# GEOM4008
# Advanced topics in GIS

## Introduction
## September 10, 2012

# Who am I?

- teaching
- research
  - environmental modelling & GIS
  - spatial pattern and environmental processes
  - primary productivity - predicting, patterns
  - land cover - data quality, comparison
  - decision support, collaborative research

# Why model?

- remove unwanted or impractical complexity
- allow otherwise impossible experiments
- test theories - build knowledge

# Spatial Models / Models across Space

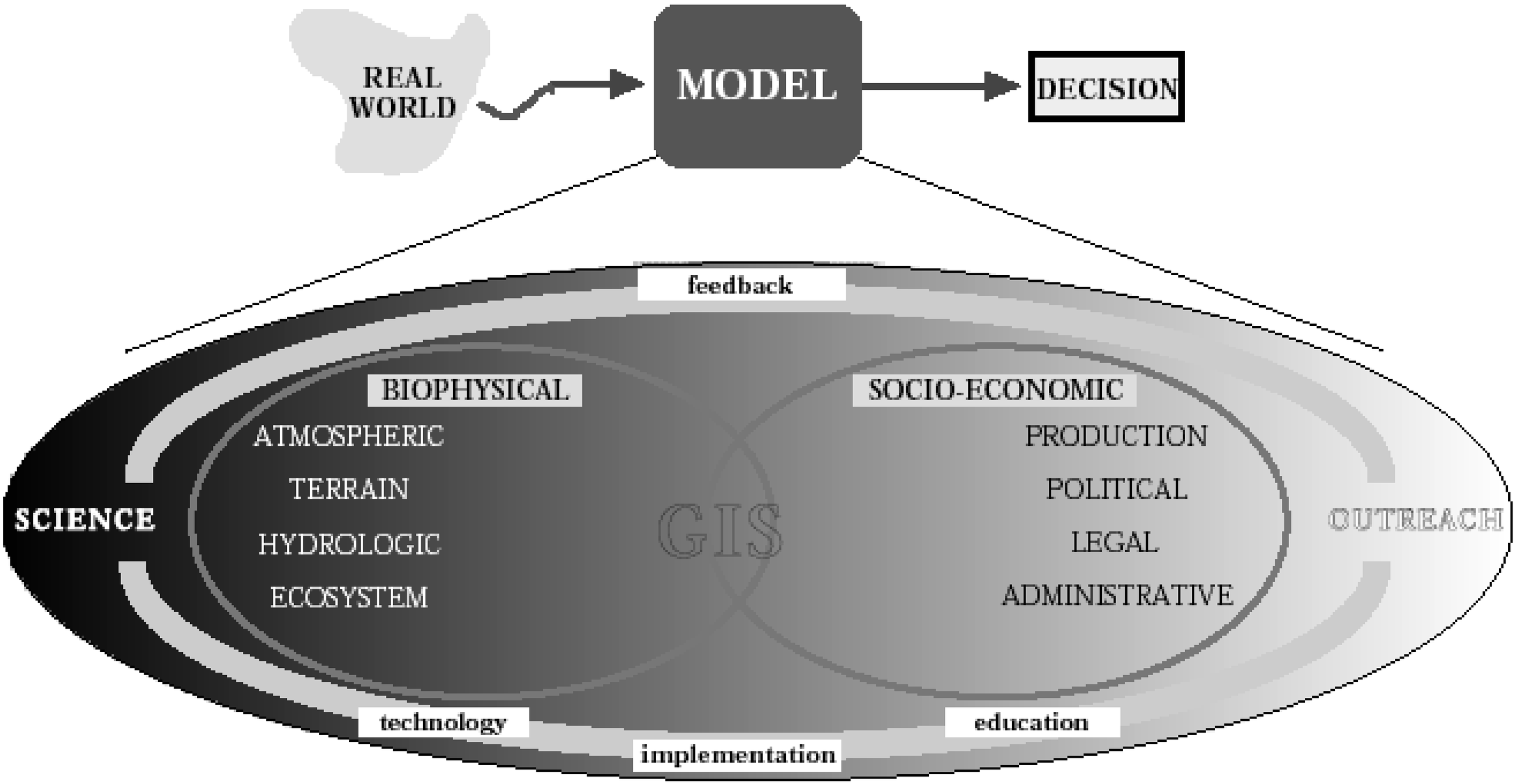
- models: spatially implicit / explicit?
- processes: spatial or not? neighbourhood?
- how do we deal with spatially distributed input?
- how do we evaluate spatial predictions?

# GIS & Env. Modelling

- most environmental problems have clear spatial dimensions
- environmental modelling handle this using a range of 1-, 2-, and 3-D approaches
- GIS clearly valuable tool for managing work with spatial data, but:
  - GIS - basic concept is location
  - env models - basic concept is state

# What's the problem with space?!

- mostly?  scale / scaling
- N.B. - need to be careful how talk about scale - terminology is NOT consistent
- much/most of our knowledge comes from studies at relatively fine scales, and we want to spread that to coarser scales*


REAL WORLD
MODEL
DECISION
feedback
BIOPHYSICAL
ATMOSPHERIC
TERRAIN
HYDROLOGIC
ECOSYSTEM
SOCIO-ECONOMIC
PRODUCTION
POLITICAL
LEGAL
ADMINISTRATIVE
SCIENCE
GIS
OUTREACH
technology
education
implementation

