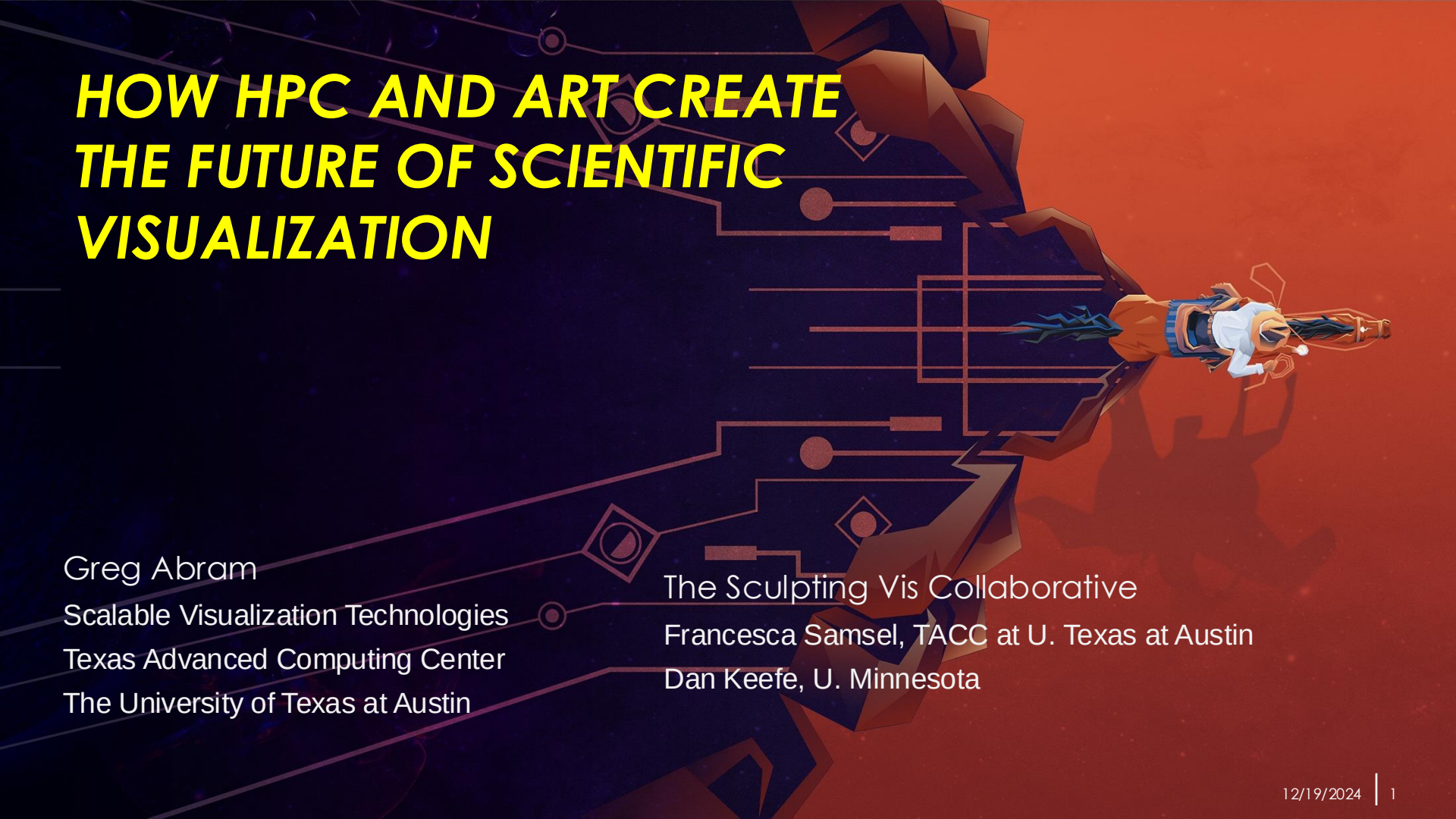
# HOW HPC AND ART CREATE THE FUTURE OF SCIENTIFIC VISUALIZATION




Greg Abram

Scalable Visualization Technologies

Texas Advanced Computing Center

The University of Texas at Austin

The Sculpting Vis Collaborative

Francesca Samsel, TACC at U. Texas at Austin

Dan Keefe, U. Minnesota

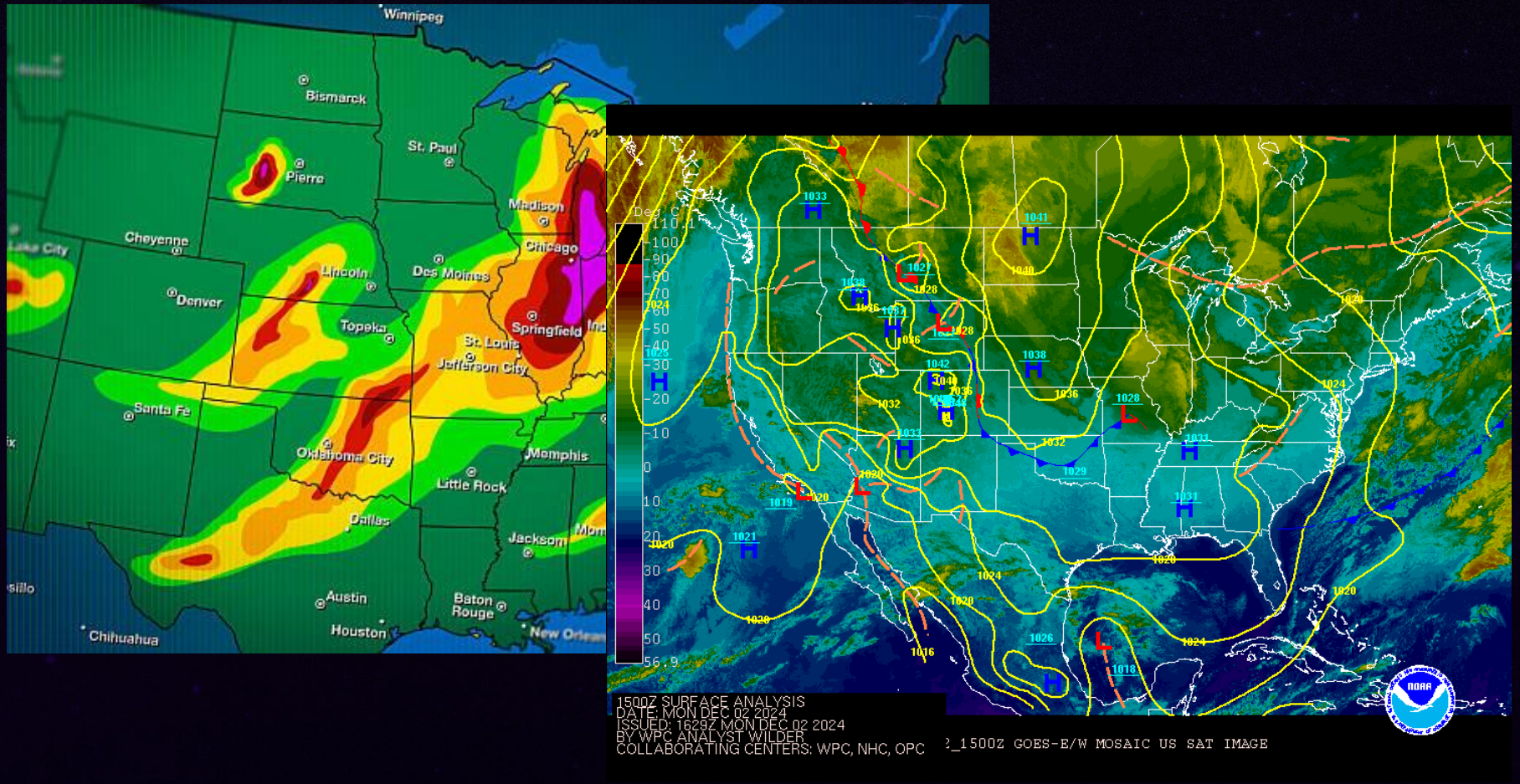
# WHAT IS SCIENTIFIC VISUALIZATION?

## F(X,Y,Z,T) = SCALARS, VECTORS, TENSORS…

- For any point in a computational space, the simulation tells you a set of properties

- Weather: F(latitude, longitude, altitude, time) =
  - Temperature
  - Barometric Pressure
  - Wind direction, speed

- We use *visualization* to convey these properties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1500Z SURFACE ANALYSIS
DATE: MON DEC 02 2024
ISSUED: 1628Z MON DEC 02 2024
BY WPC ANALYST WILDER
COLLABORATING CENTERS: WPC, NHC, OPC
2_1500Z GOES-E/W MOSAIC US SAT IMAGE
NOAA

# ACTUALLY…

- Properties are given numerically at a set of points
- *Cells* link those points geometrically so we can *interpolate* values in between

