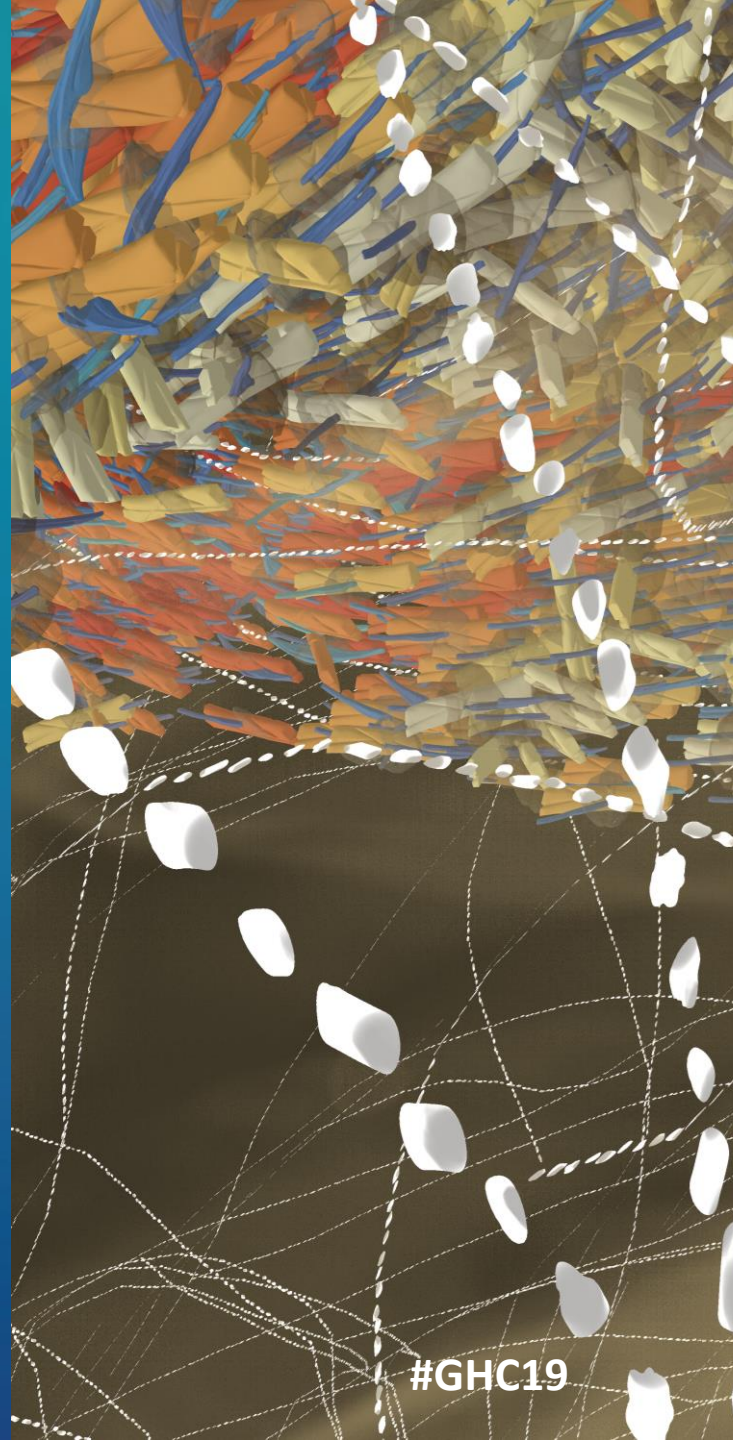
Scientific Visualization: Melding Computer Science & Artistic Design Theory



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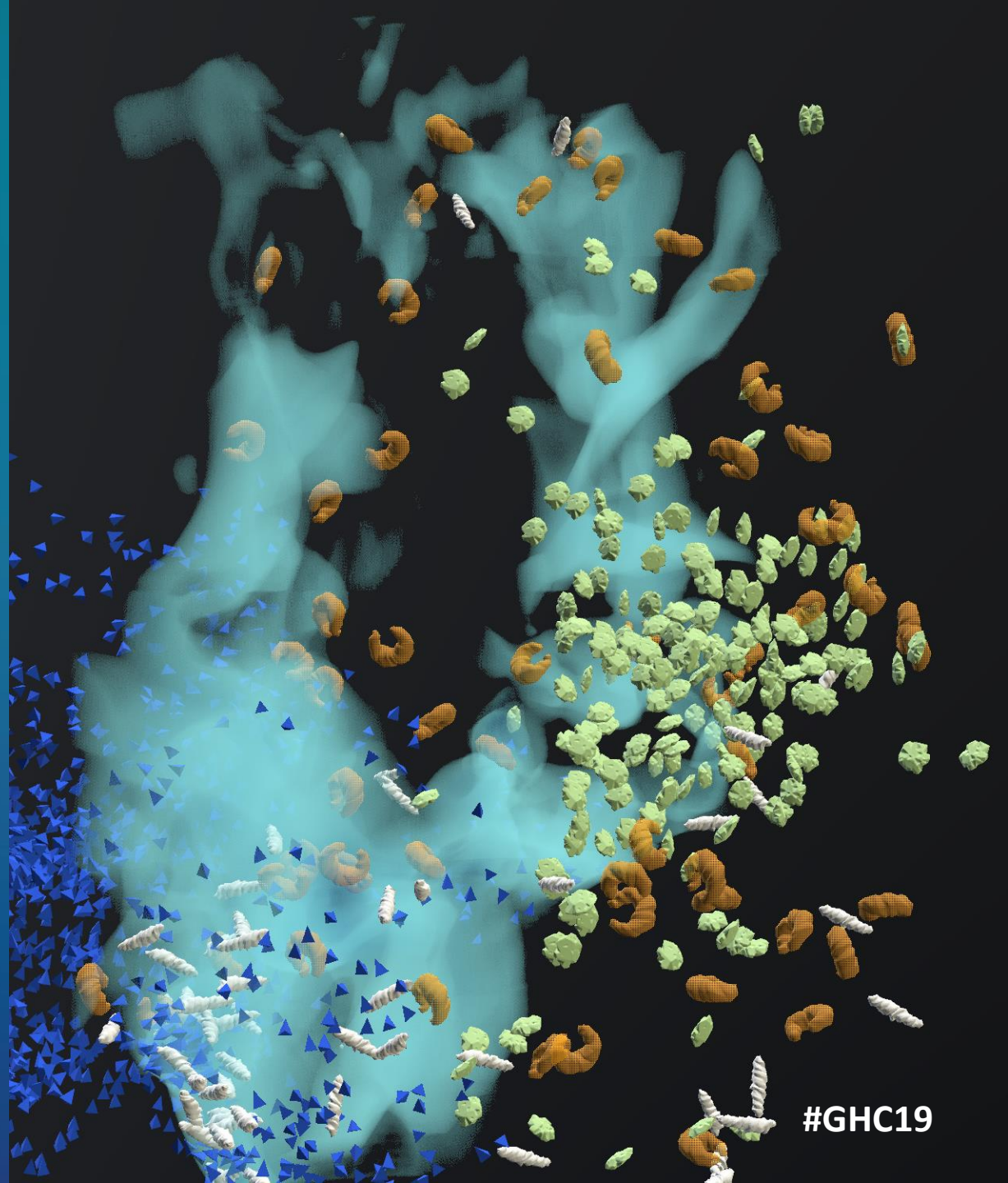
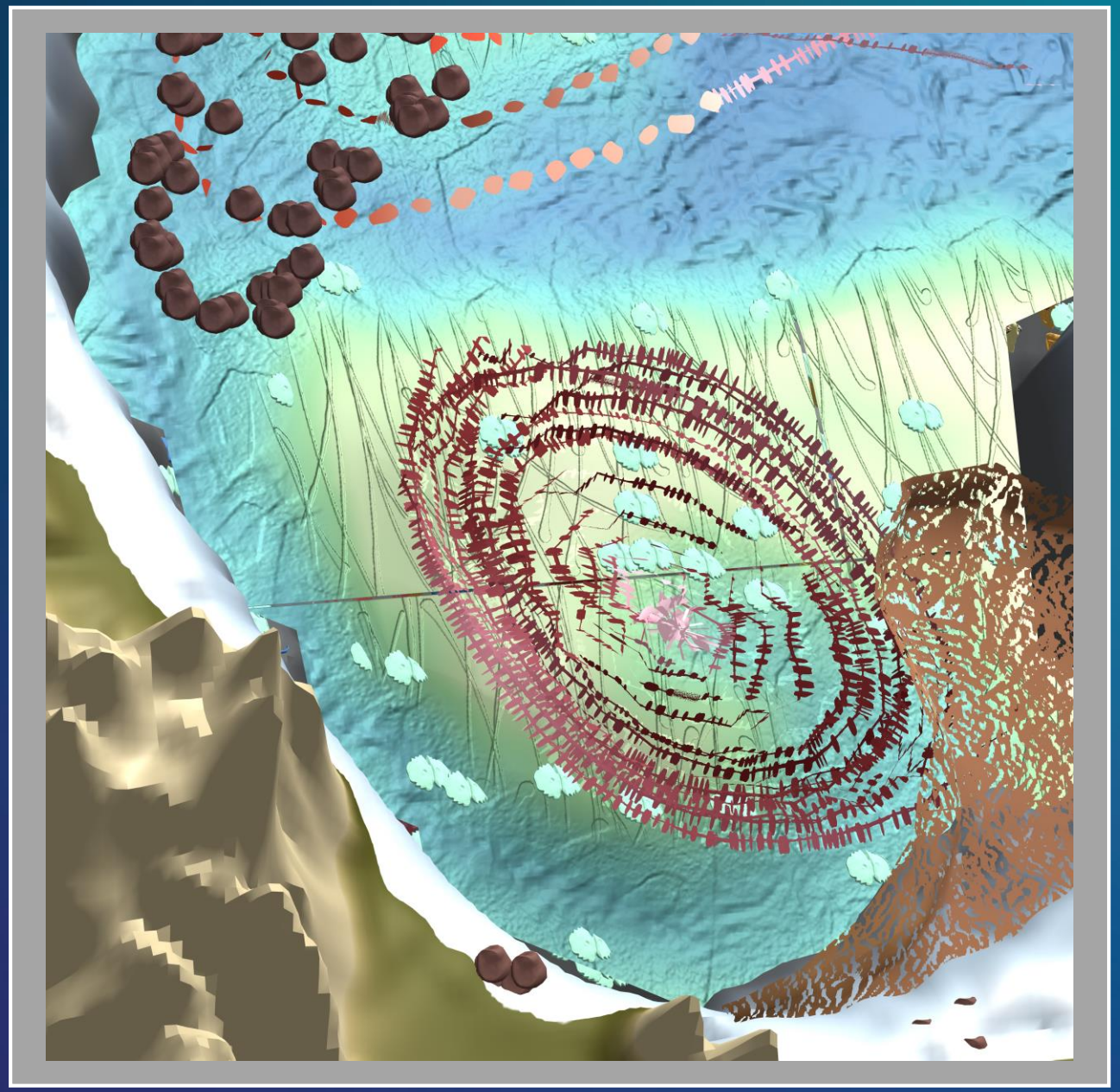




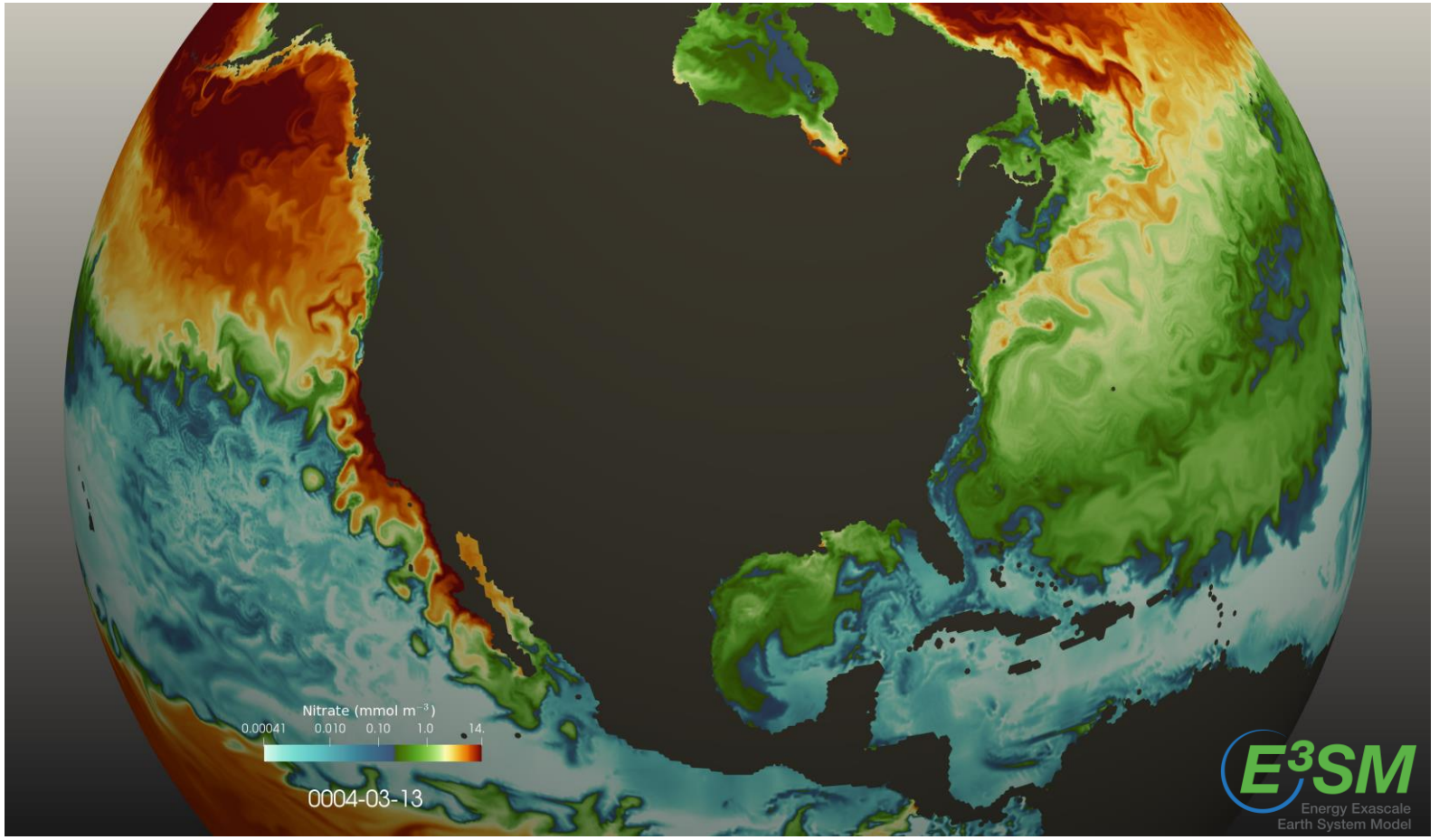
Our purpose

A multidisciplinary team working to enable the creation of scientific visualization by practitioners without computer science training enabling visualizations that employ expertise from the arts and humanities.

Climate visualization?

Scientists using complex physics models of to create climate simulations.

Climate models are built to predict climate system changes specifically where the climate is changing, at what rate and the impacts on society.

