UNIVERSITY OF CALGARY

EnvirVis 2017

Visualization in Environmental Sciences

Multivariate Visualization of Oceanography Data Using Decals

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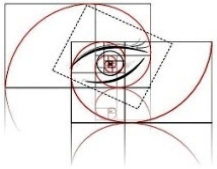
VISAGG

Visualization and Graphics Group



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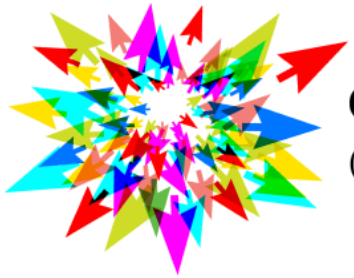
Interactive Modeling, Visualization & Analytics R&D Group

Visualization Contest

- "Visualize This!" Challenge – Organized by Compute Canada and WestGrid
- Multivariate Visualization of Tridimensional Data



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WESTGRID

Multivariate Tridimensional Data

- Earth Sciences
  - Essential to understand natural phenomena

- Examples:
  - Geological data: *porosity, permeability*
  - Meteorological data: *wind, pressure*

Multivariate Tridimensional Data

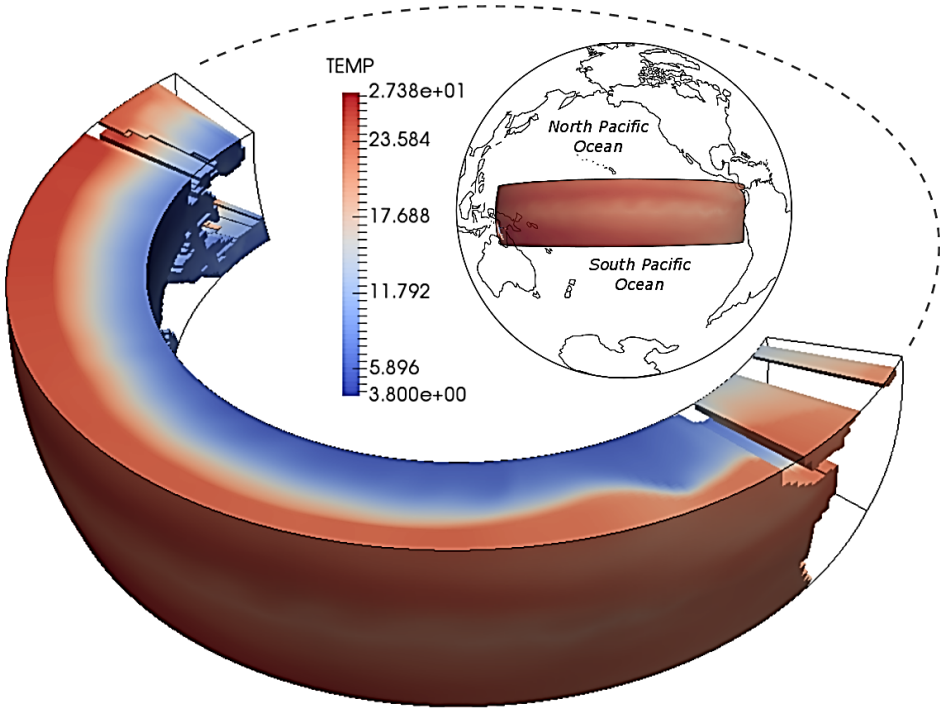
- Oceanography Data
  - Aim to understand oceans behavior and interaction with the environment
    - Example: transfer of heat
  - Oceanography Simulation Models

- Multivariate aspects
  - Analysis and correlation between oceanographic attributes

Multivariate Tridimensional Data

- Data
  - Curvilinear 3D grid
  - Tropical Pacific Area
  - Multiple Attributes
    - Time-varying (365 days)
    - Density, Salinity, Temp.

    and Ocean Currents



Oceanography Simulation Model

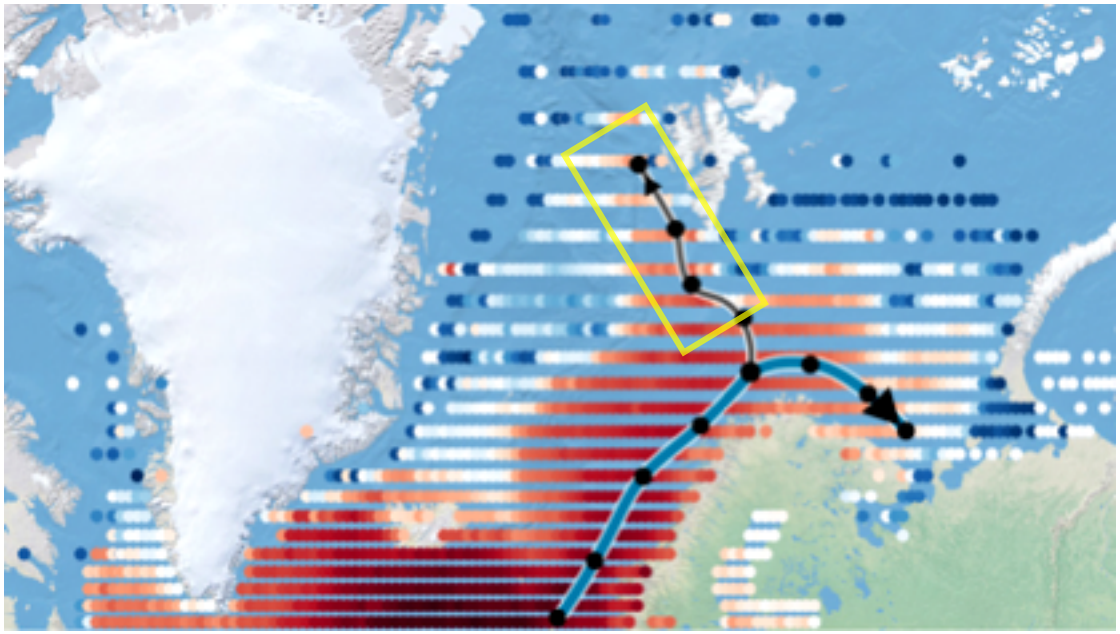
How to explore and correlate the multiple attributes embedded in these tridimensional models?

