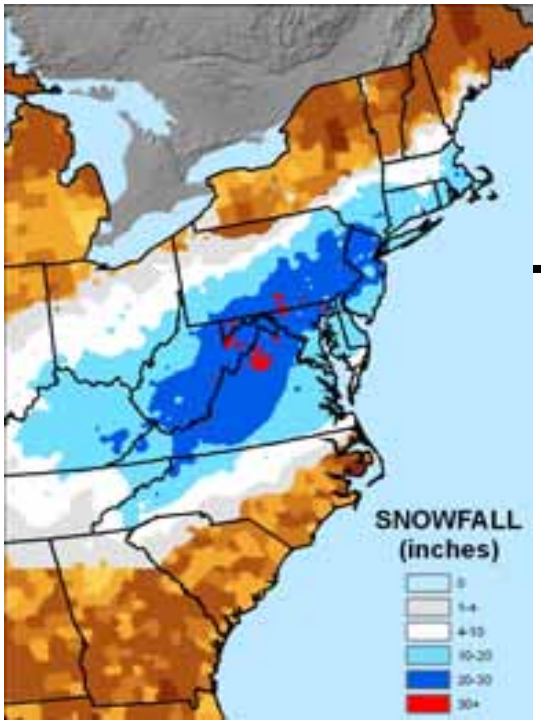
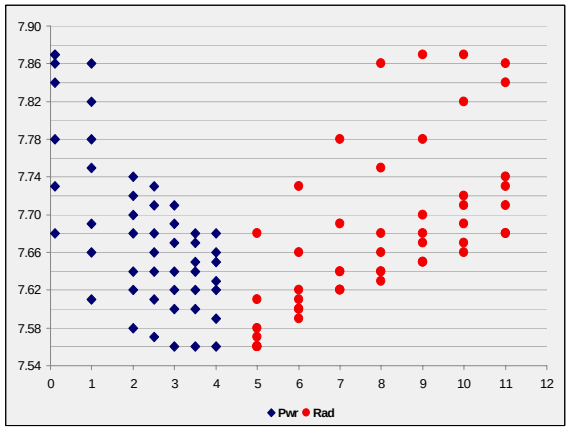
Estimating Uncertainty in GIS Applications



n	Area (SqMi)	Population
0	118,837	15,182,500
1	107,526	16,432,000
4	103,951	19,913,500
10	107,786	29,907,800
20	63,532	30,216,900
30	2,364	340,889

$$NESIS = \sum_{n=4}^{n=30} \left[\frac{n}{10} \left(\frac{A_n}{A_{mean}} \right) + \left(\frac{P_n}{P_{mean}} \right) \right]$$

NESIS = 11.78
:
NESIS Category 5
Extreme



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Northeast Snowfall Impact Scale

- Scale used to characterize NE snowstorms
- Uses amount of snow, area affected, and population
- **Impacts on society**

