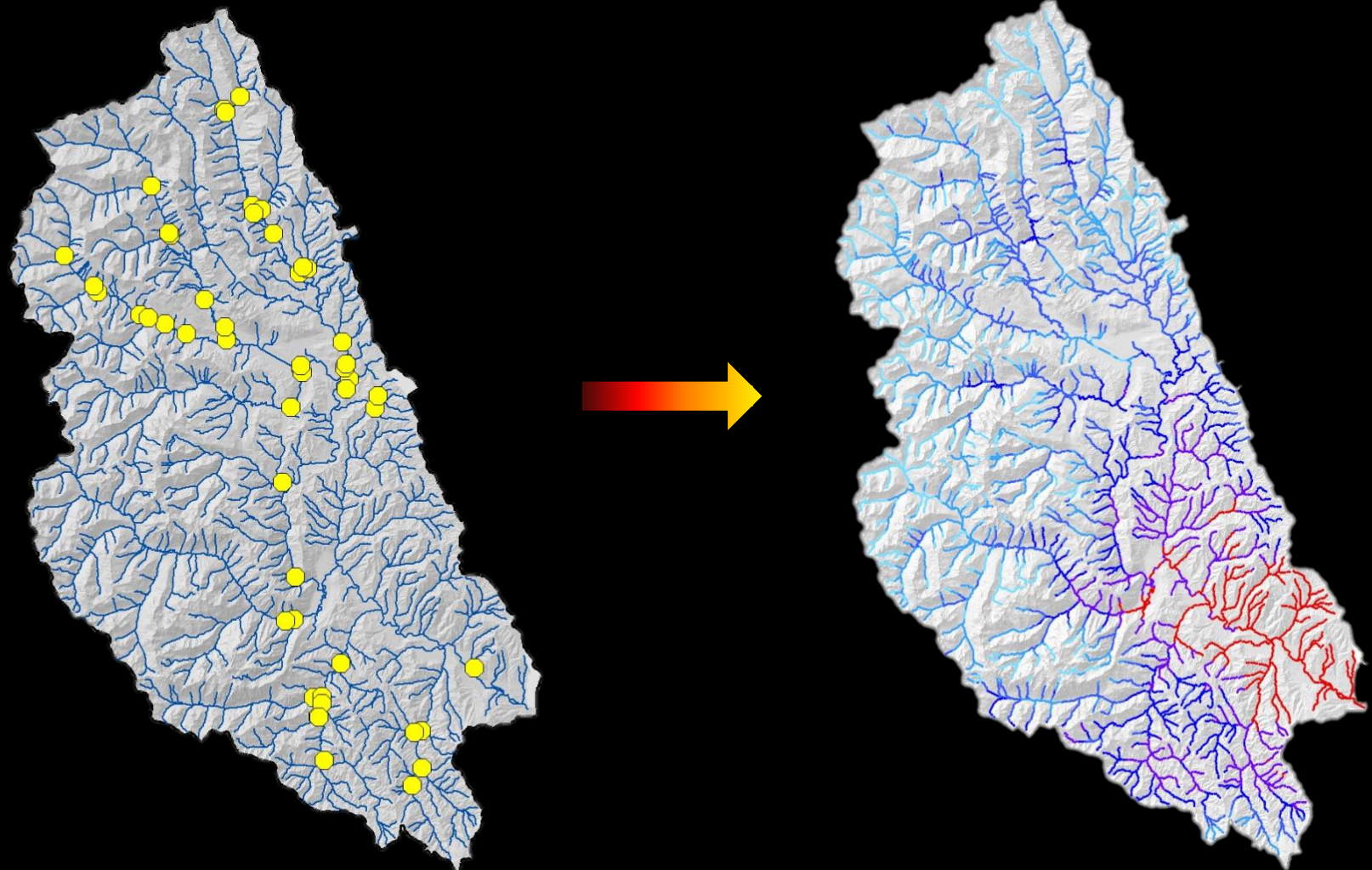
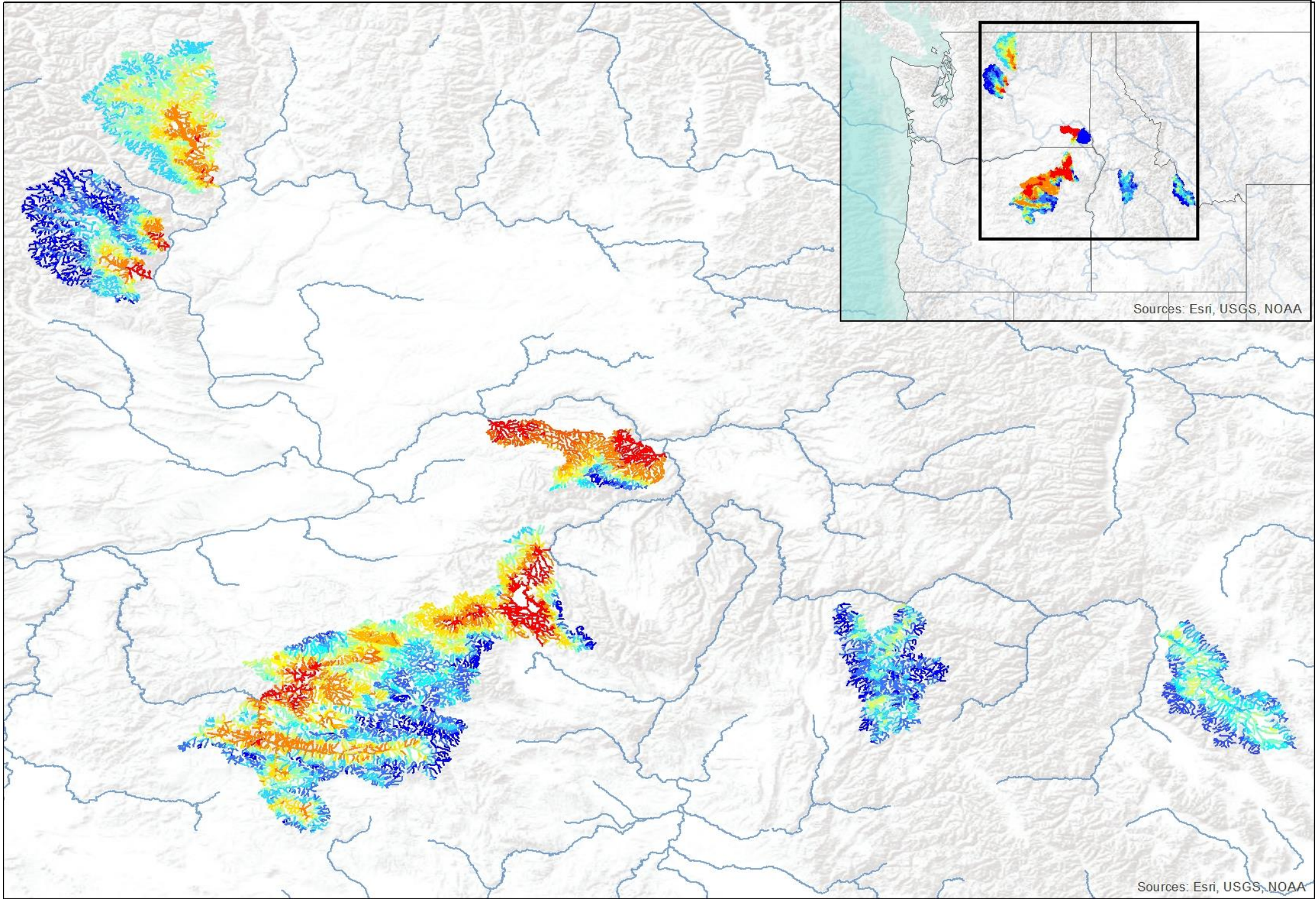


CHaMP Stream Temperature Models



Kris McNyset, South Fork Research
kristina.mcnysset@noaa.gov

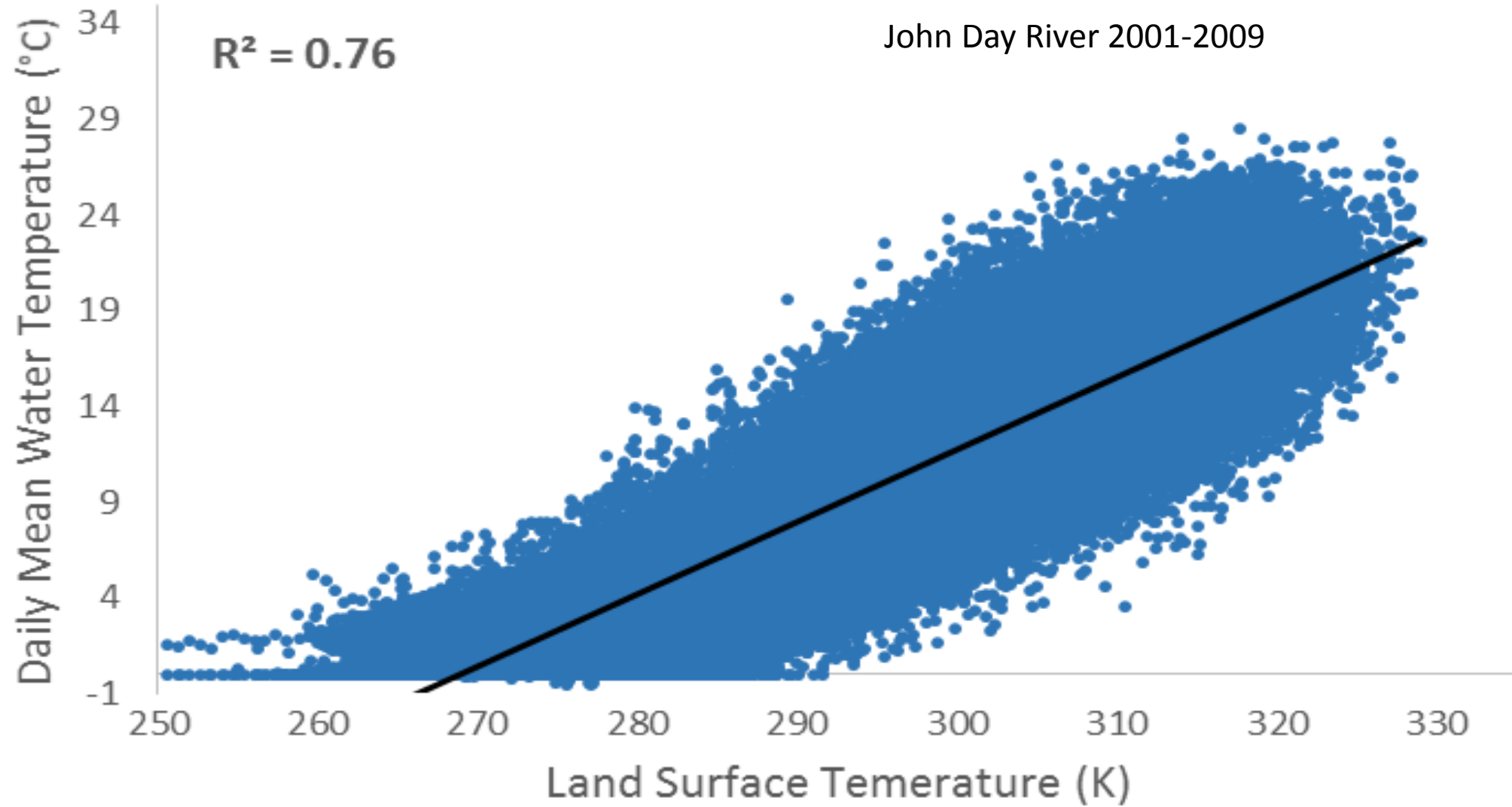
2 June 2015



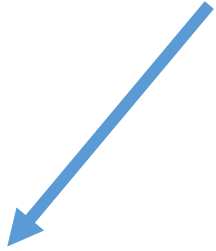
Sources: Esri, USGS, NOAA

Sources: Esri, USGS, NOAA

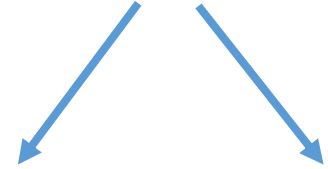
Relationship between remotely-sensed Land Surface Temperature and stream temperature



