Bathymetric Uncertainty Assessment

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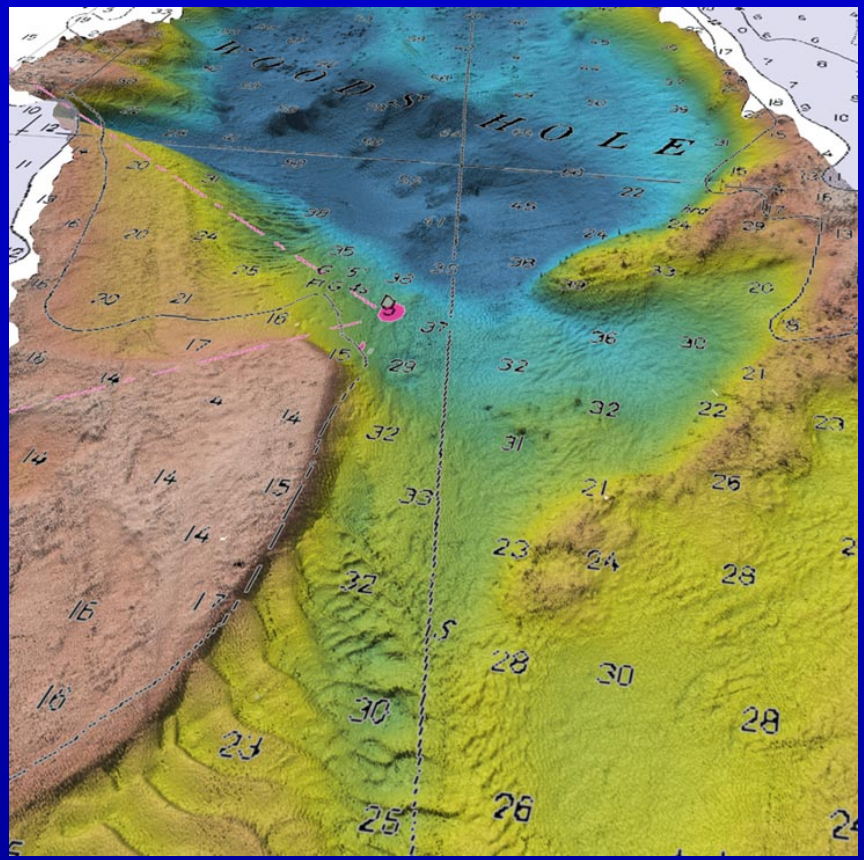
Assessing Bathymetric Uncertainty

- Components:
  - Measurement uncertainty
  - Processing uncertainty
  - Sub-/Under-sampling (space, time) uncertainty
  - Reconstruction uncertainty
- Goals:
  - Understand the components of the uncertainty
  - Provide robust methods for estimating uncertainty
  - Convey uncertainty to users of data (essential for responsible use of data)

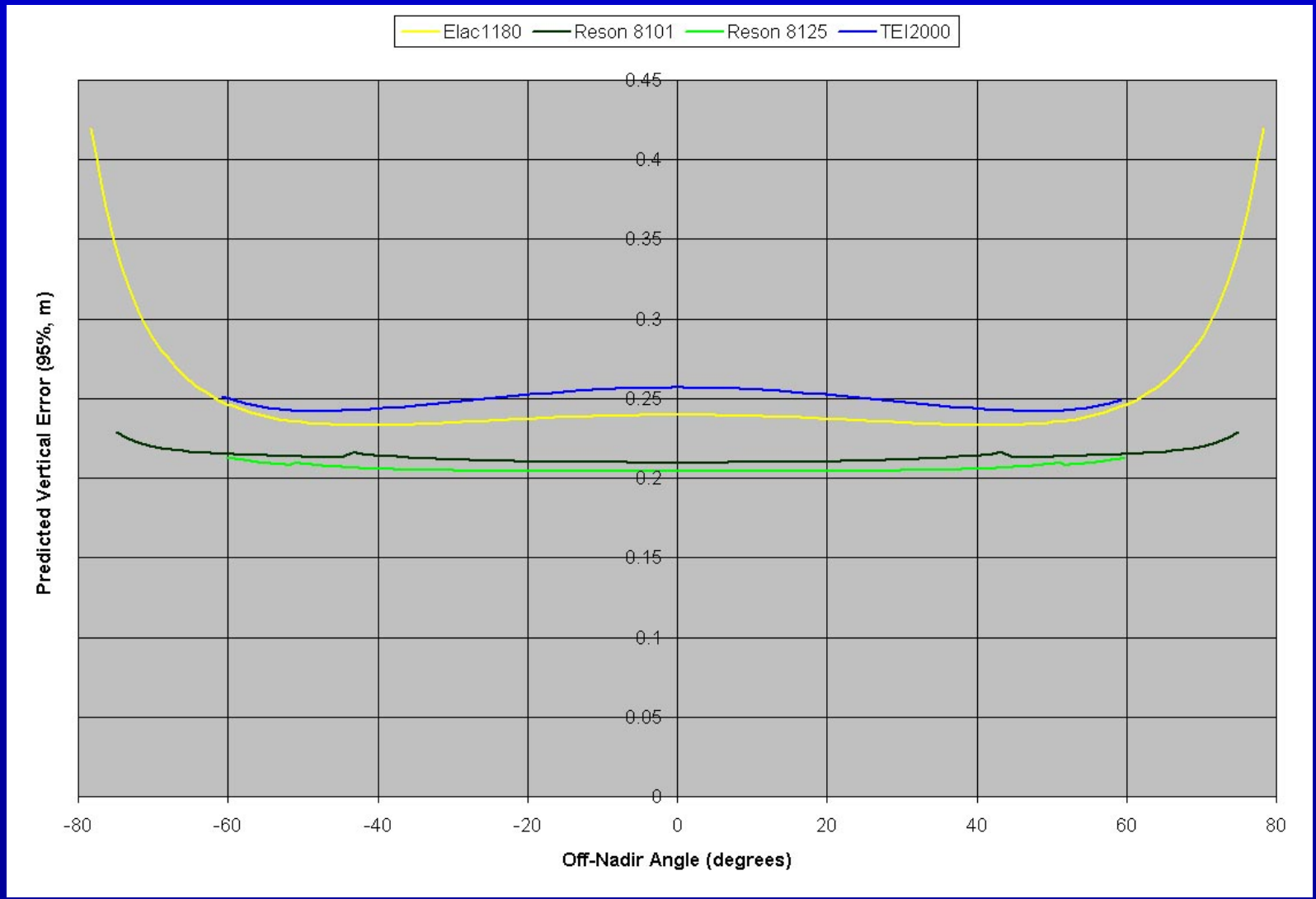
Modern Multibeam Data (CUBE Algorithm)



