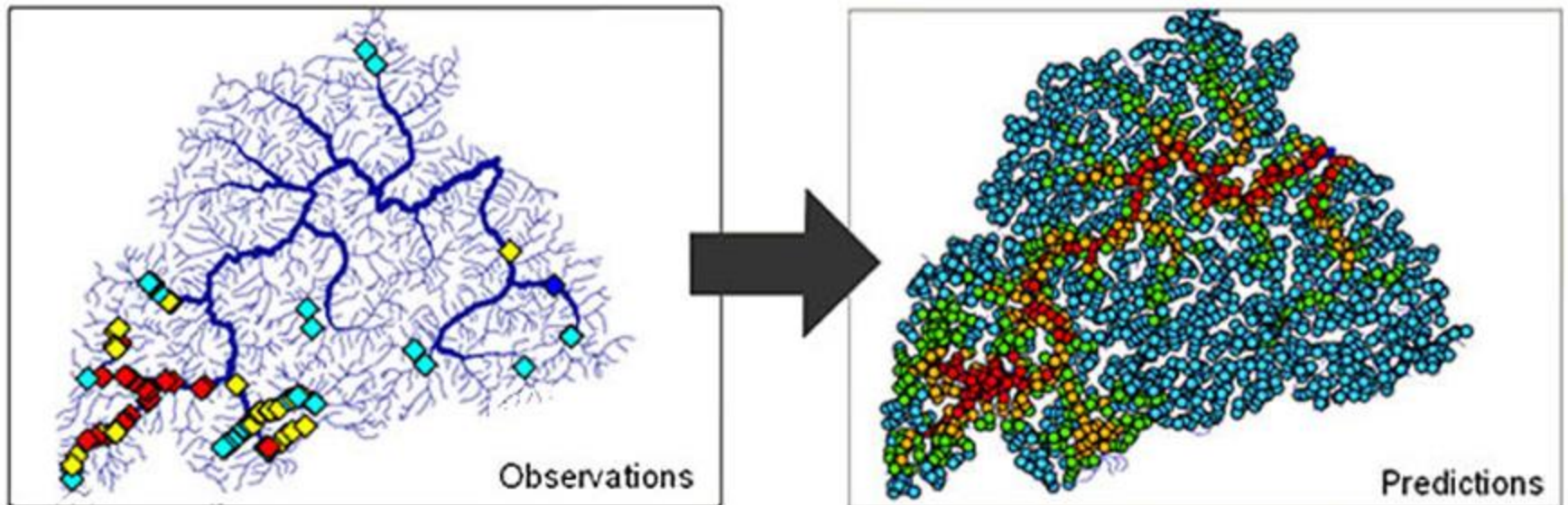


# SSN models: The nuts and bolts

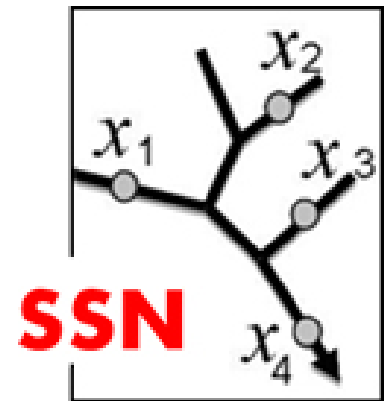
SSN Workshop 2019

Session 1



# Overview

1. What are SSN models?
2. How are they used?
3. What are their limitations?
4. What data is required?
5. What software is needed?



# 1. What are SSN models<sup>1</sup>?

- Statistical model

<sup>1</sup> Peterson & Ver Hoef 2010 Ecology

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## **General Linear Models**

Simple regression

ANOVA

T-test

*(Normal Distribution)*

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## **General Linear Models**

Simple regression  
ANOVA  
T-test

*(Normal Distribution)*

## **Generalized Linear models**

Logistic regression  
Poisson regression

*(Other Distributions)*

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# 1. What are SSN models<sup>1</sup>?

- Statistical model
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## General Linear Models

Simple regression  
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*(Normal Distribution)*