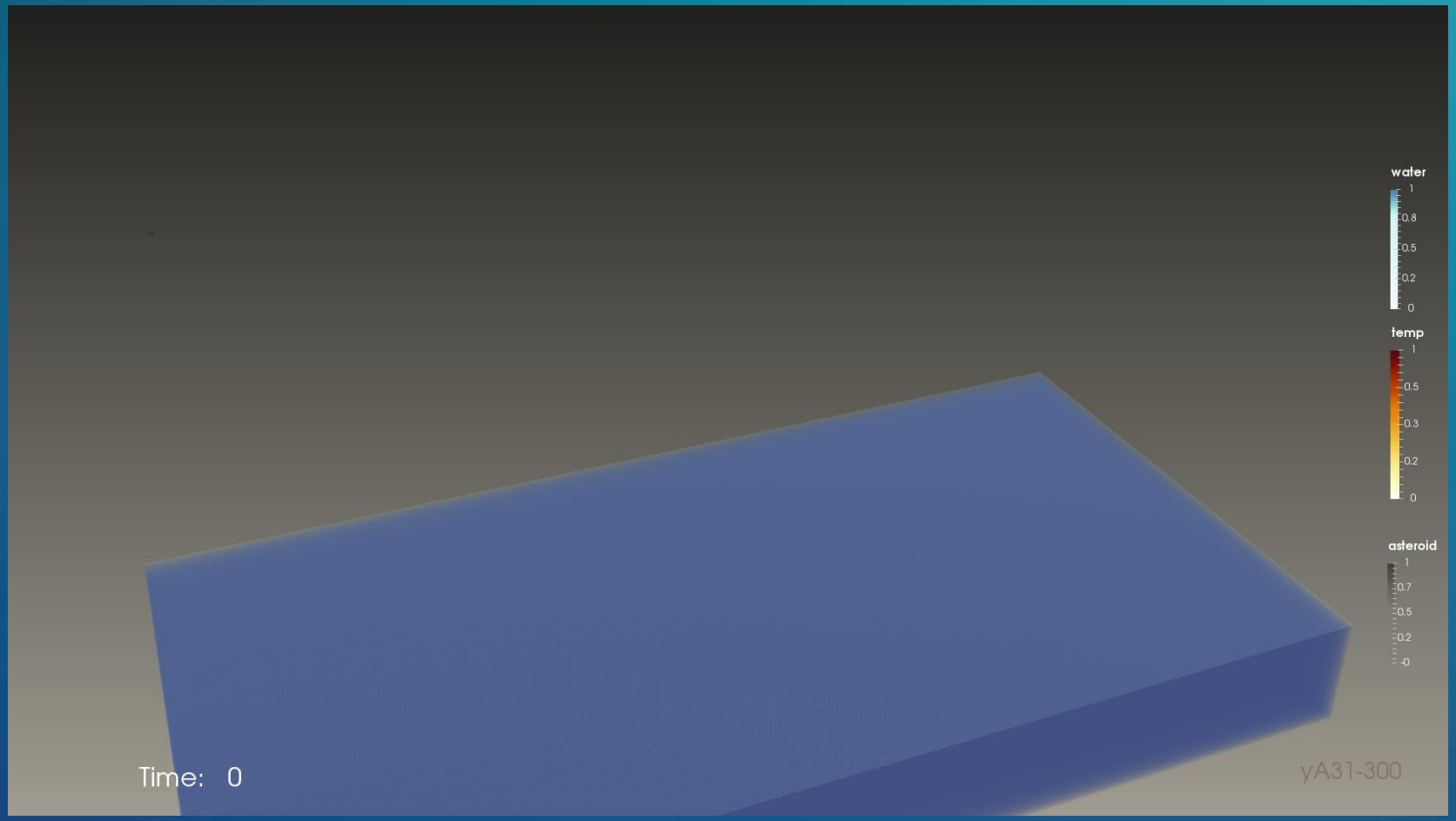


U.S. DEPARTMENT OF ENERGY | Office of Science

Two audiences

The scientist in the office next door – intuitive detailed understanding

The public – engagement, immersion, communication understanding



asteroid impact simulation, Gisler, LANL

video

Two audiences

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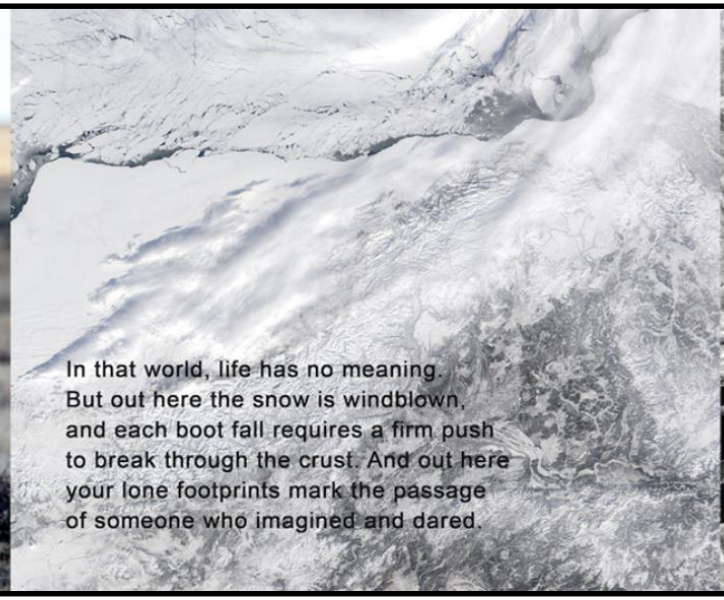
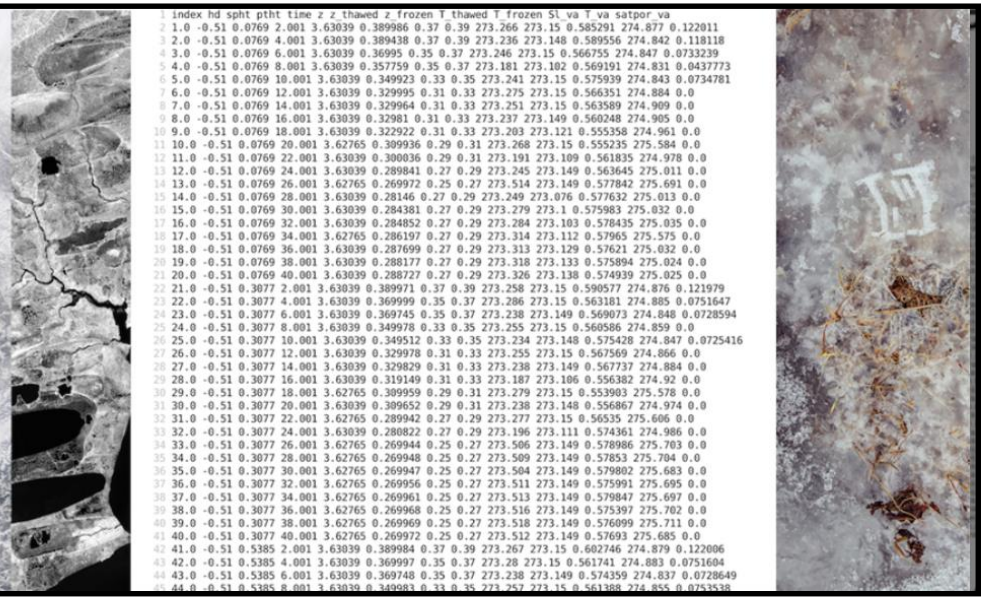
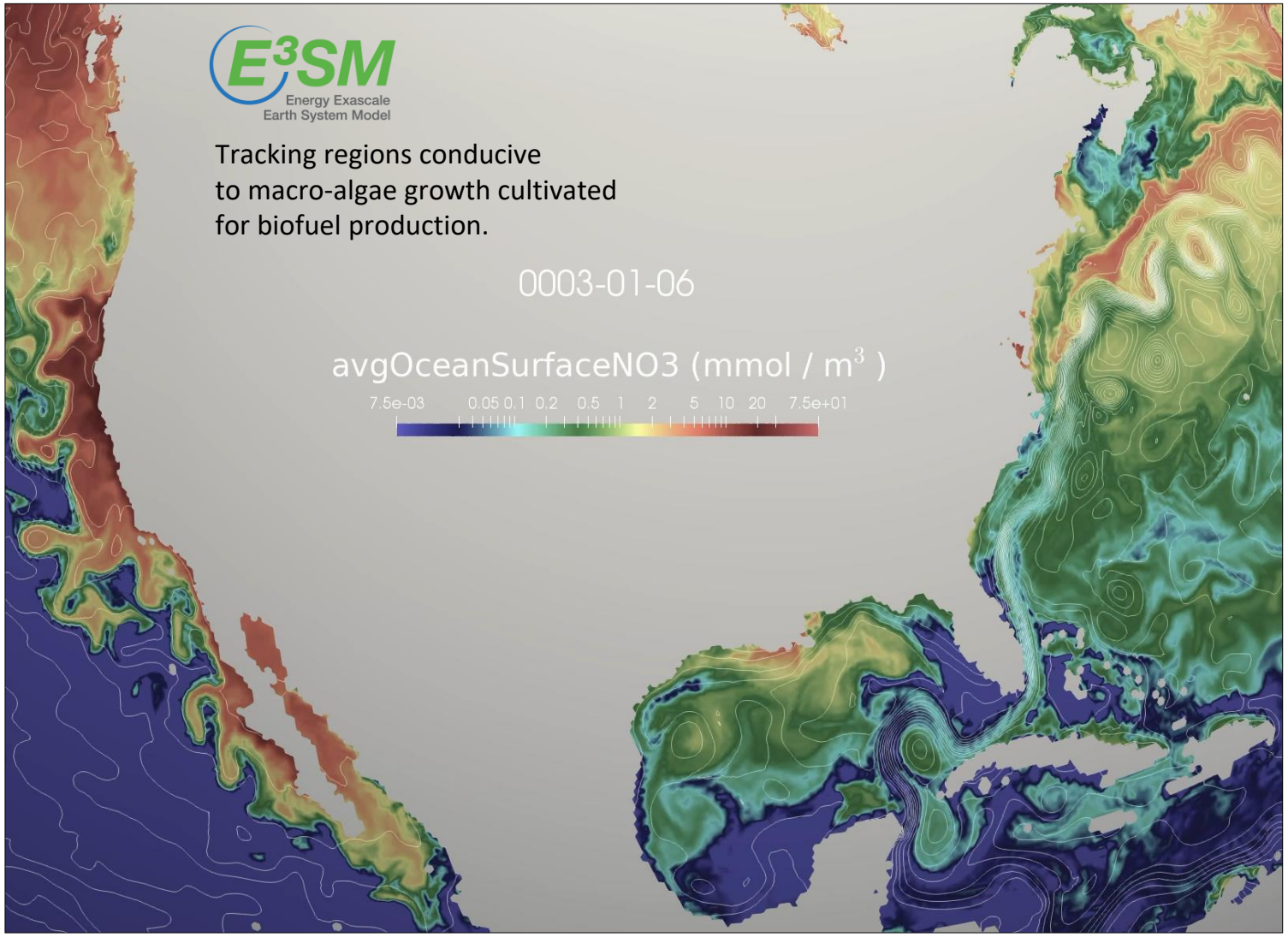




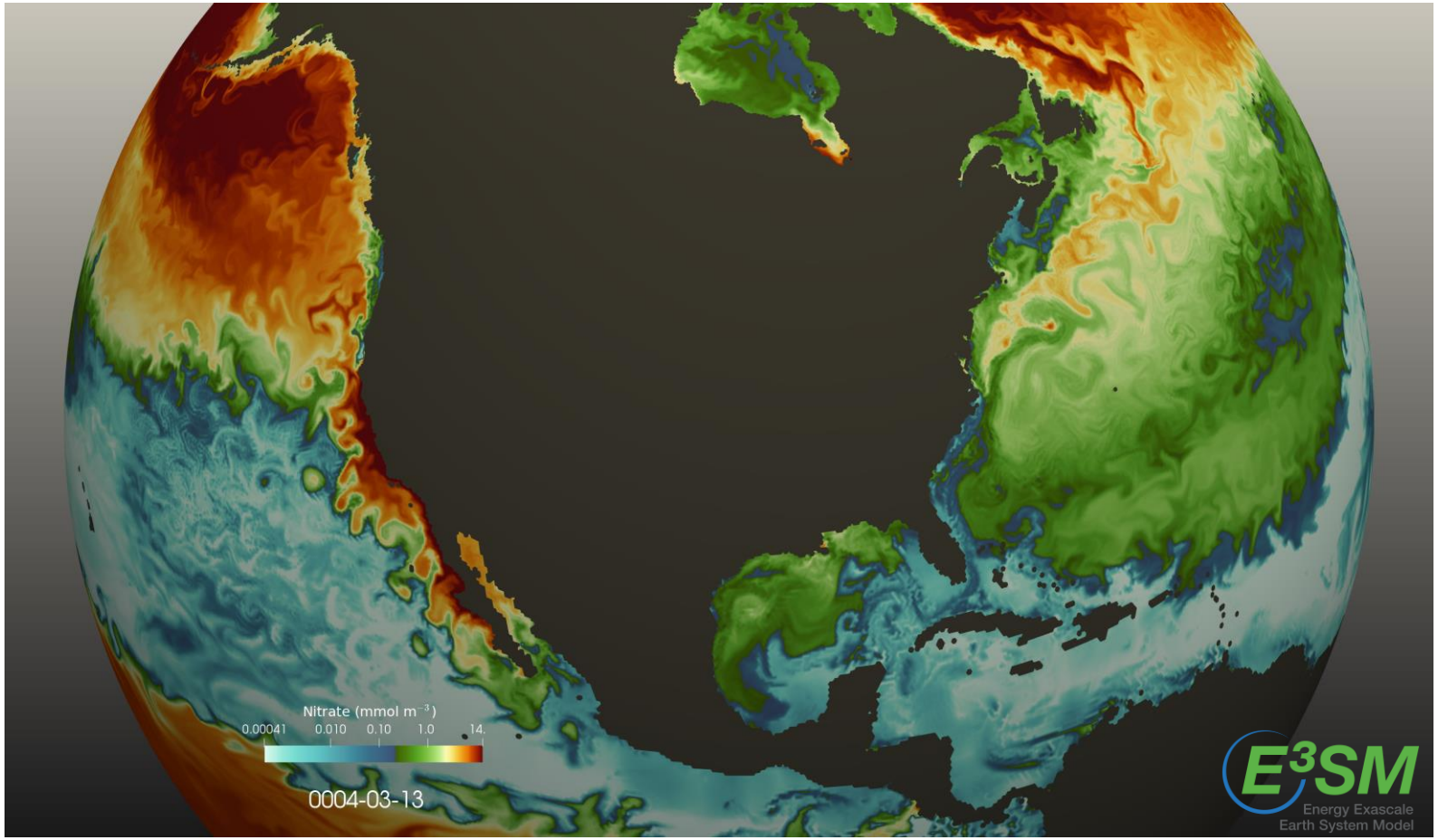
Climate Modeling



E3SM,
Energy Exascale Earth Systems Model,
is a couple climate model,
developed by the Department of Energy National Laboratories.

Visualization produced
by the climate modeling team.

