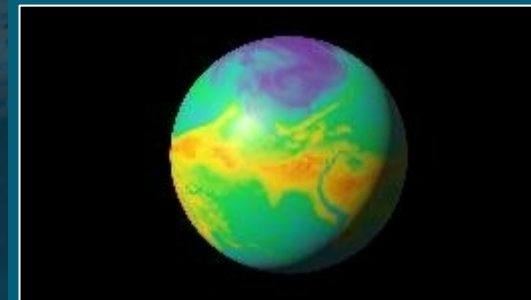




# ConFab 2022 Collaborative HPC Visualizer Tool



PRESENTED BY

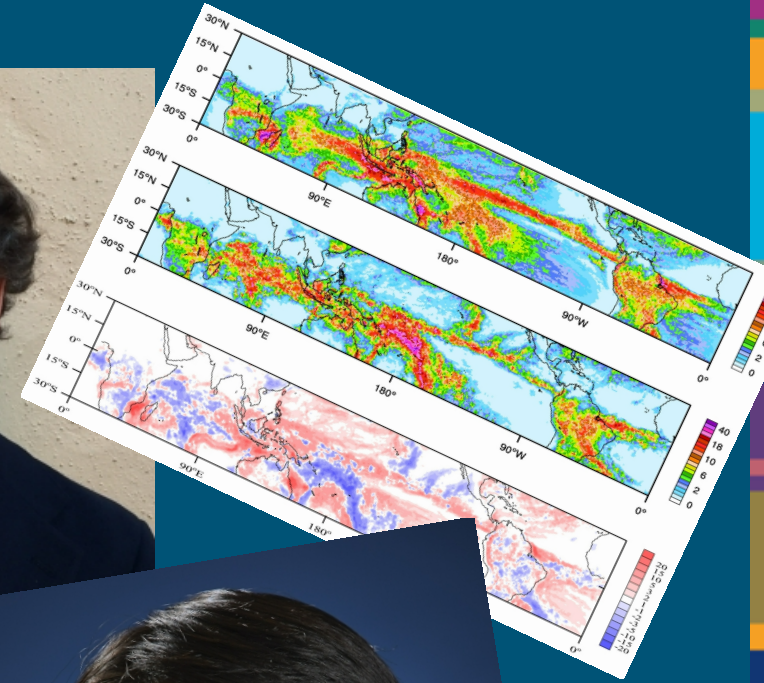
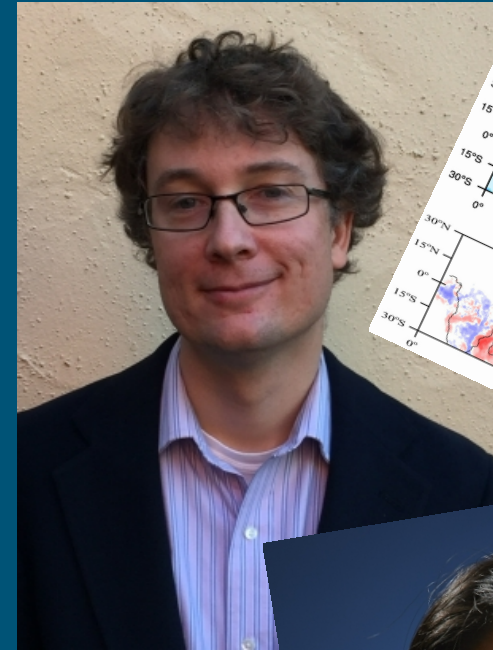
Brad Carvey (SNL) Peter Caldwell + Chris Terai (LLNL)

Approved for Unlimited Release



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# Collaborators Art and Science



# Pre Pandemic Visualization Collaboration



In person meeting between Scientist and Visualization expert.  
Interactive real time discussions of how to best visualize the Scientists Data.



# Post Pandemic Visualization Collaboration



Email exchanges.

Virtual meetings with limited interactivity and communications problems.



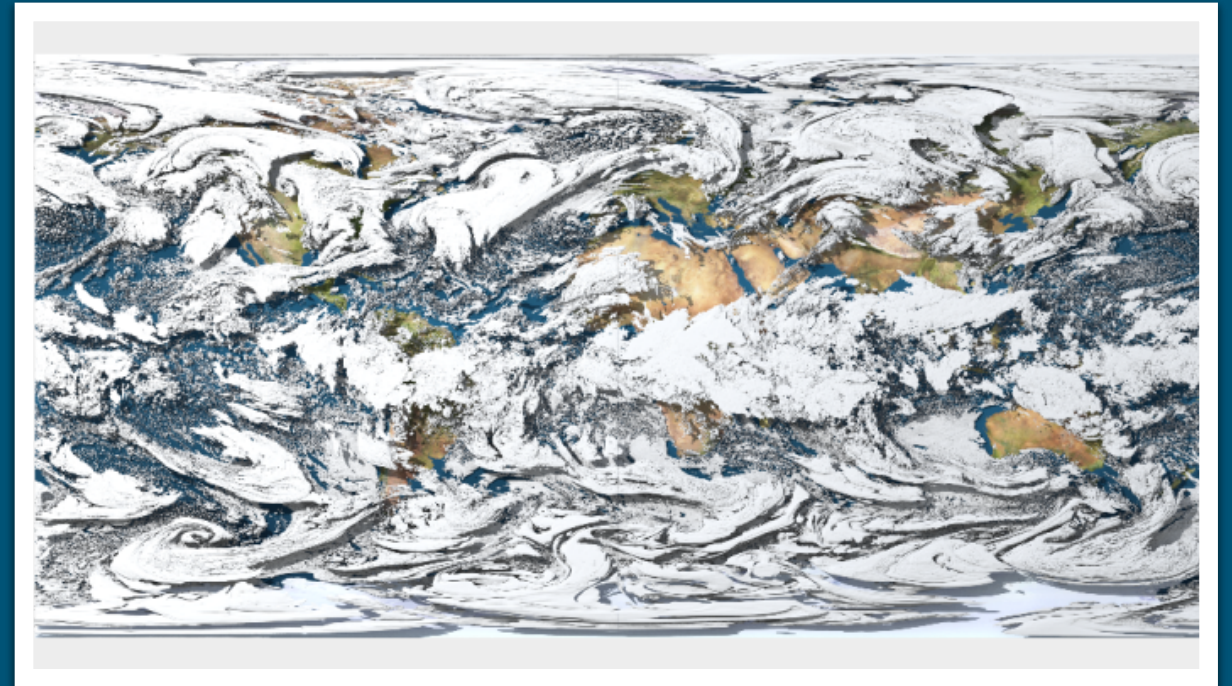
# Future Big Data Visualization Collaboration

## What is needed?

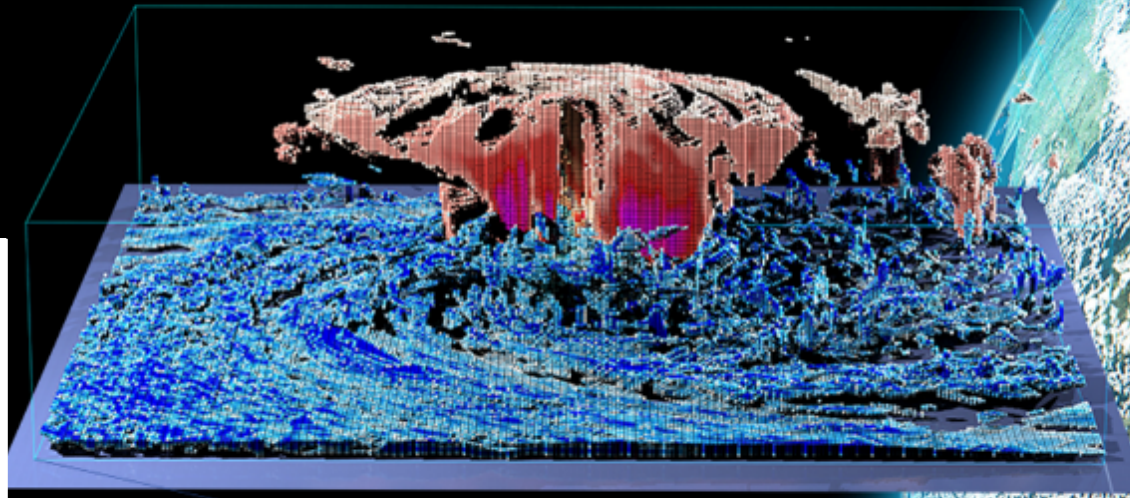
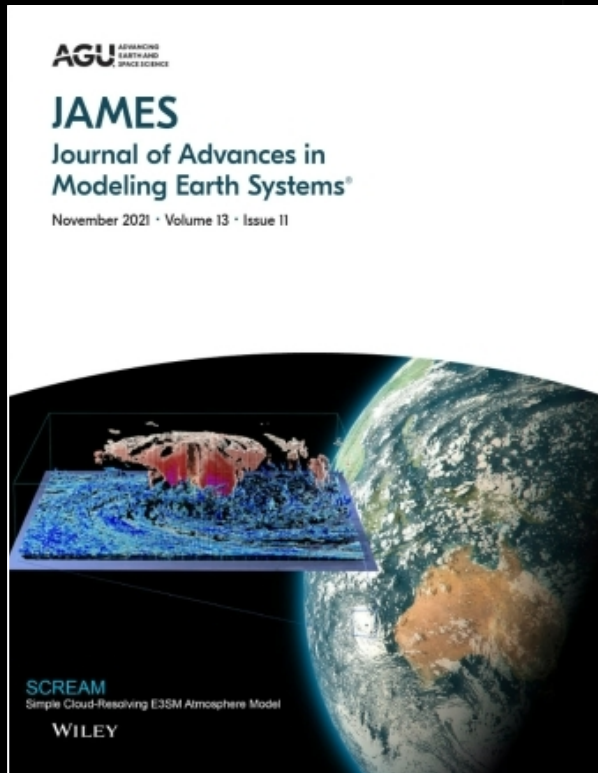
- Real time interaction
- Real time shared graphics
- Remote and local control of visualization
- Real time sharing of large datasets
- New techniques for handling big data.