## Generalized Linear models

Logistic regression  
Poisson regression

*(Other Distributions)*

## Generalized linear mixed models

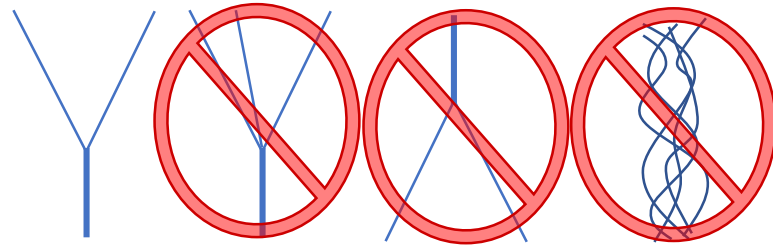
“Mixed effects models”  
**SSN**

*(+ random effects)*

<sup>1</sup> Peterson & Ver Hoef 2010 Ecology

# 1. What are SSN models<sup>1</sup>?

- Statistical model
- Generalized Linear Mixed Model
- For dendritic networks

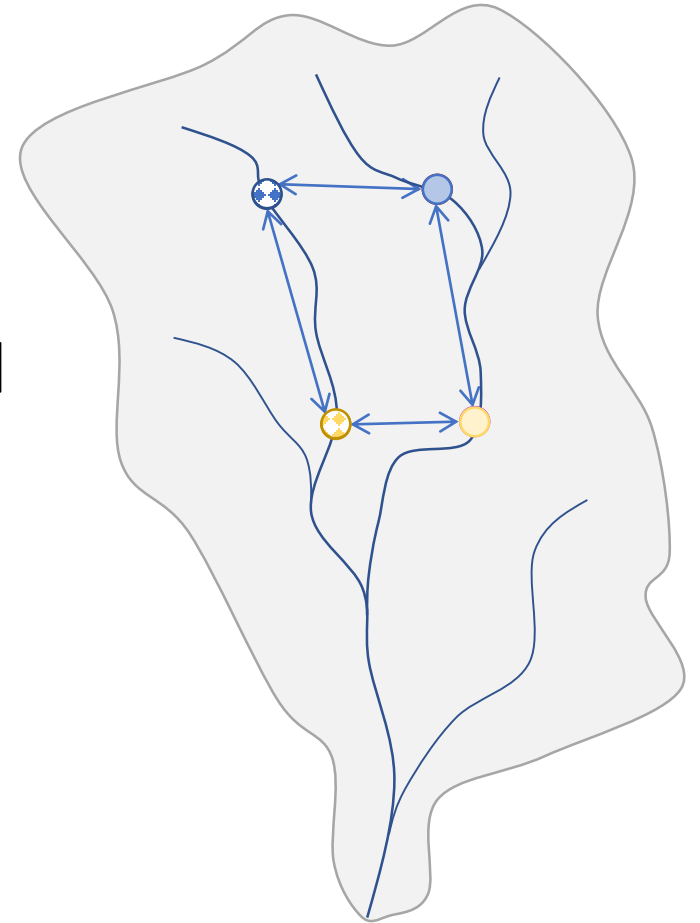


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# 1. What are SSN models<sup>1</sup>?

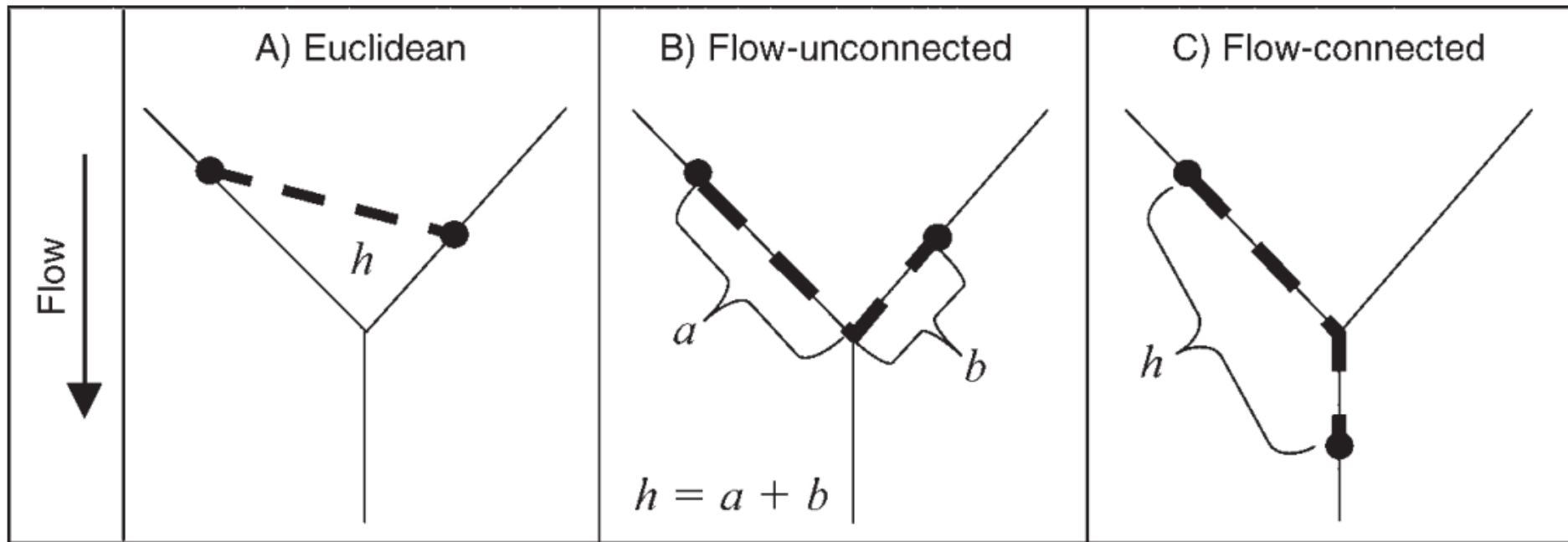
- Statistical model
- Generalized Linear Mixed Model
- For dendritic networks
- ADDRESS AUTOCORRELATION!



