



# Procedure for identifying the triggering point to dynamically vary the parameter values of a hydrologic model: a preliminary investigation



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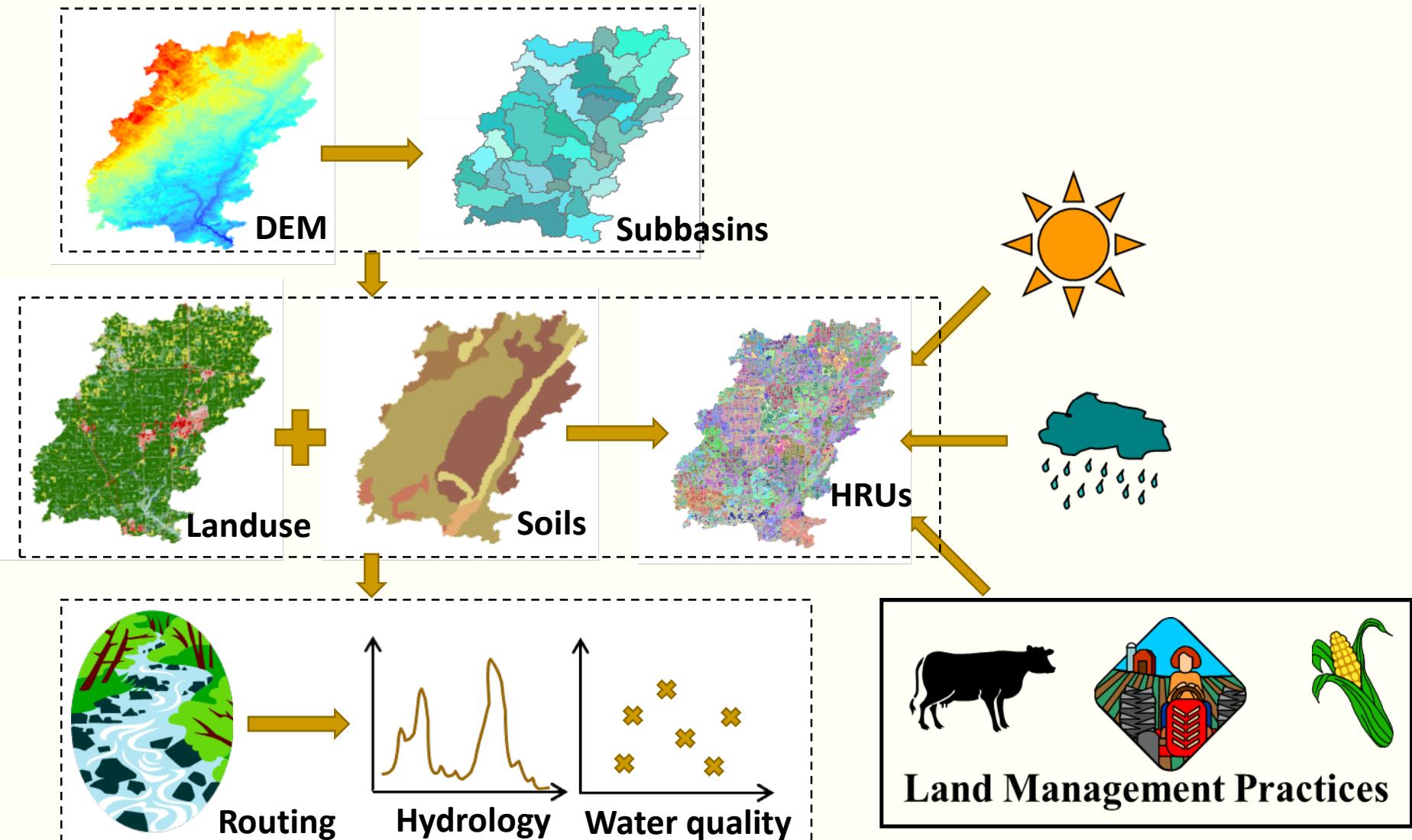
# Overview

- Introduction
- Seasonal performance of SWAT parameters
- Seasonal calibration procedures and its shortcomings
- Development of soil moisture and precipitation indices
- Clustering
- Conclusion





# Soil and Water Assessment Tool (SWAT)



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# Widespread application



**Drought  
Modeling**

**Flood Modeling**

**Ecological  
Modeling**



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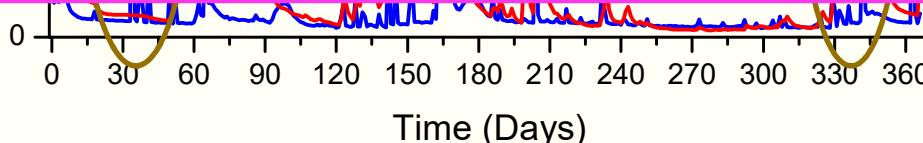
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# Limitation of SWAT model

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- 
- Erroneous input data
  - Defect in model structure
  - Inadequate representation of watershed hydrology by the model parameters

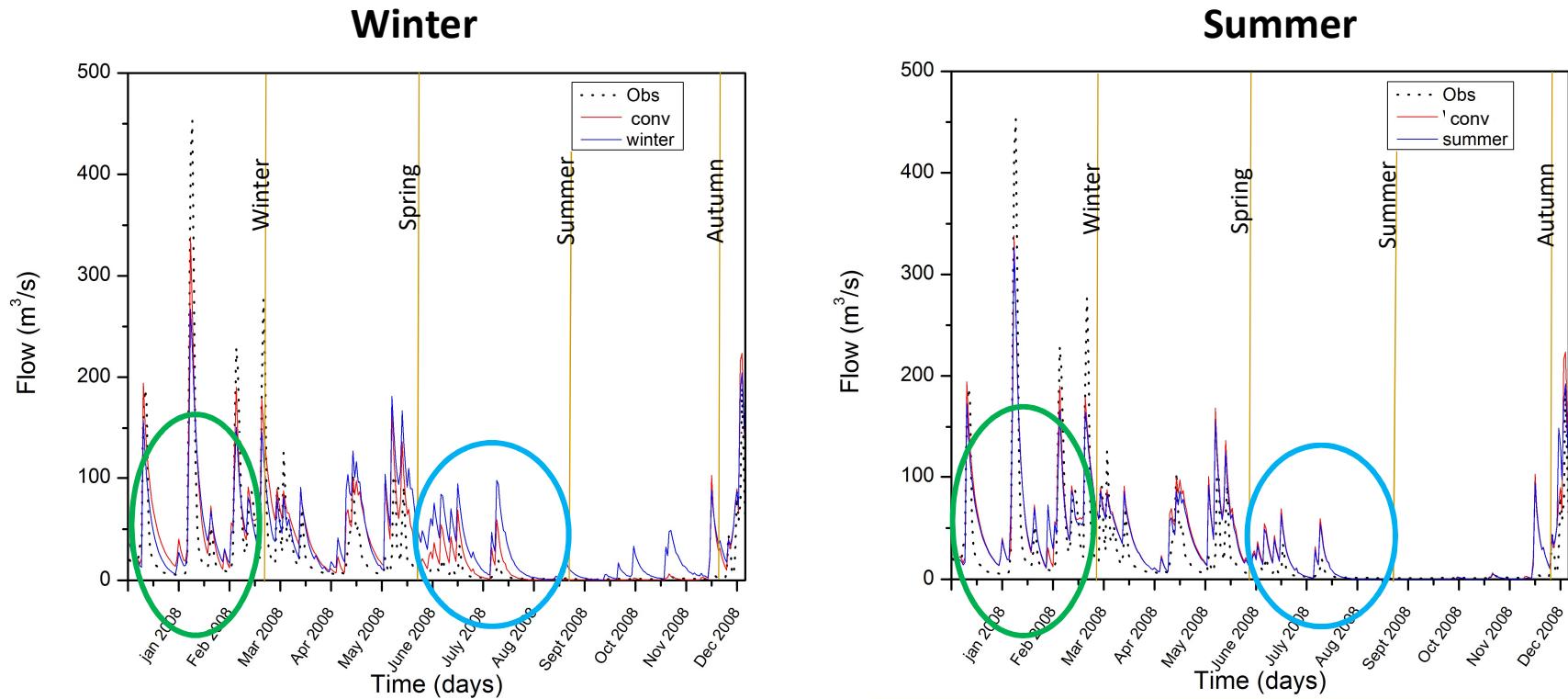


## Comparison of Simulated and Observed flow





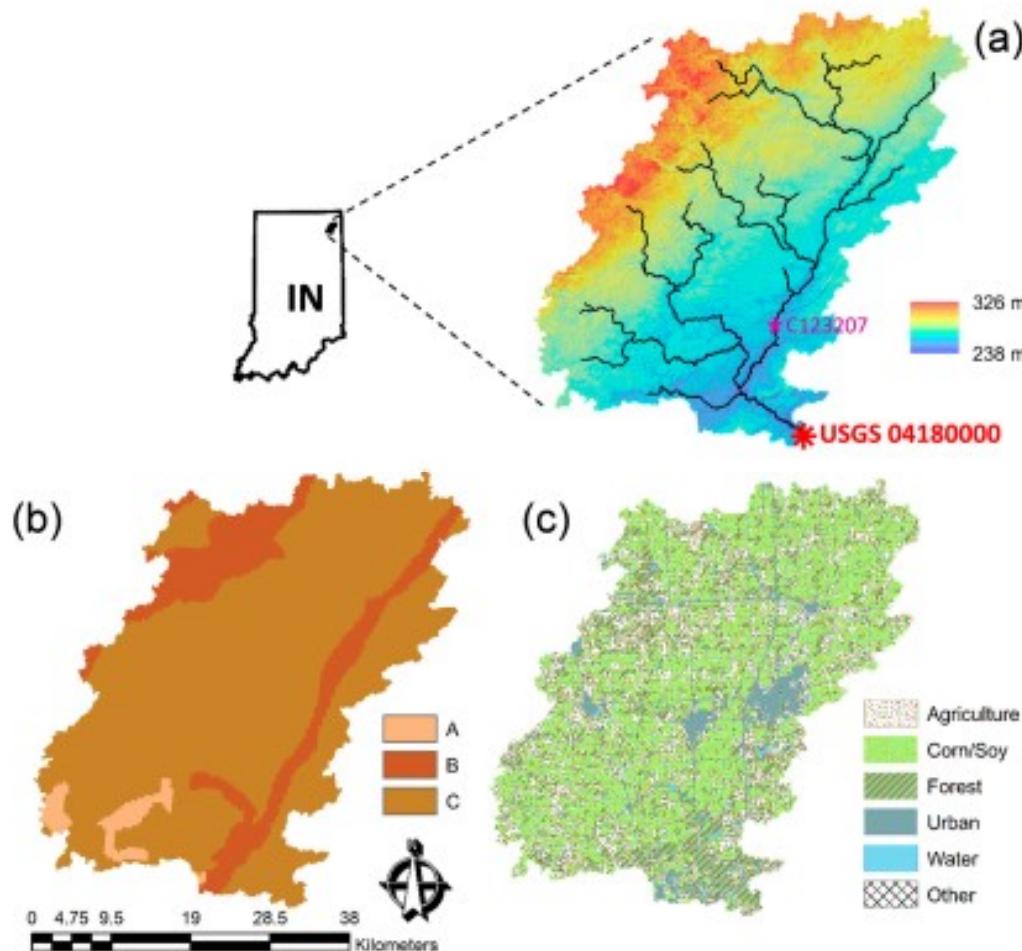
# Parameter Estimation



**Seasonal Calibration (Muleta, 2012)**



# Preliminary Investigation



SWAT model was set up for **Cedar Creek Watershed, Indiana, USA** ( $707\text{km}^2$ )

