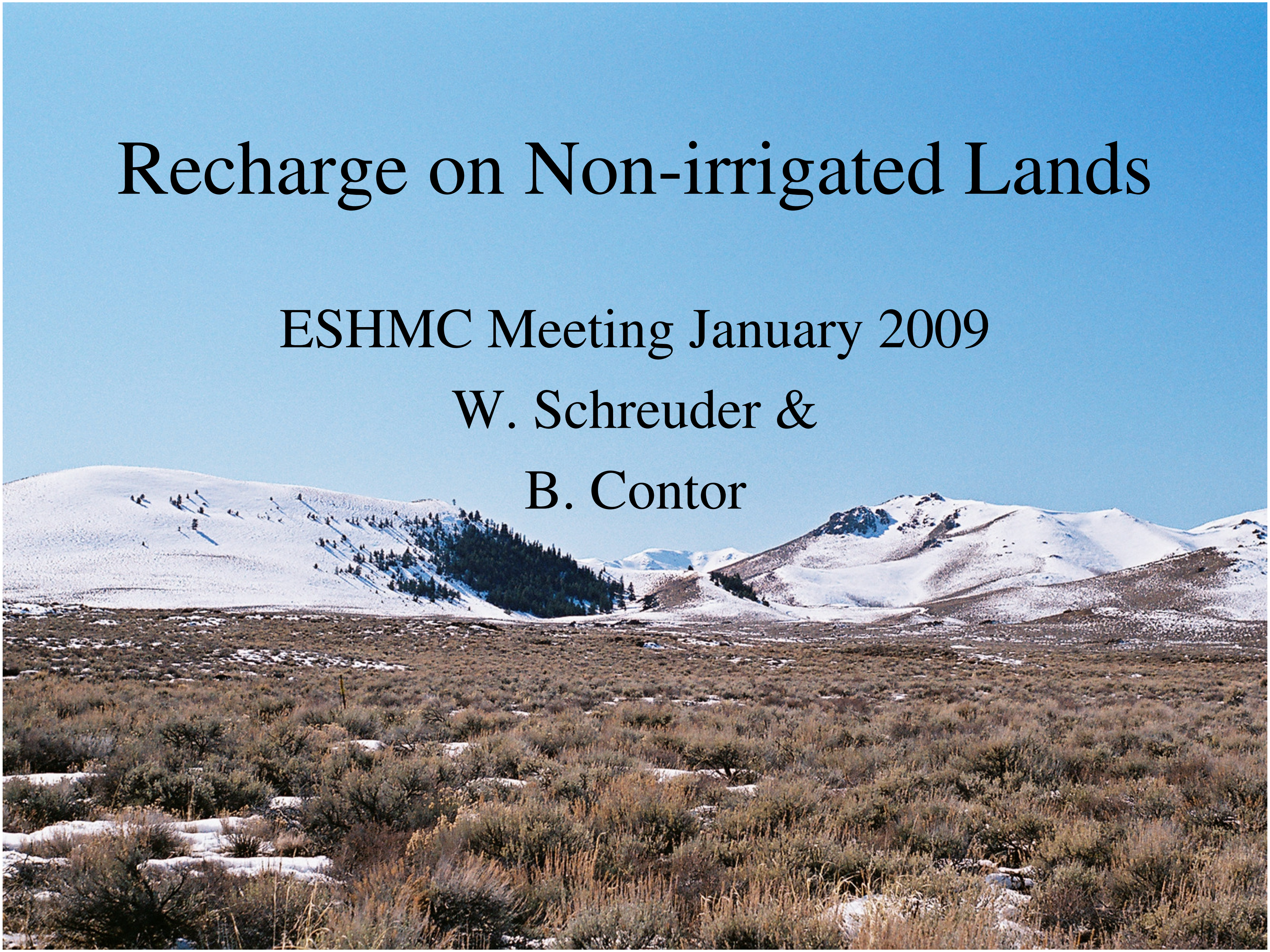
Recharge on Non-irrigated Lands

ESHMC Meeting January 2009

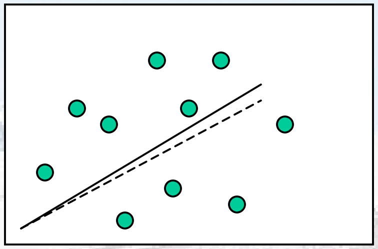
W. Schreuder &

B. Contor



BASICS

- Recharge = *f* (precip, soil, ET, vegetation....)
- Spatial distribution issues
  - – heterogeneous at small scale (cross-plots precip)
  - – anisotropic? (prevailing wind)
  - – regional gradients
    - orographic effect on precip
    - latitude & elevation effect on ET
  - – local topographic concentration of runoff
- Large temporal uncertainties
  - – snow accumulation & melting



Where we are

- Agreement in ESHMC to use Allen-Robinson (P - Prz) as proxy for recharge
  - We implicitly accepted some limitations
    - snow accumulation/melting
    - topographic concentration of runoff
    - point estimates at weather stations
  - Allen & Robinson agreed to update data series through (2007?) (2008?)

Where we are

- Three different Allen-Robinson cover types used as proxies for three basic soil covers:
  - Thick soil
  - Thin soil
  - Lava rock
- We have NOT yet agreed on an interpolation method

Where we are: Divergence of Opinion

- Simple (Contor)
  - Nearest-neighbor AKA Thiessen Polygons
- Fancy (Schreuder/Wylie)
  - Semi-log Kriging or some variant

(wikipedia)

Two Approaches

- Simple
  - fast and easy to apply
  - easily understood & explained
  - easily reverse-engineered by future evaluators of our work
- Fancy
  - theoretically superior
  - fast and easy with custom software (Willem has already written some)
  - alternately, requires lots of hand work (27 years x 12 months x 3 soil types = a big number of interpolations to do)

Black Spy's Arguments

- No method is fully satisfying
  - Heterogeneity occurs at scale much smaller than spacing between weather stations
- $RMSE_{simple} \sim RMSE_{fancy}$
- Advantages of "Fancy" are mostly perceptual

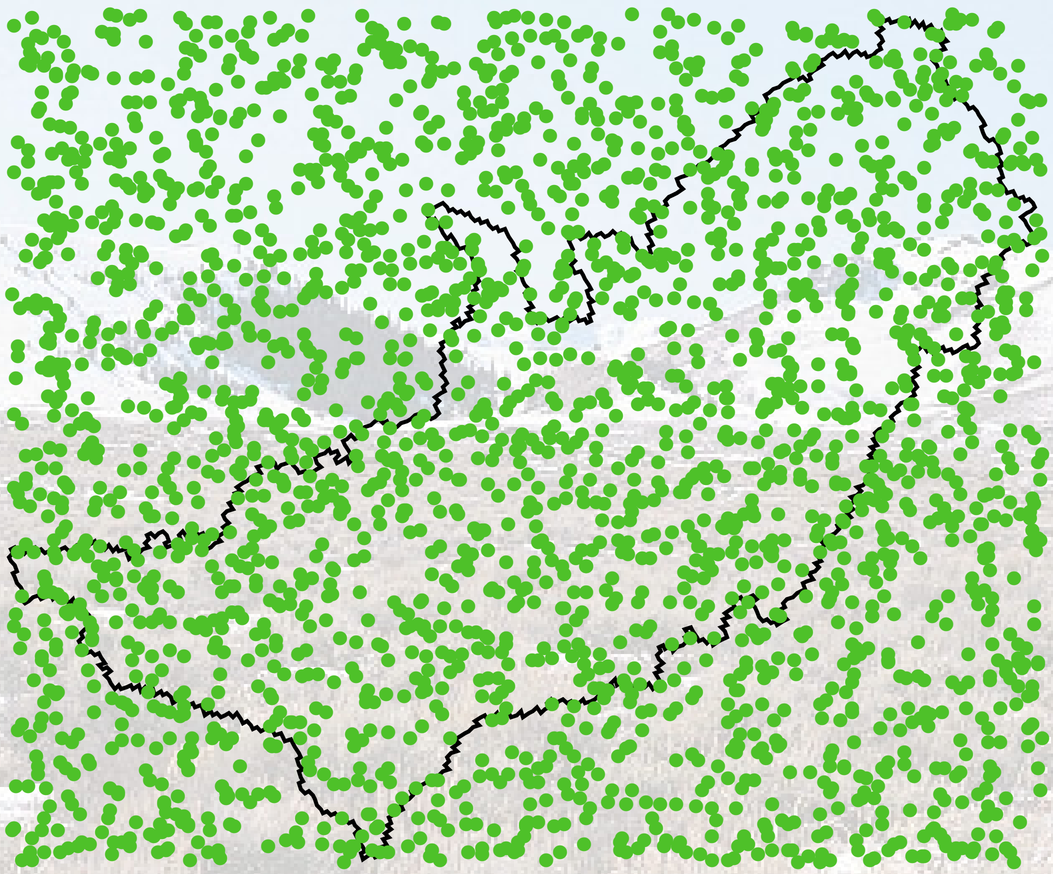
Proposal January 2009:

Bryce made a fake data set & challenged Willem to make various interpolations to test.

