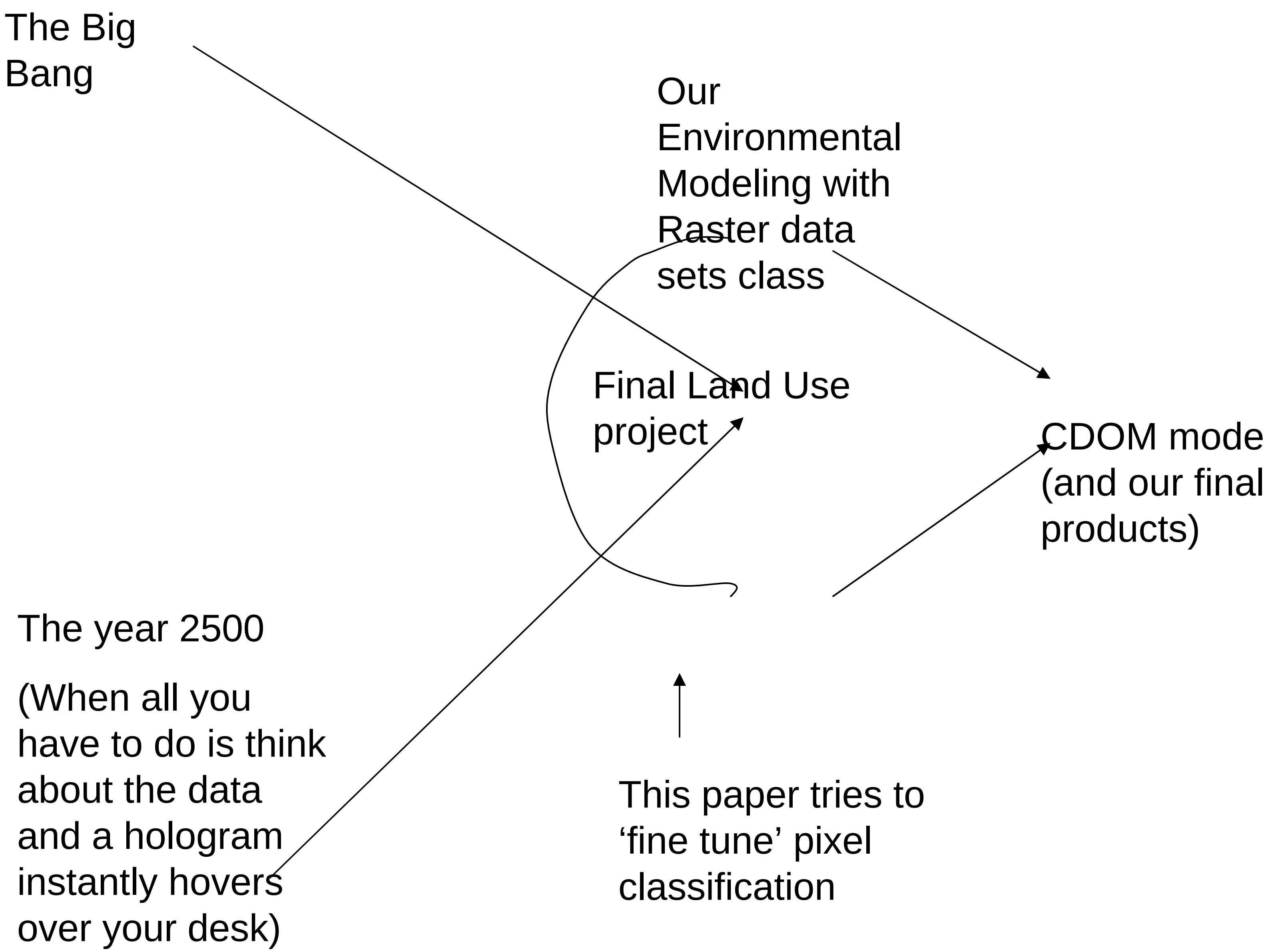
# Alternative Representations of In-Stream Habitat: Classification using Remote Sensing, Hydraulic Modeling, and Fuzzy Logic