Characteristics:

- (a) elevation (National Elevation Data (NED) 30 m) with the stream and precipitation gauging stations shown
- (b) soil hydrologic group (State Soil Geographic (STATSGO) 250 m)
- (c) land use (reclassified from NASS 2010 Crop Data Layer (CDL) 30 m)

Source: Garrett et al (2017)



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# Selection of parameters

Parameter screening

- 40 parameters are selected from available literatures

Spatial parameterisation

- Assign single parameter values for similar HRUs

Sensitivity Analysis

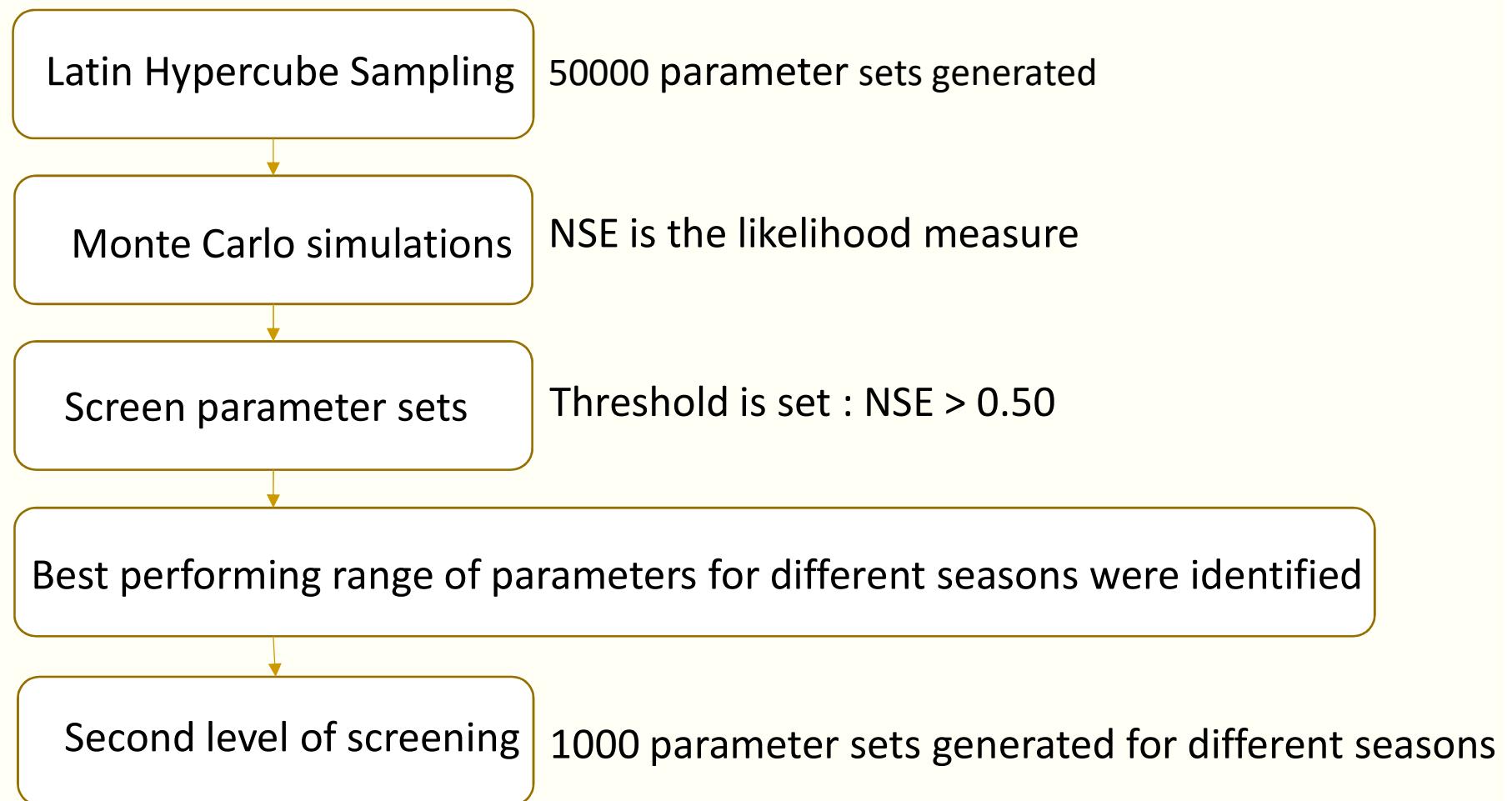
- SOBOL
- Identified 18 parameters for further analysis