CHaMP stream temperature loggers



May or may not be included

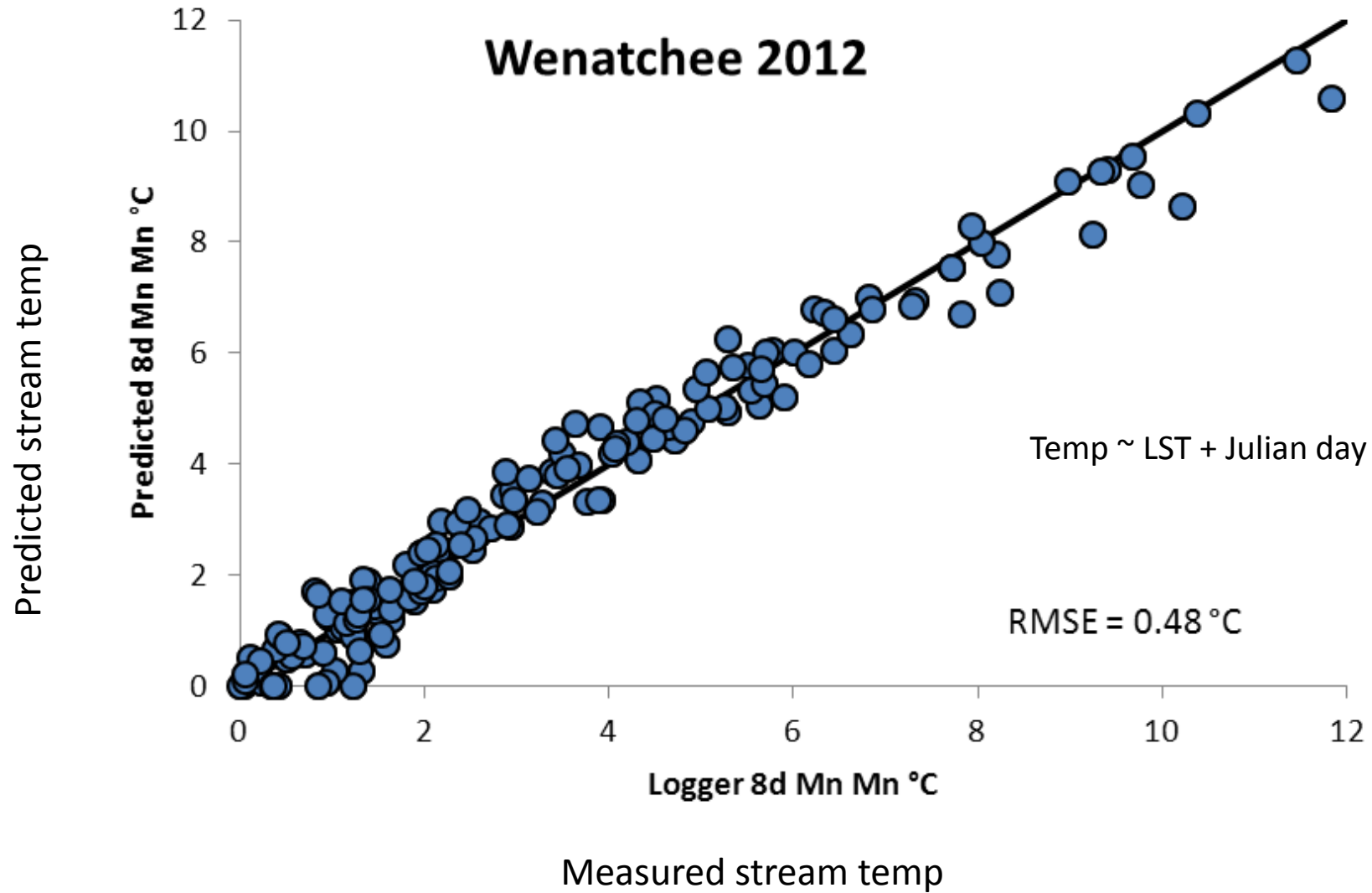


$$8DMWT \sim LST + JulDay + LST^2 + Elev$$

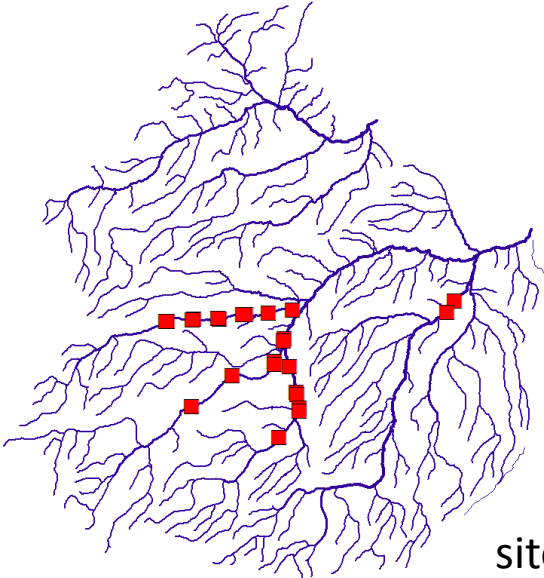


MODIS satellite data

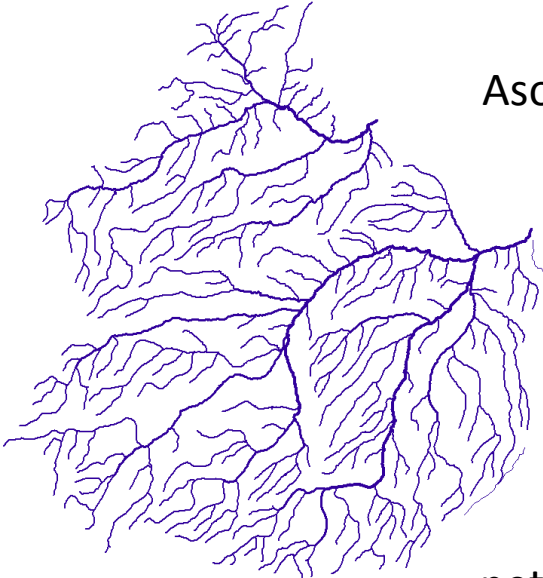
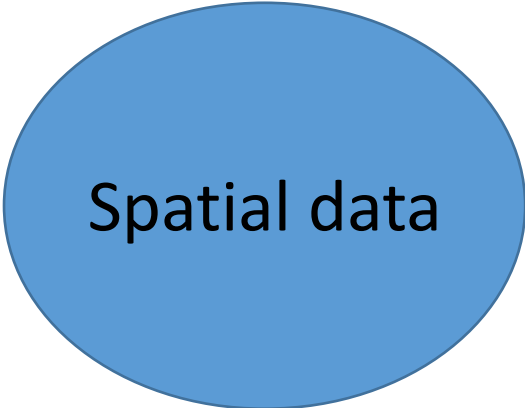
Predicted Water Temperature



Modeling process

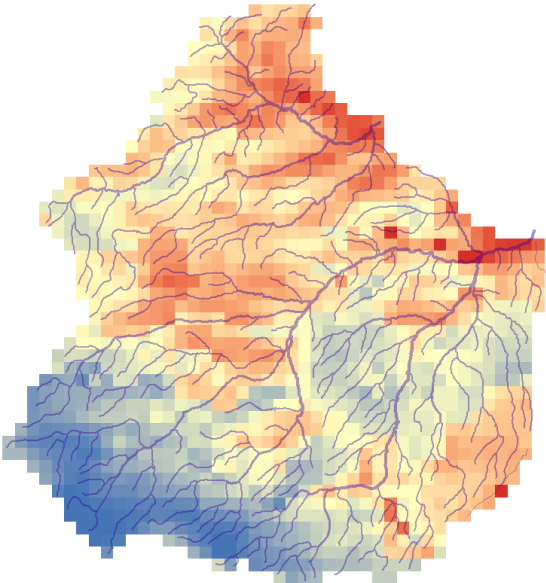


sites



Asotin

network



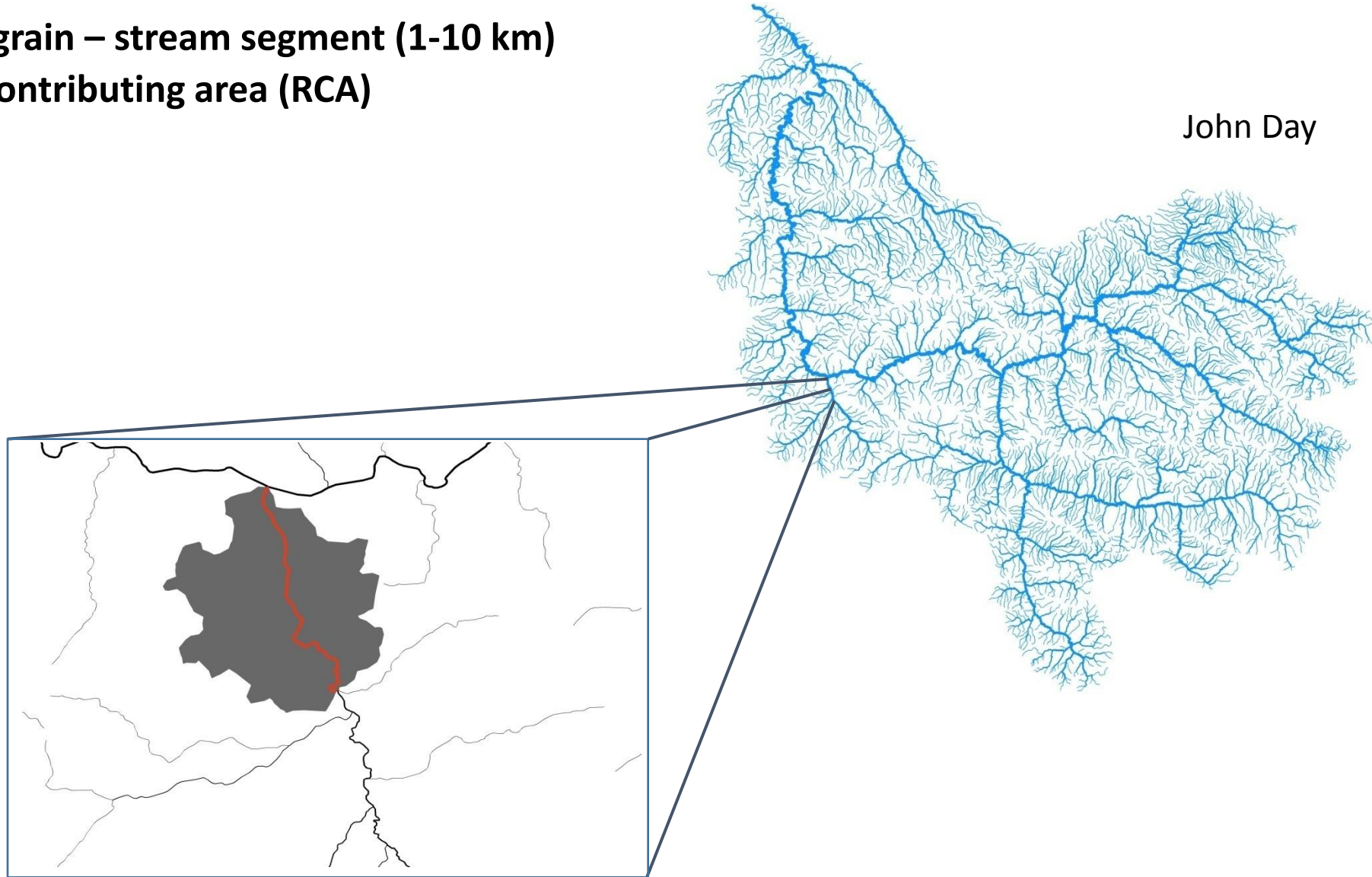
Satellite data



Spatial resolution

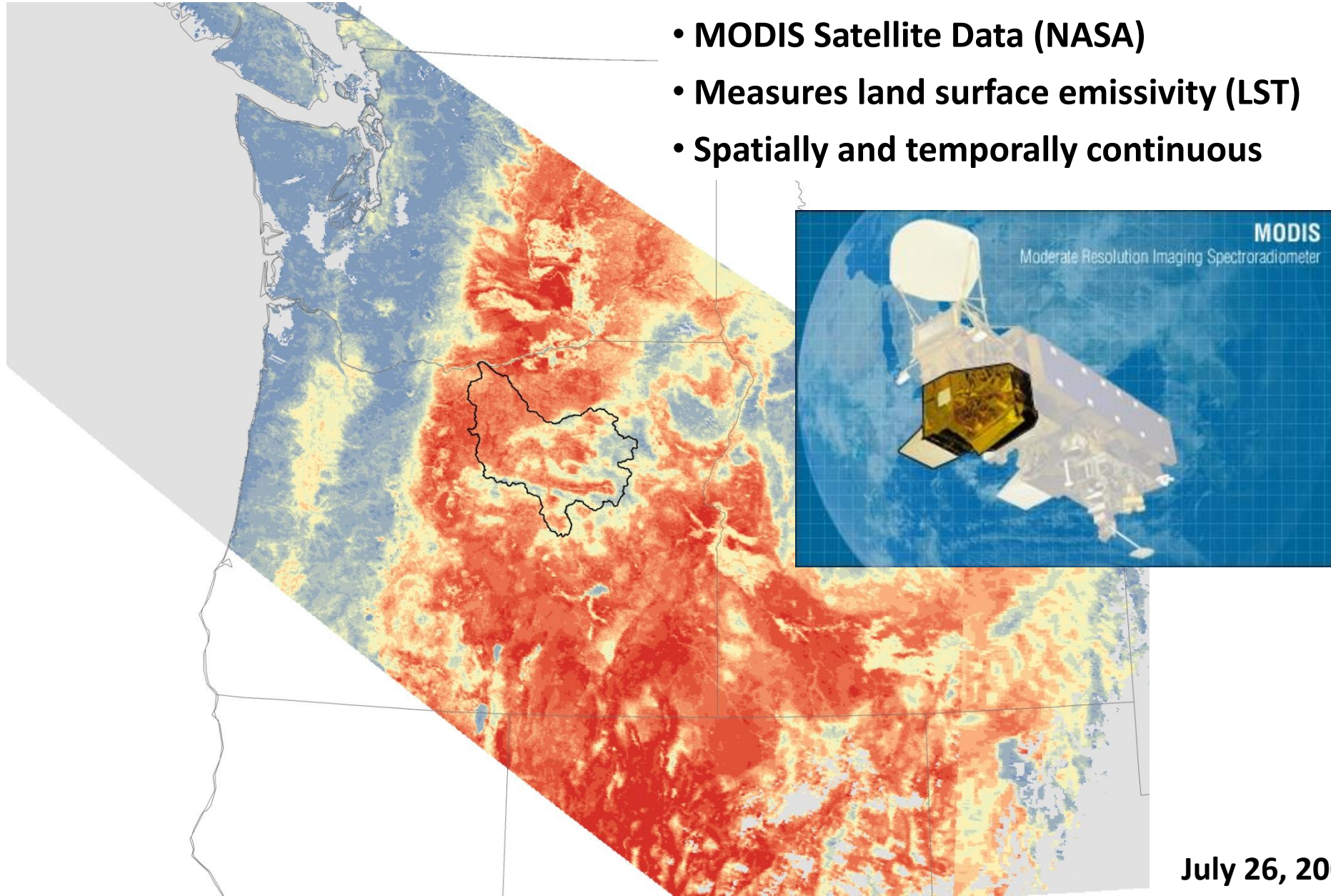
Stream Network

- **Spatial grain – stream segment (1-10 km)**
- **Reach contributing area (RCA)**