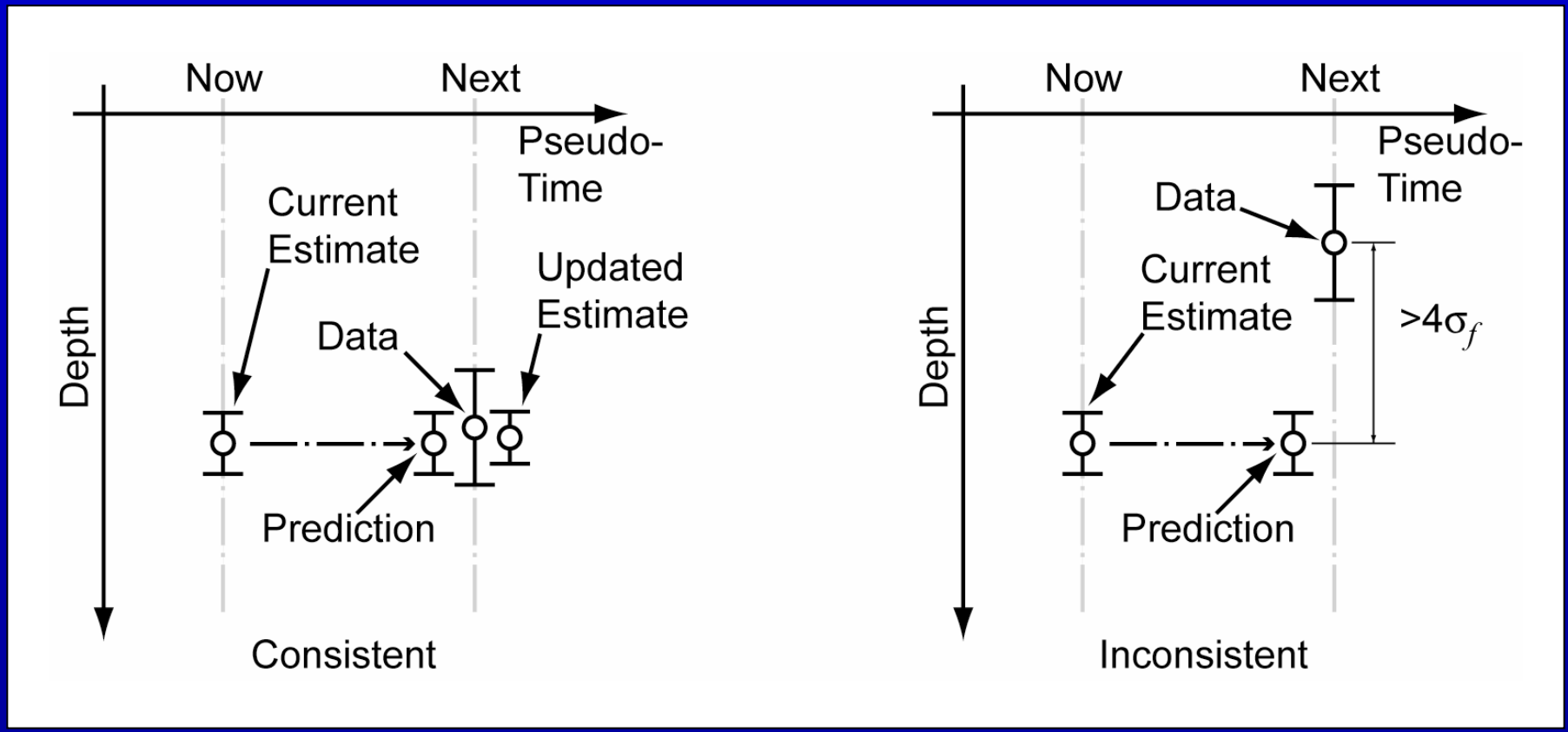
Data: Woods Hole, MA
NOAA Ship Whiting/H11077 (2001)/NOS Chart 13235

- Typically dense, high resolution data
- Limitations:
  - Measurement error
  - Spatio-temporal error in sound speed, tides
  - Subjective processing
- Primary source for hydrographic data in US waters

