Selected Presentation from the INSTAAR Monday Noon Seminar Series.

Institute of Arctic and Alpine Research, University of Colorado at Boulder.
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10 Mar. 2003 **Chris Jenkins,** INSTAAR, Email: Chris.Jenkins@instaar.Colorado.Edu
“ The Importance of Being Uncertain.”

Jenkins presentation (0.8 Mb PDF).

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10 Mar. 2003 **Chris Jenkins,** INSTAAR, Email: Chris.Jenkins@instaar.Colorado.Edu
“ The Importance of Being Uncertain.”
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Abstract

By considering uncertainty in data, it is often possible to remove impediments in research, particularly in interdisciplinary environmental research. This will by demonstrated with sea floor data examples.

‘The Importance of Being Uncertain’

Chris Jenkins
(chris.jenkins@colorado.edu)

- Nothing can be as bad as uncertainty. Philip Wylie & Edwin Balmer / When Worlds Collide 1932)

- Uncertainty is the Inner Circle of Hell. Anne Finger.

+ Education: the path from cocky ignorance to miserable uncertainty. Mark Twain.

+ Uncertainty and mystery are energies of life. Don't let them scare you unduly, … they keep boredom at bay and spark creativity. R. I. Fitzhenry

± It is the mark of an instructed mind to rest satisfied with the degree of precision which the nature of the subject permits and not to seek an exactness where only an approximation of the truth is possible. Aristotle

? It is very romantic to be in love. But there is nothing romantic about a definite proposal. ... Then the excitement is all over. The very essence of romance is uncertainty. If ever I get married, I'll certainly try to forget the fact. Oscar Wilde via Algernon

- Counters biases arising from human cognition
- Adds rigor and ability to update judgements
- Utilizes the way people work and problem solve

Quotes after Booker et al (2002) at Los Alamos Nat. Lab.

Types of Uncertainty

1. Variability, Error, Uncertainty, Reliability, Risk

2. Probabilistic:
   - Outcomes, Likelihood…
   - Objective - Experimental
   - Subjective – Willing to wager

Fuzzy:
   - Vagueness, ambiguity…
   - Memberships

Others …

A Dissection of Uncertainty in Data

Measurement uncertainty

From:
- Difficulties of sampling and instrument deployment
- Fine-scale variations relative to the footprint of the devices or samplers
- Inexact calibrations
- Physical and arithmetic assumptions
- Lack of control over other phenomena that affect the measurements

Often divided between precision and accuracy
- Precision - usually the smaller, and are judged using the scatter in replicate measurements
- Accuracy - the deviation of measurements from a known standard or the mean of a variety of analyses

Validity uncertainty

When the measured data does not correspond in its meaning, reporting, completeness, time scale or dimensional scalings to what is required by the final project.

Spatial uncertainty

Because the seabed has a natural spatial variation ('inhomogeneity' e.g., zones and patches) when not completely determined by geographic patterns of sampling and measurement.

Temporal uncertainty

From seasonal or long-term changes

Additive as variances

$\sigma^2_{total} = \sigma^2_{measurement} + \sigma^2_{validity} + \sigma^2_{spatial} + \sigma^2_{temporal}$.

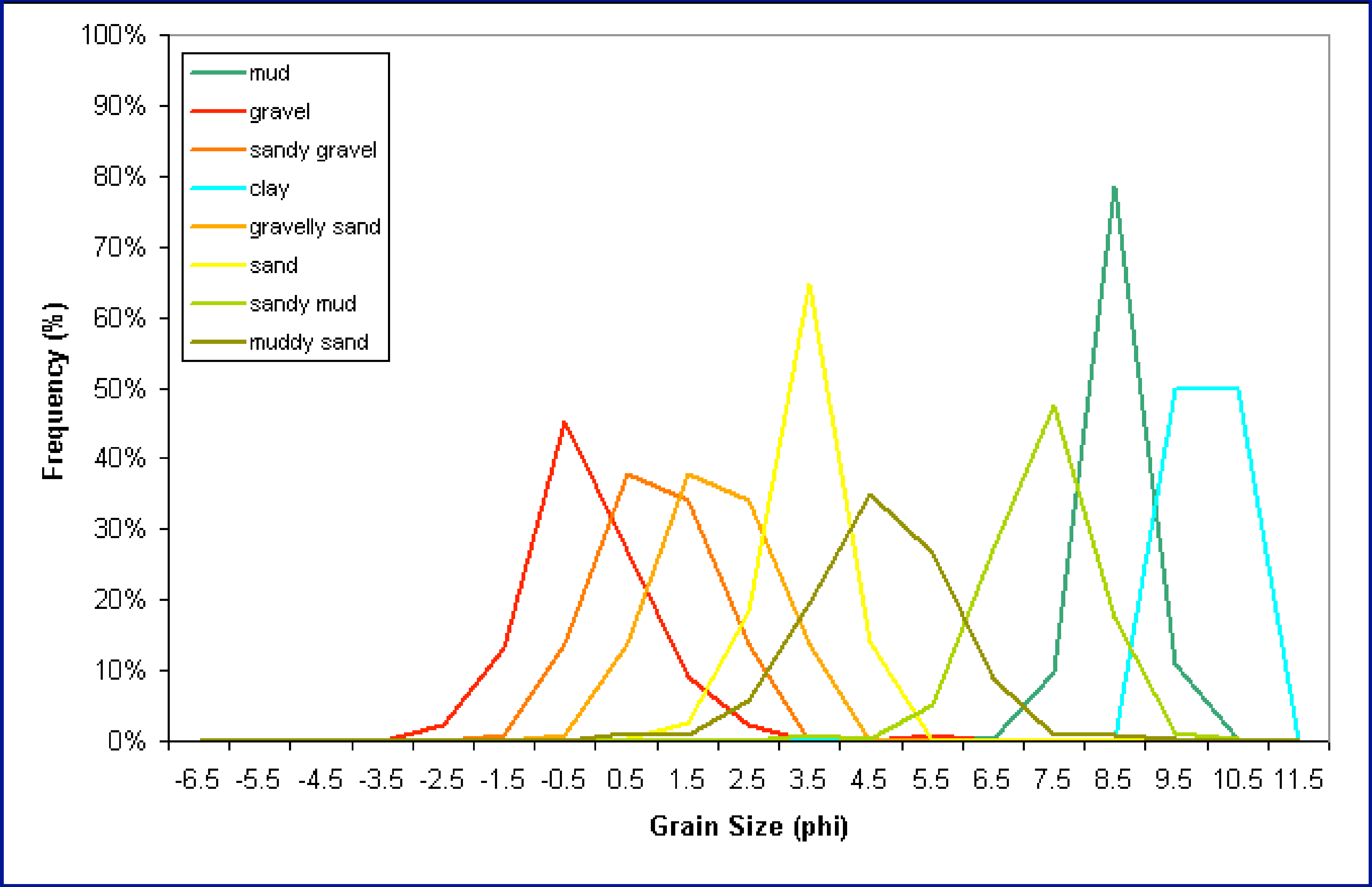
In practice the types of uncertainty cannot always be separated – for any one technique are combined / unresolved.