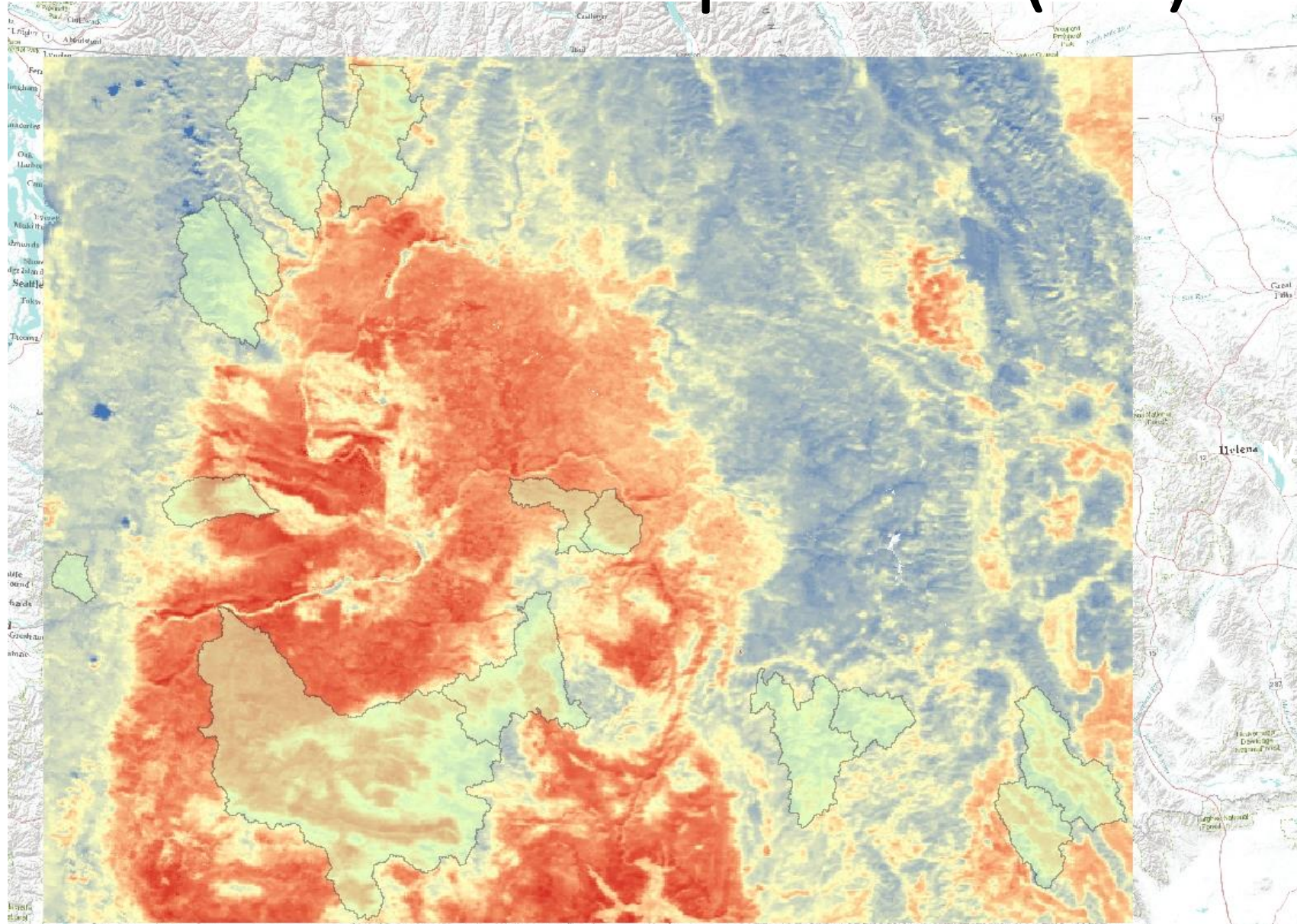
Land Surface Temperature (LST)

- MODIS Satellite Data (NASA)
- Measures land surface emissivity (LST)
- Spatially and temporally continuous



July 26, 2001

Land Surface Temperature (LST)



July 26, 2001

Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA



National Aeronautics and Space Administration

EOSDIS NASA's Earth Observing System Data and Information System

Reverb | ECHO

The Next Generation Earth Science Discovery Tool

Try the Earthdata Search beta!

Step 1: Select Search Criteria

- Search Options
- Spatial
- Search Terms
- Temporal
- Platforms & Instruments [?]
- Campaigns [?]
- Processing Levels [?]
- Science Keywords [?]

Save Query Clear Criteria

Feedback?
Tell us what you think.

Availability [?]

No GPM GMI data between 2014-10-22 and 2014-10-24
 Wed Oct 22 2014 01:14:00 GMT-0700 (Pacific Daylight Time) (GMT-7:00) to (End Date Not Provided)
 More

Notices [?]

URS Single Sign On
 Wed Jun 25 2014 05:00:00 GMT-0700 (Pacific Daylight Time) (GMT-7:00) to (End Date Not Provided)
 More

ASTER GDEM V2 Tutorial
 Mon Oct 17 2011 01:00:00 GMT-0700 (Pacific Daylight Time) (GMT-7:00) to (End Date Not Provided)
 More

Release Information [?]

Upcoming Features
 Wed Sep 19 2012 08:00:00 GMT-0700 (Pacific Daylight Time) (GMT-7:00)
 An overview of features available in future versions of Reverb.

Spatial Search [?]

Bounding Box [v] e.g. -50.736, 163.477, -11.144, 105.680 (S,E,N,W) [x] Reset Clear

Satellite [v]

Click and drag to set a bounding rectangle

Imagery ©2015 NASA Terms of Use Report a map error

Search by ESRI shape file [x]

Search Terms [?]

e.g. MODIS Fire AST_L1A Clear

Temporal Search [?]

START [x] YYYY-MM-DD HH:MM:SS Clear

END [x] YYYY-MM-DD HH:MM:SS Clear

* all times must be specified in GMT

Date Range Annual Repeating Dates

Step 2: Select Datasets

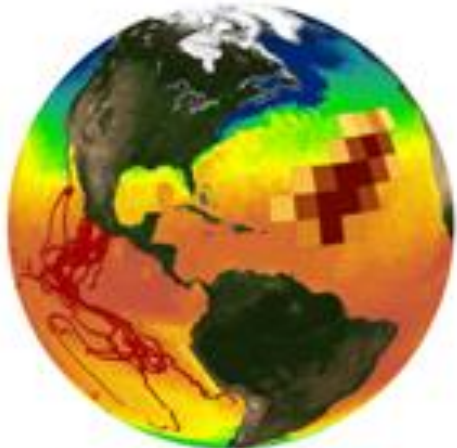
Found 4598 datasets. Total Query Time: 0.42s

- 15 Minute Stream Flow Data: USGS (FIFE)
Archive Center: ORNL_DAAC Short Name: doi:10.3334/ORNLDAAC/1 Version: 1
- 2000 Pilot Environmental Sustainability Index (ESI)
Archive Center: SEDAC Short Name: CIESIN_SEDAC_ESI_2000 Version: 2000.00
- 2001 Environmental Sustainability Index (ESI)
Archive Center: SEDAC Short Name: CIESIN_SEDAC_ESI_2001 Version: 2001.00
- 2002 Environmental Sustainability Index (ESI)
Archive Center: SEDAC Short Name: CIESIN_SEDAC_ESI_2002 Version: 2002.00
- 2005 Environmental Sustainability Index (ESI)
Archive Center: SEDAC Short Name: CIESIN_SEDAC_ESI_2005 Version: 2005.00
- 2008 Environmental Performance Index (EPI)
Archive Center: SEDAC Short Name: CIESIN_SEDAC_EPI_2008 Version: 2008.00

