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Clustering as a tool for identifying drought-prone regions

A Swedish example

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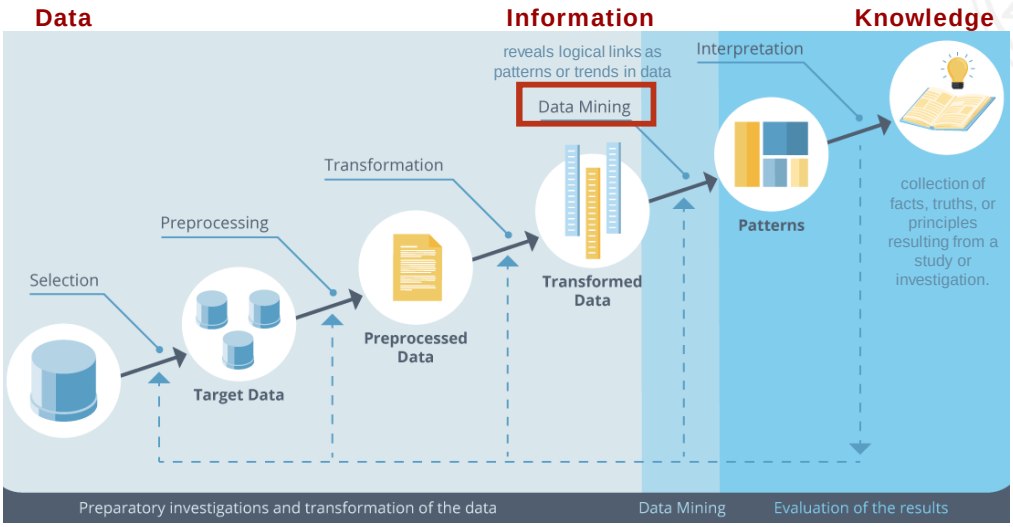
INTRODUCTION

- **information age**: we collect data faster than it can be processed
- data acquisition has grown exponentially since the introduction of mainframe computers
- improved methodologies for extracting information from data in almost every aspect of life

INTRODUCTION



Sources: https://www.industry-analytics.de/datenanalyse-und-data-mining-verfahren-im-ueberblick/ and https://job-wizards.com/en/wp-content/uploads/2019/08/JW_graphic_fs_DATA_MINING_KW29_EN.png

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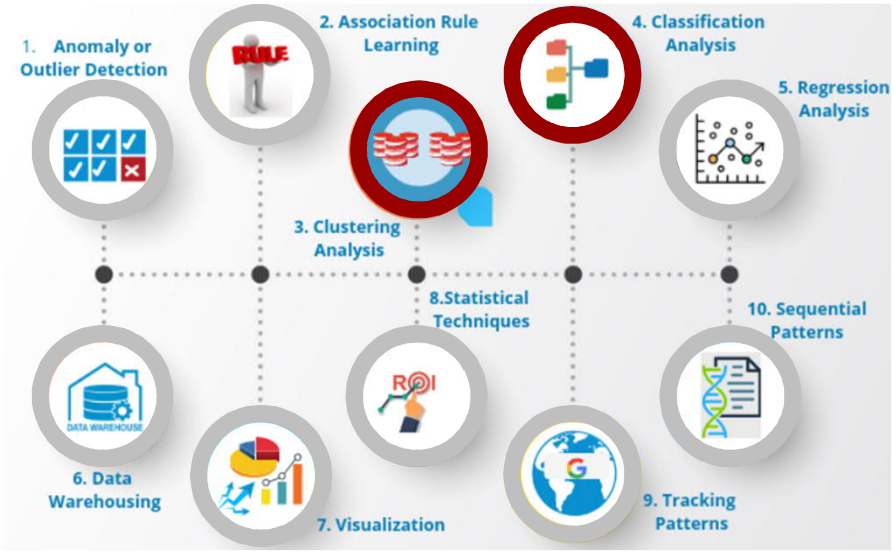
INTRODUCTION



Sources: https://www.bizprospex.com/top-10-data-mining-techniques-for-business-success/

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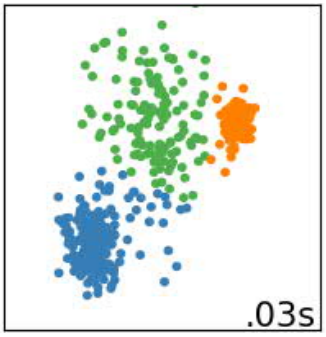
UNDERSTANDING CLUSTERING

- Clustering is a data mining method that involves grouping of data points
- Each data point is classified into a specific group, called a cluster.