Simulation period: 1991-2009  
Warm-up duration : 3 years



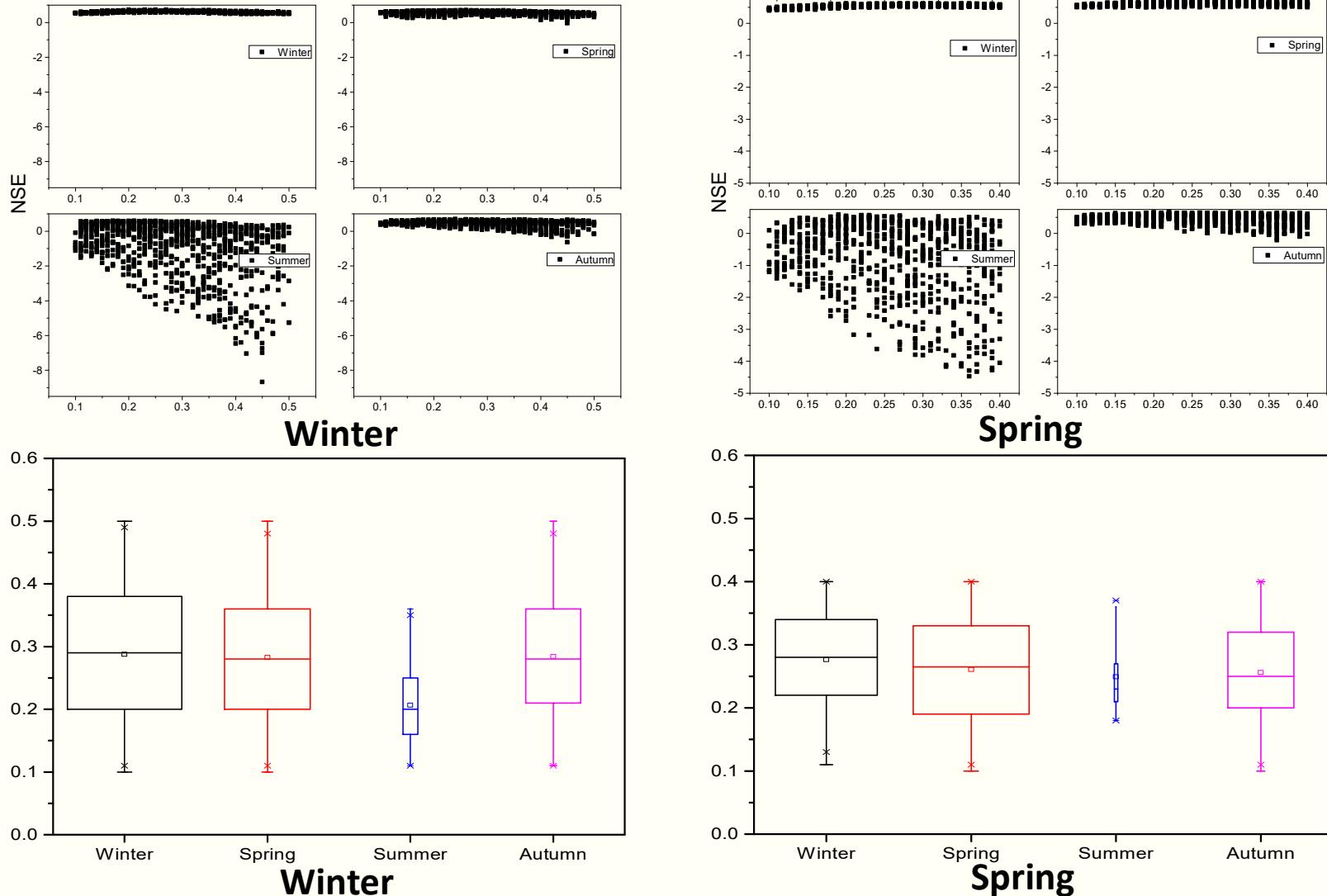


# Methodology

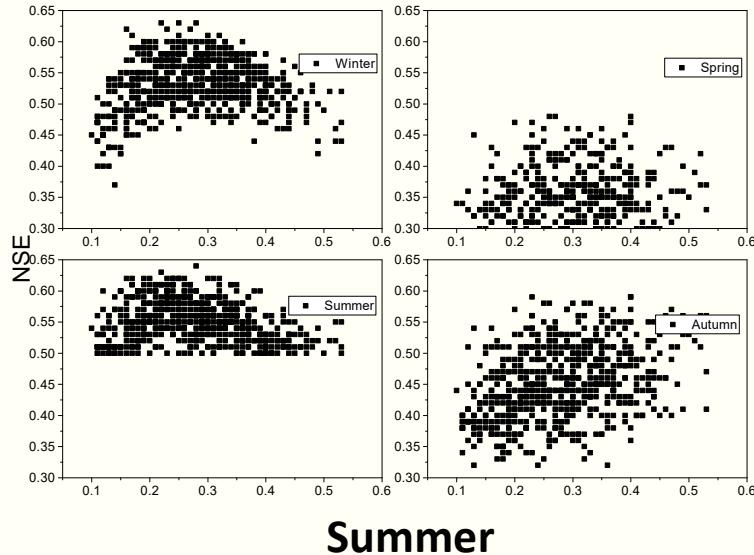




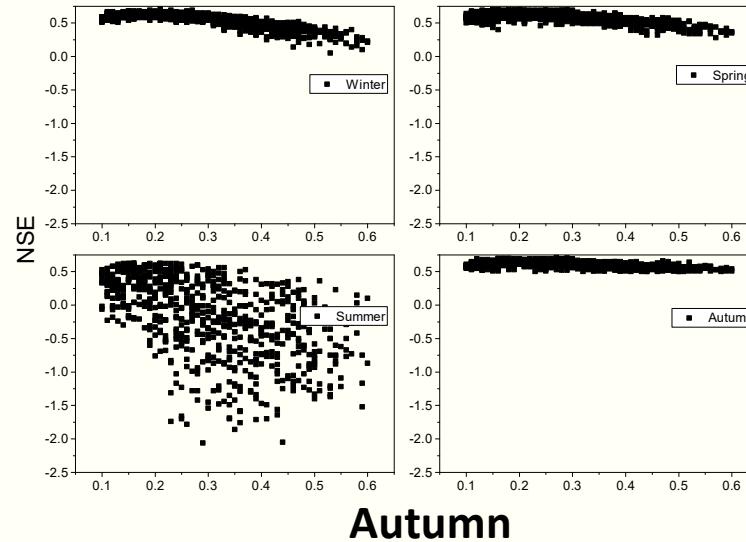
# Behavior of Surface lag (SURLAG) across seasons



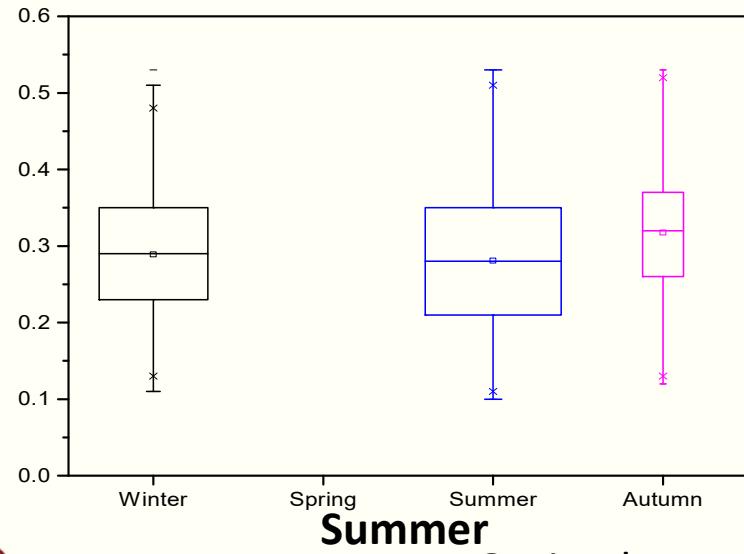
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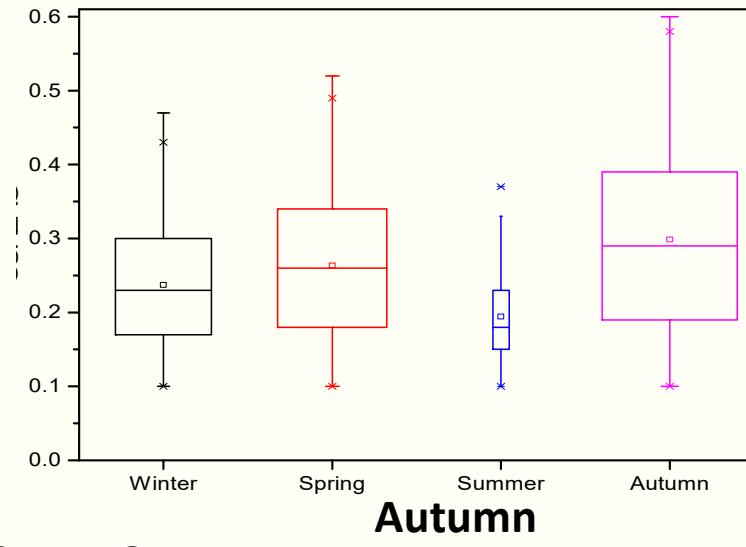
**Summer**



**Autumn**



**Summer**



**Optimal range of SURLAG across seasons**



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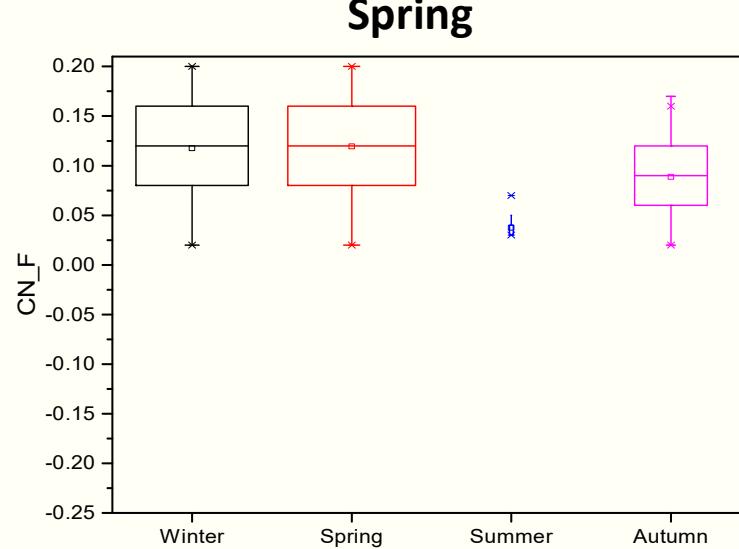
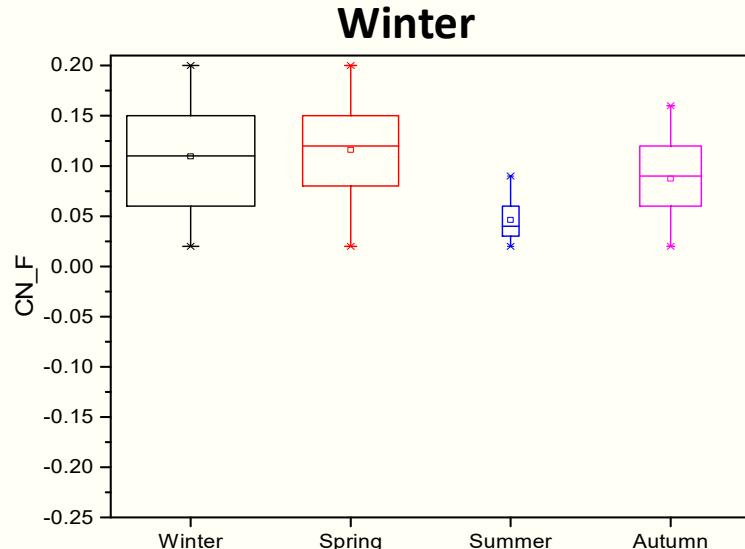
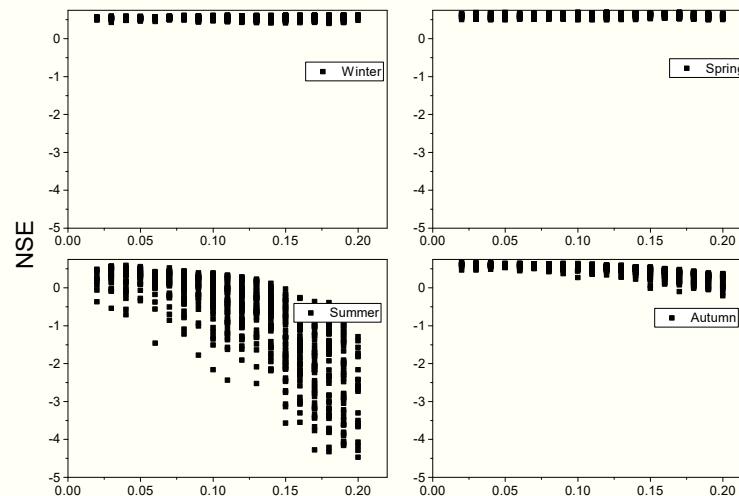
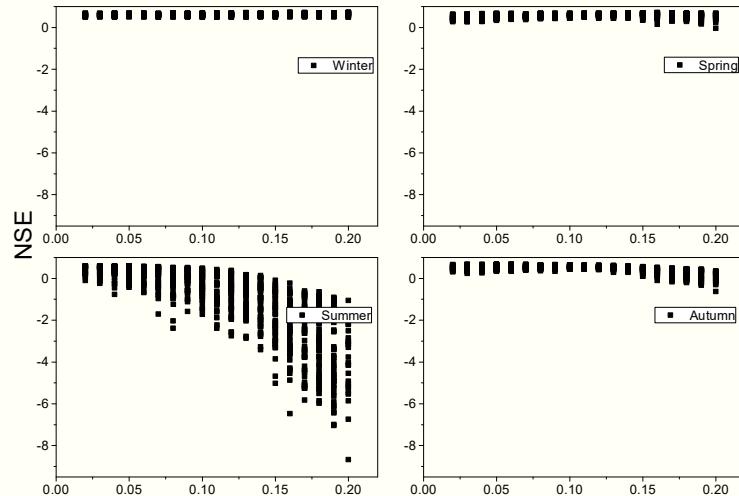
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# Behavior of Curve Number (CN\_F) across seasons