Measurement Uncertainty

Parameter	Max absolute error *	σ	Unit	N	Dynamic range	Circumstance (reference)	CV	CV_r
Mean grainsize	0.36	0.4	phi	30	-10 to +12	mud [1]	7.7%	3.5%
	1.6	0.5		21	"	sand [2]	30.2%	4.3%
Sorting			phi		0 to 6			
Grainsize fractions	5.9-19.9	0.4-1.3	%	20	0 to 100	sand-silt-clay [3]	1.1-5.3%	0.9-2.7%
	46.3	4.9		93	"	gravel (in GSM) [4]	36.8%	9.7%
	10.6-17.5	2.9-3.5		93	"	sand (in GSM) [4]	19-45%	5.8-7%
	8.2	1.9		93	"	mud (in GSM) [4]	24.5	3.7%
Carbonate content	2.8	1.92	%	11	0-100	pelagic sediment trap [6]	3.4%	3.8%
	14	1.2		93	"	gravel-sand-mud [4]		
Organic Carbon	0.19	0.16	%	11	0-10	pelagic sediment trap [6]	46.4%	3.3%
P-wave velocity	15-20	-	m/s	-	1500-3500	- [7]	1%	1.5-2%
	70	-		-	"	dispersion [8]	-	7%
S-wave velocity	7.5	-	m/s	13	0 to 200	in situ [9]	-	~5%
	11.6	-		13	"	laboratory [10]	-	~8%
Porosity	4-7	-	%	-	0 to 100	- [11]	-	8-14%
Critical shear stress	1.0	1.1	m/s^2	29	0 to 100	mud [12]	134%	2.2%

Table T. Summary of information on usual magnitude of measurement error for some properties of the seabed. [From mean or expected.]*