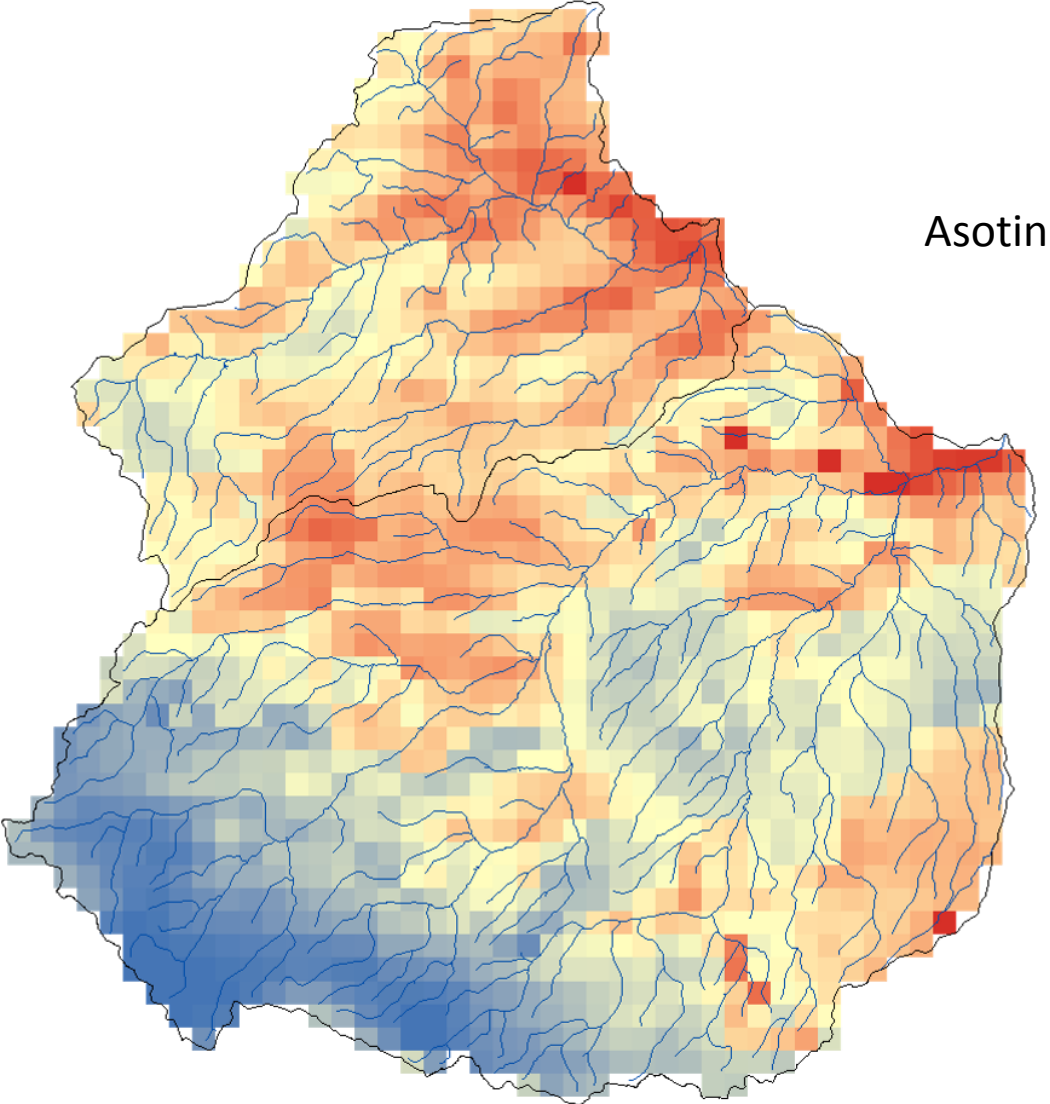
Step 3: Discover Granules

Hierarchical Data Format [HDF]: Scientific Data Set [SDS]: LST_Day_1km

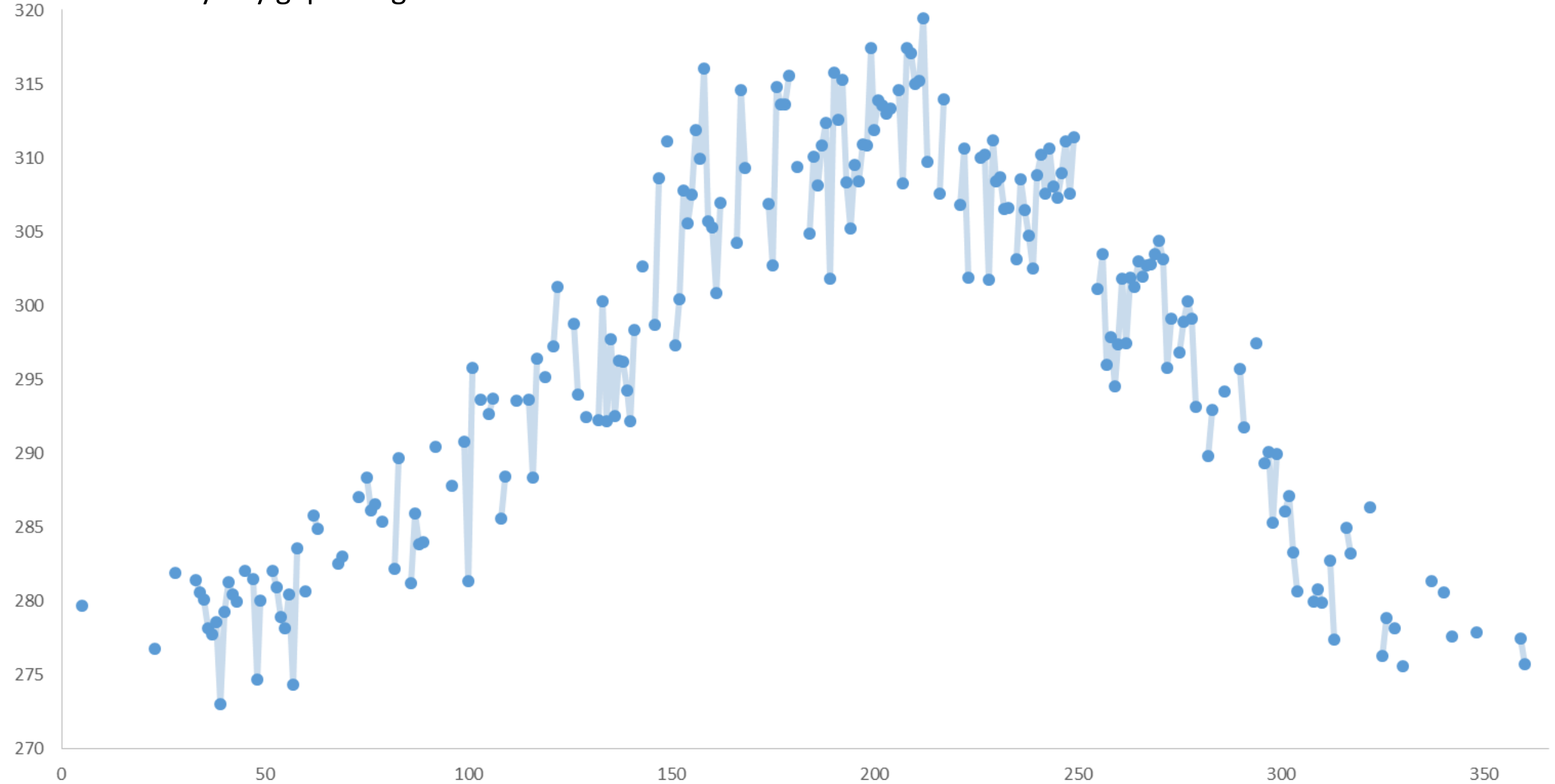
Extract, Project, & Clip



**Marine
Geospatial
Ecology
Tools**

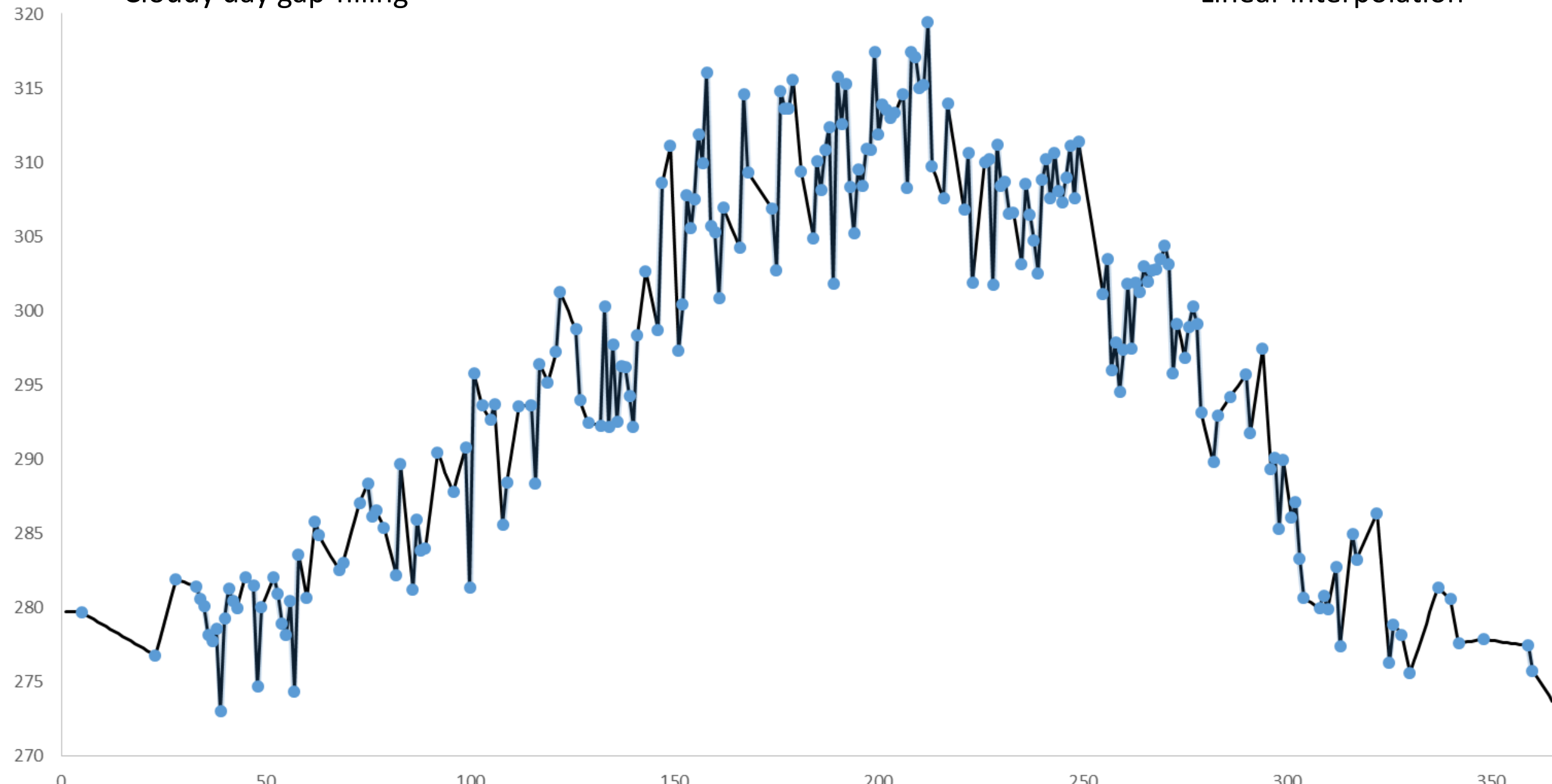


Cloudy day gap-filling



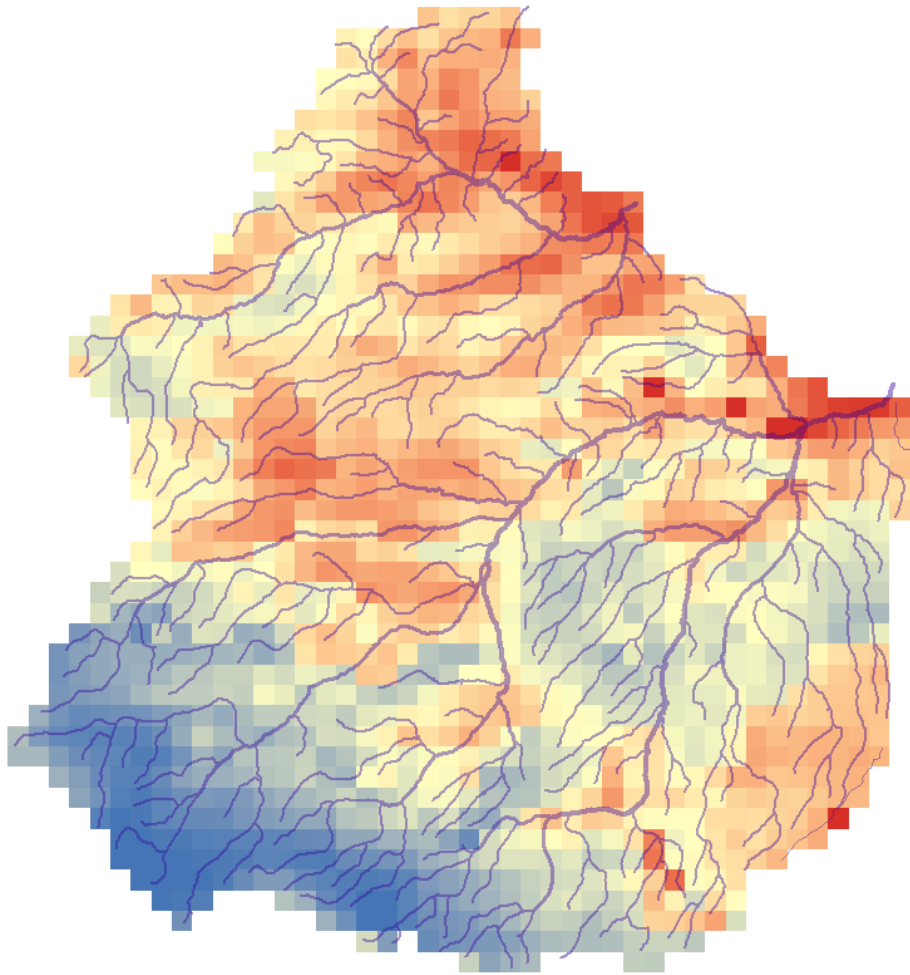
Cloudy day gap-filling

Linear interpolation

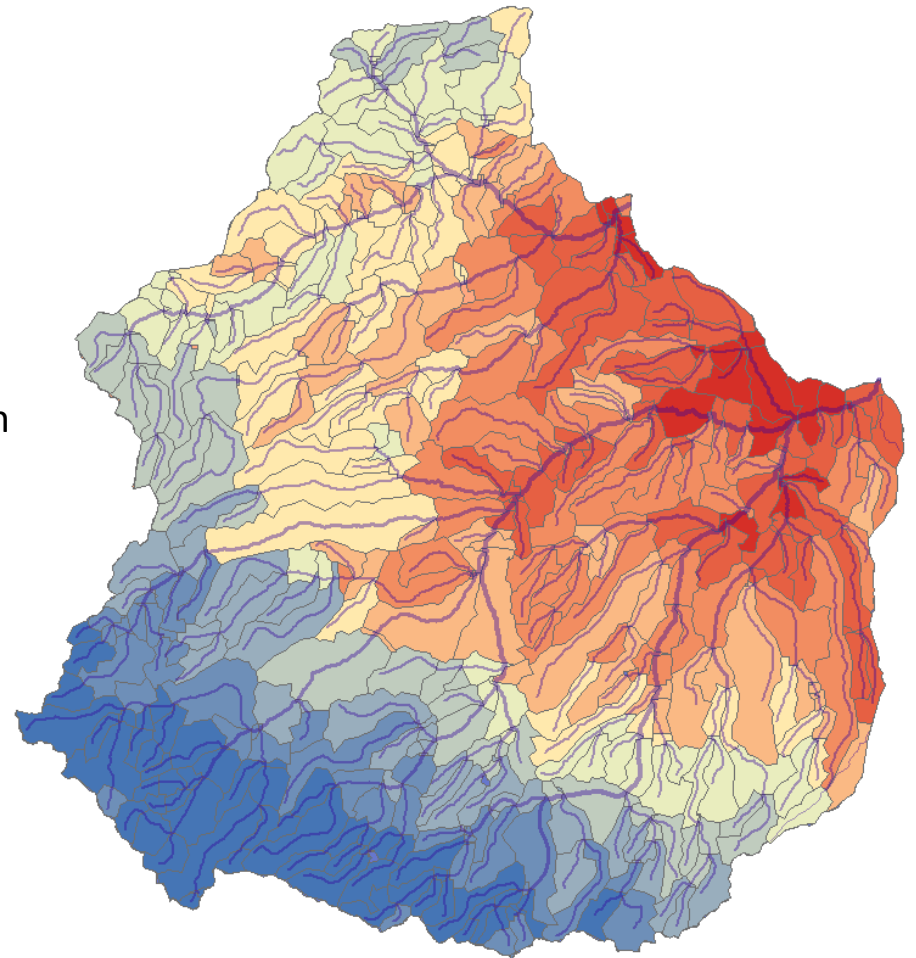


1km² grid

RCA polygons



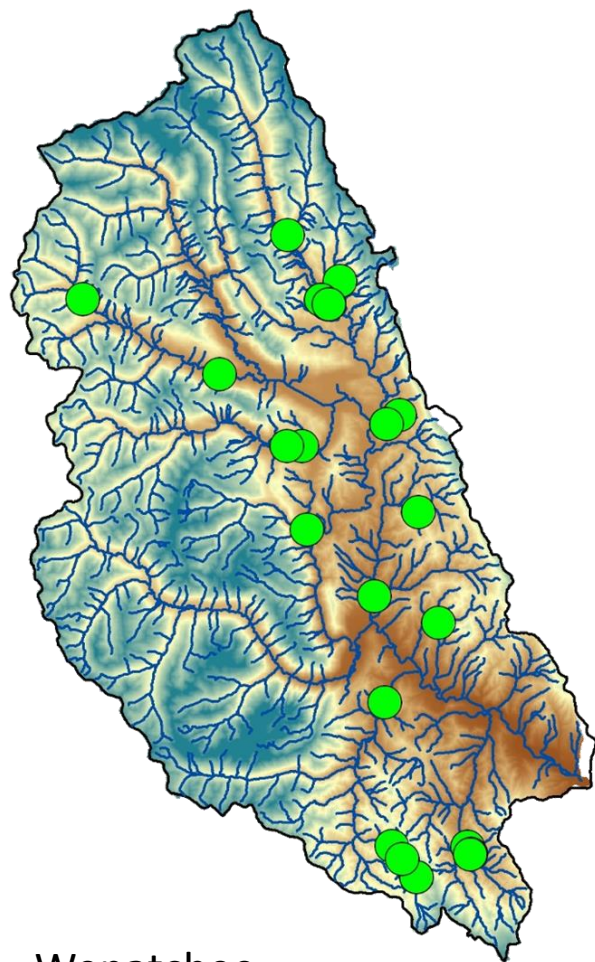
Area weighted mean



Asotin

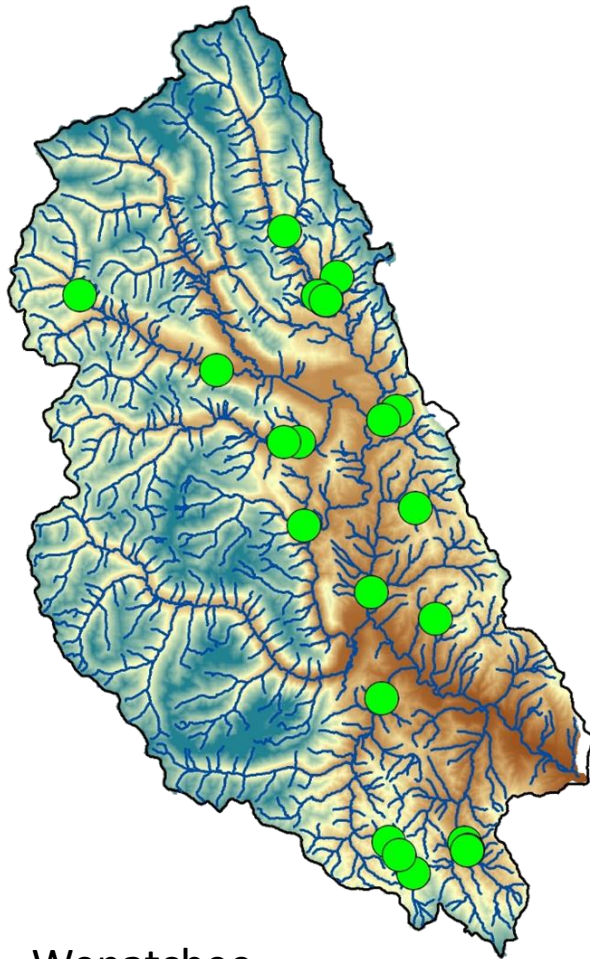
Julian day 137

Site data: stream temperature loggers and physiography



Wenatchee

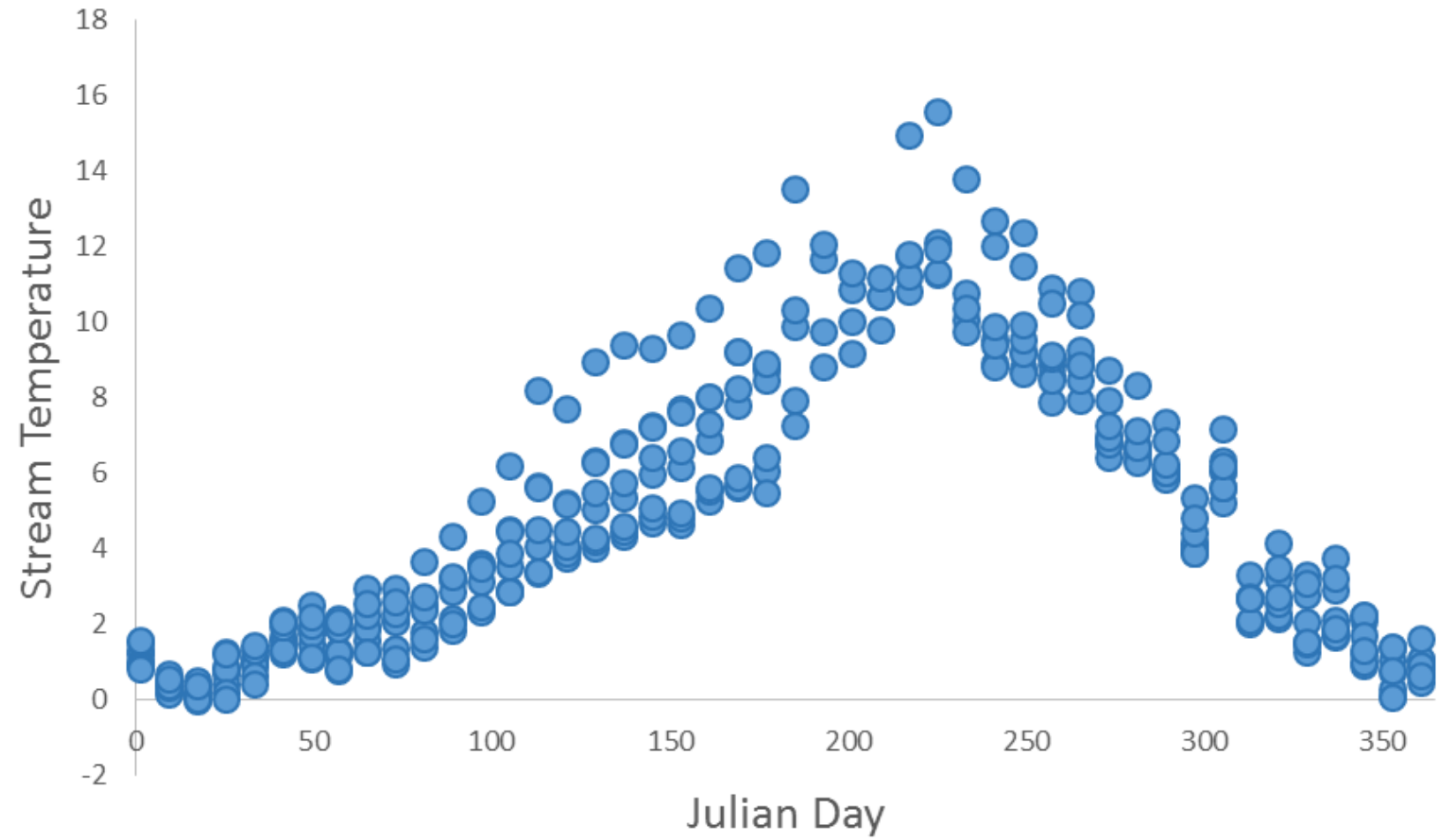
JulDay	Elev	ProgramSi	SiteName	WatershedName	CountDay	StartRange	EndRange	Avg8Day	JulianDate
1	800.8	61785	CBW05583-492715	Wenatchee	8	1-Jan-12	8-Jan-12	1.311	12001
1	376.9	67946	WC503432-000042	Wenatchee	8	1-Jan-12	8-Jan-12	1.227	12001
1	567.3	67951	WC503432-000049	Wenatchee	8	1-Jan-12	8-Jan-12	1.033	12001
1	575.3	67979	WENMASTER-000037	Wenatchee	8	1-Jan-12	8-Jan-12	0.964	12001
1	754.3	67994	WENMASTER-000071	Wenatchee	8	1-Jan-12	8-Jan-12	0.937	12001