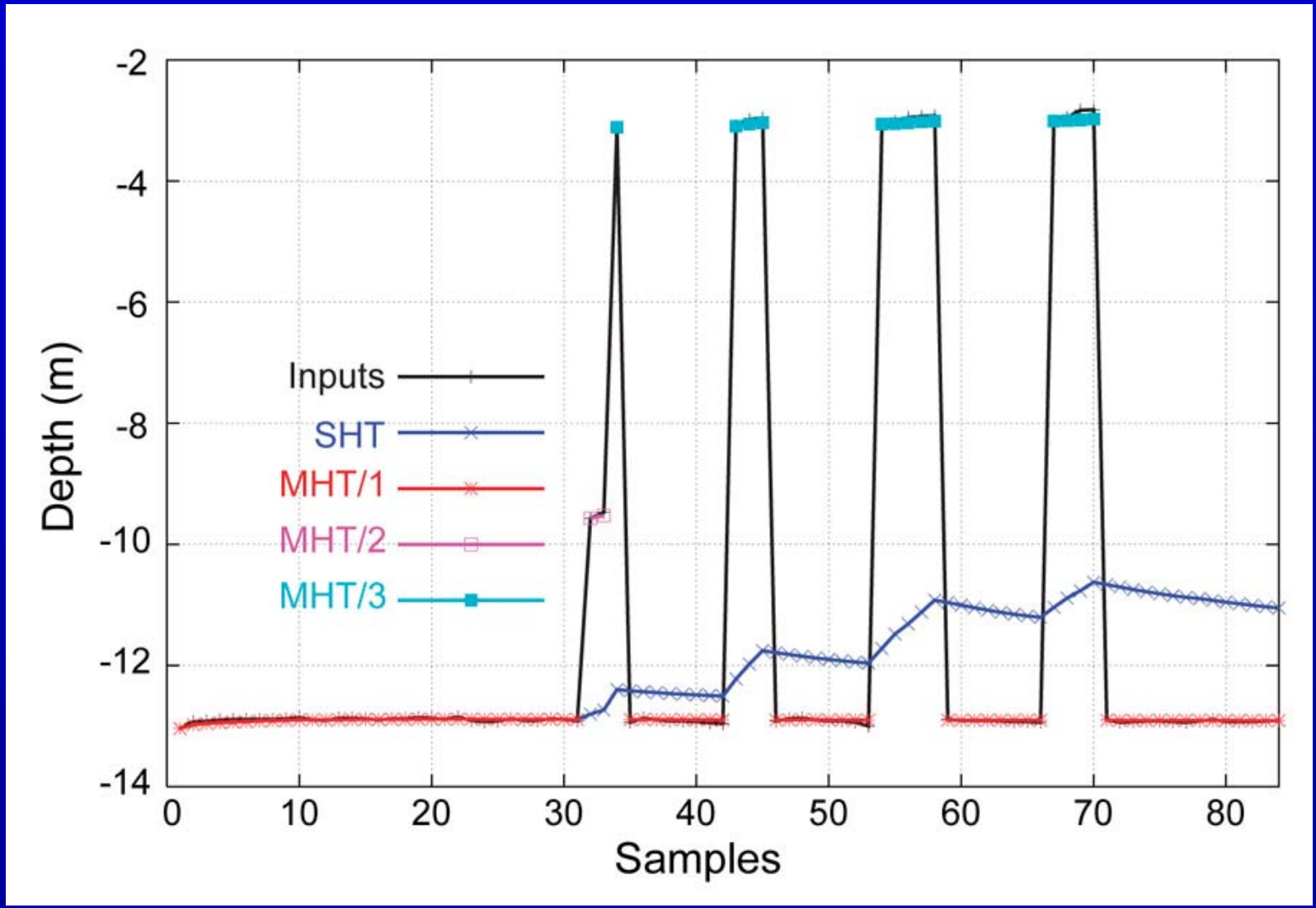
MBES Measurement Error Model



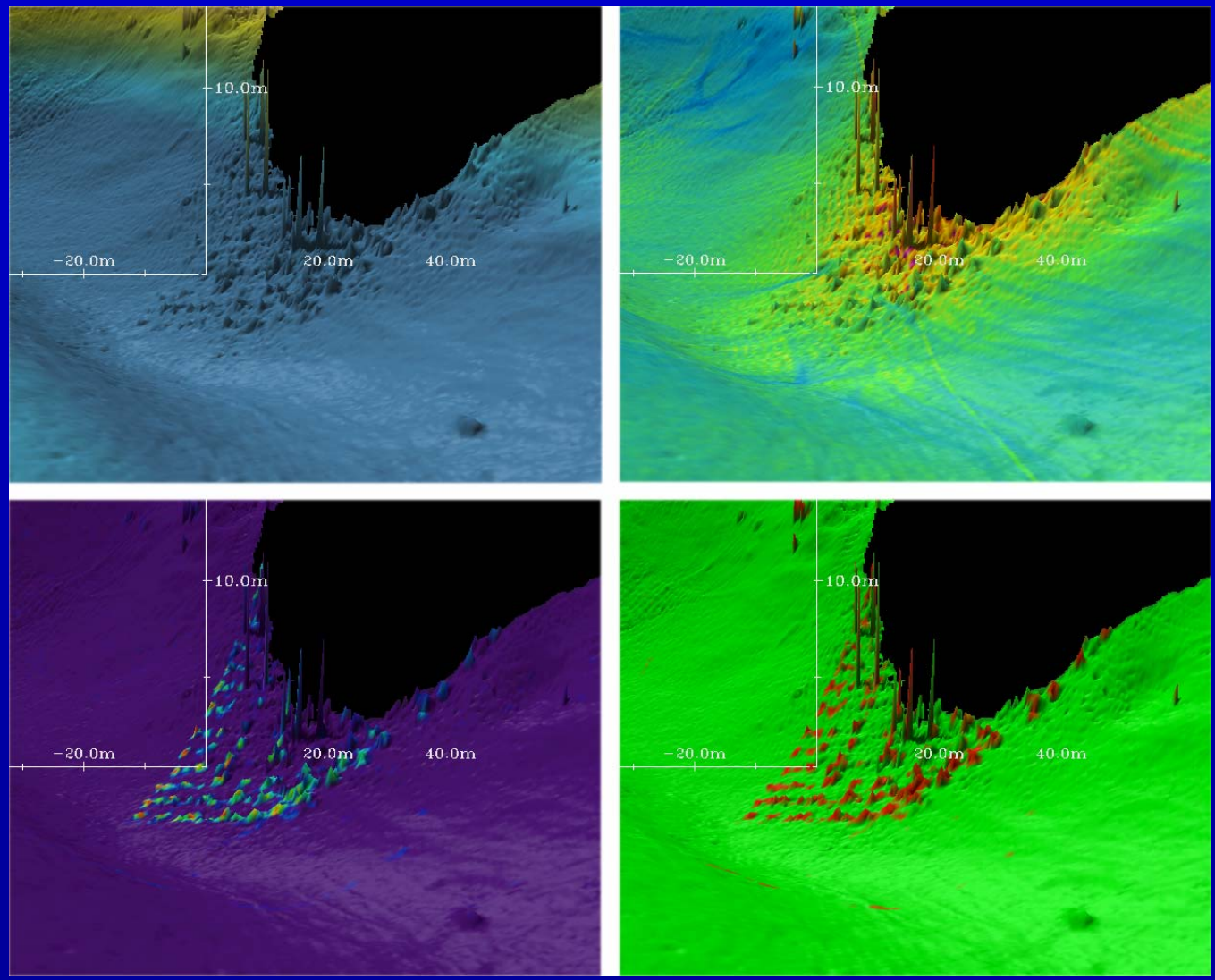
CUBE Multiple Hypothesis Construction



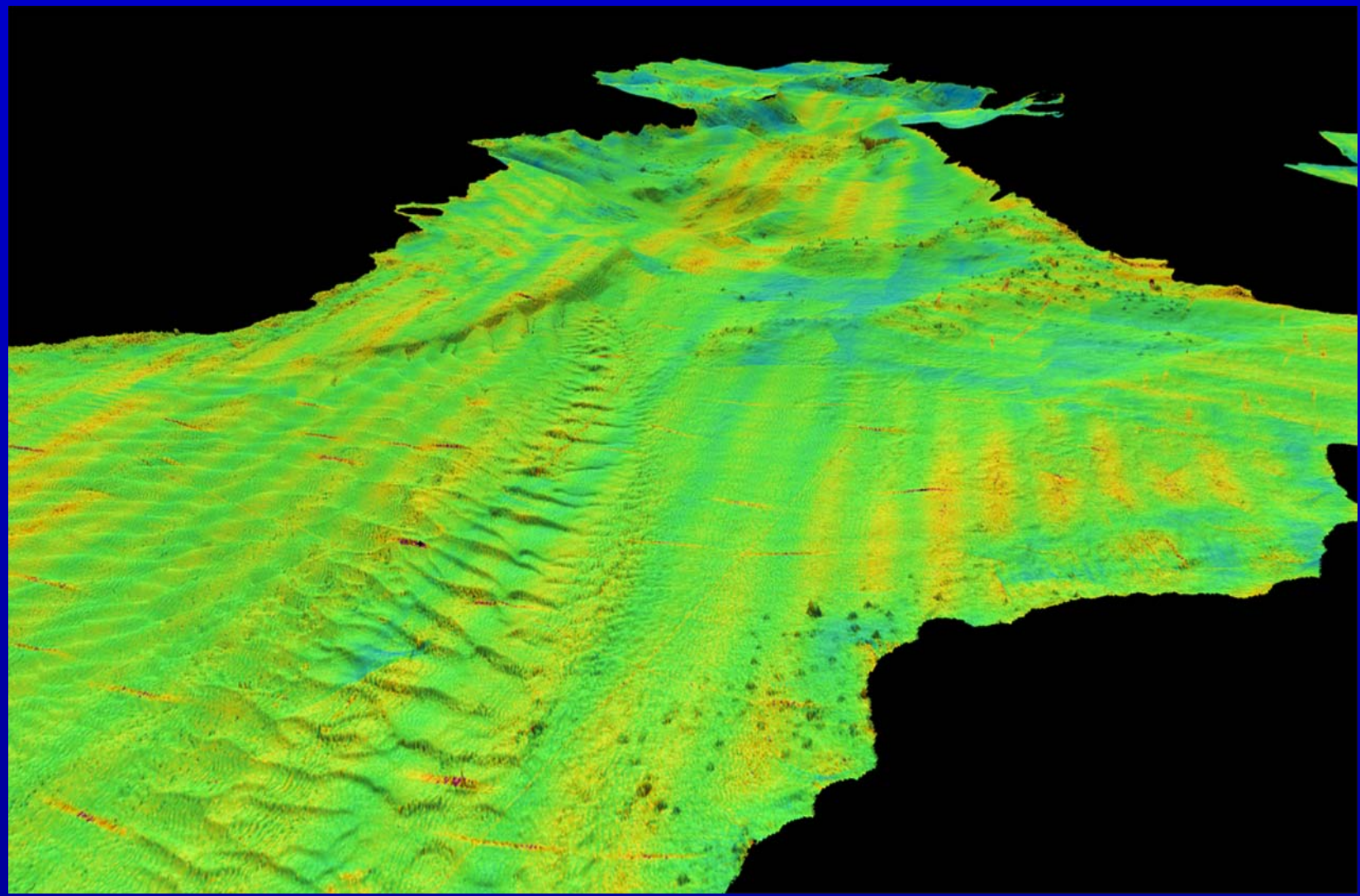
CUBE Hypothesis Tracking



Multiple Outputs: Multiple Uncertainties

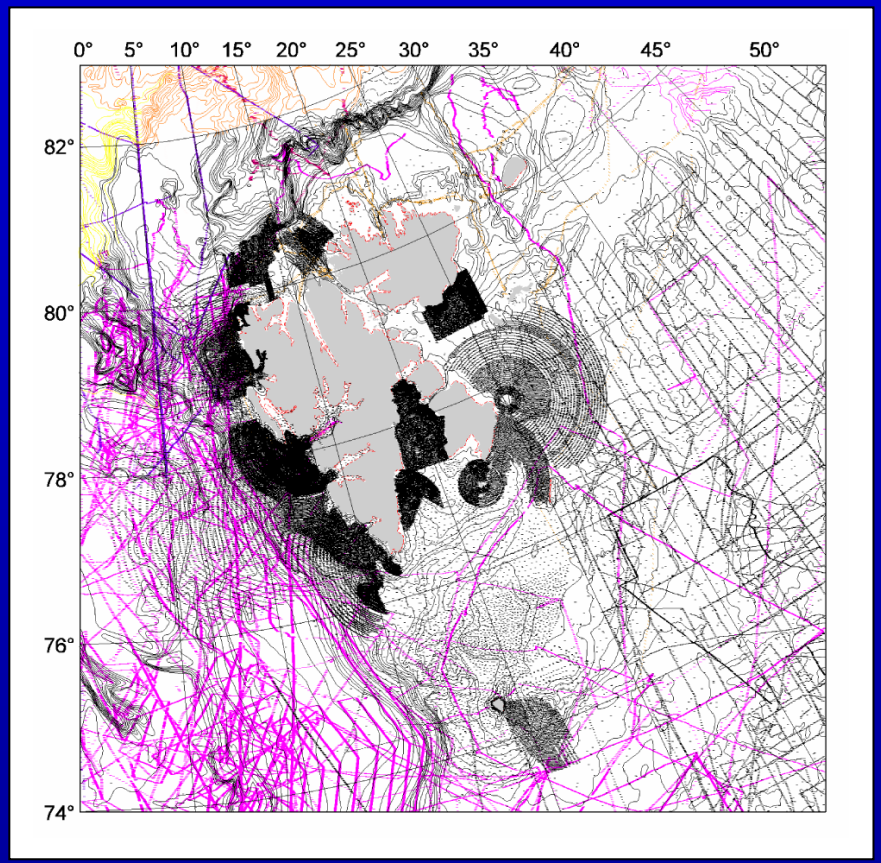


Guidance for the User: Uncertainty Maps



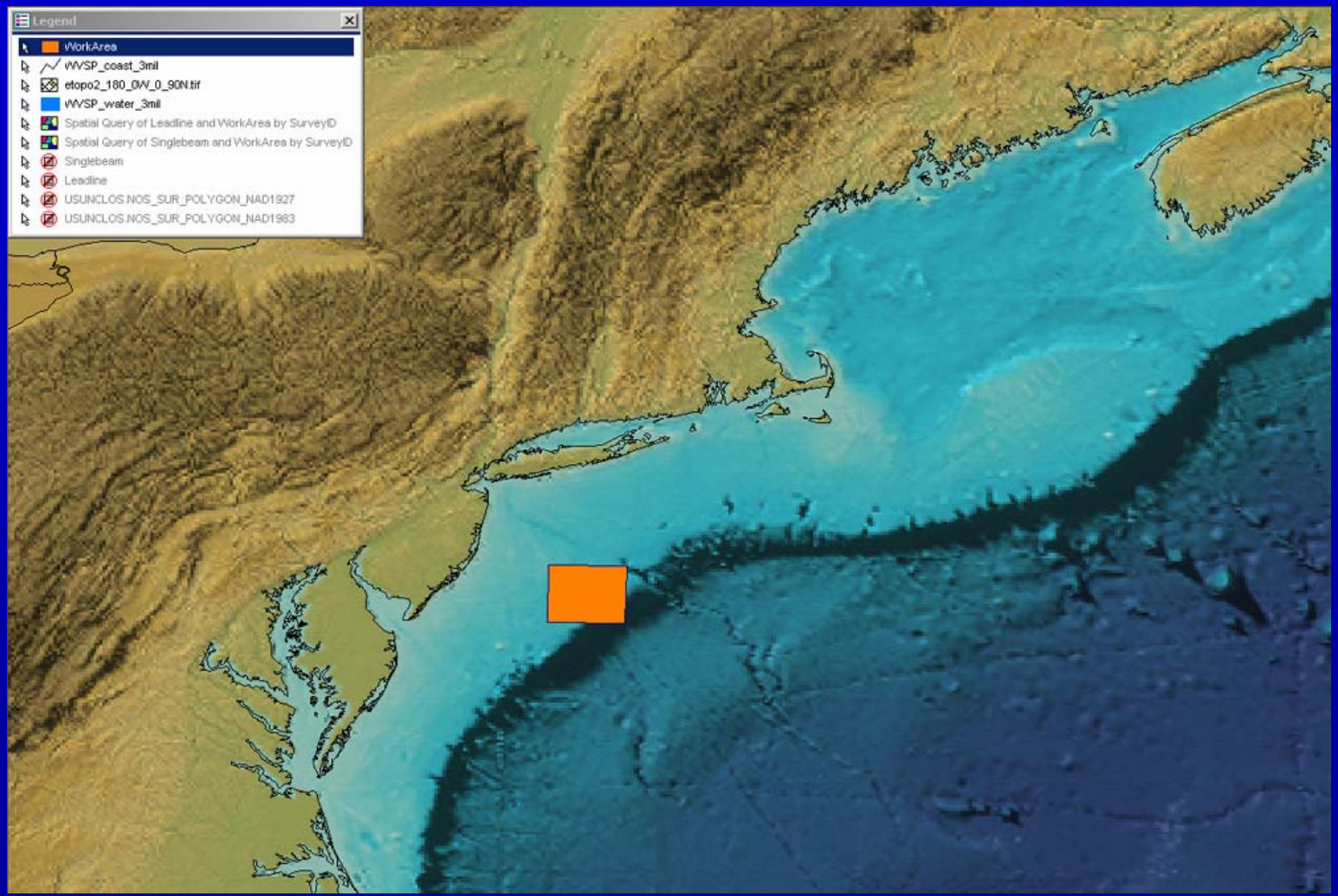