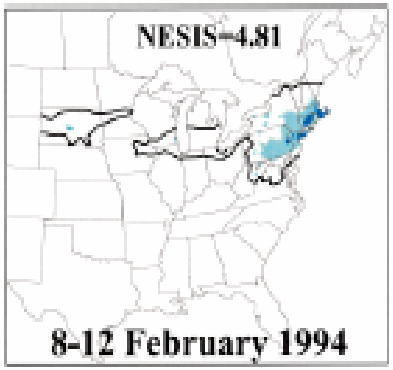

ARTICLES

A SNOWFALL IMPACT SCALE DERIVED FROM NORTHEAST STORM SNOWFALL DISTRIBUTIONS

Northeast Snowfall Impact Scale

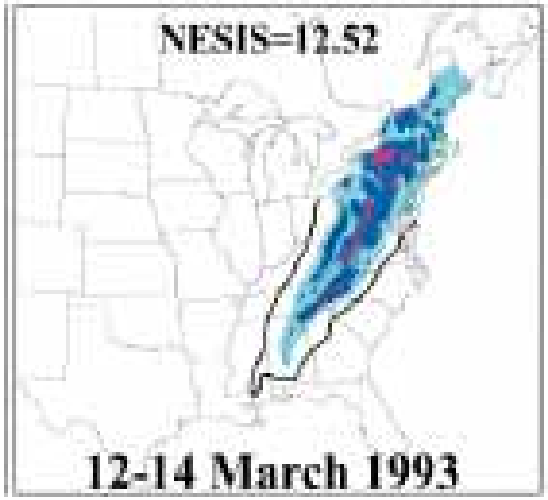
1 = Notable

2 = Significant



3 = Major

4 = Crippling



5 = Extreme

Northeast Snowfall Impact Scale

$$NESIS = \sum_{n=4}^{n=30} \left[\frac{n}{10} \left(\frac{A_n}{A_{mean}} + \frac{P_n}{P_{mean}} \right) \right]$$

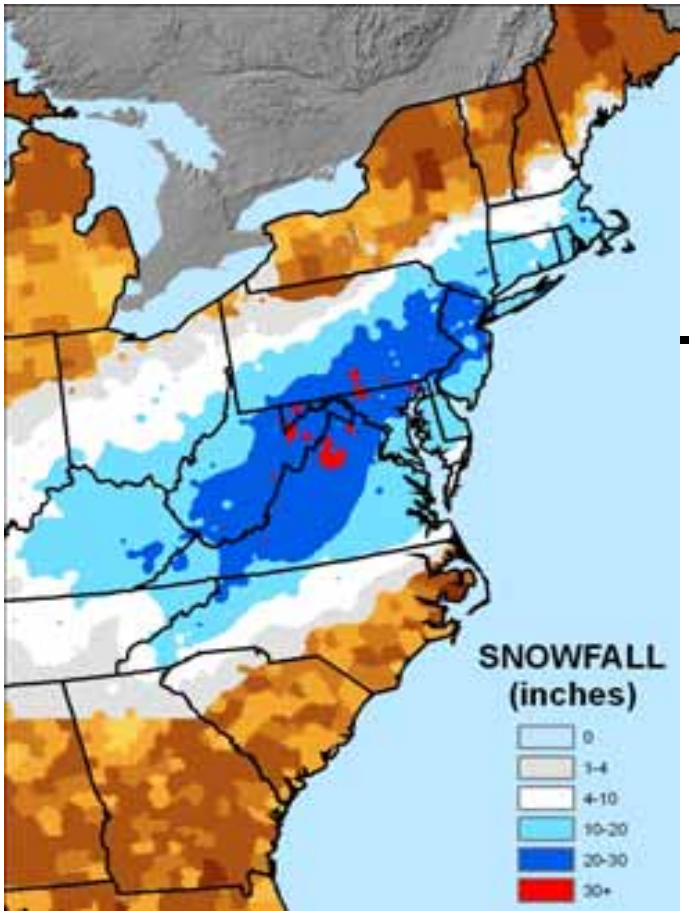
A = Area

P = Population

A_{mean} = Mean Area (91,000 mi^2)

P_{mean} = Mean Pop. (35.4 million)

n = { > 4” , > 10” , > 20” , >30” }



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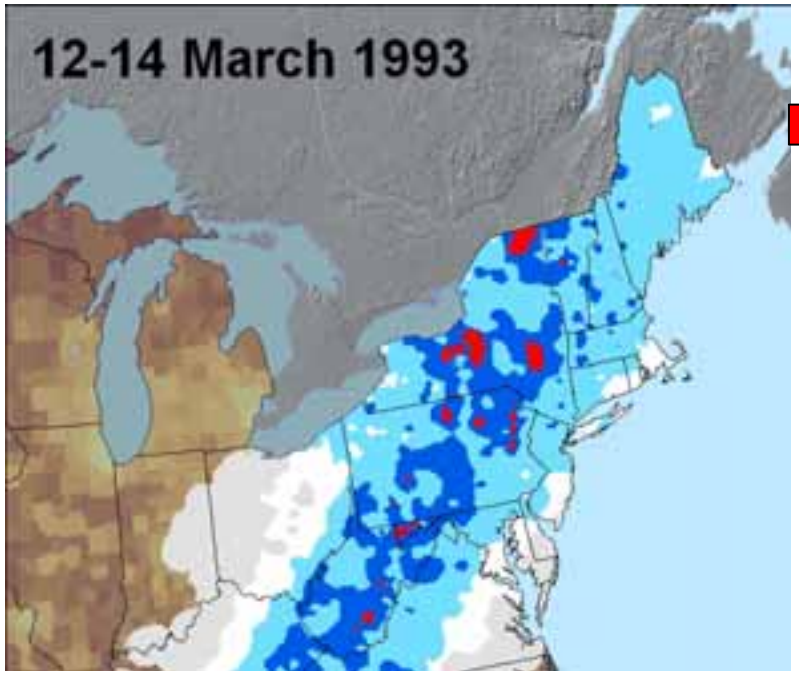
NESIS = 11.78
:
NESIS Category 5
Extreme

