Landscape predictive models for thermal regime metrics in New England

Detenbeck, N.[1], R. Abele[2], A. Morrison[3], D. Kopp[3], and I. Rubio[3]

[1]US EPA ORD Atlantic Ecology Division, Narragansett, RI , [2]US EPA Region 1, Boston, MA, [3]Student services contractor at AED

Temperature Data and Modelling Meeting

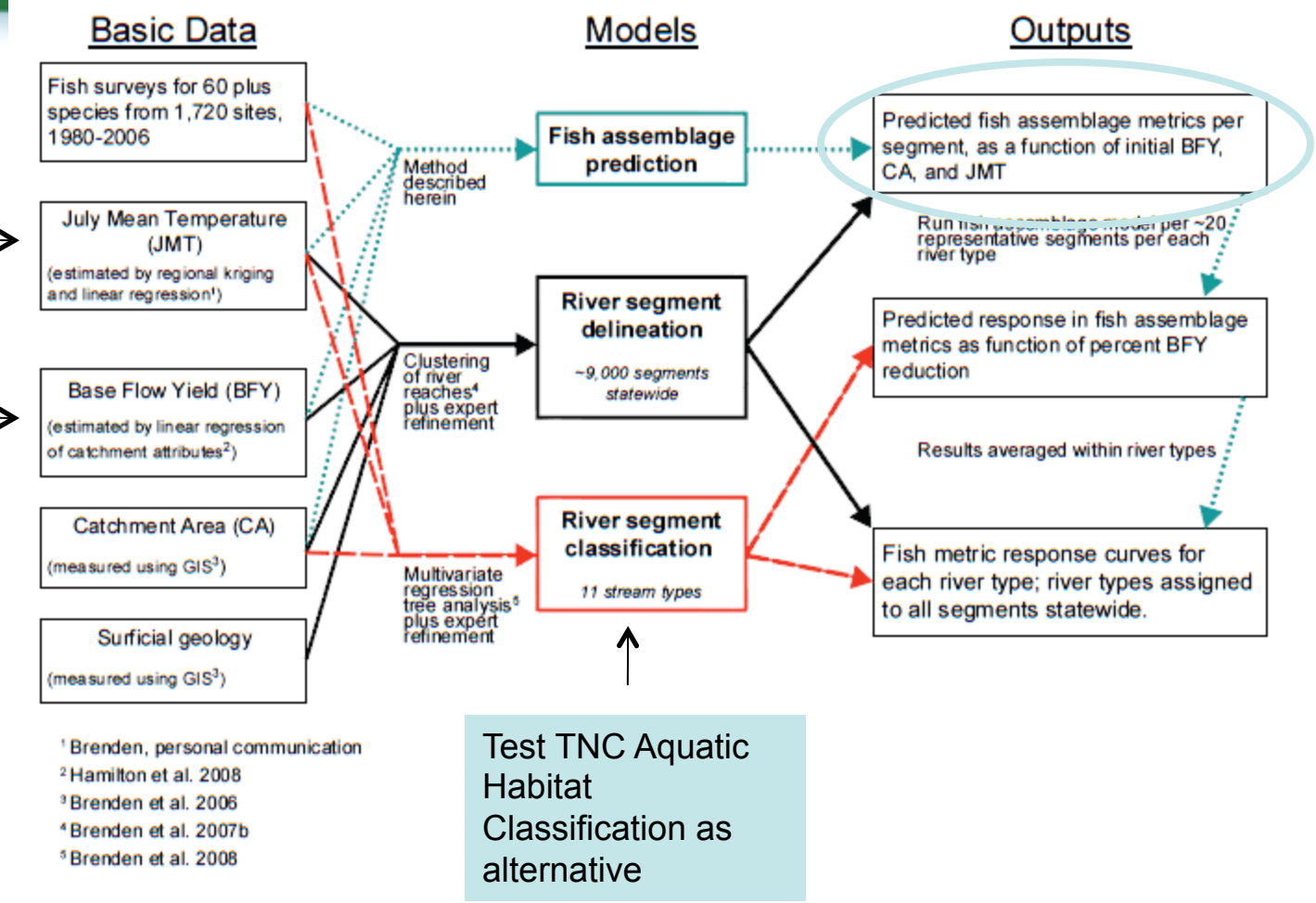
USFWS Regional Office

Hadley, MA| May 3, 2012

Fish community prediction

Alternate metrics (modelled)

