Tangible Exploration of Subsurface Data

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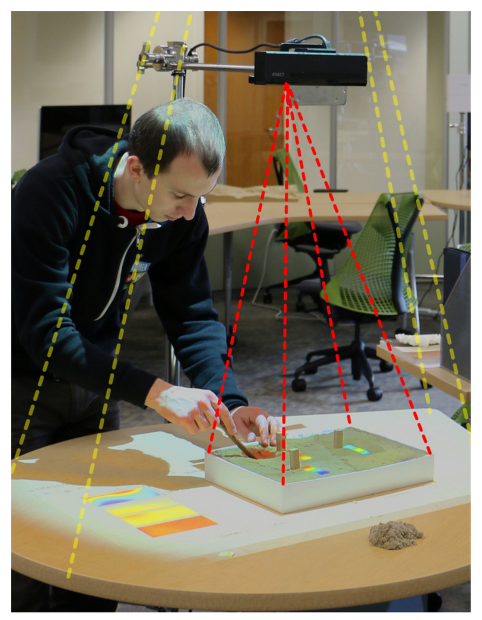
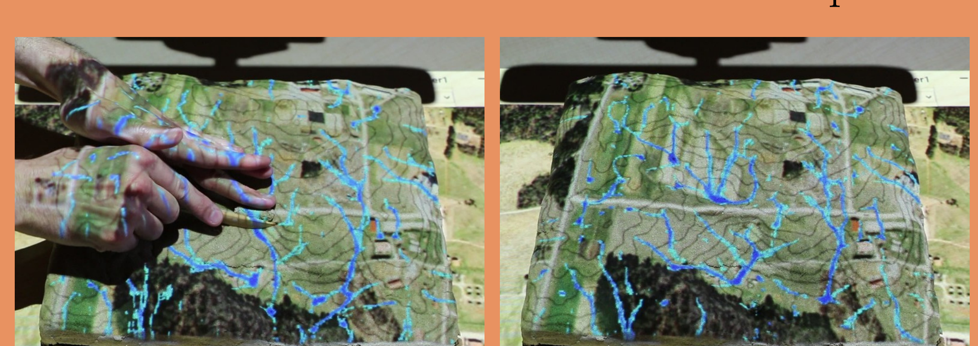
Introduction

Since traditional subsurface visualizations can be difficult to interpret and often do not convey information in an engaging form, we have developed a new tangible visualization technique which can help researchers, students and the general public to better understand and interpret volumetric subsurface data.



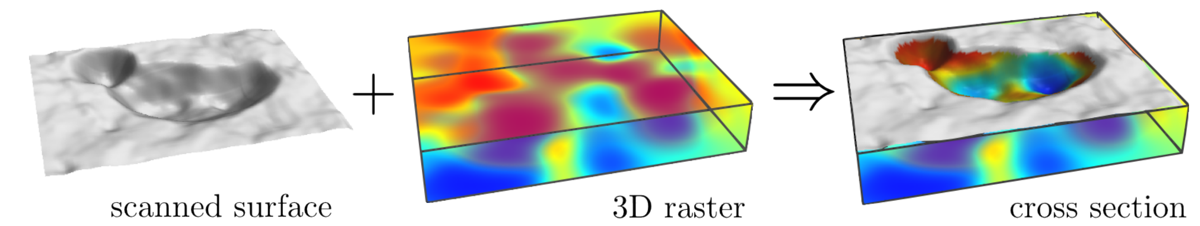
Our visualization technique uses the Tangible geospatial modeling and visualization system – a system that couples a physical 3D model with geospatial modeling through a cycle of scanning and projection – to study subsurface data. We can manipulate the surface of a sand model representing our study area to explore the subsurface conditions in a natural and intuitive way. By offering a direct, tangible interface with multiple ways of interaction, this technique is an intuitive alternative to more abstract 3D computer visualization tools.

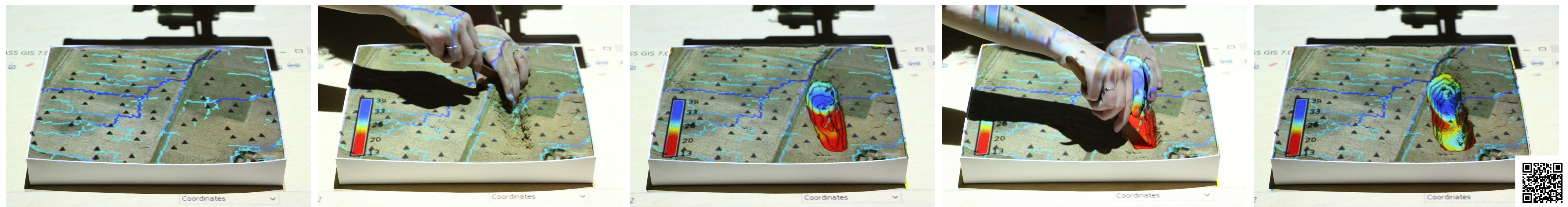
Tangeoms [1, 2] is a collaborative modeling environment. We can analyze the impact of terrain changes by capturing the changes on the model, importing them into GRASS GIS [3], performing geospatial analyses and projecting the results back on the model. Previous applications of Tangeoms explored the impact of terrain modifications on viewsheds, solar energy potential, and surface-based processes, such as overland water flow and sediment transport.