We can't compare using real data because we don't know the true underlying heterogeneity & anisotropy.

Step 1: Random Points

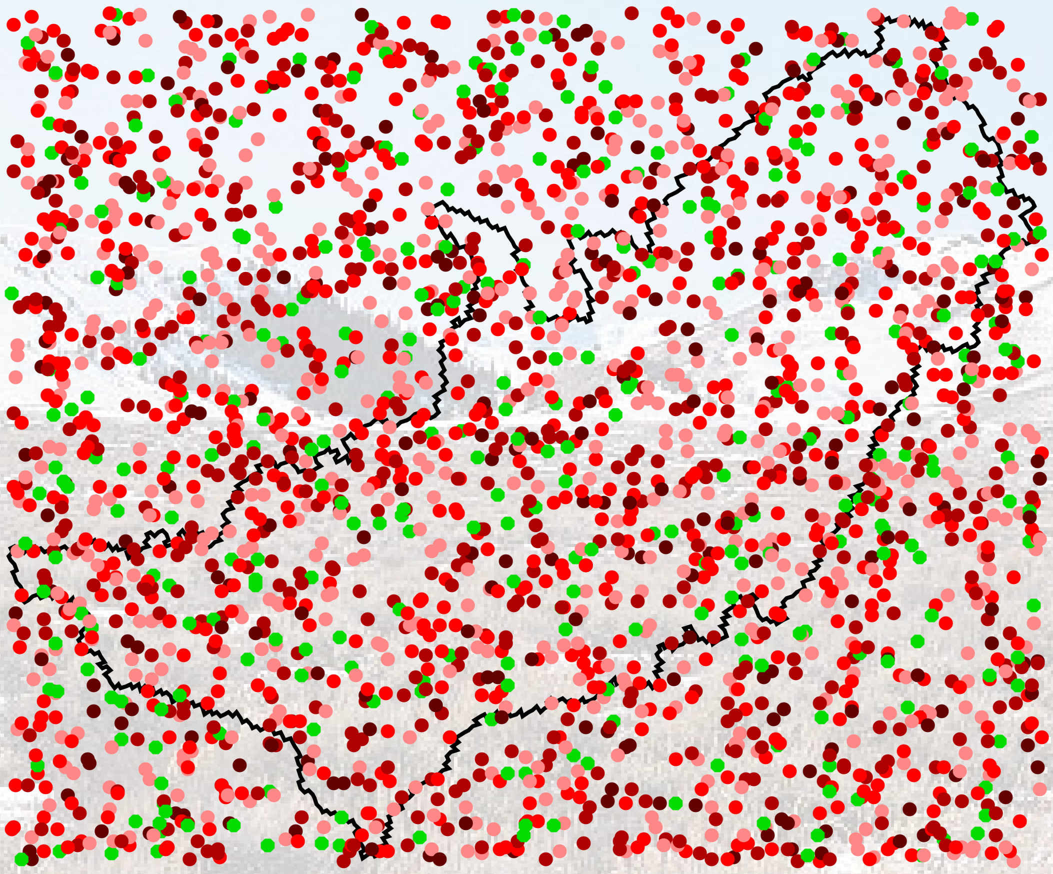
2500 points w/ X & Y randomly distributed using Microsquash Excel random-number generator, uniform distribution



Step 2: Random Points

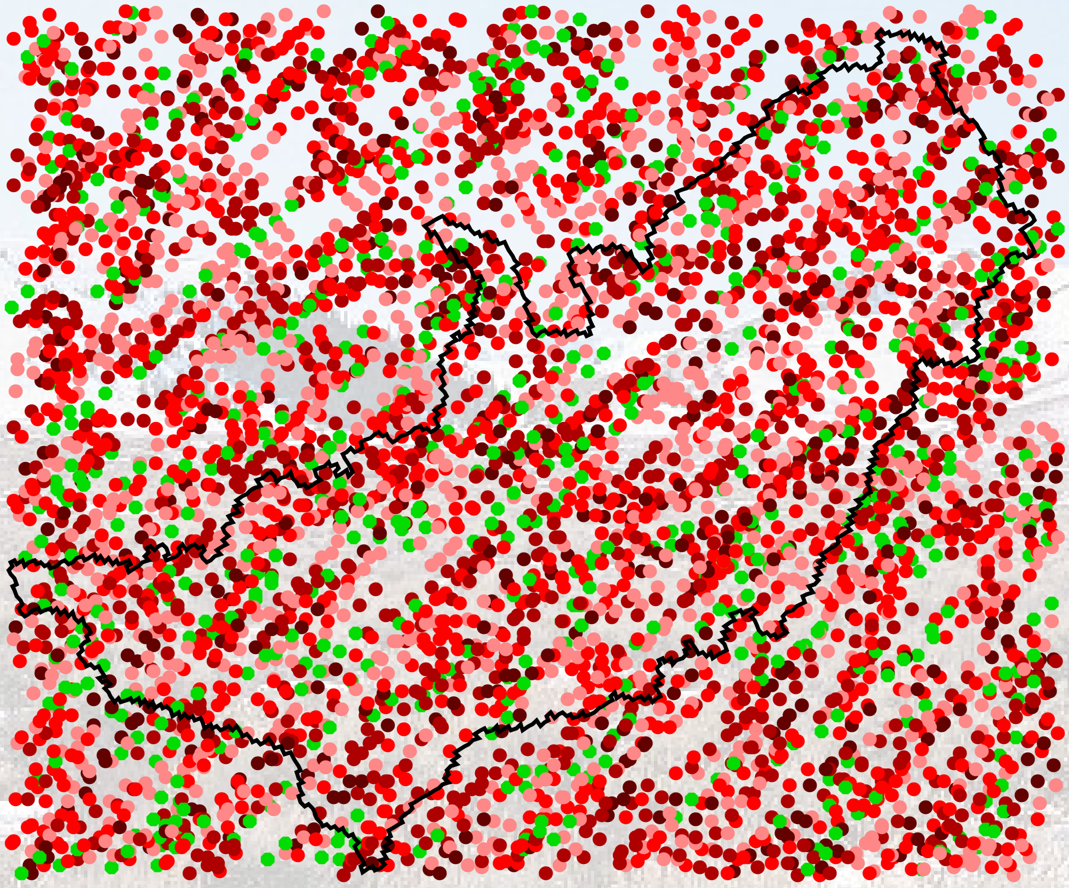
Assign preliminary depth using Microsquash normal distribution, mean 3.0, standard deviation 1.0.

(-0.2 to 7.0)



Step 3: Create Anisotropy

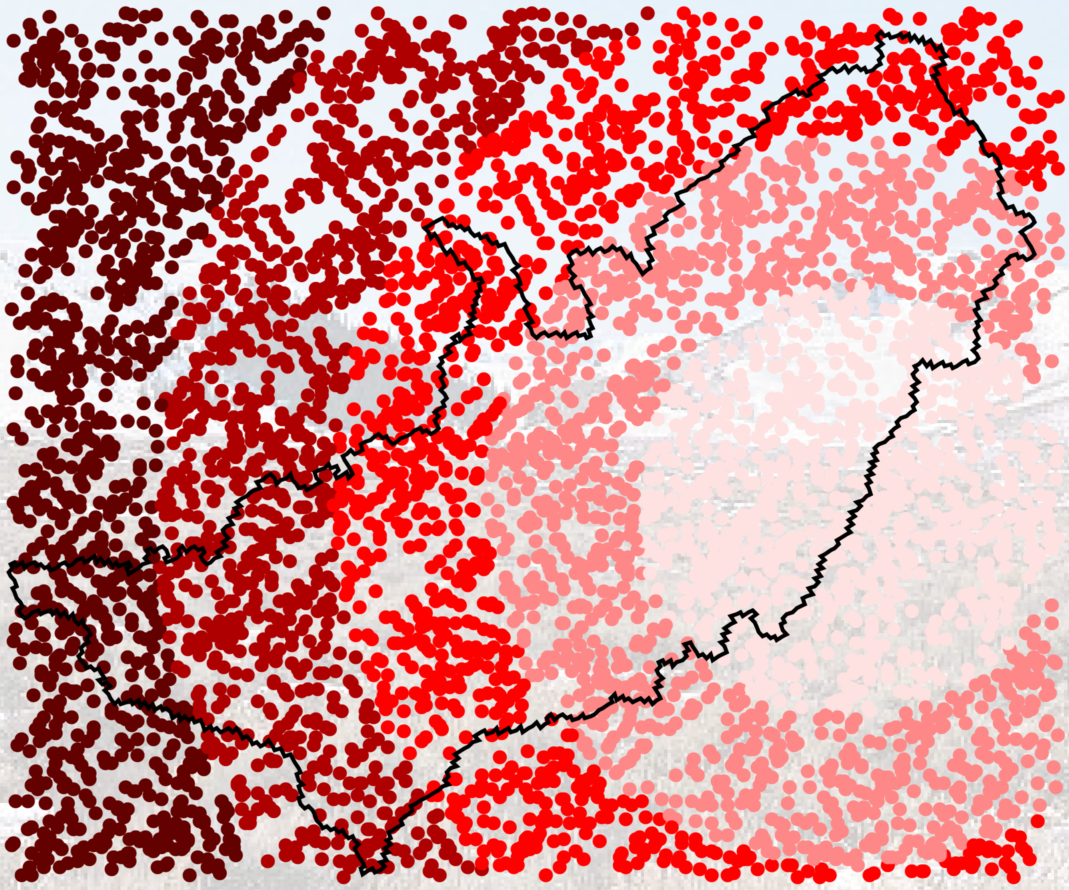
Every point was duplicated
at location (X + 5000 meters, Y + 5000 meters)