- The more points, and the smaller the cells, result in more accurate physics and thus more accurate results, but require more memory, computation and I/O
- Hence **HPC!**

# PROBLEMS DRIVING THE EARLY STAGES

- Algorithms… How do we represent these properties geometrically?
  - Isosurfacing, for 3- and 4-D volumetric scalars
  - Particle tracing for 2, 3, and 4-D vector fields
  - Yadda yadda
- Rendering… how can we *render* geometry fast enough for interactive use?
  - Hidden-Surface algorithms
  - Ray-tracing for physically accurate lighting
- Accessibility… How can we make visualization usable by end-user scientists and engineers

# HPC AND VISUALIZATION

- Initially, dedicated graphics-enabled systems provide large shared memory and multiple processors feeding graphics cards
- Gave way to doing the visualization on the same HPC platforms that the physics run on, leading to research into parallel algorithms for the above
  - *Rendering* is often not the time-limiting phase
- Nowadays we can to a lot on large-scale distributed systems

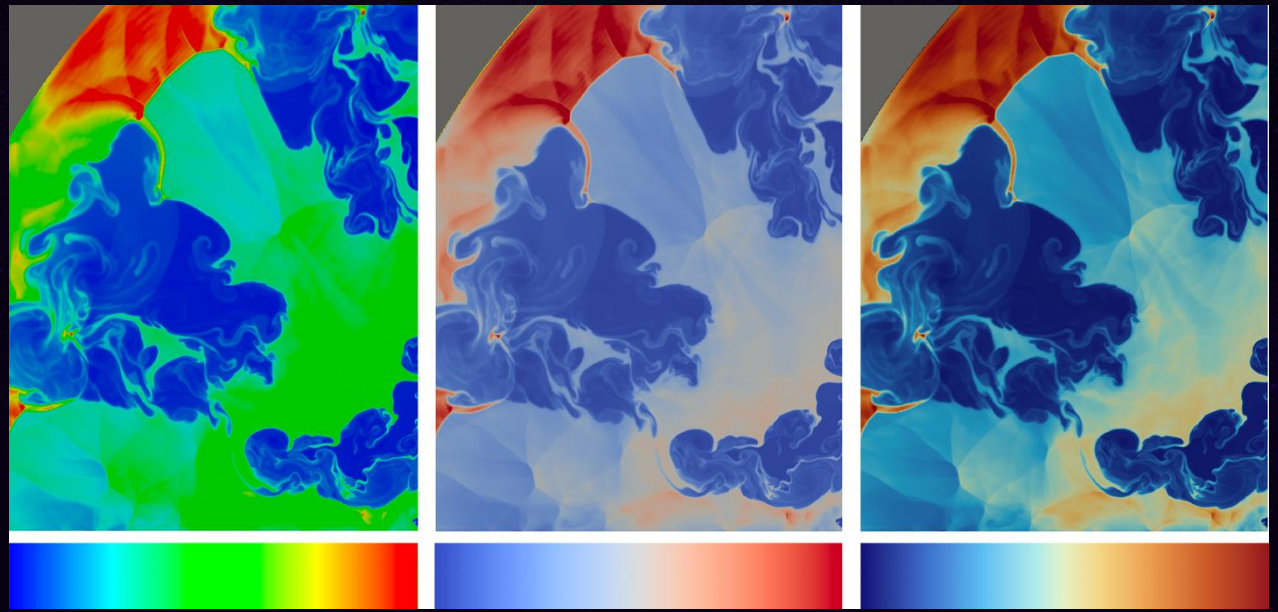
# MAKING THE MOST OUT OF WHAT WE HAVE – LESSONS FROM ART

- Today we have the algorithms, hardware and software to do a great deal, but how do we make the *best* use of it?

- *Artists have long been considering how to best use such tools to convey ideas.*

# COLOR!

- F(property) = *color*
- *Lots* of work has been done to optimize colormapping for scalar data