Data: NOAA Ship Whiting/H11077 Woods Hole, MA (2001)

Sparse/Archive Data Uncertainty

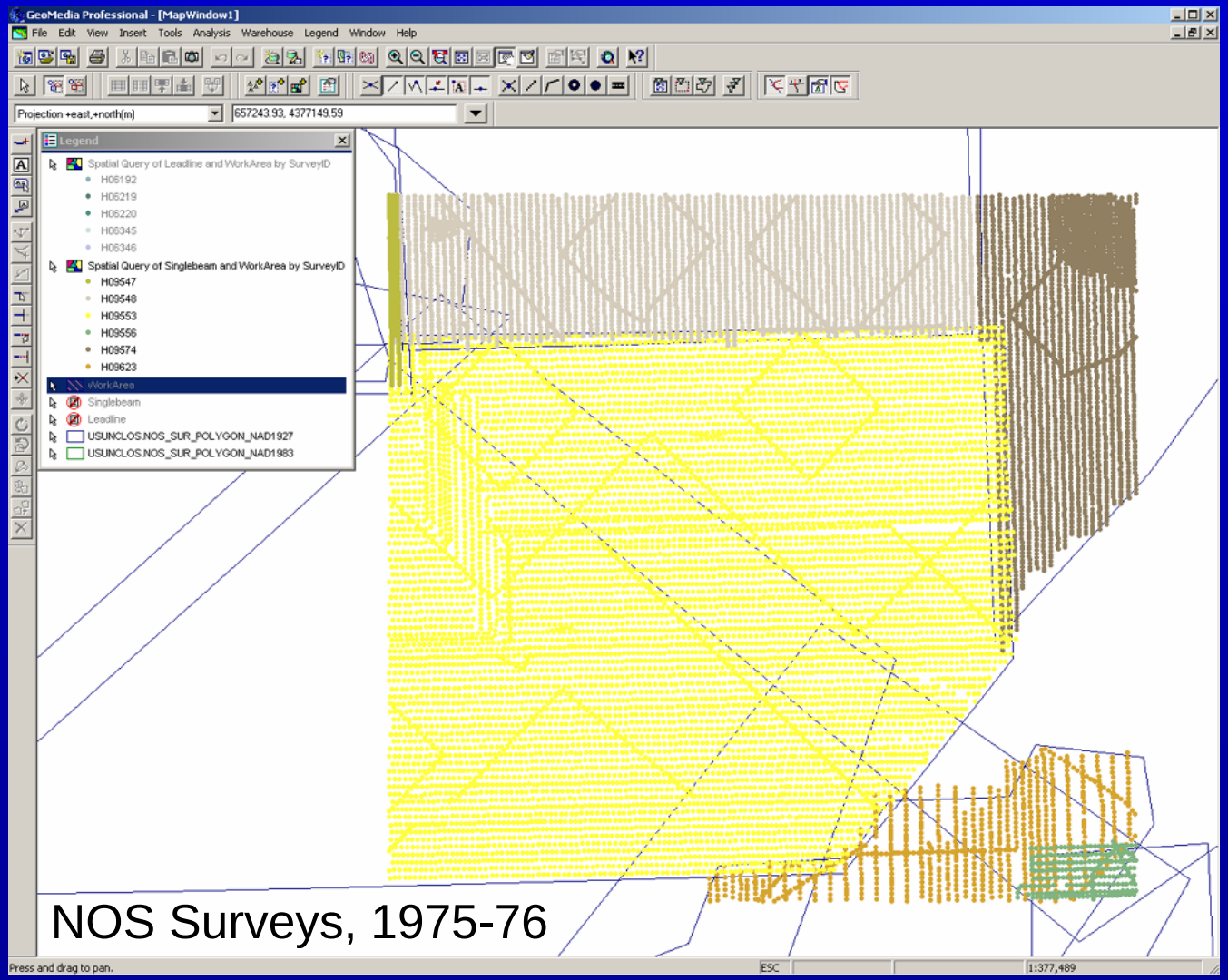


- Typically low resolution without reliable meta-data
- Limitations:
  - Sparse, much spatial aliasing possible
  - Measurement errors may be unknown
- Primary source for most chart and ‘typical’ map compilations in US waters