Step 4: Regional Gradient

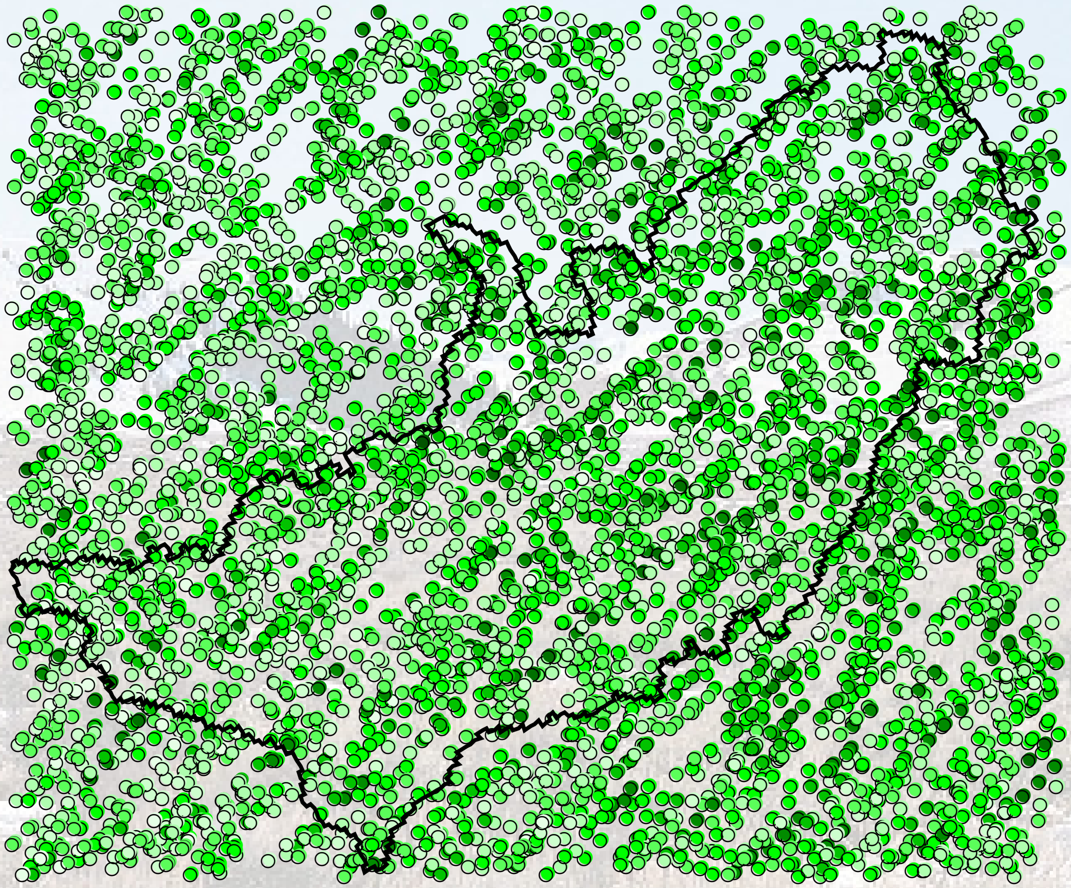
Adjustment = (Distance from secret point)/300,000

(zero to
0.95)



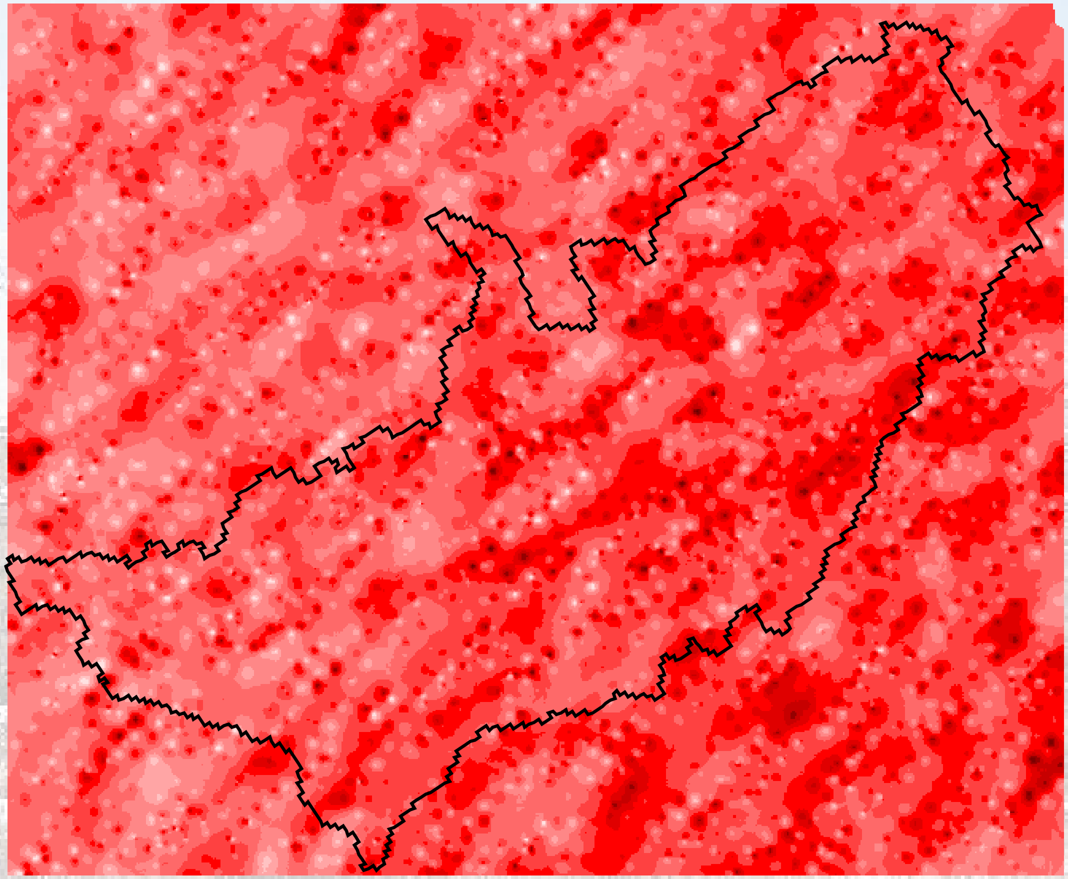
Step 5: Anisotropic w/ Gradient

Max [0, (Anisotropic - Adjustment)]