How to explore and correlate the multiple attributes embedded in these tridimensional models?

Multivariate Visualization

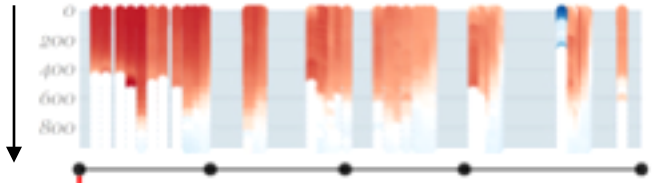
Multivariate Visualization

OceanPaths: Visualizing Multivariate Oceanography Data

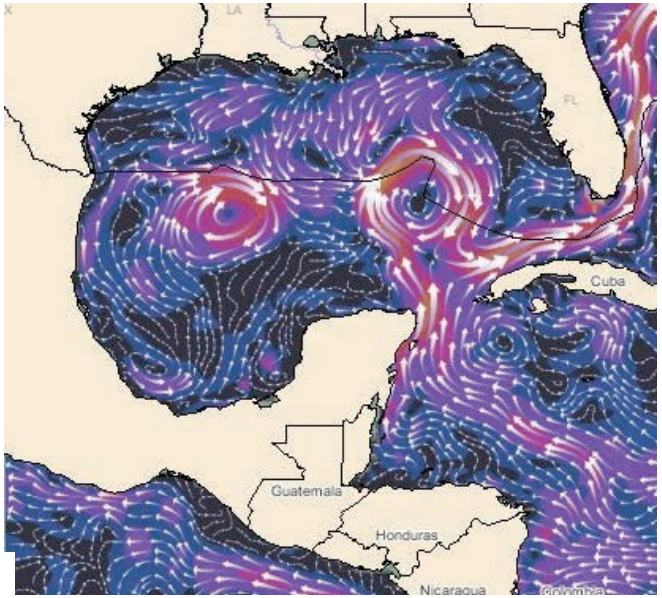


[Nobre and Lex. 2013]

depth



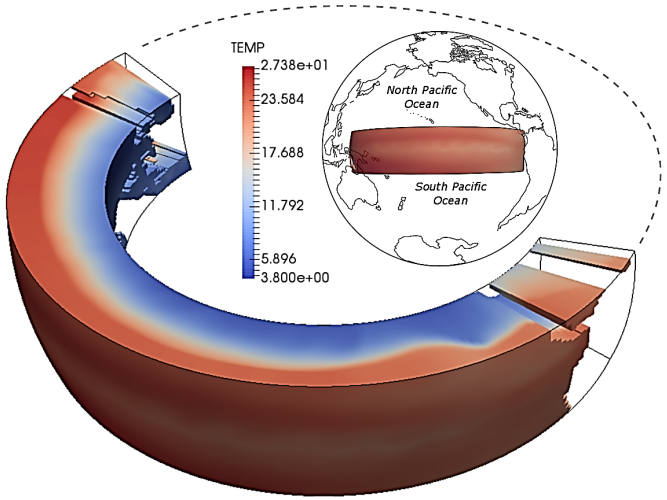
Improving the display of wind patterns and ocean currents



[Ware *et al.* 2013]

Multivariate Visualization

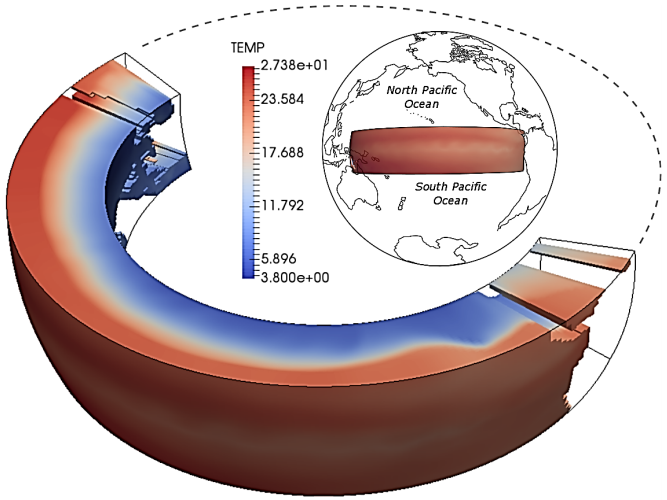
- Visualization Goals
  - (**R1**) Simultaneous display multiple variables
  - (**R2**) Animation of Ocean Currents
  - (**R3**) Access the 3D nature of the data
  - (**R4**) Interactivity



- Challenging implementation and design problem
  - *What* to visualize and *how* to visualize?

