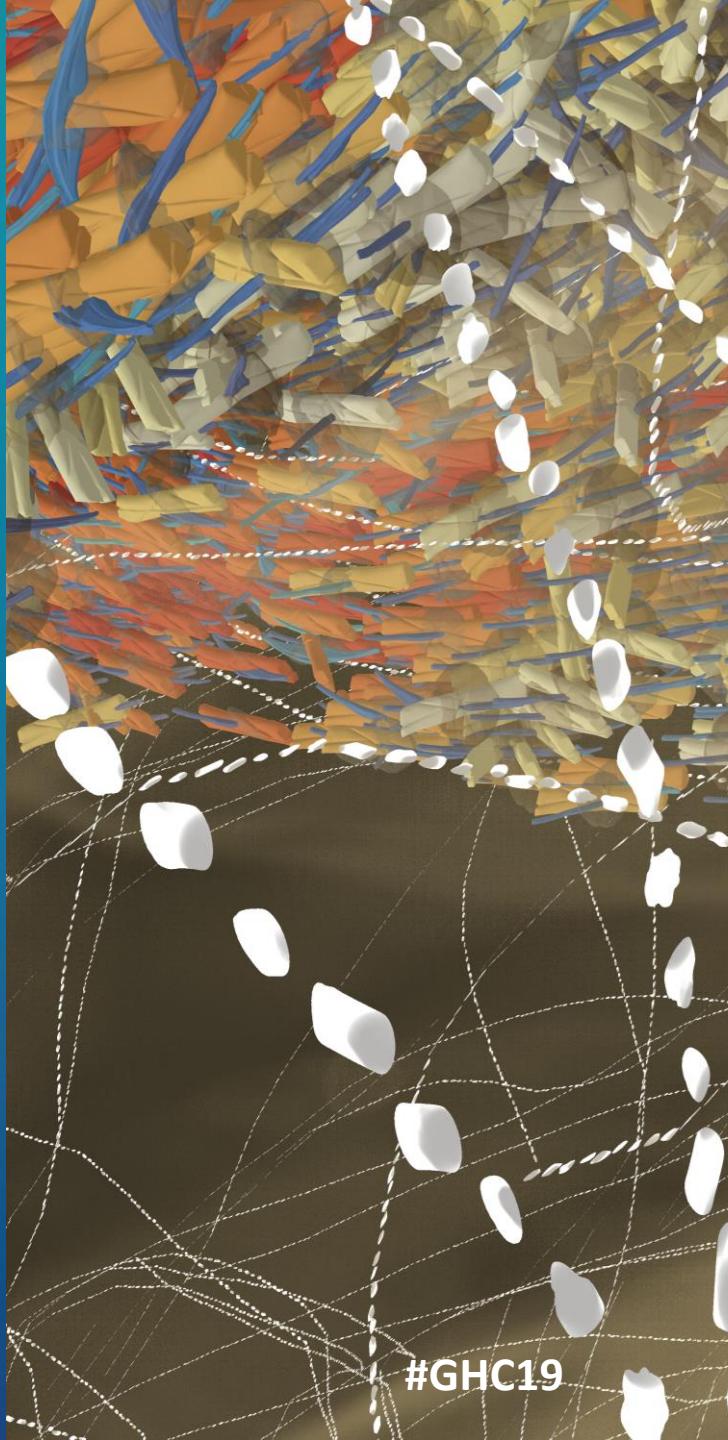


Scientific Visualization: Melding Computer Science & Artistic Design Theory



#GHC19

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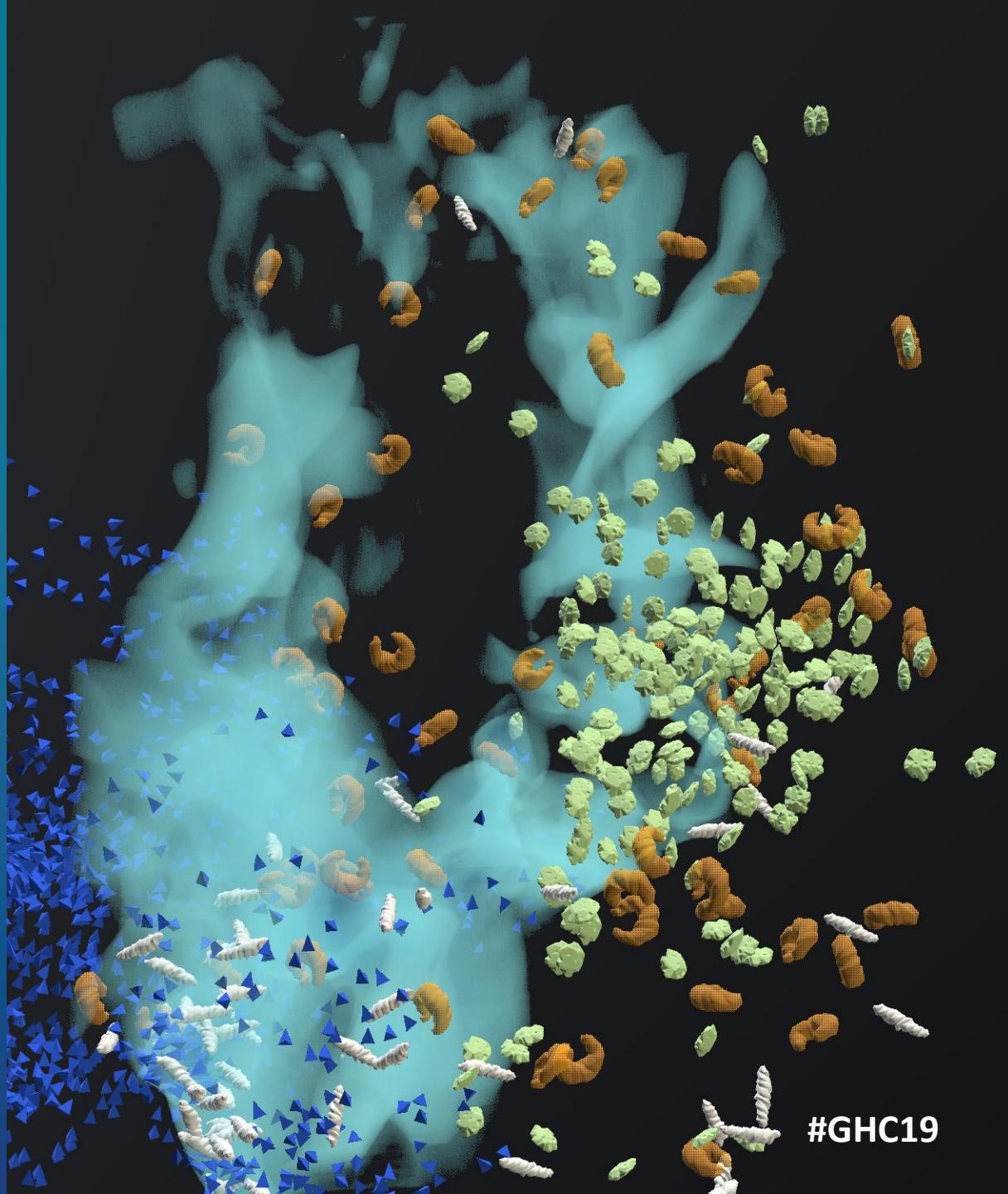
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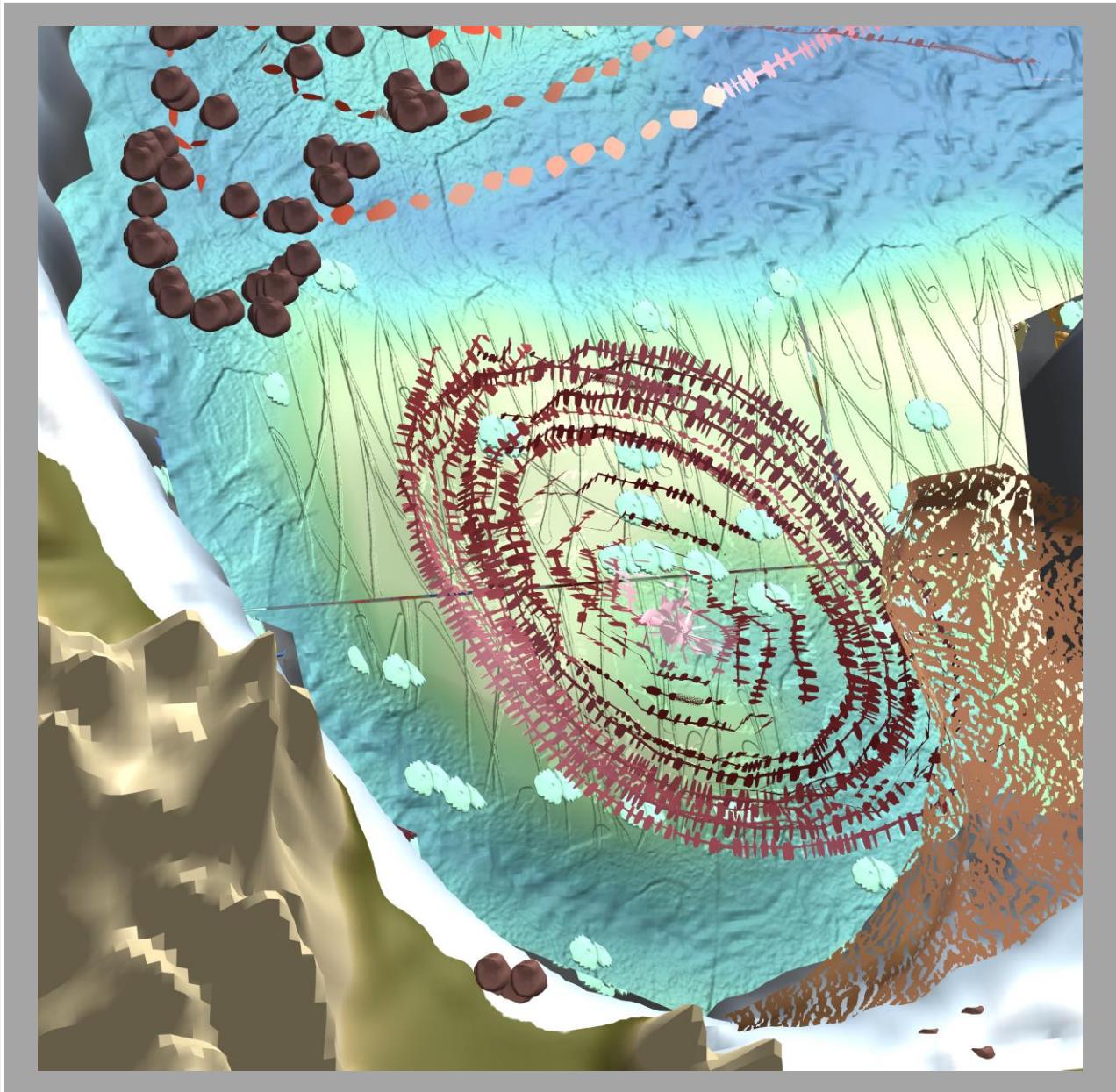
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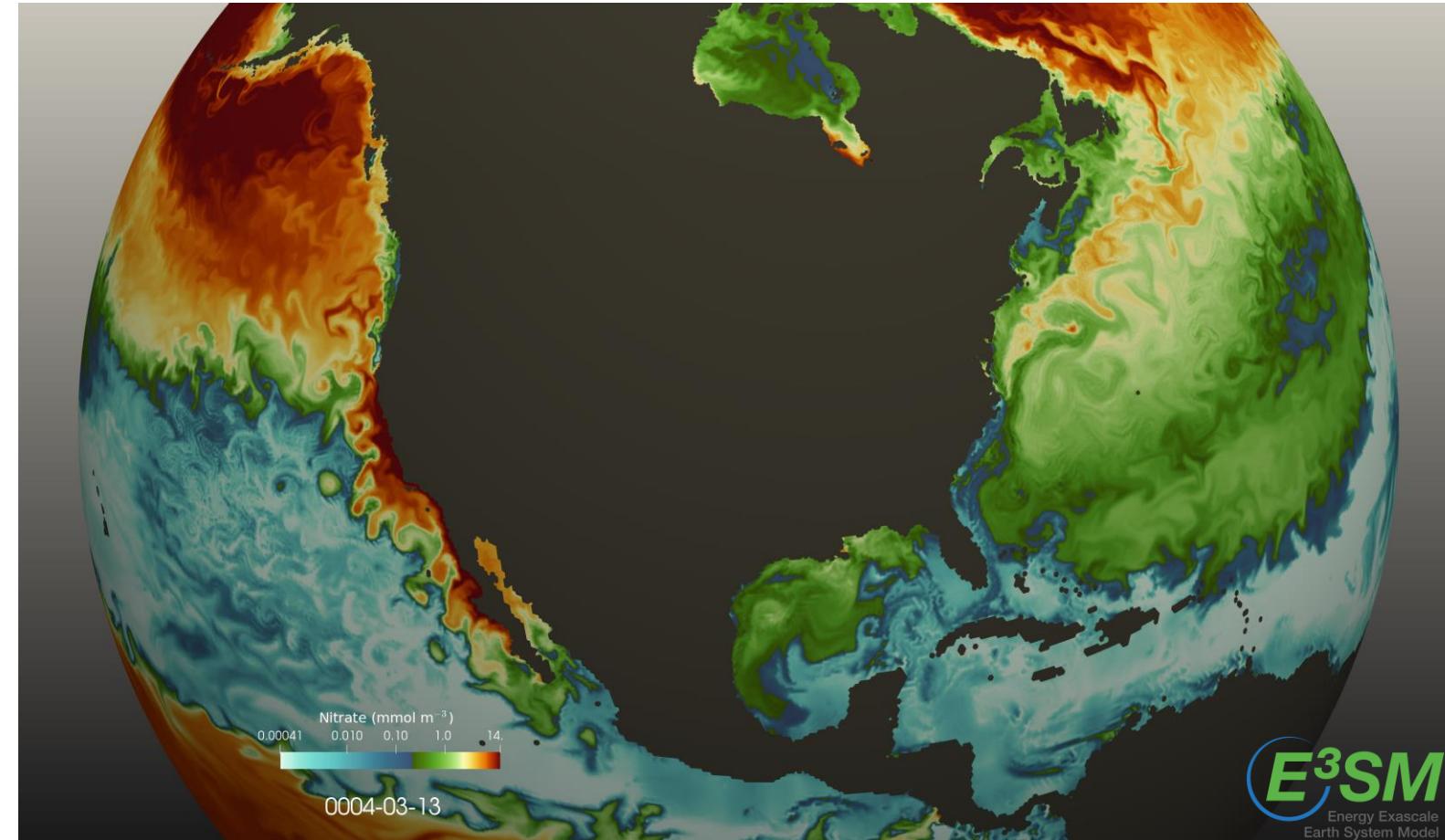
Our purpose

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.