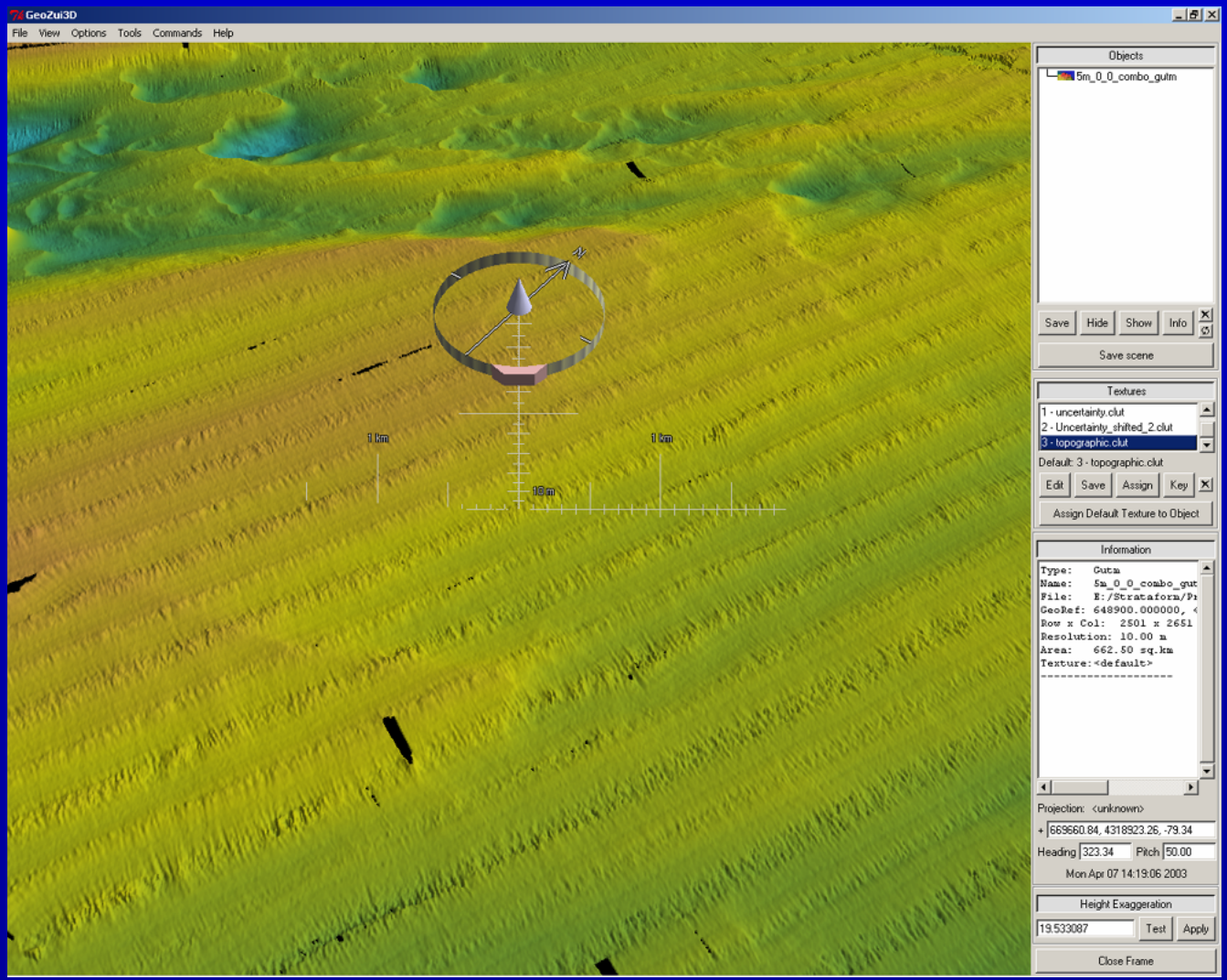
Sparse Data Test Site: STRATAFORM



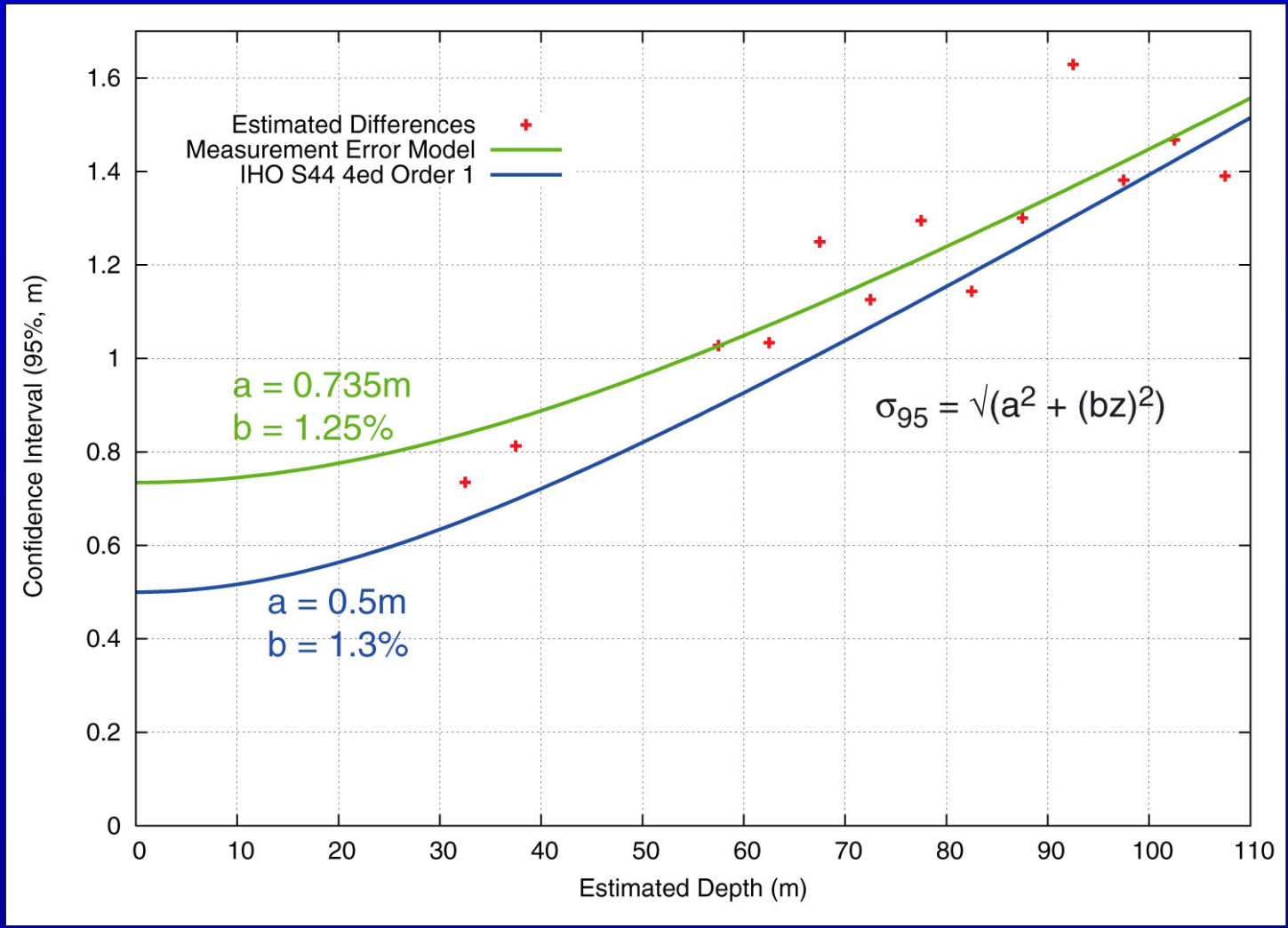
Archival Single-Beam Hydrography



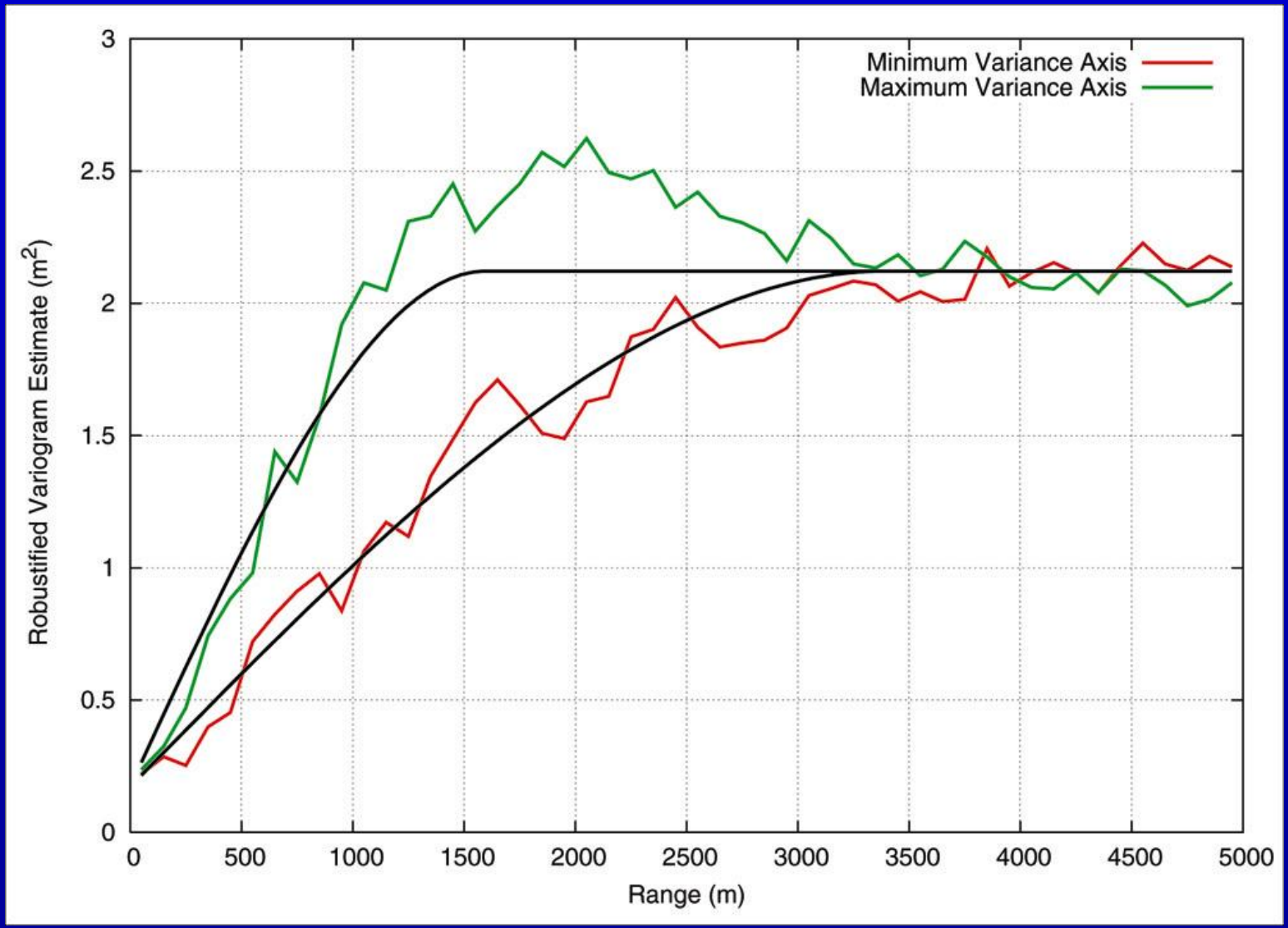