Identification Uncertainty

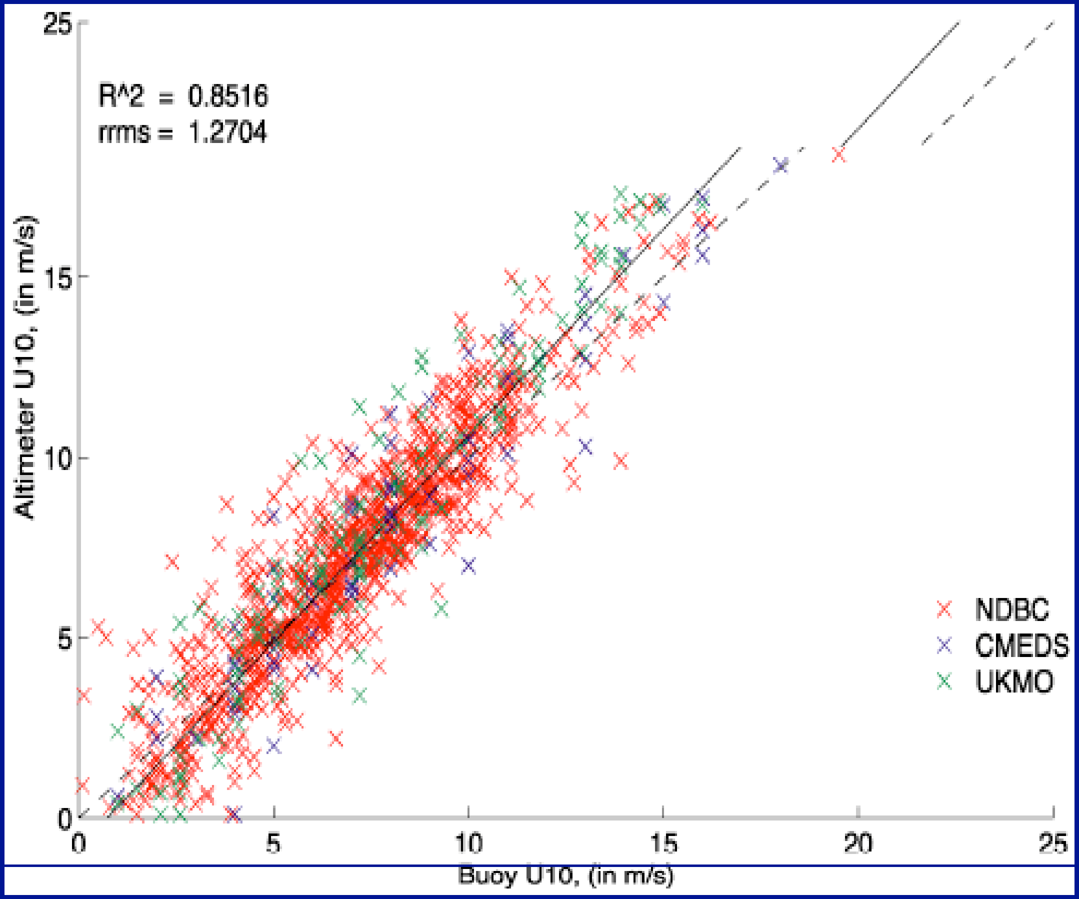


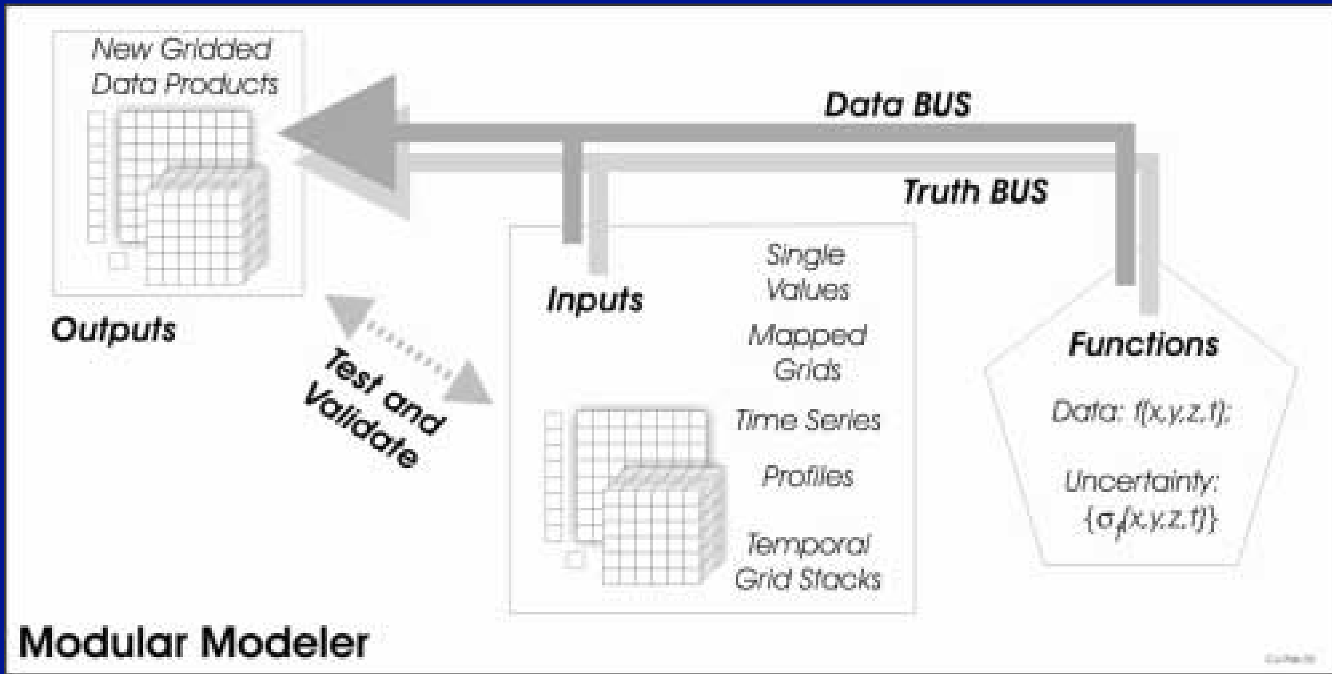
Membership(sand)={0,1,3,10,60,33,5,0}(-1,…,6) %