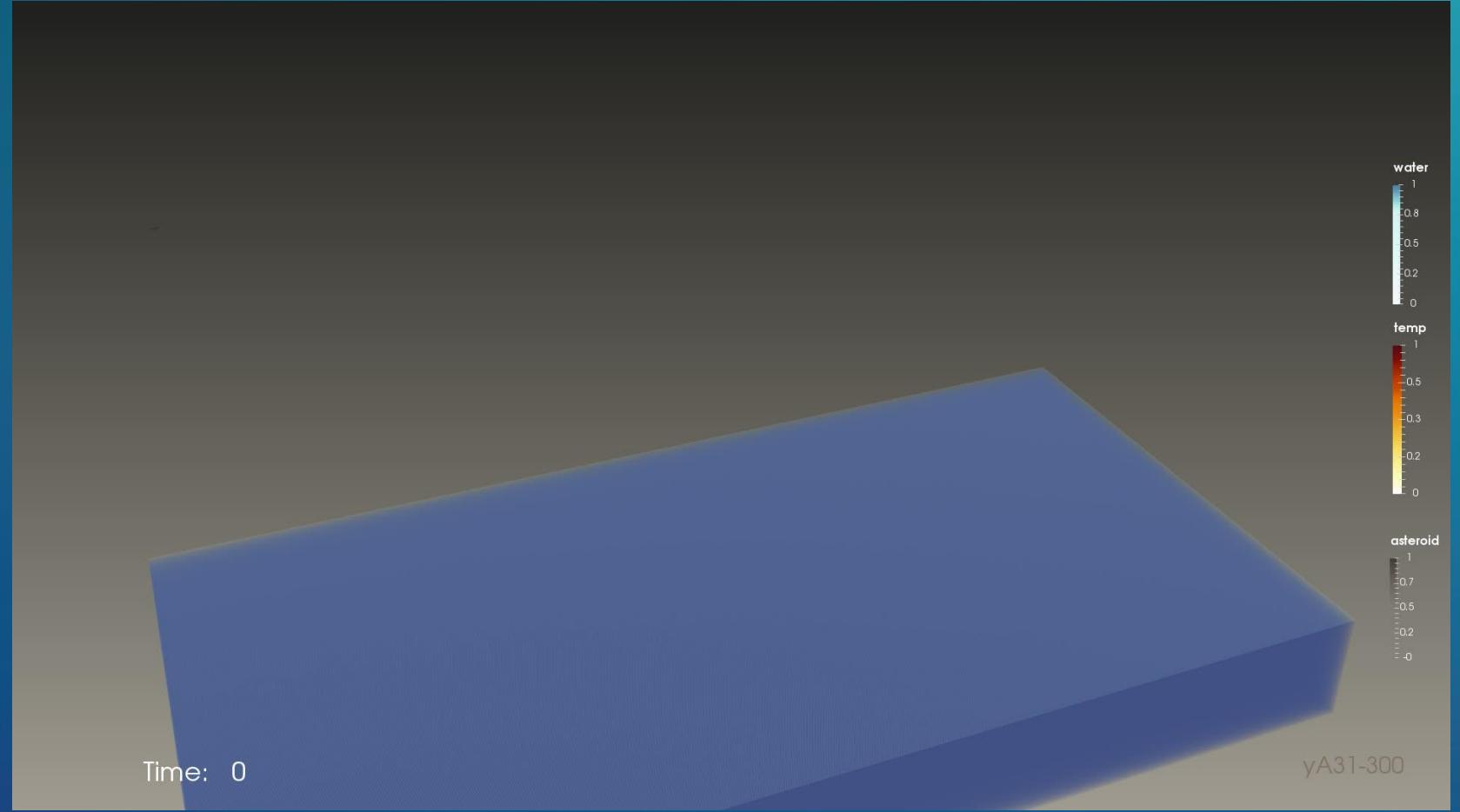
Climate models are built to predict climate system changes specifically where the climate is changing, at what rate and the impacts on society.



Two audiences

The scientist in the office next door – intuitive detailed understanding

The public – engagement, immersion, communication understanding



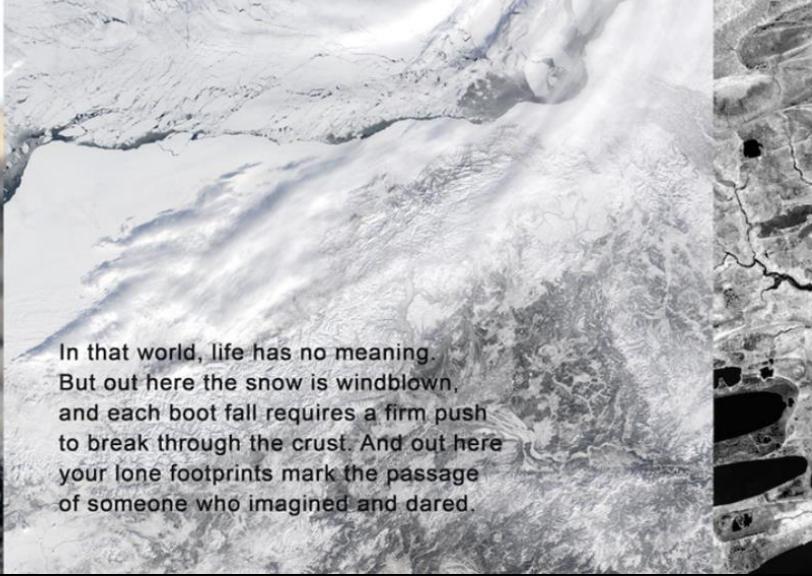
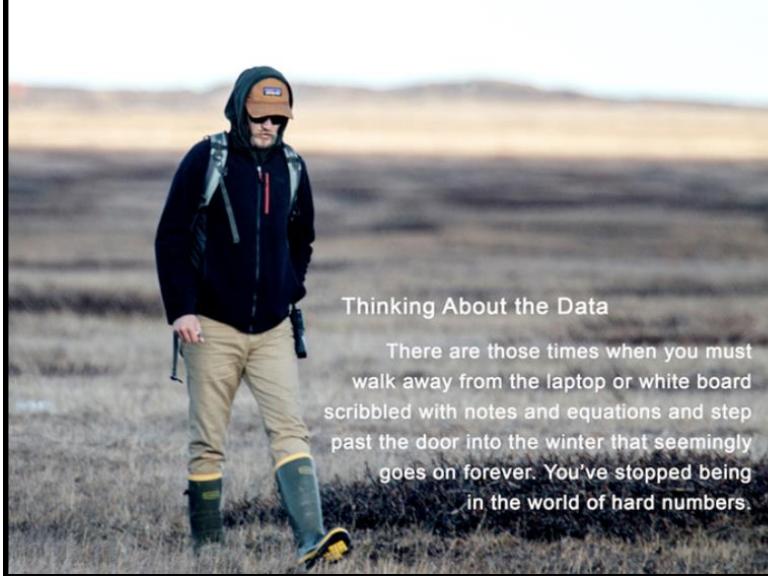
asteroid impact simulation, Gisler, LANL

video

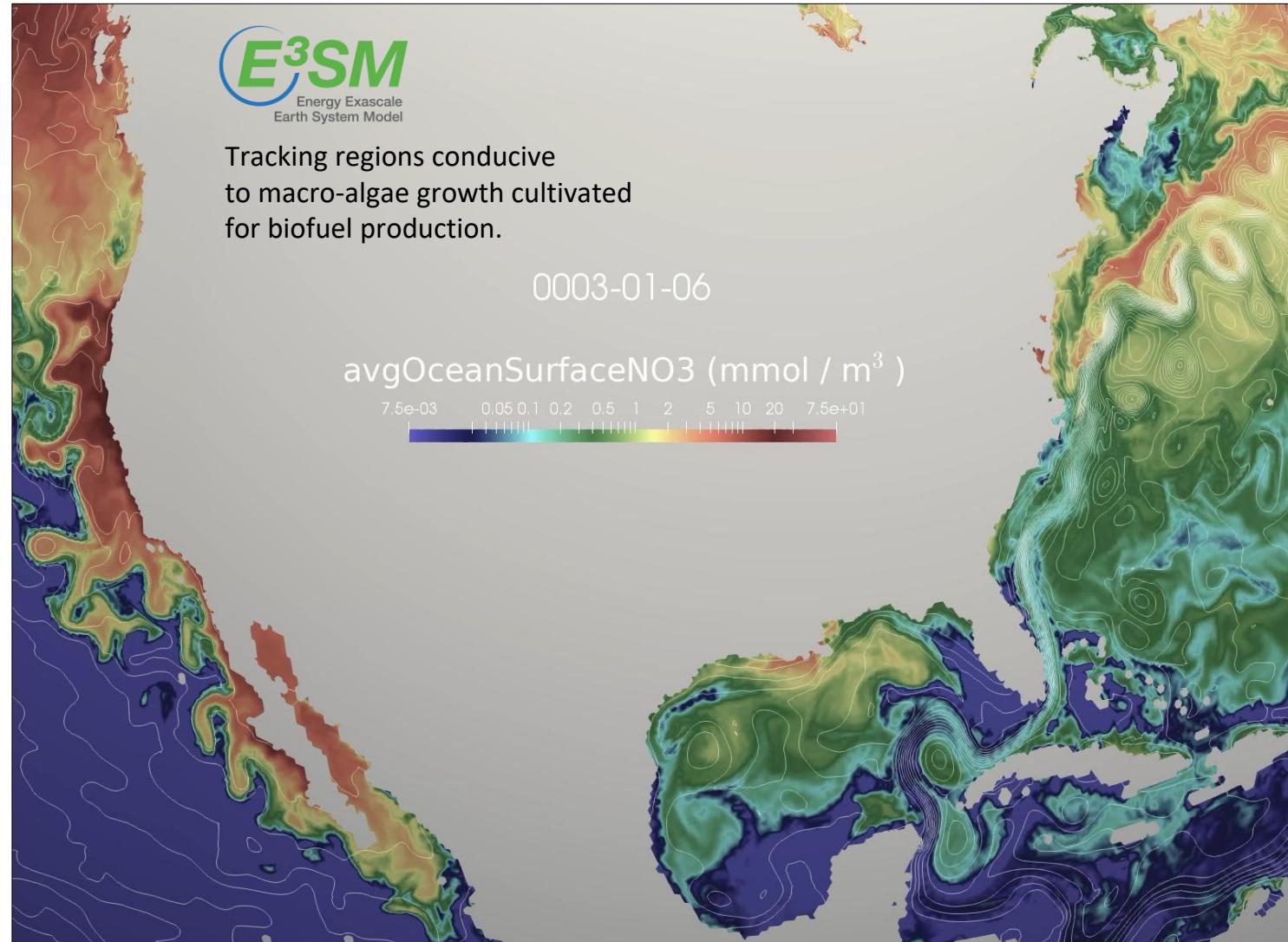
Two audiences

The scientist in the office next door -
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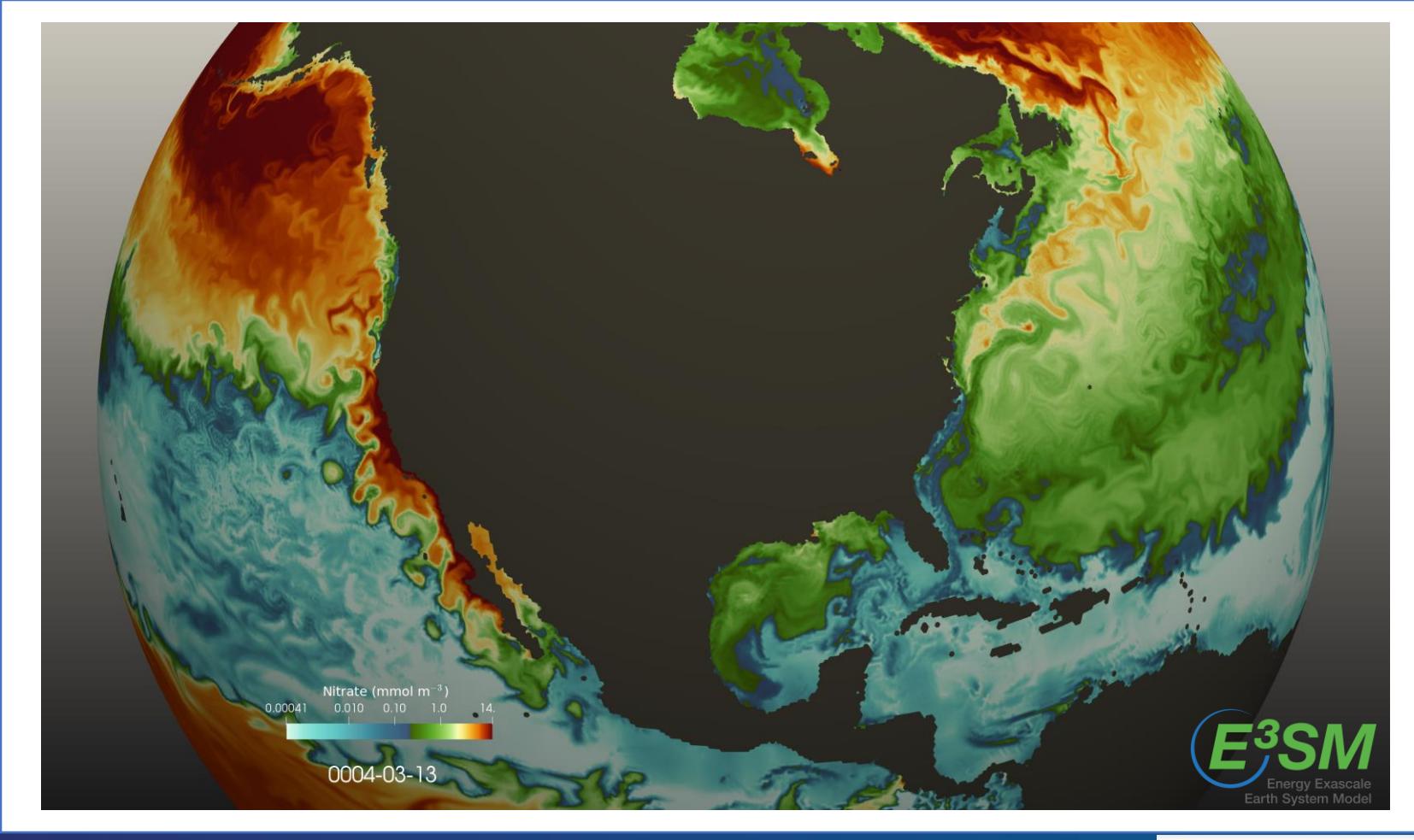
Climate Modeling