# Biogeochemical cycling

- biogeochemistry:
  biology, chemistry,
  geology, (geography)
- cycles

Sun

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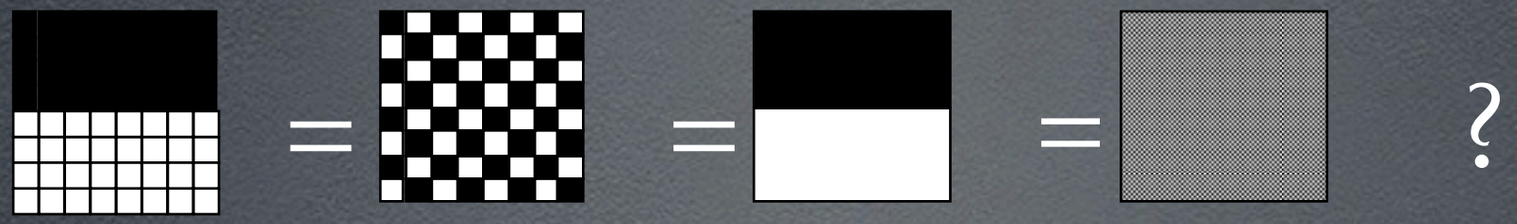


(When, Where and How Much)

# Does Pattern Matter ?

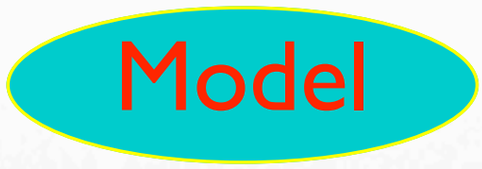
Spatio-temporal modelling strategies to predict grassland productivity dynamics, Grasslands National Park, Saskatchewan