**Summer**

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Optimal range of CN\_F across seasons

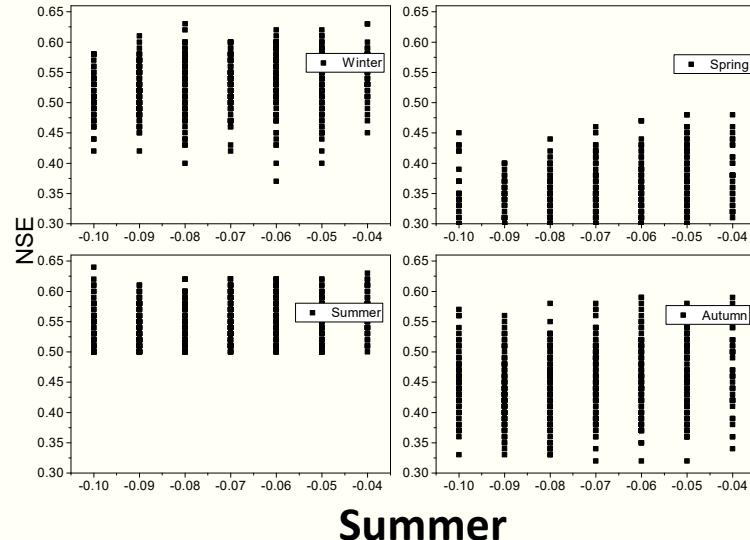


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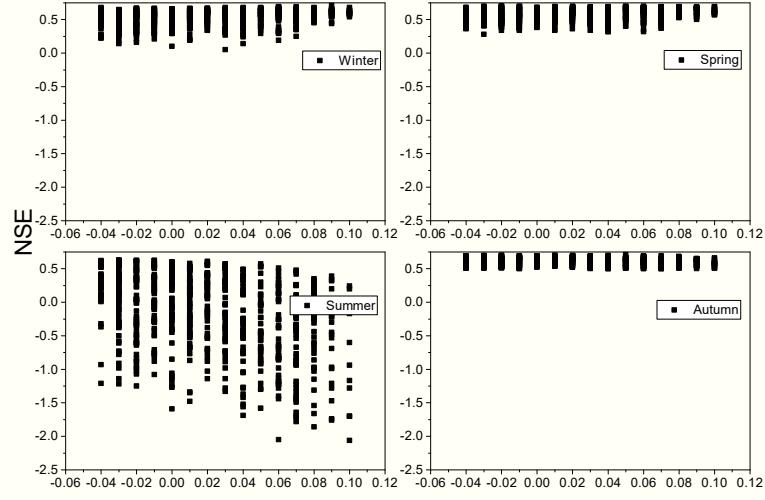
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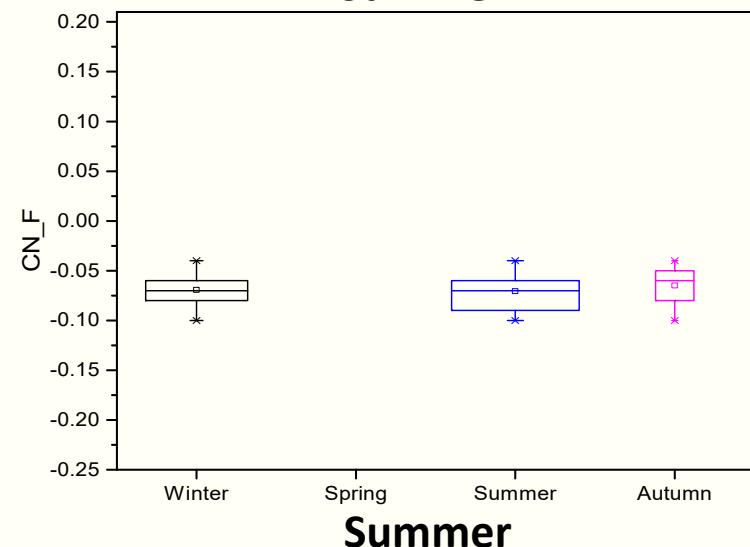
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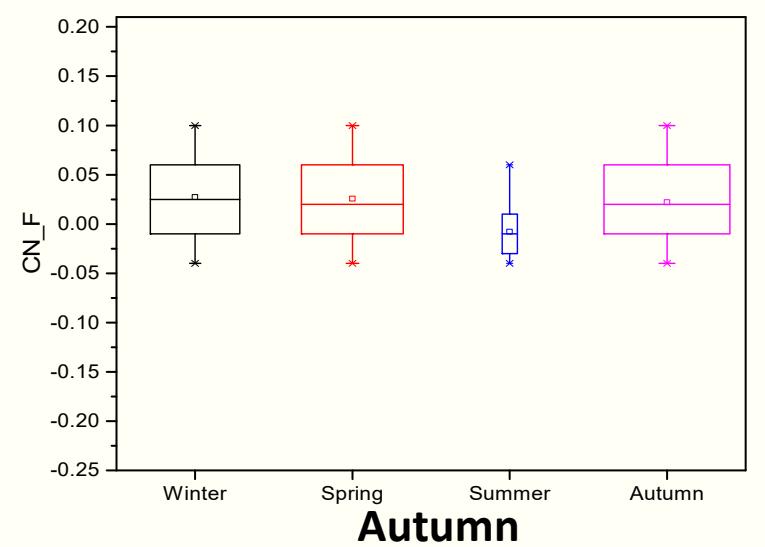
**Summer**



**Autumn**



**Summer**



**Autumn**





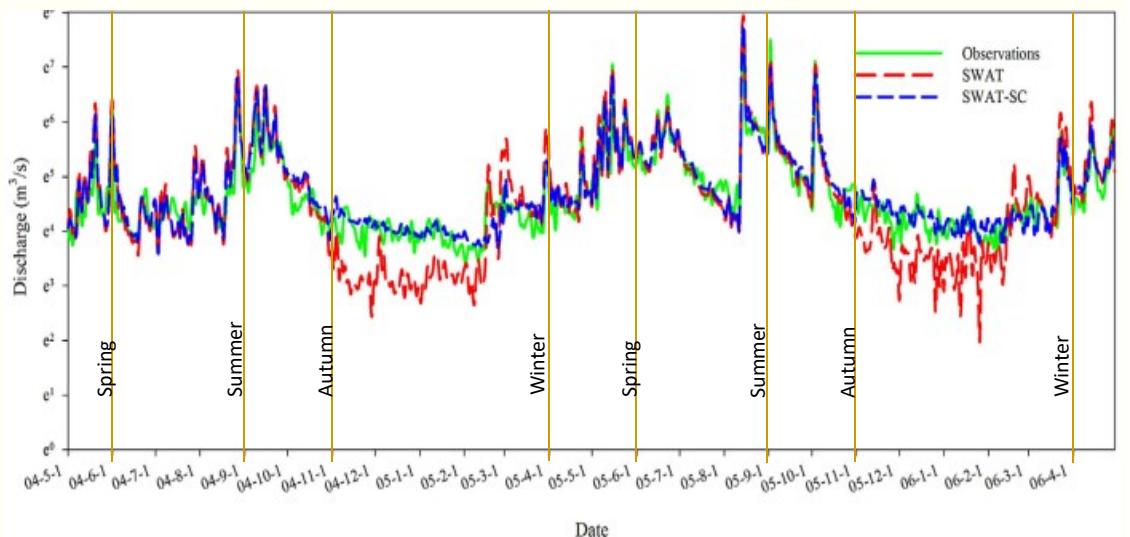
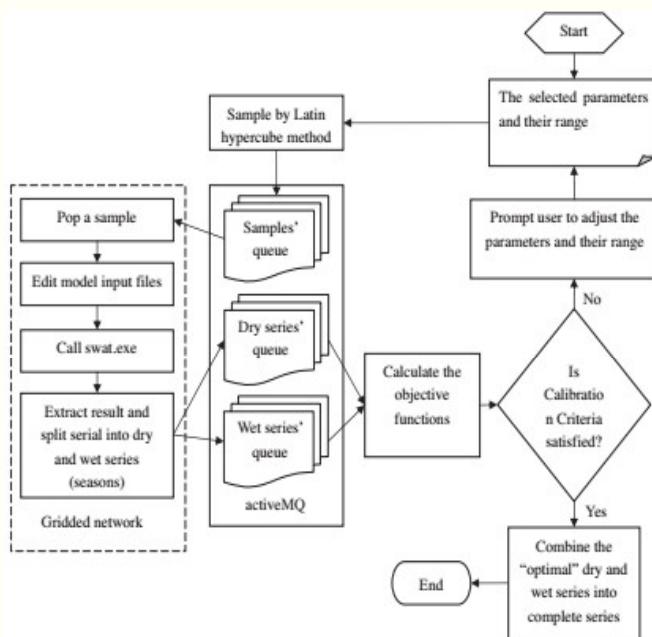
- Similar observations for other sensitive parameters

**The continuous simulation models will not be able to simulate the different seasons of the year effectively with static parameters**





# SWAT-SC (Zhang et al., 2015)



Time series plot indicating seasons

Flowchart of methodology (SWAT-SC)

Representation of physics ???