Uncertainty Issues

STORM	RANK	NESIS	Cat.
1993 Mar 12-14	1	13.20	5
1996 Jan 06-08	2	11.78	5
1960 Mar 02-05	3	8.77	4
1961 Feb 02-05	4	7.06	4
1964 Jan 11-14	5	6.91	4
1978 Jan 19-21	6	6.53	4
1969 Dec 25-28	7	6.29	4
1983 Feb 10-12	8	6.25	4



VALUE	SUM	AreaSqMi	STORM
0	6606070	70662	1993 Mar 12-14
1	25901600	166810	1993 Mar 12-14
4	**24494400**	**96427**	**1993 Mar 12-14**
10	**51712500**	**194843**	**1993 Mar 12-14**
20	**9577180**	**75400**	**1993 Mar 12-14**
30	**863108**	**6304**	**1993 Mar 12-14**

Consider simulating multiple maps to estimate a **sampling distribution**

Uncertainty Issues

- NESIS is very **sensitive** to the snow depth map
- Numerous **plausible** maps could be drawn from the point snow depth values
- Analogous to hand drawn maps by “experts”
- Simulate a NESIS *sampling distribution* by varying the spatial interpolation **parameters**.

$$\hat{s} = \frac{\sum_{i=1}^{n} \frac{1}{d_i^{p}} s_i}{\sum_{i=1}^{n} \frac{1}{d_i^{n}}}$$

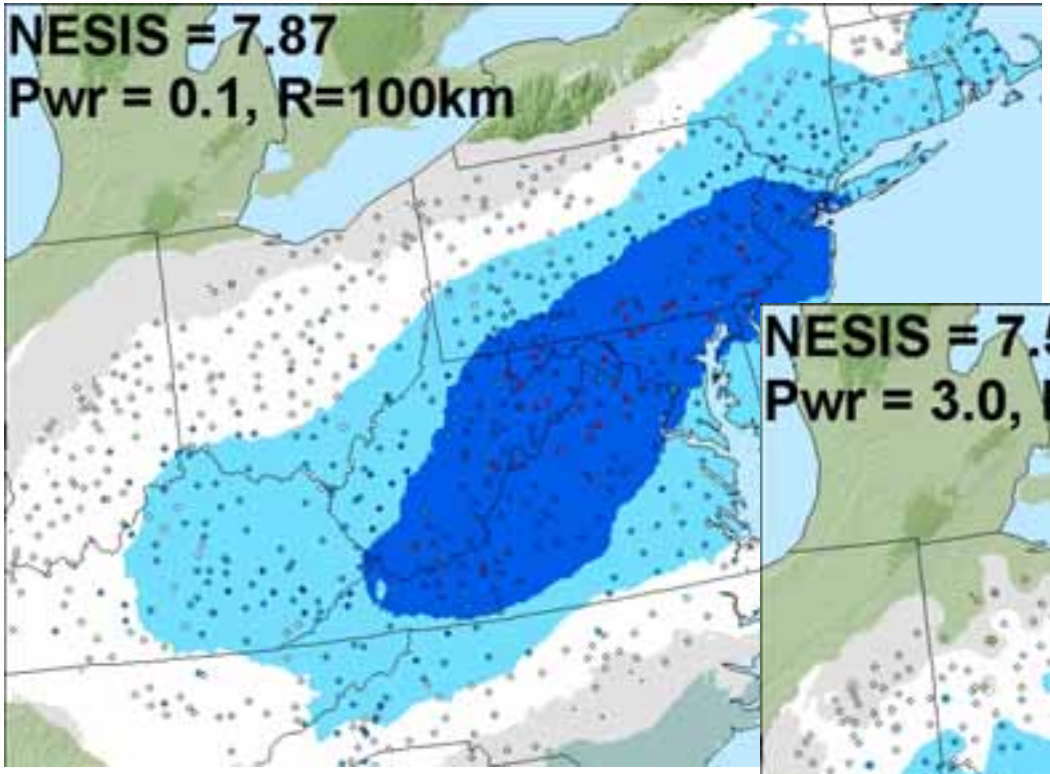
Where s = snowfall
p = **power parameter**
d = distance
n = # of stations within a set
radius parameter