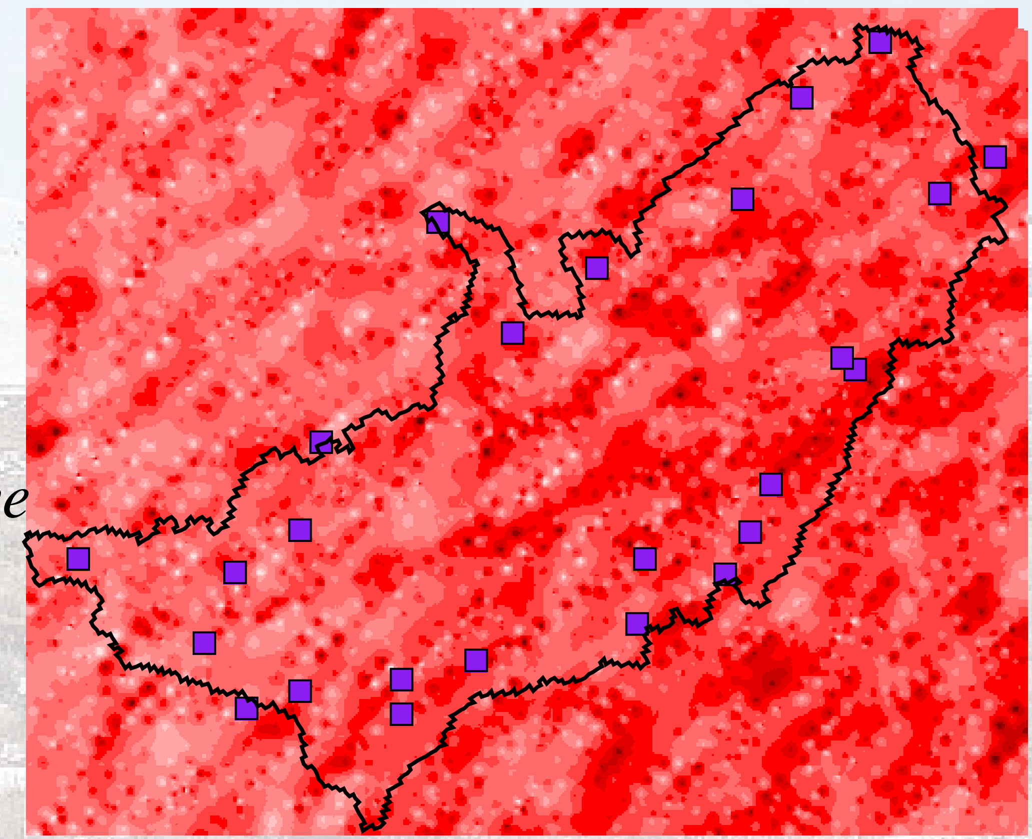
Step 6: Make into Raster

ArcGIS3.3, IDW, radius 10000 meters, power 2, cell size 500 meters



Step 7: Willem gets only the weather-station point values & a picture of the raster

(this is still more data than we have for the real world)



Step 8: Willem Creates Interpolated Surfaces

- Semilog Kriging 1
- Semilog Kriging 2
- Semilog Kriging 3
- Thiessen Polygons 1
- Thiessen Polygons 2
- Thiessen Polygons 3

Mathematical Problem

- Given measurements f_i at locations (x_i, y_i) construct the interpolation surface $f(x,y)$ as

$$f(x,y) = \sum_i w_i(x,y) f_i$$

  - For any point (x,y) what are the weights?
- To be ***unbiased***, we can show that

$$\sum_i w_i(x,y) = 1$$

- It is not required that w values be positive

Definitions

- d_{ij} is the Euclidean distance from (x_i, y_i) to (x_j, y_j)
- d_i is the Euclidean distance from (x, y) to (x_i, y_i)
- The semivariogram translates Euclidean distance to statistical distance using a monotone increasing function

$$\gamma_i = \gamma(d_i)$$
$$\gamma_{ij} = \gamma(d_{ij})$$

- Linear semivariogram

$$\gamma(d) = k \min(d, d_{range})$$

Thiessen Polygons

- Also called Voronoi or Dirichlet tessalation
- Set w_i to 1 for the nearest point, and 0 for all others

$$w_i = \begin{cases} 1 \ \forall \ i = argmin(\gamma_j) \\ 0 \ \forall \ i \neq argmin(\gamma_j) \end{cases}$$

- Note that *nearest* is measured as a statistical distance, which can be Euclidean distance, but in general it is not

(Bryce's note: In the original proposed nearest-neighbor approach, distance ***was*** *Euclidian.)*

Kriging Weights for (*x*,*y*)

- Solve the linear system *Gw=g*

$$
\begin{bmatrix}
\gamma_{11} & \gamma_{12} & \gamma_{13} & \cdots & \gamma_{1n} & 1 \\
\gamma_{21} & \gamma_{22} & \gamma_{23} & \cdots & \gamma_{2n} & 1 \\
\gamma_{31} & \gamma_{32} & \gamma_{33} & \cdots & \gamma_{3n} & 1 \\
\vdots & \vdots & \vdots & \ddots & \ddots & \vdots \\
\gamma_{n1} & \gamma_{n2} & \gamma_{n3} & \cdots & \gamma_{nn} & 1 \\
1 & 1 & 1 & \cdots & 1 & 0
\end{bmatrix}
\begin{bmatrix}
w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \\ \lambda
\end{bmatrix}
=
\begin{bmatrix}
\gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \vdots \\ \gamma_n \\ 1
\end{bmatrix}
$$

- Note that *G* uses only inter-data point distances
- Note that *g* uses only data point-(*x*,*y*) distances
- λ is a Lagrange multiplier

Transformations

- Transformations allow kriging (and other methods) to have desirable properties
  - Transform forward, krige, transform back
- Log kriging
  - order of magnitude changes
  - always positive data
- Semilog kriging
  - log for “small numbers”
  - linear for “big numbers”

$$f(x) = \begin{cases} x - \beta \ \forall \ x \geq \beta \\ \log(x/\beta) \ \forall \ x < \beta \end{cases}$$

- Many others (unitlog, hyperbolic, power, ...)
- May need placeholder for special cases (e.g. 0)

Anisotropy and Drift

- The semivariogram can be directional
  - Points appear “closer” in one direction than another
  - Simplest form is an angle and ratio
- Kriging + Regression is called Universal Kriging
  - Ordinary Kriging assumed no drift
  - Universal kriging uses regression to represent drift
  - Universal kriging can use any set of linearly independent functions to represent drift, but usually monomials are used.

Faults

- Discontinuity in the interpolated surface
  - Physical basis such as geologic fault
  - Isolated regions such as fingered alluvium
- Points on the other side of the fault are not used in computing the surface
  - $w_i = 0$ for all points across the fault
  - Compute surface as if these points do not exist

(Bryce's note: No faults in the fake data. Edge of Rexburg Bench might be considered a fault in real data. Exactly ***one*** *data point exists east of the fault)*

Step 9: Bryce makes a dirt-simple interpolation

- Average of weather-station point values

(new idea that presented itself during slide construction)

Step 9b: Bryce makes a semi-simple interpolation

- Scaled Pseudo Avg Prism + WS Avg
  - incorporates sophisticated algorithms including elevation, slope & aspect
  - therefore captures long-term average regional gradient
  - doesn't pretend to capture small-scale heterogeneity for which we have insufficient data