Scott W. Mitchell

Ph.D. Defence

# Uncertainty

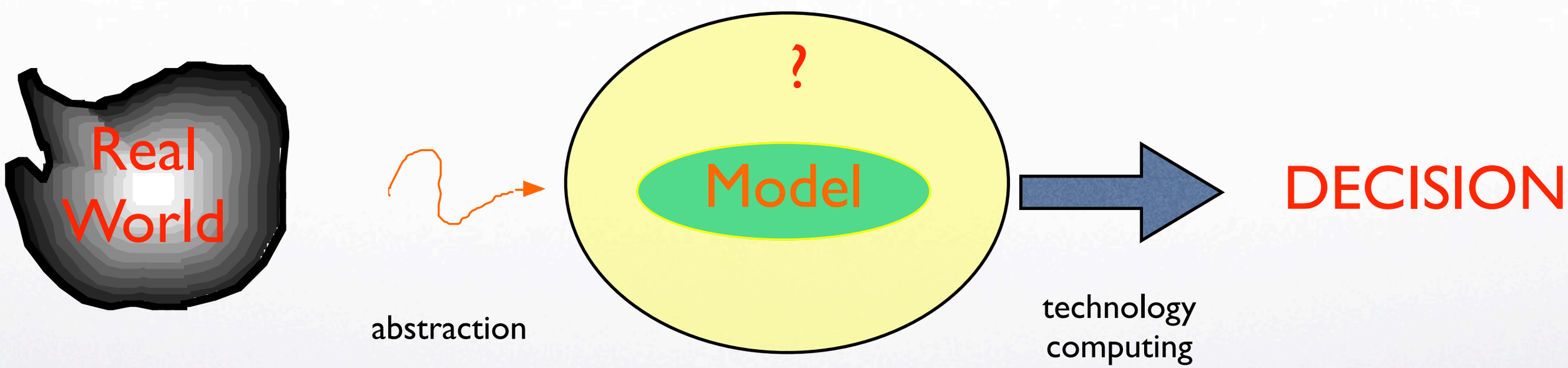

abstraction



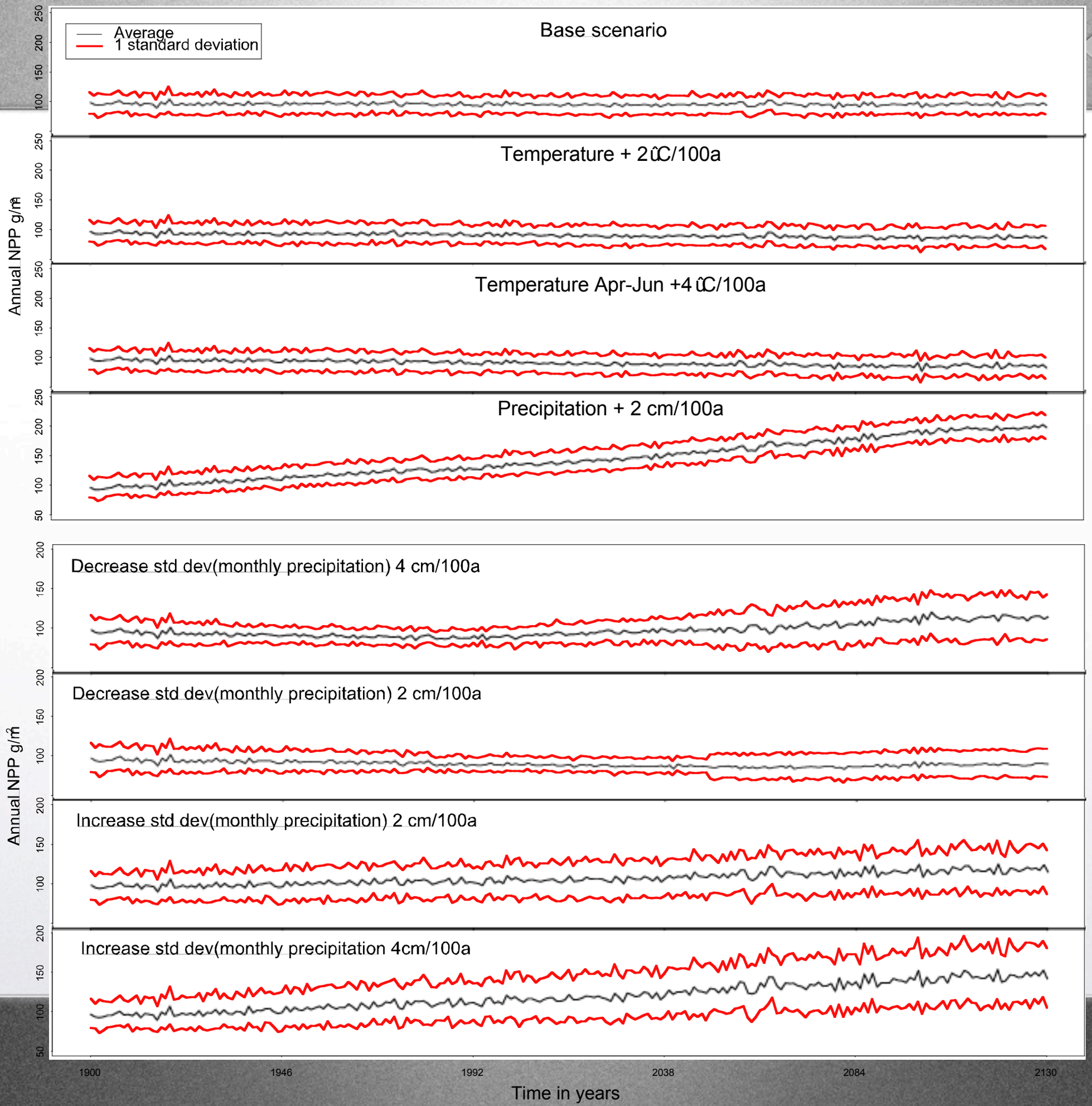

technology
computing