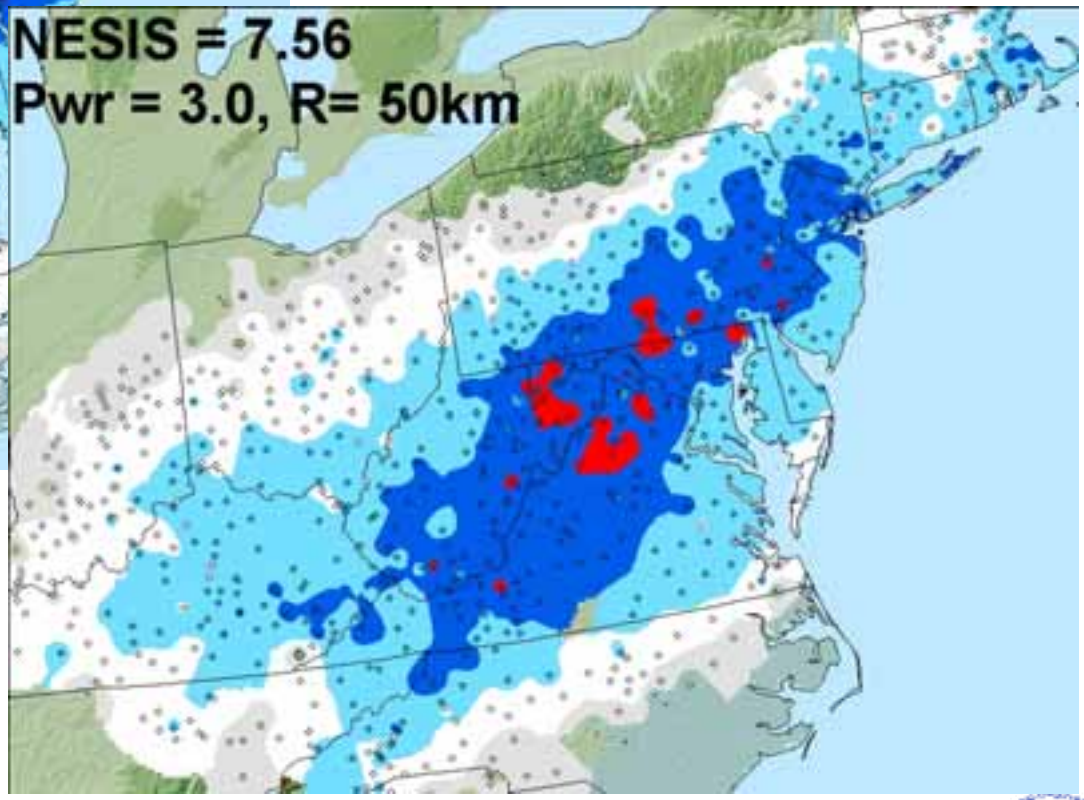
Uncertainty Issues: Choosing Parameters

- **Maps** need to be realistic
  - Simulate maps drawn by experts
    - Experts have different styles and biases
  - Parameters affect "smoothness"
    - Parameters mimic different styles and biases
- NESIS **sampling distribution** should be:
  - Normally distributed
  - Reasonable amount of variance

$$\hat{s} = \frac{\sum_{i=1}^{n} \frac{1}{d_i^p} s_i}{\sum_{i=1}^{n} \frac{1}{d_i^n}}$$