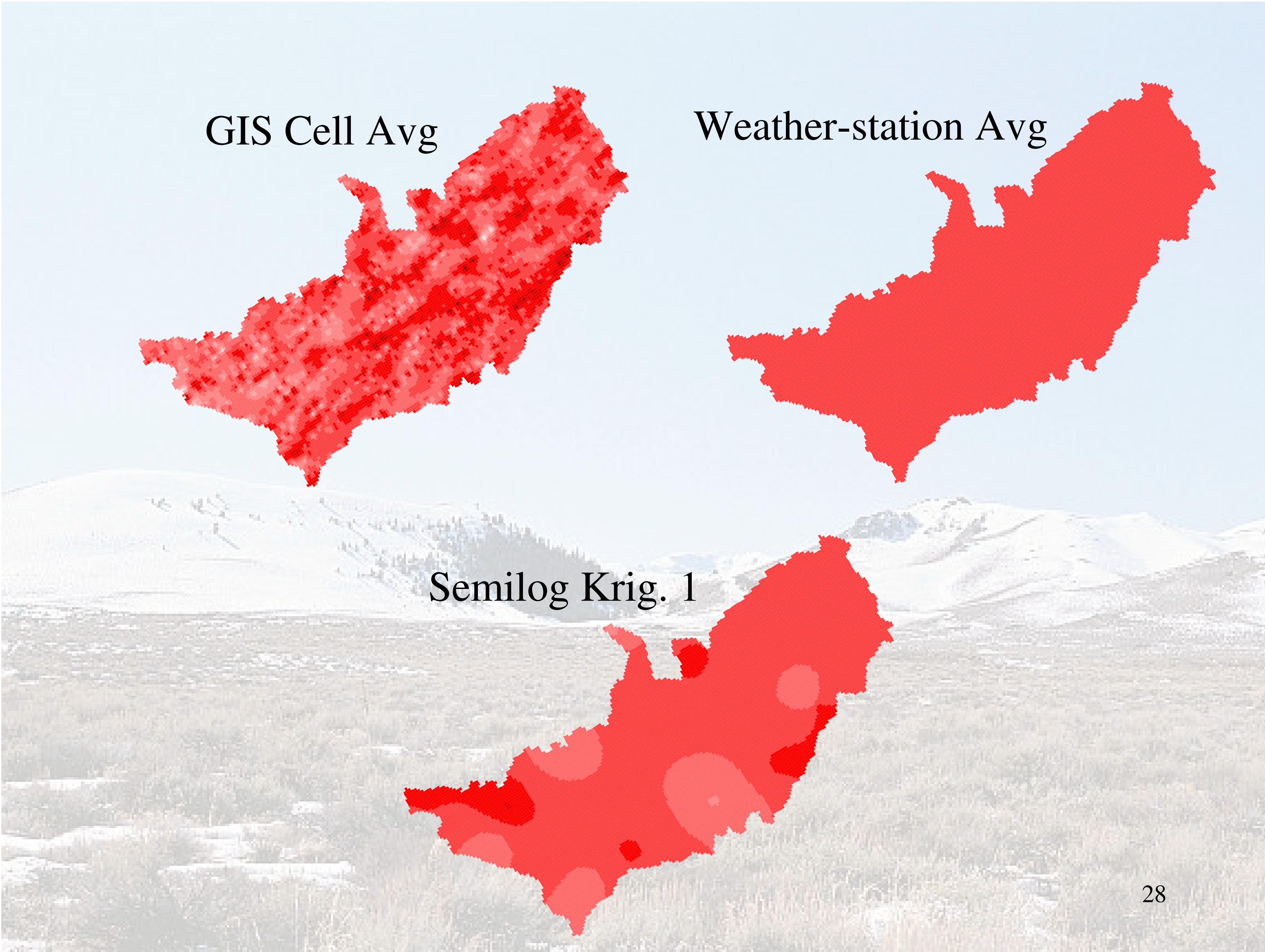
(new idea that not even Willem has seen)

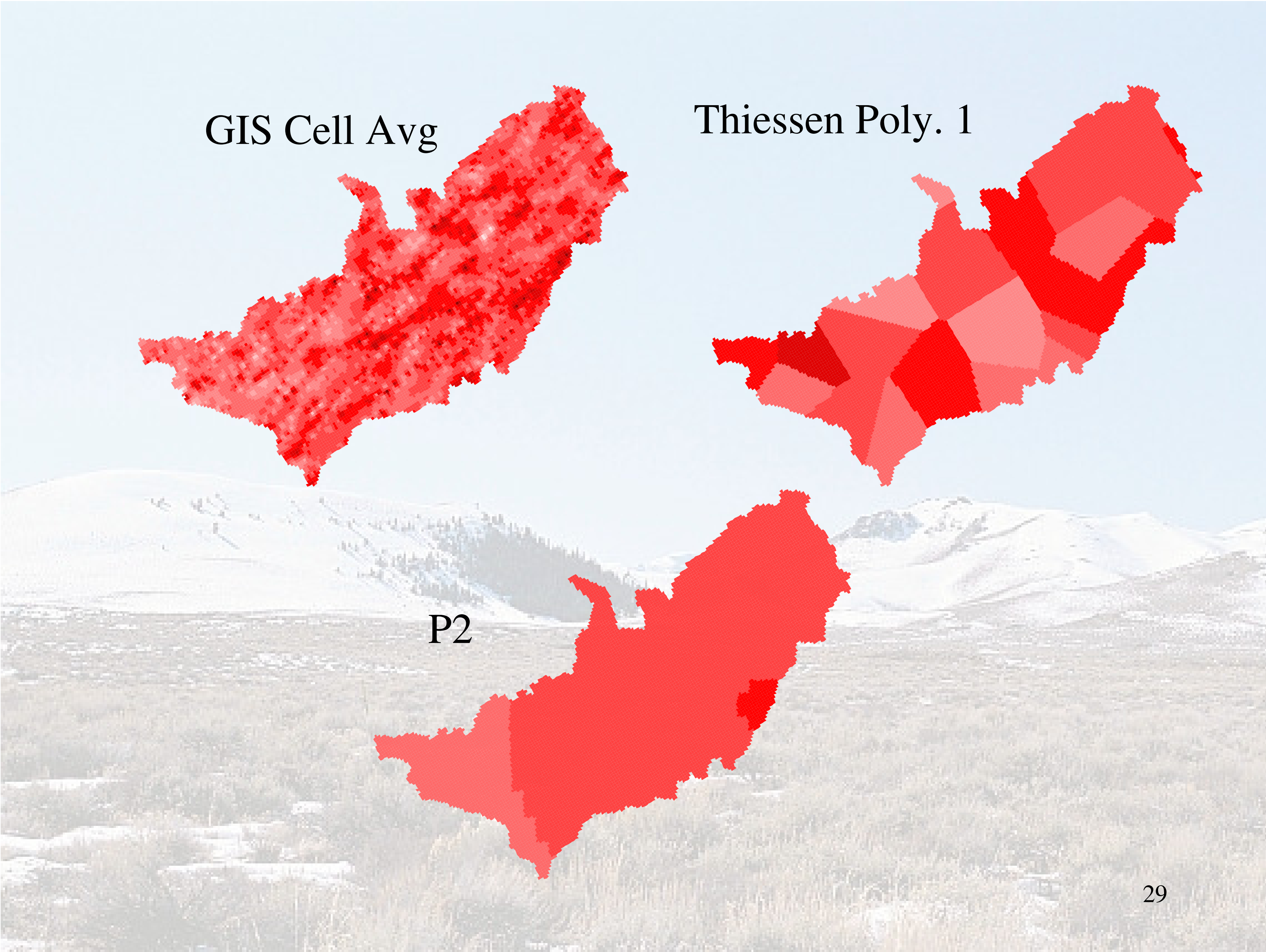
Step 10: Bryce makes comparisons

- Maps of interpolated surfaces
- Maps of $Error^2$ surface
  - $(Surface - GIS cell mean)^2$ for all active cells
- Graph of average value
  - (sum of cell values)/(cell count) for all active cells
- Graph of bias
  - (avg value - GIS avg)/(GIS avg)
- Graph of Root Mean Square Error (RMSE)
  - squrt[(sum of Err^2)/(cell count)] for all active cells

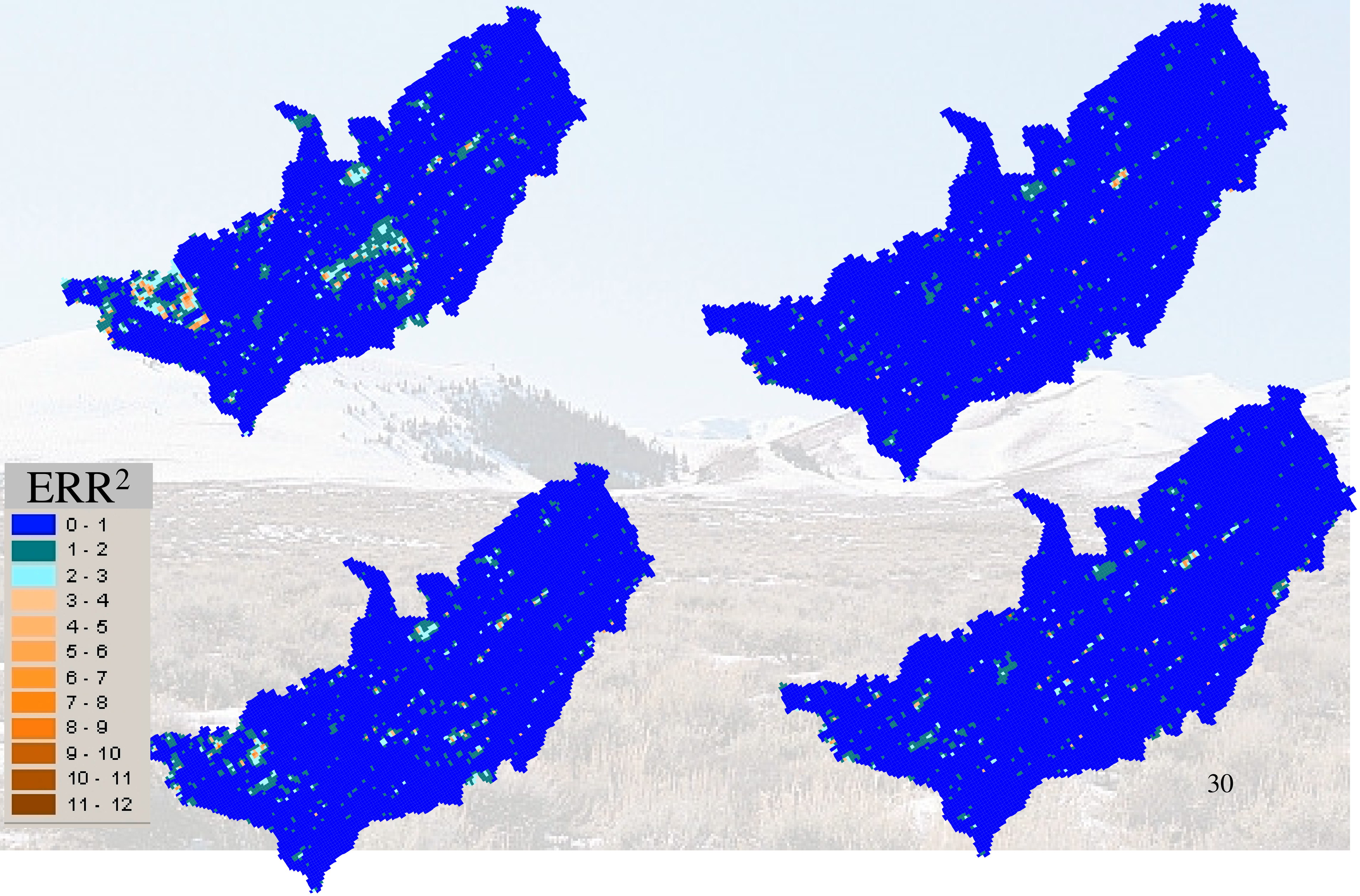
Test Results:

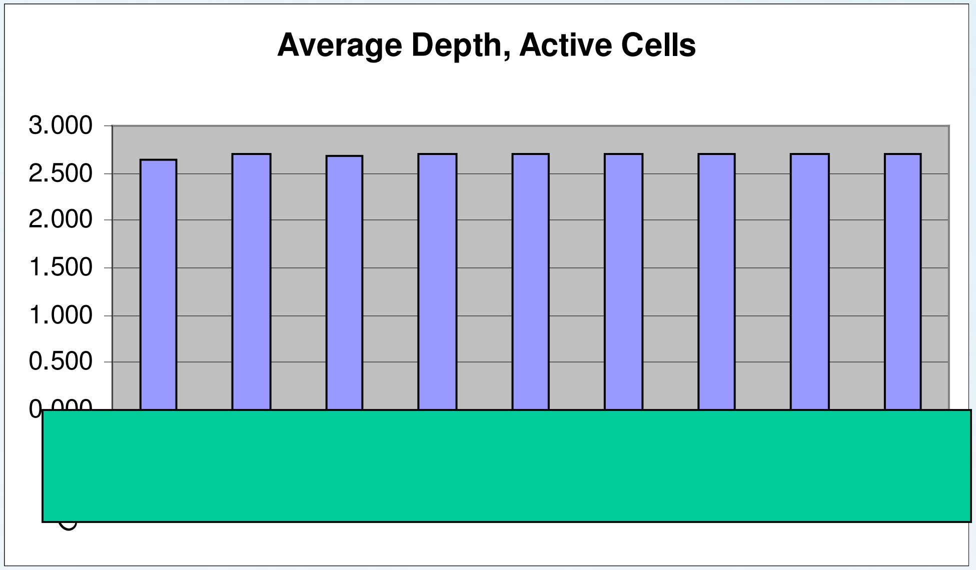
- Remember we are looking at only one interpolated surface.
- In real life we will have three surfaces (thin soil, thick soil, lava rock) for each stress period.
- General map of soil cover determines which surface is applied to which model cell.
- This is the **LARGEST POTENTIAL HETEROGENEITY** and our method addresses it (regardless of interpolation method chosen).
- We have tentatively agreed on 11 zones of PESTability (capability for up to 30).