7Q10 = f(winter/ spring prec, ann avg temp, %coarse deposits, %wetlands)

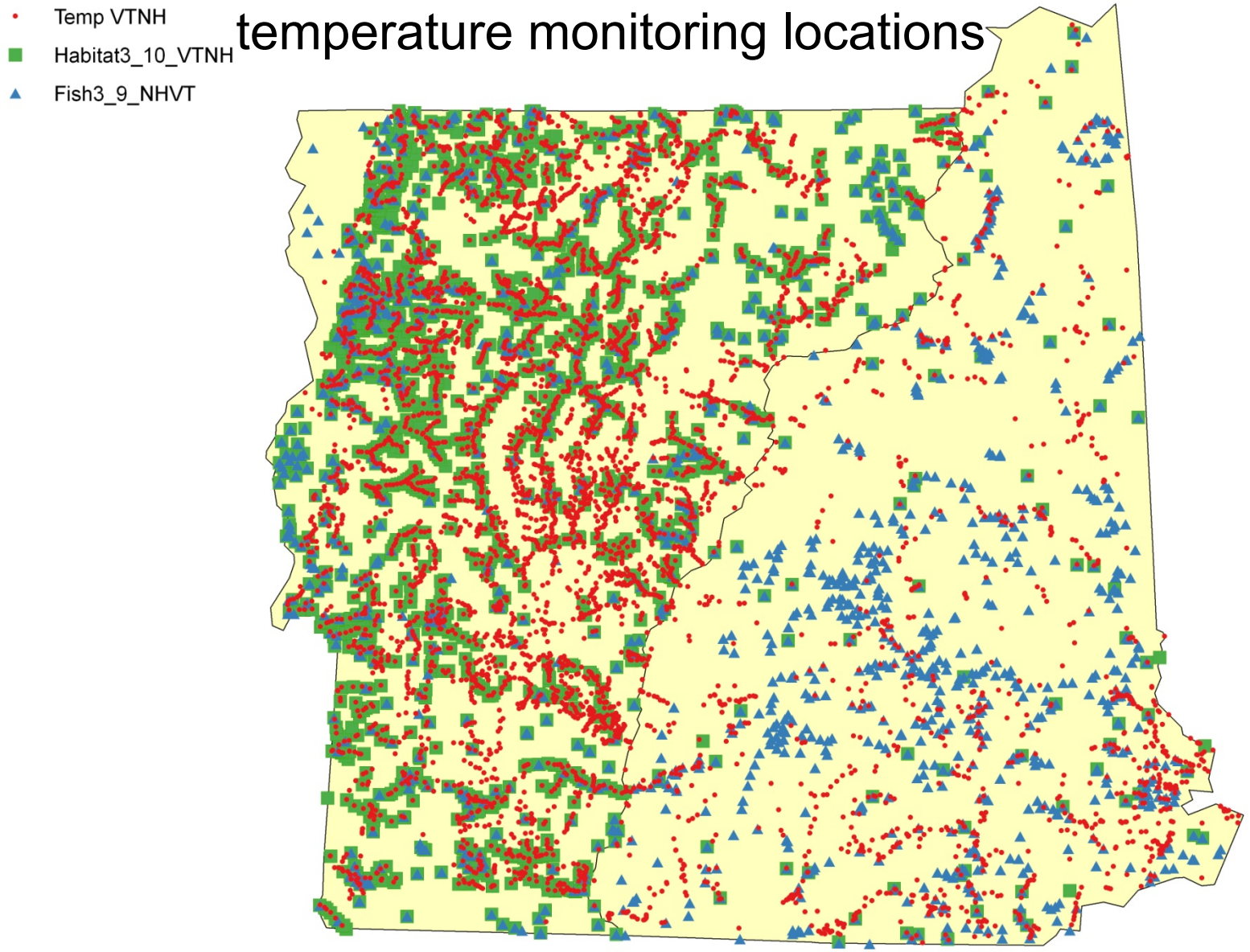


Test TNC Aquatic Habitat Classification as alternative

gure 1.–Flow chart of the flow-fish response assessment model showing major data, model, output components, and linkages.