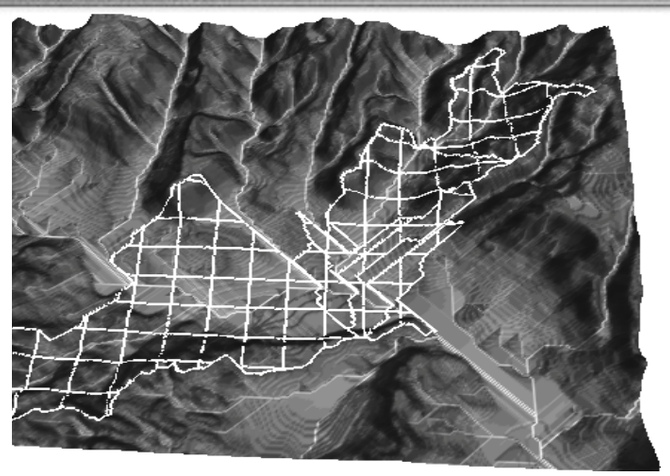
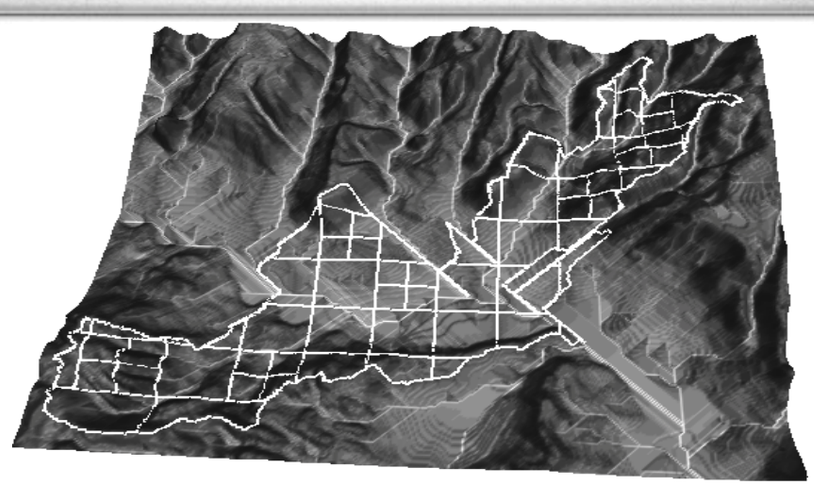
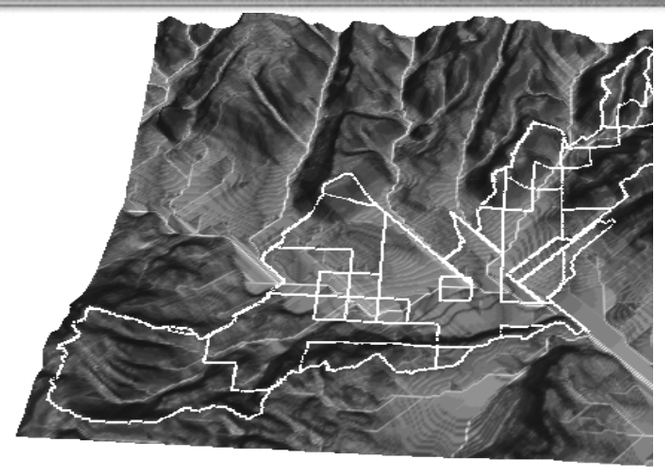
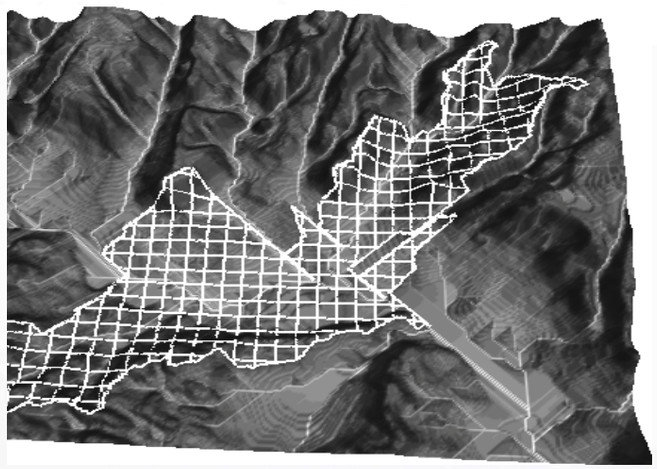
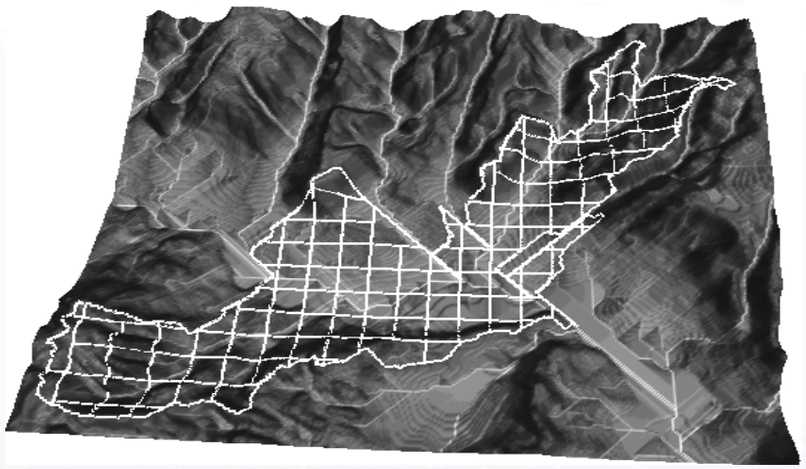