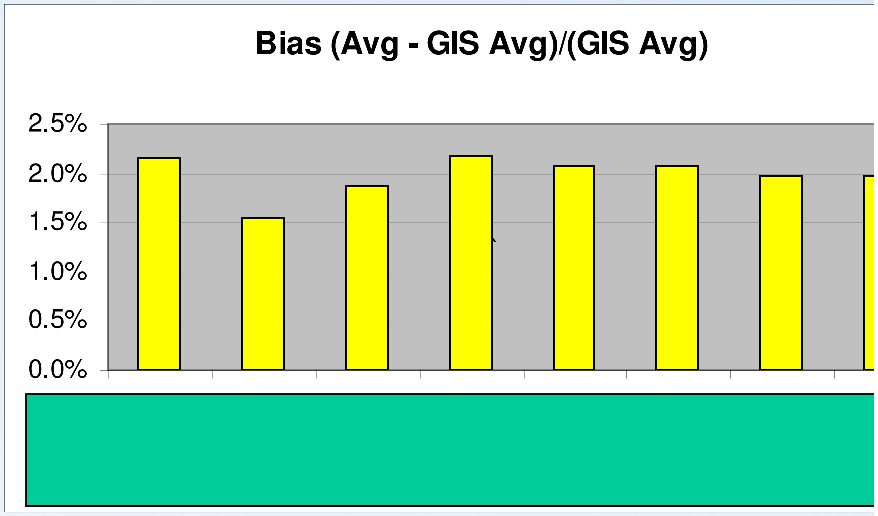

GIS Cell Avg
Weather-station Avg
Semilog Krig. 1

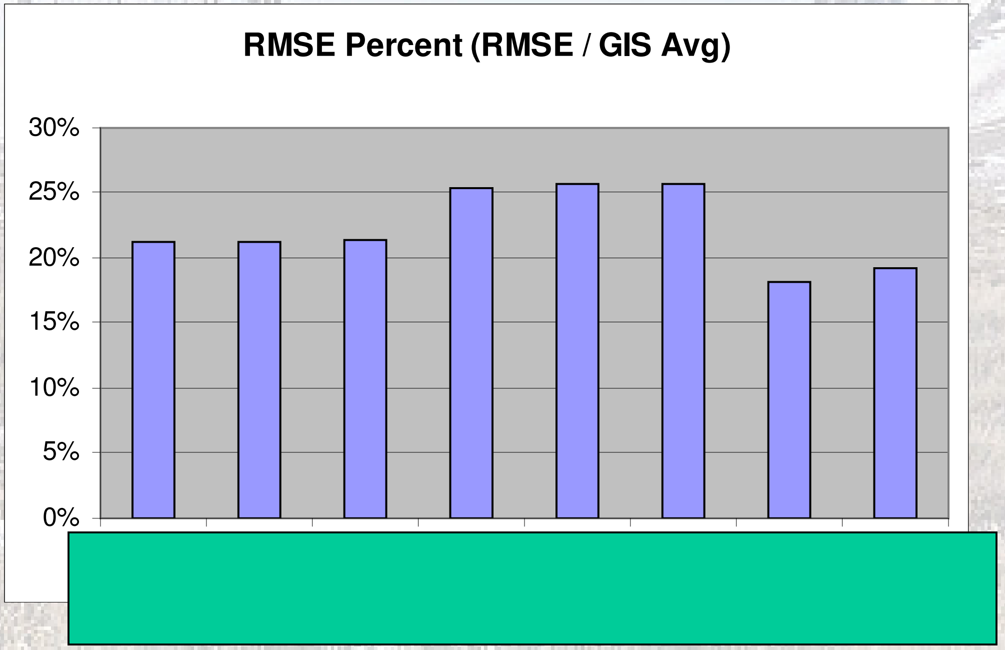

GIS Cell Avg
Thiessen Poly. 1
P2

Spatial Distribution of Errors

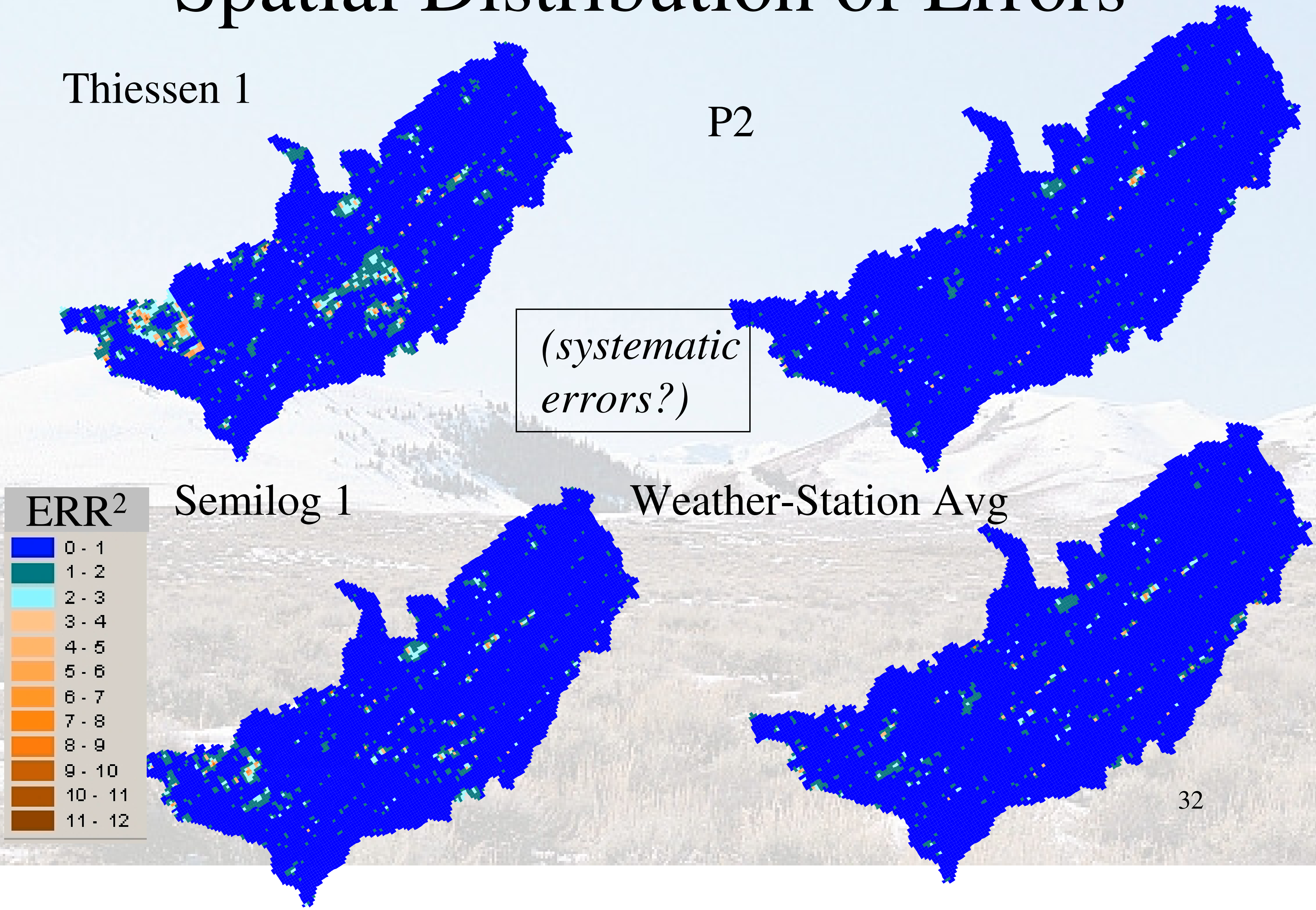


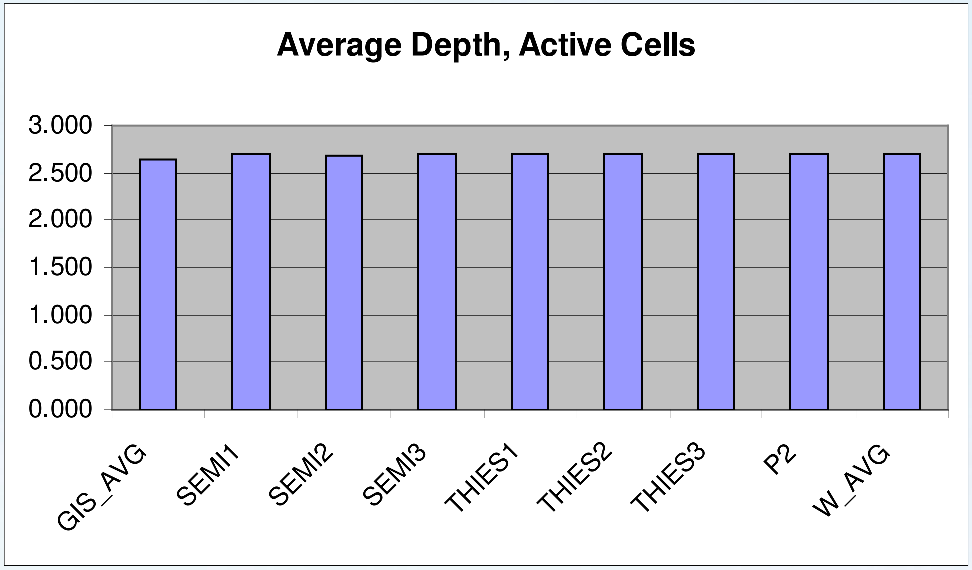

Average Depth, Active Cells
3.000
2.500
2.000
1.500
1.000
0.500

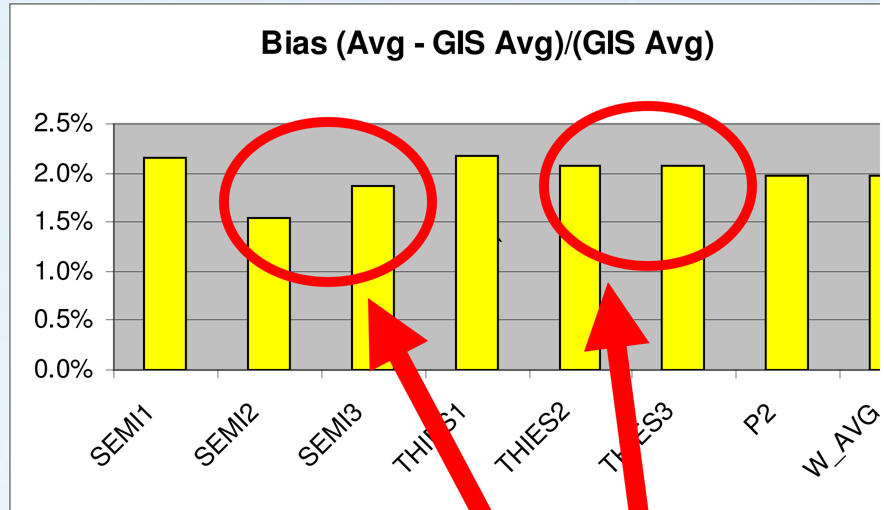

Bias (Avg - GIS Avg)/(GIS Avg)
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%


RMSE Percent (RMSE / GIS Avg)
30%
25%
20%
15%
10%
5%
0%

Spatial Distribution of Errors



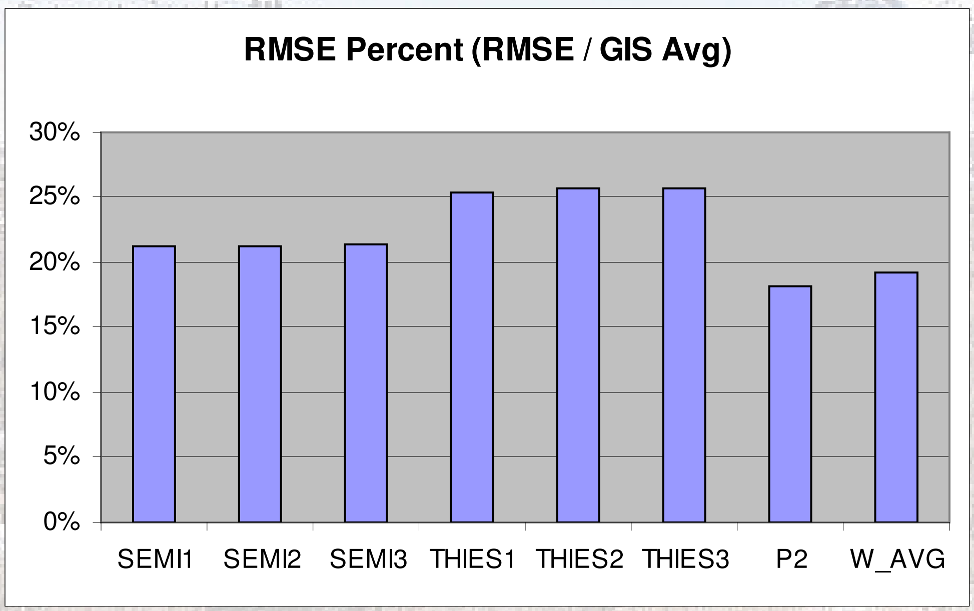




Assumes knowledge of anisotropy.