## ISSUES

- Sharing a screen (Zoom) does not allow local and remote collaborators to control the screen.
- Users may have a variety of computing platforms (Win, MacOS, iOS, Android, Linux)
- Real time data is limited by network speed
- Tools will always struggle to handle the volume of data at the cutting edge.



# SCREAM Simple Cloud-Resolving E3SM Atmosphere Model



**SCREAM**  
Simple Cloud-Resolving E3SM Atmosphere Model

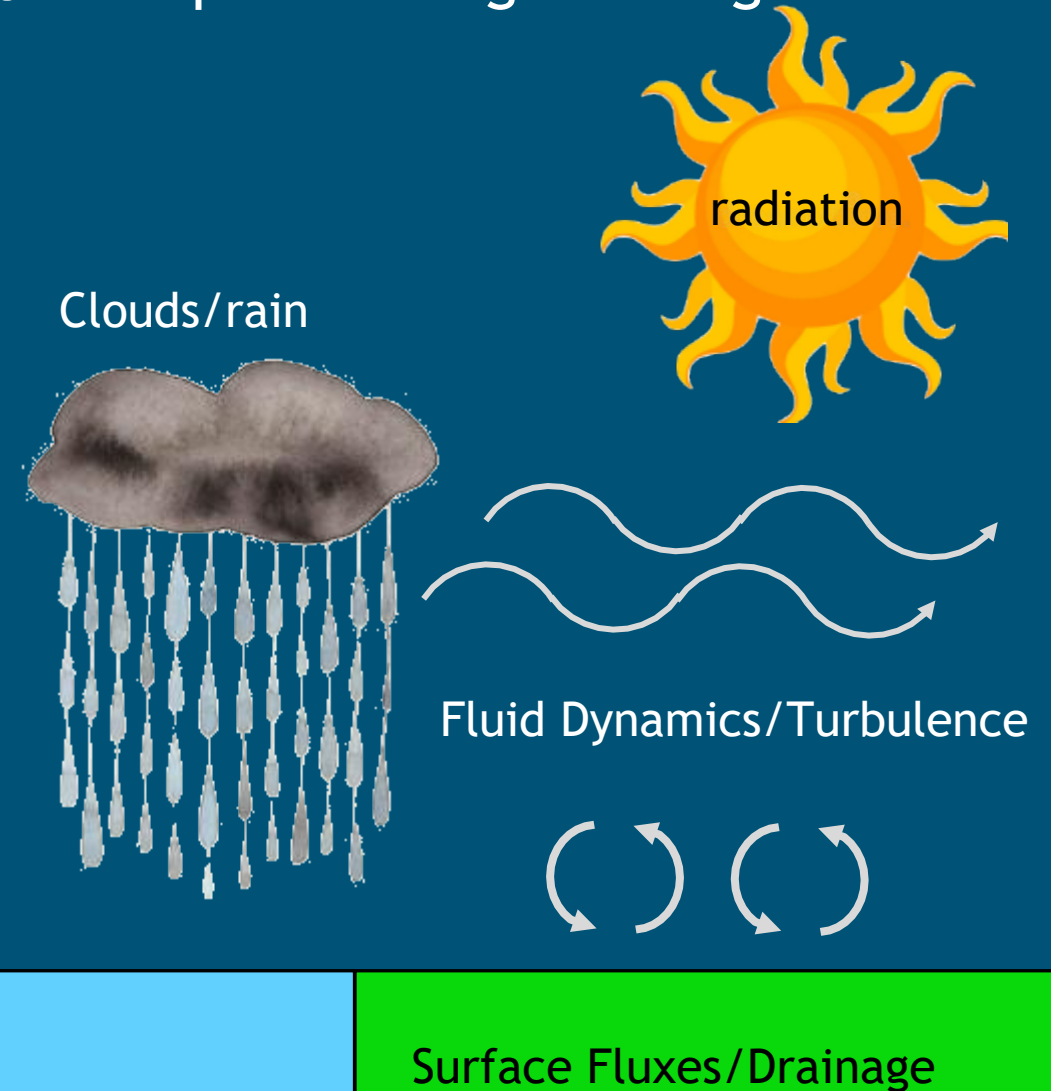
*Fig: Zoom into a  
SCREAMv0-  
simulated hurricane  
with liquid (blue) and  
ice (red) mass. From  
JAMES, Nov 2021  
cover*

# What is in SCREAM?

SCREAM was written in C++/Kokkos to run fast on exascale computers

... and includes all physical processes governing weather

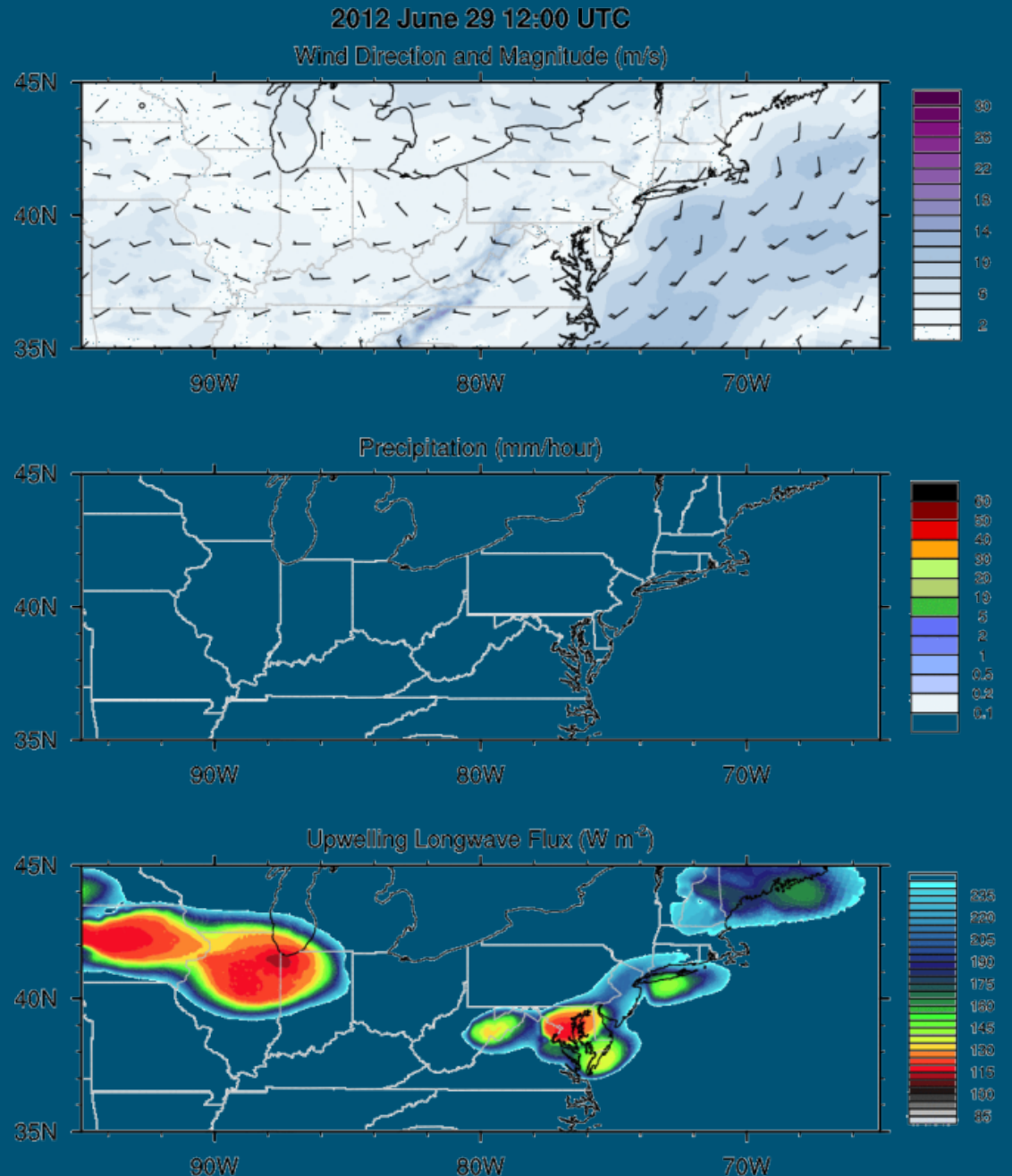
```
IntSmallPack shift_range;  
vector_simd  
for (int s = 0; s < Spack::n; ++s) {  
    shift_range[s] = range_pack[s];  
}  
  
shift_range.set(range_pack > nlev-1, 1); // don't calculate shift above nlev-1  
ekat::index_and_shift<1>(skv_term, shift_range, kv_term_k, kv_term_kp1);  
ekat::index_and_shift<1>(stmpi, shift_range, tmpi_k, tmpi_kp1);  
  
// Determine superdiagonal (du) and subdiagonal (dl) coeffs of the  
// tridiagonal diffusion matrix.  
du_k = -kv_term_kp1*tmpi_kp1*rdp_zt(k);  
dl_k = -kv_term(k)*tmpi(k)*rdp_zt(k);  
  
// The bottom element of the superdiagonal (du) and the top element of  
// the subdiagonal (dl) is set to zero (not included in linear system).  
du_k.set(range_pack == nlev-1, 0);  
dl_k.set(range_pack == 0, 0);  
  
// The diagonal elements are a combination of du and dl (d=1-du-dl). Surface  
// fluxes are applied explicitly in the diagonal at the top level.  
d_k = 1 - du_k - dl_k;  
d_k.set(range_pack == nlev-1, d_k + flux*dttime*ggr*rdp_zt(k));  
  
// Diagonals must be scalar in nlev.  
for (int p=0; p<Spack::n && range_pack[p]<nlev; ++p) {  
    du(range_pack[p]) = du_k[p];  
    dl(range_pack[p]) = dl_k[p];  
    d(range_pack[p]) = d_k [p];  
}  
});
```



