Jet Propulsion Laboratory
California Institute of Technology

Earth Science Data Visualization in the Metaverse

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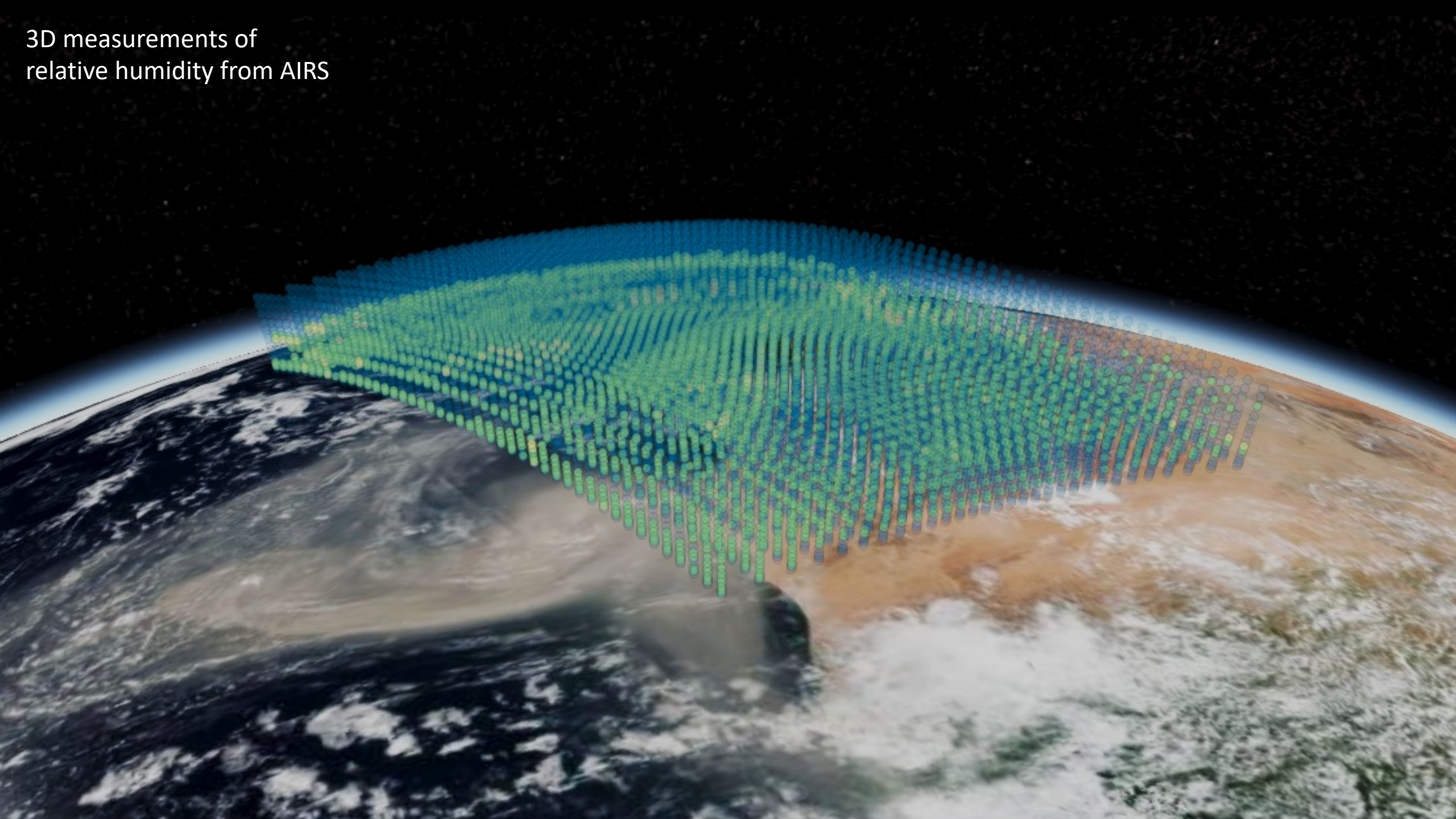
Earth Science Data in the Metaverse

- AR/VR/XR technologies in the metaverse offer new possibilities for interacting with geospatial data in a collaborative environment
- We have highly detailed 3D data of the Earth
  - Climate/weather models
  - Orbital radar, sounders, and other instruments
  - Airborne and terrestrial lidar
  - In-situ probes
- How can we aid Earth scientists with this new technology?
  - “Can we bring this from a gimmick, a wishful dream, to efficient implementation of virtual reality for science?” – Dr. Eric Larour (JPL)