Tangible visualization of soil "excavation"

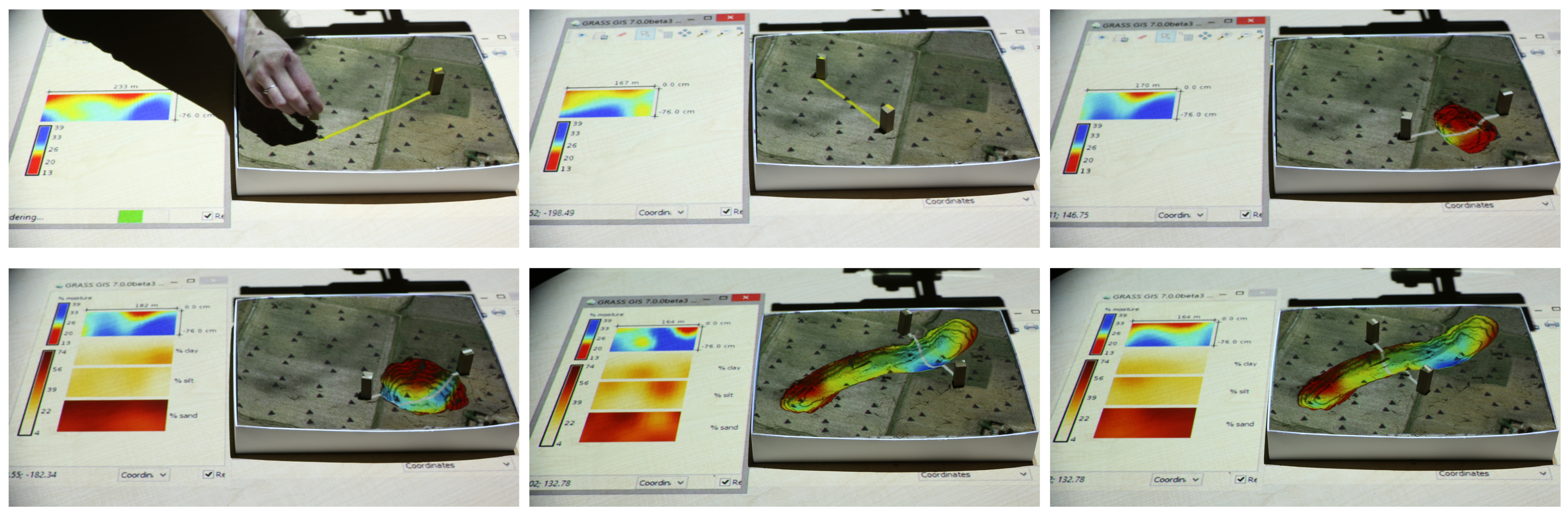
We can look under the ground as if we were at an excavation site by digging into the sand with our hands and then projecting the cross-section of the scanned surface with the 3D raster representing soil properties in a real-time feedback loop. In this example, we explore the 3D distribution of measured soil moisture [%] and its change over time. Since we are in the GRASS GIS environment, we can project additional GIS layers (such as an orthophoto, elevation contours, and the flow accumulation) over the model to provide spatial context and gain more insights into soil moisture distribution and its relation to landscape.





see animation online

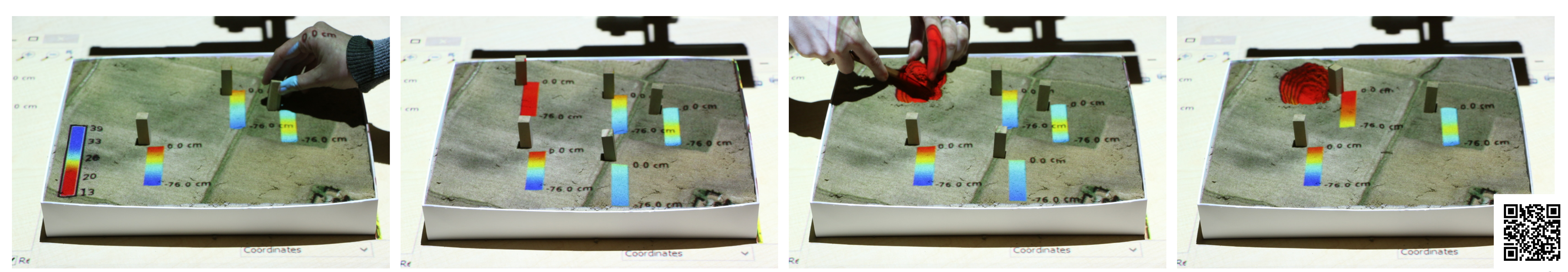
Visualizing vertical profiles



By placing two markers, we specify the location and length of a vertical subsurface profile which is then displayed in the legend. This technique is optionally combined with the "excavation" visualization. Furthermore, we can display other soil properties (such as moisture together with the distribution of clay, silt and sand particles) to discover relationships between different subsurface properties.