Archival Multibeam Survey Data



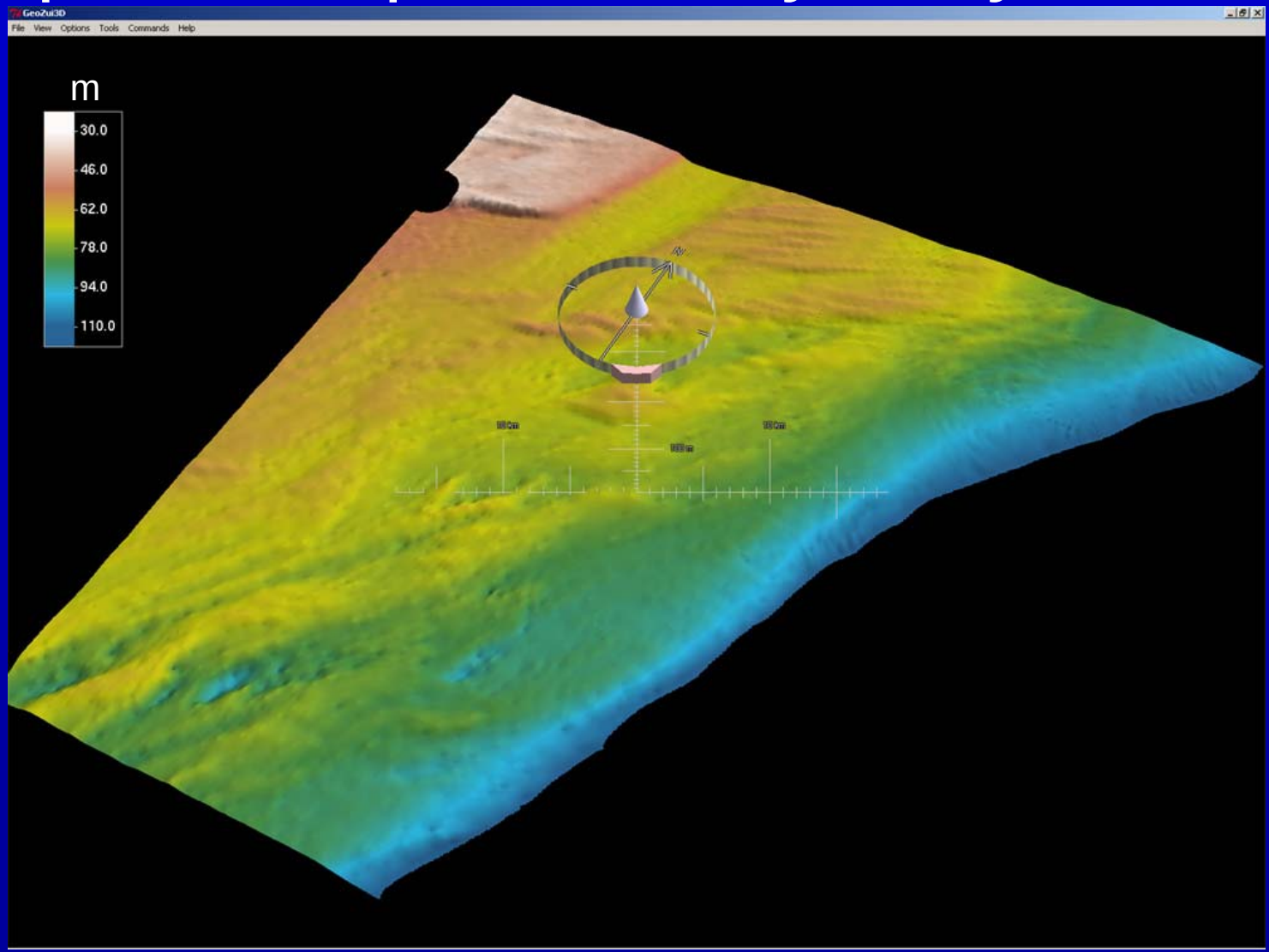
Estimated Vertical Measurement Error



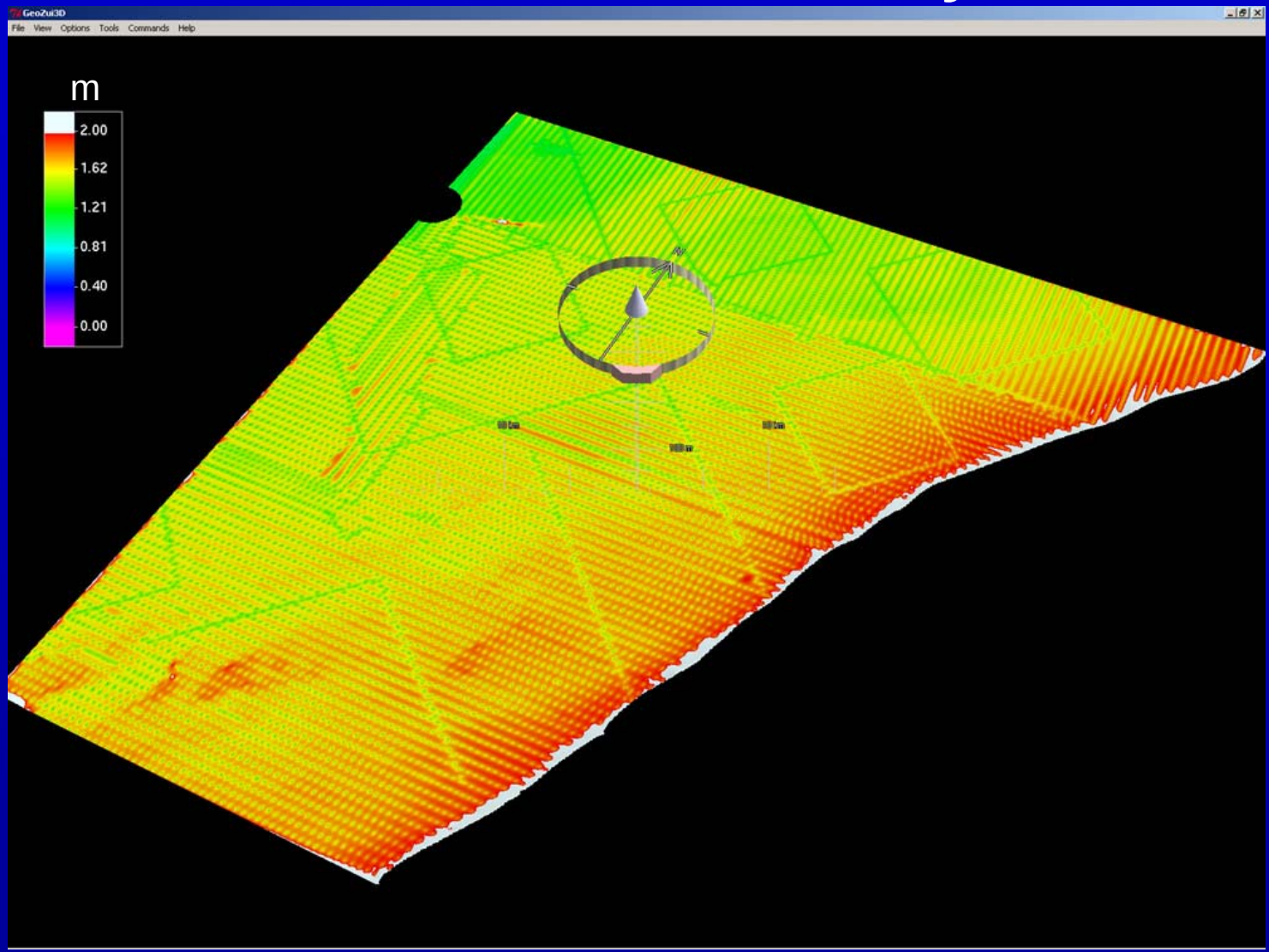
Oriented Anisotropic Variogram Estimates