1	728.8	68020	WENMASTER-000195	Wenatchee	8	1-Jan-12	8-Jan-12	0.849	12001
1	943.9	68036	WENMASTER-000269	Wenatchee	8	1-Jan-12	8-Jan-12	1.541	12001
1	897.8	67937	WC503432-000029	Wenatchee	8	1-Jan-12	8-Jan-12	1.586	12001
9	800.8	61785	CBW05583-492715	Wenatchee	8	9-Jan-12	16-Jan-12	0.506	12009
9	376.9	67946	WC503432-000042	Wenatchee	8	9-Jan-12	16-Jan-12	0.413	12009
9	567.3	67951	WC503432-000049	Wenatchee	8	9-Jan-12	16-Jan-12	0.21	12009
9	575.3	67979	WENMASTER-000037	Wenatchee	8	9-Jan-12	16-Jan-12	0.163	12009
9	754.3	67994	WENMASTER-000071	Wenatchee	8	9-Jan-12	16-Jan-12	0.347	12009
9	728.8	68020	WENMASTER-000195	Wenatchee	8	9-Jan-12	16-Jan-12	0.373	12009
9	943.9	68036	WENMASTER-000269	Wenatchee	8	9-Jan-12	16-Jan-12	0.683	12009
9	897.8	67937	WC503432-000029	Wenatchee	8	9-Jan-12	16-Jan-12	0.57	12009
17	800.8	61785	CBW05583-492715	Wenatchee	8	17-Jan-12	24-Jan-12	0.122	12017
17	376.9	67946	WC503432-000042	Wenatchee	8	17-Jan-12	24-Jan-12	0.035	12017
17	567.3	67951	WC503432-000049	Wenatchee	8	17-Jan-12	24-Jan-12	0.232	12017
17	575.3	67979	WENMASTER-000037	Wenatchee	8	17-Jan-12	24-Jan-12	0.211	12017