Multivariate Visualization

- Visualization Goals
  - (**R1**) Simultaneous display multiple variables (five)
  - (**R2**) Animation of Ocean Currents
  - (**R3**) Access the 3D nature of the data
  - (**R4**) Interactivity



Visualization	R1	R2	R3	R4
2D	✔	✔		✔
3D		✔	✔	✔

Drawbacks

distortions

clutter

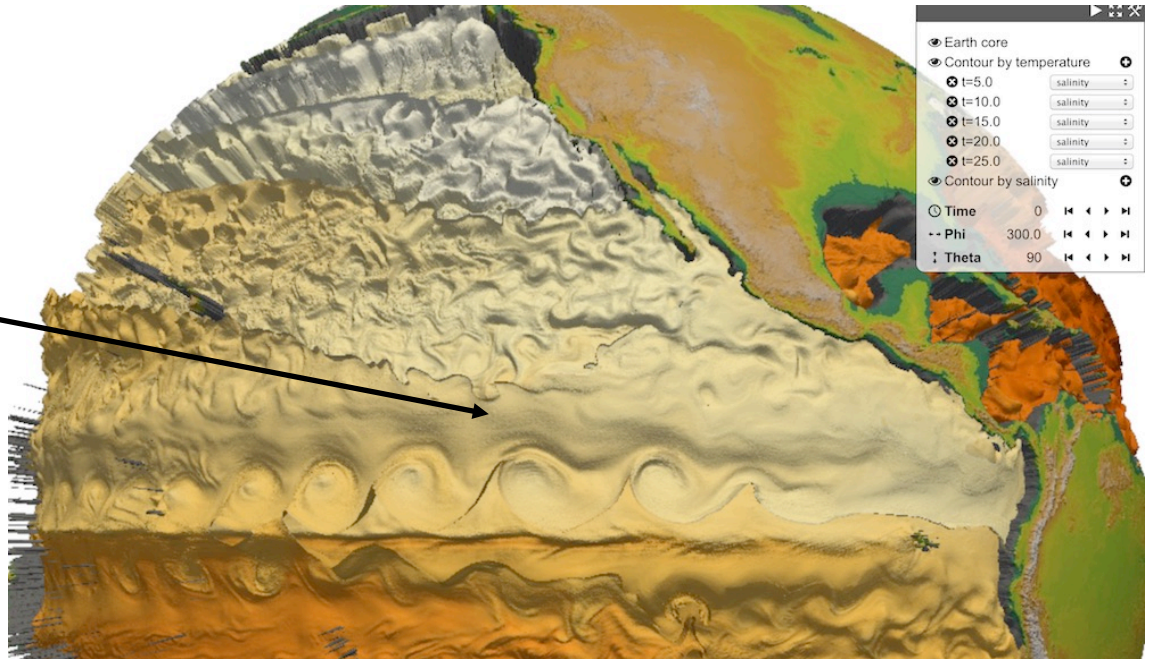
Multivariate Visualization

- Surfaces: helpful to understand and access tridimensional data

In Situ MPAS-Ocean Image-based Visualization

Temperature Isosurfaces

Colormap representing Salinity



[Ahrens *et al.* 2014]

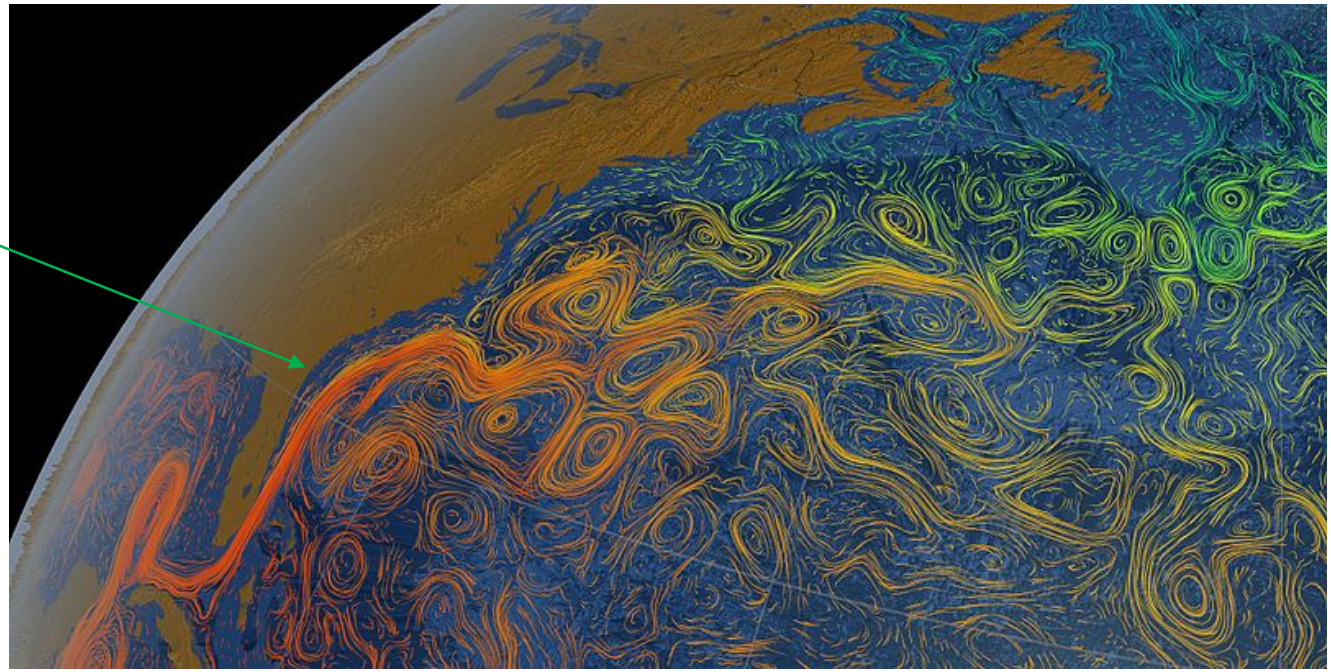
Multivariate Visualization

- Surfaces: Layering for multivariate visualization

Earth visualization of Gulf of Mexico to Western Europe

Ocean currents

Color variation represents temperature



NASA/GSFC Scientific Visualization Studio/Greg Shirah/Horace Mitchell/GSFC

Multivariate Visualization

Layering on surfaces

- Technical problem: map visual representations to arbitrary surfaces
- Design problem: combination of several attributes in a layered fashion