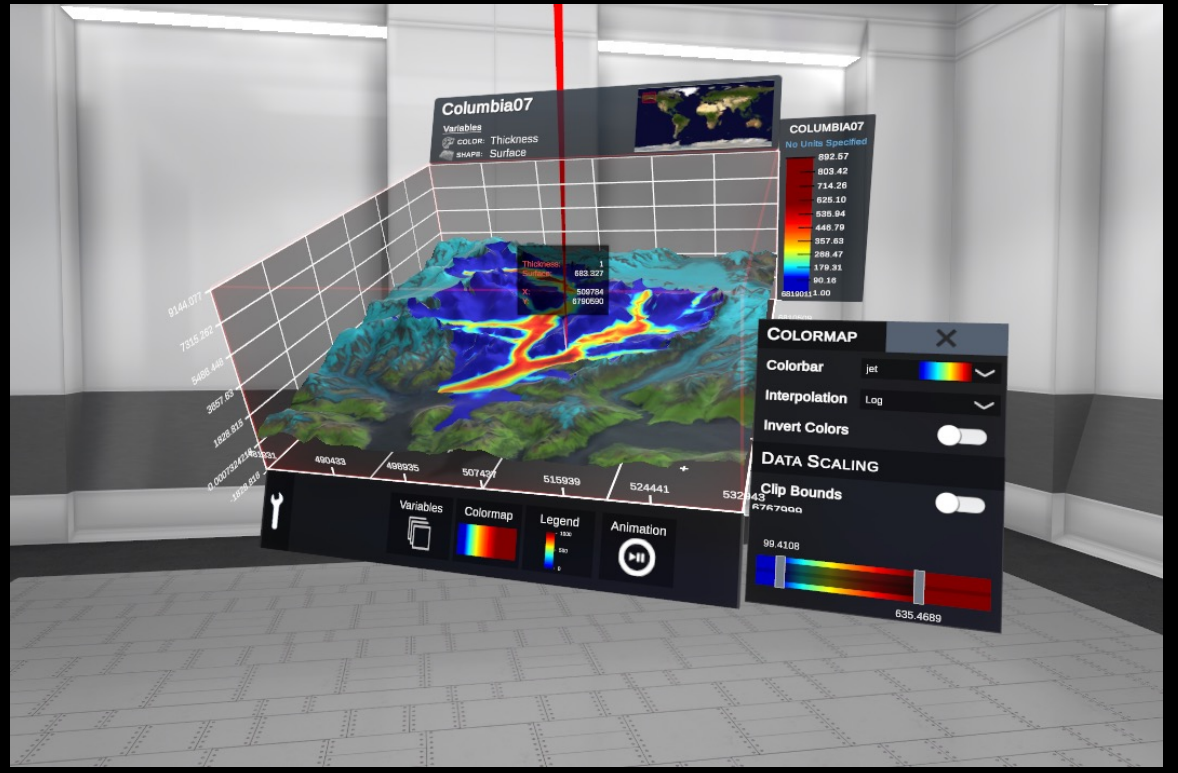
3D measurements of
relative humidity from AIRS