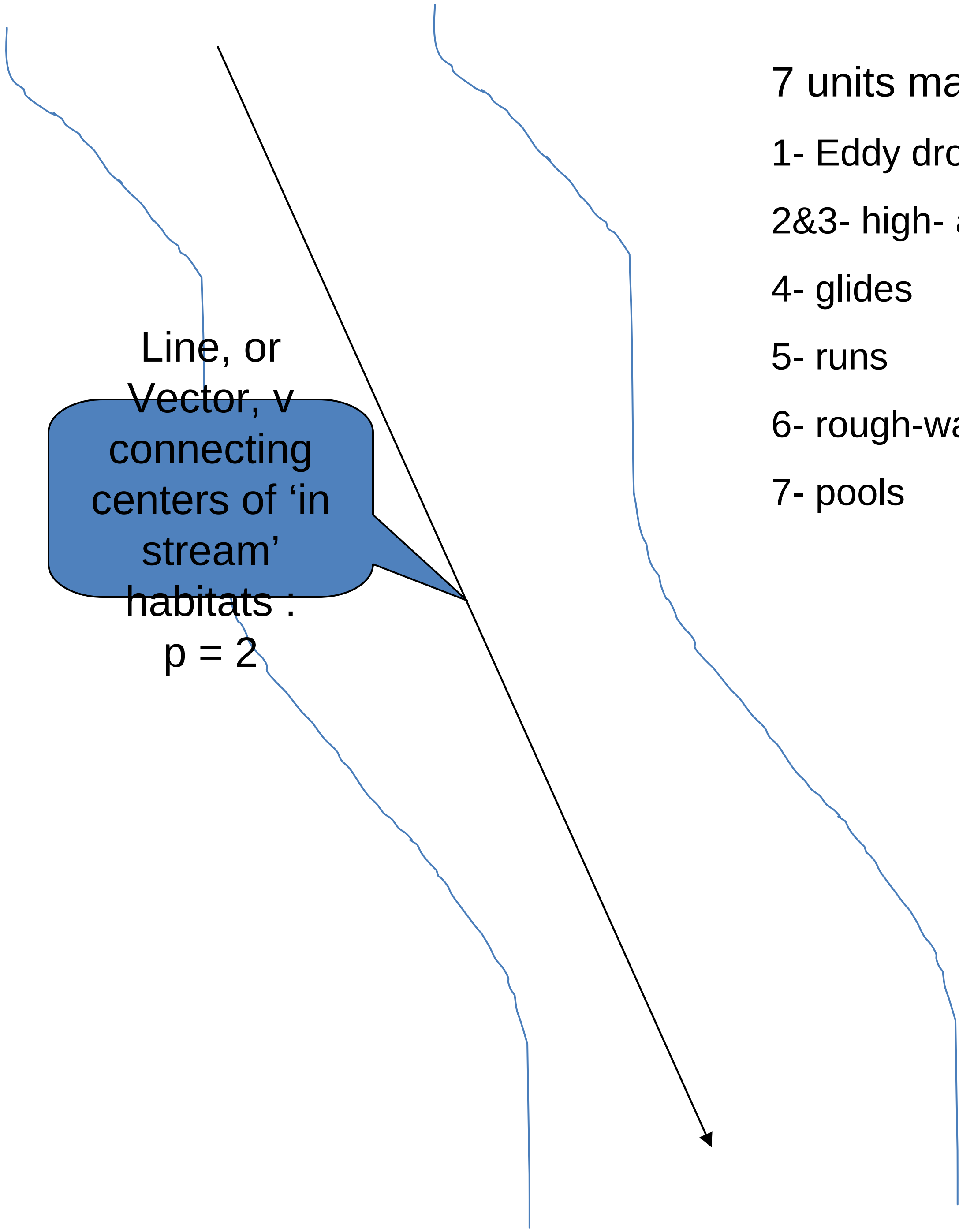
- International Journal of Geographical Informatin Science, April 6, 2004
- Carl J. Legleiter and Michael F. Goodchild