Multivariate Visualization

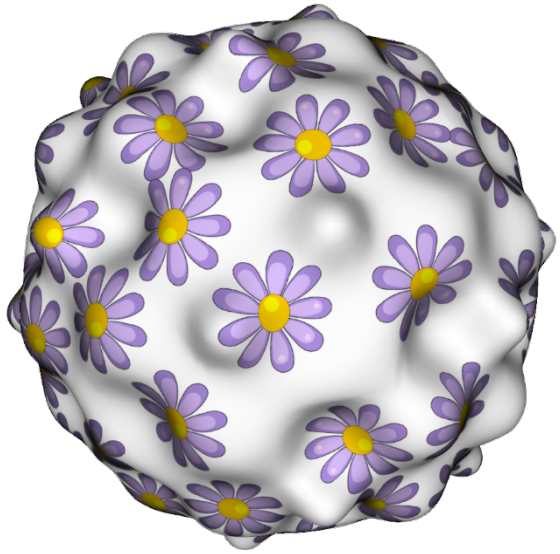
- A solution for the technical problem

Decals and *decal-maps* for multivariate visualization design on surfaces [Rocha *et al.*, 2017]

Multivariate Visualization

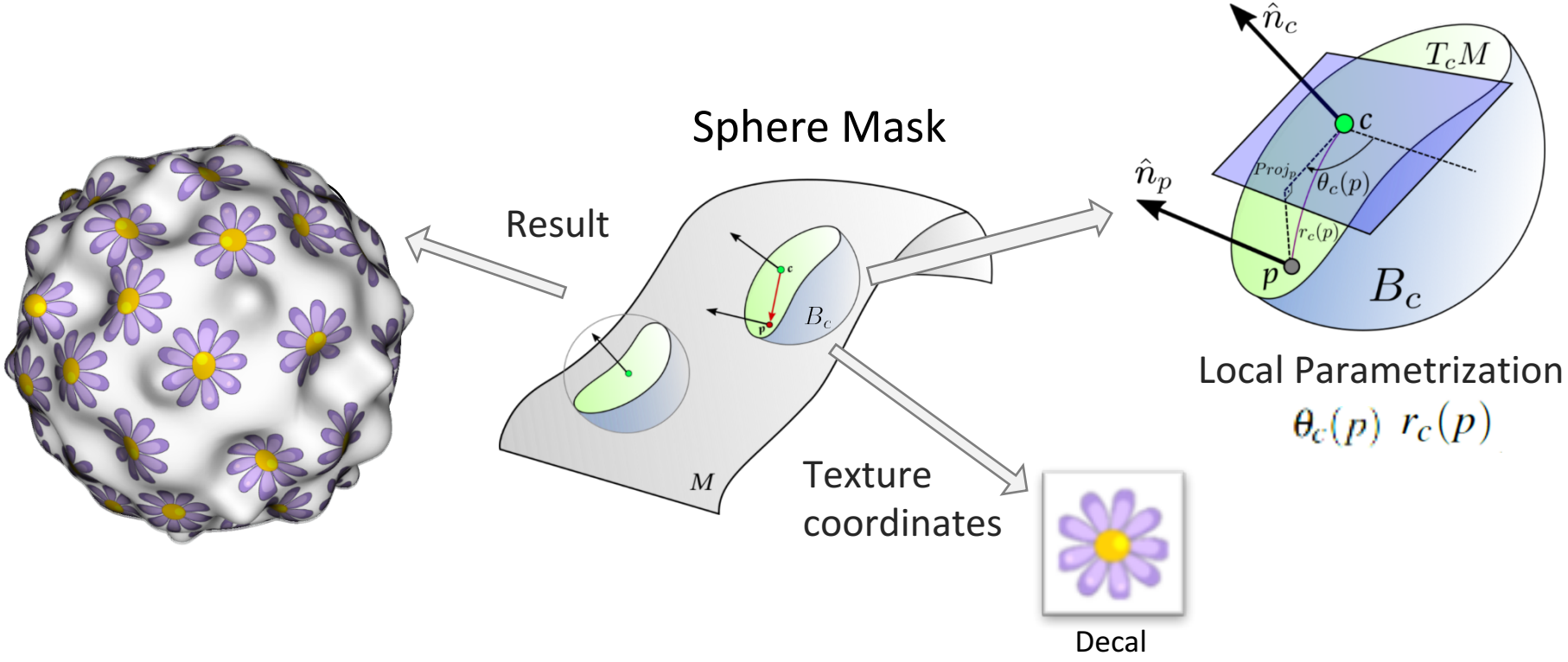
- Decals
  - Definition. *Visual representations (a pattern, a text, a glyph, or a symbol) transferred from a 2D-image to a surface upon contact.*

Decal



Multivariate Visualization

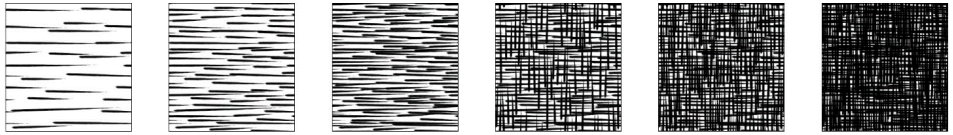
- Decals
  - Local parametrization based on the exponential maps



Multivariate Visualization

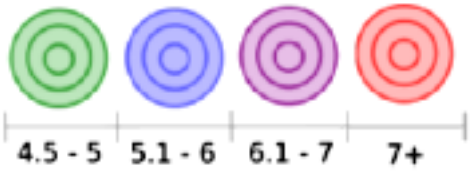
- Decals-maps
  - Definition. *A set of images designed to represent one or more data attributes.*