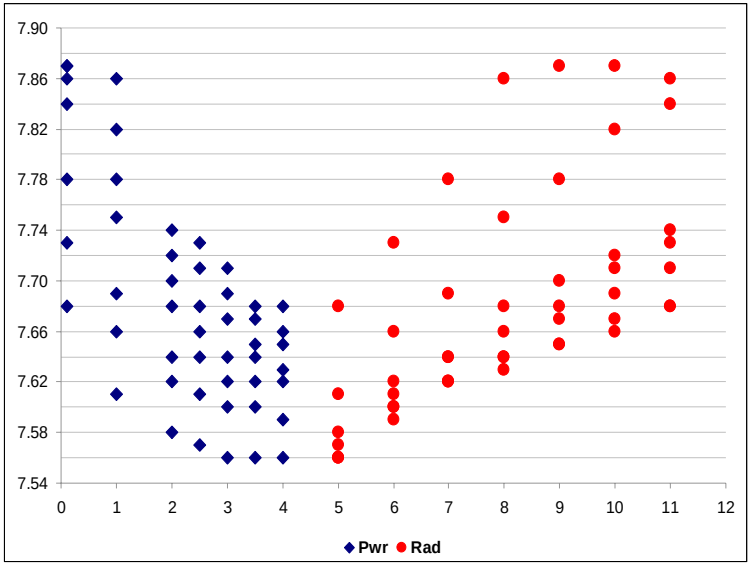
Uncertainty Issues: Choosing Parameters

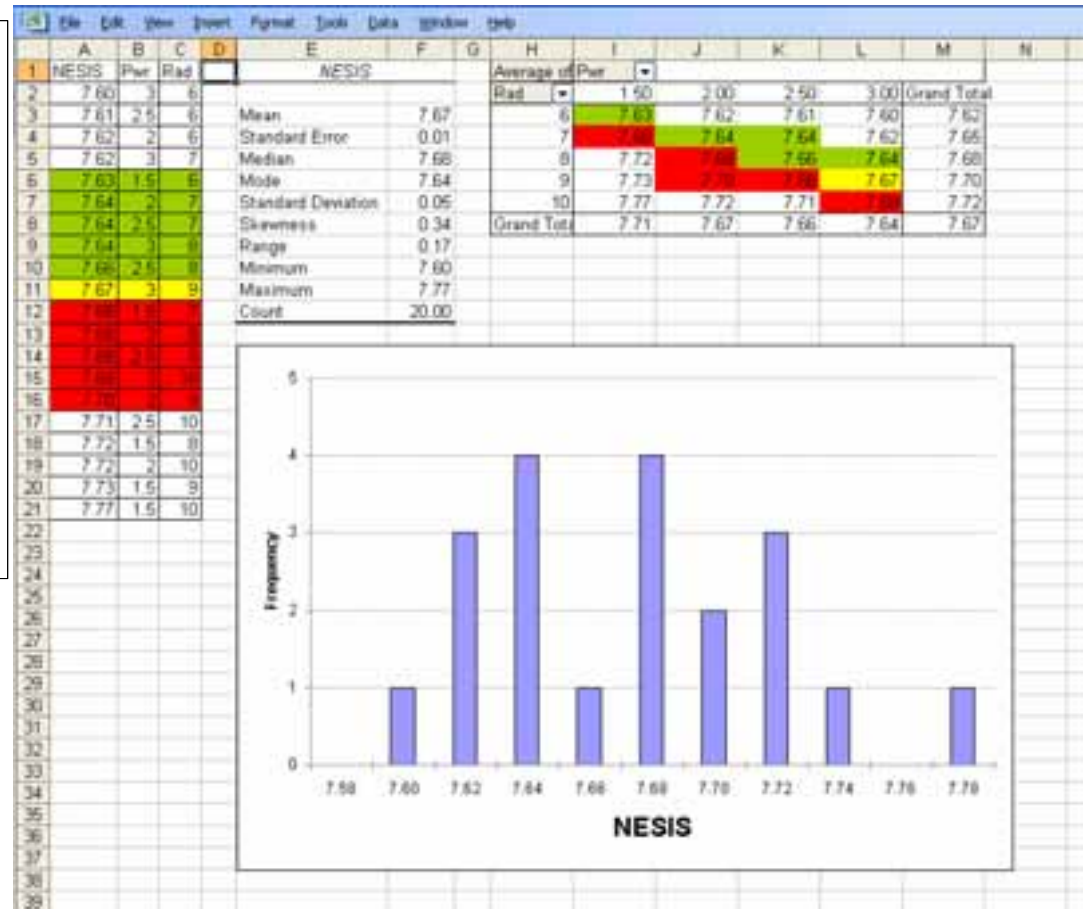




Trying to avoid
analysis paralysis!

Uncertainty Issues: Choosing Parameters





NESIS	
Mean	7.67
Standard Error	0.01
Median	7.68
Mode	7.64
Standard Deviation	0.05
Skewness	0.34
Range	0.17
Minimum	7.60
Maximum	7.77
Count	20.00

Average of Pwr / Rad	1.50	2.00	2.50	3.00	Grand Total
6	7.63	7.62	7.61	7.60	7.62
7	7.68	7.64	7.64	7.62	7.66
8	7.72	7.68	7.66	7.64	7.68
9	7.73	7.70	7.68	7.67	7.70
10	7.77	7.72	7.71	7.69	7.72
Grand Total	7.71	7.67	7.66	7.64	7.67

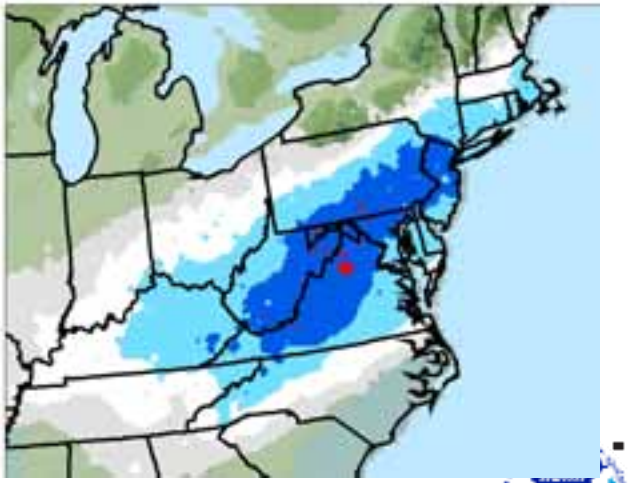
Trying to avoid
analysis paralysis!

Plausible Maps

NESIS = 11.82
Power = 3.00
Radius = 60

NESIS = 11.78
Power = 2.25
Radius = 75

NESIS = 11.73
Power = 1.75
Radius = 100



NESIS Sampling Distribution

NESIS SAMPLING DISTRIBUTION
