Visualizing Earth Science Climate Model and Digital Twin data in XR (1734326)

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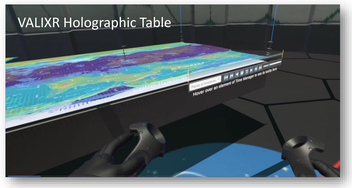
Problem and Opportunity

Earth Science benefits from a vast treasure trove of in-situ and remotely sensed observational data as well as complex modeling products. Earth Science Digital Twins (ESDT) are an emerging capability that integrates and synthesizes this and other data to help with understanding and forecasting the complex interconnections among Earth systems.

However, understanding this complex, spatially related and inherently 3D data on 2D displays and diagrams can be problematic, especially for lay people such as policy makers and the public.

- eXtended Reality (XR), as an intuitive, easily accessible and natural 3D medium, can be a compelling, multi-role front-end for visualizing, understanding, and manipulating Earth Science data in its natural context, whether from "traditional" sources or from ESDTs.
- XR can serve as a multi-role interface to Earth Science, from a user friendly front-end for policy makers and the public, to a first line investigation and exploration tool for scientists.



Understanding Earth Science Data using XR

VALIXR

A NASA Earth Science Technology Office (ESTO) Advanced Information Systems Technology (AIST) project, the Visualization And Lagrangian dynamics Immersive eXtended Reality (VALIXR) tool integrates various Earth Science products to provide an open-source, intuitive, multi-scale and multi-role XR front-end that can benefit scientists, policy makers and the public.

- Provides an **immersive, intuitive environment for visualizing and interacting with Earth System model output**
- Leverages an existing NASA open source XR tool the **Mixed Reality Exploration Toolkit (MRET)** with many features such as secure collaboration

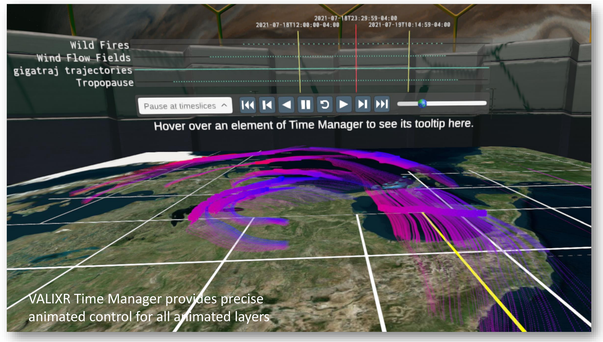
MRET
MIXED REALITY EXPLORATION TOOLKIT

- Adds a **"Holographic Table" visualization** into MRET for the "Layering" of on-demand, tiled, 2D and 3D data
  - Elevation Data and Geographical/Political Maps
  - GOES Cloud Maps, NexRAD*, and Wind Flow Fields
  - Image overlay layers
  - 3D "Layers" using Point Clouds, Volumetric Rendering, Isosurfaces*, and Procedural Meshes (Tropopause)
  - Supports Open Geospatial Consortium (OGC) standard services (i.e., WMS, WFS, WCS, etc.), NOAA Open Data Dissemination (NODD) Program, and Grid Analysis and Display System (GrADS) Data Server (OPeNDAP protocol)

Times Series Visualization

VALIXR visualizes several animated time-series science data, all controlled with a time manager:

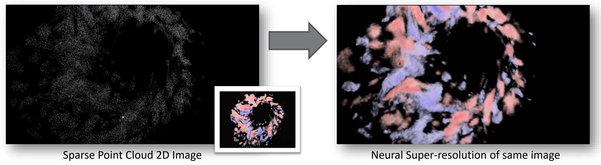
- Animated Point Clouds
- Animated Volumetrics
- Animated Wind Flow Fields



Neural Network Rendering (Optional)*

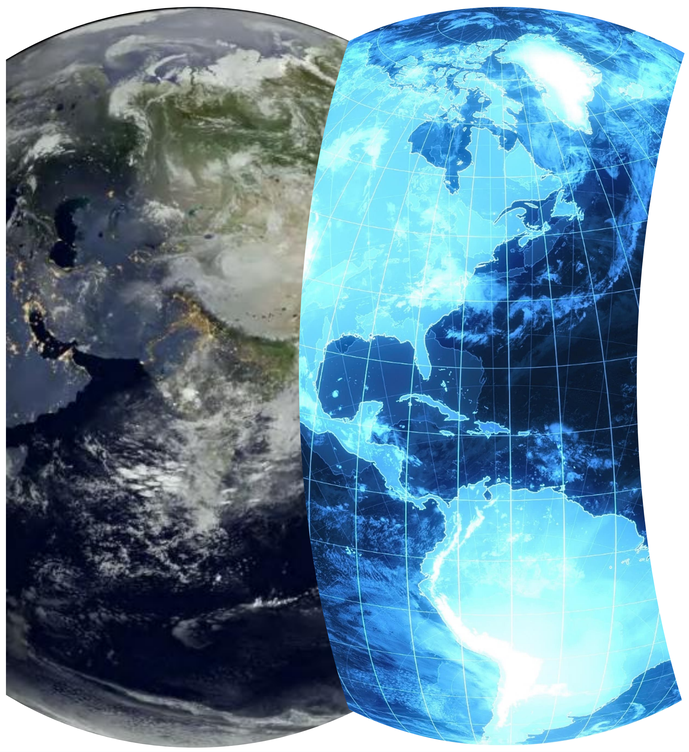
Simulations can potentially include tens of millions of particles in motion, which is a particular challenge. Computational optimizations may be necessary for animations to render quickly enough in XR, where a framerate of 90 frames per second is desired to avoid motion sickness.