<sup>1</sup> Peterson & Ver Hoef 2010 Ecology

# Autocovariance

## Spatial distance/proximity



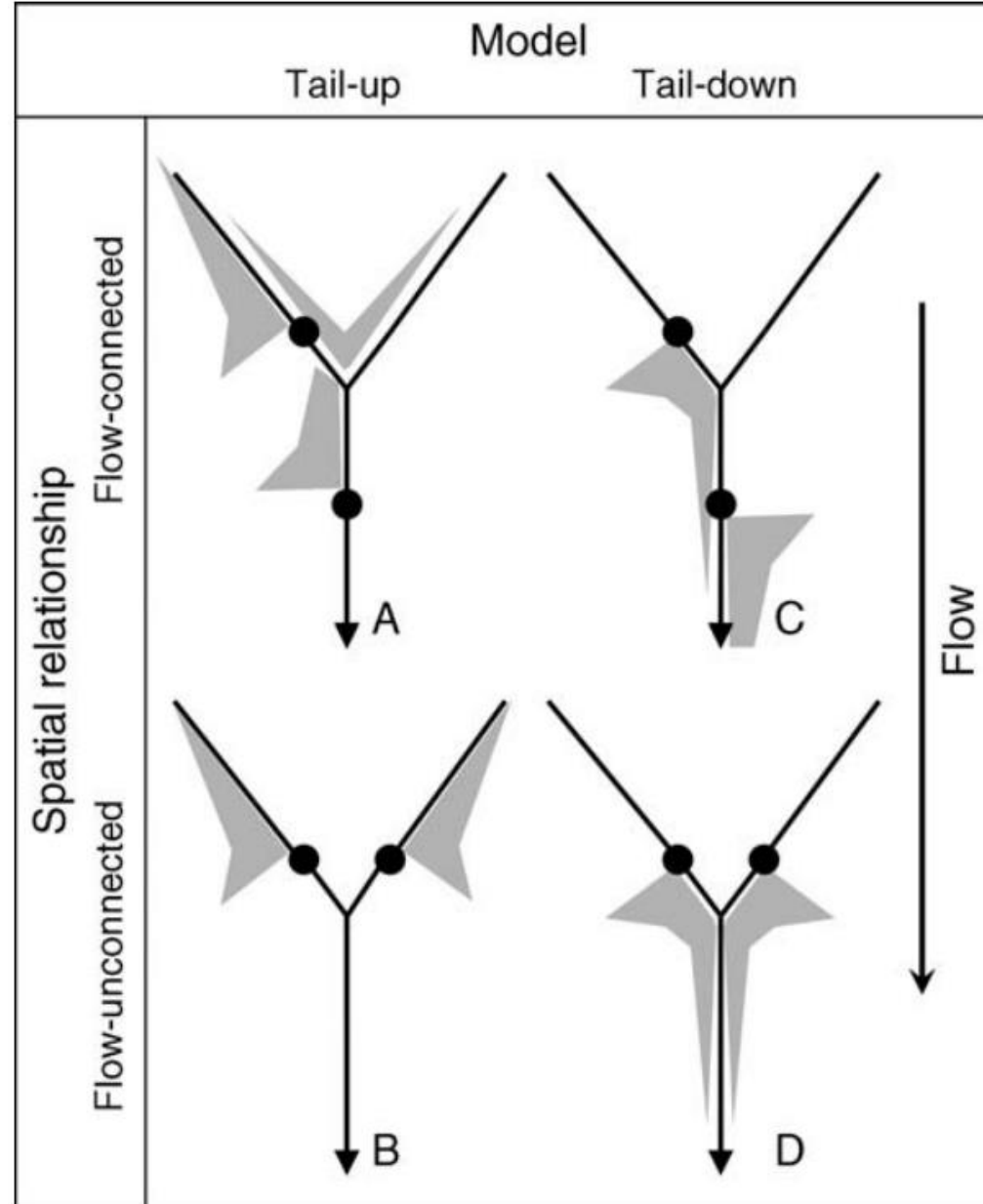
# Autocovariance functions

## Function Types

- Tail-up
- Tail-down
- Euclidean

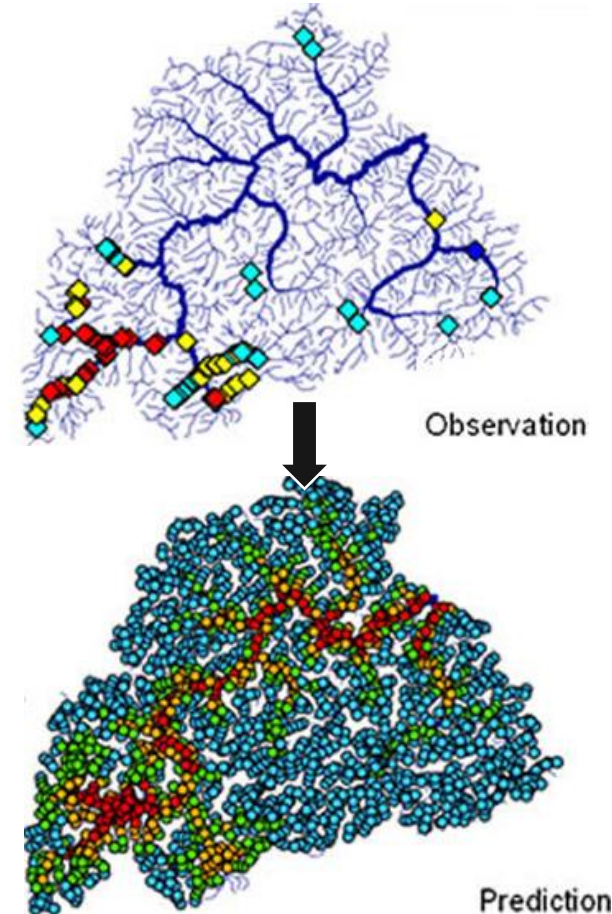
## Function Shapes

- exponential
- Gaussian
- linear-sill
- mariah
- spherical