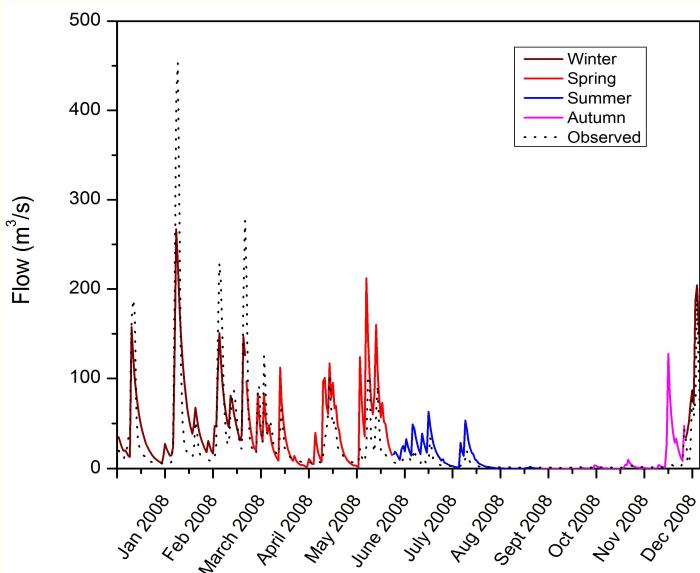
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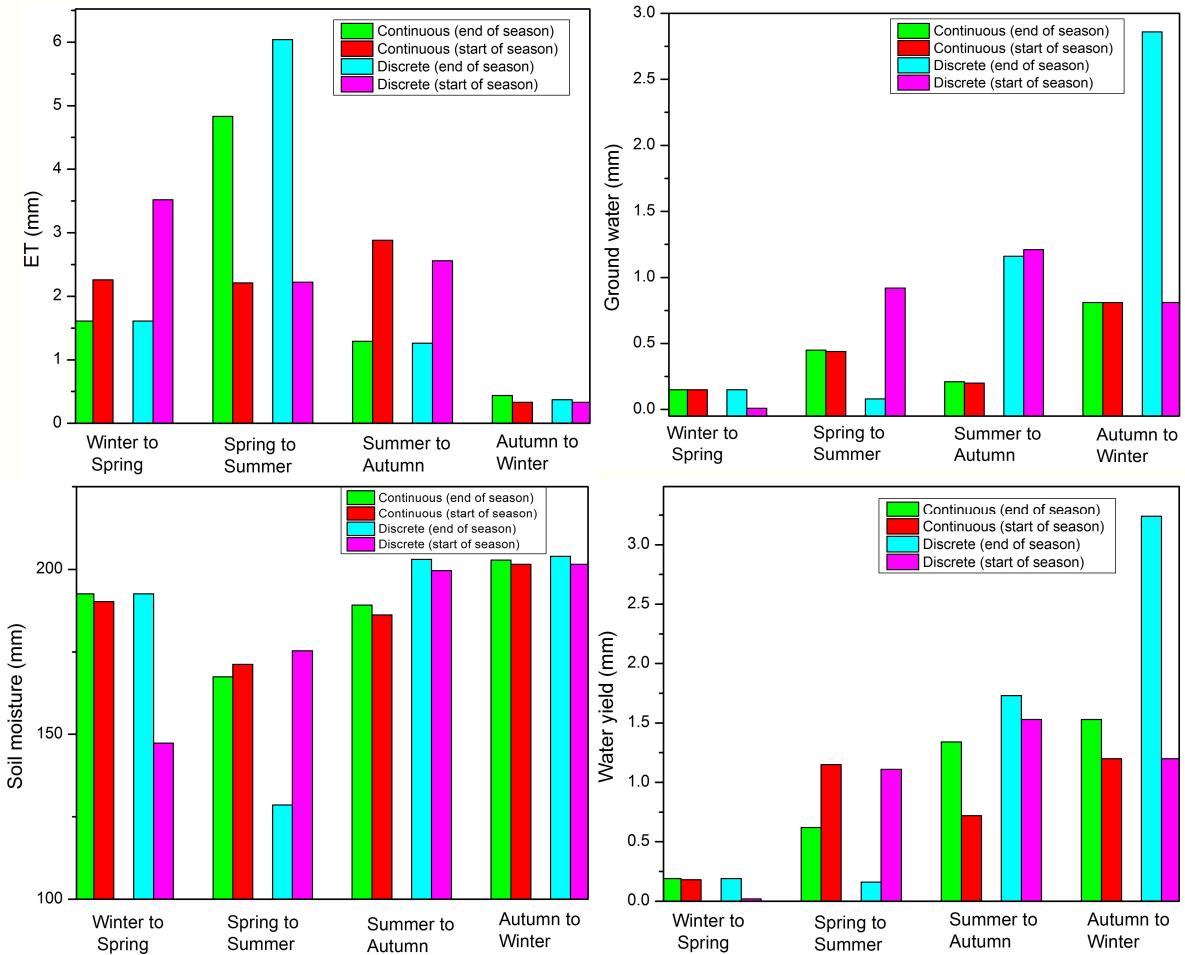
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# Physical Representation



**Time series plot of  
Seasonal discrete calibration**



**Water balance components on the transition days**



The requirement of seasonal variation of parameters in simulation models are established; however, no studies have looked at **adjusting the parameter values dynamically** during a model simulation

Can we improve the overall simulations of the model by temporally varying the parameters???



Better performance of the model???

# Line of thought

- Curve Number (CN\_F) varies on a daily basis

$$S = 25.4 * \left( \frac{1000}{CN} - 10 \right)$$

- The retention parameter varies temporally with soil profile water content:

$$S = S_{max} * \left\{ 1 - \frac{SW}{[SW + exp(w_1 - w_2 * SW)]} \right\}$$

$w_1$  and  $w_2$  are shape coefficients



- Analysis of the soil moisture variations may lead to identification of a triggering point

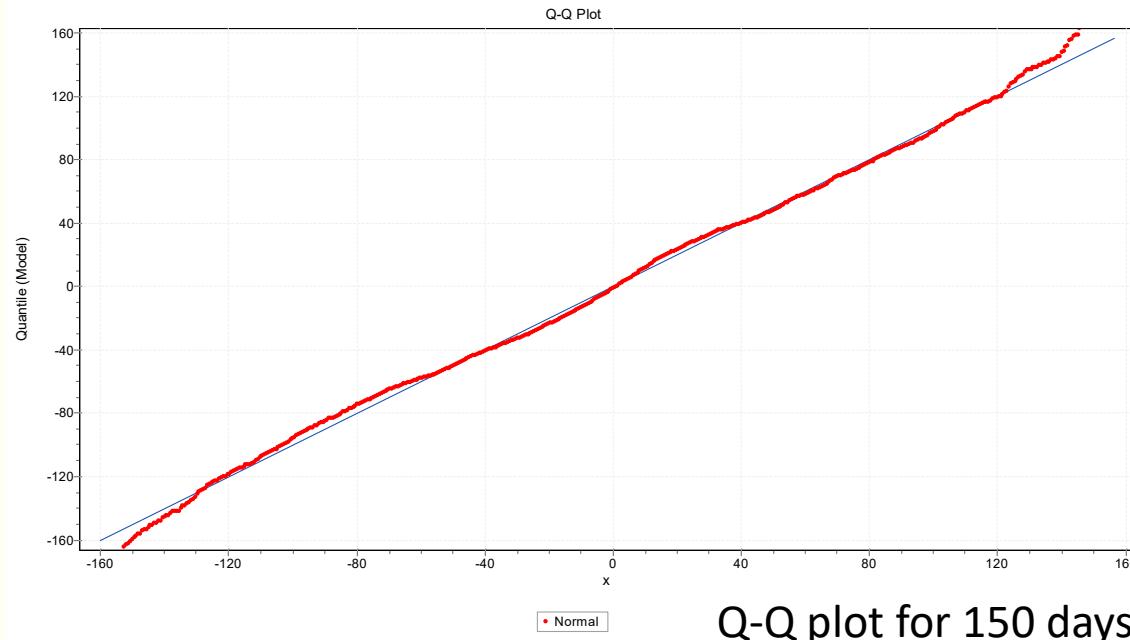
- Fix a threshold for soil moisture to vary the parameter set
- Develop an index for soil moisture and relate it to precipitation





# Development of Soil Moisture Index (SMI)

- Daily change in soil moisture ( $\Delta s$ ) is cumulated over 150 days.



- Fit a normal distribution for cumulated  $\Delta s$
- Standardized normal fit represents the SMI





# Development of Precipitation Index (PI)

Why not Standardized Precipitation Index (SPI)??

- Data of at least 40 years required
- Daily precipitation data is cumulated for 3, 6, 12 or 24 months depending on the output of interest (3 month SPI- soil moisture drought, 6 month SPI – surface water drought)
- 12 PDFs represent the 12 months of a year

Require unique value of index for each precipitation value





# Procedure for developing PI

- Precipitation is cumulated for 150 days and series generated for entire simulation period
- Gamma distribution is fit for this data
- The gamma CDF is normalized and standardized to obtain the Precipitation Index.
- Each index value corresponds to one value of precipitation