Water flow decal-map



Hatching decal-map

[Rocha *et al. Decal-maps: Real-time Layering of Decals on Surfaces for Multivariate Visualization*. IEEE TVCG, 2017]



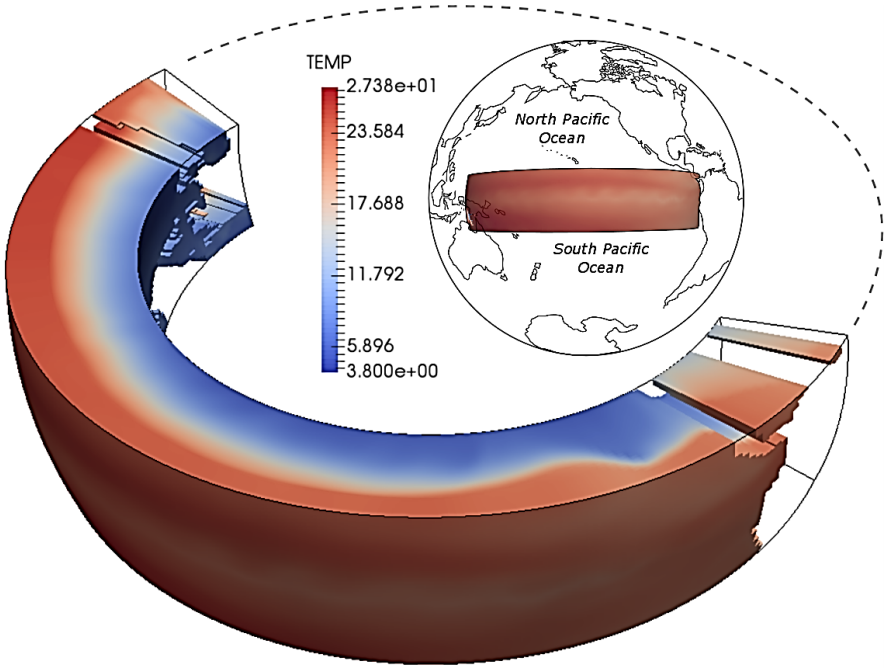
Earthquake decal-map

Multivariate Visualization

- Design problem: our focus in this work
- Layering process combining decals + colormaps

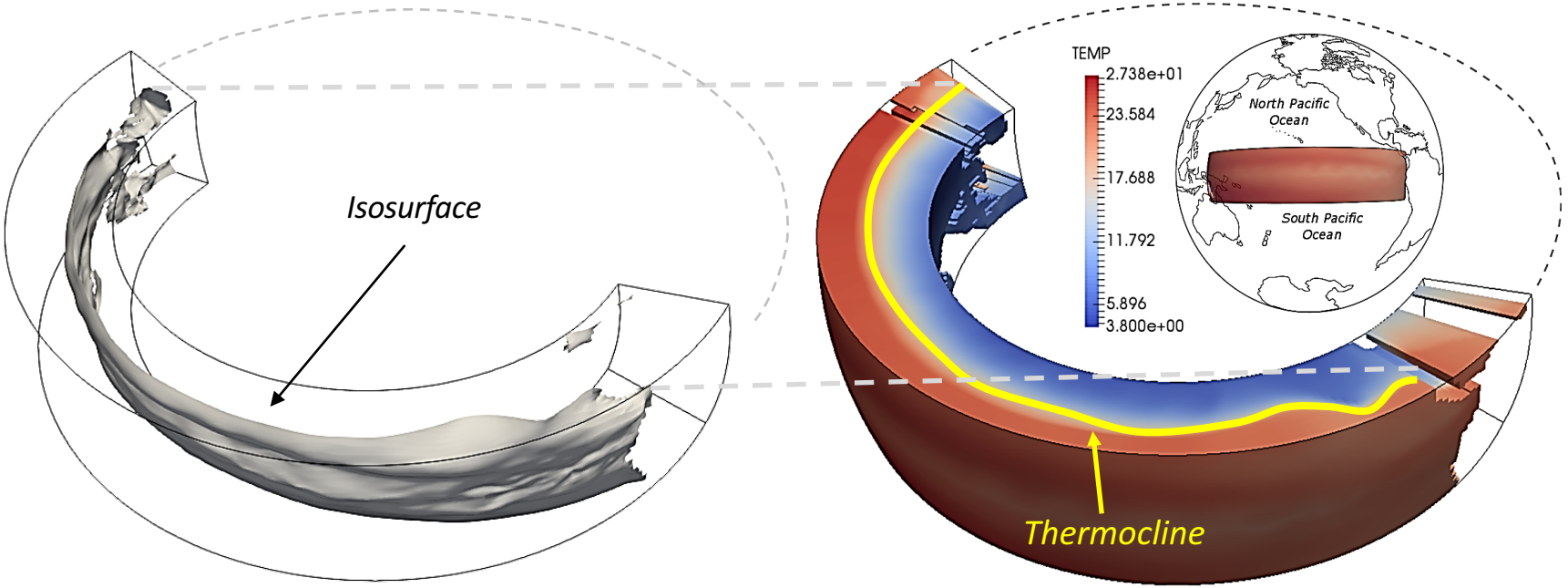
Visualization Approach

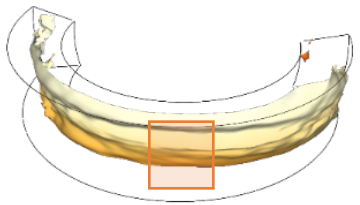
- Multivariate visualization on isosurfaces
- Attributes
  - Salinity
  - Density
  - Temperature
  - Ocean currents
    - Direction
    - Magnitude



