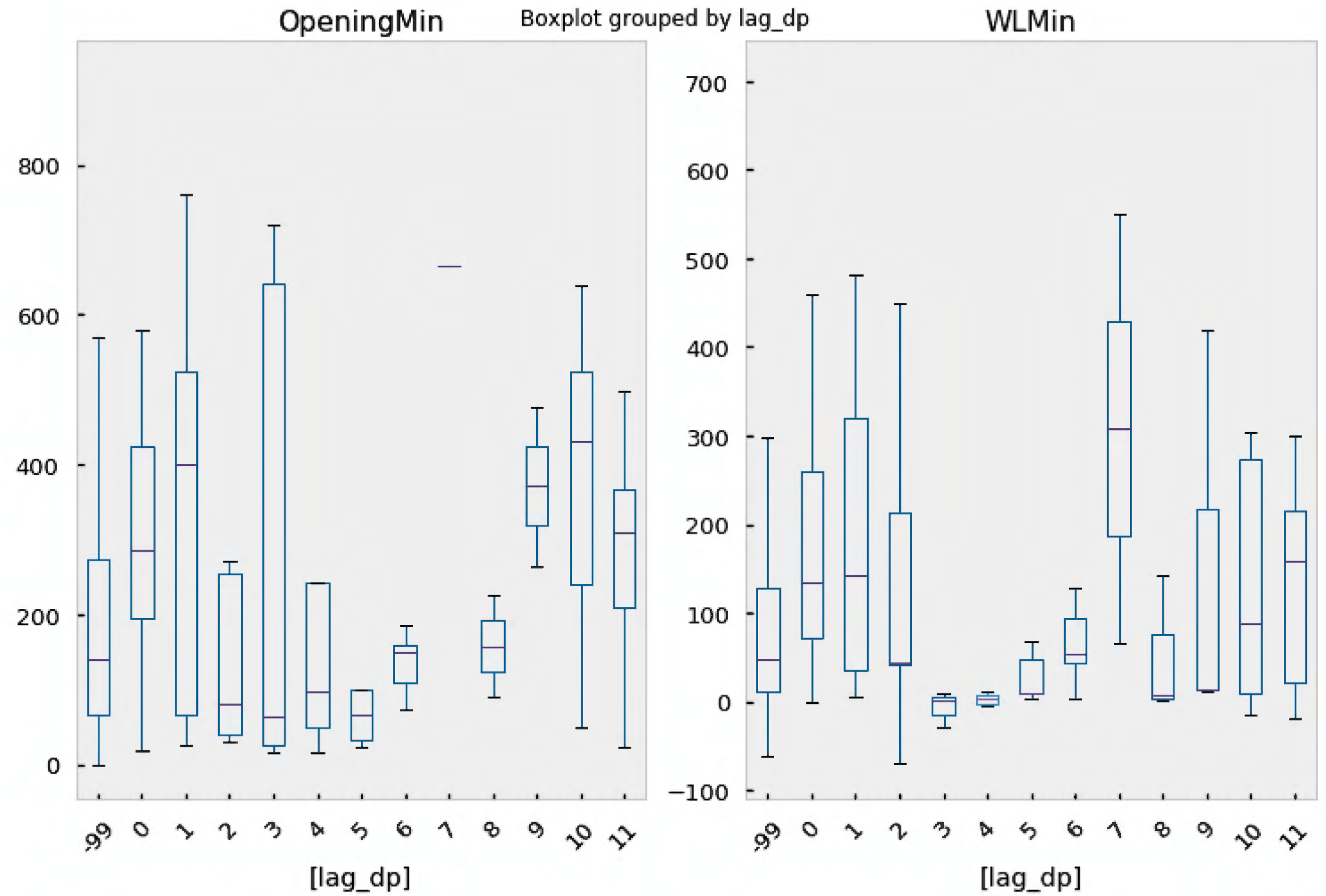


Well screens – mean water level < 100 ft


ΔWL-Precip lags, 0-300 ft
lag_dp
0
4
8
12
OpeningMin
0.0
80.0
160.0
240.0
320.0
lag_dp_sig
(0.0, 0.2]
(0.2, 0.4]
(0.4, 0.6]
(0.6, 0.8]
(0.8, 1.0]
1420000
1400000
1380000
1360000
1340000
YIDTM
2260000
2280000
2300000
2320000
2340000
XIDTM