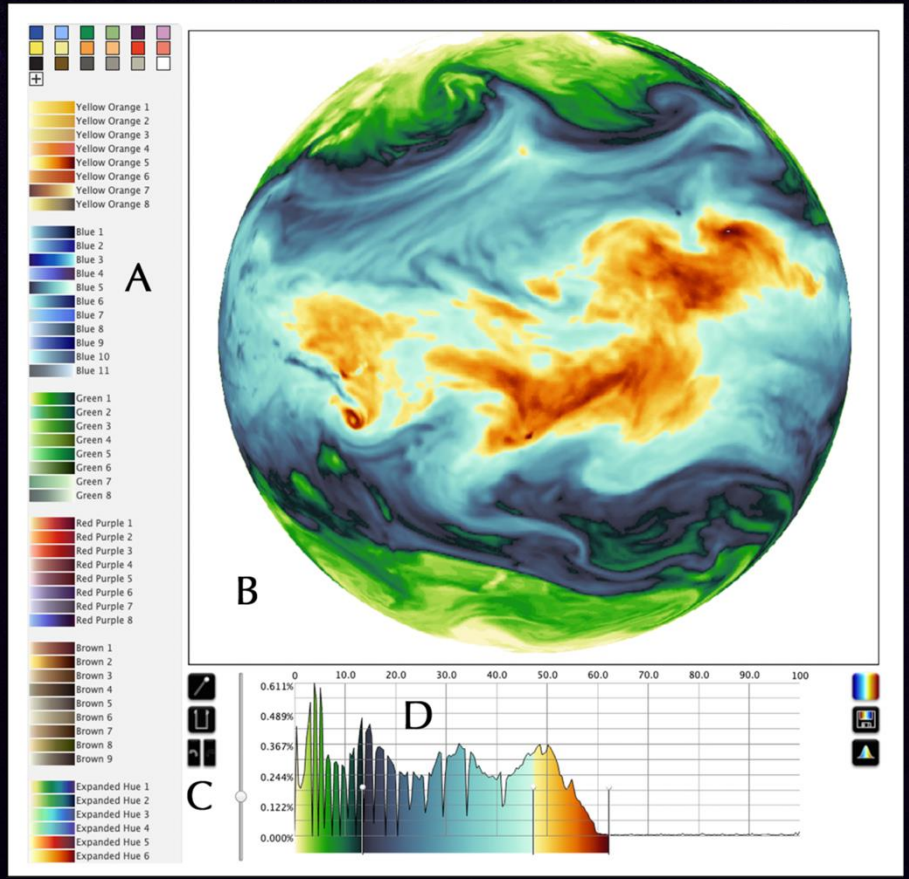
# *ART* ADDRESSES HOW COLOR CAN BE USED IN COMPLEX SCENES

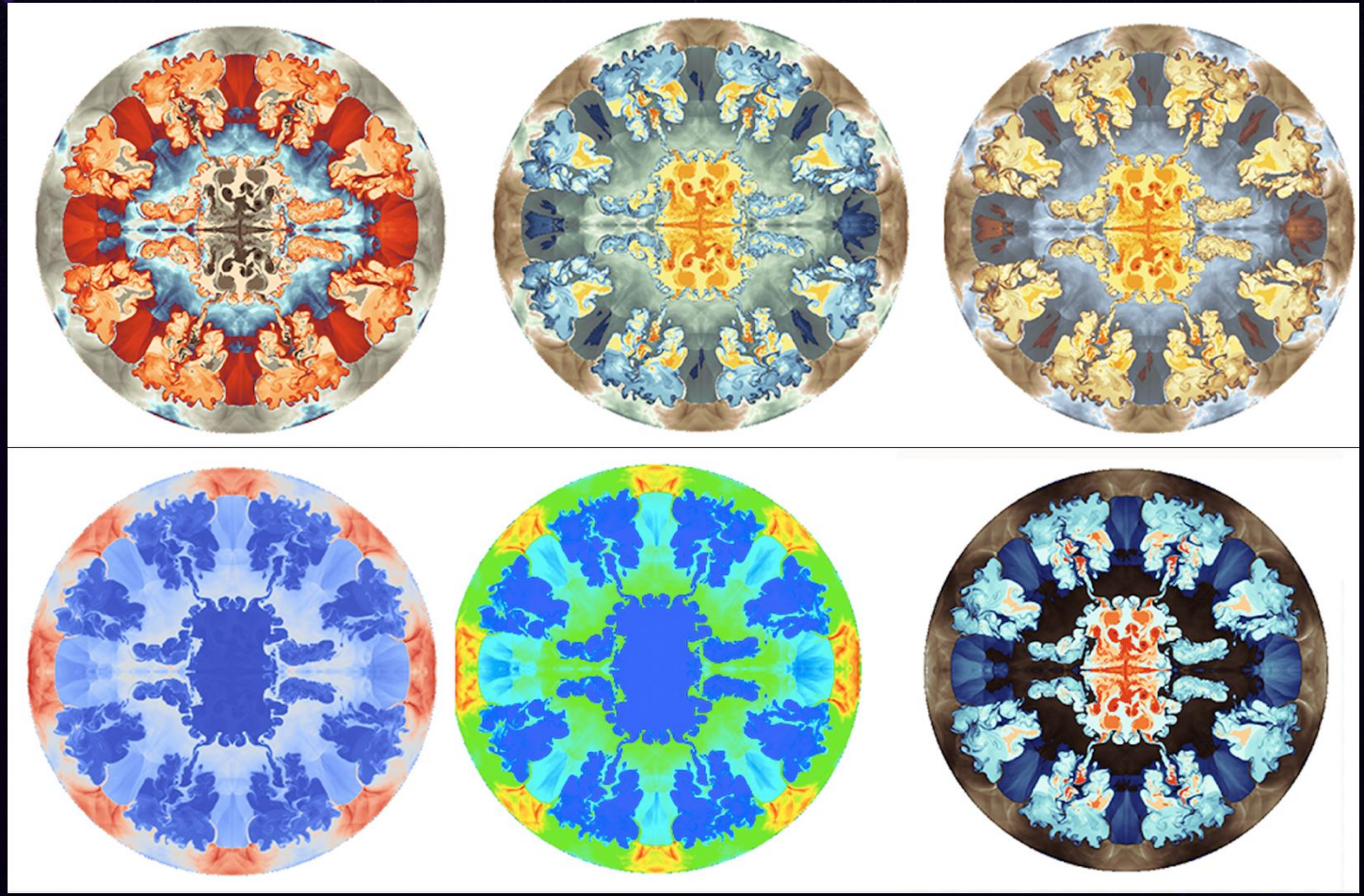
- When multiple color fields are used together
- To direct attention *between* color fields
- To avoid *cacophony*


