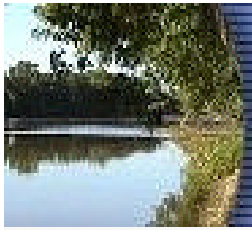


Soil and Water Science
at the University of Florida

UNIVERSITY OF FLORIDA
Institute of Food and Agricultural Sciences

Geographic Information Technology Applied to Soil Mapping

Sabine Grunwald
Assistant Professor GIS & Land Resources
Distance Education Coordinator

Conceptual Models of Real World Phenomena

Conceptual Models of Space

1. Entity (object) model = vector model

2. Continuous fields model = raster model

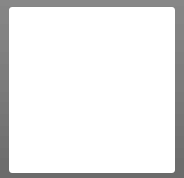
1. Geographical Data Model: Object View

basic geographical data primitives (geographical entities):

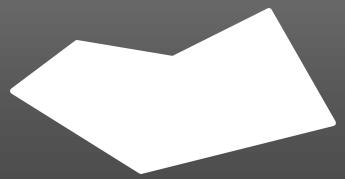
- Point

Line

Area

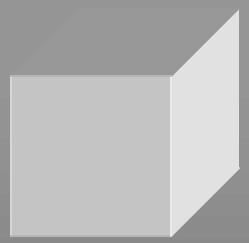


Pixel

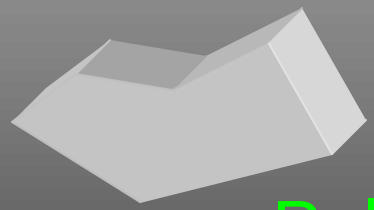


Polygon

Volumes



Voxel

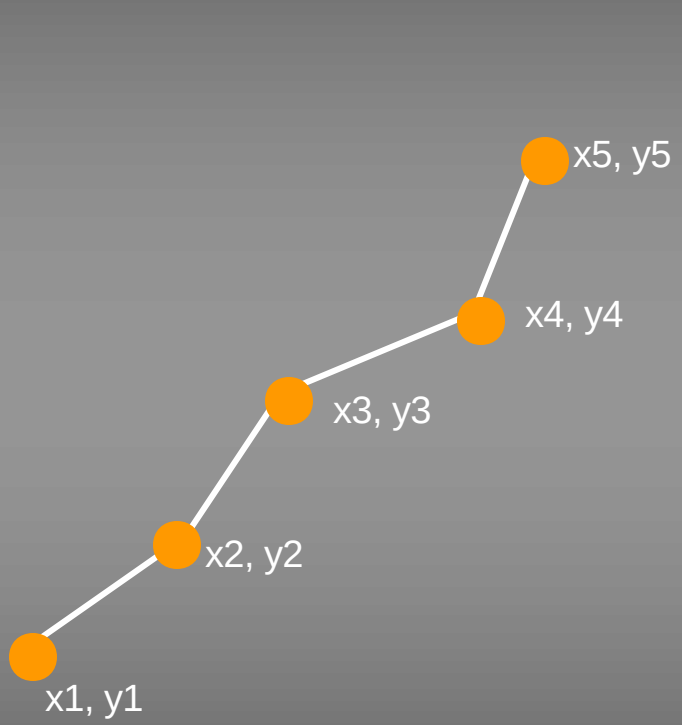


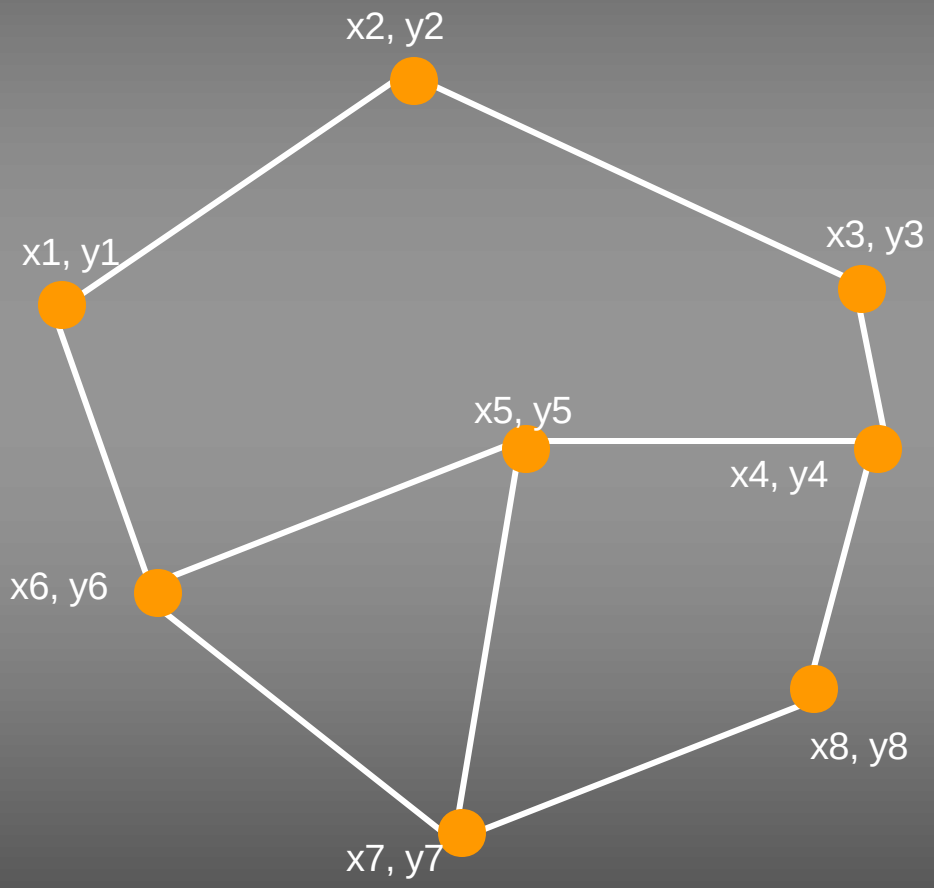
Polyhedrons

(Goodchild, 1992)