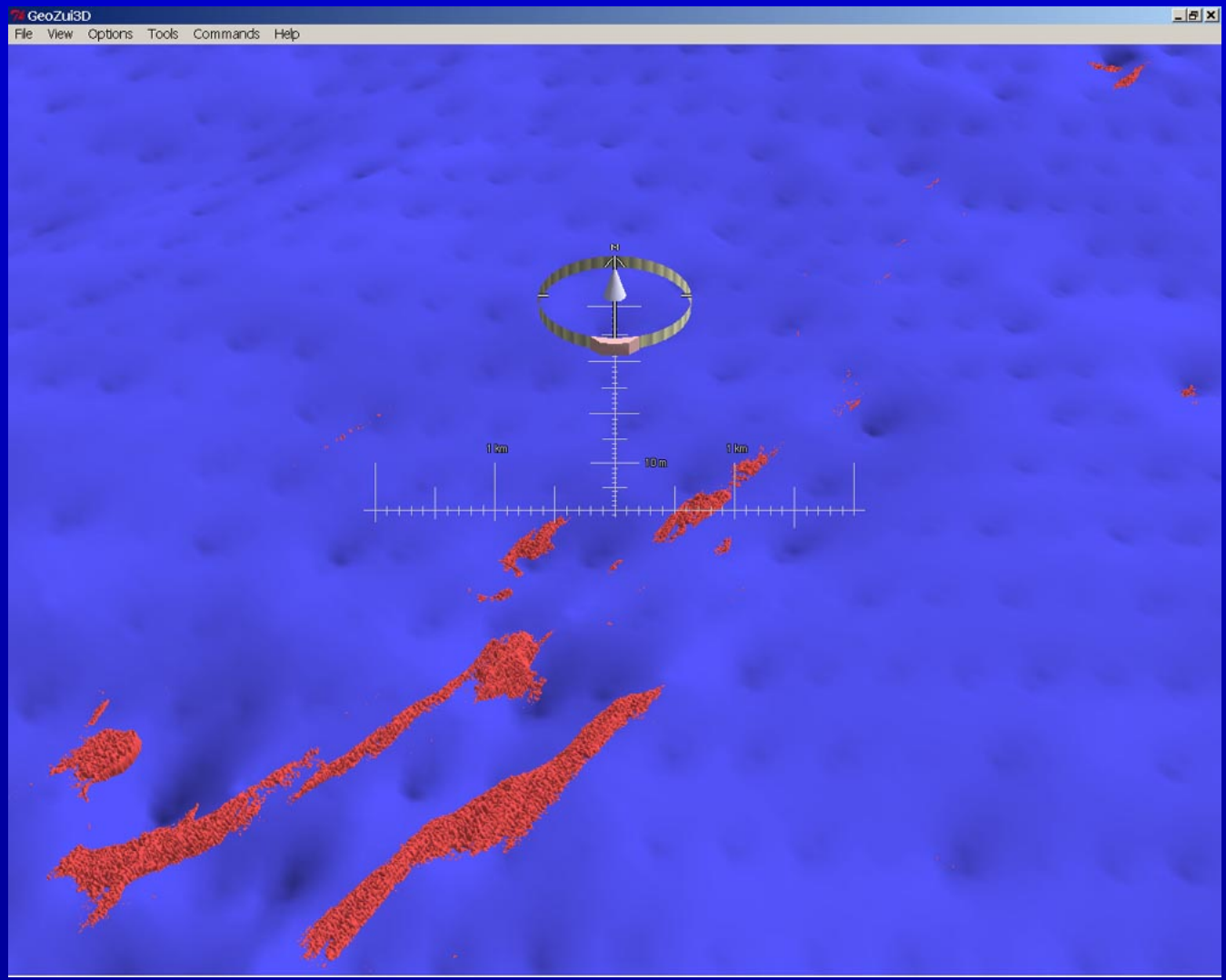
Interpolated Sparse Bathymetry



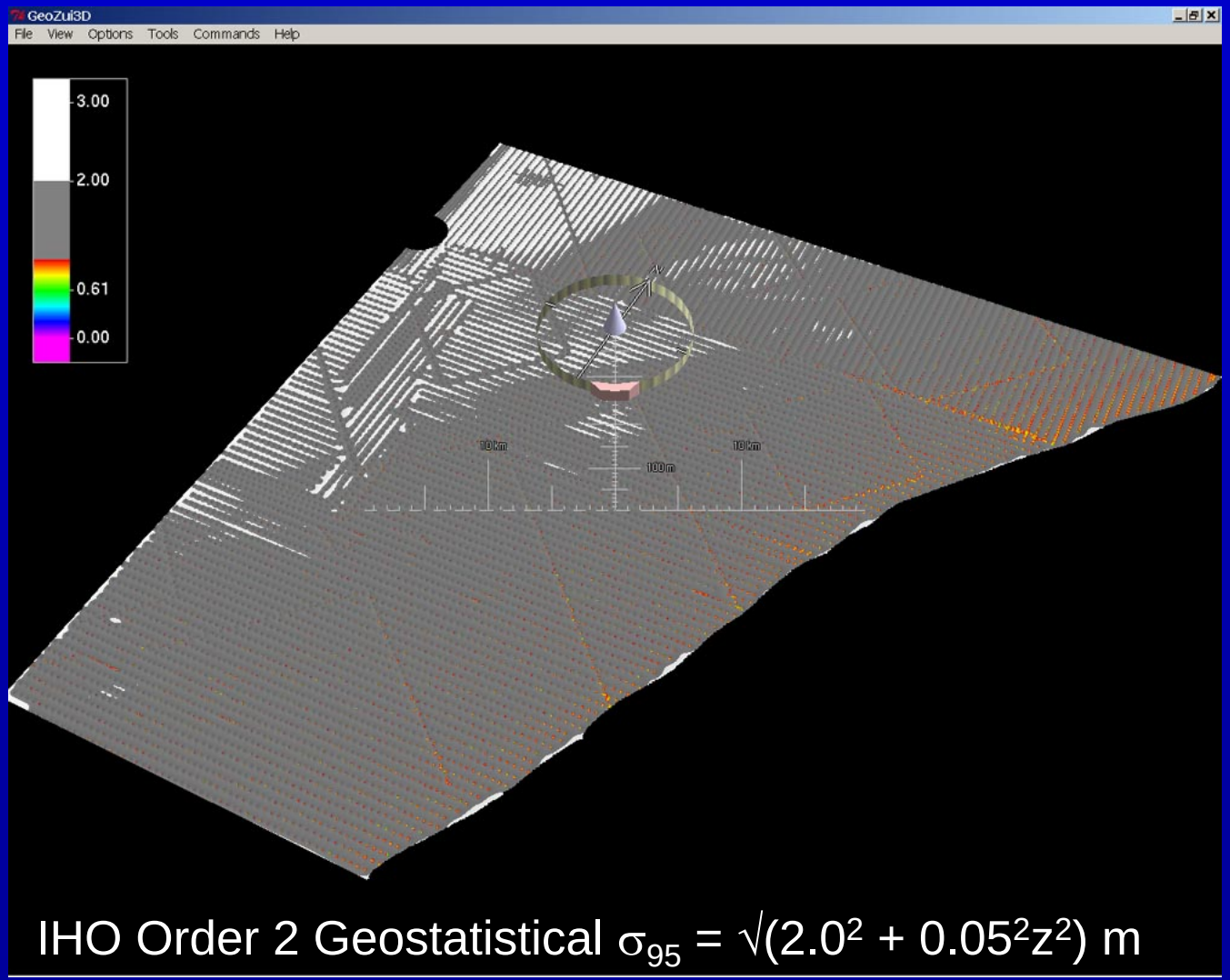
Estimated Surface Uncertainty



Spatial Aliasing



Modeling ‘The Thing Not Seen’