# 1. What are SSN models<sup>1</sup>?

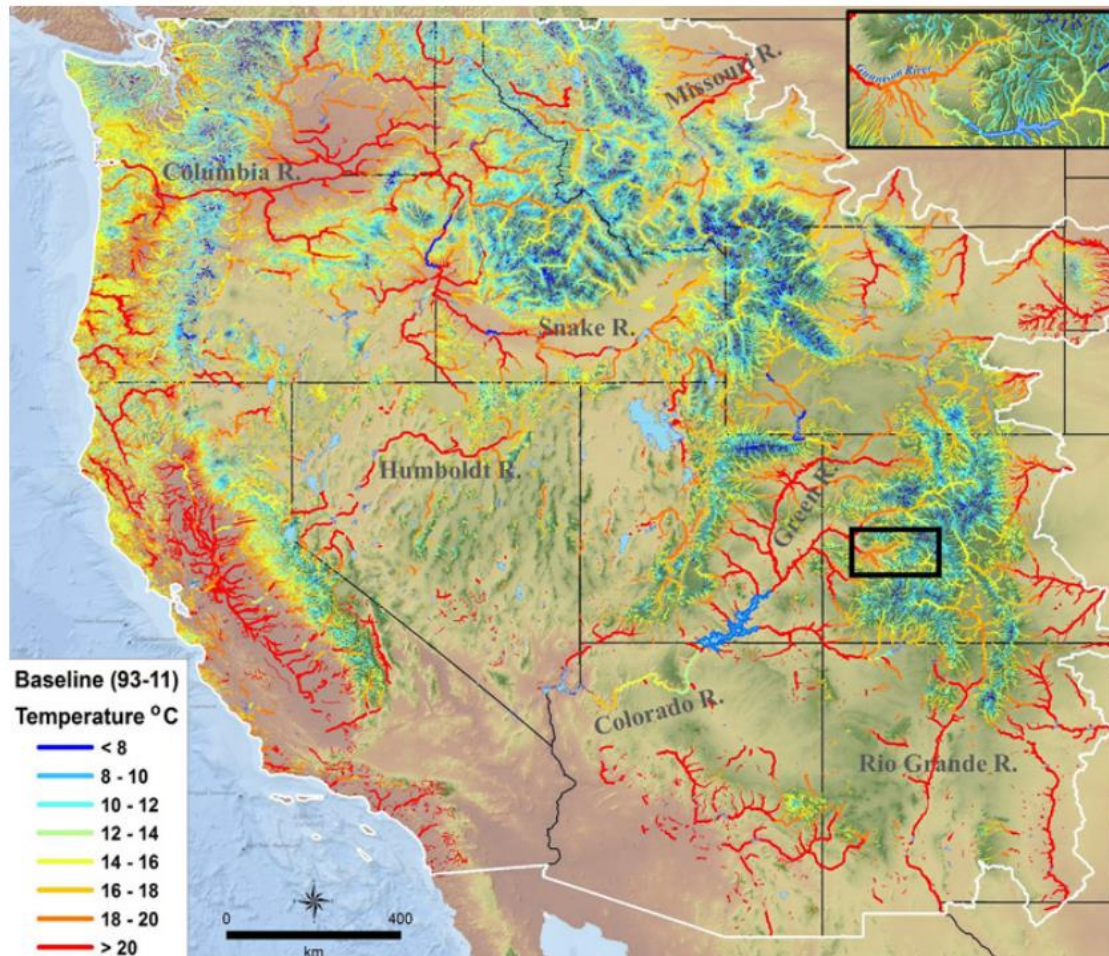
- Statistical model
- Generalized Linear Mixed Model
- For dendritic networks
- ADDRESS AUTOCORRELATION!
- Inter-/extrapolated predictions (status maps)



<sup>1</sup> Peterson & Ver Hoef 2010 Ecology

## 2. How are SSN models used?

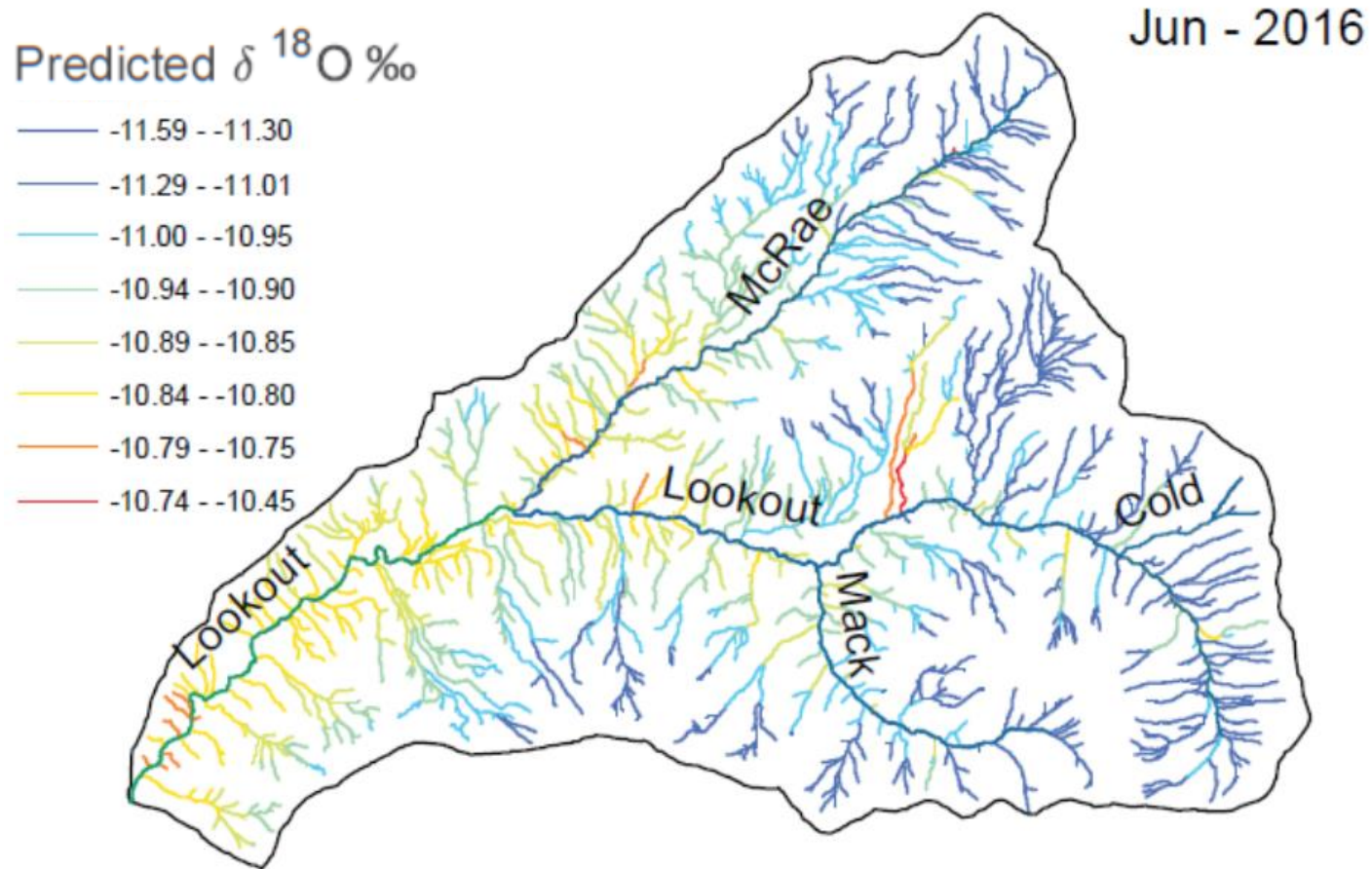
- Temperature – NorWeST – Isaak et al. 2017 WRR