Remote Sensing and Calibration

Location, Footprint

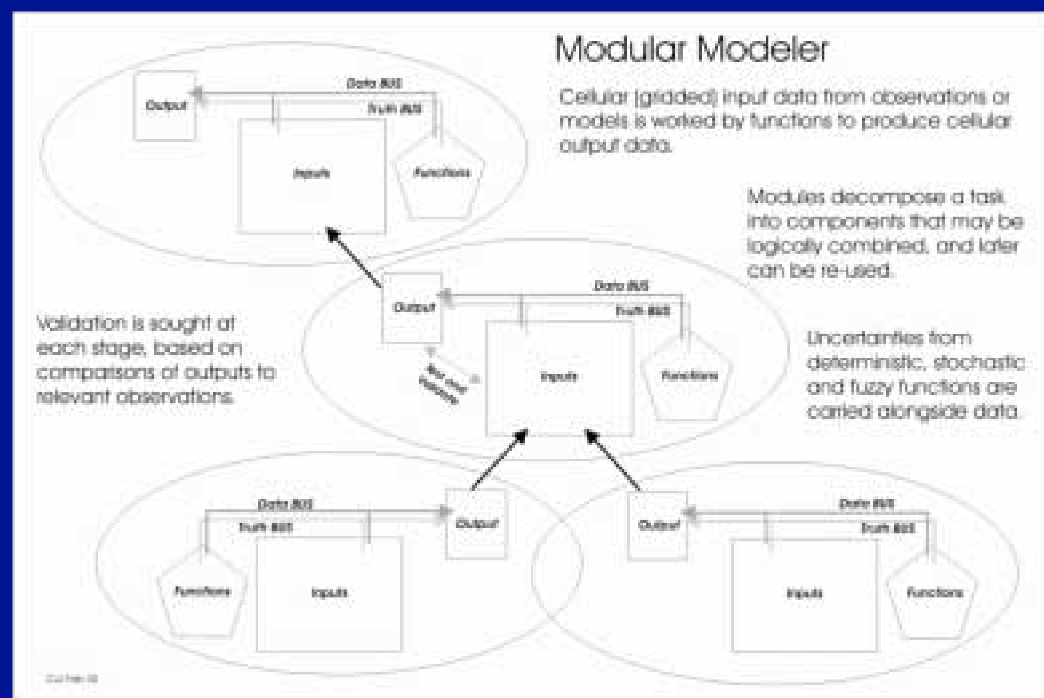
Geophysical Surrogate<>Phenomenon





Uncertainty in Modeling

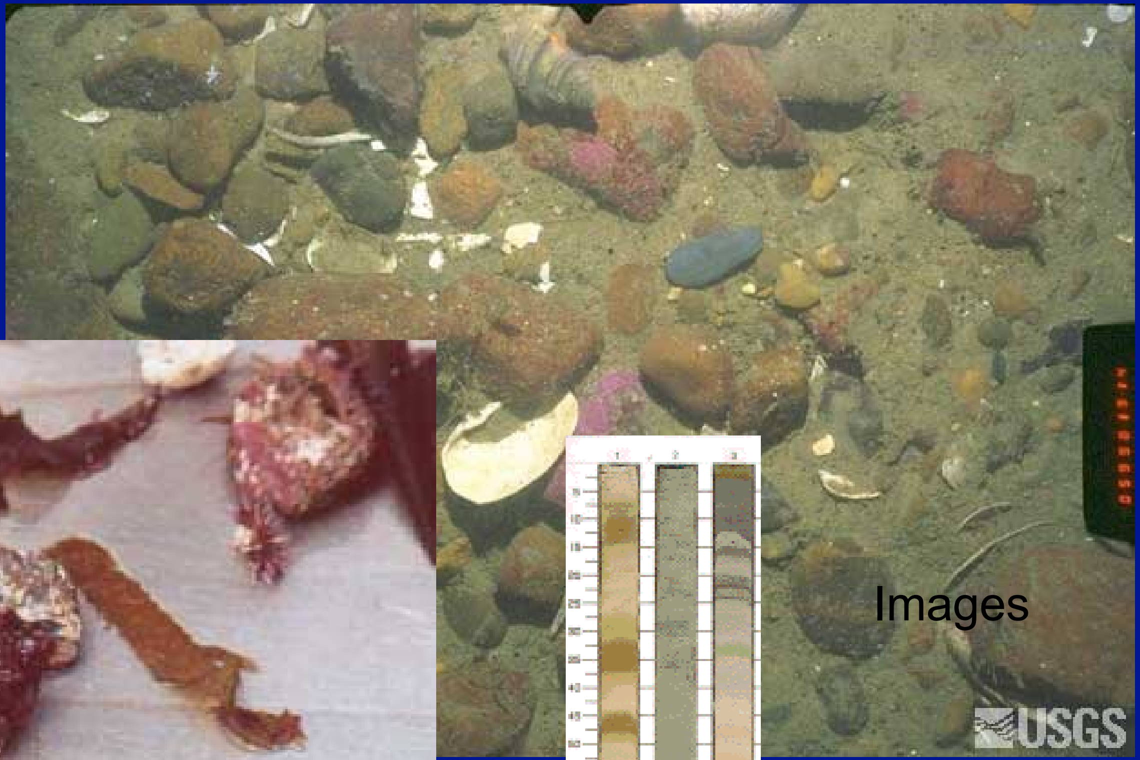
- Especially Climate Change Models (eg Cipra, B. 2000)
- Data vs Models vs Remote Sensing
- Risk analysis after modelings

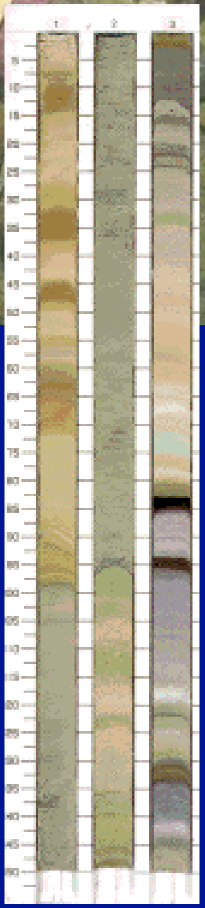


Uncertainty is extremely important in relationships

Data sets　　　　Information fusion

Incompatible Techniques ?





Cores

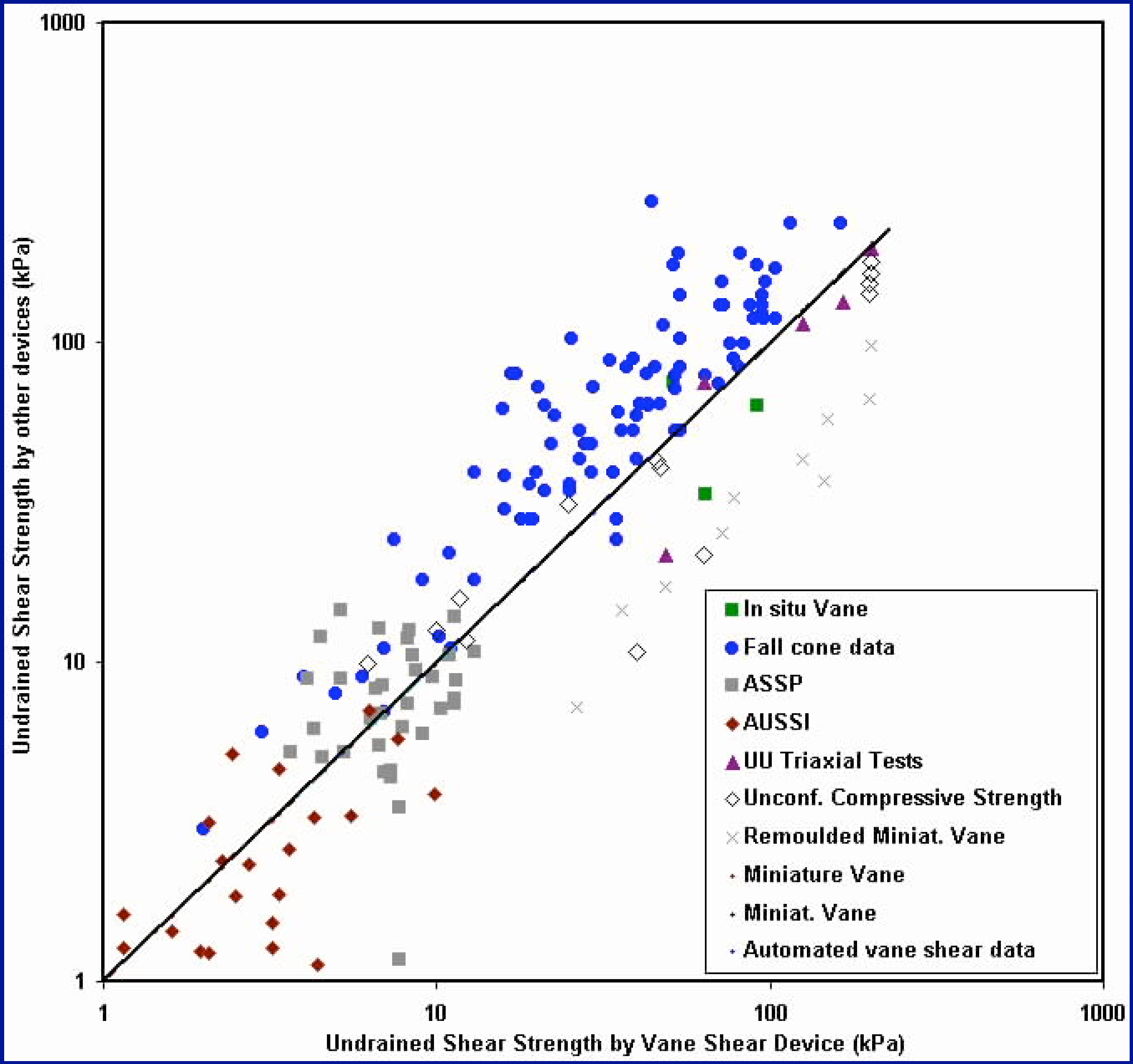
What is THE composition of the seafloor ?