“data-driven similarity relation model”


The Big Bang
Our Environmental Modeling with Raster data sets class
Final Land Use project
CDOM model (and our final products)
The year 2500
(When all you have to do is think about the data and a hologram instantly hovers over your desk)
This paper tries to 'fine tune' pixel classification

# Conclusion / Key points

- Tension between cartographic ‘exact-ness’ and ‘fuzzy’ natural environment.
- Data quality is a key issue.
- RS – watershed analysis: Hydrologic modeling – 100 M reaches & intensive ‘survey’.




7 units mapped in the field

1- Eddy drop zones

2&3- high- and low- gradient riffles

4- glides

5- runs

6- rough-water runs

7- pools

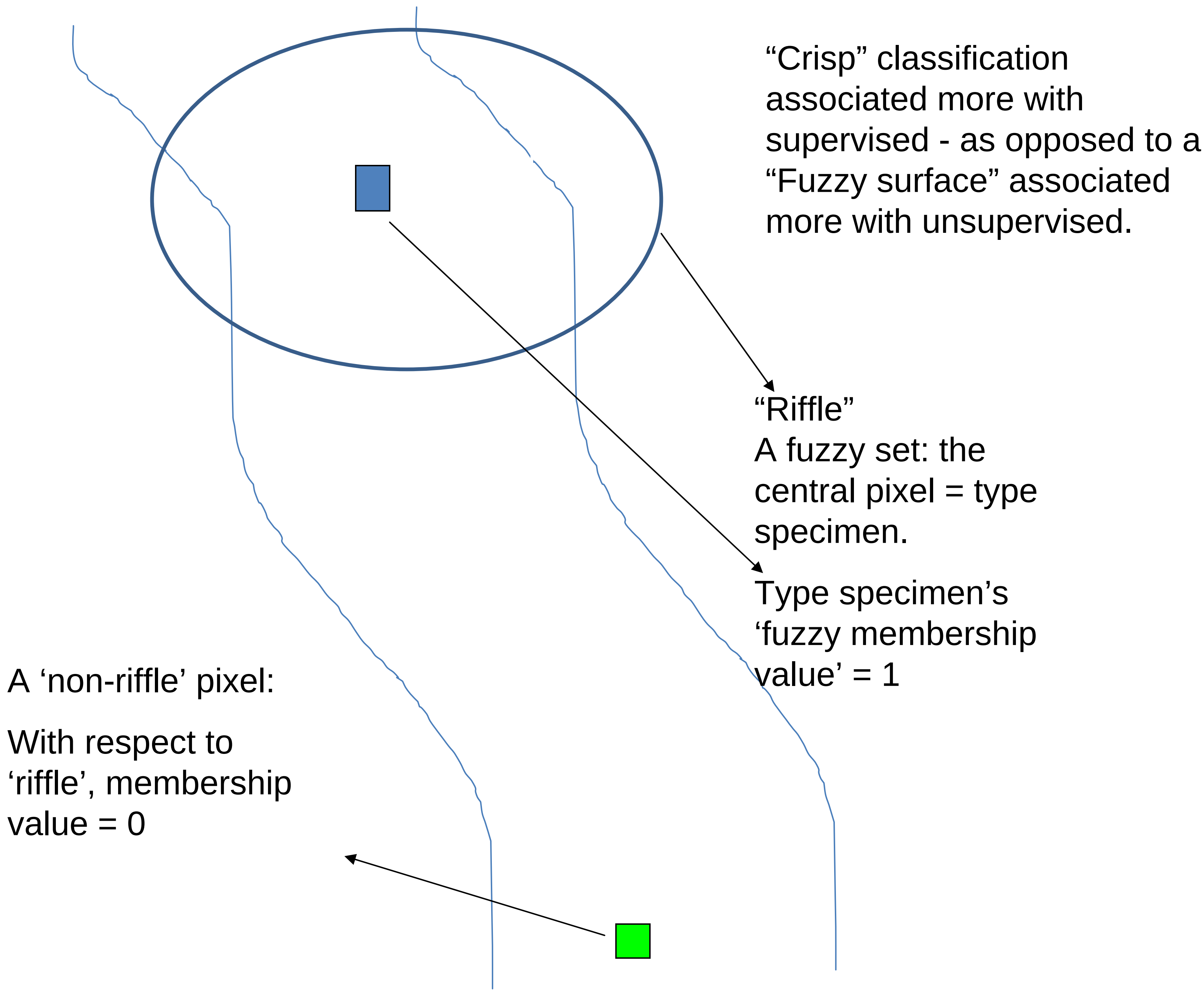
RS data trained to 4

1- eddy drop zones

2- riffles

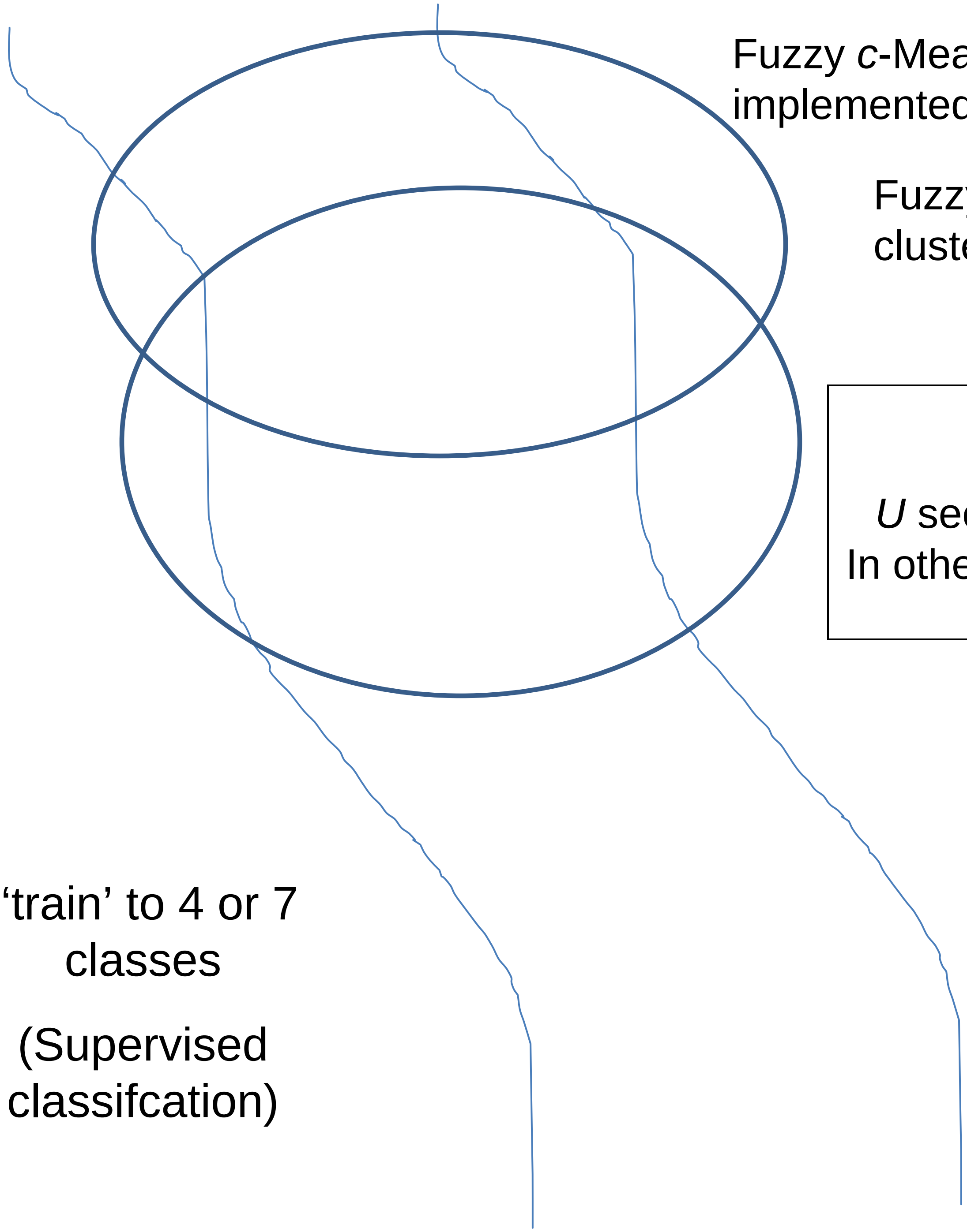
3- run / glide

4- pool