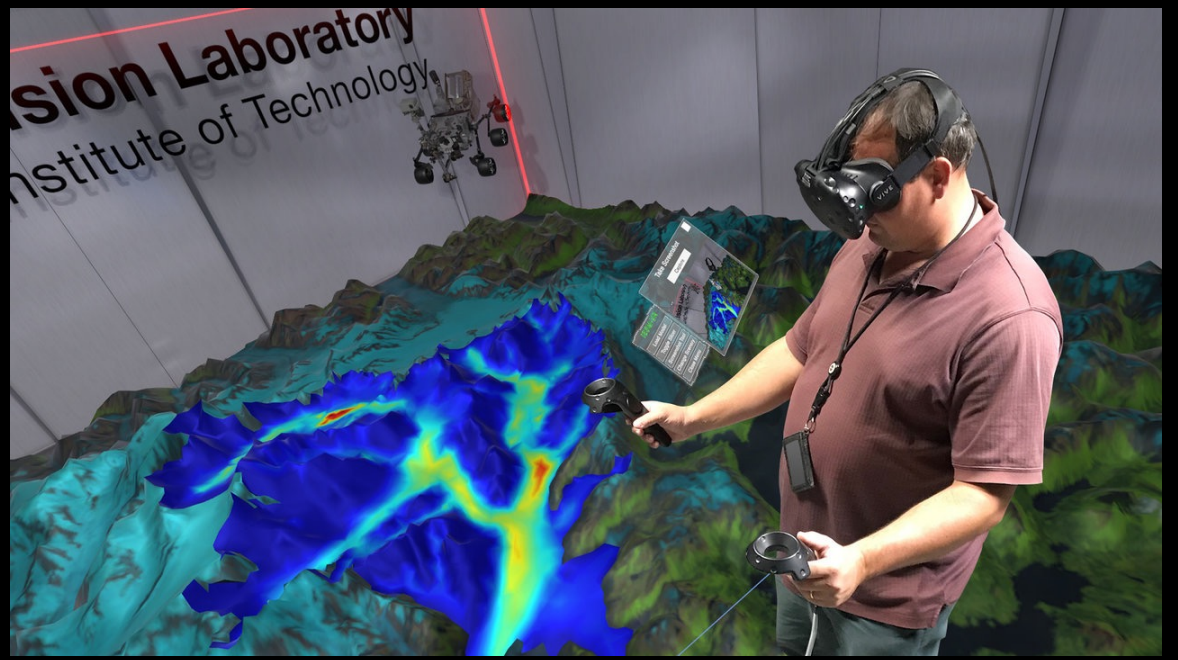


Example XR Software

SciVR

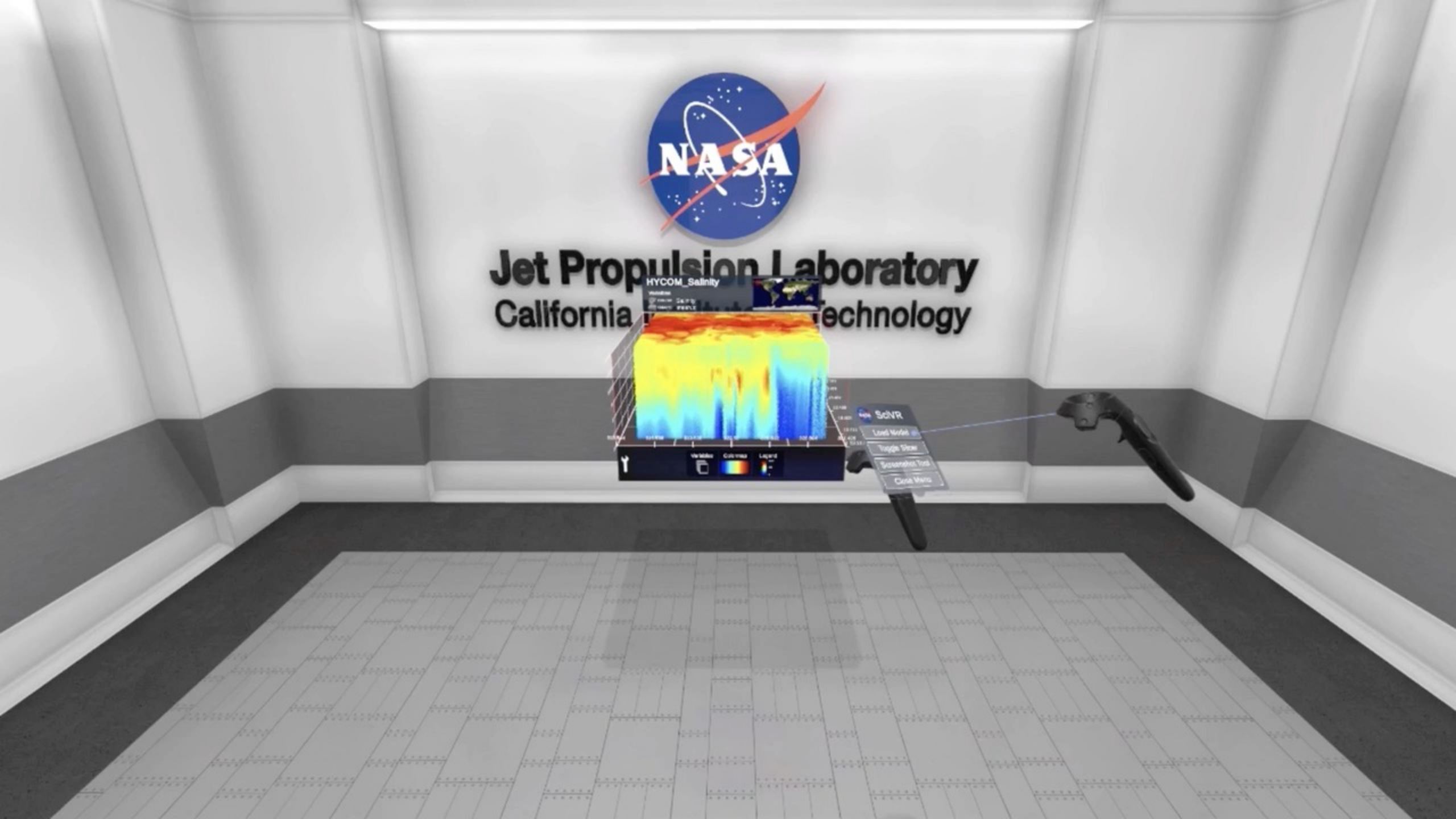
- SciVR is a fully immersive science data visualization application intended for use by Earth scientists
  - Allows scientists to explore their data within a room-scale environment in real time using:
    - natural depth perception
    - tracked hand motions
    - specialized tools (e.g., data slicer, object scaling, data-querying laser pointer)
  - Built in Unity originally for Vive