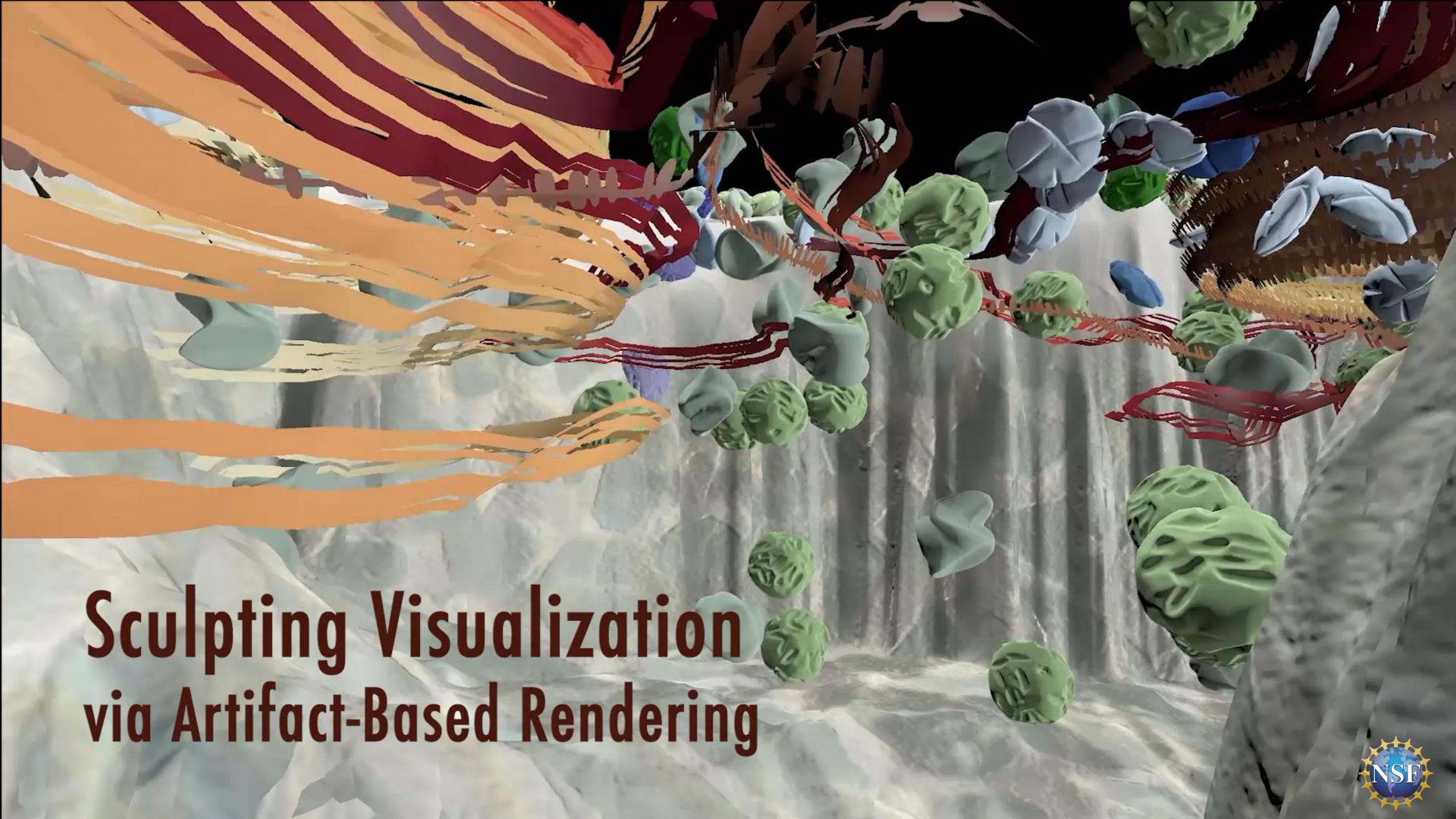
Clarity via design principles



E3SM,
a biogeochemistry simulation tracking conditions conducive to macro algae growth for biofuels.

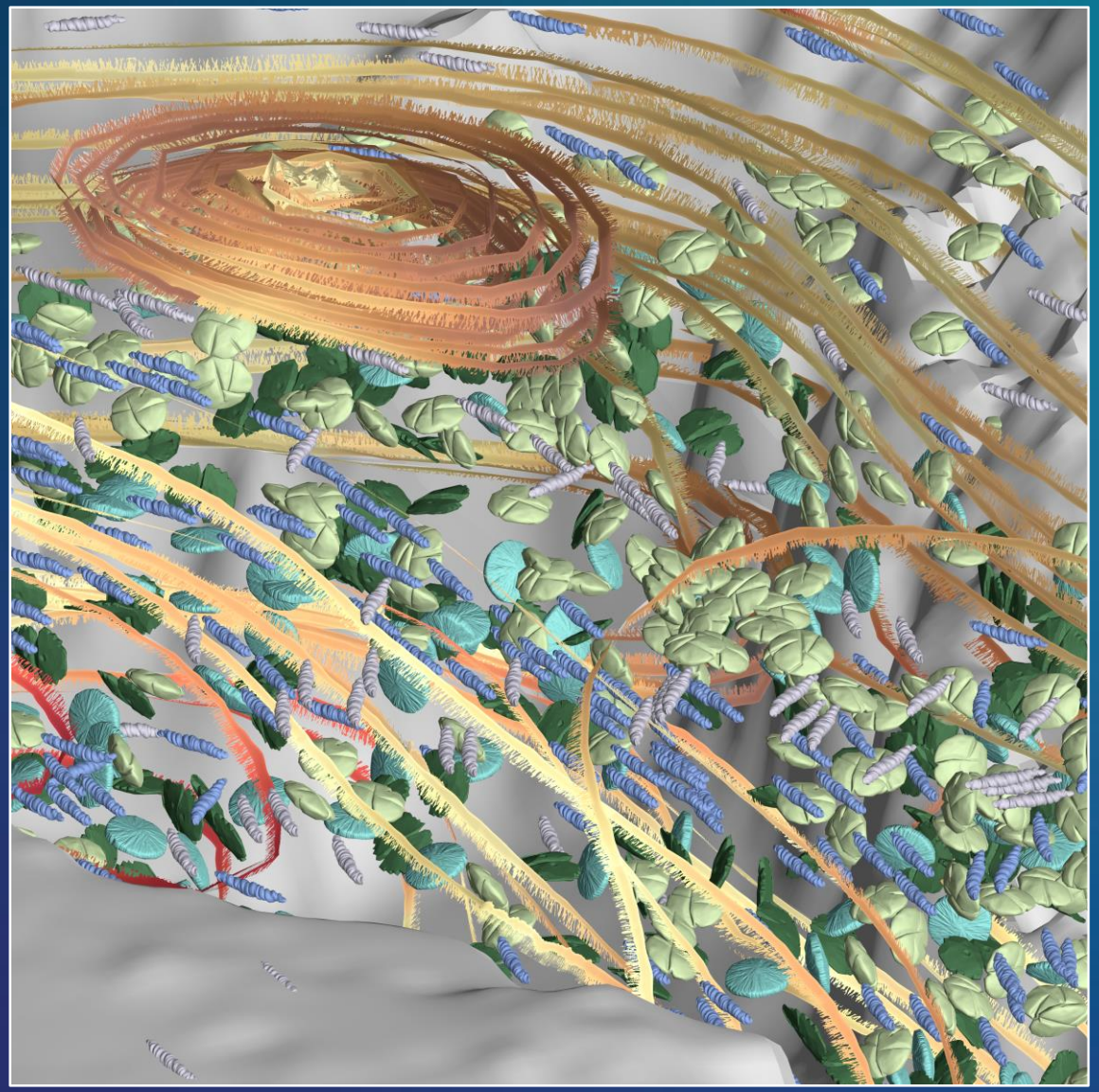
U.S. DEPARTMENT OF ENERGY | Office of Science

video



Sculpting Visualization via Artifact-Based Rendering

Virtual Reality for Science



The Why

engagement
scientific clarity
depth of understanding
communication

The What

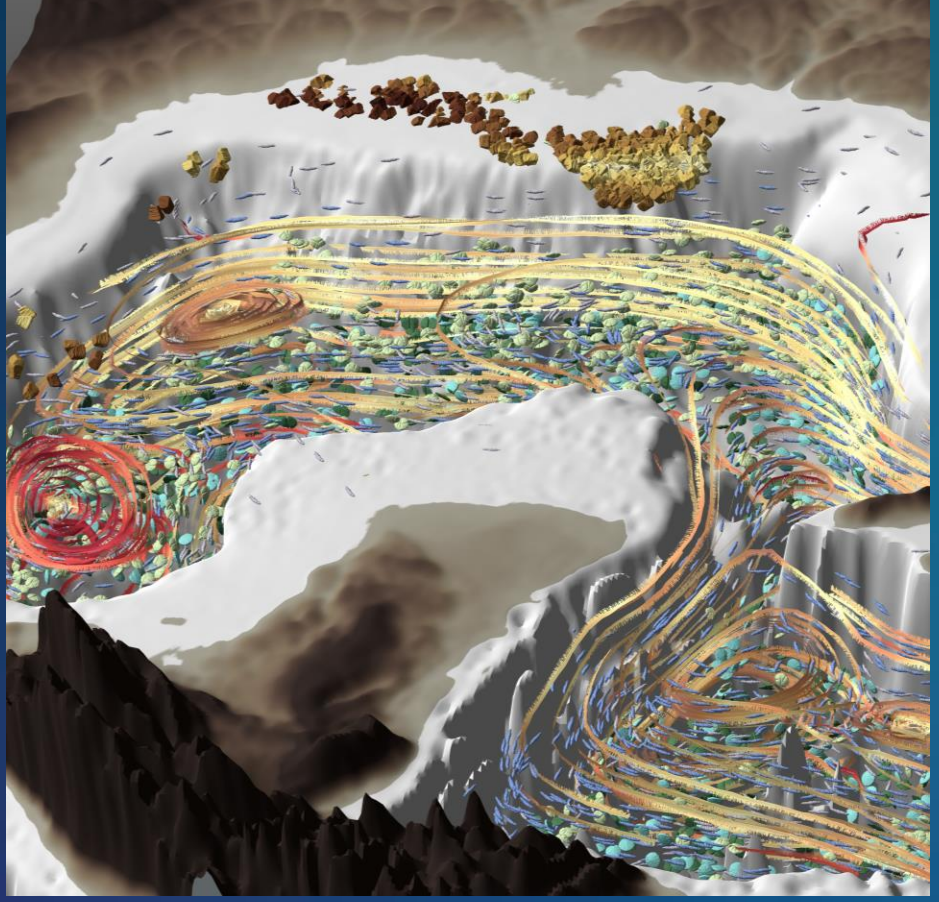
A system for creating compelling immersive scientific visualization created from ones own vocabulary.

The How

tapping artistic design principles and vocabulary
lay-person friendly user interface
sampling algorithms
a multidisciplinary team