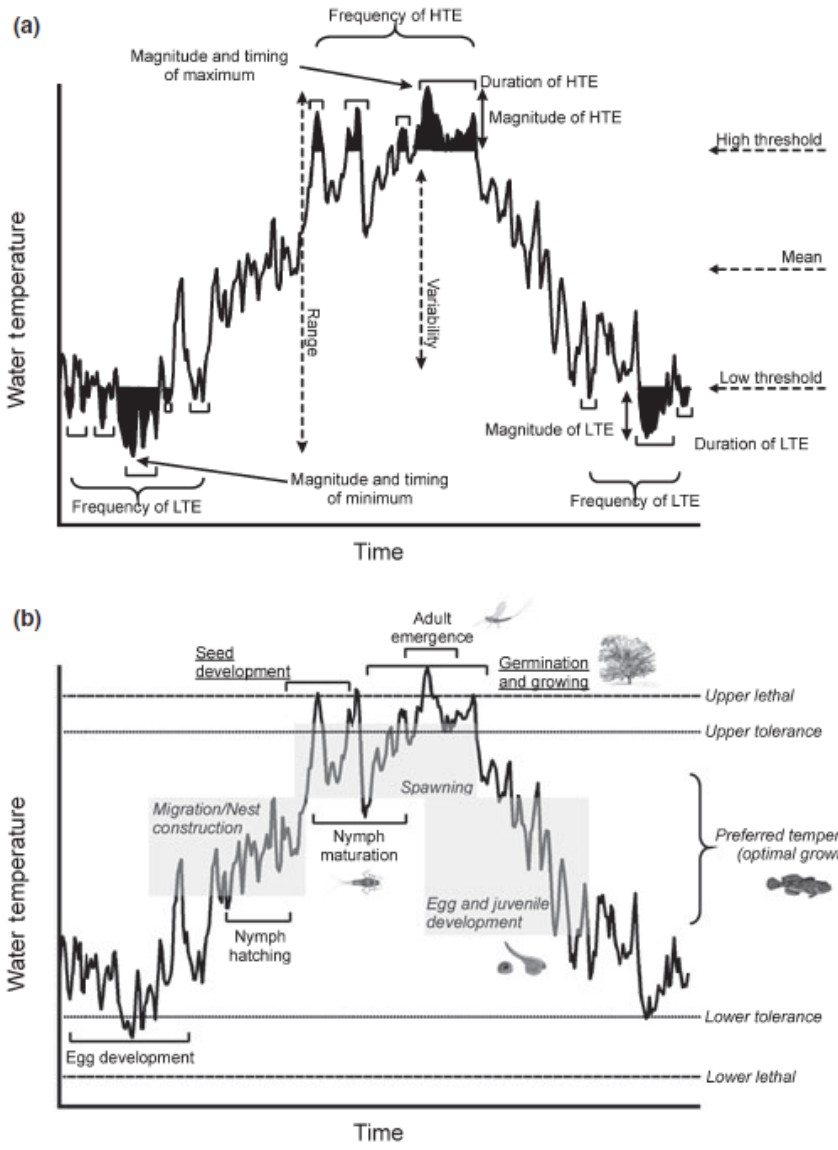
From Zorn et al. 2008. A Regional-scale Habitat Suitability Model to Assess the Effects of Flow Reduction on Fish Assemblages in Michigan Streams. MI DNR, Ann Arbor, MI. Fisheries Div Res Report 2089.

The problem: Limited matches between fish and temperature monitoring locations



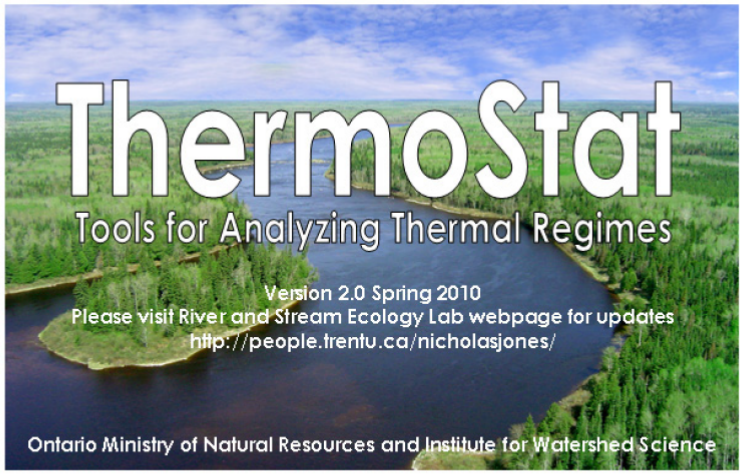
Which metrics should we predict?