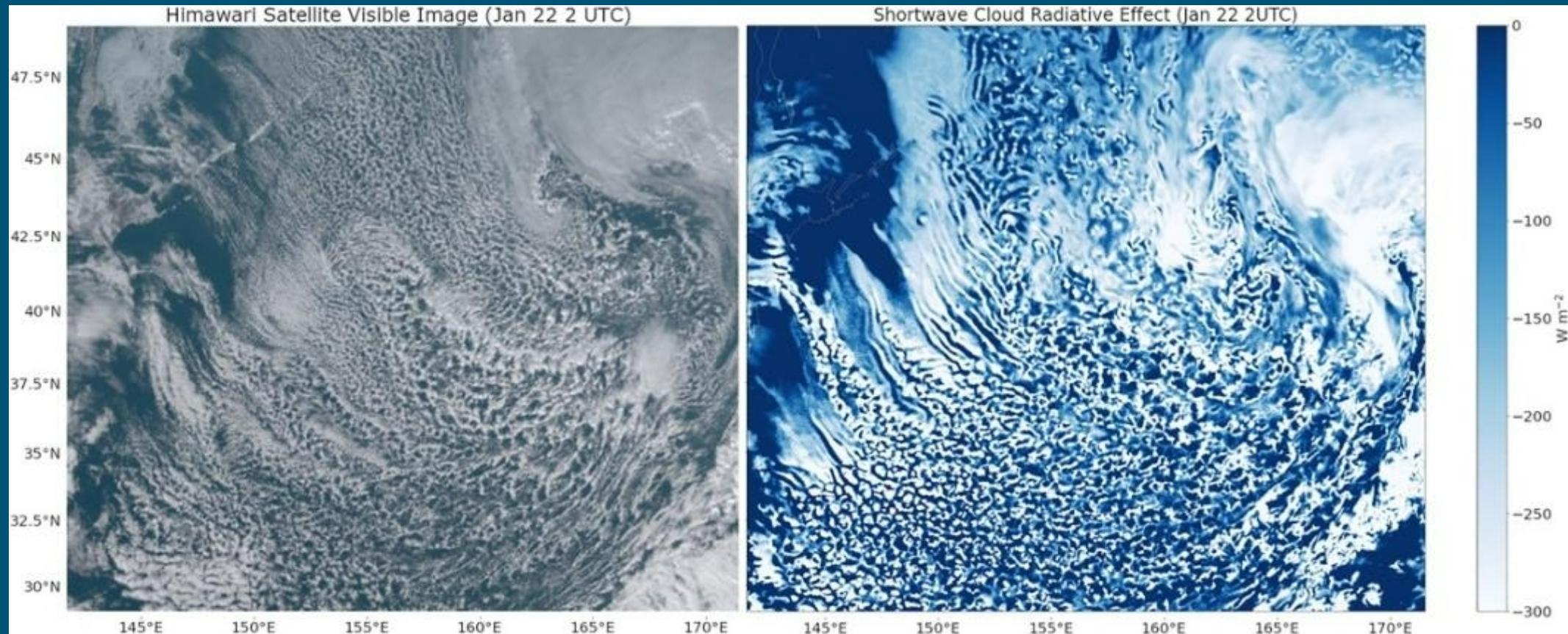
# Higher Resolution = Better Predictions

- SCREAM uses 3 km grid spacing, which explicitly resolves topography and storms
- This solves many longstanding problems in climate modeling! See:
  - Caldwell et al., (2021; JAMES)
  - Liu et al., (2023; JAMES)

*Fig: June 29<sup>th</sup> 2012 derecho over the Midwest/Mid-Atlantic US as simulated by SCREAM at 3 km by Weiran Liu and Paul Ullrich*



# Dealing with this Data is Frontier Science



*Cold-air outbreak off Siberia on January 22, 2020 at 2:00:00 UTC (~local noon) from a Himawari visible satellite image (left) and shortwave cloud radiative effect from SCREAMv0 (right). Visualization is over a region bounded by 29°-49°N and 141.5° to 171.5°E.*

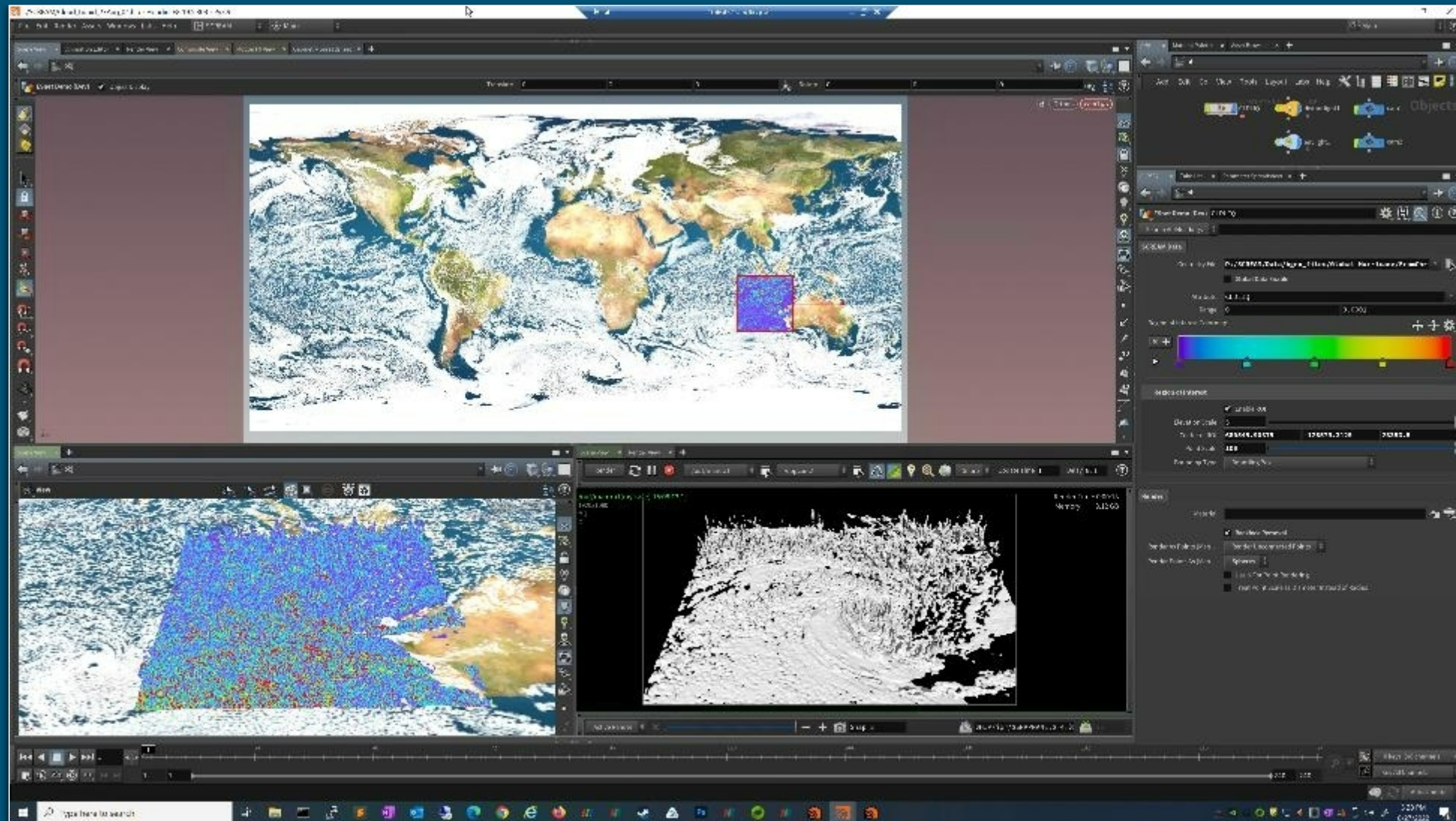
# Multi-Lab Collaboration:



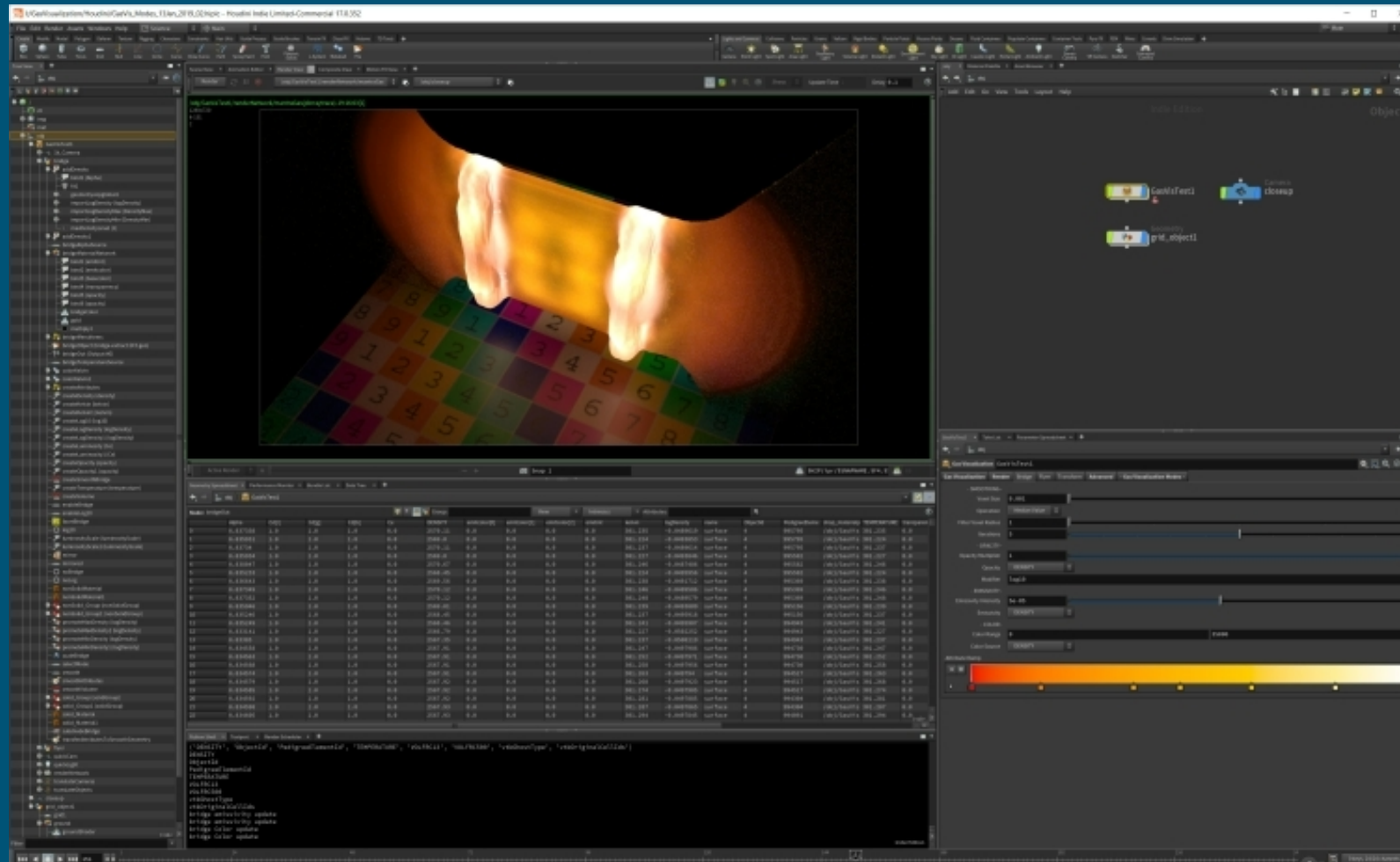
- SCREAM dataset = ~40 TB *per simulated month*
- Collaboration is only possible with reduced datasets and fast networks
- How can we explore this massive dataset together?



# Collaborative HPC Visualizer Tool



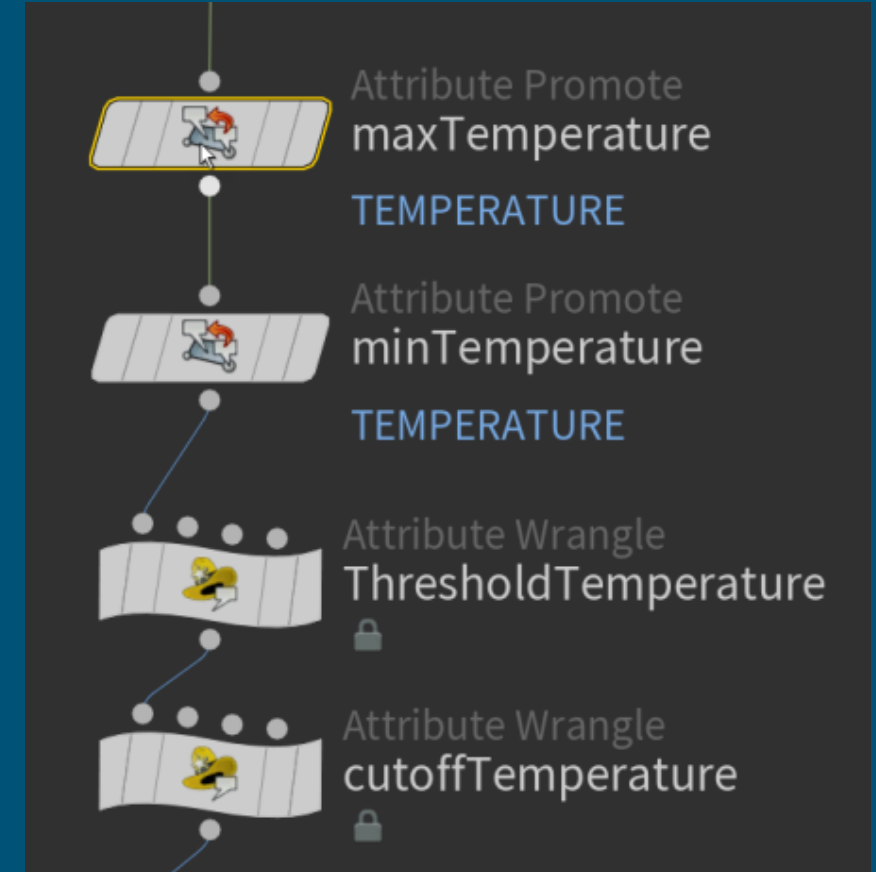
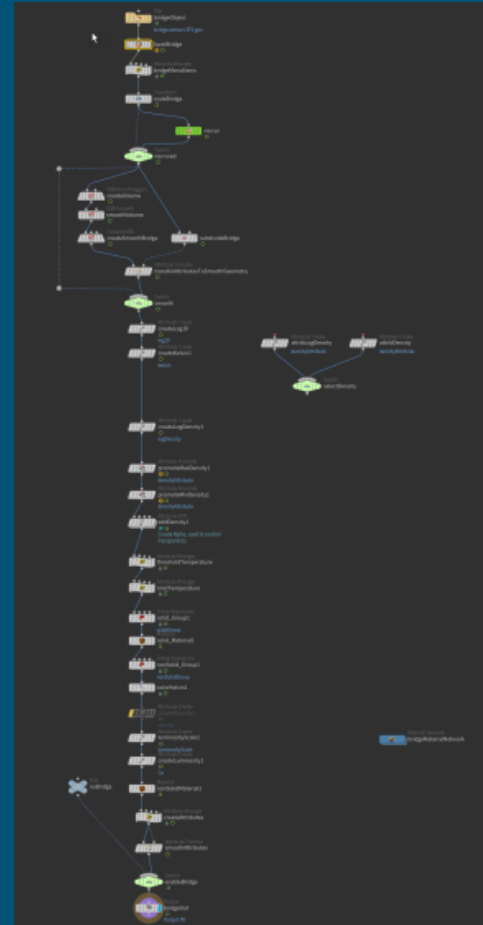
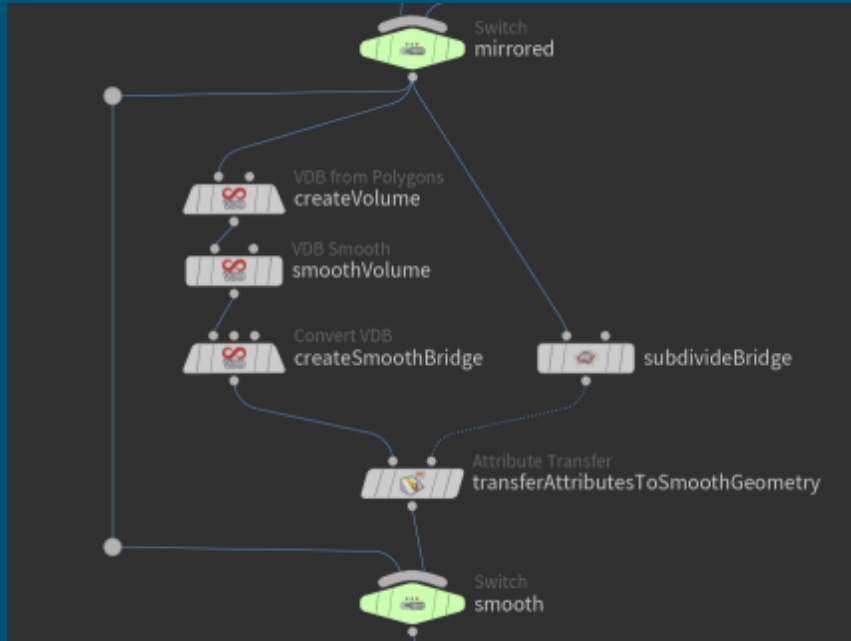
# Houdini



Houdini is a procedural 3d effects and animation software application, used by major VFX studio for the creation of Feature Films and Games.