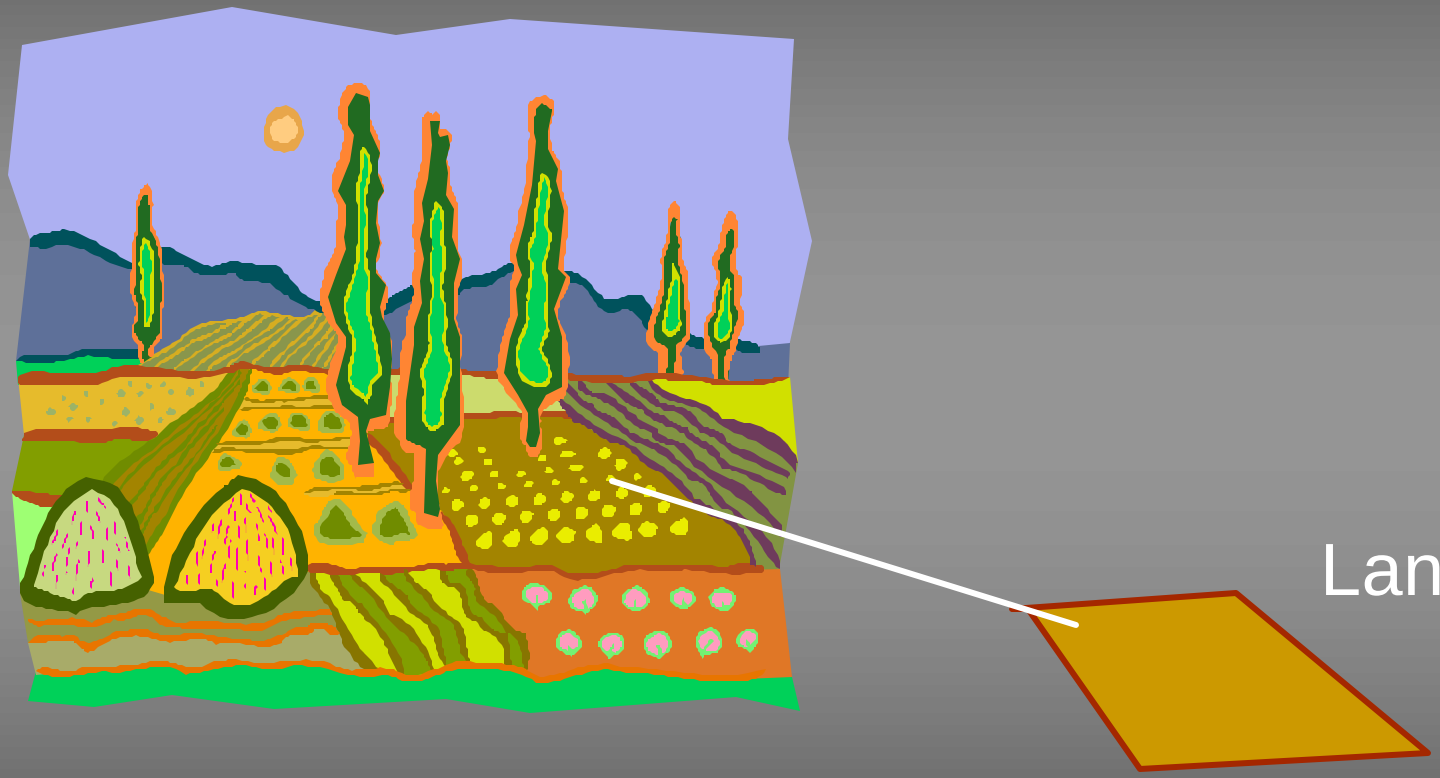
Vector Data Model

Topology

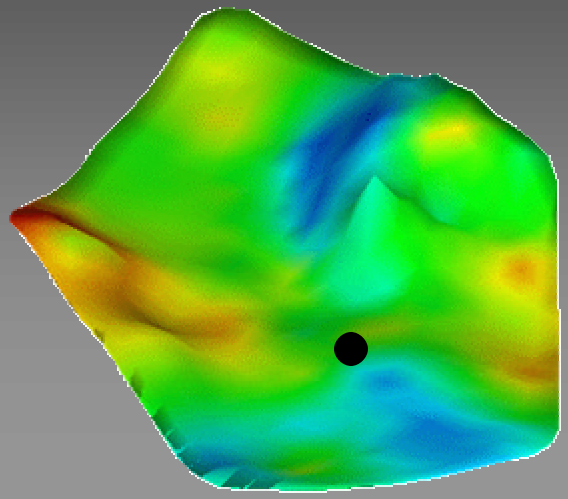




Conceptual Models of Real World Phenomena



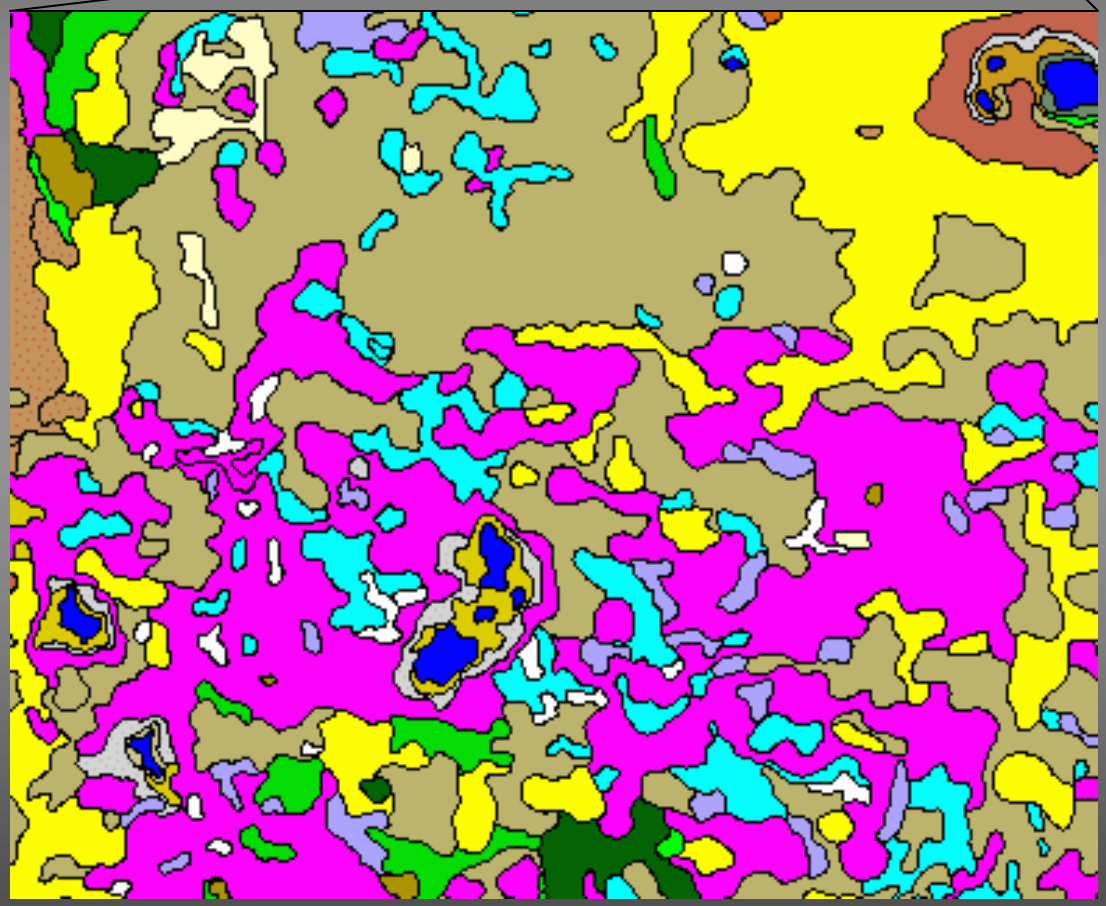
Conceptual Models of Real World Phenomena



Tree is represented as point feature with specific attributes (e.g. height, species, age, etc.)

Tree is represented by polygon structure in a visual scene with an image stamped on it

Entity-Based Soil Map



Soil map units

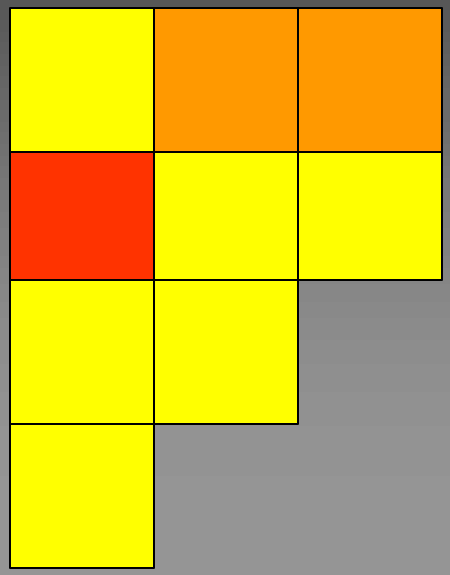
- Lake
- Kendrick
- Bonneau
- Millhopper
- Norfolk
- Candler
- Aredondo
- Apopka
- Cadillac
- Jonesville
- Urban
- Water

N

0 3,500 7,000 m

2. Geographical Data Model: Continuous Fields

Raster



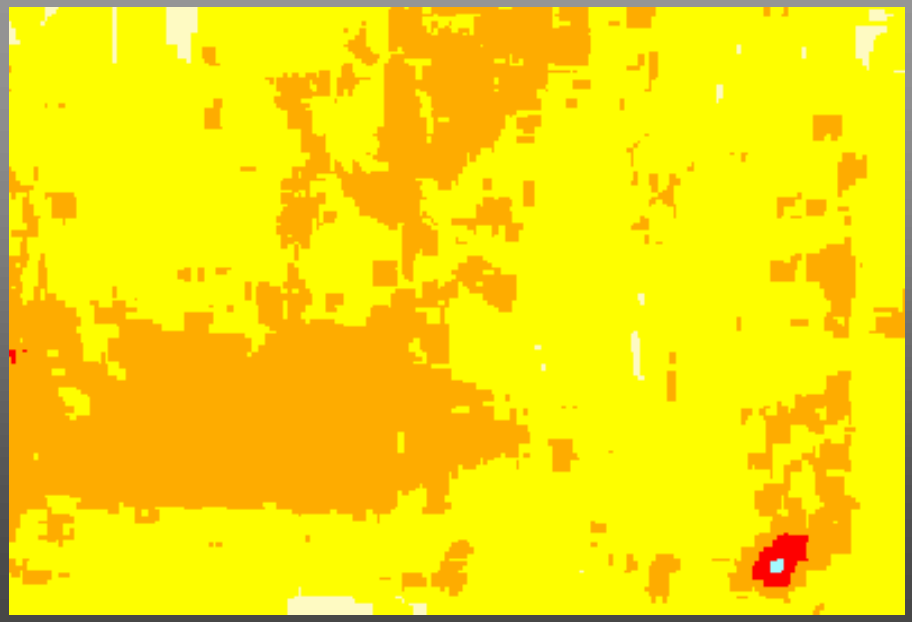
Attribute values

e.g.

1
2
3

or:

s
ls
sl



Raster-Based DEM North Florida

Elevations (m)