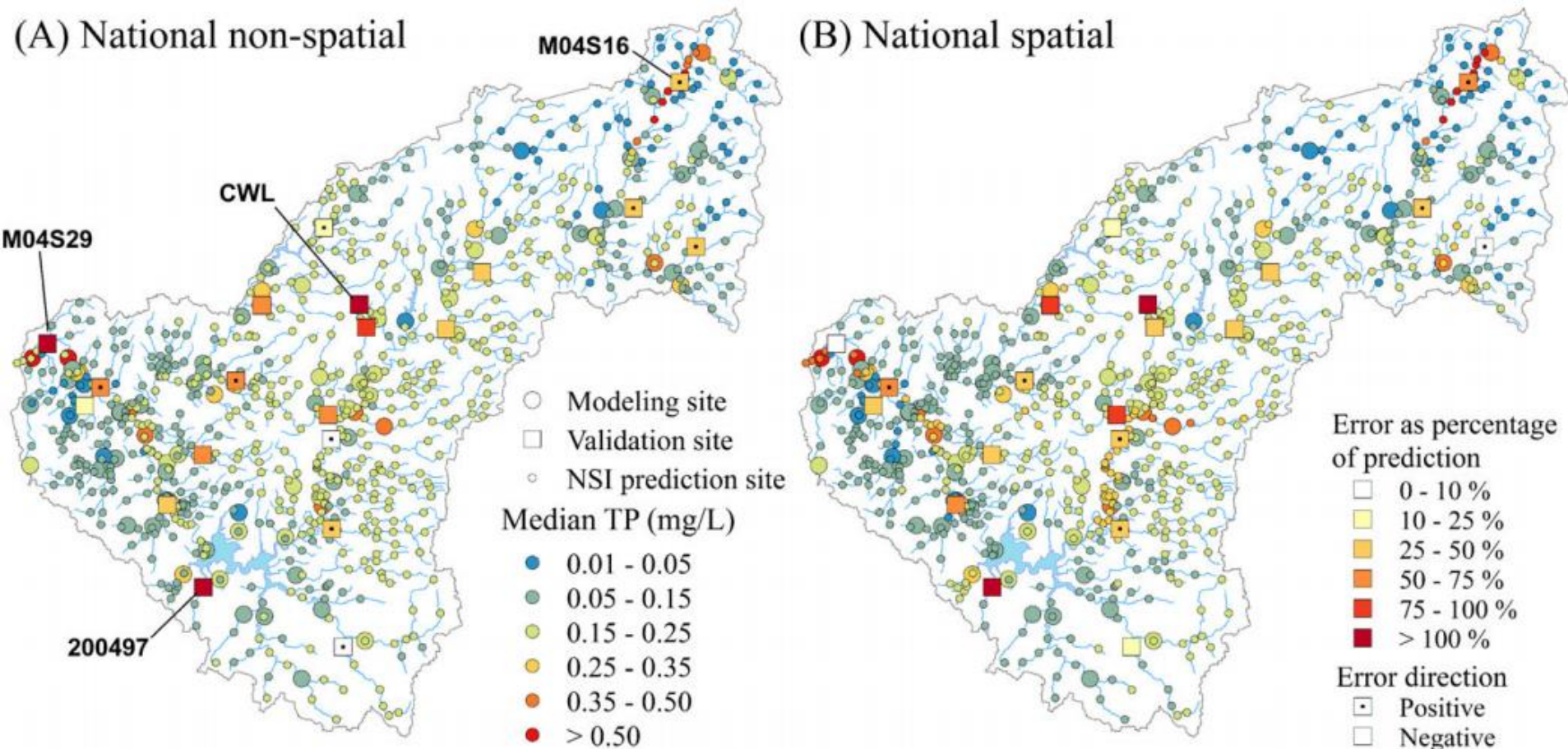
## 2. How are SSN models used?