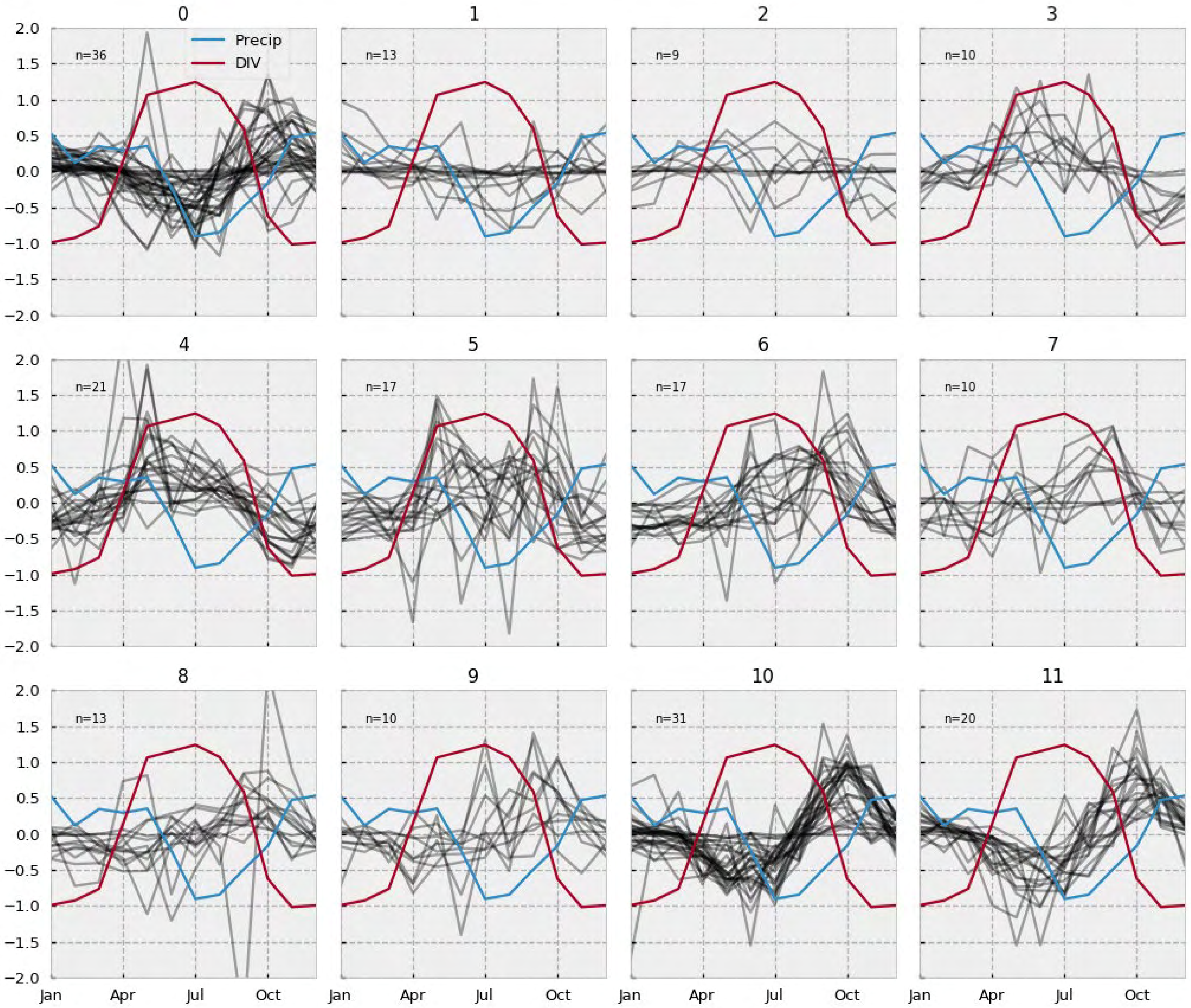


ΔWL-Div lags, 0-300 ft
lag_dd
0
4
8
12
OpeningMin
0.0
100.0
200.0
300.0
lag_dd_sig
(0.0, 0.2]
(0.2, 0.4]
(0.4, 0.6]
(0.6, 0.8]
(0.8, 1.0]
1430000
1420000
1410000
1400000
1390000
1380000
1370000
1360000
1350000
YIDTM
2260000
2280000
2300000
2320000
2340000
XIDTM



Boxplot grouped by lag_dp
OpeningMin
WLMin
0
200
400
600
800
−100
0
100
200
300
400
500
600
700
-99
0
1
2
3
4
5
6
7
8
9
10
11
[lag_dp]
[lag_dp]

Groups: Precip lags
Variable:Water level change



Groups: DIV
Variable:Water level change