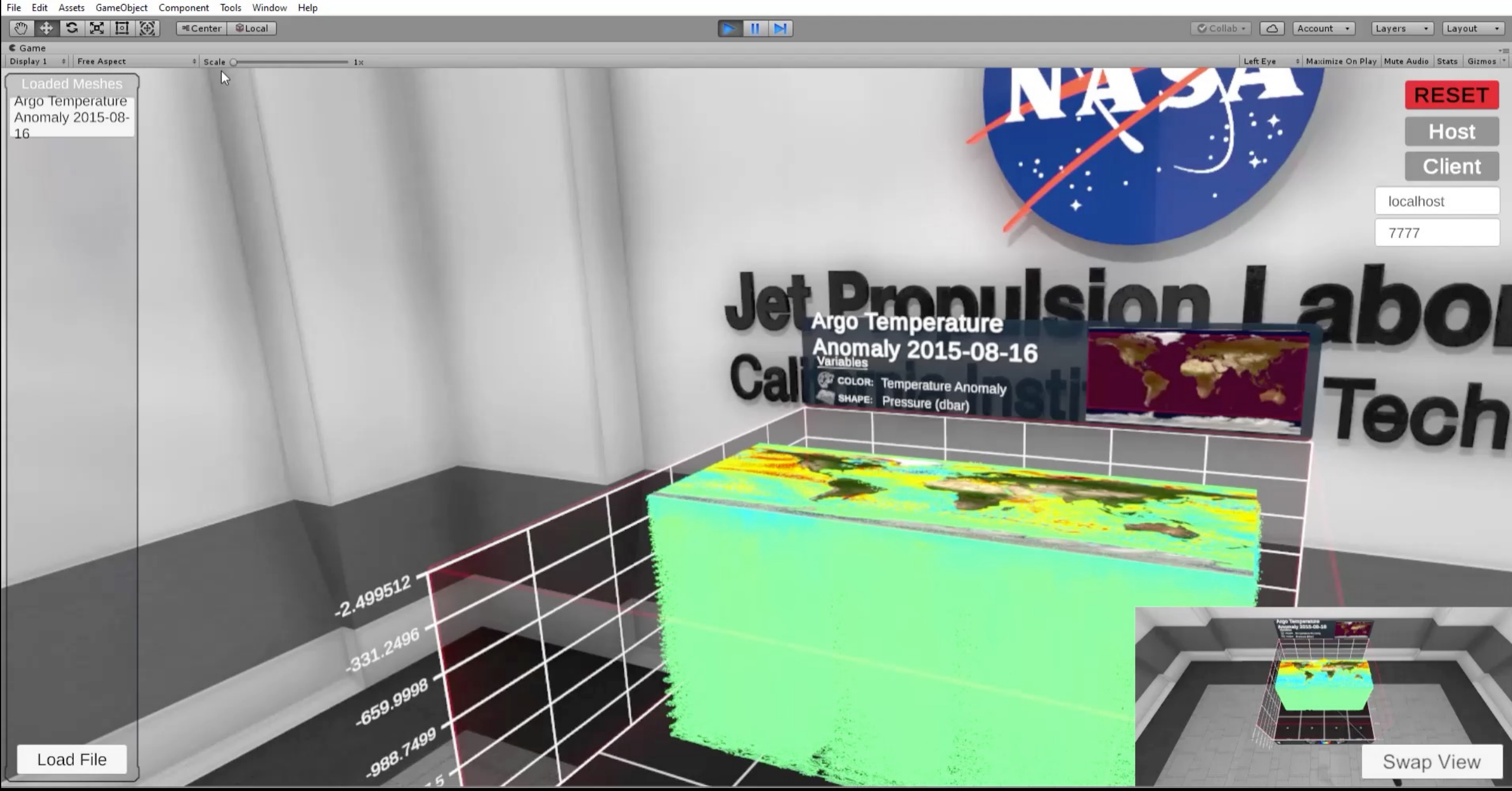




SciVR

- Developed to help scientists better understand their data and to shorten the feedback loop of scientific discovery
- Collaborative features allow multiple scientists to interact with data within the same environment
- Takes advantage of the GPU to enable high performance real time visualizations and on-the-fly computations
- Enables users to visualize and interact with data in ways that desktop applications and a traditional mouse, keyboard, and display setup cannot
- Initially built for the Sea Level Change Project and Virtual Earth System Laboratory (https://vesl.jpl.nasa.gov/)


NASA
Jet Propulsion Laboratory
California
Technology
HYCOM_Salinity
SciVR
Load Model
Toggle Skew
Screenshot Tool
Close Menu


File Edit Assets GameObject Component Tools Window Help
Center Local
Collab Account Layers Layout
Game
Display 1 Free Aspect Scale 1x
Left Eye Maximize On Play Mute Audio Stats Gizmos
Loaded Meshes
Argo Temperature Anomaly 2015-08-16
RESET
Host
Client
localhost
7777
Argo Temperature Anomaly 2015-08-16
Variables
COLOR: Temperature Anomaly
SHAPE: Pressure (dbar)
-2.499512
-331.2496
-659.9998
-988.7499
Load File
Swap View


Loaded Meshes
RESET
Host
Client
localhost
7777
Jet Propulsion Laboratory
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Load File
Swap View

SciAR

- An augmented reality version of SciVR on the HoloLens 2
- Motion sickness is a very common complaint of using VR
  - AR doesn’t have that issue because objects are drawn onto the real world
- Eliminates the need to constantly switch between headset and desktop displays
- Headset is untethered from computer, but has less compute power

Has this helped Earth scientists?