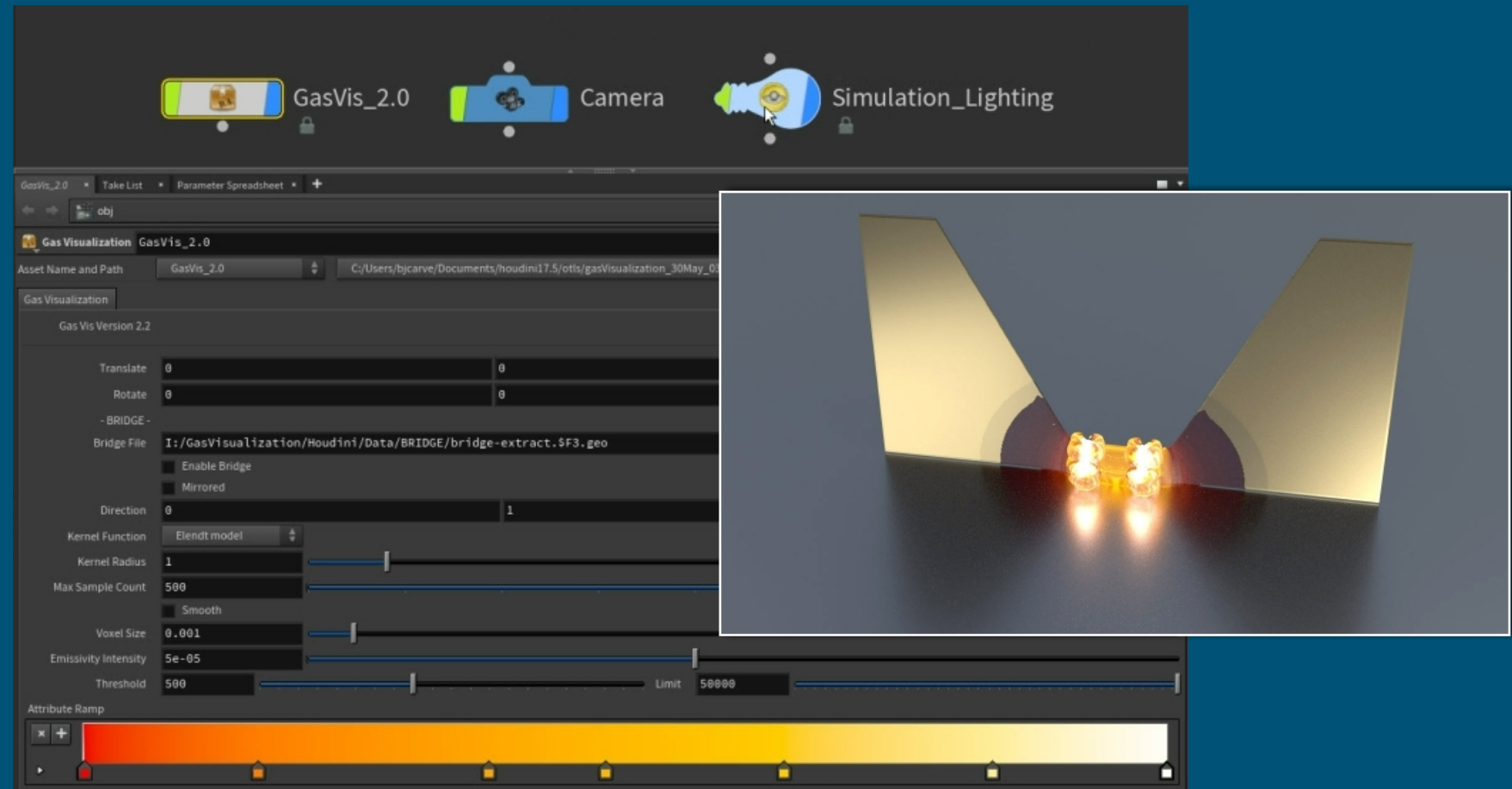
# Houdini



Experts create digital assets



# Houdini

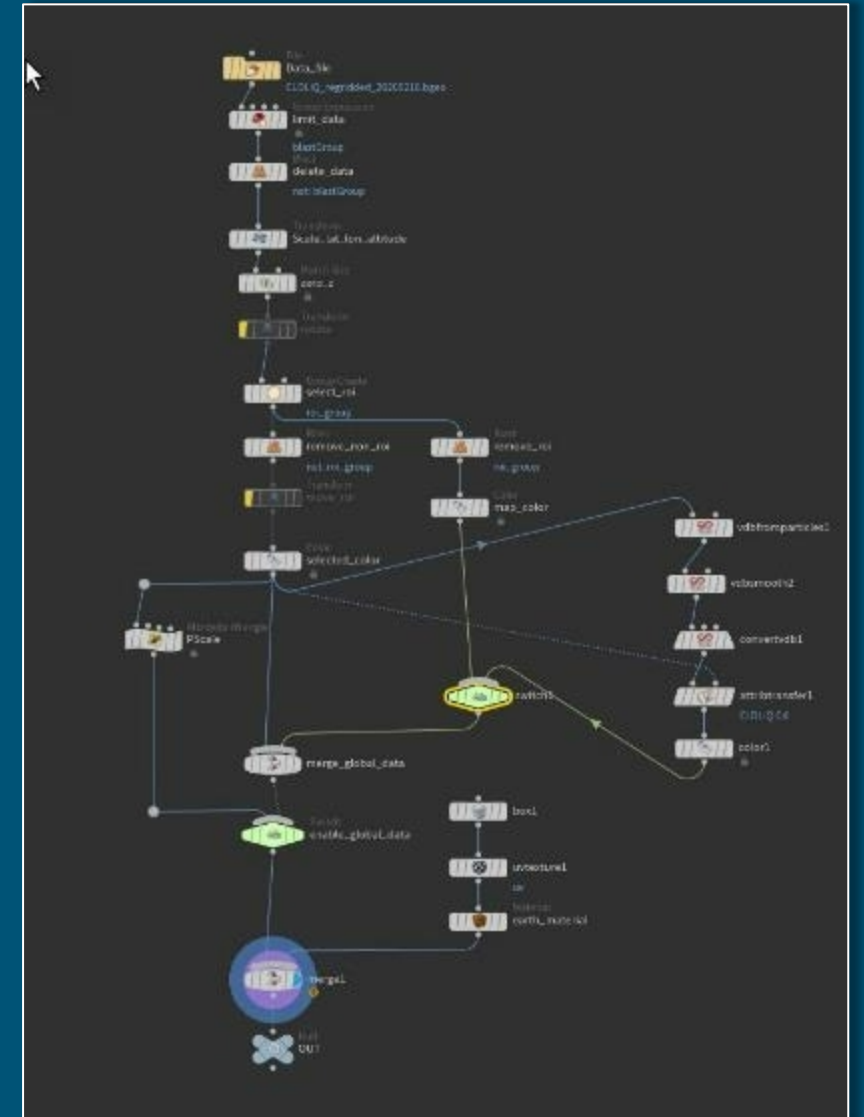
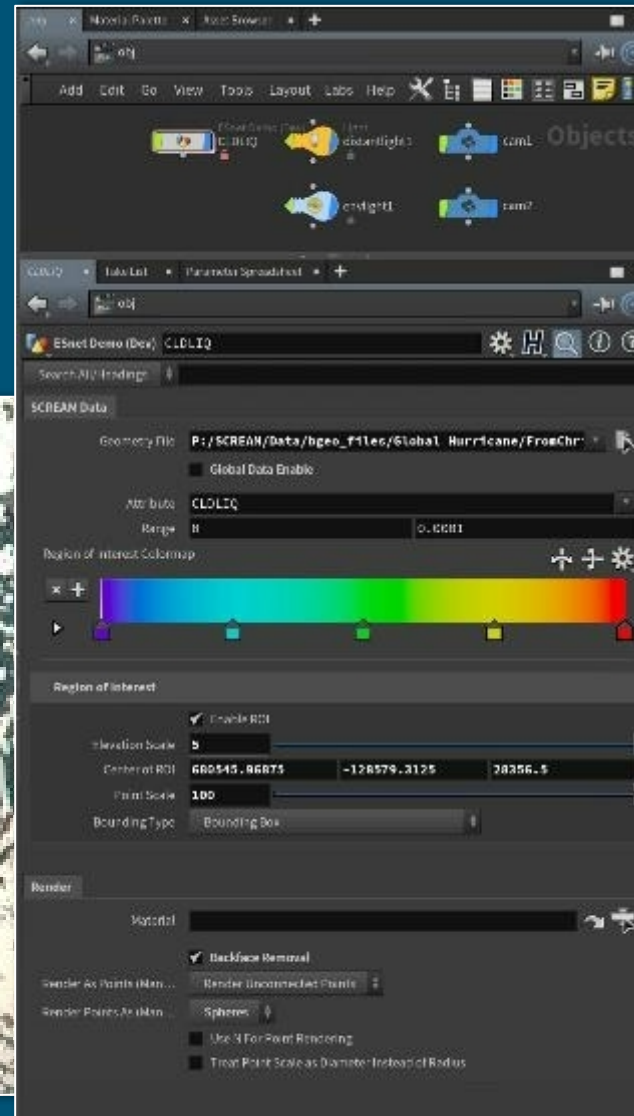


Scientists can use Houdini digital assets to create impactful visualizations, directly from their simulation datasets.