Measurement error: merging data from different instruments

Case of Seafloor Shear Strengths (Undrained, Uncompressed)

•Devices for field / lab, fluid / loose / hard
•Multiplicative vs additive error
•Pristine / Remoulded
•The 'nearby' factor

What is THE shear strength ?



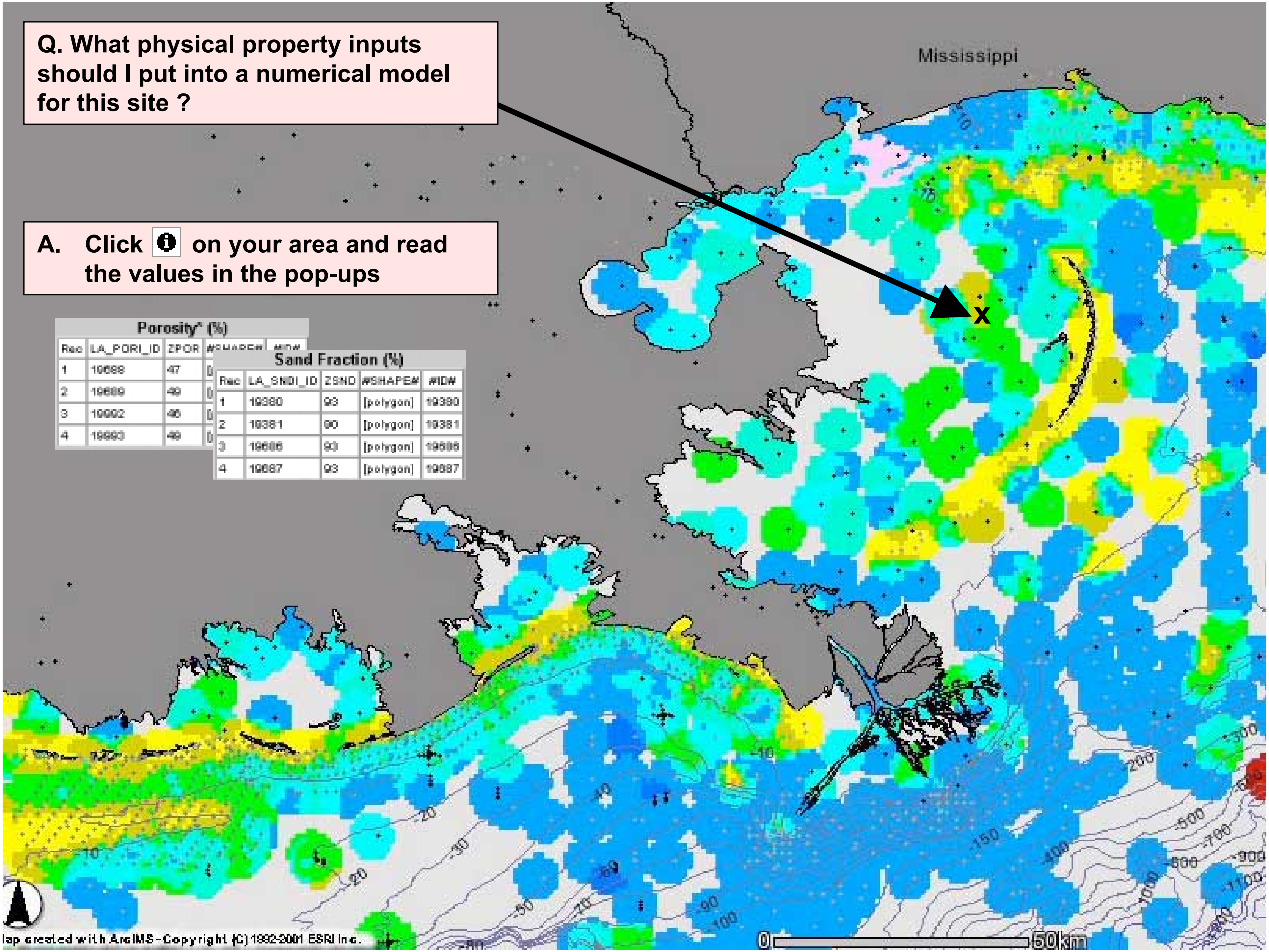
Spatial Variability Issues

Q. What physical property inputs should I put into a numerical model for this site ?

A. Click ℹ on your area and read the values in the pop-ups