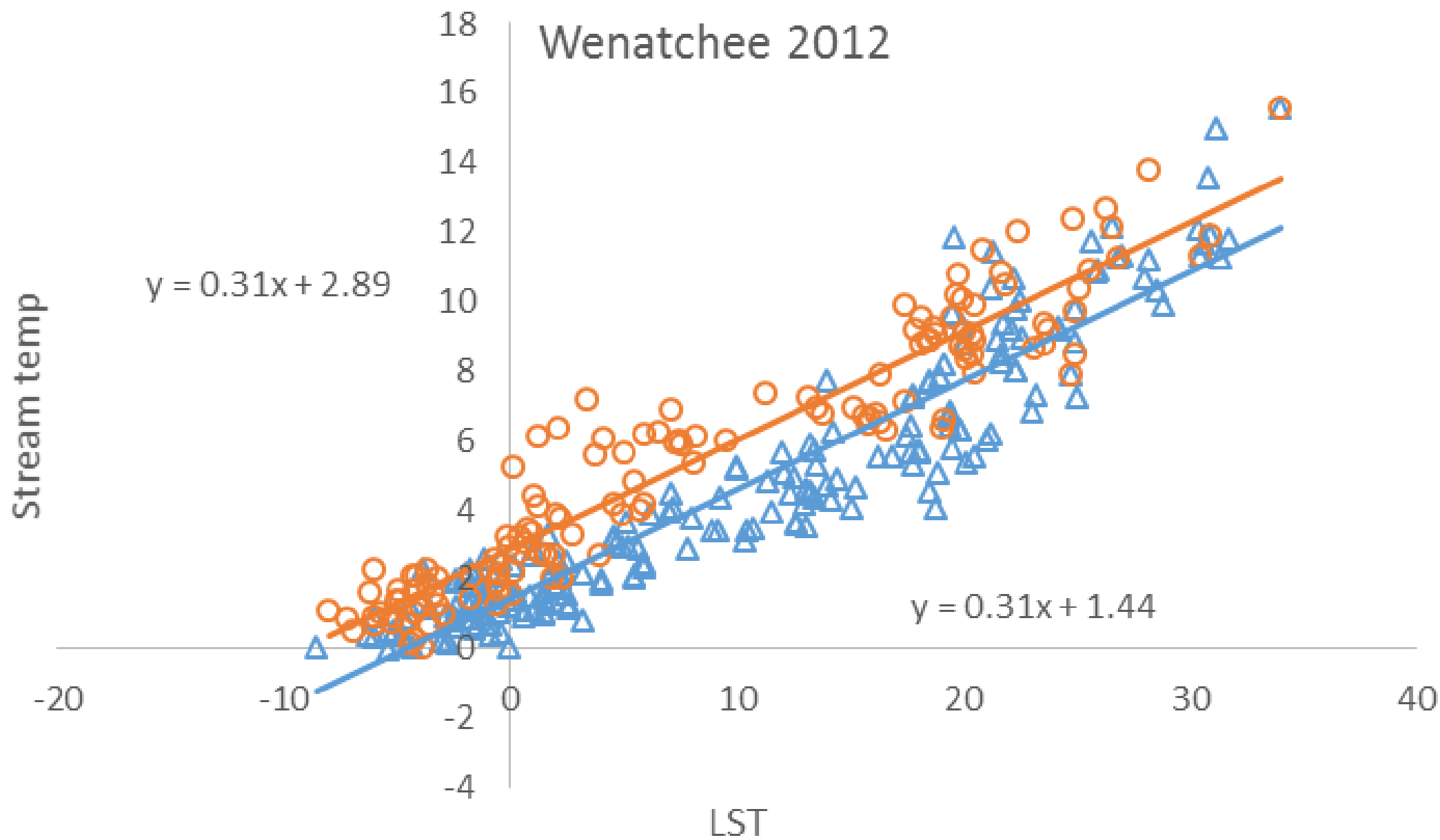
Wenatchee

Site data: stream temperature loggers

Mean 8-day temperature

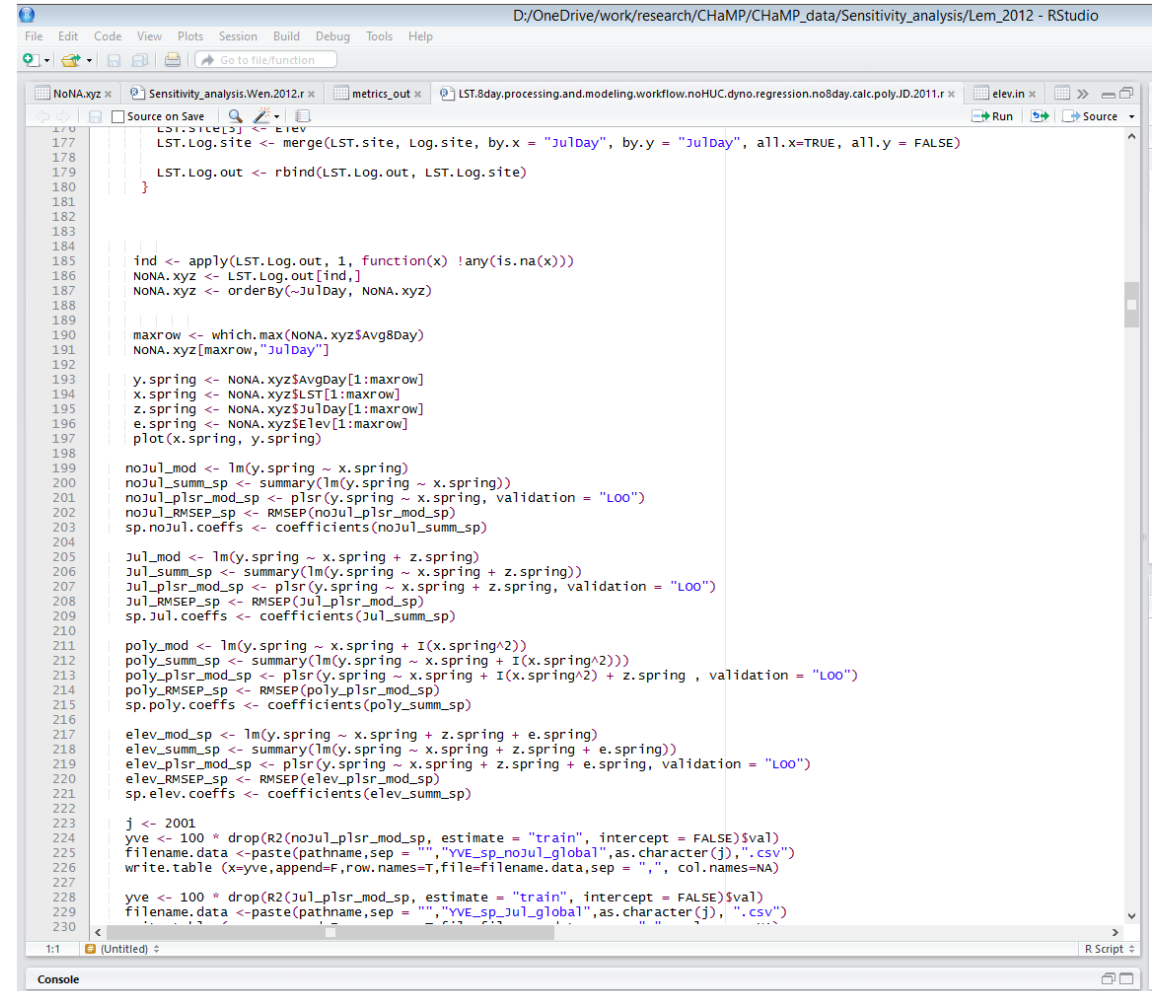


Wenatchee 2012



R script

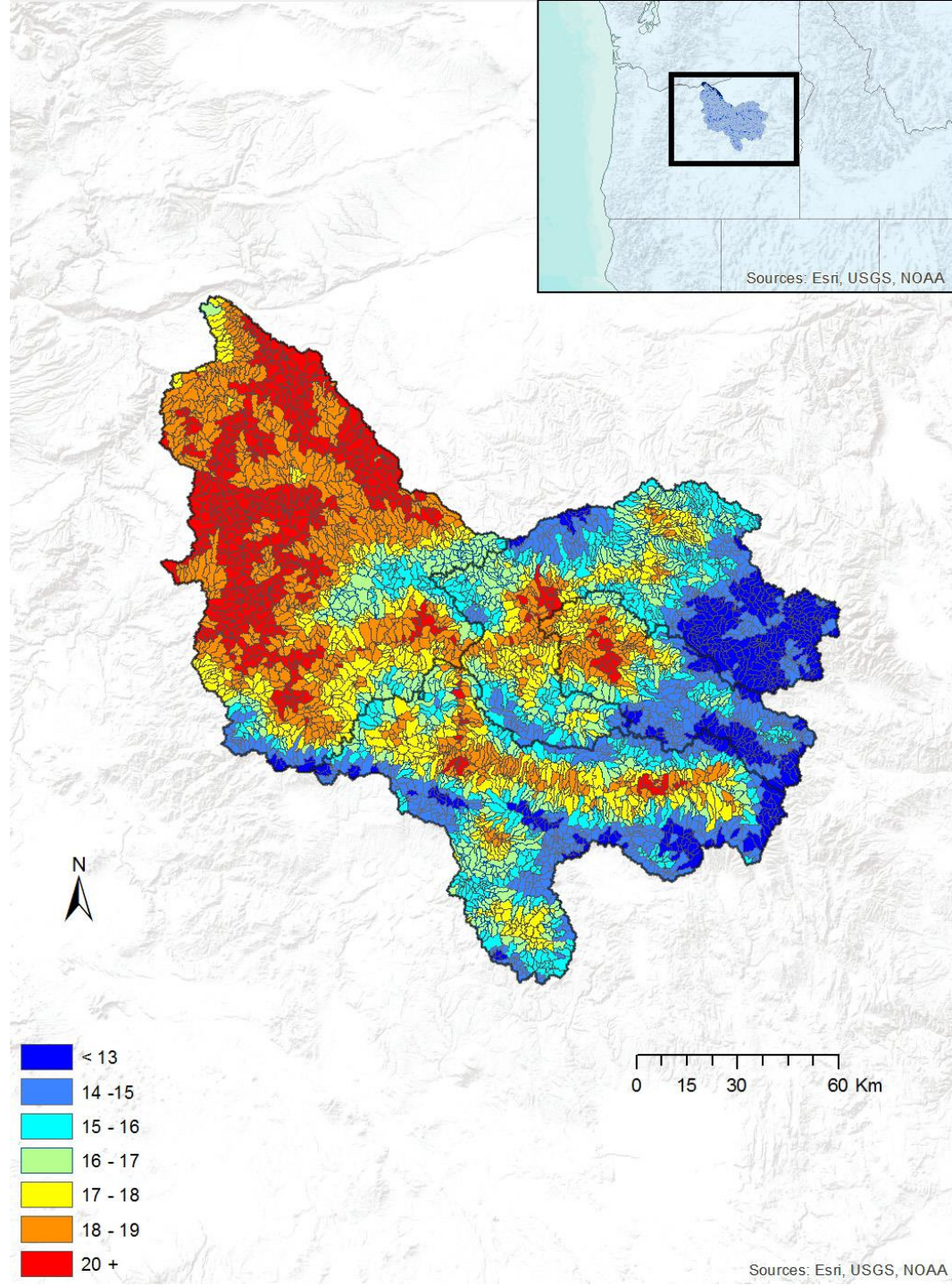
- Parses data into spring/fall set
- Finds “best” model structure
 - L-O-O PRESS Statistic
 - RMSEP
 - AIC
- Parameterizes model
- Estimates stream temp in unsampled reaches



```
177
178
179 LST.Log.site <- merge(LST.site, Log.site, by.x = "JulDay", by.y = "JulDay", all.x=TRUE, all.y = FALSE)
180
181 LST.Log.out <- rbind(LST.Log.out, LST.Log.site)
182
183
184
185 ind <- apply(LST.Log.out, 1, function(x) !any(is.na(x)))
186 NONA.xyz <- LST.Log.out[ind,]
187 NONA.xyz <- orderBy(-JulDay, NONA.xyz)
188
189 maxrow <- which.max(NONA.xyz$Avg8Day)
190 NONA.xyz[maxrow, "JulDay"]
191
192
193 y.spring <- NONA.xyz$AvgDay[1:maxrow]
194 x.spring <- NONA.xyz$LST[1:maxrow]
195 z.spring <- NONA.xyz$JulDay[1:maxrow]
196 e.spring <- NONA.xyz$elev[1:maxrow]
197 plot(x.spring, y.spring)
198
199 noJul_mod <- lm(y.spring ~ x.spring)
200 noJul_summ_sp <- summary(lm(y.spring ~ x.spring))
201 noJul_plsr_mod_sp <- plsr(y.spring ~ x.spring, validation = "Loo")
202 noJul_RMSEP_sp <- RMSEP(noJul_plsr_mod_sp)
203 sp.noJul.coeffs <- coefficients(noJul_summ_sp)
204
205 Jul_mod <- lm(y.spring ~ x.spring + z.spring)
206 Jul_summ_sp <- summary(lm(y.spring ~ x.spring + z.spring))
207 Jul_plsr_mod_sp <- plsr(y.spring ~ x.spring + z.spring, validation = "Loo")
208 Jul_RMSEP_sp <- RMSEP(Jul_plsr_mod_sp)
209 sp.Jul.coeffs <- coefficients(Jul_summ_sp)
210
211 poly_mod <- lm(y.spring ~ x.spring + I(x.spring^2))
212 poly_summ_sp <- summary(lm(y.spring ~ x.spring + I(x.spring^2)))
213 poly_plsr_mod_sp <- plsr(y.spring ~ x.spring + I(x.spring^2) + z.spring, validation = "Loo")
214 poly_RMSEP_sp <- RMSEP(poly_plsr_mod_sp)
215 sp.poly.coeffs <- coefficients(poly_summ_sp)
216
217 elev_mod_sp <- lm(y.spring ~ x.spring + z.spring + e.spring)
218 elev_summ_sp <- summary(lm(y.spring ~ x.spring + z.spring + e.spring))
219 elev_plsr_mod_sp <- plsr(y.spring ~ x.spring + z.spring + e.spring, validation = "Loo")
220 elev_RMSEP_sp <- RMSEP(elev_plsr_mod_sp)
221 sp.elev.coeffs <- coefficients(elev_summ_sp)
222
223
224 j <- 2001
225 yve <- 100 * drop(R2(noJul_plsr_mod_sp, estimate = "train", intercept = FALSE)$val)
226 filename.data <- paste(pathname, sep = "", "YVE_sp_noJul_global", as.character(j), ".csv")
227 write.table(x=yve, append=F, row.names=T, file=filename.data, sep = ",", col.names=NA)
228
229 j <- 2002
230 yve <- 100 * drop(R2(Jul_plsr_mod_sp, estimate = "train", intercept = FALSE)$val)
231 filename.data <- paste(pathname, sep = "", "YVE_sp_Jul_global", as.character(j), ".csv")
232 write.table(x=yve, append=F, row.names=T, file=filename.data, sep = ",", col.names=NA)
```