"Crisp" classification associated more with supervised - as opposed to a "Fuzzy surface" associated more with unsupervised.
"Riffle"
A fuzzy set: the central pixel = type specimen.
Type specimen's 'fuzzy membership value' = 1
A 'non-riffle' pixel:
With respect to 'riffle', membership value = 0

Fuzzy *c*-Means Algorithm: FCM implemented in MATLAB

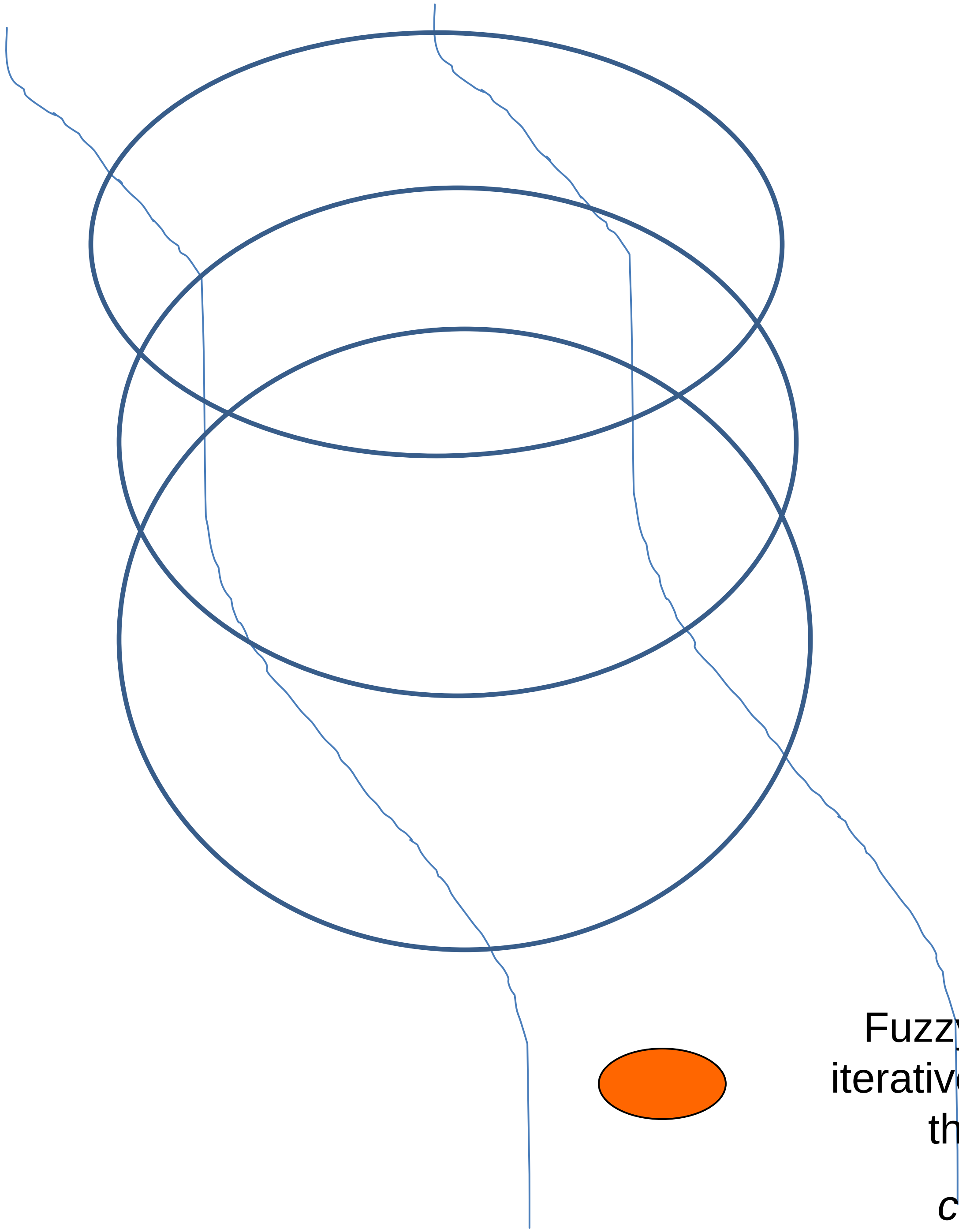
Fuzzy set = fuzzy *c*-partition = cluster