- Baseflow source water – Segura et al. 2019 WRR



## 2. How are SSN models used?

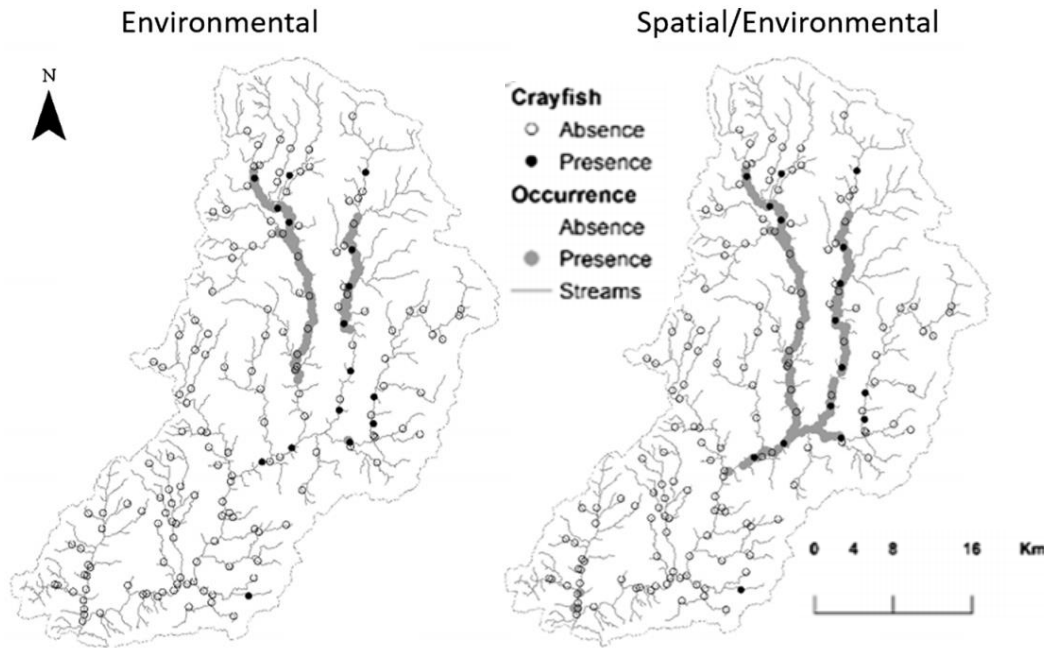
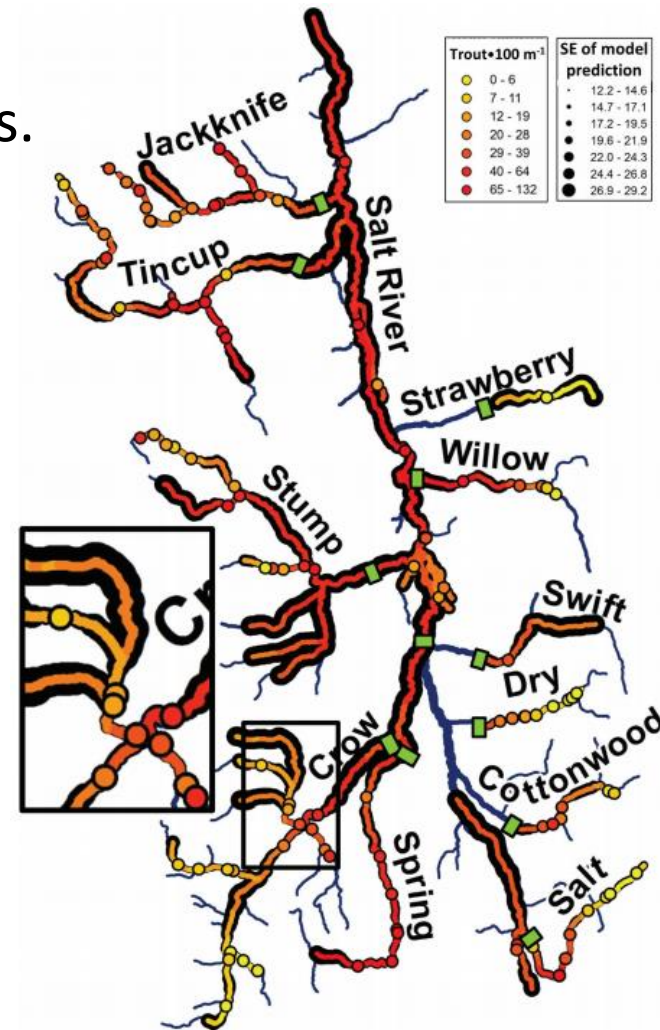
- Nutrients – Scown et al. 2017 JAWRA



## 2. How are SSN models used?

- Population estimates
  - Survey data – continuous or pres./abs.
  - **eDNA ... forthcoming!**

Isaak et al. 2017 CJFAS

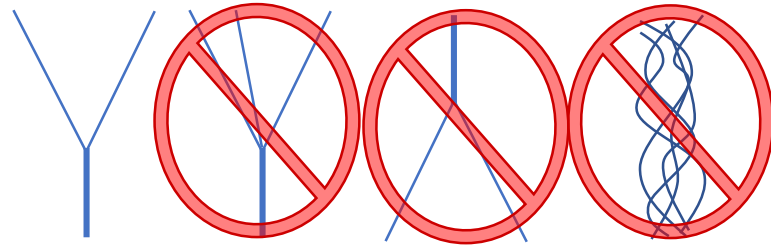


Filipe et al. 2017 Biological Invasions



### 3. SSN model limitations...

- Perfectly dendritic network



- Need fair bit of observed data ( $n \sim 50$ )
- Covariate data at same spatiotemporal resolution
- Only as good as the data put into them

## 4. Data for SSN models

### **Three (or four) generic requirements**

1. Observation data (e.g. temperature, nutrients)  
Usually your own data (Observed  $N \sim 50$ )
2. Covariate data (e.g. precipitation, discharge)  
Can come from a variety of sources
3. SSN-conditioned stream network  
Variety of good pre-conditioned data sets available
4. Prediction data  
Just covariate data, but at new sites w/in study area

## 4. Data for SSN models

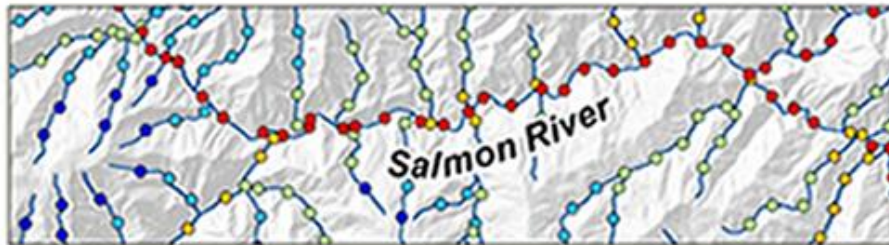
### **Four great sources to get started quickly**