Model output

Spatially continuous estimate of stream temperature



Continuous estimate of stream temperature

January 2001

Mean daily
water temperature (°C)

<predicted>

< 0

0 - 1

1 - 2

2 - 3

3 - 4

4 - 5

5 - 6

6 - 7

7 - 8

8 - 9

9 - 10

10 - 11

11 - 12

12 - 13

13 - 14

14 - 15

15 - 16

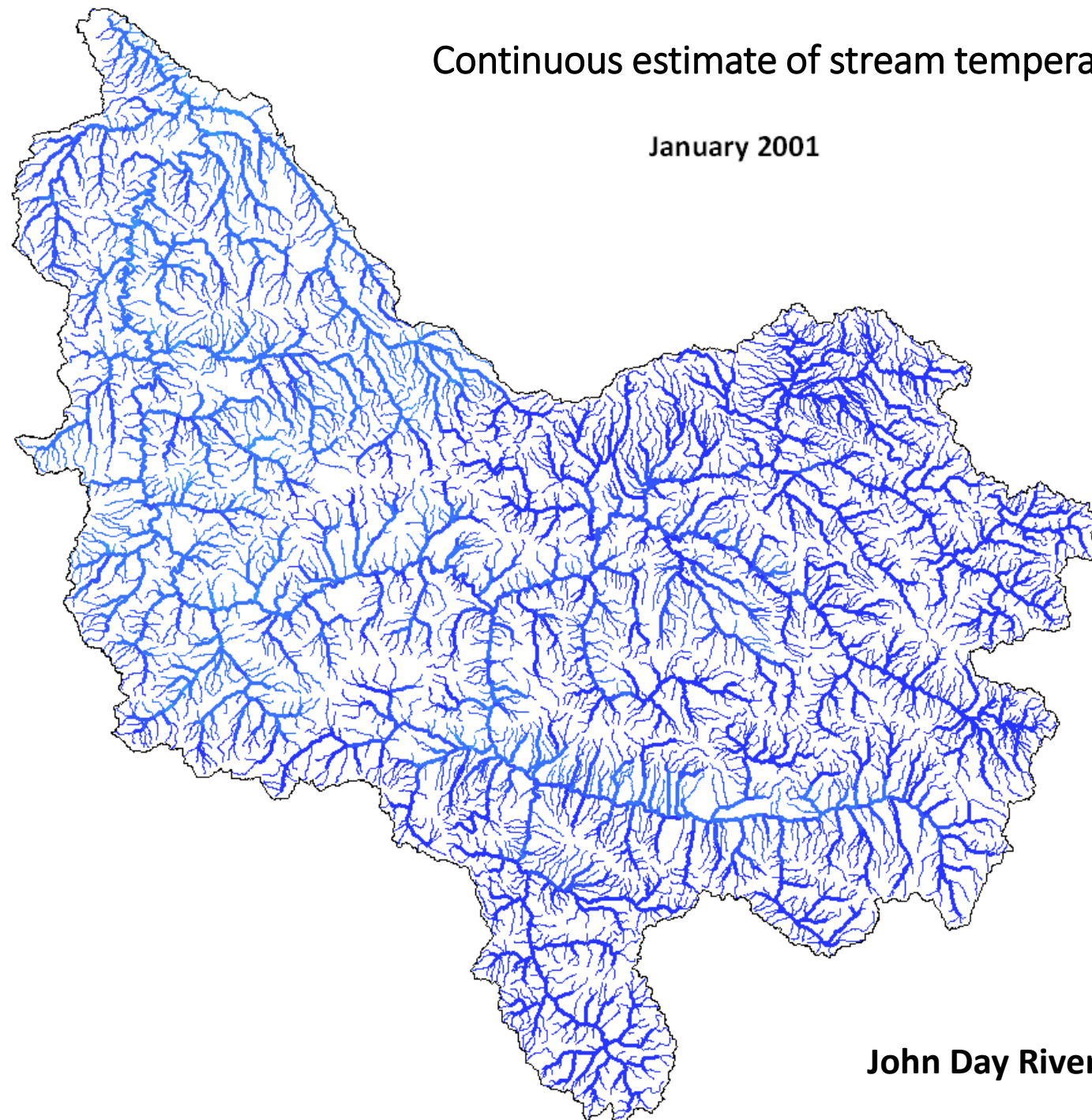
16 - 17

17 - 18

18 - 19

19 - 20

> 20



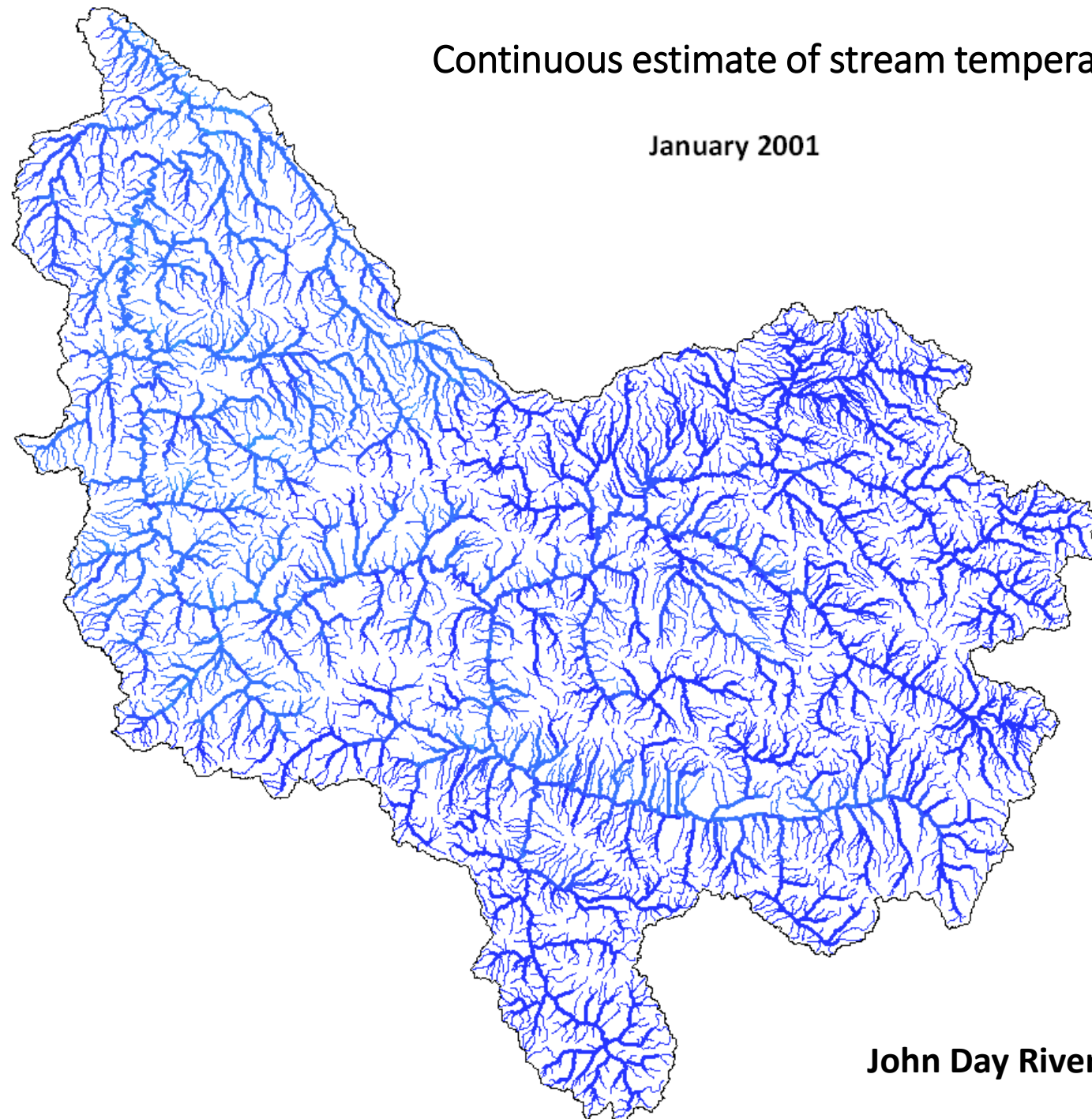
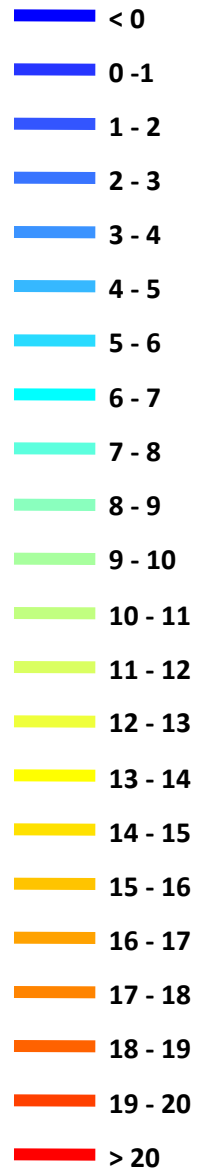
John Day River basin

Continuous estimate of stream temperature

January 2001

Mean daily
water temperature (°C)

<predicted>



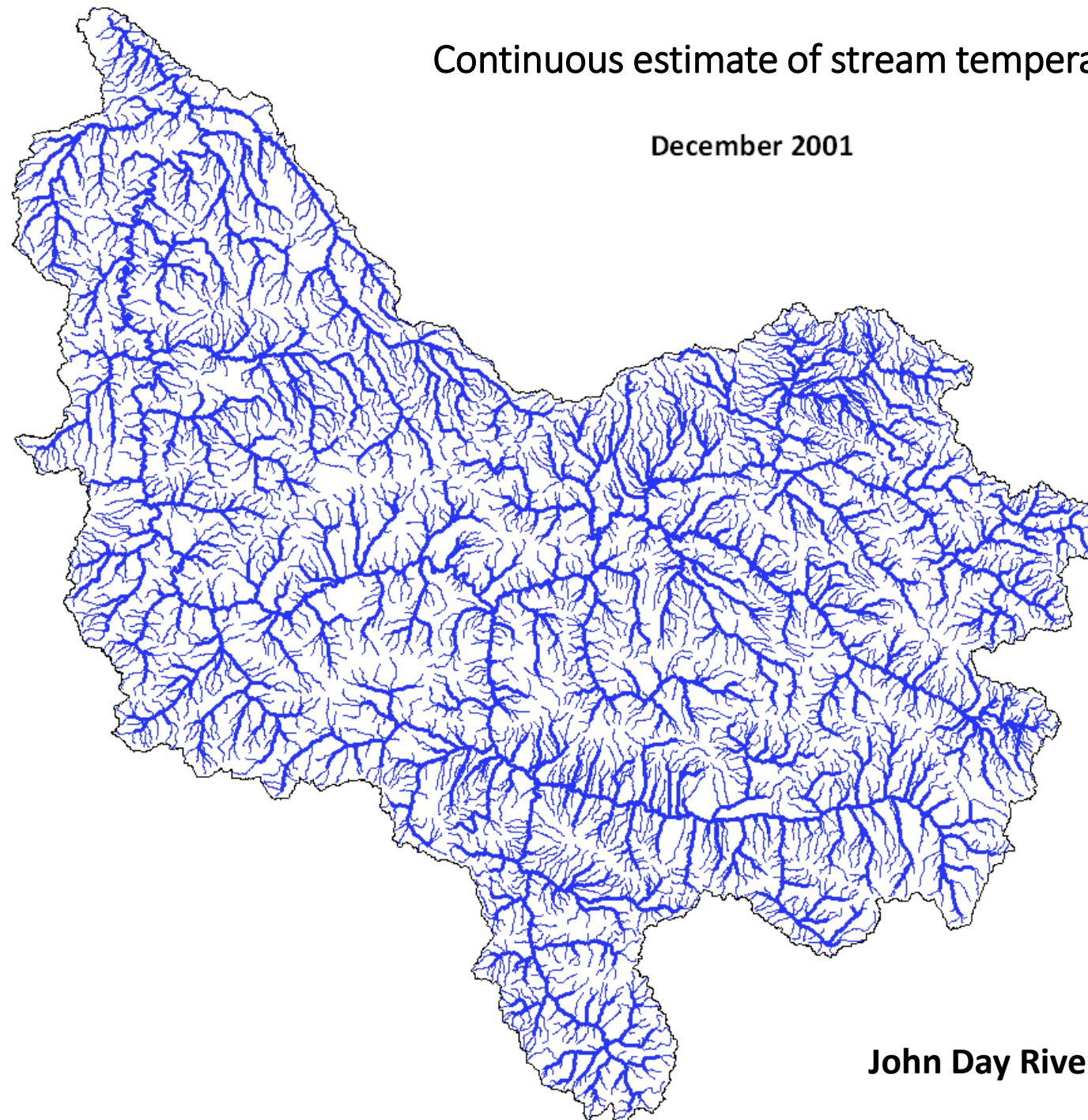
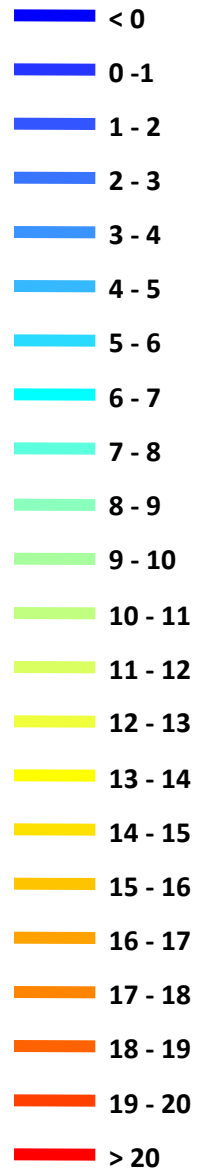
John Day River basin