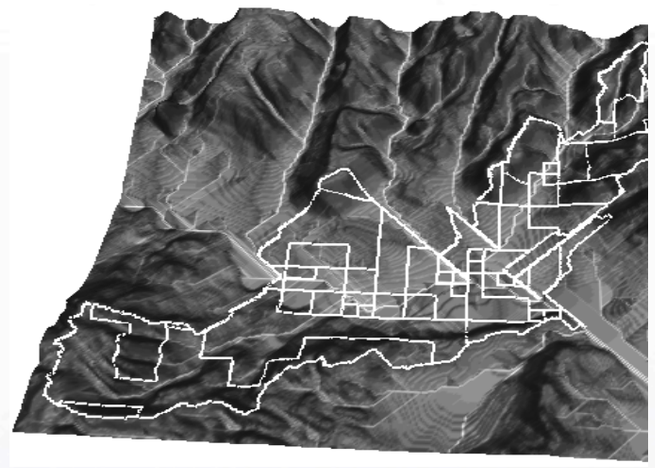
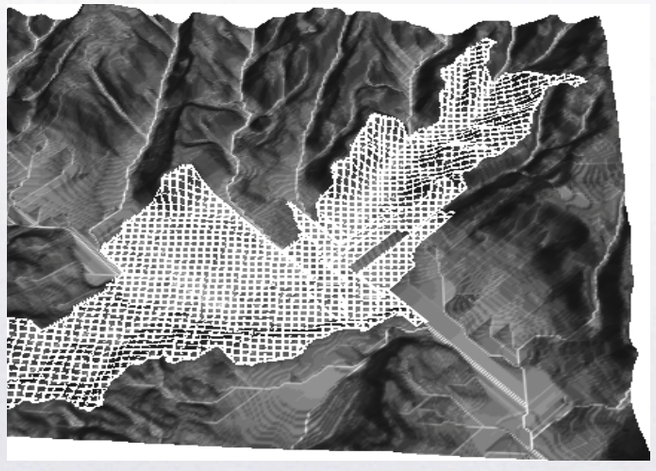
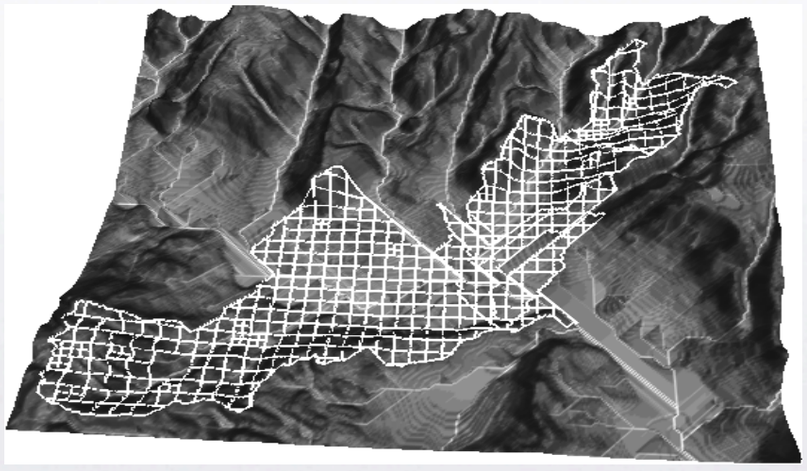
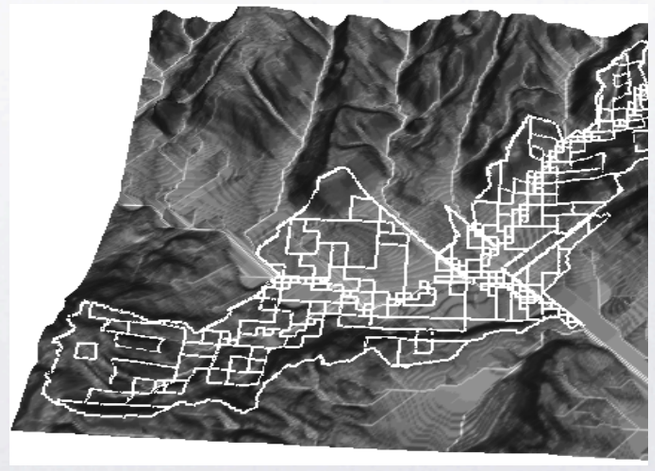
DECISION