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

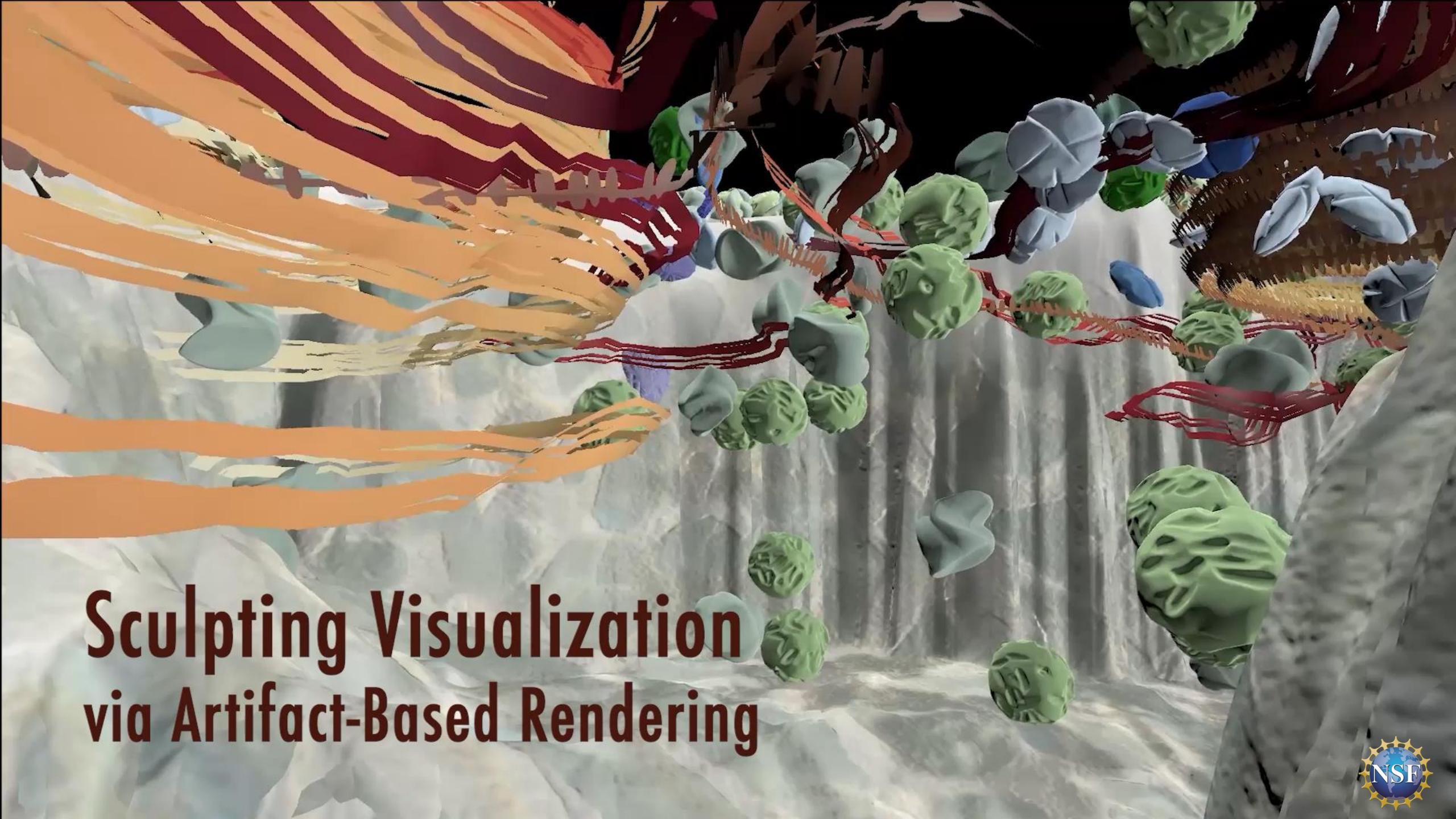
Visualization produced
by the climate modeling team.

Clarity via design principles



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

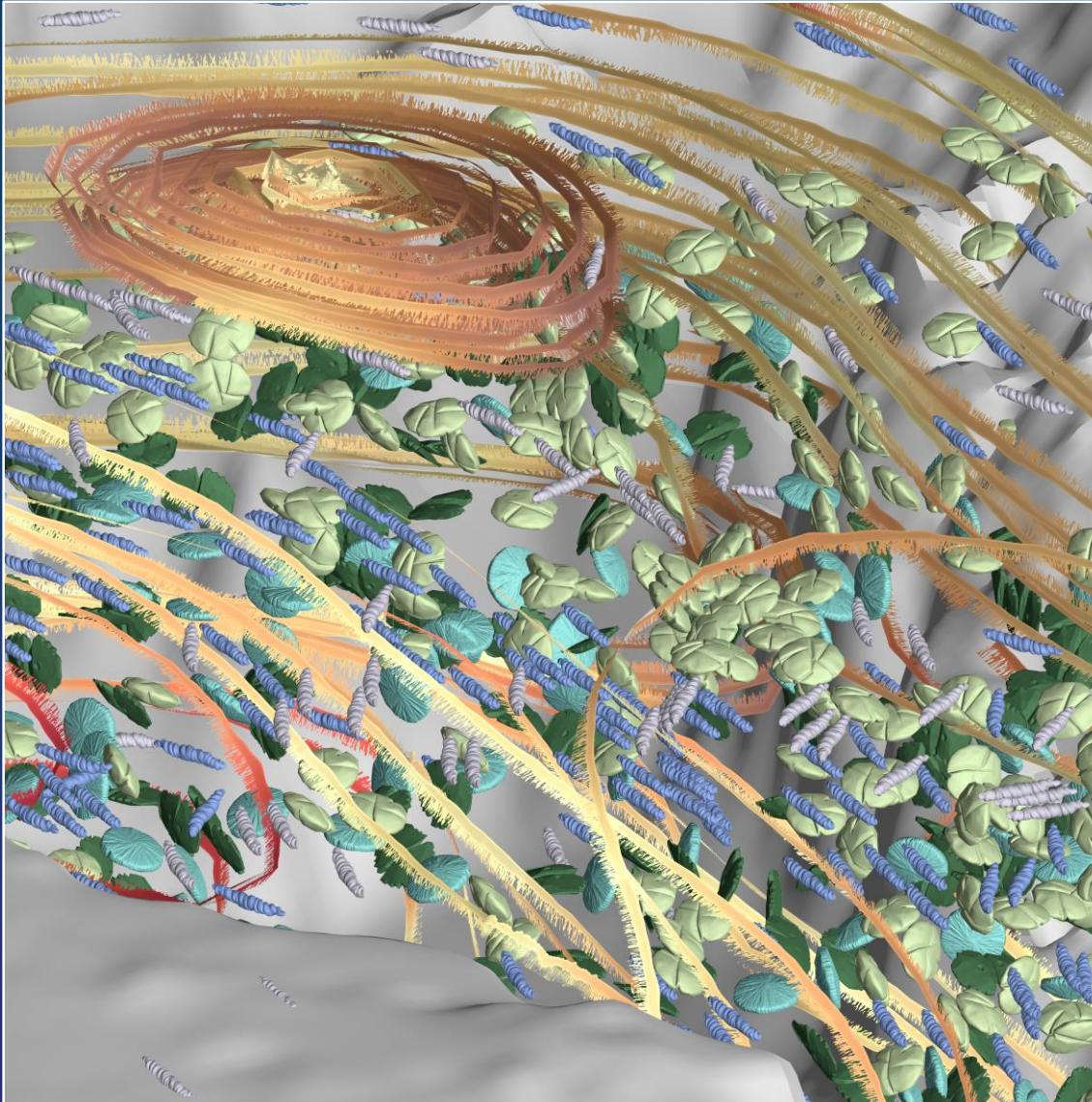
video

The background of the image is a complex, abstract 3D visualization. It features several large, translucent, light-colored spheres with intricate internal structures. Overlaid on these are numerous thin, colored bands in shades of orange, red, and blue, which appear to be flowing or deforming. Some of these bands have a textured, almost fibrous appearance. The overall effect is one of a dynamic, organic simulation, possibly representing a scientific process like molecular dynamics or a complex physical system.

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.

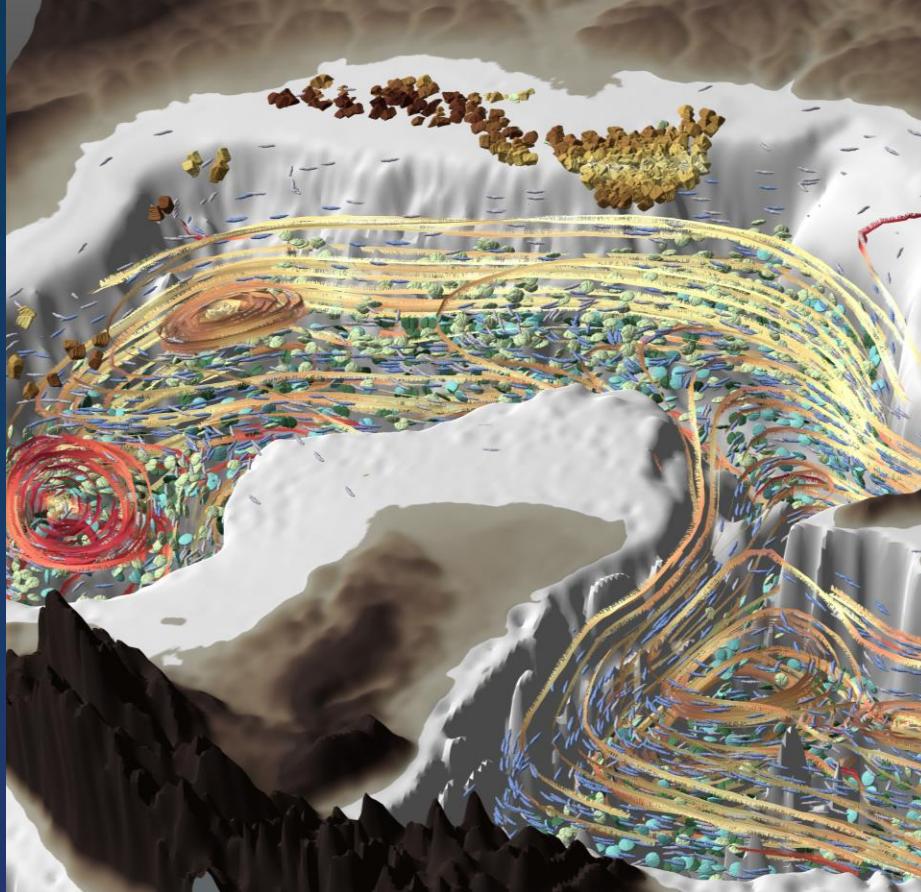
The How

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

The Where

www.sculpting-vis.org
github

#GHC19



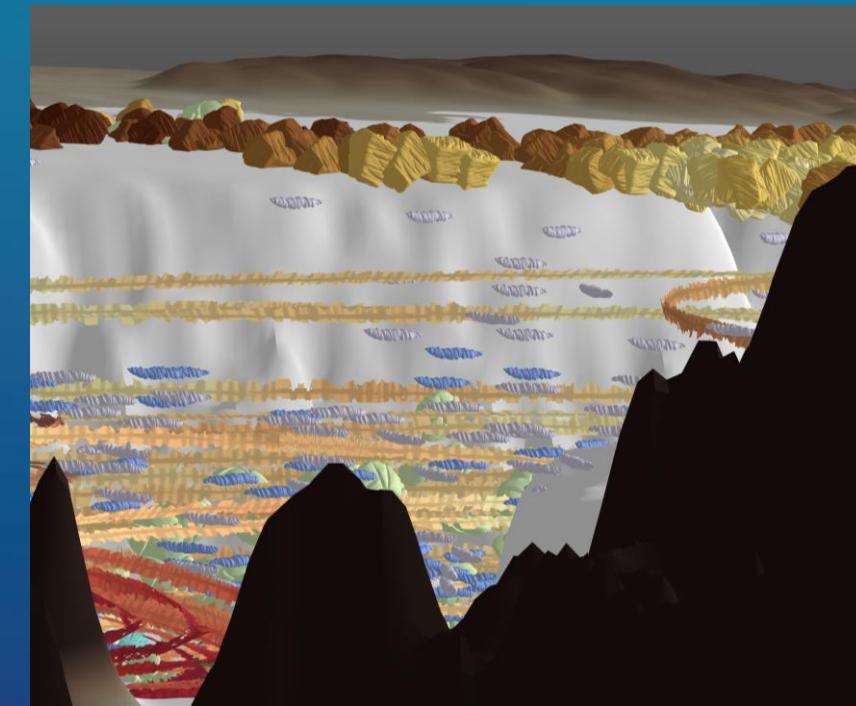
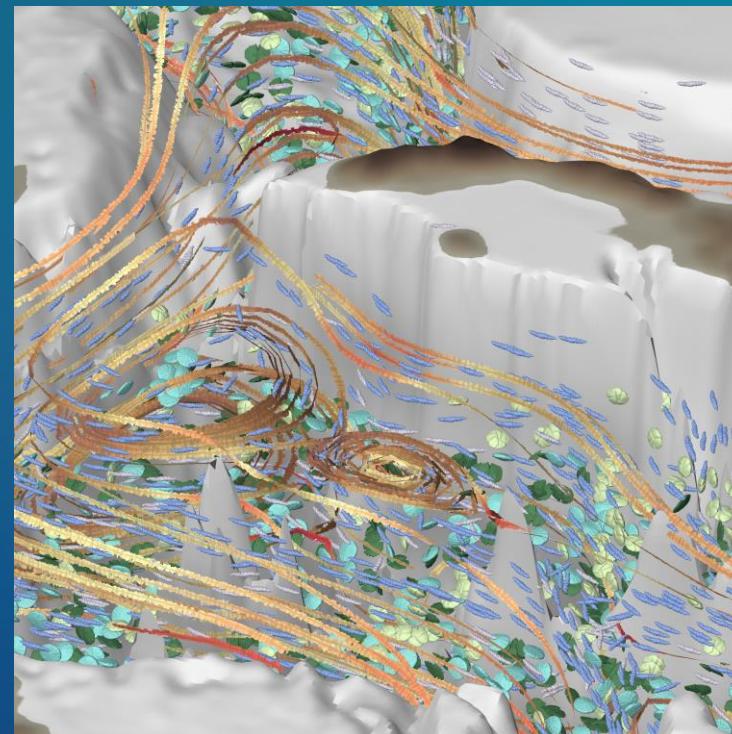
The Why