- Possible thermal metrics
  - Maximum/minimum temp
  - Magnitude of high/low temp event
  - Frequency of high/low temp event
  - Duration of high/low temp event
  - Timing
  - …



From Olden and Naiman, Freshwater Biology (2010) 55, 86–107

Processing of thermal metrics

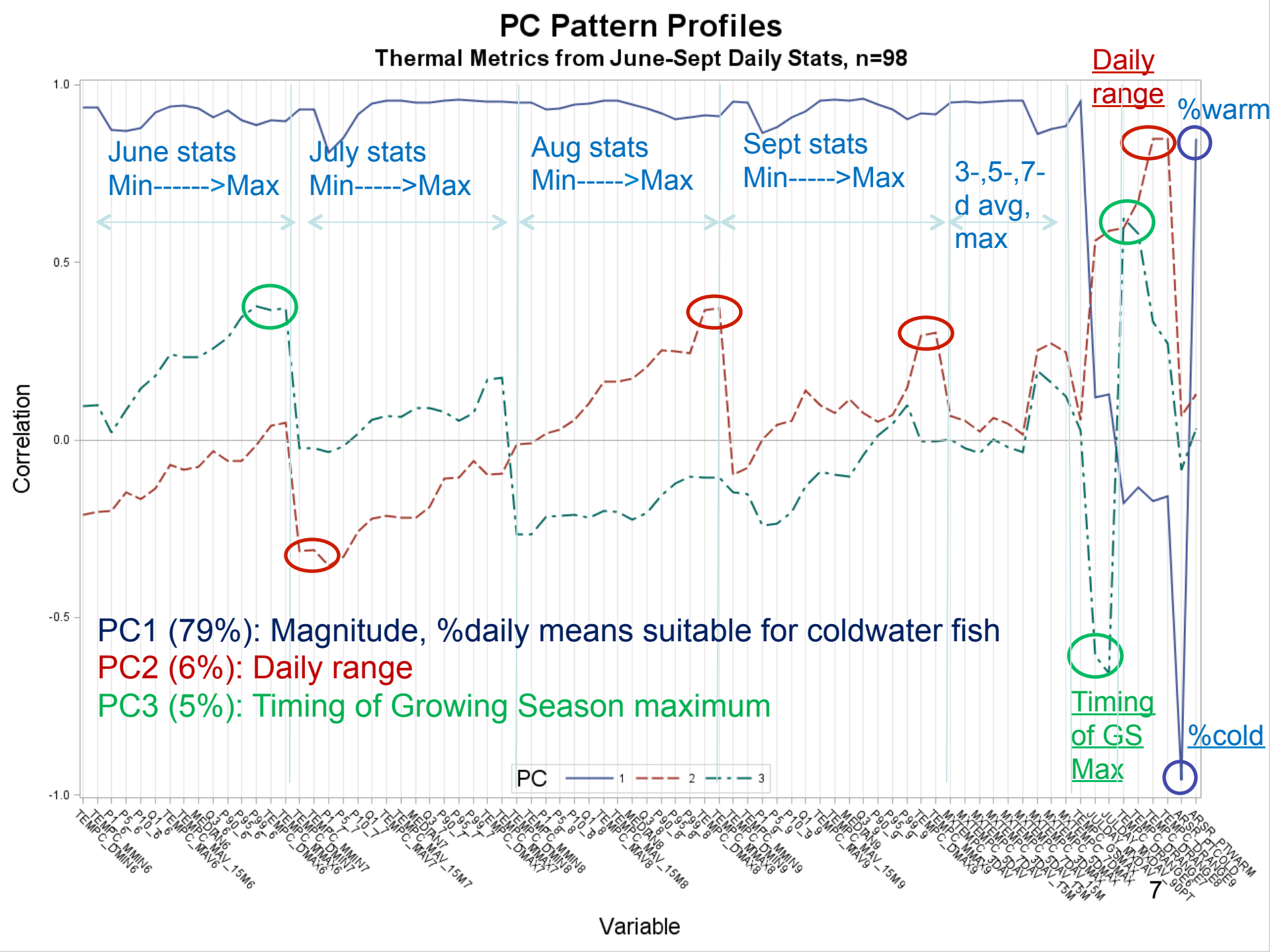


Processing

- Thermal metrics within ThermoStatv2
  - Recoded in SAS to enable batch processing
- Normalized w Box-Cox transformations
- Reduced dimensionality
  - Principal Components Analysis
  - In progress
    - Overlay of thermal metrics on ordination of fish community (in progress)
    - Test of alternative metrics for selected indicator species