Publications & Transitions

- Publications
  - B. R. Calder and S. M. Smith. *A Time Comparison of Computer-Assisted and Manual Bathymetric Processing.* Int. Hydro. Rev., 5(1), 2004.
  - B. R. Calder. *Automatic Statistical Processing of Multibeam Echosounder Data*, Int. Hydro. Review, 4(1), 2003.
  - B. R. Calder and L. Mayer. *Automatic Processing of High-Rate, High-Density Multibeam Echosounder Data*, Geochem., Geophys. and Geosystems (G3), 10.1029/2002GC000486, 4(6), 2003.
  - M. Jakobsson, B. R. Calder, and L. A. Mayer. *On the Effect of Random Errors in Gridded Bathymetric Compilations*, J Geophys. Res. B (Solid Earth), 107(B12), pp.ETG 14-1 – 14-11, 2002
  - B. R. Calder, B. Kraft, C. de Moustier, J. Lewis and P. Stein. *Model-based Refraction Correction in Intermediate Depth Multibeam Echosounder Survey*. Proc. European Conference on Underwater Acoustics, Delft, The Netherlands, 2004.
  - B. R. Calder. *On the Uncertainty of Archive Hydrographic Datasets*. Proc. Canadian Hydro. Conf., Ottawa, Canada, 2004.
  - B. R. Calder and S. M. Smith. *A Comparison of the Automated Navigation Surface to Traditional Smooth Sheet Compilation*. Proc. Canadian Hydro. Conf. 2002., Toronto, Canada, May 2002.
  - M. Jakobsson, A. Armstrong, B. R. Calder and L. A. Mayer. *Comparing Historical and Contemporary Hydrographic Datasets: An Example from Great Bay, New Hampshire*. Proc. Second. Int. Conf. On High Res. Survey in Shallow Water, Portsmouth NH, September 2001.
  - B. R. Calder, and L. A. Mayer. *Robust Automatic Multibeam Bathymetric Processing*. Proc. US Hydro 2001, Norfolk, VA, 2001
  - M. Jakobsson, B. R. Calder, L. A. Mayer, and A. A. Armstrong. *Error Estimation of Bathymetric Grid Models Derived from Historic and Contemporary Datasets*. Proc. US Hydro 2001, Norfolk, VA, 2001.
- Transitions (CUBE):
  - Released: IVS3D (Fledermaus 6.1)
  - In Development: CARIS (HIPS 6.0), SAIC, Kongsberg
  - Intent: Triton-Elics International, QPS

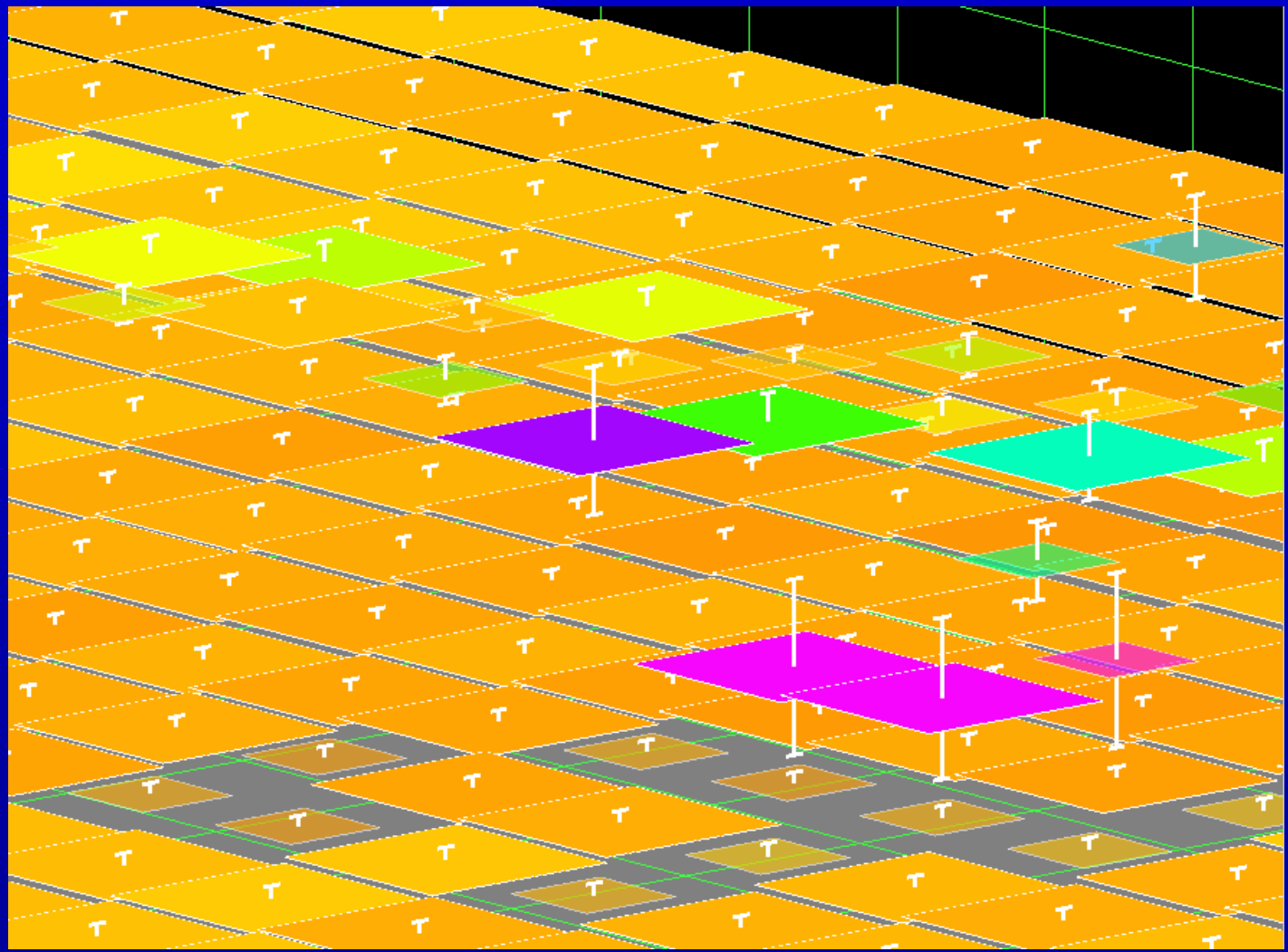
Summary

- Developed methods:
  - To assess uncertainty in bathymetric reconstructions from high-resolution MBES data
  - To assess uncertainty in sparse and archive bathymetric datasets in compilations
  - To visualize uncertainties for users
- Showed:
  - Robust capture of magnitude of uncertainty in bathymetry
  - Limitation of archive datasets due to spatial aliasing/filtering in archives
  - Presentation of processing and algorithmic uncertainty can assist in consistent and reliable data assessment.

Routes for Further Investigation

- MBES:
  - Field Calibration of error models for QA/QC
  - Improved error detection & reporting from output analysis
- Sparse Data:
  - Robust automatic archive characterization
  - More automatic analysis & uncertainty estimation
- Visualization:
  - Event-specific presentation-adaptive uncertainty

Hypothesis Visualization



Source: Mark Paton, IVS 3D Inc.