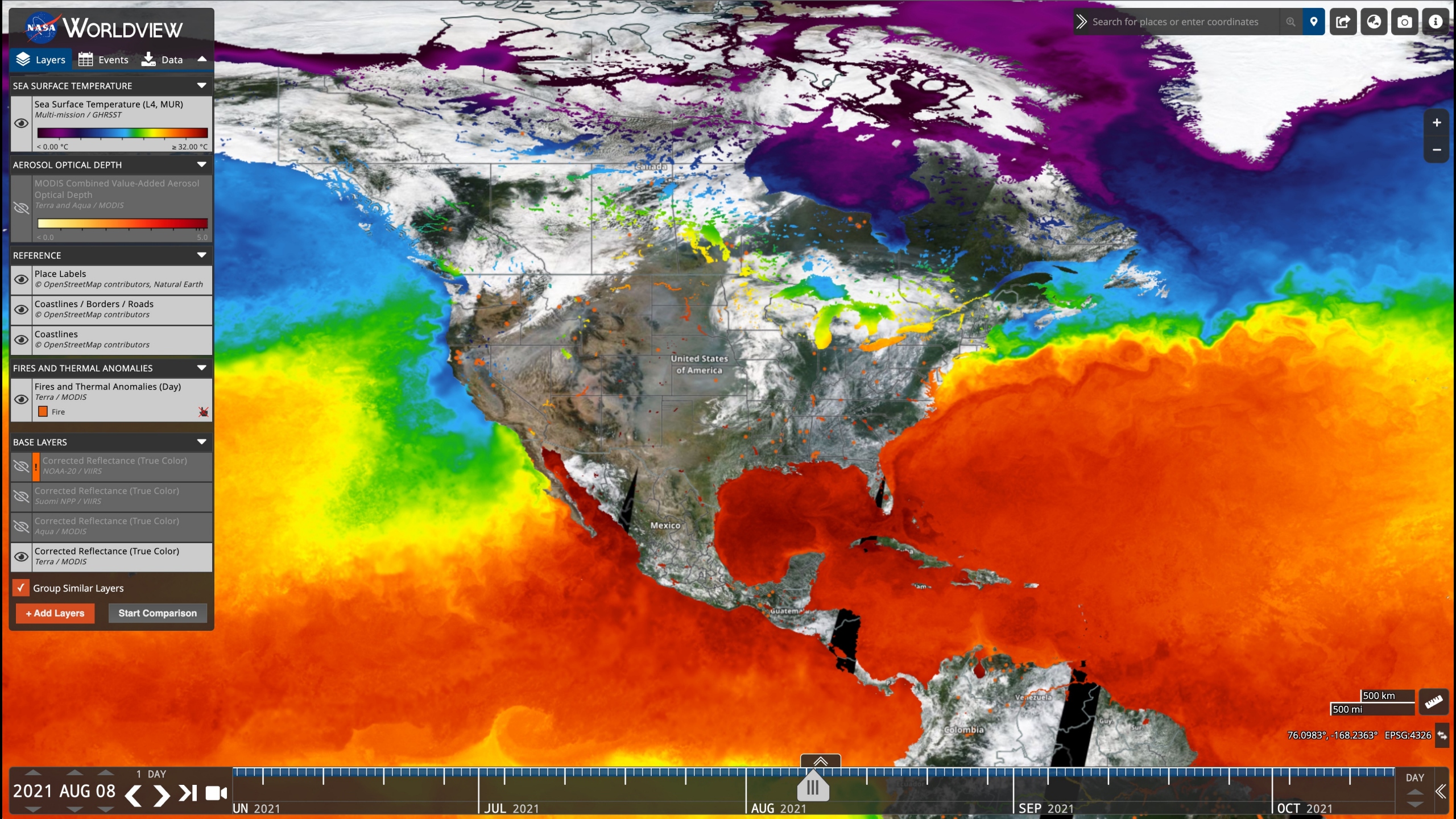
- It has been a great tool for science outreach and public engagement
- Quick insights about the data can be drawn via the sheer responsive and visual interaction with the data
  - “VR system lets us really see the 3D structure in the data by taking extremely fast, iterative slices so quickly our brain can finally stitch them together.”
- It is useful for collaborative discussions about the data
  - “Hey, look at this unusual pattern where my finger is pointing!”
- But…it has been a struggle for scientists to use due to several challenges

Challenges

- Top issue is seamlessly loading large geospatial datasets into a game engine and XR devices
  - E.g., “I want to quickly see this dataset that’s available on the web without downloading and pre-processing the data, starting a bunch of software and configuring complex VR equipment.”
  - Onboard compute power of most VR headsets are generally insufficient without pre-processing steps to reduce the data
  - Devices tethered to computers with powerful GPUs require complicated setup that are a barrier for scientists
  - Lack of services that can stream compatible data over the web; requires data to be downloaded
  - Earth science data isn’t in formats like OBJ and FBX; they’re in formats like NetCDF
- General complaints about XR – motion sickness, putting on a headset, switching between displays, additional equipment purchases, etc.
  - Industry-wide challenges that will improve as technology evolves

How can we overcome primary challenge?

- Well, we've done a decent job developing tools and services for a 2D world with flat screens
  - Kudos to NASA's Earth Observing System Data and Information System (EOSDIS) for providing a rich set of capabilities https://earthdata.nasa.gov/
  - NASA's Global Imagery Browse Services (GIBS) and Worldview lets us rapidly view a huge amount of NASA's Earth science data holdings
    - https://worldview.earthdata.nasa.gov/
    - https://earthdata.nasa.gov/gibs
  - GIS software can retrieve and visualize datasets via standard OGC-compliant web services and optimized file formats such as Cloud-Optimized GeoTIFFs


NASA WORLDVIEW
Layers
Events
Data
SEA SURFACE TEMPERATURE
Sea Surface Temperature (L4, MUR)
Multi-mission / GHRSST
< 0.00 °C
≥ 32.00 °C
AEROSOL OPTICAL DEPTH
MODIS Combined Value-Added Aerosol Optical Depth
Terra and Aqua / MODIS
< 0.0
5.0
REFERENCE
Place Labels
© OpenStreetMap contributors, Natural Earth
Coastlines / Borders / Roads
© OpenStreetMap contributors
Coastlines
© OpenStreetMap contributors
FIRES AND THERMAL ANOMALIES
Fires and Thermal Anomalies (Day)
Terra / MODIS
Fire
BASE LAYERS
Corrected Reflectance (True Color)
NOAA-20 / VIIRS
Corrected Reflectance (True Color)
Suomi NPP / VIIRS
Corrected Reflectance (True Color)
Aqua / MODIS
Corrected Reflectance (True Color)
Terra / MODIS
Group Similar Layers
+ Add Layers
Start Comparison
Search for places or enter coordinates
Canada
United States of America
Mexico
Colombia
500 km
500 mi
76.0983°, -168.2363° EPSG:4326
1 DAY
2021 AUG 08
JUN 2021
JUL 2021
AUG 2021
SEP 2021
OCT 2021
DAY