1996-01-06_08

NESIS	Pwr	Nbr	Rad
11.78	175	99	060
11.76	175	99	070
11.76	175	99	075
11.76	175	99	077
11.75	175	99	080
11.74	175	99	085
11.74	175	99	090
11.73	175	99	100
11.77	200	99	060
11.77	200	99	070
	:		
11.80	275	99	090
11.79	275	99	100
11.82	300	99	060
11.81	300	99	070
11.80	300	99	075
11.80	300	99	077
11.80	300	99	080
11.80	300	99	085
11.80	300	99	090
11.80	300	99	100

DESCRIPTIVE STATISTICS FOR THE NESIS SAMPLING DISTRIBUTION

N = 48

Measures of Central Tendency ...

Mean = 11.78
Median = 11.78
TriMean = 11.78

Measures of Spread ...

Range = 0.10
Standard Deviation = 0.02
InterQuartile Range = 0.03
Median Absolute Dev = 0.02

Measures of Symmetry ...

Yule-Kendall index = 0.31
Skewness coefficient = -0.43

Quantiles ...

Min = 11.73
25% = 11.77
50% = 11.78
75% = 11.80
Max = 11.82

FINAL RESULTS ...

NESIS = 11.78 +/- 0.04 (11.74 ... 11.78 ... 11.82)