"Core sample" visualization

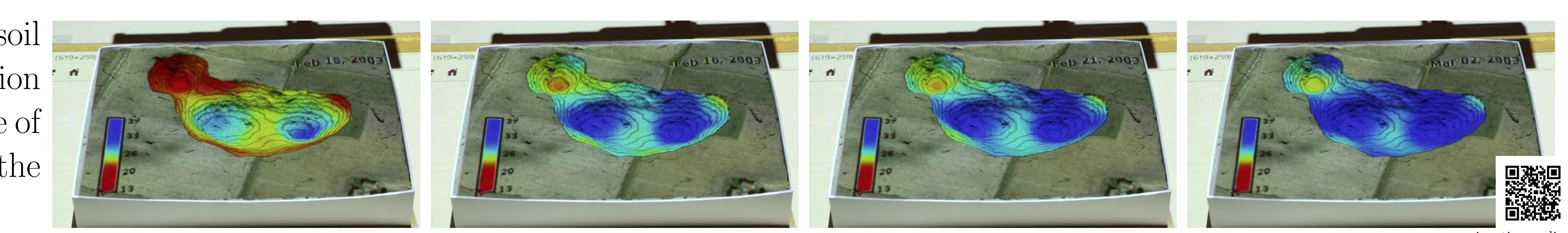
We can query the 3D raster vertically at sites specified by placing markers, similar to how we used markers to examine soil cores at given locations.



see animation online

Time series visualization

It is possible to animate measured soil moisture time series using any combination of our visualization techniques. The date of measurement is displayed together with the data and the legend.



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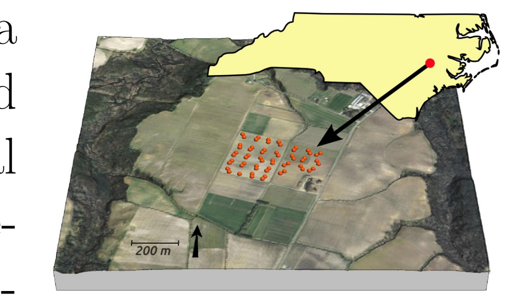
Soil data



The study site is a 12 ha field located at the Lower Coastal Plain Tobacco Research Station, Kinston, North Carolina. Measured soil physical properties include texture, bulk density, porosity and volumetric soil moisture (measured by TDR probes). Properties were measured at 60 locations and five depths (8, 23, 38, 53, and 68 cm); soil moisture measurements started in 2002 and ended in 2005 with irregular sampling intervals [4].

We imported measured data in GRASS GIS as 3D points and an interpolated 3D raster (volume) using the regularized spline with tension function implemented in the GRASS GIS module v.vol.rst [5]. The depth was exaggerated by a factor of 100.

Additional resources

Related videos

www.youtube.com/watch?v=QBPzYXiL3TY
www.youtube.com/watch?v=__fWppH9aqQ
www.youtube.com/watch?v=dy6U1jnYkl0

NCSU OSGeo Research and Education Lab

geospatial.ncsu.edu/osgeorel/tangeoms.html

GRASS GIS 3D raster data processing

grass.osgeo.org/grass70/manuals/raster3dintro.html

References

[1] Petrasova, A., Harmon, B. A., Petras, V., Mitasova, H., 2014. *GIS-based environmental modeling with tangible interaction and dynamic visualization.* In: Ames, D.P., Quinn, N.W.T., Rizzoli, A.E. (Eds.), Proceedings of the 7th International Congress on Environmental Modelling and Software, June 15–19, San Diego, California, USA.

[2] Tateosian, L., Mitasova, H., Harmon, B. A., Fogleman, B., Weaver, K., Harmon, R. S., 2010. *TanGeoMS: tangible geospatial modeling system.* IEEE Transactions on Visualization and Computer Graphics, 16(6), 1605–12.

[3] Neteler, M., Bowman, M. H., Landa, M., Metz, M., 2012. *GRASS GIS: A multi-purpose open source GIS.* Environmental Modelling & Software, 31(0), 124–130.

[4] Duffera, M., White, J. G., Weisz, R., 2007. *Spatial variability of Southeastern U.S. Coastal Plain soil physical properties: Implications for site-specific management.* Geoderma, 137(3-4), 327–339.

[5] Hofierka, J., Parajka, J., Mitasova, H., Mitas, L., 2002. *Multivariate interpolation of precipitation using regularized spline with tension.* Transactions in GIS, 6(2), 135–150.

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