- Enhance 3D point-cloud projection with deferred neural rendering in 2D
- Increase rendering quality and enable advanced visualization effects efficiently using 2D neural network
- Reduce point-cloud rendering cost - **Neural-network-based super-resolution**



* Forthcoming

Earth System Digital Twins



What now?

Digital Replica . . .

An integrated picture of the past and current states of Earth systems.

What next?

Forecasting . . .

An integrated picture of how Earth systems will evolve in the future from the current state.

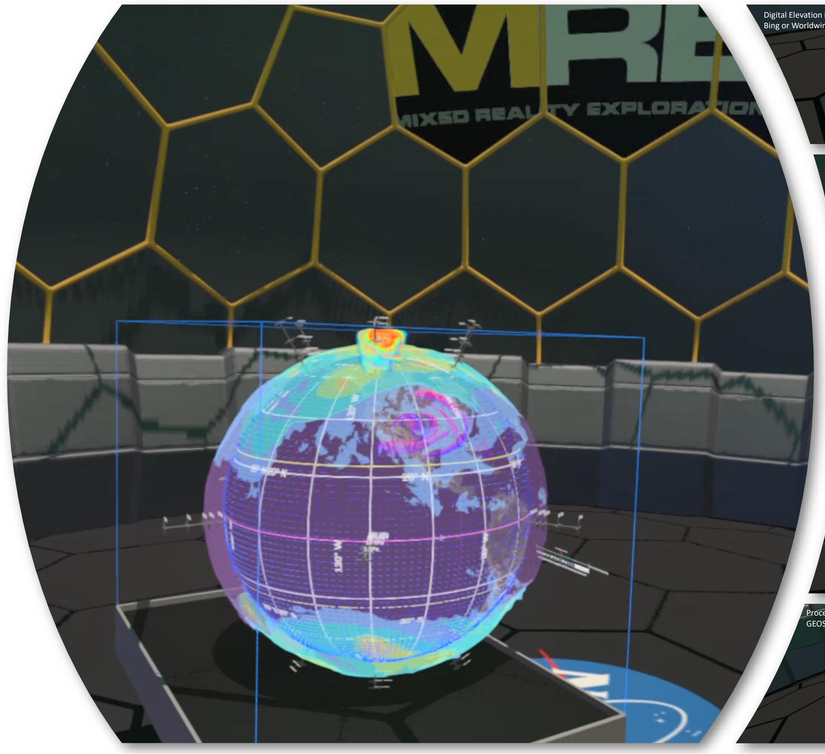
What if?

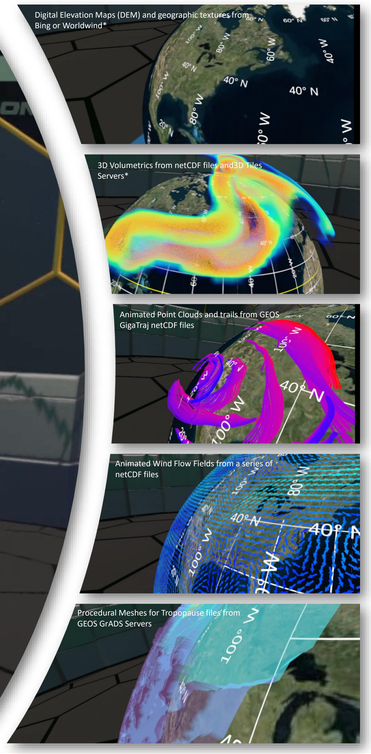
Impact Assessment . . .

An integrated picture of how Earth systems could evolve under different hypothetical what-if scenarios.

ESTO Earth Science Technology Office
AIST

Holographic Table Layered Interface





VALIXR conceptualizes a "Holographic Table" inside a Virtual Reality (VR) environment. The Holographic Table, similar to the physical relief maps used by military and emergency personnel (and some Dungeon & Dragons groups), provides a virtual relief map or spherical globe, where users can:

- Pan and scale
- Turn on/off layers and set layer properties
- Animate layers
- Select points using a Paddle Selector or 3D shapes