Worldview AR

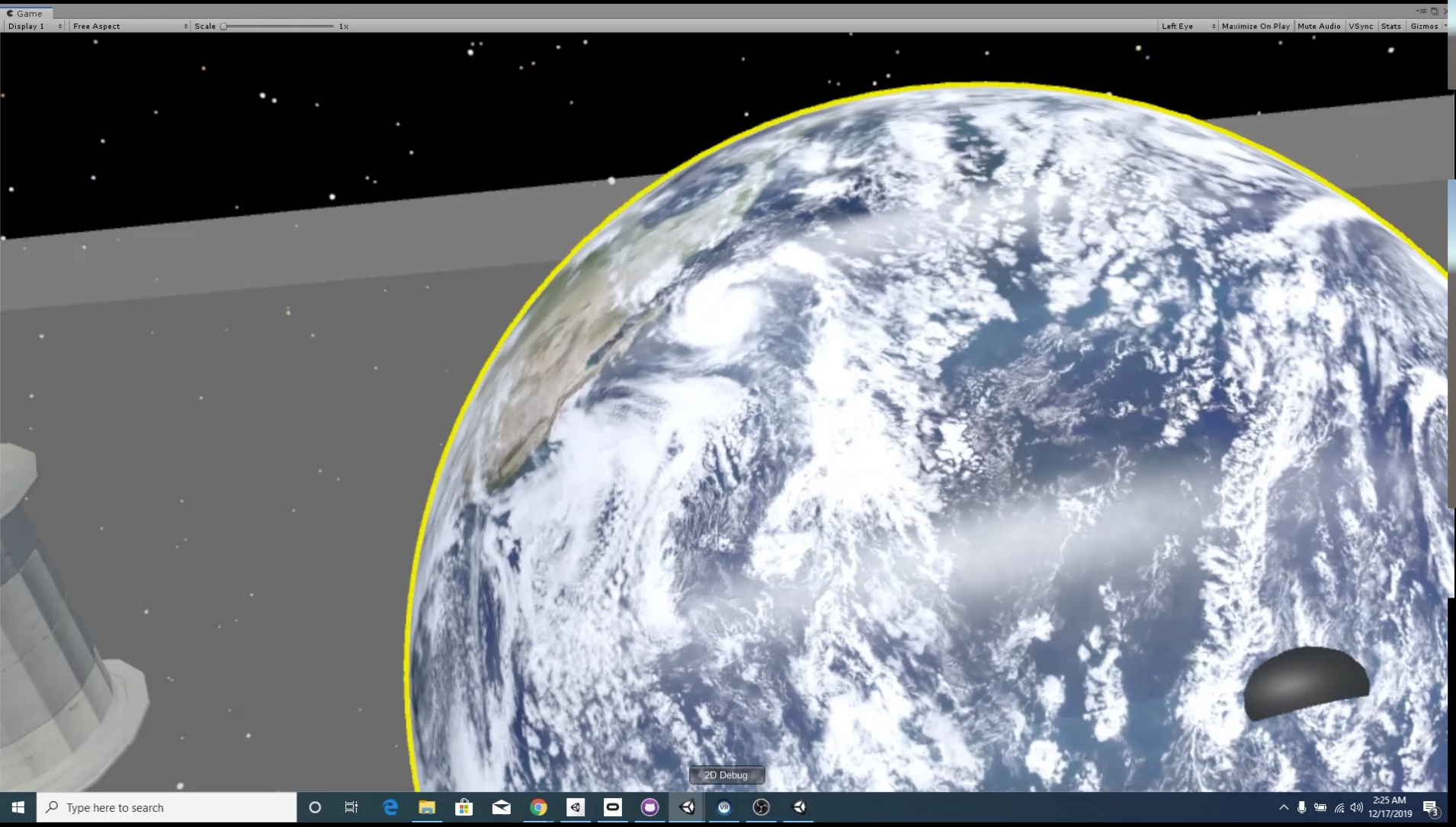
Please Select a Mode:

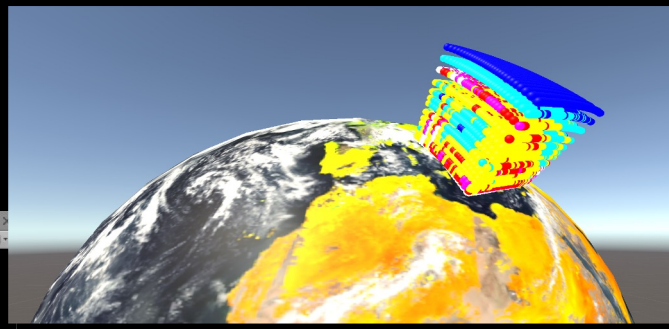
Free Play

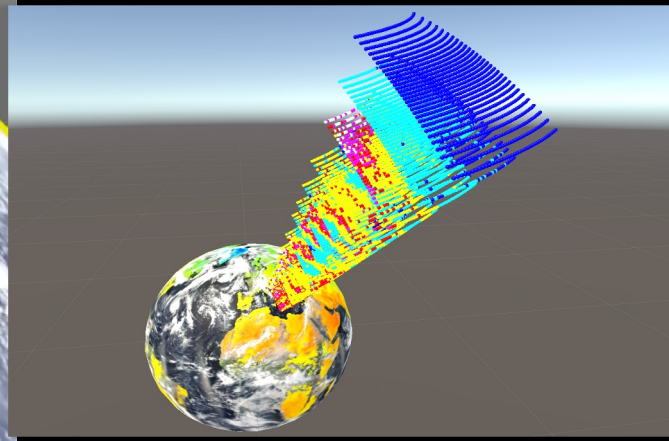
Quiz / Game (Solo)
(Coming Soon)

Quiz / Game (Multiplayer)
(Coming Soon)