# Uncertainty

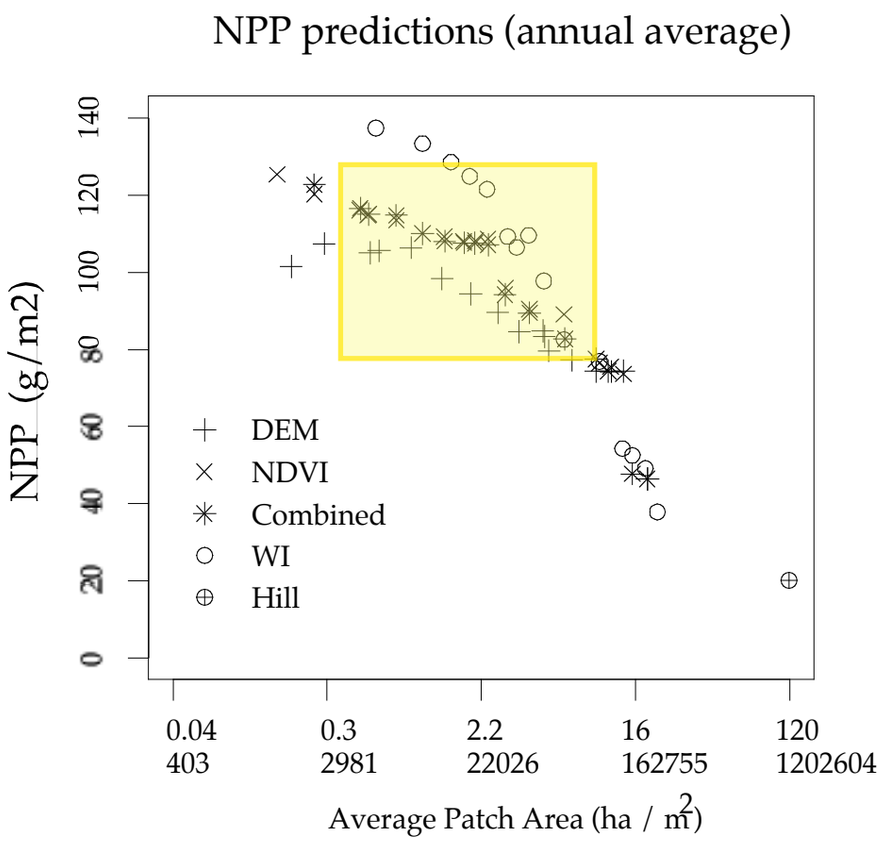


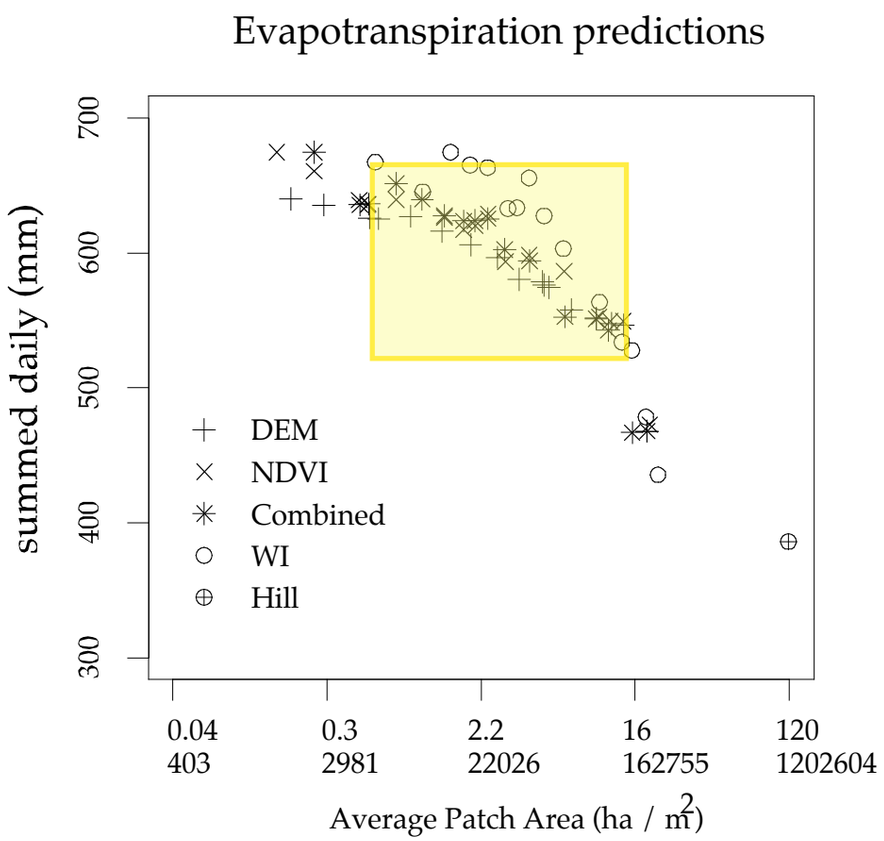
# Grasslands National Park, SK

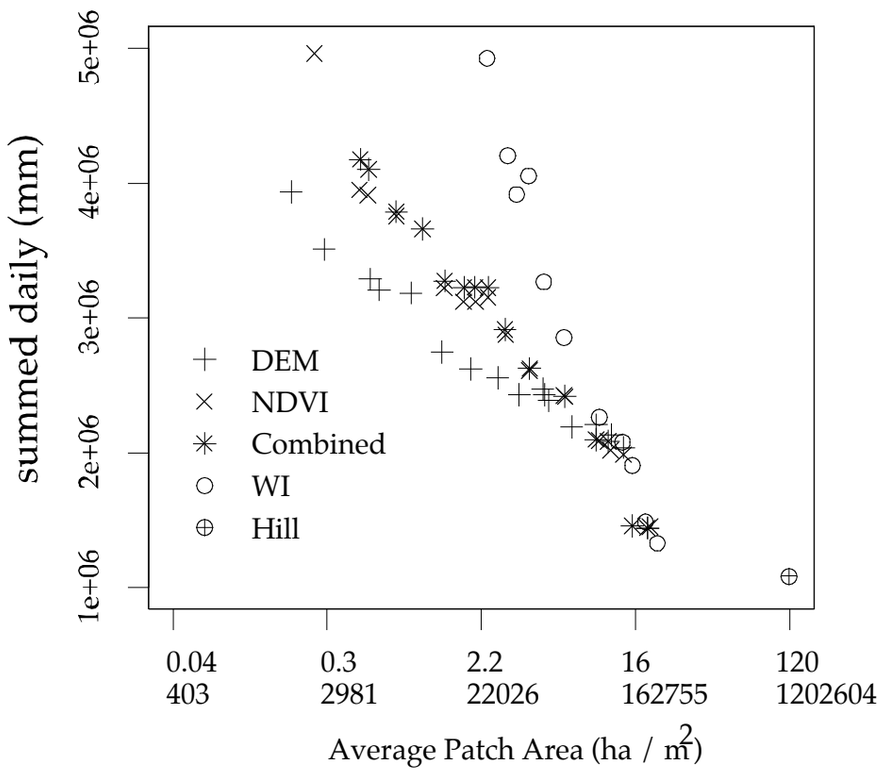

Average
1 standard deviation
Base scenario
Temperature + 2 °C/100a
Temperature Apr-Jun +4 °C/100a
Precipitation + 2 cm/100a
Decrease std dev(monthly precipitation) 4 cm/100a
Decrease std dev(monthly precipitation) 2 cm/100a
Increase std dev(monthly precipitation) 2 cm/100a
Increase std dev(monthly precipitation 4cm/100a
Annual NPP g/m²
50
100
150
200
250
1900
1946
1992
2038
2084
2130
Time in years