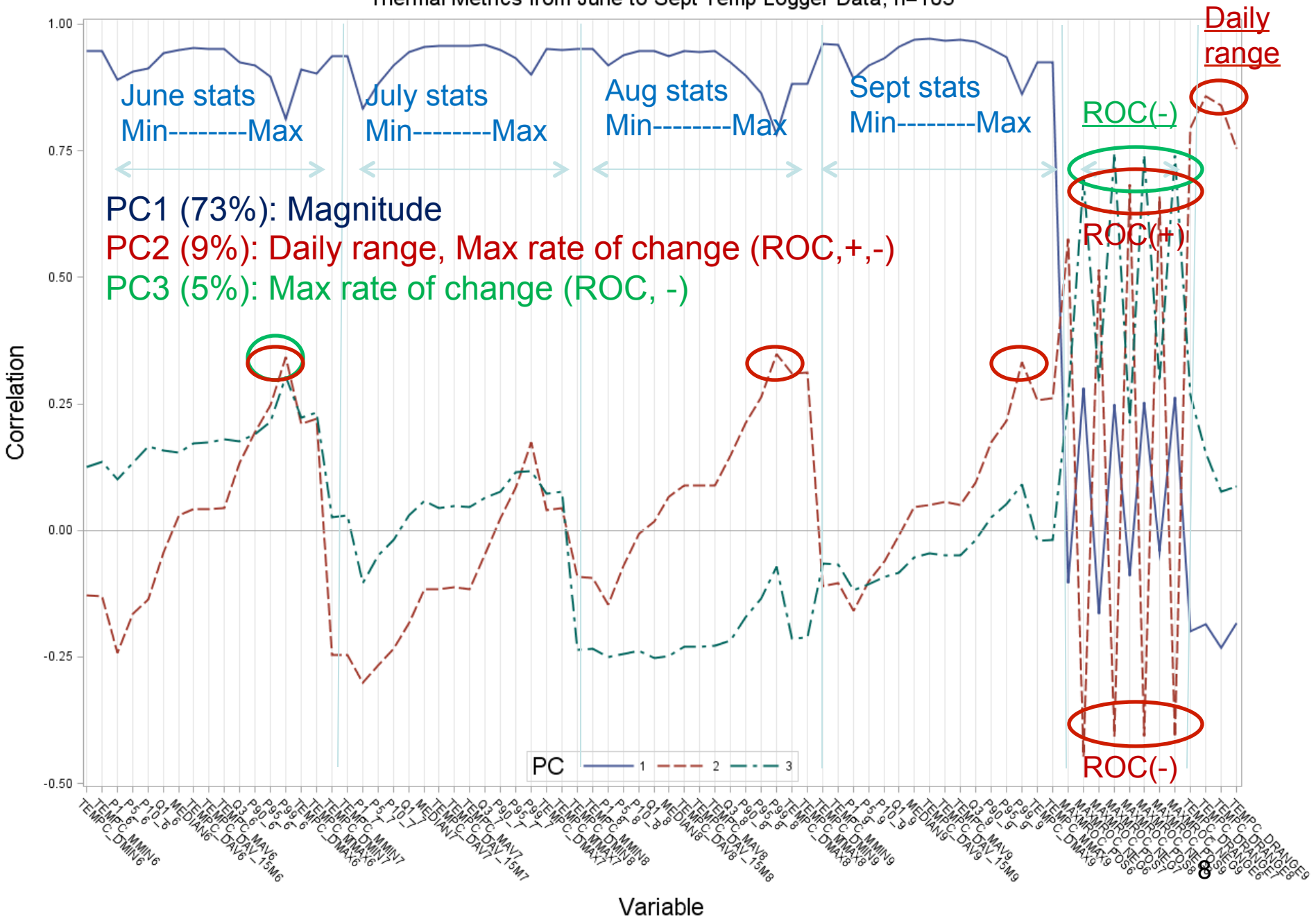
Calculation of thermal metrics

- Change
  - Maximum daily rate of change (ROC, +, -)
  - Daily range
- Growing season maximum
  - Magnitude
  - Timing
- Monthly duration curves
  - (p1, …median…,p99)
  - 15 min interval time series
  - Daily averages
- Monthly avg, min, max
- Avg and max of 3-, 5-, and 7-day running averages
- % daily averages suitable
  - Coldwater fish species
  - Coolwater fish species
  - Warmwater fish species
- Taxa-specific optima and thresholds