~ 42%*

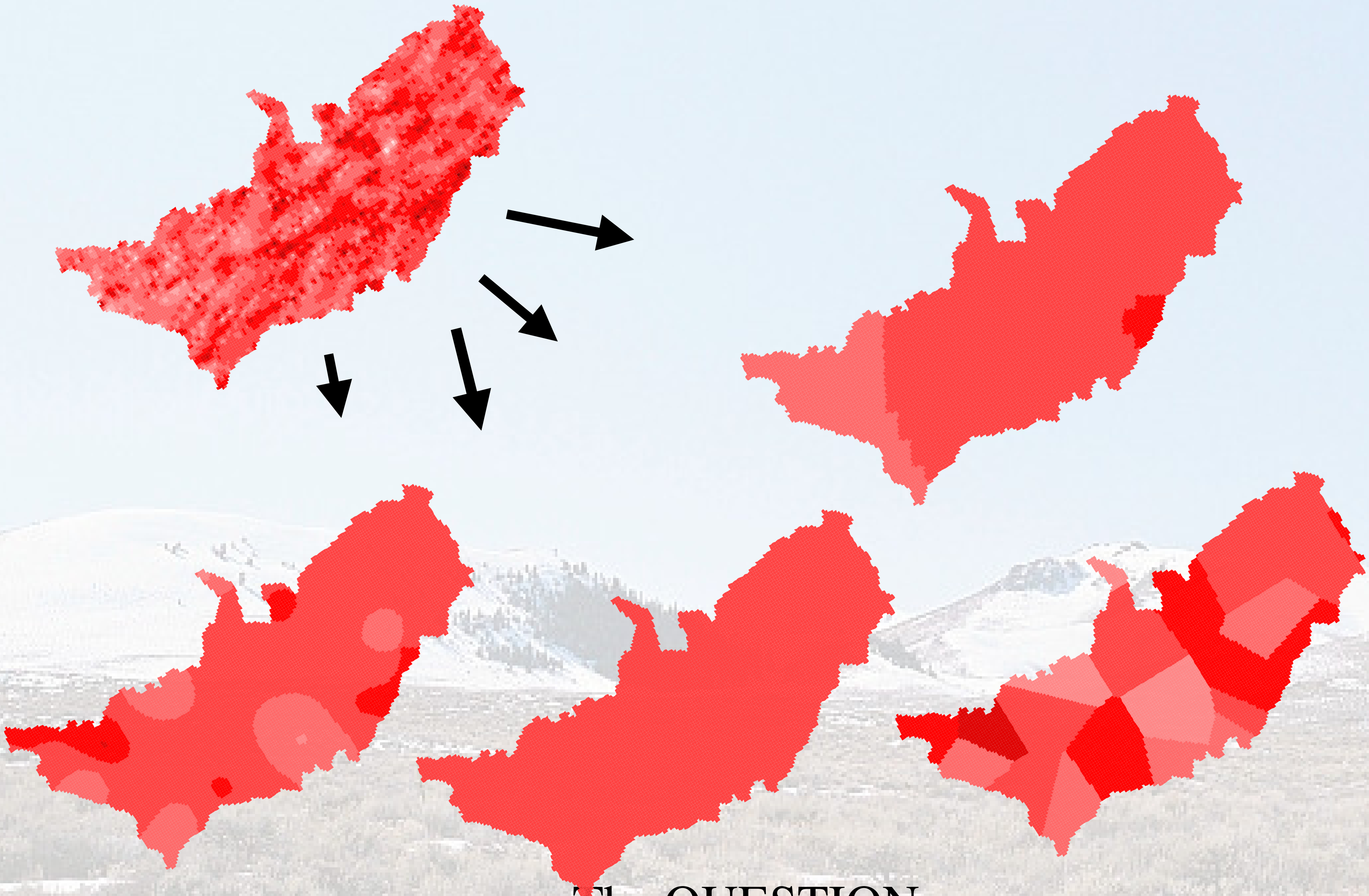
*(compare to 5%)



CAUTION!!!
These are FAKE DATA

- We don't know the true spatial scale of heterogeneity
- We only suppose there is anisotropy
- Weather stations are too sparse to infer these statistically
- I didn't calculate the true regional gradient
    - it affects error of "W-AVG" method

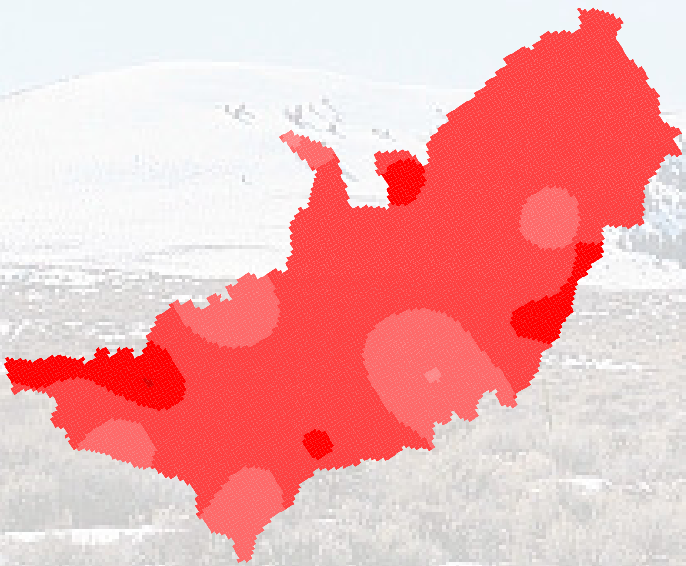
(Break to Willem's demo of actual interpolations of weather-station data)



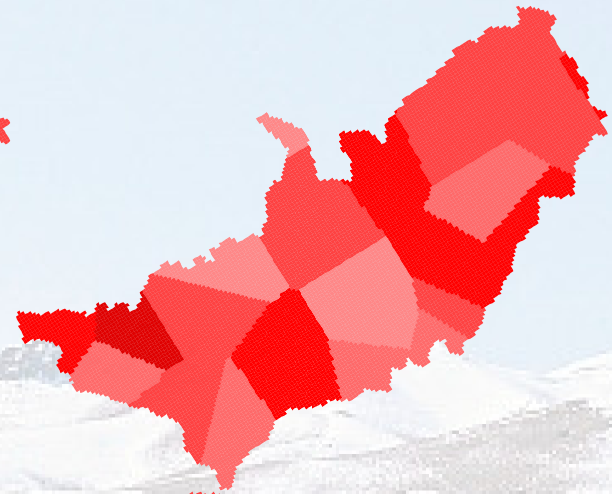
The QUESTION:

"Which fib do we tell?"

Obviously prettier



Cannot be misconstrued as a representation of true spatial distribution



Worst of both worlds?

(or is it the best?)

Choice to be made:

- Simple method(s)
  - IWRRI has resources & time to do this
- Fancy method
  - IWRRI doesn't have resources & time
  - IDWR perform the calcs?
  - Willem?
  - Other?

What is ESHMC Input?

Utah Poison Control Center reminds everyone not to take poison

"Children Act Fast, So Do Poisons" is the theme for National Poison Prevention Week, arch 20 - 26. The Utah Poison Control Center (UPCC) would like to take the opportunity to remind parents and caregivers that poisonings can be prevented. In 2004, the Utah Poison Control Center responded to over 50,000 calls, the majority of which were about actual potential poisonings.

Over 60 percent of the potential poisoning exposures involved children u...

giving or taking medicine. Check the dosage each use.

* Avoid taking medicine in front of children.
* Never refer to medicine as candy.
* Clean your medicine cabinet periodically, safely disposing of unneeded and outdated medicines.

The UPCC, part of the College of Pharmacy, has an active community outreach program. In 2004, representatives of the Utah Poison Control Center provided 126 community presentations and ...

Federal Agents Raid Gun Shop, Find Weapons

...ner Arrested Previously

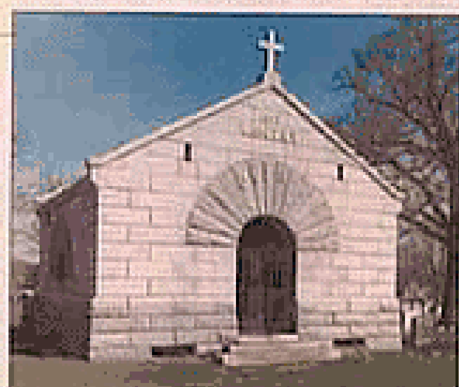
On July 2, undercover narcotics agents served a warrant at Thao's home, [redacted] to search for drugs. They found a stockpile of land mines, hand grenades, dynamite and other explo-...

... on Monday [redacted] ... Tulsa gun ... the man who ... kept in his ...

Caskets found as workers demolish mausoleum

'We had no idea anyone was buried there.'

By William R. Wineke



(sent to me by ??)