engagement

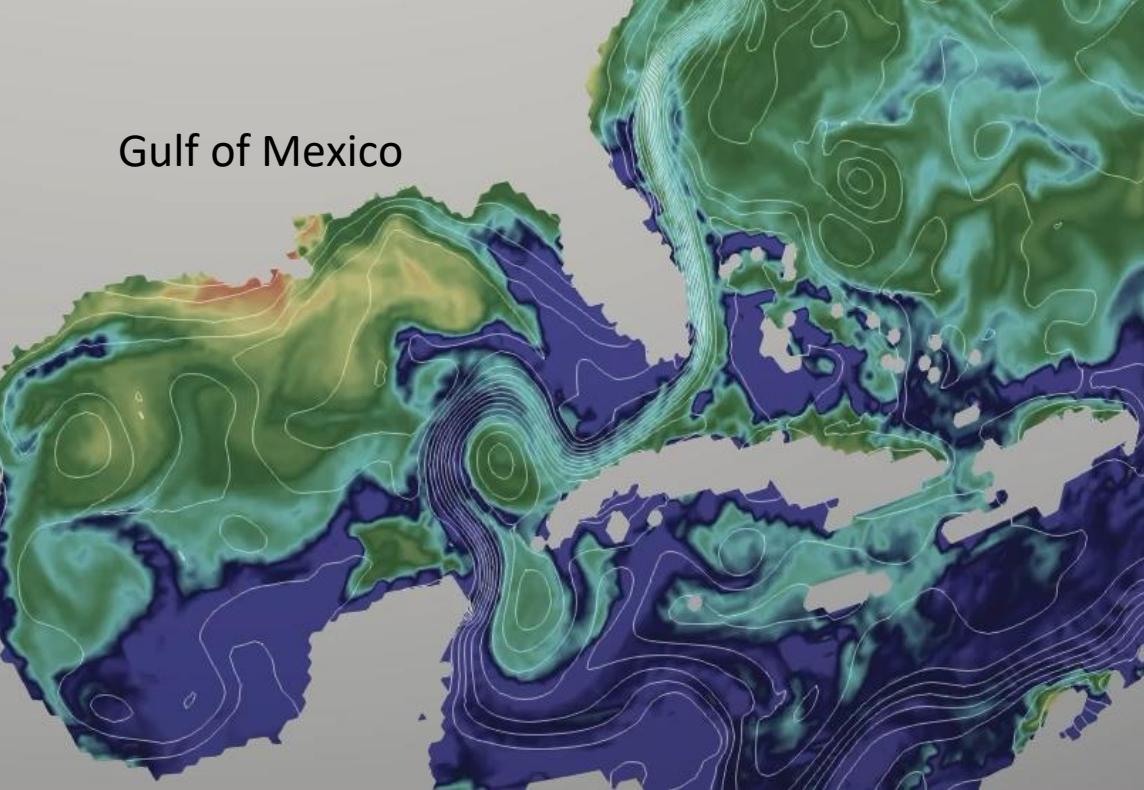
scientific clarity

depth of representation

communication



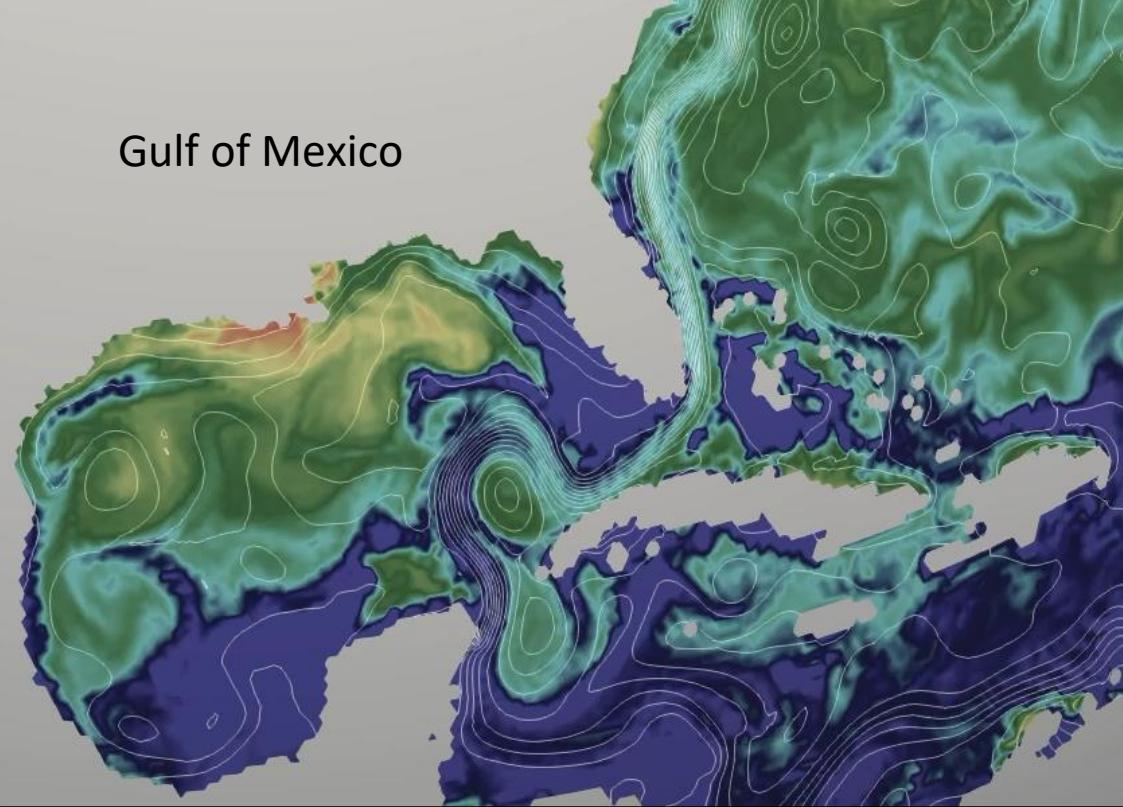
Gulf of Mexico



Existing Visualization

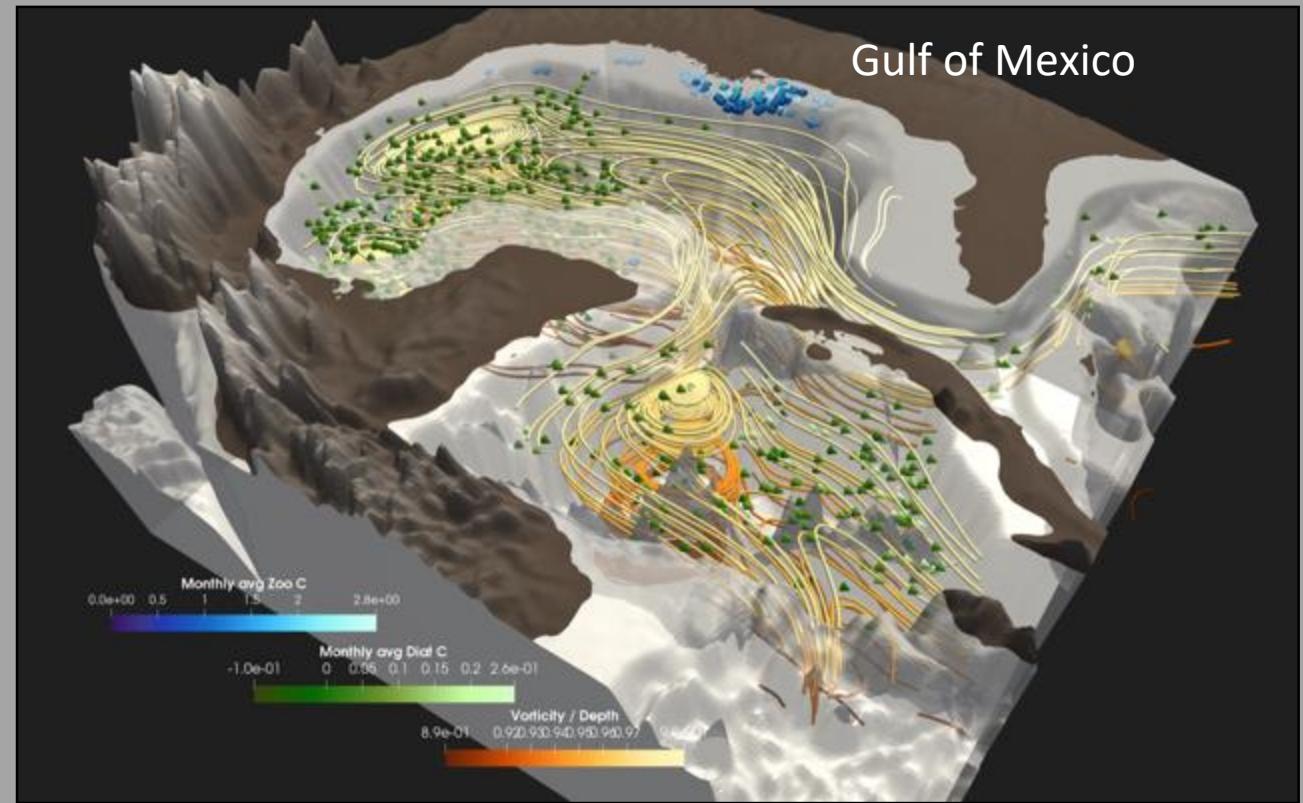
01

Gulf of Mexico



Existing Visualization

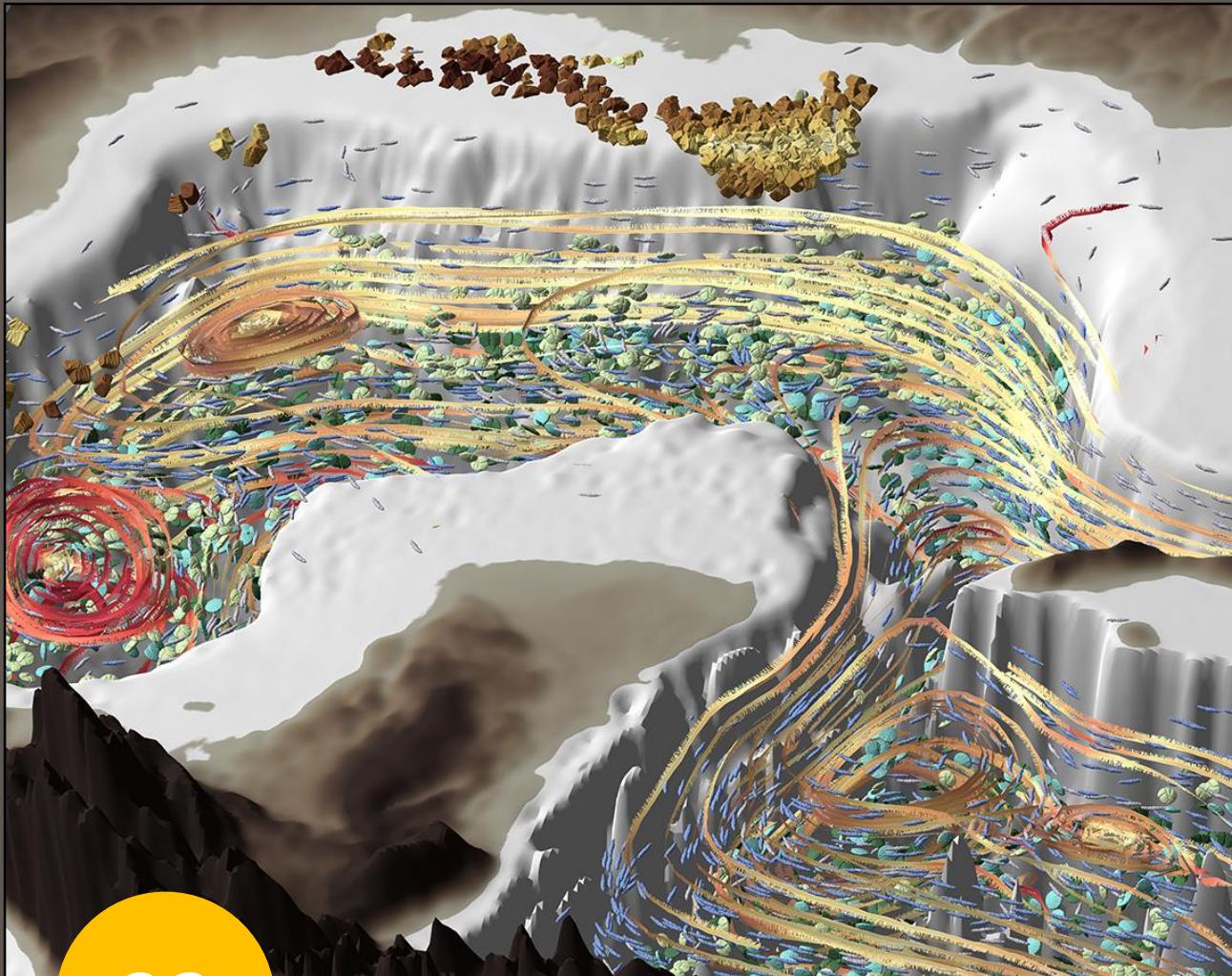
01



Clarity enabled by the sampling

02

Sculpting Visualization

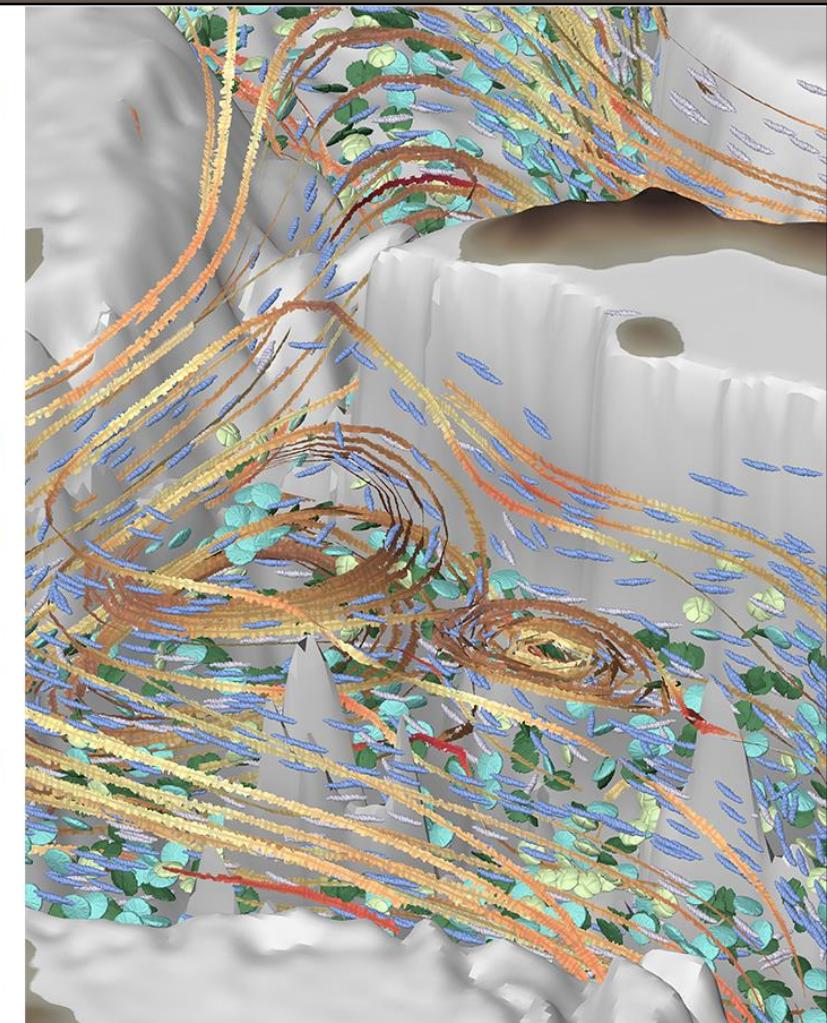


03

Gulf of Mexico, overview



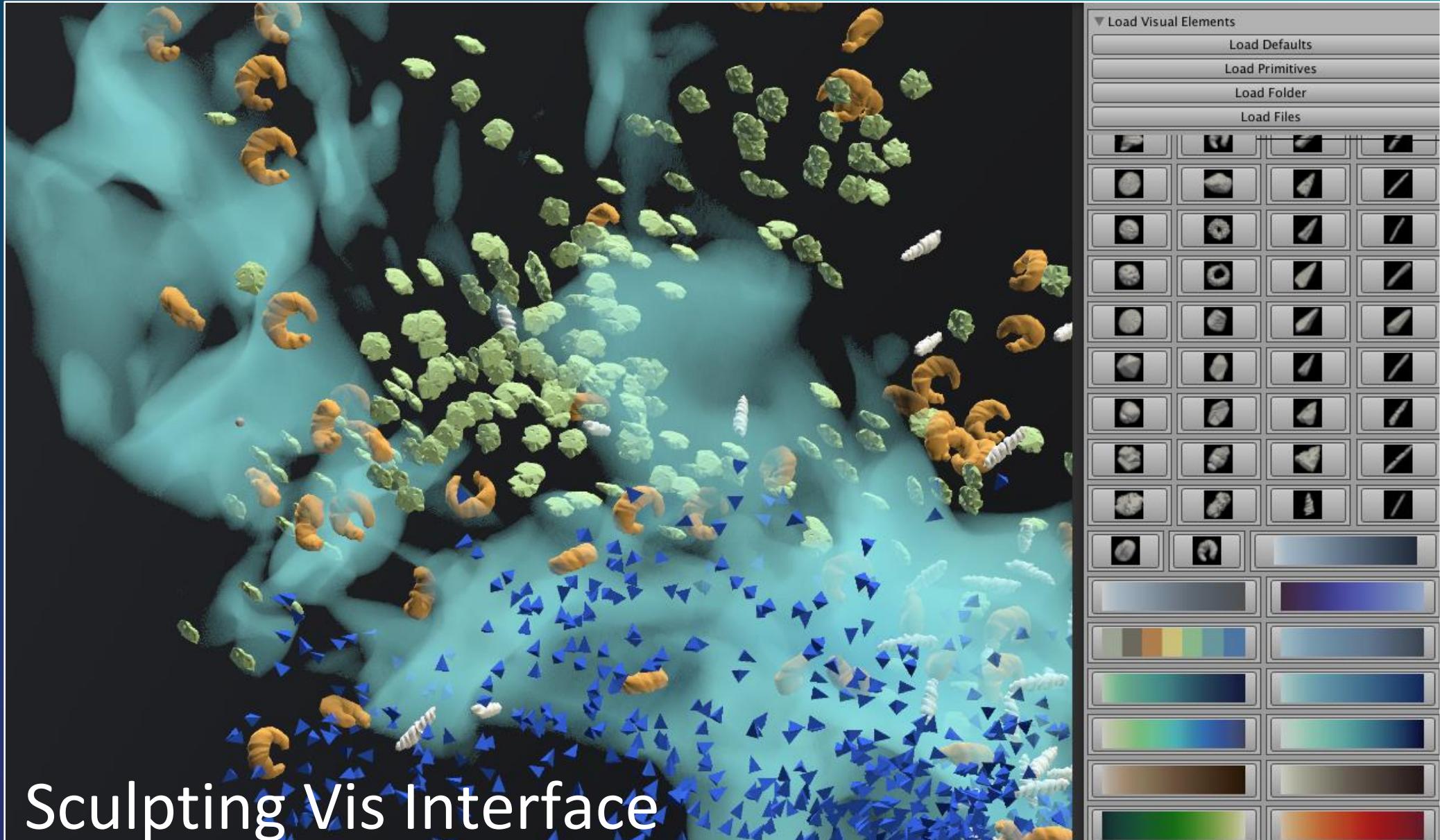
legend



3D detail

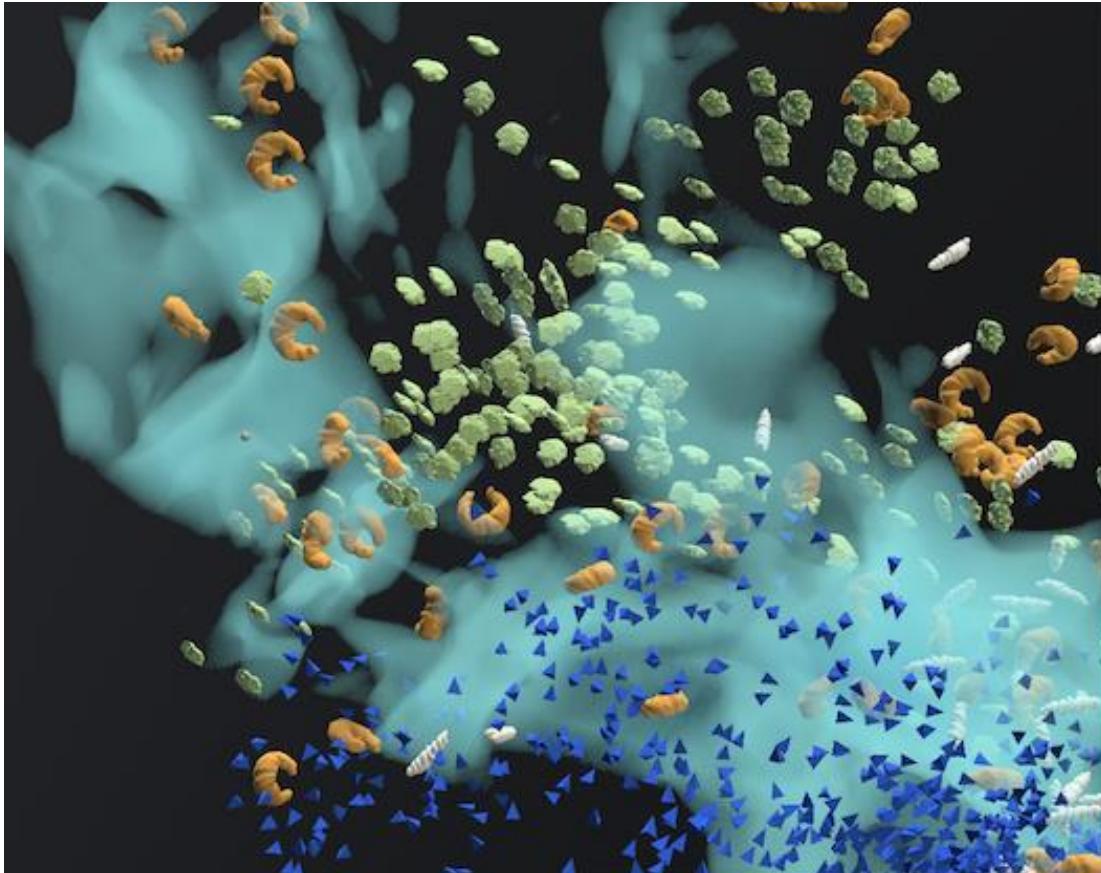
P. Wolfram, MPAS-Ocean, LANL

The What



The Sculpting Vis Interface

the visualization



the encodings

The screenshot shows the Sculpting Vis interface with the following sections:

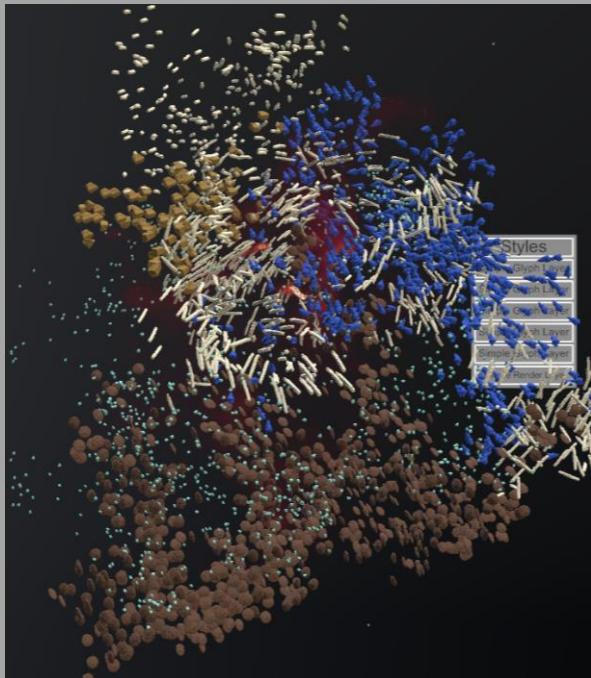
- Load Visual Elements:** Includes buttons for Load Defaults, Load Primitives, Load Folder, and Load Files. A dropdown menu for Simple Glyph Layer is open, showing options like "twist_shape_3".
- Manage Canvases:** Shows a list of canvas layers, each with a checkbox and a preview icon.
- Load Data:** Buttons for Load Astro Data, Load Brain Data, and Load File. A dropdown menu for "vt0040-all-velocity-floats.vti" lists various scalar and vector variables.
- Selected Layer Parameters:** Details for the "Simple Glyph Layer" (twist_shape_3).
 - Max glyphs:** 10000
 - Percent of glyphs:** 0.029
 - Anchor [Position]:** Direction [velocity]
 - Color Modifier:** Use Variable: Constant Color (selected)
 - Opacity Modifier:** Use Variable: Constant Opacity (0.741)
 - Scale Modifier:** Use Variable: Constant Scale (1)
 - Glyph LOD:** 2
 - Glyph scale:** 0.0433
 - Use Plane 1, 2, 3:** All checkboxes are unchecked.
 - Volume Render Layer:** Simple Glyph Layer
- Create layer:** Simple Glyph Layer