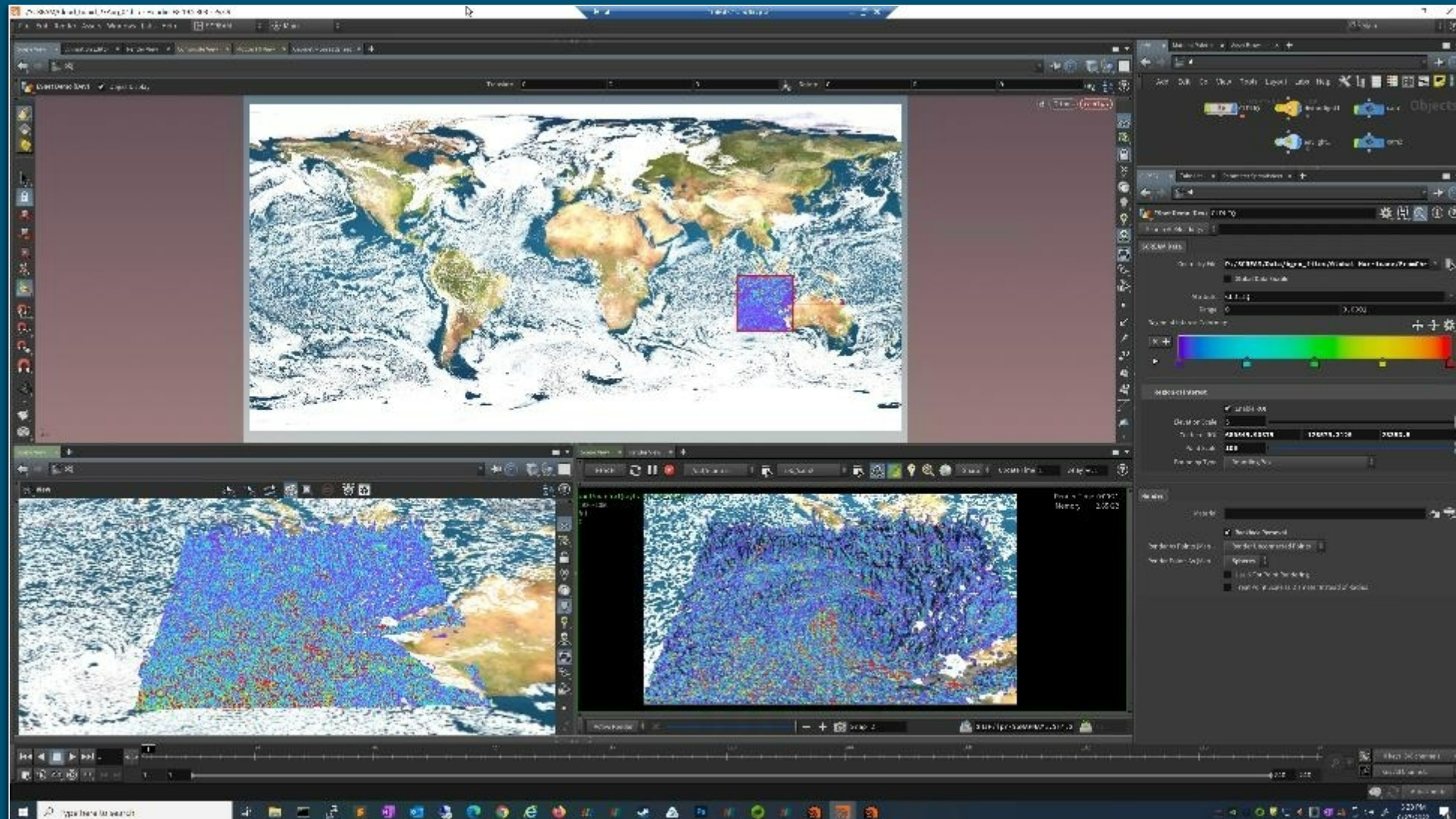
# SCREAM Visualization Tool



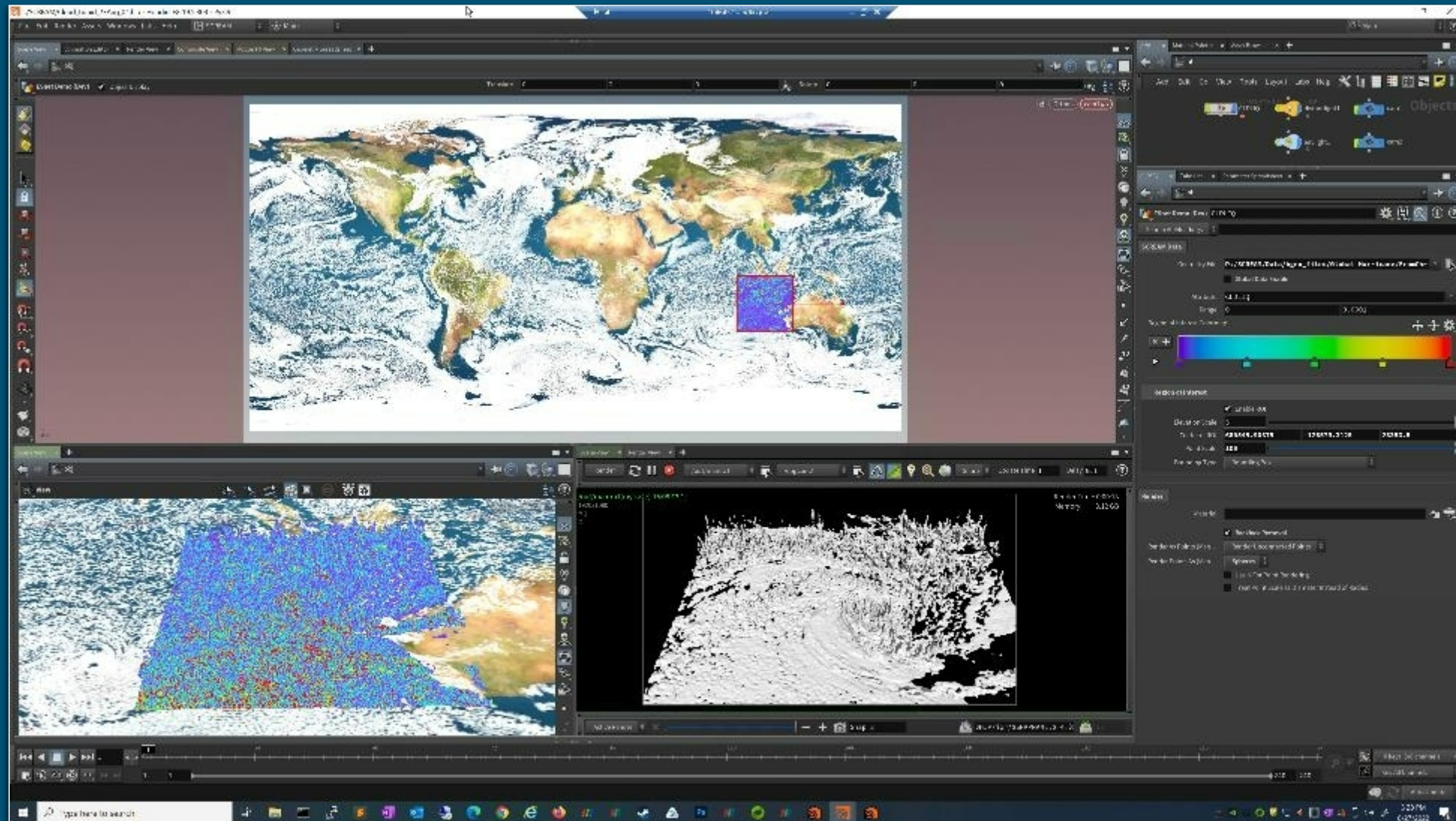
The simplified interface is easy to select a dataset and modify the way it is displayed. The tool is run by the SNL Visualization expert.