GIBS Unity Examples

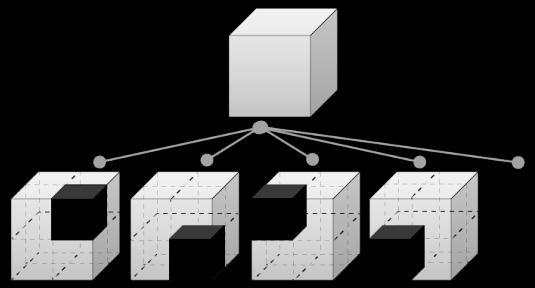


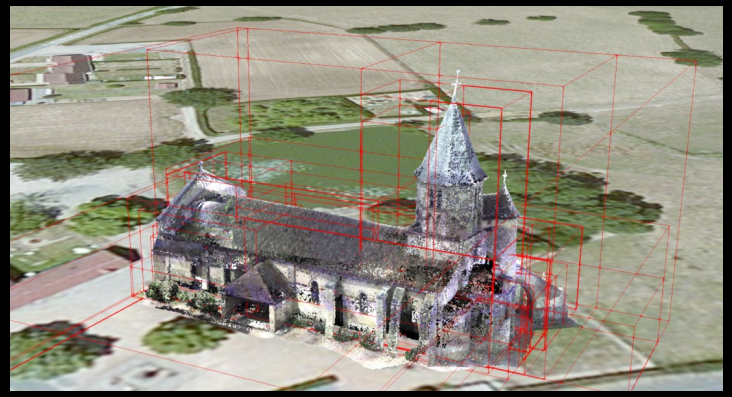




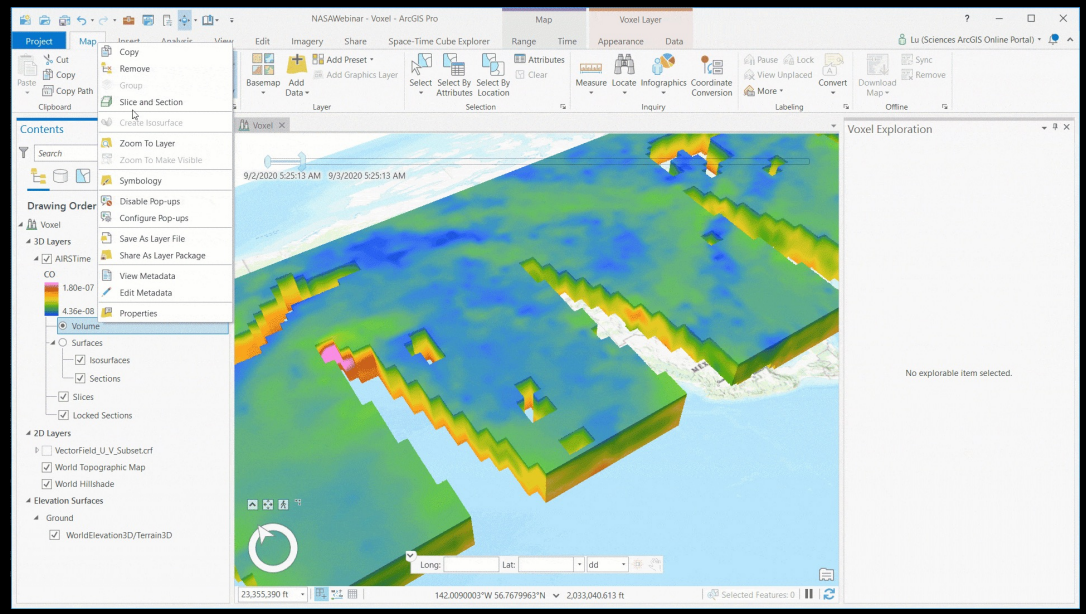
Develop 3D Data Pipelines and Services

- Emulate 2D data pipelines and services for a 3D world
- Standards exist for streaming 3D visualizations: gLTF, 3D Tiles, I3S
- GIS software such as ArcGIS Pro can support 3D data and working with voxels





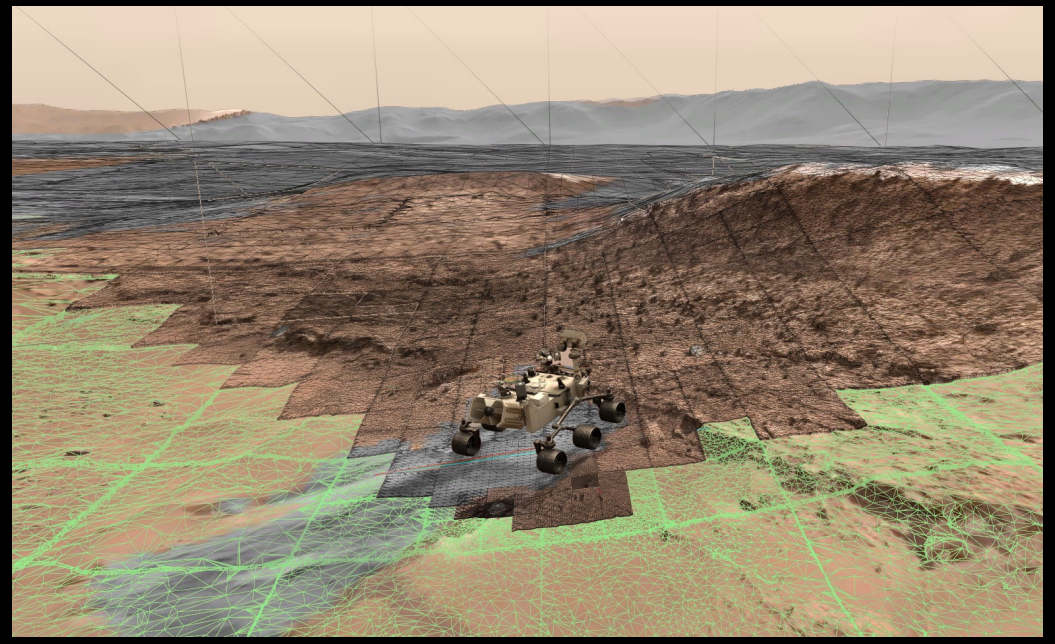
https://github.com/AnalyticalGraphicsInc/3d-tiles