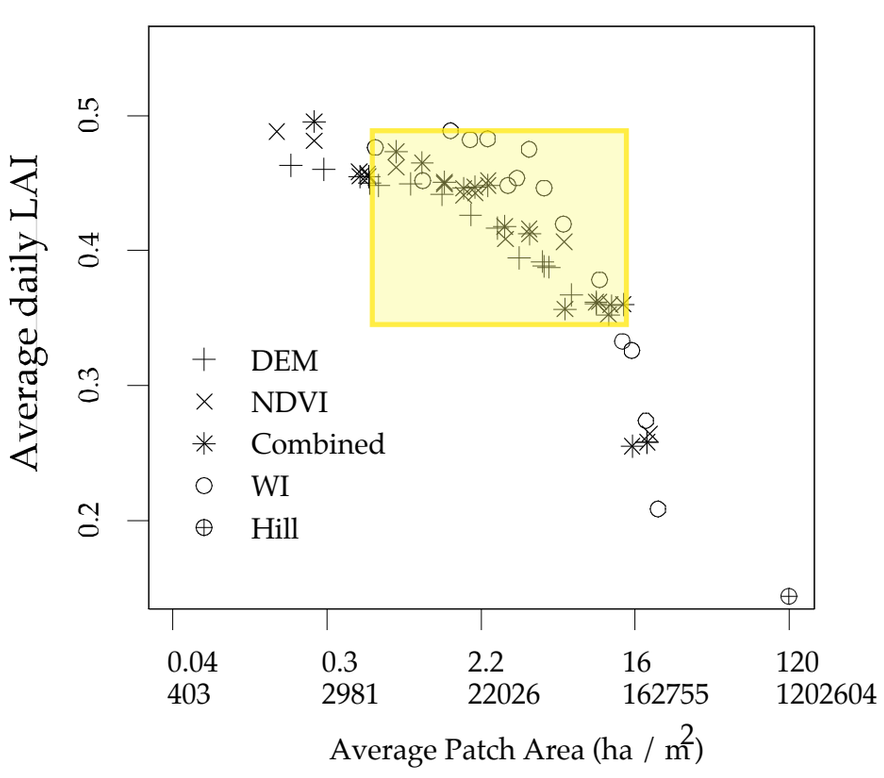










Grid qNDVI qWI


NPP predictions (annual average)
NPP (g/m2)
0
20
40
60
80
100
120
140
DEM
NDVI
Combined
WI
Hill
0.04
403
0.3
2981
2.2
22026
16
162755
120
1202604
Average Patch Area (ha / m2)

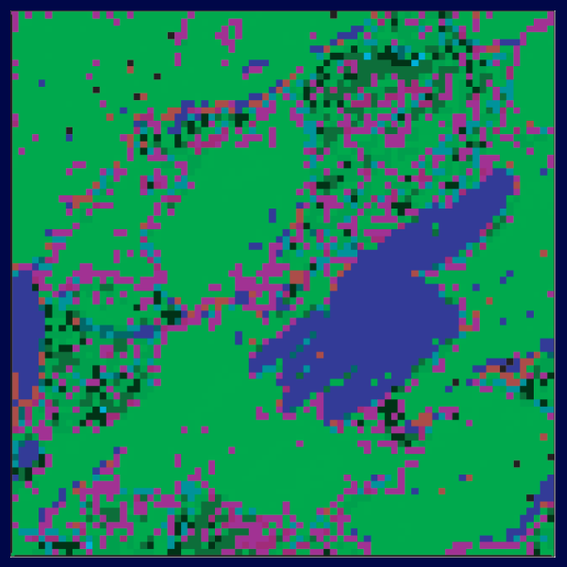

Evapotranspiration predictions
summed daily (mm)
300
400
500
600
700
DEM
NDVI
Combined
WI
Hill
0.04
403
0.3
2981
2.2
22026
16
162755
120
1202604
Average Patch Area (ha / m2)


Unsaturated storage predictions
summed daily (mm)
1e+06
2e+06
3e+06
4e+06
5e+06
DEM
NDVI
Combined
WI
Hill
0.04
403
0.3
2981
2.2
22026
16
162755
120
1202604
Average Patch Area (ha / m2)


LAI predictions
Average daily LAI
0.2
0.3
0.4
0.5
DEM
NDVI
Combined
WI
Hill
0.04
403
0.3
2981
2.2
22026
16
162755
120
1202604
Average Patch Area (ha / m2)

# Potentially confused classes

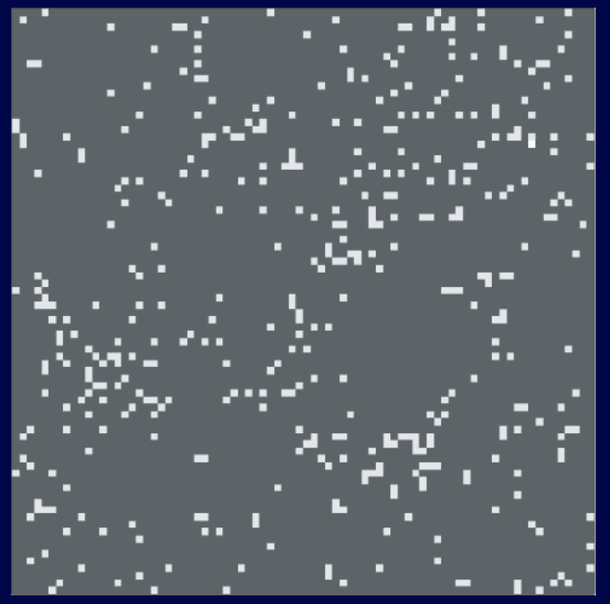
## Second Closest





Mixed-Open
Mixed-Dense
Broadleaf-Sparse
Broadleaf-Open
Broadleaf-Dense
Conifer-Sparse
Conifer-Open
Confer-Dense
Herb
Shrub-Low
Shrub-Tall
Water
Exposed Land
Shadow