- Each cluster has distinct characteristics.
- Data points within the same group should be as similar as possible
- Data points in different groups should have highly dissimilar properties and/or features.
- Various clustering approaches can be used, all coming with some advantages or disadvantages.

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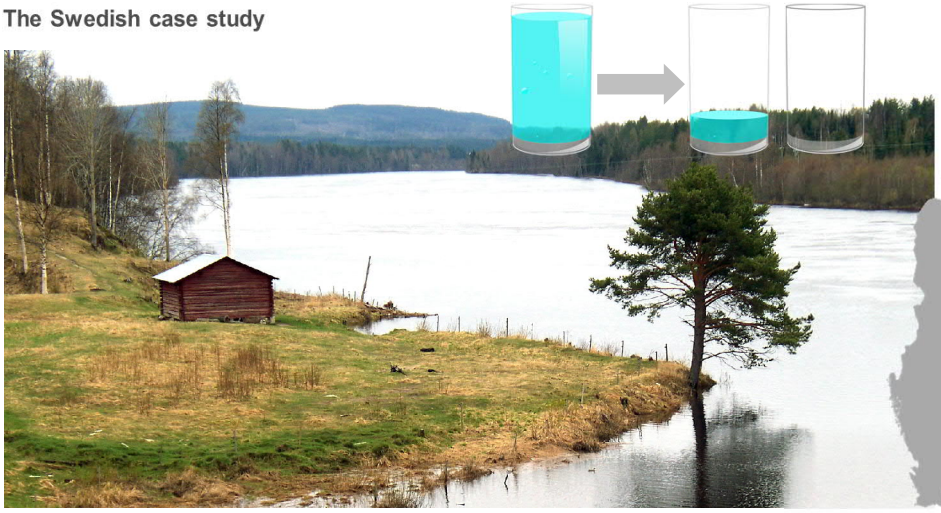
https://scikit-learn.org/stable/auto_examples/cluster/plot_cluster_comparison.html

CLUSTERING IN PRACTICE

The Swedish case study



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CLUSTERING IN PRACTICE

The Swedish case study

1996

Grundvattnet rekordlågt

Göteborgs-Posten | 21 mars 1996 | 483 ord

2003

Torka påverkar dricksvattnet

Hudiksvalls Tidning | 24 juli 2003 09:02 | 271 ord

2018

Många söker stöd för skadad skörd

Land Lantbruk | 28 sep. 2018 | sida 10 | 54 ord

2019

Risk of water shortages in 2019

Too little rain has led to low groundwater levels in parts of the country. There is a risk that it will be a difficult summer with water shortages in several counties, according to the Geological Survey of Sweden, SGU.

2020

FÖRETAGANDE UPPDATERAD: 19 MAJ 2020

Rapsen skadad av frost och torka – men hoppet är inte ute

2021

Lantmännens skördeprognos: Värme och torka i juni sänker skörden i Halland, Skåne och Blekinge

TIS, JUL 13, 2021 07:00 CET

Report this

Rekordsolig torka **2022**

UPPDATERAD 5 SEPTEMBER 2022 PUBLICERAD 1 APRIL 2022

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CLUSTERING IN PRACTICE

The Swedish case study

- Have streamflow droughts become more common in Sweden?
- Are all regions affected to the same extent?

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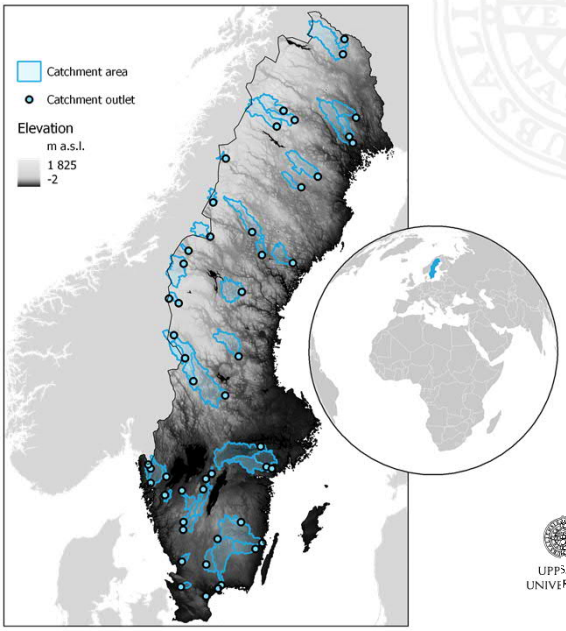
The Swedish data set