PC Pattern Profiles
Thermal Metrics from June-Sept Daily Stats, n=98
Daily range
%warm
June stats Min------>Max
July stats Min----->Max
Aug stats Min----->Max
Sept stats Min----->Max
3-,5-,7-d avg, max
PC1 (79%): Magnitude, %daily means suitable for coldwater fish
PC2 (6%): Daily range
PC3 (5%): Timing of Growing Season maximum
Timing of GS Max
%cold
PC 1 2 3
Correlation
1.0
0.5
0.0
-0.5
-1.0
Variable
7

PC Pattern Profiles

Thermal Metrics from June to Sept Temp Logger Data, n=105

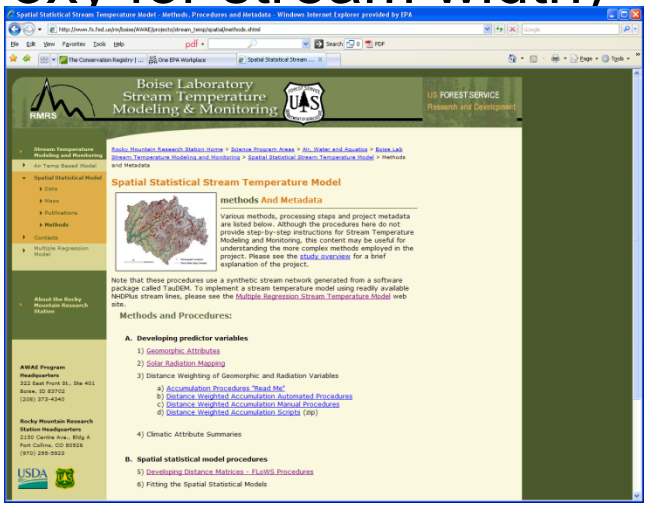


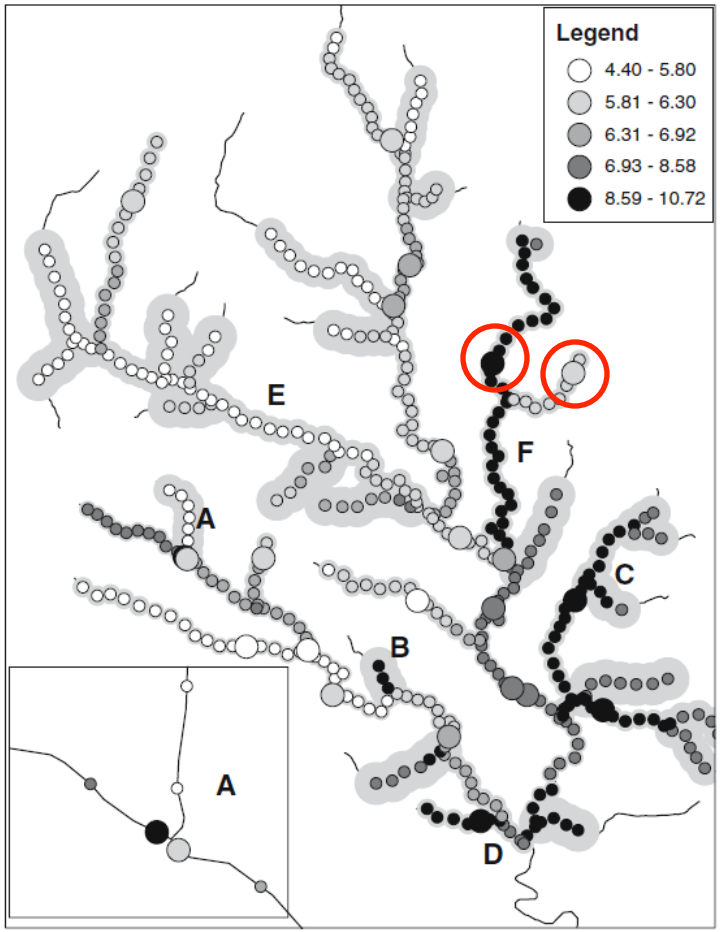
Preliminary conclusions

- Metrics to capture greatest variation across thermal regimes
  - Overall magnitude: July or August median
  - Daily range
  - Timing of growing season maximum
  - Max negative rate of change (recovery?)
- Observations limited by inconsistencies in sampling window and logger location but patterns consistent for larger data sets with shorter sampling windows