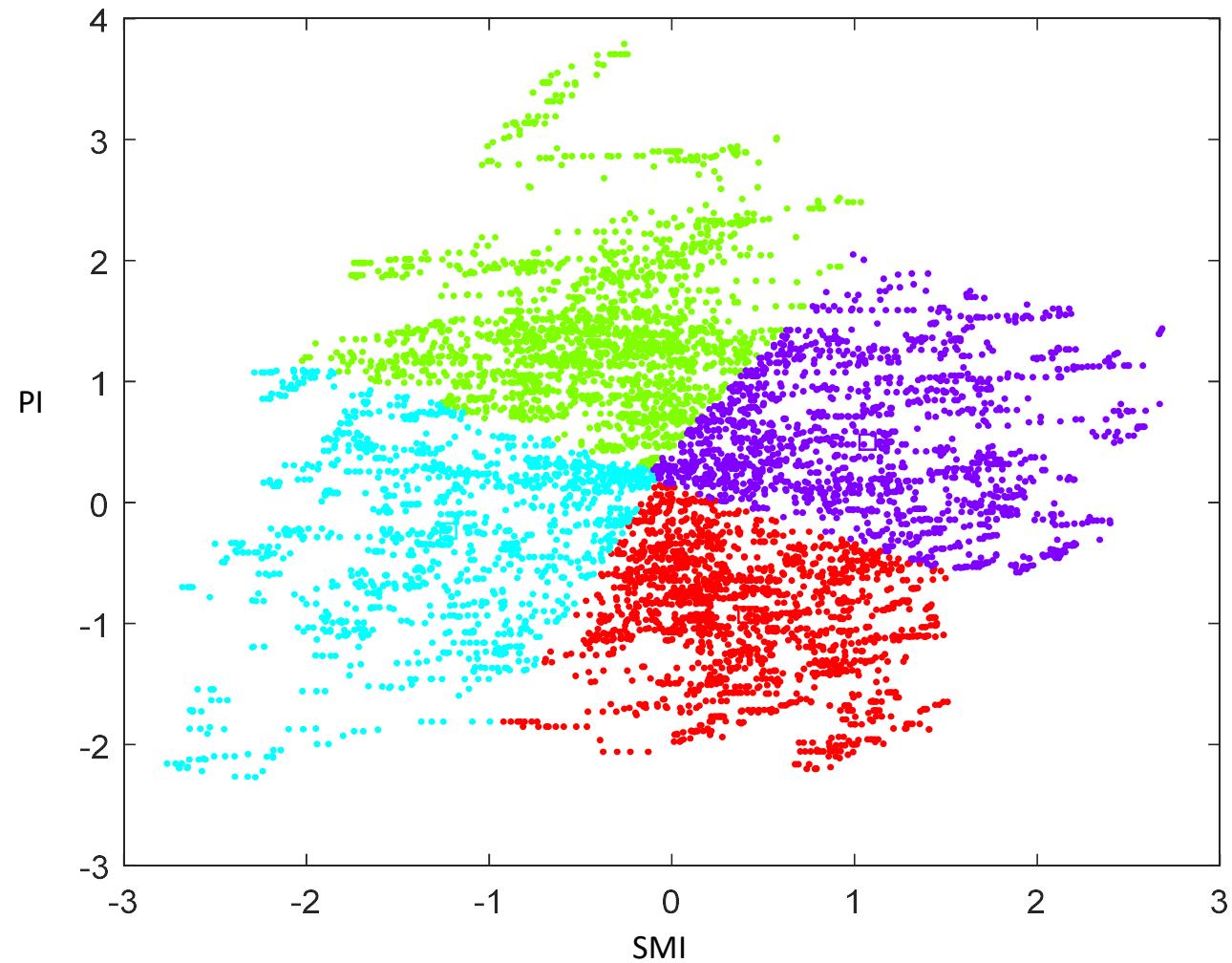
# Clustering

- **K-means clustering:** To find patterns for data in a large domain
- **Supervised clustering:** Force the data points to fit into four clusters
- Identify four centroids and assign each element to the nearest centroid based on Euclidian distance
- For each cluster, the centroid is recomputed by averaging the data points in it until convergence



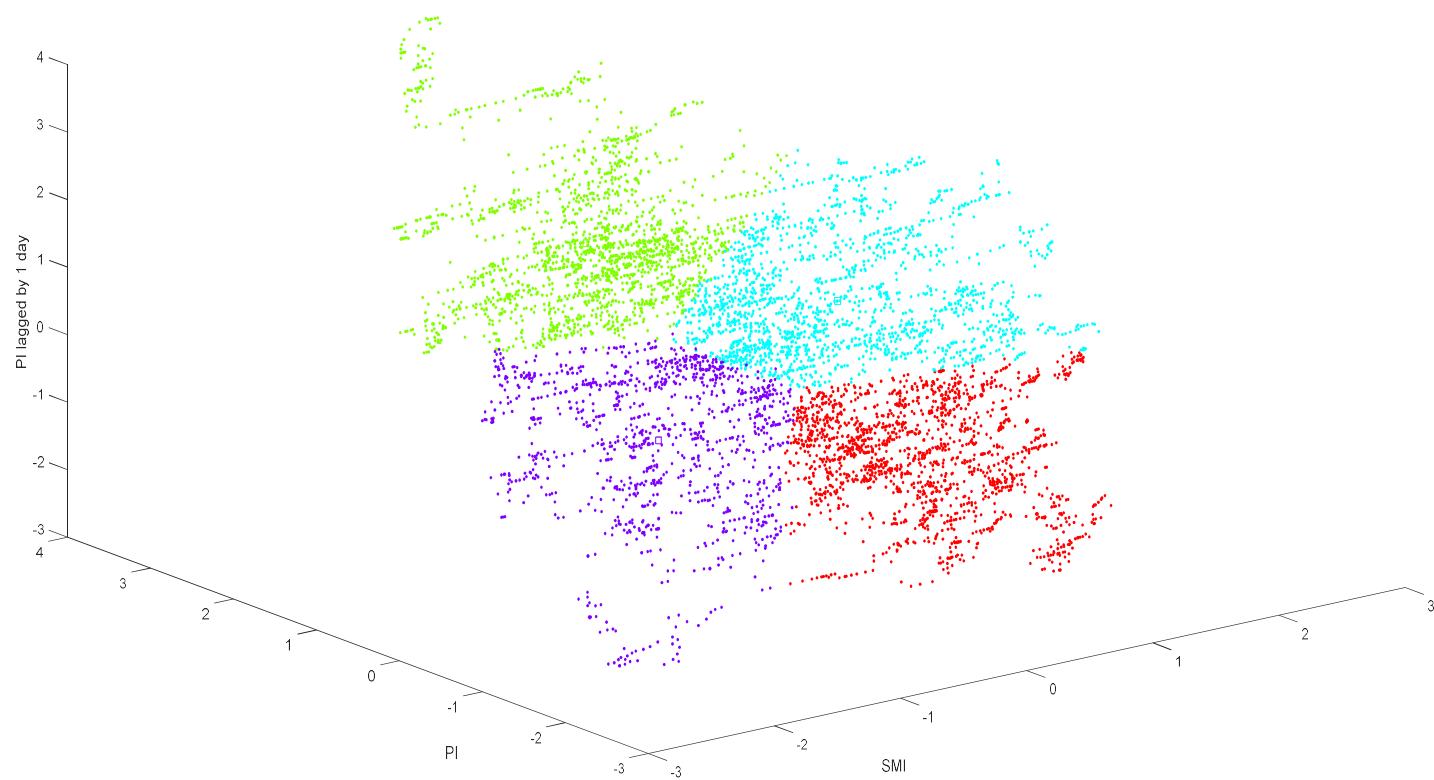


# 2-Dimensional Cluster





# 3-Dimensional Cluster



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# Conclusions

- Model parameters are sensitive to seasons
- Existing seasonal calibration procedures are inadequate
- Need to identify soil moisture thresholds over the period of simulation which can act as triggering points for varying the parameters





# Scope for future research

- Multi dimensional clustering for better identification of SMI
- Identify the thresholds of soil moisture
- Relate the thresholds to behavioral parameter sets





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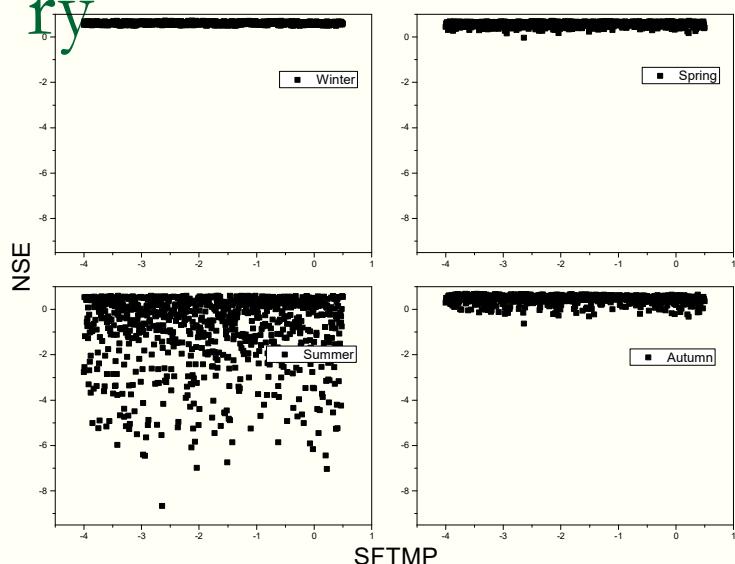
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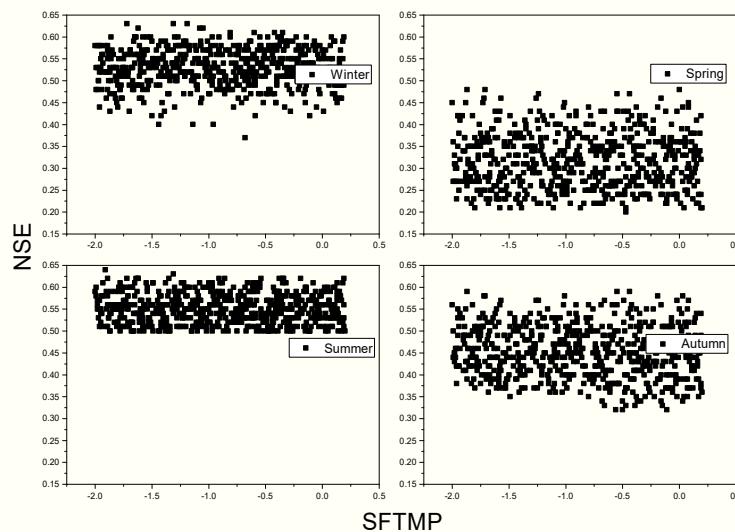
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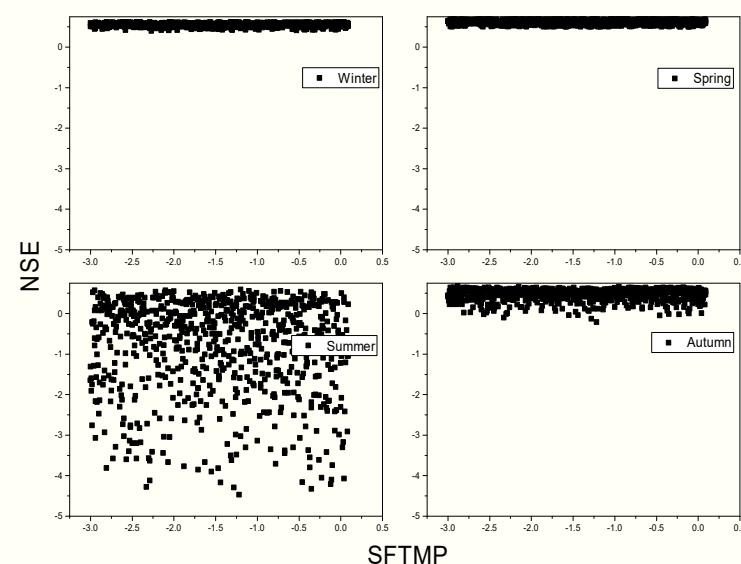
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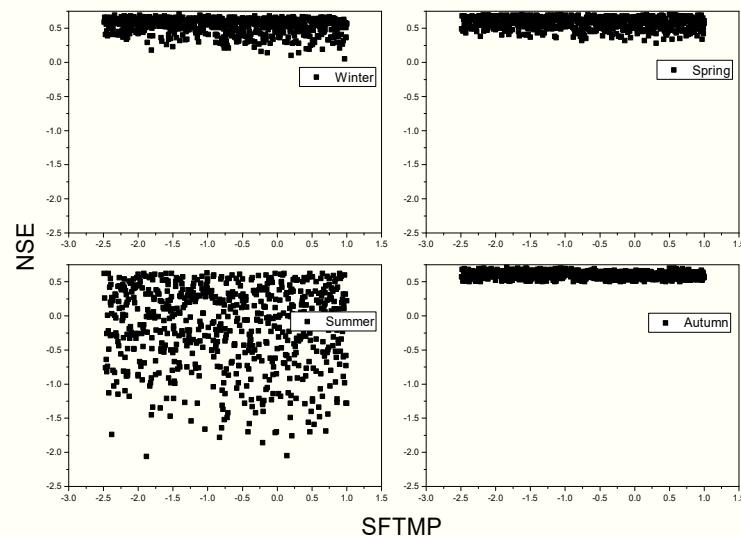
Winter