- Streamflow measured over 60 years at 50 stations across Sweden
- Different catchment properties (e.g., area, topography, landuse)
- Different climate conditions



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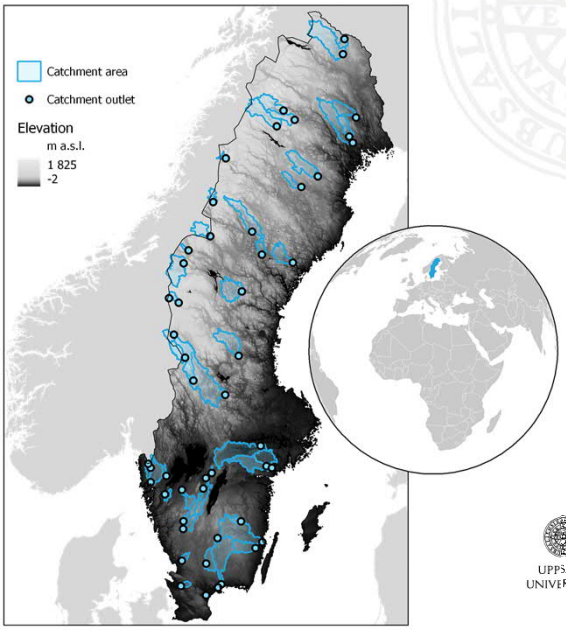
Problem

It can be challenging to derive meaningful insights when dealing with a diverse range of catchments.

How can we move beyond analyzing individual catchments and instead identify common patterns that can be generalized?



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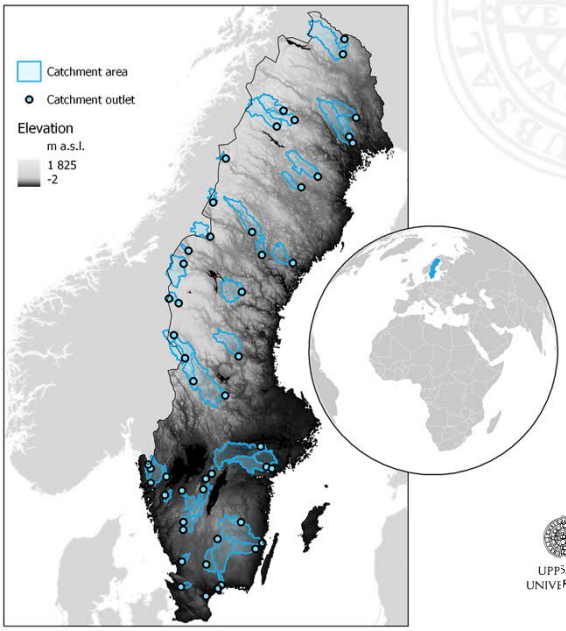
Motivation

We let the data "speak" to see which catchments behave similarly and to evaluate emerging spatial patterns.



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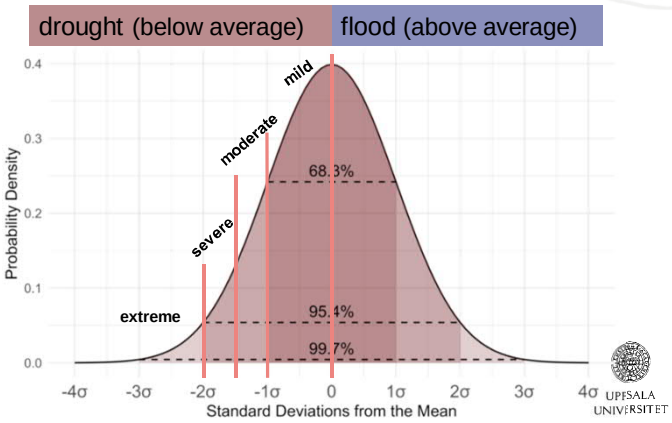
Clustering based on drought behaviour

Standardize streamflow index (SSI)

- Represents anomalies from a normal situation in a standardized way
- Calculated based on monthly data
- Transforms data into a normal distribution
- For each month, it is assessed how much the value deviates from the mean (how many stds)