## Closest



Non-significant
Significant

Difference Ratio
Z-score significance

# Logistics

- Who am I?
- Course outline
  - Topics
  - Schedule
- Who are you?
- revisit schedule

# Focus on literature

- critical issues in GIScience
- critical analysis of current research
- presentation skills
- more discussion -> better understanding

# Practical work

- focus on NEW (to you) tools
- open source
- documentation/tutorials

# So, What ARE these "Advanced Topics?"

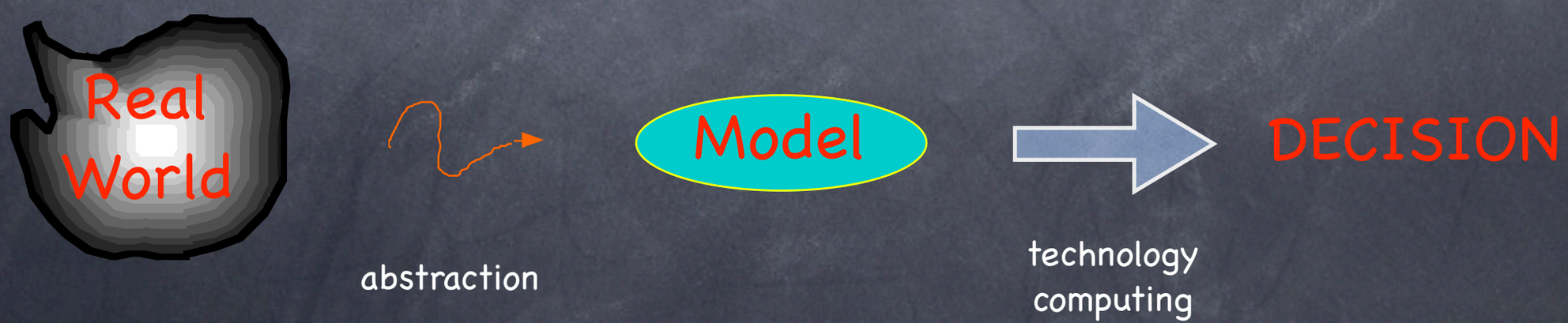
- GIScience versus GISystems
- Decision Support with GIS
- Decision Making Using Multiple Criteria:
  - Collapsing complementary objectives
  - Weighted Optimisation when objectives conflict
  - Concordance Matrix Analysis
  - Multiple Objective and Criteria Analysis
    - IDRISI modules

# Decision Support

# Decision Support

# Decision Support

- Why use GIS?
- Challenges - complexity:
  - decision making process
  - limits of data and understanding



# But:

# But:

- what does that all depend on?

# But:

- what does that all depend on?
  - spatial accuracy & resolution

# But:

- what does that all depend on?
  - spatial accuracy & resolution
  - thematic accuracy & resolution

# But:

- what does that all depend on?
  - spatial accuracy & resolution
  - thematic accuracy & resolution
  - model accuracy, uncertainty

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- how can it be used?

# But:

- what does that all depend on?
  - spatial accuracy & resolution
  - thematic accuracy & resolution
  - model accuracy, uncertainty
- how can it be used?
  - do the (objective and subjective) values captured by the GIS/model analysis match/ meet the factors/objectives of decision makers?

# Accuracy of Geo-Spatial Databases

- How well data and data structures represent the 'real' world;
- How well algorithms compute true values of products.

# Uncertainty

# Uncertainty

- Error Analysis and Propagation:
  - Position vs. attribute error
  - Sampling design to assess map accuracy
  - Analysis of accuracy of thematic classes
  - Analysis of error propagation in:
    - standard GIS operations - overlay, buffer, etc.;
    - mathematical combination of continuous variables
  - Managing error

# Interpolation and elevation models

# Interpolation and elevation models

- DEM production, spatial interpolation:
  - Review of interpolation techniques:
    - discrete (Thiessen, Delaunay), continuous (nearest neighbour, bilinear, inverse distance weighted avg., splines, kriging)
  - Methods for DEM production and evaluation of quality of DEMs
  - Ortho-image production (brief)

- spatial data manipulation
  - utilities, approaches
  - role of free and open-source / commercial
- Environmental Modelling:
  - Map Algebra - use of regression and formulae in mapping of environmental variables;
  - Temporal analysis
    - Mann-Krendall Trend Statistics, ...

- IF we have time:
  - Thematic mapping using multi-layered GIS data:
    - fuzzy classification, weights of evidence, evidential reasoning, neural networks.
  - Measurement of spatial data characteristics:
    - fragmentation, autocorrelation, semi-variance, texture, fractal analysis.
  - Measurement of spatial process:
    - diffusion, cellular automata.

# Common themes

- GIS as decision support tool - strengths, weaknesses
- over-arching issues
  - appropriate use - need for understanding
  - standards, accessibility, freedom to modify/use
  - uncertainty and error:
    - techniques to deal with uncertainty and error

# Practical work (labs)

- use different software (e.g. not ESRI)
- exposure to multiple open source packages
- flexible workshop schedule - by interest/project
- final project - produce tutorial, complete with worked up example/data set, to demonstrate how to accomplish a GIS task of your choice, with "new to you" open source software, CC license

# More logistics:

- Assignment 1
- General comment on readings (Individual & Group)
- Student-led seminars
- Workshops
- Projects