1. NorWeST
2. StreamCat
3. NHDPlus
4. National Stream Internet

## 4. Data for SSN models



**NorWeST**  
Stream Temp



***Regional Database and Modeled Stream Temperatures***

<https://www.fs.fed.us/rm/boise/AW/AE/projects/NorWeST/StreamTemperatureDataSummaries.shtml>



# 4. Data for SSN models

## National Aquatic Resource Surveys

CONTACT US

SHARE



National Aquatic Resource  
Surveys Home

## StreamCat

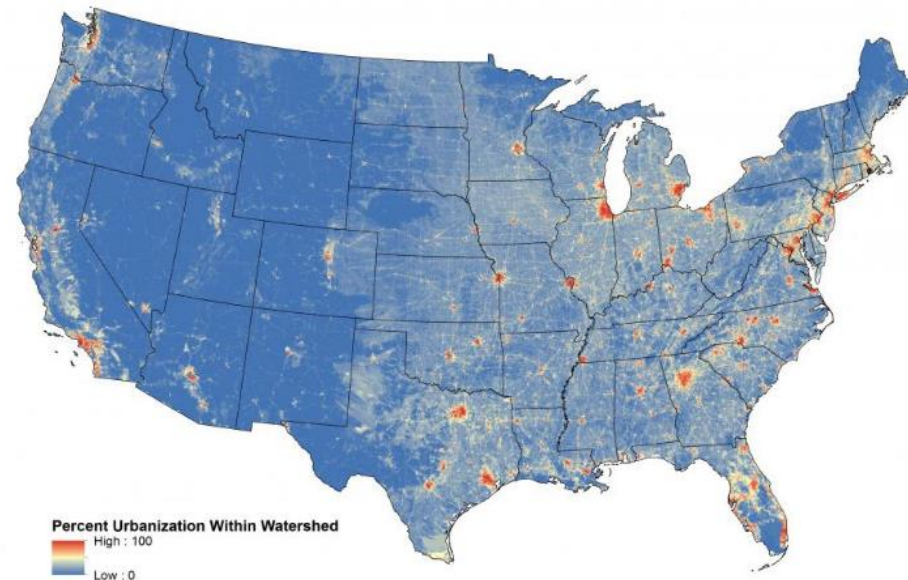


Background

Indicators

StreamCat data are available for [download](#)

<https://www.epa.gov/national-aquatic-resource-surveys/streamcat>



Example of a U.S. map created using StreamCat data on percent urbanization within a watershed.

# 4. Data for SSN models

*NHDPlus  
Version 2*

Horizon Systems → NHDPlus Version 2

Horizon  
Systems  
Corporation

NHDPlus Home

NHDPlus Version 2  
Documentation

## « NHDPlus Version 2 »

[http://www.horizon-systems.com/NHDPlus/NHDPlusV2\\_home.php](http://www.horizon-systems.com/NHDPlus/NHDPlusV2_home.php)

NHDPlusV2 consists of the following components:

- Greatly improved 1:100K National Hydrography Dataset (NHD).
- Greatly improved 30 meter National Elevation Dataset (NED).
- Nationally complete Watershed Boundary Dataset (WBD).
- A set of value added attributes to enhance stream network navigation, analysis and display.
- An elevation-based catchment for each flowline in the stream network.
- Catchment characteristics.
- Headwater node areas.
- Cumulative drainage area characteristics.
- Flow direction, flow accumulation and elevation grids.
- Flowline min/max elevations and slopes.
- Flow volume & velocity estimates for each flowline in the stream network.
- Catchment attributes and network accumulated attributes.
- Various grids from the hydro-enforcement process including the hydro-enforced DEM.



## 4. Data for SSN models



## The National Stream Internet Project

[https://www.fs.fed.us/rm/boise/AWAE/projects/NationalStreamInternet/NSI\\_network.html](https://www.fs.fed.us/rm/boise/AWAE/projects/NationalStreamInternet/NSI_network.html)



# 5. Software for SSN models

## 1. STARS (an ArcGIS toolbox)

**STARS: SPATIAL TOOLS FOR THE ANALYSIS OF  
RIVER SYSTEMS VERSION 2.0.7 - A TUTORIAL**

- Verifies the stream network for SSN models
- Adds observation and prediction site locations
- Builds SSN object to import in R