Summer



SFTMP  
Spring



SFTMP  
Autumn



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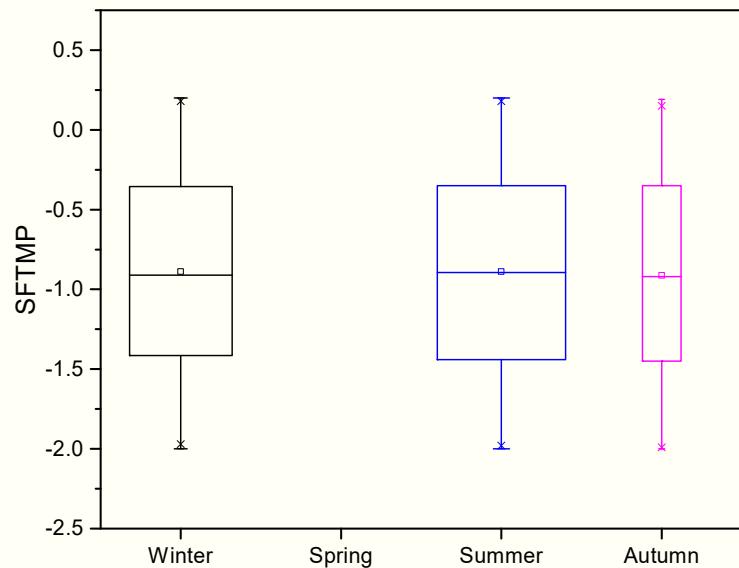
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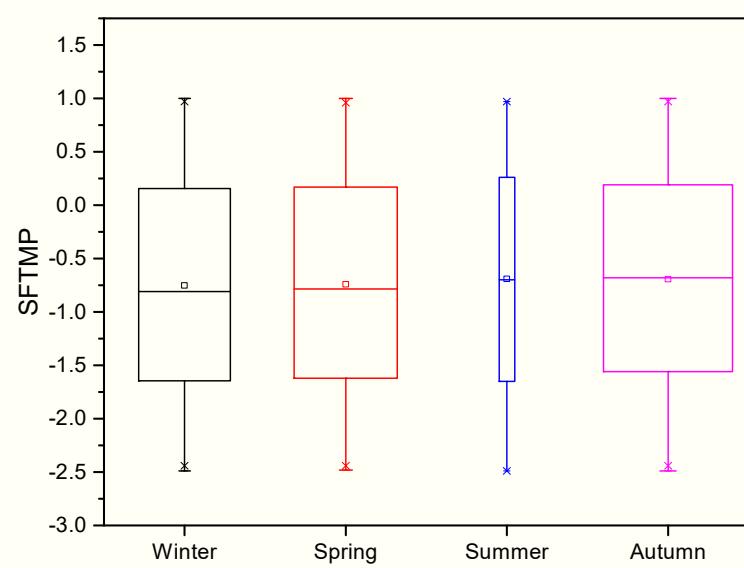


HMG-IITM

Winter



Spring



Summer

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Autumn

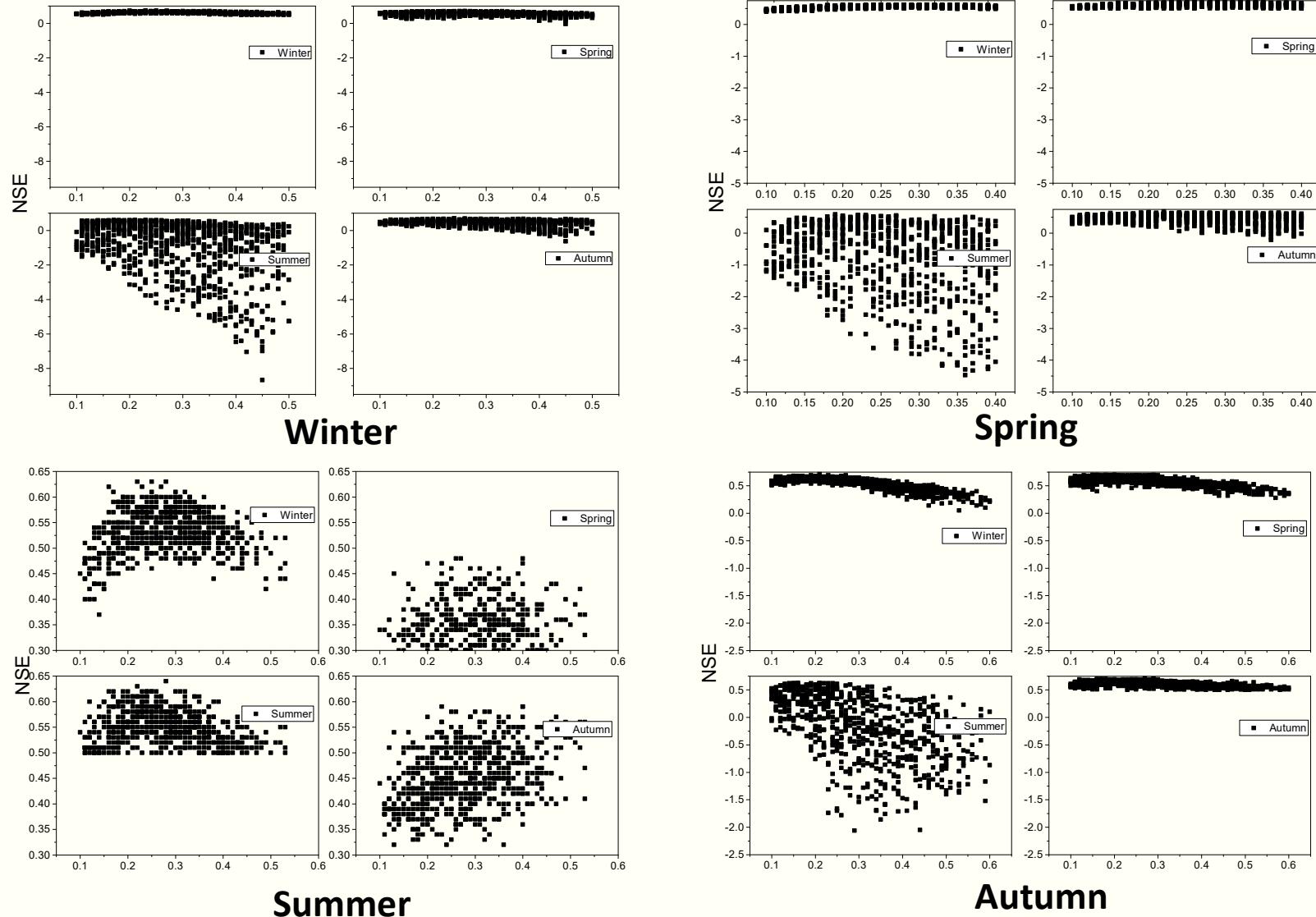
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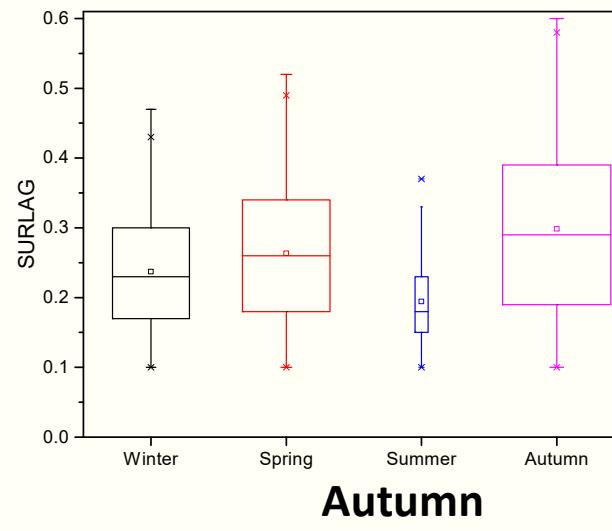
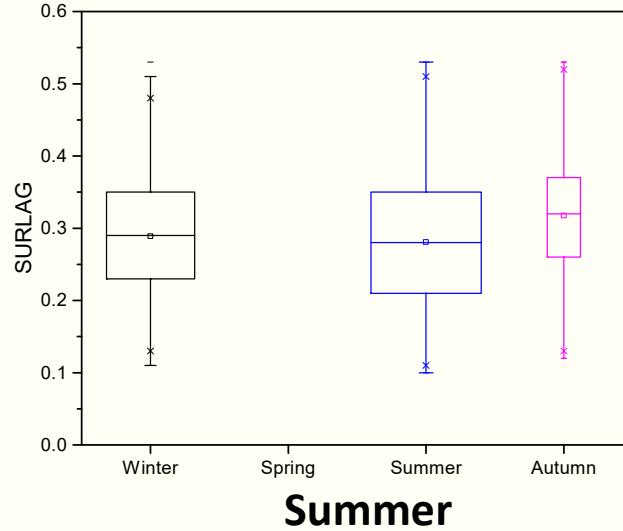
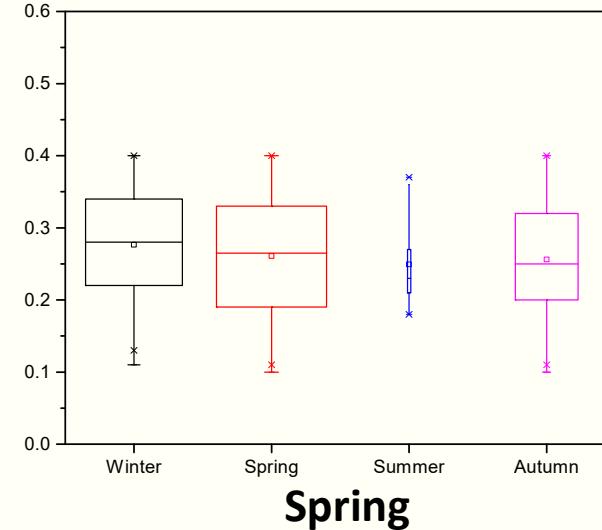
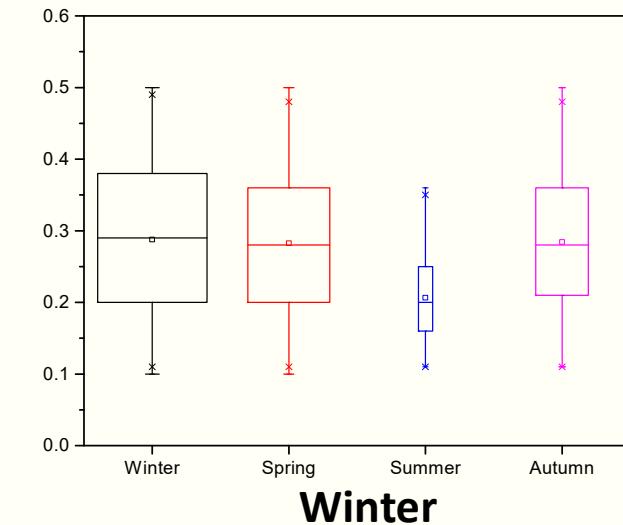