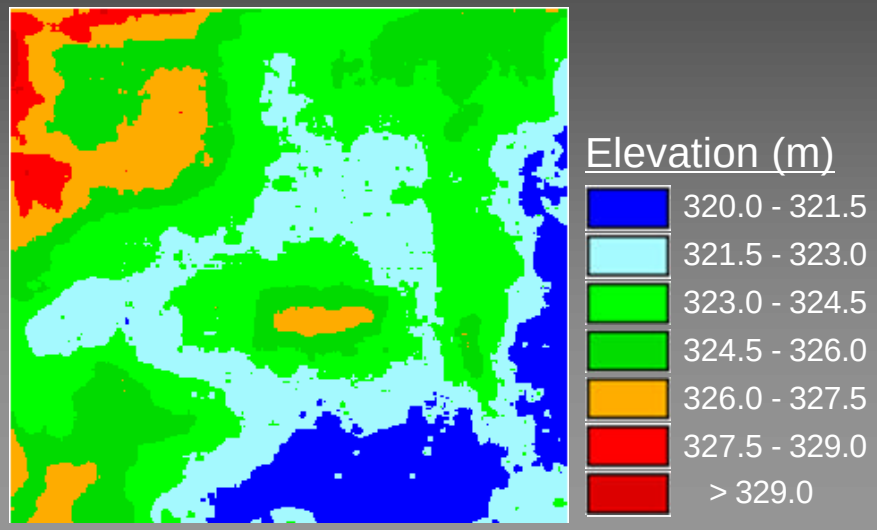
111.0

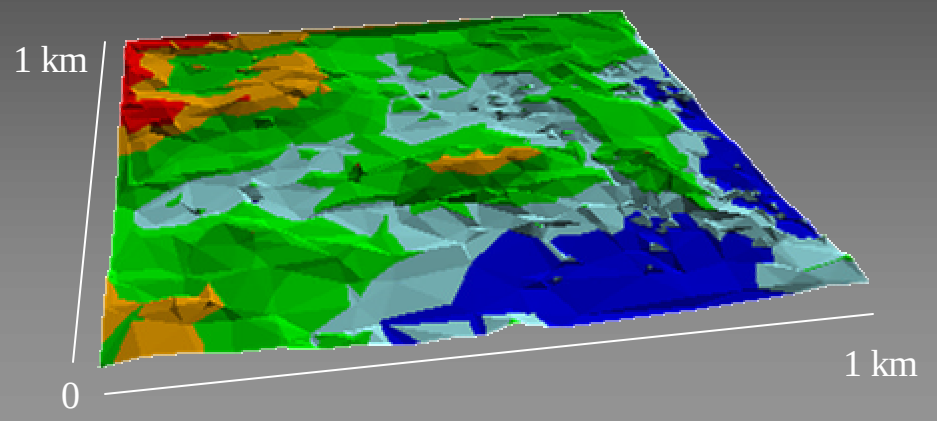
-2.72

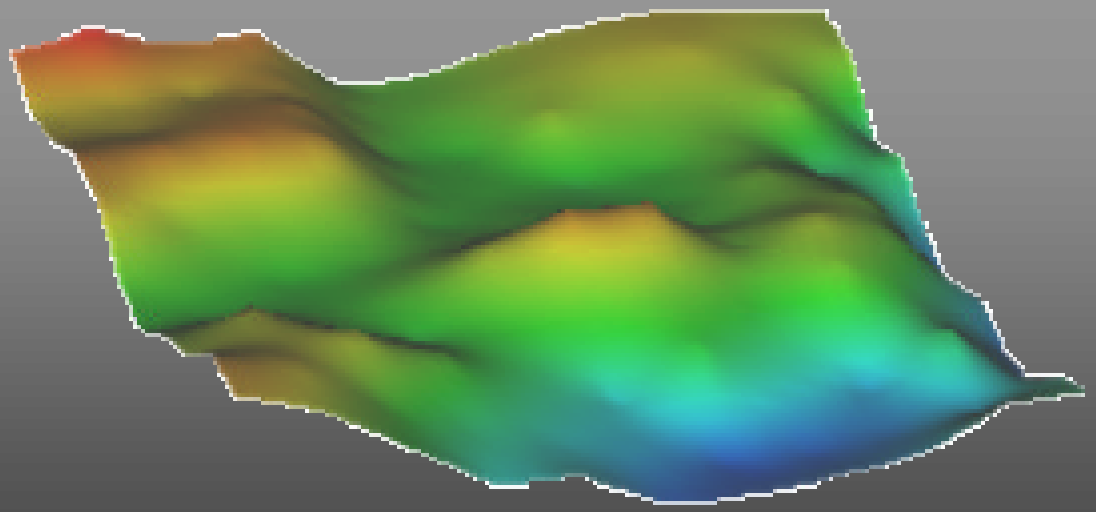
N

30-m pixel resolution

Topographic Models

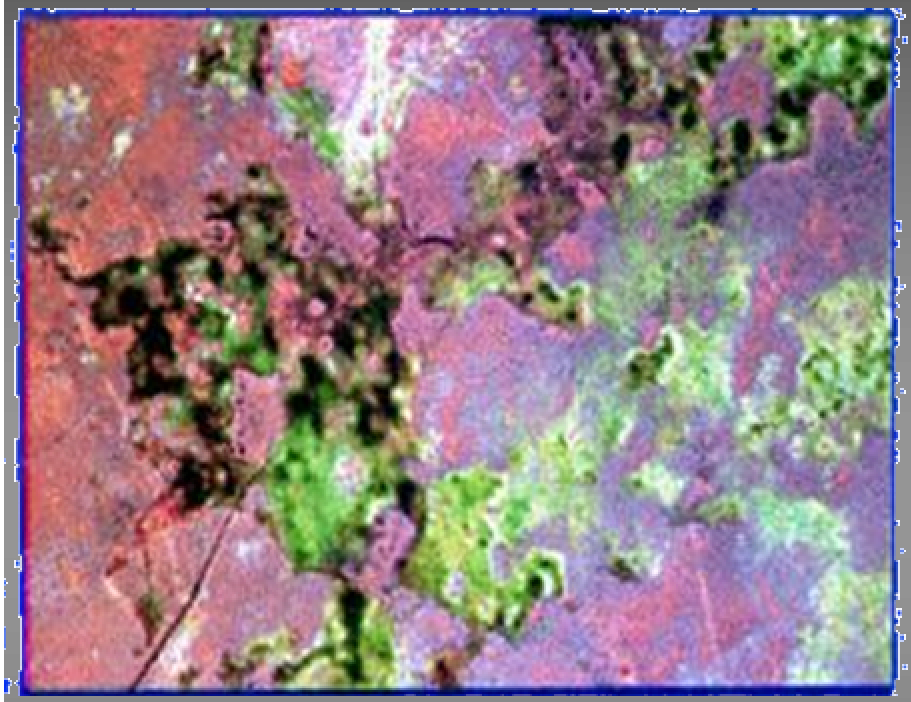


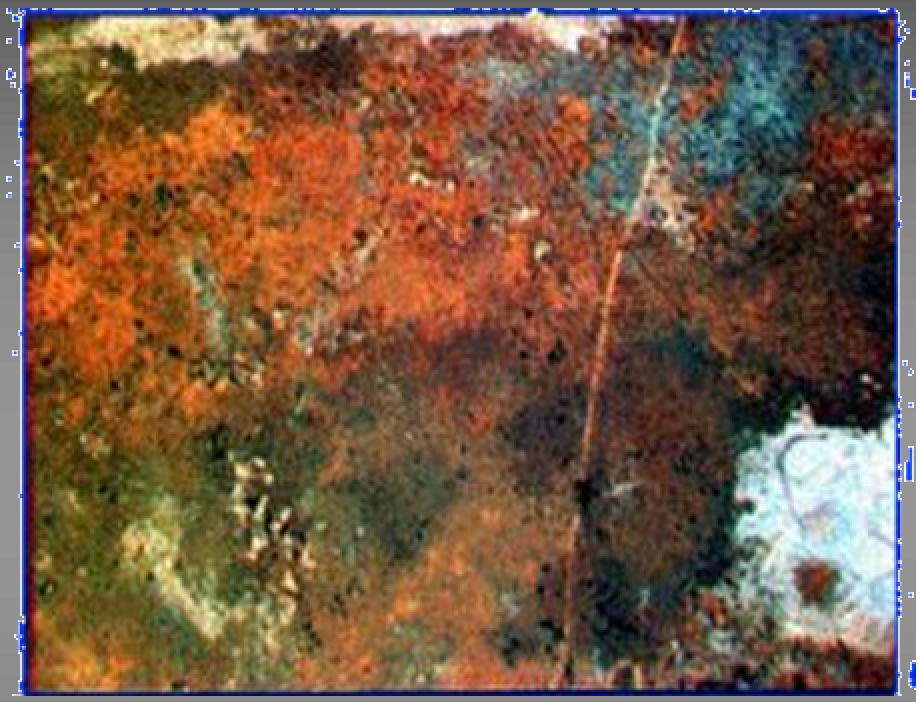




(S. Grunwald, 2001)

Raster-Based Land Cover Model

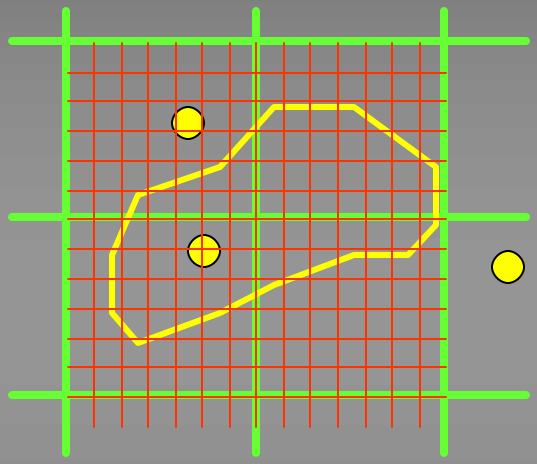




30 m

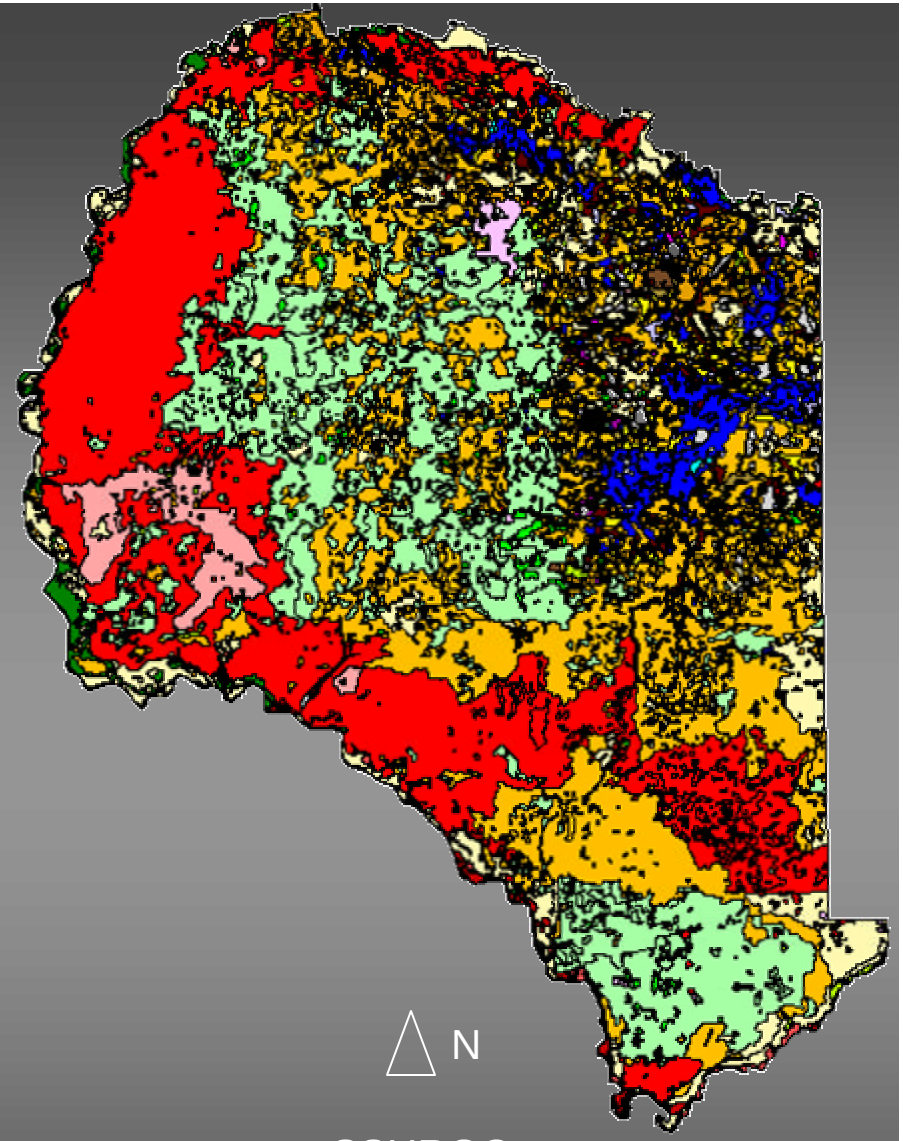
South Florida, Everglades
(Sofia, 2002)

Geographic Soil Model



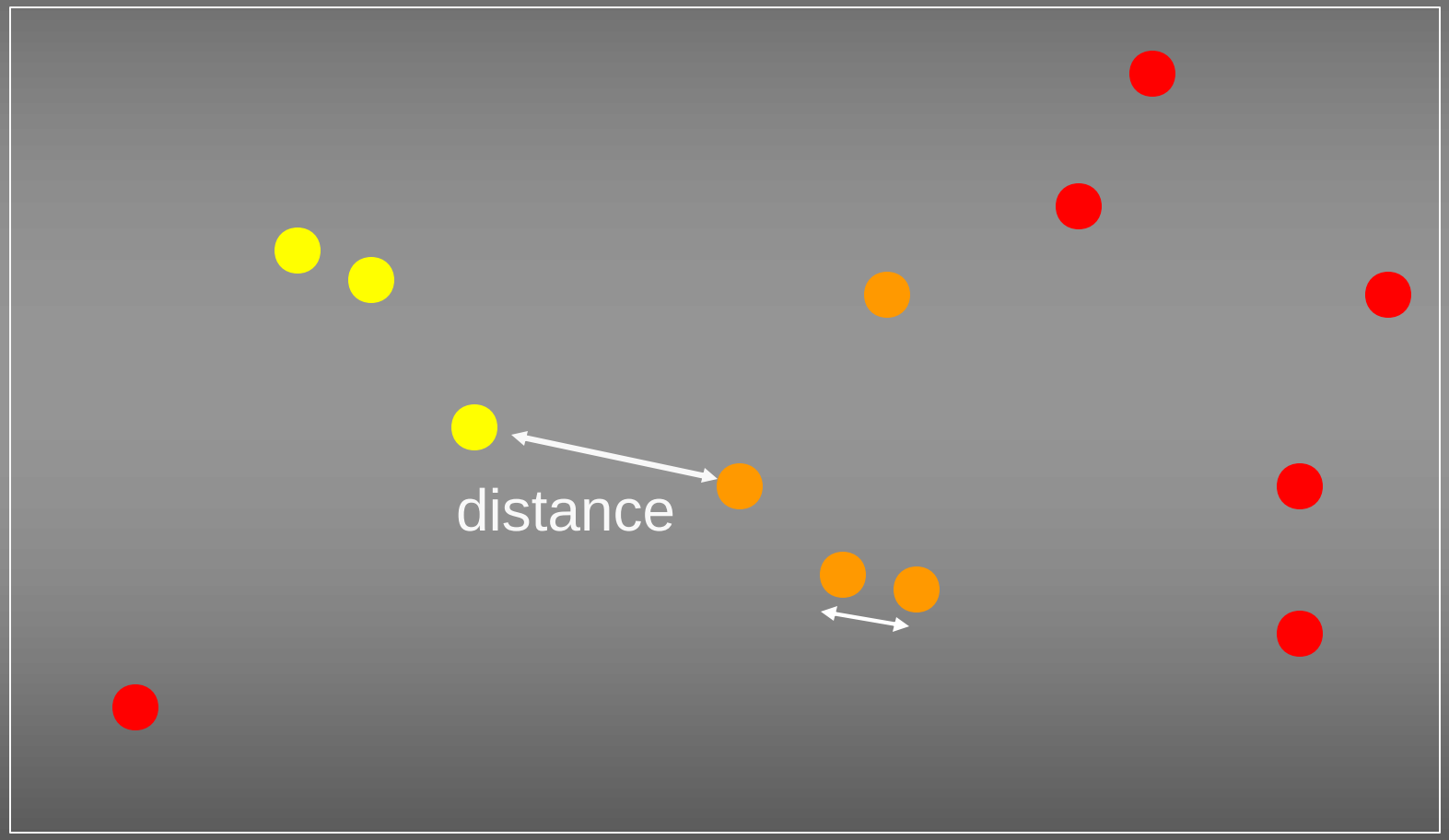
Entity model:
Crisp soil classes

Continuous field model
(raster)