# LLNL Scientist selects an area of interest



# Visualizing SCREAM surface & volume data



# Omniverse

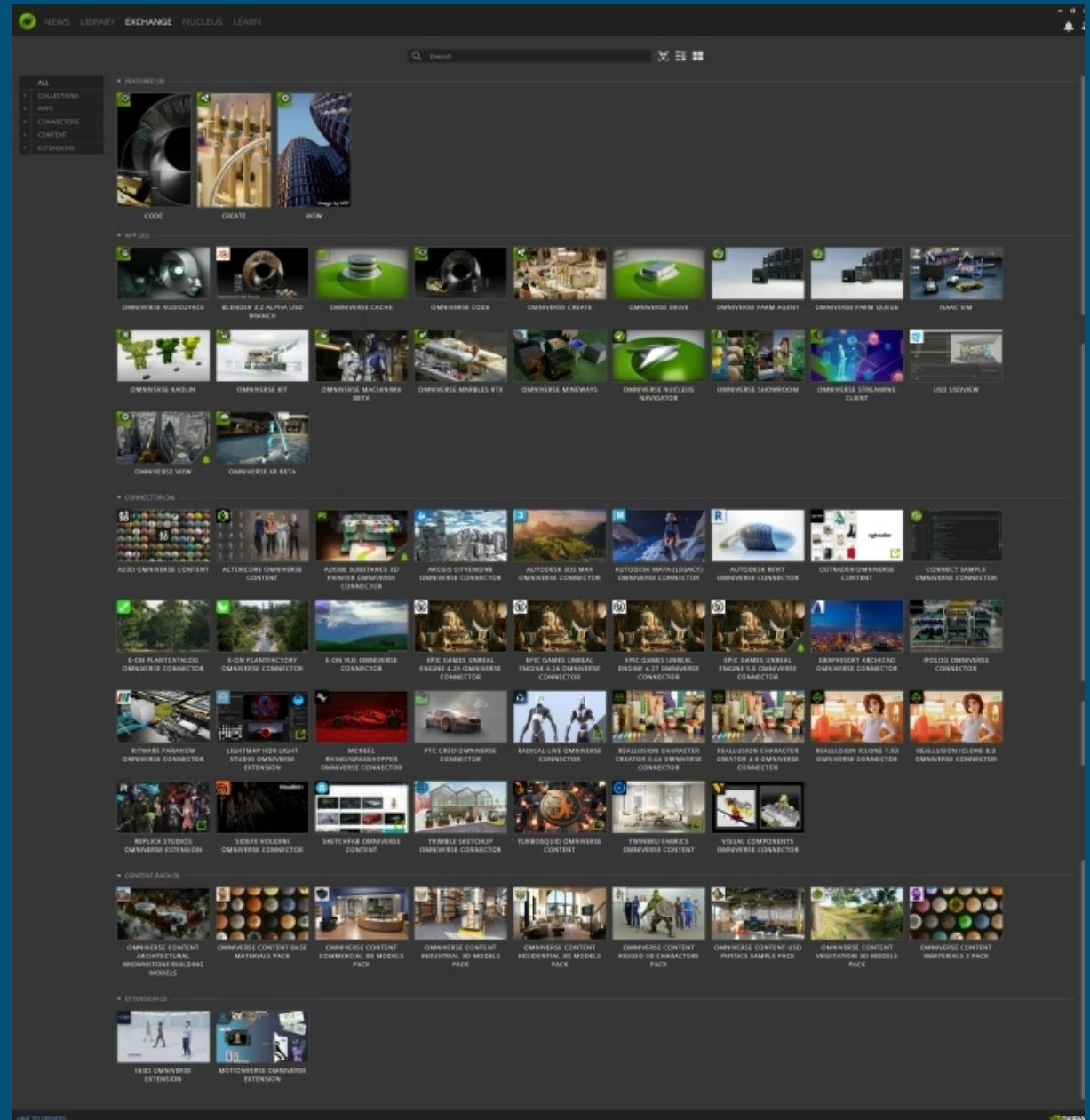
“NVIDIA Omniverse™ is an easily extensible platform for 3D design collaboration and scalable multi-GPU, real-time, true-to-reality simulation. Omniverse revolutionizes the way we create and develop as individuals and work together as teams, bringing more creative possibilities and efficiency to 3D creators, developers and enterprises.”

## NVIDIA

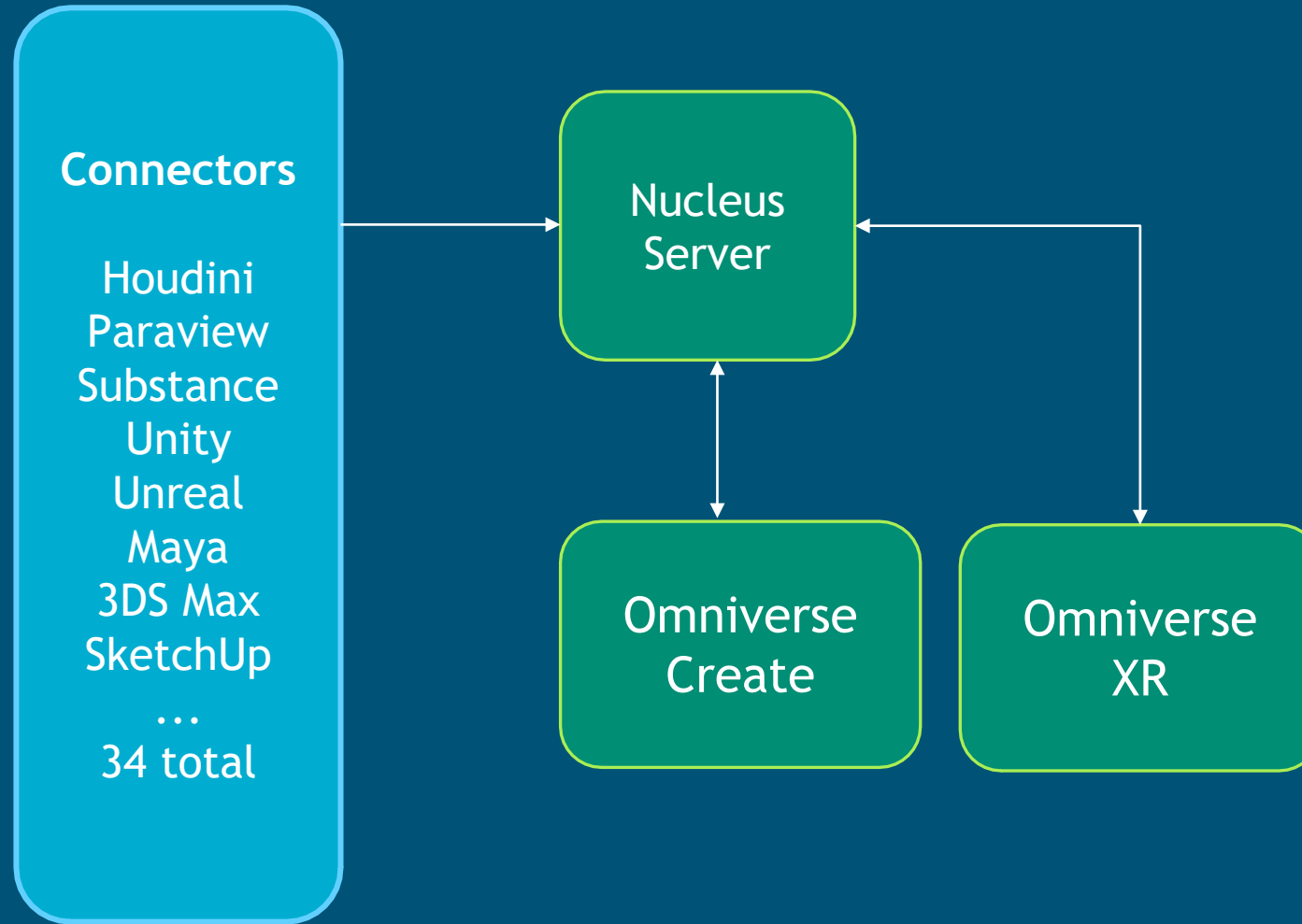
20 Omniverse apps (XR, AI, SIM, animation ...)