Visualization Approach

- Surface extraction
  - *Thermocline* area at 15°C
- Paraview

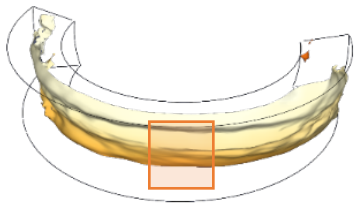




Visualization Design

- Base Layer – Density
  - Quantitative and ordinal data
  - Trends
  - Single hue colormap

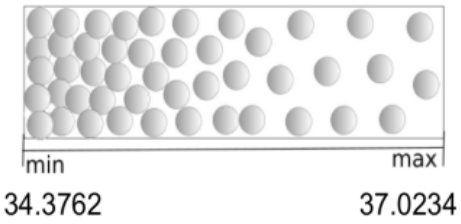
Temperature Isosurface

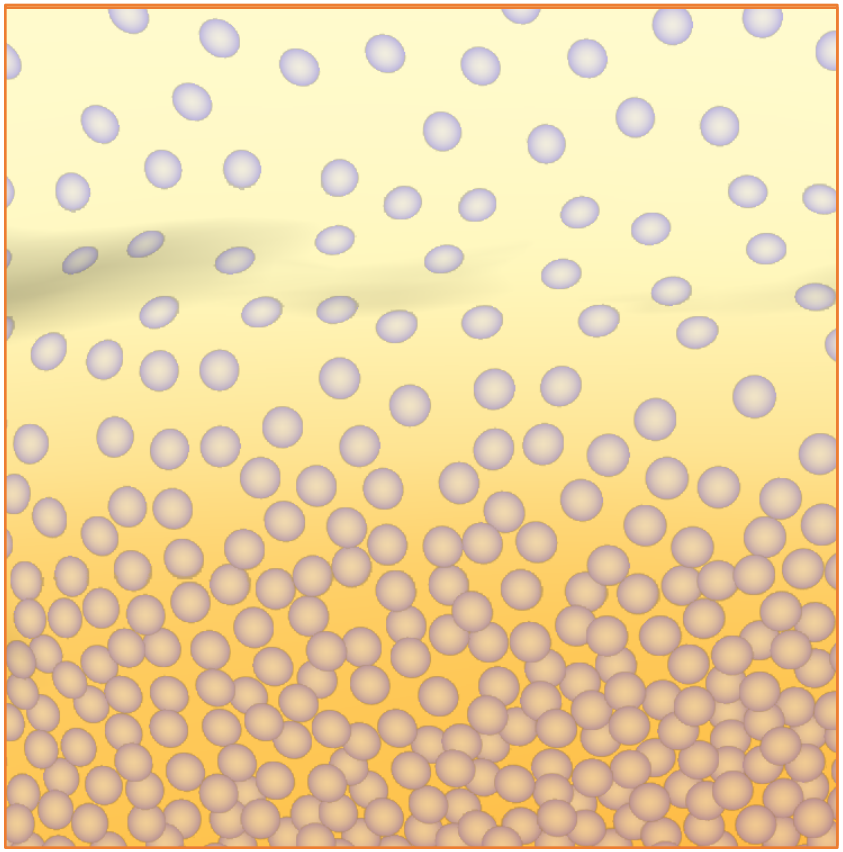


Visualization Design

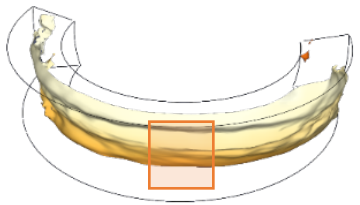
- 2nd Layer - Salinity
  - Quantitative and ordinal data
  - Trends
  - Circular shaded decals
  - Radial gradient
  - Clustering
    - Poisson importance sampling

[Corsini *et al. 2012*]



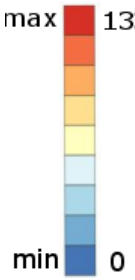


Temperature Isosurface

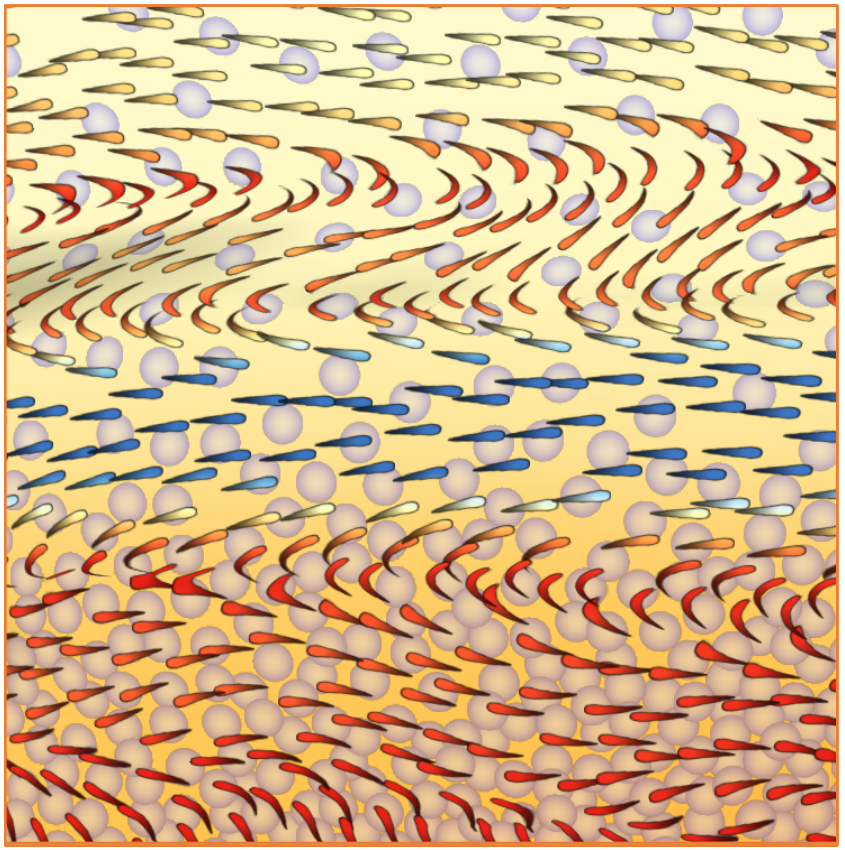


Visualization Design

- 3rd Layer – Ocean Currents
  - 3D vector field (dir, mag)
    - Consider 2D horizontal components
  - Details
  - Streamlet decals