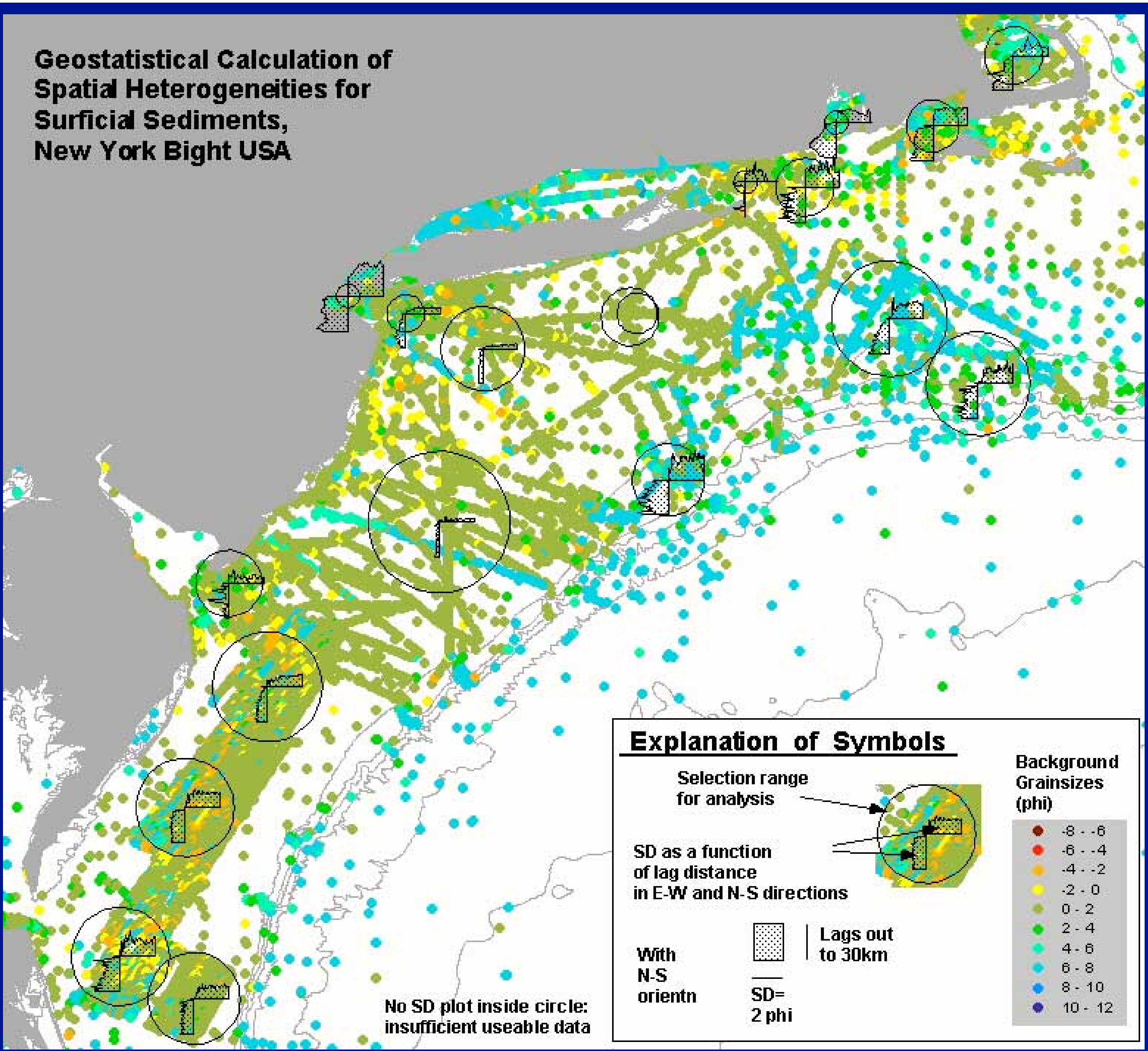
Porosity* (%)				
Rec	LA_PORI_ID	ZPOR	#SHAPE#	#ID#
1	19688	47	[illegible]	[illegible]
2	19689	49	[illegible]	[illegible]
3	19992	46	[illegible]	[illegible]
4	19993	49	[illegible]	[illegible]

Sand Fraction (%)				
Rec	LA_SNDI_ID	ZSND	#SHAPE#	#ID#
1	19380	93	[polygon]	19380
2	19381	90	[polygon]	19381
3	19686	93	[polygon]	19686
4	19687	93	[polygon]	19687



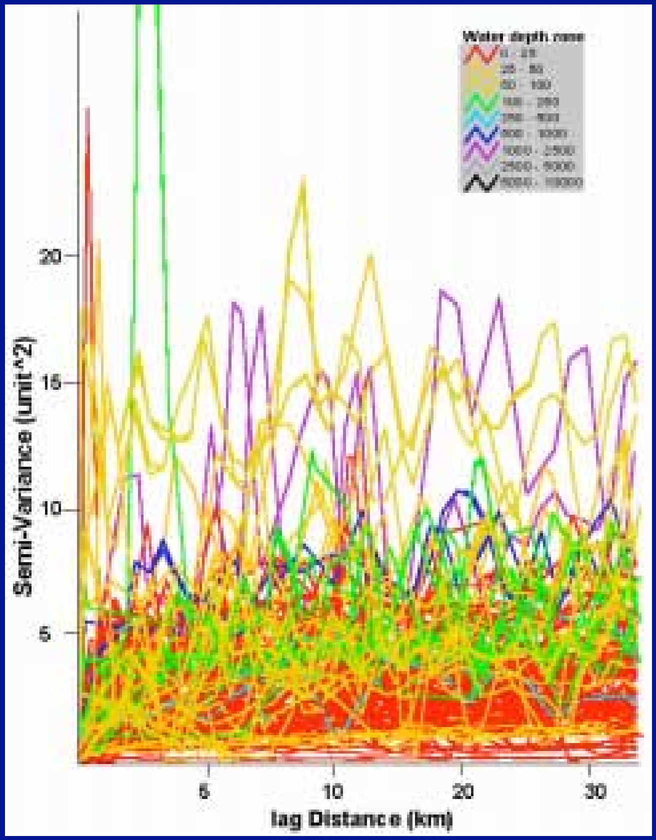
Spatial variability – a principal cause of uncertainty in environmental data