The Where

www.sculpting-vis.org
github



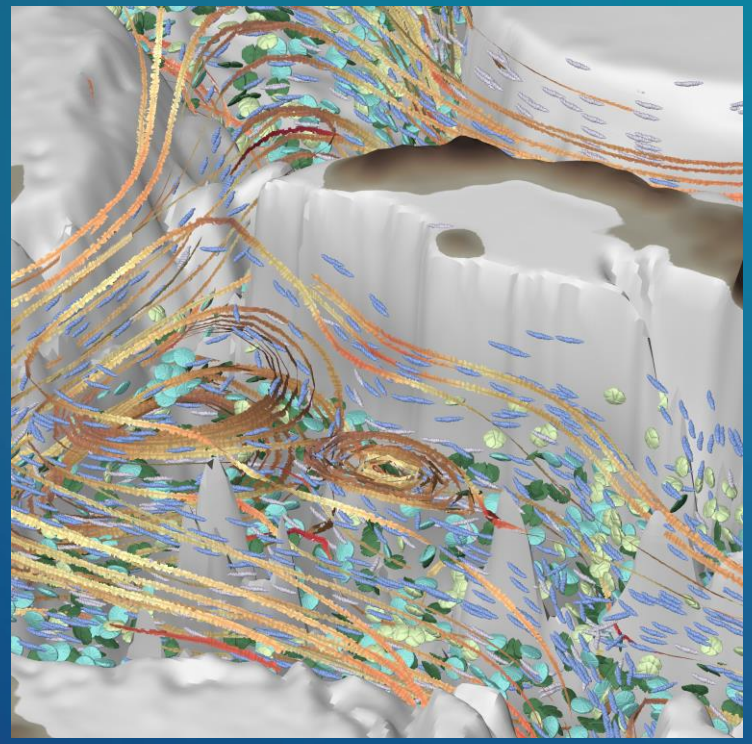
The Why

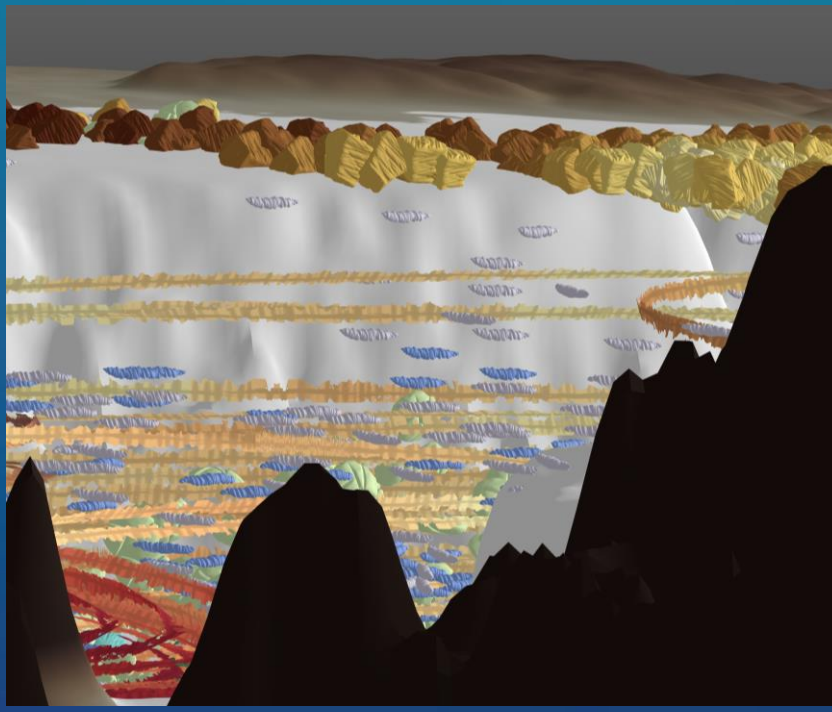
engagement

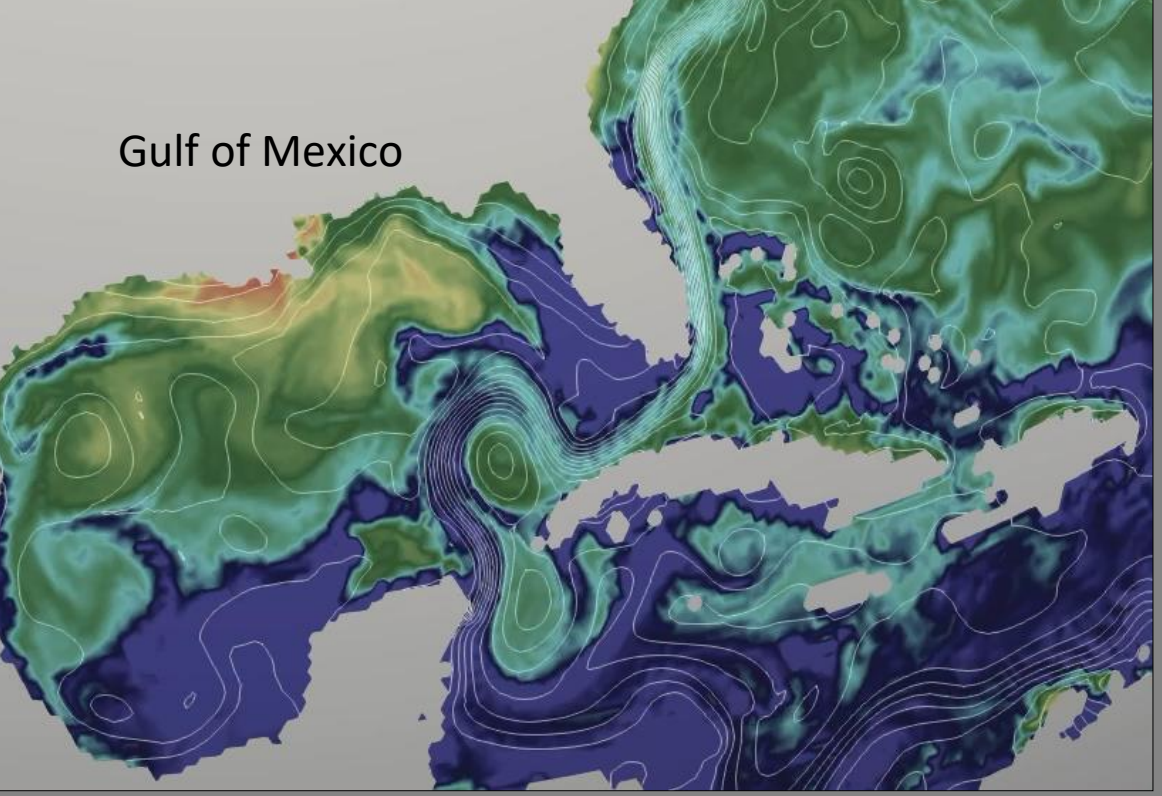
scientific clarity

depth of representation

communication

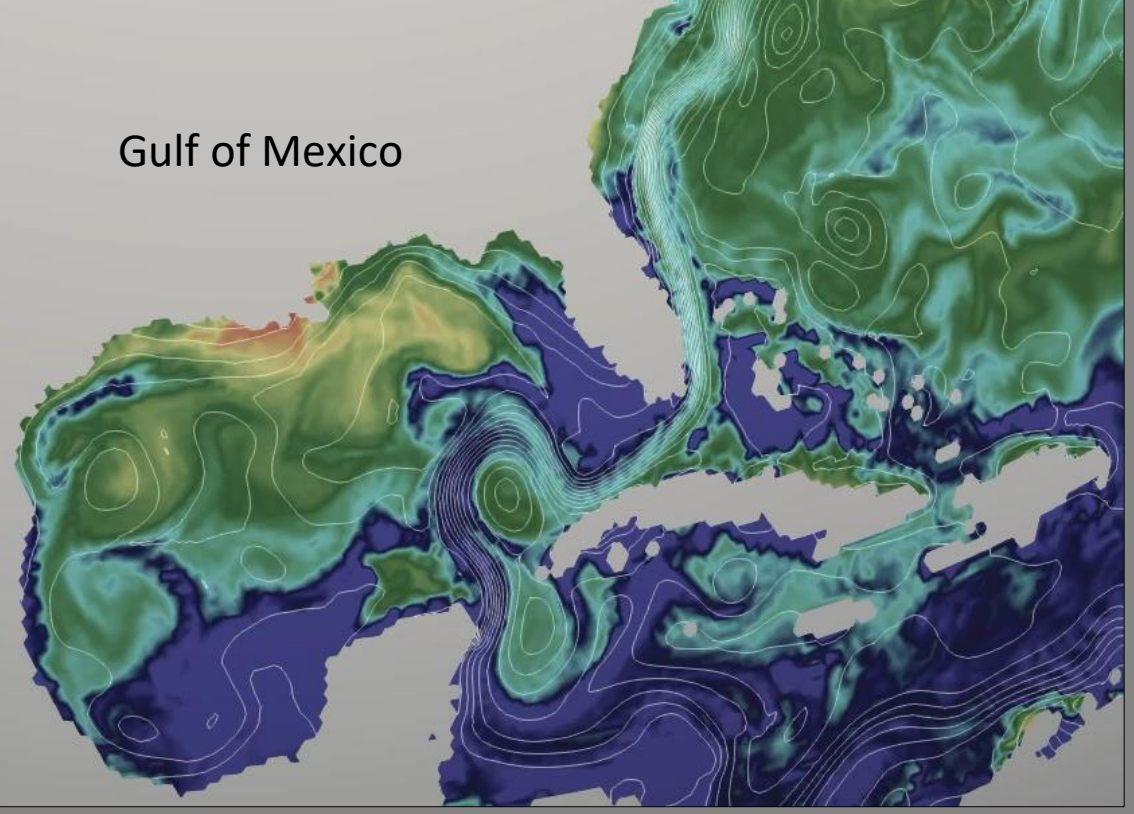






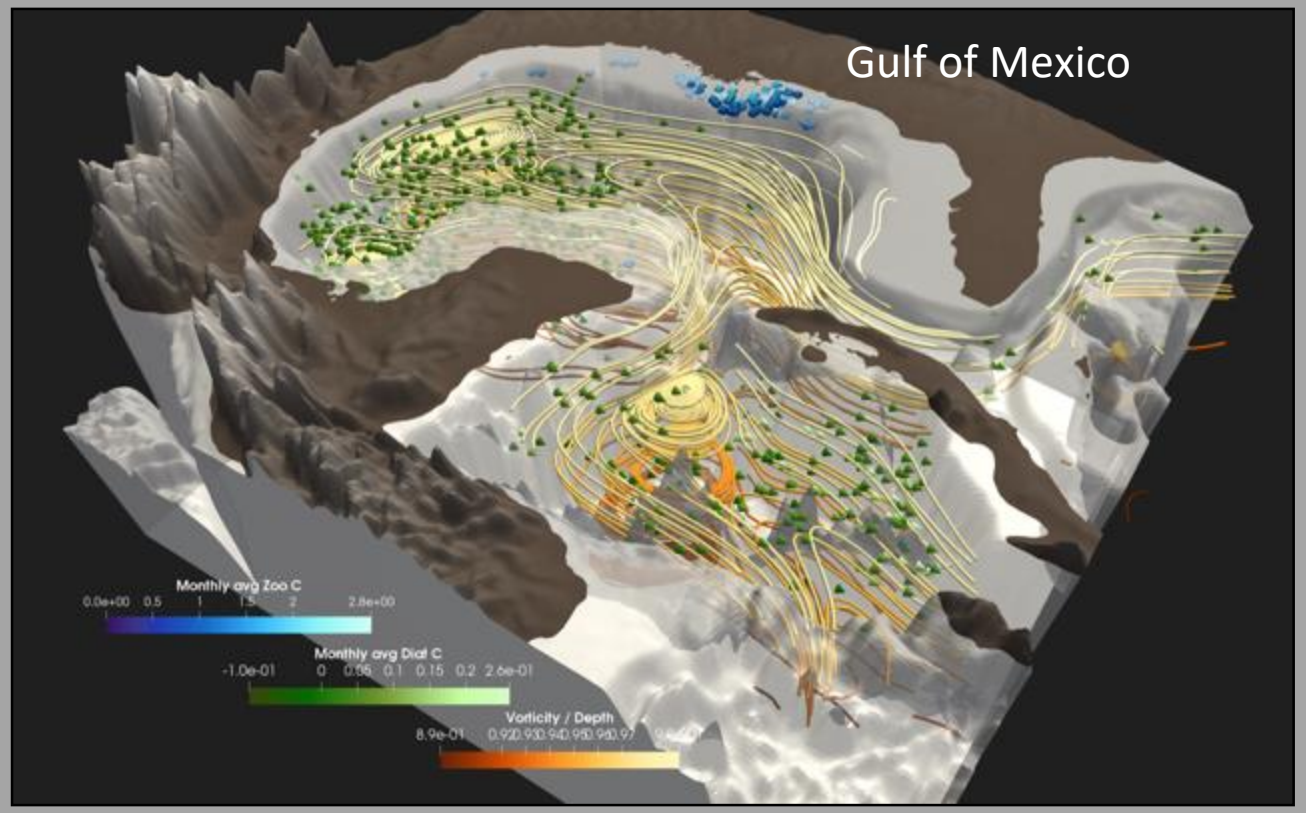
Existing Visualization

01



Existing Visualization