## 2. R and “SSN” package

- Fits SSN models
- Provides diagnostic tests to evaluate SSN models



**Package ‘SSN’**

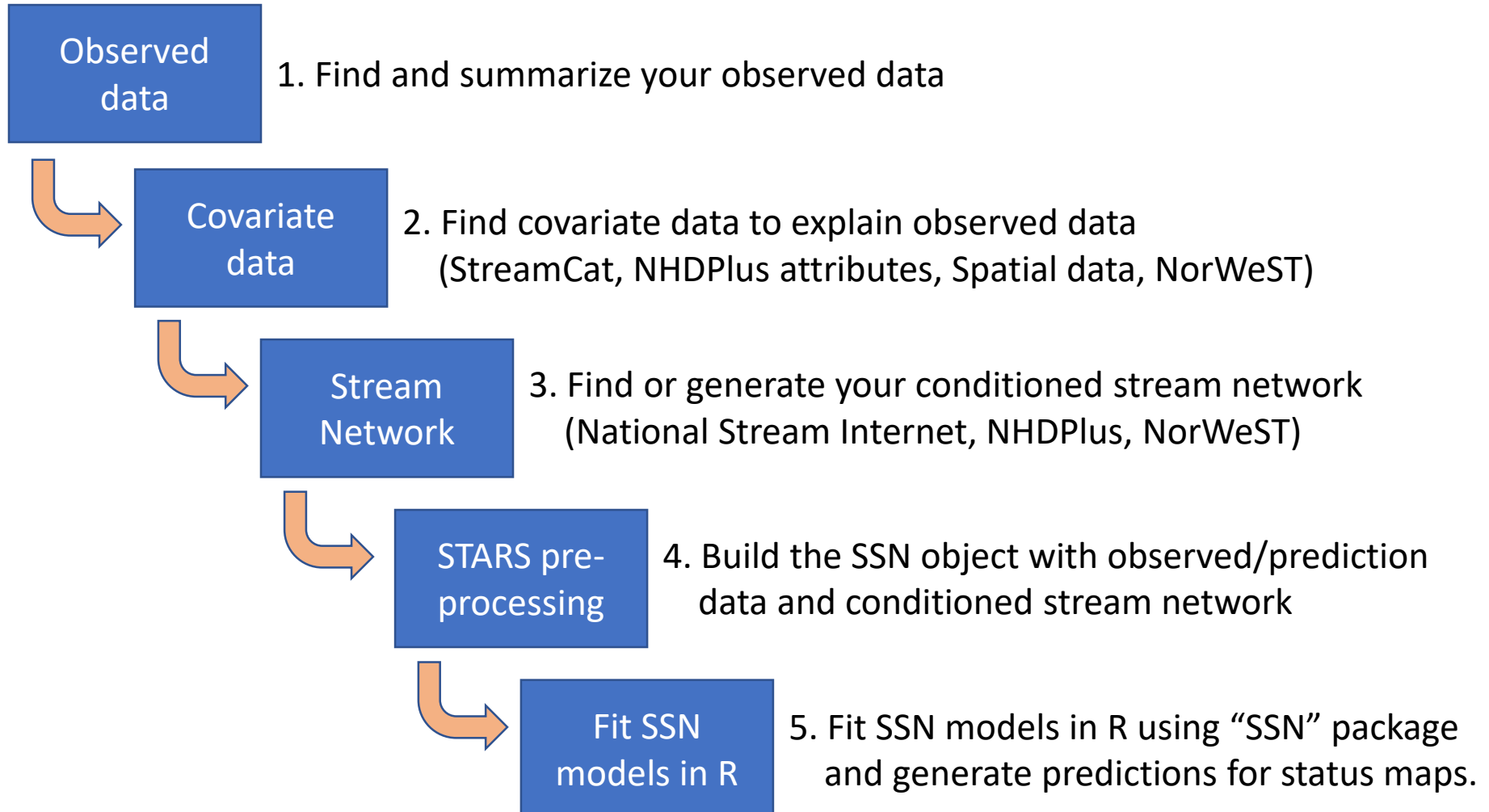
May 13, 2018

Downloads and tutorials available here: ↓

[https://www.fs.fed.us/rm/boise/AWAE/projects/SSN\\_STARS/software\\_data.html](https://www.fs.fed.us/rm/boise/AWAE/projects/SSN_STARS/software_data.html)

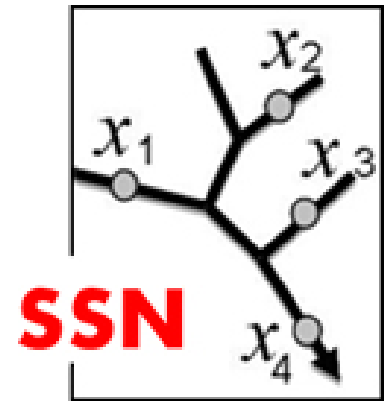


# Building SSN models flow chart



# Recap

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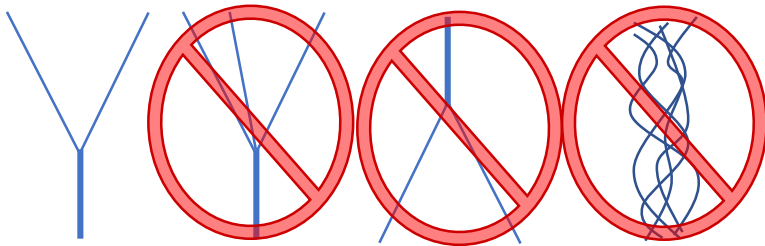
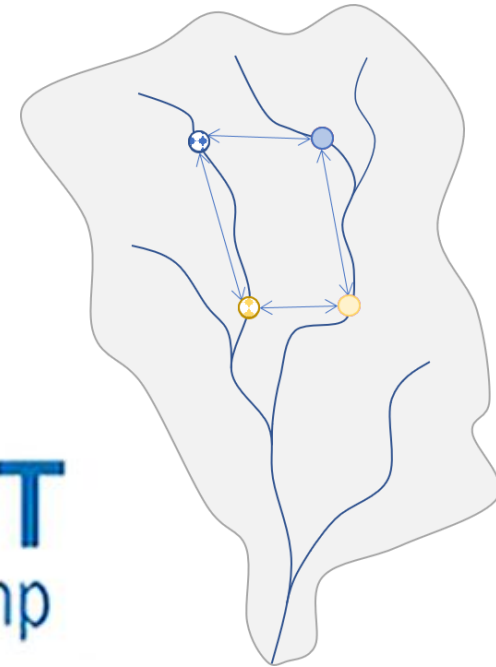


# Questions?

## The National Stream Internet Project



NorWeST  
Stream Temp



StreamCat  United States  
Environmental Protection  
Agency

StreamCat data are available for [download](#)

**STARS: SPATIAL TOOLS FOR THE ANALYSIS OF  
RIVER SYSTEMS VERSION 2.0.7 - A TUTORIAL**

**Package 'SSN'**

May 13, 2018