In some cases,
*U* seems to be any fuzzy set:
In others, *U* refers to the *last set.*

'train' to 4 or 7 classes

(Supervised classifcation)



- 2 – 10 clusters ( c )
- 15 FCM Weighting exponents ( *m* )

1.1 – 2.5

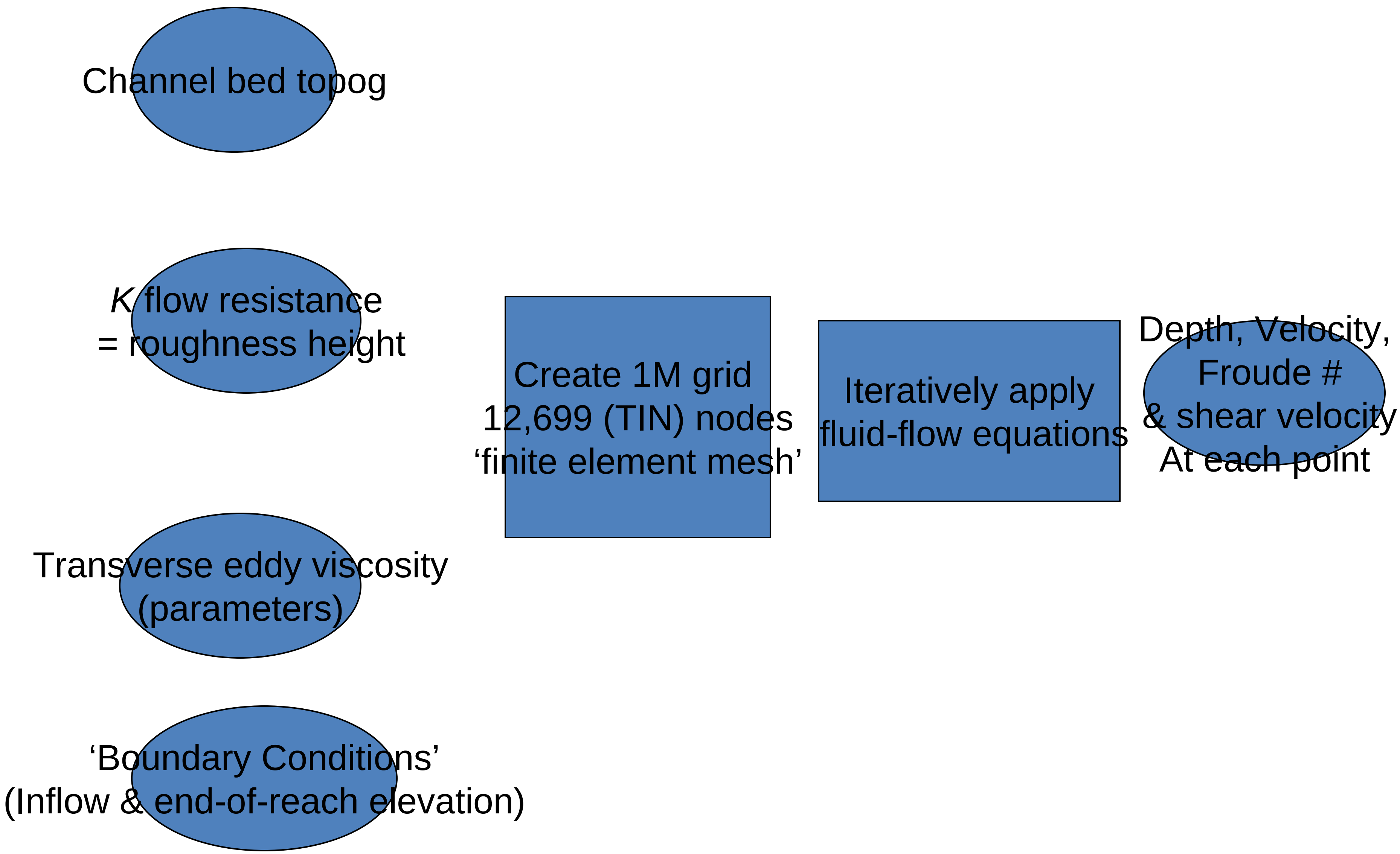
- 3 data sets = 405 rasters

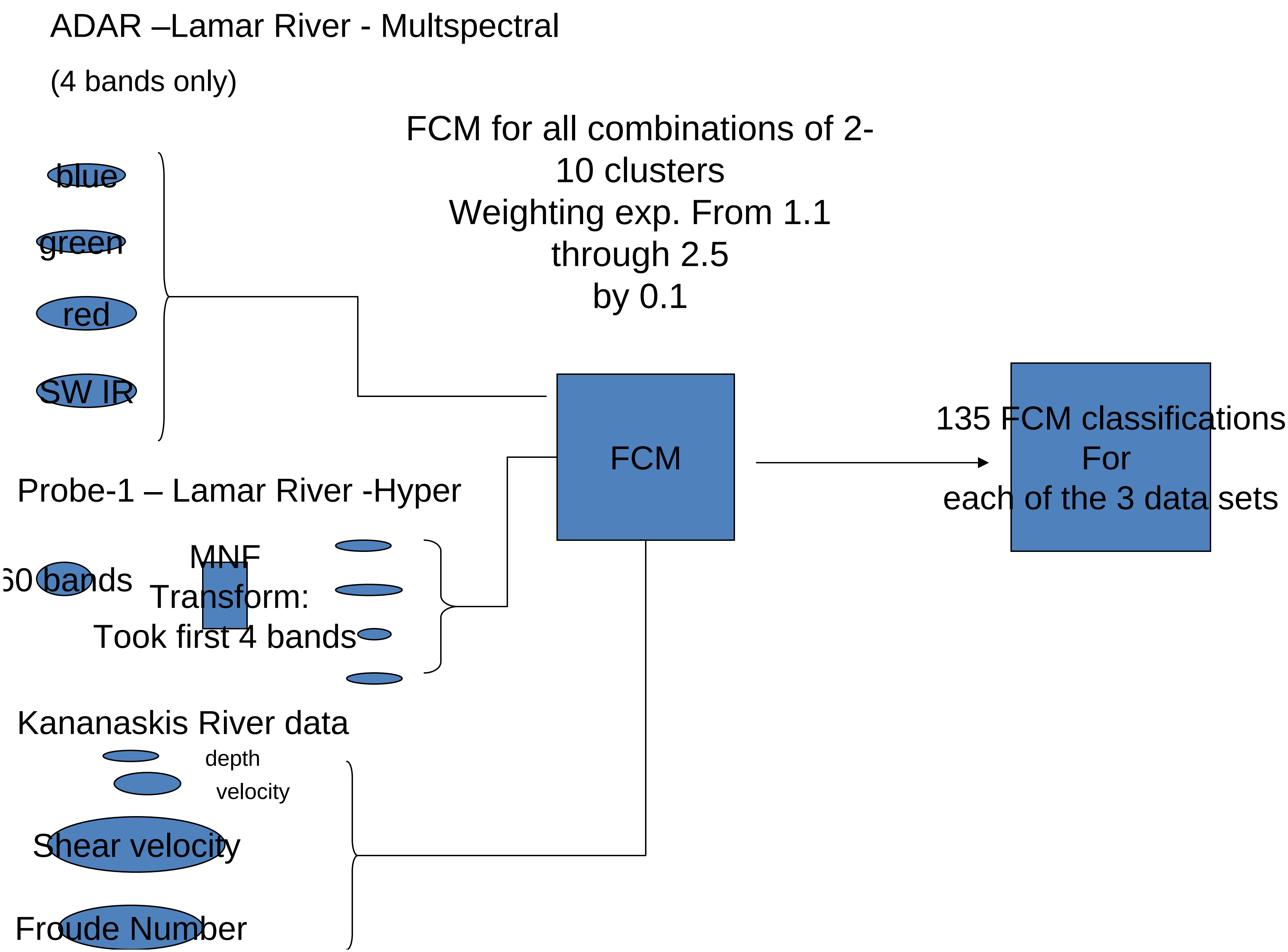
8 indices of Cluster Validity

Fuzzy *c*-Means is an iterative process: This is the final fuzzy

*c*-partition, ***U***

# River 2D Hydrodynamic Model: 625 Meters of Kananaskis River, Alberta




ADAR –Lamar River - Multspectral
(4 bands only)
blue
green
red
SW IR
FCM for all combinations of 2-10 clusters
Weighting exp. From 1.1 through 2.5 by 0.1
FCM
135 FCM classifications For each of the 3 data sets
Probe-1 – Lamar River -Hyper
0 bands
MNF Transform: Took first 4 bands
Kananaskis River data
depth
velocity
Shear velocity
Froude Number

# Cluster Validity 1 of 3

"clustery goodness" – like peanuts under the chocolate of a candy bar