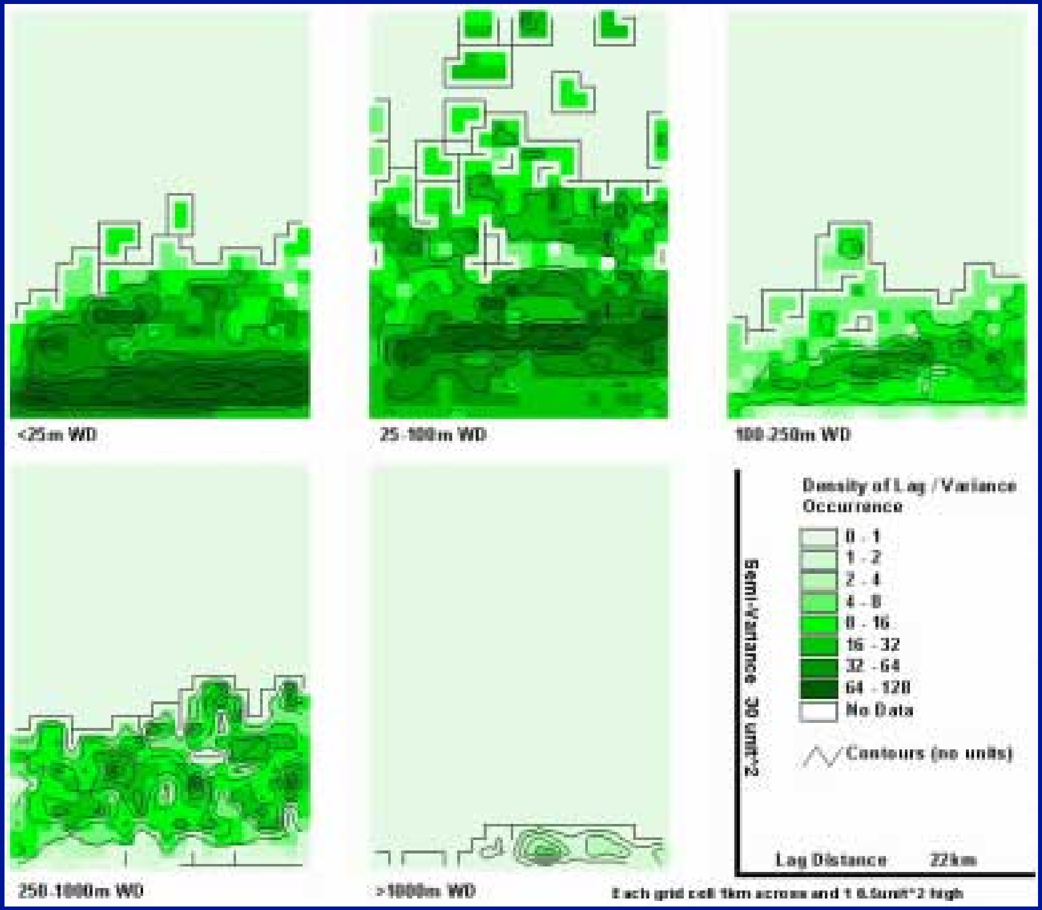
- Geostatistics of seabed heterogeneity across many environments and locations; in this case plotted using semivariograms



Spatial Heterogeneity of US Atlantic Margin Surficial Sediments

The total accumulation of observed semi-variograms for parameter grainsize from 100 sites (EW and NS directions). How can we synthesize this data ?





One method is to view the results by depth zones. Then mid-shelf and upper slope environments have consistently higher levels of patchiness. Inshore estuarine and marine are strongly distinguishable, abyssal areas have relatively no patchiness. (Note: 30 semivar units = 7.7phi SD)

Conveying Uncertainty

The Geographer's Problem

Visualizing Uncertainties

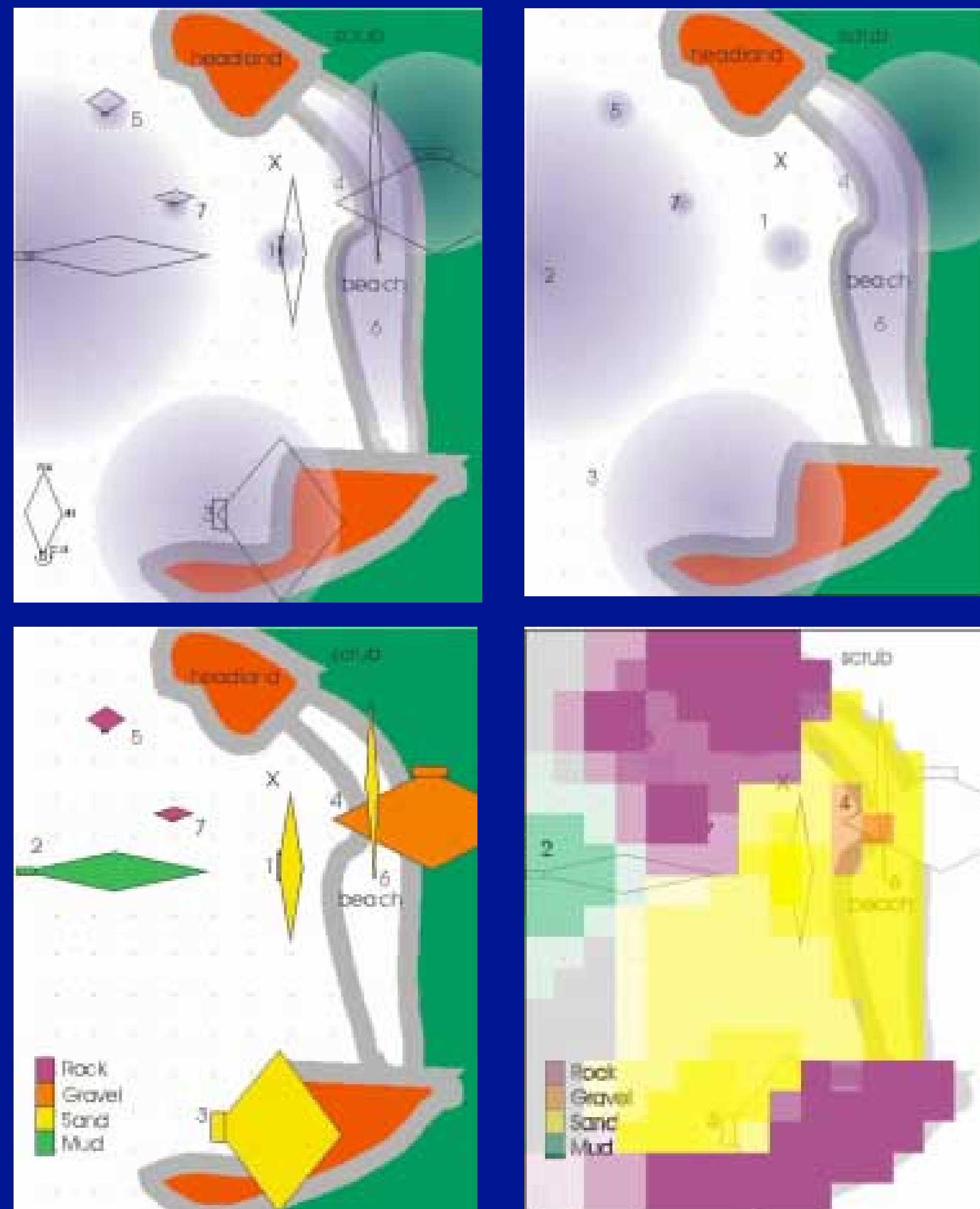
The Geographer's Problem is how to deliver the complexity of data b ut not bamboozle map-readers (products and symbolisms need to be intuitive)