SSURGO
Suwannee County, FL

Geo-Data Modeling



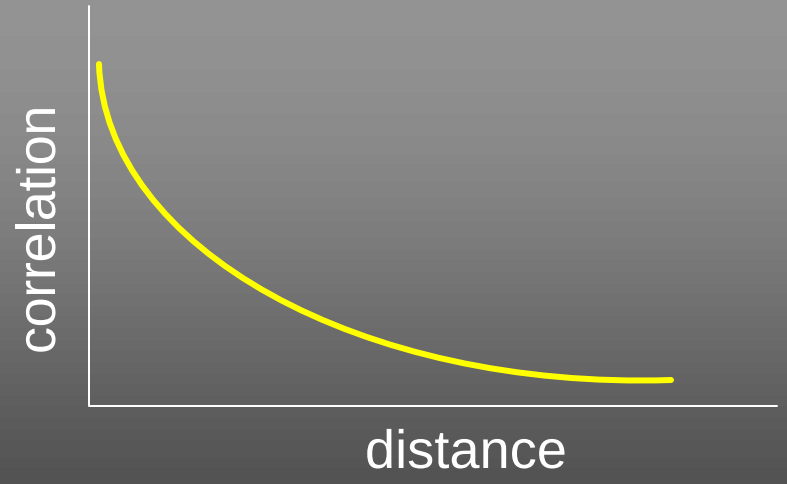
Statistics vs. Geostatistics

Observations are independent

or:

no correlation between observations

Autocorrelation modeled as a function of distance



Geostatistics

$$Z(x)? \; m(x) \; ? \; ?'(x) \; ? \; ?''$$

Z: value of a random variable

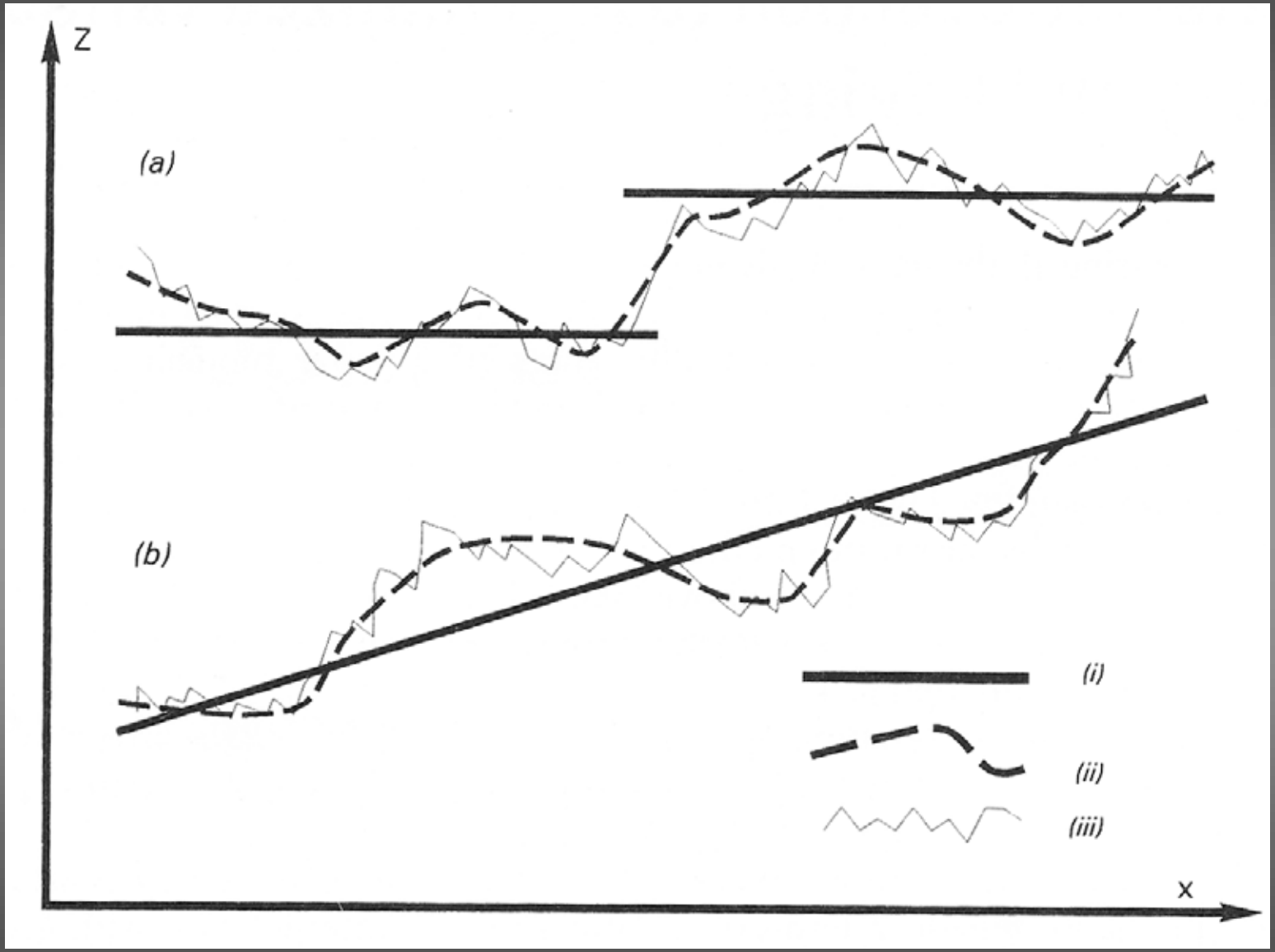
x: location

m(x): deterministic function describing the structural component of Z at x (“deterministic trend”)

?’(x): stochastic, locally varying but spatially dependent residual from m(x) - the regionalized variable (“autocorrelated errors”)

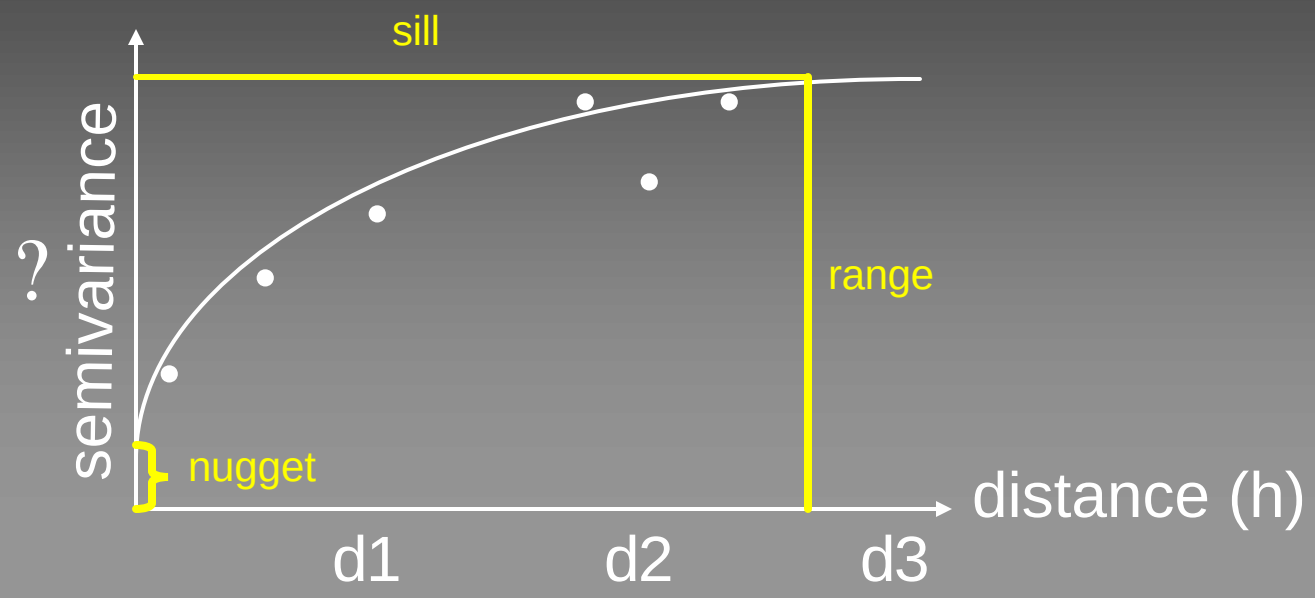
?’’: residual; a spatially independent noise term having zero mean and variance

Visualization of Regionalized Variable Theory



(Burrough and McDonnell. 1998. Principles of GIS, Oxford University Press; page 134)

Experimental Semivariogram



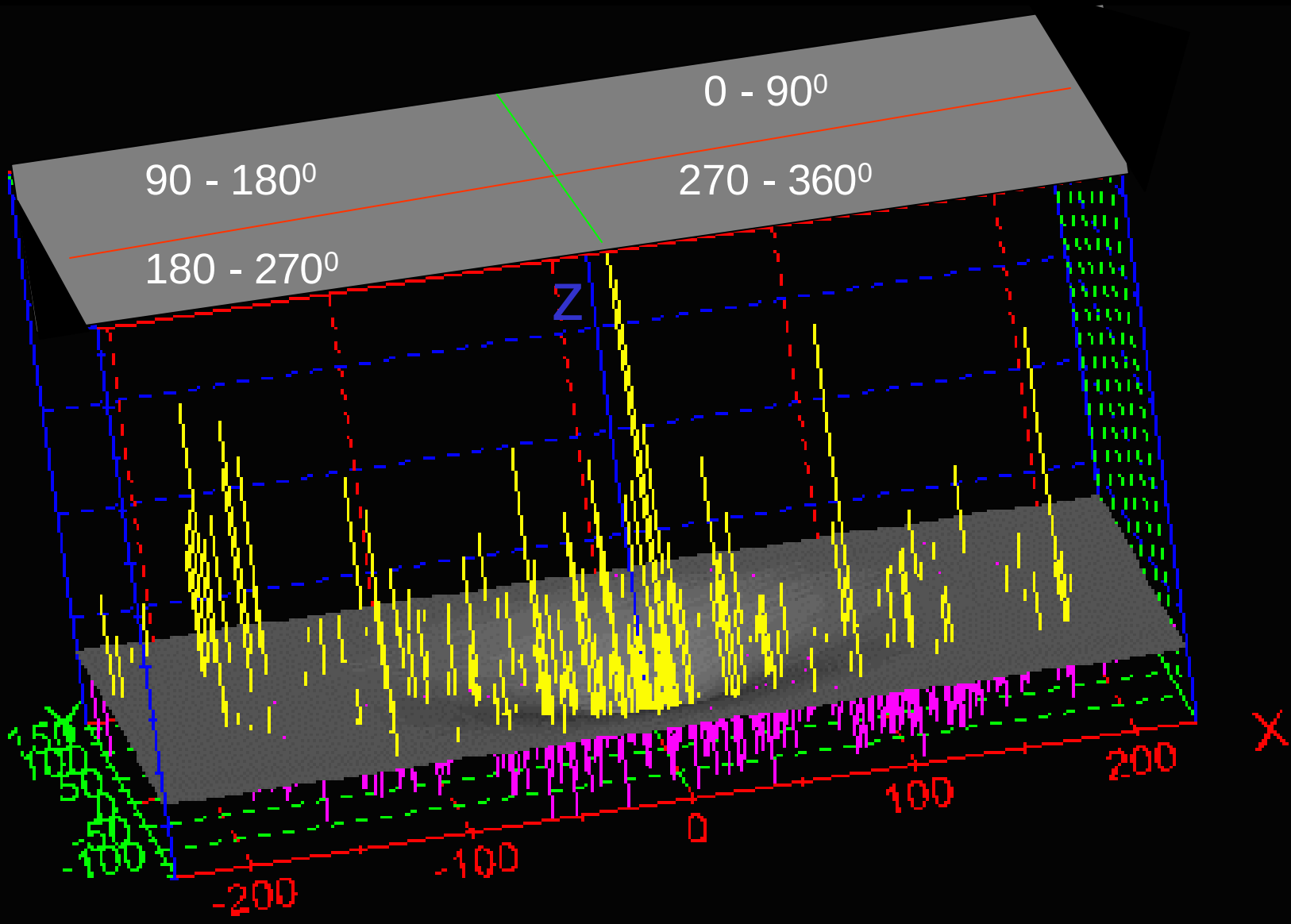
$$?(h) ? \frac{1}{2n} \sum_{i?1}^{n} \{z(x_i) ? z(x_i ? h)\}^2$$