assigning the variables
& parameters

variables

The How

sampling



volume data
converted to point data

artistic language



an expanded vocabulary

a powerful coding team

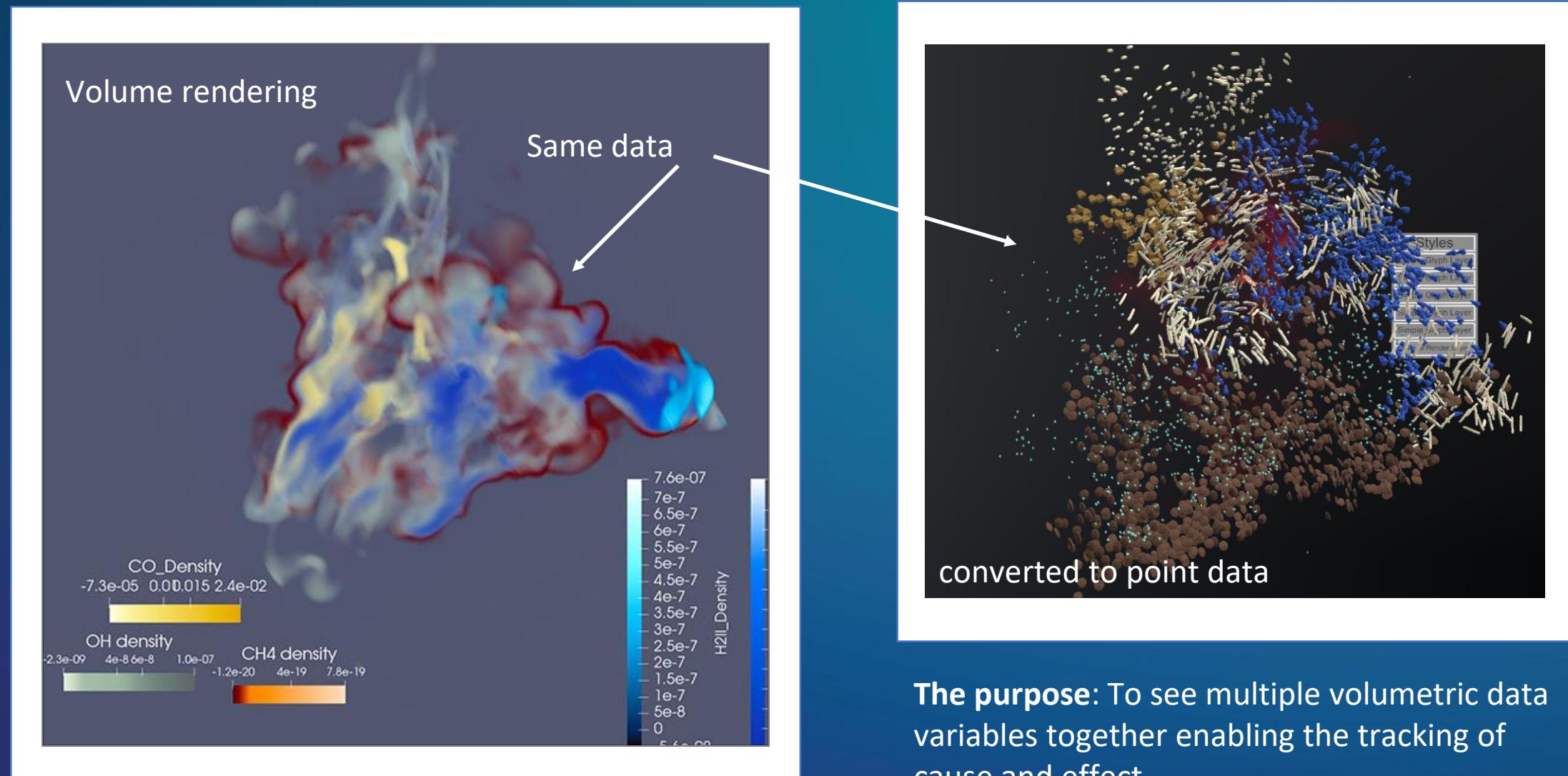


```
    f1.GetBinContent),AddToArray(f1)
f1 = m1.GetHistogram("f1").GetHistogram()
f1.SetName("f1")
f1.SetTitle("f1")
f1.SetNumberComponents(1)
f1.GetBinContent)
f2 = m1.GetHistogram("f2").GetHistogram()
f2.SetName("f2")
f2.SetTitle("f2")
f2.SetNumberComponents(1)
```

virtual reality immersion

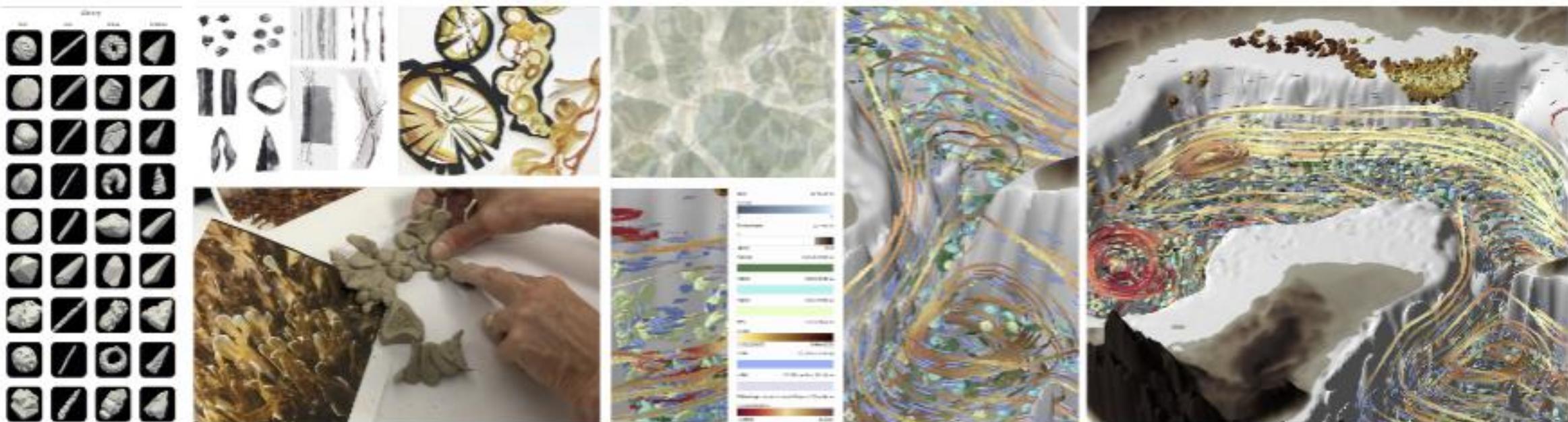


Key: converting volume data to point data; sampling the point data

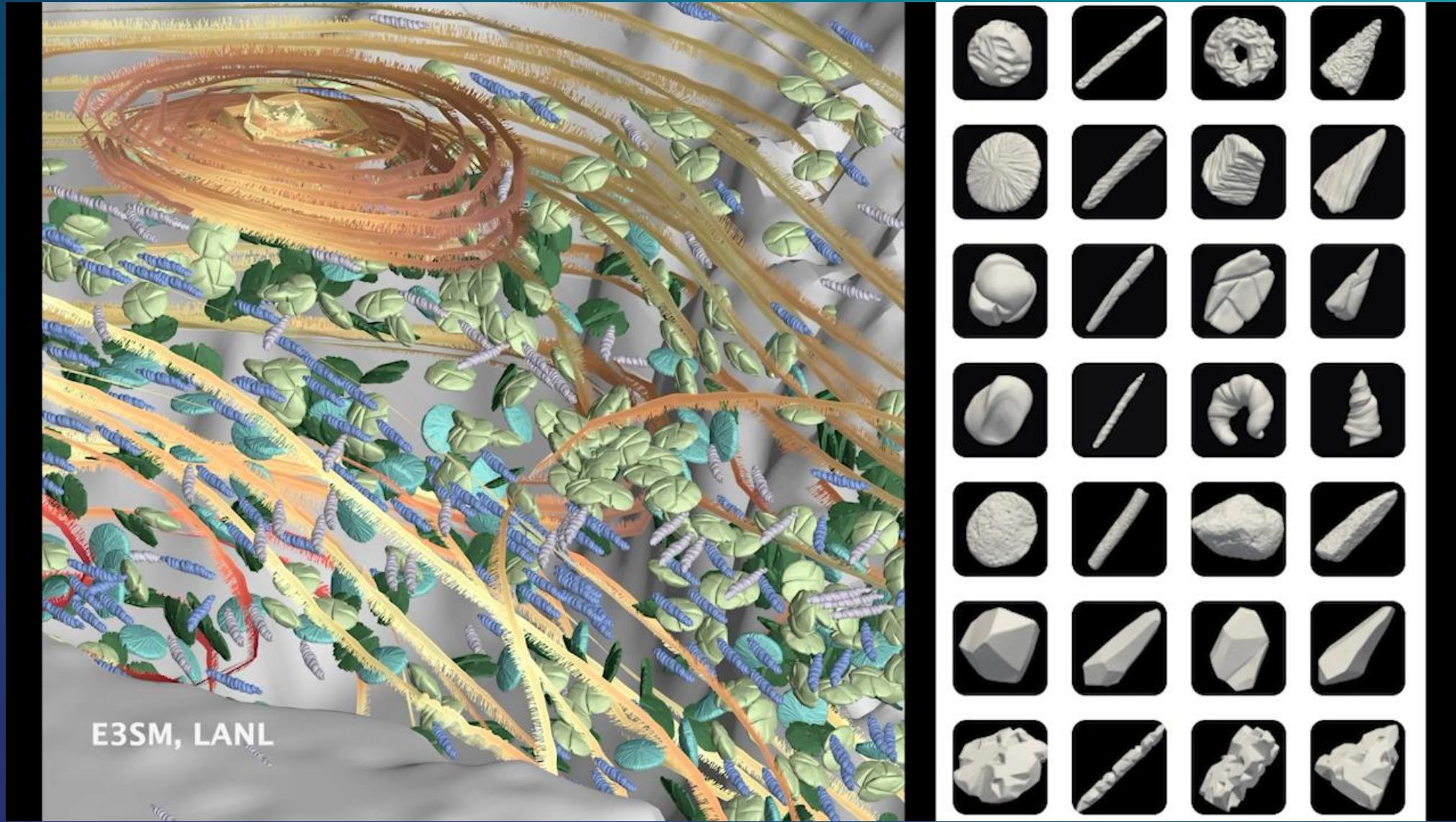


The purpose: To see multiple volumetric data variables together enabling the tracking of cause and effect.

Creating and applying the new vocabulary



Expanding the glyph vocabulary

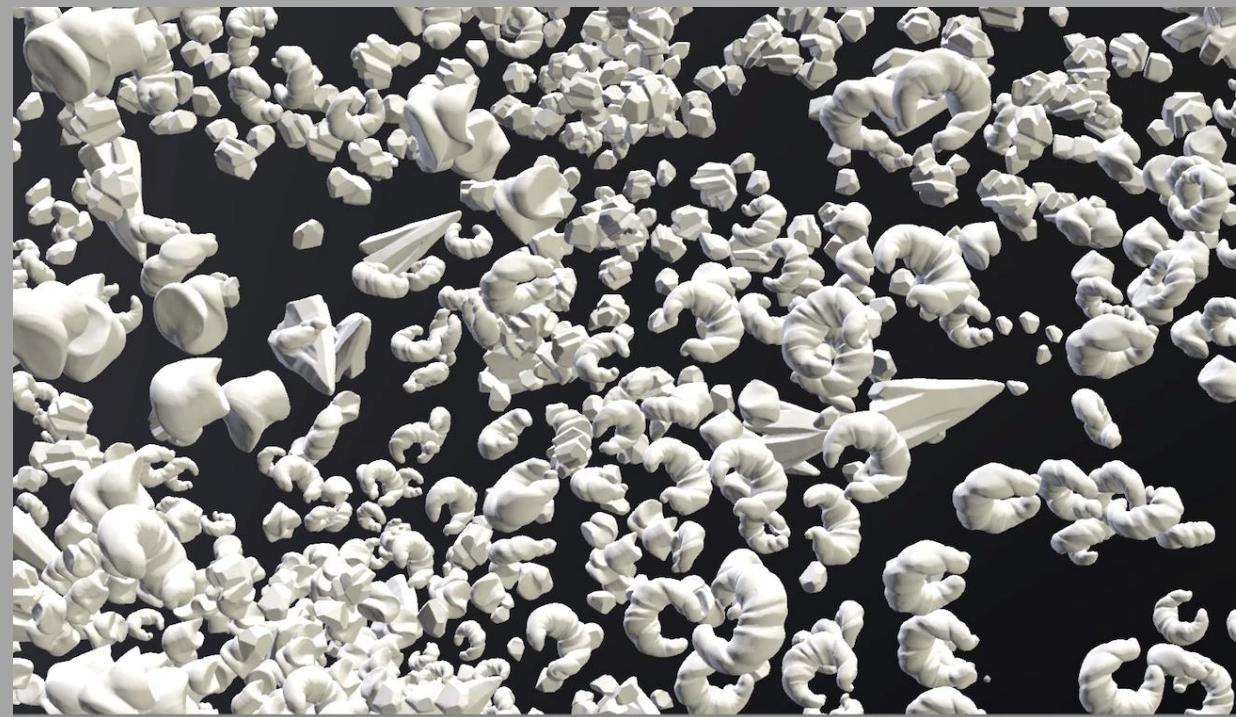


Creating Variety



Commonly available glyphs

**Adding:
variety, character, association, sets**

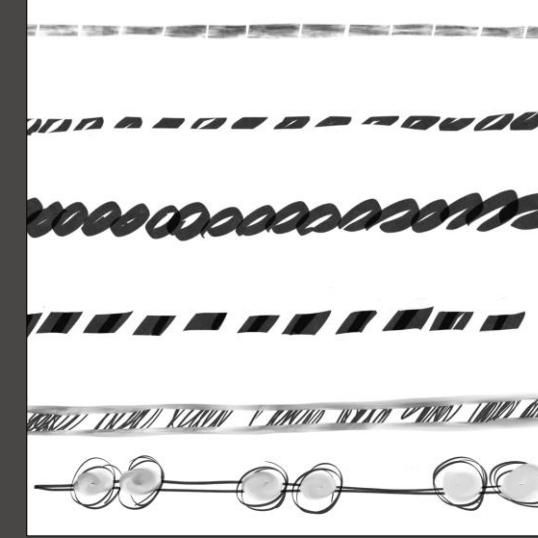


Sculpting Vis library glyphs



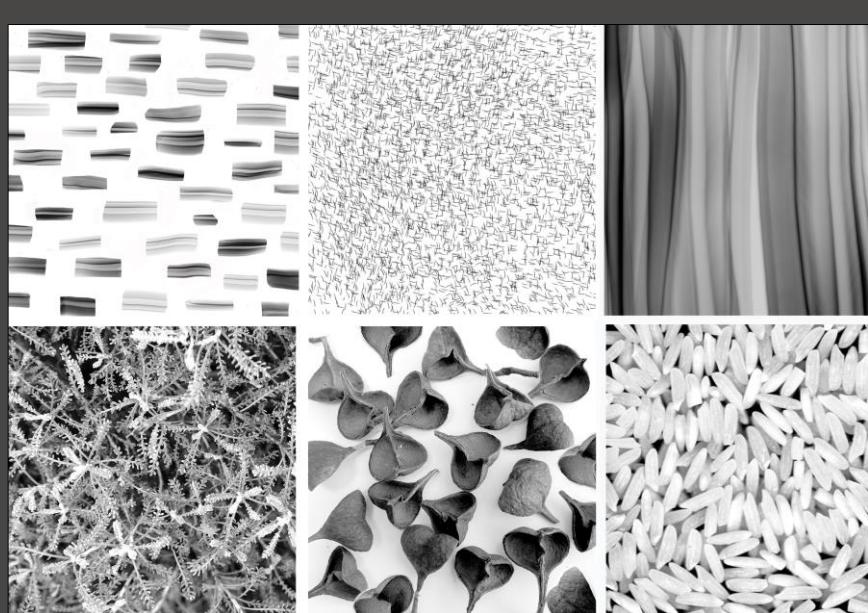
Libraries:

Lines



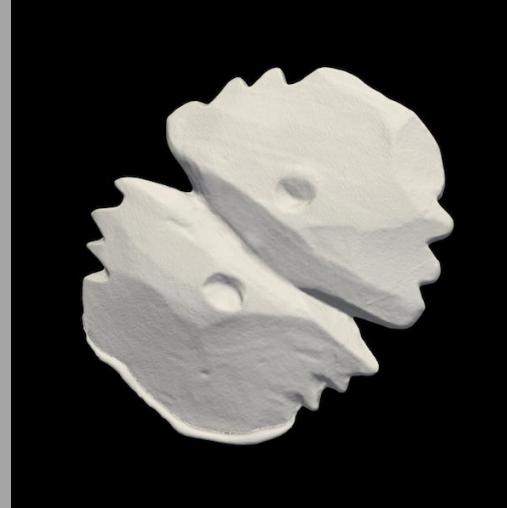
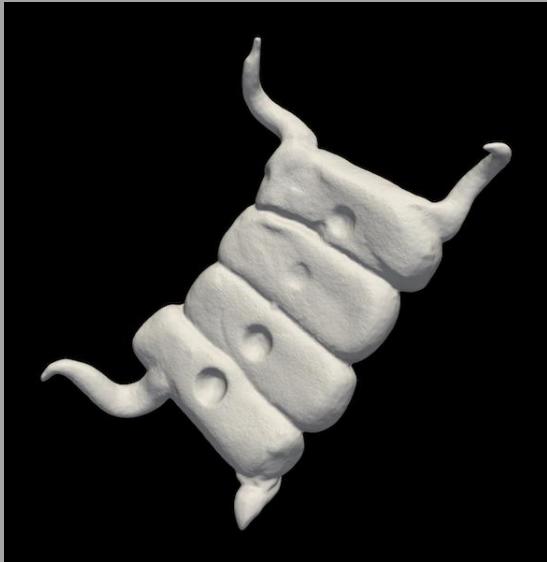
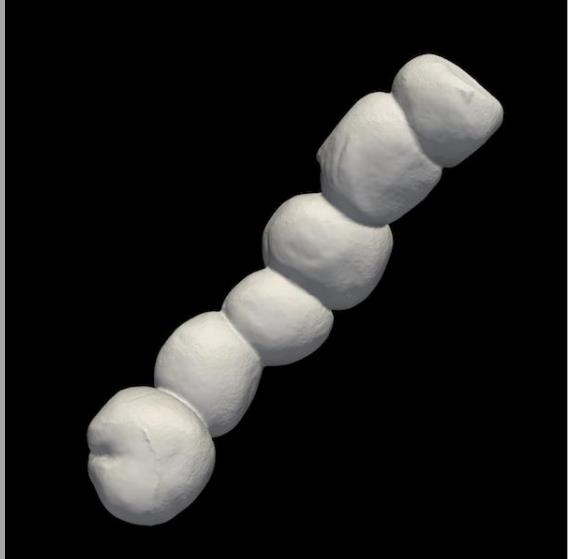
Glyphs

Textures



Creating Intuitive Encodings

**3D glyphs
associative forms**

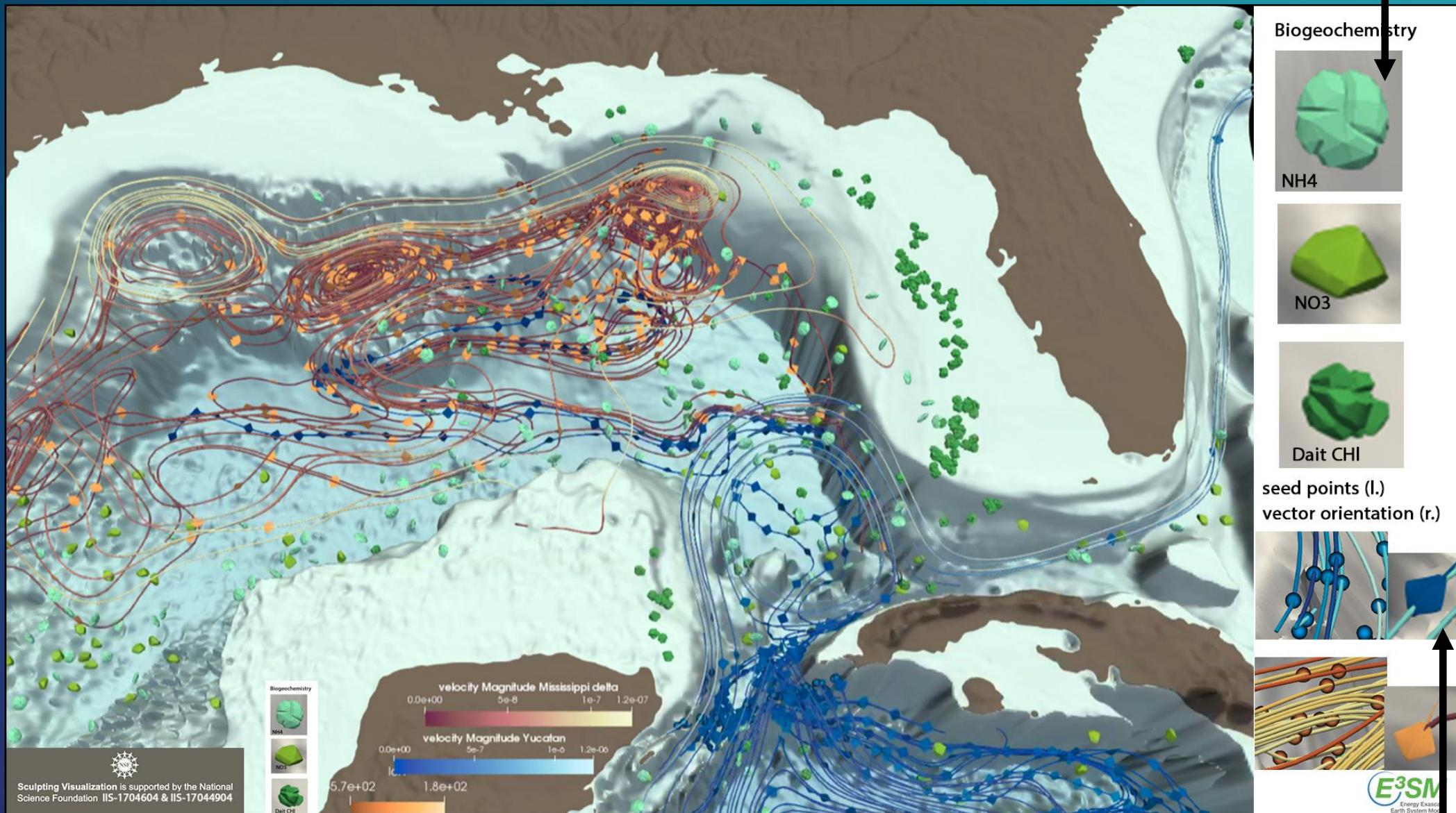


types of phytoplankton
studied in ocean biogeochemistry

2D glyphs, associative



categorial glyphs



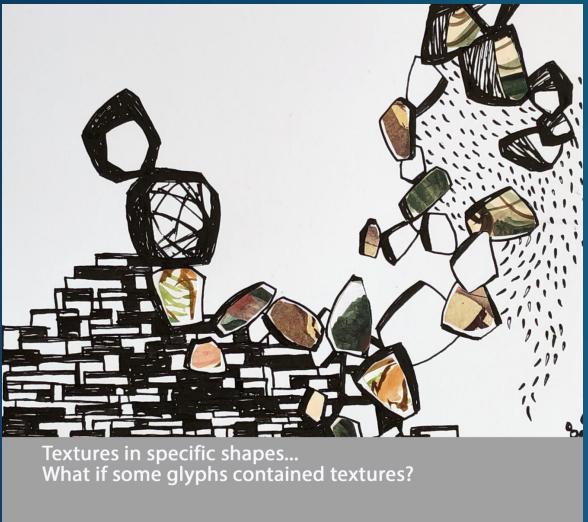
glyphs showing rotation within the vector field

Textures: a cyclical design process

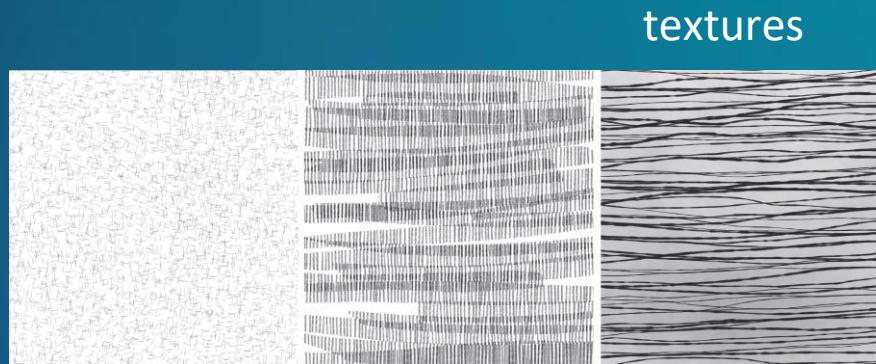


Textures in specific shapes...
What if some glyphs contained textures?

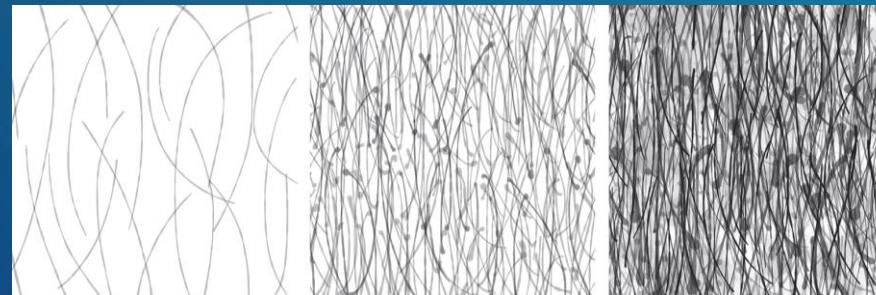
A cyclical design process



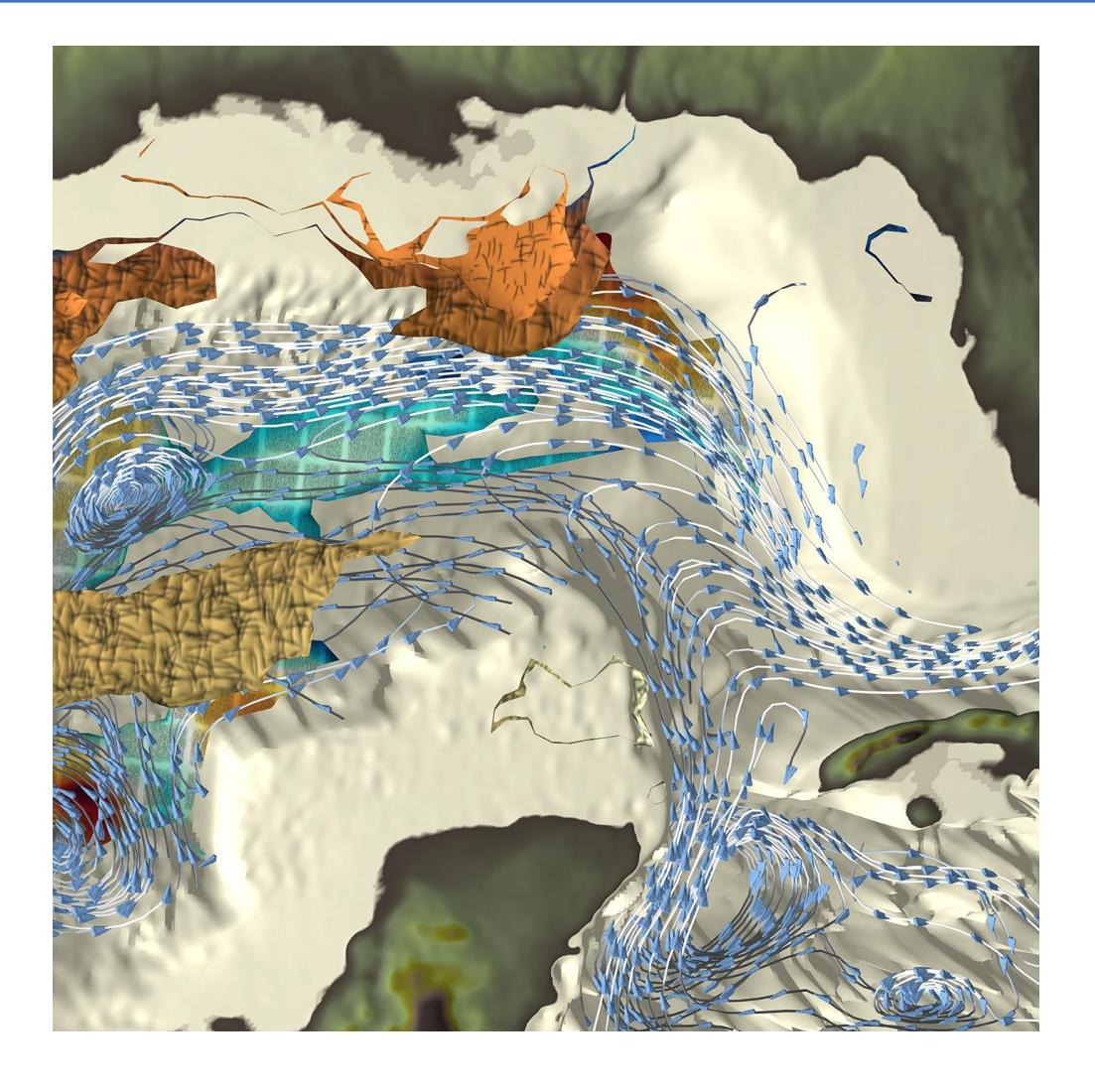
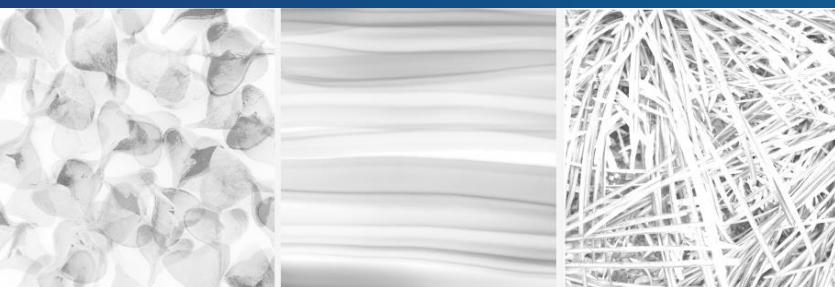
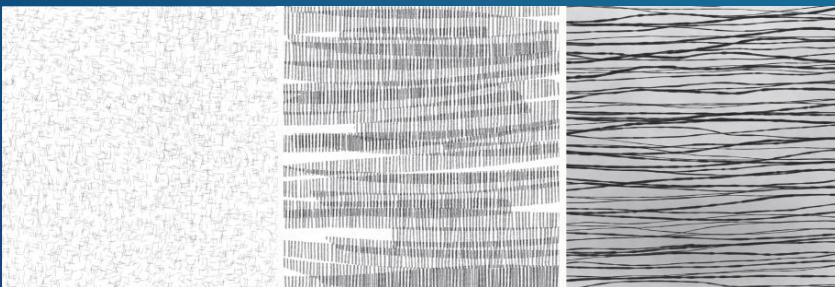
drawings