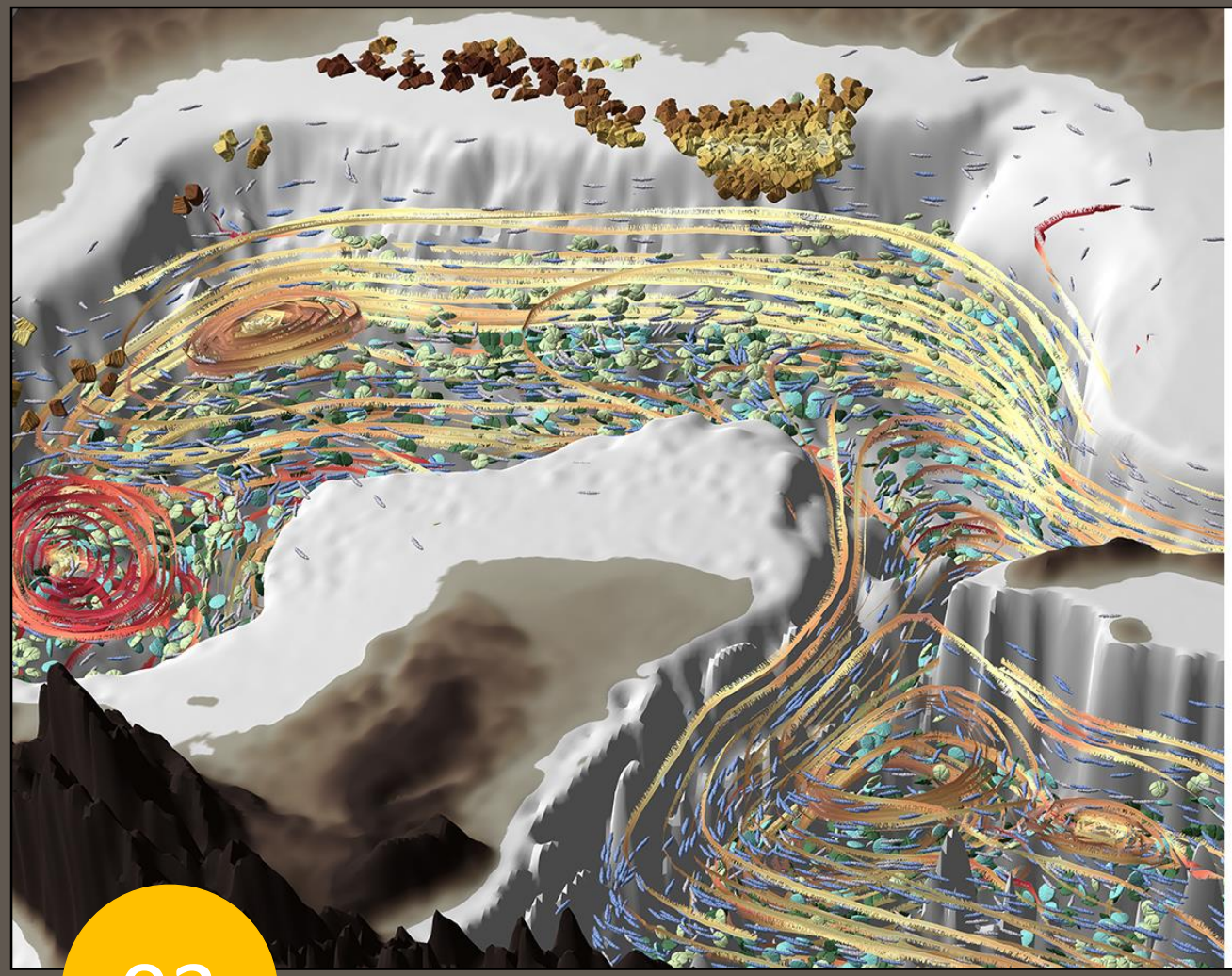
01

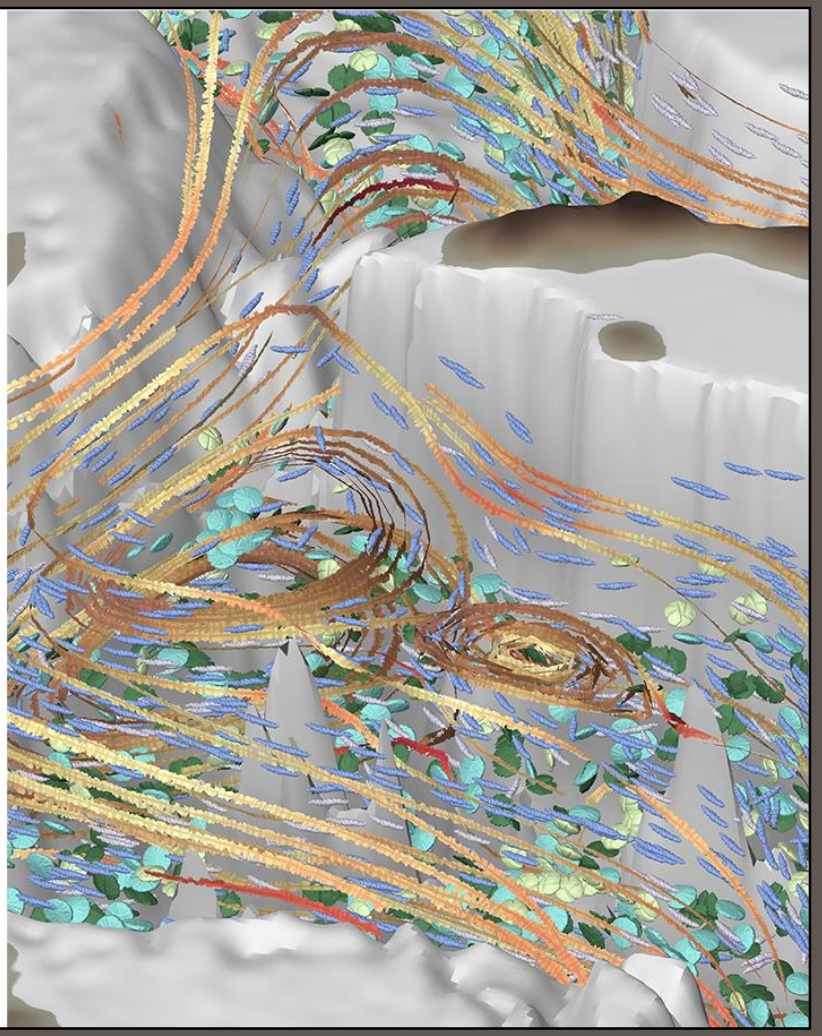


Clarity enabled by the sampling

02

Sculpting Visualization





03

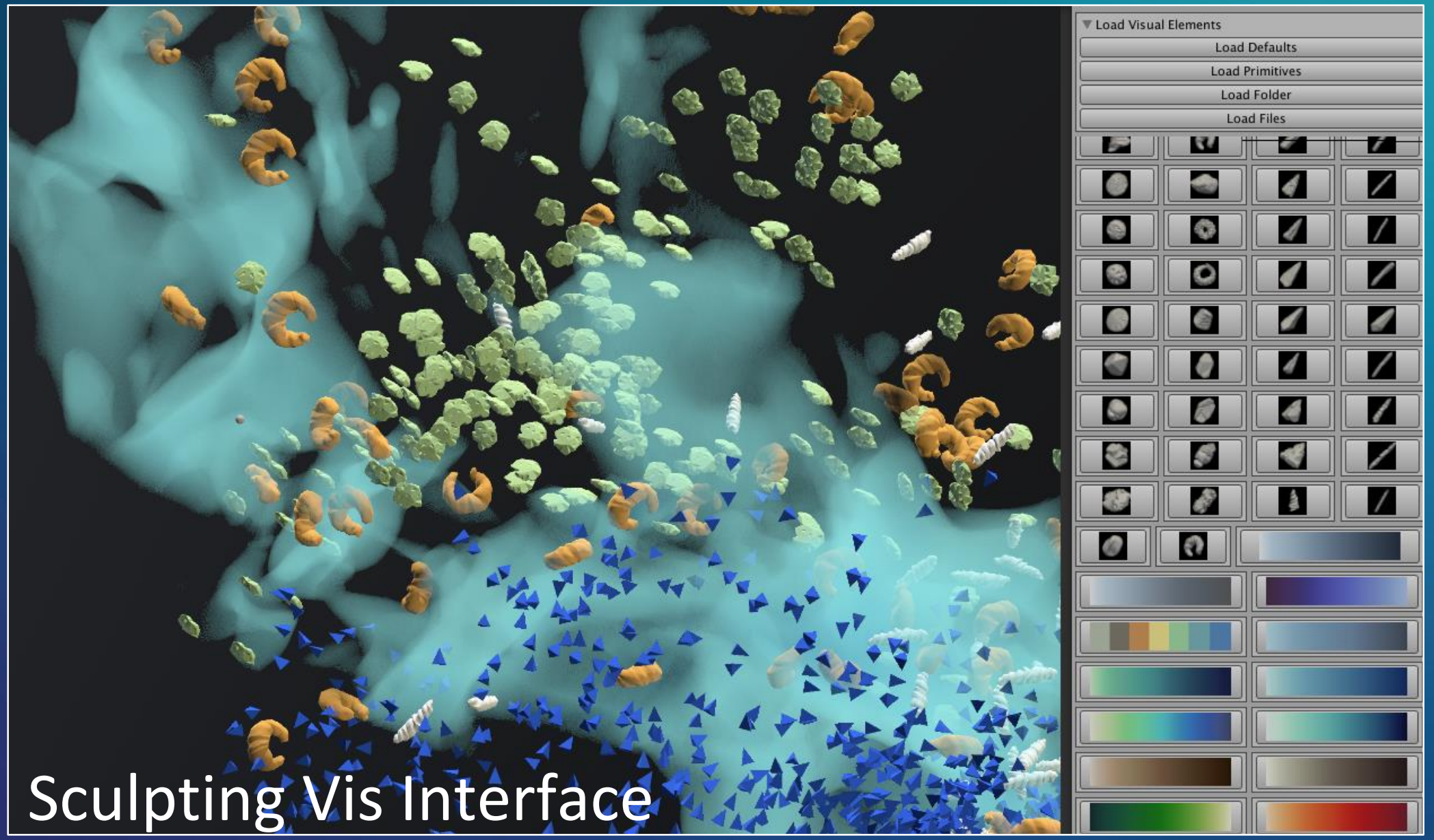
Gulf of Mexico, overview

legend

3D detail

P. Wolfram, MPAS-Ocean, LANL

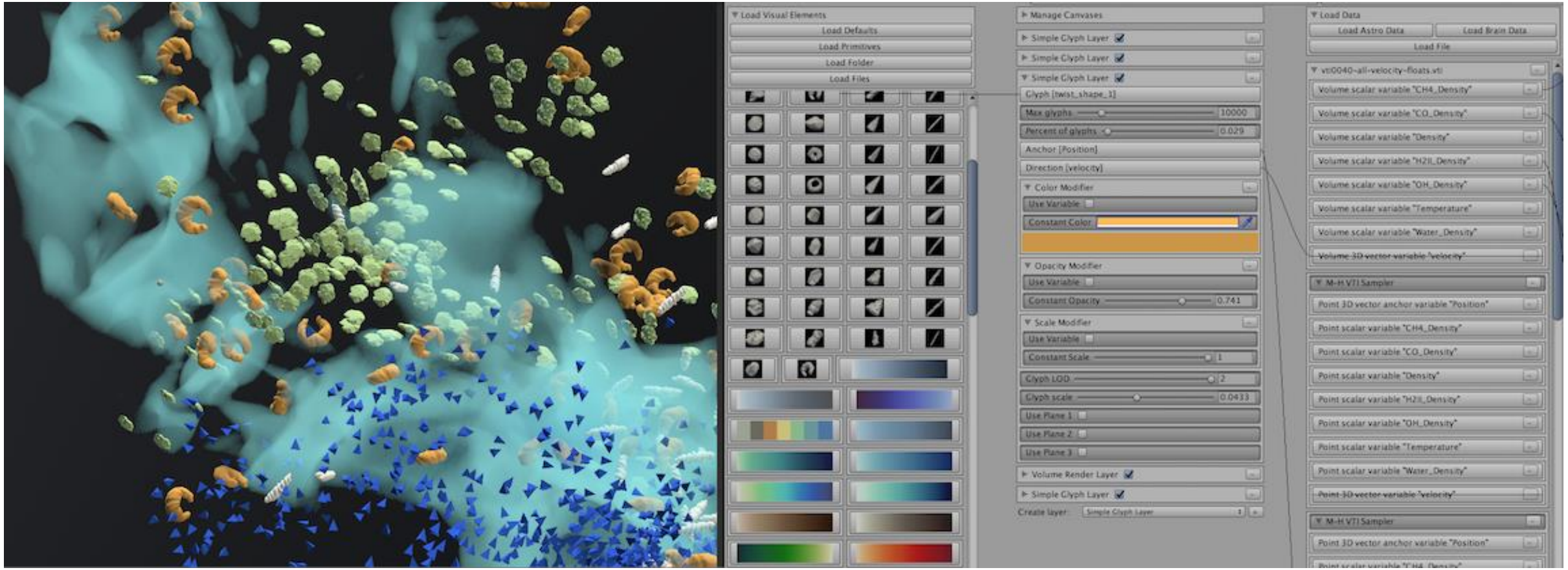
The What


Load Visual Elements
Load Defaults
Load Primitives
Load Folder
Load Files
Sculpting Vis Interface