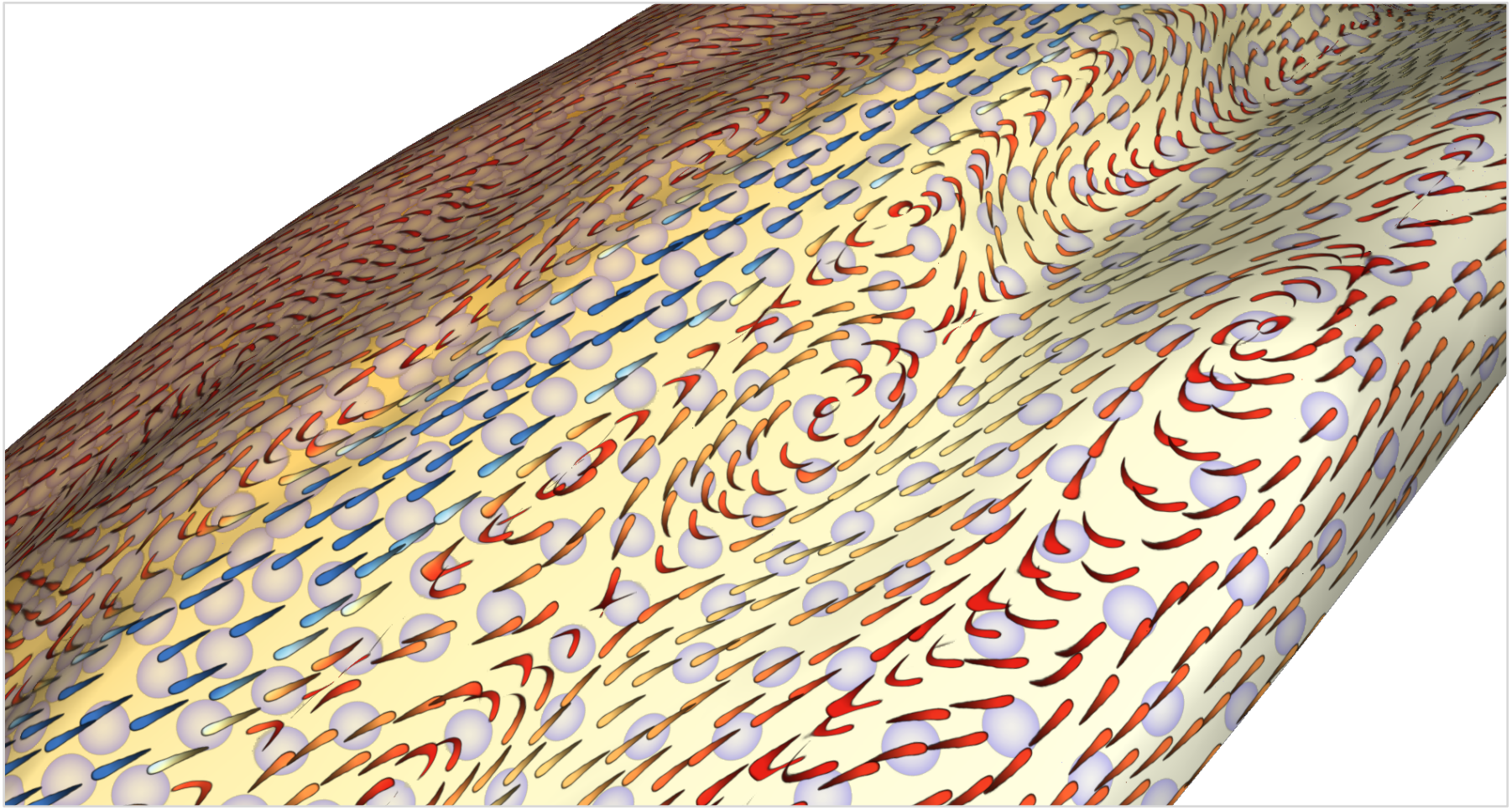


    - Gradient and head (direction)
    - Diverging colormap (magnitude)
- Features
  - Simple to resize and distribute
    - Poisson uniform sampling [Corsini et al.]
  - Deformation and animation based on the vector field [Rocha *et al.*]



Temperature Isosurface

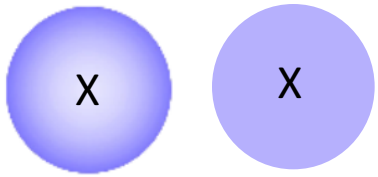
Results



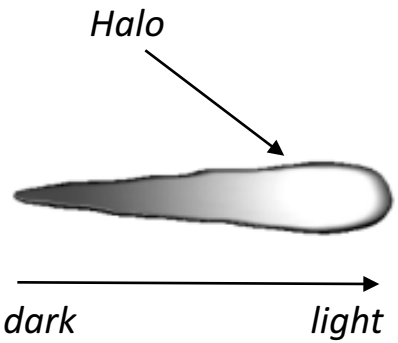
Multivariate Visualization of Oceanography Data