Lloyd-Hughes & Saunders 2002. A drought climatology for Europe. https://doi.org/10.1002/joc.846

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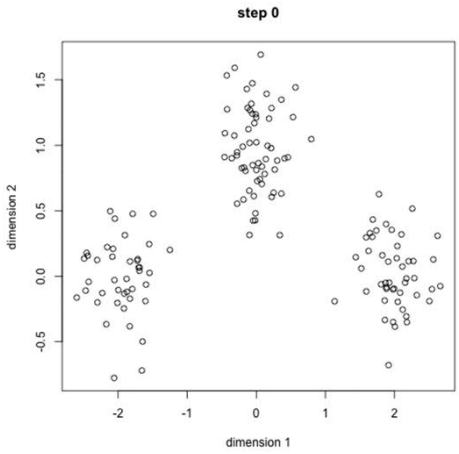
Clustering with K-Means

- Probably most well-known algorithm
- Pretty fast
- Requires pre-selection of number of groups

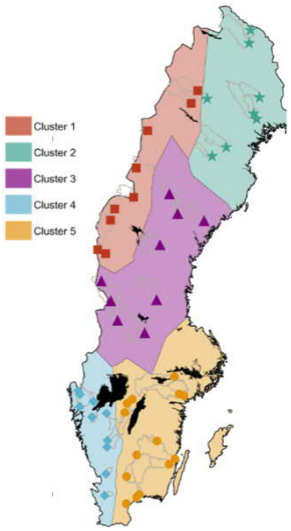


https://towardsdatascience.com/the-5-clustering-algorithms-data-scientists-need-to-know-a36d136ef68

CLUSTERING IN PRACTICE

Resulting Clusters

- 5 geographically distinct regions emerged from the clustering
- These clusters varied also in geographic, hydroclimatic and land-cover characteristics



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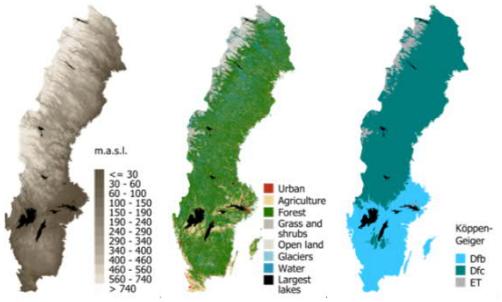
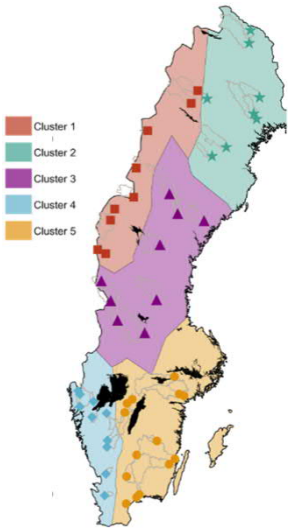
Resulting Clusters





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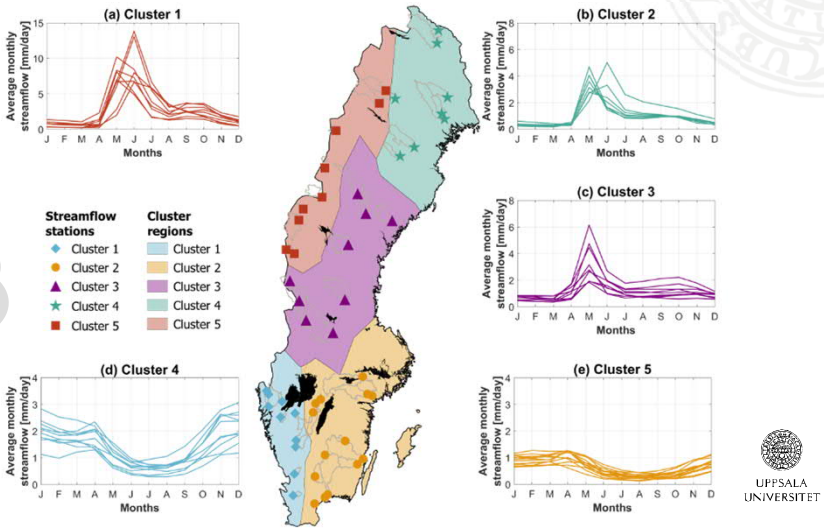
Resulting Clusters

- These clusters varied also in their hydrological regimes.