Continuous estimate of stream temperature

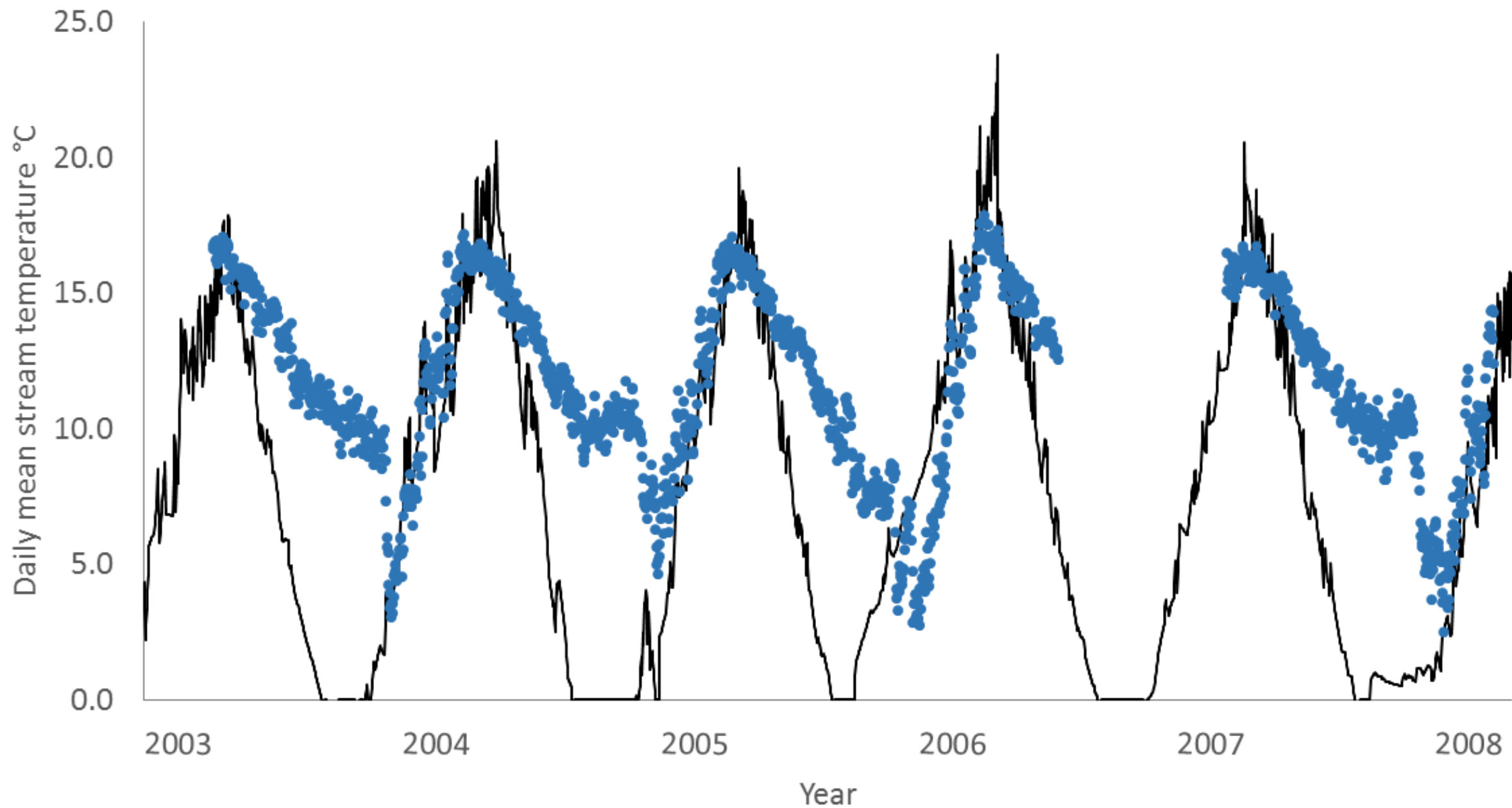
December 2001

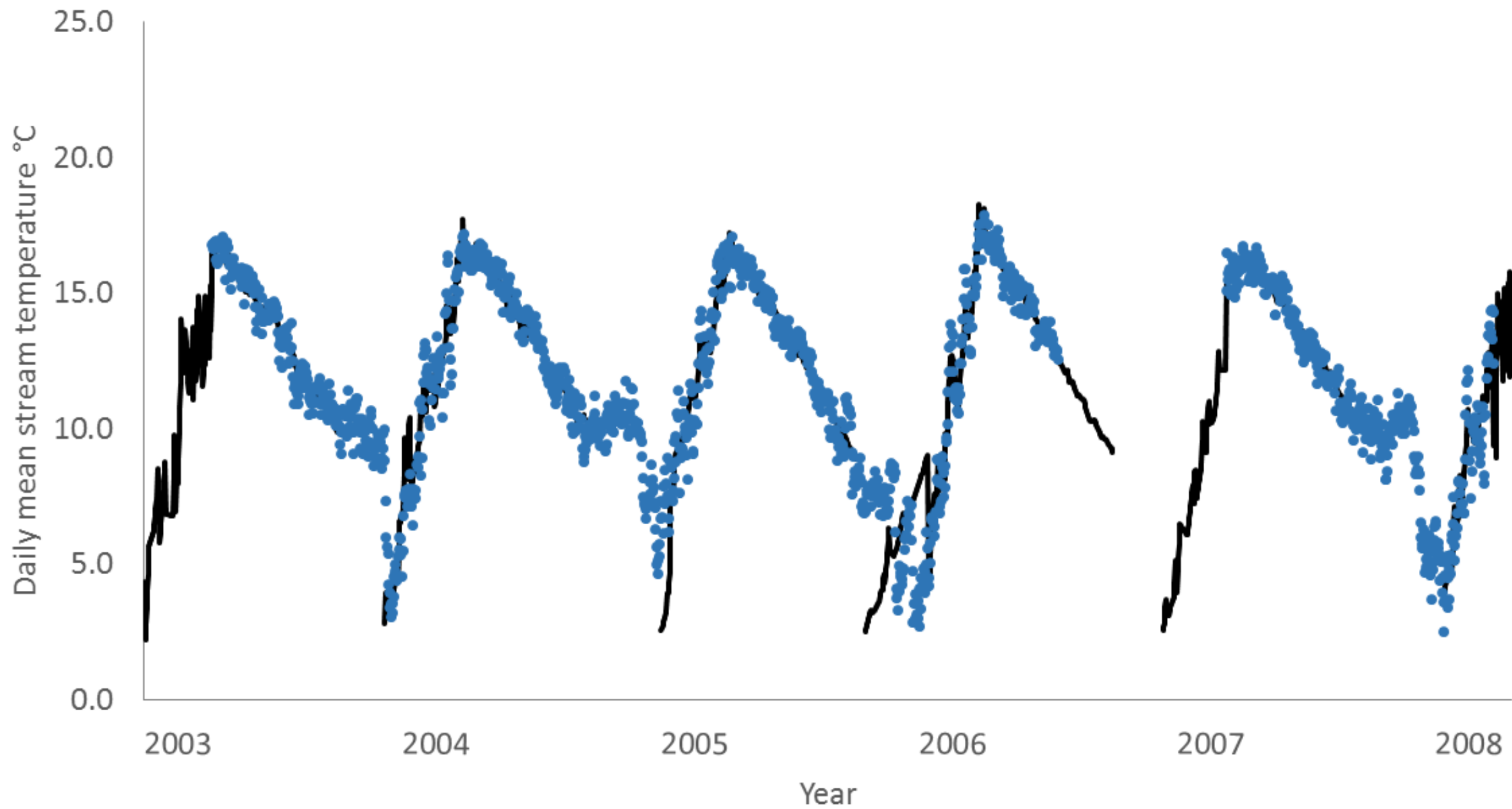
Mean daily
water temperature (°C)

<predicted>



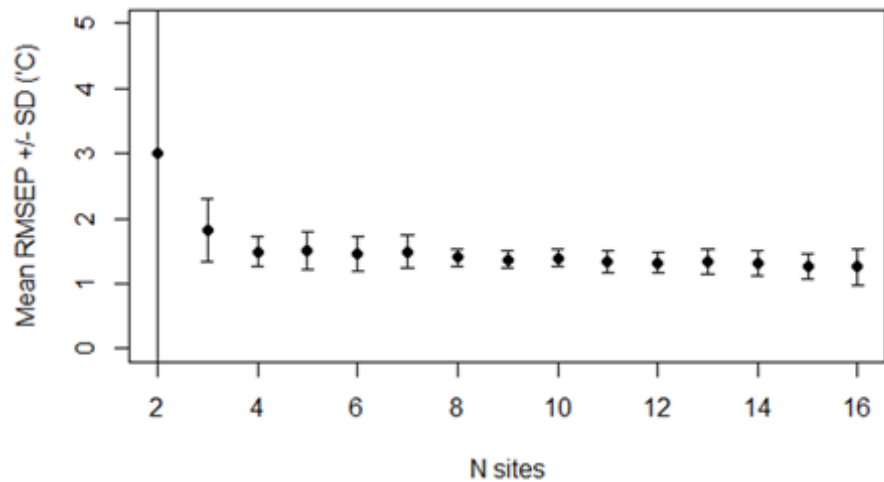
John Day River basin



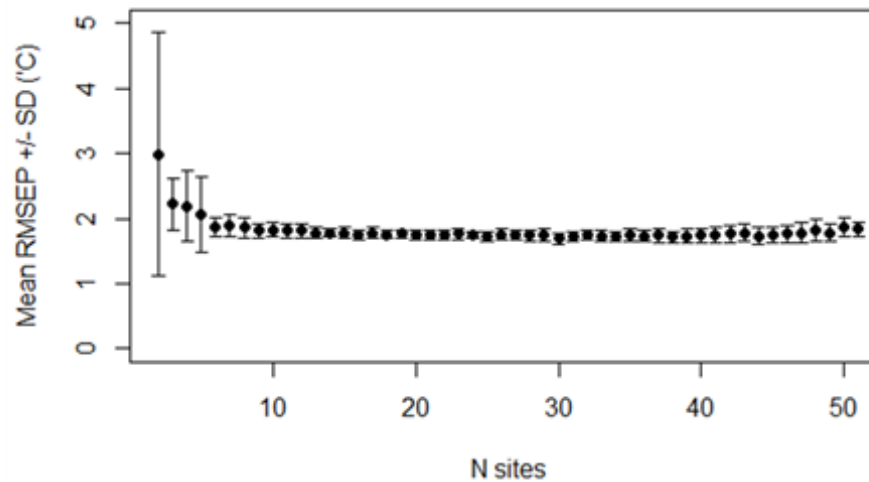


How many (or few) sites are needed?

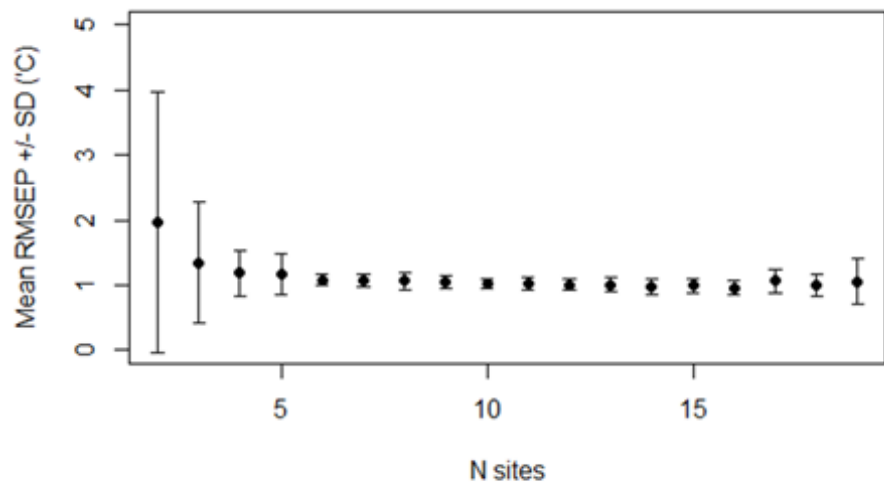
Lem 2012 fall



UGR 2012 fall



Tuc 2012 fall



Wen 2012 fall