textures



A cyclical design process



ColorLoom: creating colormaps

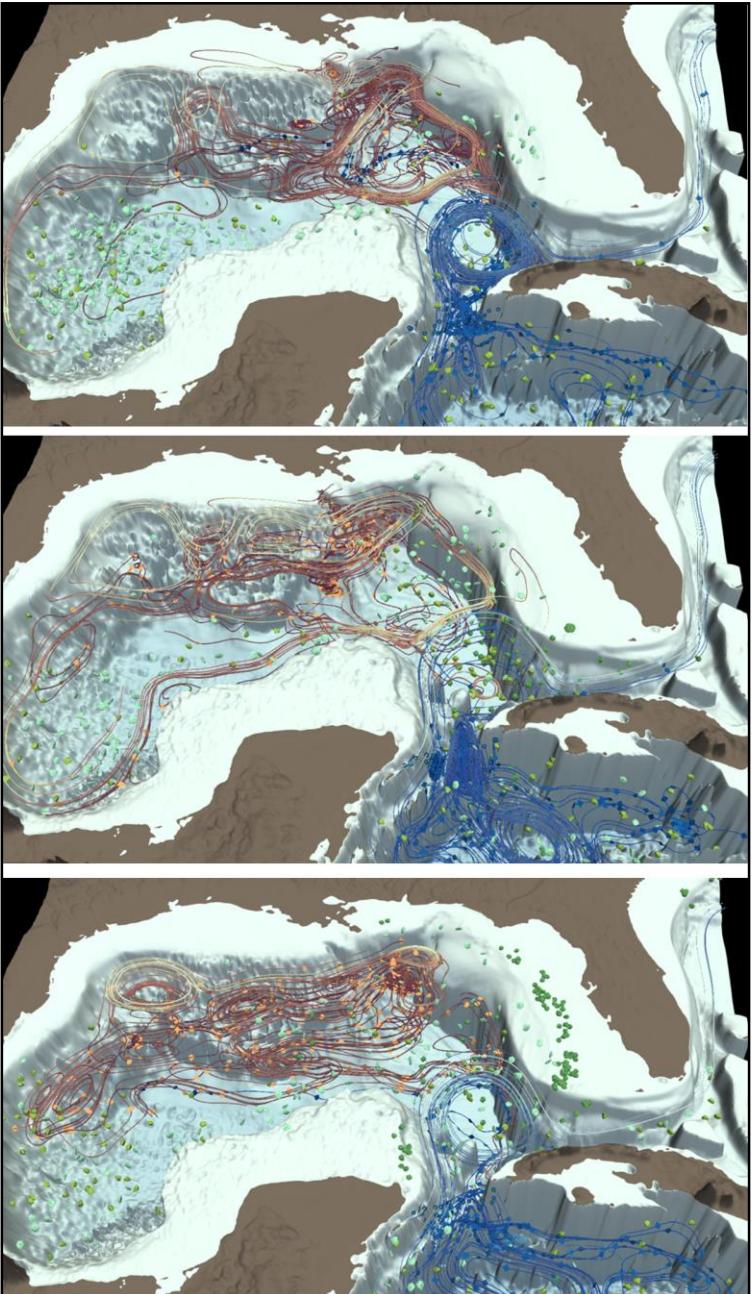
Source Image Workspace
Drag up to 4 images onto the workspace. Click and drag to sample colors from them.
When you have a color you like, drag its swatch to the ColorMap Panel.
Delete a swatch by pressing BACKSPACE or DELETE when your mouse is over it.

ColorMap Workspace
Arrange swatches vertically. Colors interpolated in Lab space.

Save and Download

The screenshot shows the ColorLoom interface. On the left, there's a vertical color bar with a gradient from red to purple. The main workspace is divided into two sections: 'Source Image Workspace' on the left and 'ColorMap Workspace' on the right. In the Source Image Workspace, there are four images: a coastal scene with green land and blue water, a satellite view of a coastline, a geological map of a terrain, and a micrograph of green cells. To the right of each image is a row of color swatches sampled from that image. In the ColorMap Workspace, there are several colored rectangles arranged vertically, representing a continuous color gradient from dark brown at the top to dark blue at the bottom. A vertical scale on the right indicates values from 0 to 100. At the top right of the workspace is a 'Save and Download' button.

Sculpting-vis.org
Use It
Applest
ColorLoom



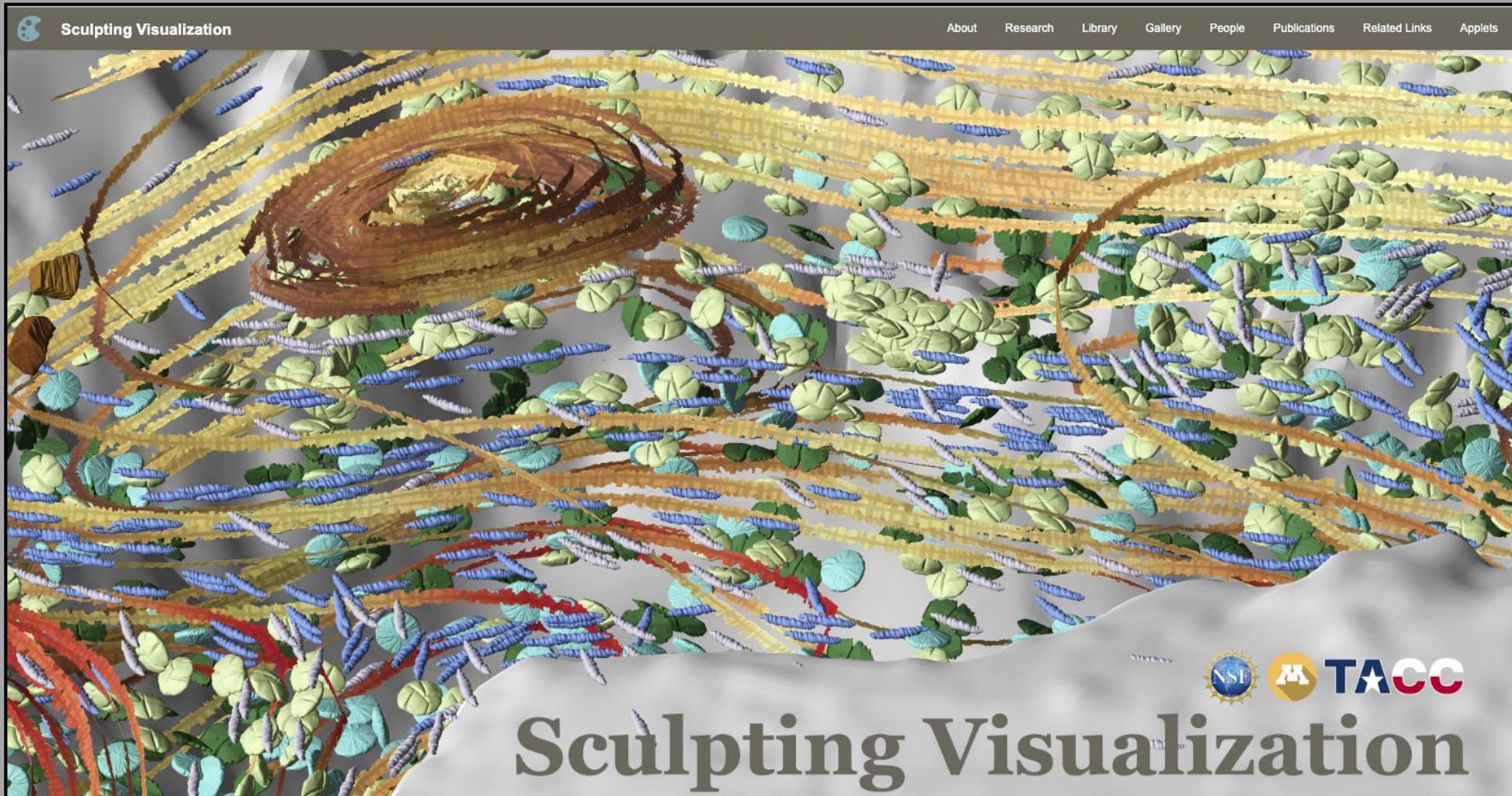
Time Sequence

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

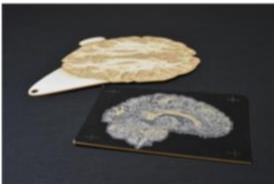
github

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Augmented Reality for Scientific Visualization



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



Various data physicalizations



Magic Leap AR headset with external trackers attached



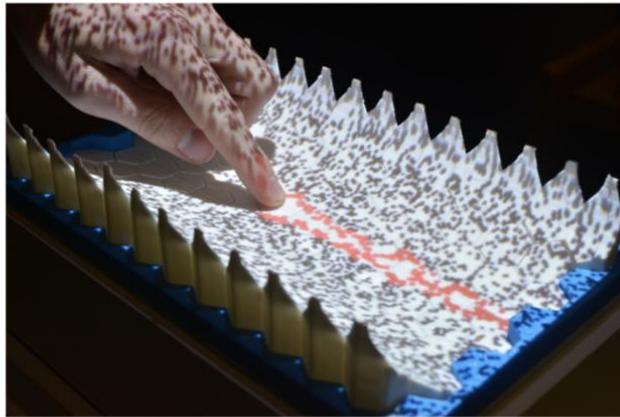
1 Data were obtained from the Energy Exascale Earth System Model project, sponsored by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research.

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.

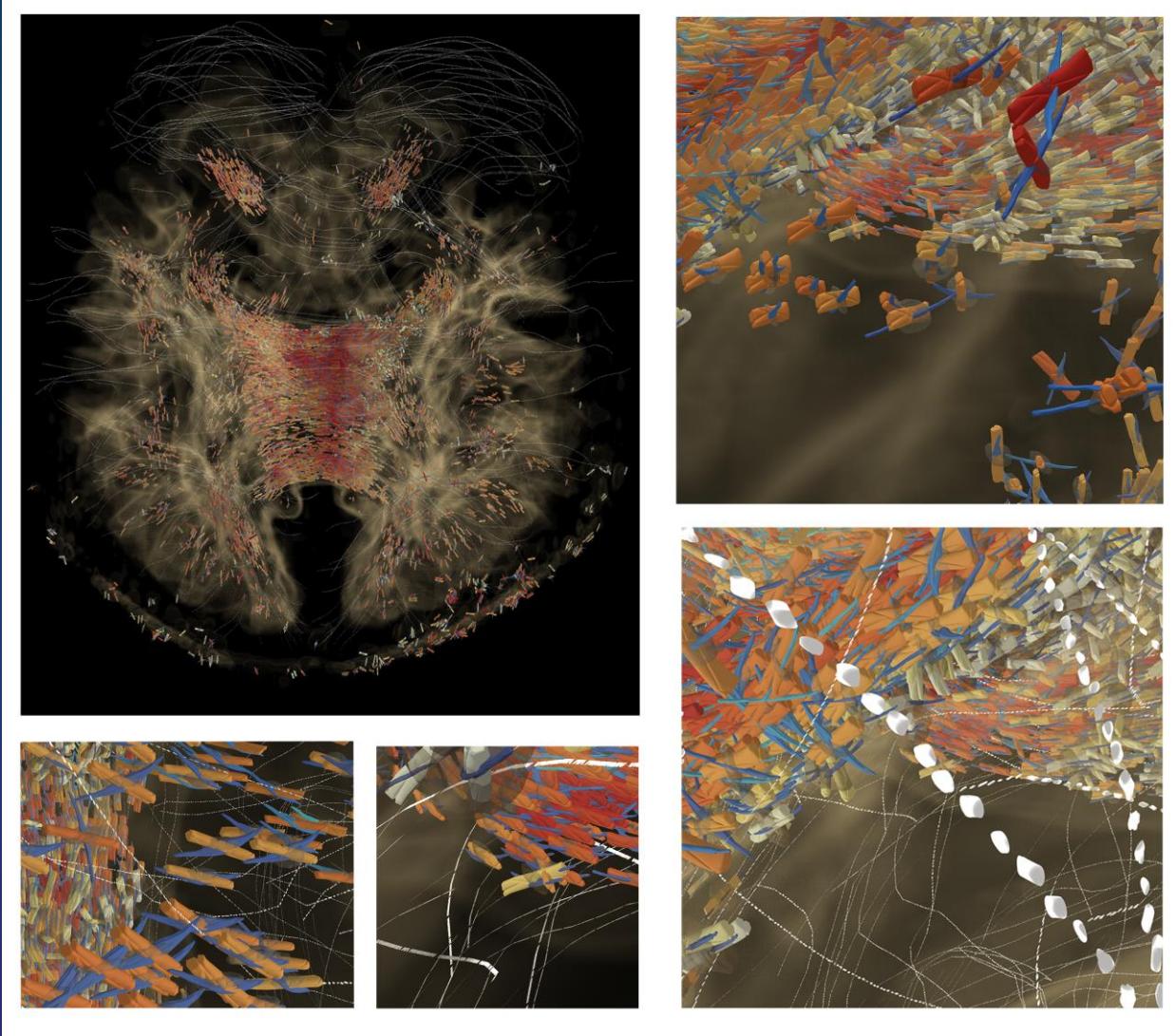
We add interactivity to physicalizations through the use of computer graphics, augmented reality headsets, high-accuracy tracking systems, and custom touch input devices. These technologies provide a means of displaying and interacting with diverse types of data. For instance, in the left figure, ocean currents from the MPAS-O¹ 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.



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.

Acknowledgements



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Ph.D. student

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University of Minnesota

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/CJ00/09/01, Pacific Northwest National Laboratory, prime recipient.



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