Esri ArcGIS Pro

Game Engine SDKs for Geospatial Data

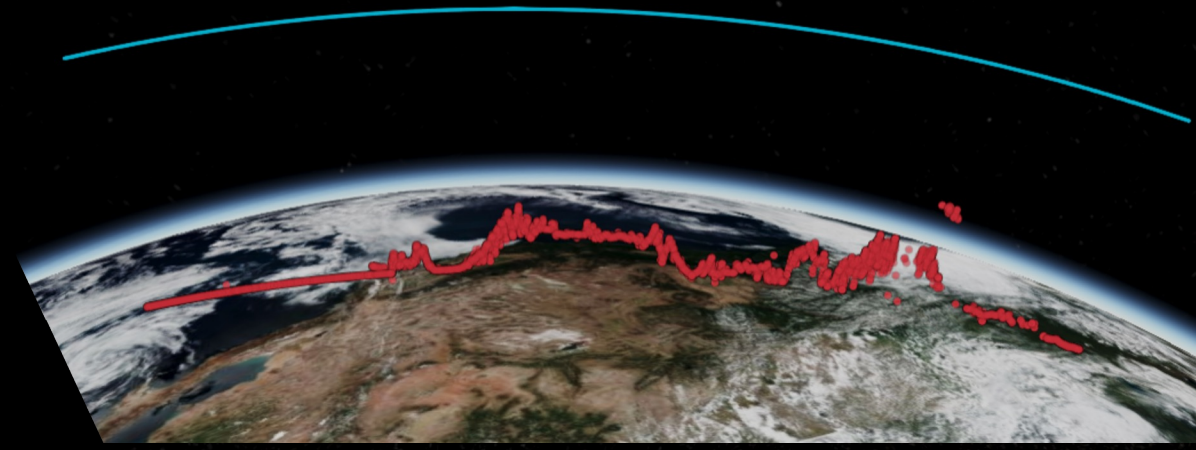
- ArcGIS Maps SDK for Unity
- ArcGIS Maps SDK for Unreal Engine
- Cesium for Unreal
- Unity3DTiles
  - https://github.com/NASA-AMMOS/Unity3DTiles



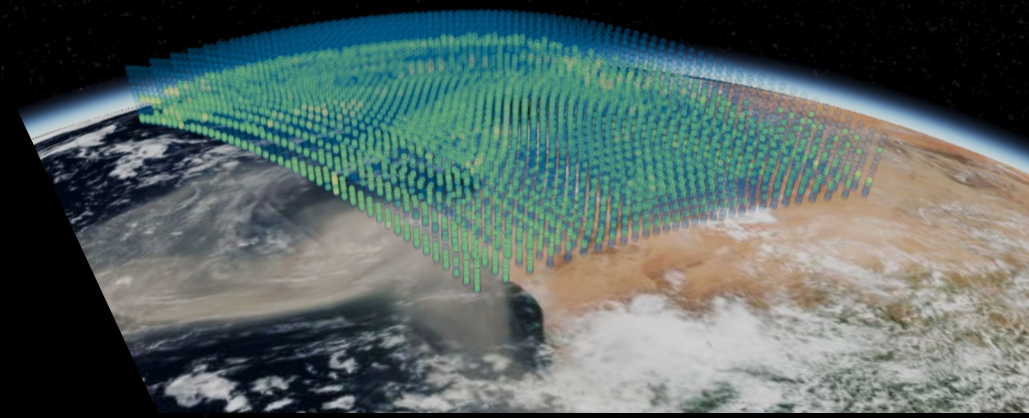
Current Development

- Current focus is building 4D (w/ time) data visualization services
- Service prototypes developed for NASA GIBS
- Support for external data streaming via 3D Tiles developed in SciVR
- Challenges of supporting hetero-genous types of visualizations (e.g. terrain meshes vs. point clouds) at greatly varying scales (e.g. cm-scale terrestrial lidar vs. km-scale satellite observations)

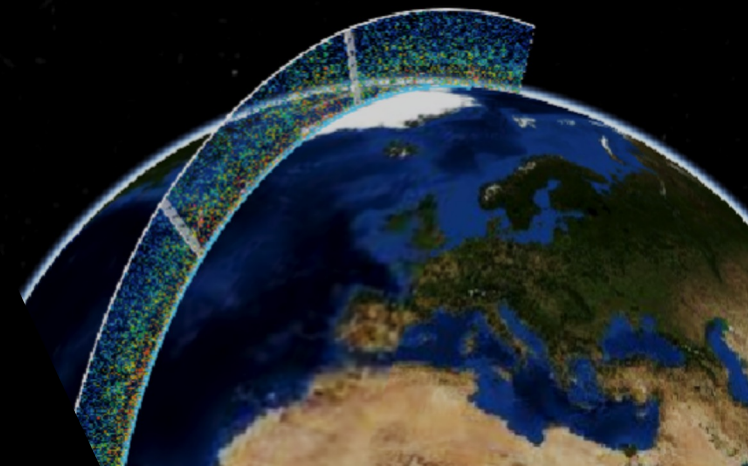
ICESat-2



AIRS



CALIPSO



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