- Partition Coefficient PC(c ) =1, then partition U should be crisp (or hard): PC(c )=1/c then U = 1/c and membership is spread evenly over all classes (max fuzz)
- Partition Entropy PE(c )= 0, hard partition:PE(c ) = log(c ) membership spread evenly
- Xie-Beni XB Smaller XB=compact & separate clusters

# Cluster Validity 2 of 3

partitions – either a cluster, or the final result- all of the clusters

- Fukuyama-Sugeno FS Small FS, compact, separate clusters
- Fuzzy Hypervolume FHV Small indicates compact clusters
- Average partition density $D_{pa}$ Larger is better, but you want both dense and loose clusters in a given partition = dense substructures

# Cluster Validity 3 of 3

- Partition Density $P_D$ Larger = compact, separate clusters.
- Separateness-compactness SC Larger = good cohesion within cluster and small overlap between pairs of clusters.

# Classification Uncertainty

- Spatial patterns of classification uncertainty highlight transitional areas. These might contain greater diversity of habit.
- Boundaries concentrate confusion in the smallest zone possible.

# Uncertainty Technique

- ‘Hardening’ fuzzy classes: Assign the pixel to the class it has the highest value for.”A kind of defuzzification”.
- Create discrete objects by ascribing boundaries to fuzzy surfaces. This can only be done by establishing specific sets of conditions. These sets of conditions are thresholds also known as α-cuts.
- Gaps are known as Epsilon bands.

# Spatial variability of Classification Uncertainty

- Exaggeration uncertainty: Describes the error incurred by assuming an observation has full membership in a class. Quantifies the dissimilarity between it and its class.
- Ignorance uncertainty: a number that describes how well this observation does *not* relate to all the other classes. Proportional to the fuzziness of the entity (I assume class).