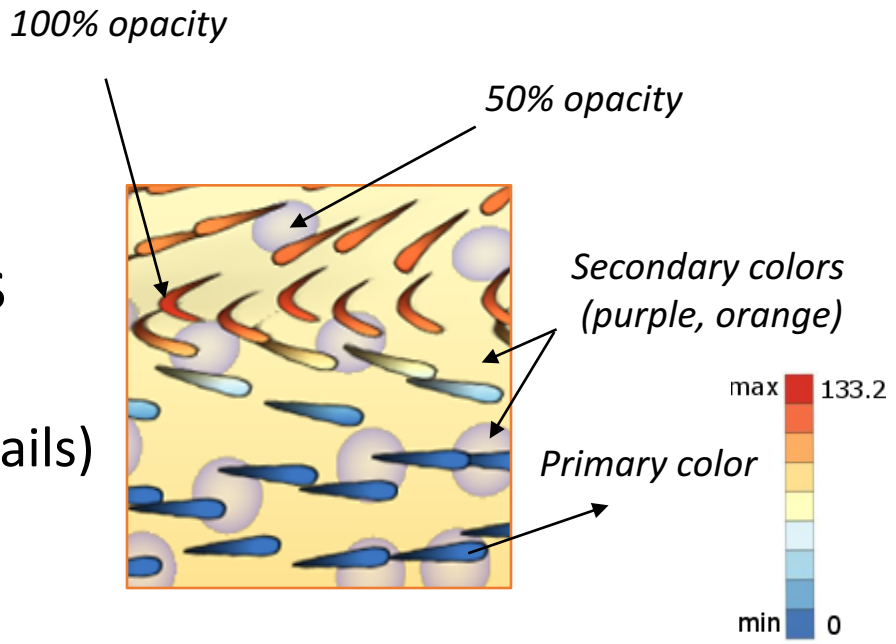
Results

- Layering Design
  - Visual contrast (colors)
  - Size (salinity *vs* currents)
  - Opacity (salinity 50% opacity)
  - Cornsweet effect
  - Halo
- Data design considerations
  - Complexity of attributes
  - Degree of interest (trends *vs* details)
  - Importance of the phenomenon



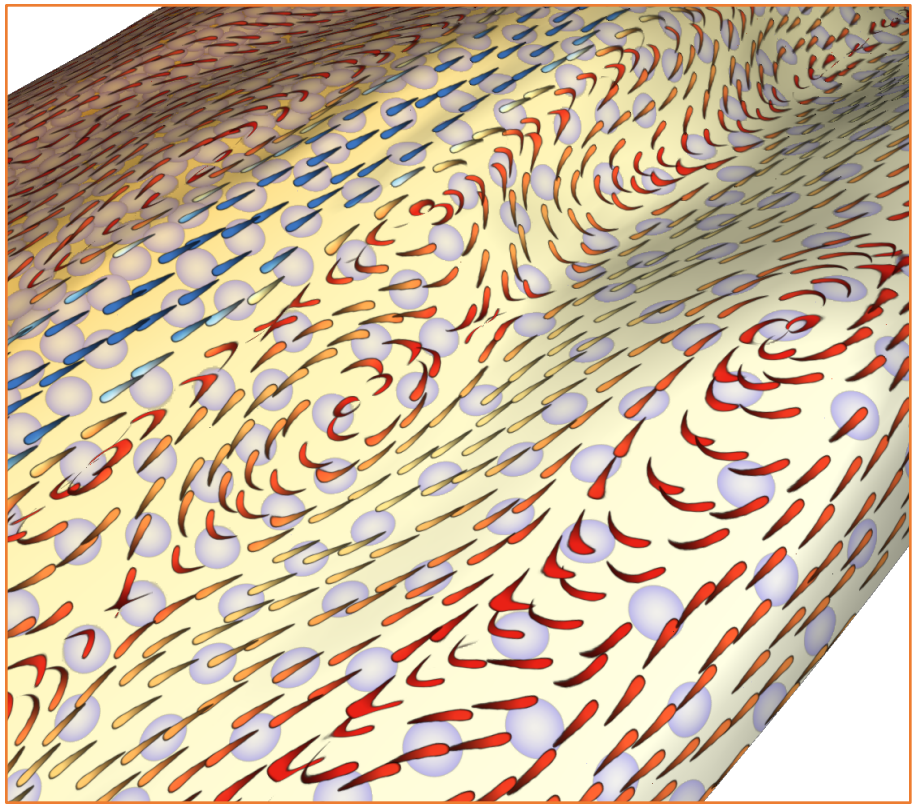
cornsweet effect





Results

- Interaction
  - Zoom and rotation
  - Turn on/off each layer
  - Scale decals
  - Animate vector field currents
- Performance
  - 1920 x 1080 pixels with 8x MSAA
  - 49 frames per second in a Intel Core i7 laptop with a NVidia GeForce GTX 960M 2G GPU (OpenGL and GLSL)



Conclusions

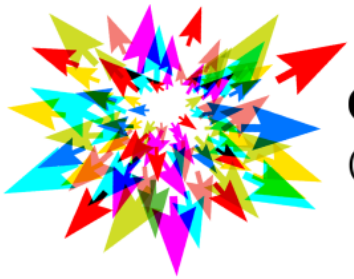
- Contributions
  - Visualization design of multiple oceanographic attributes
  - Design considerations for layering

Future Work

- Design space is vast!
- Include new variables and interaction techniques
- Consider multiple isosurfaces and time varying aspects
- Further exploration and evaluation with domain experts

Acknowledgements

- “Visualize This!” Challenge – Organized by Compute Canada and WestGrid
- Alex Razoumov
- Guido Vettoretti (University of Toronto) for provide the oceanography dataset.



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THANK YOU!

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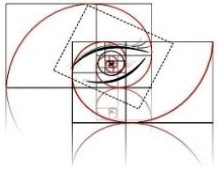

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QUESTIONS?

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