- Insufficient fish-temperature matches to explore best predictive metrics for fish thermal guilds unless filtering criteria relaxed

Temperature metric prediction model approach

- Flow-weighted spatial autocorrelation model using stream distance (ver Hoef et al. 2006)
- Potential predictors
  - Watershed area (proxy for stream width)
  - Drainage density
  - Elevation
  - Coarse deposits
  - Channel slope
  - % impervious area
  - Elevation-corrected air temperature
  - Solar radiation proxy (=f(average solar radiation, riparian vegetation type/density, stream width))
  - Stream flow (estimated)





A predictive model accounting for spatial autocorrelation using Euclidean (straight-line) distance would assume these points are similar

observed

predicted

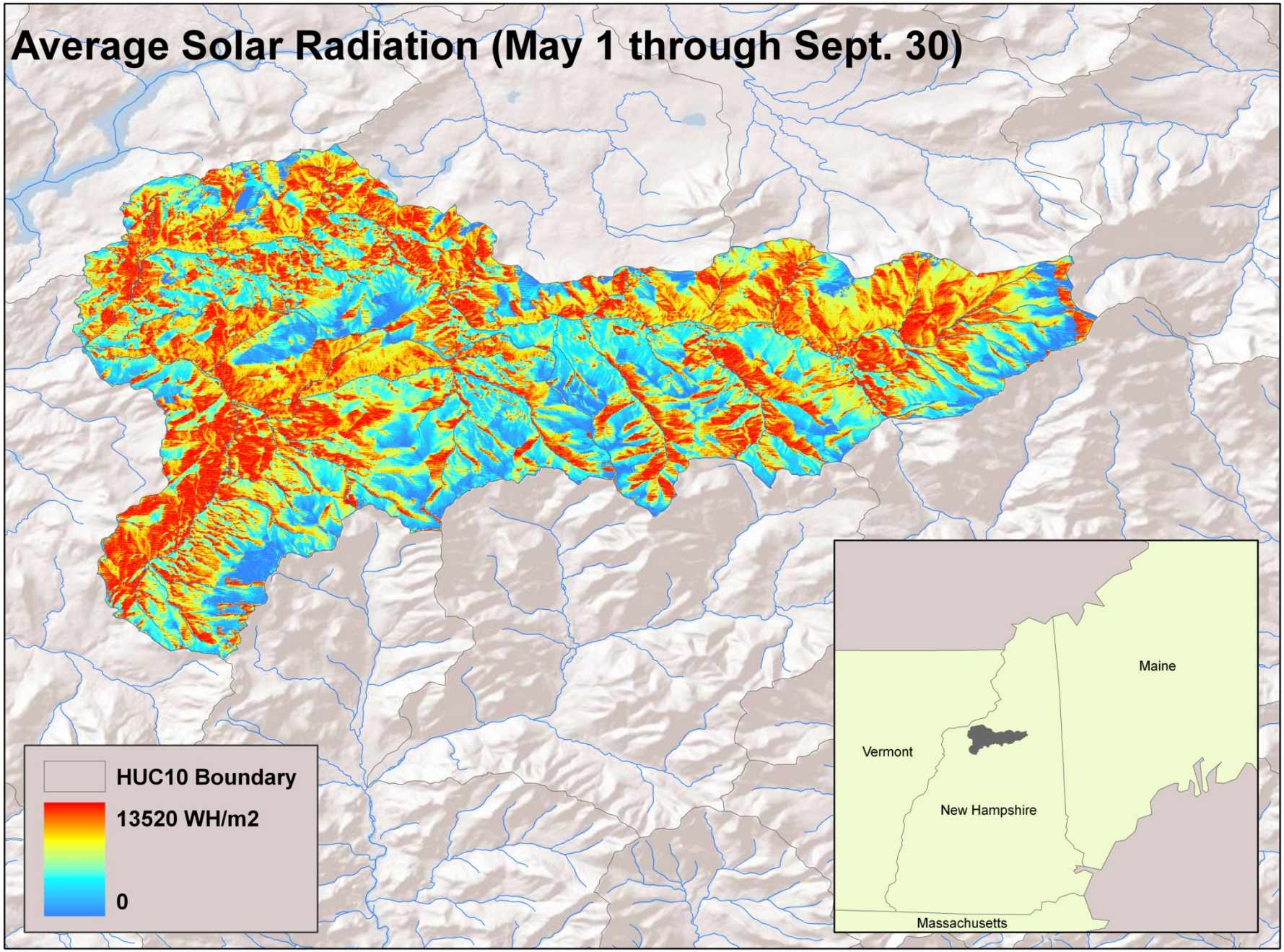
Environ Ecol Stat (2006) 13:449–464
DOI 10.1007/s10651-006-0022-8