We can visualize uncertainties using several techniques that are under development:

- glyphs for points
- translucency for grids

Note that in (a) the large grey haloes around the more uncertain points are wholly inappropriate: larger the less value.

Note that glyphs can separate locational from attribute uncertainty (vertical & horizontal sizes of glyph)



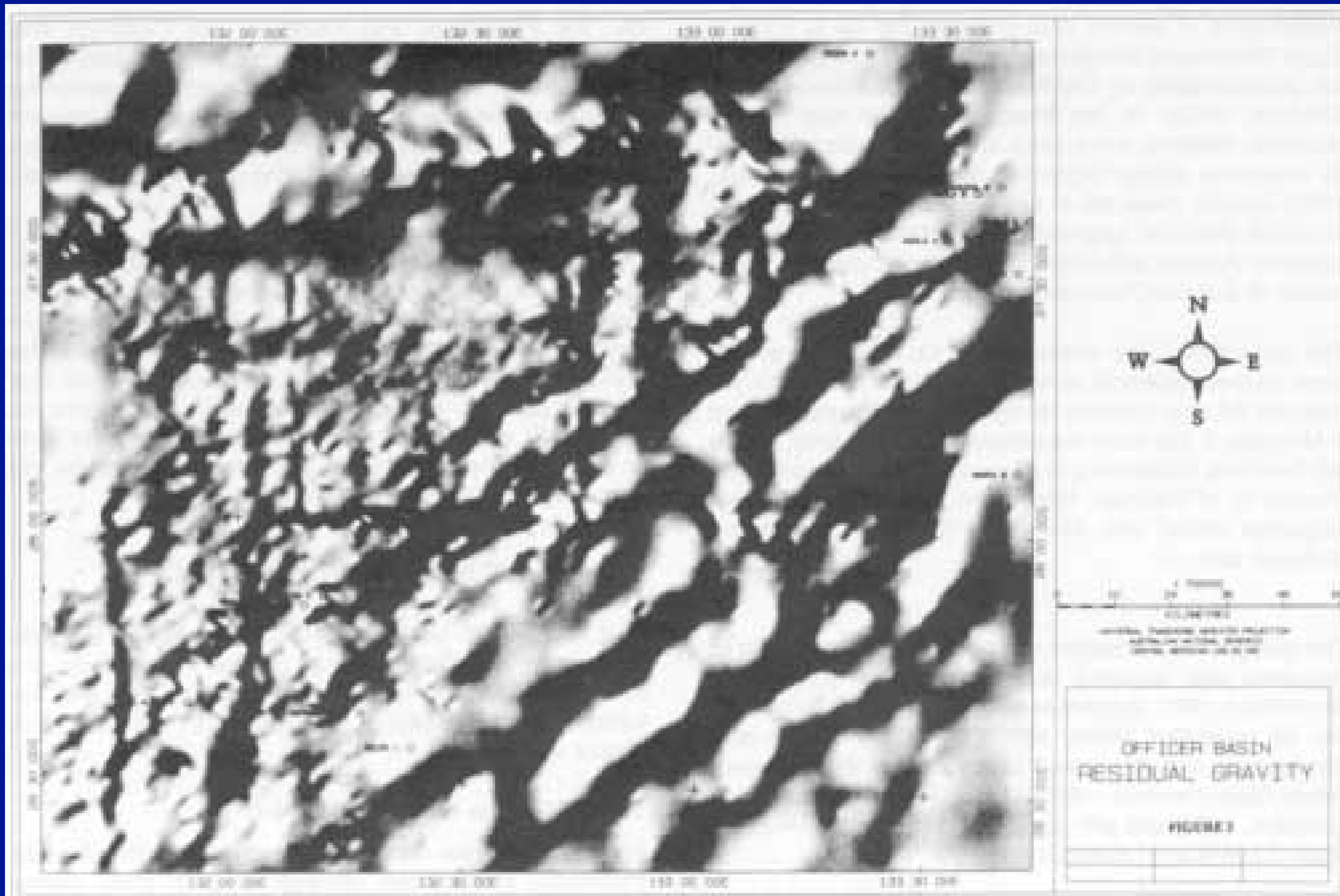


Fig. 2. Residual Gravity. Gray scale image produced from 20km and 500m regional gravity grids (MESA). Underlying E-W and NE-SW trends are overprinted by data collection "anomalies" along traverse lines and at sample points.

Another option: increase granularity as
resolution / certainty increase

End

References:

Cipra B. 2000. Revealing uncertainties in computer models. *Science* **287**, 960–961.

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With thanks to the following sources for illustrations:

Center for Space Research, University of Texas (http://www.tsgc.utexas.edu/topex/buoy/)

Travel Pictures, 3B Uplands Close, Sheen, London SW14 7AS UK (*www.travelpictures.co.uk*)

Australian Petroleum & Production Exploration Assoc. (http://www.appea.com.au/)

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ODP Texas A&M Univ., Database Services (http://www-odp.tamu.edu/isg/database.html)

Oxford University Press (http://www.oup.co.uk/)