z_i: value of attribute z

x: location

n: number of pairs of sample points of observations

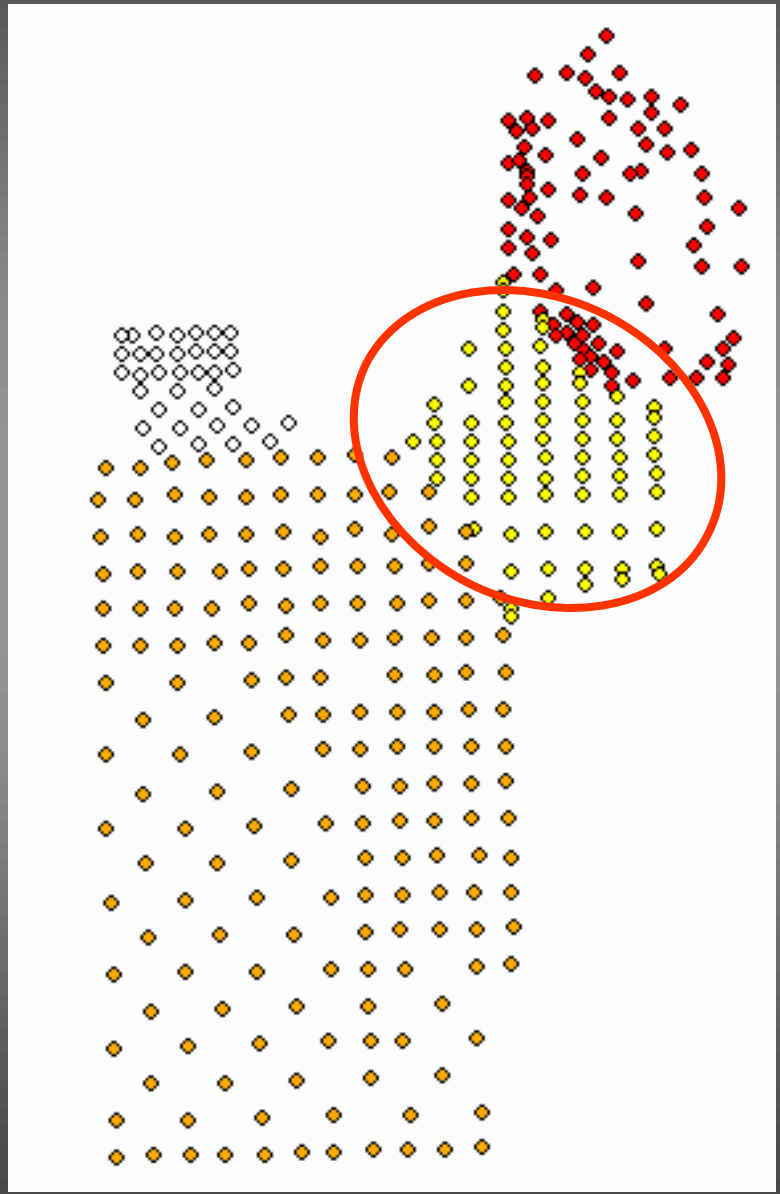
Multi-Dimensional Variogram



(S. Grunwald, 2001)

Water Conservation Areas

Holeyland
(n: 204)



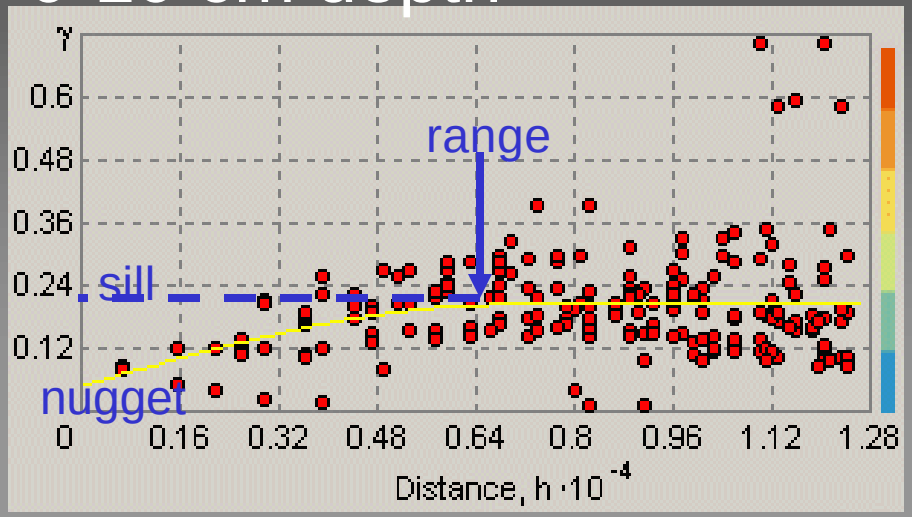
WCA1
(n: 251)

WCA2
(n: 280)

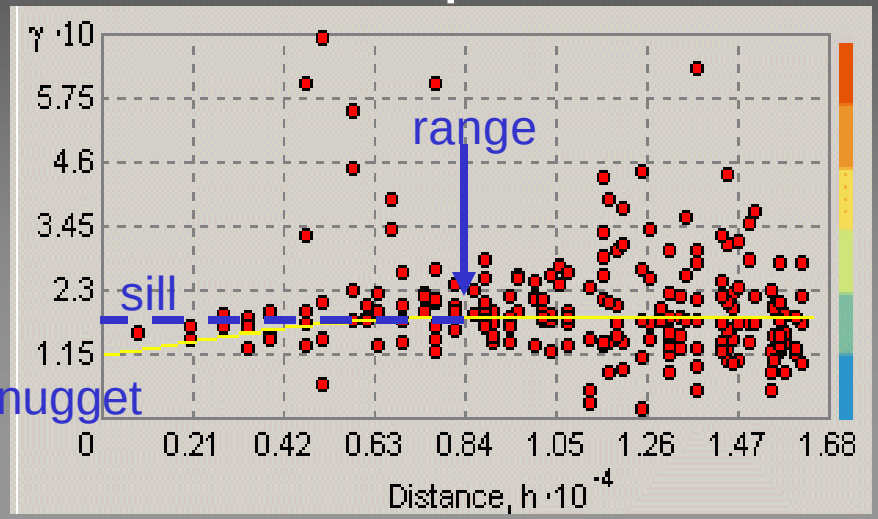
WCA3
(n: 350)

Total Phosphorus

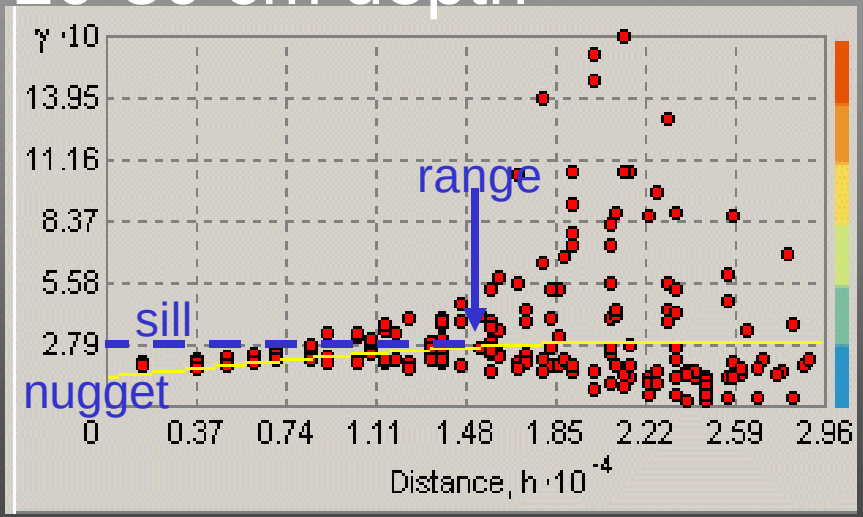
0-10 cm depth



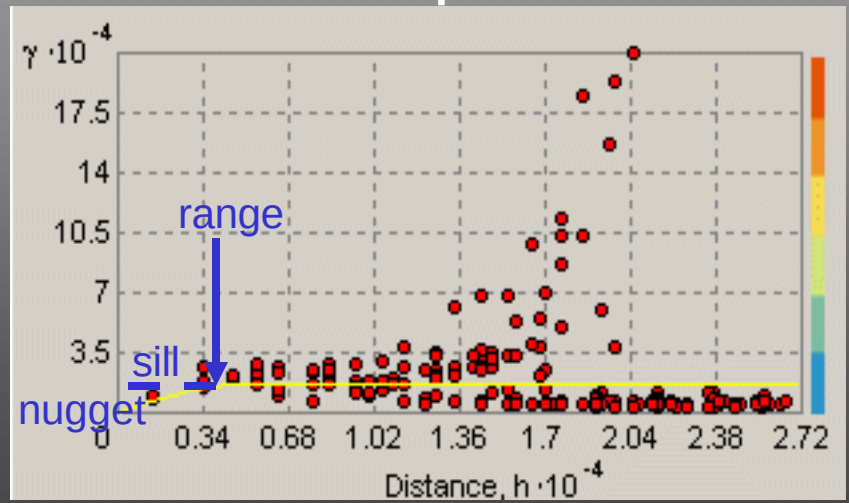
10-20 cm depth



20-30 cm depth

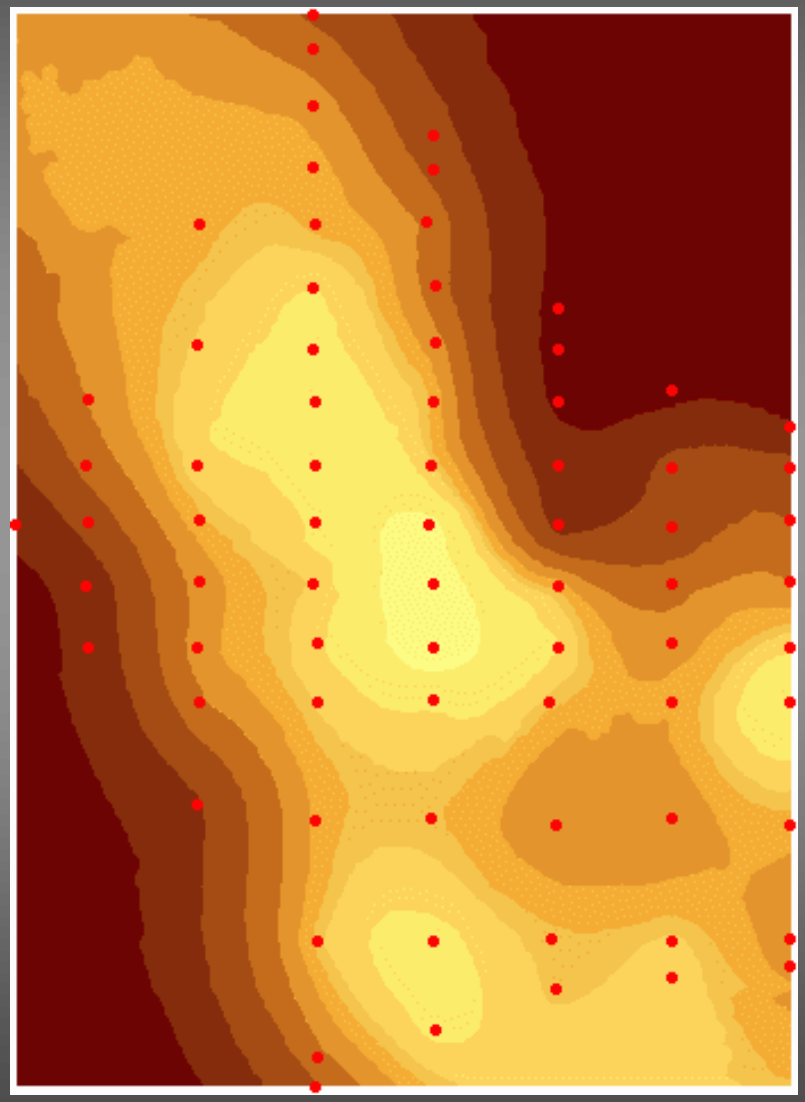


30-40 cm depth



Predictions (Ordinary Kriging)