The Sculpting Vis Interface

the visualization

the encodings

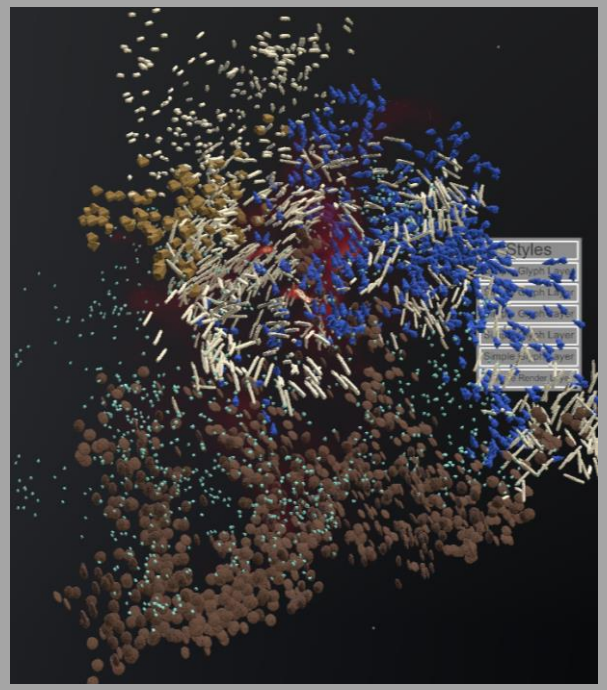


assigning the variables

variables & parameters

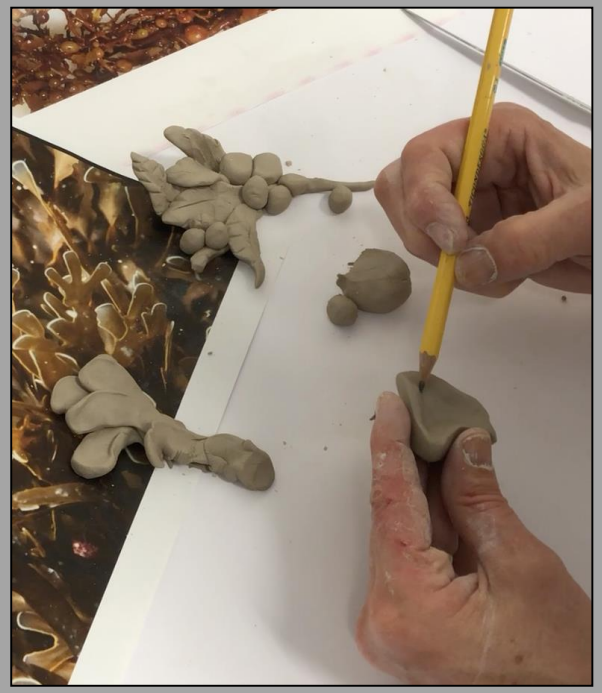
The How

sampling



volume data
converted to point data

artistic language

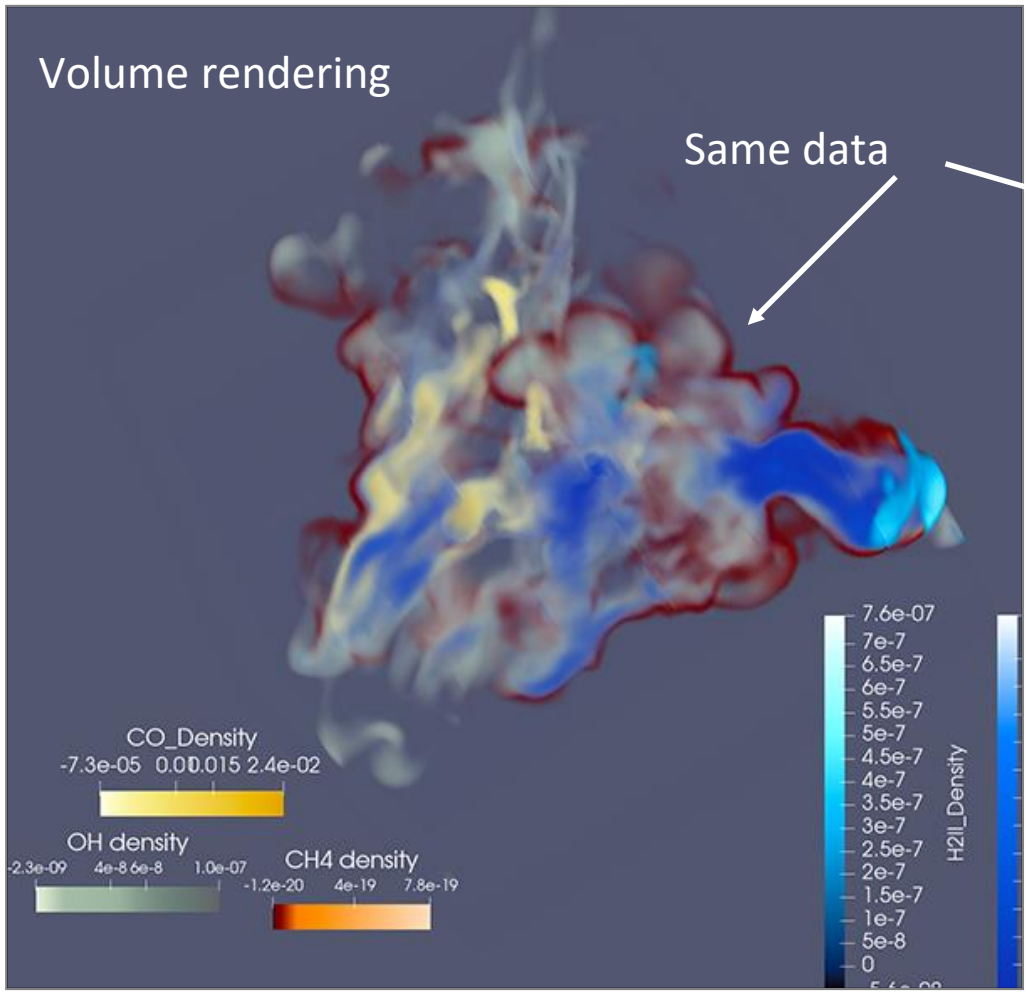


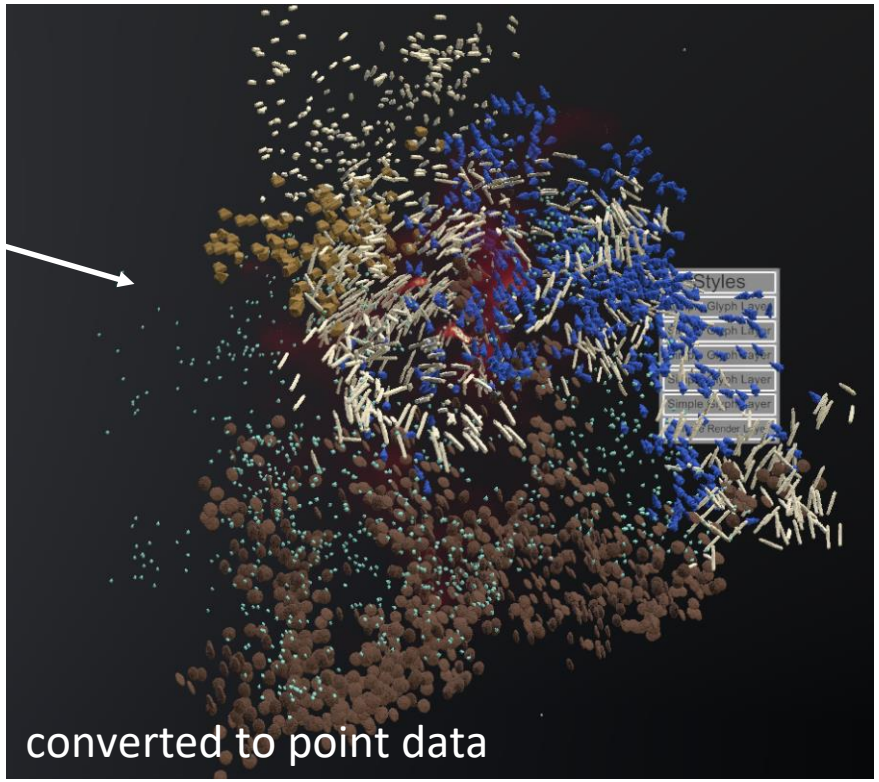
an expanded vocabulary

a powerful coding team

virtual reality immersion

Key: converting volume data to point data; sampling the point data

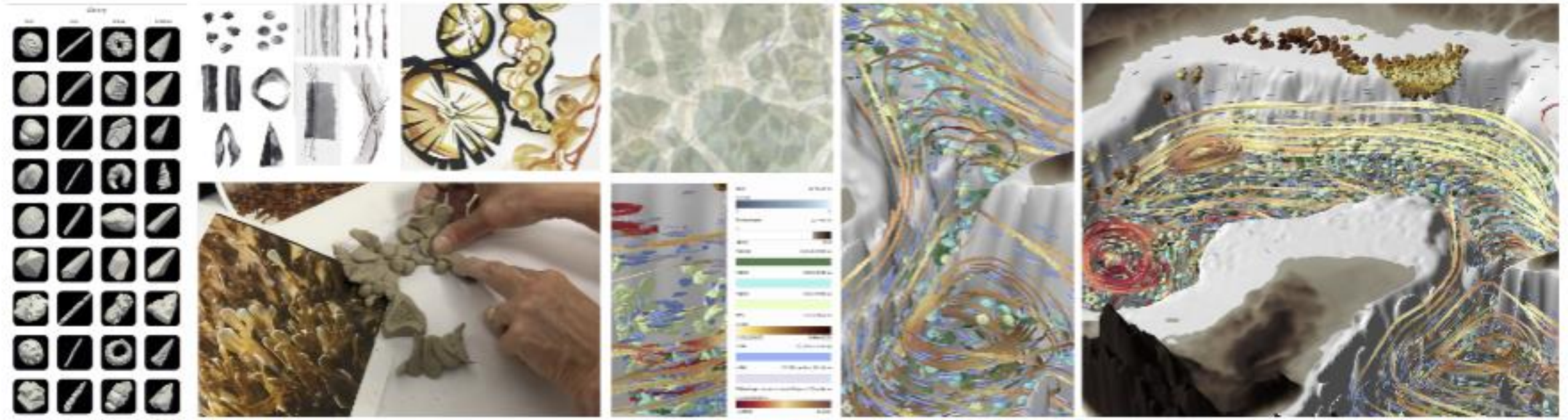




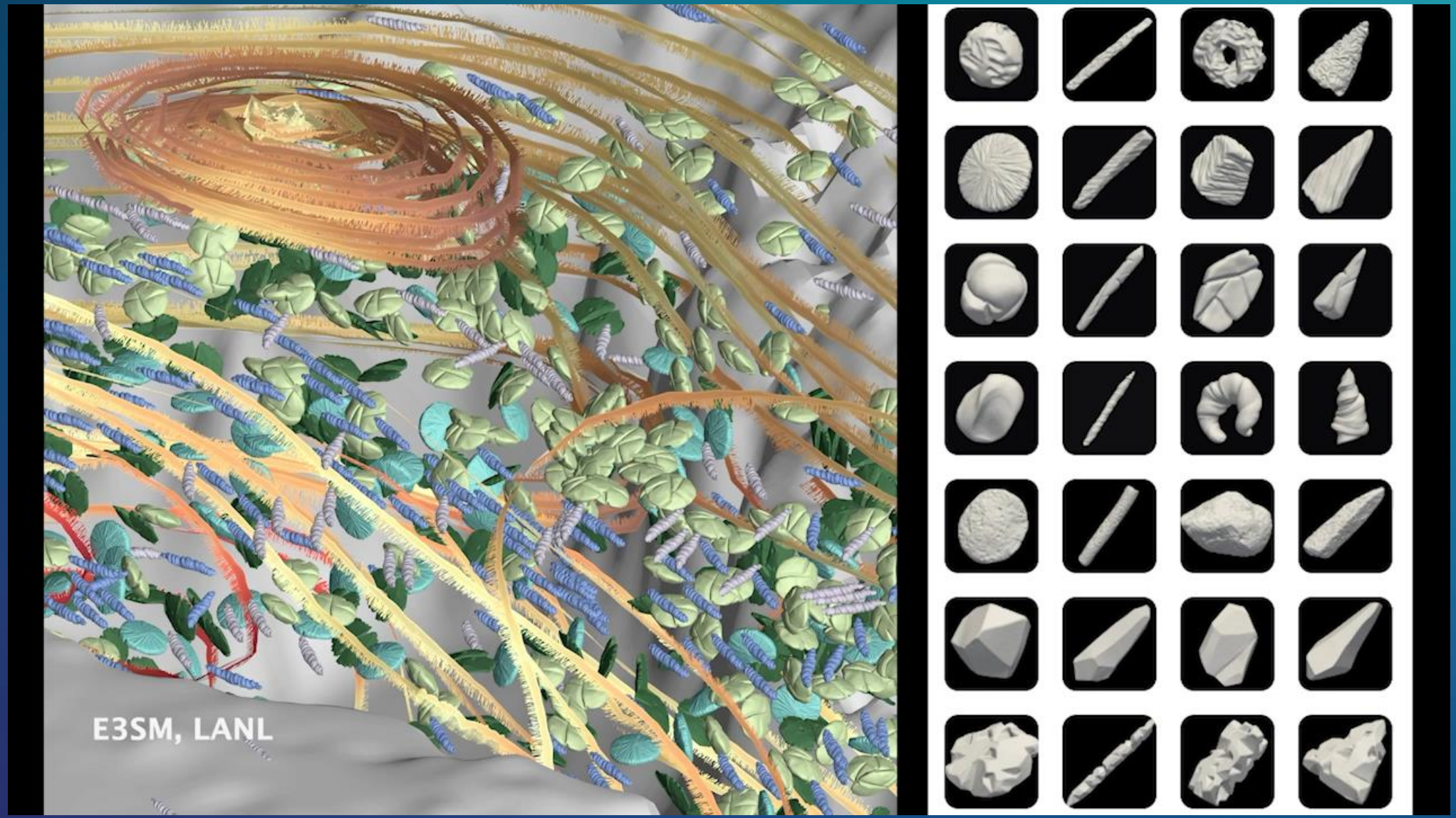
The purpose: To see multiple volumetric data variables together enabling the tracking of cause and effect.

The First Water in the Universe
J. Smidt, LANL.

Creating and applying the new vocabulary

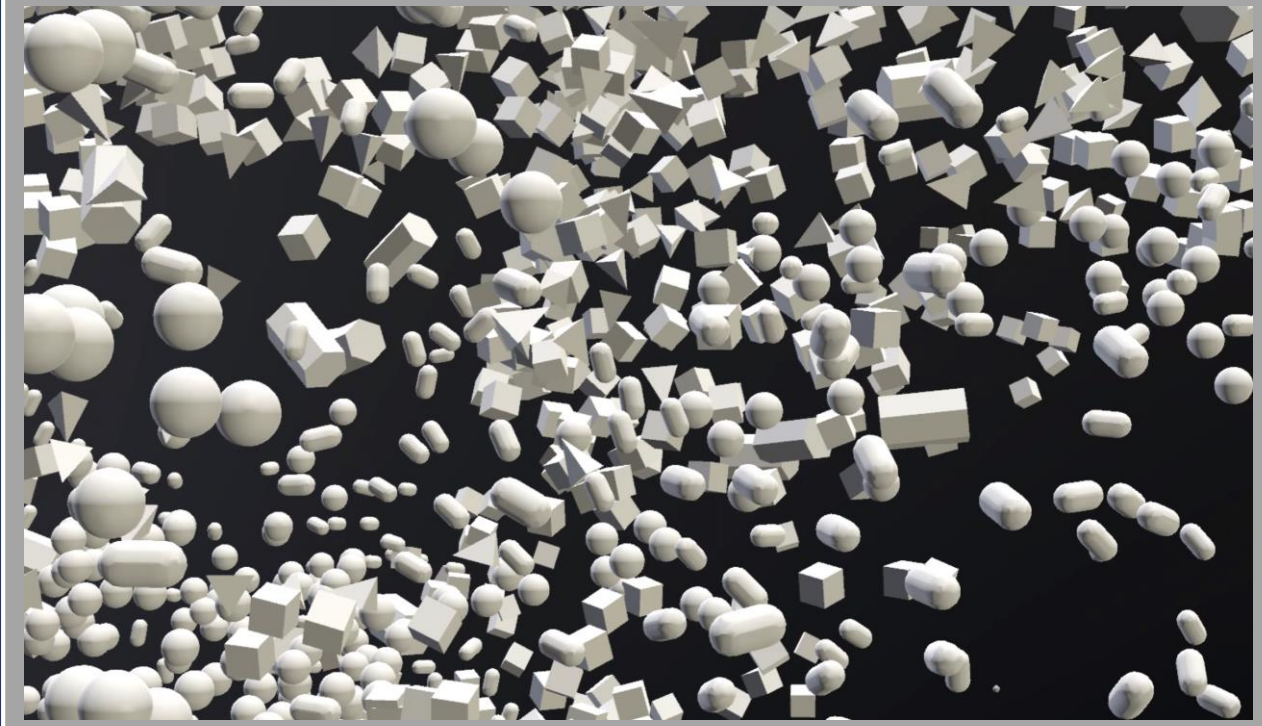


Expanding the glyph vocabulary

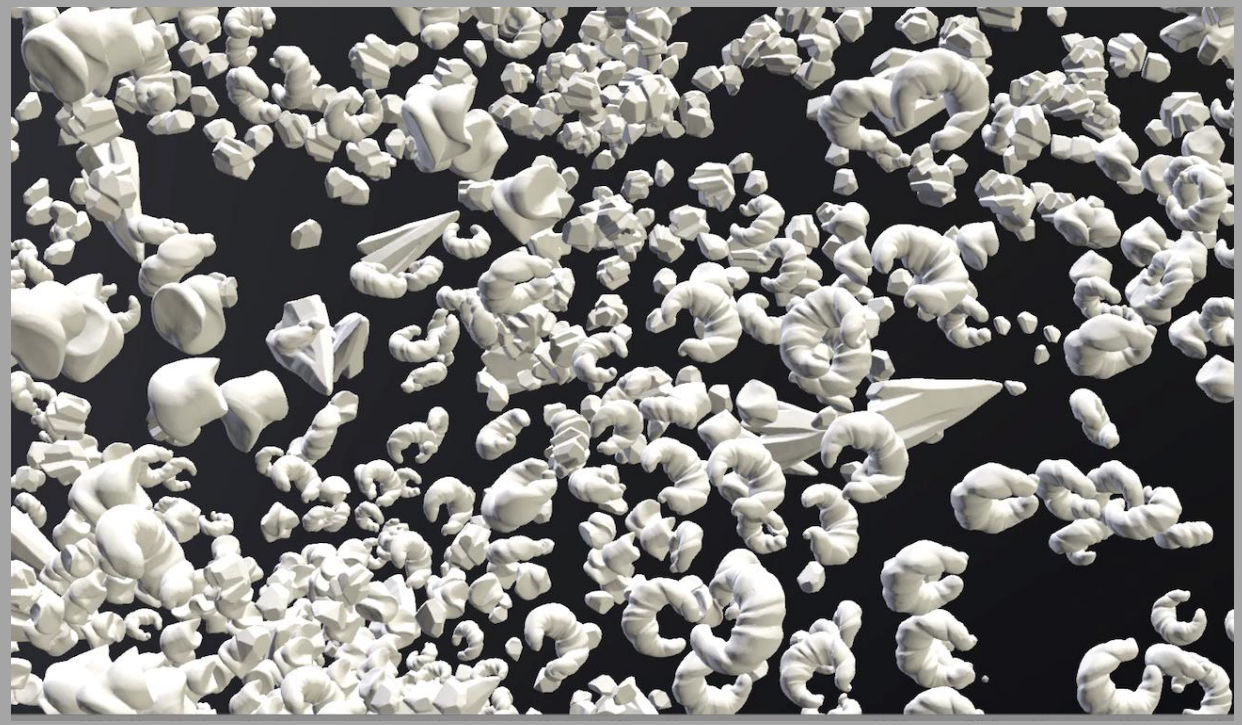


video

Creating Variety



Commonly available glyphs



Sculpting Vis library glyphs

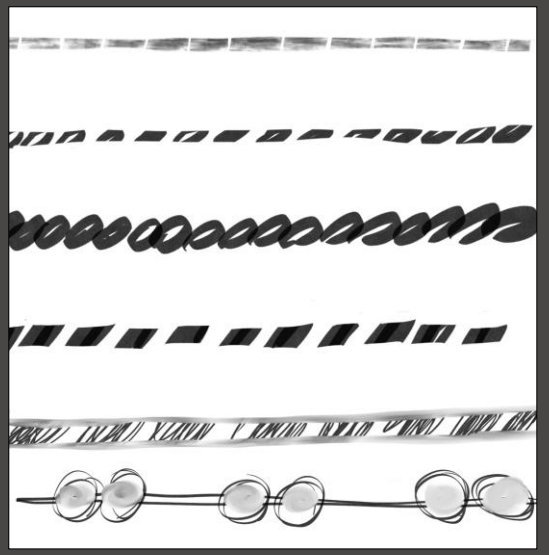
Adding:
variety, character, association, sets

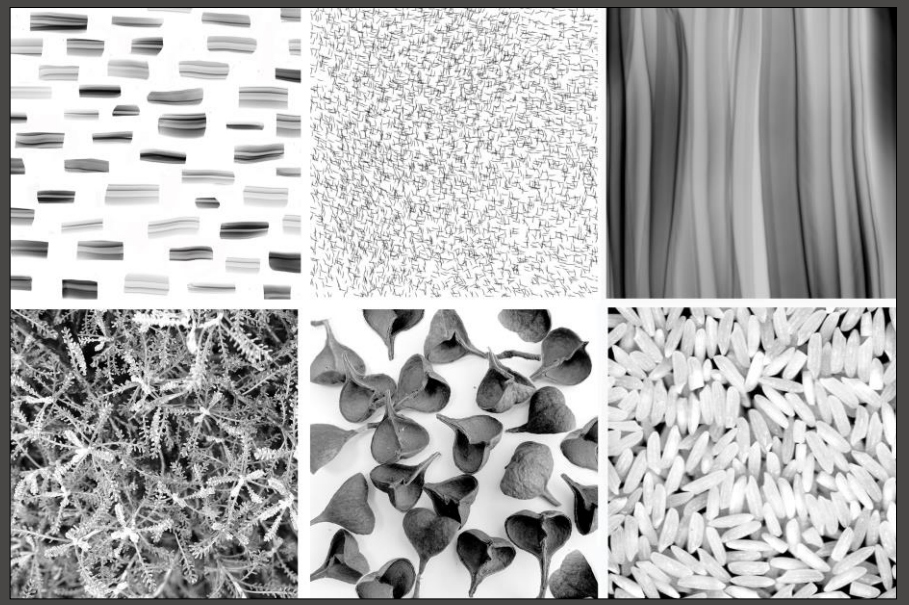
Libraries:

Lines

Glyphs

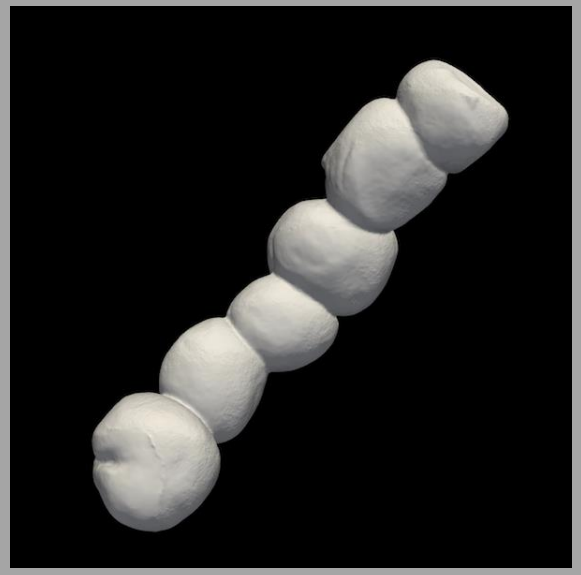
Textures

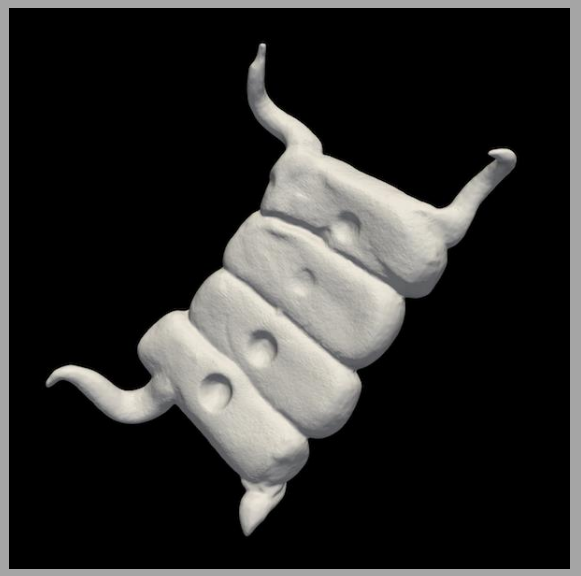




Creating Intuitive Encodings

3D glyphs
associative forms

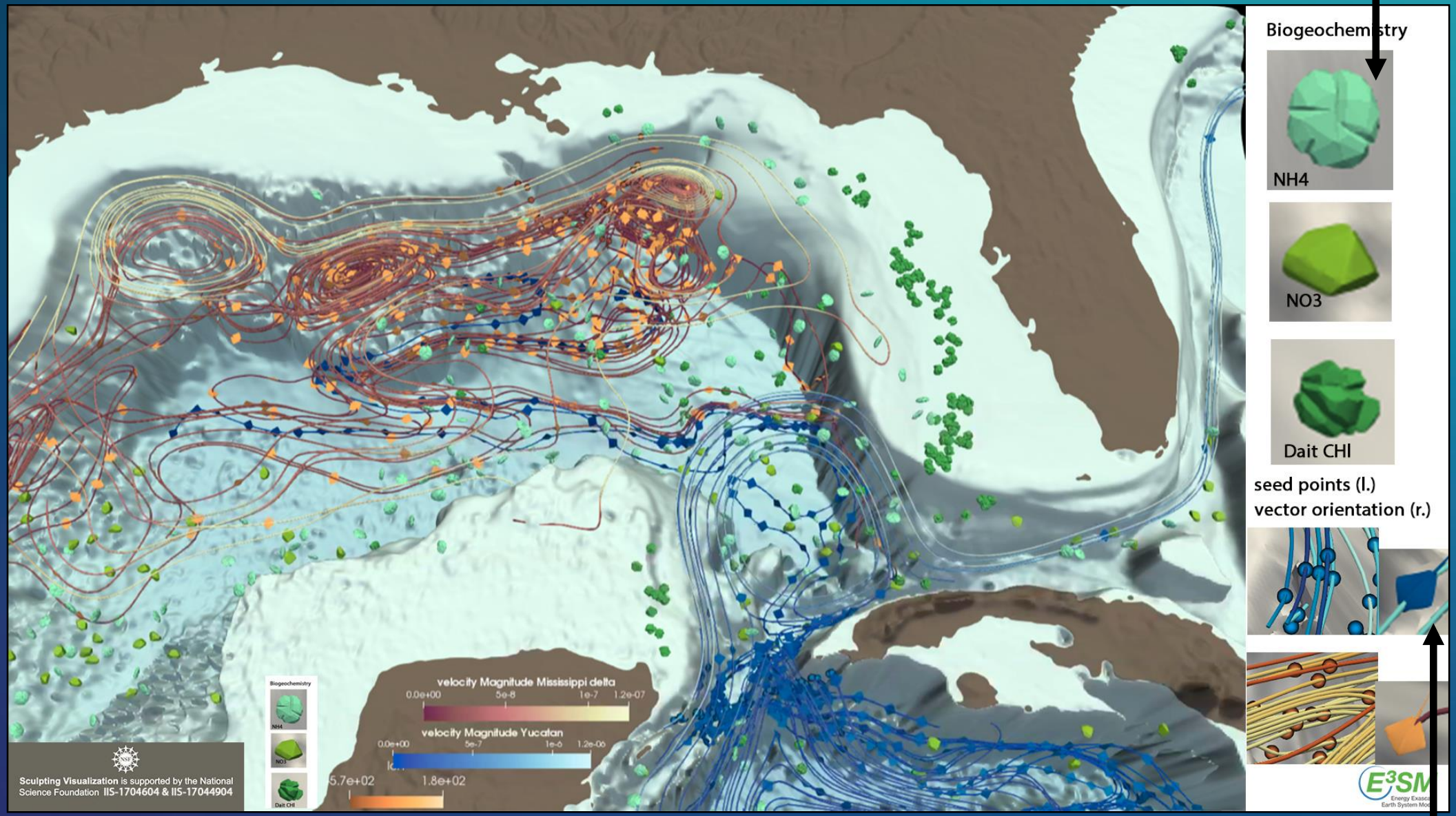




types of phytoplankton
studied in ocean biogeochemistry

2D glyphs, associative

categorial glyphs

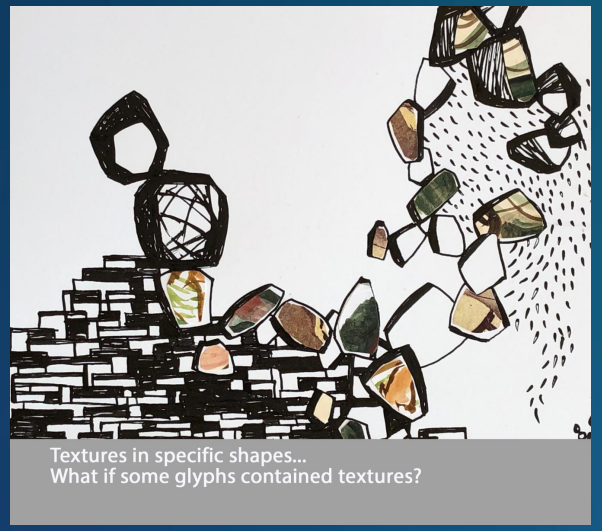


glyphs showing rotation within the vector field

Textures: a cyclical design process

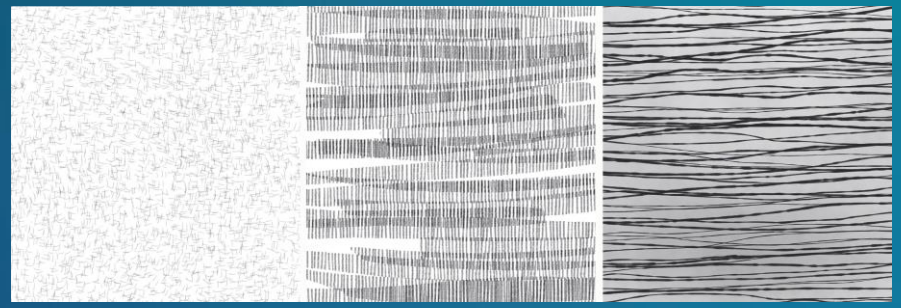
Textures in specific shapes...
What if some glyphs contained textures?