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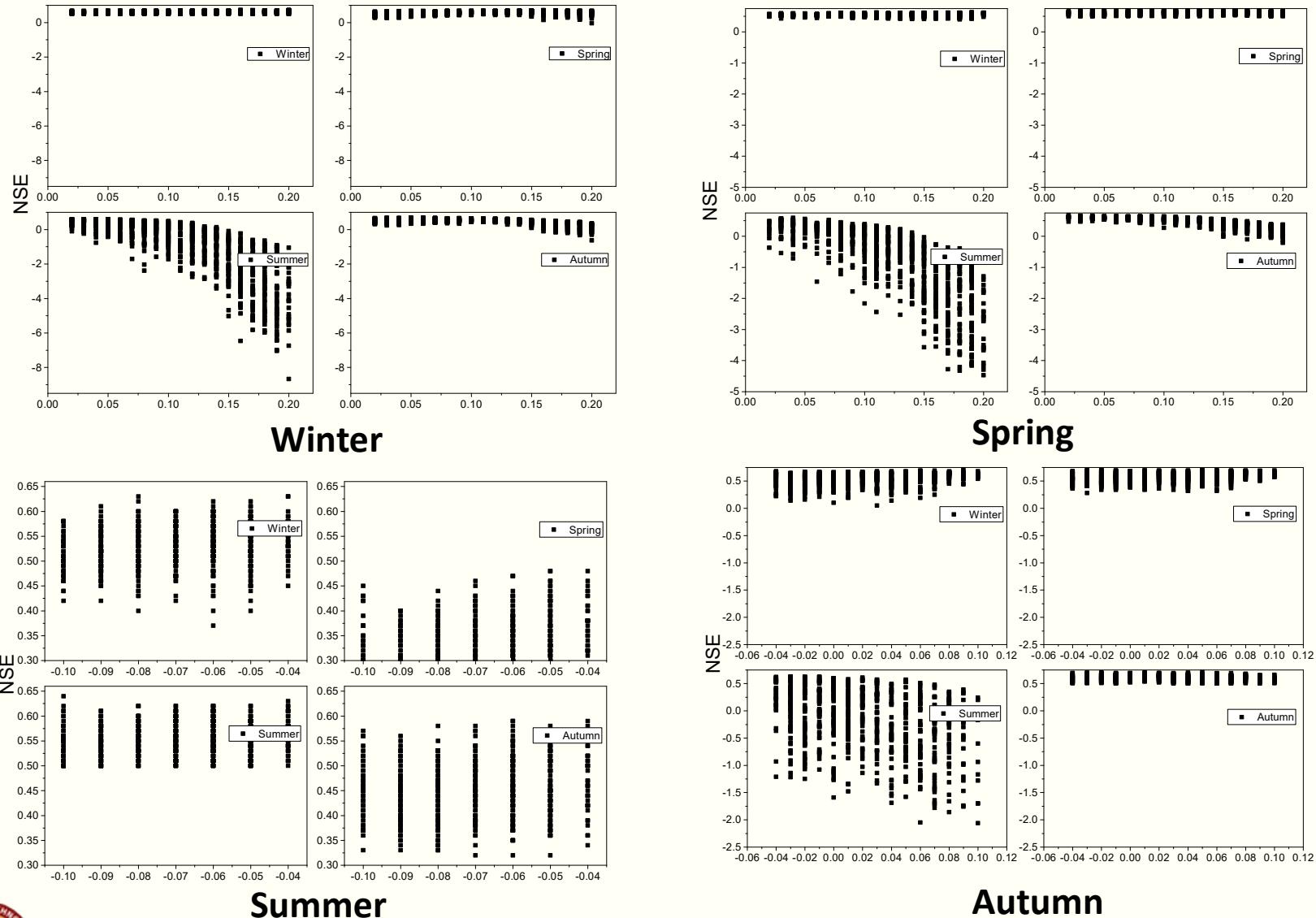


# Optimal range of SURLAG across the seasons





# Behavior of Curve Number (CN\_F) across seasons



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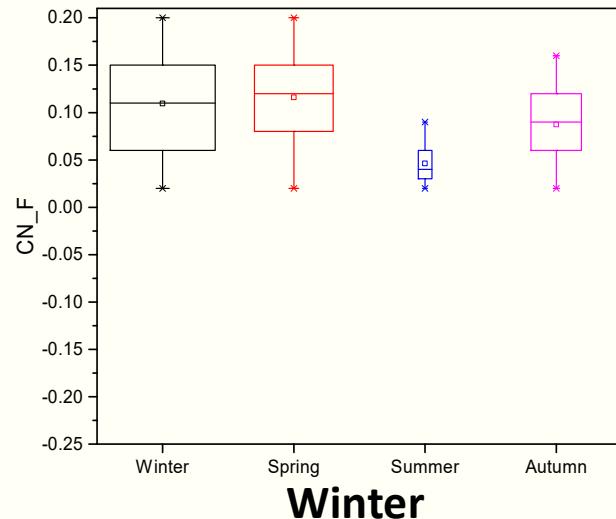
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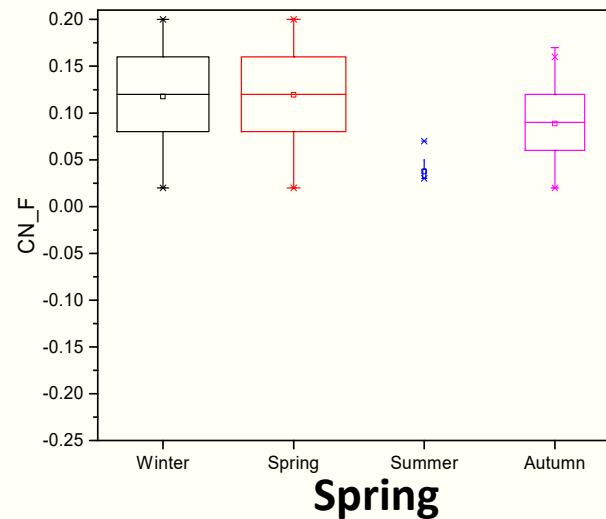
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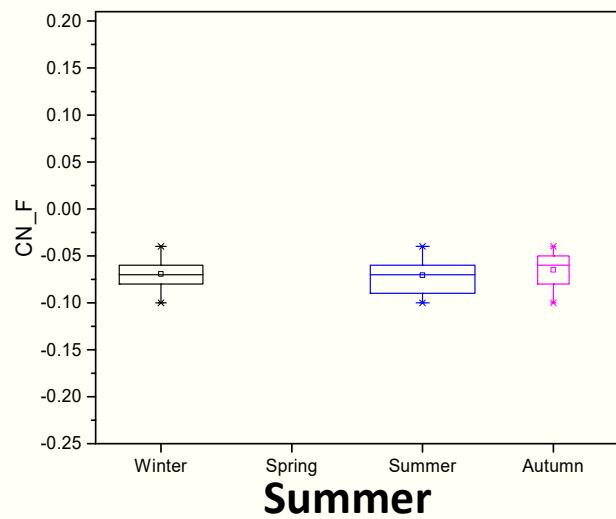
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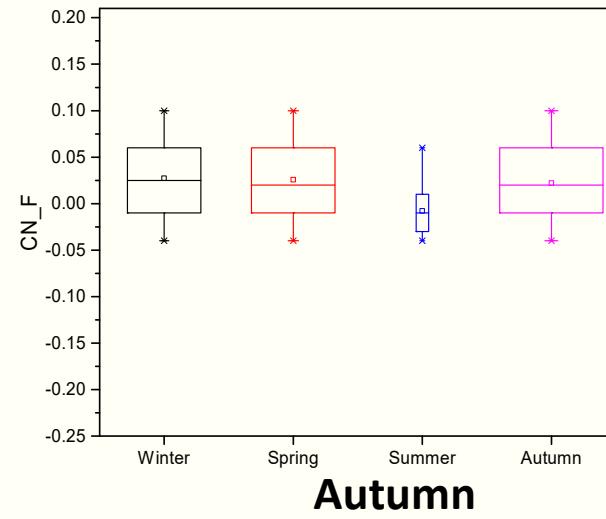
**Winter**



**Spring**



**Summer**



**Autumn**