WCA2 / Total Phosphorus (TP) / Depth 0–10 cm



0 10,000 20,000 m

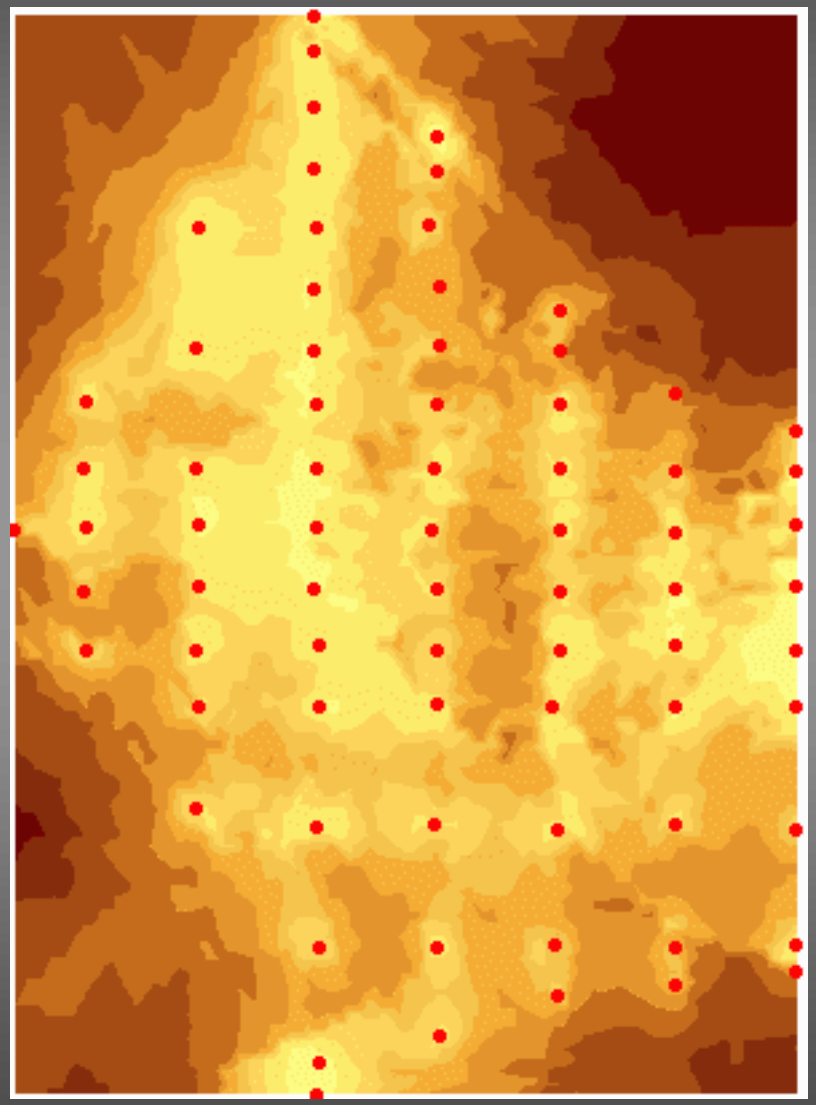
TP (mg/kg)

217.0 –	349.1
349.1 –	424.2
424.2 –	466.9
466.9 –	491.2
491.2 –	533.9
533.9 –	609.0
609.0 –	741.1
741.1 -	973.5
973.5 –	1,381.9
1,381.9 –	2,100.3

N

Prediction Error (Ordinary Kriging)

WCA2 / Total Phosphorus (TP) / Depth 0–10 cm



0 10,000 20,000 m

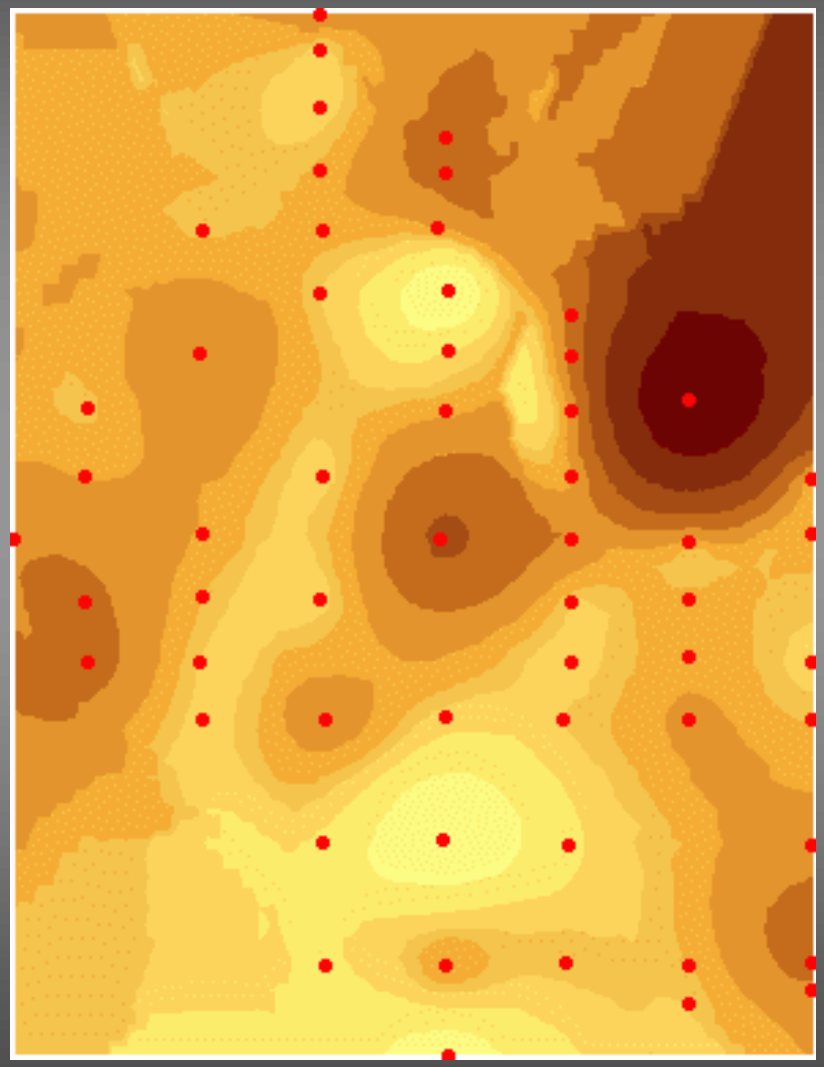
Prediction standard error

- 0.27 – 0.33
- 0.33 – 0.37
- 0.37 – 0.39
- 0.39 – 0.40
- 0.40 – 0.42
- 0.42 – 0.46
- 0.46 – 0.52
- 0.52 – 0.62
- 0.62 – 0.77
- 0.77 – 1.0

N

Predictions (Ordinary Kriging)

WCA2 / Total Phosphorus (TP) / Depth 30–40 cm



TP (mg/kg)

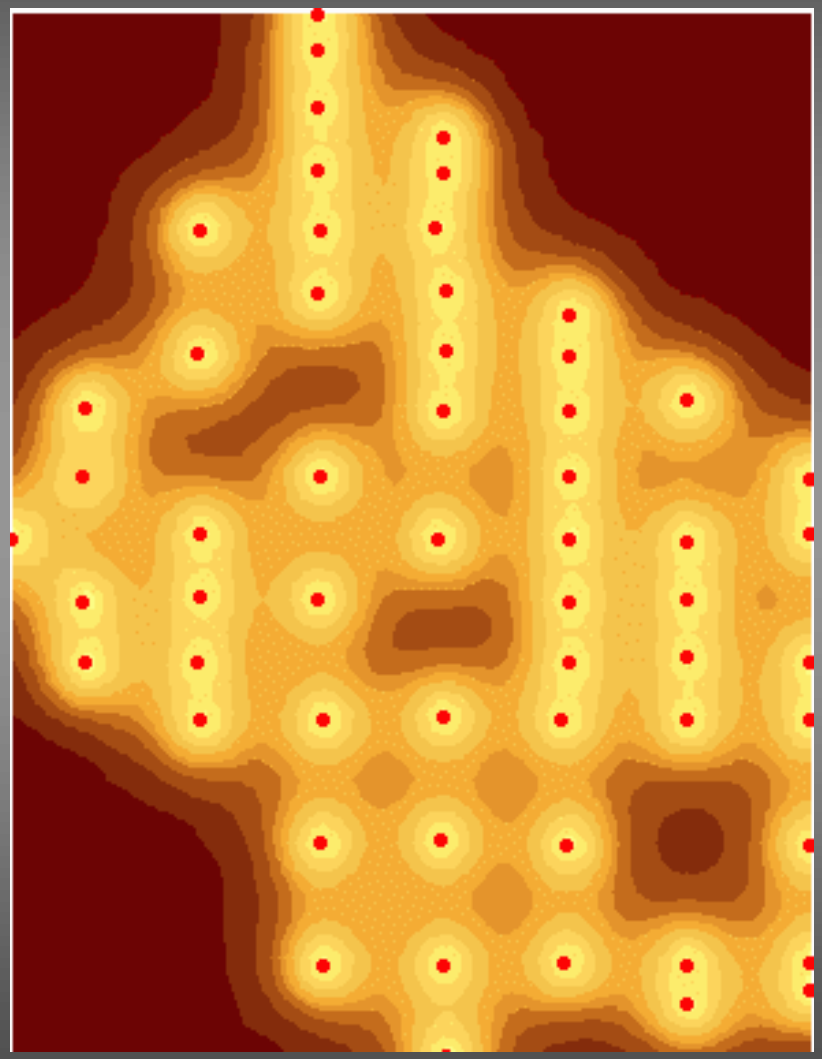
- 0.0 – 68.3
- 68.3 – 105.9
- 105.9 – 126.7
- 126.7 – 138.2
- 138.2 – 159.0
- 159.0 – 196.7
- 196.7 – 264.9
- 264.9 – 388.6
- 388.6 – 612.6
- 612.6 – 1018.5

0 10,000 20,000 m

N

Prediction Error (Ordinary Kriging)

WCA2 / Total Phosphorus (TP) / Depth 30–40 cm



0 10,000 20,000 m

Prediction standard error

- 16.4 – 44.0
- 44.0 – 64.0
- 64.0 – 78.4
- 78.4 – 88.8
- 88.8 – 96.3
- 96.3 – 101.7
- 101.7 – 109.2
- 109.2 – 119.6
- 119.6 – 133.9
- 133.9 – 153.9

Link to 3D models

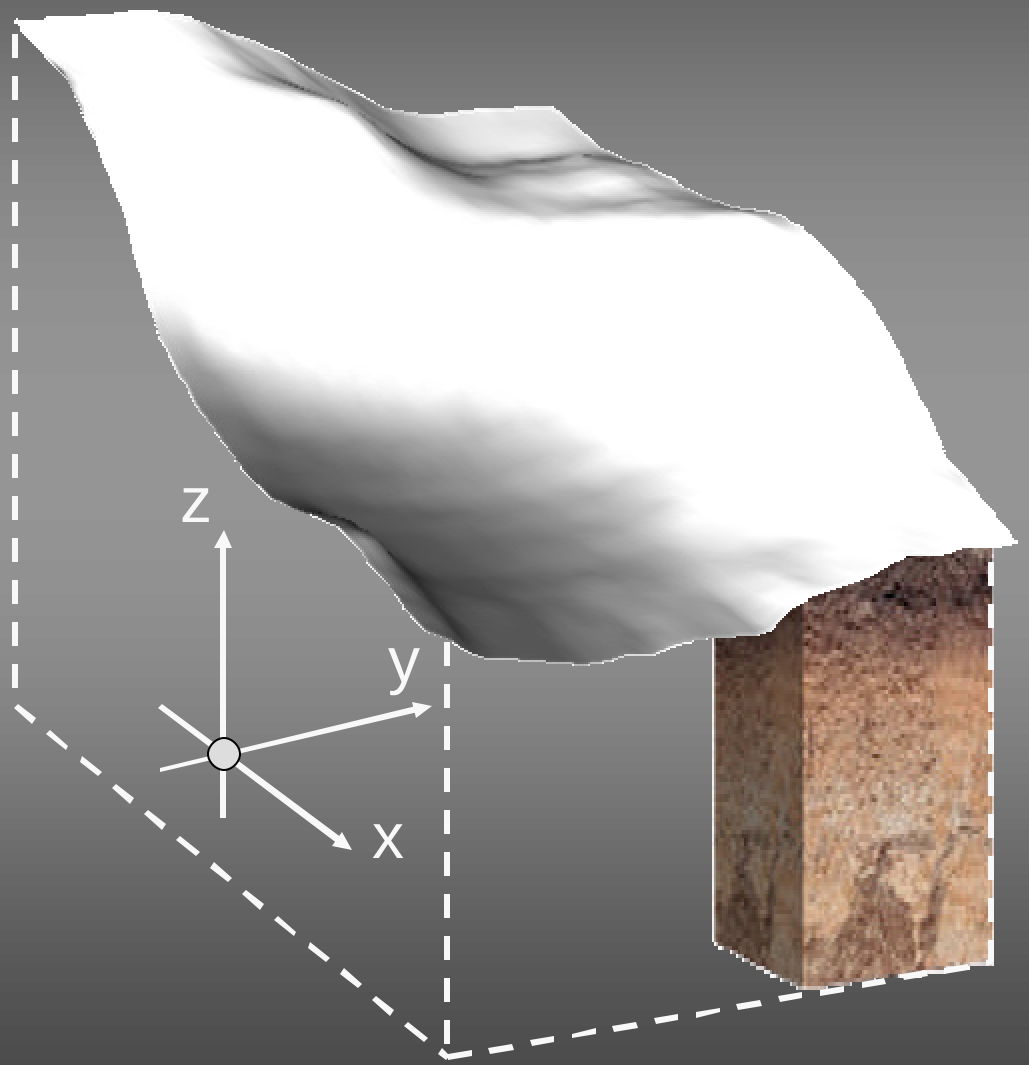
N

Conclusion

Geostatistical methods facilitate to describe:

- Changes of physical, chemical, and biological soil properties continuously across landscapes
- Output GIS format: raster or voxel
- Variograms describe the spatial variability
- Variograms can be used to guide future sampling (targeted, efficient sampling)

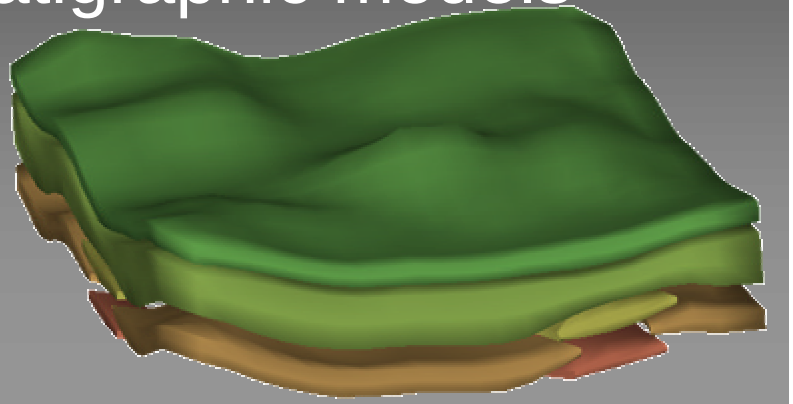
3D Soil-Landscapes



(S. Grunwald, 2001)

3D Soil-Landscape Model Types

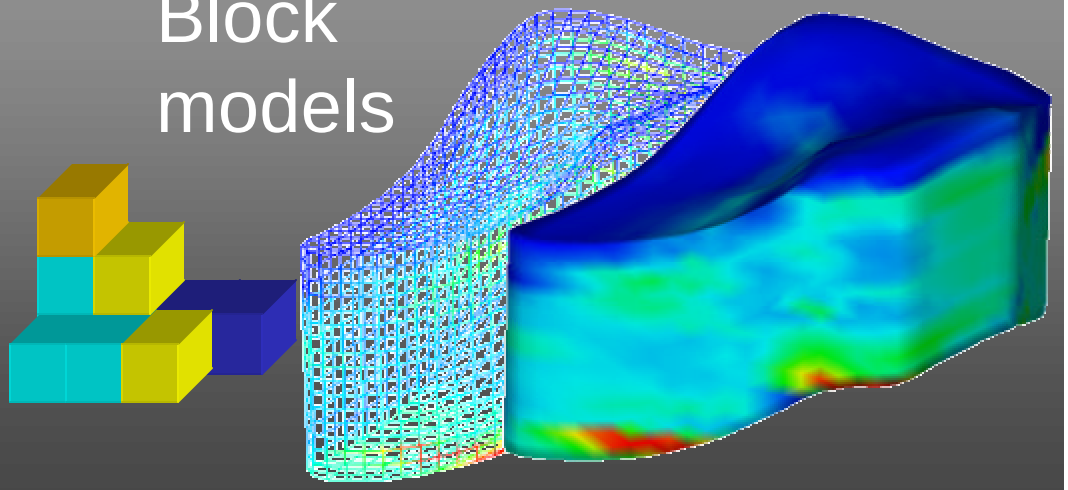
Stratigraphic models



Characteristics:

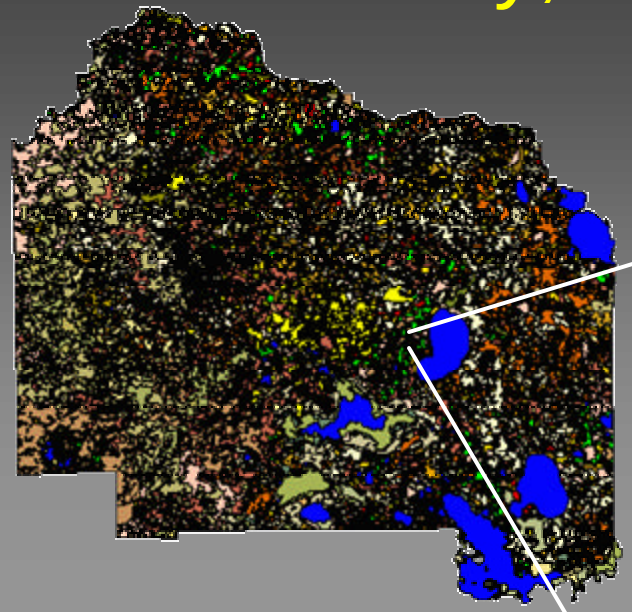
- Continuous
- 3-D

Block models

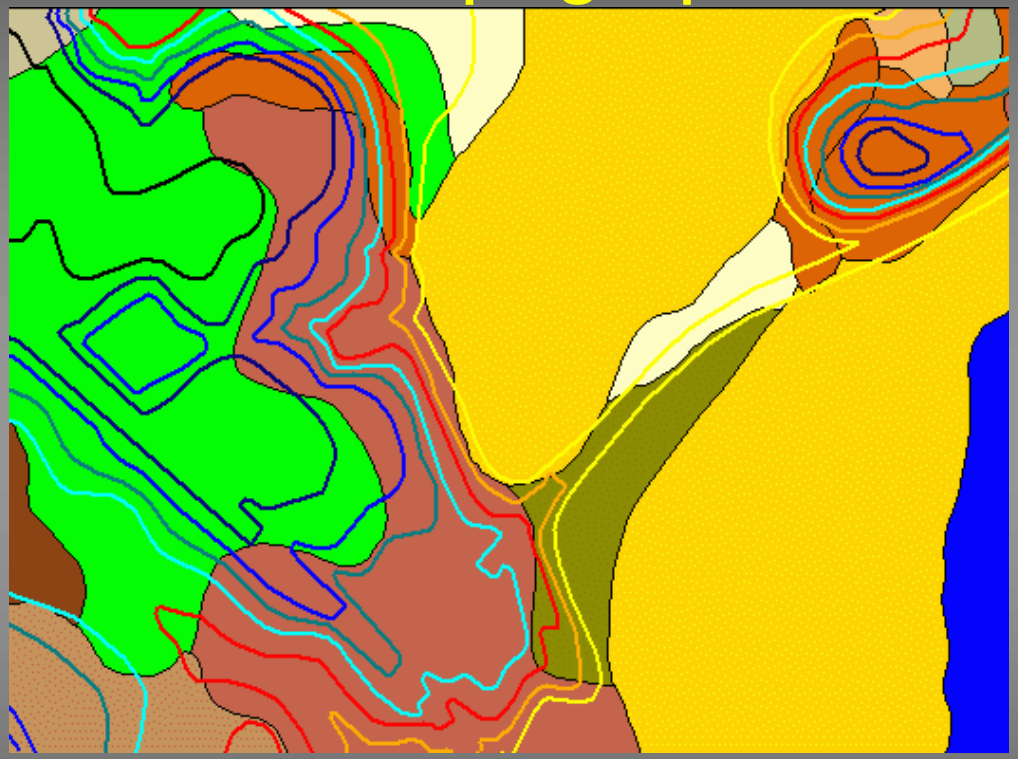


Link to 3D models

Alachua County, Florida



Soil and Topographic Data



Soil Series

- Tavares
- Millhopper
- Monteocha
- Pomona
- Lochloosa
- Plummer
- Water

(Soil Survey Geographic Database, NRCS)

Elevation (m)

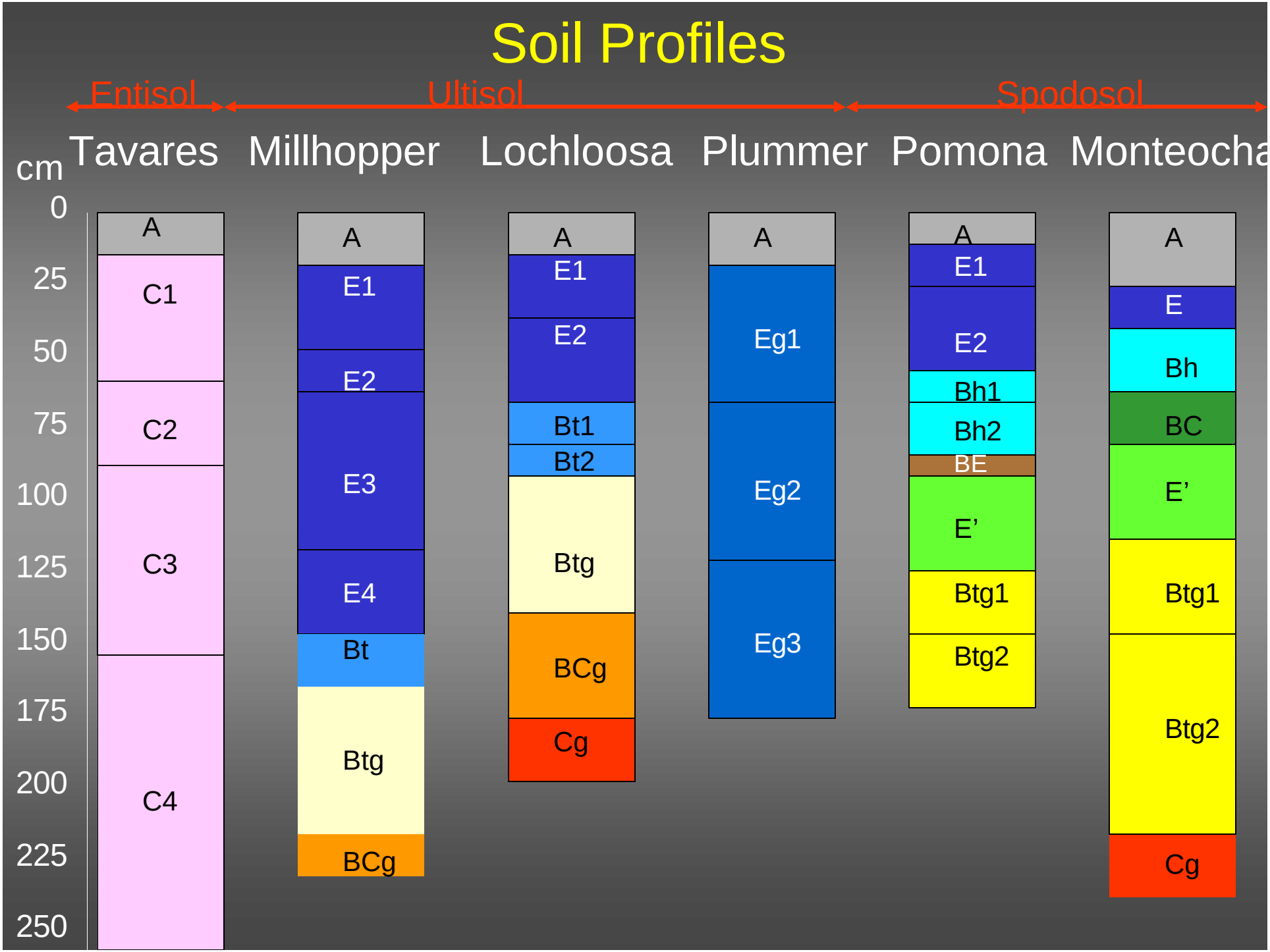
- 70
- 75
- 80
- 85
- 90
- 95
- 100
- 105