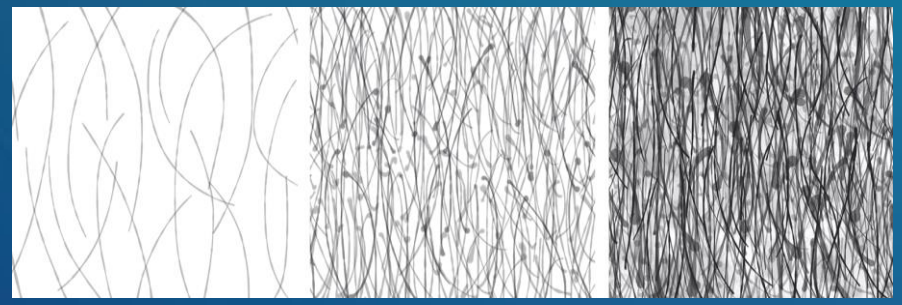
A cyclical design process



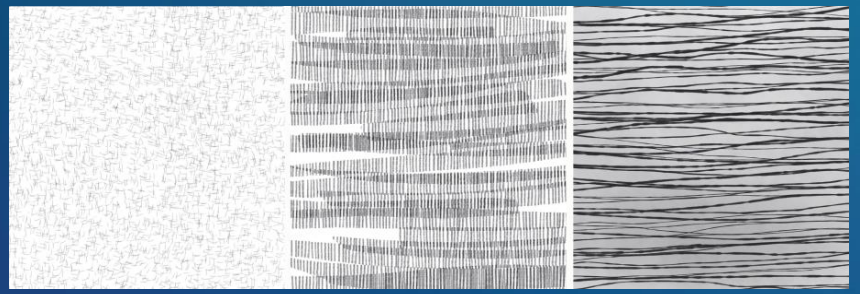
drawings

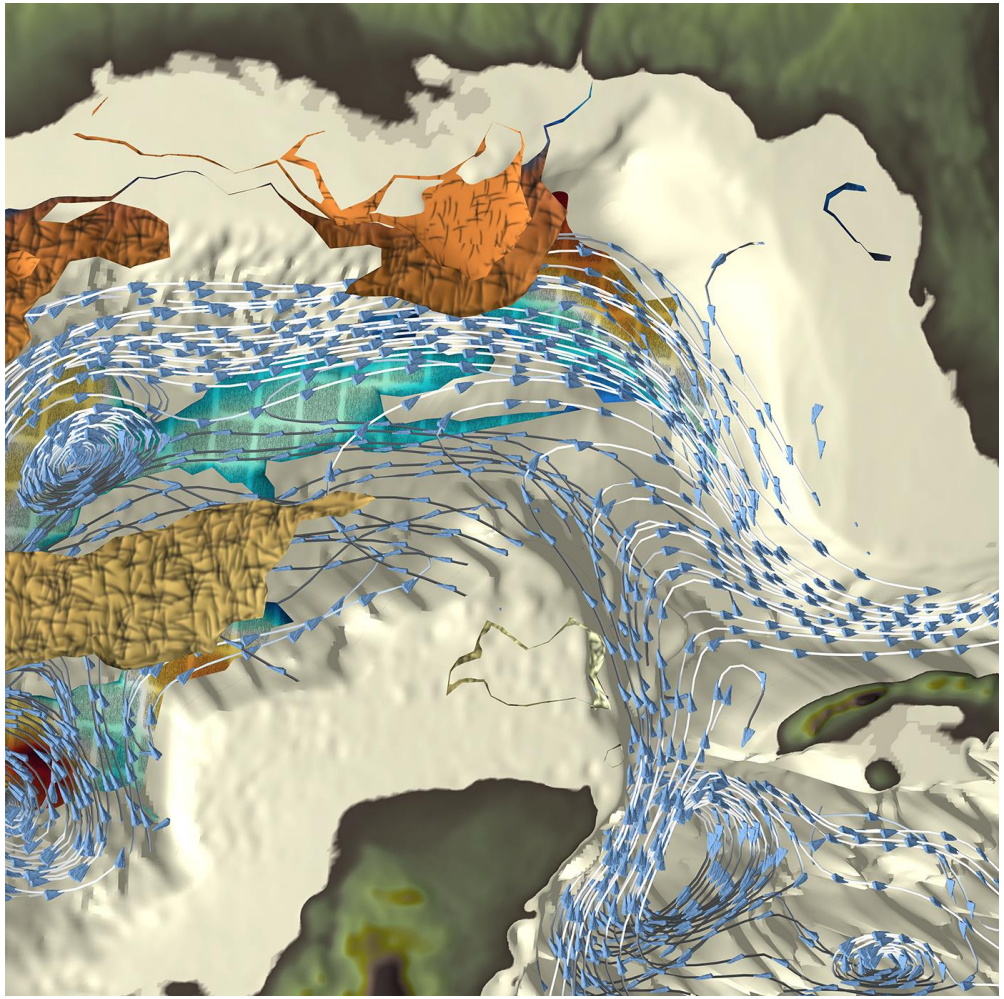
textures



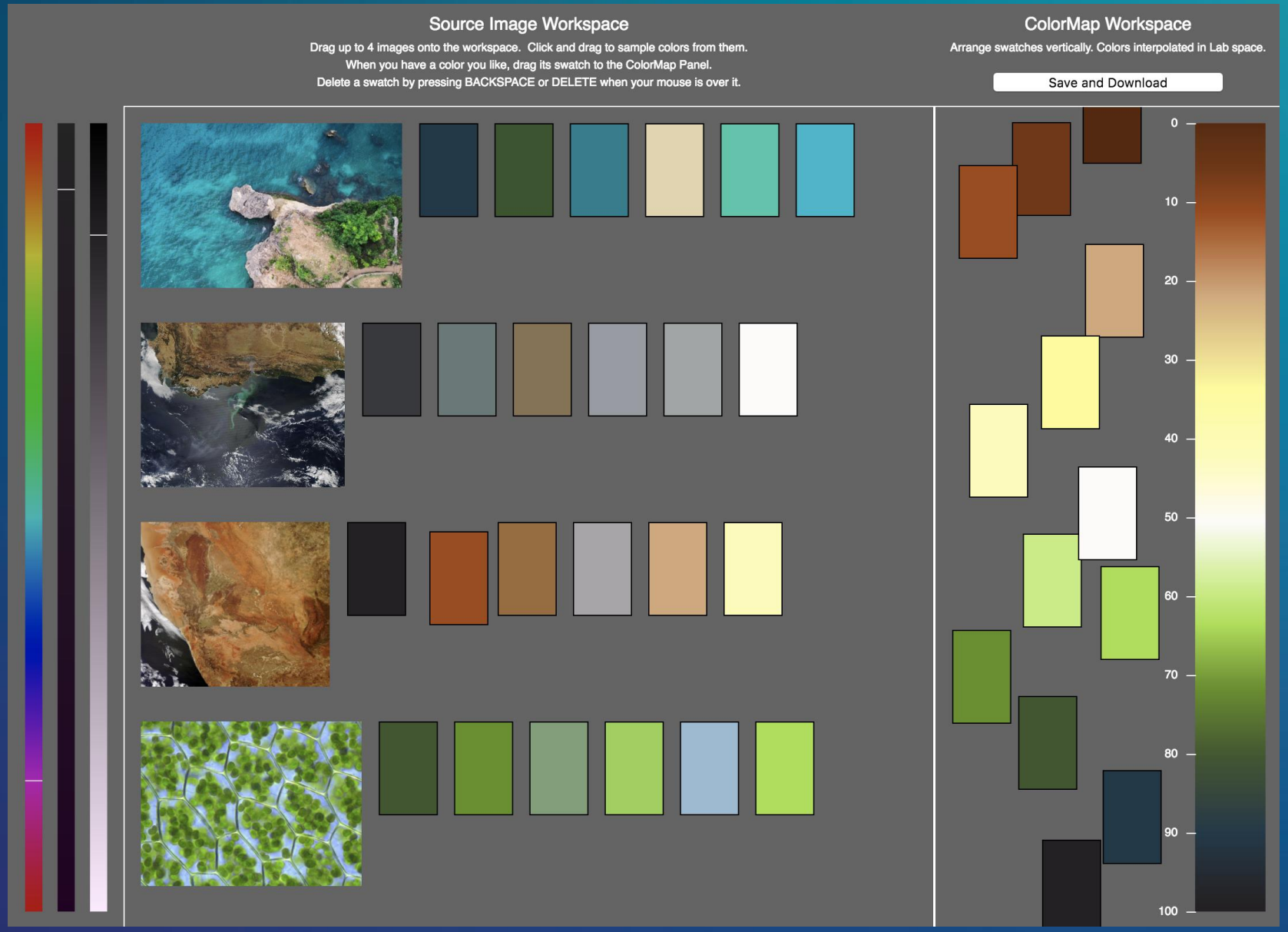


A cyclical design process





ColorLoom: creating colormaps

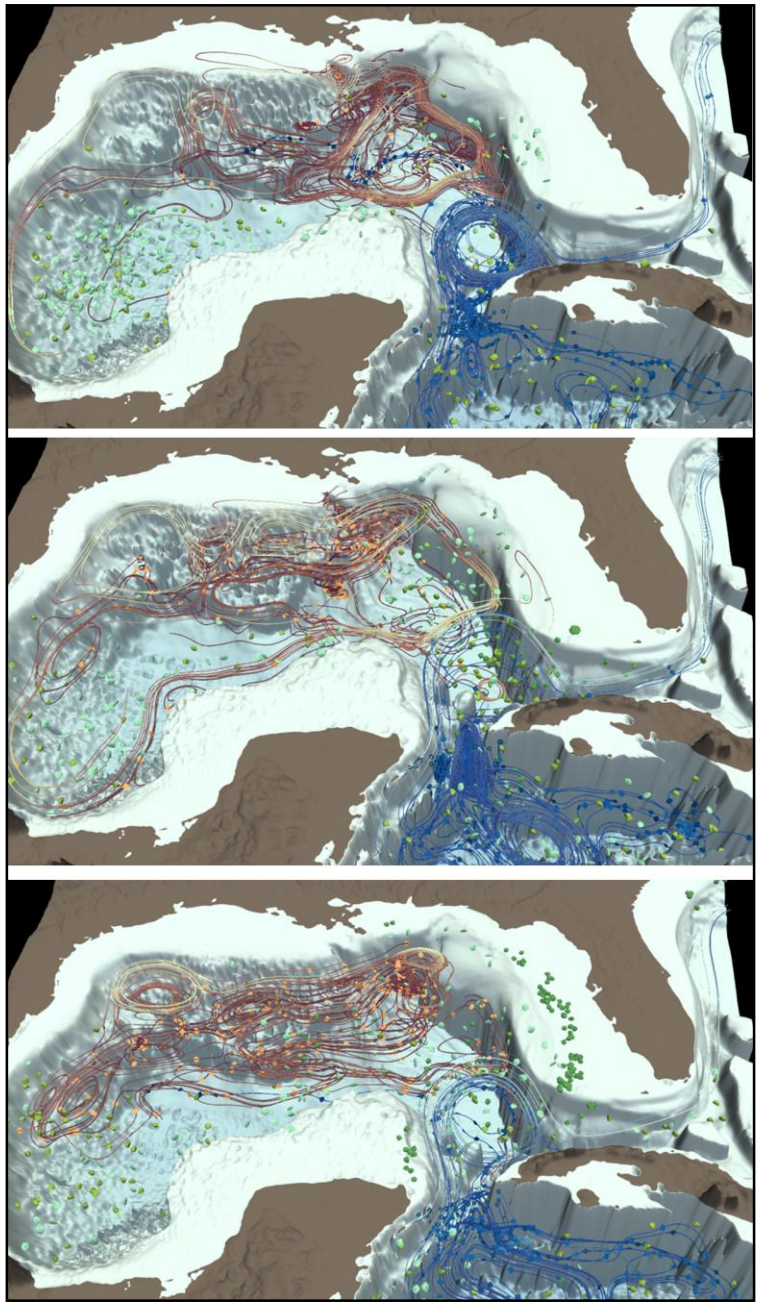


Sculpting-vis.org

Use It

Applest

ColorLoom



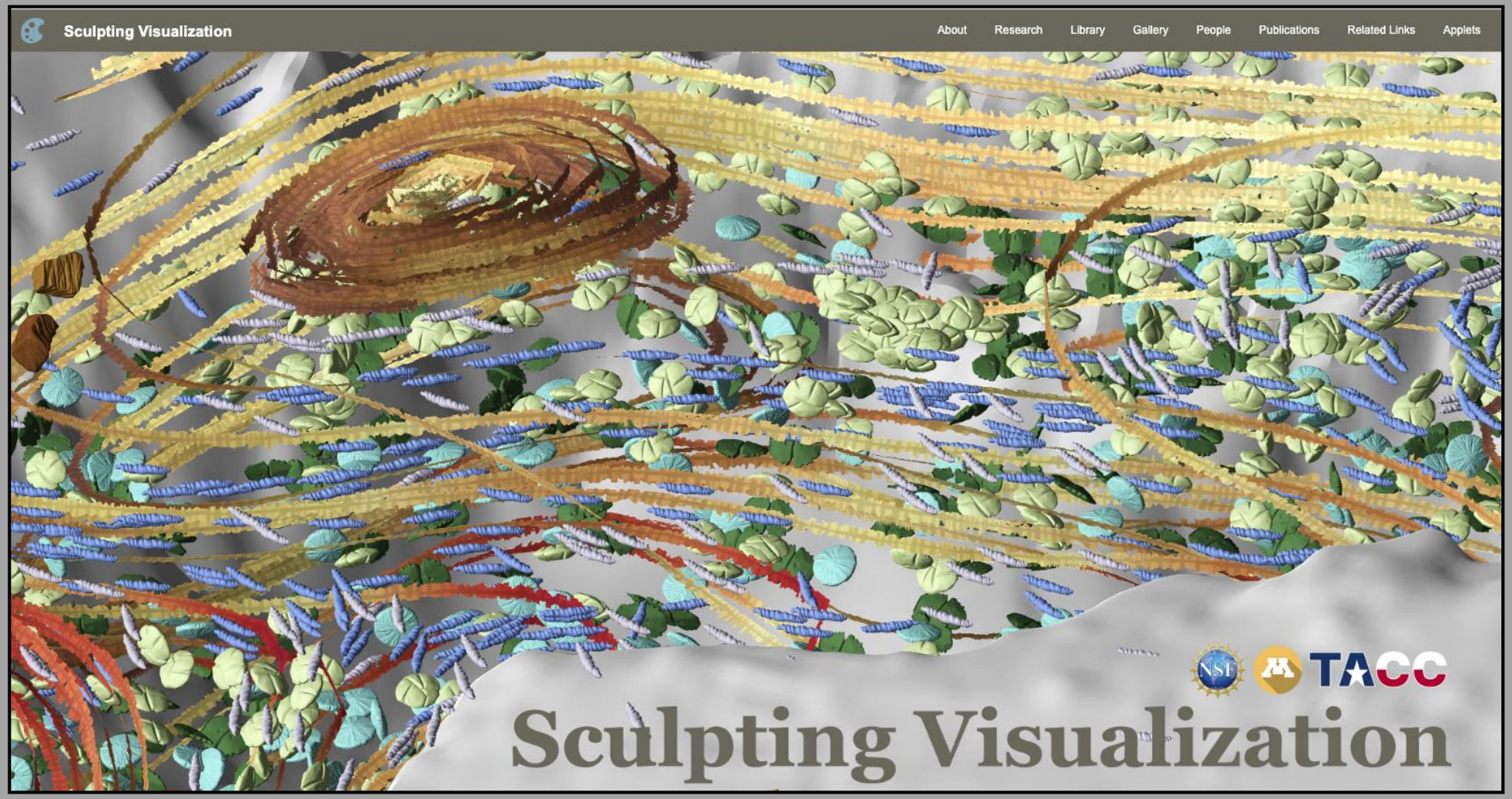
Time Sequence

Time varying visualization is needed to understand the water mixing patterns within the Gulf of Mexico.

Of particular importance is the vertical mixing which needs the 3D visualization in order to clearly depict the flow.

In VR, one can “swim below the surface”, in order tp get a viewpoint that shows not just the vertical mixing but also the positioning of the nitrates within the flow fields.

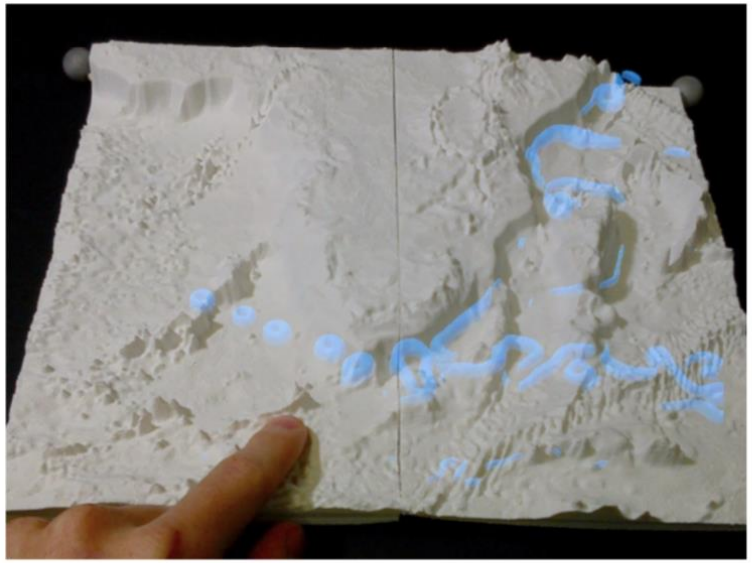
The Where



www.sculpting-vis.org

github

Augmented Reality for Scientific Visualization

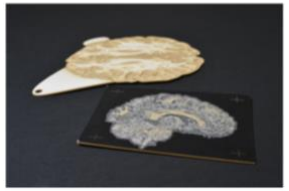


AR visualization of ocean currents along the southern coast of Africa overlayed on a physical, 3D printed model of bathymetric data (first person view from headset user)

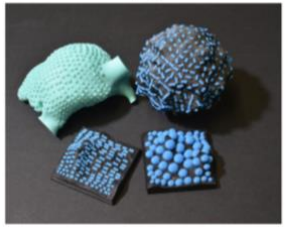
Hybrid Augmented Reality and Data Physicalization

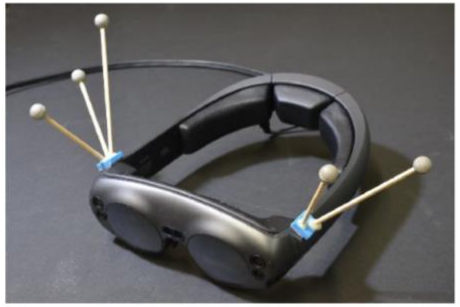
Our work with augmented reality (AR) and physicalization blends a dynamic layer of digital content with physical visualizations. Data physicalizations are a detailed, tangible way to visualize data which engage both the visual and tactile senses. Physicalizations allow us to use the knowledge and context of the real world to interpret data, and allow for collaboration between stakeholders in a visualization. However, since physicalizations are constrained by the physical world, these data representations are often static.

We add interactivity to physicalizations through the use of computer graphics, augmented reality headsets, high-accuracy tracking systems, and custom touch input devices. These technologies provide a means of displaying and interacting with diverse types of data. For instance, in the left figure, ocean currents from the MPAS-O[1] climate dataset are shown in AR on top of a physical printout of the ocean depth data. The physical model is tracked, allowing users to move it around and observe how the currents behave based on the ocean depth.



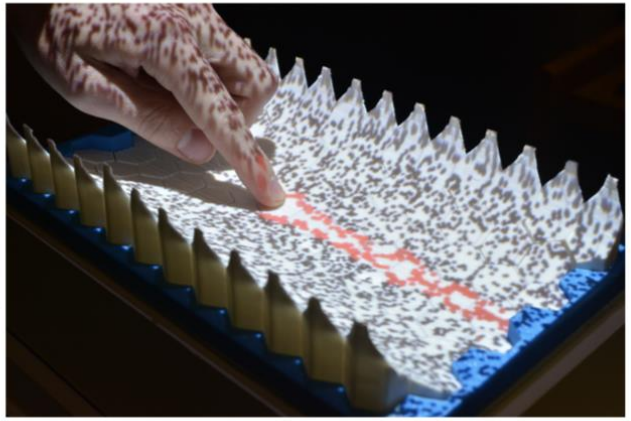
Various data physicalizations





Magic Leap AR headset with external trackers attached

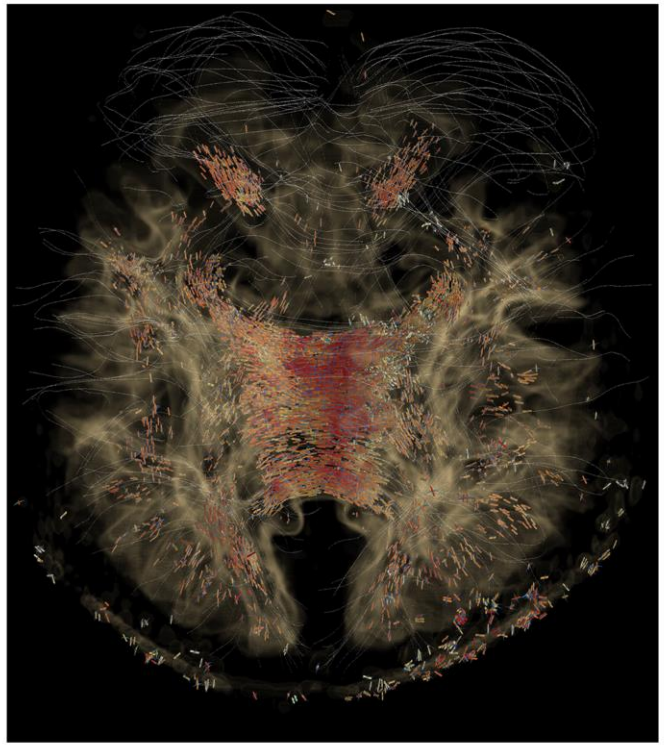
[1] Data were obtained from the Energy Exascale Earth System Model project, sponsored by the U.S.Department of Energy, Office of Science, Office of Biological and Environmental Research.

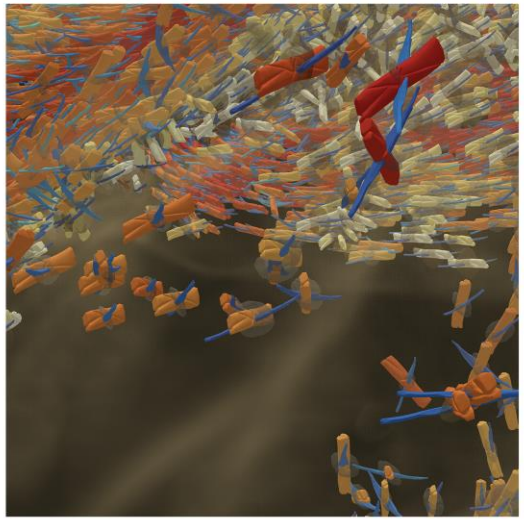


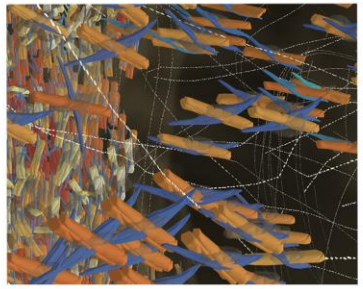
Touch-sensitive data physicalization with projected computer graphics

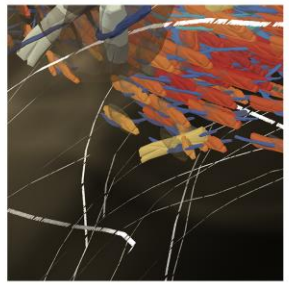
https://www.sculpting-vis.org/index.php/ar-physical-sculpting/

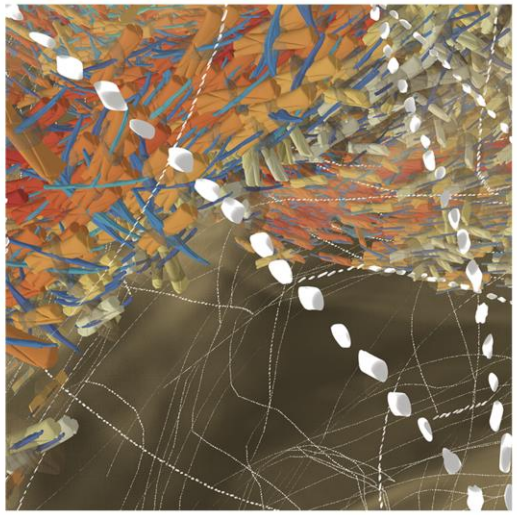
The Take Away











VR and AR, known for gaming have the potential to help **solve real world problems**.

Multidisciplinary teams are hard.
Language is the primary issue.
The reward is the capability to go where you could not go alone.

Step outside the box and see where it takes you.

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This research was supported in part by the National Science Foundation (IIS-1704604 IIS-1704904).

The science:

Brain microstructure applications were supported in part by the National Institutes of Health (P41 EB015894, P30 NS076408).

MPAS-O simulations were conducted by Mathew E. Maltrud and Riley X. Brady as part of the Energy Exascale Earth System Model (E3SM) project, funded by the U.S. Department of Energy (DOE), Office of Science, Office of Biological and Environmental Research with analyses conducted by PJW, MEM, and RXB under ARPA-E Funding Opportunity No. DE-FOA-0001726, MARINER Award 17/CJ000/09/01, Pacific Northwest National Laboratory, prime recipient.

#GHC19