Clustering made sense from a physical & process-based perspective



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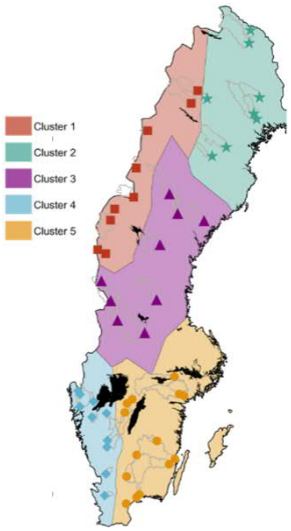
Cluster-wise computations

- 17 drought statistics
- Mann-Kendall's test and Sen's slope estimates were computed to detect potential significant trends



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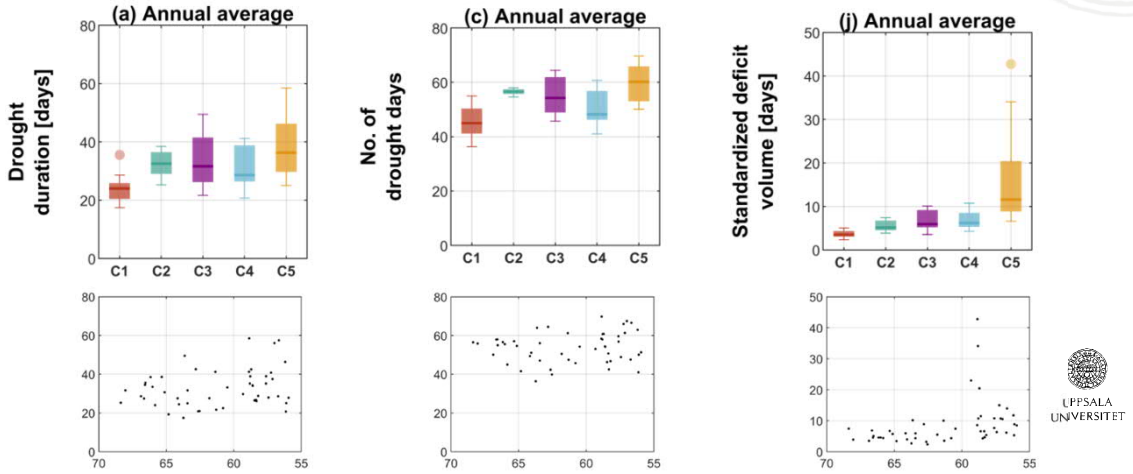
Drought Characteristics per cluster



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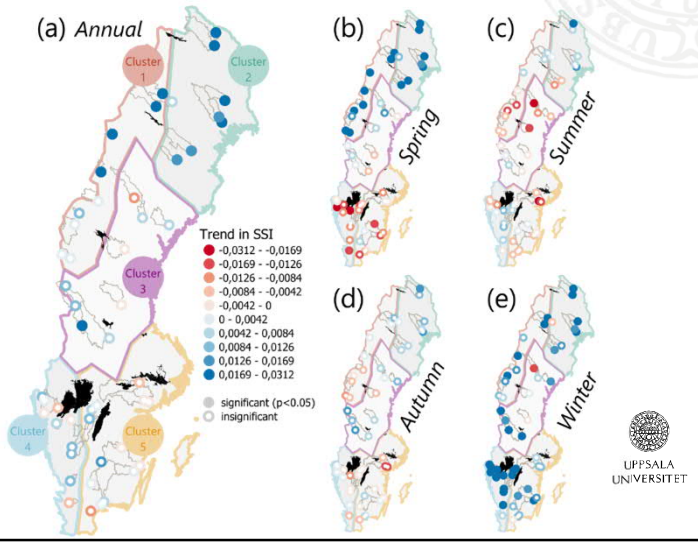
Trends per cluster

- Can be difficult to detect patterns
- Plotting by region revealed considerable differences



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CONCLUSION

- **Knowledge is power:** clustering can give you more knowledge!
- **Clustering can** be used to
  - Simplify your data and make it easier to analyze
  - Identify hydrological similarities among catchments
  - Identify areas at risk of floods or droughts and inform planning strategies
  - Uncover the underlying hydrological processes that influence streamflow patterns
- **Careful:** clustering can help efficiently evaluate past streamflow drought behavior and identify drought-prone areas, but it's important to verify and interpret the patterns with process-based knowledge.

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Streamflow droughts in Sweden: Spatiotemporal patterns emerging from six decades of observations

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