(5-foot contour lines 1:24,000, USGS & WMD, 1997)

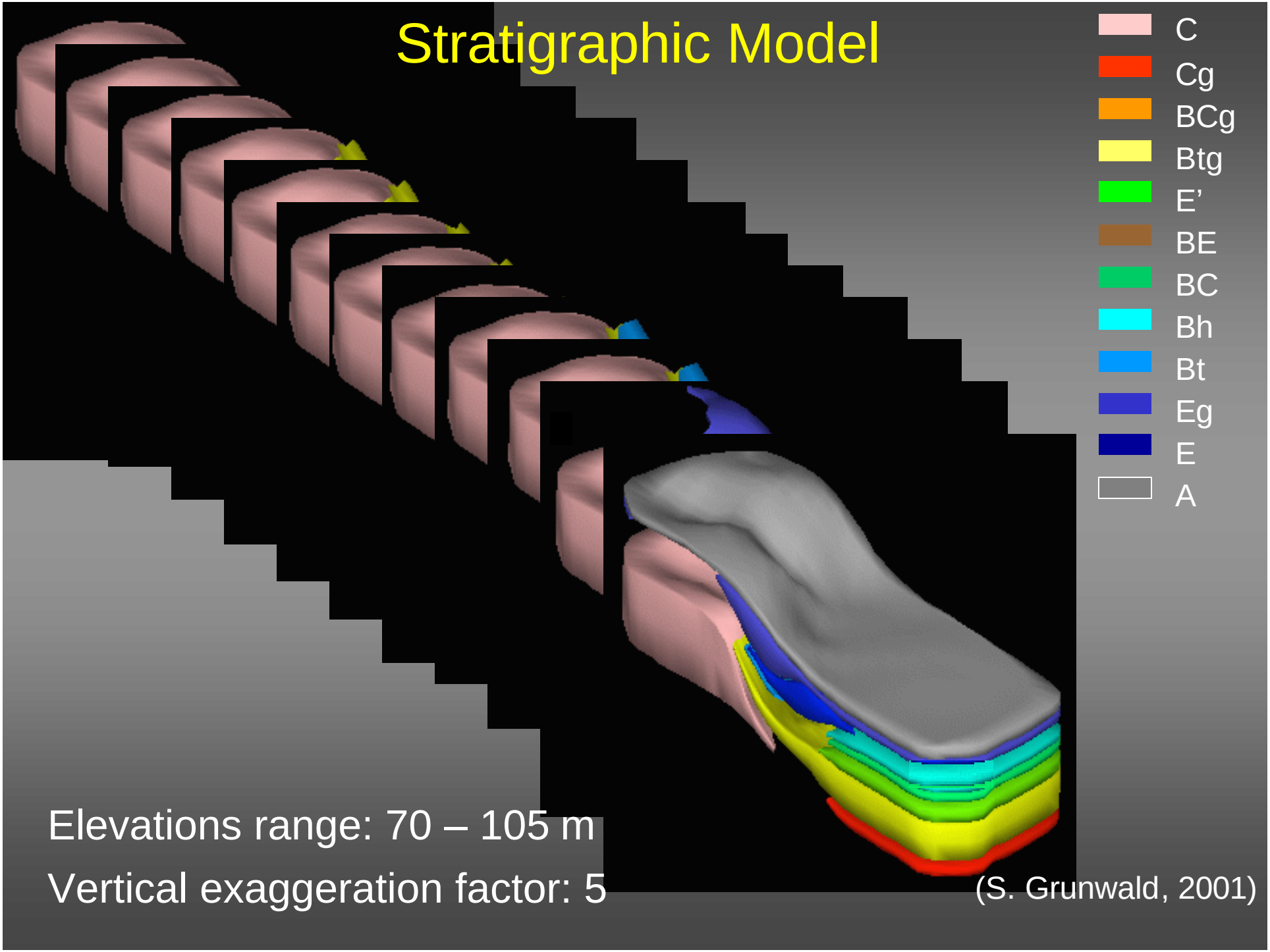
N

0 500 1000 m

Soil Profiles



Stratigraphic Model



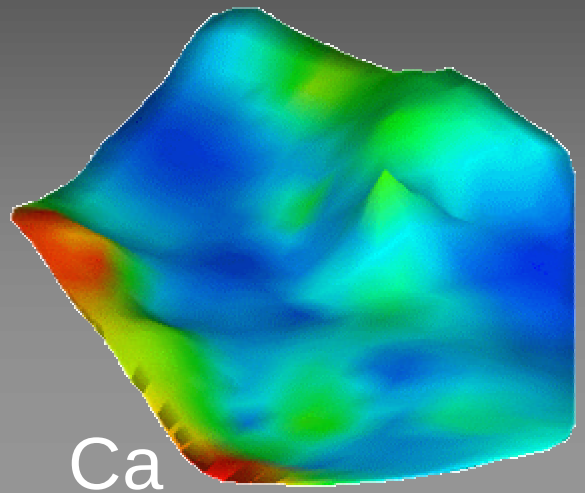
Elevations range: 70 – 105 m

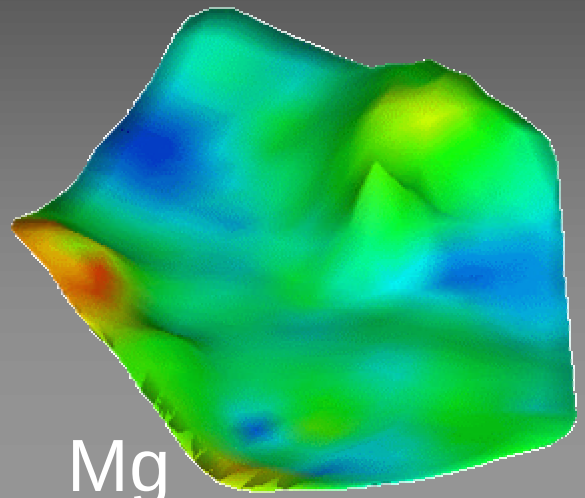
Vertical exaggeration factor: 5

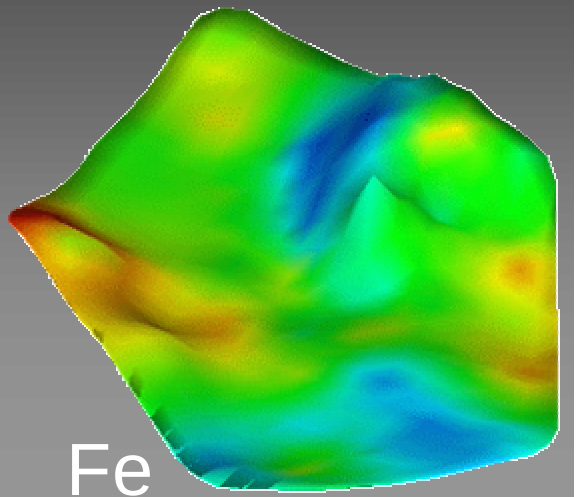
(S. Grunwald, 2001)

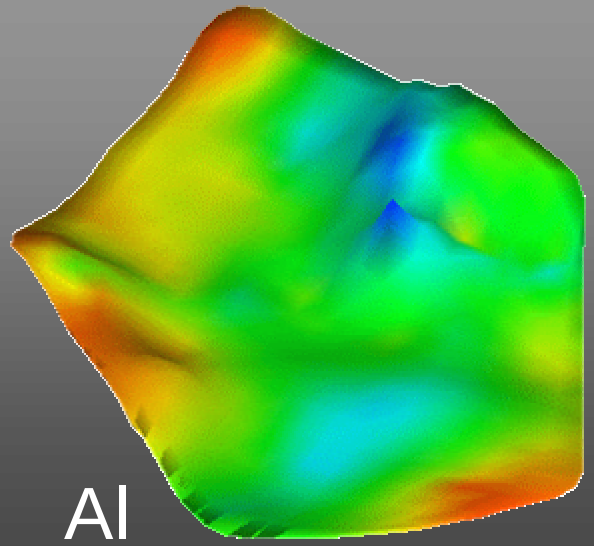
WCA2; 0-10cm depth
TP is represented as height
Parameters are represented by color

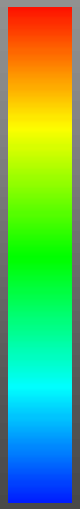
3D Scientific Visualization









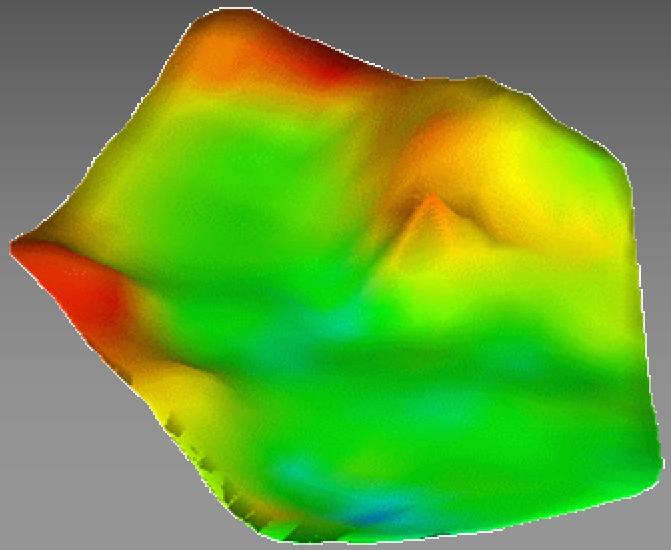


Ca	Mg	Fe	Al (mg kg^{-1})
200,000	8,000	1,750	1,500
150,000	6,000	1,500	1,250
100,000	4,000	1,250	1,000
50,000	2,000	1,000	750
18,850		750	500
		500	250
		225	

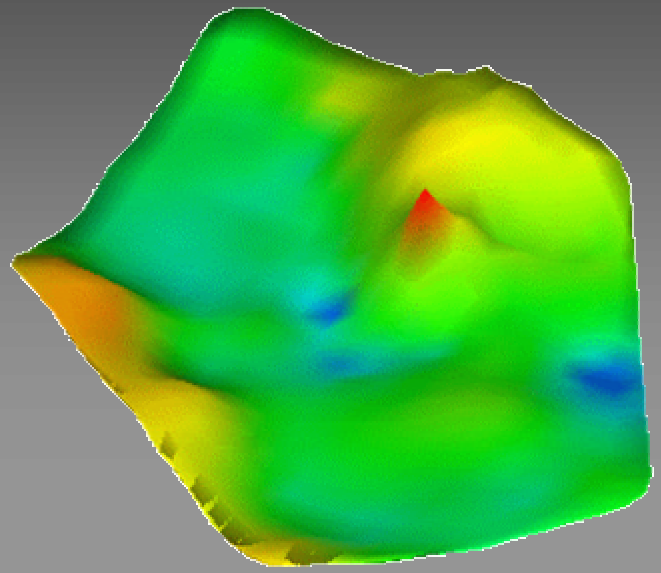
(S. Grunwald, 2001)

WCA2; 0-10cm depth
TP is represented as height
Parameters are represented by color

3D Scientific Visualization



Sodium bicarbonate extractable P (“bioavailable P”)



Hydrochloric acid extractable P (“stable P”)

NAHCO3	HCLP1 (mg kg^{-1})
25	1,250
20	1,000
15	750
10	500
5	250
0	0

(S. Grunwald, 2001)

Conclusions

3D GIT, geostatistics, and SciVis improves our understanding of the spatial distribution and variability of soil-landscape properties

Home page: http://grunwald.ifas.ufl.edu