ORIGINAL ARTICLE

Spatial statistical models that use flow and stream distance

Jay M. Ver Hoef · Erin Peterson · David Theobald

Fig. 6 Predictions for the example data in Fig. 2. The Observed locations are shown with large circles and predicted locations are shown with smaller circles; both are shaded according to their observed or predicted values. The width of the gray shading behind the circles is proportional to the prediction standard errors. Thus, areas with wider shading have less precision


Average Solar Radiation (May 1 through Sept. 30)
HUC10 Boundary
13520 WH/m2
0
Maine
Vermont
New Hampshire
Massachusetts

Status and next steps

- Completed
  - Database development w QA/QC
    - Temperature loggers (water)
    - Weather stations (air) and elevation corrections
    - Theissen polygons to match nearest air with water temperatures by year
    - Outlier identification
      - Water vs. air temperature w time lag
      - Visual checks of time series
      - Daily range (ThermoStat 10 deg C)
    - Geographic checks
      - Points on lakes/ponds/wetlands removed
      - Points associated w lake inlet/outlets removed
      - Points w/in 1 km downstream of dams removed

Status and next steps

- Completed
  - Watershed delineations, buffer zone definition, flow distance grids
  - Interpoint network distance matrix with flow wtg
  - Solar radiation models (topographic shading)
  - Watershed attributes 90% complete
  - Fish-temperature matches
    - By NHDPlus reach
    - Fish database filtering
      - Estuarine and anadromous fish taxa excluded
      - Stocked fish excluded to the extent possible
      - 1st pass electrofishing w level of effort (area, time)
      - Location (lakes/ponds/wetlands, inlets/outlets, dams)

Status and next steps

- Complete watershed attributes
  - %shade = f(channel width or watershed area, dominant riparian vegetation class and/or cover)
  - Distance-weighted attributes
- Select fish indicator species for analysis based on response to % imperviousness gradient and % high density residential in buffer zone
- Predictive models for subset of thermal metrics

Challenges w temperature data

- Lack of central repository
- Limited matched sets
  - fish + temperature
  - air + water
- Nonrepresentative logger placement
  - Nonrandom
    - relatively fewer headwater streams
    - relatively fewer warmwater, coolwater regimes represented than in full population of streams
    - geographic gaps (RI, ME)
  - Inlets/outlets and distance to dams
- Inconsistencies among collecting agencies
  - Frequency (15min – 1 hr vs. daily stats reported)
  - Sampling window timing and length
  - QA/QC (calibration, start + stop times, error coding)
- Limited metadata

Potential for future info distribution

- Estuary Data Mapper
  - Estuaries and coastal watersheds for coterminous United States
  - Downloadable application; only internet connection needed
  - Data discovery, visualization and download
- Interagency data sources
- Both distributed and centralized data sources
  - Web services (e.g., NWIS, STORET)
  - Static data sets on EPA server at RTP for rapid access
- Multiple data formats (open source: csv,ASCII grids, shapefiles, …)
  - Multi-media
  - Points w time series
  - Vector (lines, polygons)
  - Grids
  - Potential addns: calculated and predicted thermal metrics, %shade dataset, riparian zone canopy cover/type, Theissen polygons w associated air temperature time series by year, solar radiation grids, model outputs…

http://badger.epa.gov/rsig/edm/index.html