From Samsel, various

# COLORMOVES

- An interactive tool for composing colormaps to highlight and maximize detail within different ranges within the same scalar range





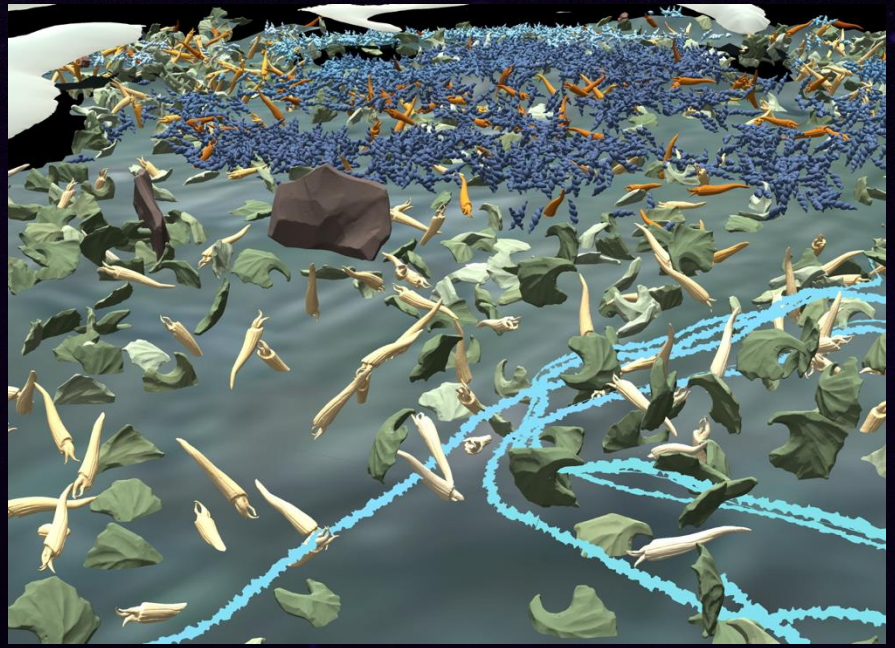
# SHAPE

- *Glyphs* are used to represent data at particular points in space
- Common visualization tools provide a small vocabulary for glyphs – arrows, spheres, cubes, tetrahedra etc.
- But natural forms can be much more evocative, and much less confusing

# MULTIPLE CO-INCIDENT PARTICLE FIELDS

- Here we've used particles to represent the relative density of different properties in the Gulf of Mexico

- *Artifacts* are developed *in clay* and scanned for use in visualizations



# LINE

- Lines need to be discriminated – here, particle traces from different seeding areas in the Gulf.
- Standard tools give simple patterns – dashes etc.
- Different line forms are *painted* and scanned for use