34 Connectors to apps (Paraview, Houdini ...)

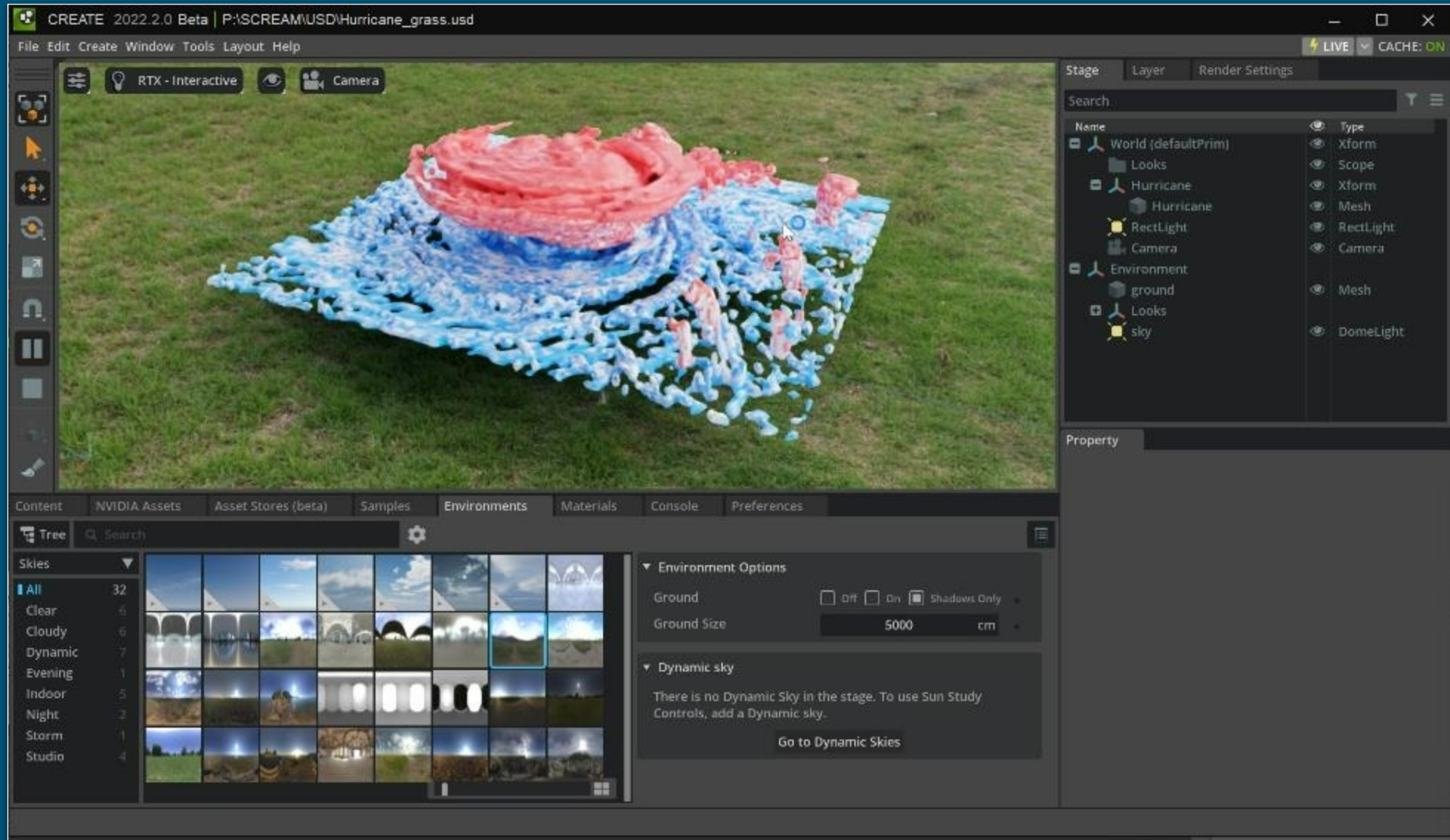
100s of extensions



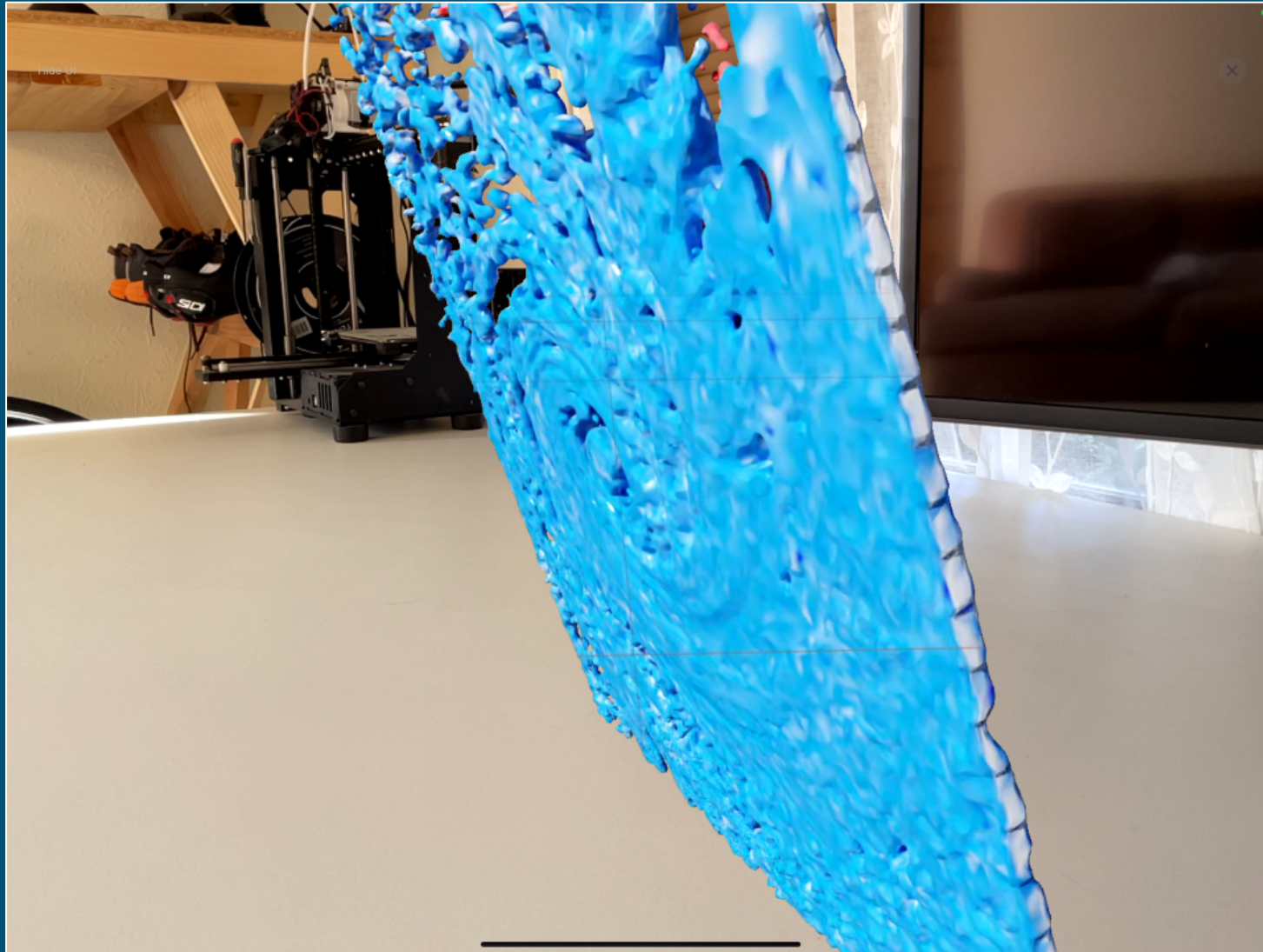
# Omniverse Connectors



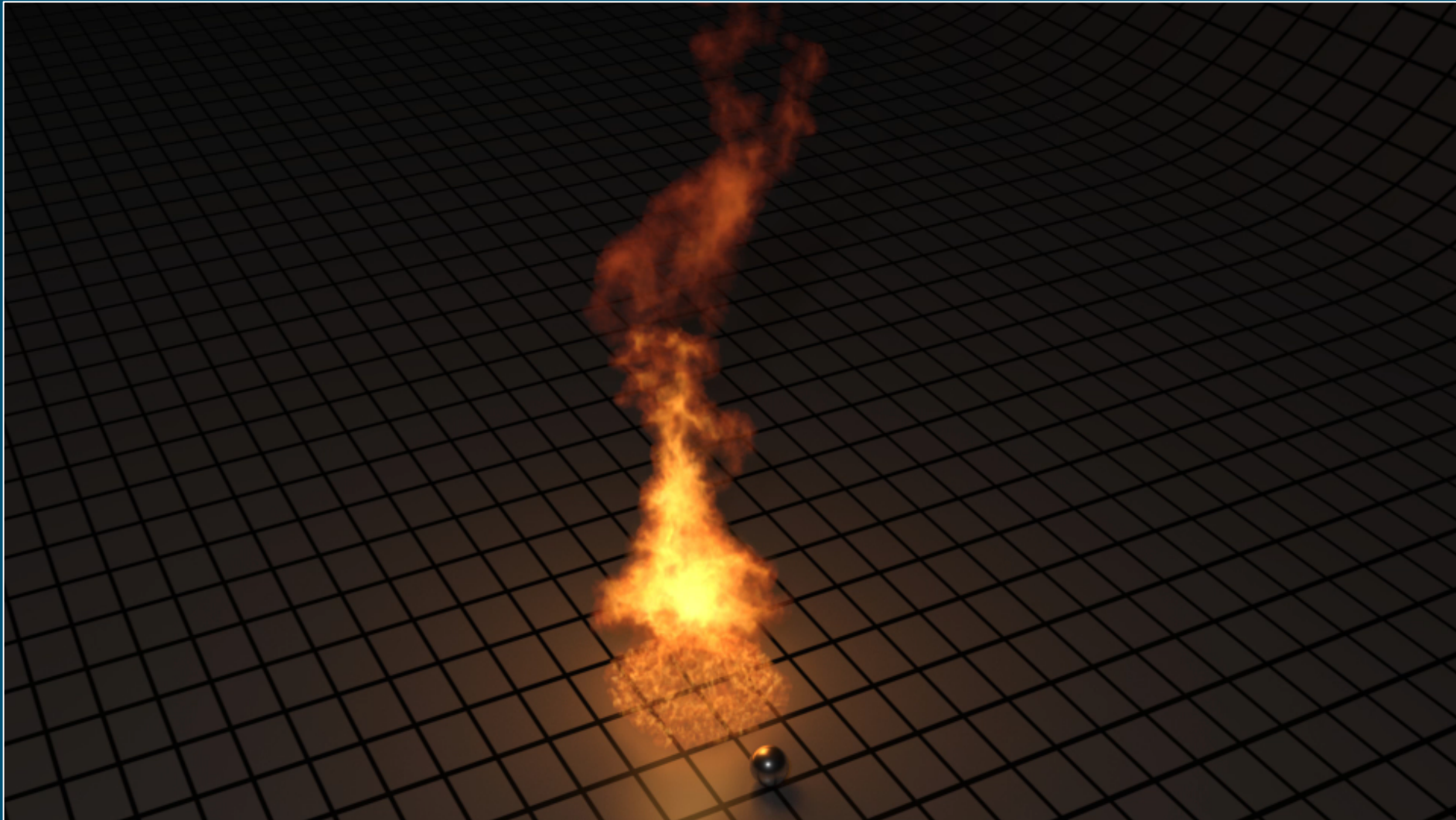
# The SCREAM data is rendered in Omniverse



# LLNL Scientist Views SCREAM data in AR



# Collaborative Visualization of other HPC datasets



# E3SM SCREAM Data



This research was supported as part of the Energy Exascale Earth System Model (E3SM) project, funded by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research. It used resources of the National Energy Research Scientific Computing Center (NERSC), a U.S. Department of Energy Office of Science User Facility located at Lawrence Berkeley National Laboratory, operated under Contract No. DE-AC02-05CH11231.

Caldwell's contribution was supported by LLNL under Contract DE-AC52-07NA27344.

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